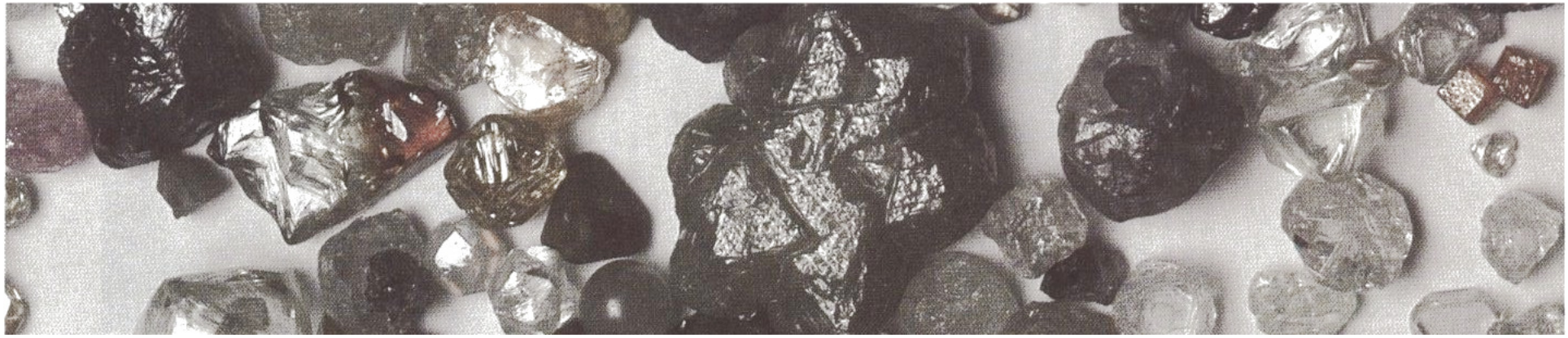


CVD-DIAMOND FOR ACCELERATOR BEAM DIAGNOSIS APPLICATIONS

E. Berdermann, K. Blasche, P. Moritz, H. Stelzer – M. Träger (GSI)

CVD-Diamond Materials – Detector Operation – Applications

Helmholtz Zentrum für
Schwerionenforschung

CVD-DIAMOND MATERIALS

Industrial Producers: Element Six Ltd. (UK);
Diamond Materials, Freiburg; IMO Hasselt Belgium
E6 diamond distributor: DDL (UK)

STANDARD

- **Poly-crystalline CVDD**

  ∅ = up to 120 mm

  d = 100 µm – 600 µm

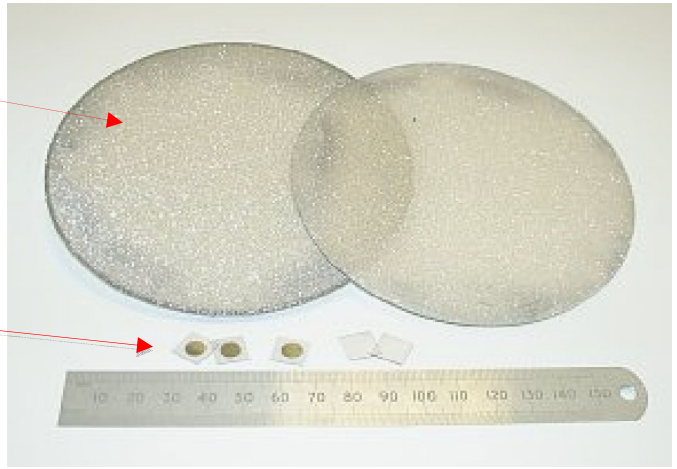
  CCE ≈ 50%-60%

- **Single-crystal CVDD**

  d = 300-500 µm

  ~ 5 x 5 mm^2

  CCE = 100%

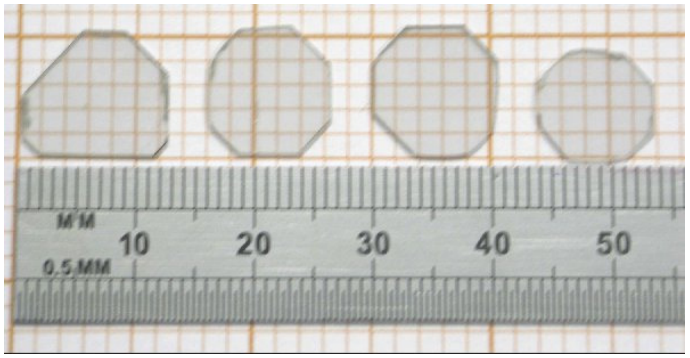


SPECIAL E6 MATERIALS

- **Large homoepitaxial SC-CVDD**

  Areas up to ≤ 10 mm x 10 mm

  Thicknesses down to ≤ 50 µm

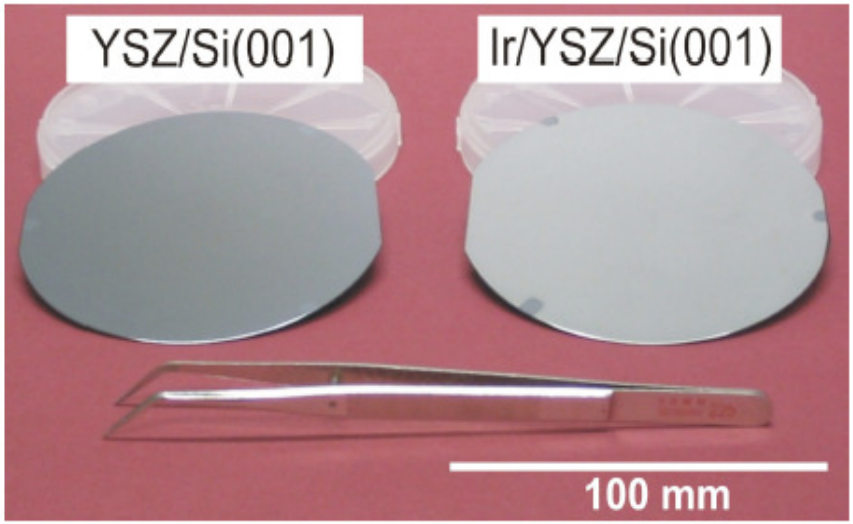


CVD-DIAMOND MATERIALS

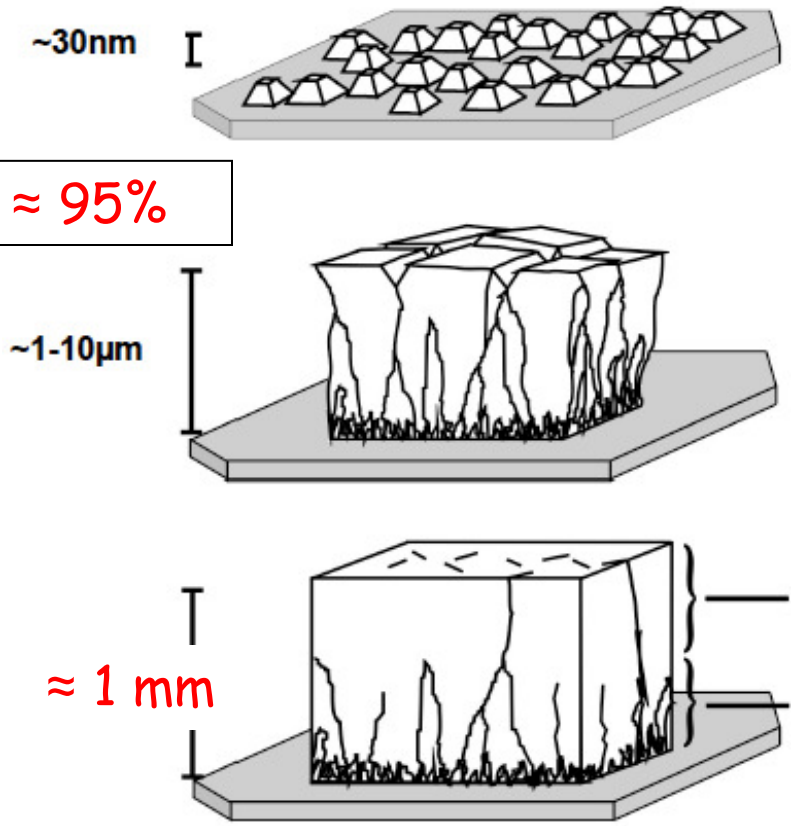
- WAFER-SCALE SINGLE-CRYSTAL DIAMOND DETECTORS

