PAUL SCHERRER INSTITUT

Irradiation Facilities at PSI

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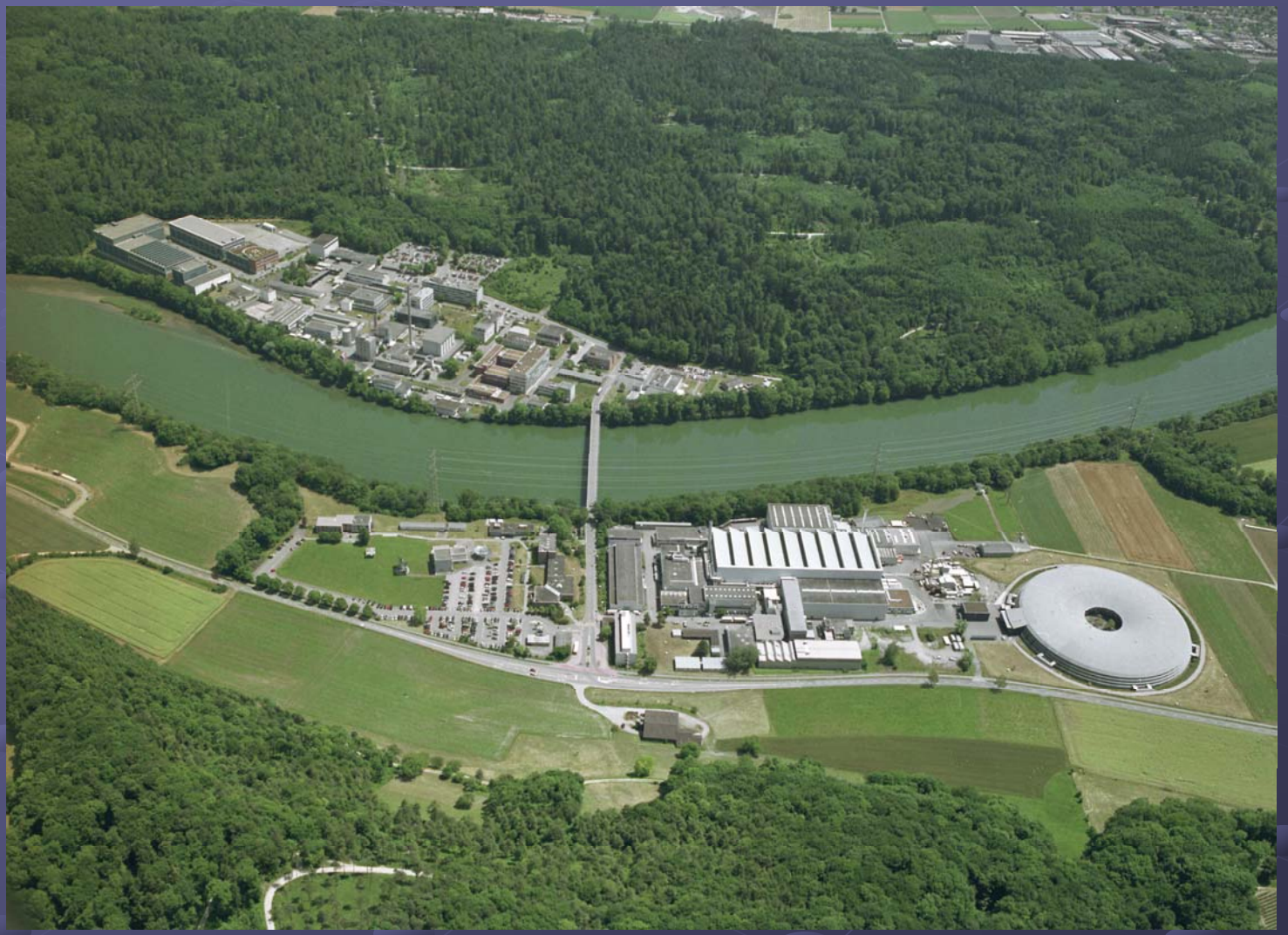
Outline

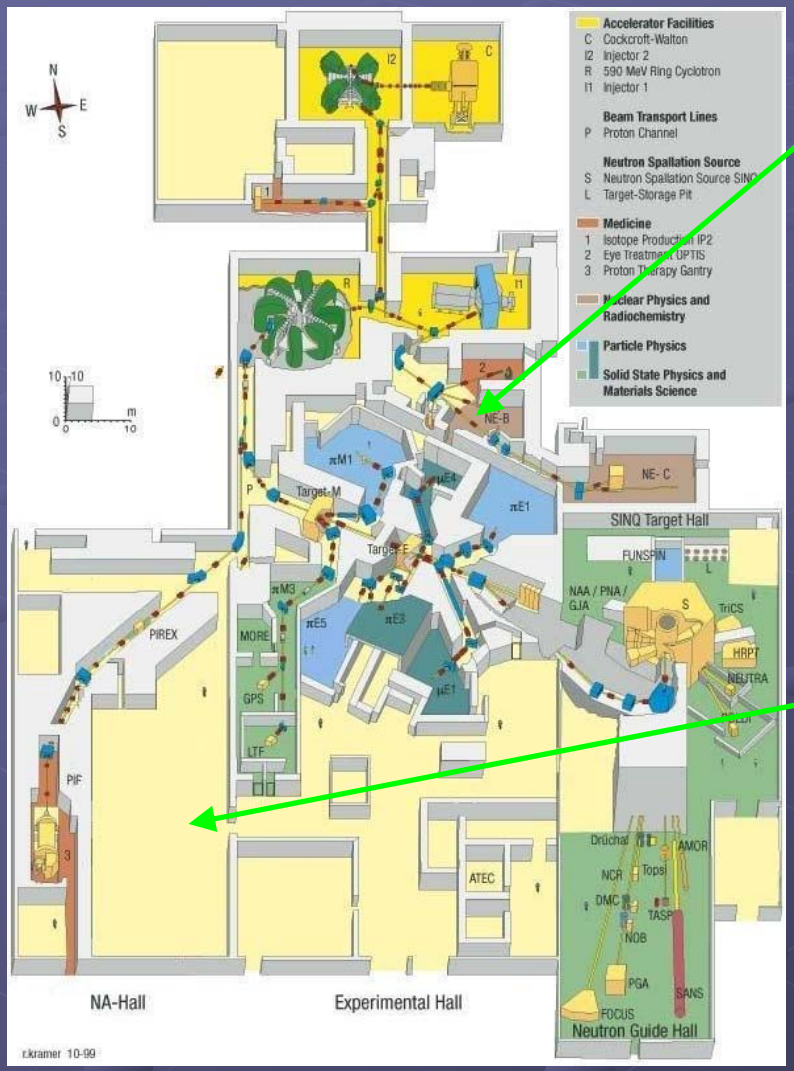
- Low energy PIF NEB
- New PIF at PROSCAN E<250 MeV
- Other PSI facilities
- Summary

Paul Scherrer Institut



Location of PSI

Experimental Hall and Accelerators

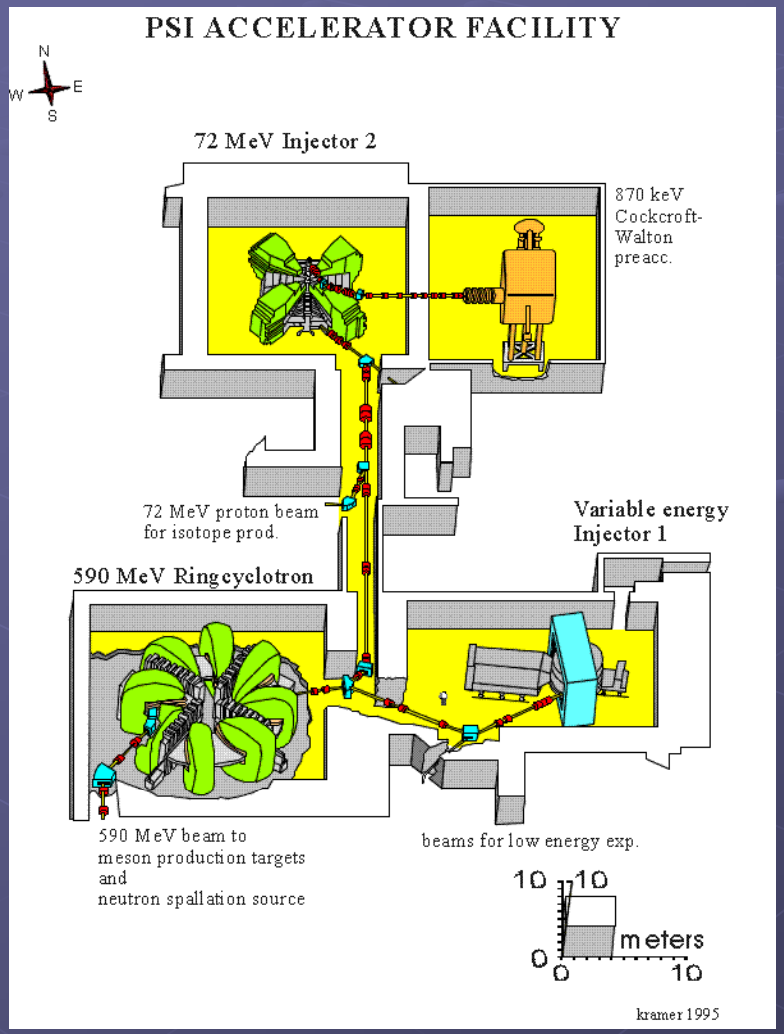


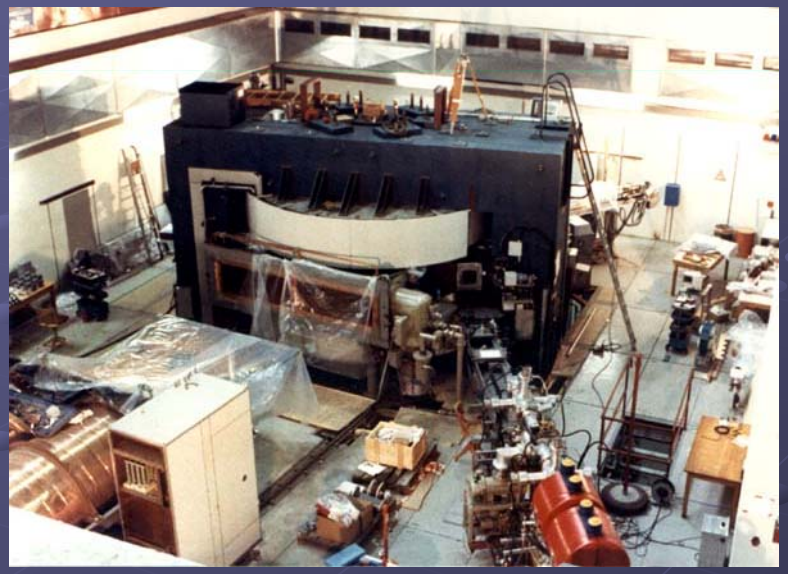
NEB Area
LE PIF

Experimental Area
HE PIF

PROSCAN Area Layout

Main Accelerators and Injector 1





Injector 1 Phillips cyclotron

Variable energy and particles

Proton E_{max} = 72 MeV

Operation until end of 2008:

- OPTIS,
- PIF,
- HI for Radiochemistry
- LISOR – material science

Proton Irradiation Facility

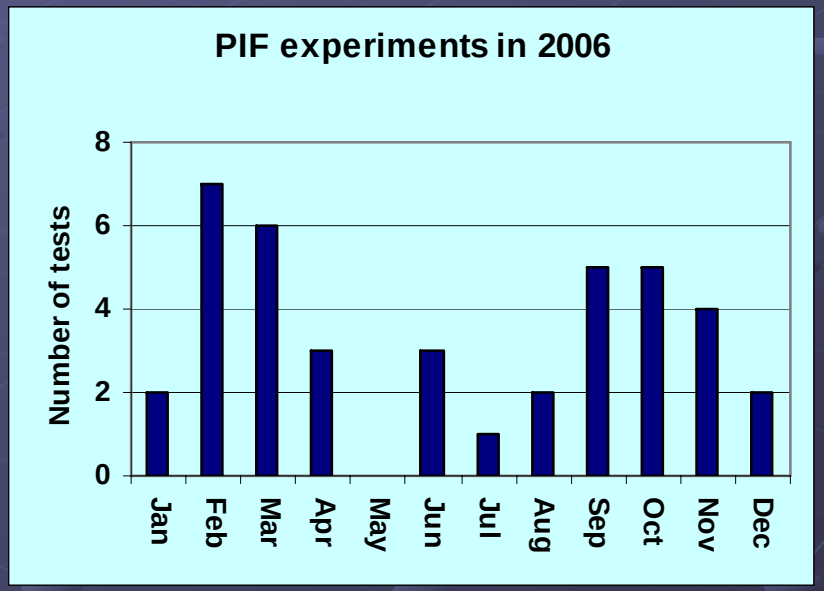
- PIF - user-lab for radiation effects studies in electronics
- Realistic simulation of proton space environment
- Mono-energetic proton beams for radiation tests
- Calibration station for monitors and detectors
- Radiation qualification for space technologies
- Operates since 1992

PIF Typical Features

- Operation: weekends and “OPTIS” weeks late/night shifts
- Total beam-time 240 h/year for ESA and 240 h/year other users
- Wide range of proton energies and intensities
- Flexible, user-specific test arrangement
- Fast, uncomplicated set-up and operation
- Irradiations & sample position supervised by computer
- Sample frame Brookhaven, RADEF and HIF compatible
- Flux/Dosimetry ≈ 5 % absolute accuracy
- Irradiation in air

PIF Operation 2006 p.I

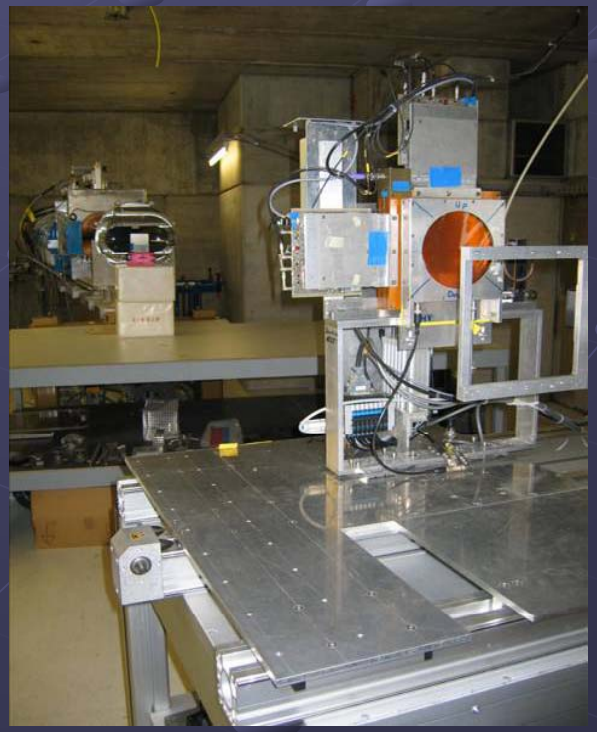
- Irradiation period extend Jan - Dec
- Number of experiments ≈ 30
- Visiting research groups 18
- Days with beam > 50
- Beam blocks total 20
- Beam shifts 54
- Setup shifts 30
- Development shifts 9



PIF Operation 2006 p.II

Beamtime and Area Utilization 2006

Area	PROSCAN	NEB	Total
Tests	10	21	31
Shifts	12	42	54



Main Users 2006

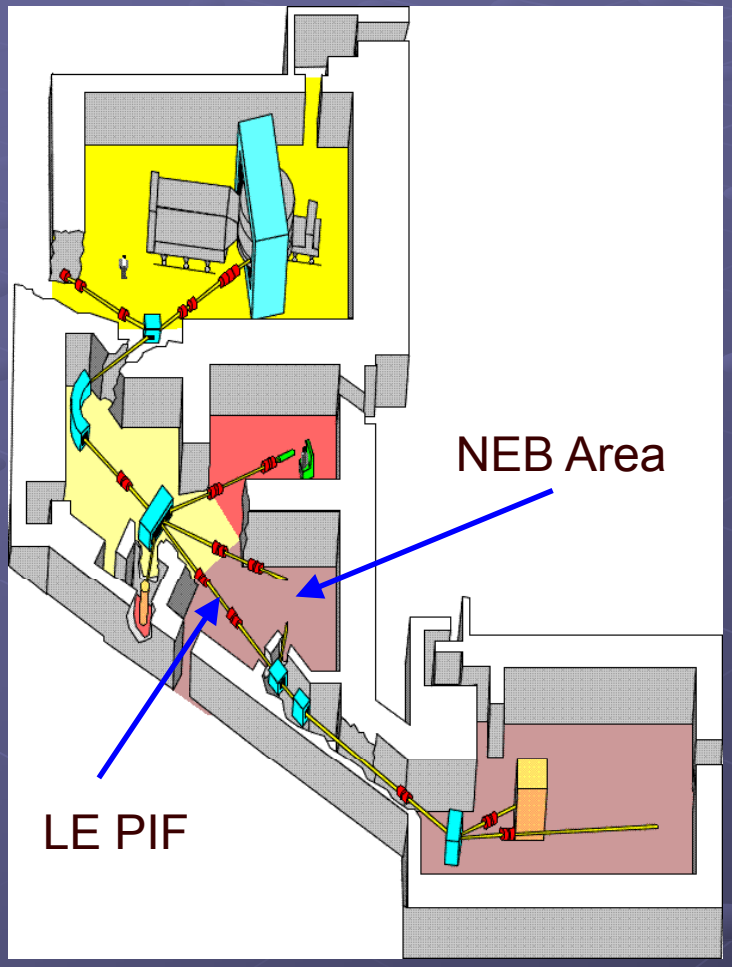
No	Research Institution
1	IEEC, Barcelona, Spain
2	INFN, Bologna, Italy
3	HIREX Engineering, Toulouse,France
4	ABB, Lenzburg, CH
5	AME, Horten, Norway
6	INFN, Padova, Italy
7	INTA, Madrit, Spain
8	OAEW, Graz, Austria
9	Nuvonyx Europe, Marcousy, France

No	Research Institution
10	ESTEC, Noordwijk, Netherlands
11	TEM, PSI Villigen, CH
12	Technical University of Denmark
13	Uni Zürich, CH
14	CERN, Genf, CH
15	CAEN Spa, Viareggio, Italy
16	ASTRIUM SAS, Velizy, France
17	E2V Technologies, Chlemsford,UK
18	IDA, Braunschweig, Germany

Main Experiments 2006

- STAR-Trackers
- Diodes
- RADFETS
- LISA Radiation Monitor
- Beam Loss Monitors
- Ionization Chambers
- Shielding Materials
- Activation of Shields
- Wireless Transmitters
- VME Controller
- SRAMs
- FPGAs
- CCDs
- Operational Amplifiers
- DC-DC converters
- Flash Memories
- Optocouplers
- Lasers Diodes
- Power Rectifiers
- High Voltage Devices

Low Energy PIF

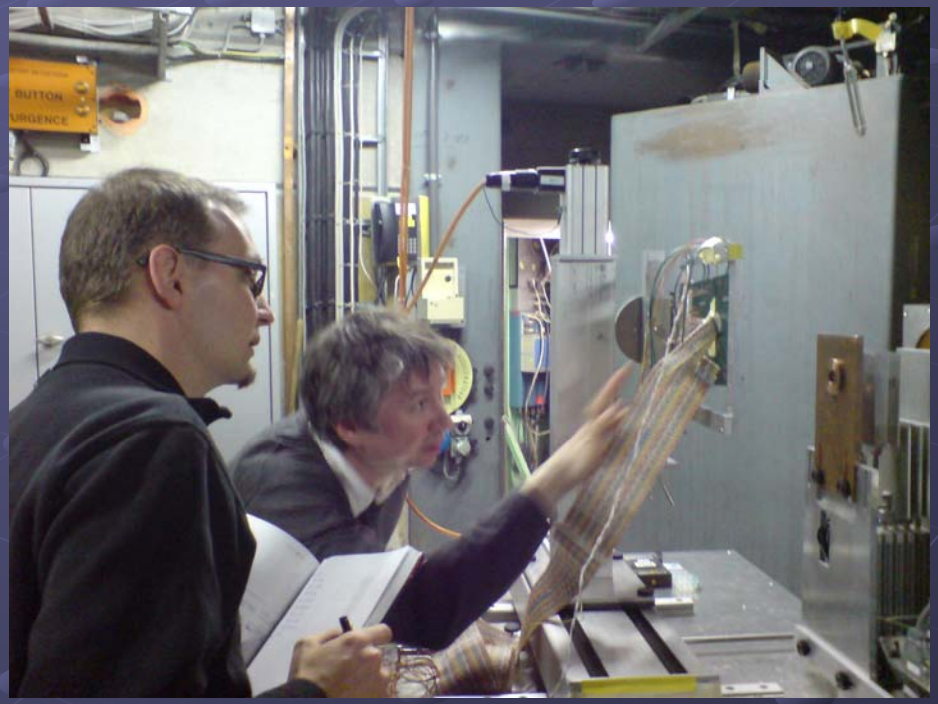


Low Energy Experimental Areas

- Initial energy:
  71 MeV
- Energy range:
  6 to 71 MeV
- Max flux (6-71 MeV)
  $< 5 \cdot 10^8$ p/cm^2/sec
- Max beam spot
  < 90 mm diameter
- Beam uniformity
  90% inside of 50 mm circle

