Novel approach to determine ion beam spot position for in-beam γ-spectroscopy

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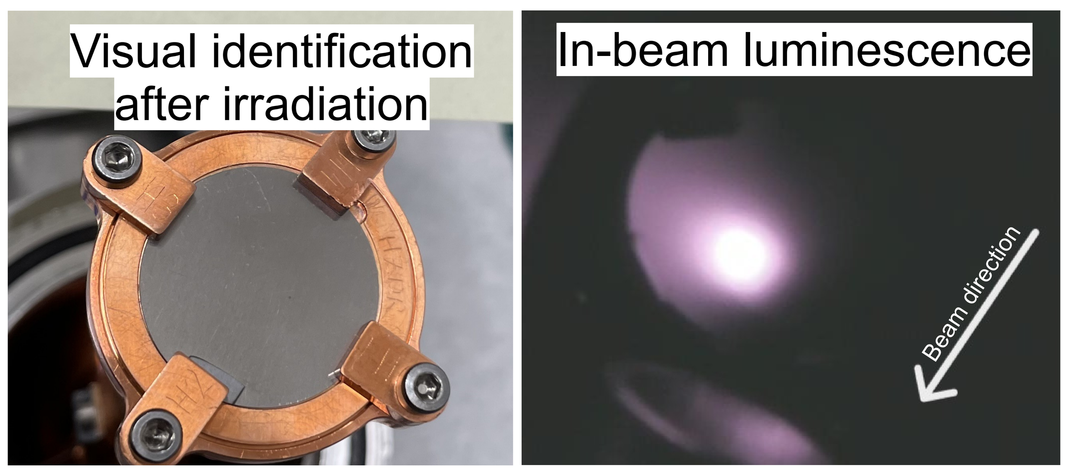
In in-beam γ-ray spectroscopy, the position of the beam spot on the target affects the efficiency of γ-ray detectors, hence cross sections and angular distributions of the reaction of interest. Not all solid target experiments allow a determination of the beam spot via camera observation of luminescence during irradiation or via a visual identification after the irradiation.
Here we present a new approach to determine the beam spot position using isotropic beam-induced background γ-lines and a Monte-Carlo description of the setup. By comparing the expected angular distribution (isotropic) for different simulated beamspots and using the reduced χ^2 of the angular distribution fit, we created a map of the target showing the most likely beamspot position. This approach was used for the $^{2}H(p,\gamma)^{3}He$-campaign at Felsenkeller, where the $^{19}F(p,\alpha\gamma)^{16}O$ parasitic reaction was used for the beam spot determination.

Effects of the beam spot position

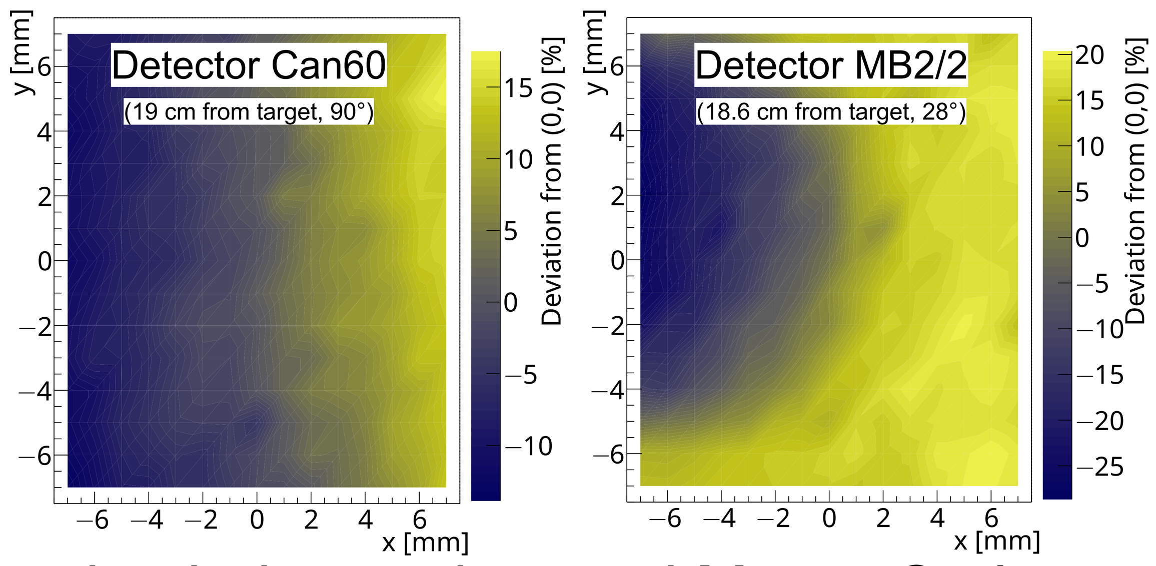
Position of beamspot affects the efficiency by up to 20 % for close geometry γ-ray detectors, hence **cross section** and **angular distribution** measurements. Monte-Carlo simulation of the beam spot can correct this effect.

