High Rate Diamond Detectors for Heavy Ions

Roman Gernhäuser, TU-München

- ultra thin detectors for REX-ISOLDE
- tracking detectors for R3B
- prototype production
- further developments

A Diamond Beam Monitor for MINIBALL

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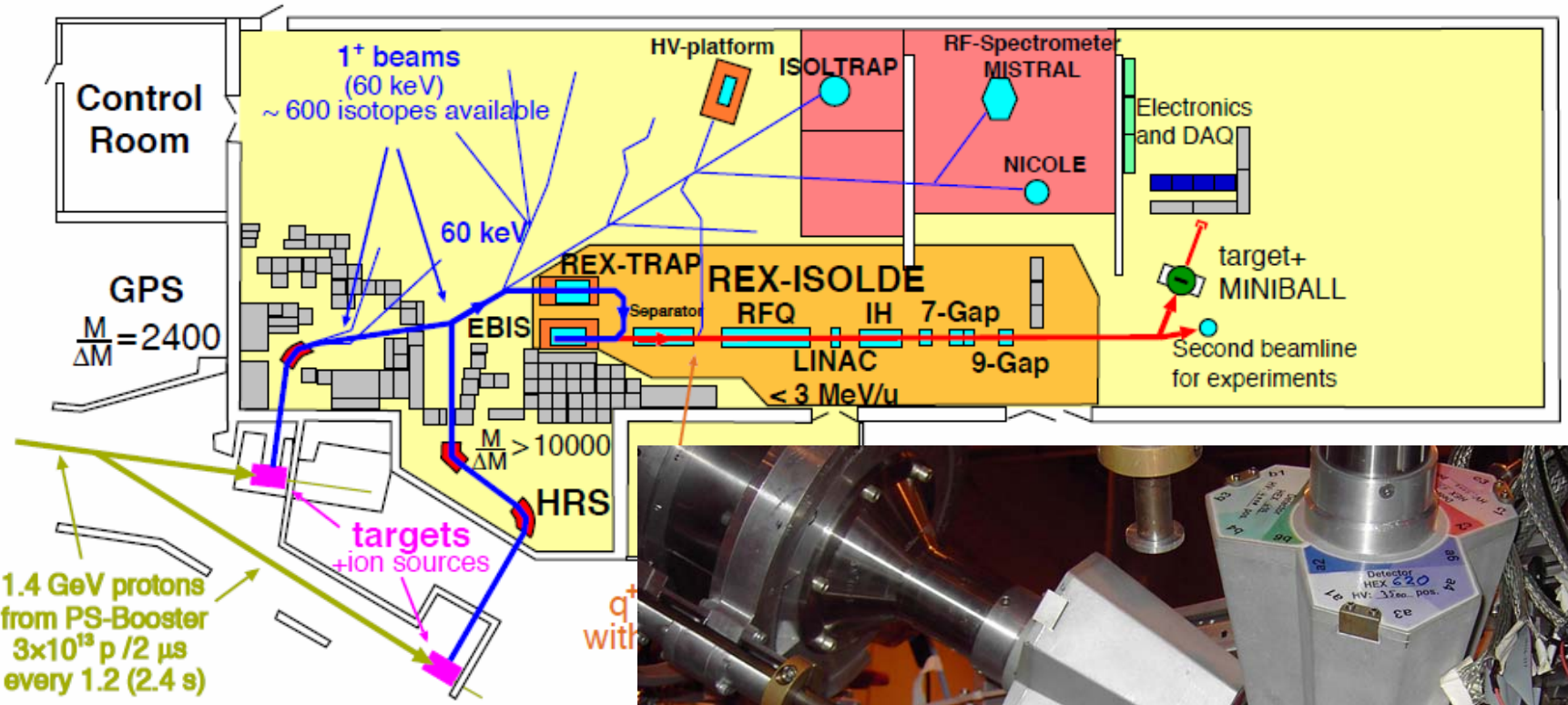
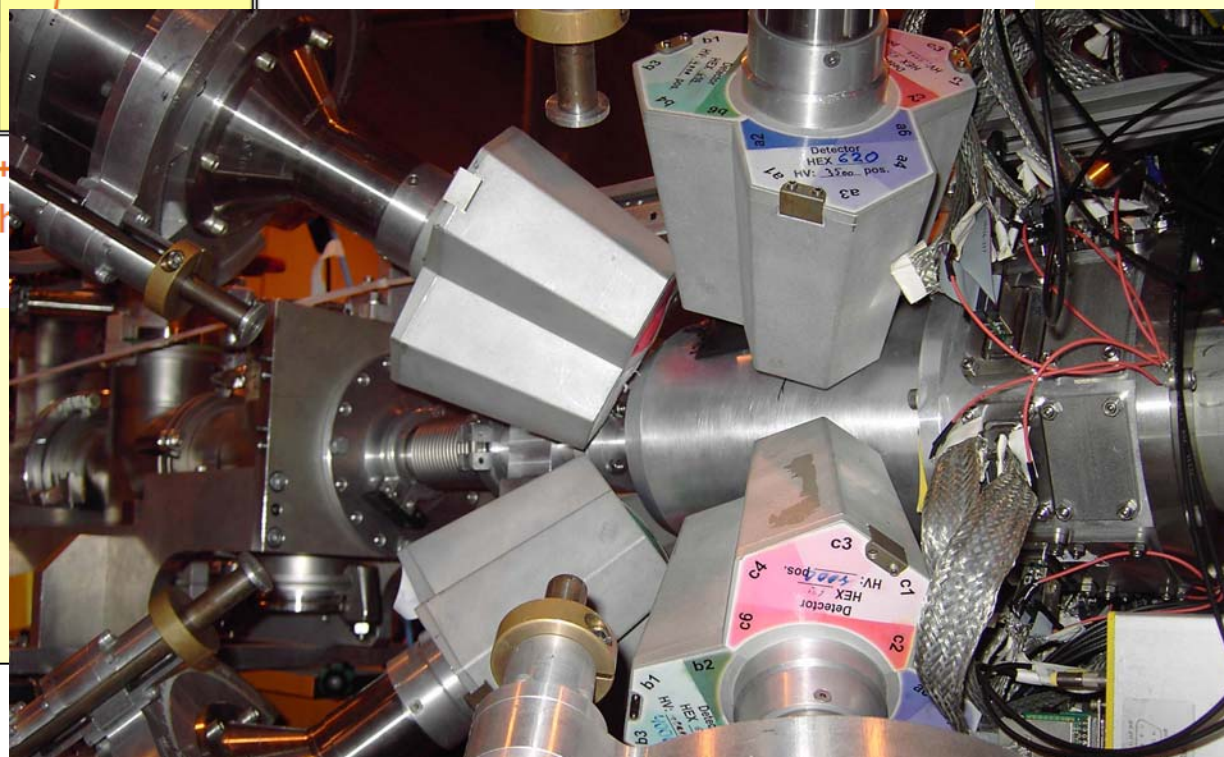
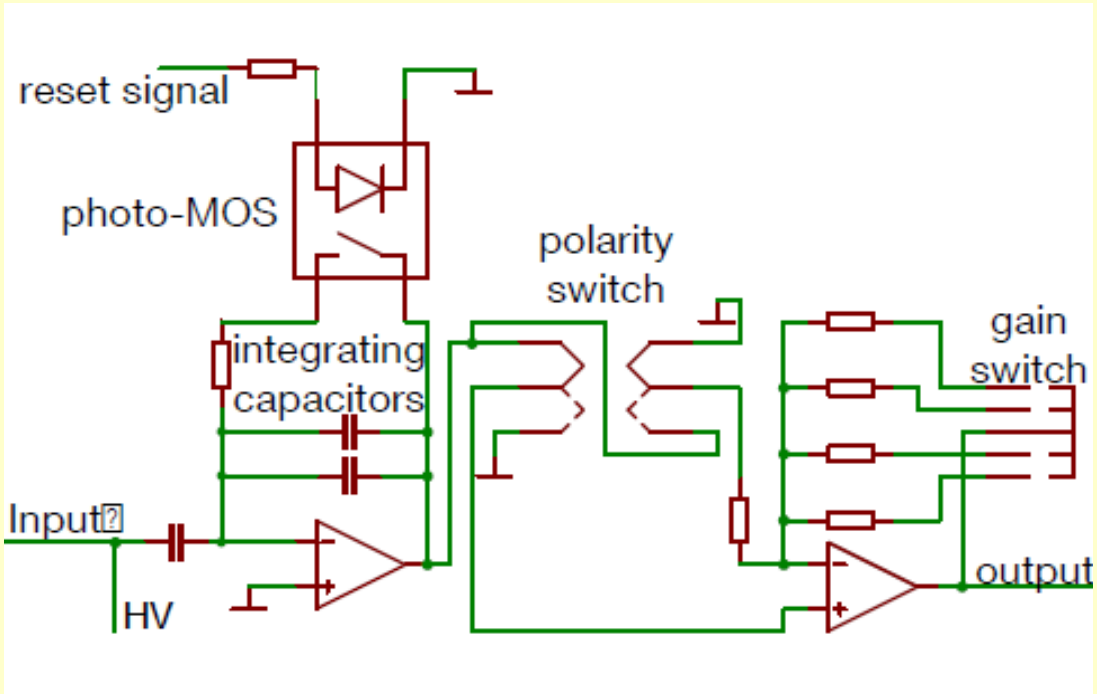


