R3B Heavy Ion Tracking

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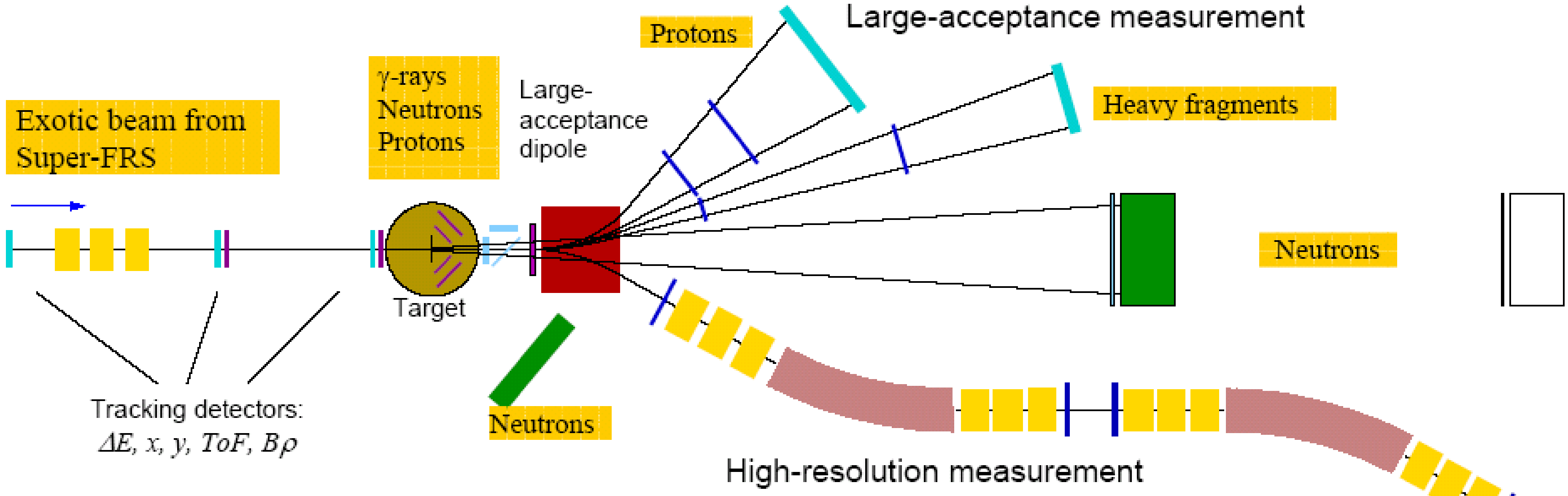
High Rate Diamond Detectors for Heavy Ion Tracking and TOF

- detector requirements and layout
- fast timing electronics
- APV based strip readout
- radiation hardness

R^{3}B (Reactions with Relativistic Radioactive Beams) Setup



$\Delta p/p \sim 10^{-4}$ @ 2.5% accept.

Measurement of all kinematic variables in a HI reaction

Different tasks: High resolution tracking in the super FRS,
radiation hard (SFRS) 10^6 cm^{-1} s^{-1}
2 x TOF (SFRS – target) (reaction products)
low material budget

Requirements for Tracking

	Super-FRS			R3B Target , Magnet		
Dimensions	50 mm x 400 mm S-FRS			40 mm x 40 mm R3B (1) 300 mm x 200 mm R3B(2)		
Rates	10^8 1/s			10^4 1/s		
Material budget	< 500 mg			asap.		
Resolution	σx [mm]	σy[mm]	σt [ps]	σx [mm]	σy[mm]	σt [ps]
PID FRS-R3B (40 m)	3	5	100	3	5	100
PID in R3B (10 m)				0.2	3	40
high resolution mode	0.5	5	100	0.1	0.1	100
high res.TOF spect.				0.1	0.1	5

Why PC-CVDD

TOF and position measurement with a single layer of 100 µm CVDD

material available and reasonable price (20 µm – 1 mm)

diameter up to 75mm

fast signal collection

radiation hardness

- C^{12} 1-2 AGeV 10^{12} cm^{-2}
- U^{238} 1 AGeV 10^{10} cm^{-2}

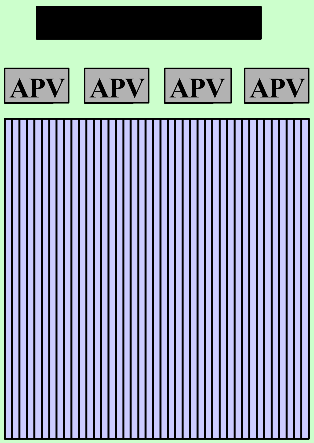
low noise

- low dielectric constant – low cap.
- small leakage current – low noise

collection distance is less important in case of heavy ions

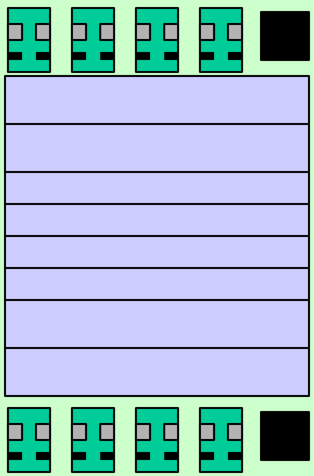
- > 99% of charge distribution above 10 ke, ΔE = 10MeV

R3B Detector Layout



tracking layer:

