Diagnostics and dosimetry solutions for laser-driven ion beams: preliminary results

Giuliana Milluzzo

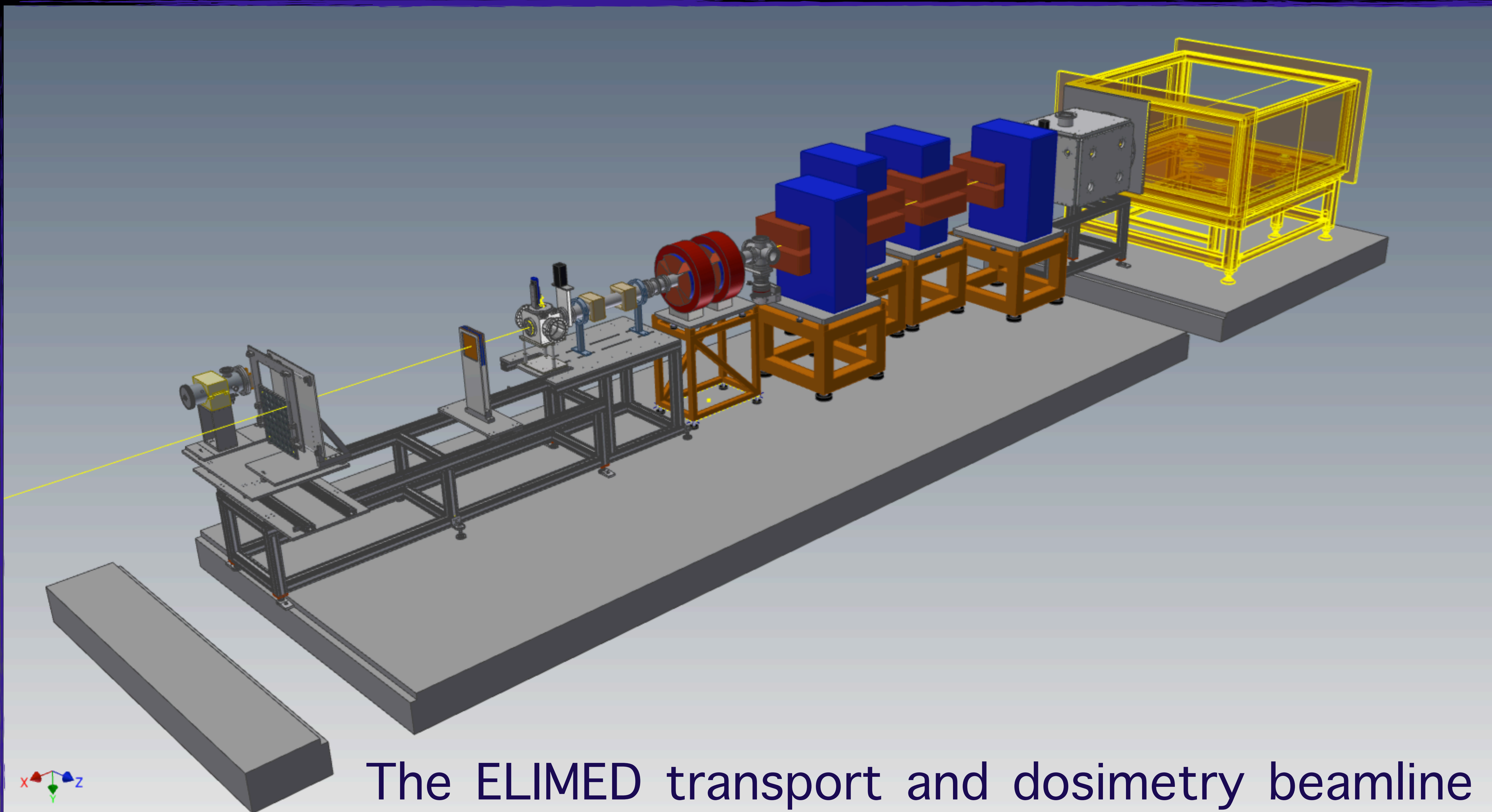
(on behalf of the ELIMED collaboration)

2nd European Advanced Accelerator Concepts Workshop

La Biodola, 13-19 September 2015

gmilluzzo@lns.infn.it

The ELIMED section at the ELIMAIA beamline



The ELIMED transport and dosimetry beamline

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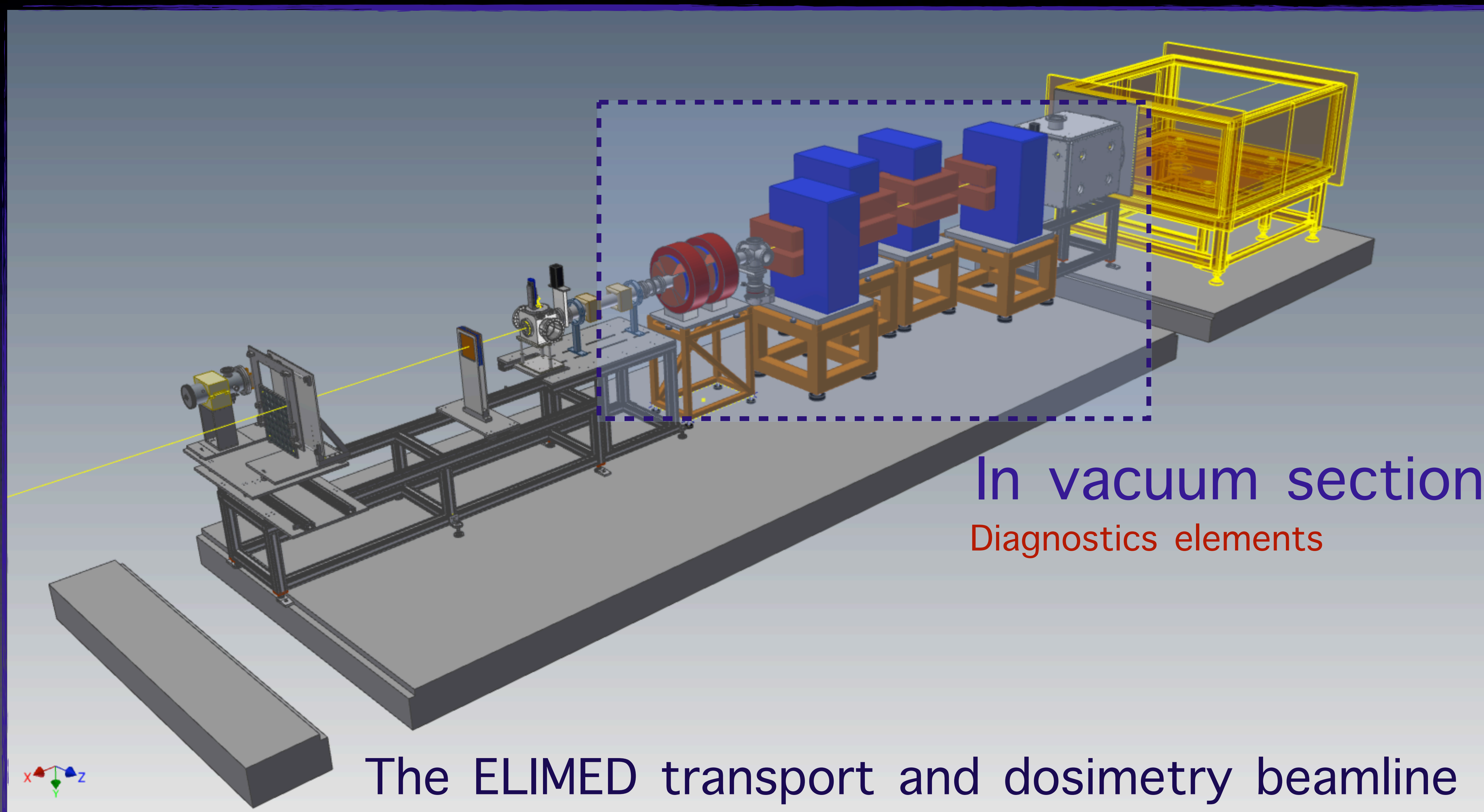
The ELIMED section at the ELIMAIA beamline



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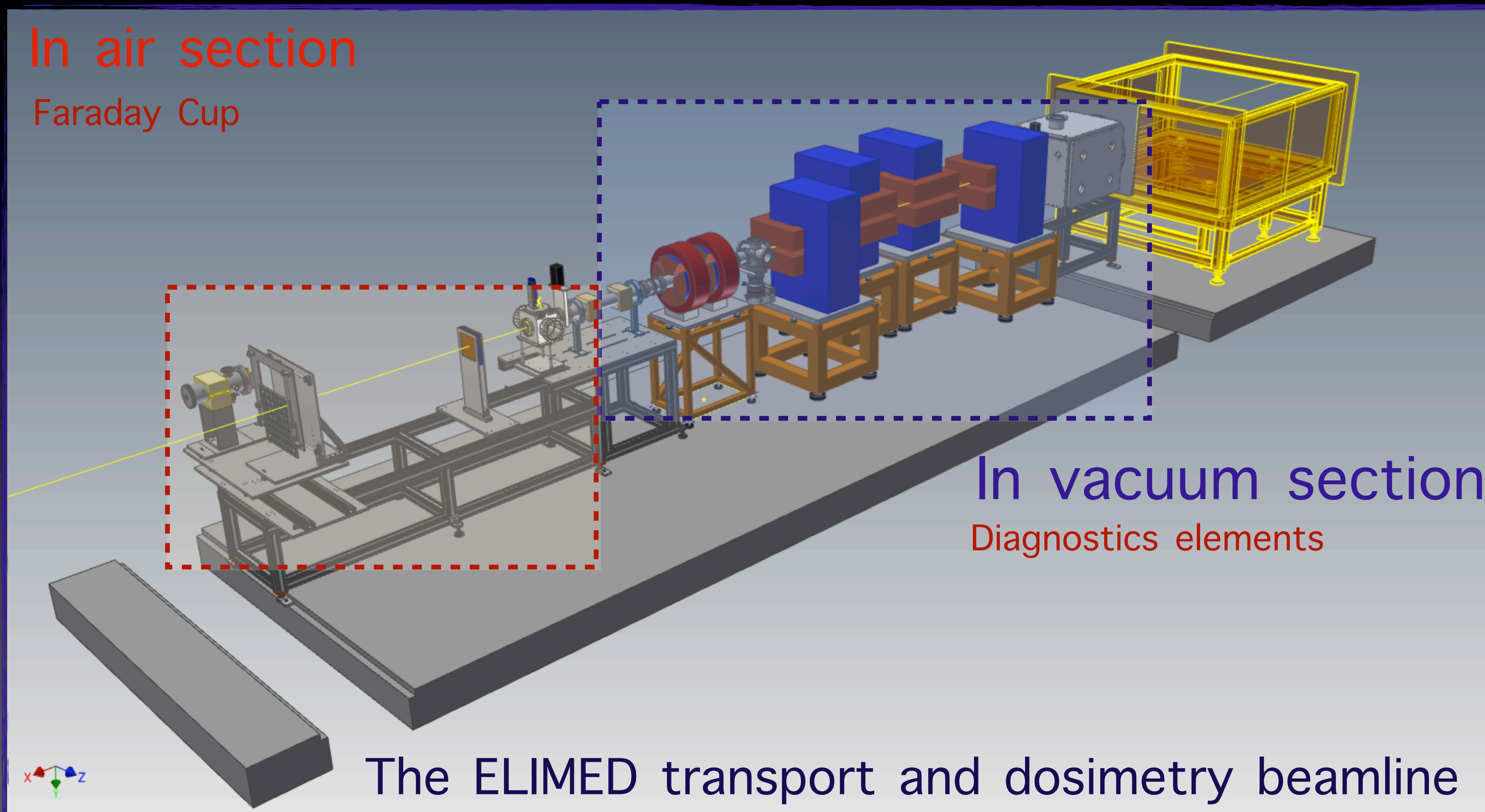

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Diagnostics of laser-driven ion beams

High pulsed ion beams
High dose-rate
High electromagnetic pulse
Very fast signal

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Very fast detectors
in Time Of Flight configuration

Special solutions for emittance measurements using a pepper pot device

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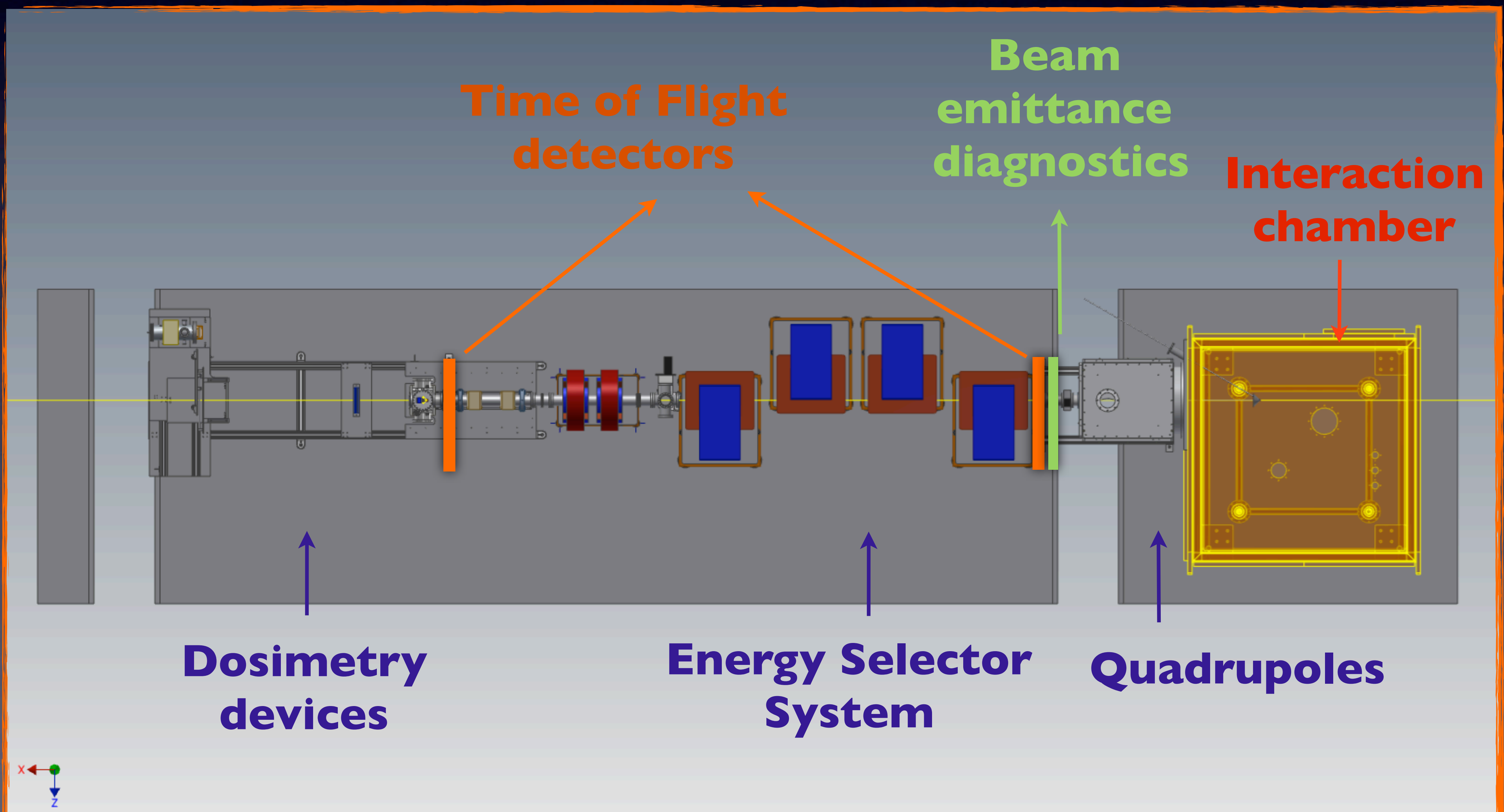

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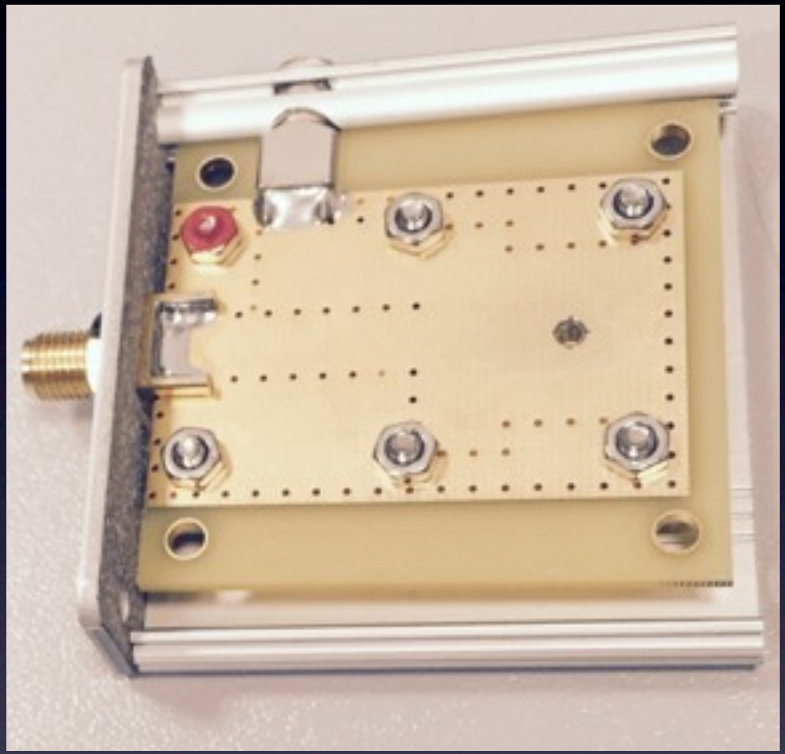
ToF detectors for ELIMAIA

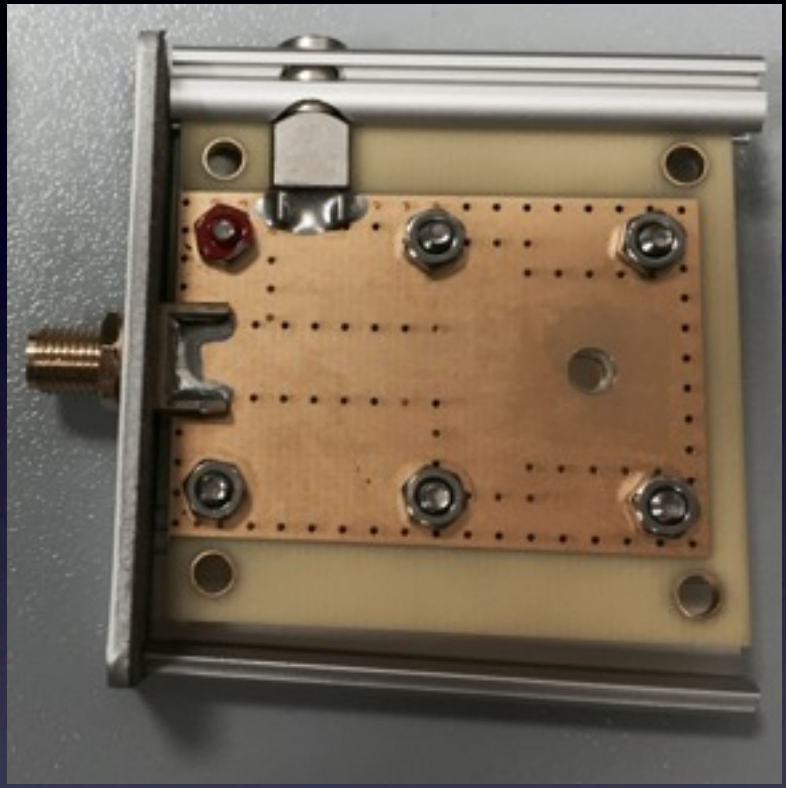
pCVD diamond:

Substrate thickness: 100 µm
Electrode size: 3 mm diameter
Detector capacitance: 4 pF
Bias voltage: 200 V



sCVD diamond

Substrate thickness: 500 µm
Substrate size: 4.5 mm x 4.5 mm
Detector capacitance: 3 pF
Bias voltage: 400 V



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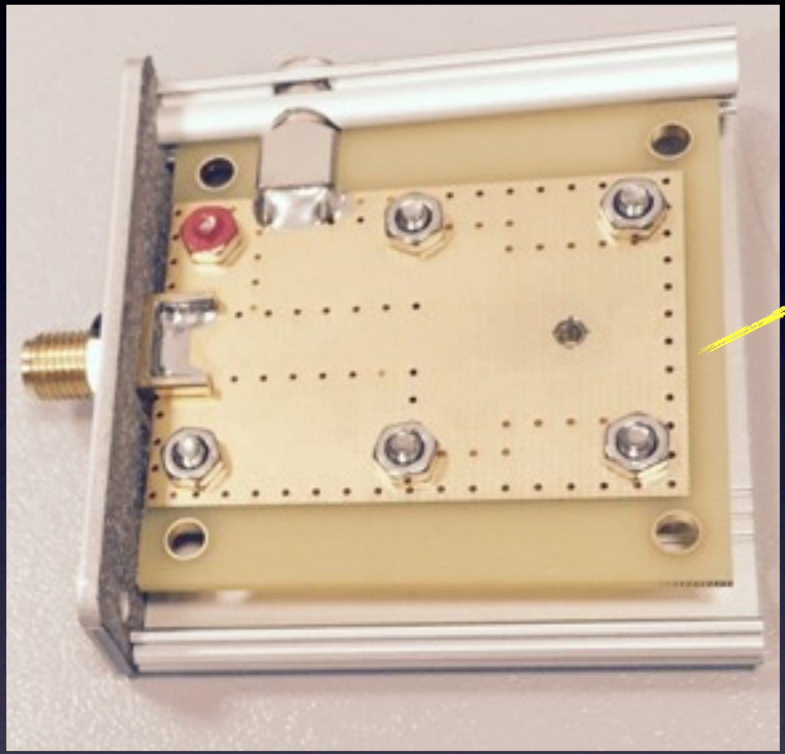

Special RF shielding

Housing:

Box size: 55 mm x 55 mm x 15 mm
Material: Alluminium with extra RF shielding

sCVD diamond

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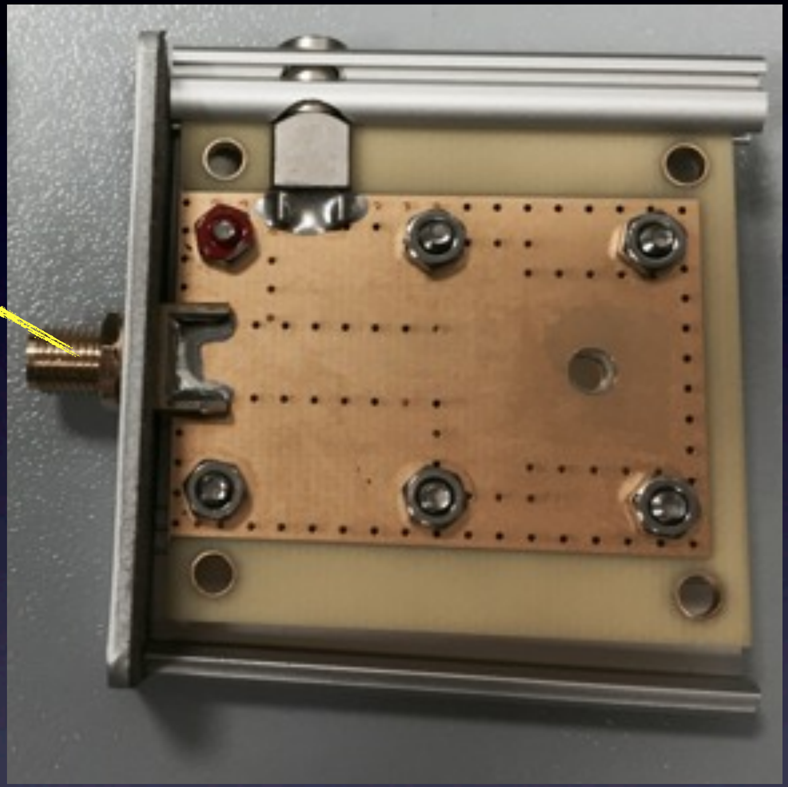

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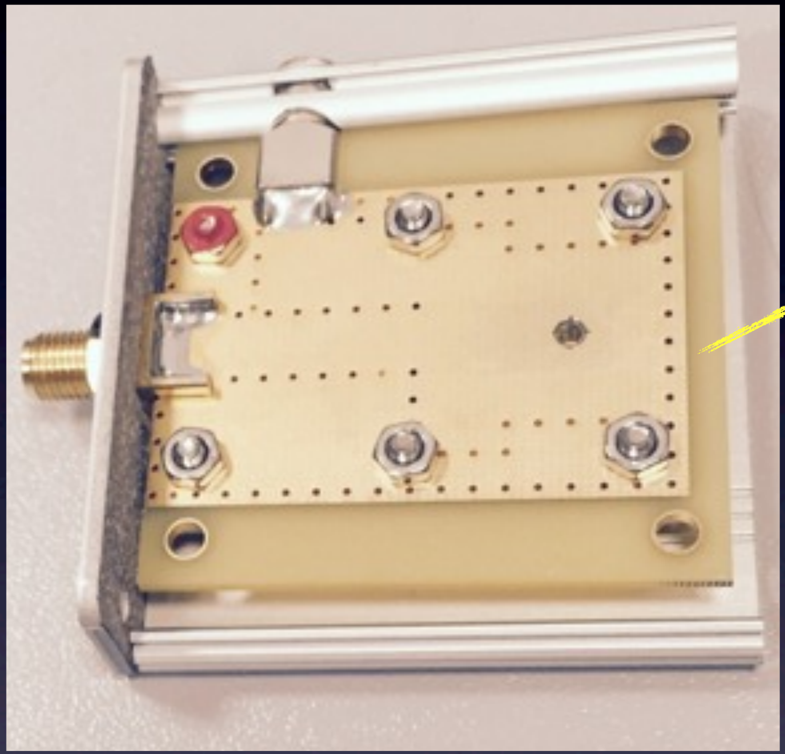

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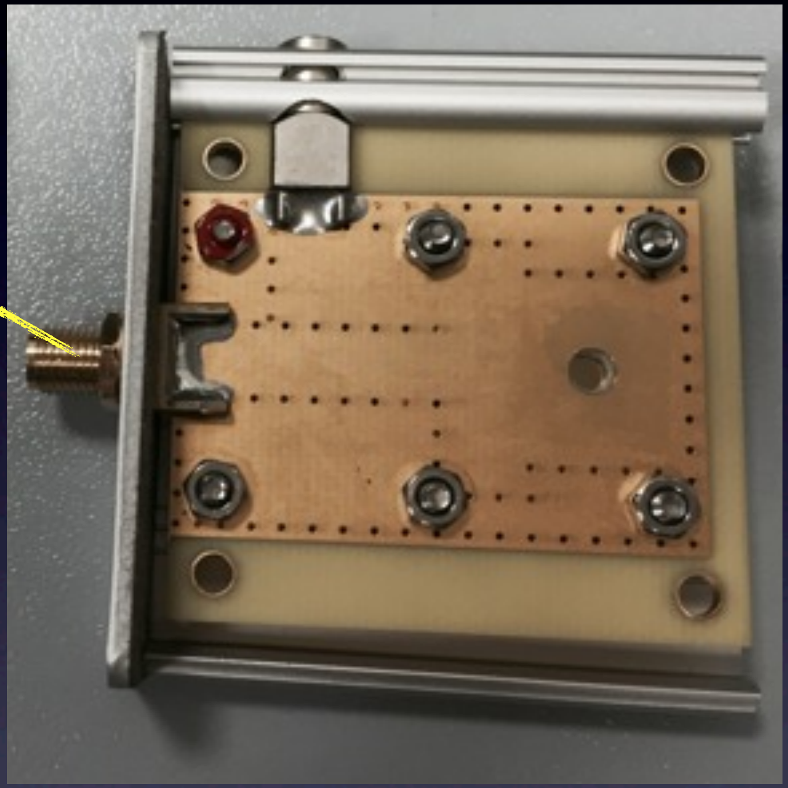

Linear response for very high intensity
Radiation hardness

Excellent signal-to-noise ratio
Good time resolution

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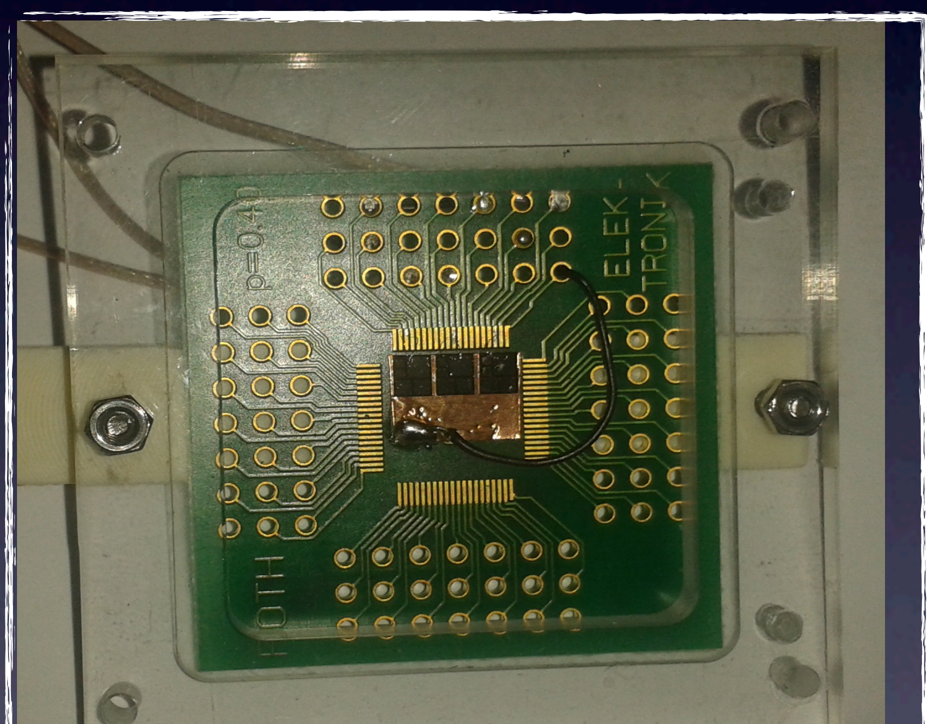
ToF diagnostics prototypes

Silicon Carbide (SiC) 4H-SiC Schottky

Maximum thickness: 43.7 µm
Active area : 4 mm^2
Energy band gap: 3.26 eV
Bias voltage: 500 V



M. De Napoli et al. NIM A 600 (2009) 618–623, NIM A 572 (2007) 831–838, NIM A 608 (2009) 80–85

Single crystal Diamond Detector

Maximum thickness: 500 µm
Active area : 4.5x4.5 mm^2
Energy band gap: 5 eV
Bias voltage: 400 V

N.Randazzo et al. Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC), 2012 IEEE10.1109/NSSMIC. 2012.6551450

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Time of Flight detectors: first experimental results

Tests with SiC and Diamond detectors prototypes @ TARANIS facility, Queen's University (UK)

Queen's University Belfast

Laser parameters

Power: 20 TW
Intensity: 10^{19} W/cm^2
Energy on target: 7 J

Focal spot diameter: 5um
Time pulse: 800 fs
wavelength: 1053 nm

Experimental setup

12 um Gold Target

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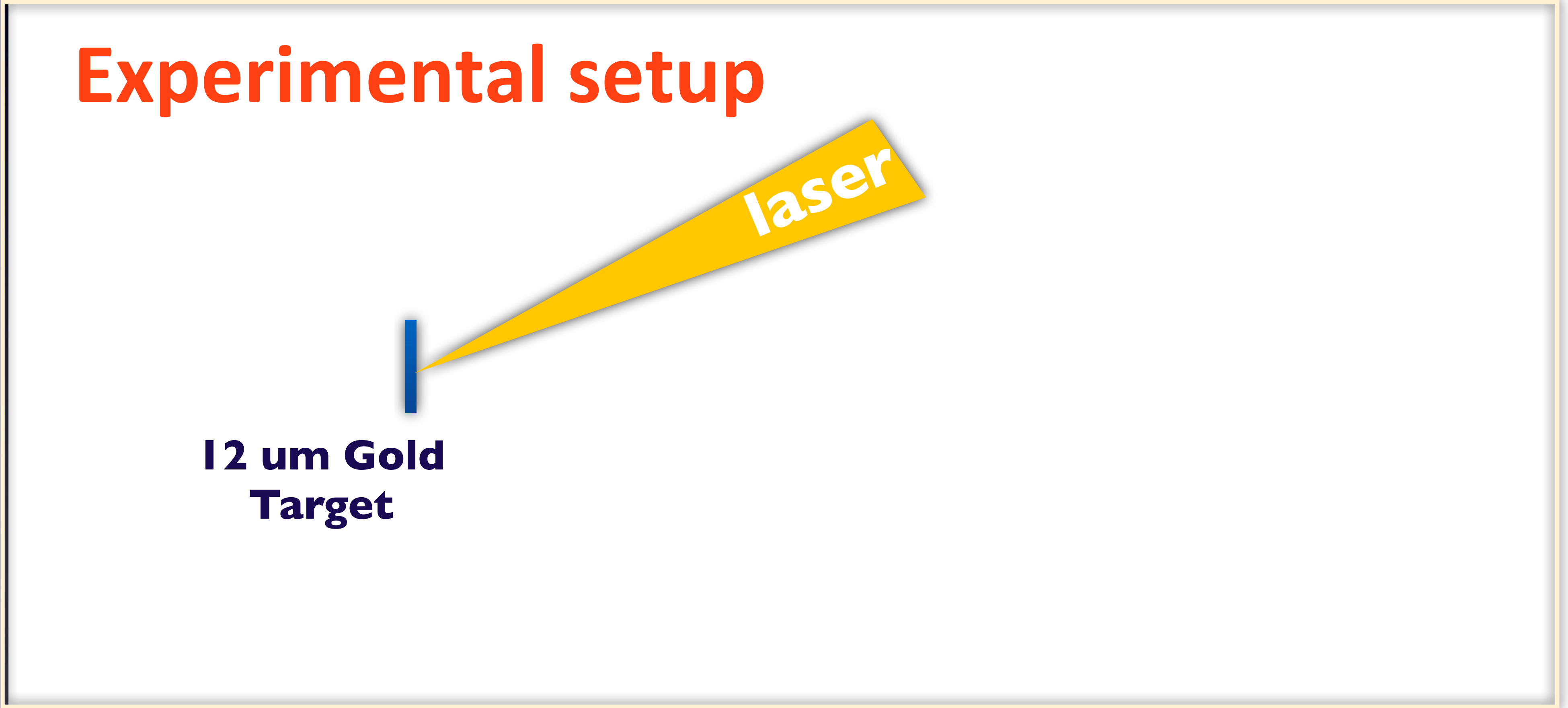

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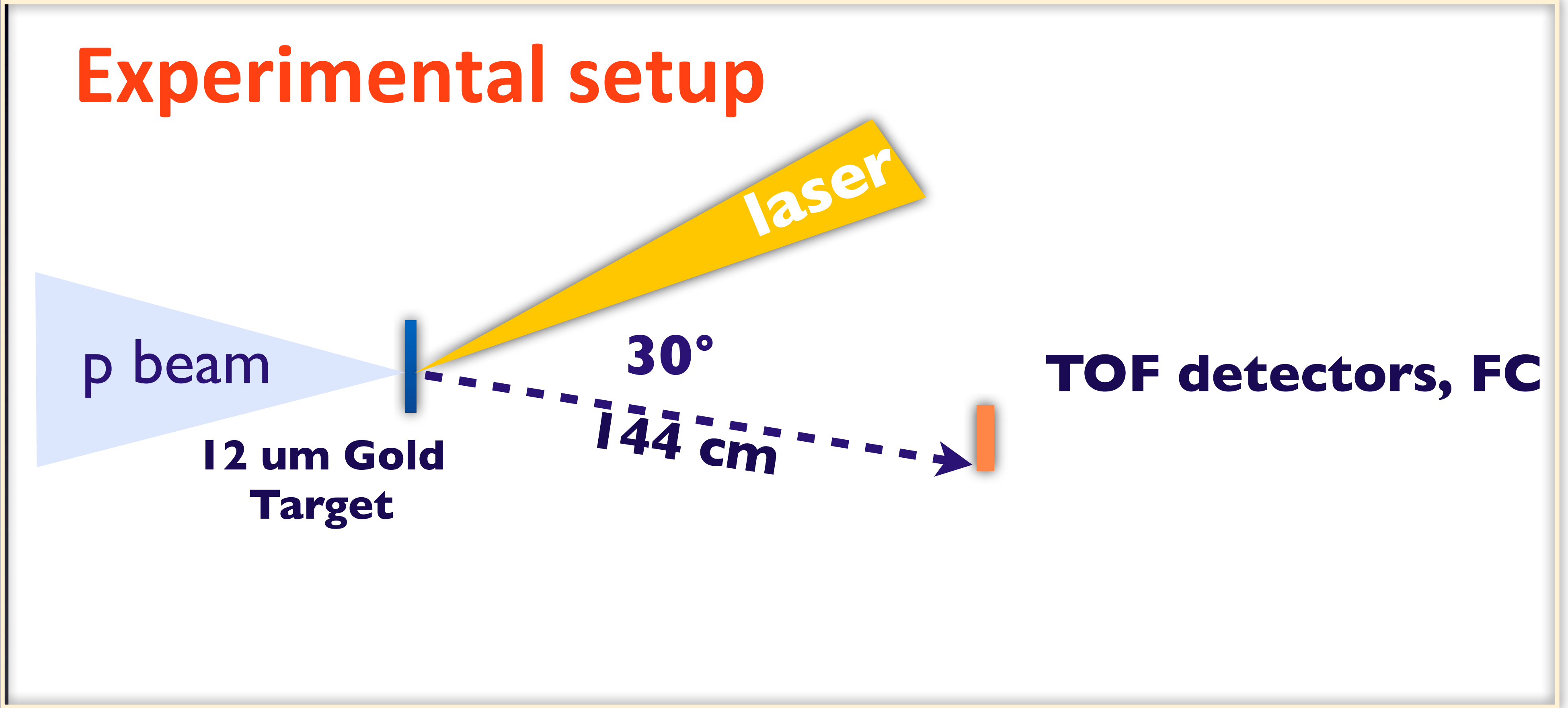

