



LINAC4 emittance measurements

BI Day

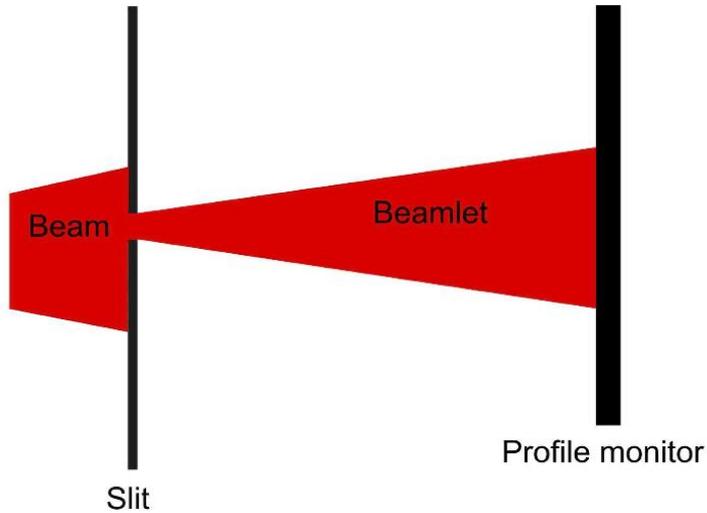
Divonne, 24th November



Outline

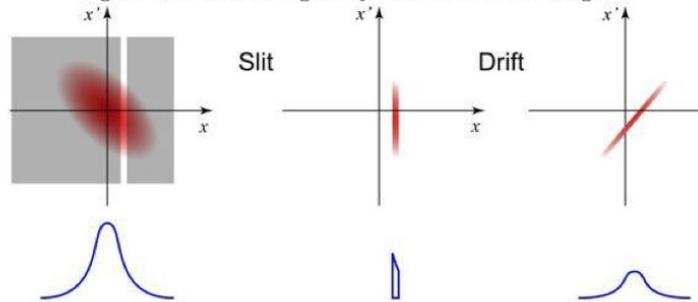
- Introduction
- LINAC4 emittance measurement
- Source and LEBT commissioning
- Slit design for 3 and 12 MeV commissioning phase
- Summary and outlook

Slit & Grid system



- Scanning slit position
- For each slit position
 - profile monitor gives beamlet divergence

Figure 5.1: Slit and grid system schematic diagram



- Transverse phase space reconstruction

Emittance measurement in LINAC4

- Slit and grid will be used during commissioning phase
 - In the low energy section (45 keV)
 - At 3 (RFQ and Chopper line) and 12 MeV (1st DTL Tank)



