

# The $\gamma$ decay behaviour of the PDR in $^{92,94}\text{Mo}$

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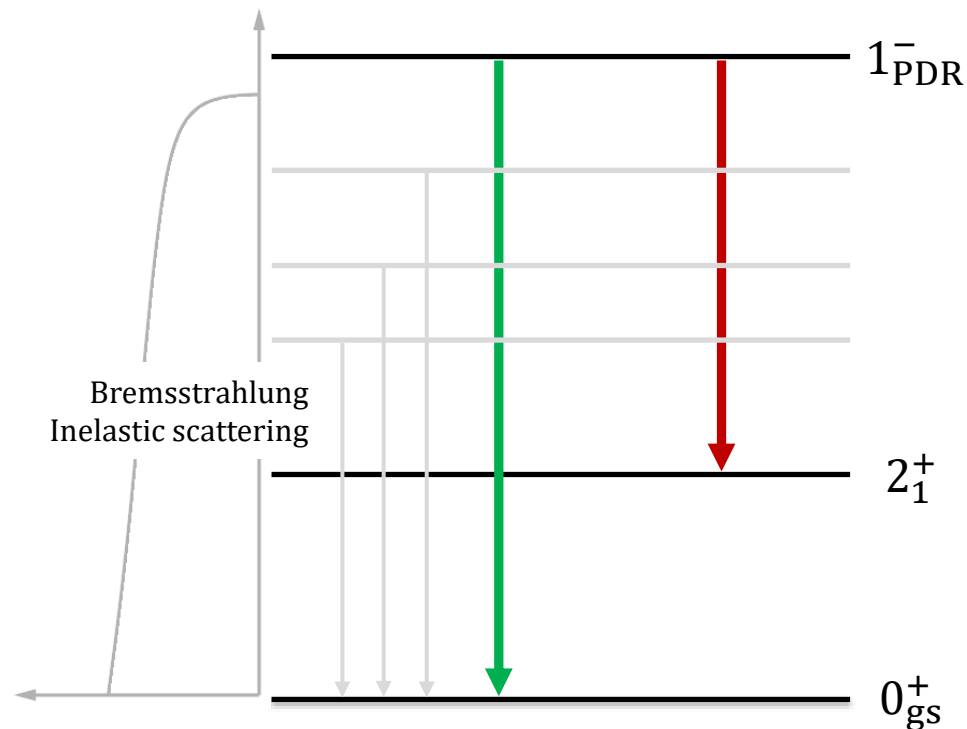
COMEX5  
Kraków

DFG



# Pygmy Dipole Resonance – decay properties

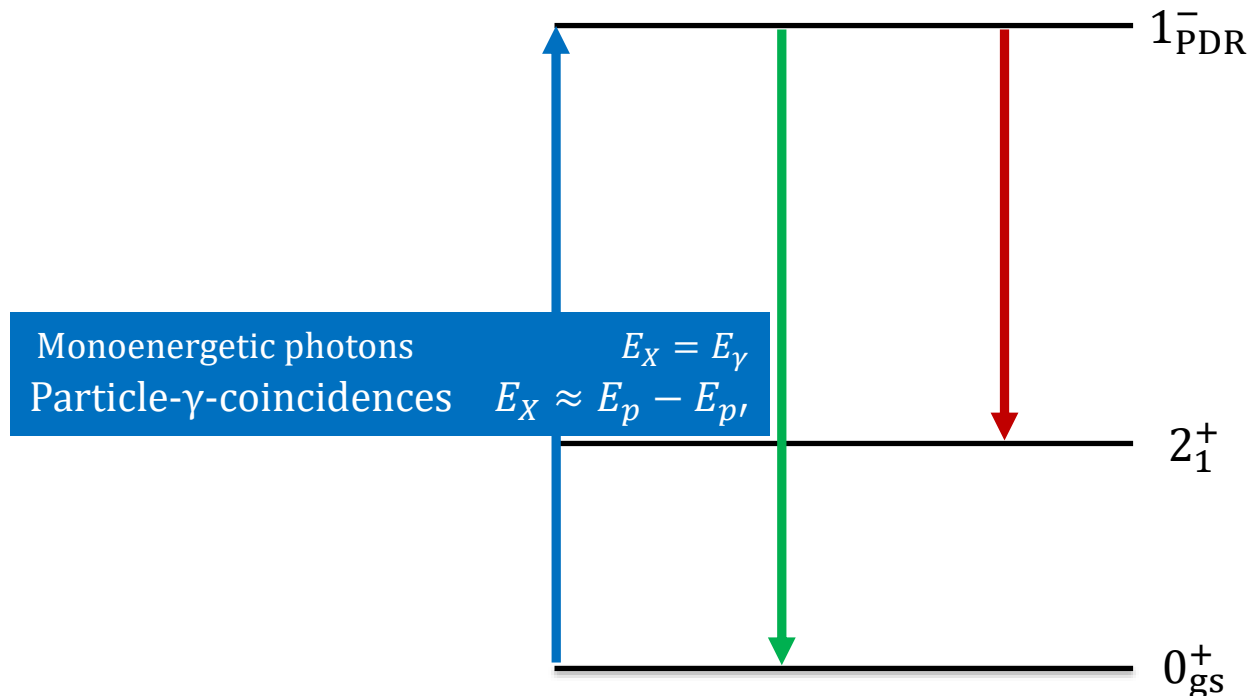
- Usually  $\Gamma_0/\Gamma=1$  assumed for  $B(E1)$  values from  $(\gamma,\gamma')$ 
  - Possible explanation of  $B(E1)$ -value discrepancy
- Branching ratios probe wave functions
- Selective excitation needed to determine weak branchings



