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PHOTON STRENGTH FUNCTIONS & NUCLEAR LEVEL DENSITIES: RECENT DEVELOPMENTS IN PHOTONUCLEAR REACTION STUDIES

- A NEW APPROACH TO SPIN-PARITY RESOLVED NUCLEAR LEVEL DENSITIES -

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Compound-Nuclear Reactions and Related Topics (CNR*24)

SFB 1245 LOEWE Nuclear Photonics ELEMENTS

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CHALLENGES

- measured signal (= reaction rates) not necessarily proportional to NLD & PSF
- model-dependent assumptions in reaction theory and/or data analysis

- selectivity for groups of nuclear states (= spin- and parity quantum numbers)

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CHALLENGES

- measured signal (= reaction rates) not necessarily proportional to NLD & PSF
- model-dependent assumptions in reaction theory and/or data analysis

  ➢ **pure electromagnetic interaction (nuclear-)model independent**

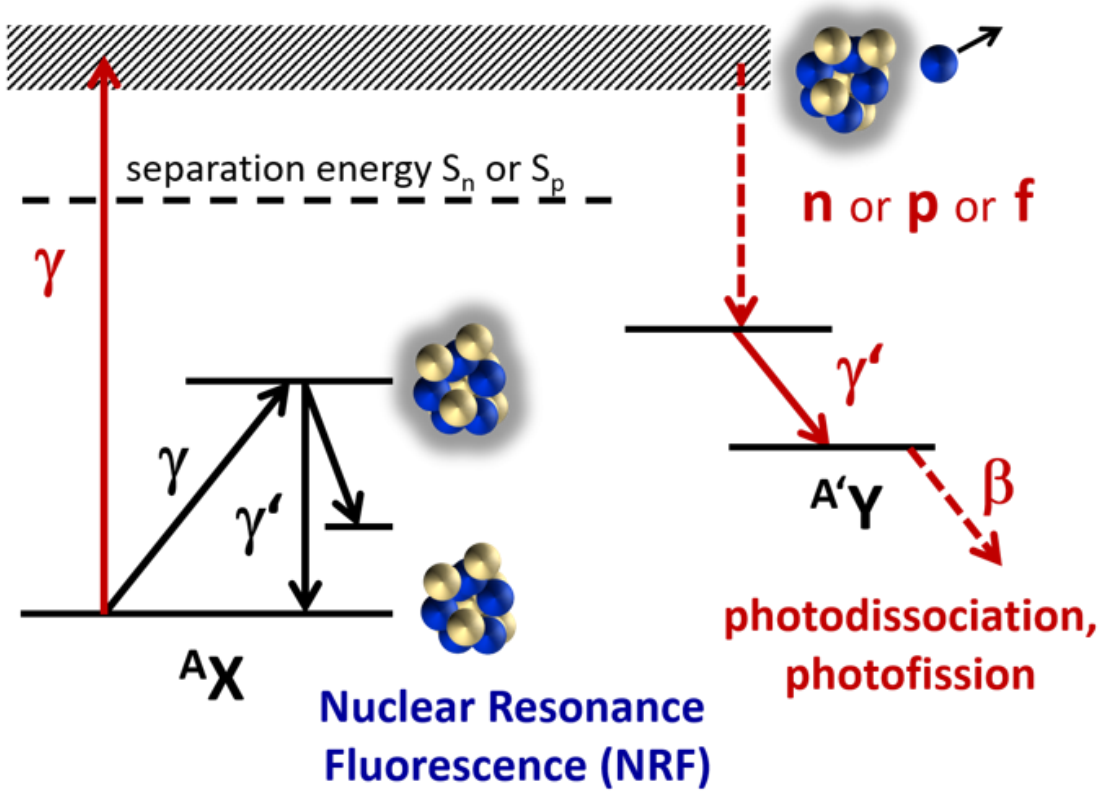
- selectivity for groups of nuclear states (= spin- and parity quantum numbers)

