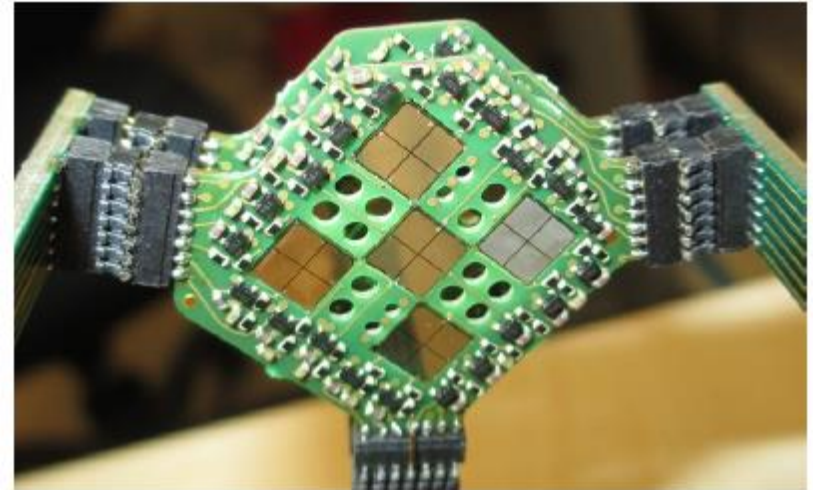


TCT characterization of new generation of DoI samples

Diamond particle detectors

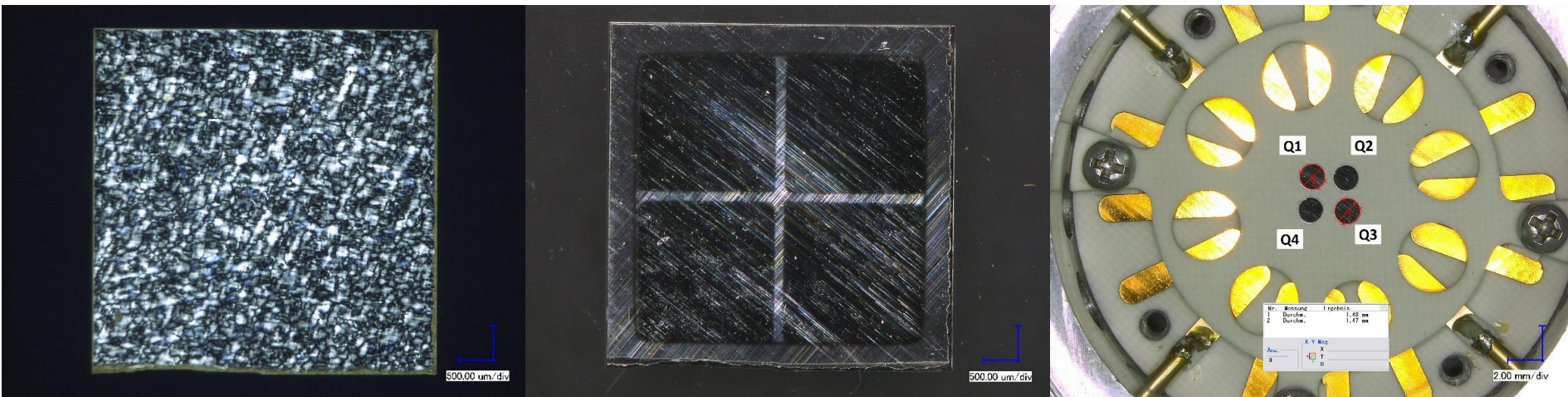
- typical use of diamond as a particle detector:
 - timing (fast rise time)
 - rate (short signals)
- major advantages:
 - low leakage current
 - operating temperature range
 - radiation hardness
- commercially available materials
 - single crystal or polycrystalline materials
 - charge collection efficiency of PCDia is significantly lower than SCDia, but SCDia are available only in small sizes
 - especially for minimum-ionizing particles large area & high CCE



W. Koenig, J. Pietraszko, HADES Collaboration

Heteroepitaxially grown diamonds

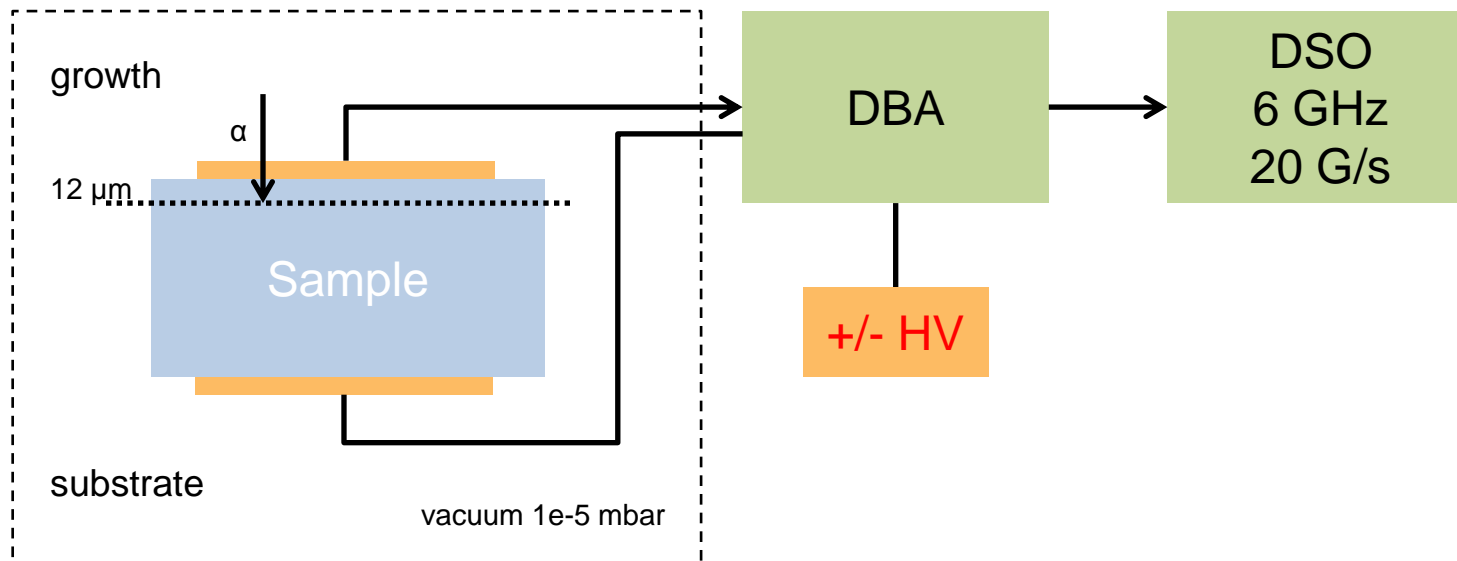
- R&D project with University of Augsburg
- heteroepitaxially films grown on Ir (diamond-on-iridium)
- buffer layer of yttrium-stabilized zirconium oxide on Si wafer is used to stabilize iridium terminated substrate
- diamonds prepared for characterization at GSI