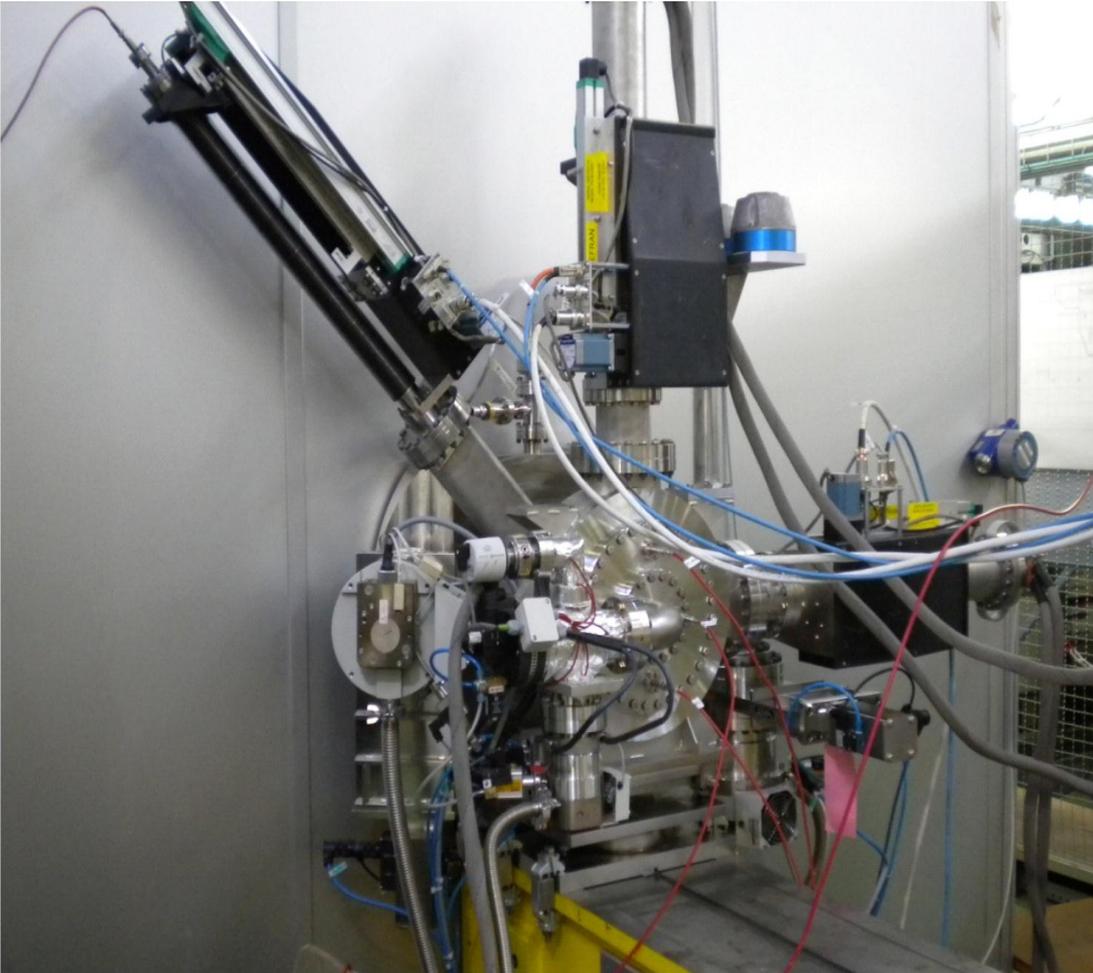
- Determination of source beam emittance
- Determination of matching parameters
- Study of the accelerator optics

- Issue of the system:
 - @ 45 KeV
 - Large beam sizes and divergence
 - Space charge forces
 - Background from beam dump
 - @ 3 and 12 MeV
 - Thermal load on the slit



Low energy emittance meter

Emittance-Meter: background reduction



P2 RING

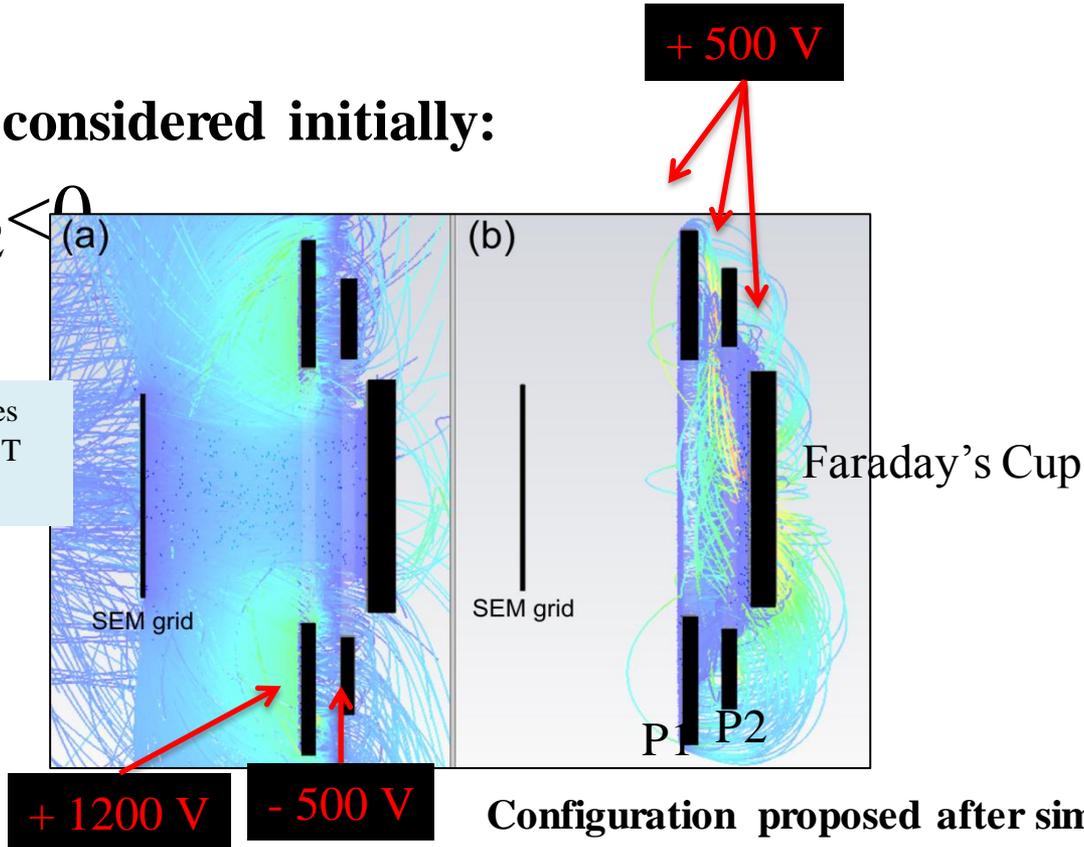
- Emittance measurement can be perturbed by SE from beam dump positioned downstream the emittance meter
- Rings can be polarized to reduce number of particles travelling backward
- Dump can be used as a Faraday cup