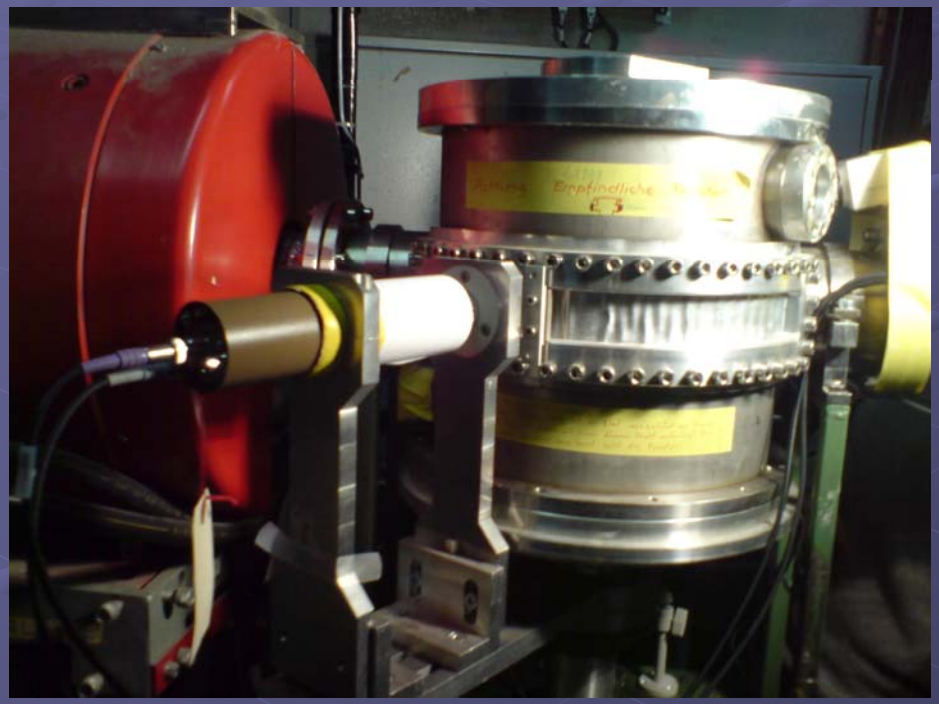
Typical CERN Experiment

Ionization chambers,
XY-table,
positioning laser



Sample DUT frame,
collimator,
energy degrader

Using Vacuum Chamber



Chamber with NaI(Tl) detectors and CH_2 target

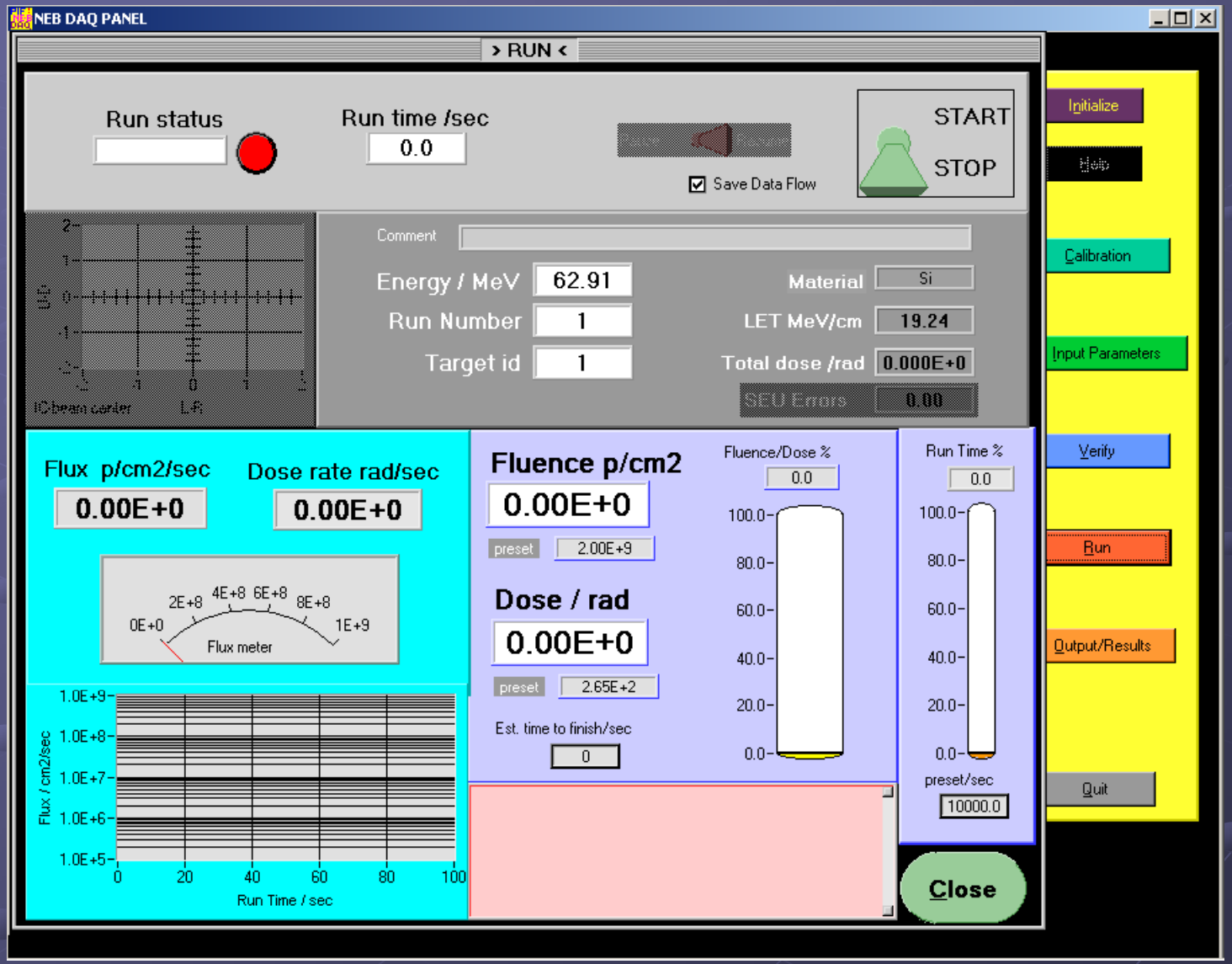
Composite sample for S/C shielding

DAQ and Beam Monitoring p.I

Laptop parade during data taking

Narrow beam spot (seen by damaged CCD)

