Diamond hodoscope for hadron therapy

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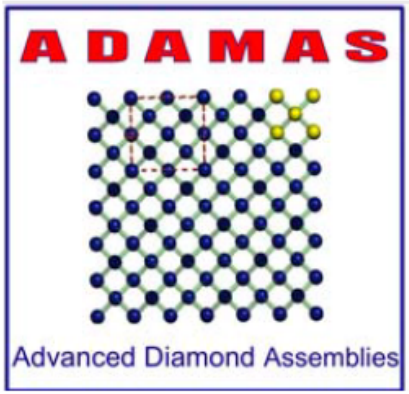


1st ADAMAS workshop, December 16-18th 2012, Darmstadt, Germany

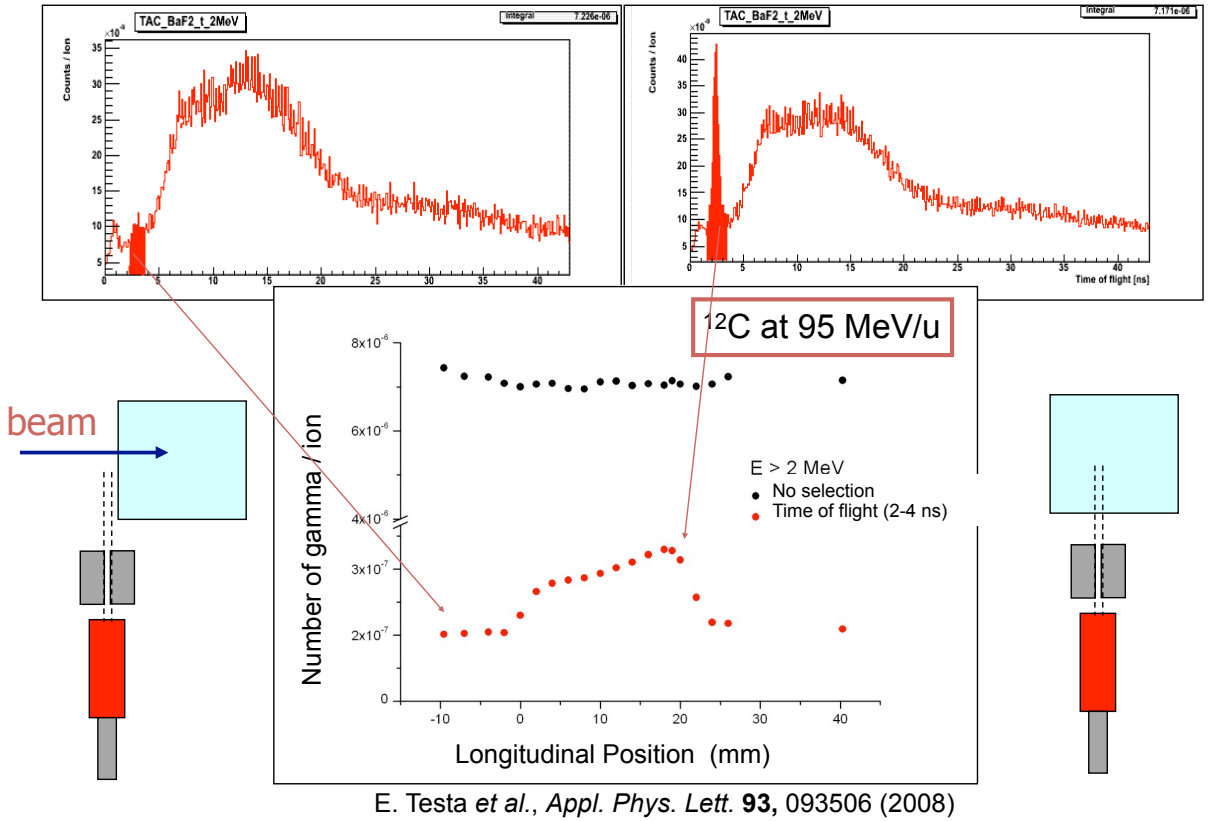
GamHadron Partners

GamHadron - Compton Camera for in vivo real time dose imaging in hadron therapy

- IPN Lyon
- CREATIS Lyon
- LPC Clermont-Ferrand

Outline

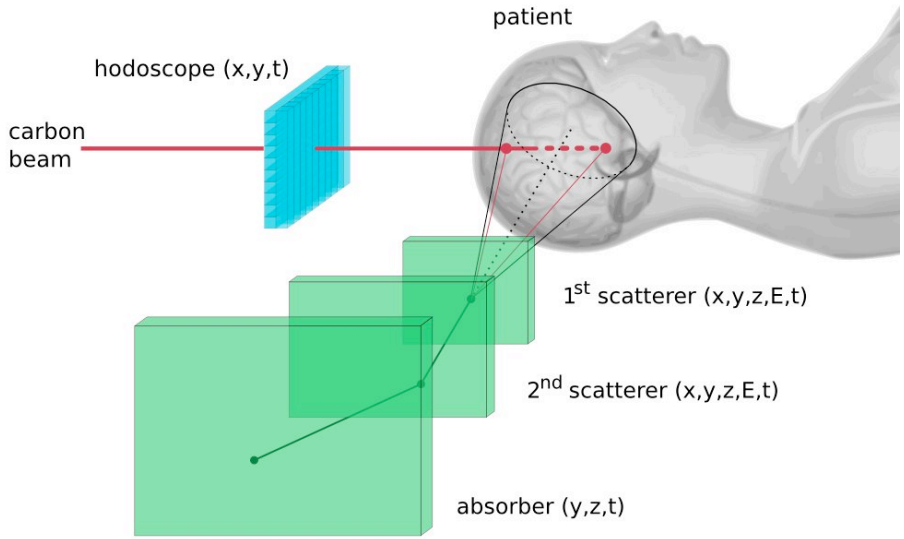
Prompt γ imaging: principle and feasibility studies



E. Testa *et al.*, *Appl. Phys. Lett.* **93,** 093506 (2008)

All content here Denis Dauvergne, IPN Lyon

