CRC
Beam lines and access
CMS upgrade meeting

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UCLouvain

March 14, 2017

CRC facilities at Louvain-la-Neuve

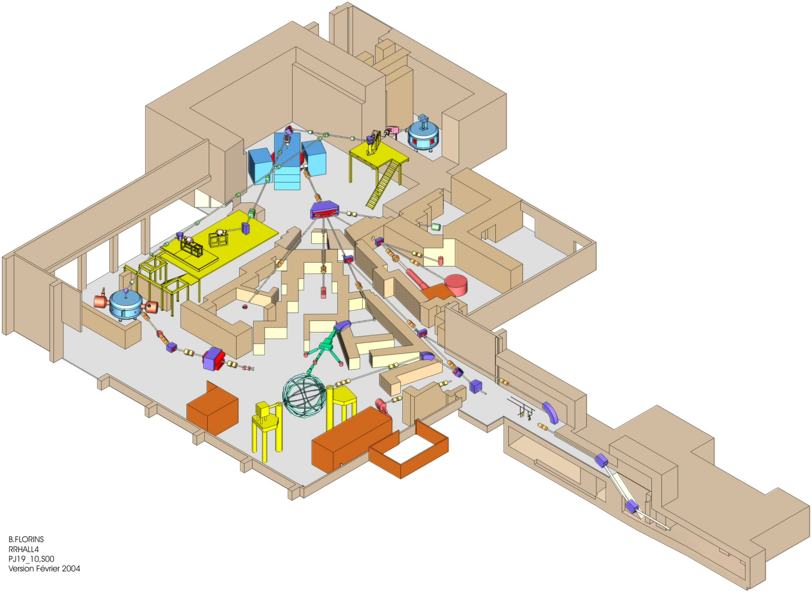
Located at Louvain-la-Neuve (∼20 km from Brussels)

Institut de Recherche en Mathématique et Physique (IRMP)
Center for Cosmology, Particle Physics and Phenomenology (CP3)
Centre de Ressources du Cyclotron (CRC)

Three irradiation facilities

- NIF: Neutron Irradiation Facility
  - Fast Neutrons (0-50 MeV)
  - Flux: 10^{11}n/(cm^2 s)
- LIF: Proton Irradiation Facility
  - Protons 10-60 MeV
  - Flux: 5×10^8p/(cm^2 s)
- HIF: Heavy-Ion Irradiation Facility
  - Heavy Ion "cocktails"
  - Electronic failures induced by radiation

CRC facilities at Louvain-la-Neuve



B.FLORINS
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Version Février 2004

1. HIF: Heavy Ion Facility

HIF: Heavy Ion Facility

Facility to measure the response of electronic components to single event effects (SEE).

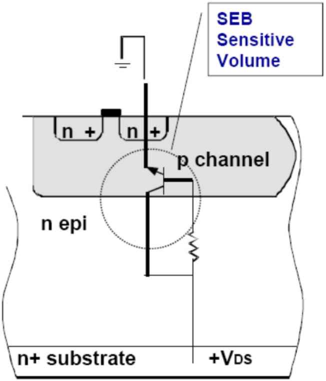
Single Event Effects

SEE: Effects caused by a single energetic particle. Depends on energy released (LET)

Non-destructive effects (Soft errors)
SET: Single Event Transient
SEU: Single Event Upset
- SBU: Single Bit Upset
- MBU: Multiple Bit Upset

SEFI: Single Event Functional Interruption
SEL: Single Event Latchup

Destructive effects (Hard errors)
SHE: Single Hard Error (bit stuck)
SEL: Single Event Latchup
SEB: Single Event Burnout
SEGR: Single Event Gate Rupture
SEDR: Single Event Dielectric Rupture



