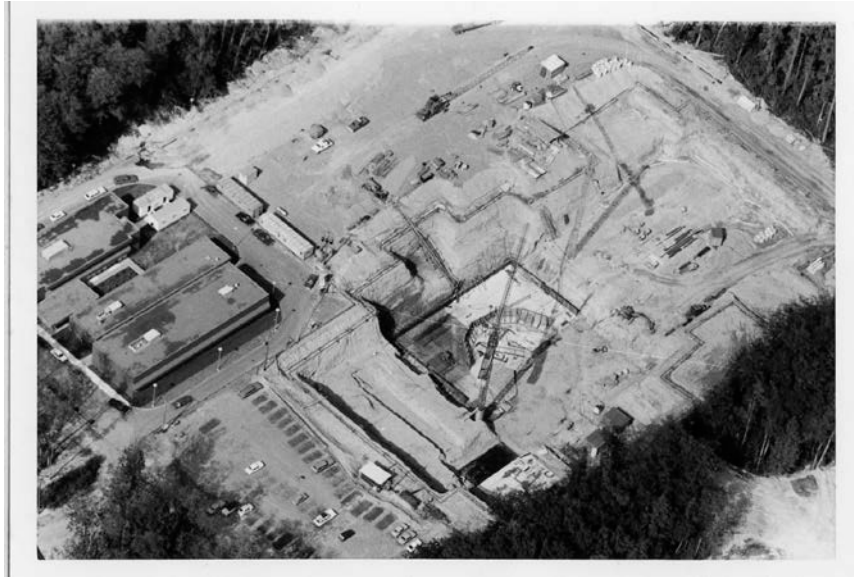


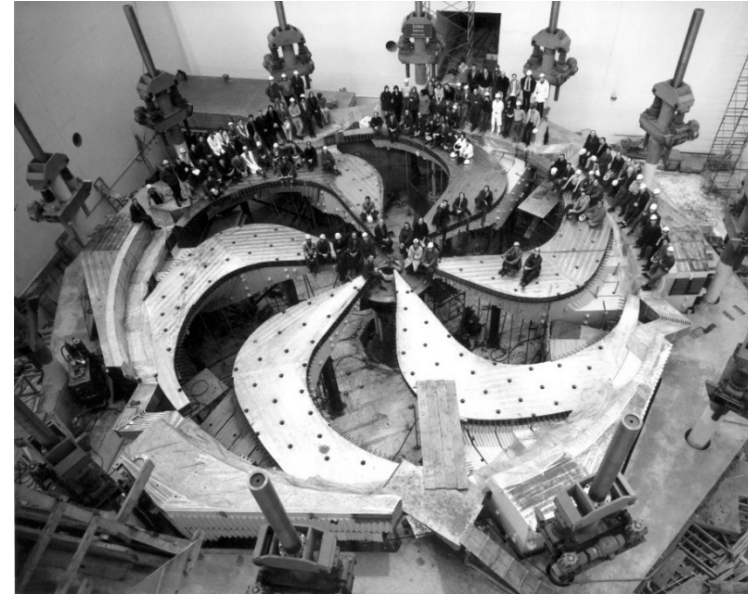
Early Days of TRIUMF

Contributions of Gerardo Dutto

Ewart Blackmore



1970



1972

Ewart Blackmore: Joined TRIUMF in September 1969

PhD 1967 UBC in Nuclear Physics –Supervisor John Warren

Accelerator experience: UBC Van de Graaff

PDF (1967-69) Rutherford Laboratory in Particle Physics
H-minus EM stripping cross section in Magnetic Field (1968)

