Experimental methods for the investigation of dipole strength functions

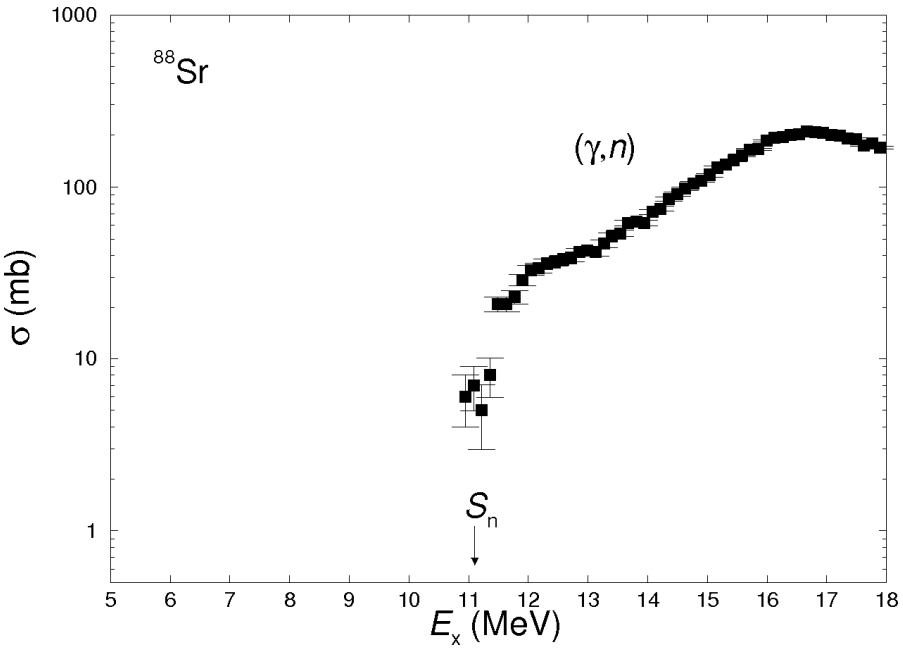
- idea, experiments and results -

Ralph Massarczyk

Forschungszentrum Dresden Rossendorf

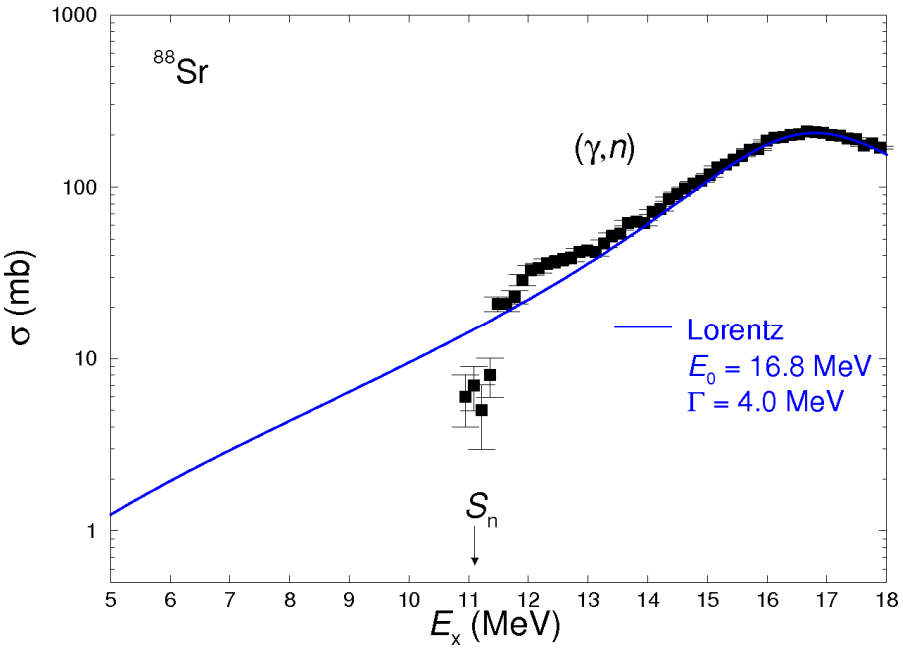
idea, *experiments and results*

- Investigation of dipole strength up to the neutron separation
- Understanding (γ,*n*)- and its inverse process (*n*, γ)
- Also interesting for astrophysical processes
- Problems:
  - Incomplete knowledge of E1 strength in the low energy tail
  - E1 strength functions do not account for shell effects, deformation ….



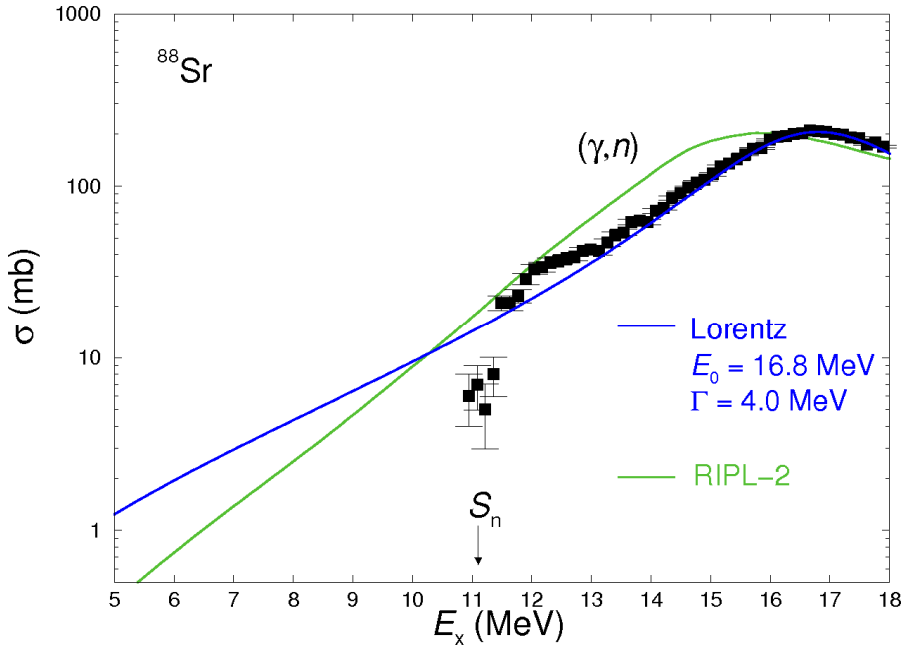
idea, *experiments and results*

- Investigation of dipole strength up to the neutron separation
- Understanding (γ,*n*)- and its inverse process (*n*, γ)
- Also interesting for astrophysical processes
- Problems:
  - Incomplete knowledge of E1 strength in the low energy tail
  - E1 strength functions do not account for shell effects, deformation ….



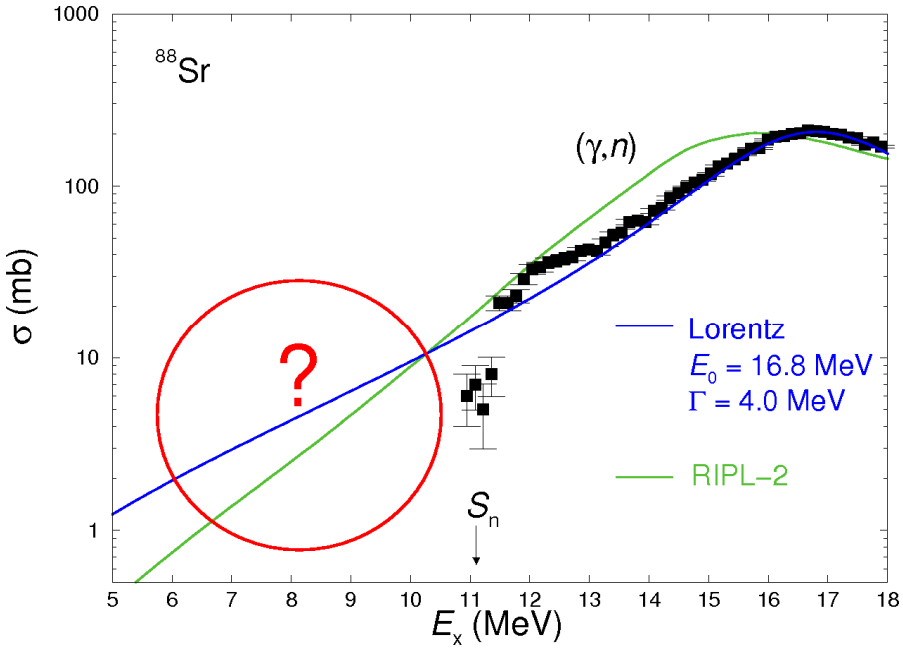
idea, *experiments and results*

- Investigation of dipole strength up to the neutron separation
- Understanding (γ,*n*)- and its inverse process (*n*, γ)
- Also interesting for astrophysical processes
- Problems:
  - Incomplete knowledge of E1 strength in the low energy tail
  - E1 strength functions do not account for shell effects, deformation ….

