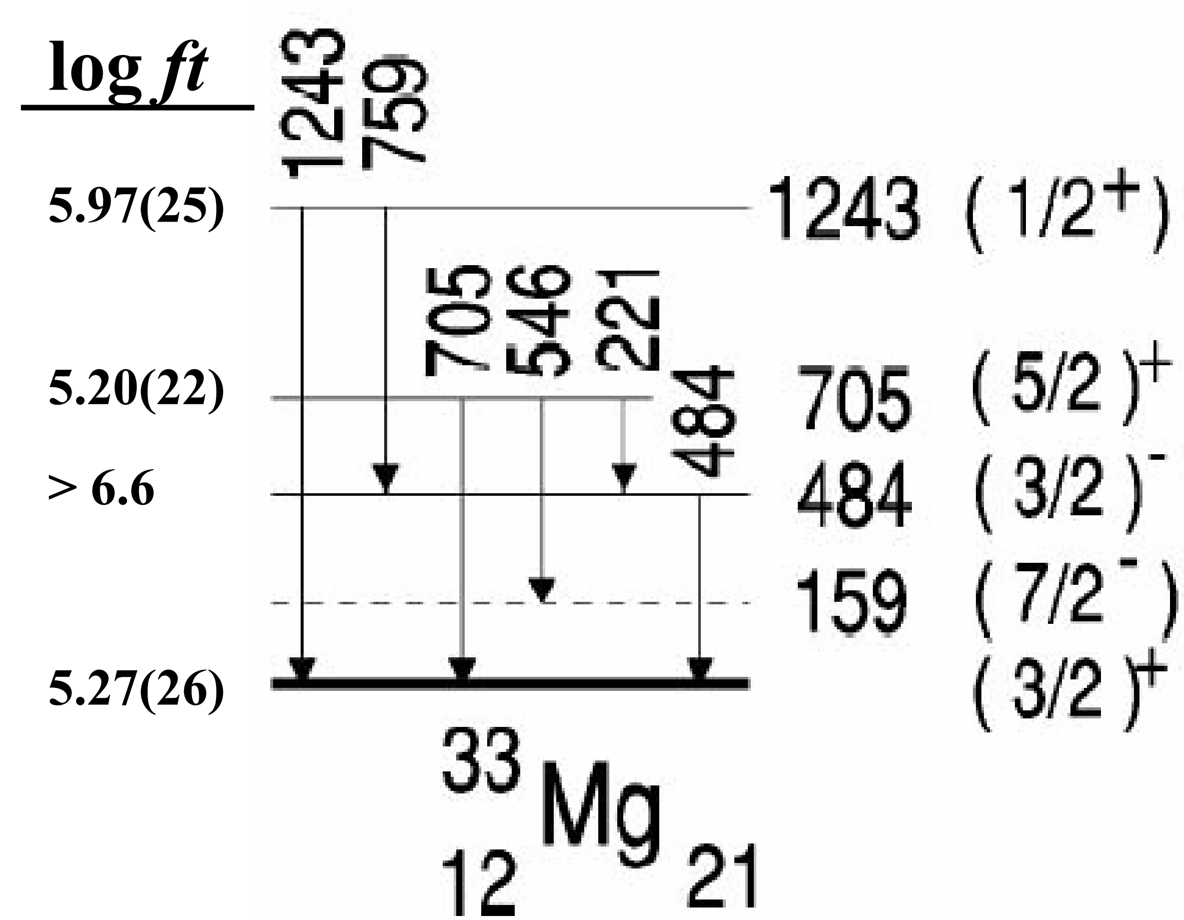
Ground state of ^{33}Mg: a puzzle

- Several measurements in contradiction
  - ß-decay of ^{33}Na: $3/2^+$ based on log ft and shell model predictions
  - g-factor and hfs parameter: $3/2^-$
  - ß-decay of ^{33}Mg: $3/2^+$ based on log ft and known ^{33}Al gs
  - Coulex on ^{33}Mg: E2 transition between gs and 484 keV state
  - (p,p’) on ^{33}Mg: 484 keV state observed
  - p(^{34}Mg, ^{33}Mg)X: both 484 keV and 546 keV states observed
- References
  - ß-decay of ^{33}Na: Nummela et al., PRC 64, 054313 (2001)
  - g-factor: Yordanov et al., PRL 99, 212501 (2007)
  - ß-decay of ^{33}Mg: Tripathi et al., PRL 101, 142504 (2008)
  - Coulex on ^{33}Mg: Pritychenko et al., PRC 65, 061304R (2002)
  - (p,p’) and p(^{34}Mg, ^{33}Mg)X: Elekes et al., PRC 73, 044314 (2006)

