Irradiation Facilities at CYCLONE (HIF – LIF – NIF)

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Outline

- ✓ CYCLONE
- ✓ Heavy Ion irradiation Facility (HIF)
- ✓ Light Ion irradiation Facility (LIF)
- ✓ Neutron Irradiation Facilities (NIF): Q – T2
- ✓ 2006 Utilization
- ✓ Foreseen upgrades

CYCLONE

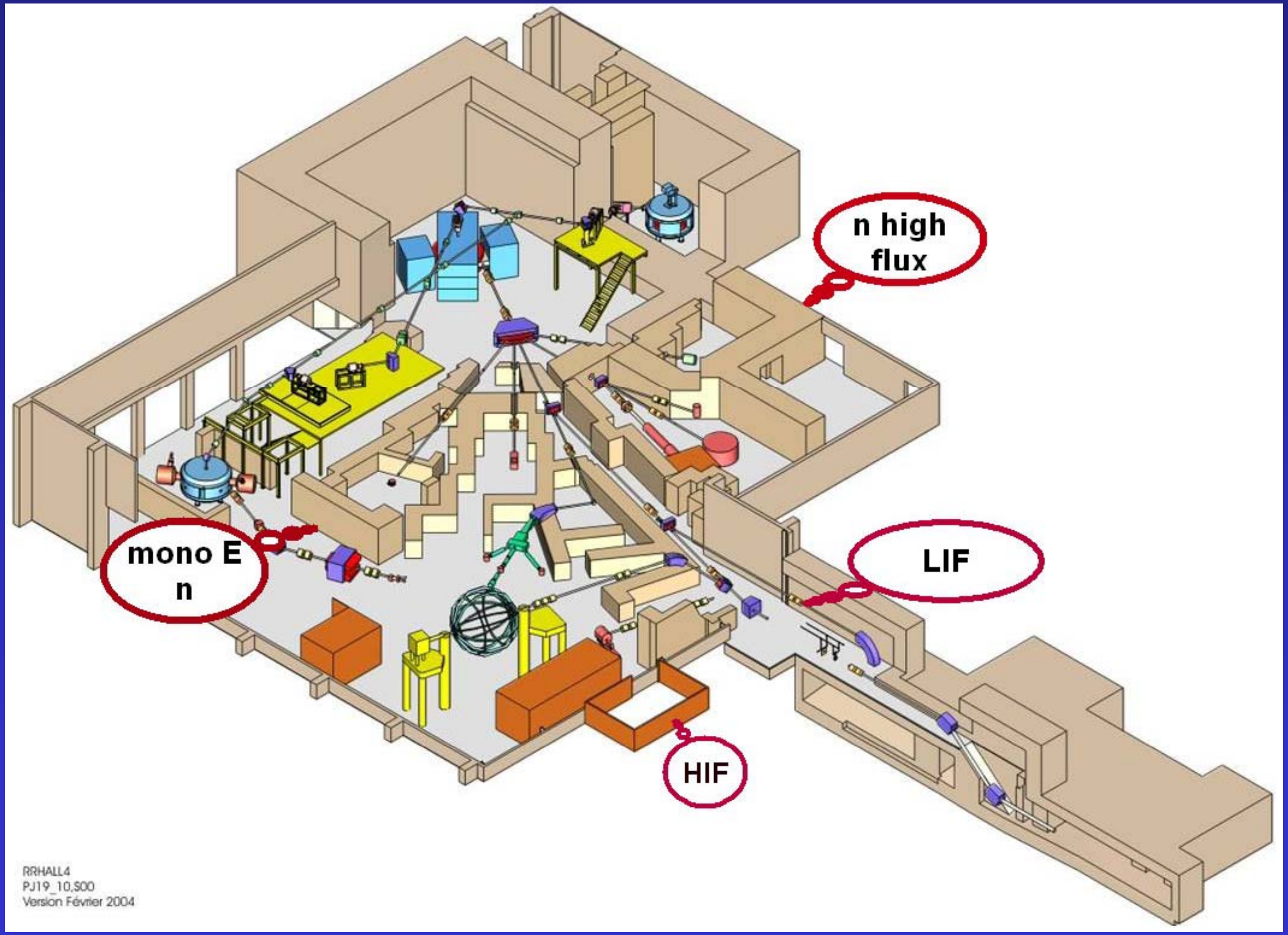
- Protons up to 75 MeV
- α and heavy ions between
  0,6 and 27,5 MeV/AMU

Heavy ions produced with an ECR source

↳ High charge state ($E = 110\ Q^2 / M$)

↳ «Cocktails» (fast ion changing)

CYCLONE


n high flux
mono E n
LIF
HIF
RRHALL4
PJ19_10.S00
Version Février 2004

Heavy Ion irradiation Facility (HIF)

- First device testing in LLN: 1992
- Qualification tests : Novembre 1996

HIF

- Beam: Homogeneity ± 10 % on diam. of 25 mm
  LET range from 0,4 to 56 MeV/mg/cm^2
  Flux from a few part/s cm^2 to a few 10^4
- Monitoring: Flux
  Uniformity
- Calibration: Scan in X and Y
  Flux calibration with PIPS detector
  ESA SEU monitor

HIF

Ion	DUT Energy [MeV]	Range [µm Si]	LET [MeV cm² / mg]
$^{15}N^{3+}$	62	64	2.97
$^{20}Ne^{4+}$	78	45	5.85
$^{40}Ar^{8+}$	150	42	14.1
$^{84}Kr^{17+}$	316	43	34
$^{132}Xe^{26+}$	459	43	55.9

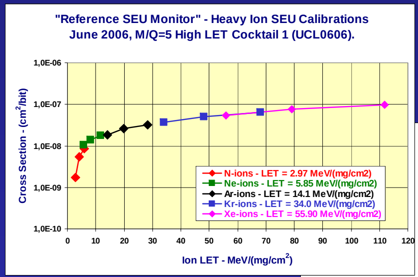
HIF

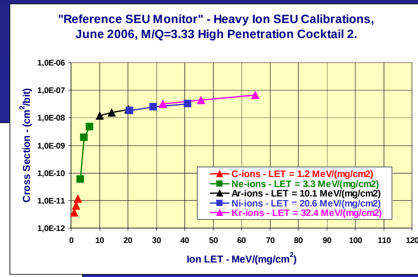
Ion	DUT Energy [MeV]	Range [µm Si]	LET [MeV cm² / mg]
$^{13}C^{4+}$	131	266	1.2
$^{22}Ne^{7+}$	235	199	3.3
$^{40}Ar^{12+}$	372	119	10.1
$^{58}Ni^{18+}$	567	98	20.6
$^{83}Kr^{25+}$	756	92	32.4

