R3B Heavy Ion Tracking

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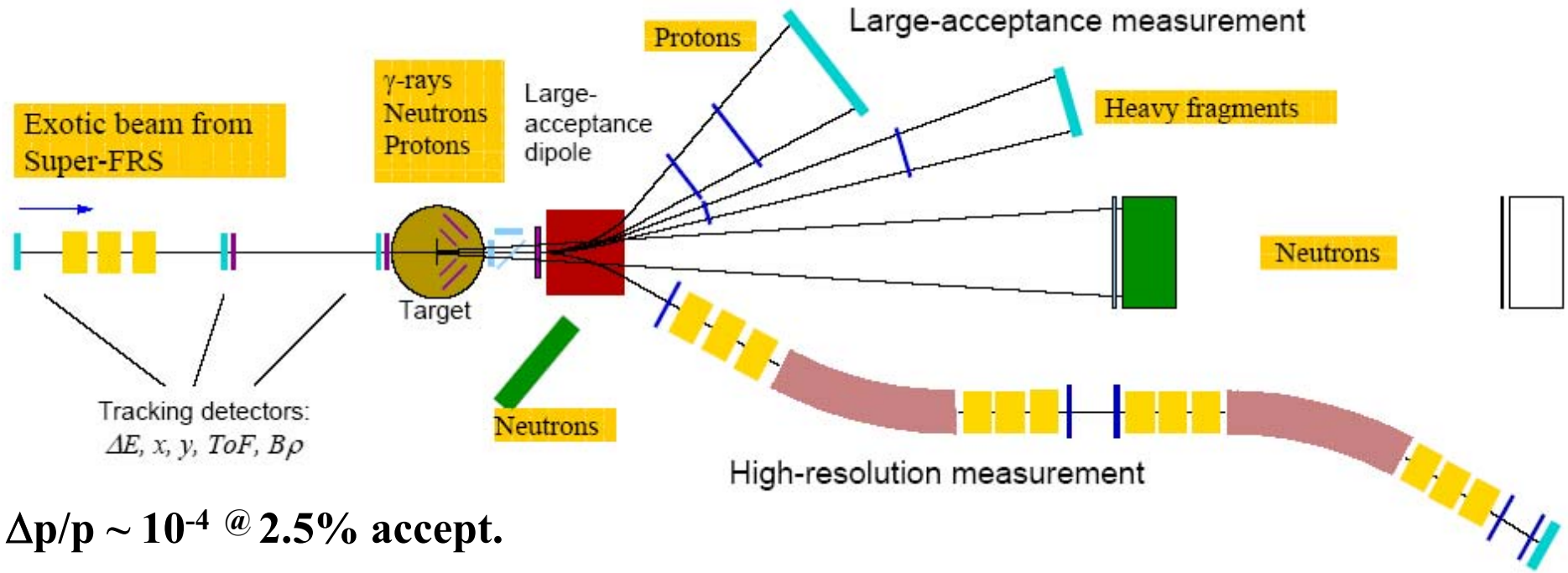
High Rate Diamond Detectors for Heavy Ion Tracking and TOF

- detector layout
- fast timing electronics
- APV based strip readout
- material investigations

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



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

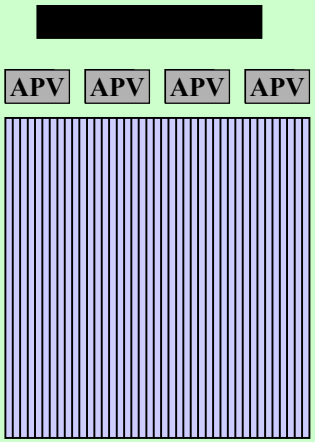
Measurement of all kinematic variables in a HI reaction

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)

