Zr Isotopes Studied Using the Oslo Method

The New SiRi Particle Detector at OCL

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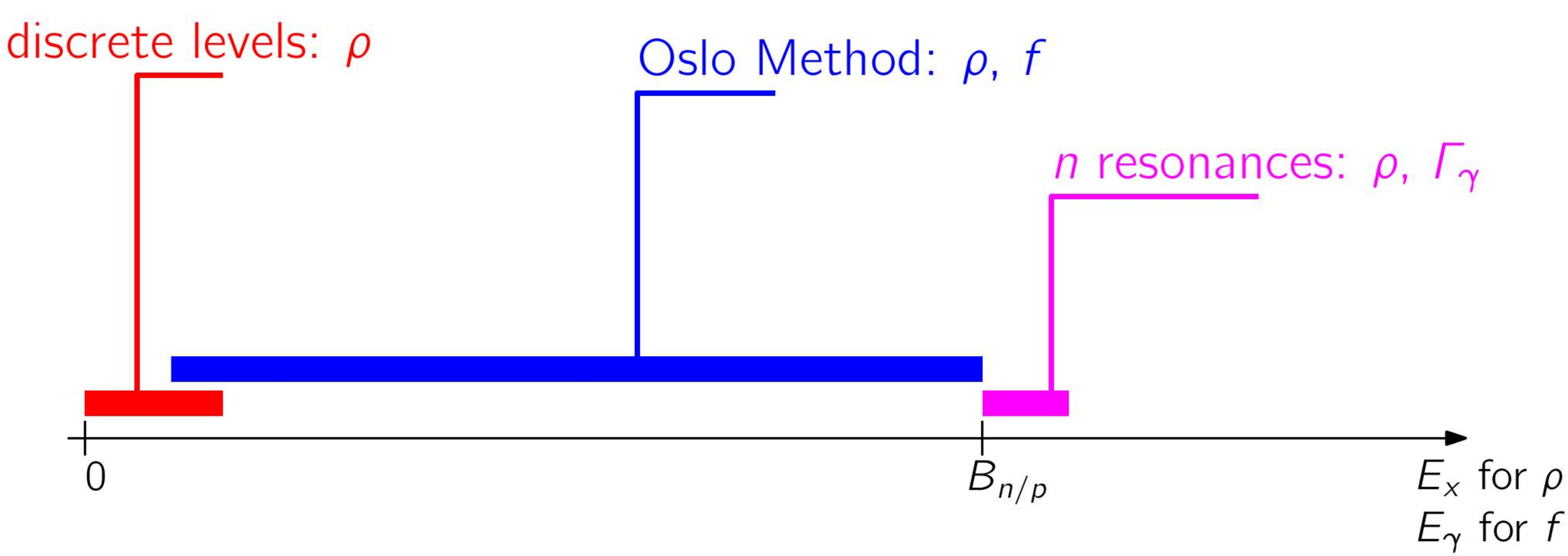
GammaStrength Workshop — Dresden, 2010

Overview

- The Oslo Method
  - Aim
  - Procedure
- Experimental Details
  - Setup Overview
  - The SiRi Detector
  - DAQ & Calibration
- Experiments
  - Zr, Th, Cd, Ni, Sn
  - Some (Preliminary) Results

