R3B Heavy Ion Tracking

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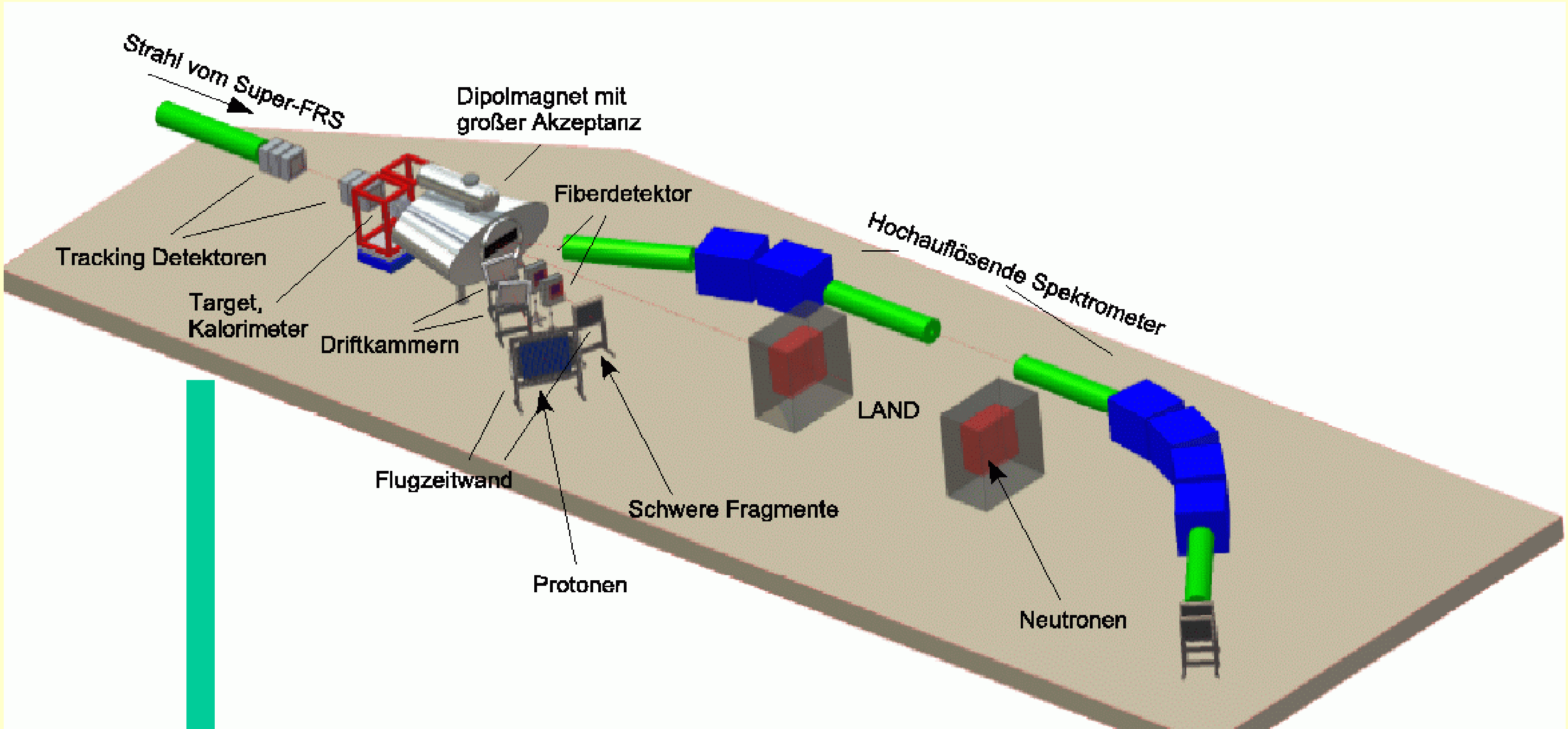
High Rate Diamond Detectors for Heavy Ion Tracking and TOF

- material investigations
- detector concept (a reminder)
- electronics development
- prototype production

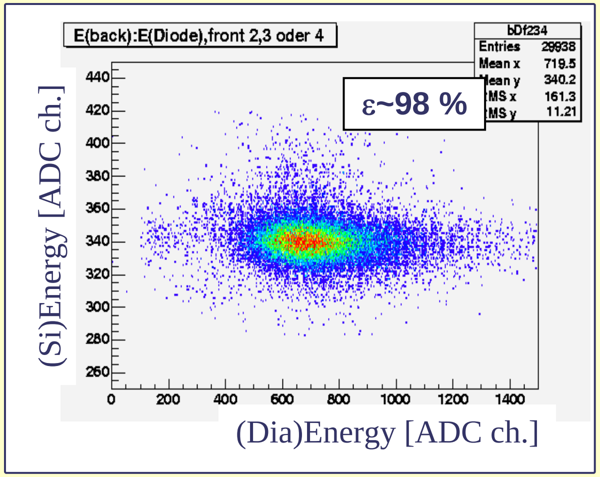
R^{3}B (Reactions with Relativistic Radioactive Beams) Setup

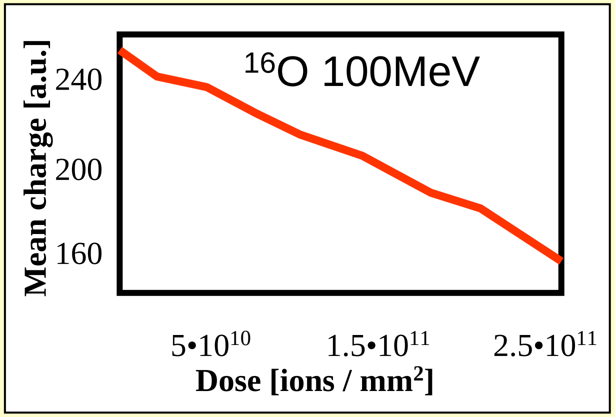


Measurement of all kinematic variables in a HI reaction

Different tasks: high resolution tracking to the target,
radiation hard (SFRS) 10^6 cm^{-1} s^{-1}
2 x TOF (SFRS – target) (reaction products)
low material budget @ several cm^2

Radiation Effects on PCCVD Diamond

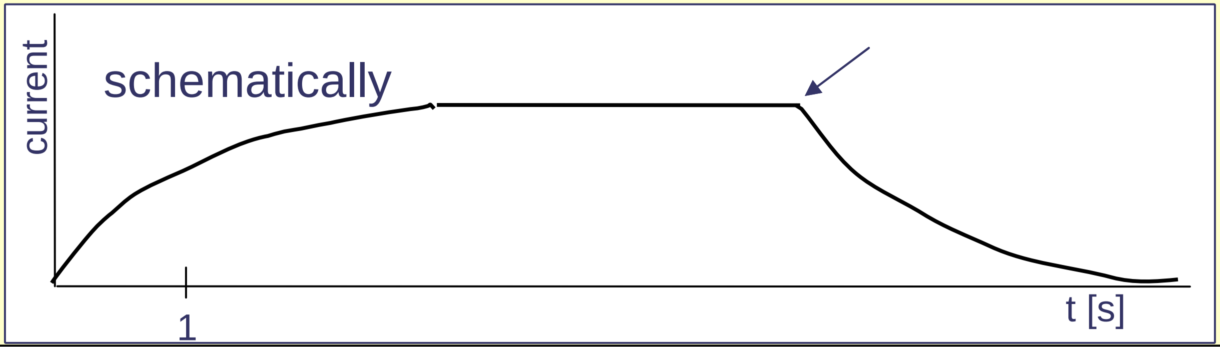




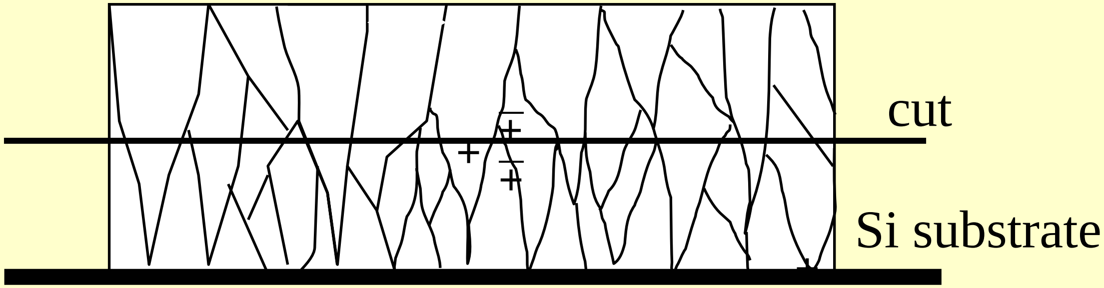
Persistent Particle Induced Currents (PPC)

	current [nA]	
Nr.	@ 15 kHz	@ 200 kHz
67	10	420
70	80	1800
74	290	1200
75	5	230
76	35	650
106	120	1000

