Gamma-Ray Spectroscopy in the HERA Tunnel

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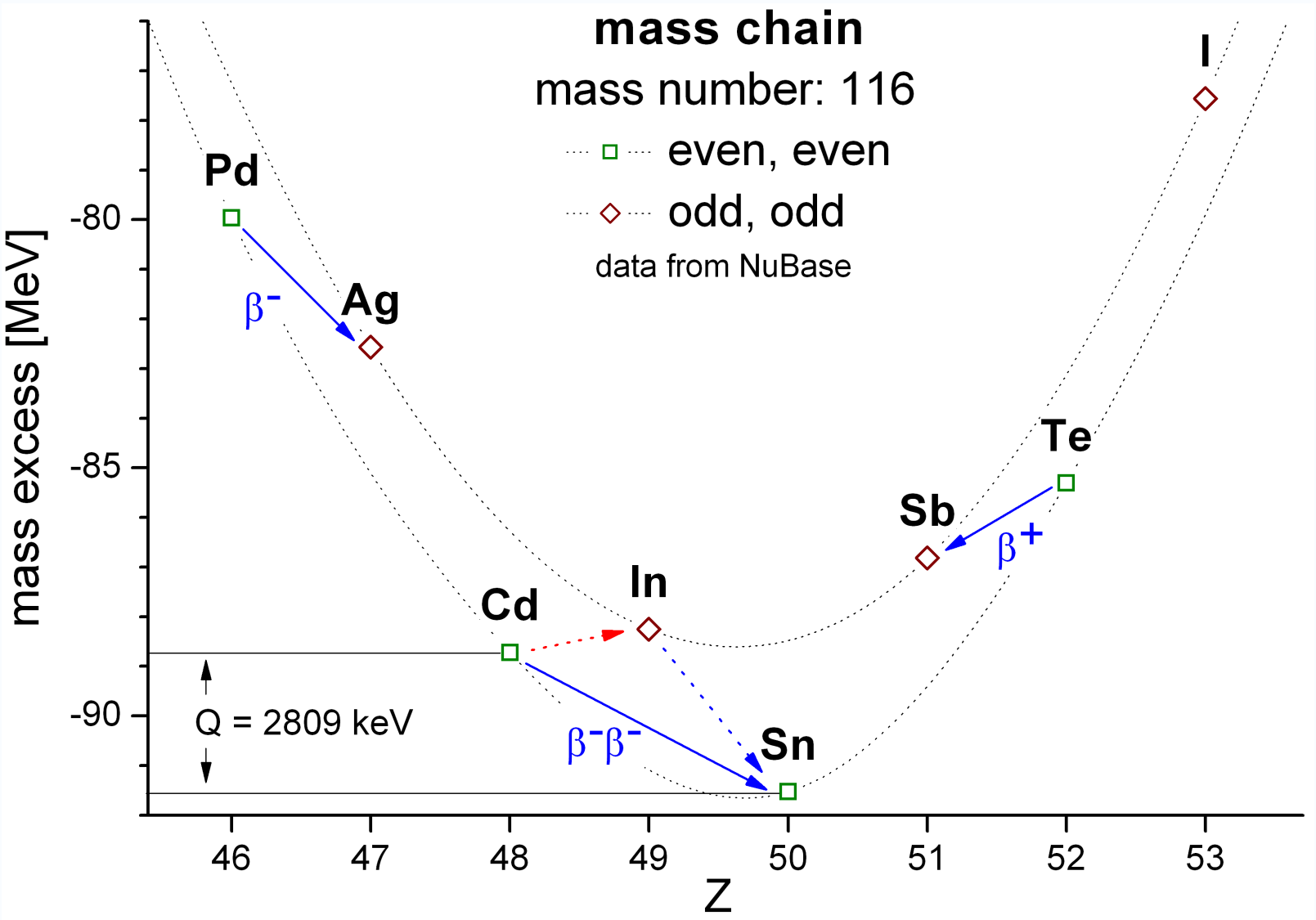
COBRA Experiment

Cadmium Zinc Telluride 0-Neutrino Double-Beta Research Apparatus

- Cadmium Zinc Telluride is a semiconductor used as detector
- 9 isotopes with double beta decay, especially Cd-116
- source = detector
- neutrinoless double beta decay
  - is possible if neutrinos are majorana particles
    - neutrinos and anti neutrinos are identically and have mass
  - expected halflife is very high: $> 10^{26}$ years

