Irradiations at the INFN-LABEC facility in Florence

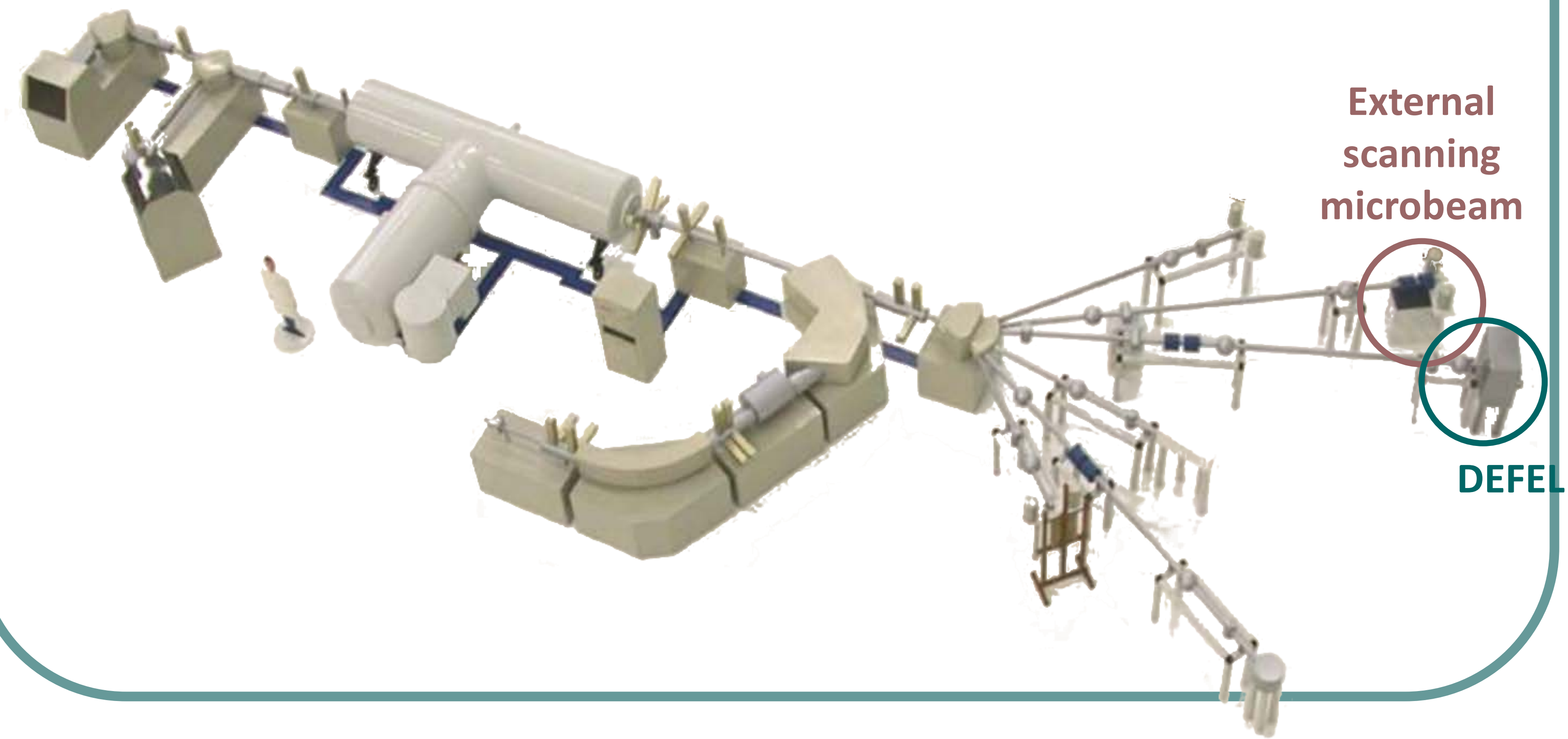
L. Giuntini, F. Taccetti

Dipartimento di Fisica e Astronomia, Università di Firenze
INFN Sezione di Firenze

VI Scuola Nazionale "Rivelatori ed Elettronica per Fisica delle Alte Energie, Astrofisica, Applicazioni Spaziali e Fisica Medica“
RADFAC 2015 thematic day
23-27 Marzo 2015
INFN-LNL

DEFEL

- ELectrostatic DEFlector (DEFlettore ELecttrostatico): the chopped beam line of the Tandem accelerator at INFN-LABEC



Capabilities of the DEFEL beam line

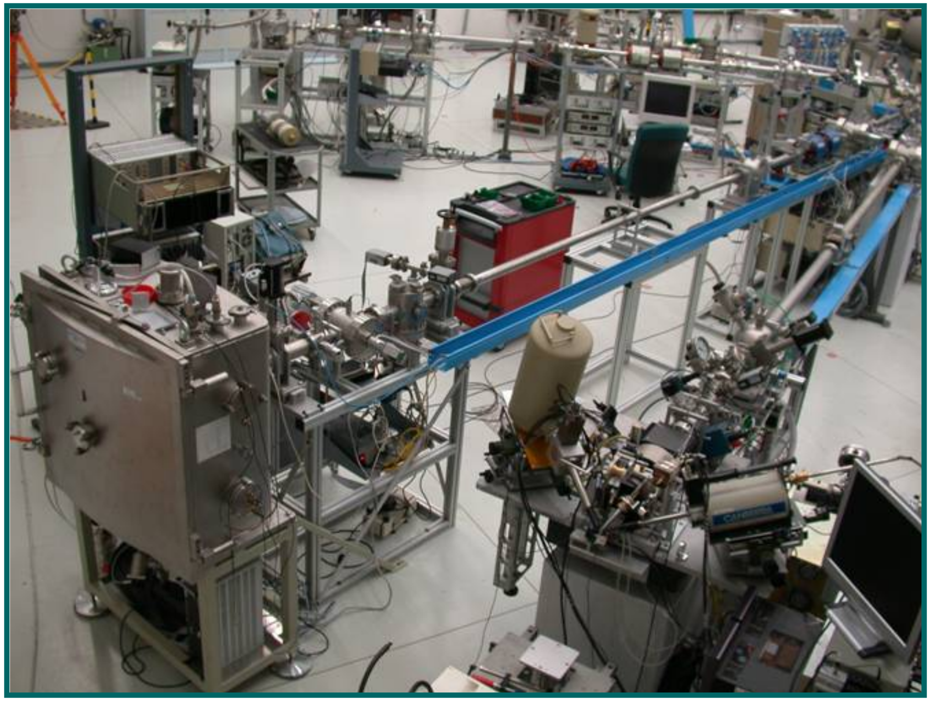
- Pulsed bunches of:
  - *Duoplasmatron*: p (and α)
  - Cs-ion sputtering source: p, Li, C, O, Si, Ti, Fe, I
- Energy:

  1÷6 MeV for protons;

