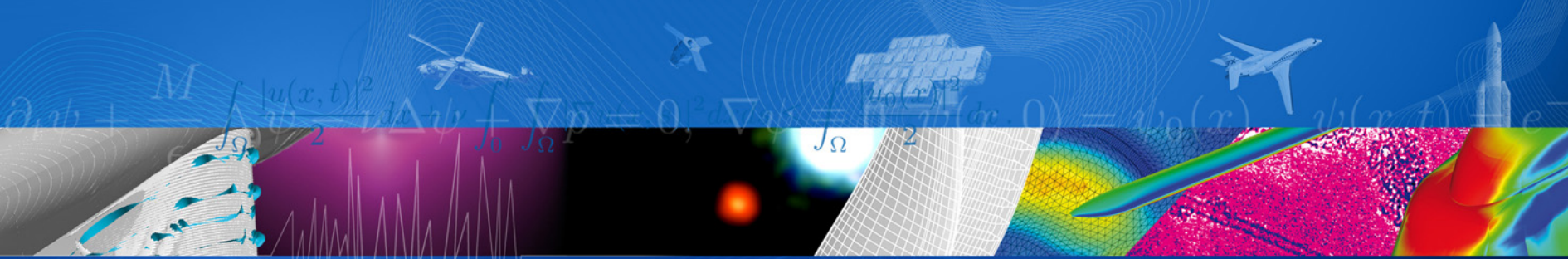

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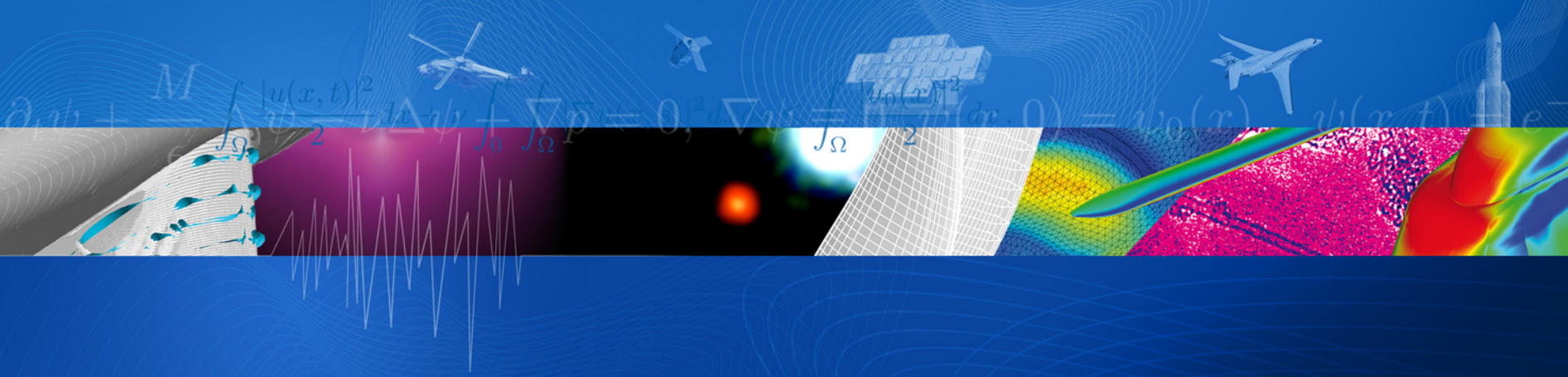

Mirage: a new proton facility for the study of direct ionization in sub-100nm technologies

S. Duzellier, G. Hubert, R. Rey (ONERA)
F. Bezerra (CNES)

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overview

- Accelerator facilities at DESP
- Mirage target chamber
  - ✓ Motivation
  - ✓ Description and capabilities
- Proton beam line
  - ✓ Characteristics
  - ✓ Testing for direct proton ionisation

Accelerator lab. at DESP

Semiramis (mat.)

