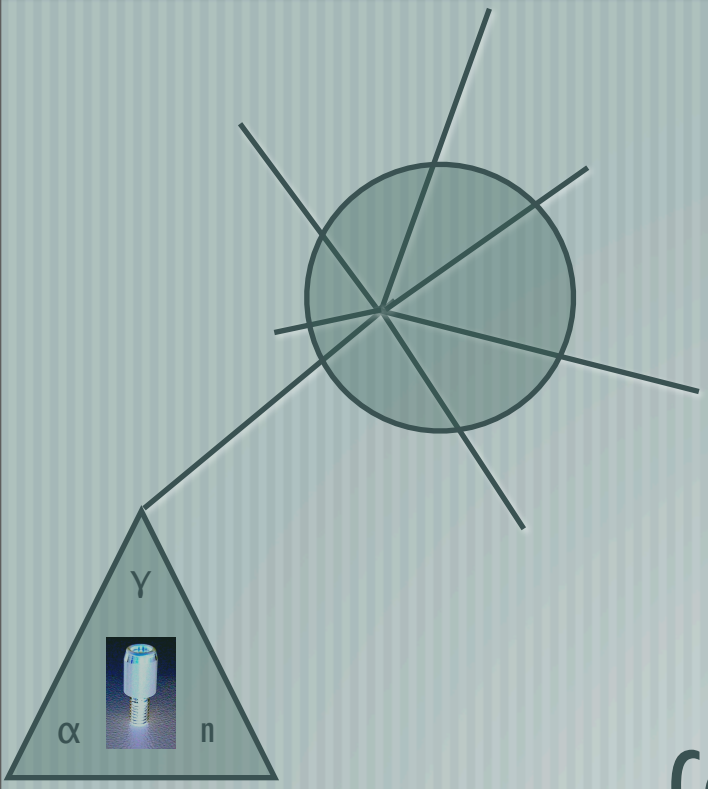
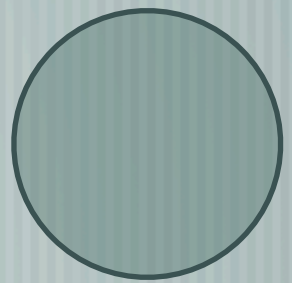
GERDA - Status of Calibration



Michał Tarka

University of Zurich
Physics Institute

Collaboration Meeting - LNGS
29.9'09



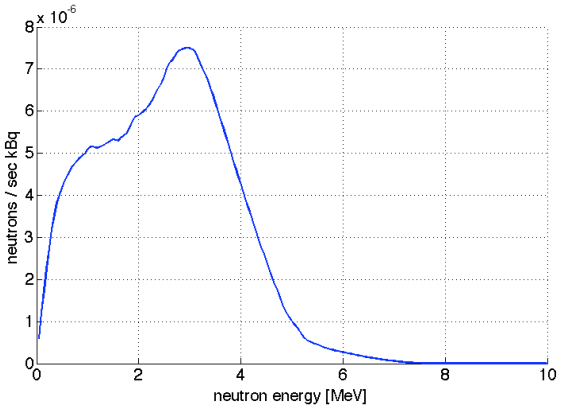
Outline

- Summary - custom ^{228}Th source
- ^{228}Th neutron measurements at LNGS
- Calibration system
  - Integration of the absorber in the commissioning lock
  - Monte Carlo simulations
  - Analysis code
- Plans

Summary custom ^{228}Th source

✓ Chemical & thermal treatment of $^{228}ThCl_4$ in 1M HCl solution at PSI

➢ 20kBq $^{228}ThO_2$ in goldfoil ➠ Encapsulation
& certification ISO C 11111
at Eckert&Ziegler - Prague



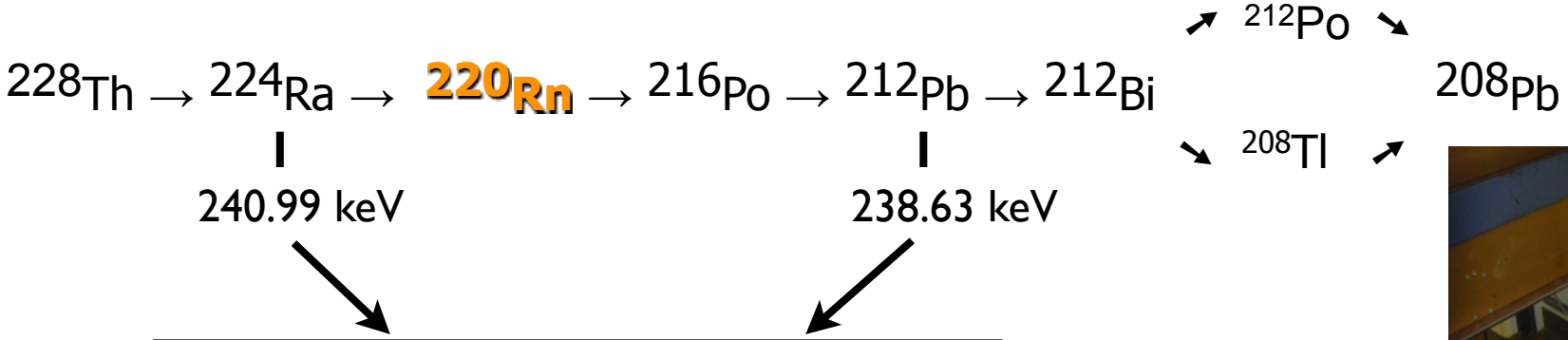
	custom $^{228}ThO_2$	commercial ^{228}Th
expected n-rate from (α-n) [n/s/kBq]	$5 \cdot 10^{-4}$	$3.8 \cdot 10^{-2}$
MC: n-background in 1.5- 2.5 MeV intervall [cts/(kg·y·keV·kBq)]	$8.6 \cdot 10^{-8}$	$1 \cdot 10^{-5}$

