Lifetime measurements via a new coincidence Doppler-shift attenuation approach in Cologne

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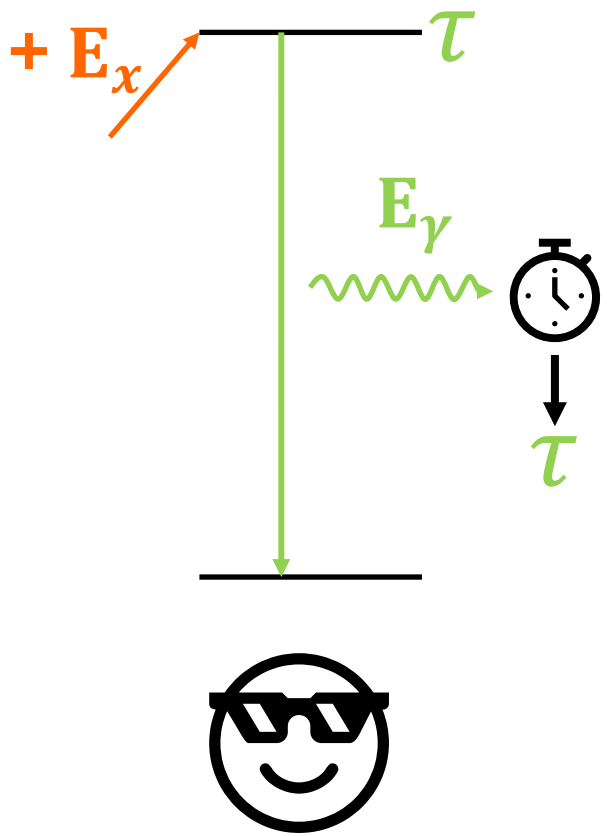
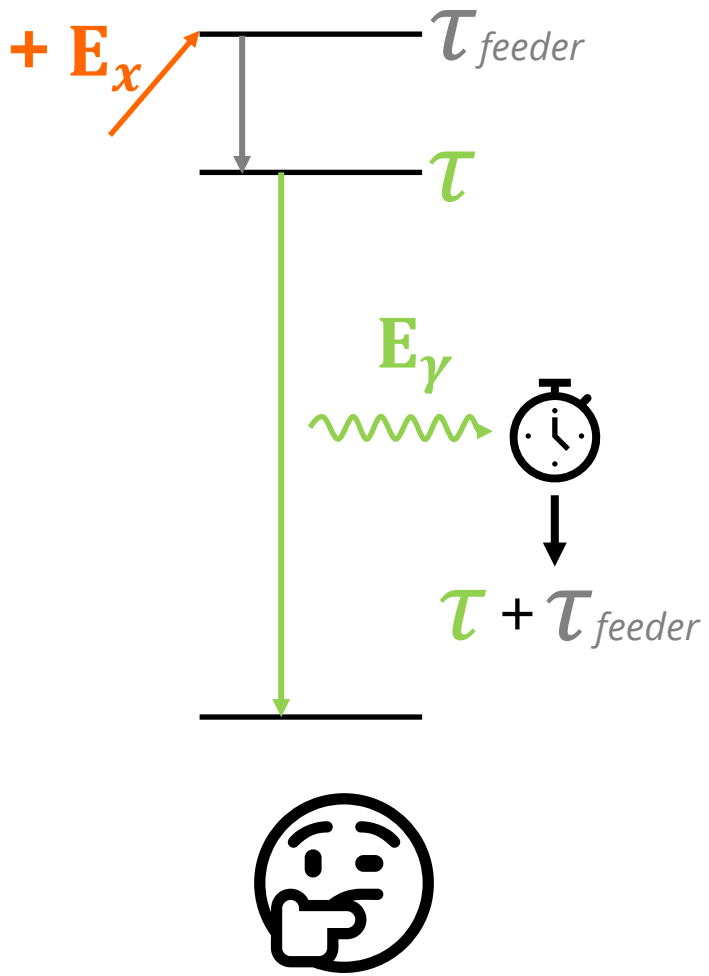
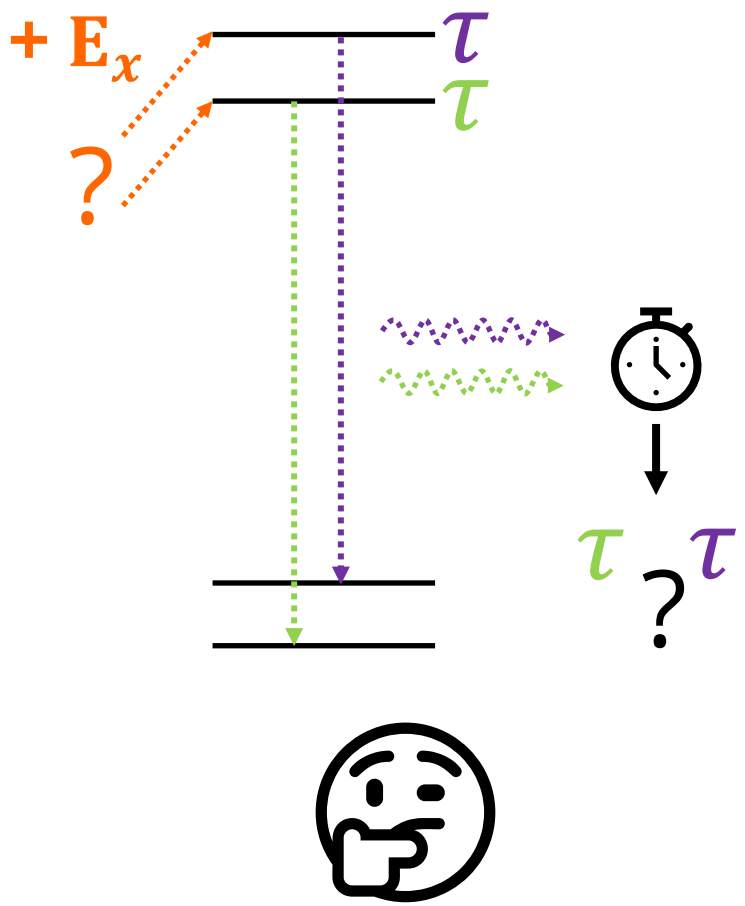
Lifetime measurements

Measurement of lifetime τ

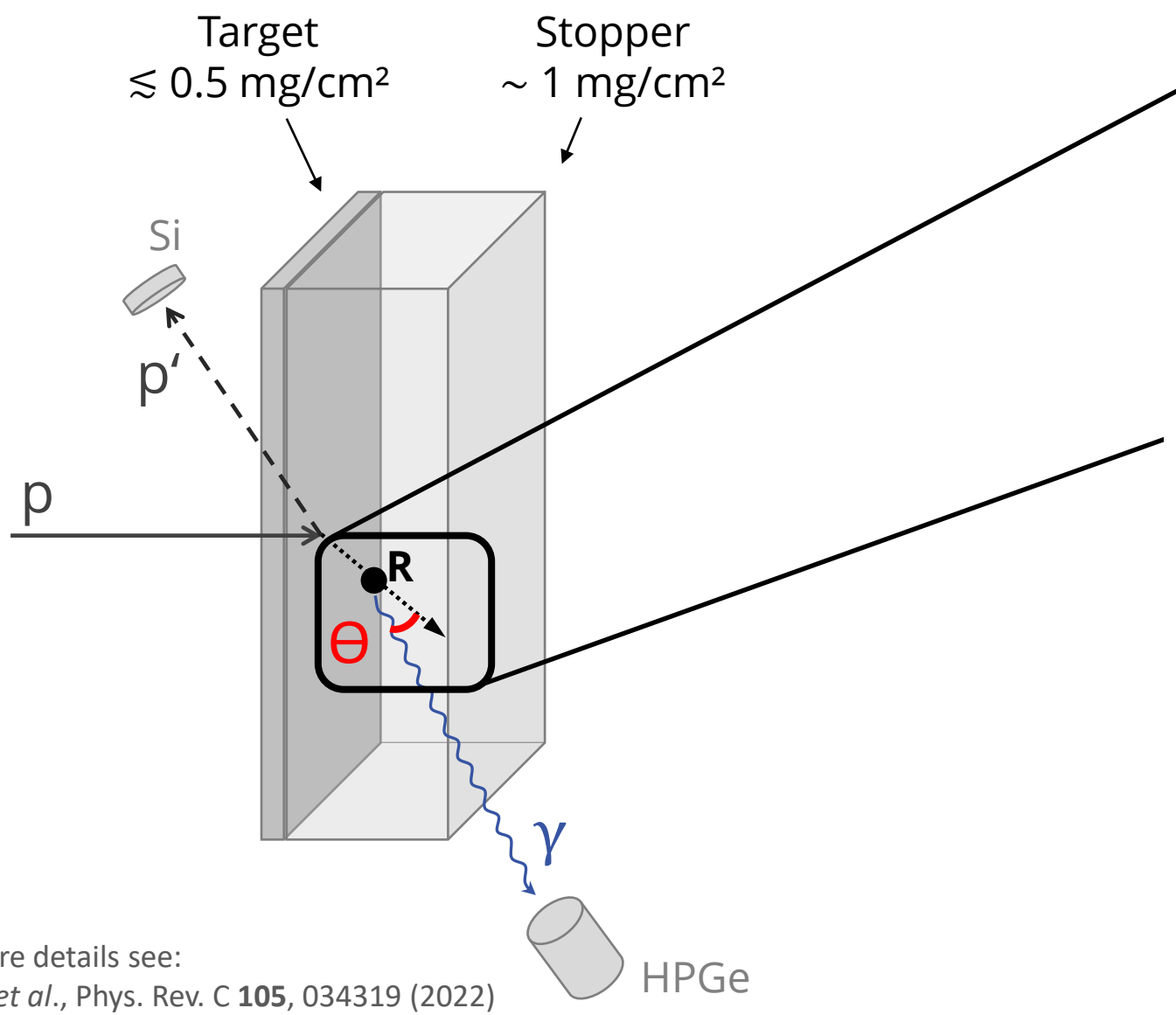


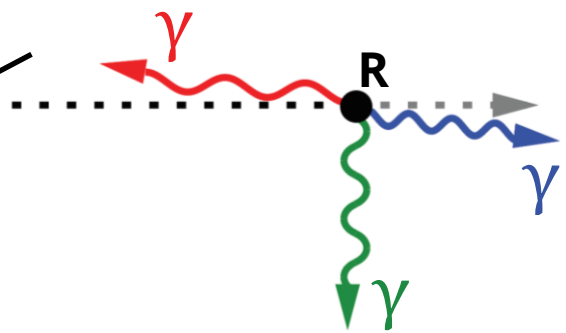
Typical challenges

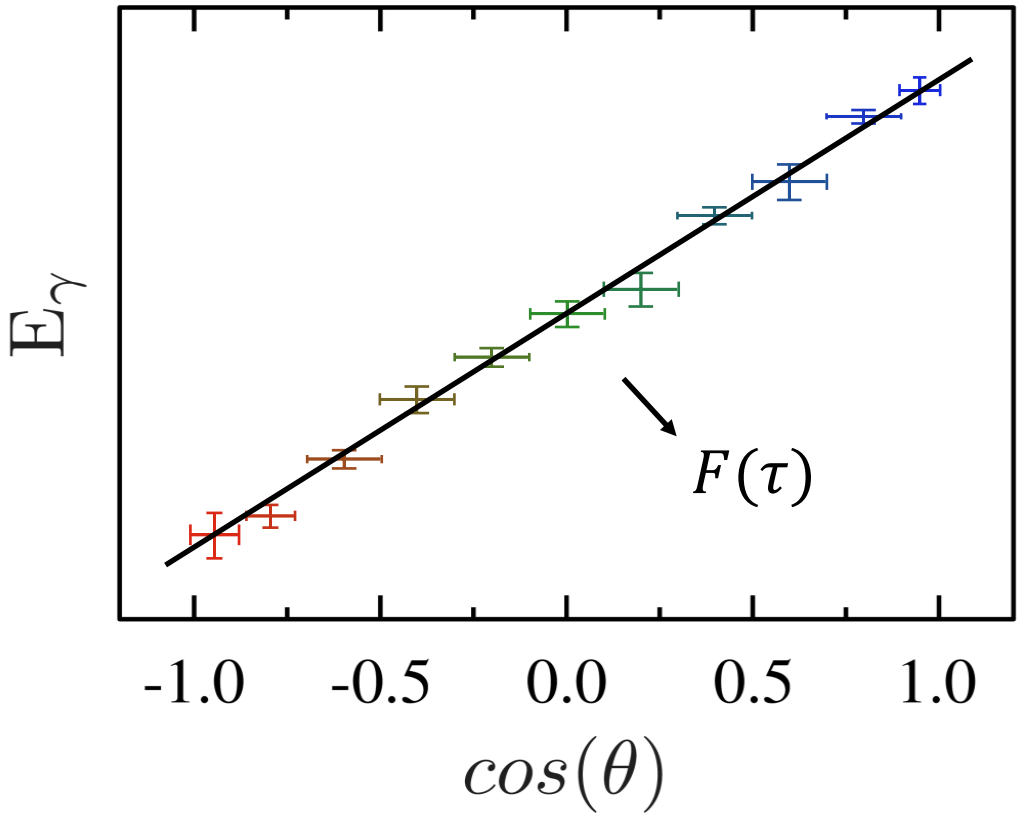




The Coincidence Doppler-shift attenuation method (CDSAM)





