# Gamma background studies in 45m and 150m deep mines

Nuclear Astrophysics Virtual Institute

TECHNISCHE UNIVERSITÄT DRESDEN

Partner von DRESDEN concept exzellenz-dresden.de

HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

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# Background in gamma detector studied in 45m and 150m deep mines

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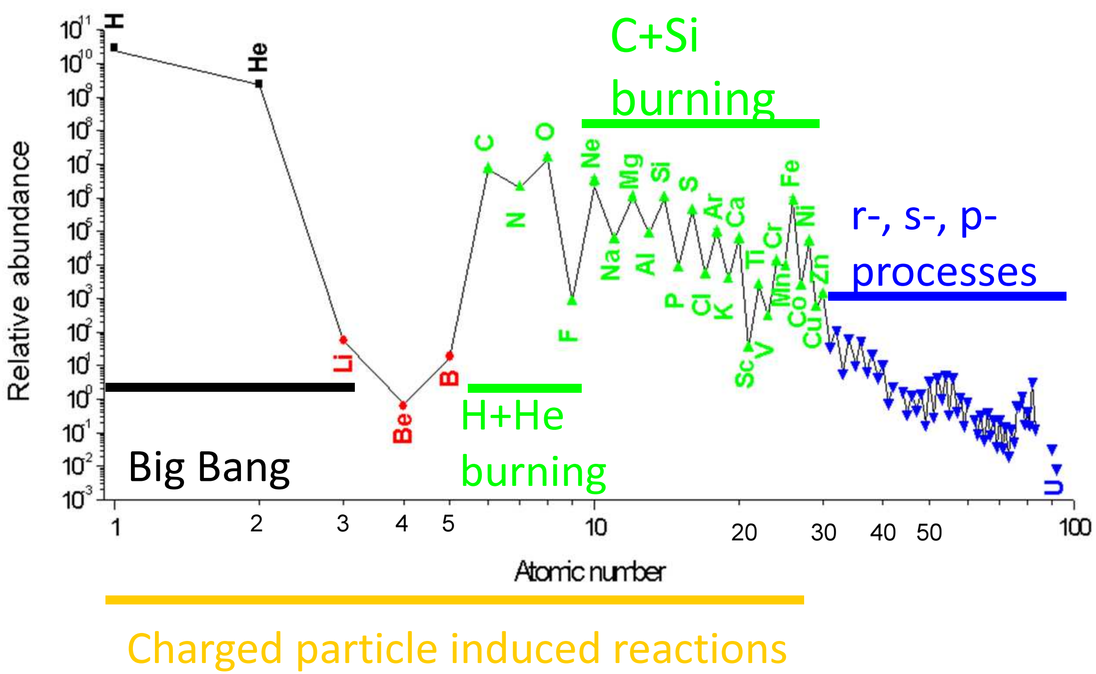
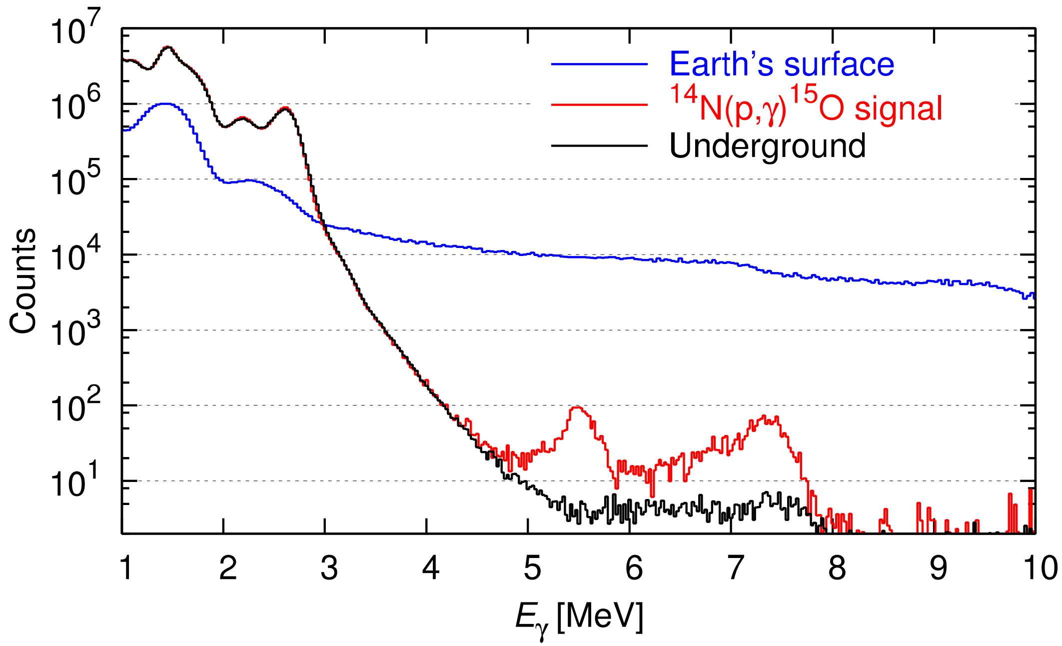
1) The science case for new underground accelerators
2) Sites investigated
3) High energy ($E_\gamma$>3MeV) background components
4) Experimental results and intercomparison
5) Felsenkeller-accelerator
6) Scientific outlook

# Stable-beam, stable-target accelerators: Why are they needed, why undergound?




- 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)

- 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)