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

# Pygmy Dipole Resonance – decay properties

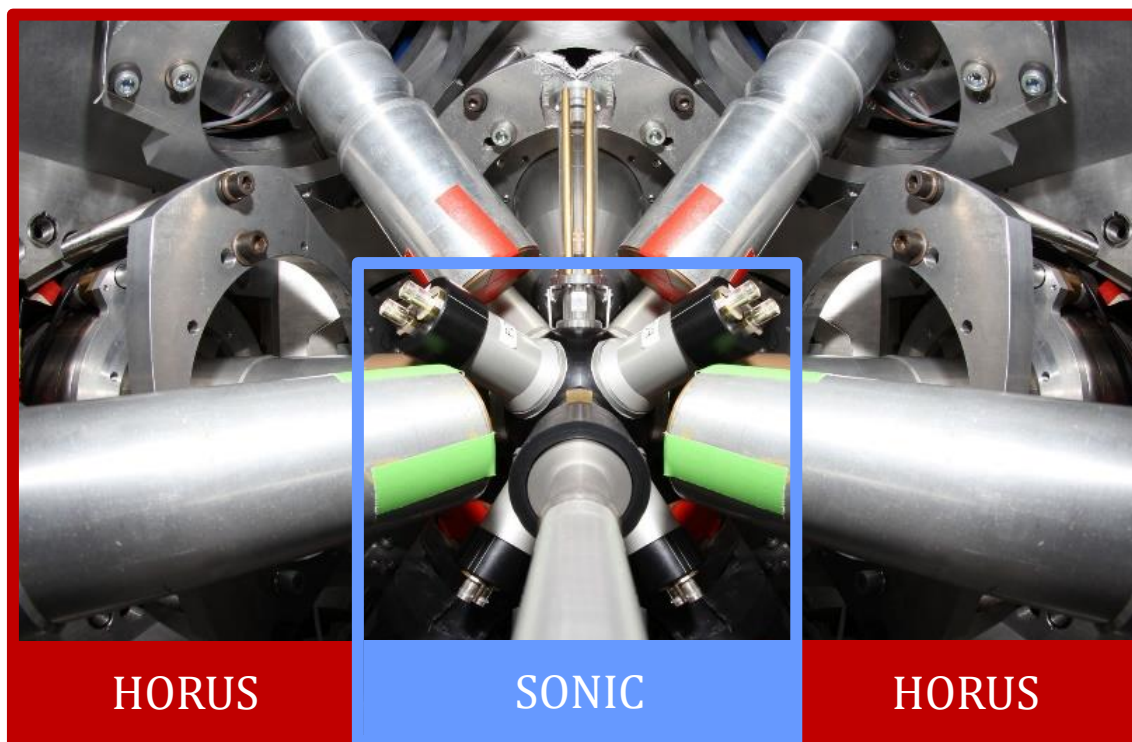
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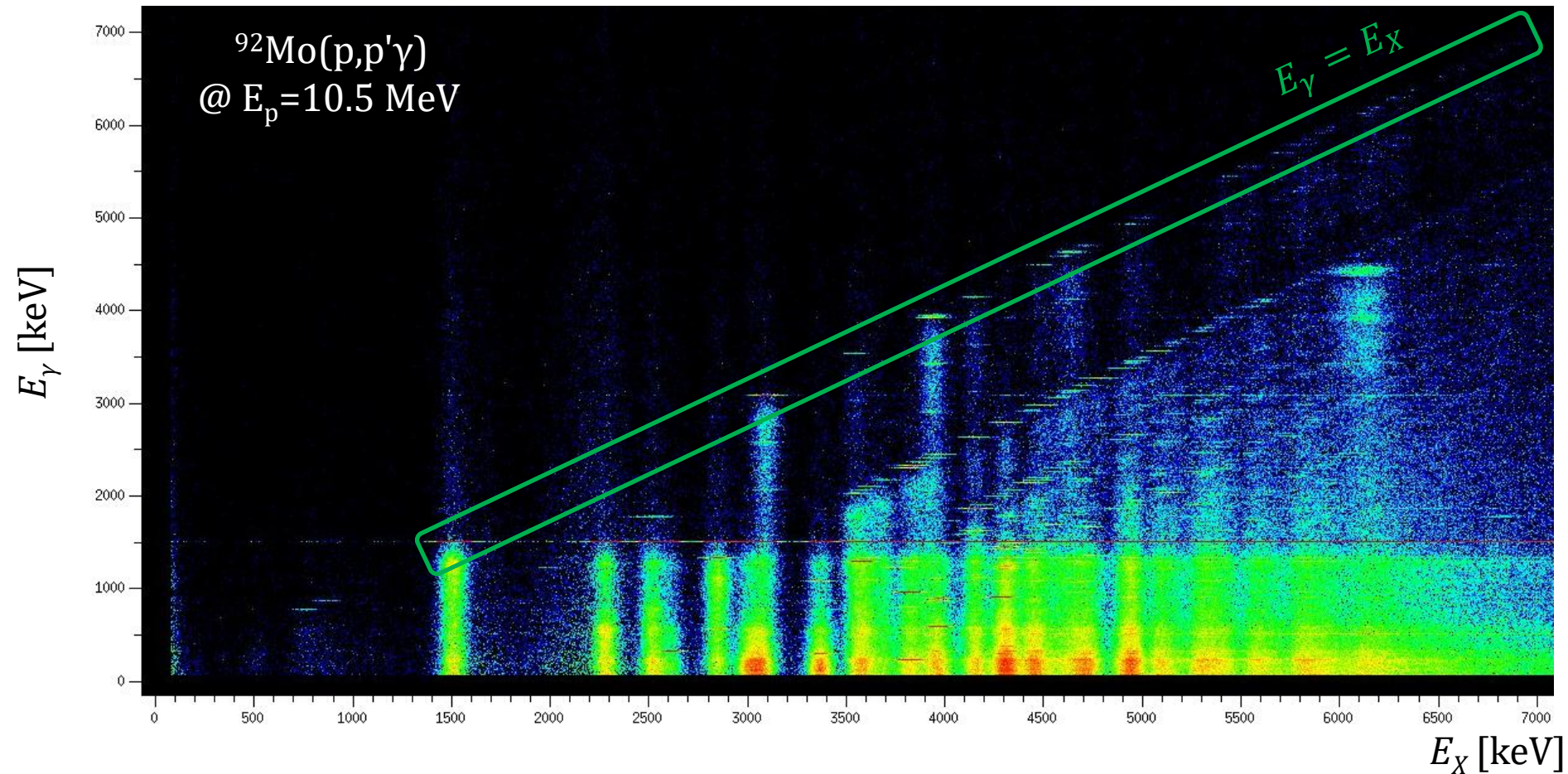
D. Savran, T. Aumann,  
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PPNP **70** (2013) 210

# Setup for p- $\gamma$ coincidence experiments

	SONIC	HORUS
Detectors	8 $\Delta E$ -E or single PIPS	14 HPGe
Angles	$\theta = 60^\circ, 90^\circ, 120^\circ, 130^\circ$	$\theta = 35^\circ, 45^\circ, 90^\circ, 135^\circ, 145^\circ$
Efficiency	4% solid angle coverage	$\sim 2\%$ @ 1.3 MeV
Resolution	typically 70 keV in-beam	$\sim 2$ keV @ 1.3 MeV