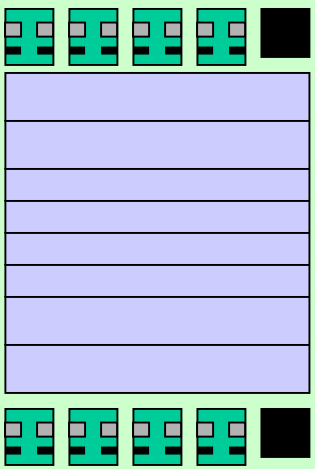
low material budget

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

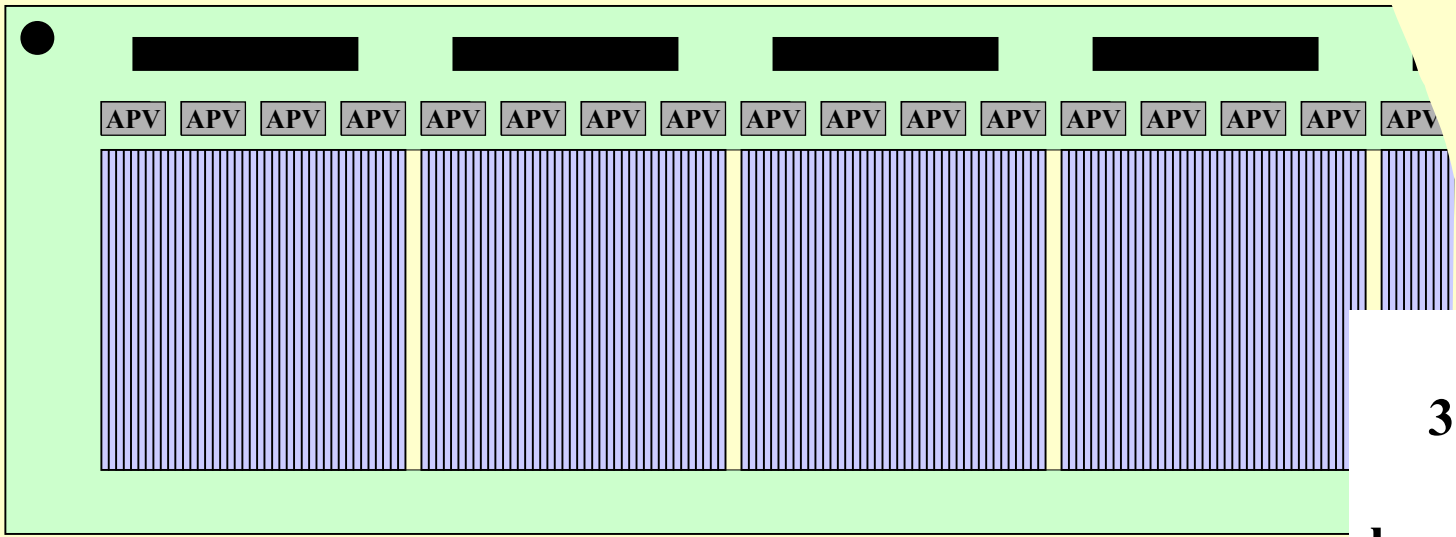


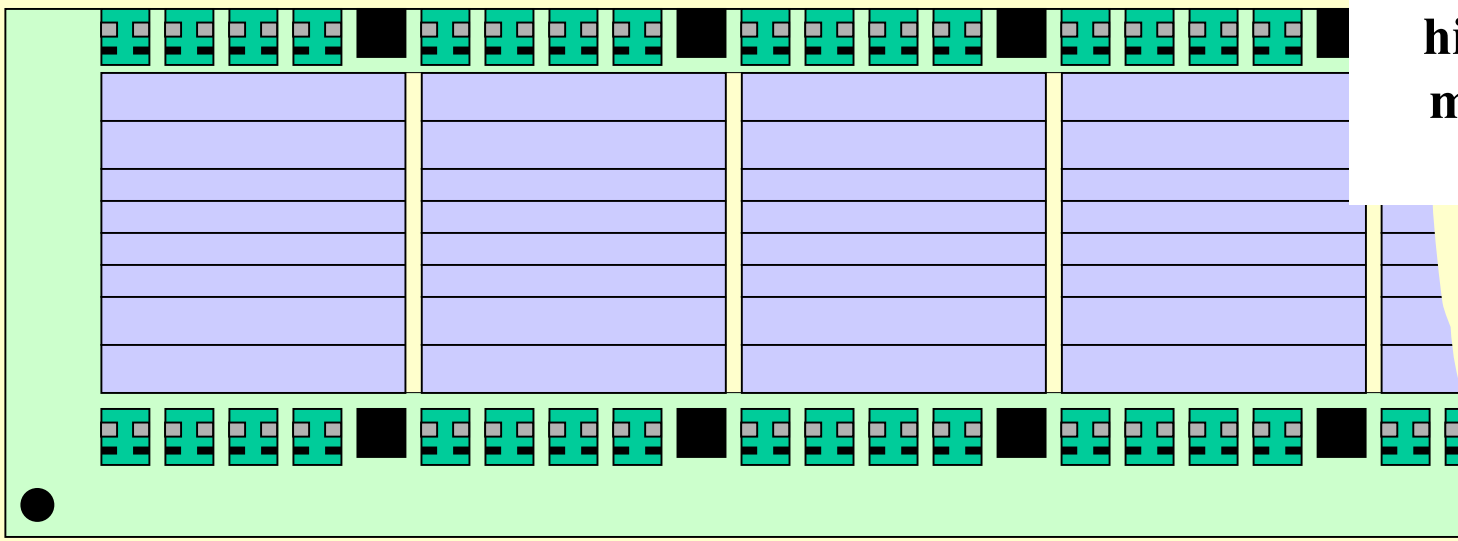
timing layer:

- 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

Input from simulation!