BY HETEROEPITAXY

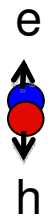
on large-area iridium substrates (CVD-DOI)



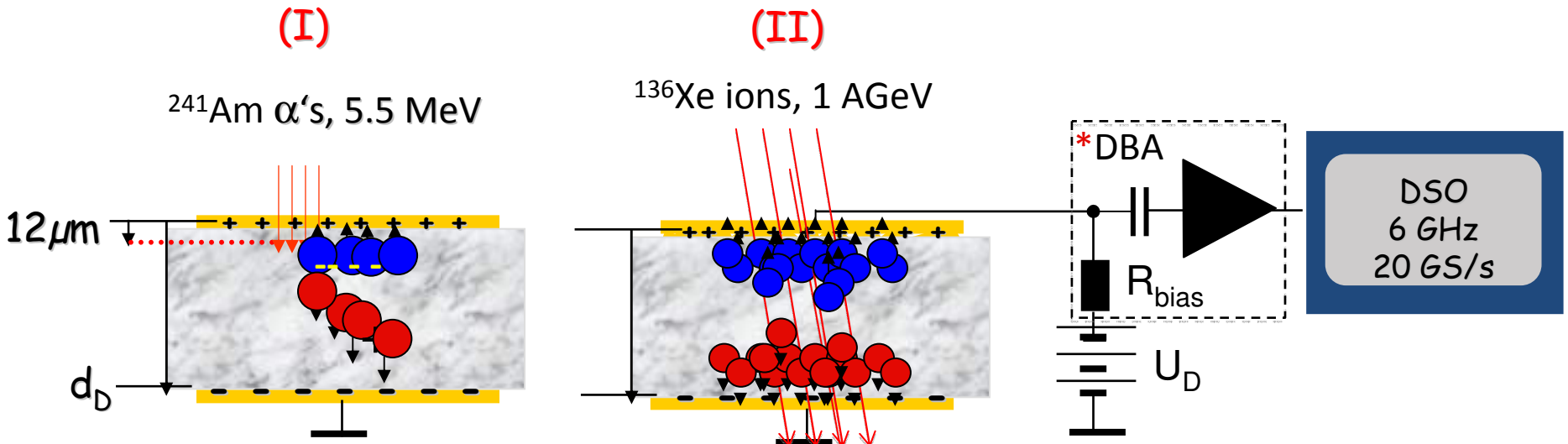
S. Gsell et al., Appl. Phys.Lett. 84 (2004)
UNIVERSITY OF AUGSBURG



PRINCIPLE DETECTOR OPERATION



- ELECTRON-HOLE PAIR CREATION, SEPARATION, DRIFT
- GOALS: TO EXPLOIT THE ULTRA-FAST DIAMOND SIGNAL;
  TO MAINTAIN THE SIGNAL PERFORMANCE BY BB FIBERS

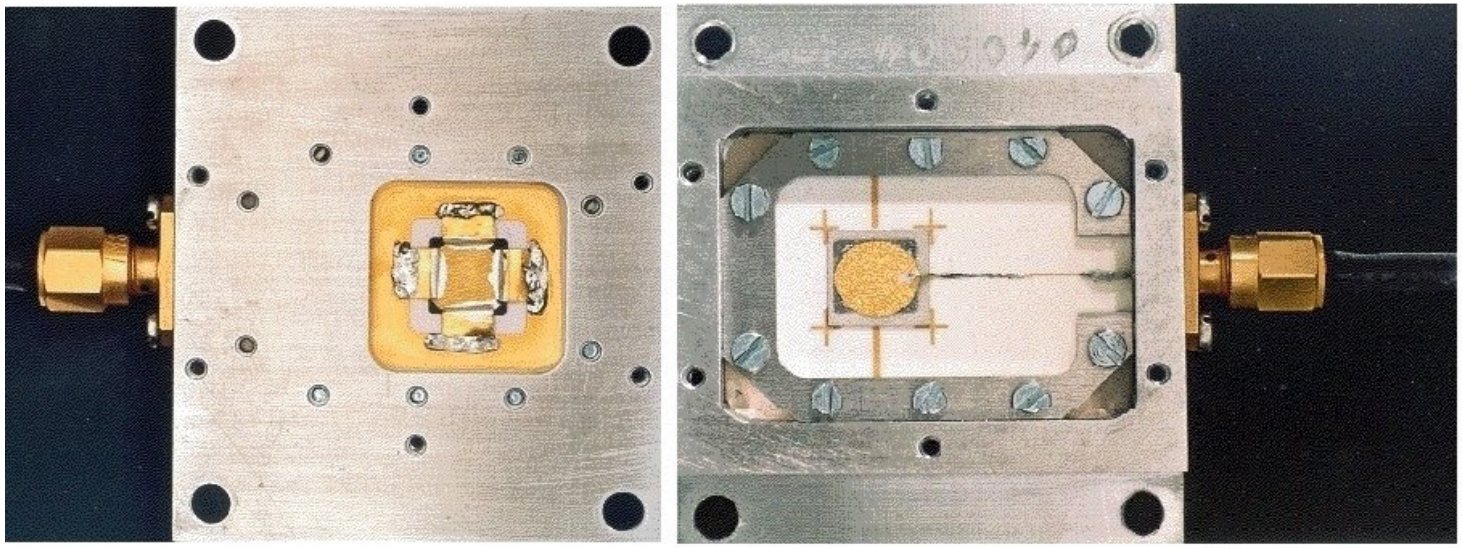


* DBA
(50 Ω; 10MHz ≤ BW ≤2.3 GHz)

Peter Moritz et al., DIPAC III, Frascati (1997)