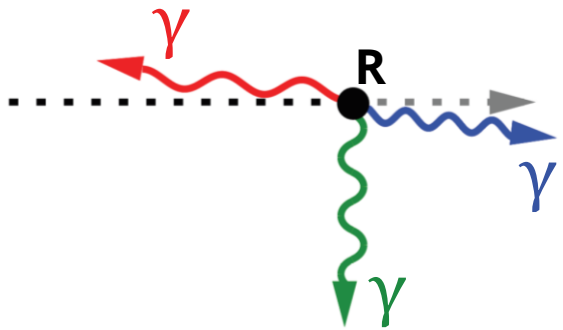


For more details see:
S. Prill *et al.*, Phys. Rev. C **105**, 034319 (2022)
A. Hennig *et al.*, NIM A **794**, 171 (2015)

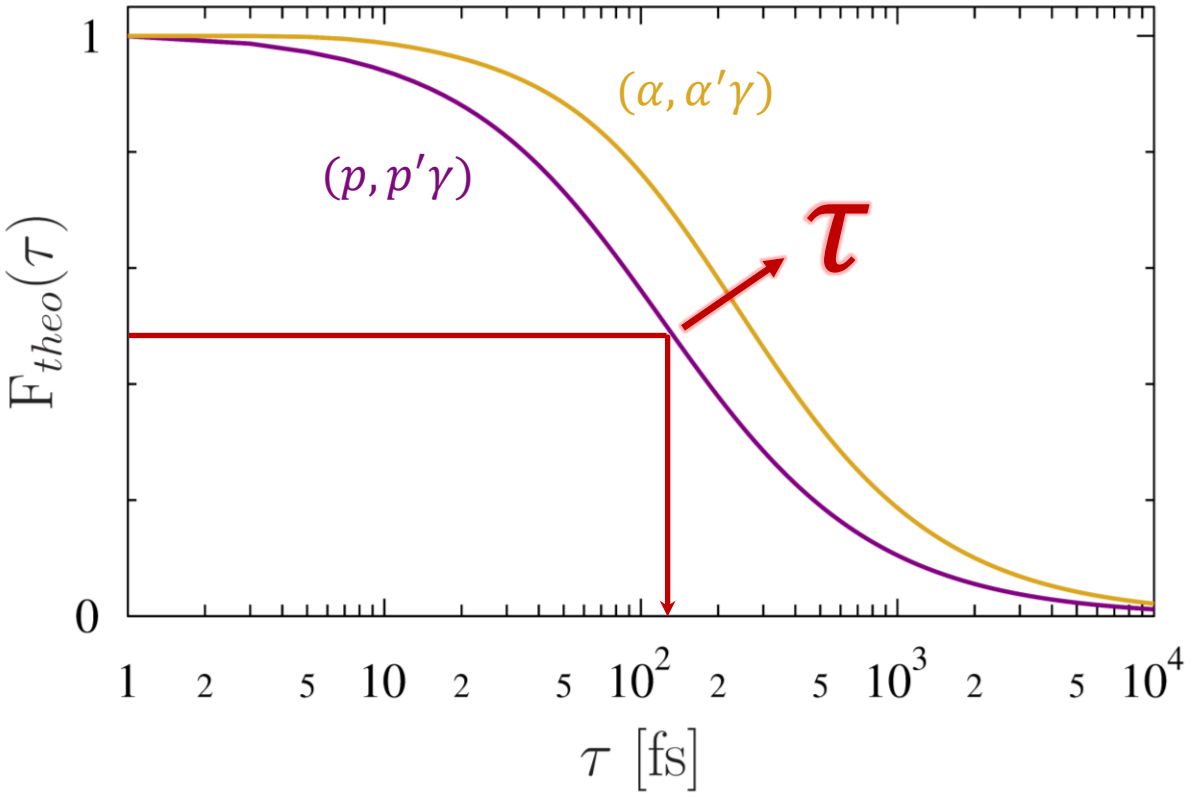
The Coincidence Doppler-shift attenuation method (CDSAM)

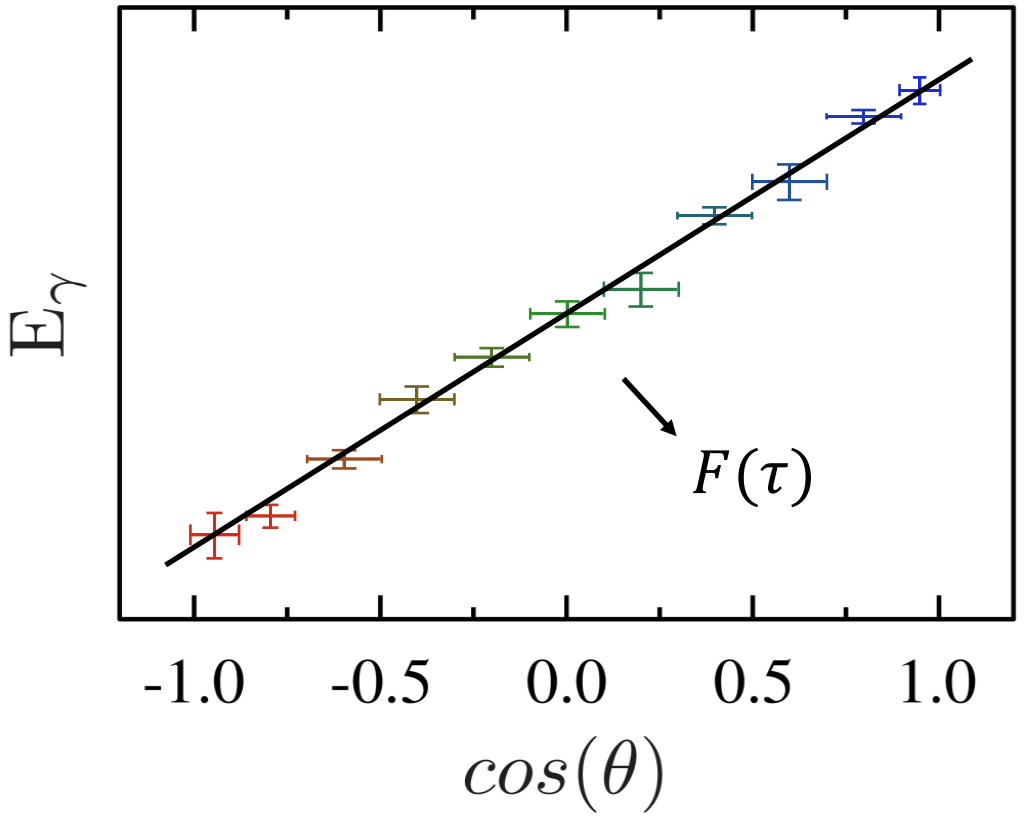
Attenuation factor: $F(\tau) = \frac{\langle v_R(t=\tau)\rangle}{v_R(t=0)}$

$$E_\gamma(cos(\theta)) = E_\gamma^0\left(1+\mathrm{F}(\tau)\frac{v_R(t=0)}{c}cos(\theta)\right)$$



Simulation of recoil stopping process



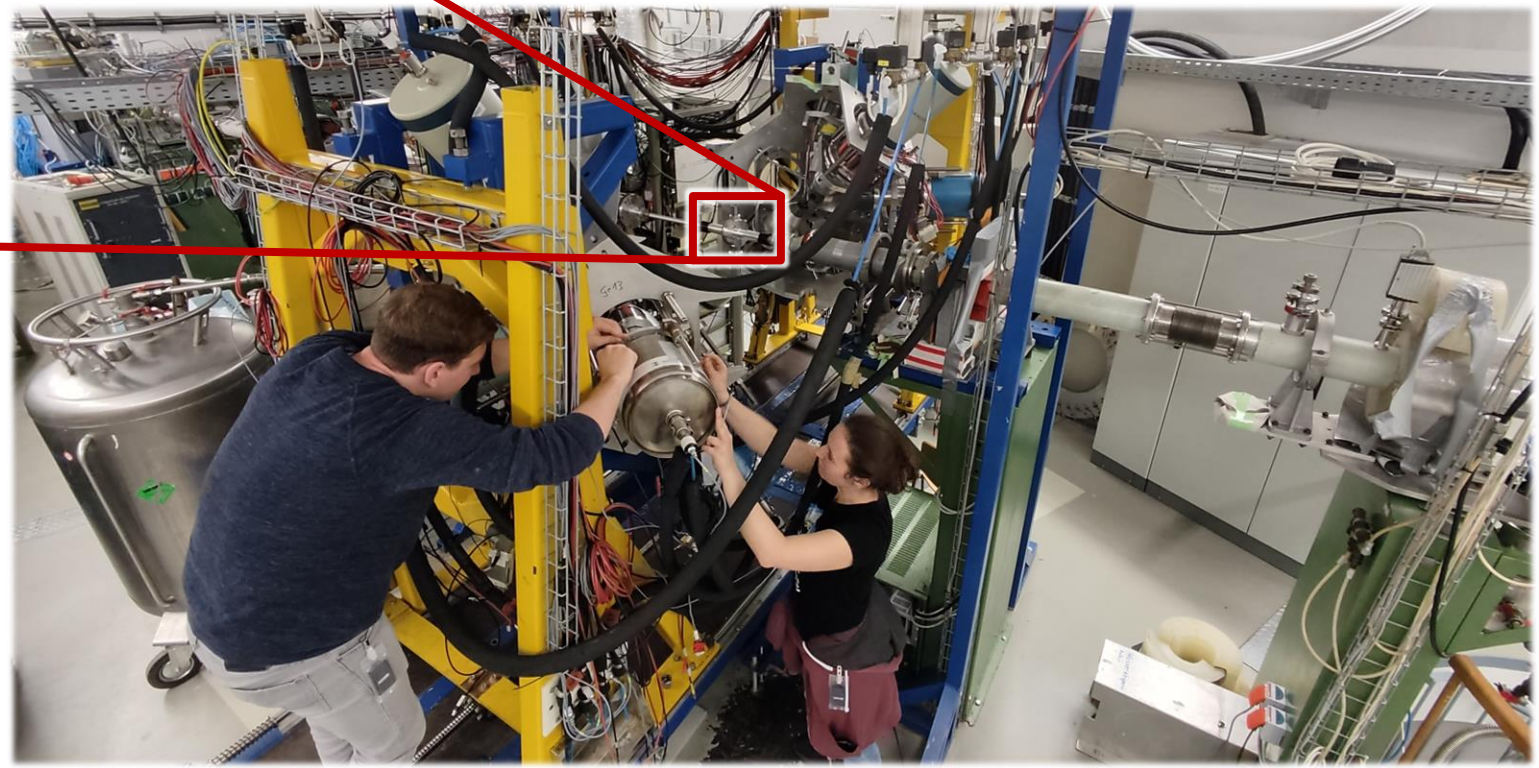


Experimental setup

SONIC@HORUS

SONIC: 12 (telescope) silicon particle detectors

HORUS: 14 HPGe γ-ray detectors, 6 equipped with BGO shields



S. G. Pickstone *et al.*, NIM A **875**, 104 (2017)

Experimental setup

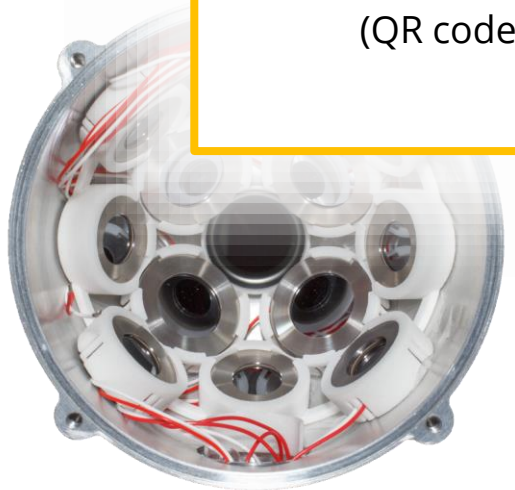
SONIC@HORUS

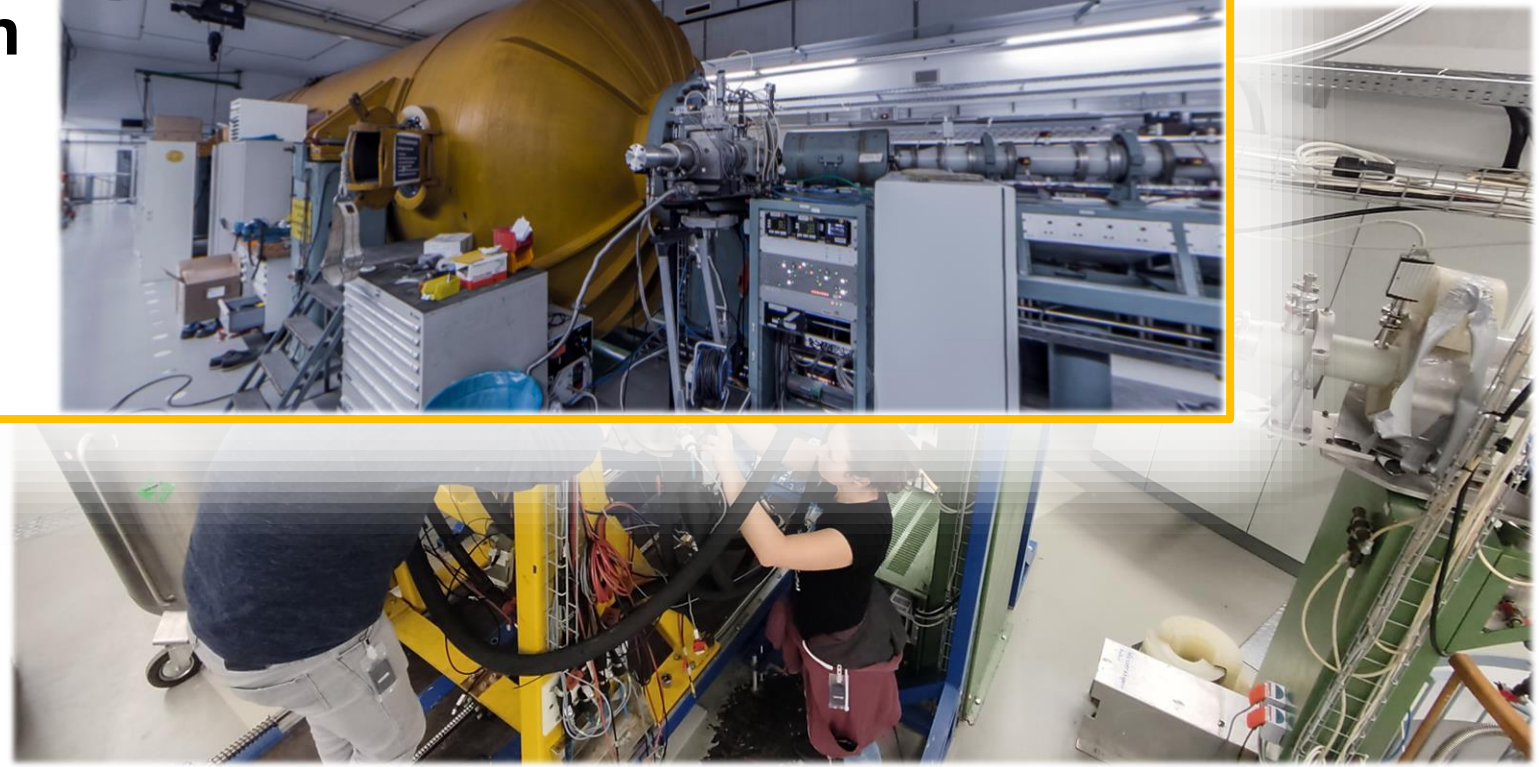
SONIC: 12 (telescope) silicon particle detectors

