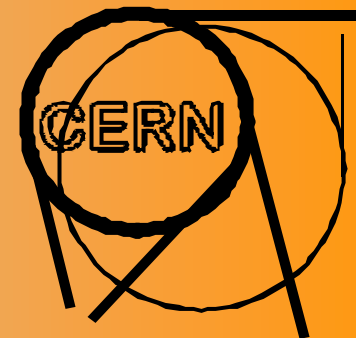


Proton and neutron radiation facilities in the PS East hall at CERN

<http://www.cern.ch/irradiation>

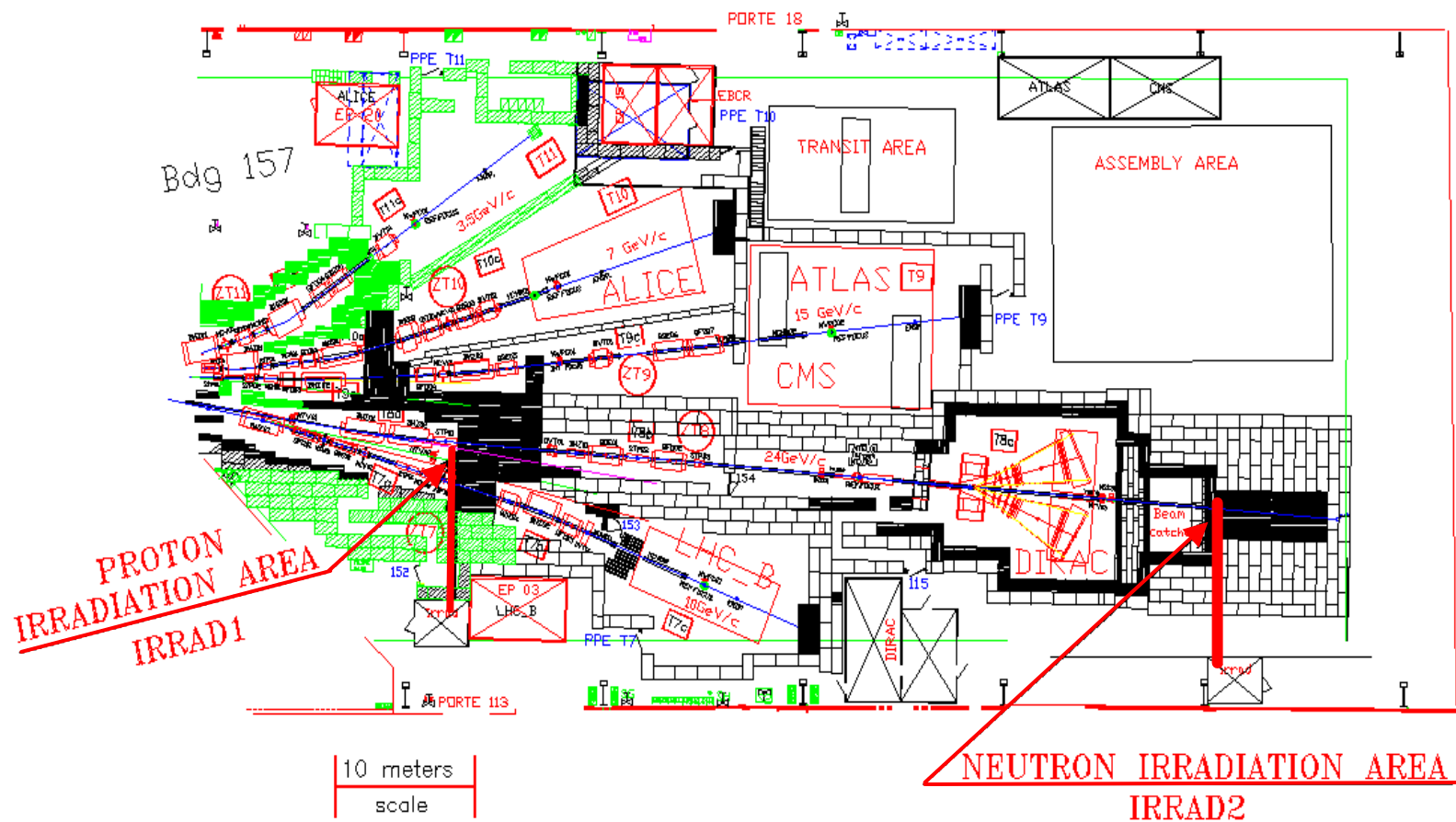
Maurice Glaser, Michael Moll
CERN Division EP-TA1-SD



