Decay behaviour of 1^- states in ^{92}Mo and ^{94}Mo observed with SONIC@HORUS

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supported by
DFG ZI 510/4-2 and BMBF 06KY9136
* Bonn-Cologne Graduate School of Physics and Astronomy

5th International Workshop on Level Density and γ Strength

Oslo

Bundesministerium für Bildung und Forschung

DFG

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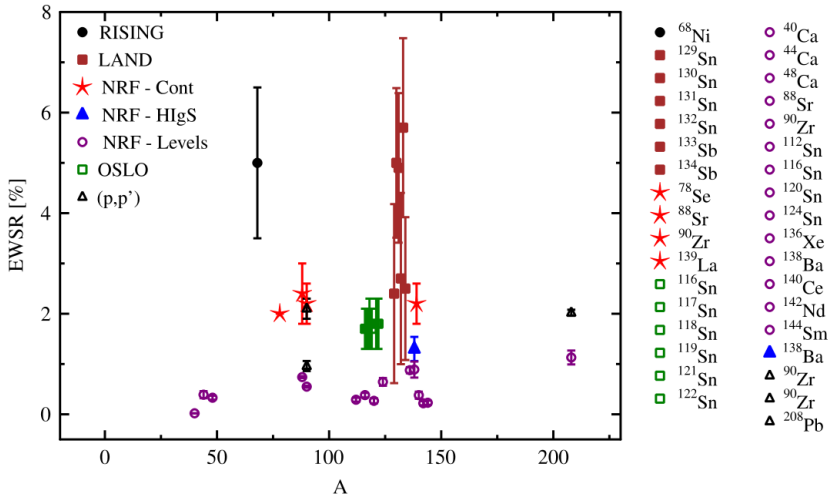
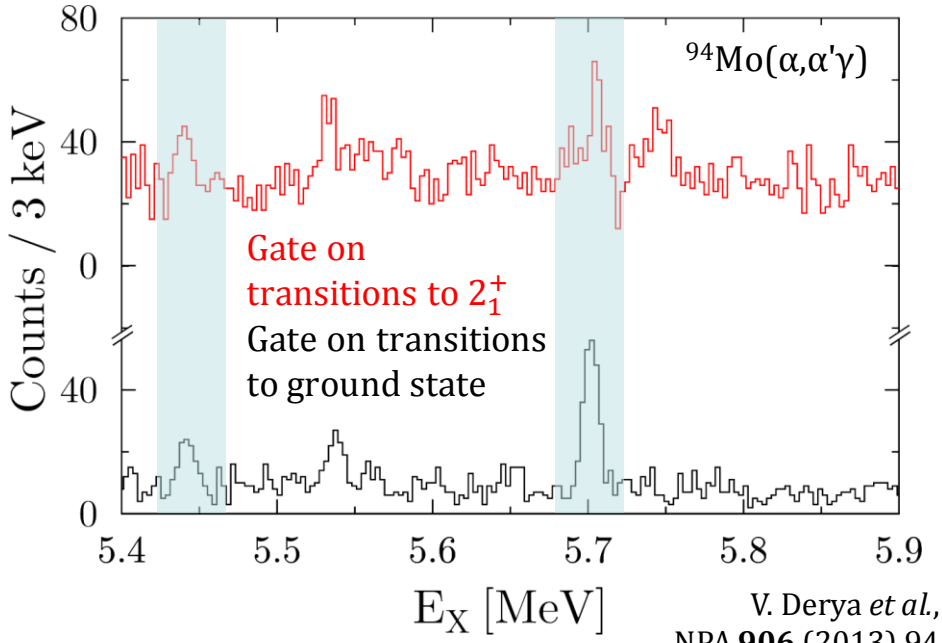
Pygmy Dipole Resonance – decay properties



D. Savran, T. Aumann, and A. Zilges,
PPNP **70** (2013) 210

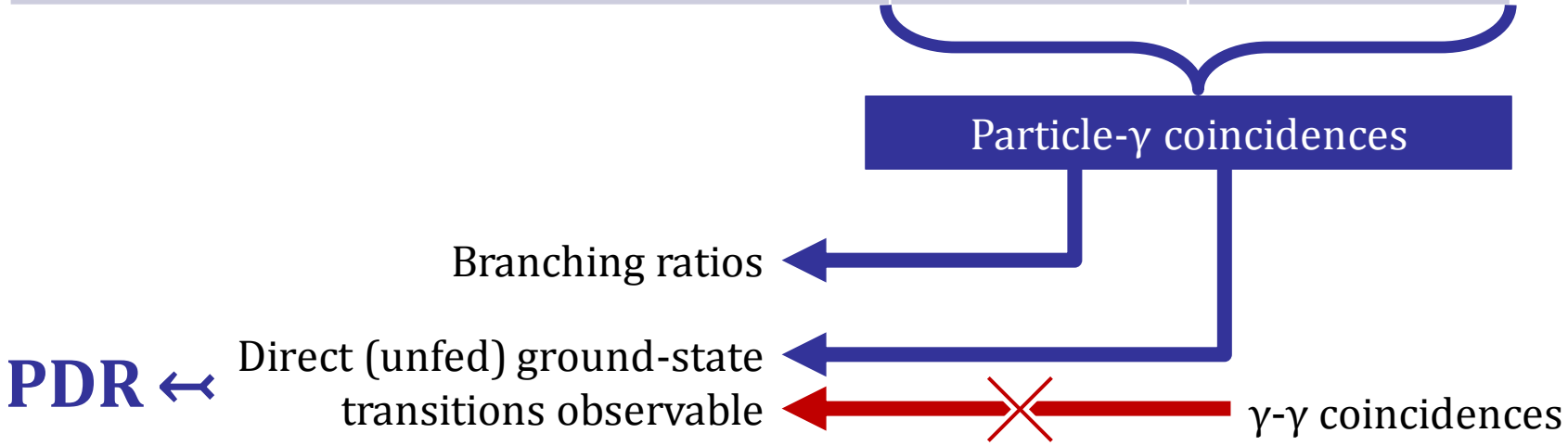


V. Derya *et al.*,
NPA **906** (2013) 94

- Usually Γ_0/Γ=1 assumed for B(E1) values
  - Possible explanation of B(E1)-value discrepancy
- Branching of PDR states observed, e.g. in ^{94}Mo(α,α'γ) @ E_α = 136 MeV
- Branching ratios probe wave functions
- In (p,p'γ) and with p-γ coincidence, weak branchings can be determined

