Determination of $^{170,172}Yb(\alpha,n)^{173,175}Hf$ cross sections in a stacked-target experiment

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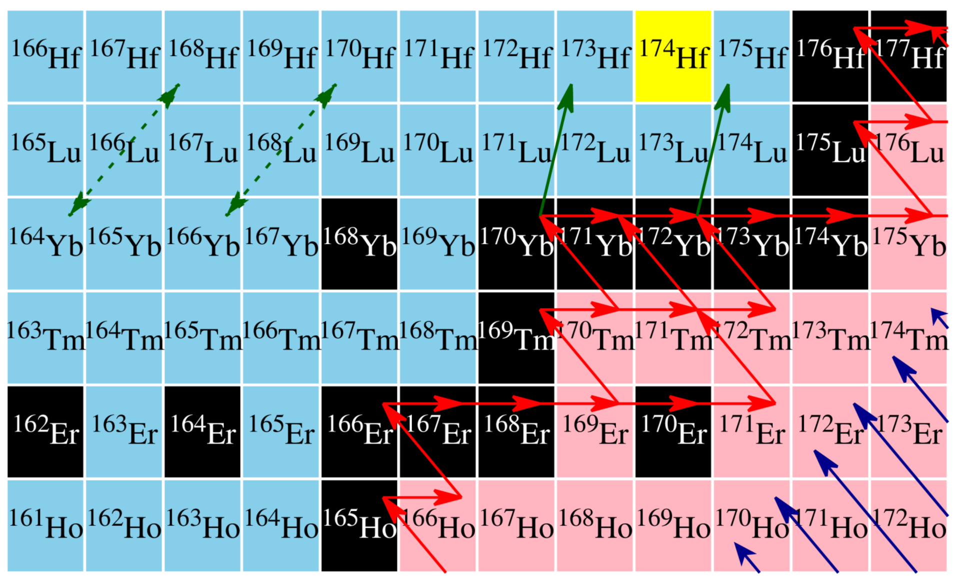
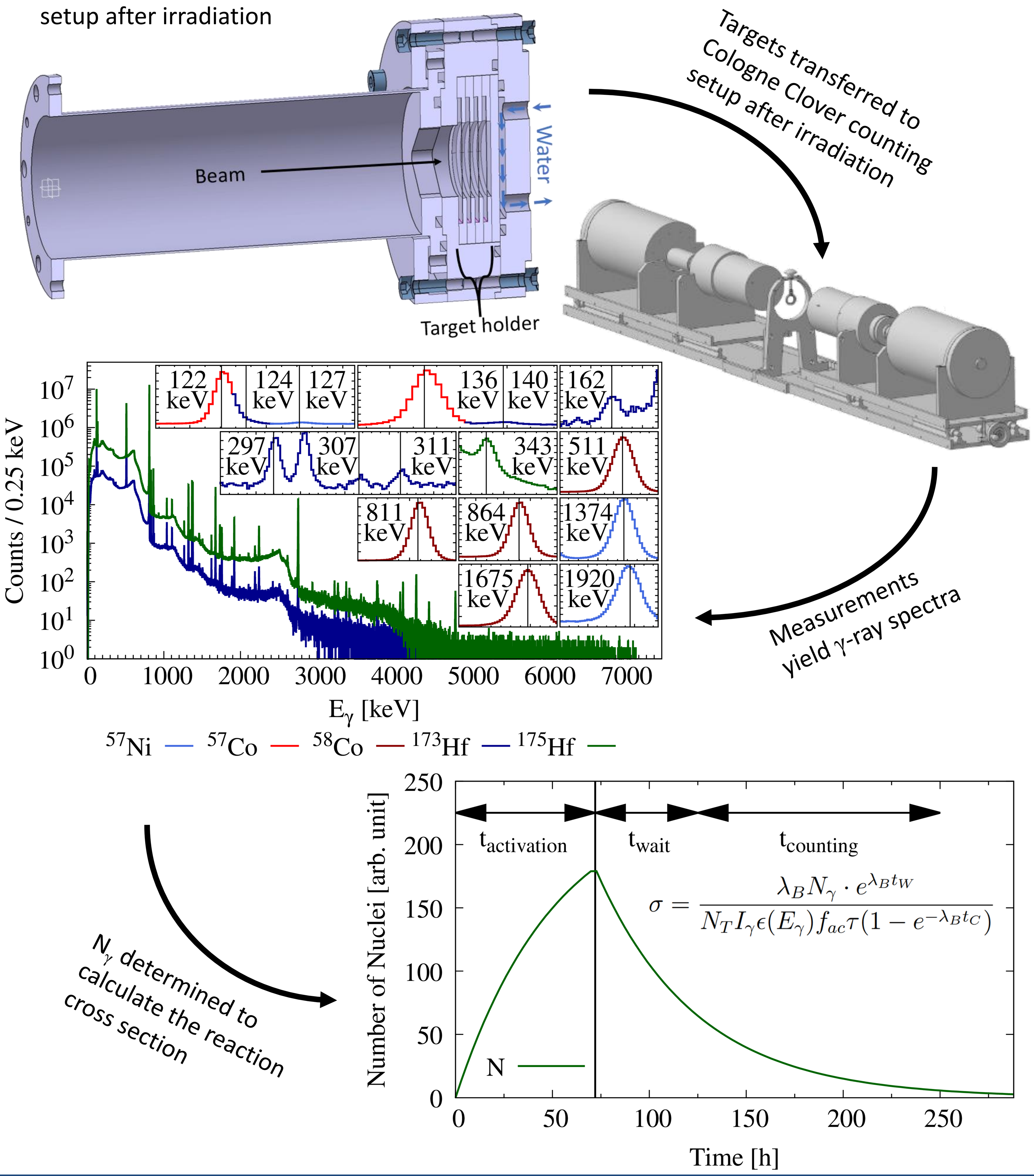
Motivation