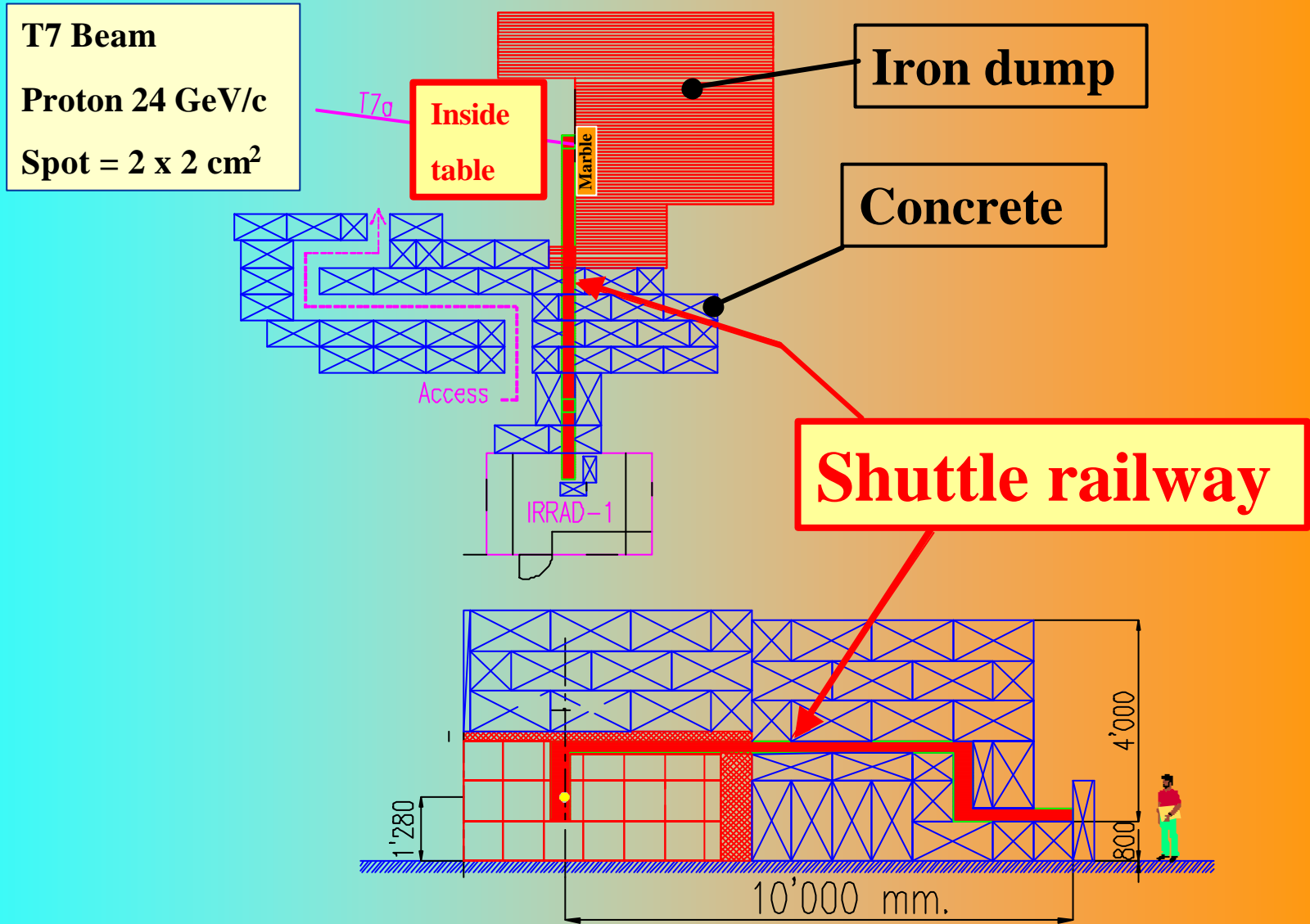
Introduction

- CERN Accelerators
- CERN-PS East Hall
- Proton irradiation facilities
- Neutron irradiation facilities
- Dosimetry
- Mounting of samples
- Conclusions

CERN-PS East Hall

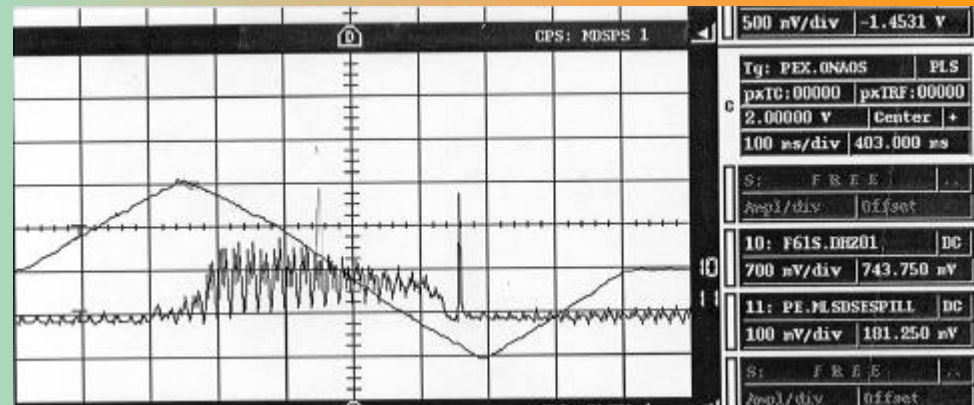
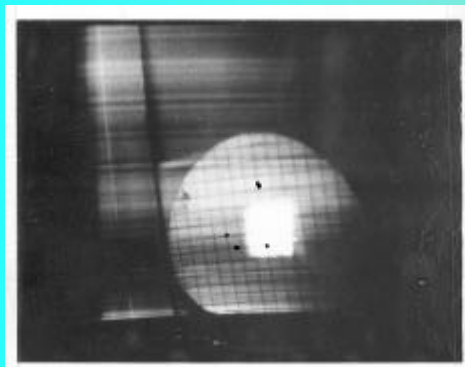
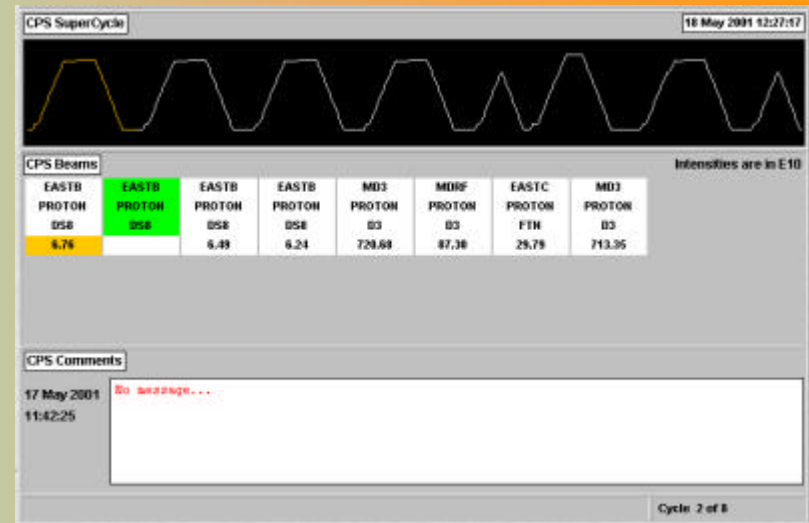


Proton shuttle and inside area facilities



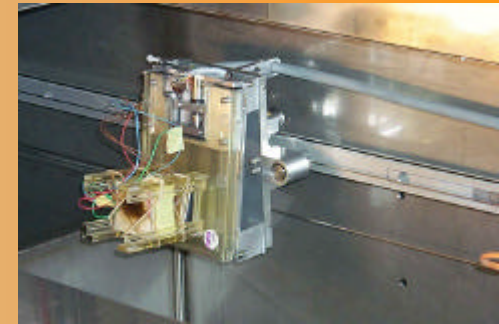
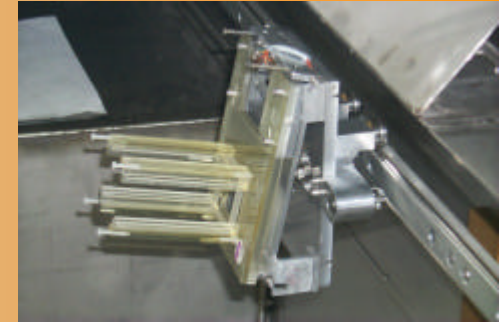
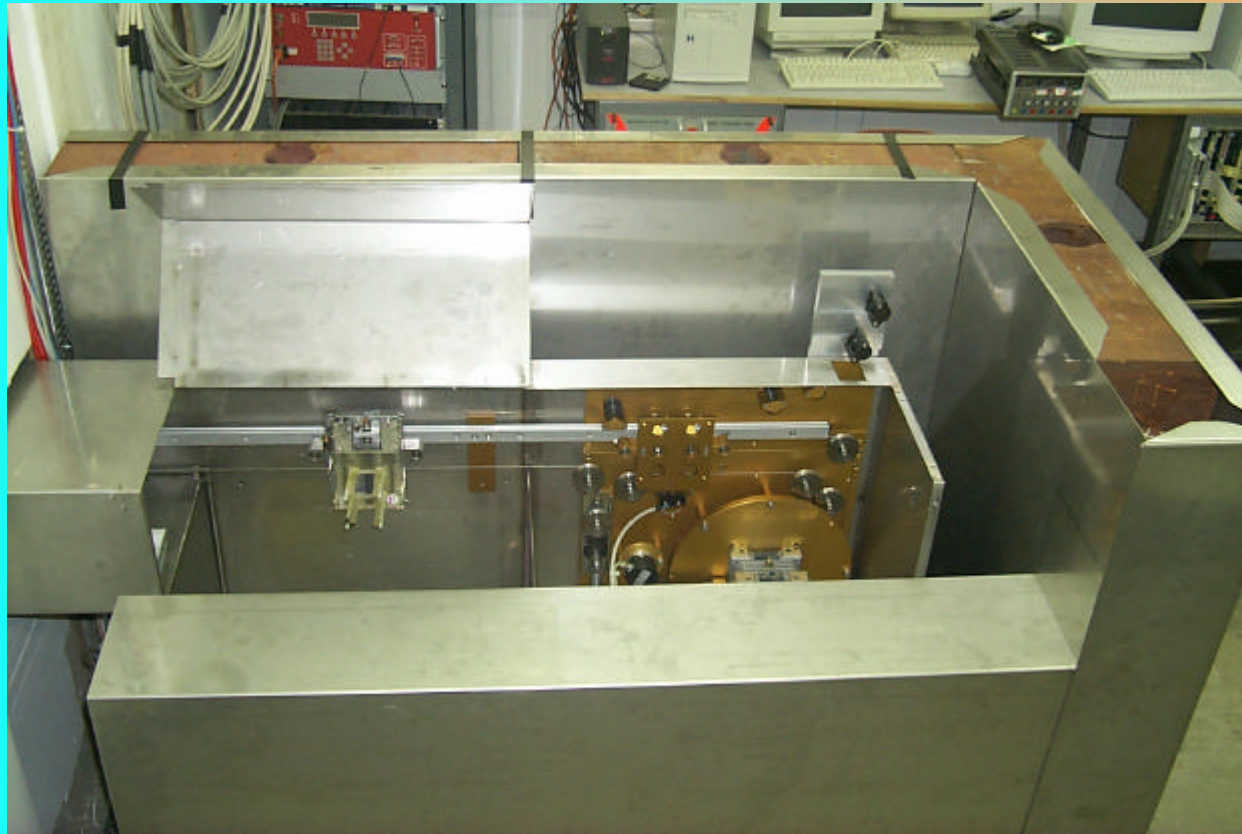
Proton irradiation facility characteristics