Particle-γ coincidences

Spectroscopy Detector	γ HPGe	Particle (Ion) Silicon
Excitation	×	✓
Deexcitation	✓	×
Energy resolution of detector	++ (2 keV @ 1.3 MeV)	+ (15 keV @ 5.5 MeV)
Energy resolution in-beam	++	o
Information	spectra	gate



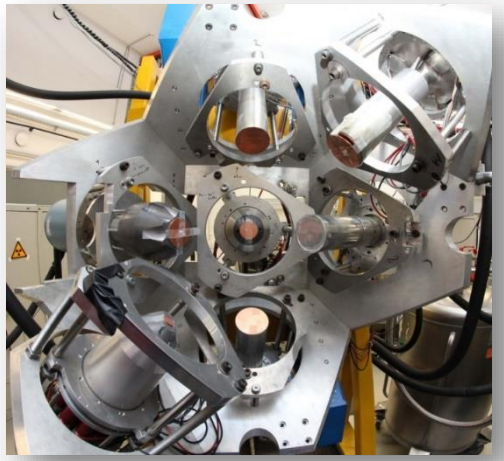
Experimental setup

SONIC

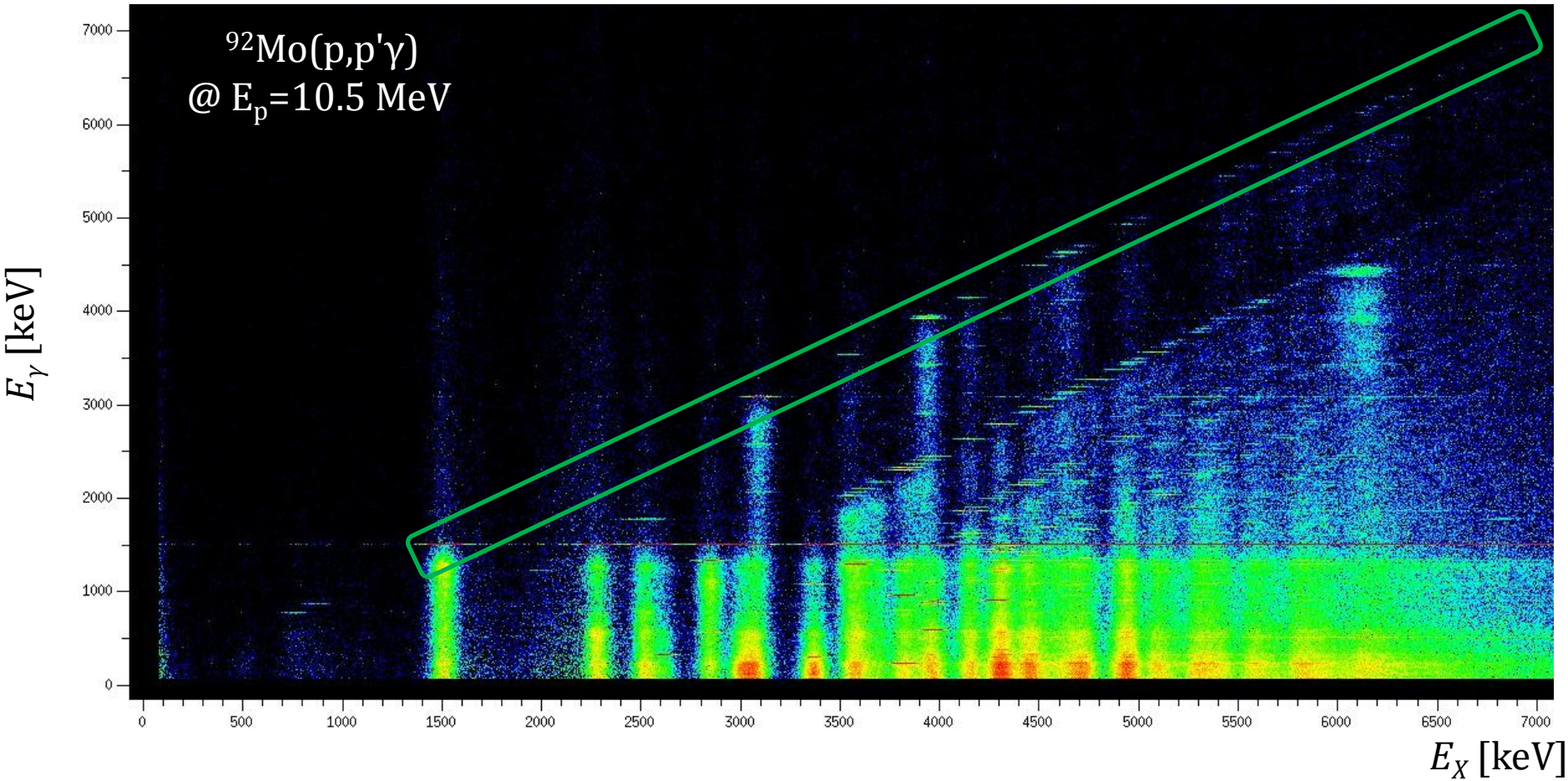
- Up to 8 detector positions
  - ΔE-E or single PIPS
- 4 angles relative to beam
  - 60°, 90°, 120°, 130°
- Solid angle coverage:
  Up to 4%
- Typical energy resolution
  ~70 keV in-beam

HORUS

- 14 HPGe detectors
  - Up to 6 BGO shields
- 5 angles relative to beam
- Photopeak efficiency:
  ~2% @1332 keV
- Energy resolution:
  ~2 keV@1332 keV

