B04: Status and first experimental Plans for NEPTUN and Double-Gamma Decay

Patrick van Beek – 06.07.2018

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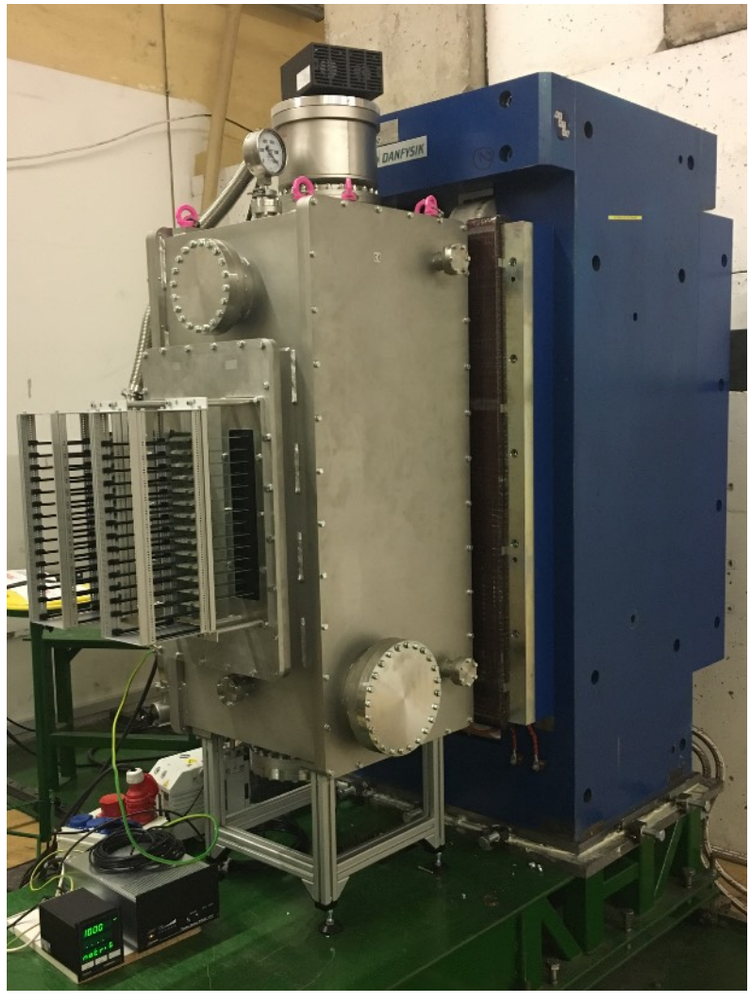
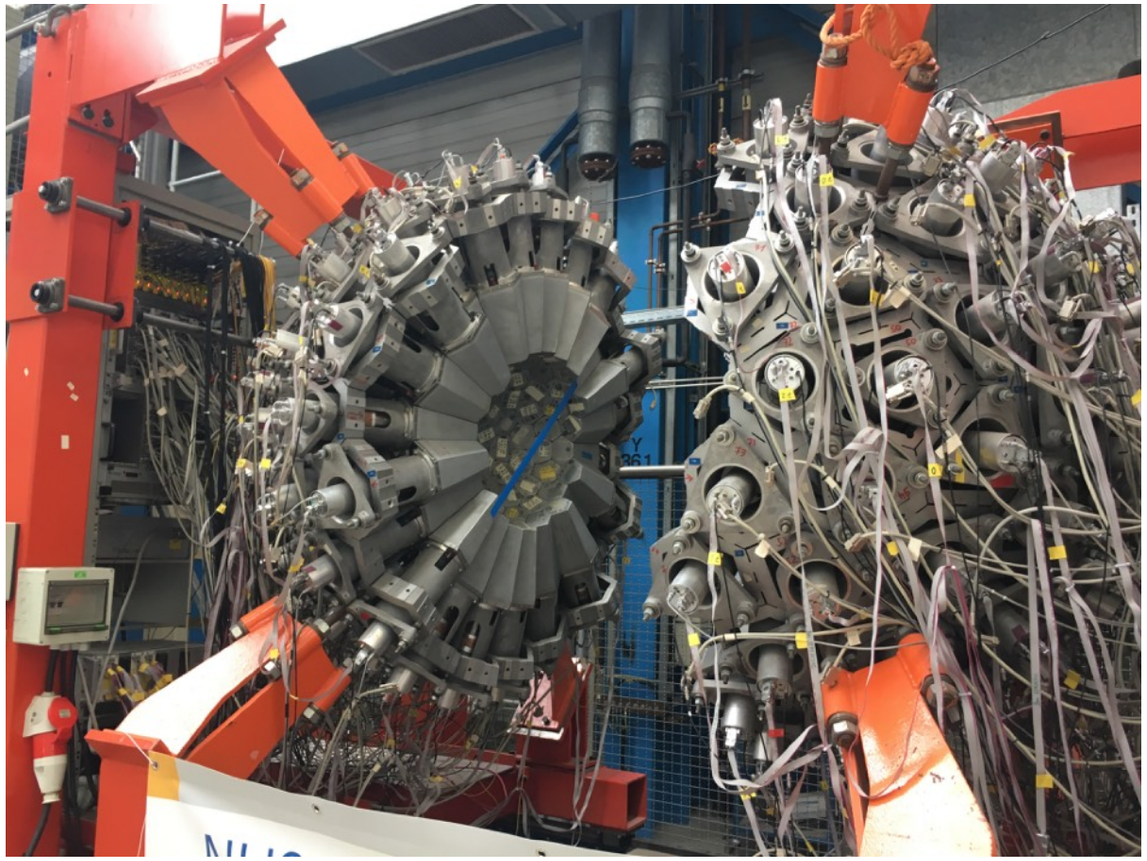
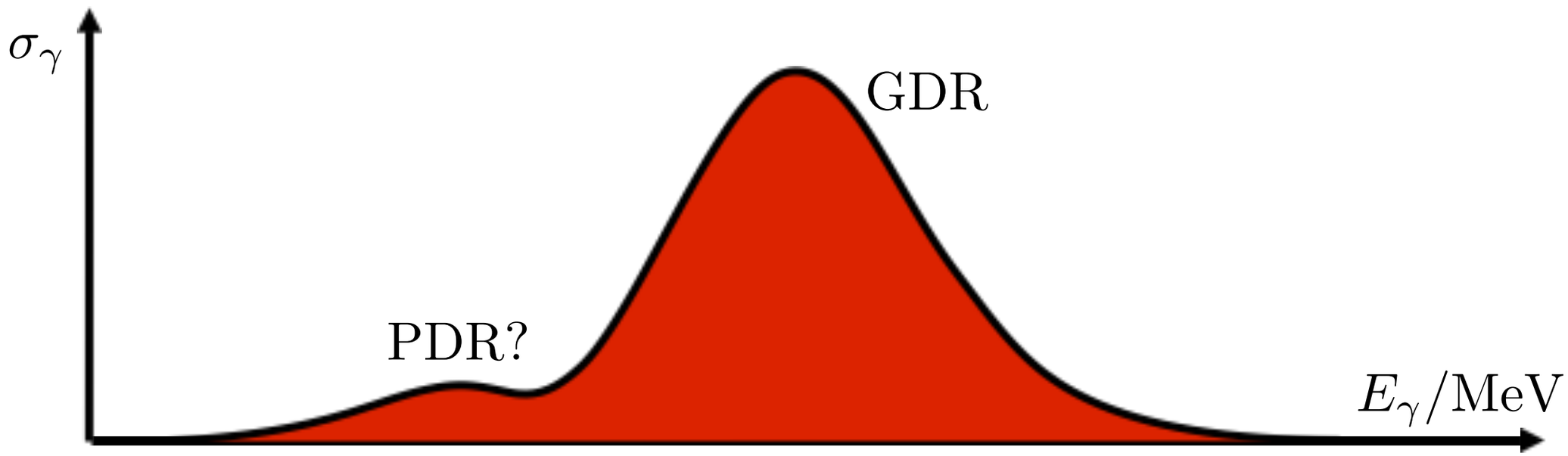




SFB 1245

Dipole Response of Nuclei



With photo nuclear cross section: calculate polarizability

$$\alpha_{\mathrm{D}} = \frac{\hbar c}{2\pi^2} \int_0^\infty \frac{\sigma_\gamma(E)}{E^2}\, dE$$

Measuring Photo Nuclear Cross Section with real Photons

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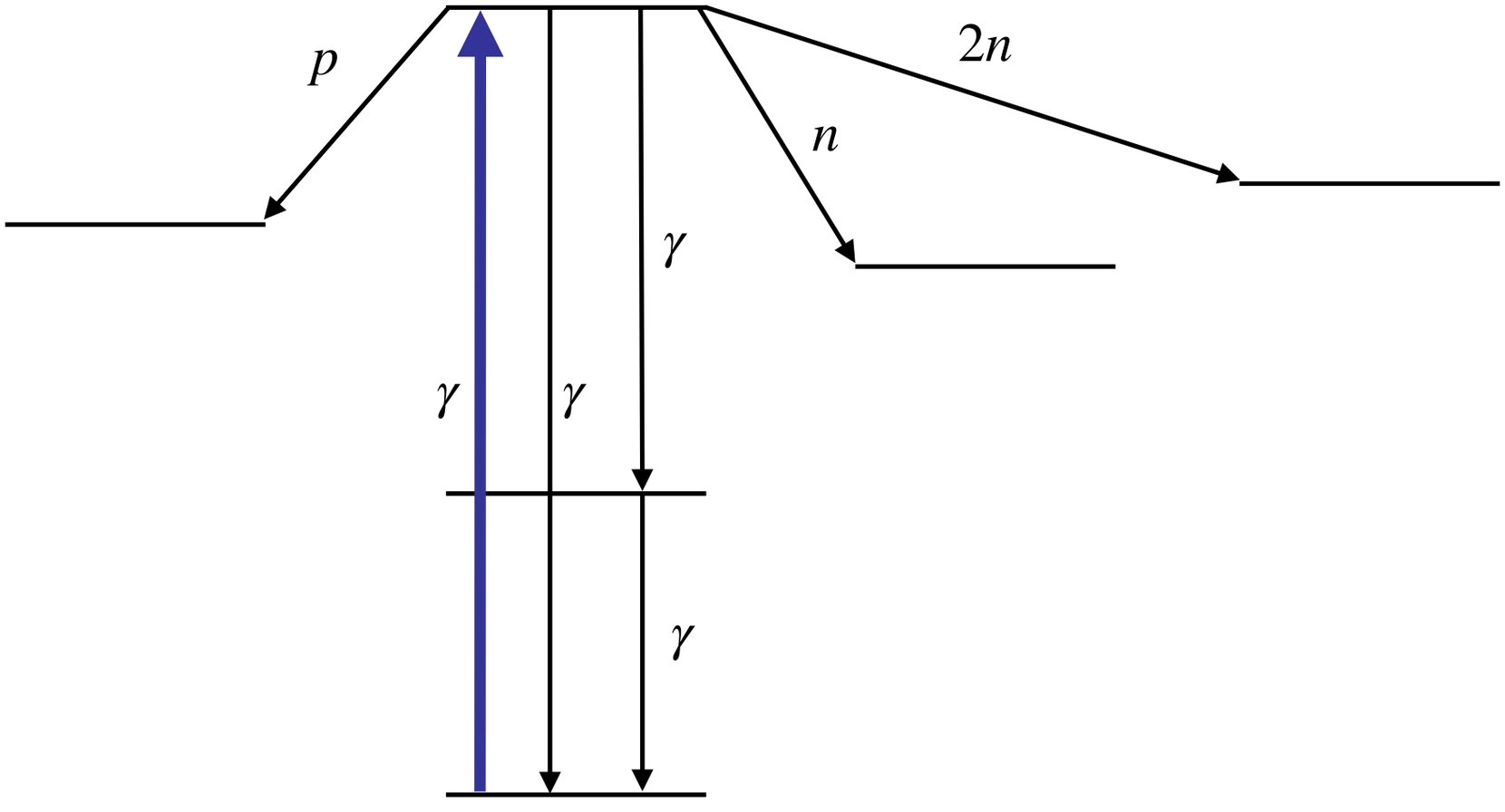
$$\sigma_{\text{tot}} = \sigma_{\gamma'} + \sigma_{\gamma'\gamma'} + \ldots + \sigma_n + \sigma_{2n} + \ldots + \sigma_p + \ldots$$



Measuring Photo Nuclear Cross Section with real Photons

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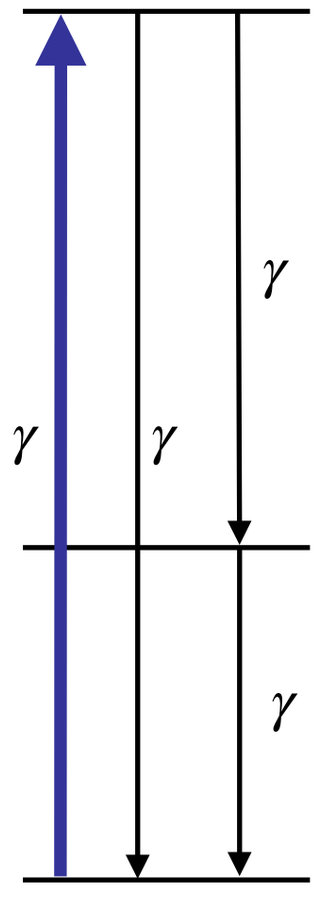