Determination of position



Both approaches difficult to quantify

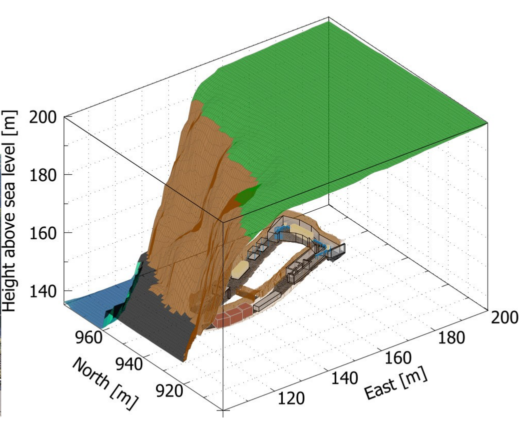
Change of efficiency depending on beamspot



Aim: Precise beam spot position using in-beam data and Monte-Carlo

Felsenkeller laboratory

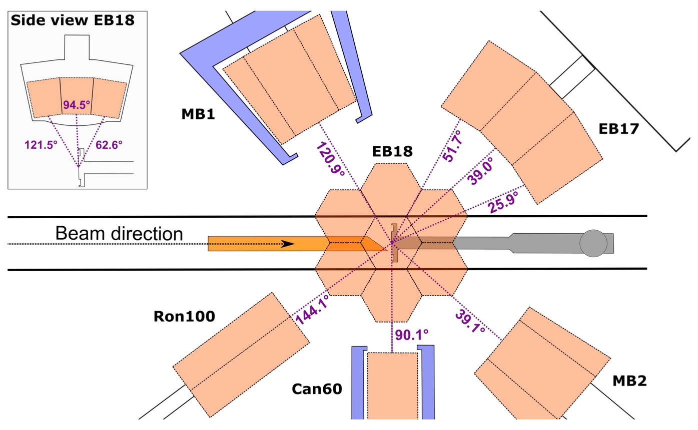
- Located in Dresden (Germany)
- 45 m of rock overburden
- 5 MV Pelletron accelerator
- Beam types: p, α, ^{12}C, ^{14}N, ^{16}O, ...
- Typical beam intensity: 5 – 20 µA



