Activation measurement of the ^{187}Re(α,n) reaction at the Cologne Clover counting-setup

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Bonn-Cologne Graduate School of Physics and Astronomy

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***Supported by the Bonn-Cologne Graduate School of Physics and Astronomy**

Outline

- Astrophysical Motivation
  - *p* process nucleosynthesis
  - α-nucleus optical-model potential
- Activation measurement of ^{187}Re(α,n)
  - Activation technique in a nutshell
  - Cologne Clover Counting-Setup
  - $\gamma\gamma$-coincidence method
- Summary

Astrophysical Motivation - *p* process

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Need for reliable theoretical predictions
for reaction rates!

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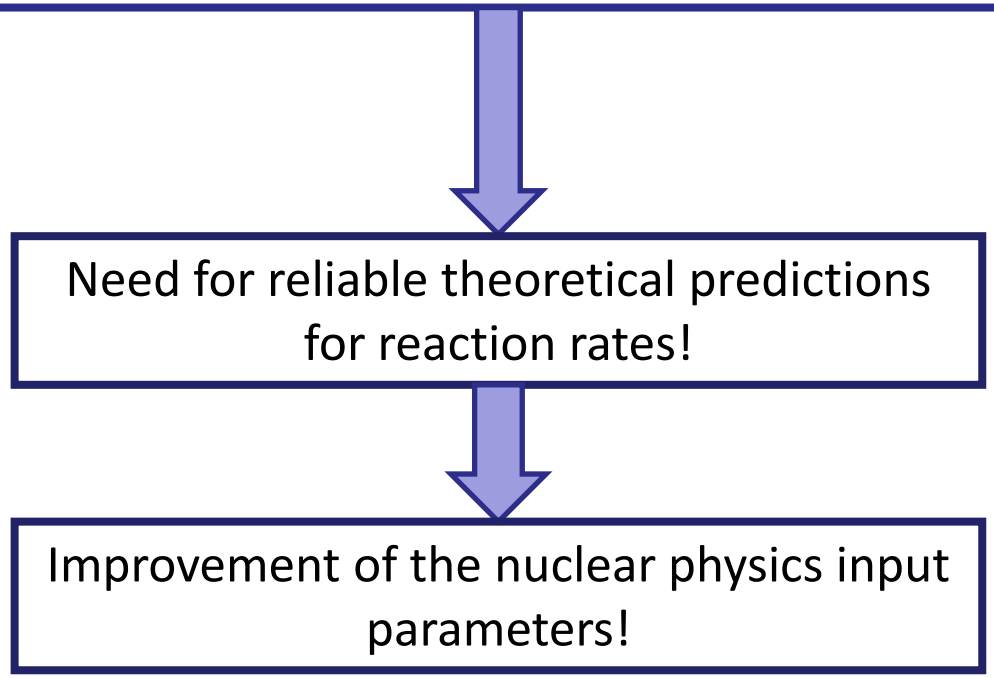

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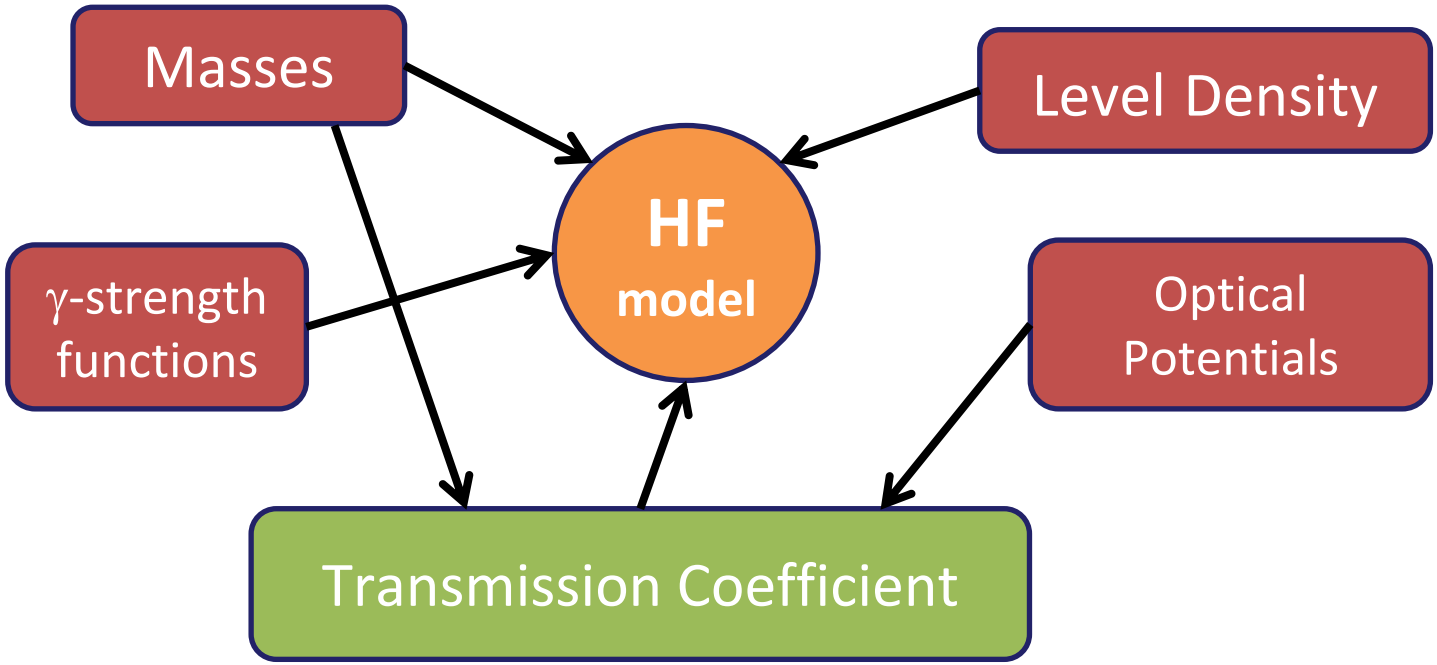

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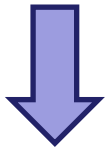

Experimental Data*		
23 x (α,γ)	72 x (α,n)	7 x (α,p)

* KADoNiS Database (February 2013)

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Only seven (α,n)-reactions for A > 160 and only three for A > 180 !!

