Current status and developments for Barrel EMC

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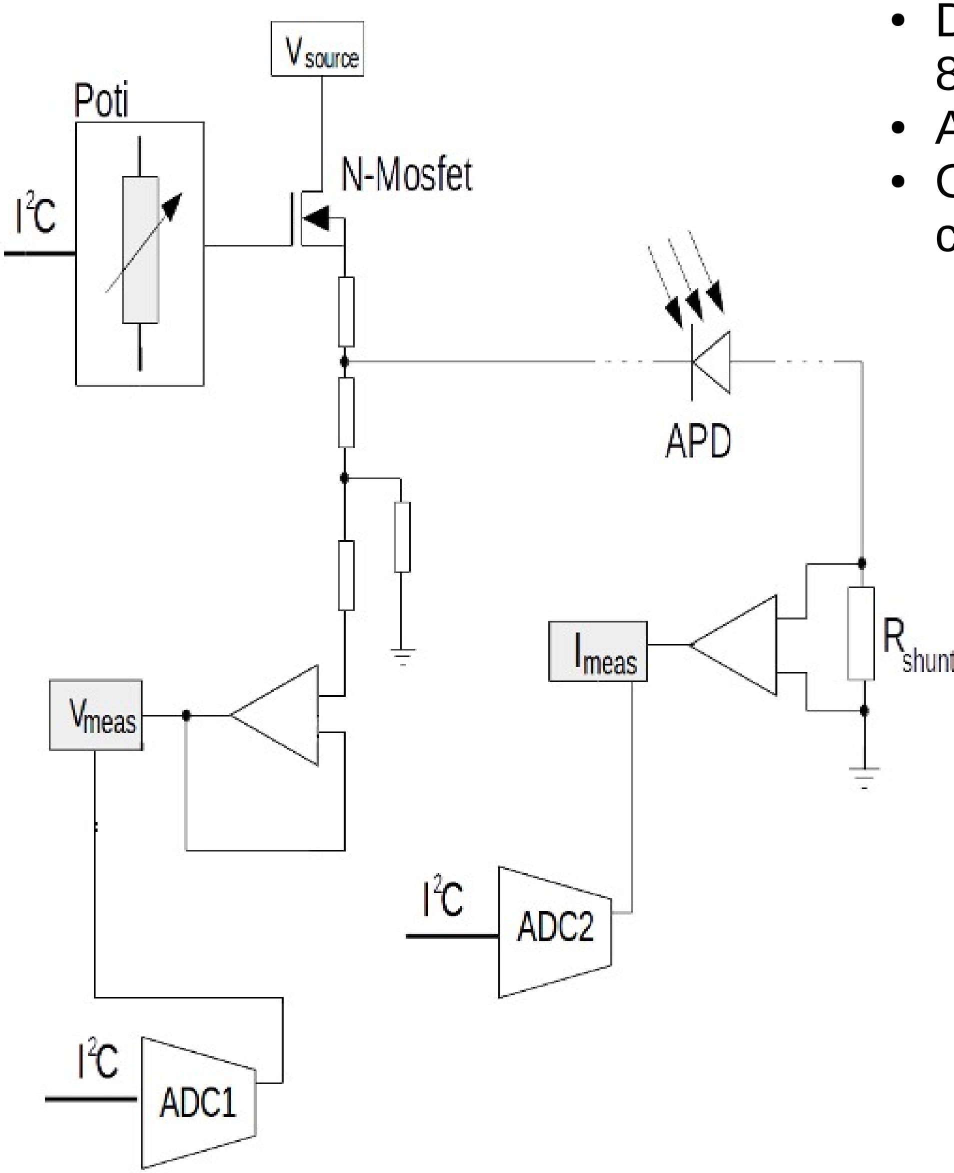
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Activities

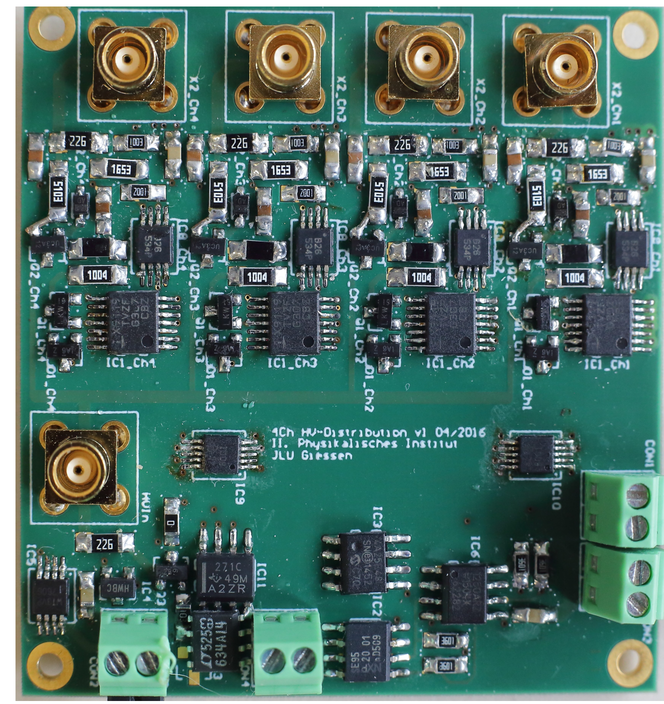
- Assembly of preseries slice → Markus
- Crystal production @ Crytur
- HV distribution electronics
- Design of Backplane electronics
- LED crystal damage recovery system
- (Estimation of Cu neutron activation)

HV distribution electronics



Single channel block schematic

- Device to independently adjust bias voltage of 8 APDs
- All channels fed from the same HV source
- Online measurement of APD voltage and current