✓ Wipe tests: γ measurements with GATOR

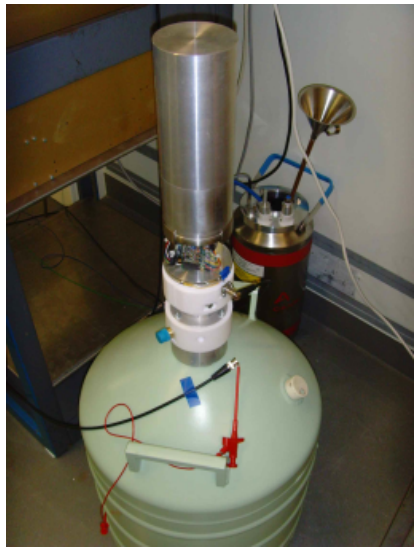
➢ Activity on the surface of encapsulation A < 0.5 mBq

Summary custom 228Th source

✓ Chain recovery after treatment verified after 2 months by γ measurements.

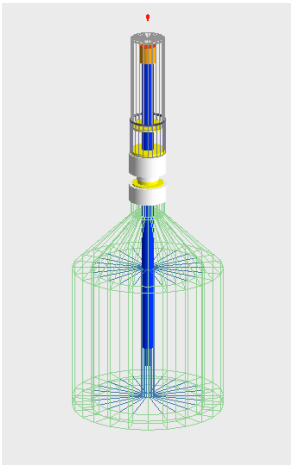


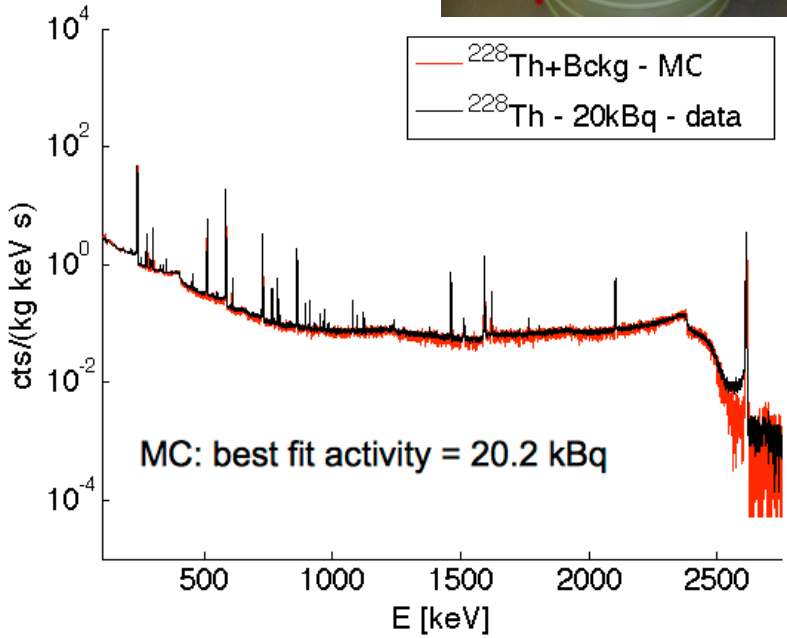
➢ $^{212}Pb / ^{224}Ra = 10.6$ (10.4 ± 0.3)



✓ Activity losses during treatment determined with γ measurements and comparison with Monte Carlo.