BASIC DESIGN OF FAST SENSORS

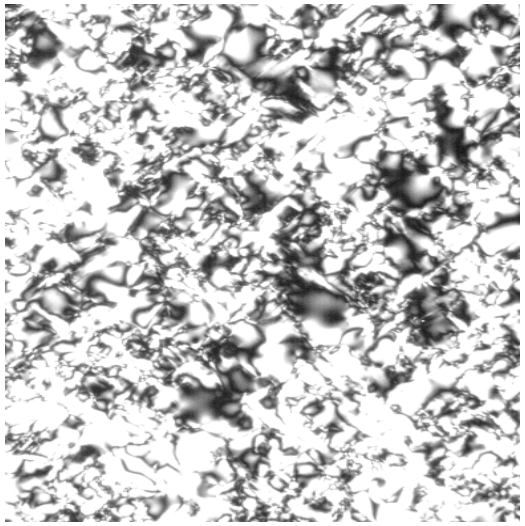
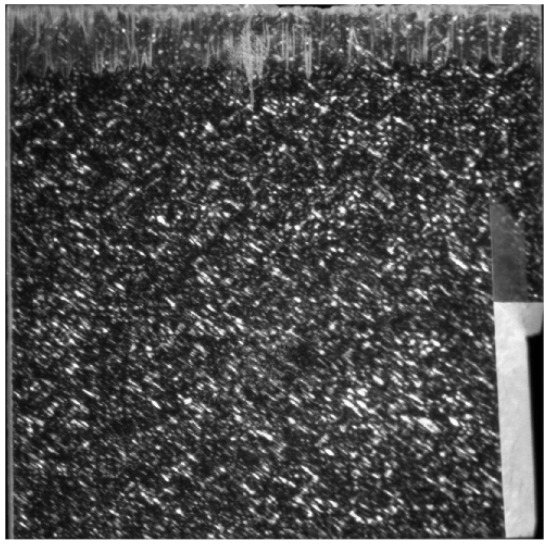
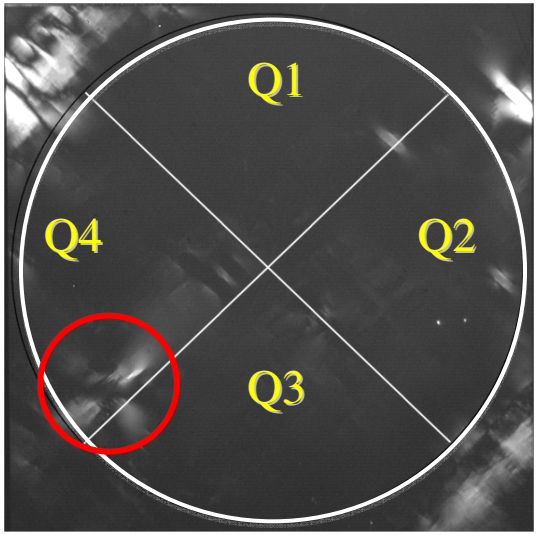
- EVERY SINGLE CHANNEL AS A 50 Ω-MICROSTRIP LINE
- BROAD MASS-POTENTIAL DEFINITION
- MINIMIZED CAPACITANCE SETUP



- HIGH-FREQUENCY DESIGN

CVD-DIAMOND MATERIALS

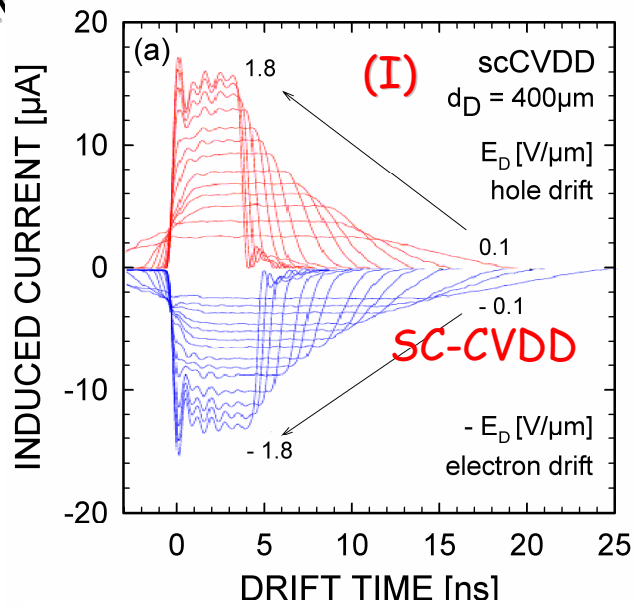
➢ CRYSTAL STRUCTURE – BIREFRINGENCE IMAGES

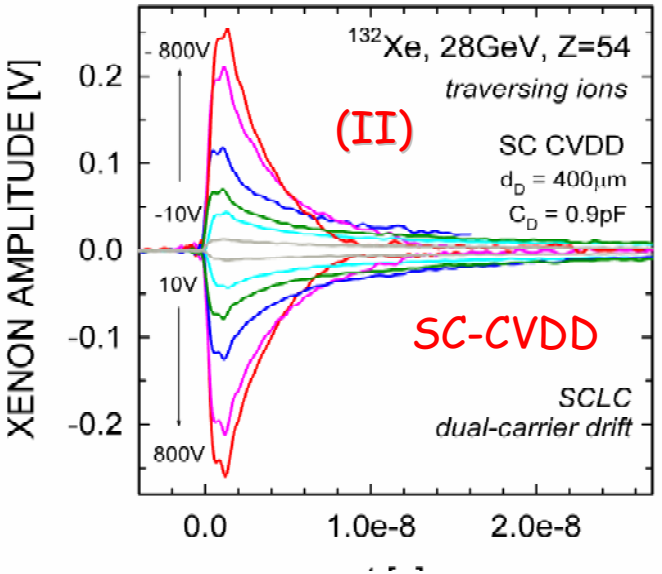
Dia-on-Silicon	Dia-on-Iridium	Dia-on-Diamond
		
‘polycrystalline’	‘defective’ single crystal	‘defect-free’ single crystal
INHOMOGENEOUS	HOMOGENEOUS	HOMOGENEOUS

TRANSIENT CURRENT SIGNALS

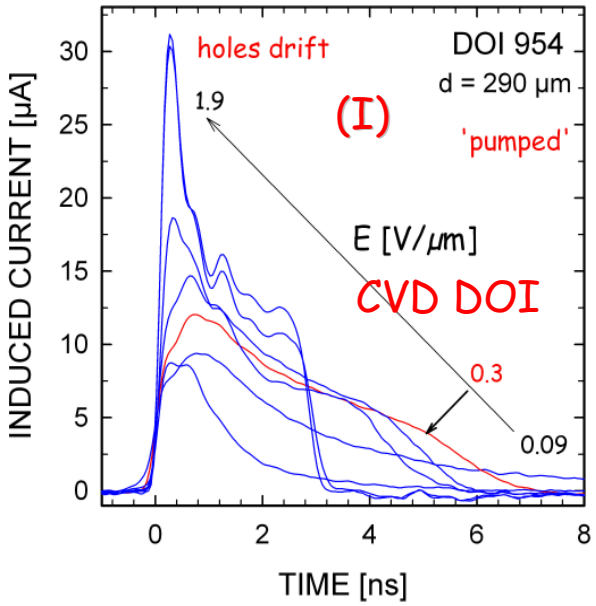
(I) 'SINGLE-CARRIER DRIFT' 'SMALL-SIGNAL' CASE