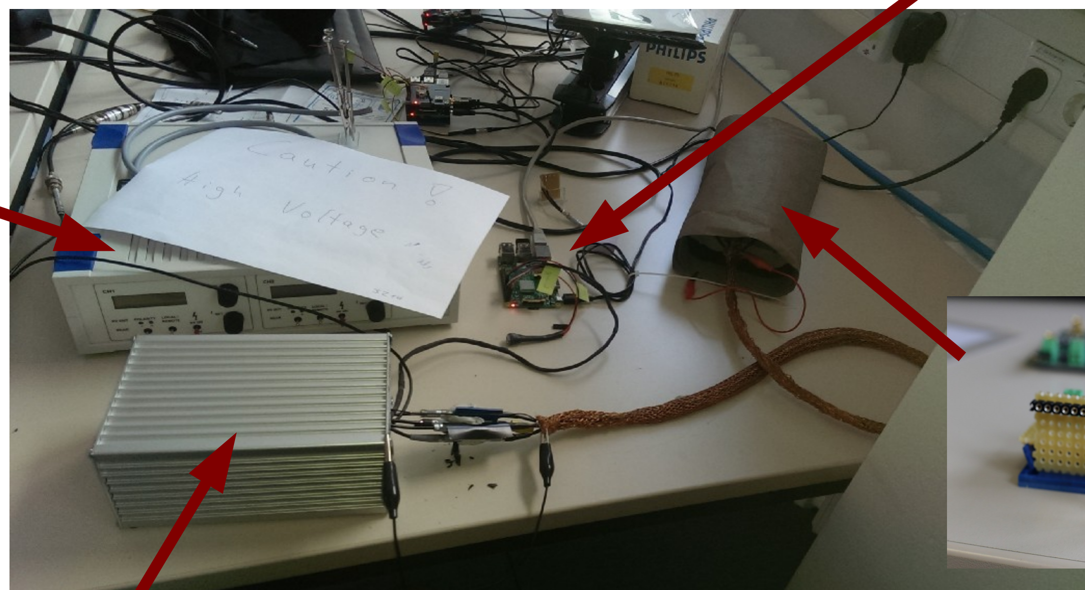
4-ch prototype
size: 6 x 5.5 cm²

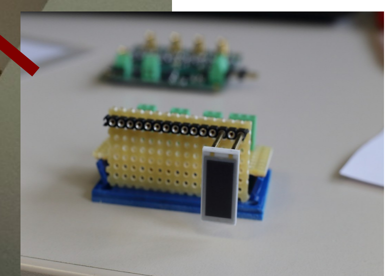
HV distribution electronics

Lab setup for characterization of HV distributor

Rpi for I2C slow control

ISEG table top HV supply



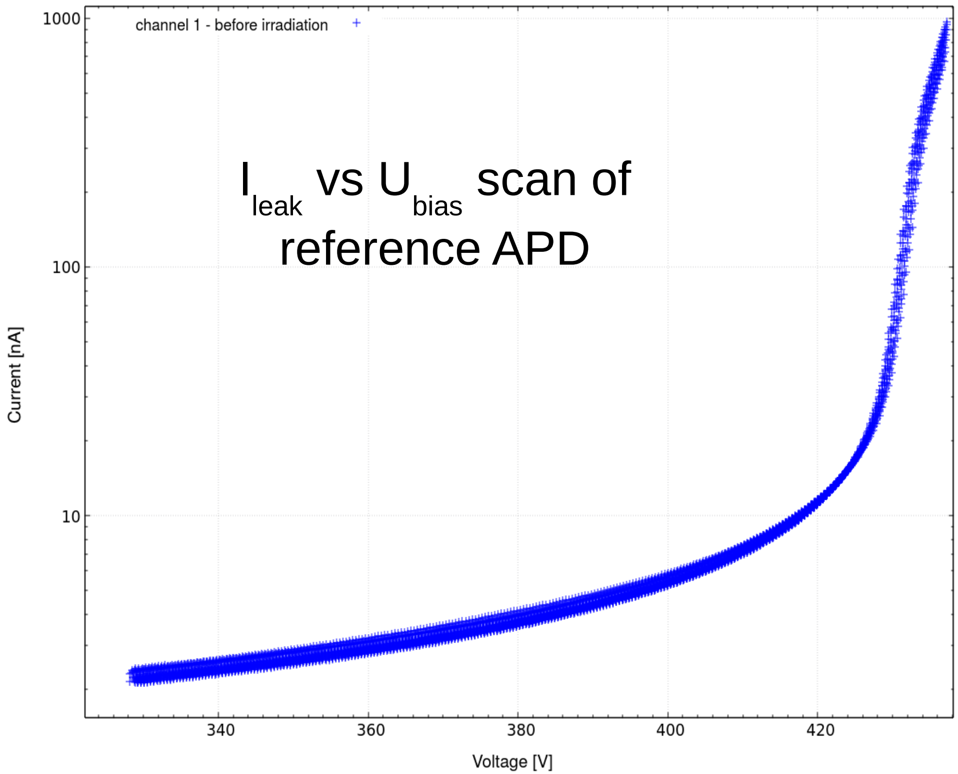


4 reference APDs in shielded box

DUT in shielded box
separated from APDs for thermal characterization

HV distribution electronics

- HV adjustment done by potentiometer setting

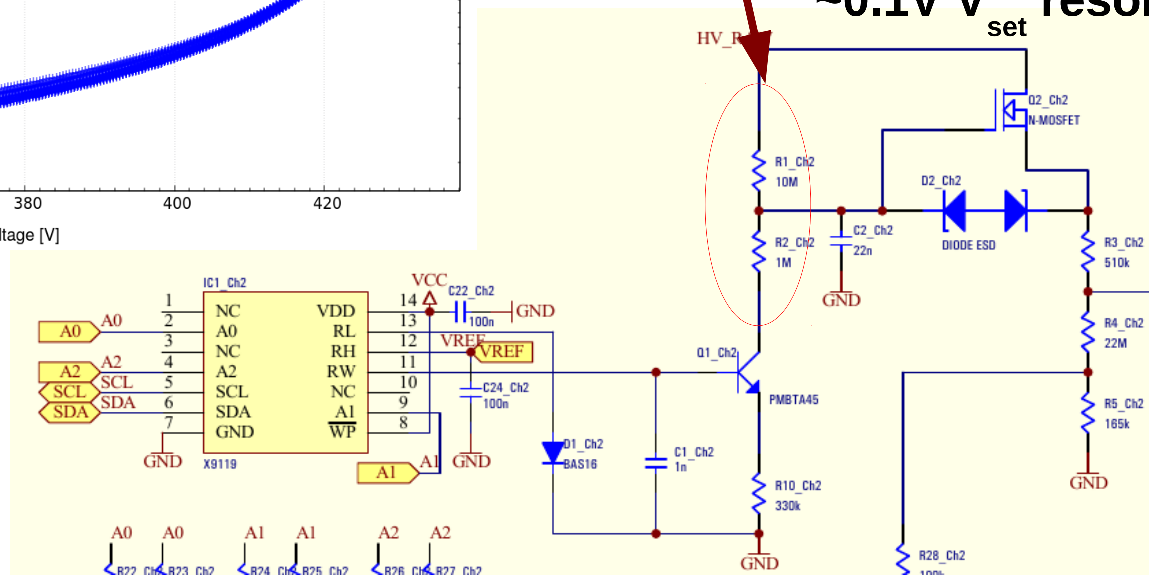


I_{leak} vs U_{bias} scan of reference APD

Regulation voltage range set by voltage divider at gate of HV Mosfet

- Current prototype: ~100 V span from HV input downwards
- 10-bit resolution of potentiometer

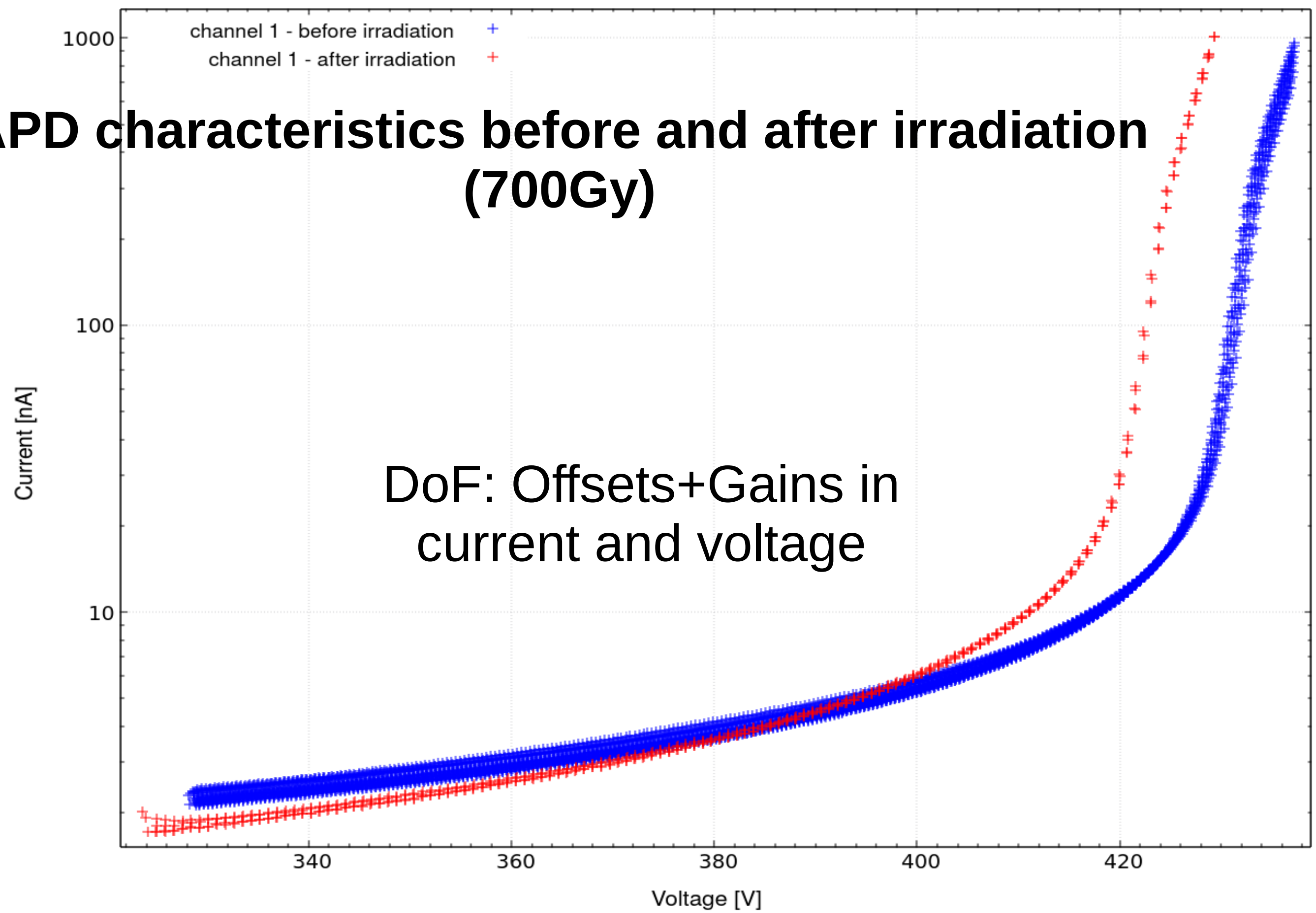
~0.1V V_{set} resolution



HV distribution electronics

Characterization of HV distributor (DUT), not of the APD itself → use standard reference APDs always at the same channels and under identical conditions

APD characteristics before and after irradiation (700Gy)