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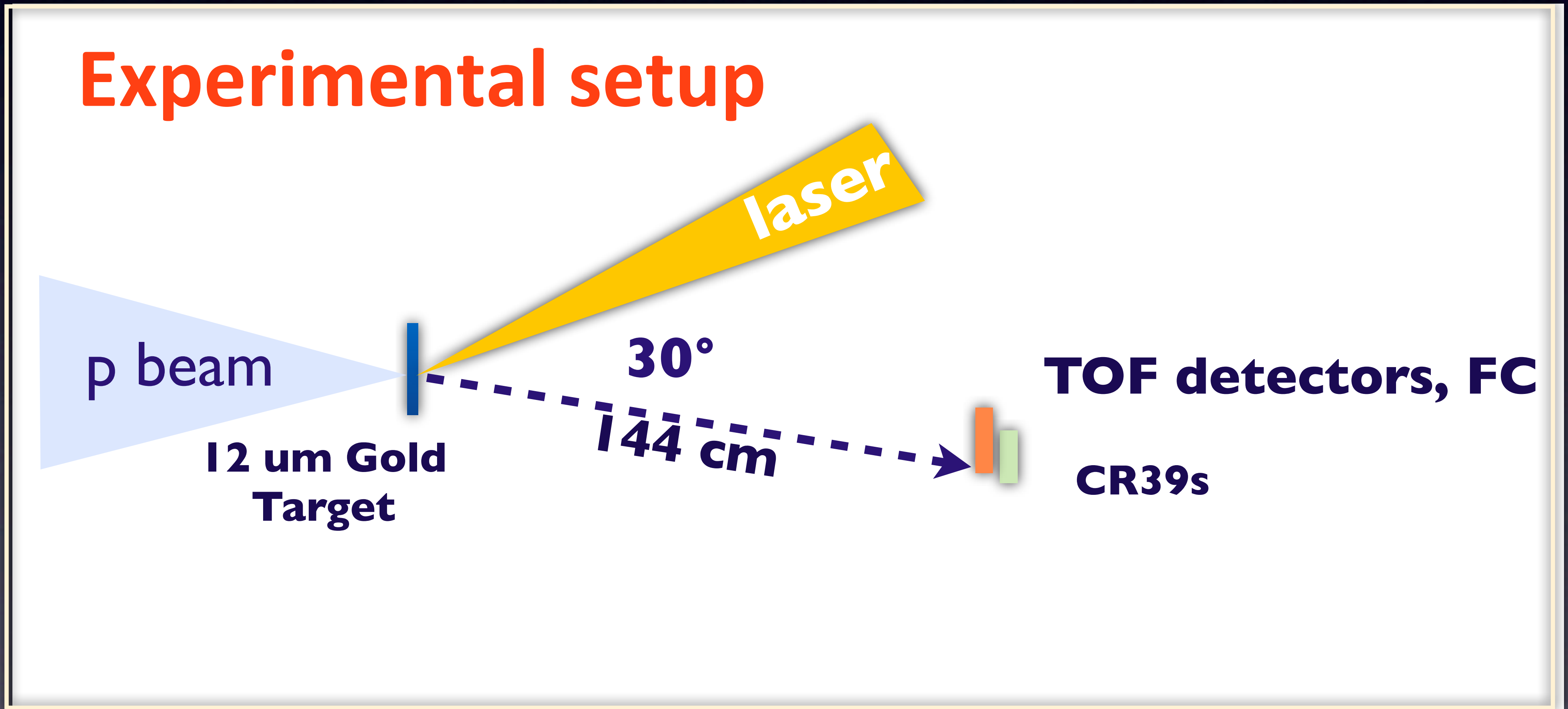

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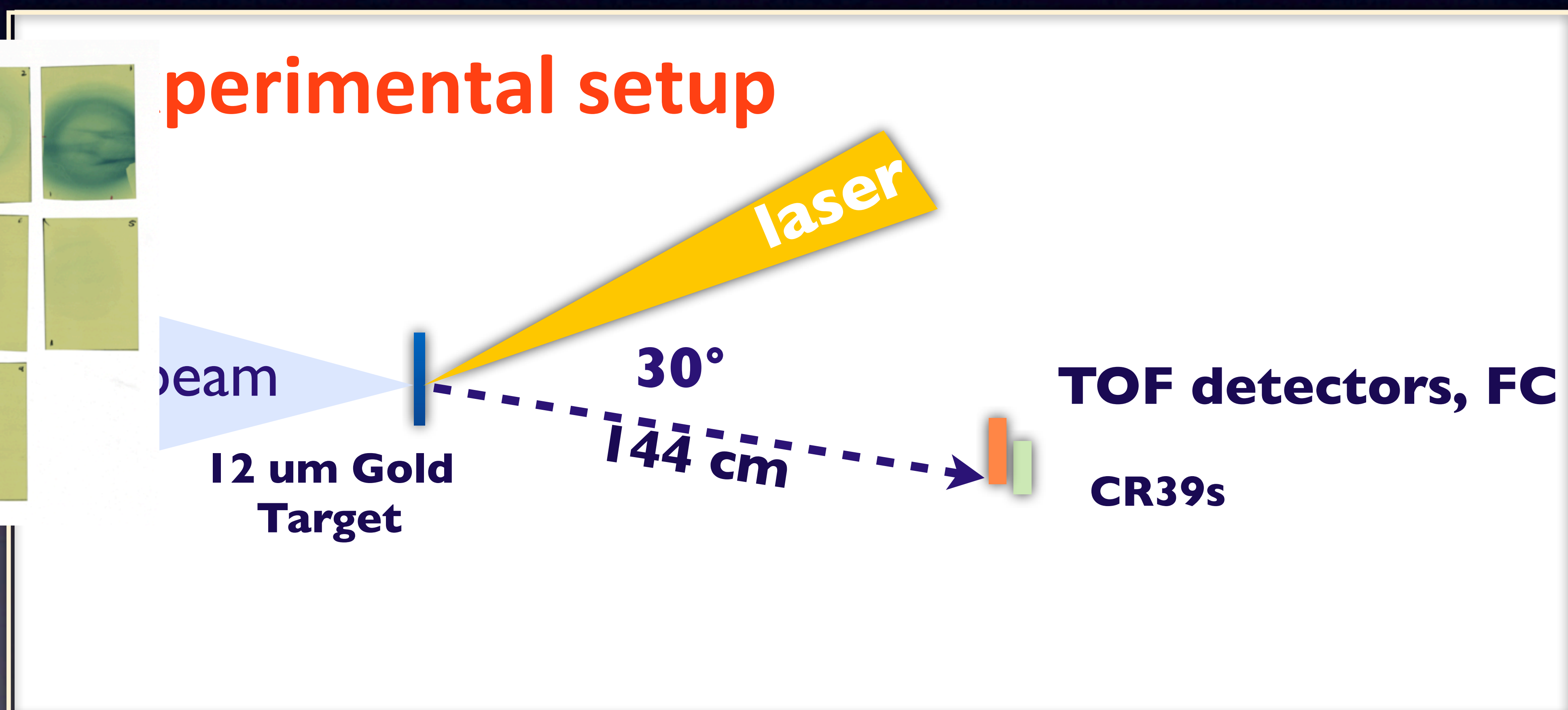

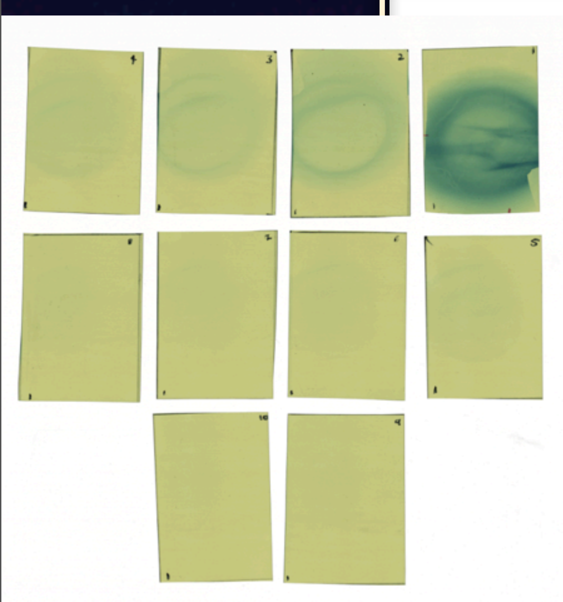

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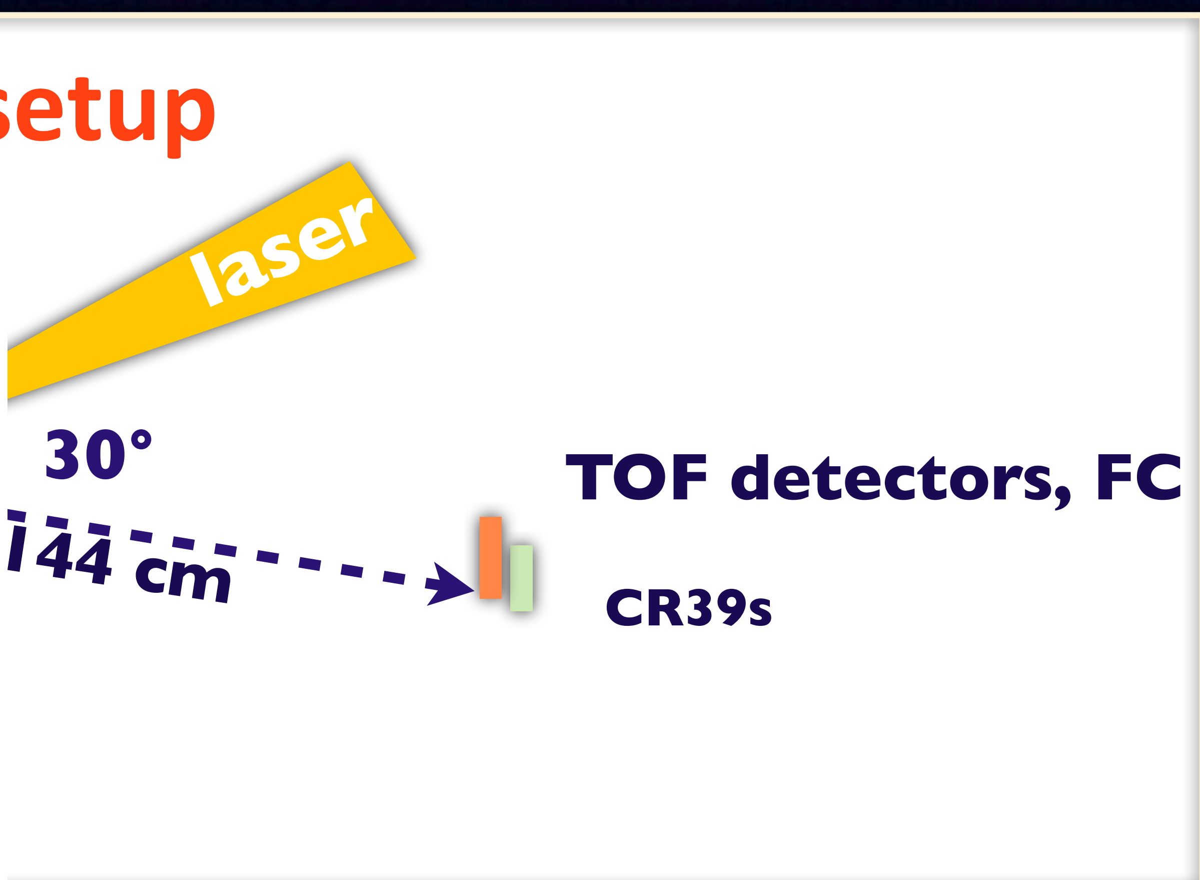

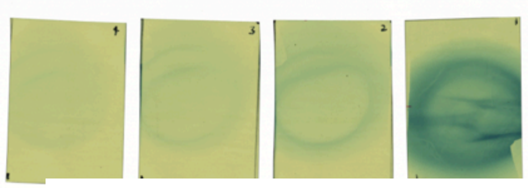

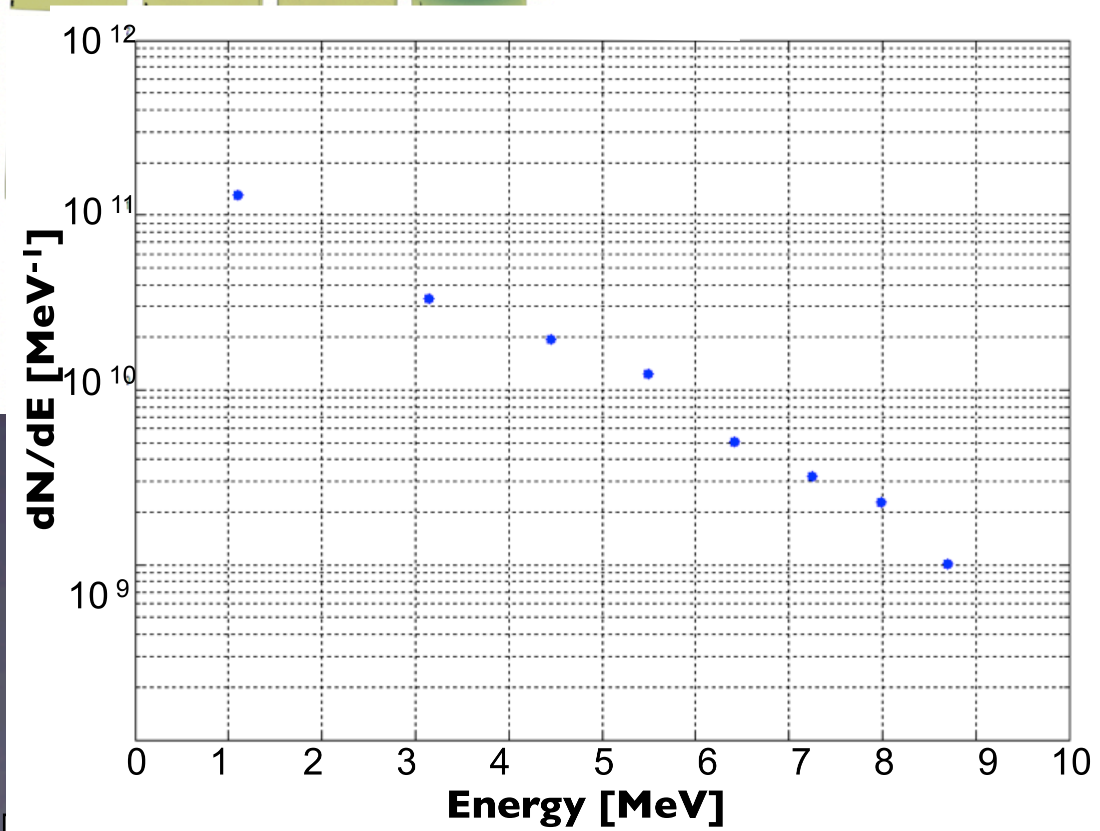

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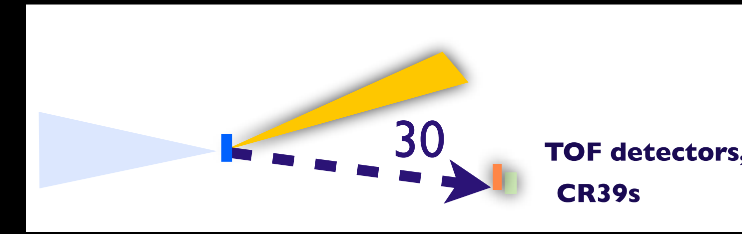
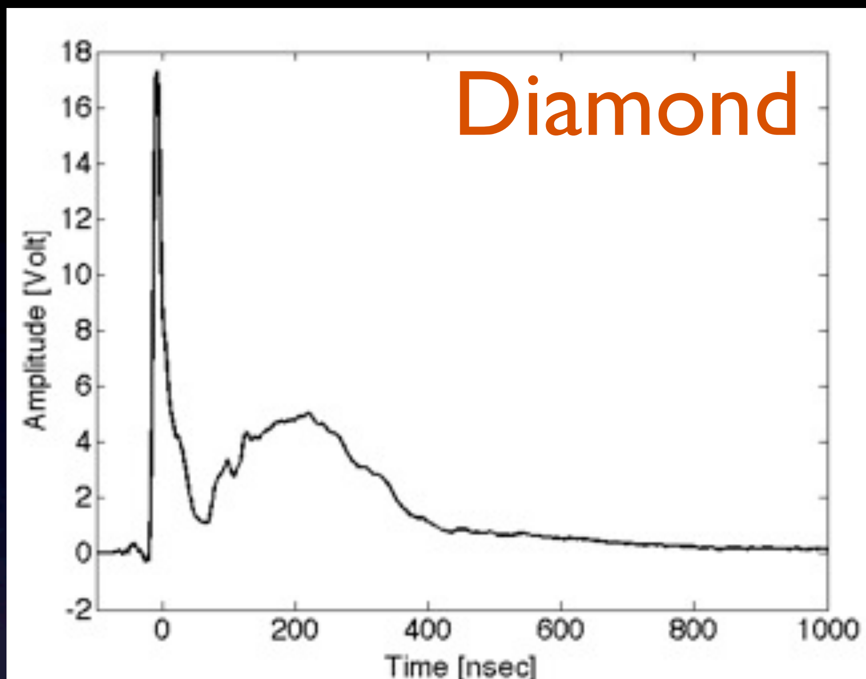
Results @TARANIS





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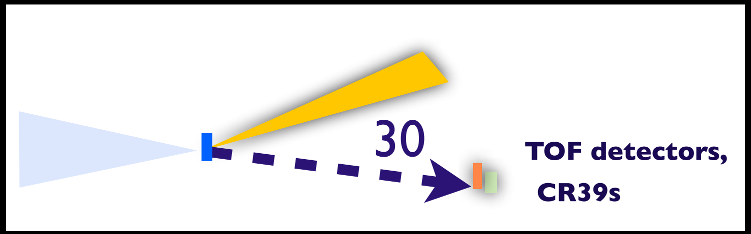
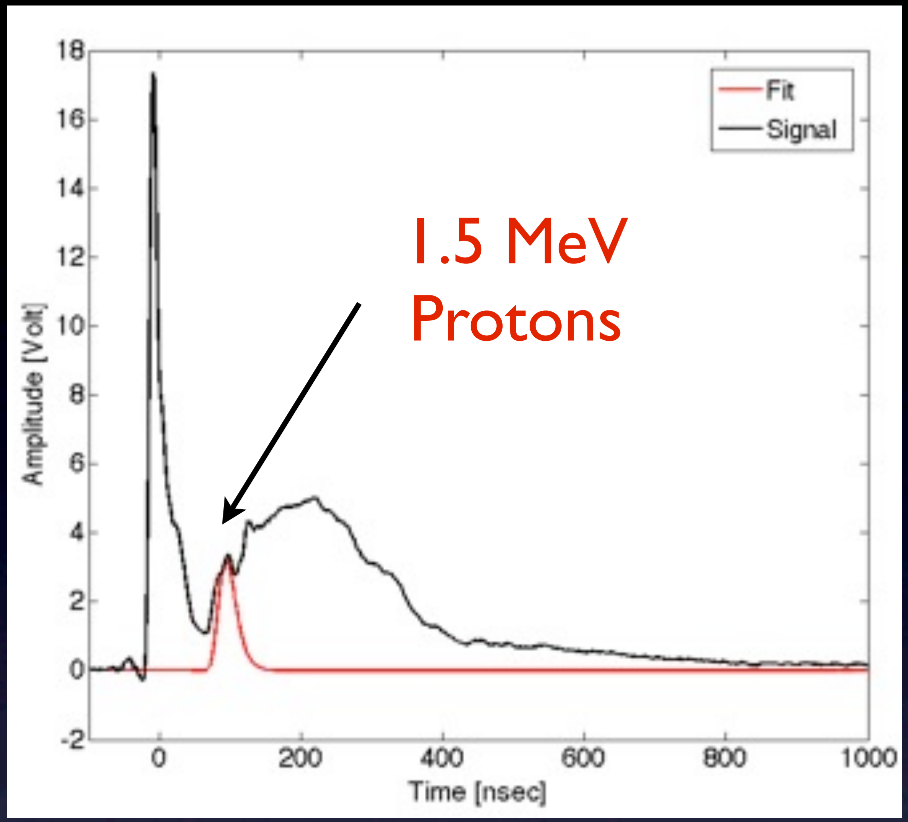