  ➢ **minimum projectile mass min. angular momentum transfer**

  ➢ **polarization parity-related observables**

  ➢ **narrow bandwidth explore specific excitation energy**

PHOTONUCLEAR REACTIONS



A. Zilges, D. L. Balabanski, J. Isaak, N. Pietralla, PPNP 122 (2022) 103903.

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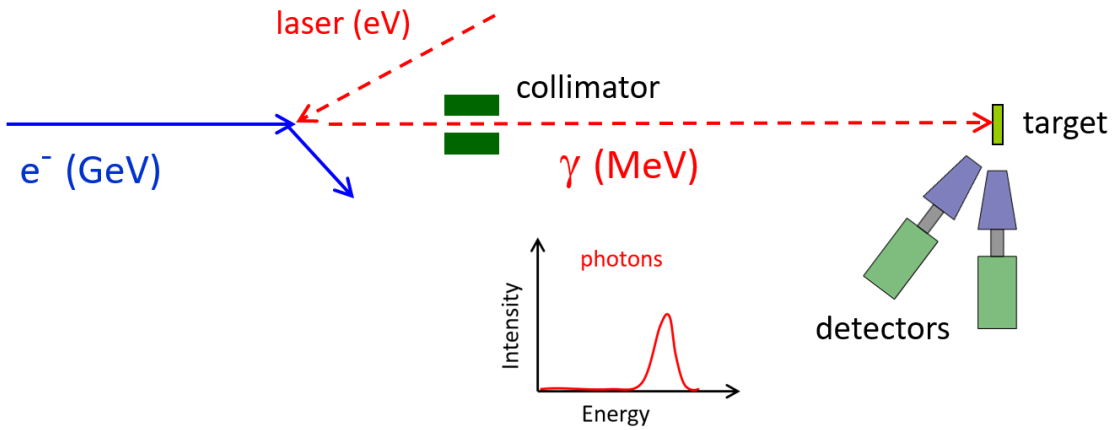
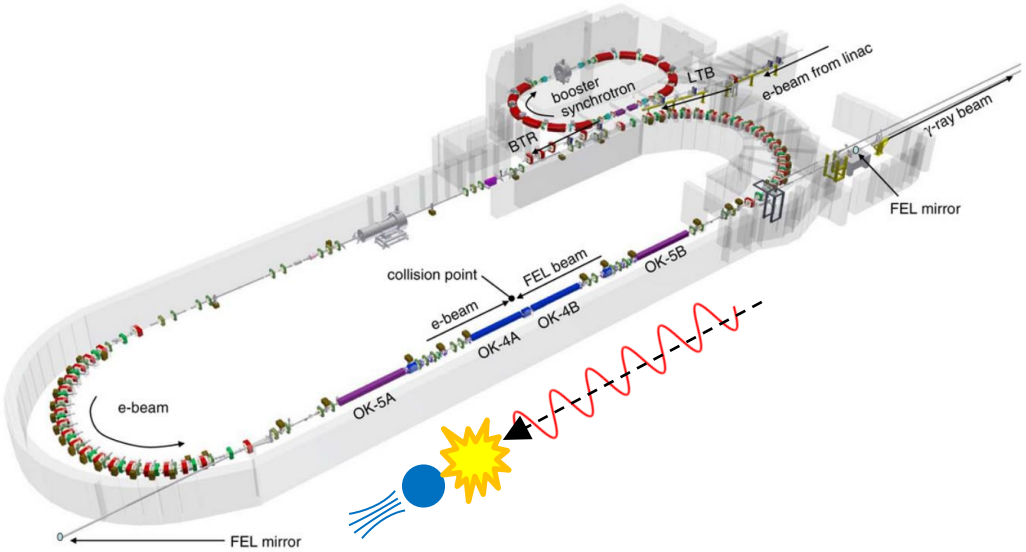
Laser-Compton Backscattering



- quasi-monoenergetic
- variable photon beam energies
- linear and circular polarization

High Intensity γ-ray Source (HIγS) at Duke University



- $\Delta E/E$ ~ 1 – 10 %
- E_{beam} ~ 1 – 100 MeV
- beam intensity ~ 3000 photons $s^{-1}eV^{-1}$

H.R. Weller et al., Prog. Part. Nucl. Phys. 62 (2009) 257.

METHOD | NUCLEAR SELFABSORPTION

Metzger, PNP 7 (1959) 53.
Pietralla et al., PRC 51 (1995) 1021.
Romig et al., PLB 744 (2015) 369-374.

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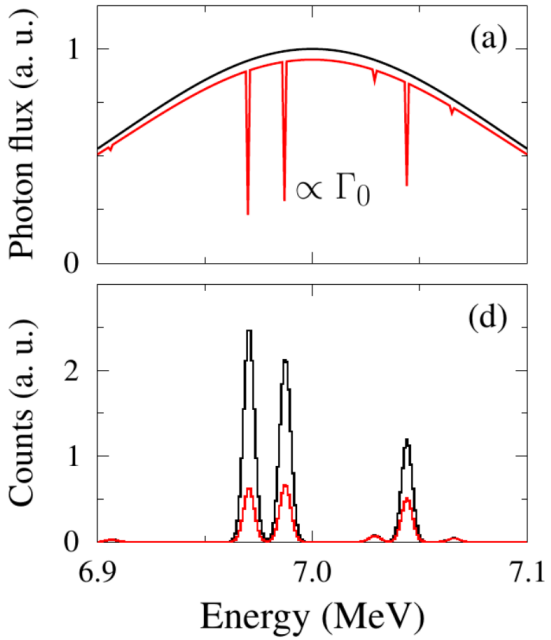

