BNL 683 (T-230)

# CATALOGUE OF HIGH ENERGY ACCELERATORS

Compiled by

MARK Q. BARTON

September 6, 1961

BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
under contract with the
United States Atomic Energy Commission

BNL 683 (T-230)
(Particle Accelerators and High-Voltage
Machines – TID-4500, 16th Ed.)

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BROOKHAVEN NATIONAL LABORATORY
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# INTRODUCTION

This report represents an attempt to present an up-to-date compilation of parameters of existing high energy accelerators. To obtain the data for this compilation, questionnaires were sent to the various laboratories. Response to the questionnaires has been excellent, but some institutions have not replied. Although it would be possible in many cases to complete the forms for these machines from published data, we have not taken the liberty of doing so. However, blank questionnaires are included for the use of those who wish to fill in data on other machines. Editing of questionnaires has been kept to a minimum.

The form of the data sheets was adapted from an Oak Ridge report, ORNL-2644, *Cyclotrons and High Energy Accelerators – 1958*, edited by Dr. F.T. Howard, and we acknowledge the extensive use we have made of that report. The precedent for presenting such compilations was established by the CERN group in 1959 in conjunction with the International Conference on High Energy Accelerators, and we acknowledge use of their report. Finally, we wish to express our appreciation to all the people from various institutions who have filled out the questionnaires.

M.Q. Barton

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## CONTENTS

# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE: ANU 10-Gev Proton Synchrotron

INSTITUTION: Australian National University

ADDRESS: Box 4, G.P.O., Canberra, A.C.T., Australia

PERSON IN CHARGE: Sir Mark Oliphant

PERSON SUPPLYING DATA: J.W. Blamey    DATE: June 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | 1953 | COMPLETION DATE | 1962-63 |
| MODEL TESTS | 1954 | SCHEDULED OPERATION | hr/wk |
| ENGINEERING DESIGN | 1954 | COST OF ACCELERATOR | and power supply £600,000 (Aust.) |
| CONSTRUCTION STARTED | 1954 | COST OF BUILDINGS | £200,000 (Aust.) |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 5 |
| ENGINEERS | 3 |
| TOTAL | 8 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| ENERGY | 10.6 Gev |
| PULSE RATE | 1 per 10 min |
| OUTPUT | part./pulse |

### INJECTOR SYSTEM

| | |
|---|---|
| TYPE | Cyclotron |
| ENERGY | 8 Mev |
| INJECTOR OUTPUT | 1 ma |
| INJECTION PERIOD | 30 turns |
| INFLECTOR TYPE | Electrostatic |

### ACCELERATION SYSTEM

| | |
|---|---|
| FINAL ROTATION FREQ. | 7.5 Mc/sec |
| HARMONIC NO. | 1 |
| NUMBER OF CAVITIES | 1 |
| FREQUENCY RANGE | 1 TO 7.5 Mc/sec |
| ENERGY GAIN | 4 kev/turn |
| INPUT TO RF, MAX. | 60 kw |

### MAGNET

| | |
|---|---|
| FOCUSING TYPE | Weak, c.g. |
| FOCUSING ORDER | |
| FIELD INDEX, $n=$ | -0.55 |
| BETATRON OSC. FREQ. $Q_r$ | |
| $Q_z$ | |
| ORBIT RADIUS | 4.8 m |
| MEAN RADIUS | 6.4 m |
| SECTORS, NO. | 4 |
| FIELD AT INJ. | 850 gauss |
| FIELD, MAX. | 80 kgauss |
| STORAGE SYSTEM | Homopolar generator |
| RISE TIME | 0.7 sec |
| WEIGHT: Fe | 0 ; Cu 80 tons |
| POWER INPUT, PEAK | 500,000 kw |
| POWER INPUT, AVERAGE | 800 kw |
| APERTURE WIDTH | 22 cm |
| APERTURE HEIGHT | 22 cm |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______________________ Gev

ENERGY SPREAD ______________________ %

BEAM CURRENT ______________________ part./pulse

PULSE RATE ______________________

DUTY CYCLE ______________________ %

WIDTH OF SHORTEST PULSE ______________________ msec

METHOD OF TARGETING ______________________

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² ______________________

NUMBER OF BENDING MAGNETS ______________________

FOCUSING MAGNETS ______________________

AVAILABLE MAGNET POWER, Mw ______________________

SHIELDING, tons ______________________

OTHER SERVICES ______________________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

For the last four years effort has been concentrated on the homopolar generator and not on the synchrotron. The upper half of the homopolar generator is due to be tested at full current late in 1961.

### OTHER FEATURES

Air-cored orbital magnet with homopolar generator of stored energy of 5 x $10^8$ joules at 800 volts as pulse power supply.

### PUBLISHED ARTICLES DESCRIBING MACHINE

J.W. Blamey, The orbital magnet and power supply of the 10-Gev Proton Synchrotron at the Australian National University, Proc. CERN Symposium High Energy Accelerators and Pion Phys., Geneva, 1956, Vol. 1, p. 344.

# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE: CERN - 25 Gev Proton Synchrotron (CPS)

INSTITUTION: European Organization for Nuclear Research "CERN"

ADDRESS: CERN - Meyrin/Geneva 23 (Switzerland)

PERSON IN CHARGE: P. Germain

PERSON SUPPLYING DATA: K.H. Reich DATE: June 15, 1961

## HISTORY AND STATUS

DESIGN (DATE): 1953-54

MODEL TESTS: 1954-57

ENGINEERING DESIGN: 1955-58

CONSTRUCTION STARTED: 1956

COMPLETION DATE: 1959

SCHEDULED OPERATION: 90 hr/wk

COST OF ACCELERATOR / COST OF BUILDINGS: 110 Million Sw. Fr. (including general expenses)

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS:

ENGINEERS:

TOTAL:

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY: (kinetic) 24.3 to 28.5 Gev

PULSE RATE: 20 per min to 12 per min

OUTPUT: $10^{10}$ part./pulse

### INJECTOR SYSTEM

TYPE: Linear accelerator

ENERGY: 50 Mev

INJECTOR OUTPUT: 1 ma

INJECTION PERIOD: 1 turns

INFLECTOR TYPE: Pulsed electrostatic

### ACCELERATION SYSTEM

FINAL ROTATION FREQ.: 0.477 Mc/sec

HARMONIC NO.: 20

NUMBER OF CAVITIES: 16

FREQUENCY RANGE: 3 TO 9.55 Mc/sec

ENERGY GAIN: 54 (av) kev/turn

INPUT TO RF, MAX.: 16 x 6 kw

### MAGNET

FOCUSING TYPE: Strong, a.g.

FOCUSING ORDER: 1/2F O 1/2F 1/2D O 1/2D

FIELD INDEX, $n =$ 288.4

BETATRON OSC. FREQ. $Q_r$: 6.25

$Q_z$: 6.25

ORBIT RADIUS: 70.079 m

MEAN RADIUS: 100.00 m

SECTORS, NO.: 100

FIELD AT INJ.: 147.6 gauss

FIELD, MAX.: 12 - 14 kgauss

STORAGE SYSTEM: Flywheel

RISE TIME: 1.0 to 1.2 sec

WEIGHT: Fe 3400; Cu Al 130 tons

POWER INPUT, PEAK: 34,600 kw

POWER INPUT, AVERAGE: 1,700 kw

APERTURE WIDTH: 14 cm

APERTURE HEIGHT: 10 cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY (kinetic) 28.5 Gev

ENERGY SPREAD <±0.02 %

BEAM CURRENT $2.5 \times 10^{11}$ part./pulse

PULSE RATE 60 per min to 12 per min

DUTY CYCLE (counter beams) ≈ 5% at 19 Gev, ≈0.5% at 27 Gev %

WIDTH OF SHORTEST PULSE 0.3 msec

METHOD OF TARGETING See attached.

### EXTERNAL AND SECONDARY BEAMS

Data are given below on some of the beams in use currently.

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| Scattered p at 20 mrad | 30,000 | 6 at 60 m* | 9,000 to 27,000** | ±1 |
| $\pi^\pm$ at 100 mrad | ≈1,000 | 75 at 80 m* | 6,000 | ±3 |
| $K^-$, $\bar{p}$ at 100 mrad | 10 | 75 at 80 m* | 6,000 | ±3 |
| Separated $\bar{p}$ at 200 mrad | 1.0<br>1.5 | 4 at 110 m* | 175<br>192 | ±0.7 |
| $e^+$ at 56 mrad† | 400 | 25 at 60 m* | 8,000 | ±2 |
| $\gamma$ at 56 mrad | 10,000 | 35 at 64 m | >200 | exponential spectrum |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² 3500 (end of 1961)

NUMBER OF BENDING MAGNETS 18

FOCUSING MAGNETS 26

AVAILABLE MAGNET POWER, ~~Mw~~ for beam transport, 4 Mw

SHIELDING, tons 11,000

OTHER SERVICES 6-Mw supplies for track chamber magnets. Two 3-m electrostatic separator tanks in Counting room 200 m². Exhaust and ventilation systems for hydrogen, propane, and ethylene.

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

See attached.

### OTHER FEATURES

See attached.

### PUBLISHED ARTICLES DESCRIBING MACHINE

See attached.

---

*Quadrupoles in beam.

**By varying machine energy.

†By conversion of $\gamma$.

## METHOD OF TARGETING

(A) For long burst (>100 msec): After debunching, the beam is made to spiral onto thin foil (normally 25 or 50-μ Al or Be) or onto "point source" (3-mm diameter as viewed from direction of secondary beam) targets by decreasing slowly the main magnetic field after it reaches the top value. (B) For short burst (a few hundred μsec): (1) Low intensity: Fast target cuts through beam (beam consumption 0.5 to 20%); (2) High intensity: Beam is rapidly brought onto thick target (beam consumption 100%). For details see references 4 and 5 below.

## USE OF MACHINE

Types of experiments in progress:

1. Bubble chambers: (a) Stopping $\bar{p}$ in $H_2$; (b) High energy jets and strange particle production in $H_2$.
2. Counter experiments: (a) Various production spectra; (b) High energy total cross section on $H_2$; (c) Quasi-elastic p-p scattering; (d) Associated production by $\pi^-$ in $H_2$; (e) Positron annihilation.
3. Chambers and counters: Exploratory runs aiming at establishing the possibilities for a neutrino experiment.
4. Nuclear emulsions: About 20 different experiments.
5. Radiochemistry: Production cross sections of $Na^{24}$ and $C^{11}$ at 24 Gev and other investigations.
6. New beams: Setting-up of a separated 2-Gev/c K-beam, 3-Gev/c $\bar{p}$-beam.

## OTHER FEATURES

1. The linac, which is equipped with a buncher and a debuncher, delivers regularly 15 to 17 ma of 50-Mev protons. Its operation is remotely controlled from the main control room, after start-up from the linac control position.
2. The automatic beam control system is switched on after 2-1/2 turns of programmed acceleration (15 μsec after completion of the first turn). The trapping efficiency is regularly 40 to 50% and occasionally 60%, the highest theoretical value being 85%.
3. The pulse-to-pulse jitter of the peak accelerated proton energy is $\lesssim$15 Mev as a result of the recent stabilization of the mean rotational frequency of the main alternator set.
4. Two of the 16 target units available are fitted with a six-head assembly. The six heads are brought up in the same radial and azimuthal position; they can be interchanged between machine cycles according to a preselected program.
5. Bending magnets can be shared between several beams by means of programmed pulsed operation synchronized with the corresponding automatic target operation.
6. The CPS is operated 76.5 hr/wk for physics research, 10 hr of operating time are devoted to its technical development, and a further 7 hr are required for starting-up and part tests. The operating crew for normal operation consists of 1 engineer and 7 technicians. The loss of scheduled time due to component failure was <15% averaged over the last year.

## PUBLISHED ARTICLES DESCRIBING MACHINE


1. The theory and design of an alternating-gradient proton synchrotron, Conf. on Alternating-Gradient Proton-Synchrotron, Geneva, 1953, CERN Proton Synchrotron Group, Geneva, 1953.
2. Proc. CERN Symposium High Energy Accelerators and Pion Phys., Geneva, 1956, Vol. 1.
3. E. Regenstreif, Le Synchrotron à Protons du CERN (lère partie), CERN 58-6a, 1.7.1958;

(2ème partie) CERN 59-26, 31.7.1959; (3ème partie) CERN 61-9, 6.3.1961. The CERN Proton Synchrotron (1st part), CERN 59-29, 21.8.1959; (2nd part) CERN 60-26, 29.7.1960.

4. M.G.N. Hine, Features of the CERN Proton Synchrotron of interest to experimenters, Proc. Intern. Conf. Instrumentation in High Energy Physics, University of California, Berkeley, Sept. 1960, PS/Int. MG 60-52, Sept. 5, 1960.
5. CPS Machine Group, Operation and Development Quarterly Reports:
   Report No. 1 - Jan.-March 1960 - CERN 60-23 (15.5.1960)
   Report No. 2 - April-June 1960 - CERN 60-29 (12.8.1960)
   Report No. 3 - July-Sept. 1960 - CERN 60-42 (17.11.1960)
   Report No. 4 - Oct.-Dec. 1960 - CERN 61-19 (16.6.1961)

# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE: SATURNE

INSTITUTION: Commissariat à l'Énergie Atomique - Centre d'Études Nucléaires de Saclay

ADDRESS: Boite Postale No. 2, Gif-sur-Yvette (Seine-et-Oise)

PERSON IN CHARGE: M.R. Maillet

PERSON SUPPLYING DATA: R. Levy-Mandel DATE: May 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | Began in 1953 | COMPLETION DATE | August 1958 |
| MODEL TESTS | " " 1954 | SCHEDULED OPERATION | 110 hr/wk |
| ENGINEERING DESIGN | 1954 | COST OF ACCELERATOR | 40 Million Fr. |
| CONSTRUCTION STARTED | 1955 | COST OF BUILDINGS | 10 Million Fr. |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

- SCIENTISTS: 20
- ENGINEERS: 70
- TOTAL: 90

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

- ENERGY: 3 Gev
- PULSE RATE: 1 per 3.2 sec
- OUTPUT: $5.8 \times 10^{10}$ part./pulse

### INJECTOR SYSTEM

- TYPE: Van de Graaff
- ENERGY: 3.6 Mev
- INJECTOR OUTPUT: 3 to 4 ma
- INJECTION PERIOD: ≈40 turns
- INFLECTOR TYPE: Electrostatic

### ACCELERATION SYSTEM

- FINAL ROTATION FREQ.: 4.22 Mc/sec
- HARMONIC NO.: 2
- NUMBER OF CAVITIES: 1
- FREQUENCY RANGE: 0.76 TO 8.44 Mc/sec
- ENERGY GAIN: 1.16 kev/turn
- INPUT TO RF, MAX.: 16 kw

### MAGNET

- FOCUSING TYPE: Weak, c.g.
- FOCUSING ORDER:
- FIELD INDEX, $n =$ 0.6
- BETATRON OSC. FREQ. $Q_r$: 0.724
- $Q_z$: 0.889
- ORBIT RADIUS: 8.42 m
- MEAN RADIUS: 11 m
- SECTORS, NO.: 4
- FIELD AT INJ.: 326 gauss
- FIELD, MAX.: 15 kgauss
- STORAGE SYSTEM: Flywheel
- RISE TIME: 0.9 sec
- WEIGHT: Fe 1080 ; Cu 55 tons
- POWER INPUT, PEAK: 24,000 kw
- POWER INPUT, AVERAGE: 1,000 kw
- APERTURE WIDTH: 36 cm
- APERTURE HEIGHT: 10.5 cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 3 Gev

ENERGY SPREAD 0.1 %

BEAM CURRENT 5 to 8 x $10^{10}$ part./pulse

PULSE RATE 1 per 3.2 sec

DUTY CYCLE ______ %

WIDTH OF SHORTEST PULSE 1 msec

METHOD OF TARGETING Hydraulic plunging target. Beam shared between 2 or 3 experiments by decreasing RF voltage.

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm² ~~sec~~ $10^{-10}$ p | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| $\pi^+$ | 100 | 15 | 1000 | ±1 |
| $\pi^-$ | 0.2 | 10 | 2000 | ±1 |
| $K^+$ | 0.4 | 2 | 600 | ±2 |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² 1900

NUMBER OF BENDING MAGNETS 11

FOCUSING MAGNETS 54 Q lenses

AVAILABLE MAGNET POWER, Mw 9

SHIELDING, tons 6000

OTHER SERVICES Hydrogen liquefier, 60-liter/hr capacity.

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

Onde Électrique No. 387, June 1959 (complete issue).

# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE ______

INSTITUTION: Technical University of Delft

ADDRESS: Kanaalweg 2b, Delft, Holland

PERSON IN CHARGE: Prof. Dr. F.A. Heyn

PERSON SUPPLYING DATA: Same — DATE: July 8, 1961

## HISTORY AND STATUS

DESIGN (DATE) ______

MODEL TESTS ______

ENGINEERING DESIGN ______

CONSTRUCTION STARTED ______

COMPLETION DATE: Tests in progress

SCHEDULED OPERATION ______ hr/wk

COST OF ACCELERATOR ______

COST OF BUILDINGS ______

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS: Built by the staff of the

ENGINEERS: Department of Electrotechnique,

TOTAL: Technical University of Delft

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY: 1 Gev

PULSE RATE: 1 every 2 sec

OUTPUT ______ part./pulse

### INJECTOR SYSTEM

TYPE: Van de Graaff

ENERGY: 0.6 Mev

INJECTOR OUTPUT: 1.5 ma

INJECTION PERIOD ______ turns

INFLECTOR TYPE: Electrostatic

### ACCELERATION SYSTEM

FINAL ROTATION FREQ. ______ Mc/sec

HARMONIC NO.: 5, up to 2 Mc/sec; thereafter fundamental

NUMBER OF CAVITIES: 2

FREQUENCY RANGE: 0.4 TO 10 Mc/sec

ENERGY GAIN: 0.2 kev/turn

INPUT TO RF, MAX.: 3 kw

### MAGNET

FOCUSING TYPE: Zero n

FOCUSING ORDER ______

FIELD INDEX, $n =$ 0

BETATRON OSC. FREQ. $Q_r$: 0.90

$Q_z$: 0.78

ORBIT RADIUS: 3.25 m

MEAN RADIUS ______ m

SECTORS, NO.: 4

FIELD AT INJ. ______ gauss

FIELD, MAX.: 17.5 kgauss

STORAGE SYSTEM ______

RISE TIME: 0.8 sec

WEIGHT: Fe 100; ~~Cu~~ Al 5 tons

POWER INPUT, PEAK: 3000 kv-a kw

POWER INPUT, AVERAGE: 250 kw

APERTURE WIDTH: 22 cm

APERTURE HEIGHT: 10 cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______________________ Gev ENERGY SPREAD ______________________ %

BEAM CURRENT ______________________ part./pulse PULSE RATE ______________________

DUTY CYCLE ______________________ % WIDTH OF SHORTEST PULSE ______________________ msec

METHOD OF TARGETING ______________________________________________

______________________________________________

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm$^2$-sec | BEAM AREA, cm$^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m$^2$ ______________________

NUMBER OF BENDING MAGNETS ______________________ FOCUSING MAGNETS ______________________

AVAILABLE MAGNET POWER, Mw ______________________ SHIELDING, tons ______________________

OTHER SERVICES ______________________________________________

______________________________________________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

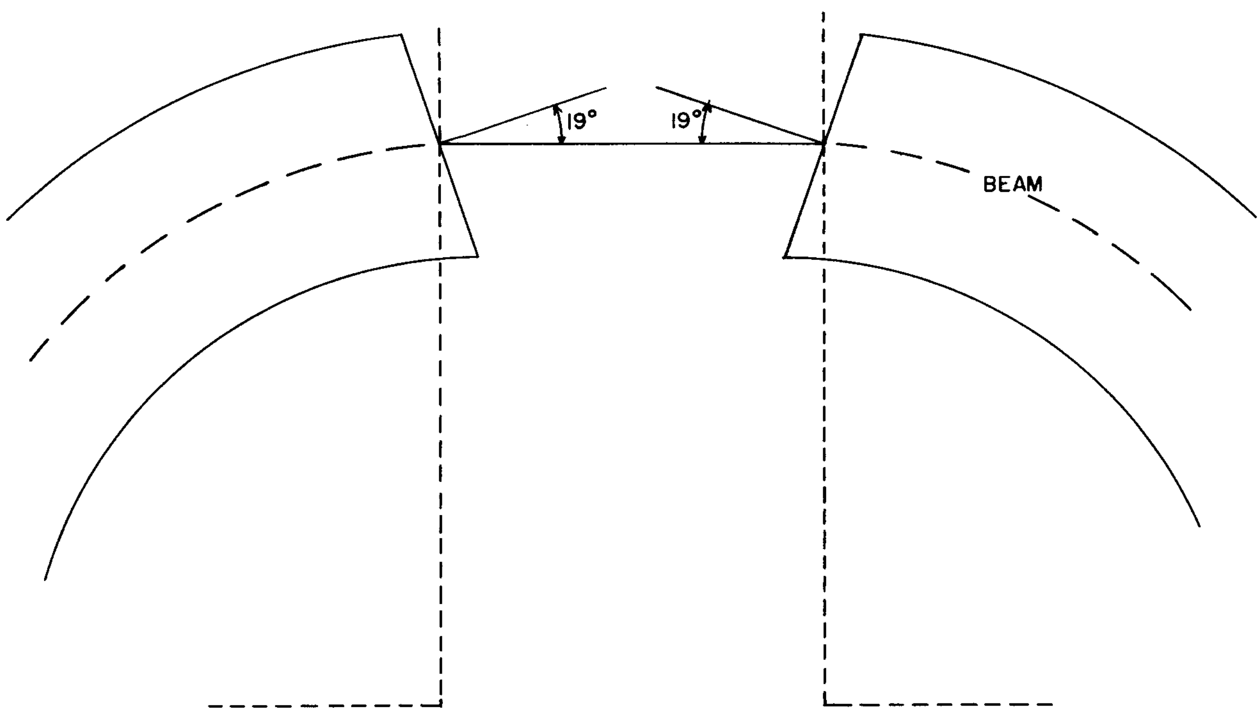
### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

TECHNICAL UNIVERSITY OF DELFT

The construction of the machine has been completed. Tests are being made. Magnet is performing well. This zero-n machine is an experimental machine. If it performs well (high output), it will be removed to a new laboratory where all the necessary facilities will be available for physicists to use it.