- $^{164,166}Yb(\alpha,\gamma)^{168,172}Hf$ identified as key reactions for the production of the ^{168}Yb *p* nucleus [1,2]
- Sensitivity studies show that the reactions are dominated by the α-optical model potential (α-OMP) [3]
- Investigation of α-OMP in stable isotopes of the Yb chain can improve its extrapolation to $^{164,166}Yb$ significantly

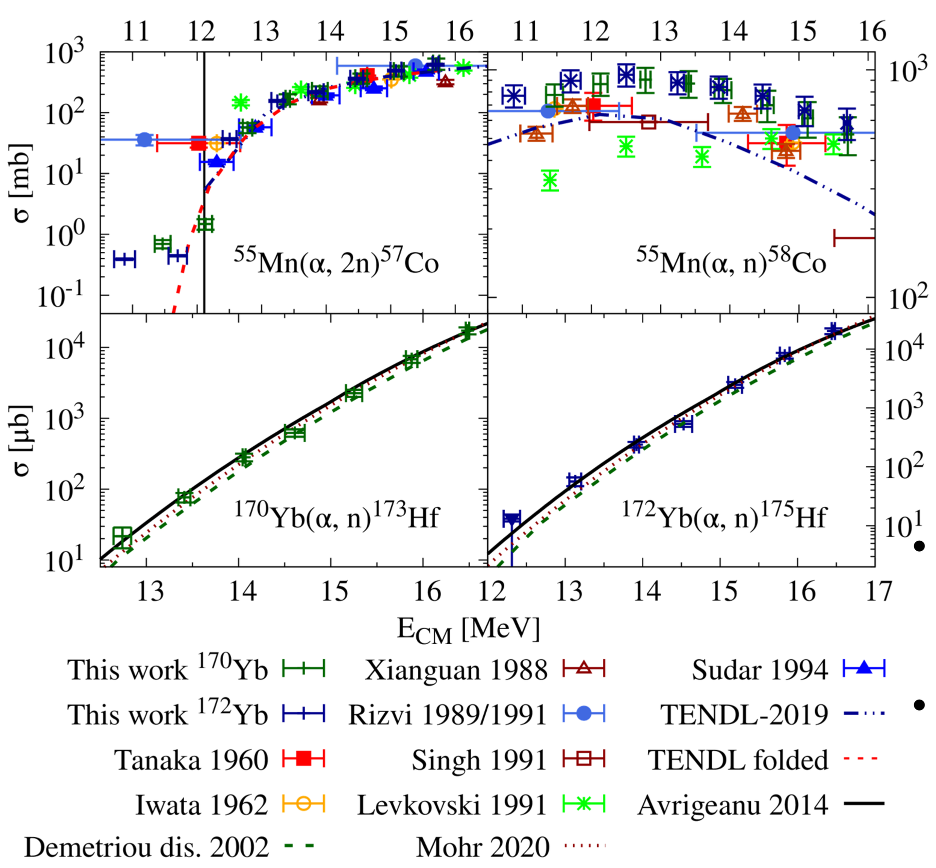


Stacked-target method

- Stacked-target method based on simultaneous activation of multiple targets
- Degrader foils placed between targets of interest to reduce beam energy
- New, water-cooled target chamber designed to hold up to four targets
- Chamber based on a design used at the Physikalisch-Technische Bundesanstalt Braunschweig in previous experiments
- Detection of γ rays emitted in the decay of the reaction product at Cologne Clover counting setup after irradiation