- RSA on a single state → $I_{abs} \propto \Gamma_0$

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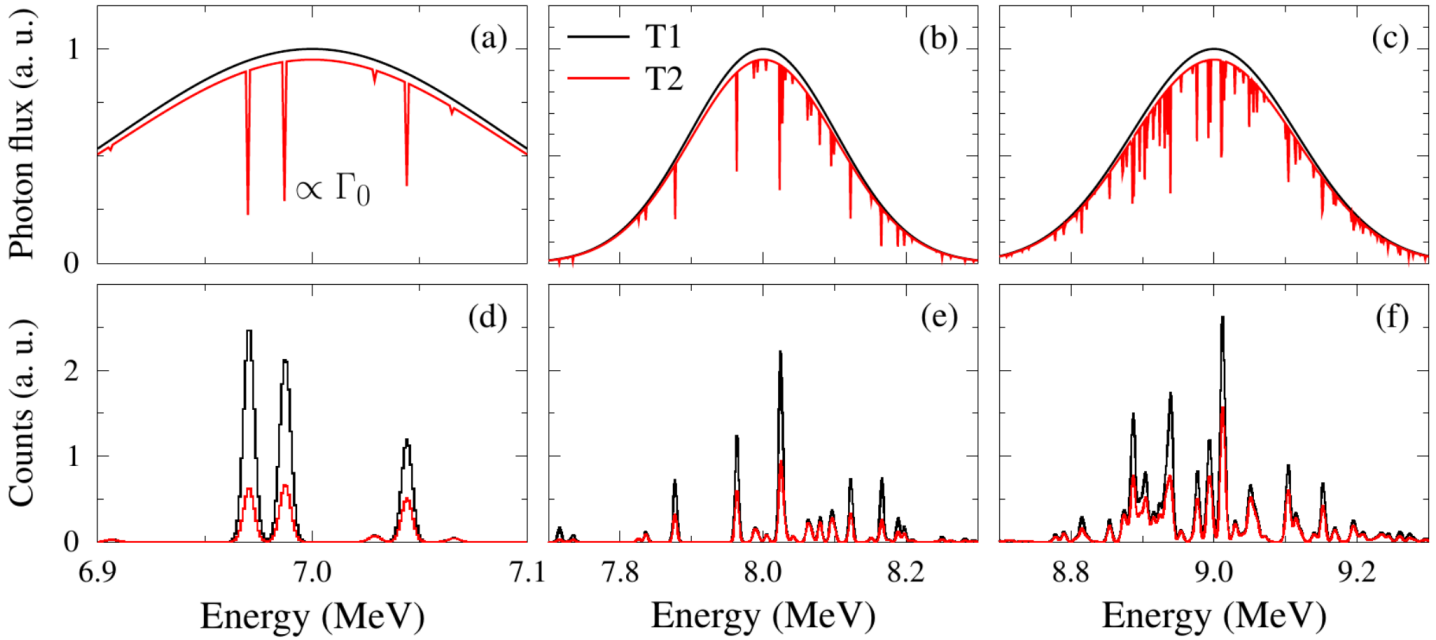
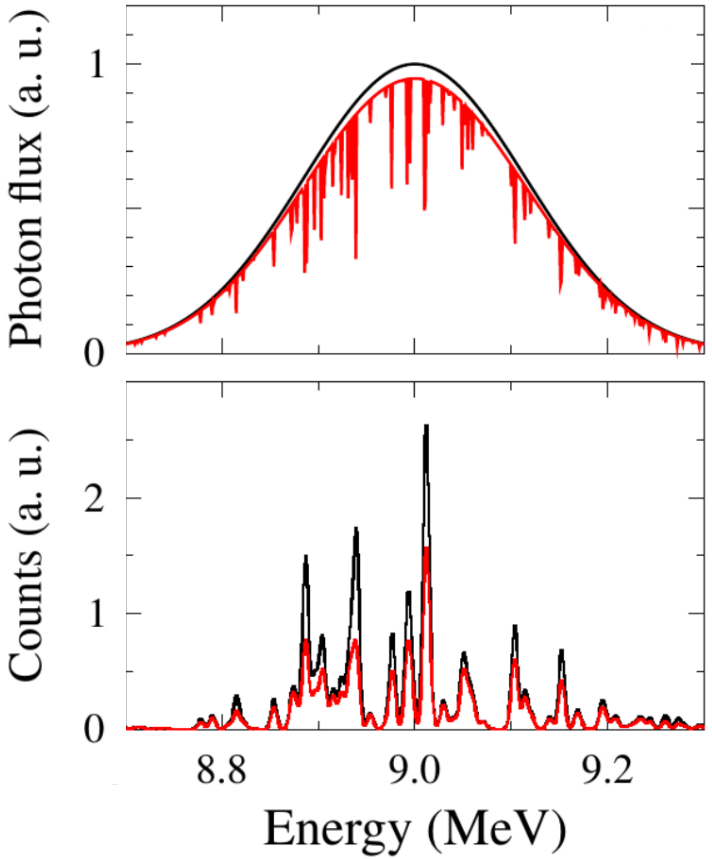


- RSA on a single state → $I_{abs} \propto \Gamma_0$
- RSA on many states → $\sum I_{abs} \propto \sum \Gamma_0$
- individual levels do not have the same strength
- distributed about the average $\langle \Gamma_0 \rangle$

  → Porter-Thomas distribution

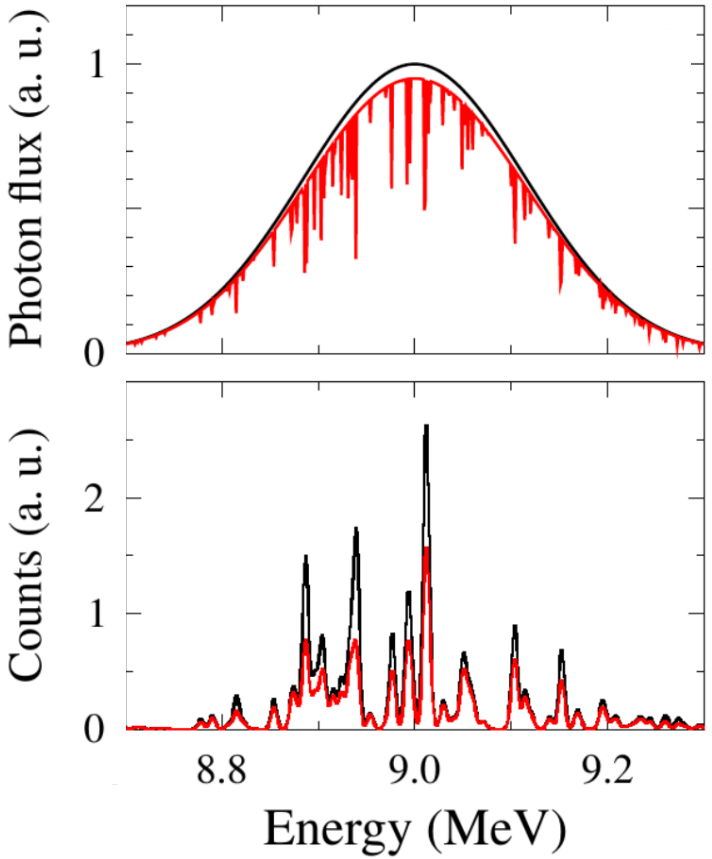
Metzger, PNP 7 (1959) 53.
Pietralla et al., PRC 51 (1995) 1021.
Romig et al., PLB 744 (2015) 369-374.