A Beam-triggered Compton



- Initial design study: 3 interaction-system
- Hodoscope: x,y,T
- Reconstruction = line-cone intersection

GamHadron Hodoscope

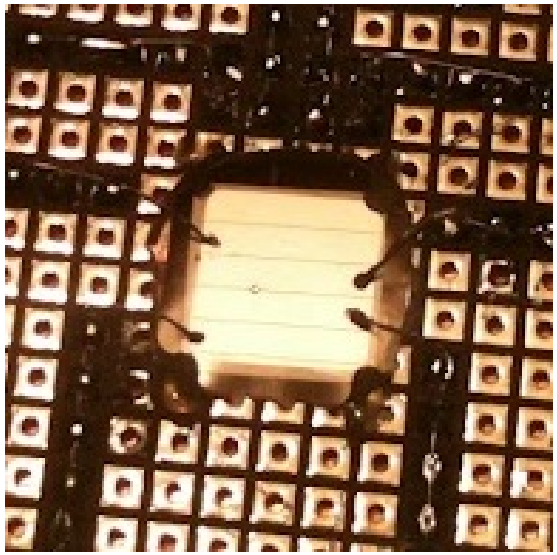
Requirements for GamHadron Hodoscope:

- area 10 x 10 mm^2
- position resolution $<$1 mm
- time resolution $<$ 1 ns
- rate capability $>$ 1 GHz/total area
- radiation hard

two candidates: scintilating fibers and diamond hodoscope

Diamond Detector

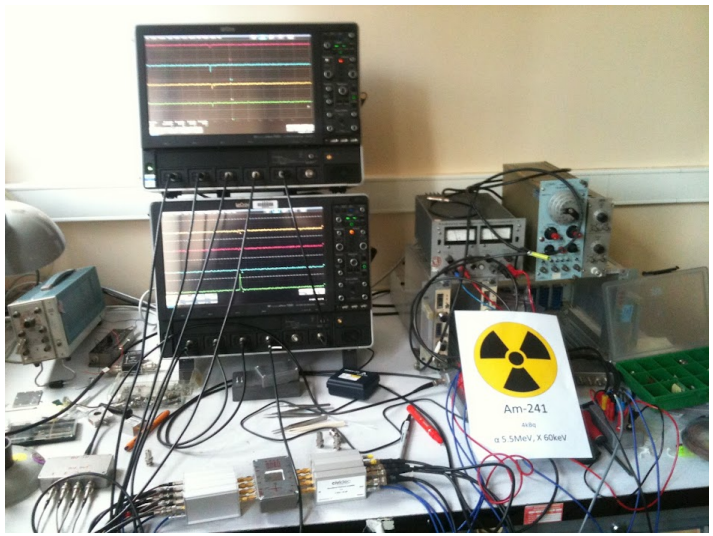
3 x 3 cm^2 pcCVD diamond forseen for the test crushed just three days before beamtime.....