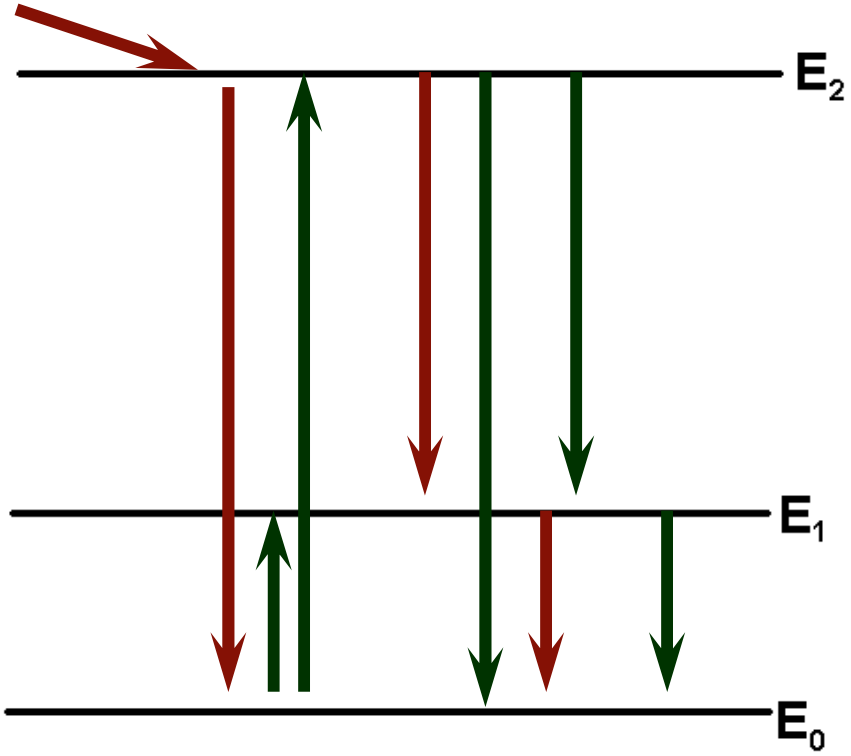


idea, *experiments and results*

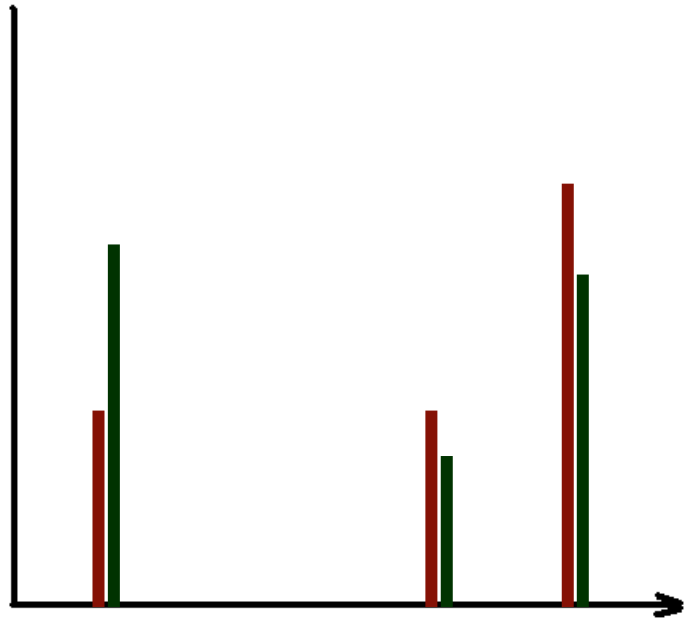
- Investigation of dipole strength up to the neutron separation
- Understanding (γ,*n*)- and its inverse process (*n*, γ)
- Also interesting for astrophysical processes
- Problems:
  - Incomplete knowledge of E1 strength in the low energy tail
  - E1 strength functions do not account for shell effects, deformation ….



An (n, γ) and (γ, γ') experiment



$$ {}^{A+1}_{Z}X + {}^{1}_{0}n \rightarrow {}^{A+1}_{Z}X^{*} \rightarrow {}^{A+1}_{Z}X + \gamma $$



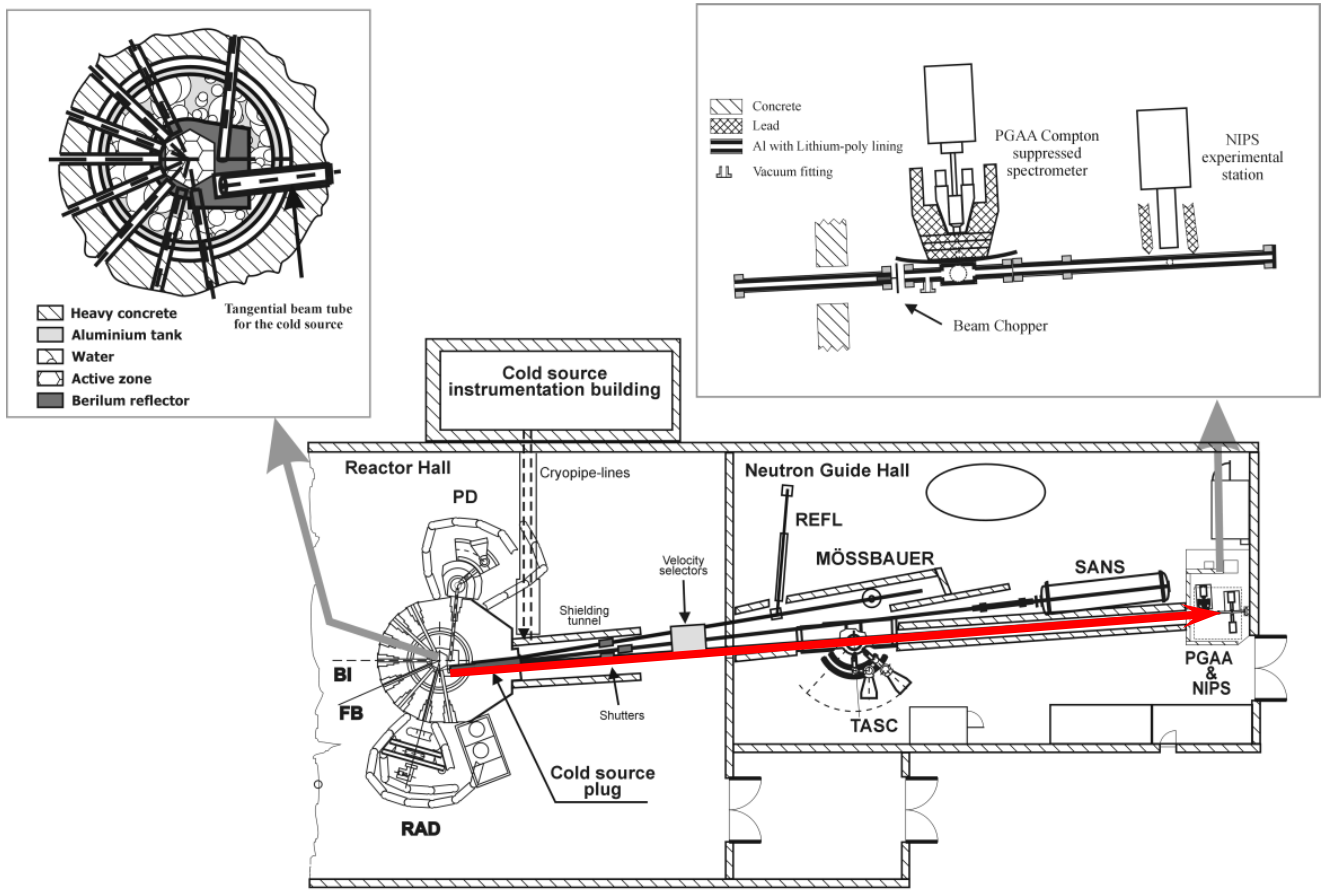
- excitation of ground state J = ½⁺ with s-wave neutrons gives 1⁻
- Excitation of ground state J = 0⁺ with dipole excitations gives 1⁻
- Experiments with ^{77}Se/^{78}Se and ^{195}Pt/^{196}Pt

