LINAC-4 Instrumentation Review
9. May 2007

I.P.H.I. Beam Diagnostic Line

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Overview of the installation of IPHI at Saclay

Procédé de réglage RF du RFQ : Maquette à l'échelle 1

1ier tronçon RFQ sur son support et manifolds de pompage

Eléments magnétiques de la LHE et Wire scanner

Bloc d'arrêt Nickel : 300 kW

Protections biologiques

Baies bas niveau RF

Ligne basse énergie IPHI

Système RF de puissance : 2.6 MW @ 352 MHz

Profils faisceau : CCD et CCD + Doppler

Distribution de refroidissement RFQ

Supports des arrivées de puissance RF

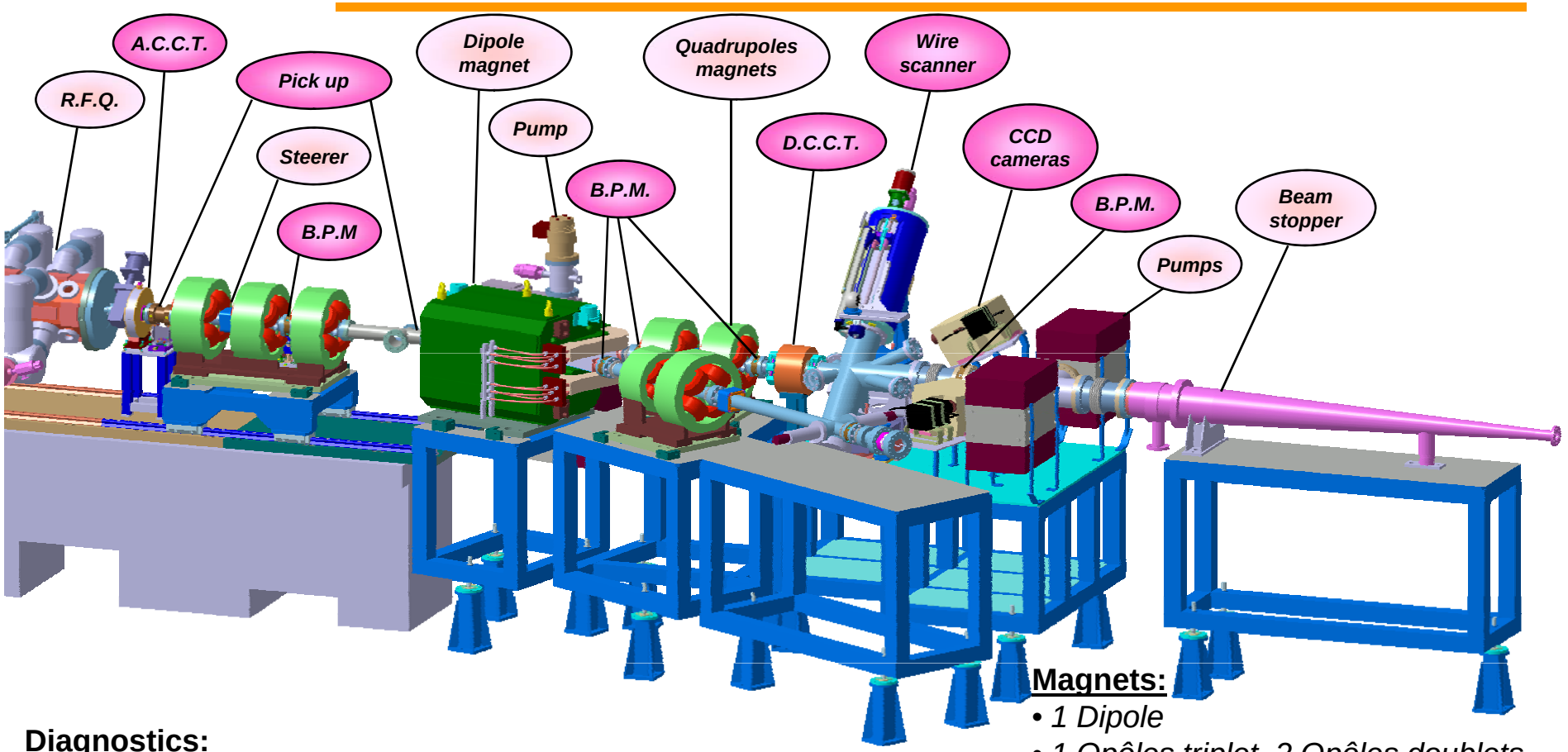
Système de régulation de θ RFQ

Tour de refroidissement 8 MW

CERN-SPL

IN2P3 Institut National de Physique Nucléaire et de Physique des Particules

Beam Diagnostics Line



Diagnostics:

- Intensity measurements*: 1 D.C.C.T et 1 A.C.C.T*
- *Beam Position Measurement: 6 P.U.*
- *Energy measurement: 3 P.U.*
- *Energy spread measurement: 2 slits + 1 F.C.*
- *Transverse profiles:*

1 W.S., optical measurements, backscattered protons

- *Temperature measurements of the beam pipe (thermocouples)*

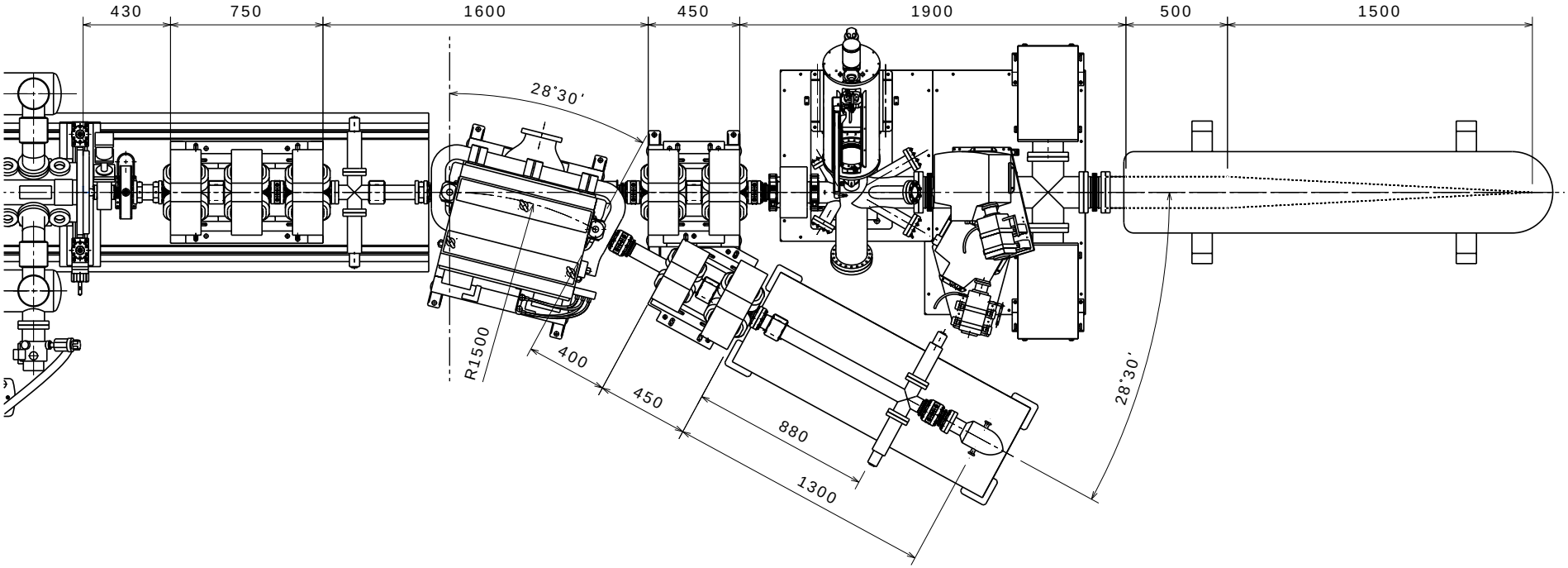
Magnets:

- *1 Dipole*
- *1 Qpôles triplet, 2 Qpôles doublets*
- *5 Steerers H and V*

Vacuum: $P_{moyen} = 6 \times 10^{-6}$ Pa

- *1 dry pump 12.5 m3/h , 1 T.M.P. 150 l /s*
- *3 ion pumps 400 l /s ,*
- *1 P.P. 30 m^3/h , 1 T.M.P. 360 l /s*
- *8 gauges couples «Pirani - Penning»*