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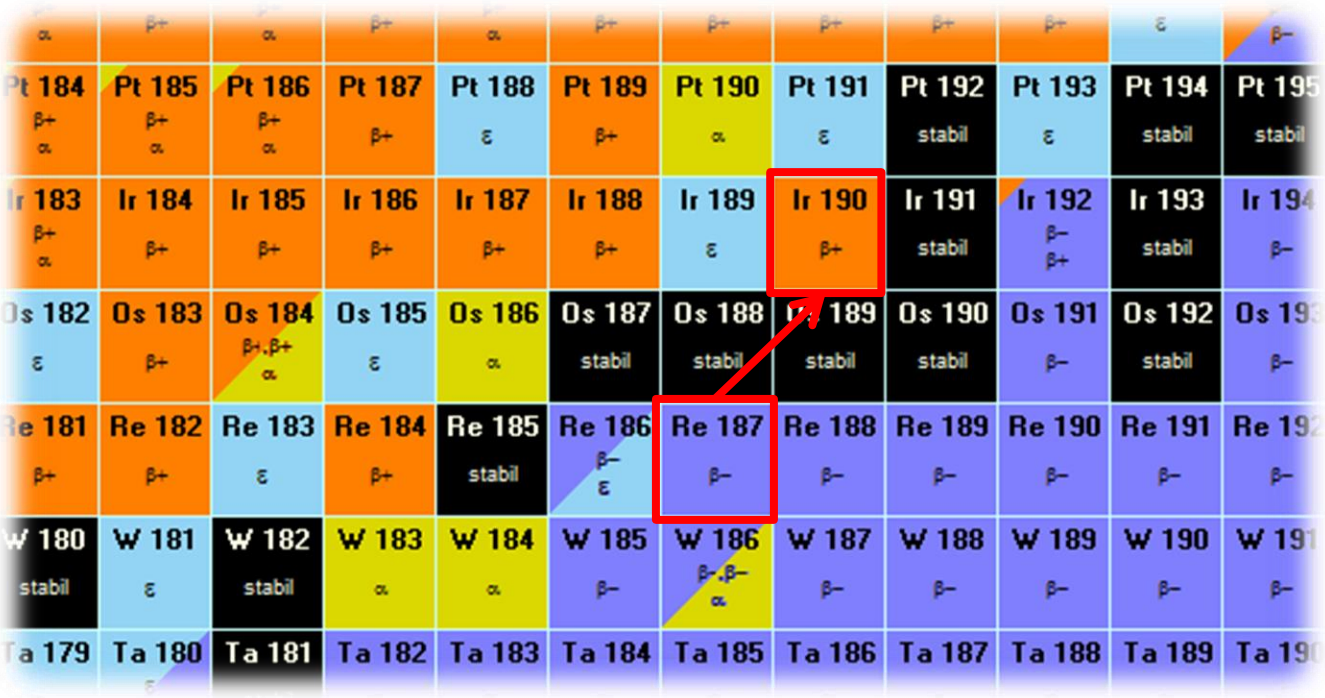

- ^{187}Re is a quasi-stable nucleus ($T_{1/2} \approx 4.33 \times 10^{10}$ y)
- ^{190}Ir decays with a half-life of 11.8 days to ^{190}Os

Activation Technique in a Nutshell

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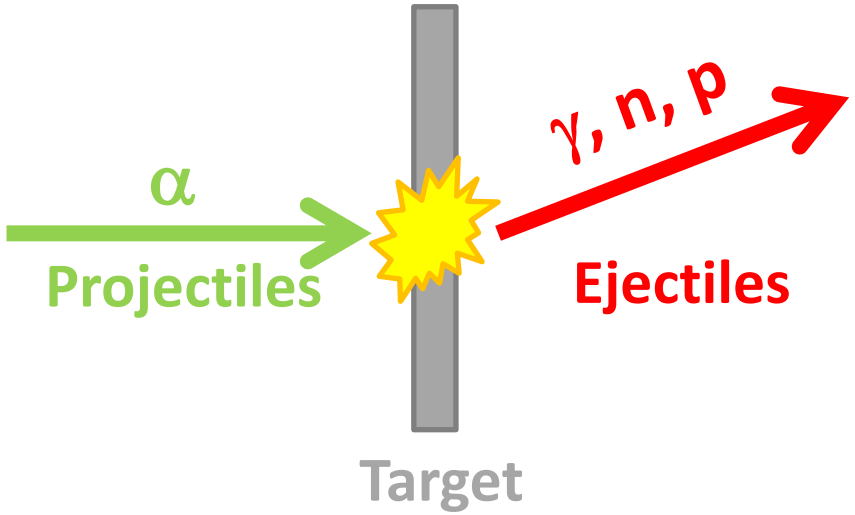
1. **In-Beam Activation:**