To obtain vertical focusing, the circulating beam enters the magnet sectors at an angle of ≈19° with respect to the normal, as shown in the sketch below.



# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE: Birmingham Proton Synchrotron

INSTITUTION: Department of Physics, The University of Birmingham

ADDRESS: Edgbaston, Birmingham, 15, England

PERSON IN CHARGE: Professor W.E. Burcham, F.R.S.

PERSON SUPPLYING DATA: P. D. Whitaker DATE: June 1961

## HISTORY AND STATUS

DESIGN (DATE): 1945

MODEL TESTS: None

ENGINEERING DESIGN: 1946

CONSTRUCTION STARTED: 1947

COMPLETION DATE: July 1953

SCHEDULED OPERATION: 75 hr/wk

COST OF ACCELERATOR: £250,000

COST OF BUILDINGS: Existing building modified

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS: 3

ENGINEERS: 13

TOTAL: 16

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY: 1-Gev protons, 650-Mev deuterons Gev

PULSE RATE: 6 per min

OUTPUT: $5 \times 10^9$ part./pulse

### INJECTOR SYSTEM

TYPE: Cockcroft-Walton

ENERGY: 0.46 Mev

INJECTOR OUTPUT: 1.0 ma

INJECTION PERIOD: 46 turns

INFLECTOR TYPE: Mu-metal drift tube

### ACCELERATION SYSTEM

FINAL ROTATION FREQ.: Deuterons 7.08, protons 9.26 Mc/sec

HARMONIC NO.: 1

NUMBER OF CAVITIES: 1 e.s. drift tube (Cee)

FREQUENCY RANGE: p, 0.31 TO 9.26; d, 0.22 TO 7.08 Mc/sec

ENERGY GAIN: 0.2 kev/turn

INPUT TO RF, MAX.: 10 kw

### MAGNET

FOCUSING TYPE: Weak

FOCUSING ORDER: -

FIELD INDEX, $n =$ 0.68

BETATRON OSC. FREQ. $Q_r$: 0.57

$Q_z$: 0.82

ORBIT RADIUS: 4.5 m

MEAN RADIUS: 4.5 m

SECTORS, NO.: No straight sections

FIELD AT INJ.: Protons 210, deuterons 300 gauss

FIELD, MAX.: 12.5 kgauss

STORAGE SYSTEM: Flywheel

RISE TIME: 1.1 sec

WEIGHT: Fe 810; Cu 9 tons

POWER INPUT, PEAK: 7000 kv-a (~~kw~~)

POWER INPUT, AVERAGE: 130 kw

APERTURE WIDTH: 33 cm

APERTURE HEIGHT: 10 cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY: Protons 1.0, deuterons 0.65 Gev

ENERGY SPREAD: ≈0.3 %

BEAM CURRENT: $5 \times 10^9$ part./pulse

PULSE RATE: 6 per min

DUTY CYCLE: max, 0.5 %

WIDTH OF SHORTEST PULSE: ______ msec

METHOD OF TARGETING: Internal, pneumatically operated. Extractor, 4-msec pulse

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-pulse | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| Protons | $10^7$ | 10 | 600 to 1000 | 1.0 |
| Deuterons | $10^7$ | 10 | 650 | 1.0 |
| 30% Polarized proton beam | $10^4$ | 5 | 1000 | 2.0 |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m²: 280

NUMBER OF BENDING MAGNETS: 1-1/2-in. and 5-in.-aperture H magnets; 6-in.-aperture C magnet on order

FOCUSING MAGNETS: 3-in.-aperture pair; 6-in.-aperture pair on order

AVAILABLE MAGNET POWER, Mw: 0.68

SHIELDING, tons: 400

OTHER SERVICES: 12-liters/hr hydrogen liquefier. Facilities for 10-liter liquid hydrogen and deuterium targets.

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

Counters: Deuteron stripping and interactions, p-p differential scattering, p-p polarization, π production, p-n differential scattering. $H_2$ and $D_2$ bubble chamber: Nucleon interactions.

### OTHER FEATURES

Extraction by means of plunged air-cored coil at outside radius of vacuum box; energy storage in lumped line; duration of extracted beam pulse, 4 msec.

### PUBLISHED ARTICLES DESCRIBING MACHINE

P.B. Moon, L. Riddiford and J.L. Symonds, Proc. Roy. Soc. A230, 204-15, (1955).
L.U. Hibbard, Nucleonics 7, No. 4, 30-43 (1950) (obsolete).

# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE: NIMROD

INSTITUTION: National Institute for Research in Nuclear Science

ADDRESS: Rutherford High Energy Laboratory, Harwell, Didcot, Berks., England

PERSON IN CHARGE: Dr. T.G. Pickavance, Director

PERSON SUPPLYING DATA: Dr. L.C.W. Hobbis — DATE: June 27, 1961

## HISTORY AND STATUS

DESIGN (DATE): 1955-56

MODEL TESTS: 1956-60

ENGINEERING DESIGN: 1956-

CONSTRUCTION STARTED: 1957 (buildings)

COMPLETION DATE: 1962

SCHEDULED OPERATION: - hr/wk

COST OF ACCELERATOR: £7.5 Million

COST OF BUILDINGS: £3 Million

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS: 60

ENGINEERS: 50

TOTAL: 310 (Including administrators, technicians, electricians, mechanics, etc.)

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY: 7.0 Gev

PULSE RATE: 28 per min

OUTPUT: $10^{12}$ part./pulse

### INJECTOR SYSTEM

TYPE: Linear accelerator

ENERGY: 15 Mev

INJECTOR OUTPUT: 10 to 20 ma

INJECTION PERIOD: ≈360 turns

INFLECTOR TYPE: Achromatic, magnetic, and electrostatic

### ACCELERATION SYSTEM

FINAL ROTATION FREQ.: 2.01 Mc/sec

HARMONIC NO.: 4

NUMBER OF CAVITIES: One (double)

FREQUENCY RANGE: 1.43 TO 8.04 Mc/sec

ENERGY GAIN: 5.5 kev/turn

INPUT TO RF, MAX.: 45 kw

### MAGNET

FOCUSING TYPE: Weak

FOCUSING ORDER: -

FIELD INDEX, $n=$ 0.6

BETATRON OSC. FREQ. $Q_r$: 0.71

$Q_z$: 0.87

ORBIT RADIUS: 18.78 m

MEAN RADIUS: 23.63 m

SECTORS, NO.: 8

FIELD AT INJ.: 296 gauss

FIELD, MAX.: 14 kgauss

STORAGE SYSTEM: Flywheel

RISE TIME: 0.72 sec

WEIGHT: Fe 7000 ; Cu 250 tons

POWER INPUT, PEAK: 110,000 kw

POWER INPUT, AVERAGE: 2,200 kw

APERTURE WIDTH: 91.4 cm

APERTURE HEIGHT: 24.1 cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 7 Gev

ENERGY SPREAD 0.1 %

BEAM CURRENT $10^{12}$ part./pulse

PULSE ~~RATE~~ length: 125 msec max. at 28 per min; 500 msec max. at 17 per min

DUTY CYCLE - %

WIDTH OF SHORTEST PULSE 50 μsec ~~msec~~

METHOD OF TARGETING

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES To Be Provided Initially

SIZE OF EXPERIMENTAL AREAS, m² 2730 and 743

NUMBER OF BENDING MAGNETS 10

FOCUSING MAGNETS 35

AVAILABLE MAGNET POWER, Mw 3

SHIELDING, tons -

OTHER SERVICES 120 ft of ±600-kv electrostatic separators;
1.5-m liquid $H_2$ bubble chamber } +4 Mw
1.5-m heavy liquid bubble chamber }

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

C-type magnet with saturable tip poles designed to compensate for effects of saturation on field gradient. Epoxy resin-glass fiber, double-walled vacuum vessel.

### PUBLISHED ARTICLES DESCRIBING MACHINE

See attached.

## PUBLISHED ARTICLES DESCRIBING MACHINE


T.G. Pickavance, The 7-GeV proton synchrotron - theoretical aspects, Nuclear Eng. 4, No. 37, 151-6 (1959).

P. Bowles, The 7-GeV proton synchrotron - engineering design, Nuclear Eng. 4, No. 37, 157-63 (1959).

G.W. Dixon and A.G. Entwistle, The 7-GeV proton synchrotron - buildings, civil engineering and services, Nuclear Eng. 4, No. 37, 164-8 (1959).

T.G. Pickavance, 7-GeV proton synchrotron (NIMROD), Proc. Intern. Conf. High Energy Accelerators and Instrumentation, CERN, 1959, pp. 343-6.

J.J. Wilkins and A.J. Egginton, NIMROD, Britain's 7-GeV proton synchrotron, J. Nuclear Energy 14, No. 141, 57-61 (1960).

S.H. Cross, System design and the choice of materials for the "NIMROD" vacuum system, Vacuum 10, No. 1/2, 86-91 (1960).

R.J.B. Hadden and R. Sheldon, The reinforced resin vacuum envelope for the 7-GeV proton synchrotron. Proc. Reinforced Plastics Conf., London, 1960.

NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

7-Gev Proton Synchrotron (NIMROD)
Rutherford High Energy Laboratory, Harwell, England

Project Status, June 1961

For a general description of NIMROD, reference may be made to the status report presented at the 1959 Conference on High Energy Accelerators and Instrumentation (Conference Proceedings, p. 343). The machine is due for completion in 1962 and should be available for the first experiments in 1963.

## Progress on Main Items

### Buildings

All plant buildings are complete including extensions to the main experimental area for the liquid hydrogen and heavy liquid bubble chambers. It is proposed to expand the smaller experimental area, known as the "parasitic" area, from 350 to 743 $m^2$. Extensions to the control block have also been planned to provide more space for the control room and counting rooms and accommodation for the operations group.

The 20-ft-thick earth mounding enveloping the injector and magnet rooms is almost complete.

### Injector

Since the 600-kev preinjector was commissioned late in 1959, work has been directed towards improvement in reliability and studies on the accelerated beam. Currents up to 40 ma are available at present, and values nearer 100 ma can be anticipated with confidence.

Installation of the 15-Mev linac and ancillary equipment is practically complete, and commissioning is imminent. The RF power system has already been operated into the unevacuated cavity at levels around 100 kw.

The inflector has been redesigned as an achromatic system, and manufacture has begun.

### Magnet

The 336 magnet yoke blocks are all installed, and coil installation is over half-way to completion. Delivery of pole pieces to the Laboratory began this month. Manufacture of pole-face windings and octant-end pole pieces also began recently.

### Magnet Power Supply

The two alternators are on test at the manufacturers, and some other components of the rotating machinery are on site. All the major components of the converter equipment are installed.

The first stage of the ripple filter system uses transformers connected in series with the magnet windings and fed by high power amplifiers. This stage has been designed and is in process of manufacture. Design work is under way on the second stage of filtering which uses auxiliary windings on the poles of the magnet itself.

## RF Accelerating System

The construction of the oscillator and programming circuits of the primary frequency generator is complete, and these components are being installed in the control room and are undergoing stability tests. Results so far indicate that the over-all stability should be equivalent to better than 2 cm of orbit radius. The master timing system, which gives triggers at any required field value, is in a similar state of completion.

The accelerating cavity itself has been tested to full power over the frequency range by using the prototype drive chain and the thermionic bias supply. Work is still required in eliminating the switch-on transient. A satisfactory gluing process for the ferrite has so far not been developed, and mechanical clamping arrangements have been adopted. The prototype high power equipment is now being installed in its final position; the final RF drive chain is being manufactured and will be installed in December 1961. A transistor bias supply has been designed and awaits manufacture.

The straight section that will house the beam control electrodes has been delivered; the electrodes will be calibrated by using electron beams prior to installation. The main observation circuitry has been tested successfully on the Birmingham Synchrotron, and it is hoped to achieve an accuracy of ±1 cm in radius measurement, and ±2% in beam current measurement. Parts of the phase lock circuitry have been completed, but the system as a whole cannot be completed until final measurements on cavity tuning response have been made.

## Vacuum System

Nearly all 40 of the 24-in. oil diffusion pumps have been delivered.

It will be recalled that the vacuum vessel is a double-walled construction in epoxy resin-bonded glass fiber. Severe problems have been encountered in the detailed development of manufacturing techniques, but intensive effort is being devoted to this work and none of the difficulties has so far proved insuperable. A prototype outer vessel (for one octant) has been delivered for test purposes, and, in spite of the presence of many areas of poor-quality laminate that have required sealing, a pressure of $2 \times 10^{-6}$ mm Hg at a leak rate of 12 lusecs has been reached. Further improvements in its performance are expected as the remaining leaks are located and sealed. The low base pressure attained is of course not functionally required in the outer vessel; diffusion pumps are being used to enhance the leak detection sensitivity, and the empty vessel presents only a fraction of the surface area and pumping impedance offered by the interspace when the machine is assembled.

## Control System

Detailed design, manufacture, and installation of the different parts of the control system are proceeding satisfactorily. In particular, installation of control equipment for the injector, vacuum system, magnet power supplies and monitoring, cooling water and electrical services, and of the various communications systems is now virtually completed. Testing and commissioning of these items has commenced.

Control of the various parts of the machine can be achieved from local control positions, and work is now commencing on the main control room, which will provide a single integrated control station for the whole machine.

## Proton Beam Extraction System

An achromatic modification of a Piccioni-type extraction system has been designed. A rectangular quadrupole magnet, located between the target and kicker magnet, considerably reduces the output beam size and eliminates the need for shims in the fringe field of the synchrotron magnet. Prototypes of the quadrupole and kicker magnets have been constructed, and suitable plunging mechanisms have been ordered.

## Beam Transport Systems

A general theoretical study of the properties of beam transport and analysis systems is under way. The design of specific components such as quadrupole magnets and crossed-field separators is also in hand, and prototypes are already available at the Laboratory for experimental development.

## Bubble Chambers

1.5-m Liquid Hydrogen Chamber. Assembly of this equipment at the Rutherford Laboratory is now nearing completion, and several components including the magnet have been commissioned and tested. First cool-down tests are planned for the autumn, and it is hoped to have the chamber operating by the year end; it will then be moved to Geneva where it will be used until NIMROD is commissioned.

1.5-m Heavy Liquid Chamber. Most of the design work on this is complete, and several major components are being manufactured. The target date for completion is the end of 1962.

80-cm Liquid Helium Chamber. The Laboratory has sponsored a design study for this chamber undertaken by a group at Oxford University.

# PROTON SYNCHROTRON DATA SHEET

| | |
|---|---|
| NAME OF MACHINE | Zero Gradient Synchrotron |
| INSTITUTION | Argonne National Laboratory |
| ADDRESS | 9700 South Case Avenue, Lemont, Ill. |
| PERSON IN CHARGE | A.V. Crewe |
| PERSON SUPPLYING DATA | A.V. Crewe |
| DATE | July 7, 1961 |

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | February 1956 | COMPLETION DATE | 1962 |
| MODEL TESTS | June 1956 | SCHEDULED OPERATION | 168 hr/wk |
| ENGINEERING DESIGN | December 1957 | COST OF ACCELERATOR | $14.9 Million |
| CONSTRUCTION STARTED | June 1959 | COST OF BUILDINGS | $14.1 Million |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 22 |
| ENGINEERS | 46 + 9 |
| TOTAL | 77 plus 5 administrative |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| ENERGY | 12.5 Gev |
| PULSE RATE | 15 per min |
| OUTPUT | $10^{12}$ to $10^{13}$ part./pulse |

### INJECTOR SYSTEM

| | |
|---|---|
| TYPE | Linear accelerator |
| ENERGY | 50 Mev |
| INJECTOR OUTPUT | 20 ma |
| INJECTION PERIOD | 100 turns |
| INFLECTOR TYPE | Magnetic |

### ACCELERATION SYSTEM

| | |
|---|---|
| FINAL ROTATION FREQ. | 1.8 Mc/sec |
| HARMONIC NO. | 8 |
| NUMBER OF CAVITIES | 3 |
| FREQUENCY RANGE | 4 TO 14.4 Mc/sec |
| ENERGY GAIN | 10 kev/turn |
| INPUT TO RF, MAX. | 450 kw |

### MAGNET

| | |
|---|---|
| FOCUSING TYPE | Weak |
| FOCUSING ORDER | |
| FIELD INDEX, $n=$ | Zero |
| BETATRON OSC. FREQ. $Q_r$ | 0.75 |
| $Q_z$ | 0.875 |
| ORBIT RADIUS | 21.715 m |
| MEAN RADIUS | 26.70 m |
| SECTORS, NO. | 8 |
| FIELD AT INJ. | 468 gauss |
| FIELD, MAX. | 22 kgauss |
| STORAGE SYSTEM | Flywheel |
| RISE TIME | 1 sec |
| WEIGHT: Fe ; Cu | 4700 ; 80 tons |
| POWER INPUT, PEAK | 117,000 kw |
| POWER INPUT, AVERAGE | 7,000 kw |
| APERTURE WIDTH | 81 cm |
| APERTURE HEIGHT | 12.5 cm |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______________________ Gev ENERGY SPREAD ______________________ %

BEAM CURRENT ______________________ part./pulse PULSE RATE ______________________

DUTY CYCLE ______________________ % WIDTH OF SHORTEST PULSE ______________________ msec

METHOD OF TARGETING ______________________

______________________

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ ______________________

NUMBER OF BENDING MAGNETS ______________________ FOCUSING MAGNETS ______________________

AVAILABLE MAGNET POWER, Mw ______________________ SHIELDING, tons ______________________

OTHER SERVICES ______________________

______________________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# PROTON SYNCHROTRON DATA SHEET

| | |
|---|---|
| NAME OF MACHINE | Cosmotron |
| INSTITUTION | Brookhaven National Laboratory |
| ADDRESS | Upton, N.Y. |
| PERSON IN CHARGE | Lyle W. Smith |
| PERSON SUPPLYING DATA | William H. Moore |
| DATE | July 10, 1961 |

