STATUS OF THE CALIBRATION

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(on the behalf of the WG)

Gerda meeting – Padova 11/03/09

Content of the talk

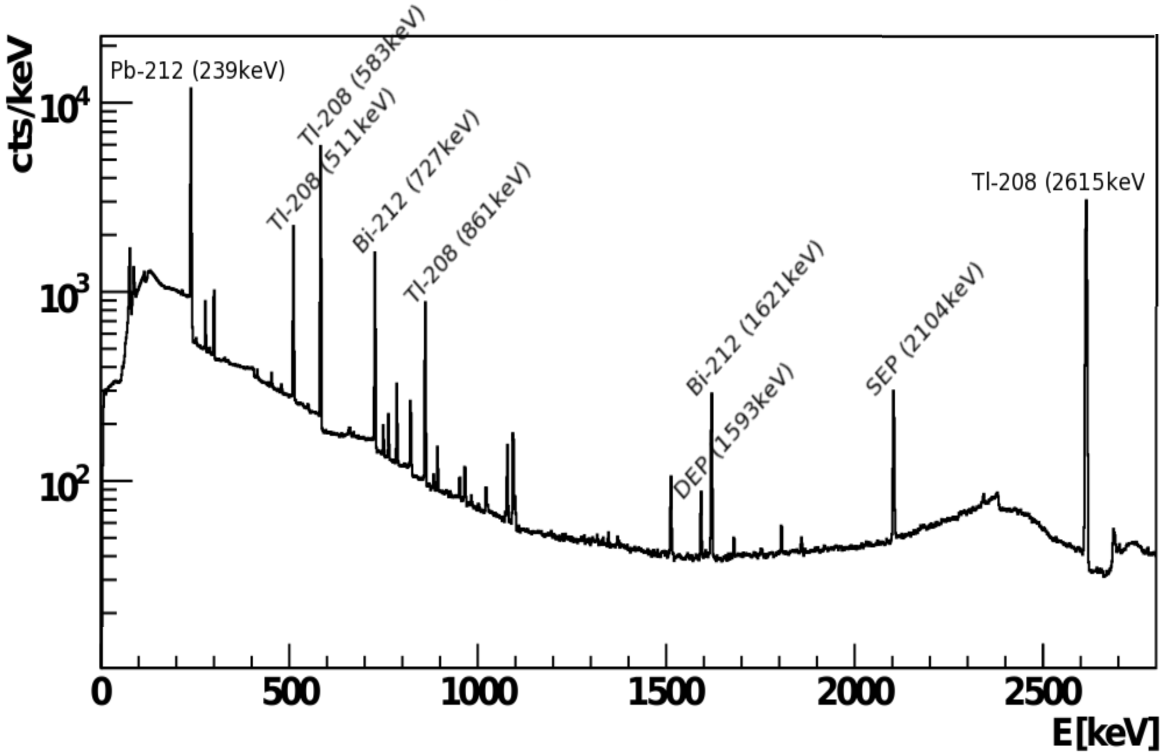
- Introduction
- Calibration system
- Estimation of the optimal source position
- Strength of the source
- Background from the parking position
- New source setup
- Zurich laboratory
- Conclusions

^{228}Th calibration source

Goals:

- Investigations of different sources → ^{228}Th chosen
- Mechanical design of the structure (Materials selection - absorber)
- Evaluations of the optimal positions and source strength
- Estimation of the induced background

^{228}Th + Ta (Sum of the spectra – layer 2 calibration)



- Sufficient number of lines
- Energy calibration in the region of interest
- Pulse shape discrimination

- α Emitter → Neutron bkg

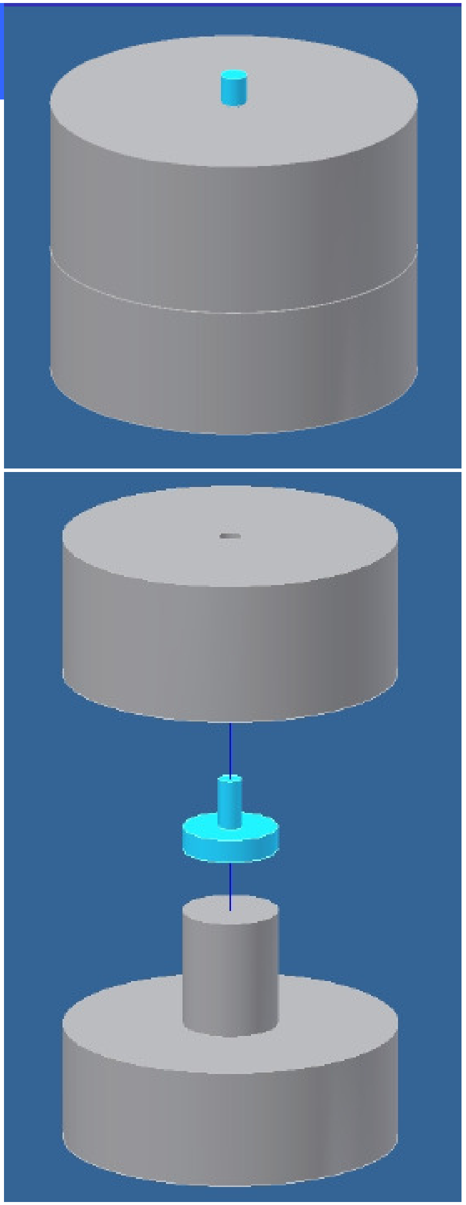
Calibration system - Absorber

- Source → Spherical (r = 0.4mm)
- Capsule → Cylinder (h=10mm,r=0.5mm) - SS
- Absorber → Cylinder (h=60mm , r=35mm)

	Tungsten	**Tantalum**
h [cm]	6.0	6.0
ρ [g/cm³]	19.3	16.65
μ (3MeV) [cm²/g]	0.0407	0.0406
Mean f.p. [cm]	1.27	1.48
Attenuation	9.0×10^{-3}	1.7×10^{-2}