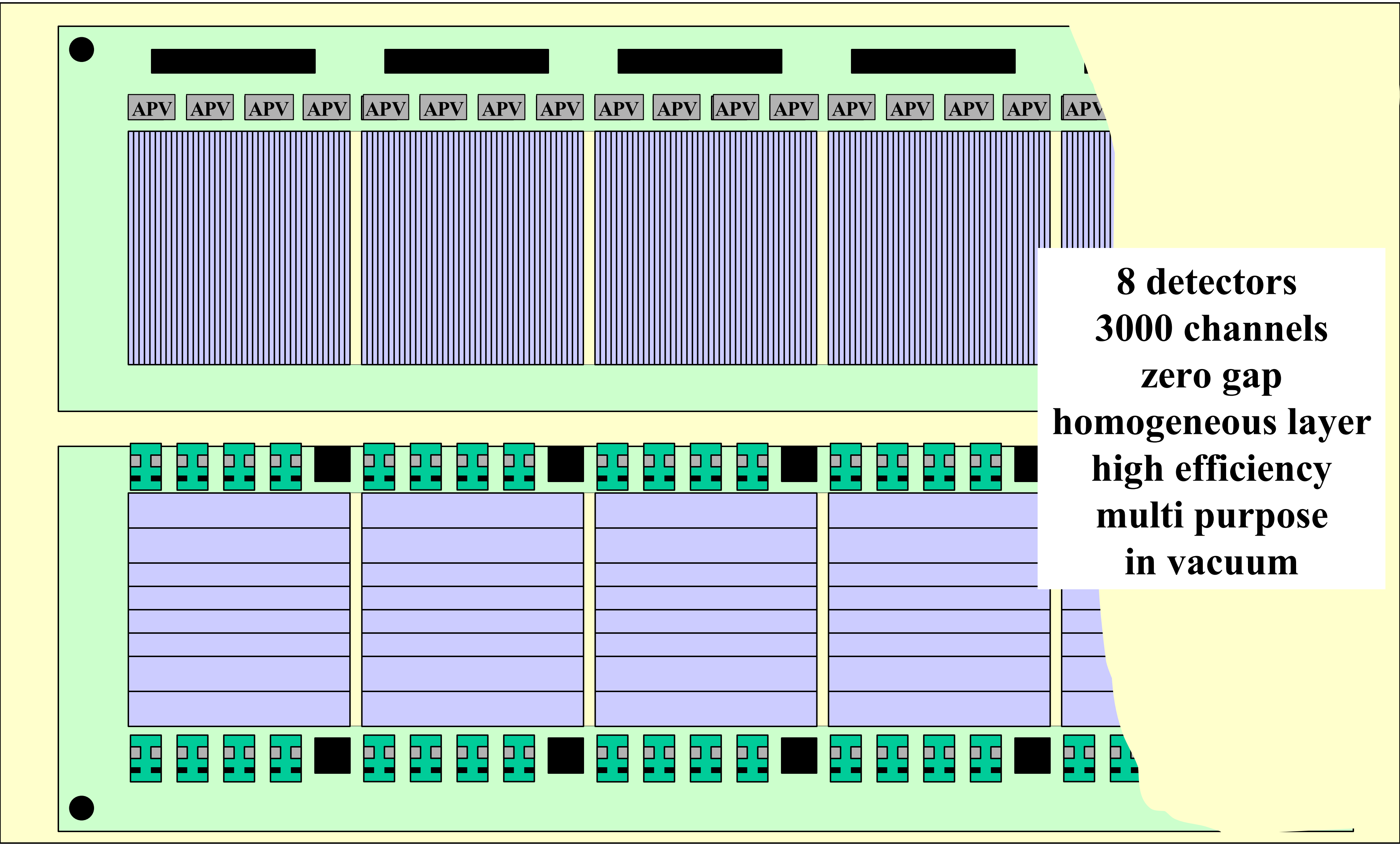
- 50 x 50 mm, d = 100 µm, PC-CVDD
- 140 µm pitch (115µm strips, 25 µm gap)
- only digital position information
- multiplexed readout in vacuum



timing layer:

- 50 x 50 mm, d = 100 µm, PC-CVDD
- 8 rate matched strips, y information, trigger
- analog preamplification in vacuum
- discriminator and TDC @ 5 m distance

FRS Detector Layout



8 detectors
3000 channels
zero gap
homogeneous layer
high efficiency
multi purpose
in vacuum

New HADES Start - Detector

4 x 4 strips xy

Al coating using a wire grid

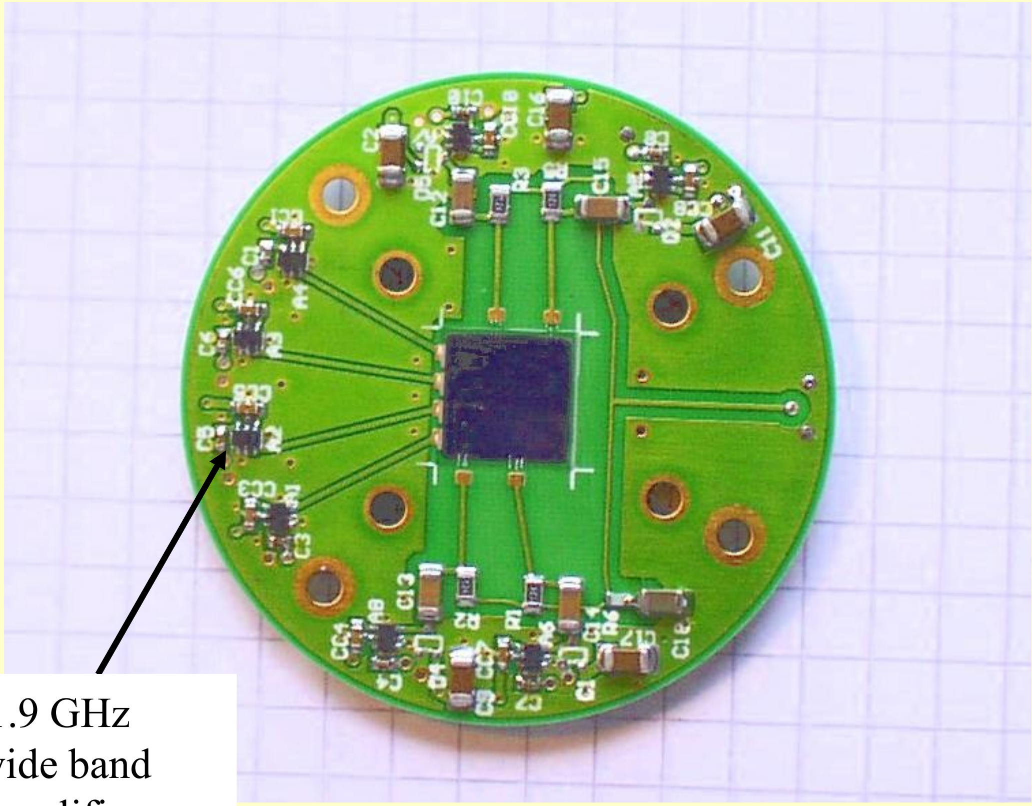
50 µm IAF material

new preamps allow to mount the detectors much closer to the target

low power in vacuum

Further amplification DBA-II (gain 130)