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | September 1947 | COMPLETION DATE | 1952 |
| MODEL TESTS | 1948-51 | SCHEDULED OPERATION | 140 hr/wk |
| ENGINEERING DESIGN | January 1948 | COST OF ACCELERATOR | $7.5 Million |
| CONSTRUCTION STARTED | December 1948 | COST OF BUILDINGS | $3 Million |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 5 |
| ENGINEERS | 28 |
| TOTAL | 154 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| ENERGY | 2.96 Gev |
| PULSE RATE | 12 per min |
| OUTPUT | $\approx 10^{11}$ part./pulse |

### INJECTOR SYSTEM

| | |
|---|---|
| TYPE | Van de Graaff |
| ENERGY | 3.6 Mev |
| INJECTOR OUTPUT | 5 ma |
| INJECTION PERIOD | 30 turns |
| INFLECTOR TYPE | Electrostatic |

### ACCELERATION SYSTEM

| | |
|---|---|
| FINAL ROTATION FREQ. | 4.18 Mc/sec |
| HARMONIC NO. | 1 |
| NUMBER OF CAVITIES | 1 |
| FREQUENCY RANGE | 0.33 TO 4.18 Mc/sec |
| ENERGY GAIN | 1 (av) kev/turn |
| INPUT TO RF, MAX. | 50 kw |

### MAGNET

| | |
|---|---|
| FOCUSING TYPE | Weak |
| FOCUSING ORDER | |
| FIELD INDEX, $n =$ | 0.65 |
| BETATRON OSC. FREQ. $Q_r$ | 0.65 |
| $Q_z$ | 0.89 |
| ORBIT RADIUS | m |
| MEAN RADIUS | 9.05 m |
| SECTORS, NO. | 4 |
| FIELD AT INJ. | 180 gauss |
| FIELD, MAX. | 13.8 kgauss |
| STORAGE SYSTEM | 45-Ton Flywheel |
| RISE TIME | 1.1 sec |
| WEIGHT: Fe ; Cu | 1650 ; 70 tons |
| POWER INPUT, PEAK | 36,000 kw |
| POWER INPUT, AVERAGE | 26,000 kw |
| APERTURE WIDTH | 70 cm |
| APERTURE HEIGHT | 15 cm |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 2.96 Gev

ENERGY SPREAD 2 %

BEAM CURRENT $10^{11}$ part./pulse

PULSE RATE 12.5 per min

DUTY CYCLE 2 %

WIDTH OF SHORTEST PULSE 0.004 msec

METHOD OF TARGETING External and internal either fixed or moved with pneumatic rams

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./~~cm² sec~~ pulse | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| p | 1 to 3 x $10^{10}$ | 10 | 1000 to 3000 | 2 |
| $\pi^-$ | $\approx 10^5$* | 100 | 1600 | 7 |
| $K^0$ | $\approx 1$* | | 900 | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² 600

NUMBER OF BENDING MAGNETS 26

FOCUSING MAGNETS 43

AVAILABLE MAGNET POWER, Mw 6

SHIELDING, tons 22,000

OTHER SERVICES Hydrogen liquefier, 90 liters/hr capacity.

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

Properties of elementary particles, strange particle interactions.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

Rev. Sci. Instr. 24, No. 9, 723-898 (1953) (complete issue).

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* Typical beams used in a recent experiment. The flux is based on an external proton beam intensity of $10^{10}$ protons per pulse.

# PROTON SYNCHROTRON DATA SHEET

| | |
|---|---|
| NAME OF MACHINE | Alternating Gradient Synchrotron |
| INSTITUTION | Brookhaven National Laboratory |
| ADDRESS | Upton, N.Y. |
| PERSON IN CHARGE | G.K. Green |
| PERSON SUPPLYING DATA | G.K. Green |
| DATE | July 20, 1961 |

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | 1953 | COMPLETION DATE | July 1960 |
| MODEL TESTS | 1955 | SCHEDULED OPERATION | 80 hr/wk |
| ENGINEERING DESIGN | 1954 | COST OF ACCELERATOR | |
| CONSTRUCTION STARTED | 1956 | Total Cost COST OF BUILDINGS | $30.65 Million |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 11 |
| ENGINEERS | 44 |
| TOTAL | 181 (Scientific, engineering, technical, and clerical) |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | | |
|---|---|---|
| ENERGY | 33 | Gev |
| PULSE RATE | 1 per 2.4 sec at 30 Gev | |
| OUTPUT | $2 \times 10^{11}$ | part./pulse |

### INJECTOR SYSTEM*

| | | |
|---|---|---|
| TYPE | Linear accelerator | |
| ENERGY | 50.8 | Mev |
| INJECTOR OUTPUT | 7 | ma |
| INJECTION PERIOD | 1 | turns |
| INFLECTOR TYPE | Pulsed electric | |

### ACCELERATION SYSTEM

| | | |
|---|---|---|
| FINAL ROTATION FREQ. | 0.380 | Mc/sec |
| HARMONIC NO. | 12 | |
| NUMBER OF CAVITIES | 12 double | |
| FREQUENCY RANGE | 1.4 TO 4.46 | Mc/sec |
| ENERGY GAIN | 100 | kev/turn |
| INPUT TO RF, MAX. | 300 | kw |

### MAGNET

| | | |
|---|---|---|
| FOCUSING TYPE | a.g. | |
| FOCUSING ORDER | 1/2F O 1/2F 1/2D O 1/2D | |
| FIELD INDEX, $n=$ | 357 | |
| BETATRON OSC. FREQ. $Q_r$ | 8.75 | |
| $Q_z$ | 8.75 | |
| ORBIT RADIUS | 85.4 | m |
| MEAN RADIUS | 128.5 | m |
| SECTORS, NO. | 240 | |
| FIELD AT INJ. | 121 | gauss |
| FIELD, MAX. | 13 | kgauss |
| STORAGE SYSTEM | Flywheel | |
| RISE TIME | ≈1 sec | |
| WEIGHT: Fe | 4000; Cu 400 | tons |
| POWER INPUT, PEAK | 30,000 | kw |
| POWER INPUT, AVERAGE | 2,400 | kw |
| APERTURE WIDTH | 15 | cm |
| APERTURE HEIGHT | 7 | cm |

*Additional injector parameters provided on attached linear accelerator data sheet.

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 33 Gev

ENERGY SPREAD Small %

BEAM CURRENT $2 \times 10^{11}$ part./pulse

PULSE RATE Depending on energy

DUTY CYCLE %

WIDTH OF SHORTEST PULSE msec

METHOD OF TARGETING Various

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| *See below. | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² 7900

NUMBER OF BENDING MAGNETS 12

FOCUSING MAGNETS 31

AVAILABLE MAGNET POWER, Mw 18

SHIELDING, tons 28,000

OTHER SERVICES Beam separators, liquid hydrogen, targets and facilities, etc.

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

Proton interactions, K interactions, particle production, antiproton interactions.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

G.K. Green and E.D. Courant, The Proton Synchrotron, Instrumentelle Hilfsmittel der Kernphysik, Handbuch der Physik, Vol. 44, Pt. 1, pp. 218-340, Springer-Verlag, Berlin, 1959.

*W.F. Baker et al., Particle production by 10 to 30-Bev protons incident on Al and Be, Phys. Rev. Letters 7, 101 (1961).

# LINEAR ACCELERATOR DATA SHEET

NAME OF MACHINE: AGS Injector

INSTITUTION: Brookhaven National Laboratory

ADDRESS: Upton, N.Y.

PERSON IN CHARGE: J.P. Blewett (construction) J.W. Bittner (operation)

PERSON SUPPLYING DATA: J.P. Blewett DATE: July 19, 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | 1955 | COMPLETION DATE | 1960 |
| MODEL TESTS | 1955 | SCHEDULED OPERATION | 80 hr/wk |
| ENGINEERING DESIGN | 1956 | COST OF ACCELERATOR | $1.5 Million |
| CONSTRUCTION STARTED | 1956 | COST OF BUILDINGS | $0.5 Million |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 4 |
| ENGINEERS | 10 |
| TOTAL | 14 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| PARTICLE ACC. | Protons |
| ENERGY | 50 Mev ~~Gev~~ |
| ENERGY SPREAD | ±0.3 % |
| OUTPUT | $10^{12}$ part./pulse |
| PULSE WIDTH | 20 μsec |
| REPETITION RATE | 2.5 per sec |
| BEAM DIAMETER | 1 cm |
| BEAM EMITTANCE | $(0.5\ \pi)^2$ (mrad cm)$^2$ |

### RF SYSTEM

| | |
|---|---|
| FREQUENCY | 201.06 Mc/sec |
| FIELD MODE | $TM_{010}$ |
| RF POWER, PEAK | 3000 kw |
| POWER UNITS | FTH triodes |
| EQUILIBRIUM PHASE | -30° from peak |
| RF PULSE DURATION | 200 μsec |
| FOCUSING TYPE | Pulsed quadrupole magnets |

### INJECTOR

| | |
|---|---|
| TYPE | Cockcroft-Walton |
| ENERGY | 750 kev |
| OUTPUT | 20 ma |

### MECHANICAL CHARACTERISTICS

| | |
|---|---|
| LENGTH | 33 m |
| DIAMETER | 95 cm |
| DRIFT TUBES, NUMBER | 124 |
| LENGTH 1st TUBE | 4.906 cm |
| DIAMETER 1st TUBE | 20.7 cm |
| APERTURE 1st TUBE | 1.27 cm |
| LENGTH 1st GAP | 1.388 cm |
| LENGTH LAST TUBE | 35.46 cm |
| DIAMETER LAST TUBE | 14.71 cm |
| LENGTH LAST GAP | 11.78 cm |
| IRIS APERTURE | - |
| IRIS SPACING | - |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 50 Mev ~~Gev~~

ENERGY SPREAD ±0.3 %

BEAM CURRENT $10^{12}$ part./pulse

PULSE RATE 2.5 per sec

DUTY CYCLE 0.005 %

WIDTH OF SHORTEST PULSE 20 μsec ~~msec~~

METHOD OF TARGETING None

### EXTERNAL AND SECONDARY BEAMS

None used

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² 0

NUMBER OF BENDING MAGNETS

FOCUSING MAGNETS

AVAILABLE MAGNET POWER, Mw

SHIELDING, tons

OTHER SERVICES

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

This machine is used only as the injector for the AGS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

Proc. CERN Symposium High Energy Accelerators and Pion Phys., Geneva, 1956, Vol. 1, p. 159.

# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE: Bevatron

INSTITUTION: Lawrence Radiation Laboratory

ADDRESS: University of California, Berkeley, Calif.

PERSON IN CHARGE: Edward J. Lofgren

PERSON SUPPLYING DATA: Same    DATE: June 1, 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | 1947 | COMPLETION DATE | January 21, 1954 |
| MODEL TESTS | April - October 1949 | SCHEDULED OPERATION | 158 hr/wk |
| ENGINEERING DESIGN | April 1948 | COST OF ACCELERATOR | $7.9 Million |
| CONSTRUCTION STARTED | December 1948 | COST OF BUILDINGS | $1.8 Million |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS: 8

ENGINEERS: 35

TOTAL: 160

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY: 6.2 Gev

PULSE RATE: 11 per min

OUTPUT: - part./pulse

### INJECTOR SYSTEM

TYPE: Linear accelerator

ENERGY: 9.8 Mev

INJECTOR OUTPUT: Best 0.6, average 0.5 ma at Inflector

INJECTION PERIOD: 90 turns

INFLECTOR TYPE: Electrostatic

### ACCELERATION SYSTEM

FINAL ROTATION FREQ.: 2.47 Mc/sec

HARMONIC NO.: 1

NUMBER OF CAVITIES: 1 electrode

FREQUENCY RANGE: 0.358 TO 2.47 Mc/sec

ENERGY GAIN: 1.5 kev/turn

INPUT TO RF, MAX.: ______ kw

### MAGNET

FOCUSING TYPE: Weak

FOCUSING ORDER: -

FIELD INDEX, $n =$ 0.62

BETATRON OSC. FREQ. $Q_r$: 0.69

$Q_z$: 0.88

ORBIT RADIUS: 15.24 m

MEAN RADIUS: 16.76 m

SECTORS, NO.: 4

FIELD AT INJ.: 299 gauss

FIELD, MAX.: 15,500 kgauss

STORAGE SYSTEM: None

RISE TIME: 1.8 sec

WEIGHT: Fe 9700 ; Cu 347 tons

POWER INPUT, PEAK: 101,000 kw

POWER INPUT, AVERAGE: 5,600 kw

APERTURE WIDTH: 120 cm

APERTURE HEIGHT: 25.4 cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 6.2 Gev

ENERGY SPREAD ____ %

BEAM CURRENT Usual $2 \times 10^{11}$, Best $3 \times 10^{11}$ part./pulse

PULSE RATE 11 per min

DUTY CYCLE Width of longest pulse 500 msec ~~%~~

WIDTH OF SHORTEST PULSE 0.2 msec

METHOD OF TARGETING Flip targets. Short beam pulse is accomplished by magnetic deflection of beam onto target.

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
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| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² 2100

NUMBER OF BENDING MAGNETS 17

FOCUSING MAGNETS 42 lenses

AVAILABLE MAGNET POWER, Mw 10.1

SHIELDING, tons ____

OTHER SERVICES ____

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

Properties of $\pi$ and K-mesons, hyperons, and antinucleons.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

Proc. CERN Symposium High Energy Accelerators and Pion Phys., Geneva, 1956, Vol. 1, p. 496.

# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE: Princeton-Pennsylvania Accelerator

INSTITUTION: Princeton University

ADDRESS: P.O. Box 682, Princeton, N.J.

PERSON IN CHARGE: Milton G. White

PERSON SUPPLYING DATA: Paul J. Reardon — DATE: July 14, 1961

## HISTORY AND STATUS

DESIGN (DATE): 1955

MODEL TESTS: 1955-56

ENGINEERING DESIGN: 1956

CONSTRUCTION STARTED: 1957

COMPLETION DATE: 1961

SCHEDULED OPERATION: ______ hr/wk

COST OF ACCELERATOR: Still under construction

COST OF BUILDINGS: Still under construction

SIZE OF STAFF ENGAGED IN DEVELOPMENT, Construction, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS: 6

ENGINEERS: 25

TOTAL: ≈150 (Includes technicians, draftsmen, and administrative personnel)

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY: 3 Gev

PULSE RATE: 19 per sec

OUTPUT: $10^{11}$ part./pulse ($2 \times 10^{12}$ part./sec)

### INJECTOR SYSTEM

TYPE: Van de Graaff electrostatic generator

ENERGY: 3.0 Mev

INJECTOR OUTPUT: 8 ma

INJECTION PERIOD: 8 turns

INFLECTOR TYPE: Electrostatic

### ACCELERATION SYSTEM

FINAL ROTATION FREQ.: 3.8 Mc/sec

HARMONIC NO.: 8

NUMBER OF CAVITIES: 4

FREQUENCY RANGE: 2.5 TO 30 Mc/sec

ENERGY GAIN: 60.5 kev/turn

INPUT TO RF, MAX.: 200 kw

### MAGNET

FOCUSING TYPE: Weak

FOCUSING ORDER: ______

FIELD INDEX, $n =$ 0.65 Inj. → 0.58

BETATRON OSC. FREQ. $Q_r$: 0.69 Inj. → 0.78 final

$Q_z$: 0.94 Inj. → 0.87 final

ORBIT RADIUS: 9.144 m

MEAN RADIUS: 12.507 m

SECTORS, NO.: 16

FIELD AT INJ.: 271 gauss

FIELD, MAX.: 14 kgauss

STORAGE SYSTEM: Choke and capacitor

RISE TIME: Sine wave, 0.025 sec

WEIGHT: Fe 368 ; Cu 14 tons

POWER INPUT, PEAK: ______ kw

Magnet POWER INPUT, ac + dc, AVERAGE: 1300 kw

APERTURE WIDTH: 16 cm

APERTURE HEIGHT: 6.5 cm

# PERFORMANCE DATA

## INTERNAL BEAM

MAX. ENERGY ______ Gev

ENERGY SPREAD ______ %

BEAM CURRENT ______ part./pulse

PULSE RATE ______

DUTY CYCLE ______ %

WIDTH OF SHORTEST PULSE ______ msec

METHOD OF TARGETING ______

## EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ 1400

NUMBER OF BENDING MAGNETS 8

FOCUSING MAGNETS 14

AVAILABLE MAGNET POWER, Mw 3

SHIELDING, tons ______

OTHER SERVICES ______

## USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

## OTHER FEATURES

## PUBLISHED ARTICLES DESCRIBING MACHINE

# PRINCETON-PENNSYLVANIA ACCELERATOR

Status Report

M.G. White

## Introduction

Since the Princeton-Pennsylvania Proton Synchrotron has already been described in previous accelerator conferences,[1,2] this report will confine itself largely to outlining the performance of various components insofar as they have been completed and tested. Complete operation is scheduled for late in 1961.

## Magnet

Figure 1 is a photograph of a completed semioctant of magnet resting upon the massive steel box girder, which in turn rests upon a rigid concrete foundation through three adjustable jacks. Alignment of the magnet yoke relative to the geometric median plane is precise to 1 mil rms azimuthally and 5 mils rms radially. Pole tips, being separable and spaced by a stainless steel spacer, are aligned with comparable accuracy. The photograph clearly shows the pole-piece clamps and the coil clamps. Also obvious from the photograph is the method of azimuthal clamping of the laminations in which 3-in. steel plates on opposite ends of the semioctants are drawn together by stainless steel tie-bands. Figure 2 is a photograph of the nearly completed magnet ring in which the injection system is also shown. Four semioctants have been briefly run at full power; no excessive vibration was observed at any point, and power losses were as expected. Magnetic median plane measurements on the full-scale prototype indicate close agreement between the magnetic and geometric median planes. The final design of the crenelated pole pieces yielded a good $\underline{n}$ region on the median plane of 6-1/4 in. at high fields and 6-1/2 in. at low fields. End pole pieces were slotted to reduce eddy currents. Special end field correction devices are also incorporated into the magnet ends to preserve proper focusing. Measurements of $\underline{n}$ off the median plane are substantially the same as on the median plane as long as one stays within the confines of the vacuum chamber.

## Magnet Power Supply

The complete power supply consists of many capacitors, a very large 130-ton air-core choke, and the 3500-hp motor generator set. The latter consists of a 1650-kv-a two-pole ac alternator and two 500-kw dc generators, all on a common drive shaft turned by a synchronous motor through an eddy current clutch. Performance to date has been excellent. Current-controlling devices for partial loads have given a stability of one part in $10^4$. In addition, separate, variable trimming devices are being incorporated with each semioctant so that additional azimuthal trimming at injection field can be had.

## Vacuum Chamber

The curved vacuum chamber within the magnet consists of copper-nickel alloy, U-shaped ribs fastened to the stainless steel pole-piece front spacer. Covering this structure is a glass fiber epoxy membrane which forms the vacuum envelope. Cemented to the outside of the membrane are flat sheets of Mylar which have embedded in them the pole-face correction windings for altering $\underline{n}$ and median plane at injection field. The inside surface of the rib structure is covered by 1-1/2-in.-wide strips of 1/2-mil stainless steel foil whose major function is to reduce the outgassing of water vapor from the epoxy. Without the stainless steel foil it is necessary to use rather extensive liquid nitrogen cold traps to reach 2 x $10^{-6}$ mm Hg. Originally it was believed that it would be possible to find an epoxy with suitably low outgassing rate to make unnecessary the use of the inner metallic liner or the liquid $N_2$ "cold fingers." Of the various epoxies tried the one recommended by Harwell for the NIMROD accelerator proved to be the best, but it was found that absorbed water required more extensive baking out than we were prepared to tolerate. Although "cold fingers" produce a satisfactory vacuum, we have devised a simple technique for applying an inner liner of stainless steel foil and believe that we will substantially reduce the need for liquid $N_2$. An additional virtue of the metal liner is that subsequent outgassing due to radiation damage will be considerably attenuated.