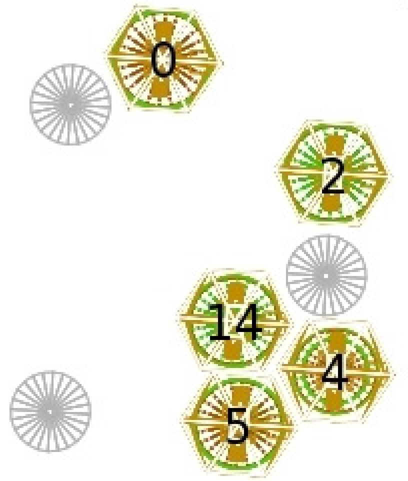
Material	**Tungsten** (99.97% purity)	**Densimet** (92.5% W + Fe,Ni)	**Tantalum**
Screening results (mBq/kg)	$^{238}U \rightarrow 300\pm100$ $^{232}Th \rightarrow 30 \pm 10$ $^{60}Co < 8.1$ $^{40}K \rightarrow 40 \pm 20$	$^{238}U \rightarrow 180 \pm 30$ $^{232}Th \rightarrow 70 \pm 20$ $^{60}Co \rightarrow 7 \pm 2$ $^{40}K < 57$	$^{238}U < 11$ $^{232}Th < 9$ $^{60}Co < 1.9$ $^{40}K < 33$ $^{137}Cs < 2.5$ $^{182}Ta \rightarrow 52 \pm 5$

Ta bkg in the parking position < 6.1×10^{-8} cts/keV/kg/y (3×4kg)