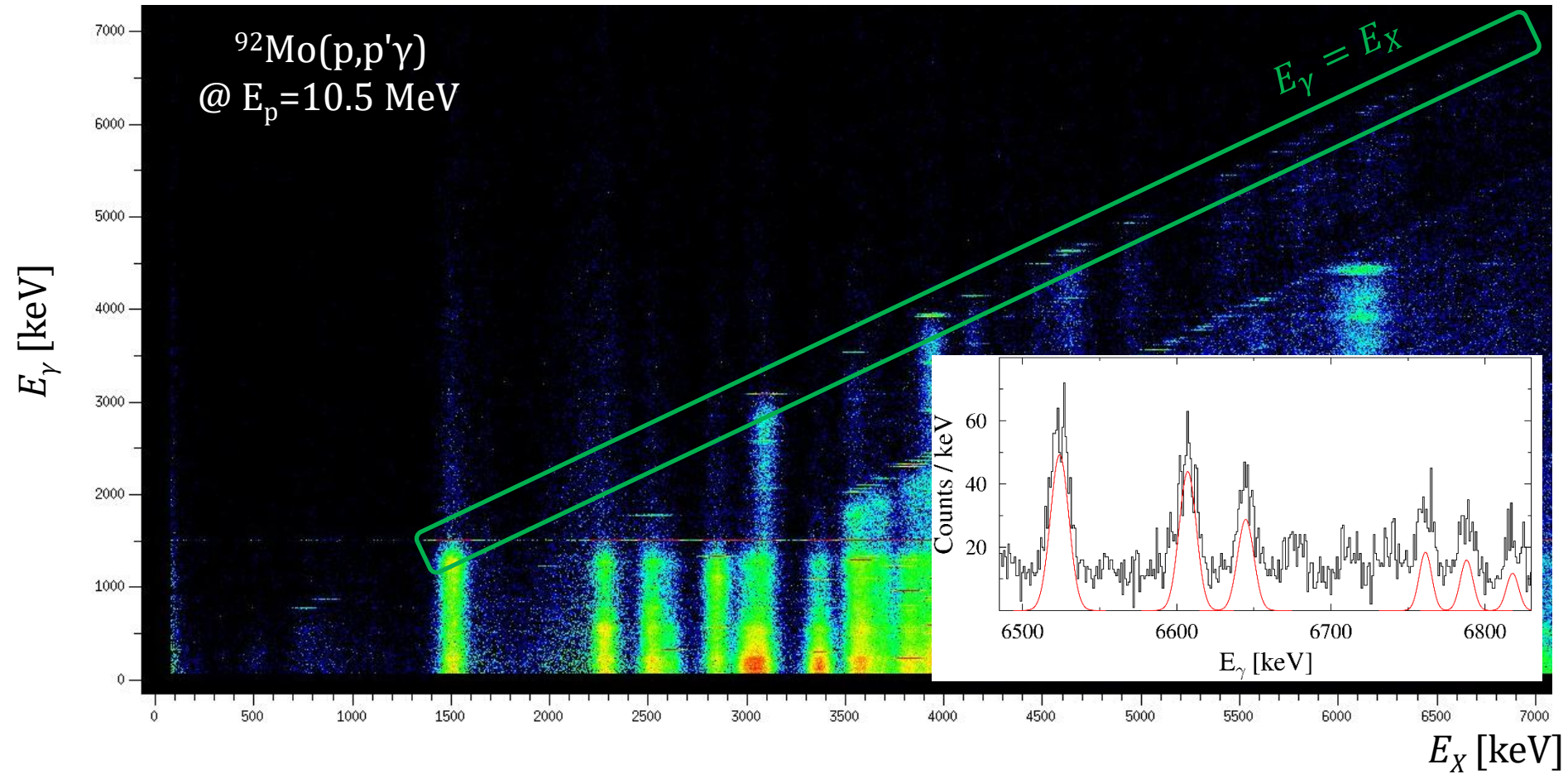


# p- $\gamma$ coincidence matrix of $^{92}\text{Mo}$



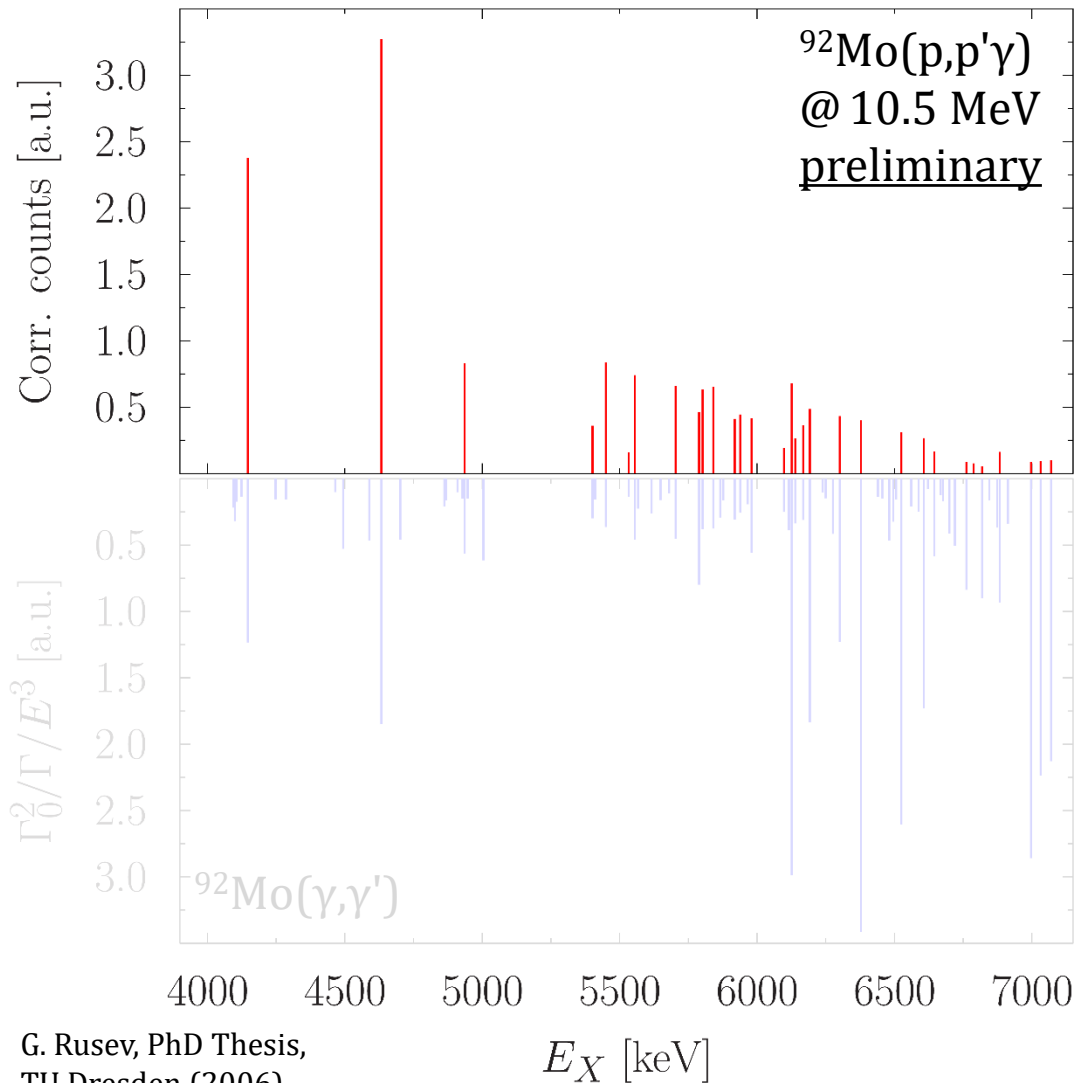
- Diagonal gates can be set to select decays to specific levels
  - Ground state decays

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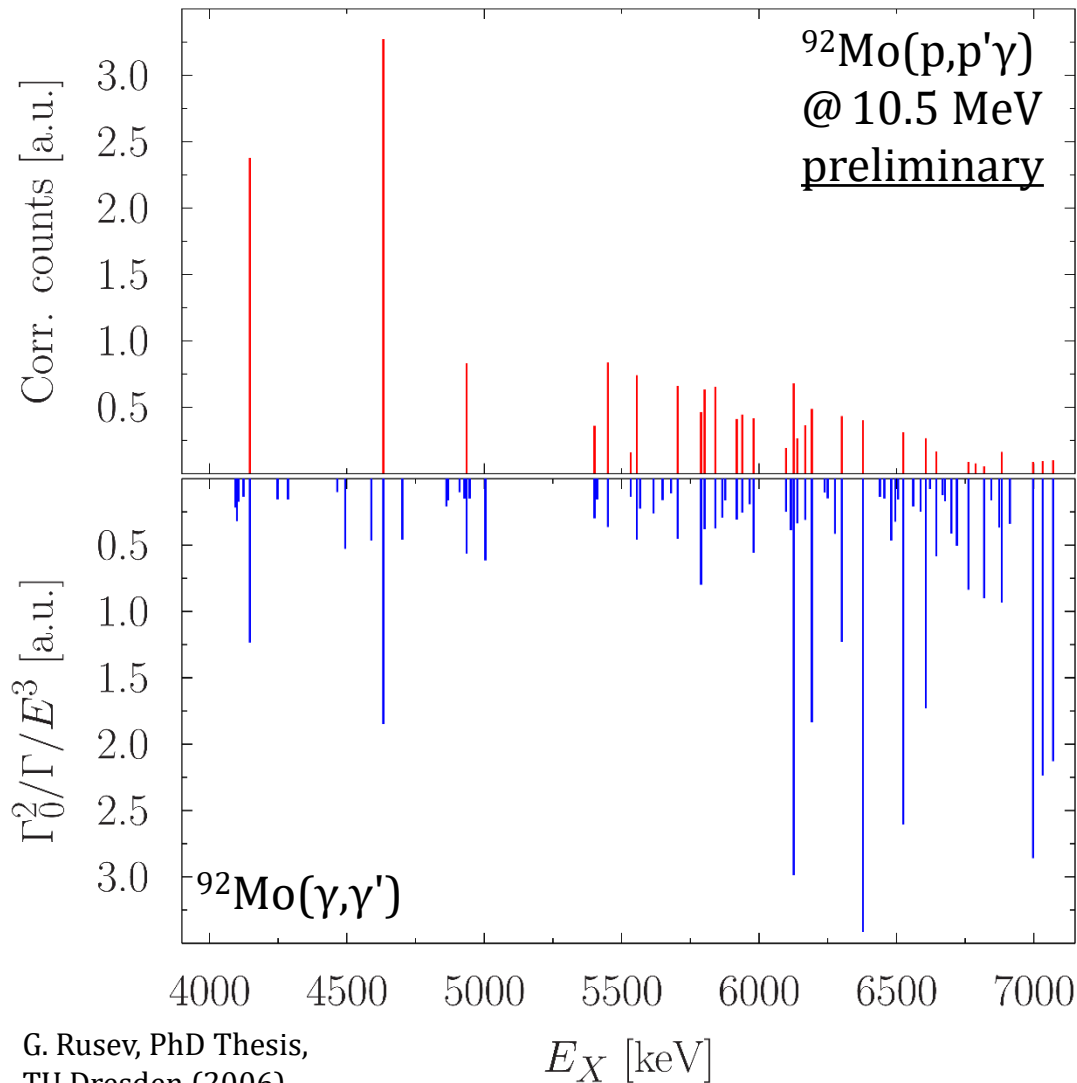
# Ground state decays – comparison to $(\gamma, \gamma')$