Gerardo Dutto: Joined TRIUMF in December 1970

PhD 1971 University Rome – Supervisor Francesco Resmini

Accelerator experience: Milan 45 MeV H-minus cyclotron

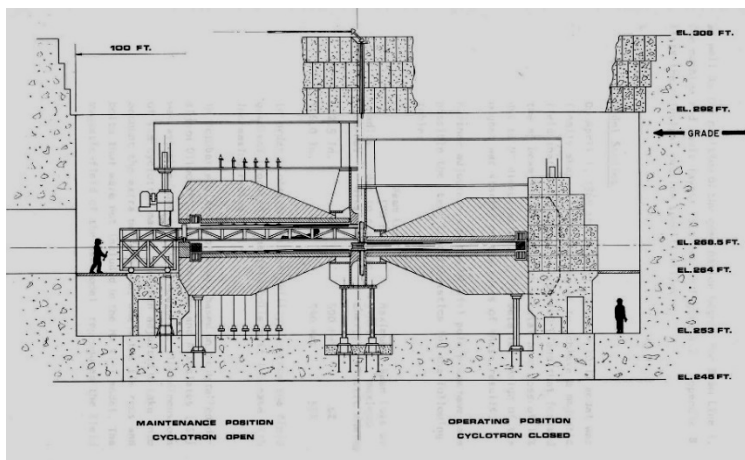
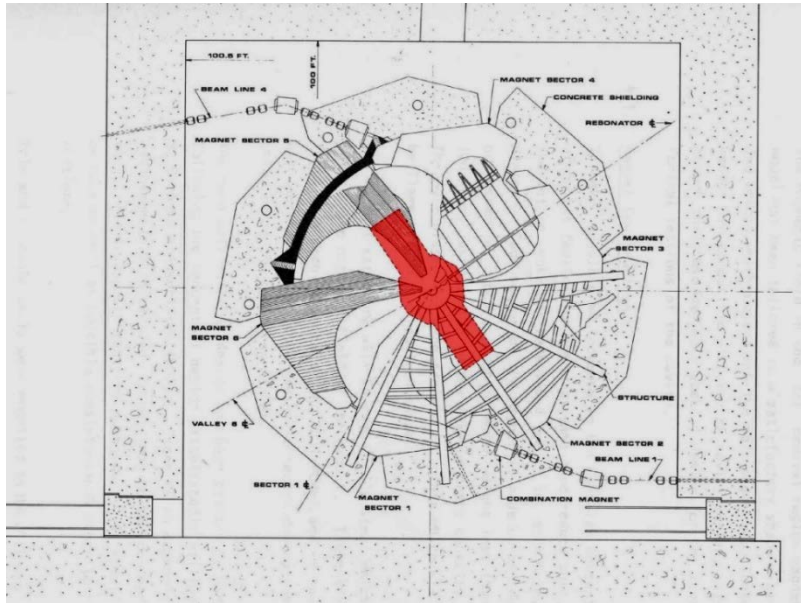
PDF @ TRIUMF

Working with Beam Dynamics group headed by Mike Craddock

*Both of us were
TRIUMF Division
Heads for most of
our careers*

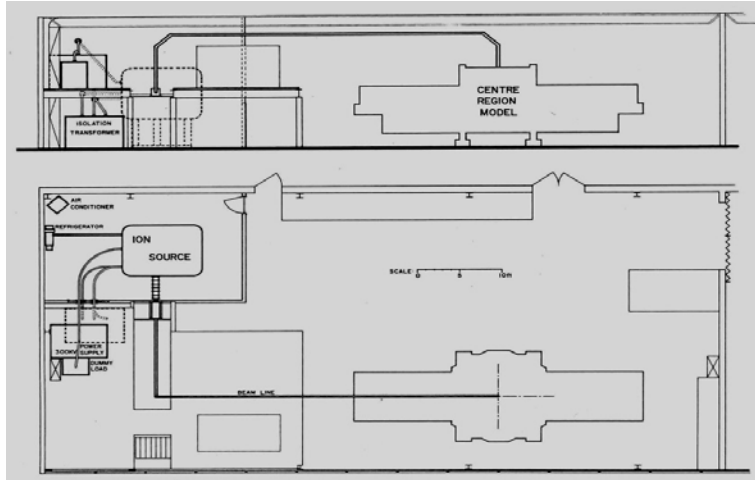
TRIUMF Cyclotron

- 500 MeV, 100 μ A, H⁻ ions
- simultaneous extraction 2 beams
- cost \$8.4M in 1968