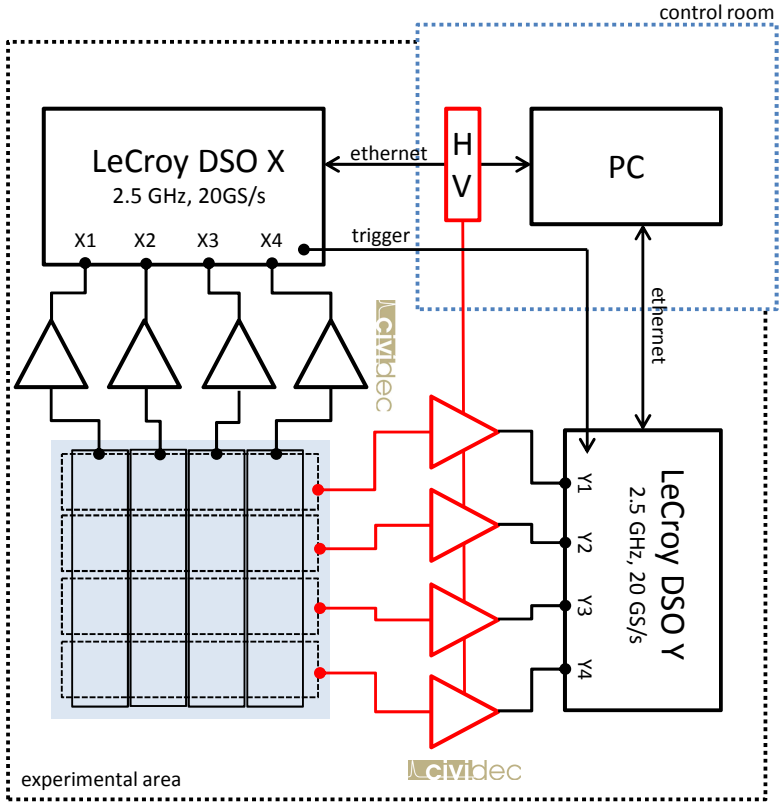
Final configuration:

1x1 cm^2 EG pcCVD diamond (500 μm thick), Al 1.8 mm 4(X)x4(Y) strips with 100 μm pitch

Electronics and DAQ



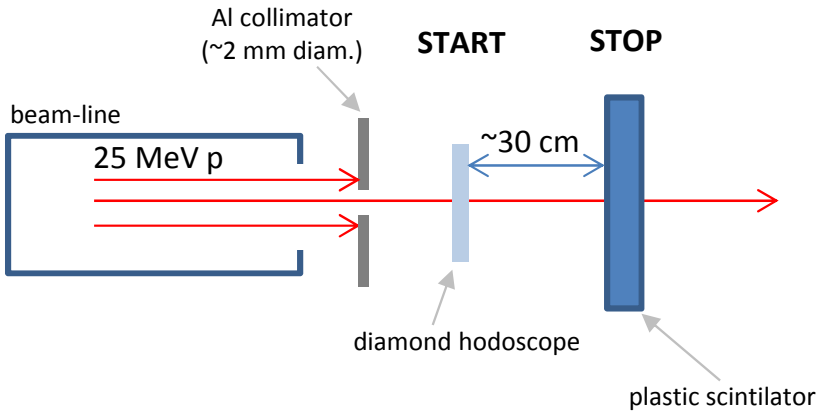
Laboratory testing with 5.48 MeV α source

