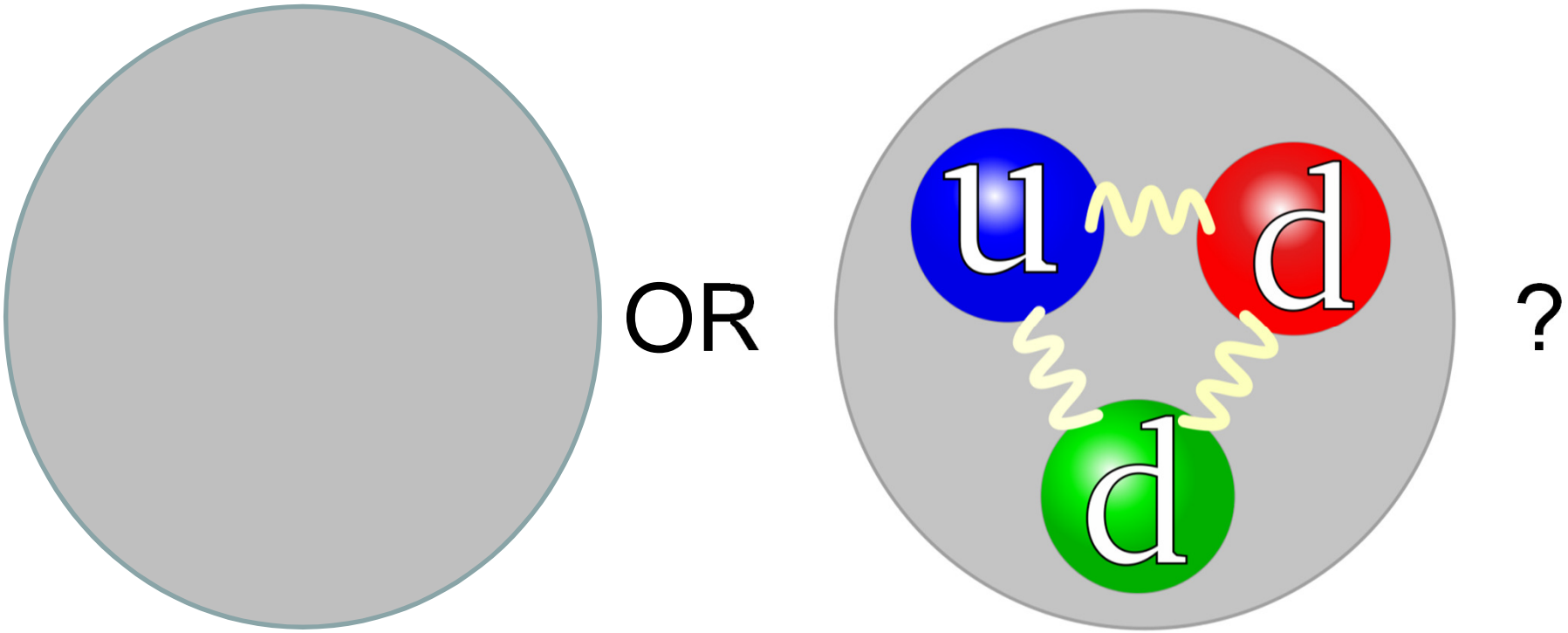
Nucleonic resonances and excited states

Role Of The Delta Resonance In The Population Of A Four-particle State In The $^{56}Fe \rightarrow {}^{54}Fe$ Reaction

Zsolt Podolyák
University of Surrey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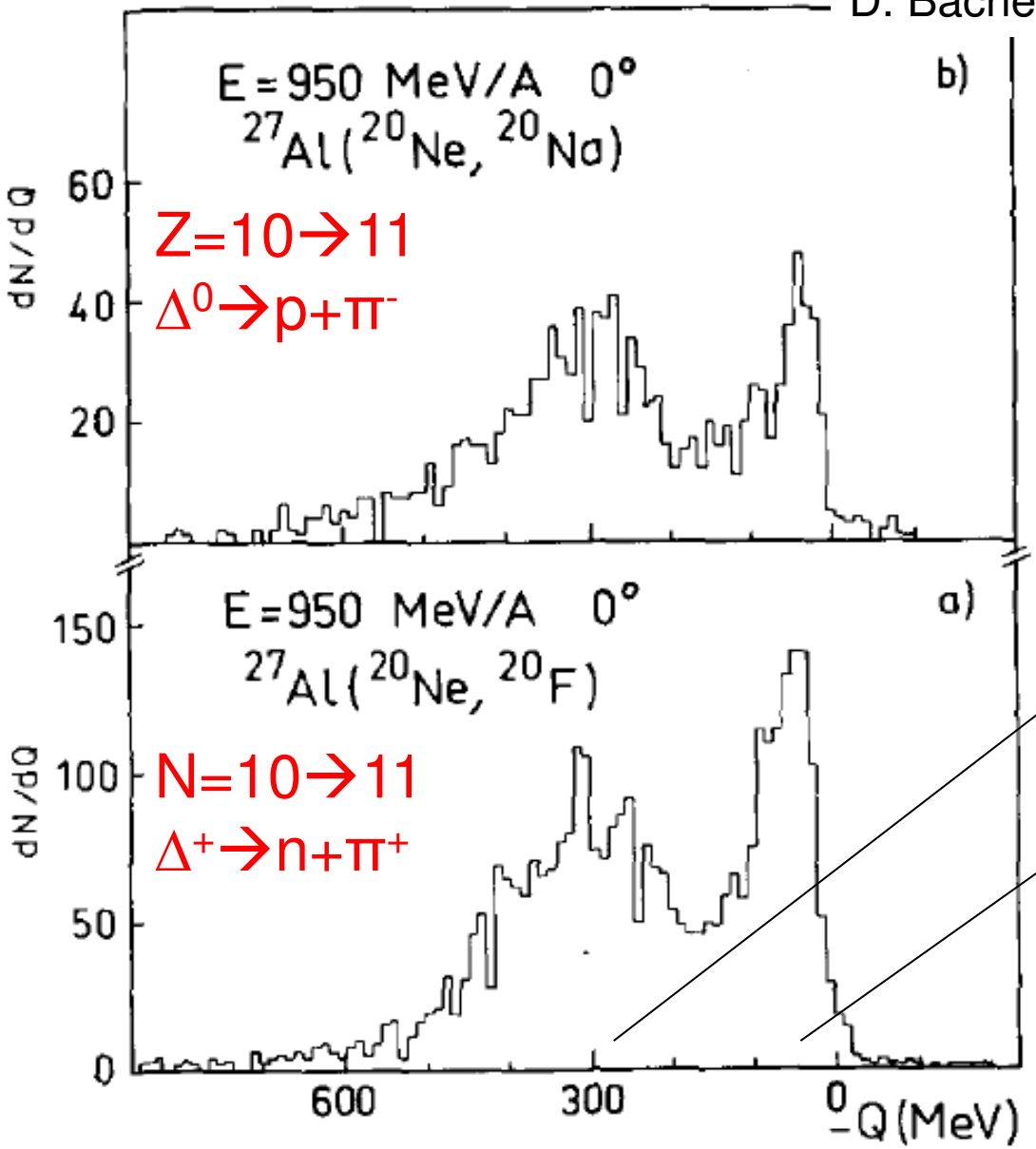
FIRST OBSERVATION OF THE Δ RESONANCE IN RELATIVISTIC HEAVY-ION CHARGE-EXCHANGE REACTIONS

D. Bachelier et al., Phys. Lett. 172, 23 (1986)



Delta resonance (shifted in energy)