DoF: Offsets+Gains in current and voltage

Offset+Gain

Offset+Gain

HV distribution electronics

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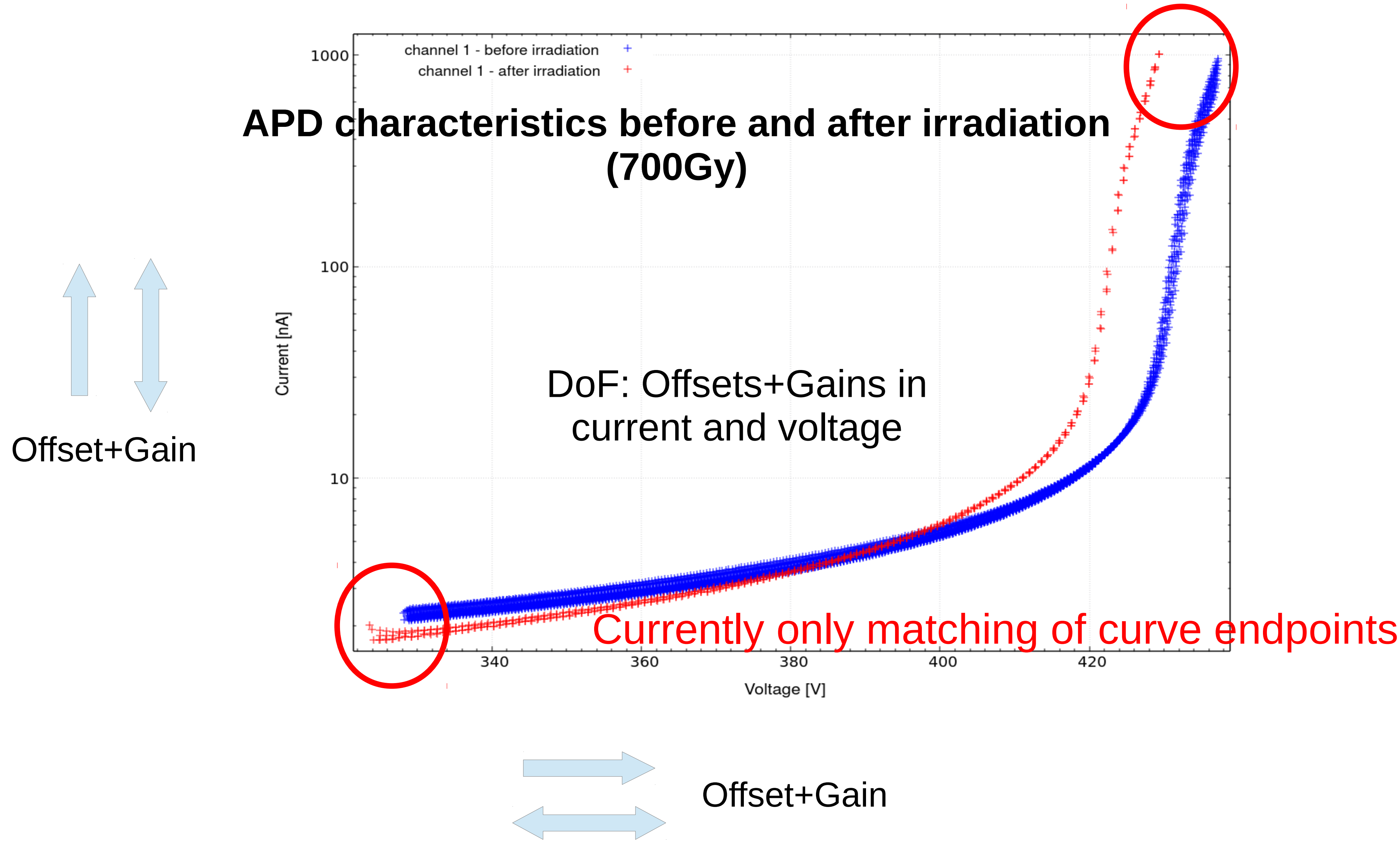
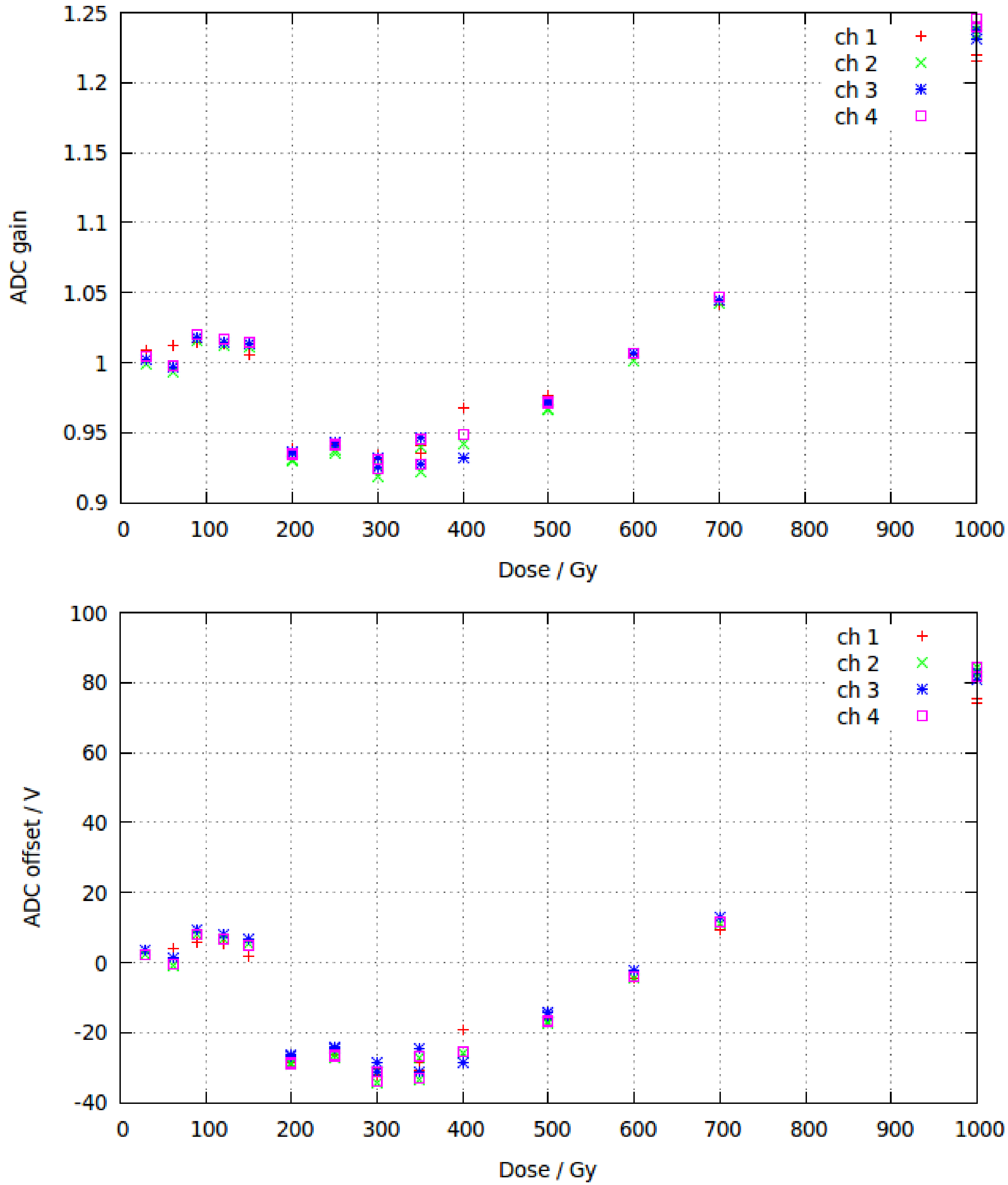
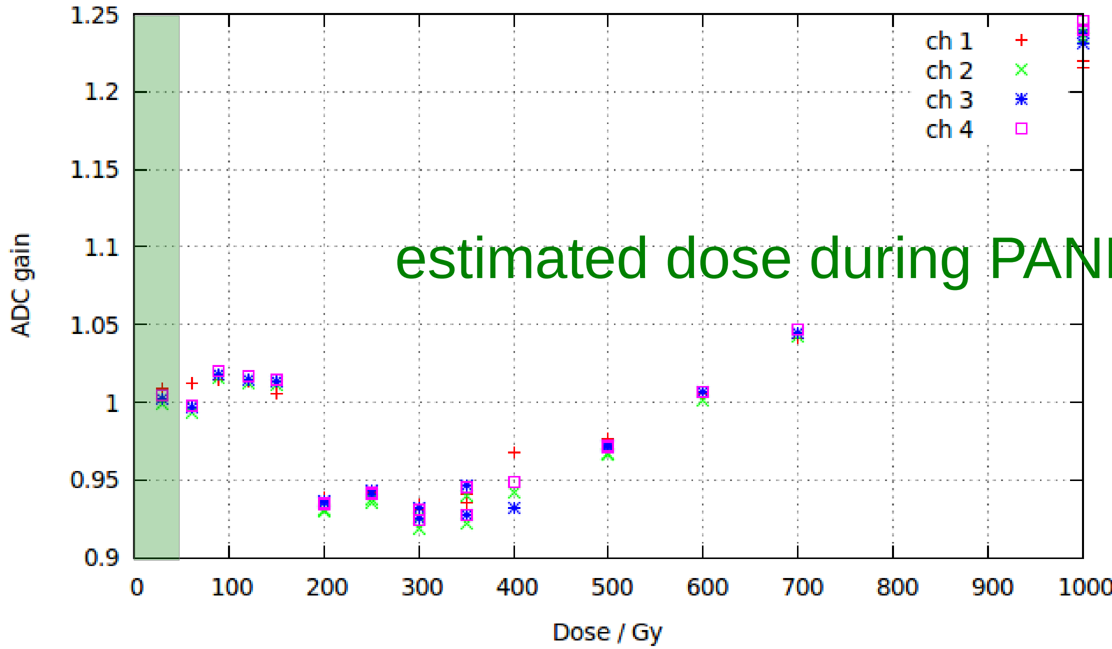