- **Primary PS proton beam**
 - Beam line : PS-T7
 - Beam energy : 24 GeV/c
 - Beam spot : 2 x 2 cm²
- **Proton flux**
 - 3 - 9 10⁹ p cm⁻² s⁻¹
 - 1 - 3 10¹³ p cm⁻² h⁻¹



Proton facility - Shuttle

- Standard volume for irradiation $5 \times 5 \times 15 \text{ cm}^3$
- Max. volume on request $10 \times 10 \times 20 \text{ cm}^3$
- No restriction for access

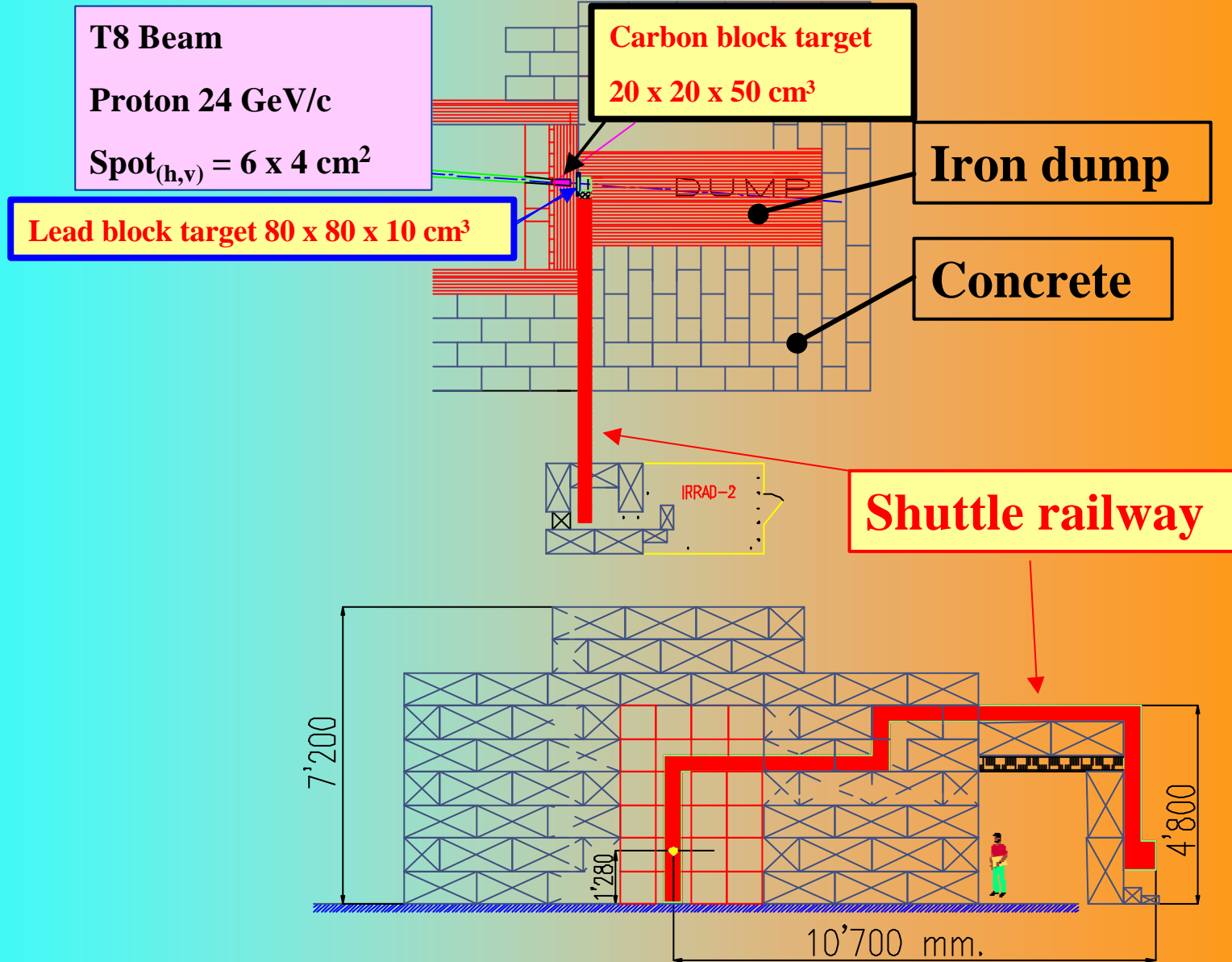


Proton facility - Inside area

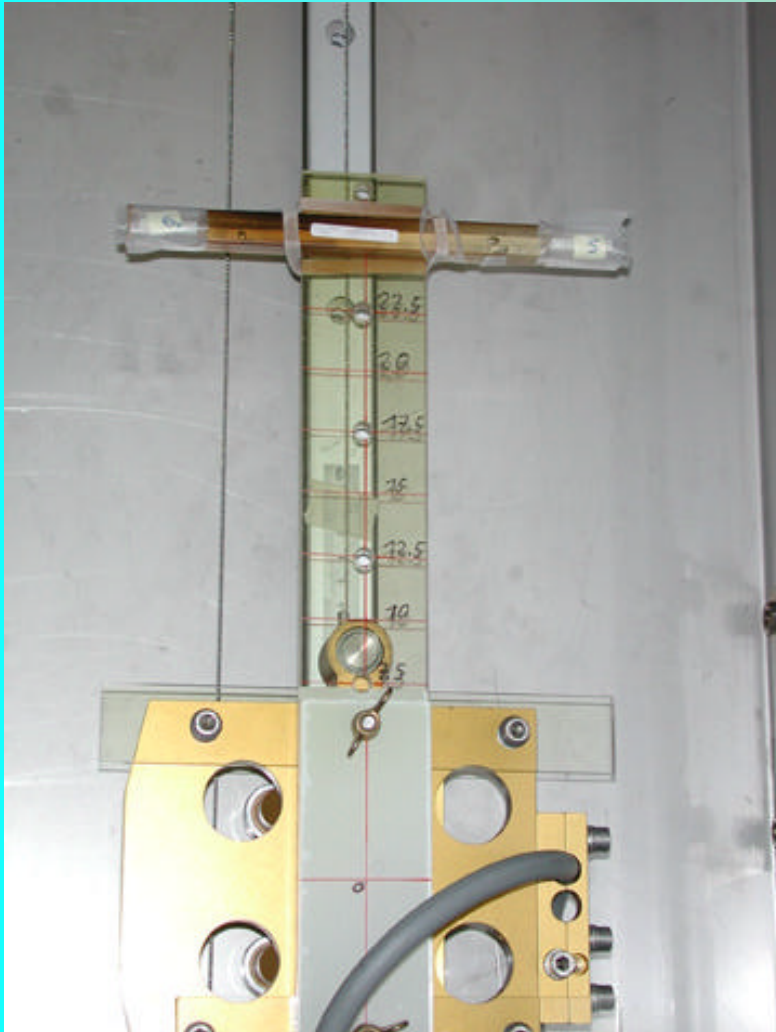
- Scanning over surface of $10 \times 10 \text{ cm}^2$
- Access only during PS machine development
 - 8 hours every one or two weeks
- Max. volume $20 \times 20 \times 50 \text{ cm}^3$