nominal activity of $^{228}ThCl_4$: 20 kBq



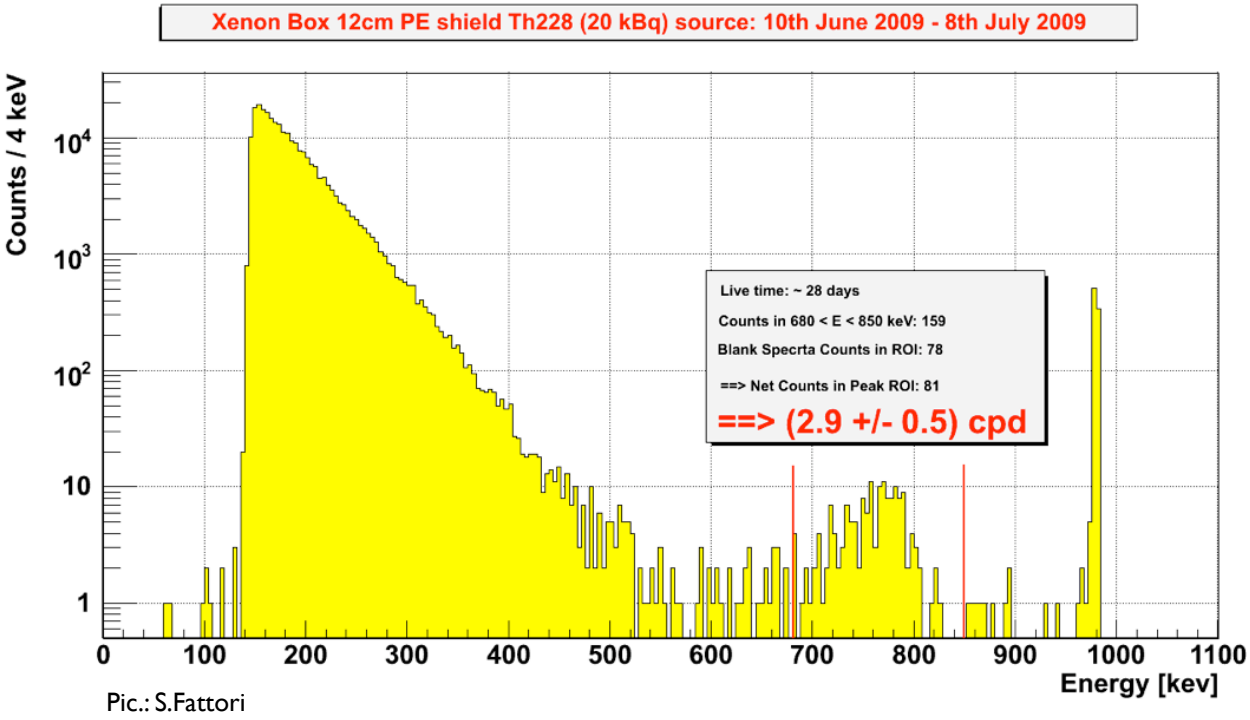


MC estimation after treatment at PSI: (20.2 ± 0.4) kBq

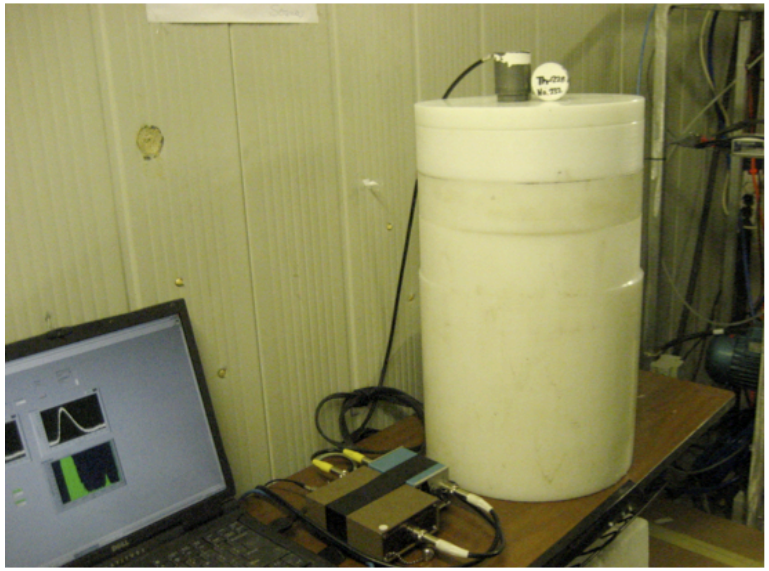
➢ no measured activity loss during the treatment at PSI

Neutron measurements at LNGS

Custom ^{228}Th source:
n-flux measurement with ^{3}He detector at LNGS



Pic.: S.Fattori



- neutrons thermalized using 12.5 cm of PE
- ^{3}He(n,p)^{3}H reaction: Q =764 keV
- 28 days data taking

Detector efficiency:

(determined by Monte Carlo simulations)

$\varepsilon_{tot} = \varepsilon_{geom} \cdot \varepsilon_{therm} \cdot \varepsilon_{capt} = 0.2\ \%$

ε_{geom} = geometrical eff.

ε_{therm} = n-thermalization eff. in PE

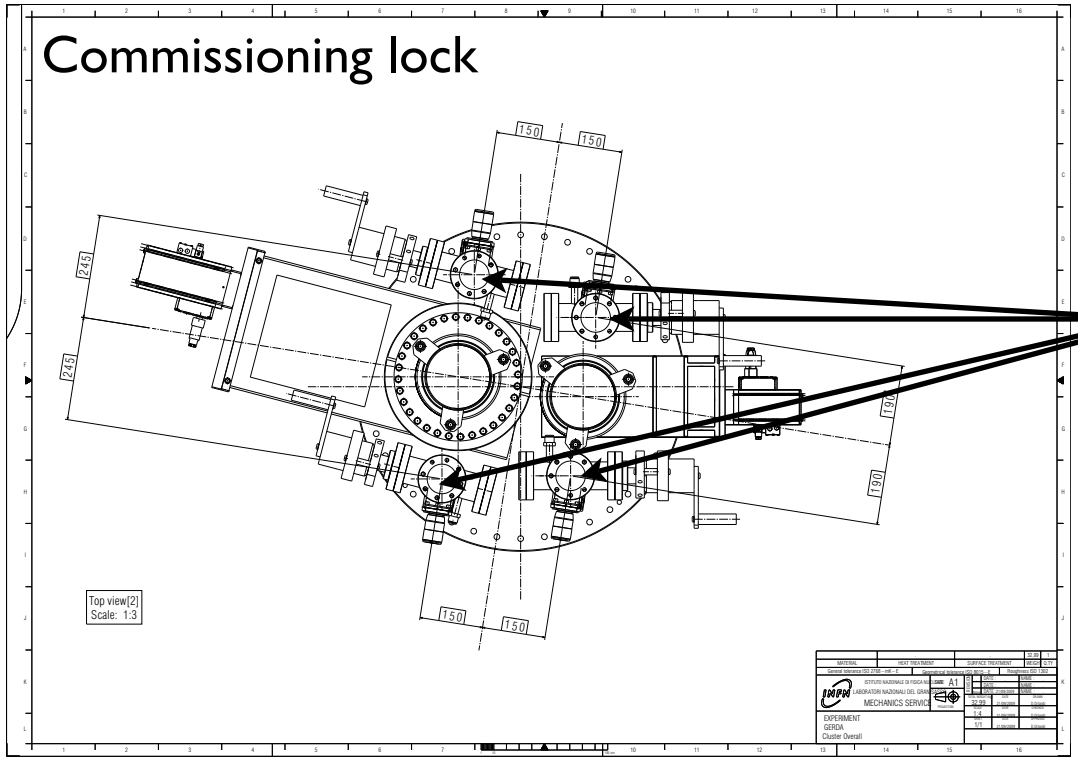
ε_{capt} = therm. n capturing eff. in ^{3}He

- Measured n-rate:

  $R = (8.5 \pm 1.5) \cdot 10^{-4}$ n/s/kBq
- Calculated n-rate (SOURCES4mv):