HIF

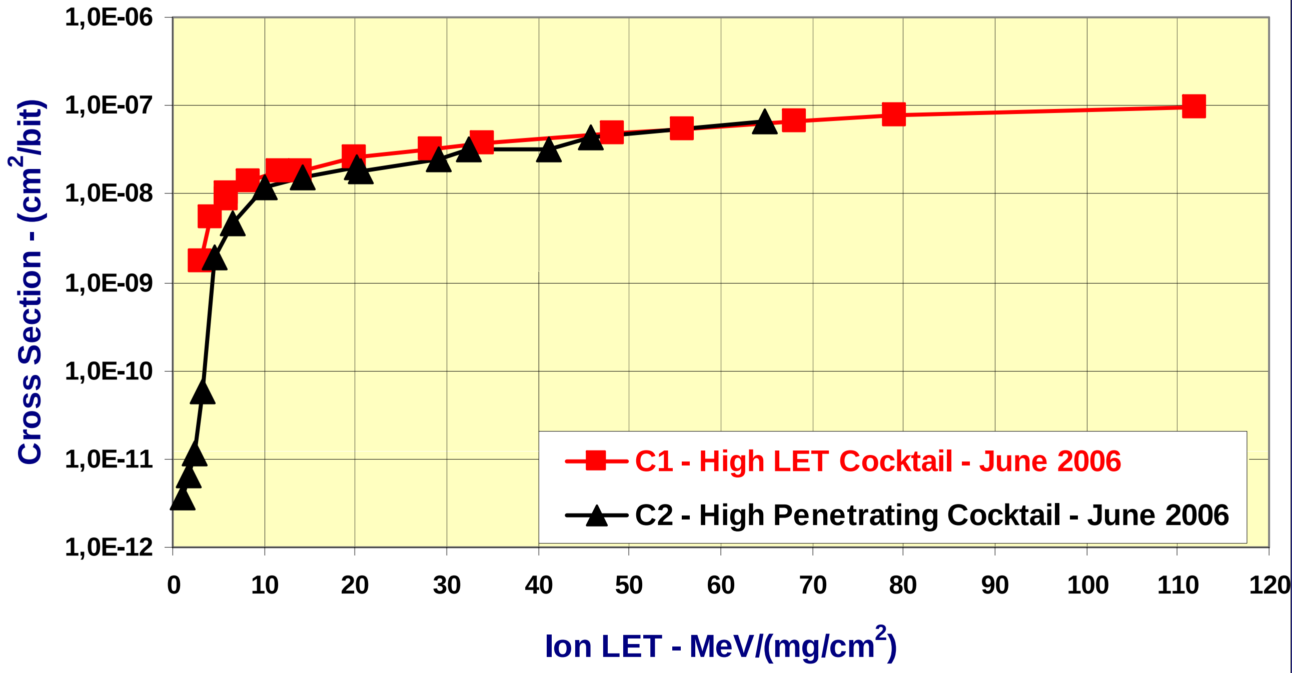
MHS CP65656EV 32K8 SRAM

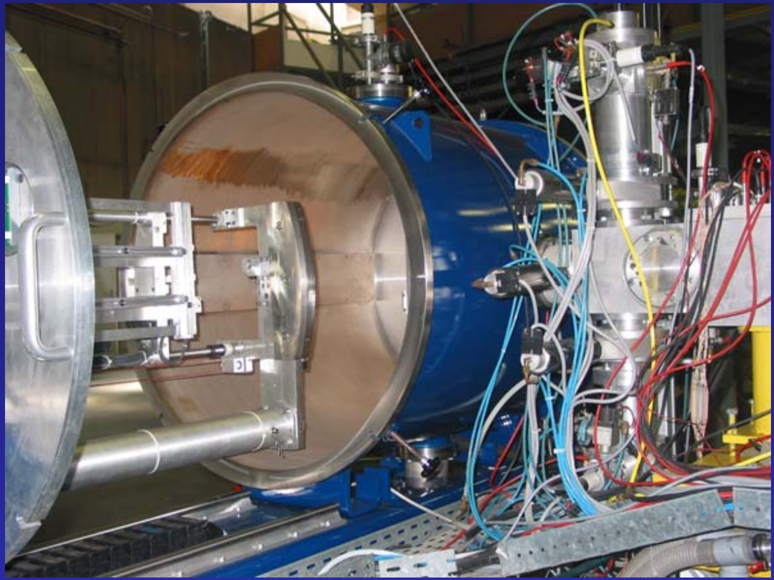
SEU results





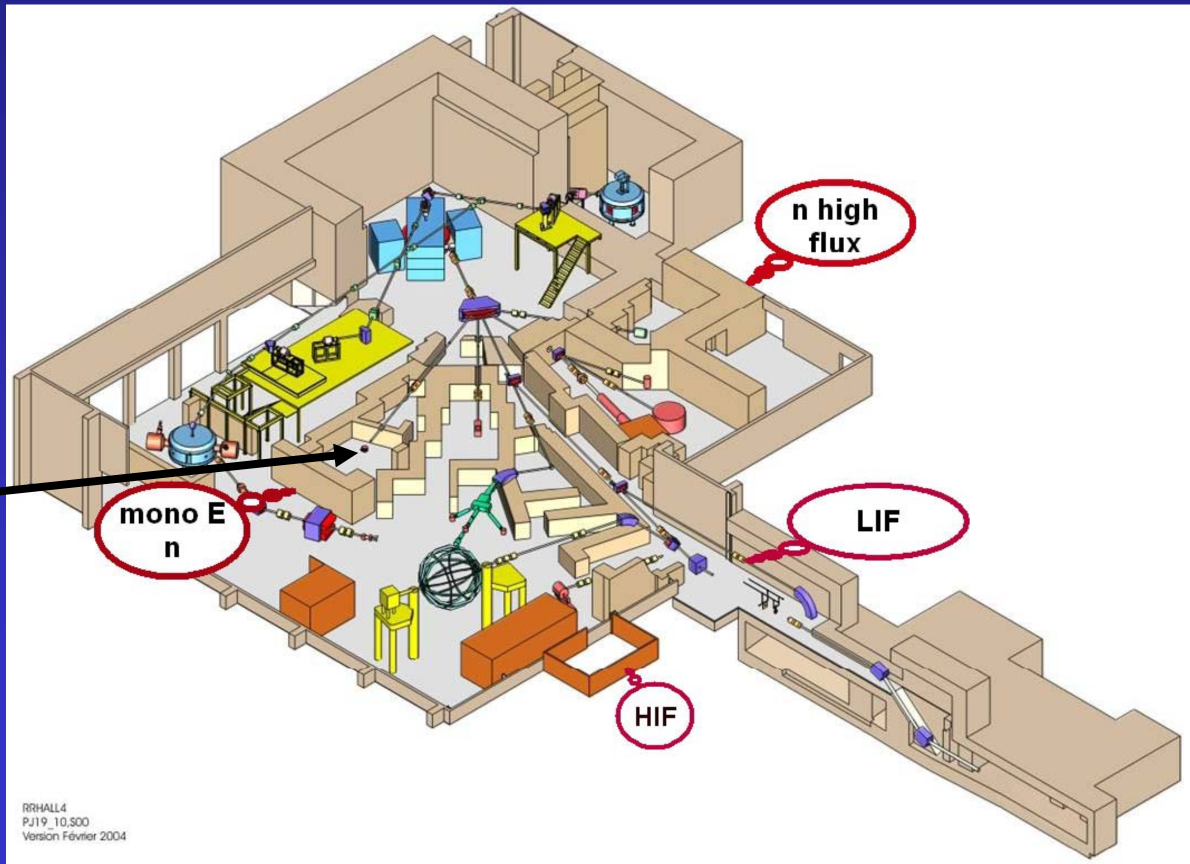
"Reference SEU Monitor" - Heavy Ion SEU Calibrations June 2006. High LET & High Penetration Cocktails.