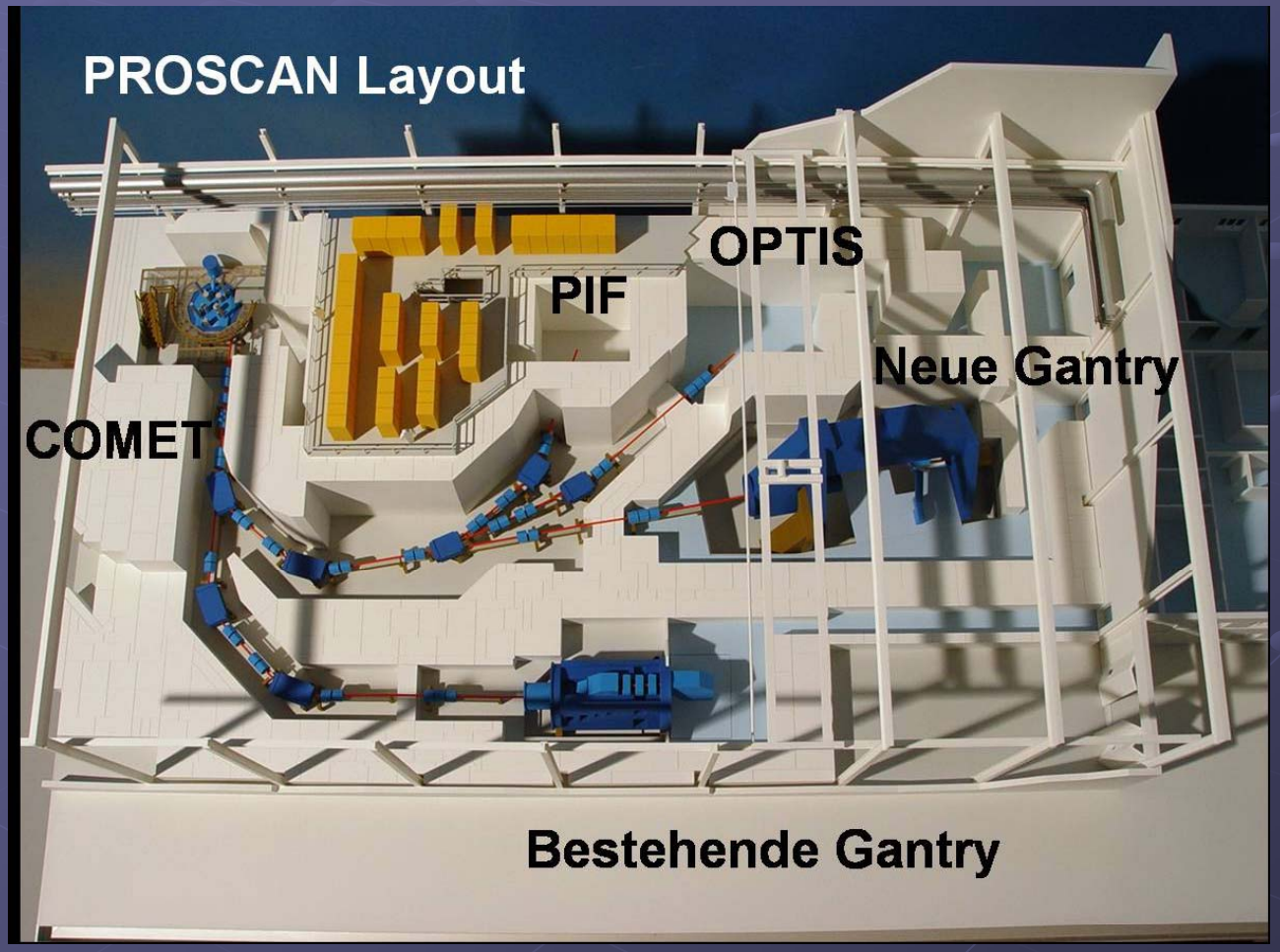
DAQ and Beam Monitoring p.II



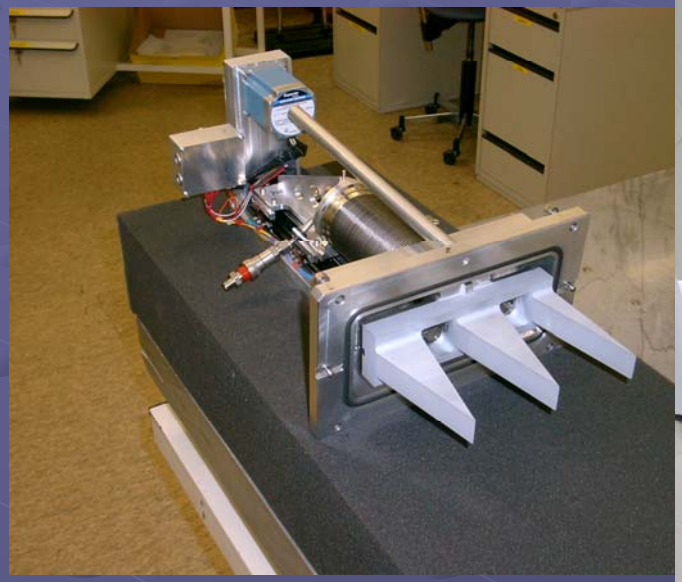
New PROSCAN Cyclotron p.I

- New PSI cyclotron for proton therapy from 2007
- First beams in April 2007
- Maximum energy 250 MeV
- Input energy range 70 – 250 MeV (main degrader)
- Intensity from the source 0.5 μA
- GANTRY1, GANTRY2, OPTIS2, Exp. Area (PIF)
- Commissioning of GANTRY1 and PIF completed

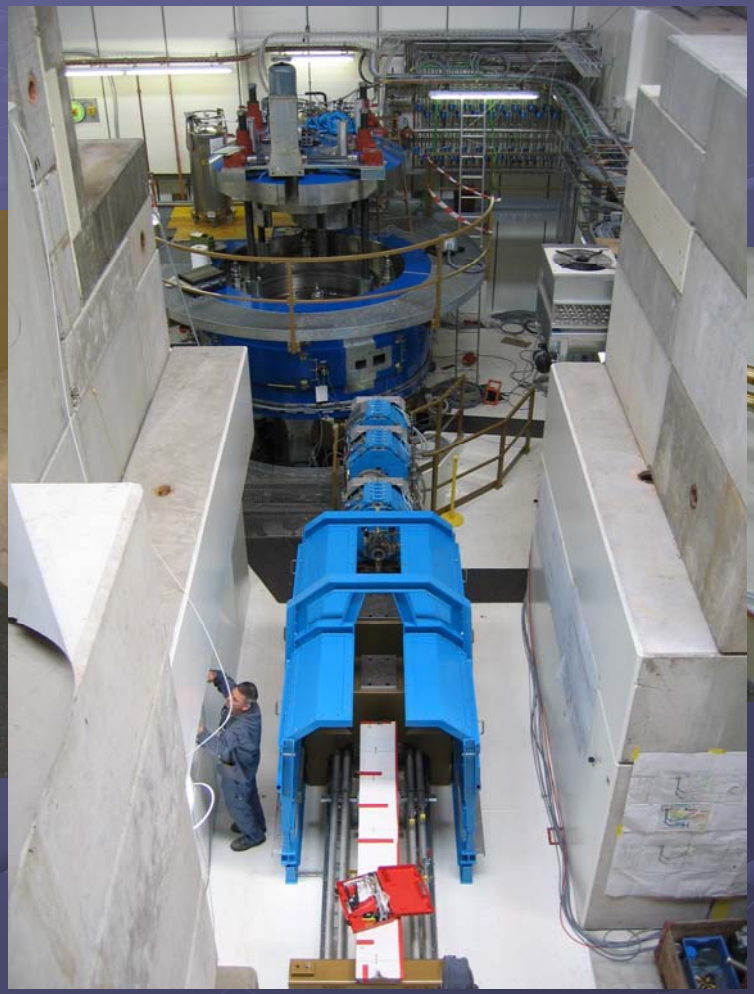
New PROSCAN Cyclotron p.II



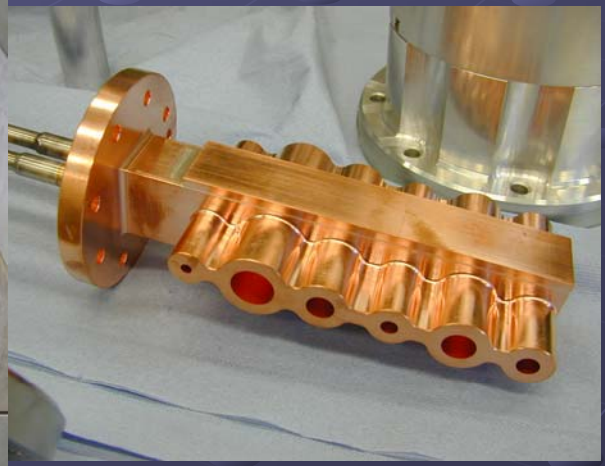
Cyclotron, Degrader, Collimator



Degrader plates



SC Cyclotron and energy degrader



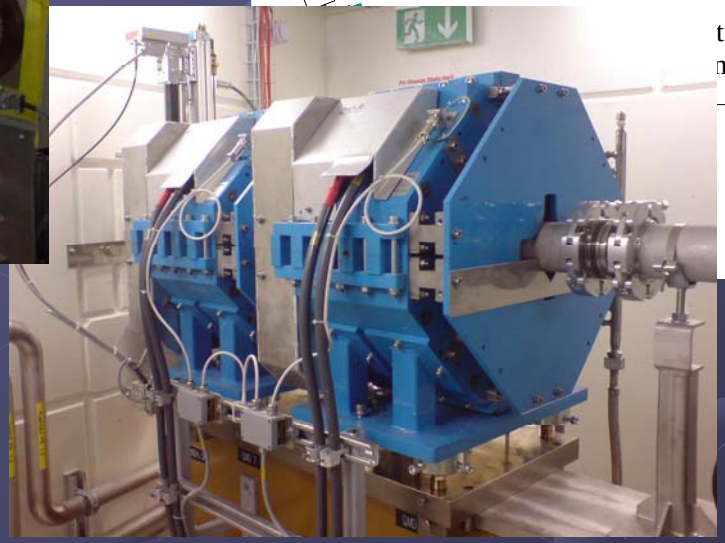
Insert with collimator

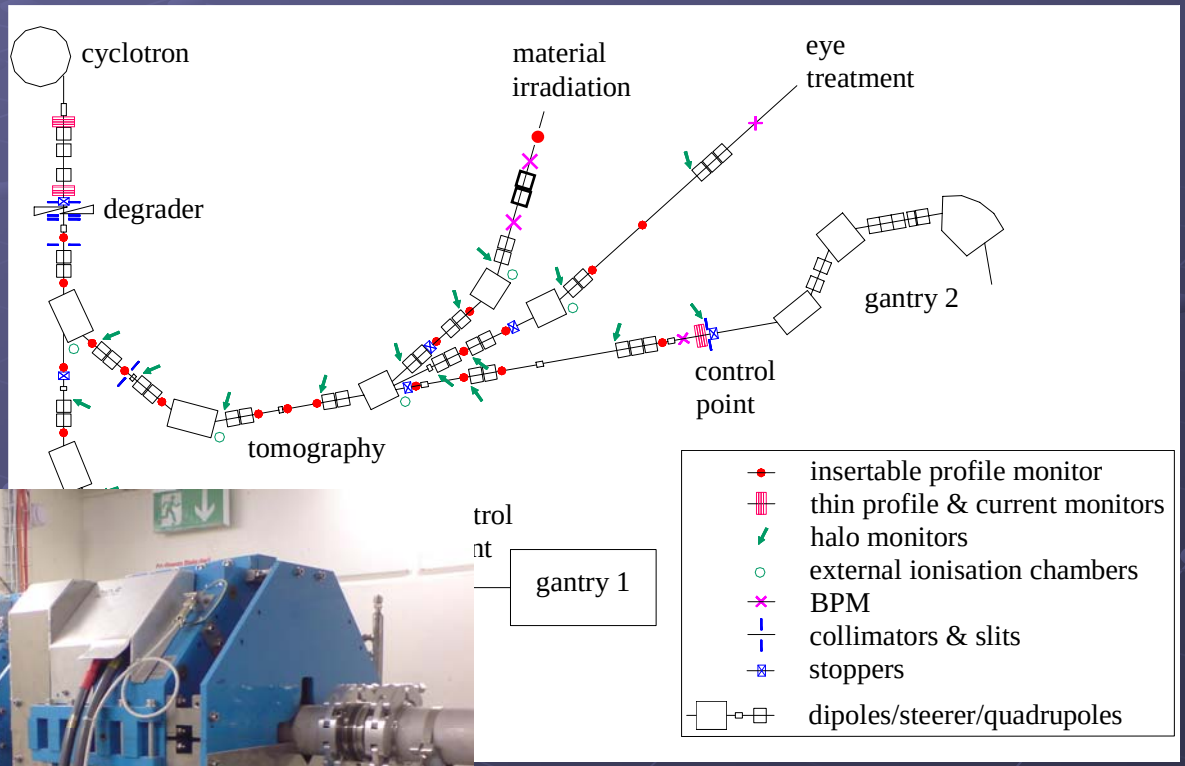
PIF @ PROSCAN Characteristics

- Currently available main energies:
  235, 200, 150, 100, 70 MeV
- Lower energies with local degrader:
  e.g. 10-70 MeV
- Intensities:
  2 nA (E>200 MeV), 10 nA (E<100 MeV)
- Operation during weekends, nights
- Standard PIF arrangement - merging
- Irradiation procedure similar to LE PIF