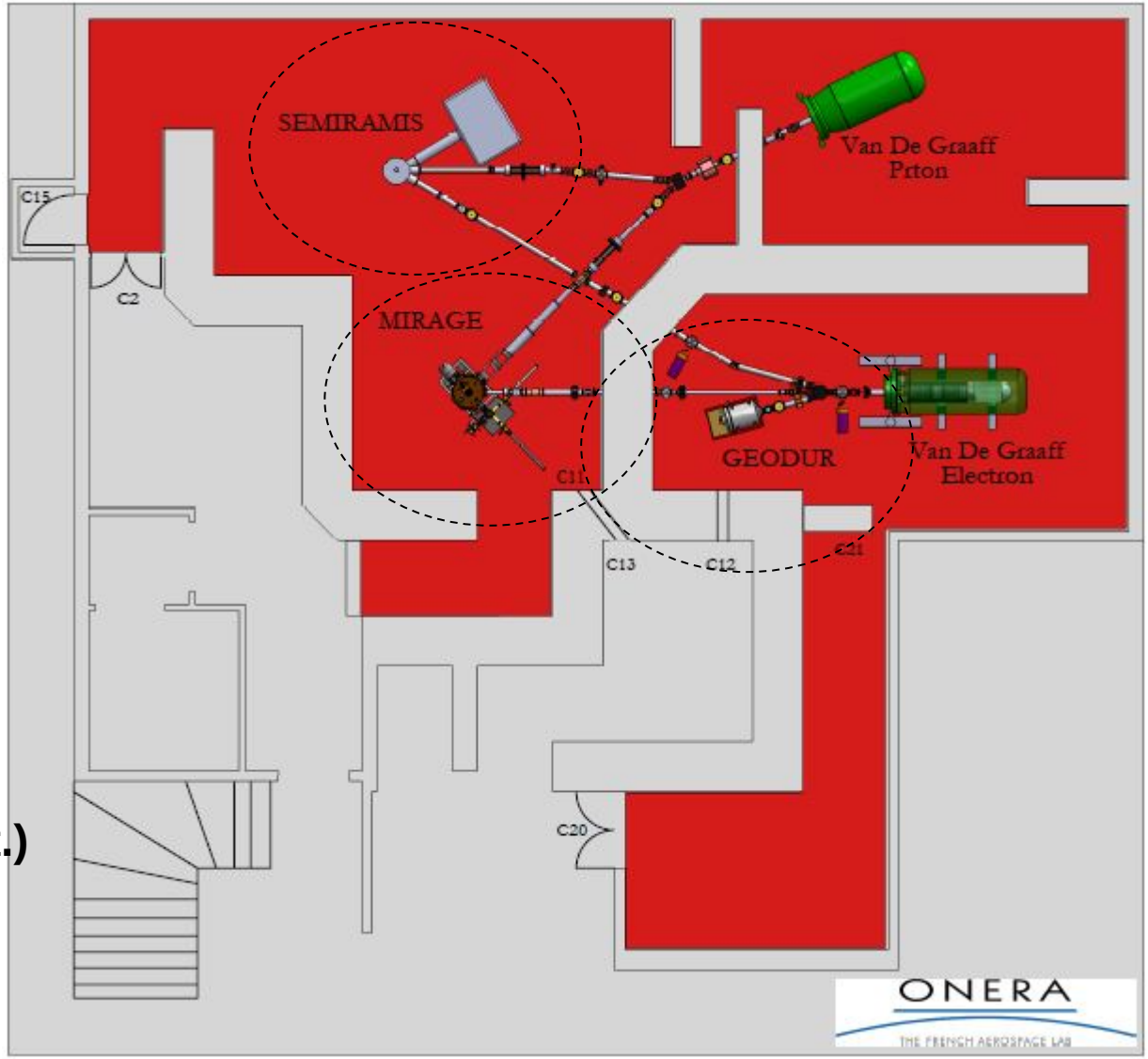
- **GEO dose profile (e-, p+, UV)**

Geodur (e-: mat., comp.)