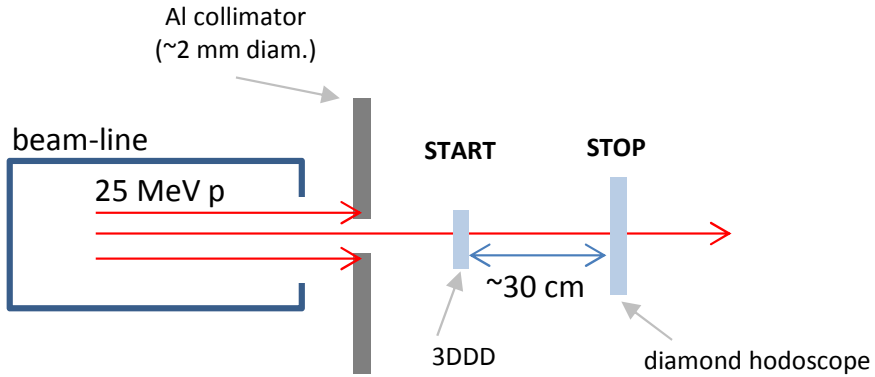


Electronics (8x Cividec voltage amplifiers) and DAQ (2 x LeCroy 2GHz DSO)

Beamtime Configuration

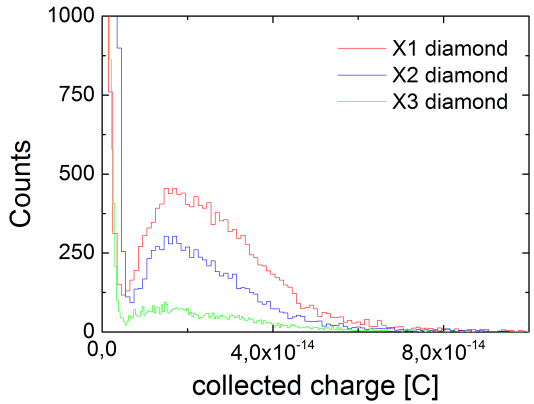
IPN Orsay tandem accelerator ALTO, 25 MeV p, 3.75MeV deposited in 500 μm diamond

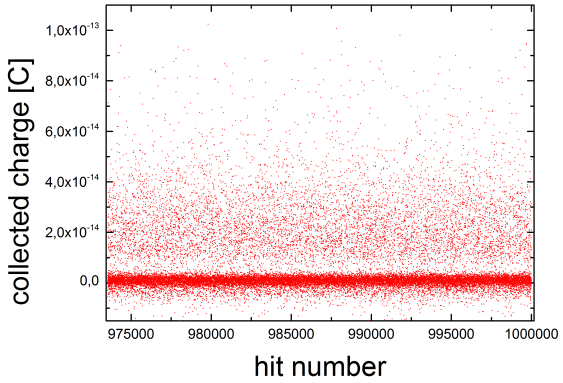


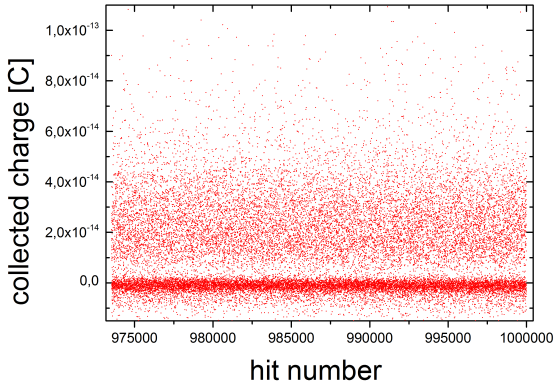


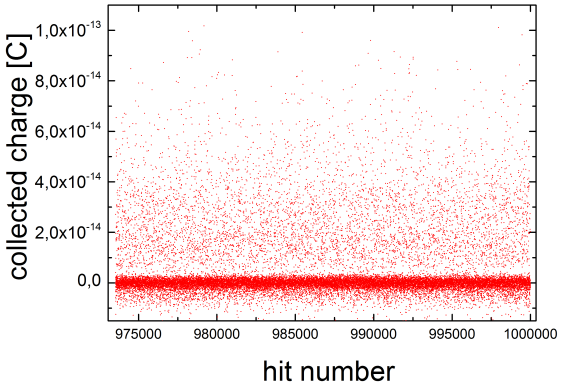
Charge Collection Spectra

Integral of current pulses for X1, X2, X3 strips from X plane, plastic trigger, HV = 700 V