## Injection System

Pulsed total ion currents of >1 ma have been obtained on the magnet ring after passing through the deflector and inflector in addition to 70 ft of vacuum pipe. While this is not as high as will eventually be desired, no great effort has been made to push the current up. The beam directional stability appears to be adequate. Energy fluctuations from the Van de Graaff are greater than desirable but can be reduced by modulating the inner liner. Beam spot size, 40 ft from the Van de Graaff, is less than 3/4 in. at 3 Mev without the use of any external focusing.

## Radio Frequency

Acceleration is accomplished essentially as described in our last report, that is, by using four ferrite-tuned resonant drift tubes over the range 2.5 to 7 Mc/sec and four ferrite-tuned resonant cavities over the range 6.5 to 30 Mc/sec. As is shown in Figure 3 the drift tubes are concentric with the cavities; no difficulties of intercoupling of the two systems have been encountered. Both drift tubes and cavities are driven by tetrodes with peak power outputs of 50 kw and 30 kw, respectively, per station. Because of the duty cycle the average power is 5 kw and 25 kw, respectively, per station. The power amplifiers are driven by 14-stage distributed amplifiers using Eimac 4CX300A tetrodes. Cavity ferrite bias field is provided by a 15,000-amp, 18-v driver which is basically a hi-fi audio amplifier with good frequency response from 2 cps to 30 kc and with automatic tap changing of its output transformer to accommodate a variable impedance load. Phase detectors, accurate to $1^{\circ}$, have been built and tested over the entire frequency range. The entire RF system provides 120 kv (max) over the frequency range 2.5 to 30 Mc/sec. Frequency control of 0.05% is planned, and modulation components of frequency, amplitude, and phase, whether they be noise or coherent, must be kept below 0.05% in the frequency range 5 to 100 kc/sec.

## Controls

Considerable effort has gone into the devising of slow controls to aid in the location of malfunction once it appears. Initiation of acceleration is to be derived from a signal generated at the beginning of each pulse by the sweeping of the injected Van de Graaff beam inward over a pickup electrode located just outside the region of good magnetic field. Radial and vertical beam position will be sensed by eight sets of induction electrodes placed equidistantly around the magnet ring.

## List of References


1. M.G. White, F.C. Shoemaker, and G.K. O'Neill, A 3-Bev high intensity proton synchrotron, Proc. CERN Symposium High Energy Accelerators and Pion Phys., Geneva, 1956, Vol. 1, pp. 525-9.
2. M.G. White and F.C. Shoemaker, The Princeton-Pennsylvania Accelerator, Proc. Intern. Conf. High Energy Accelerators and Instrumentation, CERN, 1959, pp. 362-5.

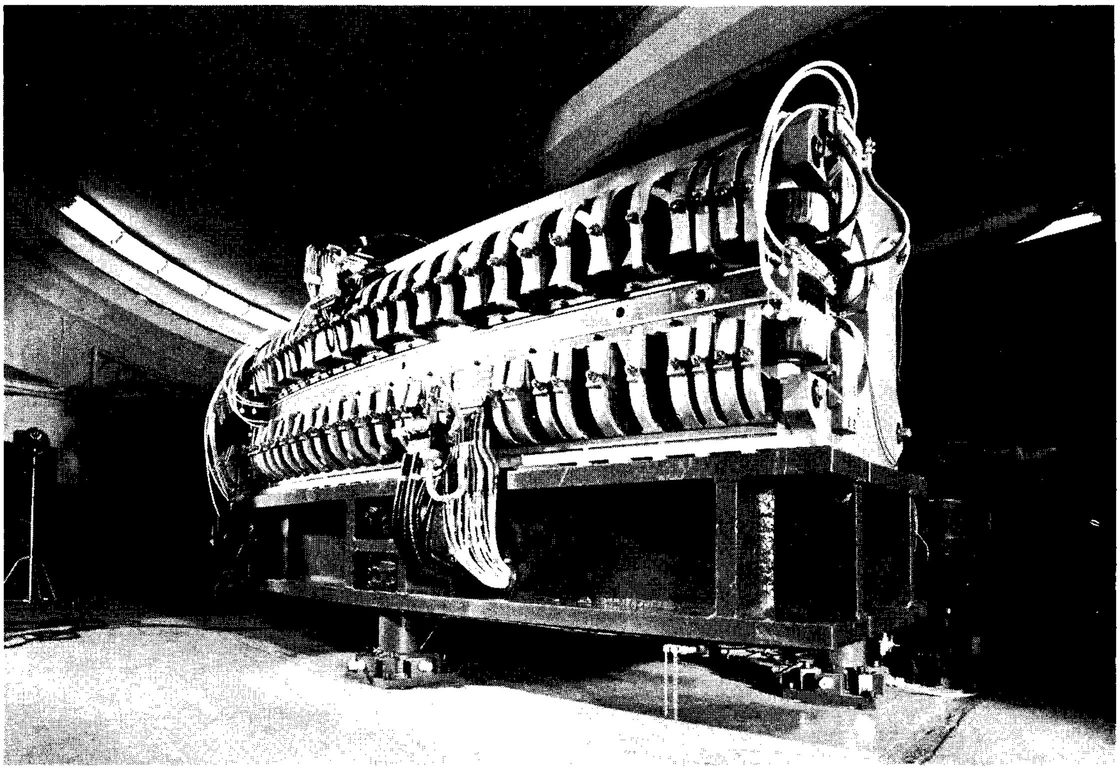

Figure 1. Magnet semioctant.

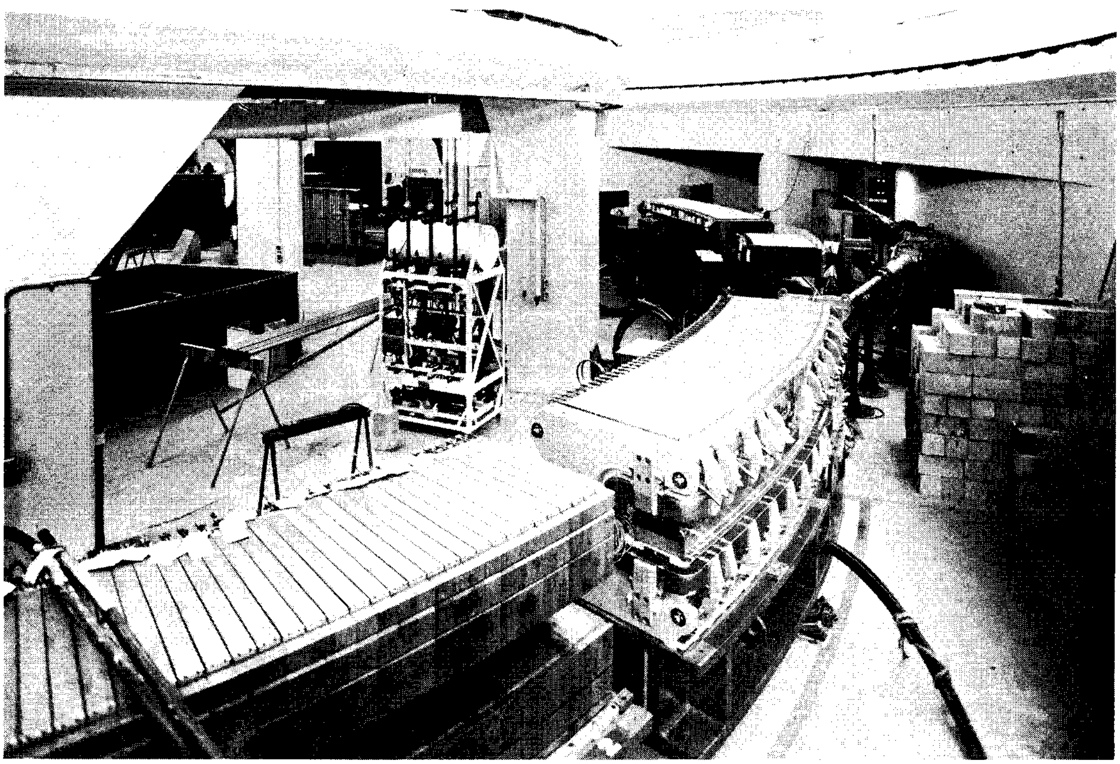

Figure 2. Nearly complete magnet ring.

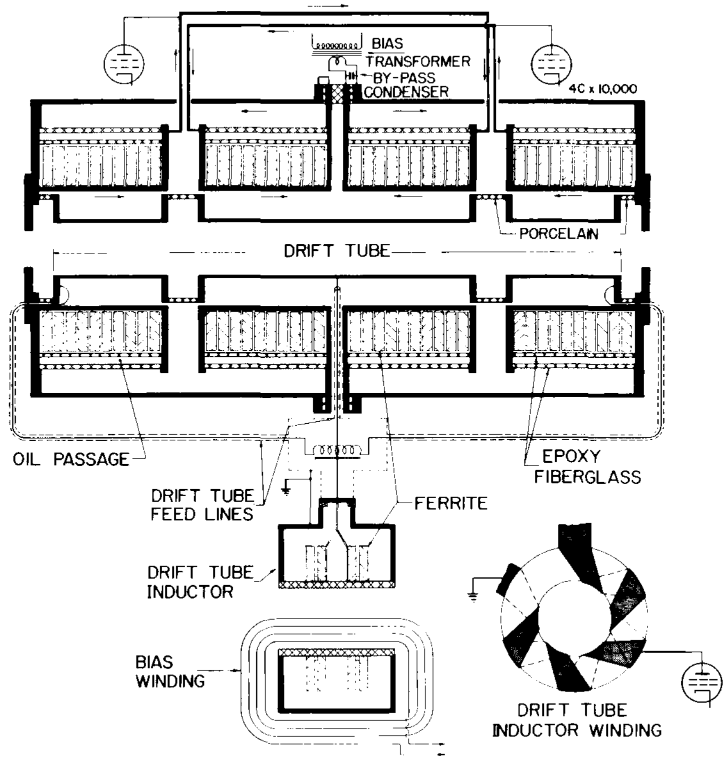


Figure 3. RF cavity and drift tube.

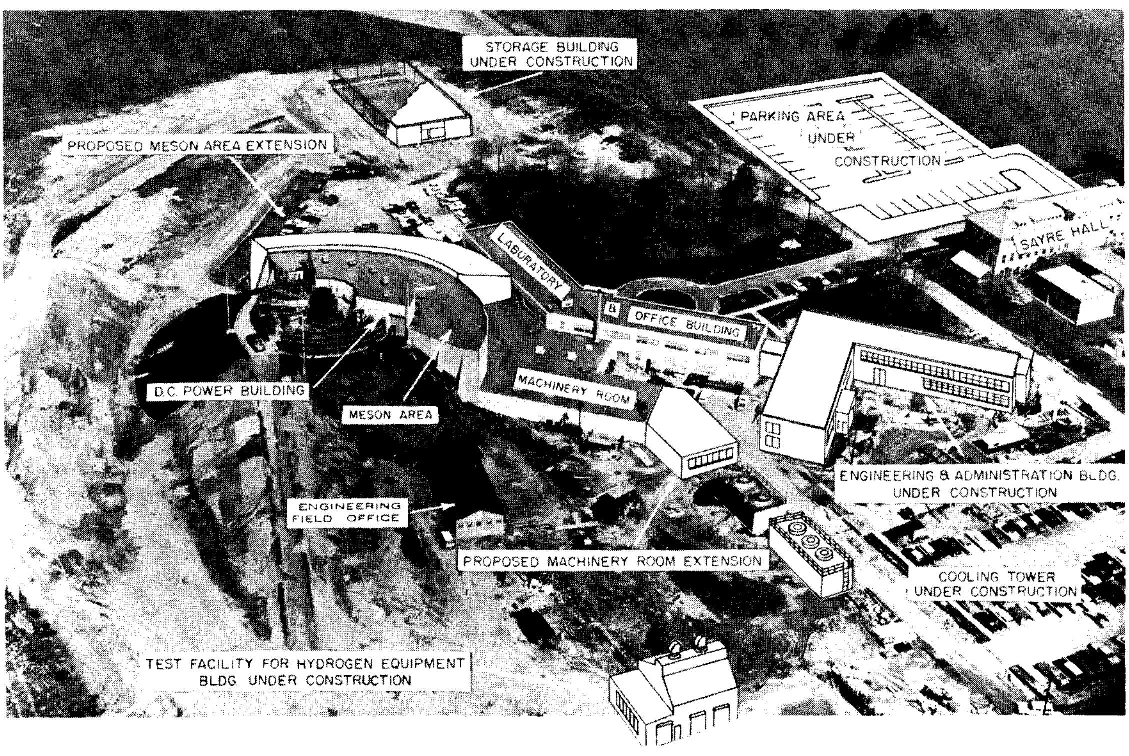


Figure 4. Princeton-Pennsylvania accelerator, existing and proposed construction, May 1961.

# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE ____________________

INSTITUTION ____________________

ADDRESS ____________________

PERSON IN CHARGE ____________________

PERSON SUPPLYING DATA ____________________ DATE __________

## HISTORY AND STATUS

DESIGN (DATE) __________

MODEL TESTS __________

ENGINEERING DESIGN __________

CONSTRUCTION STARTED __________

COMPLETION DATE __________

SCHEDULED OPERATION __________ hr/wk

COST OF ACCELERATOR __________

COST OF BUILDINGS __________

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS __________

ENGINEERS __________

TOTAL __________

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY __________ Gev

PULSE RATE __________

OUTPUT __________ part./pulse

### INJECTOR SYSTEM

TYPE __________

ENERGY __________ Mev

INJECTOR OUTPUT __________ ma

INJECTION PERIOD __________ turns

INFLECTOR TYPE __________

### ACCELERATION SYSTEM

FINAL ROTATION FREQ. __________ Mc/sec

HARMONIC NO. __________

NUMBER OF CAVITIES __________

FREQUENCY RANGE __________ TO __________ Mc/sec

ENERGY GAIN __________ kev/turn

INPUT TO RF, MAX. __________ kw

### MAGNET

FOCUSING TYPE __________

FOCUSING ORDER __________

FIELD INDEX, $n =$ __________

BETATRON OSC. FREQ. $Q_r$ __________

$Q_z$ __________

ORBIT RADIUS __________ m

MEAN RADIUS __________ m

SECTORS, NO. __________

FIELD AT INJ. __________ gauss

FIELD, MAX. __________ kgauss

STORAGE SYSTEM __________

RISE TIME __________

WEIGHT: Fe __________ ; Cu __________ tons

POWER INPUT, PEAK __________ kw

POWER INPUT, AVERAGE __________ kw

APERTURE WIDTH __________ cm

APERTURE HEIGHT __________ cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______________ Gev ENERGY SPREAD ______________ %

BEAM CURRENT ______________ part./pulse PULSE RATE ______________

DUTY CYCLE ______________ % WIDTH OF SHORTEST PULSE ______________ msec

METHOD OF TARGETING ______________

______________

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
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| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ ______________

NUMBER OF BENDING MAGNETS ______________ FOCUSING MAGNETS ______________

AVAILABLE MAGNET POWER, Mw ______________ SHIELDING, tons ______________

OTHER SERVICES ______________

______________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

## PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE ______________________

INSTITUTION ______________________

ADDRESS ______________________

PERSON IN CHARGE ______________________

PERSON SUPPLYING DATA ______________________ DATE ____________

### HISTORY AND STATUS

DESIGN (DATE) ____________ COMPLETION DATE ____________

MODEL TESTS ____________ SCHEDULED OPERATION ____________ hr/wk

ENGINEERING DESIGN ____________ COST OF ACCELERATOR ____________

CONSTRUCTION STARTED ____________ COST OF BUILDINGS ____________

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS ____________

ENGINEERS ____________

TOTAL ____________

### DESIGN SPECIFICATIONS

#### GENERAL FEATURES

ENERGY ____________ Gev

PULSE RATE ____________

OUTPUT ____________ part./pulse

#### INJECTOR SYSTEM

TYPE ____________

ENERGY ____________ Mev

INJECTOR OUTPUT ____________ ma

INJECTION PERIOD ____________ turns

INFLECTOR TYPE ____________

#### ACCELERATION SYSTEM

FINAL ROTATION FREQ. ____________ Mc/sec

HARMONIC NO. ____________

NUMBER OF CAVITIES ____________

FREQUENCY RANGE ____________ TO ____________ Mc/sec

ENERGY GAIN ____________ kev/turn

INPUT TO RF, MAX. ____________ kw

#### MAGNET

FOCUSING TYPE ____________

FOCUSING ORDER ____________

FIELD INDEX, $n =$ ____________

BETATRON OSC. FREQ. $Q_r$ ____________

$Q_z$ ____________

ORBIT RADIUS ____________ m

MEAN RADIUS ____________ m

SECTORS, NO. ____________

FIELD AT INJ. ____________ gauss

FIELD, MAX. ____________ kgauss

STORAGE SYSTEM ____________

RISE TIME ____________

WEIGHT: Fe ____________ ; Cu ____________ tons

POWER INPUT, PEAK ____________ kw

POWER INPUT, AVERAGE ____________ kw

APERTURE WIDTH ____________ cm

APERTURE HEIGHT ____________ cm

# PERFORMANCE DATA

## INTERNAL BEAM

MAX. ENERGY ______________________ Gev    ENERGY SPREAD ______________________ %

BEAM CURRENT ______________________ part./pulse    PULSE RATE ______________________

DUTY CYCLE ______________________ %    WIDTH OF SHORTEST PULSE ______________________ msec

METHOD OF TARGETING ______________________________________________

______________________________________________

## EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm$^2$-sec | BEAM AREA, cm$^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
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## FACILITIES

SIZE OF EXPERIMENTAL AREAS, m$^2$ ______________________

NUMBER OF BENDING MAGNETS ______________________    FOCUSING MAGNETS ______________________

AVAILABLE MAGNET POWER, Mw ______________________    SHIELDING, tons ______________________

OTHER SERVICES ______________________________________________

______________________________________________

## USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

## OTHER FEATURES

## PUBLISHED ARTICLES DESCRIBING MACHINE

# PROTON SYNCHROTRON DATA SHEET

NAME OF MACHINE ____________________

INSTITUTION ____________________

ADDRESS ____________________

PERSON IN CHARGE ____________________

PERSON SUPPLYING DATA ____________________ DATE ____________

## HISTORY AND STATUS

DESIGN (DATE) ____________________

MODEL TESTS ____________________

ENGINEERING DESIGN ____________________

CONSTRUCTION STARTED ____________________

COMPLETION DATE ____________________

SCHEDULED OPERATION ____________________ hr/wk

COST OF ACCELERATOR ____________________

COST OF BUILDINGS ____________________

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS ____________________

ENGINEERS ____________________

TOTAL ____________________

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY ____________________ Gev

PULSE RATE ____________________

OUTPUT ____________________ part./pulse

### INJECTOR SYSTEM

TYPE ____________________

ENERGY ____________________ Mev

INJECTOR OUTPUT ____________________ ma

INJECTION PERIOD ____________________ turns

INFLECTOR TYPE ____________________

### ACCELERATION SYSTEM

FINAL ROTATION FREQ. ____________________ Mc/sec

HARMONIC NO. ____________________

NUMBER OF CAVITIES ____________________

FREQUENCY RANGE ____________ TO ____________ Mc/sec

ENERGY GAIN ____________________ kev/turn

INPUT TO RF, MAX. ____________________ kw

### MAGNET

FOCUSING TYPE ____________________

FOCUSING ORDER ____________________

FIELD INDEX, $n=$ ____________________

BETATRON OSC. FREQ. $Q_r$ ____________________

$Q_z$ ____________________

ORBIT RADIUS ____________________ m

MEAN RADIUS ____________________ m

SECTORS, NO. ____________________

FIELD AT INJ. ____________________ gauss

FIELD, MAX. ____________________ kgauss

STORAGE SYSTEM ____________________

RISE TIME ____________________

WEIGHT: Fe ____________ ; Cu ____________ tons

POWER INPUT, PEAK ____________________ kw

POWER INPUT, AVERAGE ____________________ kw

APERTURE WIDTH ____________________ cm

APERTURE HEIGHT ____________________ cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______________ Gev ENERGY SPREAD ______________ %

