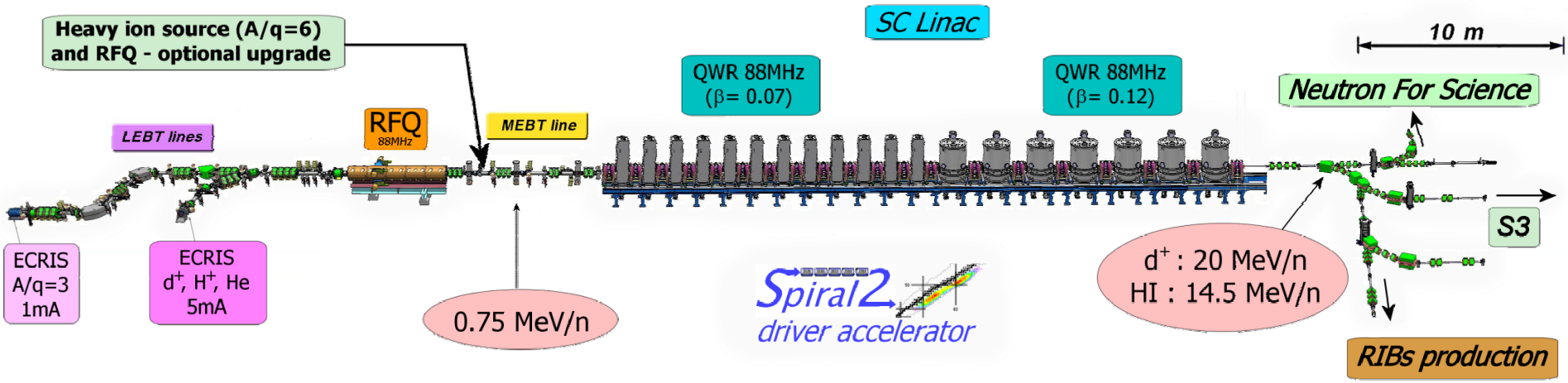
OVERVIEW OF THE BEAM DIAGNOSTICS FOR THE DRIVER OF SPIRAL2

Patrick AUSSET for the Spiral 2 Diagnostics Team

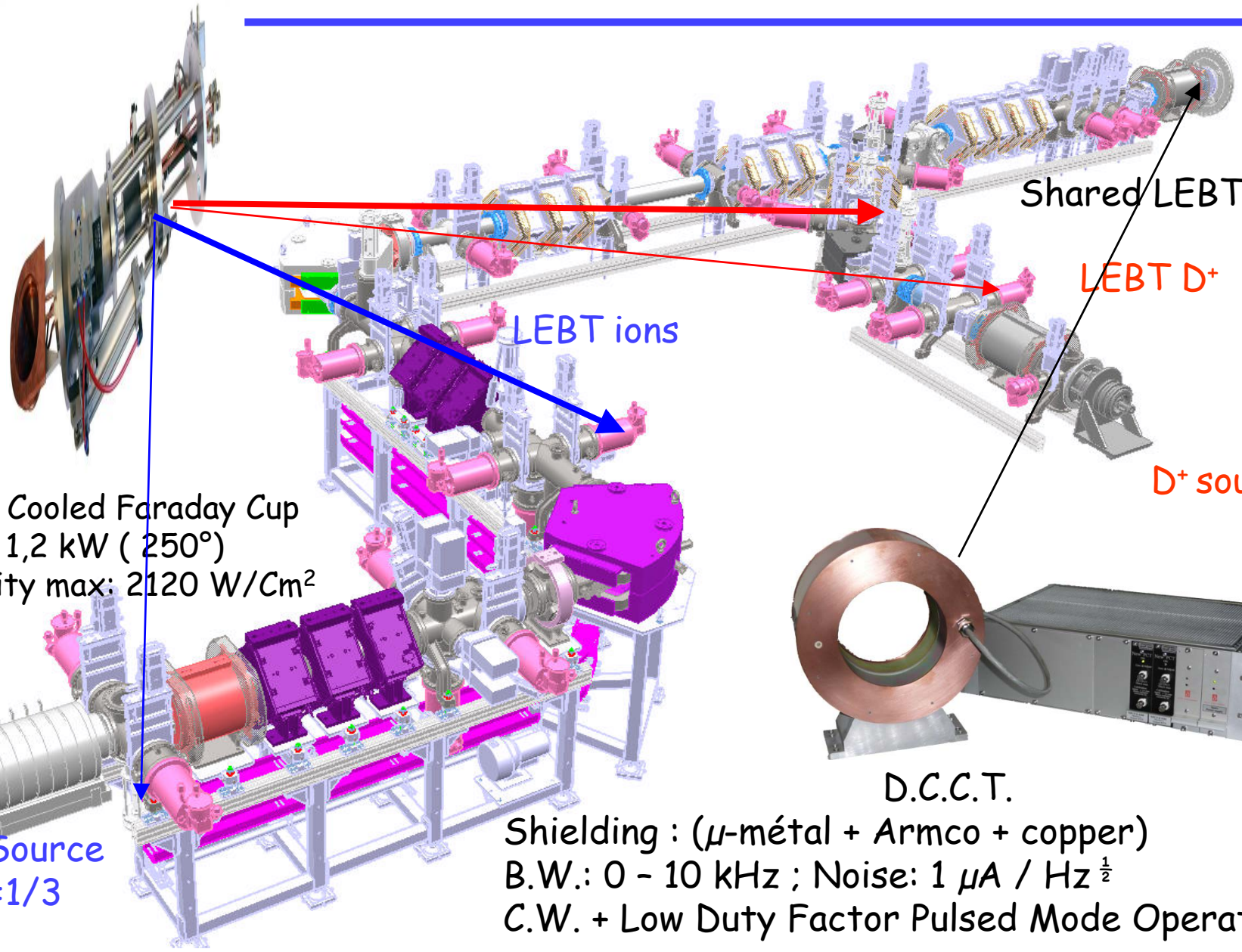
SPIRAL2 Driver and Beam Characteristics



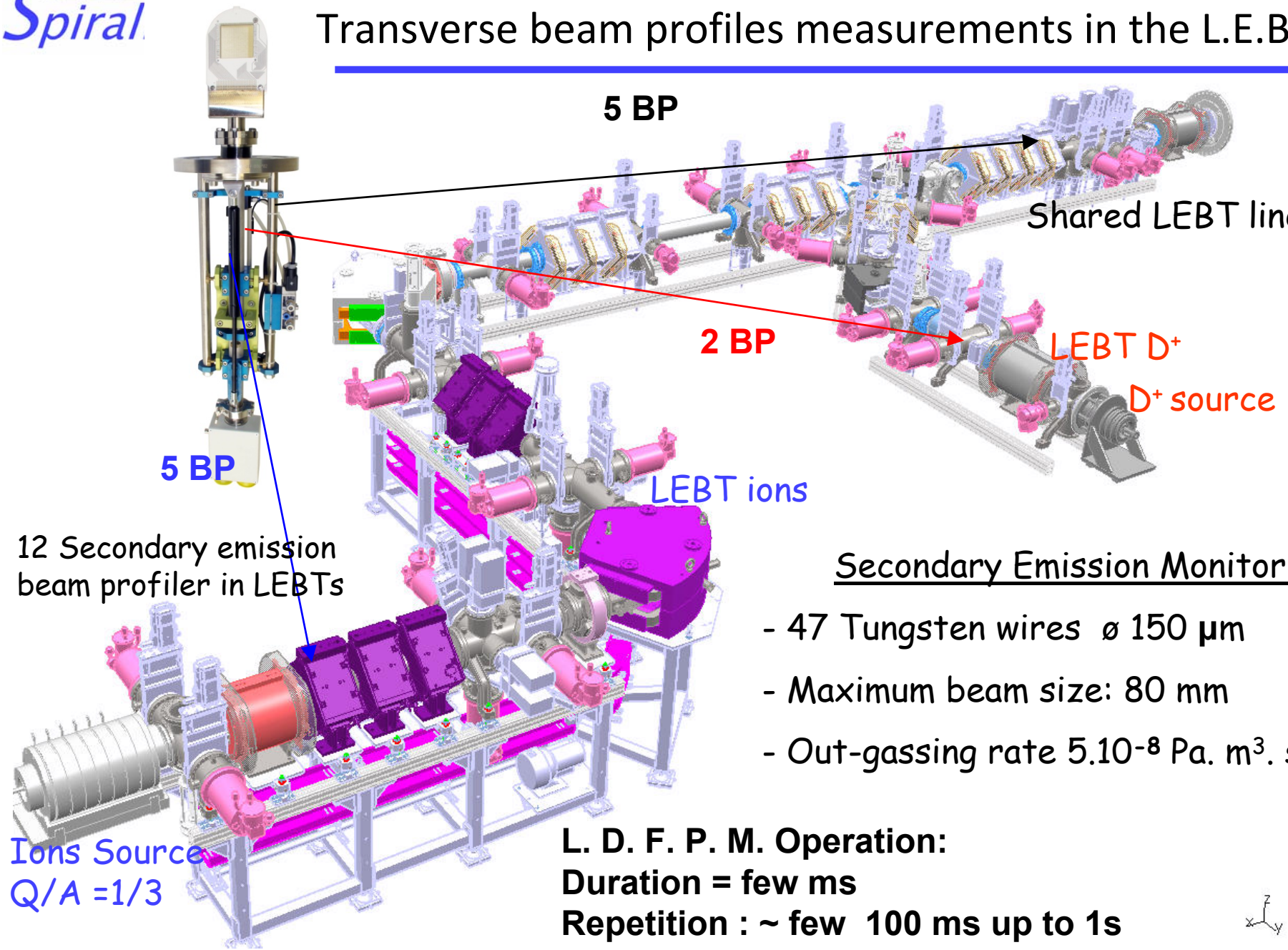
	Q/A	I (mA)	Energy (Mev/u)	CW max beam Power (KW)
Protons	1/1	5	2 - 33	165
Deuterons	1/2	5	2 - 20	200
Ions	1/3	1	2 - 14.5	45
Ions (option)	1/6	1	2 - 8	48

- Fast chopper in the MEBT line: Selection of 1/50 up to $1/10^5$ bunch
- C.W. mode
- Low Duty Factor Pulsed Mode of Operation (slow chopper)

Beam Current Measurements in the L.E.B.T.



Transverse beam profiles measurements in the L.E.B.T.



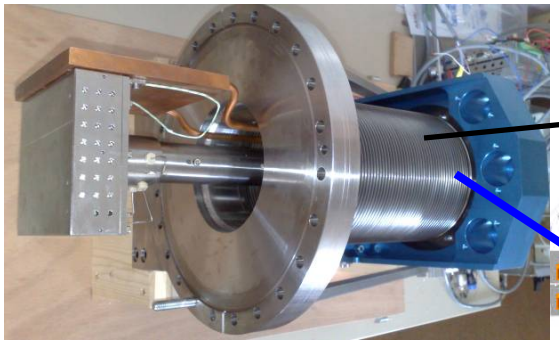
