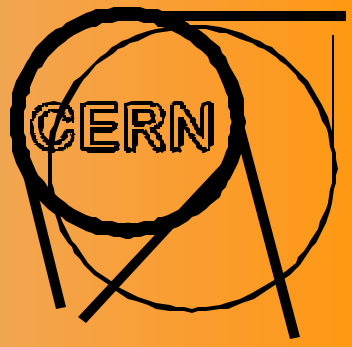
Proton and neutron radiation facilities in the PS East hall at CERN

http://www.cern.ch/irradiation

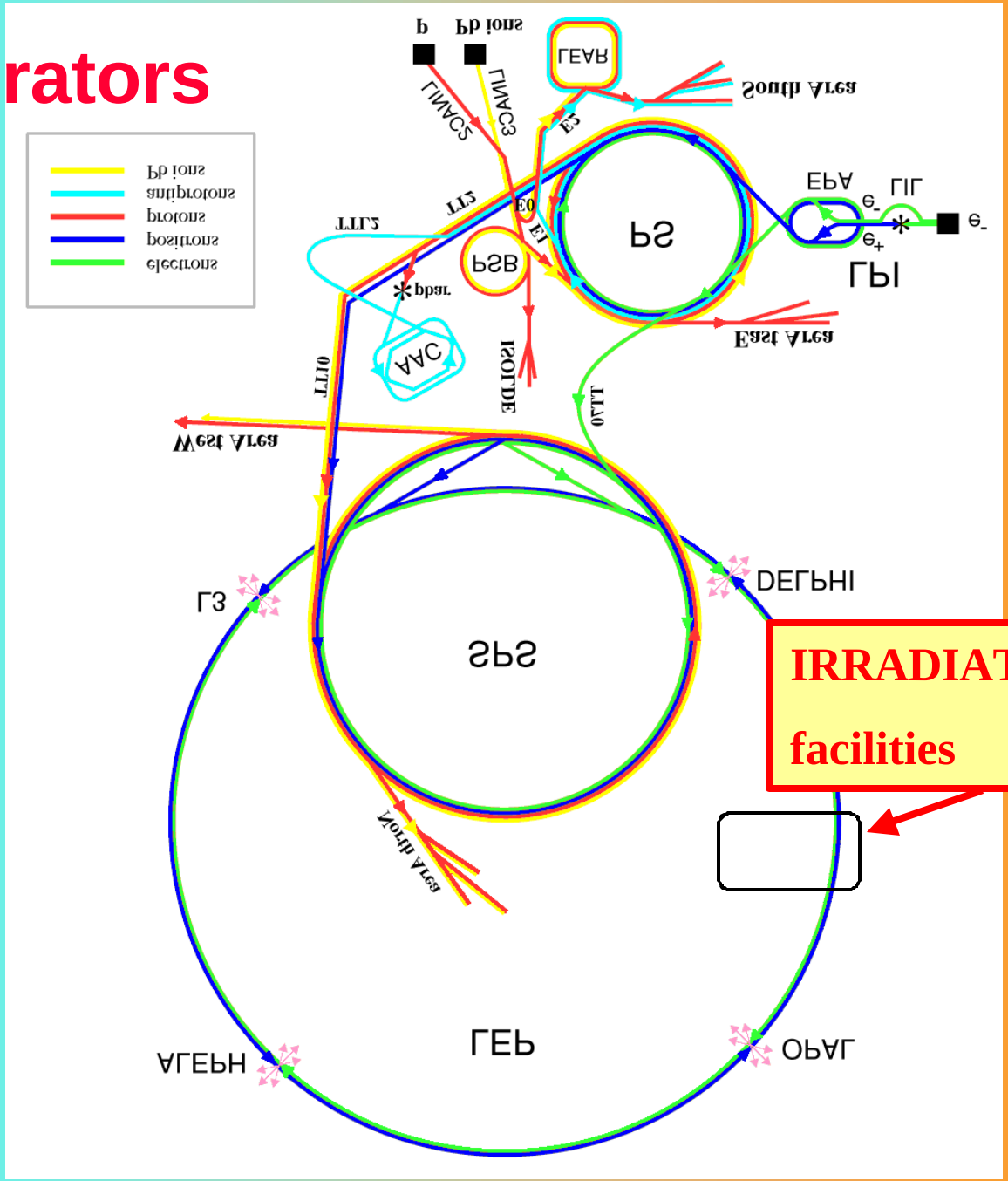
M. Glaser, CERN Division EP-TA1-SD



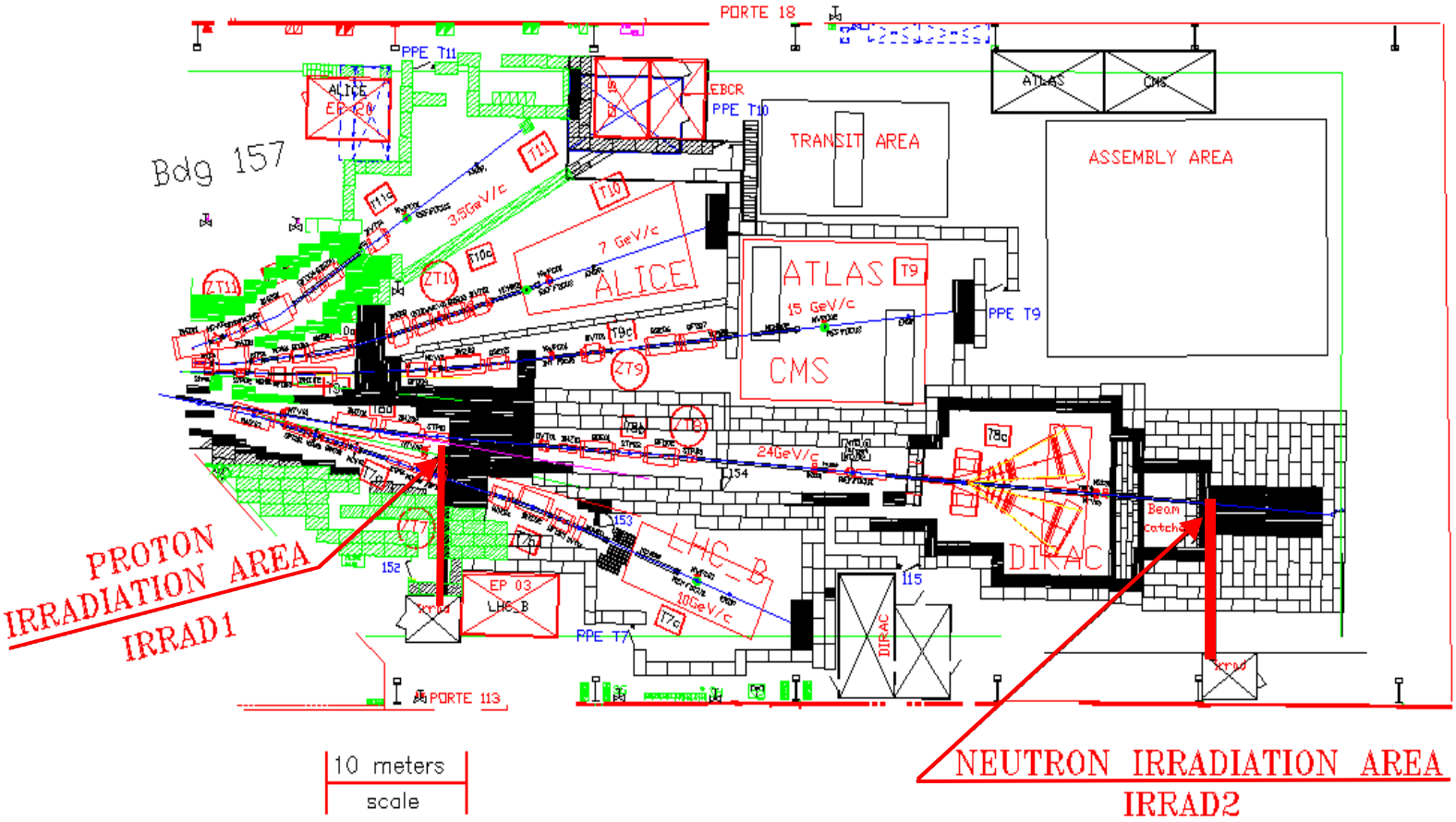
Introduction

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

CERN Accelerators



CERN-PS East Hall

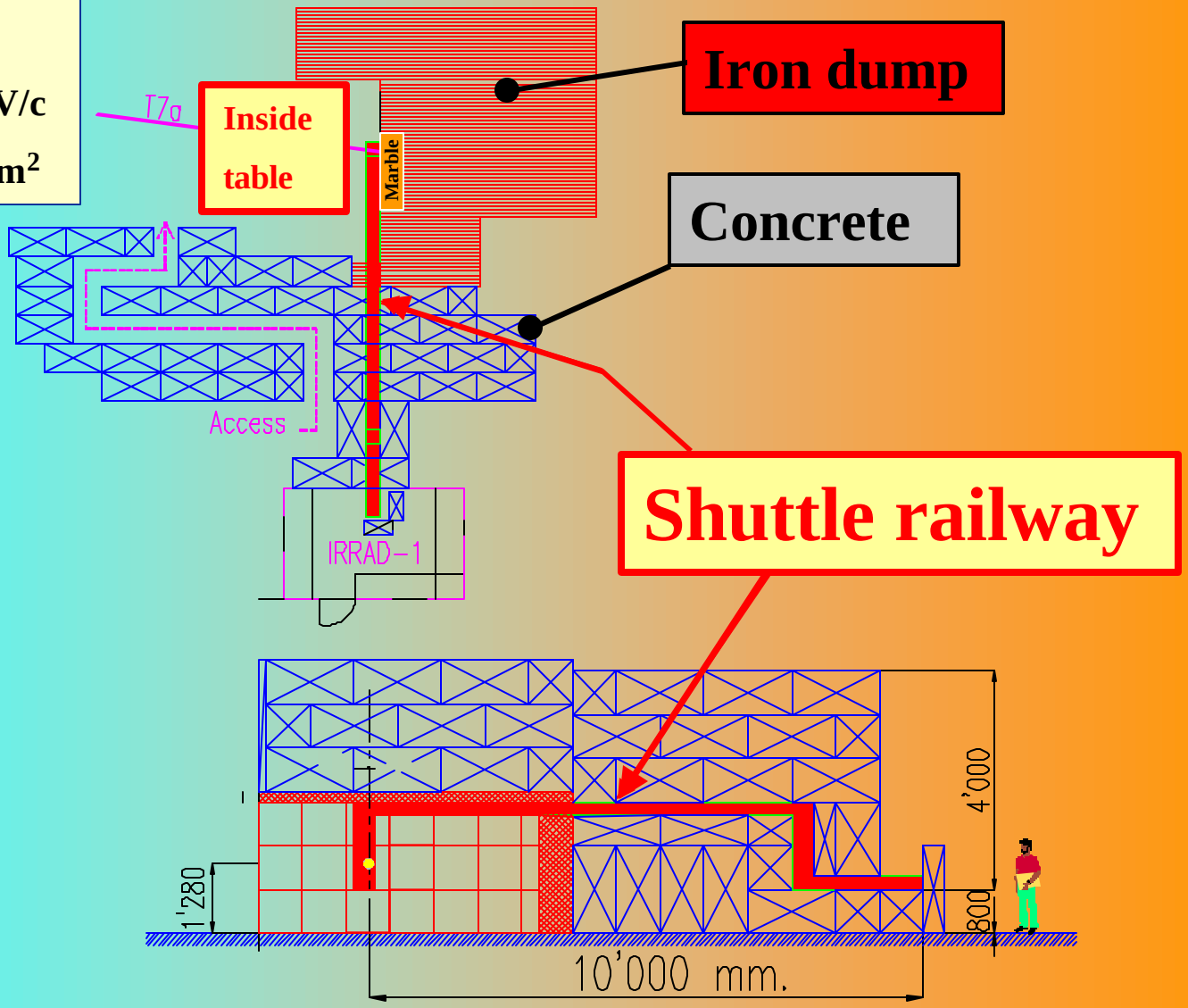