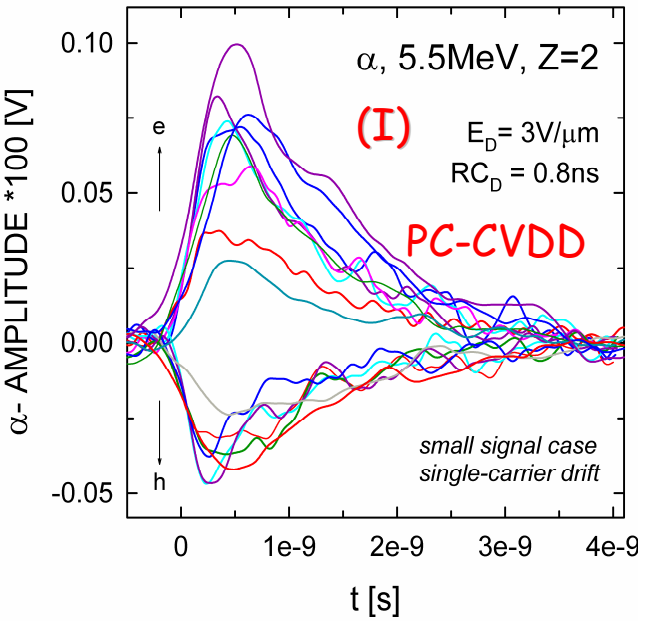
(I) INTERNAL FIELD PROFILE





(II) 'DUAL-CARRIER DRIFT' 'SCLC' CASE





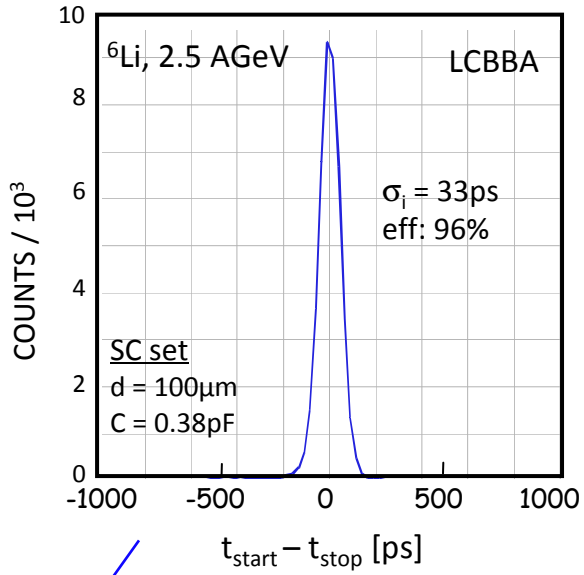
APPLICATIONS

BEAM-ENERGY BY TOF (SC and PC CVDD)

- INTRINSIC TOF RESOLUTION
- $\sigma_t = \sigma_{noise}/(dV/dt)$

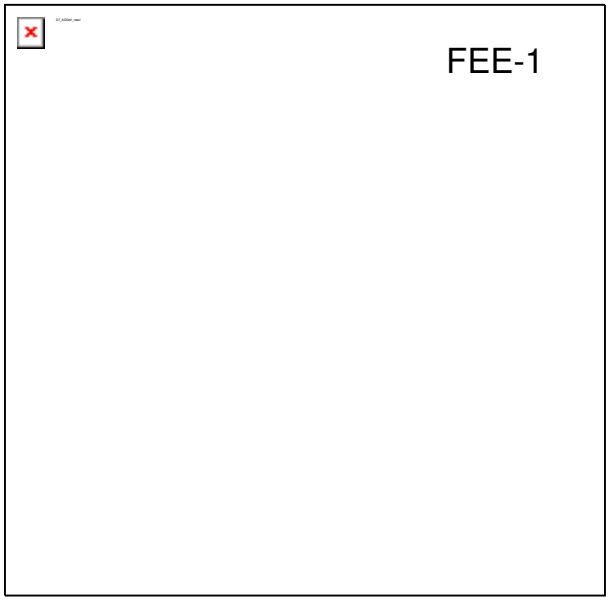
W. Koenig, HADES

Z = 3

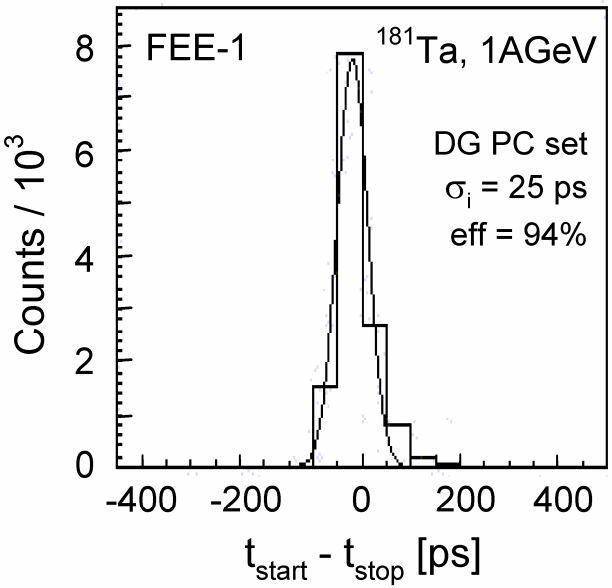


Z = 13

M. Ciobanu, FOPI



Z = 73



≈ 9 x MIP signal; Best σ_{MIP} at present ≅ 120ps

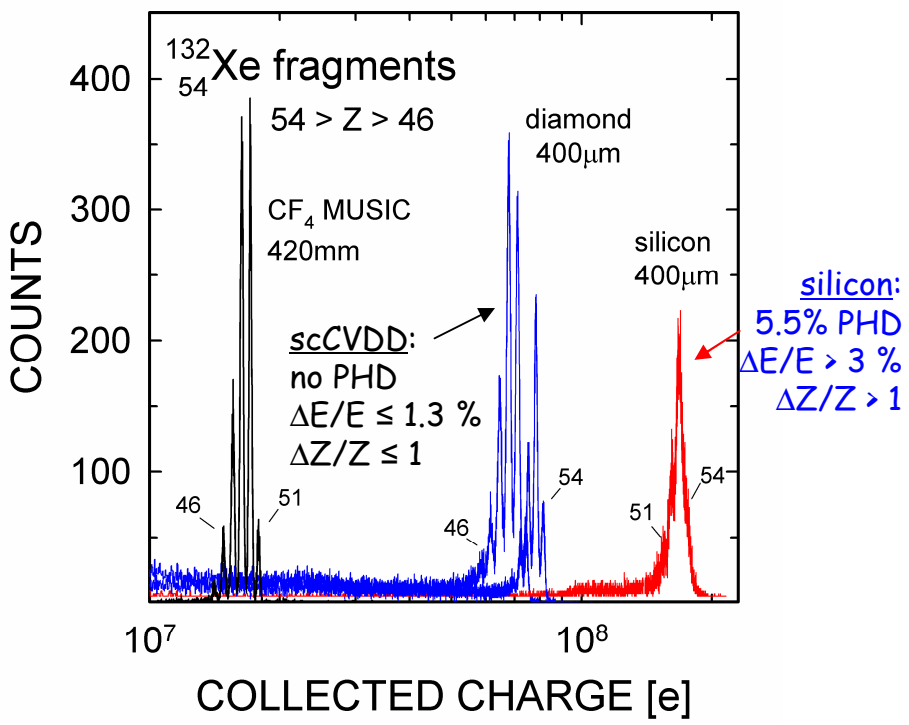
E. Berdermann, M. Ciobanu et al., Proc. IEEE NSS (2009) Orlando

BEAM-ENERGY BY SPECTROSCOPY SC CVDD)

