



Transnational access within the ChETEC project

University of Cologne

Andreas Zilges / Felix Heim

Department of Physics

... in future

Built in 2014

Under construction



Institute for Nuclear Physics

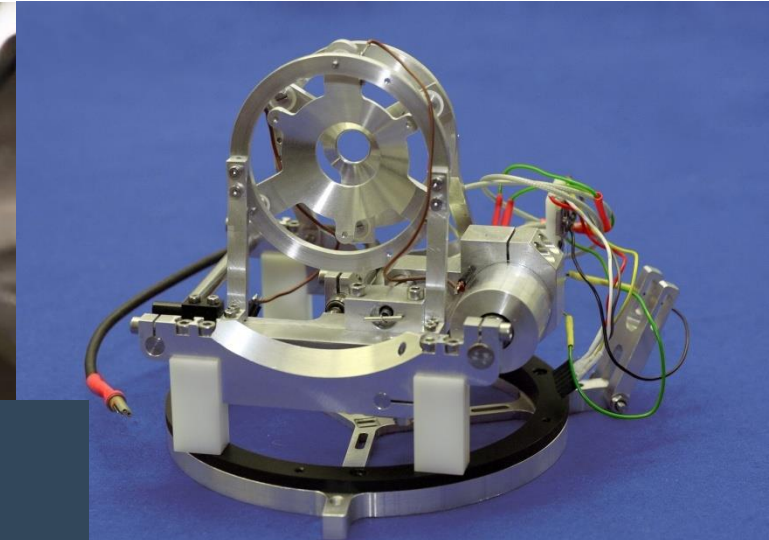
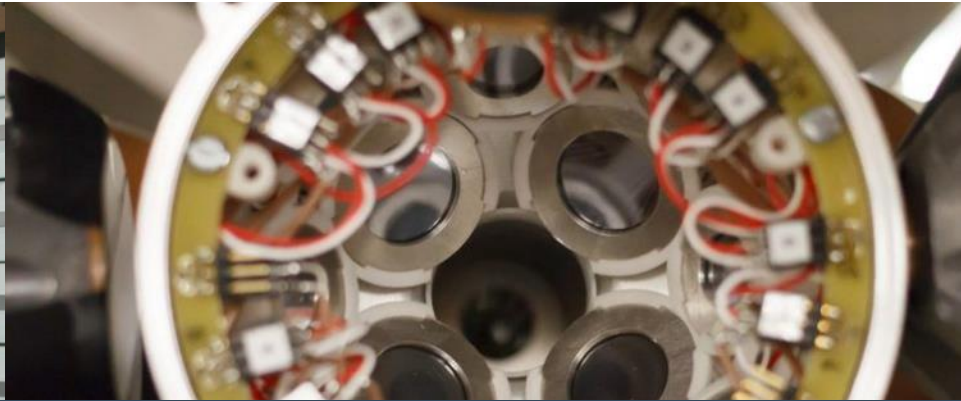
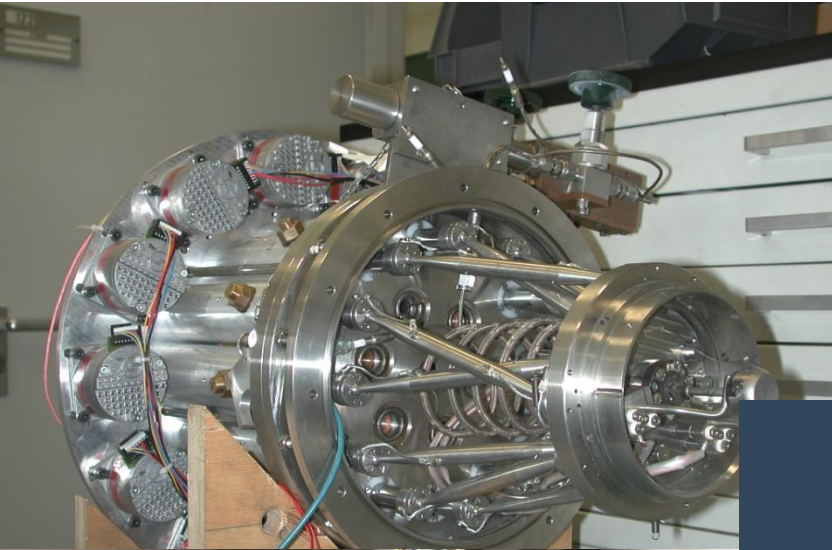
Groups:

- Prof. Jan Jolie
- Prof. Peter Reiter
- Prof. Andreas Zilges
- Prof. N.N. (AMS)
- Prof. N.N. (GSI)

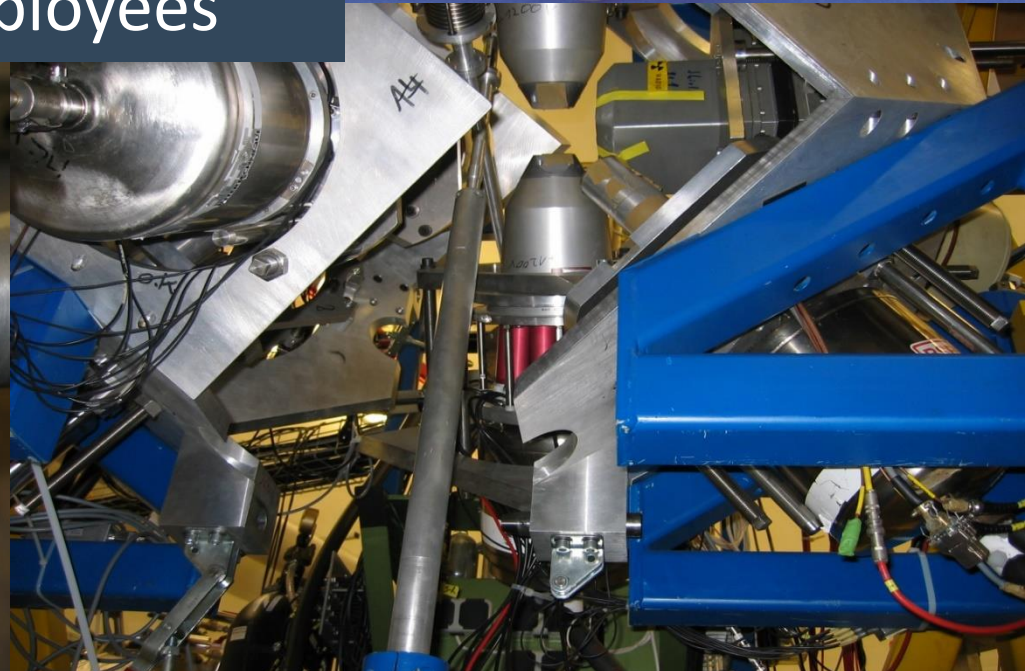
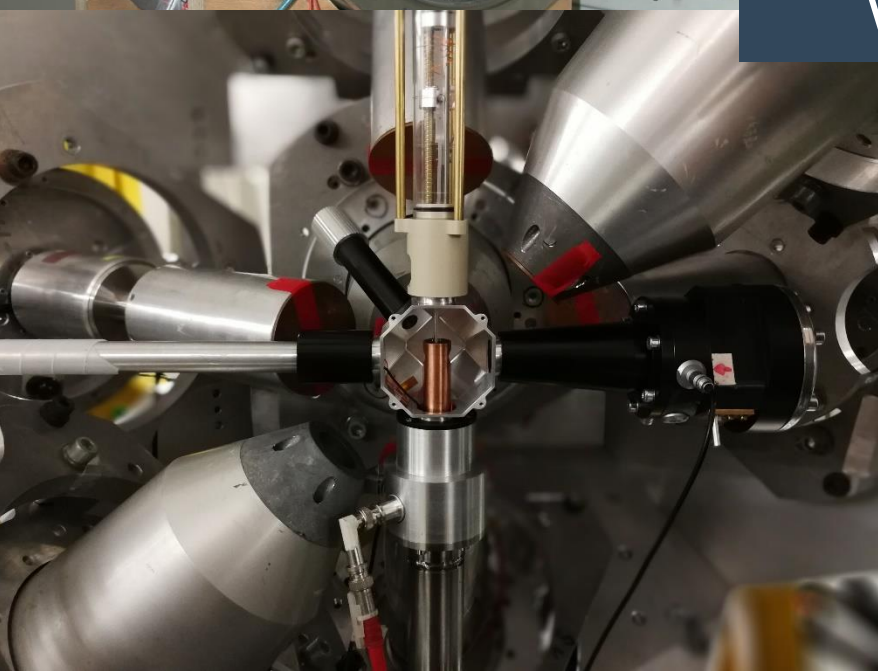
Scientific staff:

- 4 Senior scientists (including 1 lecturer)
- 6 Postdocs
- Around 25 doctoral students
- 20-30 Bachelor and Master students
- 18 technicians (workshop and accelerators)
- 3 administrative staff

Mechanical Workshop



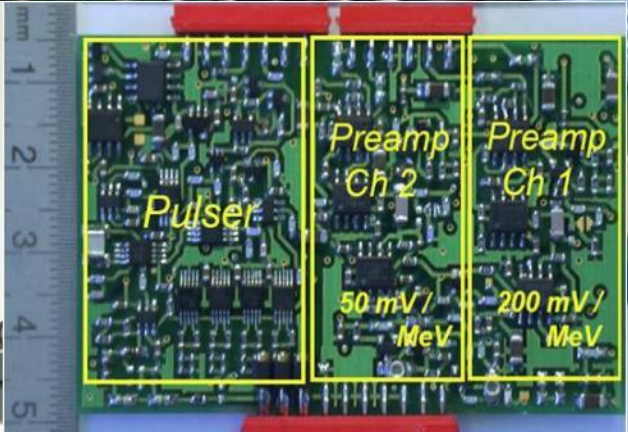
Fully equipped mechanical workshop with 15 employees



Electronics workshop



Electronics development workshop

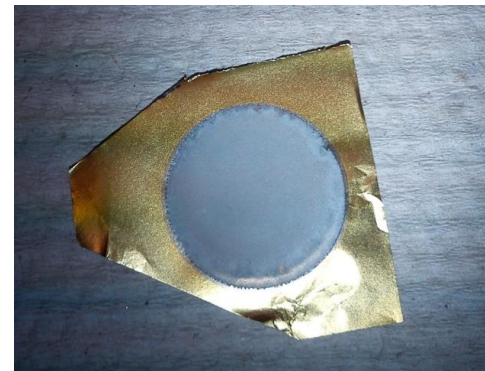
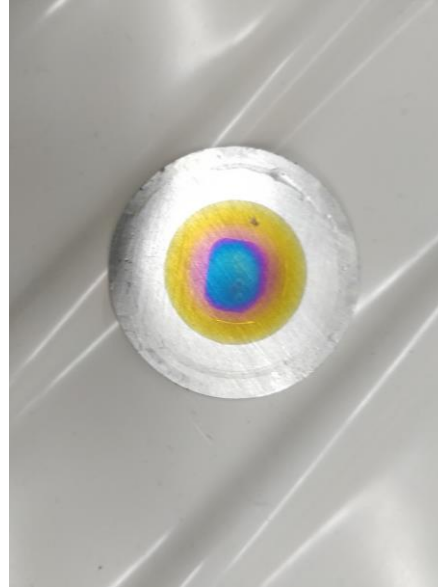


Target laboratory

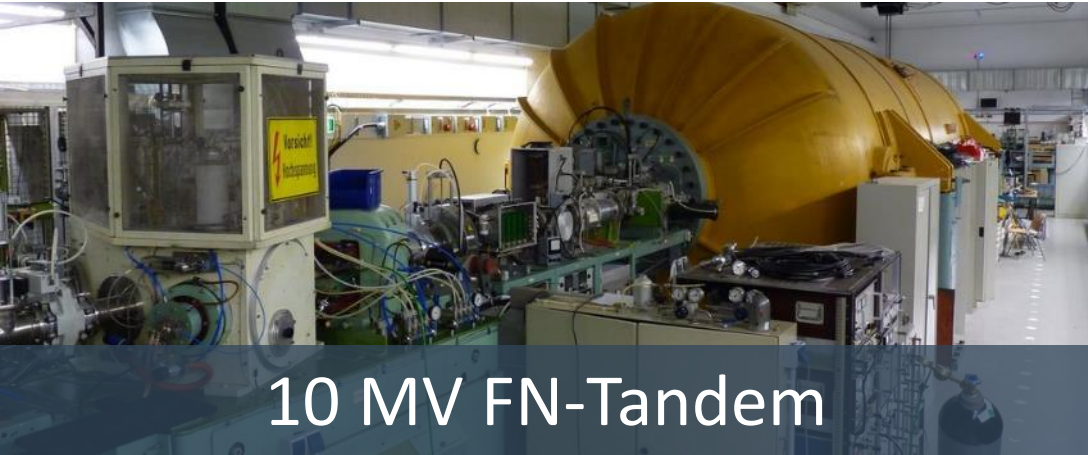
In-house target production via:

- Electrolysis
- Evaporation
- Rolling of self-supporting foils

Target laboratory



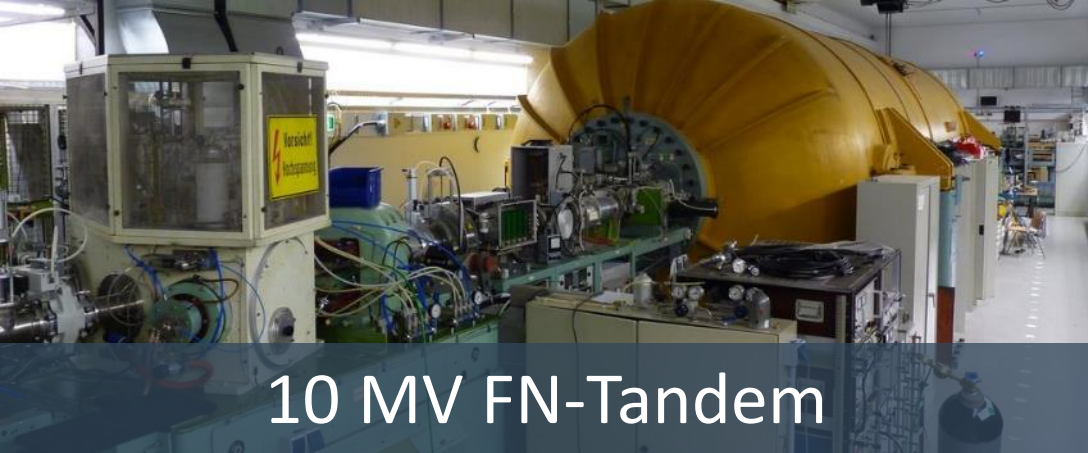
Accelerators @ Cologne



- Up to 10 MV terminal voltage
- Two ion sources:
 - Duoplasmatron (p, ^3He , ^4He)
 - Sputter source (up to $A=127$)
- Beam intensities:
 - 800 nA (p)
 - 200 nA (^4He)

- Operational since 2011
- 6 MV terminal voltage
- Standard isotopes: ^{10}Be , ^{14}C , ^{26}Al , ^{36}Cl , (^{244}Pu)
- Commissioning for p, ^4He pending