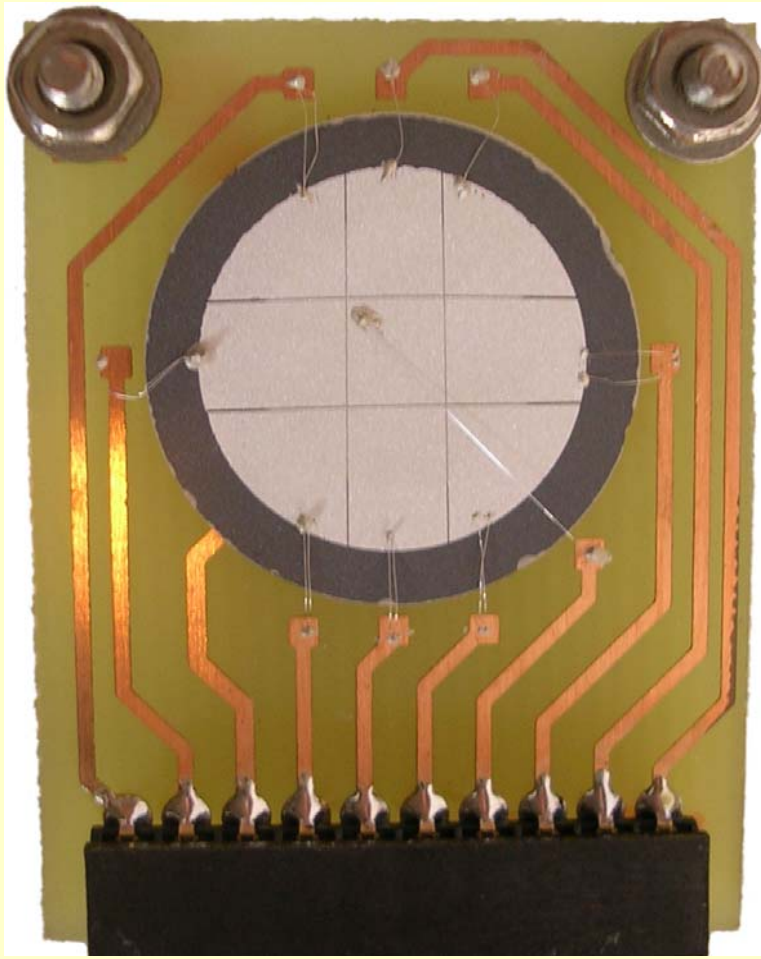


no space left
2.8 AMeV beam
radioactive beam
50 Hz 100µs long pulses
of 10^5 -10^6 particles/s

A 12 μm Beam Monitor

10 mm open diameter
10-12 μm PC-CVD film
9 segments
silicon ring for mechanical stability
calibration by single particle counting
or at high intensity, Faraday Cup (10^8 1/s)





from Diamond Materials

R3B (Reactions with Relativistic Radioactive Beams) Setup

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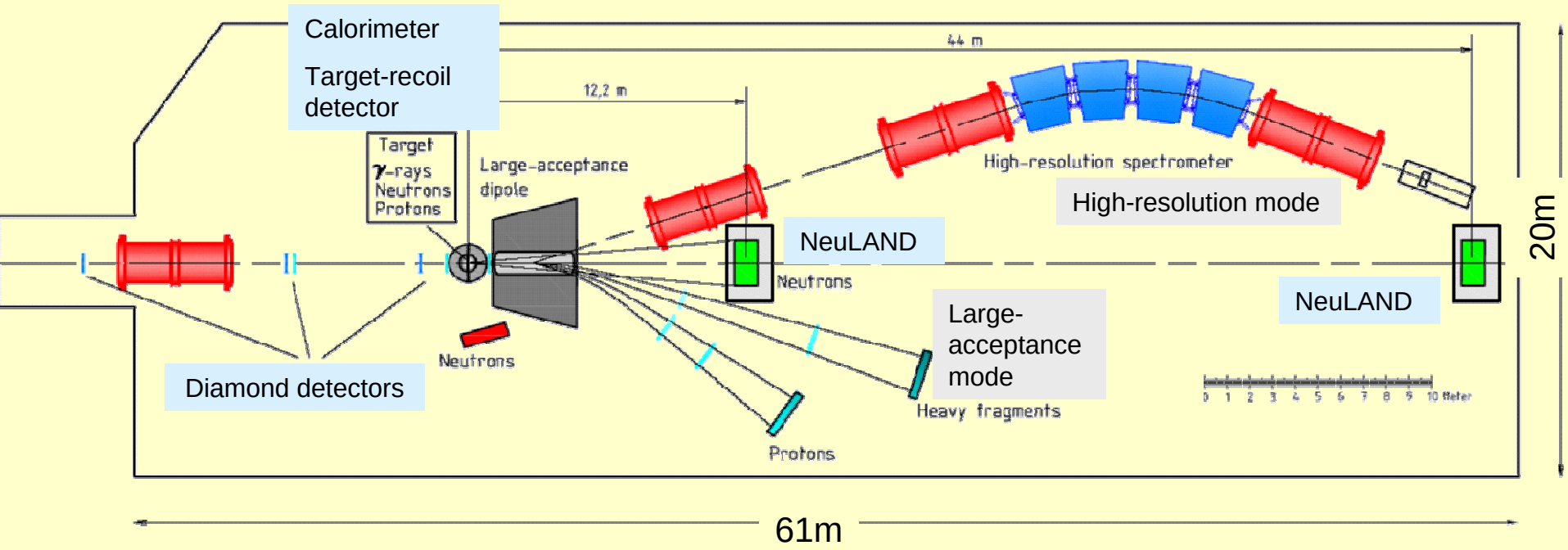
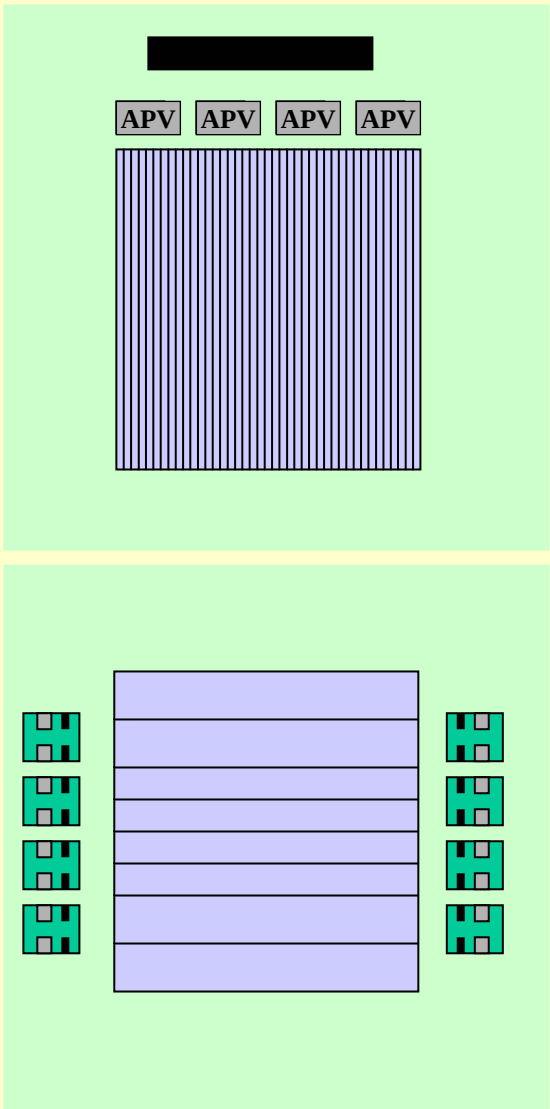