Emittance-Meter: background reduction simulations

Configuration considered initially:

$$V_{P1} > 0, V_{P2} < 0$$

Electrons trajectories as simulated by CST Microwave Studio

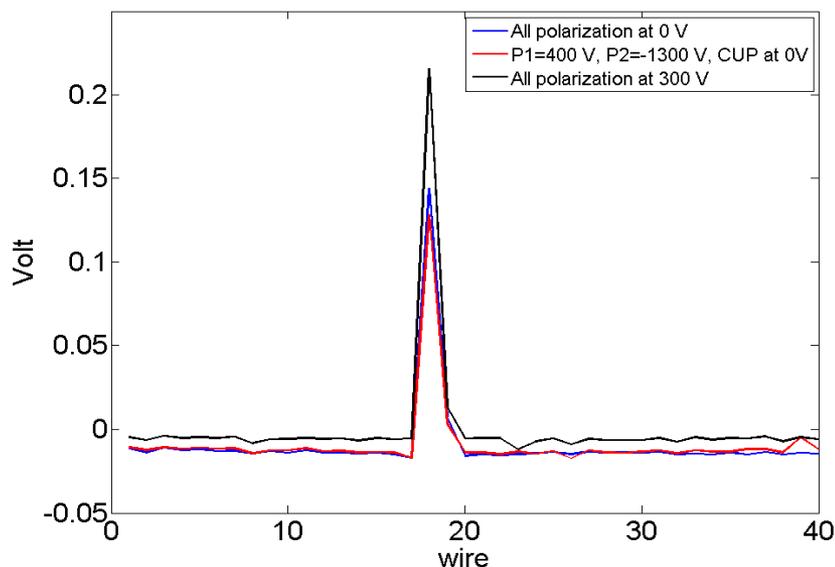


Configuration proposed after simulations:

$$V_{P1}, V_{P2}, V_{CUP} > 0$$

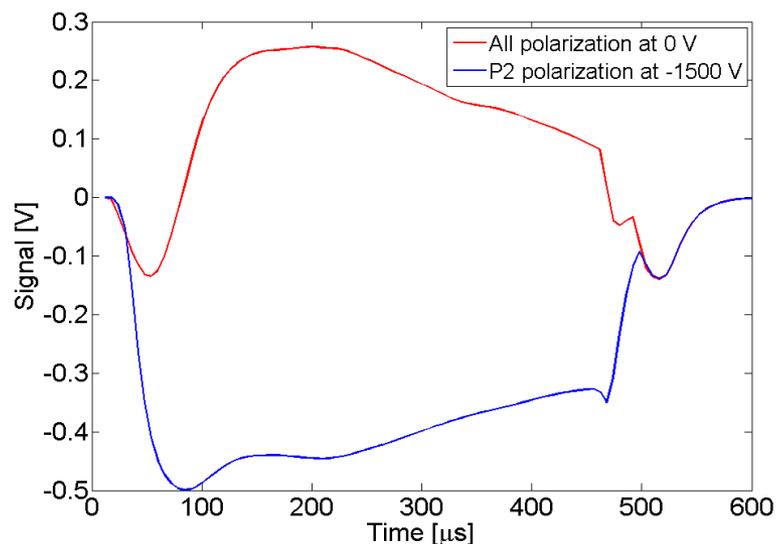
- minimizes perturbation due to FC and P1 electrons
- biasing the FC forbids charge measurements at the same time as emittance measurements

