UNIVERSITY OF SURREY

Differential isomeric ratios following two-proton knockout from ^{208}Pb

Workshop on Nuclear Isomers: Structure and Applications

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University of Surrey, May 2010

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Two-nucleon knockout

- Sudden removal of well-bound nucleons from fast beams on a light nuclear target, E > 80 MeV/nucleon

- Spectroscopic strengths and structural evolution probed via absolute cross sections and in-beam γ-ray spectroscopy

- Residue longitudinal momentum distributions give angular momentum information, final state spins

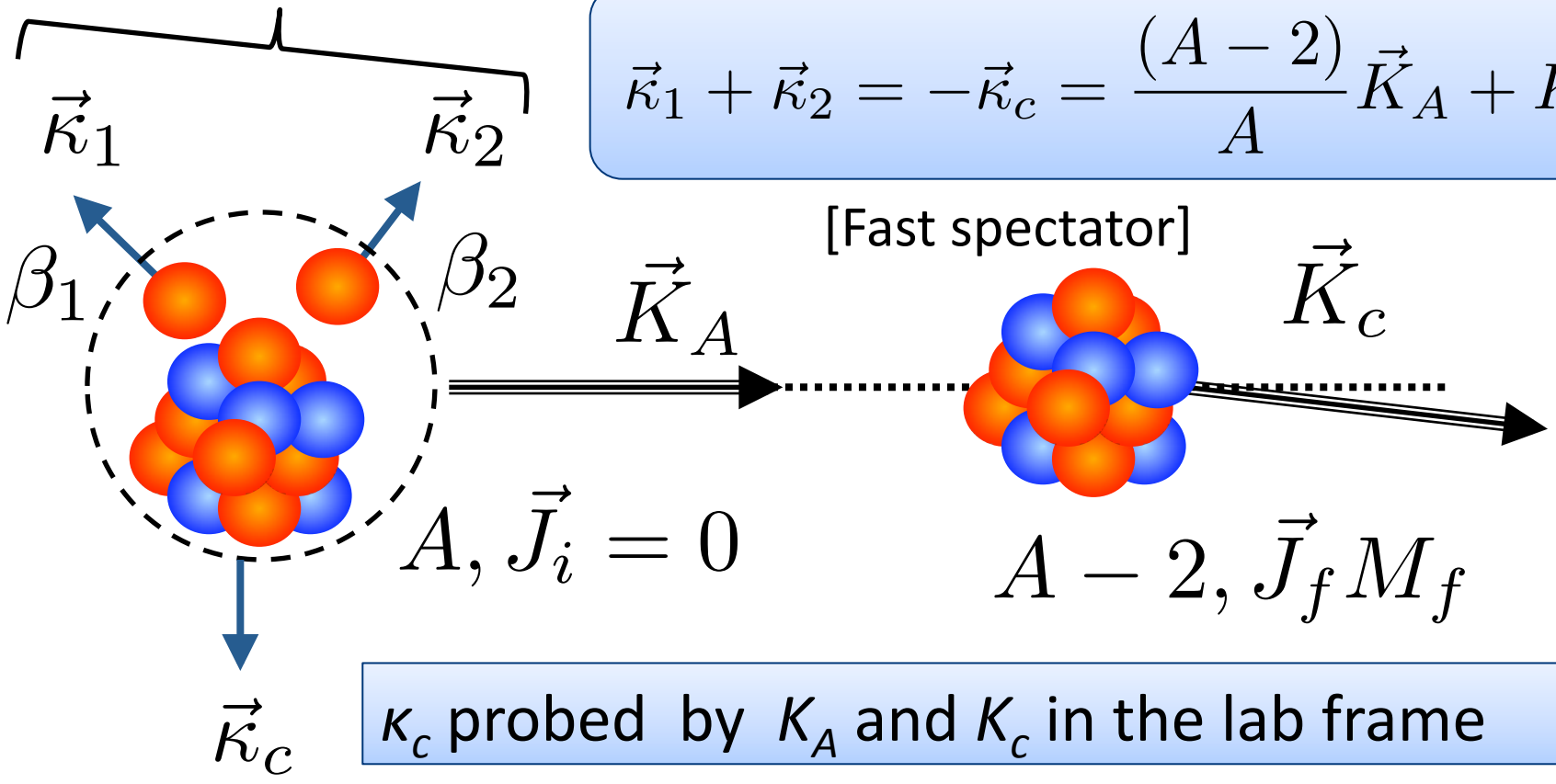
- First application to heavy systems and isomers in ^{206}Hg; Isomer production ratios for high spin isomers; slits alter isomeric ratio?