Mass Chain: Cd-116



Sensitivity

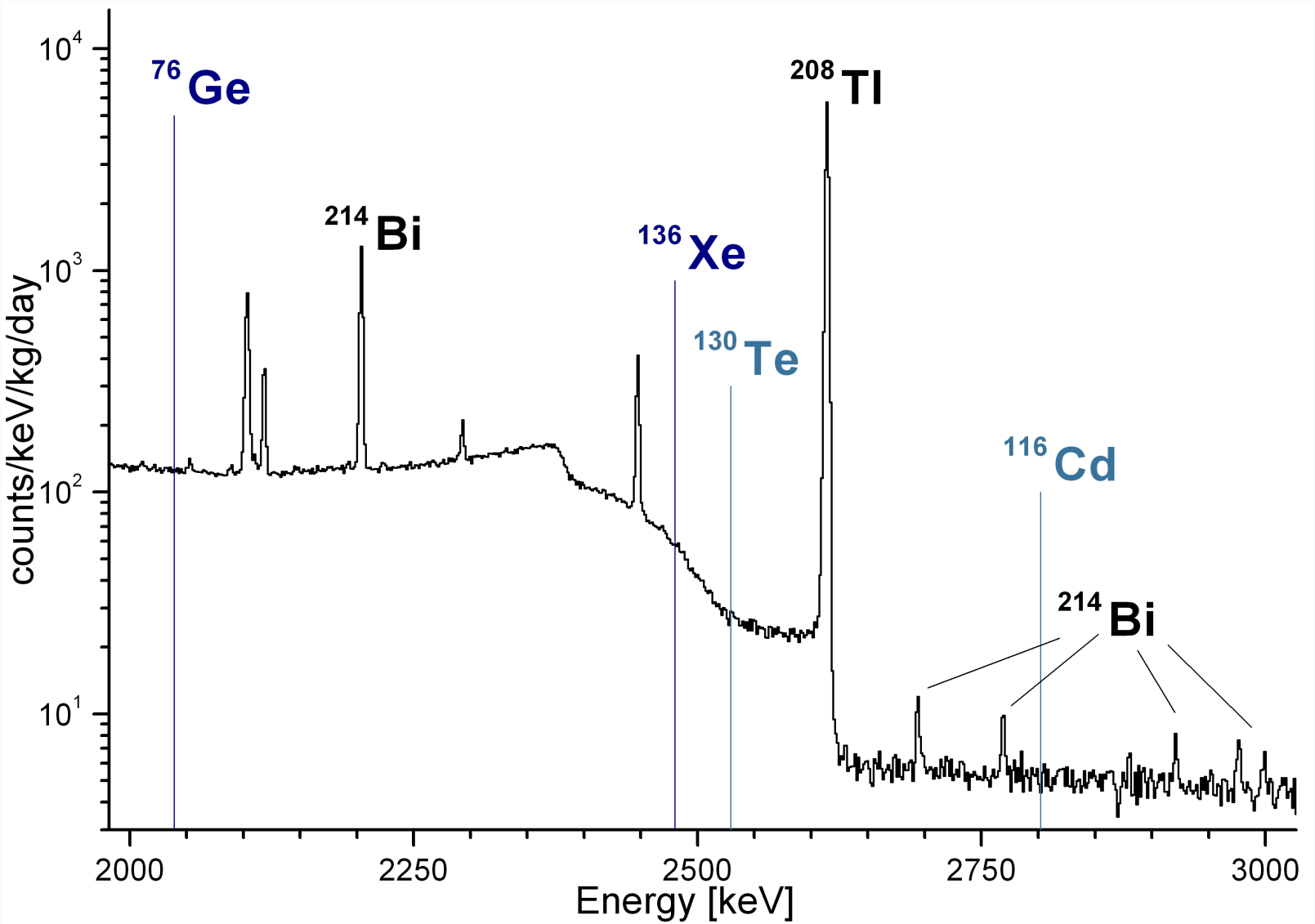
Detection Limit

$$T_{\frac{1}{2}}^{0\nu} = a \cdot \epsilon \cdot \sqrt{\frac{M \cdot t}{B \cdot \Delta E}}$$