Neutron facility - Shuttle



Neutron facility - shuttle

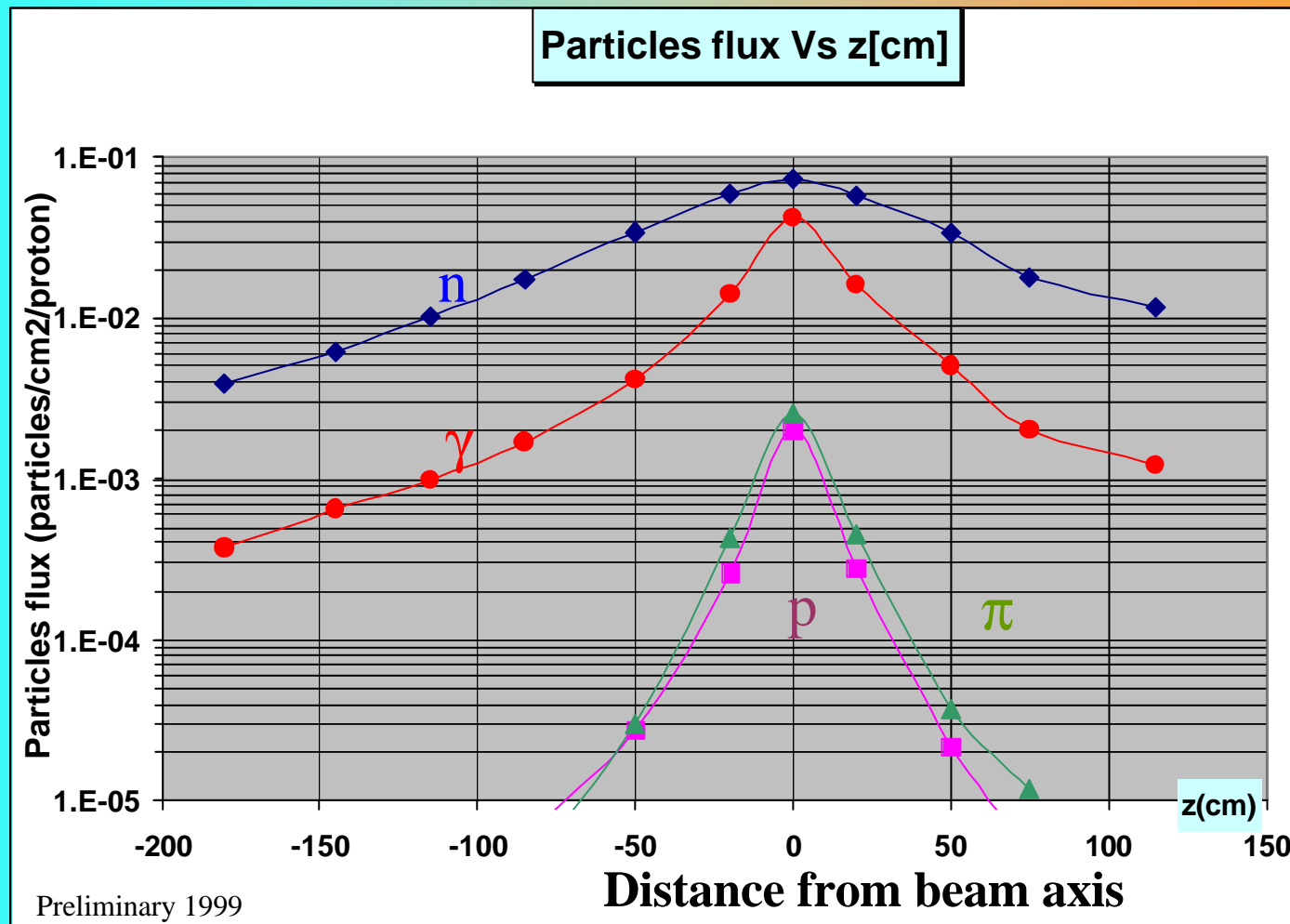


Neutron irradiation facility characteristics

- **Secondary particles in the irradiation cavity**
 - neutron : 50 KeV - 10 MeV
 - p, π^+, π^- : 0.3 - 4 GeV
 - gamma : 100 KeV - 100 MeV
- **Neutron flux**
 - Shuttle position = 50 cm from beam axis
 - $1 - 3 \cdot 10^7 \text{ n cm}^{-2} \text{ s}^{-1}$ ($E > 1 \text{ MeV}$)
 - 6 days for $10^{13} \text{ n cm}^{-2}$ ($E > 1 \text{ MeV}$)
- **Dimensions**
 - Standard volume for irradiation $20 \times 20 \times 20 \text{ cm}^3$
 - Max. volume on demand $\sim 30 \times 30 \times 35 \text{ cm}^3$
 - No restriction for access