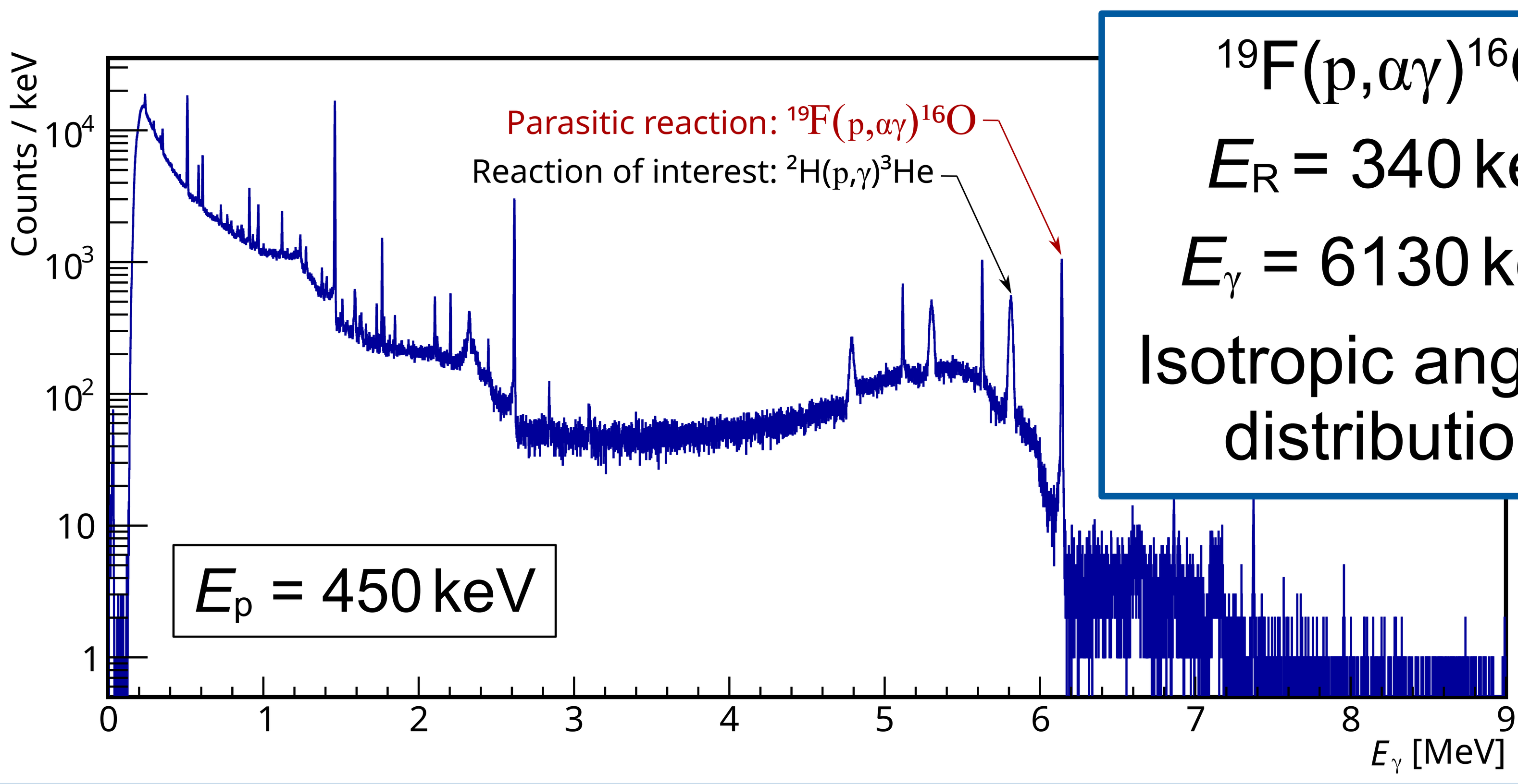
Experimental Setup

21 HPGe crystals at 4.5 – 20 cm from target (25 – 144° coverage)

ZrD_2-sputtered targets (LN2 cooled, radius = 13.5 mm)