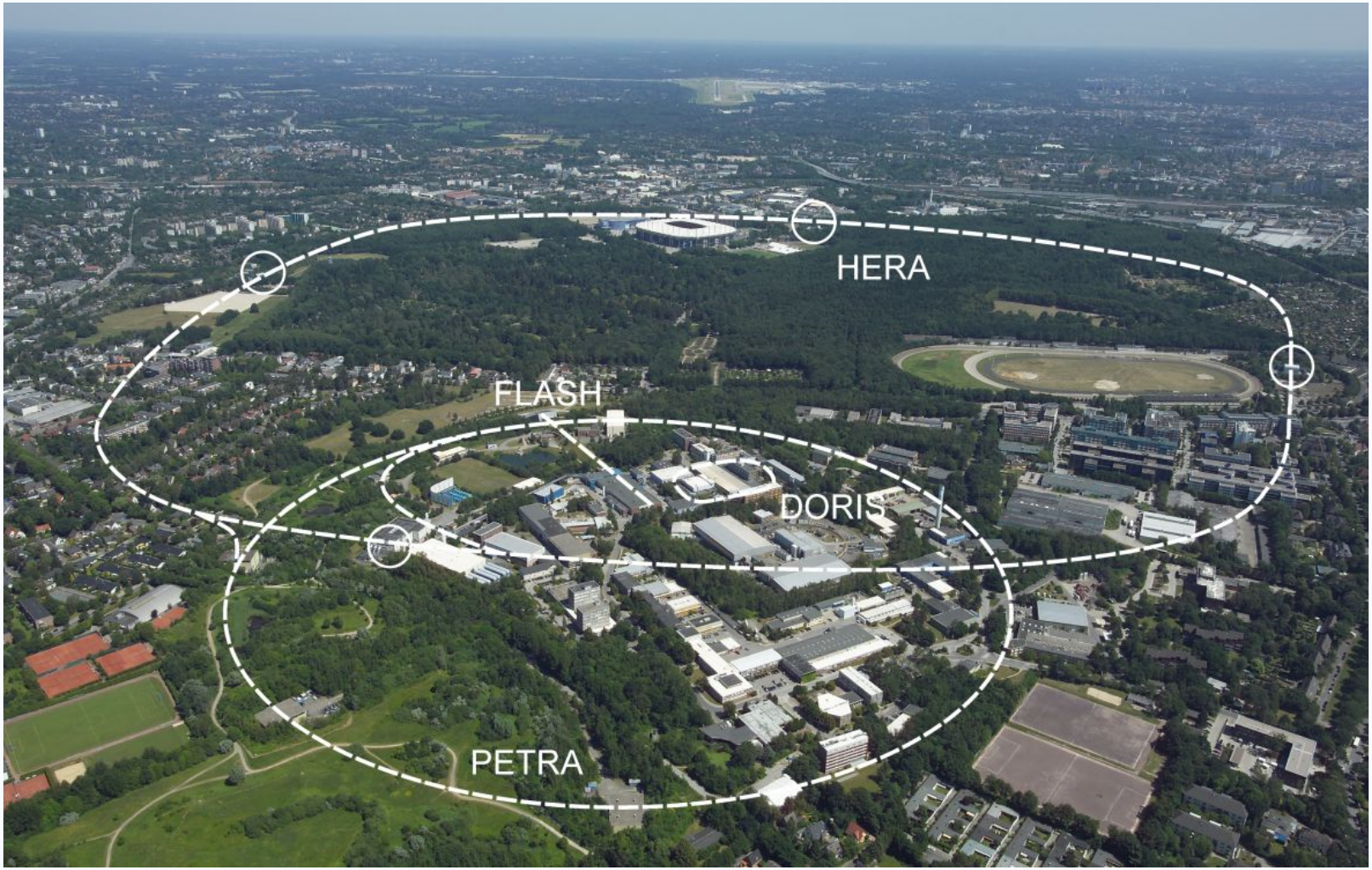
- a: enrichment
- ϵ: efficiency
- M: detector mass
- t: measurement time
- ΔE: energy resolution
- B: background rate

Goal: $B < 0,001 \, \frac{\text{counts}}{\text{keV} \cdot \text{kg} \cdot \text{year}}$