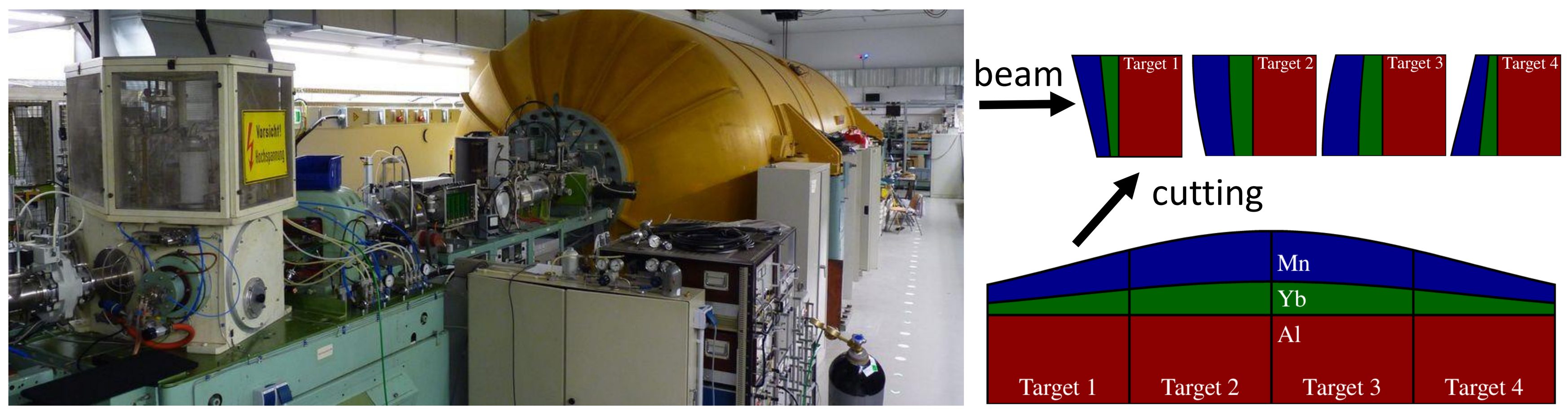
Cross sections



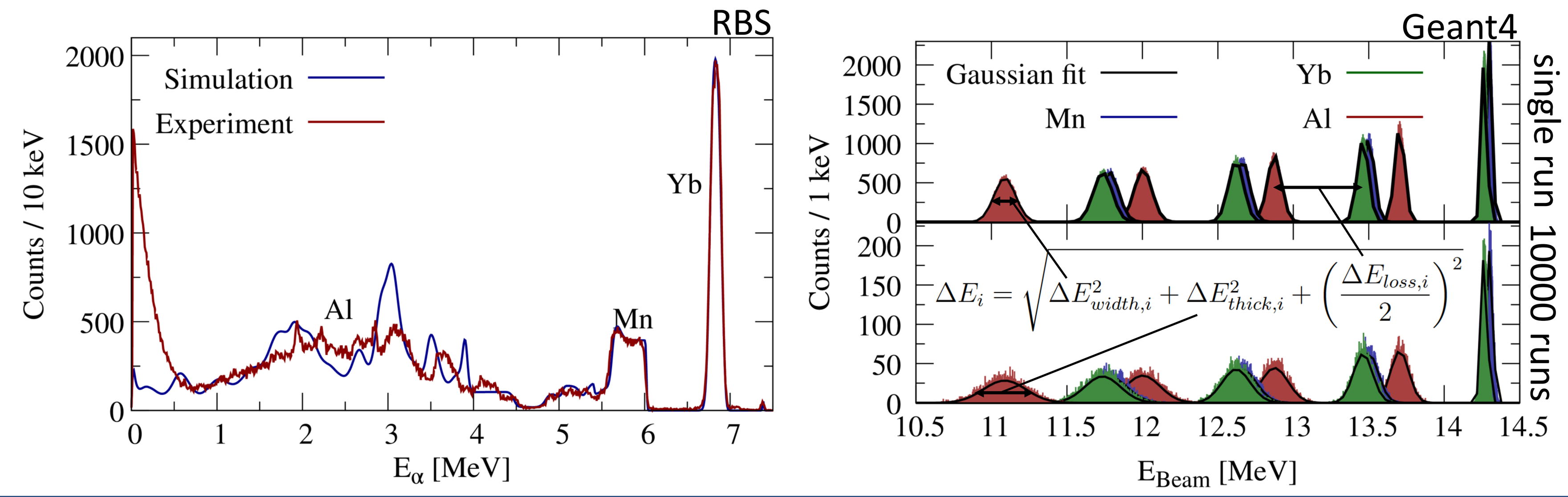
- 32 cross sections for the validation reactions $^{55}Mn(\alpha,(2)n)^{57,58}Co$ measured and compared to previous results and theoretical models [7-14]
  - Excellent agreement for the $^{55}Mn(\alpha,2n)^{57}Co$ reaction
  - Below threshold reaction explained by folding theoretical model with the energy distribution of α–particles in the target
  - Good agreement for the $^{55}Mn(\alpha,n)^{58}Co$ reaction
- For the $^{170,172}Yb(\alpha,n)^{173,175}Hf$ reactions 13 total cross sections and one upper limit were determined
- Cross sections compared to theoretical model calculations using the Talys1.95 code with default settings but different α-OMPs [15-18]