Neptun Photon Tagger – Upgrade

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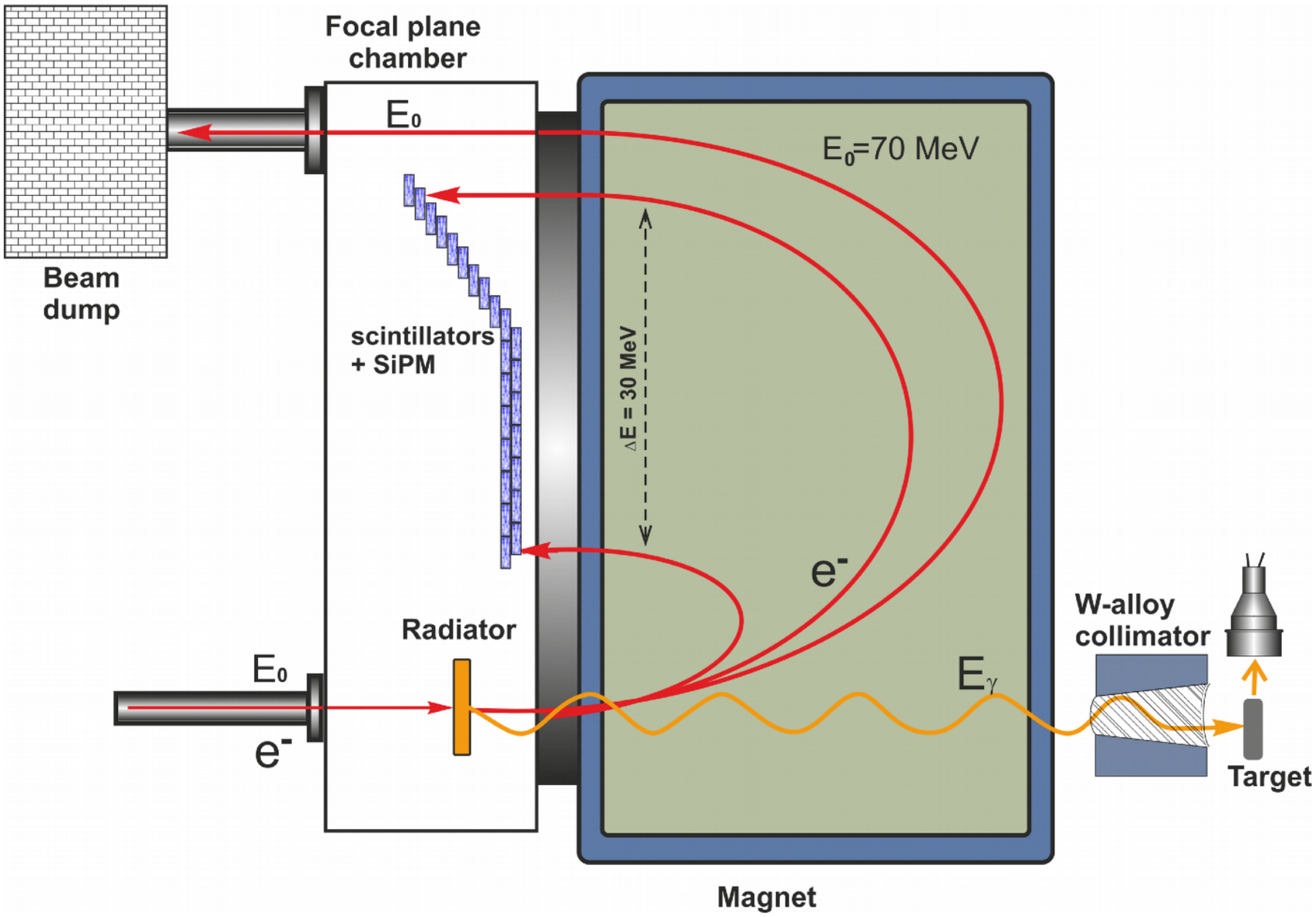
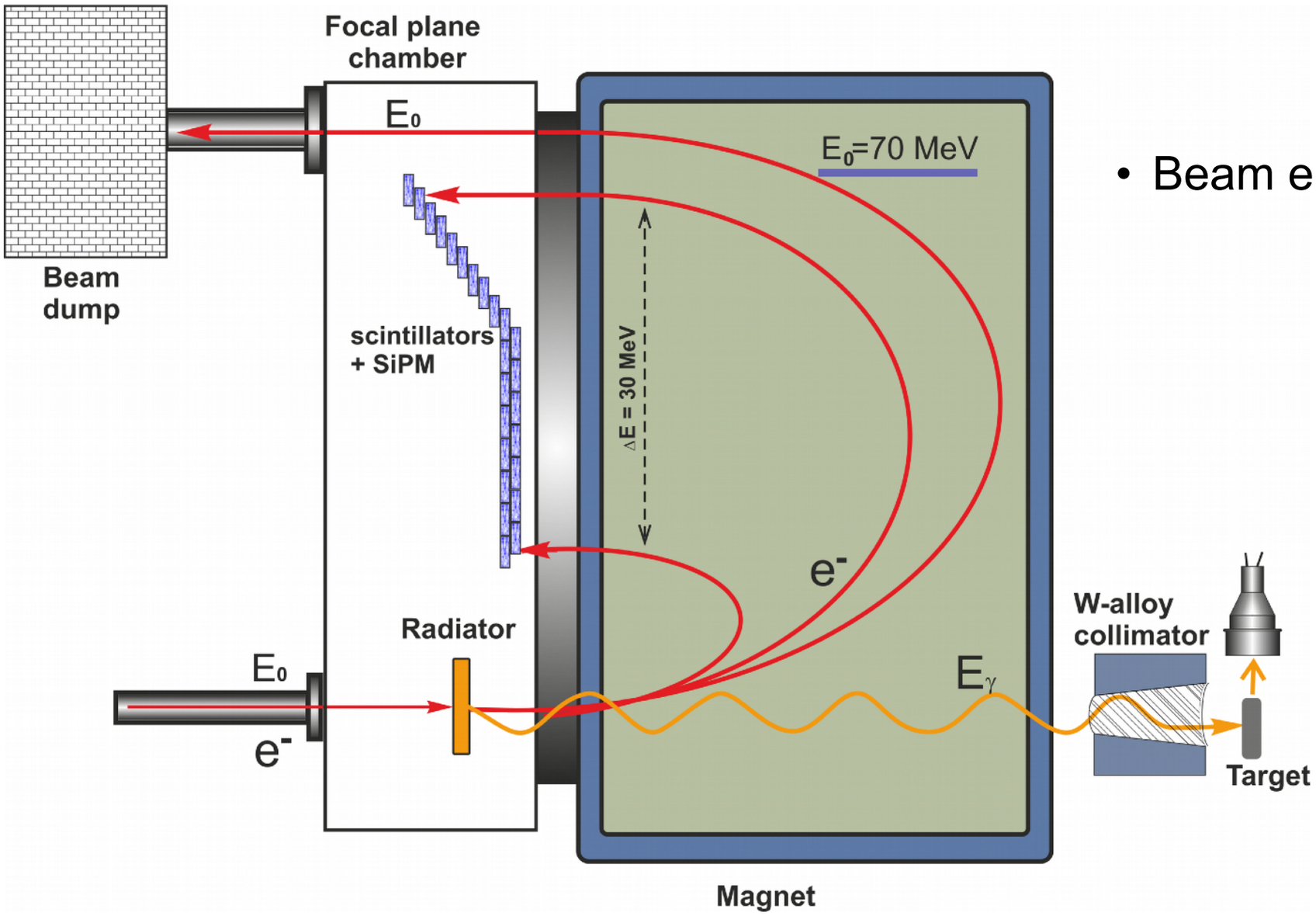
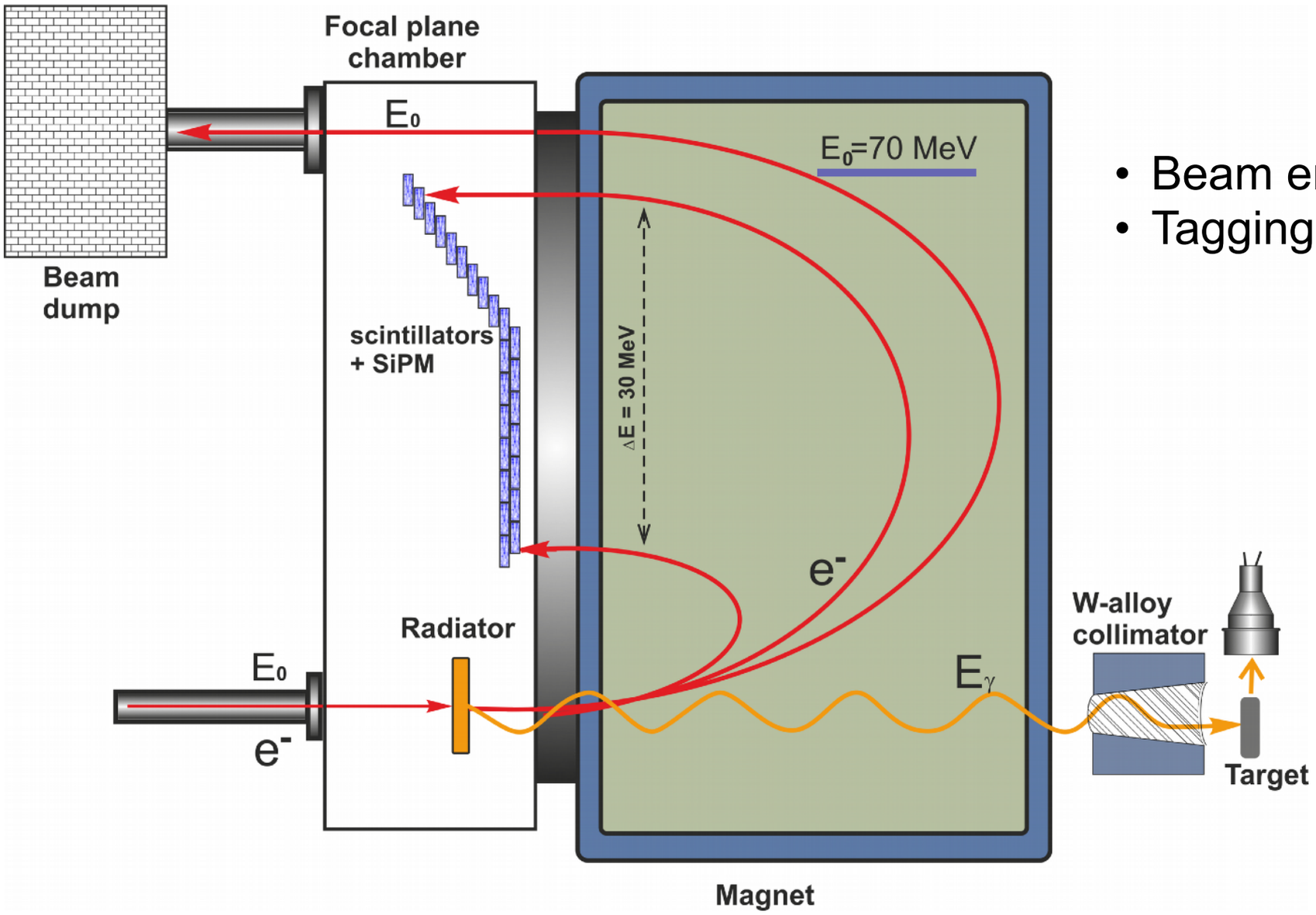


