Irradiation Facilities at CYCLONE (HIF – LIF – NIF)

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Outline

- ✓ CYCLONE
- ✓ Heavy Ion Facility (HIF)
- ✓ Proton Facility (LIF).
- ✓ Neutron Facilities (NIF).
- ✓ Scheduling and financing.
- ✓ Future developments

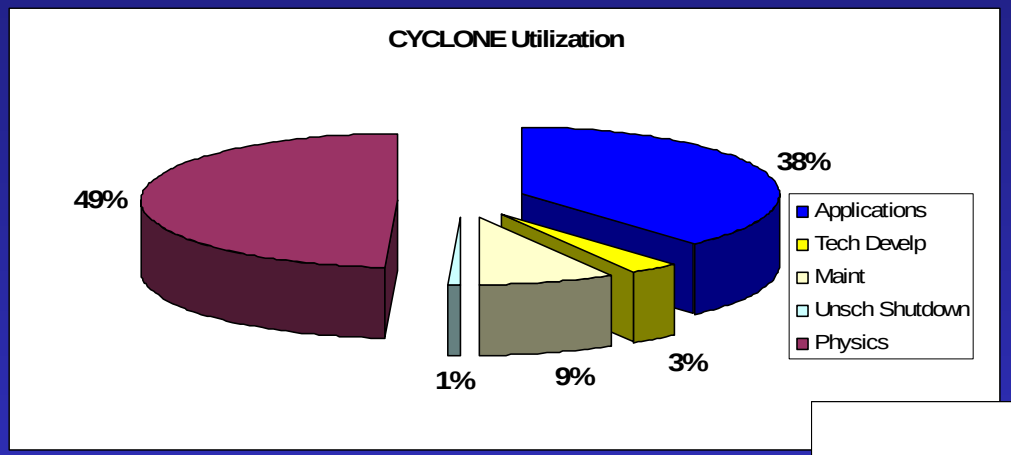
CYCLONE

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

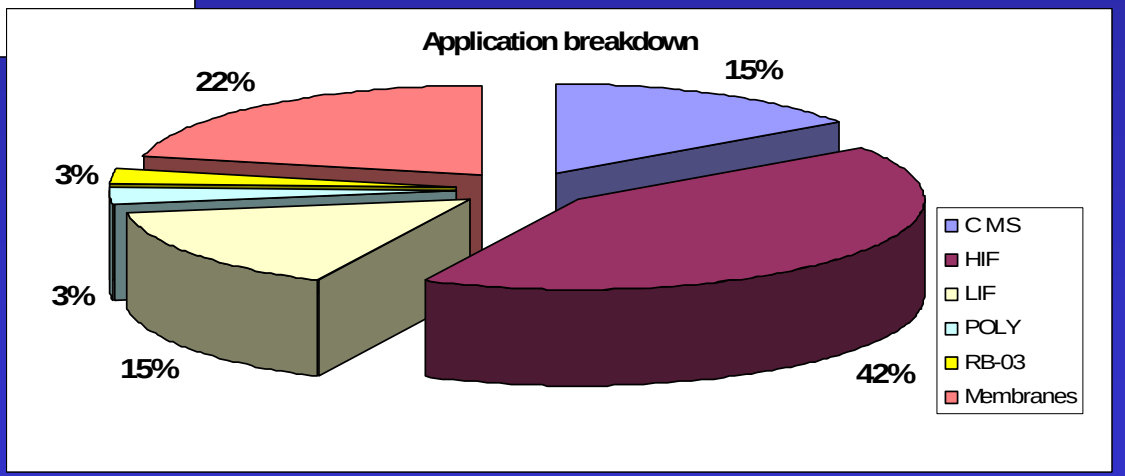
  Heavy ions produced with an ECR source
  High charge state ($E = 110\ Q^2 / M$)
  «Cocktails» (fast ion changing)