Measurement of all kinematic variables in a HI reaction
secondary beams have a large spot size (4 x 5 cm)!
→ high resolution tracking to the target,
radiation hard (SFRS) 10^6 cm^{-1} s^{-1}
material budget limits the resolution and rate capability of the whole spectrometer. (Multiple scattering in the last tracking layer)

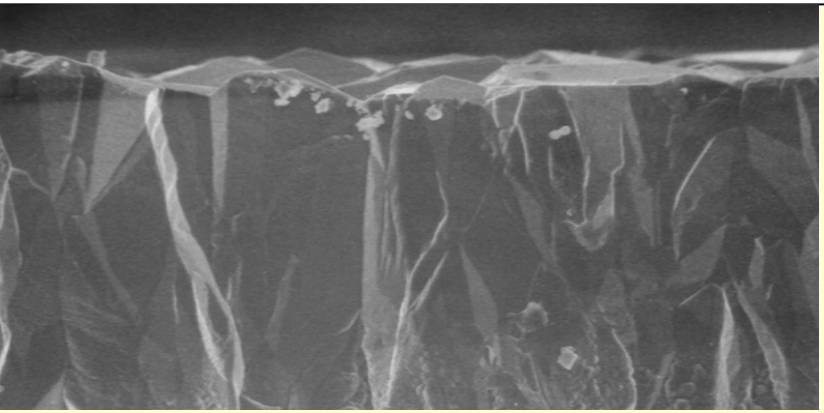
R3B Detector Concept

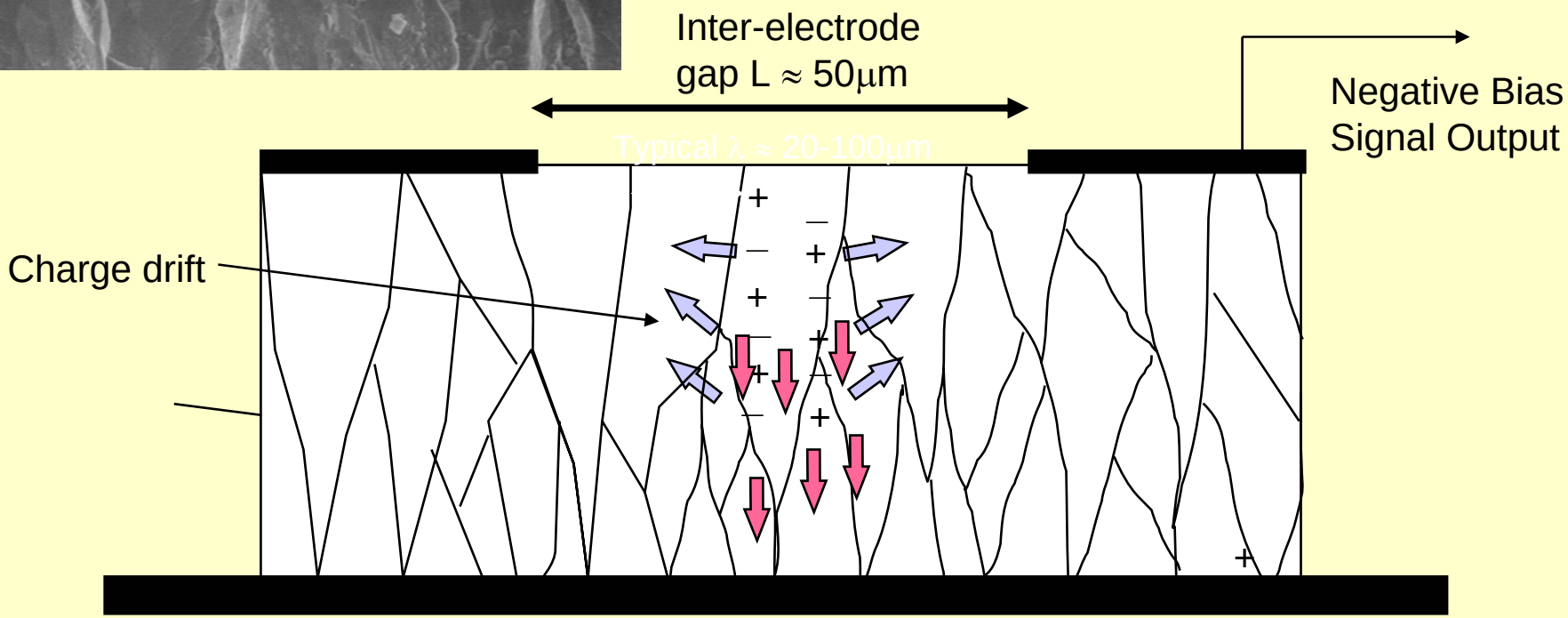


metallization layer:

- 50 x 50 mm, PC-CVDD
- d = 150 µm (thinner material is hard to handle)
- Al layer with lithographic structures
- x : 200 µm pitch (limited by multiple scattering)
- y : 1mm pitch for optional TOF
- only digital position information (PC-CVDD)
- multiplexed readout in vacuum (power consuption)
- event Rate up to 10^5 @ 10^7 1/s

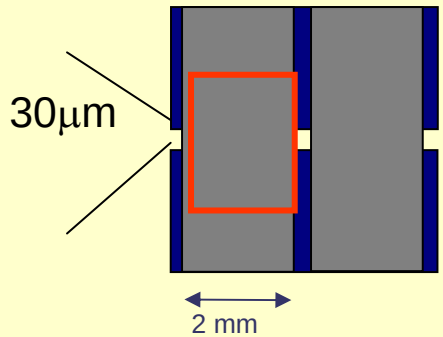
Local CCE



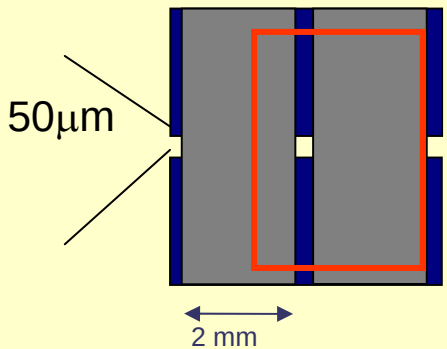

Inter-electrode
gap L ≈ 50μm
Typical λ ≈ 20-100μm
Negative Bias
Signal Output
Charge drift

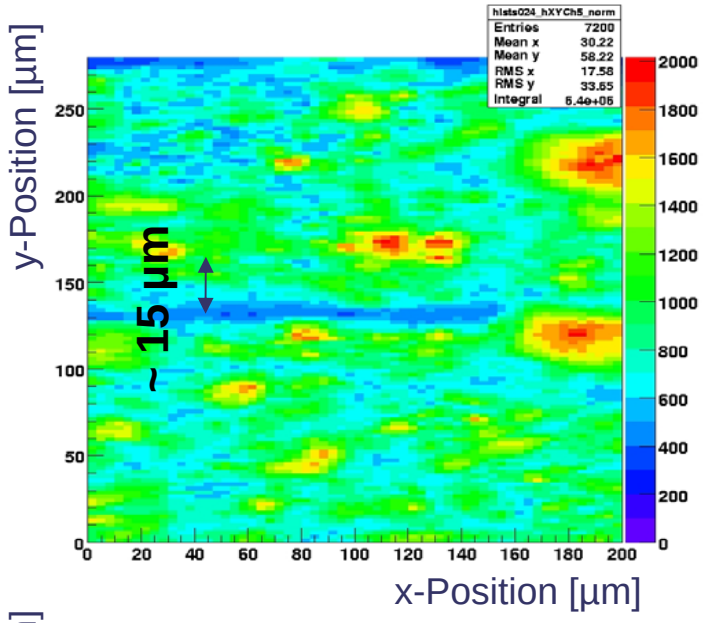
Local Charge Collection

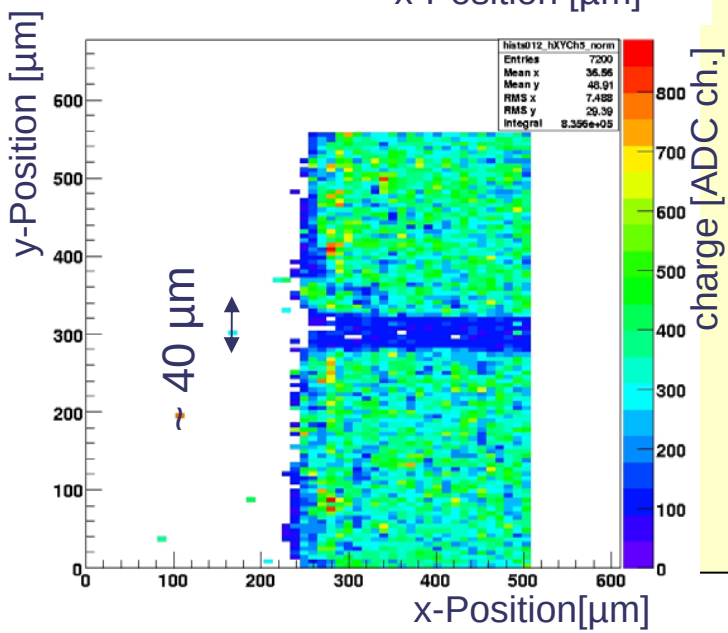
measurement with the Munich heavy ion micro beam