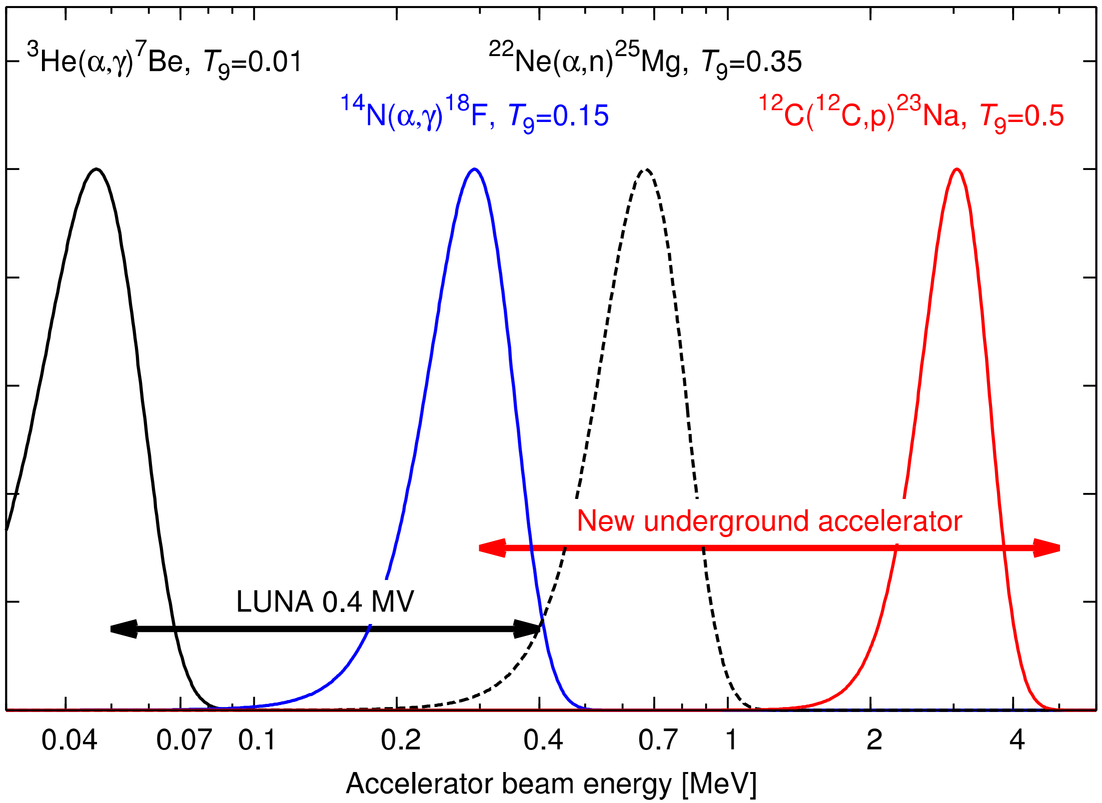


# LUNA 0.4 MV accelerator and higher-energy accelerators

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:




LUNA 0.4 MV

- Solar fusion
- Big-Bang nucleosynthesis
- Hydrogen burning

New underground accelerators

- Solar fusion
- Big-Bang nucleosynthesis
- Helium burning
- Carbon burning
- $^{44}$Ti production and destruction