Targets and beam

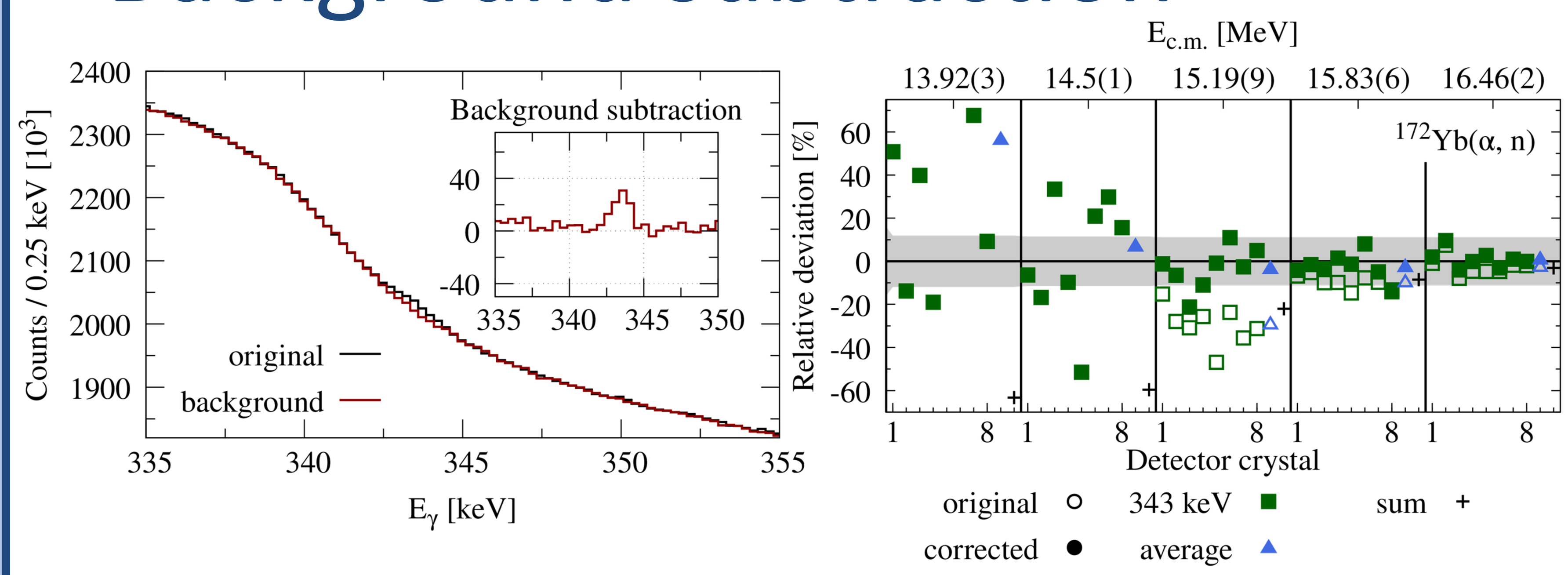
- Targets made by deposition of either ^{170}Yb or ^{172}Yb and ^{55}Mn onto a large ^{27}Al foil by evaporation and subsequent cutting into individual pieces
- Activation performed in Cologne using a 10 MV FN Tandem accelerator to provide α-beams at E_α = 14.5 MeV and E_α = 17 MeV; Beam intensity ≈ 200 nA



- Exact target compositions determined by Rutherford-backscattering (RBS) measurement at the RUBION facility of the Ruhr University Bochum
- Energy loss in each layer of the four targets per target stack determined via GEANT4 simulation
- Uncertainties of the target thicknesses taken into account by repeating the simulation 10000 times with randomly varied thicknesses for each layer and considering the distribution of averages