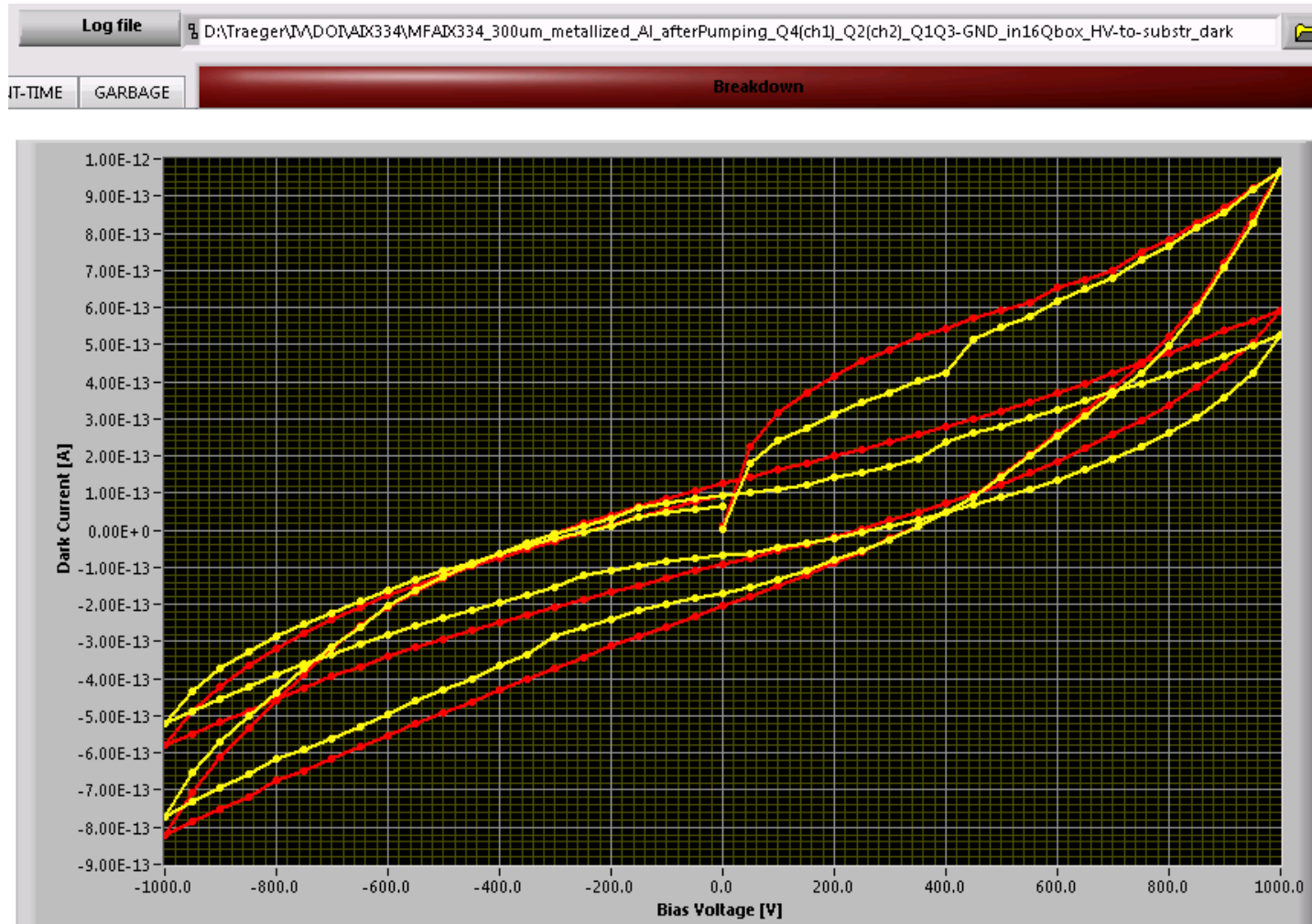
S. Gsell *et al.*, Appl. Phys. Lett. 84, 4541 (2004)

Dol characterization

- transition current technique, alpha-emitter, 5.5 MeV
- using alpha source to induce charge in a shallow layer close to surface, carrier drift is depending on biasing
- electrodes: Al, Cr/Au, Ti/Pt/Au
- diamond broad-band amplifier BW=2.3 GHz, G~40dB