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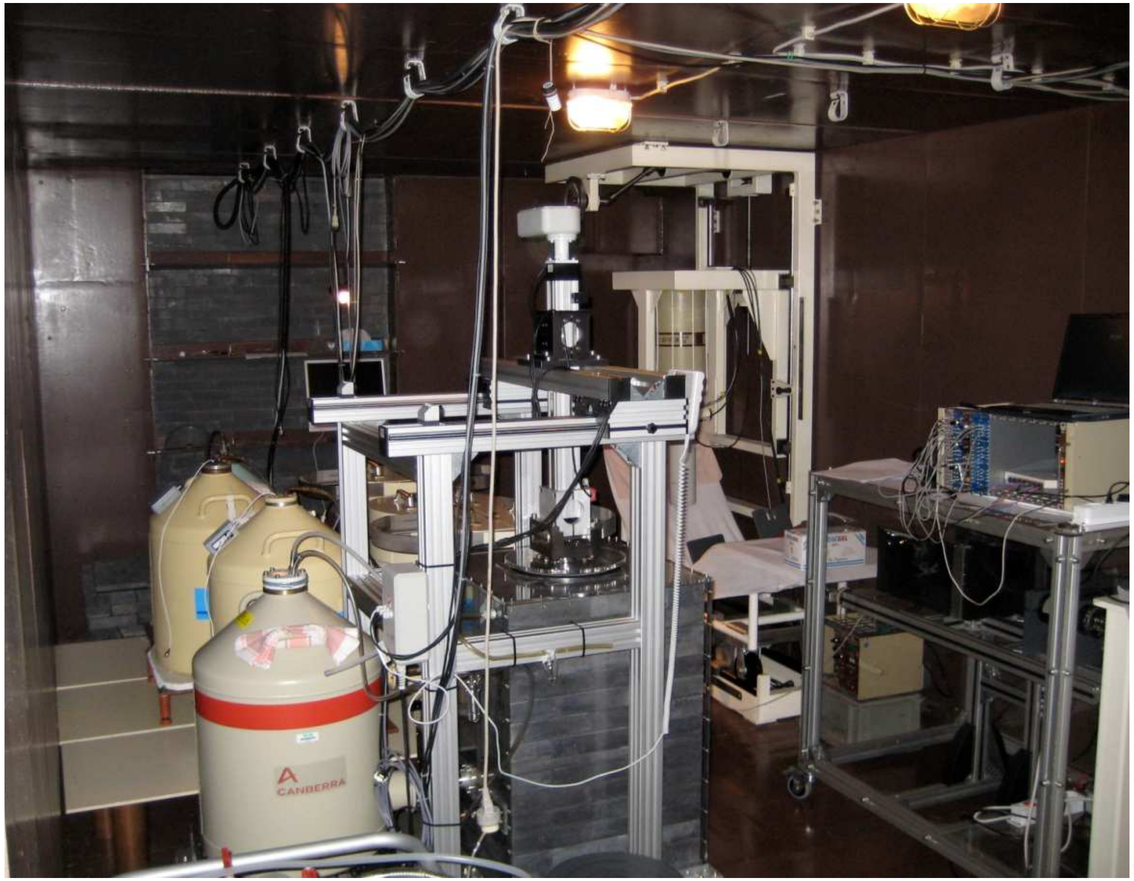
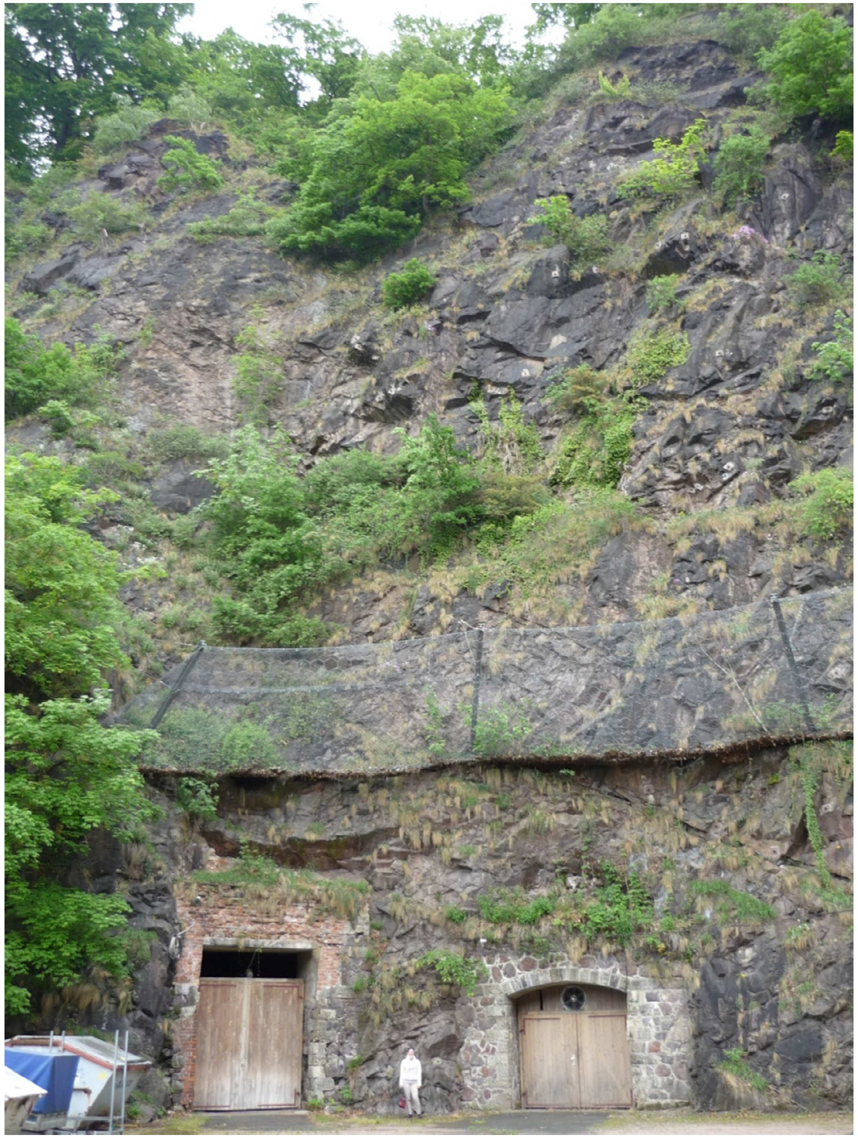
# Dresden Felsenkeller, below 45 m of rock

