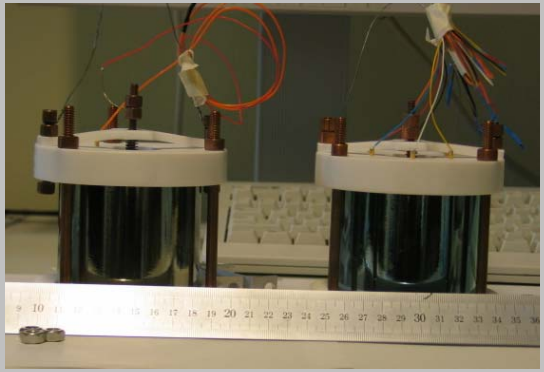
GERDA Test Stands @ MPI Munich

Xiang Liu for the MPI Munich group

- n-type detector
  18-seg. Phase-II prototype
  operated in Vacuum

- 2 p-type detectors
  non-seg. & 6-seg.
  operated in LN2

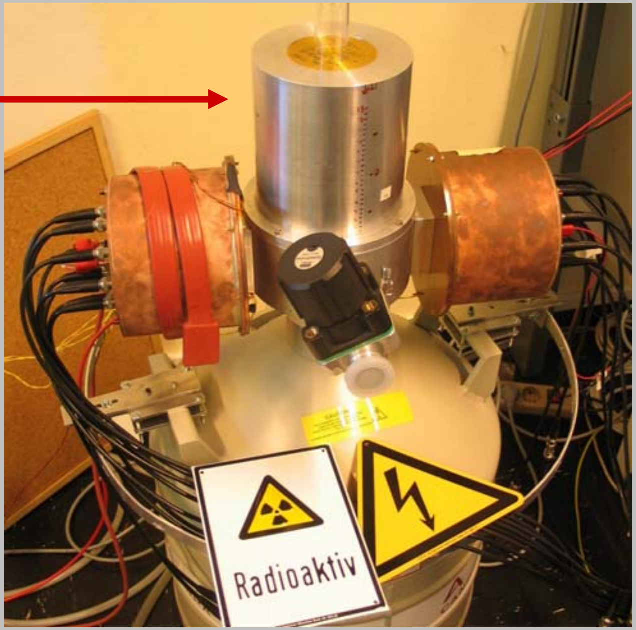


- 1 n-type detector
  non-seg.
  operated in LN2

- Test stands under construction

Phase-II prototype detector R&D

18-seg. n-type detector exposed to γ and n sources
→ confirmed segmentation technique & MC simulation



„Characterization of the first true coaxial 18-fold segmented n-type...“ NIM

„Identification of photons in double beta-decay experiments...“ NIM

„Pulse shapes from electron and photon induced events...“ EPJ-C

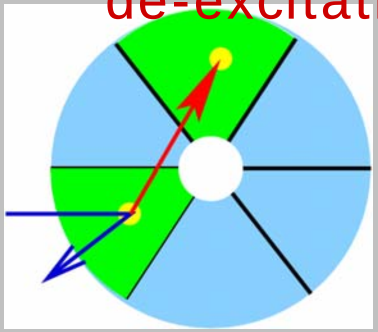
„Test of PSA using single Compton-scattering events“ EPJ-C

„Neutron interaction as seen by a segmented Germanium detector“ EPJ-A

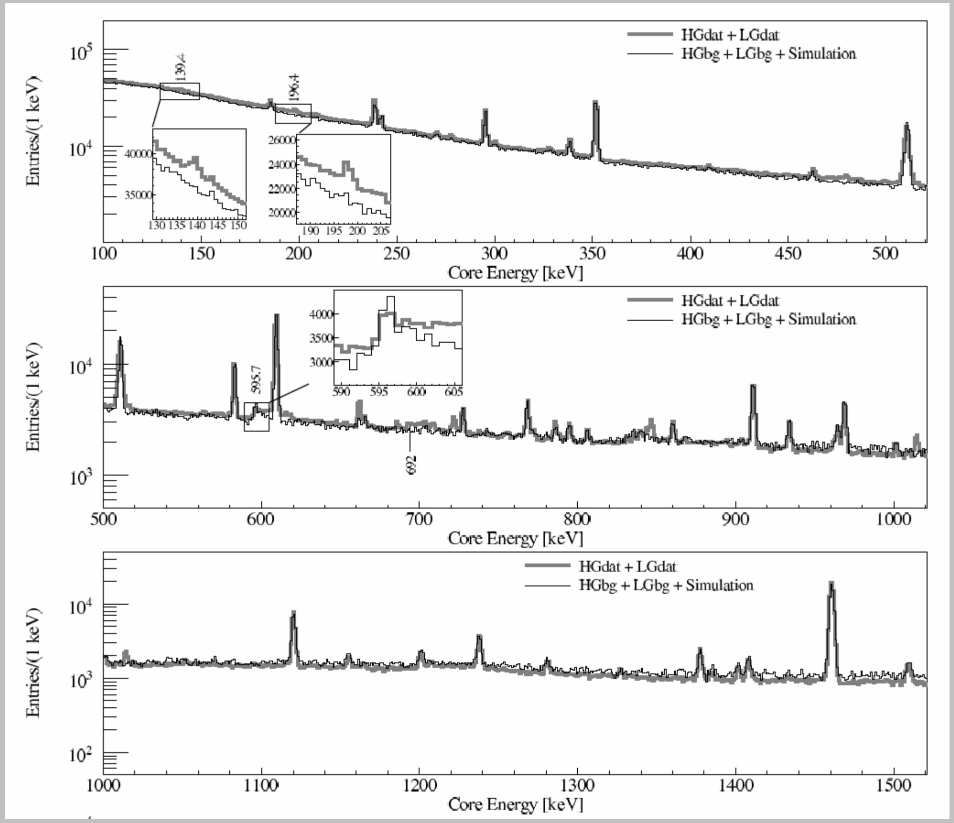
Phase-II prototype detector R&D: neutron interactions

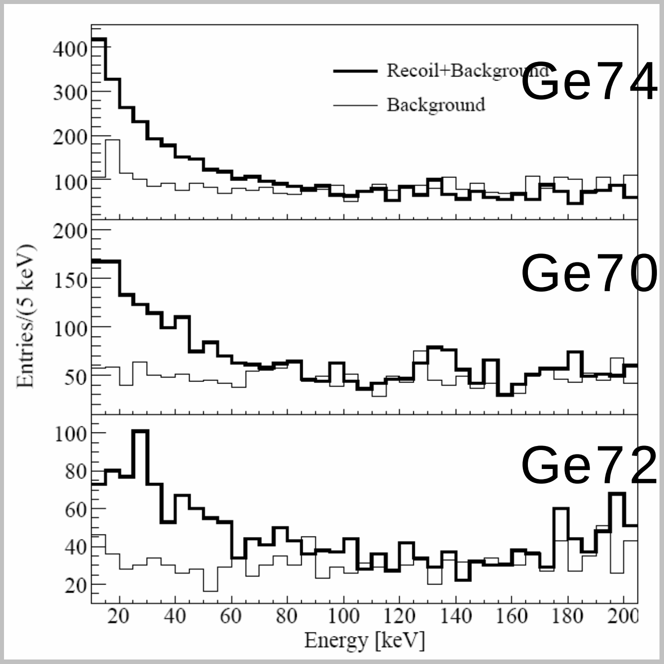
- study neutron interaction with Ge
- check Geant4 MC simulation