Neptun Photon Tagger – Upgrade



- Beam energy: 30 → 70 MeV

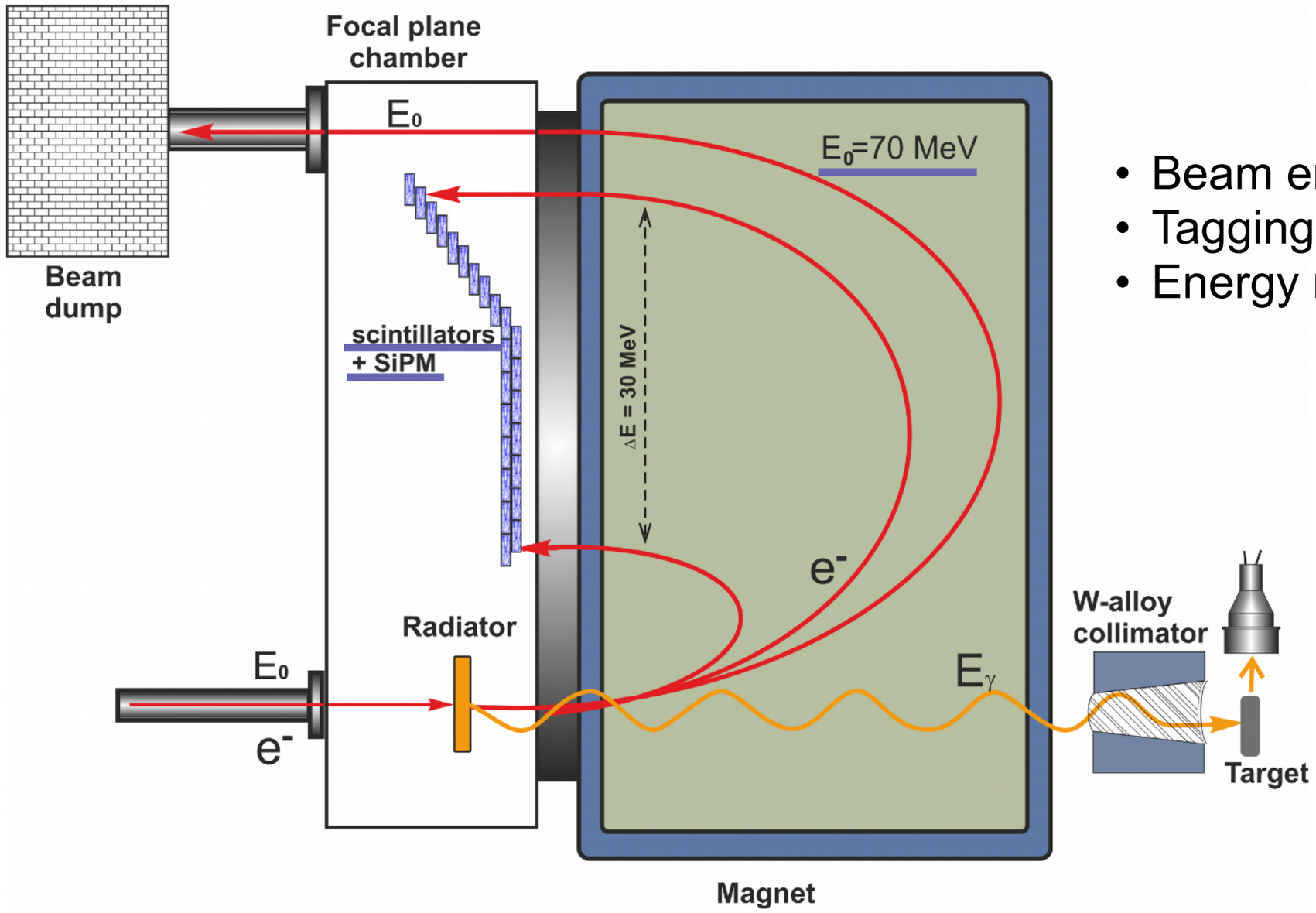
Neptun Photon Tagger – Upgrade



- Beam energy: 30 → 70 MeV
- Tagging ratio: 1.5 → 7.5%

$$R_{\text{tag}} = \frac{n_{\text{before}}}{n_{\text{after}}}$$

Neptun Photon Tagger – Upgrade



- Beam energy: 30 → 70 MeV
- Tagging ratio: 1.5 → 7.5%
- Energy range: 1.5 → 30 MeV

$$R_{\text{tag}} = \frac{n_{\text{before}}}{n_{\text{after}}}$$

Neptun Photon Tagger – Upgrade

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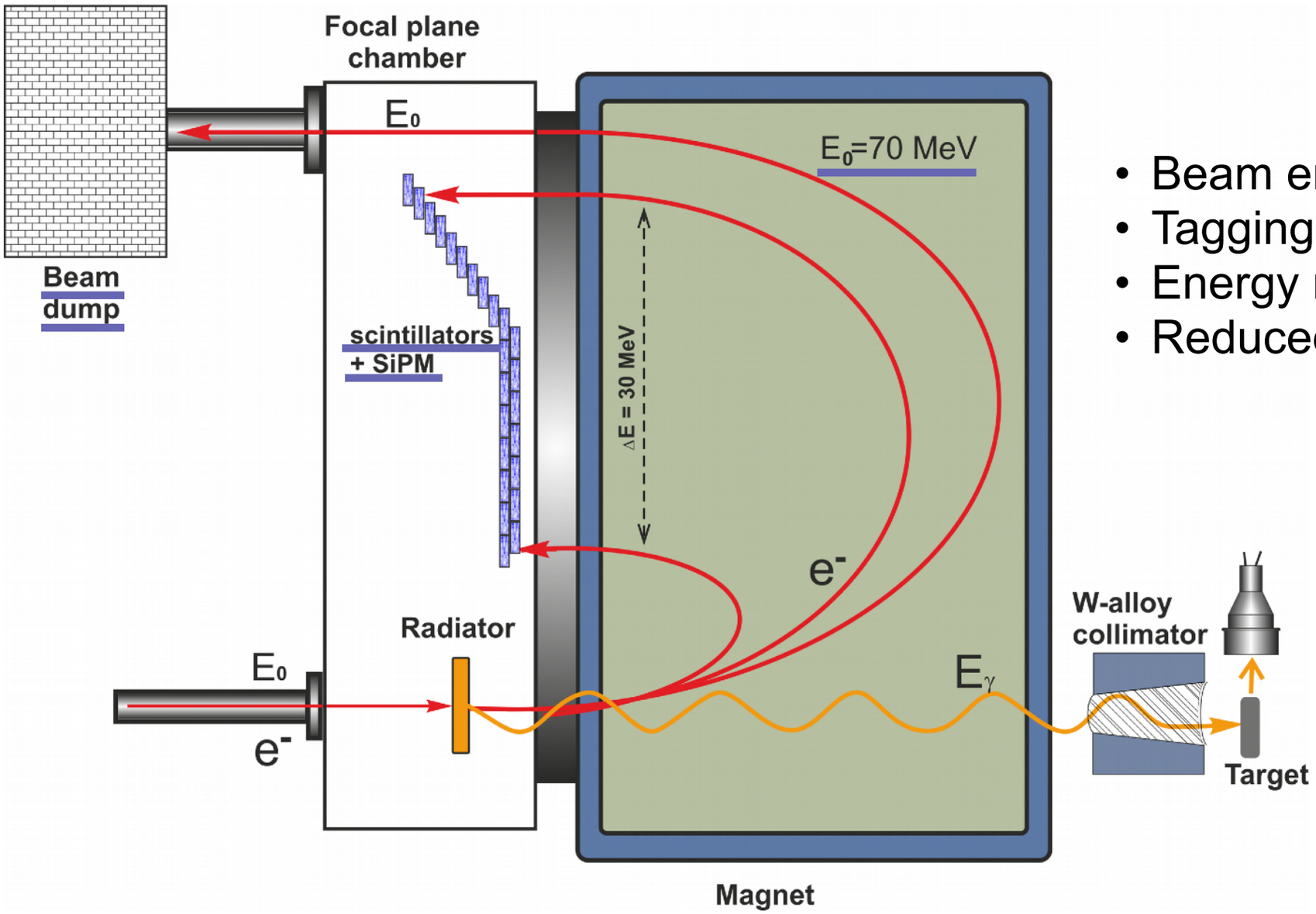

- Beam energy: 30 → 70 MeV
- Tagging ratio: 1.5 → 7.5%
- Energy range: 1.5 → 30 MeV
- Reduced background

$$R_{\text{tag}} = \frac{n_{\text{before}}}{n_{\text{after}}}$$

Neptun Photon Tagger – Current Setup

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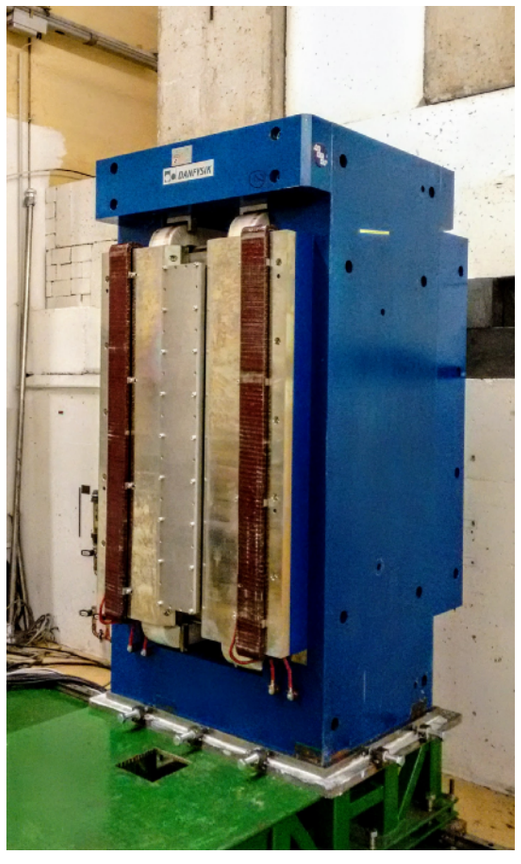
Last Year:



Neptun Photon Tagger – Current Setup

TECHNISCHE UNIVERSITÄT DARMSTADT

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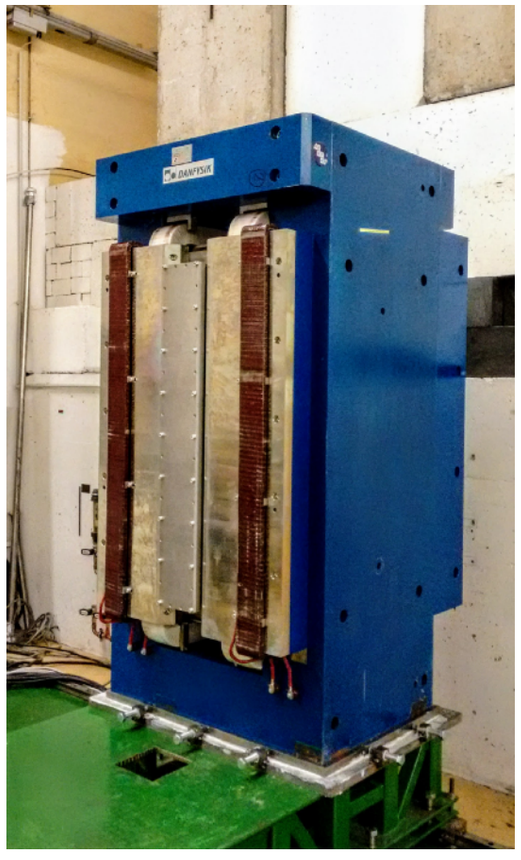
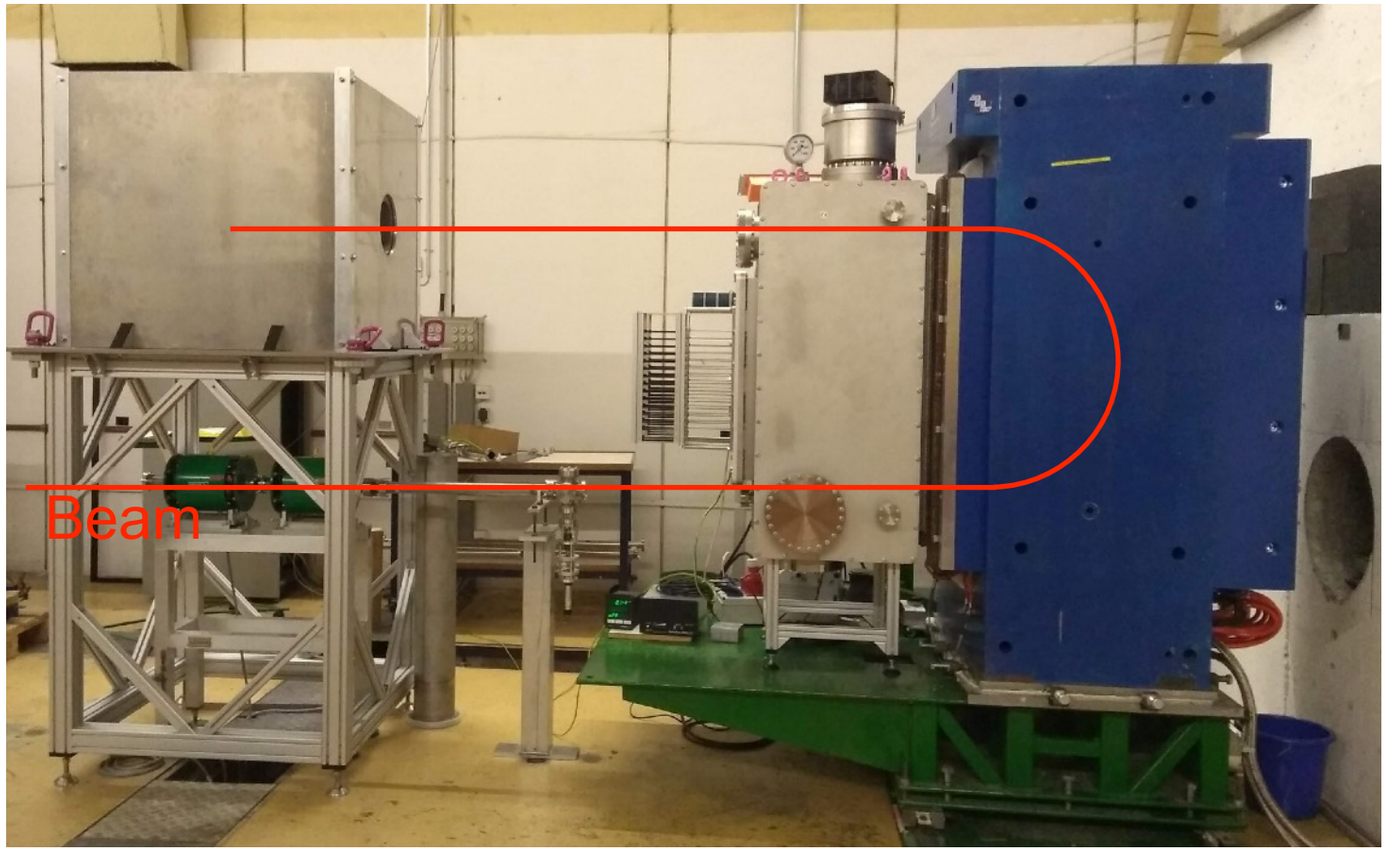