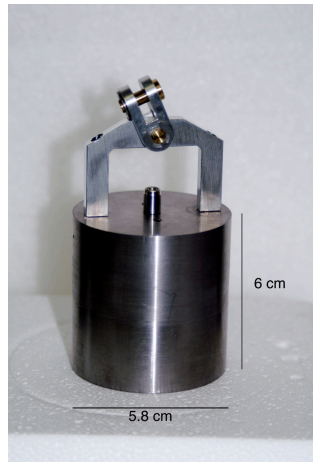
  $R \cong 5 \cdot 10^{-4}$ n/s/kBq

Calibration system: Absorber integration



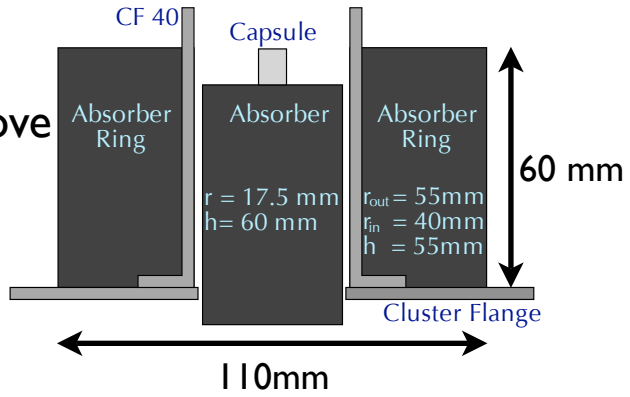
CF40 flanges for cal. sources

Mock up: absorber with holder and mounted ^{228}Th source

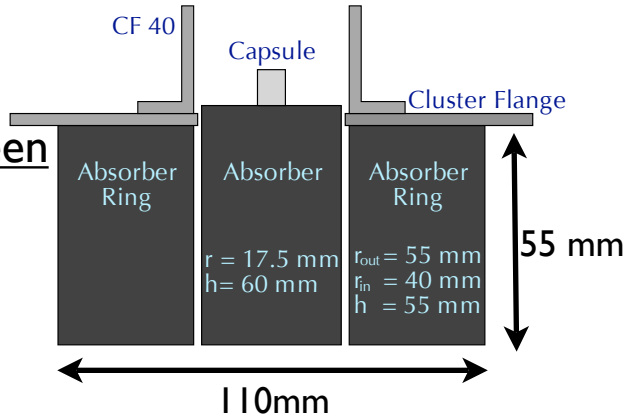


➢ Ta-absorber consisting of an outer ring & cylinder

Option 2: absorber ring above cluster flange

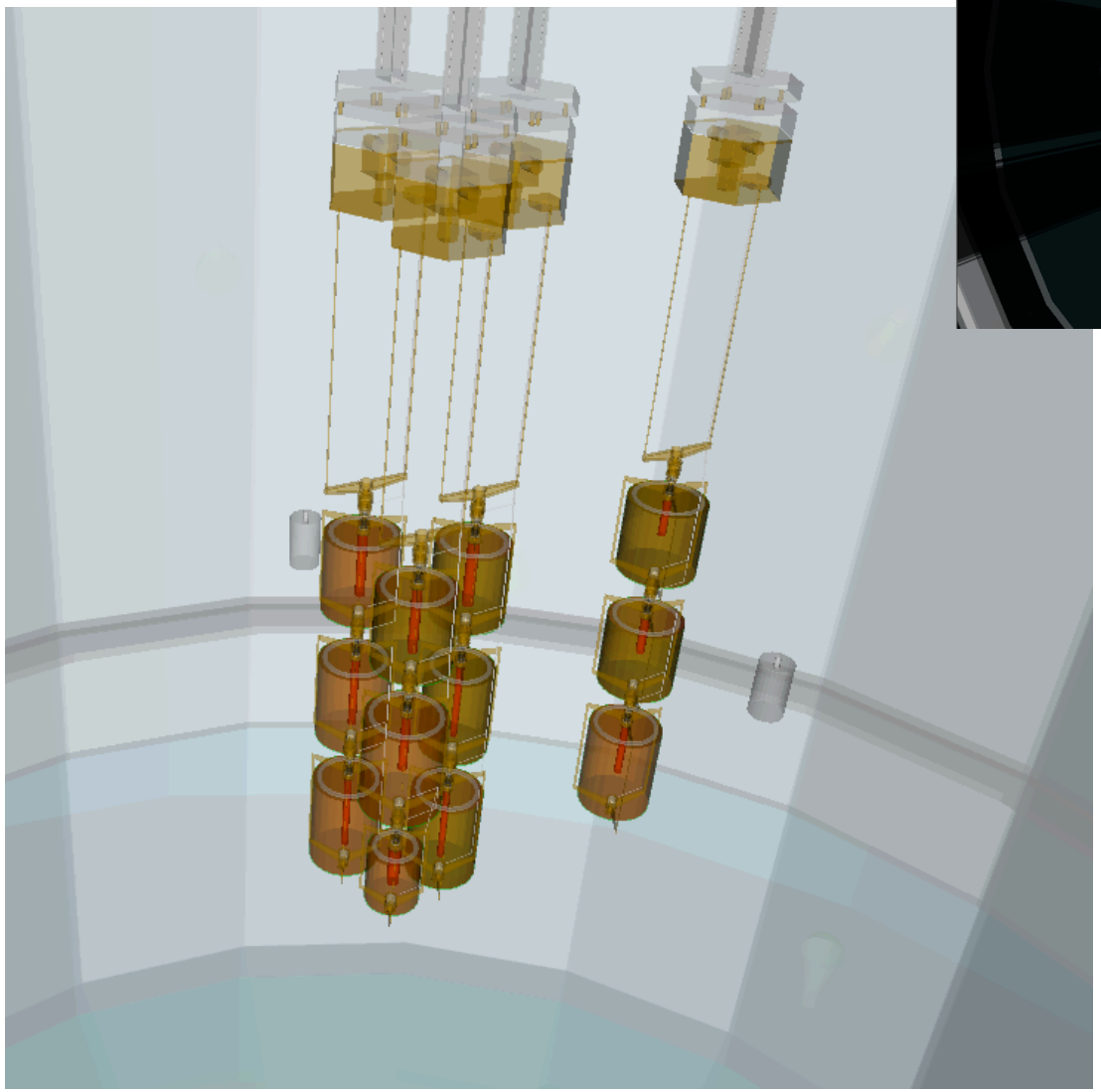


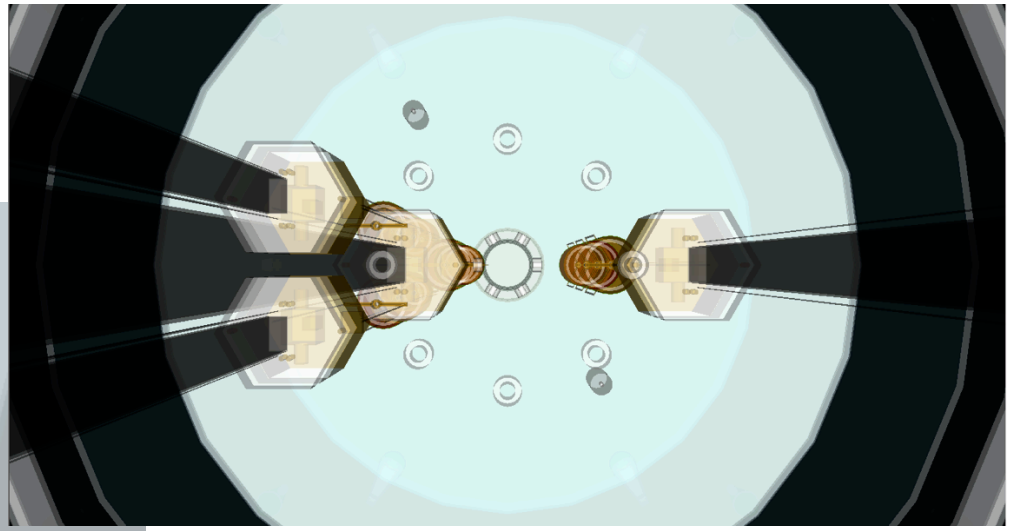
Option 1: absorber ring between cluster flange and shutter



- Asymmetrical mounted source for better statistics?
  → string oscillations - amplitude, timescale?

Calibration system: MC simulations





Monte Carlo studies assuming
20 kBq ^{228}Th sources in the
commissioning lock configuration

- calibration run time

Preliminary results:

2 sources: 4h + moving time

3 sources: 1.25 h + moving time

- optimal z-positions

- PSA study

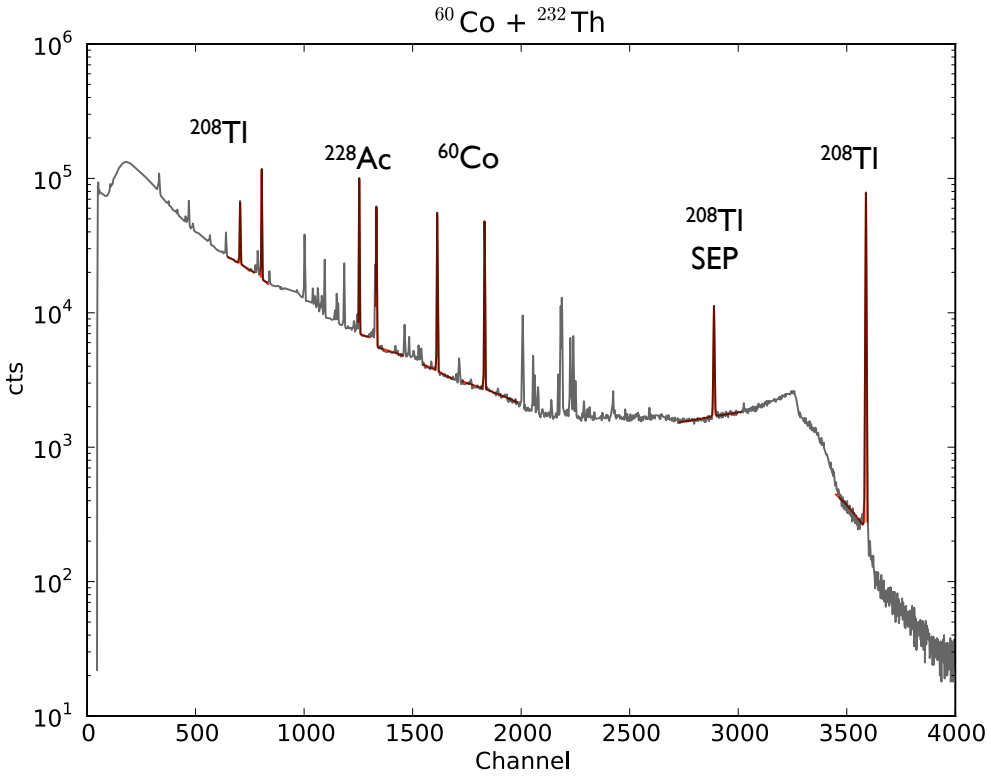
Calibration system: Calibration code

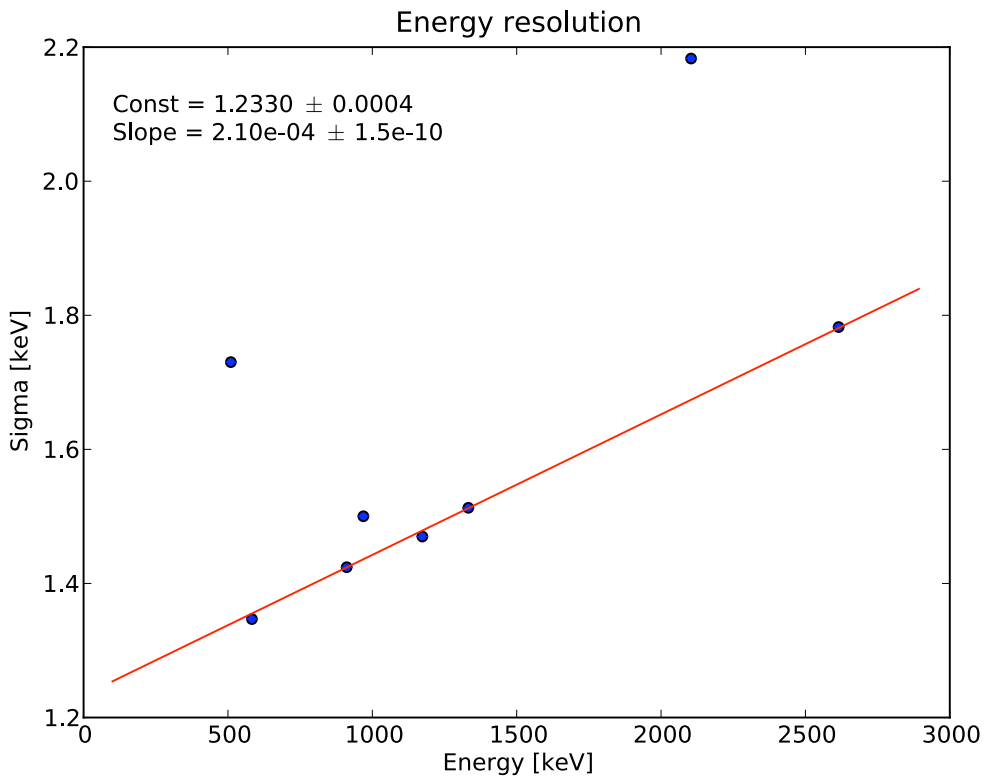
Data taken with PZ0 electronics :

➢ folding-in realistic resolutions in MC

Calibration code:

➢ goal: automated line identification, channel calibration, fit-routines, stability control



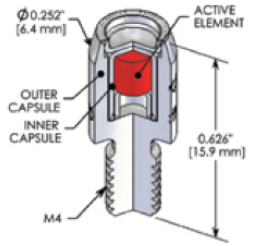


Plans

- Mounting custom ^{228}Th source, 20 kBq
- Produce a second source at PSI (order for $^{228}ThCl_4$ solution placed on 22.9'09)
- Monte Carlo - commissioning lock configuration
- Development of a calibration-analysis software
- Pulse shape studies / simulations

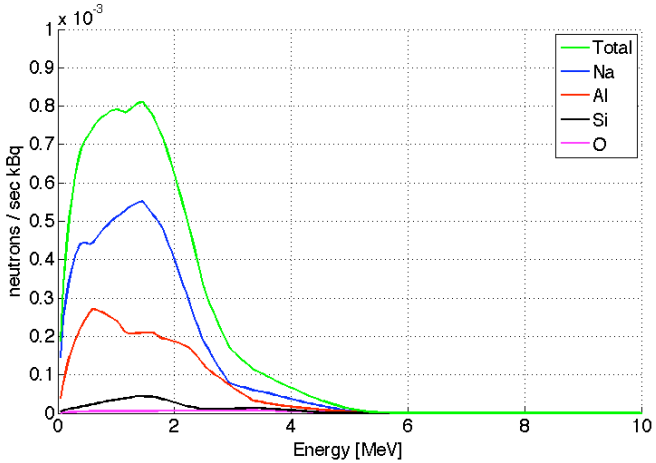
Thank You

$NaAlSiO_2$ ceramic saturated with ^{228}Th



(α-n) reactions result in

➳ n-rate = $3.8 \cdot 10^{-2}$ n/s/kBq , <E> = 1.45 MeV



Monte Carlo simulations:

- 3.5 m LAr between source and detector array