20 µm gaps should be fine







Test Measurement @ Munich Tandem

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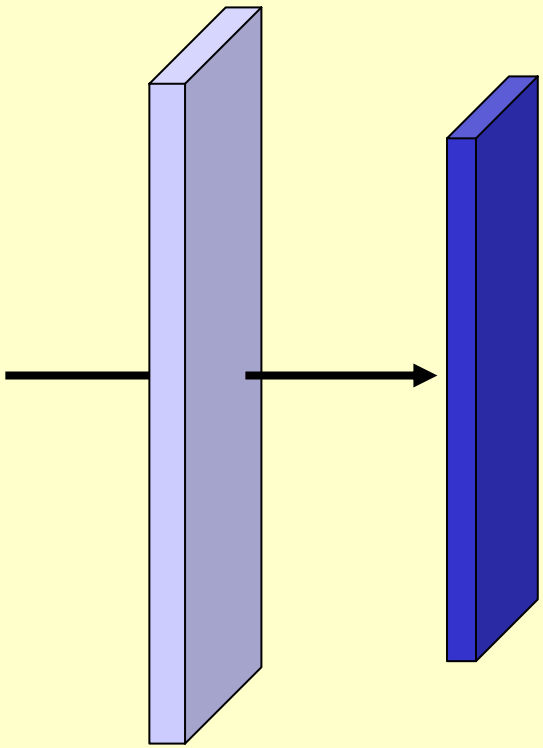
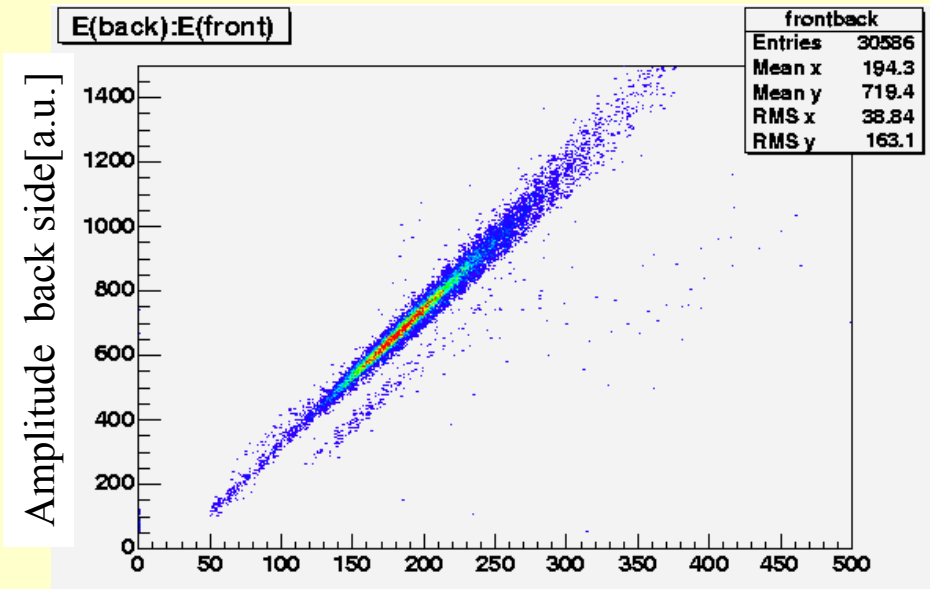
50 µm diamond
100 µm diamond

Si – diode
Trigger



efficiency 98%



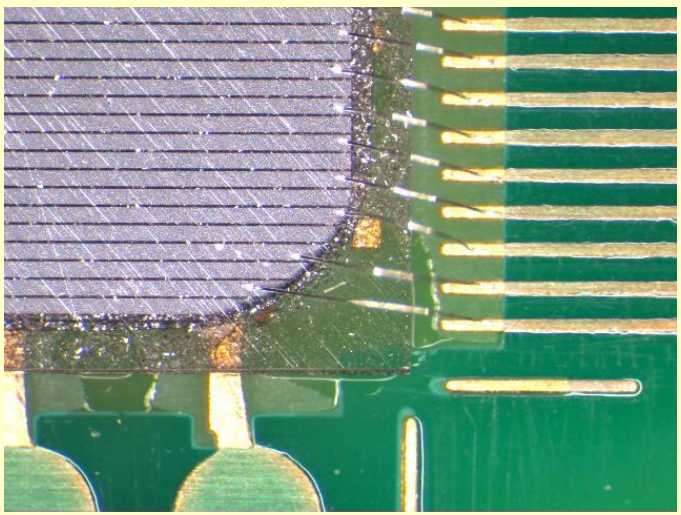
Amplitude front side[a.u.]