HORUS: 14 HPGe γ-ray detectors, [illegible] ds

10 MV FN tandem accelerator

see virtual tour
(QR code later on)





S. G. Pickstone *et al.*, NIM A **875**, 104 (2017)

Advantages of CDSAM

Particle detection

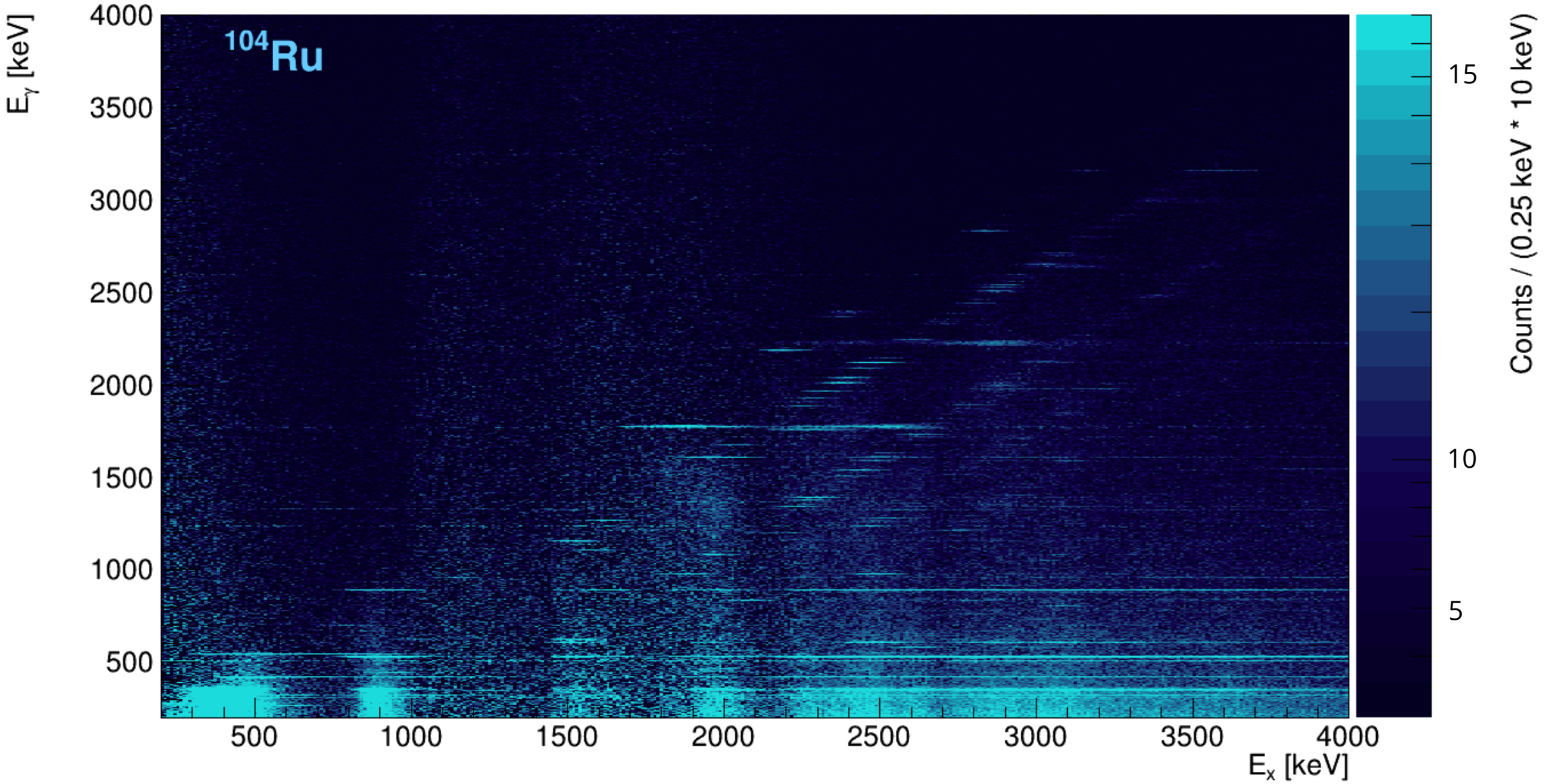
- reaction kinematics known
- excitation energy E_x known
- coincidence condition

  - precise transition selection
  - feeding contributions excluded
  - several lifetimes in single experiment
  - spectroscopy via $p\gamma\gamma$-coincidences

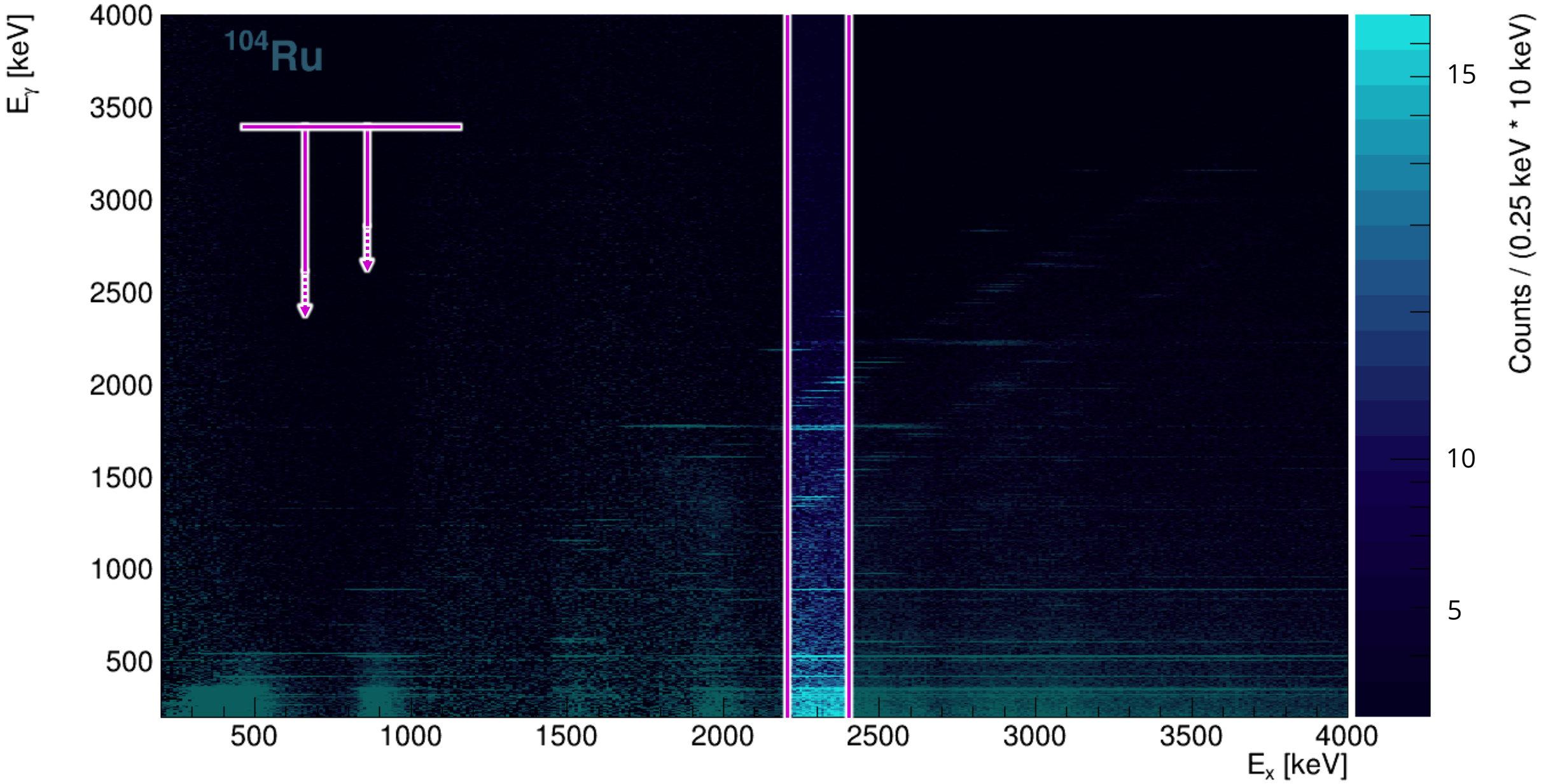
Thin targets

- ~ mg amounts of target material needed
- isotopes with low natural abundance accessible