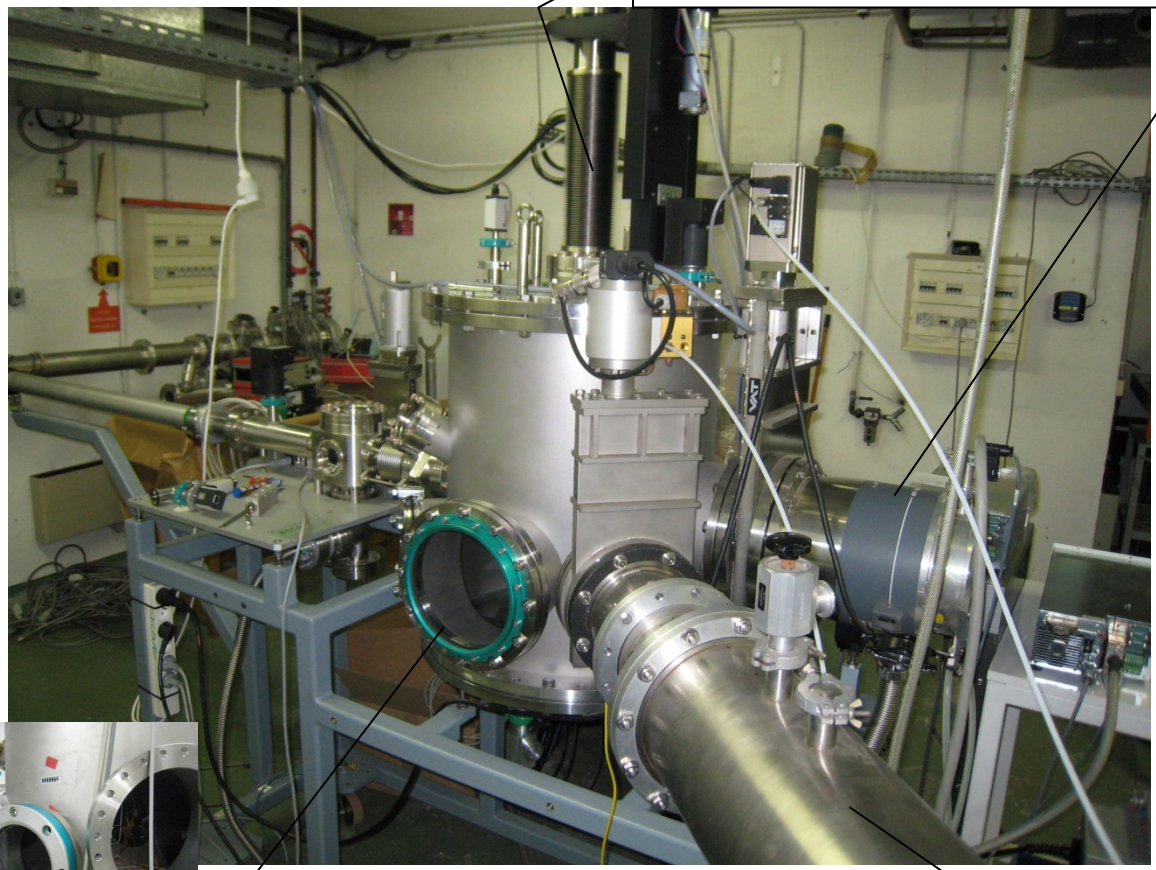
- **Deep charging**
- **Rad. monitor cal.**
- **Solar cells testing**
- **TiD/TniD dose**