Deconvolution



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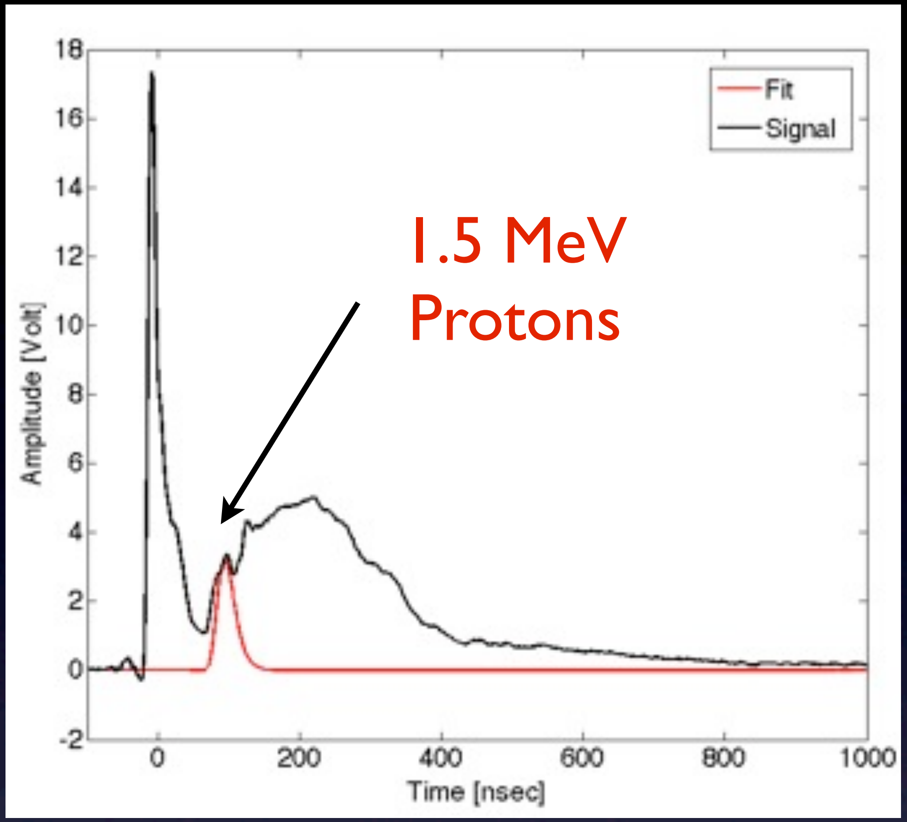

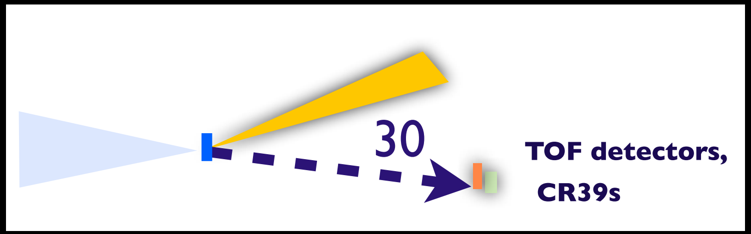

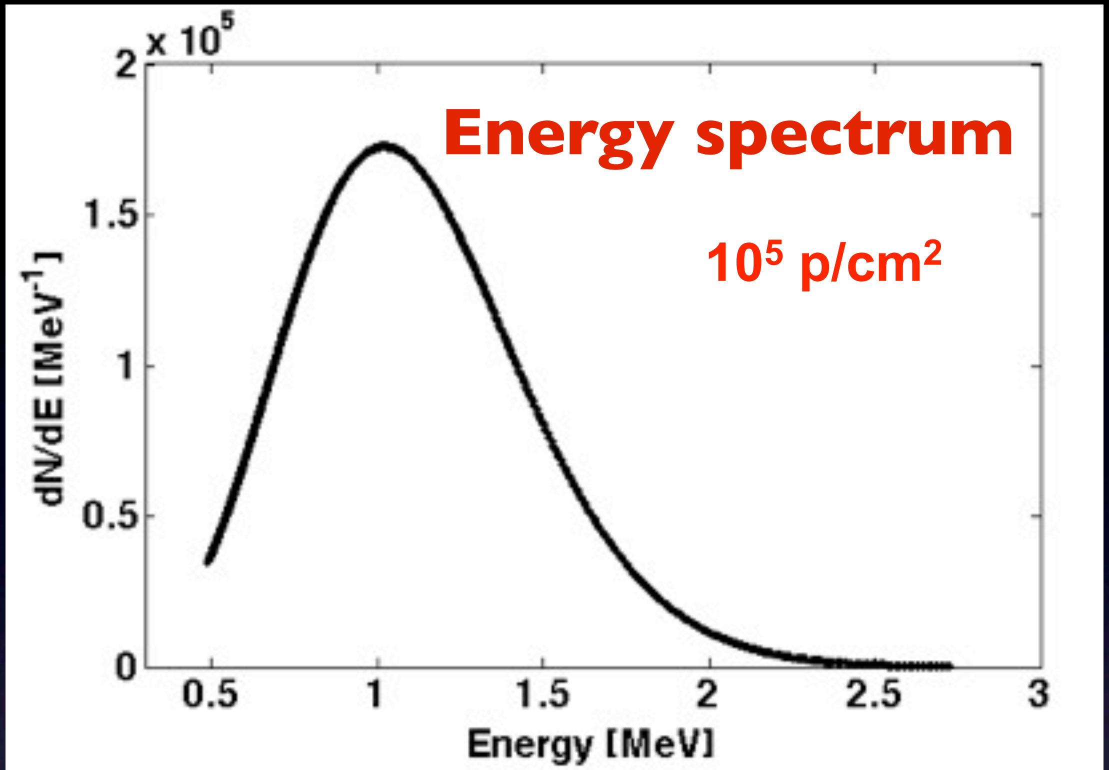

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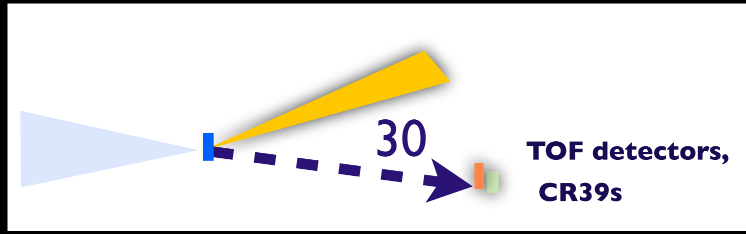

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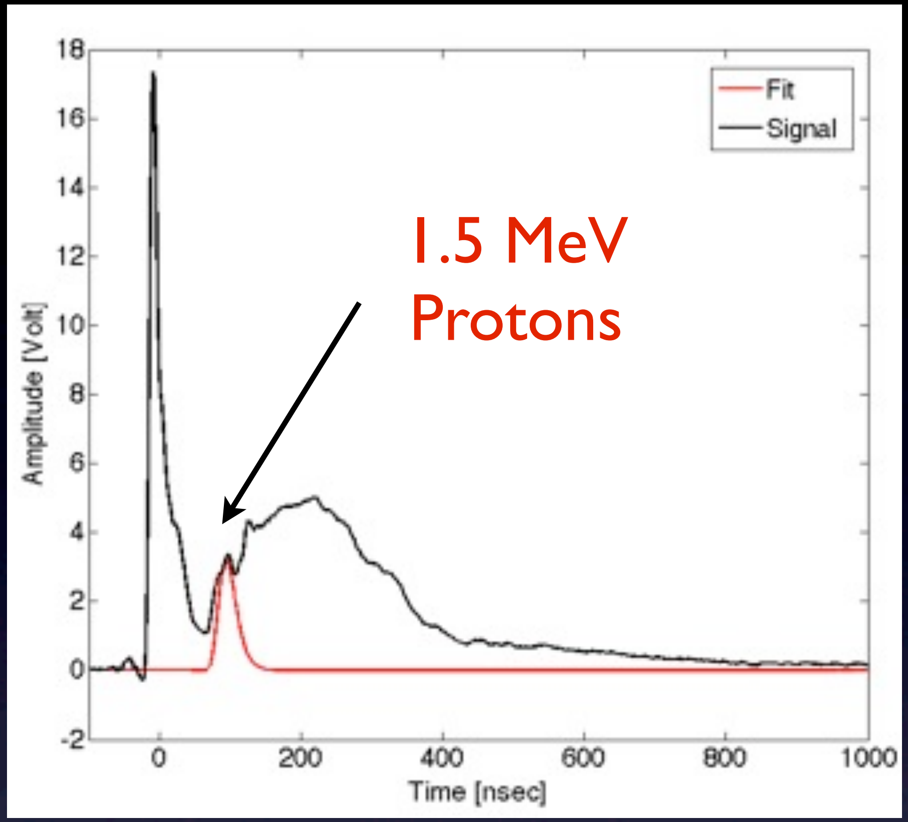

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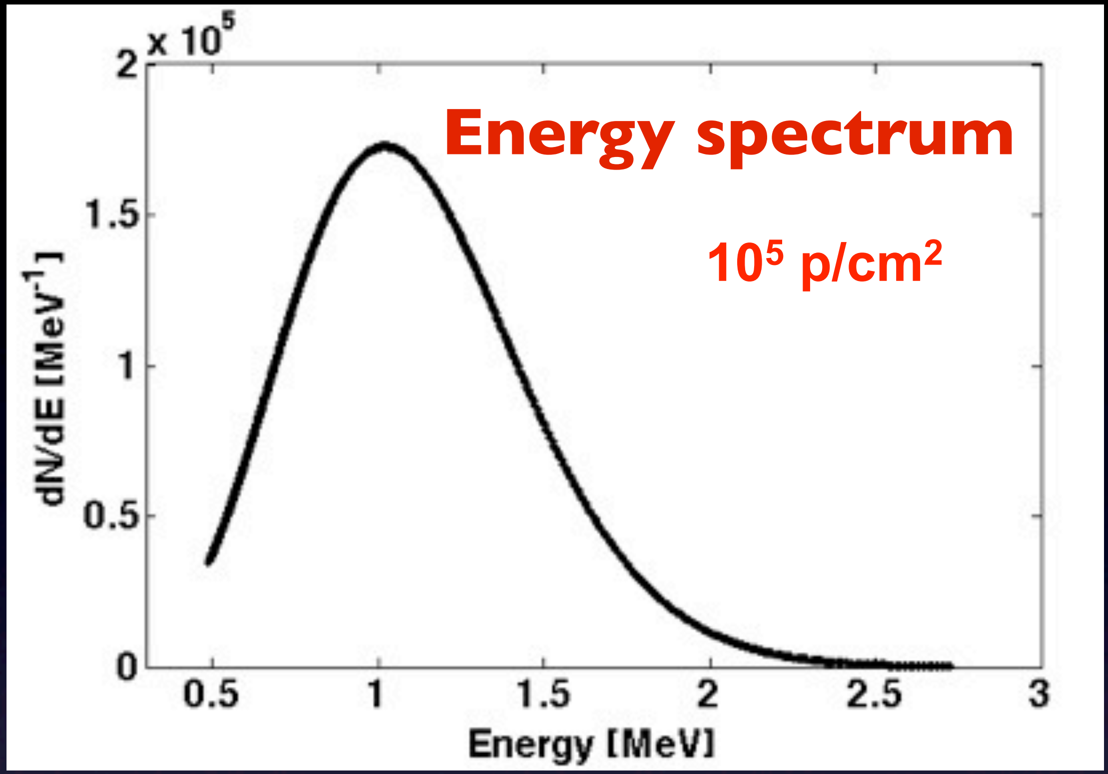
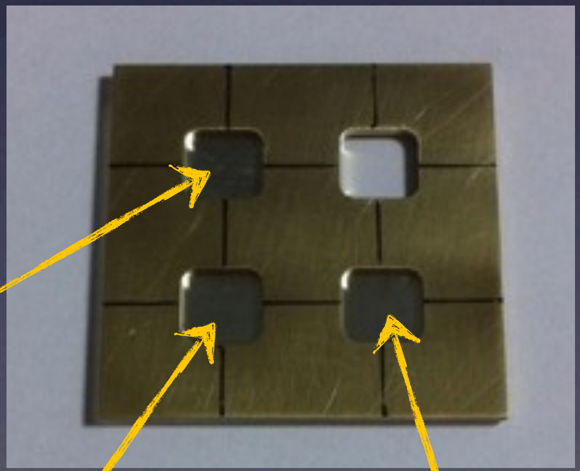


Nuclear track detectors CR39s



25 um

100 um

250 um

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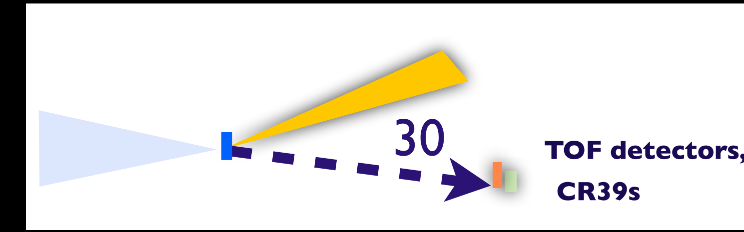
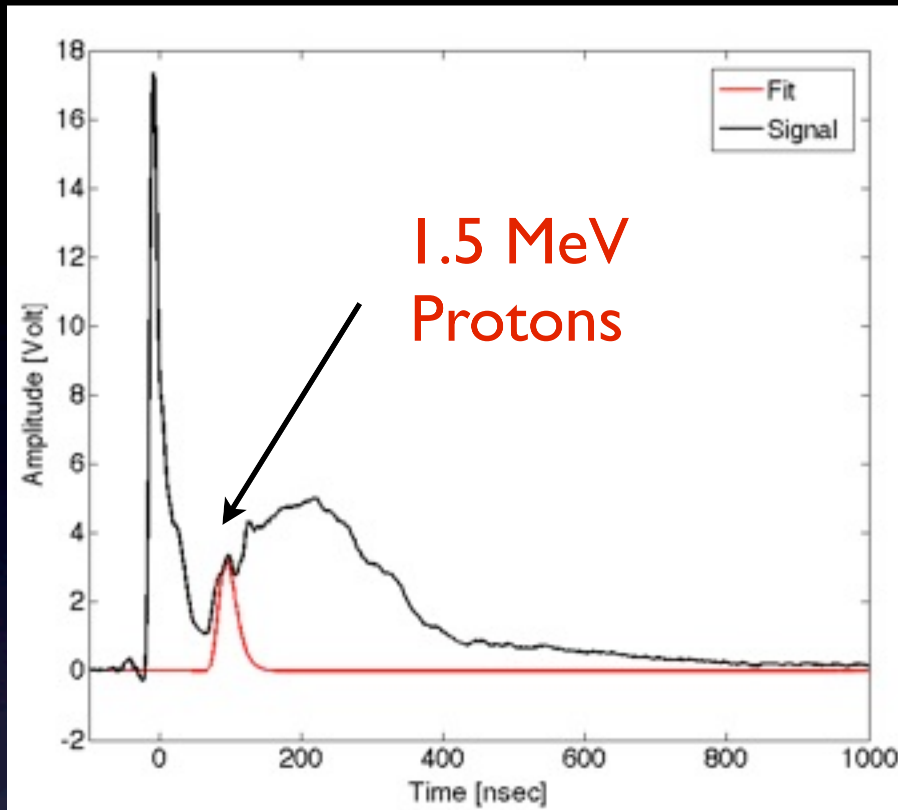
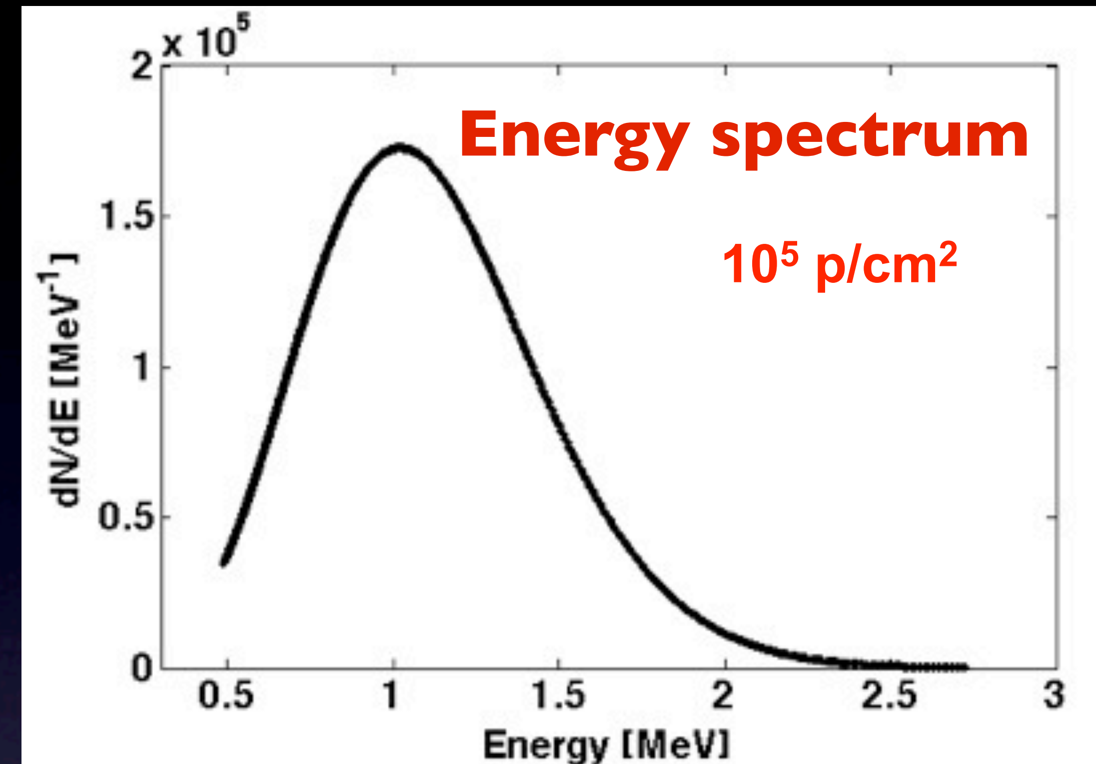


Deconvolution

Queen's University Belfast





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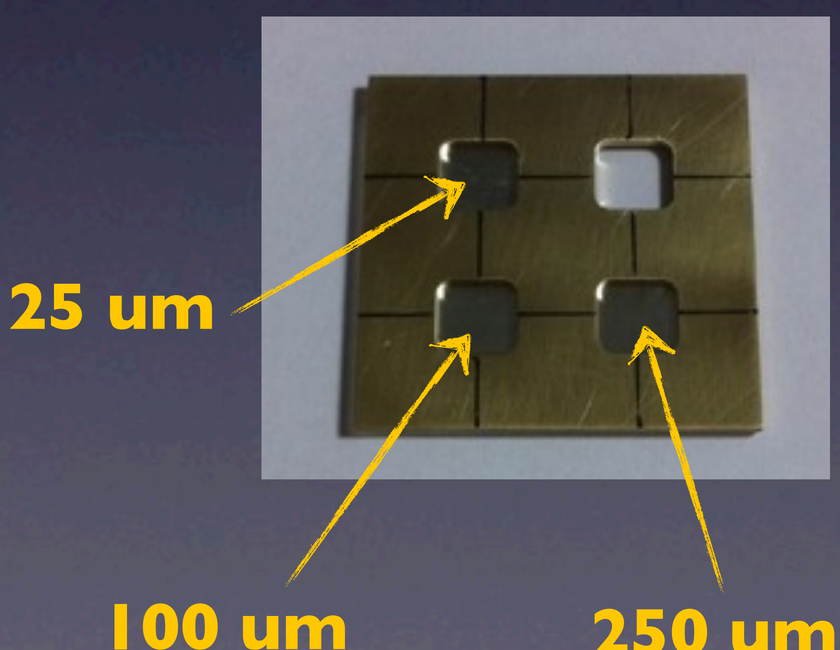

