Gamma background studies in 45m and 150m deep mines
Background in gamma detector studied in 45m and 150m deep mines
Gamma background studies in 45m and 150m deep mines

1) The science case for new underground accelerators

2) Sites investigated

3) High energy ($E_\gamma > 3\text{MeV}$) background components

4) Experimental results and intercomparison

5) Felsenkeller-accelerator

6) Scientific outlook
Stable-beam, stable-target accelerators: Why are they needed, why underground?

- Very low cross section at the relevant energies for hydrostatic stellar burning.
- Thus, very low signal counting rate in a detector, thus very sensitive to background.
- Thus, very long running time (1-3 years per nuclear reaction).

Charged particle induced reactions

- High-intensity, low beam energy accelerator
- Ultra-low background environment, deep underground.
- LUNA 0.4 MV accelerator in Italy = a success story! (previous talk by Francesca Cavanna next talk by Axel Boeltzig)
NuPECC Long Range Plan 2010-2020:

“An immediate, pressing issue is to select and construct the next generation of underground accelerator facilities. (...) There are a number of proposals being developed in Europe and it is vital that construction of one or more facilities starts as soon as possible.”

Gamow peak for selected stable-ion reactions:

- $^3\text{He}(\alpha,\gamma)^7\text{Be}$, $T_g=0.01$
- $^{14}\text{N}(\alpha,\gamma)^{18}\text{F}$, $T_g=0.15$
- $^{22}\text{Ne}(\alpha,n)^{25}\text{Mg}$, $T_g=0.35$
- $^{12}\text{C}(^{12}\text{C},p)^{23}\text{Na}$, $T_g=0.5$

LUNA 0.4 MV
- Solar fusion
- Big-Bang nucleosynthesis
- Hydrogen burning

New underground accelerators
- Solar fusion
- Big-Bang nucleosynthesis
- Helium burning
- Carbon burning
- $^{44}\text{Ti}$ production and destruction
Gamma background studies in 45m and 150m deep mines

1) The science case for new underground accelerators

2) Sites investigated

3) High energy ($E_\gamma > 3$MeV) background components

4) Experimental results and intercomparison

5) Felsenkeller-accelerator

6) Scientific outlook
Dresden Felsenkeller, below 45 m of rock

- $\gamma$-counting facility for analytics, established 1982
- Deepest underground $\gamma$-counting lab in Germany
- Contract enabling scientific use (since 2009)
- 4 km from TU Dresden and from city center
- 25 km from HZDR campus
Reiche Zeche mine / Freiberg / Germany (Measurement at 150 m depth)

- Silver mine founded in 1168
- Recently a Teaching, Research and Visitor Mine
- TU Bergakademie Freiberg
Gamma background studies in 45m and 150m deep mines

1) The science case for new underground accelerators

2) Sites investigated

3) High energy ($E_\gamma > 3\text{MeV}$) background components

4) Experimental results and intercomparison

5) Felsenkeller-accelerator

6) Scientific outlook
Source of the high energy background

Signals in a gamma detector

- Direct ionisation:
- continuous energy deposit up to 100MeV
- Inelastic scattering; continuous energy deposit of several tens of MeV
- Inelastic scattering; continuous energy deposit of several tens of MeV
- Neutrons up to max 5-8MeV but mainly thermalized neutrons
- Elastic, inelastic scattering, and nuclear reactions producing max. ~10MeV $\gamma$-rays
GEANT4 simulation of the signal of the cosmic-ray components in HPGe detectors

- Overground the soft component dominates below 10 MeV
- This component becomes negligible if a 15 cm thick lead shield is applied
What if active shielding is applied?

### Veto factors

- **200-300**
- **50-80**
- **No effect**
Gamma background studies in 45m and 150m deep mines

1) The science case for new underground accelerators

2) Sites investigated

3) High energy ($E_\gamma > 3\text{MeV}$) background components

4) Experimental results and intercomparison

5) Felsenkeller-accelerator

6) Scientific outlook
Background, in a typical HPGe detector in the Felsenkeller (45 m)

- Combination of active veto and 45m of rock shielding gives a factor of 500 background reduction

- Final value close to deep-underground background

T. Szücs et al, EPJA 48, 8 (2012)
Background, in the same HPGe detector in Reiche Zeche (150 m)

- One and the same HPGe detector (Eurisys Clover with active veto)
- At a depth of 150 m, the background rate at 6-8 MeV γ-ray energy is consistent with the deep underground one

Gamma background studies in 45m and 150m deep mines

1) The science case for new underground accelerators

2) Sites investigated

3) High energy ($E_\gamma > 3$ MeV) background components

4) Experimental results and intercomparison

5) Felsenkeller-accelerator

6) Scientific outlook
Why not place an accelerator in Felsenkeller?

- Industrial area
  (former Felsenkeller brewery)
- Tunnels driven in the 1850s into the wall of a former quarry
- Additional space available underground
5 MV Pelletron from York/UK
- High voltage tank opened
- Pellet chains dismounted and cleaned
- High voltage terminal dismounted
- Control software under re-development

Radio frequency ion source, to be installed on high voltage terminal
- Commercial NEC RF ion source
- Working plasma discharge
- Tests show successful extraction of 80 µA ion current
- Electrostatic deflector for coupling RF ion source to beam line under development

MC-SNICS 134 sputter ion source
- 100 µA C⁻ beam
- 100 µA H⁻ beam
- No useful He⁻ beam
- Has worked well for 12 years
Gamma background studies in 45m and 150m deep mines

1) The science case for new underground accelerators

2) Sites investigated

3) High energy ($E_\gamma > 3$ MeV) background components

4) Experimental results and intercomparison

5) Felsenkeller-accelerator

6) Scientific outlook
Felsenkeller accelerator: access, use, program

Collaboration between HZDR and TU Dresden
- Kai Zuber (TU Dresden)
- Daniel Bemmerer (HZDR)
- Independent scientific advisory board to advise on program, users, and development

Planned use
- In-house research by HZDR and TU Dresden
  - Solar fusion
    - Day one experiment $^{14}\text{N}(p,\gamma)^{15}\text{O}$
  - Carbon burning
    - Day two experiment $^{12}\text{C}^{(12}\text{C},p)^{23}\text{Na}$
- Proposals are welcomed

Solar fusion

Carbon burning

s-process neutron sources
Thank you for your attention!