METHOD | INTEGRAL NUCLEAR SELFABSORPTION



$$1 - R = \frac{N_{Abs}}{N_{noAbs}}$$

METHOD | INTEGRAL NUCLEAR SELFABSORPTION



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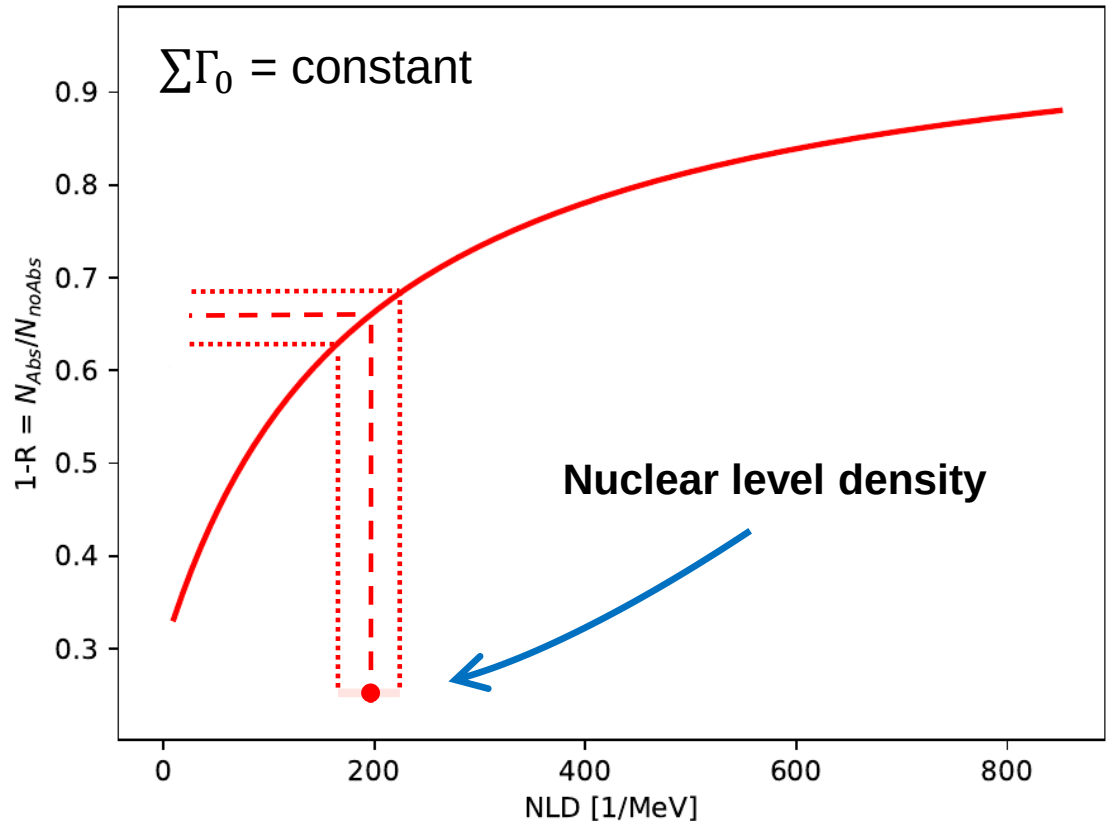