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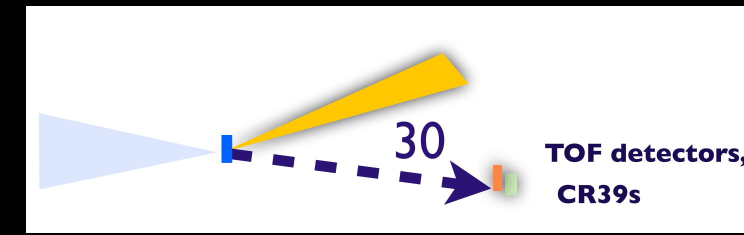

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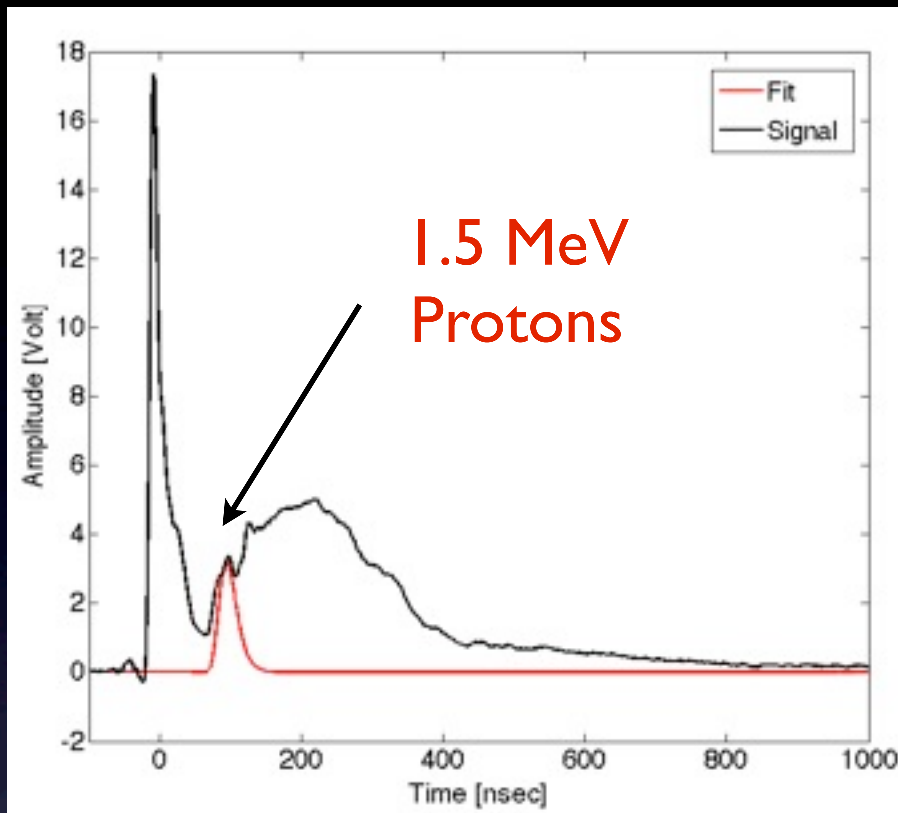

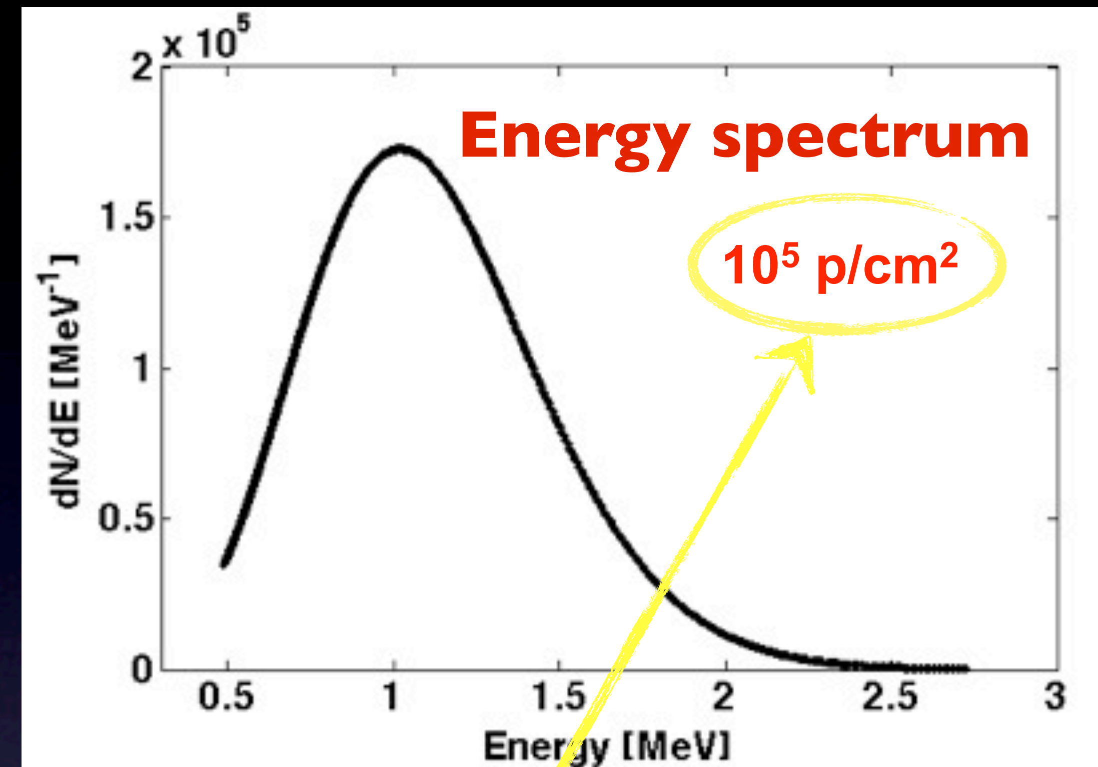

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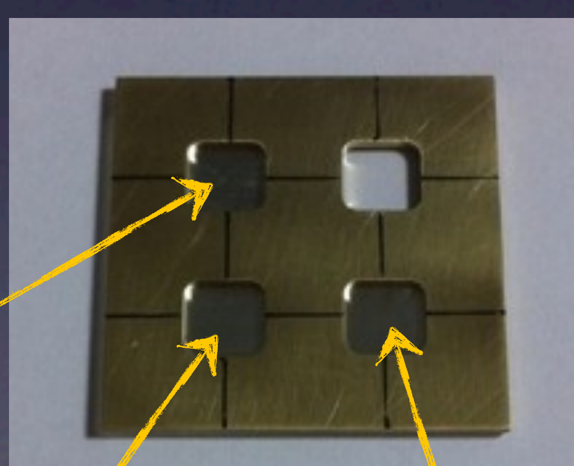

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Dosimetry of laser-driven ion beams

High dose-rate
Low reproducibility shot to shot
Very short and intense ion pulse

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Dose-rate independent absolute dosimeter

Multi-gap ionization chambers for pulsed beams for online dose measurements

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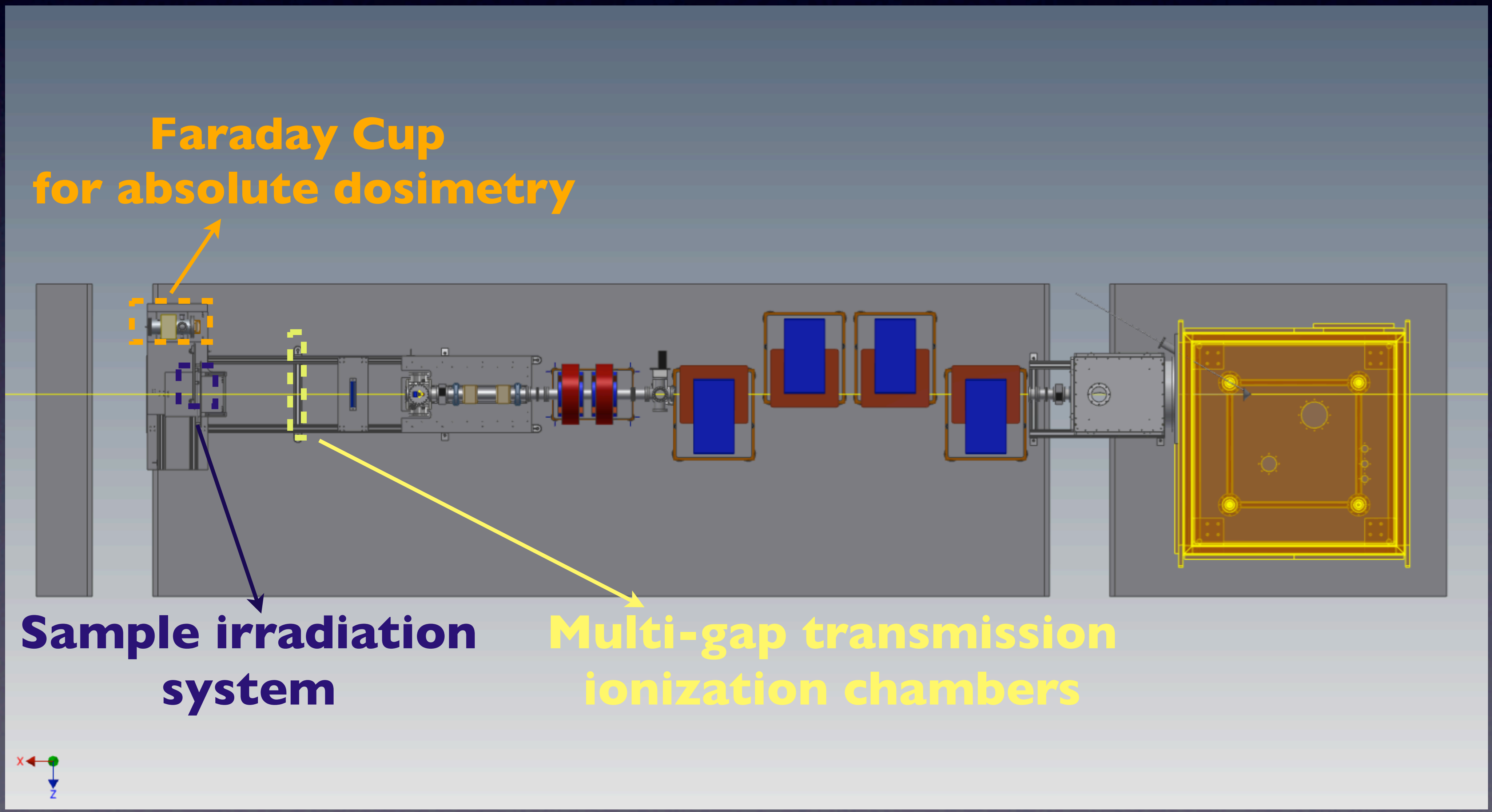

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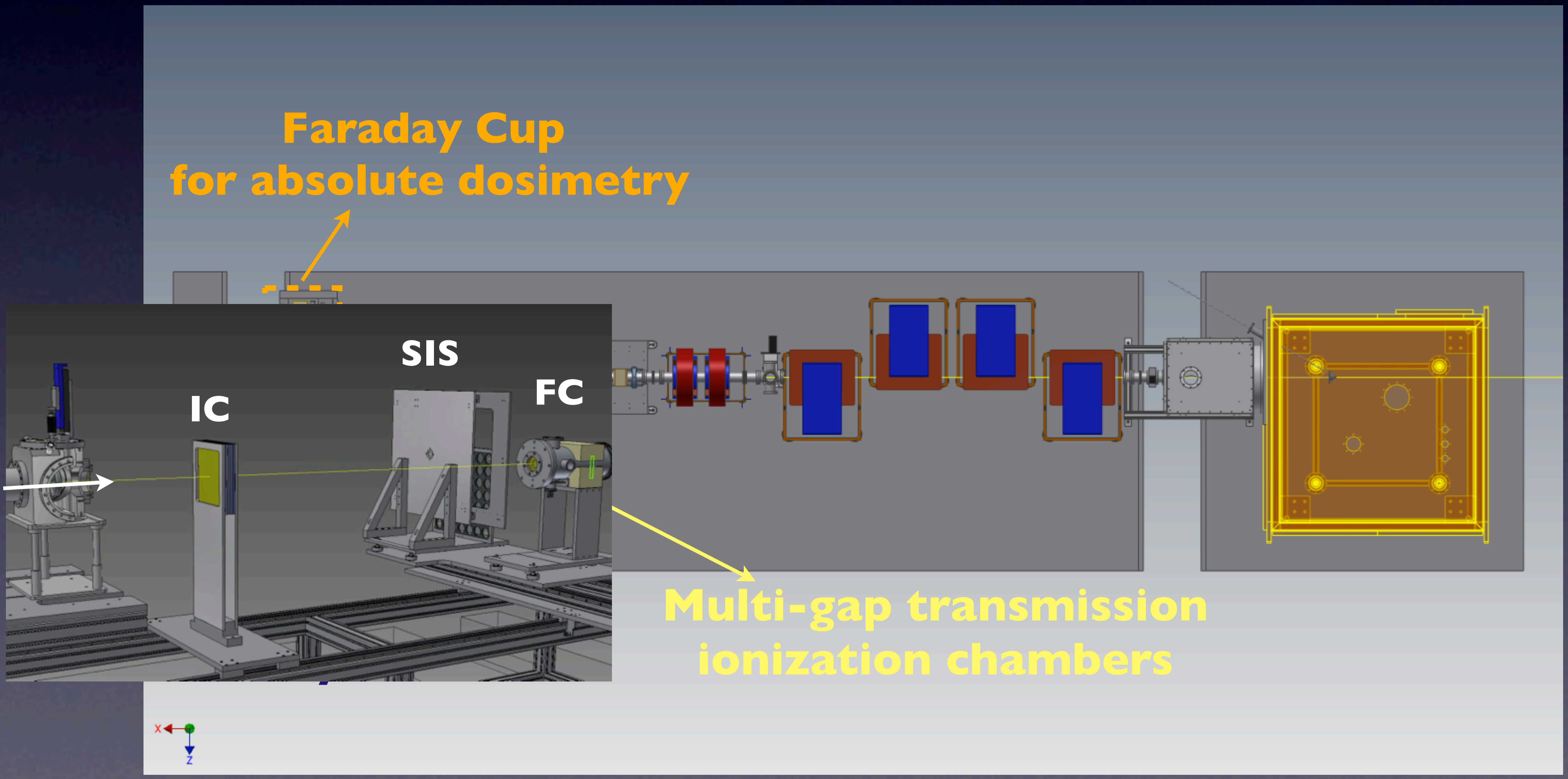

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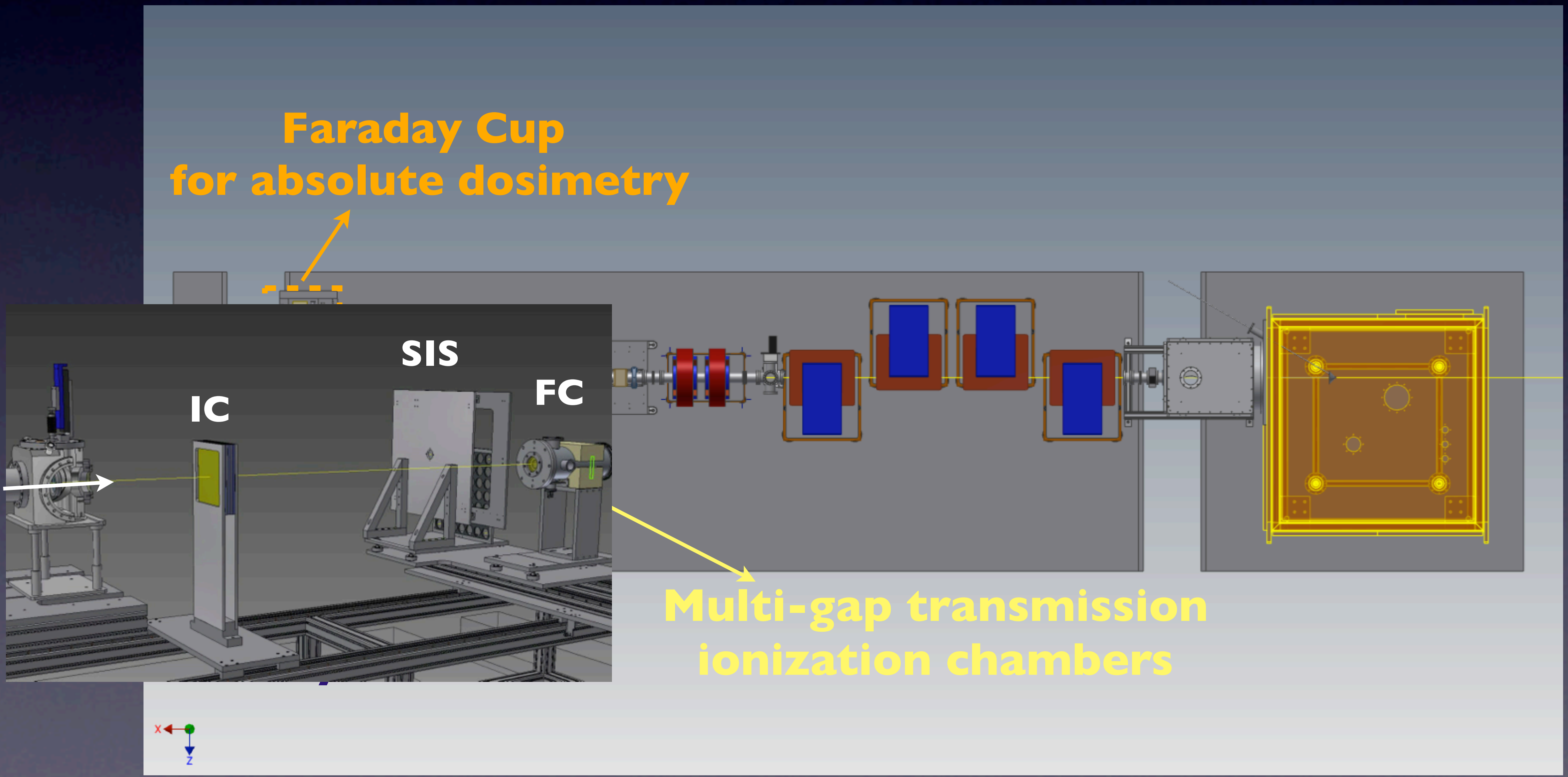