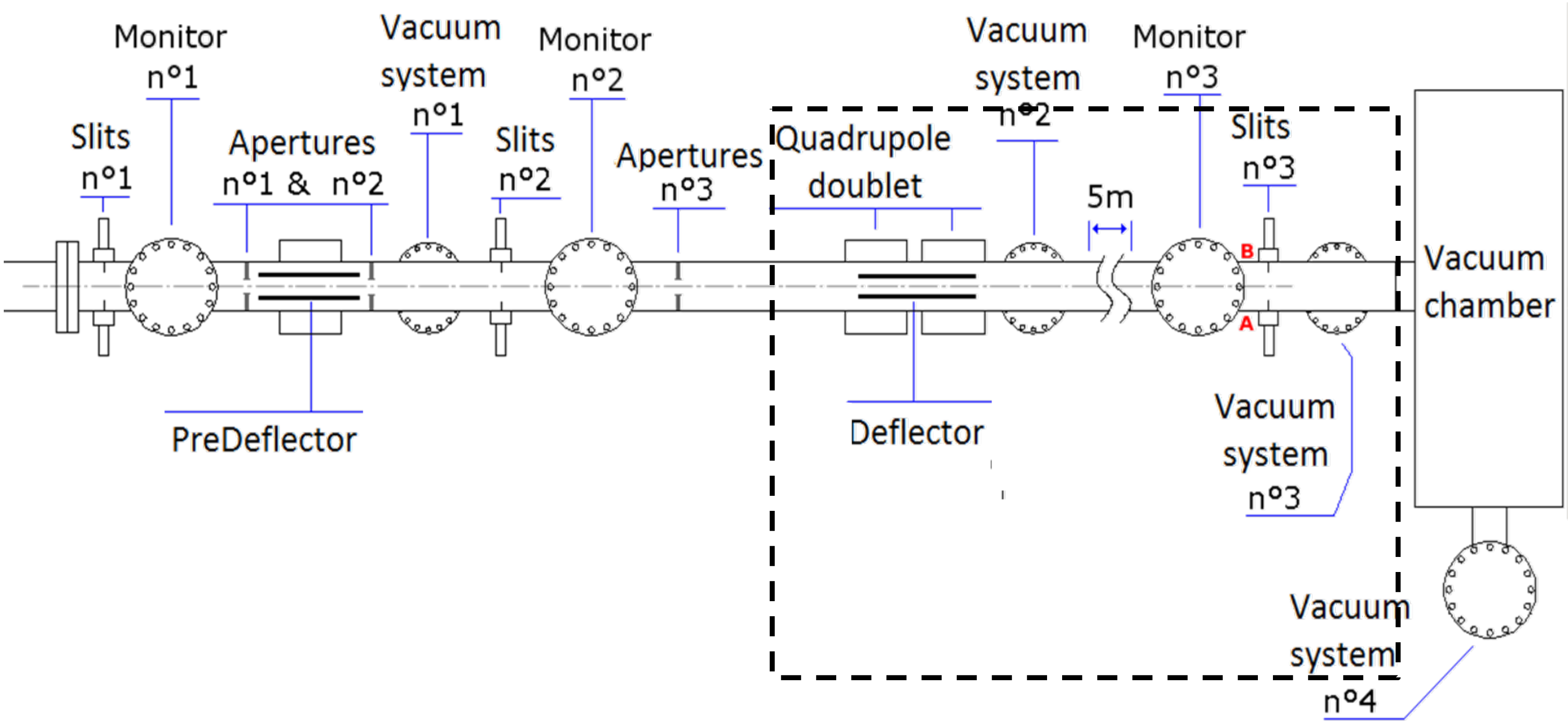
  1÷few tens MeV (heavier ions)
- Bunch frequency:

  up to ~10kHz
- Average ion multiplicity:

  hundreds particles and more

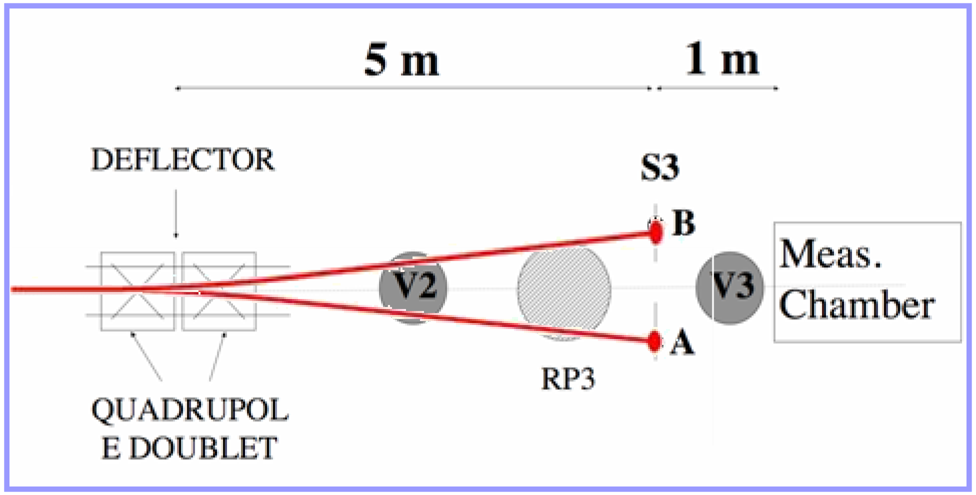


From continuous to pulsed beam

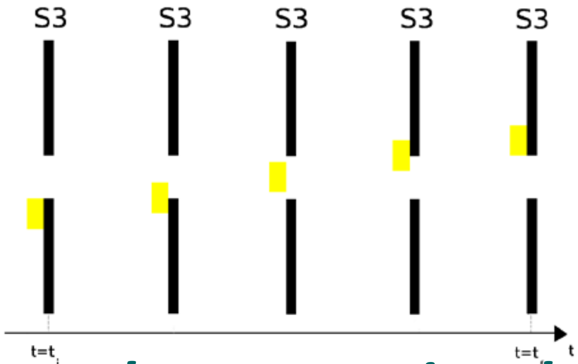


Ions are deflected from the beam line axis for most of the time (PreDeflector)
For time windows of ~ 1µs, ions are allowed to enter the main Deflector

From a continuous to a pulsed beam



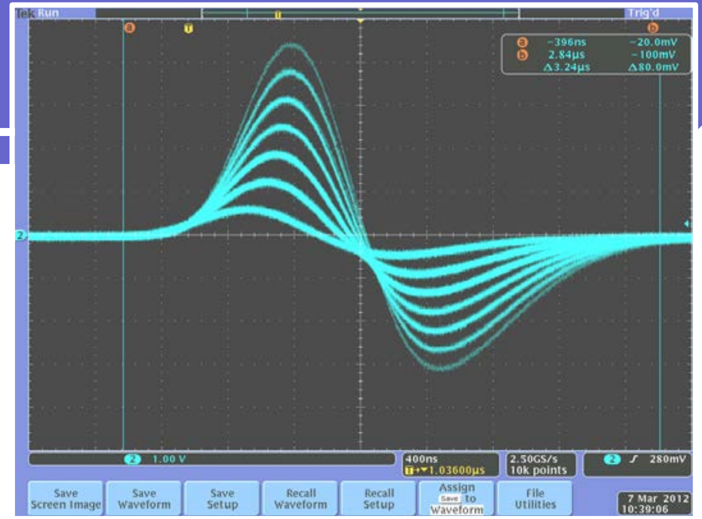
- During the transition of the applied voltage, the beam spot moves transversally from a steady state B to A



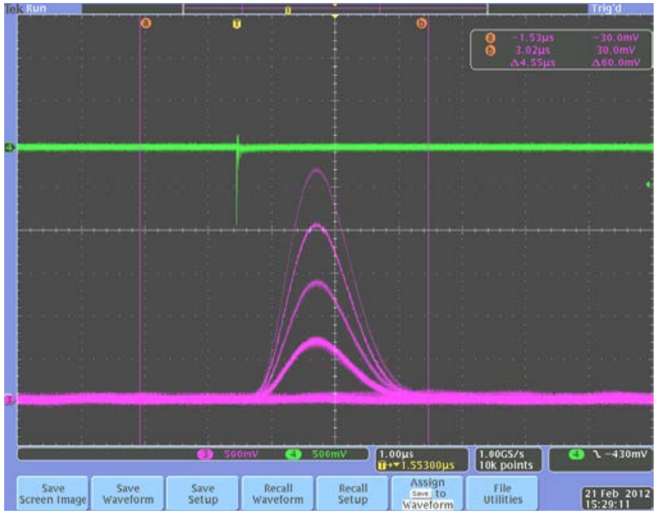
beam pulse transmitted through the final slits!