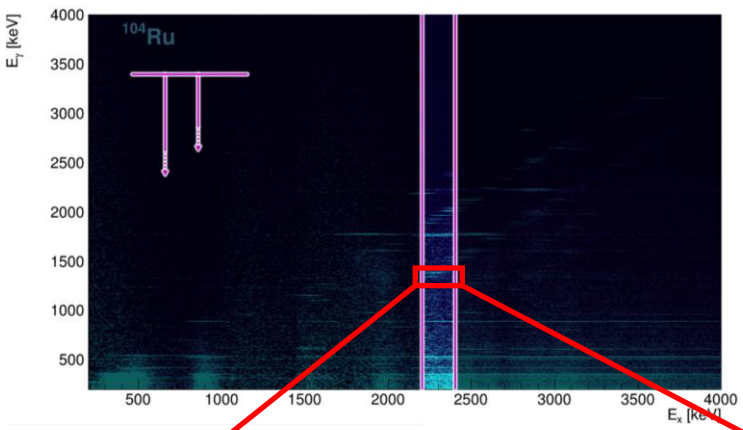
Data sorting



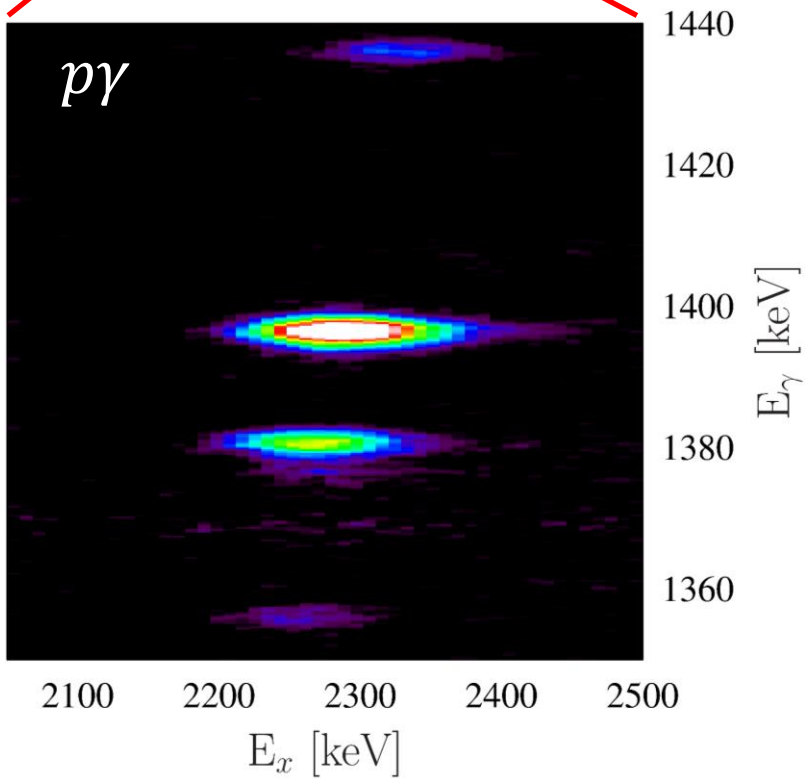
Data sorting

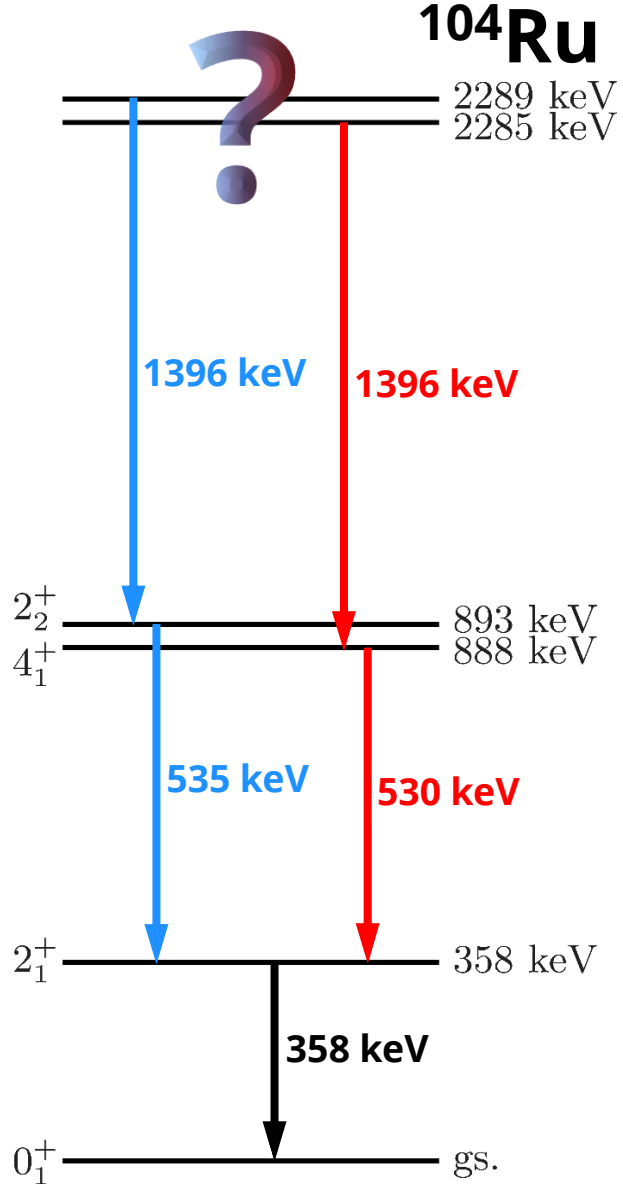


Spectroscopy

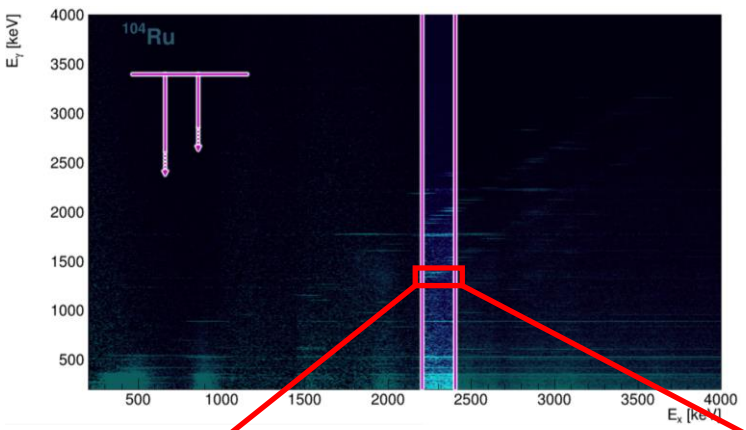


- E_x selection via particle energy

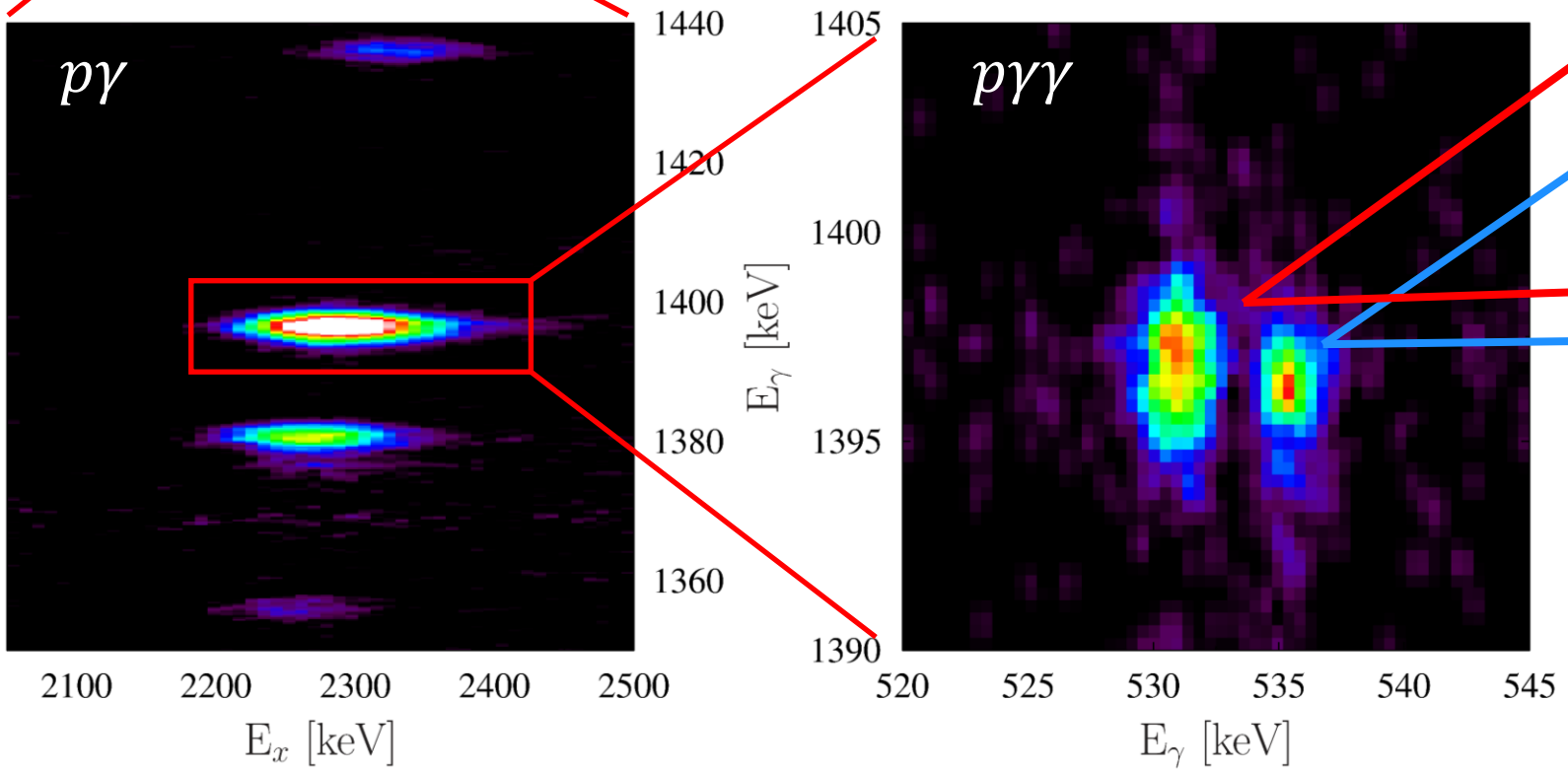


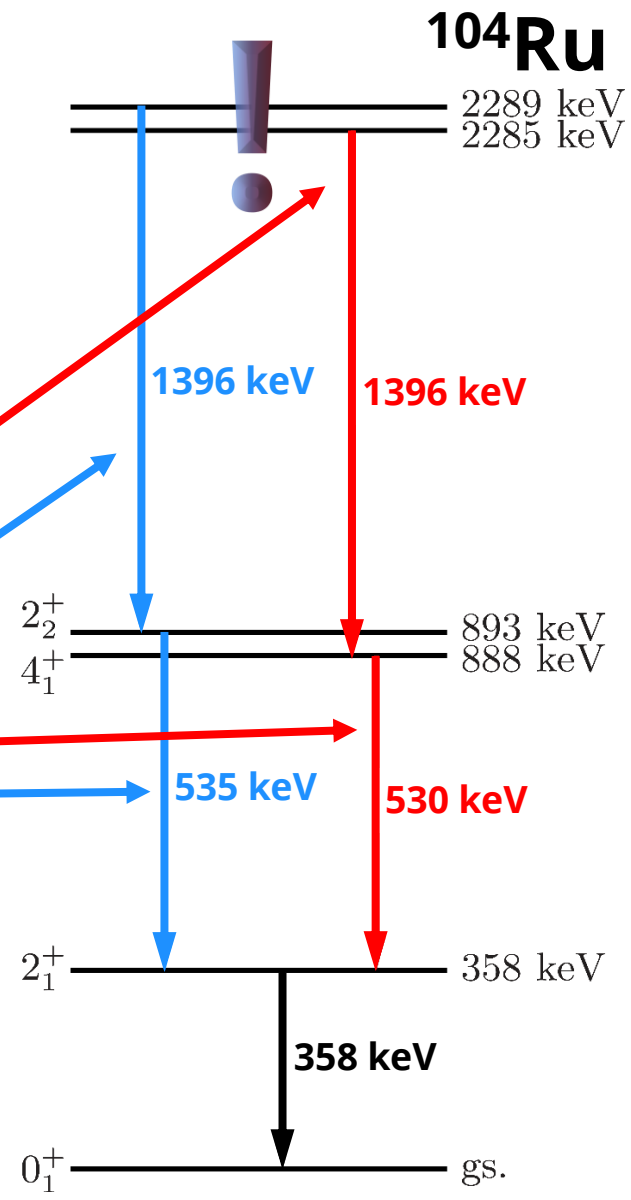


Spectroscopy

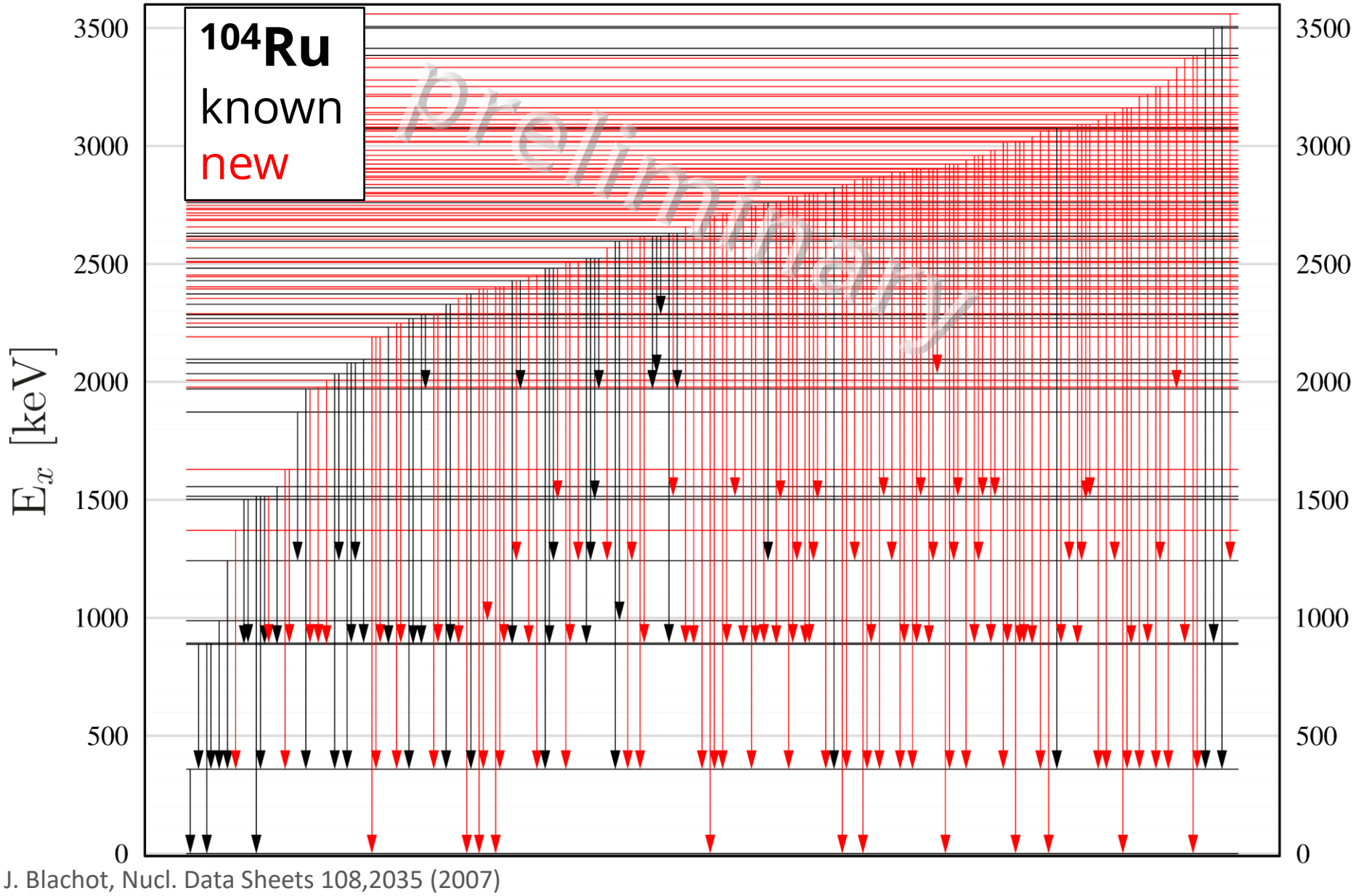


- E_x selection via particle energy
- Decay cascade identification via γ-γ coincidences