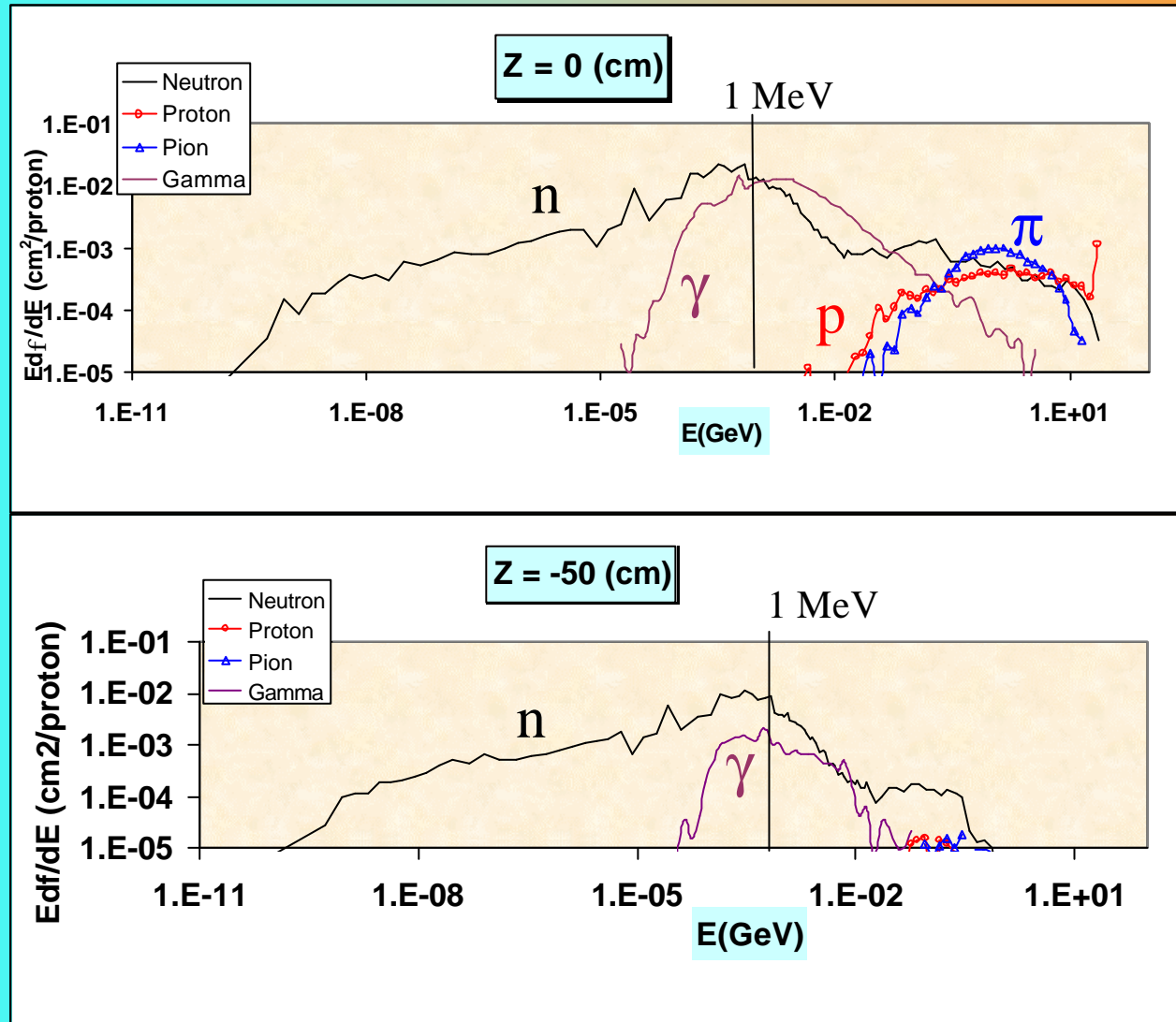
FLUKA simulation for neutron facility

M. Huhtinen CERN EP



FLUKA simulation for neutron facility

Secondary particles spectra at 0 & 50 cm versus Energy



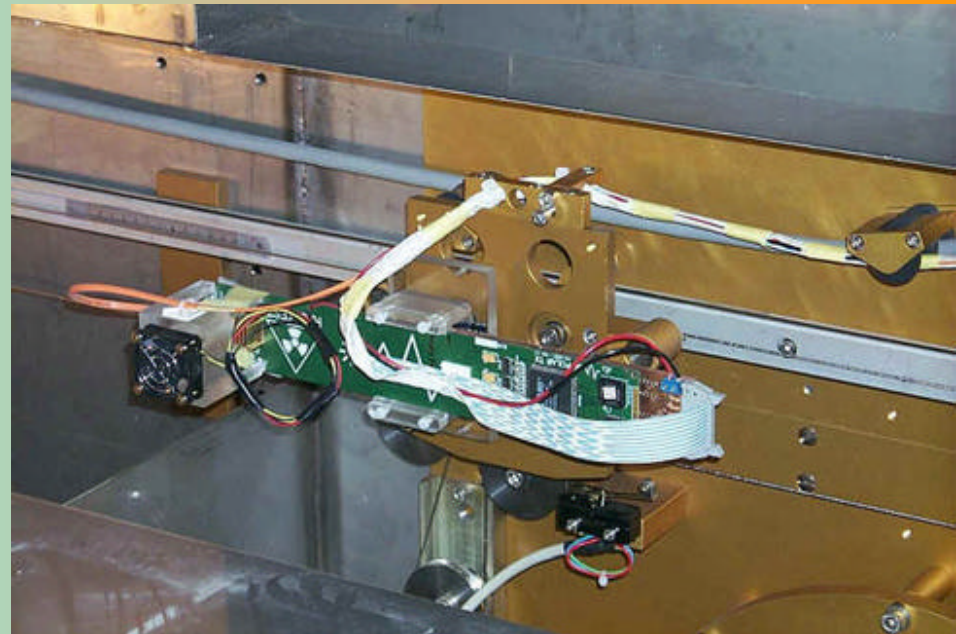
Particles predicted by FLUKA for different energy cuts

Back scattering particles @ 10 cm per $\text{cm}^{-2} \text{h}^{-1}$					
Energy	Neutrons	%	Protons	Pions	Gammas
> 1 eV	1.18E+12	100.00			
> 10 KeV	1.04E+12	88.31	5.11E+09	8.63E+09	2.82E+11
> 100 KeV	8.23E+11	69.54	5.11E+09	8.63E+09	2.78E+11
> 1 MeV	2.16E+11	18.23	5.11E+09	8.63E+09	1.26E+11
> 8 MeV	4.44E+10	3.75	5.08E+09	8.62E+09	1.33E+10
> 10 MeV	4.16E+10	3.52	5.08E+09	8.62E+09	9.38E+09
> 20 MeV	3.48E+10	2.94	5.05E+09	8.56E+09	4.39E+09
> 50 MeV	2.52E+10	2.13	4.61E+09	8.47E+09	1.72E+09
> 100 MeV	1.71E+10	1.44	4.03E+09	7.97E+09	9.64E+08