Conflicting interpretations

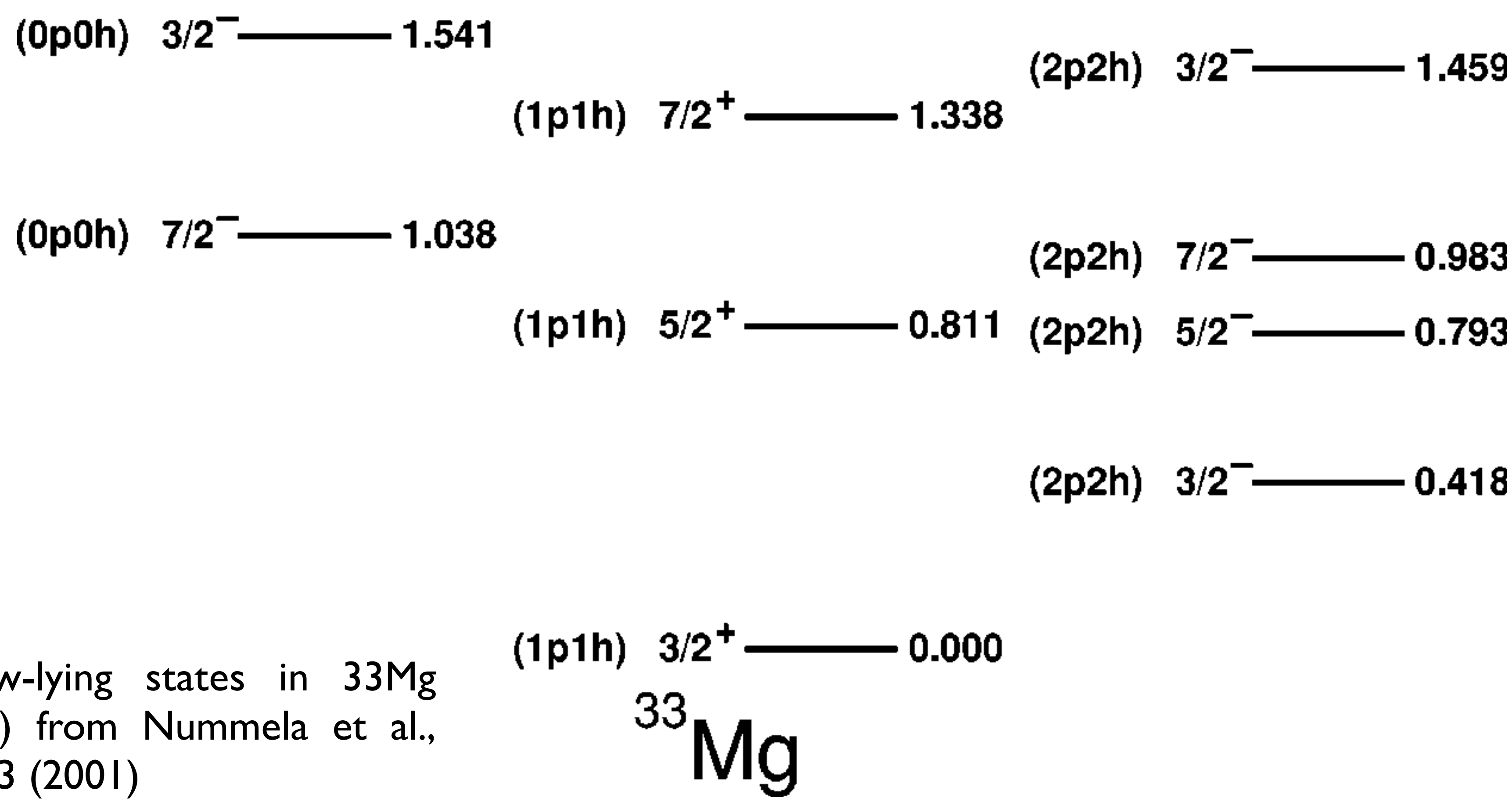
- Ground state parity: g-factor and ß-decay results in contradiction
- 484 keV state: populated in E2 transition from Coulomb excitation incompatible with different parity from ground state
- Proposed level at 159 keV solely inferred from 546 keV transition (proposed isomeric M2 159 keV transition not seen in ß-decay experiment)
- No solution that rejects only one of previous measurements