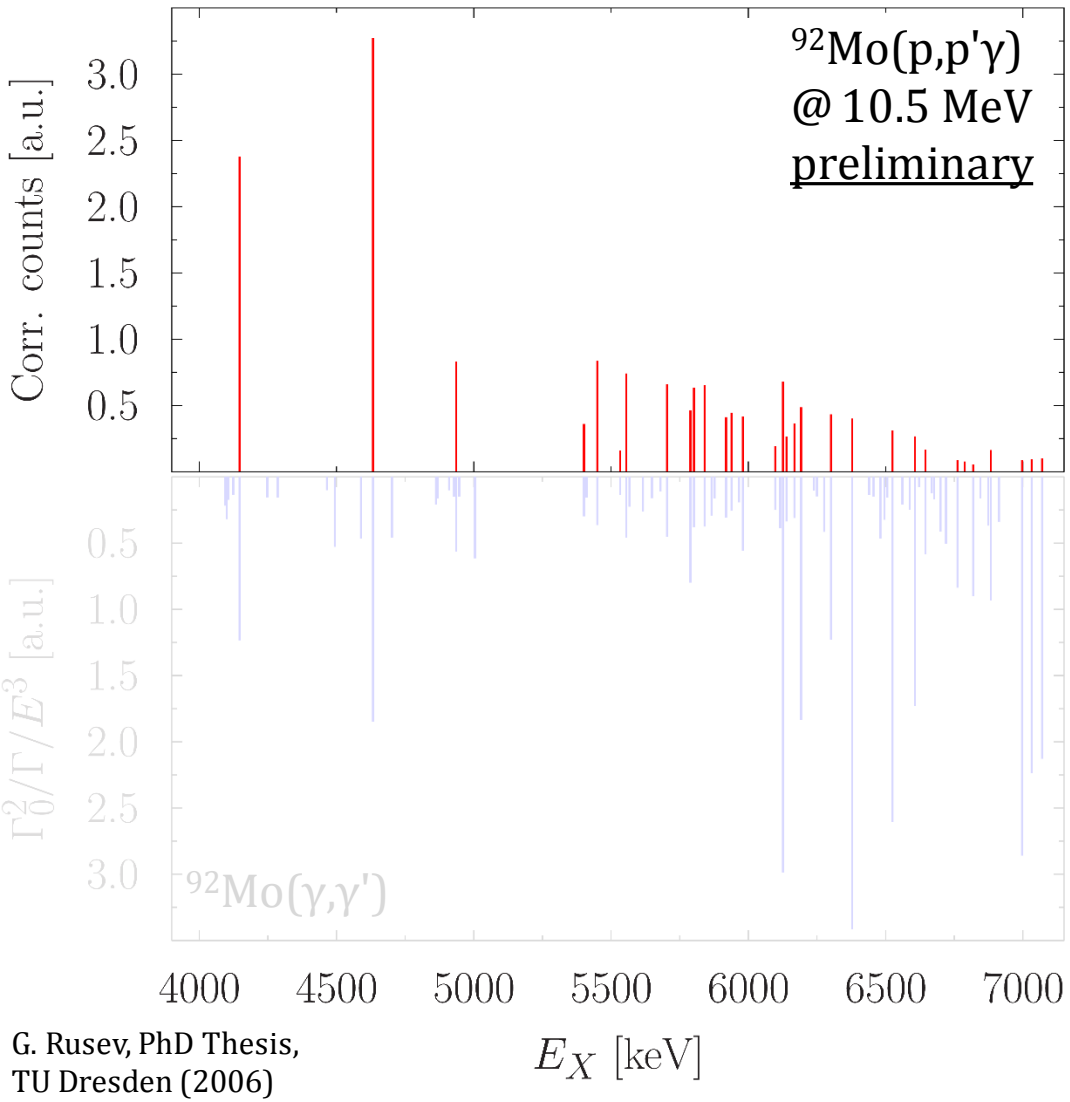


p-γ coincidence matrix of ^{92}Mo



- Diagonal gates can be set to select decays to specific levels
  - Ground state decays

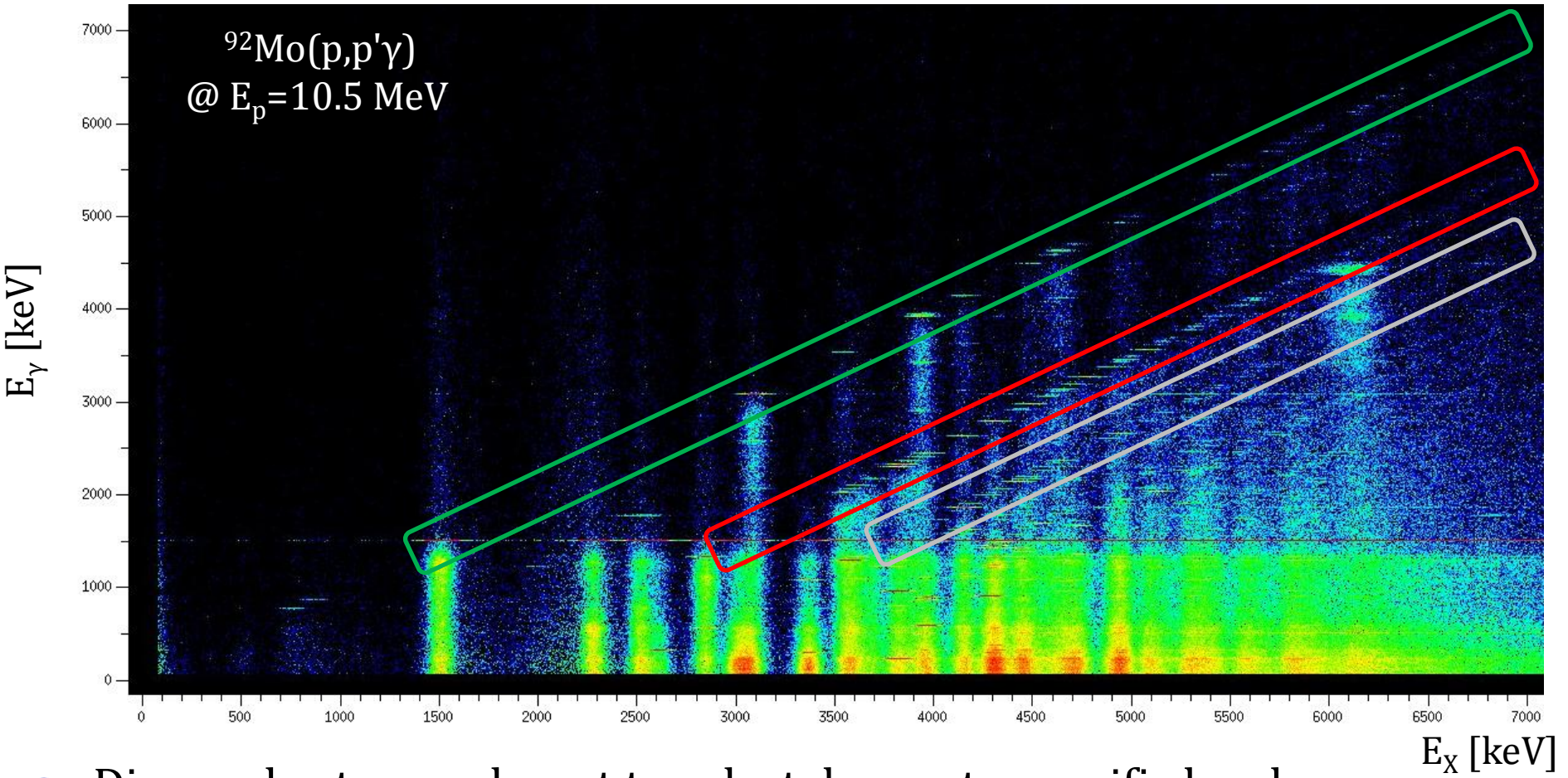
Ground state decays – comparison to (γ,γ')