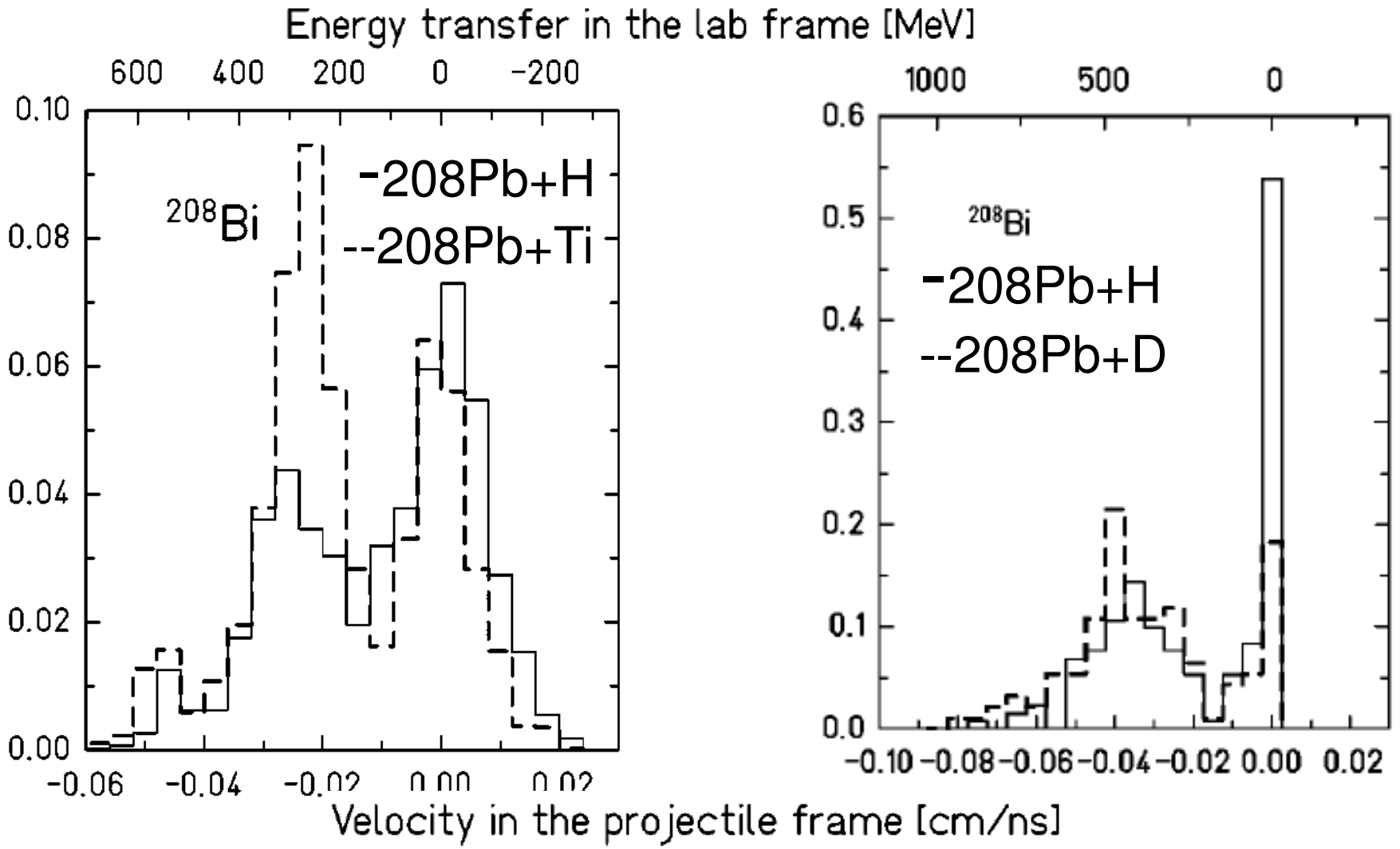
Quasi-elastic scattering

Role of nucleonic resonances in reactions

(but not for individual excited states)

experiment

theory



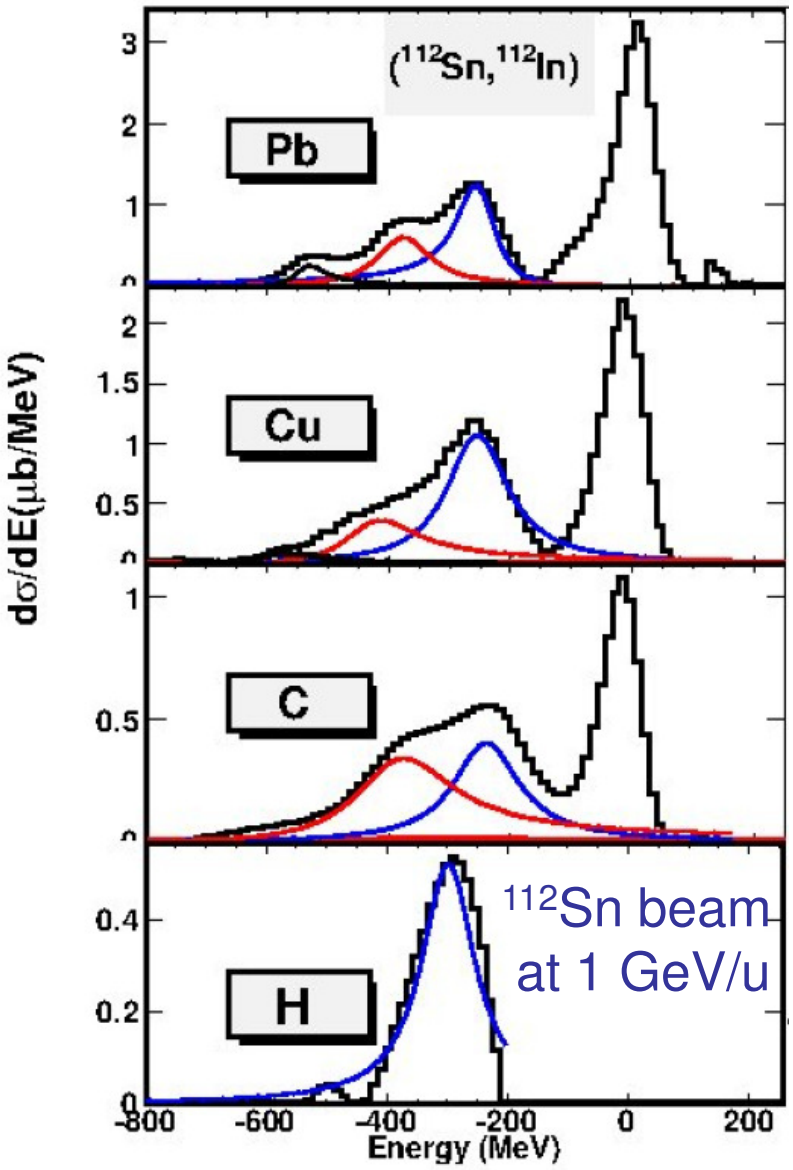
A. Kelic et al., Phys. Rev. C 70, 064608 (2004)

Theory: intranuclear cascade model, e.g. A. Boudard et al., PRC66, 044615 (2002)

Role of nucleonic resonances in reactions

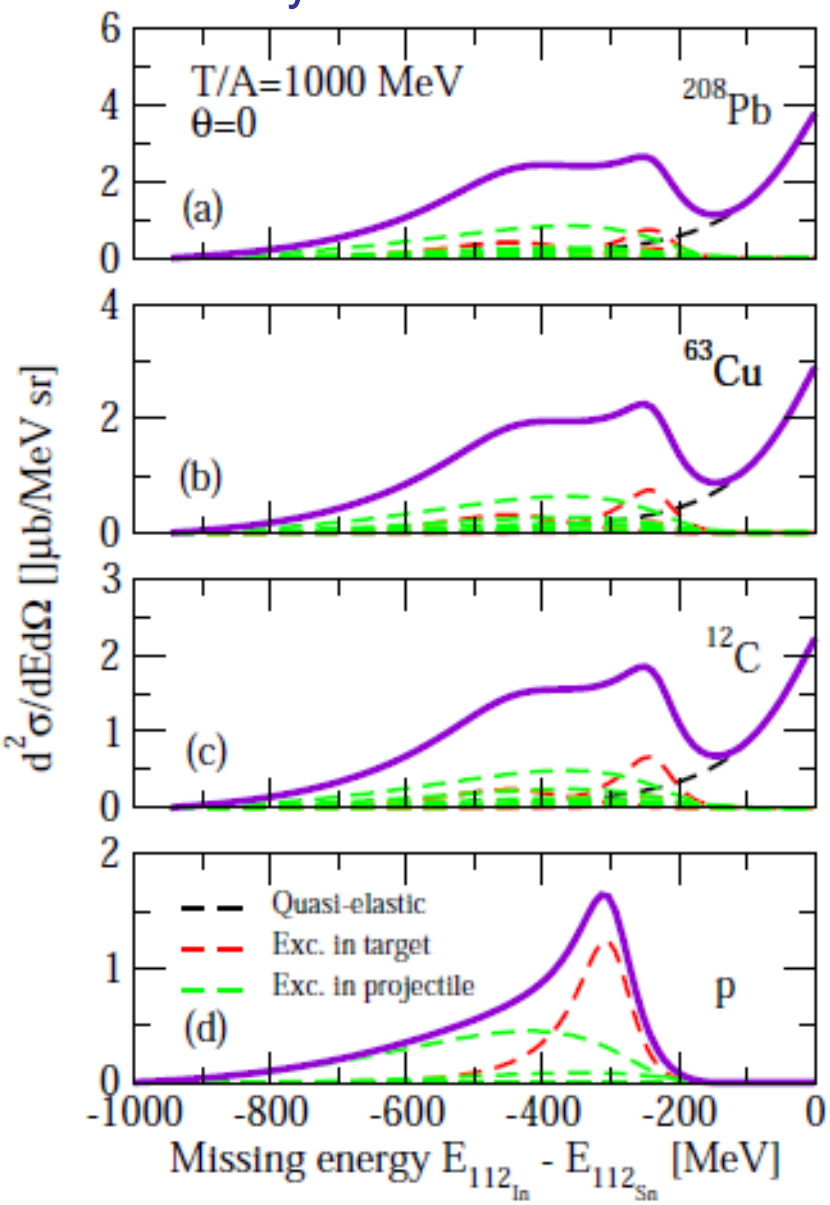
(but not for individual excited states)