Proposed level scheme for ^{33}Mg and log ft values deduced following the β-decay of ^{33}Na

Configurations

- Low-lying states in ^{33}Mg
  - Competition between different configurations
  - Shell evolution depends on deformation
  - $3/2^+$ correspond to 1p1h excitation, whereas $3/2^-$ corresponds to 2p2h excitation



Calculated low-lying states in 33Mg (unmixed case) from Nummela et al., PRC 64, 054313 (2001)

Goals of proposed experiment

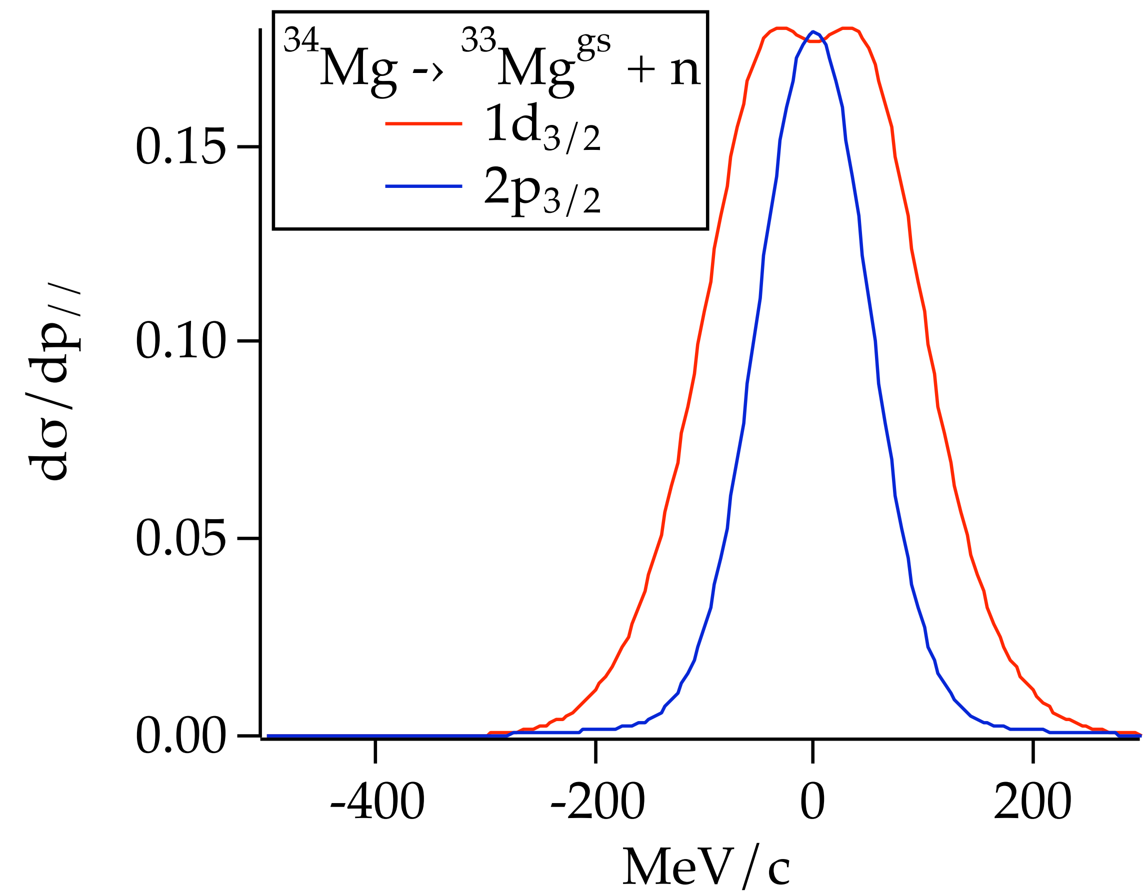
- Identify spin and parity of ^{33}Mg ground state, and resolve present conflicting information
- Identify spin and parity of excited states, in particular 484 keV level seen in Coulomb excitation
- Deduce level scheme using γ-γ coincidences
- Look for proposed long-lived M2 isomeric state at 159 keV
- Characterize intruder configurations in this nucleus