BEAM CURRENT ______________ part./pulse PULSE RATE ______________

DUTY CYCLE ______________ % WIDTH OF SHORTEST PULSE ______________ msec

METHOD OF TARGETING ______________

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² ______________

NUMBER OF BENDING MAGNETS ______________ FOCUSING MAGNETS ______________

AVAILABLE MAGNET POWER, Mw ______________ SHIELDING, tons ______________

OTHER SERVICES ______________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# ELECTRON SYNCHROTRON DATA SHEET

NAME OF MACHINE: Deutsches Elektronen-Synchrotron

INSTITUTION:

ADDRESS: Hamburg-Gr. Flottbek 1, Flottbeker Drift 56

PERSON IN CHARGE: W. Jentschke

PERSON SUPPLYING DATA: O. Beer and H.O. Wüster DATE: June 9, 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | 1958 | COMPLETION DATE | 1963 |
| MODEL TESTS | Spring 1959 | SCHEDULED OPERATION | 80 hr/wk |
| ENGINEERING DESIGN | Spring 1959 | COST OF ACCELERATOR } COST OF BUILDINGS | 70 Million DM |
| CONSTRUCTION STARTED | Autumn 1959 | | |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 15 |
| ENGINEERS | 21 |
| TOTAL | 142 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| ENERGY | 6 Gev |
| PULSE RATE | 50 per sec |
| OUTPUT | $10^{11}$ part./pulse |

### INJECTOR SYSTEM

| | |
|---|---|
| TYPE | Linear accelerator |
| ENERGY | 40 Mev |
| INJECTOR OUTPUT | Pulse current, 125 ma |
| INJECTION PERIOD | 1 turns |
| INFLECTOR TYPE | Magnetic |

### ACCELERATION SYSTEM

| | |
|---|---|
| FINAL ROTATION FREQ. | 0.946 Mc/sec |
| HARMONIC NO. | 528 |
| NUMBER OF CAVITIES | 16 |
| FREQUENCY RANGE | 499.67 TO - Mc/sec |
| ENERGY GAIN | 1300 (max.) kev/turn |
| MAX. RAD. LOSS | 3620 kev/turn |
| INPUT TO RF, MAX. | 350 kw |

### MAGNET

| | |
|---|---|
| FOCUSING TYPE | a.g. |
| FOCUSING ORDER | F O D O |
| FIELD INDEX, $n =$ | 69.26 and 70.26 |
| BETATRON OSC. FREQ. $Q_r$ | 6.25 |
| $Q_z$ | 6.25 |
| ORBIT RADIUS | 31.70 m |
| MEAN RADIUS | 50.42 m |
| SECTORS, NO. | 48 |
| FIELD AT INJ. | 42 gauss |
| FIELD, MAX. | 6.3 kgauss |
| STORAGE SYSTEM | Choke and condensers |
| RISE TIME | 10 msec |
| WEIGHT: Fe | 570 ; Cu 80 tons |
| POWER INPUT, PEAK | kw |
| POWER INPUT, AVERAGE | 2500 kw |
| APERTURE WIDTH | F, 14.4; D, 9.2 cm |
| APERTURE HEIGHT | F, 5.6; D, 8.8 cm |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______ Gev ENERGY SPREAD ______ % PULSE RATE ______

BEAM CURRENT ______ part./pulse DUTY CYCLE ______ % SHORTEST PULSE WIDTH ______ msec

TARGETING METHODS ______

### BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, $cm^2$ | MAX. ENERGY |
|---|---|---|---|
| | | | |

### SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |

IS ELECTRON BEAM EXTRACTED? ______ . ______ %

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ 2 x 3000

NUMBER OF BENDING MAGNETS ______ FOCUSING MAGNETS ______

AVAILABLE MAGNET POWER, Mw ______ SHIELDING, tons ______

OTHER SERVICES ______

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# ELECTRON SYNCHROTRON DATA SHEET

NAME OF MACHINE: Electronsynchrotron

INSTITUTION: Laboratori Nazionali di Frascati del Comitato Nazionale Energia Nucleare

ADDRESS: Casella Postale 15, Frascati (Rome, Italy)

PERSON IN CHARGE: G. Salvini, 1954 to July 1960; I.F. Quercia, July 1960 -

PERSON SUPPLYING DATA: G. Ghigo — DATE: June 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | 1954-55 | COMPLETION DATE | February 1959 |
| MODEL TESTS | 1955-56 | SCHEDULED OPERATION | 128 hr/wk |
| ENGINEERING DESIGN | 1955-56 | COST OF ACCELERATOR | $1.5 Million |
| CONSTRUCTION STARTED | January 1956 | COST OF BUILDINGS | $300,000 |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | |
| ENGINEERS | |
| TOTAL | 4 Physicists* |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| ENERGY | 1.1 Gev |
| PULSE RATE | 20 per sec |
| OUTPUT | 5 to 10 x $10^9$ part./pulse |

### INJECTOR SYSTEM

| | |
|---|---|
| TYPE | Van de Graaff |
| ENERGY | 2.5 Mev |
| INJECTOR OUTPUT | 20 ma |
| INJECTION PERIOD | 3 to 10 turns |
| INFLECTOR TYPE | Electrostatic |

### ACCELERATION SYSTEM

| | |
|---|---|
| FINAL ROTATION FREQ. | 10.9 Mc/sec |
| HARMONIC NO. | 4 |
| NUMBER OF CAVITIES | 2 |
| FREQUENCY RANGE | 43.0 TO 43.7 Mc/sec |
| ENERGY GAIN | ≈4 kev/turn |
| MAX. RAD. LOSS | 25 at 1 Gev kev/turn |
| INPUT TO RF, MAX. | 40 kw |

### MAGNET

| | |
|---|---|
| FOCUSING TYPE | Weak |
| FOCUSING ORDER | - |
| FIELD INDEX, $n=$ | 0.61 |
| BETATRON OSC. FREQ. $Q_r$ | - |
| $Q_z$ | - |
| ORBIT RADIUS | 3.60 m |
| MEAN RADIUS | 4.37 m |
| SECTORS, NO. | 4 |
| FIELD AT INJ. | ≈27 gauss |
| FIELD, MAX. | 11 kgauss |
| STORAGE SYSTEM | Capacitors |
| RISE TIME | ≈23 x $10^{-3}$ sec |
| WEIGHT: Fe ; Cu | ≈95 ; ≈8 tons |
| POWER INPUT, PEAK | kw |
| POWER INPUT, AVERAGE | 800 kw |
| APERTURE WIDTH | 22.7 cm |
| APERTURE HEIGHT | 8.6 cm |

*The total staff of Frascati Labs. is 28 physicists and 6 engineers.

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 1.1 Gev ENERGY SPREAD 0.1 % PULSE RATE 20

BEAM CURRENT 5 to 10 x $10^9$ part./pulse DUTY CYCLE† ____ % SHORTEST PULSE WIDTH 20 μsec ~~msec~~

TARGETING METHODS Fixed target of tantalum, 0.1 radiation length.

### BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, cm² | MAX. ENERGY |
|---|---|---|---|
| 4 | 1.3 x $10^{10}$ | | 1.1 Gev |

### SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |

IS ELECTRON BEAM EXTRACTED? No . - %

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² 400

NUMBER OF BENDING MAGNETS 4 FOCUSING MAGNETS 3

AVAILABLE MAGNET POWER, Mw 0.850 SHIELDING, tons 600

OTHER SERVICES 1 Diffusion chamber with 33-ton magnet.

1 Pair spectrometer with 17-ton magnet.

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

Nine experiments in pion physics.
Three experiments in electrodynamics.
One experiment in photoproduction of μ pairs.
One experiment in K-meson physics.

### OTHER FEATURES

-

### PUBLISHED ARTICLES DESCRIBING MACHINE

See attached.

†For counter experiments a pulse width of 4 msec with an energy spread of ±0.5% is normally used.

# PUBLISHED ARTICLES DESCRIBING MACHINE

1. The 1100 MeV Electronsynchrotron of the National Laboratories of Frascati, Proc. 2nd UN Conf. Peaceful Uses Atomic Energy, Geneva, 1958, Paper 15/P/1374, UN, New York, 1958.
2. Relazione tenuta al Congresso della Società Italiana di Fisica (Palermo 1958) sulla situazione dei lavori per l'Elettrosincrotrone italiano, Nuovo Cimento 11, Suppl. No. 3, 324 (1959).
3. Operation at 1000 MeV of the Frascati Electronsynchrotron, Nuovo Cimento 11, 311 (1959).
4. Frascati reports (available on request).

# ELECTRON SYNCHROTRON DATA SHEET

| | |
|---|---|
| NAME OF MACHINE | INS 1-Gev Electron Synchrotron |
| INSTITUTION | Institute for Nuclear Study, University of Tokyo |
| ADDRESS | Tanashi-machi, Kitatama-gun, Tokyo, Japan |
| PERSON IN CHARGE | Hiroo Kumagai |
| PERSON SUPPLYING DATA | Yoshiyuki Kobayashi |
| DATE | June 20, 1961 |

## HISTORY AND STATUS

| | |
|---|---|
| DESIGN (DATE) | April 1956 |
| MODEL TESTS | September 1956 |
| ENGINEERING DESIGN | October 1956 |
| CONSTRUCTION STARTED | March 1957 |
| COMPLETION DATE | Expected 1961 |
| SCHEDULED OPERATION | hr/wk |
| COST OF ACCELERATOR | $720,000 |
| COST OF BUILDINGS | $150,000 |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 11 |
| ENGINEERS | 4 |
| TOTAL | 15 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| ENERGY | 0.75 (1.3 with dc bias) Gev |
| PULSE RATE | 21.5 per sec |
| OUTPUT | $5 \times 10^9$ ($3 \times 10^{10}$) part./pulse |

### INJECTOR SYSTEM

| | |
|---|---|
| TYPE | Electron linear accelerator |
| ENERGY | 6 Mev |
| INJECTOR OUTPUT | >50 peak ma |
| INJECTION PERIOD | 1 (10) turns |
| INFLECTOR TYPE | Electrostatic ($15^o$) |

### ACCELERATION SYSTEM

| | |
|---|---|
| FINAL ROTATION FREQ. | 138.1 Mc/sec |
| HARMONIC NO. | 16 |
| NUMBER OF CAVITIES | 1 |
| FREQUENCY RANGE | Fixed TO Mc/sec |
| ENERGY GAIN | 11 kev/turn |
| MAX. RAD. LOSS | 7 (63) kev/turn |
| INPUT TO RF, MAX. | 2 kw |

### MAGNET

| | |
|---|---|
| FOCUSING TYPE | a.g. |
| FOCUSING ORDER | 1/2O 1/2F D 1/2F 1/2O |
| FIELD INDEX, $n=$ | 14.7 |
| BETATRON OSC. FREQ. $Q_r$ | 2.25 |
| $Q_z$ | 2.25 |
| ORBIT RADIUS | 4.00 m |
| MEAN RADIUS | 5.52 m |
| SECTORS, NO. | 8 |
| FIELD AT INJ. | 54 gauss |
| FIELD, MAX. | 6.25 (10.8) kgauss |
| STORAGE SYSTEM | Condenser |
| RISE TIME | $0.84 \times 10^6$ gauss/sec |
| WEIGHT: Fe | 53 ; Cu 7.9 tons |
| POWER INPUT, PEAK | 5200 kv-a ~~kw~~ |
| POWER INPUT, AVERAGE | 140 kw |
| APERTURE WIDTH | 9 (pole width 15) cm |
| APERTURE HEIGHT | 3.4 (pole gap 5.4) cm |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______ Gev ENERGY SPREAD ______ % PULSE RATE ______

BEAM CURRENT ______ part./pulse DUTY CYCLE ______ % SHORTEST PULSE WIDTH ______ msec

TARGETING METHODS ______

### BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, $cm^2$ | MAX. ENERGY |
|---|---|---|---|
| | | | |

### SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |

IS ELECTRON BEAM EXTRACTED? ______ . ______ %

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ 660

NUMBER OF BENDING MAGNETS ______ FOCUSING MAGNETS ______

AVAILABLE MAGNET POWER, Mw ______ SHIELDING, tons 450

OTHER SERVICES ______

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

H. Kumagai et al., Design Study for the INS 1-BeV Electron Synchrotron, INSJ-1, 1957.
Electron Synchrotron Group, Status Report of 1-Gev Electron Synchrotron, INSJ-17, 1959.
T. Nishikawa et al., Status Report of 6 MeV Linear Electron Accelerator, INSJ-18, 1959.
Also, INSJ-15, 1959; INSJ-28, 1960; INSJ-37, 1961; and INSJ-39, 1961.

# ELECTRON SYNCHROTRON DATA SHEET

NAME OF MACHINE: Electron Synchrotron

INSTITUTION: Physics Department, University of Lund

ADDRESS: Lund, Sweden

PERSON IN CHARGE: S. von Friesen

PERSON SUPPLYING DATA: O. Wernholm — DATE: June 15, 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | 1954-57 | COMPLETION DATE | 650 Mev, April 1961; 1.2 Gev, autumn 1961 |
| MODEL TESTS | 1954-57 | SCHEDULED OPERATION | hr/wk |
| ENGINEERING DESIGN | 1954-57 | COST OF ACCELERATOR | $450,000 (including salaries) |
| CONSTRUCTION STARTED | 1957 | COST OF BUILDINGS | |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 2 to 3 |
| ENGINEERS | 4 |
| TOTAL | 6 to 7 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | | |
|---|---|---|
| ENERGY | 1.2 | Gev |
| PULSE RATE | 12.5 per sec | |
| OUTPUT | | part./pulse |

### INJECTOR SYSTEM

| | | |
|---|---|---|
| TYPE | Microtron | |
| ENERGY | 5.9 | Mev |
| INJECTOR OUTPUT | 20 | ma |
| INJECTION PERIOD | 50 to 100 | turns |
| INFLECTOR TYPE | Electrostatic | |

### ACCELERATION SYSTEM

| | | |
|---|---|---|
| FINAL ROTATION FREQ. | 8.85 | Mc/sec |
| HARMONIC NO. | 45 | |
| NUMBER OF CAVITIES | 1 | |
| FREQUENCY RANGE | TO | Mc/sec |
| ENERGY GAIN | 0.8 to 6 | kev/turn |
| MAX. RAD. LOSS | 60 | kev/turn |
| INPUT TO RF, MAX. | 12 | kw |

### MAGNET

| | | |
|---|---|---|
| FOCUSING TYPE | a.g. | |
| FOCUSING ORDER | F O F D O D | |
| FIELD INDEX, $n =$ | 11.6 | |
| BETATRON OSC. FREQ. $Q_r$ | 1.80 | |
| $Q_z$ | 1.80 | |
| ORBIT RADIUS | 3.65 | m |
| MEAN RADIUS | 5.30 | m |
| SECTORS, NO. | 16 | |
| FIELD AT INJ. | 55 | gauss |
| FIELD, MAX. | 11,000 | kgauss |
| STORAGE SYSTEM | Condensers | |
| RISE TIME | 40 msec | |
| WEIGHT: Fe | 28 ; Cu 7 | tons |
| POWER INPUT, PEAK | | kw |
| POWER INPUT, AVERAGE | 250 | kw |
| APERTURE WIDTH | 6.0 | cm |
| APERTURE HEIGHT | 4.0 | cm |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______ Gev ENERGY SPREAD ______ % PULSE RATE ______

BEAM CURRENT ______ part./pulse DUTY CYCLE ______ % SHORTEST PULSE WIDTH ______ msec

TARGETING METHODS ______

### BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, $cm^2$ | MAX. ENERGY |
|---|---|---|---|
| | | | |

### SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |

IS ELECTRON BEAM EXTRACTED? ______ . ______ %

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ 300

NUMBER OF BENDING MAGNETS 1 FOCUSING MAGNETS 1

AVAILABLE MAGNET POWER, Mw 0.5 SHIELDING, tons ______

OTHER SERVICES ______

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# ELECTRON SYNCHROTRON DATA SHEET

NAME OF MACHINE: CalTech Synchrotron

INSTITUTION: California Institute of Technology

ADDRESS: Pasadena, Calif.

PERSON IN CHARGE: Robert F. Bacher

PERSON SUPPLYING DATA: Matthew Sands — DATE: May 11, 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | | COMPLETION DATE | I, July 1952; II, August 1956 |
| MODEL TESTS | I, 1950-51; II, 1952-3 | SCHEDULED OPERATION | >120 hr/wk |
| ENGINEERING DESIGN | I, 1950-51; II, 1952 | COST OF ACCELERATOR | $1.3 Million |
| CONSTRUCTION STARTED | I, 1951; II, 1954 | COST OF BUILDINGS | |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 9 |
| ENGINEERS | 7 |
| TOTAL | 16 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| ENERGY | >1.0 Gev |
| PULSE RATE | 1 per sec |
| OUTPUT | - part./pulse |

### INJECTOR SYSTEM

| | |
|---|---|
| TYPE | Pulse transformer |
| ENERGY | 1.0 Mev |
| INJECTOR OUTPUT | 60 ma |
| INJECTION PERIOD | ≈2 turns |
| INFLECTOR TYPE | 90° Electrostatic |

### ACCELERATION SYSTEM

| | |
|---|---|
| FINAL ROTATION FREQ. | 10.06 Mc/sec |
| HARMONIC NO. | 4 |
| NUMBER OF CAVITIES | 1 FM; 1 high power |
| FREQUENCY RANGE | 37.8 TO 40.2 Mc/sec |
| ENERGY GAIN | 0.6 kev/turn |
| MAX. RAD. LOSS | 120 kev/turn |
| INPUT TO RF, MAX. | 100 kw |

### MAGNET

| | |
|---|---|
| FOCUSING TYPE | c.g. |
| FOCUSING ORDER | - |
| FIELD INDEX, $n=$ | 0.6 |
| BETATRON OSC. FREQ. $Q_r$ | 0.68 |
| $Q_z$ | 0.82 |
| ORBIT RADIUS | 3.76 m |
| MEAN RADIUS | 4.70 m |
| SECTORS, NO. | 4 |
| FIELD AT INJ. | 13 gauss |
| FIELD, MAX. | 14 kgauss |
| STORAGE SYSTEM | Flywheel |
| RISE TIME | 0.25 sec |
| WEIGHT: Fe | 155; Cu 18 tons |
| POWER INPUT, PEAK | 8500 kw |
| POWER INPUT, AVERAGE | 250 kw |
| APERTURE WIDTH | 18 cm |
| APERTURE HEIGHT | 7.5 cm |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 1.5 Gev ENERGY SPREAD 0.1 % PULSE RATE 1 per sec

BEAM CURRENT $3 \times 10^9$ part./pulse DUTY CYCLE 6 % SHORTEST PULSE WIDTH ______ msec

TARGETING METHODS ______

### BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, $cm^2$ | MAX. ENERGY |
|---|---|---|---|
| 2 | $\approx 10^8$ | 35 | 1500 Mev |

### SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| None | | | | |

IS ELECTRON BEAM EXTRACTED? No . ______ %

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, ~~m²~~ 2000 $ft^2$

NUMBER OF BENDING MAGNETS 4 FOCUSING MAGNETS 0

AVAILABLE MAGNET POWER, Mw 0.2 SHIELDING, tons 200

OTHER SERVICES ______

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

Charged and neutral pion photoproduction.
Charged and neutral K photoproduction.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

The CalTech Synchrotron was first constructed from the magnet iron and vacuum chamber of the 1/4-scale model of the Berkeley Bevatron, and was operated from July 1952 to December 1954 at 500 Mev. In 1955 the synchrotron was rebuilt to operate at higher energies. New magnet coils were installed, pole tips were added to the magnet, and the vacuum and RF systems were completely rebuilt. Since August 1956 the synchrotron has been operated at energies >1000 Mev. From 1956 to 1959 the peak energy was determined by the RF voltage available. Since October 1960 the synchrotron has operated at energies up to 1500 Mev, the maximum permitted by the guide magnet. RF gap voltages >300 kilovolts are required.