experiment



J. Benlliure et al., JPS Conf. Proc. 6, 020039 (2015)

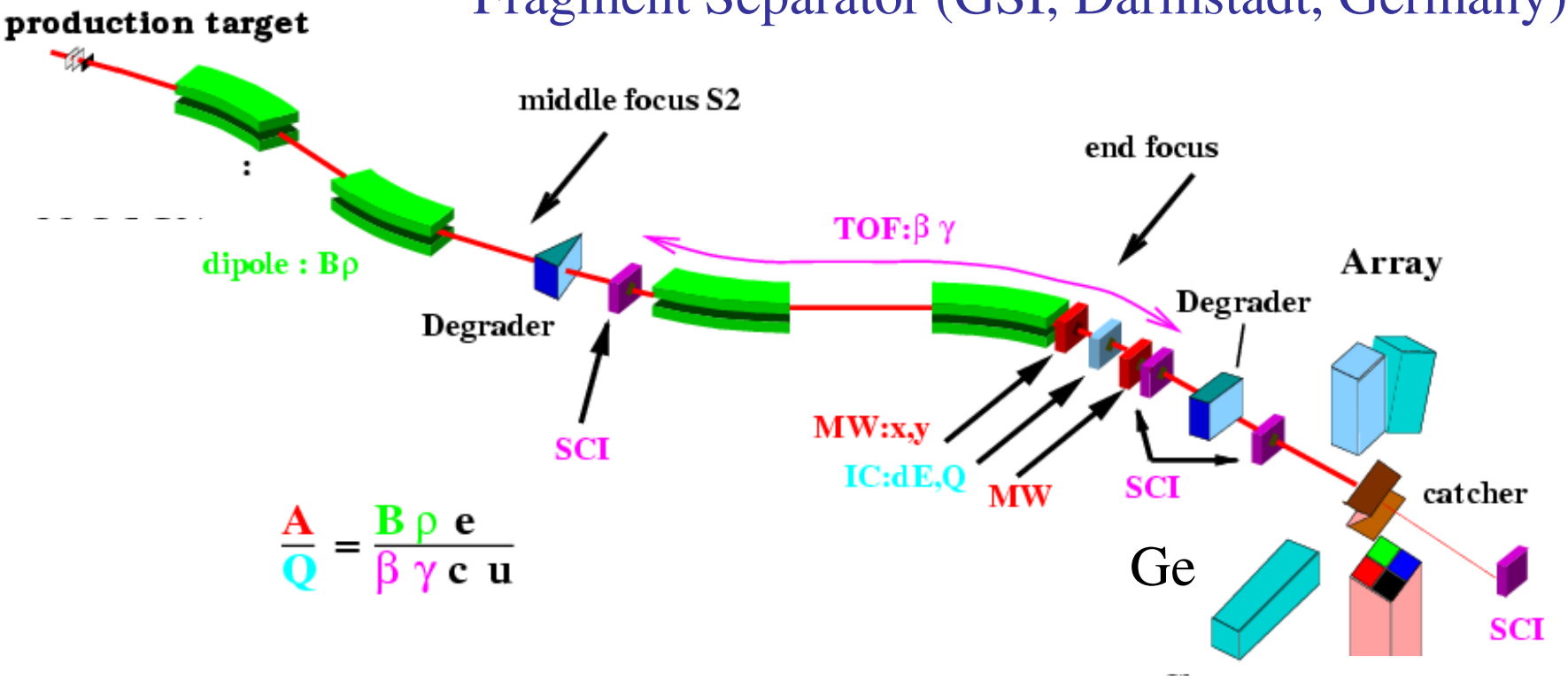
theory (^{112}Sn, ^{112}In)



I. Vidana et al., EPJ Web of Conferences 107, 10003 (2016)

In flight fragmentation: separation and identification

Fragment Separator (GSI, Darmstadt, Germany)



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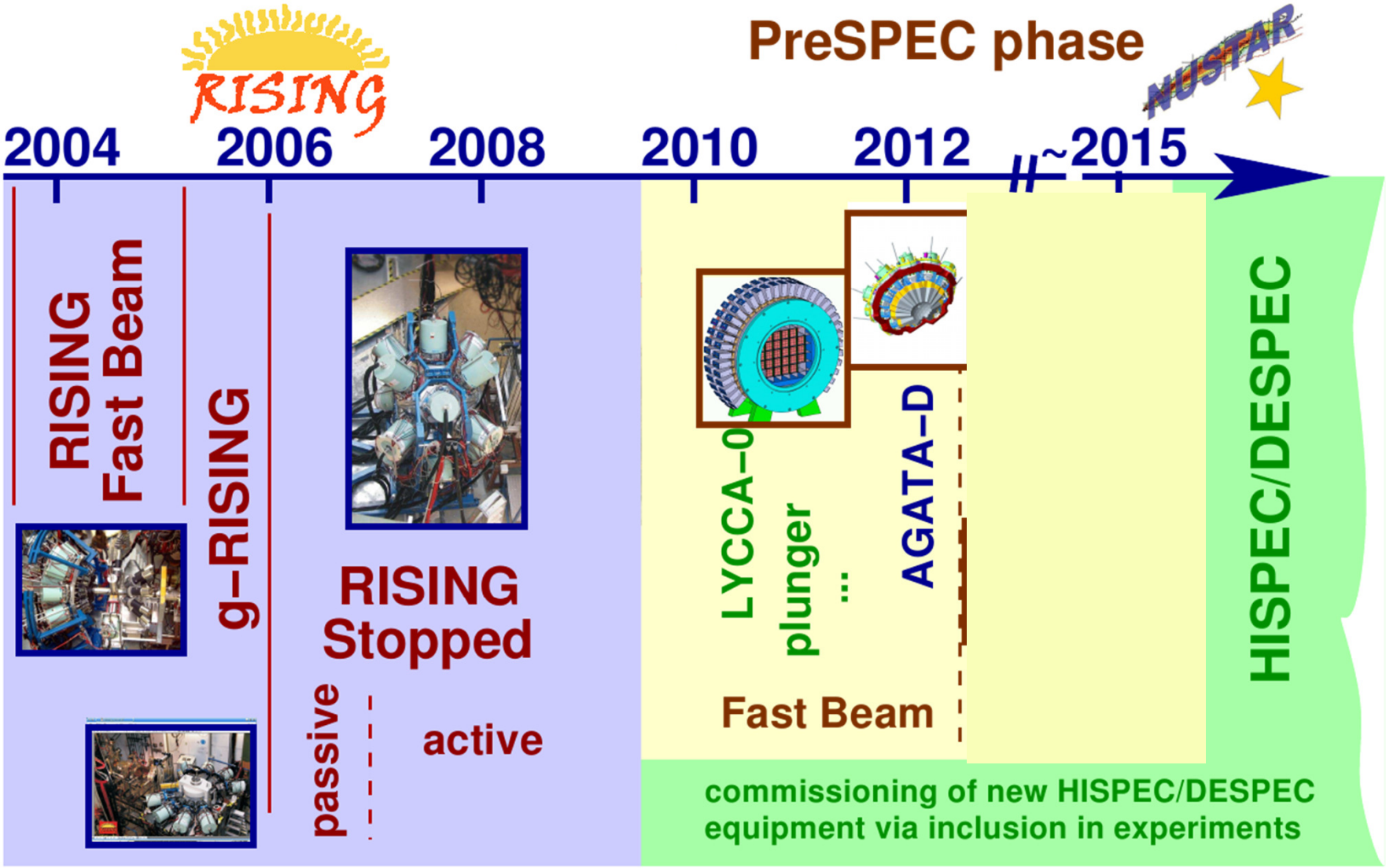
^{56}Fe beam at E/A=500 MeV.

^{54}Fe secondary beam stopped.

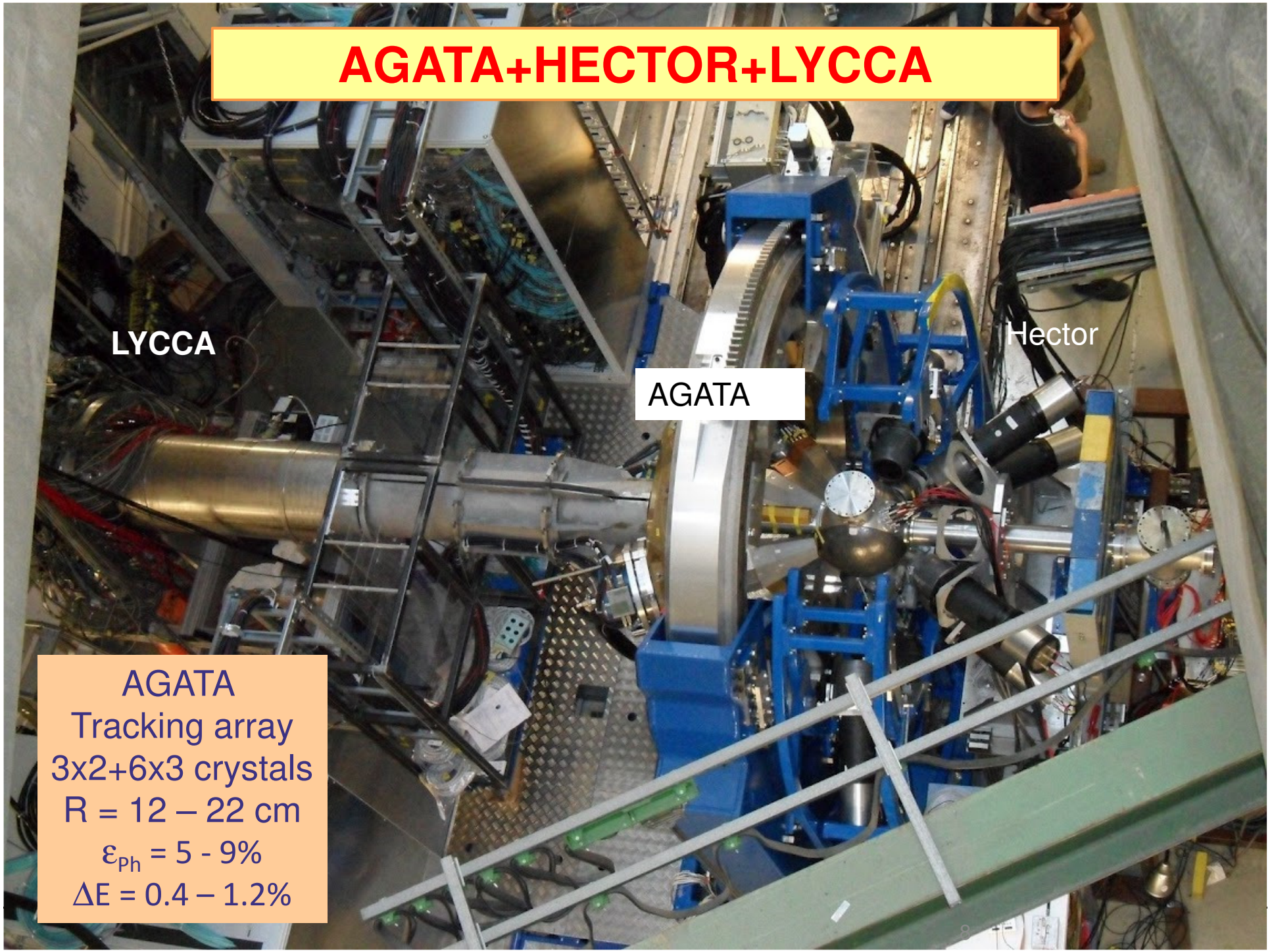
Isomeric decays detected with AGATA array.