Secondary Emission Monitor:

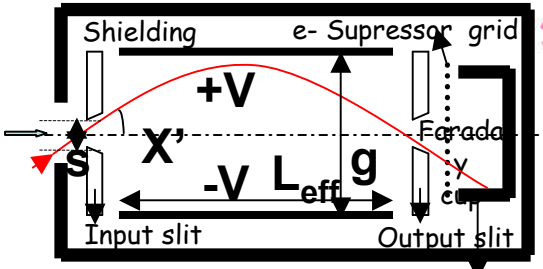
- 47 Tungsten wires ø 150 µm
- Maximum beam size: 80 mm
- Out-gassing rate 5.10^{-8} Pa. m^3. s^{-1}

L. D. F. P. M. Operation:
Duration = few ms
Repetition : ~ few 100 ms up to 1s

Beam Transverse Emittance Measurements in the L.E.B.T.

Emittancemeter H + V





Shared LEBT line

LEBT D+

LEBT ions

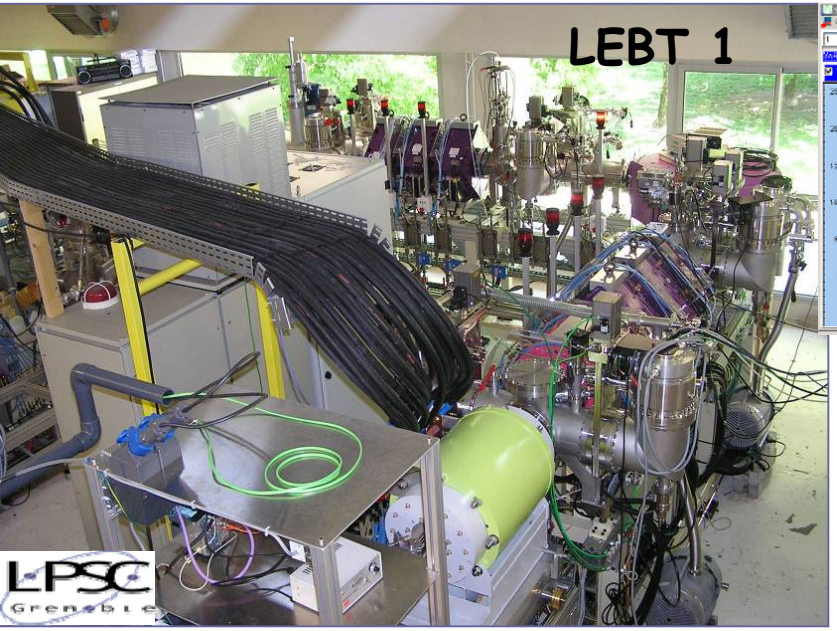
D+ source

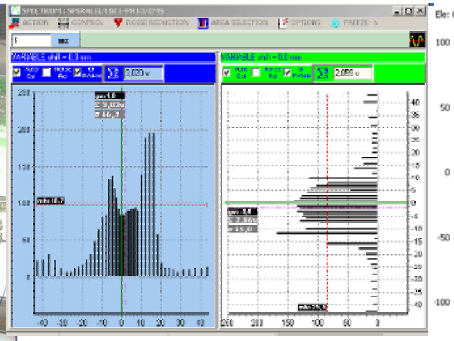
Ions Source
Q/A =1/3

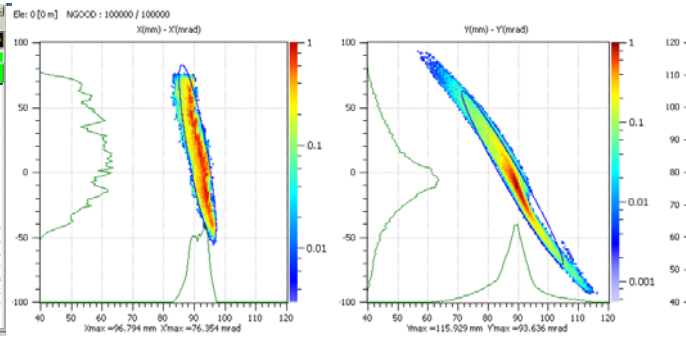
Emittancemeter: Allison Scanner

- Max. diameter beam: 80 mm
- Stroke: 120 mm
- Max measurable angle: ± 100mrad
- H.V. max: 2.8 kV
- Max Beam power: 300 W
- Beam Expected emittance: 1.6π mm mrad rms (N)