# ELECTRON SYNCHROTRON DATA SHEET

| | |
|---|---|
| NAME OF MACHINE | Cambridge Electron Accelerator |
| INSTITUTION | Massachusetts Institute of Technology and Harvard University |
| ADDRESS | 42 Oxford St., Cambridge 38, Mass. |
| PERSON IN CHARGE | Prof. M. Stanley Livingston |
| PERSON SUPPLYING DATA | Same |
| DATE | May 8, 1961 |

## HISTORY AND STATUS

| | |
|---|---|
| DESIGN (DATE) | April 1956 |
| MODEL TESTS | Continuous |
| ENGINEERING DESIGN | Continuous |
| CONSTRUCTION STARTED | November 1957 |
| COMPLETION DATE | September 1961 (est.) |
| SCHEDULED OPERATION | ? hr/wk |
| COST OF ACCELERATOR | $7.5 Million |
| COST OF BUILDINGS | $3.7 Million |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 14 |
| ENGINEERS | 20 |
| TOTAL | 110 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| ENERGY | 6.0 Gev |
| PULSE RATE | 60 per sec |
| OUTPUT | $1 \times 10^{11}$ part./pulse |

### INJECTOR SYSTEM

| | |
|---|---|
| TYPE | S-band linac |
| ENERGY | 25 Mev |
| INJECTOR OUTPUT | 150 ma |
| INJECTION PERIOD | 1 turns |
| INFLECTOR TYPE | Magnetic-pulsed |

### ACCELERATION SYSTEM

| | |
|---|---|
| FINAL ROTATION FREQ. | 1.32 Mc/sec |
| HARMONIC NO. | 360 |
| NUMBER OF CAVITIES | 32 |
| FREQUENCY RANGE | 475.83 TO - Mc/sec |
| ENERGY GAIN | Av, 600 kev/turn |
| MAX. RAD. LOSS | 4500 kev/turn |
| INPUT TO RF, MAX. | 400 kw |

### MAGNET

| | |
|---|---|
| FOCUSING TYPE | a.g. |
| FOCUSING ORDER | F O D O |
| FIELD INDEX, $n=$ | 90 |
| BETATRON OSC. FREQ. $Q_r$ | 6.4/turn |
| $Q_z$ | 6.4/turn |
| ORBIT RADIUS | 27.5 m |
| MEAN RADIUS | 36.0 m |
| SECTORS, NO. | 48 |
| FIELD AT INJ. | 32 gauss |
| FIELD, MAX. | 8.0 kgauss |
| STORAGE SYSTEM | Capacitor-inductor |
| RISE TIME | 60 cps, sinusoidal |
| WEIGHT: Fe | 300 ; Cu 40 tons |
| POWER INPUT, PEAK | 1100 kw |
| POWER INPUT, AVERAGE | 1100 kw |
| APERTURE WIDTH | 16.5 cm |
| APERTURE HEIGHT | Av, 5.1 cm |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ________________ Gev ENERGY SPREAD ________ % PULSE RATE ________________

BEAM CURRENT ________________ part./pulse DUTY CYCLE ________ % SHORTEST PULSE WIDTH ________ msec

TARGETING METHODS ________________________________________________

________________________________________________

### BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, $cm^2$ | MAX. ENERGY |
|---|---|---|---|
| | | | |

### SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |

IS ELECTRON BEAM EXTRACTED? ________________ ________________ %

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ ________________________________

NUMBER OF BENDING MAGNETS ________________________________ FOCUSING MAGNETS ________________

AVAILABLE MAGNET POWER, Mw ________________________________ SHIELDING, tons ________________

OTHER SERVICES ________________________________________________

________________________________________________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# ELECTRON SYNCHROTRON DATA SHEET

NAME OF MACHINE: Cornell Bev Synchrotron

INSTITUTION: Laboratory of Nuclear Studies, Cornell University

ADDRESS: Ithaca, N.Y.

PERSON IN CHARGE: Robert R. Wilson

PERSON SUPPLYING DATA: Raphael M. Littauer — DATE: June 27, 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | 1953 | COMPLETION DATE | 1955 |
| MODEL TESTS | Not made | SCHEDULED OPERATION | 160 hr/wk |
| ENGINEERING DESIGN | 1953 | COST OF ACCELERATOR | $500,000 |
| CONSTRUCTION STARTED | 1953 | COST OF BUILDINGS | Existing buildings used |

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

| | |
|---|---|
| SCIENTISTS | 15 |
| ENGINEERS | 3 |
| TOTAL | 18 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| ENERGY | 1.3 Gev |
| PULSE RATE | 30 per sec |
| OUTPUT | $2 \times 10^{10}$ part./pulse |

### INJECTOR SYSTEM

| | |
|---|---|
| TYPE | Linear accelerator |
| ENERGY | 10 ± 0.05 Mev |
| INJECTOR OUTPUT | 100 ma |
| INJECTION PERIOD | 5 turns |
| INFLECTOR TYPE | dc Electrostatic |

### ACCELERATION SYSTEM

| | |
|---|---|
| FINAL ROTATION FREQ. | 10.8 Mc/sec |
| HARMONIC NO. | 8 |
| NUMBER OF CAVITIES | 1 |
| FREQUENCY RANGE | 86.6 TO 87.0 Mc/sec |
| ENERGY GAIN | 13 (max.) kev/turn |
| MAX. RAD. LOSS | 70 kev/turn |
| INPUT TO RF, MAX. | 7 kw |

### MAGNET

| | |
|---|---|
| FOCUSING TYPE | a.g. |
| FOCUSING ORDER | 1/2F D 1/2F quasi octant |
| FIELD INDEX, $n =$ | ≈15 |
| BETATRON OSC. FREQ. $Q_r$ | 2.25 |
| $Q_z$ | 1.75 |
| ORBIT RADIUS | 3.81 m |
| MEAN RADIUS | 4.40 m |
| SECTORS, NO. | 4 (each double) |
| FIELD AT INJ. | 87 gauss |
| FIELD, MAX. | 11.4 kgauss |
| STORAGE SYSTEM | Capacitors |
| RISE TIME | 30 cps, sine wave, dc bias |
| WEIGHT: Fe | 20 ; Cu 4 tons |
| POWER INPUT, PEAK | kw |
| POWER INPUT, AVERAGE | 250 kw |
| APERTURE WIDTH | 7 cm |
| APERTURE HEIGHT | 4 cm |

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 1.3 Gev ENERGY SPREAD ____ % PULSE RATE 30 per sec

BEAM CURRENT $2 \times 10^{10}$ part./pulse DUTY CYCLE 5 % SHORTEST PUBLSE WIDTH ____ msec

TARGETING METHODS Fixed internal targets for bremsstrahlung, scattering. Rotating and vibrating targets also useful.

### BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, cm² | MAX. ENERGY |
|---|---|---|---|
| 4 (typical) | $3 \times 10^{10}$ | 6 (typical) | 1.3 Gev |

### SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |

IS ELECTRON BEAM EXTRACTED? No ____ %

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² 250

NUMBER OF BENDING MAGNETS 4 FOCUSING MAGNETS 4

AVAILABLE MAGNET POWER, Mw 0.8 SHIELDING, tons 350

OTHER SERVICES ____

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

Photoproduction of single pions, pion pairs, K-hyperon pairs. Elastic scattering of electrons, photons. Search for new particles.

### OTHER FEATURES

Bremsstrahlung beam can be brought out at any point along orbit.

### PUBLISHED ARTICLES DESCRIBING MACHINE


1. R.R. Wilson, The Cornell Bev Synchrotron 1956 (ONR report), unpublished.
2. Silverman, Corson, DeWire, Luckey, Martin, McDaniel, Wilson and Woodward, Bull. Am. Phys. Soc. 1, 59 (1956).
3. E. Malamud and A. Silverman, Nuclear Instr. 4, 67 (1959).
4. Jackson, Martin, and Waggoner, Rev. Sci. Instr. 30, 187 (1959).

The Cornell Bev synchrotron has recently (December 1960) been modified by the addition of a linear accelerator as injector. This accelerator, manufactured by ARCO, operates in the L-band and achieves the following typical performance: Energy, 10 Mev. Beam intensity with 1% energy interval, 100 to 200 ma. Pulse duration, 0.2 to 0.8 μsec. Beam diameter, 5 mm. Beam divergence, 1 mrad total. Injection into the synchrotron is via an achromatic system composed of magnets (105° total deflection) and an electrostatic inflector (15°). Use of the linac injector has increased the beam intensity by a factor of 10 to 20 and has greatly enhanced operating stability.

# ELECTRON SYNCHROTRON DATA SHEET

NAME OF MACHINE ______________________

INSTITUTION ______________________

ADDRESS ______________________

PERSON IN CHARGE ______________________

PERSON SUPPLYING DATA ______________________ DATE __________

## HISTORY AND STATUS

DESIGN (DATE) __________ COMPLETION DATE __________

MODEL TESTS __________ SCHEDULED OPERATION __________ hr/wk

ENGINEERING DESIGN __________ COST OF ACCELERATOR __________

CONSTRUCTION STARTED __________ COST OF BUILDINGS __________

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS __________

ENGINEERS __________

TOTAL __________

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY __________ Gev

PULSE RATE __________

OUTPUT __________ part./pulse

### INJECTOR SYSTEM

TYPE __________

ENERGY __________ Mev

INJECTOR OUTPUT __________ ma

INJECTION PERIOD __________ turns

INFLECTOR TYPE __________

### ACCELERATION SYSTEM

FINAL ROTATION FREQ. __________ Mc/sec

HARMONIC NO. __________

NUMBER OF CAVITIES __________

FREQUENCY RANGE __________ TO __________ Mc/sec

ENERGY GAIN __________ kev/turn

MAX. RAD. LOSS __________ kev/turn

INPUT TO RF, MAX. __________ kw

### MAGNET

FOCUSING TYPE __________

FOCUSING ORDER __________

FIELD INDEX, $n=$ __________

BETATRON OSC. FREQ. $Q_r$ __________

$Q_z$ __________

ORBIT RADIUS __________ m

MEAN RADIUS __________ m

SECTORS, NO. __________

FIELD AT INJ. __________ gauss

FIELD, MAX. __________ kgauss

STORAGE SYSTEM __________

RISE TIME __________

WEIGHT: Fe __________ ; Cu __________ tons

POWER INPUT, PEAK __________ kw

POWER INPUT, AVERAGE __________ kw

APERTURE WIDTH __________ cm

APERTURE HEIGHT __________ cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______________ Gev ENERGY SPREAD ________ % PULSE RATE ______________

BEAM CURRENT ______________ part./pulse DUTY CYCLE ________ % SHORTEST PULSE WIDTH ________ msec

TARGETING METHODS ______________________________

______________________________

### BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, $cm^2$ | MAX. ENERGY |
|---|---|---|---|
| | | | |

### SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |

IS ELECTRON BEAM EXTRACTED? ____________ ____________ %

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ ______________________________

NUMBER OF BENDING MAGNETS ______________________________ FOCUSING MAGNETS ____________

AVAILABLE MAGNET POWER, Mw ______________________________ SHIELDING, tons ____________

OTHER SERVICES ______________________________

______________________________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# ELECTRON SYNCHROTRON DATA SHEET

NAME OF MACHINE ______

INSTITUTION ______

ADDRESS ______

PERSON IN CHARGE ______

PERSON SUPPLYING DATA ______ DATE ______

## HISTORY AND STATUS

DESIGN (DATE) ______

MODEL TESTS ______

ENGINEERING DESIGN ______

CONSTRUCTION STARTED ______

COMPLETION DATE ______

SCHEDULED OPERATION ______ hr/wk

COST OF ACCELERATOR ______

COST OF BUILDINGS ______

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS ______

ENGINEERS ______

TOTAL ______

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY ______ Gev

PULSE RATE ______

OUTPUT ______ part./pulse

### INJECTOR SYSTEM

TYPE ______

ENERGY ______ Mev

INJECTOR OUTPUT ______ ma

INJECTION PERIOD ______ turns

INFLECTOR TYPE ______

### ACCELERATION SYSTEM

FINAL ROTATION FREQ. ______ Mc/sec

HARMONIC NO. ______

NUMBER OF CAVITIES ______

FREQUENCY RANGE ______ TO ______ Mc/sec

ENERGY GAIN ______ kev/turn

MAX. RAD. LOSS ______ kev/turn

INPUT TO RF, MAX. ______ kw

### MAGNET

FOCUSING TYPE ______

FOCUSING ORDER ______

FIELD INDEX, $n =$ ______

BETATRON OSC. FREQ. $Q_r$ ______

$Q_z$ ______

ORBIT RADIUS ______ m

MEAN RADIUS ______ m

SECTORS, NO. ______

FIELD AT INJ. ______ gauss

FIELD, MAX. ______ kgauss

STORAGE SYSTEM ______

RISE TIME ______

WEIGHT: Fe ______ ; Cu ______ tons

POWER INPUT, PEAK ______ kw

POWER INPUT, AVERAGE ______ kw

APERTURE WIDTH ______ cm

APERTURE HEIGHT ______ cm

# PERFORMANCE DATA

## INTERNAL BEAM

MAX. ENERGY ____________ Gev ENERGY SPREAD ________ % PULSE RATE ____________

BEAM CURRENT ____________ part./pulse DUTY CYCLE ________ % SHORTEST PULSE WIDTH ________ msec

TARGETING METHODS ________________________________________

________________________________________

## BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, $cm^2$ | MAX. ENERGY |
|---|---|---|---|
| | | | |

## SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |

IS ELECTRON BEAM EXTRACTED? ____________ . ____________ %

## FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ ____________________

NUMBER OF BENDING MAGNETS ____________________ FOCUSING MAGNETS ____________

AVAILABLE MAGNET POWER, Mw ____________________ SHIELDING, tons ____________

OTHER SERVICES ________________________________________

________________________________________

## USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

## OTHER FEATURES

## PUBLISHED ARTICLES DESCRIBING MACHINE

# ELECTRON SYNCHROTRON DATA SHEET

NAME OF MACHINE ____________________

INSTITUTION ____________________

ADDRESS ____________________

PERSON IN CHARGE ____________________

PERSON SUPPLYING DATA ____________________ DATE __________

## HISTORY AND STATUS

DESIGN (DATE) ____________________

MODEL TESTS ____________________

ENGINEERING DESIGN ____________________

CONSTRUCTION STARTED ____________________

COMPLETION DATE ____________________

SCHEDULED OPERATION ____________________ hr/wk

COST OF ACCELERATOR ____________________

COST OF BUILDINGS ____________________

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS ____________________

ENGINEERS ____________________

TOTAL ____________________

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

ENERGY ____________________ Gev

PULSE RATE ____________________

OUTPUT ____________________ part./pulse

### INJECTOR SYSTEM

TYPE ____________________

ENERGY ____________________ Mev

INJECTOR OUTPUT ____________________ ma

INJECTION PERIOD ____________________ turns

INFLECTOR TYPE ____________________

### ACCELERATION SYSTEM

FINAL ROTATION FREQ. ____________________ Mc/sec

HARMONIC NO. ____________________

NUMBER OF CAVITIES ____________________

FREQUENCY RANGE __________ TO __________ Mc/sec

ENERGY GAIN ____________________ kev/turn

MAX. RAD. LOSS ____________________ kev/turn

INPUT TO RF, MAX. ____________________ kw

### MAGNET

FOCUSING TYPE ____________________

FOCUSING ORDER ____________________

FIELD INDEX, $n =$ ____________________

BETATRON OSC. FREQ. $Q_r$ ____________________

$Q_z$ ____________________

ORBIT RADIUS ____________________ m

MEAN RADIUS ____________________ m

SECTORS, NO. ____________________

FIELD AT INJ. ____________________ gauss

FIELD, MAX. ____________________ kgauss

STORAGE SYSTEM ____________________

RISE TIME ____________________

WEIGHT: Fe __________ ; Cu __________ tons

POWER INPUT, PEAK ____________________ kw

POWER INPUT, AVERAGE ____________________ kw

APERTURE WIDTH ____________________ cm

APERTURE HEIGHT ____________________ cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______________ Gev ENERGY SPREAD ________ % PULSE RATE ______________

BEAM CURRENT ______________ part./pulse DUTY CYCLE ________ % SHORTEST PULSE WIDTH __________ msec

TARGETING METHODS ______________________________________________

______________________________________________

### BREMSSTRAHLUNG BEAMS

| NUMBER OF BEAMS | FLUX (equivalent quanta/sec) | BEAM AREA, $cm^2$ | MAX. ENERGY |
|---|---|---|---|
| | | | |

### SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |

IS ELECTRON BEAM EXTRACTED? ______________ ______________ %

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ ______________________________

NUMBER OF BENDING MAGNETS ______________________________ FOCUSING MAGNETS ______________

AVAILABLE MAGNET POWER, Mw ______________________________ SHIELDING, tons ______________

OTHER SERVICES ______________________________________________

______________________________________________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# LINEAR ACCELERATOR DATA SHEET

NAME OF MACHINE: Laboratoire de l'Accélérateur Linéaire

INSTITUTION: École Normale Supérieure

ADDRESS: Boite postale No. 5 - Orsay (Seine-et-Oise)

PERSON IN CHARGE: Professeur H. Halban

PERSON SUPPLYING DATA: Dr. G.R. Bishop and L. Burnod — DATE: June 1, 1961

## HISTORY AND STATUS

DESIGN (DATE): 

MODEL TESTS: 

ENGINEERING DESIGN: 

CONSTRUCTION STARTED: July 1, 1956

COMPLETION DATE: January 1, 1961, at 1 Gev

SCHEDULED OPERATION: 80 hr/wk

COST OF ACCELERATOR: $5 Million

COST OF BUILDINGS: $4 Million

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS: 24

ENGINEERS: 31

TOTAL: 55

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

PARTICLE ACC.: Electron

ENERGY: 1.3 Gev

ENERGY SPREAD: 3 %

OUTPUT: $3 \times 10^{11}$ part./pulse

PULSE WIDTH: 1 μsec

REPETITION RATE: 50 pulses/sec

BEAM DIAMETER: 1 cm

BEAM EMITTANCE: (mrad cm)$^2$

### RF SYSTEM

FREQUENCY: 2998.97 Mc/sec

FIELD MODE: $\pi/2$

RF POWER, PEAK: 2000 kw

POWER UNITS: 22

EQUILIBRIUM PHASE: -

RF PULSE DURATION: 2 μsec

FOCUSING TYPE: Axial up to 60 Mev; no focusing system after 60 Mev

### INJECTOR

TYPE: Tungsten filament

ENERGY: 40 kev

OUTPUT: 100 ma

### MECHANICAL CHARACTERISTICS

LENGTH: 150 m

DIAMETER: Vacuum tube 25 cm

DRIFT TUBES, NUMBER: 

LENGTH 1st TUBE: 

DIAMETER 1st TUBE: 

APERTURE 1st TUBE: 

LENGTH 1st GAP: 

LENGTH LAST TUBE: 

DIAMETER LAST TUBE: 

LENGTH LAST GAP: 

IRIS APERTURE: 2 cm

IRIS SPACING: 2.5 cm

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY 1.3 Gev ENERGY SPREAD 3 %

BEAM CURRENT $3 \times 10^{11}$ part./pulse PULSE RATE 50 per sec

DUTY CYCLE 0.02 % WIDTH OF SHORTEST PULSE ______ msec

METHOD OF TARGETING ______

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm²-sec | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| Electrons | | | 250 | 0.1 to 2.5 |
| | | | 500 | " " |
| | | | 1000 | " " |
| | Not built yet | | 1300 | " " |
| | | | | |
| | | | | |

### FACILITIES - See attached.

SIZE OF EXPERIMENTAL AREAS, m² ______

NUMBER OF BENDING MAGNETS ______ FOCUSING MAGNETS ______

AVAILABLE MAGNET POWER, Mw ______ SHIELDING, tons ______

OTHER SERVICES ______

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

Electron scattering, elastic and inelastic. Meson production by electrons on protons.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

In preparation.