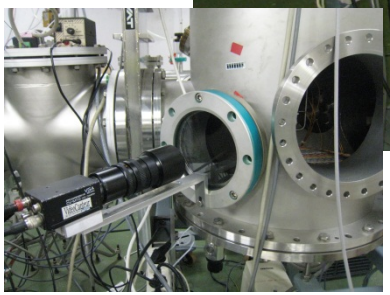
Mirage (e-, p+: comp., mat.)

- **TiD/TniD dose**
- **SEE proton ionization**

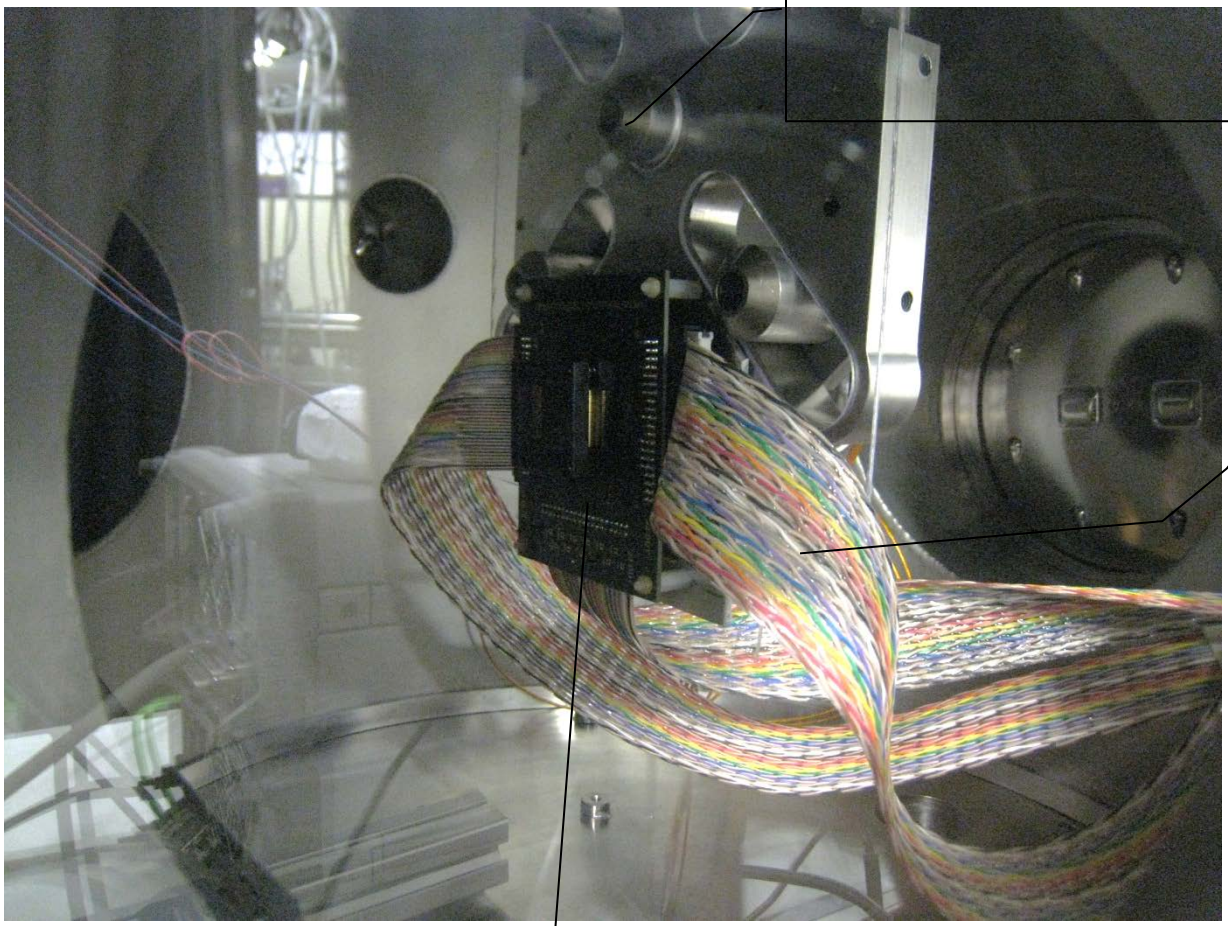


Mirage target chamber





Mirage target chamber



Sample plate fitted with faraday cups
& temperature
(-150° /+250°)

Cables ->
feedthrough

Test board *(Trad)*

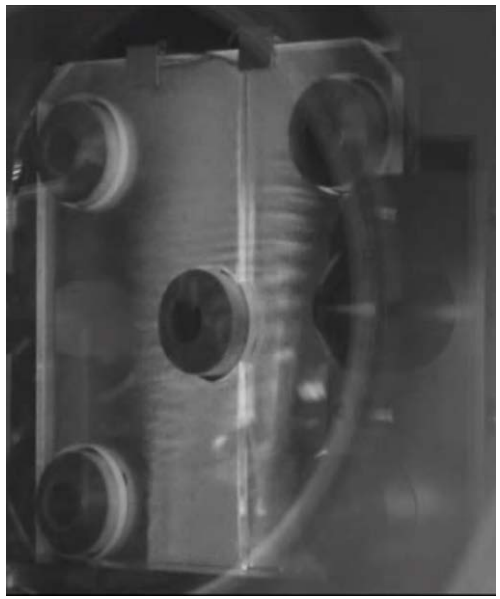
Proton beam monitoring

Beam generation

- extracted from plasma created with H_2 gas and RF source
- mixture of H+, H_2^+ and H_3^+ ions which are accelerated at first by a focus stage then injected into the acceleration tube
- a bending magnet acting as a mass spectrometer and selecting H^+ with the correct current setting (MIRAGE beam line at 25°)
- beam energy defined and adjusted by the acceleration voltage and bending magnet current with great accuracy (~1%)

Beam monitoring at target level

- XY sweeping on target →
- adjustment with scintillators
- dosimetry with 5 faraday cups



Proton beam line

Automatic Command & Control

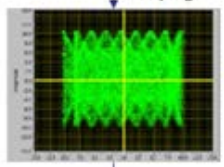
•Accelerator

(injector, acceleration, vacuum, temperature…)

•beam line

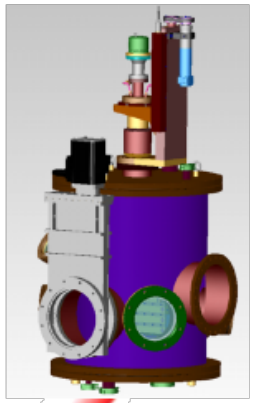
(collimators, sweeper & bending magnets, steerers, shutters, faraday cups, imaging devices)