Aug. 05 – Test:
- new preamps
- TOF resolution
- efficiency

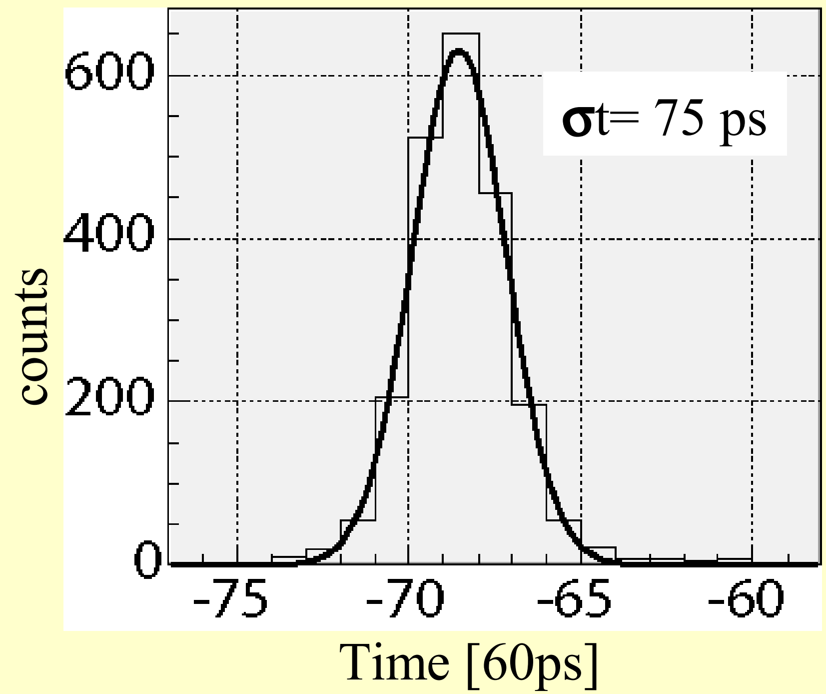


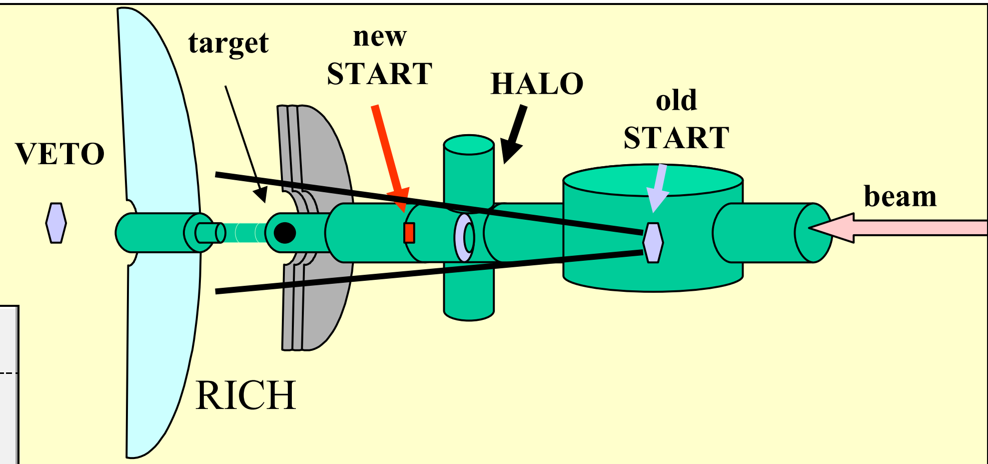
1.9 GHz wide band amplifier BGA2748

Design by W. König (GSI)

Time Resolution 50 µm Detector

Al beam, 1.9 AGeV
t (100 µm) – t (50 µm)





resolution quite independent from reference detector

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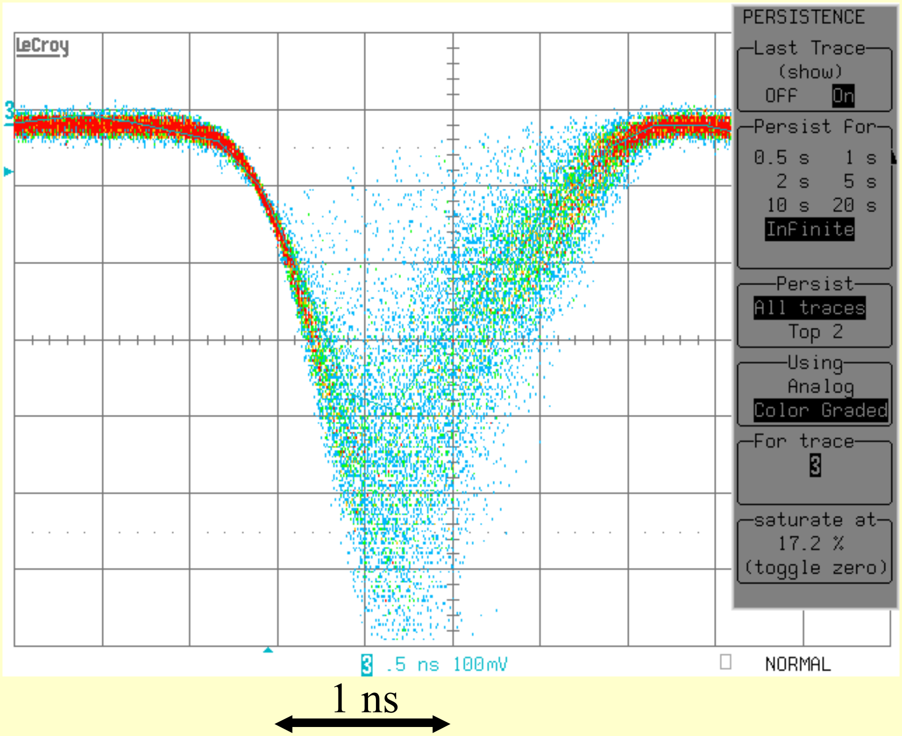
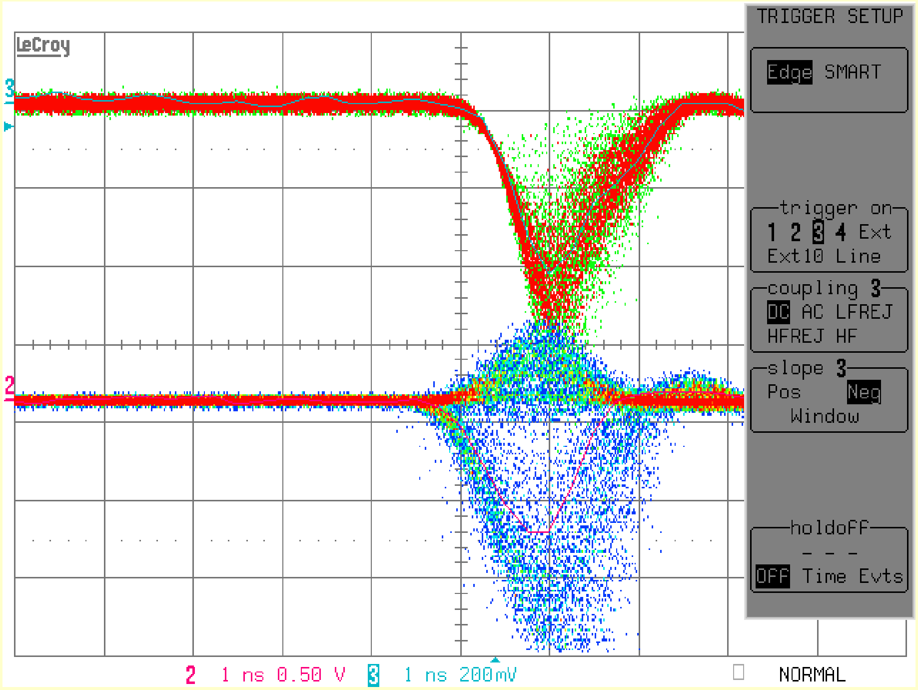
resolution limited by noise?
walk correction needed?