Proton shuttle and inside area facilities

T7 Beam

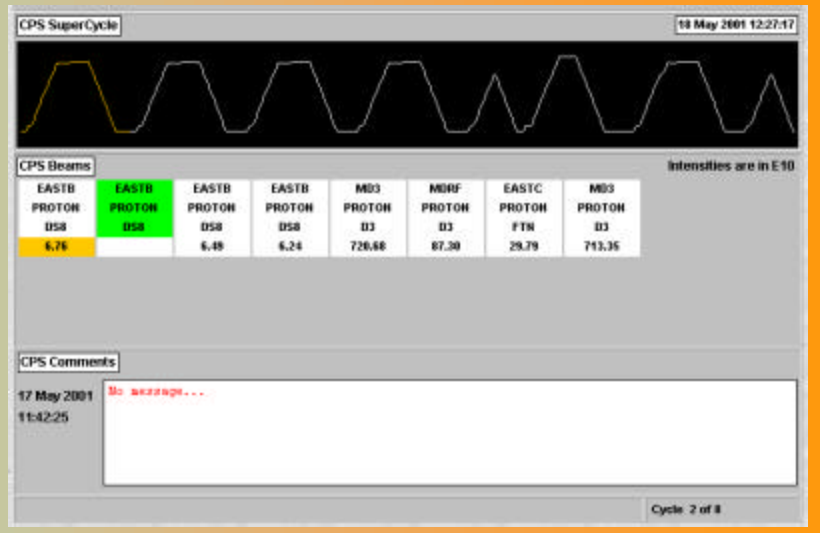
Proton 24 GeV/c

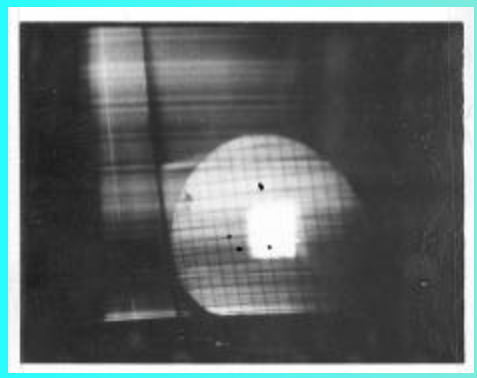
Spot = 2 x 2 cm^2

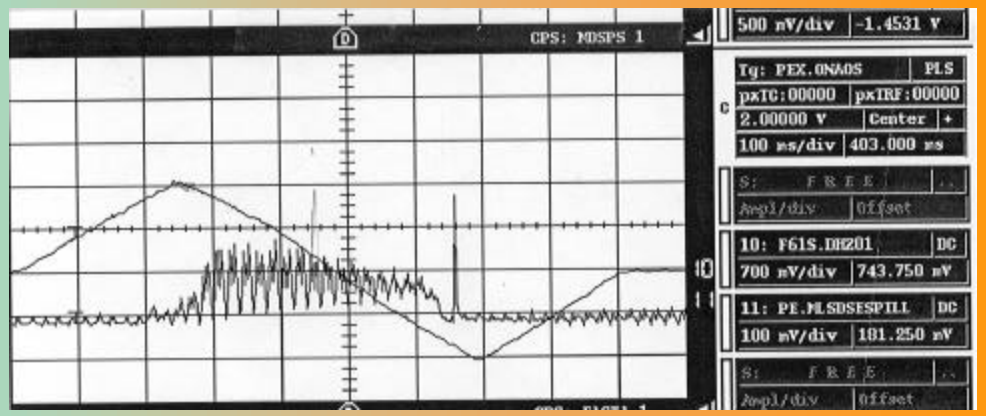


Proton irradiation facilitity characteristics

- **Primary PS proton beam**
  - Beam line : PS-T7
  - Beam energy : 24 GeV/c
  - Beam spot : 2 x 2 cm^2
- **Proton fluence**
  - 3 - 9 10^9 p cm^{-2} s^{-1}
  - 1 - 3 10^{13} p cm^{-2} h^{-1}