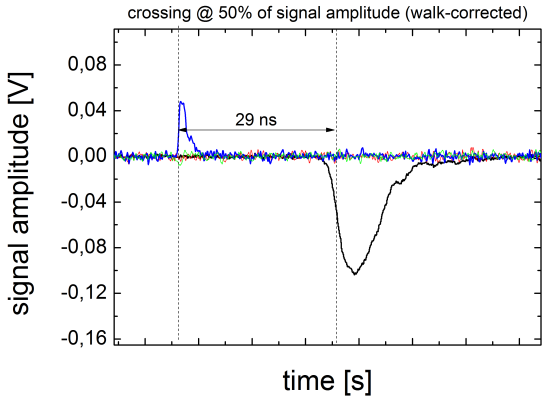


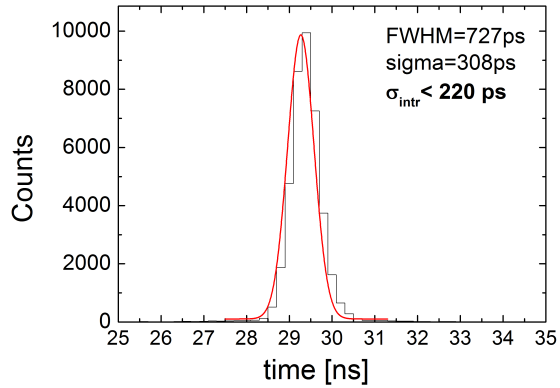


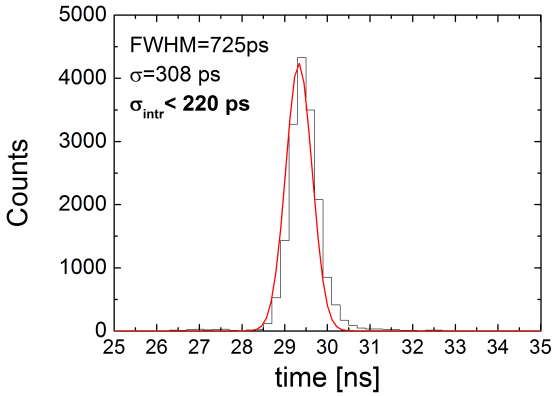
Time Measurements

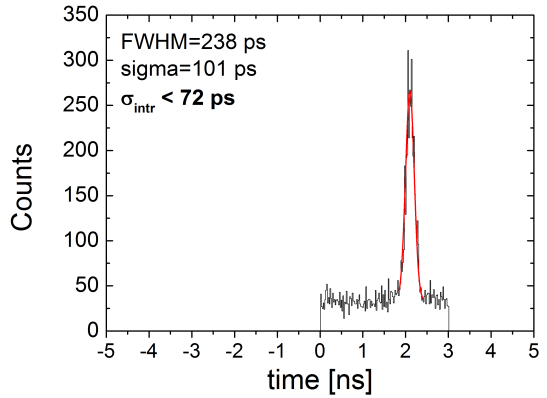
Δt pcCVD diamond hodoscope (@700V) vs. plastic

and pcCVD hodoscope (@150V) vs. 3DDD (@150V)