OUR CHOICE TANTALUM

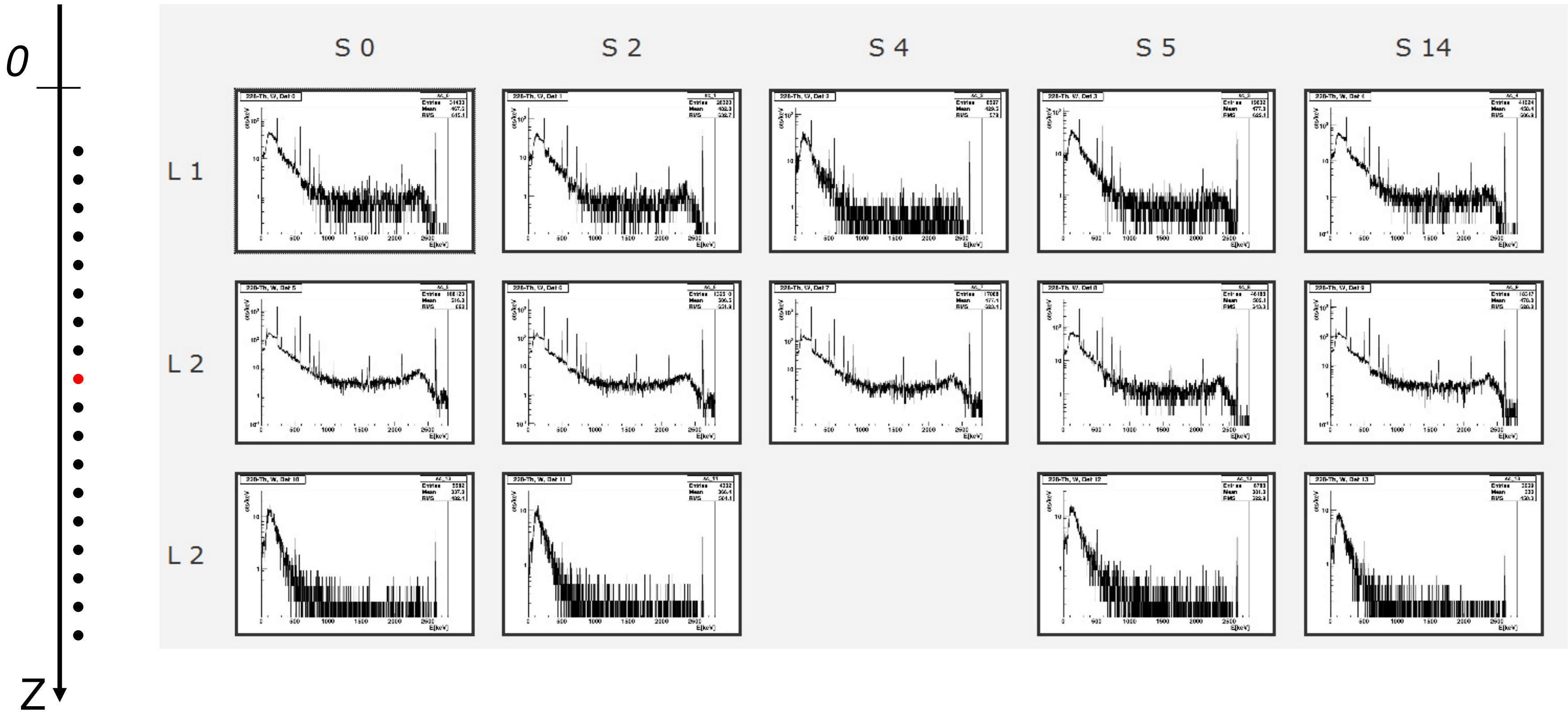
Optimal source position



Optimal source position estimated for each layer

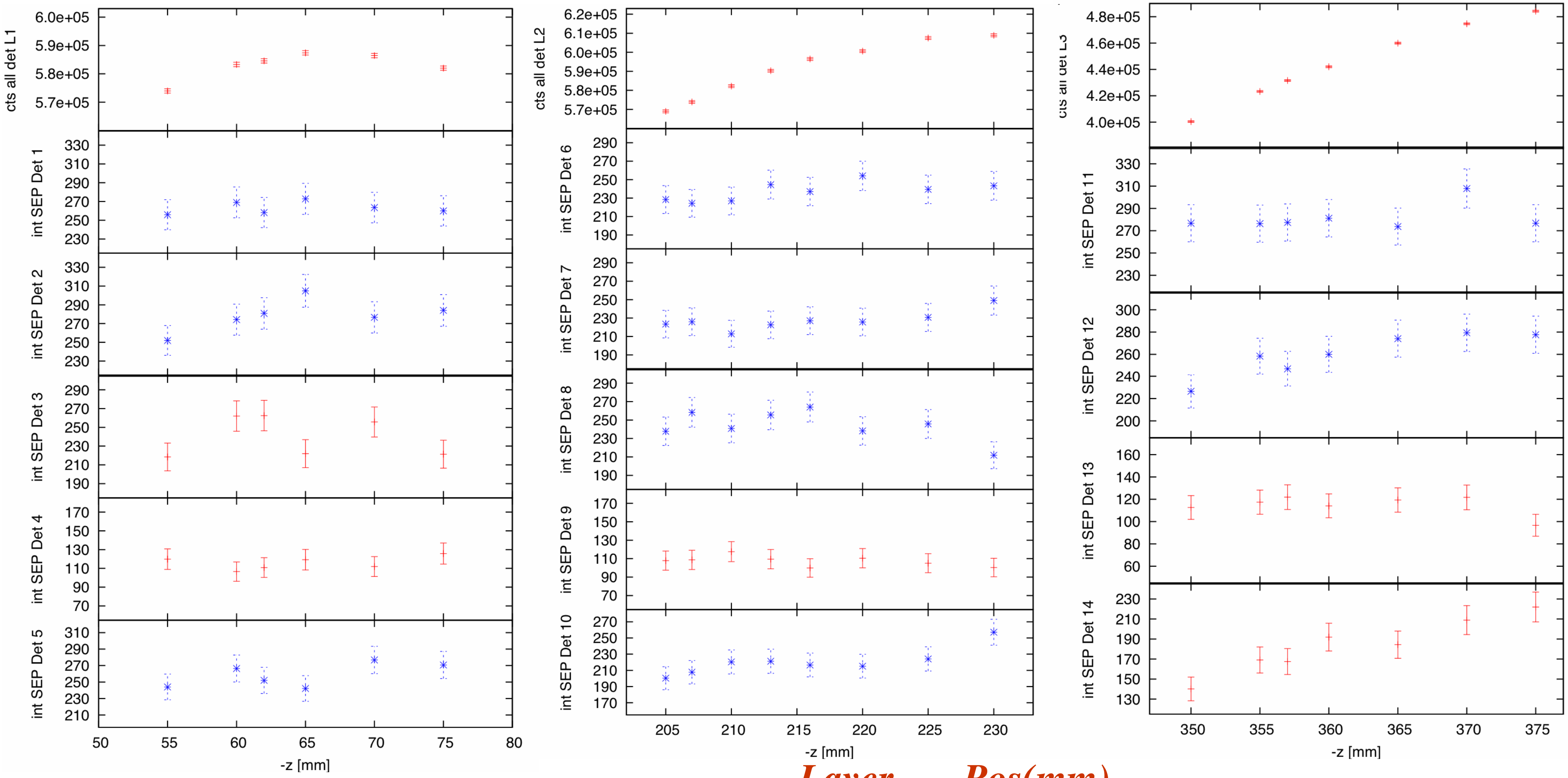
Simulations at different z

^{228}Th + W absorber considered with the previous dimensions
(simulation with ^{228}Th + Ta in progress)



(5×10^6) ^{228}Th decays simulated in each z position (3 sources)

Total events in the layer and SEP events in detector with the lowest statistic considered



Optimal positions:

Layer	*Pos(mm)*
1	*-70*
2	*-210*
3	*-370*

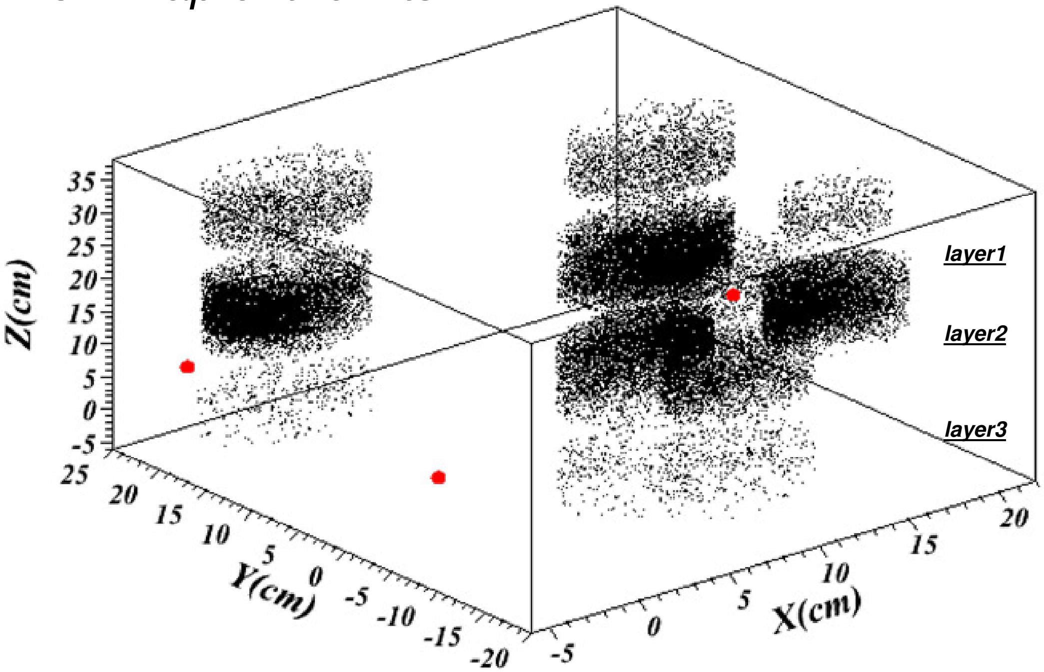
Minimum source strength

Investigation on:
- Energy calibration
- Pulse shape discrimination

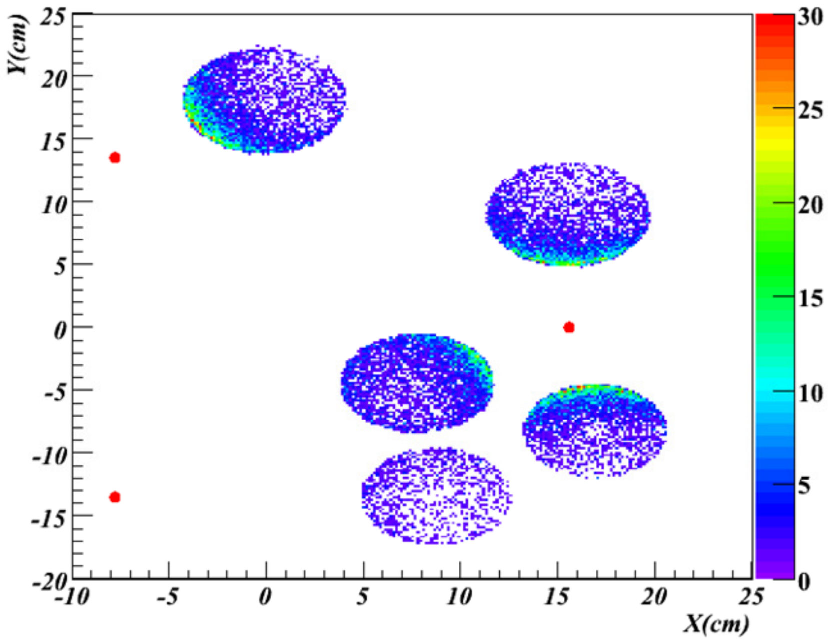
- 3×10^9 ^{228}Th decays each in three positions
- Usual geometry
- Tantalum absorber
- Optimal z positions for the three layers simulated

Total and single detector spectra analyzed
Peak to bkg ratio for several lines considered (Gaussian fits – bkg integrated in 3σ)
Detector with the lowest statistic in each layer identified

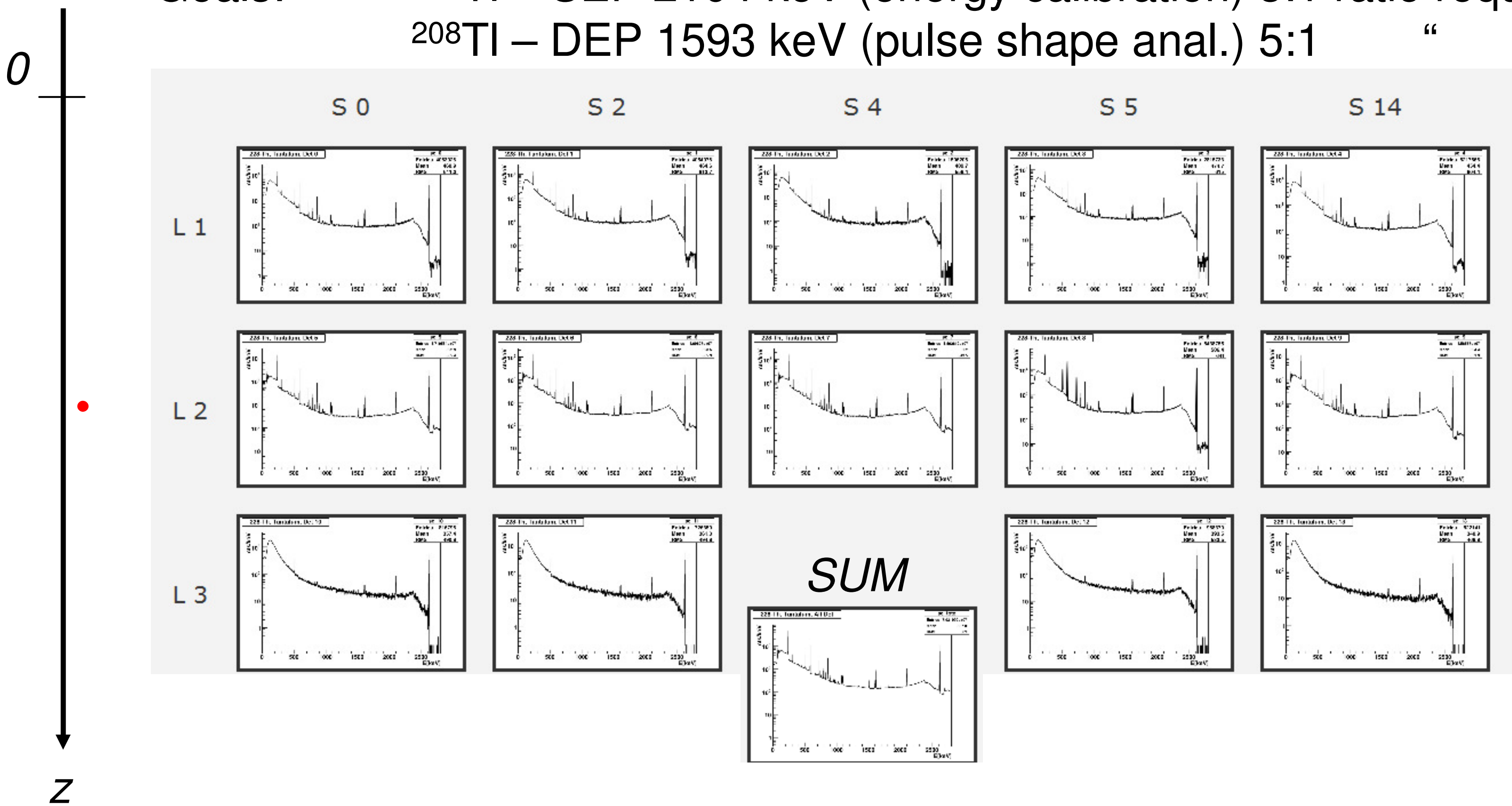
3D Map of the hits



xy Map of the hits (layer2)



Goals: ^{208}Tl – SEP 2104 keV (energy calibration) 3:1 ratio required
^{208}Tl – DEP 1593 keV (pulse shape anal.) 5:1 "