- $\gamma$-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

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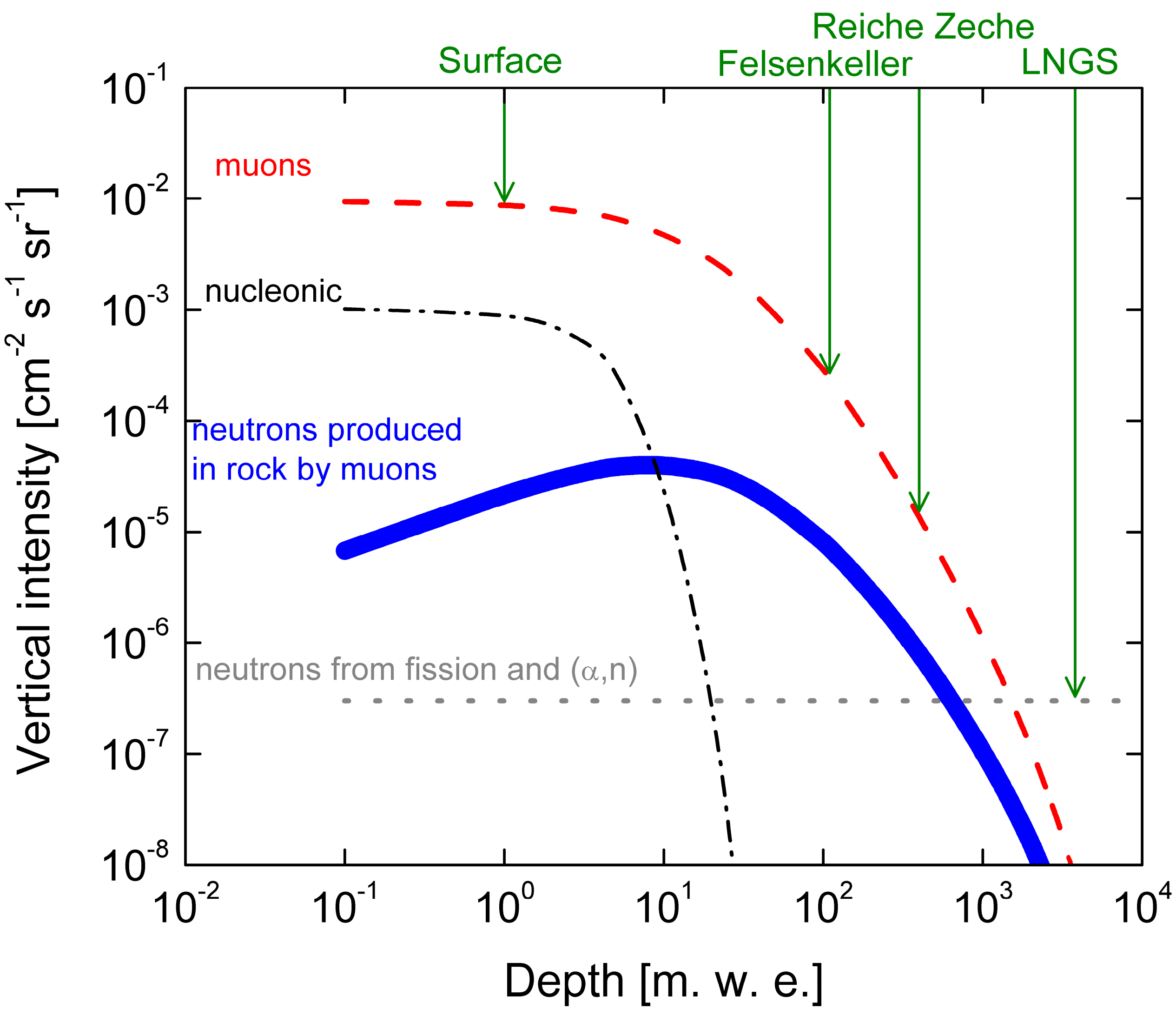
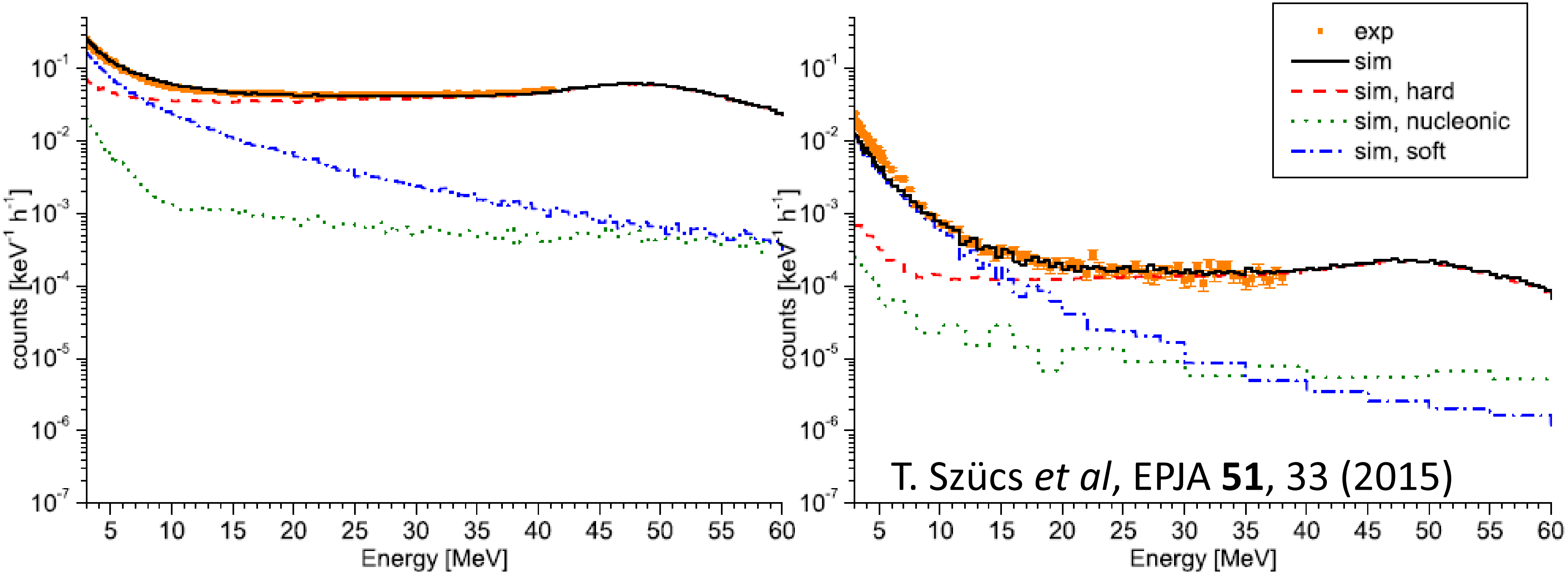
# Source of the high energy background