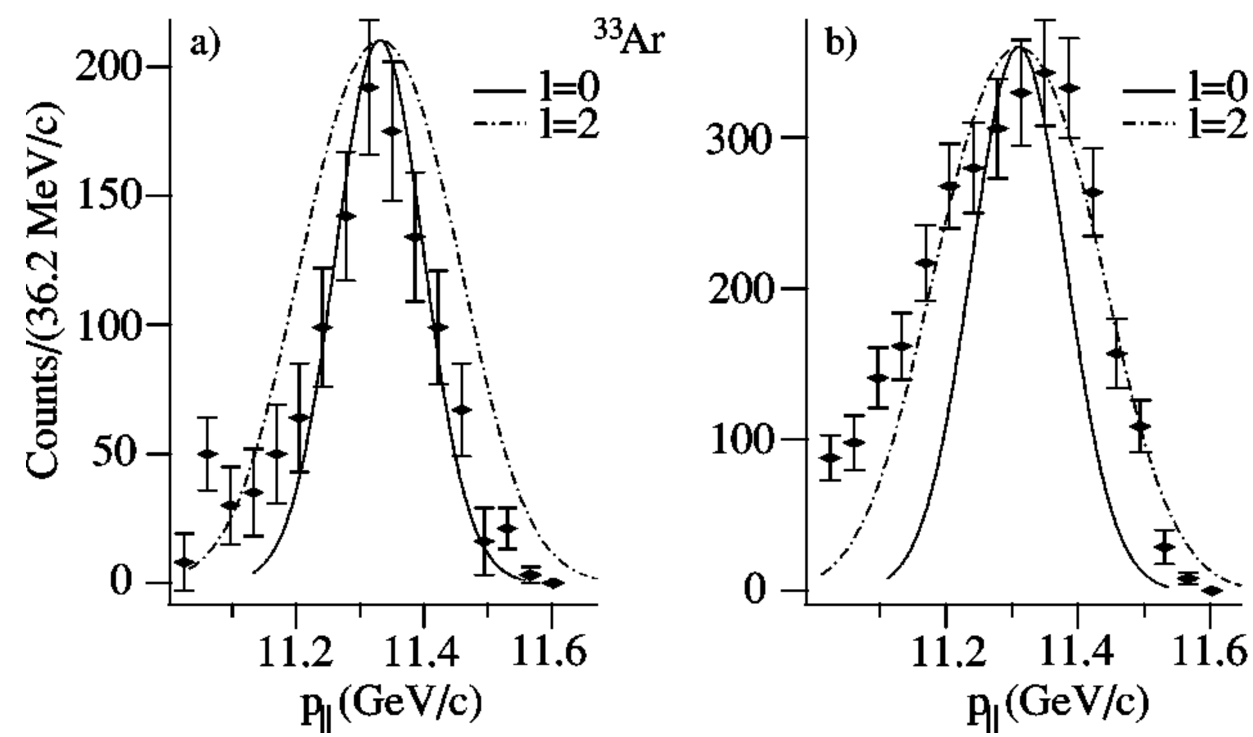
Single nucleon knockout reactions

- One-neutron removal from ^{34}Mg
  - Populate excited and ground states in ^{33}Mg
  - Measure longitudinal momentum distributions of ^{33}Mg residue tagged on gamma-rays
  - Unambiguous identification of angular momentum of removed nucleon
  - Ground state momentum distribution from inclusive minus excited states
  - 484 keV - tagged momentum distribution after subtraction of feeding from 705 keV and 1243 keV states
- One-proton removal from ^{34}Al
  - Favors population of positive parity states in ^{33}Mg
  - Complementary information on the structure of excited states in ^{33}Mg by comparison with one-neutron knockout from ^{34}Mg