Residue momentum distributions

$$\vec{j}_1 + \vec{j}_2 = \vec{J}_f$$

Distribution sensitive to J_f

$$\vec{\kappa}_1 + \vec{\kappa}_2 = -\vec{\kappa}_c = \frac{(A-2)}{A}\vec{K}_A + \vec{K}_c$$



κ_c probed by K_A and K_c in the lab frame

[PRL 102, 132502 (2009); PRC 79, 064621 (2009)]

Calculation inputs

Two-nucleon overlap (J_i=0)

Two-nucleon amplitude (TNA)

$$\Psi_{JM} = \sum_{j_1 j_2} (-1)^{J-M} \frac{C(j_1 j_2 J)}{\sqrt{2J+1}} [\phi_{j_1} \otimes \phi_{j_2}]_{JM}$$

Two-nucleon wave function

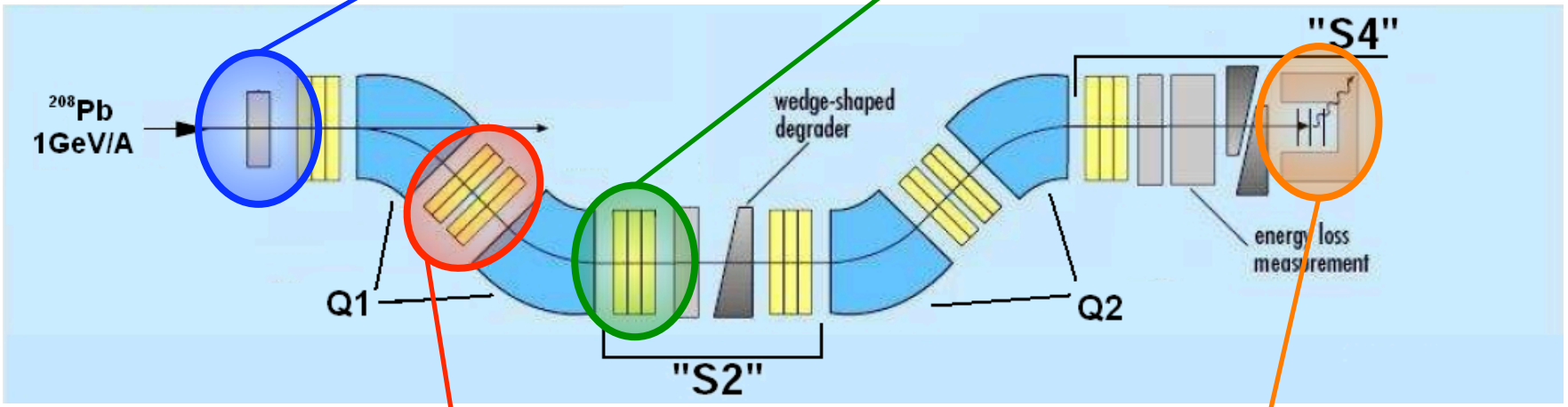
- Oxbash TNA using *khhe* interaction in proton [$2s_{1/2}$, $1d_{3/2}$, $0h_{11/2}$, $1d_{5/2}$, $0g_{7/2}$] model space
- Woods-Saxon radial wave functions, constrained by HF r.m.s. radii
- Glauber elastic S-matrices, density folding model, (HF calculations, reaction cross sections)

[PRC 70, 064602 (2004); PRC 74, 064604 (2006); EPJ ST 150 67 (2007)]

Isomer decay spec: FRS at GSI

Thick ^{9}Be reaction target: many final states populated, prompt decay unobserved, momentum distribution broadened