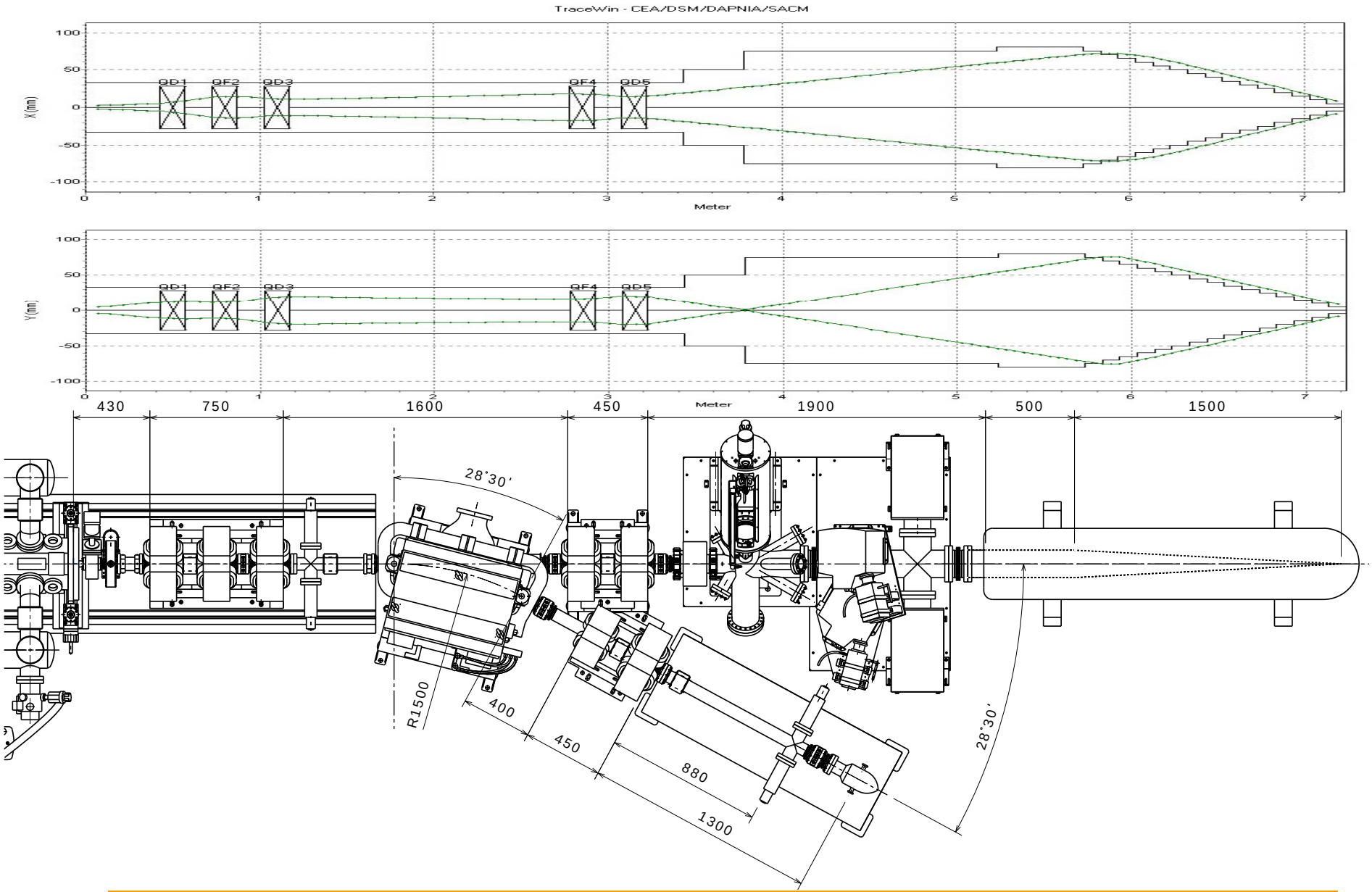
Beam Dynamics in the IPHI diagnostics line



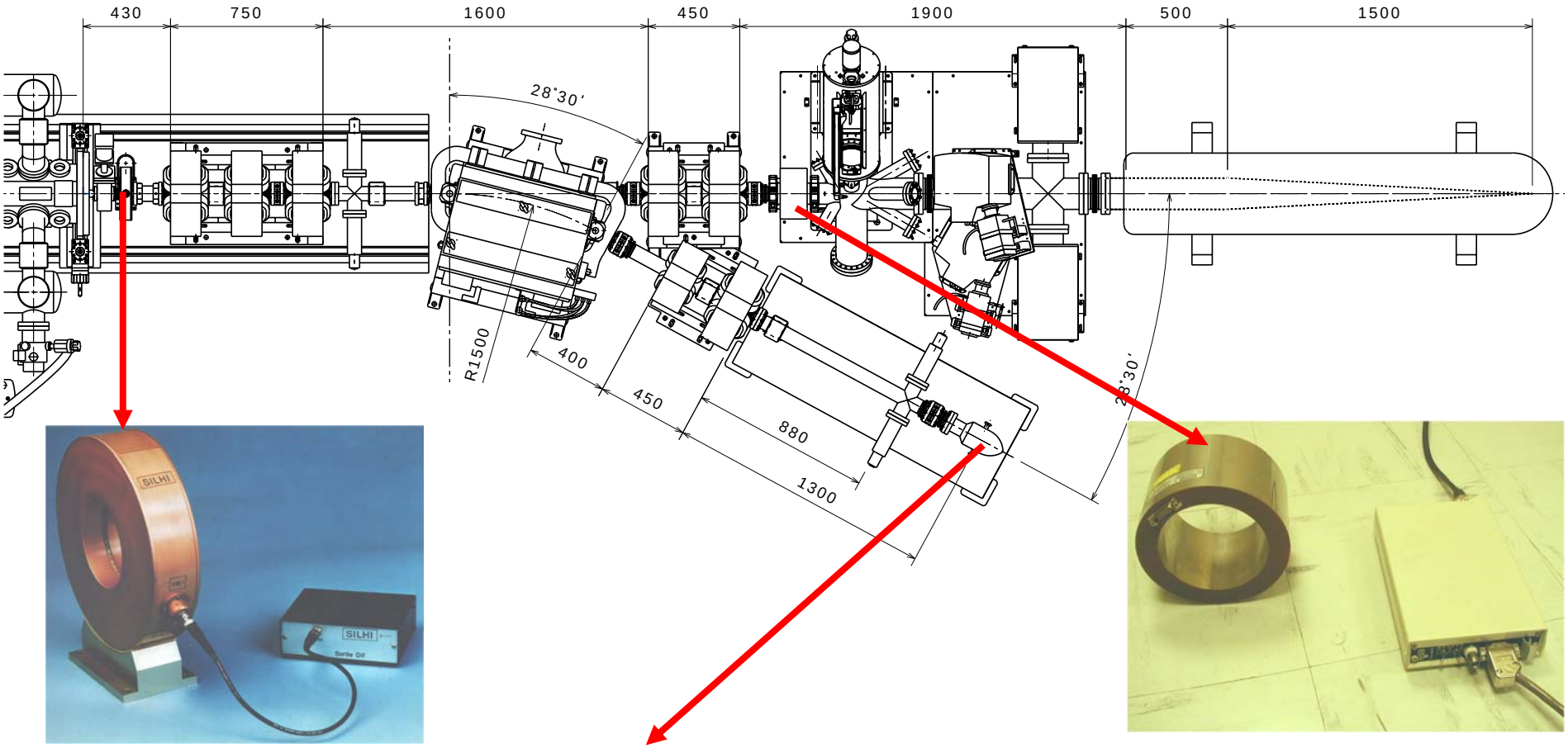
Beam dynamics description report on E.D.M.S. (Jean Louis Coacolo)

- Beam dynamics optimization ("Tracewin" - BETA). Beam parameters at the entrance: "Toutatis". Mean energy and intensity of the beam: 3.015 MeV - 99,4 mA.
- Heat deposition on the beam stopper simulation:
optimization of the distance last Qpôle - entrance of the beam stopper / diameter of the vacuum pipe at the entrance of the beam stopper and its length
- Description of the emittance measurement method
- Description of the energy spread measurement method
- Steerers determination

Beam Dynamics in the IPHI diagnostics line



Beam Diagnostics Line: Intensity Measurements

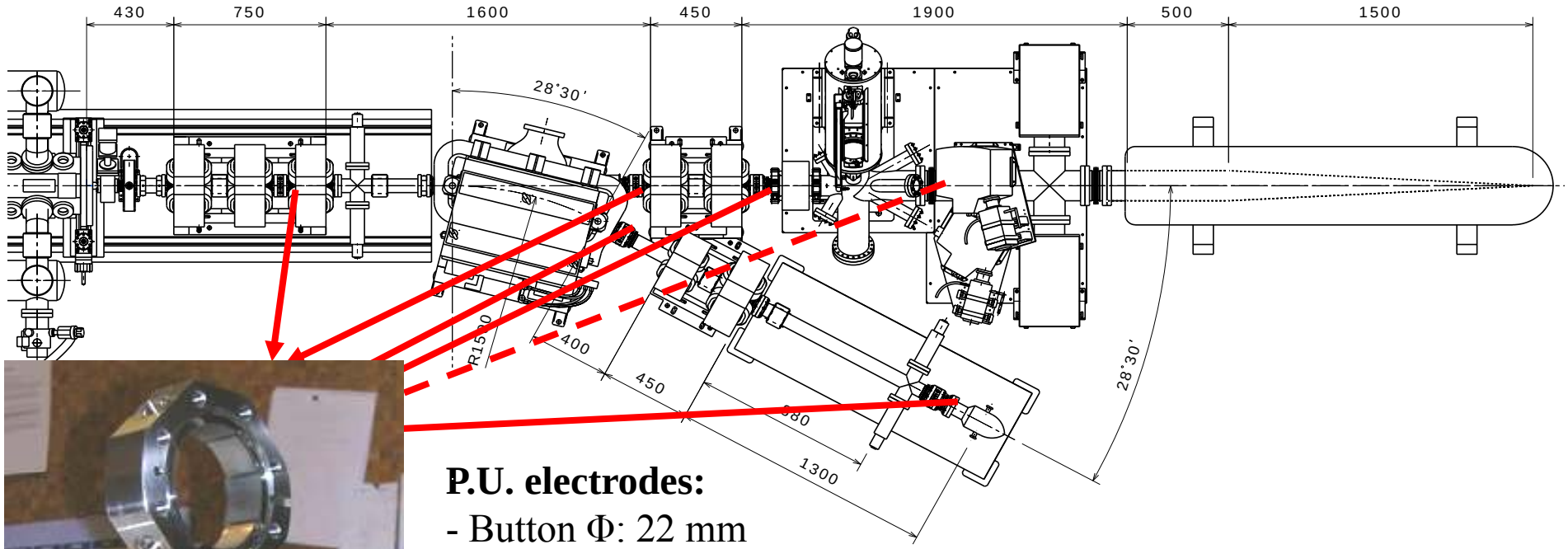


A.C.C.T.:
pulsed mode operation
Sensitivity: 1V / 20 mA
Bandwidth: 5 Hz- 6.5 MHz
Noise: 10 µA - rms