- Neutrons by 7Li(p,n) and 9Be(d,n) reactions

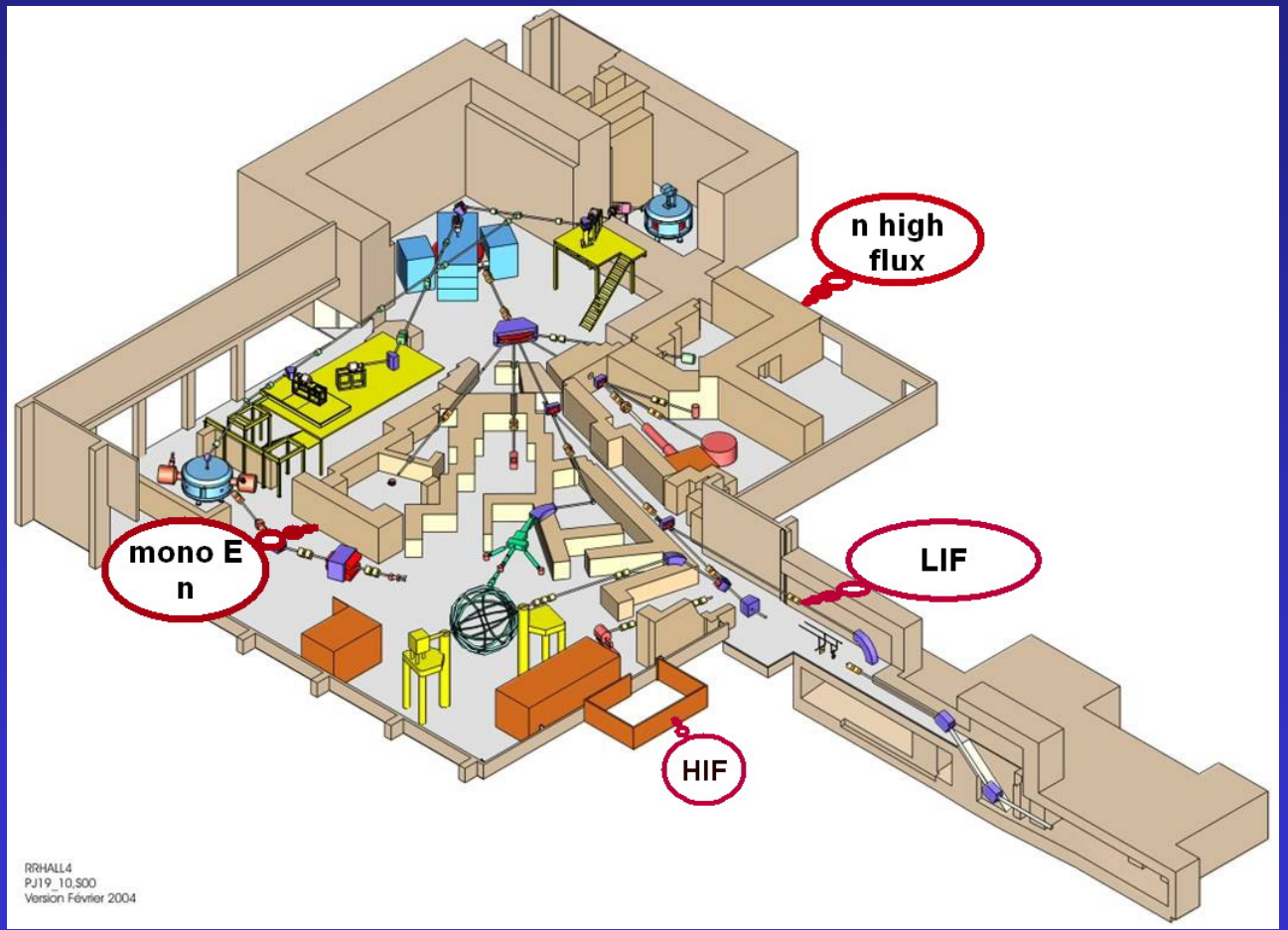
CYCLONE Beam time breakdown



For 2004



CYCLONE


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

Heavy Ion irradiation Facility (HIF)

- 1992: First HI test in LLN
- 1993: First setup
- 1995: HIF kick off
- 1996: HIF validation test

HIF

- Beam: Homogeneity ± 10 % on diam. of 25 mm
  Flux from a few part/s cm² to 2 10^4
  Ion changing time 3 minutes

- Interface: 2 flanges with BNC (2 X 10 BNC)
  1 flange with 6 sub D-25
  1 flange with 10 SMA
  2 flanges with 40 pin connectors
  1 thermocouple flange available