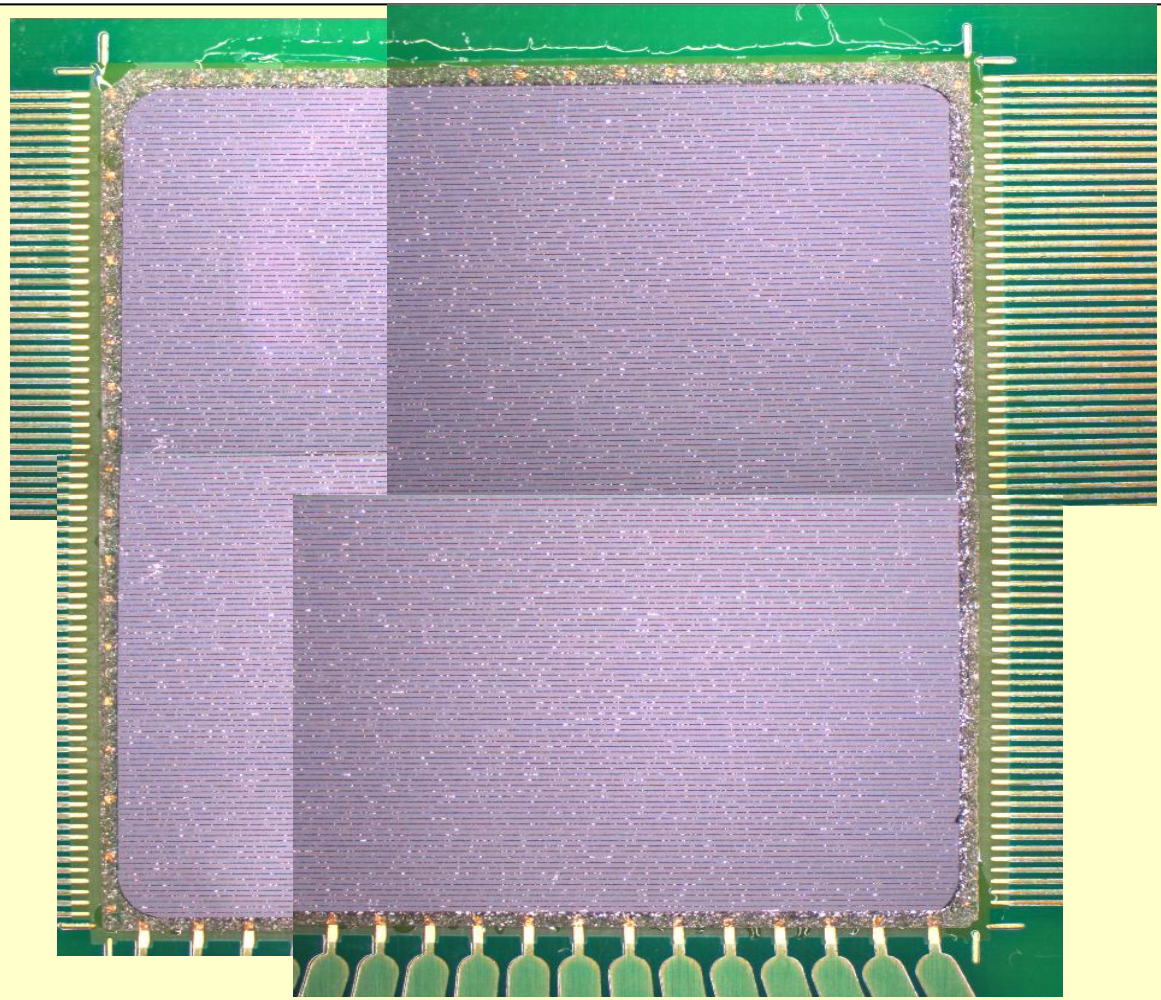
Beam: 120 MeV ^{16}O
36 MeV ^{6}Li

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

1’’ Prototype

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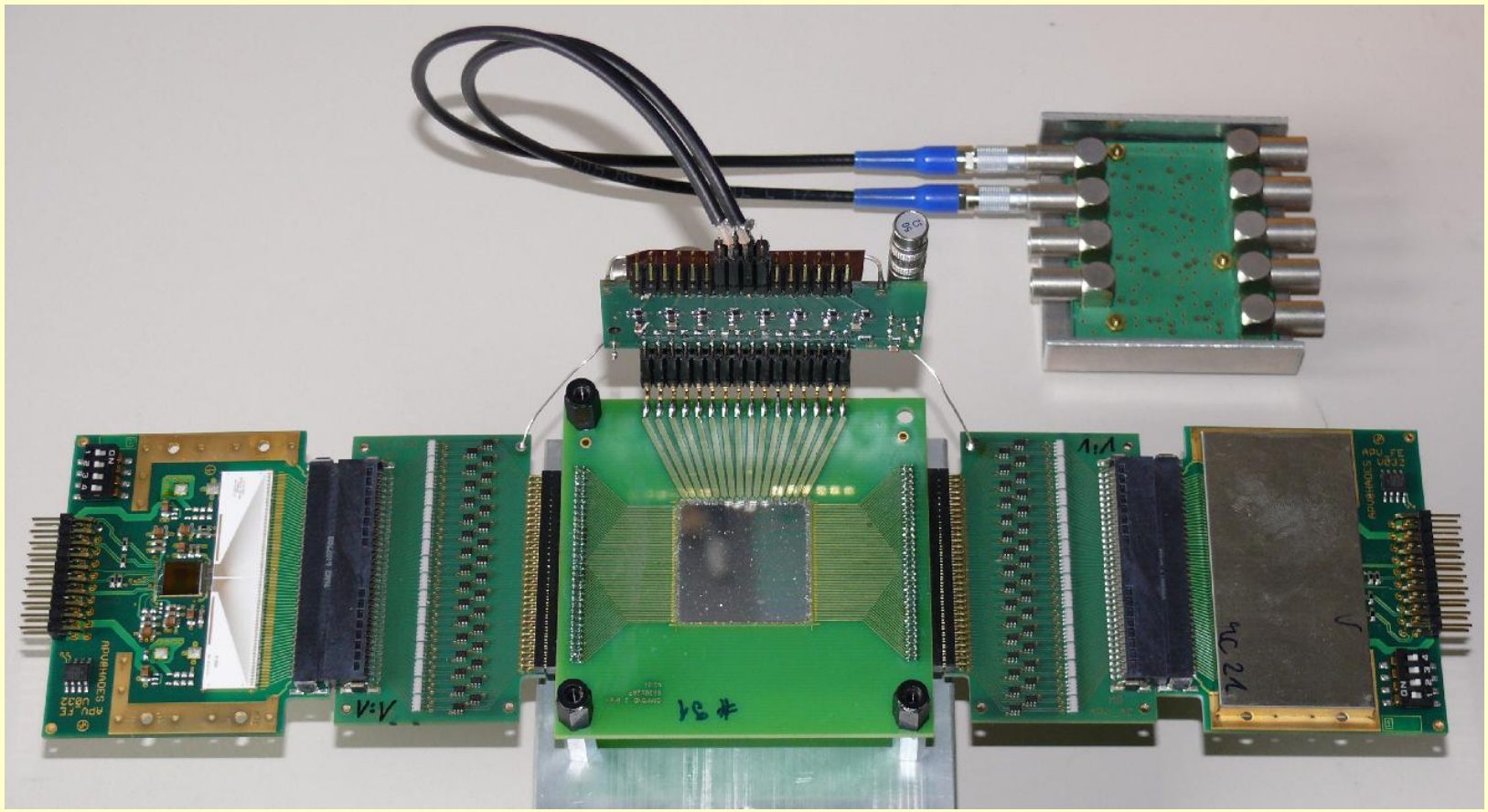
parts in vacuum



APV Revision 3.0

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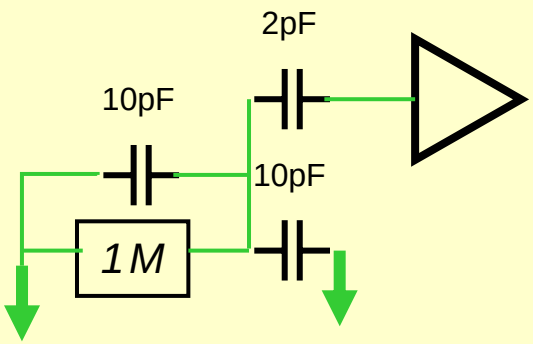
why can we use
readout electronics
designed for
silicon detectors
also in diamond?