During Emittance Measurement
 -all biases > 0 clearly optimizes the wire signal



During Beam charge measurement at the Faraday's Cup (H^- 35 keV)

-Need $V_{P2} < 0$ to retain secondary electrons that would escape the CUP



All well in agreement with MWS simulations



Source and LEBT commissioning

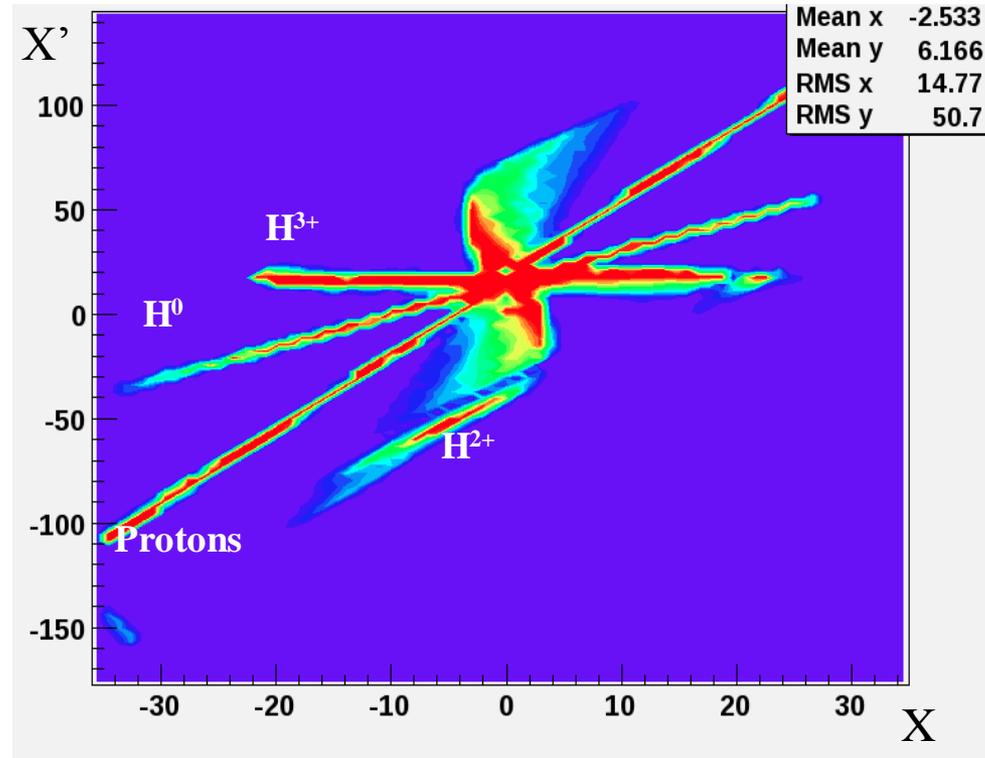
L4 LEBT Commissioning Stages



- Stage 4 completed
- Now: will re-check stage 1 while re-arranging LEBT to host RFQ (beginning of 2012)

Emittance-Meter Measurement Example (I)

Emittance-meter measurement after 1st solenoid



80% of protons

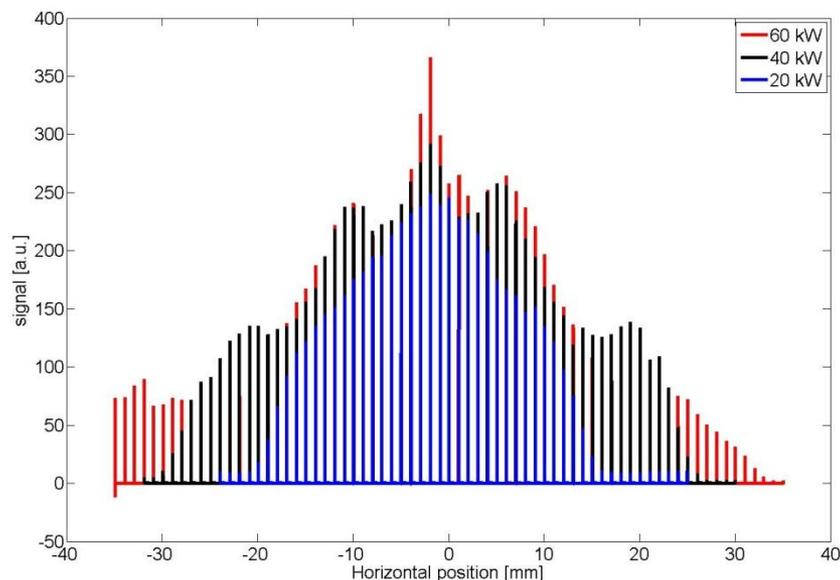
45 keV Proton source: different charge states produced by the source are focused differently as they pass through the solenoid