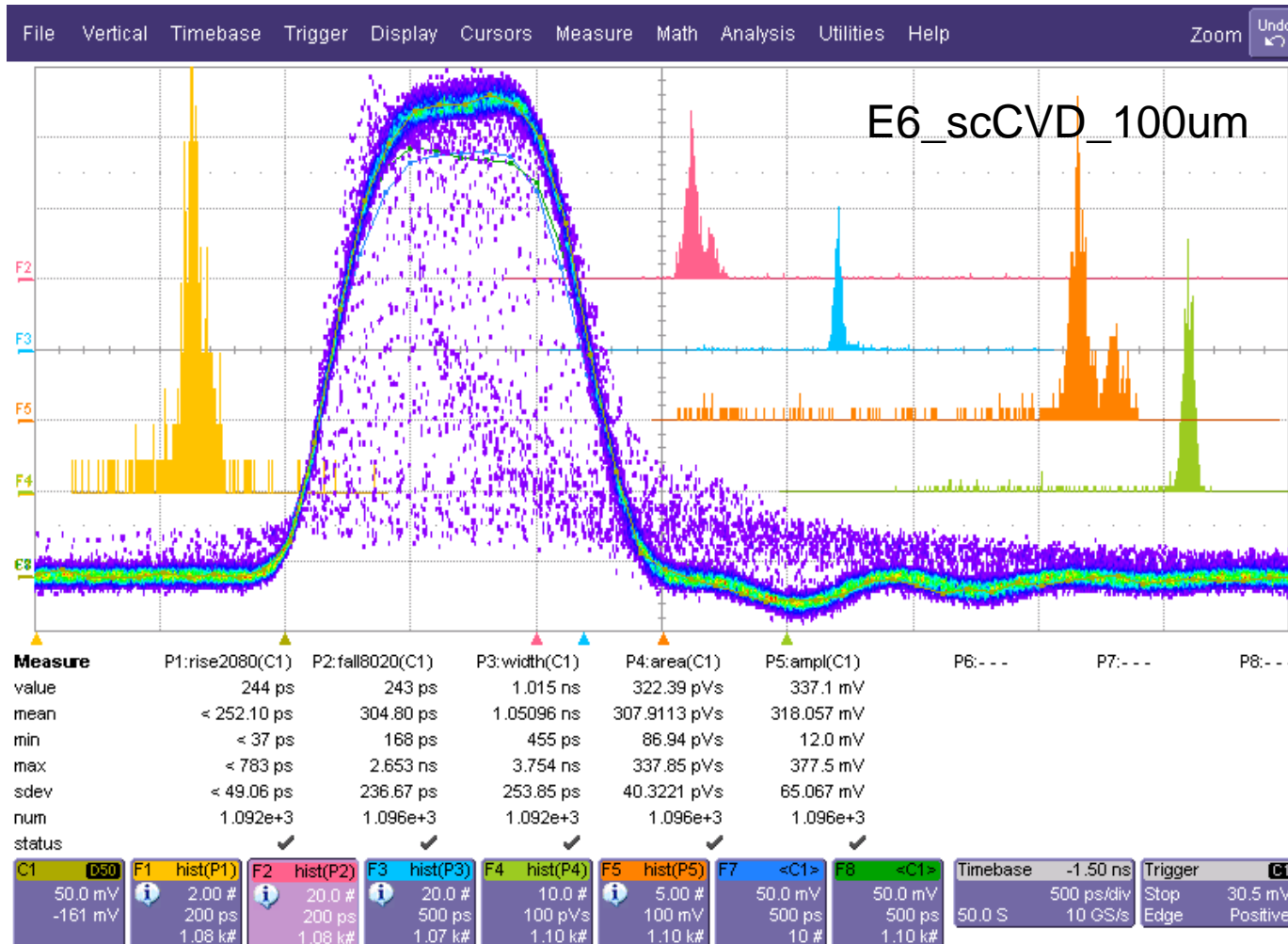


V-I measurement



MFAIX334
5 mm x 5 mm
d = 300 μ m

Waveform acquisition



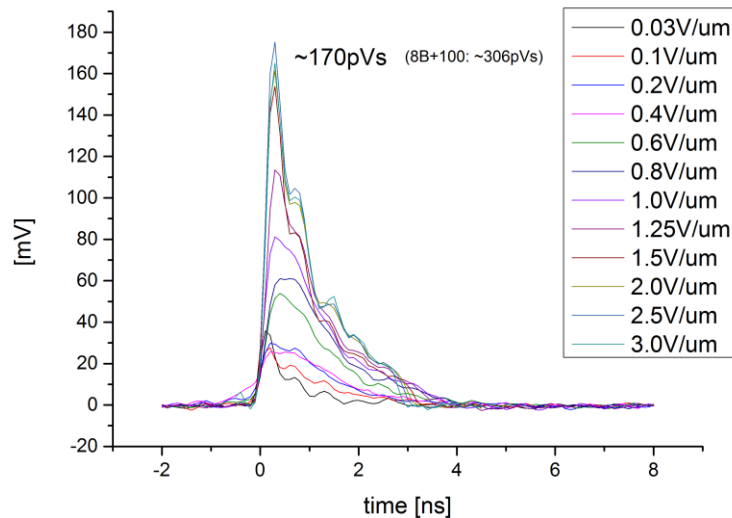
voltage
+
carrier
scan

LeCroy

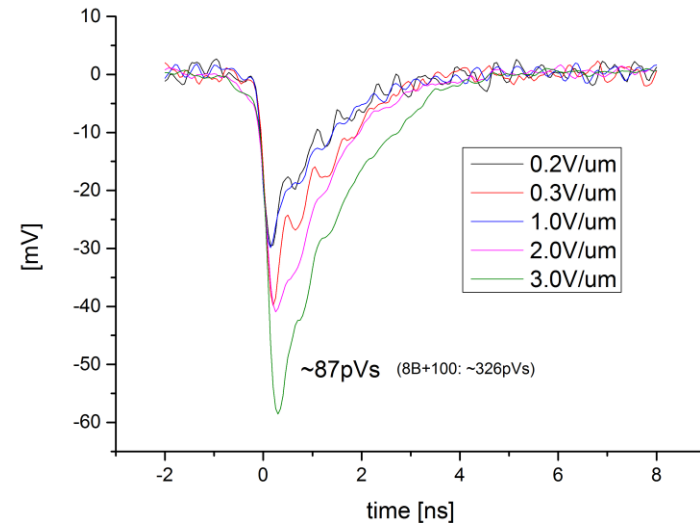
2/5/2015 11:47:13 AM

Initial TCT waveforms (MFAIX334)

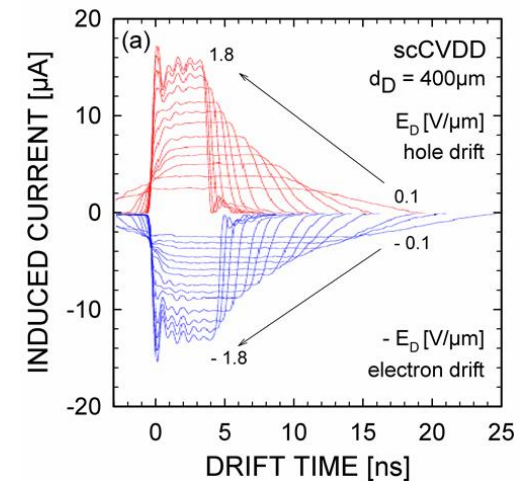
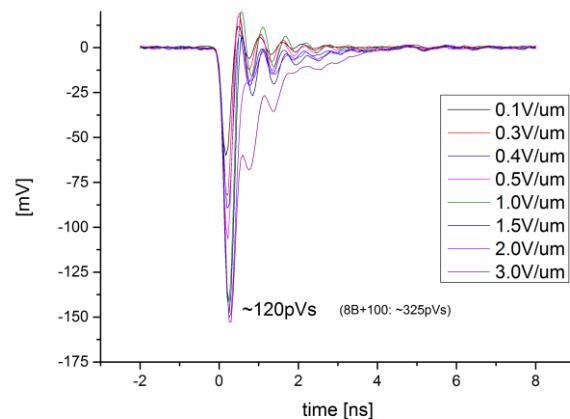
hole drift