EXPERIMENT | MEASUREMENT SETUP

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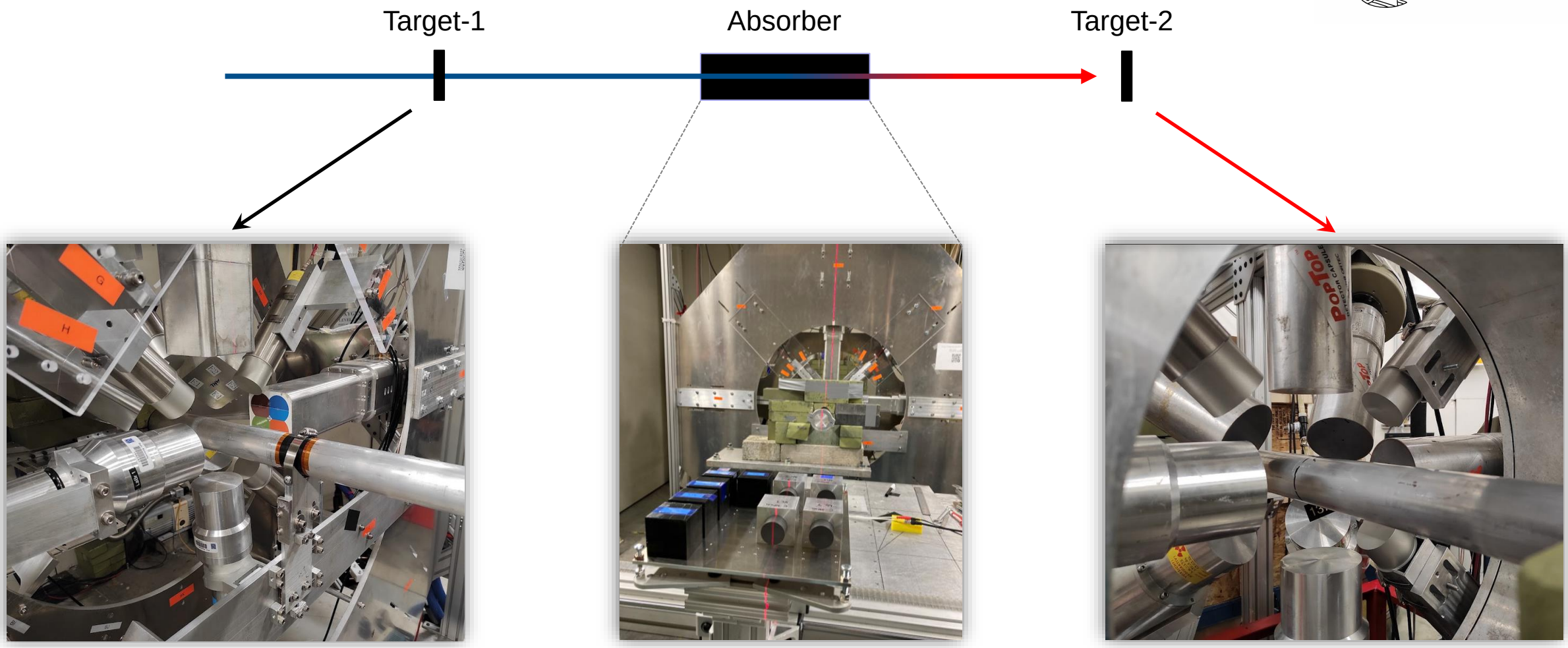
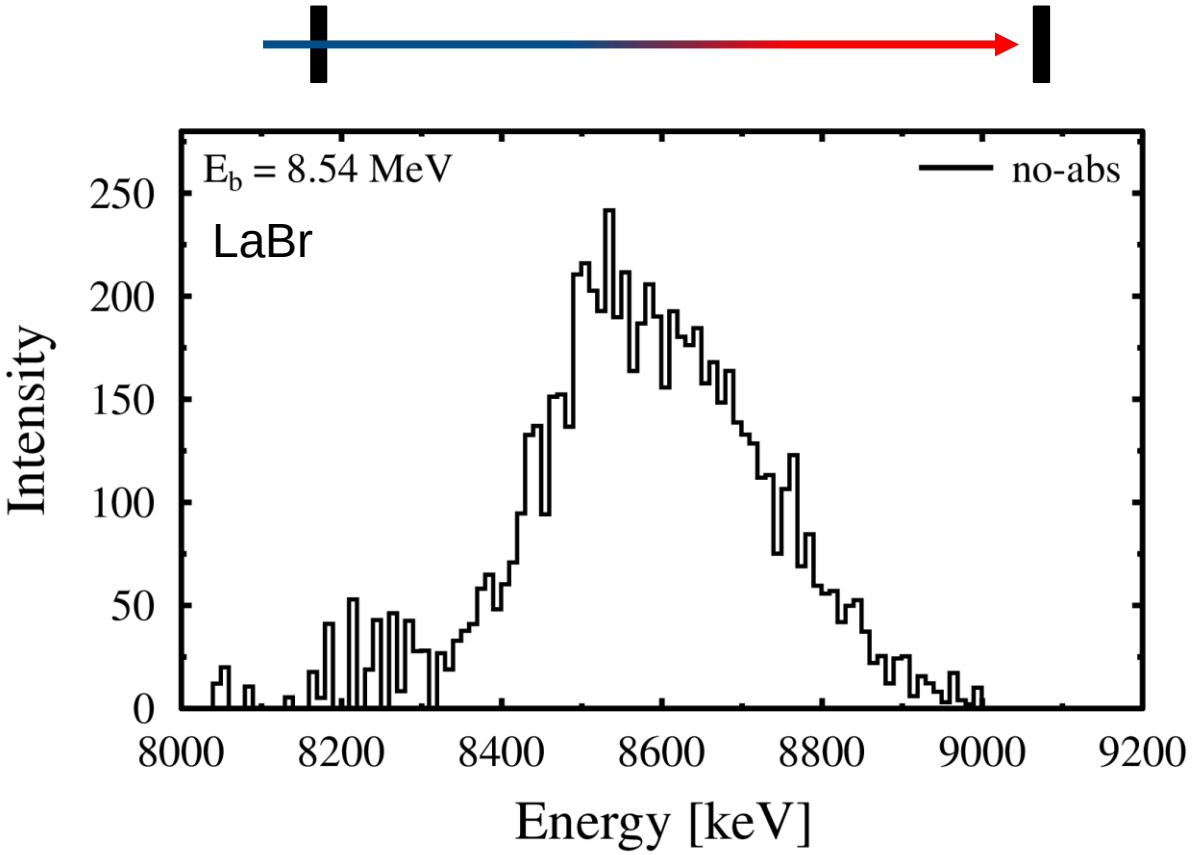