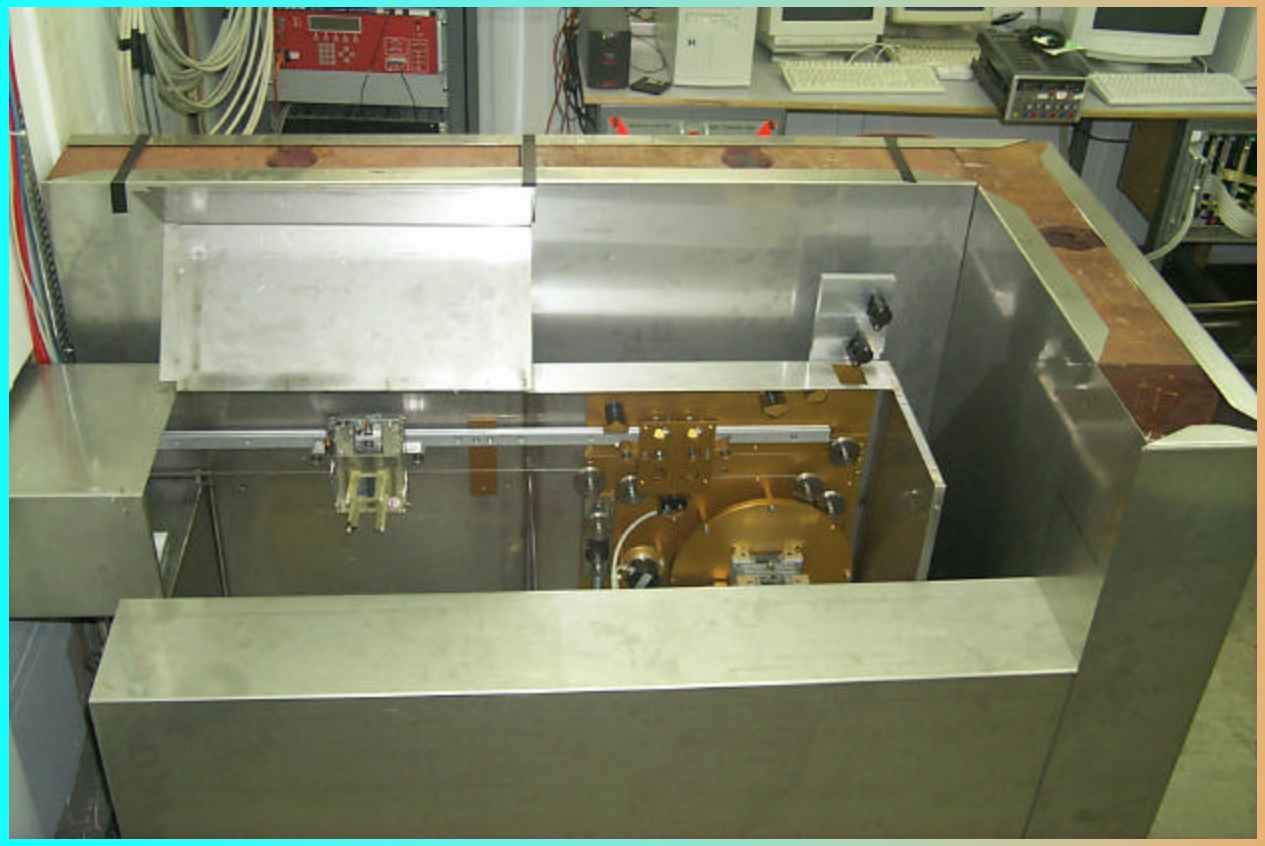


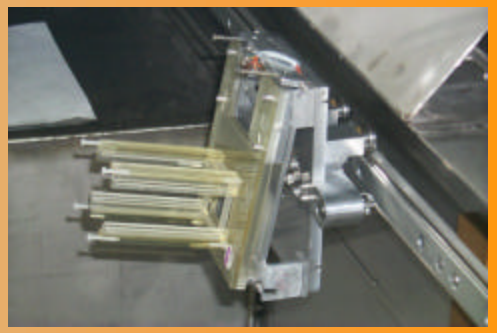


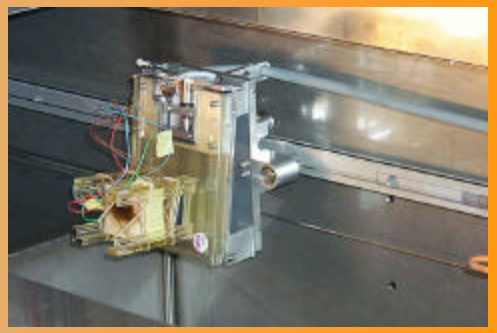


Proton facility - Shuttle

- Standard volume for irradiation 5 x 5 x 15 cm^3
- Max. volume on request 10 x 10 x 20 cm^3
- No restriction for access







Proton facility - Inside area

- Scanning over surface of 10 x 10 cm^2
- Access only on PS machine development
  - 8 hours every one or two weeks
- Max. volume 20 x 20 x 50 cm^3