Extension of ^{104}Ru-level scheme



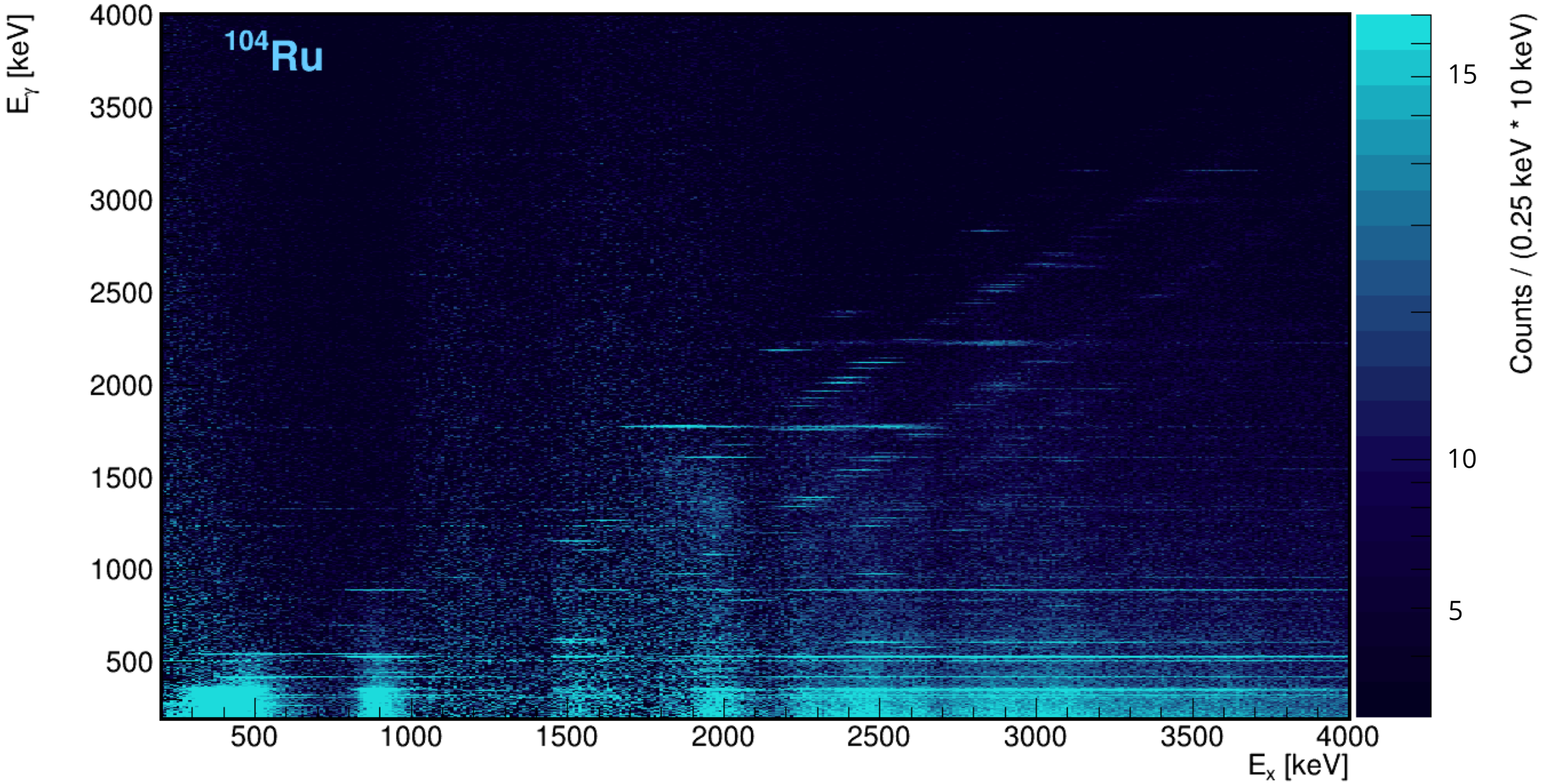
J. Blachot, Nucl. Data Sheets 108,2035 (2007)