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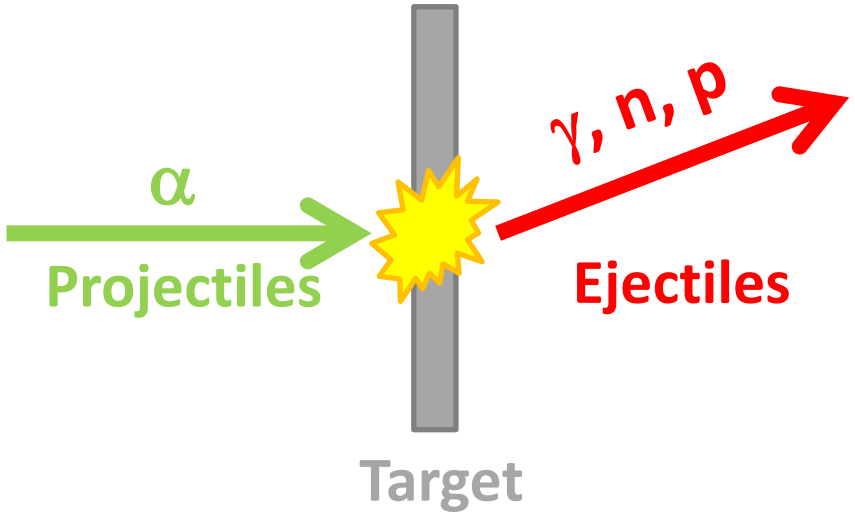
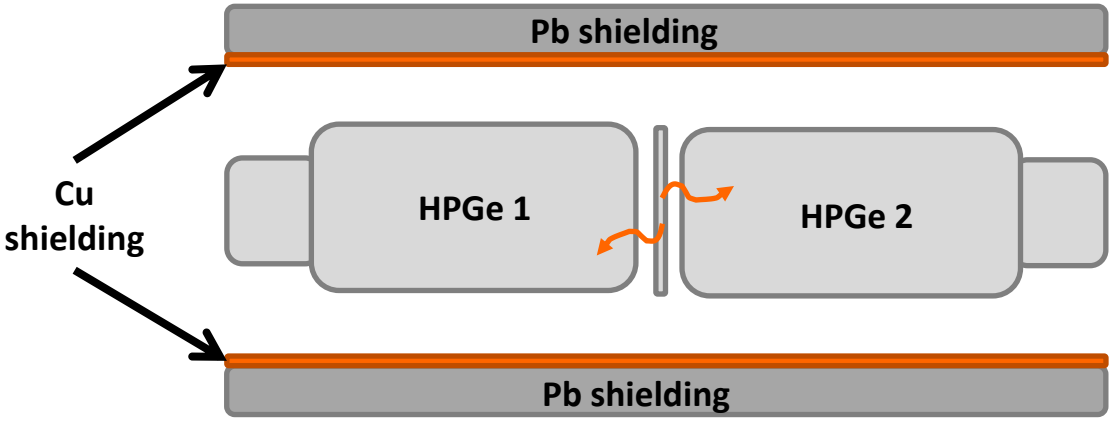


2. Off-Beam Counting:



Activation Technique in a Nutshell

- Produced nuclei B by activating nuclei A with a constant beam current for time t

$$N_B(t) = \frac{N_A \cdot \sigma \cdot \varphi(t)}{\lambda_B}\left(1 - e^{-\lambda_B t}\right)$$

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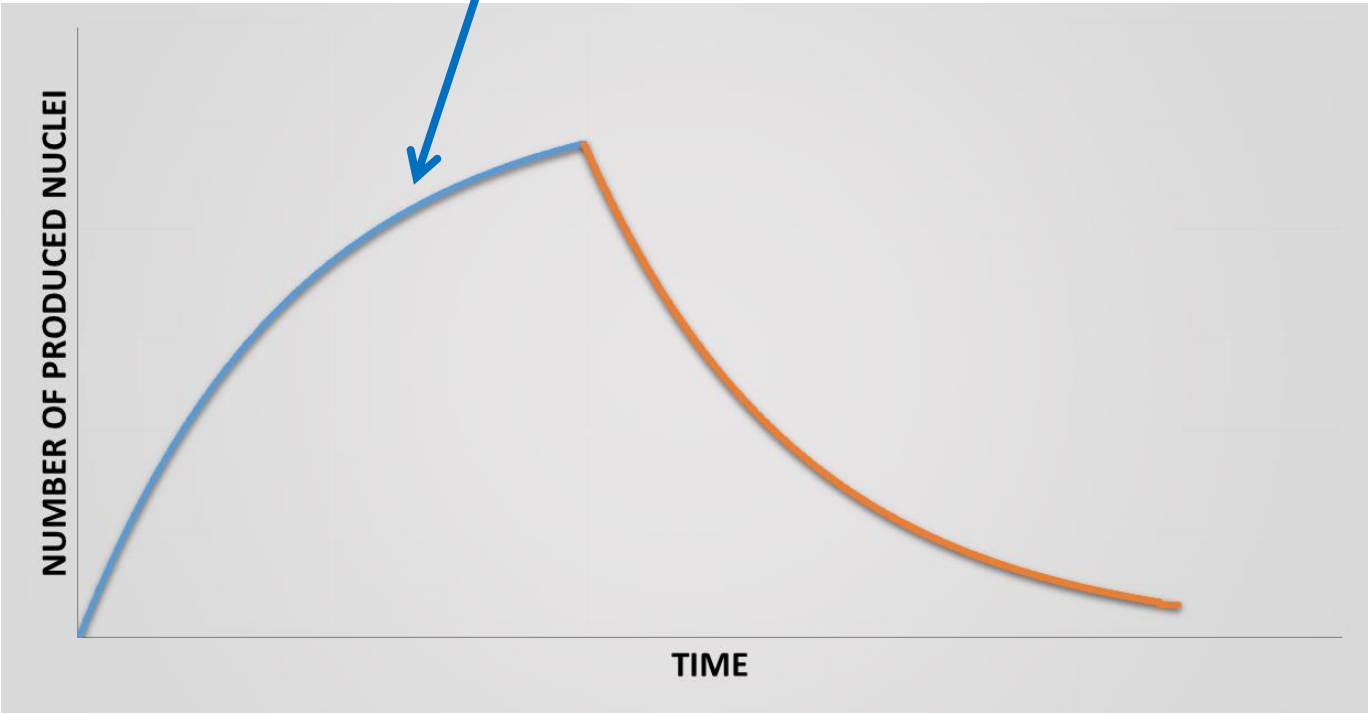