Faraday Cup:
pulsed mode operation
Sensitivity:1V / 200 µA, 20 µA, 2 µA
Bandwidth: D.C.- 25 kHz
Noise : 40 pA - rms

D.C.C.T.:
C.W. operation
Sensitivity:1V / 20 mA
Bandwidth: D.C.- 3.5 kHz
Noise:100 µA - rms

Beam Diagnostics Line: Beam Position Measurements



P.U. electrodes:

- Button Φ: 22 mm
- Inner Φ pipe: 66mm
- C ~ 9.5 pF

Beam Characteristics:

• β=0.08 - I = 100 mA CW - E = 3 MeV

Electronic acquisition card

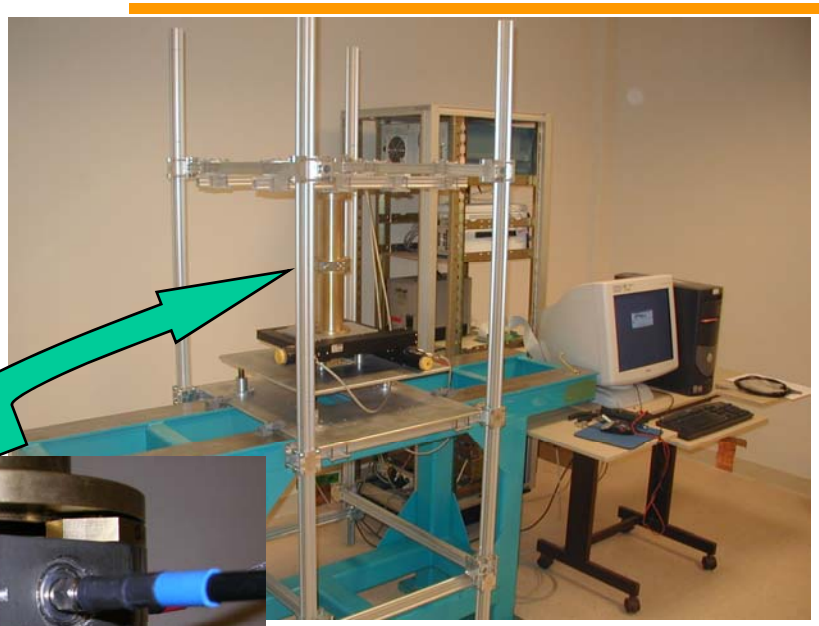
C.W. & pulsed mode operation >0,2 ms

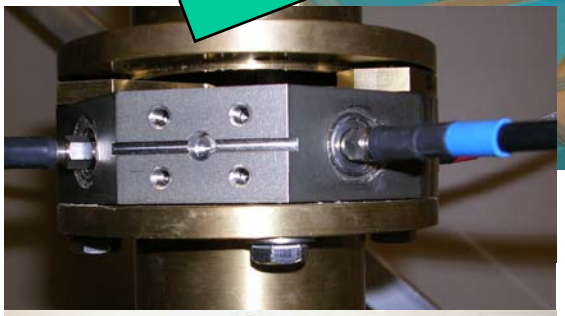
Selected: Log ratio

Beam intensity range: 40 µA - 100 mA

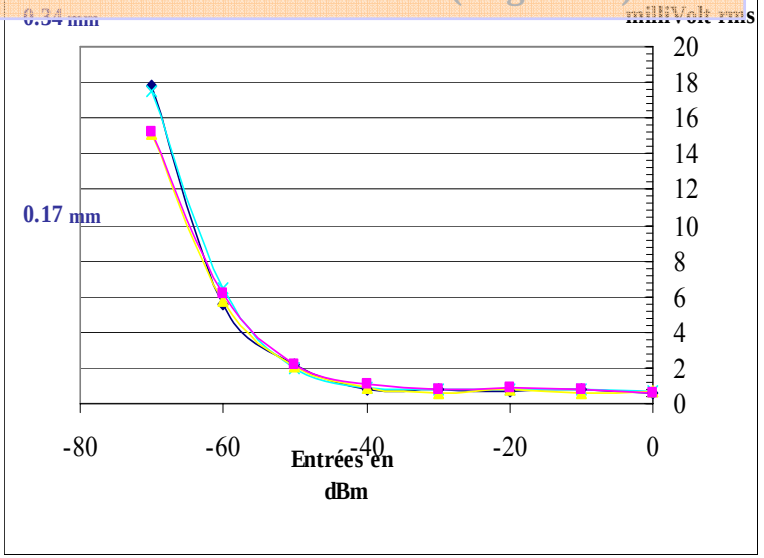
Fore seen absolute precision: ± 170 µm rms - I beam > 25 mA

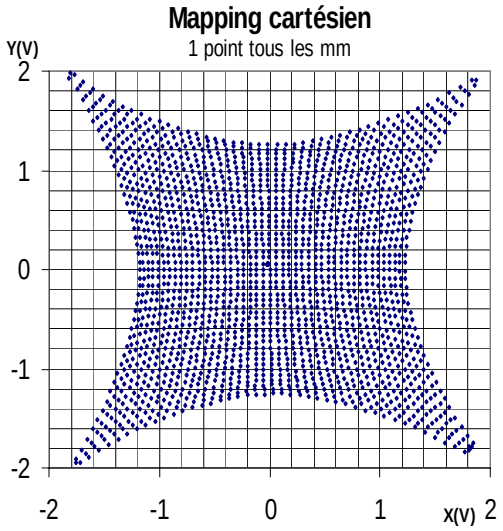
Beam Diagnostics Line: Beam Position Measurements



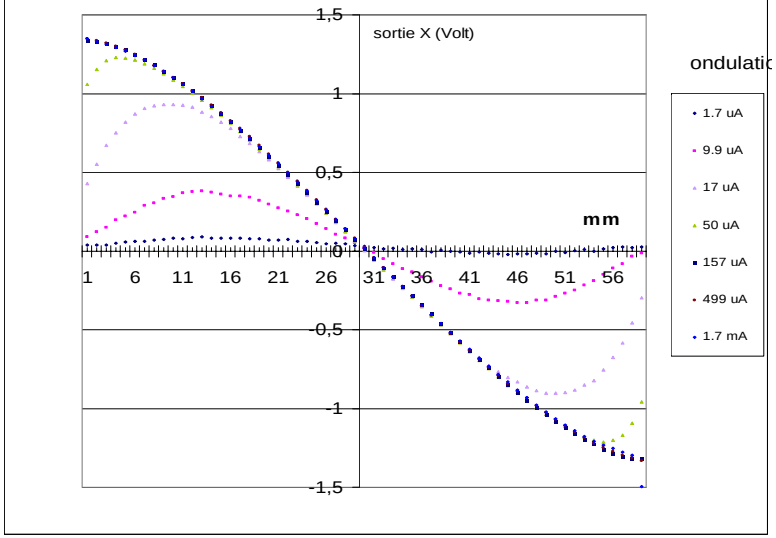


Electronic noise X Y (Log Ratio)