- Total Ge mass: 250 kg

➳ Background: $1 \cdot 10^{-5}$ cts/kg·y·keV·kBq)

Basic idea for the n-rate reduction:

➵ replace the ceramic by materials with higher threshold energies for (α-n) reactions.

Interesting candidates:

Gold: E_{THR} = 9.94 MeV
Tungsten: E_{THR} = (9.4 - 11.9) MeV
^{90}Zr: E_{THR} = 7.95 MeV

Best candidate:
Gold:

➵ no (α-n) reactions in contact with ^{228}Th
➵ easy to handle, Au foils available
➵ chemically inert

Final procedure determined in collaboration with **PSI**

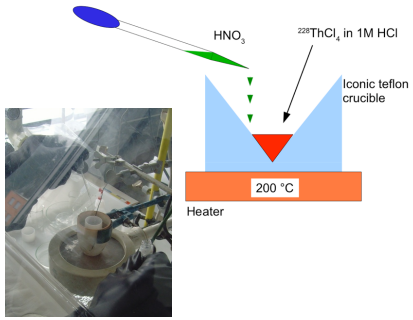
R.Dressler
R.Eichler
D.Schumann

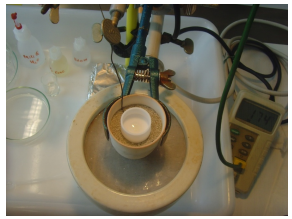
Road-map followed:

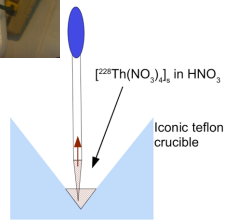
- (2.2'09) : Ordering 20kBq $^{228}ThCl_4$ in 1M HCl solution (0.5 ml V-vial) at Isotopic Products.
- (30.3'09) : Processing the solution at PSI.
- (6.5'09) : Encapsulation + certification at Isotopic Products.
- (June/July '09) : Determining the limit on the n-flux in LNGS.