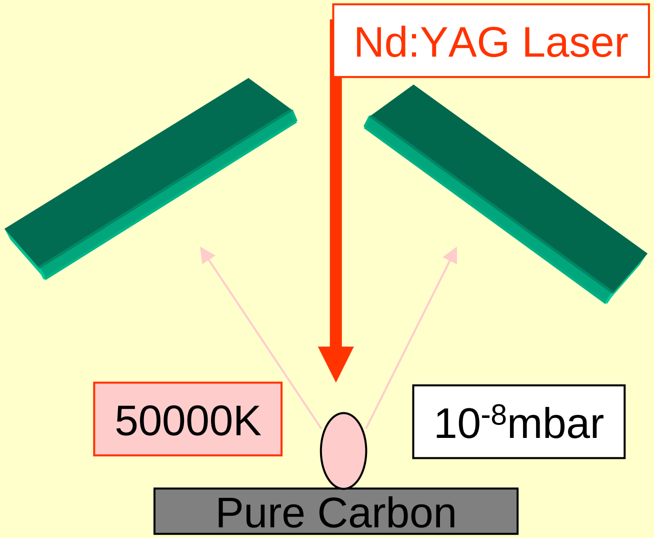
Many samples had been investigated. **70%** show particle induced current variation with batch and producer.
Same production parameters but different behaviour



Improved Samples



Material or Surface effect



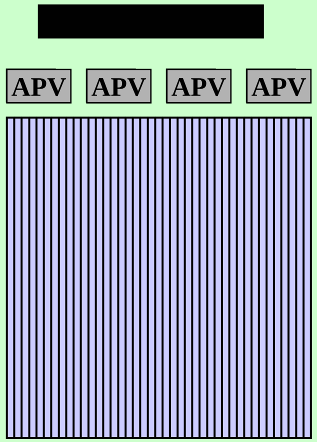
1. two step growth, polishing, round shaped corners, (less stress, larger grains)
2. different polishing to reduce stress
3. additional heat treatment (we saw better performance on SC diamond)
4. metallisation by sputtering
5. connection layer of LPA Carbon

0.4 µg / cm² carbon (~1nm)
interstrip resistivity of 1MΩ
better contact
surface cleaning and passivation

Sample	15kHz	200kHz
106_AL	120nA	1000nA
106_LPA	10nA	120nA
expected	10nA	150nA

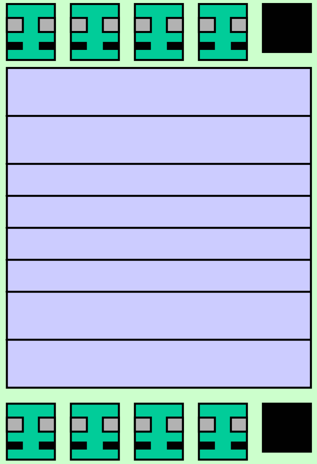
1 sample tested, 60 MeV 11B beam (stopped)

R3B Detector Concept



tracking layer:

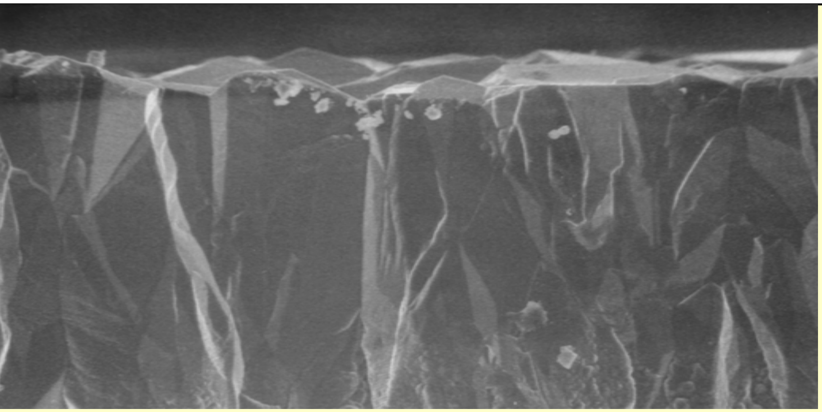
- 50 x 50 mm, d = 100 µm, PC-CVDD
- 200 µm pitch (185µm strips, 15 µm gap)
  (limited by multiple scattering)
- only digital position information
- multiplexed readout in vacuum

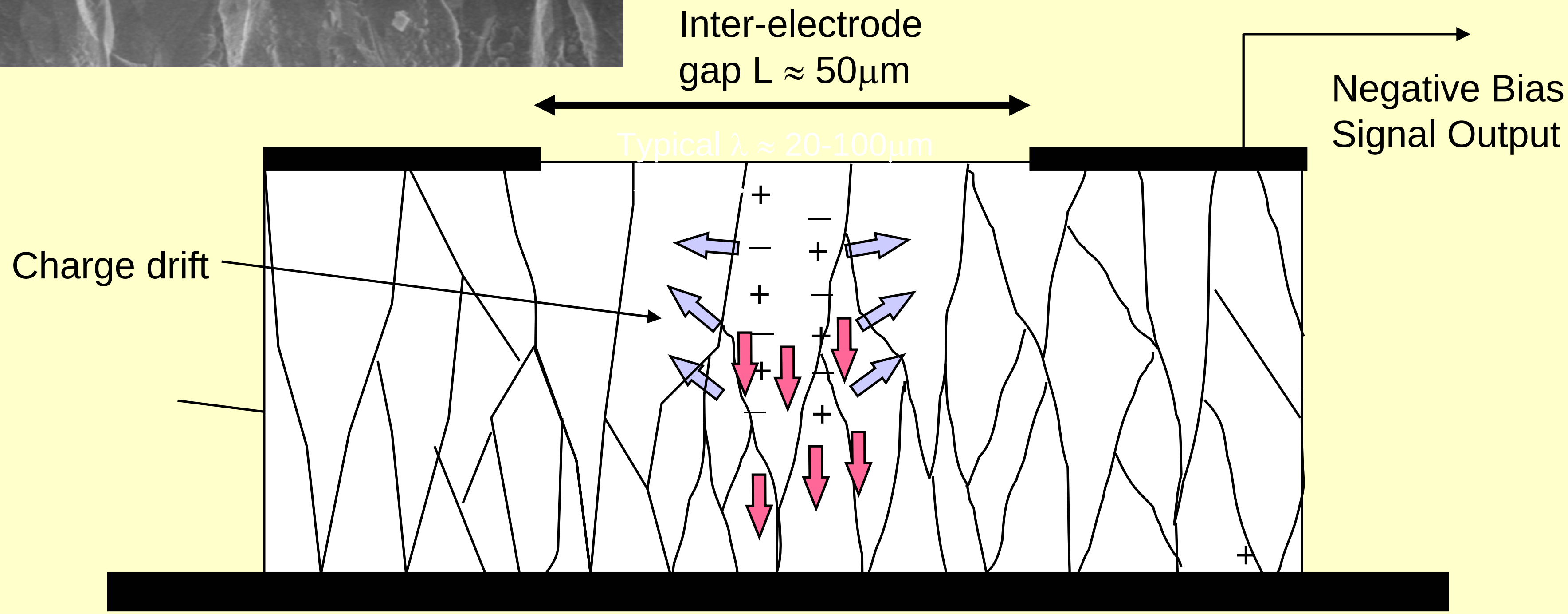


timing layer:

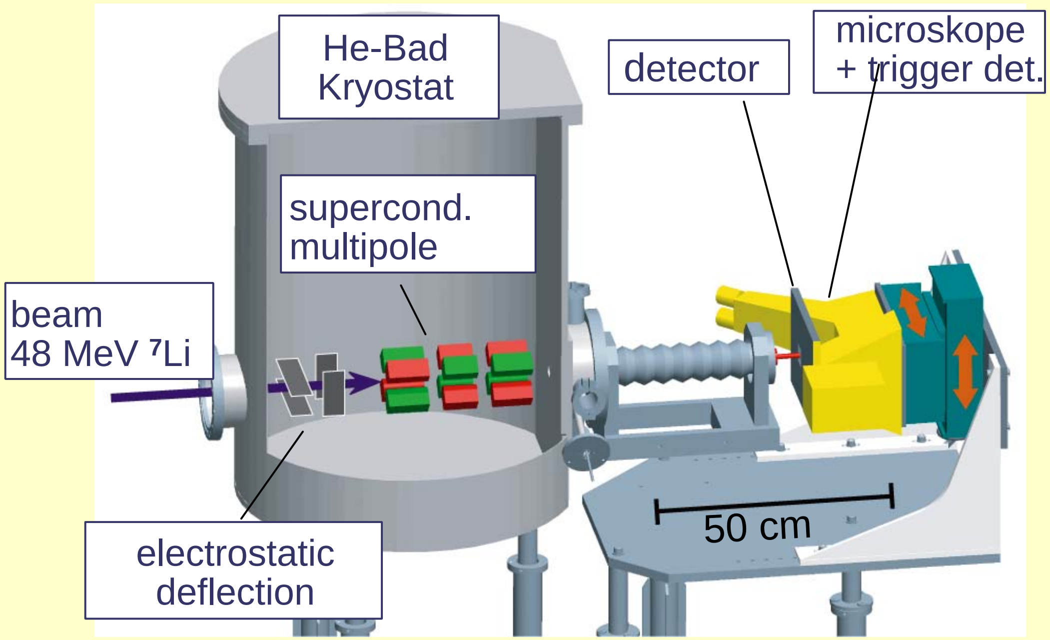
- 50 x 50 mm, d = 100 µm, PC-CVDD
- 16 rate matched strips, y information, trigger
- analog preamplification in vacuum
- $\sigma\tau < 100$ps

Local CCE

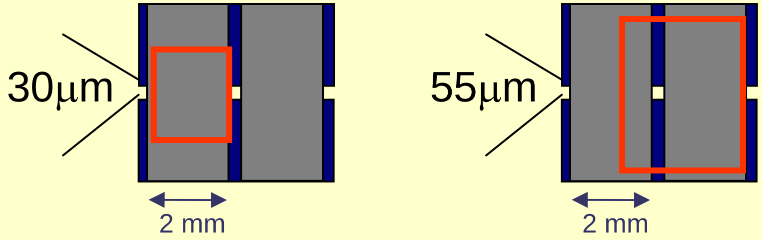


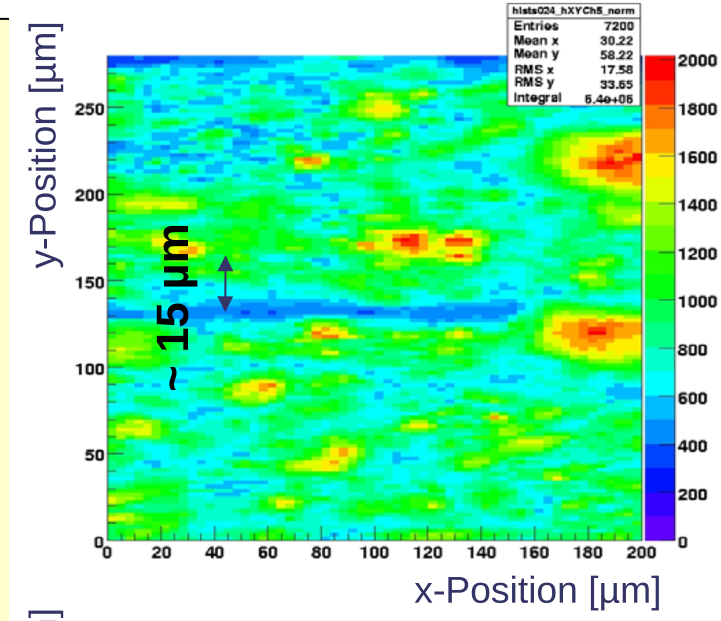

Inter-electrode
gap L ≈ 50µm
Typical λ ≈ 20-100µm
Negative Bias
Signal Output
Charge drift

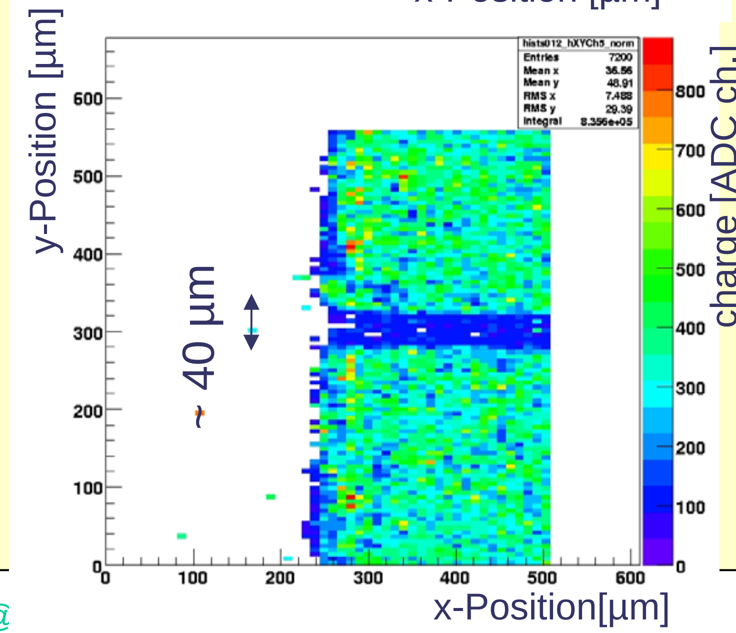
Local Charge Collection



fine scan: 3 µm in x-, 2 µm in y-direction
rough scan: 10 µm in x-, 5 µm in y-direction