electron drift

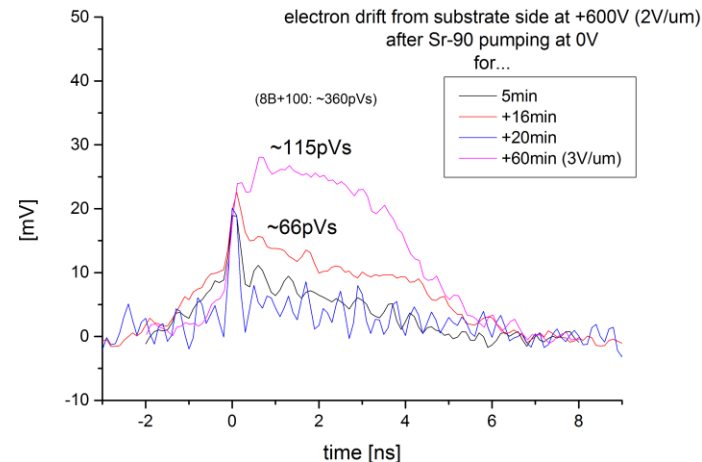
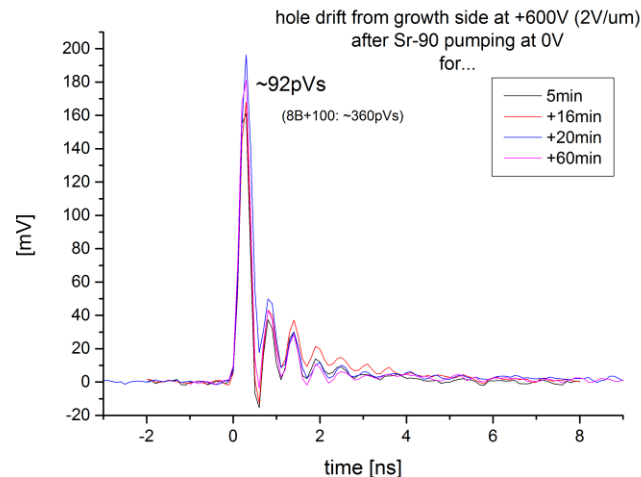
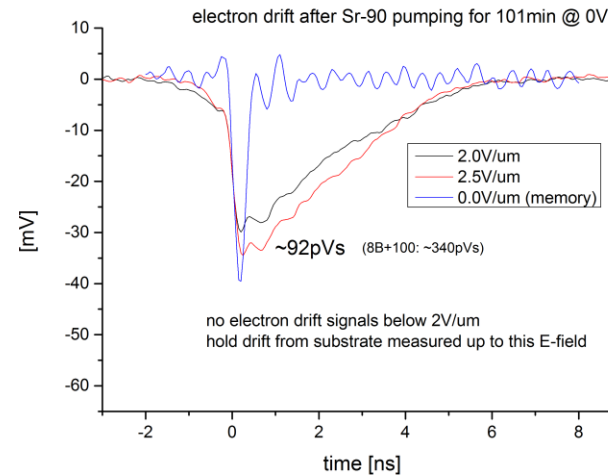
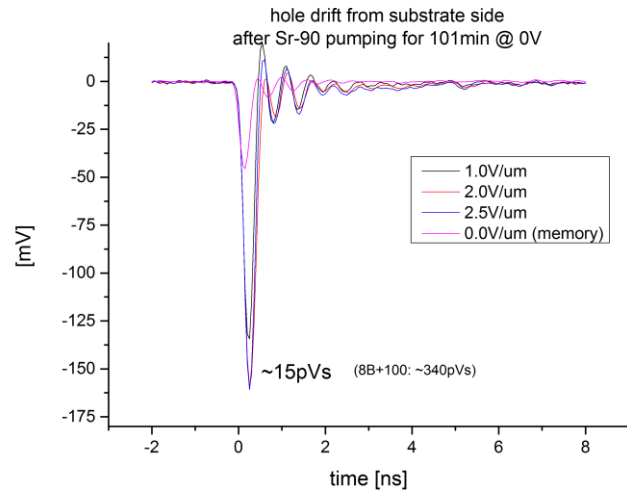


hole drift substrate side

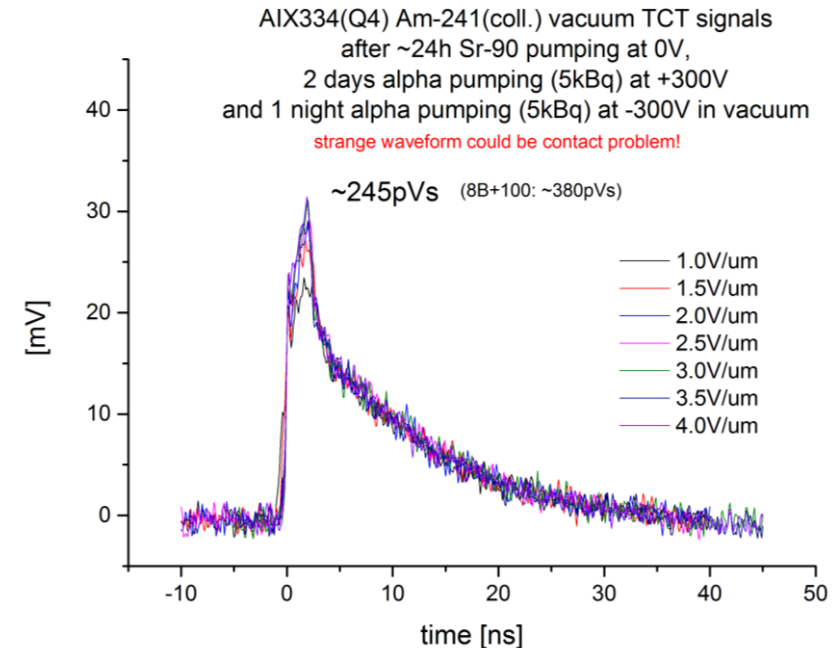
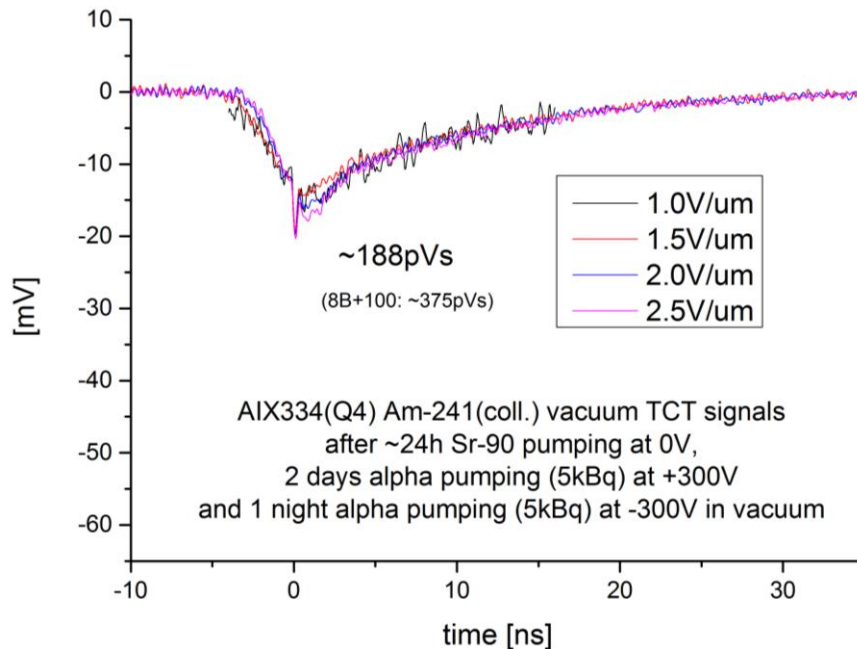