γ-ray spectroscopy at GSI



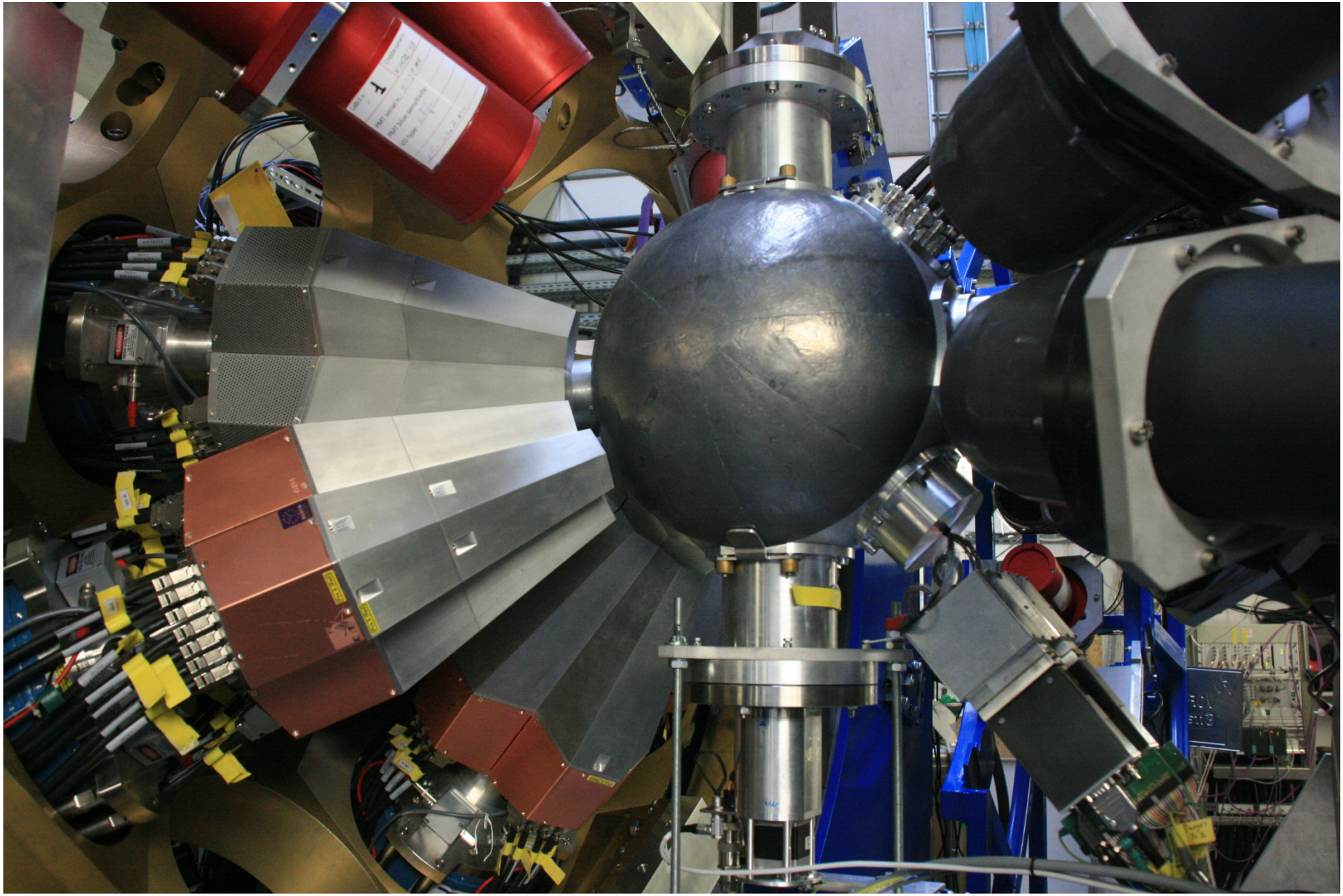
AGATA 2012-2014

AGATA+HECTOR+LYCCA

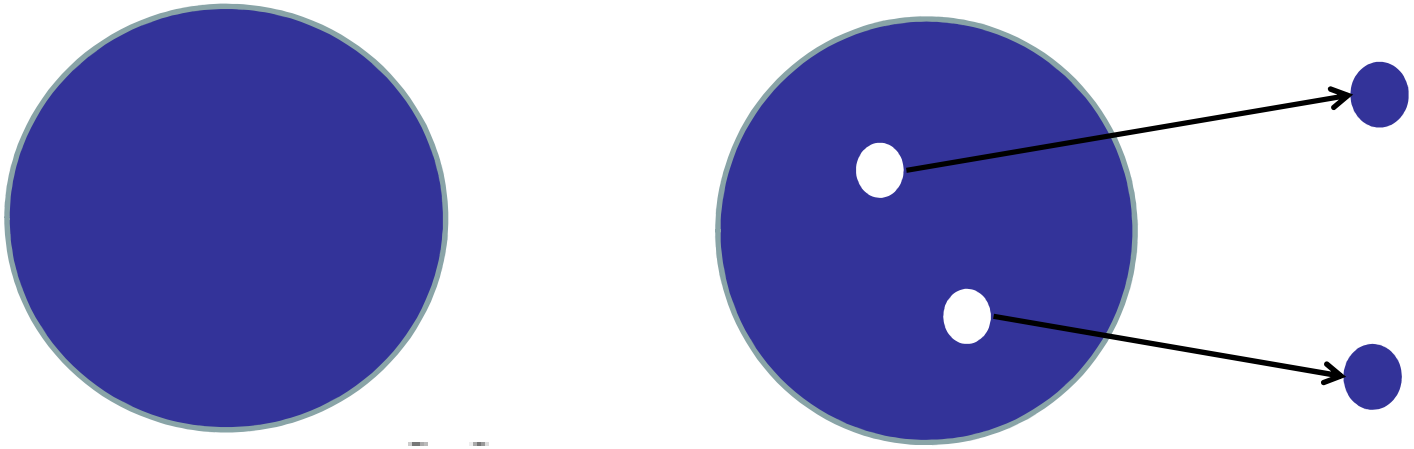


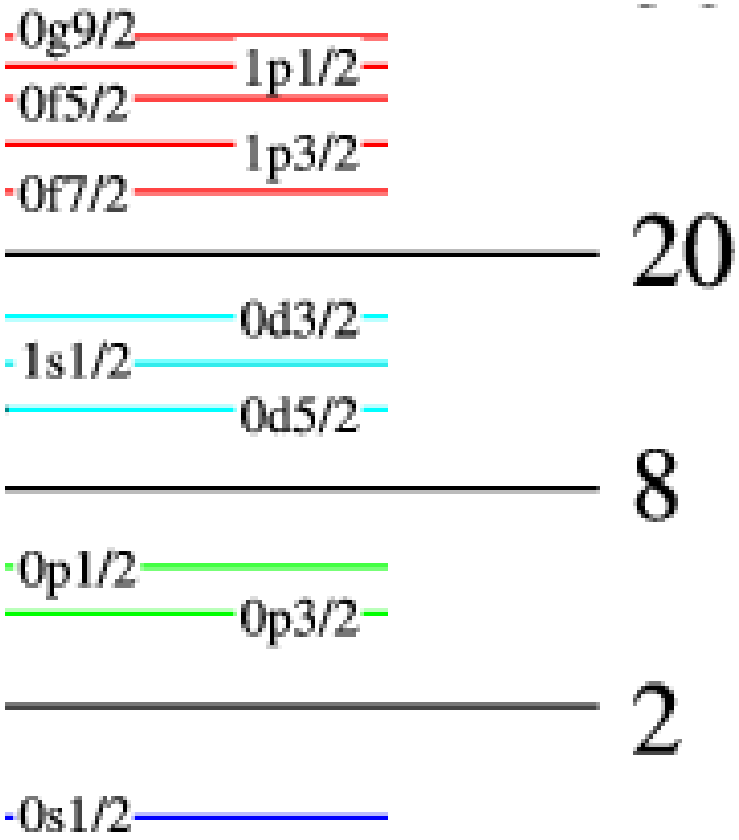
AGATA
Tracking array
3x2+6x3 crystals
R = 12 – 22 cm
ε_{Ph} = 5 - 9%
ΔE = 0.4 – 1.2%