Signal amplitude not written to file

Signal shape

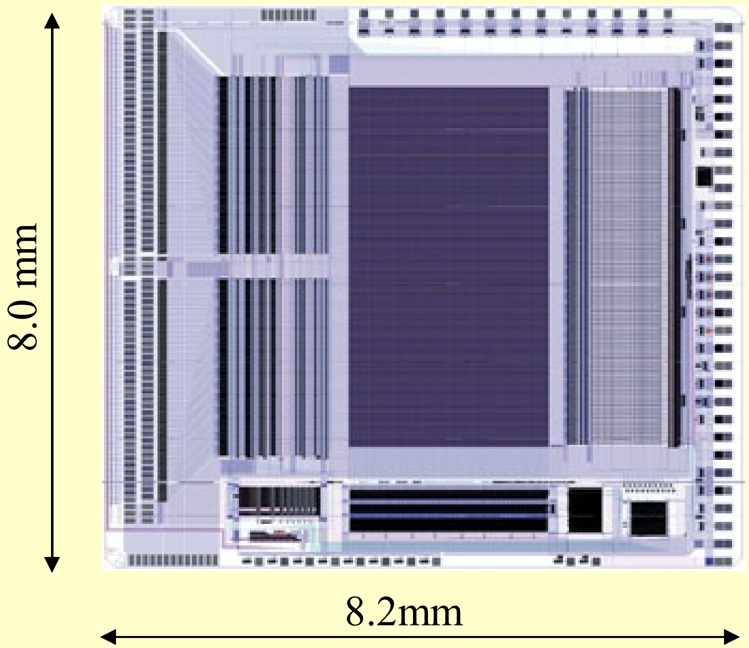




rise time limited by 1GHz scope and cables ?

positive and negative coupling of neighboring strips

CMS Readout Chip APV25



Readout Chip for CMS Detector

- 128 channels
- radiation hard (0.25 μm)
- 8 MIPS dynamic range (100 mV/mip)
- analog pipeline 4 μs
- 40 MHz readout
- 44 μm pitch !
- 2.3 mW /ch.
- Vacuum suitable

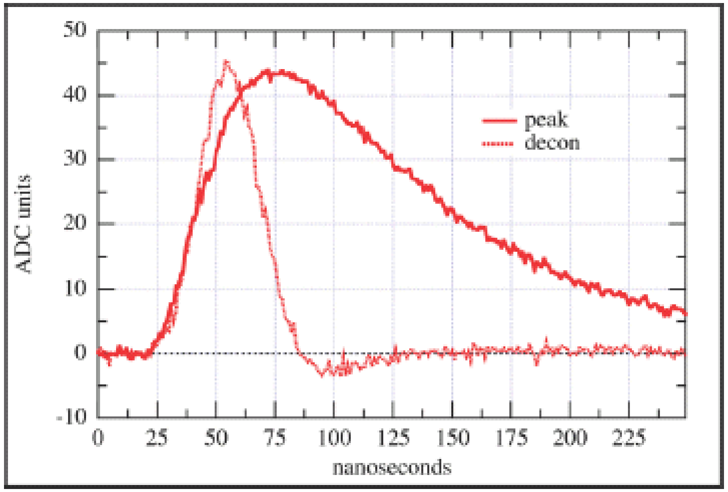
Effective thickness 20% of Si
CCE 20%
W = 13 eV

→ 8x5x5x3.6 = 720 mips linear range
Z < 27 could be linear limit in HI

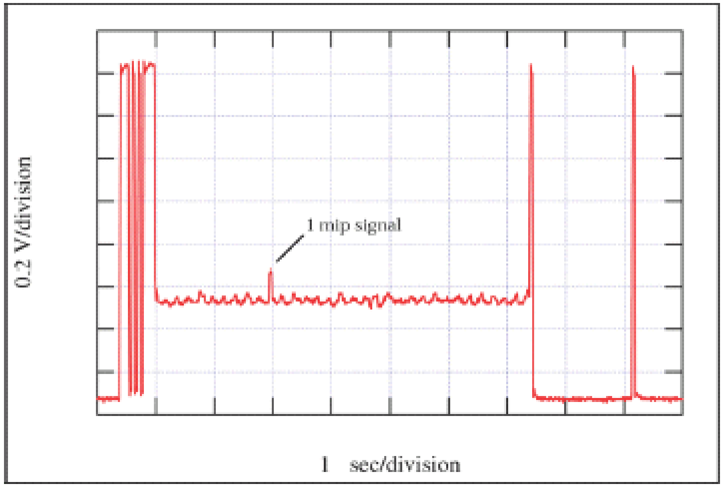
Several ideas like charge split, over range behavior, or even thinner CVDD have to be tested.