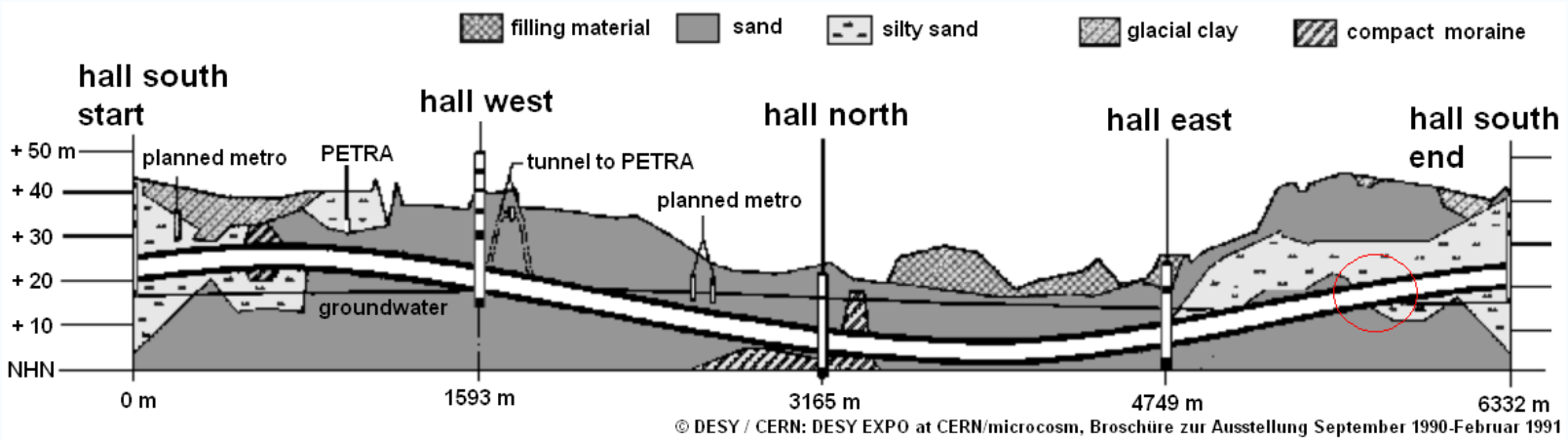
Natural Background in Region of Interest



HERA



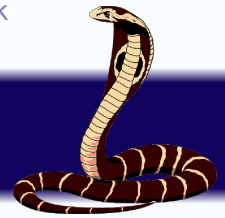
Coverage of the HERA Tunnel



- 16 m sand and 10 m silty sand
- sand and silt are mostly quartz (SiO_2)
  - density: 2,65 g/cm^3
  - 50 % porosities
  - grain size of silt is (0,002 - 0,063) mm and sand (0,063 - 2) mm

$\rightarrow \sim$ 41 meters of water equivalent (mwe)