AGATA demonstrator at GSI (Germany) ~20 crystals



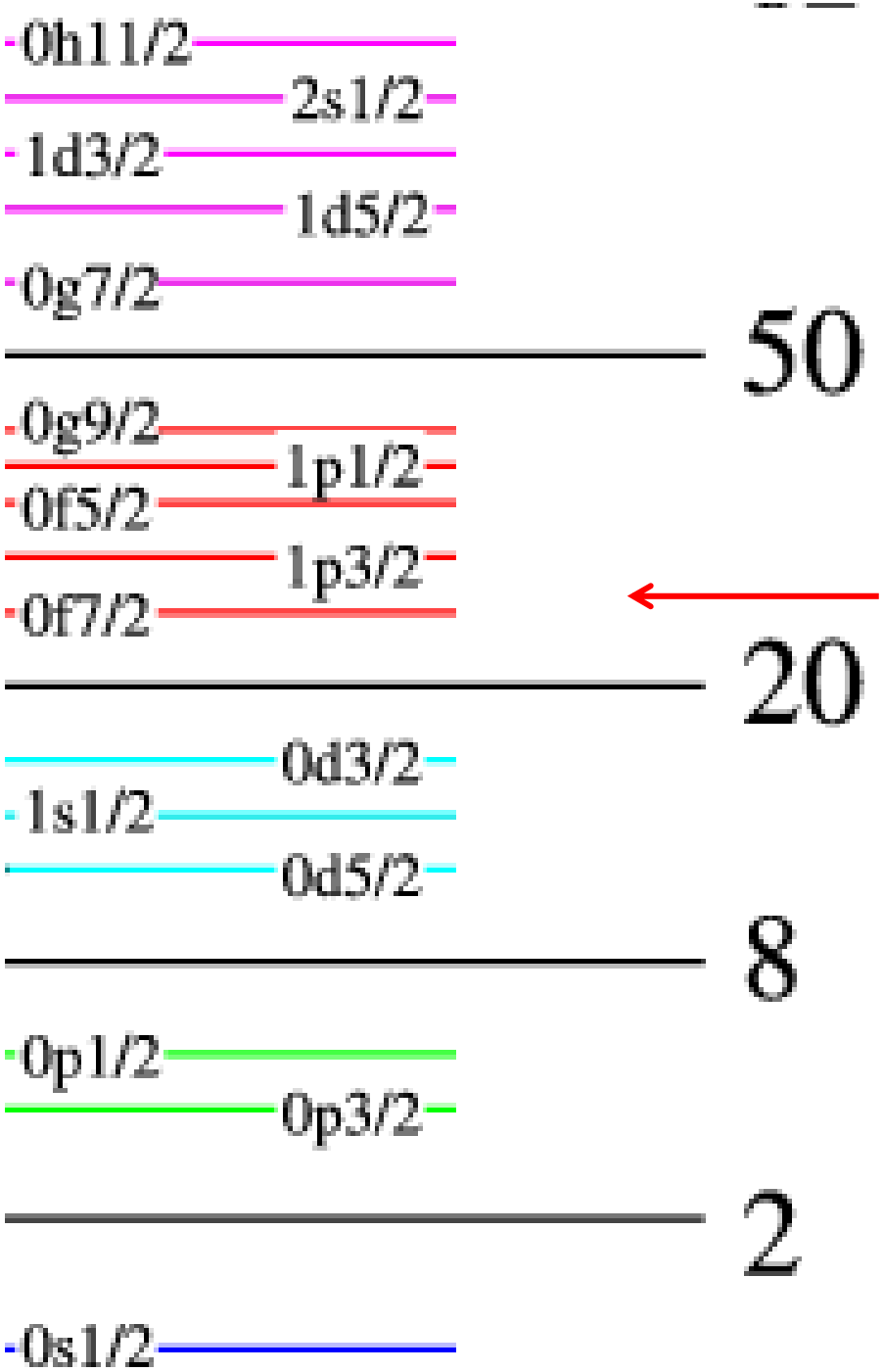
$^{56}Fe_{30}$ → $^{54}Fe_{28}$ + 2n





2 neutron states populated

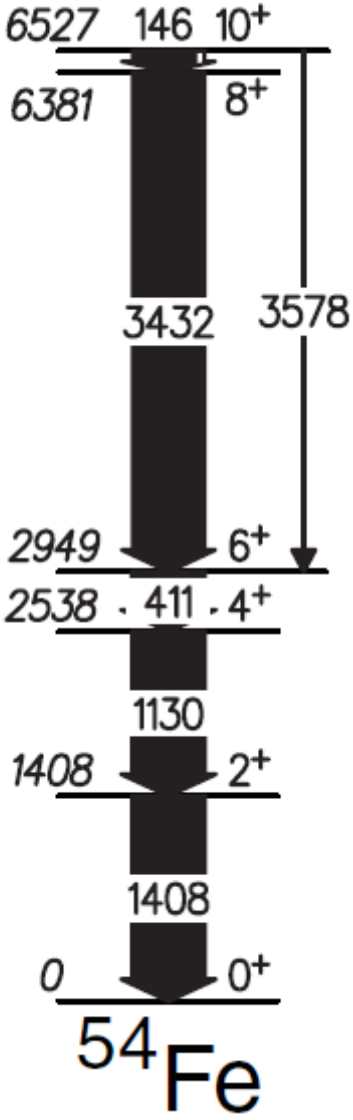
Max spin is 6



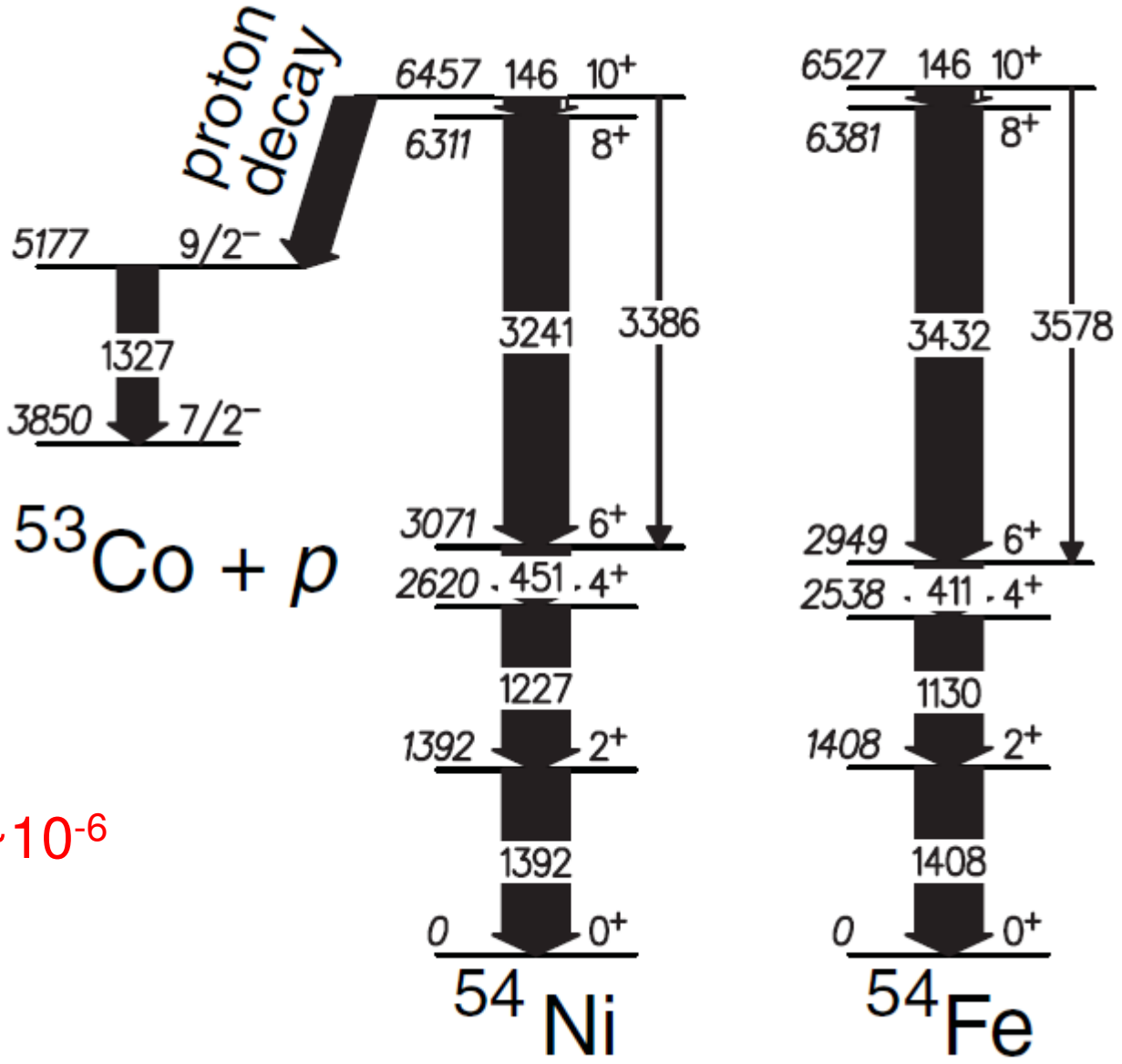
10^+ isomer in ^{54}Fe

$T_{1/2}$=364(7) ns

Predominantly $\pi f^{-2}_{7/2}\ \nu f^{-1}_{7/2} p_{3/2}$



$h^2_{11/2}$ component of the 10+ isomer?



l=5 proton decay

$h^2_{11/2}$ component ~10^{-6}

Very low!