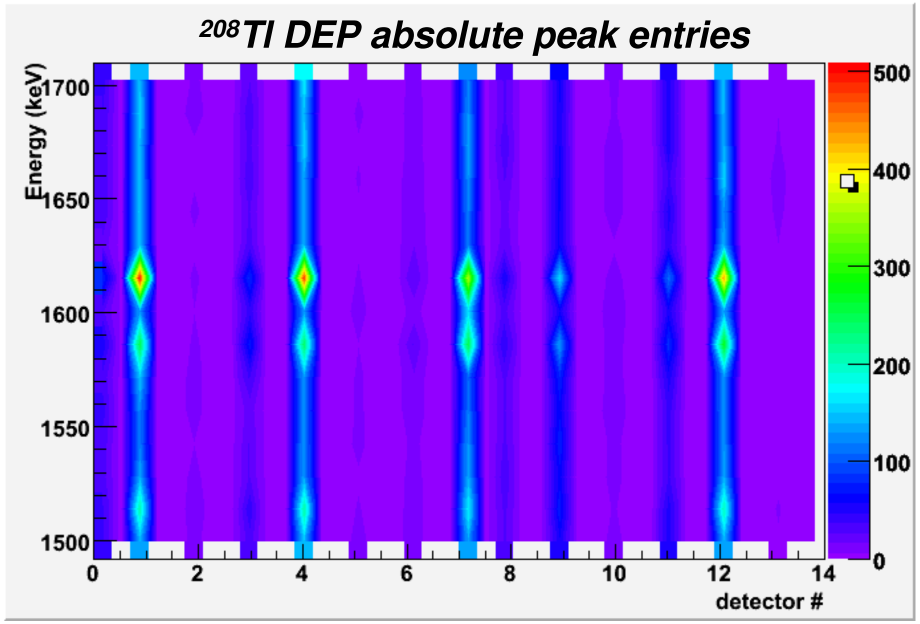
DET 5 (layer 2) with 3 x 20 kBq sources in 25 minutes

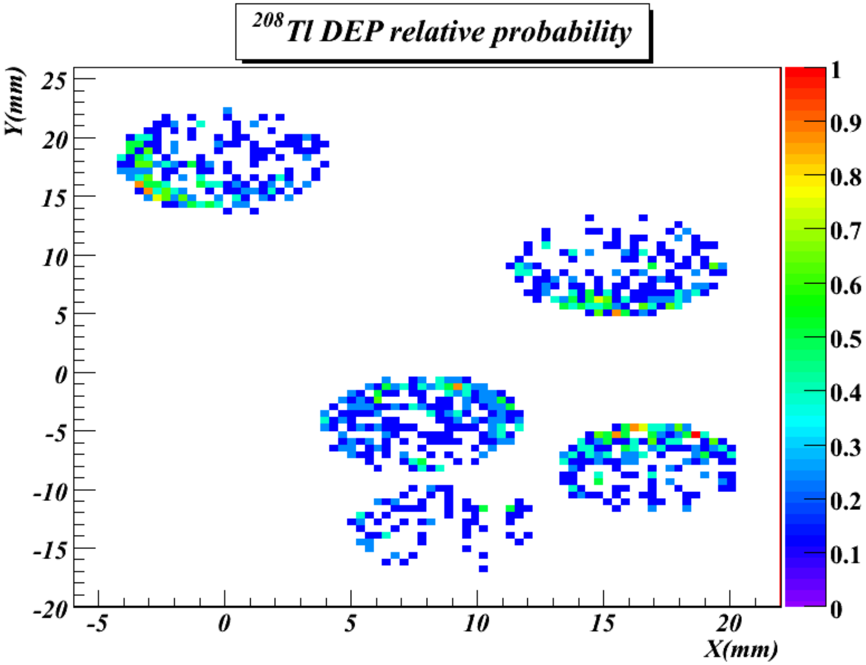
Line	Peak entries	P:B	Line	Peak entries	P:B
239 keV	22866	3.1:1	1593 keV (DEP)	575	2.1:1
511 keV	7002	4.4:1	1621 keV	767	2.7:1
583 keV	17244	21.8:1	2104 keV (SEP)	1638	4.2:1
727 keV	3602	6.8:1	2615 keV	14979	485:1
861 keV	2458	6.5:1			

- *SEP* → *good statistic in all the detectors*
- DEP → *Not sufficient statistic for PSD*

- Optimization of the P:B ratio
- Bkg investigation
- Source ↔ detector dependence

⇩



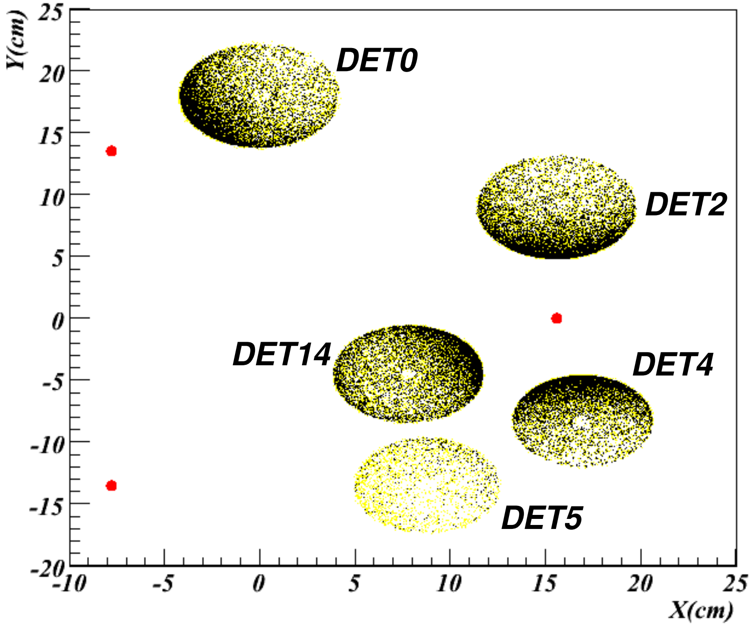


Investigations on the DEP

Some conclusions:

- P:B not dependent on the number of simulated events
- The Absorber effect is small
- Main bkg from scattering in LAr
- P:B ratio similar for all the detector (even bigger for Det5)