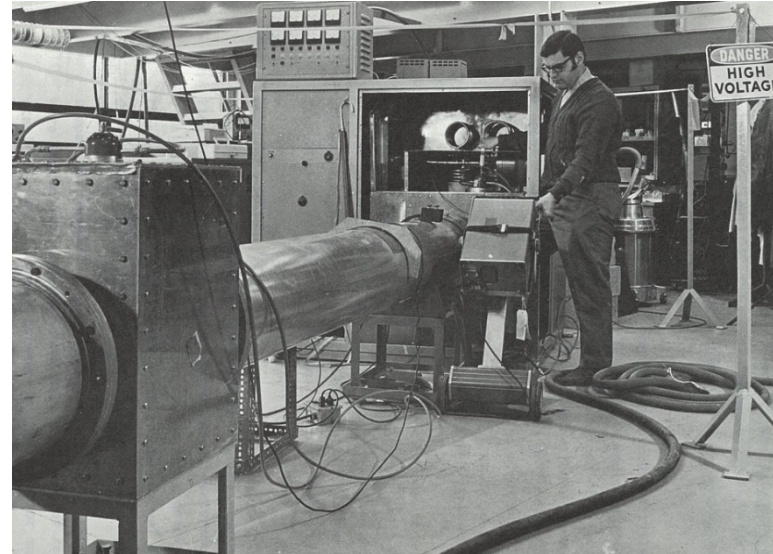


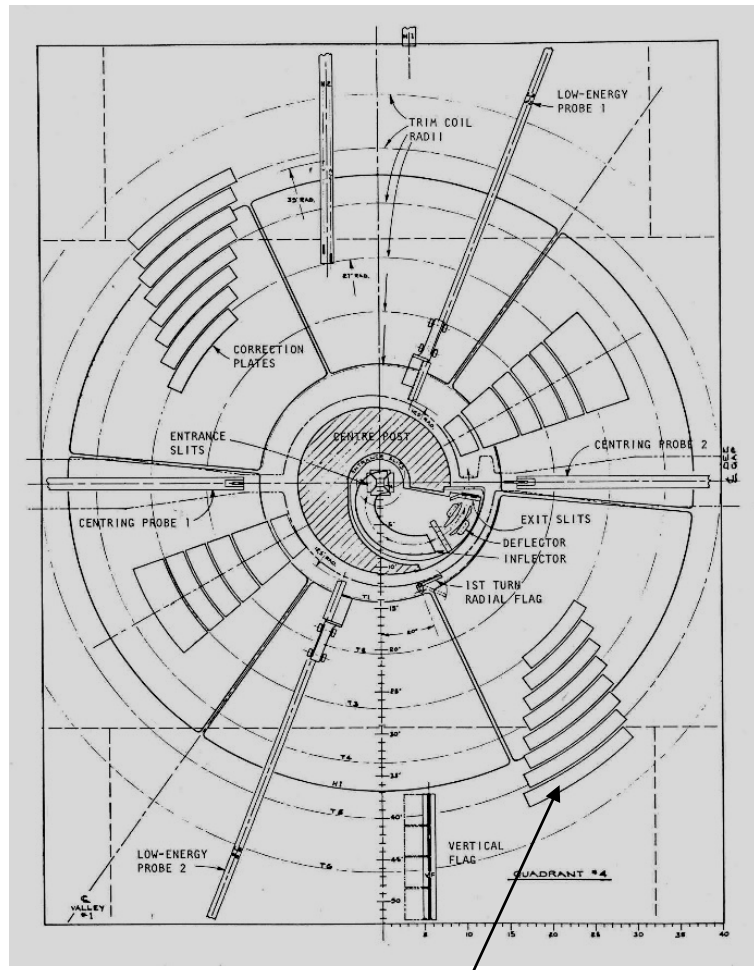
(1972) TRIUMF(110) University
 Director Reg Richardson
 Chief Eng'r Joop Burgerjon
 Magnet: Al Otter Ed Auld
 Beam George Mackenzie Mike Craddock
 Dynamics: Gerardo Dutto
 Corrie Kost
 RF: Roger Poirier Karl Erdman
 Milos Zach
 Vacuum: Dennis Healey Dave Axen
 ISIS: Peter Bosman Bruce White
 Probes: Bruno Duelli (EWB)
 Controls: Don Heywood Dick Johnson
 Dave Gurd Ken Dawson (UofA)
 Safety: Ian Thorson Brian Pate (SFU)
 Gary Wait
 CRC: Ewart Blackmore