Accelerators @ Cologne



10 MV FN-Tandem

- Up to 10 MV terminal voltage
- Two ion sources:
 - Duoplasmatron ($p, {}^3\text{He}, {}^4\text{He}$)
 - Sputter source (up to $A=127$)
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Virtual tour

(<https://www.ikp.uni-koeln.de/apps/tour/fn/>)



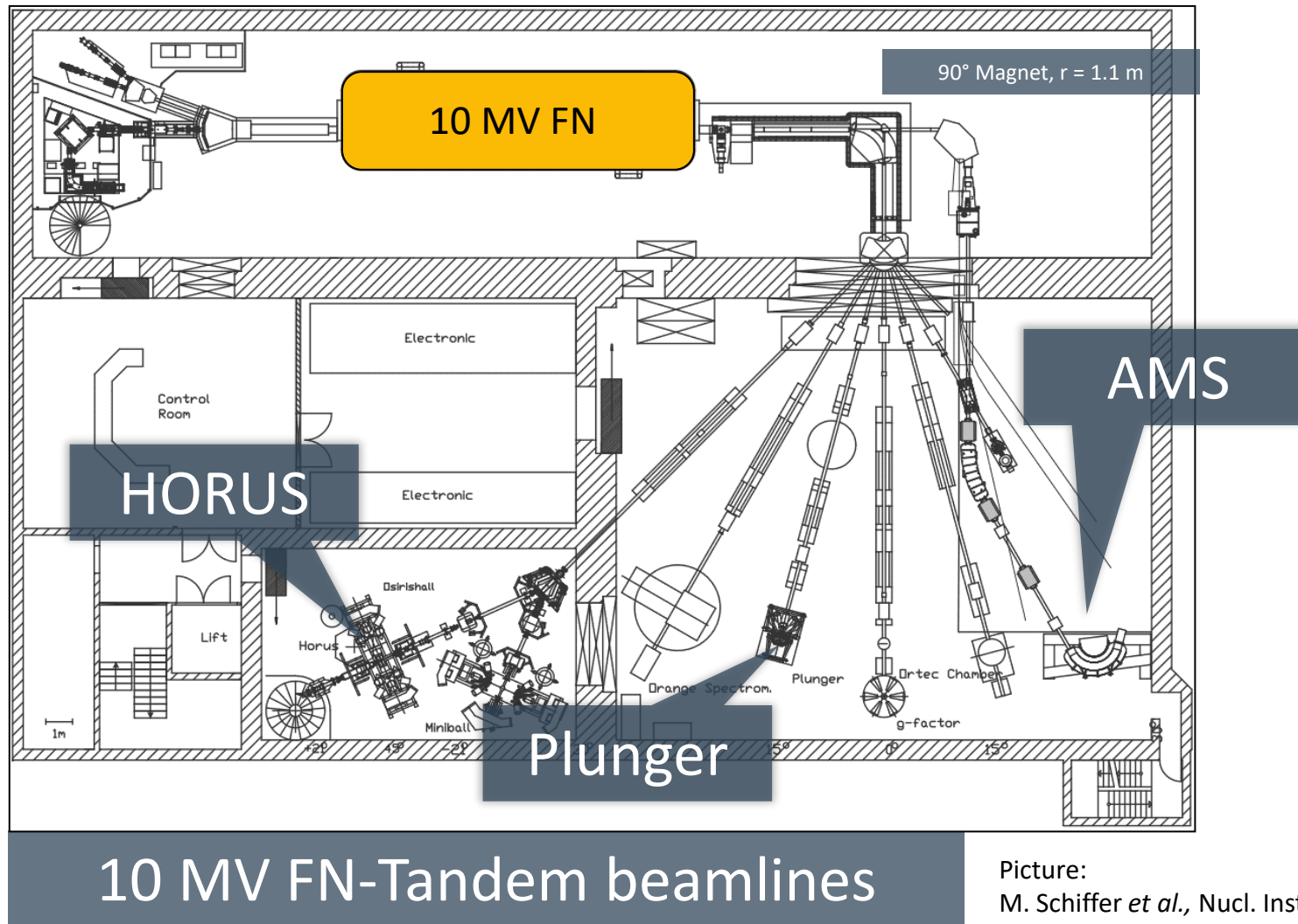
10 MV Tandem accelerator



10 MV FN-Tandem beamlines

- Different beam lines for different experimental setups available
- Most frequently used:
 - Plunger setup for lifetime measurements
 - HORUS γ -ray spectrometer for nuclear structure and nuclear astrophysics

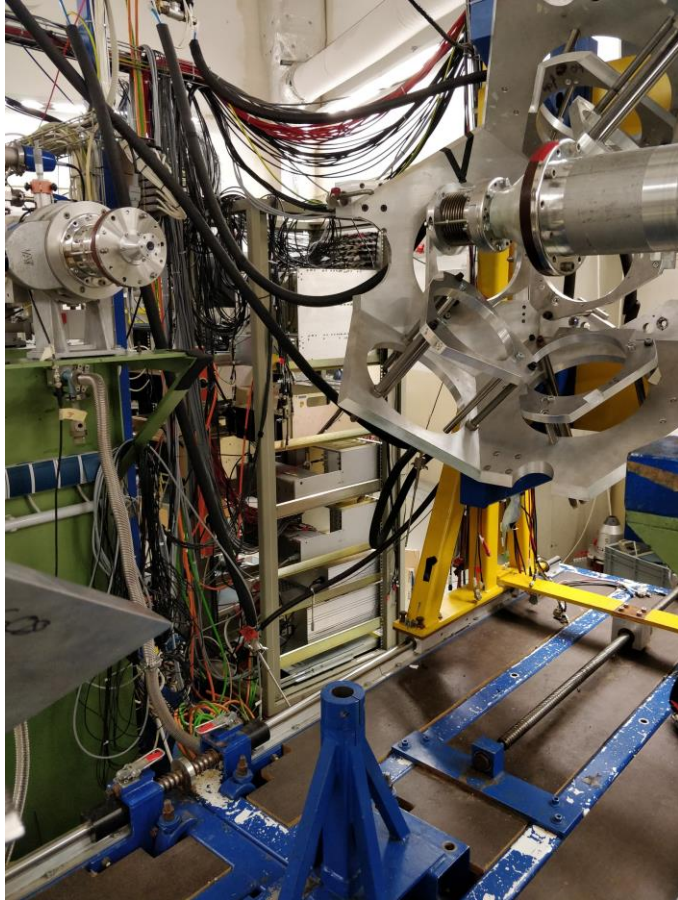
10 MV Tandem accelerator



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Picture:
M. Schiffer *et al.*, Nucl. Inst. Meth. Phys. Res. B **361** (2015) 95