Layer 2 – xy map of the hits



DEP statistic

3 x 20 kBq sources in 25 minutes

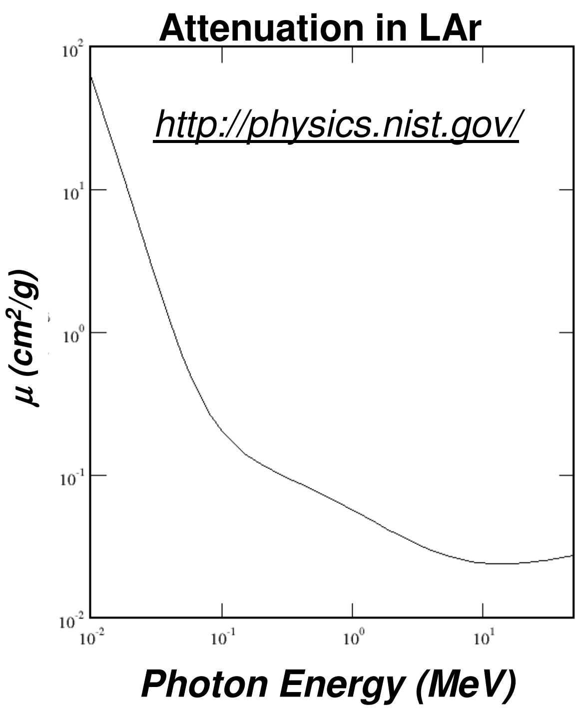
(9e7 ^{228}Th decays simulated)

	Det 0	Det 2	Det 4	Det 5	Det14
Entries in the peak	**720±20**	**660 ±20**	**990 ±30**	**574 ±20**	**742 ±30**
P:B	**1.6 ±0.1**	**1.4 ±0.1**	**1.9 ±0.2**	**2.1 ±0.2**	**1.6 ±0.1**

Summary of a calibration run

- Absorber : Tantalum (h=60mm , r=35mm, m≈4kg)
- Z Positions : Z_1 = -70 mm , Z_2=-210 mm , Z_3=-370 mm
- 3 x 20kBq sources
- 3 x 25 min calibration runs → SEP statistic > $1.5 \cdot 10^3$ entries in each detector

Gamma bkg from the source

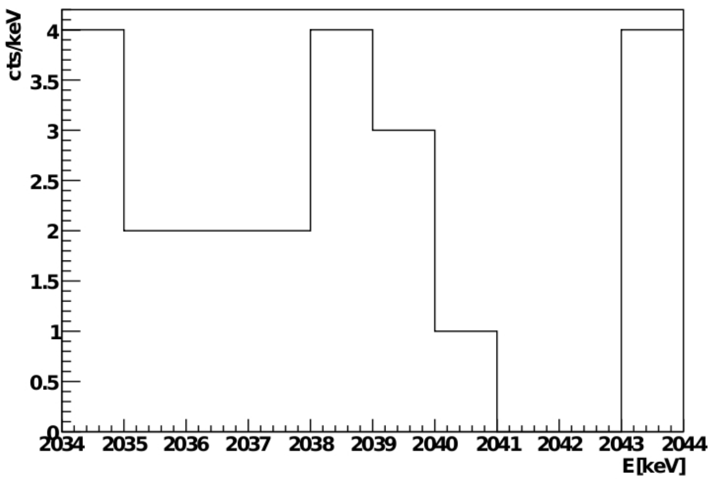


Combination of analytical calculations and MC simulation
Conservative upper limits required
Real simulation on going

- Shield: d=350 cm LAr + d=6.0 cm absorber (Ta)
- Linear attenuation at 3.0 MeV considered

  $\Rightarrow$ Total attenuation 3.8×10^{-11}

- Full simulations at 70 cm and 100 cm above the detectors
- Source strength rescaled according to the analytical attenuation
- Only downward direction considered



$B_{Ta,LAr} = (1.8 \pm 1.0)\ 10^{-7}$ cts/keV/kg/y/kBq

$B_{Ta,LAr} = (1.1 \pm 0.6)\ 10^{-4}$ cts/keV/kg/y

3 x 20kBq sources

10keV range on the $0\nu\beta\beta$ Q-value

4cm more of absorber can additionally reduce the gamma bkg by a factor 15

Neutron bkg from the source

^{228}Th $\rightarrow$ α emitter $E_{mean}(\alpha)$ ~ 6.5 MeV

$E_{max}(\alpha)$ = 8.8 MeV

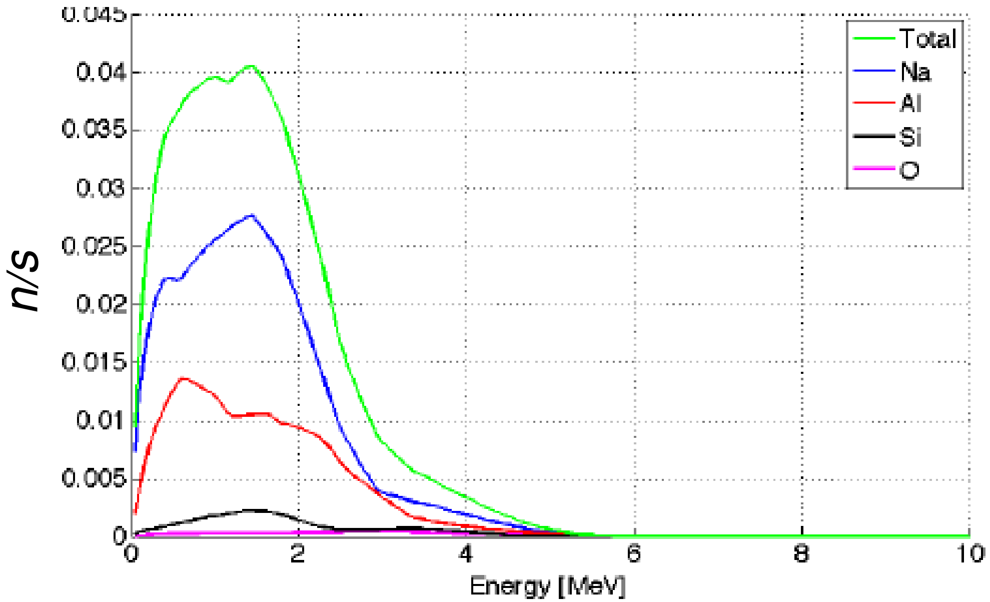
$\Rightarrow$ neutron produced through (α,n)