Diagnostics tests at LPSC and Irfu @ CEA Saclay



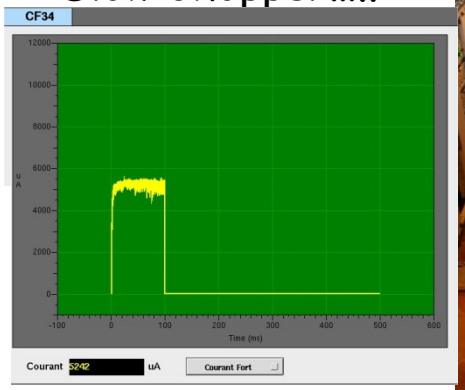




Beam profiles and emittance (Beam: O16 6+, March 2010)

LEBT 2 @ Saclay

Tests in progress
- ACCT + DCCT
- Emittancemeter
- Slow Chopper.....

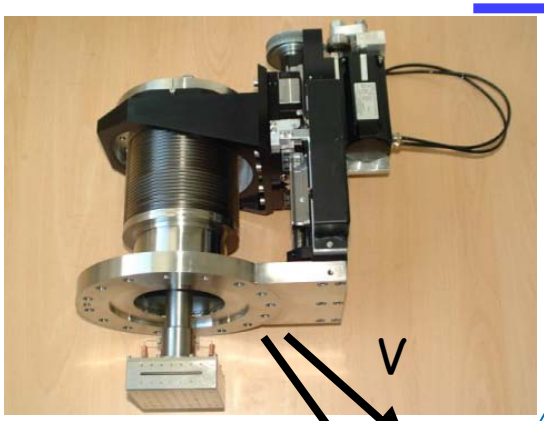


Slow chopper Test

Beam dump current

Driving signal

Beam Measurements in the M.E.B.T



DCCT+ACCT
0- 300 kHz
Part of MPS

Slow Faraday cup
3kW CW- 5.3 kW/cm²max

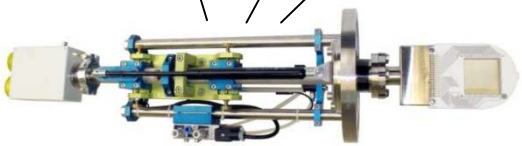
Slits H

Slits V

BEAM

Slits V

Fast Chopper - F. C. T
- BW > 1.5 GHz

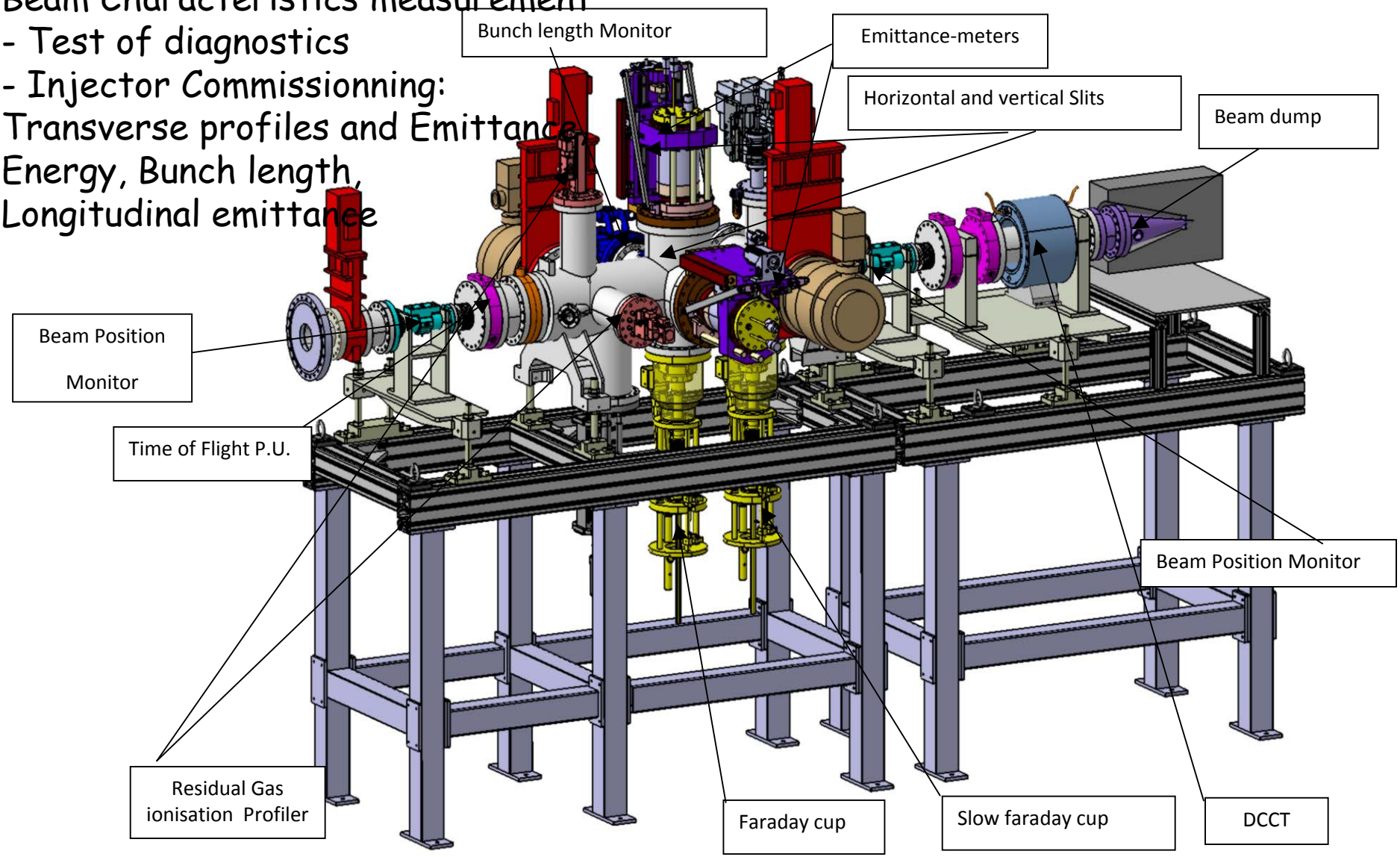


- Harp S.E.M profilers
L. D. F. P. M. operation
D = few 100 µs, T: ~ 100 ms up to 1s