How to measure SEE

$$\sigma = \frac{N_{SEE}}{\Phi}$$

← Number of SEE

← Fluence $ions/cm^2$ → Φ: $1 - 10^4$ $ions/cm^2 s$ → dead time

$\Phi \uparrow$ → better statistical error

→ Total Dose effects

Weibull function

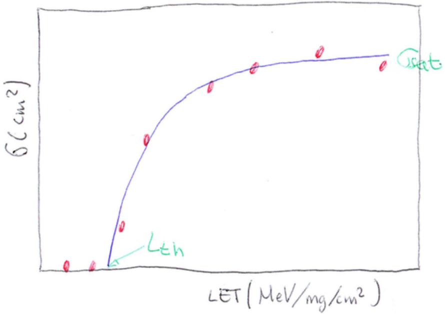
$$\sigma = \sigma_{sat}\left(1 - e^{-\left(\frac{L-L_{th}}{w}\right)^{s}}\right)$$

σ_{sat}: Saturation Cross-section

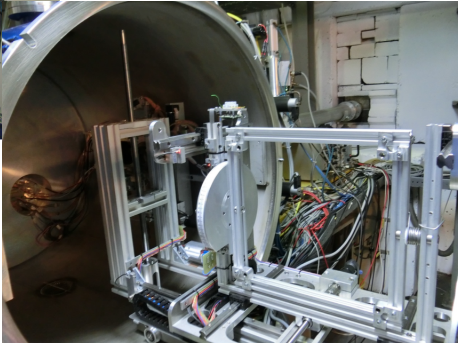
L_{th}: Threshold value

$L <$ → $\sigma = 0$

w, s: fit parameters



HIF facility: the pictures



HIF characteristics

- Two heavy ions cocktails covering a wide range of LET and ranges.
  - Fully characterisation of SEE response of electronic components.
  - Fast ion changing within the same cocktail (few minutes)
- Beam flux is variable between a few ions/s.cm^2 and $\sim 10^4$ ions/s.cm^2
  - Can be modified from user station
  - Online monitoring $\rightarrow$ high precision in fluence delivered
- Several and redundant metrology
  - Fluence and energy
  - Moving frame, alignment system
  - ESA SEU monitor: 4x4 Mbit SRAM (Atmel AT60142F) arranged in a square region of 24mm x 24mm
- Beam homogeneity of 10% on a 25 mm diameter.
- Standard mechanical interface and feedthroughs
- Irradiations are done in vacuum and for most of the ions naked chips are needed.

next

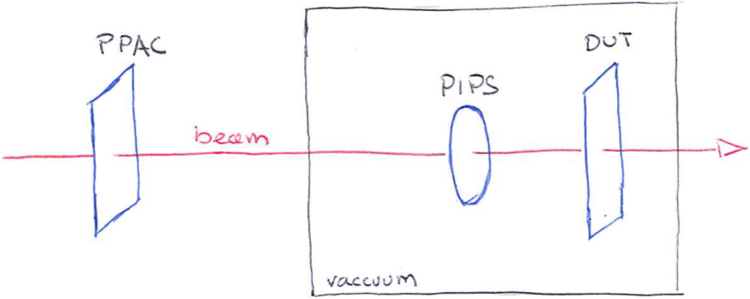
HIF "cocktails"

		M/Q	Ion	DUT energy [MeV]	Range [μm Si]	LET [MeV/mg/cm^2]
Cocktail 1	High LET	5	$^{15}N^{3+}$	60	59	3.3
		5	$^{20}Ne^{4+}$	78	45	6.4
		5	$^{40}Ar^{8+}$	151	40	15.9
		4.94	$^{84}Kr^{17+}$	305	39	40.4
		4.96	$^{124}Xe^{25+}$	420	37	67.7
Cocktail 2	High penetration	3.25	$^{13}C^{4+}$	131	292	1.1
		3.14	$^{22}Ne^{7+}$	235	216	3
		3.33	$^{40}Ar^{12+}$	372	117	10.2
		3.22	$^{58}Ni^{18+}$	567	100	20.4
		3.32	$^{83}Kr^{25+}$	756	92	32.6
		3.54	$^{124}Xe^{35+}$	995	73	62.5

Quality assurance

For each run/cocktail a whole calibration and quality assurance procedure is performed.