Centre Region Cyclotron

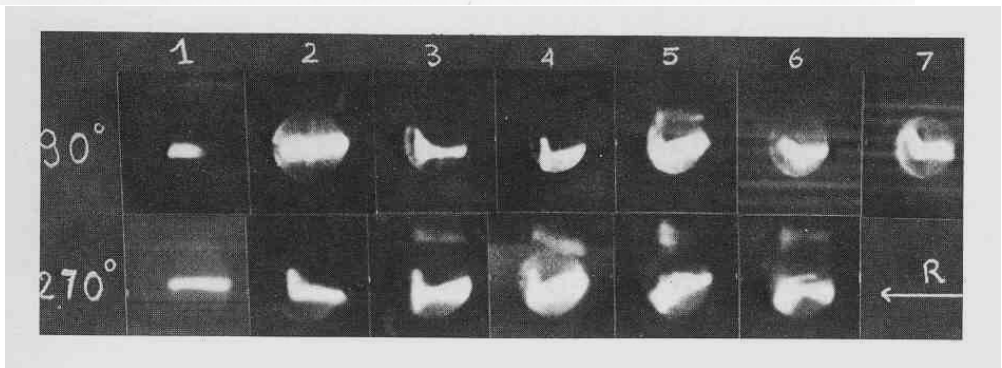


- 80 ton magnet
- 8 resonators with flux guides
- 300 keV ion source 0.5 mA
- 3 MeV in 6.5 turns, 100 μ A





Correction Plates



**First six turns of beam
viewed on a scintillator**

Centre Region Cyclotron

Prototype Testing

- ion source, injection system
- inflector and centre region
- resonators and rf amplifier
- probes and diagnostics
- magnet & field mapping
- controls

Achieved/Learned

- first beam to full energy October 1972
- intensity to 100 μA June 1973
- resonators too sensitive to temperature
- correction plates required (G. Dutto)
- beam dynamics understood
- ISIS, inflector and probes design
- fabricator identified (EBCO Industries)

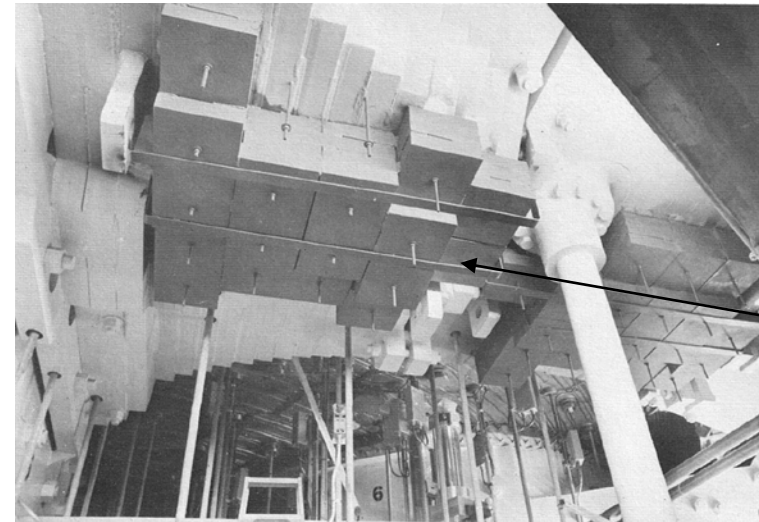


Inflector/Deflector

Cyclotron Systems and Challenges

Magnet

- fabrication and assembly went well (1972)
- 4000 tons of steel in 50 ton shipments
- vacuum tank and elevating system installed
- first field maps-centre field too high by 100 g
- difference in steel permeability 0.5" vs 5"
- required gouging out/adding 16 tons of steel
- field tolerance of 1 g required (1 in 4000)
- took ~ 9 months of shimming/measurements
- delays gave other groups time to be ready