APV Features

- Noise figure: 246 e + 36 e/pF
- 3000 e (SNR) with 60cm lines
- 50 ns CR-RC shaper
- both polarities
- discharge path
- peak mode for low rates
- deconvolution mode for high rates
  analog FIR - filter included.



Operation:
pipeline of 128 x 192 columns
write pointer circulates continuously
with 25 ns intervals.
column x marked by trigger
bidirectional differential current output
using 2 lines (1± mA)

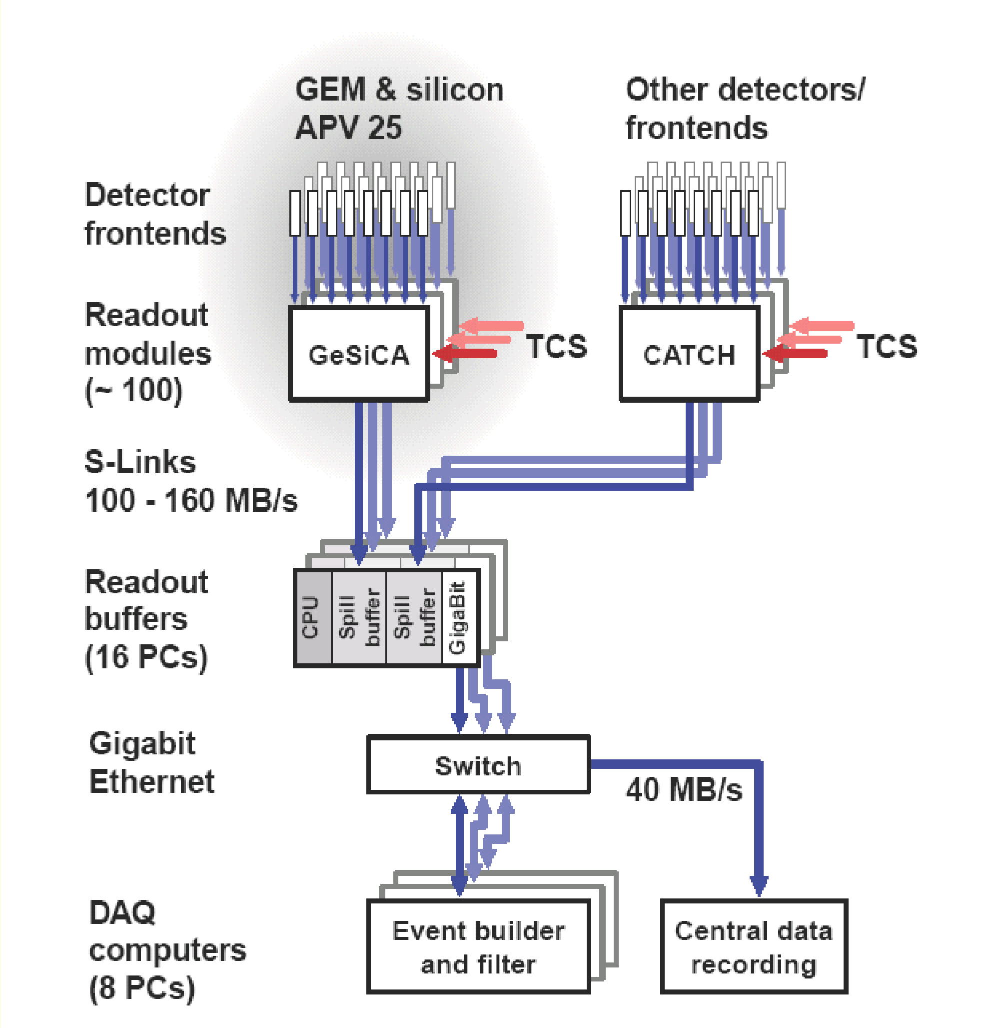


Compass DAQ System

APV is used in Compass for many k ch.

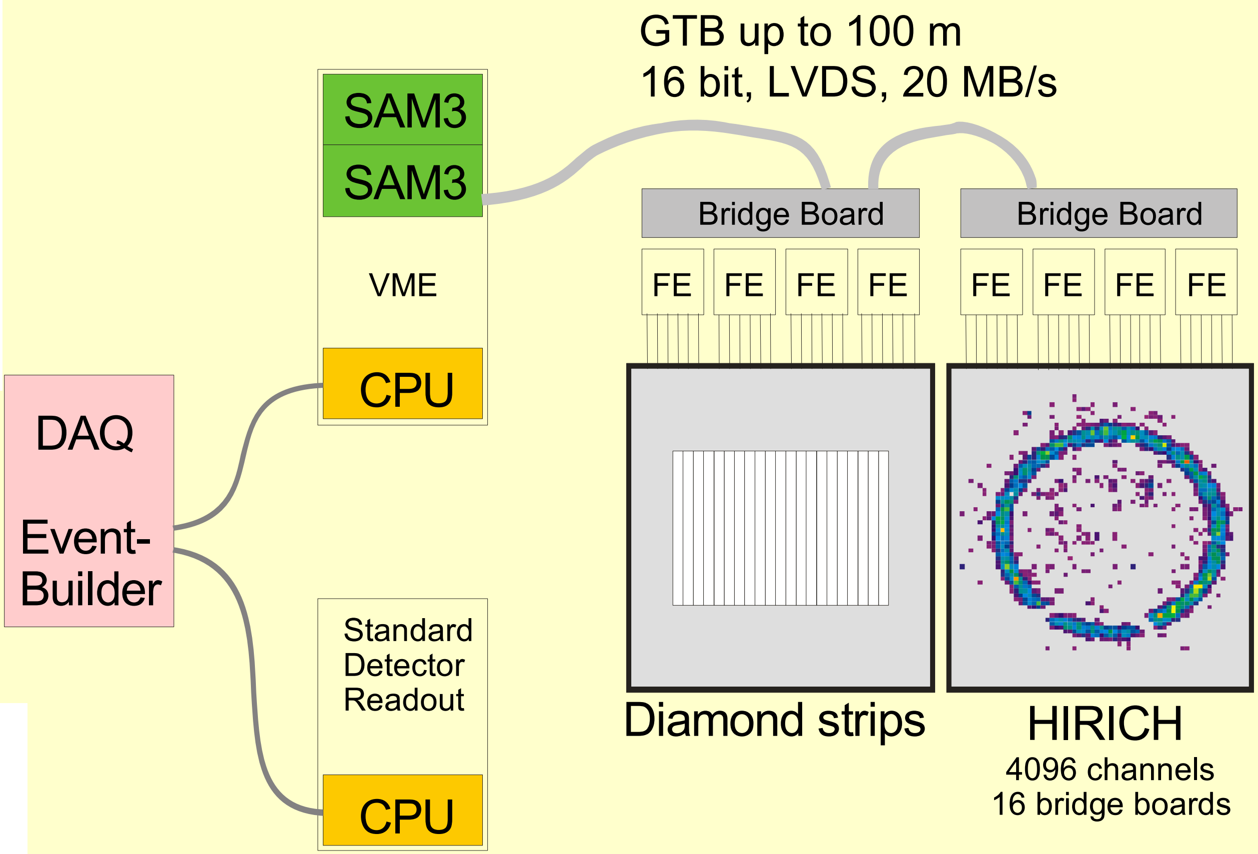
But :