Now:



Neptun Photon Tagger – Focal Plane

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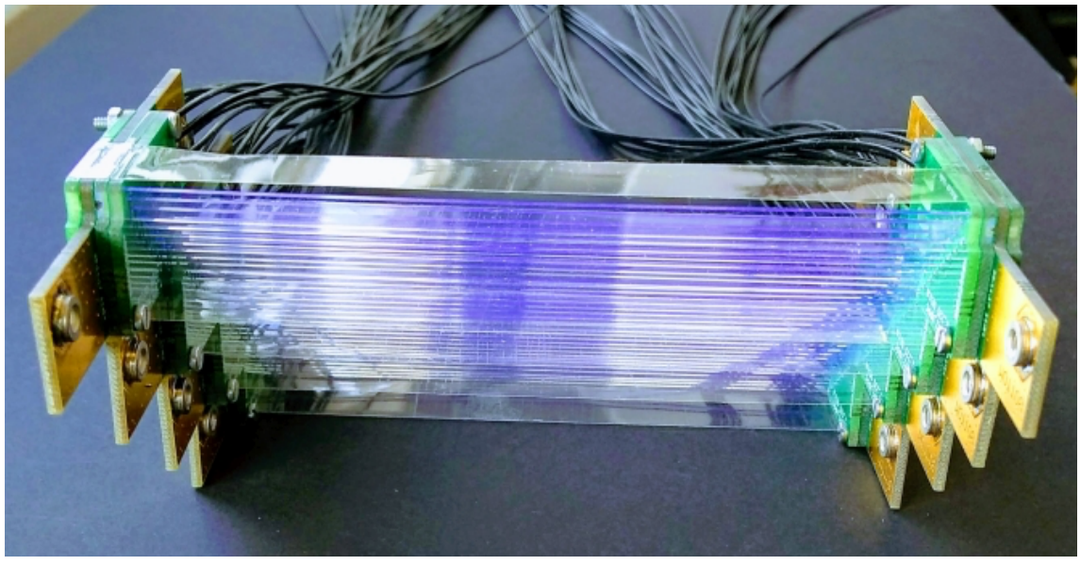

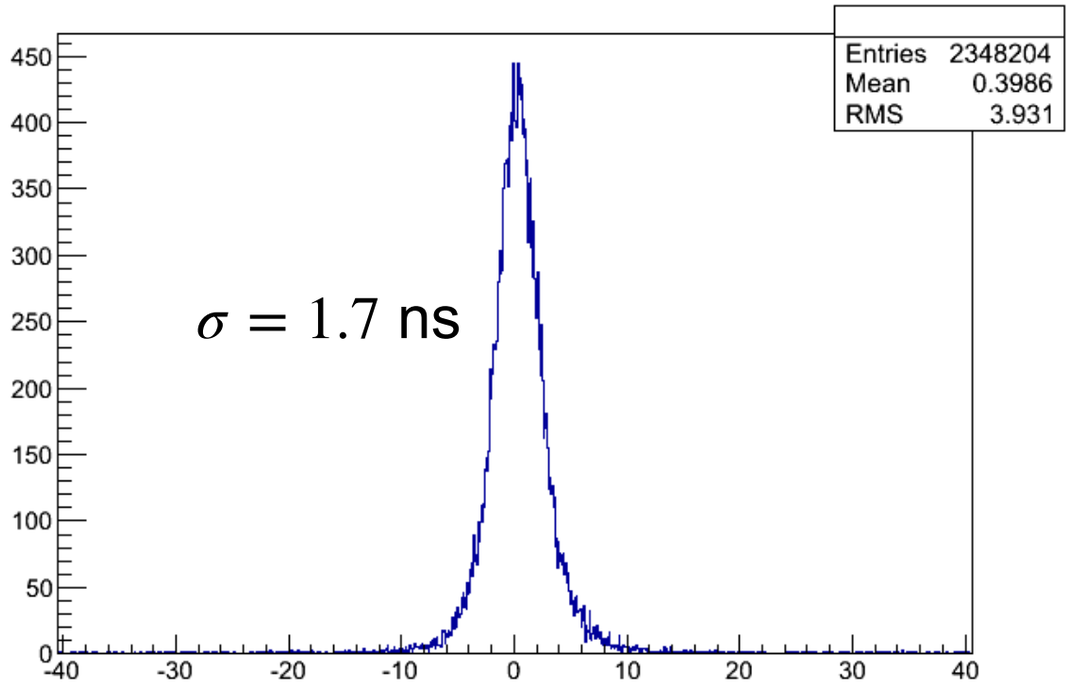

8 modules (64 stripes) are ready for commissioning run
→corresponds to ~1/3 of complete focal plane

Neptun – Current Status

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Time Schedule

Upgrade of NEPTUN magnet
Upgrade of vacuum chamber and focal plane

First commissioning
- Analysis of commissioning data
- Implement needed changes

Second commissioning:
- Extended focal plane
- Direct absorption

Production run:
- Direct absorption: Al (, O)
- (γ, γ') for ^{120}Sn

Neptun – Current Status

TECHNISCHE UNIVERSITÄT DARMSTADT

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TECHNISCHE UNIVERSITÄT DARMSTADT

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Neptun – Current Status

TECHNISCHE UNIVERSITÄT DARMSTADT

Time Schedule

Upgrade of NEPTUN magnet	✓
Upgrade of vacuum chamber and focal plane	✓
First commissioning Analysis of commissioning data Implement needed changes	According to accelerator schedule (08/18)
Second commissioning: Extended focal plane Direct absorption	
Production run: Direct absorption: Al (, O) (γ, γ') for ^{120}Sn	

Neptun – Current Status

TECHNISCHE UNIVERSITÄT DARMSTADT

Time Schedule

Upgrade of NEPTUN magnet	✓
Upgrade of vacuum chamber and focal plane	✓
First commissioning	According to accelerator schedule (08/18)
Analysis of commissioning data	
Implement needed changes	
Second commissioning:	10/18
Extended focal plane	
Direct absorption	
Production run:	
Direct absorption: Al (, O)	
(γ, γ') for ^{120}Sn	

Neptun – Current Status

TECHNISCHE UNIVERSITÄT DARMSTADT

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Upgrade of NEPTUN magnet	✓
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First commissioning Analysis of commissioning data Implement needed changes	According to accelerator schedule (08/18)
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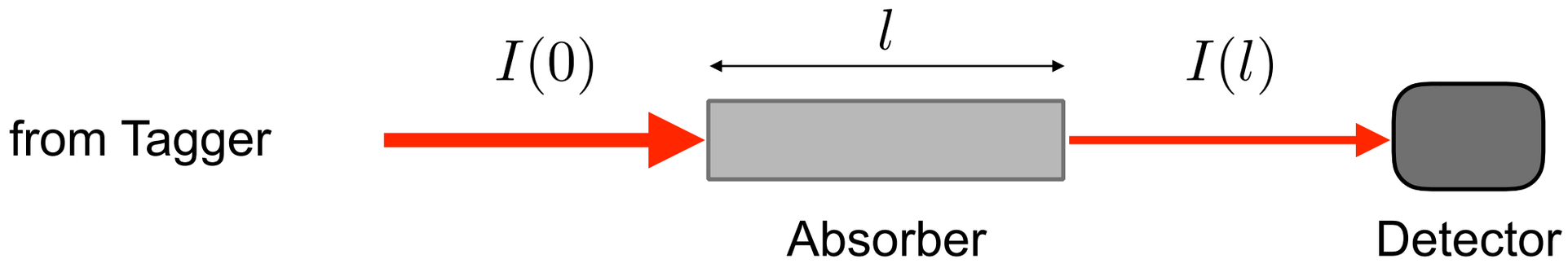
Production run: Direct absorption: Al (, O) (γ, γ') for ^{120}Sn	11/18

Total Absorption Experiments – A Basic Idea



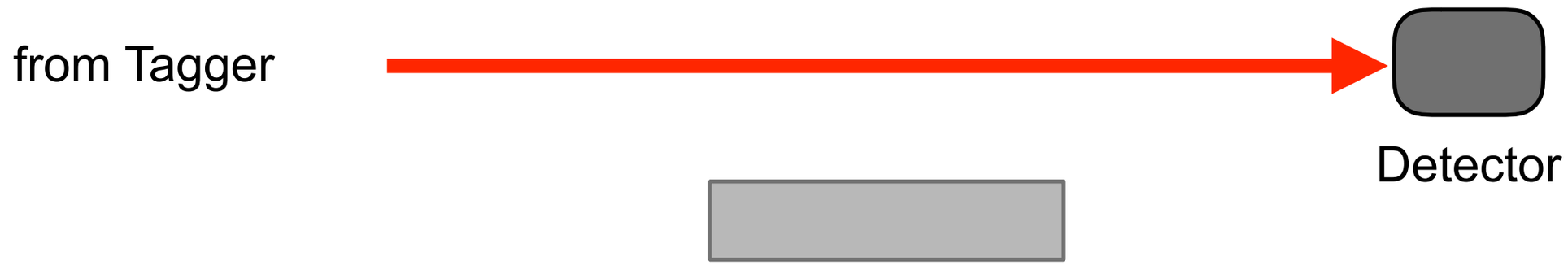
calculating the cross section:

$$I(l) = I(0) \cdot \exp\left(-\frac{N}{A} \cdot \sigma_{\mathrm{tot}}\right)$$

$$\Rightarrow \sigma_{\mathrm{tot}} = -\frac{A}{N} \cdot \ln\left(\frac{I(l)}{I(0)}\right)$$

I: γ-Intensity, N: #Atoms, A: Area

Total Absorption Experiments – A Basic Idea



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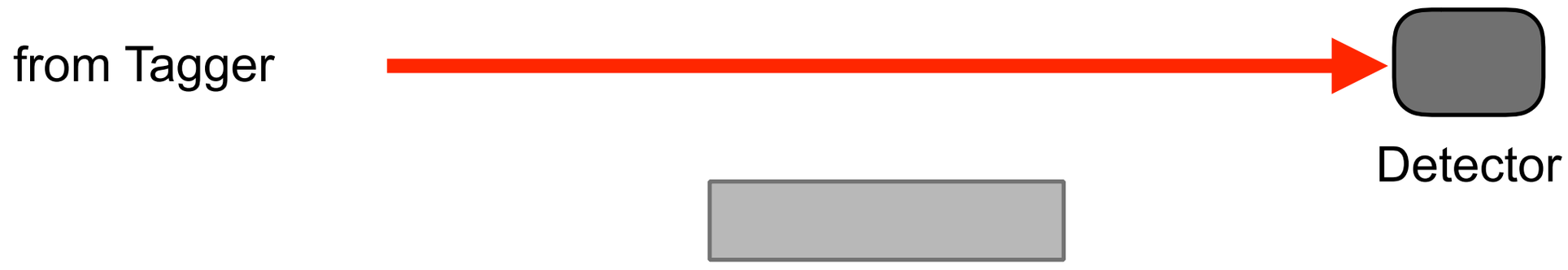

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I: γ-Intensity, N: #Atoms, A: Area

Advantages:
- Using single detector
- No change of its properties
- Independent of efficiency