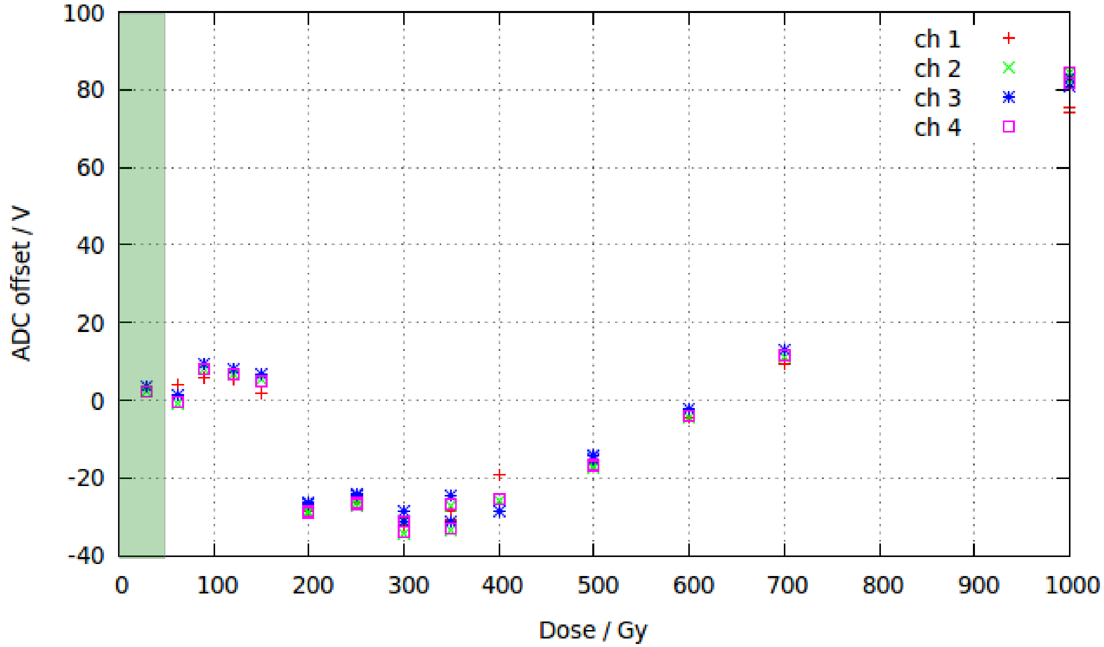
HV distribution electronics



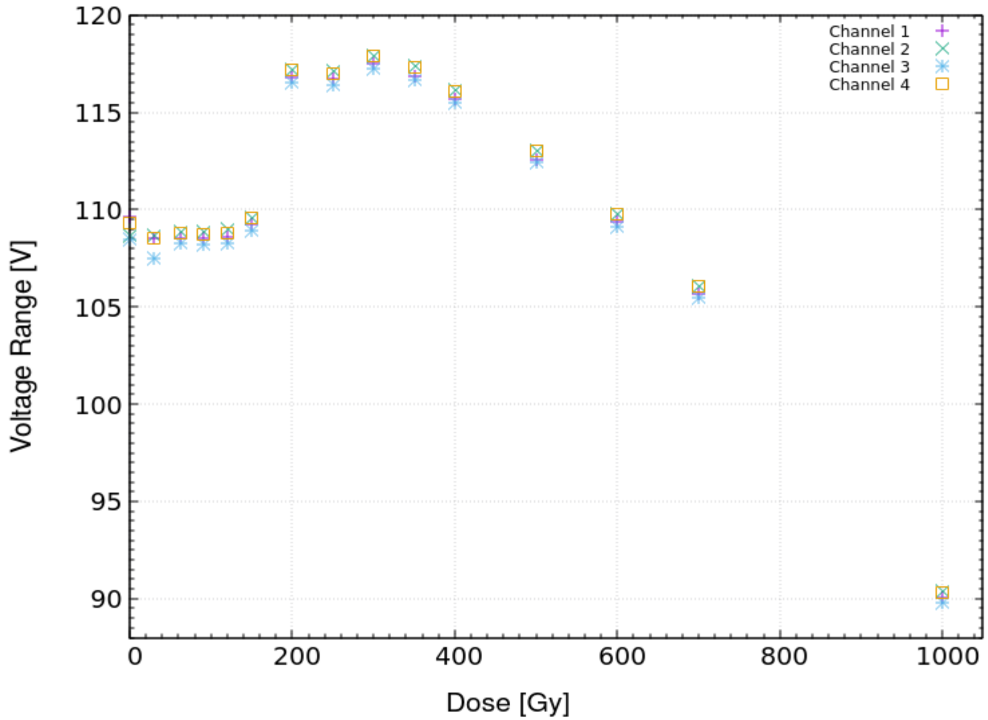
HV distribution electronics

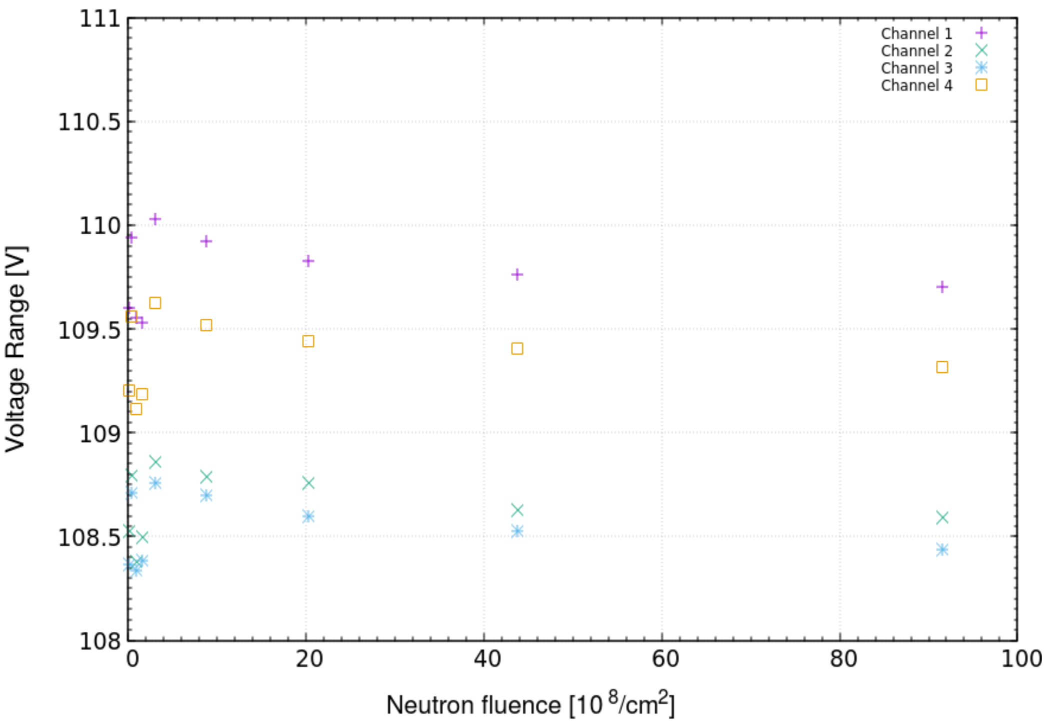


estimated dose during PANDA operation



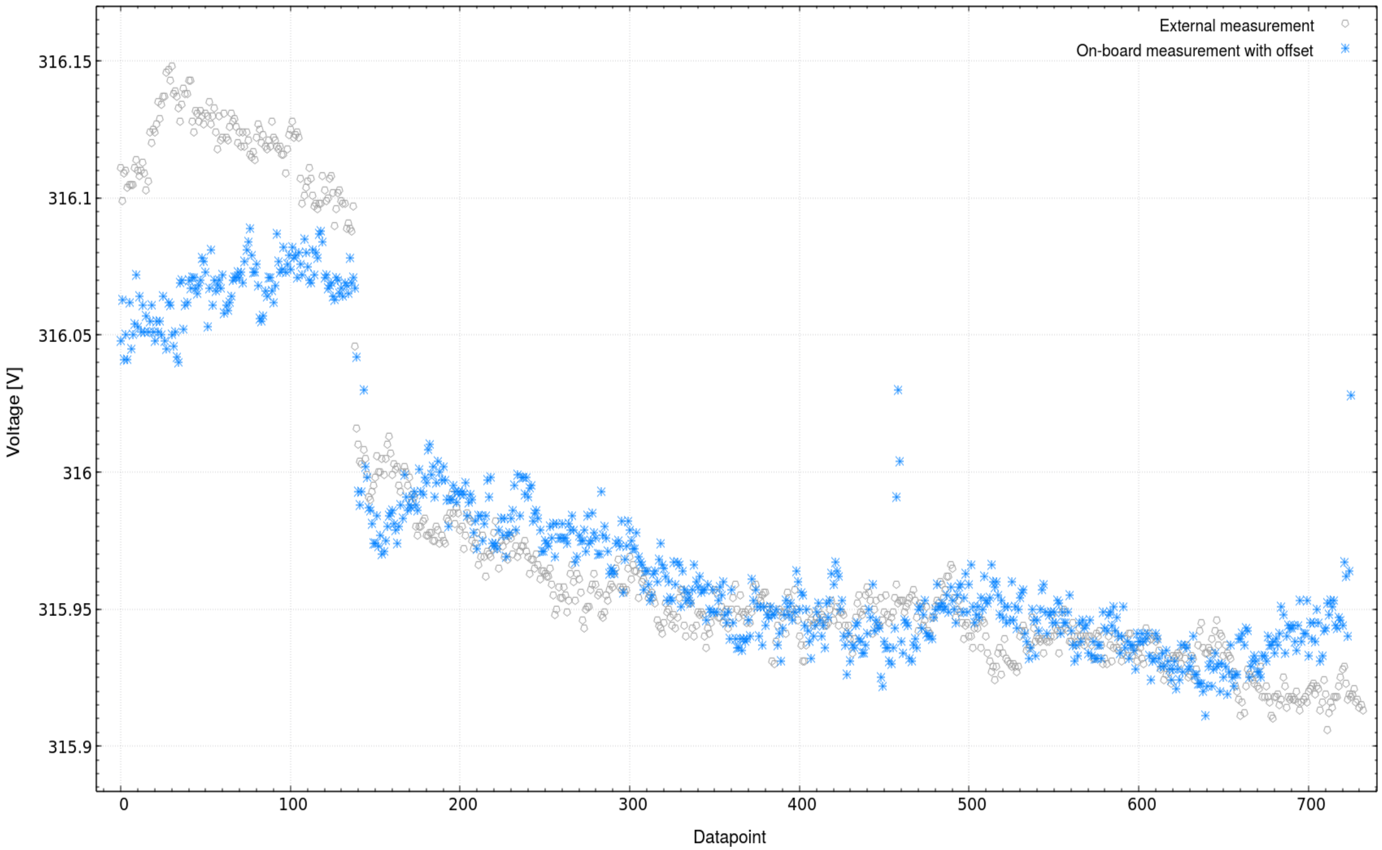
HV distribution electronics





- Usable voltage range reflects radiation induced changes (ADC gain)
- No changes (within measurement precision) for ionizing doses up to ~170 Gy
- Slight shift at low neutron fluence (~10E8 n/cm²), stable up to 10E10 n/cm², max. 0.25 V difference
- Same observation for proton fluence up to 10E10 p/cm² (irrad. At KVI, 180MeV)
- Irradiations at fluences of 10E11 neutrons and protons done. Characterizations pending due to high activation