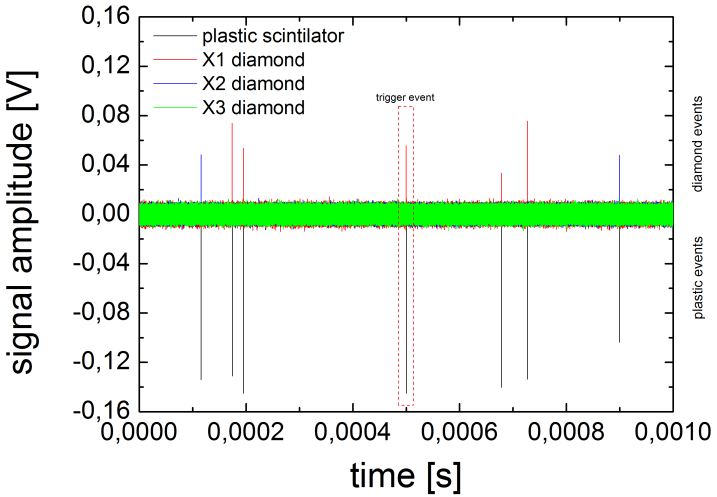




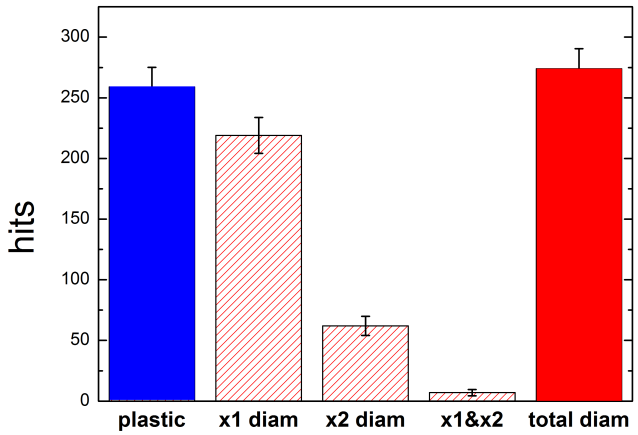
Detection Efficiency

About 100 random single-shots with aquistion time of 1 ms

trigger event = plastic and diamond X(i) coincidence



An example of single-shot

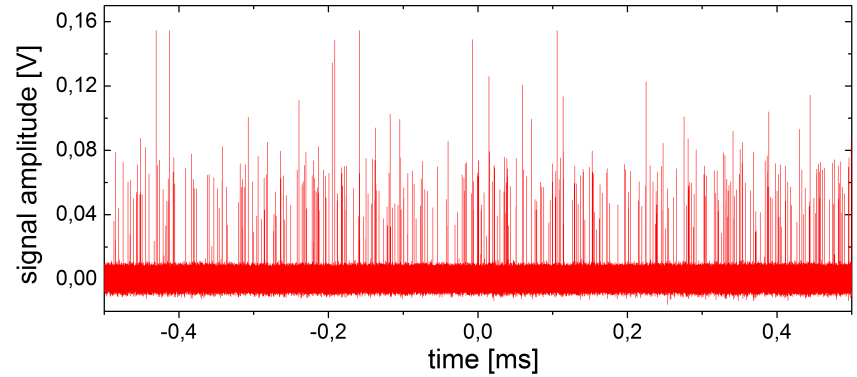


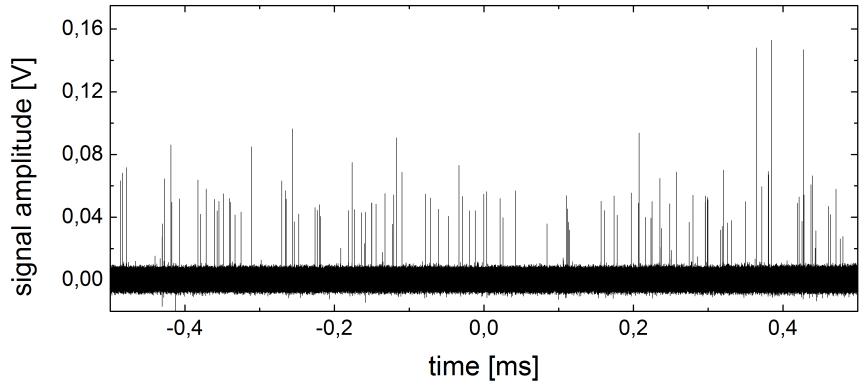
hit efficiency (inter-strip events corrected)

100% detection efficiency vs. plastic

High Rate

Plastic out of the beam, no collimator, asked operators for highest intensity possible ...





stable, no cross-talk

Hit Map

no hit map at current stage..... we lost synchronization between files on two scopes .... need to analize about 30 Gb data
but:

- all chanels active
- no evidence of cross-talk
- inter-strips events observed
- double hit at high rate(?)

Summary

1 x 1 cm^2 pcCVD diamond double sided strip detector tested in 25 MeV proton beam. All requirements (apart of size.....) of GamHadron hodoscope fulfiled:

- position resolution - strip size limited (more precise for inter-strip events)
- time resolution σ =308 ps (vs. plastic (plastic limited)) and σ =101 ps (vs. 3DDD (low E field))
- rate capability (drift velocity limited) 0.1 GHz per strip for 500 μm thick
- stable operation, no evidence of cross-talk
- radiation hard (?)

Now need: 10 x 10 cm^2 diamond (mosaic), multichannel integrated electronics ...