inelastic scattering (n, n'γ)
→ tag recoil energy

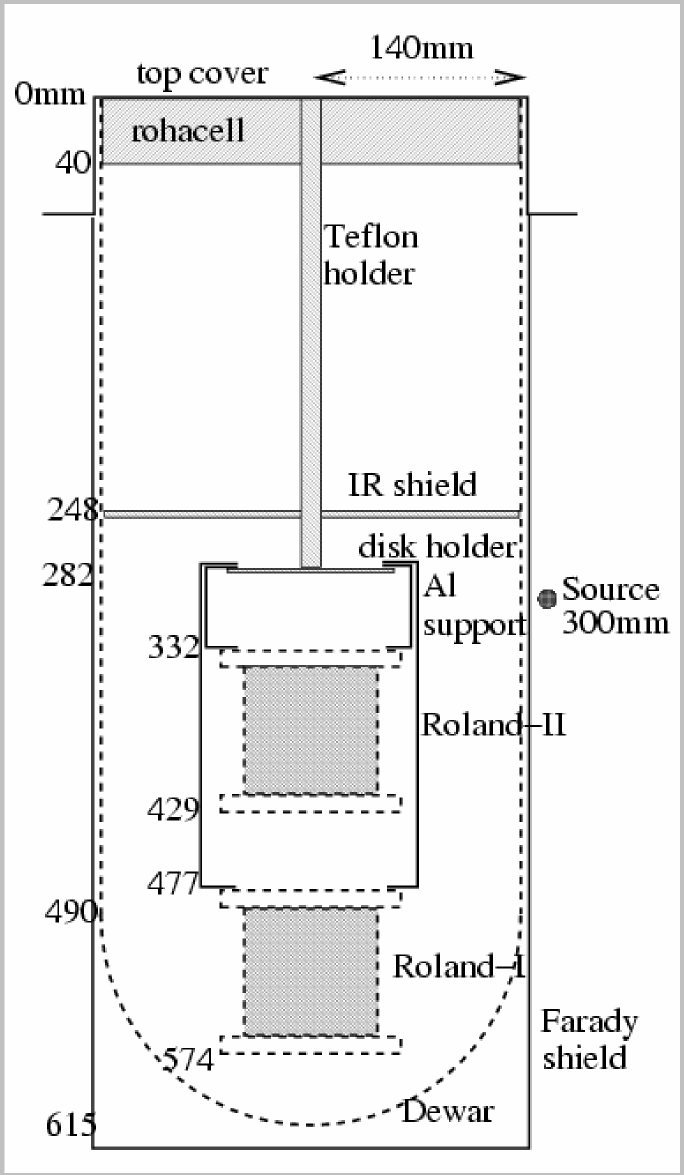


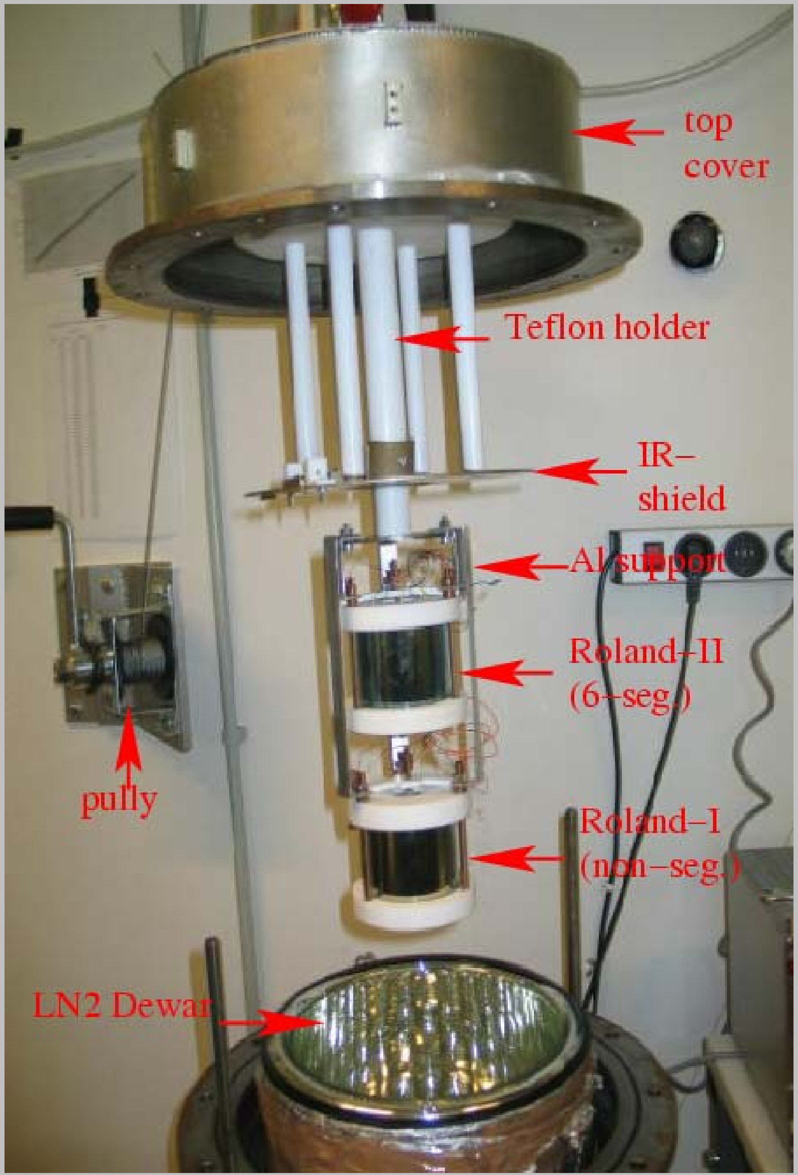
energy spectrum from AmBe source





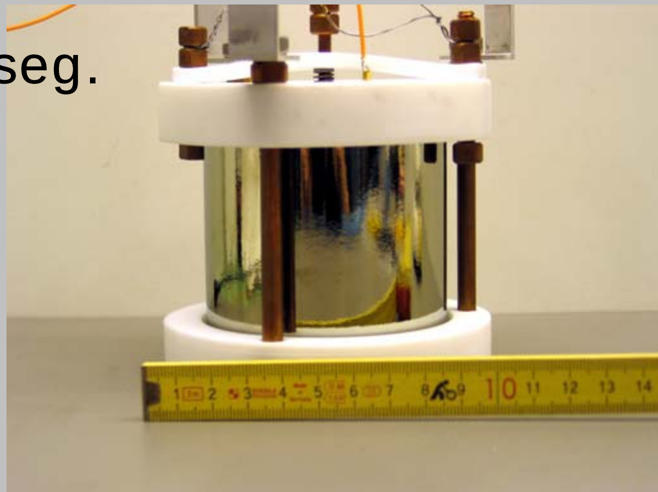
2 p-type detectors running together in LN2: Gerdalinchen-I



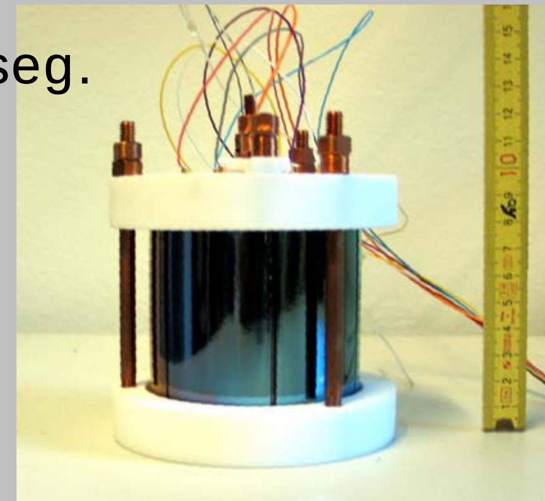


2 p-type DSG detectors in Gerdalinchen-I

non-seg.



6-seg.

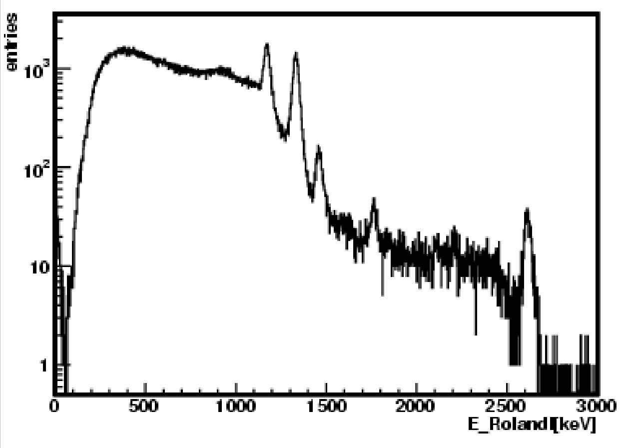


- Both true coaxial, 80mm x 80mm, 10mm hole.
- All channels AC-coupled.
- Stayed in LN2 for 5 months (May-Oct., 07) (frequently HV on & off, with/without radiation).
- Need solid grounding scheme for simultaneous operation.