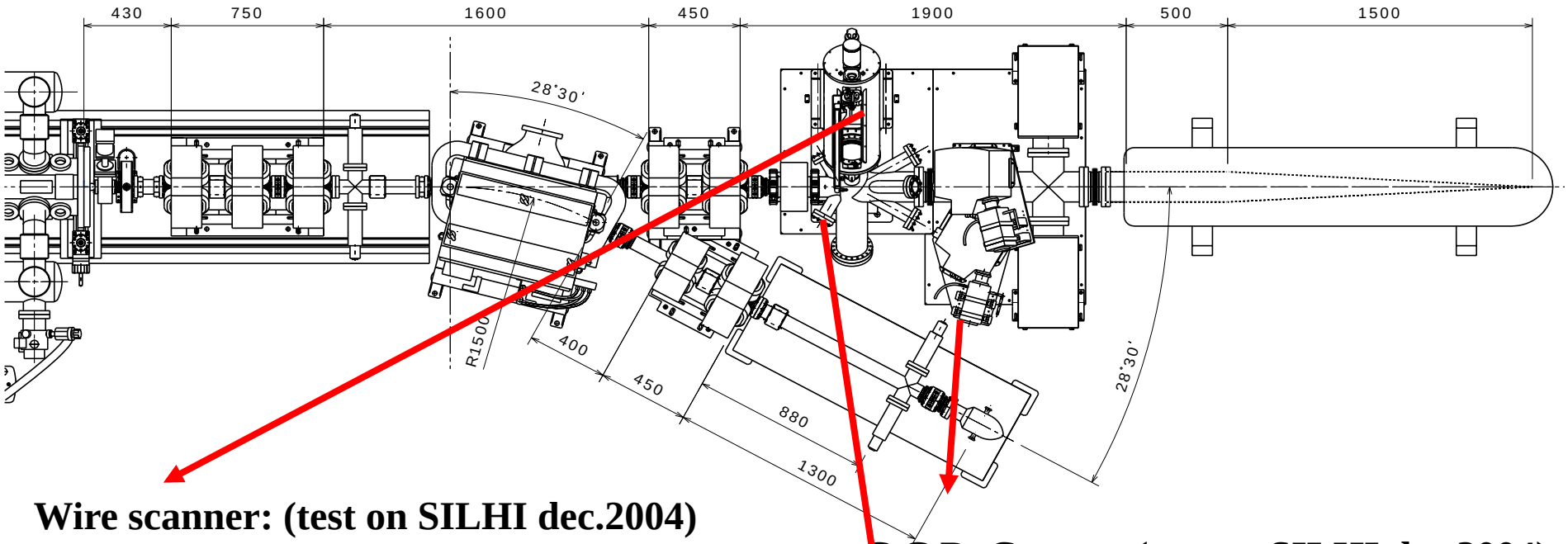




Sensitivity (measured): 17.0 µm / mV



Beam Diagnostics Line: Tansverse profiles measurements



Wire scanner: (test on SILHI dec.2004)

Pulsed mode operation

Electronics: Sensibility: 1V/mA 1V/0.1 mA

C.C.D. Camera (test on SILHI dec.2004)

C.W. and Pulsed mode operation

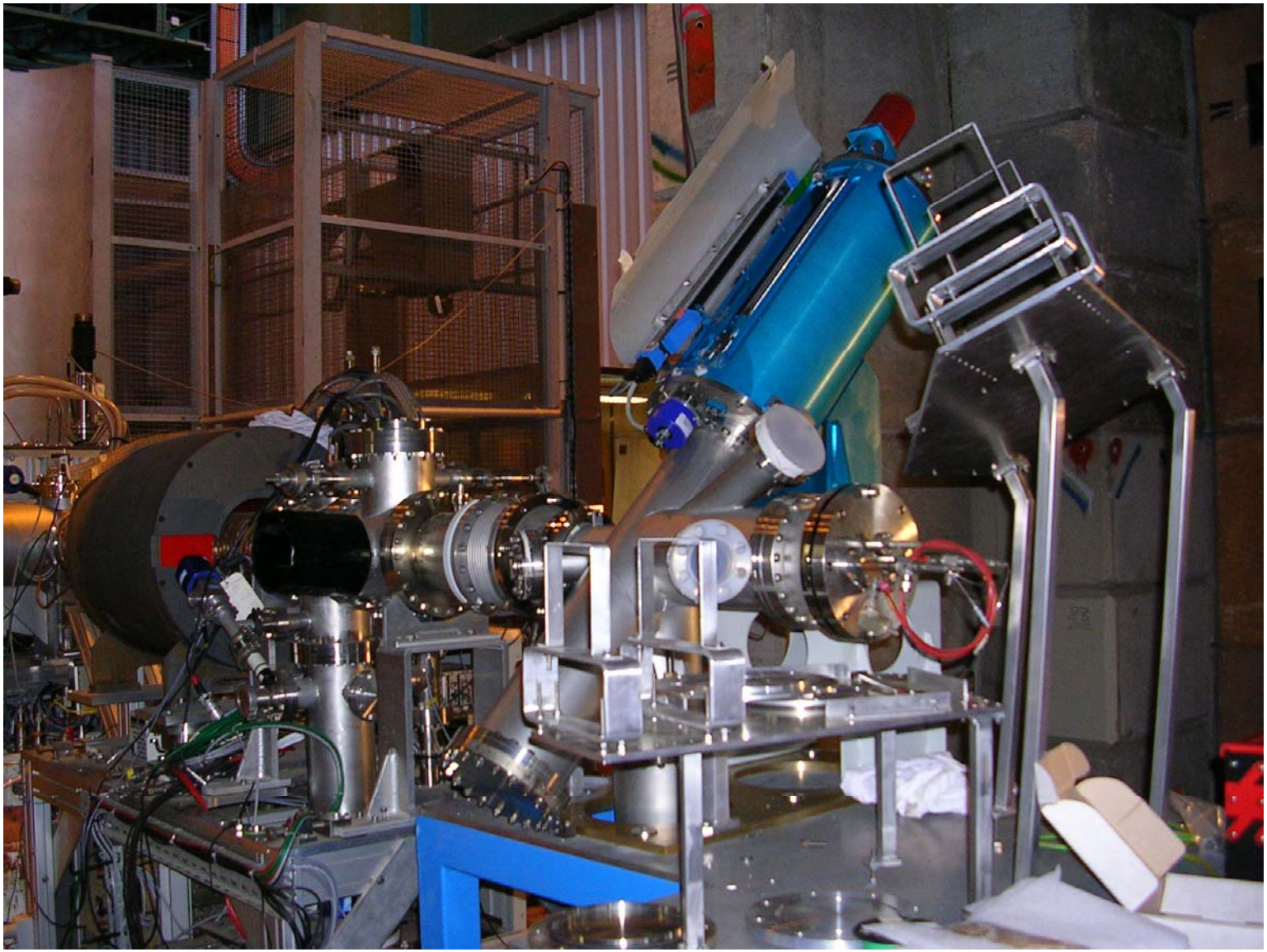
Data acquisition: must be finalized.

Back scattered protons

Pulsed mode operation

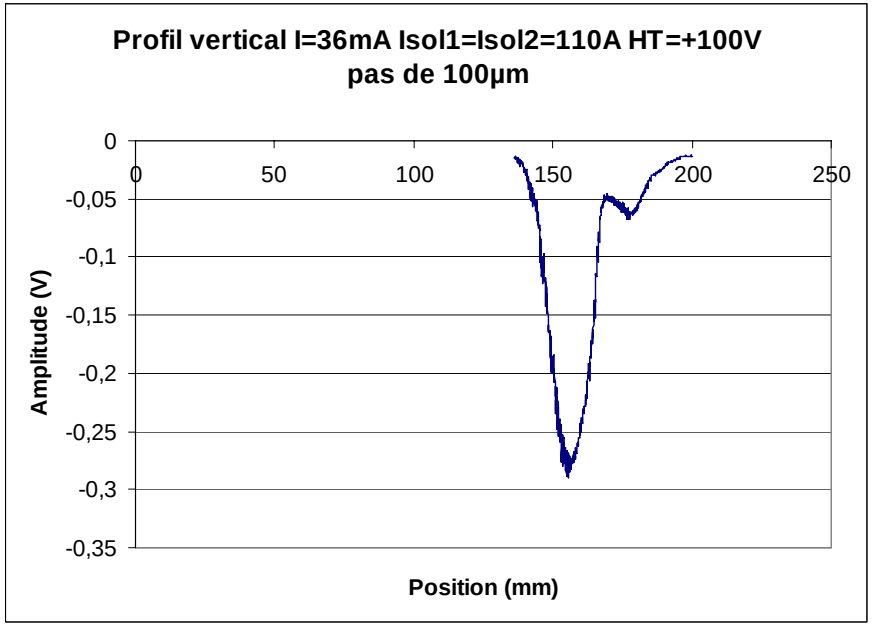
Previously tested (2002) on Tandem

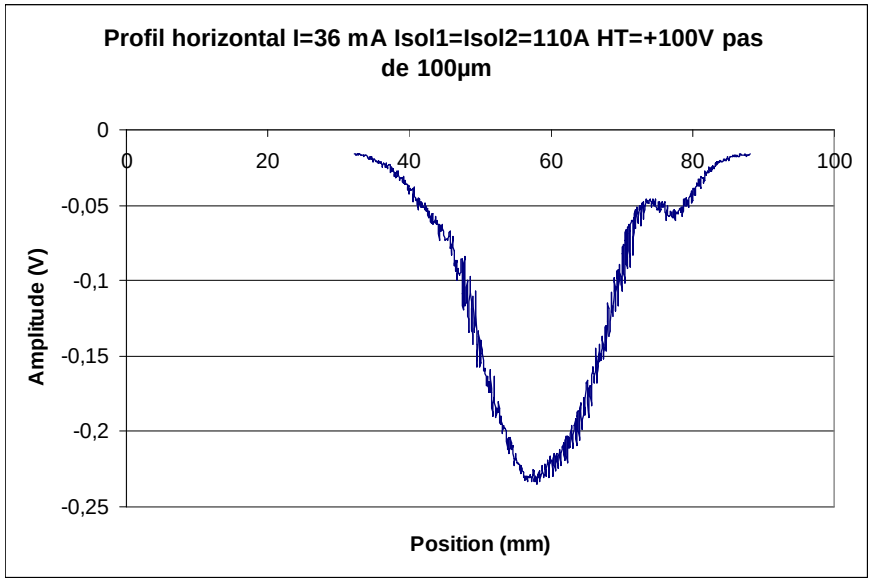
Beam Diagnostics Line: Tansverse profiles measurements