Reminder:

standard source with ceramic pallet

(α,n) reaction on the surrounding materials

Neutron fluxes for different materials



Neutron Rate = 3.8 10^{-2} n/(s ·kBq)

E_{mean} = 1.45 MeV

MC simulations:

350 cm LAr attenuation

6.7 10^{7} neutrons considered

$\Downarrow$

- Mean interaction probability ~ $4\cdot10^{-4}$
- 1.0×10^{-5} cts/(keV·kg·y·kBq)
- 6.0×10^{-4} cts/(keV·kg·y) @ 3×20kBq

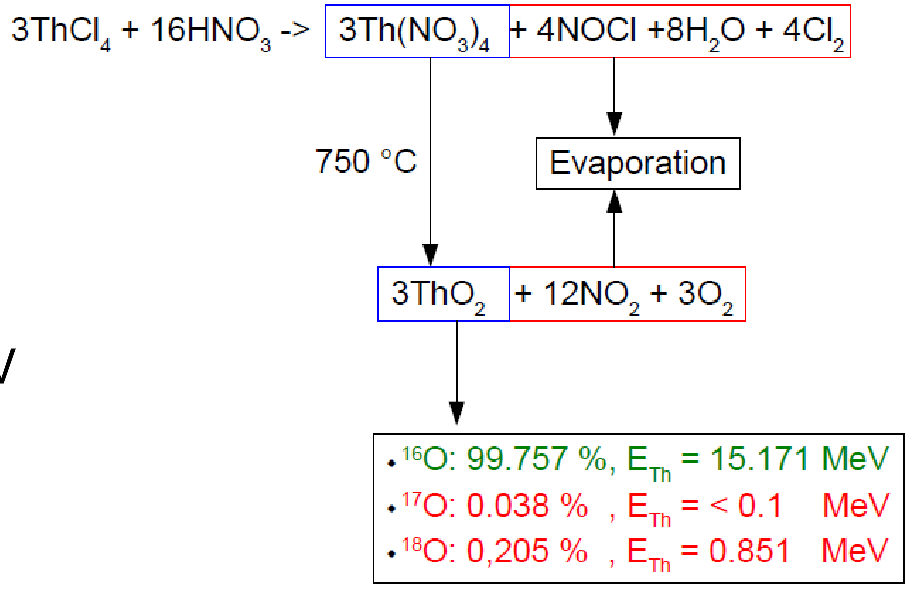
New Source development

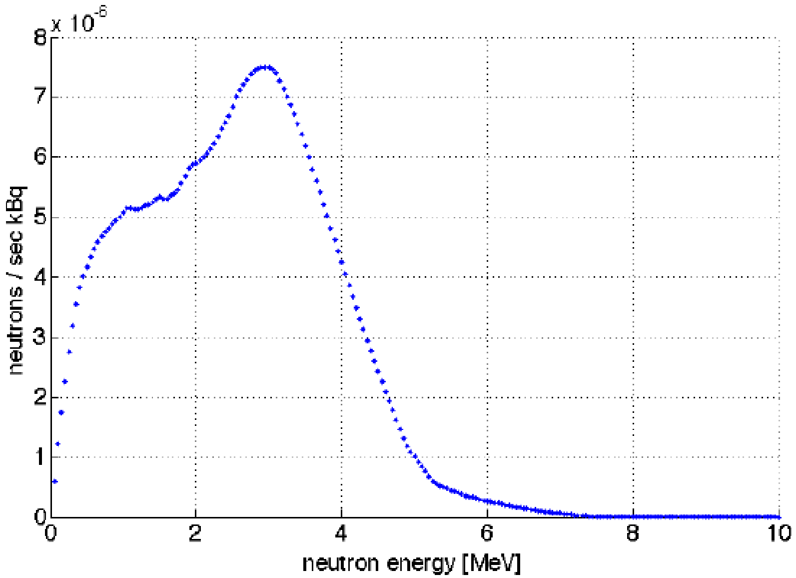
Aim: reduction of the neutron flux through the development of a new setup