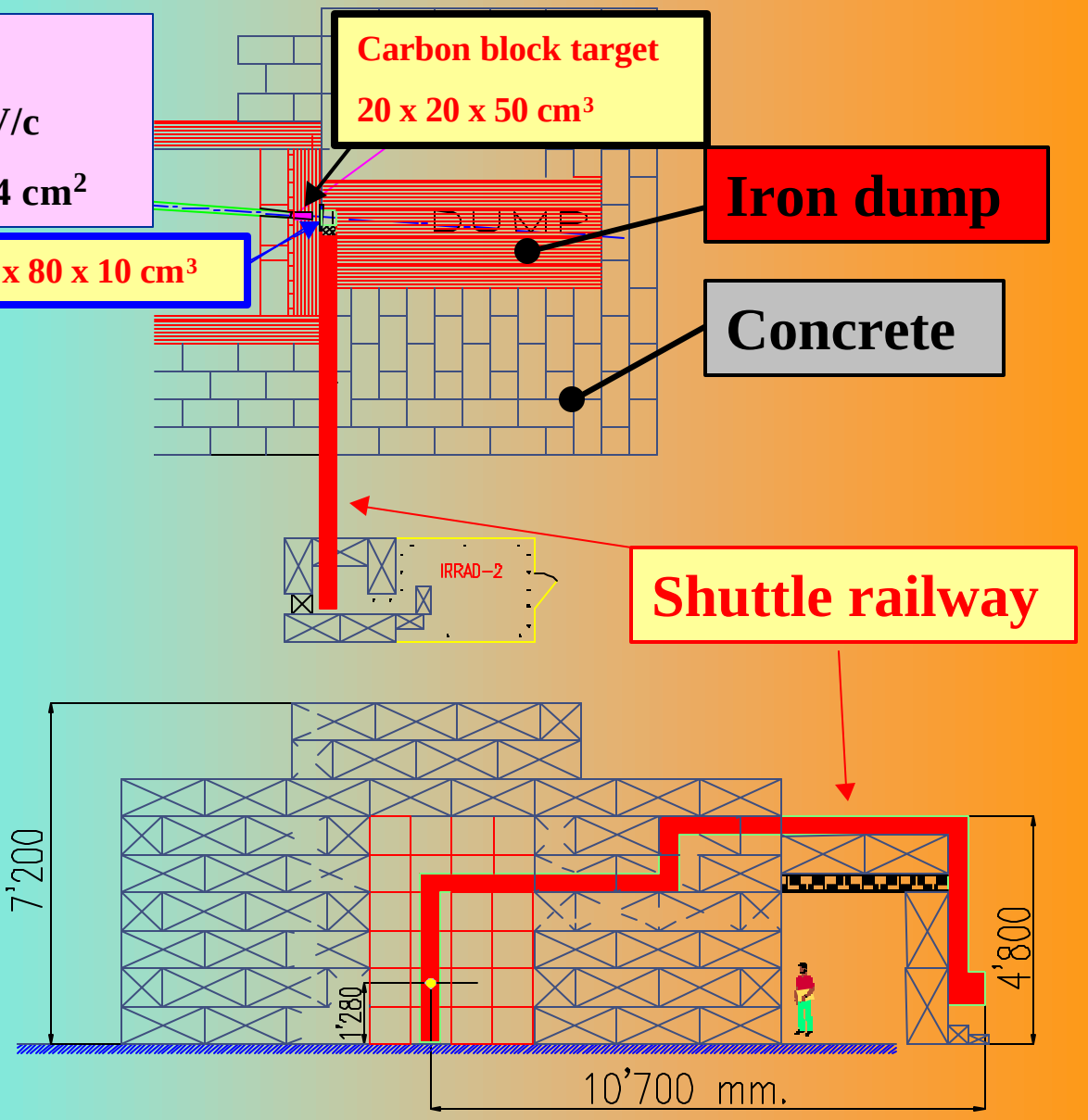
Neutron facility - Shuttle

T8 Beam

Proton 24 GeV/c

Spot$_{(h,v)}$ = 6 x 4 cm^2

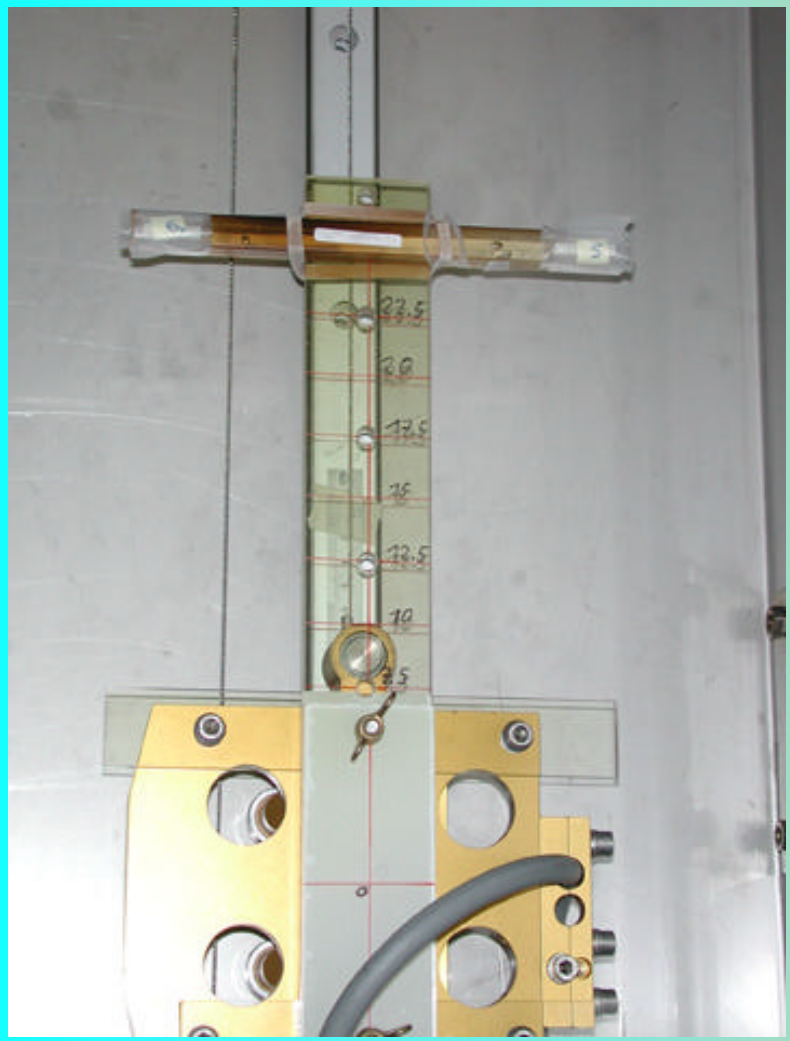
Lead block target 80 x 80 x 10 cm^3



Neutron irradiation facilitity characteristics

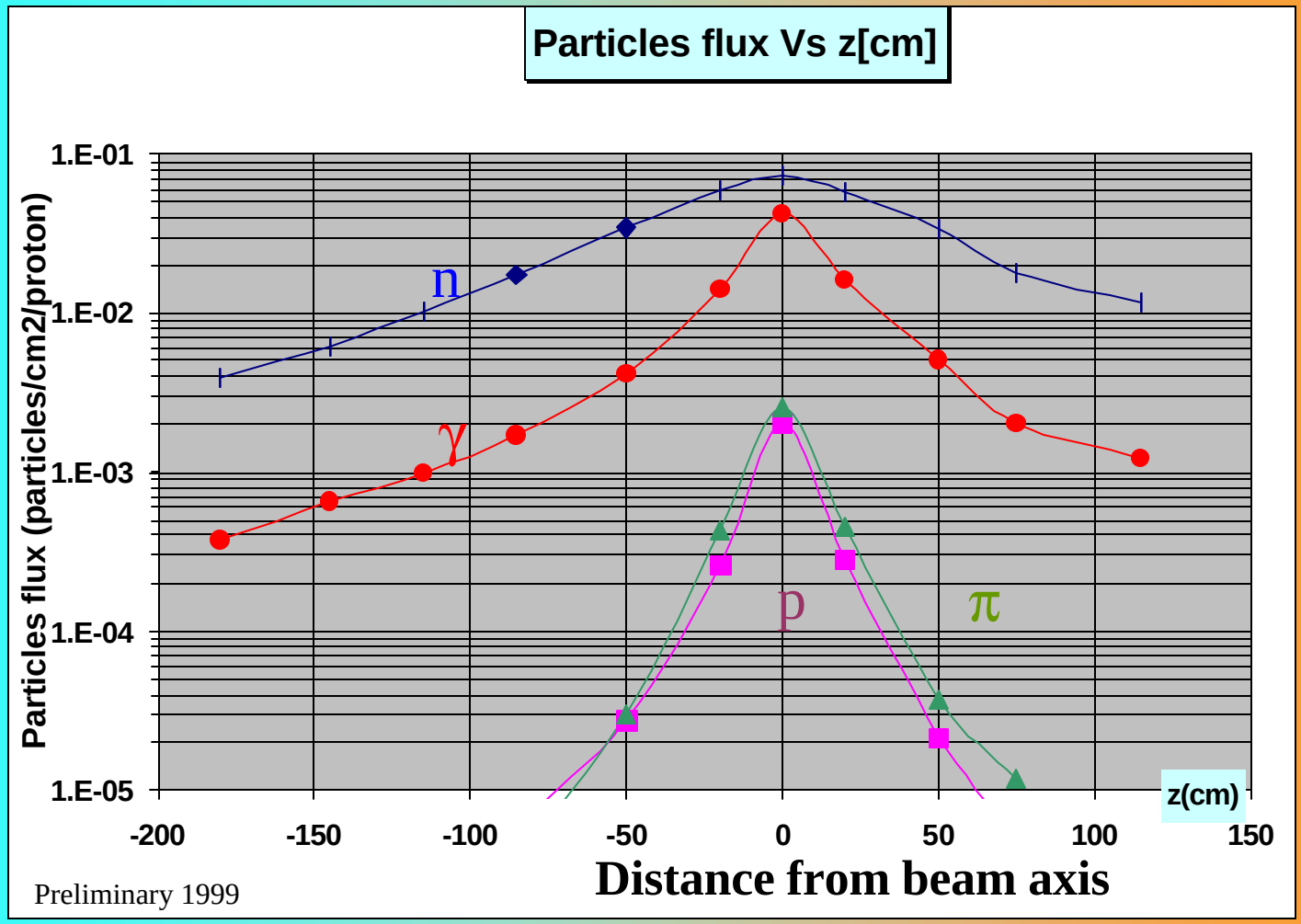
- **Secondary particles in the irradiation cavity**
  - neutron : 50 KeV - 10 MeV
  - p, π+, π- : 0.3 - 4 GeV
  - gamma : 100 KeV - 100 MeV
- **Neutron fluence**
  - Shuttle position = 50 cm from beam axis
  - 1 - 3 10^{7} n cm^{-2} s^{-1} (E > 1 MeV)
  - 6 days for 10^{13} n cm^{-2} (E > 1 MeV)
- **Dimensions**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