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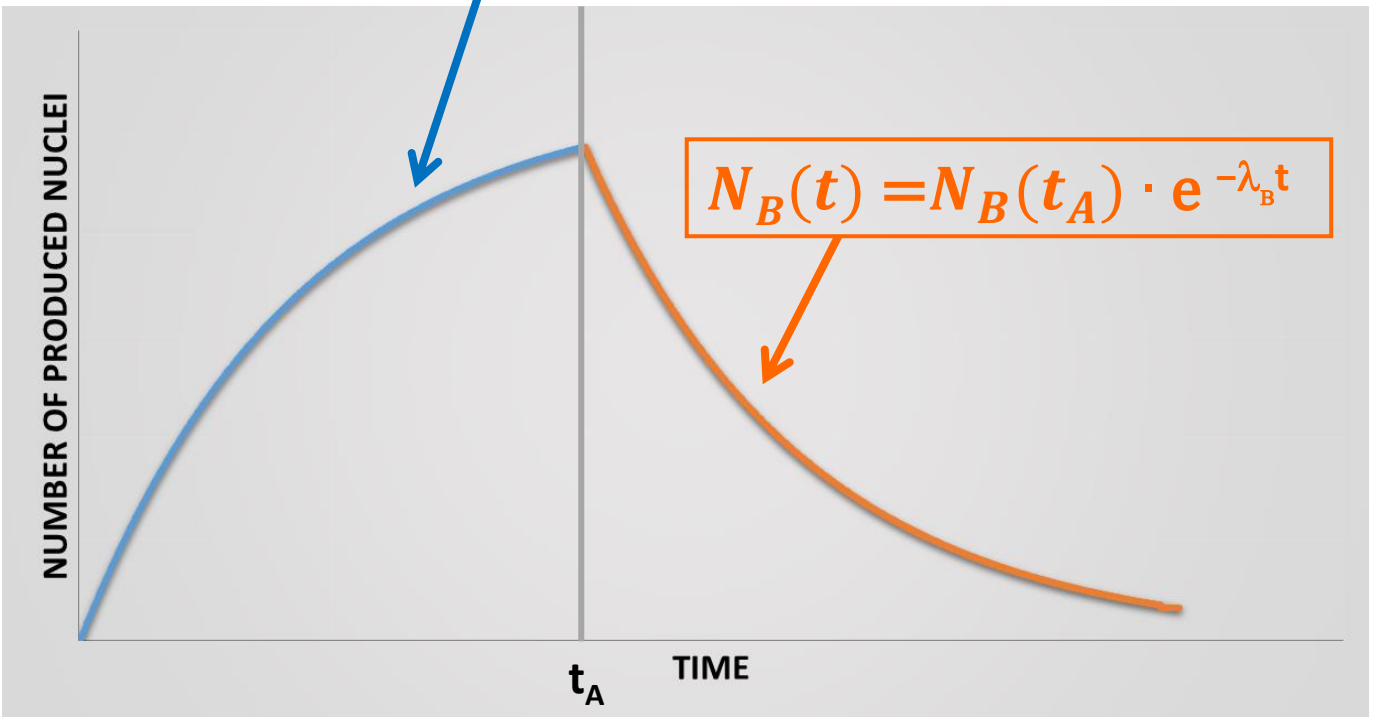
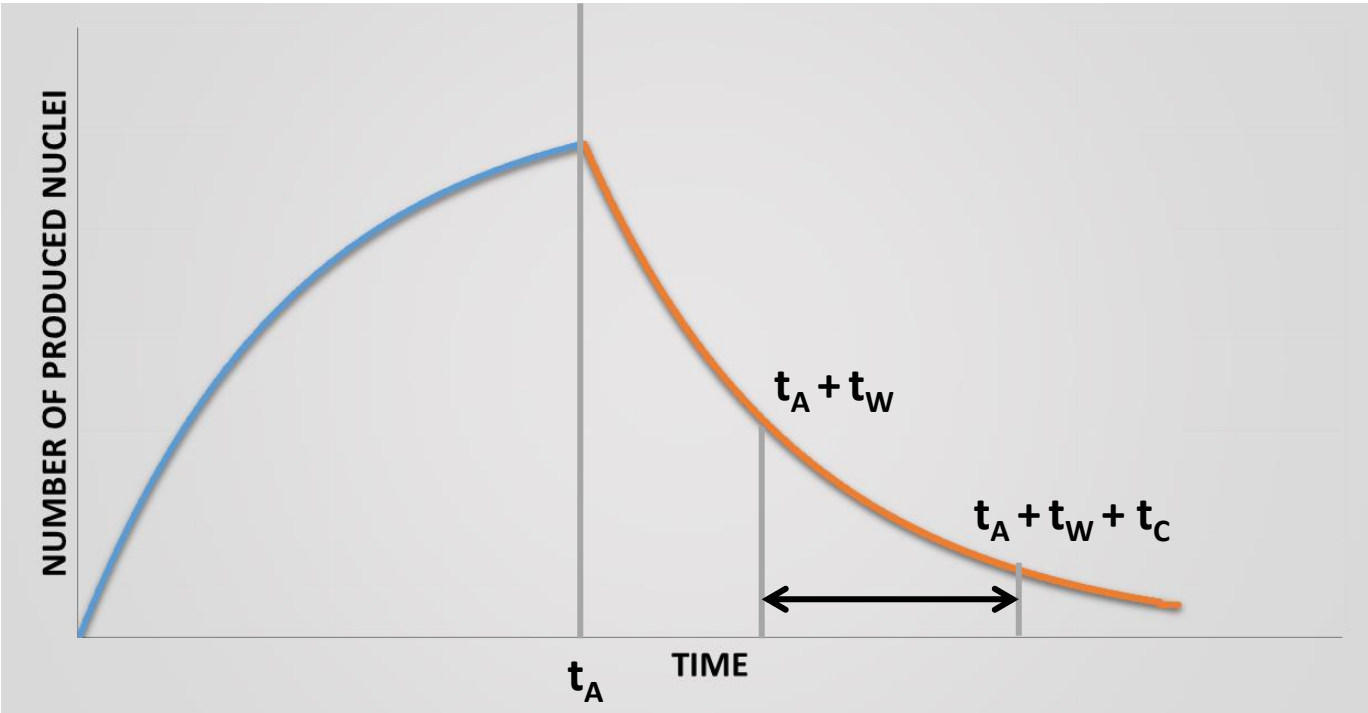