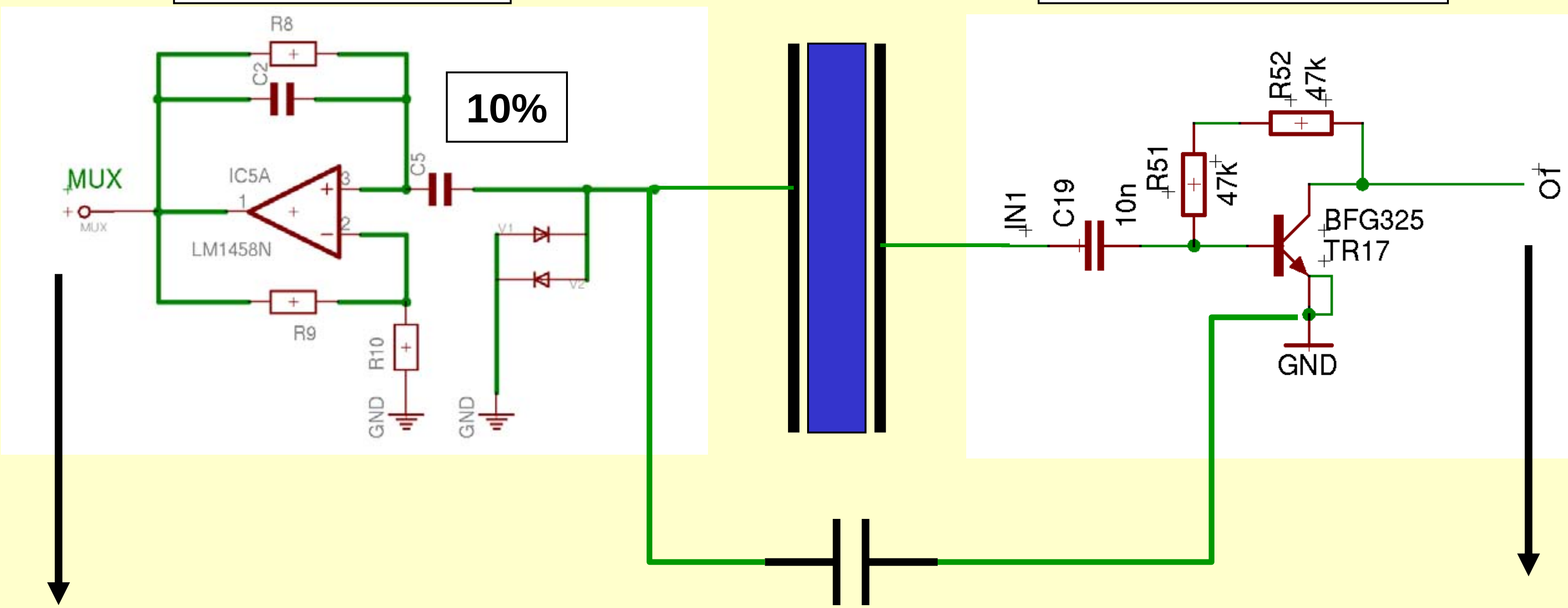




Readout Concept

APV electronics
many channels

broad band amplifier
few channels



90%

Made for Si-Detectors using MIPs

Std. interface GTB, SAM3

COG measurement

large inductance
large stray capacity
parasitic capacity

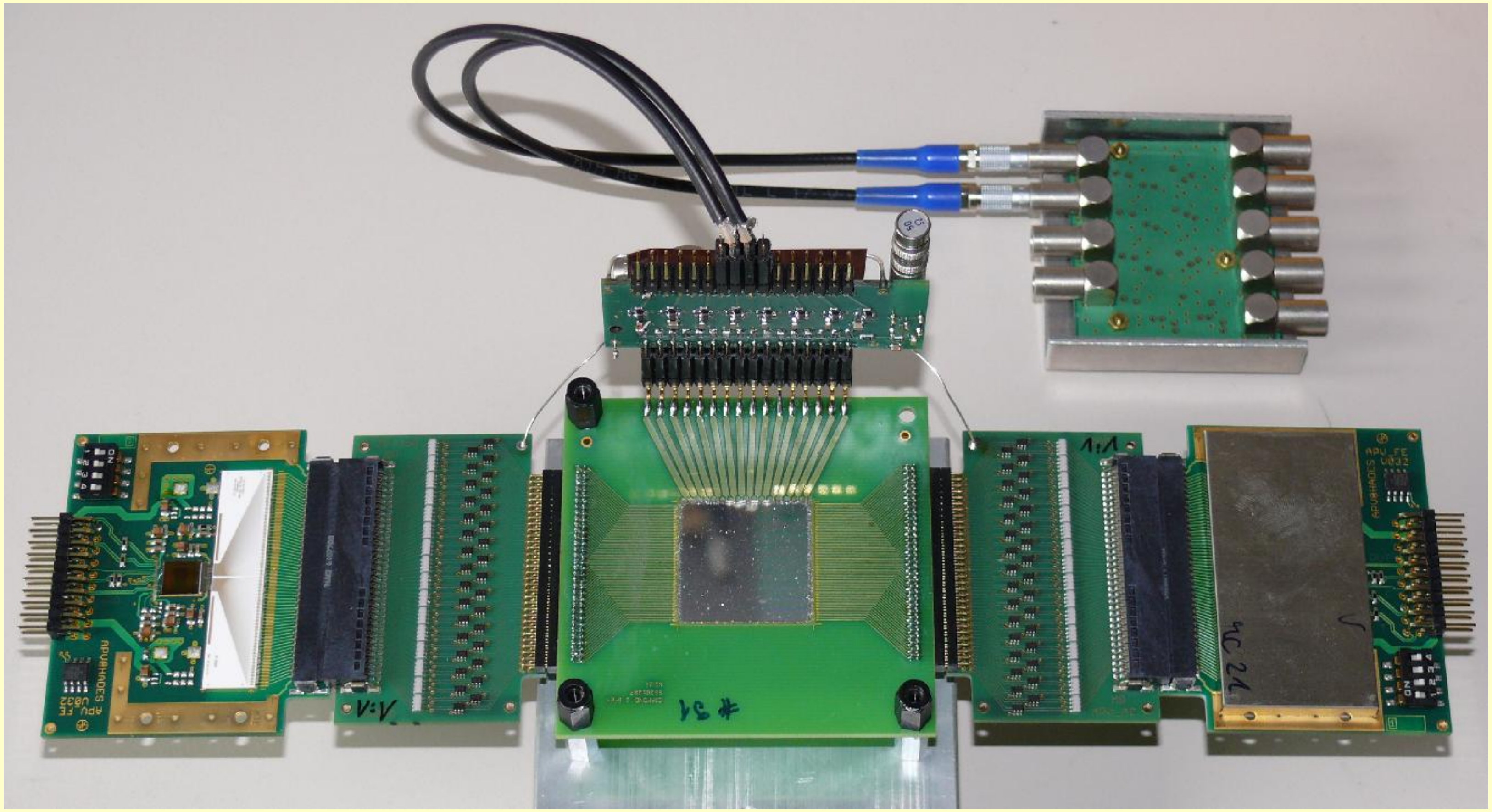
Main amplifier

Discriminator

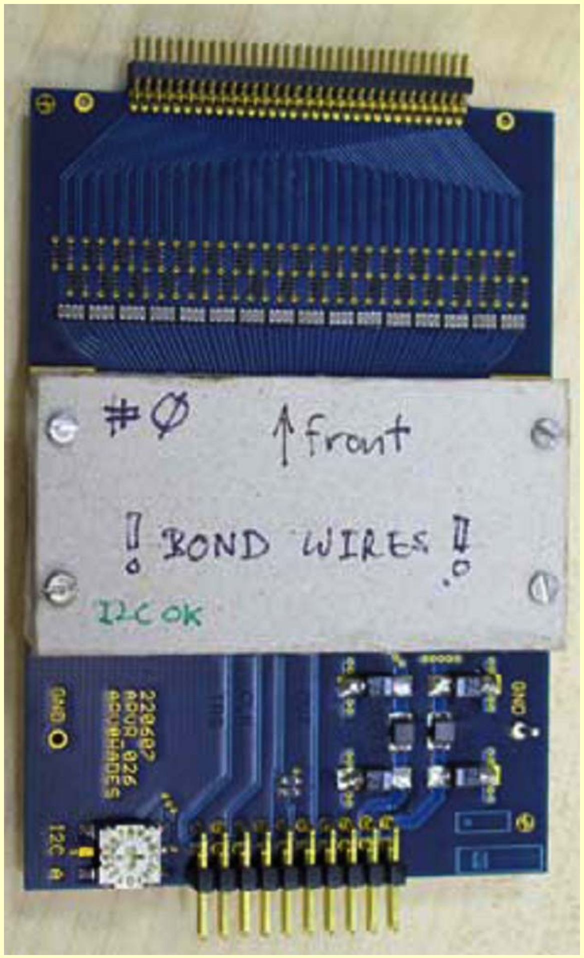
TOT measurement

1'' Prototype

parts in vacuum



APV Revision 3.0



64 ch. Input

diode array