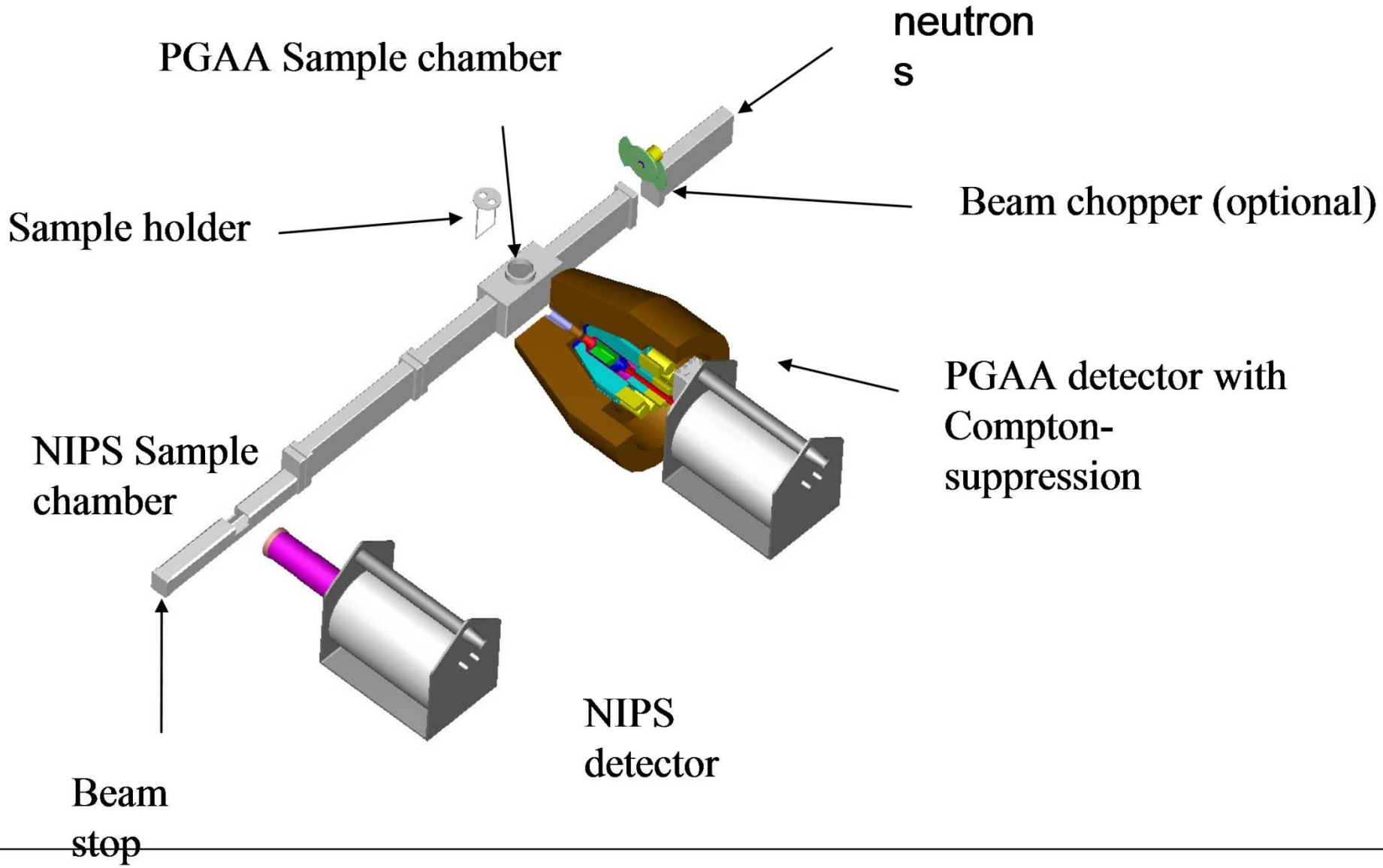
(n, γ) – experiment at the IKI Budapest

- Experiment at the Budapest research reactor (10 MW)
- 2.2 x10^{14} $cm^{-2}s^{-1}$ maximal thermal neutron flux
- Neutron beam guided to cold neutron source (CNS)
- beam size 2 x 2 cm^2
- 5x10^{7} $cm^{-2}s^{-1}$ neutron flux in cold energy range at target position

http://www.iki.kfki.hu/nuclear/research/index_en.shtml

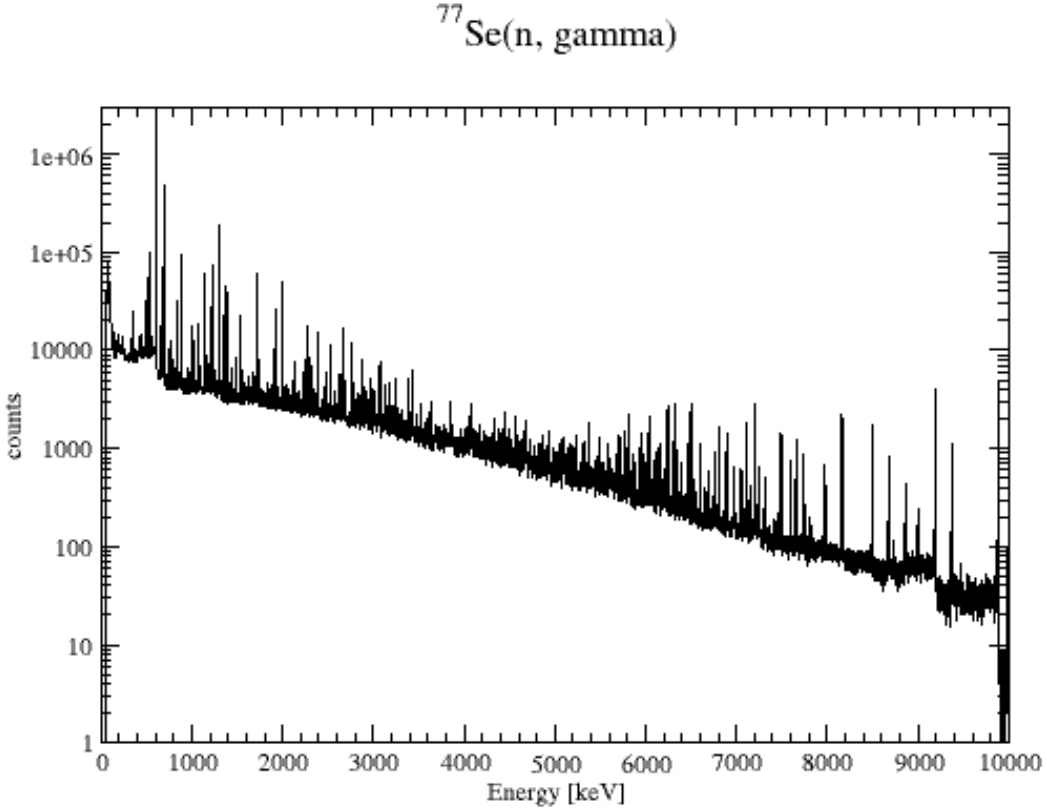
overview


Heavy concrete
Aluminium tank
Water
Active zone
Berilum reflector
Tangential beam tube for the cold source
Concrete
Lead
Al with Lithium-poly lining
Vacuum fitting
PGAA Compton suppressed spectrometer
NIPS experimental station
Beam Chopper
Cold source instrumentation building
Reactor Hall
PD
Cryopipe-lines
Neutron Guide Hall
REFL
MÖSSBAUER
SANS
Velocity selectors
Shielding tunnel
BI
FB
Shutters
Cold source plug
RAD
TASC
PGAA & NIPS