FRS Detector Layout

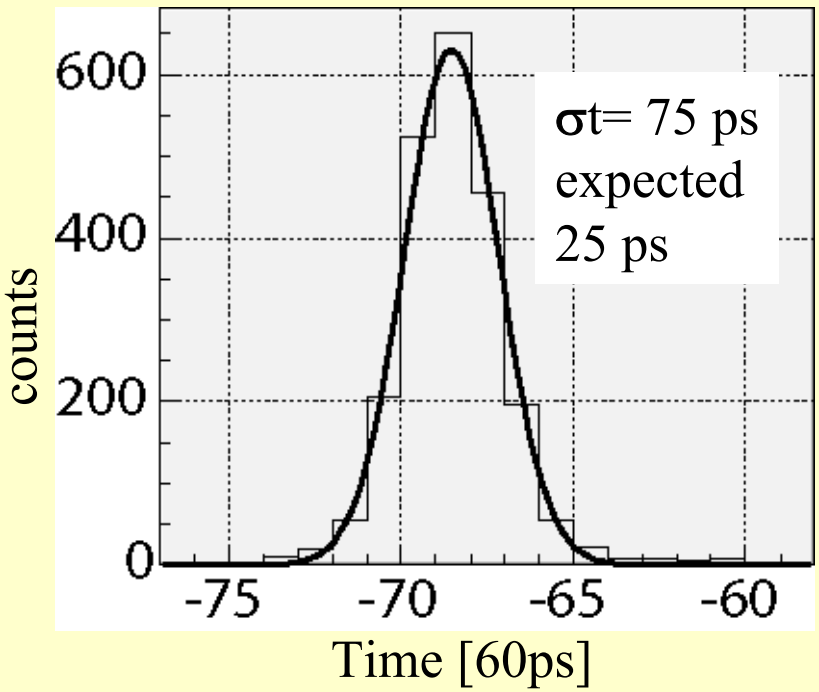


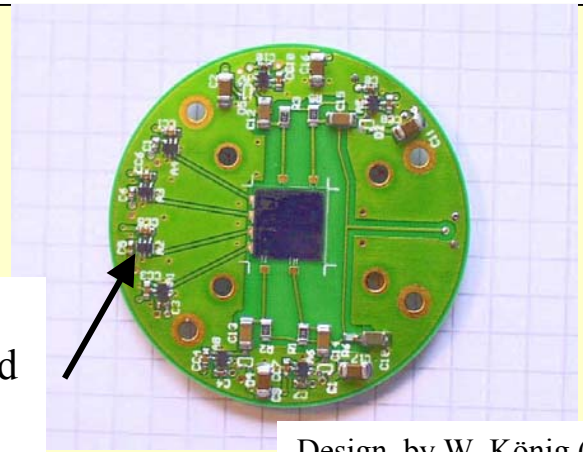


8 detectors
3000 channels
zero gap?
homogeneous layer
high efficiency
multi purpose
in vacuum

Time Resolution 50 μm Detector

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





1.9 GHz
wide band
amplifier
BGA2748

Design by W. König (GSI)

resolution quite independent from S/N, projectile and detector thickness

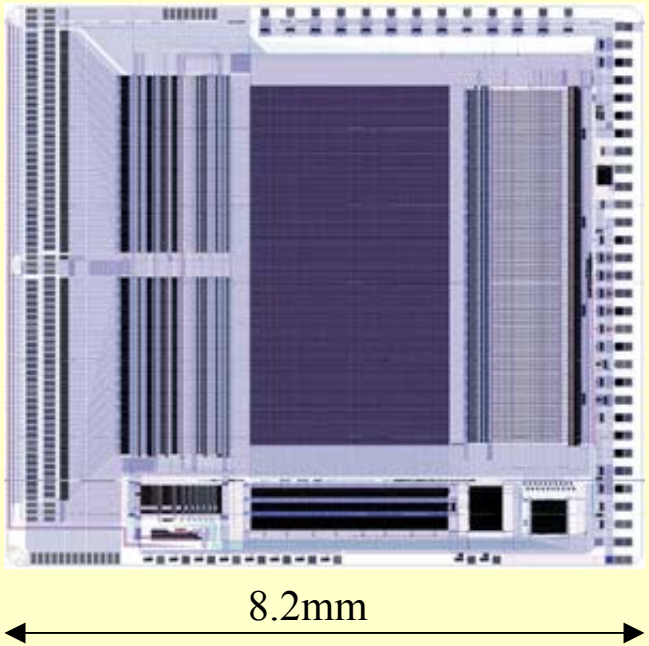
↓

Systematic error ?
walk correction needed?

100 μm Material seems to be the better choice (more signal, less noise).

Investigations on MMICs show nearly ideal noise figures.
Signal amplitude not written to file

CMS Readout Chip APV25



Readout Chip for CMS Detector

- 128 channels
- radiation hard (0.25 μm)
- 8 MIPS linear 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