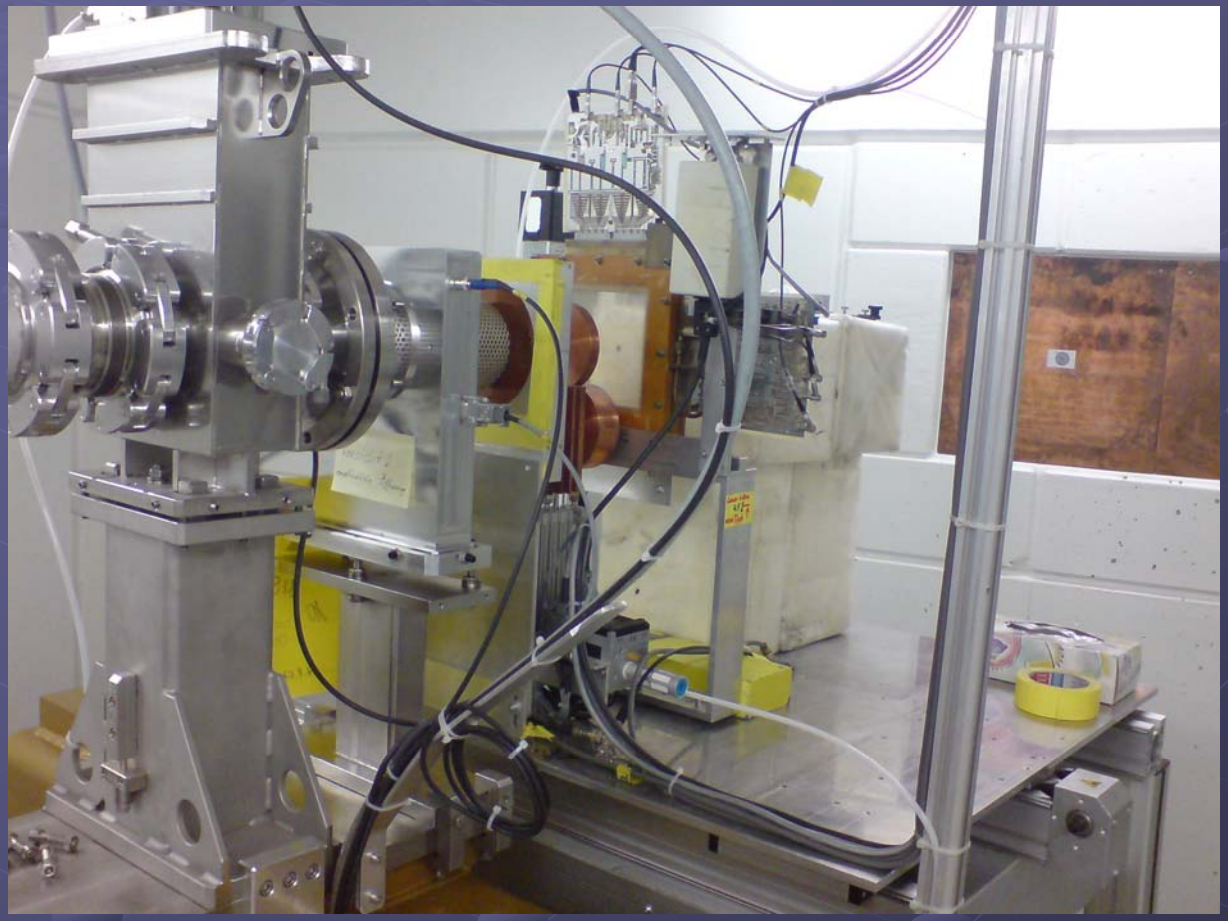
Beam Line and Setup

Two BPM and Q-dublet in PIF area

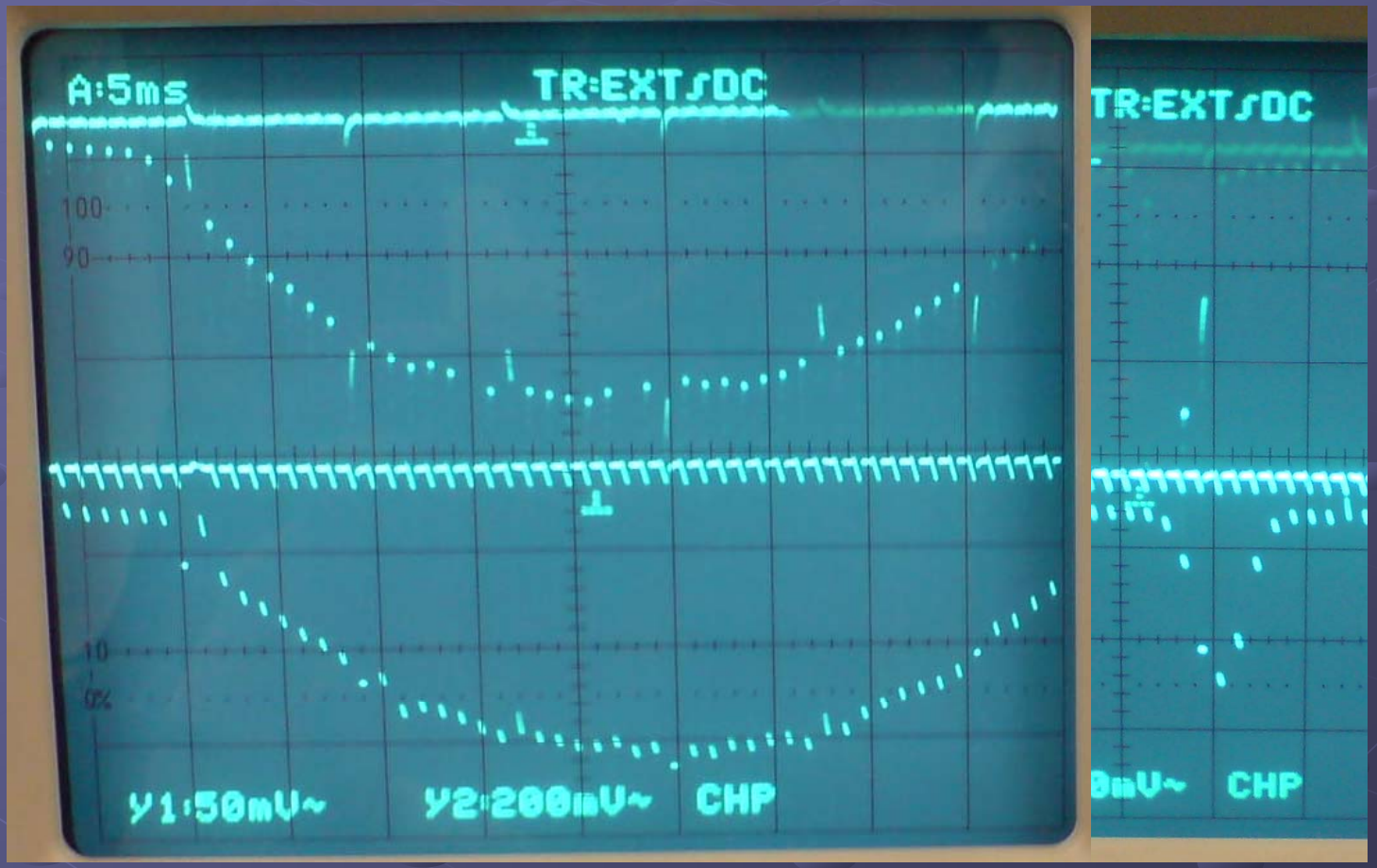




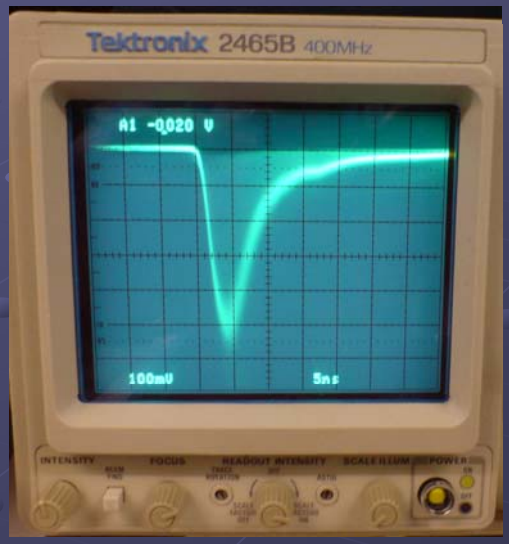
Experimental Area with PIF



Beam Parameters



Wide and narrow beam profiles; FWHM ca. 6 cm for wide beam



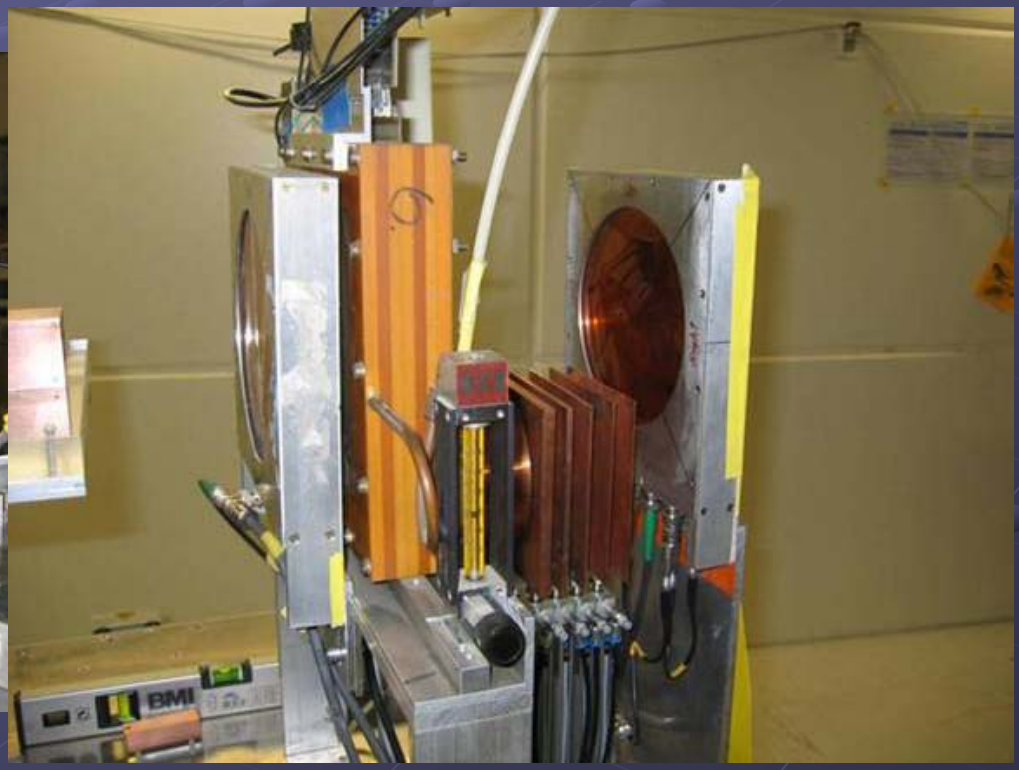
Beam signal in plastic
For 100 MeV protons