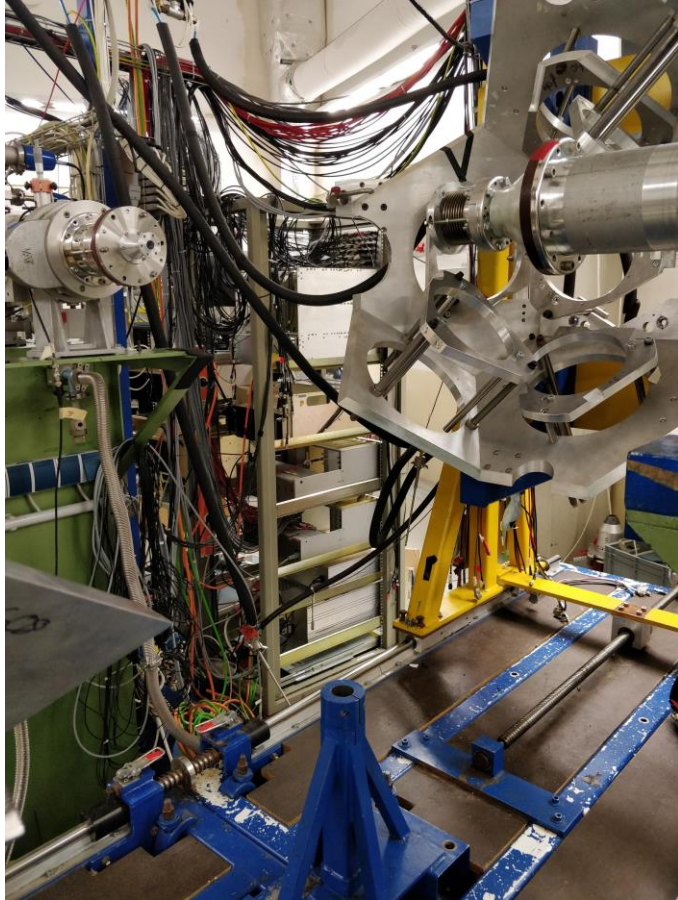
HORUS γ -ray spectrometer



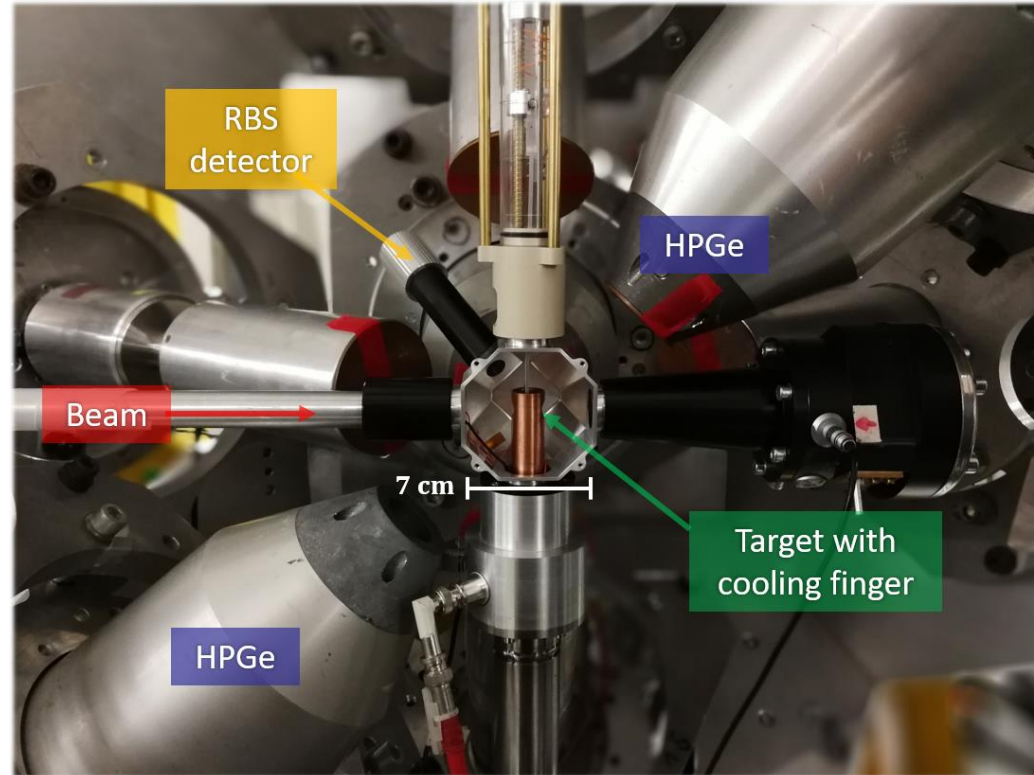
HORUS

- 14 HPGe detectors
 - Resolution $\approx 2\%$ @ 1.3 MeV
 - Total efficiency $\approx 2-4\%$ @ 1.3 MeV
- 5 different angles with respect to the beam axis for angular distribution measurements
- BGO shields for 6 detectors
- $\gamma\gamma$ -coincidence measurements
- Various target chambers can be mounted inside of HORUS