$W_{dia} \sim 4W_{Si}$
$d_{dia} \sim 0.5\, d_{Si}$
$CCD \sim 0.1\, d_{dia}$

but we have HI
$\Delta E \sim Z^2$
Z=32 gains 1000



64 ch. Input

diode array
capacitive splitter

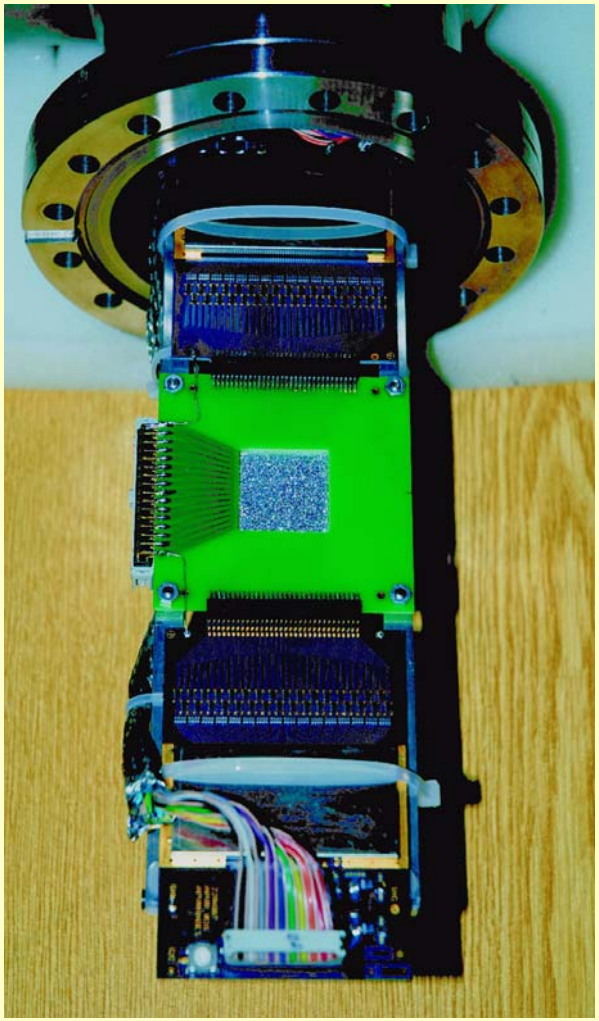
64 pin connector

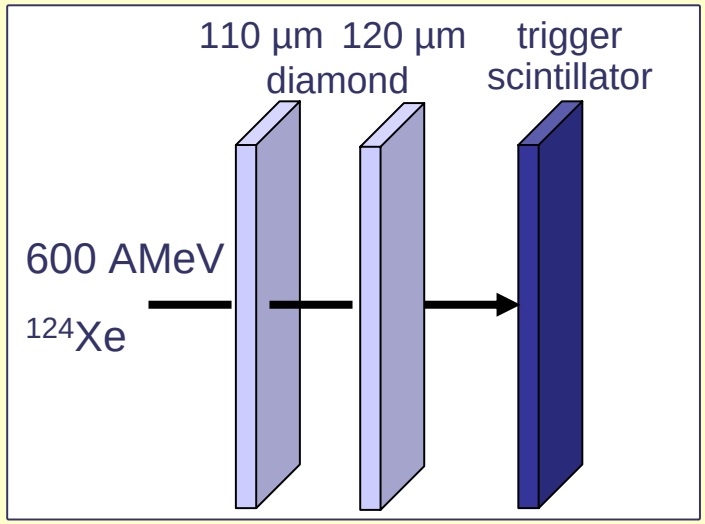
pitch adapter

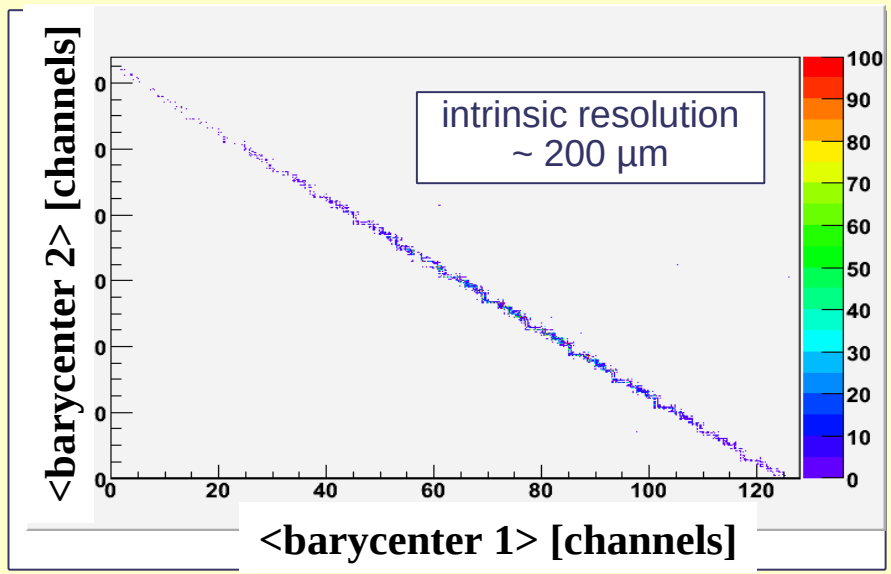
APV

ADC and control
interface

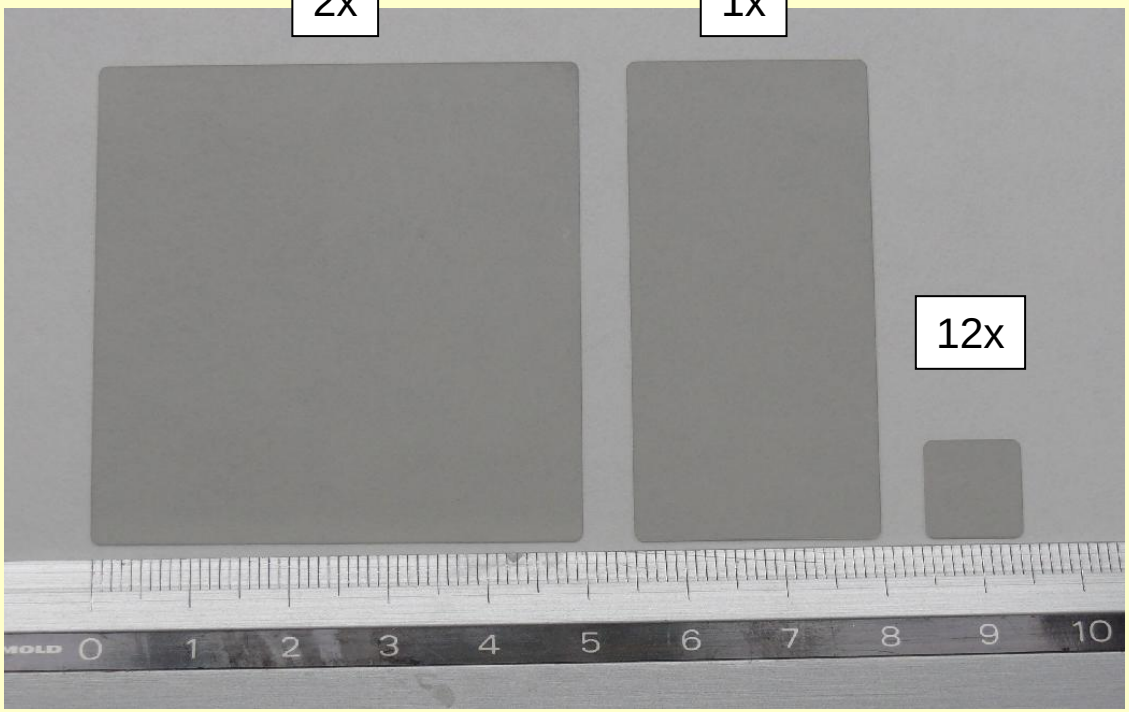
Prototype Test @ GSI







Final Size Detectors Production



150mm material
just to limit the risk

minimize the risk during and after production

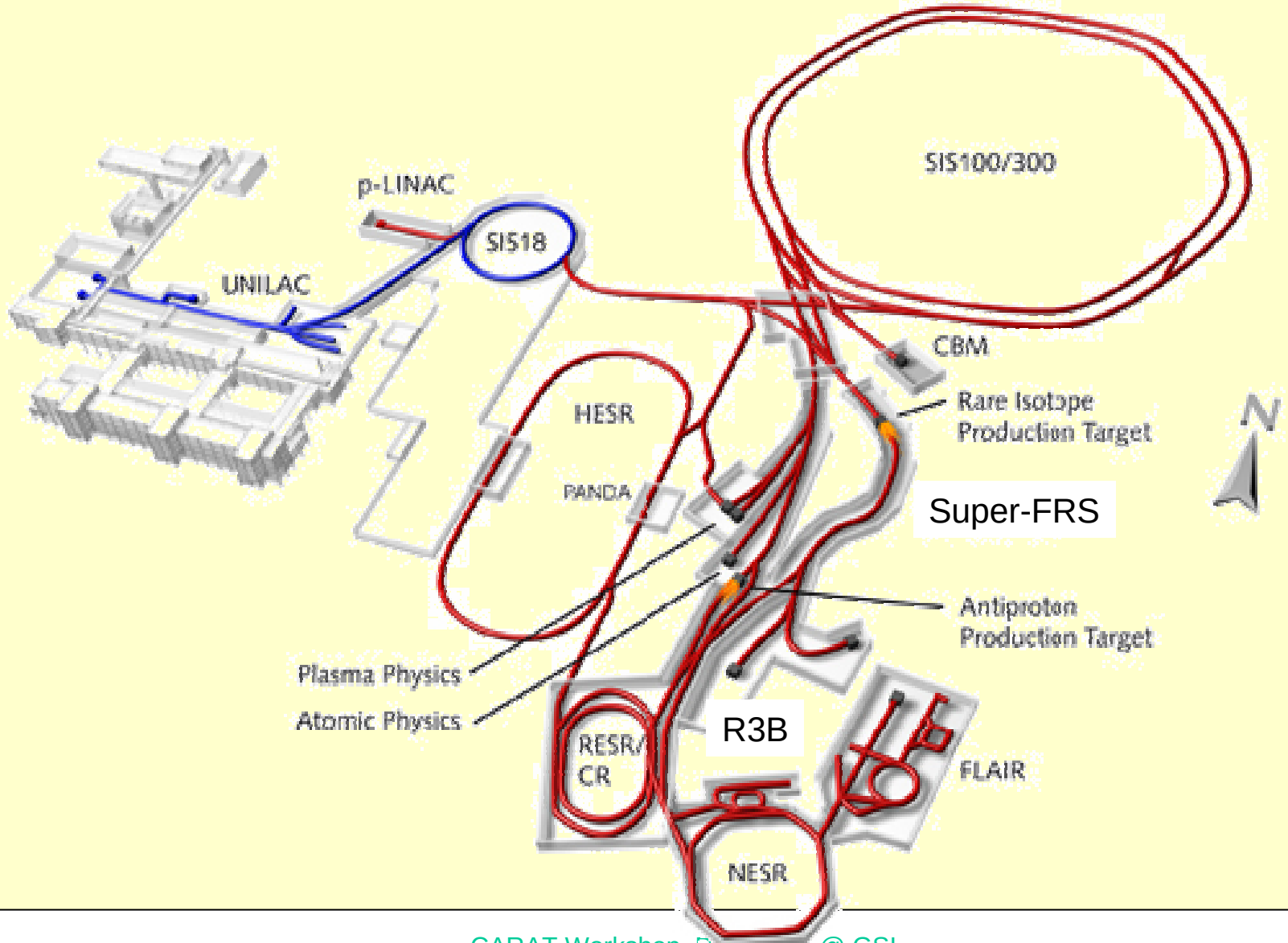
Verify effect of DLC coating (summer 2010) – no effect??