from PhD Thesis
of M. Pomorski

TCT waveforms after Sr-90 pumping



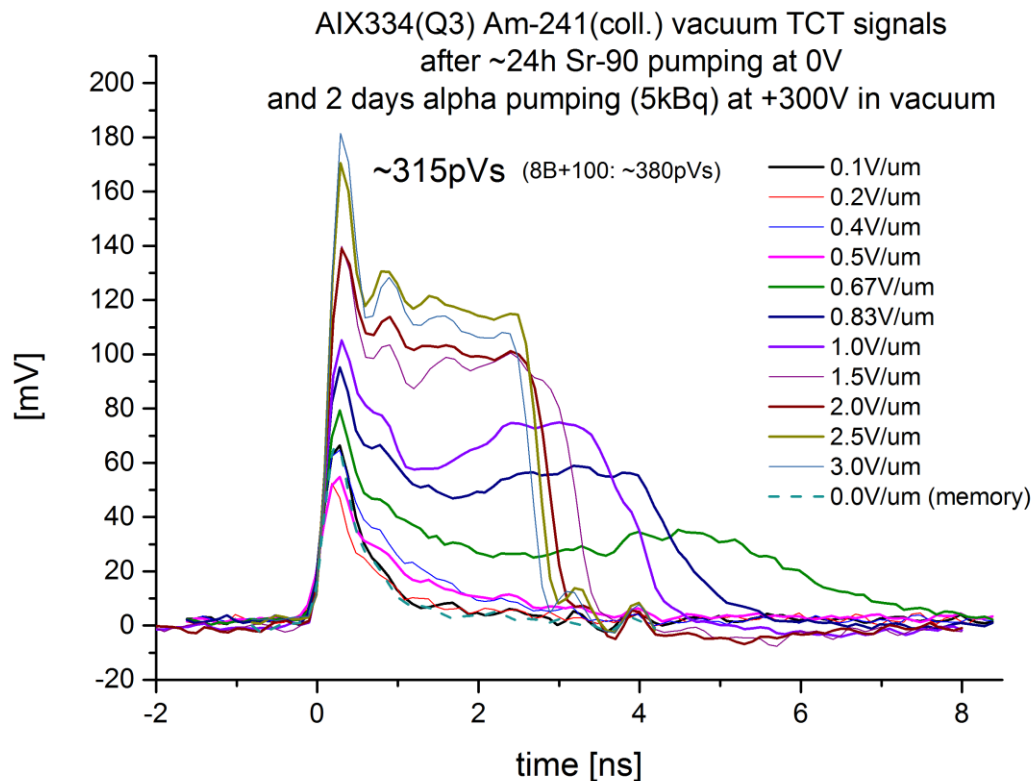
TCT waveforms after prolonged α -pumping



- significant signal in efficiency after alpha-pumping for both electrons and holes
- under study
- possible contact problem

After α -pumping another contact

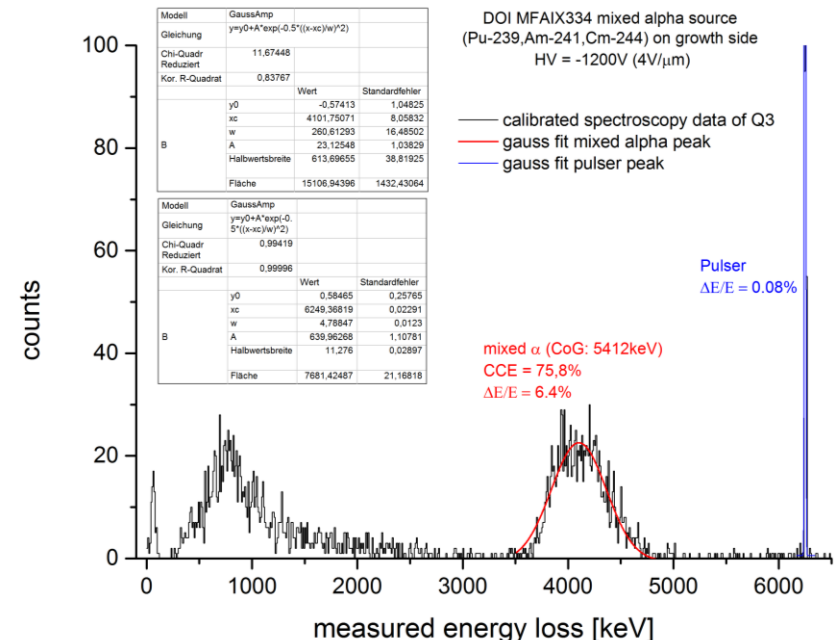
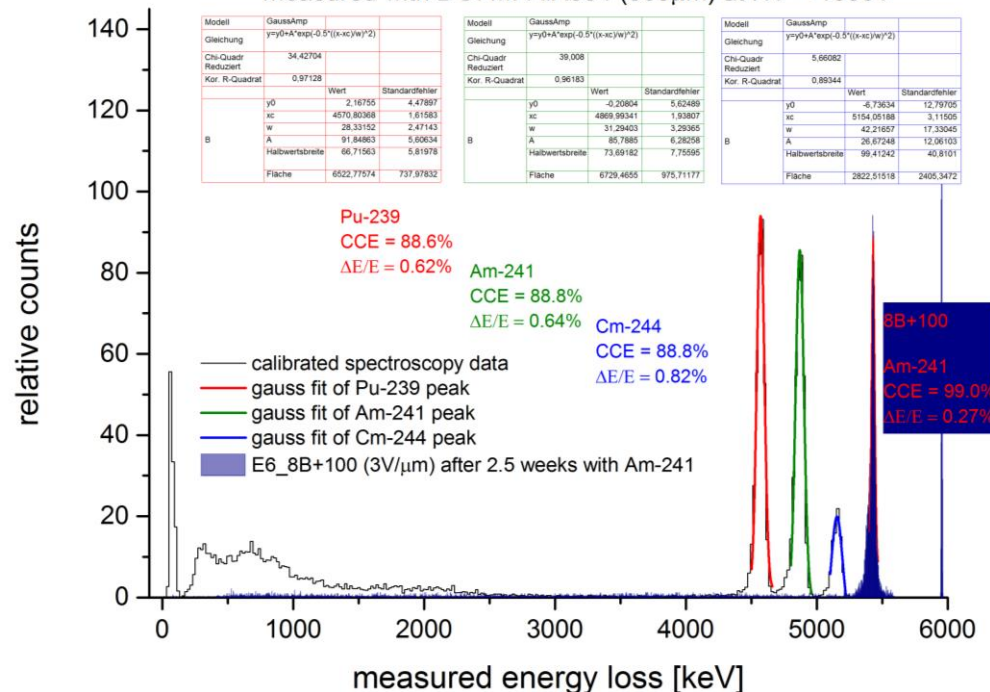
- after prolonged alpha pumping signals are indicating very small amount of active defects