G. Rusev, PhD Thesis,
TU Dresden (2006)

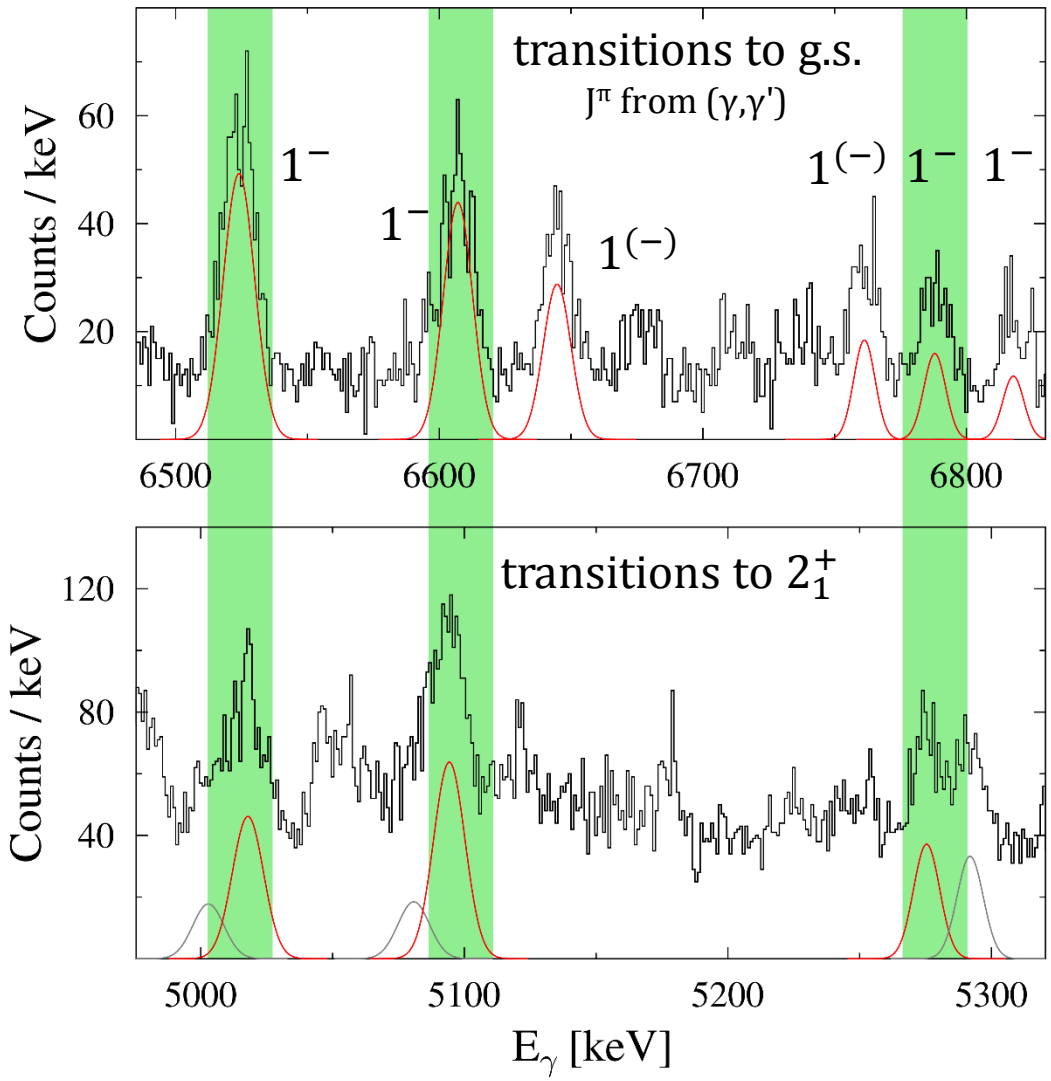
- Upper panel: experimental results from (p,p'γ)
  - Counts corrected by preliminary efficiency
  - Isotropic distribution assumed
- Lower panel: experimental results from (γ,γ')
  - ~∝ B(E1) without branching