Back scattering particles @ 50 cm per $\text{cm}^{-2} \text{h}^{-1}$					
Energy	Neutrons	%	Protons	Pions	Gammas
> 1 eV	6.70E+11	100.00			
> 10 KeV	5.64E+11	84.23	5.43E+08	6.48E+09	7.64E+10
> 100 KeV	4.13E+11	61.76	5.43E+08	6.48E+09	7.50E+10
> 1 MeV	7.06E+10	10.54	5.38E+08	6.01E+08	2.47E+10
> 8 MeV	1.04E+10	1.55	5.08E+08	5.82E+08	1.68E+09
> 10 MeV	9.59E+09	1.43	5.08E+08	5.82E+08	1.07E+09
> 20 MeV	7.64E+09	1.14	5.05E+08	5.82E+08	5.53E+08
> 50 MeV	5.18E+09	0.77	4.54E+08	5.11E+08	1.87E+08
> 100 MeV	3.00E+09	0.45	2.61E+08	4.53E+08	7.74E+07

Irradiations with low flux of hadrons

- Low flux of hadrons ($\sim 4 \times 10^9 \text{ cm}^{-2} \text{ h}^{-1}$)
- Test SEU, SEE.... Electronic components
- Readout electronics can be installed on second platform (in distance of 50 cm)

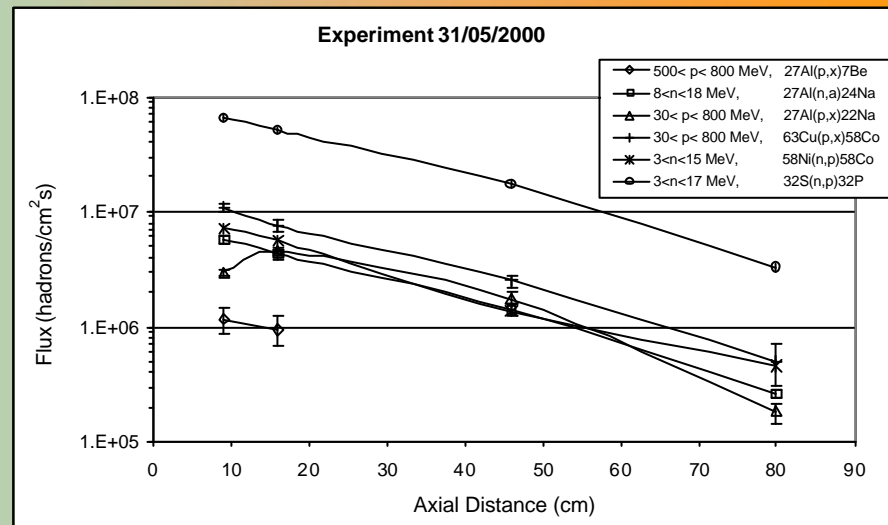
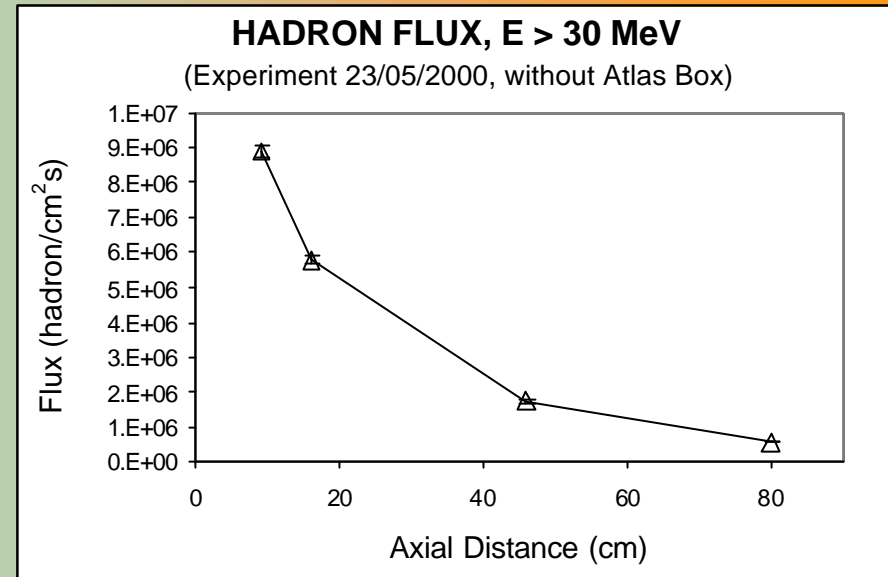
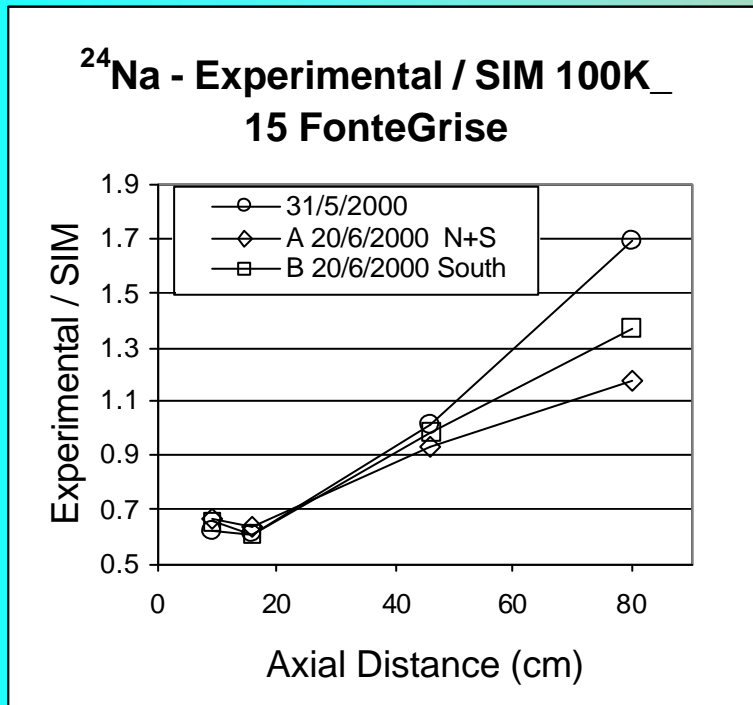


Irradiations with low flux of hadrons calibration & simulation

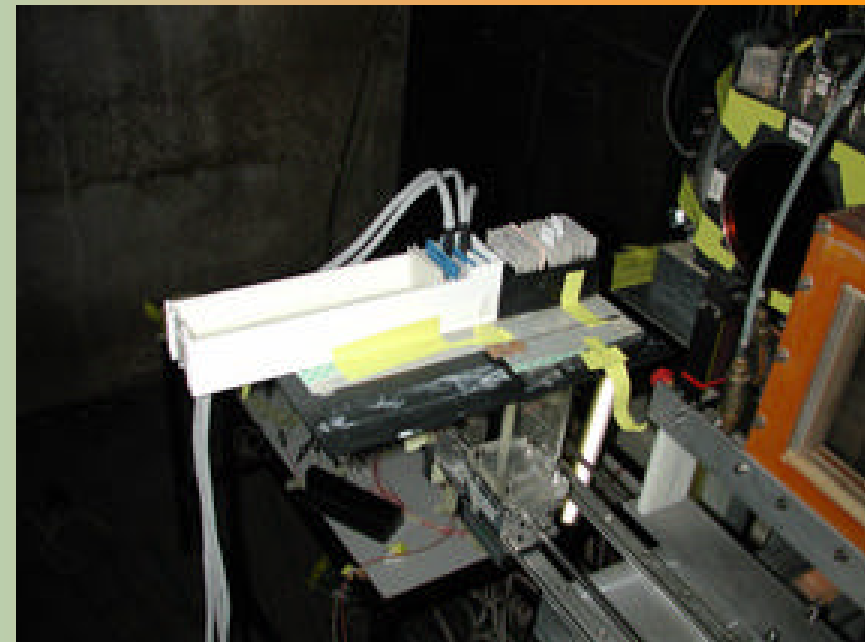
Ignasi Bacardit, Universitat politècnica de Catalunya