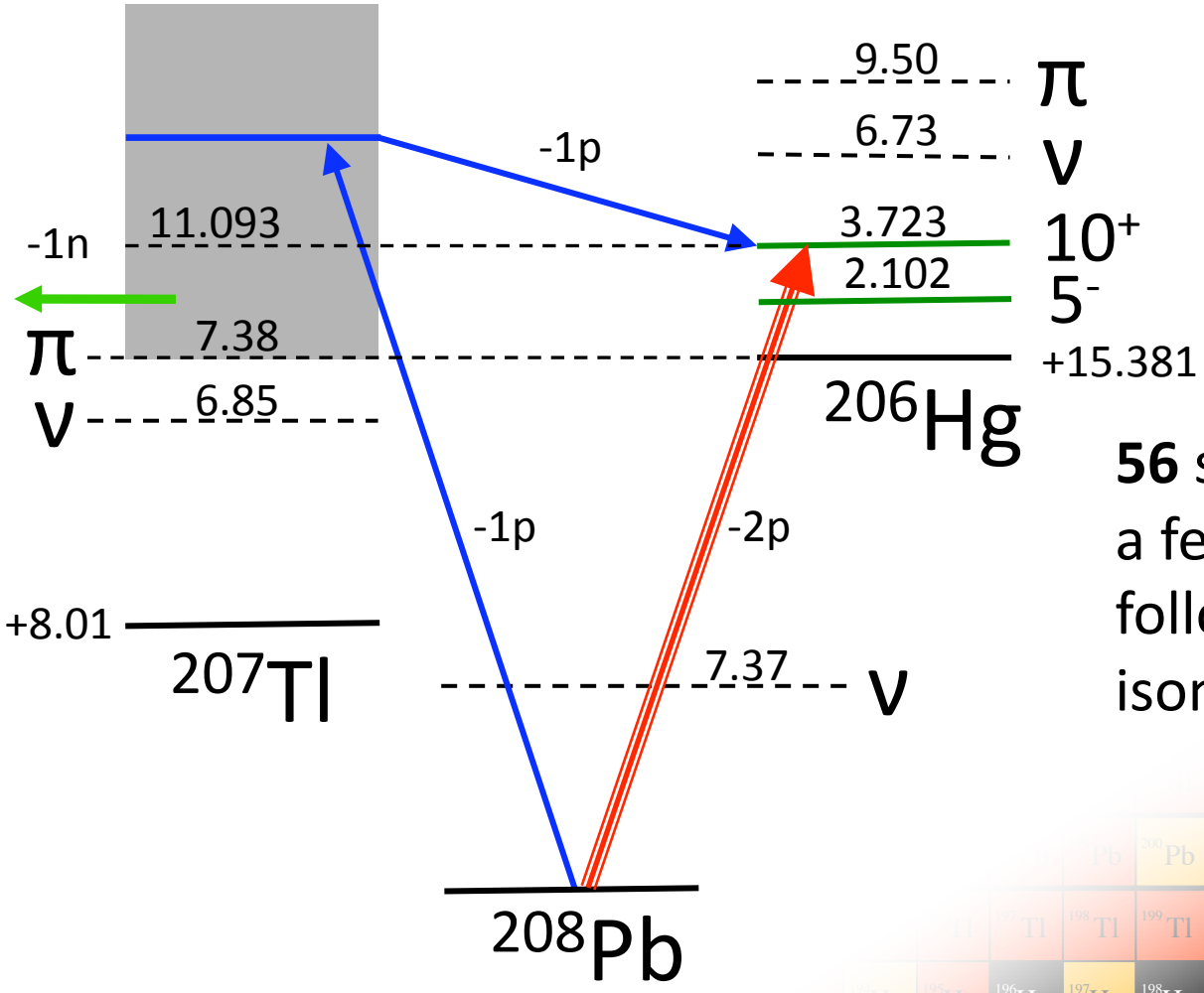
Fragment position measured at **S2** converted to momentum



S1 slits remove primary beam but cut residue momentum distribution (not at focal plane!)