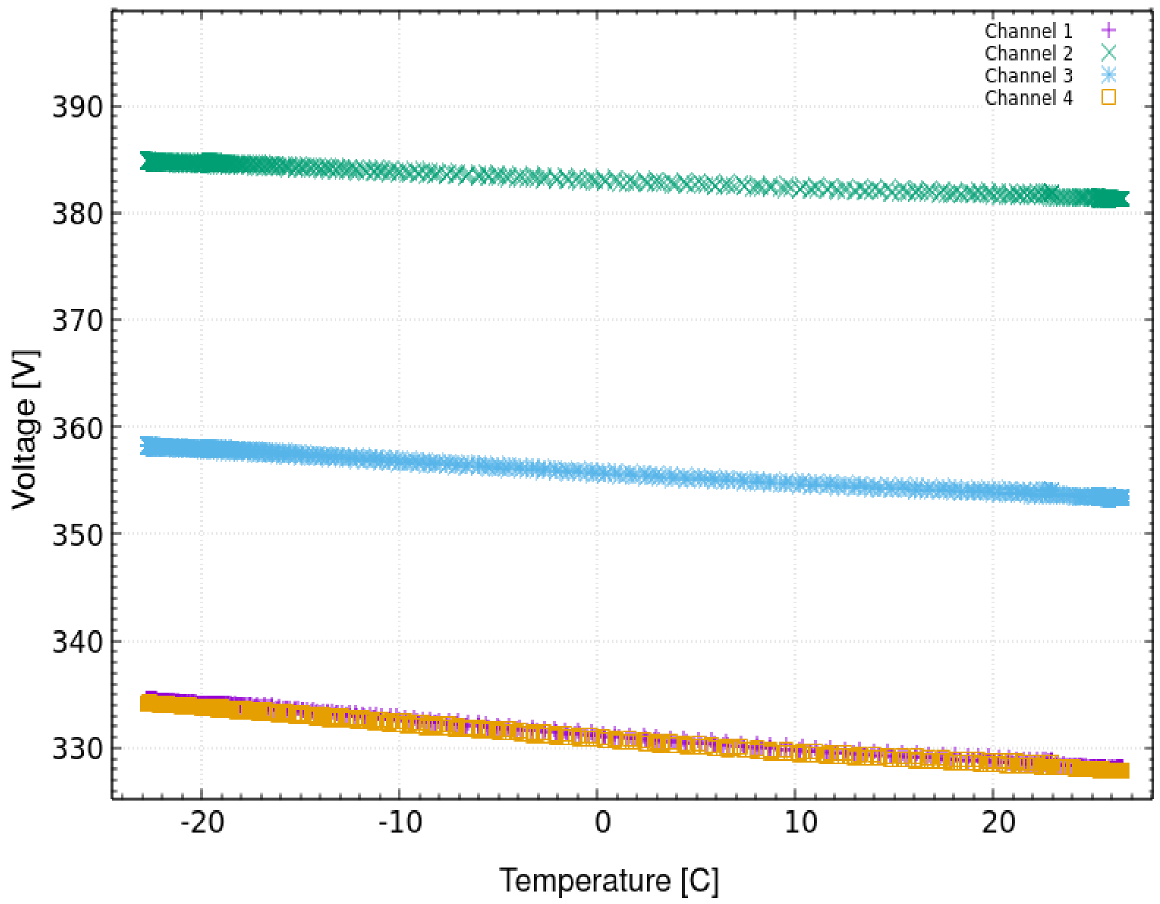
HV distribution electronics



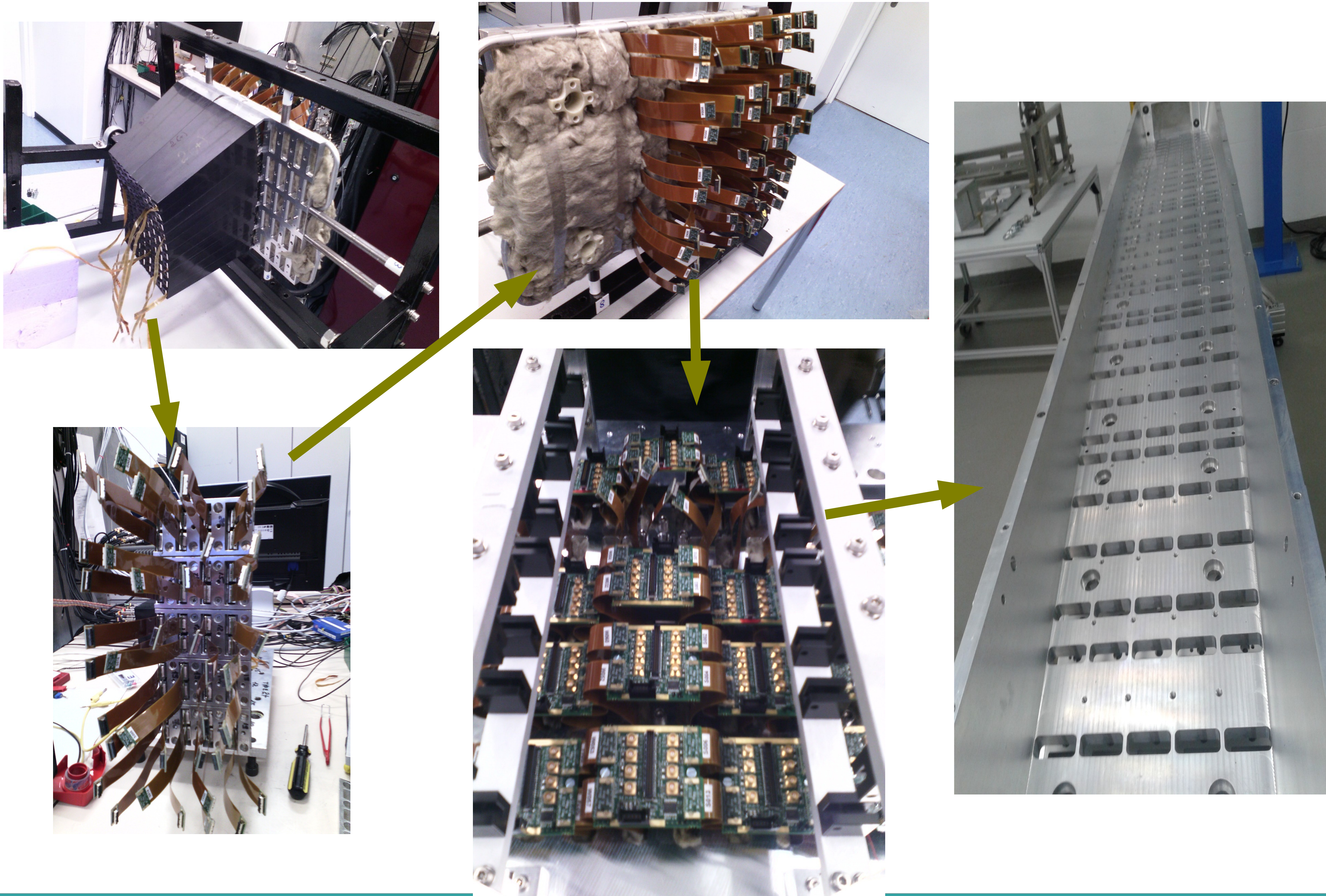
- Comparison of on-board measured voltage and true output voltage (Keithley multimeter)
- Const offset from component tolerances removed
  → part of channel calibration (Eeprom)

HV distribution electronics

- Temperature dependence of on-board measured voltage
- Temp measurement from on-board sensor, resolution ~0.01K
- Temp coeff: ~0.15 V/K



Backplane Electronics



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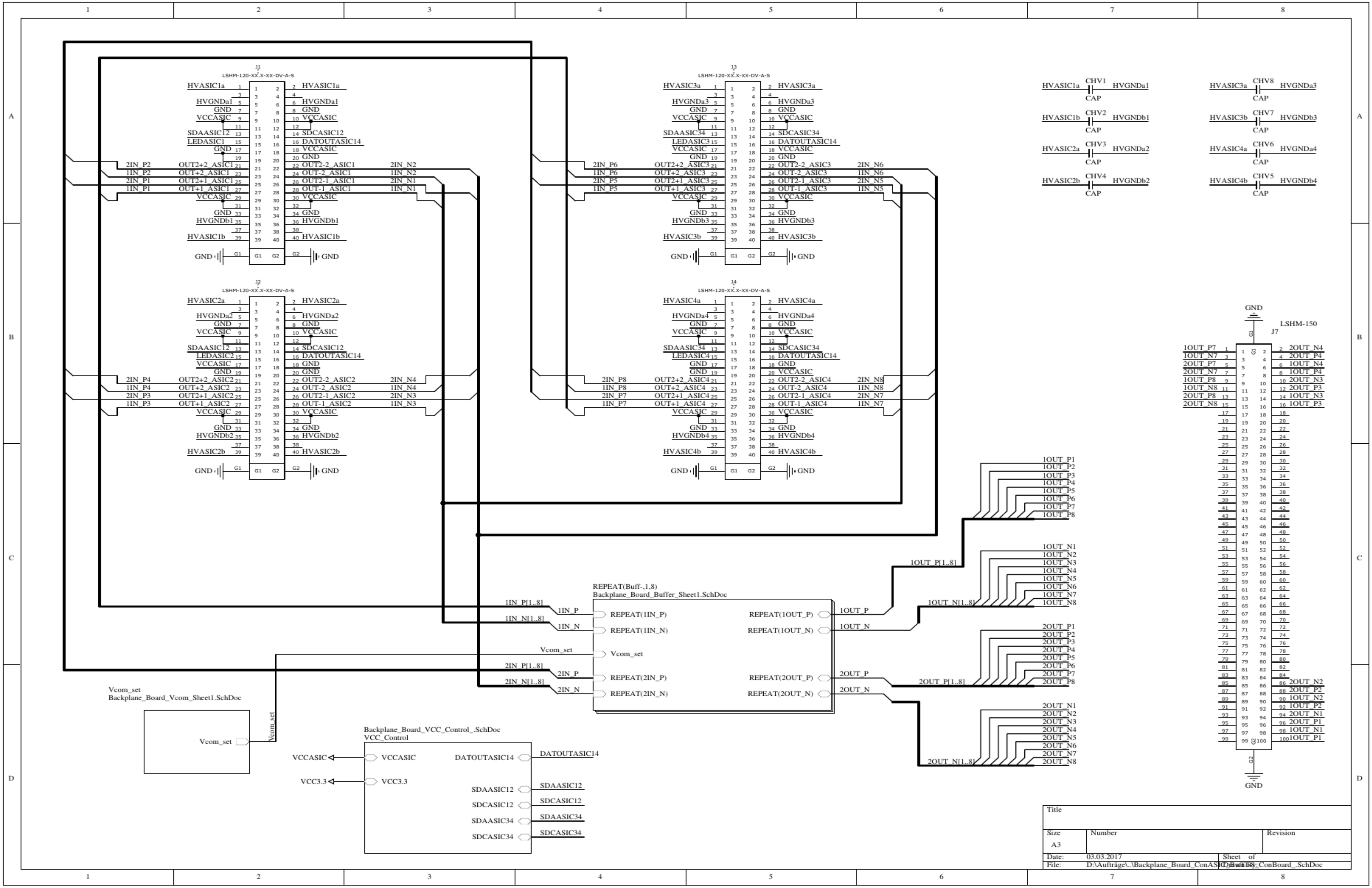
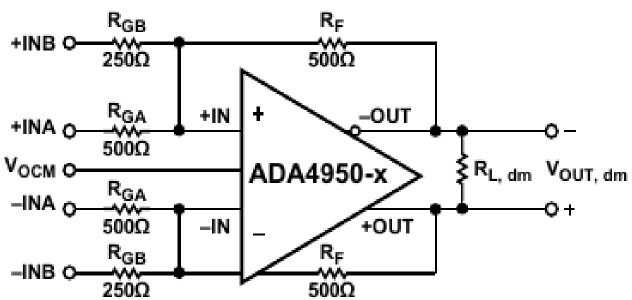
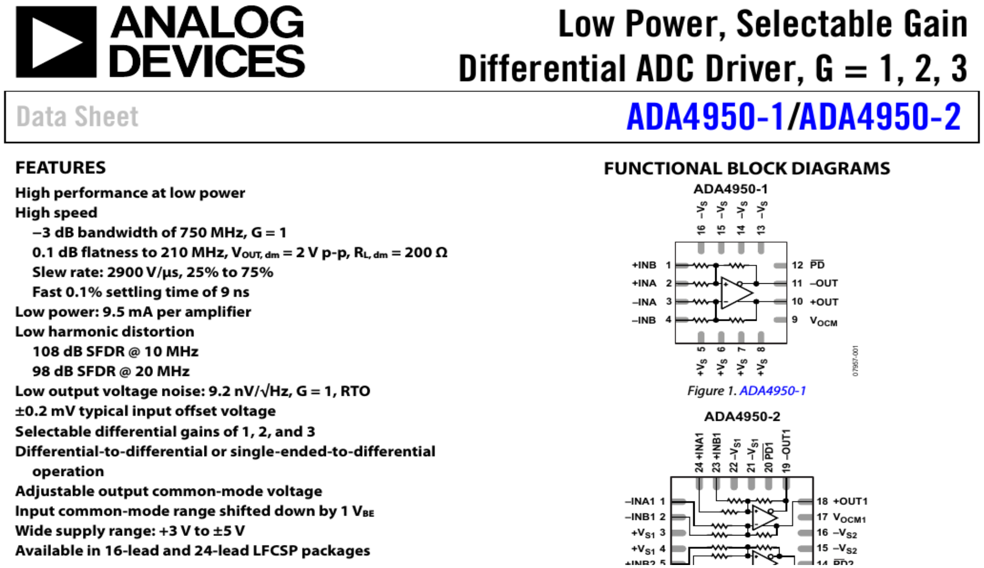