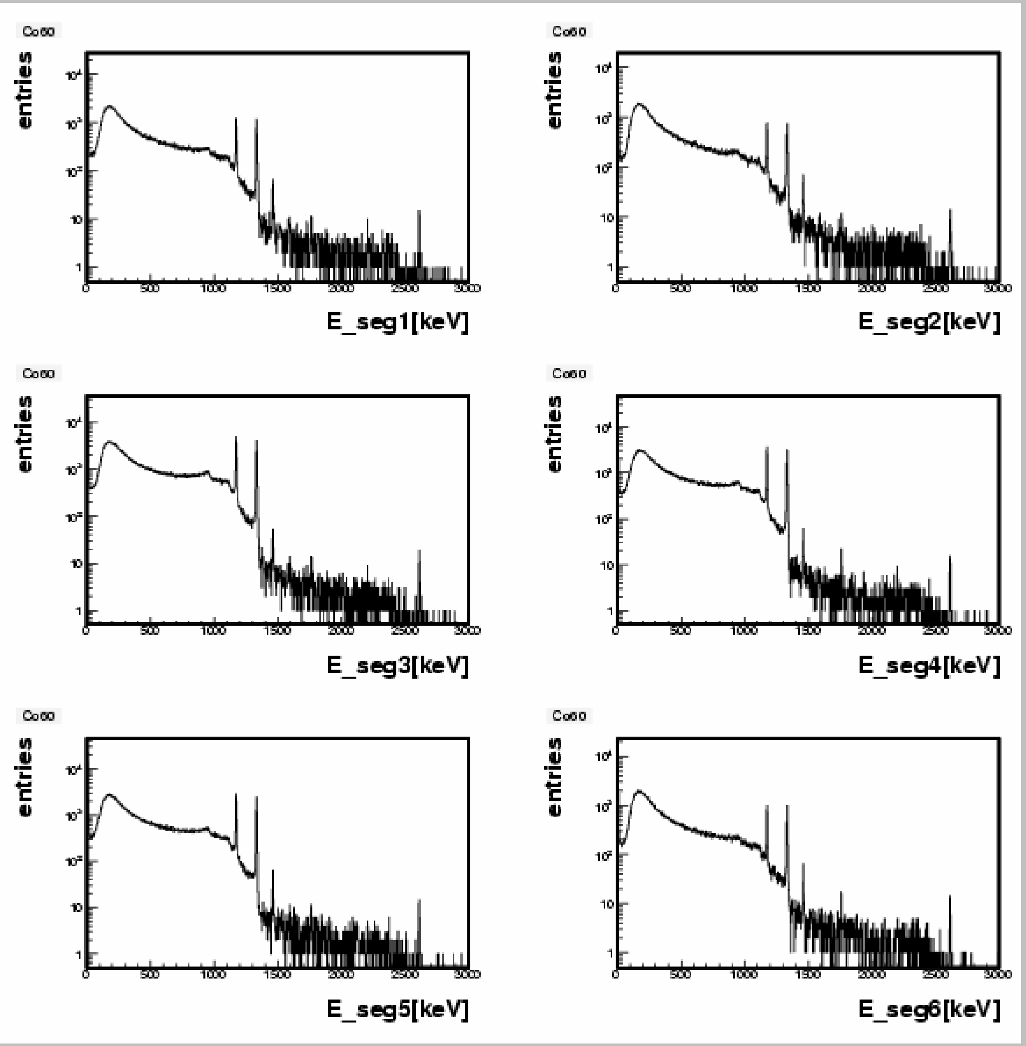
detector	Voltage	LC	FWHM at 1.3MeV
non-seg.	+1400V	300nA	36keV
6-seg.	-2000V	0.9nA	core 7.2keV segments 5-8keV

2 p-type detectors: Co60 spectra

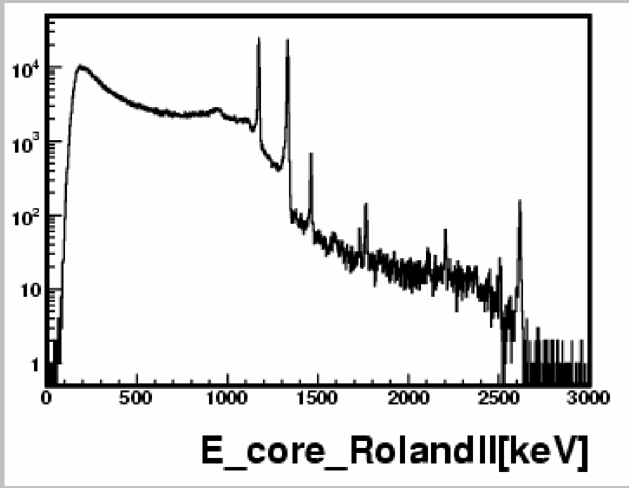
non-seg.



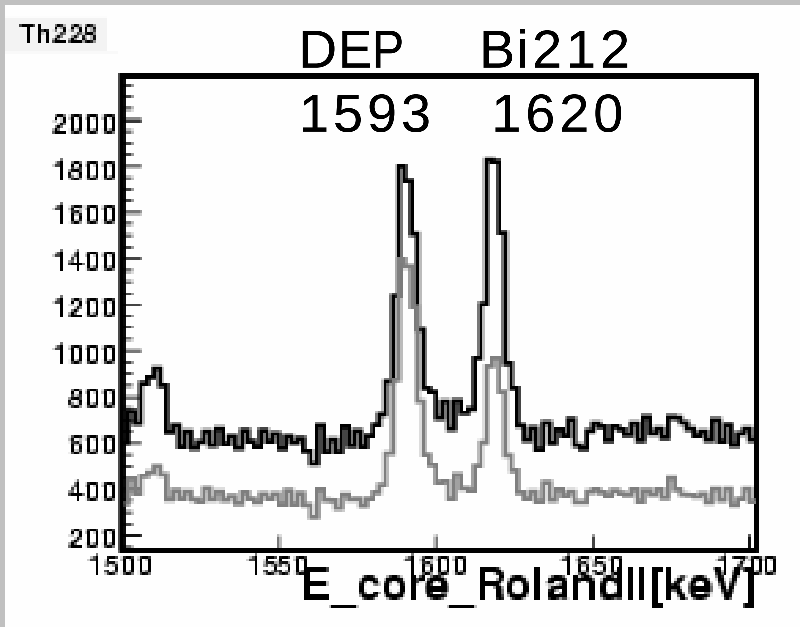
6 segments

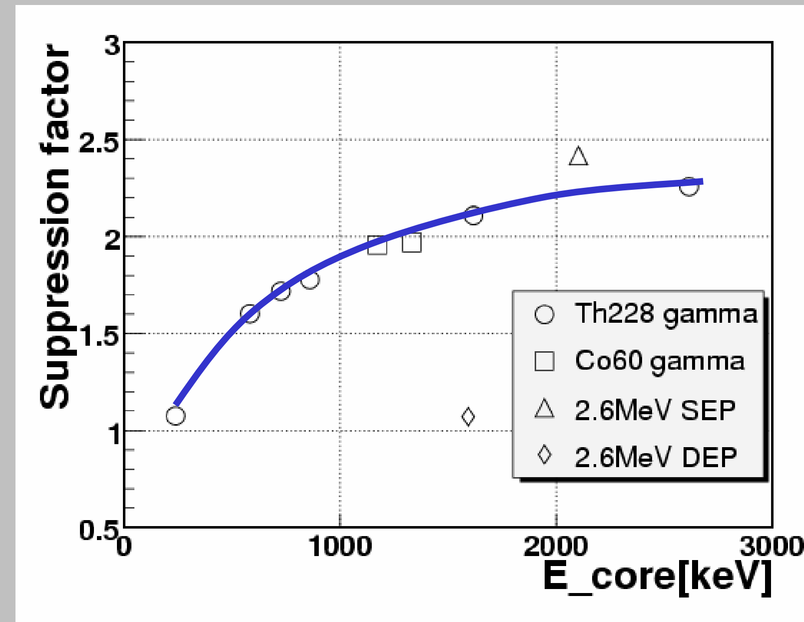


6-seg. core



6-seg. detector: single-segment events





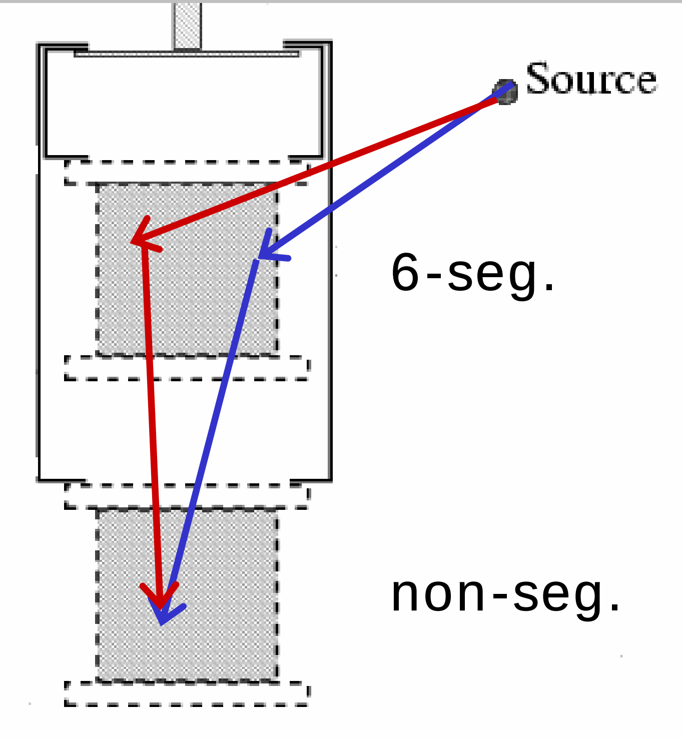
$$SF = \frac{\text{\# events under peak before single-seg. cut}}{\text{\# events after cut}}$$