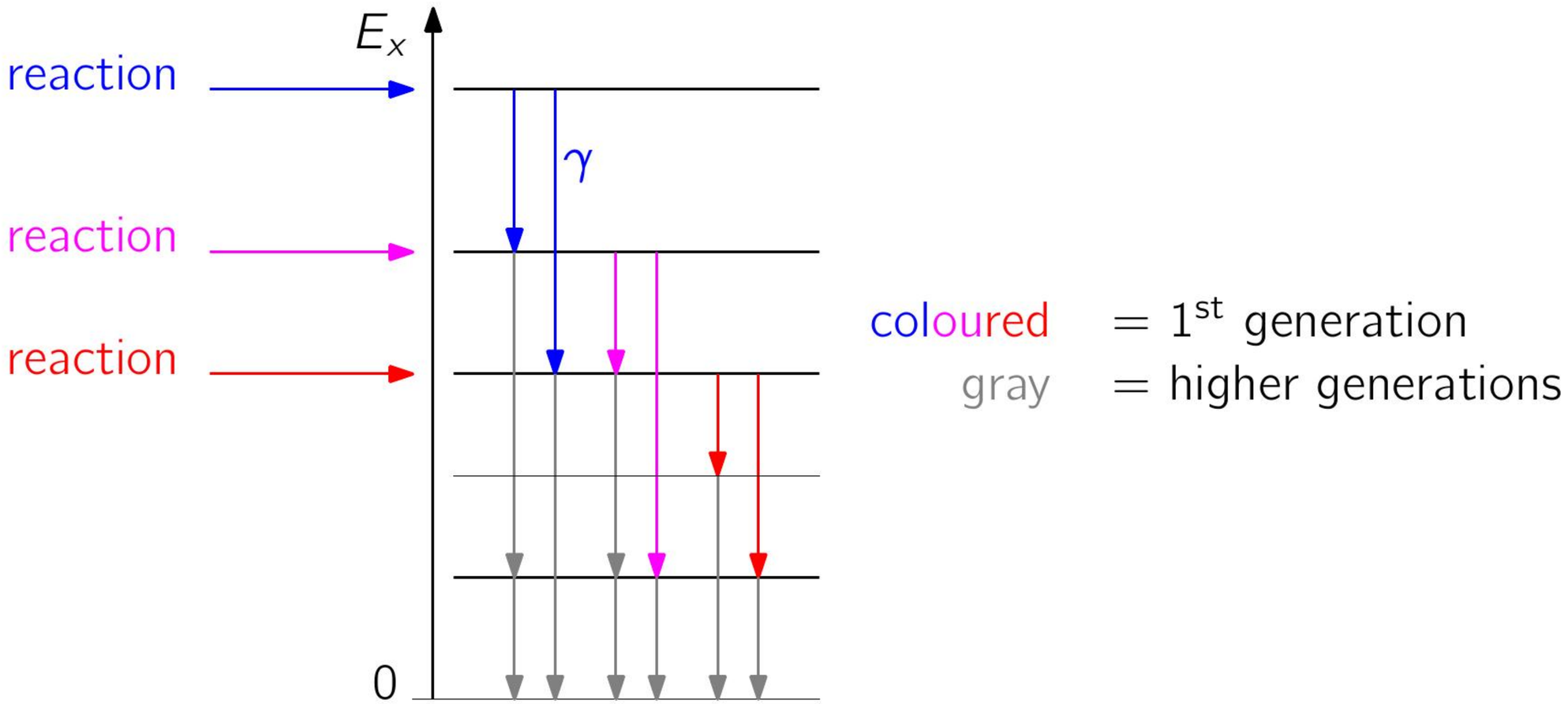
The Oslo Method – Aim

measure ρ and f simultaneously



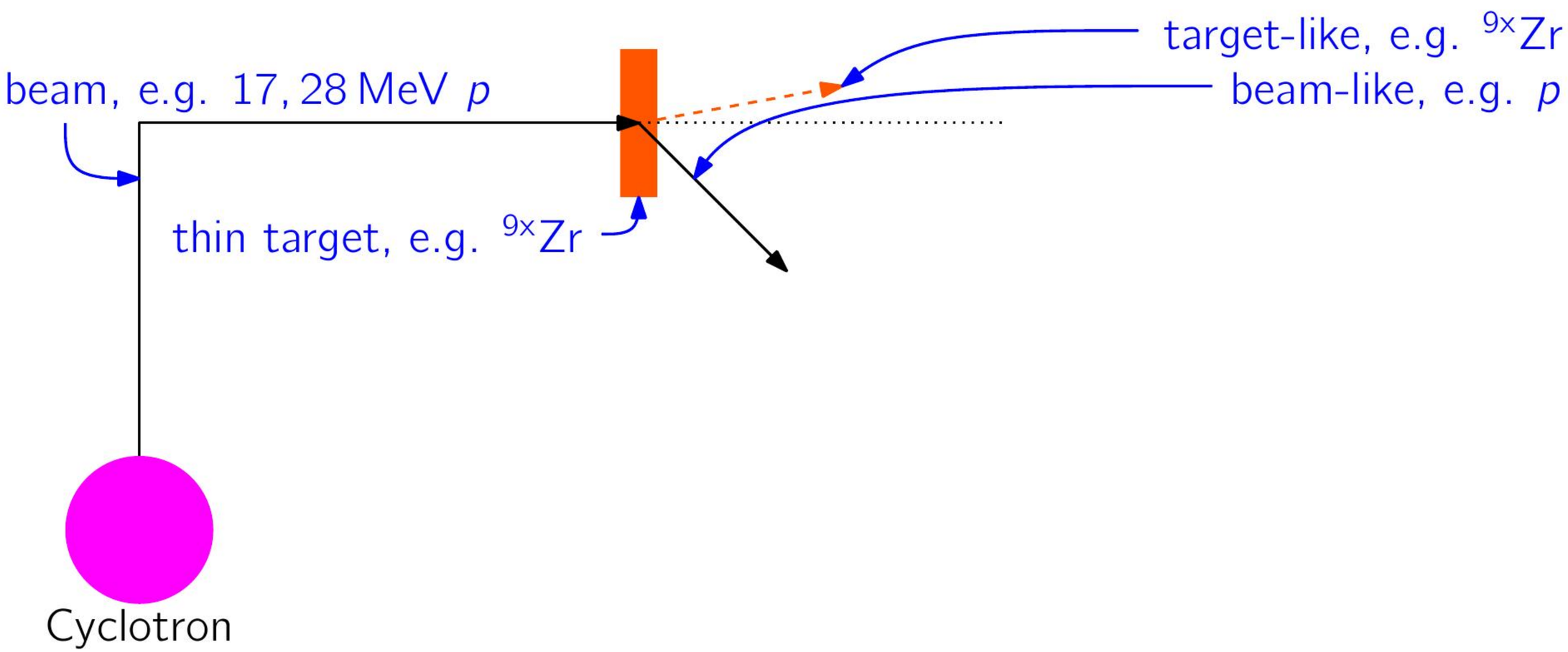
The Oslo Method – Procedure

- measure E_x vs. E_γ matrix
- correct E_γ for detector response function ("unfolding")
- extract 1st generation spectra (P)



- derive ρ and $\mathcal{T}$ according to factorization $P(E_i, E_\gamma) \sim \rho(E_i - E_\gamma)\mathcal{T}(E_\gamma)$
- normalize ρ and $\mathcal{T}$
- discuss ρ steps, fit $\mathcal{T}/f$ with pygmy/GLO/...

The Oslo Method – Experiment



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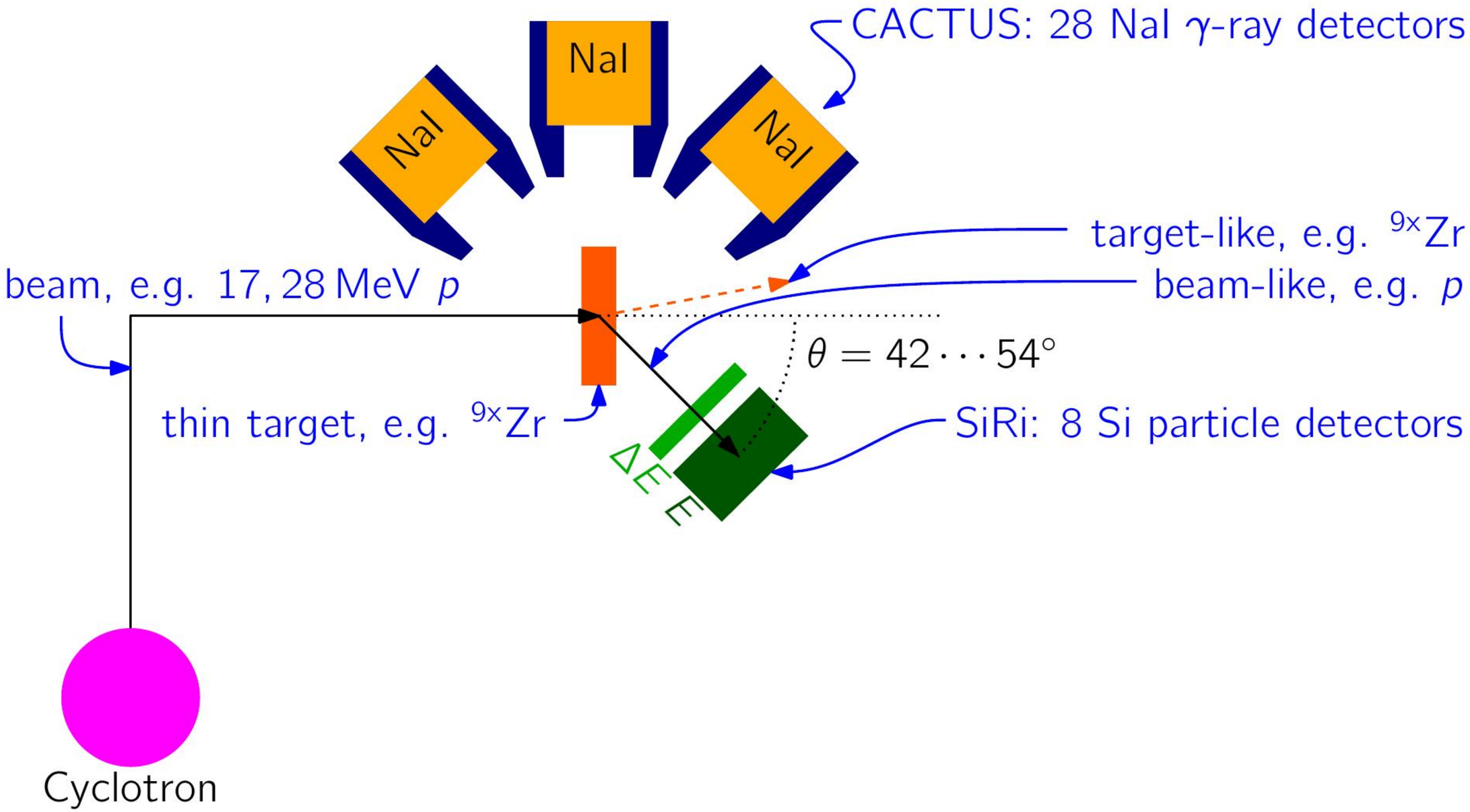
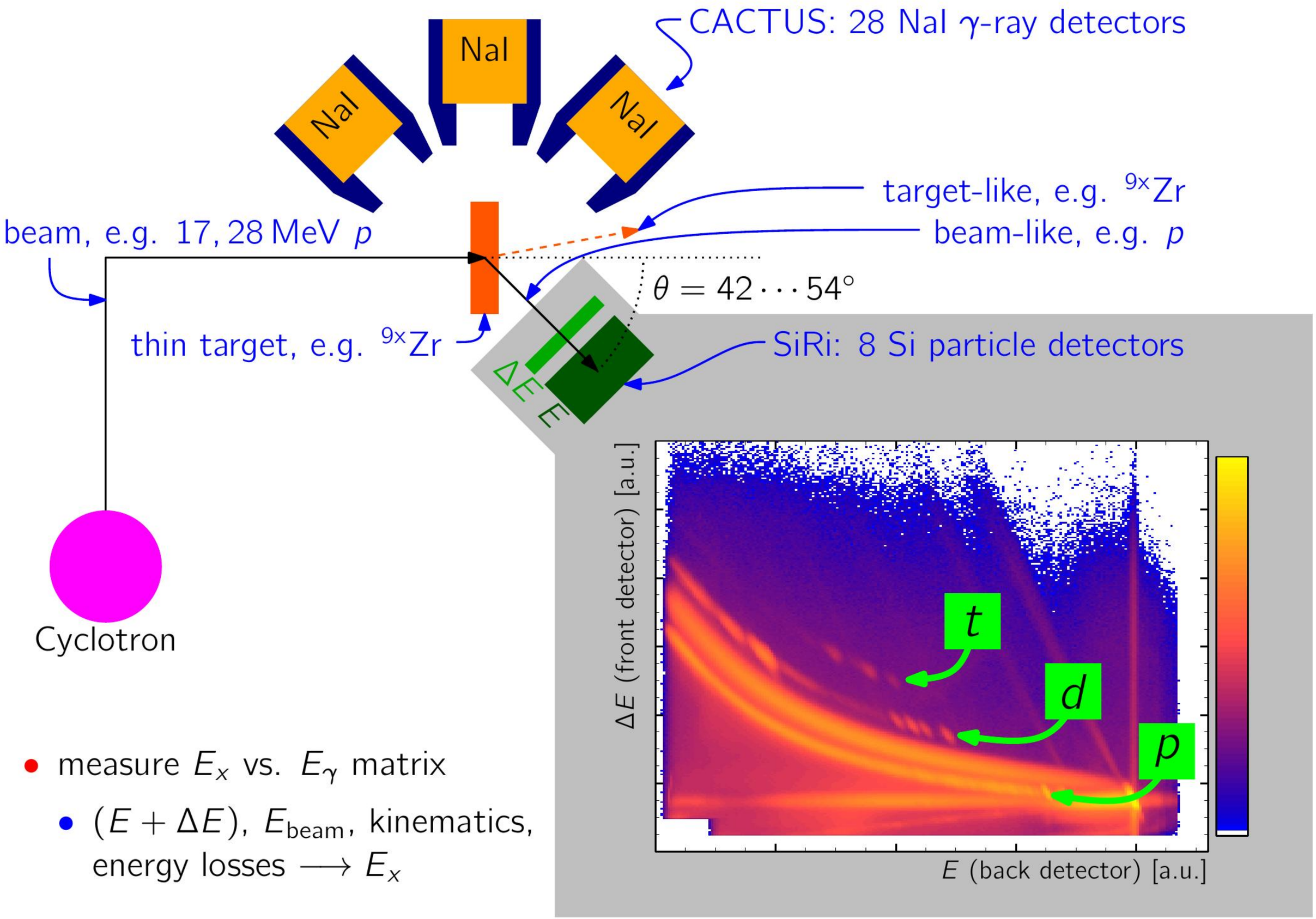


