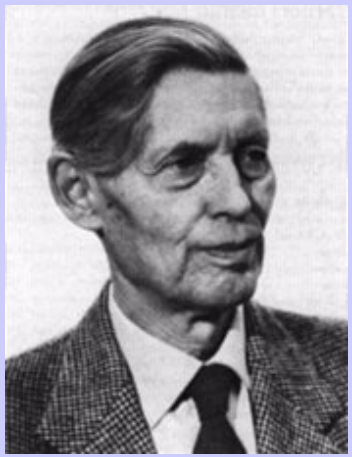
Experimental facilities at The Svedberg Laboratory, Uppsala

Lars Westerberg

The Svedberg Laboratory,

Uppsala University,

Uppsala, Sweden

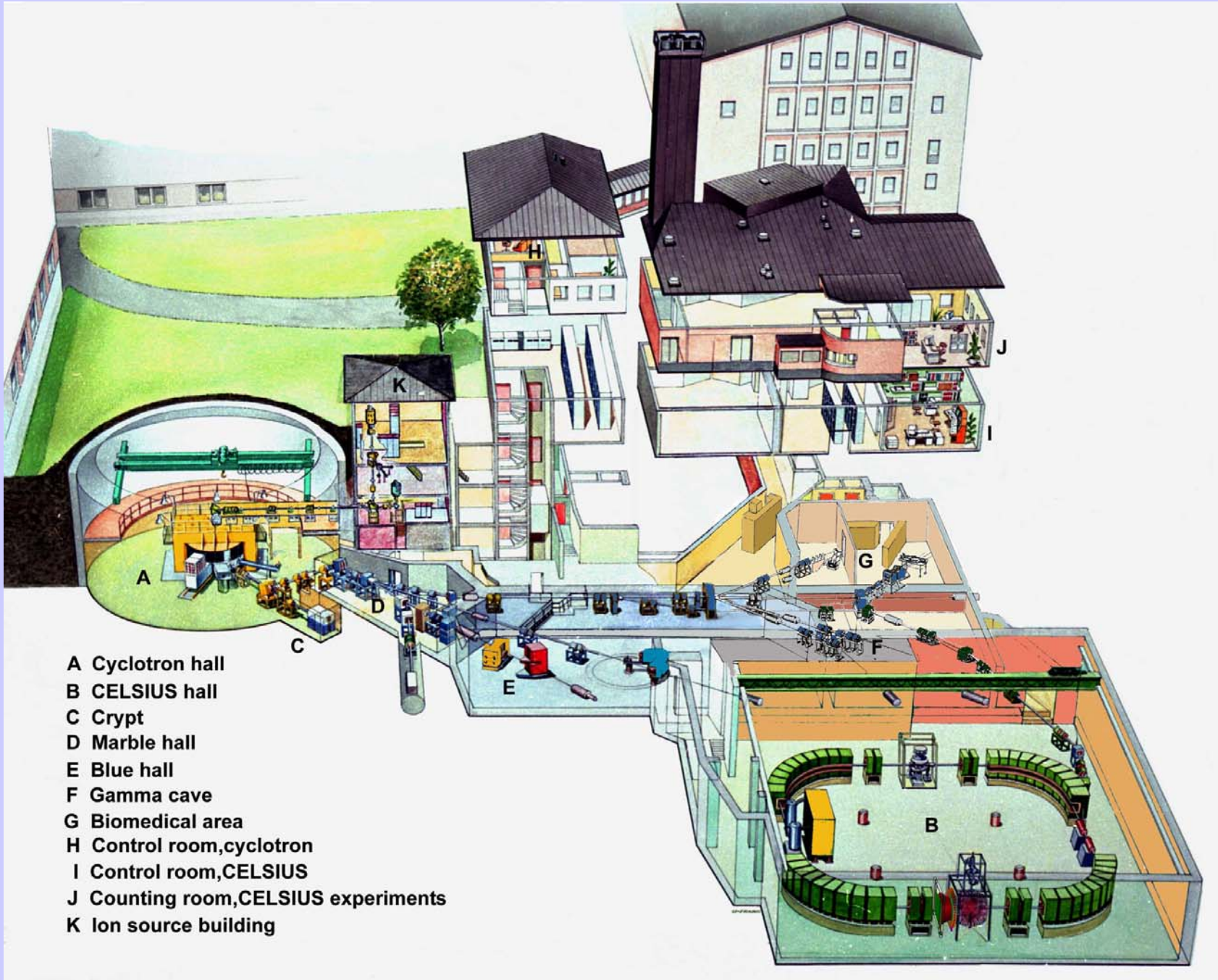


The(odor) Svedberg
Nobel prize laureate in
Chemistry 1926

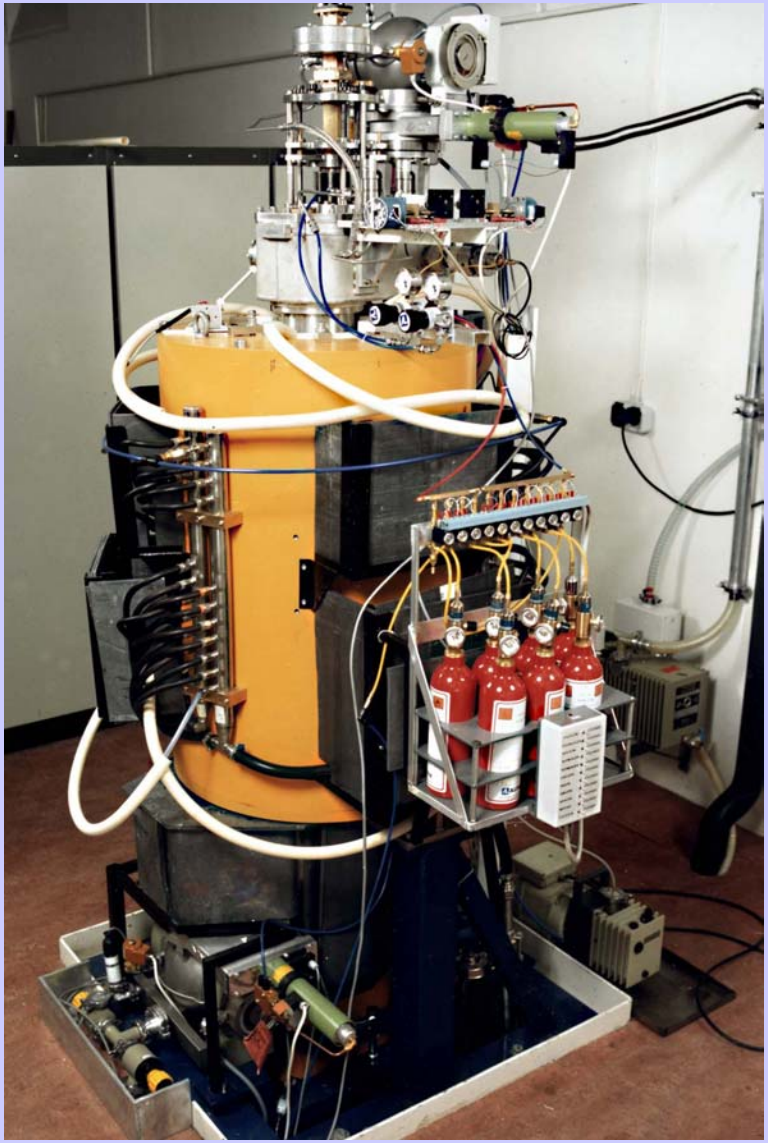
The Svedberg Laboratory

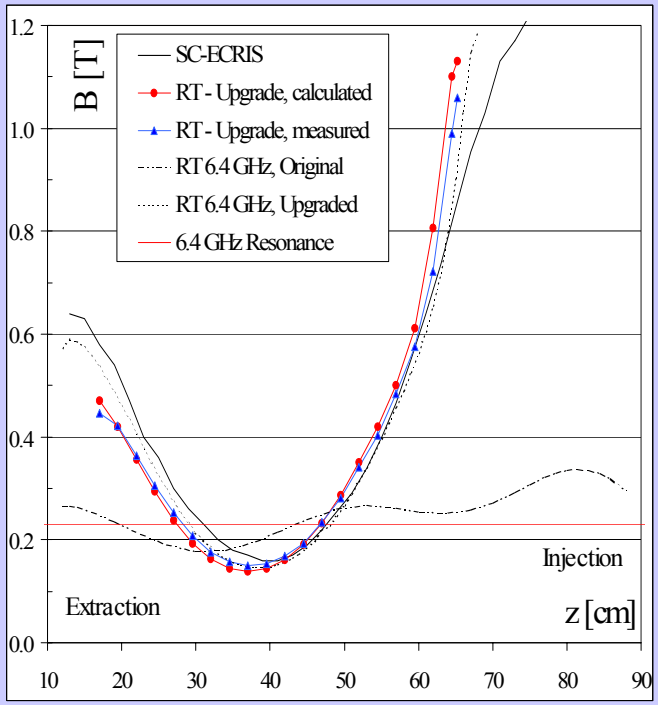
- Accelerators
- Experiments with cyclotron beams
- Experiments at the CELSIUS storage ring

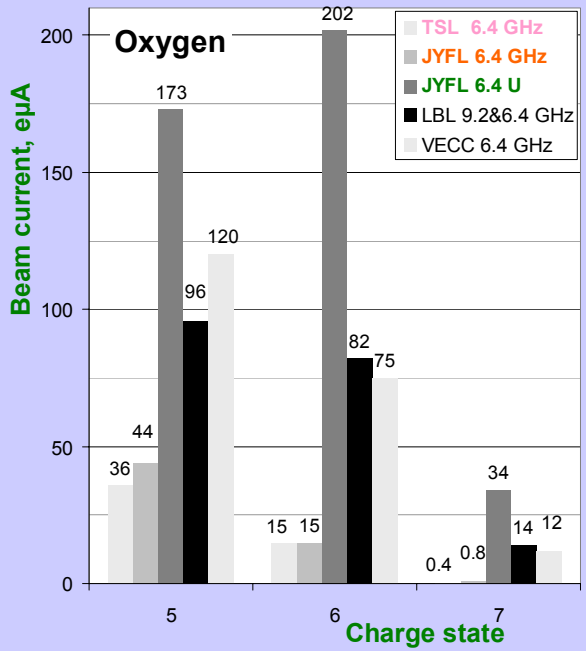
www.tsl.uu.se


A Cyclotron hall
B CELSIUS hall
C Crypt
D Marble hall
E Blue hall
F Gamma cave
G Biomedical area
H Control room,cyclotron
I Control room,CELSIUS
J Counting room,CELSIUS experiments
K Ion source building

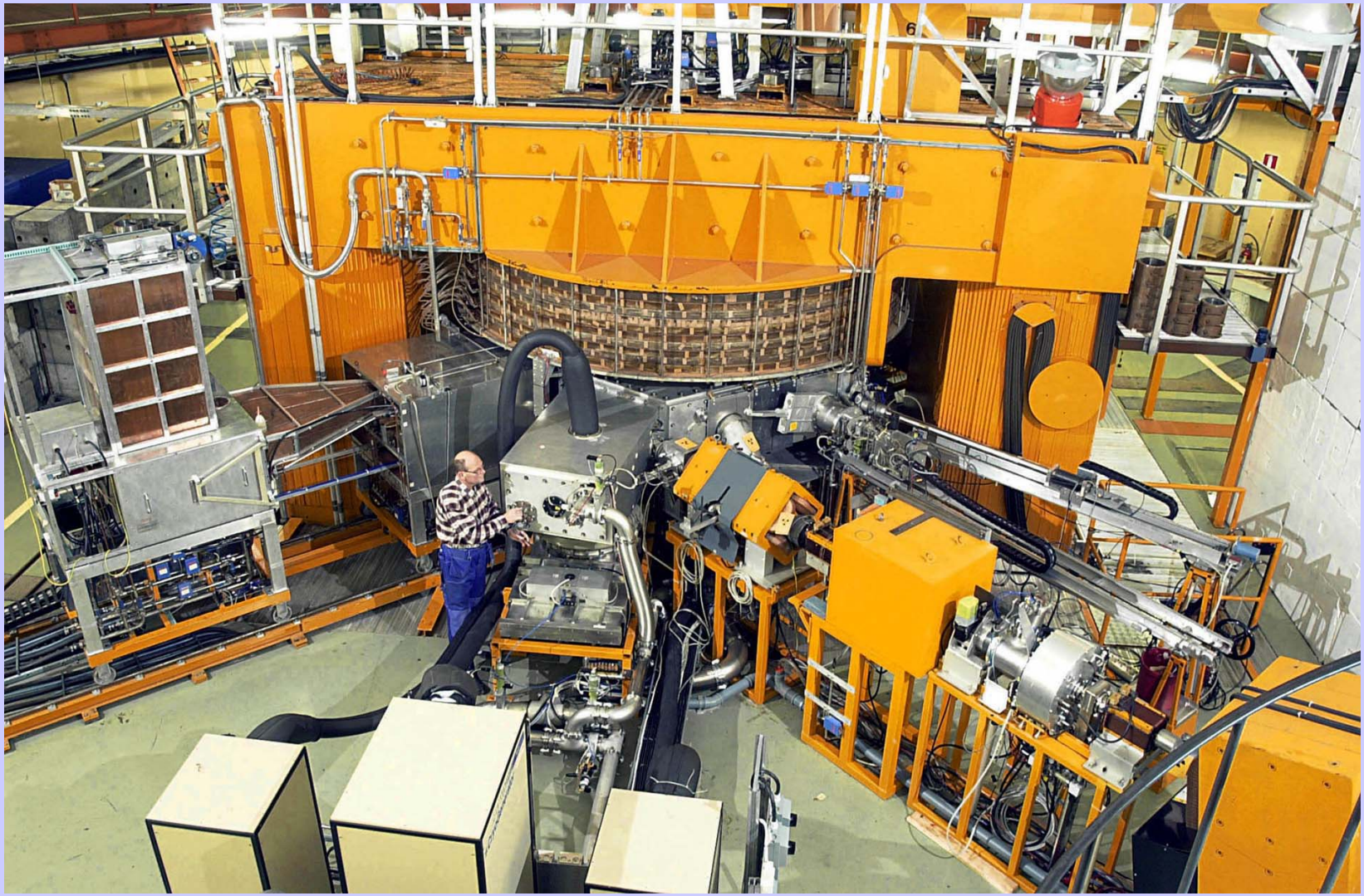
ECR Ion source







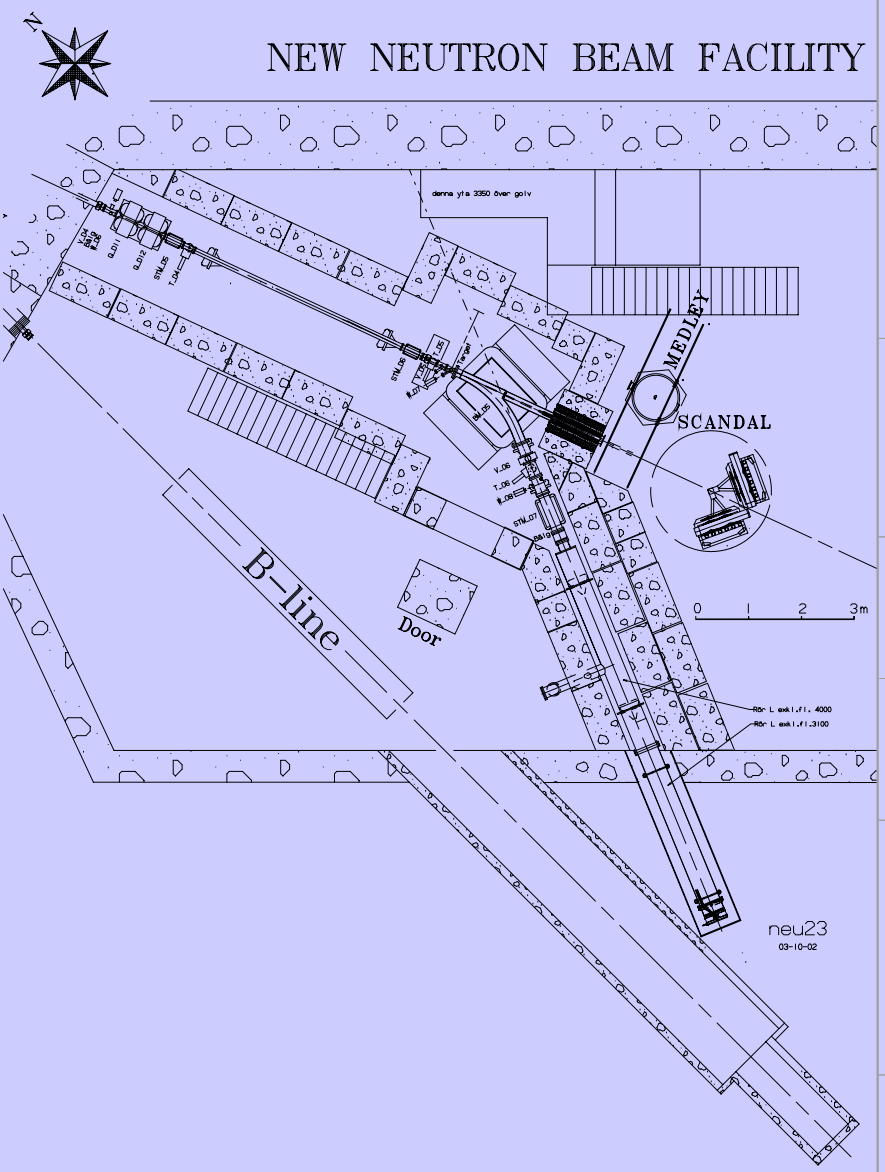
Gustaf Werner Cyclotron



Available beams

• P	24 - 180	MeV		
• d	9.5 - 48	MeV/A		
• ^{3}He	20 - 73.3			
• ^{4}He	12.5 - 46.3		280	enA
• $^{10}B^{5+}$	45		2	
• Etc. C, N, O				
• $^{20}Ne^{9+}$	40		40	
• $^{40}Ar^{12+}$	17.2		250	
• $^{129}Xe^{29+}$	9.6		0.5	

Neutron beam facility



Parameter	Value at the old facility	Value at the new facility	Factor of difference
Energy (MeV)	20-180	20-180	-
Distance (m)*	10	3	3.3
Flux ($cm^{-2}s^{-1}$)**,***	8E4	9E5	**11**
Beam diameter (cm) - at the entrance ** - at the end of beam-line	 8.7 22	 5-30 **≤135**	 ≤3.5 ≤6
Max intensity(s^{-1})	5E6	6E8	**~130**

Present and potential beam users

Development of neutron dosimetry/monitoring devices

- SSI (Sweden)
- Yale/Pisa (USA/Italy)

  Etc.

Single Event Effect studies:

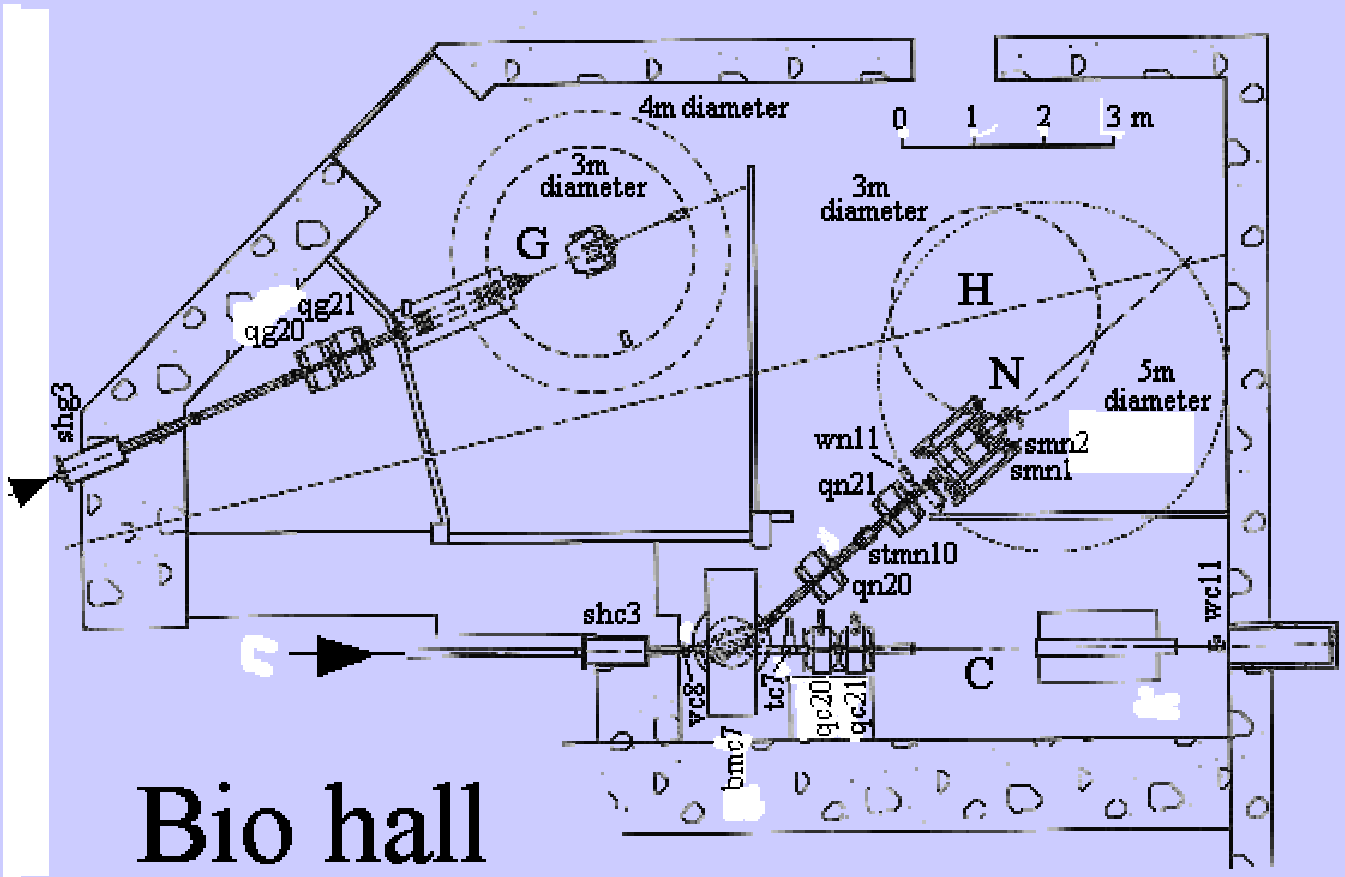
- Hitachi (Japan)
- IrocTech (France)
- Saab (Sweden)

  etc.