Observed transitions that have been previously known

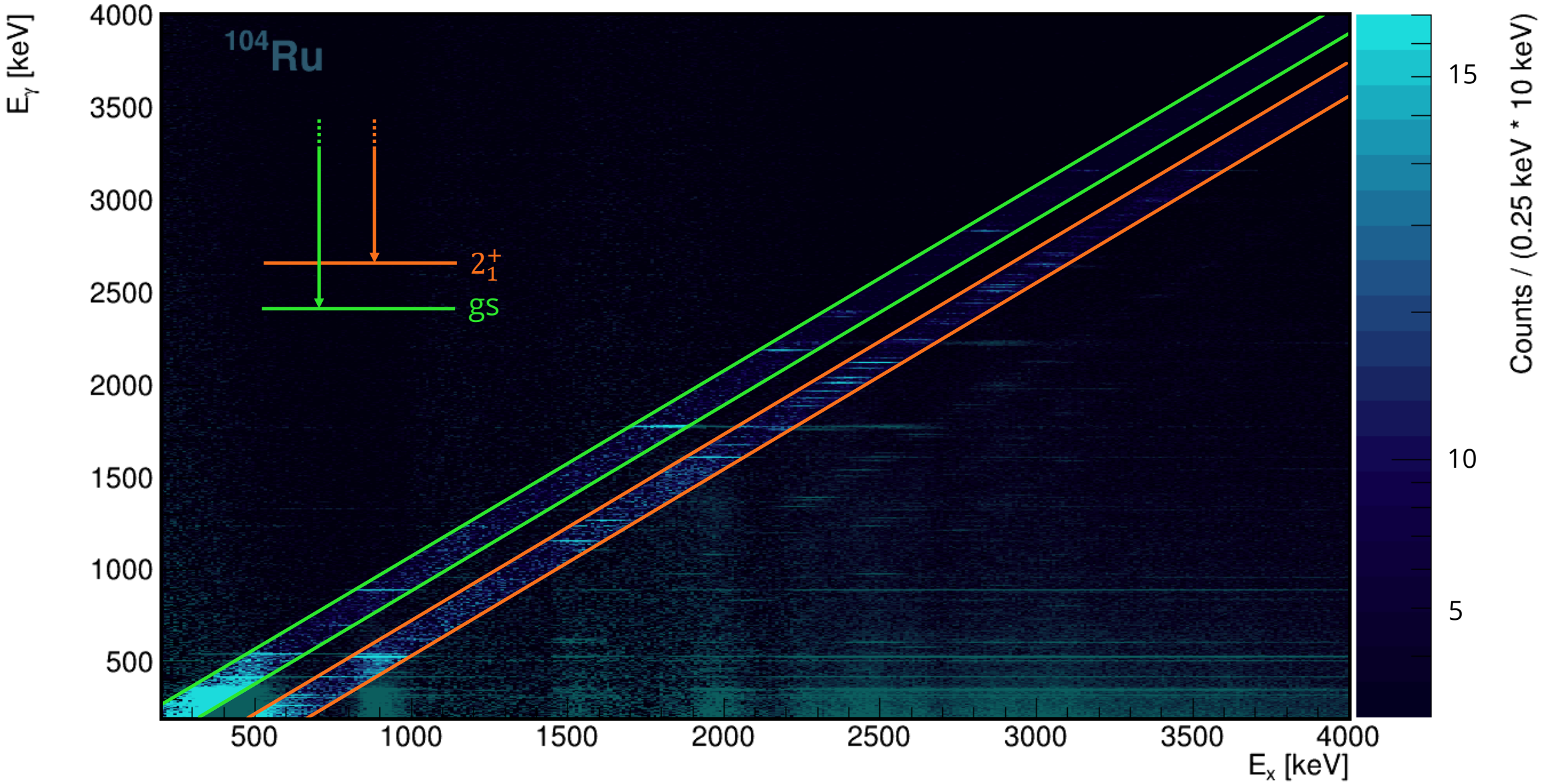
+

~ 100 previously unknown transitions

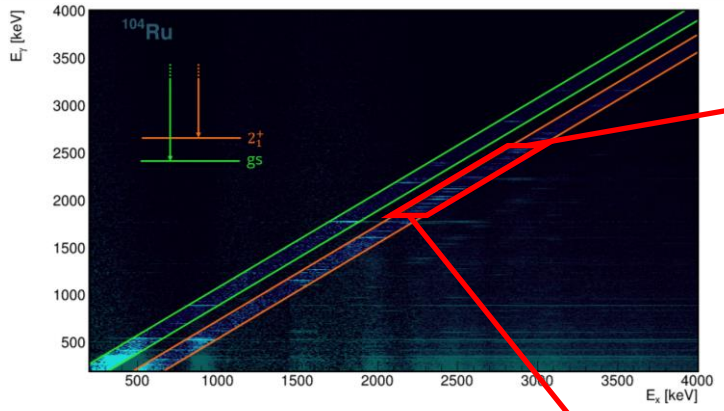
Data sorting



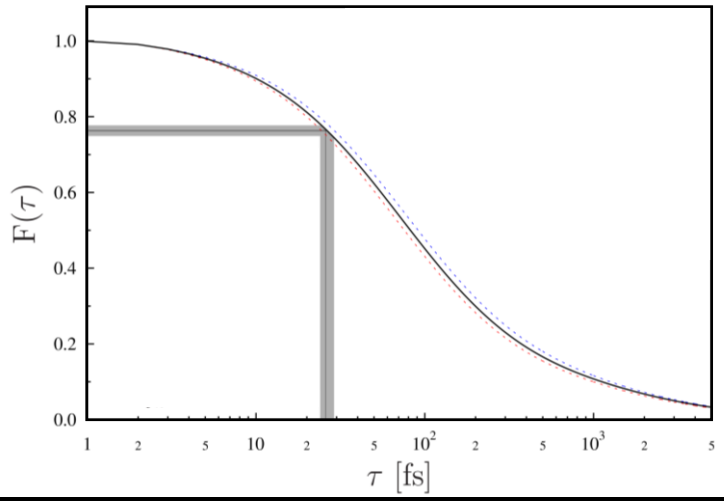
Data sorting

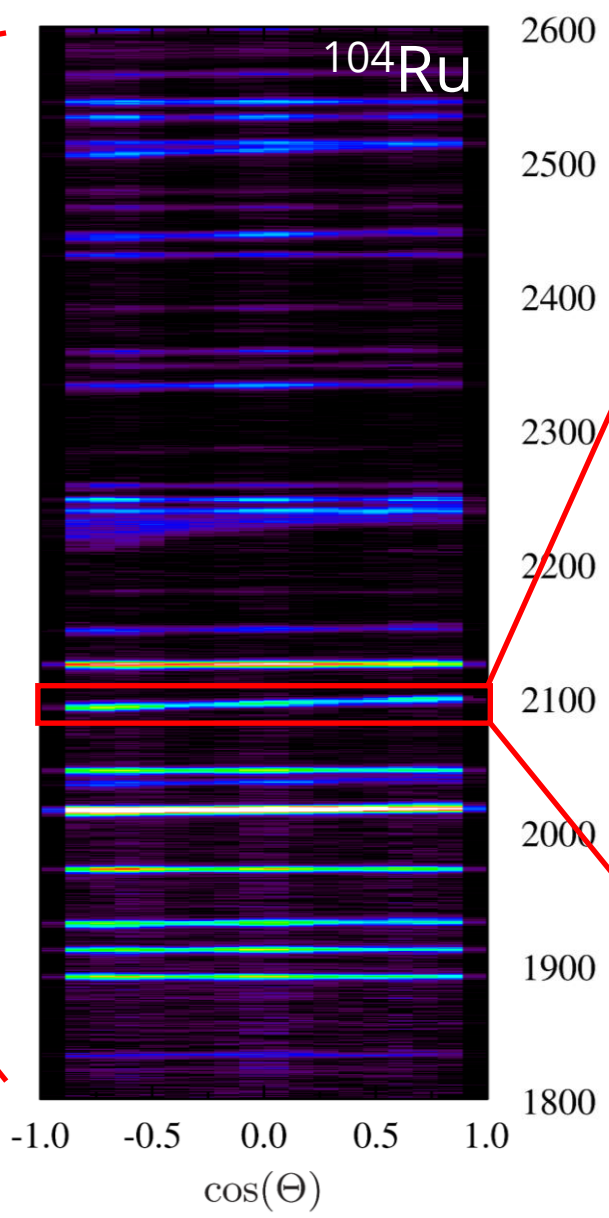


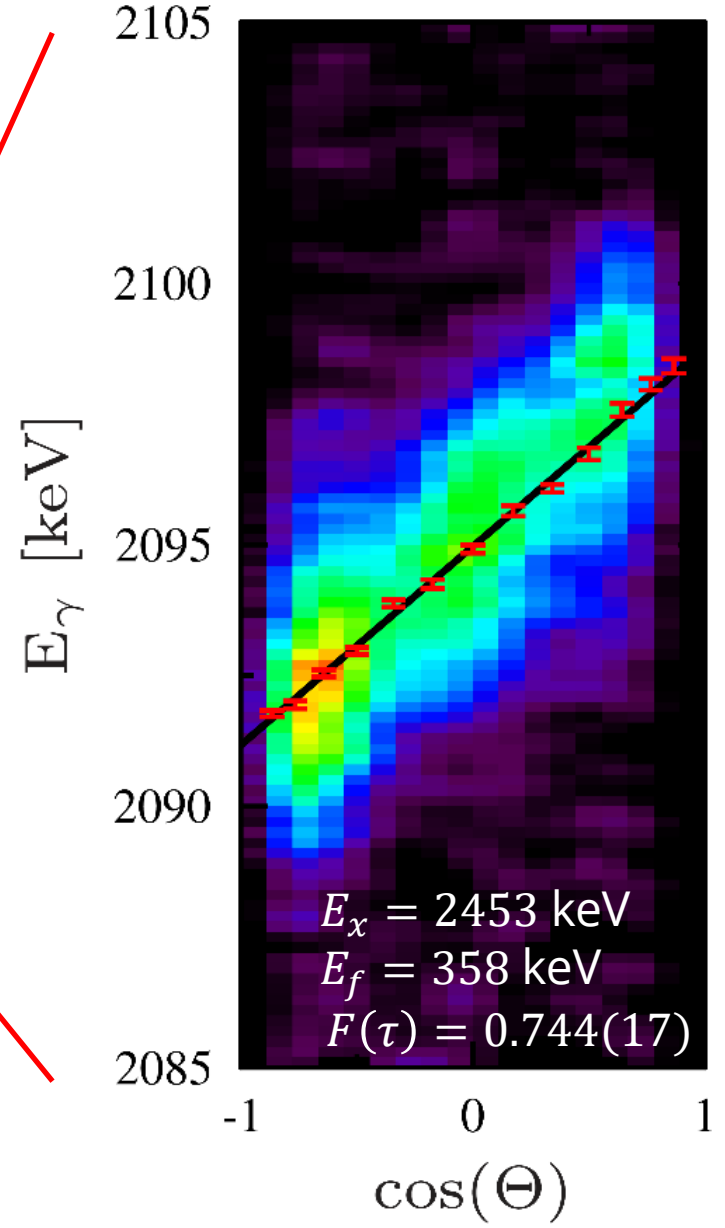
Lifetime determination



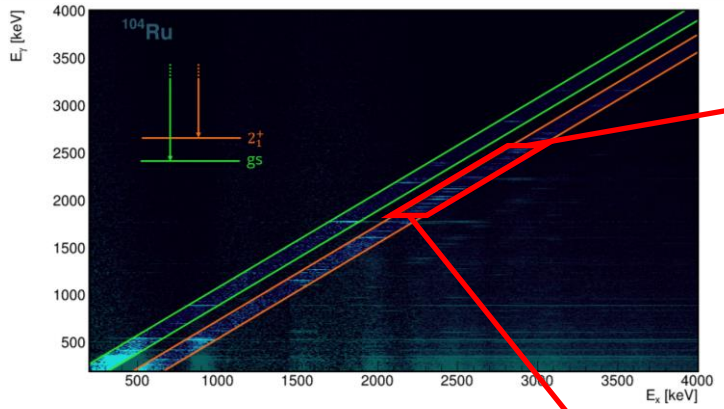
$F(\tau)$ determination via $E_\gamma(\cos\theta)$ sorting in diagonal gates