Residues stopped and **isomer decay** observed

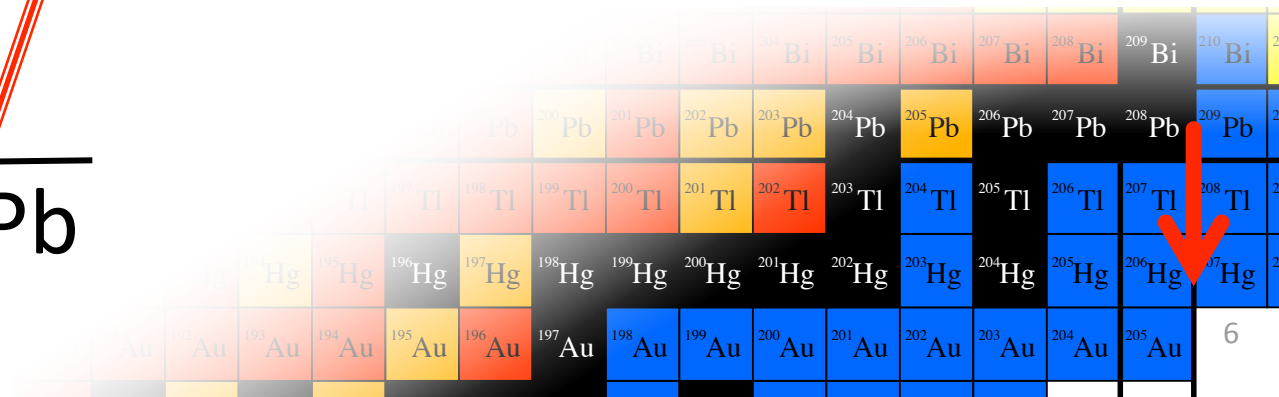
Thresholds and isomers



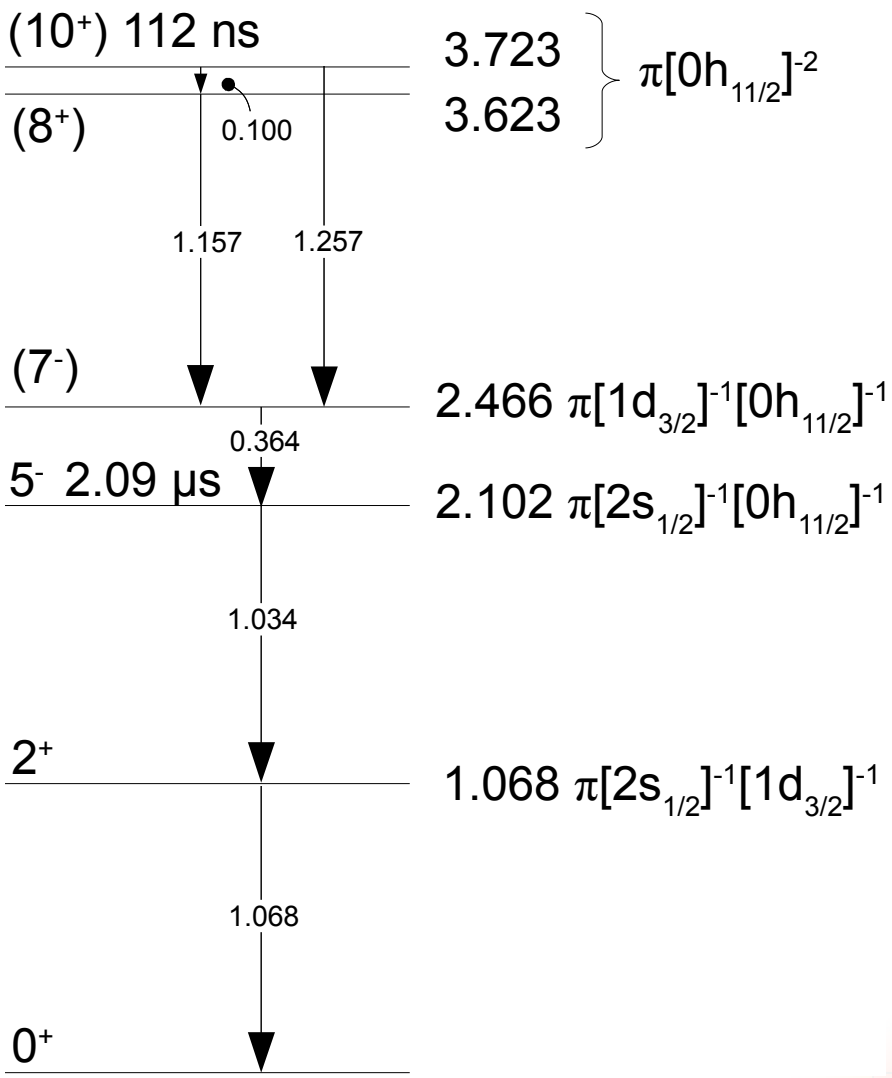
π: $2s_{1/2}$, $1d_{3/2}$, $0h_{11/2}$, $1d_{5/2}$, $0g_{7/2}$

5^- and **10^+** isomers are populated. **7^-** and **8^+** states are observed in subsequent gamma cascades

56 states are populated, only a few of which are observed following the decay of the isomeric states



Observed states and transitions



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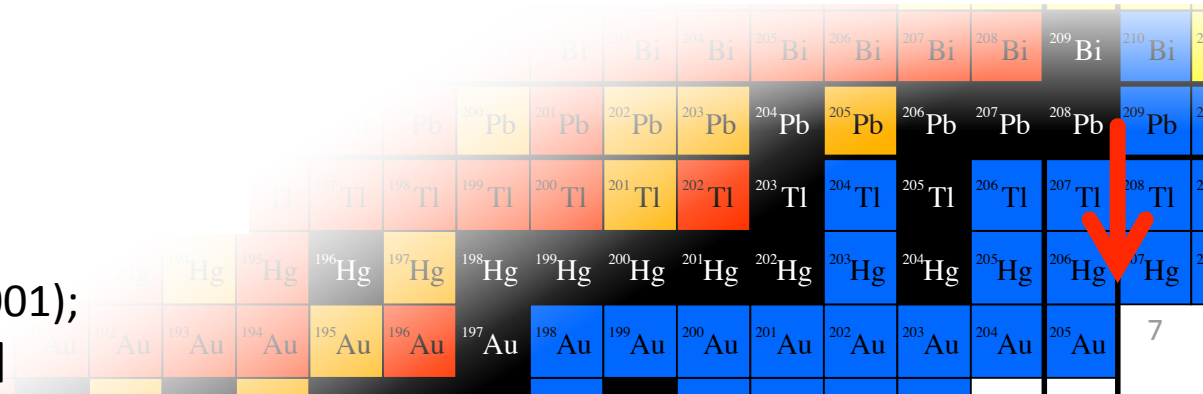