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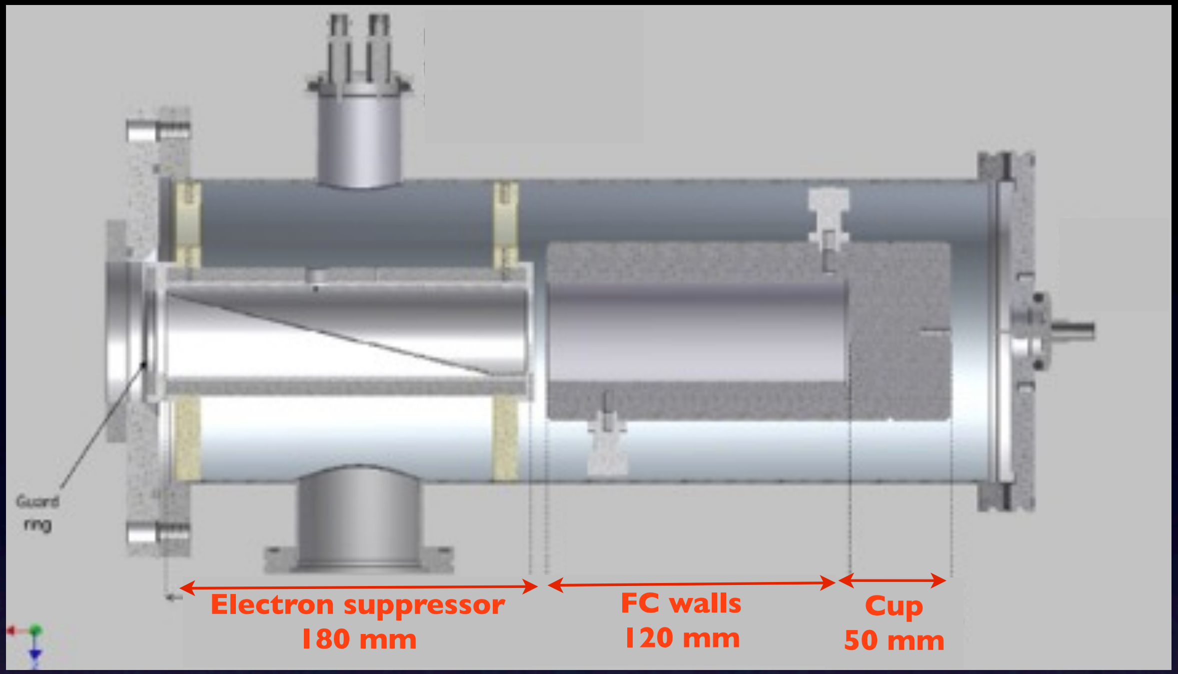
Absolute dose measurement

Faraday Cup



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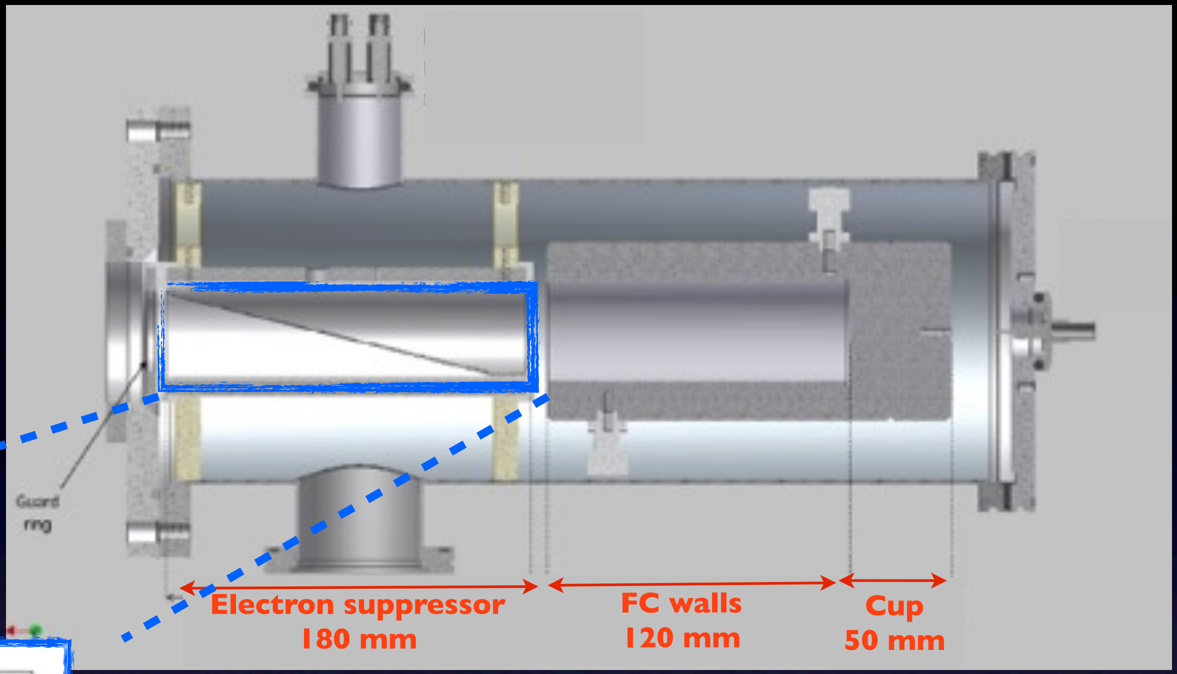
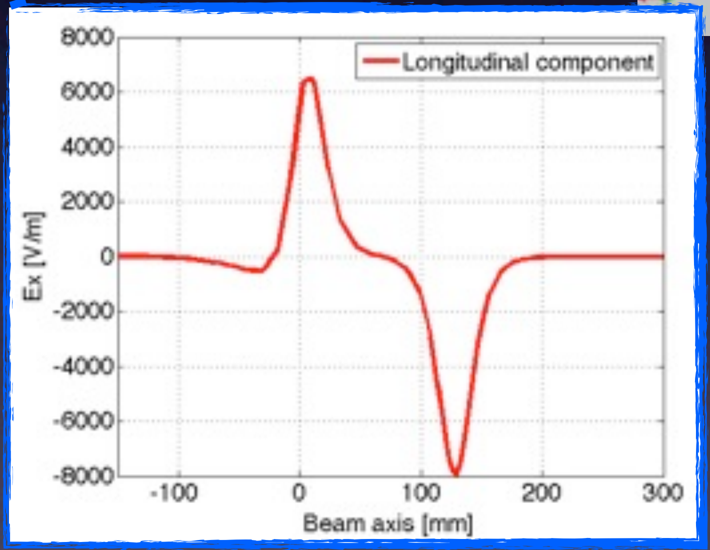


Electric field along the beam axis



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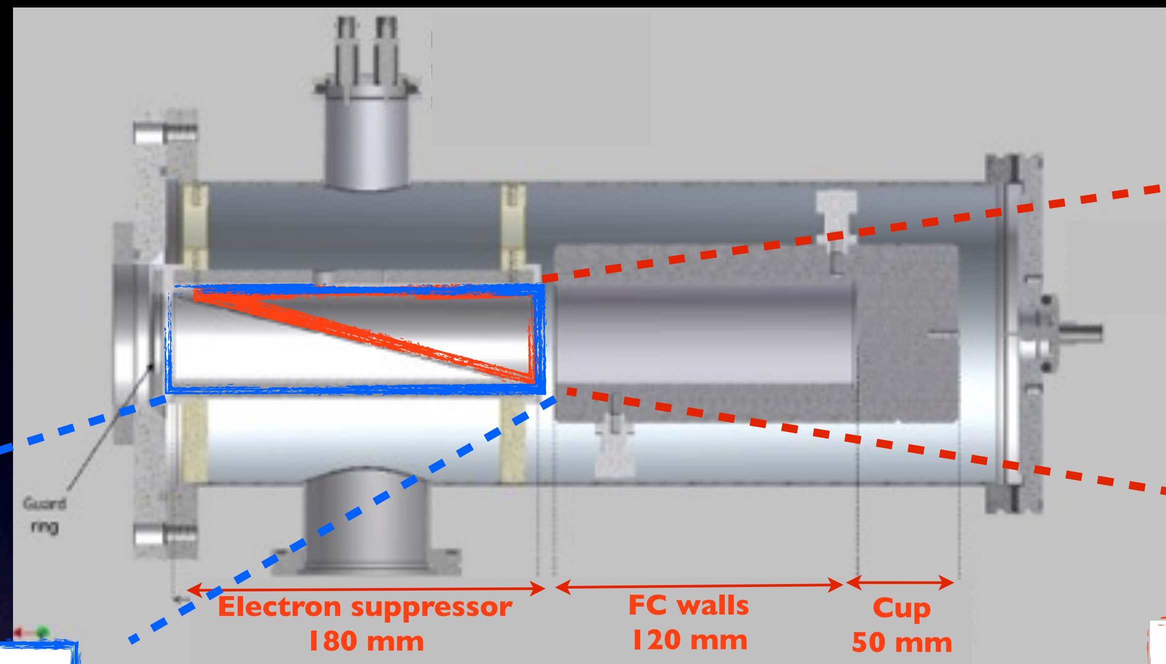
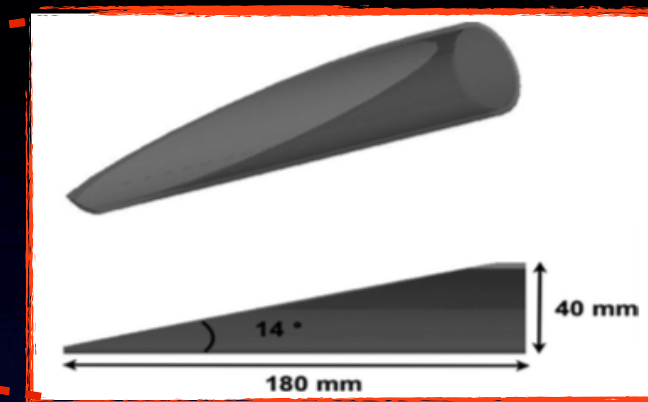


Special beveled electrode



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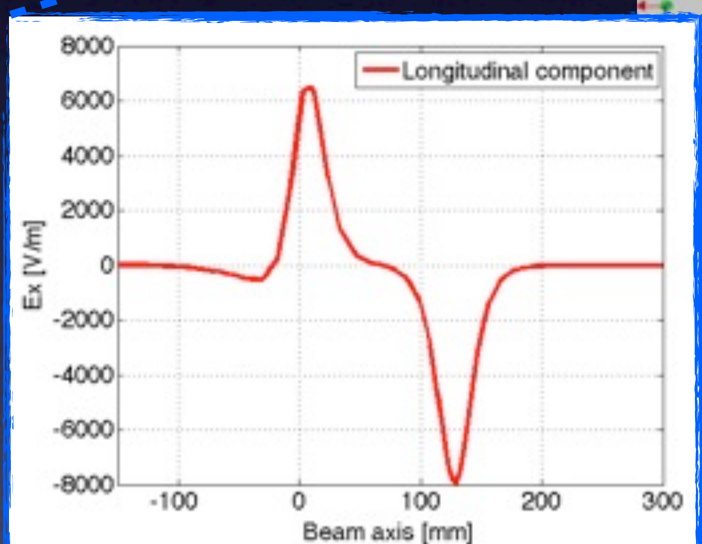

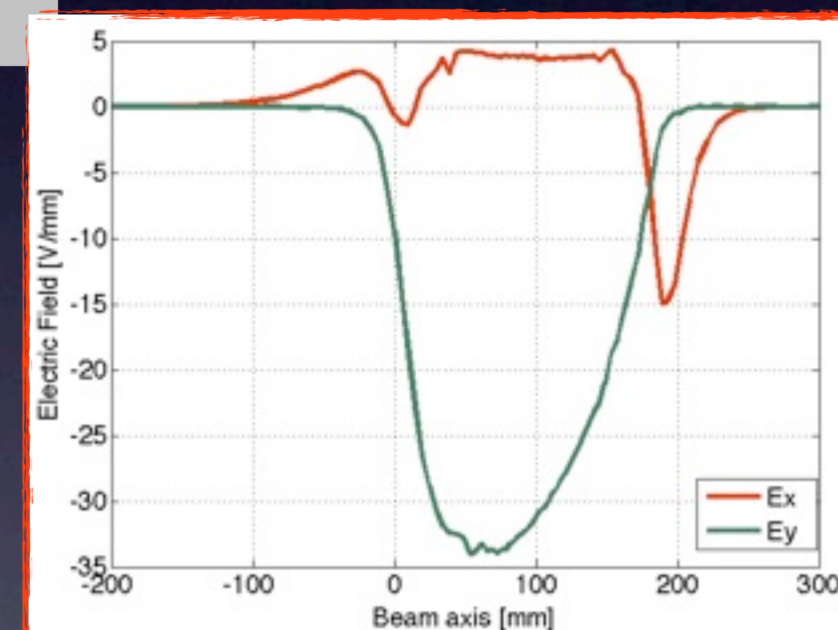

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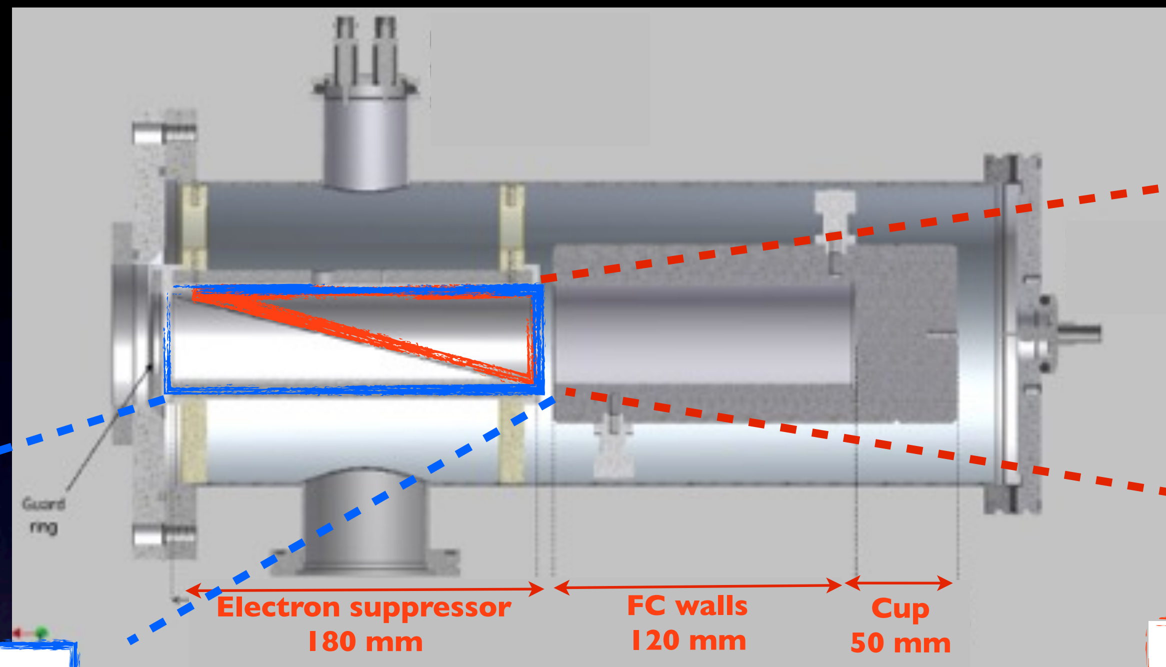

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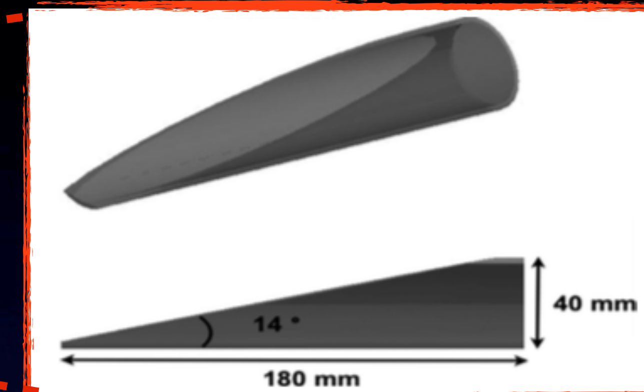

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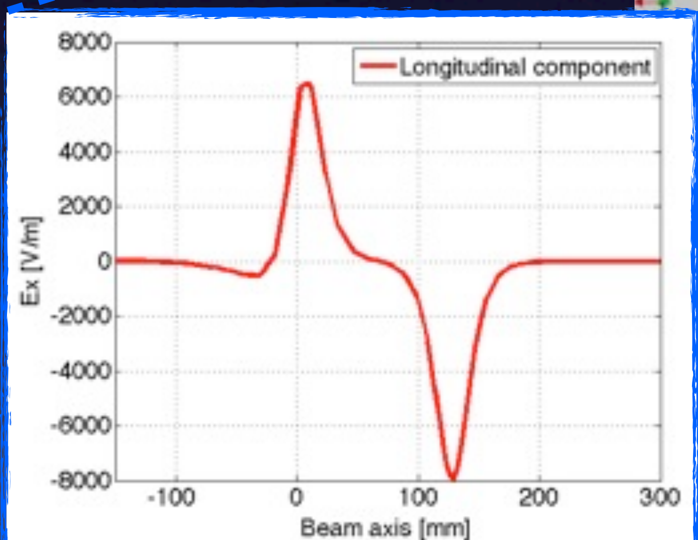
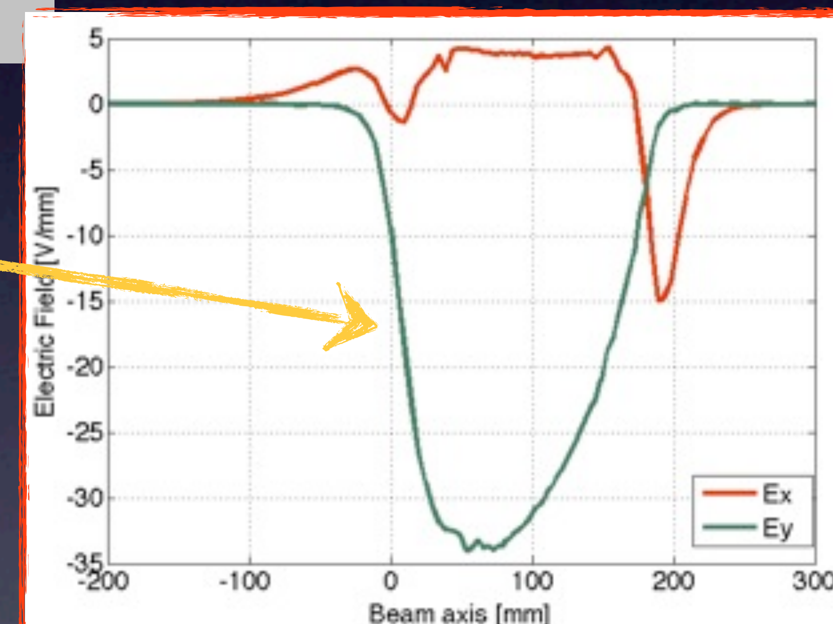


High transverse electric field component



Absolute dose measurement

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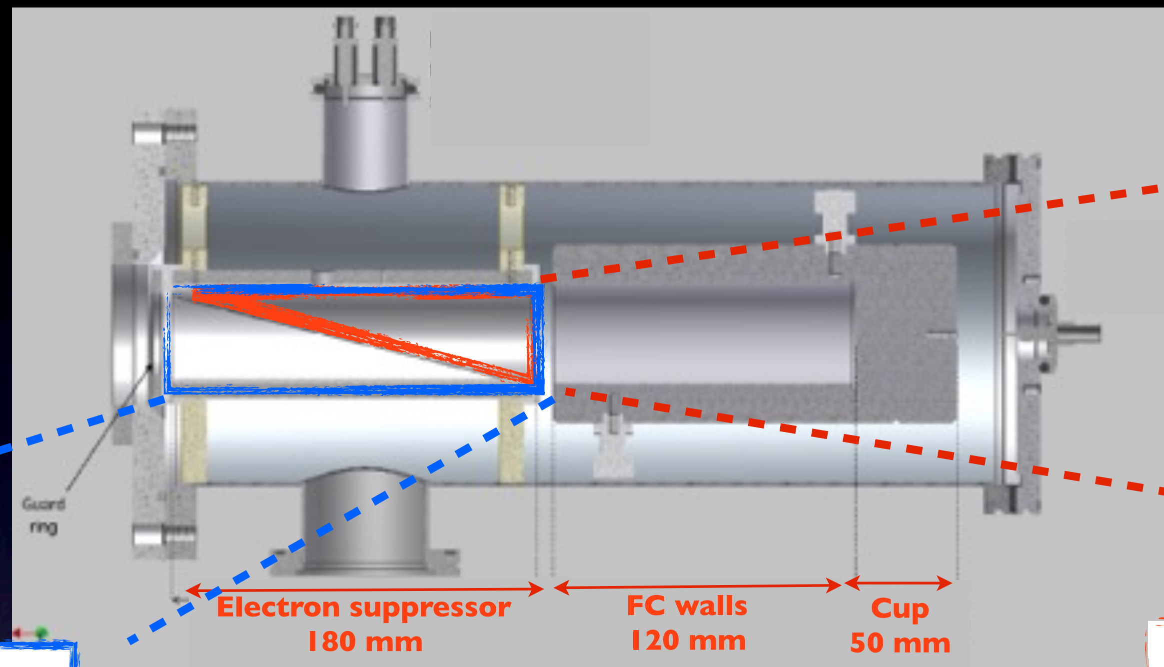