Neutron facility - shuttle



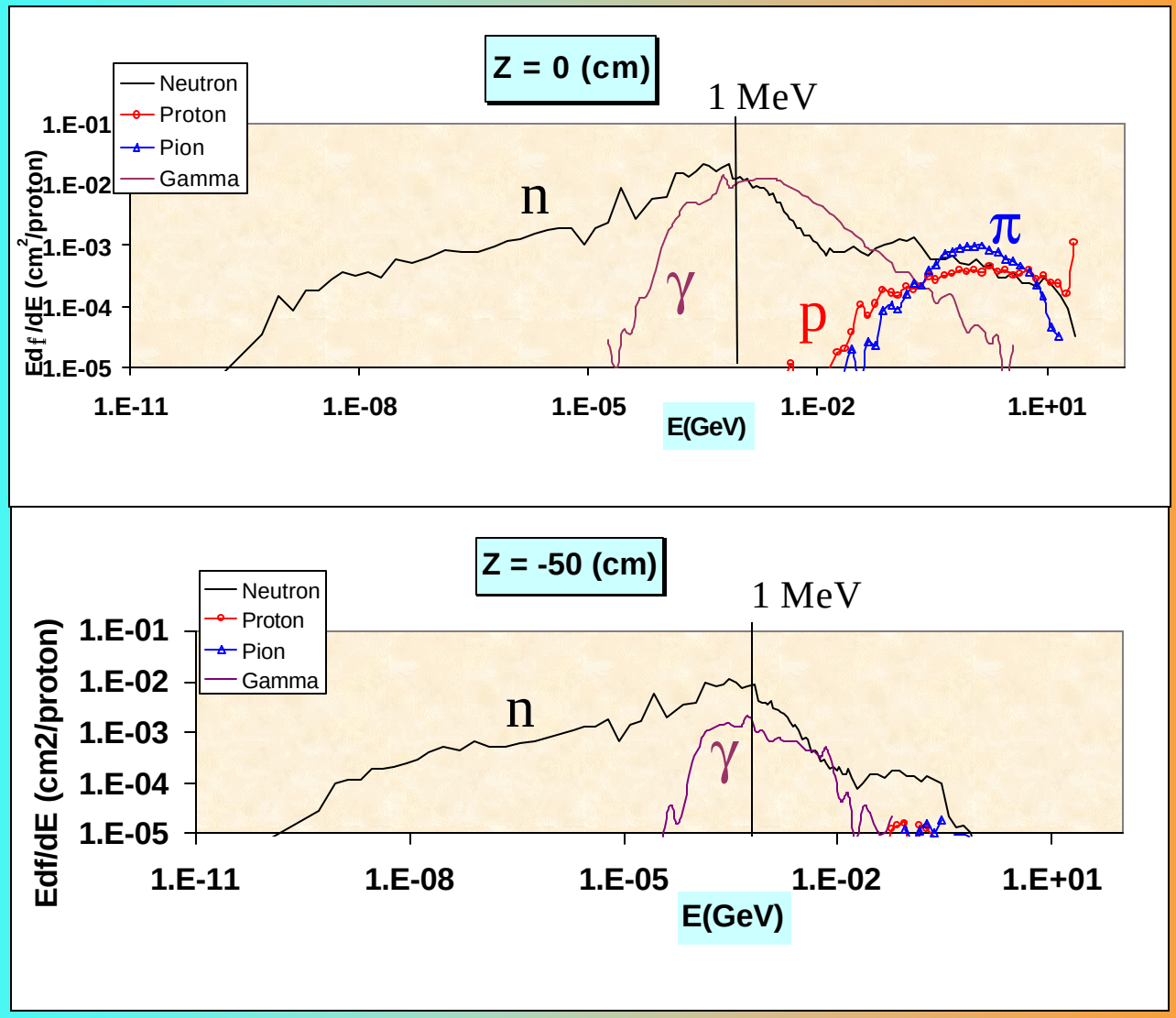
FLUKA simulation for neutron facility

M. Huhtinen CERN EP



FLUKA simulation for neutron facility

Secondary particles spectra at 0 & 50 cm versus Energy



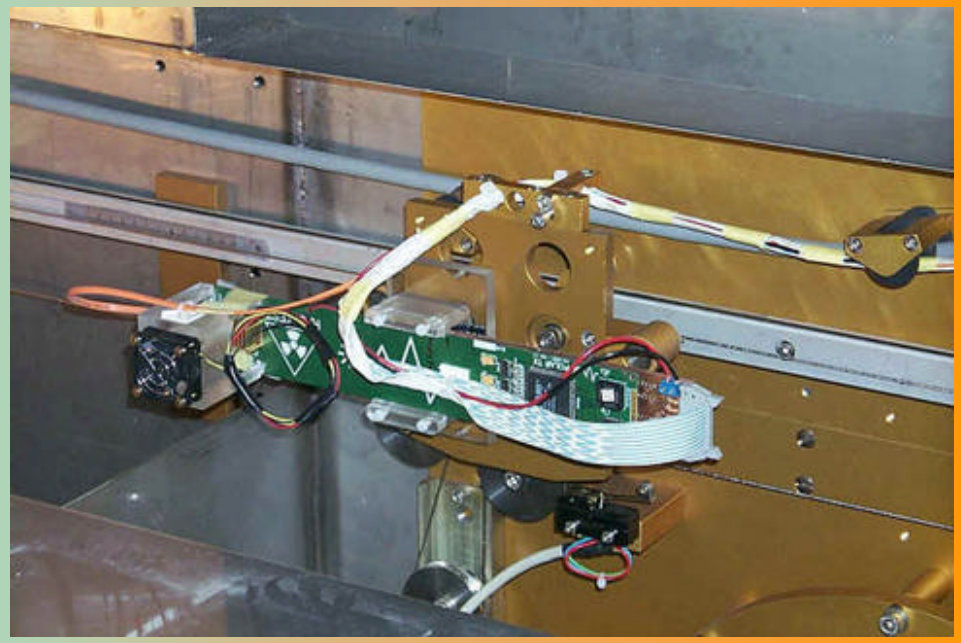
Particles predicted by FLUKA for different energy cuts

Back scattering particles @ 10 cm per cm^{-2} 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 cm^{-2} 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 (~ 4 x 10^9 cm^{-2} h^{-1})
- Test SEU, SEE…. Electronic components
- Readout electronics can be installed on second platform (in distance of 50 cm)

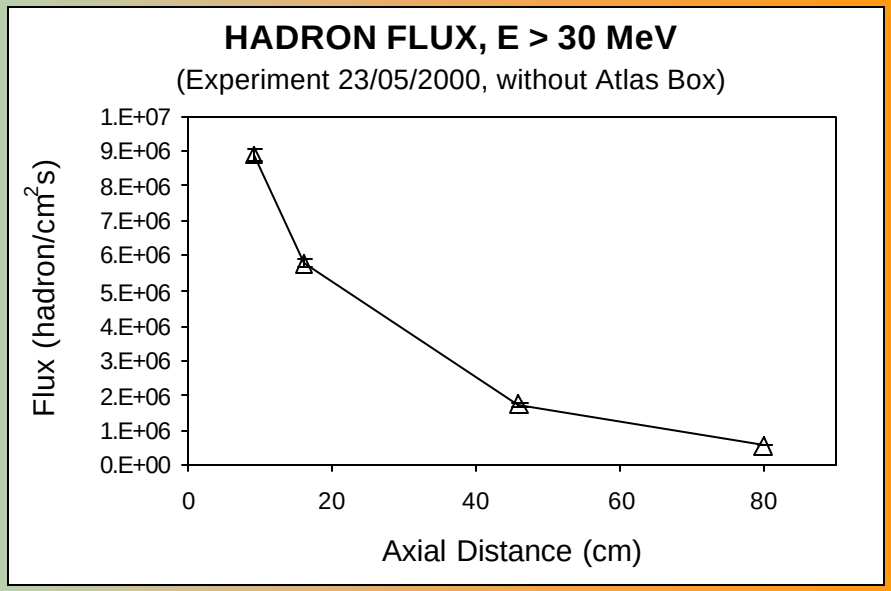


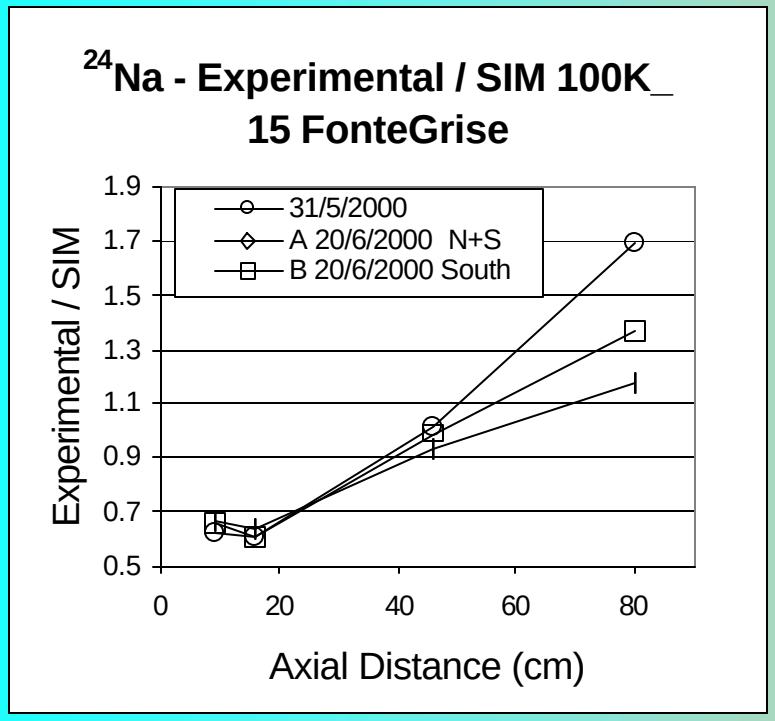
Irradiations with low flux of hadrons calibration & simulation