Setup

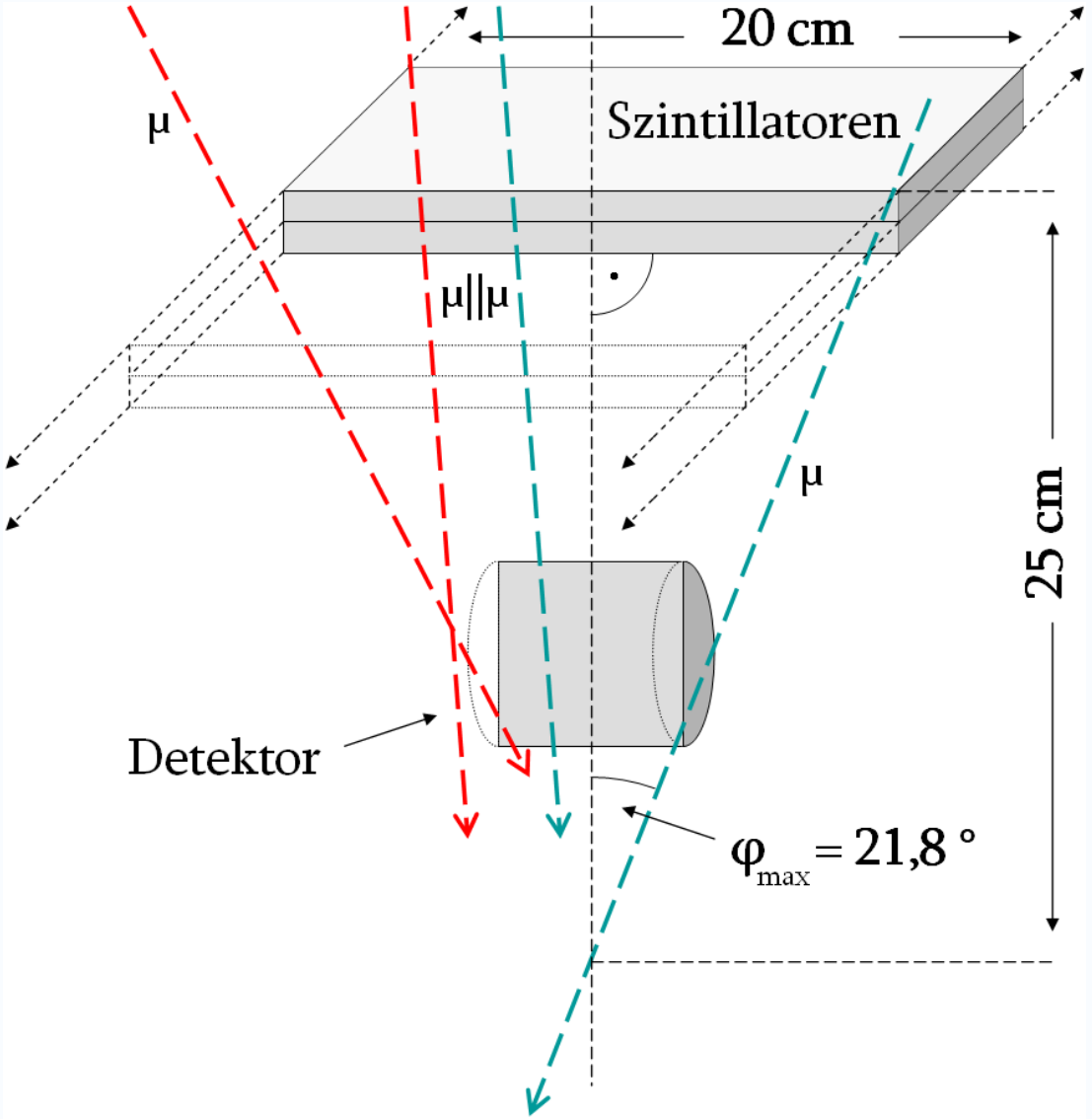


- Ortec GEM Profile Series HPGe Coaxial Detector (GEM30P4-76-S)
- detector mass: 0,8207 kg
- electrically cooled with Ortec X-Cooler II
- Canberra Spectroscopy Amplifier Model 2020 at $0{,}6 \times 30$ gain and 4 μs shaping time
- ORTEC Model 659 5 kV Detector Bias Supply at 4,8 kV
- CAEN 8k Multi-Channel Analyzer Model NIM N957
- peak-to-compton ratio, ^{60}Co: 55
- resolution (FWHM) at 1,33 MeV, ^{60}Co: $(1{,}95 \pm 0{,}05)$ keV