## Signals in a gamma detector

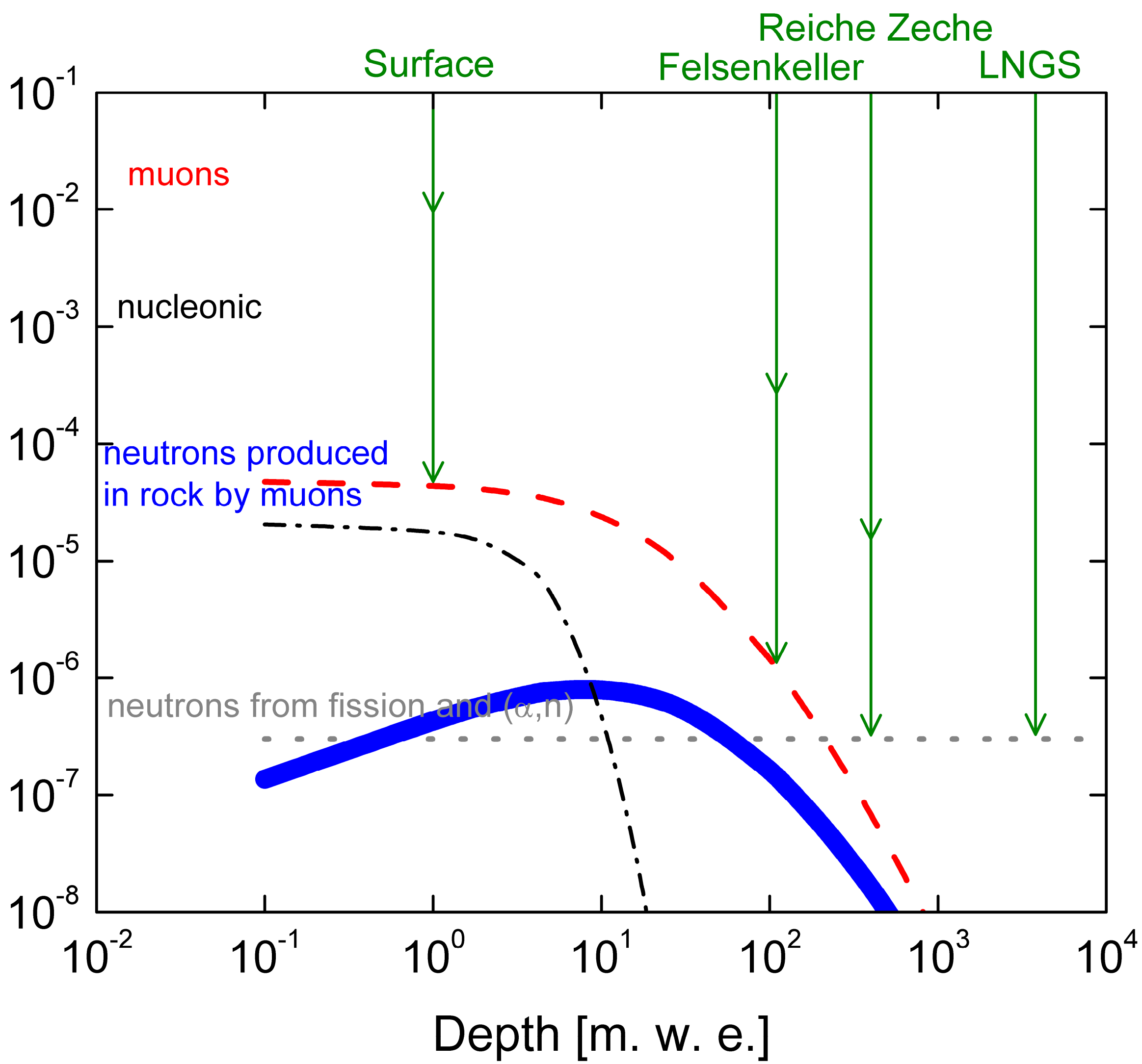
- Direct ionisation:
- continuous energy deposit
- up to 100MeV
- Inelastic scattering; continuous energy deposit of several tens of MeV
- Inelastic scattering; continuous energy deposit of several tens of MeV
- Neutrons up to max 5-8MeV but mainly thermalized neutrons
- Elastic, inelastic scattering, 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
- 50-80
- No effect