GSI has different requirements !



Current scheme of R3B readout

- Existing hardware
- Existing software
- GSI support
- **Compatible to existing detectors**

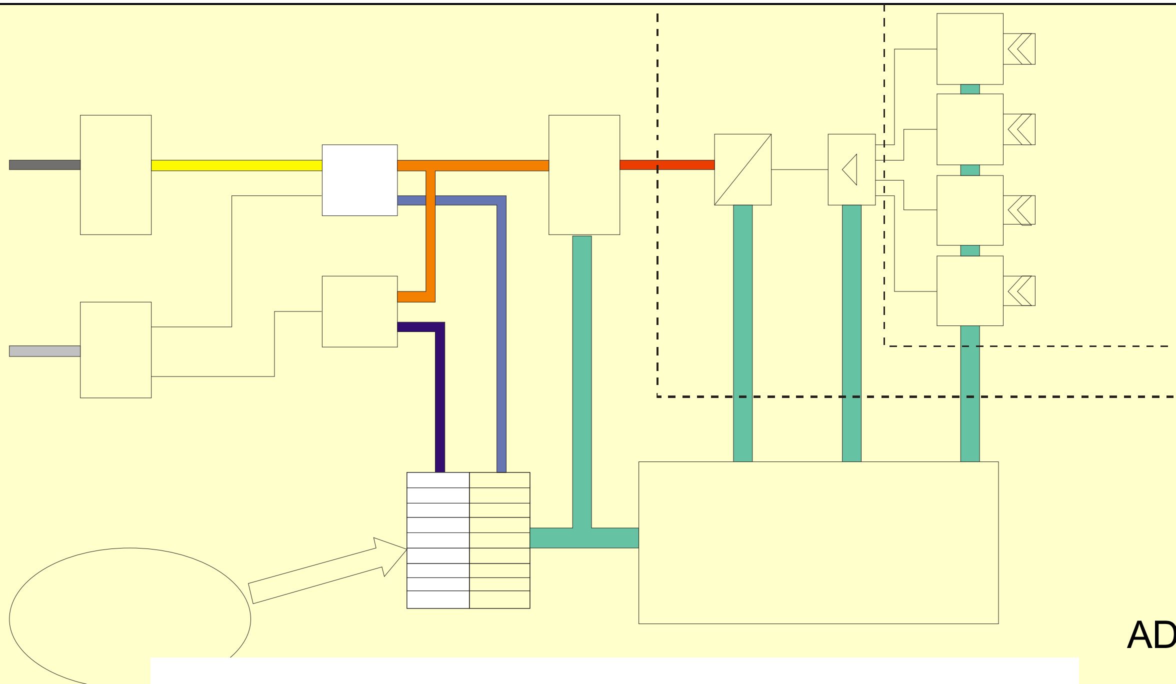


faster FE electronics for diamond needed

Gassiplex > APV25

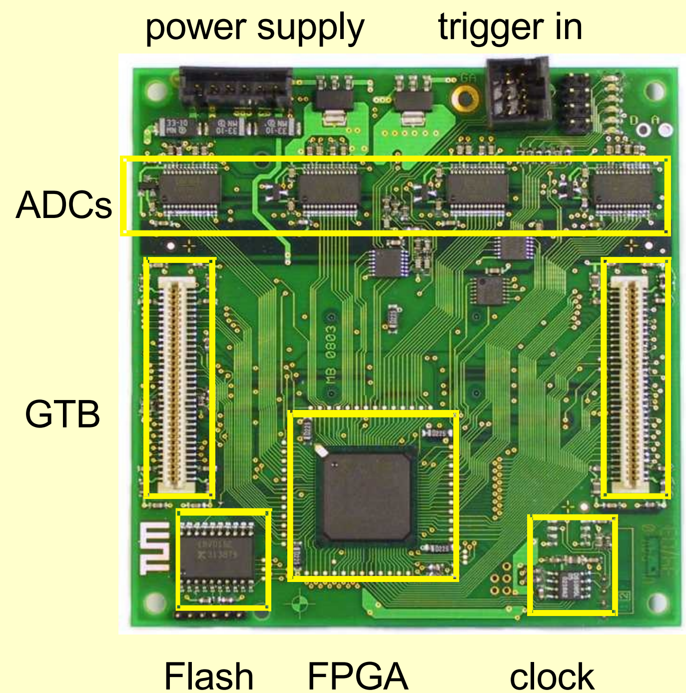
Used in S248

The GTB Bridge Board (GTB^3)



unified interface close to the detector

- gain matching
- A/D Conversion (4 ADCs)
- programmable control logic for FE
- data preprocessing, data reduction
- trigger control / trigger numbering
- event buffer



SAM3

GTB^3

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GSI development

DSP based data concentrator
2 independent GTB interfaces master/slave
data request on trigger
busy handling
subevent building
Multi event capability