Few examples - I

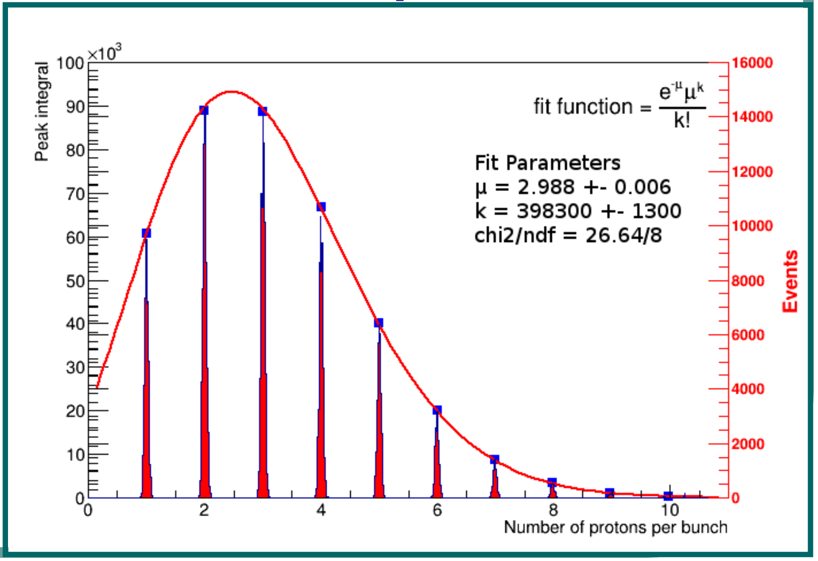
11.235 MeV O^{3+} Ions



10.035 MeV $^{12}C^{3+}$ ions

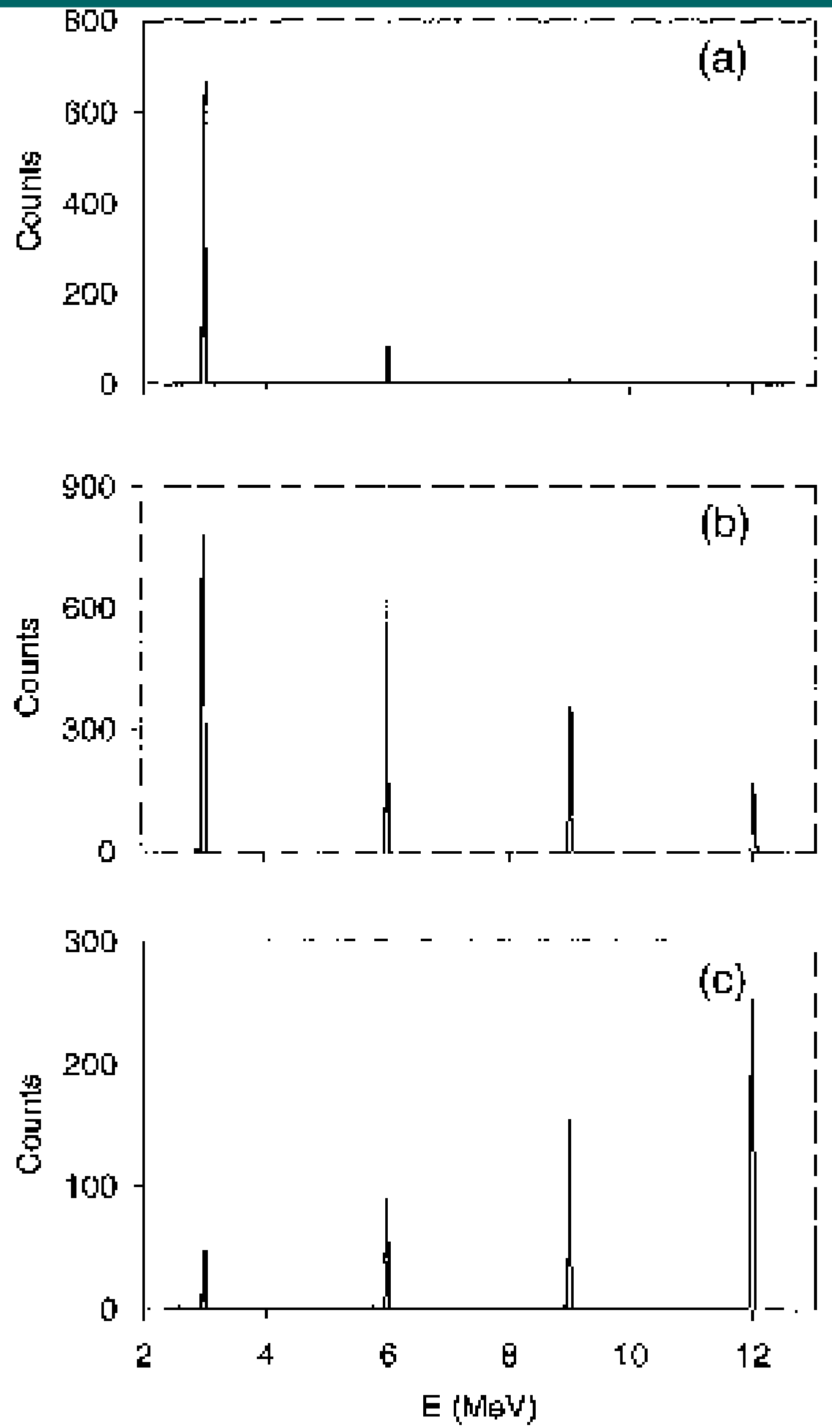


1 MeV protons



Few examples - II

3 MeV Protons beams of different intensities



The role of the final slits S3

Aperture of slits on y axis →

- number of transmitted ions per pulse (it also depends on beam current – once voltage steps, deflector plates length and deflector-to-slits distance are fixed)
- spatial resolution

Aperture of slits on x axis →

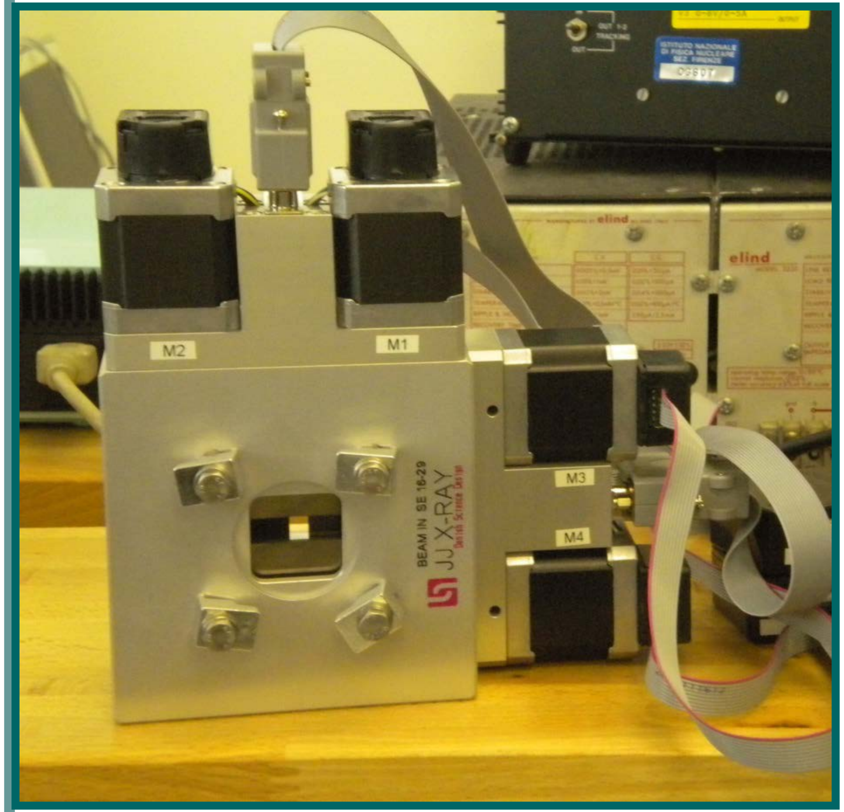
- spatial resolution

Tipically, 4-independent sectro slits (by Fischer Gmbh) →

- 30-50 μm spatial resolution
- ~50 μm uncertainty on aperture size

→ Not suitable for precision applications!