Magnet shims



Field mapping using flip coils

Cyclotron Systems and Challenges

Radiofrequency System

- 80 resonators, 1.8 MW 23 MHz
- installation and alignment
- water connections, rf contacts

August 1974 RF early operations

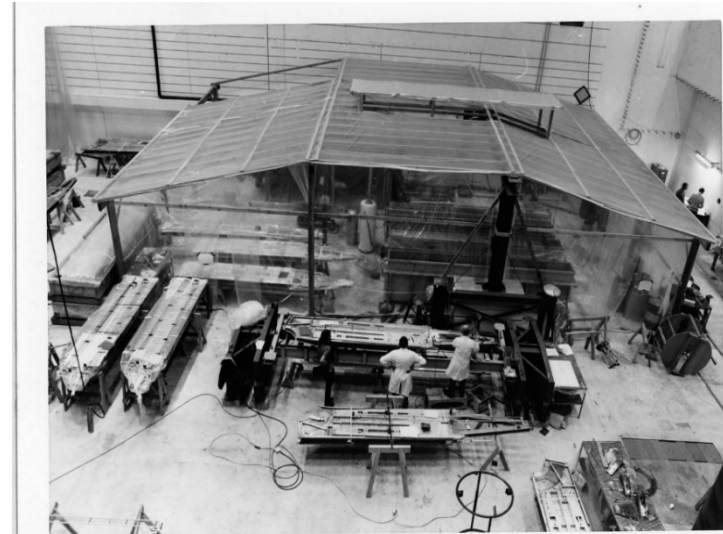
- outgassing and hydrogen pumping
- water leaks and vibrations
- rf contact damage, strongback temp.

Later 1975-80

- centre region electrodes melting
- damage to diagnostic probes
- resonator strongback sagging

(1990-1992) Resonator replacement

- 24 new resonators installed – Major effort organized by **Gerardo Dutto** as head of the Cyclotron Division