neutron
s
PGAA Sample chamber
Sample holder
Beam chopper (optional)
PGAA detector with
Compton-
suppression
NIPS Sample
chamber
NIPS
detector
Beam
stop

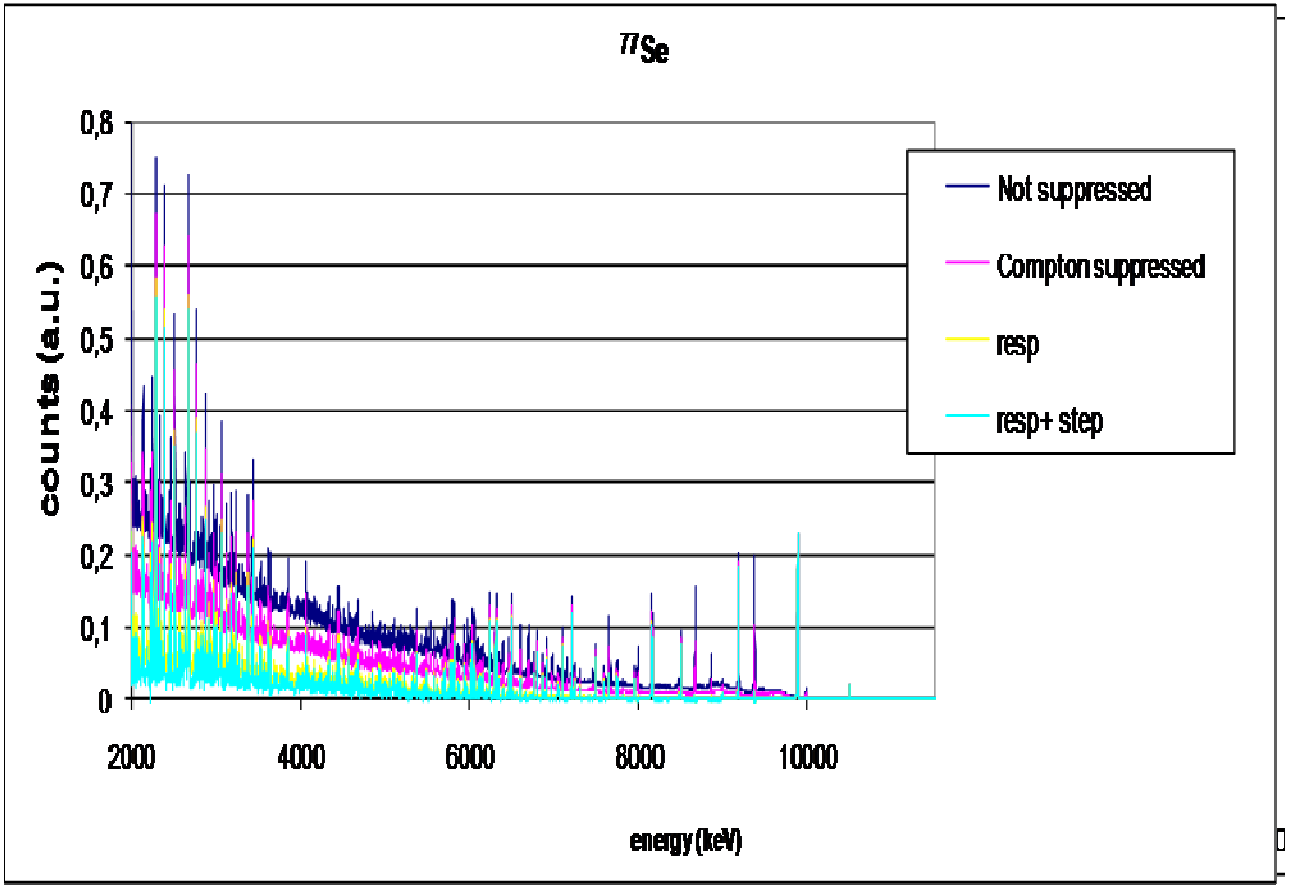
(n, γ) – experiment at the IKI Budapest

- HPGe – detector from FZD
- Compton suppressed by BGO shield
- Successful beam time in October 2009
- Also measurement of ^{195}Pt, natural Se and H_2O



Status of the data analysis (*n*, γ)

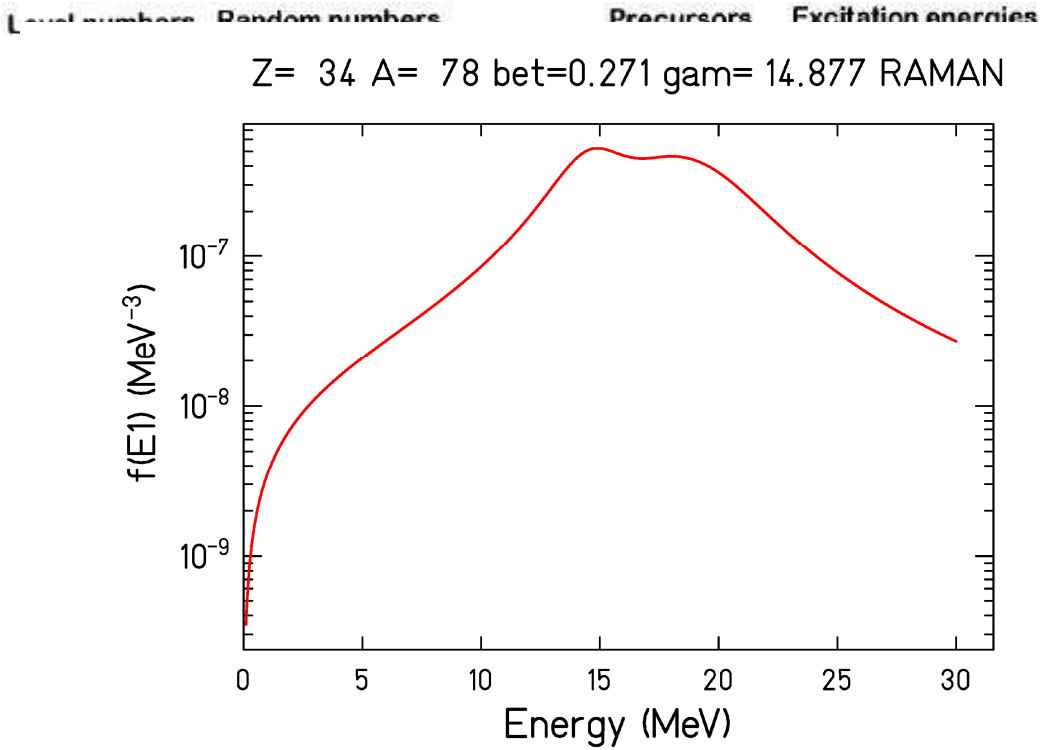
- Subtraction of background peaks
- Simulation of Detector response with Geant4
- Clean spectrum is input for statistical analysis to deduce strength function