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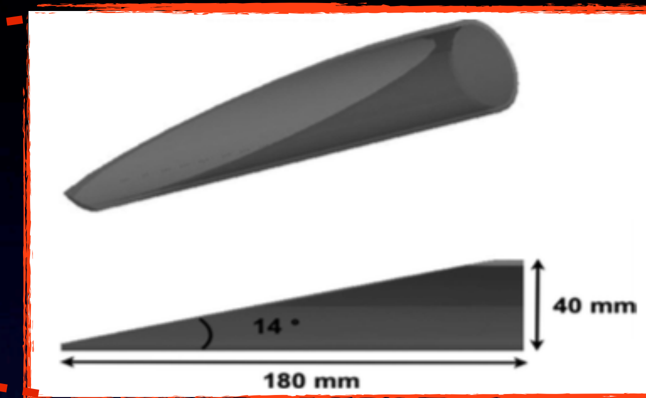

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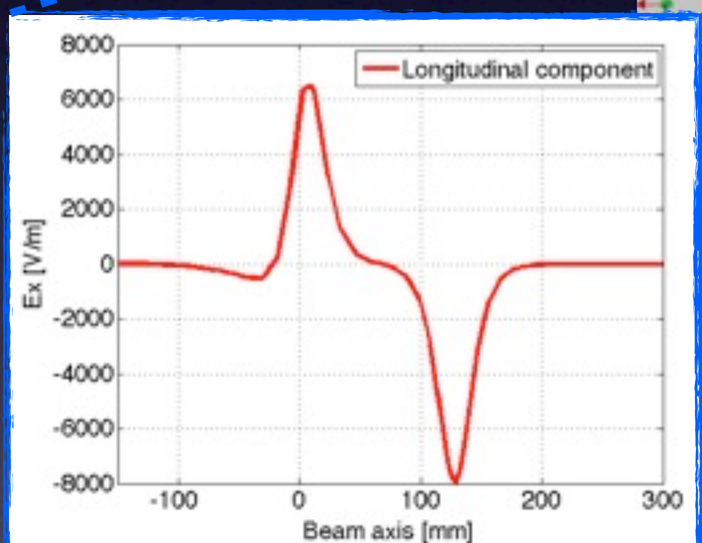

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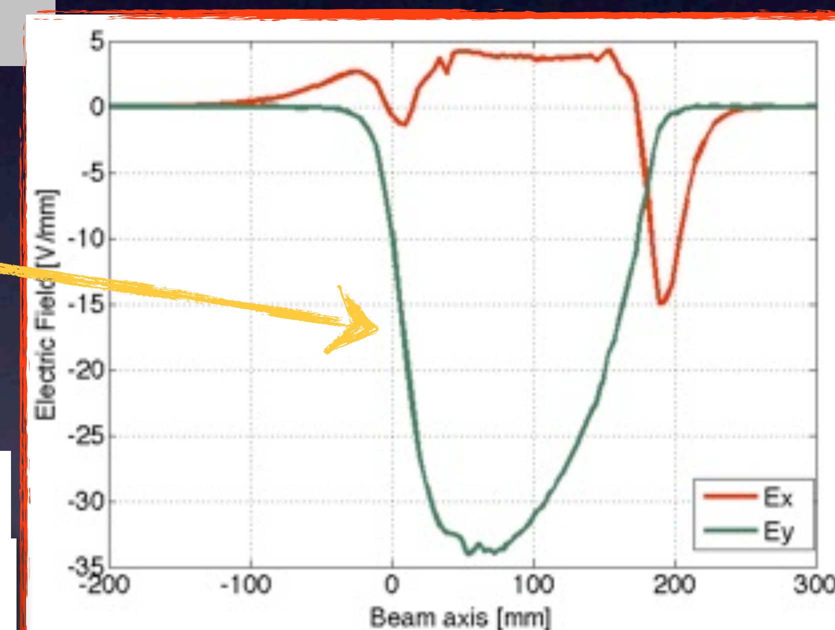
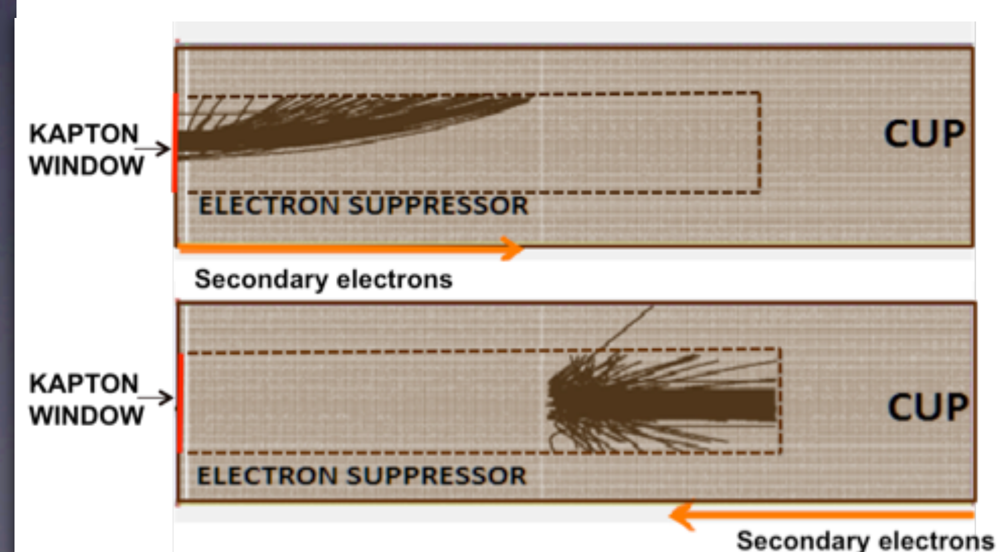


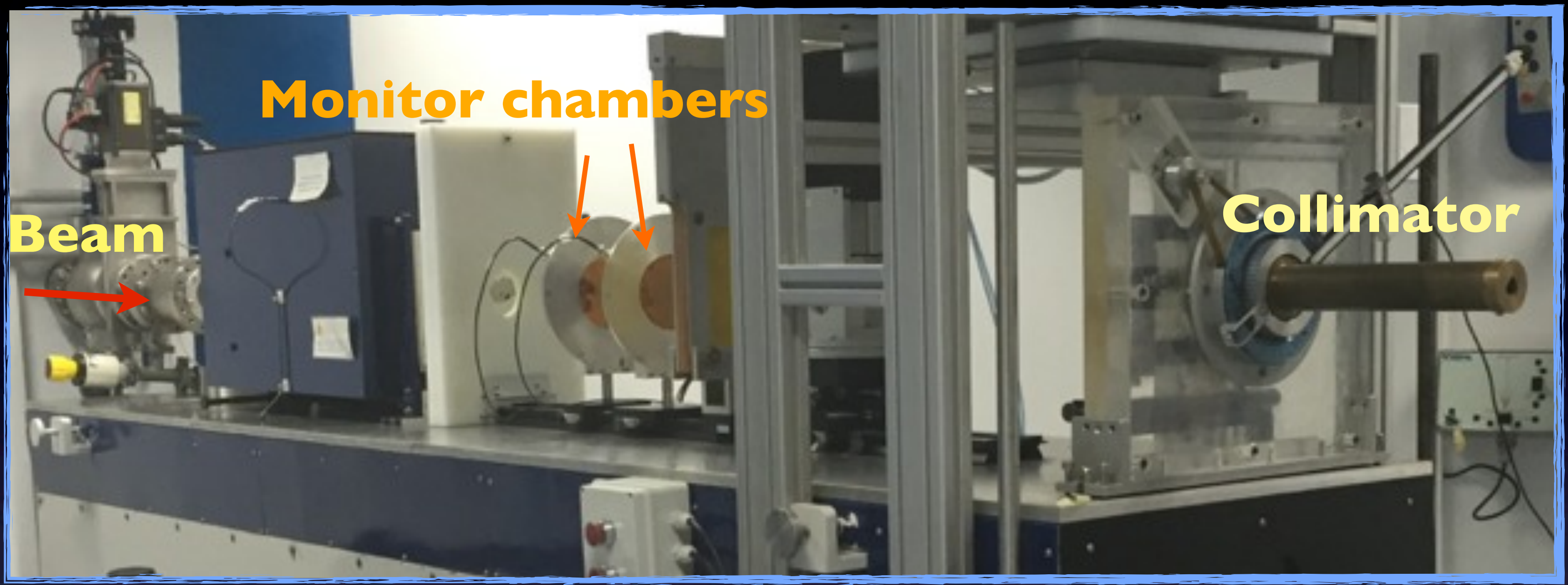
SIMION simulations



FC characterization @CATANA proton therapy facility (INFN-LNS)

Experimental setup

CATANA facility



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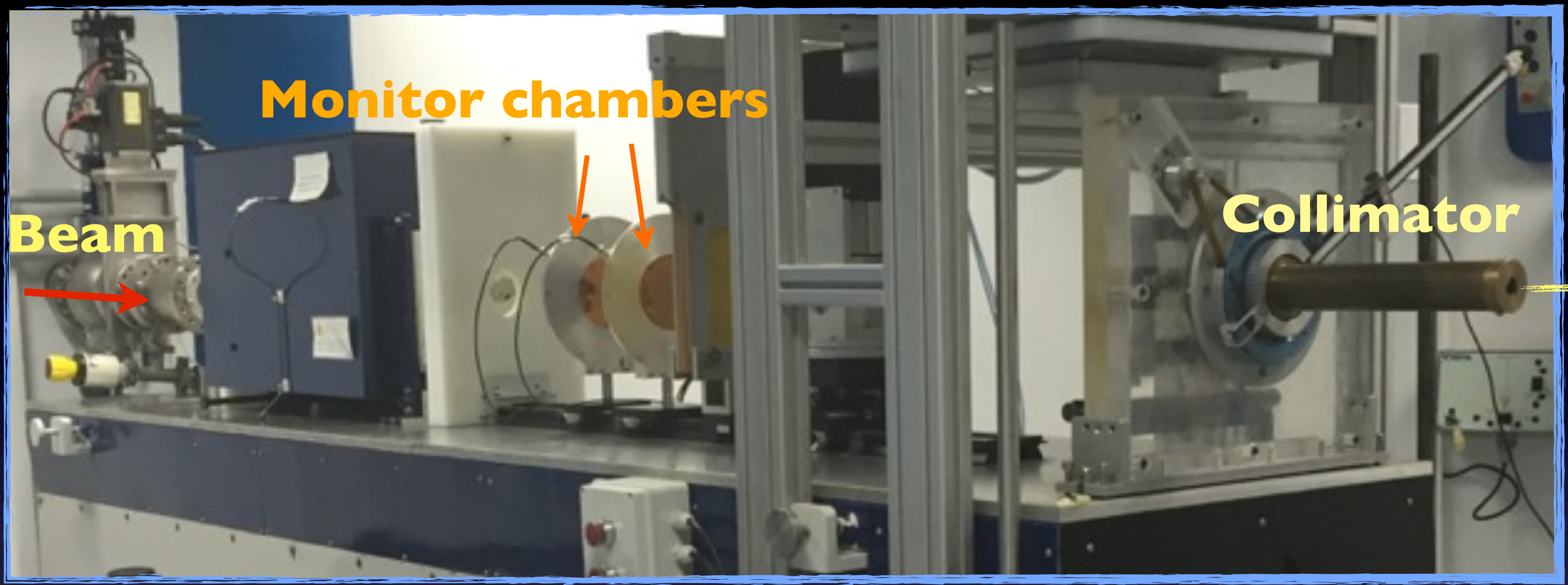
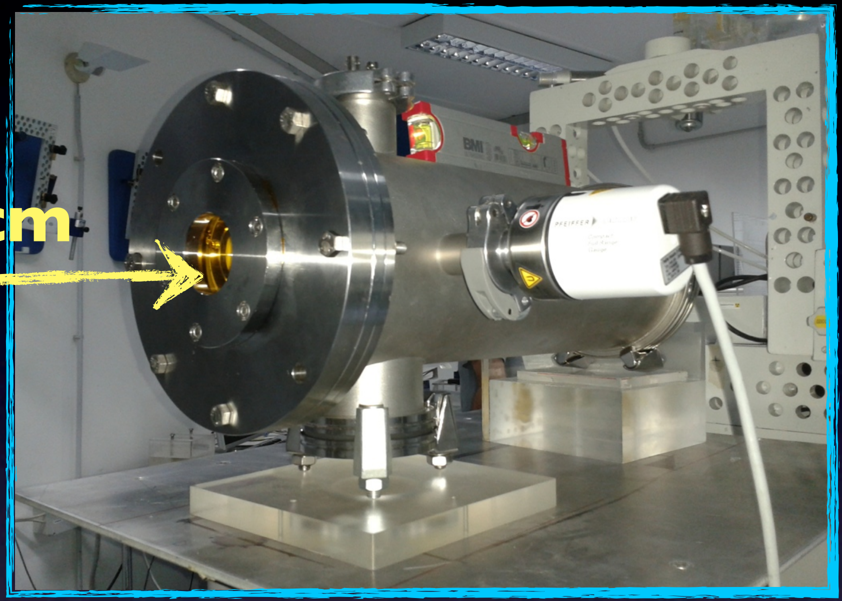


9 cm



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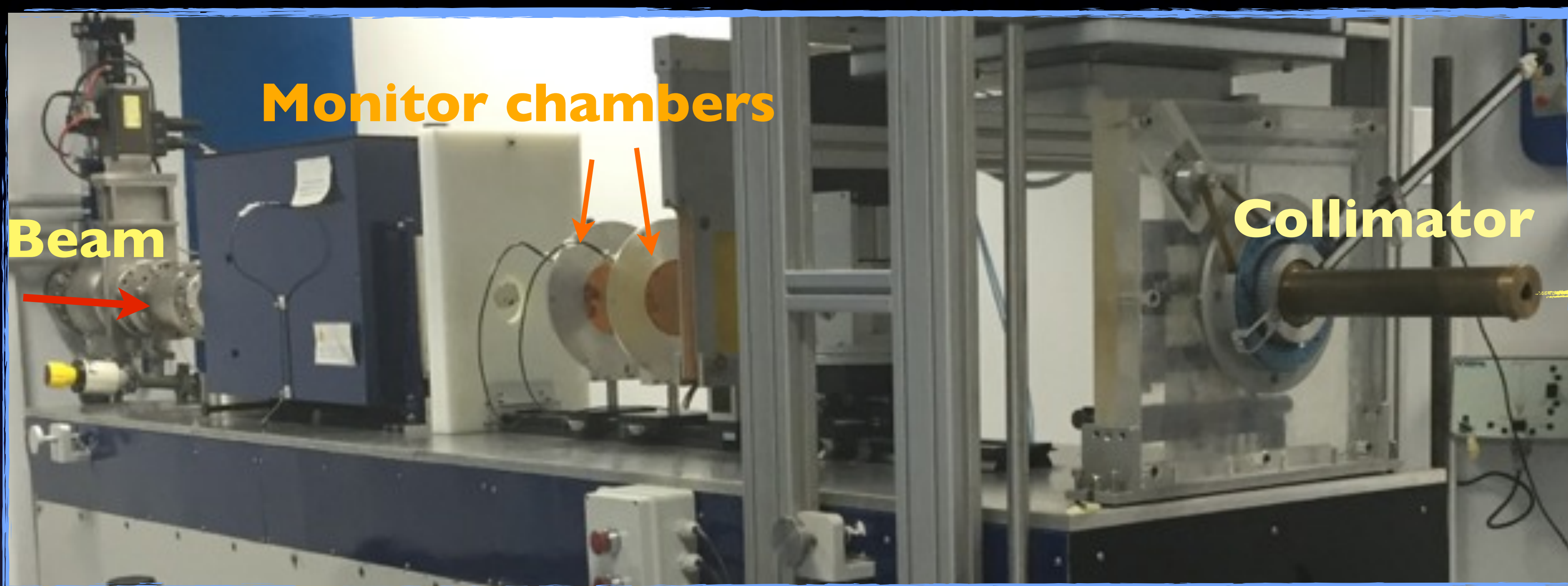
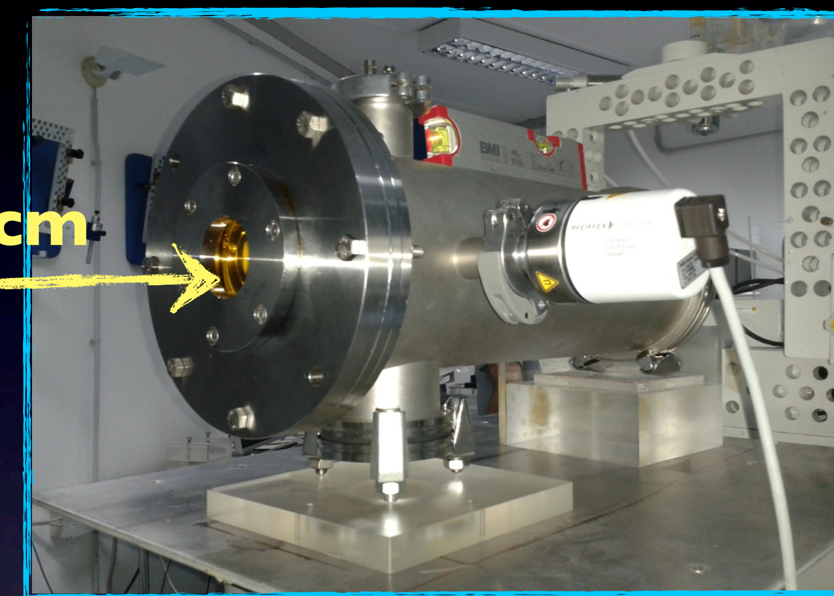
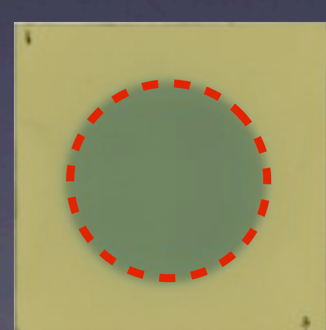
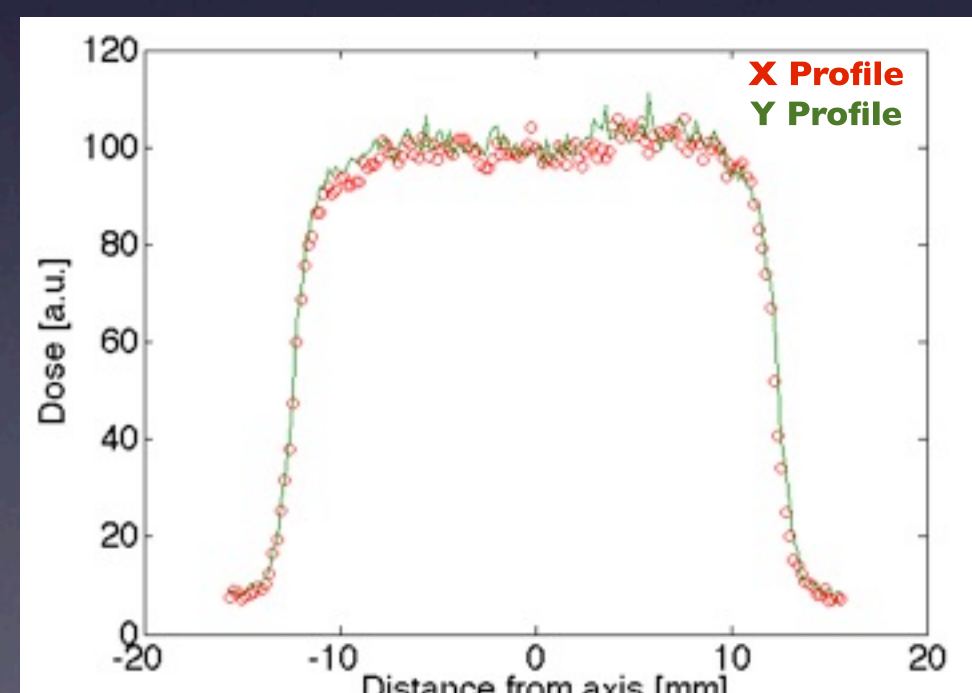