- Bunch length measurement:
- Fast F. C. (B.W. > 1.5 GHz)
400 W max. D= 45 mm

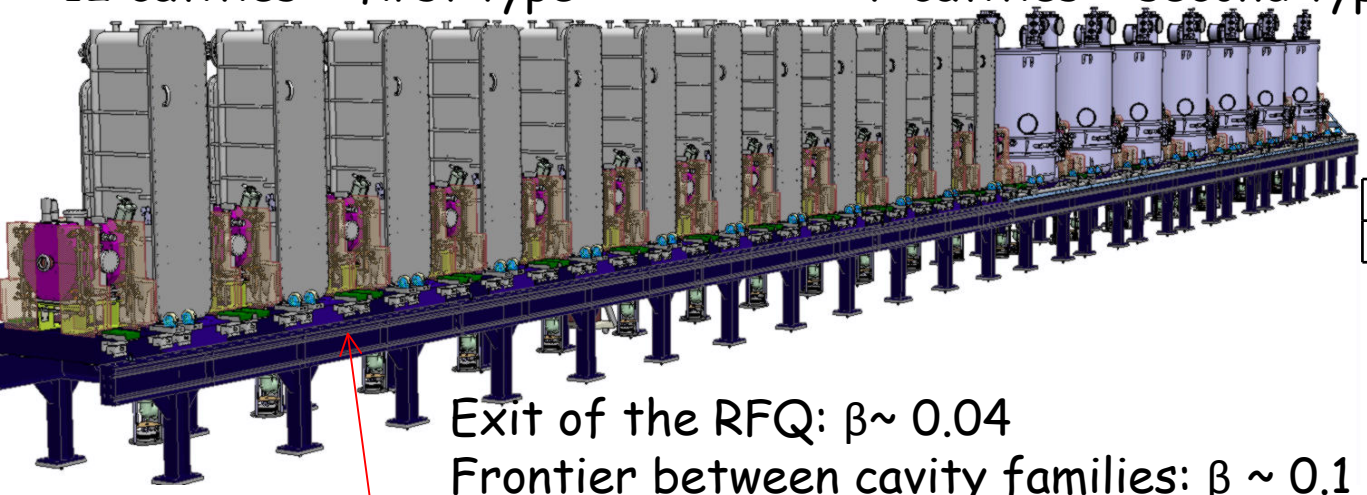
INTERMEDIATE TEST BENCH

Beam Characteristics measurement
- Test of diagnostics
- Injector Commissionning:
Transverse profiles and Emittance,
Energy, Bunch length,
Longitudinal emittance



Beam Position Measurement in the LINAC. Sensor

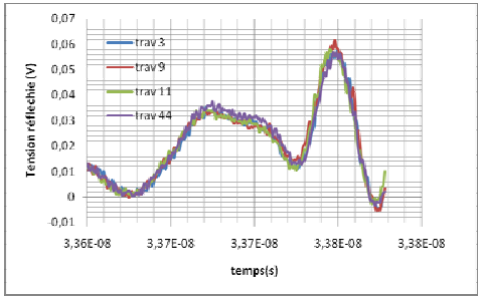
- 12 cavities « first type »
- 7 cavities « second type »

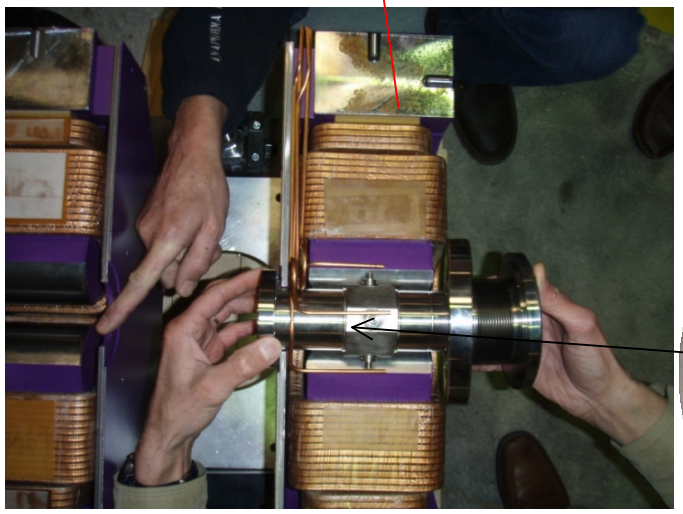


Exit of the RFQ: β~ 0.04
Frontier between cavity families: β ~ 0.1
End of the LINAC: β ~ 0.2