Thanks to E. Birgersson

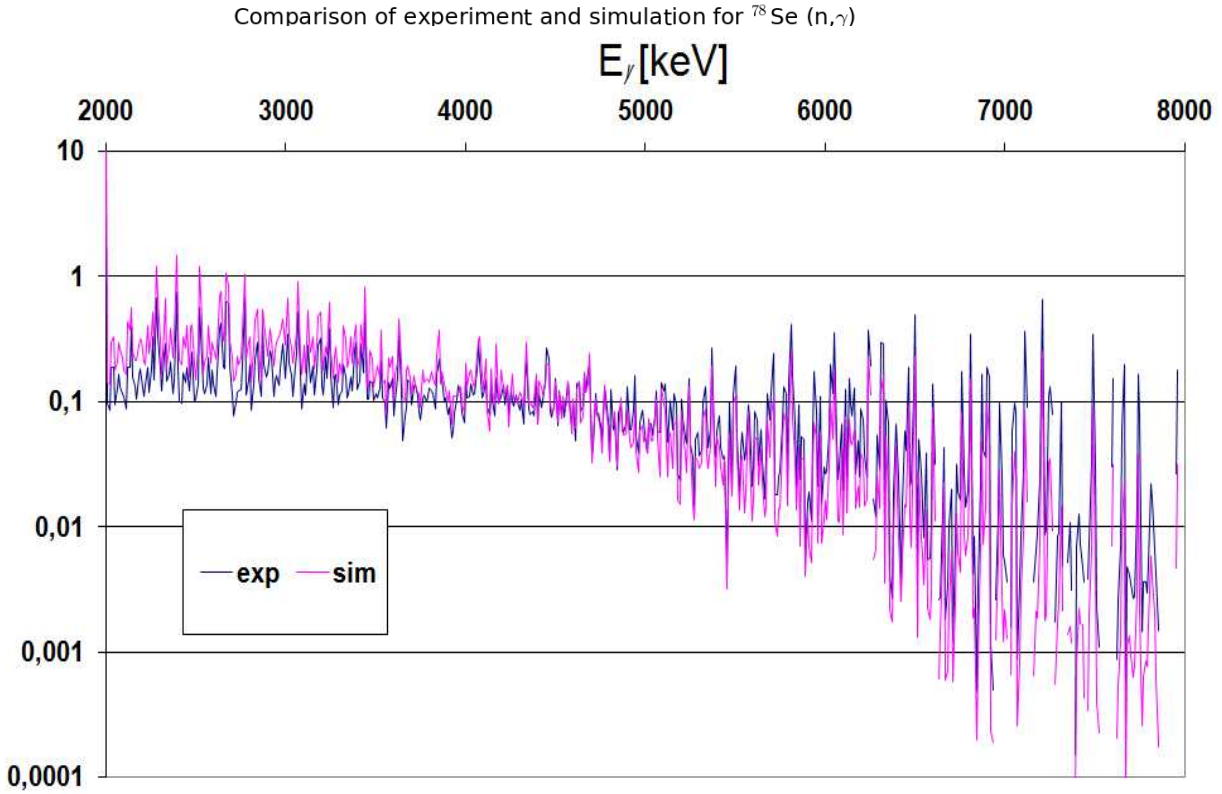
Status of the data analysis (n, γ)

- Neutrons captured in one level
- Input:
  - Level densities (Back-shifted Fermi Gas model, paramters from Egidy et al. PRC 72 044311)
  - Strength function described according to Junghans et al. Phys let. 670 2008
- Work in progress:
  - Varying of the strength function to reproduce experimental spectra



F. Bečvář et al. Nucl. Instr. and Meth in Phys. Res. A 417

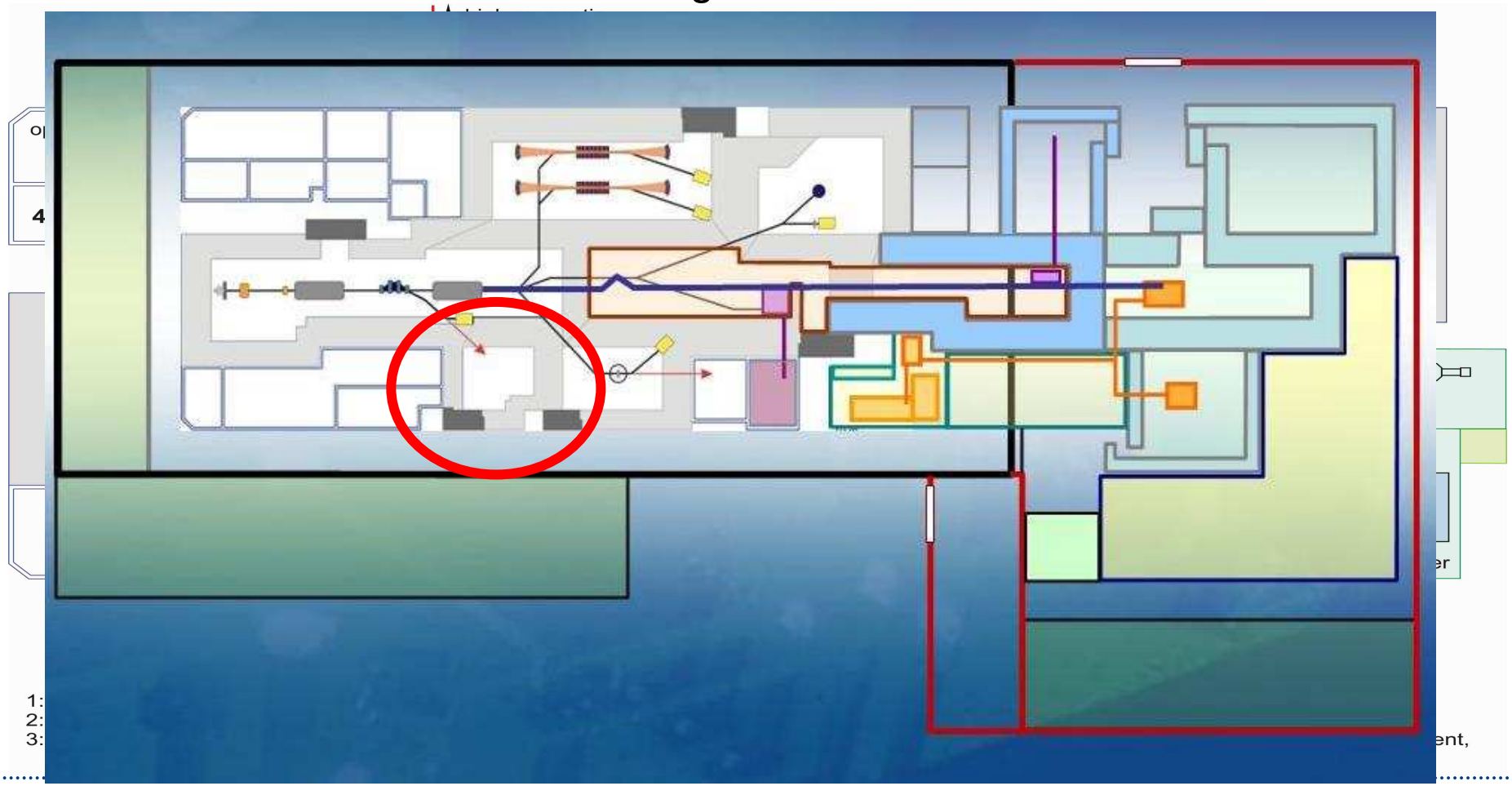
Status of the data analysis (*n*, γ)



- It is possible to reproduce the spectrum
- Improvements are in progress (strength functions, calculation time, (γ, γ‘))
- Comparison with data from (γ, γ‘) Dresden