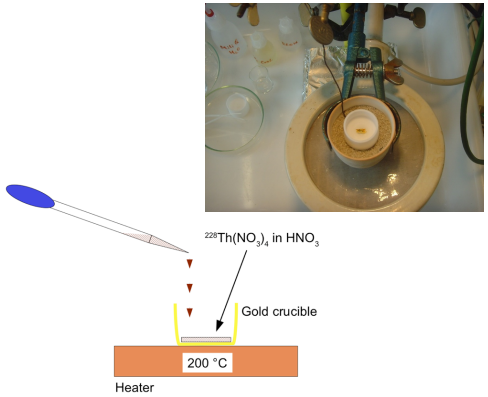
$3ThCl_4 + 16HNO_3$

→ 200°C

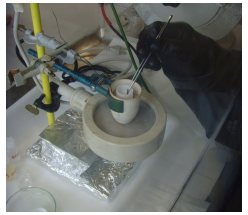


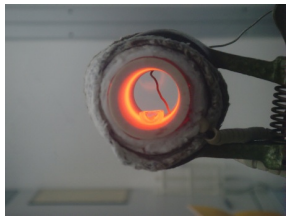






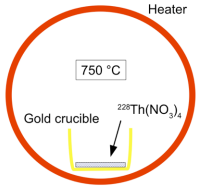
→ $[3Th(NO_3)_4]_s + [4NOCl + 8H_2O + 4Cl_2]_{gas}$





→ 750°C

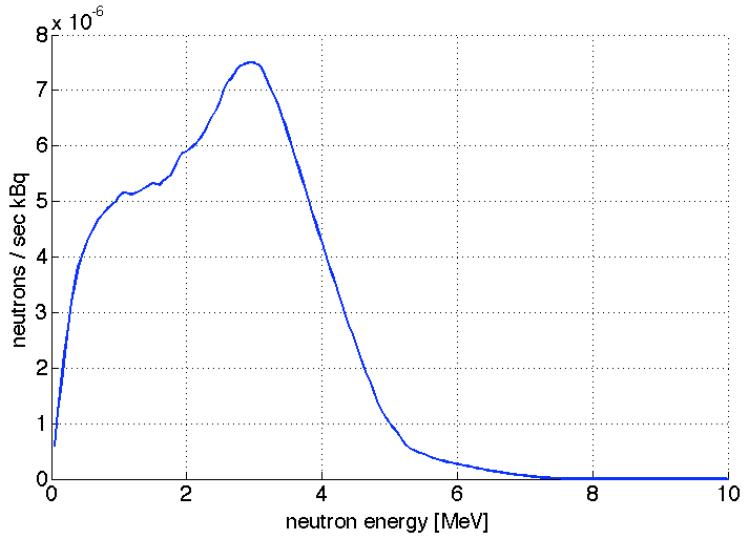
→ $[3ThO_2]_s + [12NO_2 + 3O_2]_{gas}$



Encapsulation & Certification at IP

ThO_2 in goldfoil

^{16}O: 99.76 % , E_{Thr} = 15.17 MeV
^{17}O: 0.038 % , E_{Thr} = < 0.1 MeV
^{18}O: 0.205 % , E_{Thr} = 0.851 MeV



$^{228}ThO_2$ (α-n) reactions result in

➛ n-rate = $5 \cdot 10^{-4}$ n/s/kBq , <E> = 2.5 MeV

Monte Carlo simulations:

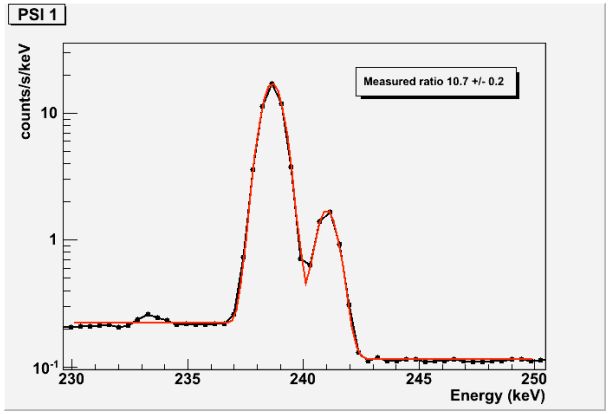
- 3.5 m LAr between source and detector array
- Total Ge mass: 250 kg

➛ Background: $8.6 \cdot 10^{-8}$ cts / (kg · y · keV · kBq) , (Reduction by ~116)

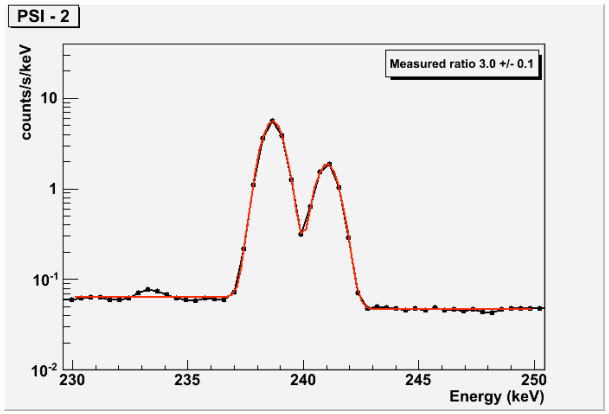
$^{228}Th \rightarrow \underline{^{224}Ra} \rightarrow \mathbf{^{220}Rn} \rightarrow {}^{216}Po \rightarrow \underline{^{212}Pb} \rightarrow {}^{212}Bi \rightarrow \begin{matrix} \nearrow\ {}^{212}Po\ \searrow \\ \searrow\ {}^{208}Tl\ \nearrow \end{matrix} \rightarrow {}^{208}Pb$

$T_{1/2}$:	1.9a	**3.7d**	55.6s	0.15s	10.6h	60.5m	2m/0.3µs

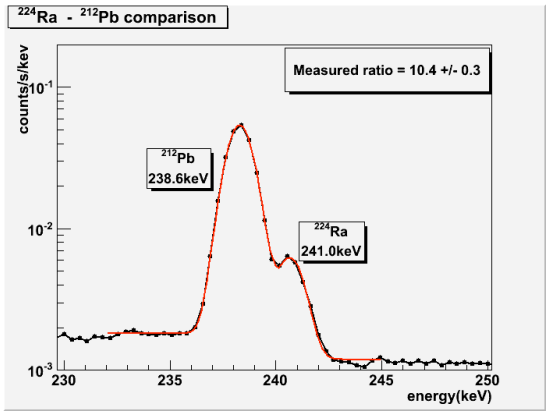
Relative peak height ratio in equilibrium : $^{212}Pb/^{224}Ra = 10.6$