Angular momentum identification

- Longitudinal momentum distribution of residue
  - From initial 0^+ state, only one angular momentum value possible to final state
  - Calculation shows difference between *d* and *p* orbitals
- Example on ^{34}Ar-1n
  - Ground state $p_{//}$ distribution shows agreement with *l*=0 shape whereas excited states with *l*=2
  - From A. Gade et al., PRC 69, 034311 (2004)



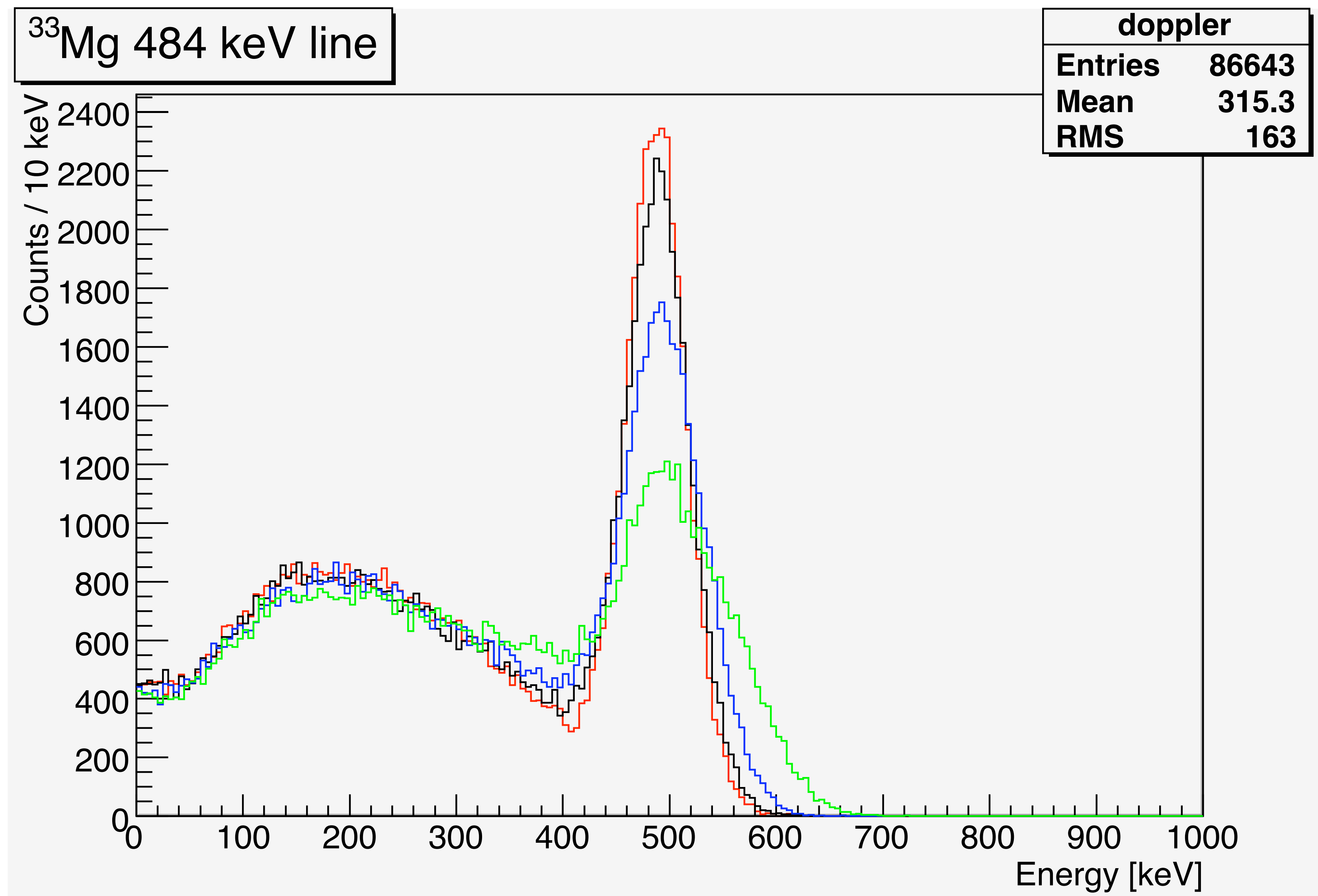


Proposed setup

- Production, filtering and identification of ^{34}Mg and ^{34}Al beams
  - Use BigRIPS fragment separator with 345 MeV/u ^{48}Ca primary beam on 16 mm Be production target
- Knockout reactions on radioactive beams
  - Place reaction target (Be or C) at F8 focal point of BigRIPS