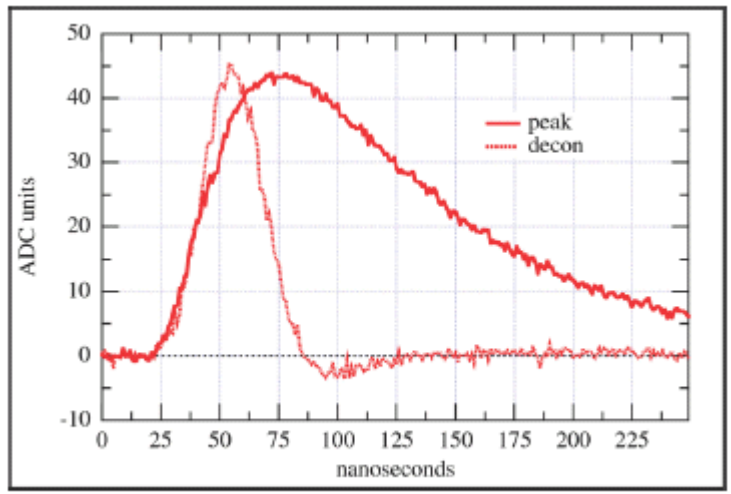
→ 8x5x5x3.6 = 720 mips linear range

Z < 27 could be linear limit in HI

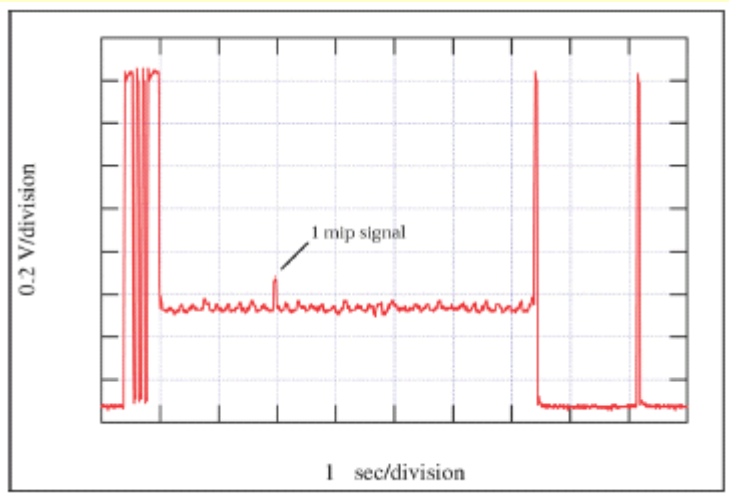
Several ideas like charge split, over range behavior, have to be tested.

APV Features

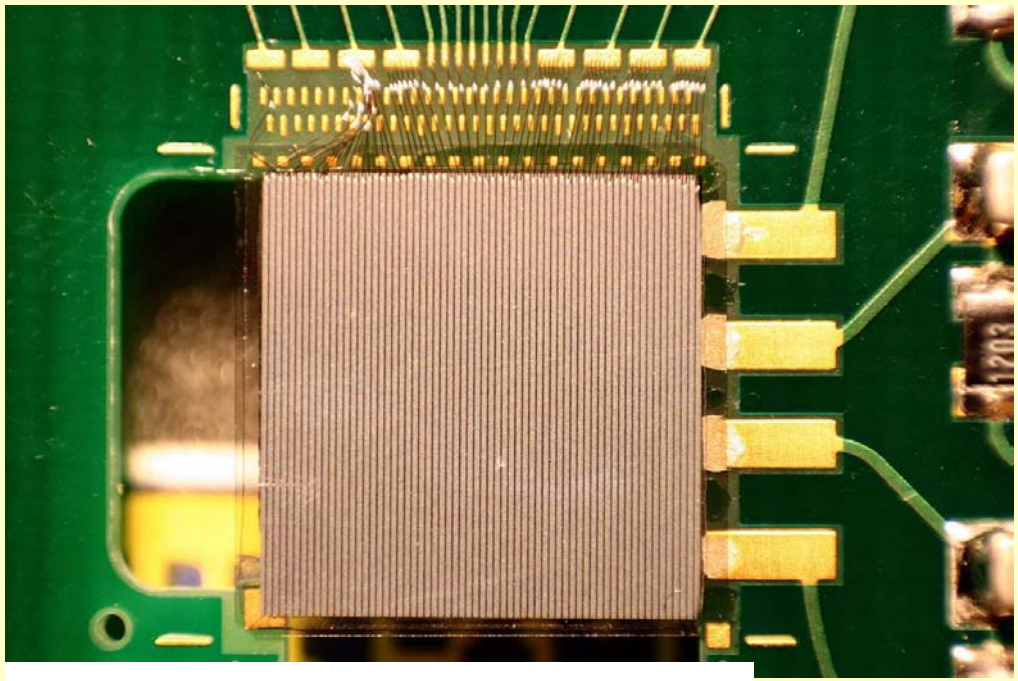
- Noise figure: 246 e + 36 e/pF
- 3000 e (SNR) with 60cm lines
- 50 ns CR-RC shaper
- both polarities
- discharge path
- peak mode for low rates
- deconvolution mode for high rates
  analog FIR - filter included.