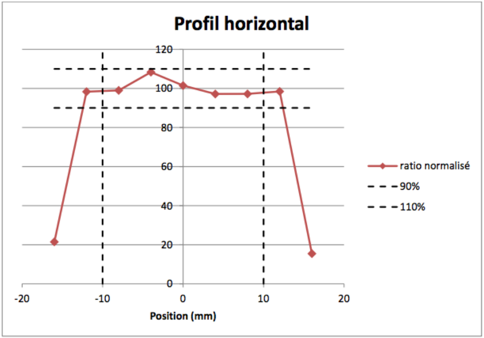
1. Fluence: PPAC+PIPS
2. Profile: PIPS+SEU monitor
3. Energy: PIPS



QA: Beam profile and beam energy

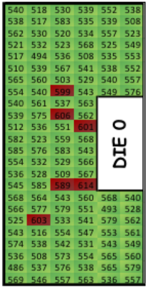
1) Horizontal profile

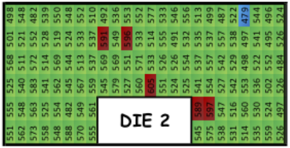
Reference beam :	$^{40}Ar^{8+}$ 151MeV
Horizontal homogeneity :	24 mm
Minimum X value(mm) :	-12 mm
Maximum X value (mm) :	+12 mm



Cocktail	Particle	Energy DUT (MeV)	Measured energy (MeV)
M/Q =5	$^{15}N^{3+}$	60	60
	$^{20}Ne^{4+}$	78	76
	$^{40}Ar^{8+}$	151	144
	$^{84}Kr^{17+}$	305	290
	$^{124}Xe^{25+}$	420	410

QA: SEU monitor

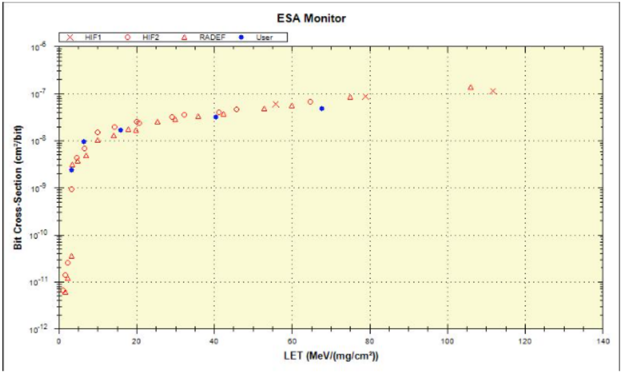




COKTAIL :	M/Q = 5	
ION :	40Ar8+	
ENERGIE DUT :	151	MeV
LET :	15,9	Mev/(mg/cm²)
TOTAL WORD ERROR :	258944	
TOTAL BIT ERROR :	274072	
FLUENCE :	1,00E+06	Part/cm²
CROSS SECTION :	1,633E-08	cm²/bit

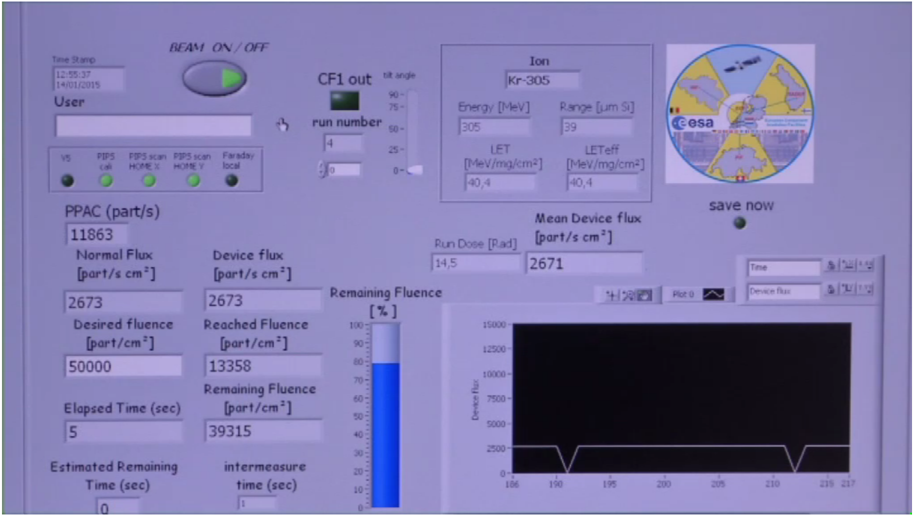
Moyenne	535
110%	589
90%	482

Courbe des sections efficace $\sigma_{(LET)}$



return

User station control panel



2. NIF: Neutron Irradiation Facility

NIF: Neutron Irradiation Facility

Bulk damage in materials.