Activation Technique in a Nutshell

- Counting numbers of emitted γ's for a certain time to reconstruct $N_B\ (t_A)$

$$N_B\ (t_A) = \frac{N_\gamma \cdot e^{\lambda t_w}}{I \cdot \varepsilon \cdot \tau \cdot \left(1 - e^{-\lambda t_c}\right)}$$



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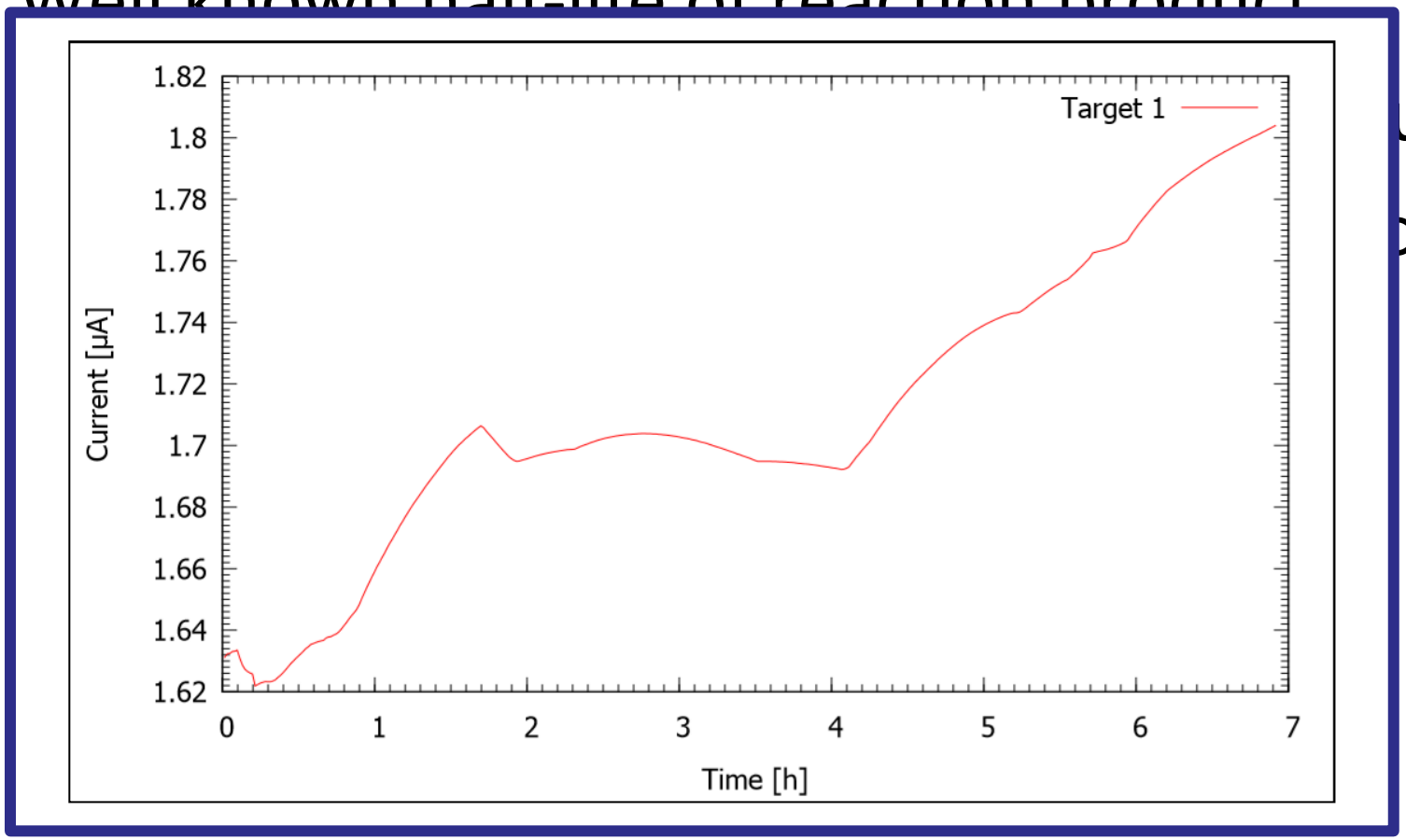

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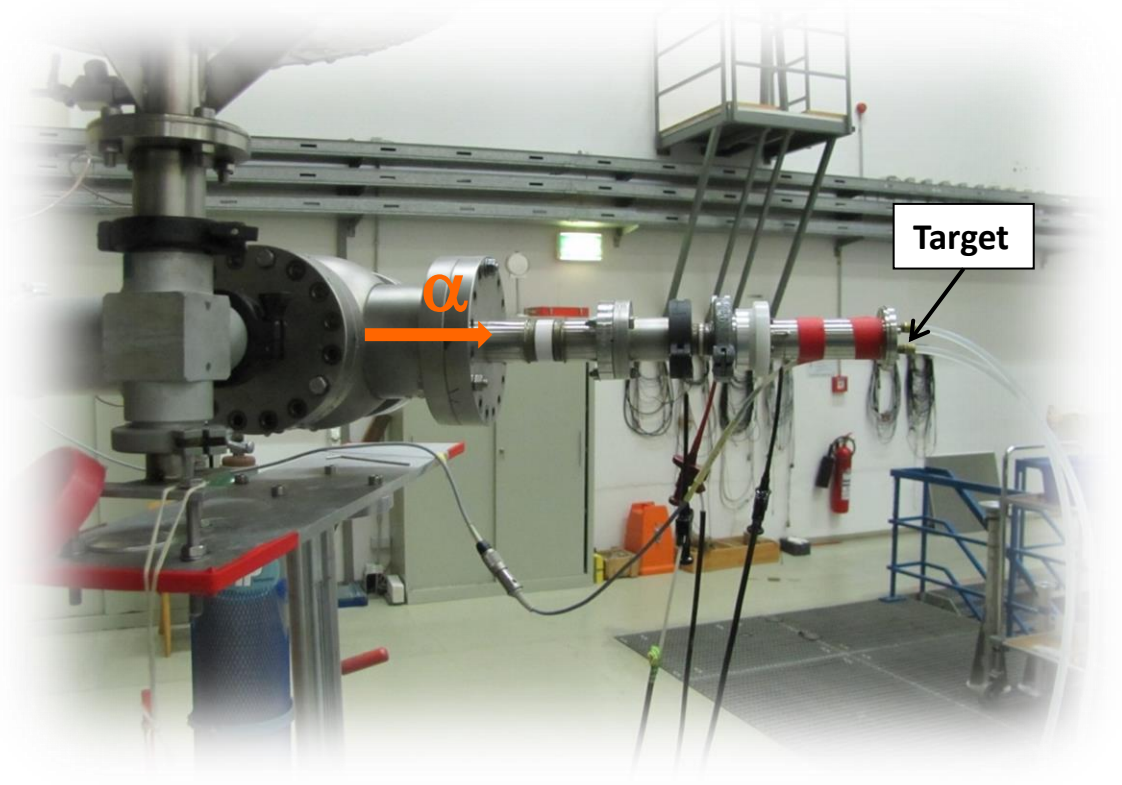
- Absolute γ-ray intensities
- Precise current measurement