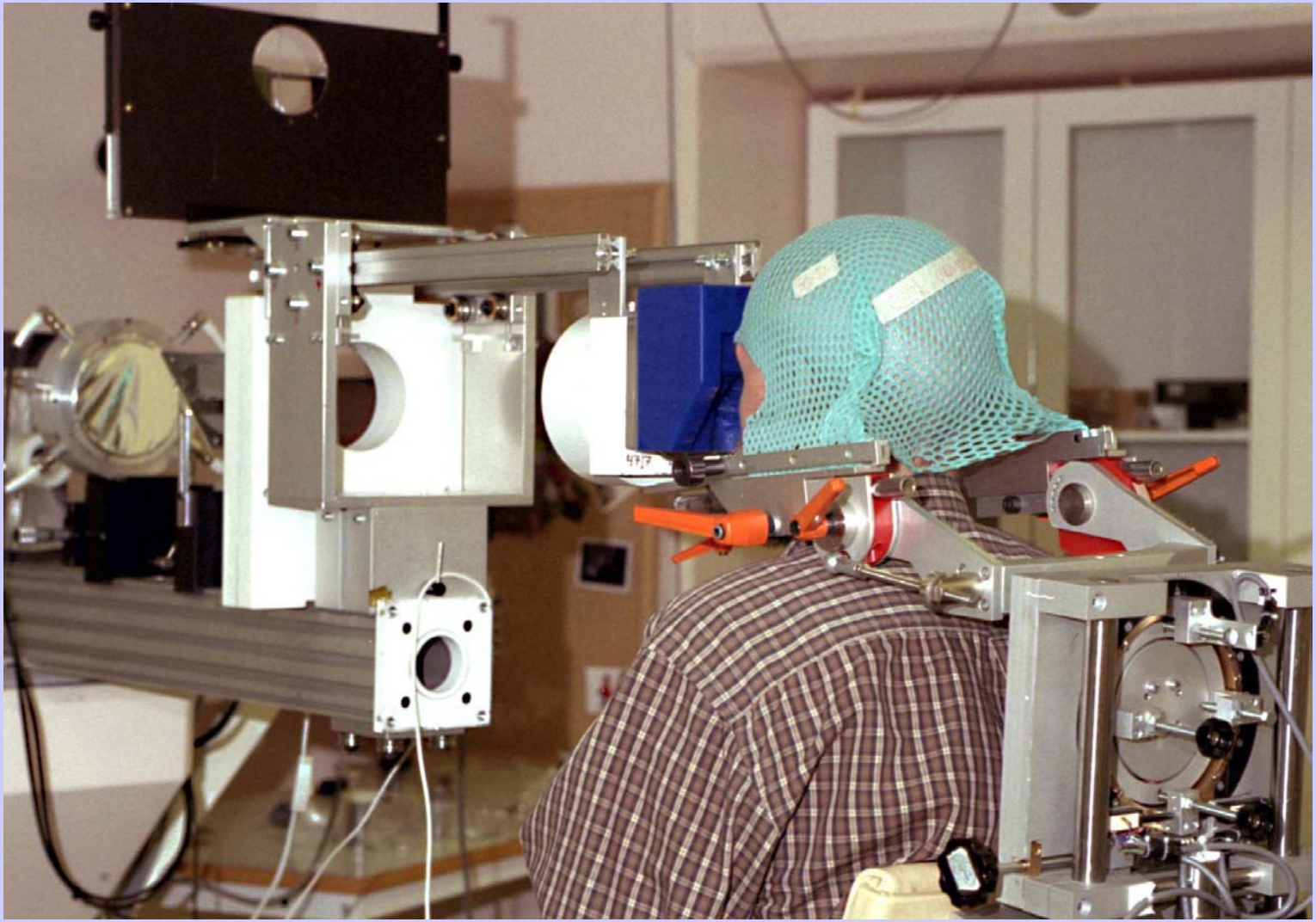
Nuclear data/Transmutation

- Elastic/inelastic neutron scattering (Sweden/France)
- Neutron-induced charge particle production (Sweden/France)
- Neutron-induced fission (Sweden/Russia)
- Neutron-induced radionuclide production (Sweden/Germany)

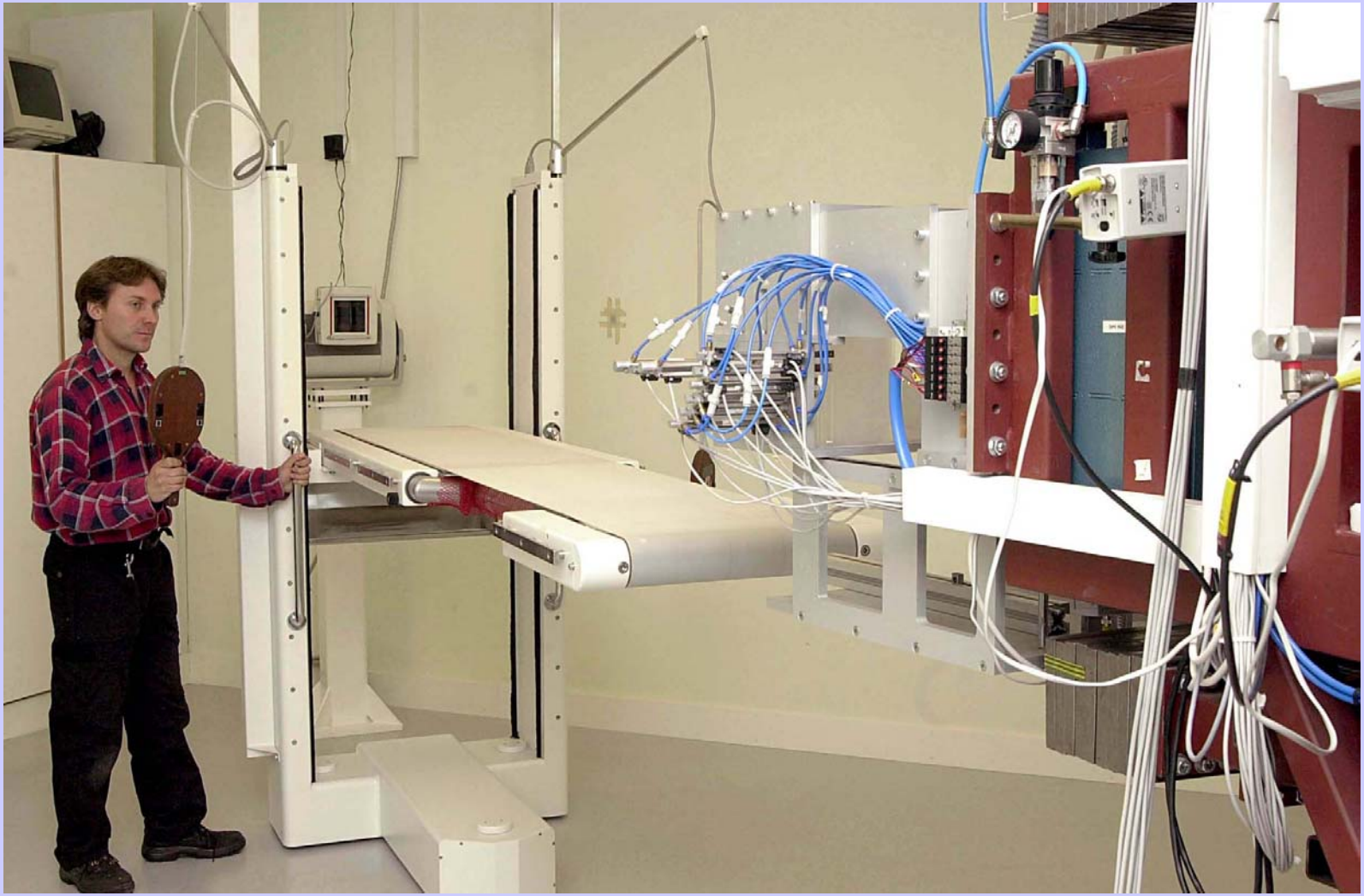
Ion-beam therapy



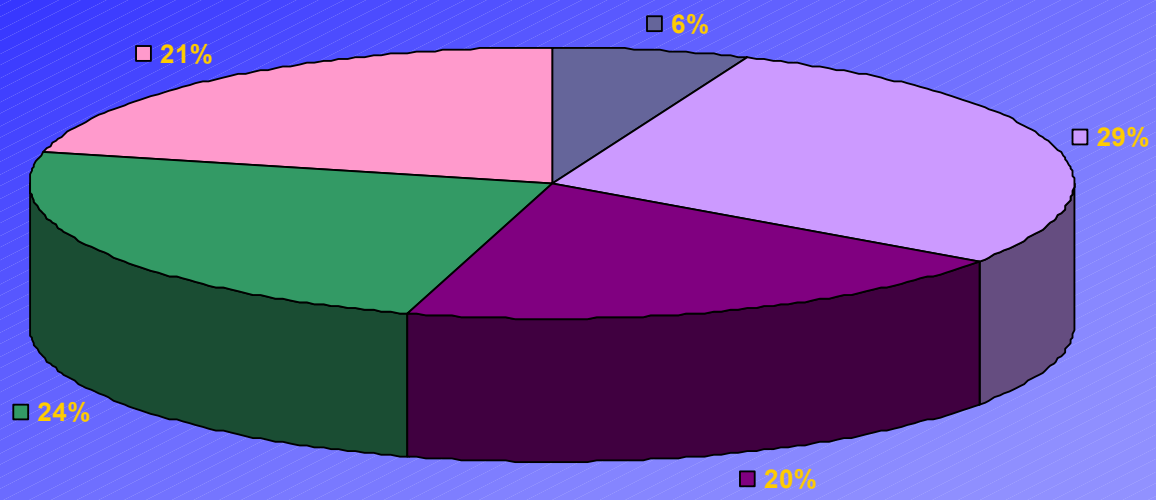
Patient cancer treatment
Narrow beam



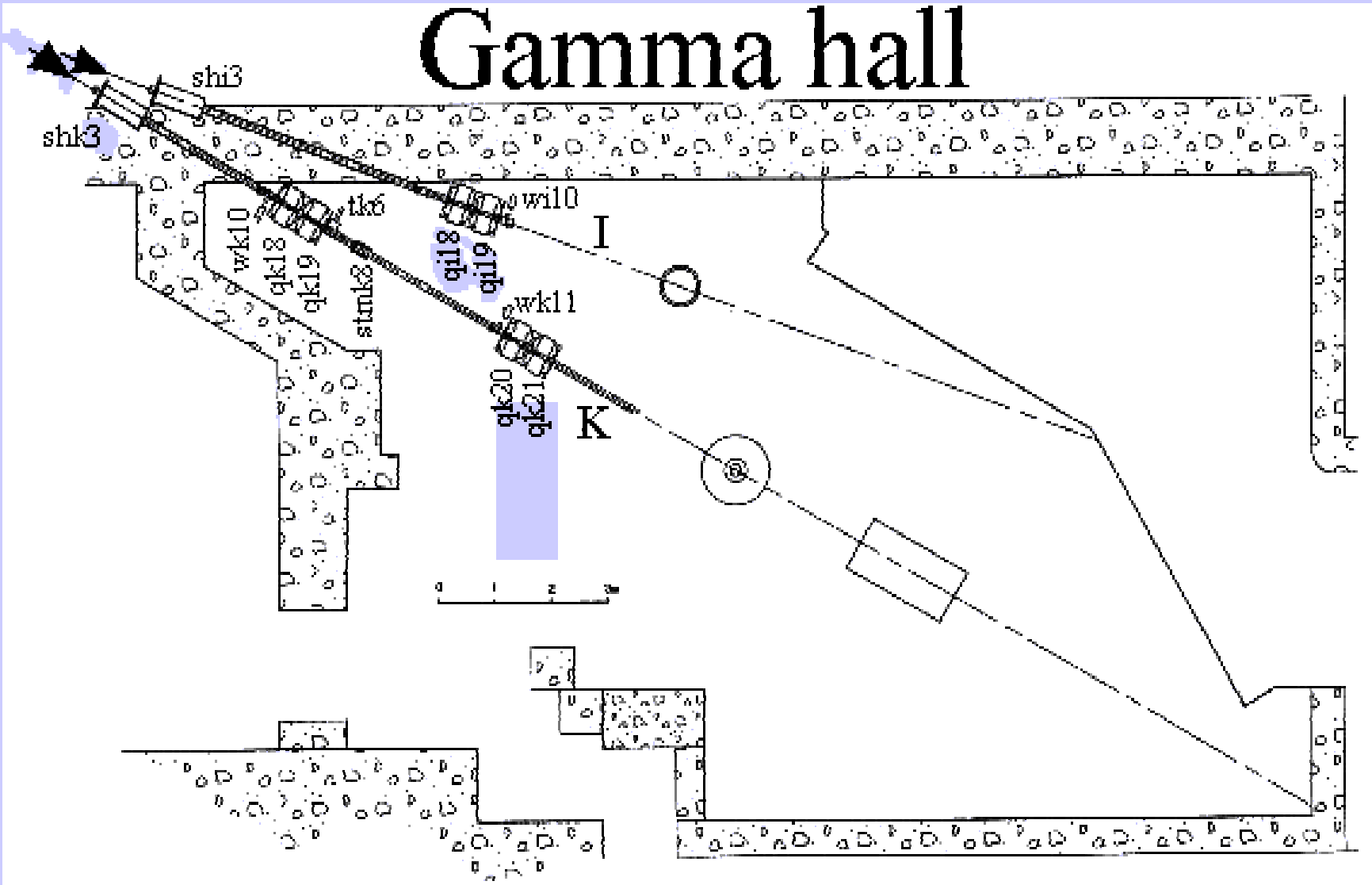
Patient cancer treatment
Broad beam



Proton treatments April 1989 - Sept 2002 at the "The Svedberg Laboratory", Uppsala University, Sweden



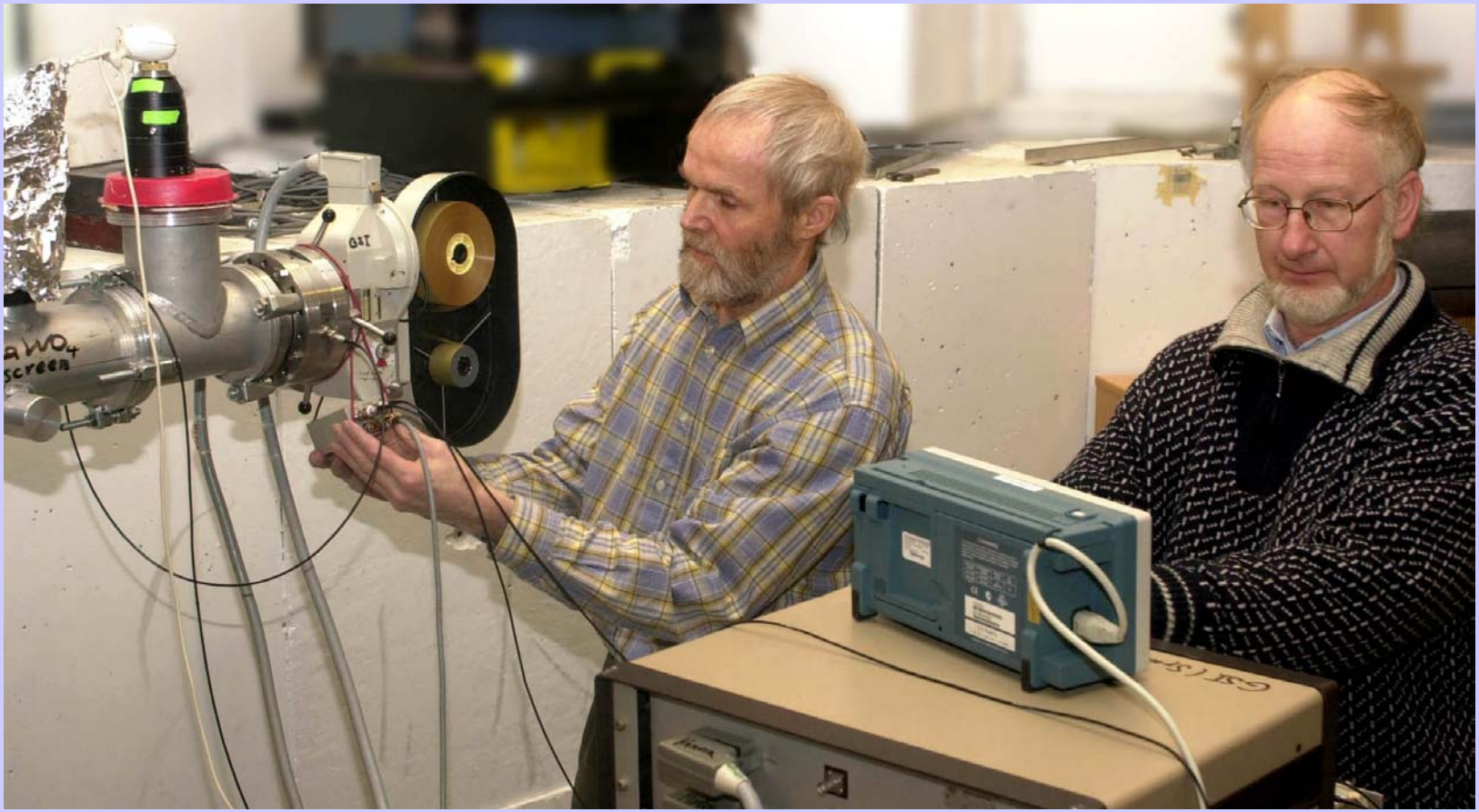
Gamma hall


shi3
shk3
wk10
qk18
qk19
tk6
stmk2
wi10
qi18
qi19
wk11
qk20
qk21
I
K


LYFTDON-
STAHL AB


ION TRACK TECHNOLOGY GROUP

Ion-track irradiations



Single track irradiations

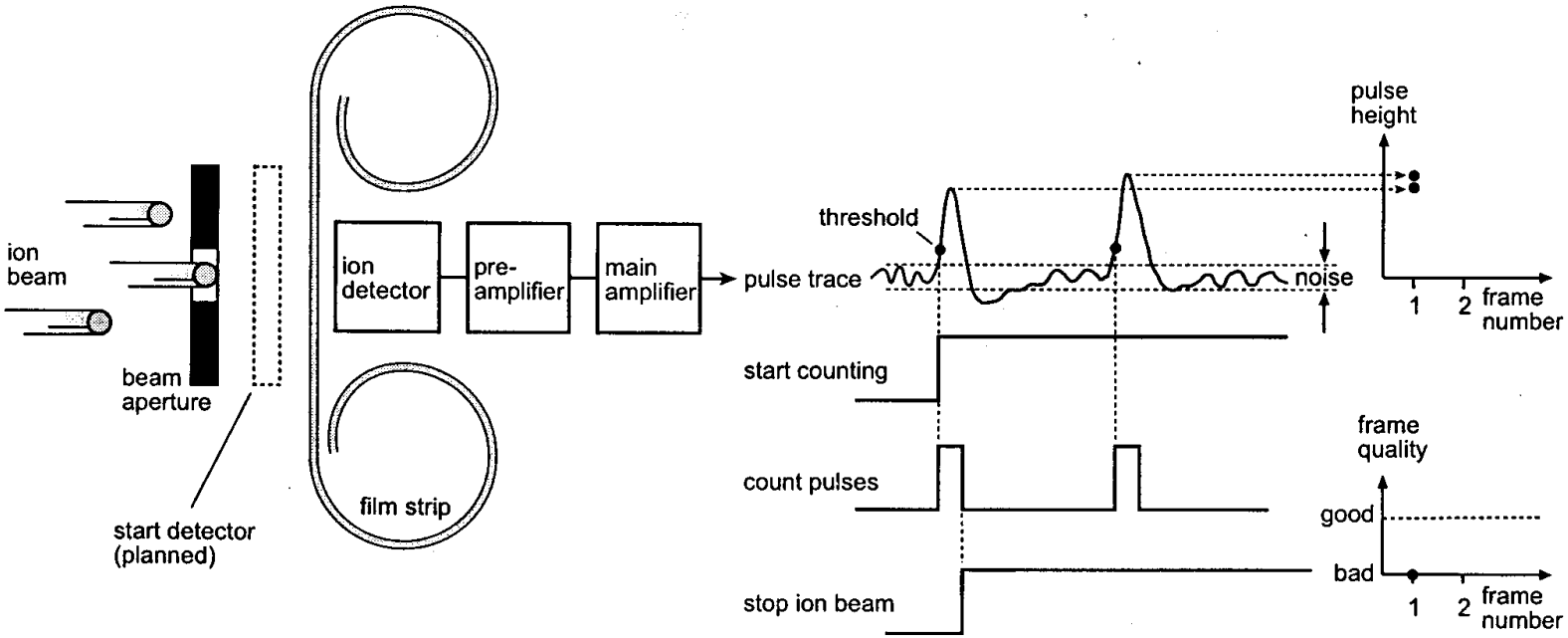


Fig. 1 Principle of irradiation system

Electrolytical cell for single ion track etching and replication

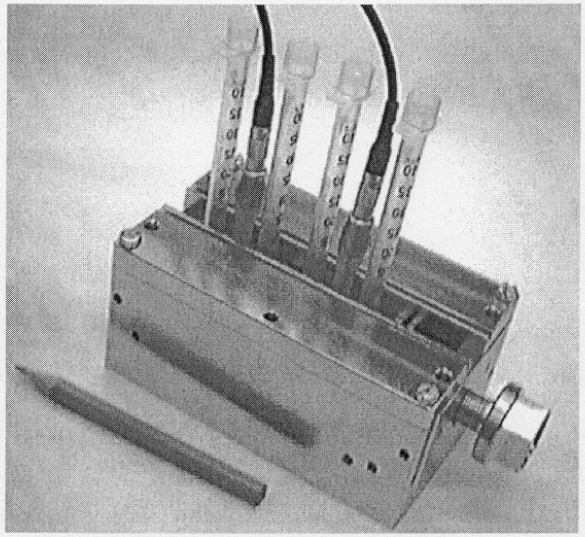


Fig. 1 Electrolytical cell with electrical and thermal shield [1].

Goals

- Controlled etching of single and multiple ion tracks in polymer foils
- Controlled preparation of nano-wires
- Measurement of current-voltage characteristics

Working principle

- Compress ion track membrane between two cell halves close to plastic yield of material.
- Insert electrodes
- Insert etching or replication media
- Record current
- Flush or interrupt at preset current

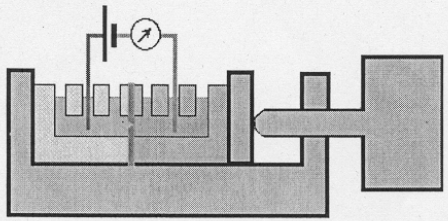


Fig. 2 Principle of electrolytical cell.

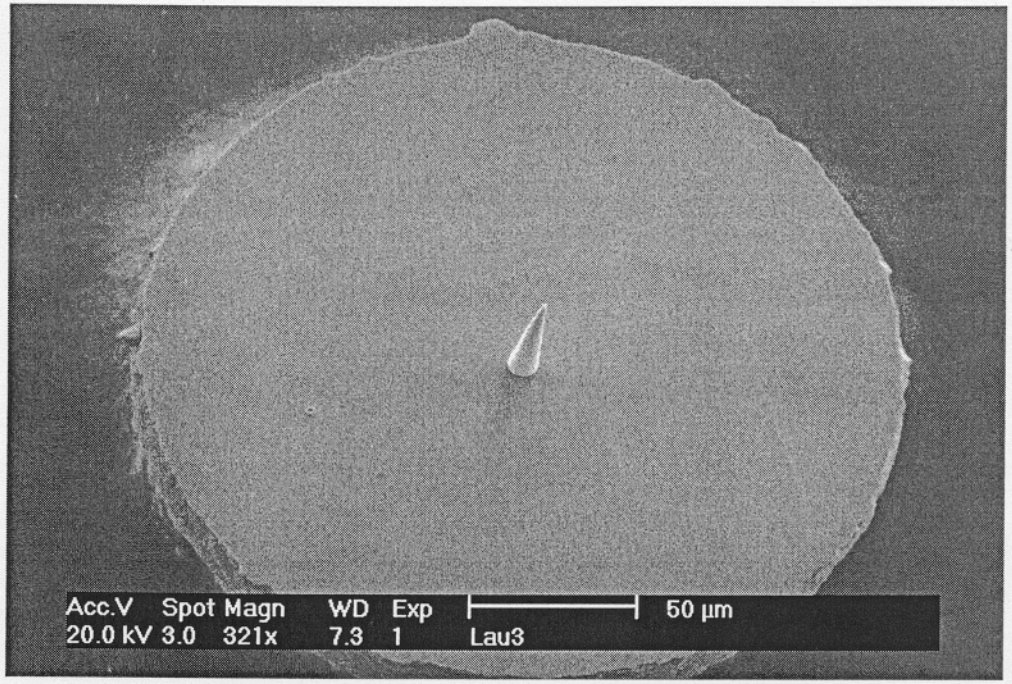


Fig. 5 Single-ion track replica of large-angle single-track cone standing in the center on its 2mm diameter cap. [5].