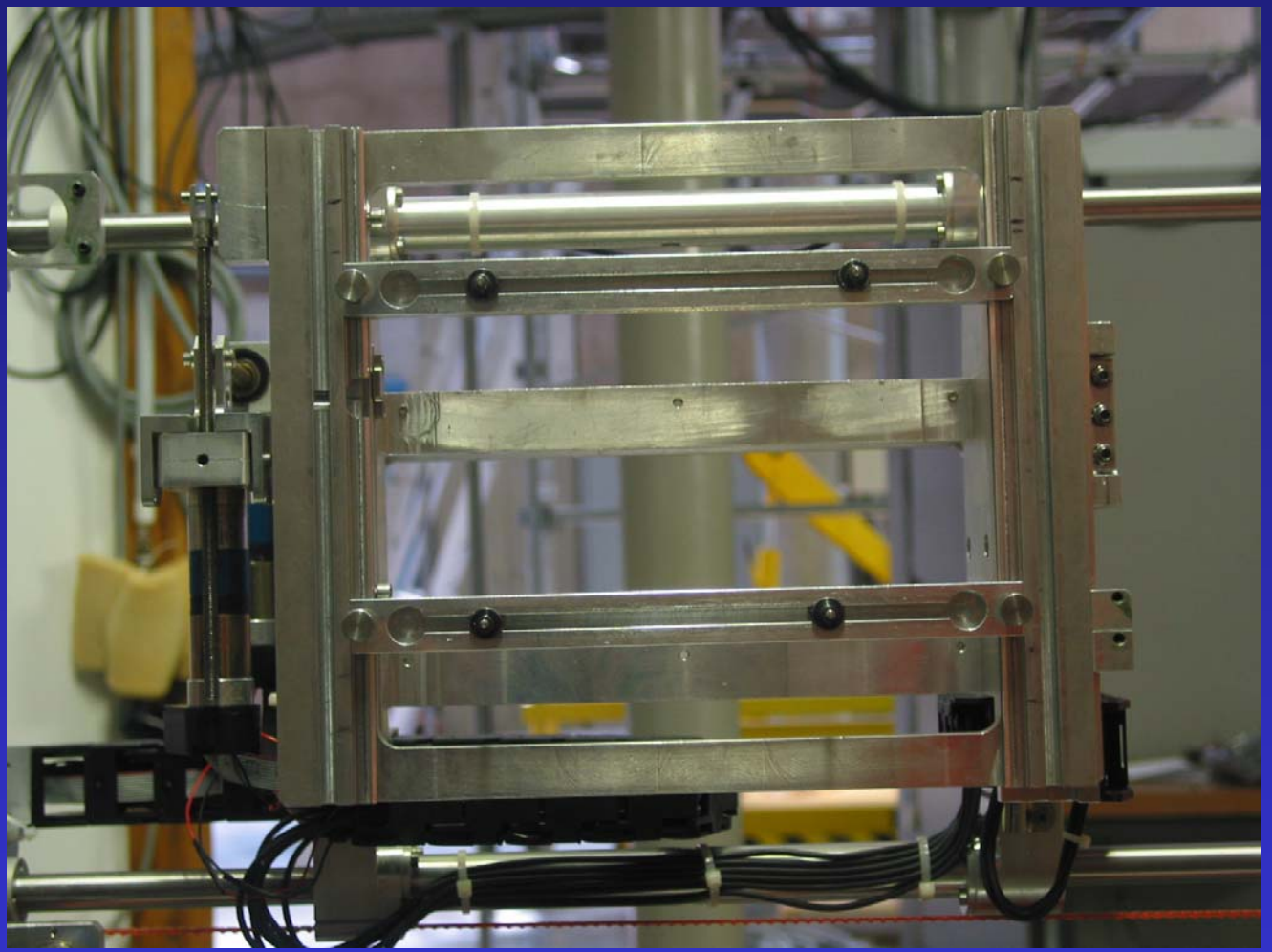
- Miscellaneous: Chamber pumping time: 5 minutes
  User controllable beam shutter
  Power supplies, scope, counter and tools available