Light Ion irradiation Facility (LIF)

New
Localization



LIF

- ✓ Energy:
  - o CYCLONE primary energy 65 MeV
  - o DUT energy between 10 and 62 MeV

- ✓ Flux:

  Between a few 10 p/s cm² and 5E8 p/s cm²

LIF

- Diffusion foil 250µm lead foil
- Beam transport tube

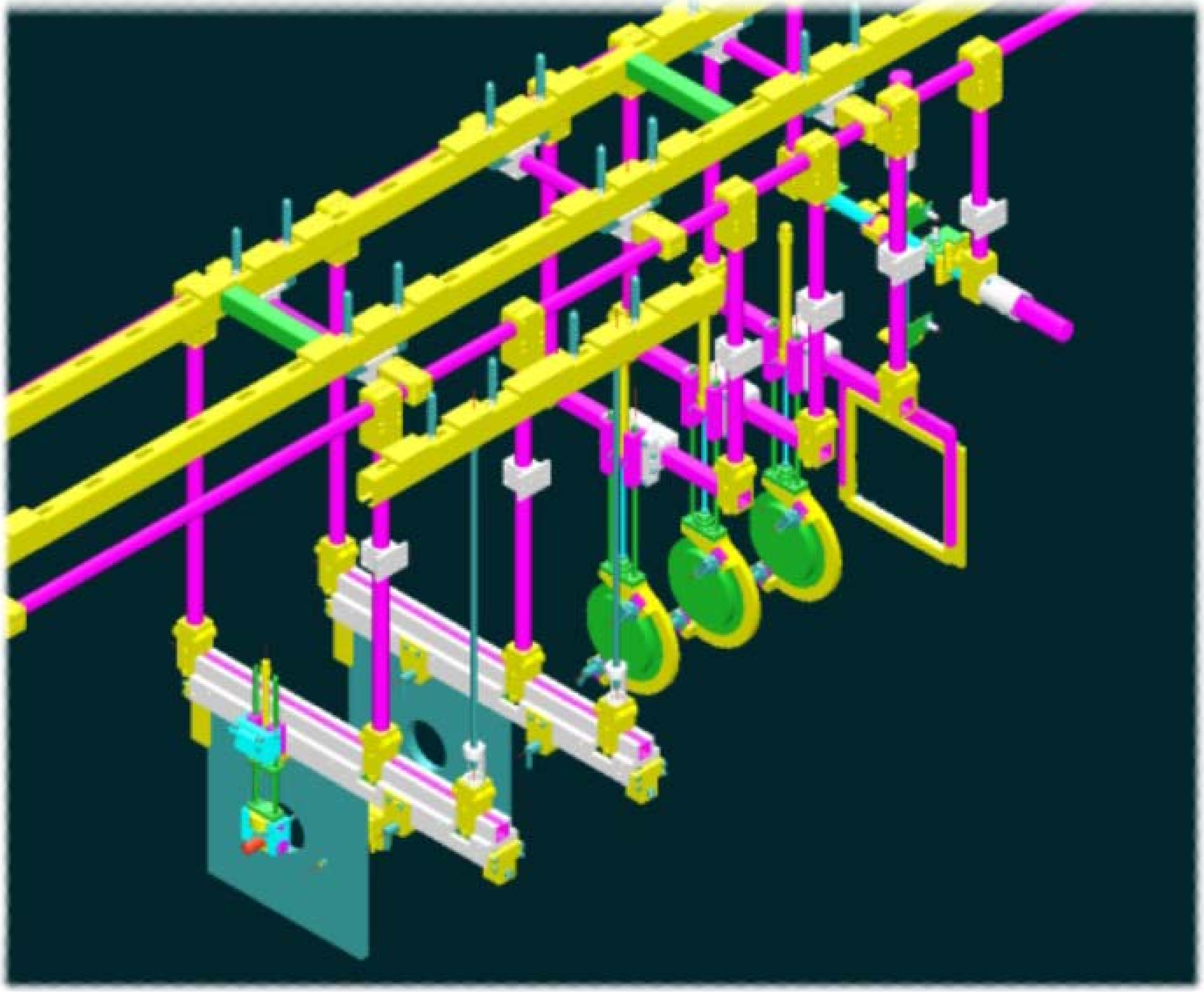
  avoid the energy losses in and activation of the surrounding air
- Beam collimators

  between 10 and 80 mm in step of 10 mm in diameter
- 2 plane laser diodes and camera.
- Water phantom (X-Y-Z)

LIF

- Energy degraders
  30 plastic slabs (10 different thicknesses, 3 of each)
  Energies between 9.3 and 62 MeV available

- X-Y table
  Similar to existing HIF one.
  Clamp on plate



LIF

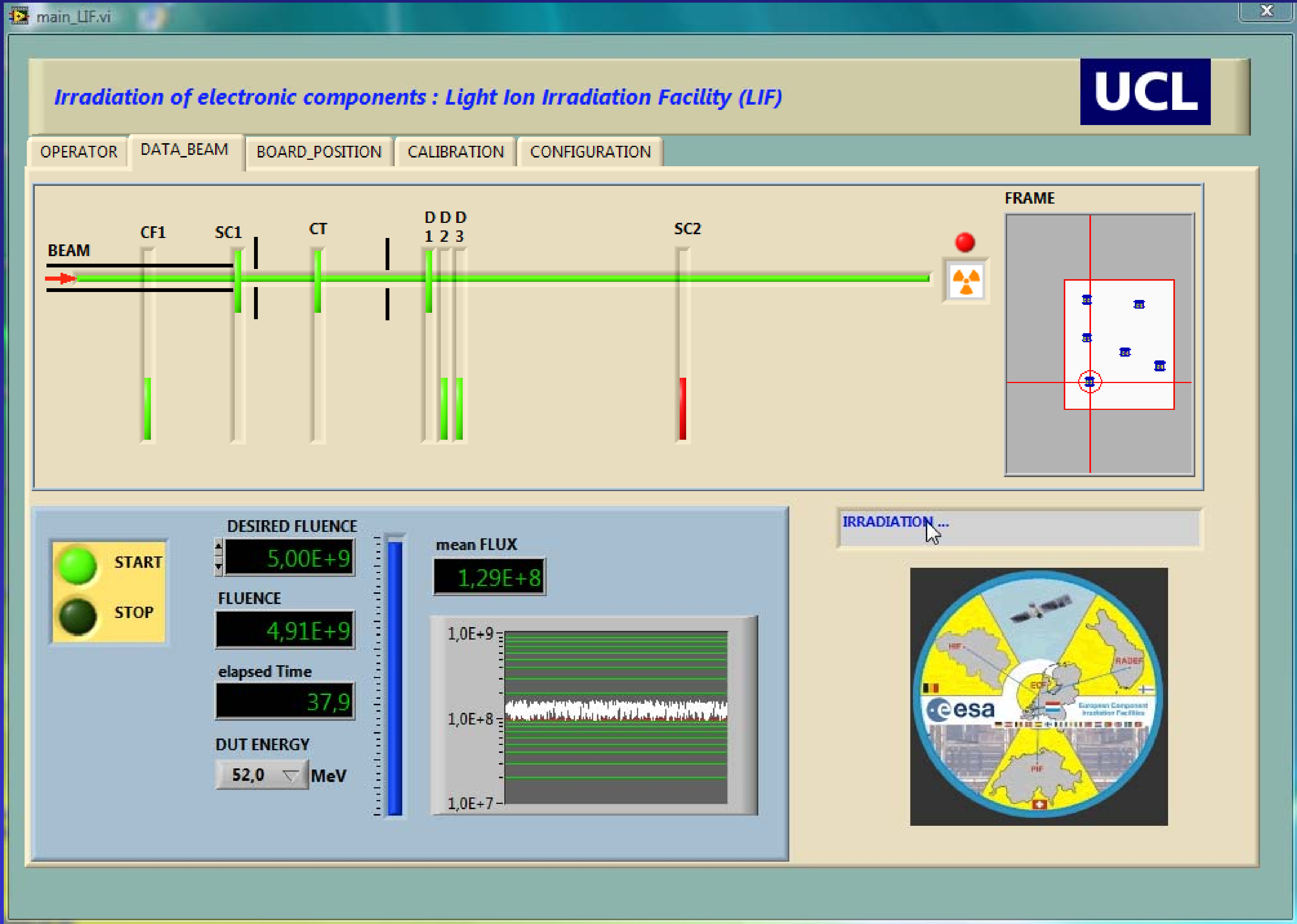
- large fluxes transmission chamber and annular detector calibrated vs. a precision faraday cup