Disadvantages:
- Dominated by atomic contribution

Total Absorption Experiments – The Planned Setup

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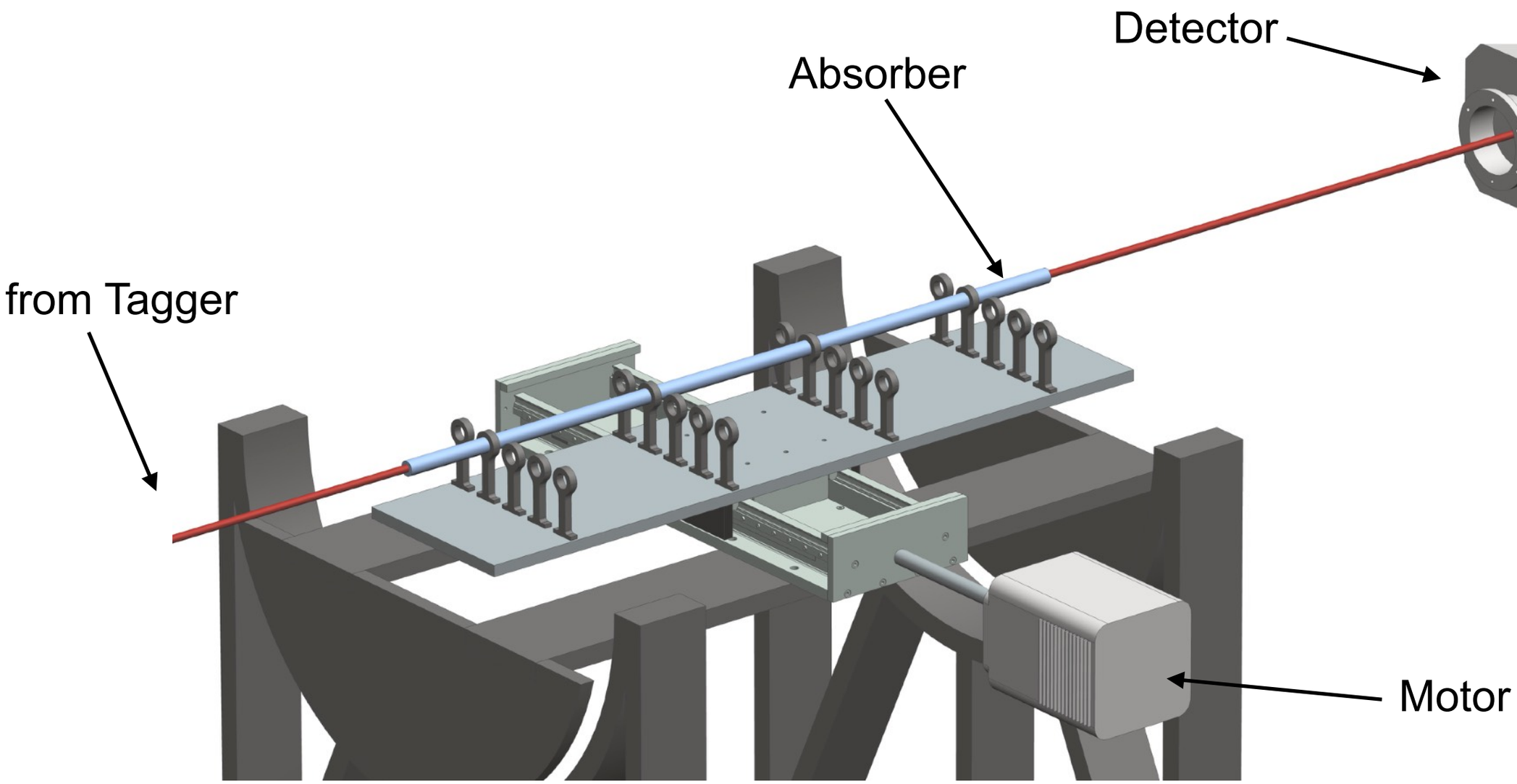

Total Absorption Experiments – The Planned Setup

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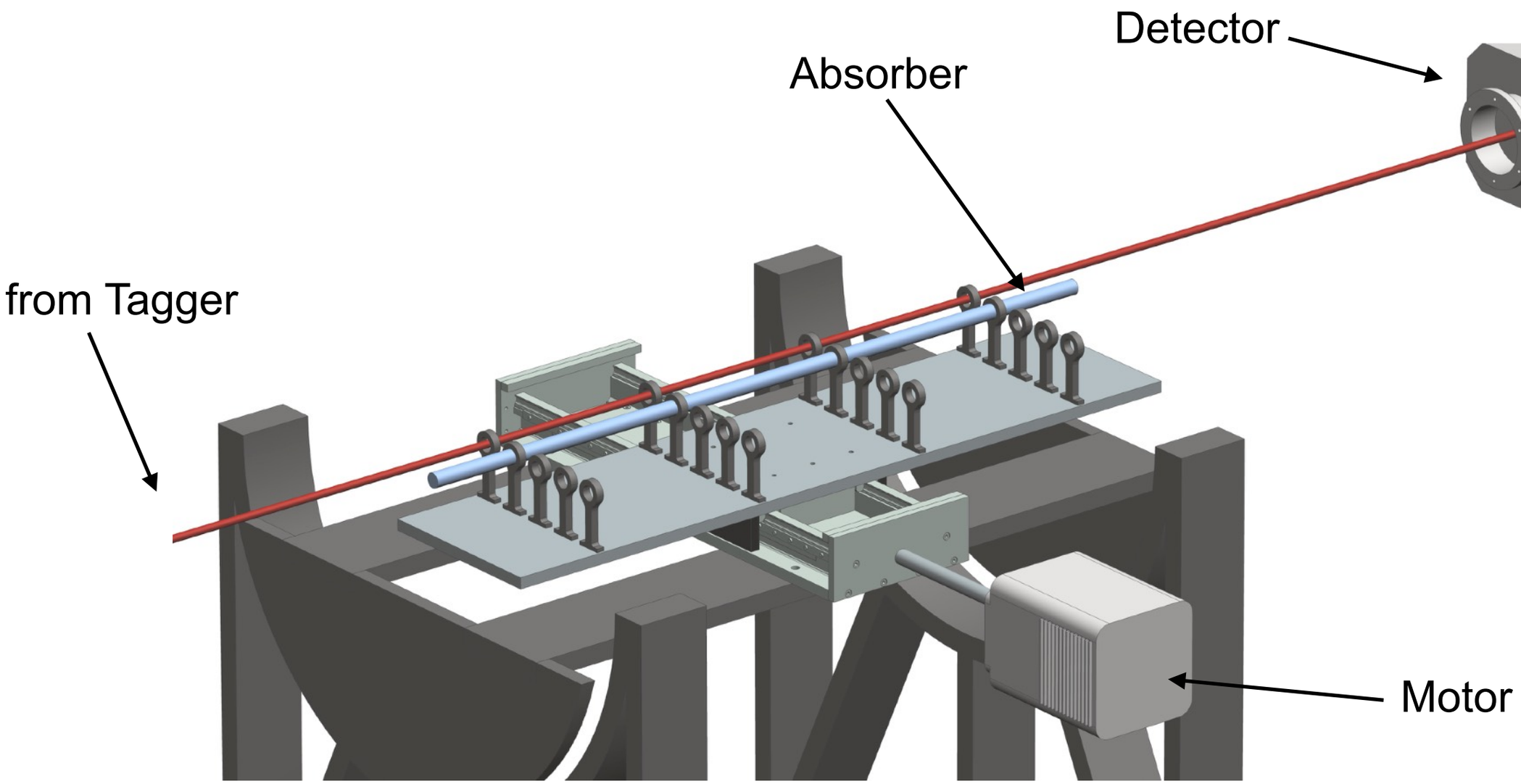

Total Absorption Experiments – Status

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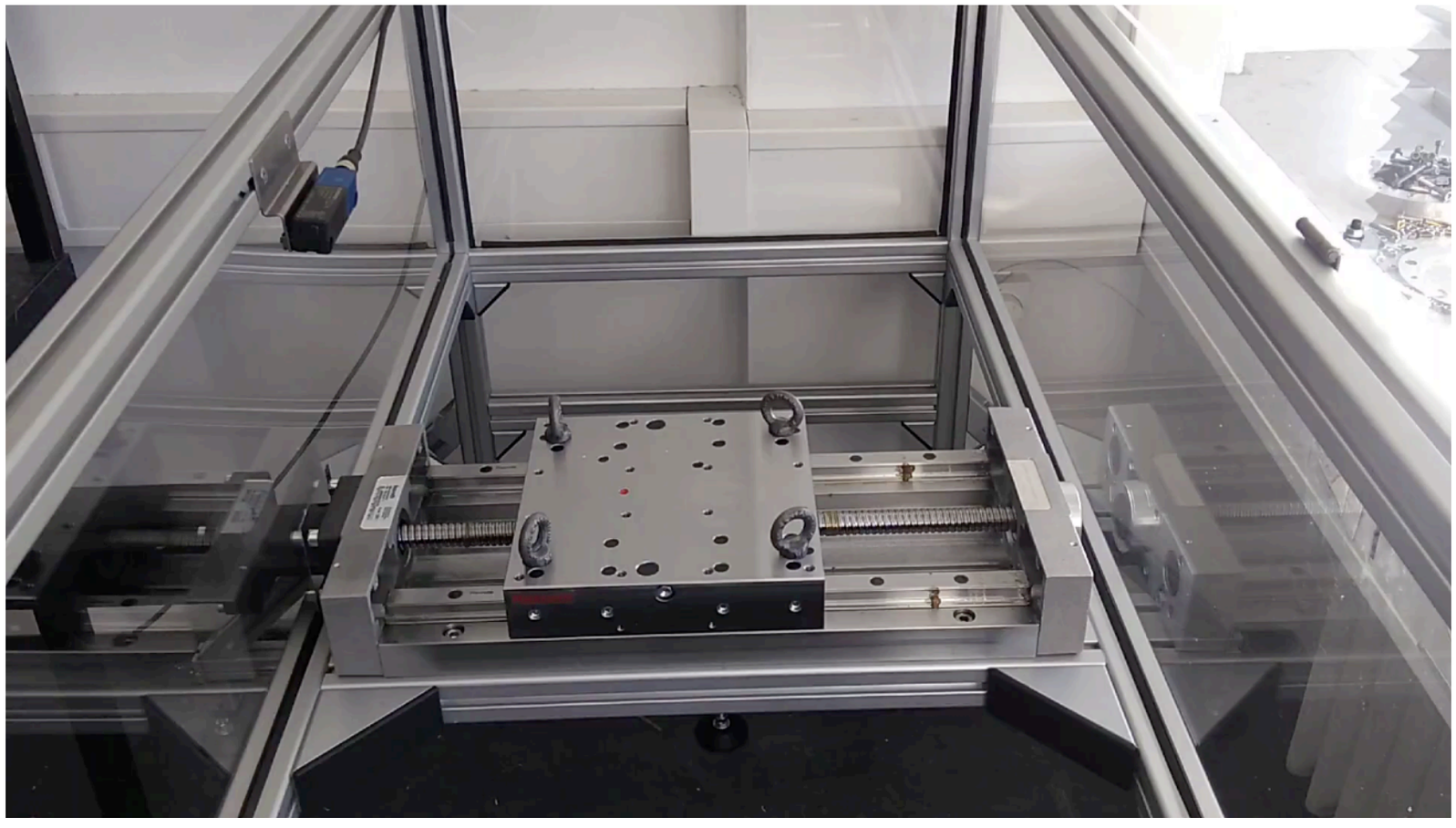
- Bsc-Thesis of Alexander Fuchs
  - Cooperation with Maschinenbau
  - planned to finish 10/18