HORUS γ -ray spectrometer



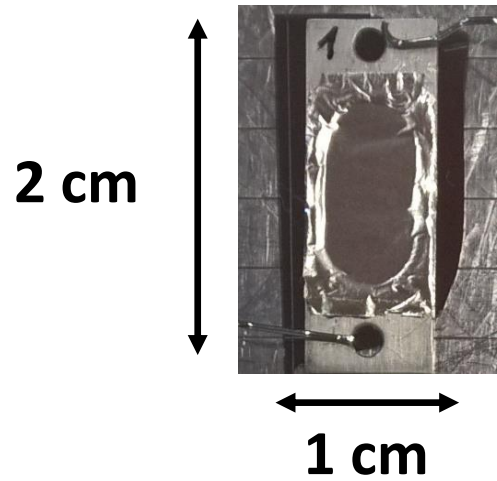
HORUS



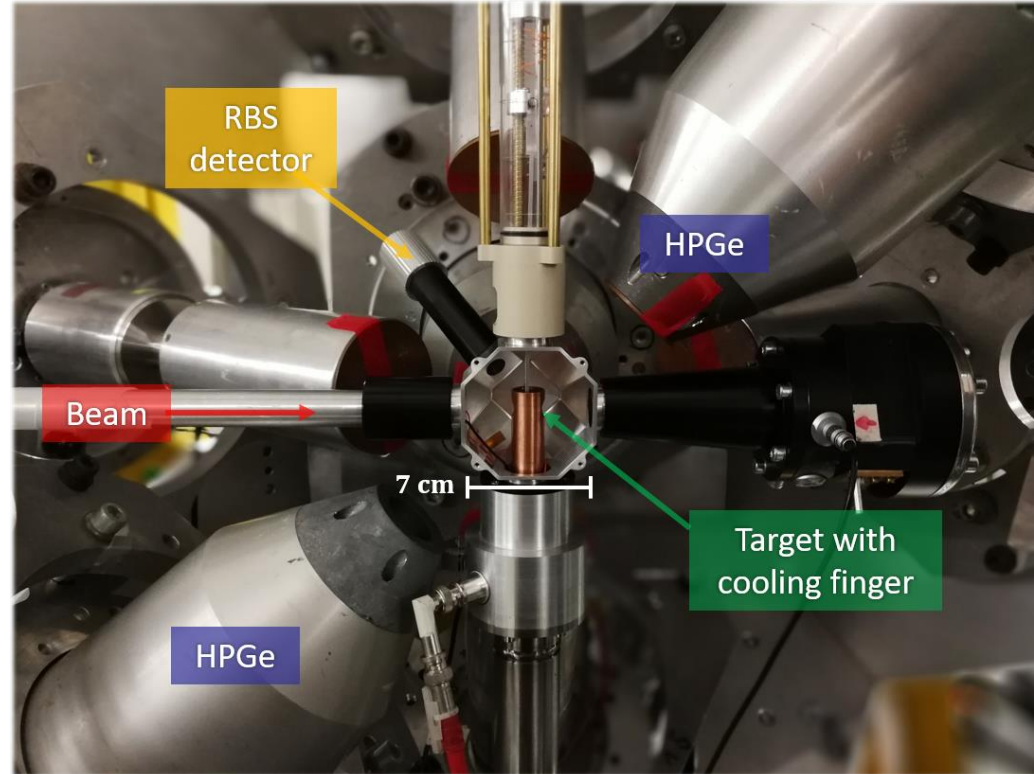
Nuclear astrophysics

- Compact dimension
- Absolute beam current measurements

HORUS γ -ray spectrometer



Foil thickness:
 $100 \mu\text{g}/\text{cm}^2$ - $1500 \mu\text{g}/\text{cm}^2$

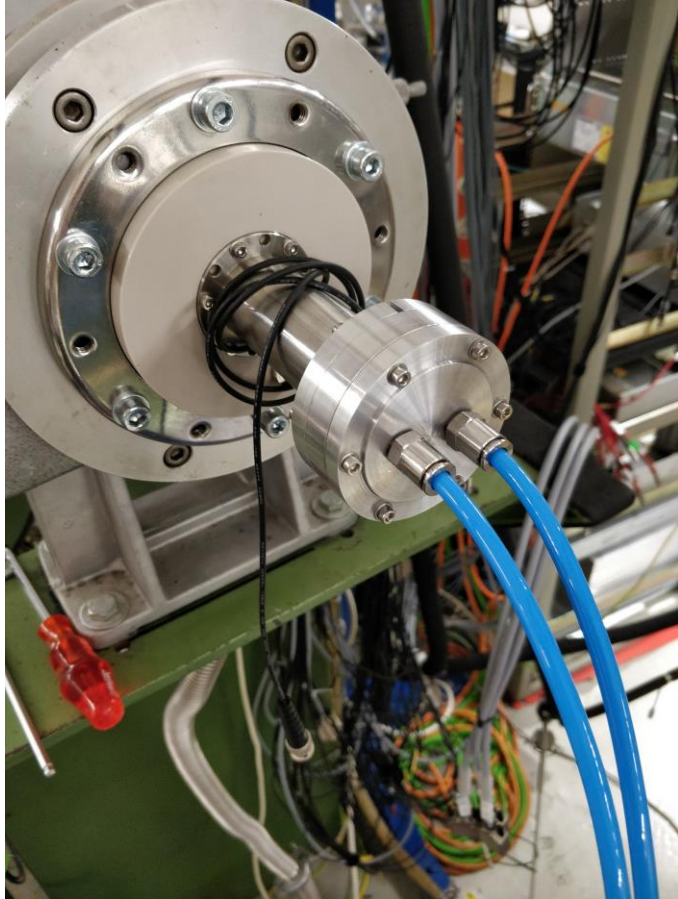


Target mounting

Nuclear astrophysics

- Compact dimension
- Absolute beam current measurements

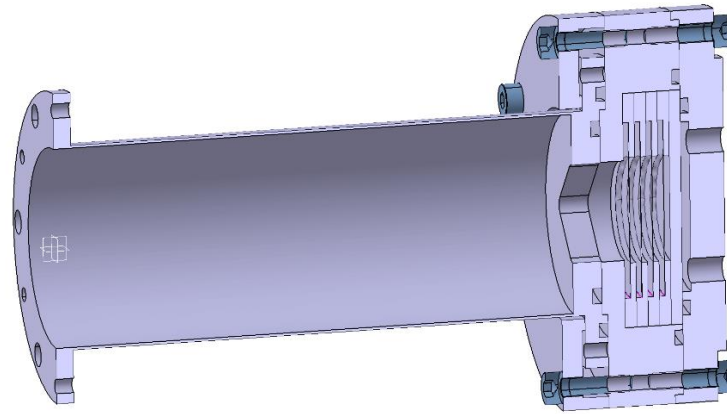
Stacked-target experiments



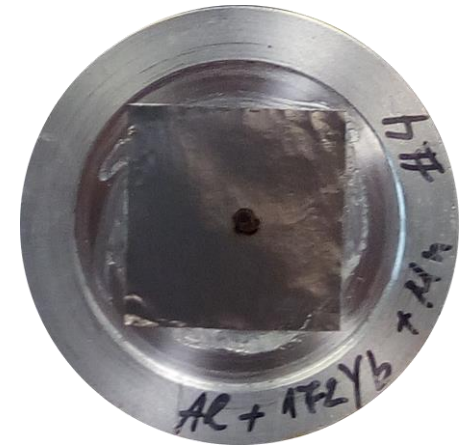
Stacked Target

Stacked targets

- Up to four targets irradiated simultaneously
- Water cooling possible

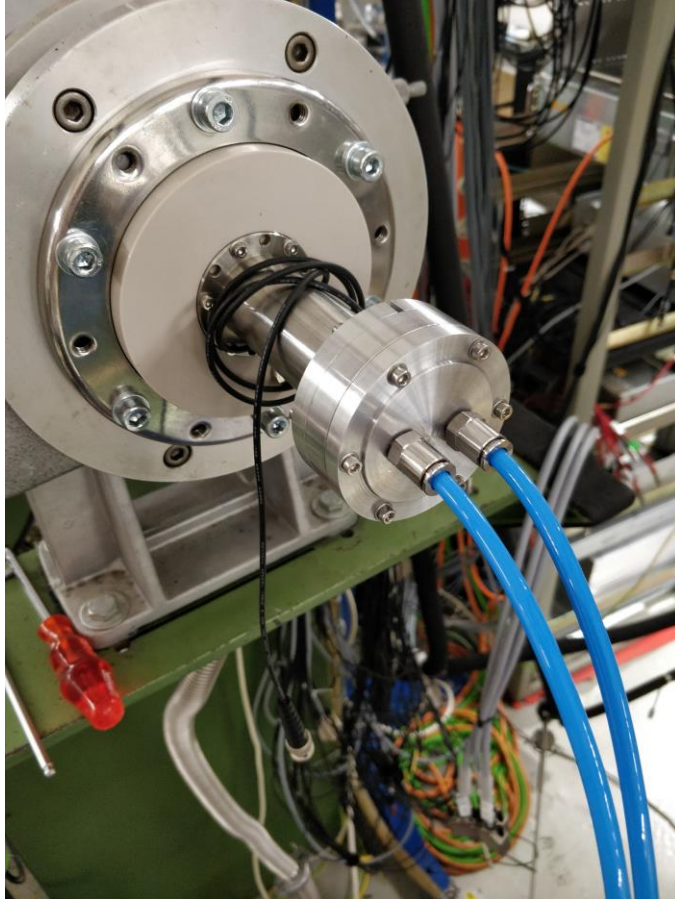


Approx. 20 cm



Approx. 5 cm

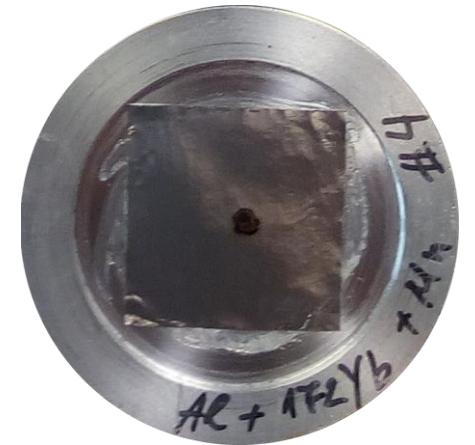
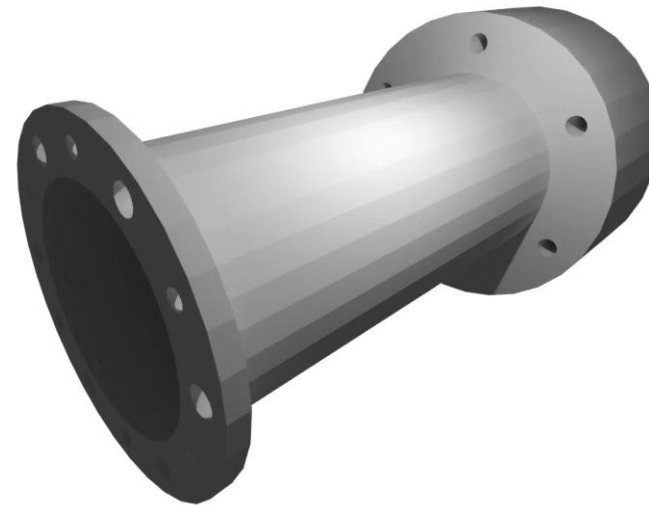
Stacked-target experiments