p-γ-coincidence matrix of ^{92}Mo



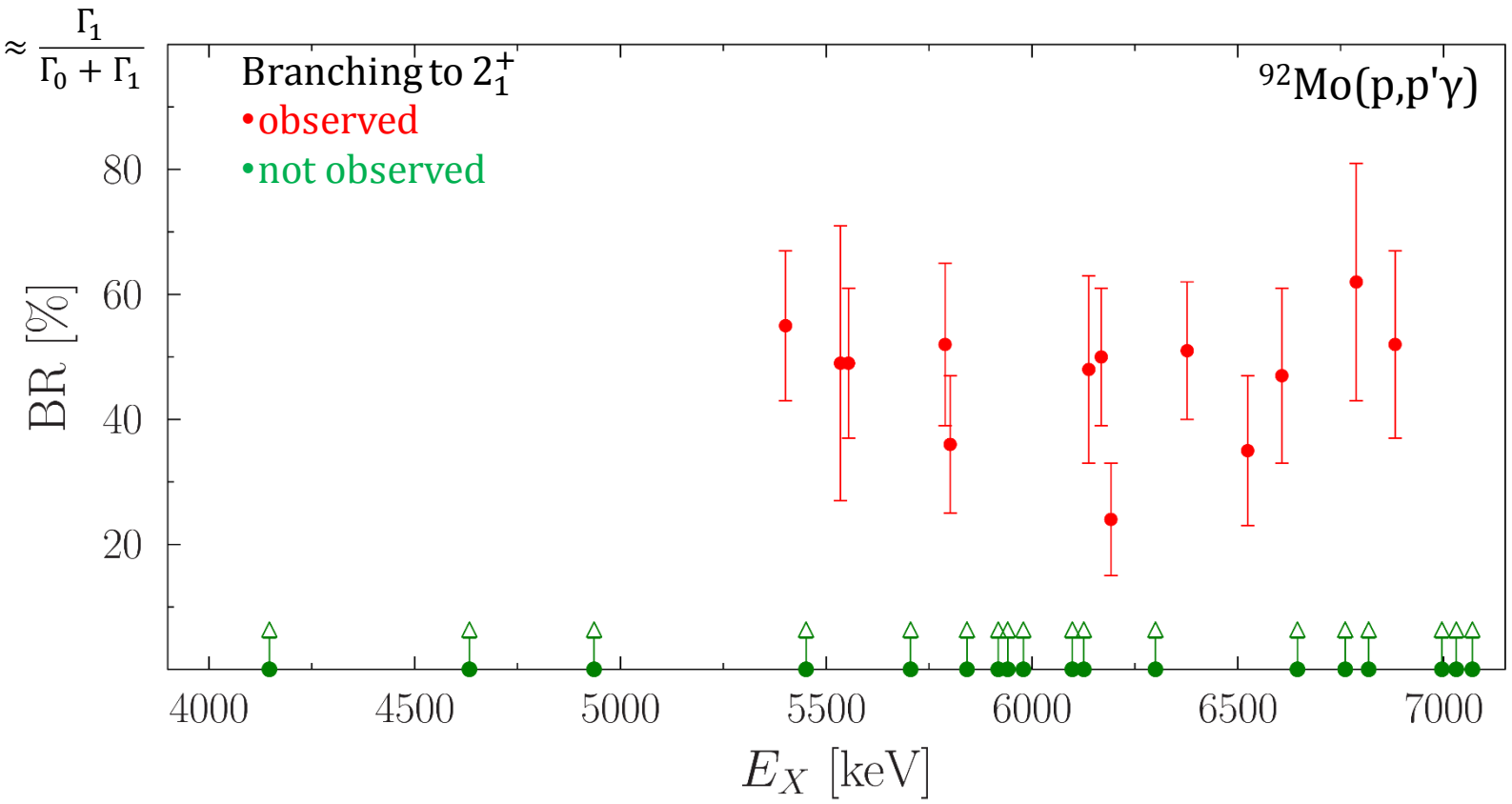
- Diagonal gates can be set to select decays to specific levels
  - Ground state decays
  - Decays to 2_1^+, to 4_1^+, …

Decay properties of PDR states



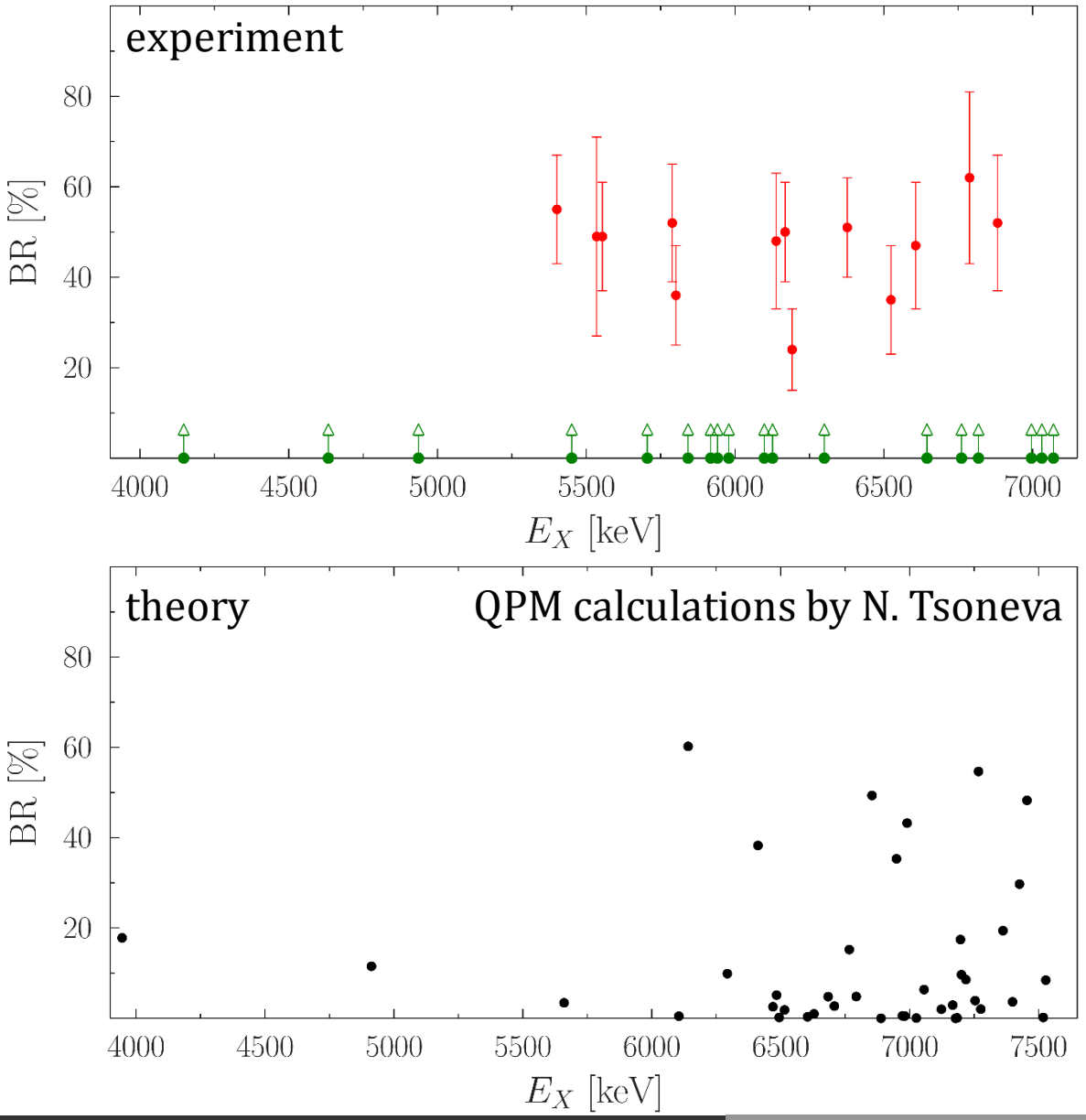
E_X [keV]	$\gamma \rightarrow 0_1^+$	$\gamma \rightarrow 2_1^+$	$\gamma \rightarrow 2_2^+$	$\gamma \rightarrow 0_2^+$
5401	✓	✓		
5533	✓	✓	✓	
5555	✓	✓	✓	✓
5703	✓			✓
5789	✓	✓		✓
5842	✓			✓
5981	✓			
6126	✓		✓	
6139	✓	✓		
6192	✓	✓		
6300	✓			
6378	✓	✓	✓	
6525	✓	✓		
6606	✓	✓	✓	
6645	✓		(✓)	
6761	✓		✓	
6787	✓	✓		
6818	✓			
6883	✓	✓	✓	
6996	✓			
7031	✓			
7070	✓			
7077	✓			