D. Savran und J. Isaak, Nucl. Instr. Meth. Res. A899 (2018) 28-31.

EXPERIMENT | SPECTRA: THE CASE OF ^{88}SR

- linearly-polarized photon beam → sensitive to $J^{\pi} = 1^{-}$ states



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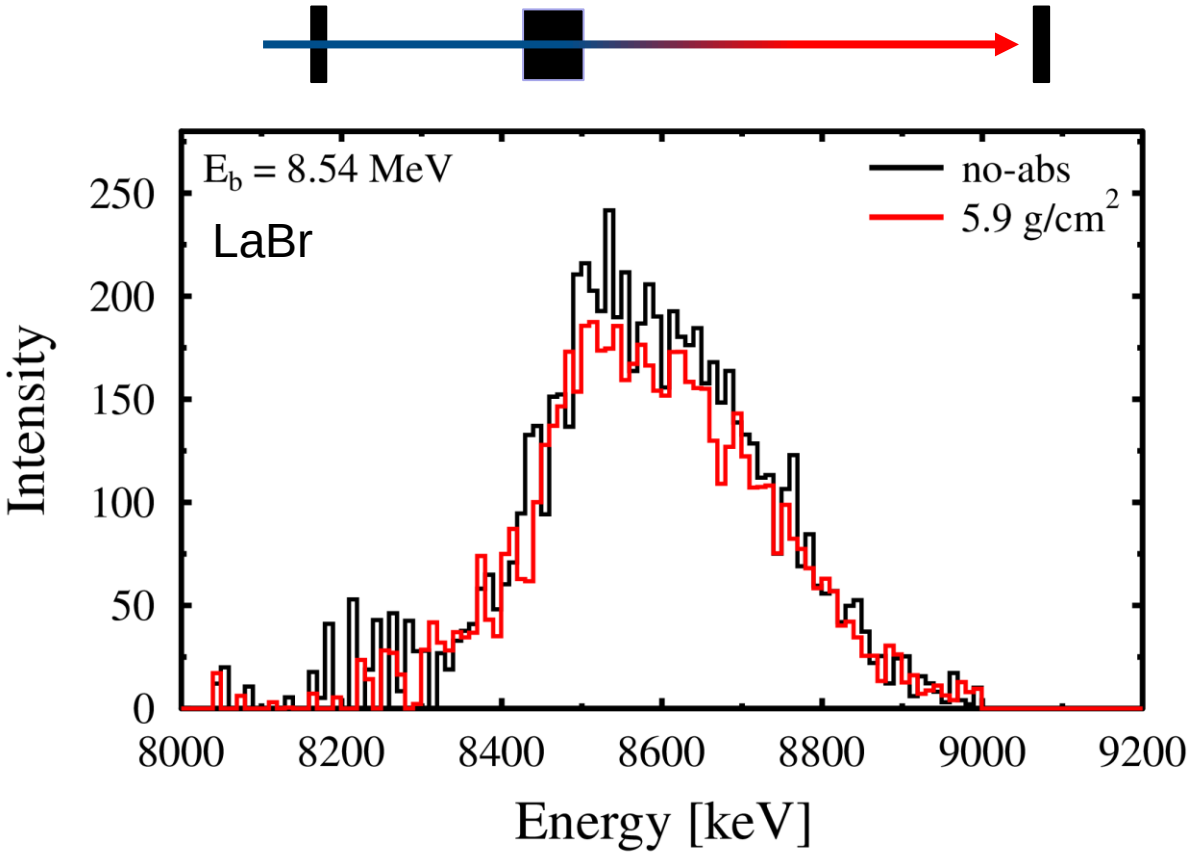
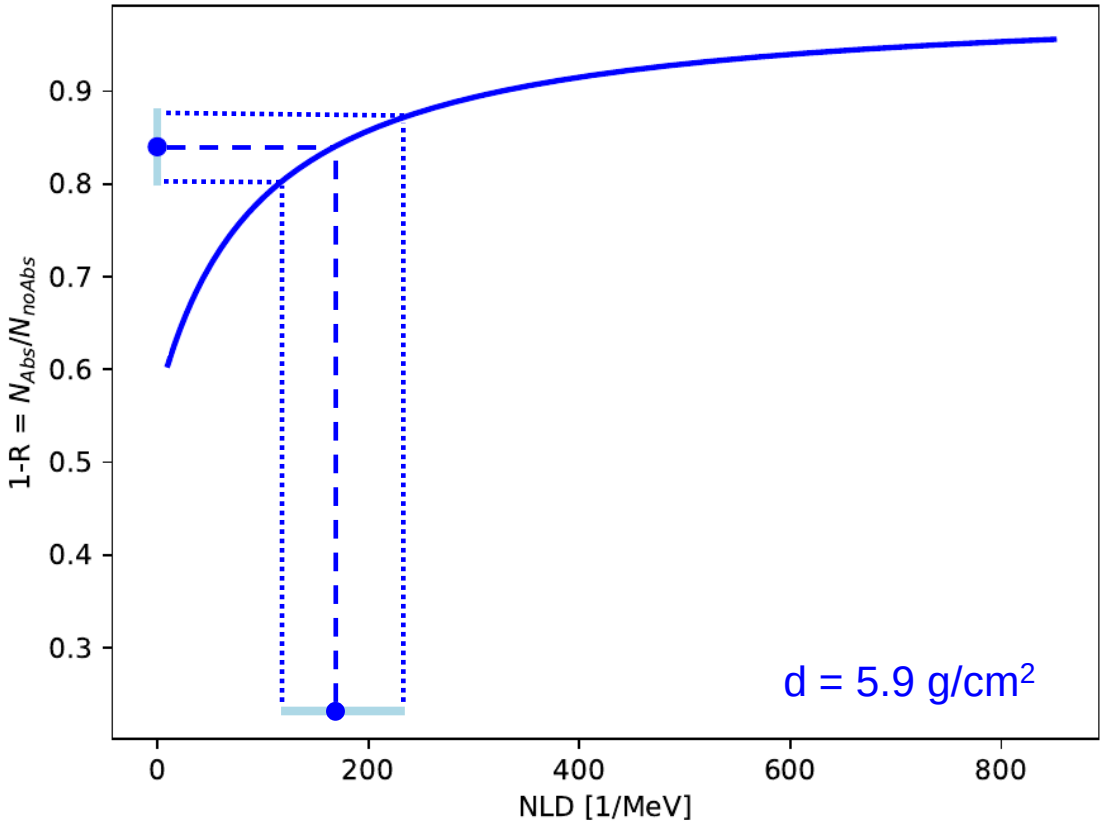