Beam induced background

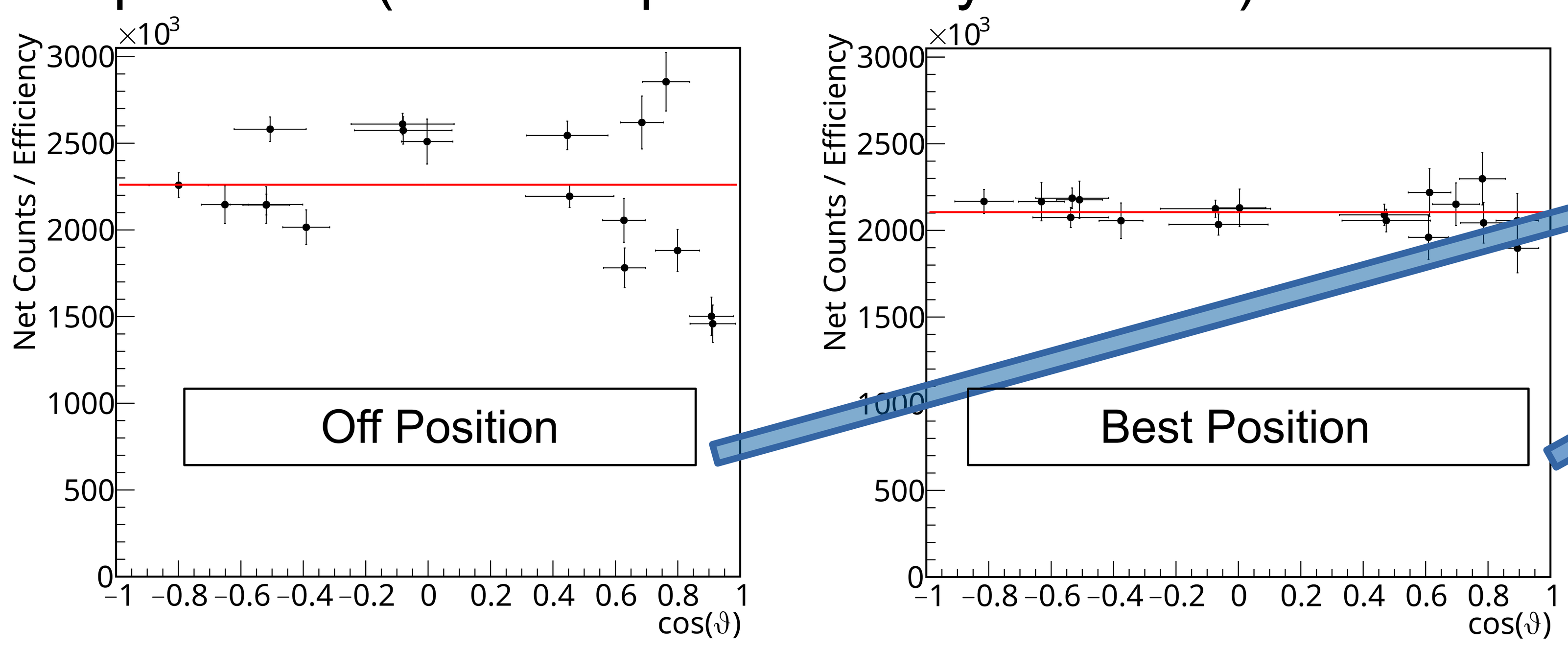


$^{19}F(p,\alpha\gamma)^{16}O$
E_R = 340 keV
E_γ = 6130 keV
Isotropic angular distribution

$^{19}F(p,\alpha\gamma)^{16}O$-data

Calculate yield using:

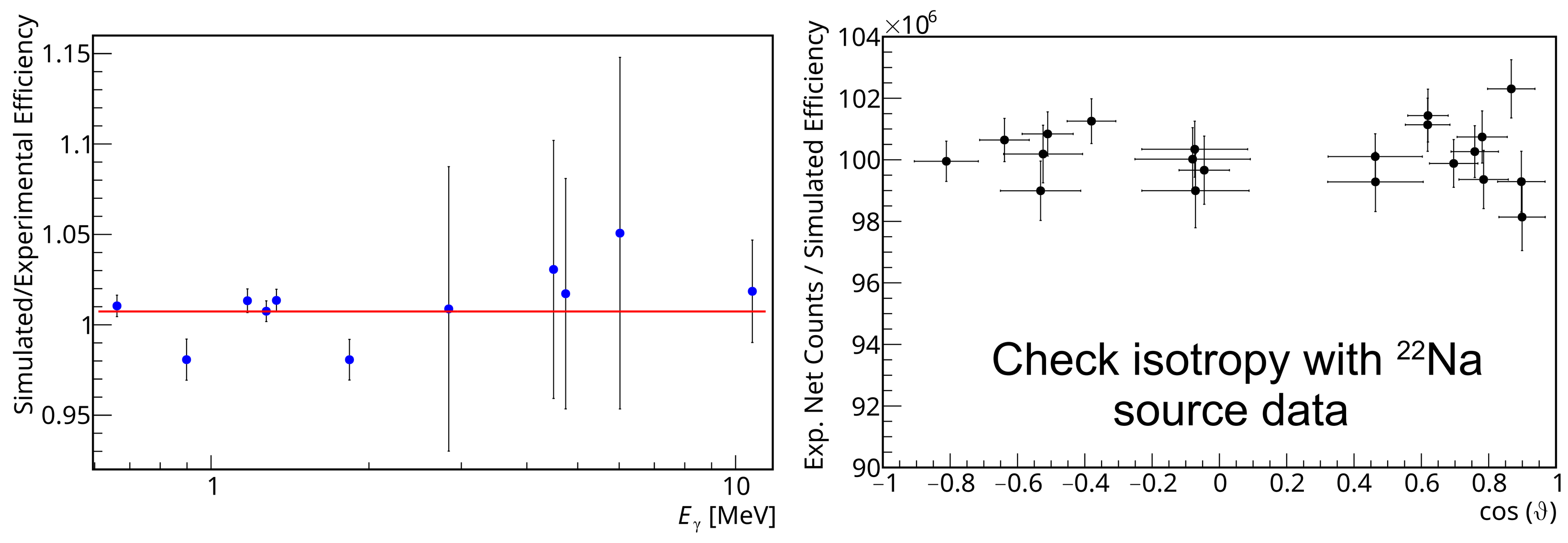
- Net counts from experimental γ-ray spectra
- Efficiency from Monte-Carlo for different beam spot positions (1 mm steps in x and y direction)



Fit of yield data: **isotropic** (0th order polynomial)
Calculate χ^2/ndf of the fit for each step and create a beamspot map