WIRE SCANNER mounted in the diagnostics beam line of IPHI

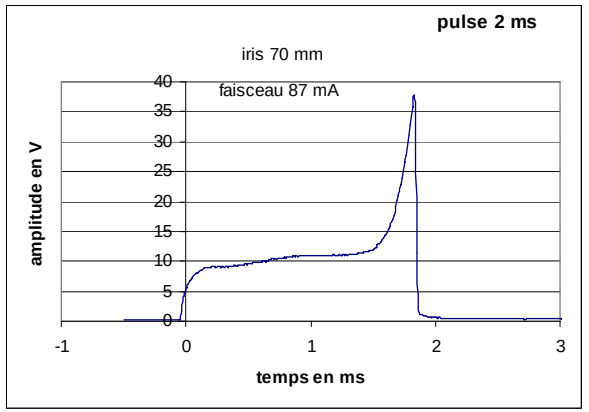
Beam Diagnostics Line: Tansverse profiles measurements

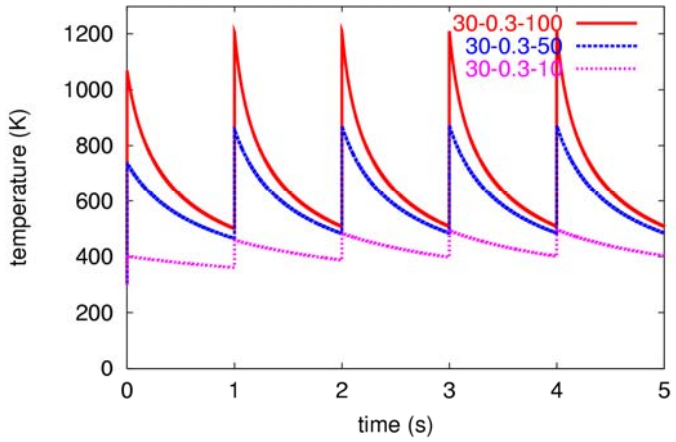




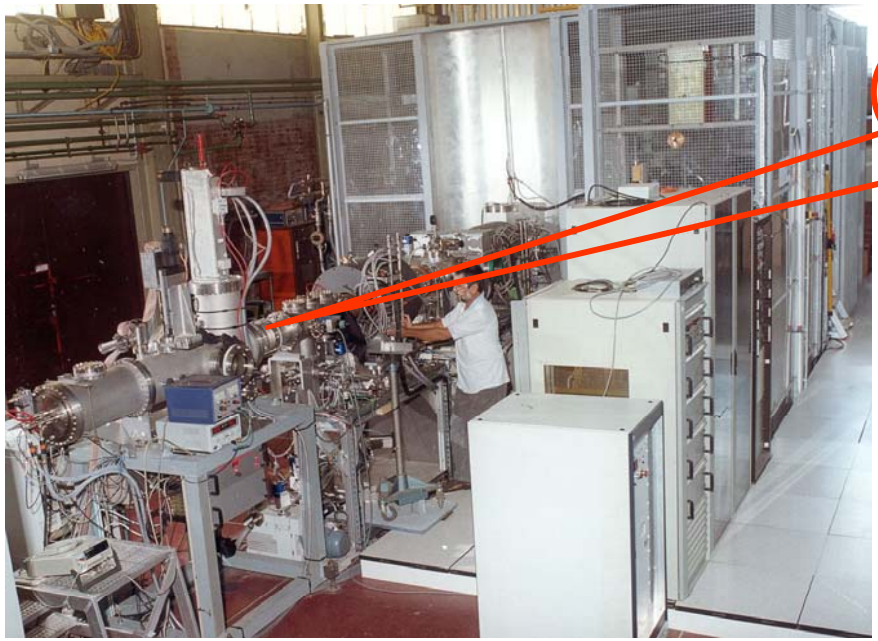
Pulsed mode operation of SILHI:

- Pulse duration: 1 ms
- Repetition rate: 1 s
- Beam current: 36 mA
- Step: 100 µm

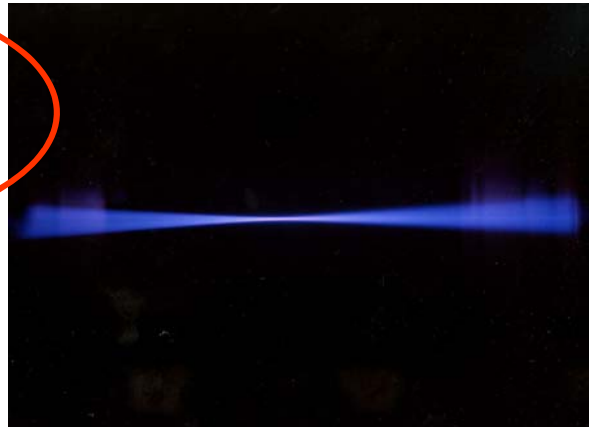


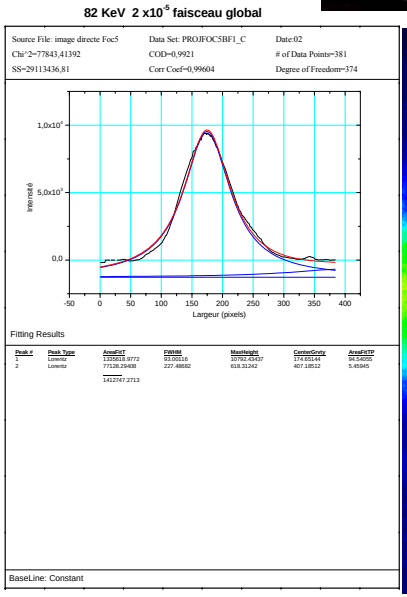


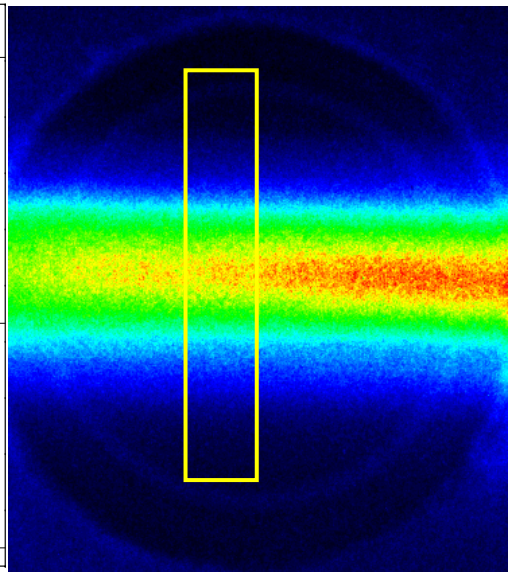
Optical based measurements : Fluorescence



"Diagnostic box"