[Pfützner *et al.*, PRC 65, 064604 (2001); Fornal *et al.*, PRL 87, 212501 (2001)]

Isomeric Ratios

- Reasonable agreement once feeding is included
- Unobserved feeding?
- Cuts on momentum?

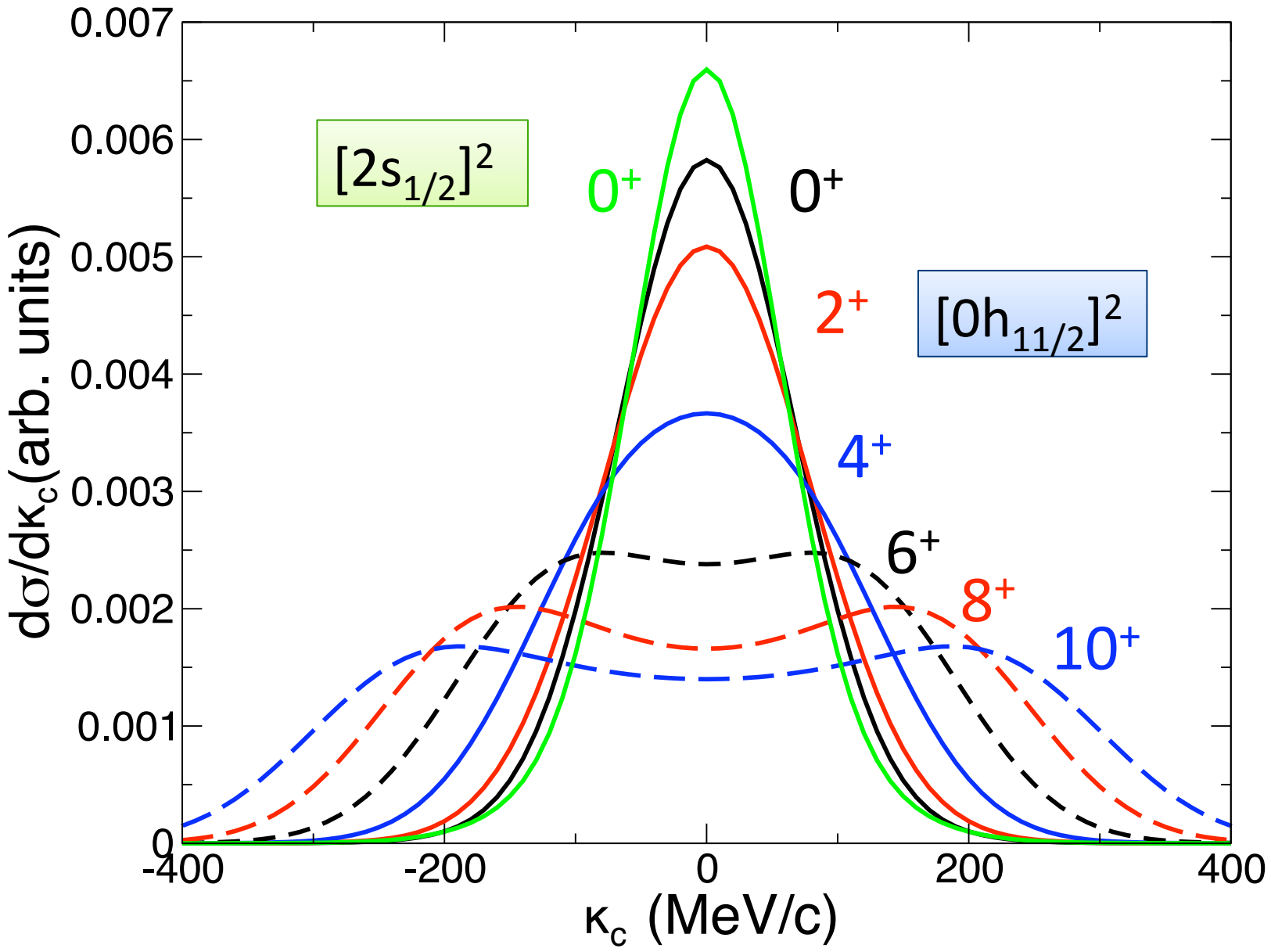
$$R_I = \frac{\sigma_I}{\sigma_T} = \frac{\int dK_A\, \sigma_I(K_A)}{\int dK_A\, \sigma_T(K_A)}$$