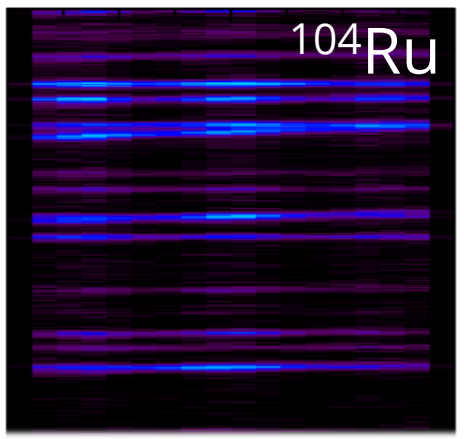


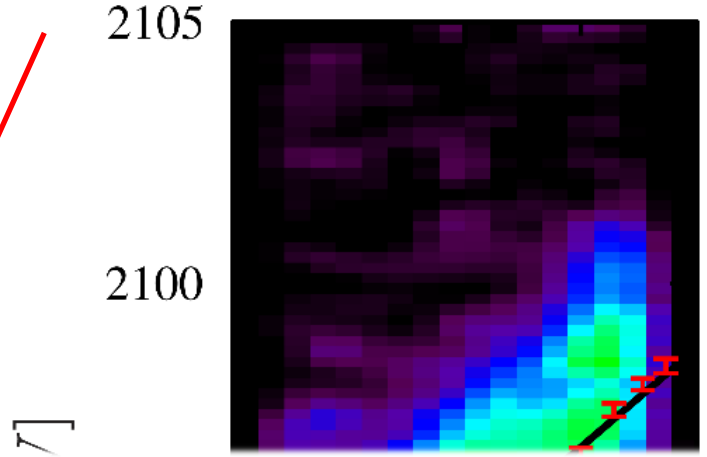


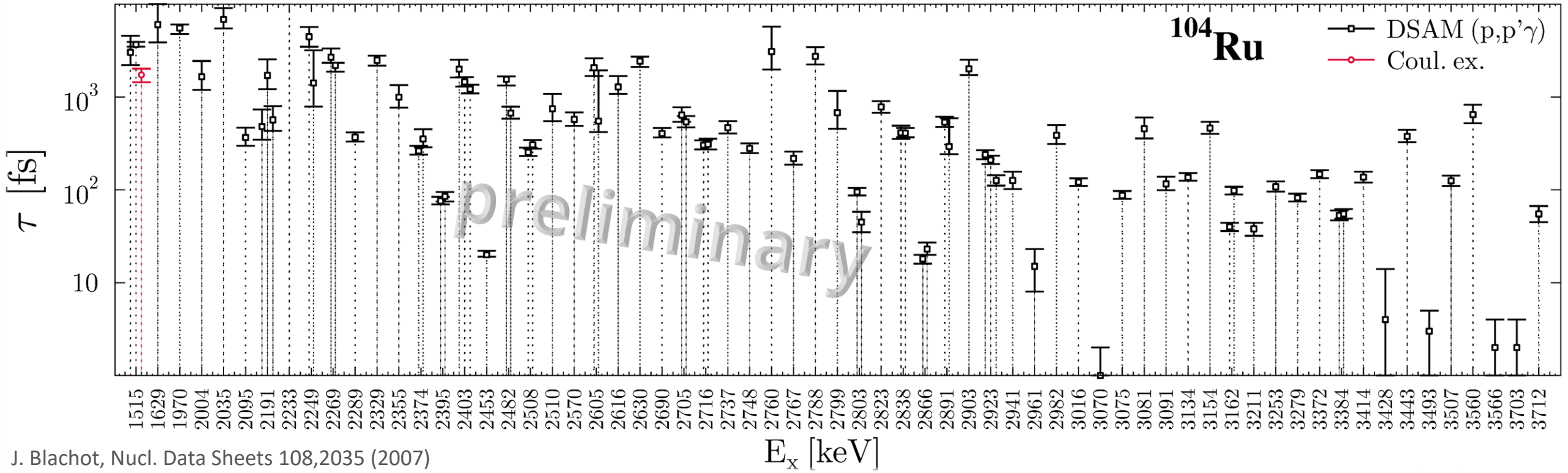


Lifetime determination



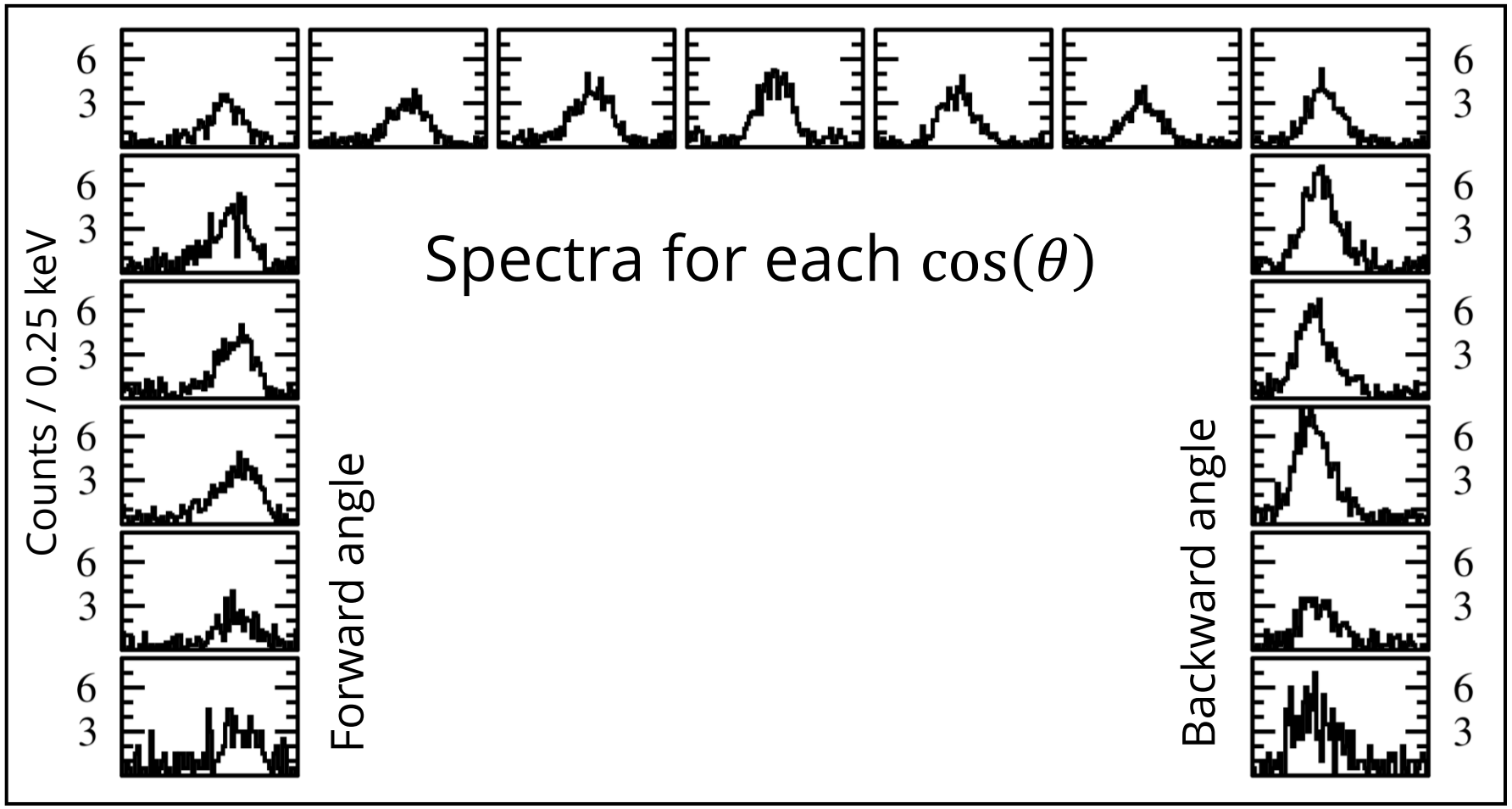


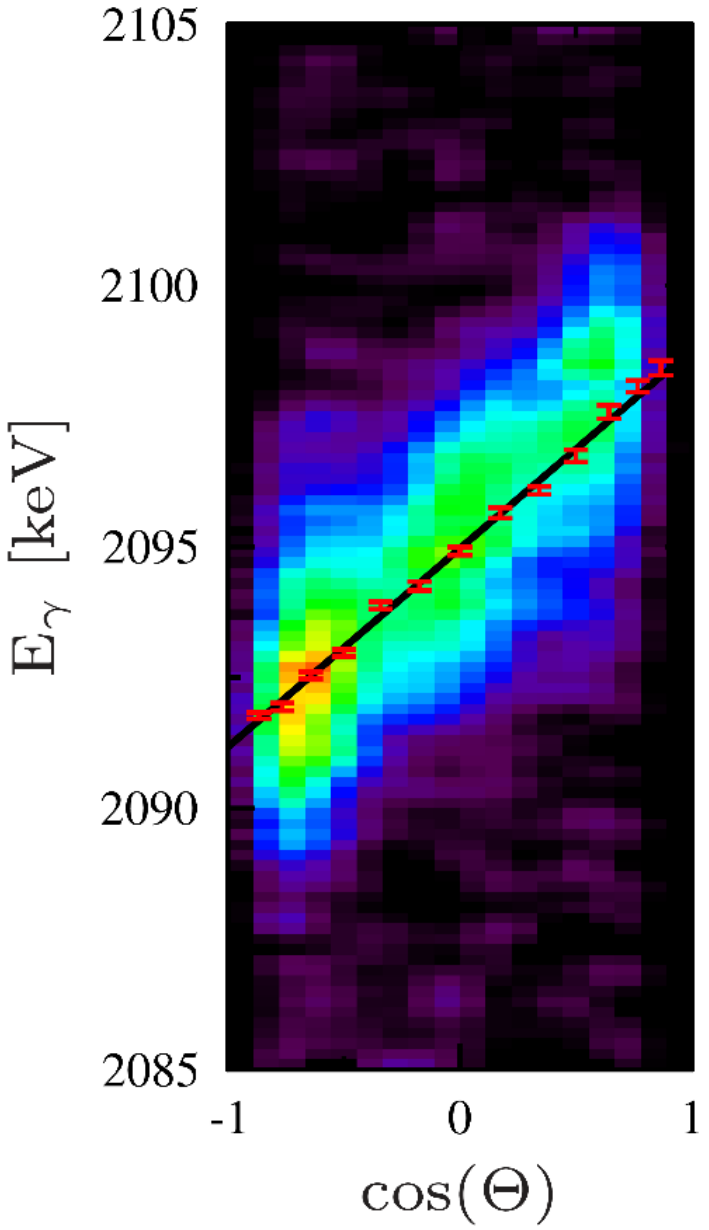




J. Blachot, Nucl. Data Sheets 108,2035 (2007)

“Reverse CDSAM“





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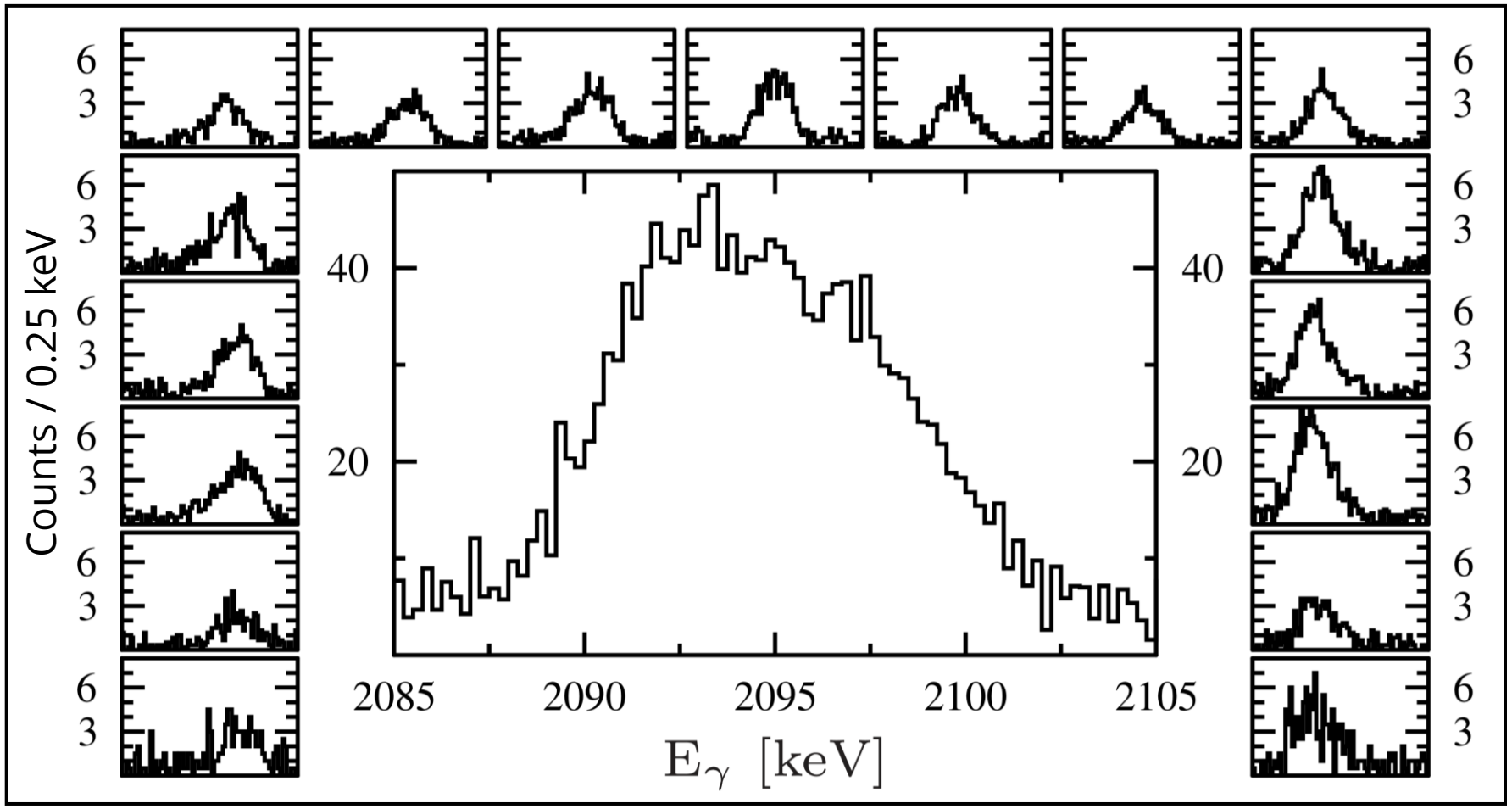
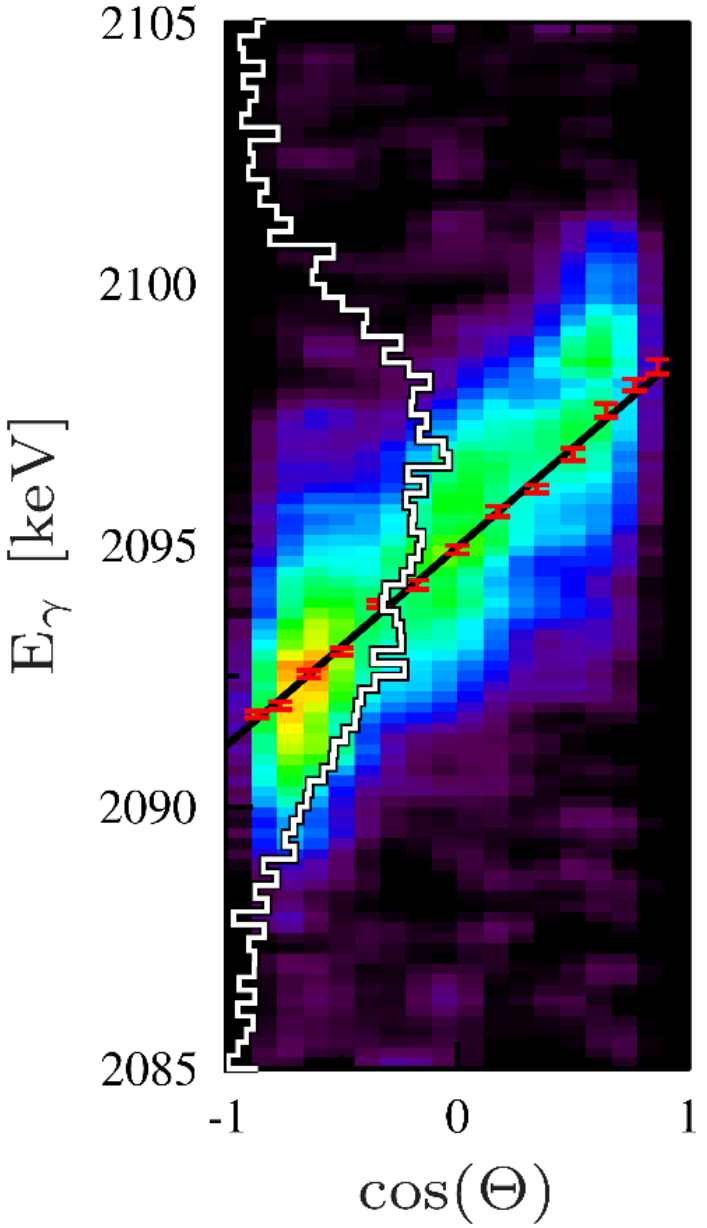
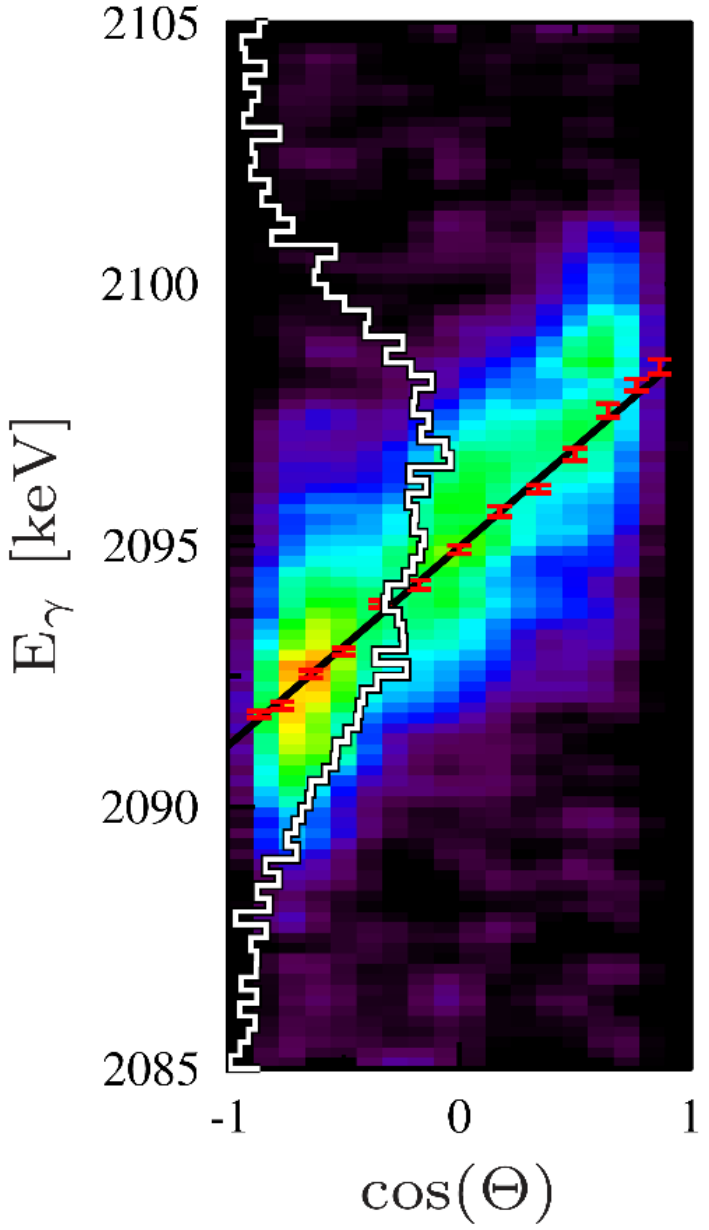




“Reverse CDSAM“

- Assuming some lifetime τ
- Performing resulting Doppler correction
- Peak-shape analysis in E_γ spectrum