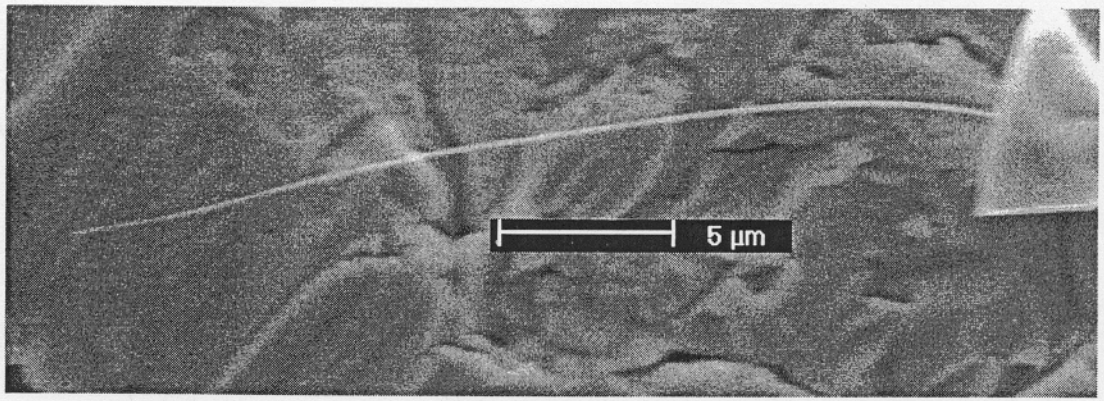
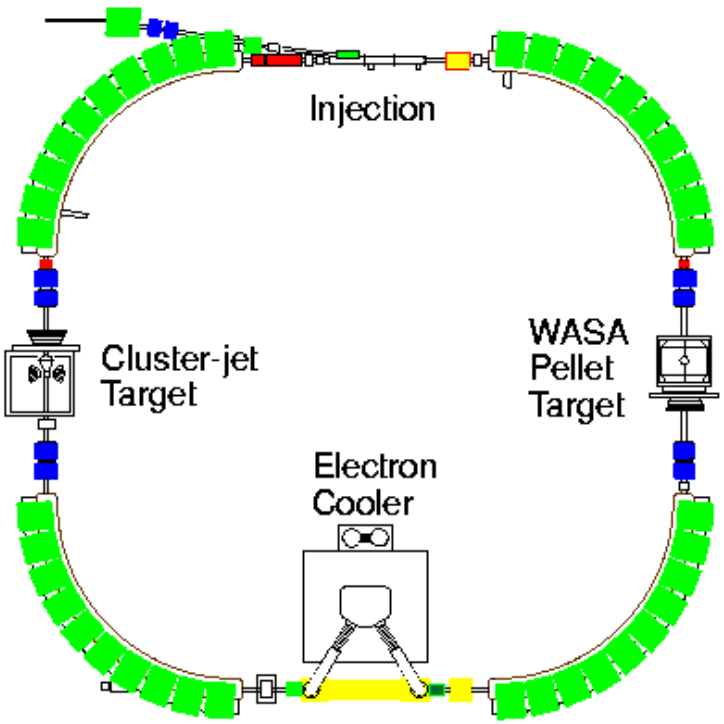


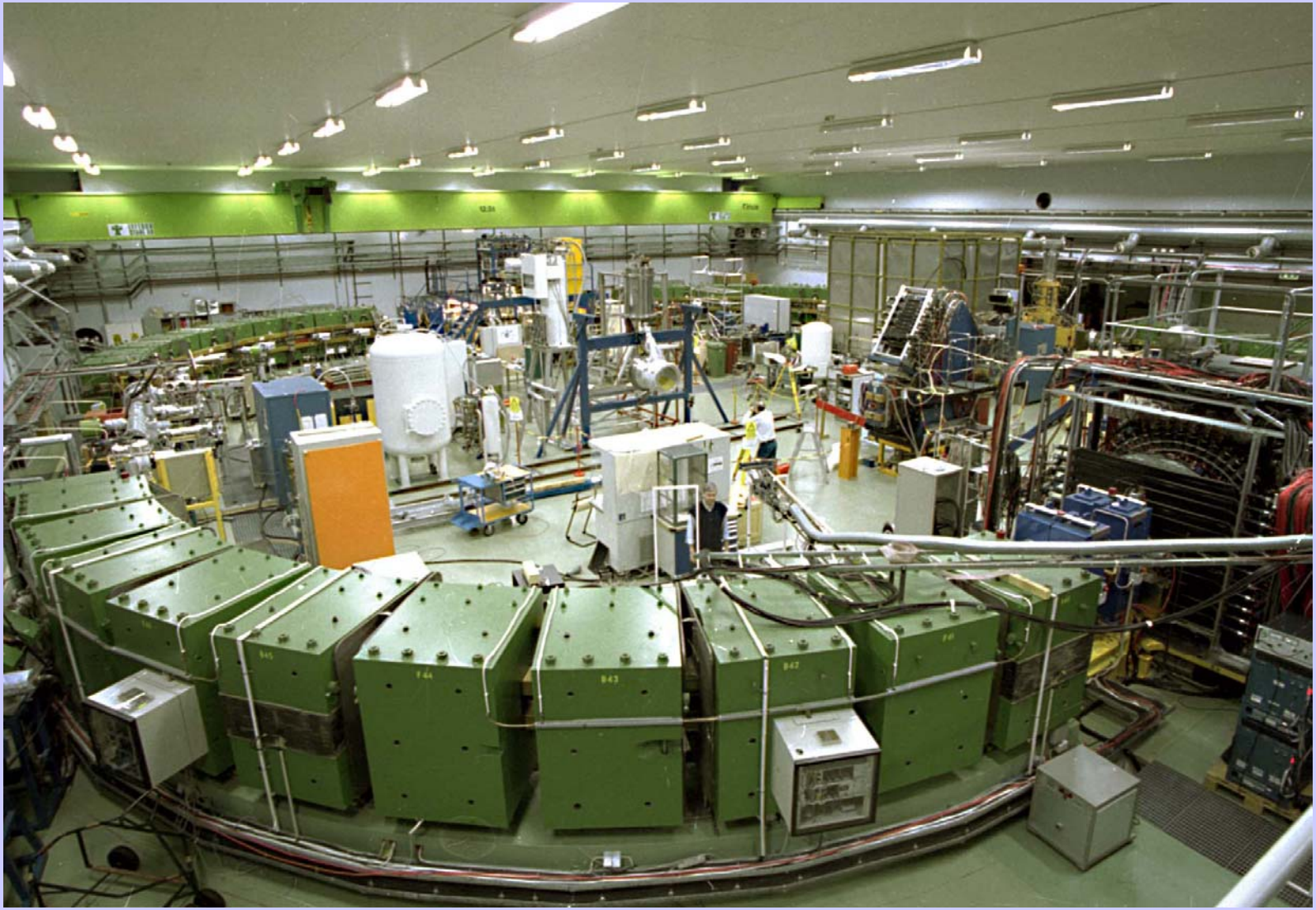
Fig. 6 Nanowire with small cone opening angle replicated from ion track membrane etched for 30min in 9M NaOH [6].

The CELSIUS Ring

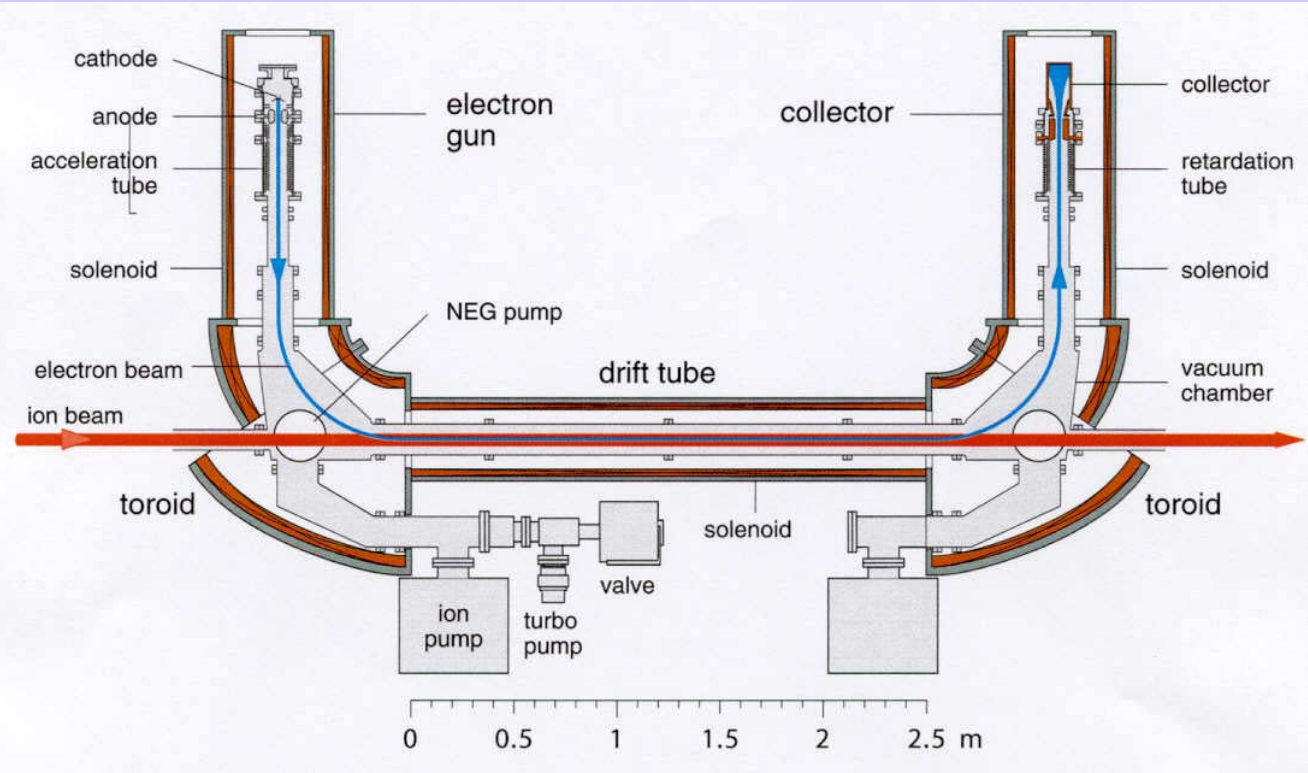


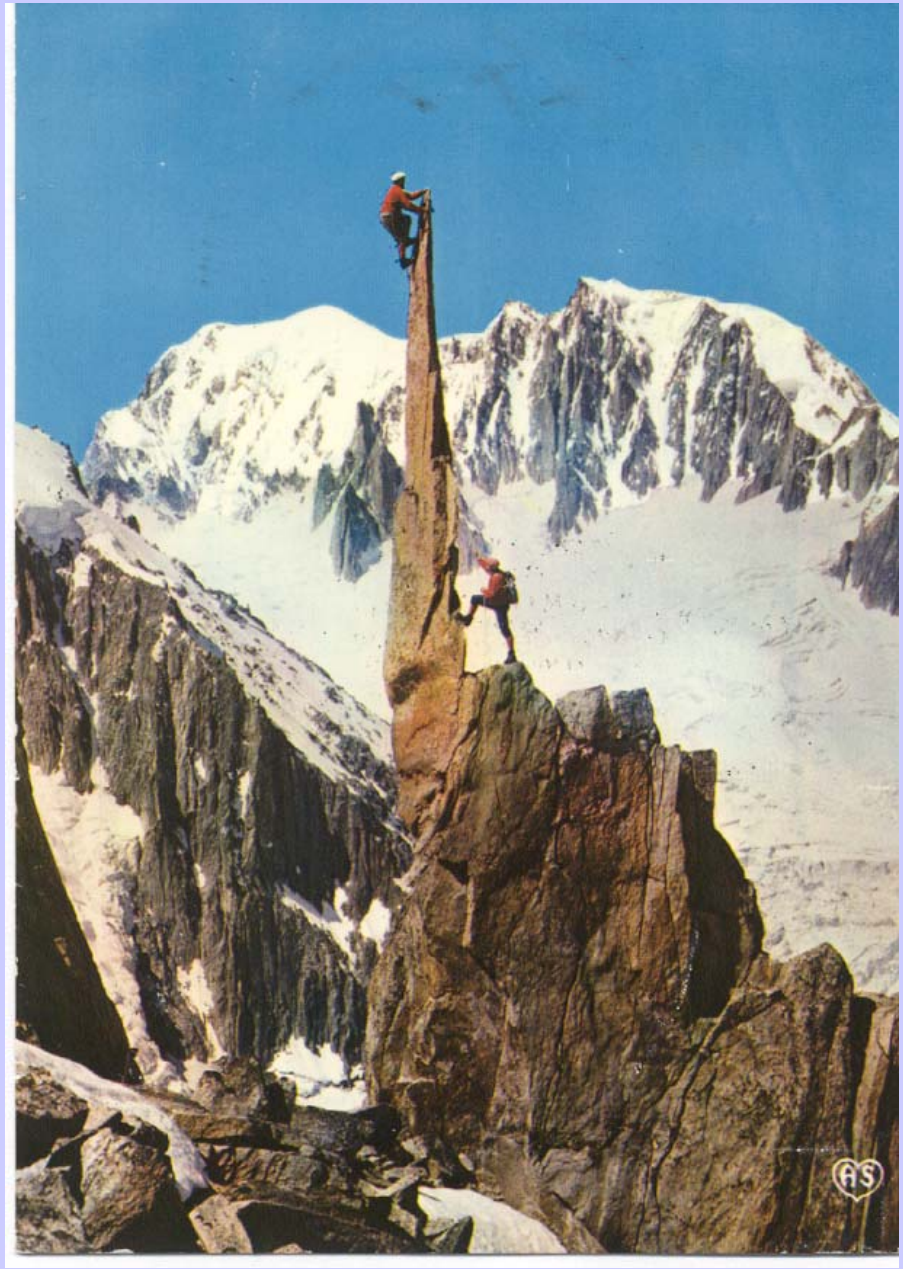
Circumference	81.8 m
Length of cooling and injection straight sections	9.6 m
Length of target straight sections	9.3 m
Bending radius	7.0 m
Maximum rigidity	7.0 Tm
Maximum kinetic energy (protons)	1.36 GeV
Maximum kinetic energy per nucleon for ions with $Q/A = 1/2$	470 MeV