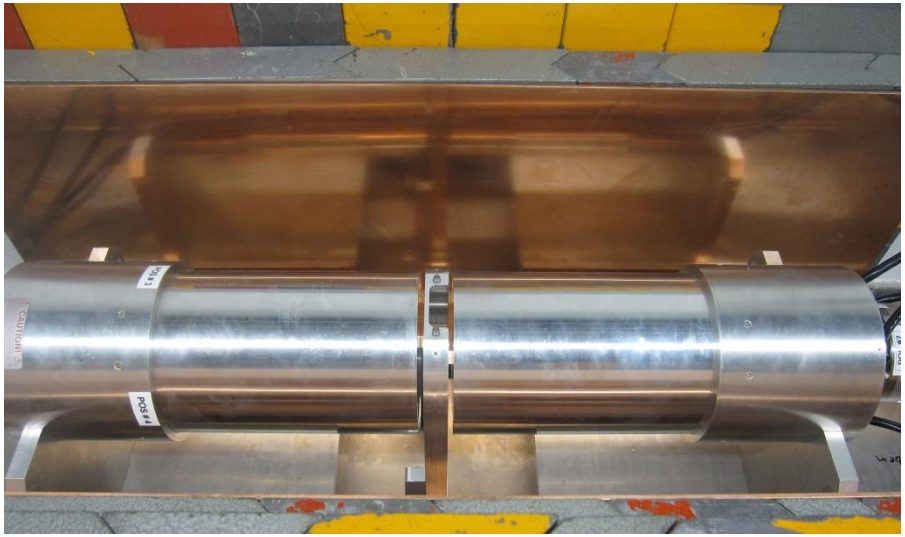
Activation @ PTB Braunschweig

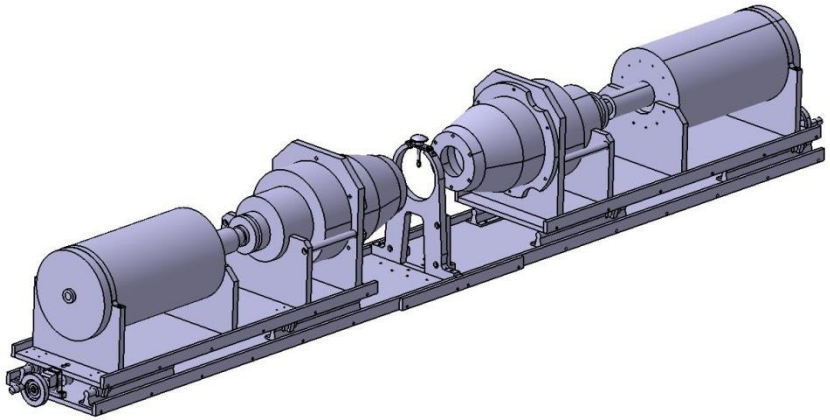


- Cyclotron @ PTB Braunschweig
- α -beam currents of a few µA
- Water cooled target & cooling trap at temperature of liquid nitrogen
- Activation of natural rhenium targets at 5 different α-energies between 12.4 MeV and 14.1 MeV (Gamow window @3GK: 8.21 – 11.03 MeV)

Cologne Clover Counting-Setup

- Two HPGe clover detectors in a very close face-to-face geometry
- Cover a solid angle of almost 4π
- Total photopeak efficiency between 5 and 8 % @ 1332 keV
- Can be equipped with BGO-shields
- Good energy resolution:
  ca. 2 keV @ 1332 keV
- Digitized data acquisiton writing data event-by-event in listmode files
- moveable mounting allows to vary distance to target
- Shielding with lead and copper