$$\sigma(K_A) \equiv \frac{d\sigma}{dK_A}$$

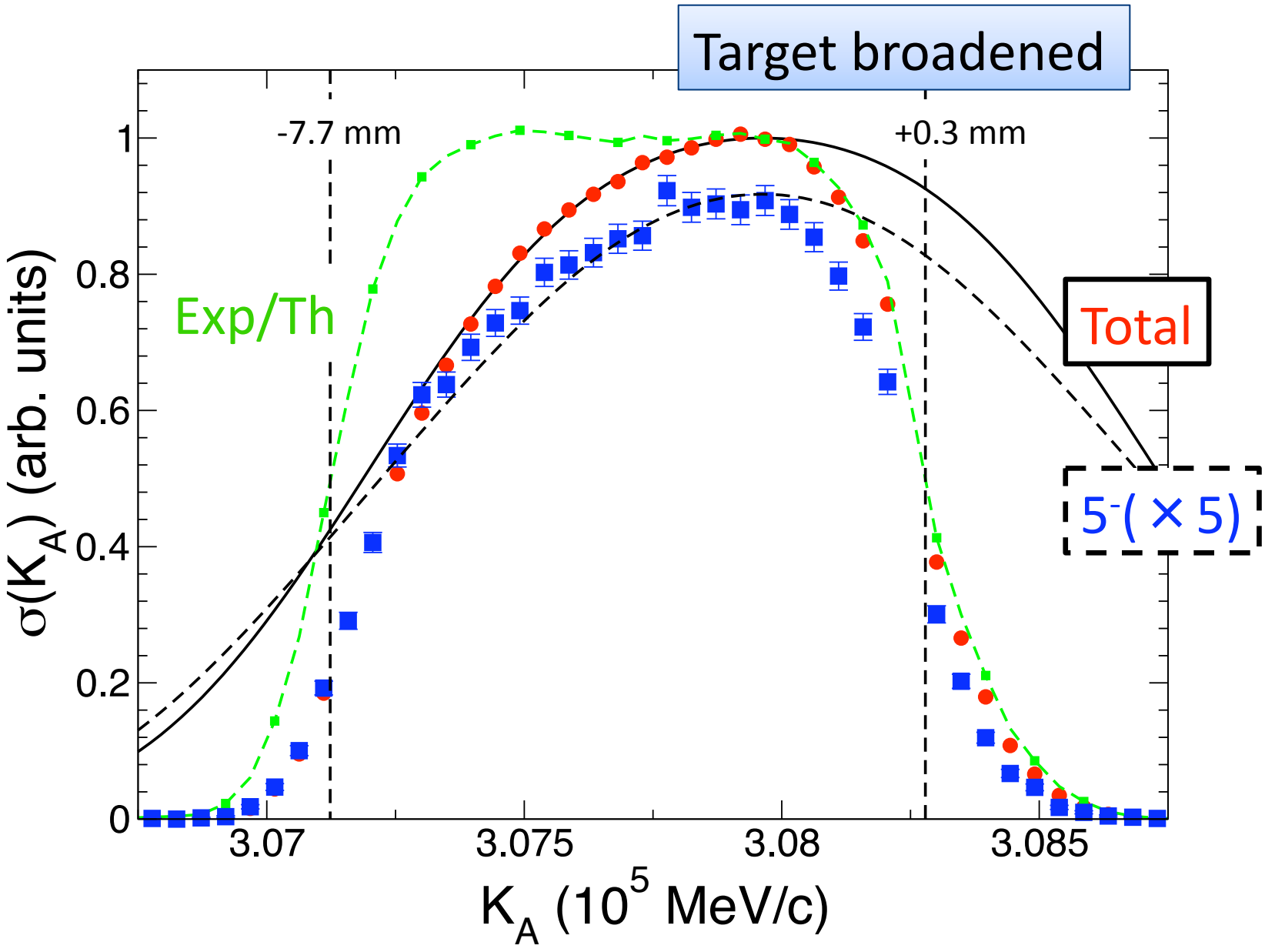
Isomeric state	Isomeric ratio, R_I (%)
5^- (exp)	21.9(+1.2,-2.9)
5^- (theory)	4.8
5^- (theory: 5^-, 7^-, 8^+, 10^+)	18.8 [Unobserved feeding?]
10^+ (exp)	3.1(+1.0,-1.2)
10^+ (theory)	4.7 [Differential cutting by slit?]