The CELSIUS hall

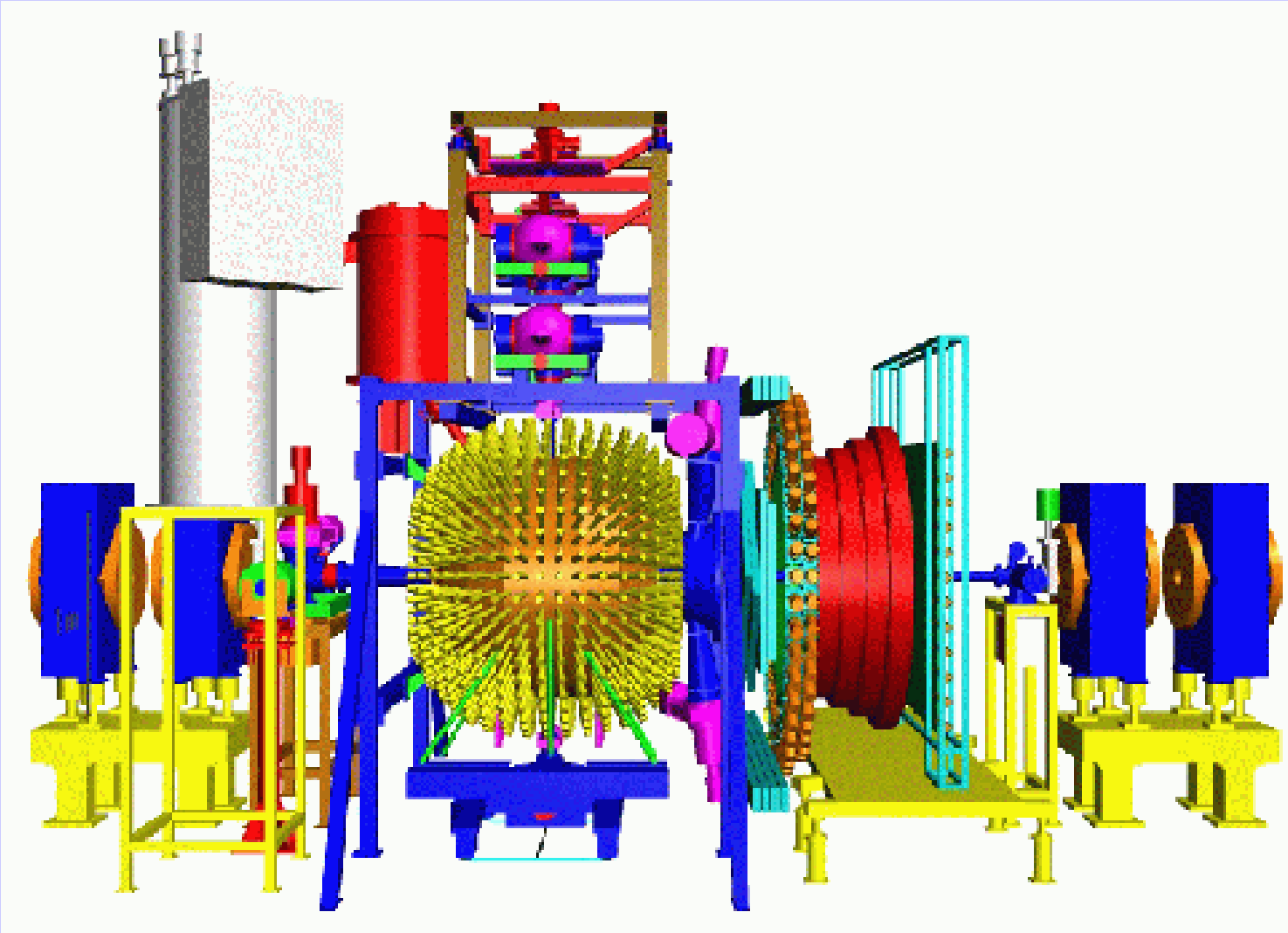


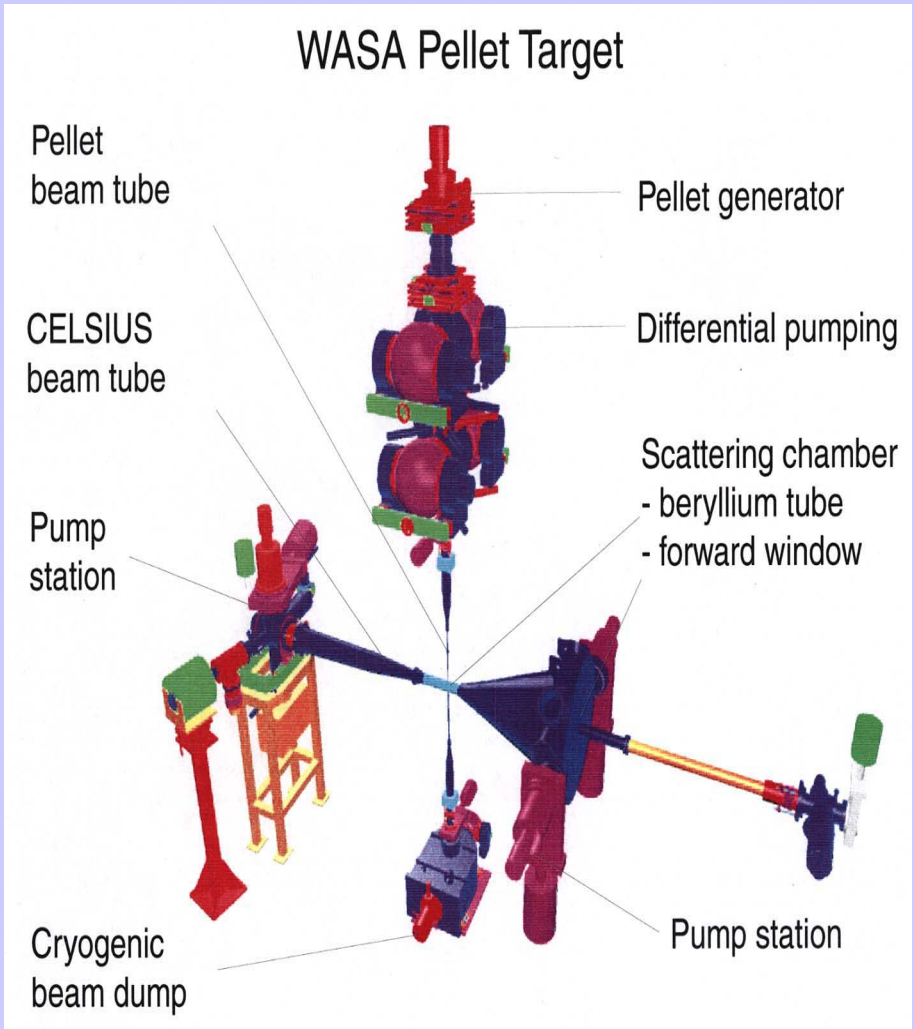
Electron cooler

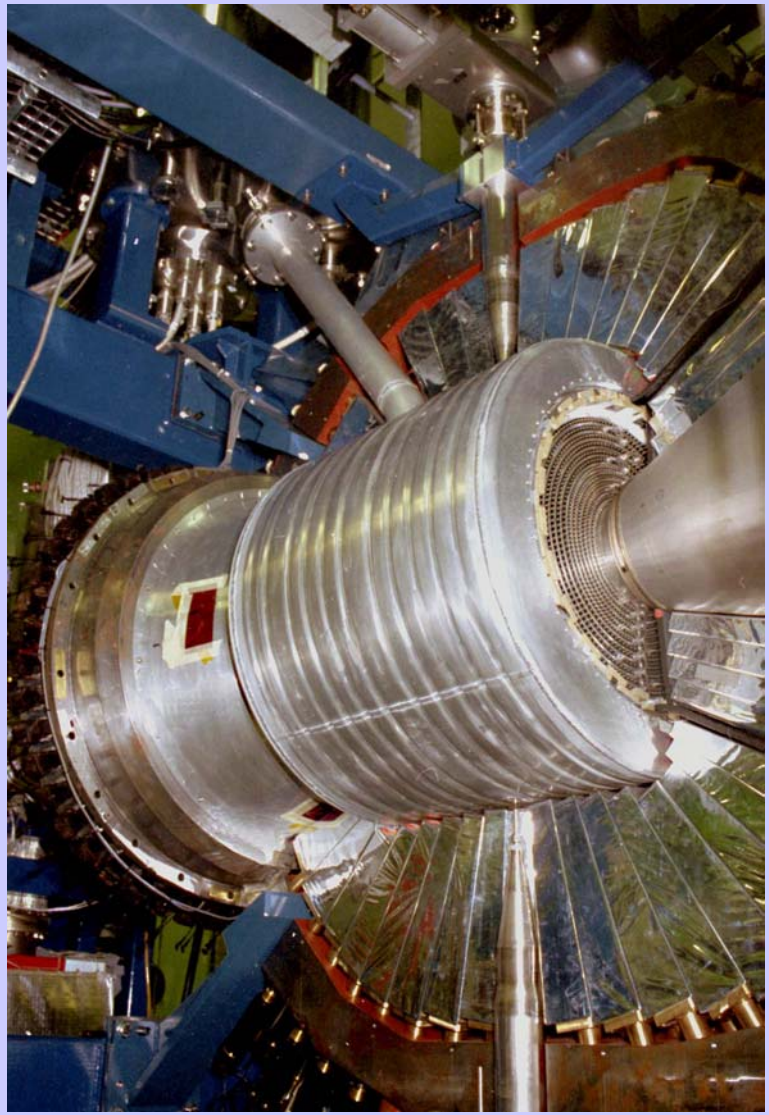


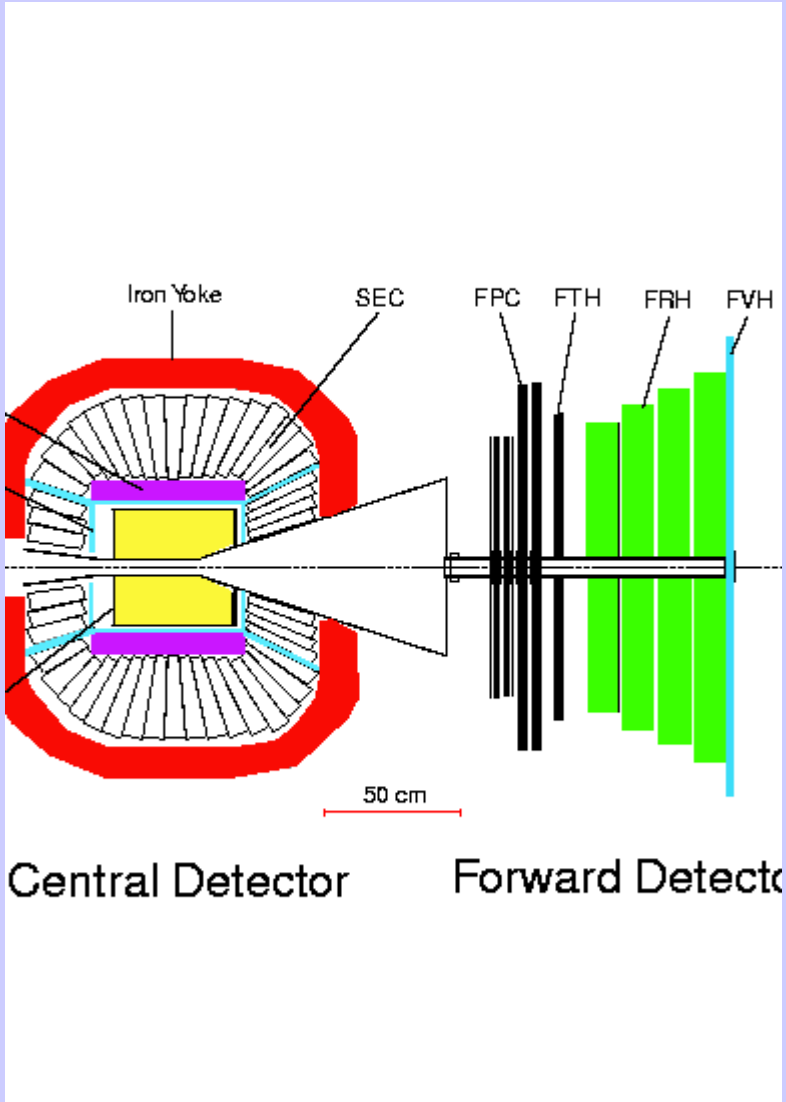


CELSIUS-VASA detector

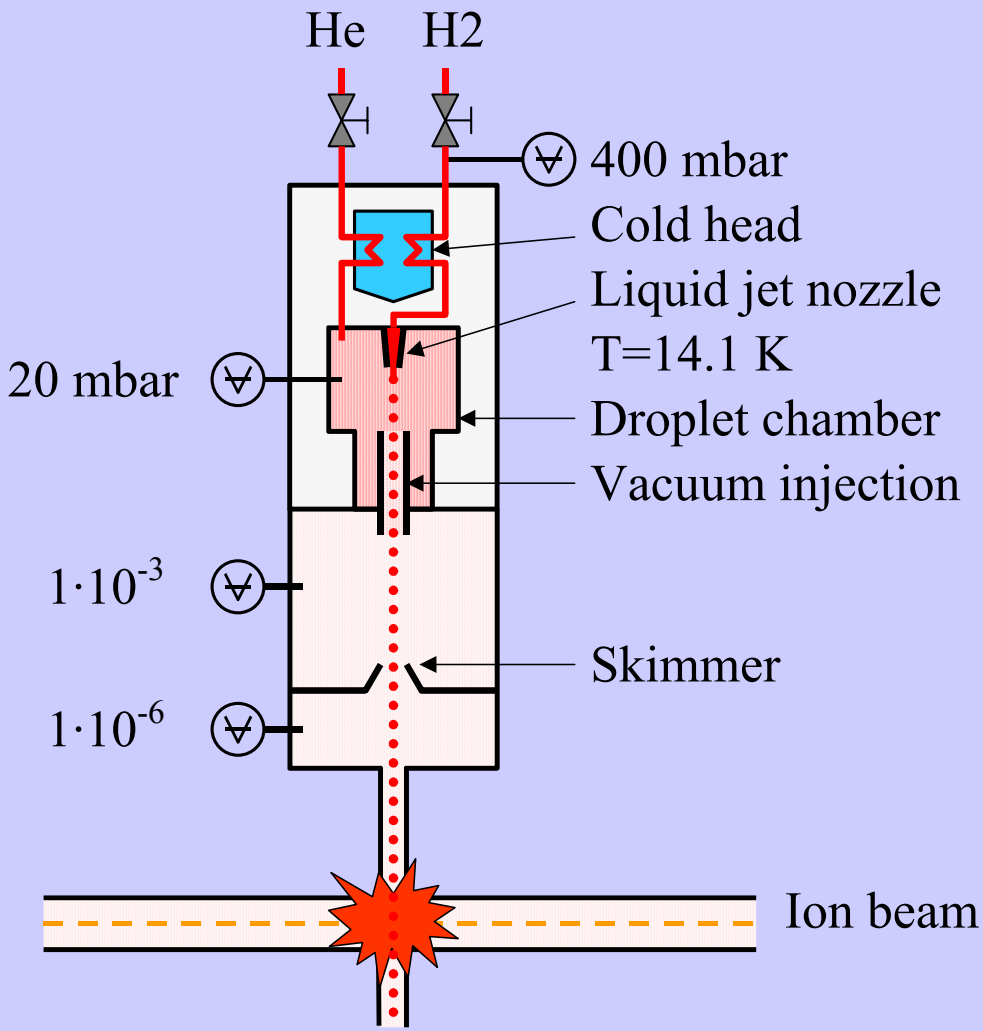



WASA Pellet Target
Pellet
beam tube
Pellet generator
CELSIUS
beam tube
Differential pumping
Scattering chamber
- beryllium tube
- forward window
Pump
station
Pump station
Cryogenic
beam dump

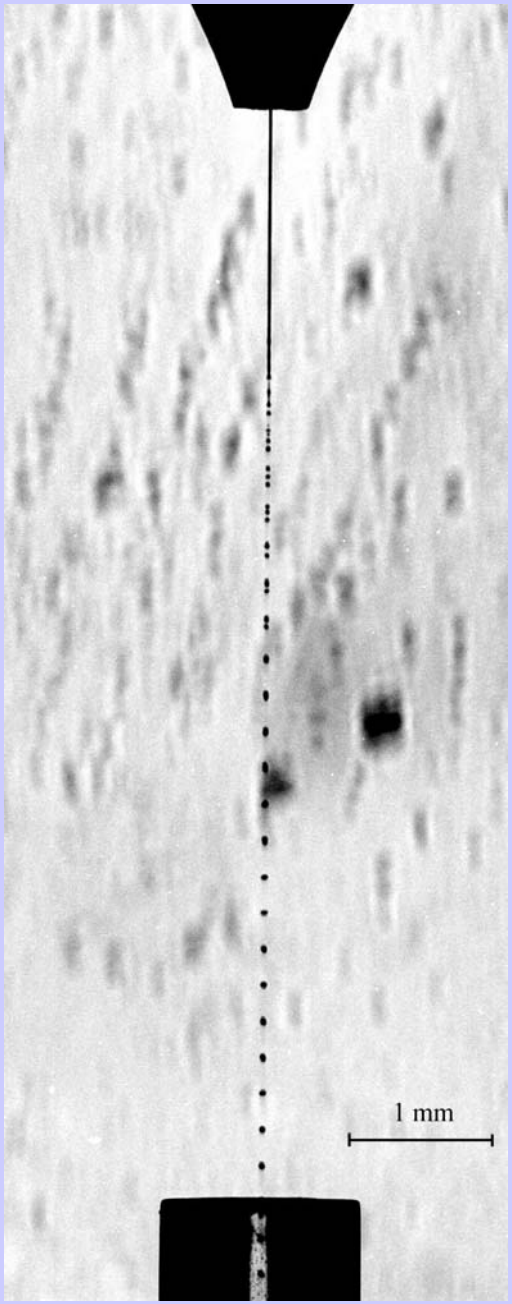


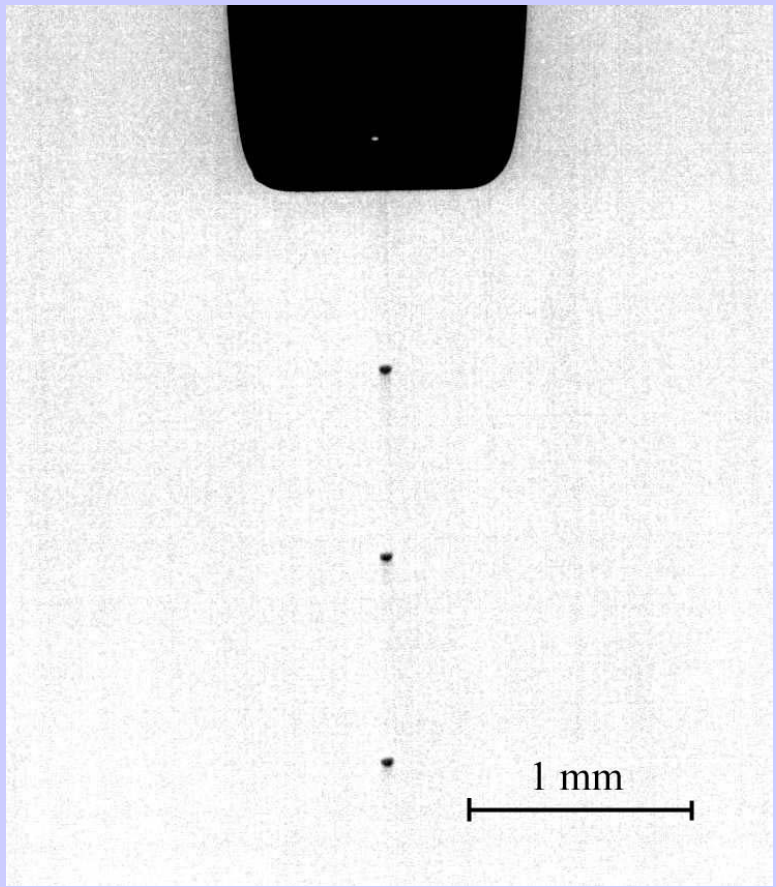

Iron Yoke
SEC
FPC
FTH
FRH
FVH
50 cm
Central Detector
Forward Detecto

Pellet target



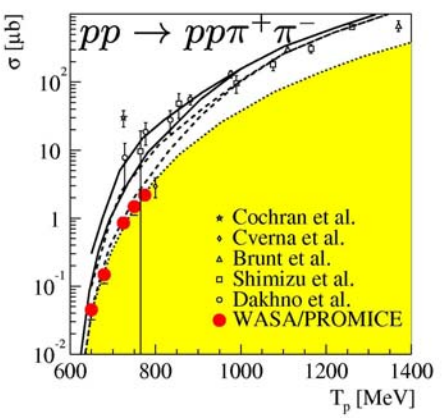
Pellet generator

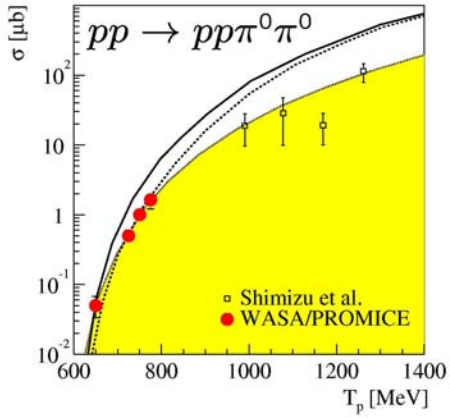


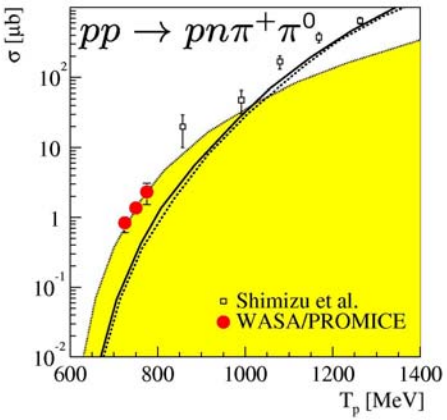


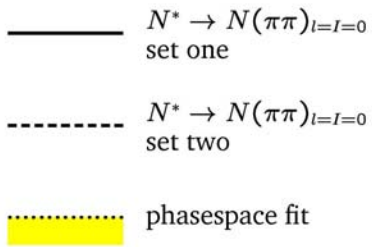
Two-pion production.

Total cross-sections









L. Alvarez-Ruso et al.
Nucl. Phys. A 633 (1998) 519

Jan Johanson, PhD Thesis Uppsala University, 2000;
Nucl. Phys. A712,(2002) 75

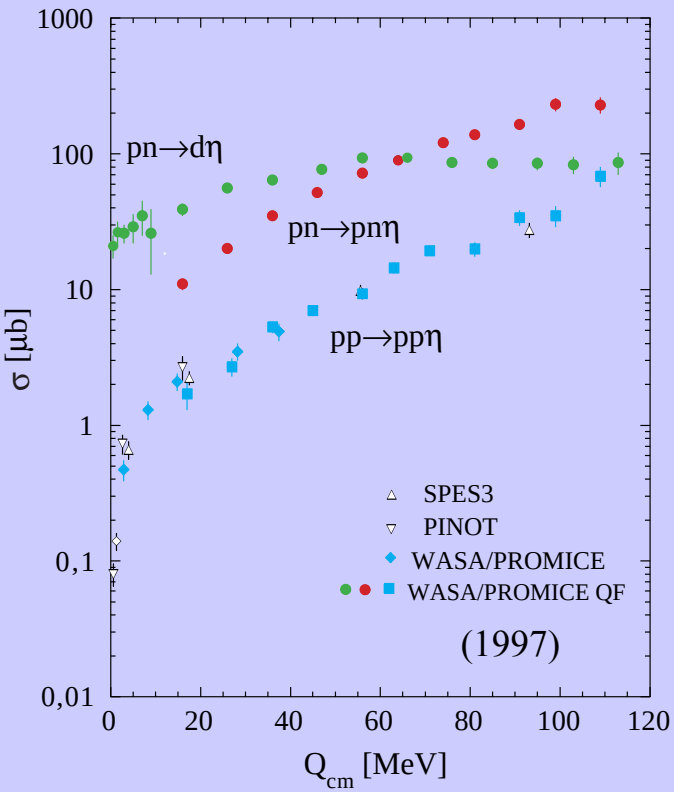
Wolfram Brodowski, PhD Thesis Universität Tübingen, 2001;
Phys. Rev. Lett.88 (2002) 192301

Jens Paetzold, PhD Thesis Universität Tübingen, 2002;
Phys. Lett. B550 (2002) 147; Phys. Rev. C67 (2003) 052202

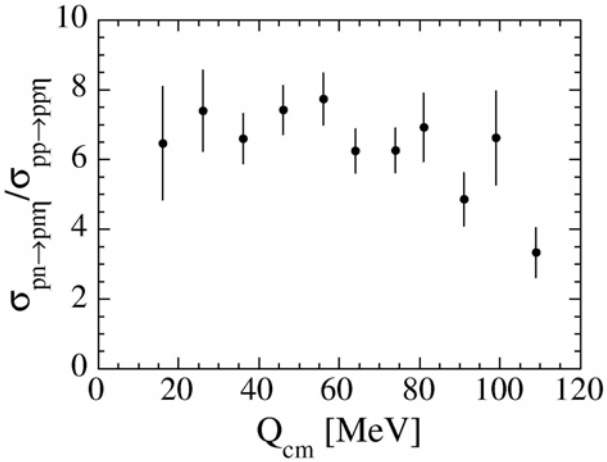
η production mechanism in NN reactions

General assumption: production via excitation of the N*(1535) S_{11} resonance

η production in pN reactions in the threshold region



η production ratio **pn/pp**



A high ratio implies that isovector mesons dominates as exchange particles ……?

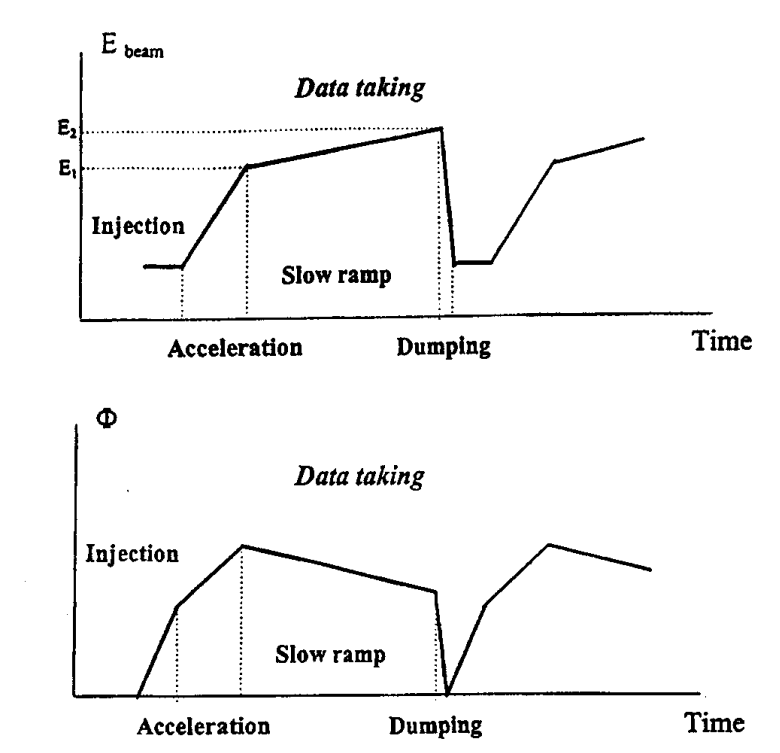
CHIC

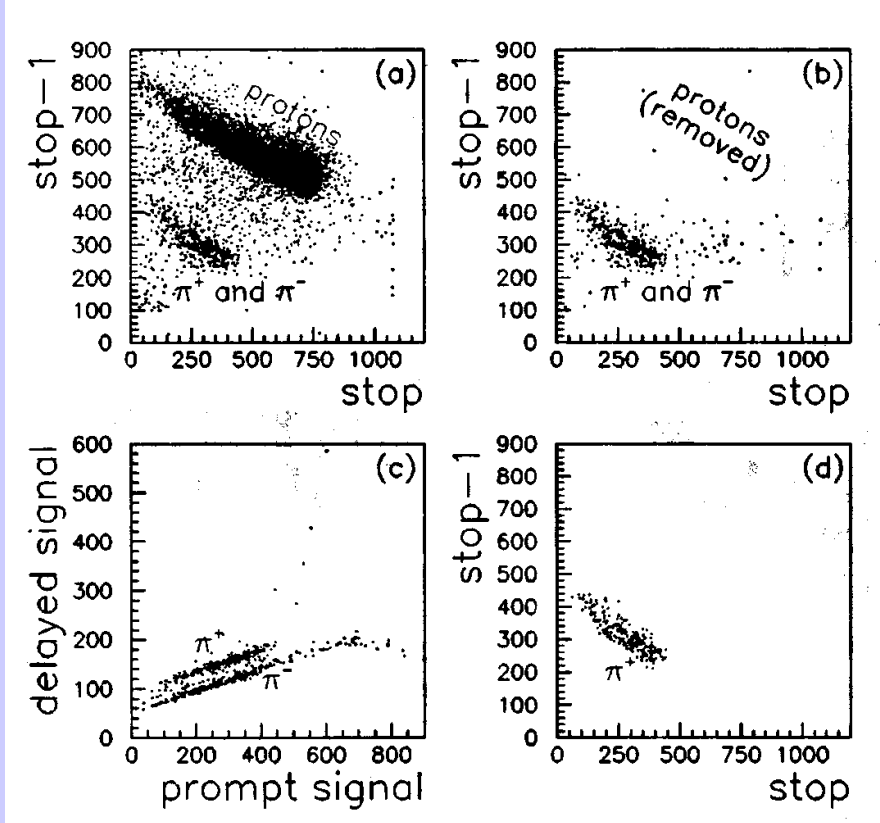
CELSIUS **H**eavy **I**on **C**ollaboration

CHICSi

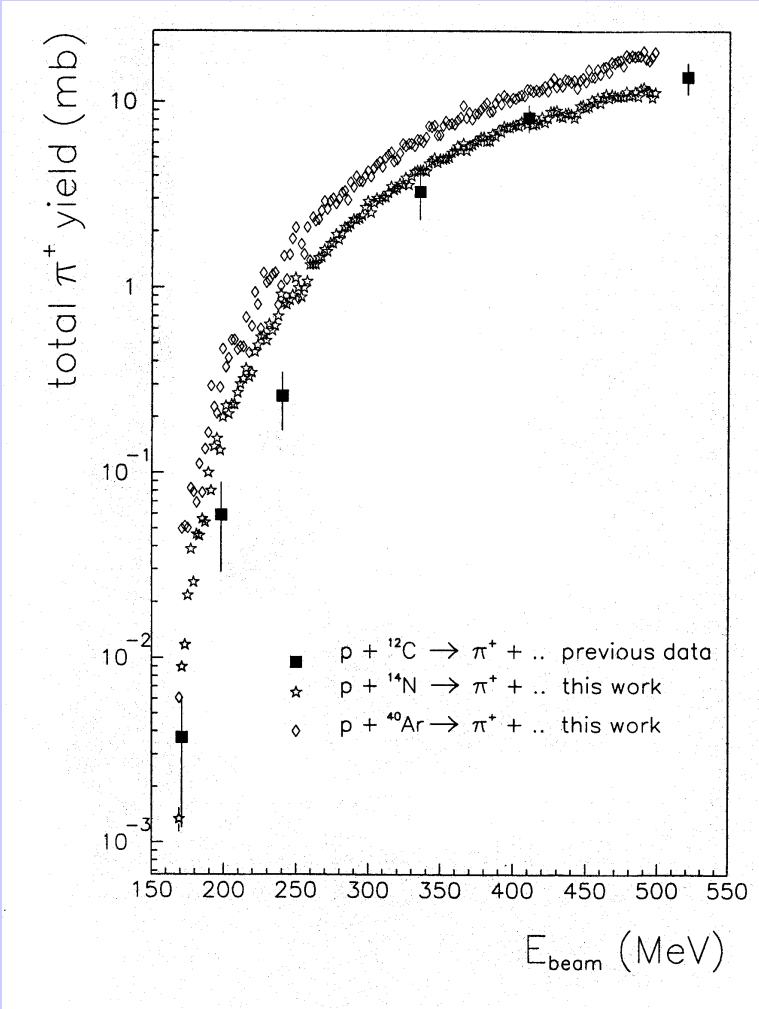
CELSIUS **H**eavy **I**on **C**ollaboration
Silicon detector system