E. Berdermann et al., Diam. Relat. Mater. **17** (2008) 1159

➢ UNILAC ENERGIES

➢ SIS ENERGIES

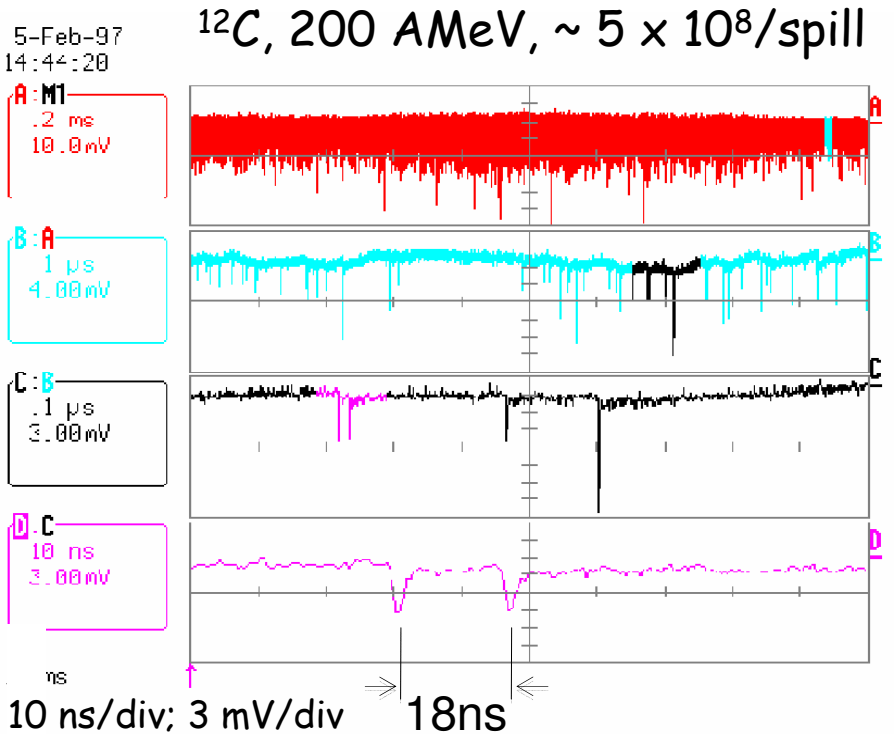


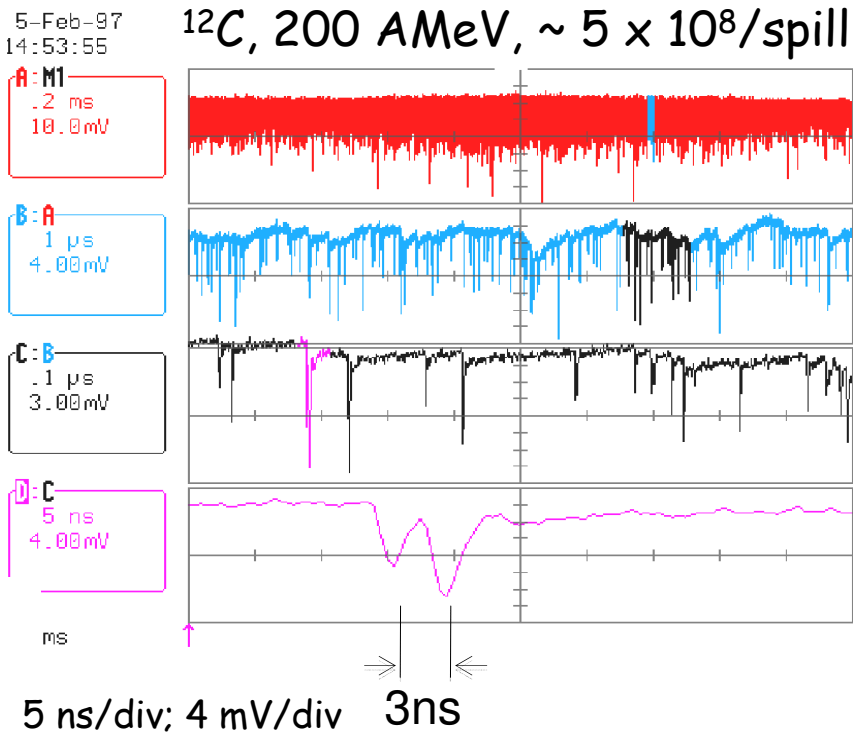
pcCVDD: no E resolution

scCVDD: superior to silicon

HIGH-FREQUENCY SPILL STRUCTURE

- INHOMOGENEOUS DISTRIBUTION OF IONS WITHIN THE SIS SPILLS





Peter Moritz et al., Beam Instrumentation WS: Stanford CA (1998)