DSP used e.g for generating thresholds

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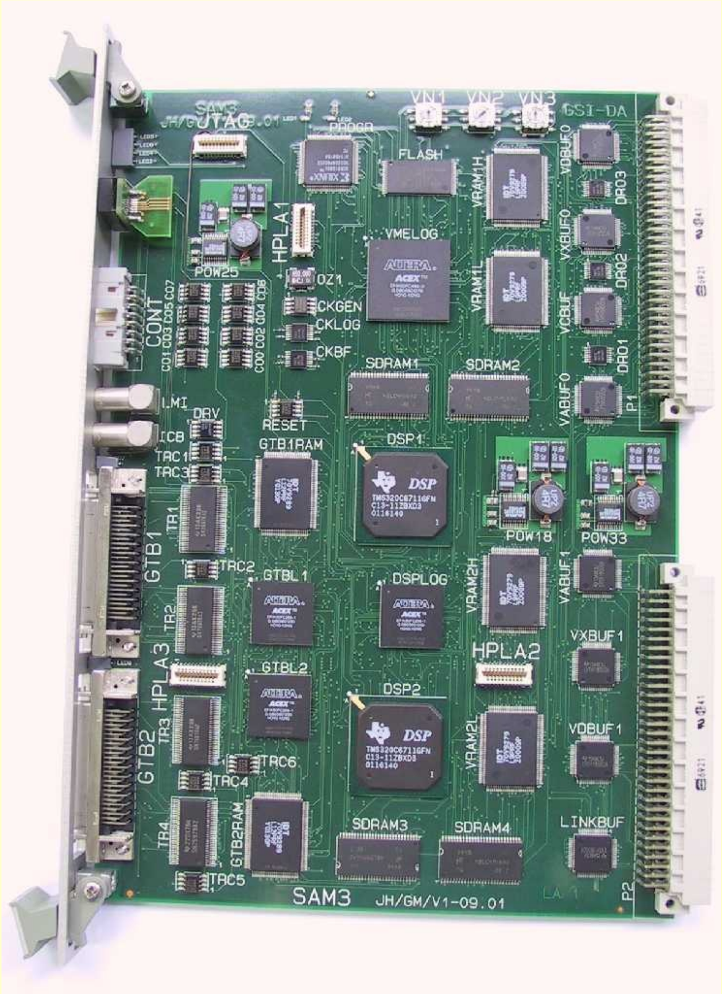
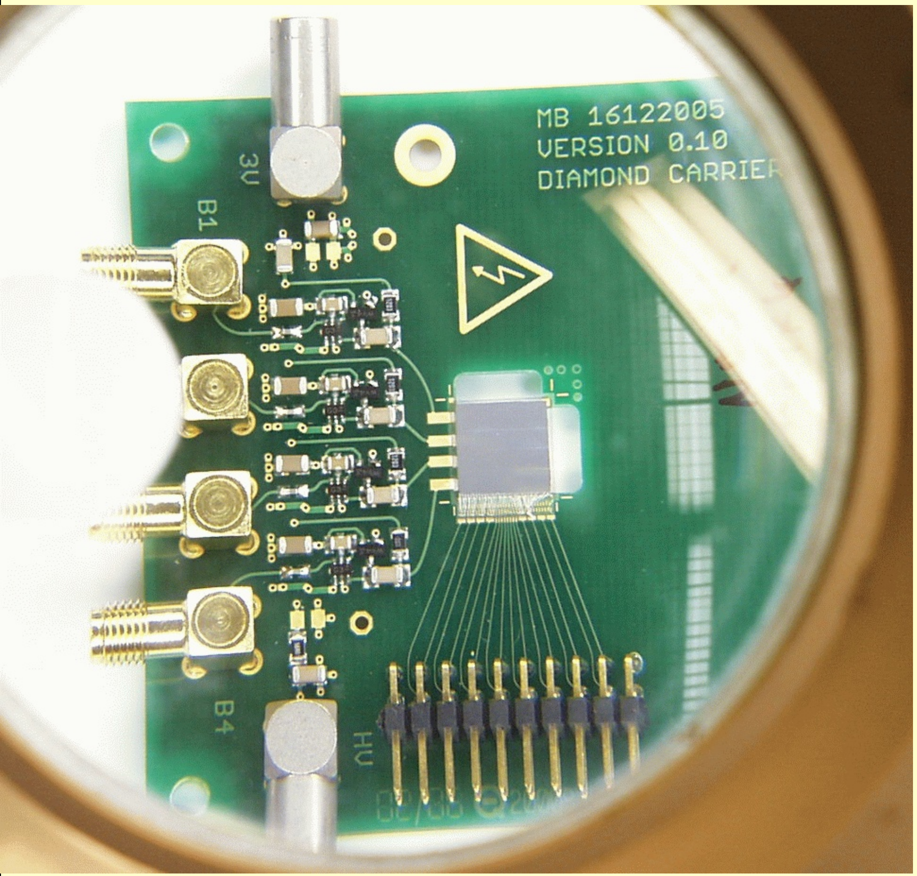
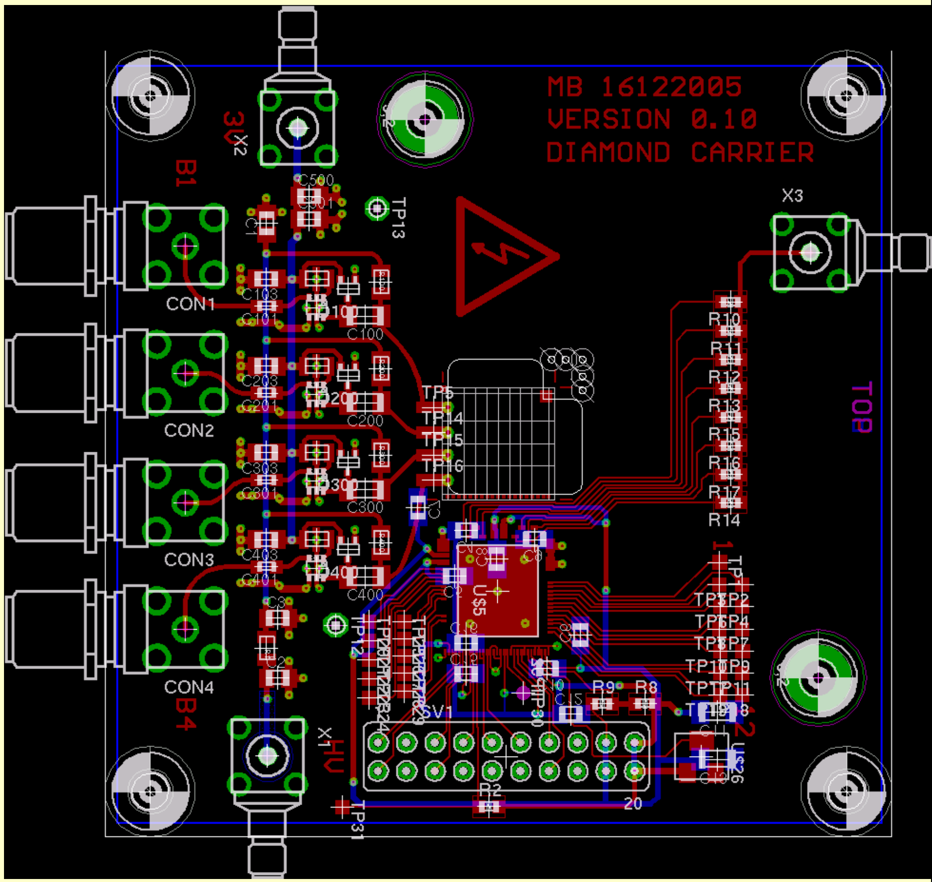
MBS