Emittance-Meter Measurement Example (II)

Transverse distribution vs Source RF power

Profiles extracted from Emittance Measurements

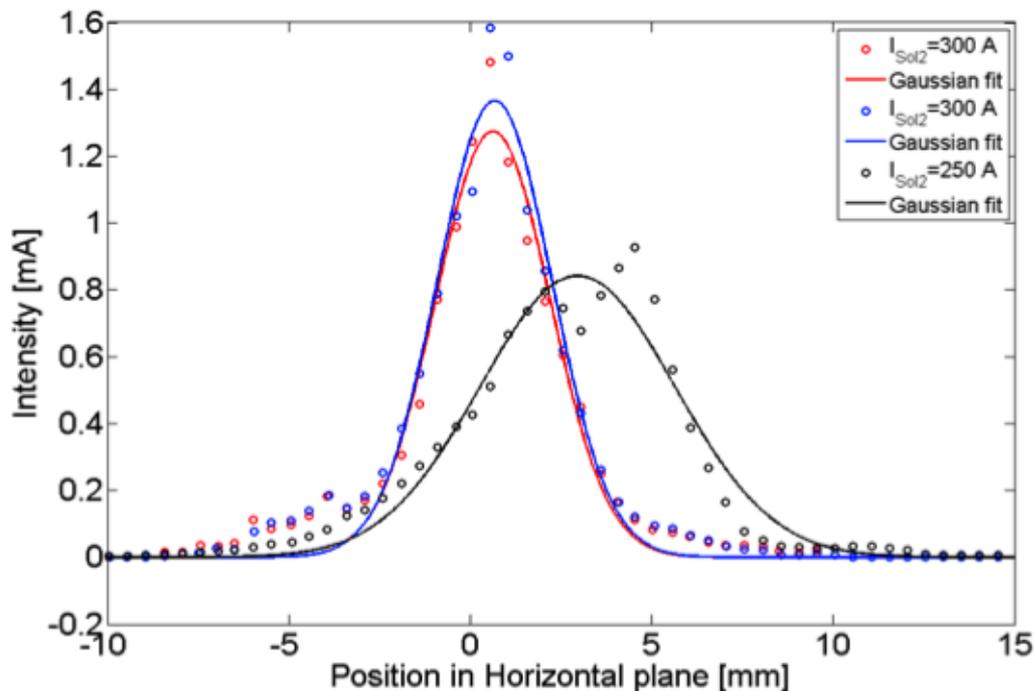
(phase space projection on HOR axis)



Horizontal plane			
RF Power (kW)	$\epsilon_{rms}[\pi.mm.mrad]$	α	$\beta[mm/\pi.mrad]$
20	0.07	-54.97	9.47
40	0.19	-44.77	7.96
60	0.29	-45.73	8.25
Vertical plane			
RF Power (kW)	$\epsilon_{rms}[\pi.mm.mrad]$	α	$\beta[mm/\pi.mrad]$
20	0.06	-65.09	10.9
40	0.19	-44.77	7.96
60	0.29	-45.73	8.25

Profile measurements with emittance meter

Profile Measurement performed after the second solenoid by measuring the FC current while scanning the slit position