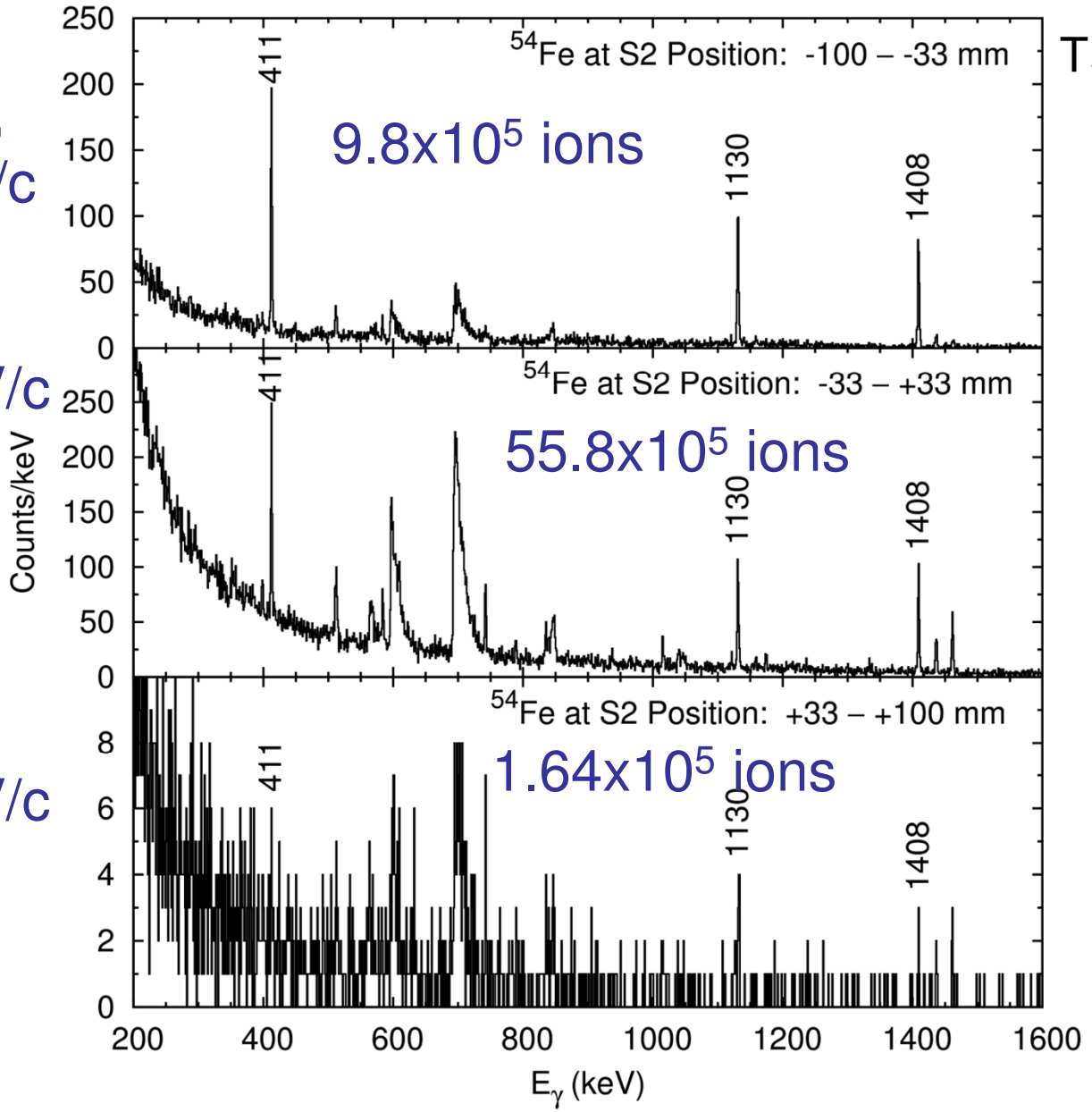
D. Rudolph *et al.*, Phys. Rev. C78, 021301(R) (2008).