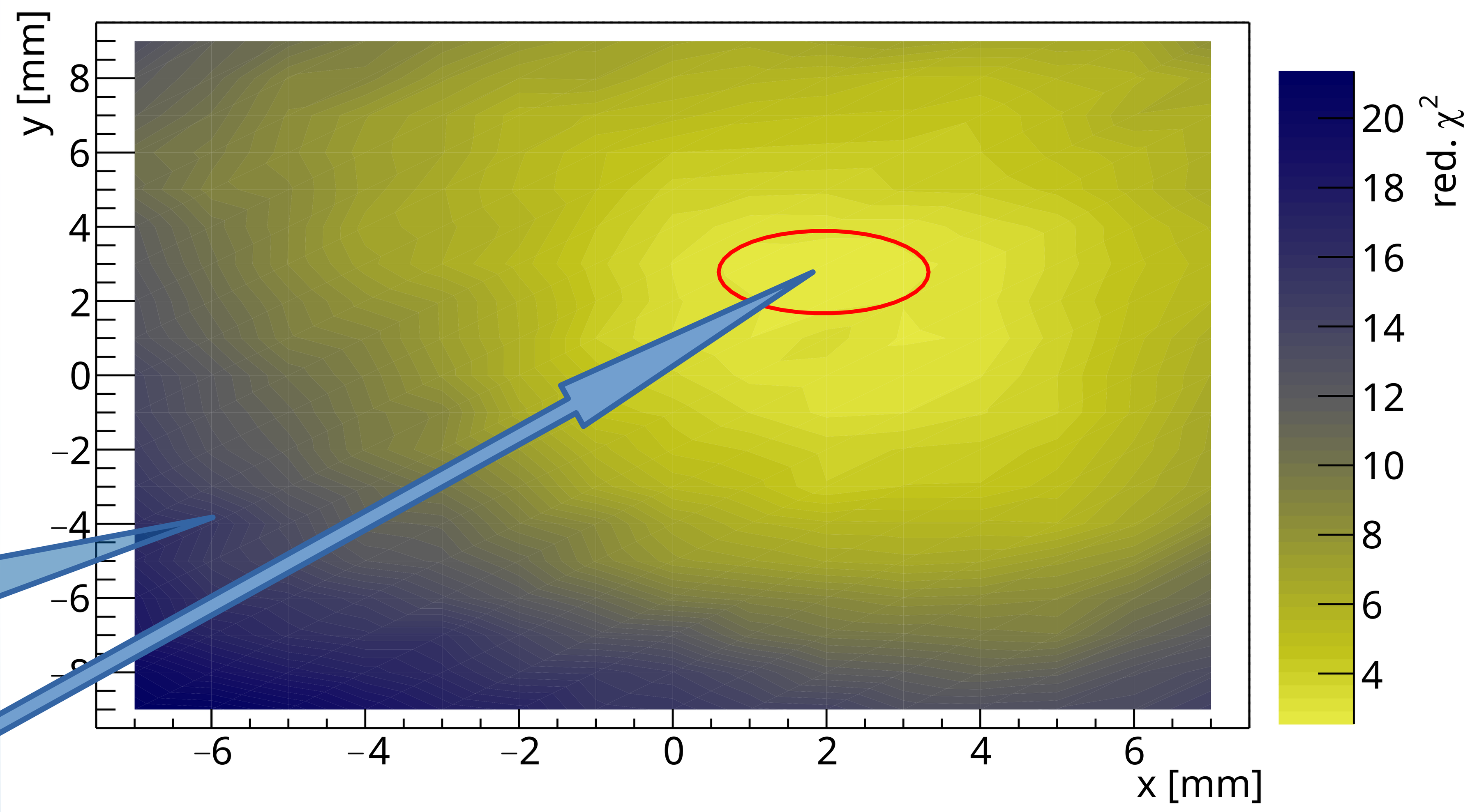
Monte-Carlo-Simulation

Geant4-Simulation of the setup benchmarked with radioactive sources and the $^{27}Al(p,\gamma)^{28}Si$-reaction (beam spot determined by visual inspection after irradiation)



Use Monte-Carlo to simulate efficiency of E_γ = 6130 keV ($^{19}F(p,\alpha\gamma)^{16}O$-reaction) for different possible beam spot positions: → 1 mm grid on target

Find beamspot on χ^2-map



Estimated beamspot position and shape depending on the lowest χ^2/ndf

Future Plan: Apply this method to other (parasitic) reactions and test the robustness of this method with non-isotropic reactions with well know angular distributions.

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