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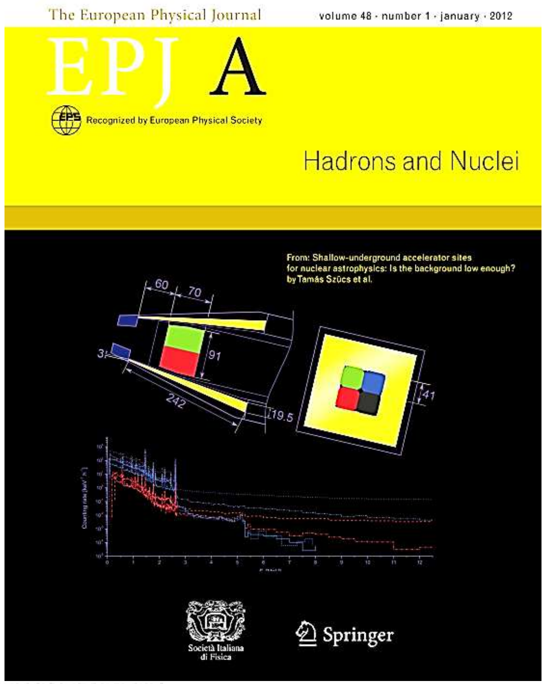
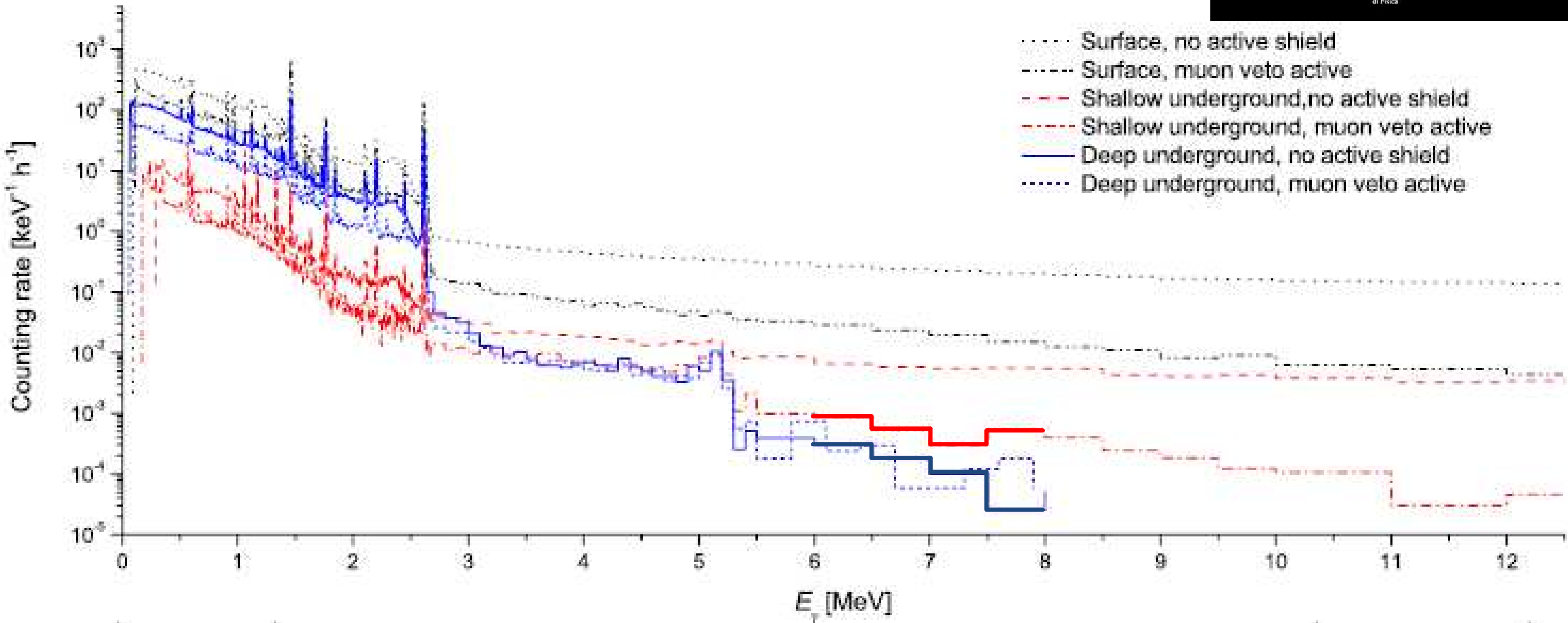
# Background, in a typical HPGe detector in the Felsenkeller (45 m)

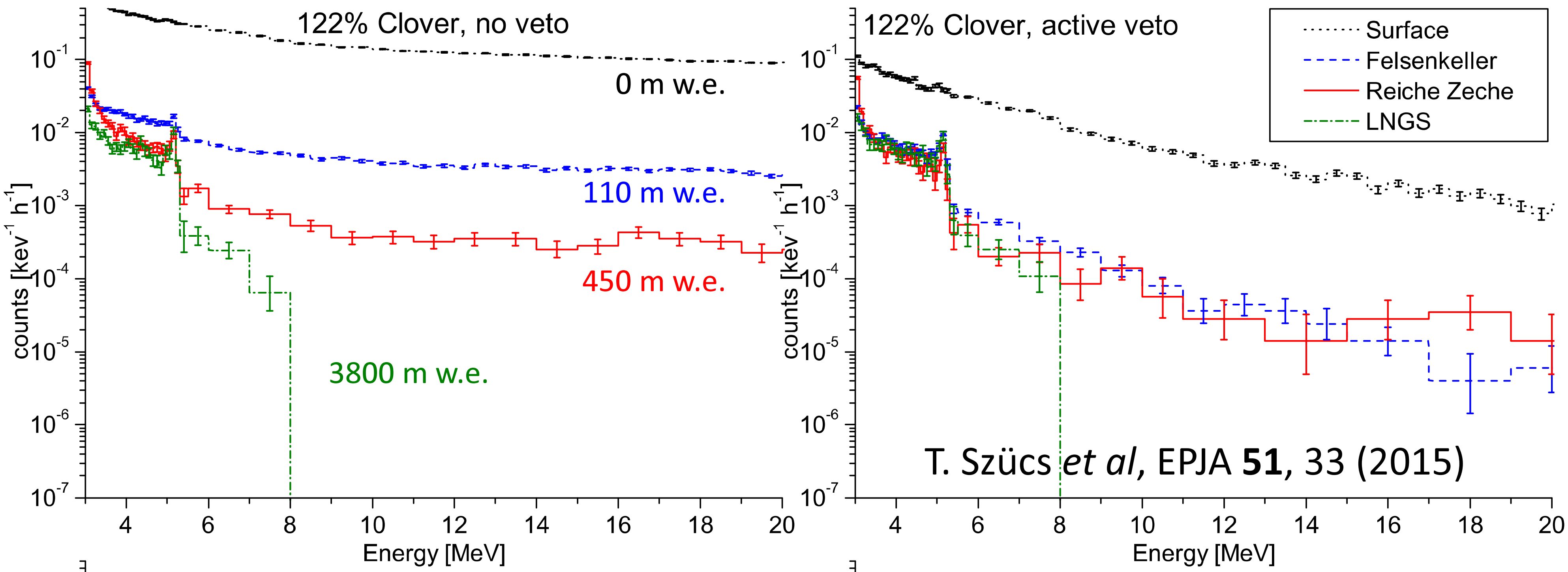
- Combination of active veto and 45m of rock shielding gives a factor of 500 background reduction