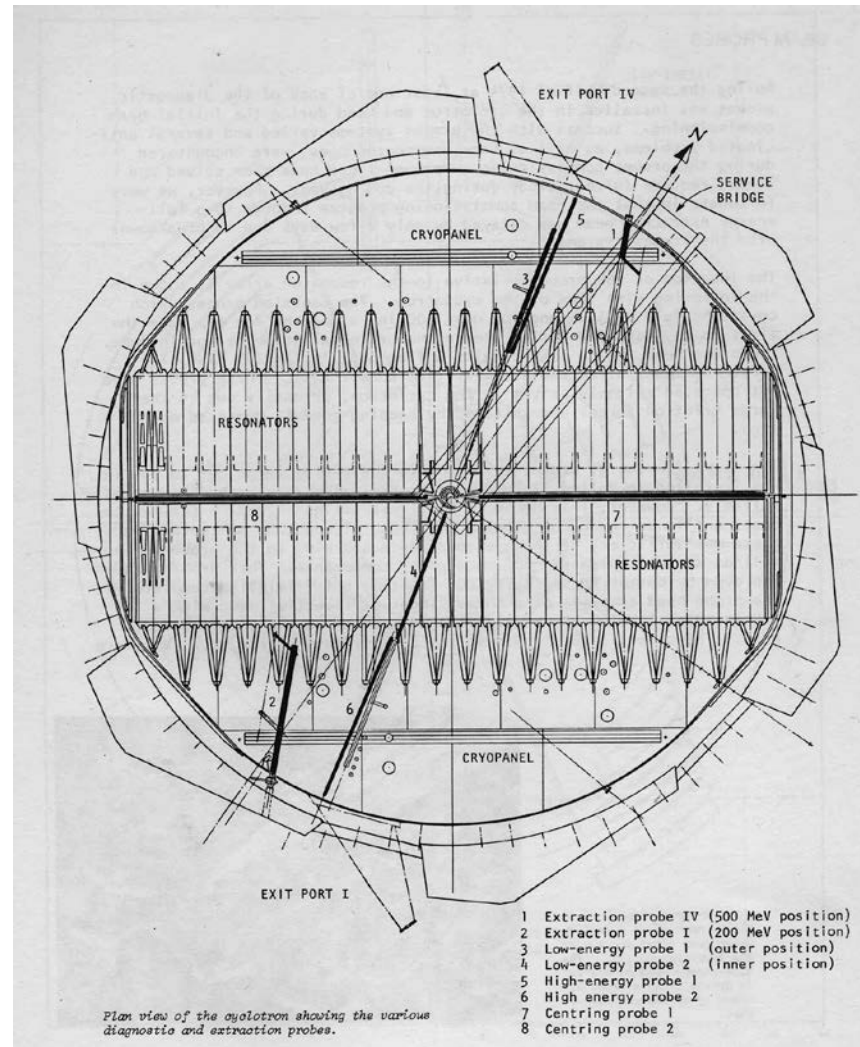


Probes & Beam Diagnostics

- Some probe concepts did not work eg RF gap probe
- LE probes very sensitive to RF fields in gap
- HE probes pretty reliable
- Temporary extraction foil installed for 500 MeV

Later 1975

- Extraction probes 1 and 4 installed and proved reliable.
- Installed water-cooled probe and PIPs for quicker tuning.
- Found TOF method for tuning isochronism



EWB 1974

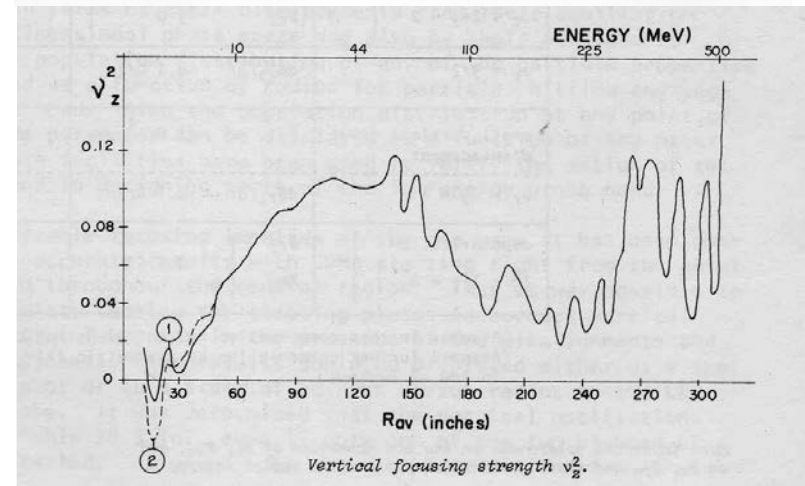
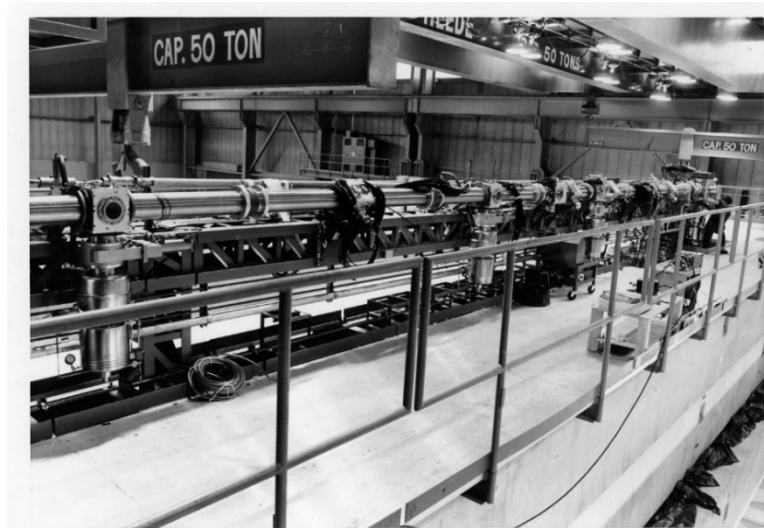
Cyclotron Systems and Challenges