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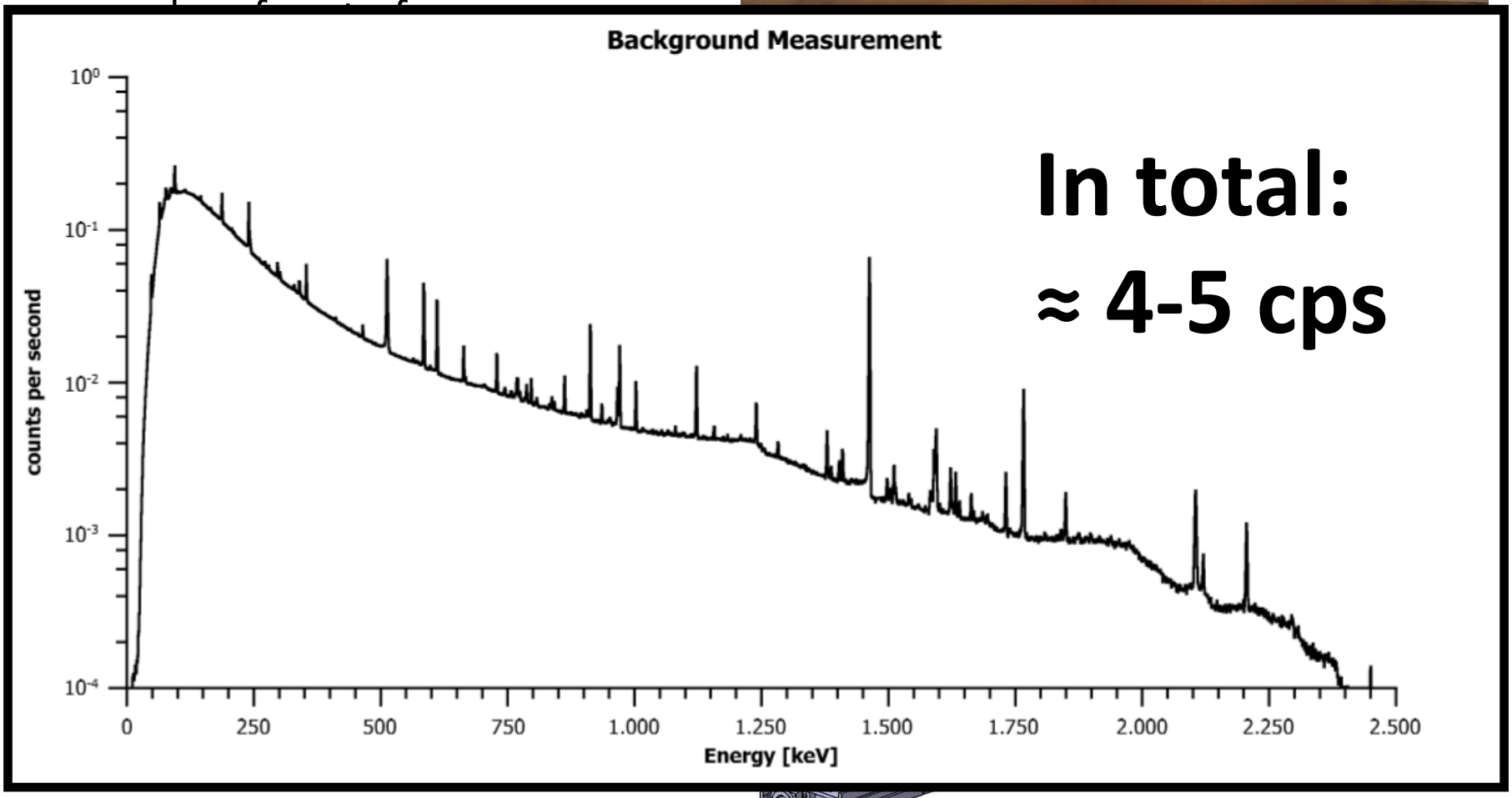

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Cologne Clover Counting-Setup

- Each clover detector consists out of 4 individual HPGe-crystals with their own preamplifier

G. Duchêne *et al.*, Nucl. Instr. and Meth. A **432** (1999) 90

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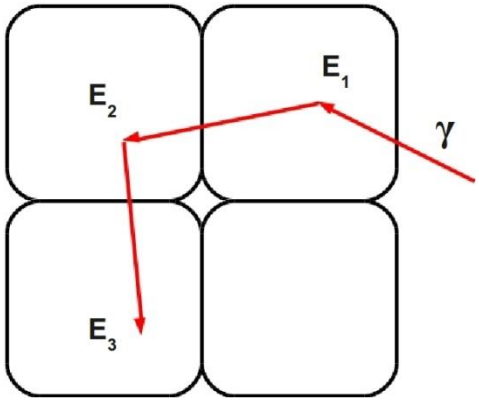
- Each clover detector consists out of 4 individual HPGe-crystals with their own preamplifier
- Active compton-background reduction via addback



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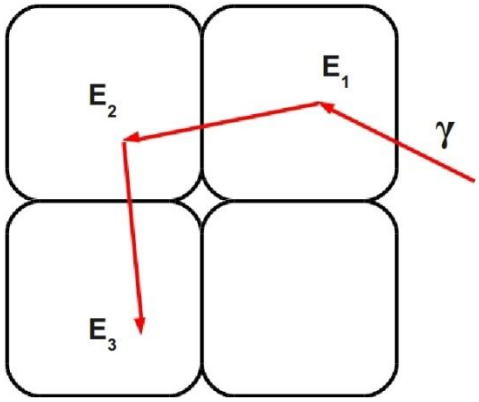
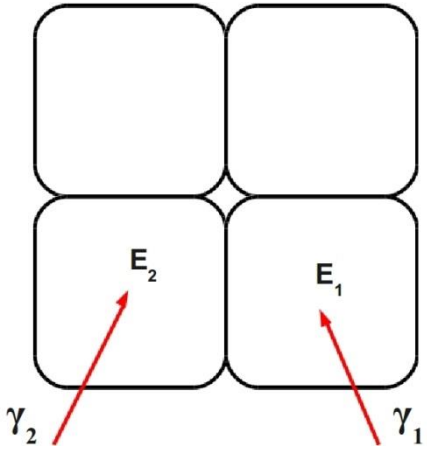
Cologne Clover Counting-Setup

- Each clover detector consists out of 4 individual HPGe-crystals with their own preamplifier
- Active compton-background reduction via addback
- Using $\gamma\gamma$-coincidence method to reduce the background in the spectra and determine absolute cross sections (successfully applied for $^{141}Pr(\alpha,n)^{144}Pm$ *)