- 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

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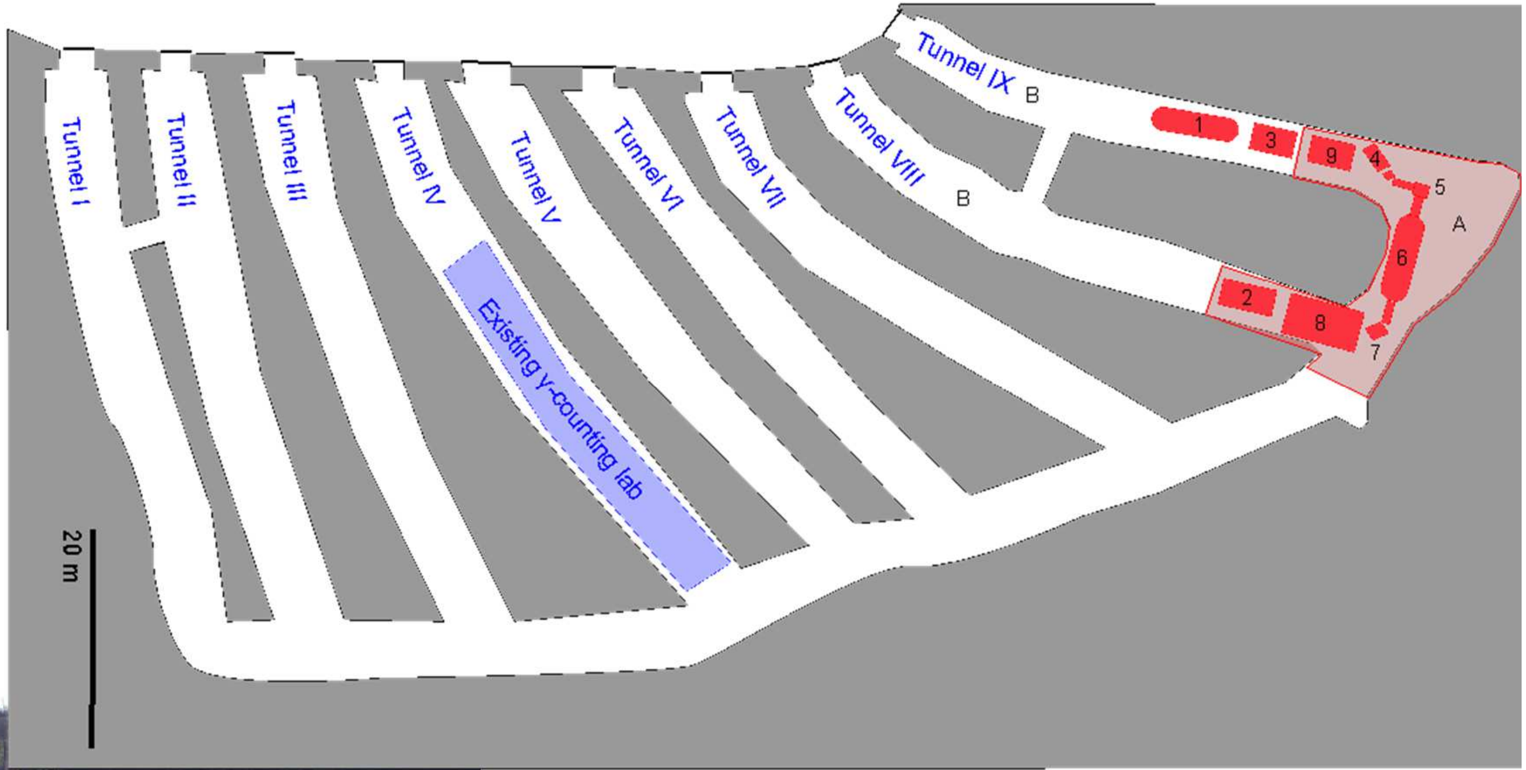
# Why not place an accelerator in Felsenkeller?






- Industial area
  (former Felsenkeller brewery)
- Tunnels driven in the 1850s into the wall of a former quarry
- Additional space available underground