Decay of the $I^{\pi}=10^{+}$ metastable state in ^{54}Fe

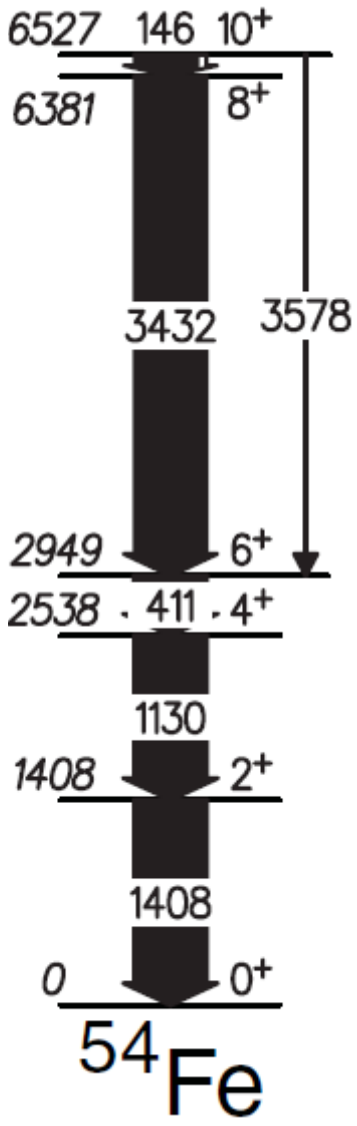
Δp = -750, -247 MeV/c

Δp= -247, +247 MeV/c

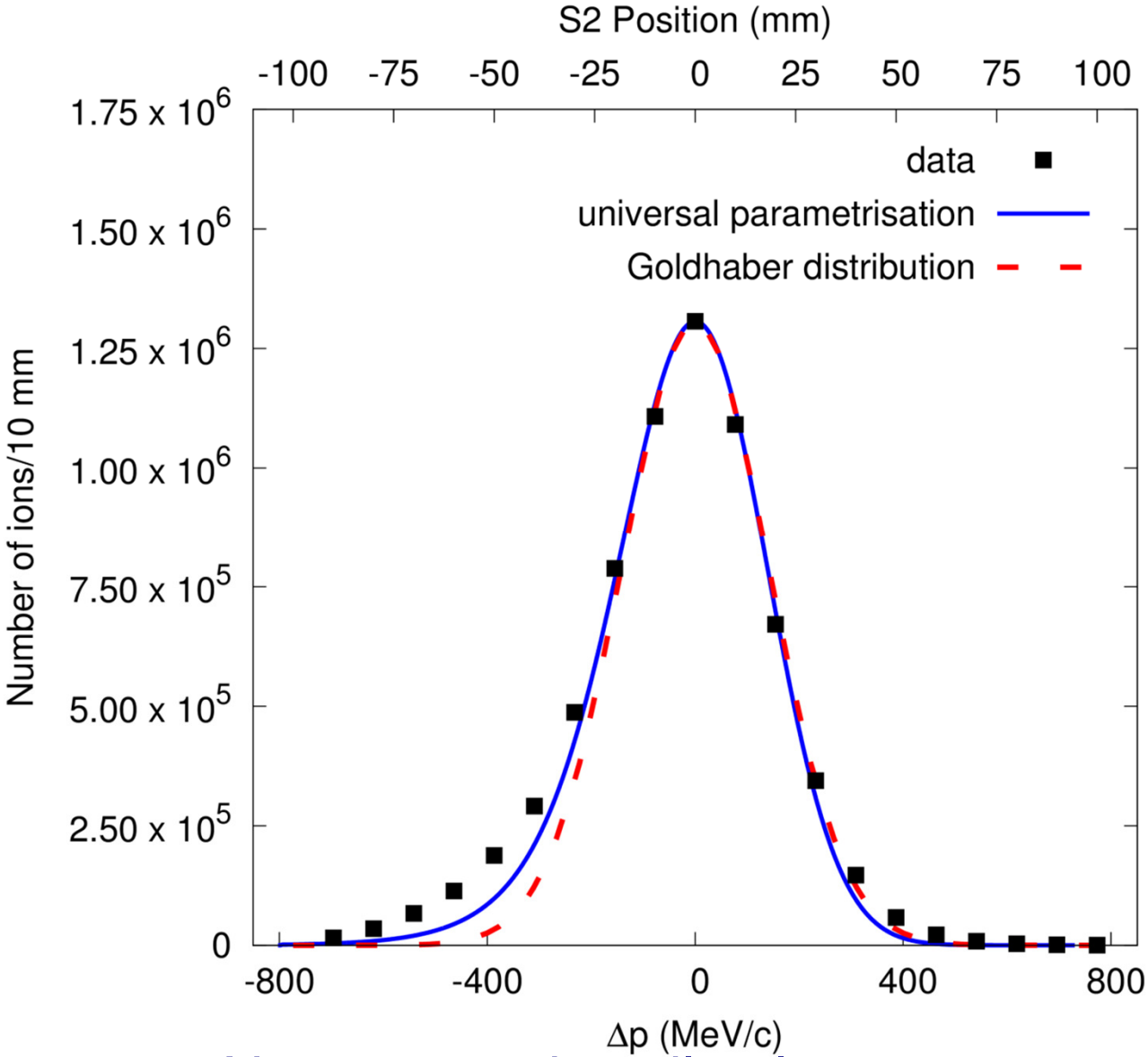
Δp= +247, +750 MeV/c



$T_{1/2}$=364(7) ns



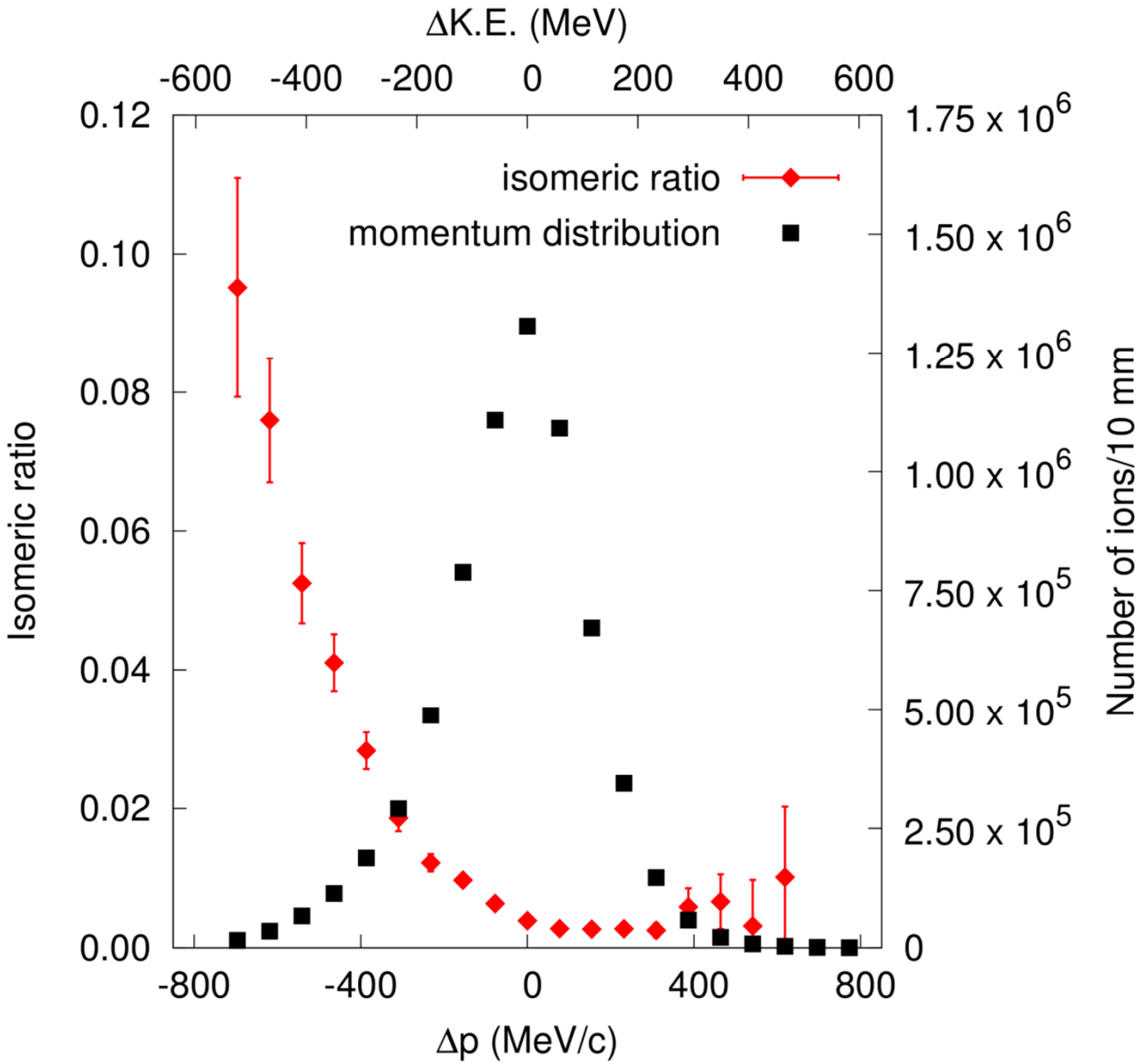
Momentum distribution of ^{54}Fe nuclei



Not symmetric: tail at low momentum

Universal distribution: O. Tarasov, NPA 734 (2000) 536

Isomeric ratio of the 10^+ isomer



=> the isomer is produced in the low momentum tail

Isomeric ratios following fragmentation

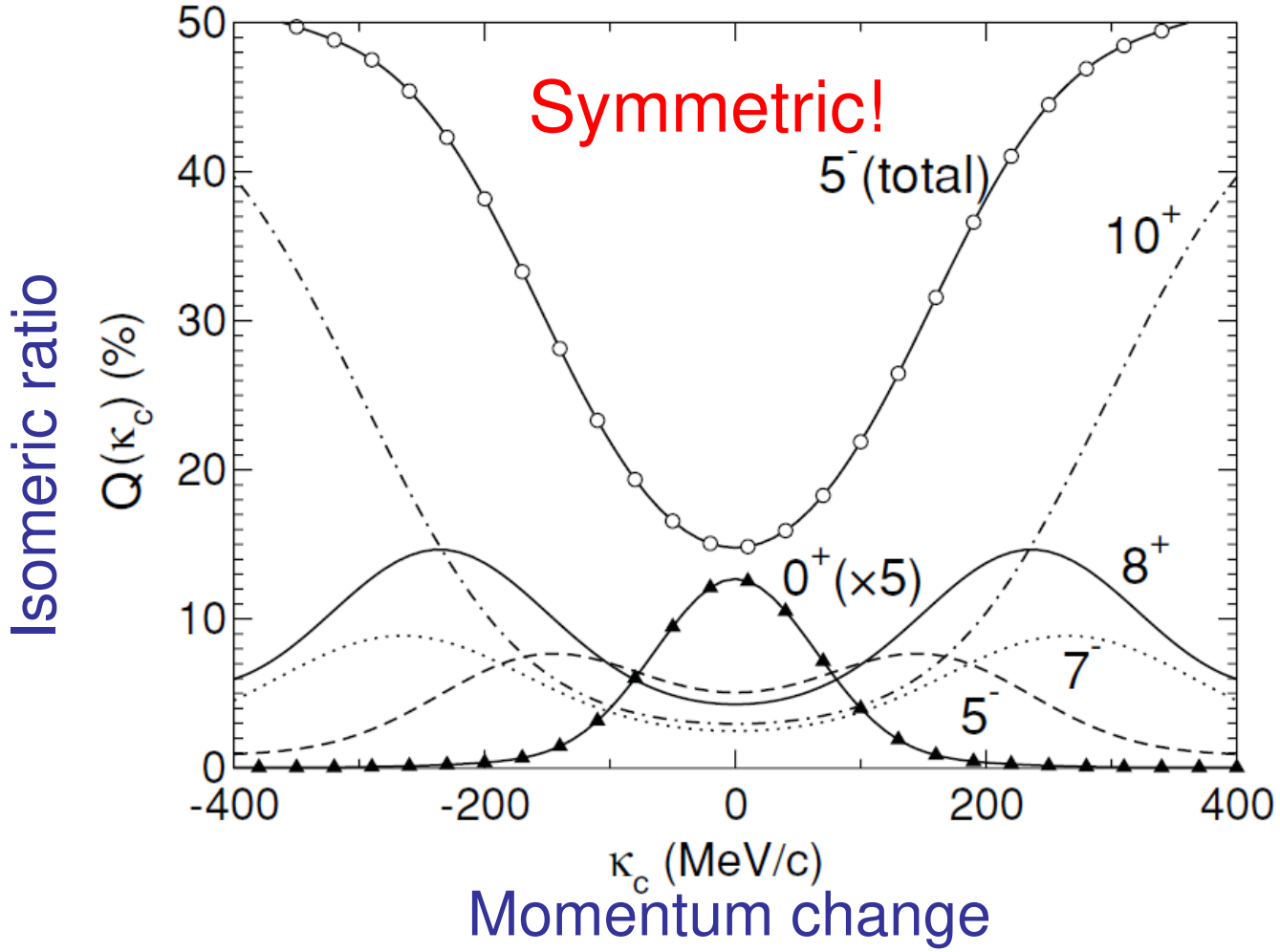
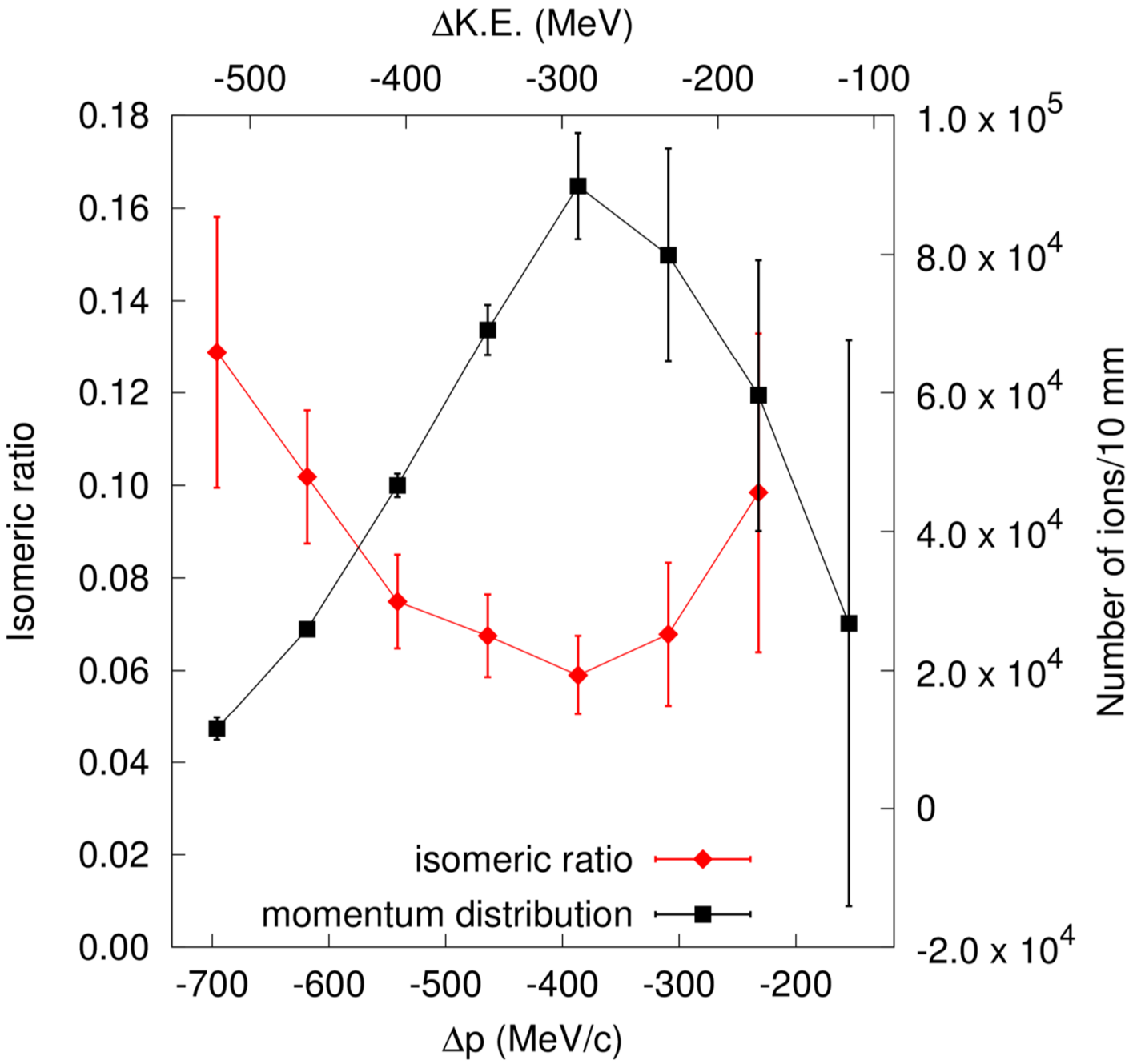