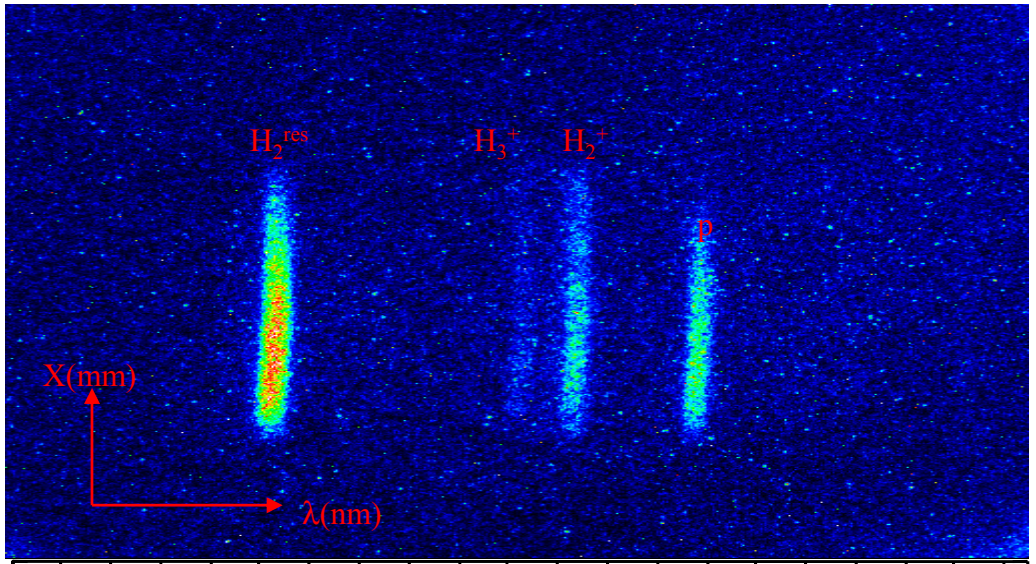


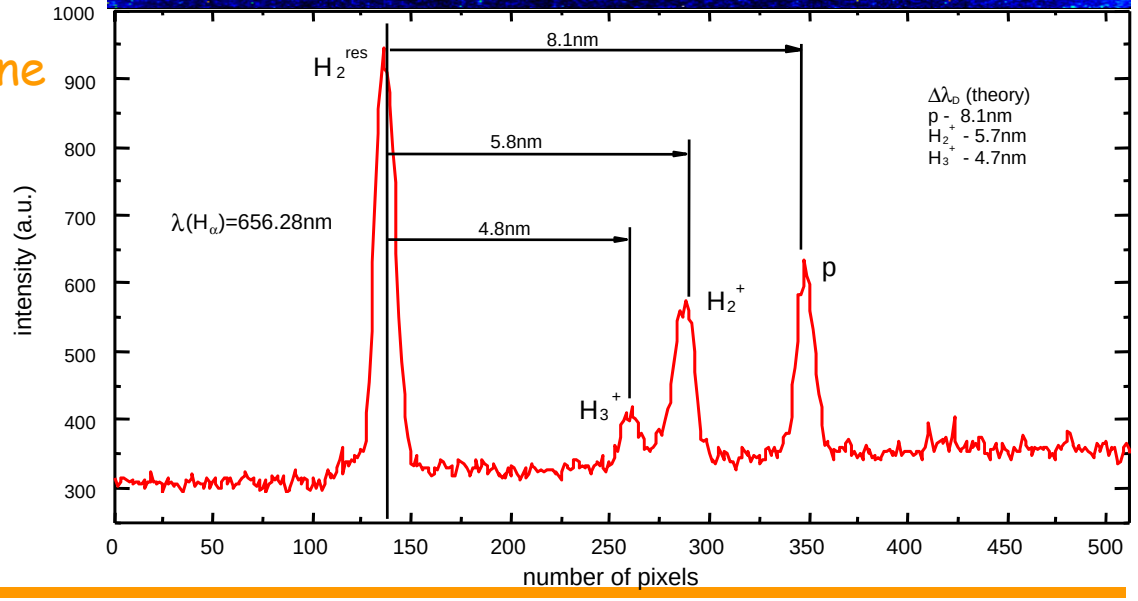
Proton Beam-Residual Gas Interaction
(Hydrogen: 2.10^{-3} Pa)

Beam Diagnostics Line: Tansverse profiles measurements

Optical based monitors: Luminescence analysis

Shifted Doppler a Balmer line



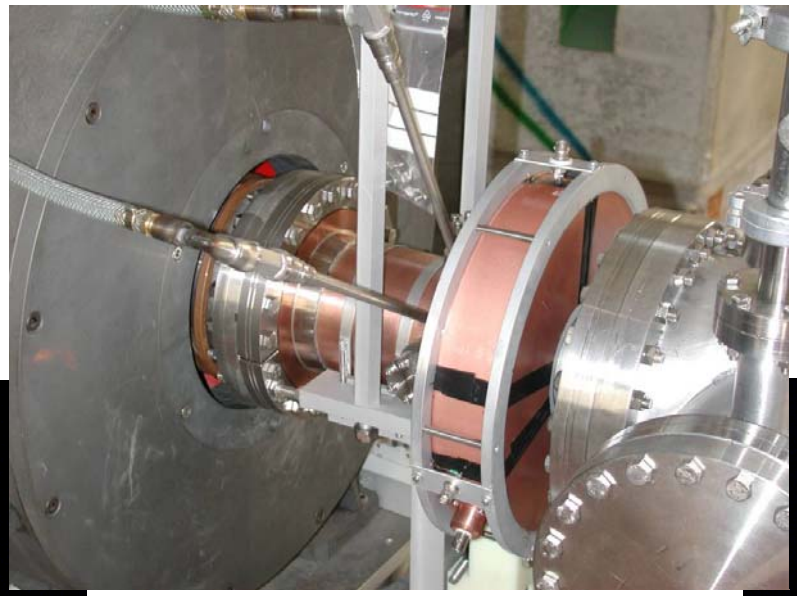


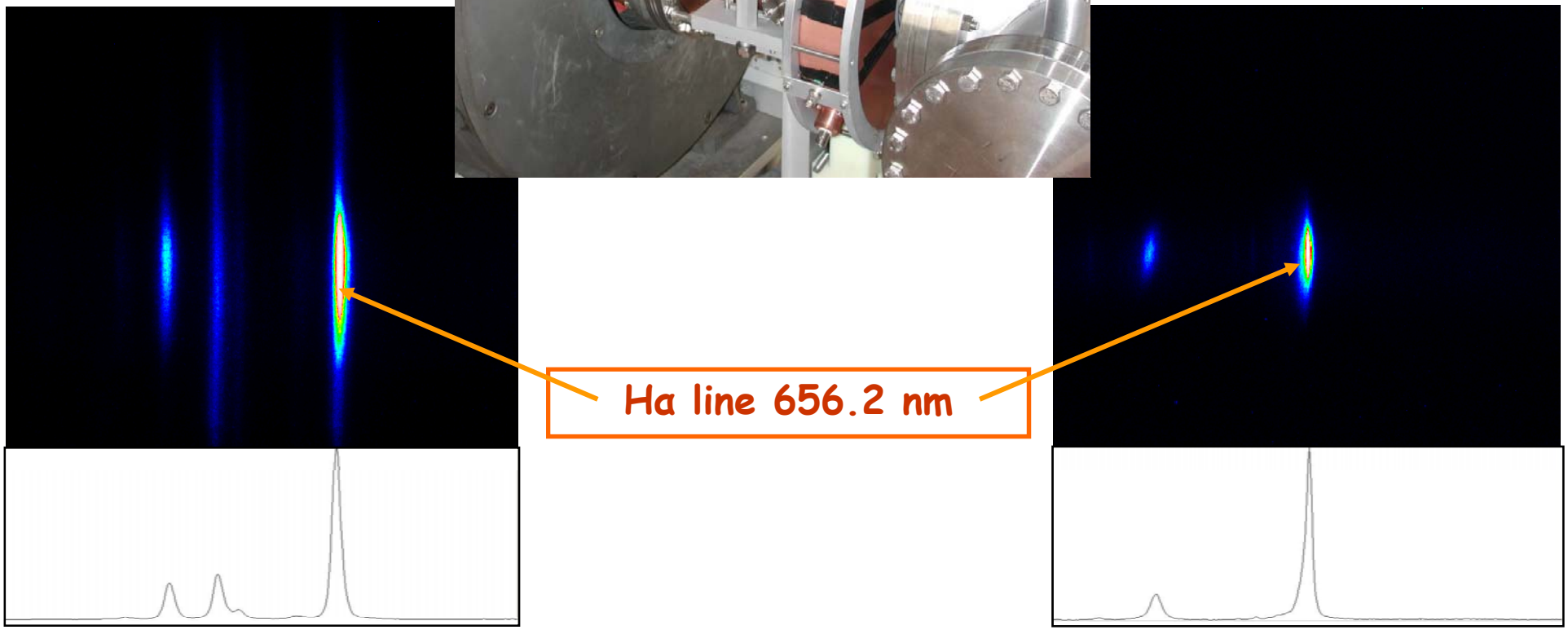
Tuning of the low energy beam transfer line