- low fluxes scintillators
  - 1 thin scintillator placed before the first collimator plate
  - 1thick scintillator placed at 0 ° for calibration purpose

LIF

- FieldPoint PLC
- Motor controllers and A/D I/O cards from National Instruments

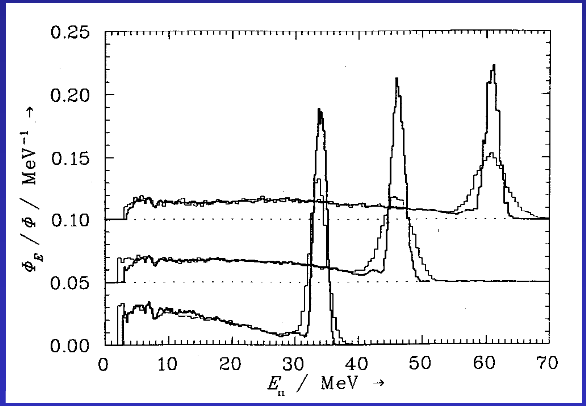
- LabVIEW environment
  - Beam data flux, reached fluence, dose, energy …
  - Beam line status.
  - Component positioning and selection.
  - Automatic procedures (detector calibration, beam profile …).


main_LIF.vi
Irradiation of electronic components : Light Ion Irradiation Facility (LIF)
UCL
OPERATOR
DATA_BEAM
BOARD_POSITION
CALIBRATION
CONFIGURATION
BEAM
CF1
SC1
CT
D D D
1 2 3
SC2
FRAME
START
STOP
DESIRED FLUENCE
5,00E+9
FLUENCE
4,91E+9
elapsed Time
37,9
DUT ENERGY
52,0
MeV
mean FLUX
1,29E+8
1,0E+9
1,0E+8
1,0E+7
IRRADIATION ...
esa

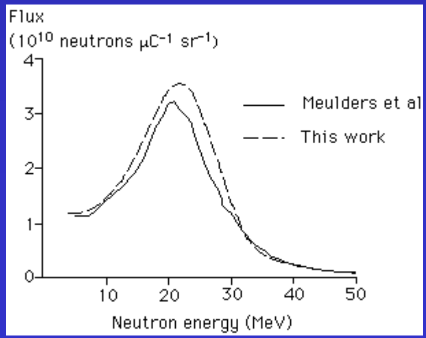
Neutron Lines (NIF)

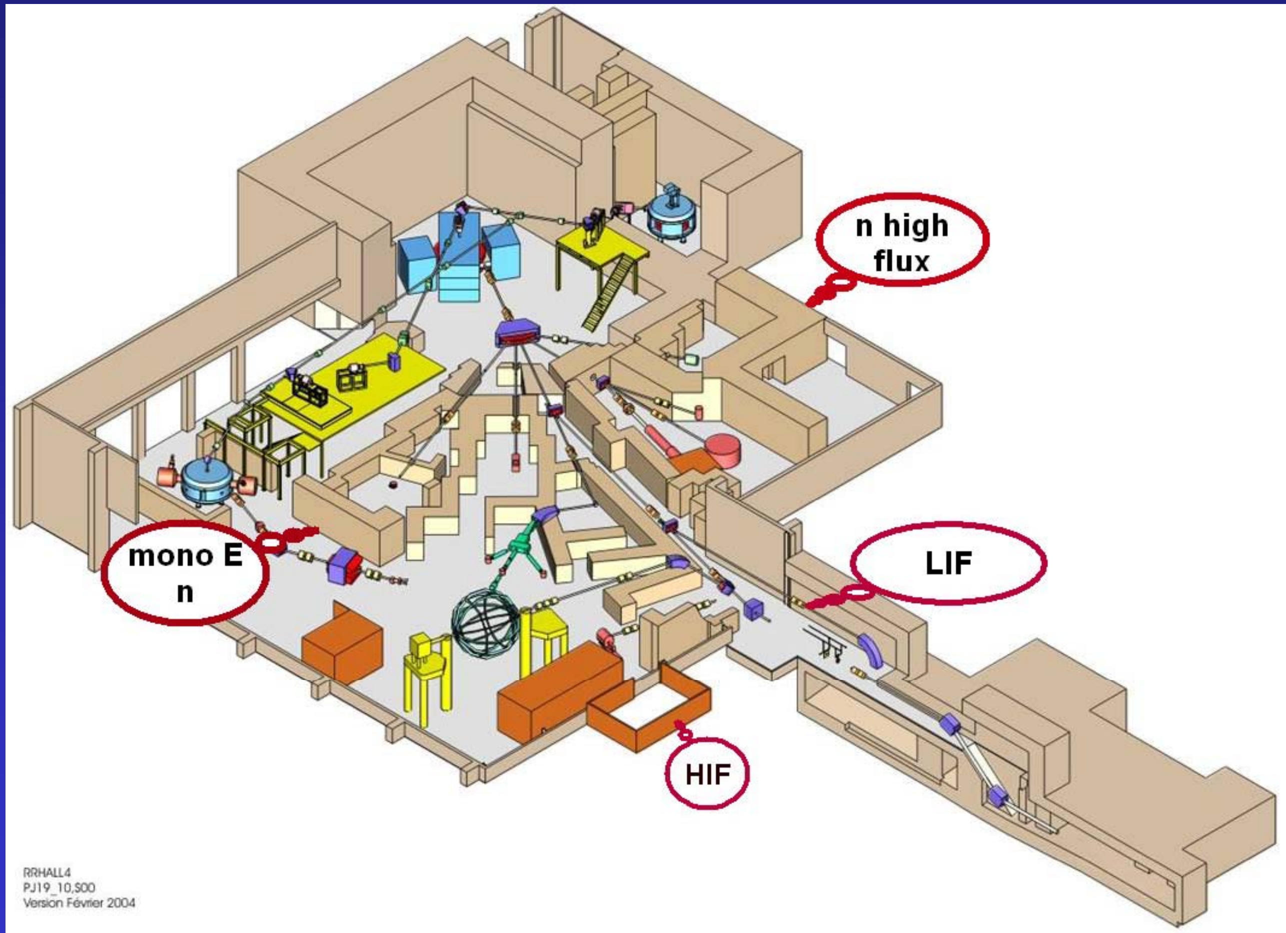
Two lines are available:

- Mono Energetic Line



- High Flux Line

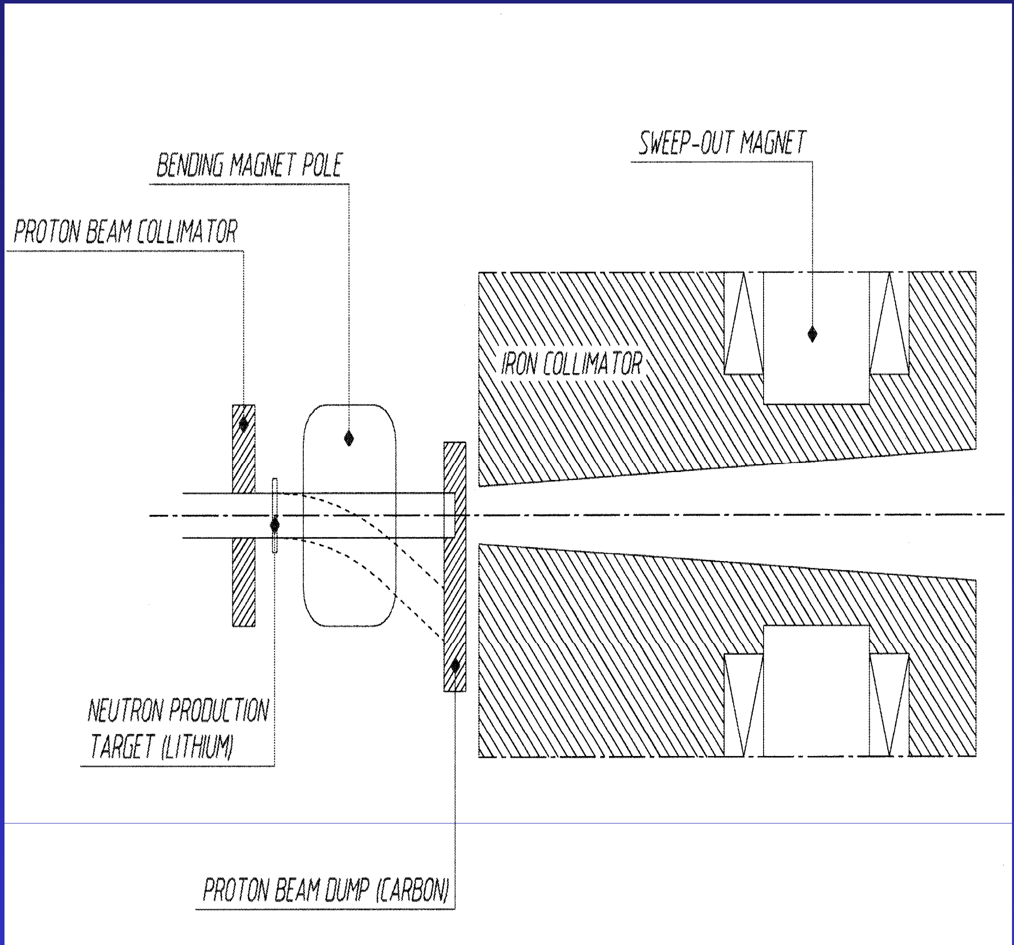


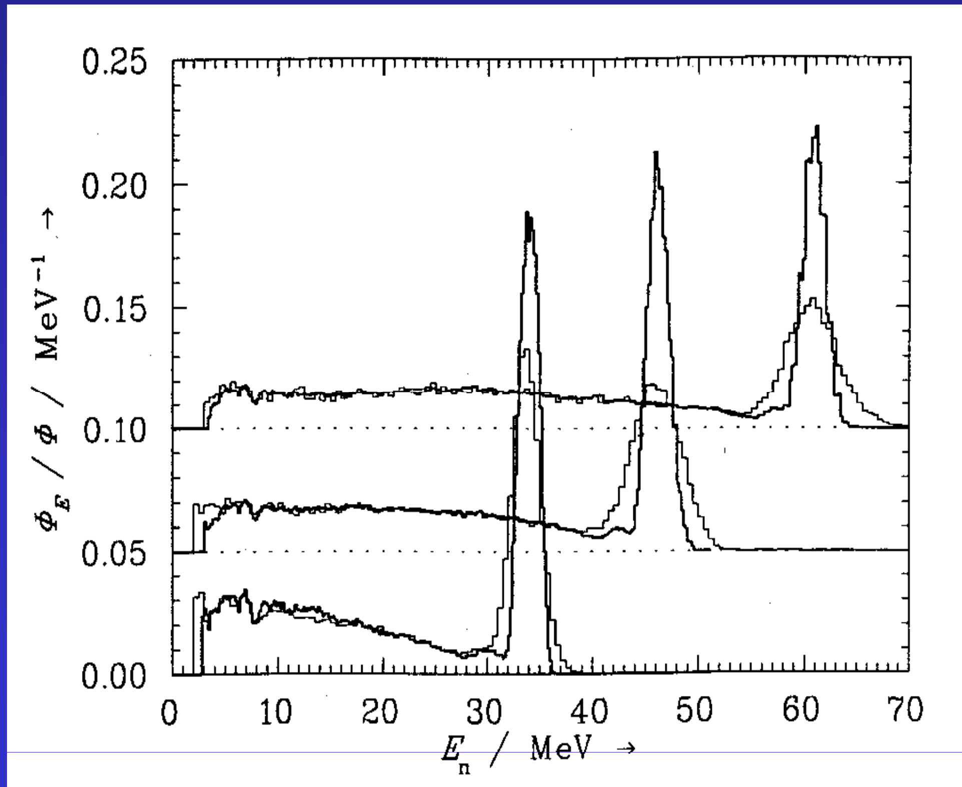

n high
flux
mono E
n
LIF
HIF
RRHALL4
PJ19_10,500
Version Février 2004

Monoenergetic Neutron Line (Q cave)

- Reaction: $^{7}Li\ (p,n)\ ^{7}Be$ Q= - 1,644 MeV
  Thin target
- Peak energy range: from 25 to 65 MeV
- Homogeneity ± 10 % on a 25 mm diameter spot