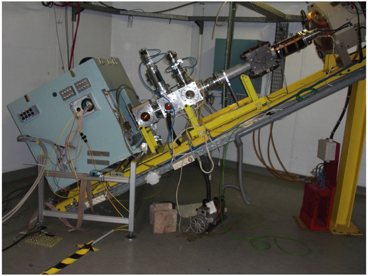
- 50 MeV deuterons on Be target:
- $I_d \sim \mu A$
- Filters for γ and low energy neutrons
  - 10 mm polyethylene
  - 1 mm cadmium
  - 1 mm lead
- Cool box (downto -25 C)

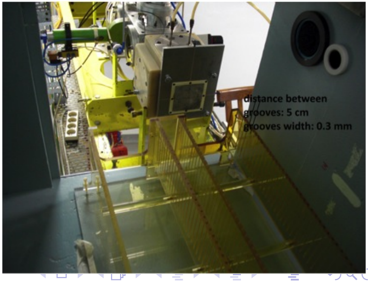
d(cm)	R(cm)	t(h)
5	2	1.6
20	5	24
40	8	88

d : distance to target

R : Radius (80% neutrons)

t : time for $\Phi = 10^{14}$ n/cm^2 ($I_d = 1\mu A$)





Neutron Energy

- Continuous spectra
- Low energy neutrons removed
- MPV = 23 MeV
- Maximum neutron energy 50 MeV

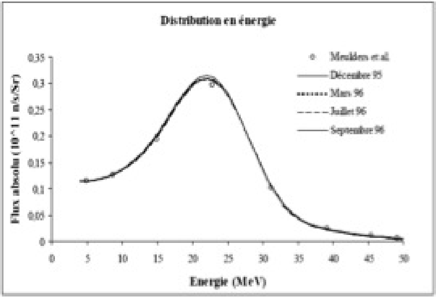


Figure 3.12 : Comparaison des résultats de "déconvolution" ajustés par une fonction « spline » avec quelques points mesurés par Meulders et al. [42].

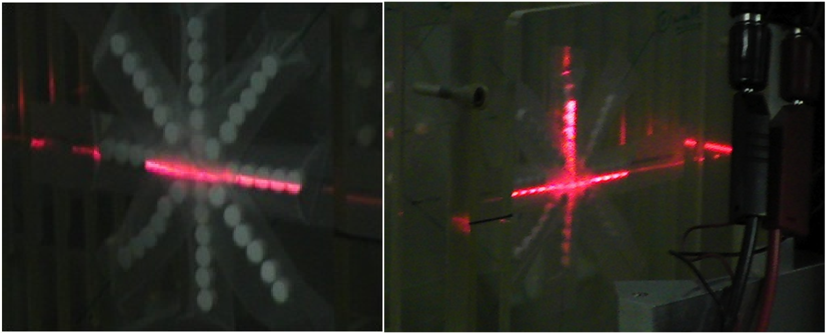
Fluence control

- Deuterons current measured continuously.

$$\Phi(\mathrm{n/cm^2}) = 10^{14}\frac{I(\mu A)\,t(h)}{0.079r^{1.902}}$$

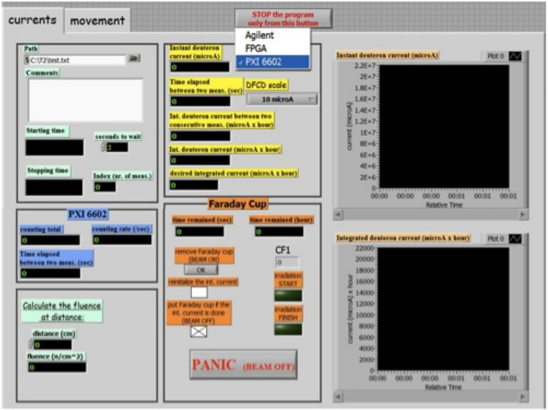
- Alanine dosimeters: present in all irradiations