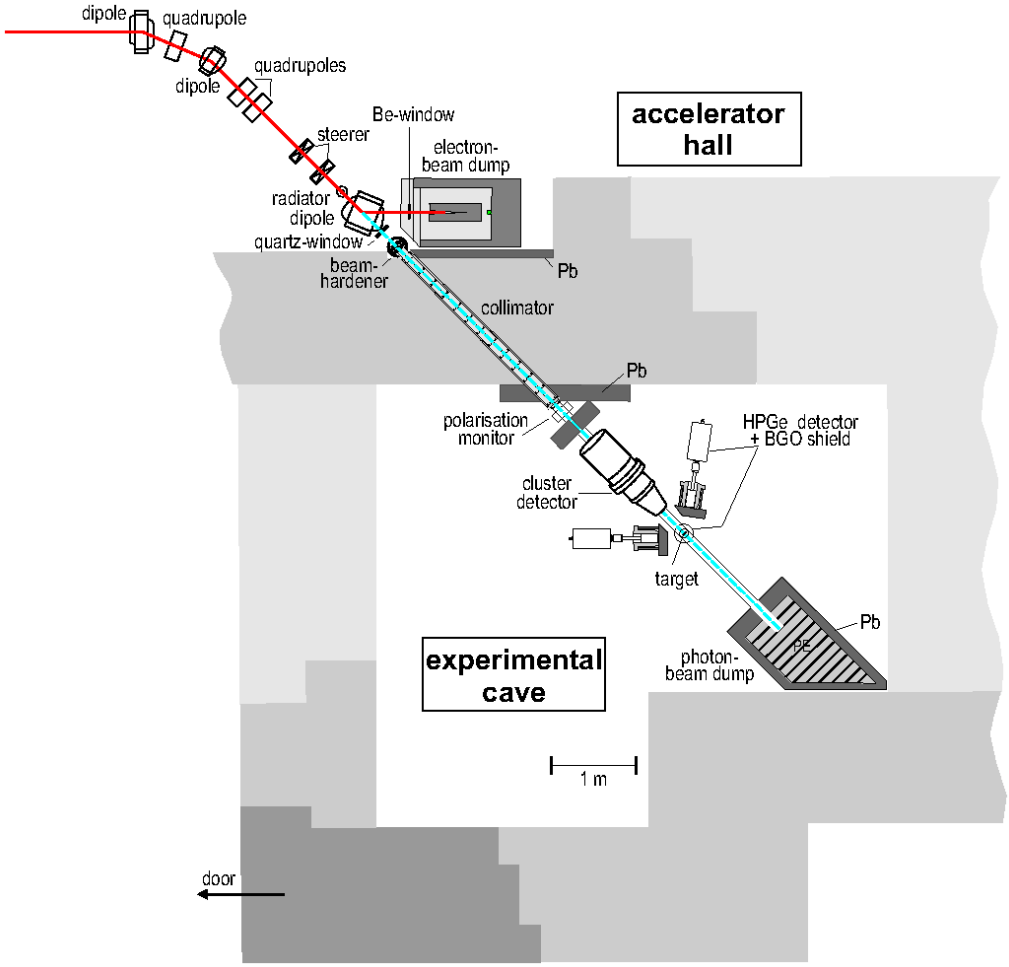
(γ, γ') – experiment at the ELBE accelerator in Dresden

Electron **L**inac for beams with high **B**rilliance and low **E**mittance



(γ, γ') – experiment at the ELBE accelerator in Dresden

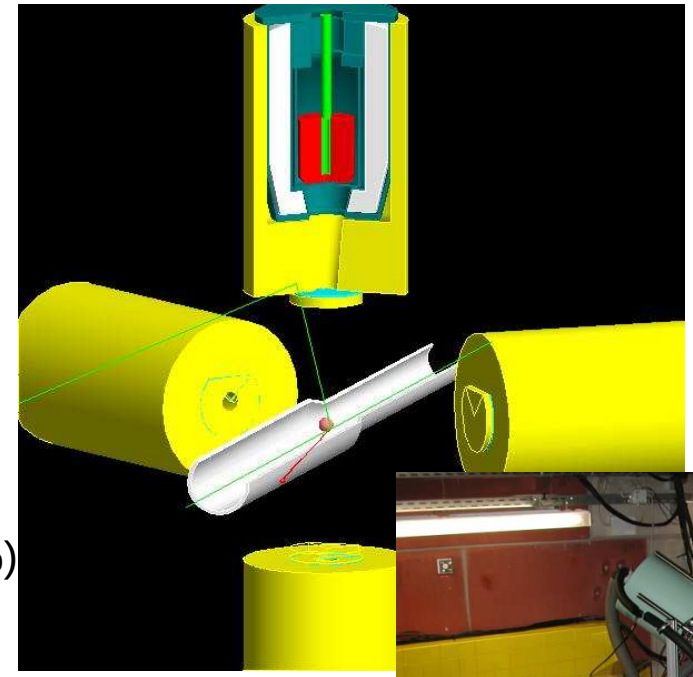
- Accelerator parameters:
  - Maximum electron energy: 18 MeV
  - Maximum average current: 1 mA
  - Operation in cw mode $f = 26 / 2^n$ MHz
- Bremsstrahlung produced in 7 µm Niobium foil
- through collimator on target beam spot ø 2 cm
- Neutron separation energy for ^{78}Se S_n=10.49 MeV



R.Schwengner. et al., NIM A 555 (2005) 211

(γ, γ') – experiment at the ELBE accelerator in Dresden

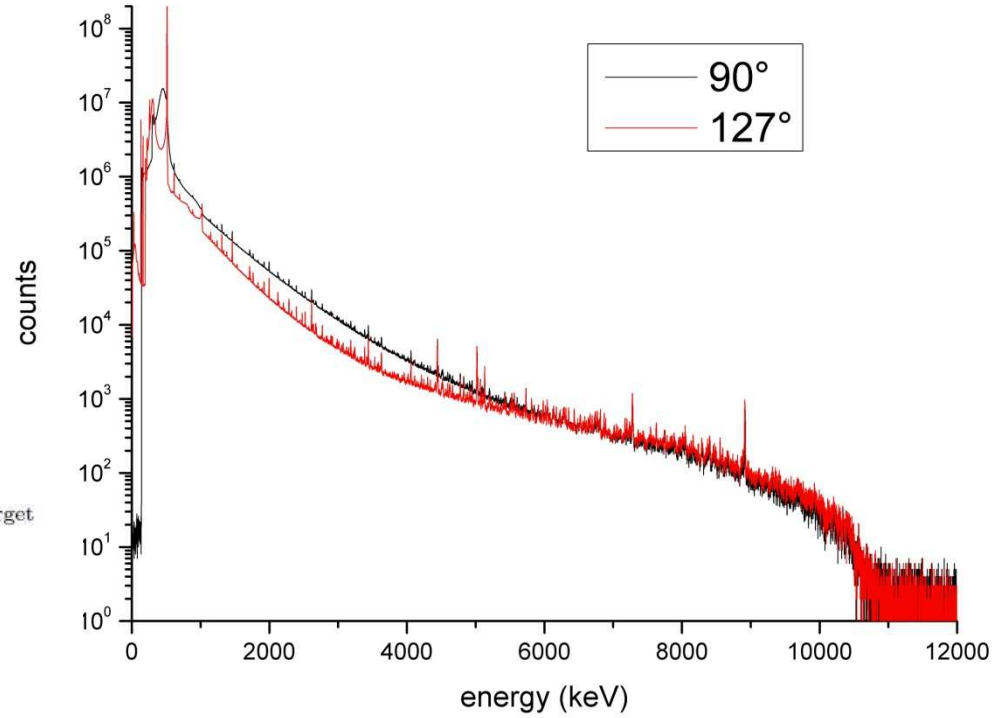
- Setup:
  - 4 HPGermanium detector (90° and 127°)
  - Each with Compton surpression by BGO shield
- Target
  - 2 g enriched ^{78}Se (99.3%)
  - 318 mg ^{11}B