Beam characteristics

62 MeV proton beam
Very flat spatial profile
Beam spot diameter 20 mm





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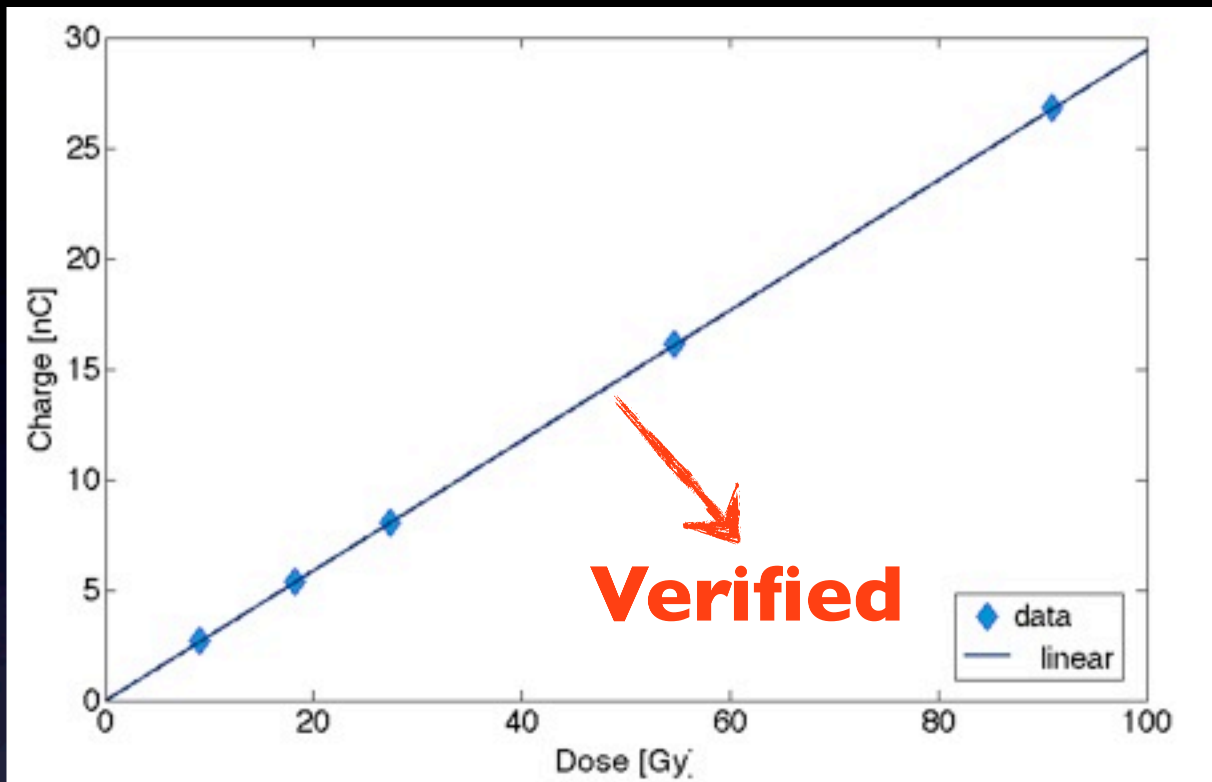
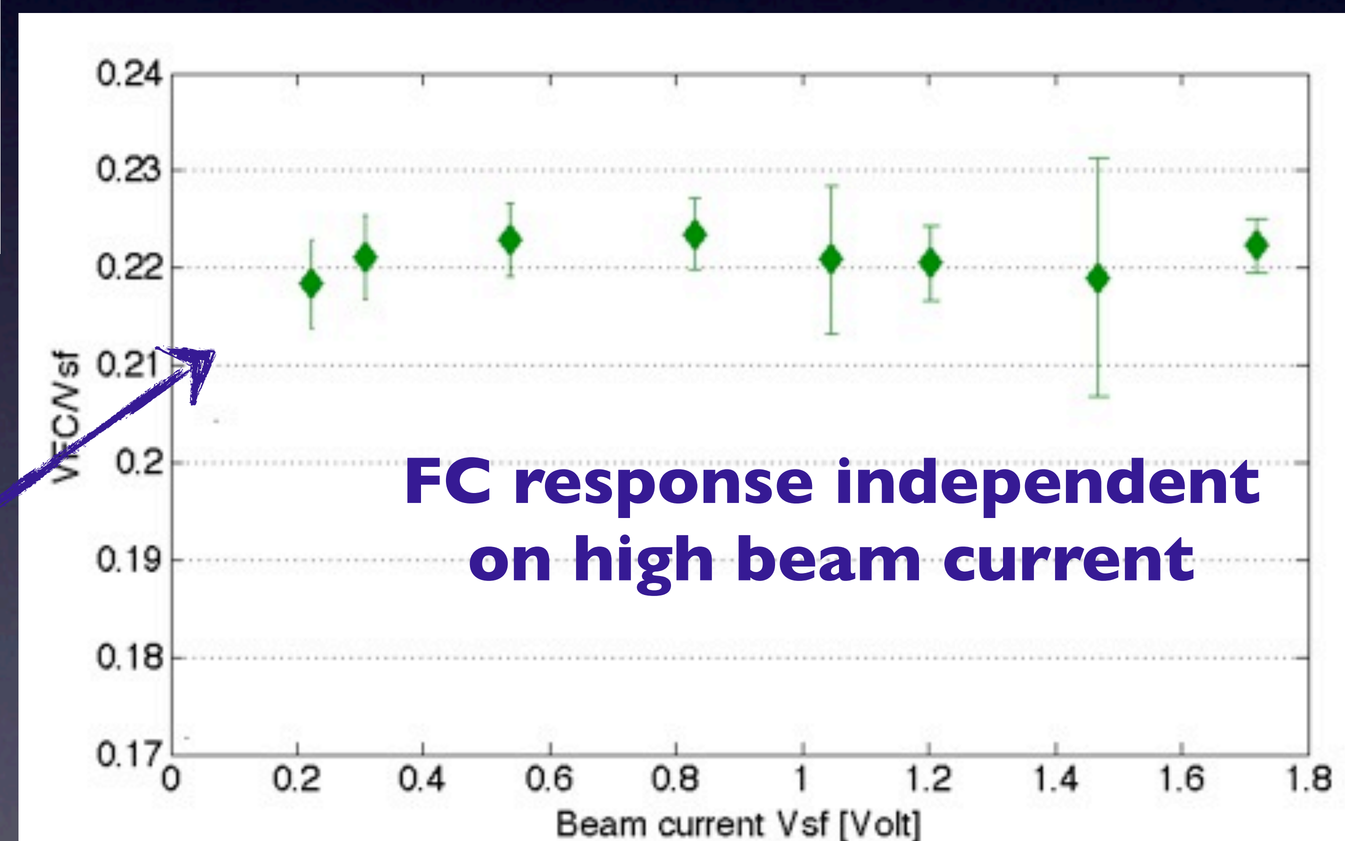
Charge dose linearity





Investigations at low beam current will be soon performed

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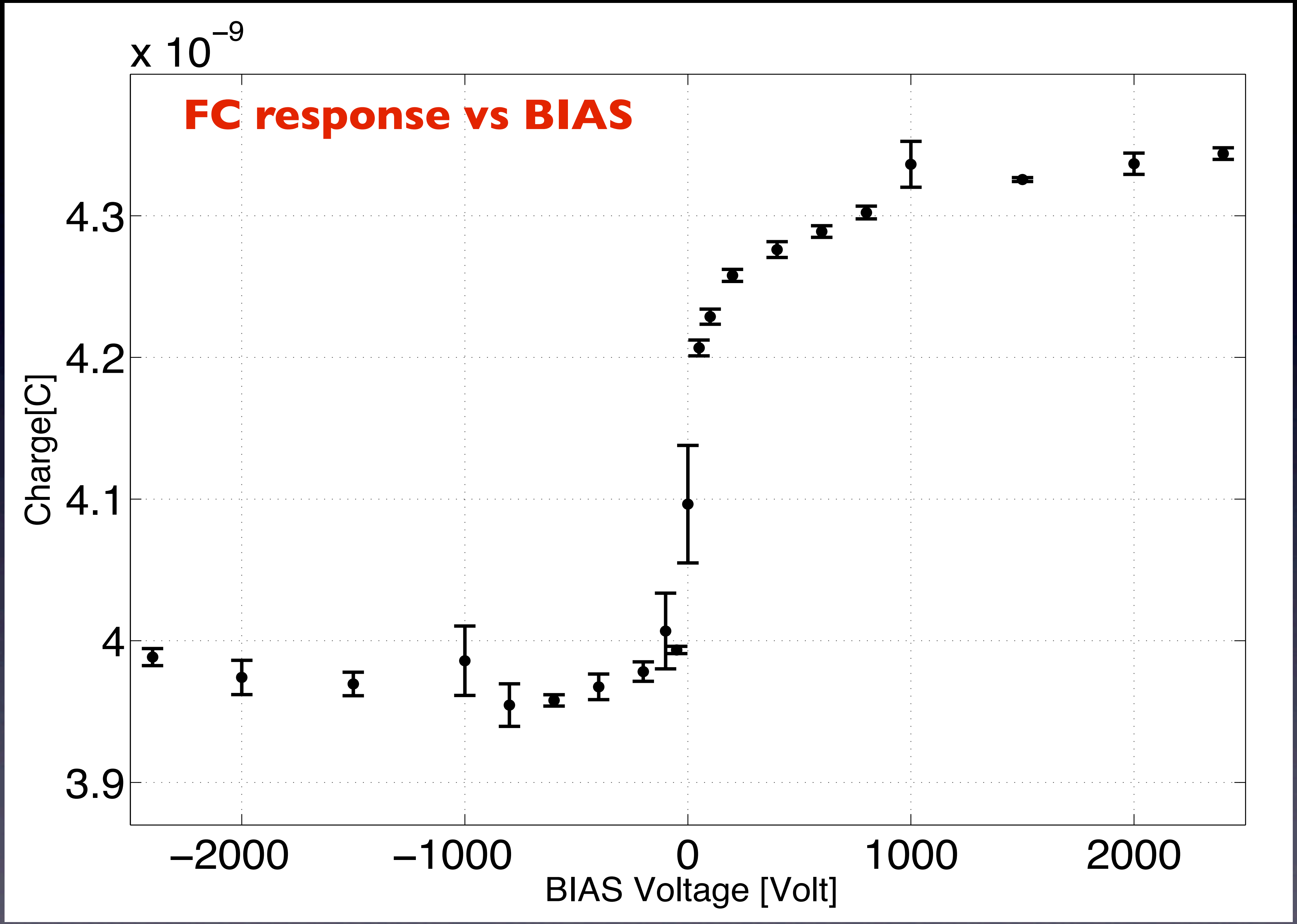

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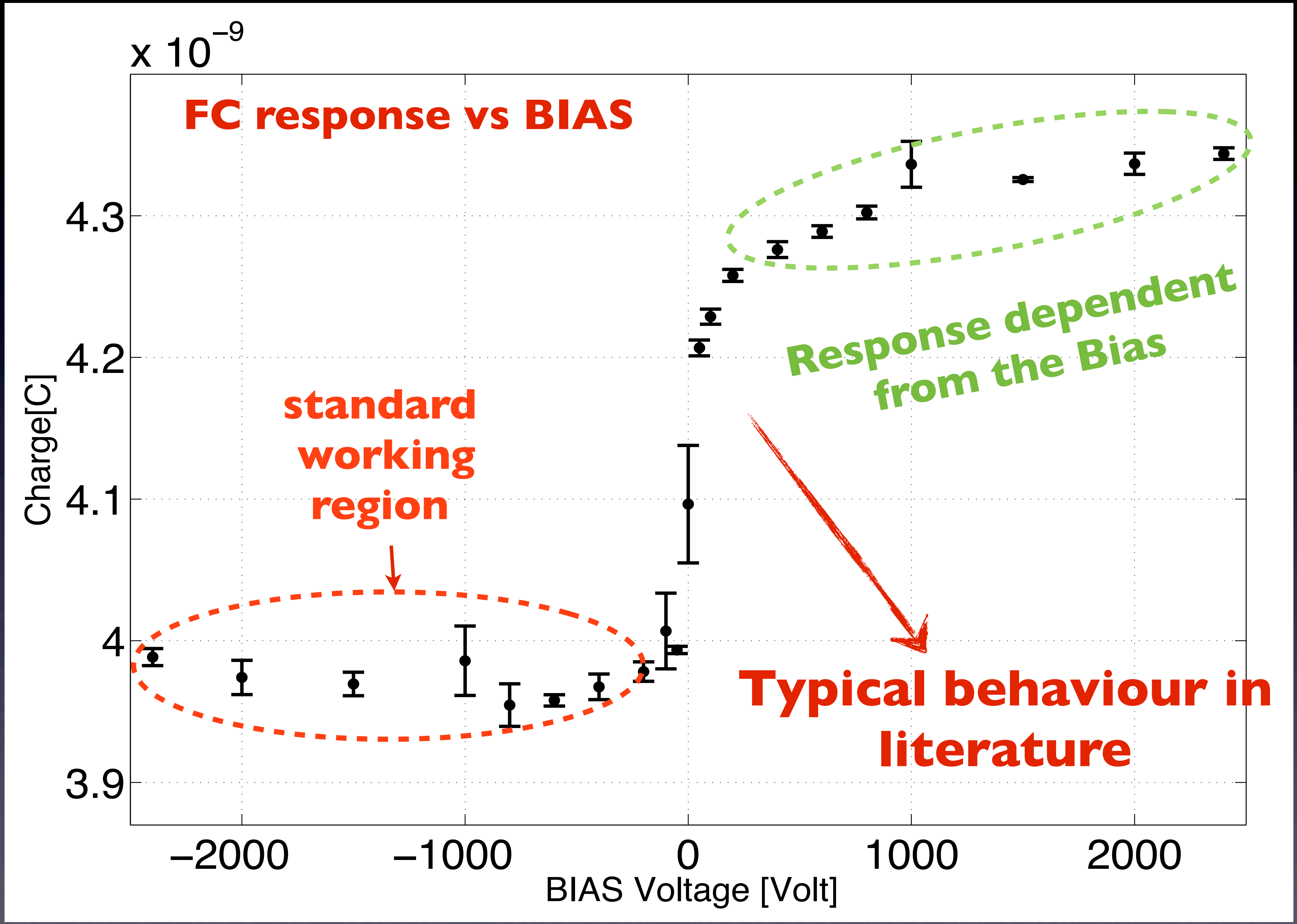

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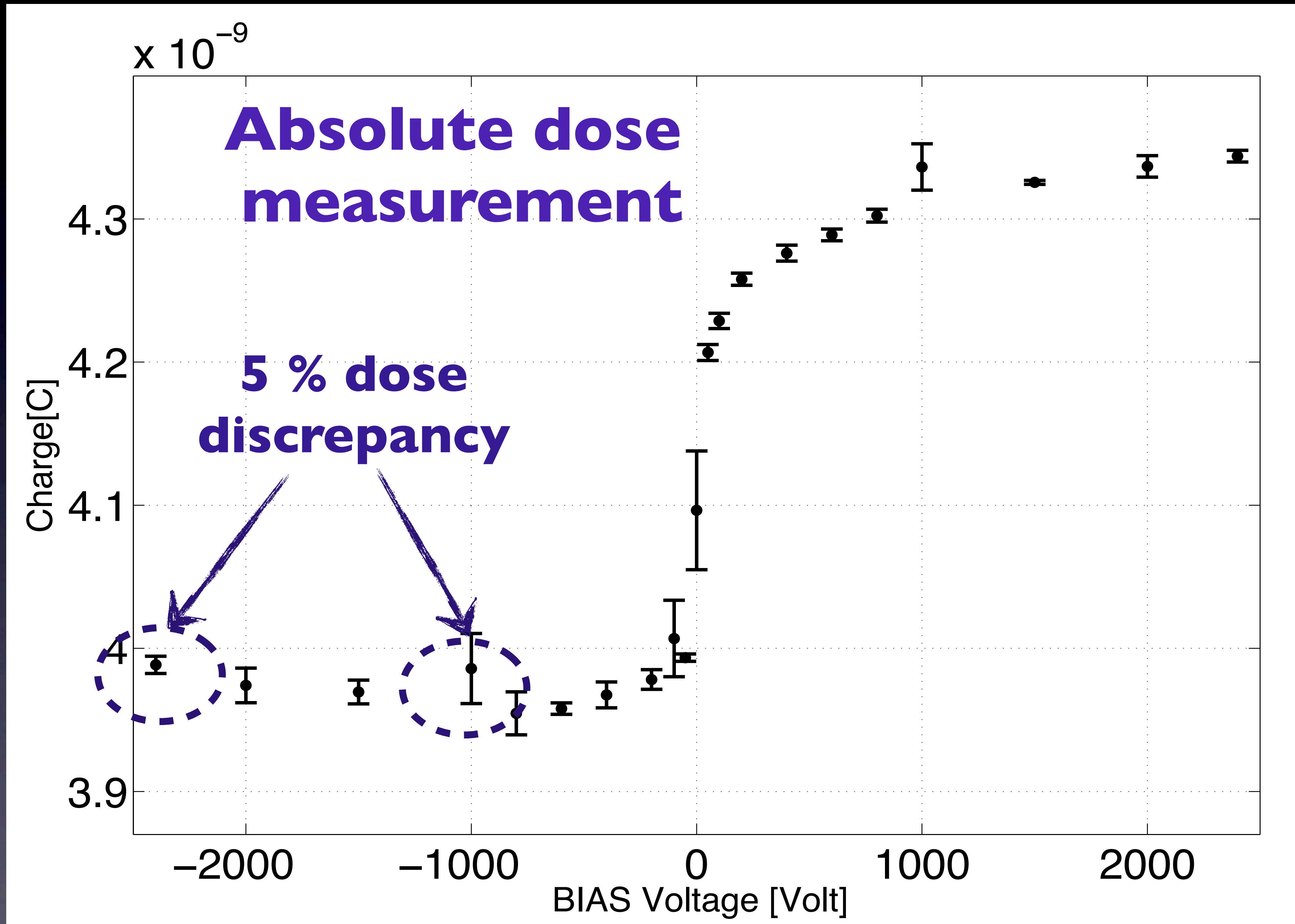

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Summary& Perspectives

ToF prototypes
tests@TARANIS

Summary& Perspectives

ToF prototypes tests@TARANIS → ToF spectrum analysis procedure for particle energy and fluence measurements

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Faraday Cup
characterization
with conventional proton beams

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Faraday Cup characterization with conventional proton beams → Investigation on the FC response in agreement with literature

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FC dose measurements with laser-driven proton beams

Thank you for your attention