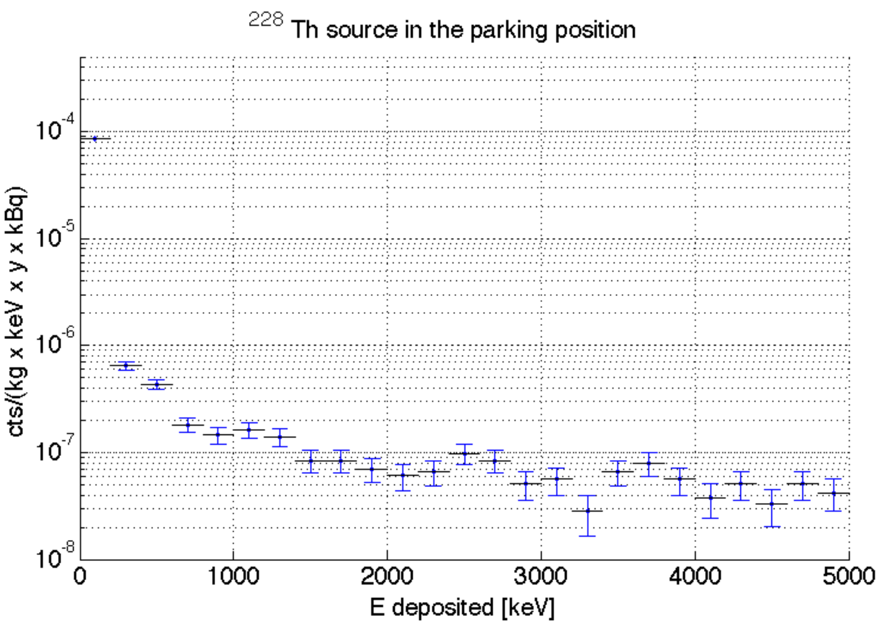
Gold: no oxidation

Threshold for (α,n) ~ 9.94 MeV

Collaboration with PSI







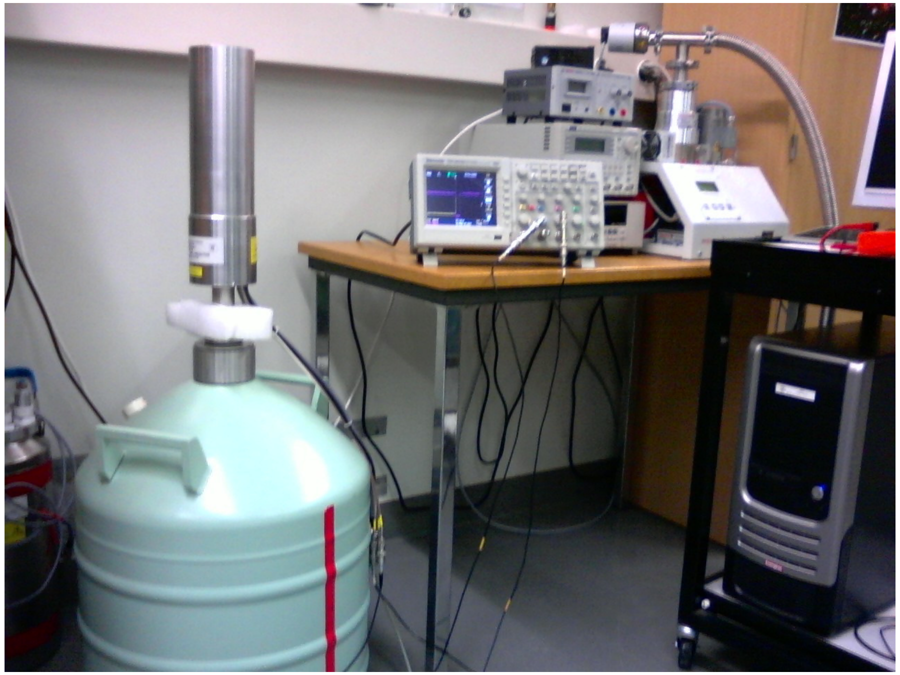
Neutron Rate = 5.0×10^{-4} n/(s ·kBq)

E_{mean} = 2.5 MeV

B = 8.6×10^{-8} cts/(kg· keV· y · kBq)

B = 5.1×10^{-6} cts/(keV·kg·y) @ 3×20kBq

Lab @ UZH

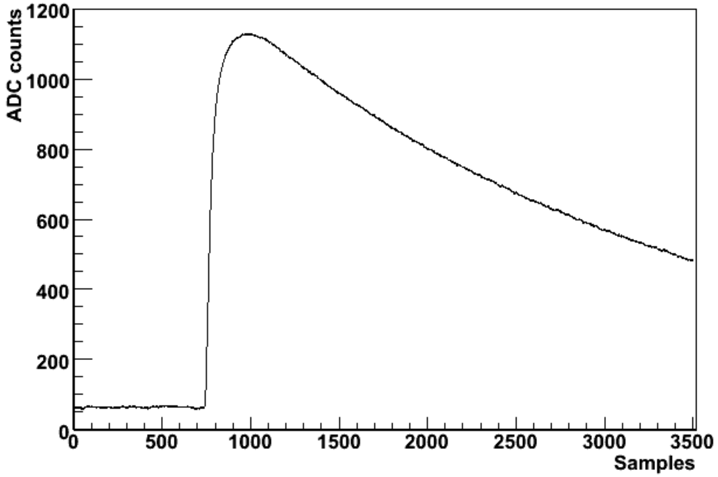


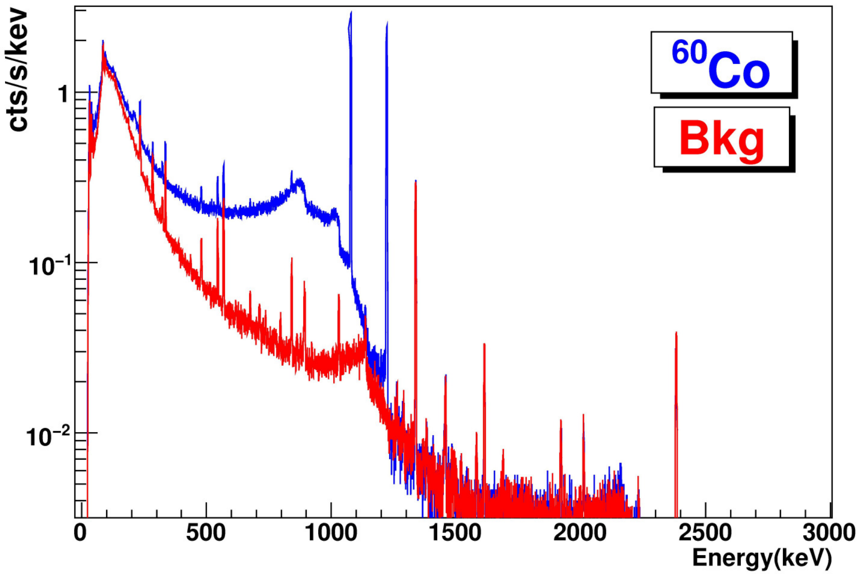
n-type HPGe
- *40× 40 mm*
- *266 g*

MCA → CAEN N957 (8k)
ADC → CAEN V1720 (12b – 250 MHz)

Resolution (FWHM -1332keV)	*1.80 keV*
FWTM/FWHM	*1.82*
FWFM/FWHM	*2.46*
Relative eff.	*9.5%*
Peak to compton	*41*

Gamma event acquired with the ADC (→ 718 keV)





Conclusions

- *^{228}Th $\rightarrow$ Preliminary simulations done*
- *Ta absorber selected*
- *Optimal positions investigated*
- *^{208}Tl SEP $\rightarrow$ good statistic in all the detectors*
  ^{208}Tl DEP $\rightarrow$ probably not good P:B ratio for PSD
- *γ bkg from the source $\rightarrow$ 10 cm absorber suggested from the preliminary results (more simulations in progress)*
- *n bkg from the source $\rightarrow$ new source developed with PSI*
  bkg reduced by two order of magnitude