- measure E_x vs. E_γ matrix
  - $(E + \Delta E)$, E_{beam}, kinematics, energy losses $\longrightarrow E_x$

The Oslo Method – Experiment



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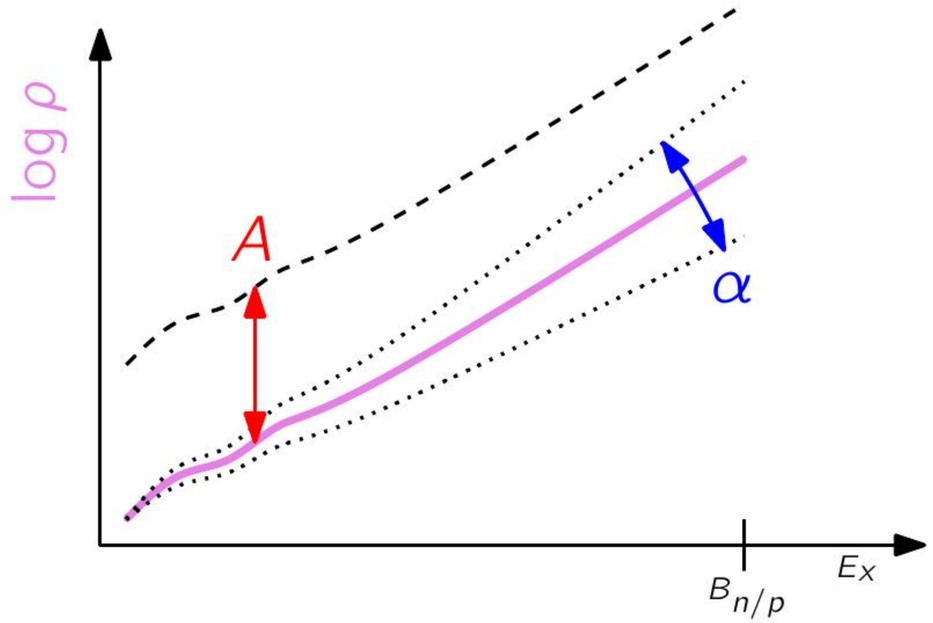
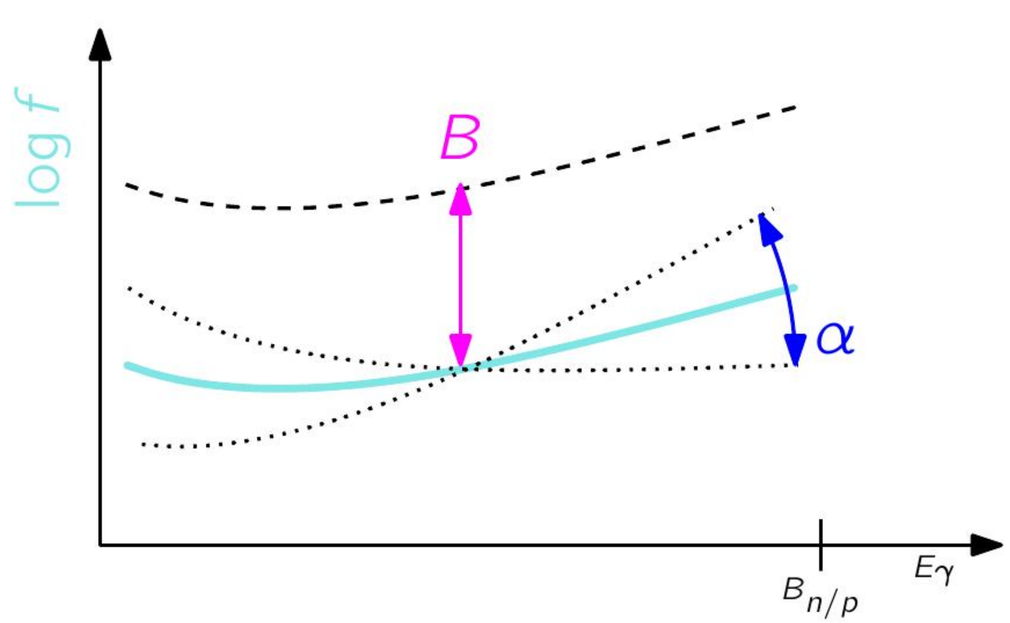
  - $(E + \Delta E)$, E_{beam}, kinematics, energy losses $\longrightarrow$ E_x

The Oslo Method – ρ and f

- derive level density and strength function from 1st generation spectra
  - more data points than variables, iterative χ^2 minimization
- solutions can be re-normalized
  - $\rho(E_f) \longrightarrow A\exp(\alpha E_f)\rho(E_f)$
  - $\mathcal{T}(E_\gamma) \longrightarrow B\exp(\alpha E_\gamma)\mathcal{T}(E_\gamma)$