Decay branching ratio vs. energy



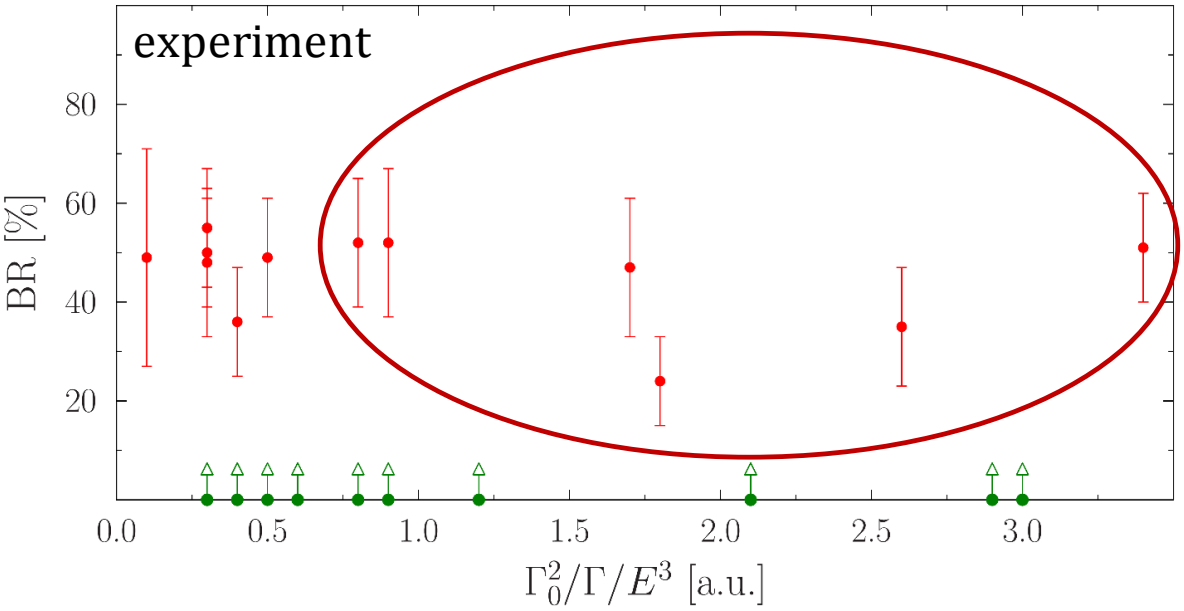
➢ No trend with energy

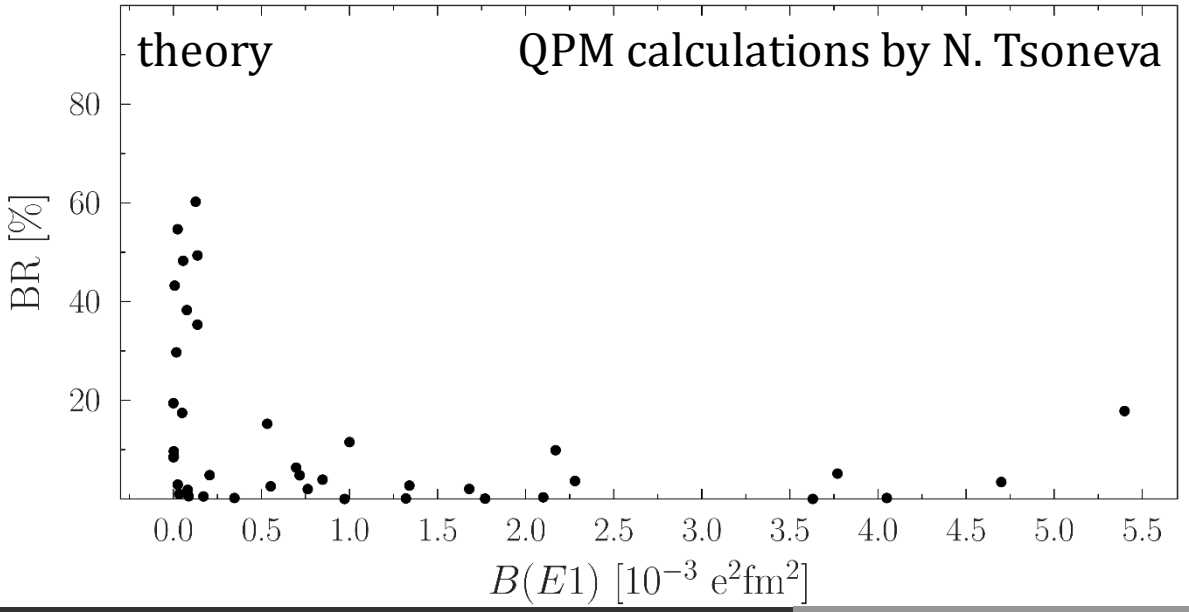
Experiment vs. theory



- Experiment and theory show similar picture
- Smaller error bars needed for higher significance