Stacked Target

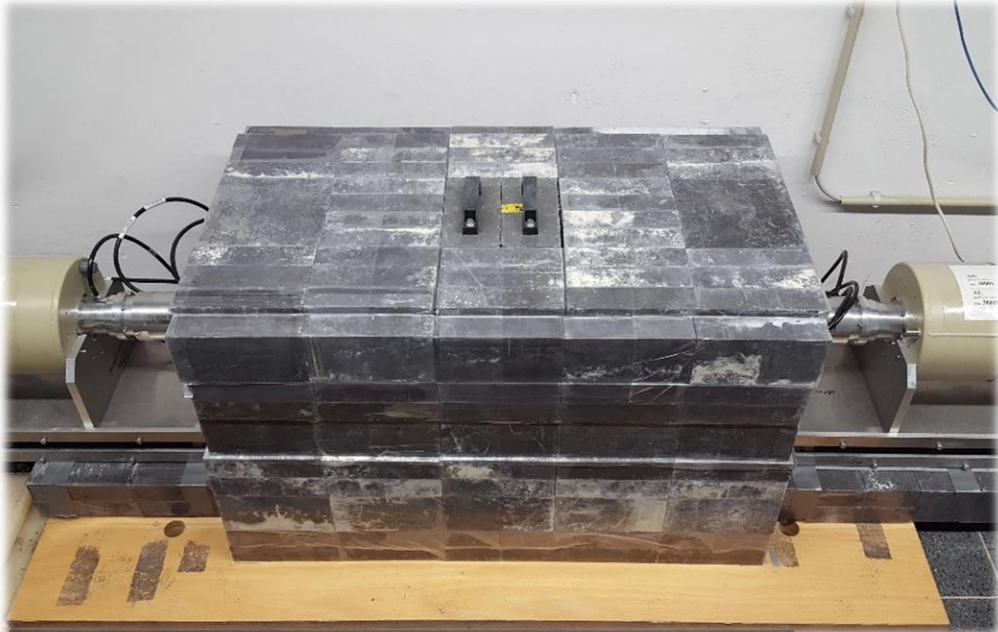
Stacked targets

- Up to four targets irradiated simultaneously
- Water cooling possible

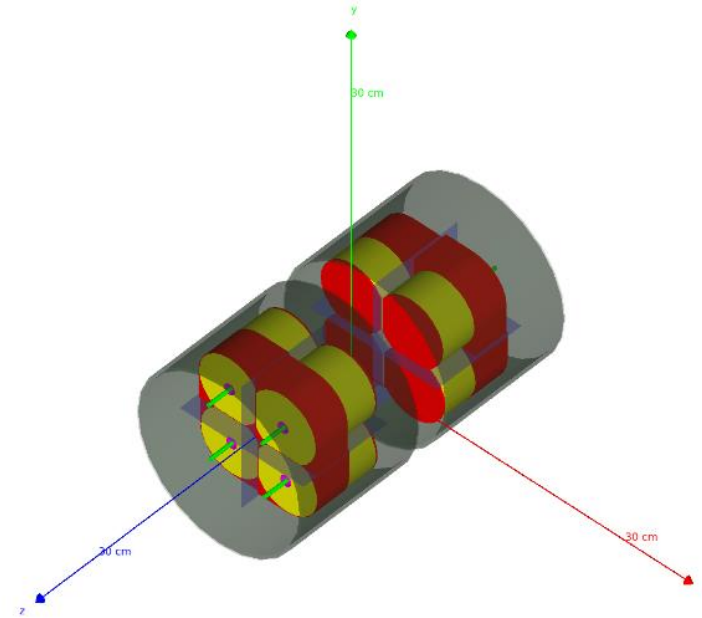


Approx. 5 cm

Offline γ -ray counting



Clover counting setup



Geant4 simulation

- Two HPGe Clover detectors with 4 crystals each \rightarrow $\gamma\gamma$ -coincidences
- Target-detector distance 13 mm
- Approx. 8 % tot. efficiency at 1.3 MeV

Nuclear astrophysics

(p,γ)

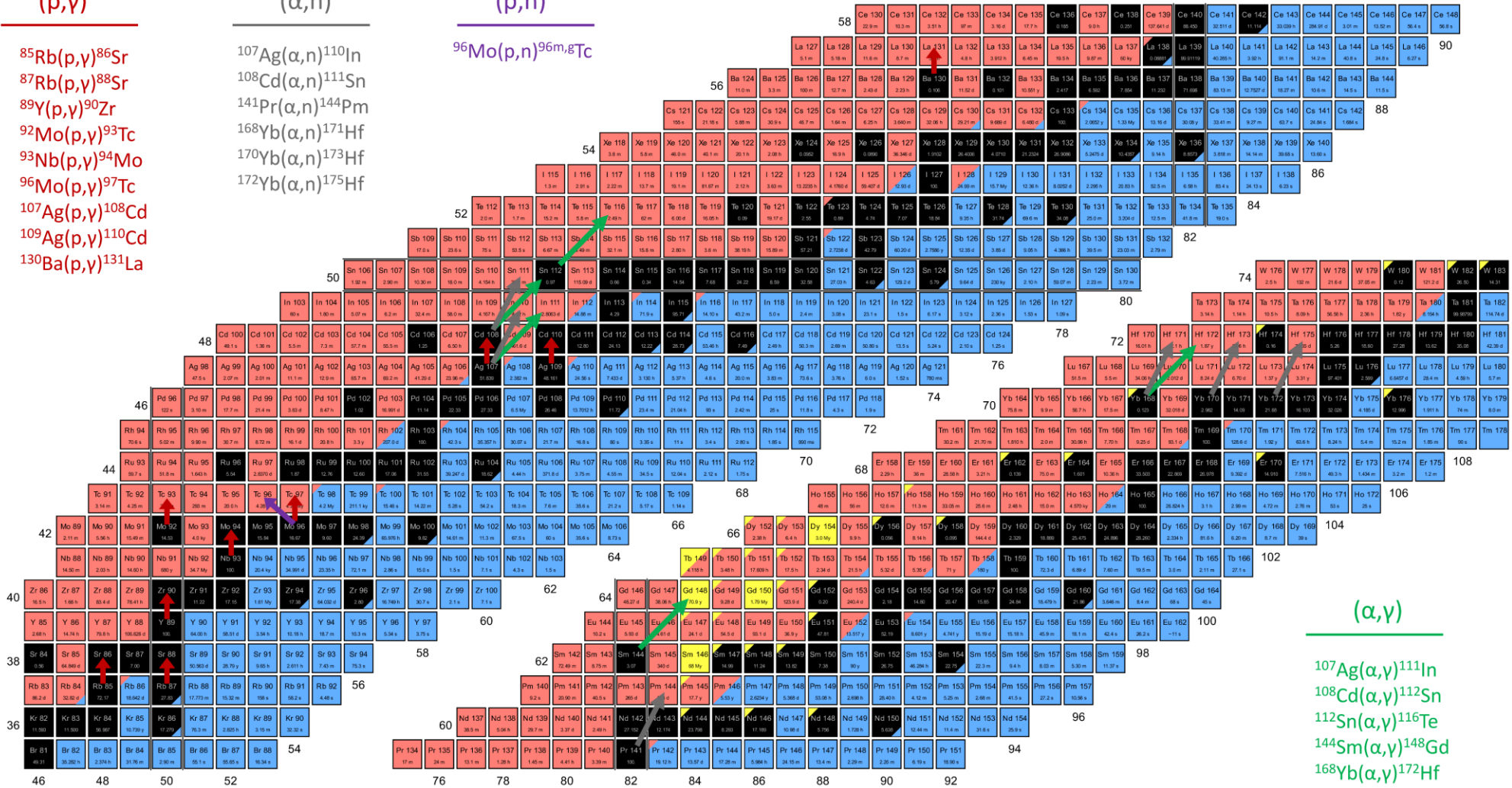
- $^{85}\text{Rb}(p,\gamma)^{86}\text{Sr}$
- $^{87}\text{Rb}(p,\gamma)^{88}\text{Sr}$
- $^{89}\text{Y}(p,\gamma)^{90}\text{Zr}$
- $^{92}\text{Mo}(p,\gamma)^{93}\text{Tc}$
- $^{93}\text{Nb}(p,\gamma)^{94}\text{Mo}$
- $^{96}\text{Mo}(p,\gamma)^{97}\text{Tc}$
- $^{107}\text{Ag}(p,\gamma)^{108}\text{Cd}$
- $^{109}\text{Ag}(p,\gamma)^{110}\text{Cd}$
- $^{130}\text{Ba}(p,\gamma)^{131}\text{La}$