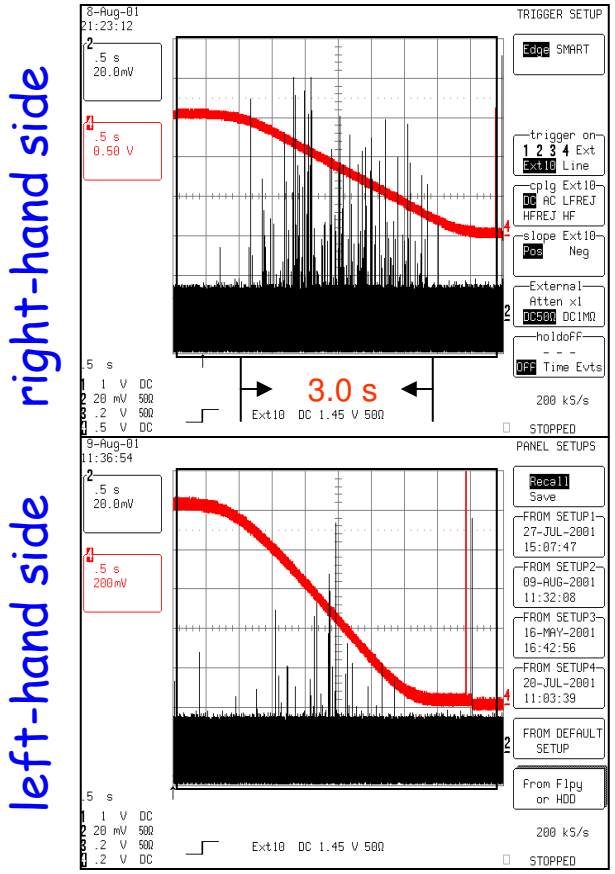
BEAM-LOSS AND CONDITION MONITORS

- Slow Extraction: Spill = 3-4 s

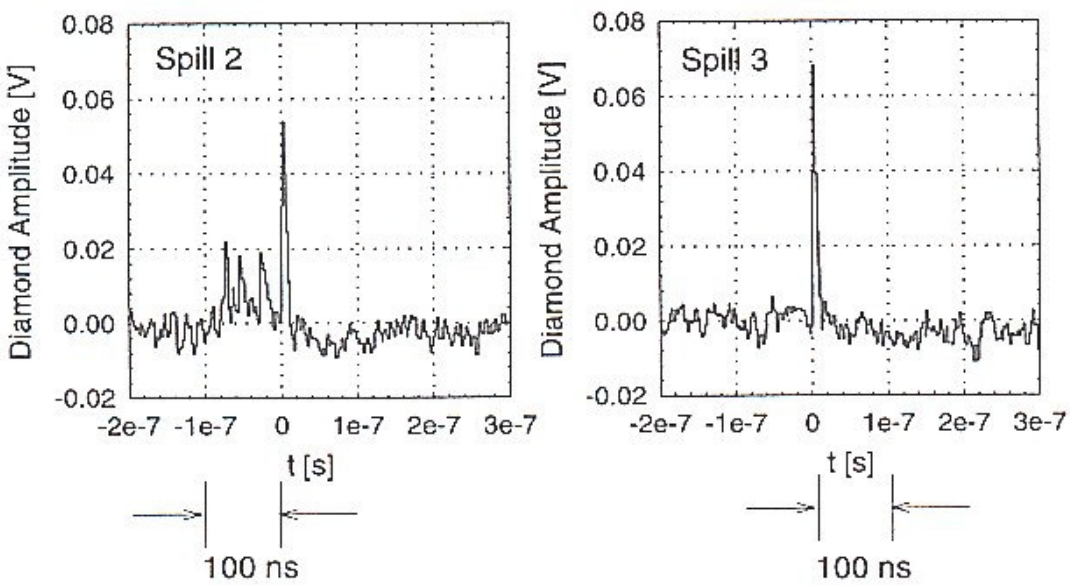
  ^{238}U, 1 GeV/amu, ~ 8 x 10^8/spill

- Fast Extraction: Bunch = 100-200 ns

  ^{58}Ni, 300 MeV/amu



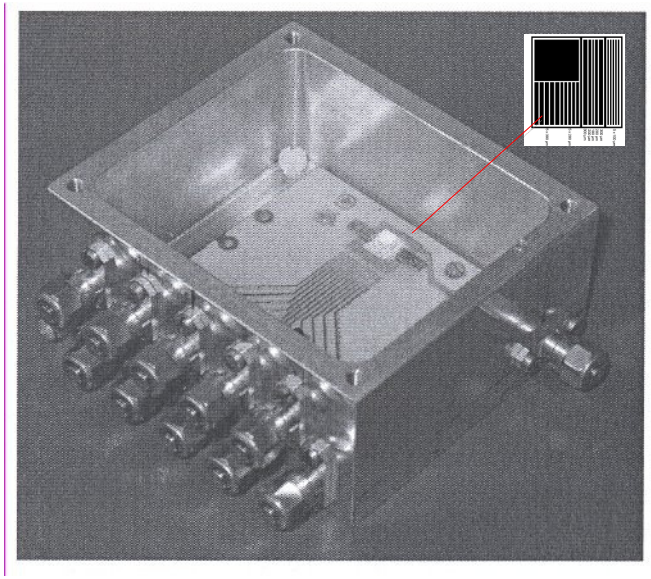
Internal bunch structure thitherto unobserved in the single-bunch extraction mode (2001)

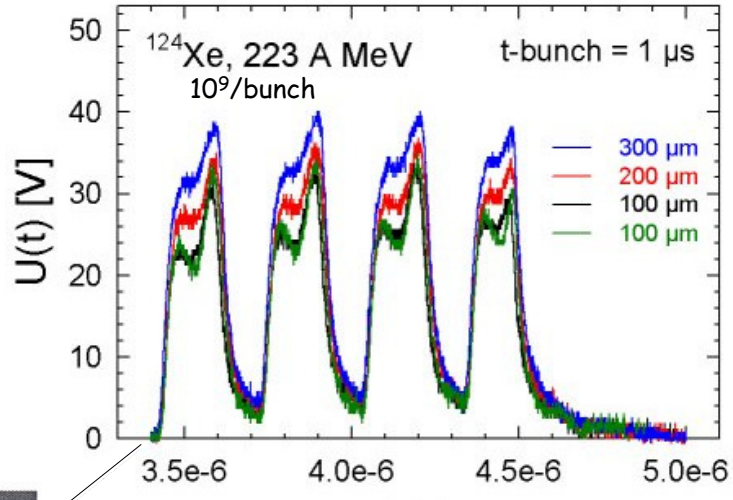


E. Berdermann, K. Blasche et al., Proc. ICATPP-7 (2001) Como, Italy

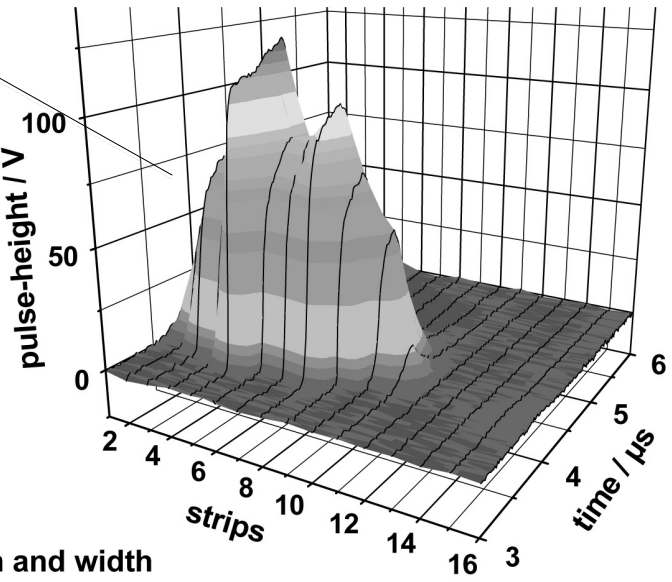
BUNCH MONITORING

J. Bol et al., Industrie Rundschau, 0_IDR 4/04_V4 (2004) Seite 401





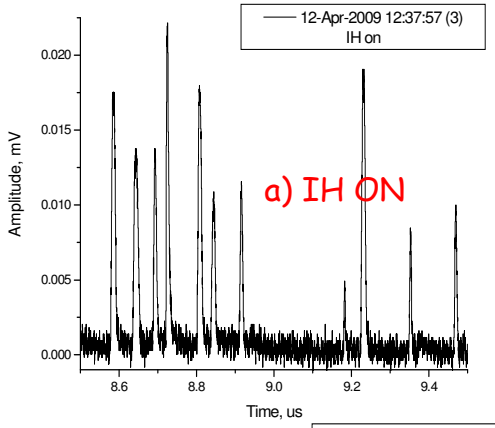
lin. increase with strip width

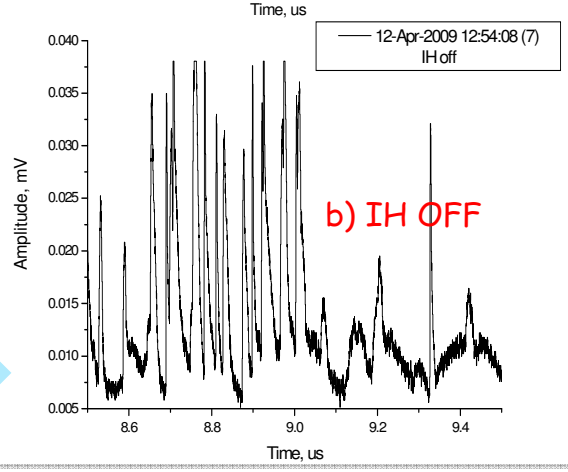


pitch and width
of strips are not uniform

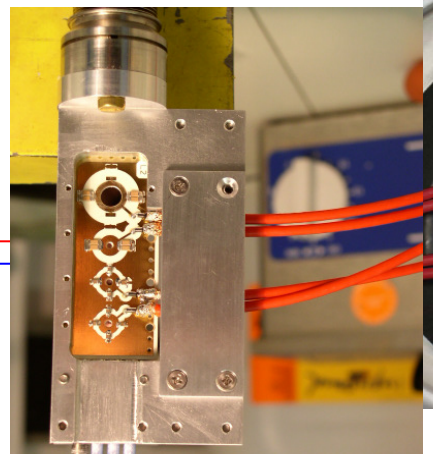
IH COMMISSIONING (HITRAP)

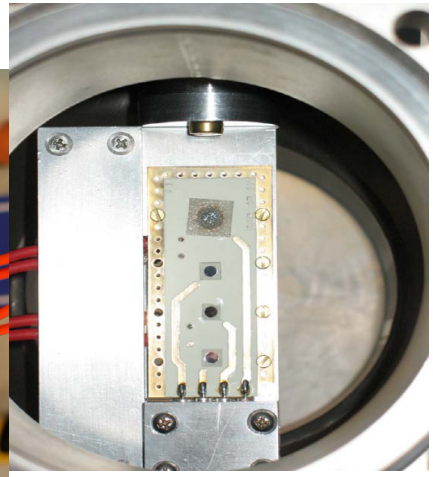
- DEACCELERATION OF BUNCHED ION BEAMS from 4 MeV/u to 0.5 MeV/u