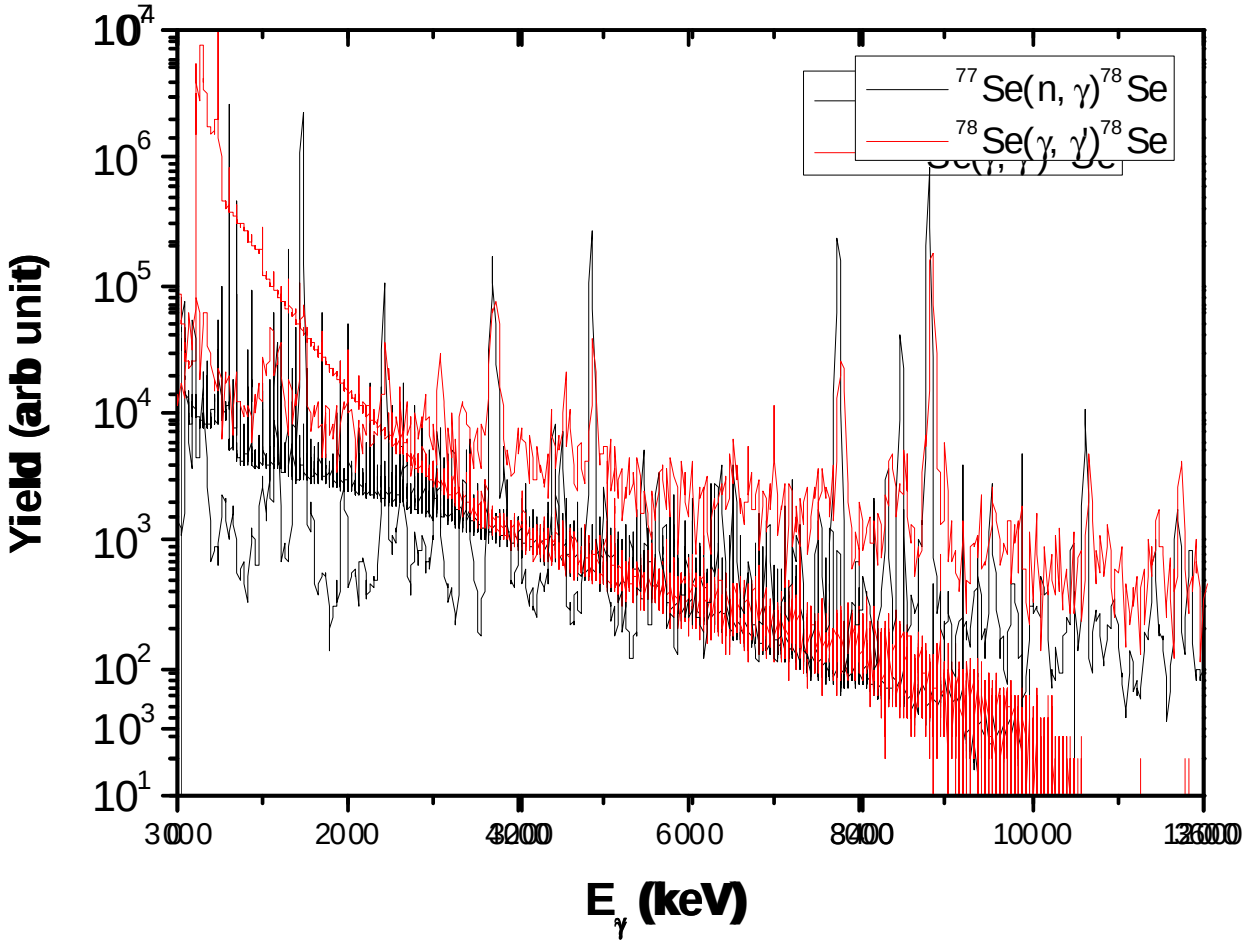
(γ, γ') – experiment at the ELBE accelerator in Dresden

- one week successful beam time in May 2009
- Goal :
  - Identify levels
  - Calculation of energy integrated cross sections
  - Relative to known cross sections in ^{11}B

$$I_S = \frac{n_{cal}}{n_{target}} \cdot \left(\frac{\Phi_\gamma \epsilon(E,\theta) W(\theta) I_S}{A(\theta)} \right)^{cal} \cdot \left(\frac{A(\theta)}{\Phi_\gamma \epsilon(E,\theta) W(\theta)} \right)^{target}$$