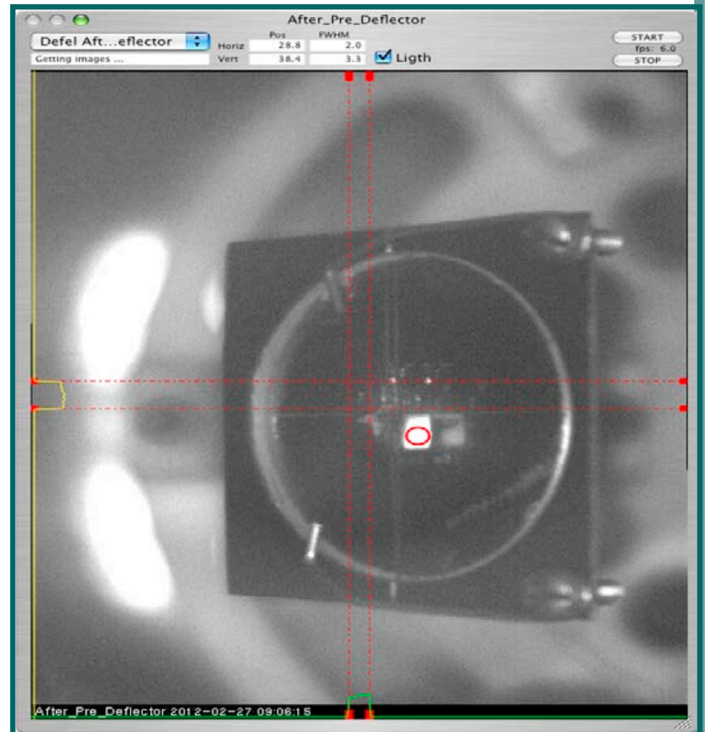
Our new slits



- Aperture formed by 4 independent blades
- 30 mm x 30 mm maximum size
- 1 μm resolution
- Designed for high vacuum applications
- Tungsten carbide blades with a 0.5° knife-edge

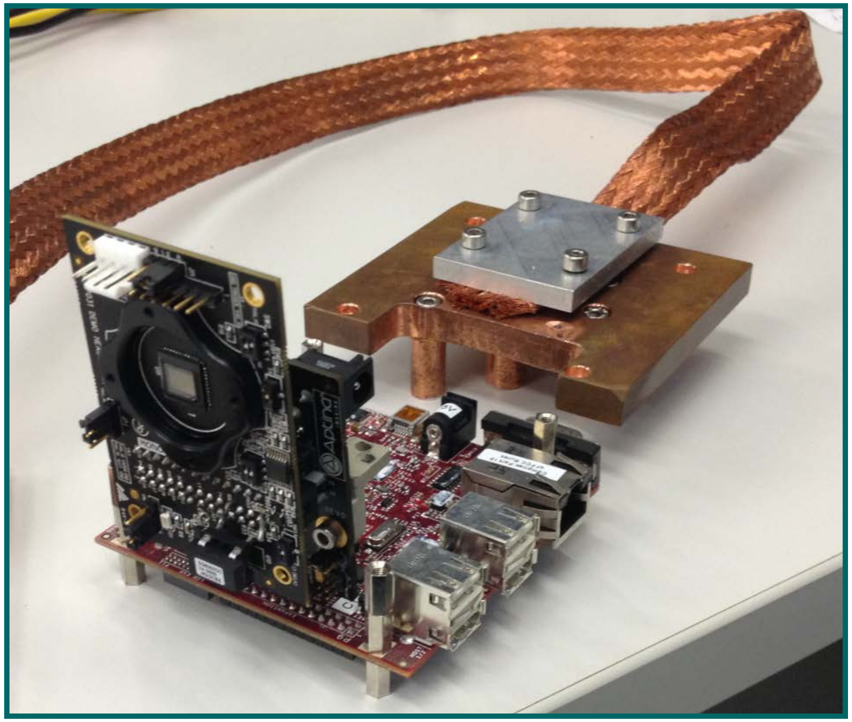
How to look at the beam

- Typical devices:
  - Beam profile monitor
  - Luminescent quartz
- downstream the final slits,
  transmitted beam intensity too low
- Need of a new visualisation
  system



The Aptina camera

- 752 x 480 pixels
- Pixel dimensions 6x6 µm
- Programmable through serial interface
- Images acquired using services added to Linux kernel



(MT9V034)

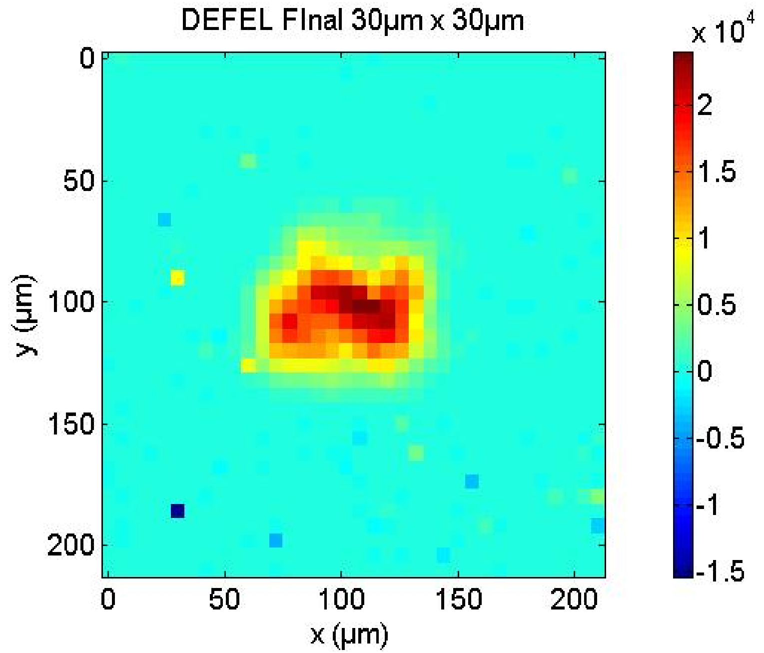
Here is the beam

Slits aperture 1mm x 400 µm

Here is the beam

Slits aperture 200 x 200 µm

Here is the beam



3 MeV protons

A new sensor (Aptina, 5M pixels, 2x2 µm pixel size) is going to be tested…

10 MeV Si implantation in diamond

State of charge = Si^{3+}

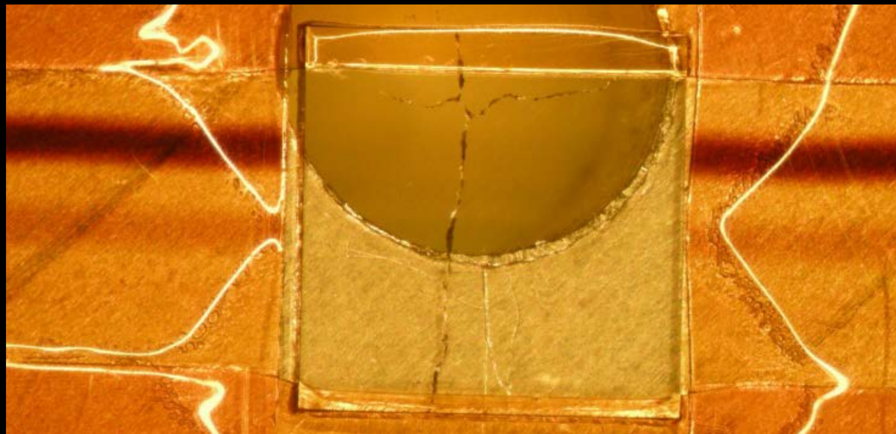
Energies = 8 – 11 MeV

Probe size = 0.2 to 1 mm wide (*x* and *y*)

Implantation times ranging from 100 μs (pulsed) to 1 h (continuum)