Charge collection efficiency

- charge-sensitive preamplifier (CSTA2) + Ortec 672 spectroscopy amplifier + Silena 4418V peak-sensing ADC
- CCE(preliminary): ~90% for holes and ~76% electrons

energy spectrum of mixed alpha source particles
measured with DOI MFAIX334 (300 μ m) at HV=+1350V

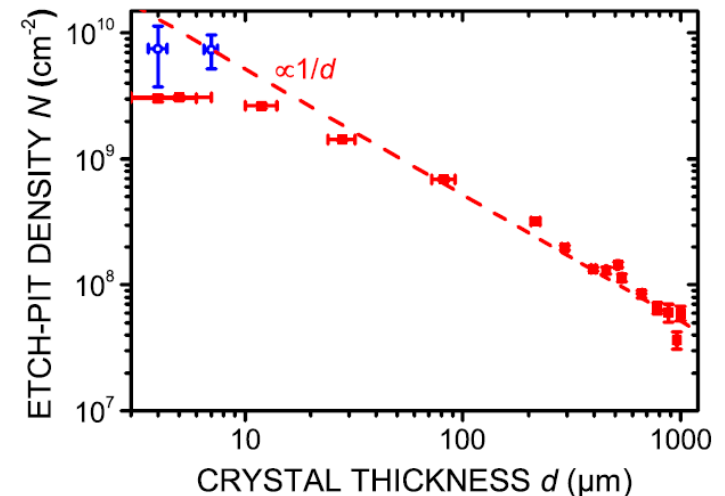


Dol development

- the best overall characteristics for the last five years
- improved electron transport and material homogeneity
- Dol for detector applications, but no spectroscopy
- further improvements difficult; dislocation density is slowly decreasing -> another approach to growing: epitaxial lateral overgrowth

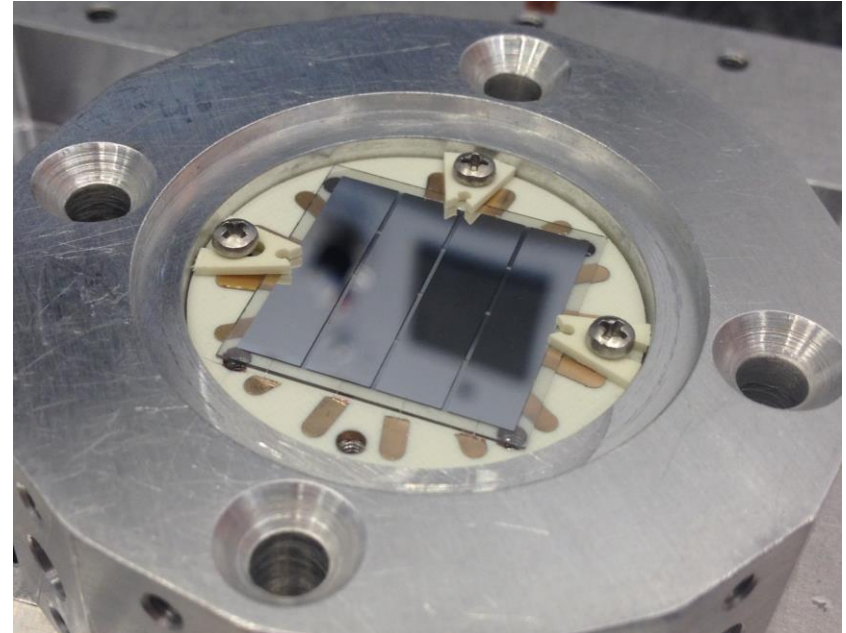
Year	sample	CCE [%]		E_σ [%]	
		hole	electron	hole	electron
2010	886-2	92.5	18.6	2.05	5.23
2011	952-1	79.4	19.7	11.1	42.8
2011	954	92.3	52.2	3	27.4
2012	955-1	77.1	51.2	13.2	28.6
2013	962	87	50.7	3.1	10.8
2014	AIX334	84.5	61	0.84	9