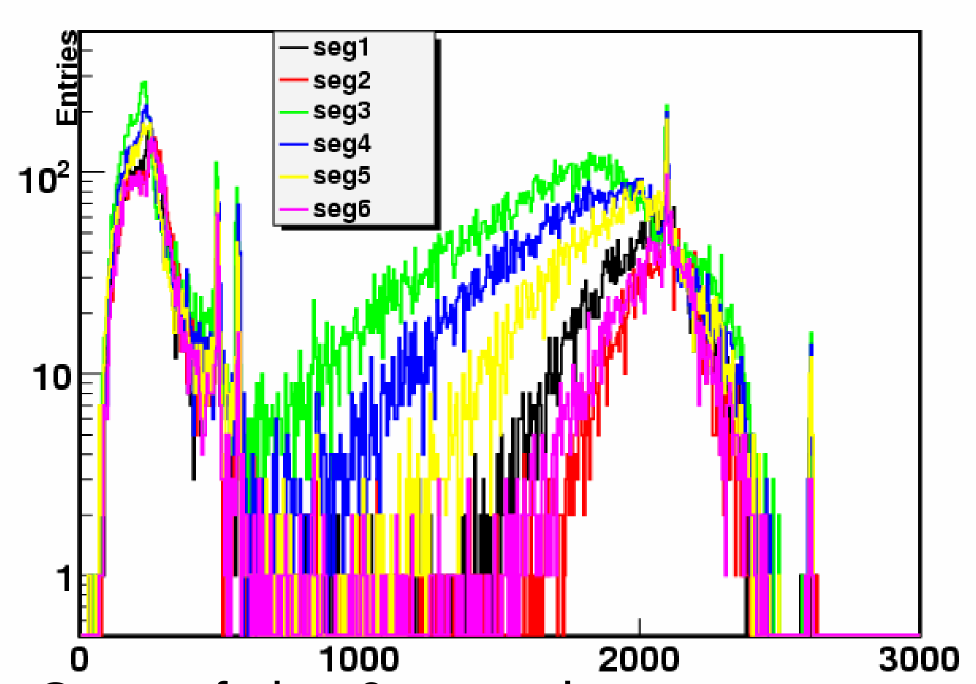
source	energy [keV]	SF	SF (published)
Co60	1332	1.97±0.01	1.94±0.01
Tl208	2614.5	2.26±0.01	2.16±0.01

(statistical error only)

2 detectors: single Compton-scattering events

event selection: coincidence-trigger,
sum energy at 2614.5keV & single-segment (6-seg. detector)





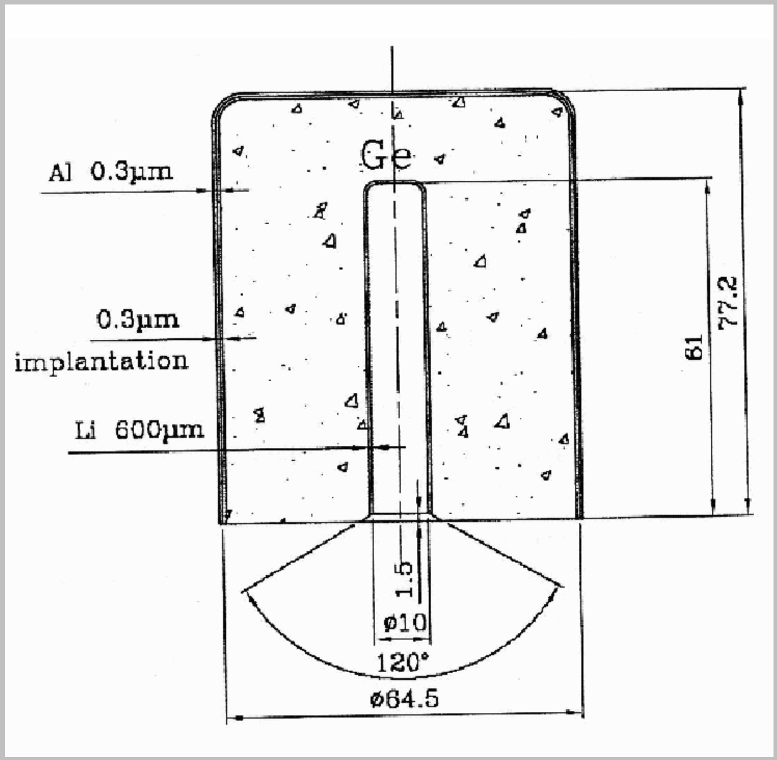
Core of the 6-seg. detector

→ library of single-segment & single-site events for further PSA

(GSTR 08-004)

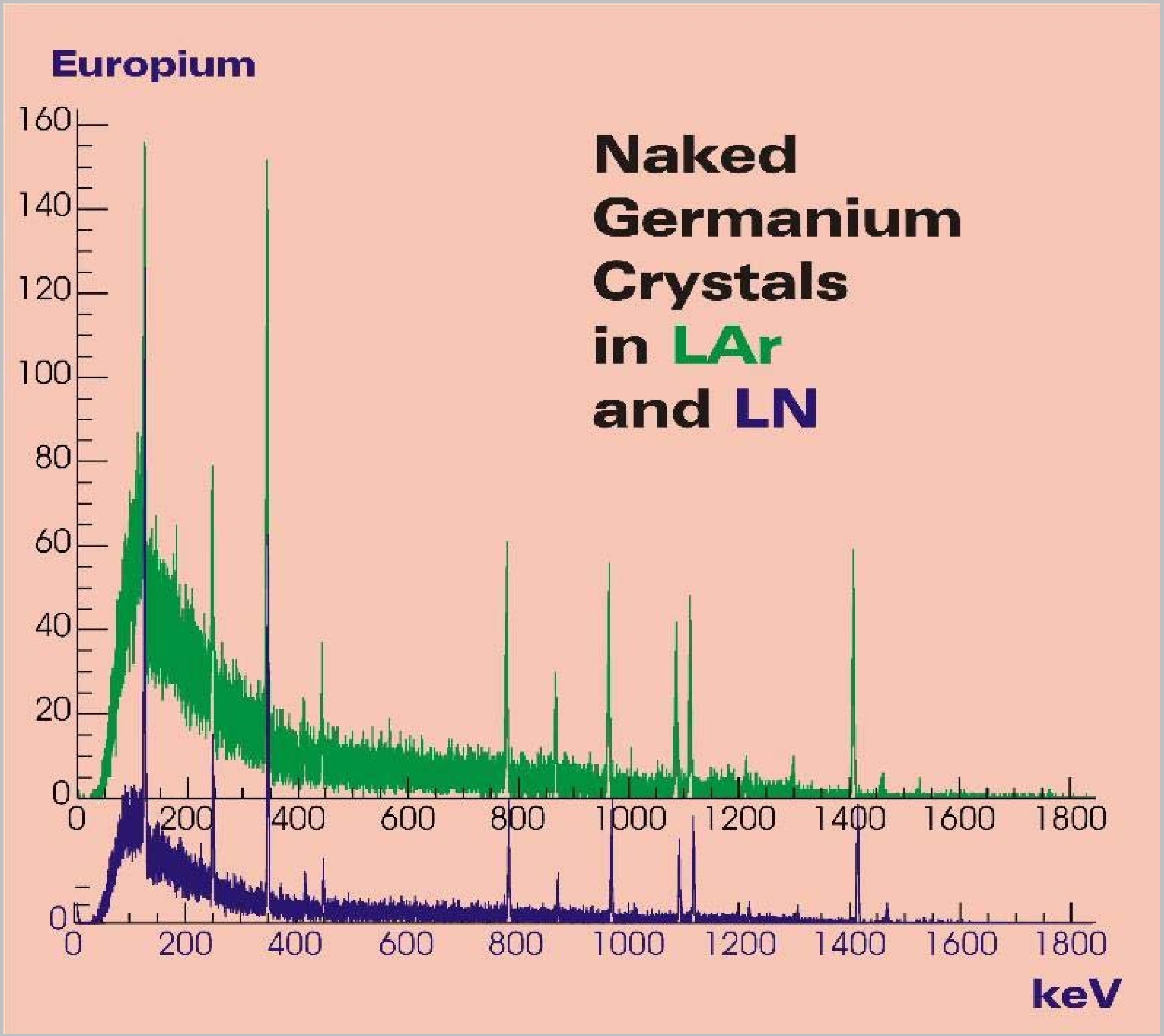
n-type non-seg. detector

- ✓Detector submerged in ~10 seconds.
- ✓61x in LN2, 4x in LAr.
- ✓FWHM 3.5-4keV at 1.3MeV (dominated by electronic noise).
- ✓LC<20pA at -3500V.