Primary degrader –
energy spread < 1%

Dosimetry and Calibration

Plastic detectors

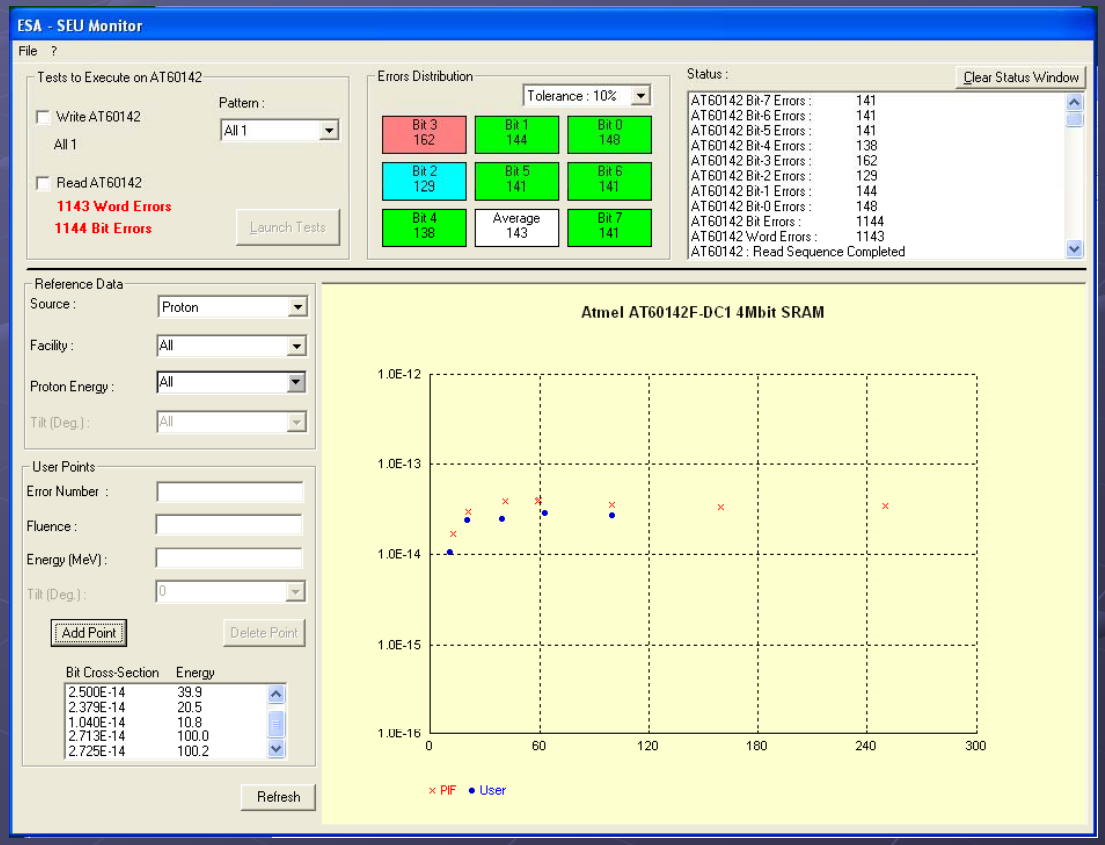
Small IC



Ionization and wire chambers

Dosimetry Cross-check - SEU Mon

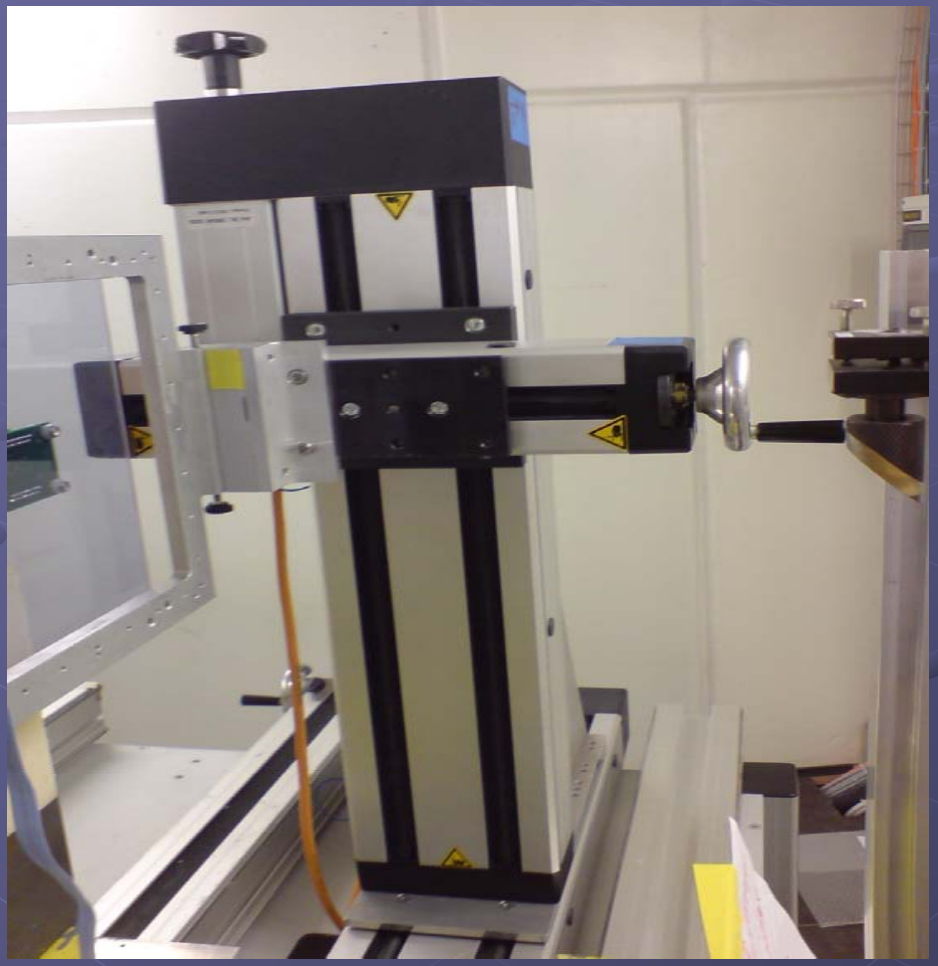
ESA SEU Monitor

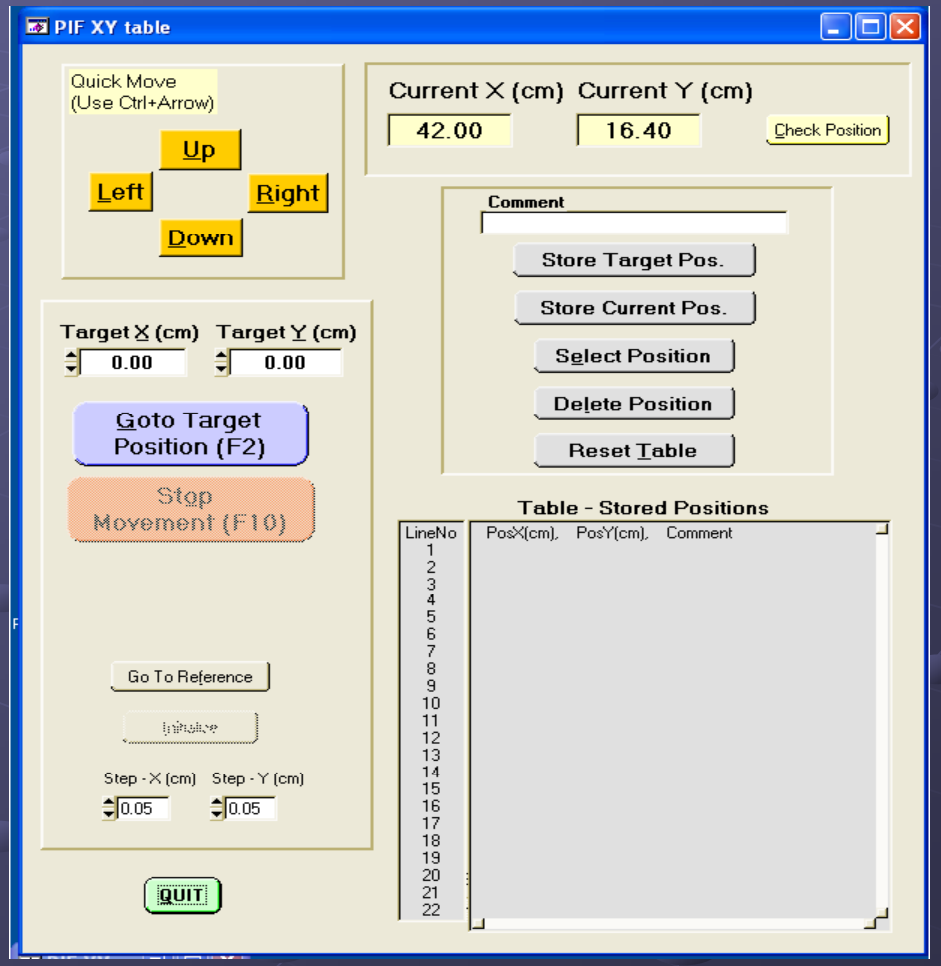


Flux value comparison

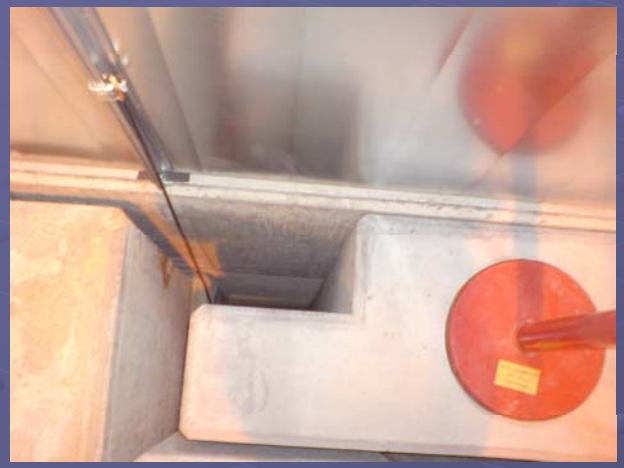
Degrader, Collimator

XY-Table

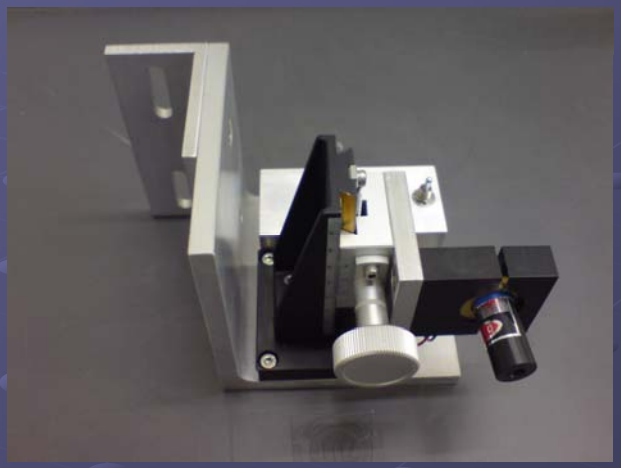



PIF XY table
Quick Move
(Use Ctrl+Arrow)
Up
Left
Right
Down
Current X (cm)
Current Y (cm)
42.00
16.40
Check Position
Comment
Store Target Pos.
Store Current Pos.
Select Position
Delete Position
Reset Table
Target X (cm)
Target Y (cm)
0.00
0.00
Goto Target Position (F2)
Stop Movement (F10)
Table - Stored Positions
LineNo
PosX(cm), PosY(cm), Comment
Go To Reference
Step - X (cm)
Step - Y (cm)
0.05
0.05
QUIT

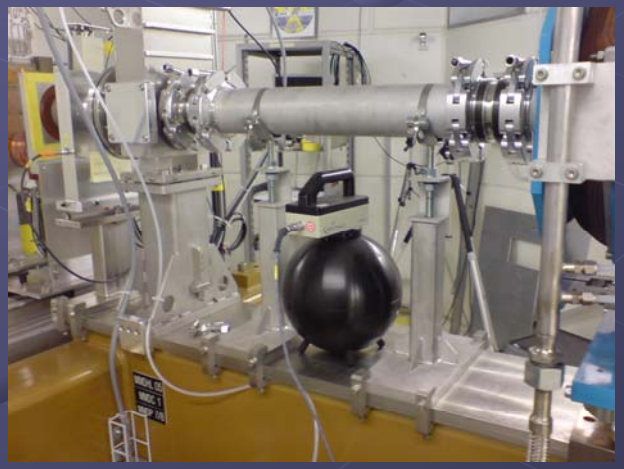
Utilities and Safety



Shaft for individual users cables