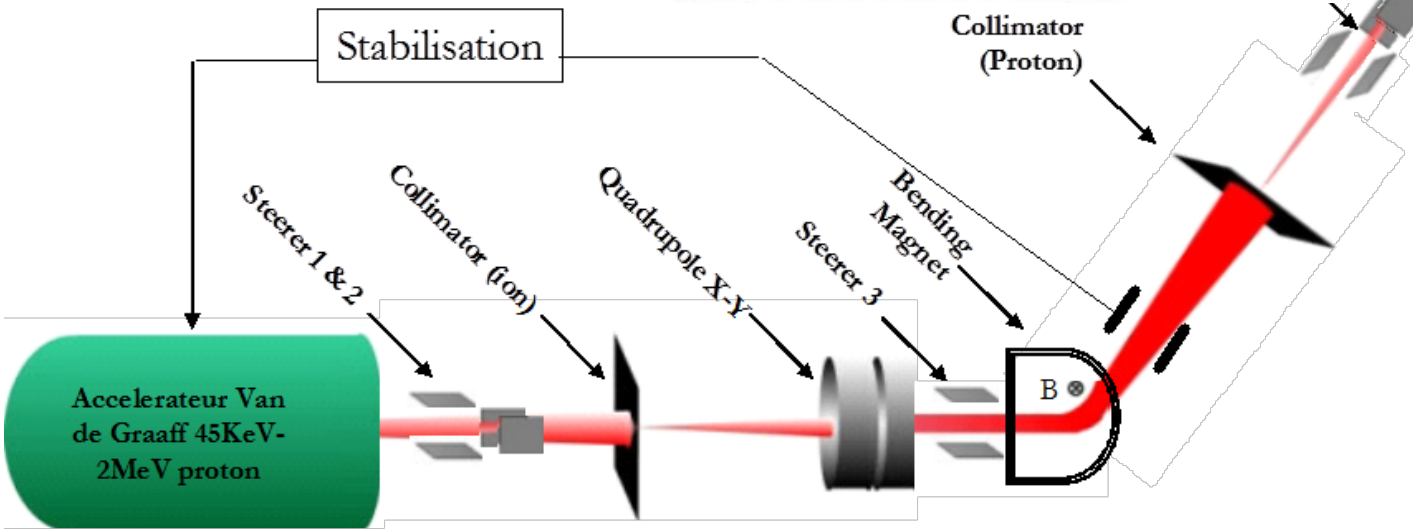
Beam monitoring



Faraday cups
Measured currents

MIRAGE





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Beams characteristics

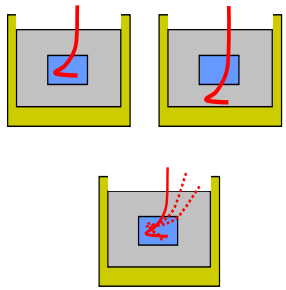
Standard

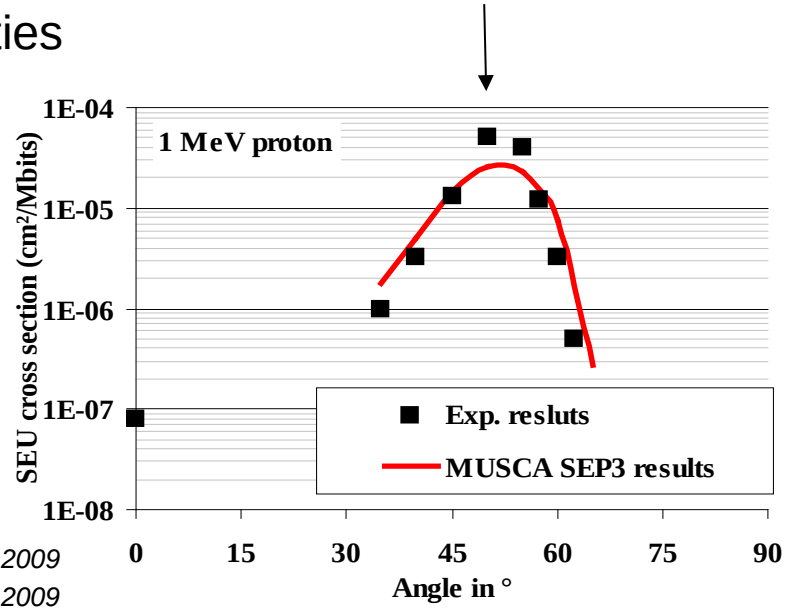
- Electron (scattered) or proton (swept) beams
- Energy : 2MeV max (electrons 1.3MeV for radioprotection purpose)
- Beam current / Flux : 1-80nA on target (6 10^9 – 5 10^{11} part./cm².s)
- Homogeneity 20% on 120x120 mm²

Specific needs for SEE thematic (direct p+ ionization)

- mono-energetic beam (good definition of dose profile),
- energy : range > upper-layers, allows for tilting (probing capabilities),
- lower flux: adapted to techno. sensitivities

improvement of SER operational calculation (occurrence models)