Finalize readout concept with medium size detectors

Further investigation on fast readout for FRS applications.

Full system test in 2011 (FRS000)

R3B and the Super-FRS



Focal Plane Detector for the Super-FRS

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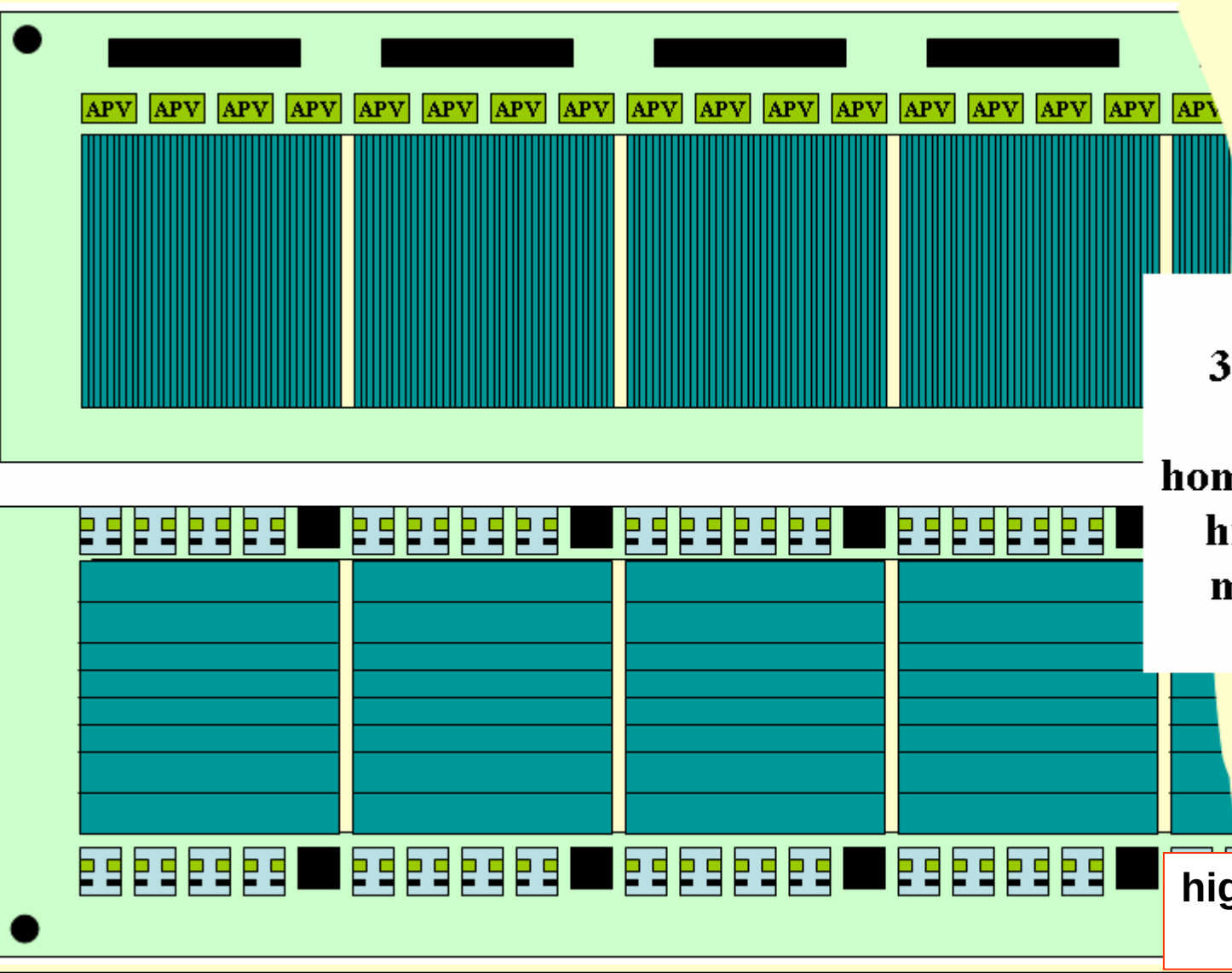
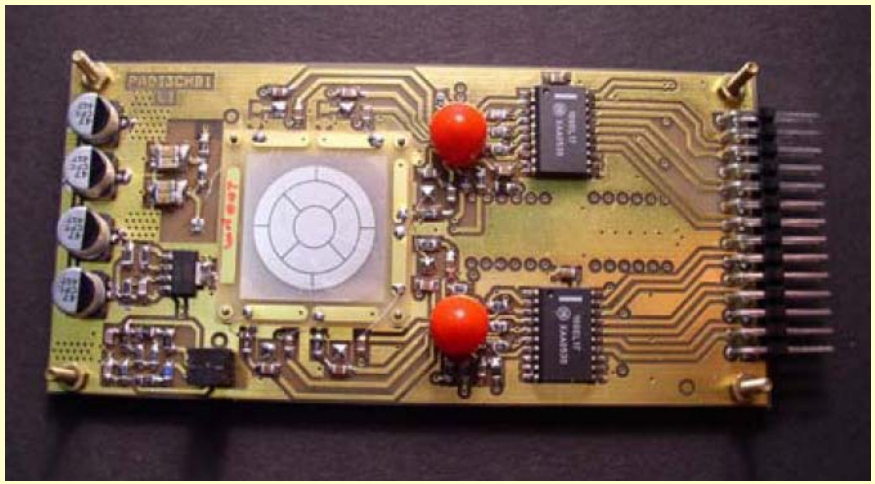


8 detectors
3000 channels
zero gap?
homogeneous layer
high efficiency
multi purpose
in vacuum

high resolution TOF
@ 10^7 needed

Preamplifier Options



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

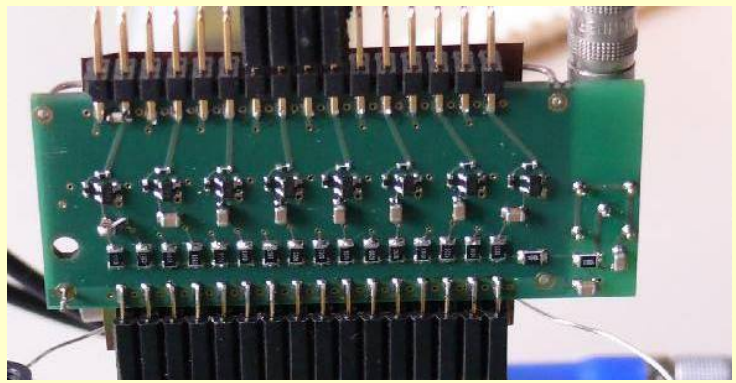
M. Ciobanu, N. Herrmann, K. D. Hildenbrand, M. Kiš, A. Schüttauf