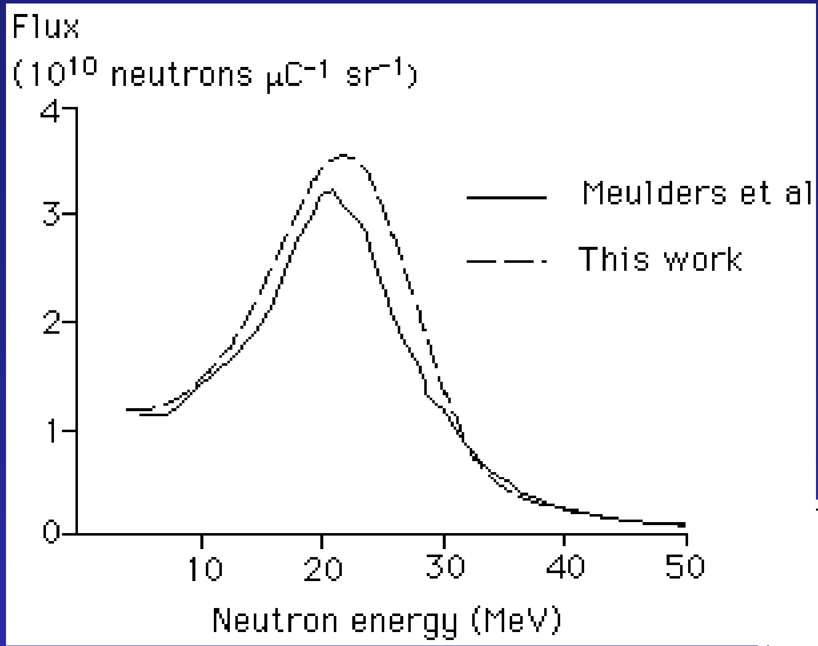
- Typical flux: with 10µA proton beam
  10^{6} n / cm² s

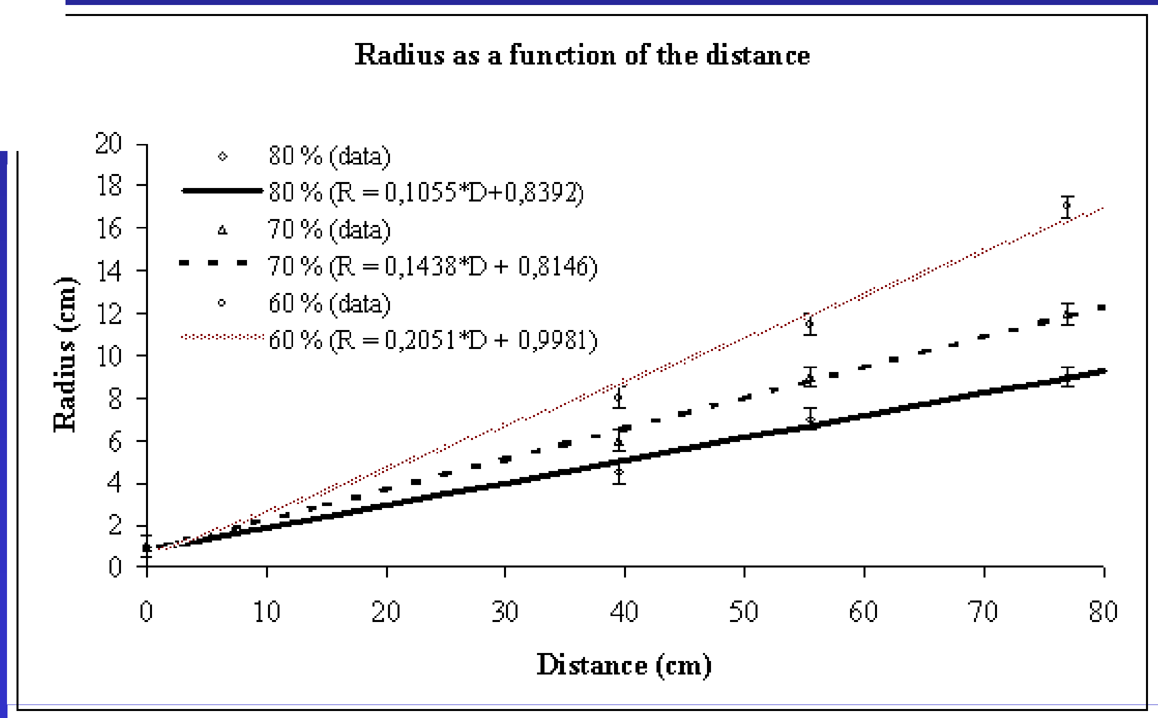

SWEEP-OUT MAGNET
BENDING MAGNET POLE
PROTON BEAM COLLIMATOR
IRON COLLIMATOR
NEUTRON PRODUCTION
TARGET (LITHIUM)
PROTON BEAM DUMP (CARBON)


0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
70
Φ_E / Φ / MeV^{-1} →
E_n / MeV →

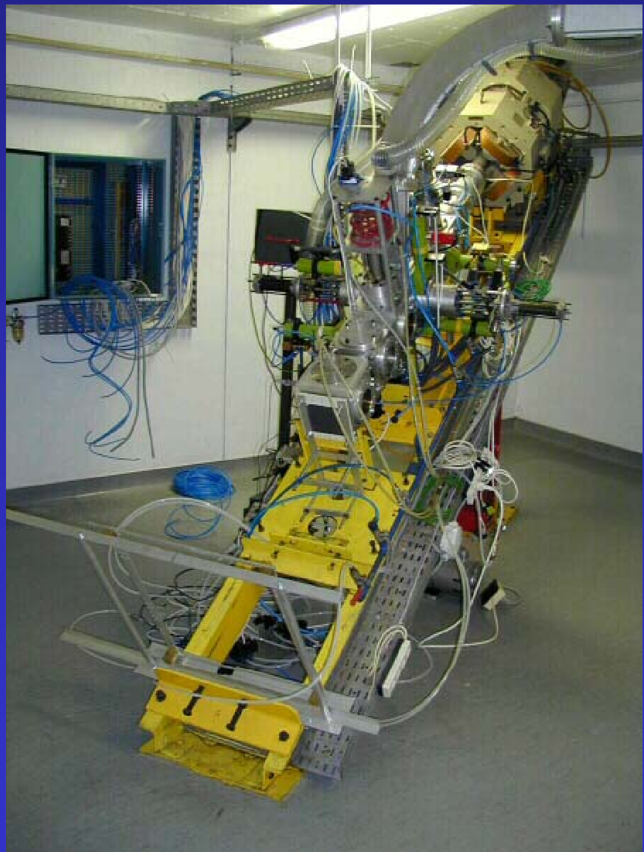
High Flux Neutron Line (T2 cave)

- Reaction: $^{9}Be + d \rightarrow n + X$ using a 50 MeV beam
  1 cm thick target
- Mean energy: 20.4 MeV (1 MeV equivalent ≈ 1.95)
- Typical flux: $7.3 * 10^{10}$ neutrons / cm^2 s at 9 cm from target (spot size ≈ 25 mm diameter)


Flux
(10^10 neutrons μC^-1 sr^-1)
4
3
2
1
0
10
20
30
40
50
Neutron energy (MeV)
Meulders et al
This work


Radius as a function of the distance
80 % (data)
80 % (R = 0,1055*D+0,8392)
70 % (data)
70 % (R = 0,1438*D + 0,8146)
60 % (data)
60 % (R = 0,2051*D + 0,9981)
Radius (cm)
20
18
16
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
80
Distance (cm)