Experiments: Heidel et al., NSREC 2009
Modeling: Hubert et al., RADECS 2009

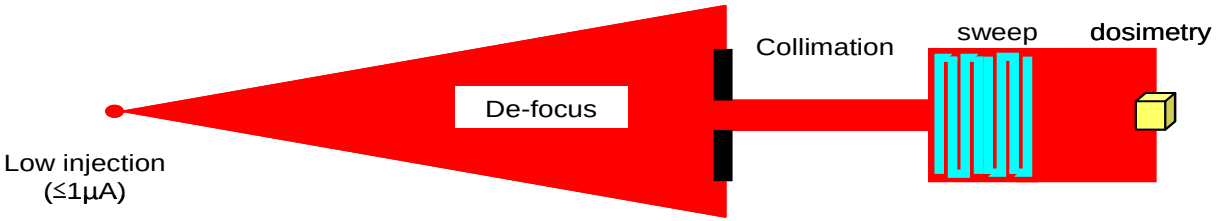
Beams characteristics

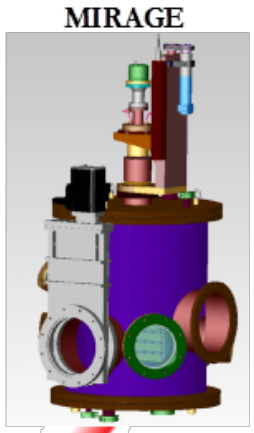
Main requirements

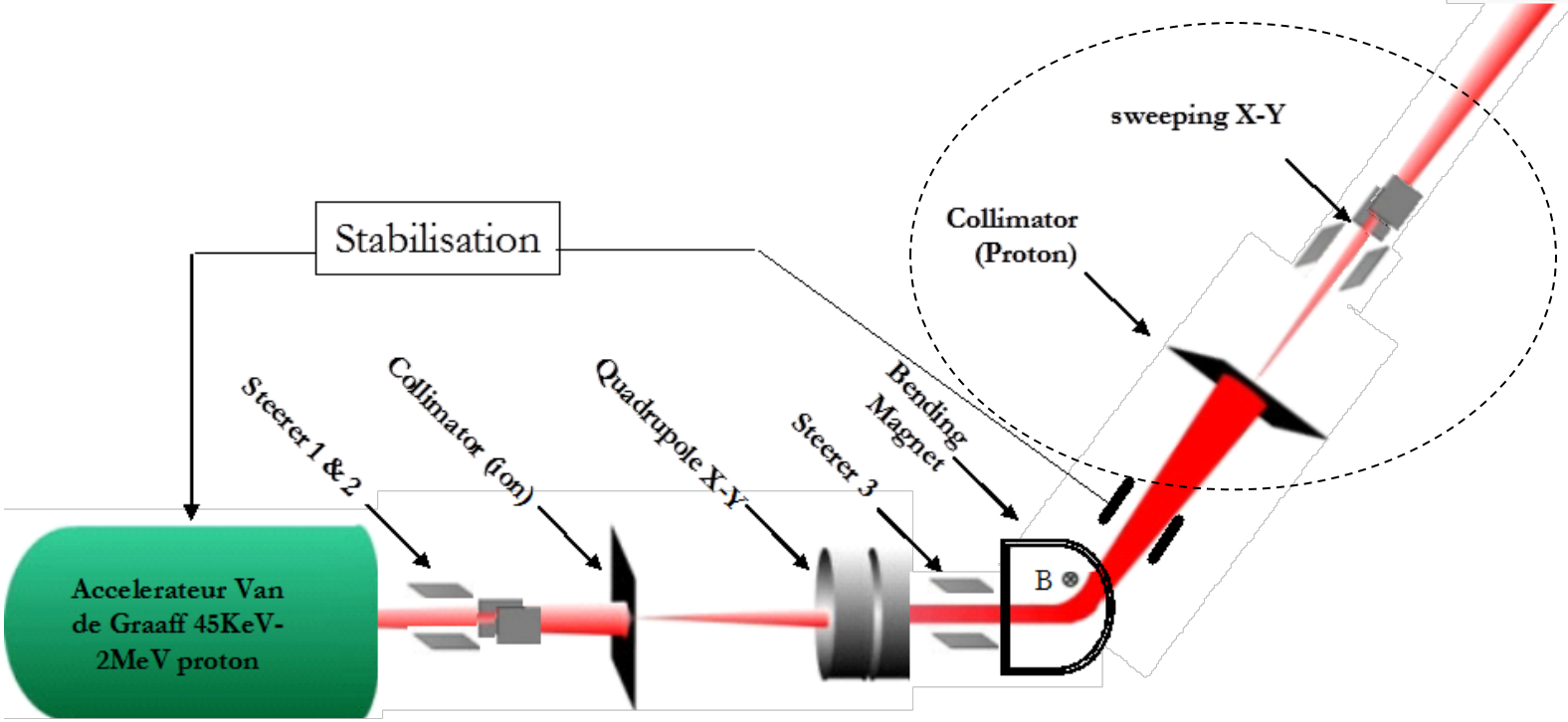
Parameter	*Criteria*	*Comment*
Energy	Mono-energetic adjustable up to E_{max}	range ≤ 10-47µm
Flux	Adjustable (few 10^6-10^9 #/cm².s)	Depends on device response
Fluence	10^8-10^{10} #/cm²	10%
Homogeneity	10% on die area	
Beam spot	>> die area	Adjustable
Tilt	0° -> 60°	limited by min. range
Feed-through	Standard connectors	BNC, Jaeger, SMA, HE10-40 …