Experimental Areas:

| | |
|---|---|
| 250-Mev room | 28 x 8 $m^2$ |
| 500-Mev room | 28 x 8 $m^2$ |
| 1-Gev end station | 40 x 30 $m^2$ |

The 1.3-Gev end station is yet to be constructed. Circular, 35 m in diameter.

Magnets:

Extraction systems at 250 and 500 Mev each contain 2 bending magnets ($\rho$ = 1.85 m, $\theta$ = 30°) and 2 quadrupoles.

Extraction systems at 1 Gev and 1.3 Gev each contain 3 bending magnets ($\rho$ = 4.5 m, $\theta$ = 28°).

Analyzing Spectrometers:

1 Double focusing spectrometer ($\theta$ = 180°, $\rho$ = 52.5 cm, magnetic rigidity = 300 Mev/c).

1 Triple focusing spectrometer consisting of two sector magnets ($\theta$ = 110°, $n \cong 1/3$, magnetic rigidity = 500 Mev/c) and 1 sector magnet ($\theta$ = 36°).

# LINEAR ACCELERATOR DATA SHEET

NAME OF MACHINE: Mark III Electron Linear Accelerator

INSTITUTION: High Energy Physics Laboratory, Stanford University

ADDRESS: Stanford, Calif.

PERSON IN CHARGE: W.K.H. Panofsky, Director

PERSON SUPPLYING DATA: P.B. Wilson  DATE: May 26, 1961

## HISTORY AND STATUS

| | | | |
|---|---|---|---|
| DESIGN (DATE) | 1946-47 | COMPLETION DATE | 1950 (80 ft); 1952 (200 ft); 1960 (310 ft) |
| MODEL TESTS | 1947 | SCHEDULED OPERATION | 128 hr/wk |
| ENGINEERING DESIGN | 1948 | COST OF ACCELERATOR | ≈$3 Million |
| CONSTRUCTION STARTED | 1949 | COST OF BUILDINGS | ≈$950,000 |

Present SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

(Original development done by staff of ≈20 scientists and 20 engineers.)

| | |
|---|---|
| Technicians + operators | 14 |
| SCIENTISTS | 1 |
| ENGINEERS | 6 |
| TOTAL | 21 |

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

| | |
|---|---|
| PARTICLE ACC. | Electrons |
| ENERGY | 1.0 Gev |
| ENERGY SPREAD | 0 to 4%, depending on energy slits used % |
| OUTPUT | $1 \times 10^{11}$ part./pulse in 2% spread |
| PULSE WIDTH | 1.0 (max.) μsec |
| REPETITION RATE | 60 pulses/sec |
| BEAM DIAMETER | 0.6 cm (depending upon collimators used cm |
| BEAM EMITTANCE | 0.002 (mrad cm)$^2$ (beam diam x full angular divergence x $10^{-3})^2$ |

### RF SYSTEM*

| | |
|---|---|
| FREQUENCY | 2856 Mc/sec |
| FIELD MODE | $\pi/2$ $TM_{01}$ |
| RF POWER, PEAK | 350 Mw ~~kw~~ |
| POWER UNITS | 31 klystrons |
| Asymptotic ~~EQUILIBRIUM~~ PHASE | $-90^{\circ}$ (wave-crest) |
| RF PULSE DURATION | 2.2 μsec |
| FOCUSING TYPE | None. 5 steering coils, 2 quadrupole pairs, degaussing wires used |

### INJECTOR

| | |
|---|---|
| TYPE | Oxide-cathode gun with grid-controlled emission driven by line-type pulsers |
| ENERGY | 80 kev |
| OUTPUT | ≈300 ma |

### MECHANICAL CHARACTERISTICS†

| | |
|---|---|
| LENGTH | 310 ft |
| DIAMETER | 3.247 in. i.d. |
| DRIFT TUBES, NUMBER | Not applicable |
| LENGTH 1st TUBE | " |
| DIAMETER 1st TUBE | " |
| APERTURE 1st TUBE | " |
| LENGTH 1st GAP | " |
| LENGTH LAST TUBE | " |
| DIAMETER LAST TUBE | " |
| LENGTH LAST GAP | " |
| IRIS APERTURE | 0.822 in. |
| IRIS SPACING | 1.033 in. |

*See also attached.

†See also attached.

# PERFORMANCE DATA

## INTERNAL BEAM

MAX. ENERGY 1.0 Gev

ENERGY SPREAD ≈2% at half-current points %

BEAM CURRENT $1.5 \times 10^{11}$ part./pulse

PULSE RATE 60 pulses/sec

DUTY CYCLE 0.006 (max.) %

WIDTH OF SHORTEST PULSE 10 mμsec ~~msec~~

METHOD OF TARGETING See attached.

## EXTERNAL AND SECONDARY BEAMS

| PARTICLE | ~~Flux, part./cm² sec~~ Part./pulse | BEAM AREA, cm² | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| Electrons | Depends on collimator and energy slits used: | | | |
| " | $6 \times 10^{10}$ | 0.3 | 900 | 1 |
| " | $1.0 \times 10^{11}$ | 0.3 | 900 | 2 |
| " | $1.5 \times 10^{11}$ | 0.3 | 900 | total |
| Positrons | $6 \times 10^{6}$ | 0.3 | 300 | 1 |
| " | ? | | 800 | |
| Gammas | Dependent upon radiator thickness and location. | | | |

## FACILITIES

SIZE OF EXPERIMENTAL AREAS, m² 500

NUMBER OF BENDING MAGNETS 2 energy-analyzing systems, 5 experimental spectrometers

FOCUSING MAGNETS

AVAILABLE MAGNET POWER, Mw 3.7

SHIELDING, tons 3300

OTHER SERVICES Colliding-beams experimental area under construction: diameter of storage rings, 112 in.; circulating beam, 1 amp/ring at 500 Mev.

## USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

See attached.

## OTHER FEATURES

Auxiliary gun at 194-ft point for low energy (330-Mev or less) experiments. Provision is being made to obtain 1.2-Gev energy at reduced current. Plan to add prebuncher to increase current by a factor of 2 to 3.

## PUBLISHED ARTICLES DESCRIBING MACHINE

M. Chodorow et al., Stanford High Energy Linear Electron Accelerator (Mark III), Rev. Sci. Instr. 26, 134 (1955).

*Additional data on RF system:

| | |
|---|---|
| Group velocity . . . . . . . . . . . . . . | 0.01 c |
| Phase velocity . . . . . . . . . . . . . . | c |
| Filling time . . . . . . . . . . . . . . . | 1 μsec |
| $Q_0$ . . . . . . . . . . . . . . . . . . . . . | 10,000 |
| Shunt impedance . . . . . . . . . . . . . | $4.7 \times 10^5$ ohm/cm |
| Attenuation . . . . . . . . . . . . . . . . | 0.3 nepers/m |

First three sections have lower attenuation to reduce beam loading.

†Additional mechanical details:

| | |
|---|---|
| Iris thickness . . . . . . . . . . . . . . | 0.230 in. |
| Distance between feeds . . . . . . . . . . | 10 ft |
| Number of sections . . . . . . . . . . . . | 31 |

## METHOD OF TARGETING

Beam is collimated (variable 1/16 in. to 1/4 in.) and then delivered to experimental area straight ahead unanalyzed, or diverted either right or left through energy-analyzing systems (slits variable, 0 to 4%) and then to experimental areas. Radiators used at various points in machine to produce γ's and positrons. Positrons can be accelerated by reverse-phasing.

## USE OF MACHINE

The following fields of research are covered in the Status Report of the High Energy Physics Laboratory of Stanford University, 1 November 1960 - 31 January 1961, HEPL-227.

Electron-neutron scattering.
Electron-proton scattering.
Electron scattering from heavy nuclei.
$\pi^0$, $\pi^+$ photoproduction in hydrogen and deuterium.
Photoproduction of μ-meson pairs.
Pion electroproduction in hydrogen.
Large-angle pair production.
Positron-proton scattering.
Pion production by polarized bremsstrahlung.
Colliding beam electron-electron scattering.

# LINEAR ACCELERATOR DATA SHEET

NAME OF MACHINE ____________________

INSTITUTION ____________________

ADDRESS ____________________

PERSON IN CHARGE ____________________

PERSON SUPPLYING DATA ____________________ DATE ____________

## HISTORY AND STATUS

DESIGN (DATE) ____________ COMPLETION DATE ____________

MODEL TESTS ____________ SCHEDULED OPERATION ____________ hr/wk

ENGINEERING DESIGN ____________ COST OF ACCELERATOR ____________

CONSTRUCTION STARTED ____________ COST OF BUILDINGS ____________

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR: SCIENTISTS ____________

ENGINEERS ____________

TOTAL ____________

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

PARTICLE ACC. ____________

ENERGY ____________ Gev

ENERGY SPREAD ____________ %

OUTPUT ____________ part./pulse

PULSE WIDTH ____________ $\mu$sec

REPETITION RATE ____________

BEAM DIAMETER ____________ cm

BEAM EMITTANCE ____________ (mrad cm)$^2$

### RF SYSTEM

FREQUENCY ____________ Mc/sec

FIELD MODE ____________

RF POWER, PEAK ____________ kw

POWER UNITS ____________

EQUILIBRIUM PHASE ____________

RF PULSE DURATION ____________ $\mu$sec

FOCUSING TYPE ____________

### INJECTOR

TYPE ____________

ENERGY ____________ kev

OUTPUT ____________ ma

### MECHANICAL CHARACTERISTICS

LENGTH ____________

DIAMETER ____________

DRIFT TUBES, NUMBER ____________

LENGTH 1st TUBE ____________

DIAMETER 1st TUBE ____________

APERTURE 1st TUBE ____________

LENGTH 1st GAP ____________

LENGTH LAST TUBE ____________

DIAMETER LAST TUBE ____________

LENGTH LAST GAP ____________

IRIS APERTURE ____________

IRIS SPACING ____________

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______________________ Gev ENERGY SPREAD ______________________ %

BEAM CURRENT ______________________ part./pulse PULSE RATE ______________________

DUTY CYCLE ______________________ % WIDTH OF SHORTEST PULSE ______________________ msec

METHOD OF TARGETING ______________________________________________

______________________________________________

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm$^2$-sec | BEAM AREA, cm$^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m$^2$ ______________________

NUMBER OF BENDING MAGNETS ______________________ FOCUSING MAGNETS ______________________

AVAILABLE MAGNET POWER, Mw ______________________ SHIELDING, tons ______________________

OTHER SERVICES ______________________________________________

______________________________________________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# LINEAR ACCELERATOR DATA SHEET

NAME OF MACHINE ______________________________

INSTITUTION ______________________________

ADDRESS ______________________________

PERSON IN CHARGE ______________________________

PERSON SUPPLYING DATA ______________________________ DATE ______________

## HISTORY AND STATUS

DESIGN (DATE) ______________

MODEL TESTS ______________

ENGINEERING DESIGN ______________

CONSTRUCTION STARTED ______________

COMPLETION DATE ______________

SCHEDULED OPERATION ______________ hr/wk

COST OF ACCELERATOR ______________

COST OF BUILDINGS ______________

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS ______________

ENGINEERS ______________

TOTAL ______________

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

PARTICLE ACC. ______________

ENERGY ______________ Gev

ENERGY SPREAD ______________ %

OUTPUT ______________ part./pulse

PULSE WIDTH ______________ μsec

REPETITION RATE ______________

BEAM DIAMETER ______________ cm

BEAM EMITTANCE ______________ $(\text{mrad cm})^2$

### RF SYSTEM

FREQUENCY ______________ Mc/sec

FIELD MODE ______________

RF POWER, PEAK ______________ kw

POWER UNITS ______________

EQUILIBRIUM PHASE ______________

RF PULSE DURATION ______________ μsec

FOCUSING TYPE ______________

### INJECTOR

TYPE ______________

ENERGY ______________ kev

OUTPUT ______________ ma

### MECHANICAL CHARACTERISTICS

LENGTH ______________

DIAMETER ______________

DRIFT TUBES, NUMBER ______________

LENGTH 1st TUBE ______________

DIAMETER 1st TUBE ______________

APERTURE 1st TUBE ______________

LENGTH 1st GAP ______________

LENGTH LAST TUBE ______________

DIAMETER LAST TUBE ______________

LENGTH LAST GAP ______________

IRIS APERTURE ______________

IRIS SPACING ______________

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ________ Gev ENERGY SPREAD ________ %

BEAM CURRENT ________ part./pulse PULSE RATE ________

DUTY CYCLE ________ % WIDTH OF SHORTEST PULSE ________ msec

METHOD OF TARGETING ________

________

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./cm$^2$-sec | BEAM AREA, cm$^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, m$^2$ ________

NUMBER OF BENDING MAGNETS ________ FOCUSING MAGNETS ________

AVAILABLE MAGNET POWER, Mw ________ SHIELDING, tons ________

OTHER SERVICES ________

________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# LINEAR ACCELERATOR DATA SHEET

NAME OF MACHINE ______

INSTITUTION ______

ADDRESS ______

PERSON IN CHARGE ______

PERSON SUPPLYING DATA ______ DATE ______

## HISTORY AND STATUS

DESIGN (DATE) ______

MODEL TESTS ______

ENGINEERING DESIGN ______

CONSTRUCTION STARTED ______

COMPLETION DATE ______

SCHEDULED OPERATION ______ hr/wk

COST OF ACCELERATOR ______

COST OF BUILDINGS ______

SIZE OF STAFF ENGAGED IN DEVELOPMENT, OPERATION, OR MAINTENANCE OF ACCELERATOR:

SCIENTISTS ______

ENGINEERS ______

TOTAL ______

## DESIGN SPECIFICATIONS

### GENERAL FEATURES

PARTICLE ACC. ______

ENERGY ______ Gev

ENERGY SPREAD ______ %

OUTPUT ______ part./pulse

PULSE WIDTH ______ μsec

REPETITION RATE ______

BEAM DIAMETER ______ cm

BEAM EMITTANCE ______ (mrad cm)$^2$

### RF SYSTEM

FREQUENCY ______ Mc/sec

FIELD MODE ______

RF POWER, PEAK ______ kw

POWER UNITS ______

EQUILIBRIUM PHASE ______

RF PULSE DURATION ______ μsec

FOCUSING TYPE ______

### INJECTOR

TYPE ______

ENERGY ______ kev

OUTPUT ______ ma

### MECHANICAL CHARACTERISTICS

LENGTH ______

DIAMETER ______

DRIFT TUBES, NUMBER ______

LENGTH 1st TUBE ______

DIAMETER 1st TUBE ______

APERTURE 1st TUBE ______

LENGTH 1st GAP ______

LENGTH LAST TUBE ______

DIAMETER LAST TUBE ______

LENGTH LAST GAP ______

IRIS APERTURE ______

IRIS SPACING ______

## PERFORMANCE DATA

### INTERNAL BEAM

MAX. ENERGY ______________________ Gev ENERGY SPREAD ______________________ %

BEAM CURRENT ______________________ part./pulse PULSE RATE ______________________

DUTY CYCLE ______________________ % WIDTH OF SHORTEST PULSE ______________________ msec

METHOD OF TARGETING ______________________

______________________

### EXTERNAL AND SECONDARY BEAMS

| PARTICLE | FLUX, part./$cm^2$-sec | BEAM AREA, $cm^2$ | ENERGY, Mev | ENERGY SPREAD, % |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### FACILITIES

SIZE OF EXPERIMENTAL AREAS, $m^2$ ______________________

NUMBER OF BENDING MAGNETS ______________________ FOCUSING MAGNETS ______________________

AVAILABLE MAGNET POWER, Mw ______________________ SHIELDING, tons ______________________

OTHER SERVICES ______________________

______________________

### USE OF MACHINE

DESCRIBE TYPES OF EXPERIMENTS IN PROGRESS.

### OTHER FEATURES

### PUBLISHED ARTICLES DESCRIBING MACHINE

# MODEL ACCELERATOR DATA SHEET

NAME OF MACHINE: CERN Storage Ring Model

INSTITUTION: CERN

ADDRESS: Geneva 23, Switzerland

PERSON IN CHARGE: A. Schoch

PERSON SUPPLYING DATA: K. Johnsen and C.J. Zilverschoon — DATE: May 12, 1961

## HISTORY AND STATUS

DESIGN (DATE): Started March 1960

MODEL TESTS: Started Fall 1960

ENGINEERING DESIGN: Started August 1960

CONSTRUCTION STARTED: 

COMPLETION DATE: Expected March 1962

SCHEDULED OPERATION: ______ hr/wk

TOTAL COST: 1.5 Million Sw. Fr.
(Building and salaries not included)

STAFF WORKING ON MODEL PROGRAM:

SCIENTISTS / ENGINEERS: 7

TOTAL: 16

## DESIGN SPECIFICATIONS

### MAGNET

FOCUSING TYPE: a.g.

FIELD CONFIGURATION: Split focusing and bending.
One period: F B D SS

FIELD, INJ.: (bending) 133 gauss

MAX.: Same gauss

Mean ORBIT RADIUS: 3.80 TO 3.85 m

Bending radius: 0.6 m

BETATRON OSCILLATION DESCRIPTION: No. of betatron osc. variable between 2.25 to 3.75. Planned, 2.75.

APERTURE OF VACUUM: 95 x 42 mm

OVER-ALL MAGNET DIAMETER: 9 m

WEIGHT: Fe 6 ; Cu 0.5 tons

POWER INPUT: 0.1 kw

### GENERAL FEATURES

PARTICLE ACCELERATED: Electrons

ENERGY: 2 Mev

PULSE RATE: 50 per sec

OUTPUT: ______ part./pulse

### INJECTOR SYSTEM

TYPE: Van de Graaff

ENERGY: 1750 kev

OUTPUT: Pulsed 1500 ma

INJECTION PERIOD: 1 turns

### ACCELERATION

ENERGY GAIN: 2 volts/turn

ROTATION FREQ.: 12.1 Mc TO 12.0 Mc

PROPERTIES OF BETATRON CORES: Small core for beam gymnastic purposes

PROPERTIES OF RF SYSTEM: One cavity, harmonic No. 2

## PERFORMANCE AND USE OF MACHINE

The purpose of the model is to study beam stacking under such conditions that there is no help from radiation losses. We expect to stack 10 to 50 pulses according to energy spread of injected beam.

Although the ring is supposed at the beginning to handle only 2-Mev electrons, it is designed so that it can take electrons of much higher energy if desired (≈100 Mev) and also protons.