(α,n)

- $^{107}\text{Ag}(\alpha,n)^{110}\text{In}$
- $^{108}\text{Cd}(\alpha,n)^{111}\text{Sn}$
- $^{141}\text{Pr}(\alpha,n)^{144}\text{Pm}$
- $^{168}\text{Yb}(\alpha,n)^{171}\text{Hf}$
- $^{170}\text{Yb}(\alpha,n)^{173}\text{Hf}$
- $^{172}\text{Yb}(\alpha,n)^{175}\text{Hf}$

(p,n)

- $^{96}\text{Mo}(p,n)^{96\text{m}}\text{gTc}$



(α,γ)

- $^{107}\text{Ag}(\alpha,\gamma)^{111}\text{In}$
- $^{108}\text{Cd}(\alpha,\gamma)^{112}\text{Sn}$
- $^{112}\text{Sn}(\alpha,\gamma)^{116}\text{Te}$
- $^{144}\text{Sm}(\alpha,\gamma)^{148}\text{Gd}$
- $^{168}\text{Yb}(\alpha,\gamma)^{172}\text{Hf}$



SONIC (SilicON Identification Chamber)



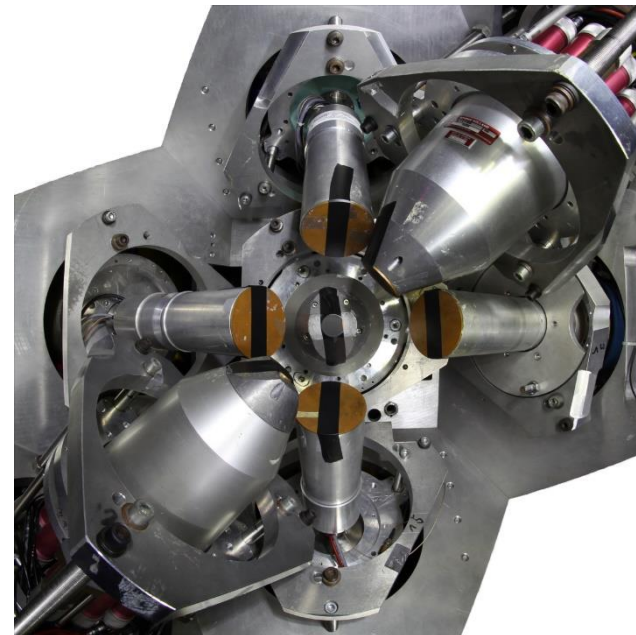
SONIC@HORUS

SONIC@HORUS



Particle detection

- 12 Silicon detector positions
- ΔE -E telescopes possible
- Solid angle coverage up to 9%
- In-beam energy resolution ≈ 70 keV



γ -ray detection

- 14 HPGe detectors
- 6 BGO shields
- Full-energy peak efficiency $\approx 2\%$ @ 1332 keV