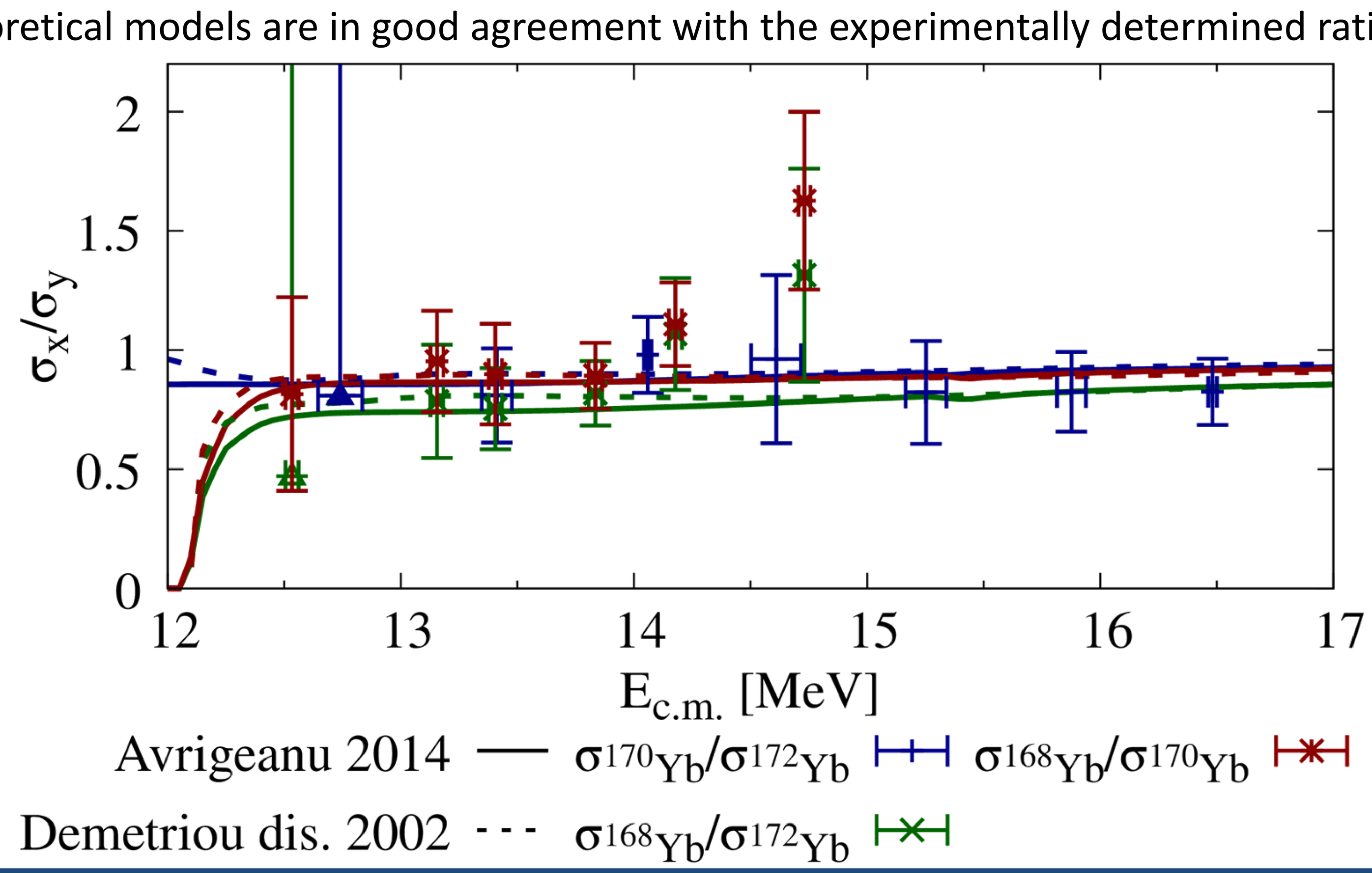
Background subtraction



- $^{55}Mn(\alpha,n)^{58}Co$ validation reaction produced a lot of background
- Solution: background subtraction using a target irradiated at an energy low enough to show no Yb decay lines at all
- Background subtraction validated by comparing cross section results obtained from background corrected and original spectra as well as from the yield determined for each detector crystal individually

Cross section ratios

- $^{168}Yb(\alpha,n)^{171}Hf$ and $^{168}Yb(\alpha,\gamma)^{172}Hf$ reactions have already been measured [19]
- Evolution of the α-OMP in the Yb chain with the proton-to-neutron ratio systematically investigated by comparing theoretical models to the ratio of total (α,n) cross sections
- Logarithmic interpolation to calculate ratios → energy and cross section uncertainties mix
- Theoretical models are in good agreement with the experimentally determined ratios



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