  - Use Zero Degree Spectrometer (ZDS) in dispersive mode to filter, identify and measure momentum of ^{33}Mg residue
  - Surround reaction target with the DALI2 array to detect γ-rays emitted in coincidence with the heavy residue
- Stopped ^{33}Mg at F11 focal plane
  - Use high efficiency Ge detector to look for proposed long-lived isomer, and measure its lifetime if found

Lifetime issues

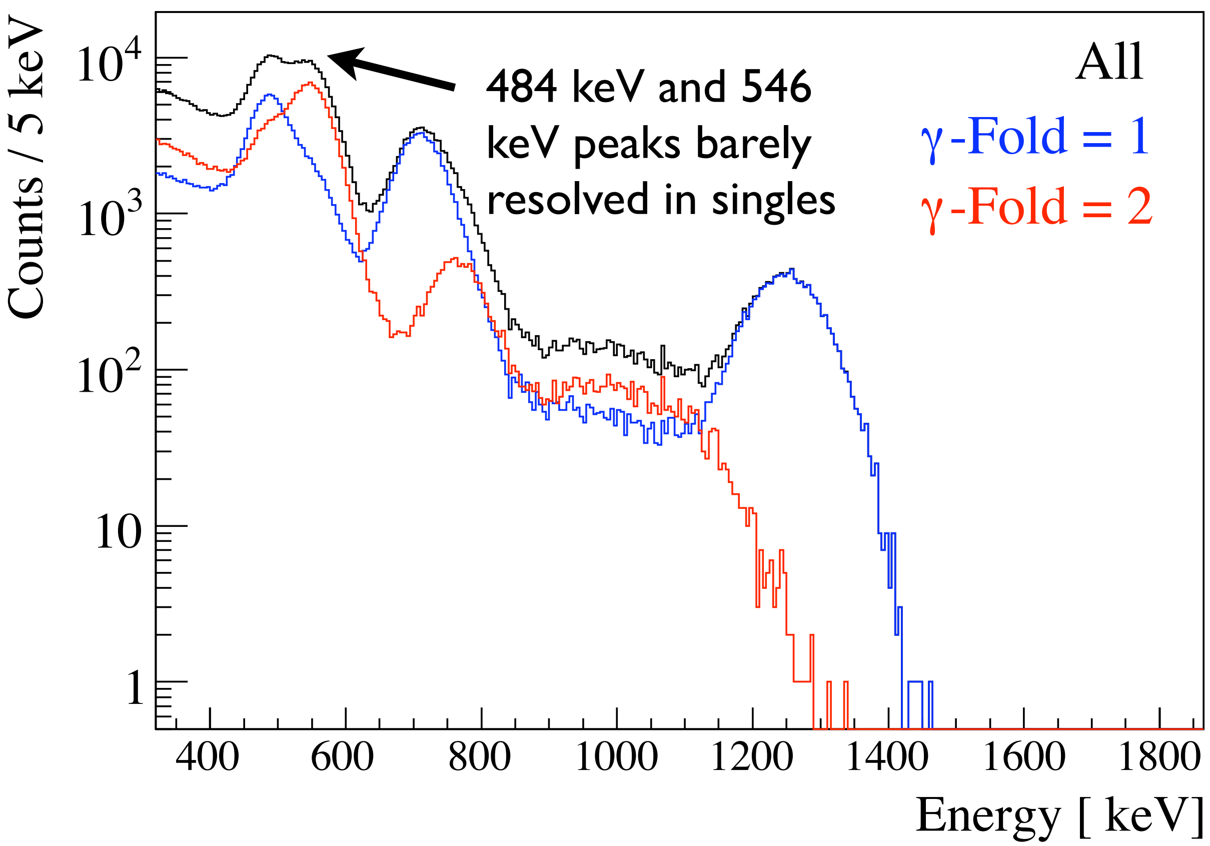
- Doppler broadening and long lifetimes
  - Assuming transition from $7/2^+$ to $5/2^+$ for 484 keV line: $T_{1/2}$=69 ps which corresponds to 2-3 cm at ß=0.6
  - High resolution γ-ray array cannot be used to its full capacity
  - Geant simulation of DALI2 array shows evolution of peak shape as a function of lifetimes: 50, 100, 200 and 400 ps