all values for fields 1.5V/μm



C. Stehl et al., Appl. Phys. Lett. 103, 151905 (2013)

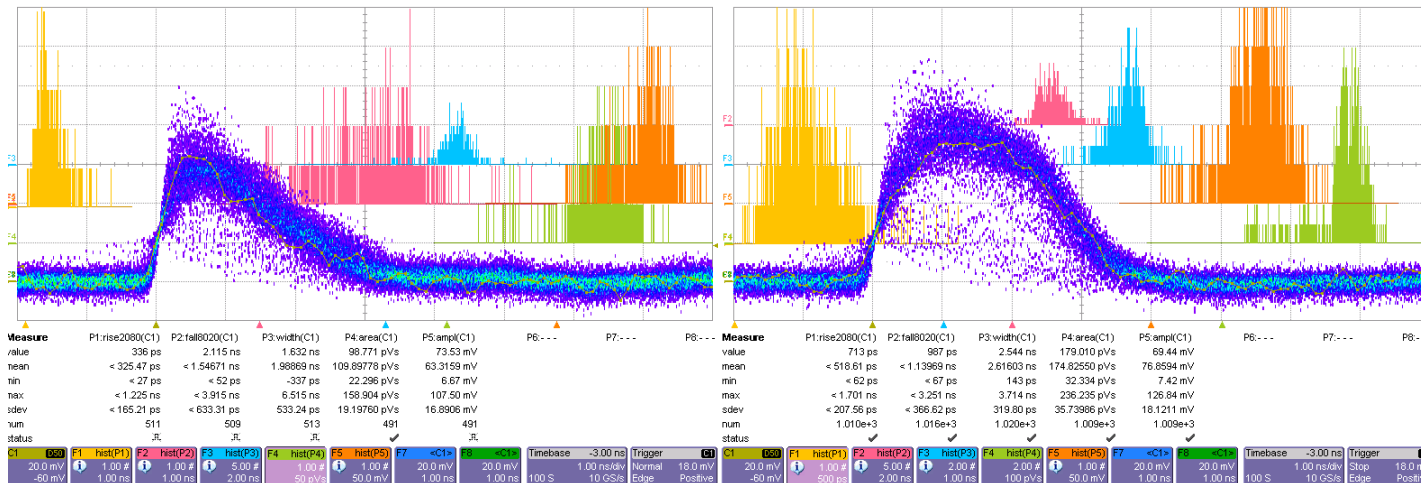
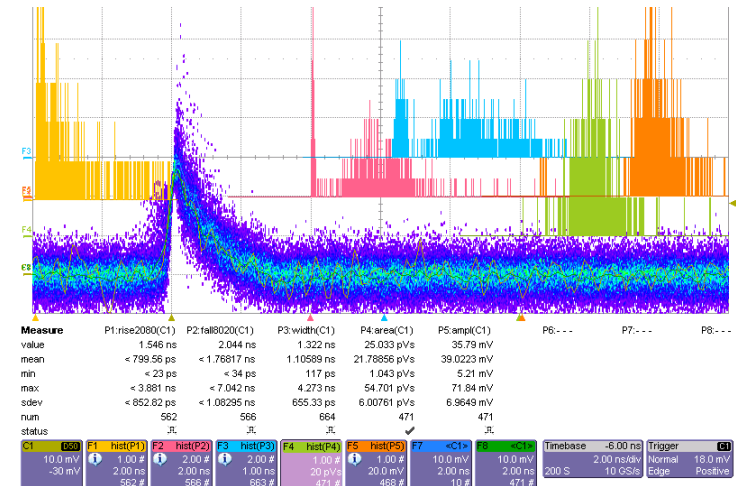
Characterization of “large” Dol sample



- MFAIX239L
- 20 x 20 mm², ~300 μm, surface slanted
- metallization: Al 4-strips

Waveforms positive polarization (hole drift)

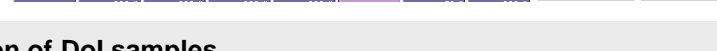
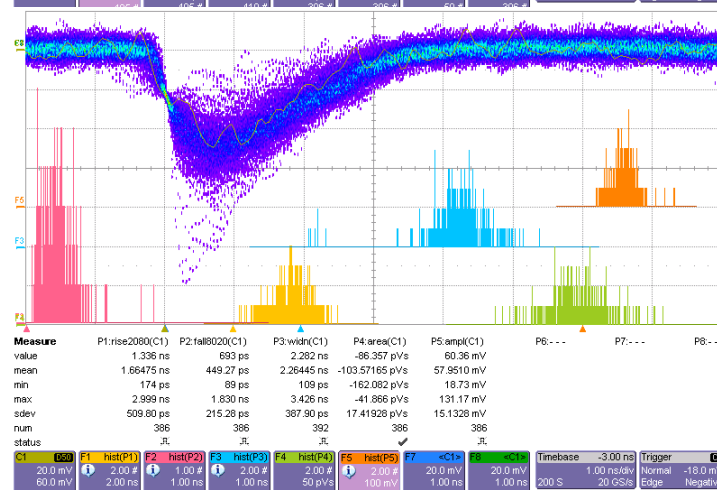
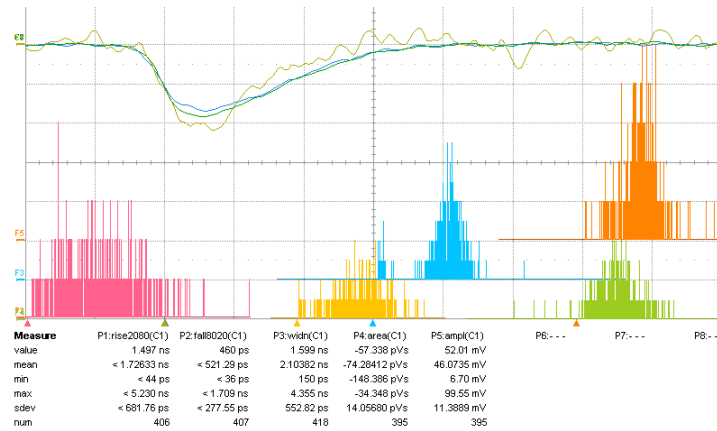
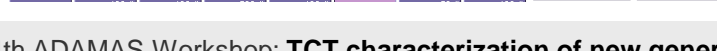
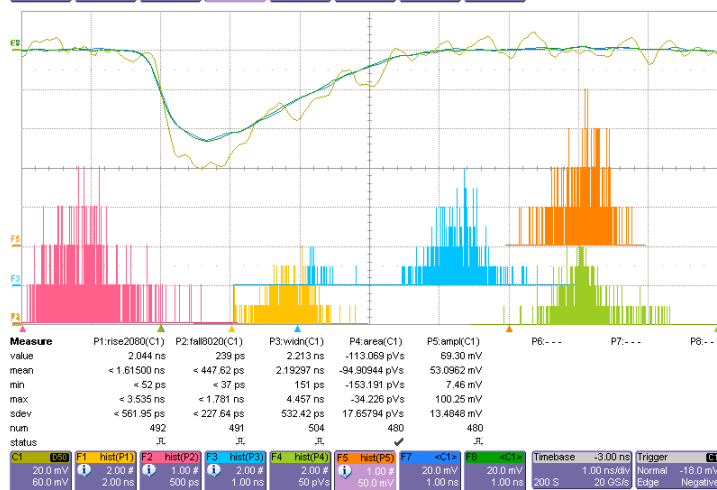
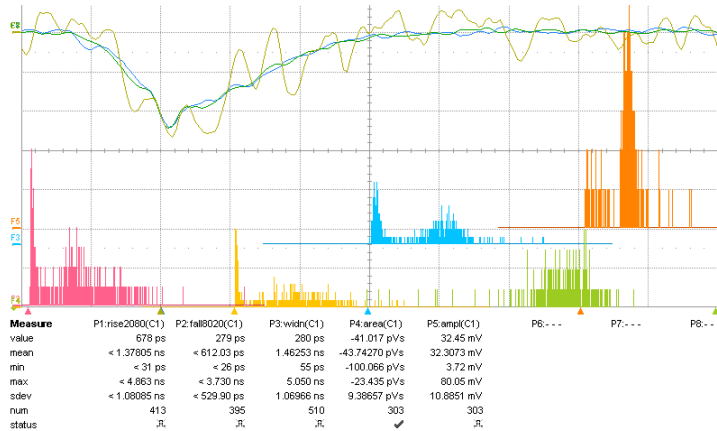
- setup in air
- non-pumped sample
- hole drift
- voltages 50V, 600 V, 1200 V