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



Gain 10 Broad Band Amplifier

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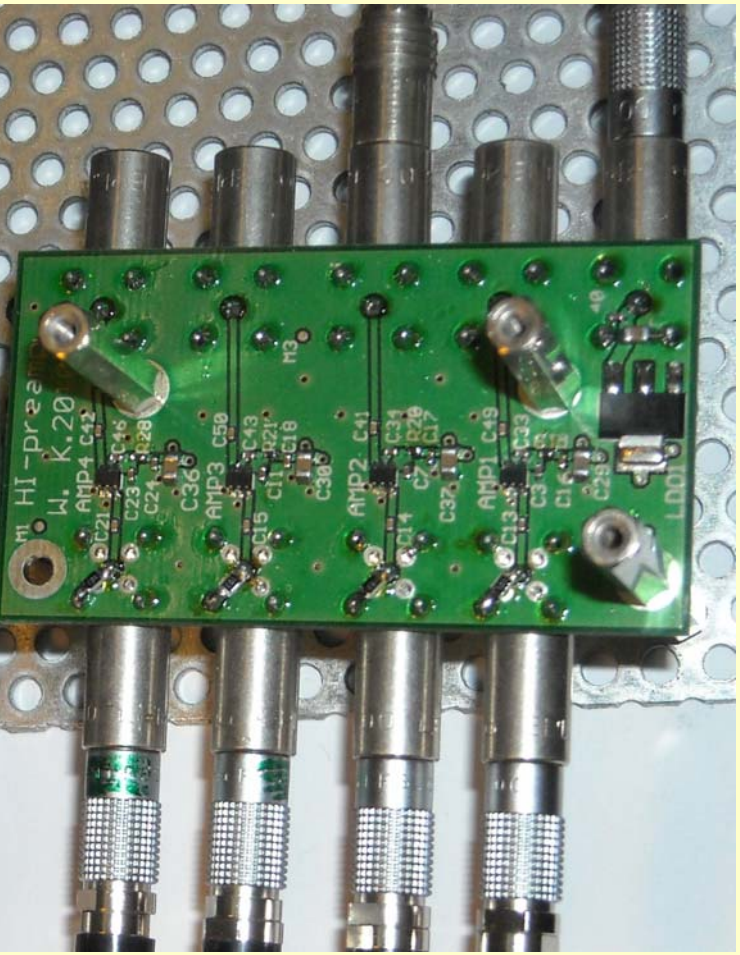

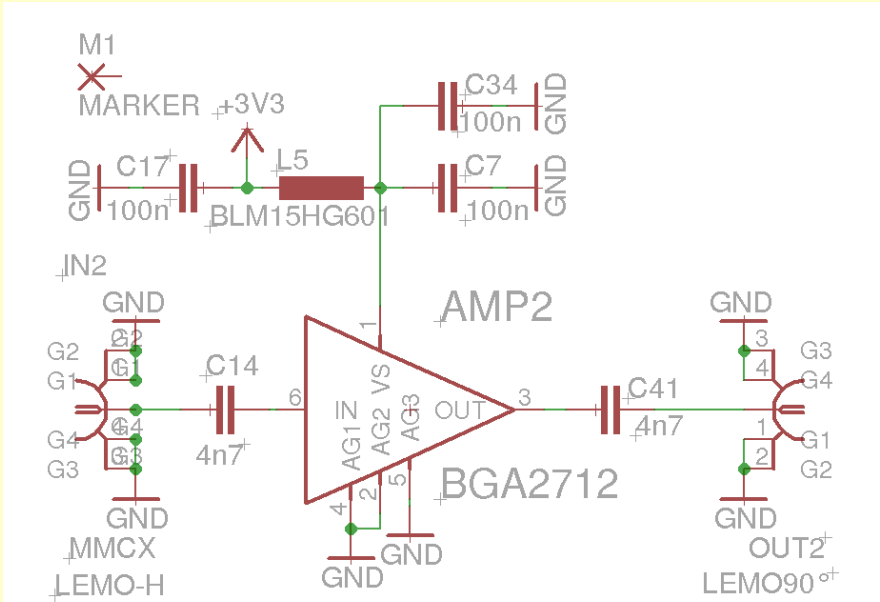

W.Koenig used in HADES 2010 -> J. Pietraszko

Part Number	Impedance (at 100MHz/20°C)	Impedance (at 1GHz/20°C)	Rated Current	DC Resistance(max.)
BLM15HG601SN1☐	600ohm±25%	1000ohm±40%	300mA	0.7ohm
BLM15HG102SN1☐	1000ohm±25%	1400ohm±40%	250mA	1.1ohm
BLM15HB121SN1☐	120ohm±25%	500ohm±40%	300mA	0.7ohm
BLM15HB221SN1☐	220ohm±25%	900ohm±40%	250mA	1.0ohm
BLM15HD601SN1☐	600ohm±25%	1400ohm±40%	300mA	0.85ohm
BLM15HD102SN1☐	1000ohm±25%	2000ohm±40%	250mA	1.25ohm
BLM15HD182SN1☐	1800ohm±25%	2700ohm±40%	200mA	2.2ohm

Optimum solution

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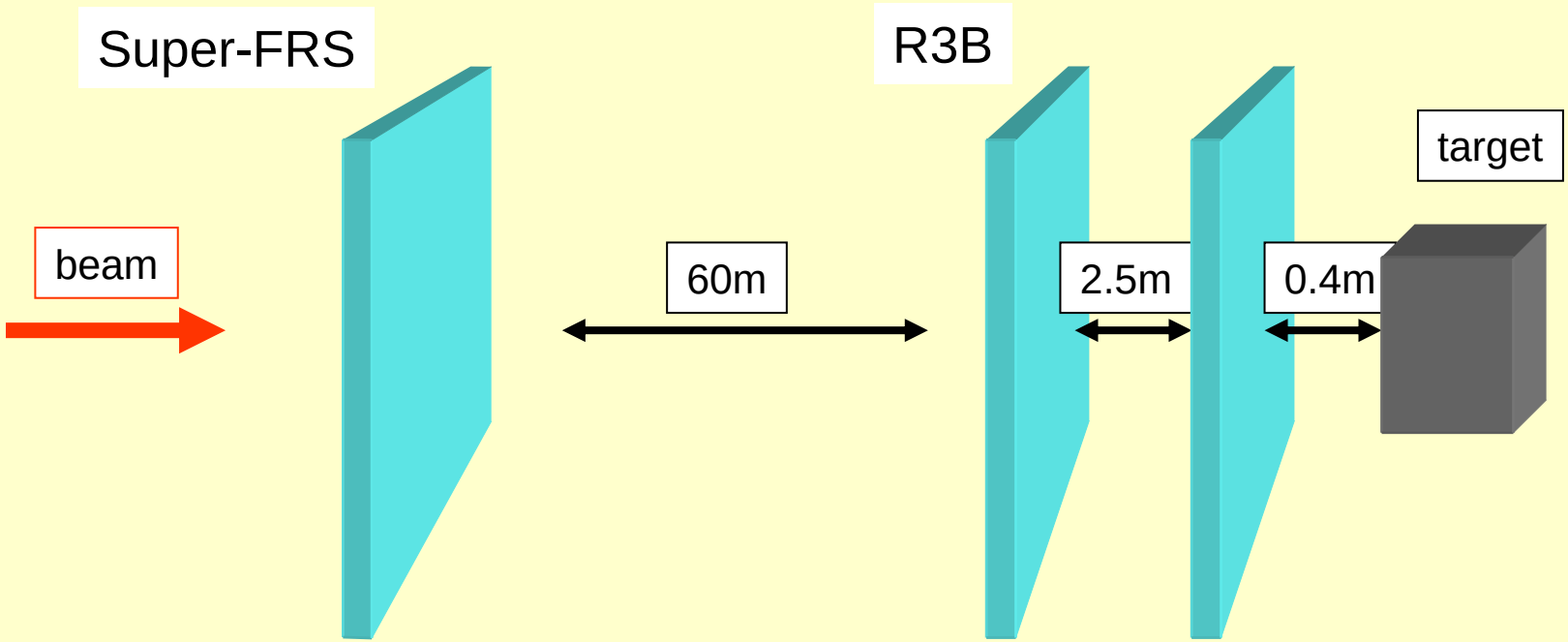

400 x 50 mm 1st side x-readout (200µm) charge integrating (APV) 2nd side y-readout (1.5mm) BBA (100ps resolution)	50 x 50 mm 1st side x-readout (200µm) charge integrating (APV) 2nd side y-readout (1.5mm) BBA (100ps resolution)	50 x 50 mm 1st side x-readout (200 µm pitch) 2nd side y-readout (200 µm pitch) Both sides charge integrating (APV) fits to multiple scattering

Next Milestones:

Test experiment 2011 @ GSI
TDR in 2011

Acknowledgements:
Sabine Schwertel, Wolfgang Koenig, Jurek Pietraszko and Chiara N.