capacitive splitter

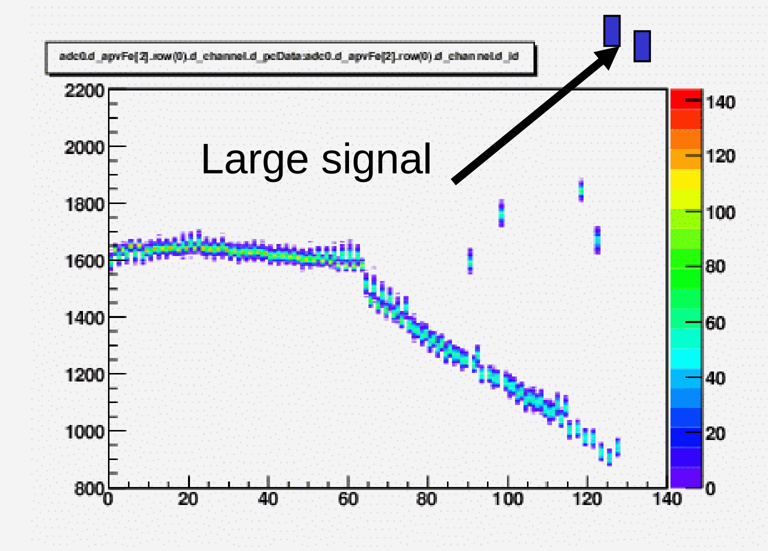
64 pin connector

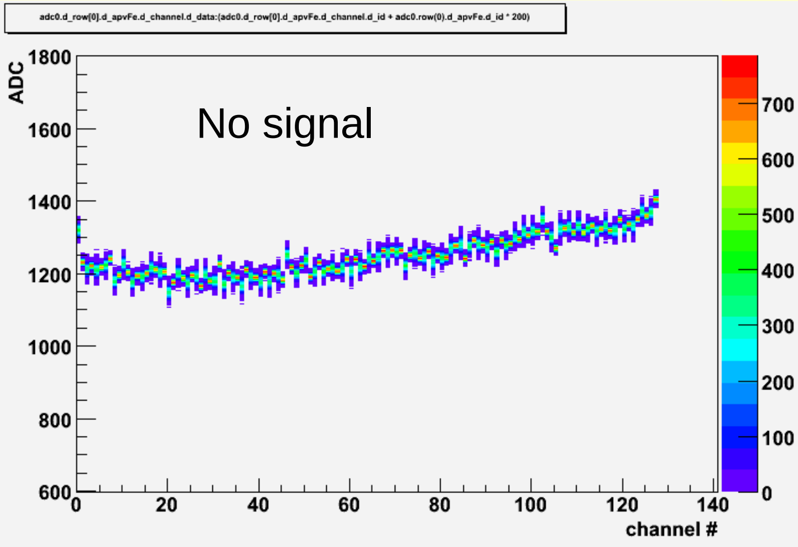
pitch adapter

APV

ADC and control
interface

APV Common Mode





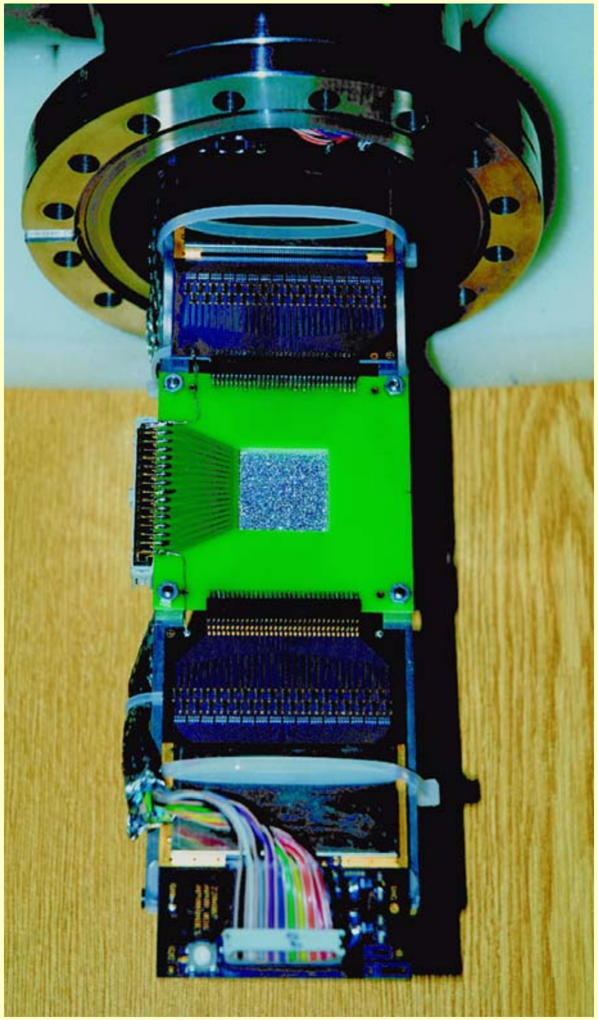
- stabilized by:
  - capacitors
  - diodes

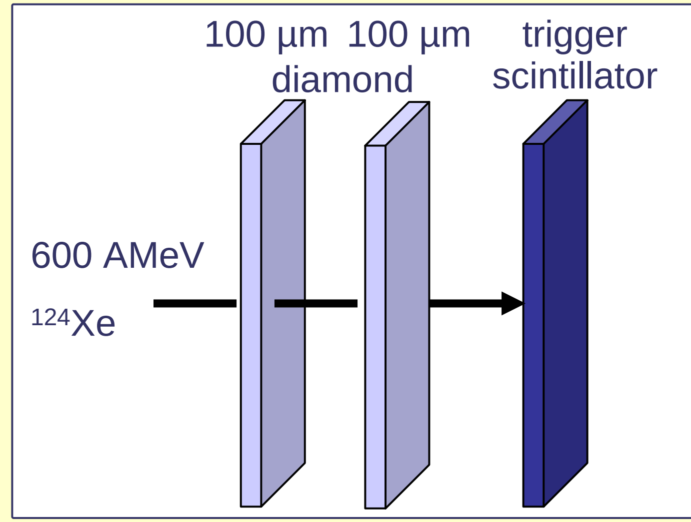
→ effect reduced

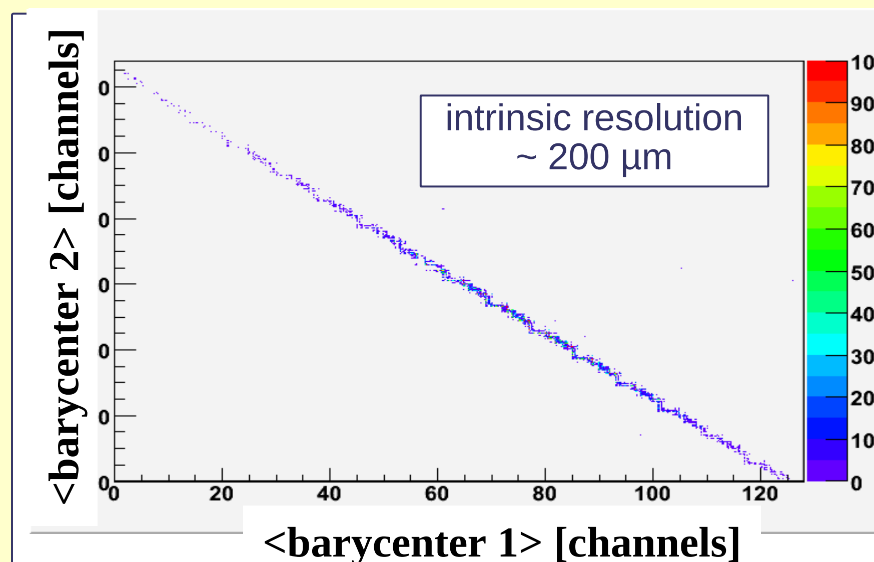
→ linearity conserved

Neighbor correction
using every second channel
not connected
Offset = (A(n-1)+A(n+1))/2