Fluences = $\sim 10^{9}$ - $\sim 10^{16}$ cm^{-2}

Results

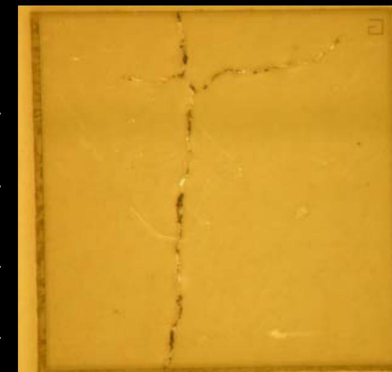


5.6×10^{13} cm^{-2}

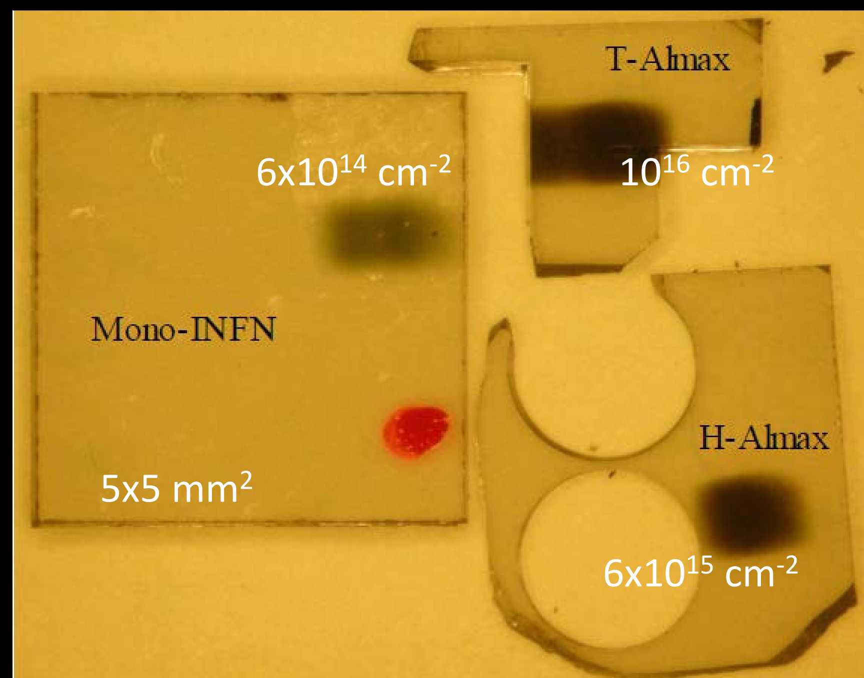
1.1×10^{13} cm^{-2}

2.3×10^{12} cm^{-2}

3.7×10^{11} cm^{-2}



5x5 mm^2



applications

energy losses and straggling

- N. Taccetti, et al., *The pulsed beam facility at the 3MV Van de Graaff accelerator in Florence: overview and examples of applications,* Nucl.Instr. & Meth.B 188 (2002), 255

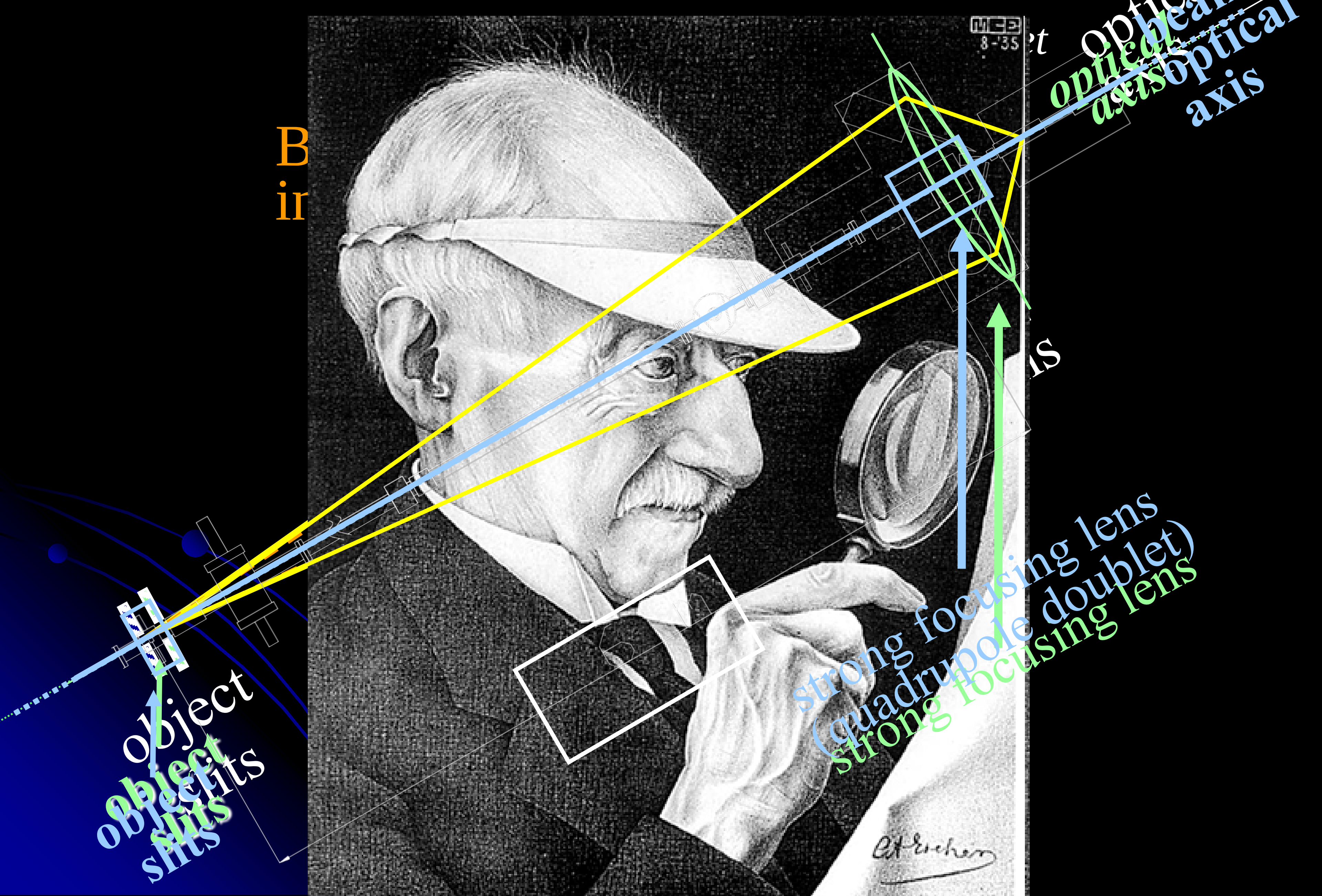
Characterization of detectors

- L. Carraresi, et al., *Pulsed Proton Beams as a Diagnostic Tool for the Characterization of Semiconductor Detectors at High Charge Densities.* IEEE Nuclear Science Symposium Conference Records (2010), 737
- A. Castoldi, et al., *Characterization and diagnostics of fast X-ray Imaging detectors for X-ray free electron sources,* Proc. of SPIE 8078 (2001), 80780P-1
- A. Castoldi, et al., *Mapping of the response function of DePFET-based pixel sensors at different levels of charge injection,* IEEE Nuclear Science Symposium Conference Records (2011), 1747
- P.G. Bizzeti, et al., *Response of CdWO4 crystal scintillator for few MeV ions and low energy electrons,* Nucl.Instr. & Meth. A 696 (2012), 144
- V.I. Tretyak, *Semi-empirical Calculation of Quenching Factors for Ions in Scintillators,* Astroparticle Physics 33 (2010) 40