Waveforms negative polarization (electron drift)



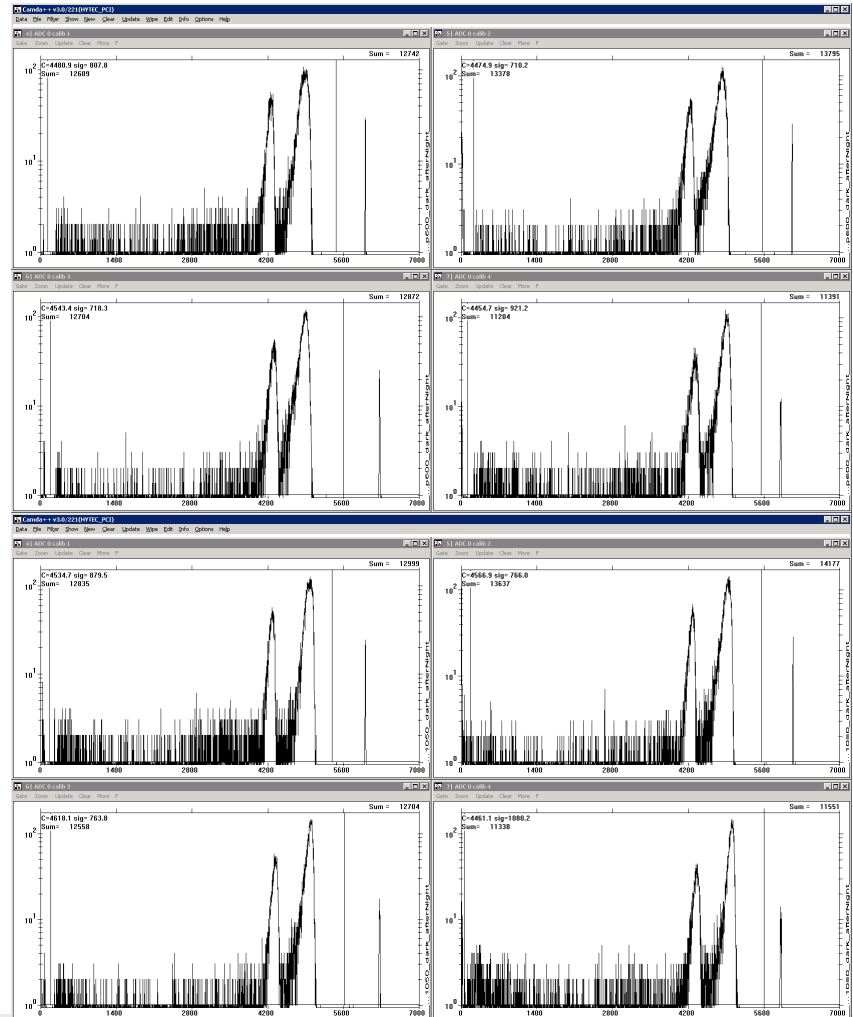
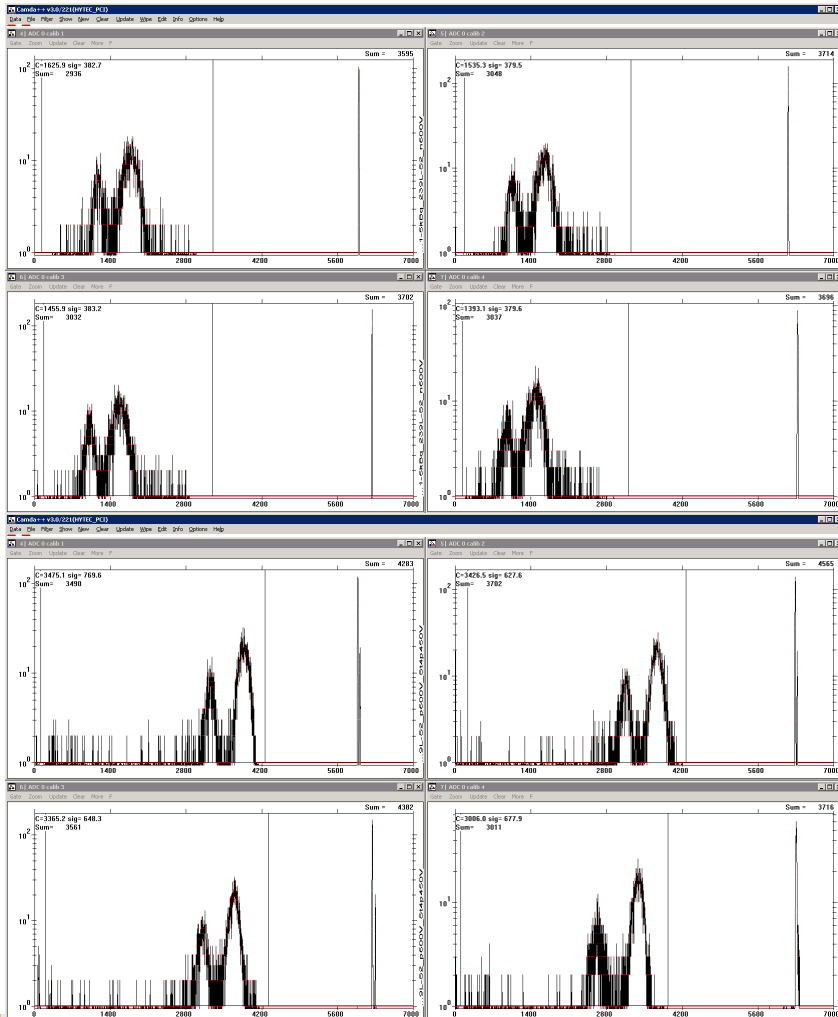
300, 600, 900, 1150 V



Spectroscopy Am-241

■ -/+ 600 V, not pumped

Sr-90 pumped over night +600/1050V



Summary

- the latest generation of Dol samples is showing a significant improvement in CCE i.e. sample quality
- Dol material cannot be compared to homoepitaxially grown diamonds yet, at least not to the detector grade material, the concentration of defects is comparably much higher and requires conditioning of detector
- additional study of material is needed
- nevertheless, the present level of performance is way beyond pcCVD and therefore makes Dol a material of choice for construction of new detector devices
- next step is construction of Dol detector device: a high rate MiP beam profile + timing detector