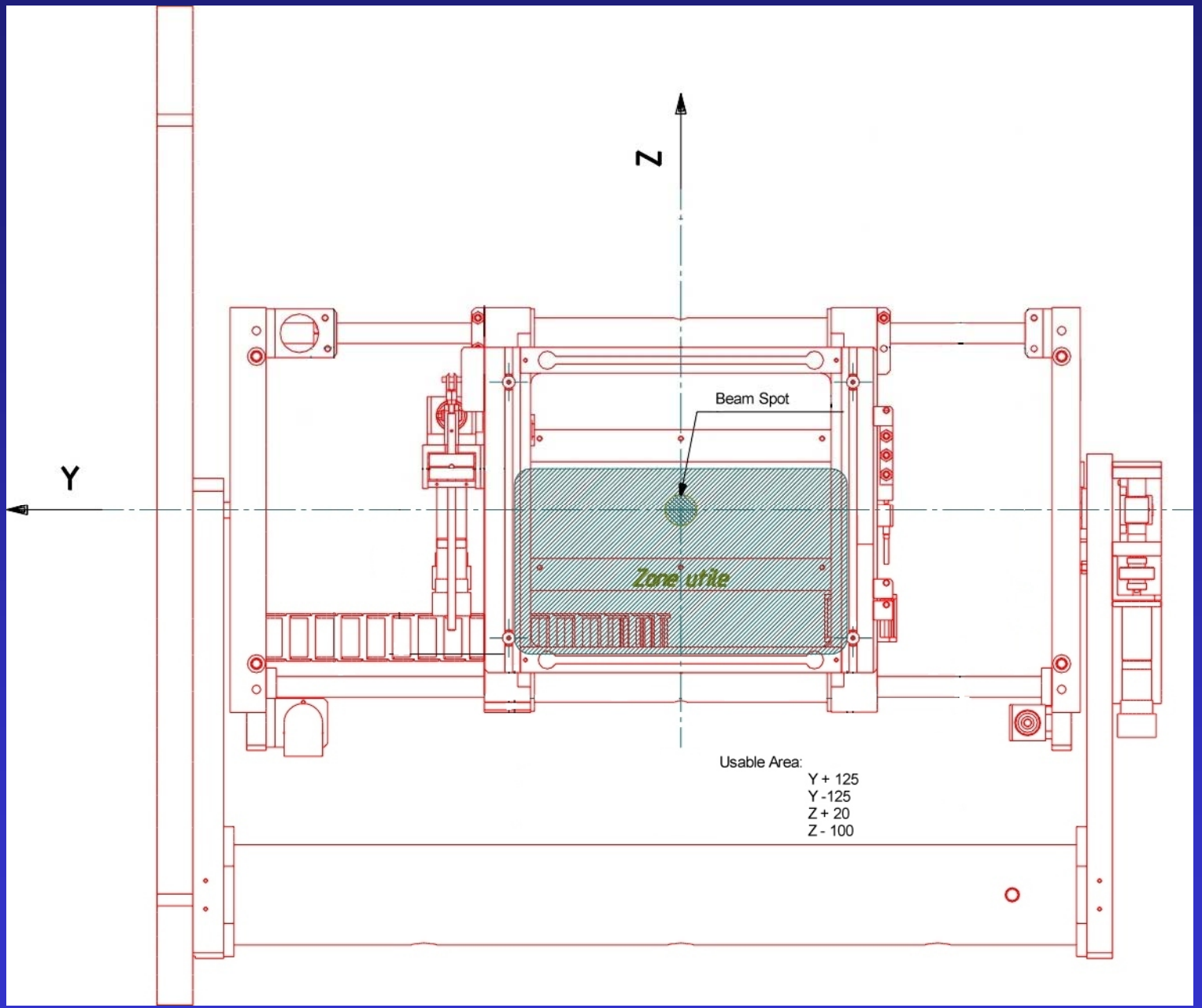
Ion	DUT Energy [MeV]	Range [μm Si]	LET [MeV cm² / mg]
$^{15}N^{3+}$	62	64	2.97
$^{20}Ne^{4+}$	78	45	5.85
$^{40}Ar^{8+}$	150	42	14.1
$^{84}Kr^{17+}$	316	43	34
$^{132}Xe^{26+}$	459	43	55.9

High LET Cocktail

Ion	Cyclo Energy [MeV]	Range Cyclo [µm Si]	LET(Si) Cyclo [MeV cm² / mg]	DUT Energy [MeV]	Range [µm Si]	LET (Si) [MeV cm² / mg]
$^{13}C^{4+}$	133	276	1.2	131	266	1.2
$^{22}Ne^{7+}$	241	207	3.2	235	199	3.3
$^{28}Si^{8+}$	248	115	6.6	236	106	6.8
$^{40}Ar^{12+}$	390	125	9.9	372	119	10.1
$^{58}Ni^{18+}$	603	106	19.9	567	98	20.6
$^{83}Kr^{25+}$	813	100	31	756	92	32.4