Prototype Test

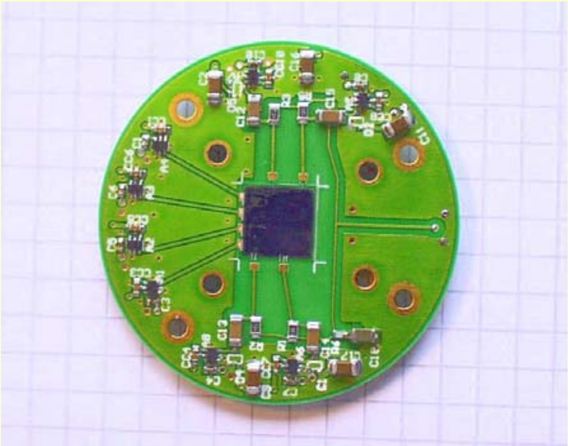


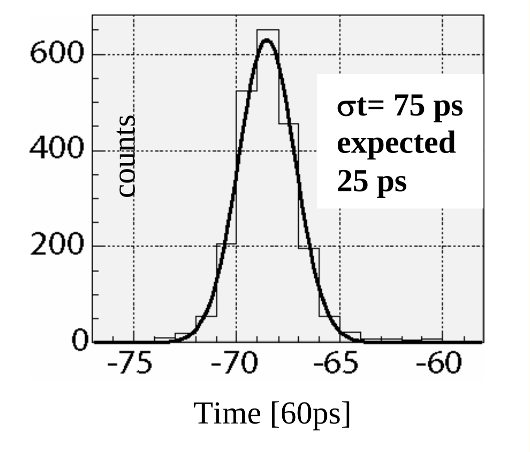


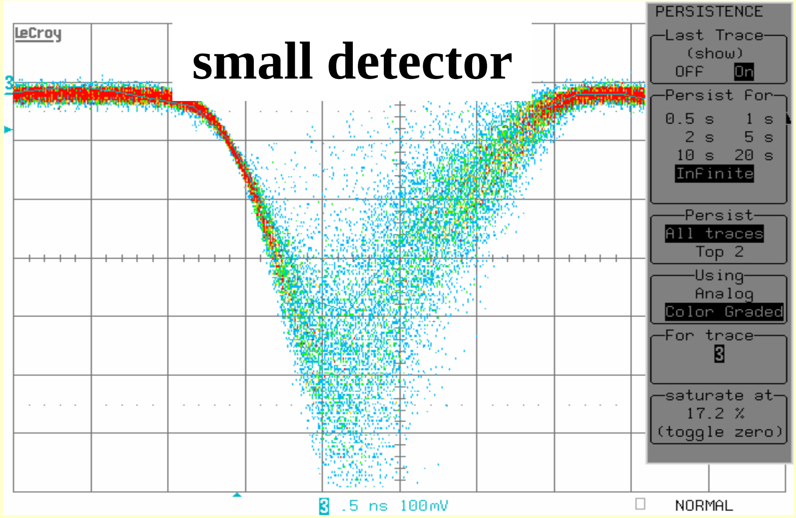


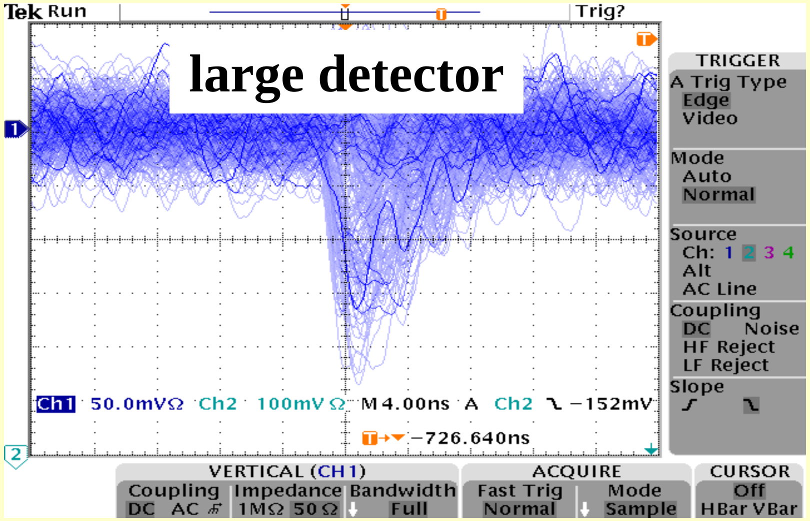
TOF Readout

Monolithic GHz amplifier+
DBA 3 (GSI) gain 30









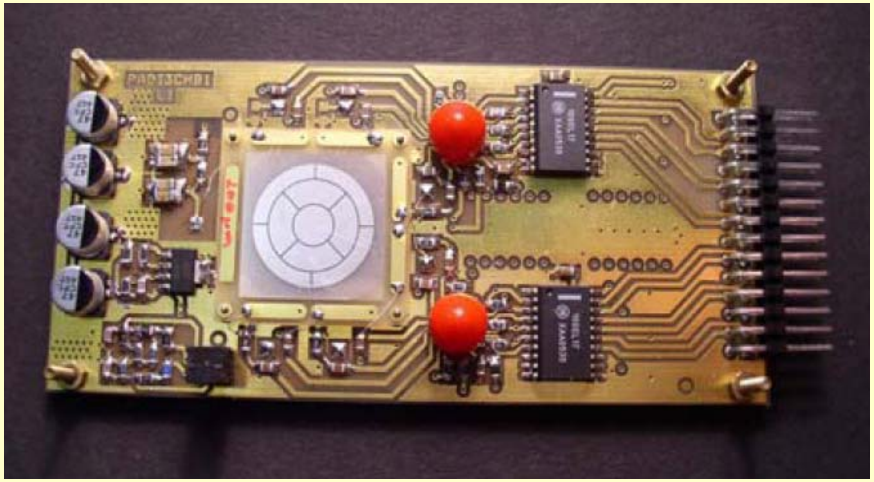
Reduce bandwidth

Better impedance matching

More compact design

?

Preamplifier Options



PADI, a fast Preamplifier – Discriminator for Time-of-Flight Measurements

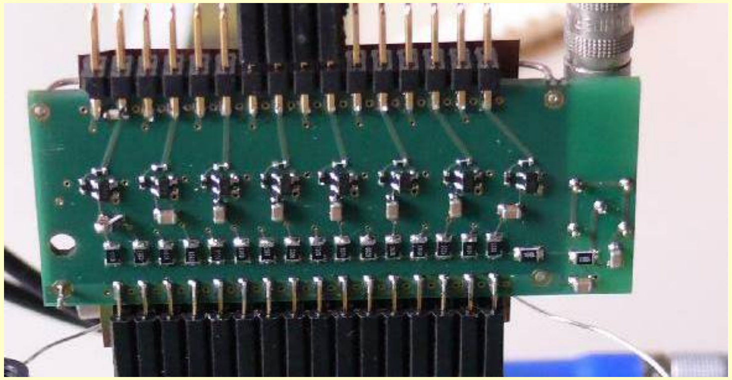
M. Ciobanu, N. Herrmann, K. D. Hildenbrand, M. Kiš, A. Schüttauf

IEEE Conf. Proc. (2006)