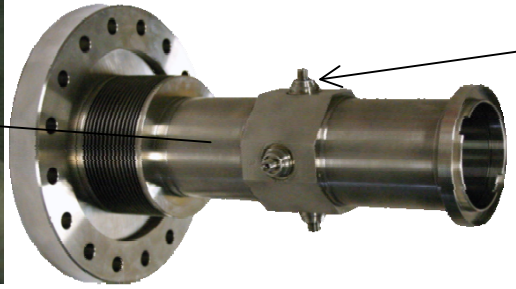
4 x

N° Feedthrough	1	2	3	4
Capacité (pF)	1,35	1,35	1,36	1,36

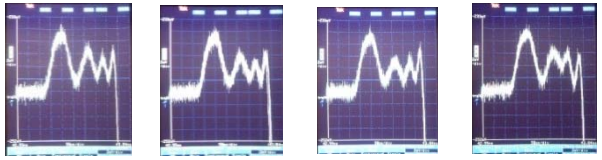




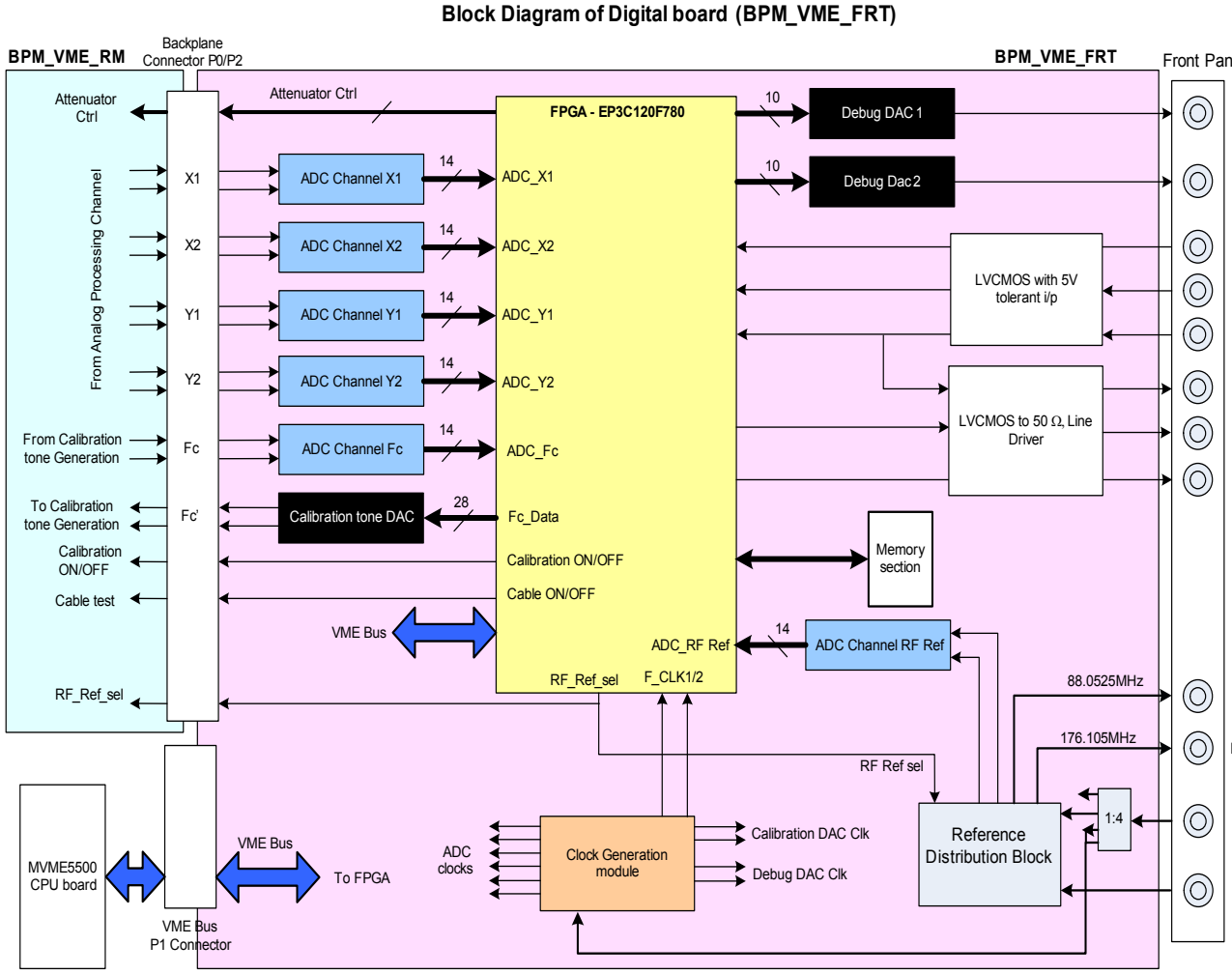
<u>Beam Position Monitor:</u>
Capacitive probe
- Inner ø: 48 mm
- Length : 39 mm
- Subtented lobe-angle: 60°



N° sensor	1	2	3	4
Capacitance (pF)	10.25	10.27	10.28	10.26



Beam Position Measurement in the LINAC. Electronics



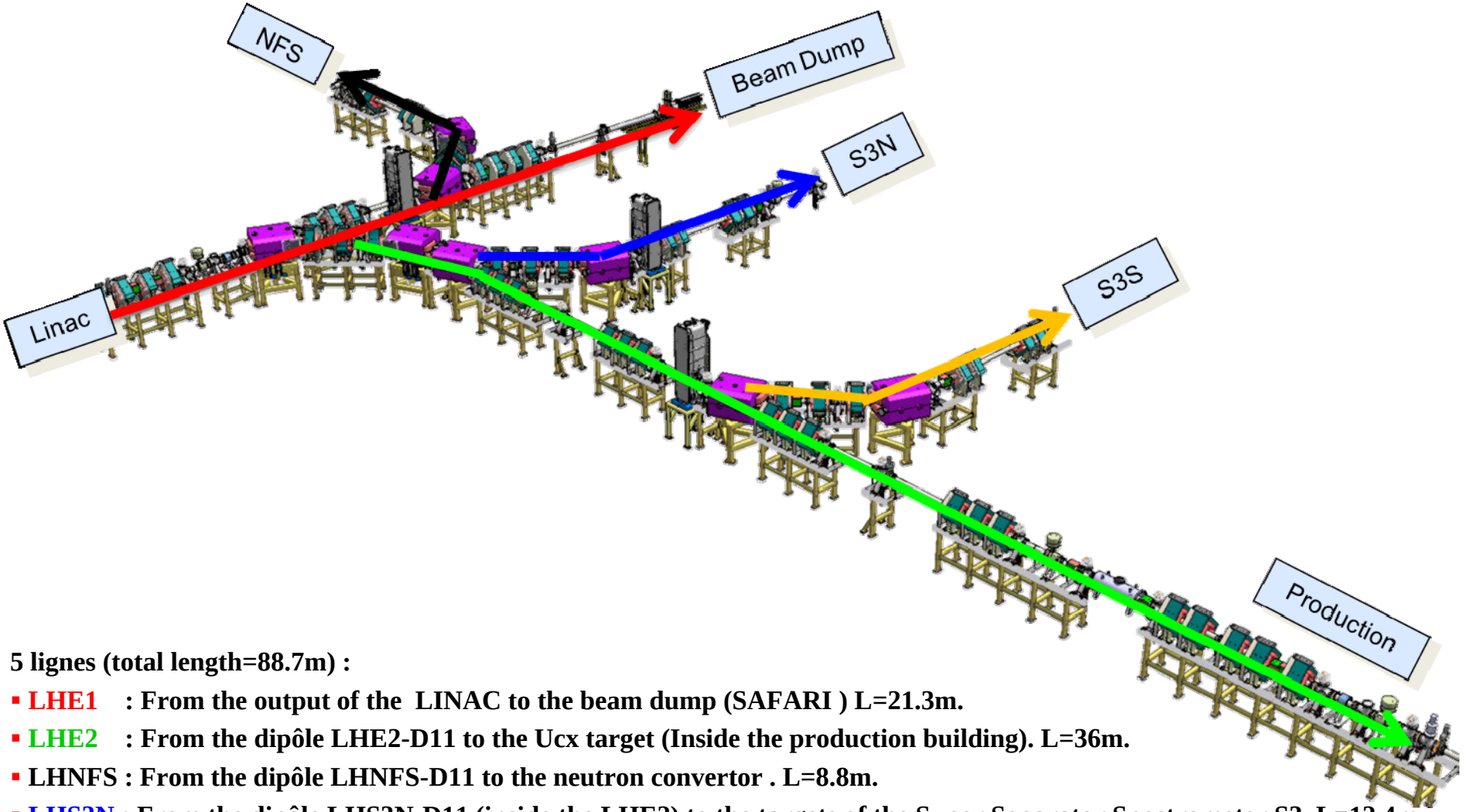
Input data

- Kx, Ky, K: BPM sensitivity (X and Y) ellipticity factor
- Xerror, Y error: (mechanical/electrical) BPM center offset
- Δ_D: trigger delay
- "N": Number of acquisitions
- Selection of the harmonic to process the data : 88,0525 MHz or 176,105 MHz
- On/Off calibration system
- offset trim between the four channels of the electronic card.
- Valid position range of the gravity center of the beam (interlock for MPS)

Out put data

- Beam Position of the center of the beam (dynamic range: ± 20 mm). Resolution : 150 µm
- Beam phase. Resolution ± 1°
- Beam ellipticity (σ^2_x - σ^2_y). Resolution: ~ ± 20 %
- Shape reproduction of the bunch at the output of the 4 electrodes.
- Post mortem data over 2.5s (after beam break down)
- Interlock signal (In case of position of the center of the beam out of range)