Claude Leroy, University of Montreal

Patrick Roy, University of Montreal



Pions irradiation facility at the PSI Villigen



Dosimetry - Proton irradiation

Guy Roubaud CERN TIS

- **Fluence measurement**
 - By activation of Al foil
 - $^{27}\text{Al}(p,3p\text{n})^{24}\text{Na}$, $^{27}\text{Al}(p,3p3\text{n})^{22}\text{Na}$
 - Spectrometry with NaI spectrometer (+- 6%)
 - ^{24}Na , halflife 15h, $E_{\gamma} = 1368.53 \text{ keV}$
 - Spectrometry with Ge spectrometer (+- 2%)
 - ^{24}Na , halflife 15h, $E_{\gamma} = 1368.53 \text{ keV}$
 - ^{22}Na , halflife 2.6y, $E_{\gamma} = 1274.54 \text{ keV}$

NaI



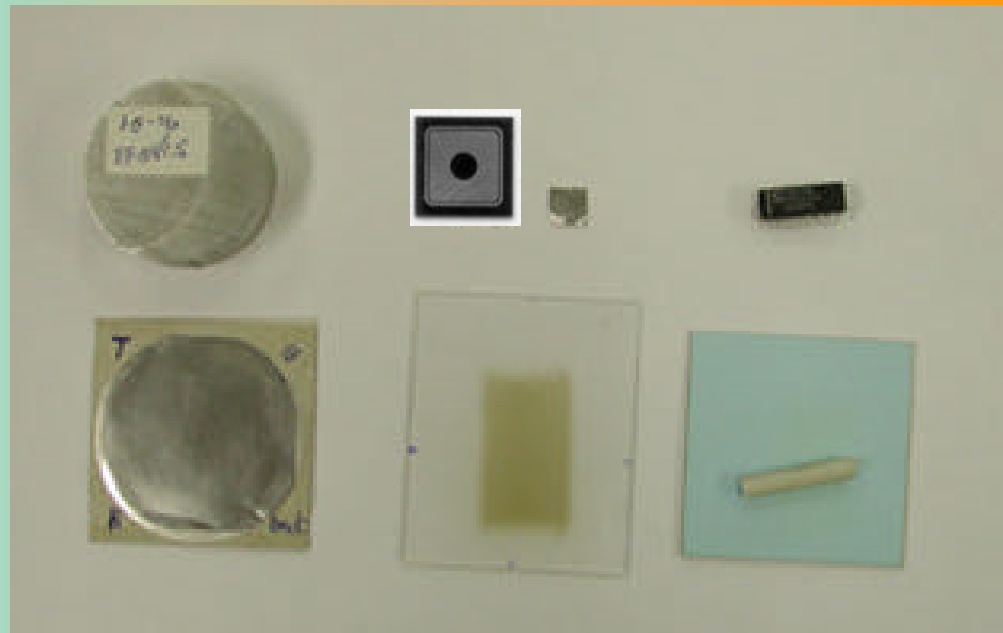
Ge



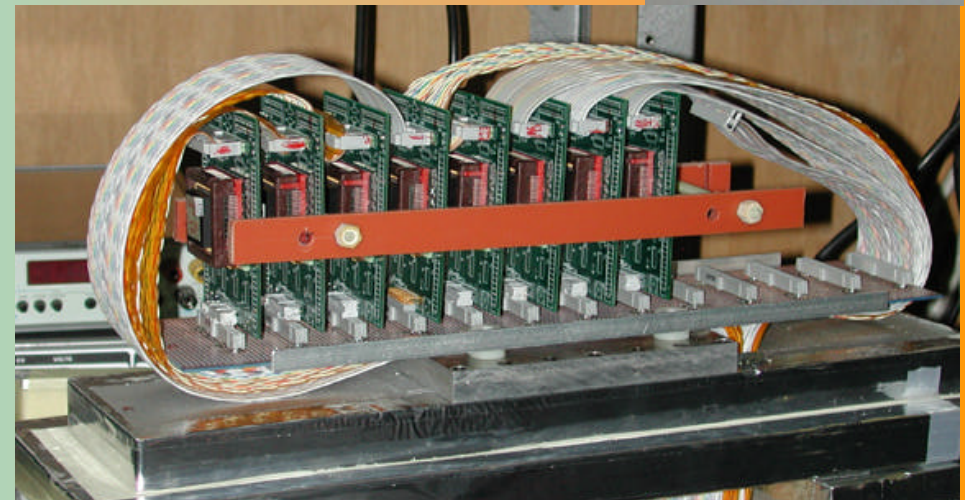
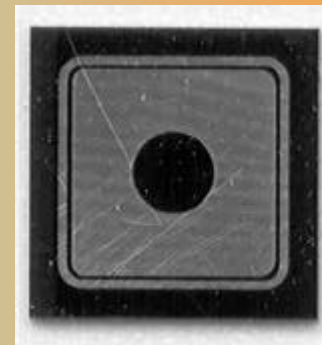
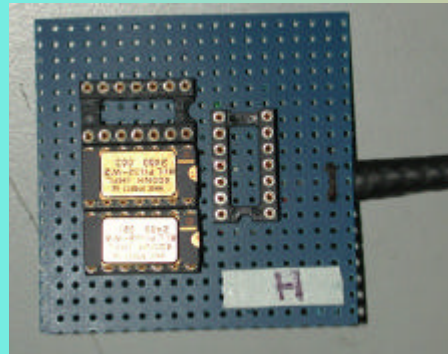
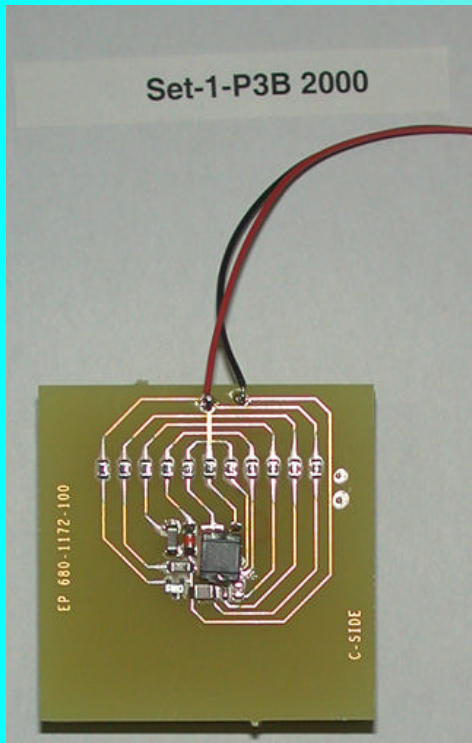
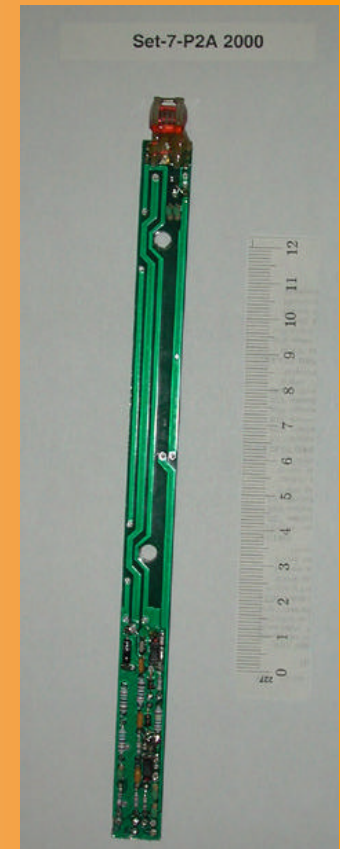
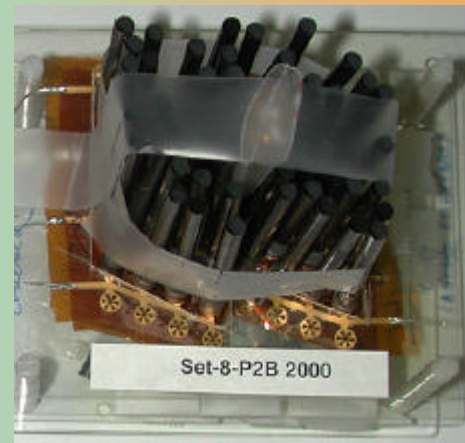
Dosimetry - Neutron irradiation