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 (± 1mA)



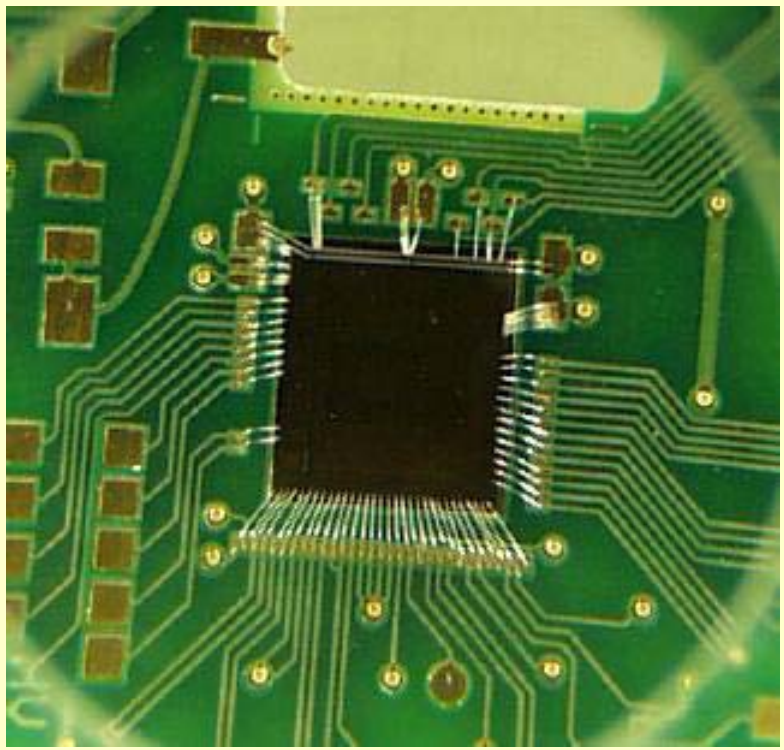
APV Test Board



First fine pitch detector tested,
First readout chip bonded
Next beam test in November