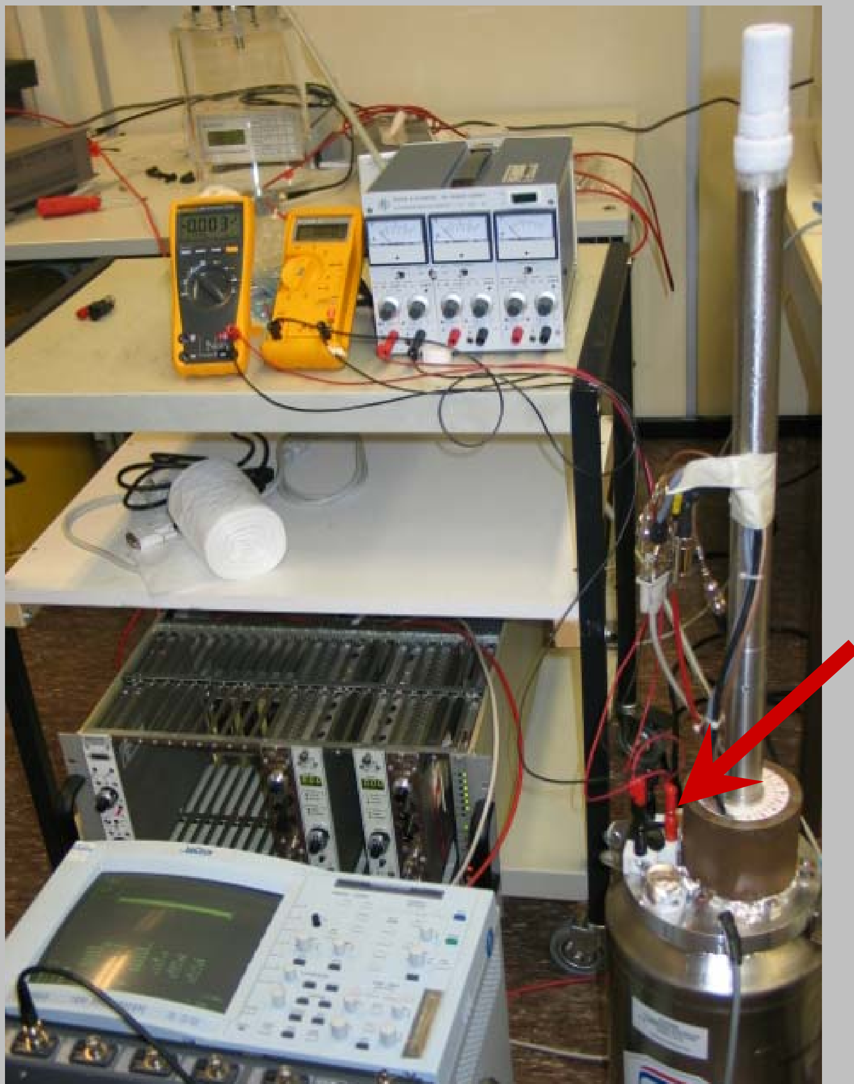


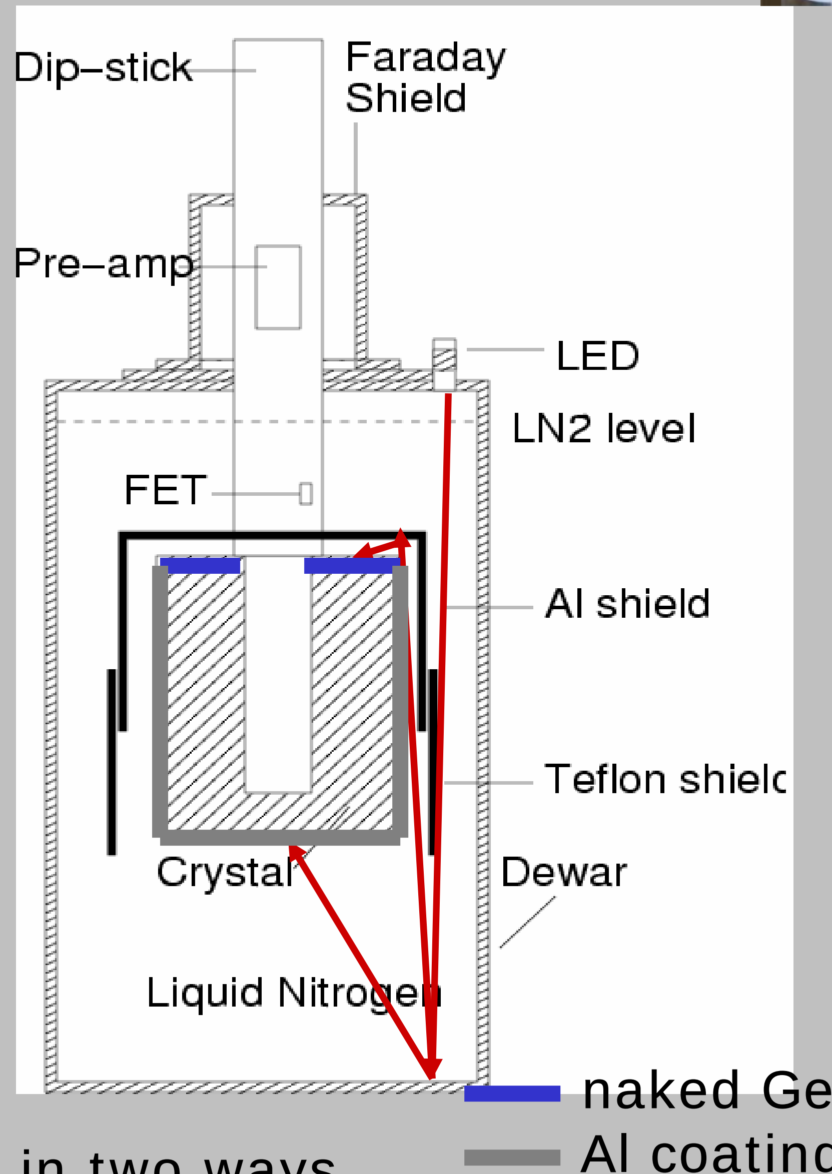
operating the detector

Eu152 energy spectra of the detector



detector exposed to IR- UV-light

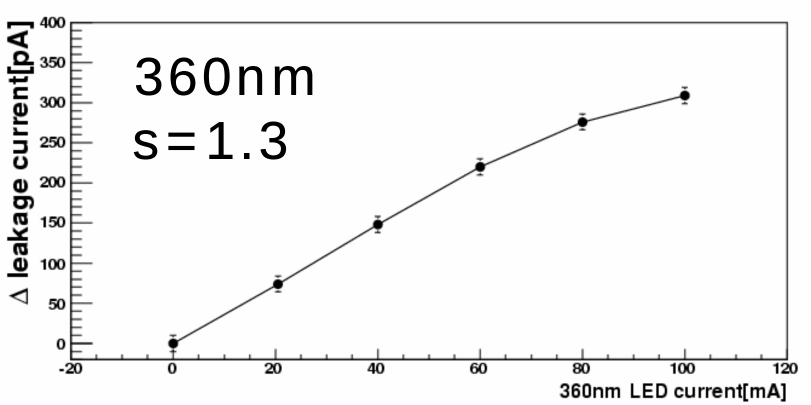


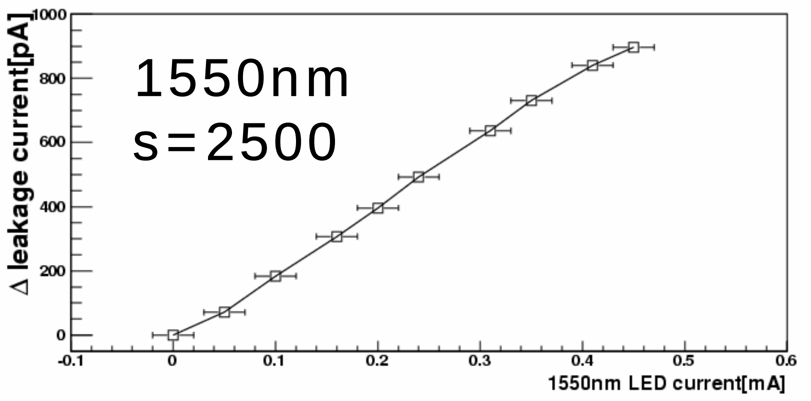


Photons could reach active detector in two ways.