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

- Upper panel:  
experimental results  
from  $(p,p'\gamma)$ 
  - Counts corrected by  
preliminary efficiency
  - Isotropic distribution  
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- Lower panel:  
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  - $\propto B(E1)$  without  
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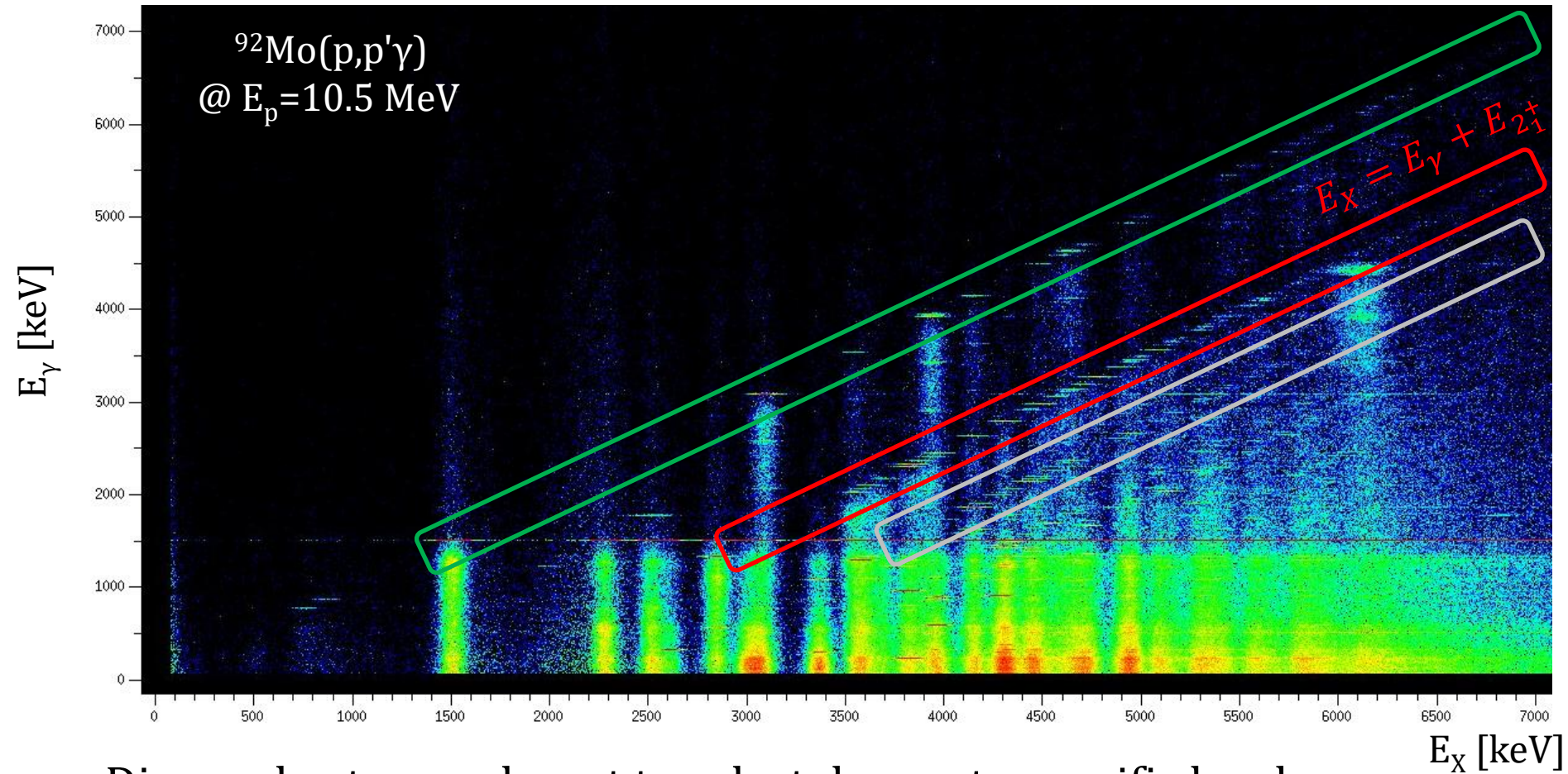


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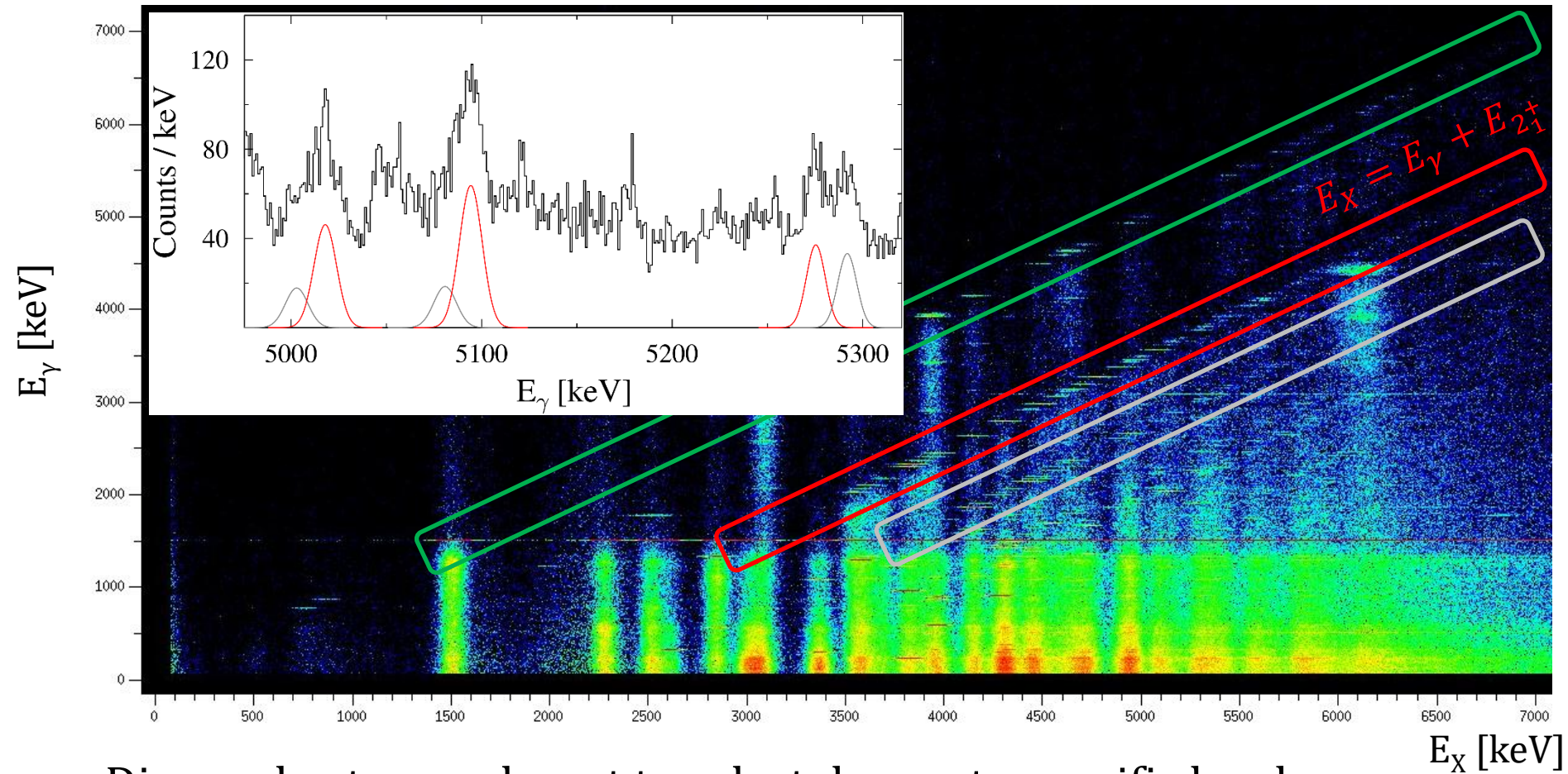