## PUBLISHED ARTICLES DESCRIBING MACHINE

# MODEL ACCELERATOR DATA SHEET

NAME OF MACHINE: AdA (Storage Ring for $\underline{e}^+$, $\underline{e}^-$ Colliding Beams)

INSTITUTION: Laboratori Nazionali di Frascati del Comitato Nazionale Energia Nucleare

ADDRESS: Casella postale 15, Frascati (Rome, Italy)

PERSON IN CHARGE: Staff (C. Bernardini, U. Bizzarri, F. Corazza, G. Ghigo, R. Querzoli, B. Touschek)

PERSON SUPPLYING DATA: -  DATE: June 1961

## HISTORY AND STATUS

DESIGN (DATE): March-June 1960

MODEL TESTS: -

ENGINEERING DESIGN: -

CONSTRUCTION STARTED: June 1960

COMPLETION DATE: -

SCHEDULED OPERATION: - hr/wk

TOTAL COST: $25,000

STAFF WORKING ON MODEL PROGRAM:

SCIENTISTS: 6

ENGINEERS:

TOTAL:

## DESIGN SPECIFICATIONS

### MAGNET

FOCUSING TYPE: Weak

FIELD CONFIGURATION: 4 sectors with 4 quasi-straight sections

FIELD, INJ.: ≈14,000 gauss

MAX.: ≈14,000 gauss

ORBIT RADIUS: 0.58 TO 0.61 m

BETATRON OSCILLATION DESCRIPTION: $\underline{n}$ = 0.55

APERTURE OF VACUUM: 4.5 x 9 $cm^2$

OVER-ALL MAGNET DIAMETER: ≈1.40 m

WEIGHT: Fe 7.7 ; Cu 0.5 tons

POWER INPUT: 100 kw

### GENERAL FEATURES

PARTICLE ~~ACCELERATED~~ stored: $\underline{e}^+$, $\underline{e}^-$

ENERGY: 250 Mev

PULSE RATE: -

OUTPUT: - part./pulse

### INJECTOR SYSTEM

TYPE: γ-ray conversion

ENERGY: of gammas, 1000 Mev ~~kev~~

OUTPUT: ≈5 x $10^{11}$ eq. quanta/min ~~ma~~

INJECTION PERIOD: - turns

### ACCELERATION

ENERGY GAIN: 0 volts/turn

ROTATION FREQ.: 73.5 Mc TO

PROPERTIES OF BETATRON CORES: -

PROPERTIES OF RF SYSTEM: 10 kv to 1 kw

147 Mc

## PERFORMANCE AND USE OF MACHINE

It is expected to store $\underline{e}^+$ and $\underline{e}^-$ particles produced on internal targets by the γ-ray beam of the Frascati Electron Synchrotron. From the machine point of view, AdA should provide information on beam lifetimes and dimensions. If the injection and storage are successful (say $3 \times 10^7$ circulating particles of each kind for some 10 hr), it should be possible to look for $\underline{e}^+ + \underline{e}^- \rightarrow 2\gamma$, and maybe for $\underline{e}^+ + \underline{e}^- \rightarrow \pi^+ + \pi^-$.

## PUBLISHED ARTICLES DESCRIBING MACHINE

C. Bernardini, G.F. Corazza, G. Ghigo and B. Touschek, The Frascati Storage Ring, Nuovo Cimento 18, 1293 (1960).

# MODEL ACCELERATOR DATA SHEET

NAME OF MACHINE 4-Mev Spiral-Ridge Cyclotron

INSTITUTION National Institute for Research in Nuclear Science

ADDRESS Harwell, Berkshire, England

PERSON IN CHARGE J.D. Lawson

PERSON SUPPLYING DATA E.J. Jones DATE May 18, 1961

## HISTORY AND STATUS

DESIGN (DATE) ______

MODEL TESTS ______

ENGINEERING DESIGN ______

CONSTRUCTION STARTED ______

COMPLETION DATE April 1959

SCHEDULED OPERATION ______ hr/wk

TOTAL COST ______

STAFF WORKING ON MODEL PROGRAM: SCIENTISTS ______

ENGINEERS ______

TOTAL ______

## DESIGN SPECIFICATIONS

### MAGNET

FOCUSING TYPE AVF

FIELD CONFIGURATION Four ridges following the spiral law $r = 0.15\ \theta$ ($r$ in inches, $\theta$ in degrees). Maximum flutter is 8%

FIELD, INJ. ______ gauss

Mean ~~MAX.~~ 13,000 gauss

ORBIT RADIUS 0 TO 0.23 m

BETATRON OSCILLATION DESCRIPTION ______

APERTURE OF VACUUM ______

OVER-ALL MAGNET DIAMETER 0.56 m

WEIGHT: Fe 6 ; Cu 1 tons

POWER INPUT 70 kw

### GENERAL FEATURES

PARTICLE ACCELERATED Proton

ENERGY 4 Mev

PULSE RATE 50 per sec

OUTPUT $4.5 \times 10^{10}$ part./pulse

### INJECTOR SYSTEM

TYPE ______

ENERGY ______ kev

OUTPUT ______ ma

INJECTION PERIOD ______ turns

### ACCELERATION

ENERGY GAIN 70,000 volts/turn

ROTATION FREQ. 20 Mc/sec TO ______

PROPERTIES OF BETATRON CORES ______

PROPERTIES OF RF SYSTEM Single dee, $\lambda/4$ coaxial line system

## PERFORMANCE AND USE OF MACHINE

With the present rather inadequate coil system for radial trimming of the mean magnetic field, the maximum proton current at the outer radius (8-1/2 in.) is ≈300 μa (mean during the RF pulse). Measurements of the radial oscillation amplitudes indicate no serious effects due to the $Q_r = 1$ resonance, and by careful positioning of the ion source the maximum amplitude has been kept down to 0.2 in. over the greater part of the machine. The phase history of the protons during their acceleration has also been measured by using two different techniques, namely (a) a sampling oscilloscope to compare directly the phase of the proton bunch with that of the RF cycle, and (b) a two-wire probe to measure the orbit separation, from which the phase can be determined. The amount of phase bunching in the machine is such that the proton bunches have a width at half-height $\leqslant 12^{\circ}$ (this being the limit of the equipment).

A new system of multiturn pole-face coils is to be installed soon, so that more extensive investigations of the focusing conditions near the center can be made.

## PUBLISHED ARTICLES DESCRIBING MACHINE

A description of the machine and of the measurements up to date is about to appear as a N.I.R.N.S. report.

# MODEL ACCELERATOR DATA SHEET

NAME OF MACHINE: MURA Two-Way Electron Accelerator

INSTITUTION: Midwestern Universities Research Association

ADDRESS: 2203 University Avenue, Madison 5, Wis.

PERSON IN CHARGE: Bernard Waldman and William A. Wallenmeyer

PERSON SUPPLYING DATA: F.E. Mills and B. Waldman — DATE: June 27, 1961

## HISTORY AND STATUS

DESIGN (DATE): July 1957 to November 1957

COMPLETION DATE: December 24, 1959

MODEL TESTS: October 1957 to March 1958

SCHEDULED OPERATION: 40 to 120 hr/wk

ENGINEERING DESIGN: October 1957 to June 1958

TOTAL COST: $750,000 (Hardward only)

CONSTRUCTION STARTED: January 1958

STAFF WORKING ON MODEL PROGRAM:

SCIENTISTS: 10

ENGINEERS: 7

TOTAL: 35 (Including technical support)

## DESIGN SPECIFICATIONS

### MAGNET

FOCUSING TYPE: FFAG radial sector

FIELD CONFIGURATION: Flutter ≈5

Field index, $\underline{k} = \frac{\underline{r}}{\underline{B}} \frac{\partial B}{\partial r} = 9.3$

FIELD, INJ.: 40 gauss

MAX.: 5200 gauss

ORBIT RADIUS: 1.20 TO 1.97 m

BETATRON OSCILLATION DESCRIPTION:

$\underline{Q}_r = 4.4$, $\underline{Q}_z = 2.7$

APERTURE OF VACUUM: Width 90 cm, height 6 cm

OVER-ALL MAGNET DIAMETER: 5 m

WEIGHT: Fe 32 ; Cu 7 tons

POWER INPUT: 250 kw

### GENERAL FEATURES

PARTICLE ACCELERATED: Electrons

ENERGY: 45 Mev

PULSE RATE: 60 per sec

OUTPUT (est.): $10^{11}$ part./pulse

Circulating current, 20 amp

### INJECTOR SYSTEM

TYPE: Electron gun and inflector

ENERGY: 125 kev

OUTPUT: 500 ma

INJECTION PERIOD: 1 to 100 turns

Inflector - Programmed bump

### ACCELERATION

ENERGY GAIN: 200 to 400 volts/turn

ROTATION FREQ.: 20 to 29 TO 23 Mc

PROPERTIES OF BETATRON CORES: 0.06 Webers, pulsed 60 per sec on 500-cps sine wave. Accelerated to 2 Mev

PROPERTIES OF RF SYSTEM: See attached.

## PERFORMANCE AND USE OF MACHINE

Accelerator was operated as a two-way machine in March 1960. Both beams were accelerated simultaneously to 25 Mev. $10^{10}$ Electrons were injected; not all were accelerated. In April 1960 the accelerator was disassembled for magnetic field adjustment. A new injector has been developed. At present the accelerator is being reassembled for operation in the summer of 1961.

## PUBLISHED ARTICLES DESCRIBING MACHINE

MURA Two-Way Electron Accelerator, by the MURA Staff, Proc. Intern. Conf. High Energy Accelerators and Instrumentation, CERN, 1959, p. 71.

## PROPERTIES OF RF SYSTEM

System 1 accelerates from 2 Mev to 45 Mev and stacks. System 2 resupplies radiation energy loss of stacked beam by phase displacement. Both systems are broad band power amplifier with programmed frequency and voltage. Phase lock optional on System 1.

# MODEL ACCELERATOR DATA SHEET

NAME OF MACHINE: Cyclotron Analogue II

INSTITUTION: Oak Ridge National Laboratory

ADDRESS: P.O. Box X, Oak Ridge, Tenn.

PERSON IN CHARGE: Robert S. Livingston

PERSON SUPPLYING DATA: John A. Martin DATE: June 22, 1961

## HISTORY AND STATUS

DESIGN (DATE): August 1958

COMPLETION DATE: June 1961

MODEL TESTS: None

SCHEDULED OPERATION: 20 to 40 hr/wk

ENGINEERING DESIGN: May 1959

TOTAL COST: $138,000

CONSTRUCTION STARTED: January 1960

STAFF WORKING ON MODEL PROGRAM:

SCIENTISTS: 1.5

ENGINEERS: 1.5

TOTAL: 3.0

## DESIGN SPECIFICATIONS

### MAGNET

FOCUSING TYPE: AVF-fixed frequency

FIELD CONFIGURATION: 8 sector; $\theta = \underline{r}^2$ spiral;
4 sectors at center

FIELD, INJ.: 41.926 gauss

MAX.: 75 (azimuthal av) gauss

ORBIT RADIUS: 0 TO 0.34 m

BETATRON OSCILLATION DESCRIPTION: $\underline{Q_z} = \approx 0.2$
$\underline{Q_r} = 1.0$ to $2.0$

APERTURE OF VACUUM: 1.6 cm

OVER-ALL MAGNET DIAMETER: 0.95 m

WEIGHT: Fe ; Cu tons

POWER INPUT: 7 kw

### GENERAL FEATURES

PARTICLE ACCELERATED: Electron

ENERGY: 450 kev ~~Mev~~

PULSE RATE: Non-pulsed

OUTPUT: part./pulse

### INJECTOR SYSTEM

TYPE: None

ENERGY: kev

OUTPUT: ma

INJECTION PERIOD: turns

### ACCELERATION

ENERGY GAIN: 550 volts/turn

ROTATION FREQ.: 117.34 ~~TO~~ Mc/sec

PROPERTIES OF BETATRON CORES: None

PROPERTIES OF RF SYSTEM: $\lambda/4$ strip coaxial line

## PERFORMANCE AND USE OF MACHINE

Initial operation of the Analogue is expected in June 1961. Problems to be studied are: (1) tolerances to imperfection harmonics, (2) the efficient extraction of a high quality beam, and (3) acceleration through the $\underline{Q_r} = 2$ resonance.

## PUBLISHED ARTICLES DESCRIBING MACHINE

A.J. Martin, A 450-kev Eight-Sector Fixed-Frequency Electron Cyclotron, Proc. Intern. Conf. High Energy Accelerators and Instrumentation, CERN, 1959, pp. 205-11.

# MODEL ACCELERATOR DATA SHEET

NAME OF MACHINE: Princeton-Stanford Colliding Beam Experiment

INSTITUTION: Stanford University

ADDRESS: Stanford, Calif.

PERSON IN CHARGE: (5 Partners)

PERSON SUPPLYING DATA: G.K. O'Neill  DATE: May 23, 1961

## HISTORY AND STATUS

DESIGN (DATE): 1957-58

MODEL TESTS: -

ENGINEERING DESIGN: 1959

CONSTRUCTION STARTED: 1959

COMPLETION DATE: 1961

SCHEDULED OPERATION: - hr/wk

TOTAL COST: $1 Million (including all development costs and salaries)

STAFF WORKING ON ~~MODEL PROGRAM~~ complete system:

SCIENTISTS: 4 (3 of them half-time)

ENGINEERS: 2

TOTAL: 6, or ≈3 equivalent full-time

## DESIGN SPECIFICATIONS

### MAGNET

FOCUSING TYPE: Weak but varying gradient

FIELD CONFIGURATION: Straight-section; $n = 0$; $n = 1.05$; $n = 0$; straight-section

FIELD, INJ.: 11,000 gauss

MAX.: 12,000 gauss

ORBIT RADIUS: 56 in. TO m

BETATRON OSCILLATION DESCRIPTION: $Q_z = 0.9$, $Q_r = 0.8$

APERTURE OF VACUUM: 1.7 x 5 in.

OVER-ALL MAGNET DIAMETER: 4.0 m

WEIGHT: Fe 43 ; Cu 3 tons

POWER INPUT: 450 kw

### GENERAL FEATURES

PARTICLE ACCELERATED: Electrons

ENERGY: 500 Mev

PULSE RATE: None. Beam storage

OUTPUT: part./pulse

### INJECTOR SYSTEM

TYPE: Linear accelerator (Stanford Mark III) plus pulsed delay-line inflector

ENERGY: 500 Mev ~~kev~~

OUTPUT: 1 ma

INJECTION PERIOD: 1.5 turns

### ACCELERATION

ENERGY GAIN: 4 kv ~~volts~~/turn

ROTATION FREQ.: 25.5 TO

PROPERTIES OF BETATRON CORES: None

PROPERTIES OF RF SYSTEM: Fixed frequency, fixed amplitude; $V_{peak} = 20$ kv

PERFORMANCE AND USE OF MACHINE

Predicted upper limit on stored circulating beam, ≈1 amp. Purpose: Study of electron-electron scattering at 1 Bev (c.m. system).

PUBLISHED ARTICLES DESCRIBING MACHINE


1. G.K. O'Neill, Bull. Am. Phys. Soc. 3, D2 (1958).
2. G.K. O'Neill, Proc. Intern. Conf. High Energy Accelerators and Instrumentation, CERN, 1959, pp. 125-8.

# MODEL ACCELERATOR DATA SHEET

NAME OF MACHINE ____________________

INSTITUTION ____________________

ADDRESS ____________________

PERSON IN CHARGE ____________________

PERSON SUPPLYING DATA ____________________ DATE ____________

## HISTORY AND STATUS

DESIGN (DATE) ____________________

MODEL TESTS ____________________

ENGINEERING DESIGN ____________________

CONSTRUCTION STARTED ____________________

COMPLETION DATE ____________________

SCHEDULED OPERATION ____________________ hr/wk

TOTAL COST ____________________

STAFF WORKING ON MODEL PROGRAM:

SCIENTISTS ____________________

ENGINEERS ____________________

TOTAL ____________________

## DESIGN SPECIFICATIONS

### MAGNET

FOCUSING TYPE ____________________

FIELD CONFIGURATION ____________________

____________________

____________________

FIELD, INJ. ____________________ gauss

MAX. ____________________ gauss

ORBIT RADIUS ____________ TO ____________ m

BETATRON OSCILLATION DESCRIPTION ____________________

____________________

____________________

APERTURE OF VACUUM ____________________

____________________

OVER-ALL MAGNET DIAMETER ____________________ m

WEIGHT: Fe ____________ ; Cu ____________ tons

POWER INPUT ____________________ kw

### GENERAL FEATURES

PARTICLE ACCELERATED ____________________

ENERGY ____________________ Mev

PULSE RATE ____________________

OUTPUT ____________________ part./pulse

### INJECTOR SYSTEM

TYPE ____________________

ENERGY ____________________ kev

OUTPUT ____________________ ma

INJECTION PERIOD ____________________ turns

### ACCELERATION

ENERGY GAIN ____________________ volts/turn

ROTATION FREQ. ____________ TO ____________

PROPERTIES OF BETATRON CORES ____________________

____________________

____________________

PROPERTIES OF RF SYSTEM ____________________

____________________

PERFORMANCE AND USE OF MACHINE

PUBLISHED ARTICLES DESCRIBING MACHINE

# MODEL ACCELERATOR DATA SHEET

NAME OF MACHINE ____________________

INSTITUTION ____________________

ADDRESS ____________________

PERSON IN CHARGE ____________________

PERSON SUPPLYING DATA ____________________ DATE ____________

## HISTORY AND STATUS

DESIGN (DATE) ____________________

MODEL TESTS ____________________

ENGINEERING DESIGN ____________________

CONSTRUCTION STARTED ____________________

COMPLETION DATE ____________________

SCHEDULED OPERATION ____________________ hr/wk

TOTAL COST ____________________

STAFF WORKING ON MODEL PROGRAM:

SCIENTISTS ____________________

ENGINEERS ____________________

TOTAL ____________________

## DESIGN SPECIFICATIONS

### MAGNET

FOCUSING TYPE ____________________

FIELD CONFIGURATION ____________________

____________________

____________________

FIELD, INJ. ____________________ gauss

MAX. ____________________ gauss

ORBIT RADIUS ____________ TO ____________ m

BETATRON OSCILLATION DESCRIPTION ____________________

____________________

____________________

APERTURE OF VACUUM ____________________

____________________

OVER-ALL MAGNET DIAMETER ____________________ m

WEIGHT: Fe ____________ ; Cu ____________ tons

POWER INPUT ____________________ kw

### GENERAL FEATURES

PARTICLE ACCELERATED ____________________

ENERGY ____________________ Mev

PULSE RATE ____________________

OUTPUT ____________________ part./pulse

### INJECTOR SYSTEM

TYPE ____________________

ENERGY ____________________ kev

OUTPUT ____________________ ma

INJECTION PERIOD ____________________ turns

### ACCELERATION

ENERGY GAIN ____________________ volts/turn

ROTATION FREQ. ____________ TO ____________

PROPERTIES OF BETATRON CORES ____________________

____________________

____________________

PROPERTIES OF RF SYSTEM ____________________

____________________

## PERFORMANCE AND USE OF MACHINE

## PUBLISHED ARTICLES DESCRIBING MACHINE

# MODEL ACCELERATOR DATA SHEET

NAME OF MACHINE ____________

INSTITUTION ____________

ADDRESS ____________

PERSON IN CHARGE ____________

PERSON SUPPLYING DATA ____________ DATE ____________

## HISTORY AND STATUS

DESIGN (DATE) ____________

MODEL TESTS ____________

ENGINEERING DESIGN ____________

CONSTRUCTION STARTED ____________

COMPLETION DATE ____________

SCHEDULED OPERATION ____________ hr/wk

TOTAL COST ____________

STAFF WORKING ON MODEL PROGRAM:

SCIENTISTS ____________

ENGINEERS ____________

TOTAL ____________

## DESIGN SPECIFICATIONS

### MAGNET

FOCUSING TYPE ____________

FIELD CONFIGURATION ____________

____________

____________

FIELD, INJ. ____________ gauss

MAX. ____________ gauss

ORBIT RADIUS ____________ TO ____________ m

BETATRON OSCILLATION DESCRIPTION ____________

____________

____________

APERTURE OF VACUUM ____________

____________

OVER-ALL MAGNET DIAMETER ____________ m

WEIGHT: Fe ____________ ; Cu ____________ tons

POWER INPUT ____________ kw

### GENERAL FEATURES

PARTICLE ACCELERATED ____________

ENERGY ____________ Mev

PULSE RATE ____________

OUTPUT ____________ part./pulse

### INJECTOR SYSTEM

TYPE ____________

ENERGY ____________ kev

OUTPUT ____________ ma

INJECTION PERIOD ____________ turns

### ACCELERATION

ENERGY GAIN ____________ volts/turn

ROTATION FREQ. ____________ TO ____________

PROPERTIES OF BETATRON CORES ____________

____________

____________

PROPERTIES OF RF SYSTEM ____________

____________

PERFORMANCE AND USE OF MACHINE

PUBLISHED ARTICLES DESCRIBING MACHINE