http://www-rpc2010.gsi.de

DBA II, DBA III, DBA4,
P. Moritz,GSI development

HADES diamond readout
W. Koenig,GSI development



1ns Shaping

larger impedance
less noise sensitive
better adopted to APV

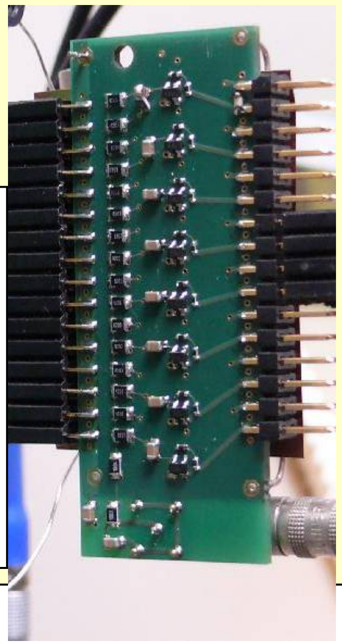
simple signal transport

use of standard discriminators

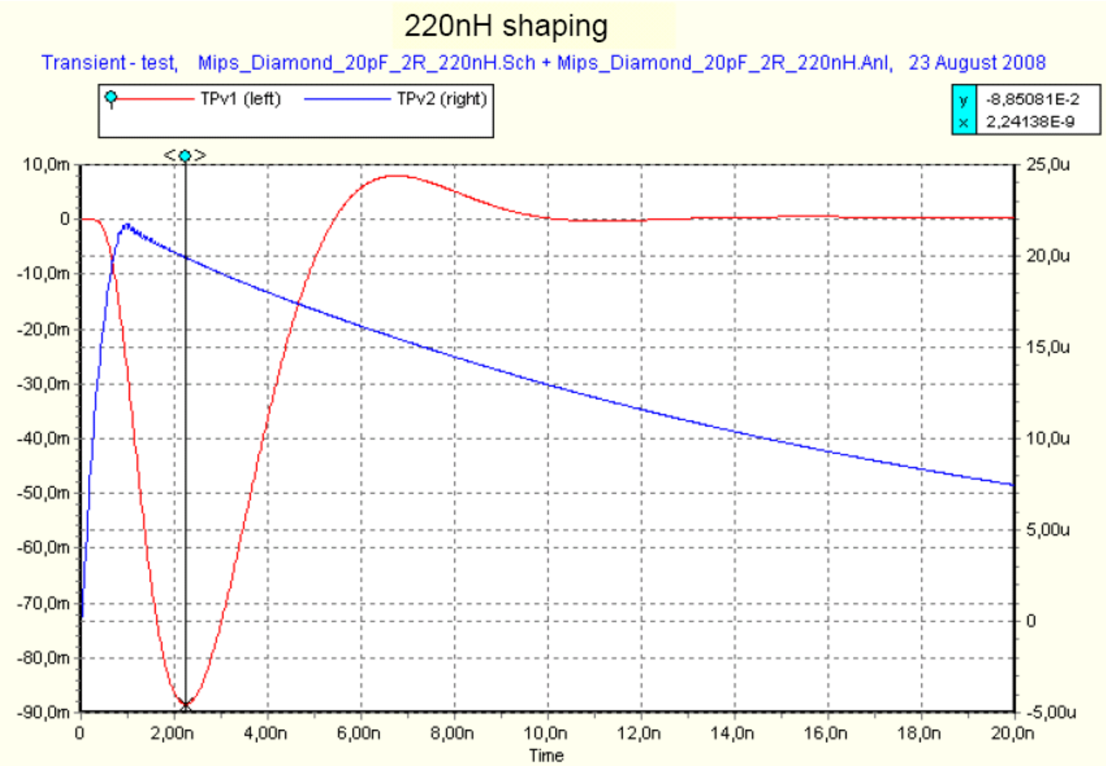
16 ch.
S/N (1pF)> 20

S/N(10pF) ~2

30 pF
did not work

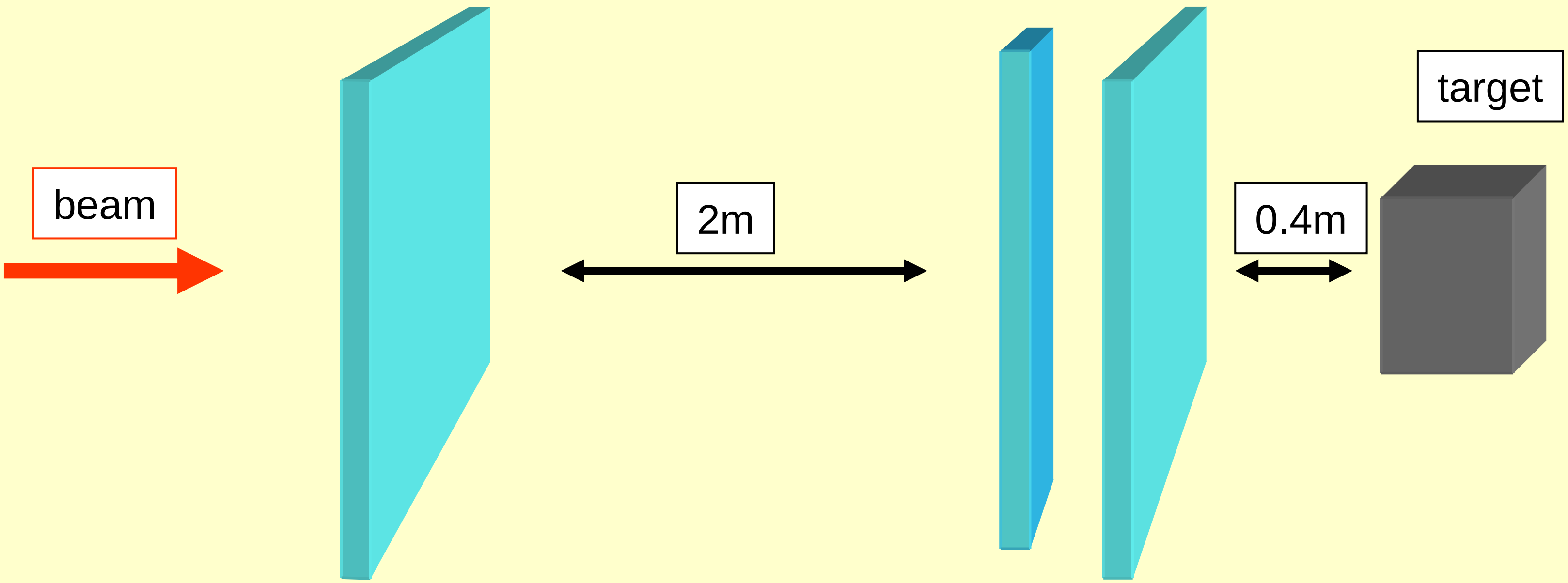


Input signal (**blue**, right scale) and output signal (**red**, left scale):



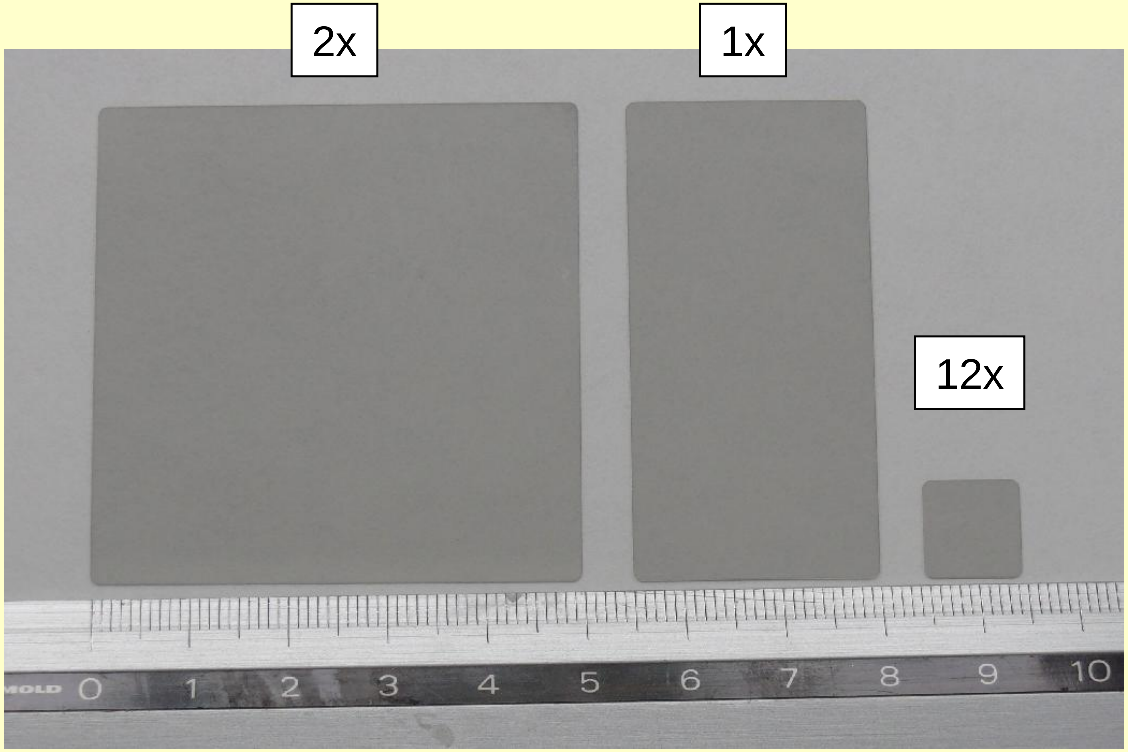
Amp Type	Shaping	T_r [ns]	S / N	T_{res} [ps]	Det. Thickness
Op-Amp	22 kOhm	4.9	9.4	521,5	100u
Transistor	220 nH	1.1	41.6	26,7	100u
Transistor	120 nH	0.9	38.5	23,9	100u
Transistor	220 nH	1.0	21.4	46,7	50u

Fall back solution



50 x 50 mm 1st side x-readout (200μm pitch) 2nd side y-readout (1.5mm pitch) Both sides charge integrating (APV + Mesytec + Trigger) (2ns resolution)	50 x 25 mm 1st side high voltage (not segmented) 2nd side y-readout (1.5mm pitch) DBA4 or PADI	50 x 50 mm 1st side x-readout (200 μm pitch) 2nd side y-readout (200 μm pitch) Both sides charge integrating (APV) fits to multiple scattering

Final Size Detectors Production



150mm material
just to limit the risk

Verify effect of carbon coating (CC) (March 2010)

Test low(er) cost material with (CC) (different production parameters)

Test effect of CC on electronics

Further investigation on fast readout

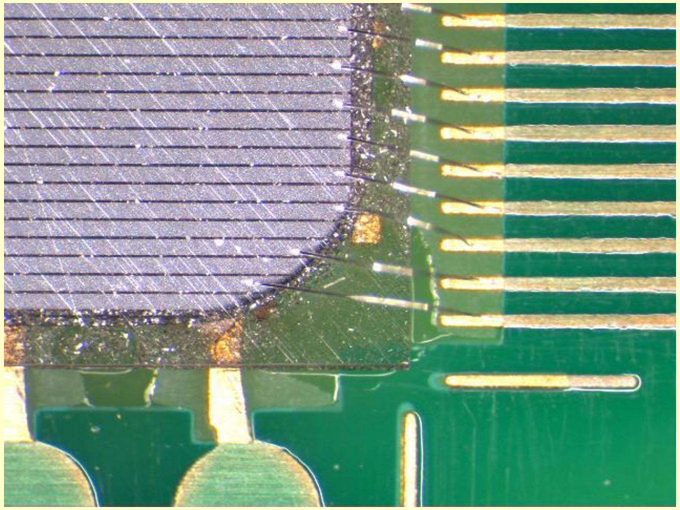
Finalize readout concept with medium size detectors