^{88}Sr: E_b = 8540 keV



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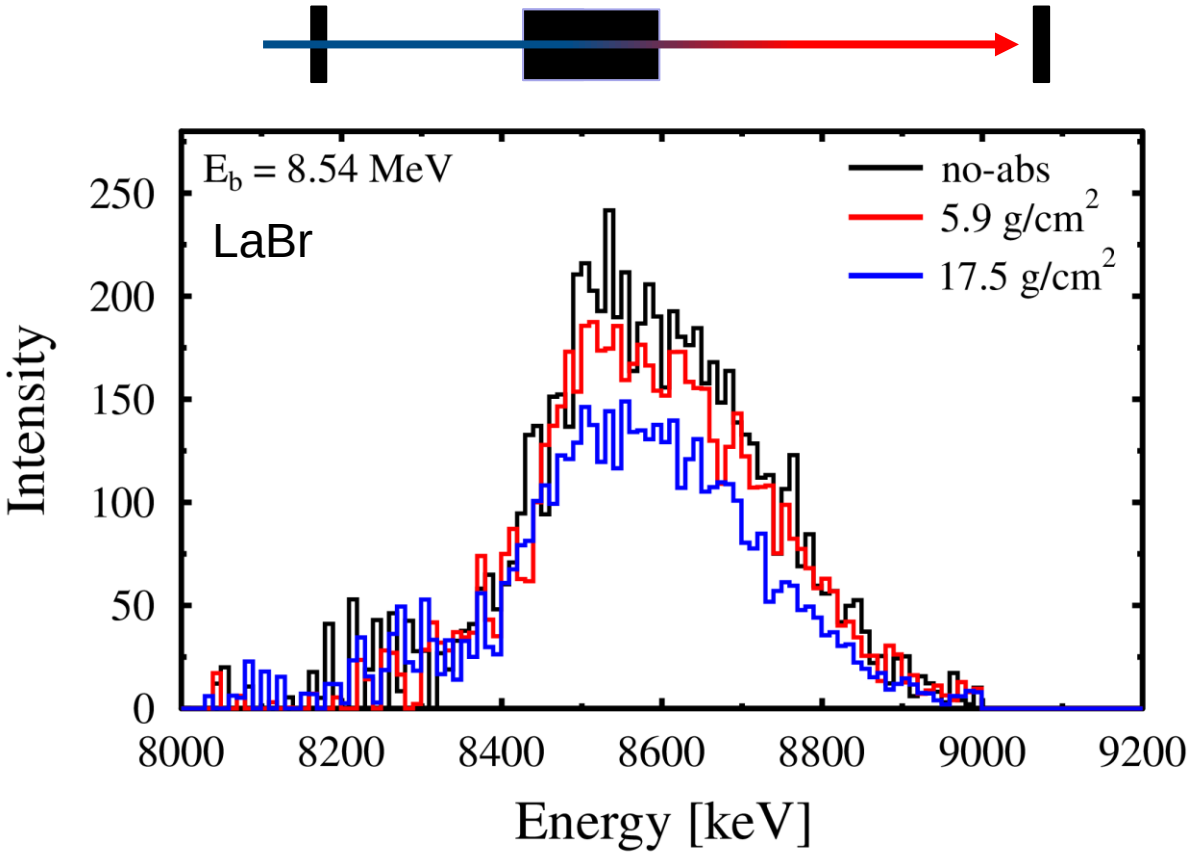