Proton beam line

Adaptation of flux







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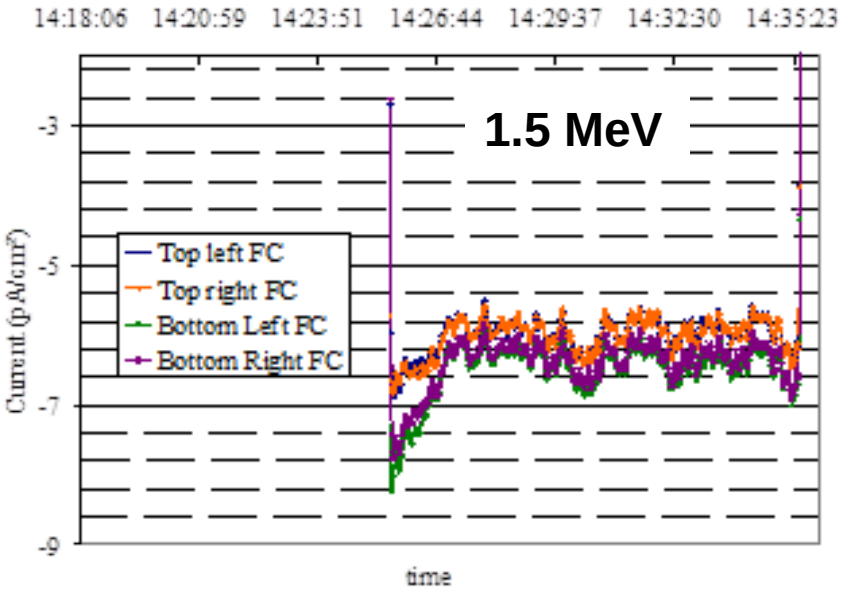
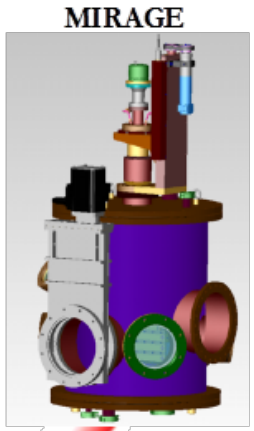
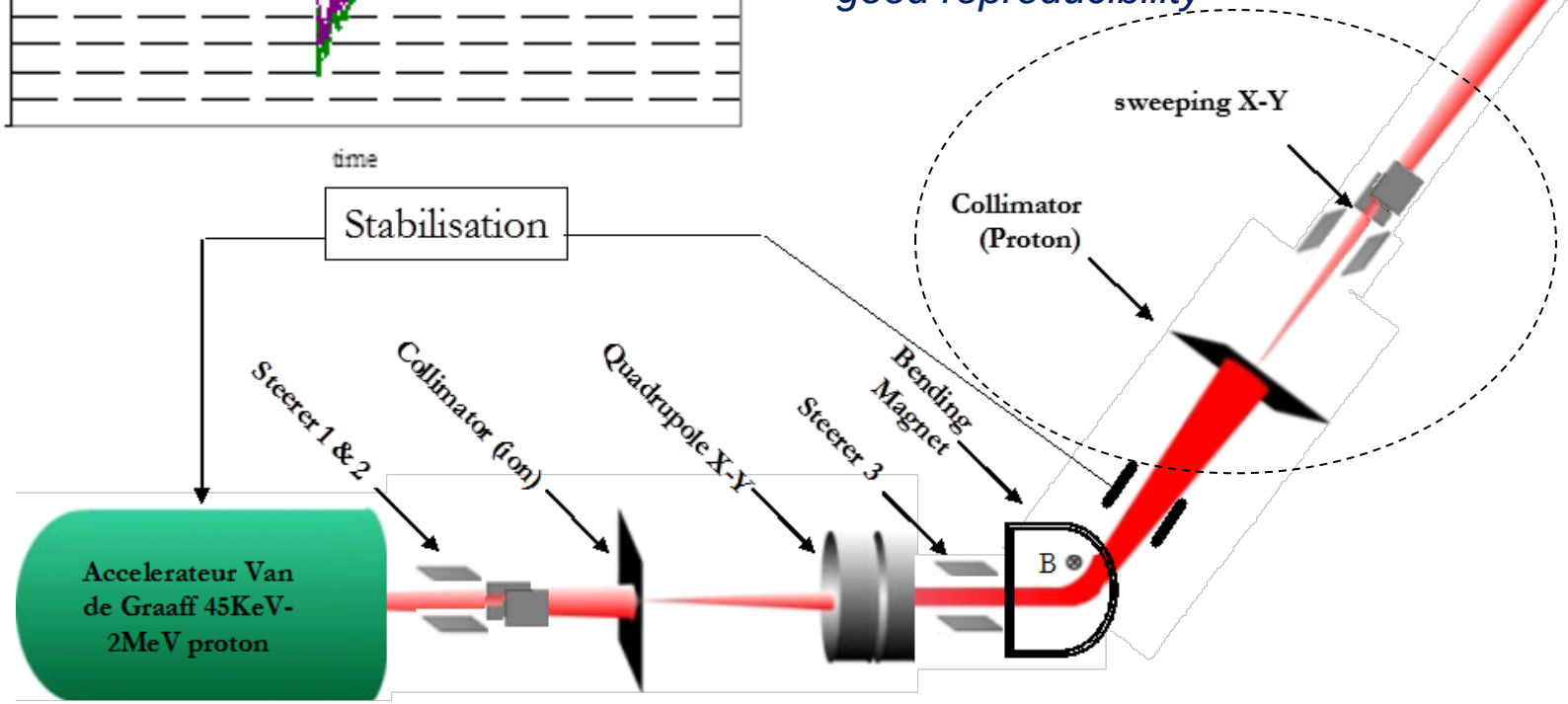
Proton beam line