R.F.Q. entrance

A.C. Beam current transformer

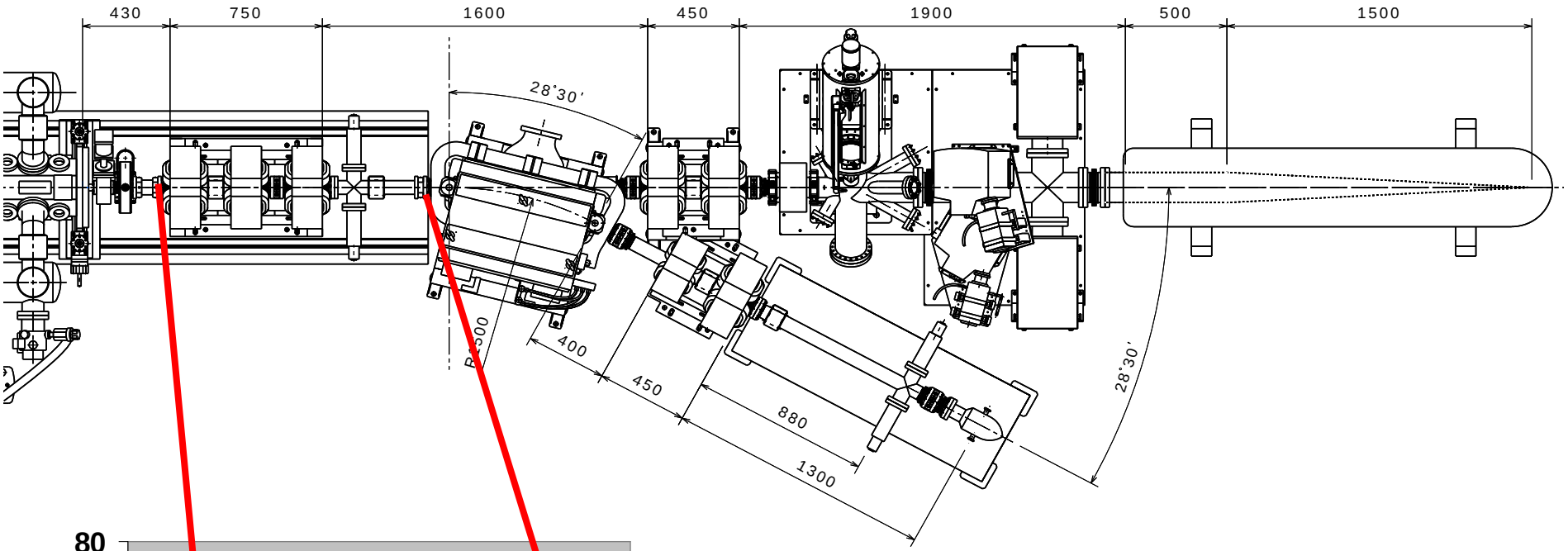
Solenoid

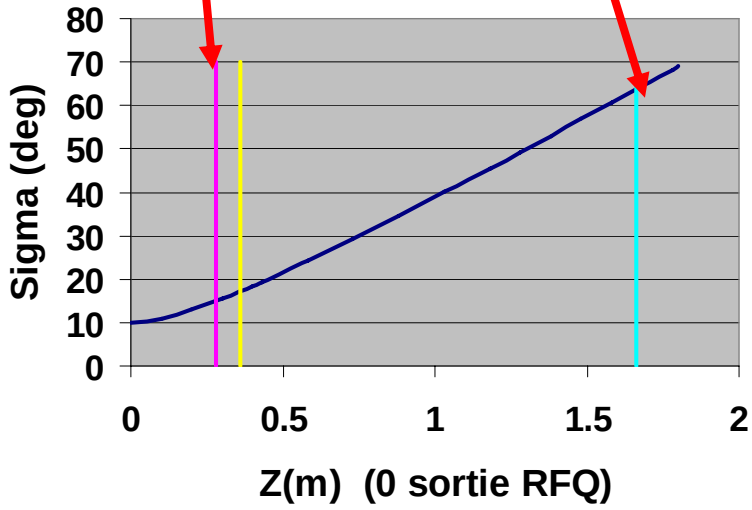




Beam tuning at the entrance of the RFQ by mean of residual gas fluorescence analysis

Beam Diagnostics Line: Beam Energy measurement



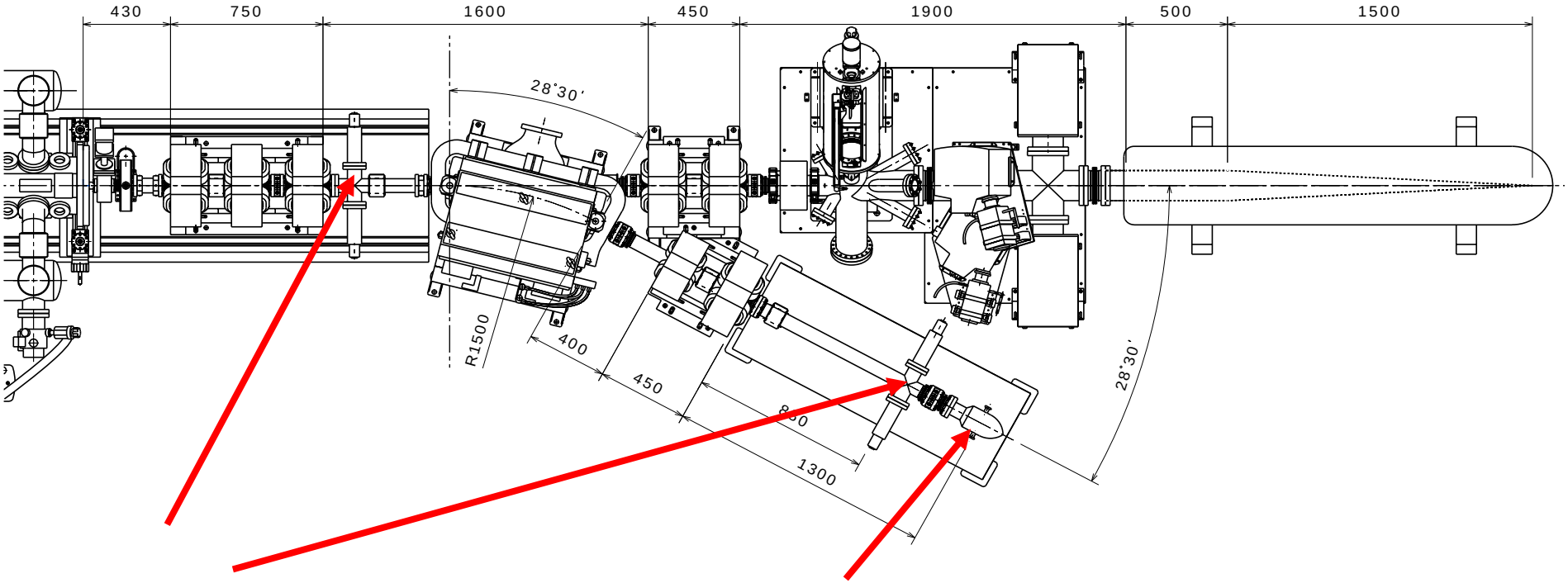


- Time of flight between P.U. electrodes: 1.4 m

$\Delta E/E = 10^{-3}$: $\Delta\Phi = \pm 1°$; $\Delta L = \pm 0.3$mm

- Intensity range : ~1 mA – 100 mA

Beam Diagnostics Line: Energy spread measurement



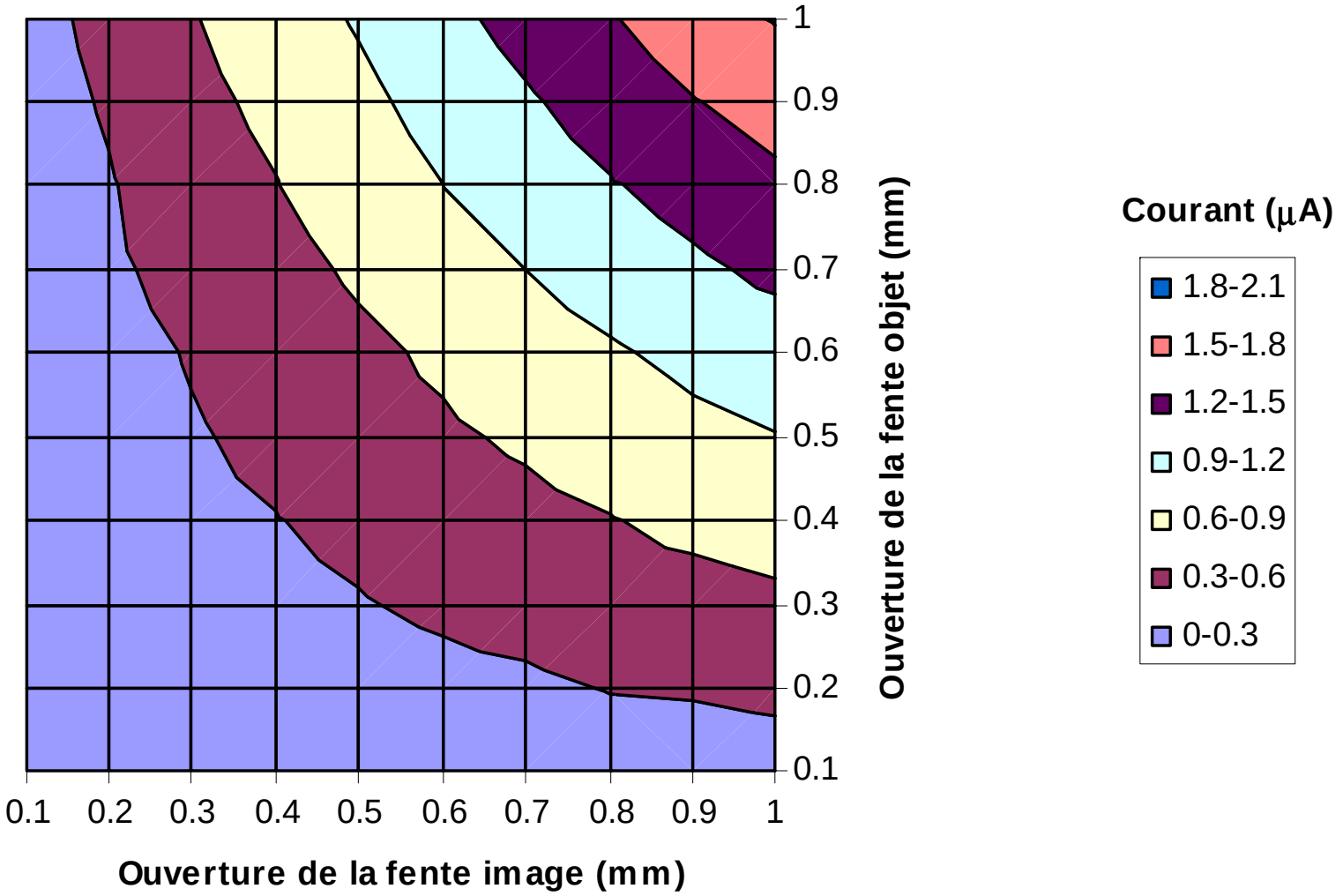
2 slits (first slit watercooled)

Faraday Cup

- Mechanics collected from «L.N.S.»
- Intensity to be measured: 0- 0.5 µA
- Sensitivity:1V / 200 µA, 20 µA, 2 µA
- Bandwidth: D.C.- 25 kHz