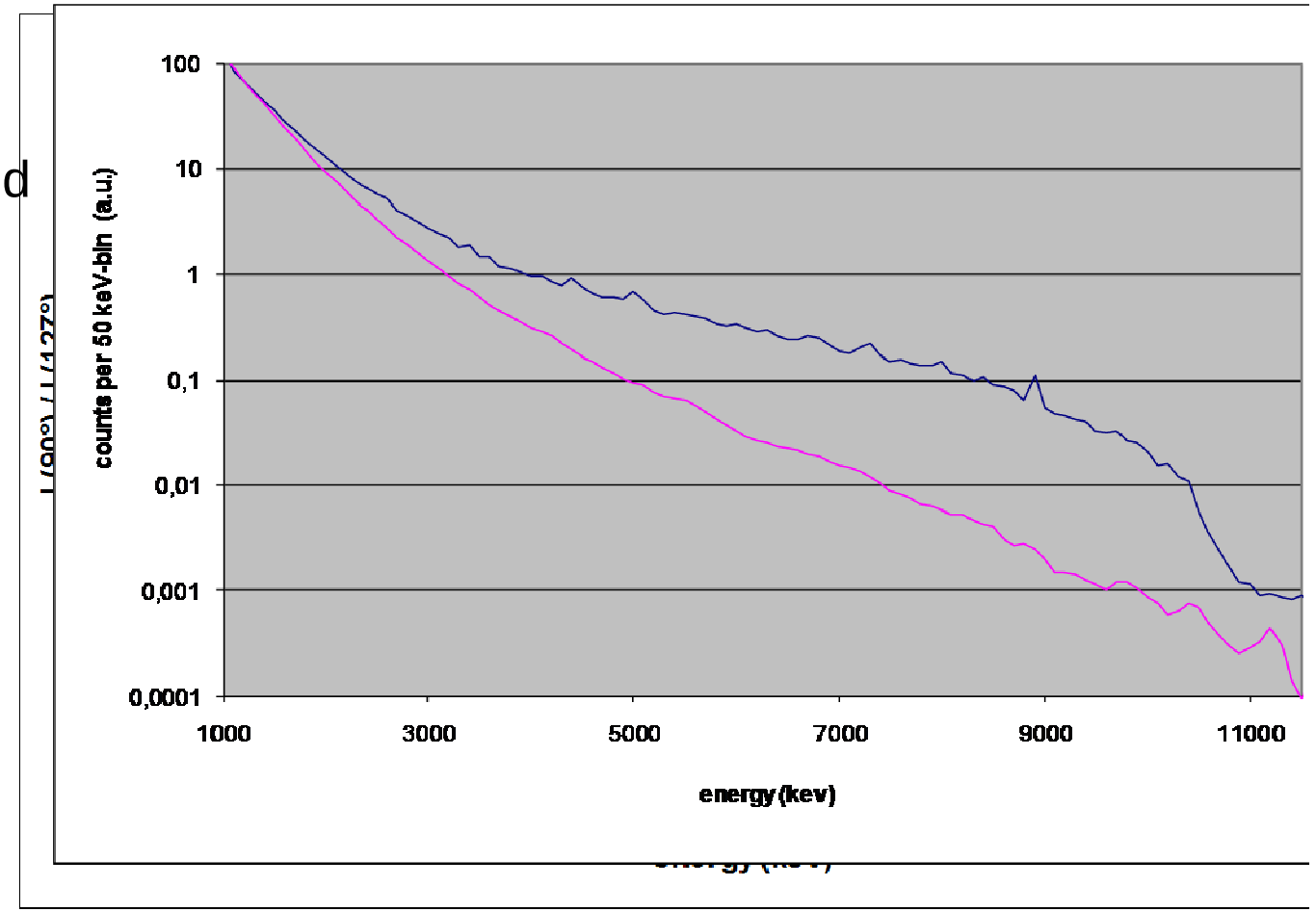


A first comparison

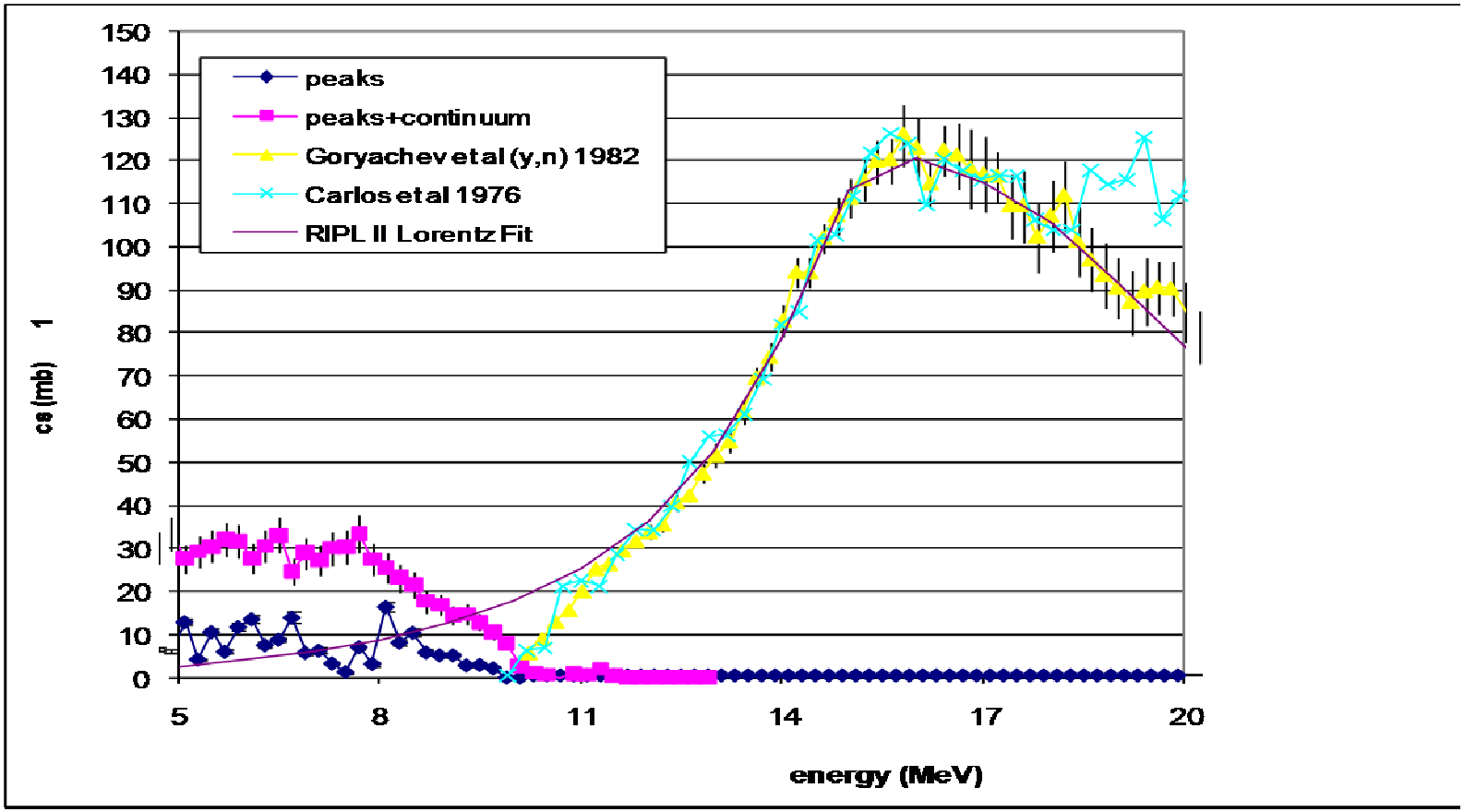


(γ, γ') – experiment at the ELBE accelerator in Dresden

- Analysis of peaks
- Simulation of non-nuclear background with Geant4
- Correction for detector response



results

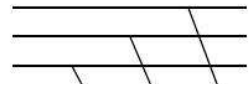


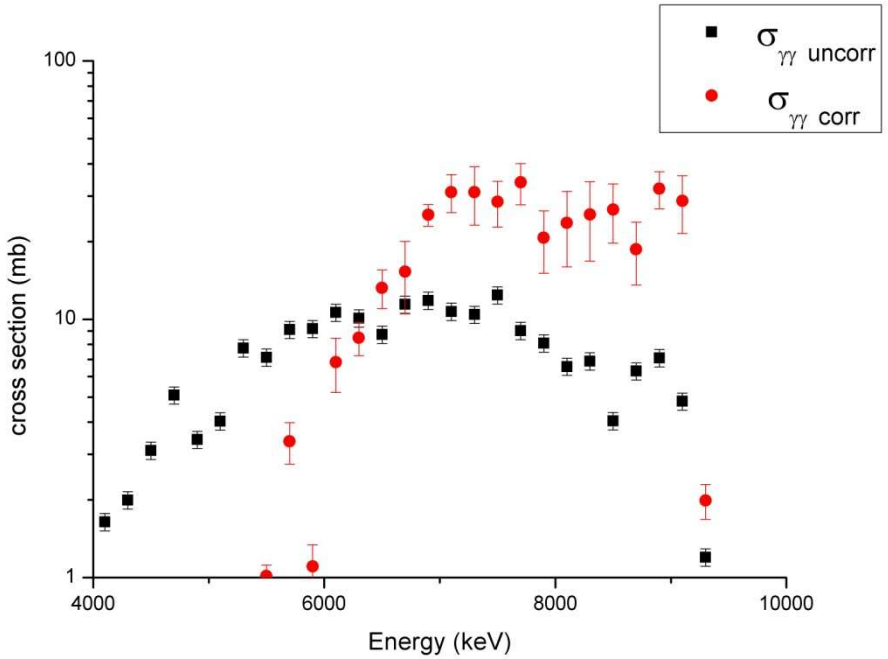
- strength in continuum (60 – 70 %)
- Additional strength in energy range between 5 to 8 MeV
  - Pygmyresonance ?
  - Effect from M1-strength ? (see Heyde et al , arXiv:1004.3429v2, April 2010)
- Correction for branching needed

results

- Feeding and branching correction needed
- Analog to branching correction in (n, γ)
- γ -ray cascades have to be simulated and applied to the measured spectra
- Subtraction of intensities of inelastic transitions
- Correction for branching ratios of the ground-state transitions

$$\sigma_\gamma = \sigma_{\gamma\gamma 0}\,(\Gamma_0 / \Gamma)^{-1}$$





g

Correction effect in ^{136}Ba

summary

- Successful experiments
- Data analysis in progress
  - analysis of peaks done
  - simulation of atomic background done
  - simulation of detector response and efficiency done
  - gamma ray cascade simulation runs and will be improved

Thanks to all Collaborators

FZD, Institute of Radiation Physics:

D. Bemmerer, R. Beyer ,E. Birgersson, F. Dönau, E. Grosse, R. Hannaske, A. Hartmann, A.R. Junghans, M. Kempe, A. Matic, K.-D. Schilling, G. Schramm, R. Schwengner, A. Wagner, The ELBE Crew

IKI Budapest, Department of Nuclear Research :

T. Belgya, Z. Kis, L. Szentmiklósi, K.Takács, J. Weil

TUNL Durham:

G. Rusev