Ion Source & Injection

- high intensity → reliability and filament lifetime
- polarized source polarization and intensity
- 40 m long injection line, cyclotron fringe field, reproducibility
- inflector HV reliability at high current

Beam Dynamics

- large magnet, low field, large gap → weak focusing
- low $\Delta E/\text{turn}$ → many turns, tight tolerance on mag field, isochronism and vertical centring
- high intensity → space charge, large phase acceptance



Cyclotron Commissioning Team



Reg at the controls

Milestones

Injected beam	November 17, 1974
500 MeV	December 15, 1974
100 μ A	July 1977 (beam dump)



The "Commissioning Team"

Don Heywood	Reg Richardson
Dave Gurd	George Mackenzie
Corrie Kost	Ewart Blackmore
Gerardo Dutto	Milos Zach
missing Mike Craddock	

First Beam December 15, 1974

	Maximum Radius of Beam	Energy (if centred)
Nov. 17	42 in.	6 MeV
Nov. 18	55 in.	10 MeV
	(Radiation in vault!)	
	85 in.	24 MeV
	Replaced low-energy probe	
Nov. 22	150 in.	71 MeV
Nov. 23	183 in.	113 MeV
	Replaced B-20 cryogenerator	
Nov. 25	179 in.	109 MeV
	Vacuum problems	
Nov. 26	195 in.	135 MeV
	Deflector sparking	
Nov. 27	223 in.	195 MeV
Nov. 28	231 in.	210 MeV
	Check $v_z^2 = 0.02$ at R=223in.	
Dec. 1	259 in.	295 MeV
Dec. 3	265 in.	315 MeV
	Beam appears to be centred 300 kV supply in ISIS kaput	
Dec. 11	Trying to re-establish beam RF problems	
Dec. 12	273 in.	345 MeV
	Sparking in ISIS	
Dec. 14	278 in.	363 MeV
Dec. 15 12:10	278 in.	363 MeV
	13:07	309 in.
		500 MeV



PROGRESS ACHIEVED
✓ 15th DEC. 74

15 nA @ 500 MeV
RF @ = 92 kV

AT EXTERNAL DUMP IN FAULT
10 nA

CONGRATULATIONS TO
YOU ALL.



Cyclotron Operations and Beam Delivery

IEEE Transactions on Nuclear Science, Vol.NS-22, No.3, June 1975

PRODUCTION OF SIMULTANEOUS, VARIABLE ENERGY BEAMS
FROM THE TRIUMF CYCLOTRON

J. Reginald Richardson*, E.W. Blackmore, G. Dutto,
C.J. Kost, G.H. Mackenzie, TRIUMF and M.K. Craddock
Physics Department, University of British Columbia,
Vancouver, B.C.

Specification (1972)

2 beams – 100, 10 μA

180-520 MeV

Achieved (today)