SONIC@HORUS

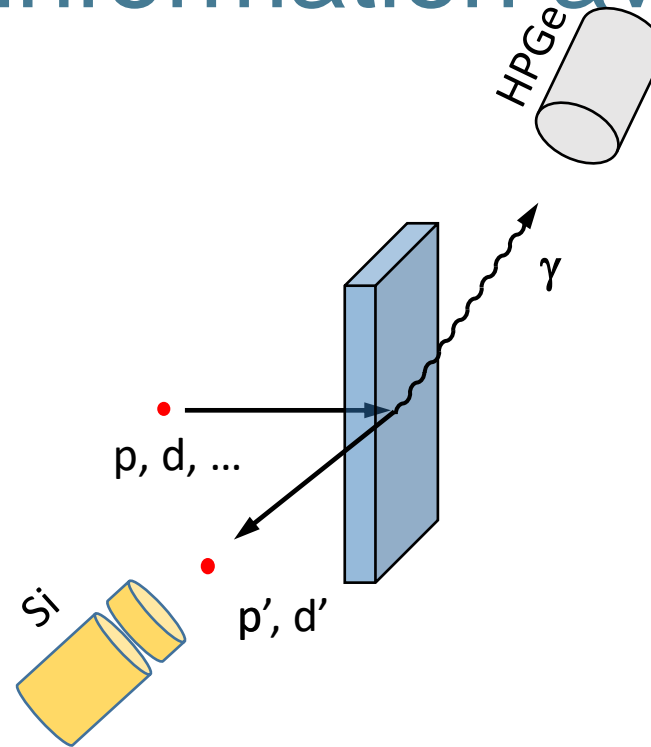
Experimental information available

Projectile

- Energy
- Direction
- Probe

Ejectile

- Energy
- Time
- Angles Θ , Φ
- Particle ID



Gamma rays

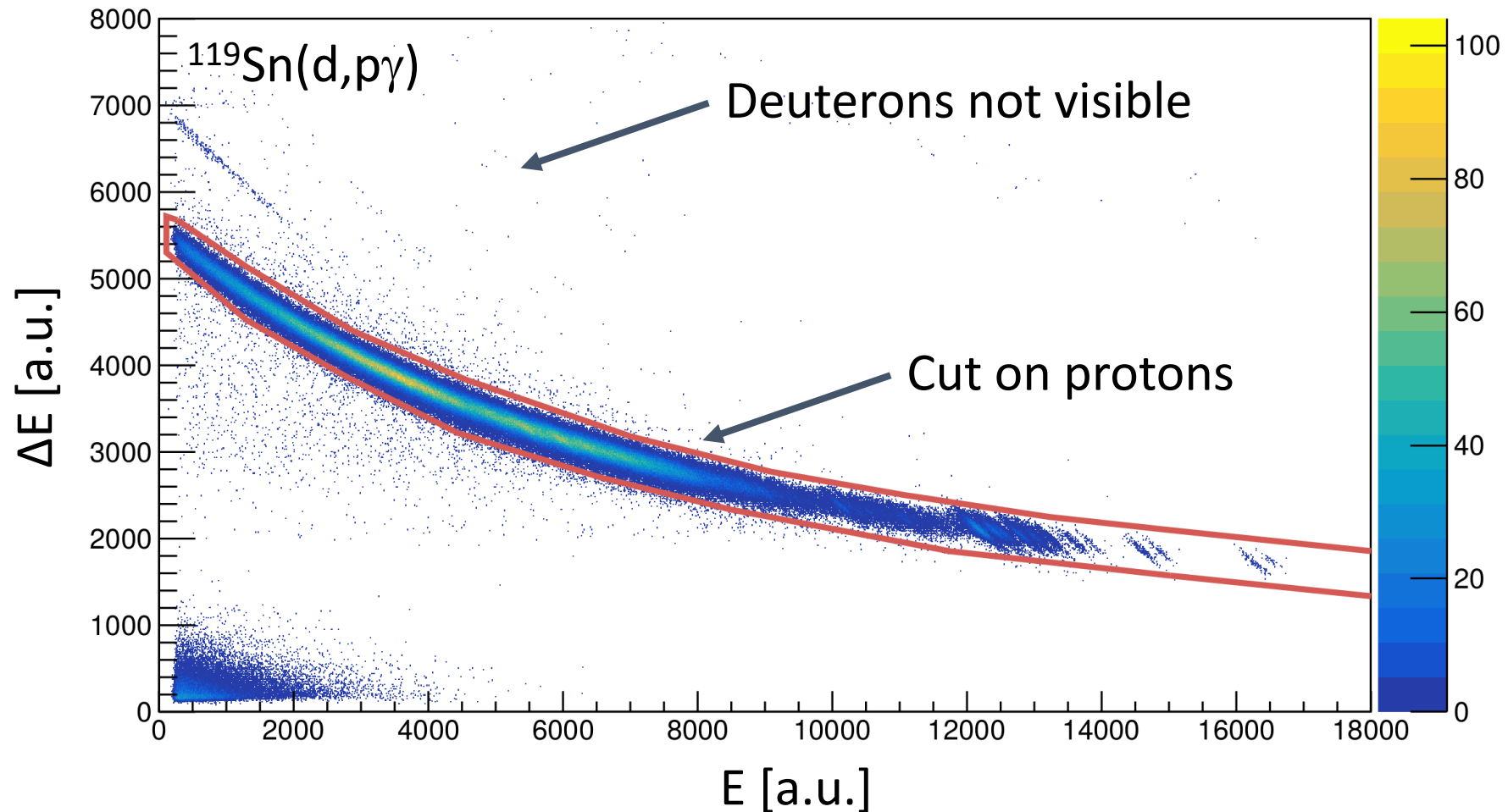
- Energy
- Time
- Angles Θ , Φ

- Reaction channel
- Excitation and decay energies
- Recoil energy and direction

Complete kinematics in scattering and transfer experiments!

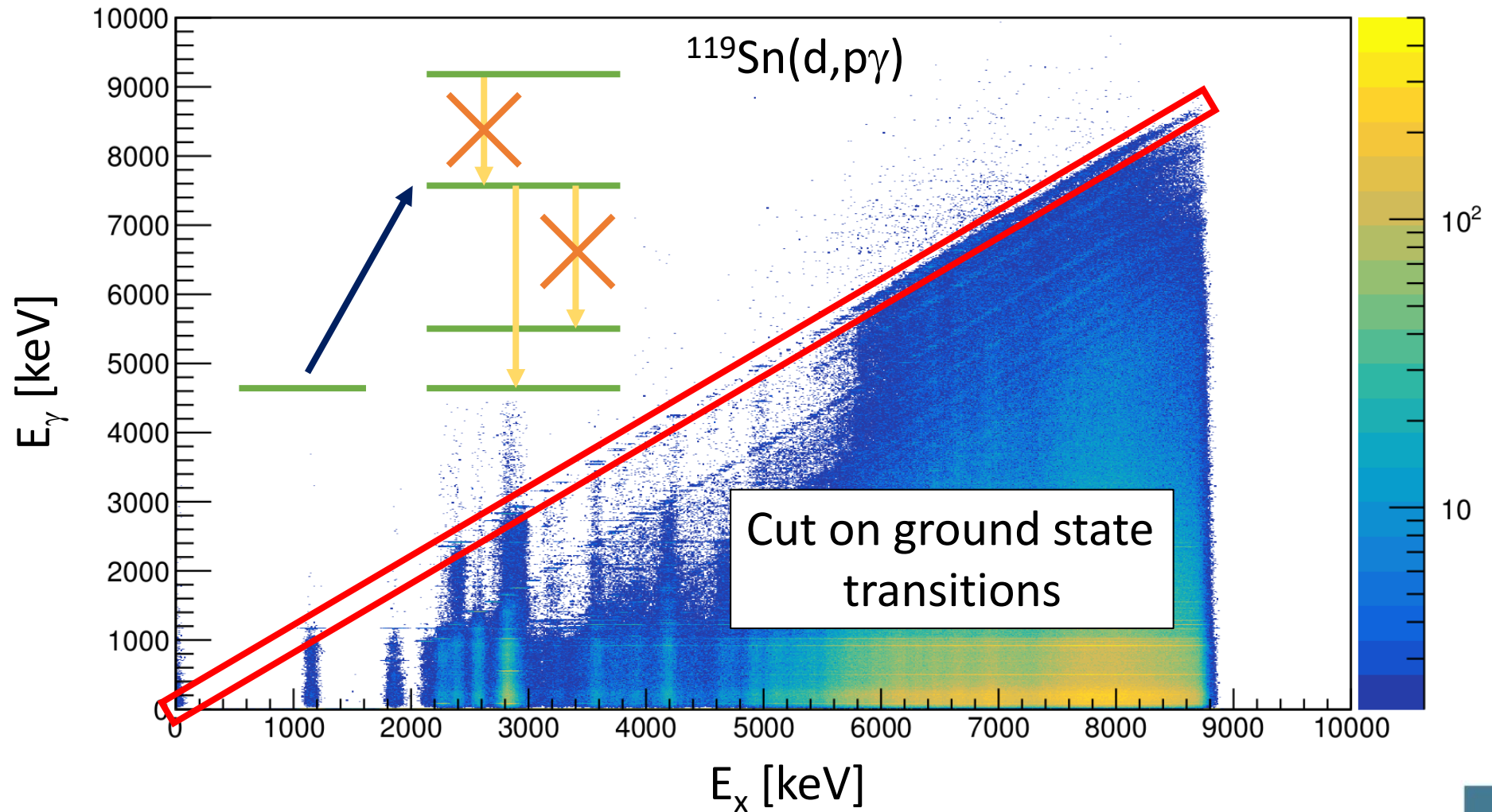
-> Excitation, decay, branching, lifetime, ...

$^{119}\text{Sn}(d,p\gamma)$ – Particle identification



Graphical gate in ΔE - E to distinguish (d,p) from (d,d')

$^{119}\text{Sn}(d,p\gamma)$ – Excitation and decay channel



Select direct excitation and decay into specific state in ^{120}Sn

TNA @ Cologne



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- Beam intensities:
 - 800 nA (p)
 - 200 nA (^4He)

Contact

If you are interested in TNA, please contact us informally in advance:

- Contact for TNA at University of Cologne:

Prof. Dr. Andreas Zilges

zilges@ikp.uni-koeln.de

- Representative:

Dr. Felix Heim

fheim@ikp.uni-koeln.de

References

HORUS array + nuclear astrophysics target chamber

F. Heim *et al.*, Nucl. Inst. Meth. Phys. Res. A **966**, 163854 (2020)

In-beam (p, γ) experiments

F. Heim *et al.*, Phys. Rev. C **101**, 035805 (2020) (^{107}Ag)

F. Heim *et al.*, Phys. Rev. C **101**, 035807 (2020) (^{93}Nb)

P. Scholz *et al.*, Phys. Rev. C **101**, 045806 (2020) ($^{63,65}\text{Cu}$)

F. Heim *et al.*, Phys. Rev. C **103**, 055803 (2021) (^{109}Ag)

Activation experiments

F. Heim *et al.*, Phys. Rev. C **103**, 054613 (2021) (^{96}Mo)

P. Scholz *et al.*, Phys. Lett. B **761**, 247 (2016) (^{108}Cd)

SONIC target chamber

S. G. Pickstone *et al.*, Nucl. Inst. Meth. Phys. Res. A **875**, 104 (2017)

Transfer reactions (PDR studies)

M. Weinert *et al.*, Phys. Rev. Lett. **127**, 242501 (2021) (^{120}Sn)

Nuclear level lifetimes

S. Prill *et al.*, accepted at PRC ($^{128,130}\text{Te}$)

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