# p- $\gamma$ coincidence matrix of $^{92}\text{Mo}$



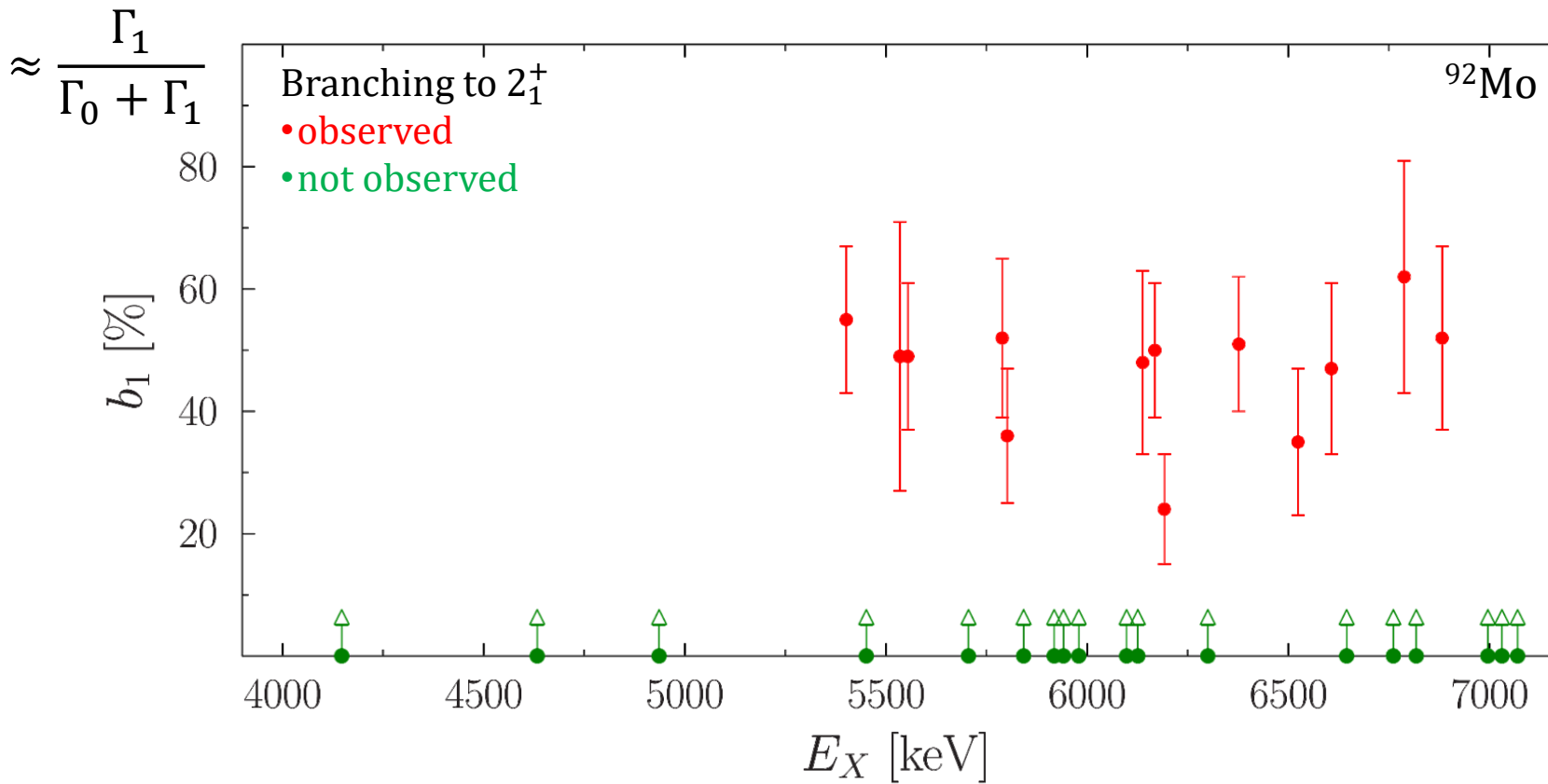
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  - Ground state decays
  - Decays to  $2_1^+$ , to  $4_1^+$ , ...

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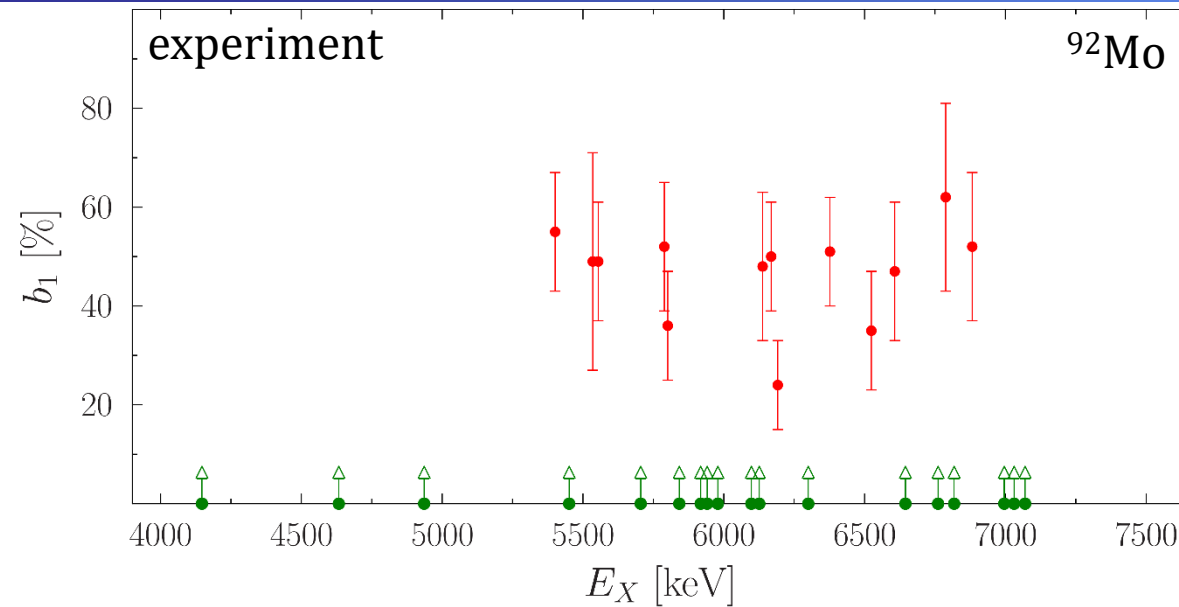
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# Decay branching ratio vs. energy