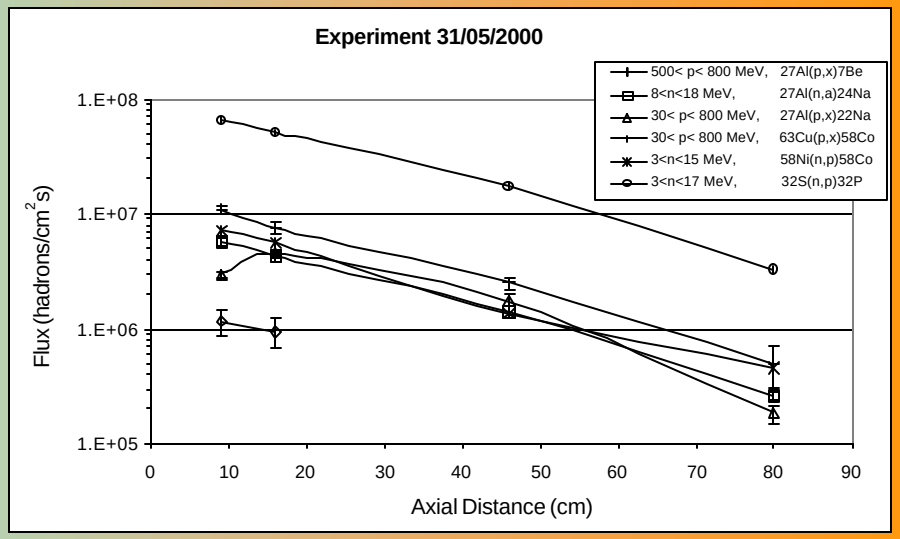
Ignasi Bacardit, Universitat politècnica de Catalunya

Claude Leroy, University of Montreal

Patrick Roy, University of Montreal







Dosimetry - Proton irradiation

Guy Roubaud CERN TIS

- **Fluence measurement**
  - By activation of Al foil
    - $^{27}Al(p,3pn)^{24}Na$, $^{27}Al(p,3p3n)^{22}Na$
  - Spectrometry with NaI spectrometer (+- 6%)
    - ^{24}Na, halflife 15h, $E\gamma$ = 1368.53 keV
  - Spectrometry with Ge spectrometer (+- 2%)
    - ^{24}Na, halflife 15h, $E\gamma$ = 1368.53 keV
    - ^{22}Na, halflife 2.6y, $E\gamma$ = 1274.54 keV

NaI

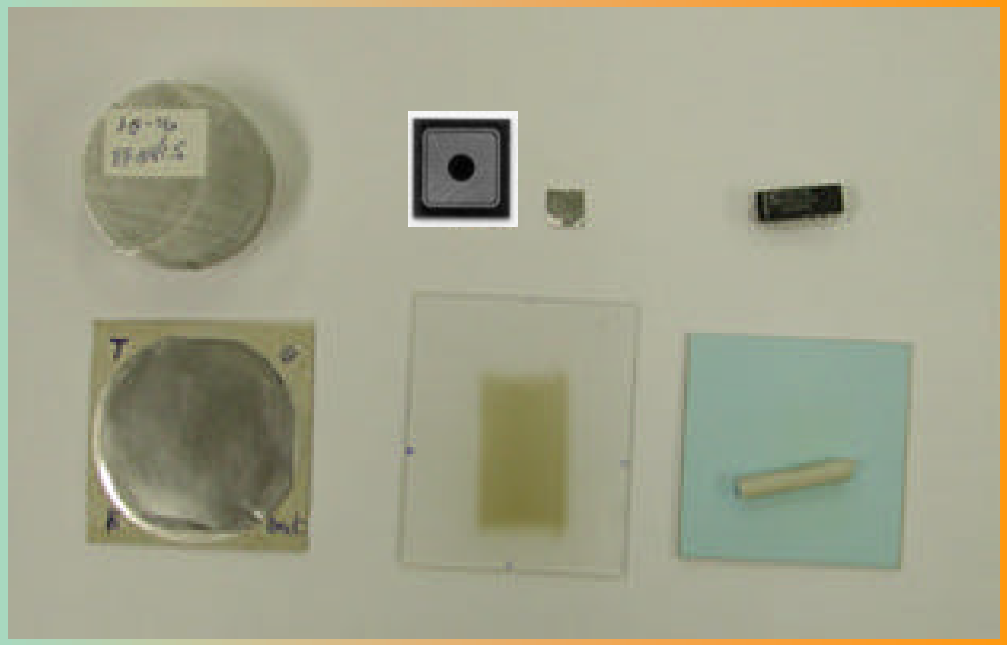
Ge

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.



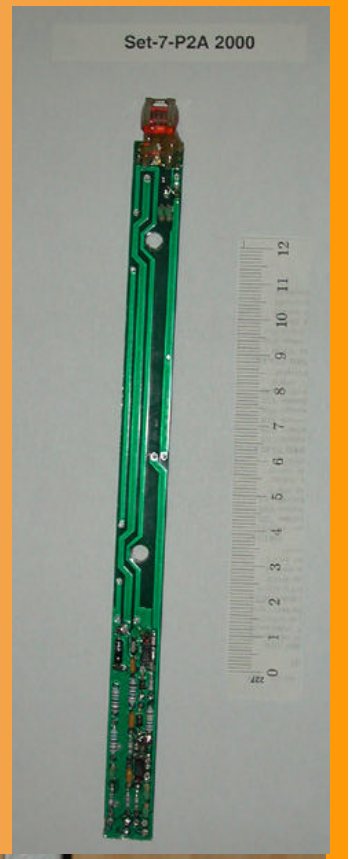
Irradiation, Storage, Expedition…..in 2000

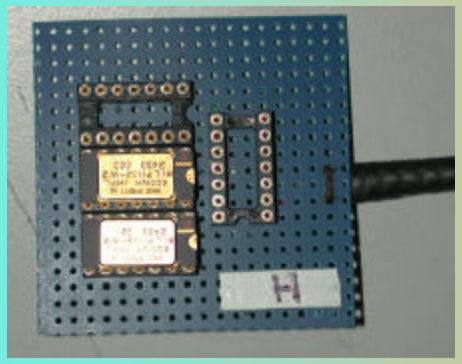
50% more than 1999

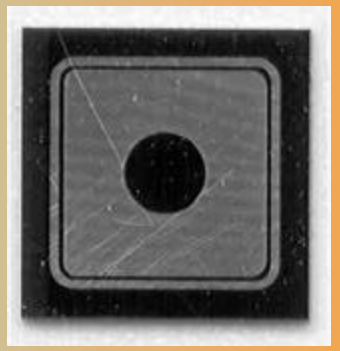
- **3410** Hours of proton irradiation (142 Days)
- **1099** Hours of neutron irradiation (46 Days)
- **649** Dosimetry with NaI spectrometer
- **430** Samples irradiated to store
- **165** Dosimetry with Ge spectrometer
- **65** Users from 30 institutes
- **55** Expeditions all aver the world (T @-5^{o}C)
- **50** Dosimetry with Si detector
- **5** Different places for storage (with freezer)

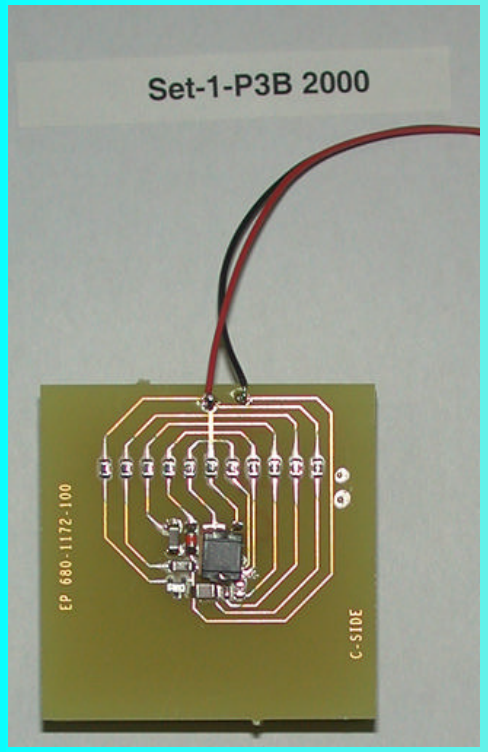
This year ……?