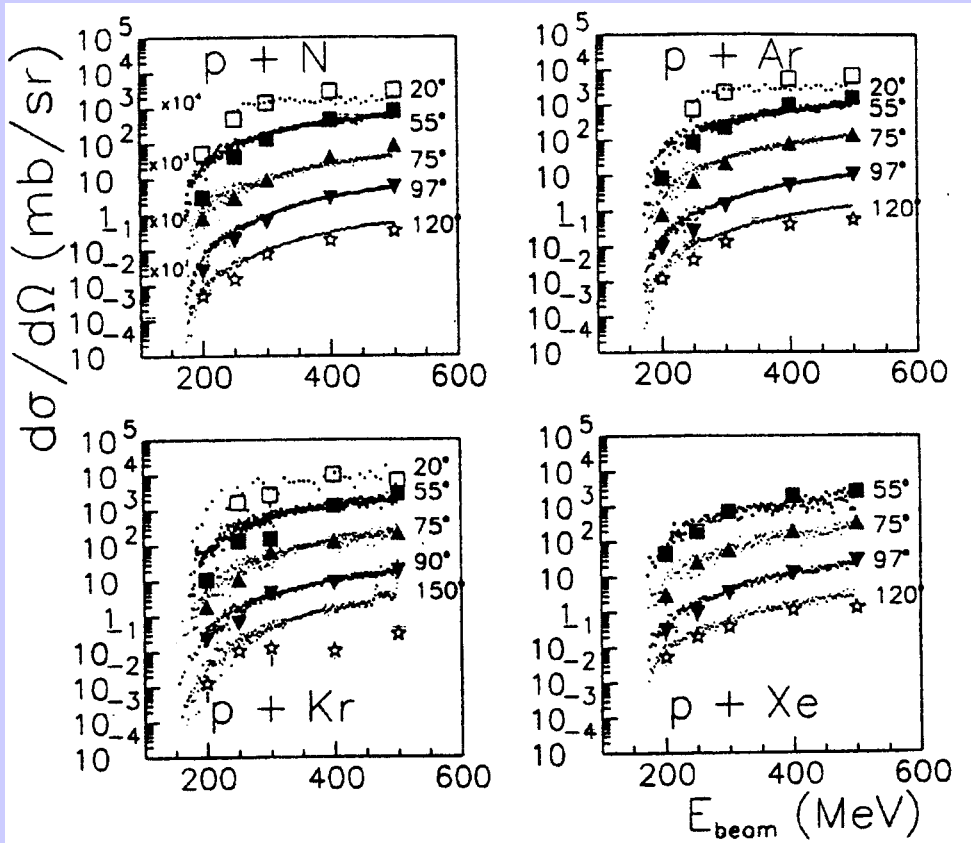
Pion production experiments at CELSIUS





Pion production experiments at CELSIUS



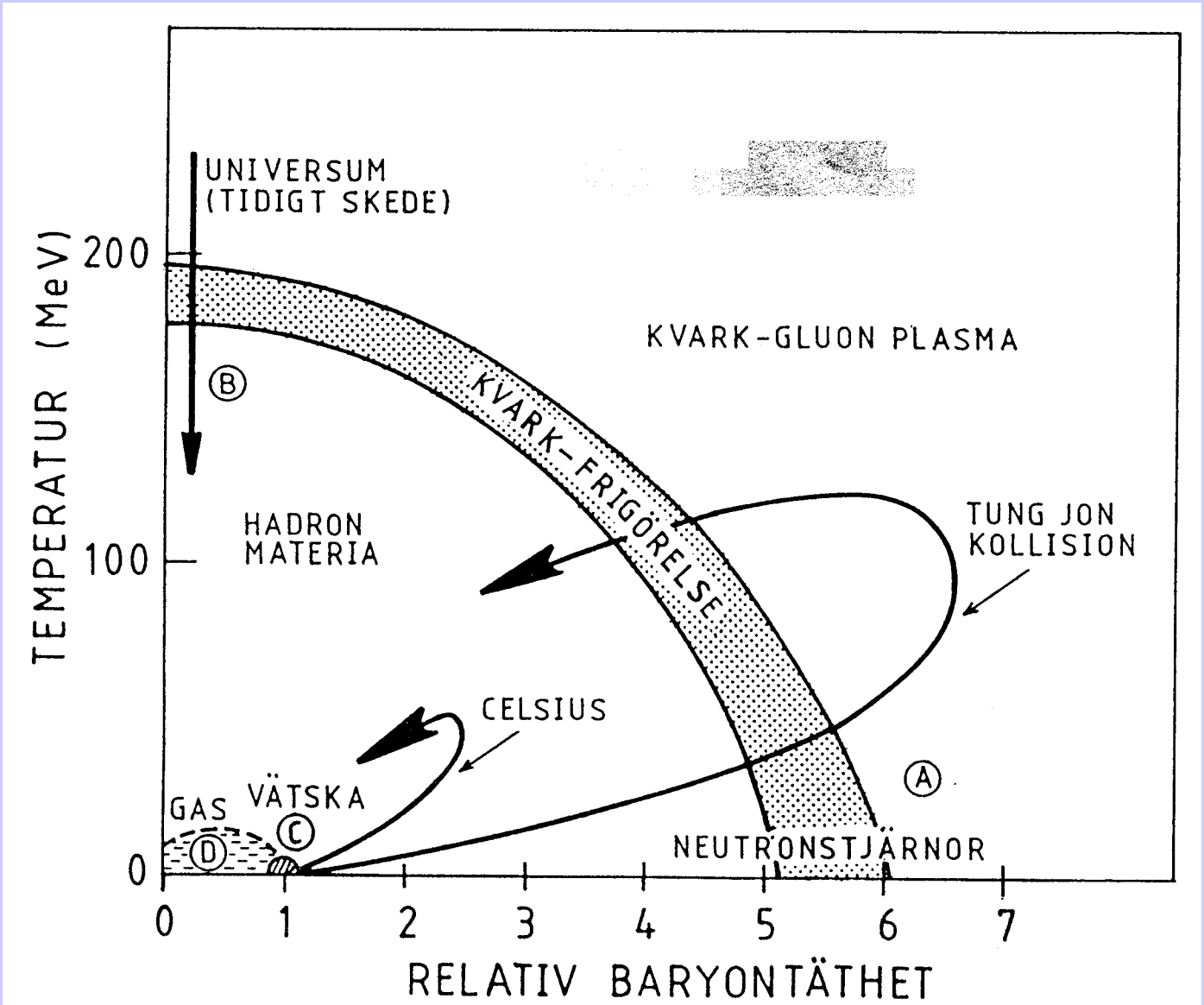


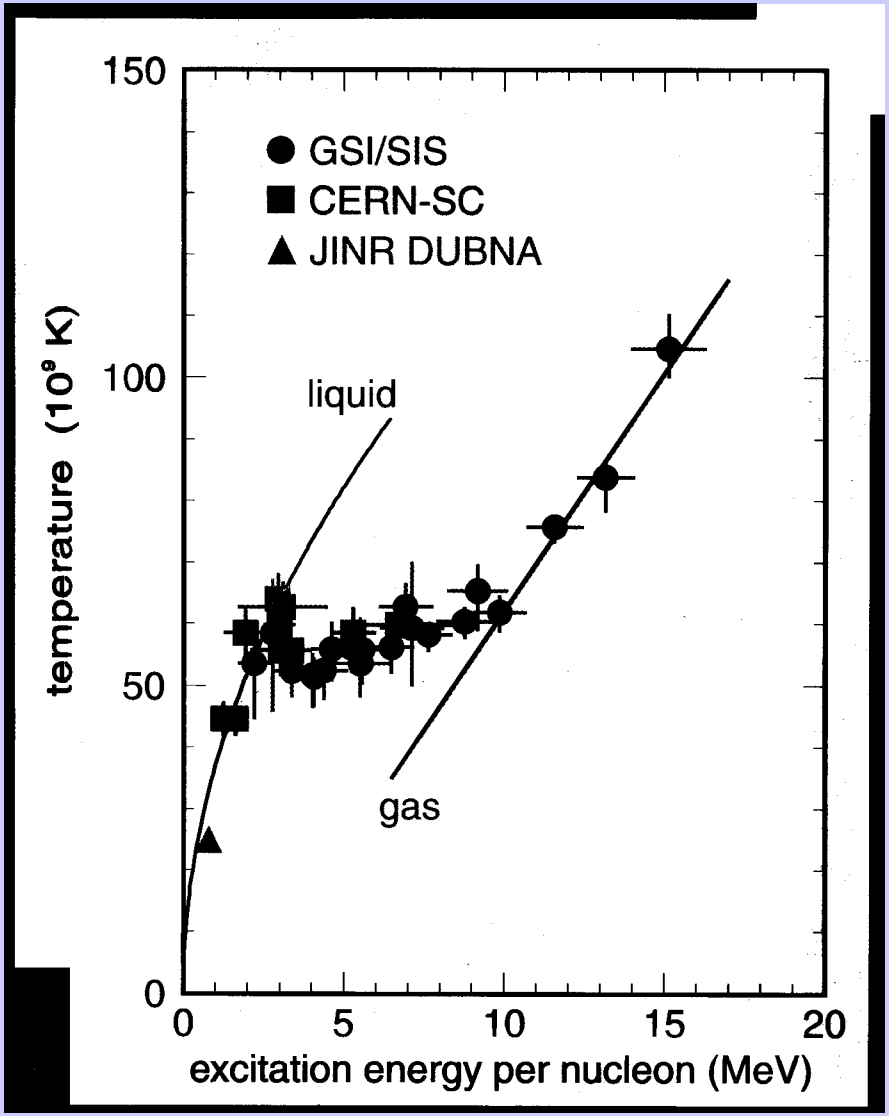
CHICSi

A UHV compatible system of detector telescopes for Heavy-ion reaction studies at the CELSIUS Storage ring

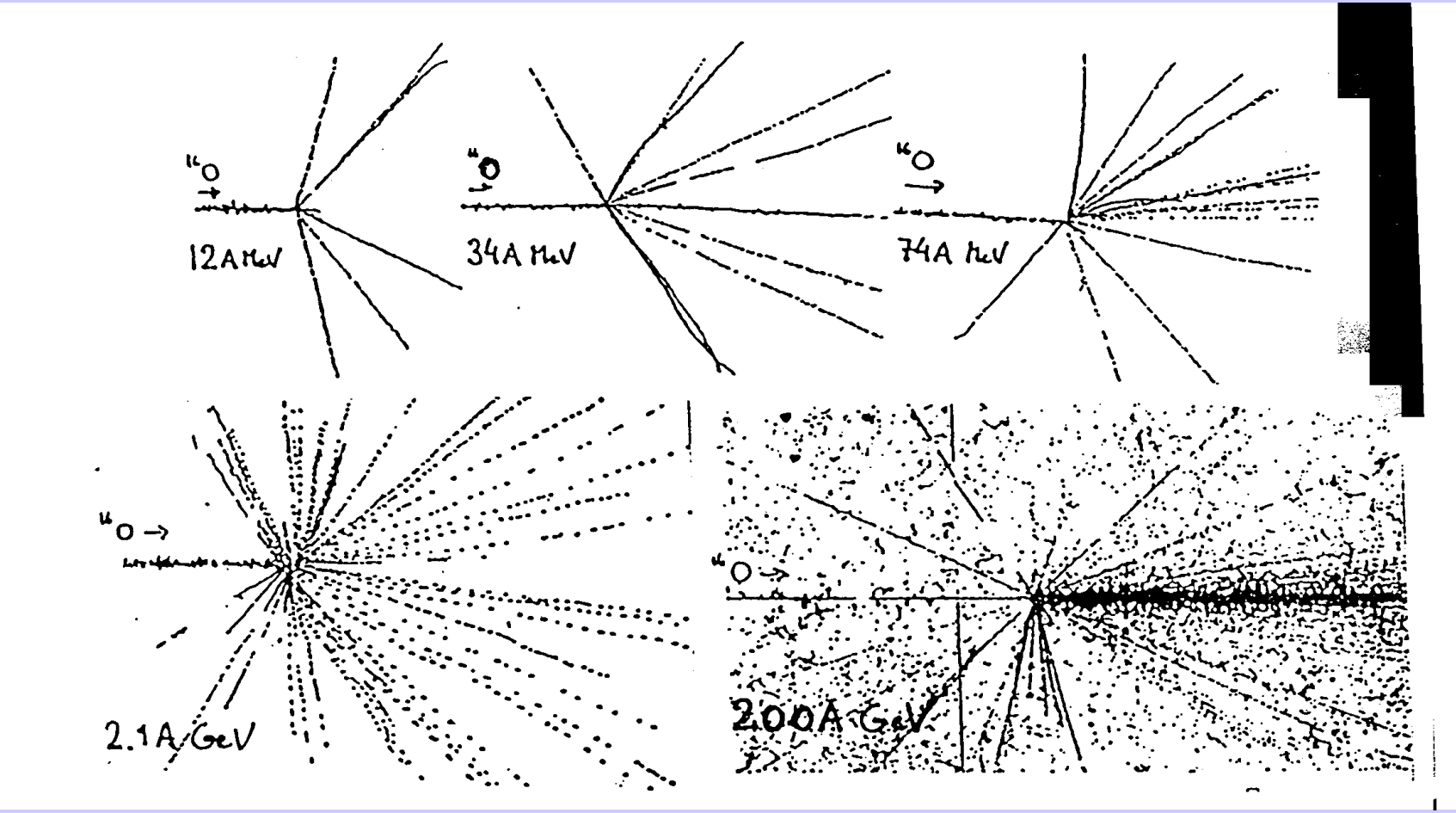
Particles: p (45-1360 MeV)
He, C, N, O, Ne, Ar (10-470 MeV/A)

Targets: ^{3}He, ^{4}He, CH_4, N, O, Ne, Ar, Kr, Xe
^{132}Xe

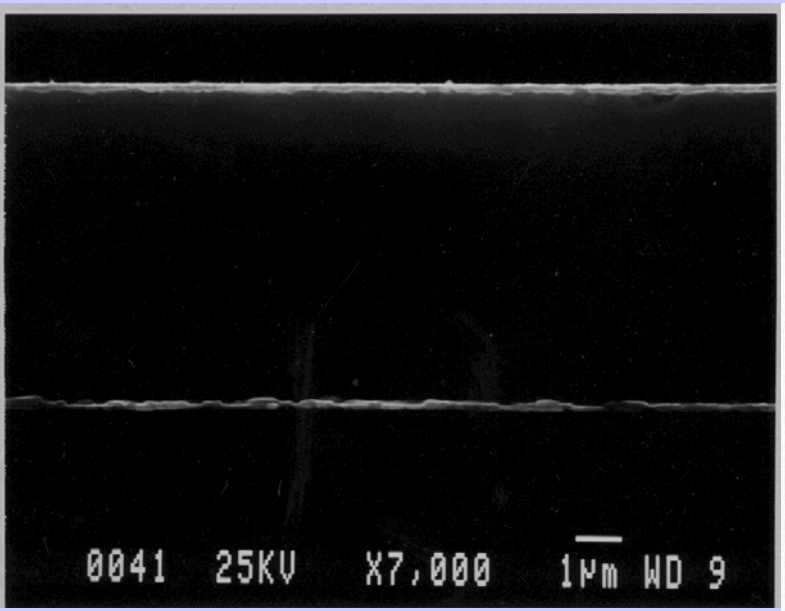

UNIVERSUM
(TIDIGT SKEDE)
TEMPERATUR (MeV)
200
100
0
KVARK-GLUON PLASMA
Ⓑ
KVARK-FRIGÖRELSE
HADRON
MATERIA
TUNG JON
KOLLISION
CELSIUS
GAS
VÄTSKA
Ⓒ
Ⓓ
Ⓐ
NEUTRONSTJÄRNOR
0
1
2
3
4
5
6
7
RELATIV BARYONTÄTHET

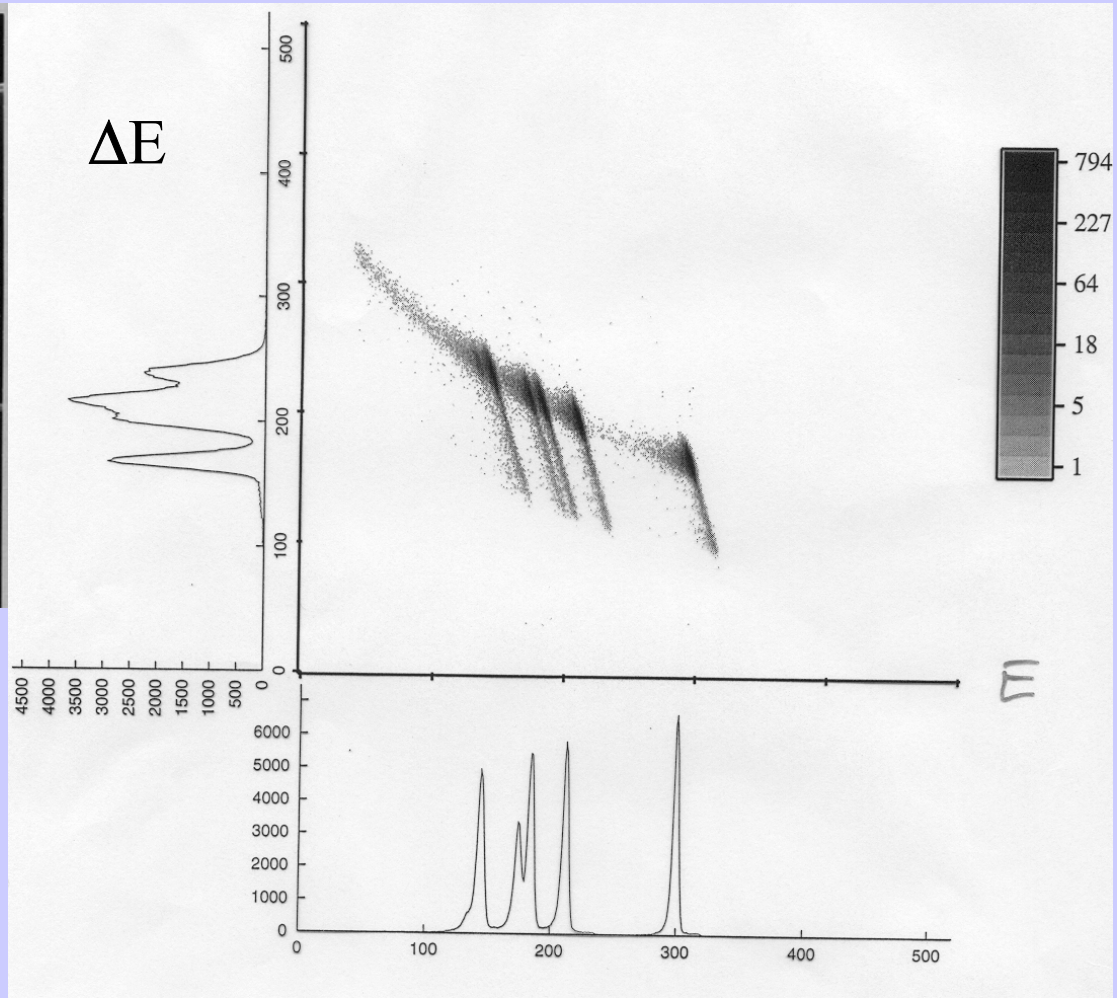

150
100
50
0
temperature (10^9 K)
GSI/SIS
CERN-SC
JINR DUBNA
liquid
gas
0
5
10
15
20
excitation energy per nucleon (MeV)