A. Schiller *et al.*, NIM A 447, 498 (2000)

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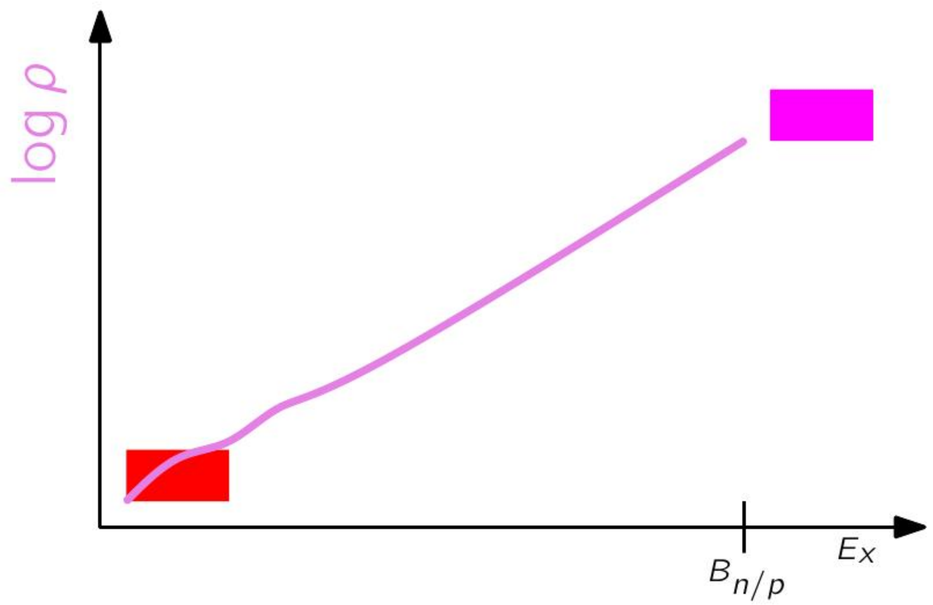
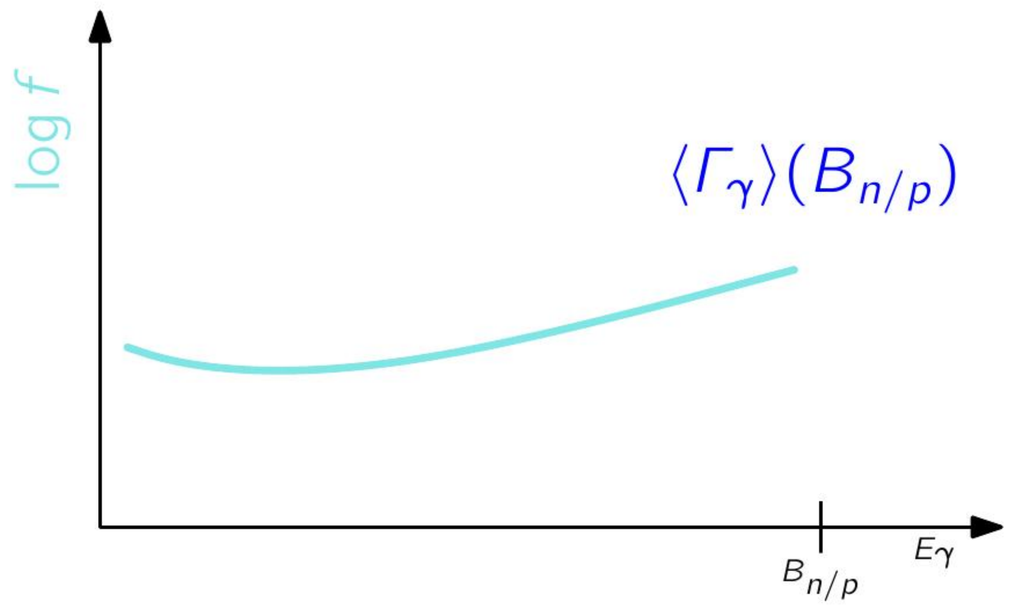
  - $\rho(E_f) \longrightarrow A\exp(\alpha E_f)\rho(E_f)$
  - $\mathcal{T}(E_\gamma) \longrightarrow B\exp(\alpha E_\gamma)\mathcal{T}(E_\gamma)$
- $\Rightarrow$ need "external" normalization
  - discrete levels at low energy
  - resonance spacings and γ widths near B_n





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The Oslo Method – Compilation

http://ocl.uio.no/compilation

Department of Physics | Studies | Research | Internal

Oslo Cyclotron Laboratory - Strength functions

OCL
Oslo Cyclotron Laboratory

Level densities and gamma-ray strength functions

The data are extracted according to the Oslo-method (A. Schiller et al., Nucl. Instrum. Methods A 447 (2000) 498). For the present data set, both the (^{3}He,^{3}He) and (^{3}He,^{4}He) reactions have been used. A comparison between the two reactions is performed in Ref.: A. Schiller et al., Phys. Rev. C61, 044324 (2000).

Some papers show, together with new data, also previously published data. These may be identical, however, in some cases small adjustments have been made from more recent information, e.g. new (n,g) neutron resonance spacing data. Therefore, the data from the most recent paper should be adopted.

You may download these data and pdf figures. If you publish them, please give references to the method and the journal where the data were published (see below).

Level densities

You may download pdf figures for some of these data here:
SmDyErYb, Dy, Yb, Mo, Fe, V, new 96Mo, Sc, new 56.57Fe, 116.117Sn

A. Schiller et al., Phys. Rev. C63, 021306(R) (2001): (^{3}He,^{4}He)^{161}Dy
A. Schiller et al., Phys. Rev. C63, 021306(R) (2001): (^{3}He,^{4}He)^{162}Dy

E. Melby et al., Phys. Rev. C63, 044309 (2001): (^{3}He,^{4}He)^{166}Er
E. Melby et al., Phys. Rev. C63, 044309 (2001): (^{3}He,^{3}He)^{167}Er

A. Schiller et al., Phys. Rev. C63, 021306(R) (2001): (^{3}He,^{4}He)^{171}Yb
A. Schiller et al., Phys. Rev. C63, 021306(R) (2001): (^{3}He,^{4}He)^{172}Yb

S. Siem et al., Phys. Rev. C65, 044318 (2002): (^{3}He,^{4}He)^{148}Sm
S. Siem et al., Phys. Rev. C65, 044318 (2002): (^{3}He,^{3}He)^{149}Sm

The SiRi Particle Detectors

Old Detectors:

- 8 collimated ΔE–E detectors
- collimator size: 3–8 mm $\varnothing$ / $6 \times 10\,\mathrm{mm}^2$, depending on mass, to limit energy uncertainty from kinematics
- small solid angle coverage

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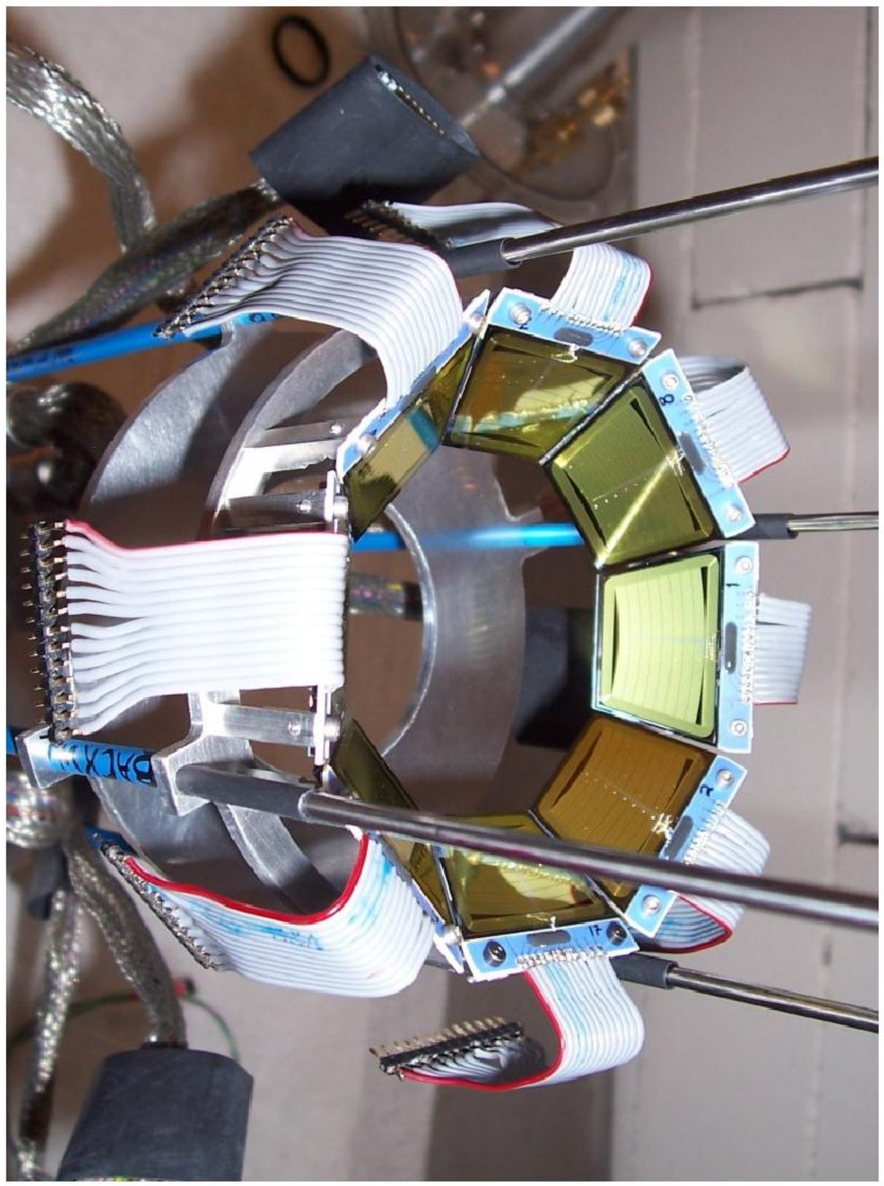
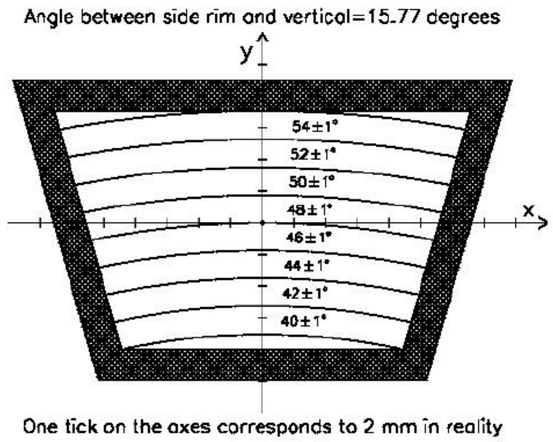