This particular measurement proved

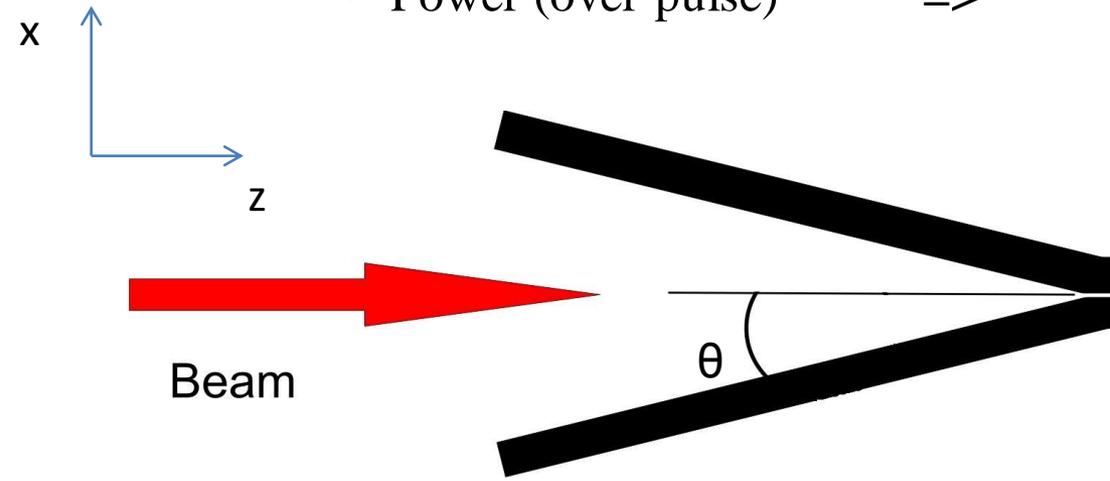
- Source reproducibility (red and blue measurements taken in different days)
- beam-solenoid misalignment (beam centroid depends on Solenoid current)



Slit design for 3 and 12 MeV commissioning phase

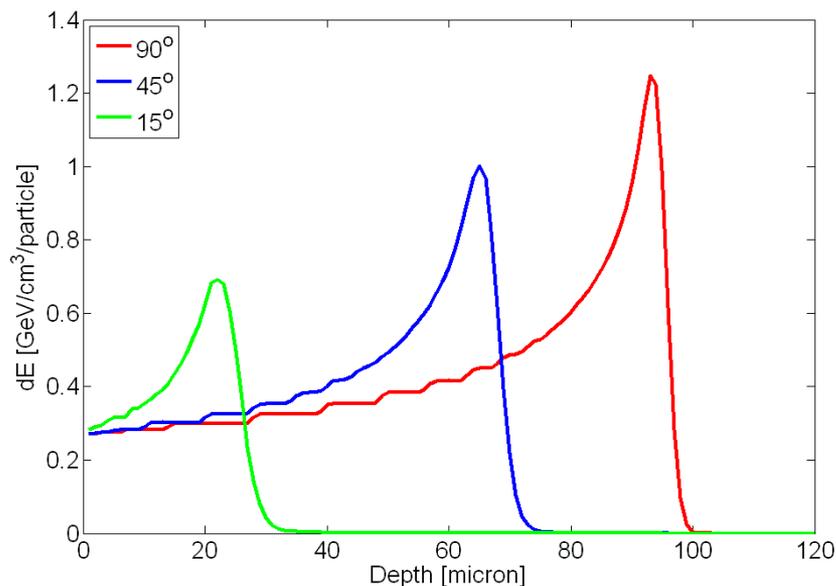
Thermal load at 3 and 12 MeV

- Commissioning will be done with a 65 mA and 100 μ s beam (4×10^{13} particles per pulse)
- @ 3MeV:
 - Power (over pulse) \Rightarrow **0.31 MW.cm⁻²**
- @ 12 MeV:
 - Power (over pulse) \Rightarrow **7.56 MW.cm⁻²**



- The blade is tilted to spread the energy deposition on a larger surface.
- Graphite has been chosen for thermal properties

Slit geometry



	SRIM		FLUKA	
Angle [deg]	90	90	45	15
MEBT	2673 K	2613 K	2065 K	1696 K
DTL	4669 K	4594 K	3931 K	2790 K

Maximum in temperature for the three commissioning stages, as estimated by analytical model (SRIM) and numerical simulations (FLUKA) when considering a 65 mA, 100 μs pulse.