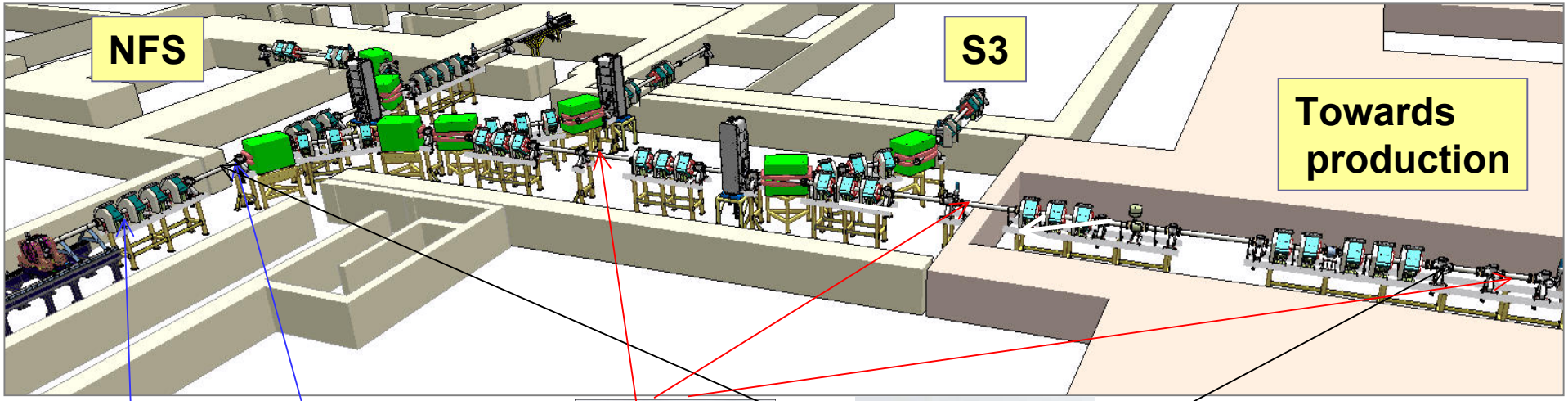
HEBT LINES: GENERAL CONFIGURATION

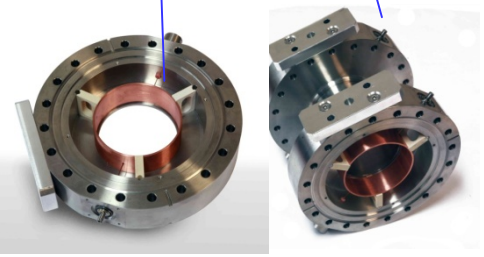


5 lignes (total length=88.7m) :

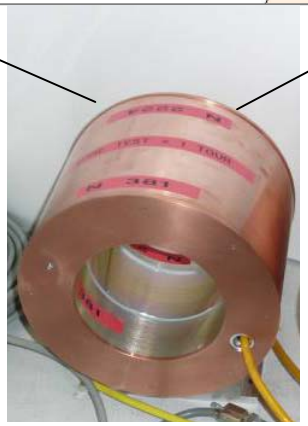
- **LHE1 : From the output of the LINAC to the beam dump (SAFARI) L=21.3m.**
- **LHE2 : From the dipôle LHE2-D11 to the Ucx target (Inside the production building). L=36m.**
- **LHNFS : From the dipôle LHNFS-D11 to the neutron convertor . L=8.8m.**
- **LHS3N : From the dipôle LHS3N-D11 (inside the LHE2) to the targets of the Super Separator Spectrometer S3. L=12.4m.**
- **LHS3S : From the dipôle LHS3S-D11 (inside the LHE2) . Future option of the project L=9.5m**

High Energy Beam Transfert line: diagnostics





Ionization Profile Monitor or BPM



Beam Intensity measurement:
DCCT + ACCT
- Part of MPS

11 Beam Loss monitors:
1l plastic scintillator + Photo multiplier

Location: 1m from beam pipe
Response time E_B> 5Mev: 10 μs
(« high » beam losses)
Spatial resolution : 1m

Beam energy measurement:
Set of « Time Of Flight P.U. »

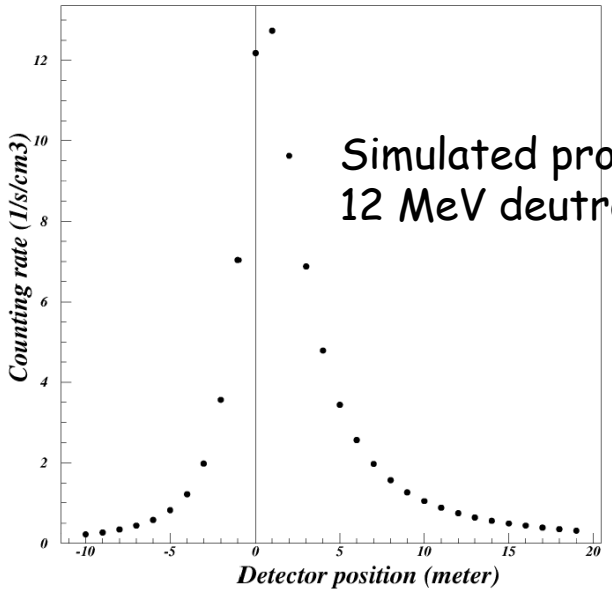
Beam profile measurement:
22 EMS profilers