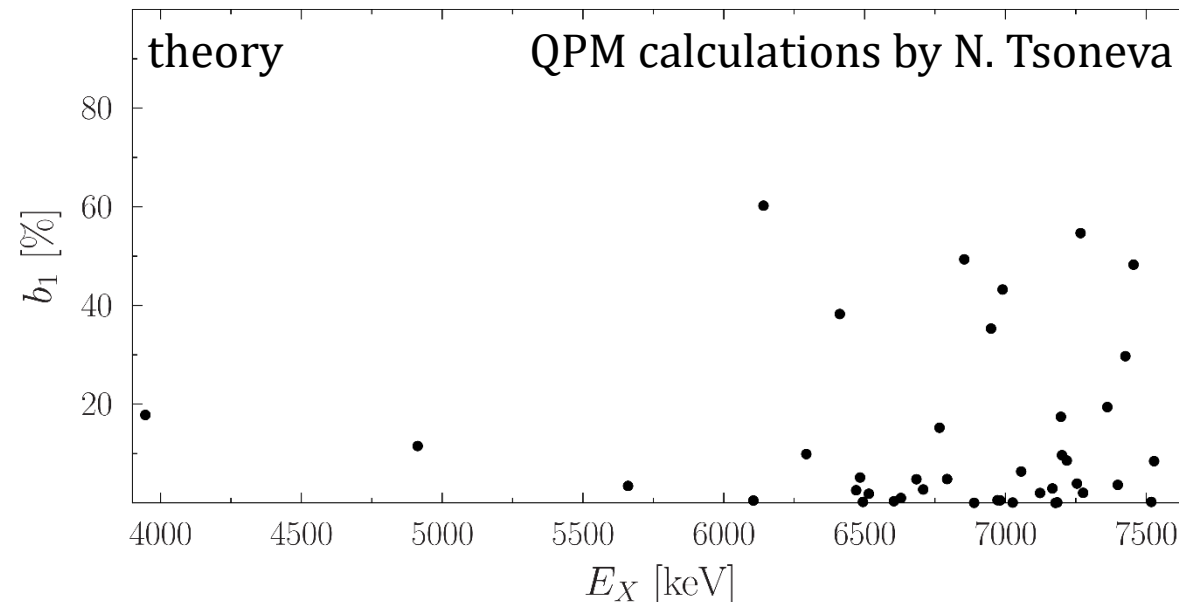


➤ No trend with energy

# Branching ratio: experiment vs. theory

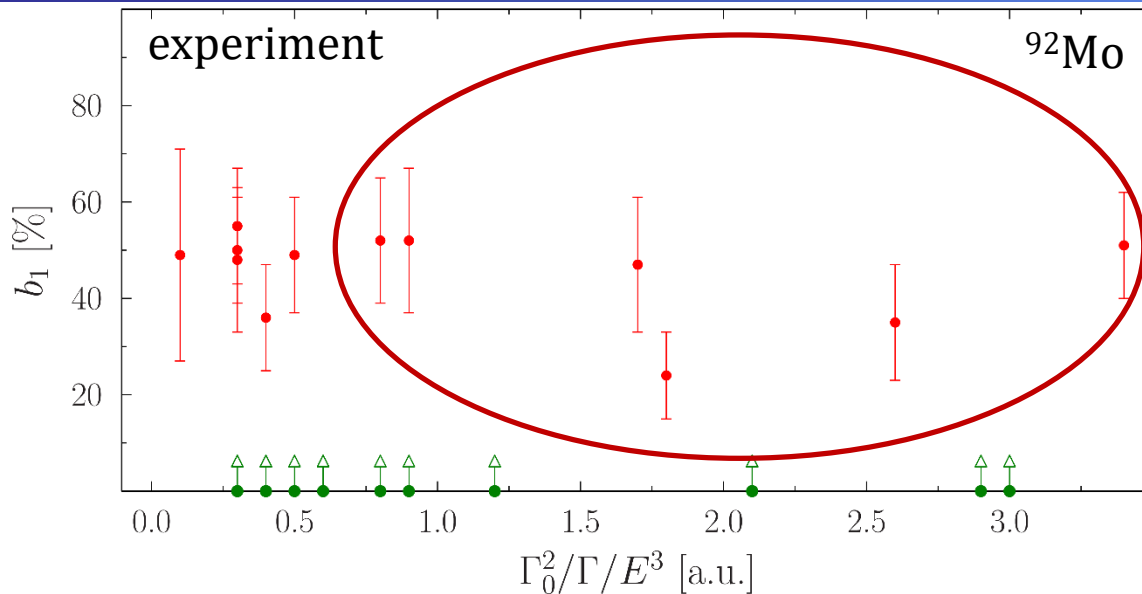


➤ Experiment and theory show similar picture

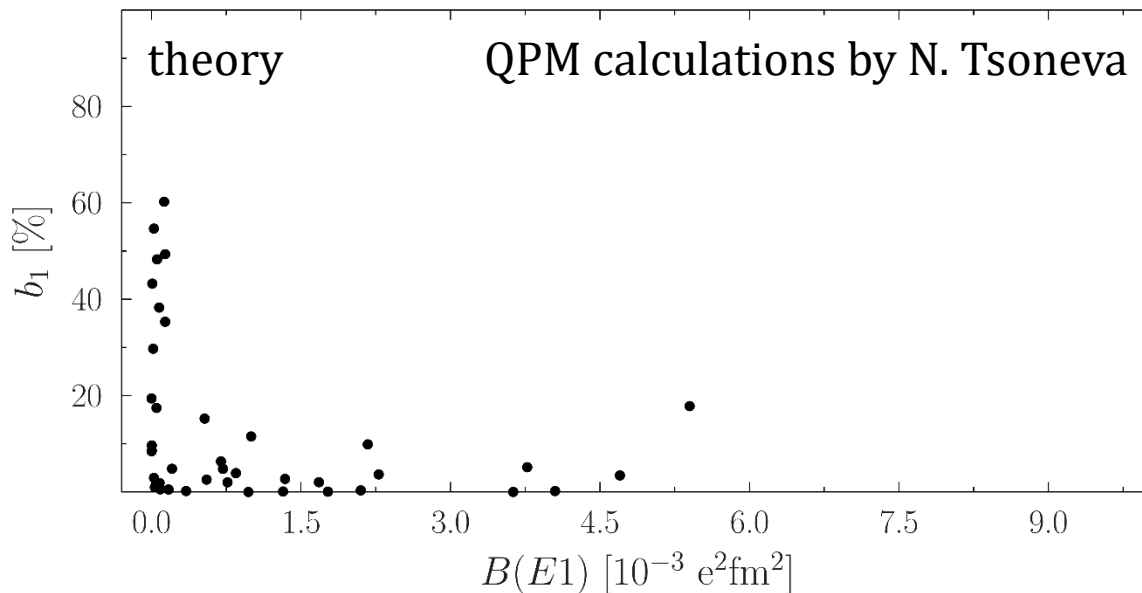


➤ Smaller error bars needed for higher significance

# Branching ratio: experiment vs. theory



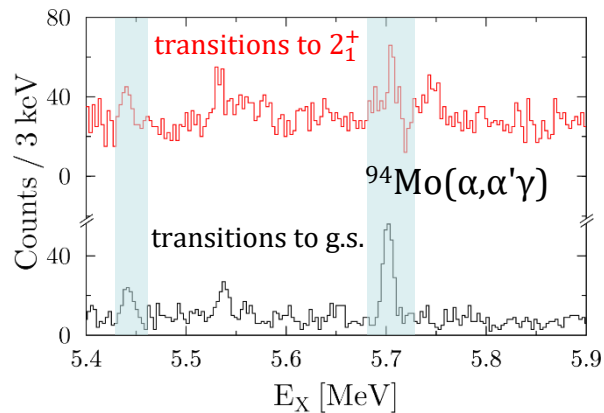
➤ No trend of branching ratio with strength observed