Leakage current ↑ when IR- UV-light ↑

slope = Δ LC/ΔI_LED [pA/mA]

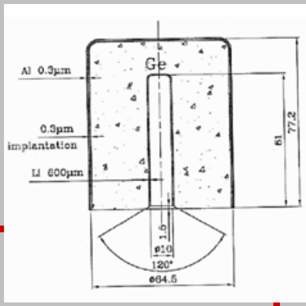




→Why different slopes?

LEDs have similar radiation power P, not the reason.

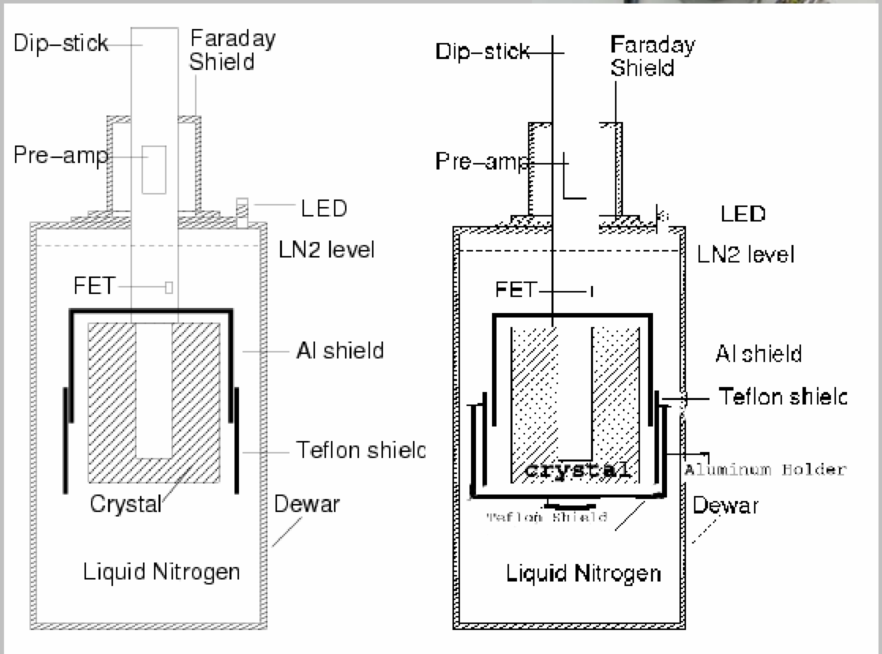
wavelength [nm]	360	1550
P at 20mA [mW]	1	0.4

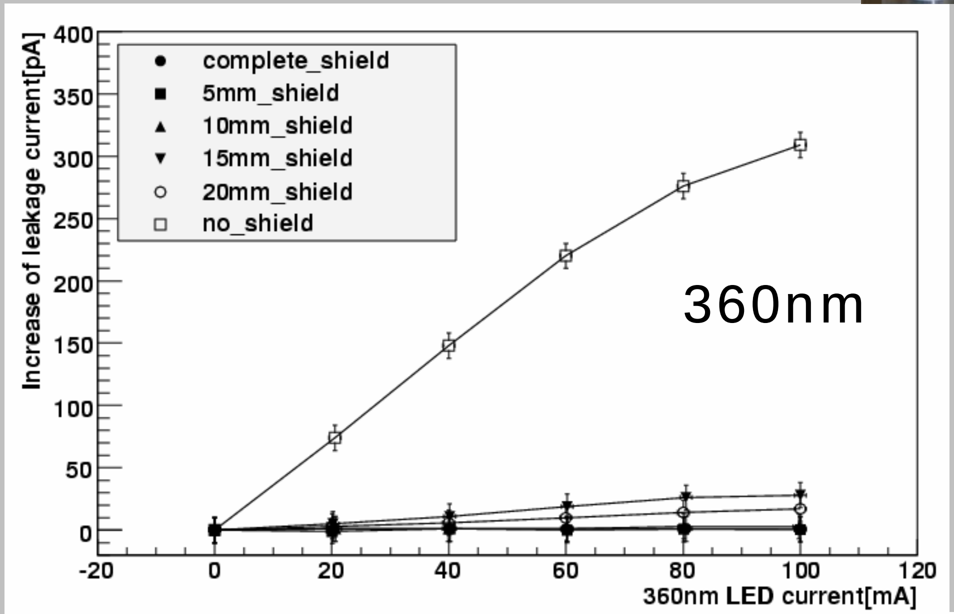


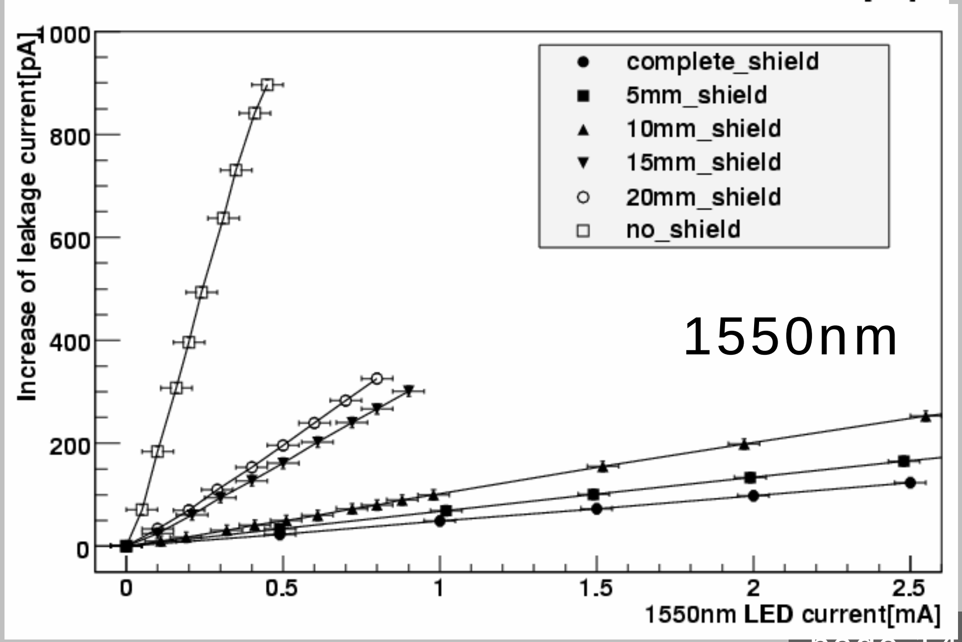
Main reason:
Al coating reflects more UV than IR.
→
Most UV lights reach active volume through the naked Ge surface, while lot more IR goes through Al coating.

UV gets in through naked Ge surface

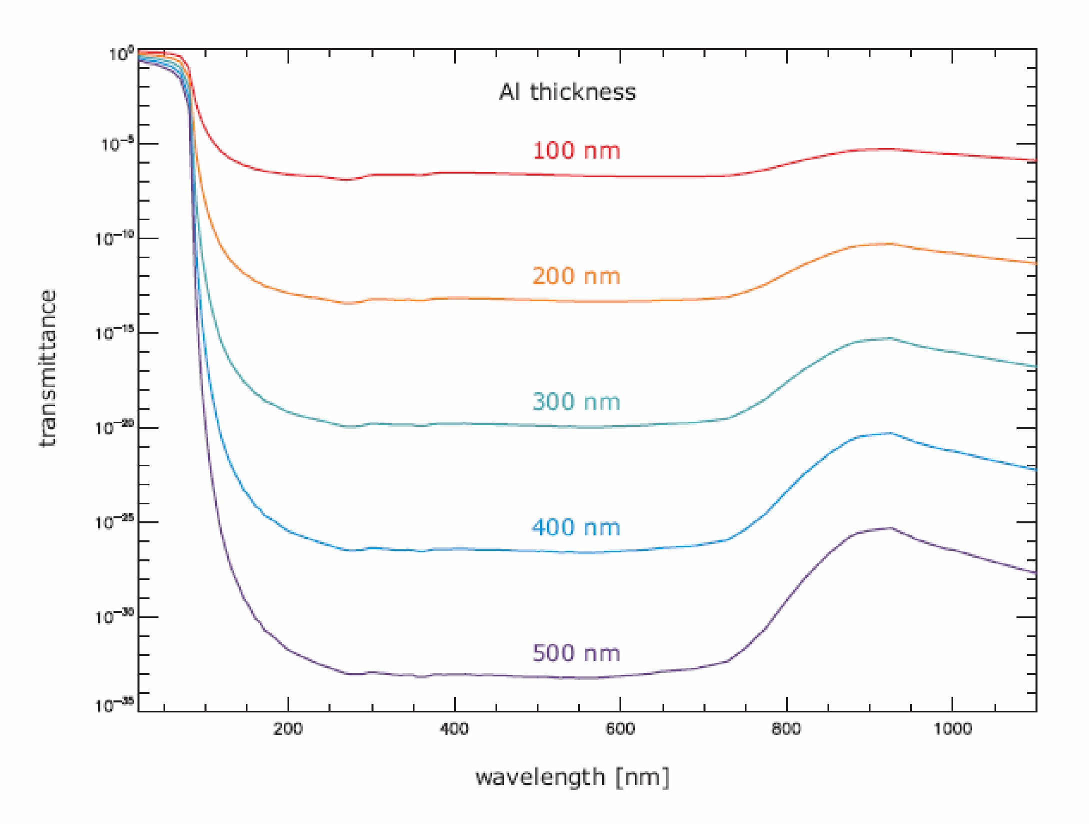
✓Detector shielded with extra 2mm-thick al-plate.
✓Center hole with different size.