High penetration Cocktail




Z
Y
Beam Spot
Zone utile
Usable Area:
Y + 125
Y -125
Z + 20
Z - 100

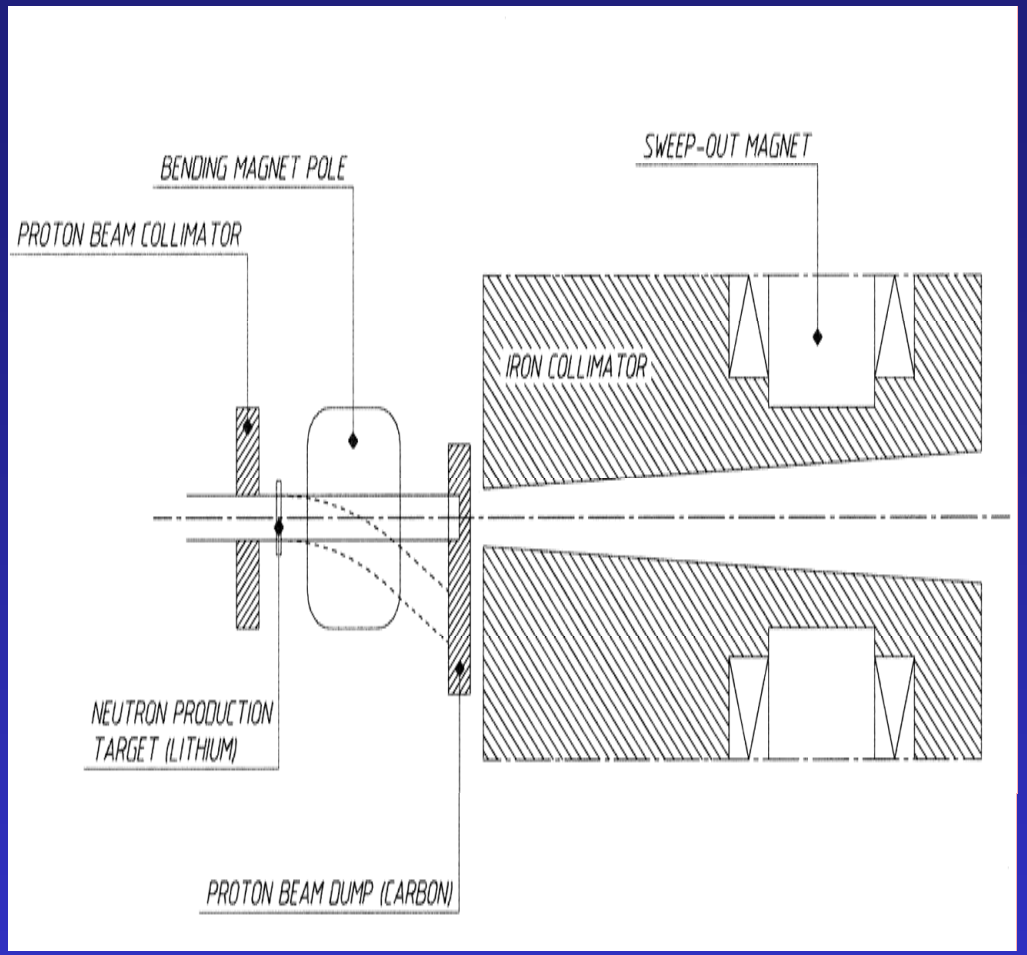
Light Ion irradiation Facility (LIF)

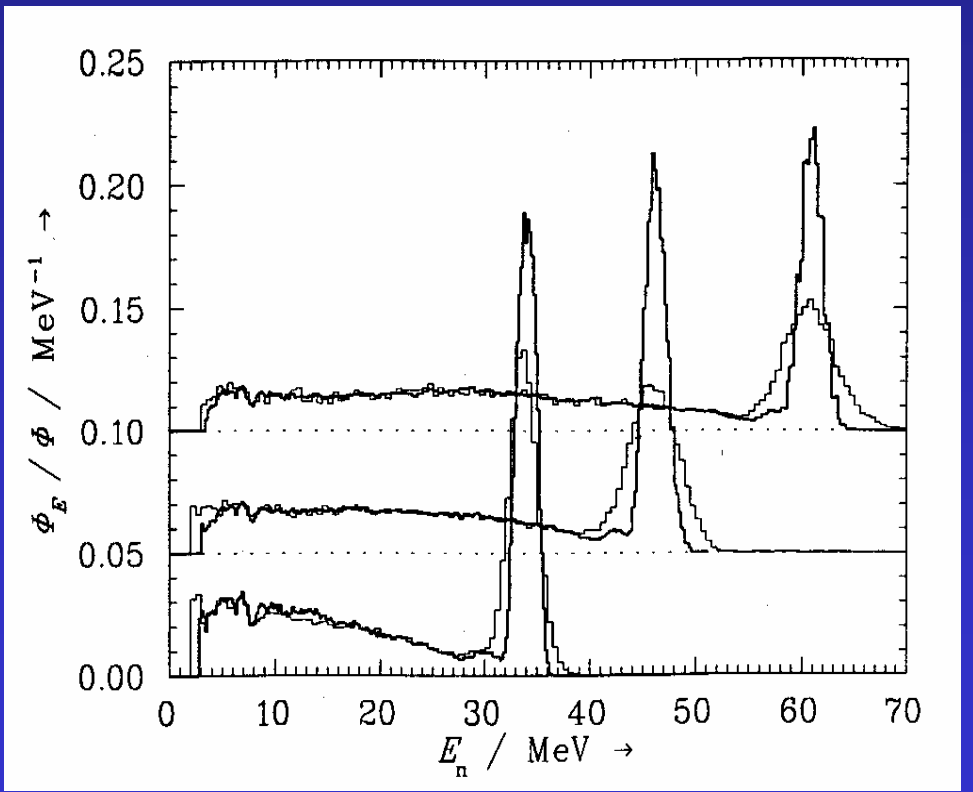
- Proton energy: from 10 to 67 MeV
- Energy modulation: Polystyrene blocks
- Homogeneity: ± 10 % on a diam. of 10 cm
- Flux: between a few p/s cm^2 and 10^9 p/s cm^2
- Dosimetry:

  - Profile: diode in a water phantom
  - Monitoring: transmission chamber + Scintillators
  - Calibration with a Faraday cup

Monoenergetic Neutron Line

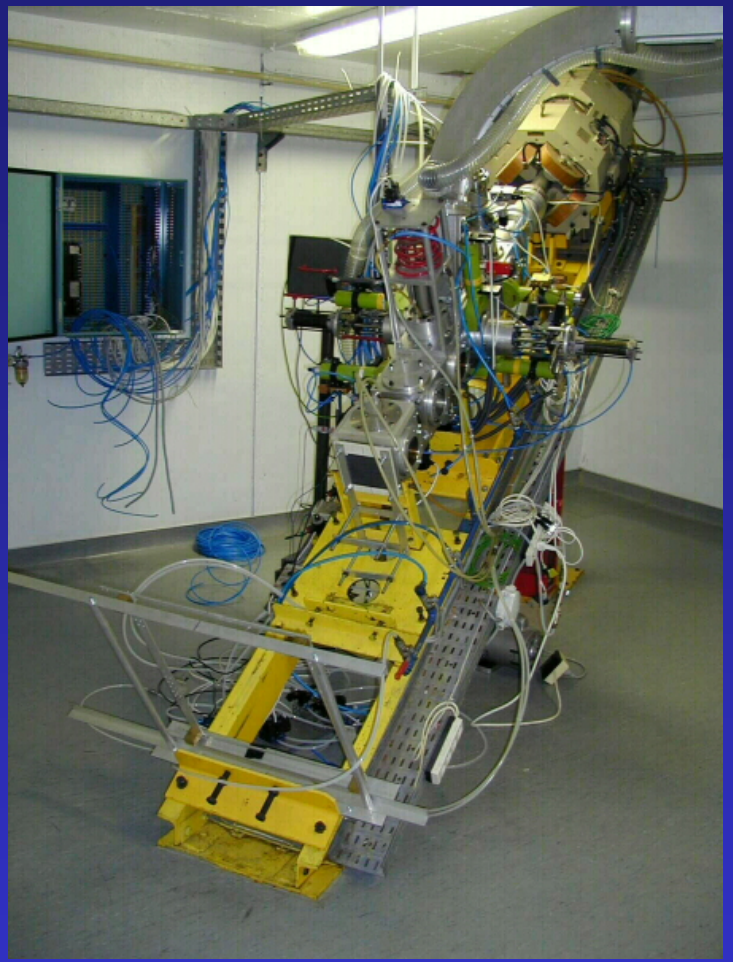
- Reaction: $^{7}Li\ (p,n)\ ^{7}Be$ Q= - 1,644 MeV
  Thin target
- Peak energy range: from 25 to 70 MeV
- Typical flux: with 10μA proton beam
  3 mm thick target
  10^{6} n / cm² s on a 30 mm diameter area
- Homogeneity ± 10 %