Detection of high-energy charged particles



Integrated ΔE-E detector





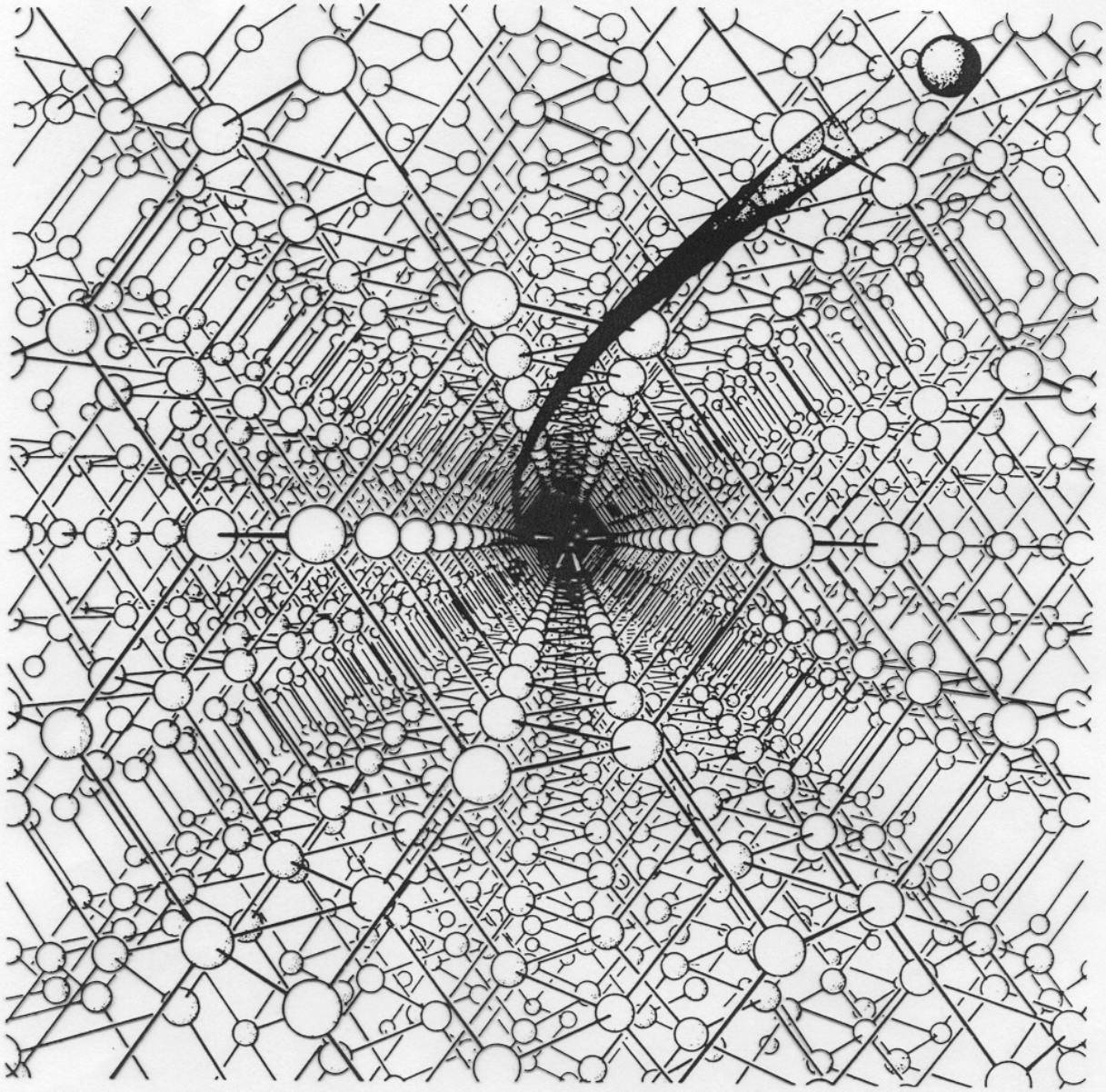
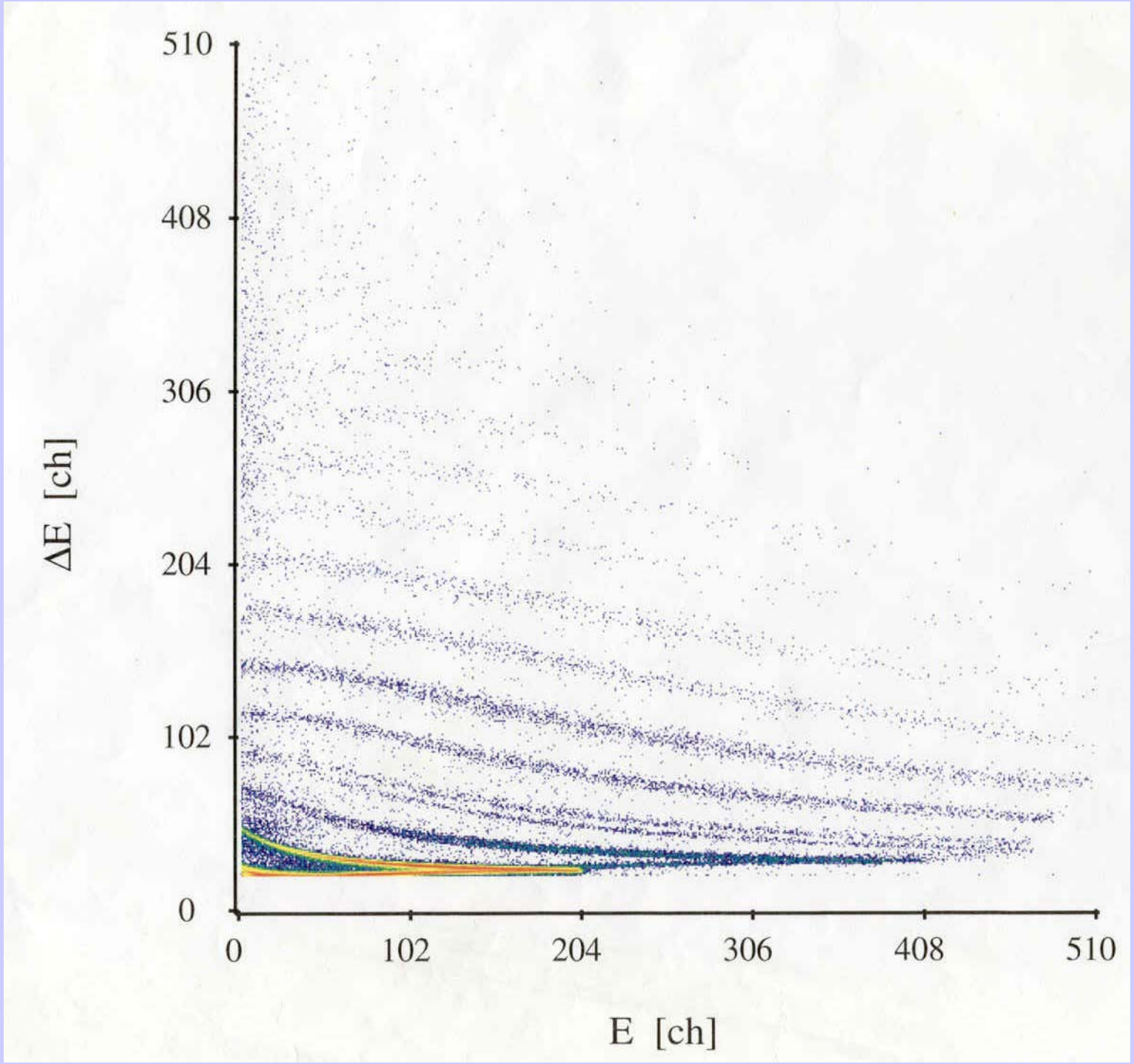
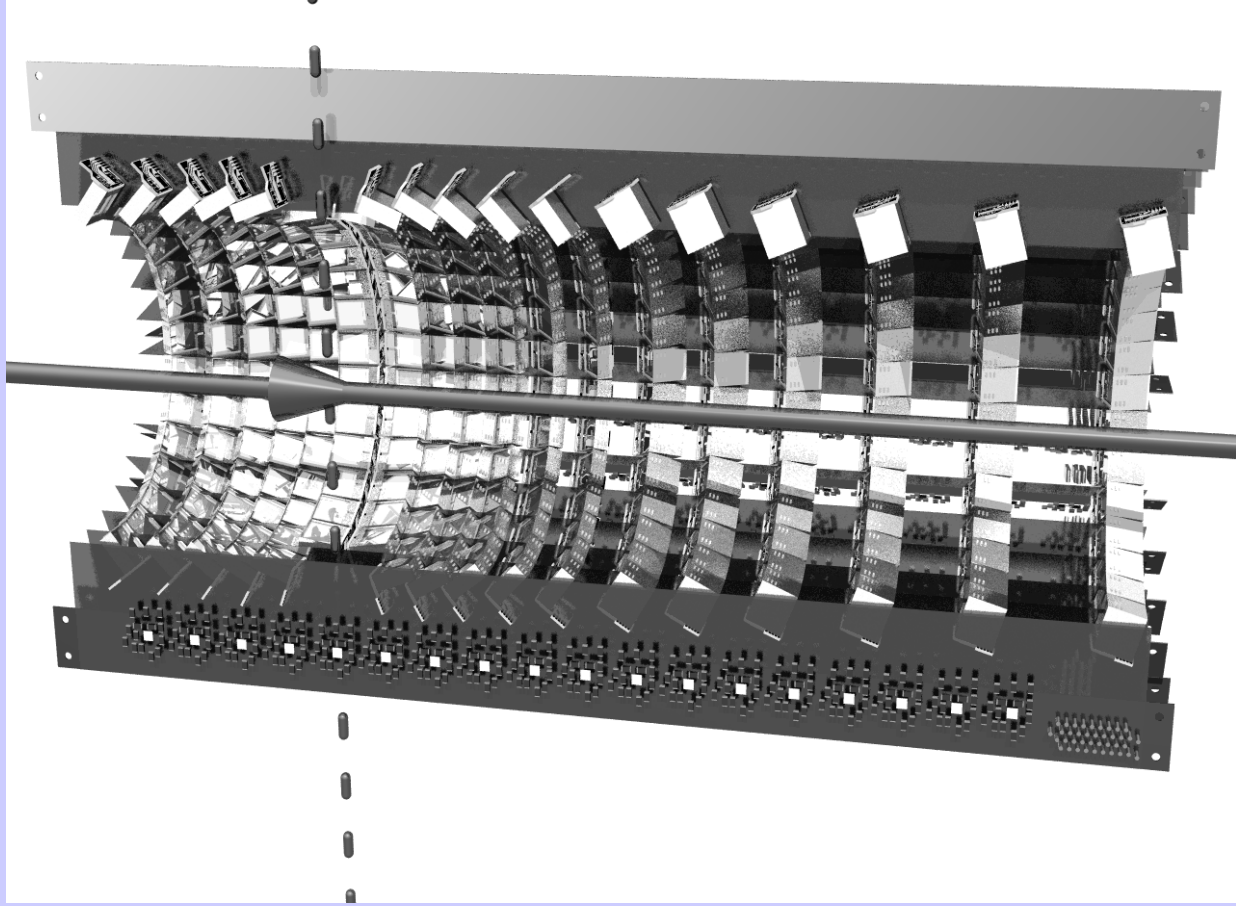


Fig. 9. Channeling of a particle in a crystal. From "Channeling in Crystals", by W. Brandt,


510
408
306
204
102
0
ΔE [ch]
0
102
204
306
408
510
E [ch]

CHIC
Collaboration
Lund
Uppsala
Copenhagen
Dubna
St. Petersburg
Cracow

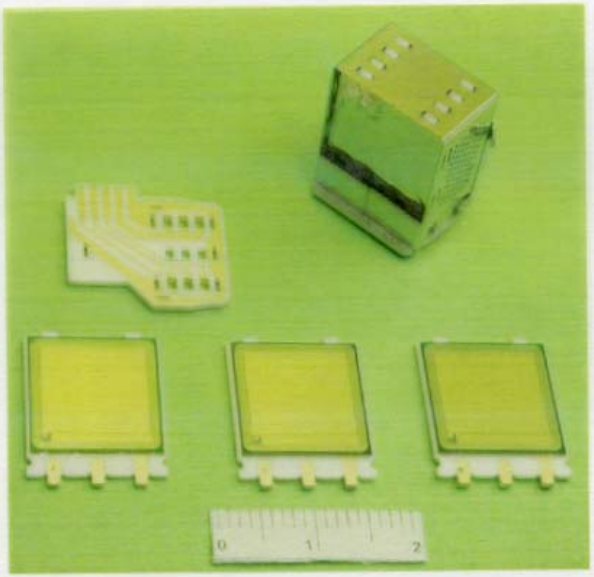


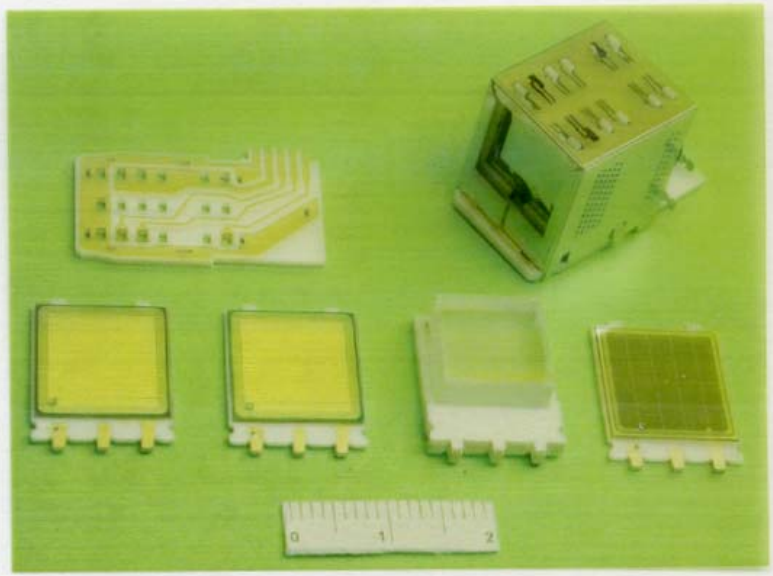
CHICSi: **C**ELSIUS **H**eavy **I**on **C**ollaboration **Si**licon detector system

- A compact Ultra-High Vacuum compatible detector system for studies of proton and light heavy-ion (N-Ar) reactions on cluster-jet targets of Ar - Xe

- 500 1.0 cm^2 telescopes Si (10 μm) + Si (300 μm) + Si (300 μm veto) or
  6 mm GSO crystal + PhD

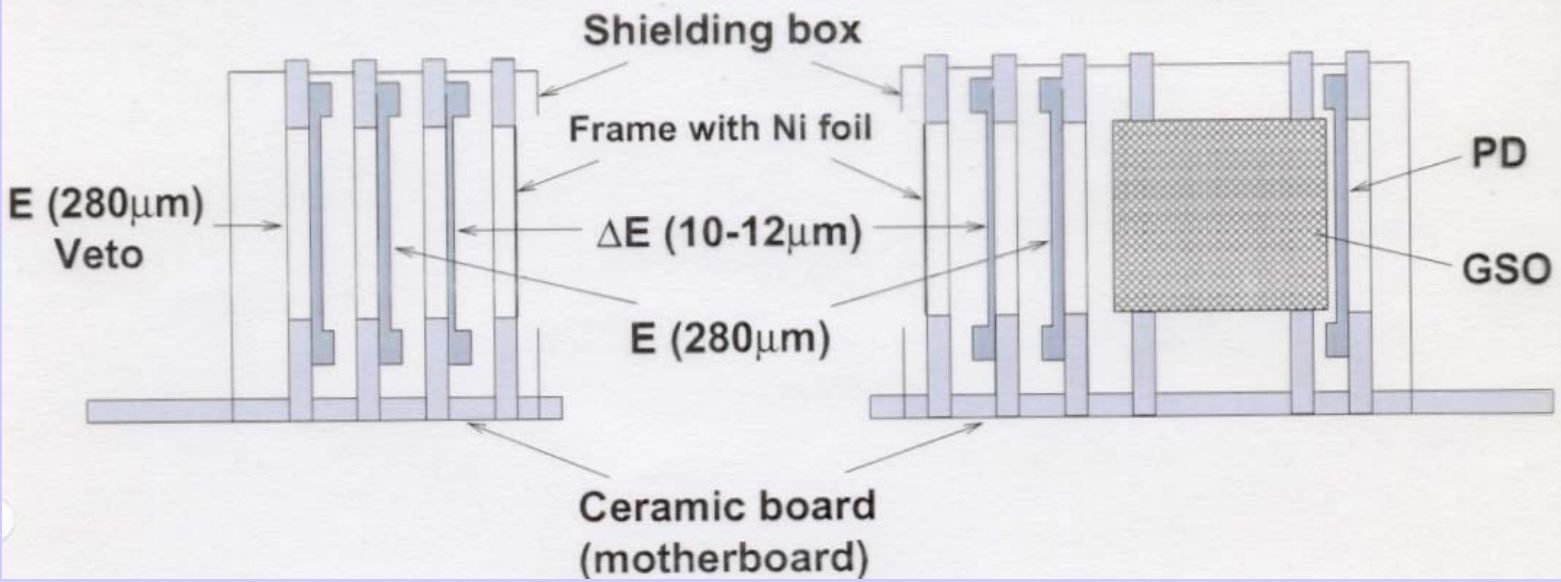
-Identify intermediate mass fragments **$3 \leq Z \leq 10$;** Threshold 700A keV