8 Halo monitors (loss rings)

HEBT lines: BLM detectors configurations

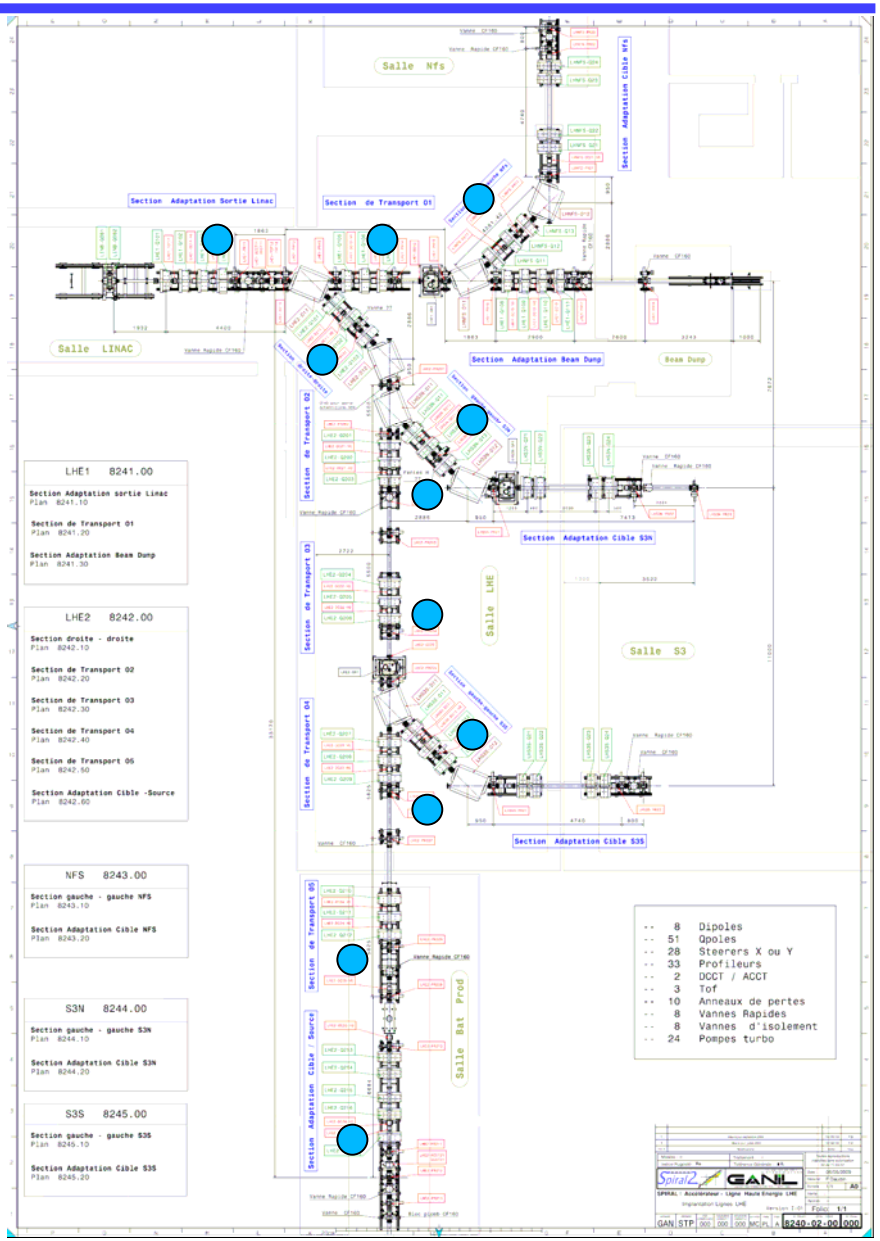
- LINAC: 1 detector per cryomodule along linac
- HEBT: 11 detectors in HEBT lines

Expected output:
longitudinal profile of counting rates



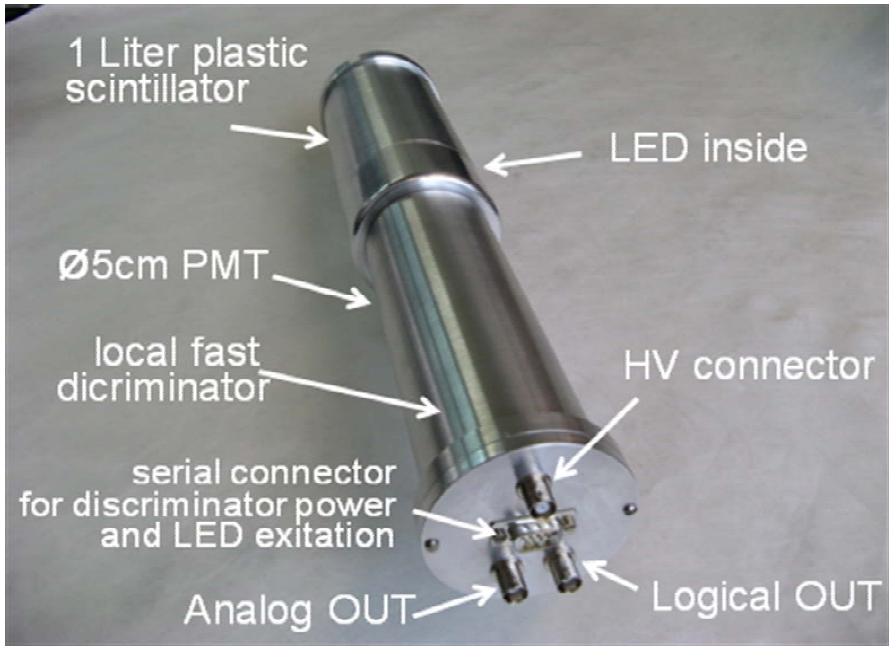
Simulated profile for
12 MeV deutrons

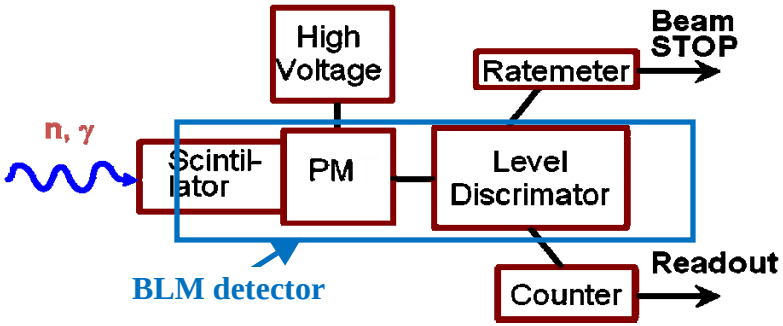
Distortions factors:
- X-ray background
- activation build-up
- scattering/absorption on beam line elements
- complex profiles losses



HEBT lines: BLM detectors final design

Slide by courtesy of Florin Negoita

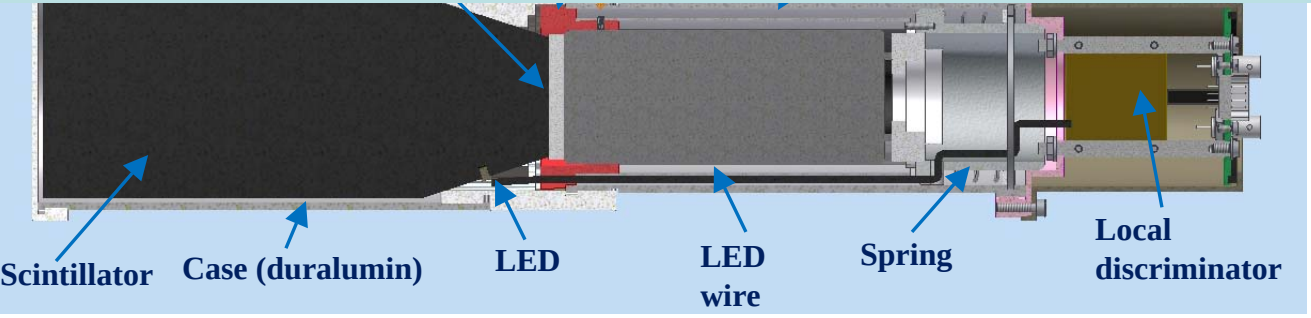


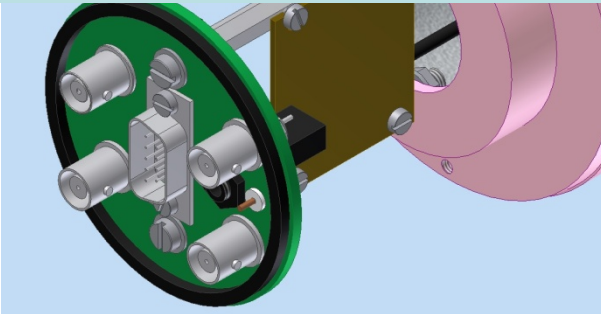


Radiation hardness tests at 10^{14} n/cm^2 (~ 1kGy) using d+Be reaction at Bucharest cyclotron:

- no effect on local discriminator
- strong effect on LED (30 times reduction)
- replacing the LED the pulse shape was recovered =>
  - no effect on PM amplification
  - no effect on optical transmission