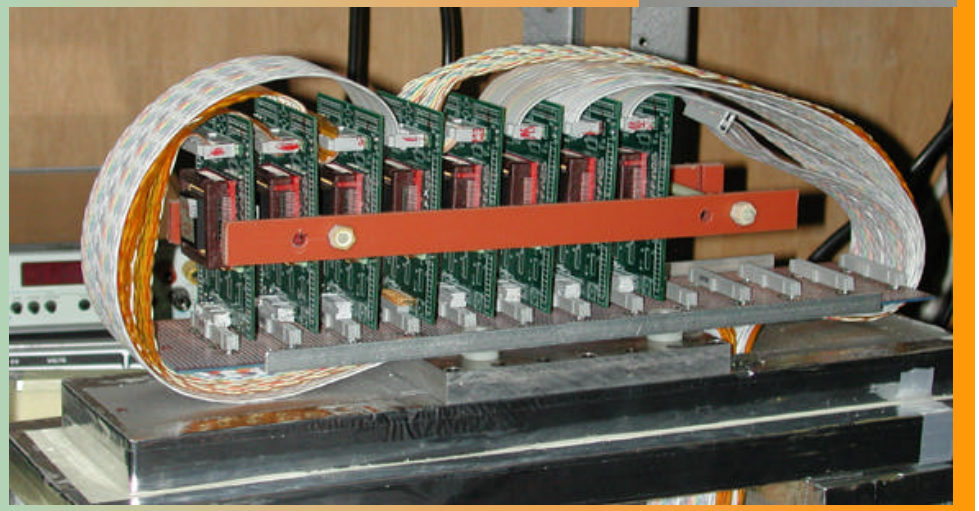
Samples irradiated











Irradiation time table for 2001

Proton facilities

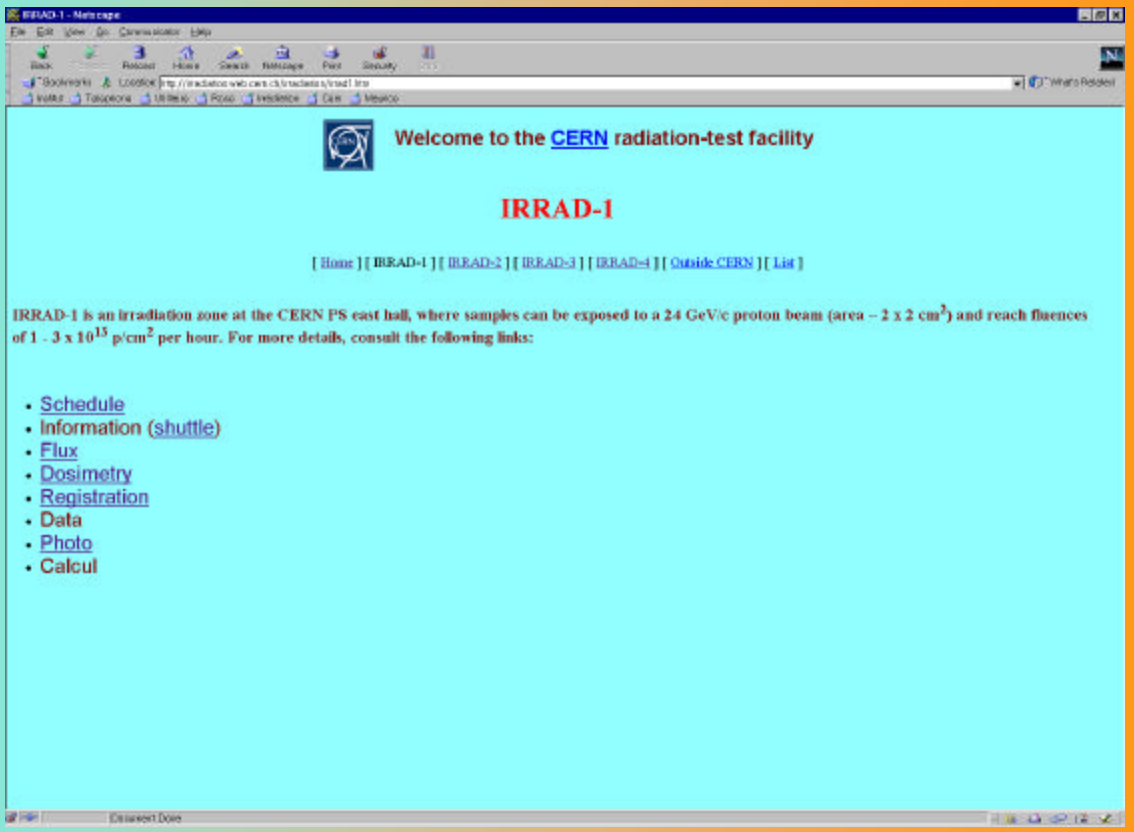
Periode	Start	Stop	Comment
P1A	4/16/01 8:00:00 AM	4/25/01 8:00:00 AM	18/4 MD 8-16h 3 EASTA (8 days)
P1B	5/28/01 8:00:00 AM	6/4/01 8:00:00 AM	30/5 MD 8-16h 3 EASTA (7 days)
P2B	7/2/01 8:00:00 AM	7/18/01 8:00:00 AM	(16 days) 2 EASTA
P2C	8/8/01 8:00:00 AM	8/21/01 8:00:00 AM	(11 days) 1 EASTA/day 2 EASTA/night
P3A	9/3/01 8:00:00 AM	9/14/01 8:00:00 AM	12/9 MD 8-16h (12 days) ? EASTA
P3B	10/24/01 8:00:00 AM	11/5/01 8:00:00 AM	1/11 MD 8-16h (12 days) 1 EASTA/day 2 EASTA/night

Neutron facilities

Periode	Start	Stop	Comment
P1A	4/16/01 8:00:00 AM	5/2/01 8:00:00 AM	MD 18, 25 April 8h00-16h00 (Total 16 days)
P1B	5/2/01 8:00:00 AM	6/4/01 8:00:00 AM	MD 9, 16, 23, 30 May 8h00-16h00 (Total 33 days)
P2A	6/11/01 8:00:00 AM	7/4/01 8:00:00 AM	MD 13, June 8h00-16h00 (Total 23 days)
P2B	7/4/01 8:00:00 AM	8/1/01 8:00:00 AM	MD 1 August 8h00-16h00 (Total 28 days)
P2C	8/1/01 8:00:00 AM	8/27/01 8:00:00 AM	MD 27 August 0h00-End (Total 26 days)
P3A	9/17/01 8:00:00 AM	10/1/01 8:00:00 AM	MD 26 September 8h00-16h00 (Total 14 days)
P3B	10/1/01 8:00:00 AM	11/5/01 8:00:00 AM	MD 10/10, 1/11 8h00-16h00 (Total 35 days)

Registration, time table, info

http://www.cern.ch/irradiation



New developments

Rawi Eggert, Karlsruhe University

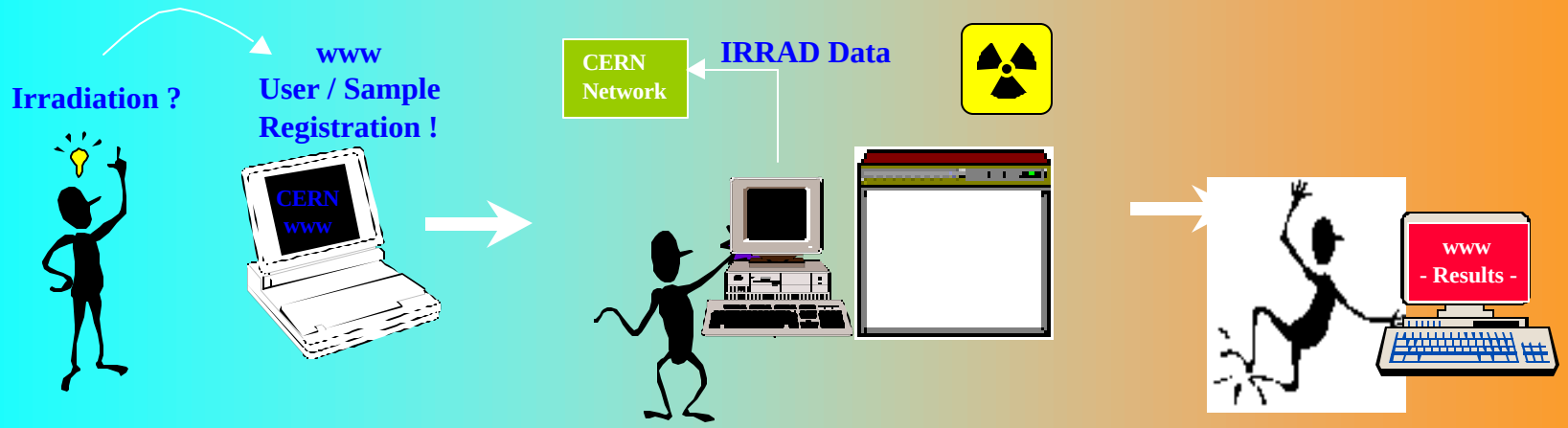
Irradiation control software

- Automation & Functionality
- Registration
- Dosimetry security
- Traceability
- Radiation Sample Check
- Spectrometer control and fluence calculation
- Data management
- User alarm system
- SEC Fluence Monitoring
- Sample irradiation scheduling