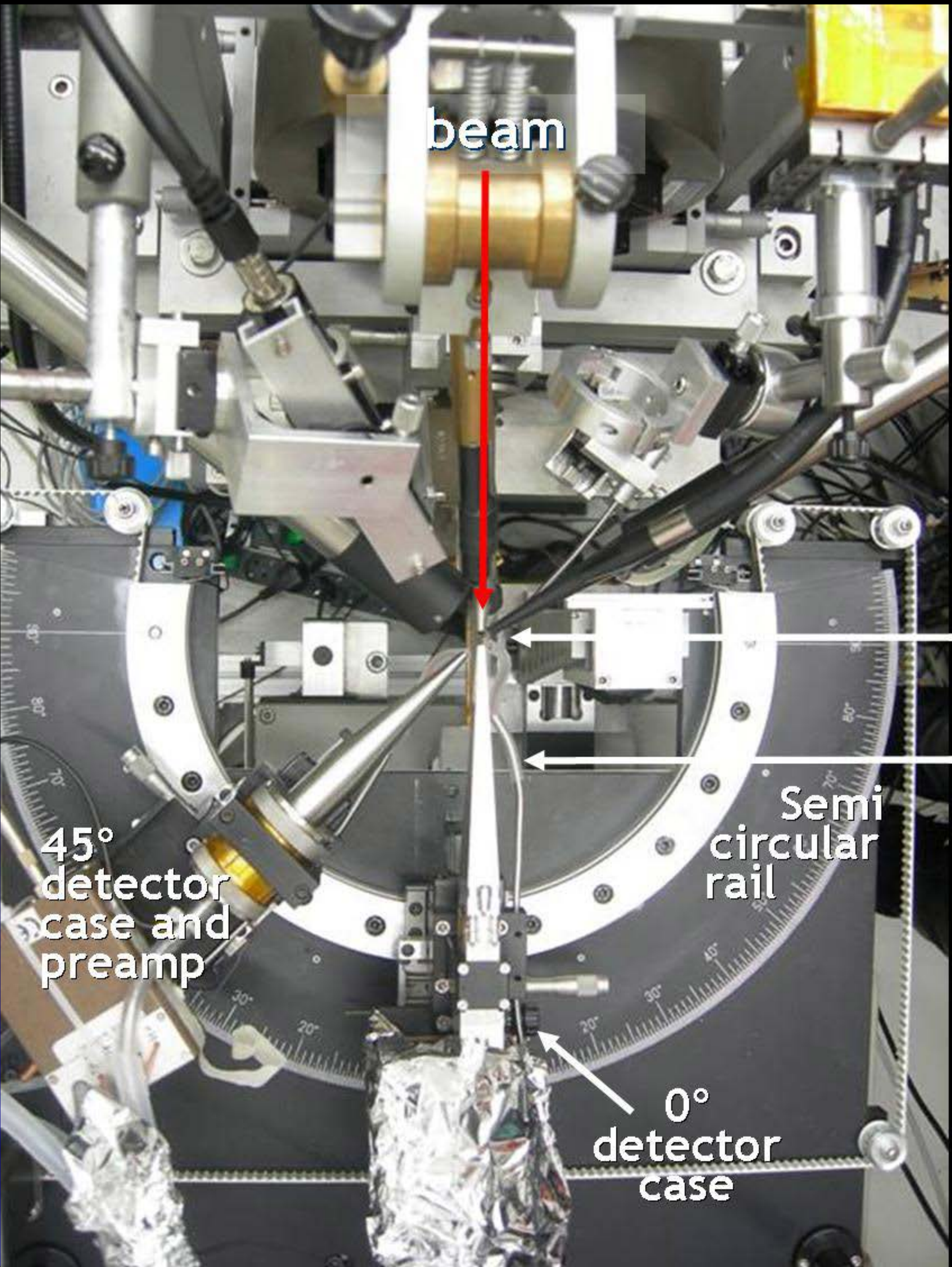
Time resolved ion beam induced luminescence

- C. Czelusniak, *PhD Thesis, ongoing*

Microbeam line

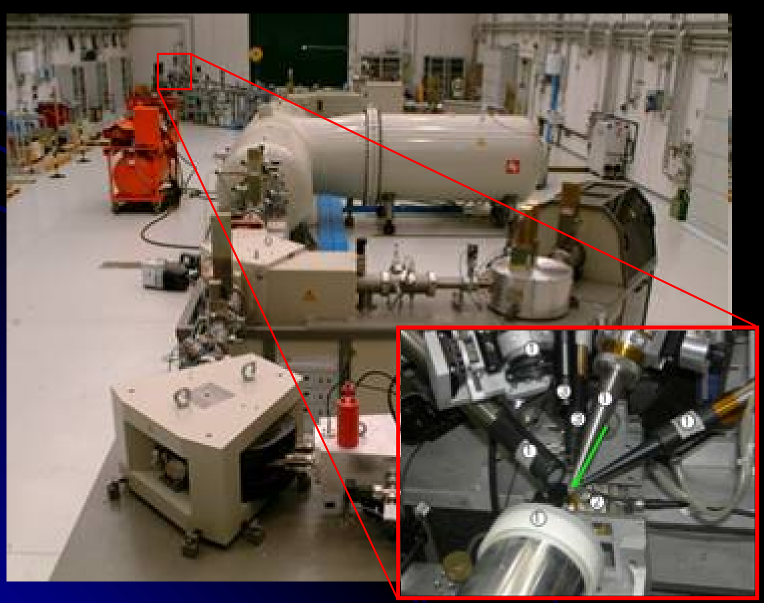


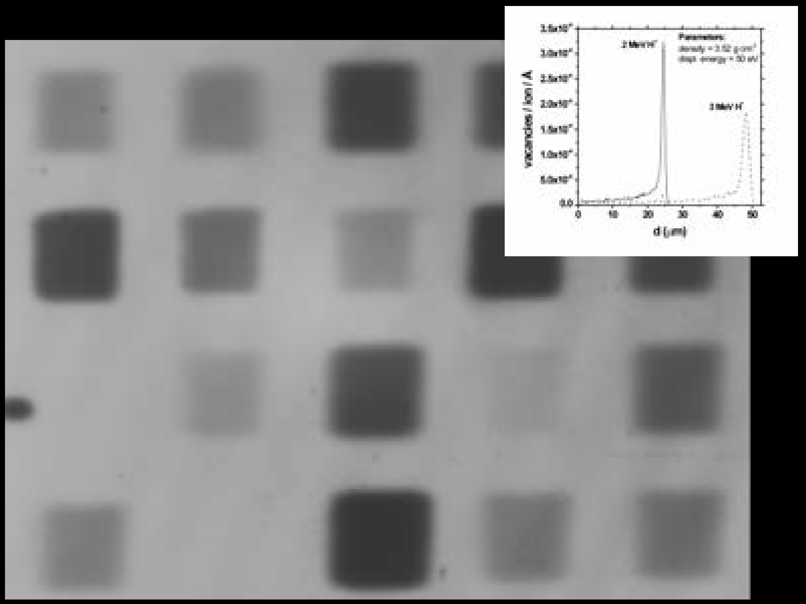
The set-up for ultra-low intensity measurements