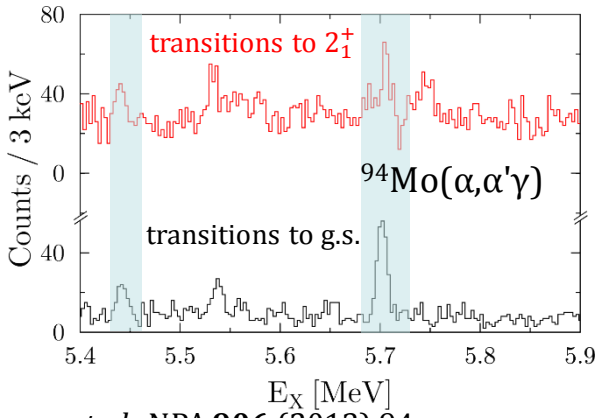
Experiment vs. theory





- No trend of branching ratio with strength observed
- Different theoretical prediction
- Discrepancy for strong transitions

^{94}Mo(p,p'γ) @ E_p = 13.5 MeV



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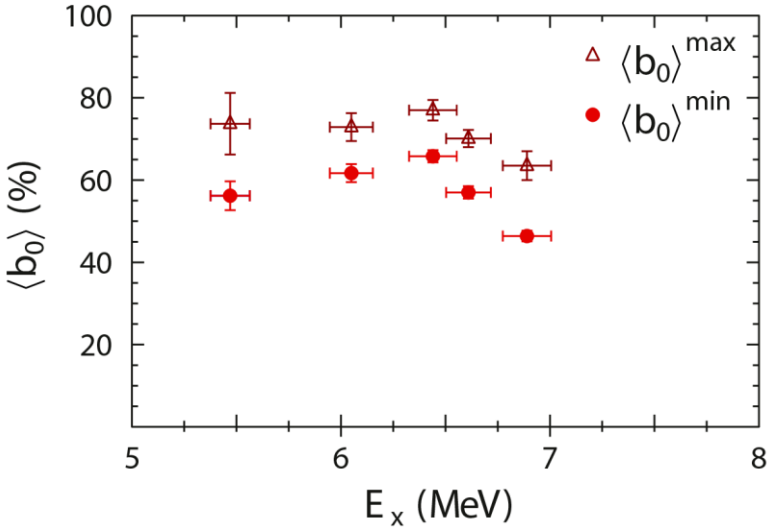


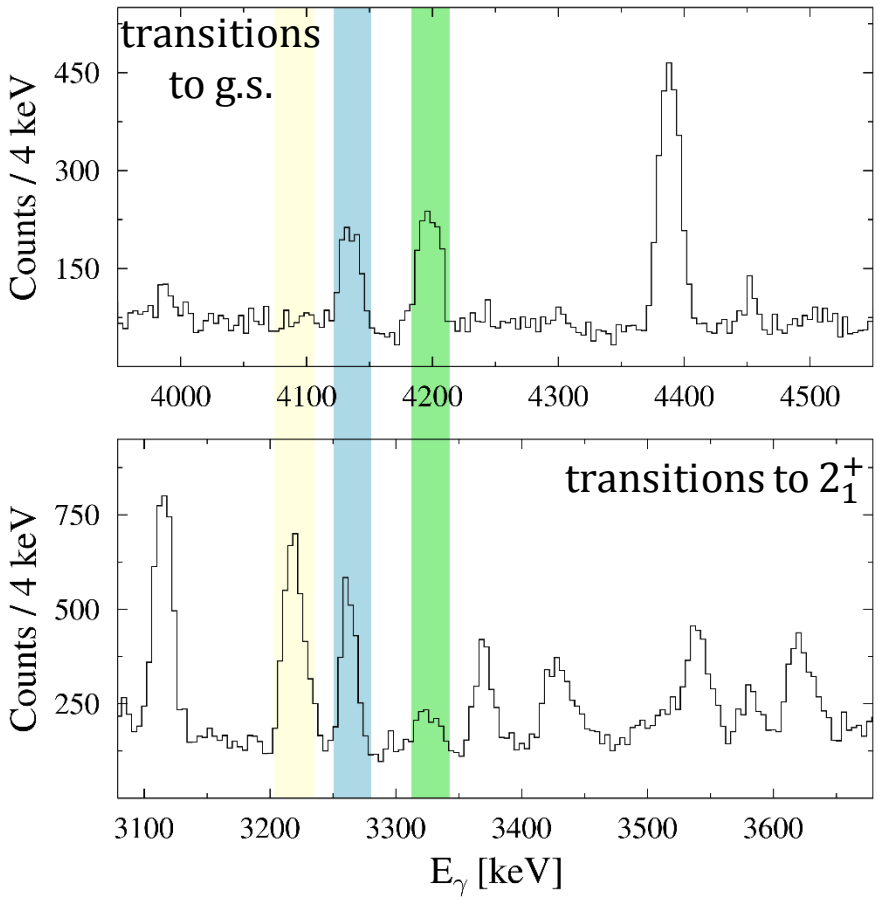
Adopted from C. Romig *et al.*, PRC **88** (2013) 044331

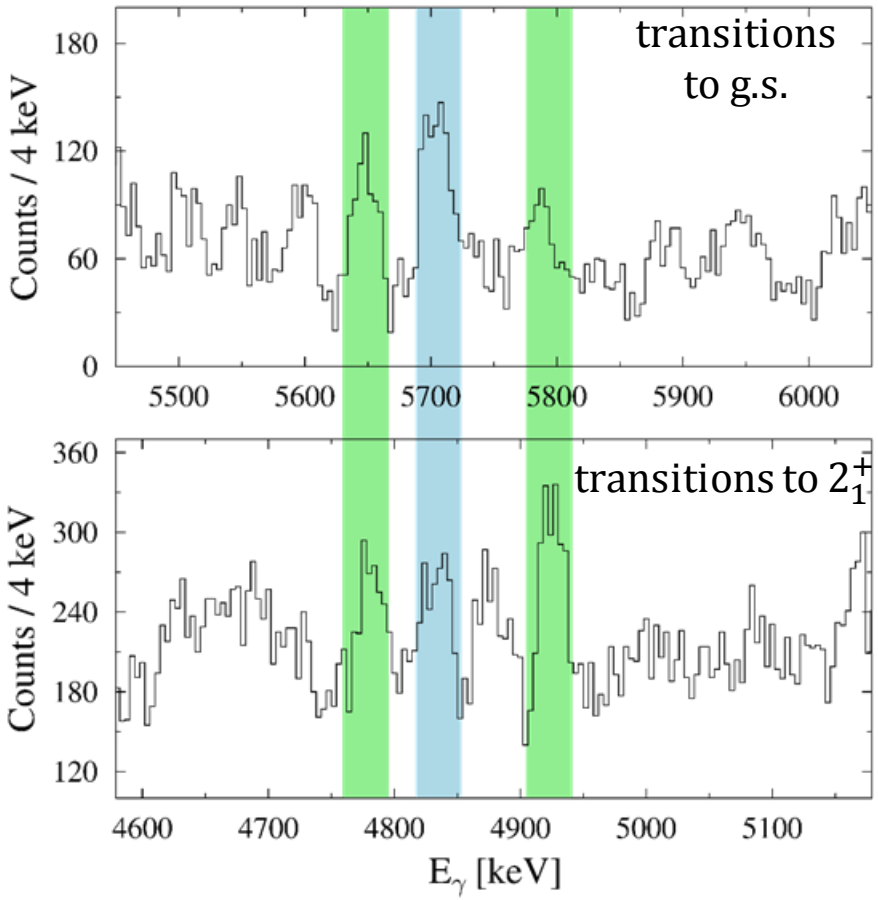
- Goals of experiment:
  - Study decay behaviour in non-magic nucleus
  - Individual and mean branching already observed in (α,α'γ) and (γ,γ')
  - With our setup:
    - More states (if similar to ^{92}Mo)
    - Individual branching
  - Higher beam energy to excite states at higher energies