60nA injection, 1mm collimation, beam current adjusted to 6pA ($3{,}7\ 10^7$ #/cm².s)

- ✓ *Good homogeneity over 6.5cm x 6.5cm*
- ✓ *good stability with time*
- ✓ *good reproducibility*





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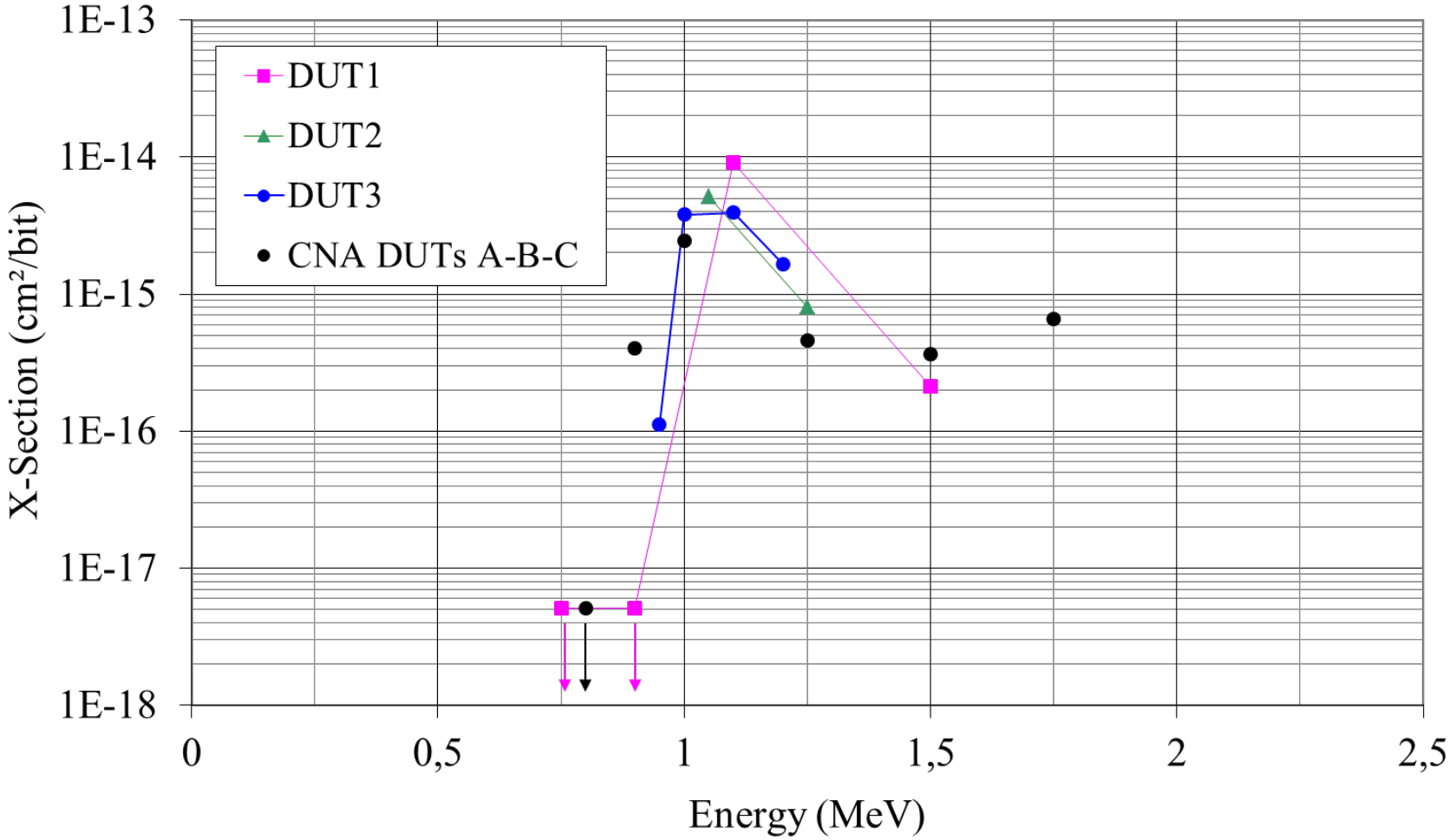
First test campaigns and example of test outputs

Comparison with CNA data *(A. Samaras et al., NSREC 2014)*

Normal incidence beams, 0,75-1,7MeV



Summary & Perspectives

Summary

- SEE testing in the 0.5 to 2MeV range with flux of few 10^6 to 10^9 proton/cm².s,
- 10 to 15% of homogeneity on a large beam spot (6,5cm x 6,5cm),
- good stability of beam current and energy over long period of time,
- good reproducibility of beam parameters,
- rapid adjustment of beams (15-20 minutes to change energy or flux),
- E and tilt ranges allow for complete investigation of device response.

Possible improvements

- new frame and positioning system (x, z, θ),
- calibration in test plan and counting device upstream,
- larger surface for testing (up to full 12x12cm²).

Thank you!