SC-CVDD
PC-CVDD

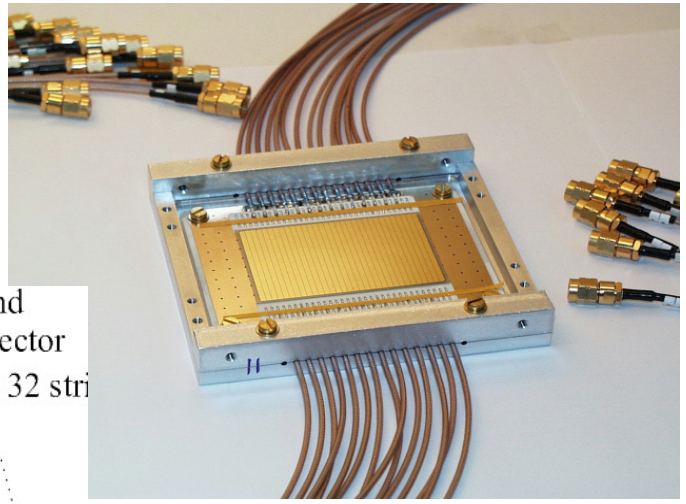


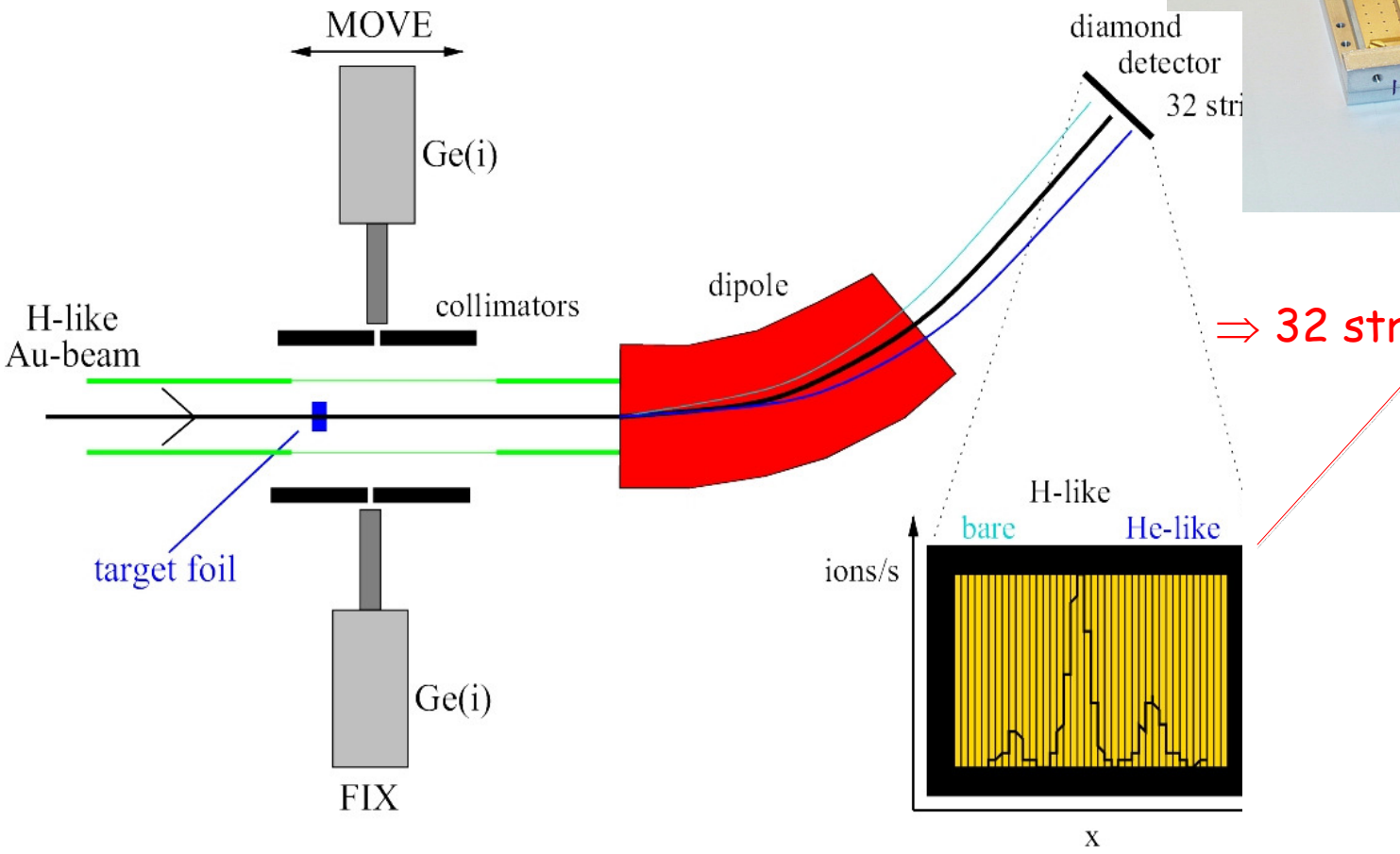


Vorobjev et al.,
Proc. DIPAC 2011

FOCAL-PLANE DETECTORS

AP GROUP:
S. Toleikis, A. Bräuning-Demian, et al.