Line Drivers

- Need for low power, high density diff. line drivers
- Compensate for cable loss (Bedea cable), gain>2




ANALOG DEVICES

Low Power, Selectable Gain Differential ADC Driver, G = 1, 2, 3

Data Sheet ADA4950-1/ADA4950-2

FEATURES

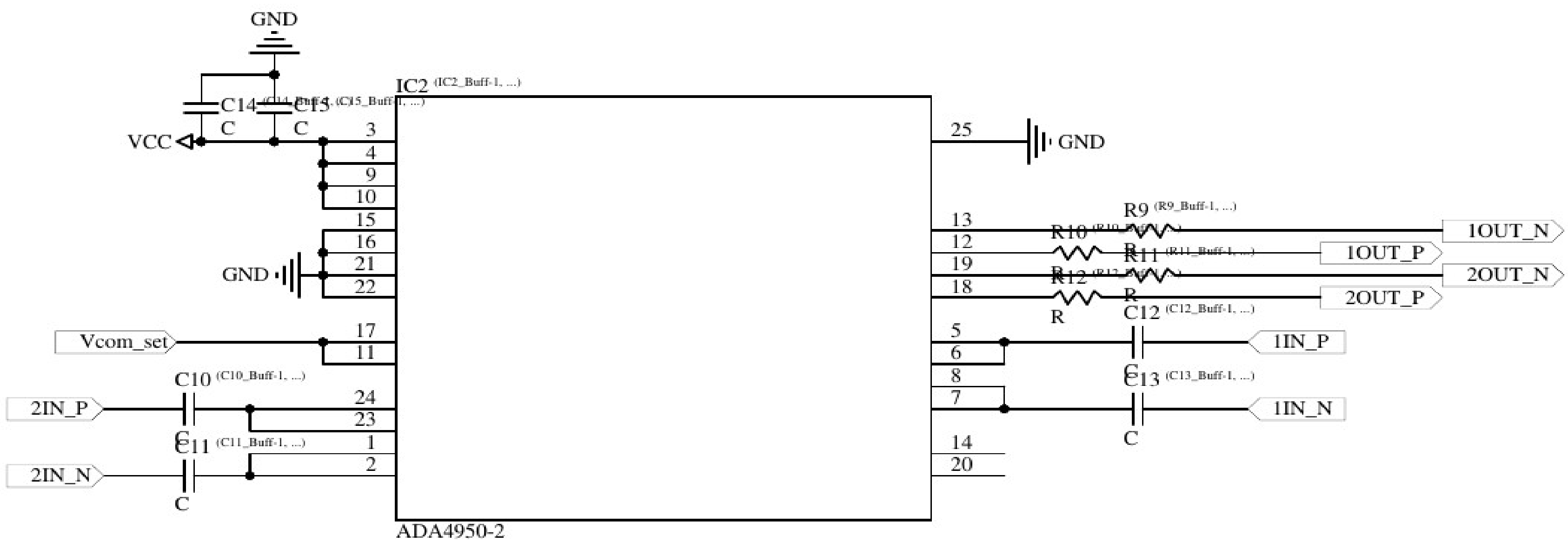
- High performance at low power
- High speed
  - −3 dB bandwidth of 750 MHz, G = 1
  - 0.1 dB flatness to 210 MHz, $V_{OUT, dm}$ = 2 V p-p, $R_{L, dm}$ = 200 Ω
  - Slew rate: 2900 V/µs, 25% to 75%
  - Fast 0.1% settling time of 9 ns
- Low power: 9.5 mA per amplifier
- Low harmonic distortion
  - 108 dB SFDR @ 10 MHz
  - 98 dB SFDR @ 20 MHz
- Low output voltage noise: 9.2 nV/√Hz, G = 1, RTO
- ±0.2 mV typical input offset voltage
- Selectable differential gains of 1, 2, and 3
- Differential-to-differential or single-ended-to-differential operation
- Adjustable output common-mode voltage
- Input common-mode range shifted down by 1 V_{BE}
- Wide supply range: +3 V to ±5 V
- Available in 16-lead and 24-lead LFCSP packages

FUNCTIONAL BLOCK DIAGRAMS

ADA4950-1

Figure 1. ADA4950-1

ADA4950-2



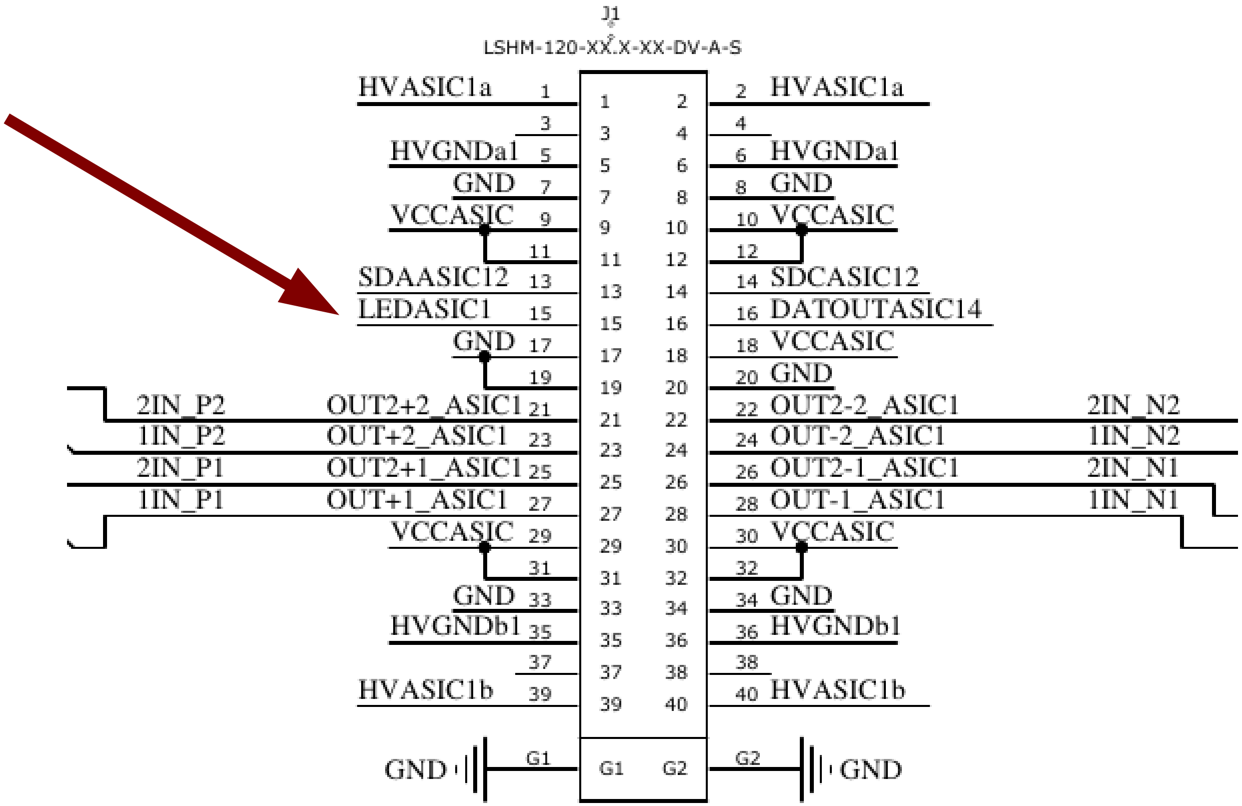
Drive of blue LED for stimulated recovery of crystals

Bpl-Connector to FE ASIC PCB

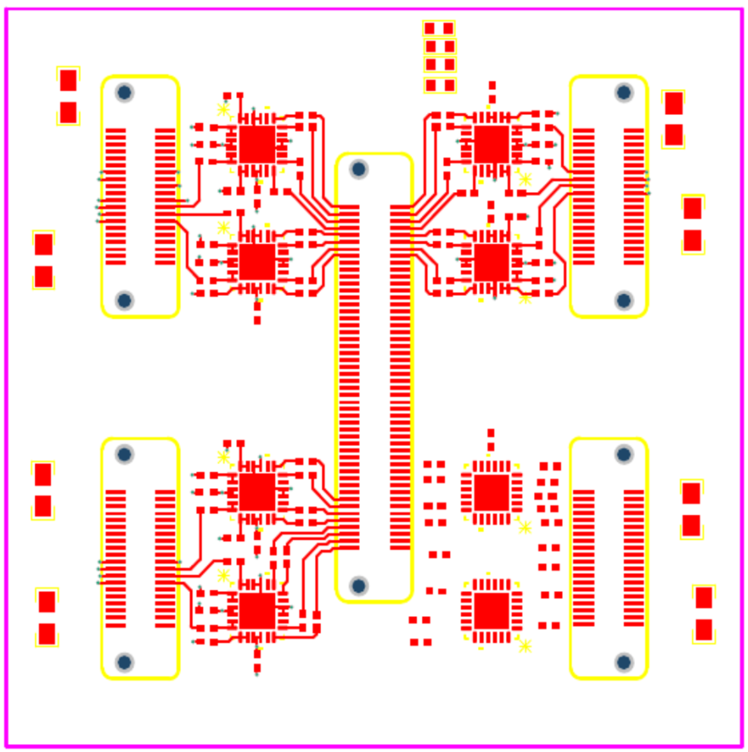
Added line for LED drive

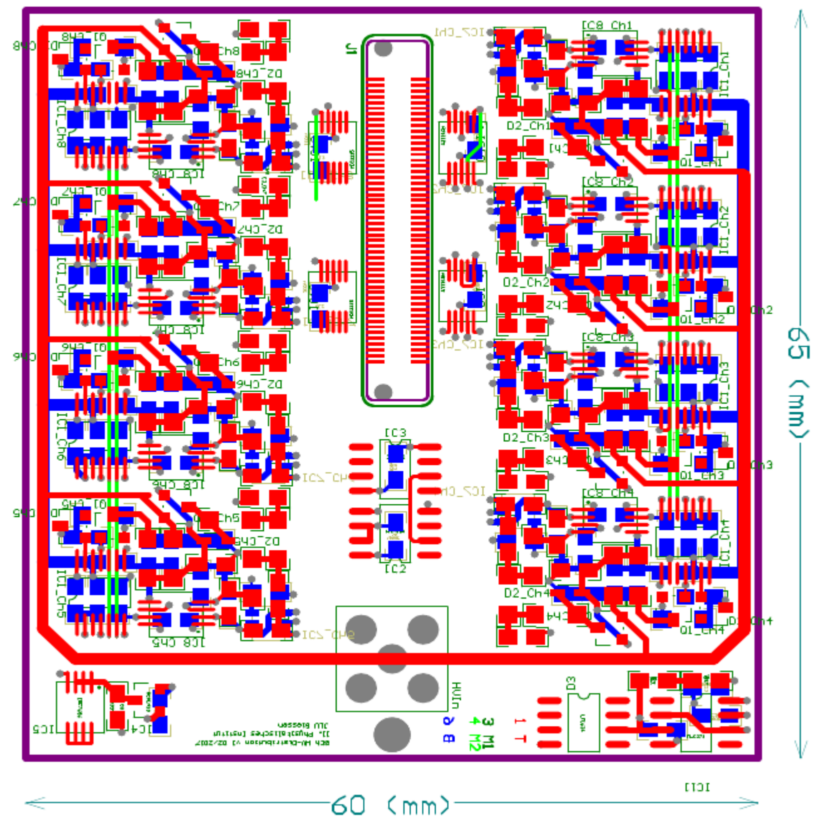
Requirements:

- Up to 20 mA drive current
- Ideal RF decoupling to Gnd at several places along the line!