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

AC coupling needed?
PPC investigations



Prototyping 2006

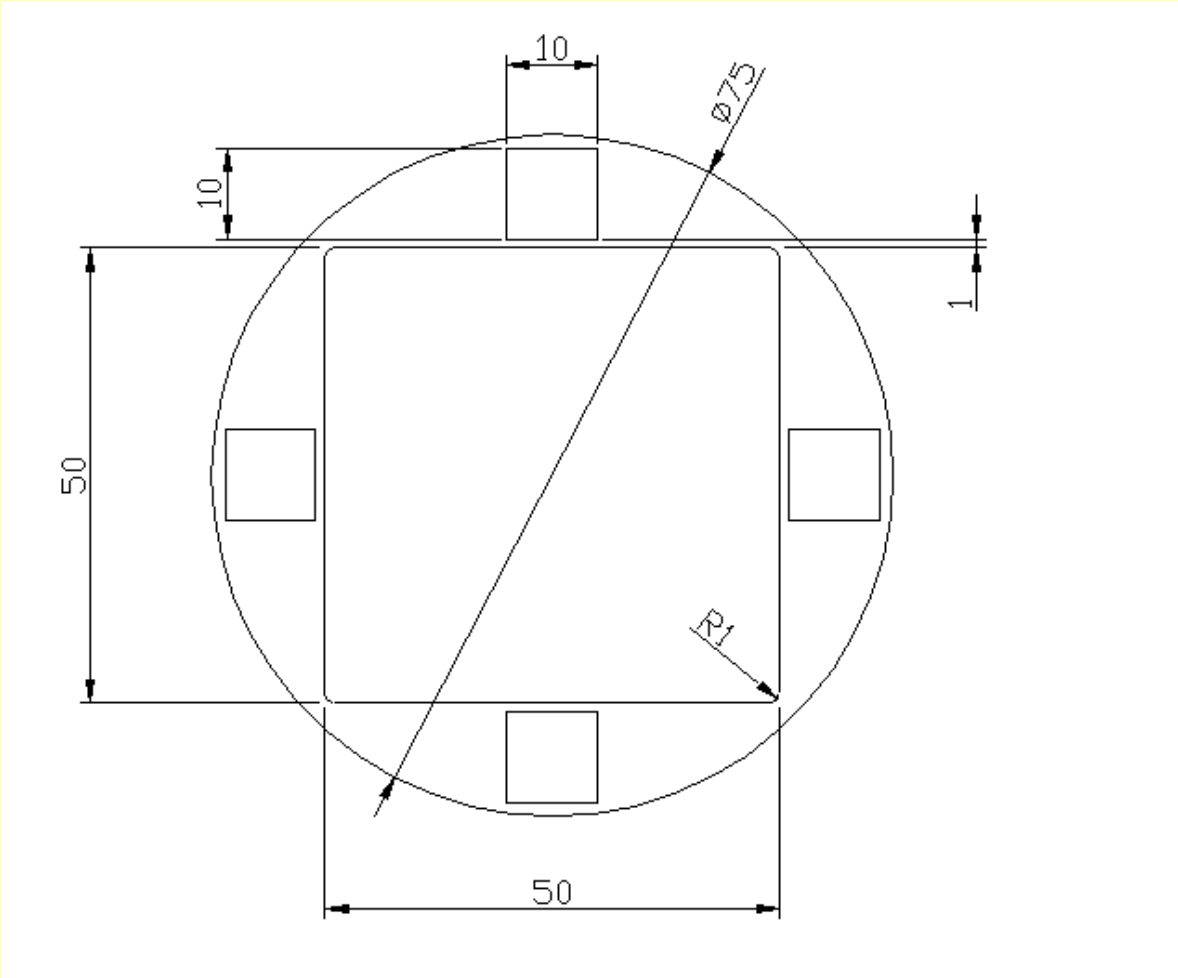
IAF cooperation contract

money for 12 detectors

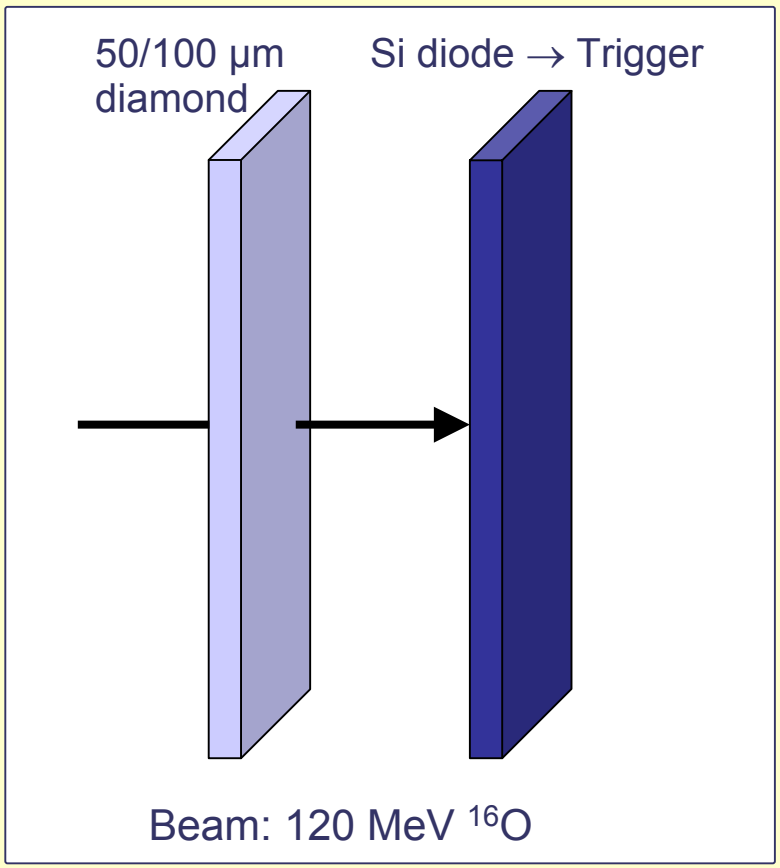
4 witness samples
reproduce material quality

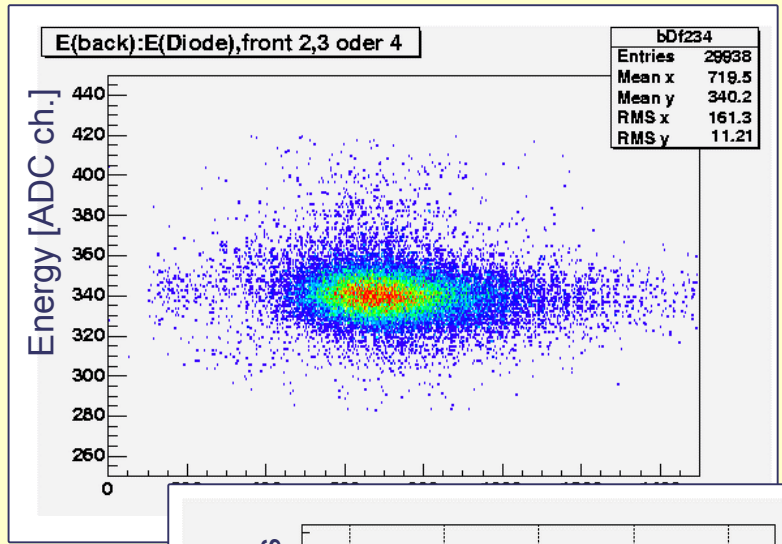
first full size prototype
in December 2006