High Flux Neutron Line (T2 cave)



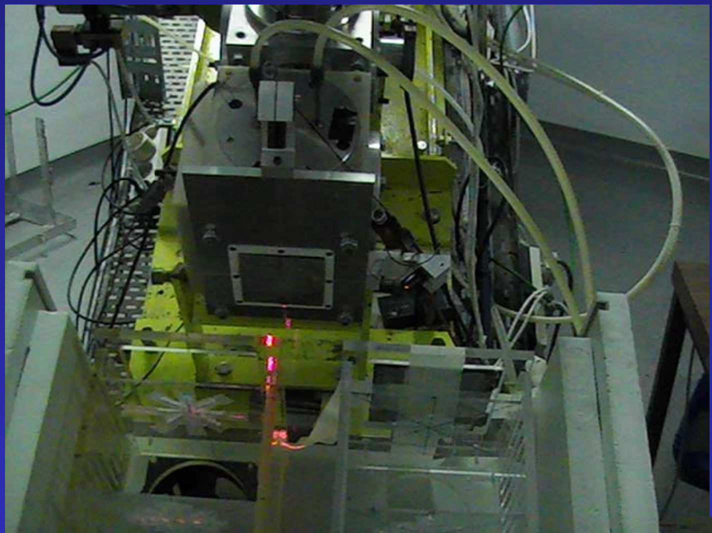
New fixture system

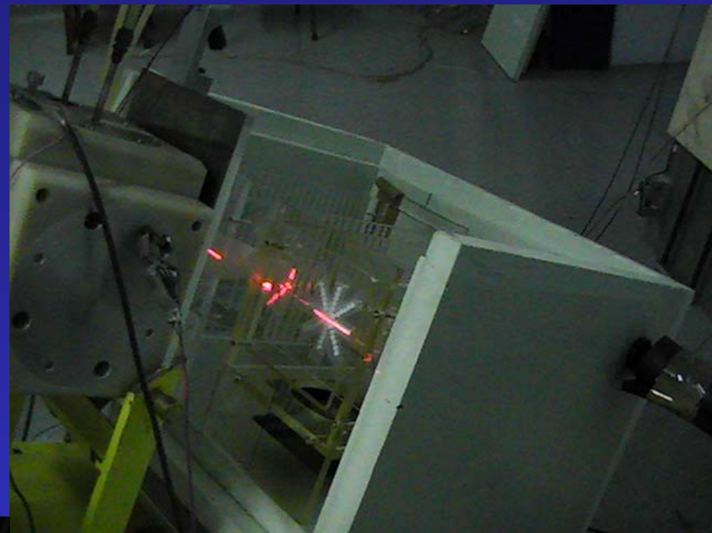
- Motor controlled (LabView)

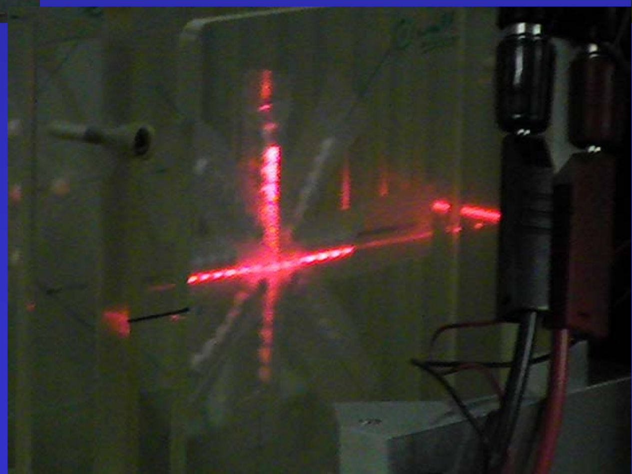
Lateral Stroke	30 cm
Vertical Stroke	10 cm
Precision	1 mm
Speed	5mm/sec

- Laser alignment system

High Flux Neutron Line (T2 cave)

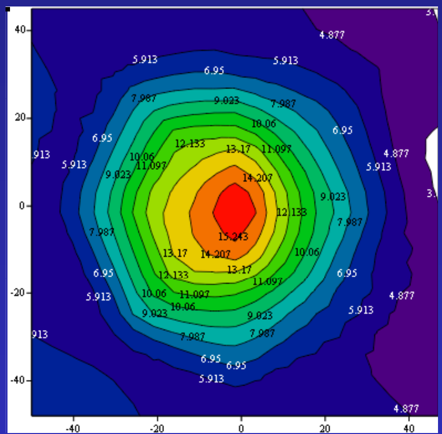






High Flux Neutron Line (T2 cave)

- **Dosimetry**



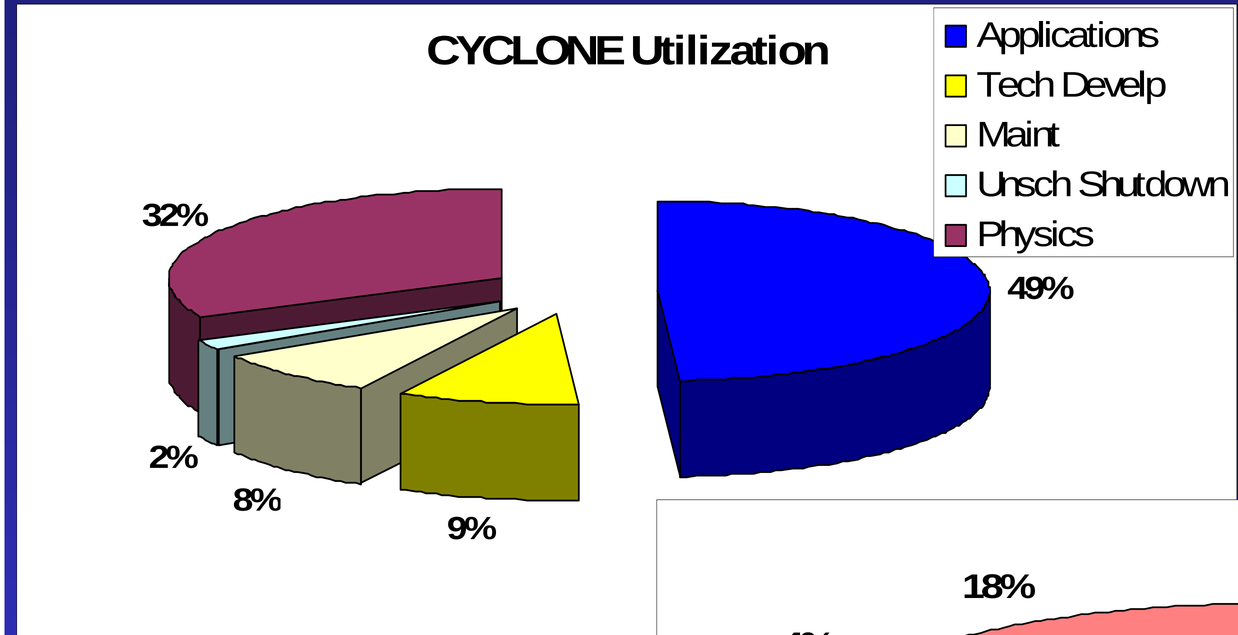
- Geometry and the deuterons integrated current
- Absorbed dose with alanine pellets (range: 50 Gy up to 80 kGy, corresponding to 10^{12} up to 3.5×10^{15} (1 Mev n/cm²)