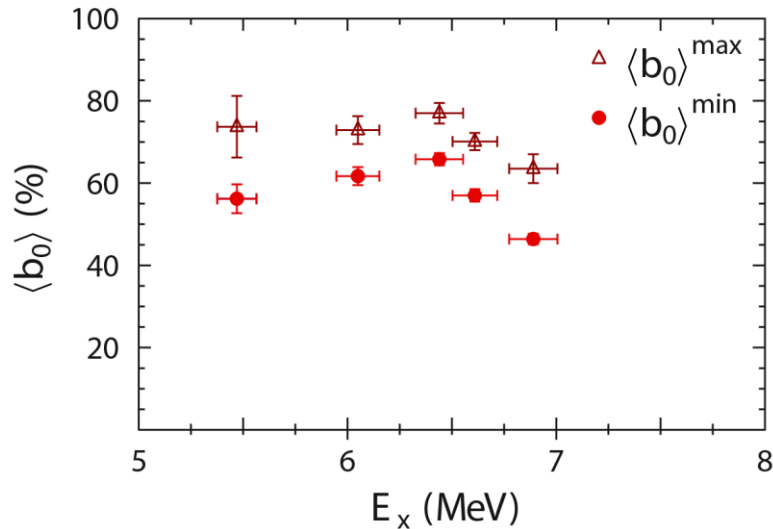
➤ Different theoretical prediction

➤ **Discrepancy for strong transitions**

# $^{94}\text{Mo}(p,p'\gamma)$ @ $E_p = 13.5$ MeV



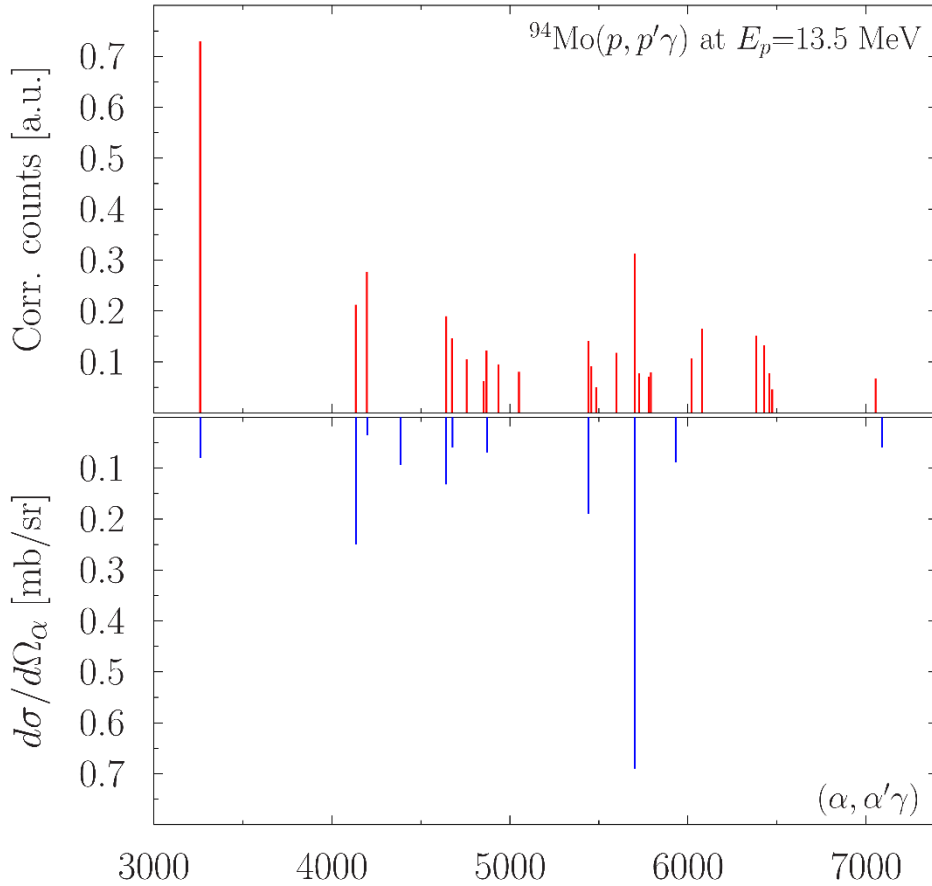
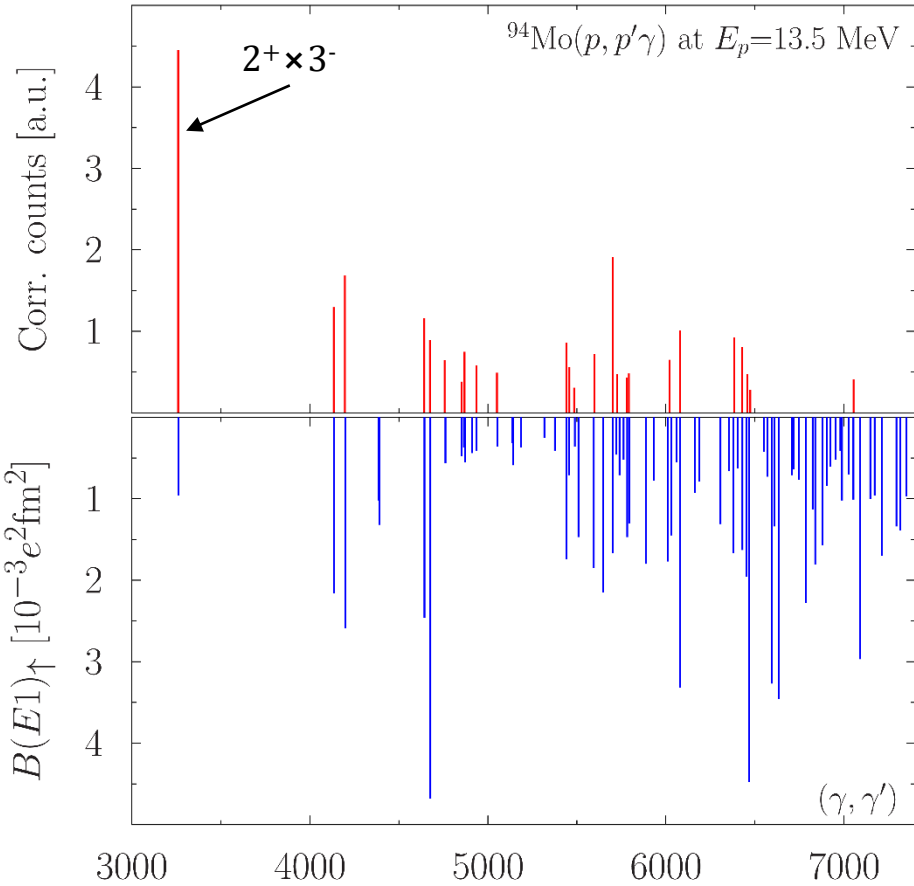
V. Derya *et al.*, NPA **906** (2013) 94



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  $(\alpha, \alpha'\gamma)$  and  $(\gamma, \gamma')$
  - With our setup:
    - More states (if similar to  $^{92}\text{Mo}$ )
    - Individual branching
  - Higher beam energy to excite states at higher energies

# Excitation pattern vs. $(\gamma, \gamma')$ and $(\alpha, \alpha'\gamma)$

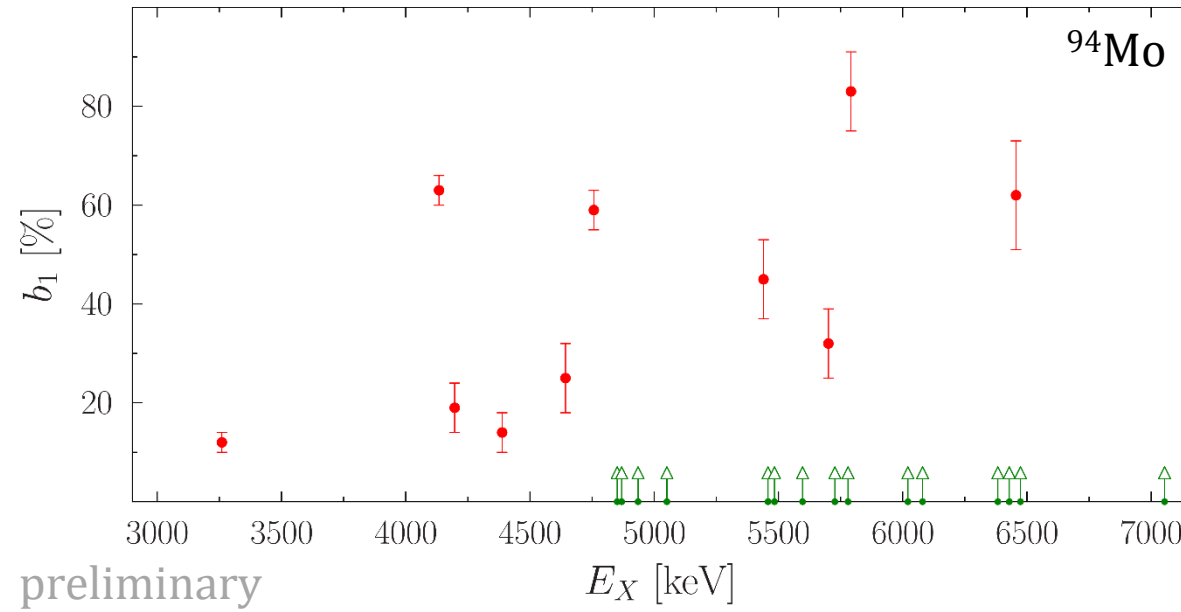


C. Romig *et al.*,  
 PRC **88** (2013) 044331

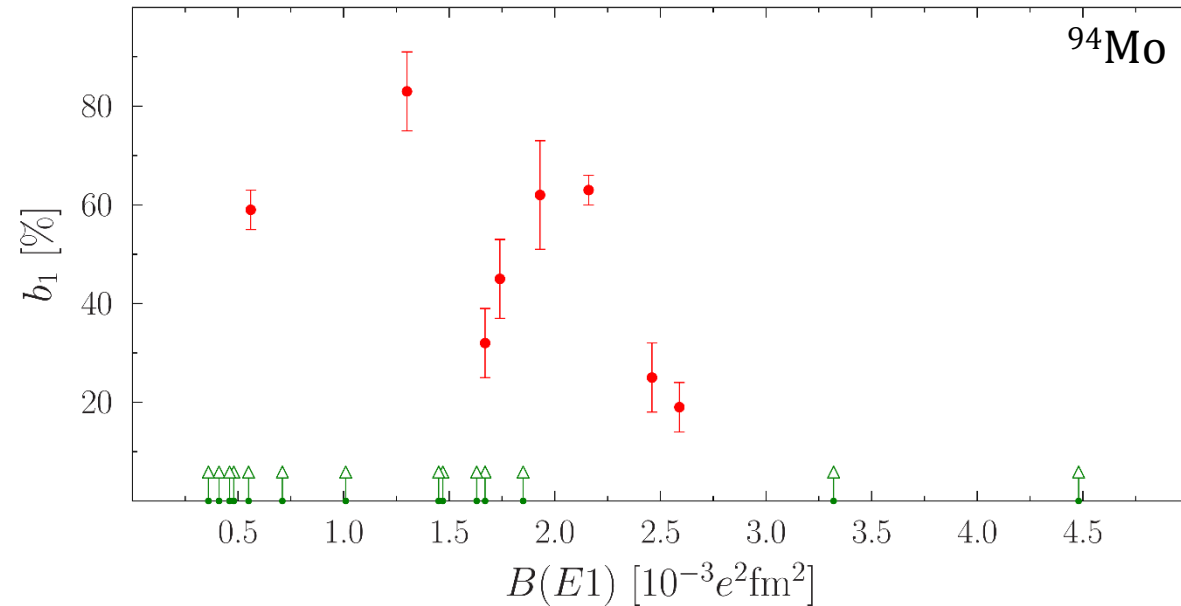
V. Derya *et al.*,  
 NPA **906** (2013) 94

- Observed less states than in  $(\gamma, \gamma')$ , but more states than in  $(\alpha, \alpha'\gamma)$