Aluminum optical property

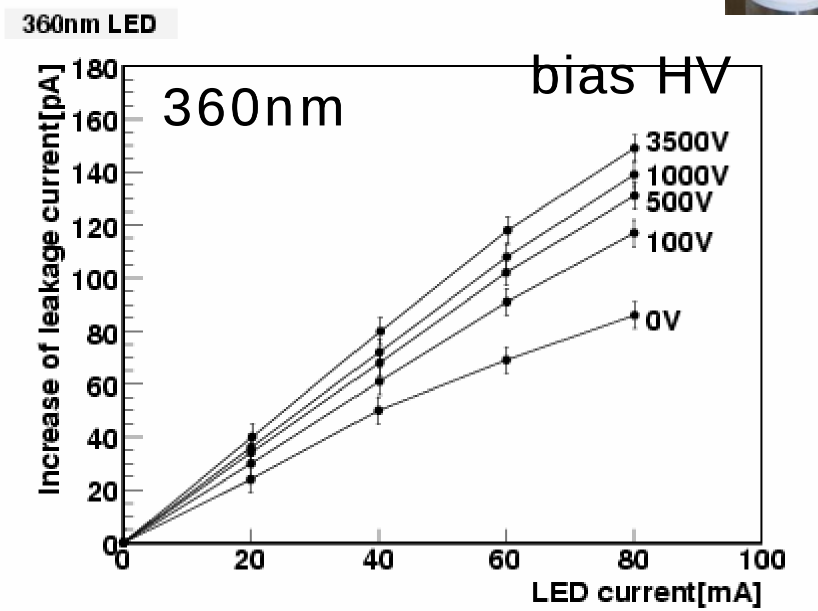


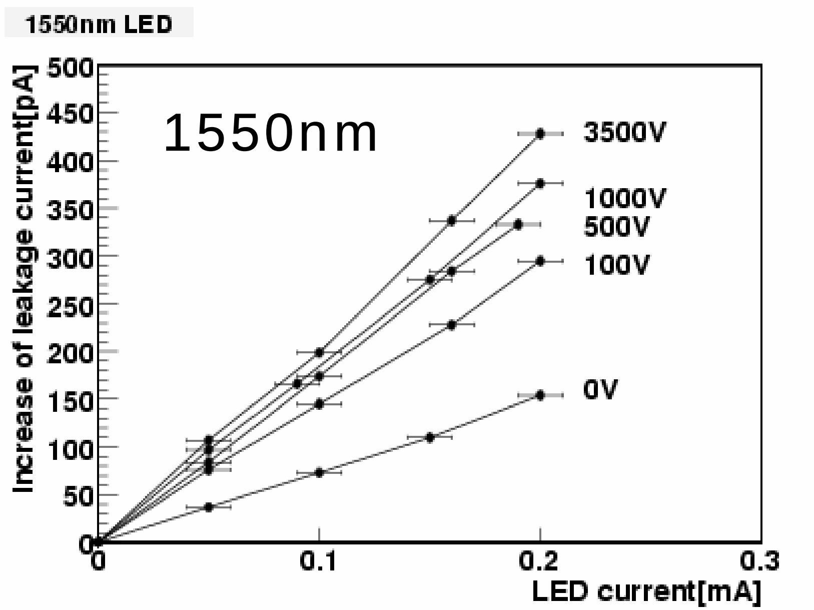
material	λ [nm]	α [cm^{-1}]	n	
Al	360	1.5E6	0.397	(total reflection at 19°)
Al	1550	1.3E6	1.44	
LN2	IR-UV		1.21	

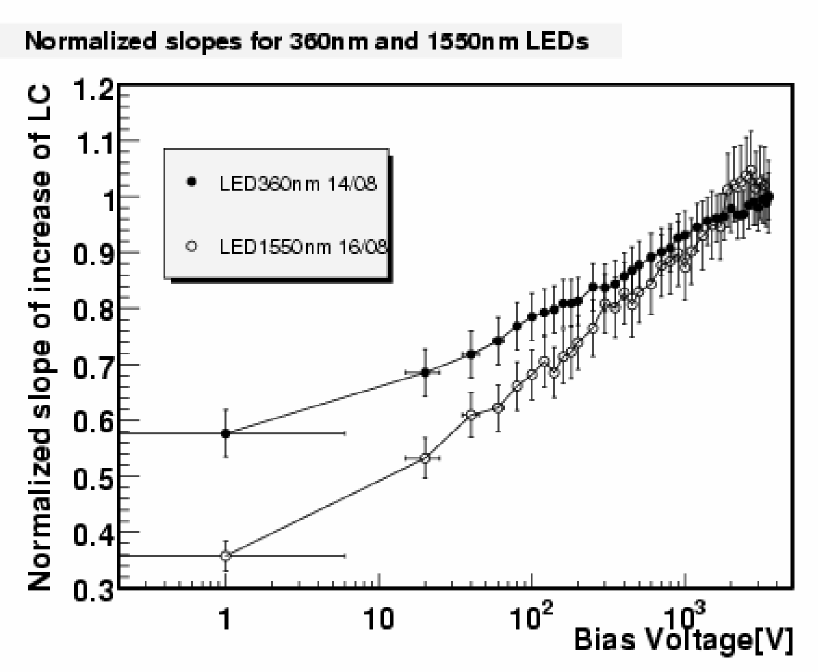
LC induced on surface vs. LC induced in bulk

Germanium optical property:

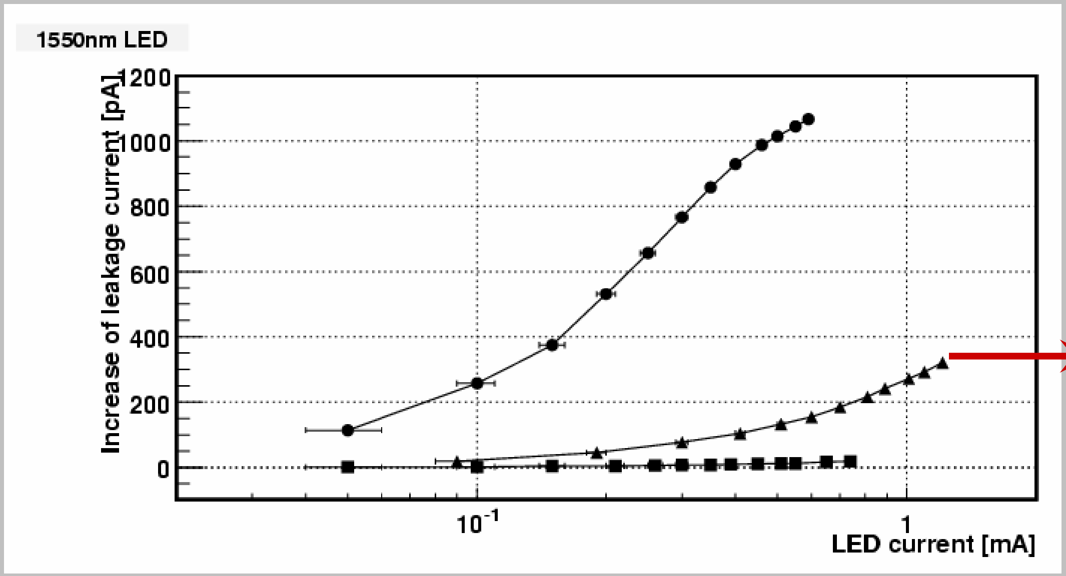
λ [nm]	T [K]	α [cm^{-1}]
360	300	0.6E6
360	77	?
1550	300	10E3
1550	77	9