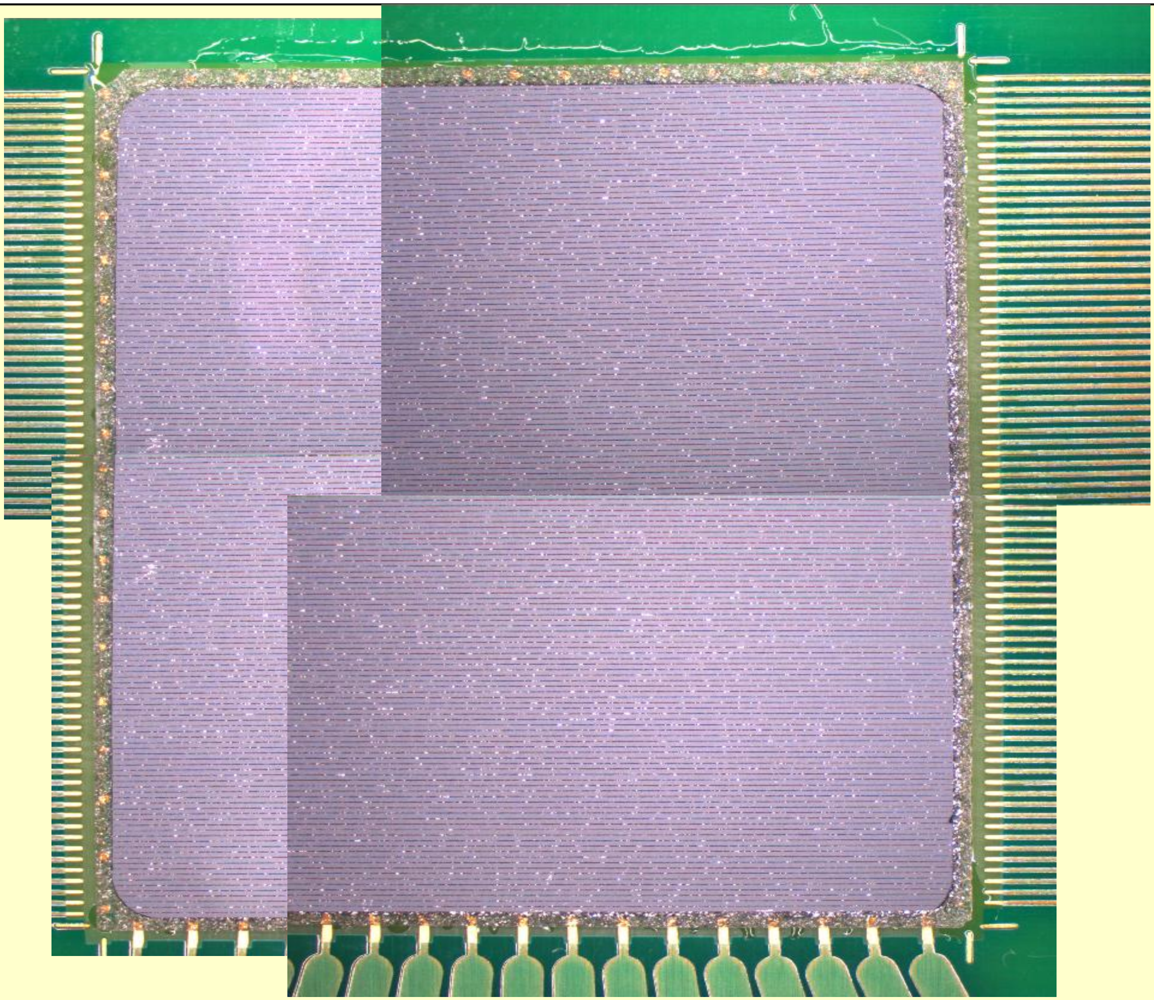
Full system test June 2010

Larger Area Detector

8 prototypes produced
4 operational
lithography under control

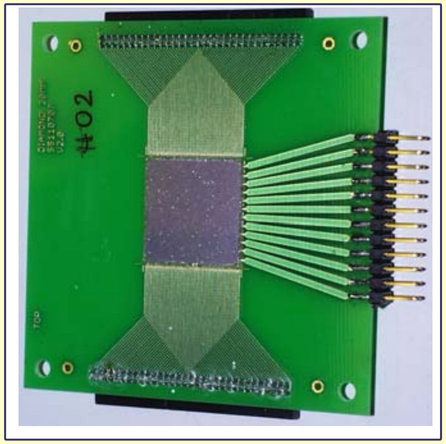
Front side:
128 strips
170 μm wide 20 μm gap
Backside:
16 strips



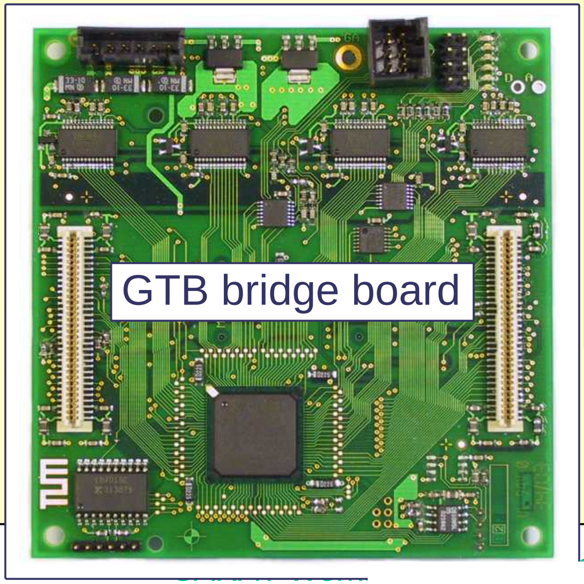


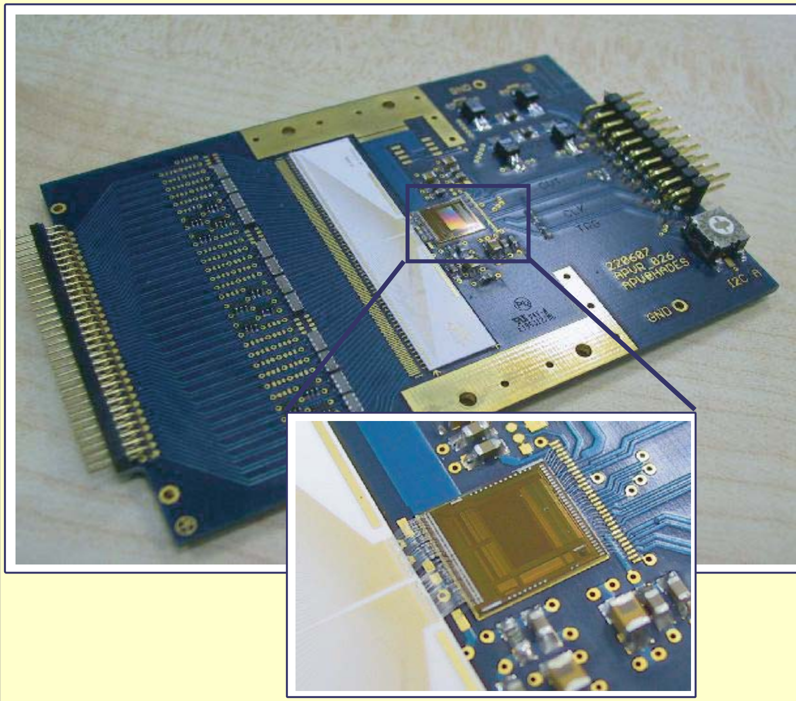
25.4 mm

Full system test in R3B Setup



- 25.4 x 25.4 mm^2
- 128 micro strips (200 µm)





M.Boehmer, TU Muenchen, PhD Thesis (20

Data

Parameter		Diamant	Silizium
σ_W	[W cm^{-1} K^{-1}]	20	1.27
$E_{lattice}$	[eV]	80	24
E_{gap}	[eV]	5.45	1.12
$\mu(e^+)$	[cm^2 (Vs)$^{-1}$]	2200	1500
$\mu(e^-)$	[cm^2 (Vs)$^{-1}$]	1600	600
W	[eV]	13	3.6