APV Test Board

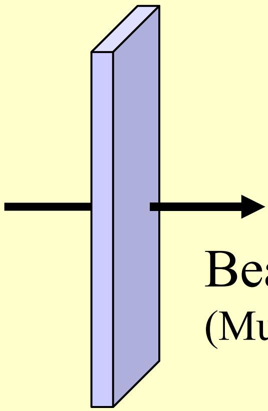




Check readout scheme, crosstalk, range
Different readout on both sides

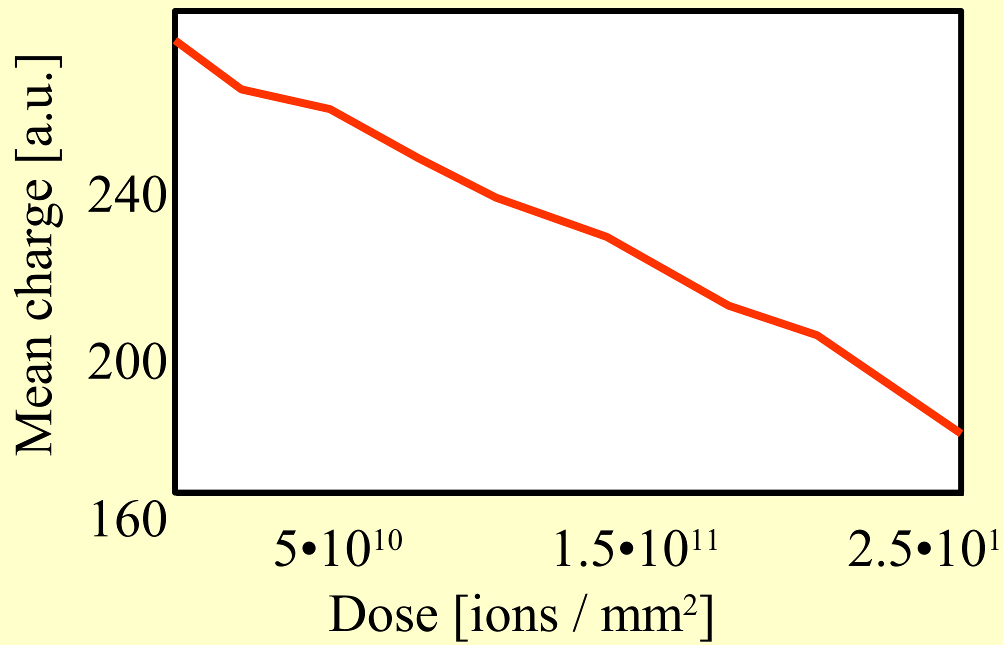
Test of Radiation Hardness with HI

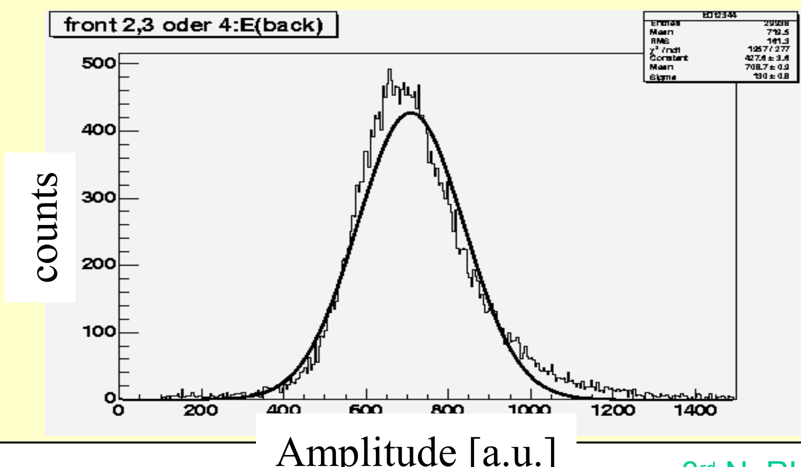
IAF diamond
100 µm



Beam: 120 MeV ^{16}O
(Munich Tandem)

beam attenuators 33 and 1000
measurement @ 17kHz and 1 kHz
every 30 min





20% signal loss after 10^{13} ions/cm^2 (^{16}O, 120MeV)
Bragg peak, partially stopping ....

Task List

Radiation Hardness

- Some samples show persistent photo current (PPC) after irradiation
- limit O^{16} 112 MeV 10^{13} cm $^{-2}$ (prove single measurement)

Signal Properties

- coupling between channels
- time resolution worse than expected (may be due to electronics)
- walk correction should be possible with APV readout
- test of APV and fast timing electronic on a single detector .

Detector Production

- shadow technique for bigger structures
- photo lithography (first problems solved)
- large area substrate handling still under investigation (50 x 50 mm, d = 50 µm sample in house but more than fragile)