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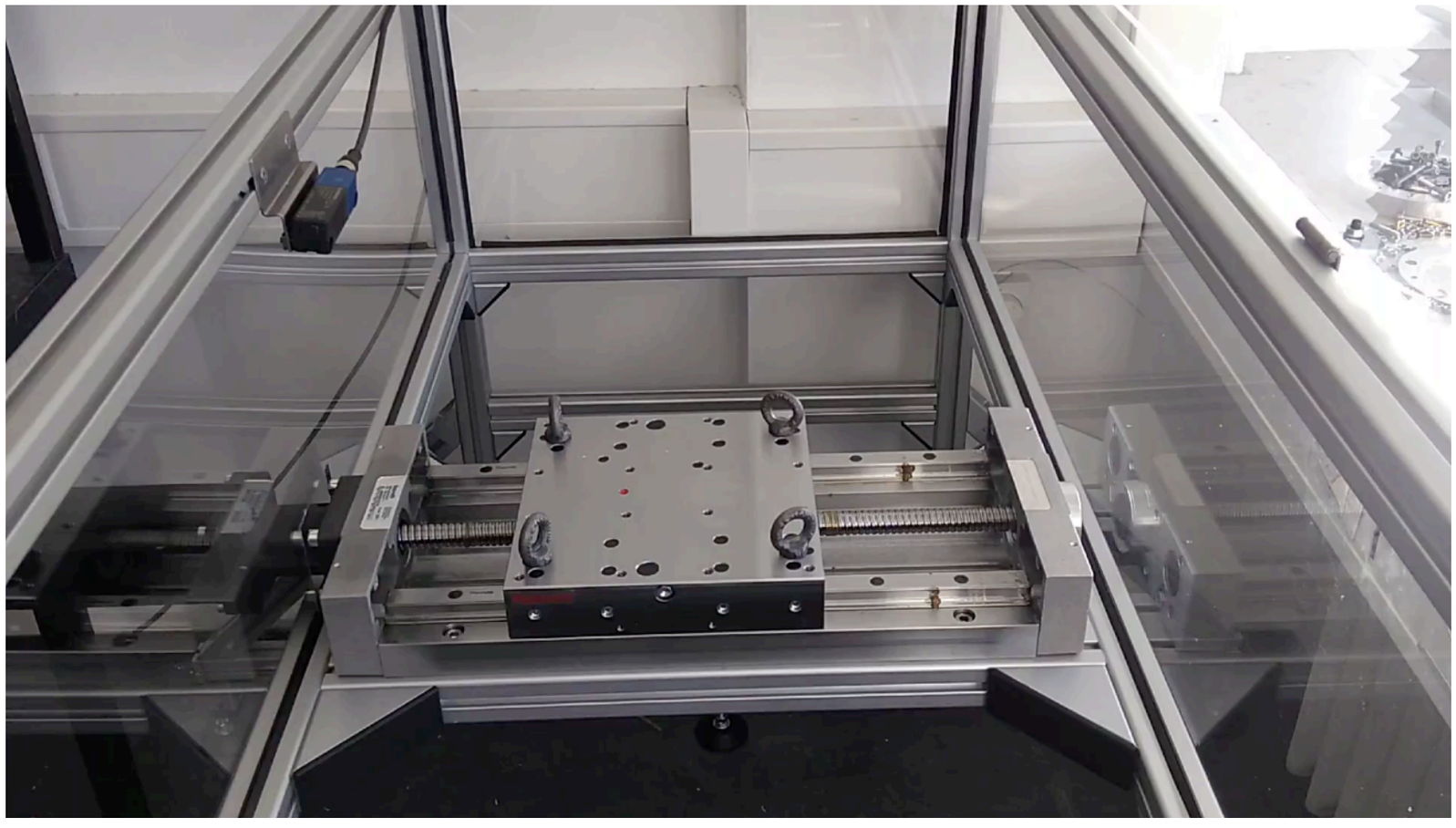
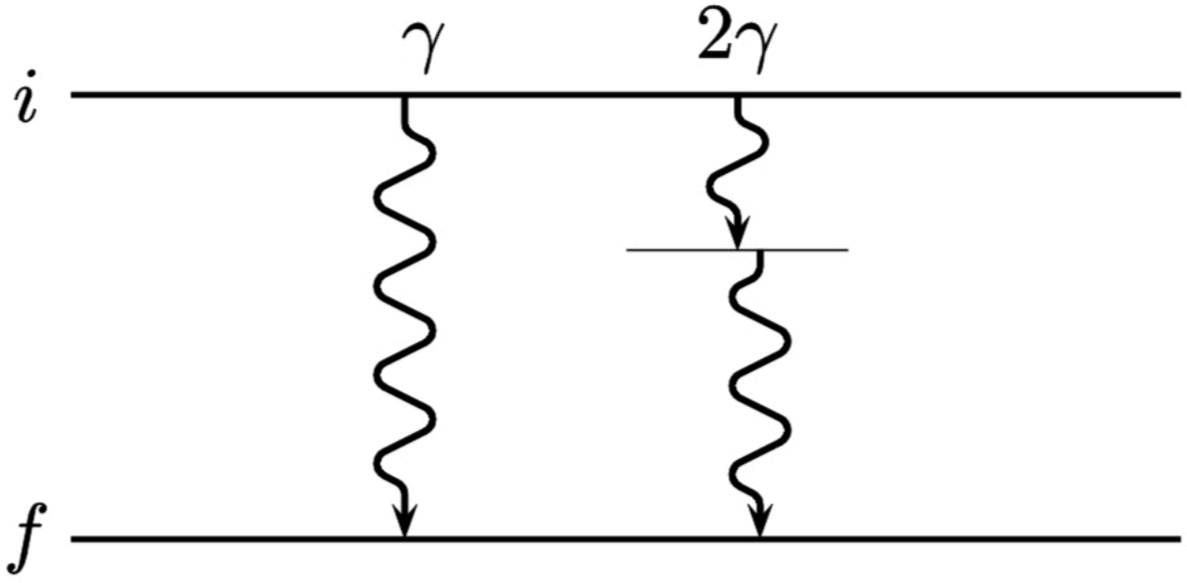


Competitive 2-Gamma Decay



- 2-gamma decay can occur
- QM process of second order

2-Gamma Decay – Current Setup

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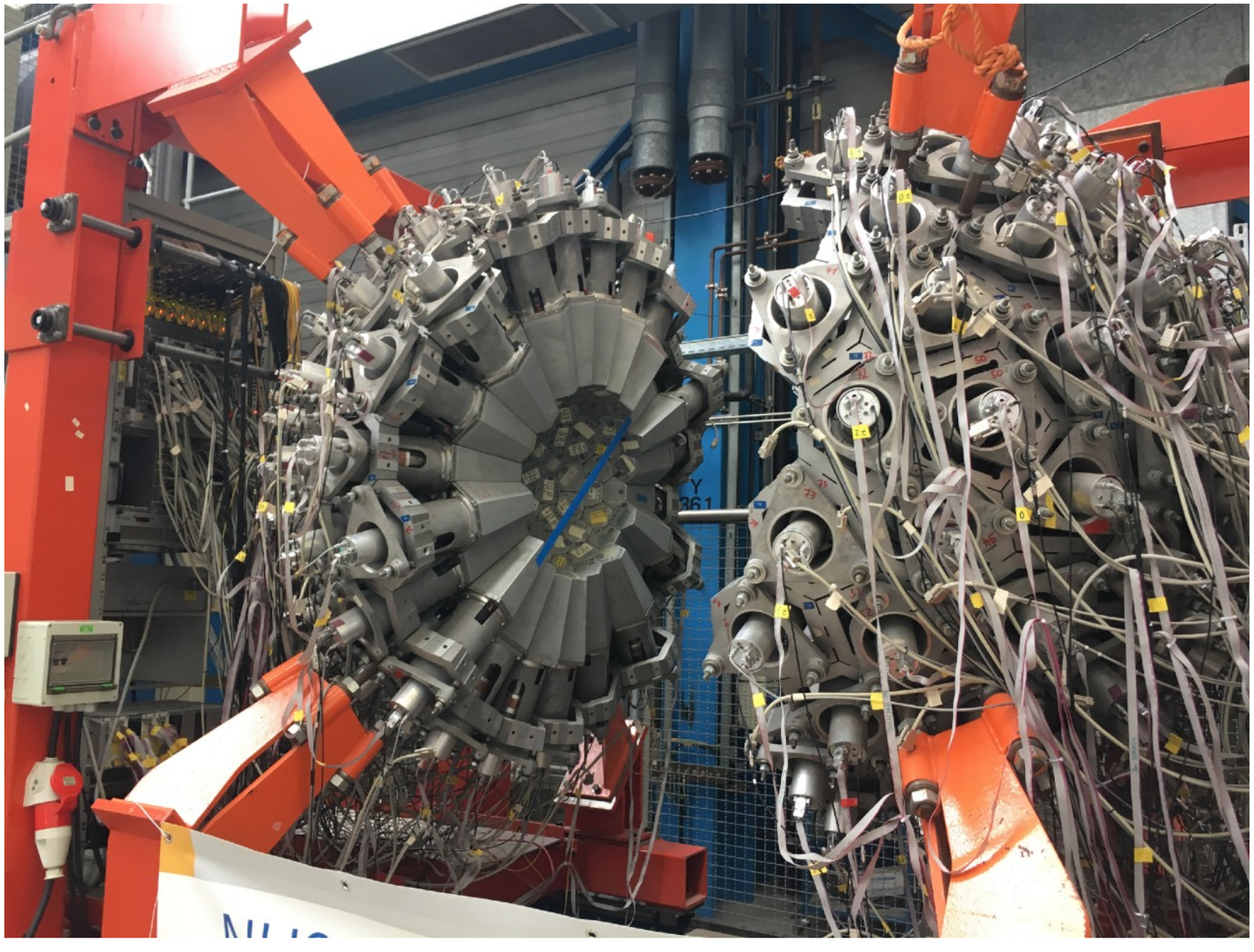
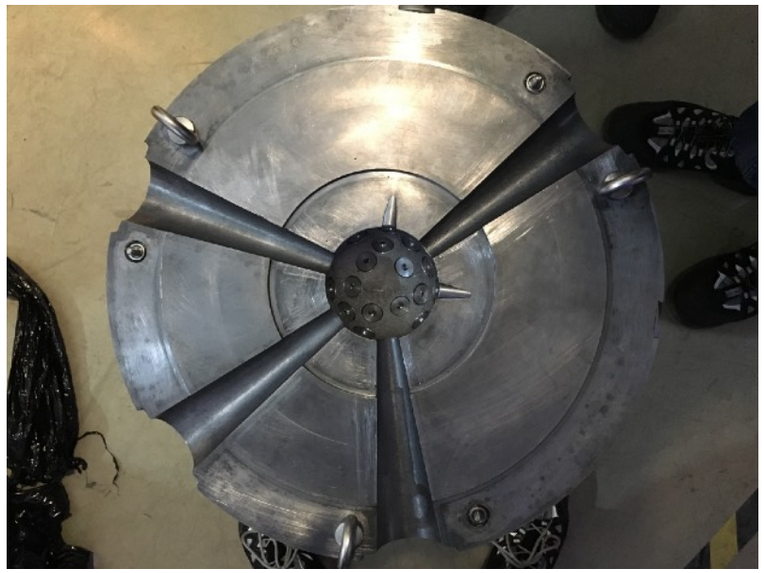


- Heidelberg-Darmstadt CrystalBall
- Solid angle: 4 pi
- 162 NaI-detectors

BACCHUS LeadBall



- LeadBall BACCHUS with 37 holes
- To be placed inside CrystalBall
- Shields gamma rays (20cm of lead)
- Delivery in Q4/17

2-Gamma Decay – Current Status

SFB Milestones

2016

Design of new focal plane	✓
Upgrade of NEPTUN magnet	✓
Simulation for design of BACCHUS	✓
Find further nuclei for 2-gamma decay	✓

2017

NEPTUN commissioning	**08/18**
High-statistics run with standard sources	**now**

2018

(γ, γ') experiments with Sn-isotopes	**11/18**
Measure 2-gamma decay of selected isotopes	**later this year**

Thanks!

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Thank you for your attention!

Questions?

Appendix

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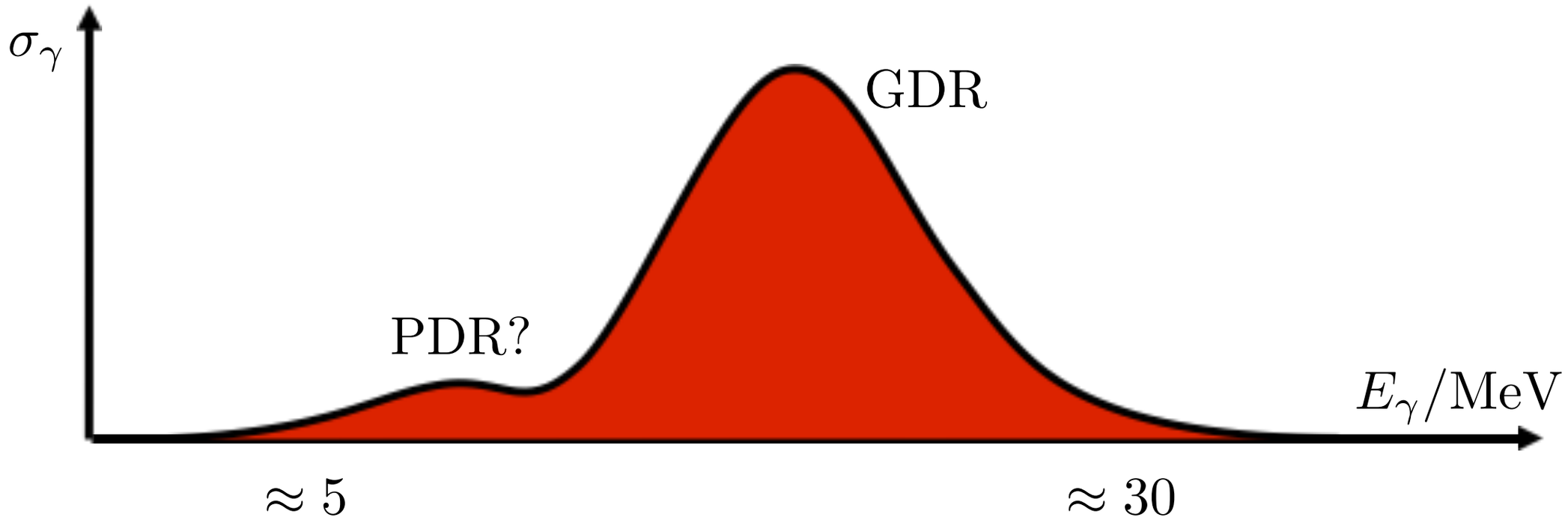
Another Approach – Total Absorption