Backplane Electronics



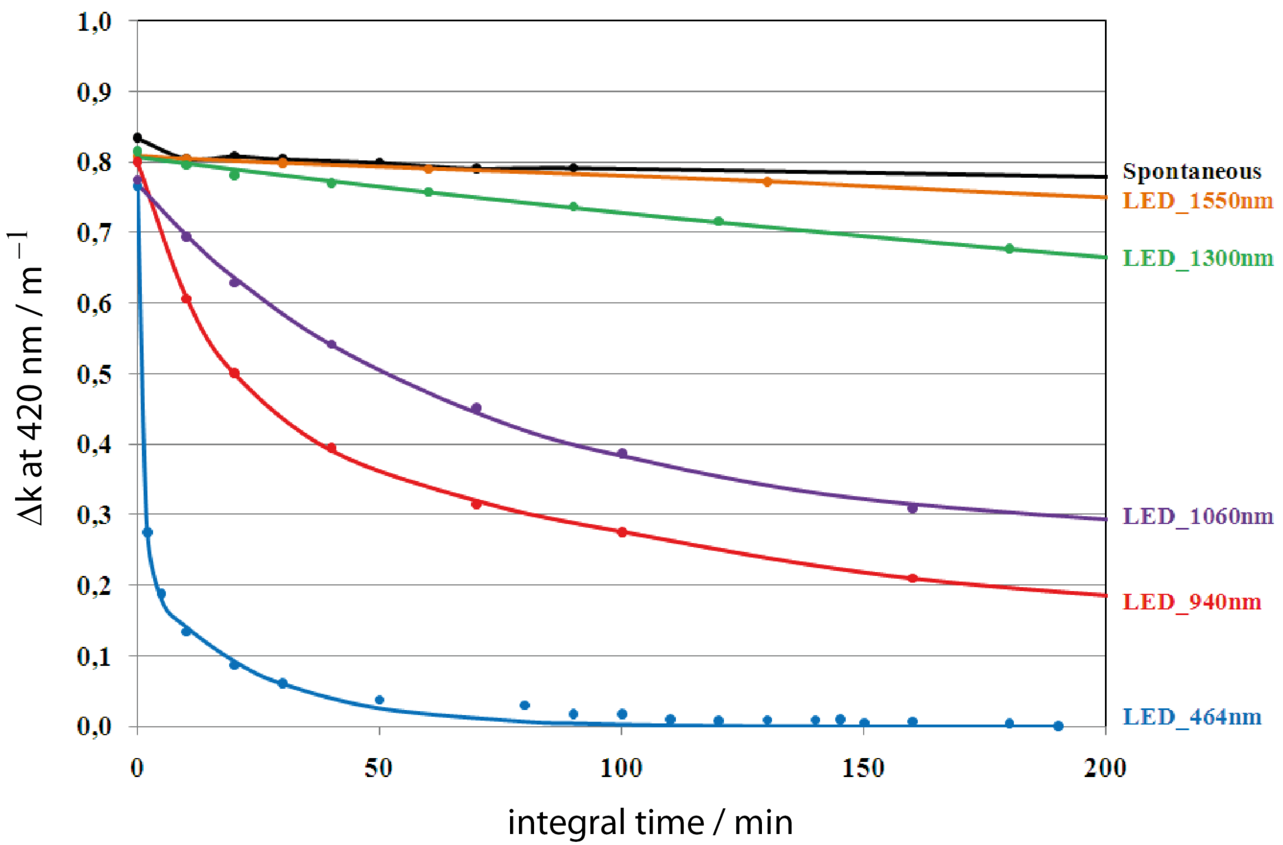


Lower PCB
- Connectors to FEs
- 8x2 Diff. Line drivers
- Vregs: low noise, high PSRR
- APFEL I/F buffers
- Temp/Humidity sensors

Upper PCB
- HV regulators, distribution, measurements
- Eeprom for regulator calibrations
- One HV in, outputs routed to lower board via 100pin HD connector (Samtec)

Offline Crystal Recovery

- Annealing of crystals' radiation damage by irradiation with (visible) light from LED

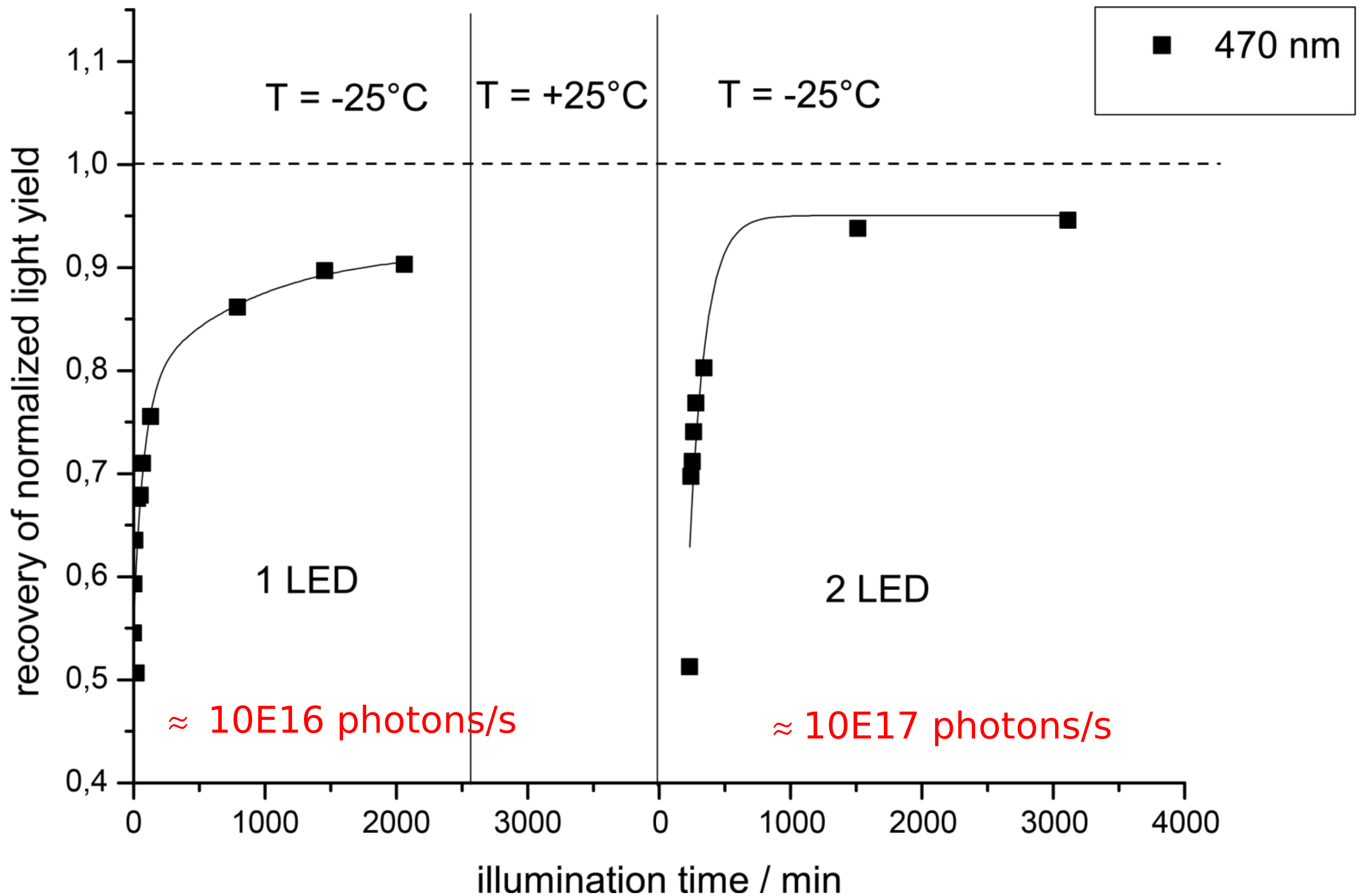


Room temperature

- blue led flux ≈ 10E16 photons/s
  100% recovery after 160 min
- caveat: recovery amplitude includes effect from thermal spontaneous recovery

Offline Crystal Recovery

Recovery flux dependence, cold crystals, D = 30 Gy



- Blue LED flux measured with Ulbricht sphere and power-calibrated spectrometer
- Sequence: 1st irrad., light recovery, full thermal recovery, 2nd irrad., light recovery – same crystal

Offline Crystal Recovery

- molar mass of PWO 455.05 g/mol
- volume of full size crystal ~ 100 cm^3
- color center concentration ~ 10-20 ppm

$$N_{PWO} = 6.022 \cdot 10^{23} \frac{atoms}{mol} \cdot \frac{8.3g}{455.05 \frac{g}{mol}} \approx 1.1 \cdot 10^{22} \frac{atoms}{cm^3}$$

atoms in full size crystal ~ 10^{24}

0.5-1.0 · 10^{19} traps per crystal

Room temperature recovery data:
- Time for full recovery ~100 min = 6000 s
  -> total fluence $6 \cdot 10^{19}$ photons

Offline Crystal Recovery

- $0.5\text{-}1.0 \cdot 10^{19}$ traps per crystal
- recovery probability value = 0.1 (empirical)

- 1MeV should create 10^{5} electron-hole pairs
  - 1Gy ~ 10^{18} traps (with 100% efficiency)

  - PANDA irradiation ~ $2 \cdot 10^{-6}$ Gy/s
    - Trap yield ~$2 \cdot 10^{12}$ traps/s