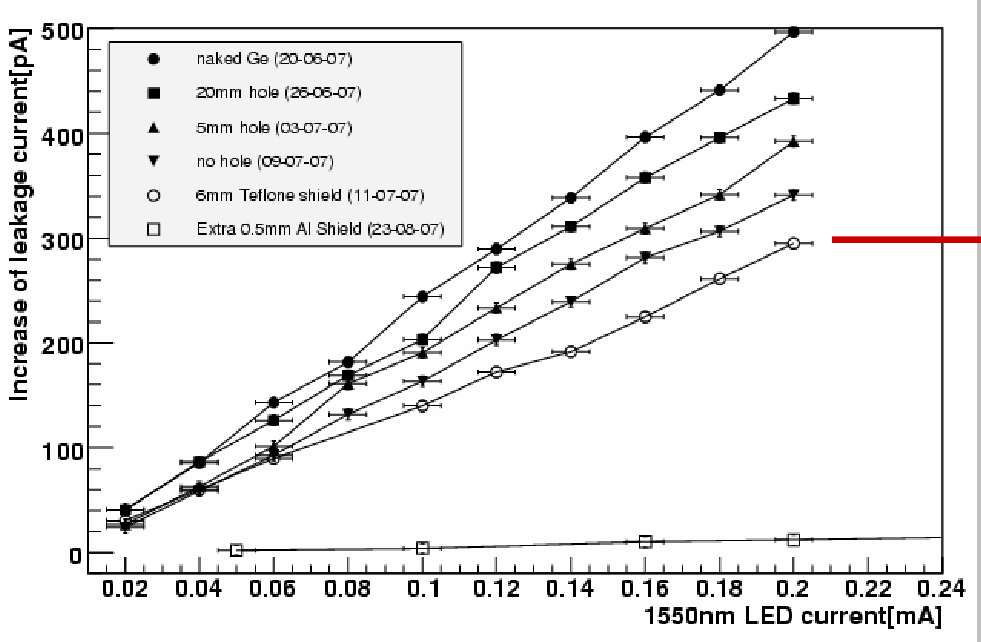




Different optical property of Teflon in air vs. in LN2?



LED wrapped with ~50μm of Teflon
→slope = 270 pA/mA



6mm-thick Teflon plate in LN2
→ Slope = 1436 pA/mA

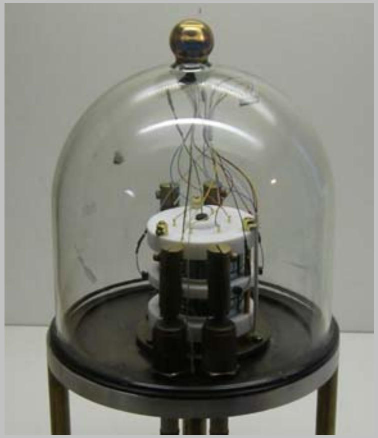
(GSTR-08-005, -006)

New test stand for phase-II prototype detectors: Gerdalinchen-II

up to 3 detectors directly in LN2/LAr:
2 18-fold n-type &
1 18-fold p-type detectors

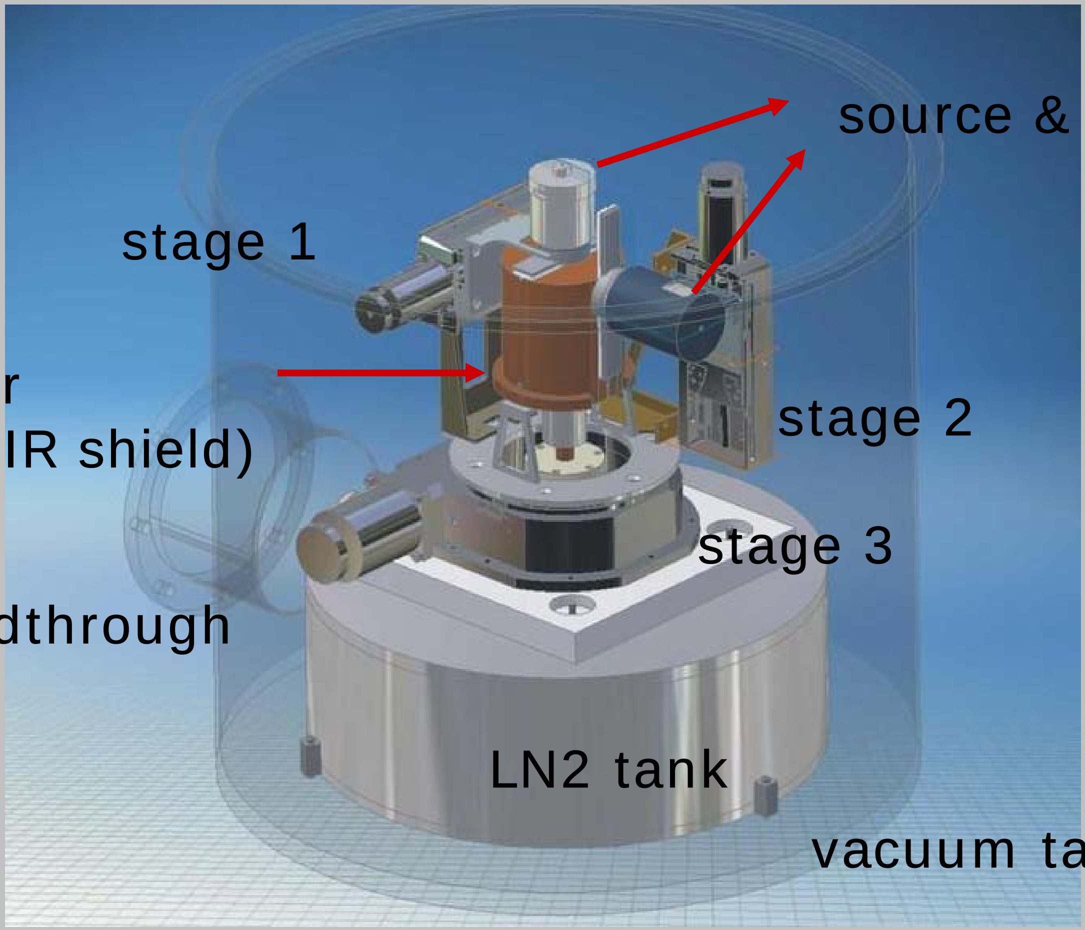
Program:
- detector performance
- segment & crystal anti-coincidence cut
- pulse shape

construction finished, under testing.



18-fold p-type

New test stand for general purpose: Galatea



3D scan with γ, α sources & laser,
Program: segment boundary, pulse shape, IR-UV reaction...
→Can multi-segment & single-site events be recognized?

Design finished, under construction.

Conclusion & outlook

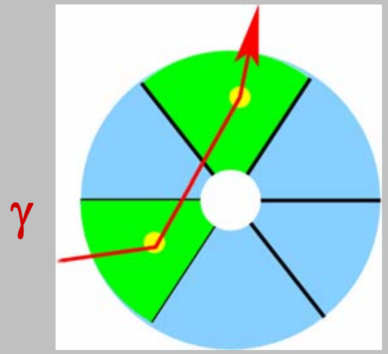
Rich physics program for GERDA phase-II:
- successfully operation of 18-seg. detector.
- experience for multiple cooling & warming.
- experience for operating 2 detectors simultaneously.
- More with the new coming test stands.

Physics program beyond GERDA:
- study of n-type reaction to IR & UV.
- will study p-type reaction to IR & UV.

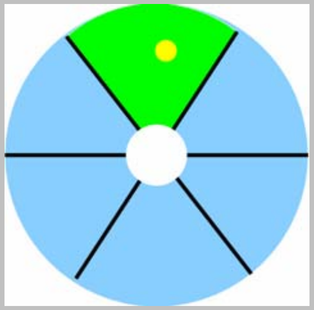
backup

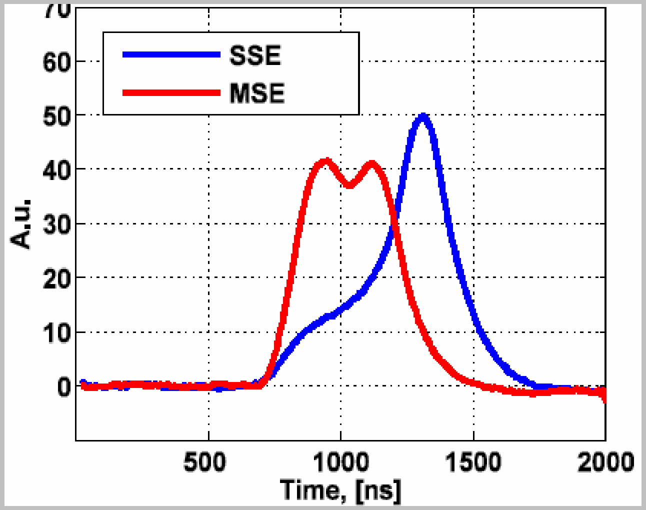
Phase-II prototype detector R&D: remove γ background

γ background
multi-site event



singal: 2 electrons
single-site event





step 1: single-segment (crystal)

step 2: pulse shape analysis