[PRC 78, 061302 (2008); Int. J. Mod. Phys. E 18, 1002 (2008); PRC 80, 064608 (2009)]

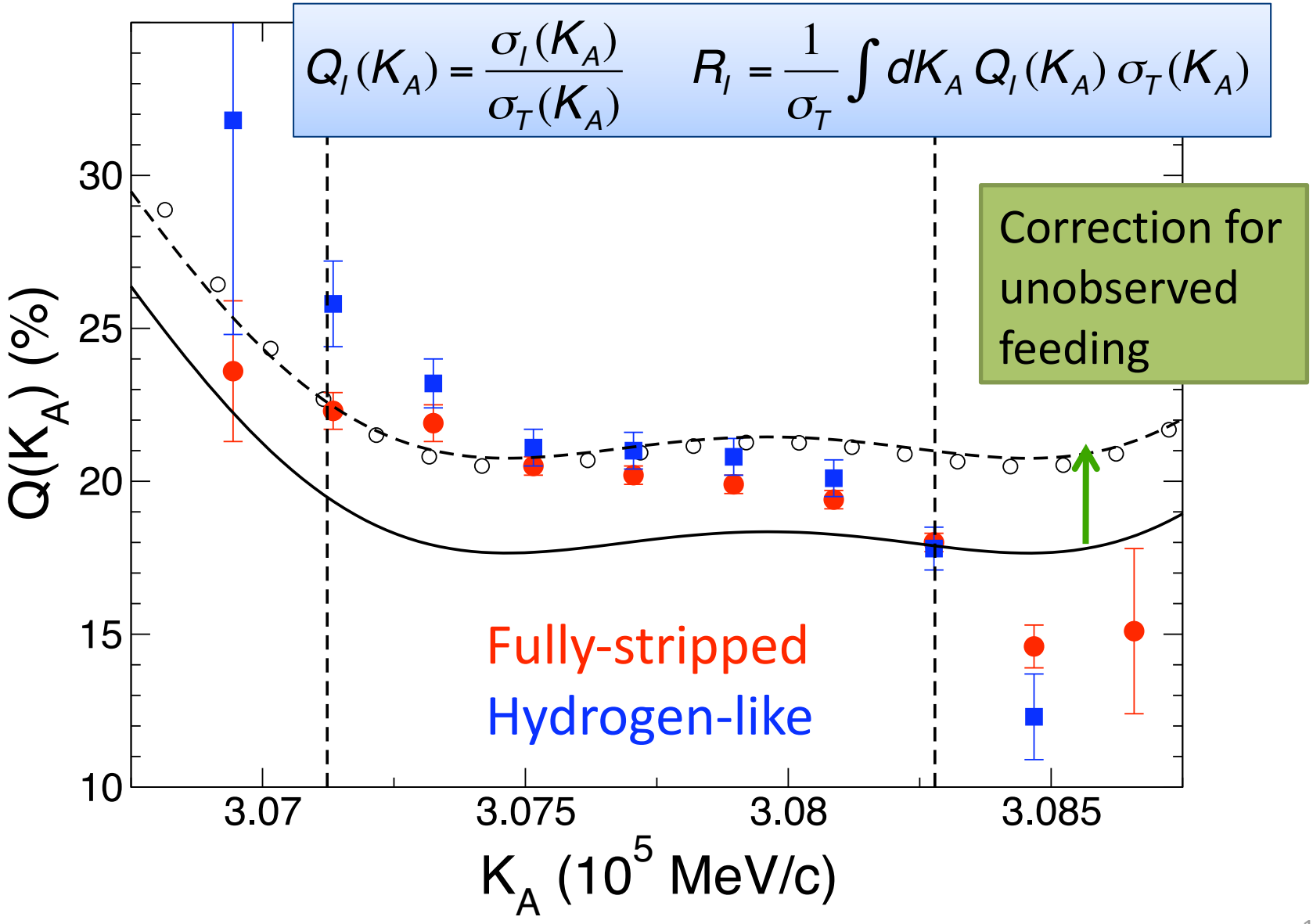
^{208}Pb(-2p) $[0h_{11/2}]^2$ Distribution