FIG. 2. Calculated isomeric ratios, as a function of residue momentum, in the projectile rest frame in the absence of broadening

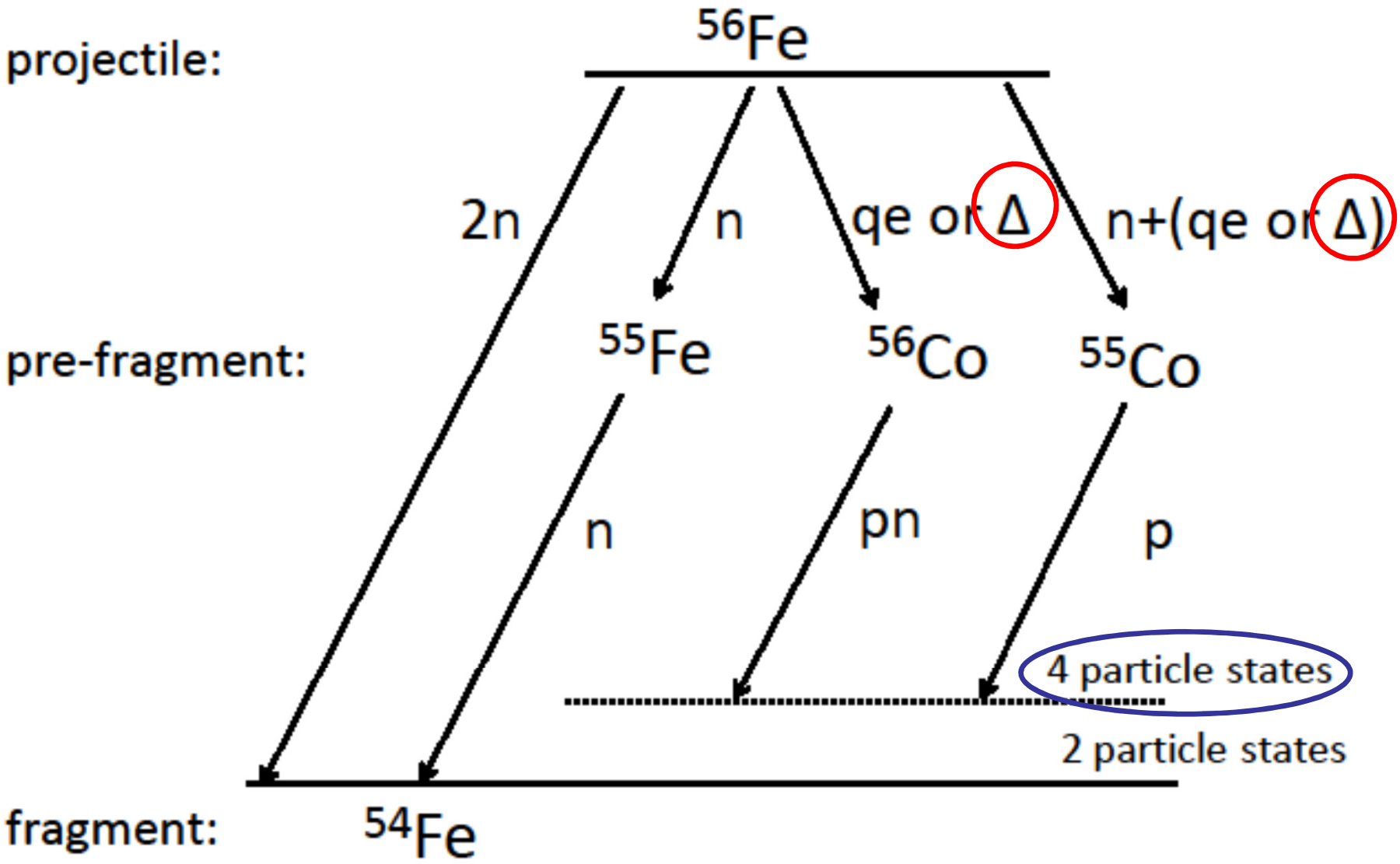
E.C. Simpson et al., Phys. Rev. C 82, 037602 (2010)

^{208}Pb -> ^{206}Hg

Population via nucleonic resonances



$^{56}Fe \rightarrow {}^{54}Fe$



qe=quasi-elastic

If Δ => kinetic energy/momentum shift

Conclusions

The 10^+ isomer in ^{54}Fe populated from ^{56}Fe at E/A=500 MeV
The 10^+ state is a four particle state
10^+ populated mainly at negative momentum transfer

=> It is populated via the Δ resonance

PRL **117,** 222302 (2016) PHYSICAL REVIEW LETTERS week ending 25 NOVEMBER 2016

Role of the Δ Resonance in the Population of a Four-Nucleon State in the ^{56}Fe → ^{54}Fe Reaction at Relativistic Energies

Zs. Podolyák,[1] C. M. Shand,[1] N. Lalović,[2,3] J. Gerl,[3] D. Rudolph,[2] T. Alexander,[1] P. Boutachkov,[3] M. L. Cortés,[3,4] M. Górska,[3] I. Kojouharov,[3] N. Kurz,[3] C. Louchart,[4] E. Merchán,[4] C. Michelagnoli,[5] R. M. Pérez-Vidal,[6] S. Pietri,[3] D. Ralet,[4,3] M. Reese,[4] H. Schaffner,[3] Ch. Stahl,[4] H. Weick,[3] F. Ameil,[3] G. de Angelis,[7] T. Arici,[3,8] R. Carroll,[1] Zs. Dombrádi,[9] A. Gadea,[6] P. Golubev,[2] M. Lettmann,[4] C. Lizarazo,[4,3] D. Mahboub,[10] H. Pai,[4] Z. Patel,[1] N. Pietralla,[4] P. H. Regan,[1] L. G. Sarmiento,[2] O. Wieland,[11] E. Wilson,[1] B. Birkenbach,[12] B. Bruyneel,[13] I. Burrows,[14] L. Charles,[15] E. Clément,[5] F. C. L. Crespi,[16,11] D. M. Cullen,[17] P. Désesquelles,[18] J. Eberth,[12] V. González,[19] T. Habermann,[4,3] L. Harkness-Brennan,[20] H. Hess,[12] D. S. Judson,[20] A. Jungclaus,[21] W. Korten,[13] M. Labiche,[14] A. Maj,[22] D. Mengoni,[23,24] D. R. Napoli,[7] A. Pullia,[16,11] B. Quintana,[25] G. Rainovski,[26] P. Reiter,[12] M. D. Salsac,[13] E. Sanchis,[19] and J. J. Valiente Dóbon[7]

PRESPEC-AGATA campaign

Thanks

END