*A. Sauerwein *et al.*, Phys. Rev. C **84** (2011) 045808

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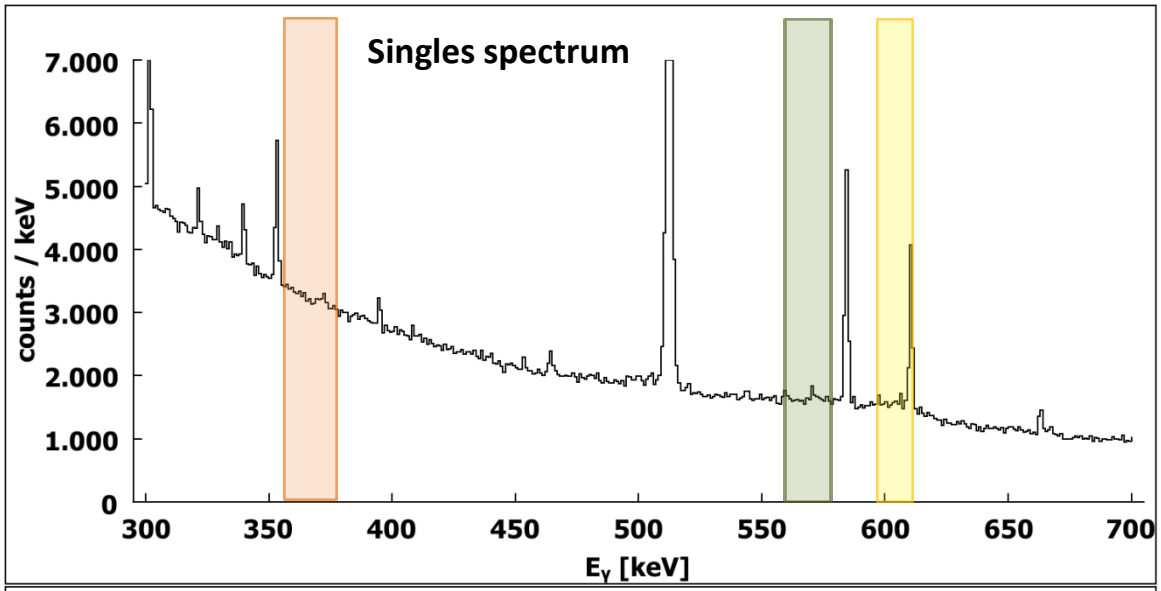
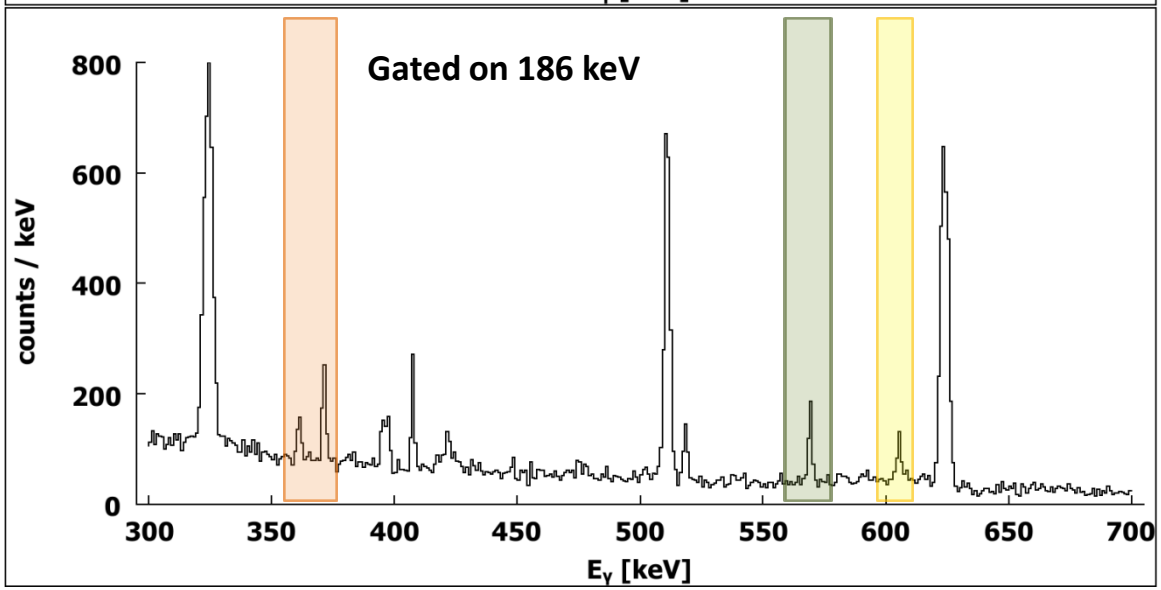
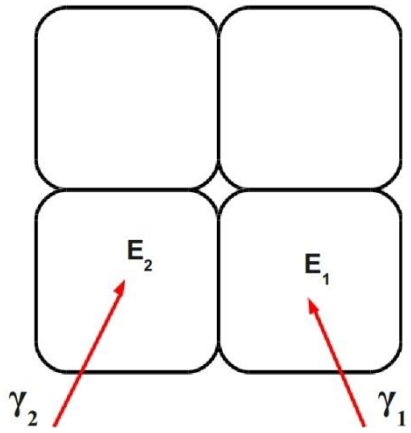
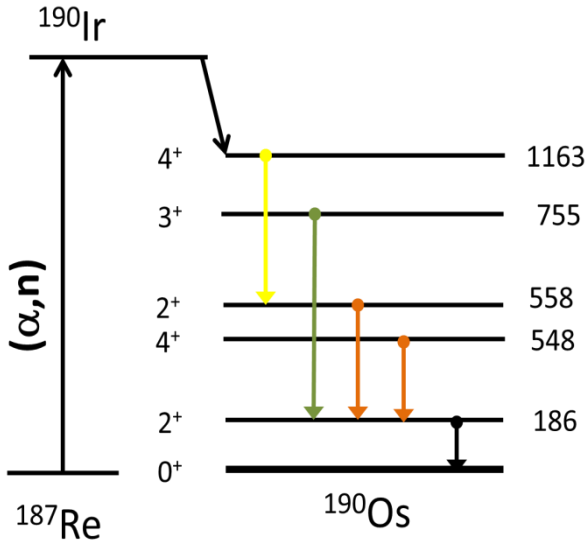
γγ-coincidence method









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