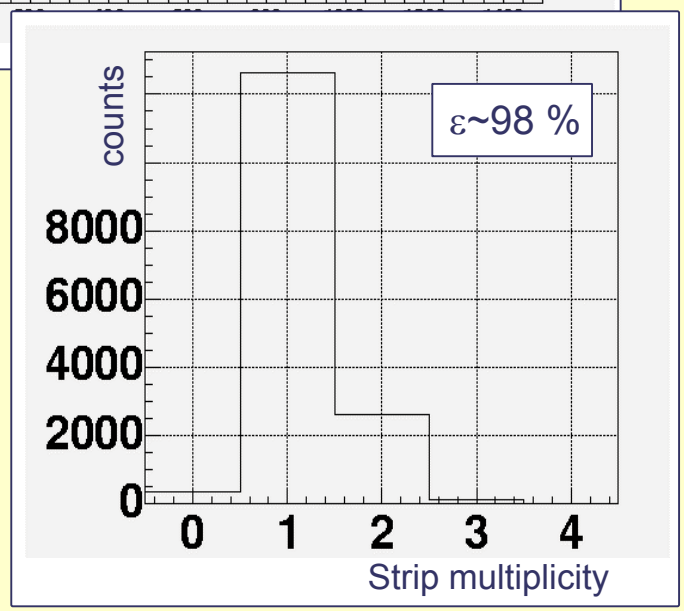
First beam test needed in 2007



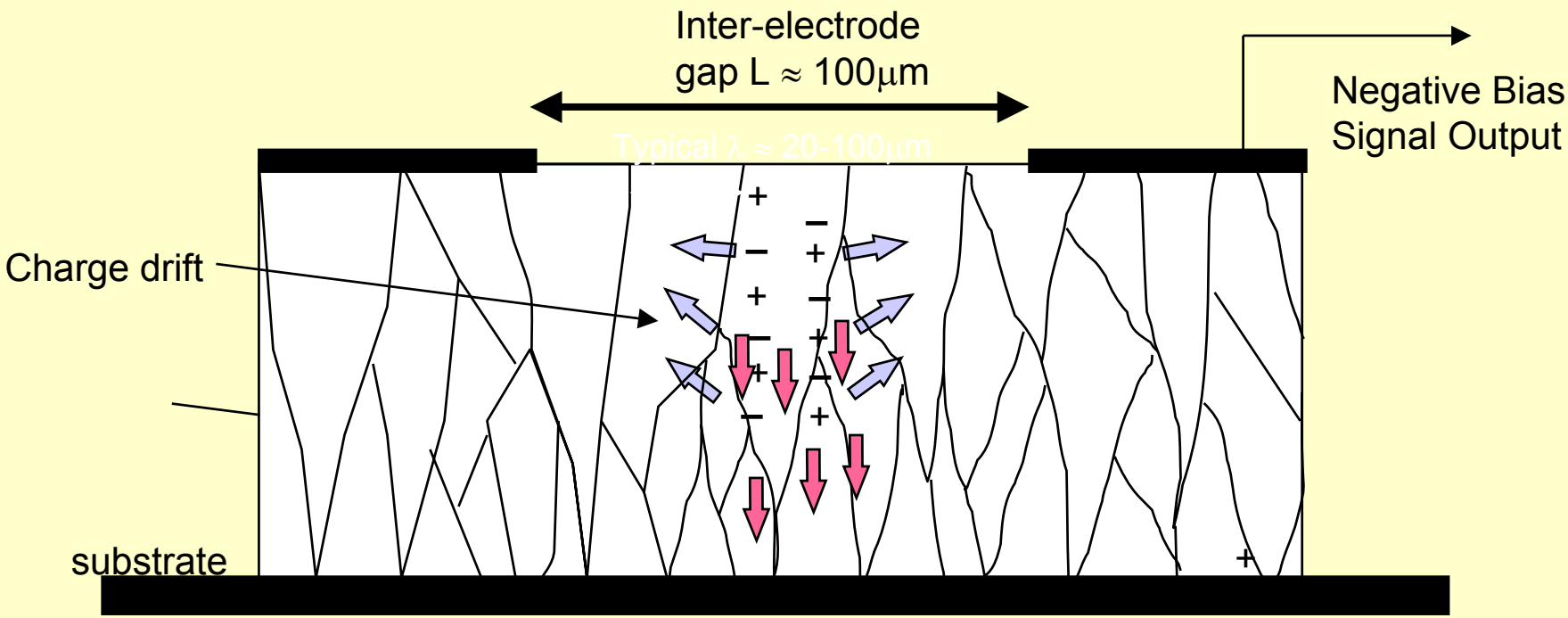
Efficiency


50/100 µm
diamond
Si diode → Trigger
Beam: 120 MeV ^{16}O


E(back):E(Diode),front 2,3 oder 4
bDf234
Entries 29938
Mean x 719.5
Mean y 340.2
RMS x 161.3
RMS y 11.21
Energy [ADC ch.]
440
420
400
380
360
340
320
300
280
260
0


counts
ε~98 %
8000
6000
4000
2000
0
0
1
2
3
4
Strip multiplicity

Local CCE



Paul Sellin, Radiation Imaging Group Surrey

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)