New Detectors:

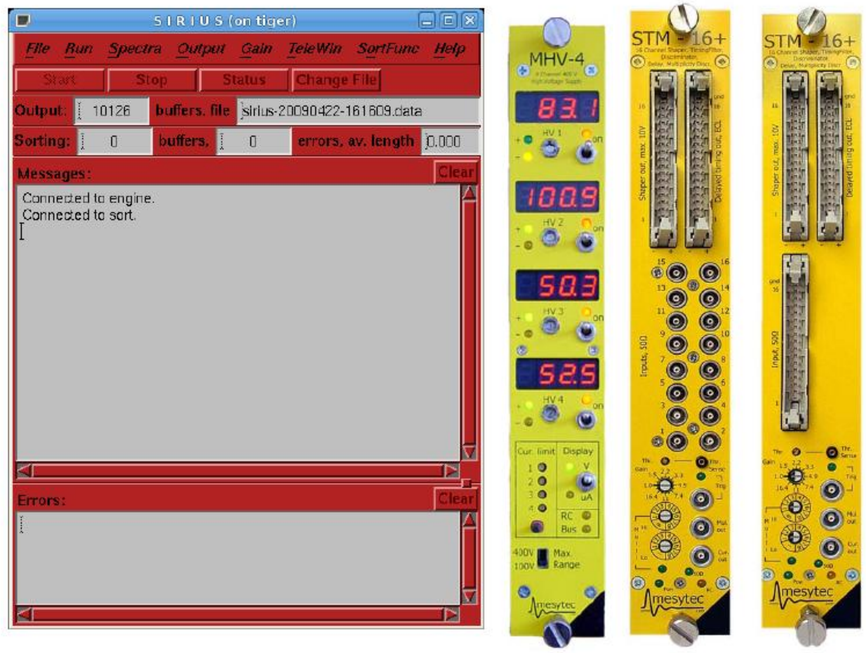
- 8 uncollimated ΔE–E detectors with 8 strips each
- each has 8 θ angles: 40°, 42°, . . . , 54°
- each covers ϕ range of $\approx 40°$
- thicknesses: $\Delta E = 130\,\mathrm{um}$, $E = 1550\,\mathrm{um}$
- 8–70 times more solid angle coverage



DAQ & Calibration

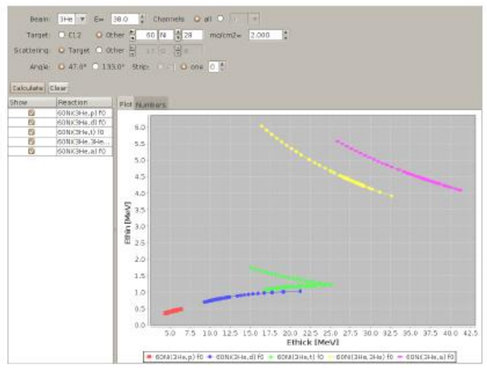
Data acquisition system:

- VME based
- transfer to PC via USB
- remote control of SiRi high-voltage power supplies
- remote control of SiRi and CACTUS amplifiers
- on-line monitoring system
- electronic logbook (with semi-automatic entries)



SiRi Calibration:

- energy loss and reaction kinematics calculation for SiRi geometry
  - also for the case of target contaminants



Experiments

Beamtimes using the new SiRi detectors:

June 2009:

^{90}Zr(p,X), ^{92}Zr(p,X) — A. B.

December 2009:

^{232}Th(d,p), ^{232}Th(p,p′) — J. Wilson, A. Görgen, . . .

February 2010:

^{106}Cd(^{3}He,X) — P. Mansouri and

^{60}Ni(^{3}He,X) — T. Renstrøm

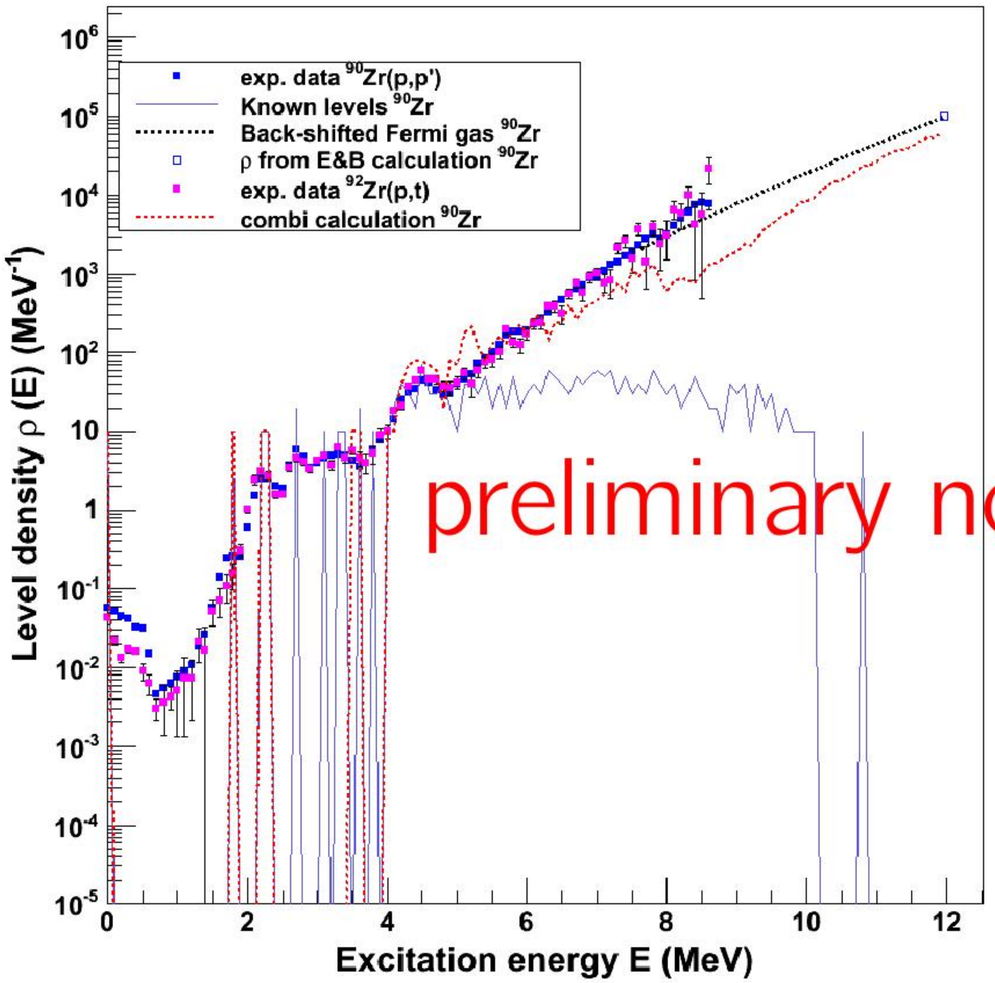
March 2010:

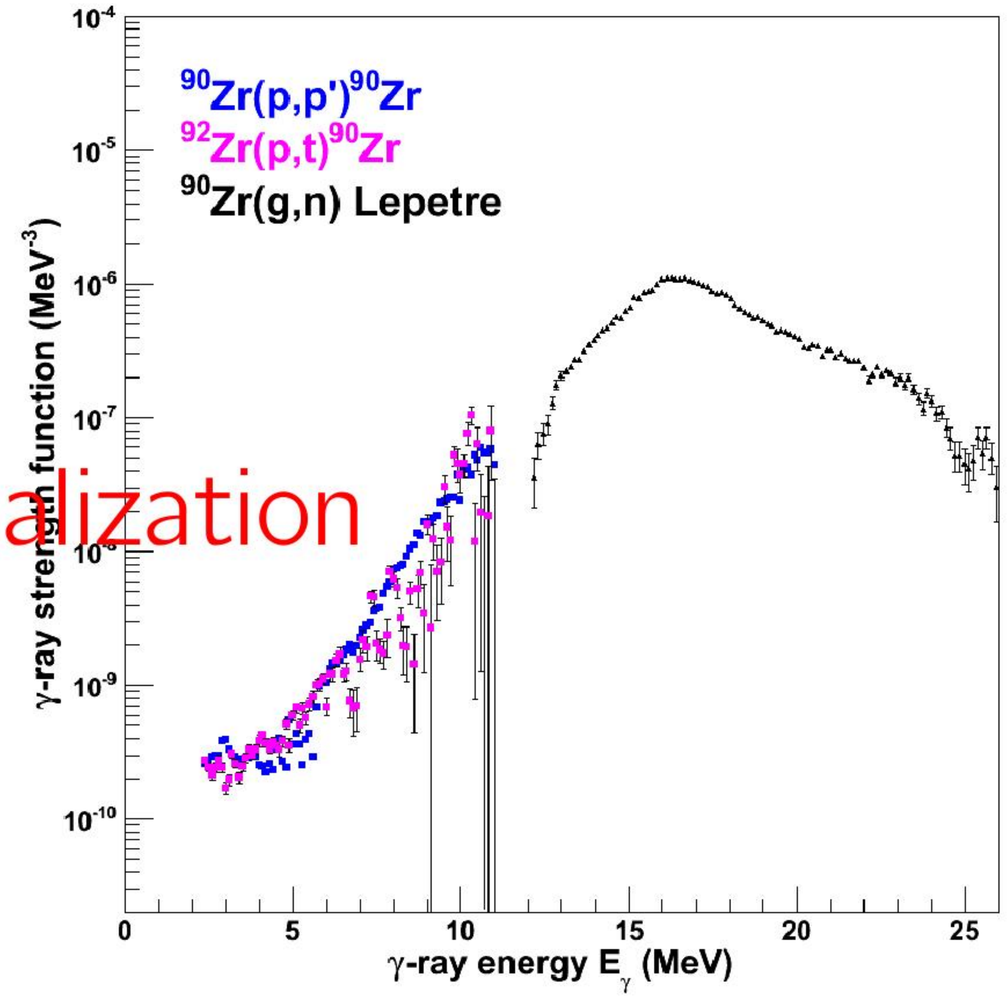
^{112}Cd(^{3}He,X) — A.C. Larsen, I.E. Ruud and

^{122}Sn(^{3}He,X) — H.K. Toft

$^{90/92}$Zr(p,p/t) Experiment – ρ and f

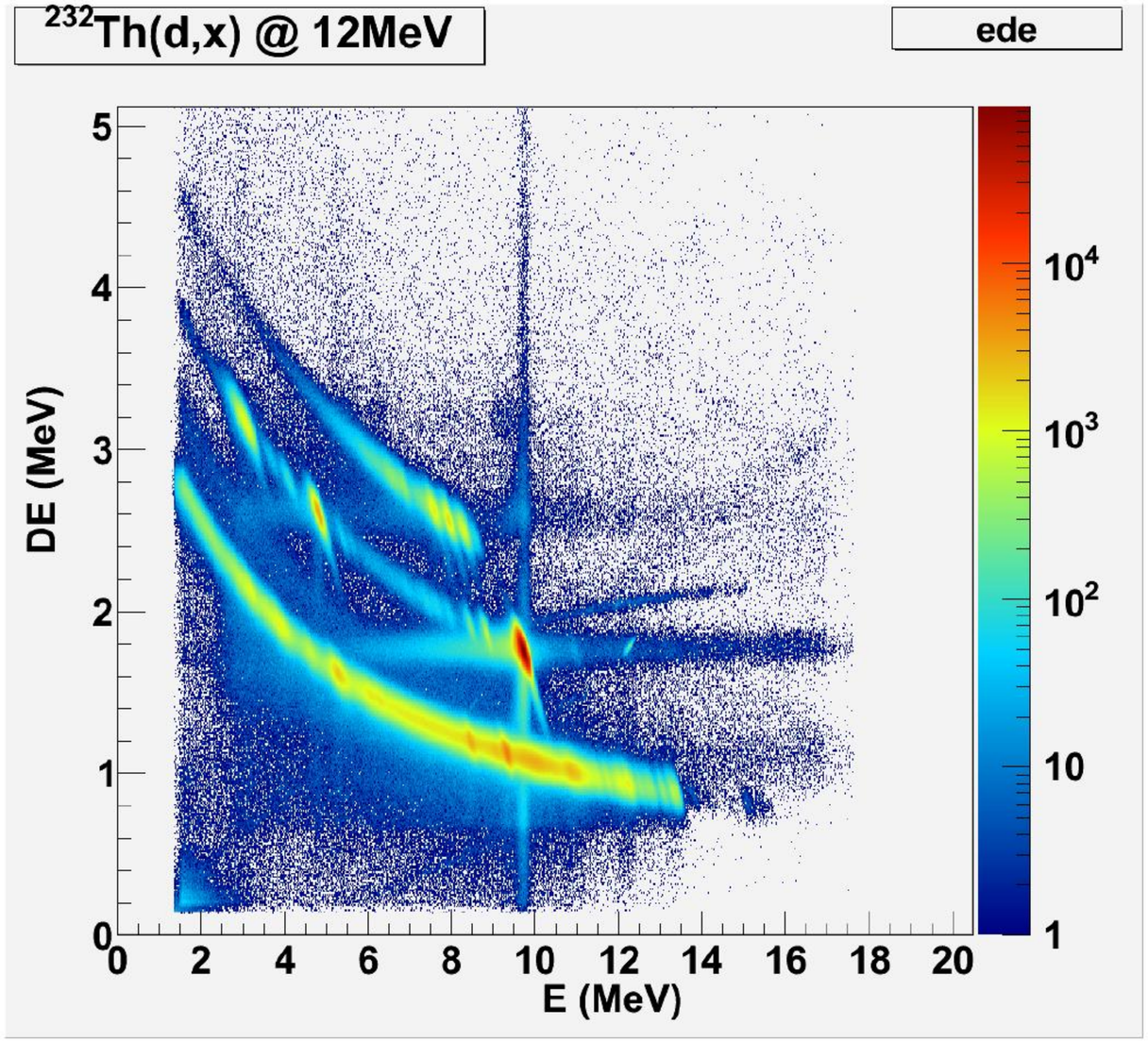
- very first experiment with new SiRi and DAQ – all working fine
- same ρ and (almost) same f from ^{90}Zr(p,p′) and ^{92}Zr(p,t)