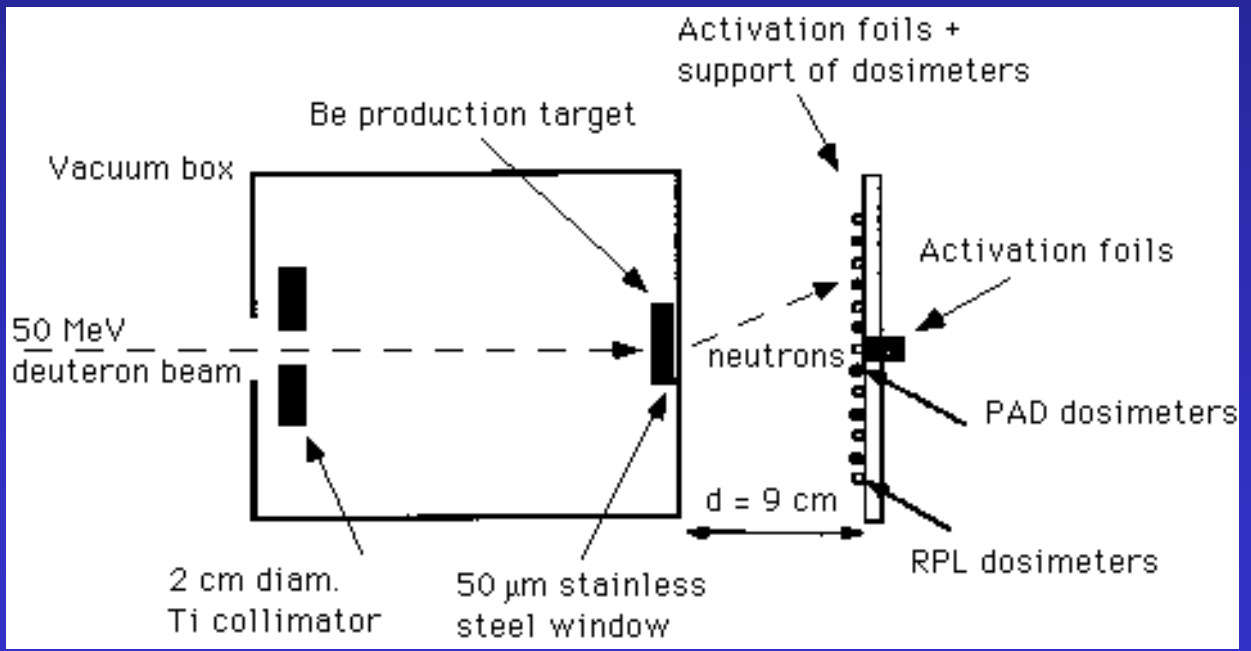

BENDING MAGNET POLE
SWEEP-OUT MAGNET
PROTON BEAM COLLIMATOR
IRON COLLIMATOR
NEUTRON PRODUCTION
TARGET (LITHIUM)
PROTON BEAM DUMP (CARBON)