- **Fluence measurement**
 - By activation of Al, Co, Ni, In, Au foils
 - Spectrometry by Ge spectrometer
 - Silicon detectors
 - Reverse current measurement with I-V/C-V Bench test
 - Radfets, Pin diodes for Gamma's dosimetry
 - Voltage measurement with stable current source

Dosimeters SI, Radfet, AL,
Glass, Alanine.

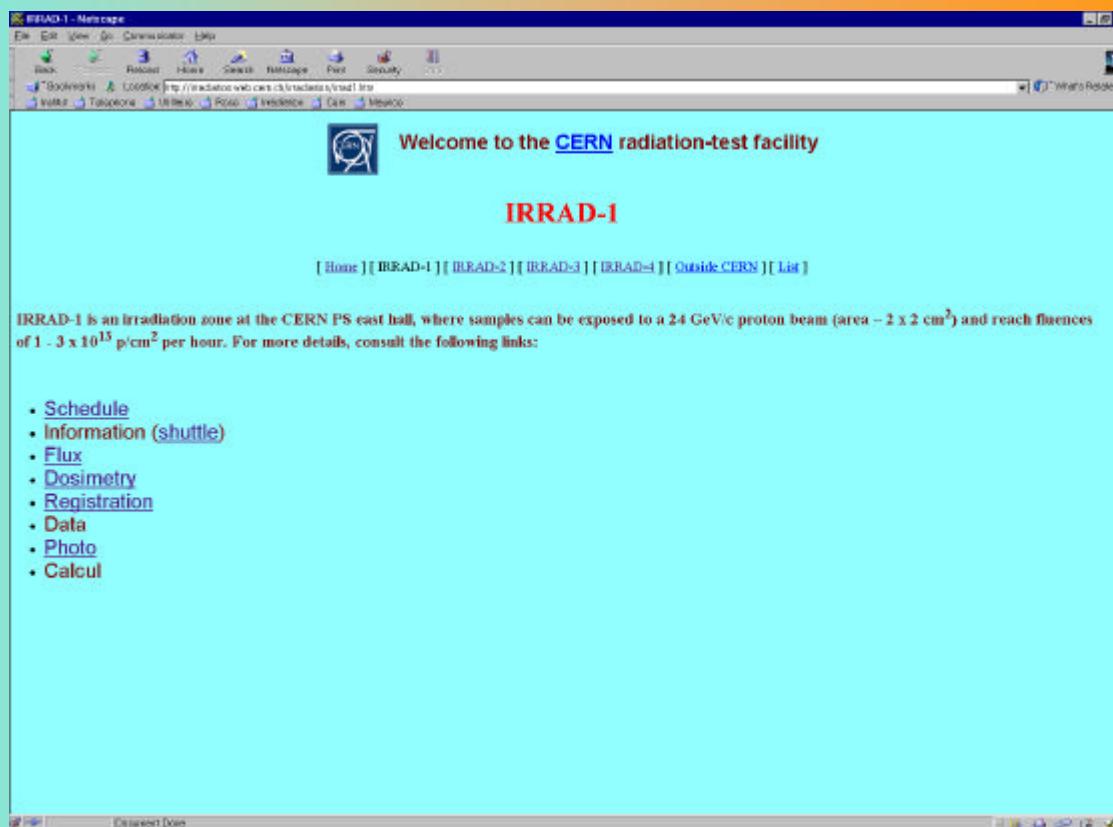


Samples irradiated



Registration, time table, info

<http://www.cern.ch/irradiation>



Laboratory facilities



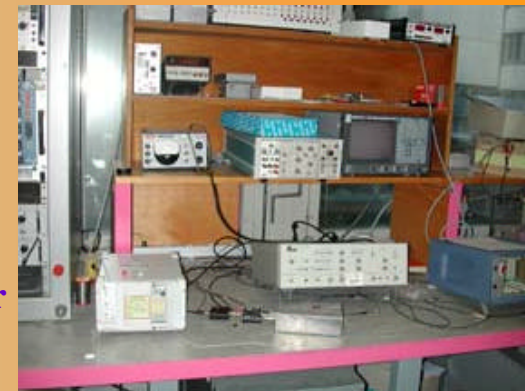
IV-CV bench test



Cryostat for DLTS



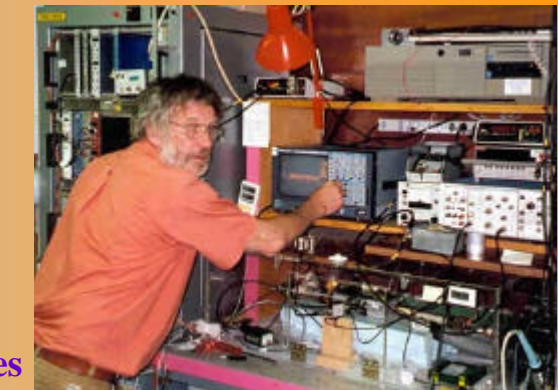
Probe station



Charge collection by Laser



3 Furnaces for Si treatment



Charge collection
by Radioactive sources

Conclusions

– Shuttles

- Fast irradiation : sample exchange without beam stop
- Improved radiation safety : no access to irradiation area needed

– IRRAD Proton

- Convenient for 24 GeV proton irradiation
- Including irradiation at -10°C

– IRRAD Neutron

- Spectrum dominated by neutron
- Radiation field similar to LHC trackers field

– PS East Hall physics (May 6, until October 27, 2002)

- Proton 4-5 Periods (Period ~ 2-3 weeks)
- Neutron “May to October”
- Pion at PSI (Villigen) (Request has been done for April & June 2002)