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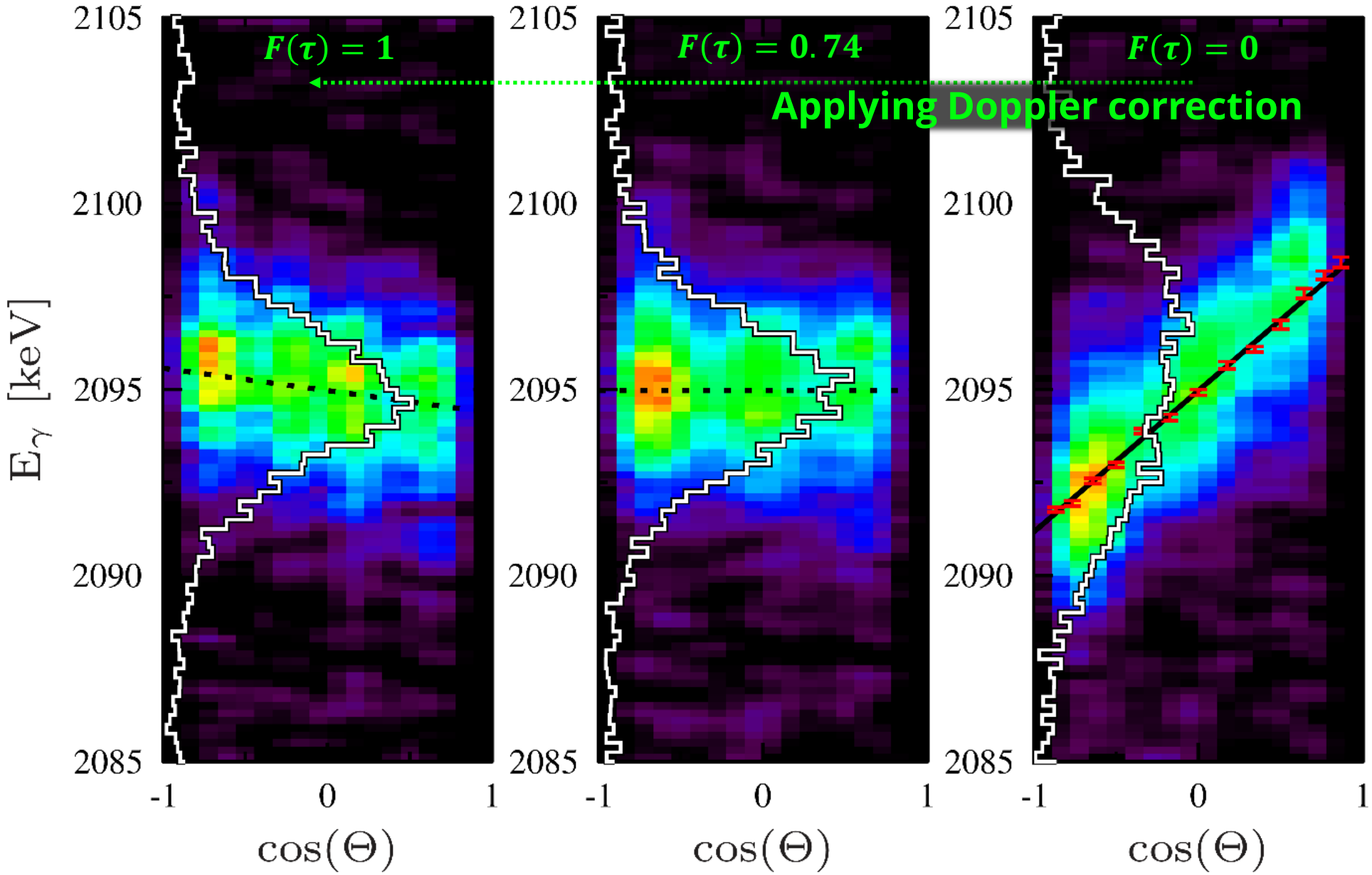
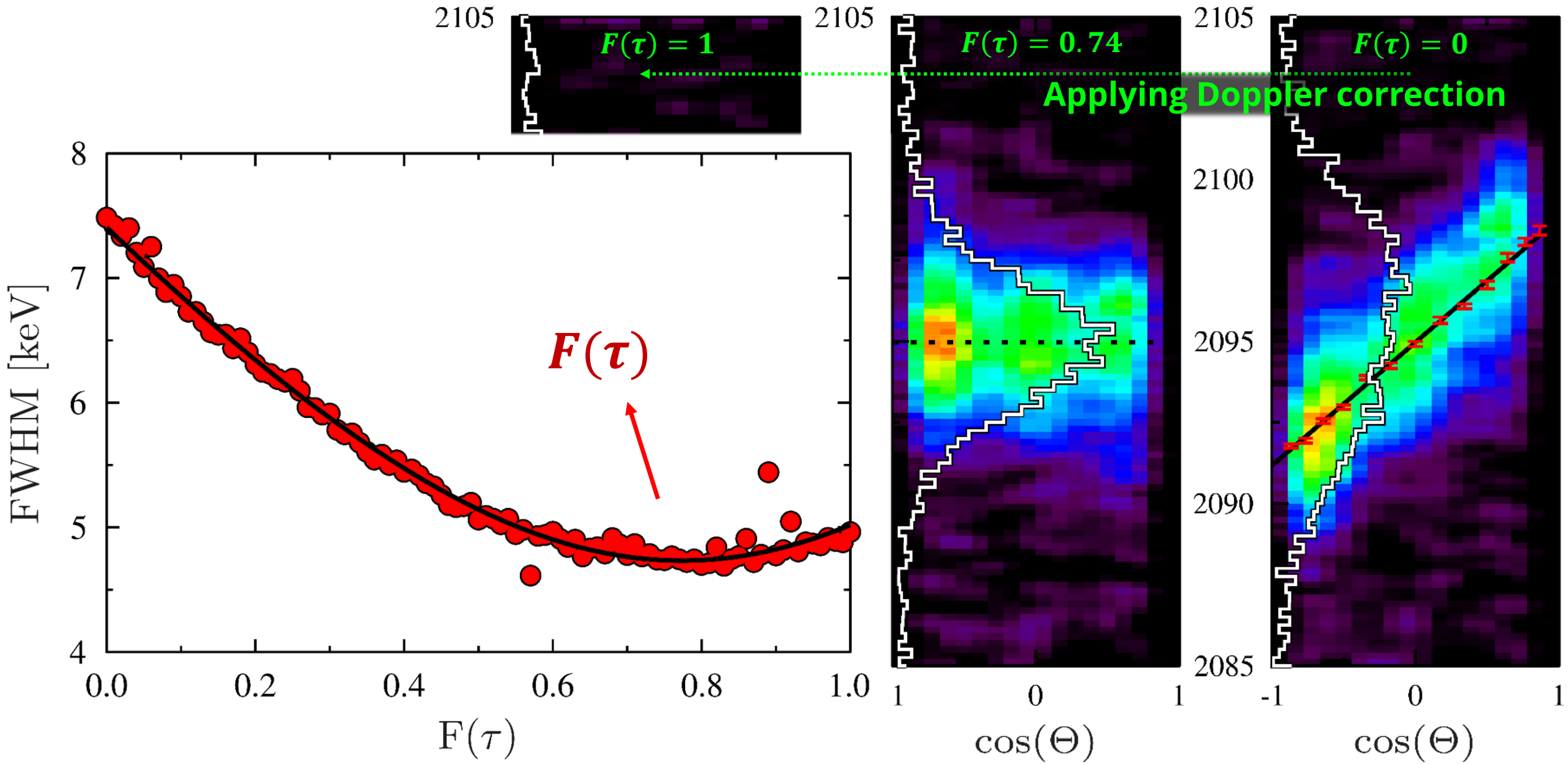
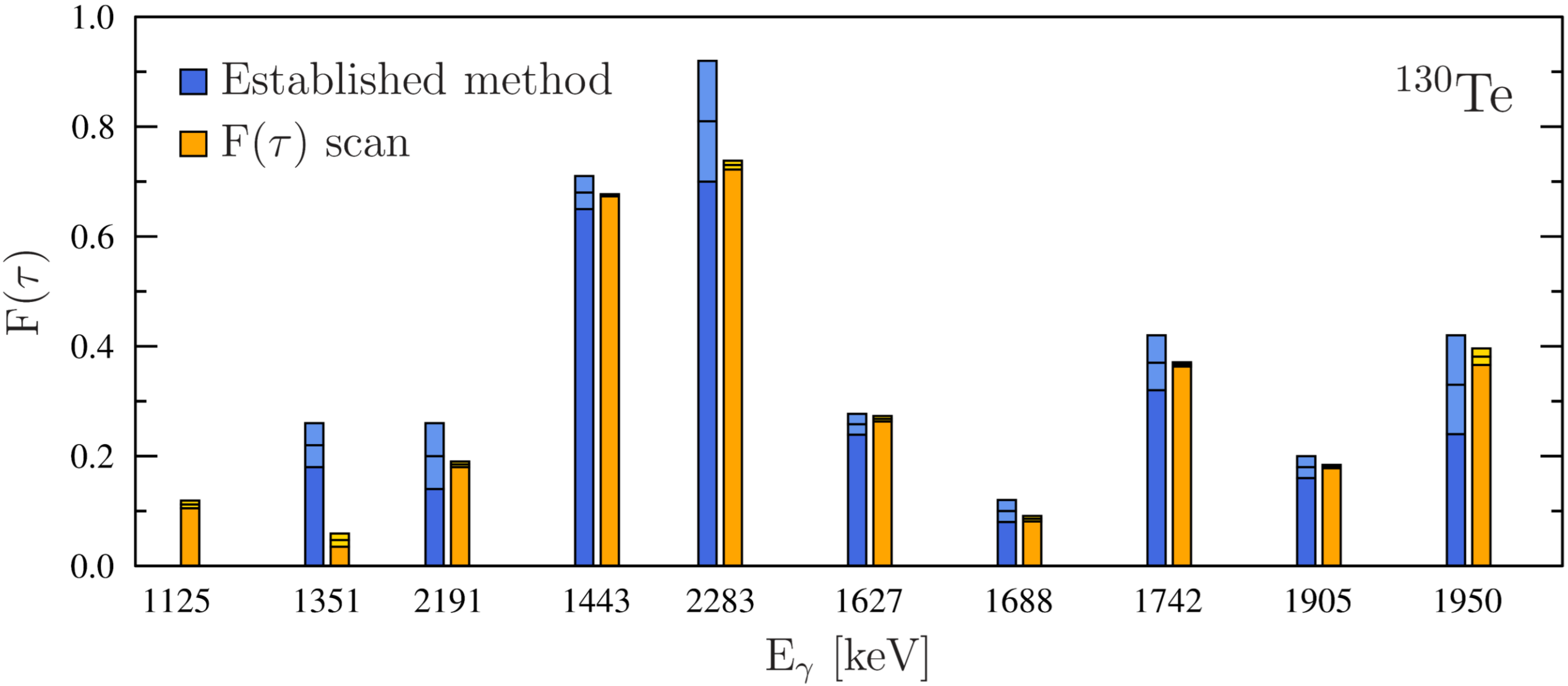


“Reverse CDSAM“

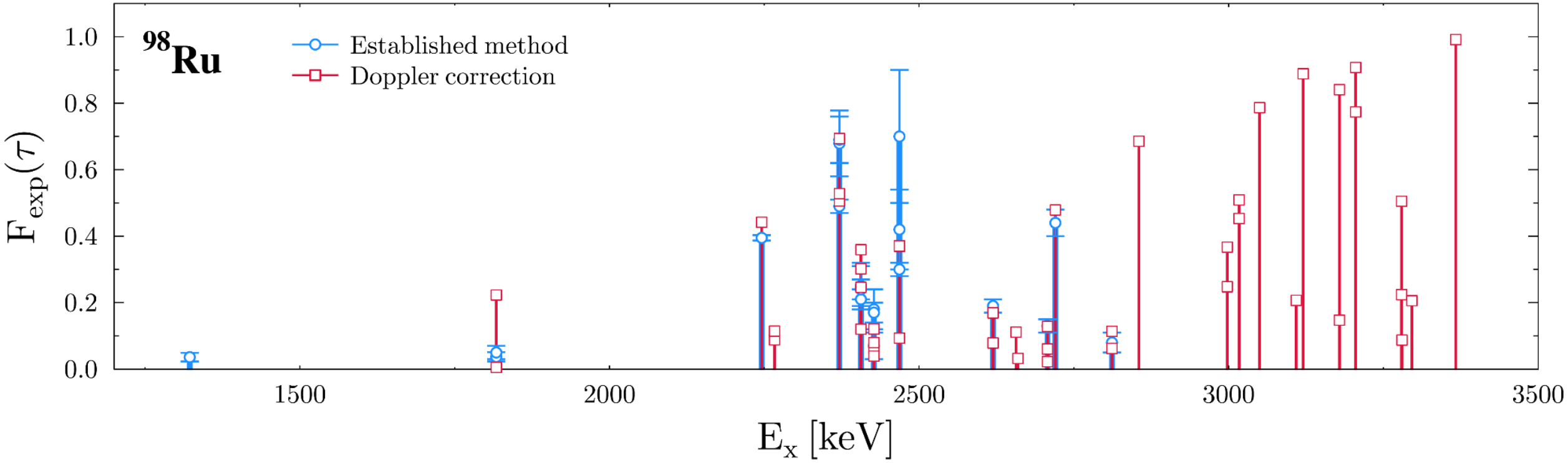


^{130}Te(p,p'γ) @ 10 MeV



For CDSAM results on ^{130}Te see: S. Prill *et al.*, Phys. Rev. C **105**, 034319 (2022)

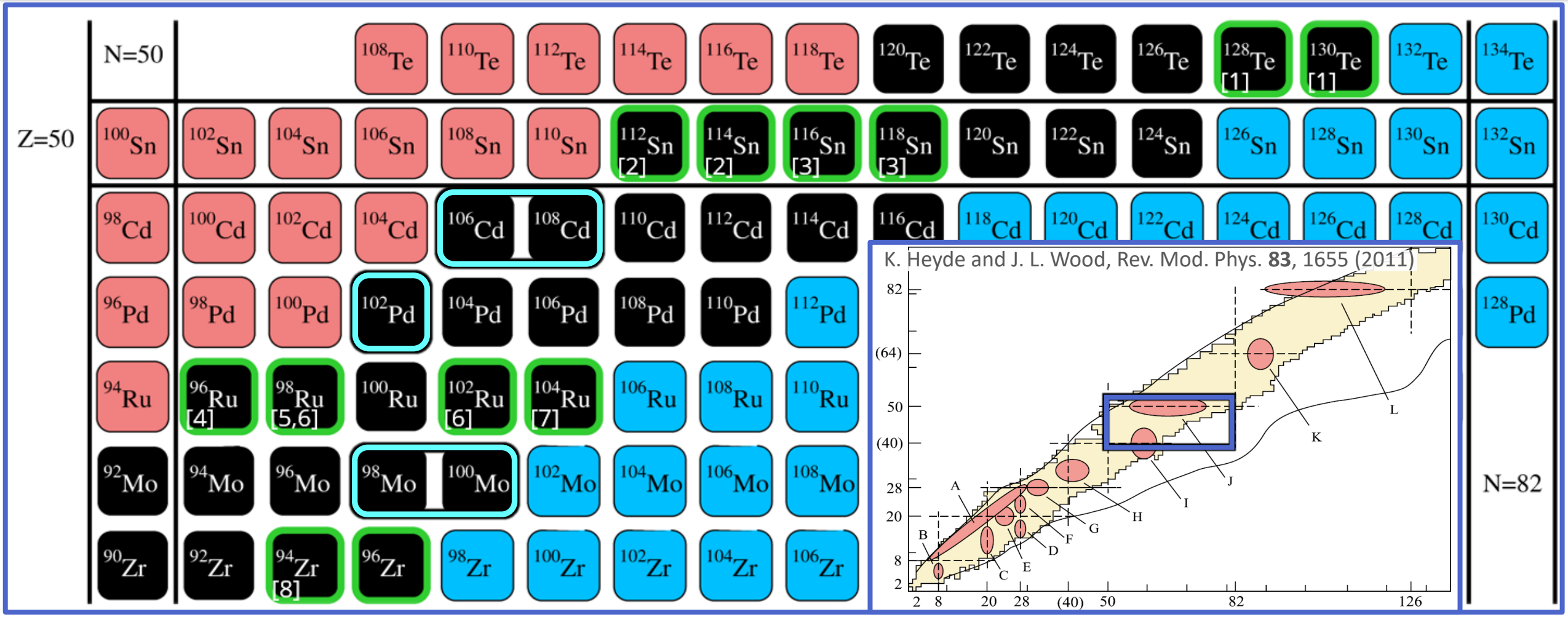
^{98}Ru(p,p'γ) @ 8 MeV



11 additional lifetimes determined via “reverse CDSAM“

Data taken from
C. Deke, Bachelor‘s thesis, University of Cologne (2022)
V. Everwyn, Master‘s thesis, University of Cologne (2020)

Outlook



measured
planned

For more details see:

[1] S. Prill *et al.*, Phys. Rev. C **105**, 034319 (2022)
[2] M. Spieker *et al.*, Phys. Rev. C **97**, 054319 (2018)
[3] S. Prill in preparation
[4] A. Hennig *et al.*, Phys. Rev. C **92**, 064317 (2015)
[5] V. Vielmetter, Bachelor's thesis, University of Cologne (2016)
[6] V. Everwyn, Master's thesis, University of Cologne (2020)
[7] A. Bohn, Master's thesis, University of Cologne (2021)
[8] S. Prill *et al.*, Phys. Conf. Ser. **1643**, 012157 (2020)

Summary

- Experimental setup
- Coincidence DSAM
- Gating strategy
- Spectroscopy
- Lifetime determination
- “Reverse CDSAM“
- Planned campaigns