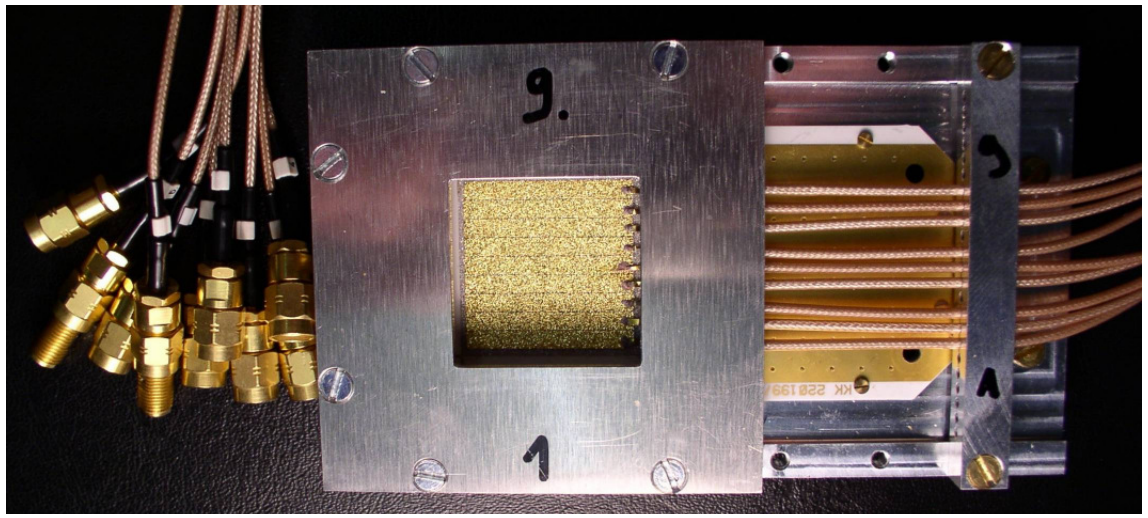


$A = 60 \times 40\ mm^2$

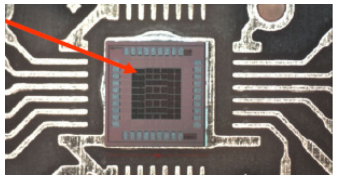
$\Rightarrow$ 32 stripes, 1.8 mm pitch

BEAM MONITOR DESIGNS

NEW: BB ASICs for MICRO-STRUCTURED DIAMOND DETECTORS

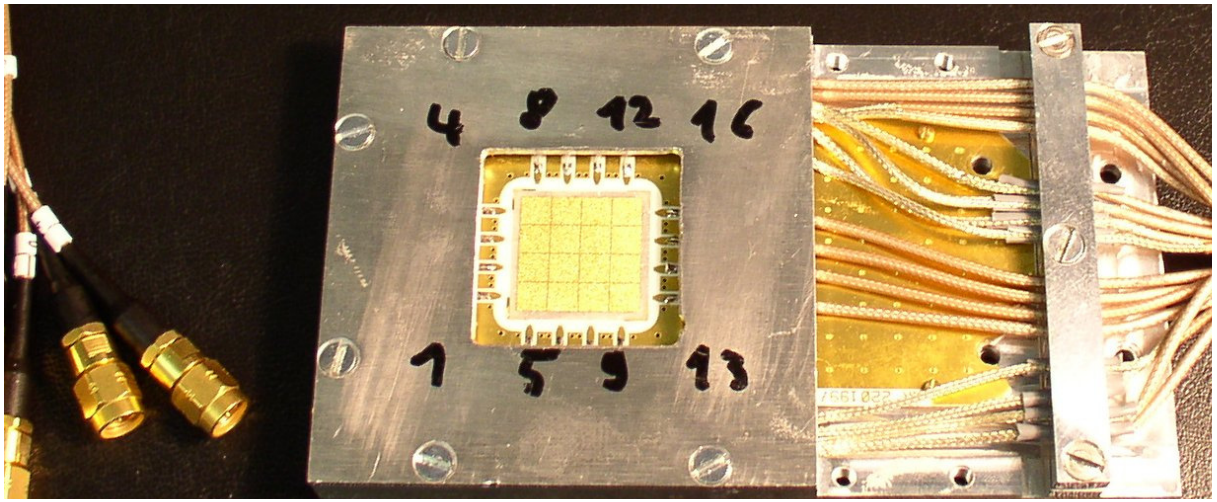


PADI-4

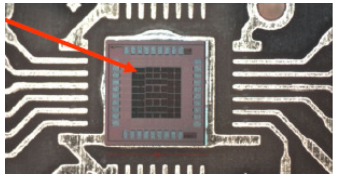


AG PC-CVDD

30mm x 30mm
d = 350µm
9 x stripes
3,1 mm pitch



PADI-4

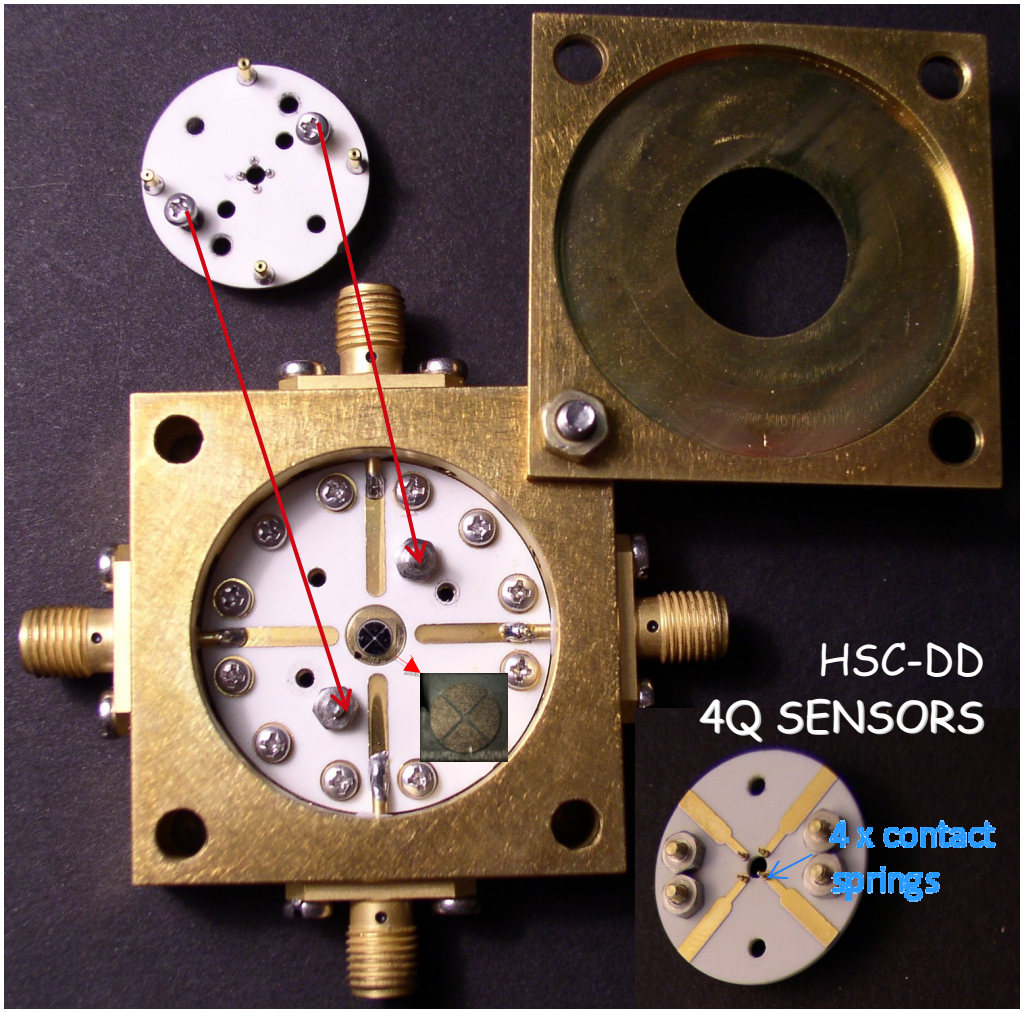


AG PC-CVDD

30mm x 30mm
d = 330µm
16 x pads
4,1 mm pitch

BEAM MONITOR DESIGNS

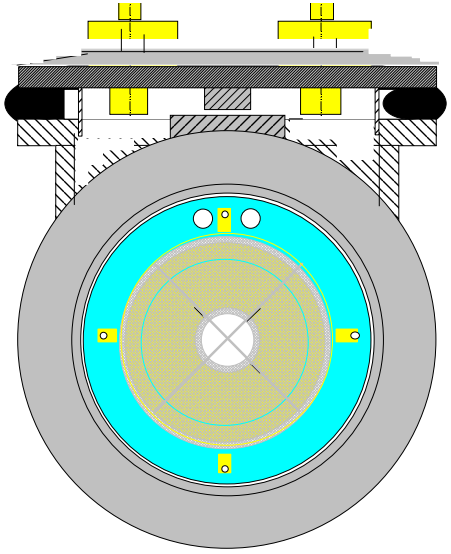
HIGHLY FOCUSED BEAMS



FOPI START

PC-CVDD 30mm x 30mm

HADES BEAM-HALO



PC-CVDD mounted in 40KF

SUMMARY AND OUTLOOK

- SINGLE-PARTICLE SIGNAL WIDTH << 1ns
  - ➔ RATE CAPABILITY ≈ 1/s - 10^9/s PC, DOI, THIN SC-CVDD
- TOF RESOLUTION ➔ $\Delta T < 25$ ps ALL THREE CVDD TYPES
- ENERGY RESOLUTION ➔ SIMILAR TO SILICON SC-CVDD
- APPLICATIONS ⇒ MONITORS FOR SLOW and FAST EXTRACTION
  - BUNCH and SPILL structure
  - BEAM INTENSITY and PROFILE
  - BEAM-LOSS and CONDITION
  - FOCAL-PLANE DETECTORS
  - ★ OUTLOOK
  - DIAMOND-ON-IRIDIUM SENSORS