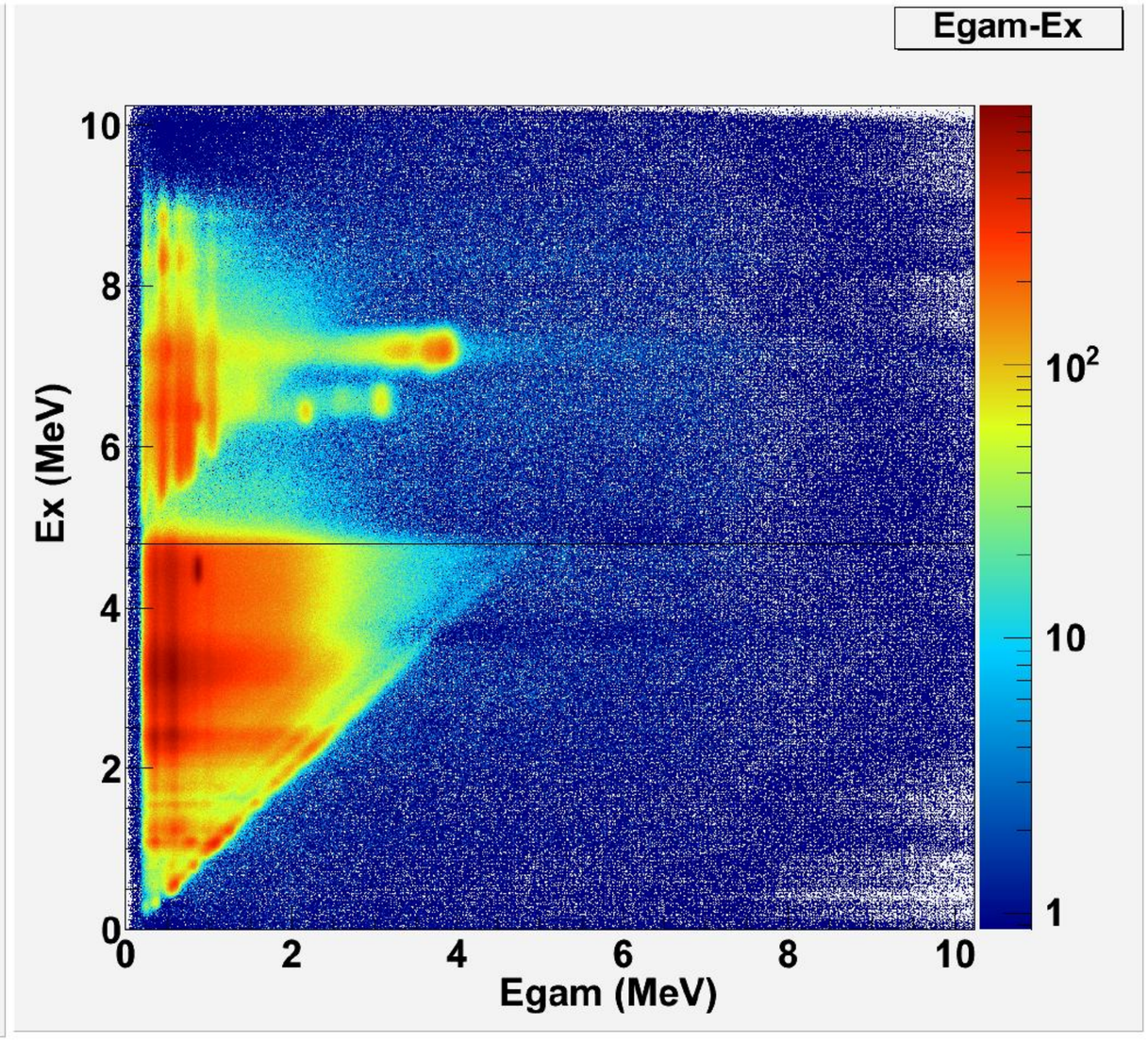




^{232}Th(d/^{3}He,X) Experiment

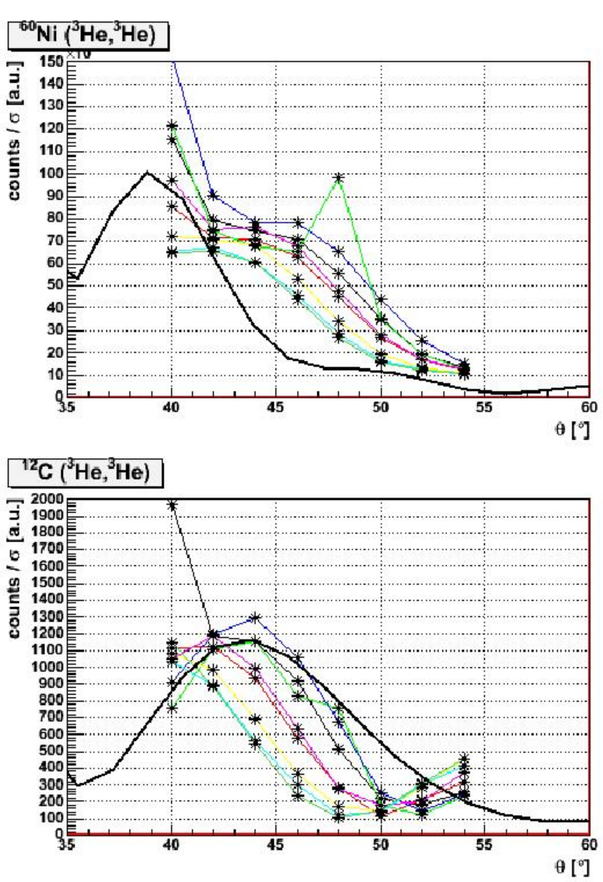
- study level density of $^{231–233}$Th
- test for heavy-mass nuclei — SiRi detectors in backward angles
- independent analyses by J. Wilson and A. Görgen