Flat beam lasers



Neutron and ionization detectors

Users Measurement Barrack

Experimental Setup

Controller for PROBA 3 (under control …)

Optocouplers (displacement effects)

Infrastructure, Cables, Connectors

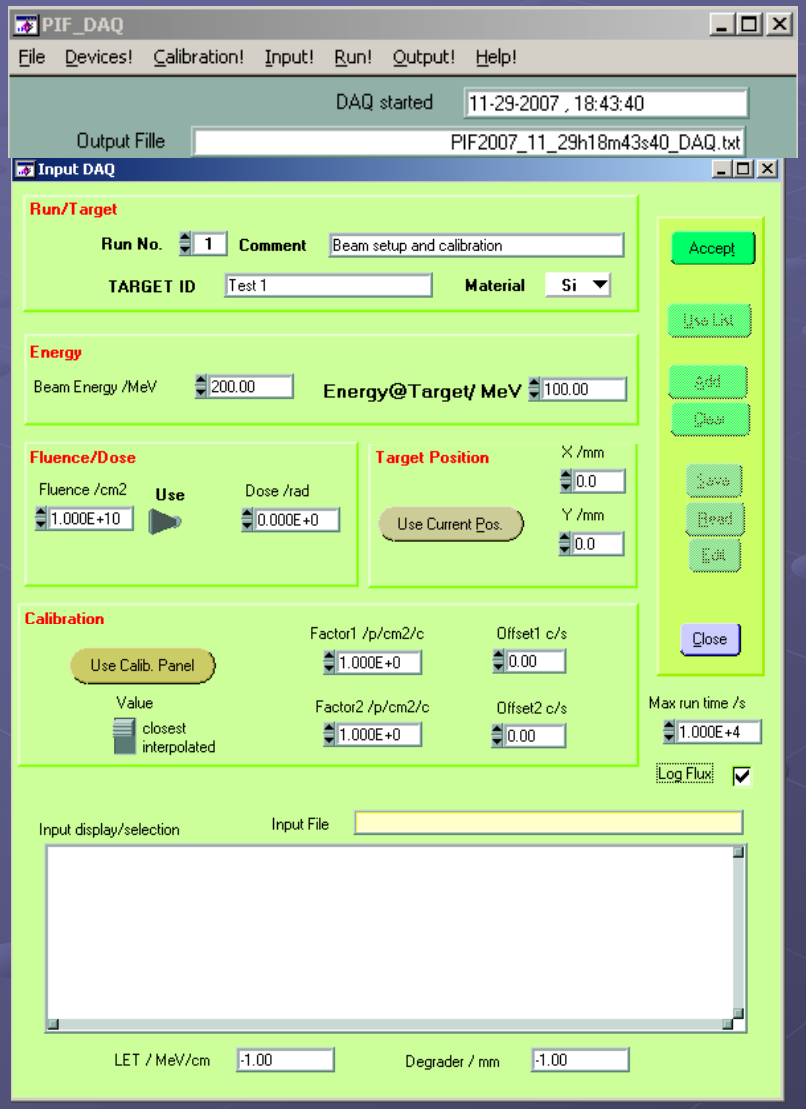
- Number of BNC, HV, RJ45, D9 and D25 (RS) cables is free for the users
- Individual cables (15-20 m) can be put via shaft on the roof with the PIF barrack
- Scopes, power supplies, multimeters, monitors etc. are available (reserve early pls)
- Special extra structures, shielding: lead and paraffin blocks, must be requested in advance

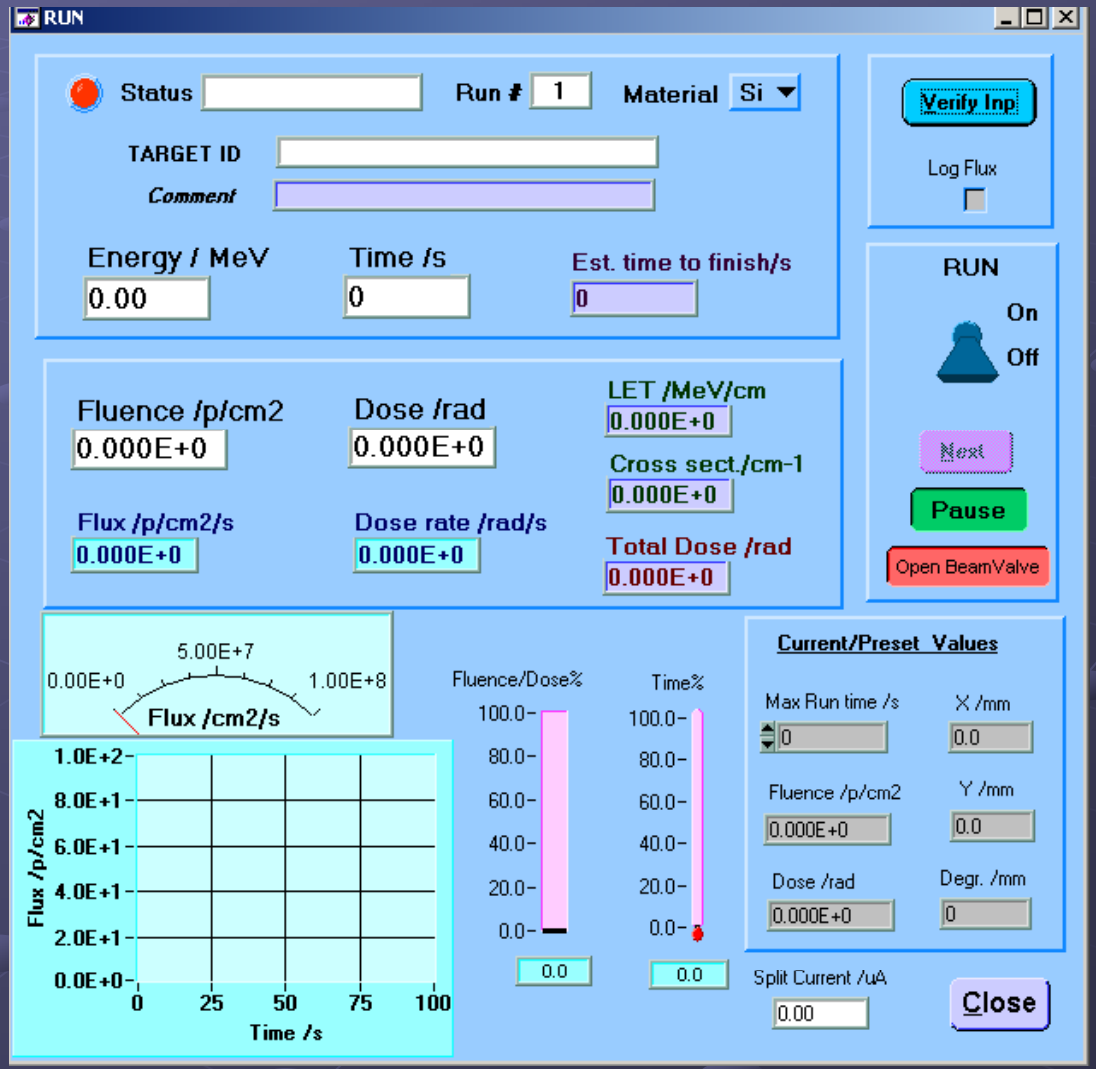
Test Arrangement

Selecting Energy and Intensity

- Energy on target set using local PIF degrader (requires calibration)
- Selection of different primary energy still performed by PIF operator (requires verification of positions and profiles)
- Application for user-setting of the beam intensity is currently under tests