    - **4 weeks of runtime equals $5 \cdot 10^{18}$ traps**

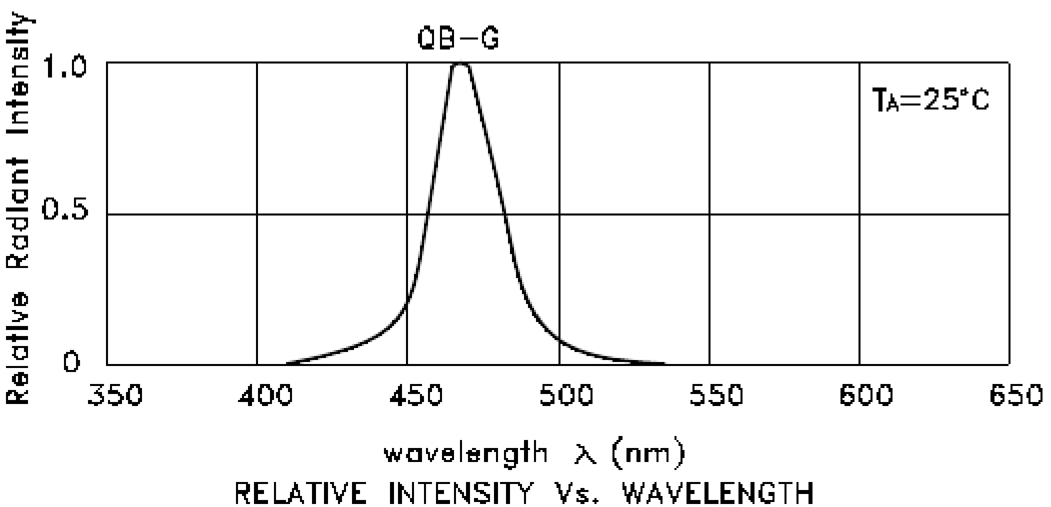
Recovery (95%) in 1.5...5 hours
at T=-25°C and 10^{16} photons/s

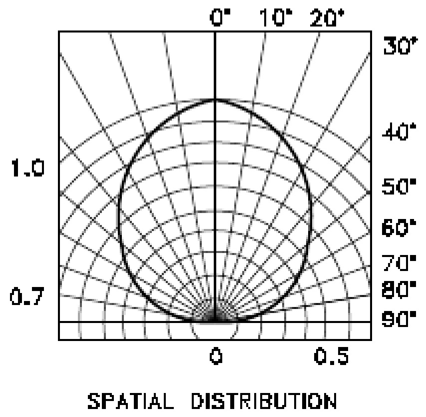
Suggested LED:

KINGBRIGHT KA-2810AQBS-G

Blue, lambda(max)~465nm, efficiency ~0.35, Uf ~3.3V, If ~20 mA, right angle radiance

Price: 0.478 Eur (4000+ pcs)





Offline Crystal Recovery

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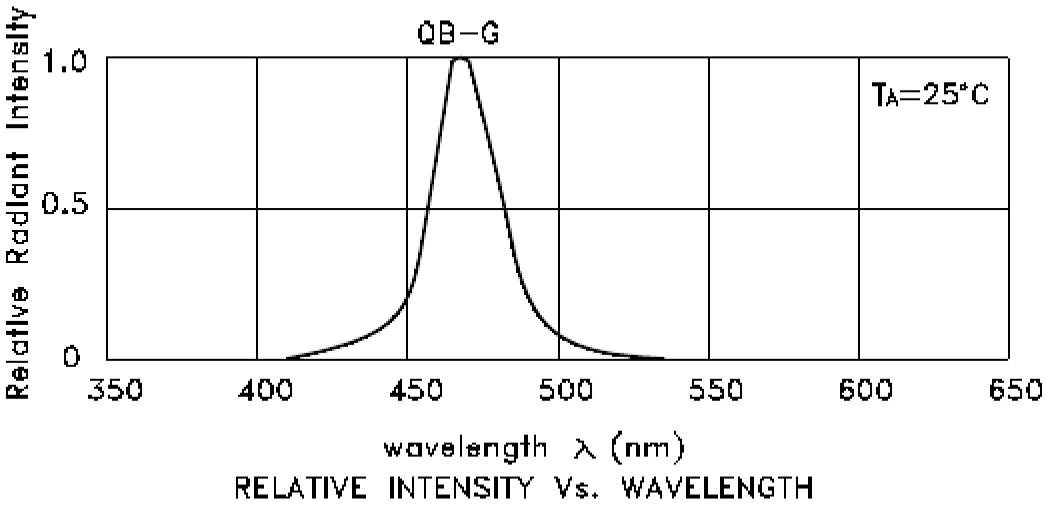
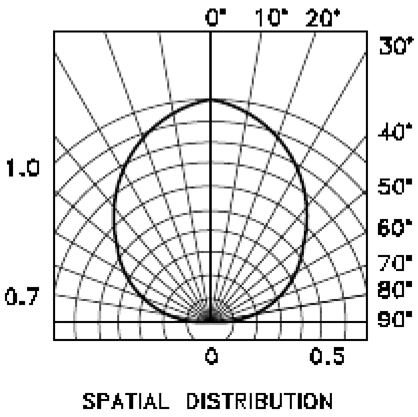


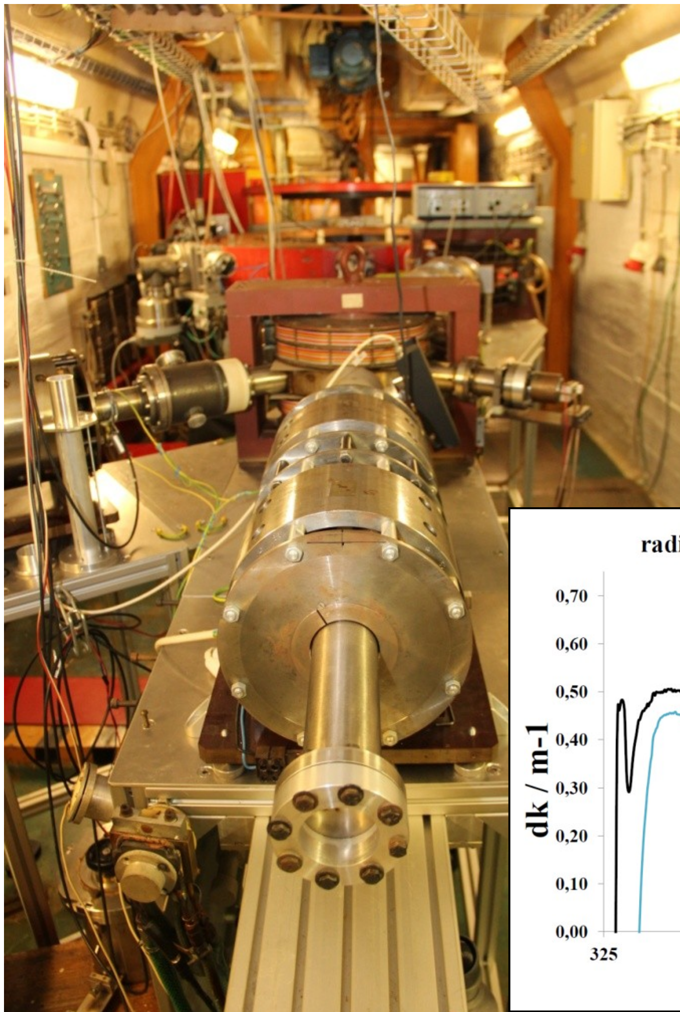


Crystal Quality Screening

Test of Radiation Hardness of Ingots @ Microtron Lab of CTU

Irradiation of samples of the top and bottom part of the ingot

MT25 Facility at Prague

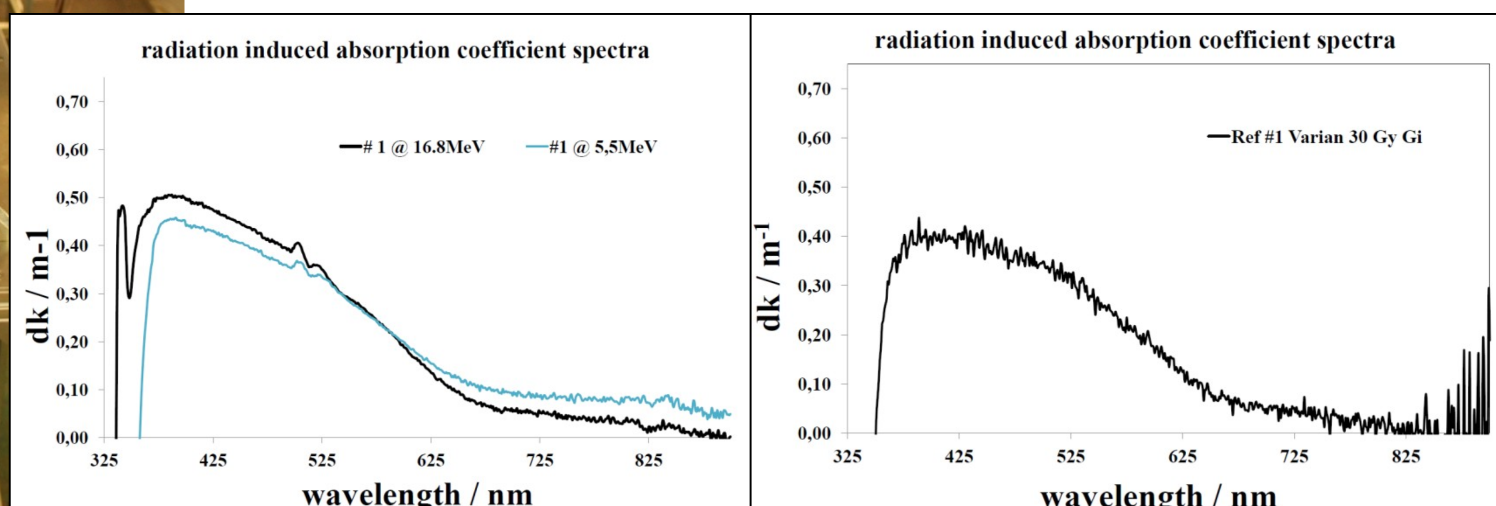


electrons: 5.5 MeV < E_e < 16.6 MeV

homogeneous illumination of the (rotated) sample

integral beam intensity adjusted to radiation damage
caused by illumination with γ-rays (^{60}Co, 30Gy)
illumination for 5-10 minutes

immediate measurements of the **optical transmission** before
and after irradiation (sample thickness ~ 10mm)



fast response for immediate reactions of CRYTUR