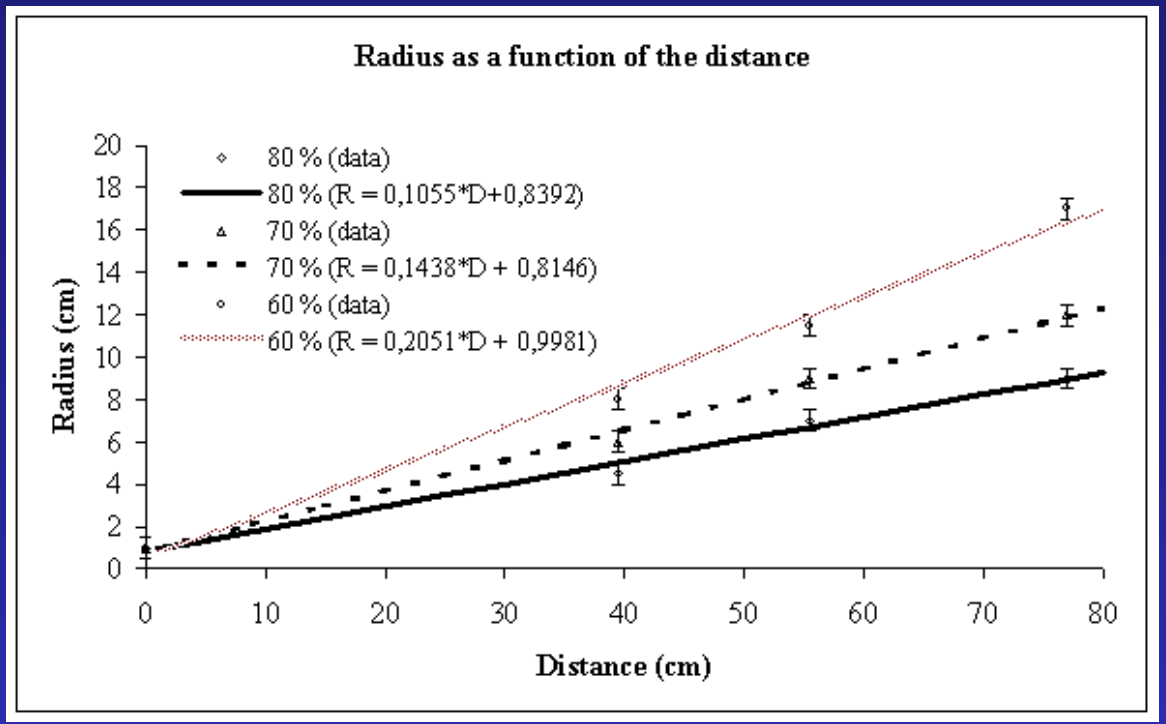

0.25
0.20
0.15
0.10
0.05
0.00
Φ_E / Φ / MeV^{-1} →
0
10
20
30
40
50
60
70
E_n / MeV →

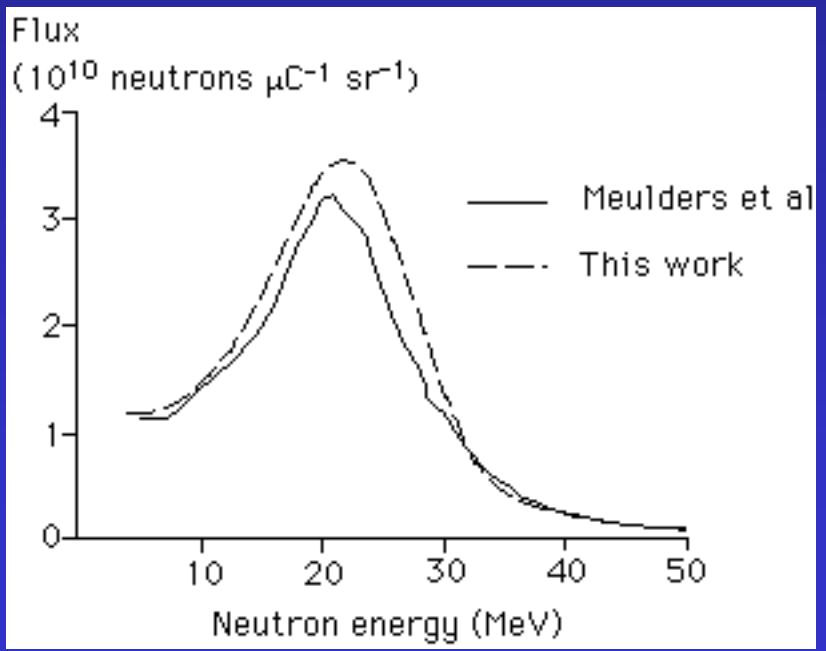
High Flux Neutron Line

- Reaction: $^{9}Be + d \rightarrow n + X$ using a 50 MeV beam
  1 cm thick target
- Peak energy range: from 25 to 70 MeV
- Typical flux: $7.3 * 10^{10}$ neutrons / cm^2 s at 9 cm from target




Activation foils +
support of dosimeters
Be production target
Vacuum box
Activation foils
50 MeV
deuteron beam
neutrons
PAD dosimeters
d = 9 cm
RPL dosimeters
2 cm diam.
Ti collimator
50 µm stainless
steel window


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)
Distance (cm)
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50
60
70
80


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

Scheduling and financing

o CYCLONE shut down periods for maintenance : from Xmas to mid February

mid July to last week of August

o Scheduling : semestrial planning meeting

HIF : 8 periods of 4 days per year

LIF : 4 periods of 2 days per year

Neutron : on request

o Request to : berger@cyc.ucl.ac.be

o CYCLONE Web site : http://www.cyc.ucl.ac.be

Scheduling and financing

- Hourly rates:
  - HIF : - ESA, ESA-contractors (upon approval by the ESA Technical Manager)
    other non-profit organisations and institutions: 495 €
    - all other companies, organisations : 516 €
  - LIF – NIF : Non - CERN516 €

- Cancellation policy: if within 2 weeks before scheduled period, 50 % of the ordered beam time will be charged.

Future Developments

- HIF : High penetration ion with high LET
- LIF : Labview environment interface
- Heavy ion Micro beam line