Running Proton Exposure Test





Pre Irradiation Procedures

- Similar as before
- Short test description (as on the pif-web)
- List of attendants and arrival times
- Highly recommended:
  - early registration at PSI virtual user office
  - Advanced finishing of the dosimetry class
- Timely request of extra equipment, shield etc.
- Contact information about material transport

Post Irradiation Procedures

- DUTs and materials check by the radiation protection officers
- Storage in the Active Magazine
- Post-measurements possible in selected rooms
- Reserve enough time – some services e.g. SU don't work on weekends

Station of Radiation Protection SU

Studio B for post-tests inside Zone

Beam Schedule

- Program presented on the web gives available and booked periods
  - http://pif.web.psi.ch/LAP_files/PIF_Calender_Jan_Dec_07.pdf
- Early request of at least 3 months highly recommended

Kalender

PIF Calendar from July to December 2007

W	July			W	August			W	September			W	Oktober			W	November			W	December		
	Sun 1			31	Wed 1				Sat 1	booked		40	Mon 1			44	Thu 1				Sat 1		
27	Mon 2				Thu 2				Sun 2				Tue 2				Fri 2				Sun 2		
	Tue 3				Fri 3			36	Mon 3				Wed 3				Sat 3			49	Mon 3		
	Wed 4				Sat 4				Tue 4				Thu 4				Sun 4				Tue 4		
	Thu 5				Sun 5				Wed 5		booked		Fri 5			45	Mon 5				Wed 5		
	Fri 6	booked		32	Mon 6				Thu 6		booked		Sat 6				Tue 6				Thu 6		
	Sat 7	booked			Tue 7				Fri 7				Sun 7				Wed 7				Fri 7		
	Sun 8	booked			Wed 8				Sat 8			41	Mon 8				Thu 8				Sat 8		booked
28	Mon 9	LE			Thu 9				Sun 9				Tue 9				Fri 9				Sun 9		booked
	Tue 10	booked			Fri 10			37	Mon 10				Wed 10				Sat 10			50	Mon 10	LE	
	Wed 11	booked			Sat 11				Tue 11				Thu 11				Sun 11				Tue 11	booked	
	Thu 12				Sun 12				Wed 12				Fri 12			46	Mon 12				Wed 12	booked	
	Fri 13			33	Mon 13				Thu 13				Sat 13				Tue 13				Thu 13		
	Sat 14				Tue 14				Fri 14				Sun 14				Wed 14				Fri 14	booked	
	Sun 15				Wed 15				Sat 15			42	Mon 15				Thu 15				Sat 15	booked	
29	Mon 16				Thu 16				Sun 16				Tue 16				Fri 16				Sun 16	booked	
	Tue 17				Fri 17			38	Mon 17				Wed 17				Sat 17			51	Mon 17		
	Wed 18				Sat 18				Tue 18				Thu 18				Sun 18				Tue 18		
	Thu 19				Sun 19				Wed 19				Fri 19			47	Mon 19	LE			Wed 19		
	Fri 20			34	Mon 20				Thu 20				Sat 20				Tue 20	booked			Thu 20		
	Sat 21				Tue 21				Fri 21				Sun 21				Wed 21				Fri 21		
	Sun 22				Wed 22				Sat 22			43	Mon 22	LE			Thu 22	booked			Sat 22		
30	Mon 23				Thu 23				Sun 23				Tue 23	booked			Fri 23	booked			Sun 23		
	Tue 24				Fri 24				Mon 24	LE			Wed 24	booked			Sat 24	booked	booked		Mon 24		
	Wed 25				Sat 25			39	Tue 25	booked			Thu 25	booked			Sun 25	booked	booked	52	Tue 25		
	Thu 26				Sun 26				Wed 26	booked			Fri 26	booked		48	Mon 26				Wed 26		
	Fri 27			35	Mon 27	LE			Thu 27	booked			Sat 27	booked			Tue 27				Thu 27		
	Sat 28				Tue 28				Fri 28	booked	booked		Sun 28	booked			Wed 28				Fri 28		
	Sun 29				Wed 29	booked			Sat 29	booked	booked	44	Mon 29				Thu 29				Sat 29		
31	Mon 30				Thu 30	booked			Sun 30	booked	booked		Tue 30				Fri 30				Sun 30		
	Tue 31				Fri 31	booked							Wed 31								Mon 31		

LE	Low Energy PIF OPTIS Week /NEB (Overnight, after OPTIS, Tue - Fri ~16.00 - 06.00)		booked	User Operation Booked	Facility (NEB) available
HE	High Energy PIF - Proscan (Weekends, after Medical Science, Fri - Mon ~17.00 - 06.00)		booked	User Operation Booked	High-Energy-Facility (Proscan) not available

PIF Parameters in Brief

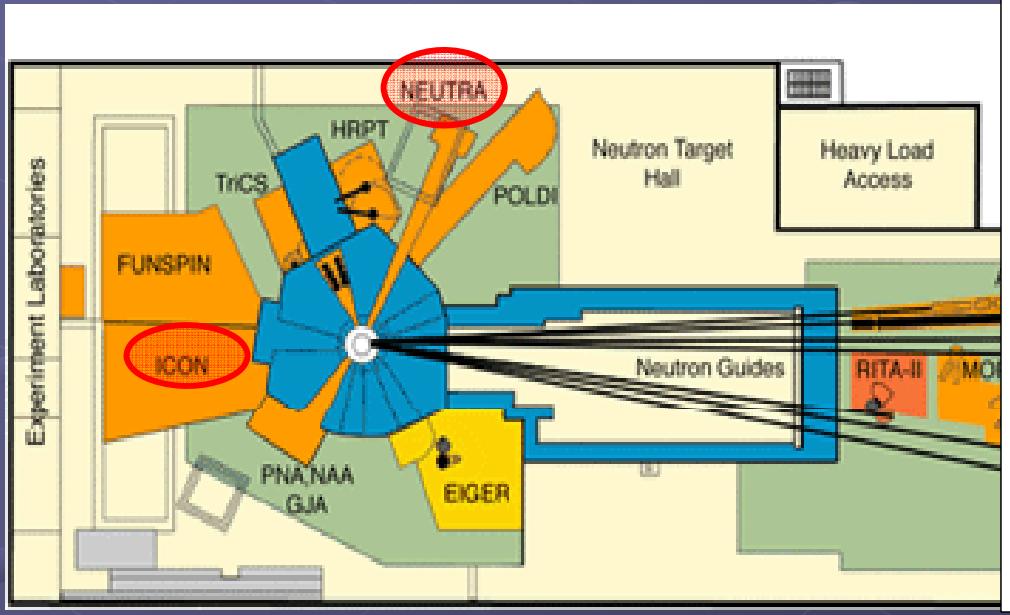
- Low and high energy PIF merged in PROSCAN Experimental Area
- Initial energies (now): 235, 200, 150, 100 and 70 MeV
- Lower energies set with a degrader: ca. 10 up to 70 MeV
- Maximum beam intensity above 200 MeV: 2 nA
- Maximum beam intensity below 100 MeV: 10 nA
- Maximum flux at any primary energy $2\text{-}5 \cdot 10^8$ p/sec/cm^2 (wide beam)
- Beam profiles are Gaussian-form with FWHM≅6 cm or focused
- Irradiations, devices and sample positioning by the computer
- DUT frame 25 x 25 cm2 RADEF and HIF facilities compatible

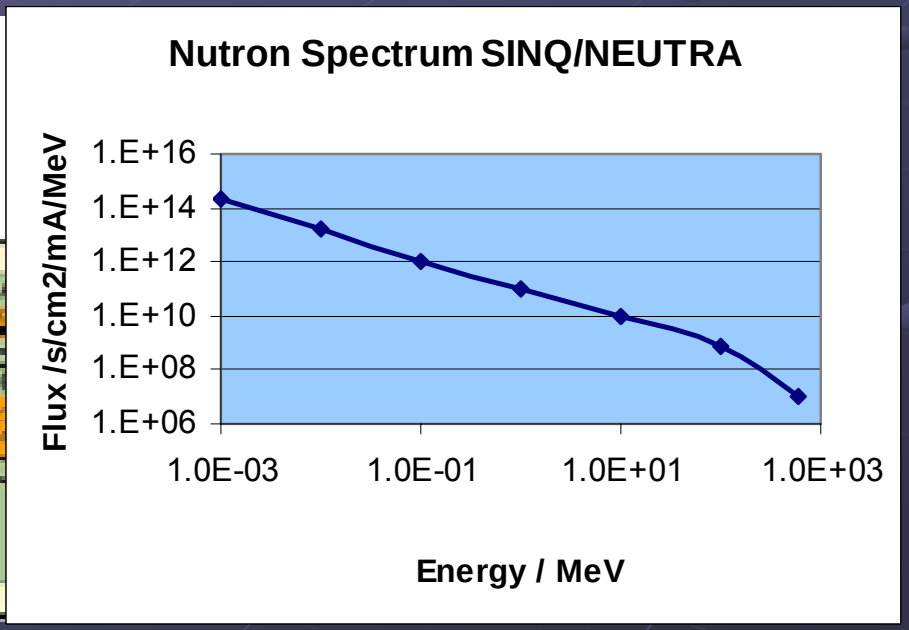
Further Irradiation Options at PSI

- Synchrotron Light Source
  - E.g. high intensity X-rays with energies of few keV
- Cold neutrons at SINQ
- Atmospheric neutrons at SINQ
- Very high dose beams:
  - Isotope Production station
  - station in Injector I NEA (Lisor)
- Radiochemical analysis of secondary isotopes

Atmospheric Neutrons

- PSI accelerator can be used for atmospheric neutrons e.g. SINQ
- Studies required to assess feasibility, two locations identified
- Spectral shape based on MC very promising for ICON and NEUTRA





Summary

- New proton facility constructed at PSI
- Energy range extended up to 250 MeV
- Beam time during nights and weekends
- Commissioning completed, first test performed
- User-friendly and easy to operate
- Other facilities at PSI:
  - synchrotron light (e.g. X-rays)
  - cold and atmospheric neutrons
  - very high dose proton beams
  - Radiochemical isotope analysis

Thank You!