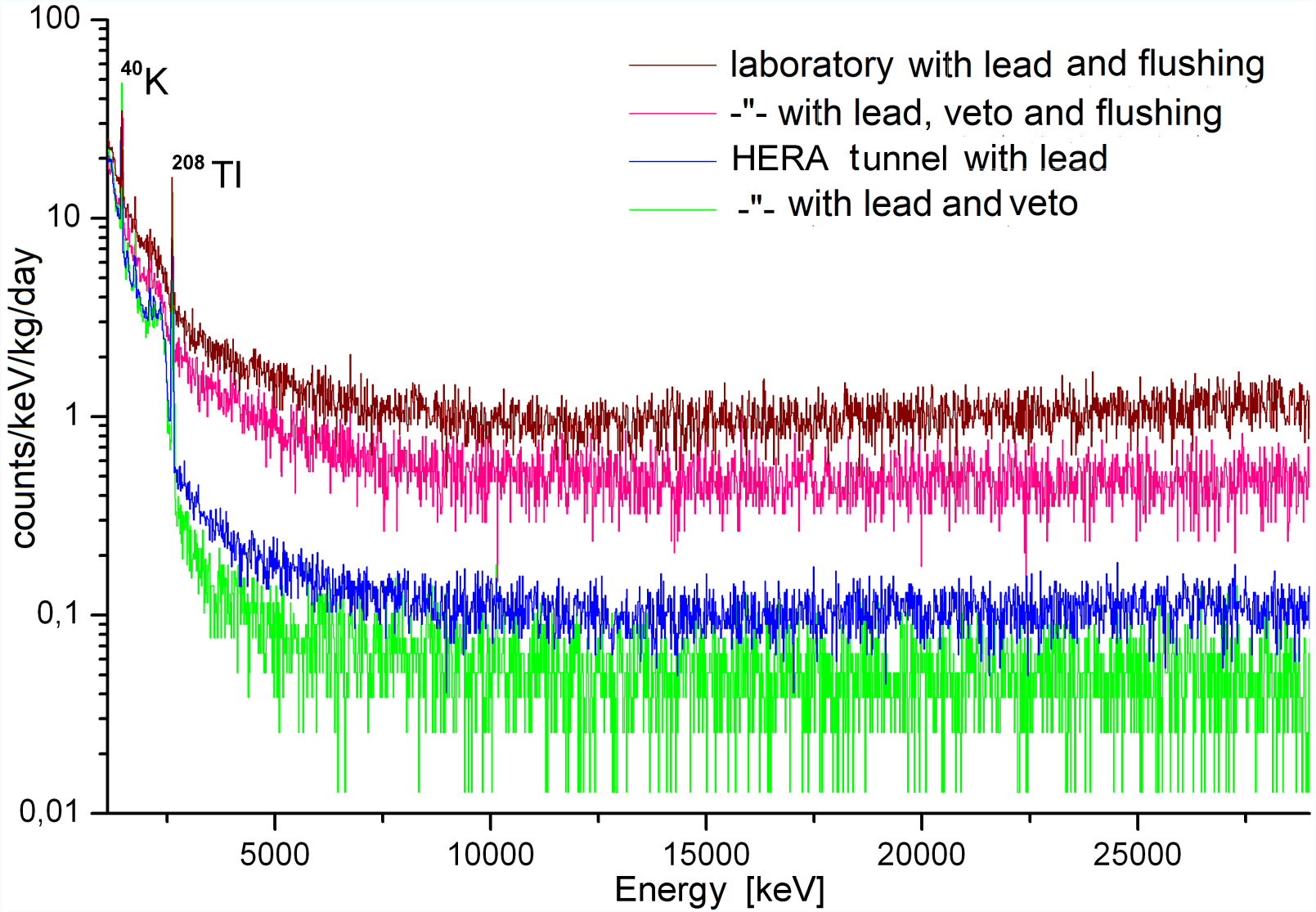
Setup

Myon-Veto with Scintillators

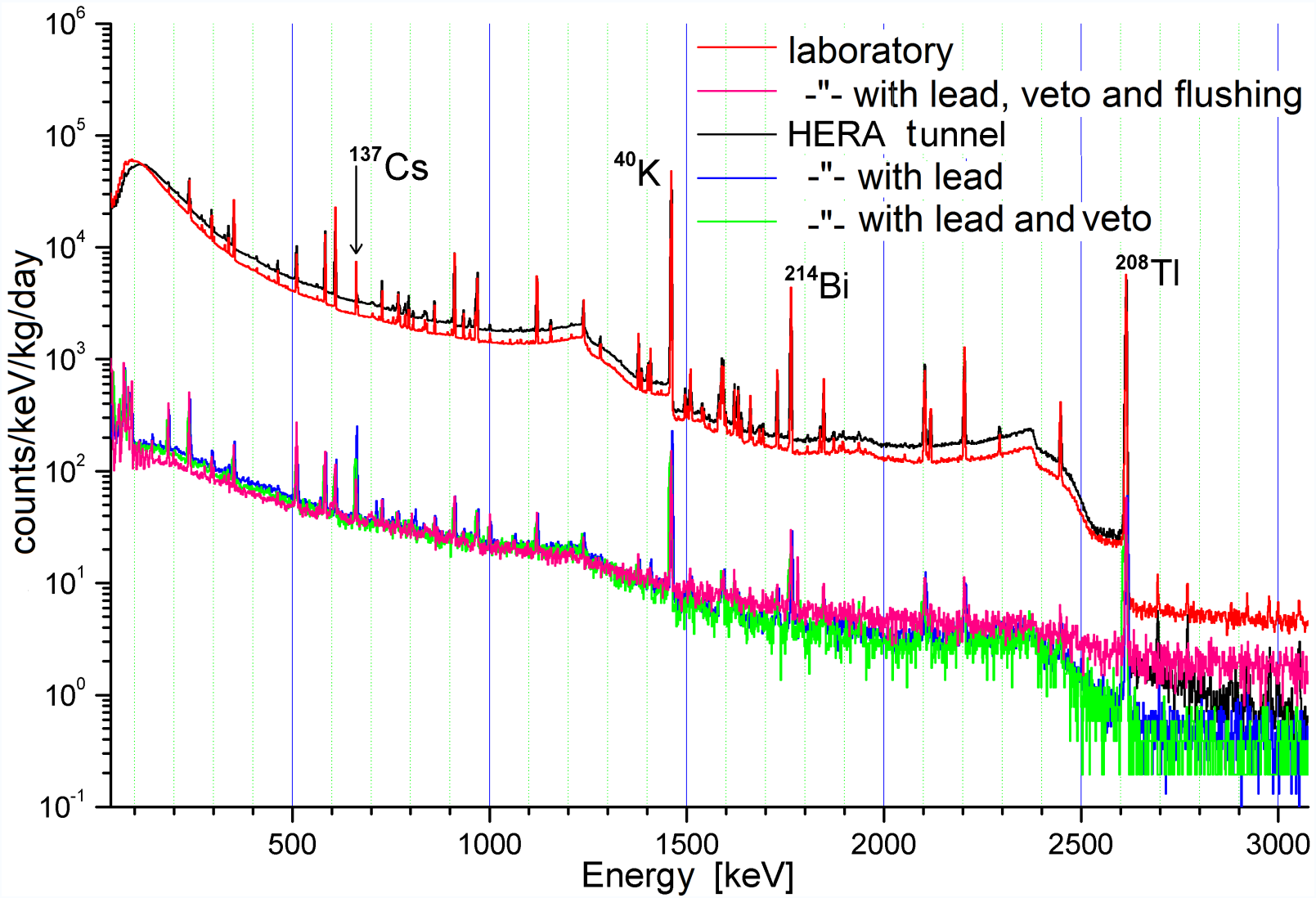
$$\frac{\int_0^{\varphi_{max}} \cos^2\varphi \, d\varphi}{\int_0^{\pi/2} \cos^2\varphi \, d\varphi} \approx 40\,\%$$



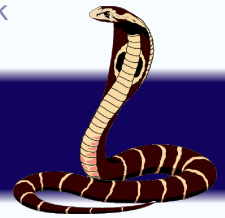
Spectra up to 30 MeV



Spectra up to 3 MeV



Integral Count Rate



location	[counts/kg/s] (0,04 - 2,7) MeV	[counts/kg/keV/day] (2,7 - 3) MeV	(3 - 8,5) MeV
laboratory	$124 \pm 0{,}01$	$5{,}19 \pm 0{,}04$	—
lead and flushing	—	—	$1{,}52 \pm 0{,}01$
lead, veto and flushing	$0{,}986 \pm 0{,}001$	$1{,}79 \pm 0{,}03$	$0{,}88 \pm 0{,}01$
tunnel	$159 \pm 0{,}01$	$1{,}11 \pm 0{,}02$	—
lead	$1{,}1 \pm 0{,}01$	$0{,}48 \pm 0{,}01$	$0{,}153 \pm 0{,}001$
and veto	$1{,}078 \pm 0{,}002$	$0{,}27 \pm 0{,}02$	$0{,}097 \pm 0{,}001$
DLB with veto	0,071	0,025	—
15 mwe			
Felsenkeller without Veto	0,034	—	—
110 mwe			

Summary and Outlook

Summary

- the Hera tunnel offers a coverage of 40 mwe
- 10% more integral activity up to 3 MeV in comparison to laboratory
  - basically due to 50% more of thorium decay chain
- no more radon in comparison with the laboratory

Outlook

- the HERA tunnel offers possibility to
  - supporting material screening
  - storage of materials

End

Thanks
for
your attention!