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

1. Introduction-GamHadron

2. Experimental
   - Detector, Electronics and DAQ
   - Charge Collection Spectra
   - Timing
   - Detection Efficiency
   - High Rate
   - Hit Map

3. Summary
Prompt $\gamma$ imaging: principle and feasibility studies

$^{12}$C at 95 MeV/u

A Beam–triggered Compton

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

- area $10 \times 10 \text{ mm}^2$
- position resolution $<1 \text{ mm}$
- time resolution $< 1 \text{ ns}$
- rate capability $> 1 \text{ GHz/total area}$
- radiation hard

Two candidates: scintillating fibers and diamond hodoscope
Diamond Detector

3 x 3 cm² pcCVD diamond foreseen for the test crushed just three days before beamtime.....

Final configuration:

1x1 cm² EG pcCVD diamond (500 μm thick), Al 1.8 mm 4(X)×4(Y) strips with 100 μm pitch
Electronics and DAQ

Laboratory testing with 5.48 MeV $\alpha$ 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
Integral of current pulses for X1, X2, X3 strips from X plane, plastic trigger, HV = 700 V
\( \Delta t \) pcCVD diamond hodoscope (@700V) vs. plastic and pcCVD hodoscope (@150V) vs. 3DDD (@150V)
About 100 random single-shots with acquisition time of 1 ms
trigger event = plastic and diamond X(i) coincidence

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 analyze about 30 Gb data but:

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

1 x 1 cm² pcCVD diamond double sided strip detector tested in 25 MeV proton beam. All requirements (apart of size.....) of GamHadron hodoscope fulfilled:

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

Now need: 10 x 10 cm² diamond (mosaic), multichannel integrated electronics ...