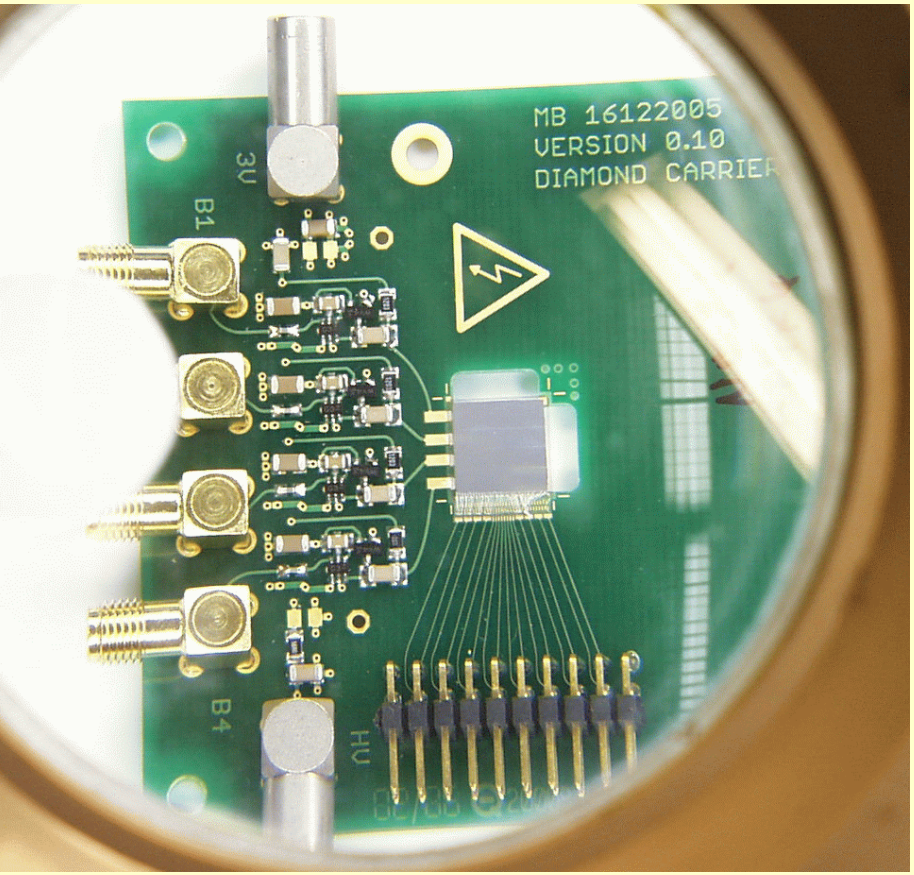
Signal Properties

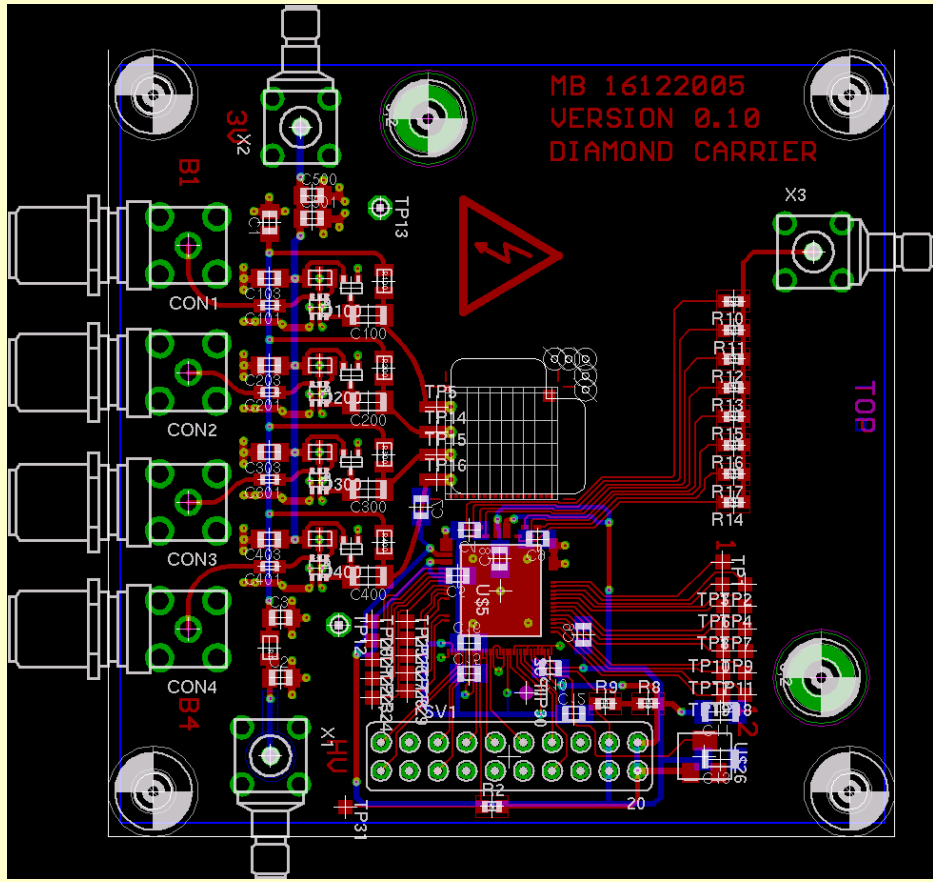
- coupling between channels
- time resolution worse than expected (may be due to electronics)
- walk correction should be possible with APV readout
- test of APV and fast timing electronic on a single detector .

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)

APV Test Board





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

AC coupling needed?
PPC investigations

Systematic investigations on PPC

Persistent photo current (PPC) only in beam

Nr.	sample	d[μm]	U[V]	I[nA]	CCD [μm]	type
13	ER VI 171	110	250	100		8x4
14	ER VI 171	110	150	300	10	4x4
16	ER V 274	55	200	350		8x4
17	ER VII 115	20	50	65		
20	ER WO 17	55	200	**0-2**	**9**	4x4
21	ER 00	55	150	375		64x4
23	ER 00	55	200	180	5	4x4
27	ER 00	55	150	200	2	4x4
38	ER 00	110	200	4150	7	4x4

WO 17
different production technique

more expensive?