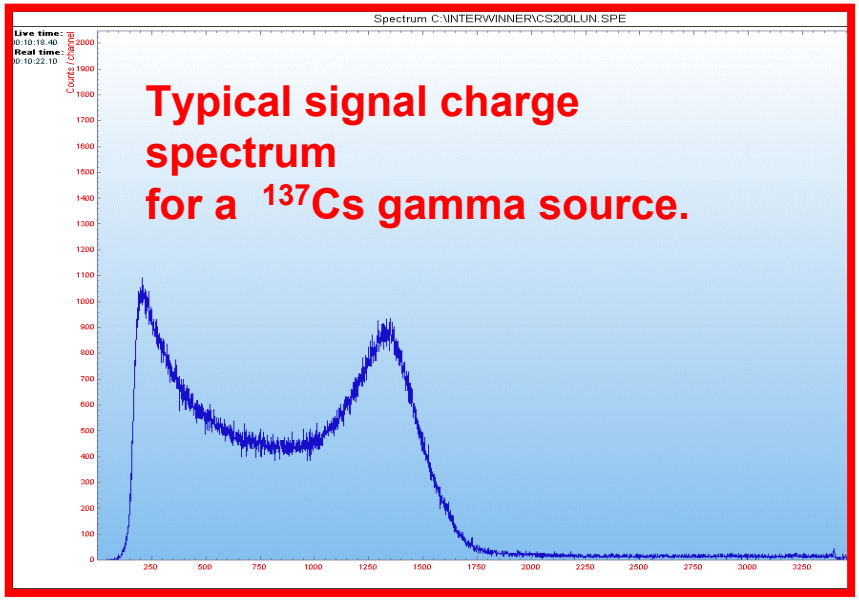
The results are consistent with expectations and values used in simulations





Test of the final design of BLM detectors

First detector in final design has been built and fully characterized



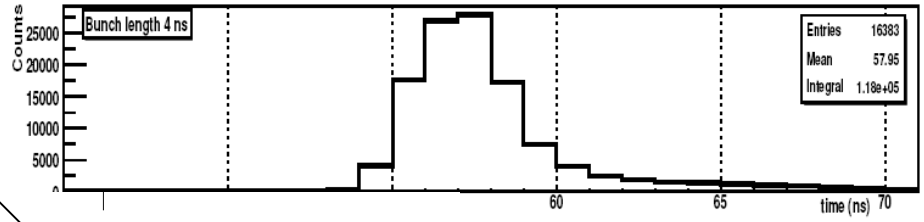
Threshold (mV)	Threshold (eekeV)	Background (cps)
50	25	411
100	50	313
200	100	246
300	150	167
400	200	139
500	250	119

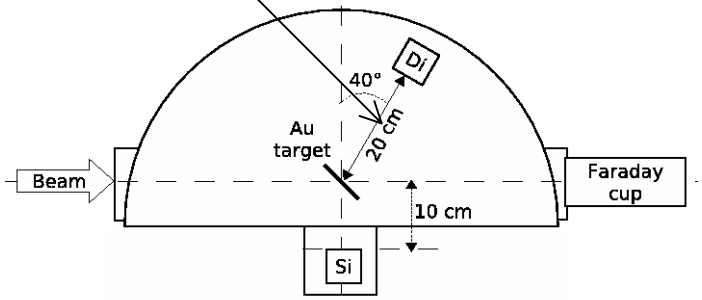
Background count rate at 1200 V as function of threshold.

The results are consistent with expectations and values used in simulations.

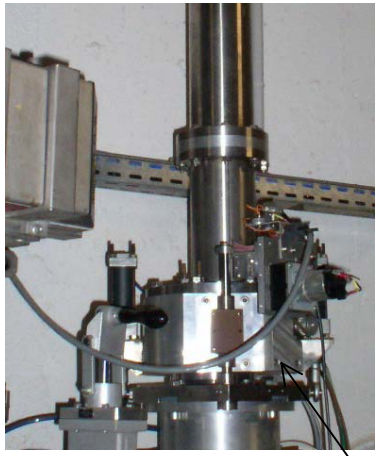
Slide by courtesy of Florin Negoita

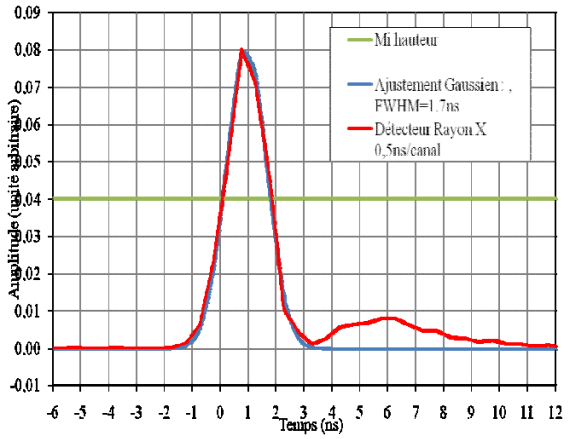
Bunch length measurements



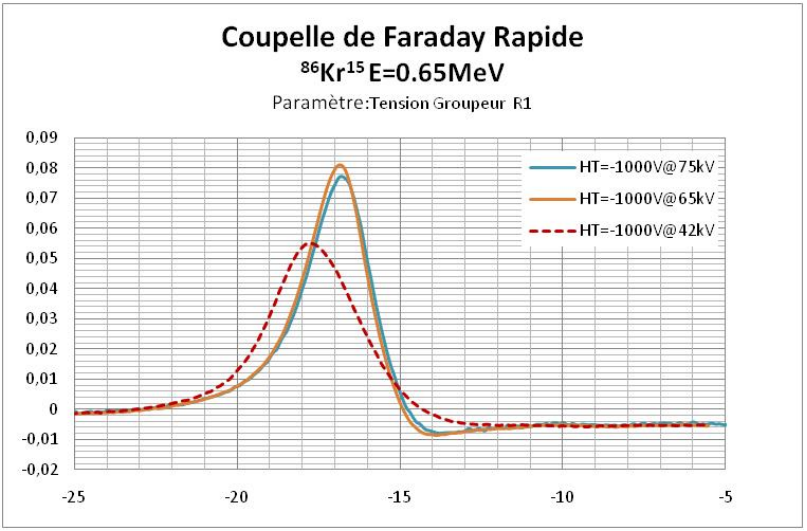


Test @IPNO : Diamond detector-X ray monitor
Beam : ^{12}C– 60 MeV





Test @IPNO: X ray monitor
- Beam : ^{12}C– 60 MeV



Test @GANIL
-Faraday cup
-Residual ionisation gas detector

ACKNOWLEDGMENTS

- Special Thanks to the contributors to SPIRAL2 diagnostics

  - Ganil : *Profilers , Faraday cups, Beam Current transformers, phase and energy* m*easurements, controls.*
  - IPNO: *B.P.M.*
  - IPNL: *Thermal simulations. Faraday cup design*
  - *Barc Institute: BPM electronic*
  - I.P.H.C : *Transverse Emittancemetter , Intermediate Testing Bench.*
  - C.E.A - Dapnia : *Controls*
  - NIPNE *: Beam Loss Monitors*

  - *….And many other people*