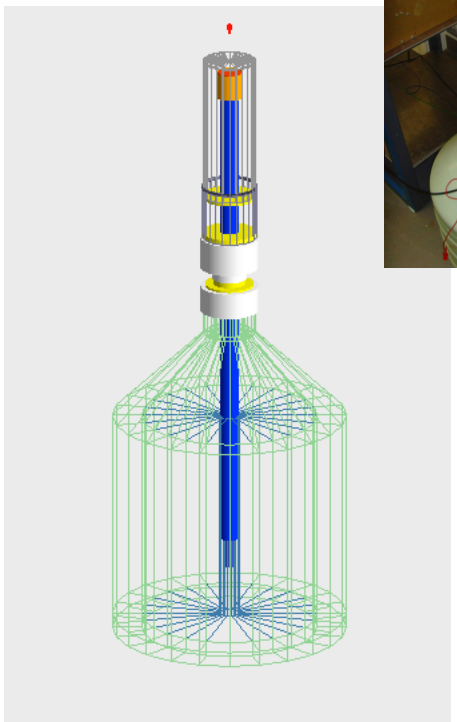
Before treatment:
$^{212}Pb/^{224}Ra = 10.7 \pm 0.2$



1h after treatment
$^{212}Pb/^{224}Ra = 3 \pm 0.1$



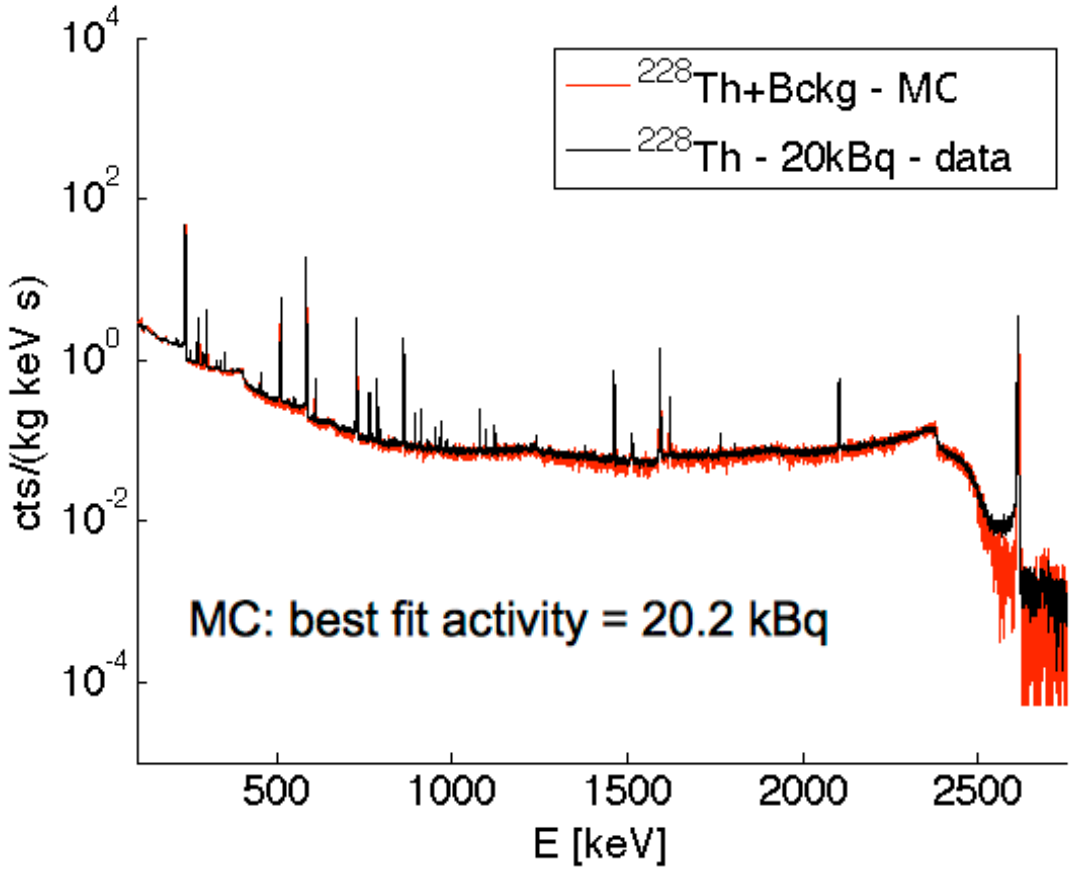
2 month after treatment
$^{212}Pb/^{224}Ra = 10.4 \pm 0.3$



- Source position: 6 cm above endcap
- MC: $2.4 \cdot 10^8$ decays started
- Data: taken for 21 h

nominal activity of $^{228}ThCl_4$: 20 kBq

MC estimation after trearment at PSI: 20.2 ± 0.4kBq



→ no measured activity loss during the treatment at PSI

SEP		6.00E+07	9.00E+07	1.20E+08	1.50E+08	5.00E+07	5.00E+07
A	cts	368	534	710	898	442	218
	P:B	2.8	2.7	2.8	2.7	3.1	3.3
B	cts	293	441	611	746	242	462
	P:B	2.8	2.4	2.6	2.6	2.6	3.7
C	cts	301	454	580	733	347	104
	P:B	2.8	2.6	2.5	2.6	2.8	2.7
D	cts	333	510	692	863	69	95
	P:B	2.8	2.8	2.8	2.8	1.9	3.3
		3 Sources				2 Sources	1 Source Old
		1.25 h + moving time				4 h + mt	15 h + mt