$$D(Gy) = \Phi \times K \qquad K{=}4.16\ fGy\ m^2$$



NIF control

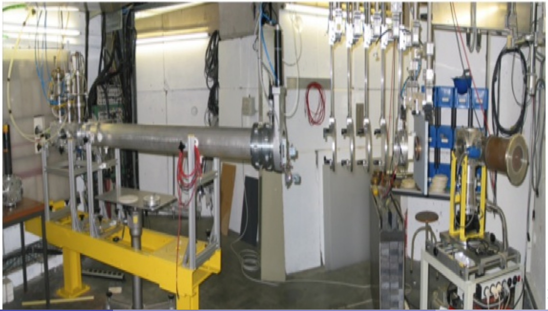
- Control fully automatized
  - Instantaneous and integrated current
  - Beam control
  - Box temperature and movement



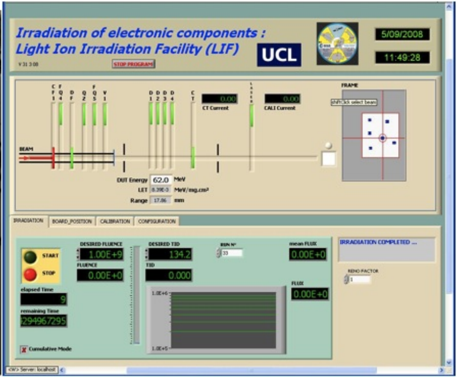
3. LIF: Proton Irradiation Facility

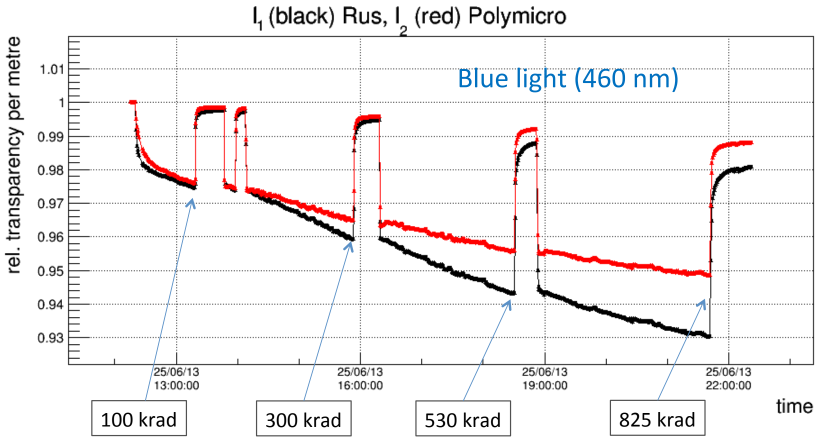
LIF: Proton Irradiation Facility

- Protons 62 MeV + Energy degraders (Polystyrene blocks)
- Max Flux: 10^9p/(cm^2 s)
- Homogeneity: ±10% on a diameter of 8 cm
- Spot size: collimator from 1-8 cm
- Dosimetry:
  - Profile: Water Phantom + diodes
  - Flux: Ionization chamber
  - Energy: Faraday cup + SEU monitor from ESA



Energy degraders and control





Tested were two types of pure silica-high OH quartz fibers with 200 µ core, produced by Polymicro (USA) and Fryazino (Russia). Both found to be good enough for the upgrade of LHCb ECAL calibration system.

Transparency loss measured after short (20-30 min) annealing, for LHCb dose rates (< 0.01 rad/s) can be considered as an upper limit.

dose, krad	transparency loss, % / m	
	Polymicro	Rus
100	0.14	0.23
300	0.45	0.54
530	0.8	1.2
825	1.2	1.9

I. Guz, P. Shatalov

Access to CRC

- CRC runs from March to December (2-3 weeks break in summer)
  - HIF 2/3 weeks/month
  - LIF,NIF 1-2 days/month

- Access cost: $\sim$ 750 EUR/h (for all facilities)
  $\sim$ 400 EUR/h (for belgian universities)
  "Free" for AIDA2020 (belgian institutes not eligible)
  "Free" for UCL users

- Contact persons:
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