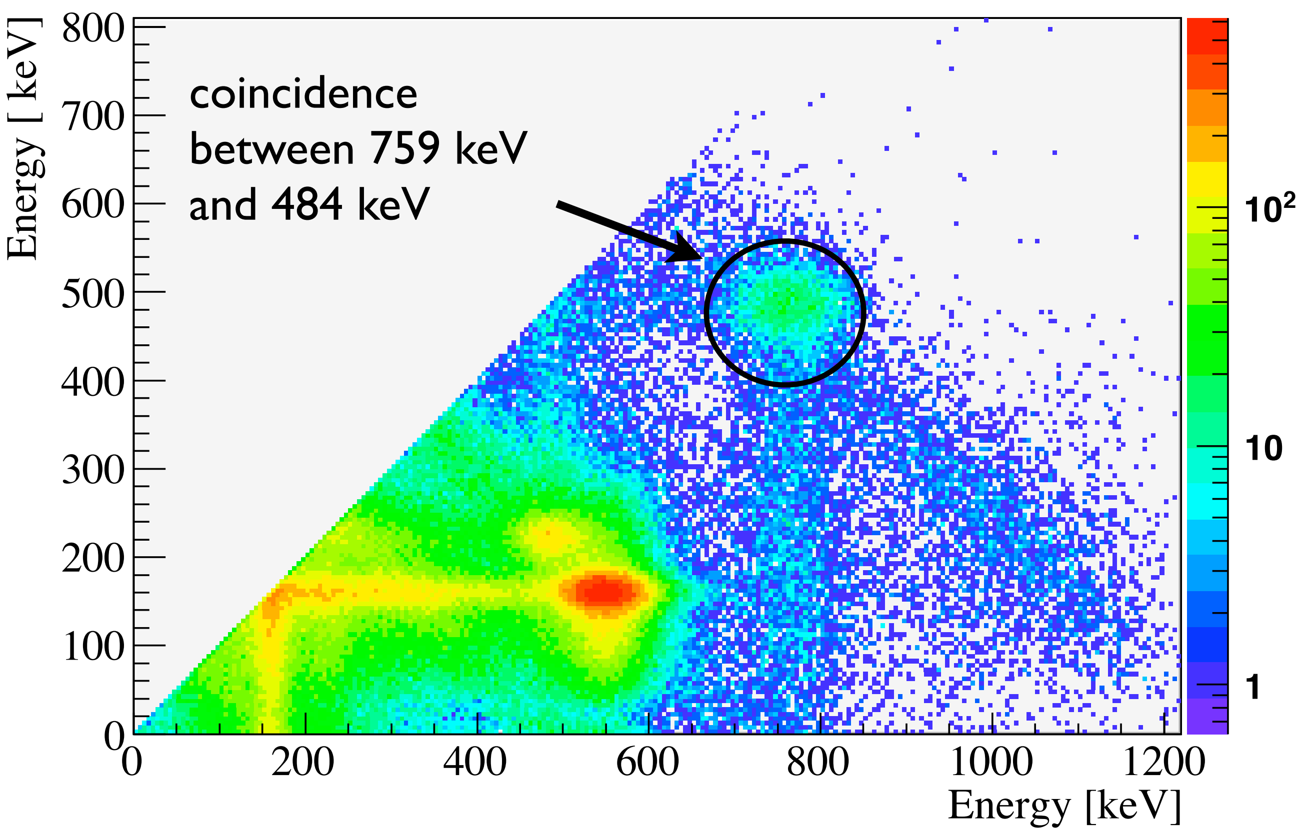


Simulation courtesy of
P. Doornenbal

Resolution issues

- γ-ray tagging of momentum distributions
  - Relatively high level density and low energy of ^{33}Mg level scheme
  - Difficult to resolve 484 keV and 546 keV lines
  - Necessary to use γ-γ coincidences with feeding transitions
  - Calculated spectra using branching ratios from ß-decay of ^{33}Na





Simulations courtesy of P. Doornenbal