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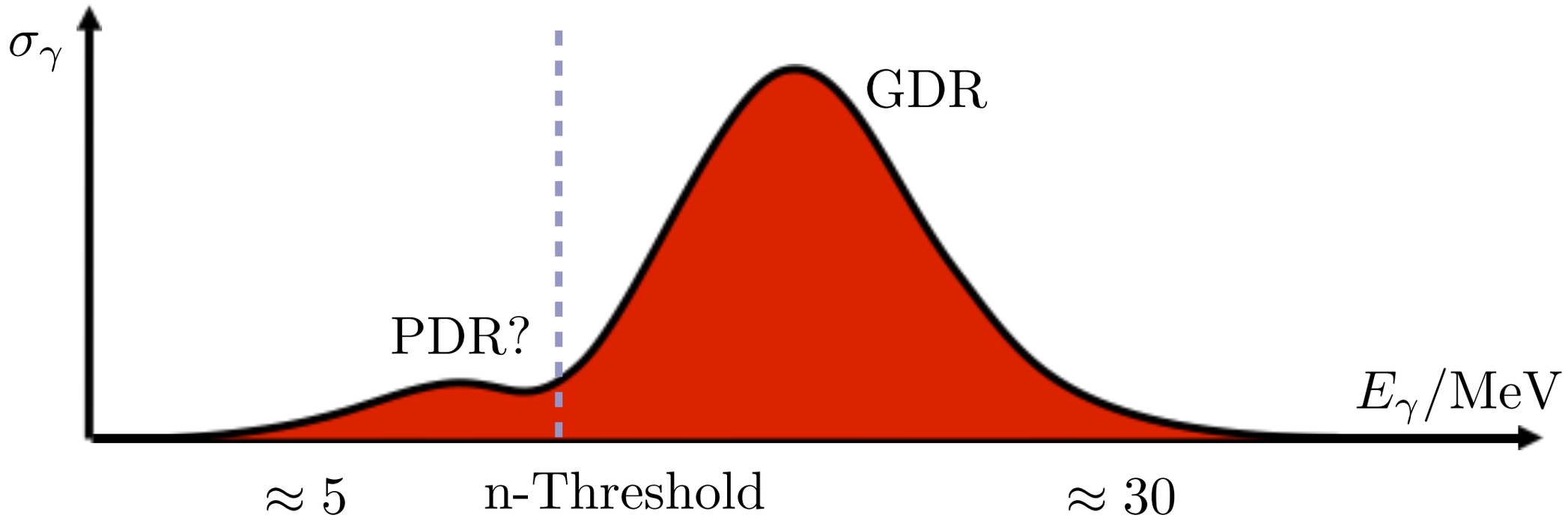

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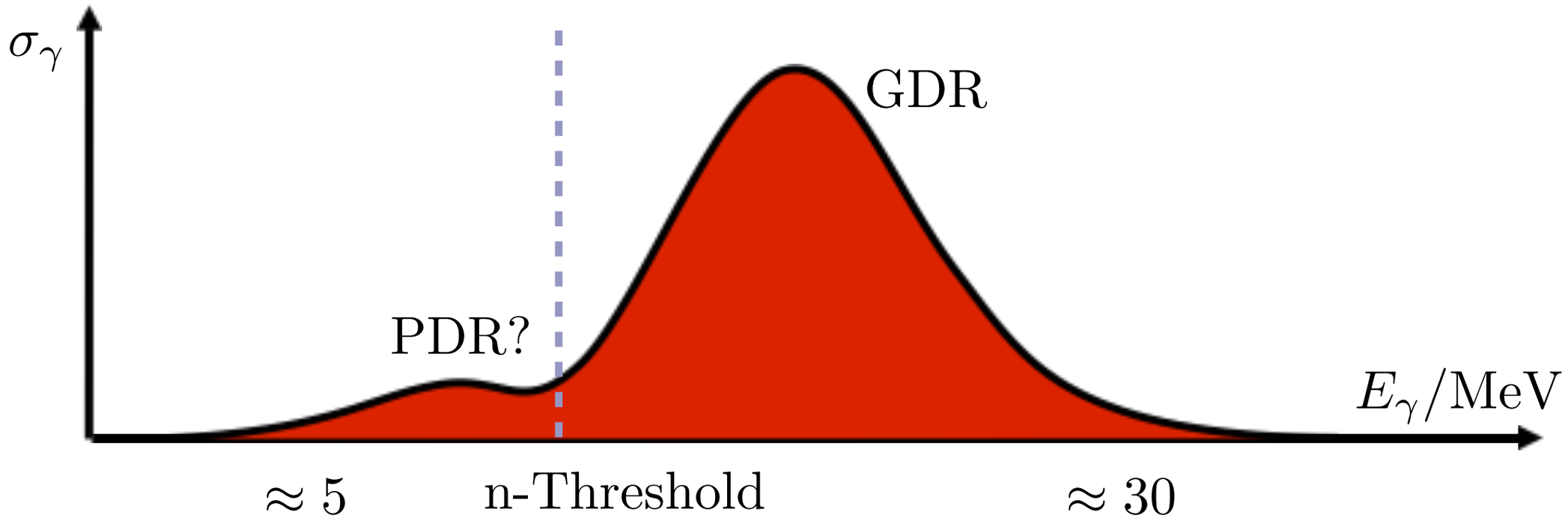
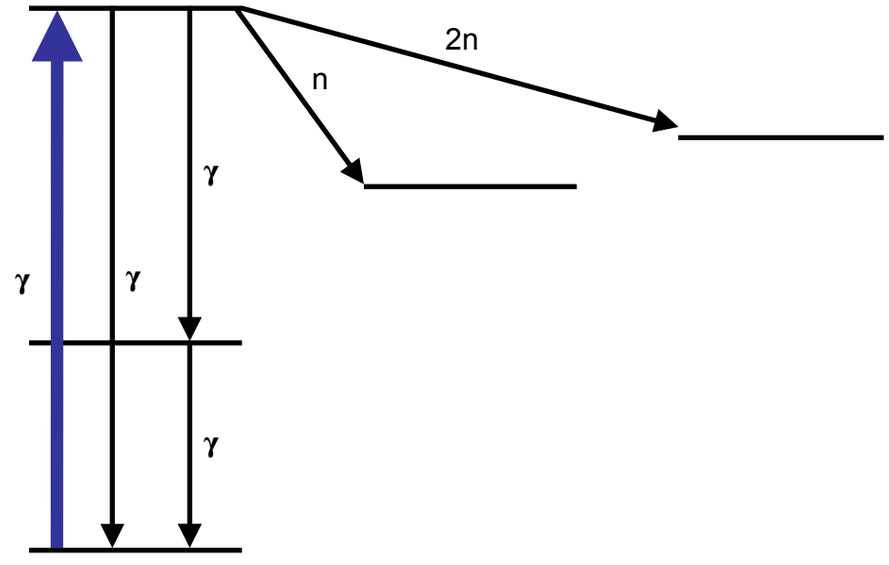
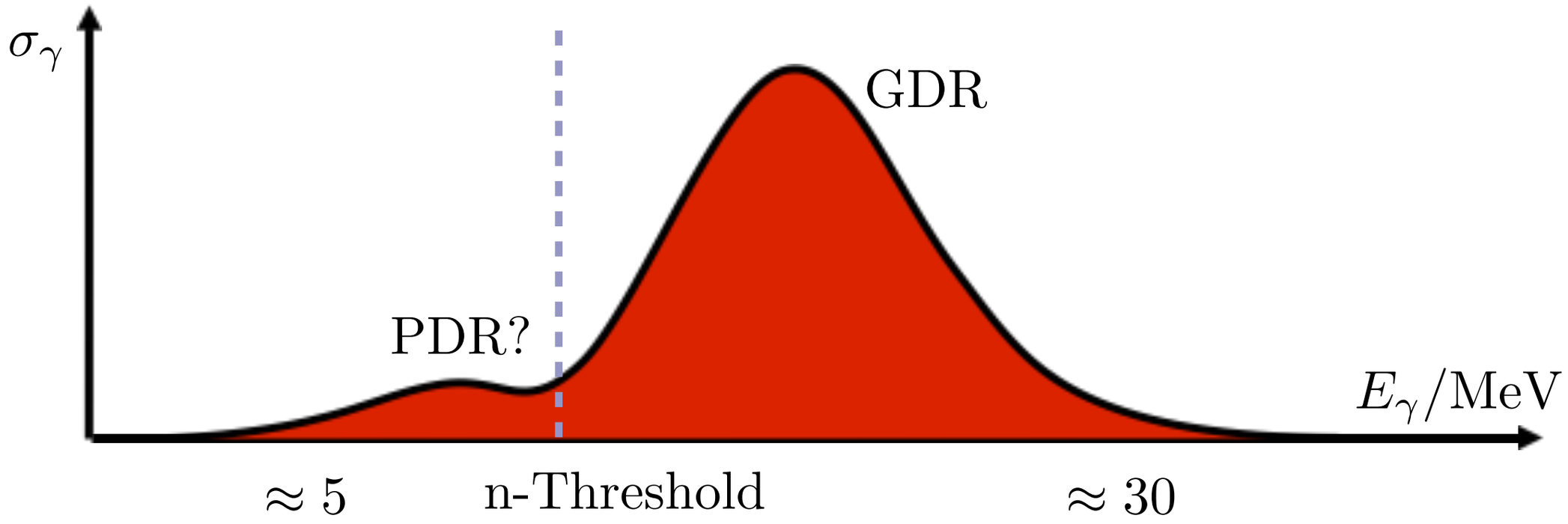