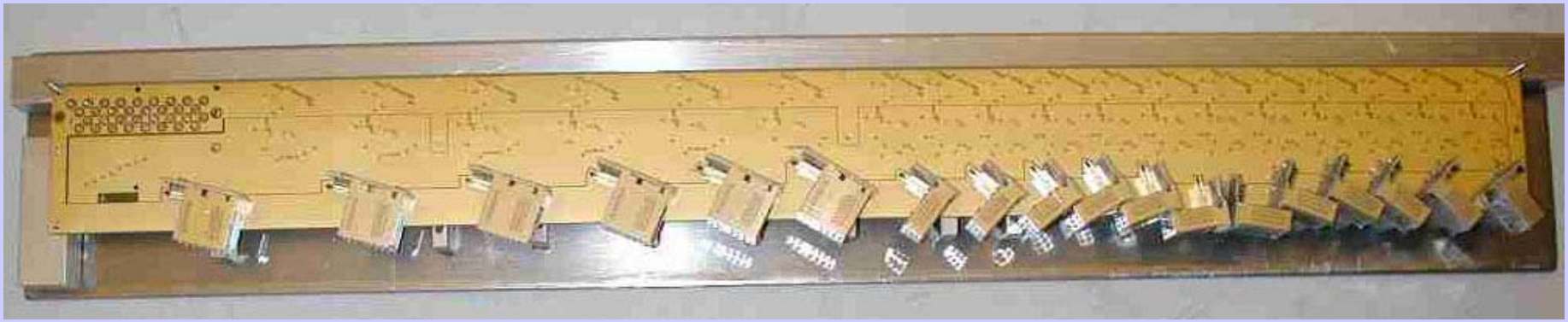


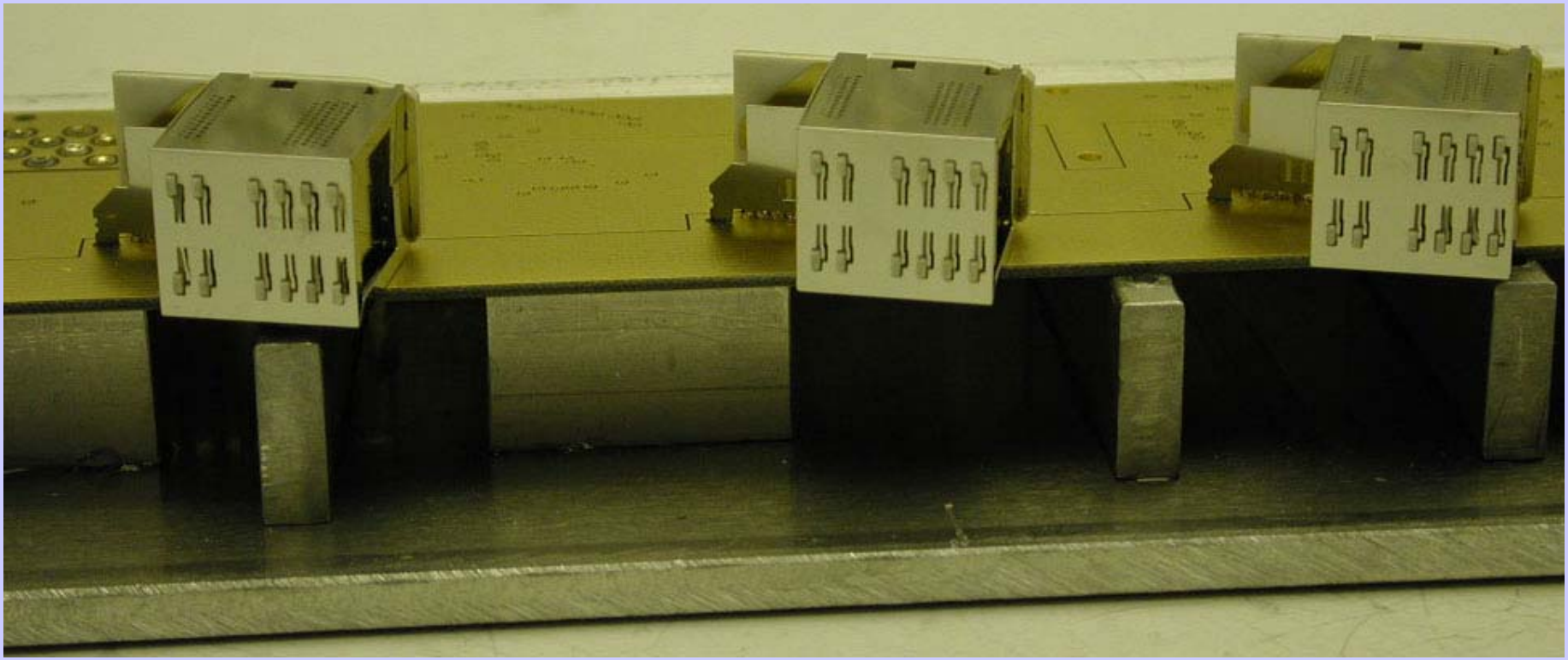
Large Angle Telescope

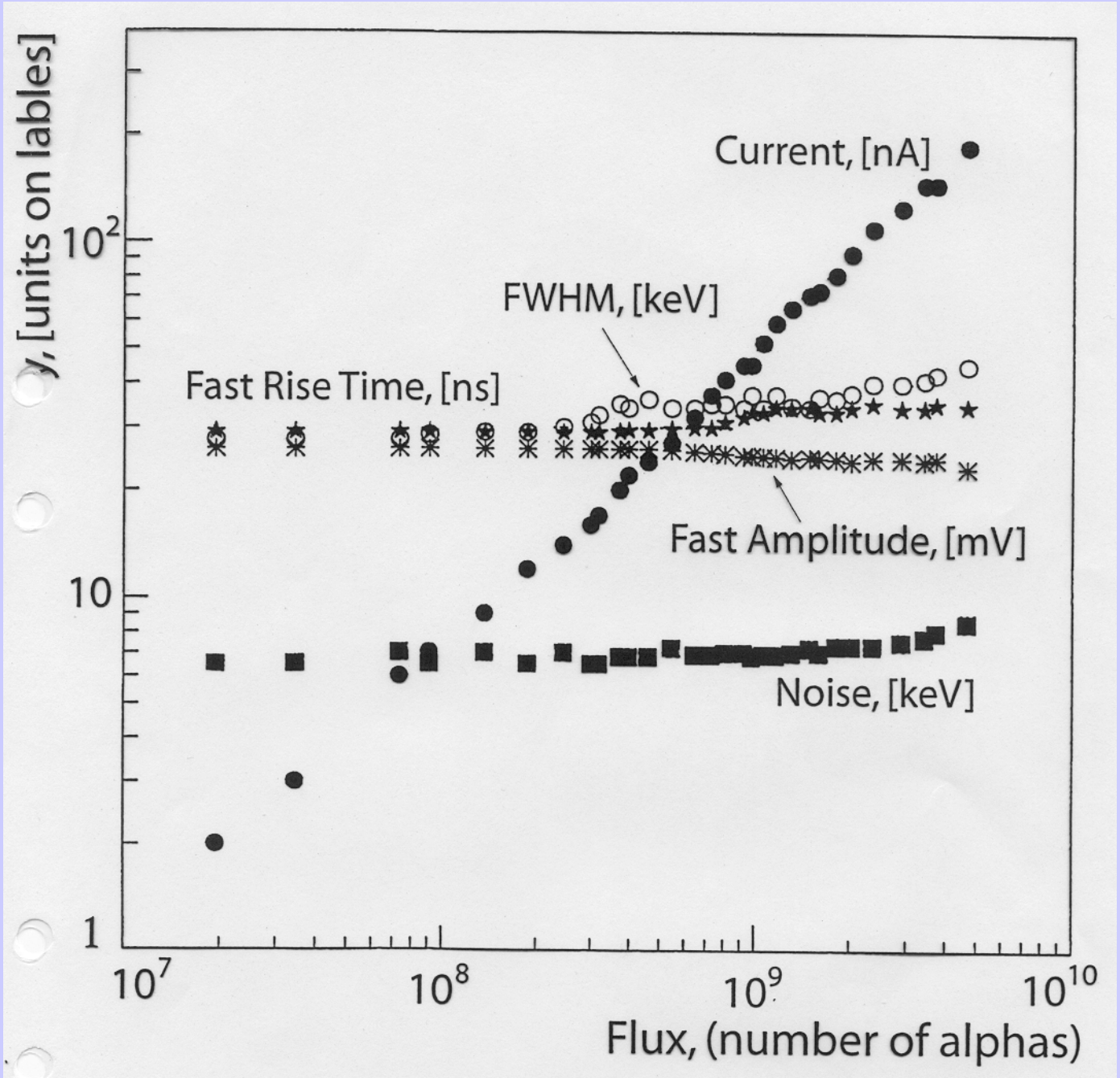
Forward Angle Telescope



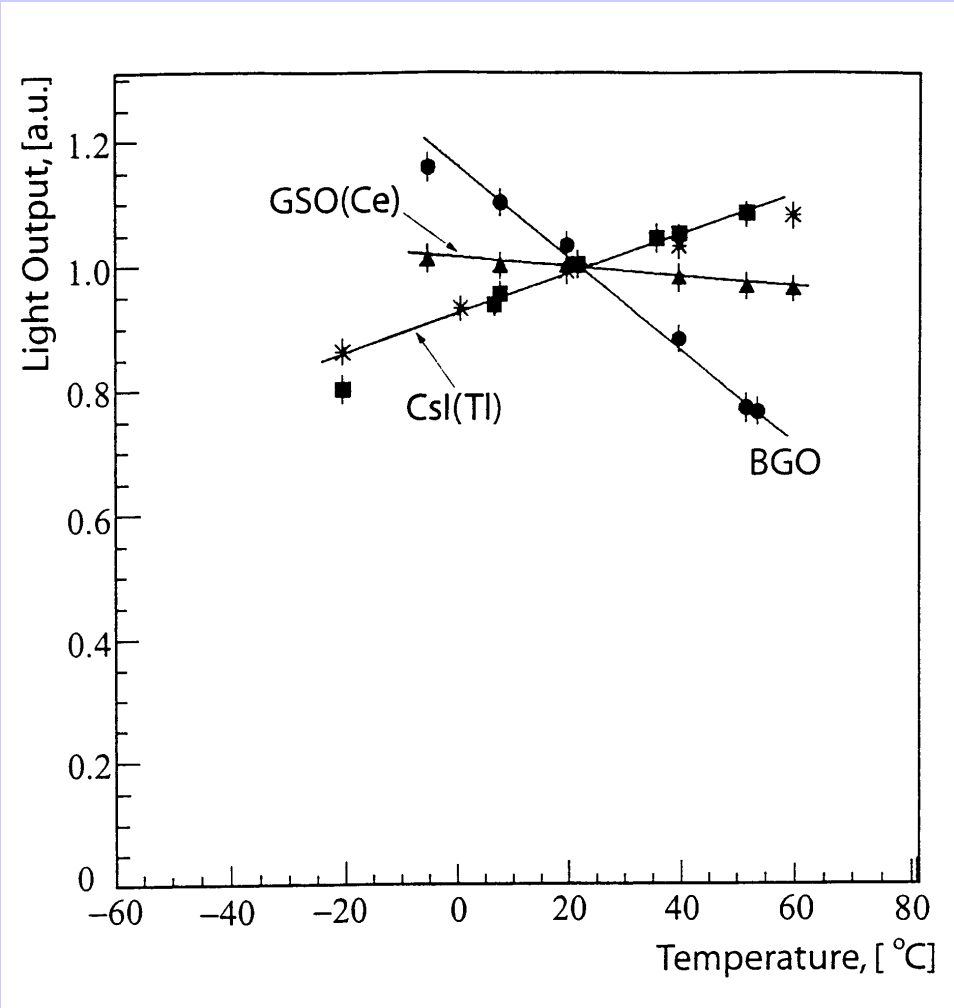
GrandMother board

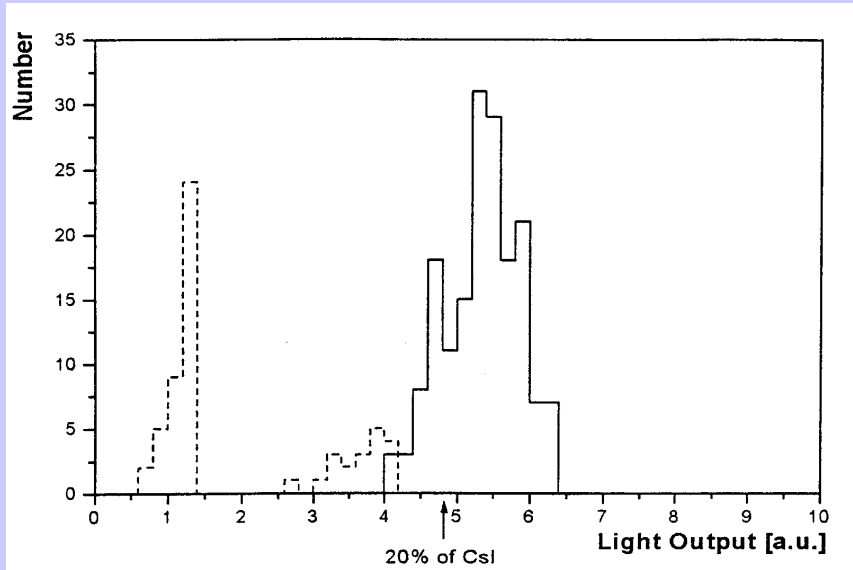


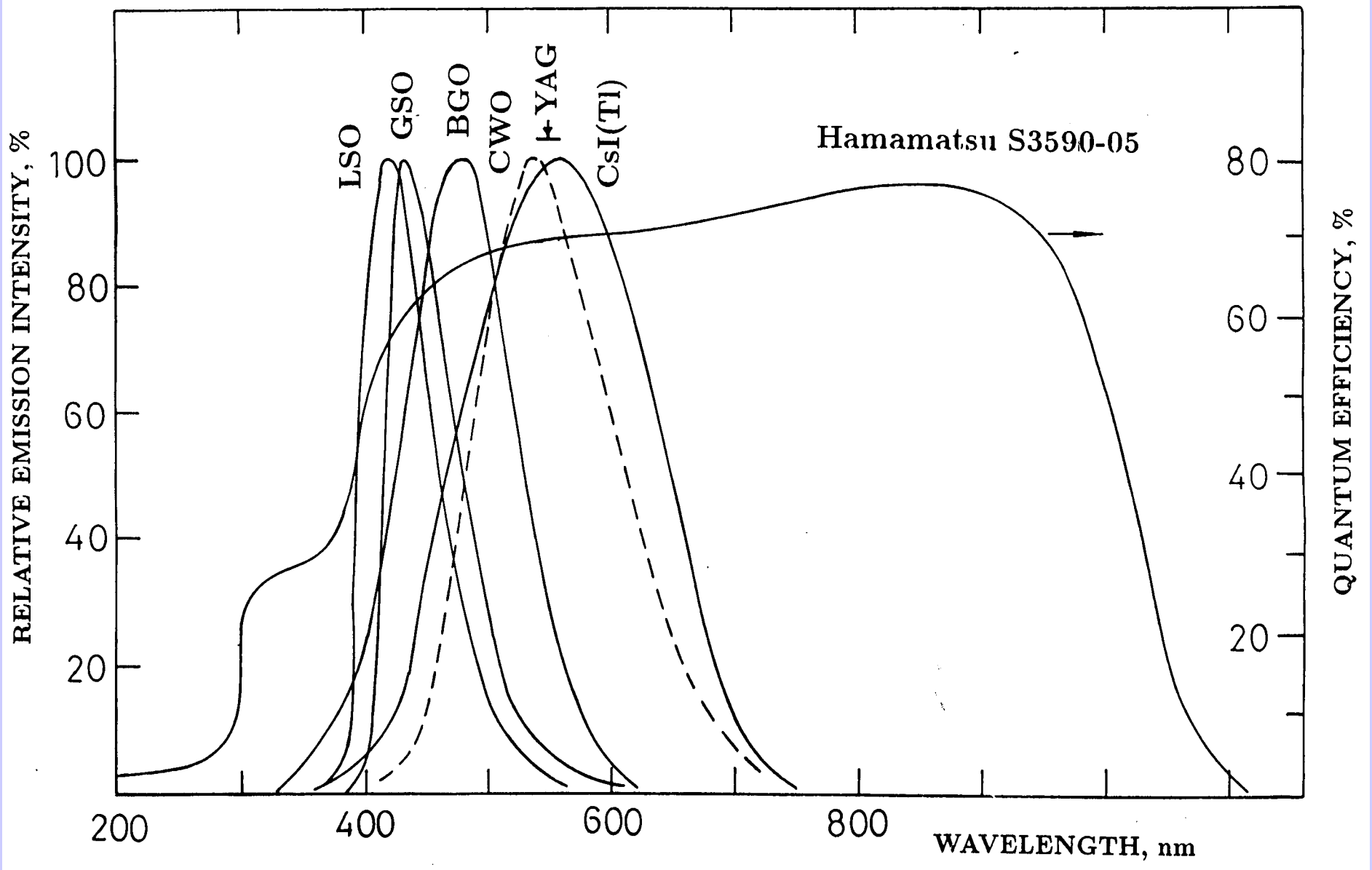


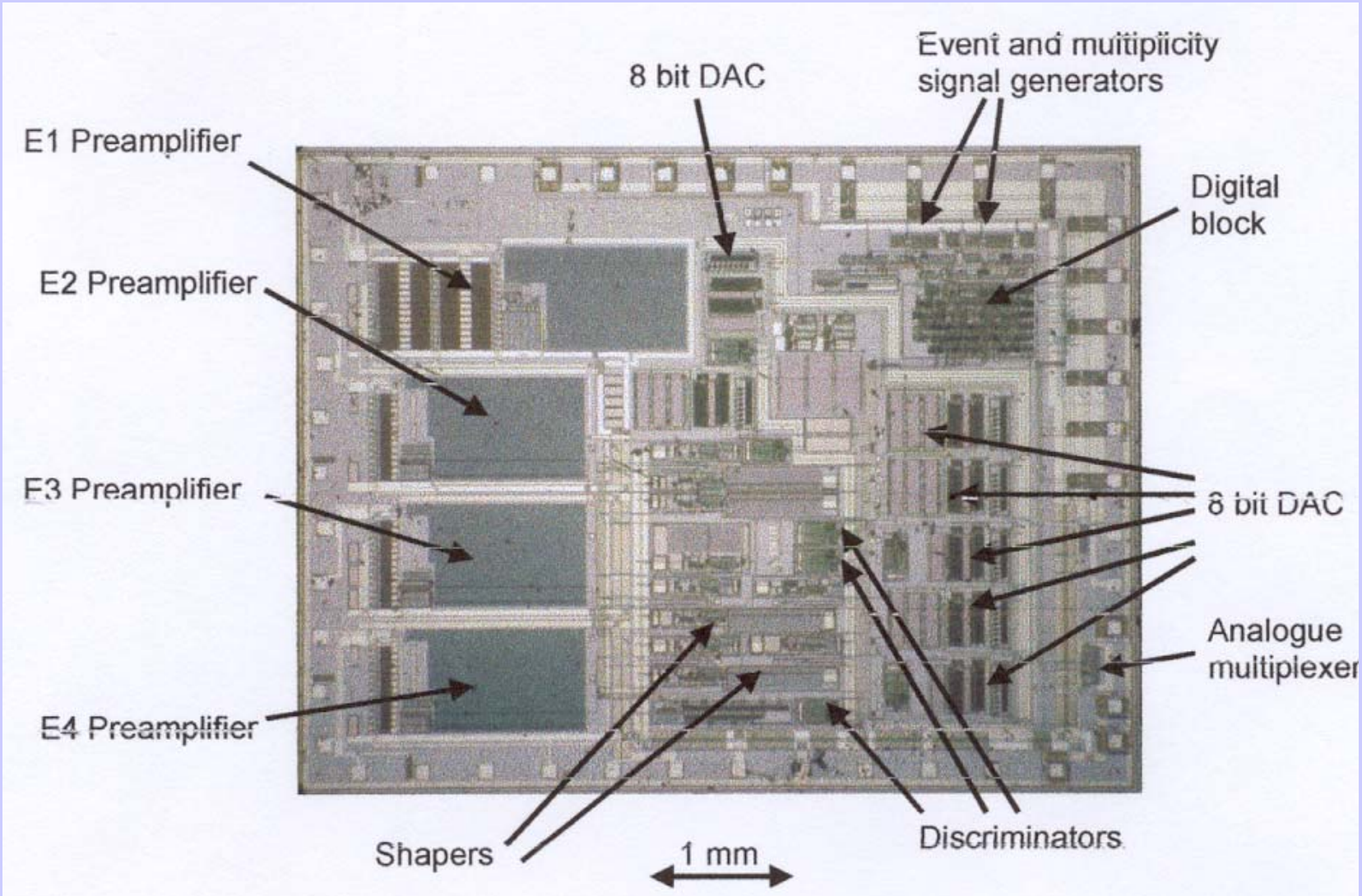

y, [units on lables]
10^2
10
1
Current, [nA]
FWHM, [keV]
Fast Rise Time, [ns]
Fast Amplitude, [mV]
Noise, [keV]
10^7
10^8
10^9
10^{10}
Flux, (number of alphas)

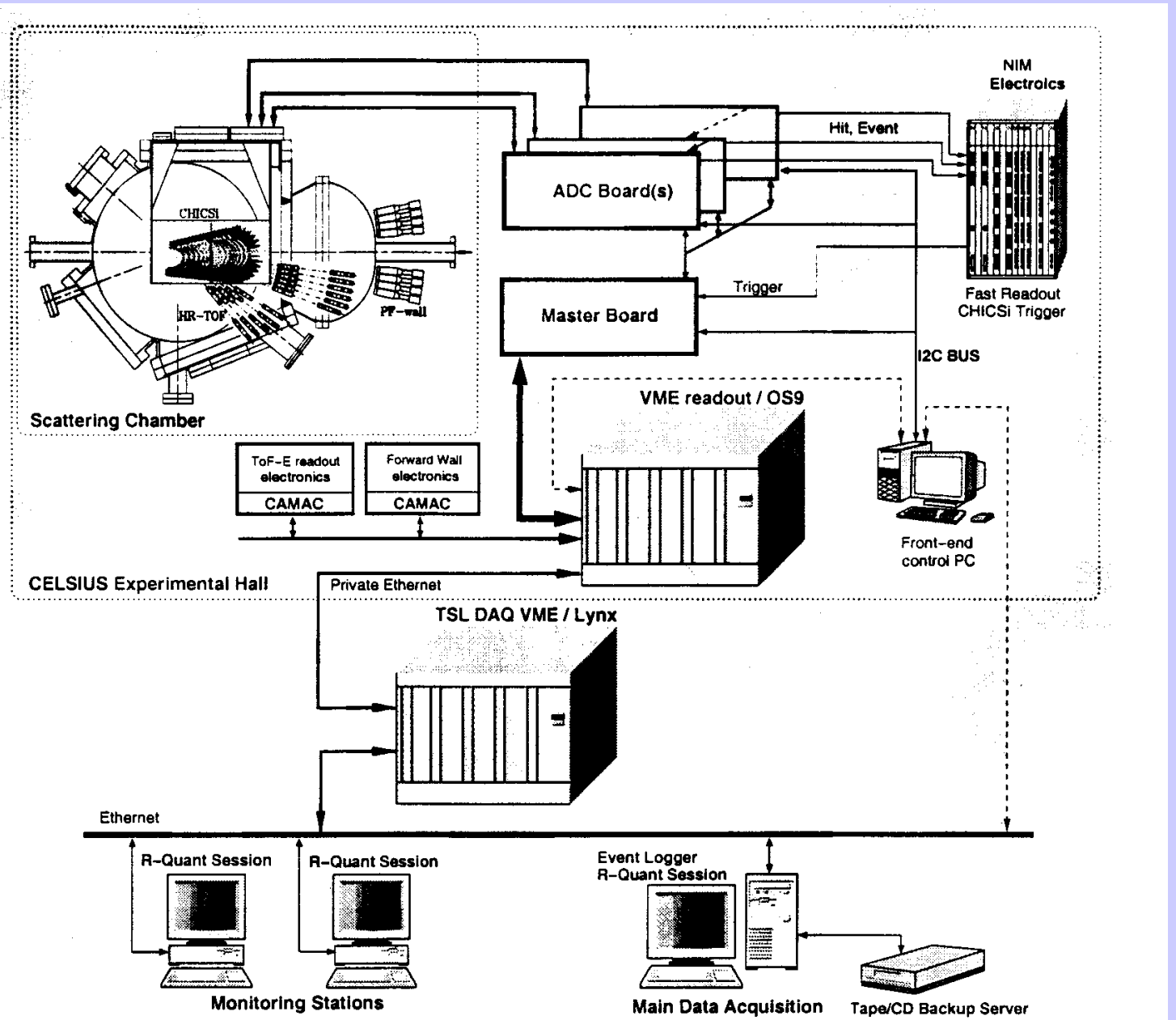
GSO
(GD_2SiO_5)

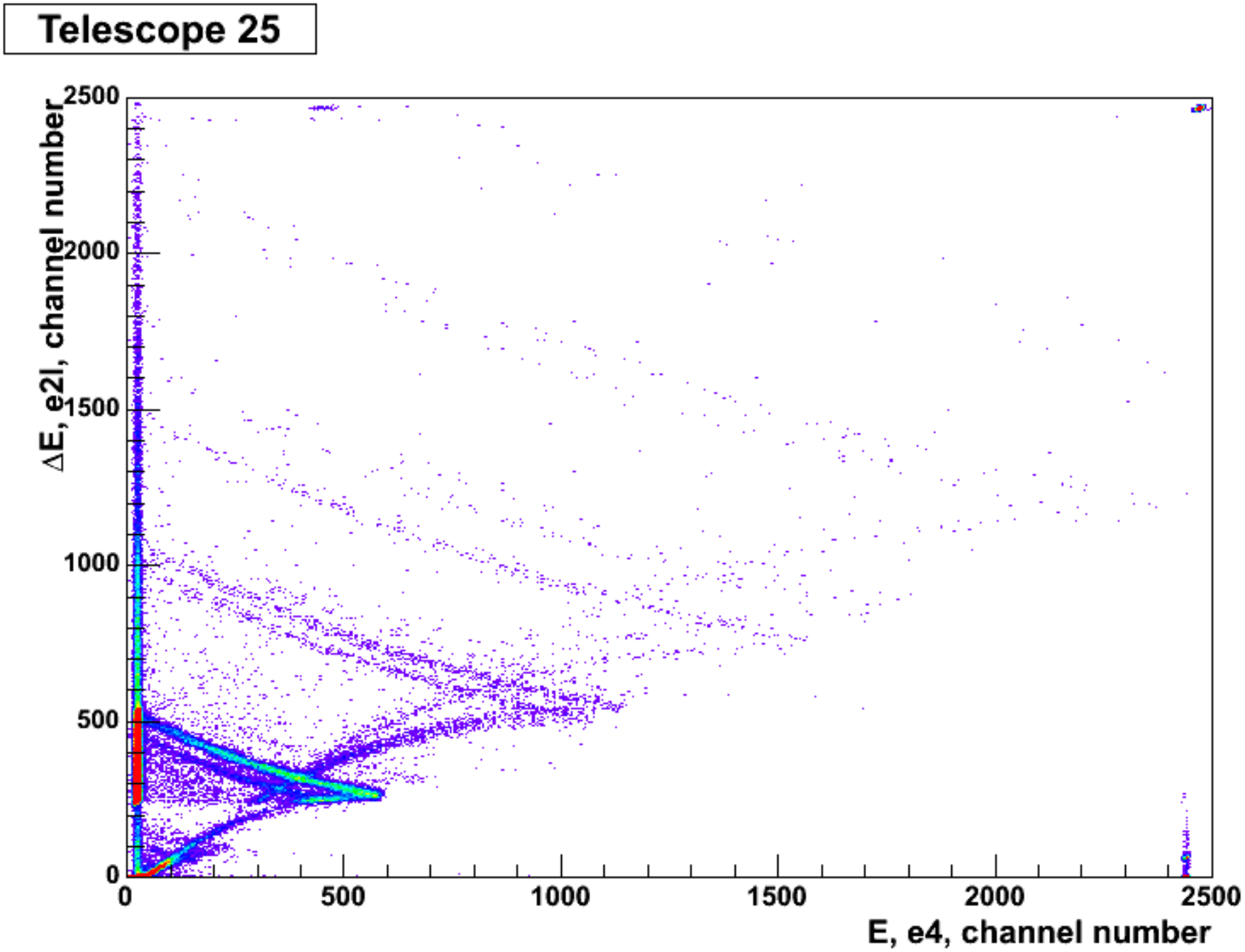

Light Output, [a.u.]
1.2
1.0
0.8
0.6
0.4
0.2
0
GSO(Ce)
CsI(Tl)
BGO
−60
−40
−20
0
20
40
60
80
Temperature, [°C]


Number
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
20% of CsI
Light Output [a.u.]

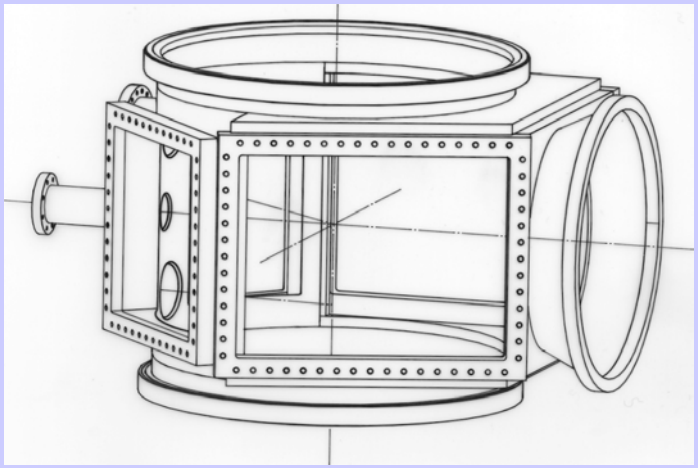

LSO
GSO
BGO
CWO
YAG
CsI(Tl)
Hamamatsu S3590-05
RELATIVE EMISSION INTENSITY, %
QUANTUM EFFICIENCY, %
WAVELENGTH, nm
100
80
60
40
20
80
60
40
20
200
400
600
800

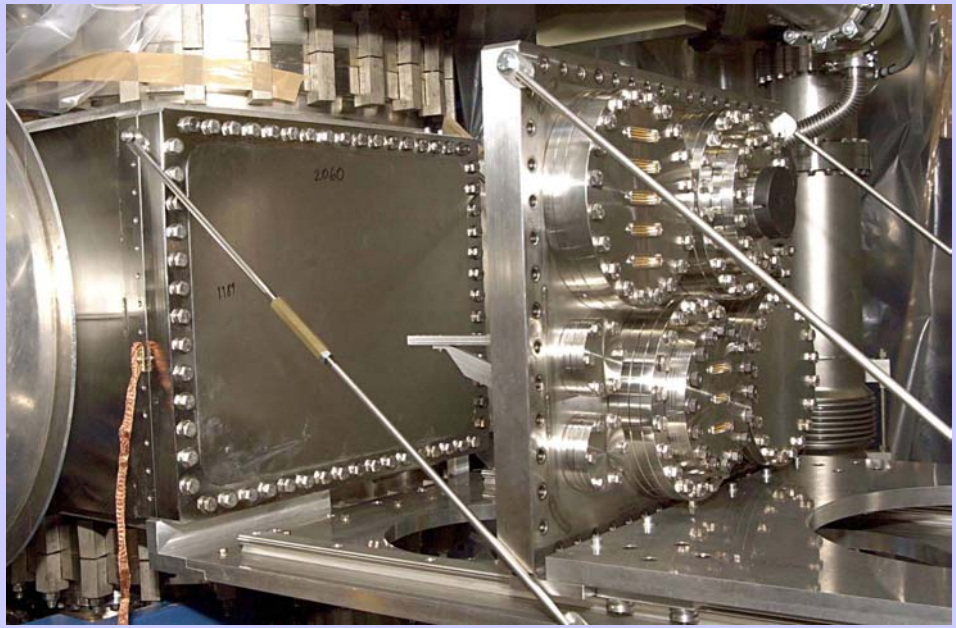

8 bit DAC
Event and multiplicity signal generators
E1 Preamplifier
Digital block
E2 Preamplifier
E3 Preamplifier
8 bit DAC
Analogue multiplexer
E4 Preamplifier
Shapers
1 mm
Discriminators


NIM
Electroics
Hit, Event
ADC Board(s)
CHICSi
HR-TOF
PF-wall
Trigger
Master Board
Fast Readout
CHICSi Trigger
I2C BUS
VME readout / OS9
Scattering Chamber
ToF-E readout
electronics
CAMAC
Forward Wall
electronics
CAMAC
Front-end
control PC
CELSIUS Experimental Hall
Private Ethernet
TSL DAQ VME / Lynx
Ethernet
R-Quant Session
R-Quant Session
Event Logger
R-Quant Session
Monitoring Stations
Main Data Acquisition
Tape/CD Backup Server


Telescope 25
ΔE, e2l, channel number
2500
2000
1500
1000
500
0
0
500
1000
1500
2000
2500
E, e4, channel number

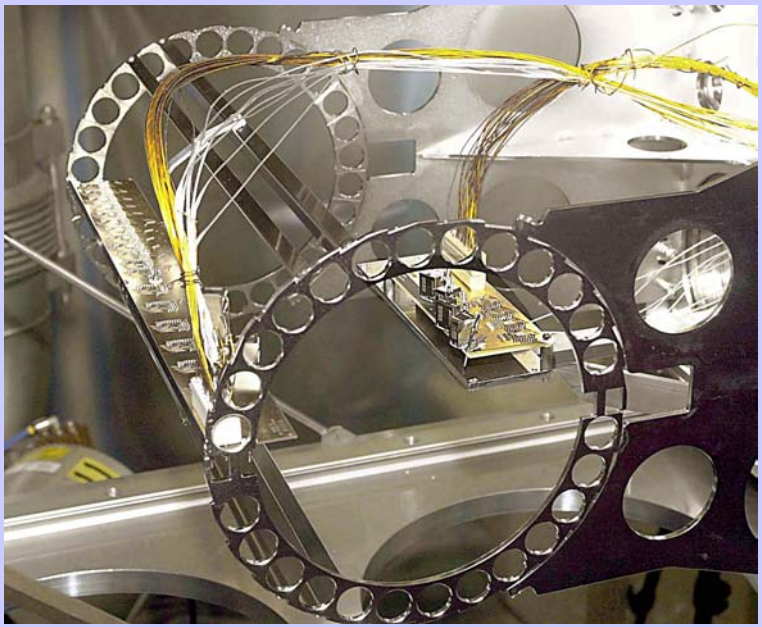
Scattering chamber



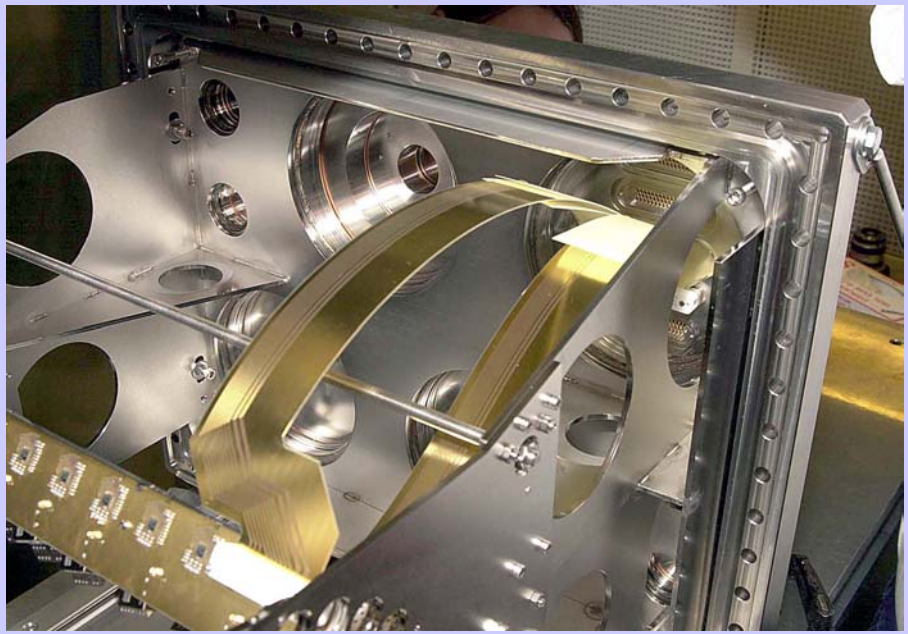


Readout cables

Kapton-insulated cables



Printed-circuit board cable



Auxiliary detector systems:

External:

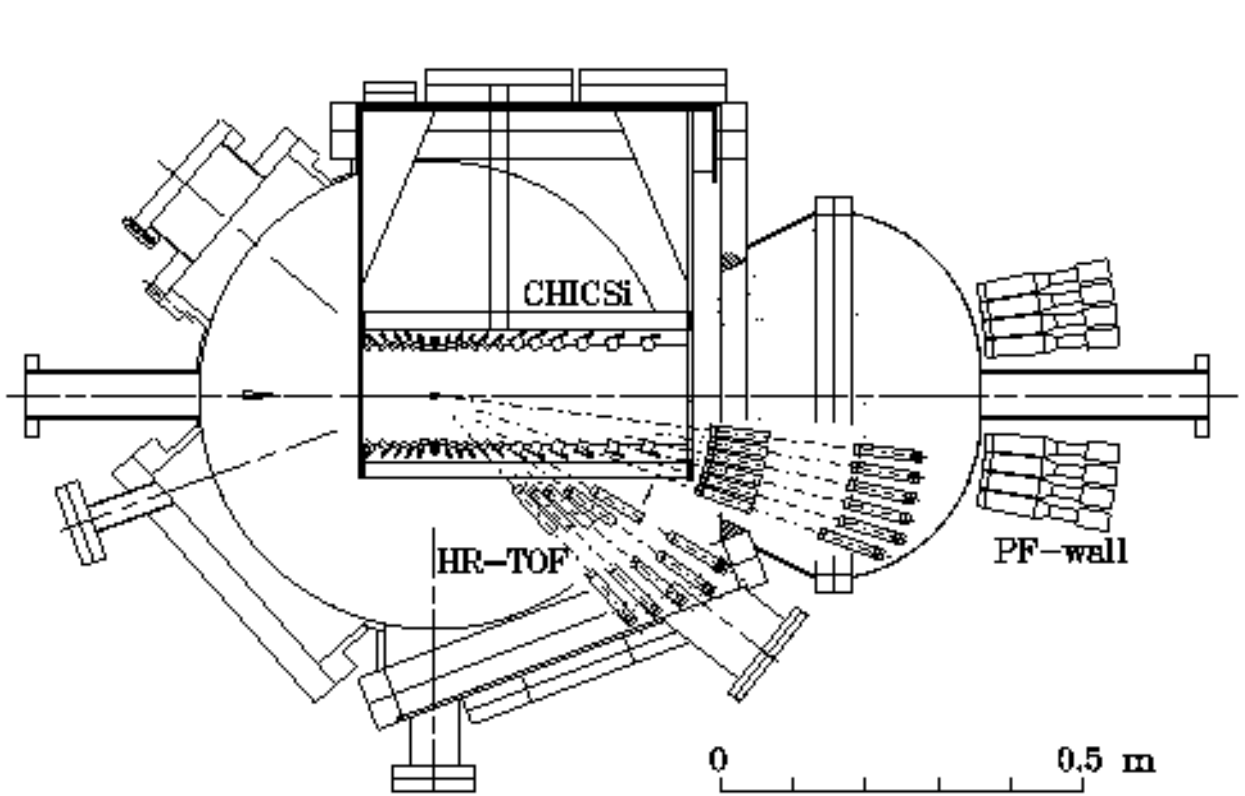
PF-WALL

Projectile **F**ragmentation **WALL**

3.9 ° – 11-7 °

Z identification: **Z ≤ 18,**

Mass identification: **H - He**



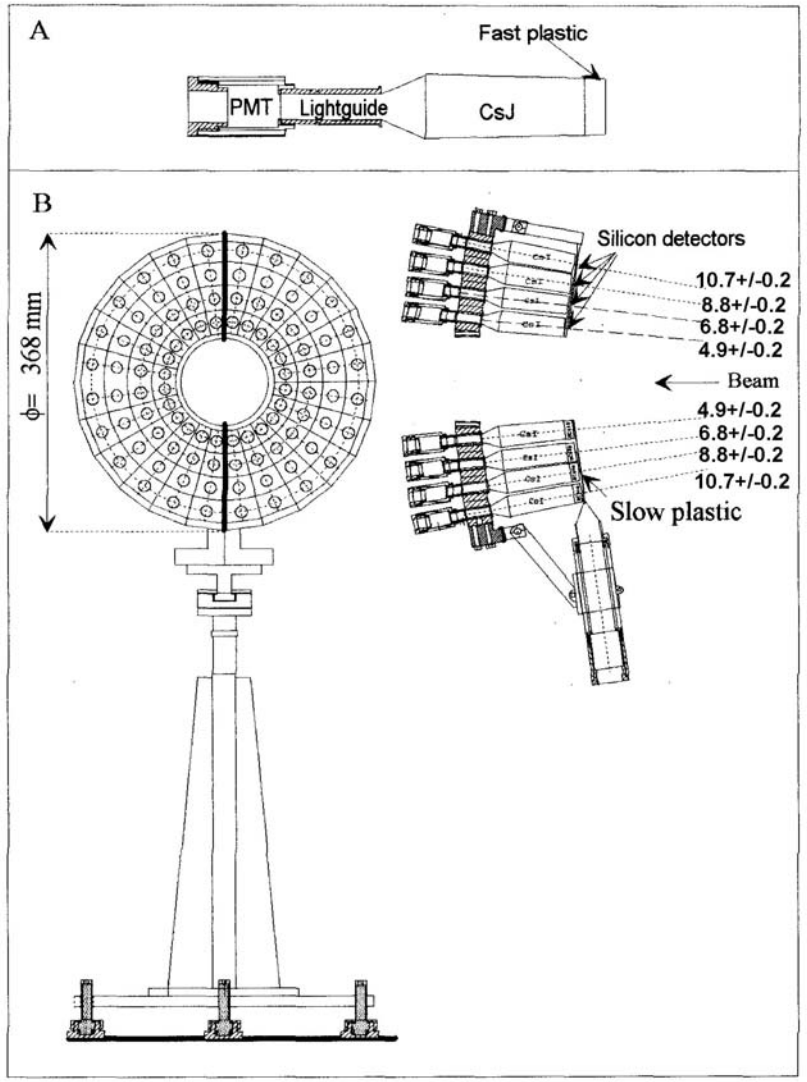
Pion detectors External range detectors

Internal:

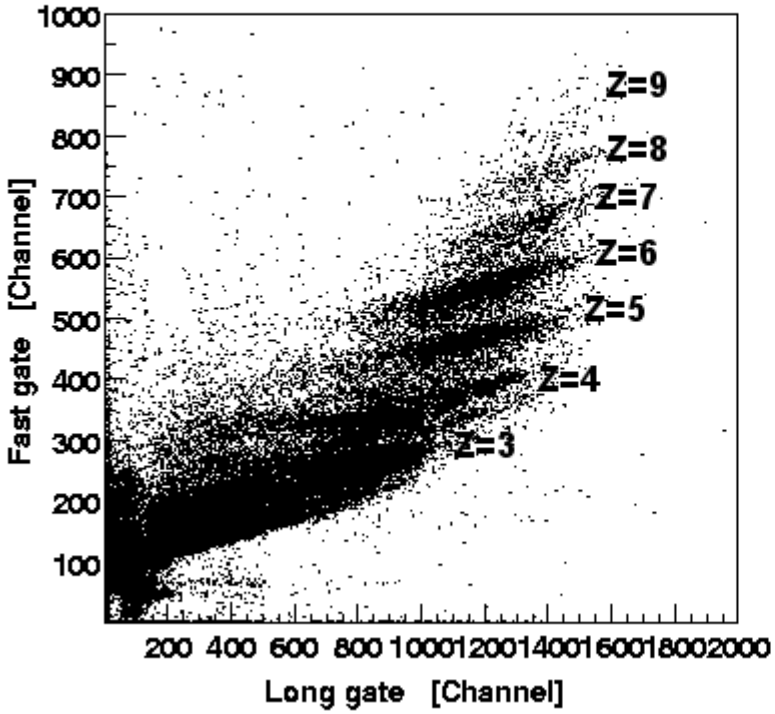
HR-TOF Internal **H**eavy-**R**ecoil **T**ime **o**f **F**light detector system

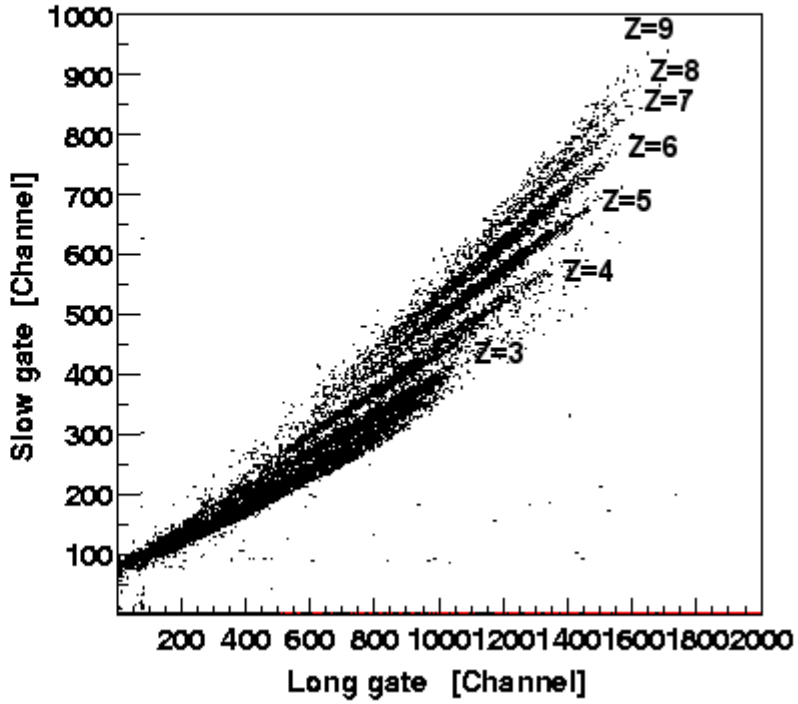
50 – 500A keV (Threshold 35A keV for mass 100)

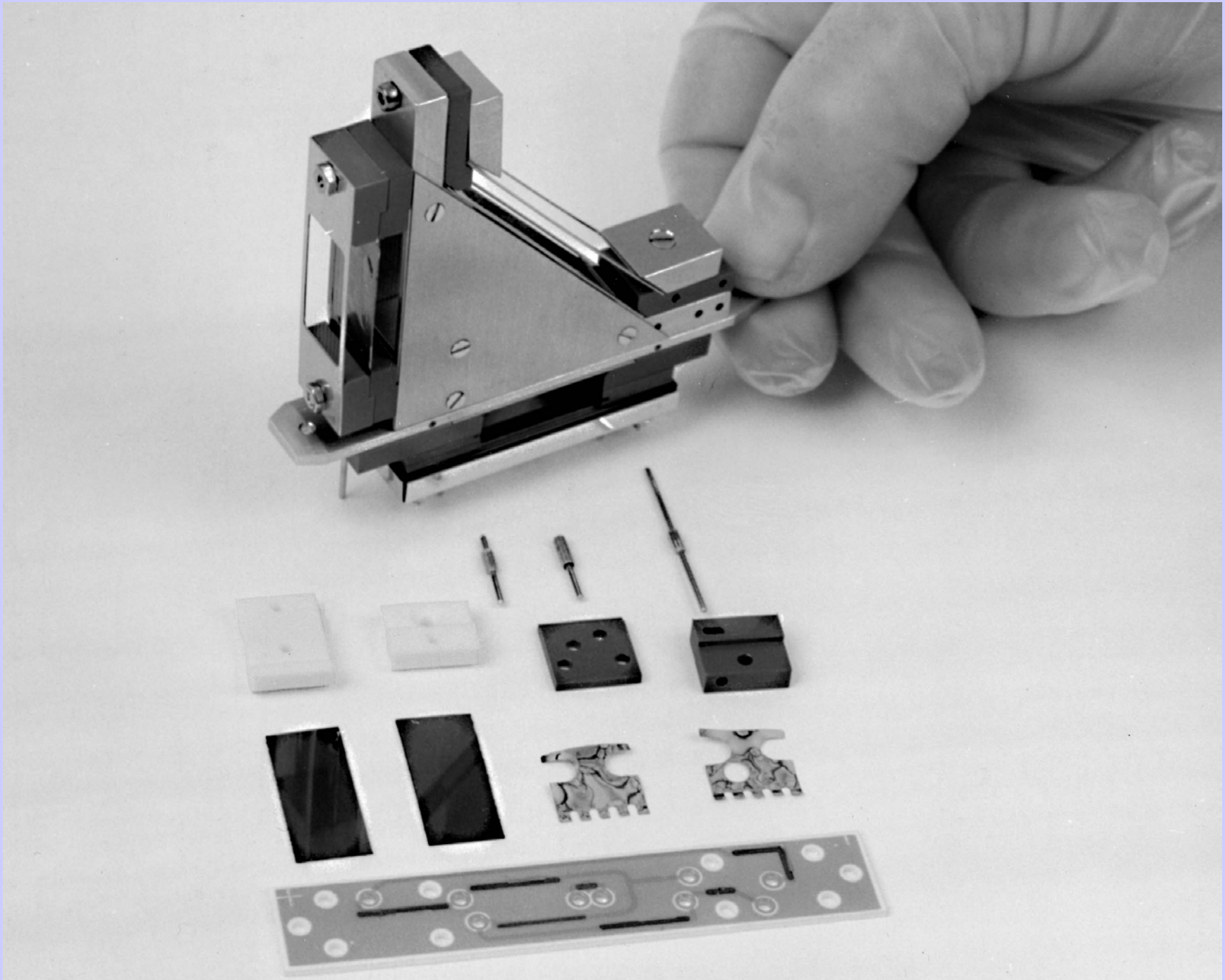
PF-WALL

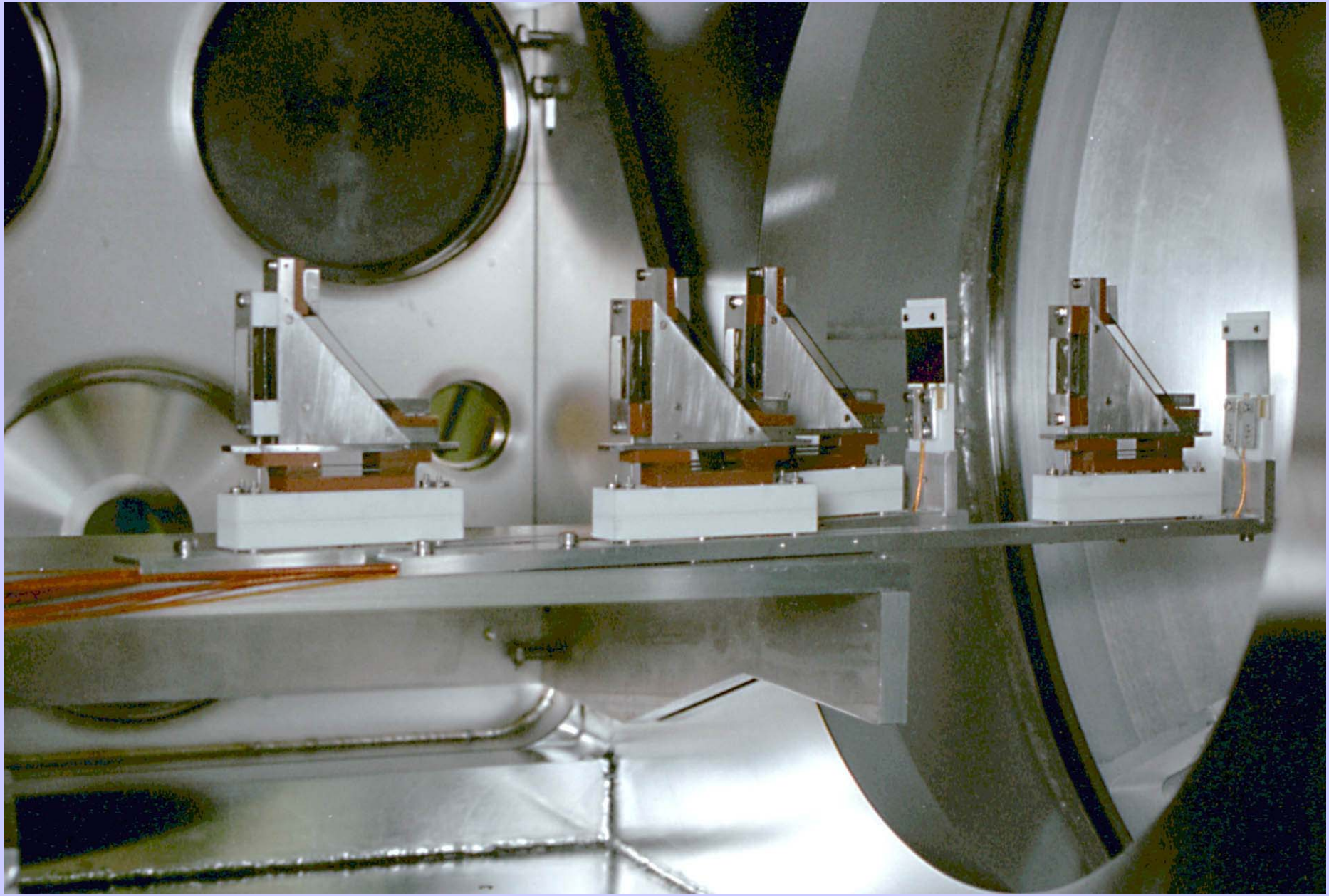

A
Fast plastic
PMT
Lightguide
CsJ
B
368 mm
Silicon detectors
10.7+/-0.2
8.8+/-0.2
6.8+/-0.2
4.9+/-0.2
Beam
4.9+/-0.2
6.8+/-0.2
8.8+/-0.2
10.7+/-0.2
Slow plastic

Phoswich detector @ 4.9 deg [Ne + Kr @ 200MeV/nucleon]

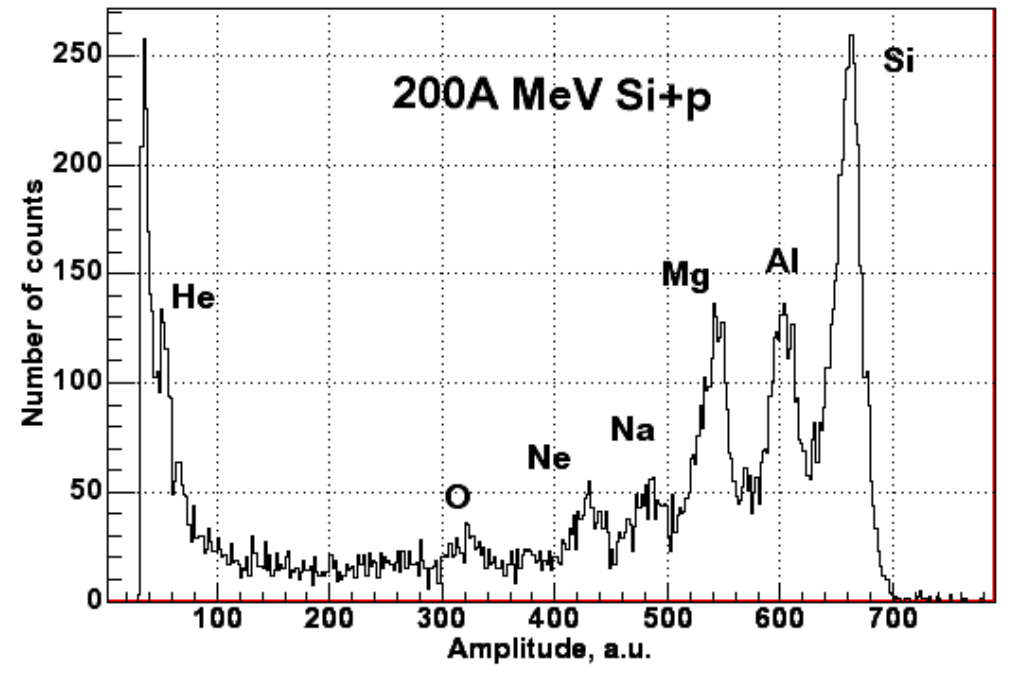


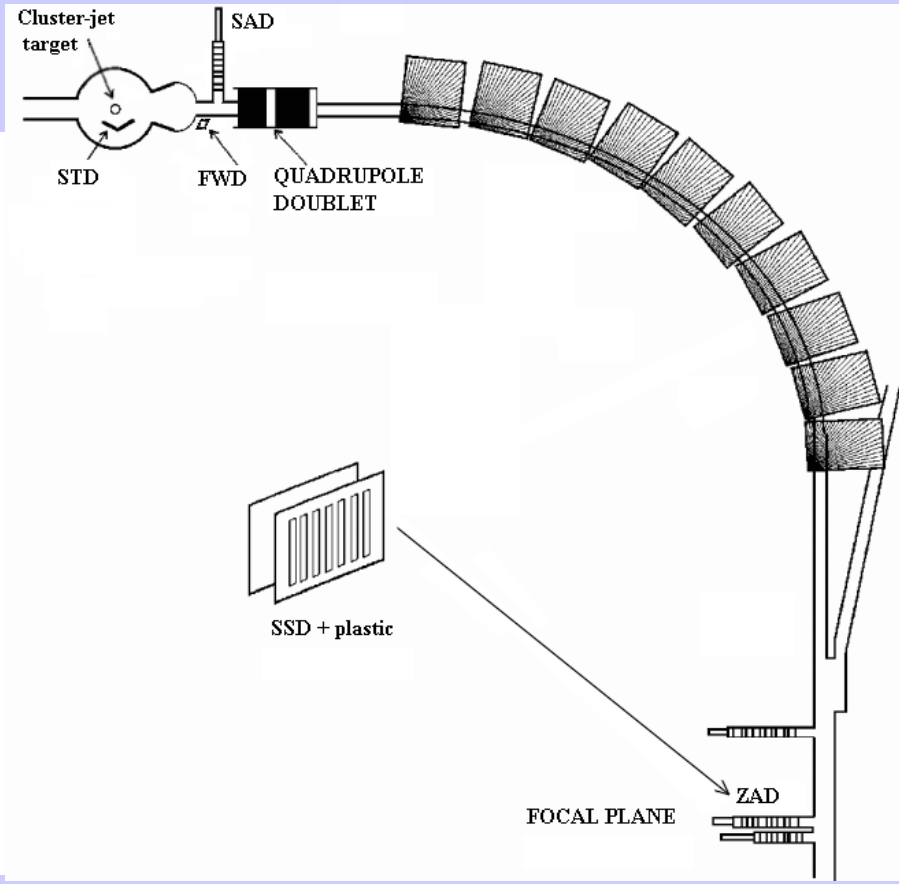






Inverse kinematics for study of intermediate energy reactions relevant to SEE and medical problems





Att utforska mikrokosmiska föremål är som att försöka lista ut vad som finns i ett mörkt rum utan att gå in och tända ljuset. Man måste oftast störa, t.o.m. förstöra, föremålet för att det skall sända ut signaler som kan avslöja hur det "ser ut".