^{206}Hg momentum distributions

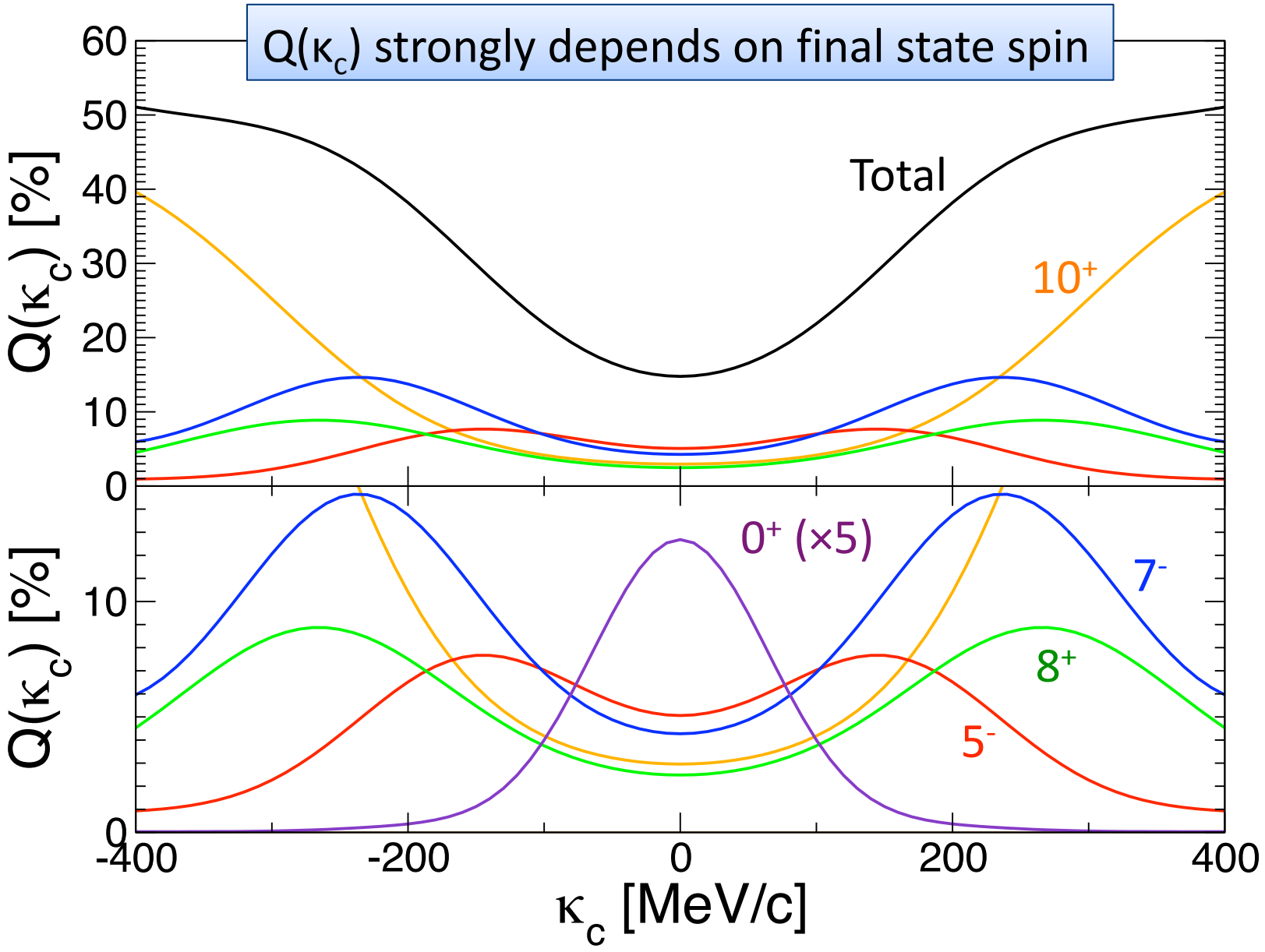


^{206}Hg differential isomeric ratios



[Daugas *et al.*, PRC 63, 064609 (2001); Schmidt-Ott *et al.*, Z. Phys. A. 250, 215 (1994)]

$Q(\kappa_c)$: zero-thickness target



Conclusions

- ^{208}Pb(-2p) calculations reproduce observed isomeric ratios and (strongly broadened) experimental momentum distributions

- Residue momentum distributions and differential isomeric ratios allow determination of final state spin; thin targets beneficial

- Cuts in the residue momentum could alter measured isomeric ratios, particular for near-beam residues

- Deformed systems: Isomers population? Momentum distributions? Isomeric beams?

Acknowledgements

Collaborators

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B. A. Brown

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^{208}Pb(-2p) ⟶ ^{206}Hg(J_f=3$^+$)