New developments

Situation in November 2000

Situation in August 2001



Laboratory facilities

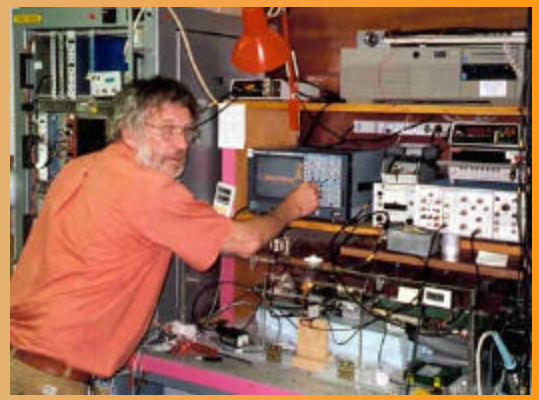
IV-CV bench test

Cryostat for DLTS

Probe station

Charge collection by Laser

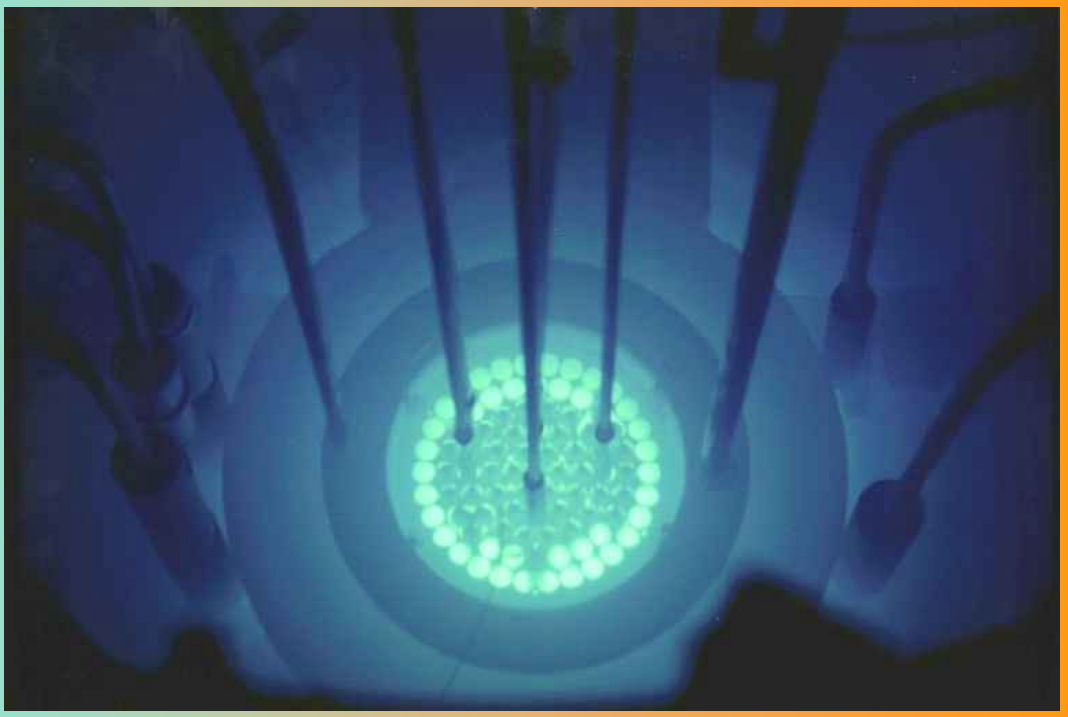
3 Furnaces for Si treatment



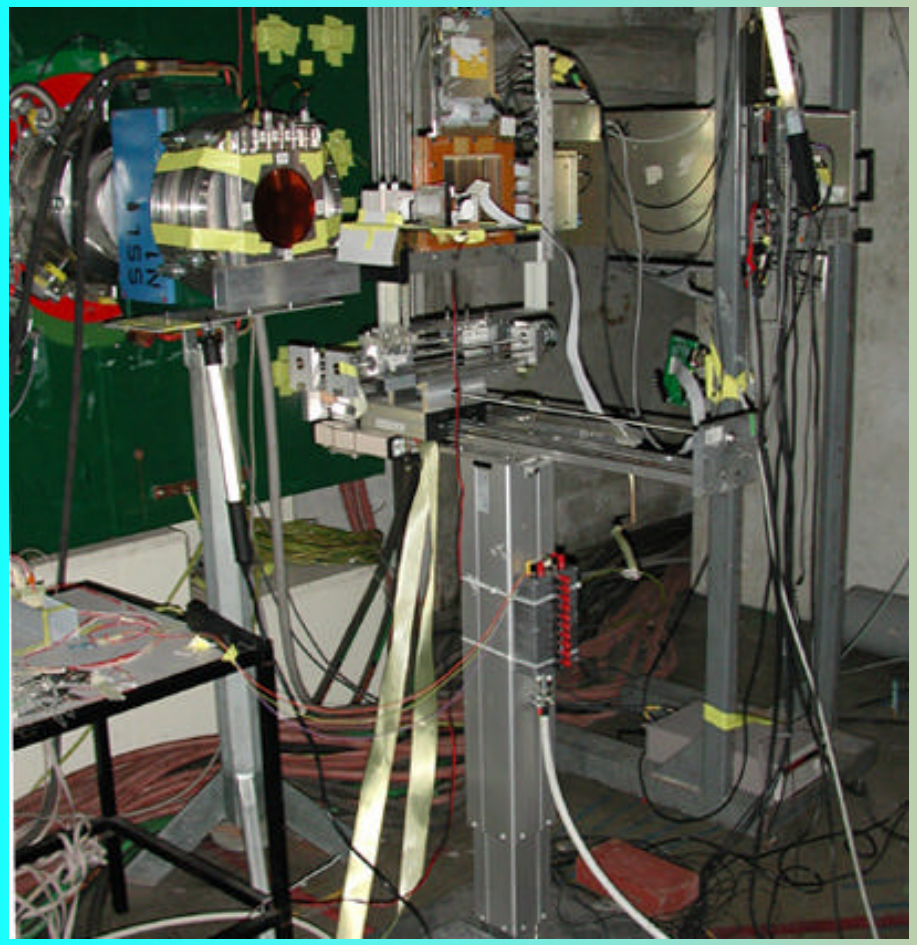
Charge collection

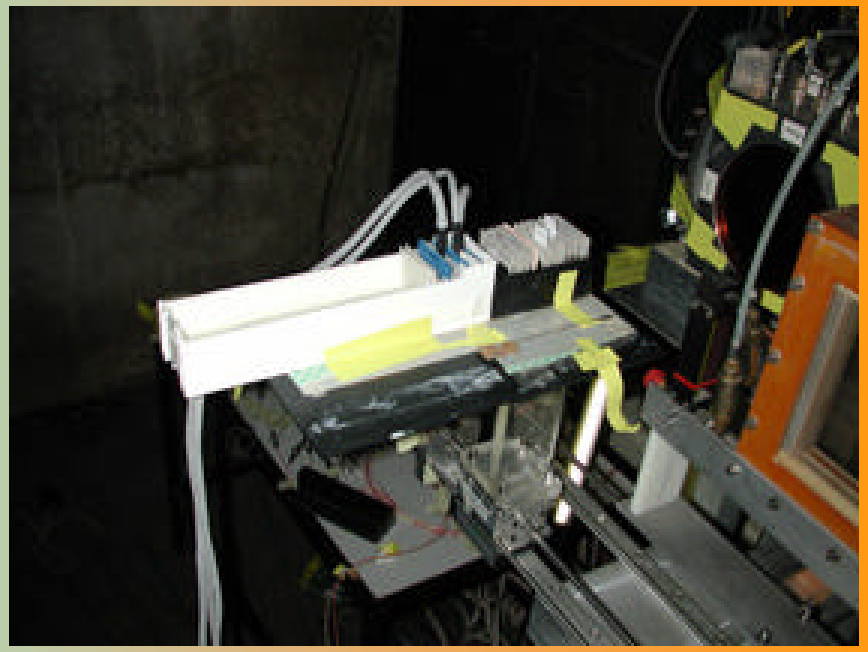
by Radioactive sources

Neutrons irradiation facility at the Ljubljana TRIGA MARK II Research Reactor



Pions irradiation facility at the PSI Villigen





Conclusions

- **Shuttles**
  - Fast irradiation : sample exchange without beam stop
  - Improved radiation safety : no access to irradiation area needed
- **IRRAD 1 & IRRAD 3**
  - Convenient for 24 GeV proton irradiation
  - Including irradiation at -10 ^{0}C (IRRAD 3)
- **IRRAD 2**
  - Spectrum dominated by neutron
  - Radiation field similar to LHC trackers field
- **IRRAD 4**
  - Low flux backscattered hadrons
  - Convenient for SEE, SEU… electronic events
- **FLUKA simulations**
  - Good agreement with measured spectra