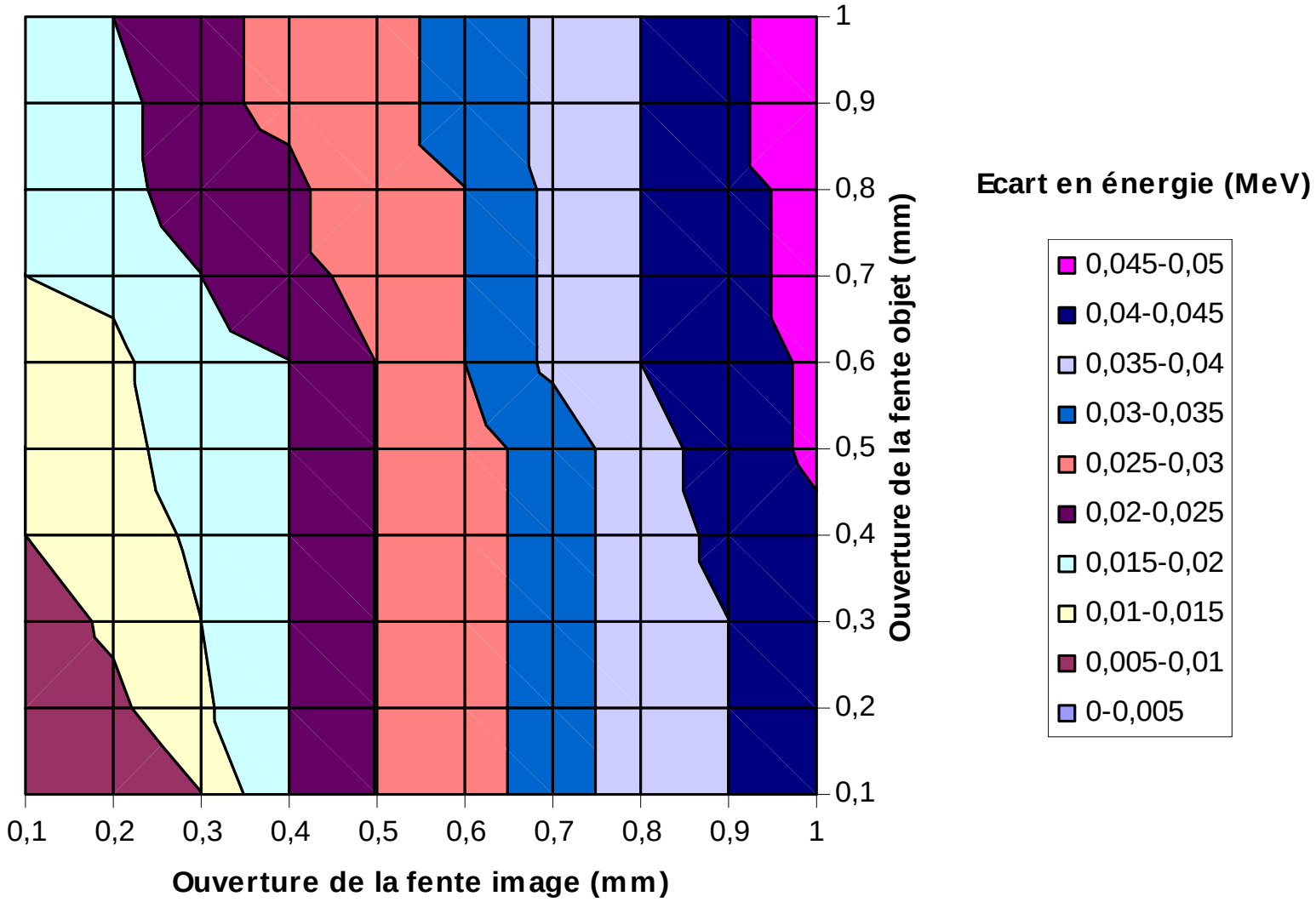
Resolution: depends on aperture of the slits and intensity of the beamlet: ± 10 keV foreseen.

Beam Diagnostics Line: Energy spread measurement



Intensity of the current measured by the Faraday Cup

Beam Diagnostics Line: Energy spread measurement



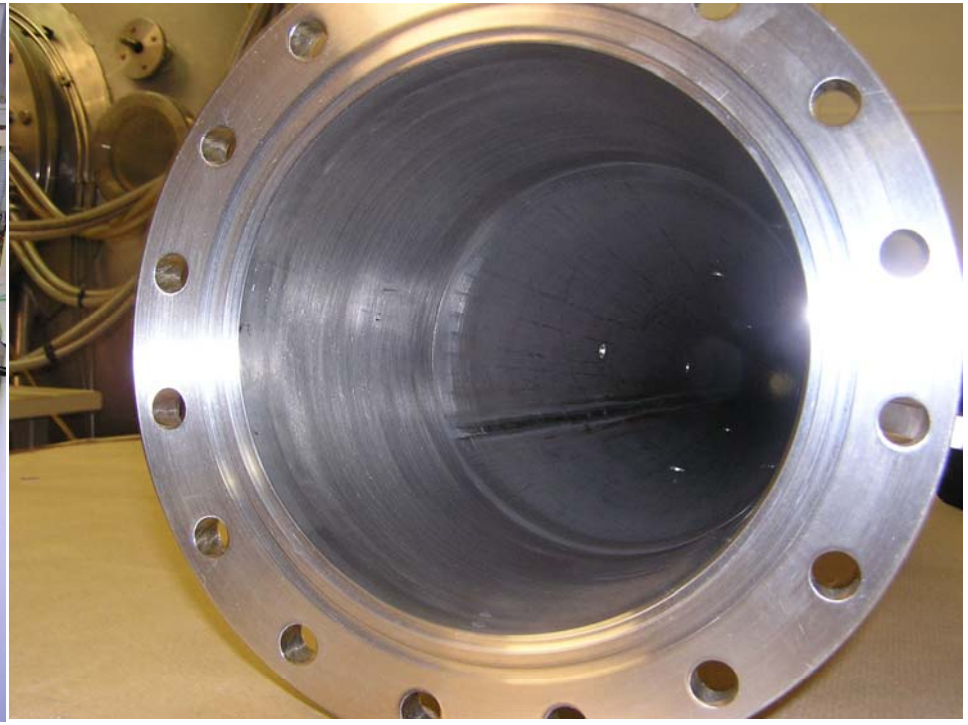
Evolution of the measurable energy spread as a function of aperture of the slits

Beam Diagnostics Line: Beam Stopper

Mechanical design : Nickel 201 cone Length = 1,6m. (thickness 3 mm) .

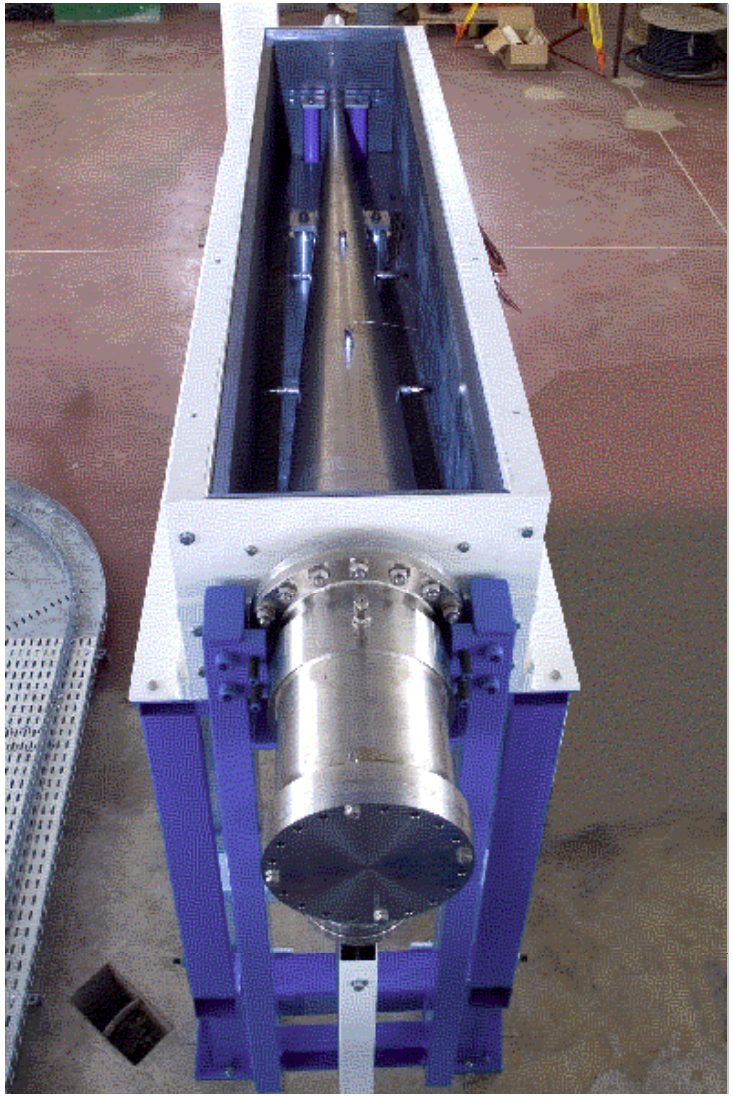
•Beam energy deposition 120 W/cm^2 , T_{max} nickel : 150 ° C

- Pressurized water cooled refrigeration system : 5 bar, débit 300 l/mn, ΔT= 15 °C.



Beam Diagnostics Line: Beam Stopper

Beam stopper cooling system



Beam stopper

IPHI beam Diagnostics Line