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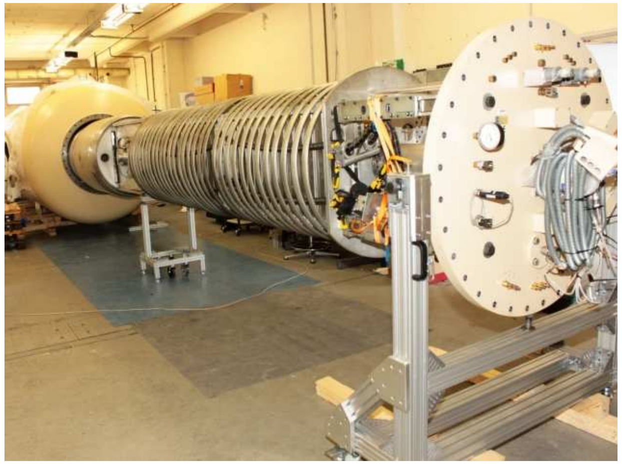
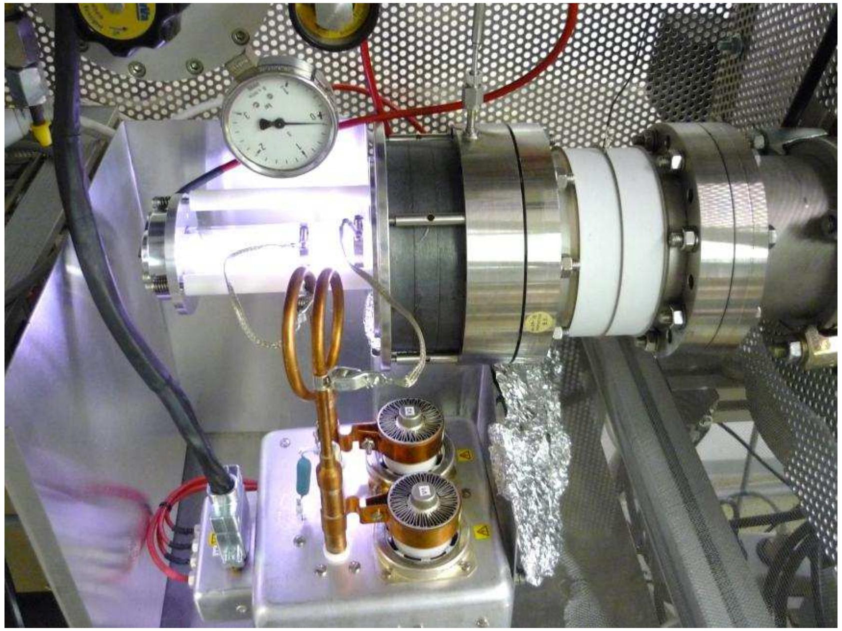
# 5 MV Pelletron from York/UK

- High voltage tank opened
- Pellet chains dismounted and cleaned
- High voltage terminal dismounted
- Control software under re-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

## 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

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# Felsenkeller accelerator: access, use, program

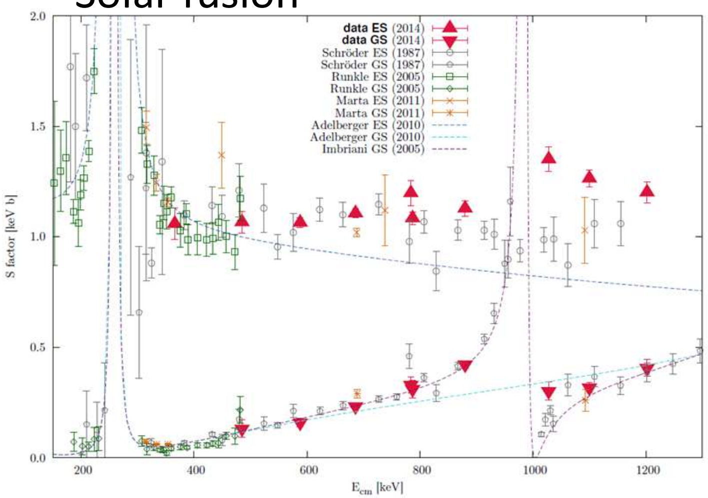
Collaboration between HZDR and TU Dresden

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

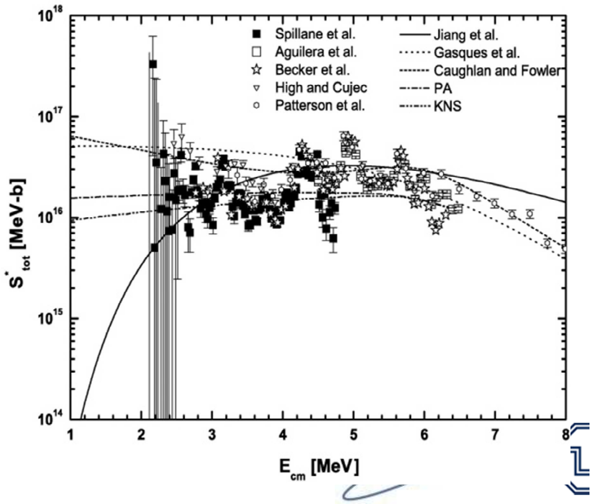
Planned use

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

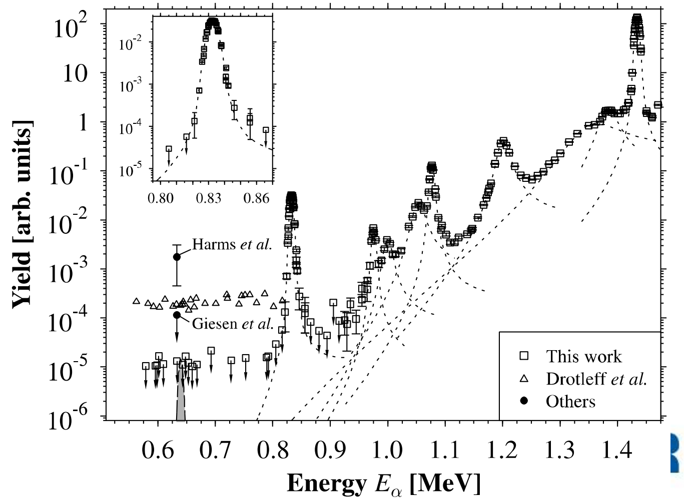
Solar fusion




Carbon burning




s-process neutron sources



Thank you for your attention!