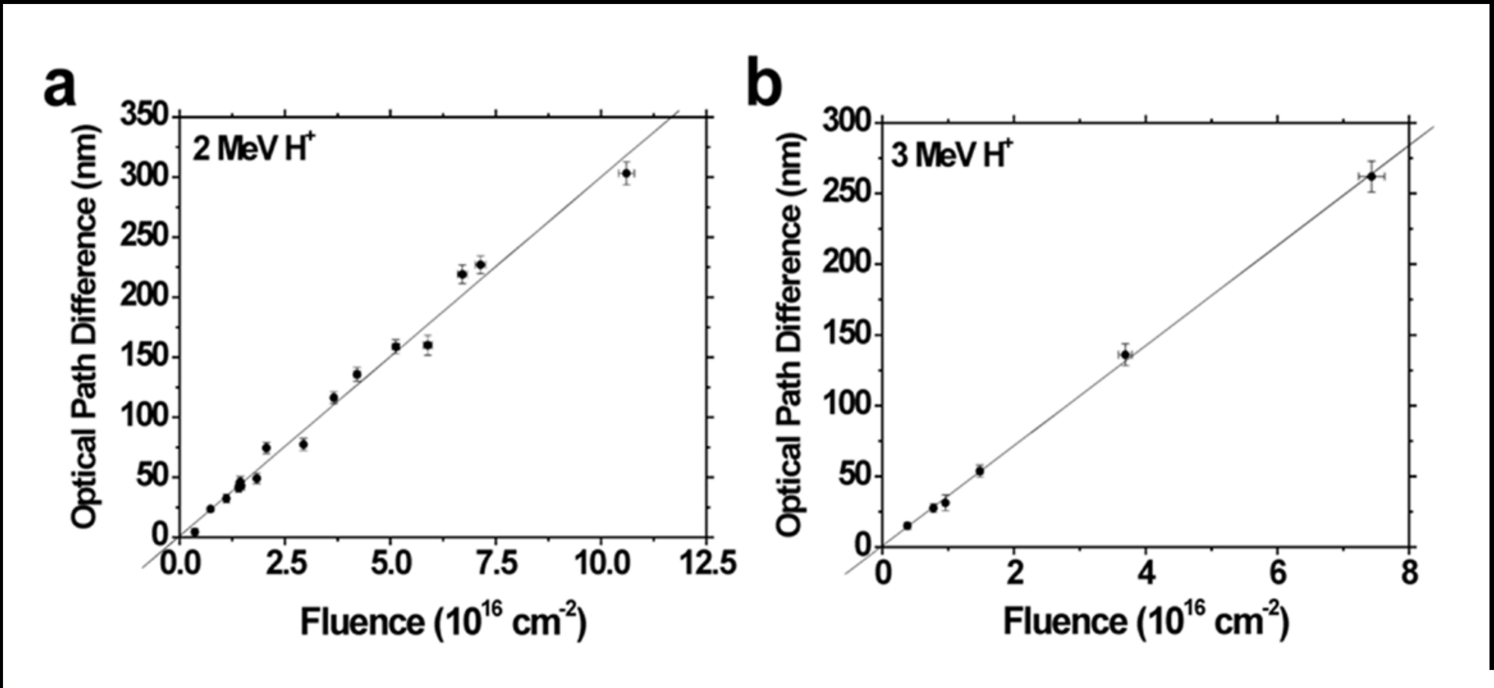
Refractive index control

- 2 and 3 MeV proton implantation in the low damage regime
- fluences ($\Phi = 10^{13} - 10^{17}\ cm^{-2}$) measured at the Florence microbeam
- refractive index variation OPD =$(n-n_0)$ of implanted diamond measured at the Florence INOA

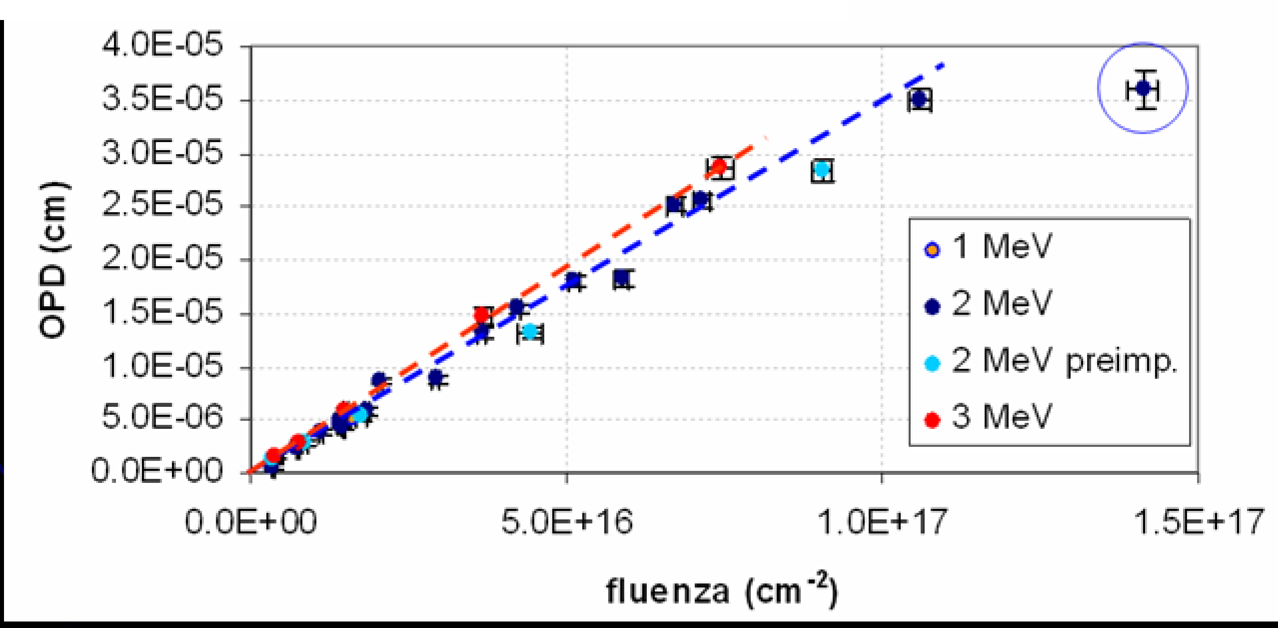




Experimental data: OPD vs. Fluence



- linear trends
- different trends for 2 & 3 MeV implantations



Diamond studies at LABEC

PRL **105,** 233903 (2010) PHYSICAL REVIEW LETTERS week ending 3 DECEMBER 2010

Evidence of Light Guiding in Ion-Implanted Diamond

S. Lagomarsino*
Department of Energetics University of Firenze and INFN, Via S.Marta 3, 50136 Italy

P. Olivero and F. Bosia
Experimental Physics Department and Nanostructured Interfaces and Surfaces Centre of Excellence, University of Torino and INFN, via P. Giuria 1, 10125 Torino, Italy

M. Vannoni
CNR, Istituto Nazionale di Ottica (INO), Largo E. Fermi 6, 50125 Arcetri, Firenze, Italy

S. Calusi, L. Giuntini, and M. Massi

Diamond & Related Materials 19 (2010) 428–431

Contents lists available at ScienceDirect

ELSEVIER

Diamond & Related Materials

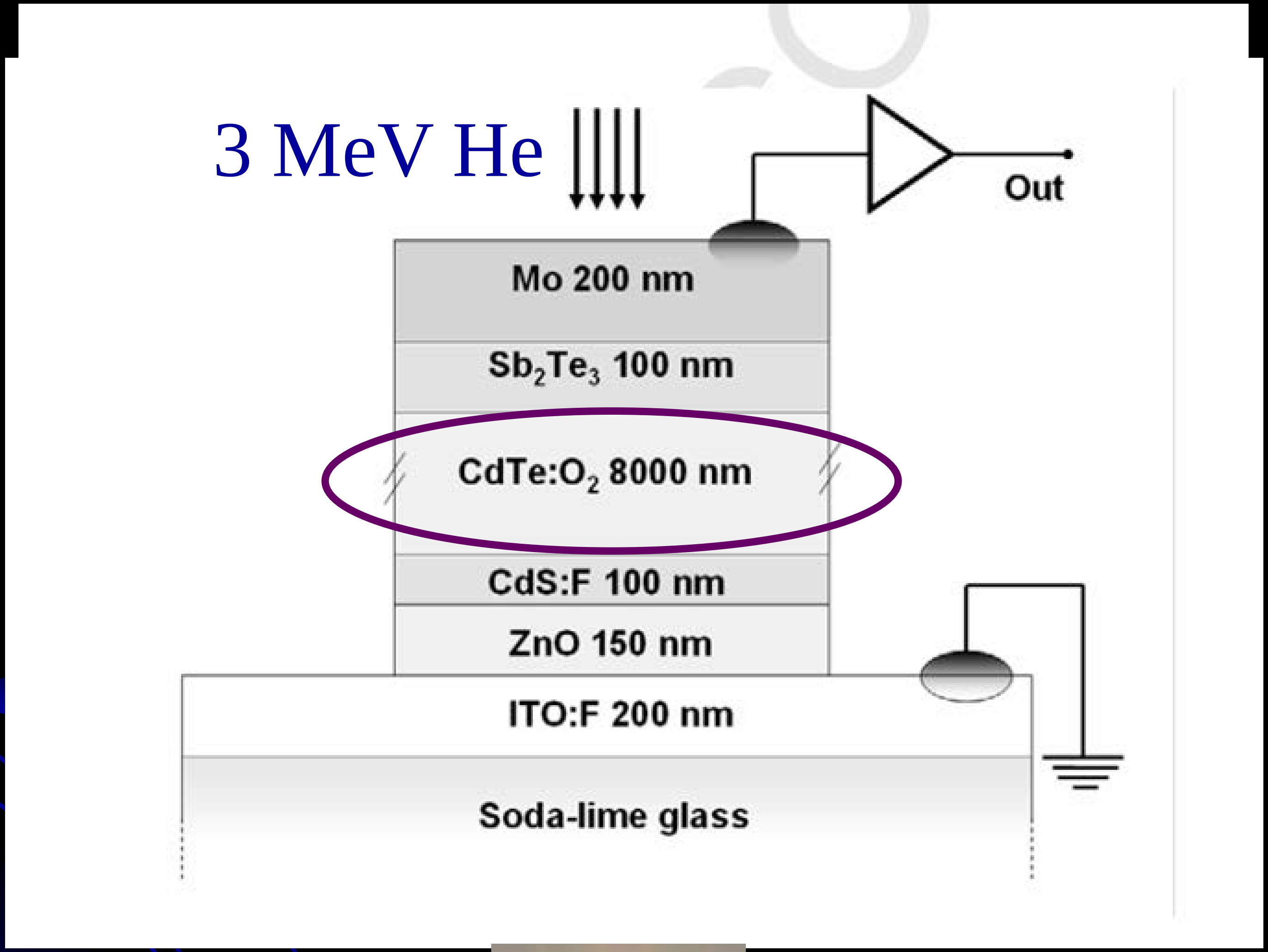
journal homepage: www.elsevier.com/locate/diamond