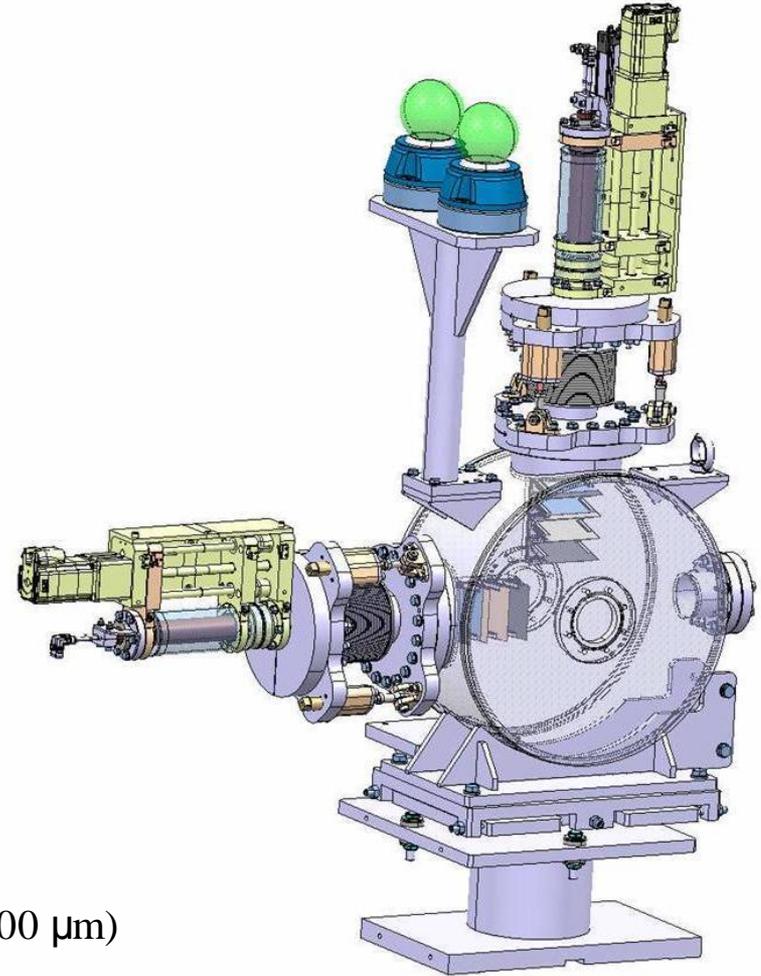
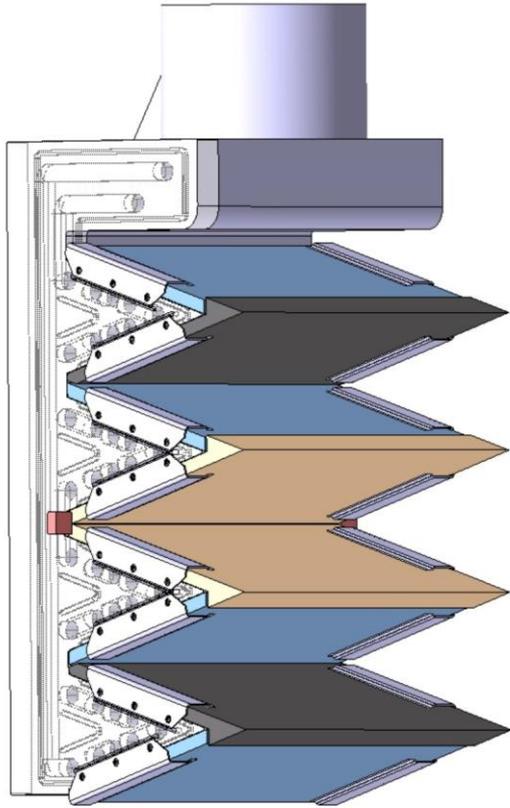
Energy deposition along the z axis for three slit angles at 3 MeV(MEBT), in case of a Graphite slit.

Even with 15°, thermal load is too high for DTL case.

Decided to move the slit 1 m downstream beam sizes increase by a factor 1.5

Temperature drops to 1520 K

High energy Slit design



- Graphite plates clamped on a copper block
- Slit aperture adjustable at the assembly (100 or 200 μm)
- Slit thickness equal to 1 mm.



Status



- Mechanical design Completed (done by CERN design office)
- Slit tank is under assembly (followed by D. Gerard)
- Emittance meter will be ready for RFQ commissioning (March-April 2012)

Summary and outlook

- Source and LEBT test stand operated for two years
 - Commissioning stages with 45 keV proton source completed
- Beam parameter and optics has been characterized
 - Faraday's cups to validate transmission
 - Emittance meter to validate matching to nominal optics
 - Spectrometer SEM grid to measure energy spread
- RFQ and Chopper commissioning with proton beam in 2012
- Commissioning of the new H⁻ source and LEBT (with larger aperture)