Decay branching in ^{94}Mo from (p,p'γ)

- Known branching
- New branching

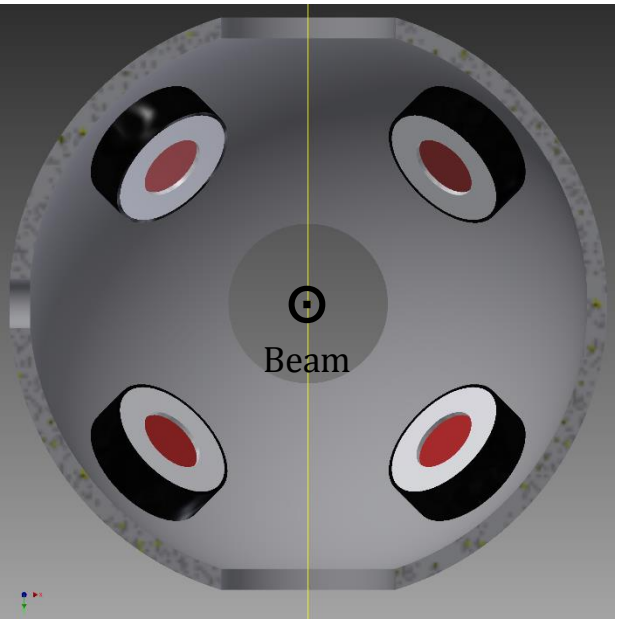
preliminary

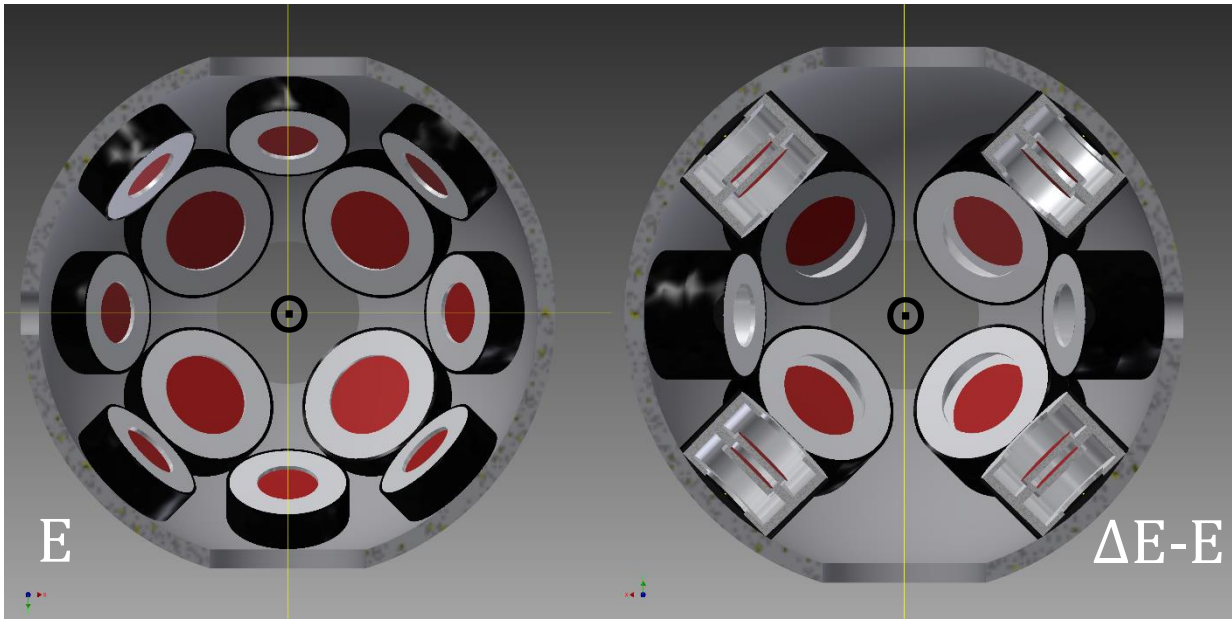




- ^{94}Mo is similar to ^{92}Mo:
  - State-to-state difference in decay behaviour

Improvement of setup – solid angle coverage





Old setup

(consider only backward angles)

- Up to 2.2% for E
- Up to 1.6% for dE-E

Variable distance in tubes

New setup

(detectors only placed at backward angles)

- Up to 8.9% for E
- Up to 7.8% for dE-E

Apertures to reduce count rate in silicon detectors

Summary & Outlook

- **Many decays of PDR** states to **several final states** observed in **^{92}Mo**
  - $2_1^+, 0_2^+, 2_2^+$
  - State-to-state difference

- Promising results for **^{94}Mo**
  - Branchings to 2_1^+ observed

- ^{92,94}Mo(p,p'γ)
  - Thorough analysis
  - Comparison to known BR from (α,α'γ) and (γ,γ')
  - Comparison to theory

- Future experiments for PDR
  - Inelastic scattering
  - Transfer reactions

  with p, d, α beams ≤ 30 MeV