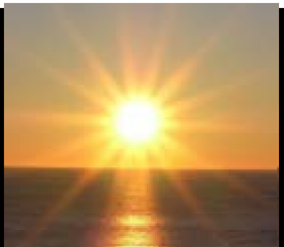
DIAMOND AND RELATED MATERIALS

Controlled variation of the refractive index in ion-damaged diamond

P. Olivero [a,b,*], S. Calusi [b,c], L. Giuntini [c], S. Lagomarsino [d], A. Lo Giudice [a,b], M. Massi [c], S. Sciortino [d], M. Vannoni [e], E. Vittone [a,b]

IBIC study of a CdS/CdTe solar cell

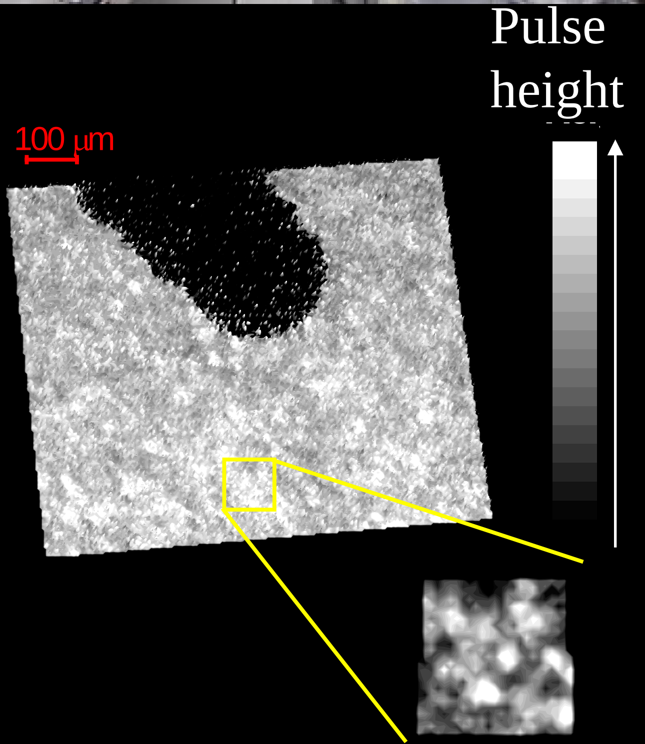




lighting direction

IBIC study of a CdS/CdTe solar cell

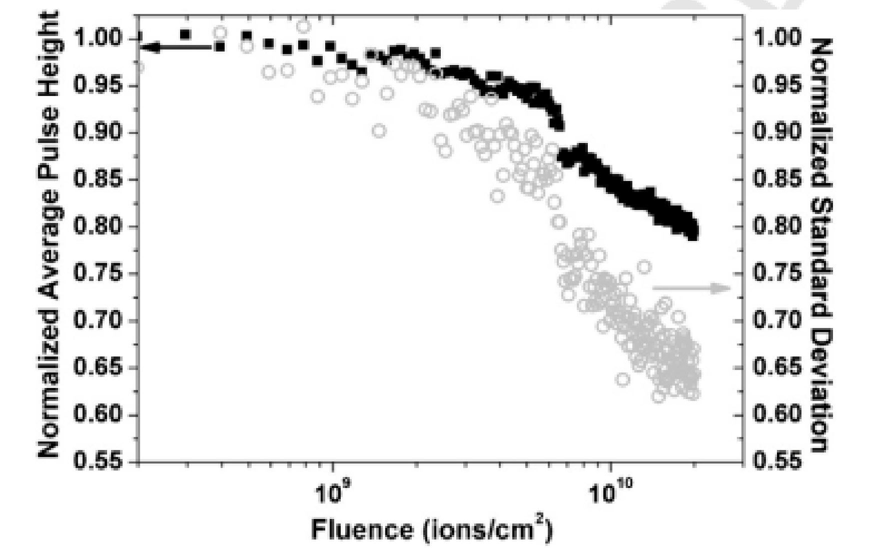
- 3 MeV He ions
- the **set-up** for beam current control allowed an easy and fast intensity reduction down to **10^3** particles per second injected directly into the solar cell
- charge collection efficiency (CCE) maps show inhomogeneous response due to the polycrystalline nature of the CdTe bulk material

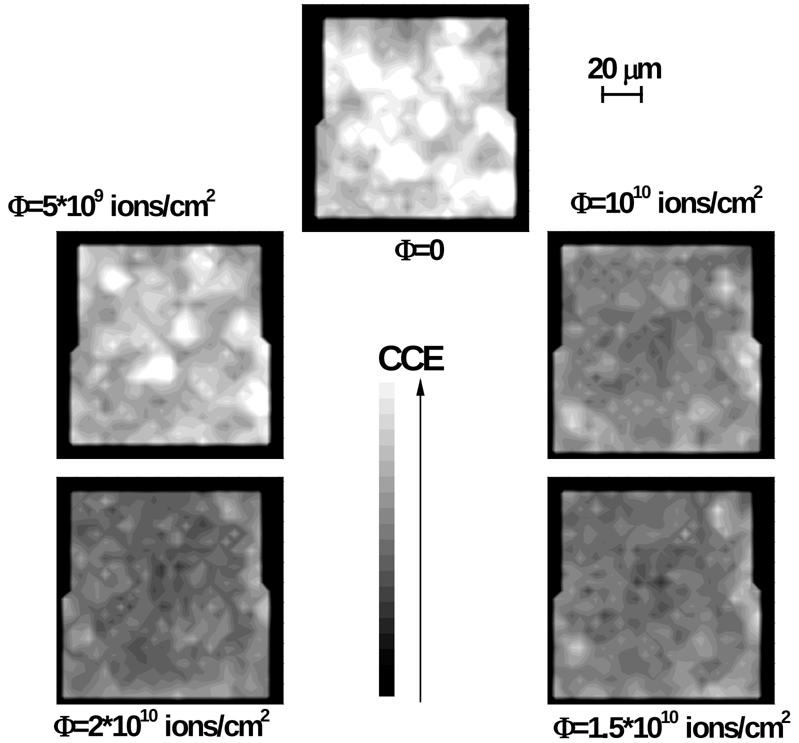


radiation resistance

- average pulse height decrement of 20% for fluences up to $2 \cdot 10^{10}$ alpha/cm^2

- maps show non-uniform decrease of CCE: large grains with higher efficiencies more sensitive to radiation damage





Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research B

journal homepage: www.elsevier.com/locate/nimb

ELSEVIER

IBIC analysis of CdTe/CdS solar cells

E. Colombo [a,b], A. Bosio [c], S. Calusi [a,d], L. Giuntini [d], A. Lo Giudice [a,b], C. Manfredotti [a,b], M. Massi [d], P. Olivero [a,b], A. Romeo [e], N. Romeo [c], E. Vittone [a,b,*]

Thank you for your attention!

The collaboration: L. Carraresi, F. Taccetti, L. Giuntini, A. Castoldi, C. Guazzoni, G.V. Montemurro, C. Czelusniak, L. Castelli, M. Massi, N. Gelli, S. Calusi, L. Liccioli, A. Mazzinghi, C. Ruberto, L. Palla, M.E. Fedi, P.A. Mandò, F. Taccetti

CHNet
Cultural Heritage
Network

giuntini@fi.infn.it
labec.fi.infn.it
www.infnbeniculturali.net