# Decay branching ratios for $^{94}\text{Mo}$



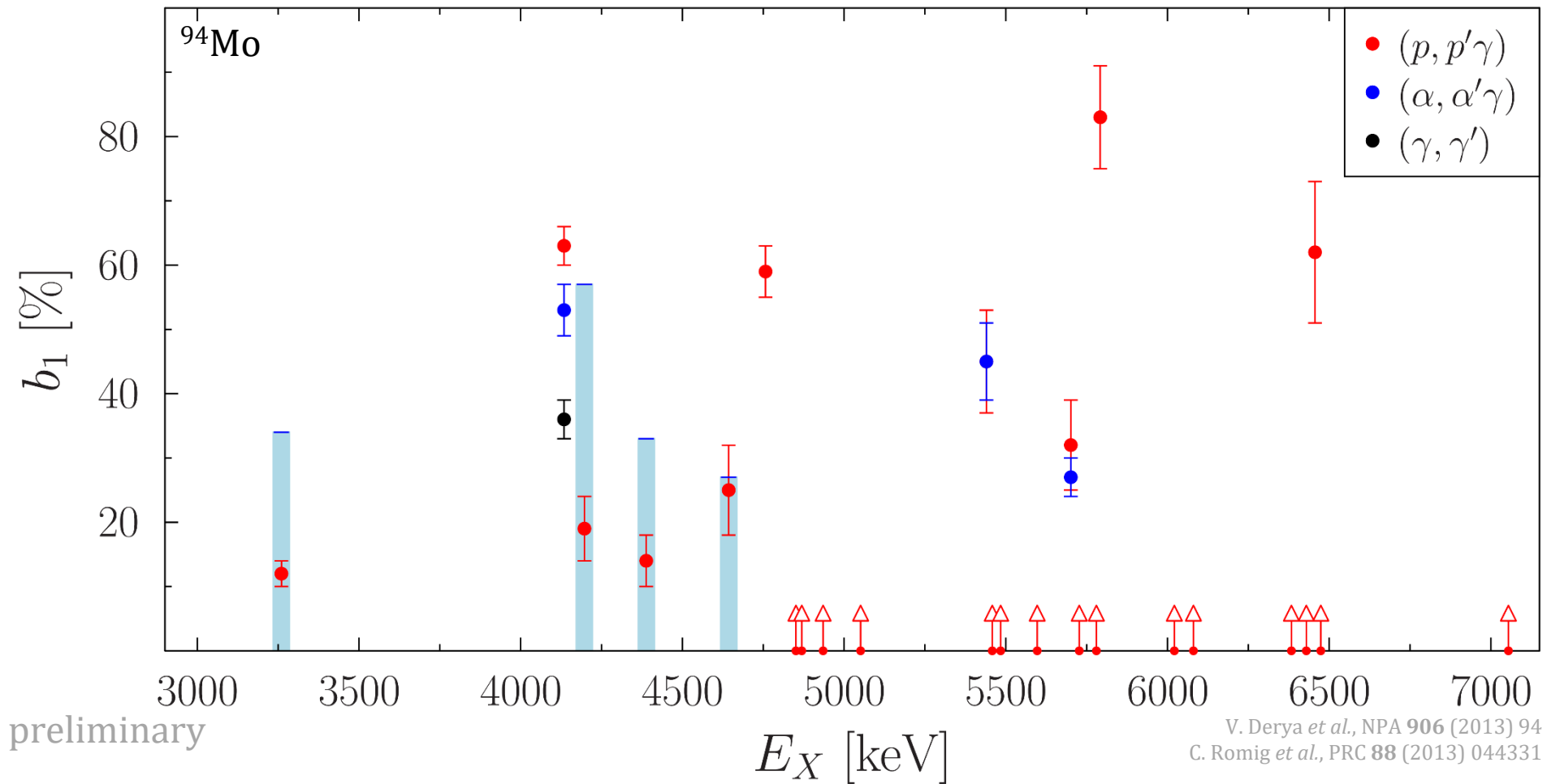
- Only statistical errors are shown
- No clear trend, again state to state difference



- Needs to be compared to theoretical predictions

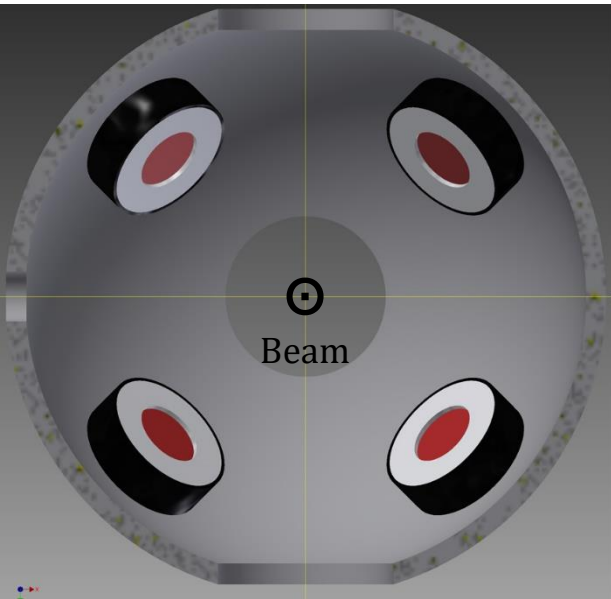


# Validation of setup and method

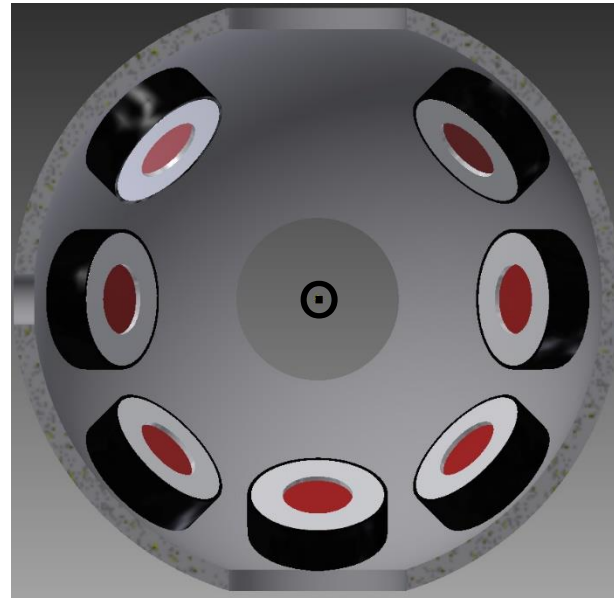


- Very good agreement with  $b_1$  values and upper limits from  $^{94}\text{Mo}(\alpha, \alpha'\gamma)$  performed at KVI with  $E_\alpha = 136$  MeV

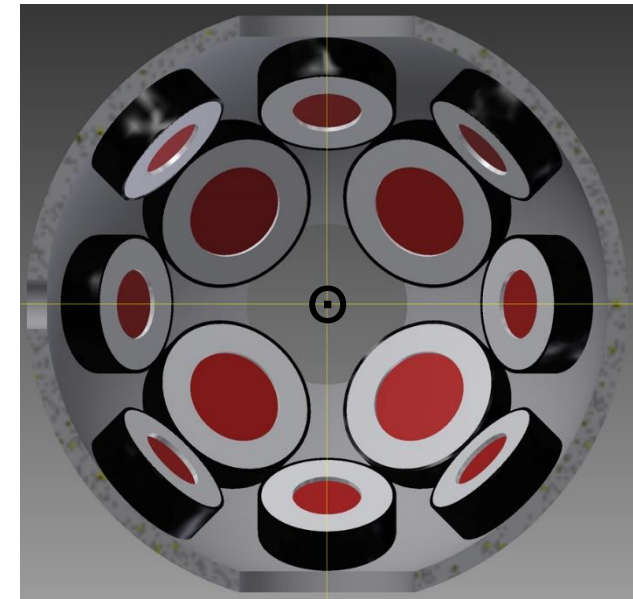
# Improvement of setup – solid angle coverage



Old



Current



New

- 2.2% for E
- 1.6% for  $\Delta E-E$

- 3.9% for E
- Up to 2.8% for  $\Delta E-E$

- 8.9% for E
- 7.8% for  $\Delta E-E$

# Summary & Outlook

- ❑ **Many decays of PDR states to several final states** observed in  $^{92}\text{Mo}$  and  $^{94}\text{Mo}$ 
  - $2_1^+, 0_2^+, 2_2^+$
- ❑ Preliminary branching ratios for PDR states could be determined for both nuclei
  - Thorough analysis ongoing
- ❑ Setup and method was validated by comparison to  $^{94}\text{Mo}(\alpha, \alpha'\gamma)$  experiment at KVI
  - Comparison to mean branching ratios
- ❑ Theoretical calculations needed for both cases!
- ❑ Future experiments for PDR
  - Inelastic scattering
  - Transfer reactionswith  $p, d, \alpha$  beams  $\leq 30$  MeV