- **Beam control** from user station
- **Monitoring** integrated beam current, T° and relative humidity
- **Cooling** during irradiation down to - 20 degrees
- **Cold storage** after irradiation at -10 degrees

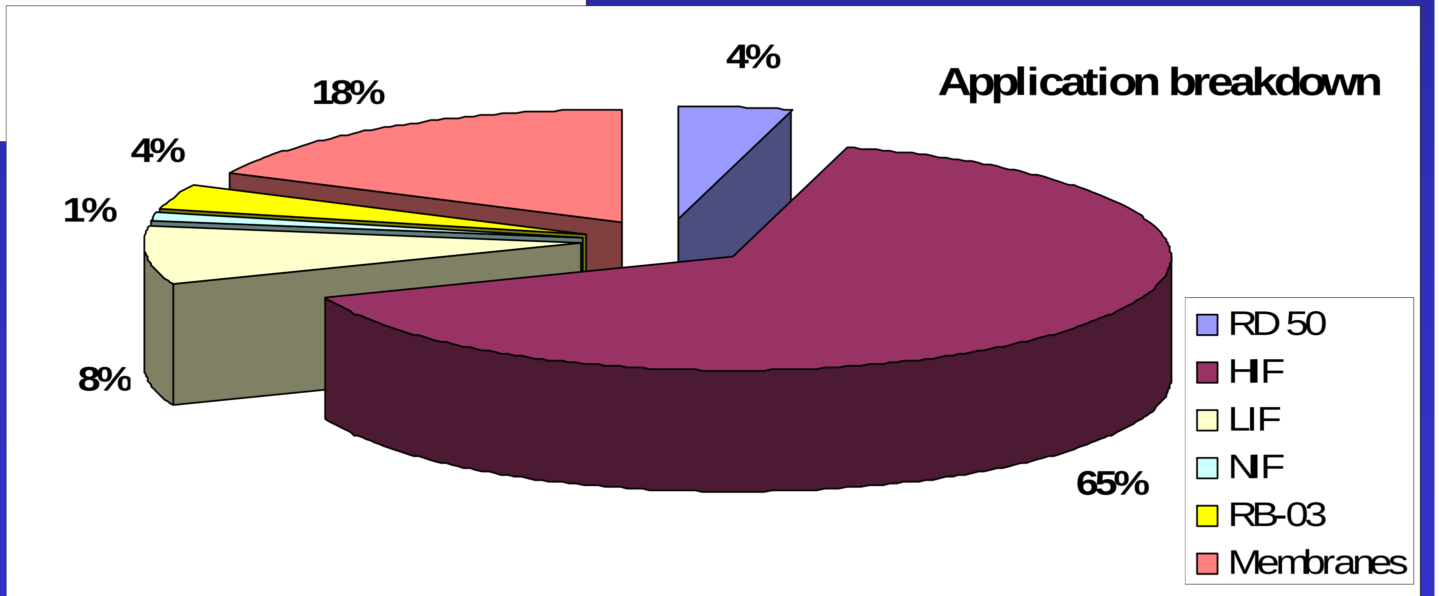
Beam Scheduling

- HIF : In 2006 nearly 1400 h scheduled (57 days).
  Two 5 days period per month (Monday 8 AM to Friday 12 PM).
- LIF : About 200 h/year scheduled.
- NIF : On request.

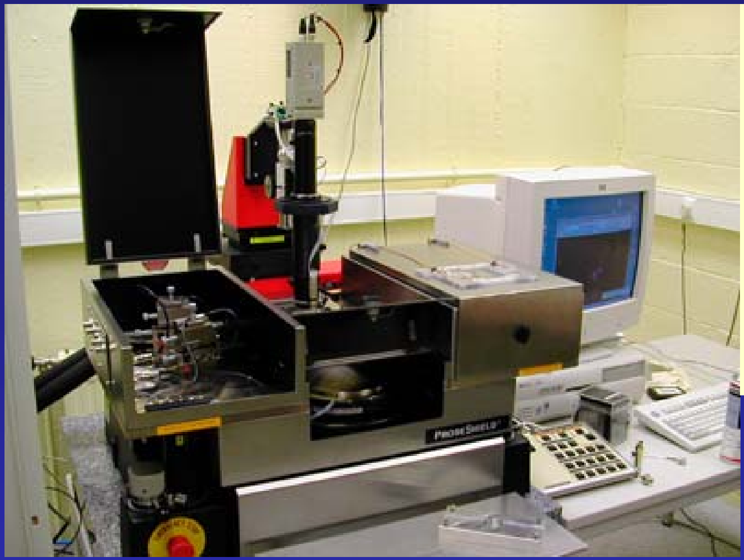
CYCLONE Beam time breakdown



For 2006



CMS – SLHC in Louvain la Neuve



Probe station with cold chuck and instruments:

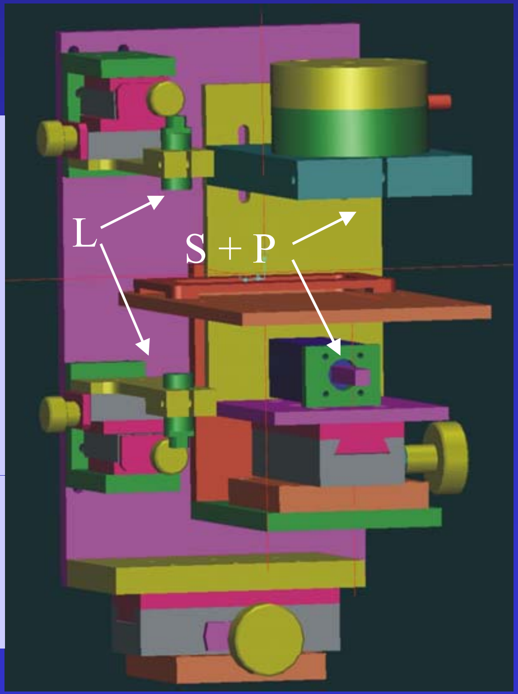
<u>Fully operational !!</u>

LabView interface that allow flexible electrical measures, with different instruments and input parameters.

Charge Collection Efficiency setup in collab. with CERN (RD50):

<u>In construction !!</u>

Will have **Sr-90 beta source + Hamamatsu photomultiplier** (S+P) and **2 lasers beams (visible)** facing each other (L), read-out electronics for 7 channels: to study the signal generated on double-sides detectors, measure charge collection efficiency and transient current for very hard irradiated silicon. The tests could be done in a large scale of temperature.



Foreseen Upgrades and Developments

- **Co^{60} source**: Refurbishing ready in Q2 2008

  Dose rate (max): 50 Krad/hour (close to the source)
  Dose rate (min): 0.3 Krad/hour (1.5 m from source)

- **LIF flux upgrade**: To reach usable flux for SLHC testing

- **Universal Tester for SEE Characterization**: 2008 Developed by TIMA Grenoble France