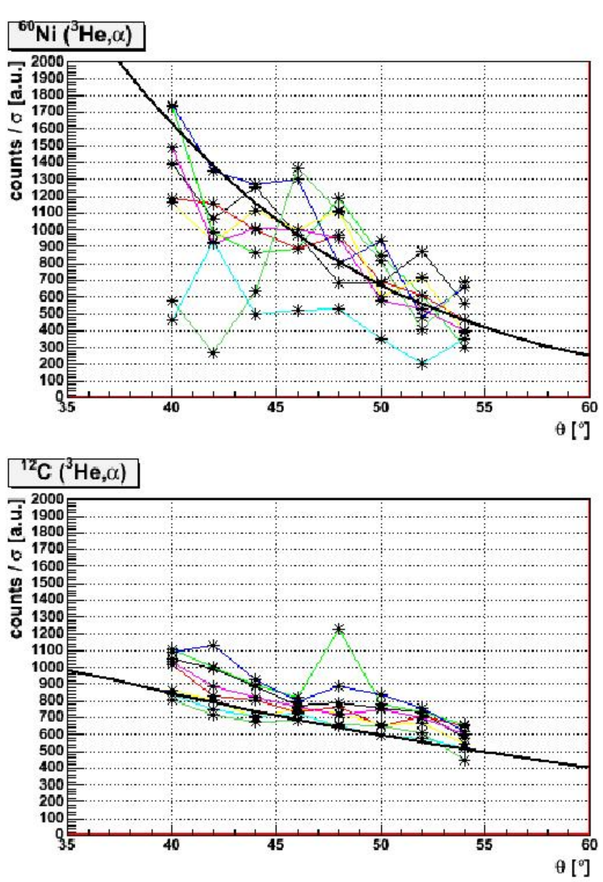


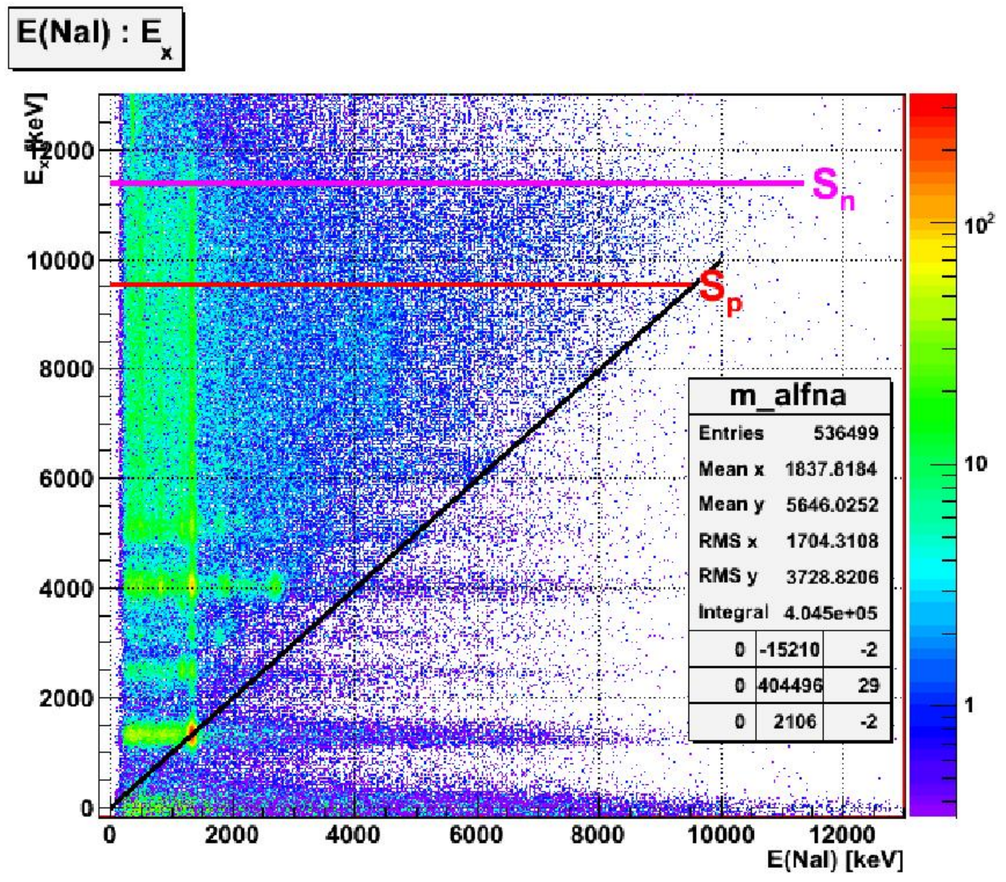


^{60}Ni(^{3}He,^{3}He') Experiment

- master thesis project of T. Renstrøm
- angular dependence of σ observed, but not yet explained
- ρ, f analysis in progress

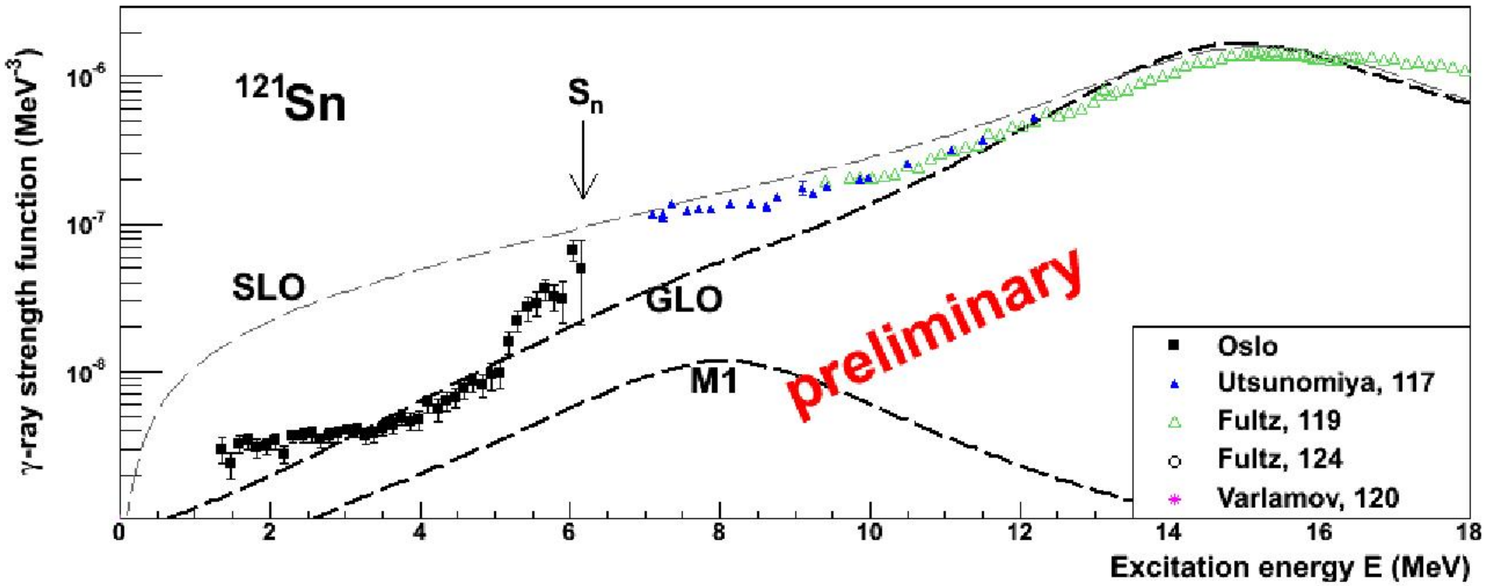


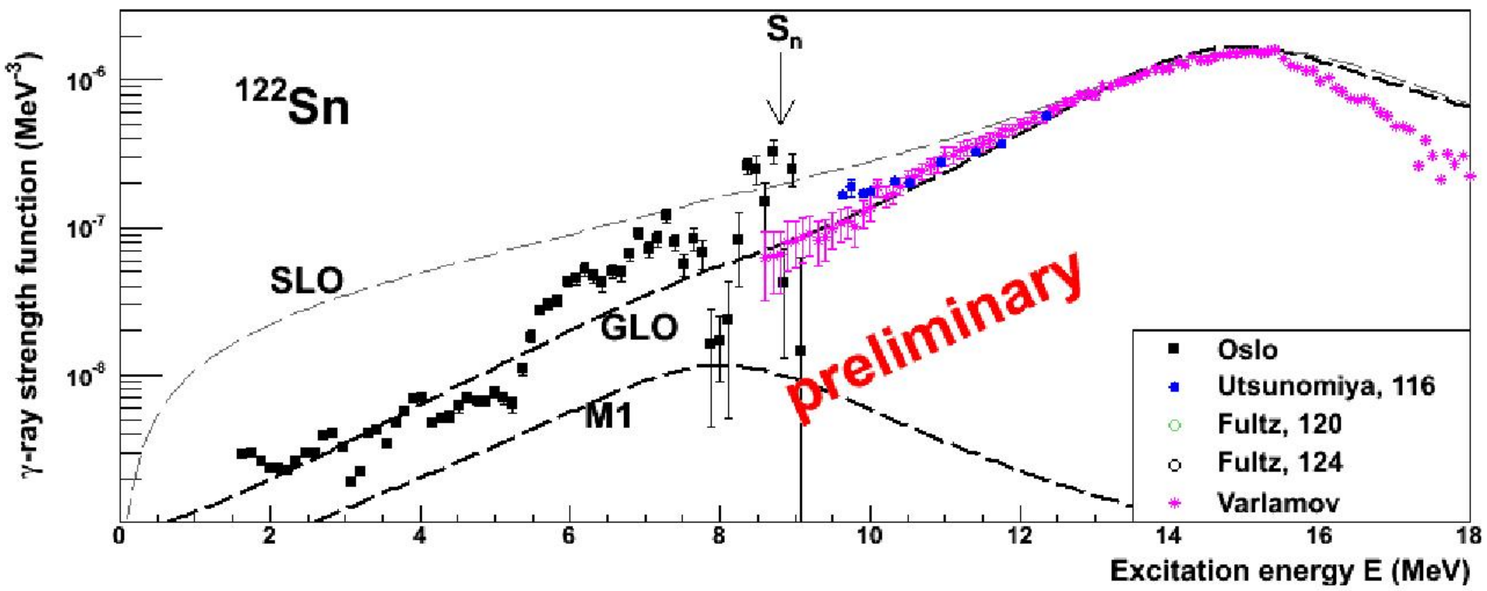




^{122}Sn(^{3}He,X) Experiment

- part of PhD project of H.K. Toft
- results on ρ and f in preparation for publication





Collaboration:

A. Bürger[1], A. Görgen[2,1], F. Gunsing[2], M. Guttormsen[1], T.W. Hagen[1], A.C. Larsen[1], P. Mansouri[1], Md.M.H. Miah[3], H. Nyhus[1], T. Renstrøm[1], S.J. Rose[1], I.E. Ruud[1], S. Siem[1], N.U.H. Syed[1], H.K. Toft[1], A. Voinov[4], M. Wiedeking[5], K. Wikan[1] and J. Wilson[6],

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Workshop 23.–27.05.2011 in Oslo

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