3(4) beams

BL1A -170 μA 500 MeV

BL2A -100 μA 500 MeV

BL2C -100 μA 100 MeV

Total – 300 μA today

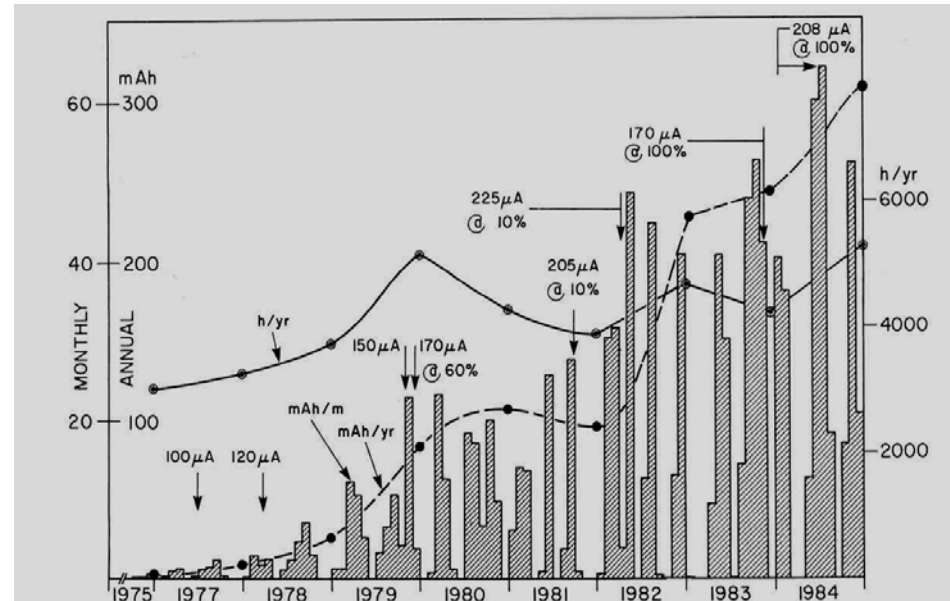


Fig. 71. Beam charge delivered (broken line) and hours of operation (solid line) over the past several years. Milestones in extracted peak current are also indicated. The histogram shows the charge delivered per month.

100 μ A Task Force

Gerardo Dutto led this important effort 1975-1978

1976 10 μ A dc operation as soon as shielding allowed it on BL1A

1977 July ran 114 μ A for 45 mins demonstration on temporary beam dump

1978 Installation of TNF and final beam dump with 120 μ A peak delivered and 30 μ A dc operation on a regular basis.

Concerns addressed:

- **Ion source delivery and use of duty cycle pulser for peak intensity tuning**
- **thermal damage to uncooled beam elements, scrapers and beam spill monitors and radiation protection monitors**
- **activation in cyclotron and beam lines before all installations completed**

Erich Vogt Director 1981-1994

Introduction of the Divisional Structure

Science – Dave Axen, later Peter Kitching and Jean-Michel Poutissou

Cyclotron – Gerardo Dutto until his retirement in 2003

Experimental Facilities – Ewart Blackmore

Accelerator Research – Michael Craddock

Applied Program – Brian Pate, later Dick Johnson

Technical & Administration – Ken Dawson

Main goal - User friendly laboratory for Science

Early Publications on Cyclotron

EXPERIMENTAL RESULTS FROM THE TRIUMF CENTRAL REGION CYCLOTRON

E.W. Blackmore, G. Dutto, W. Joho[†], G.H. Mackenzie, L. Root, and H. Zach
TRIUMF, University of British Columbia, Vancouver, Canada

**IEEE PAC
1973**

PROPERTIES OF THE TRIUMF CYCLOTRON BEAM

M.K. Craddock

Physics Department, University of British Columbia, Vancouver, Canada

E.W. Blackmore, G. Dutto, C.J. Kost, G.H. Mackenzie, J.R. Richardson,* L.W. Root and P. Schmor
TRIUMF, Vancouver, Canada

**7th Int Conf Cycl
1975**

ACHIEVEMENT AND CONTROL OF THE 100 μ A BEAM AT TRIUMF

E.W. Blackmore, P. Bosman, R. Burge, G. Dutto, D. Gill, G.H. Mackenzie and P.W. Schmor
TRIUMF, Vancouver, B.C., Canada V6T 1W5

**8th Int Conf Cycl
1978**

BEAM DEVELOPMENTS AT TRIUMF

R. Baartman, J. Beveridge, E.W. Blackmore, M.K. Craddock*, D. Dohan, J. Doornbos,
G. Dutto, K.L. Erdman, C.J. Kost, R. Laxdal, J.A. Macdonald, G.H. Mackenzie, P.W. Schmor, J.S. Vincent
TRIUMF, Vancouver, B.C., Canada V6T 2A3

**IEEE PAC
1981**

**Gerardo took responsible for initiating papers on TRIUMF
cyclotron latest developments at PAC and Cyclotron
Conferences**

Gerardo's Strengths

Conscientious manager, loyal and supportive of his staff.

Fought hard for budgets for cyclotron improvements and developments.

**Important member of the Cyclotron Conference Organizers
Co-editor of the 1992 Cyclotron proceedings.**

Worked hard but enjoyed his longer lunches – Italian style and Mexico vacations.

Excellent recruiter of new staff with accelerator experience from international laboratories.

Thank you Gerardo