- close to n-Threshold: more reaction channels

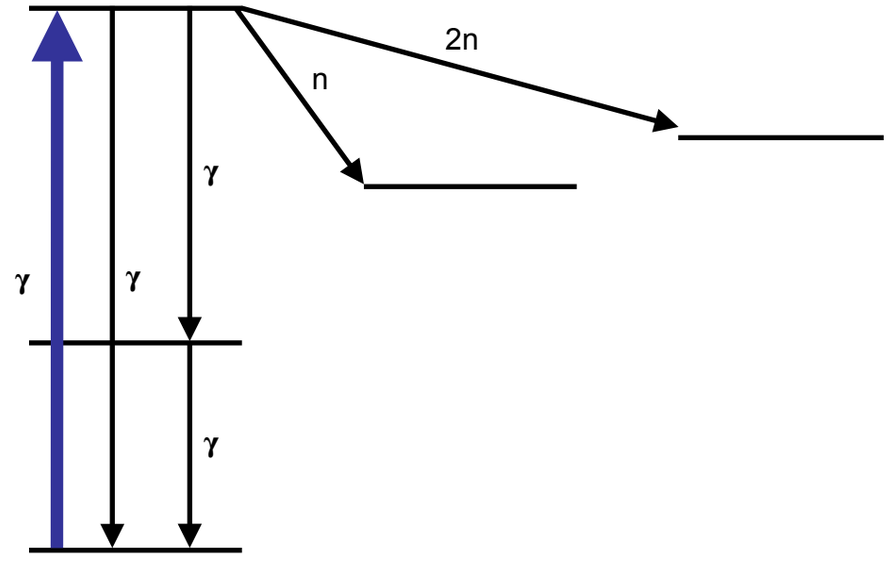


Another Approach – Total Absorption

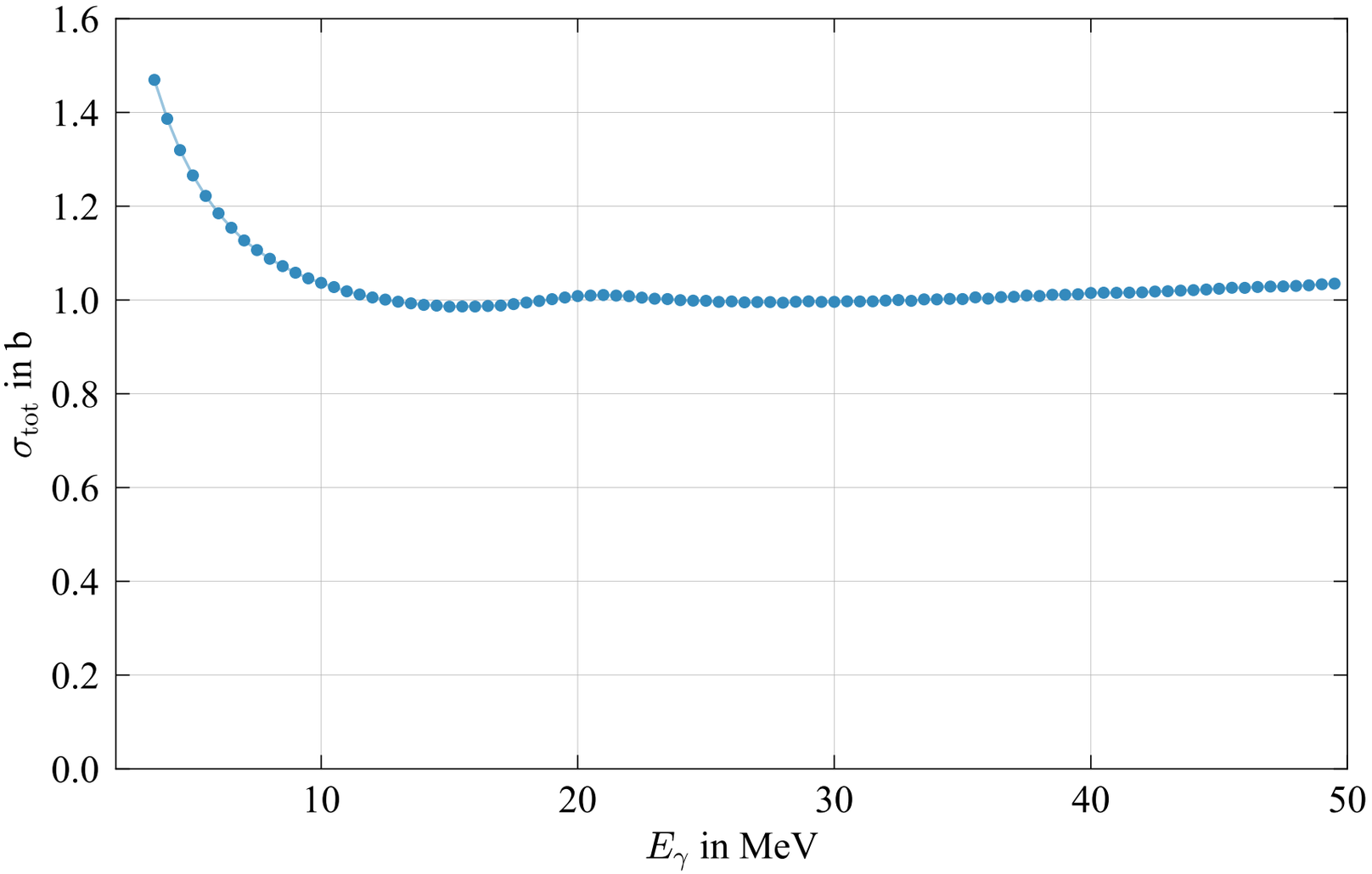


- close to n-Threshold: more reaction channels

↳measuring total absorption directly



Total Absorption Experiments – Simulation



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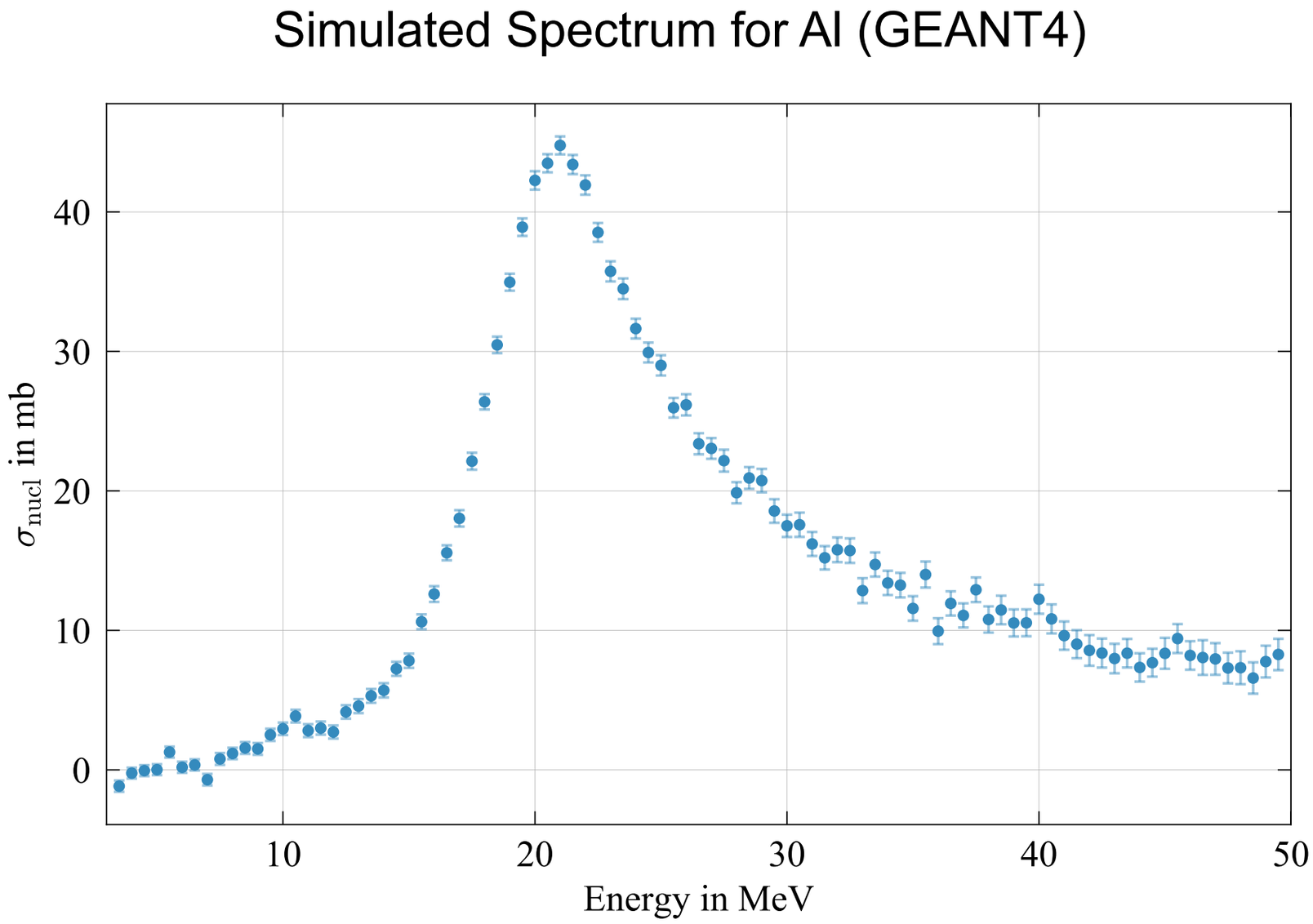
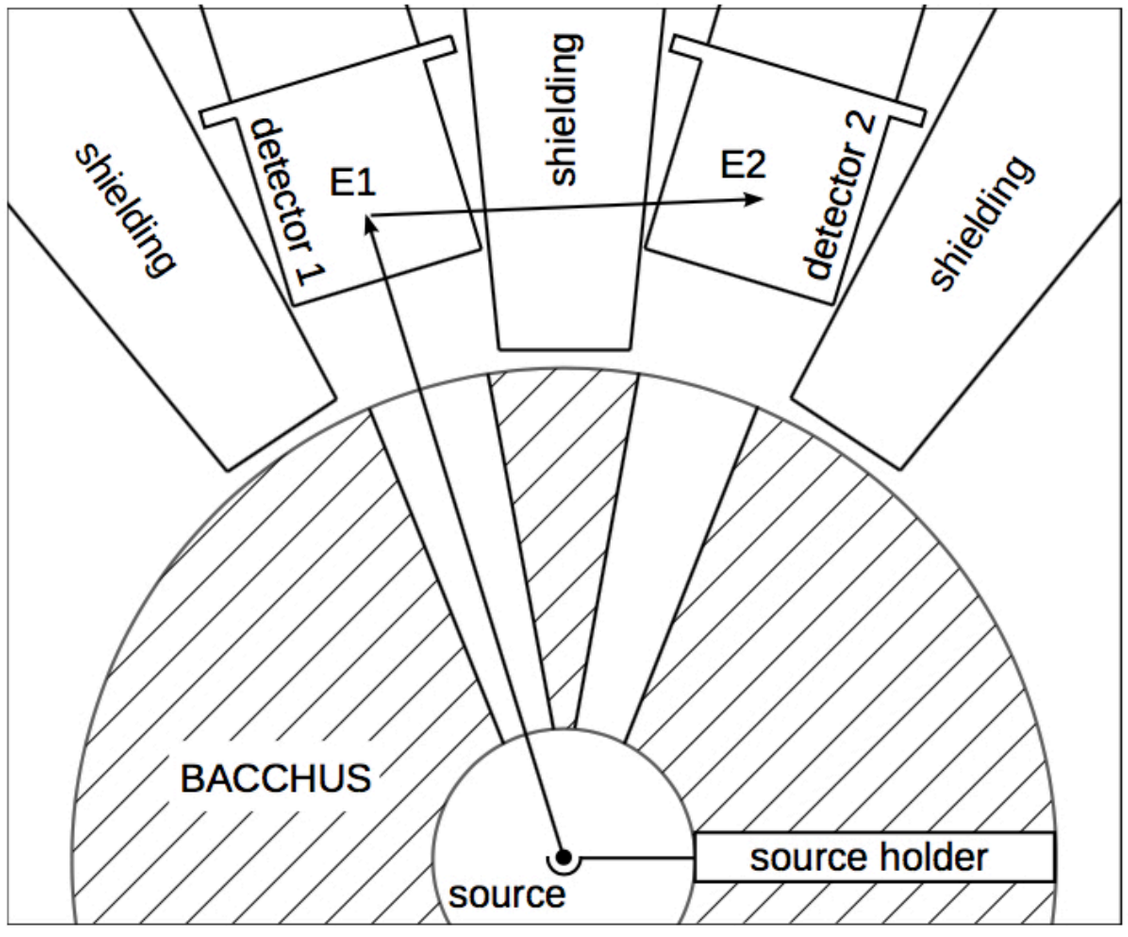


Simulated Beamtime: 4 – 5h

Stat. uncertainty: ±1mb@30MeV

Principle of new Measurement



- Using LaBr-detectors for measurement
- Active shielding: NaI
- Holes serve as collimators

Neptun Photon Tagger – Vacuum Chamber

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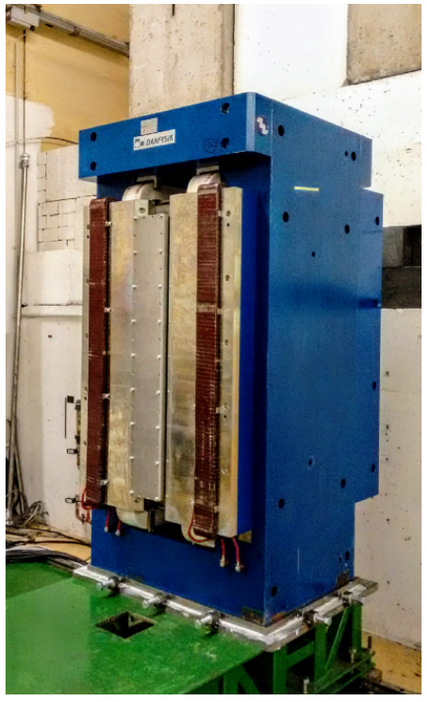

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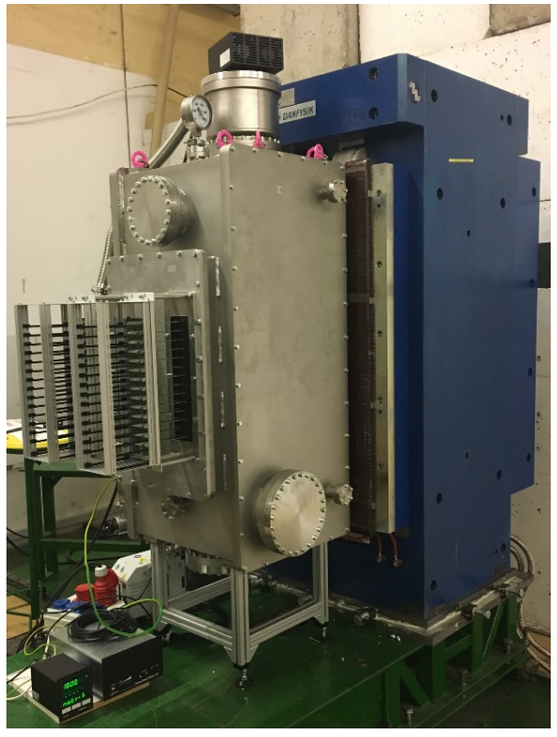

Electronic vacuum feedthrough: ~450 signal wires

Vacuum Tested: $p < 2 \cdot 10^{-6}$ mb