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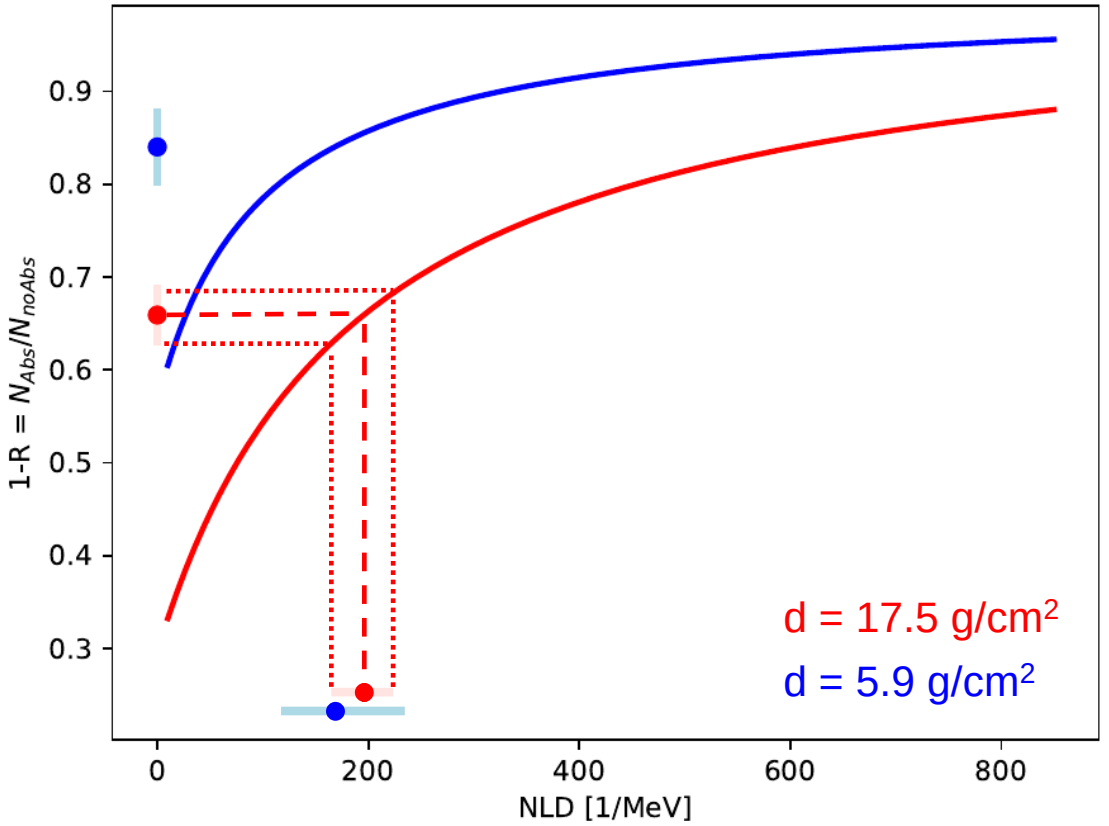

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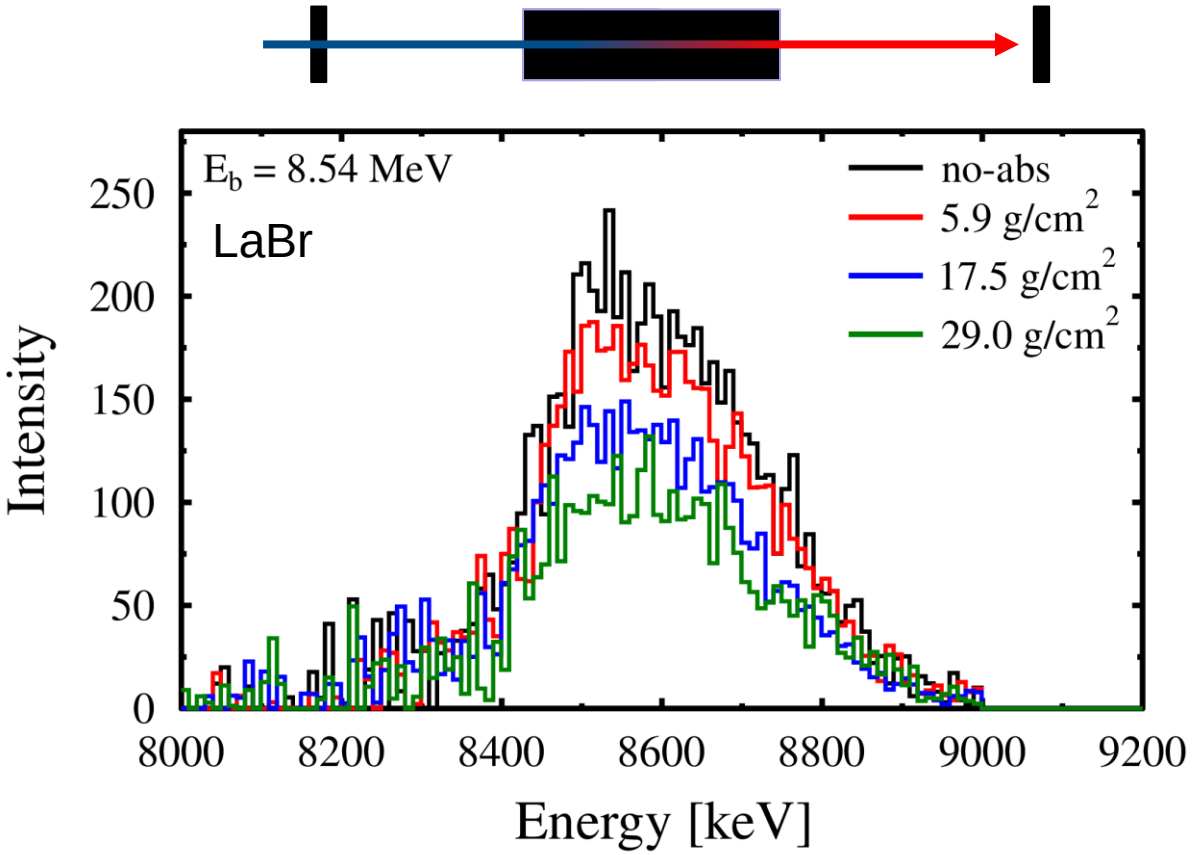

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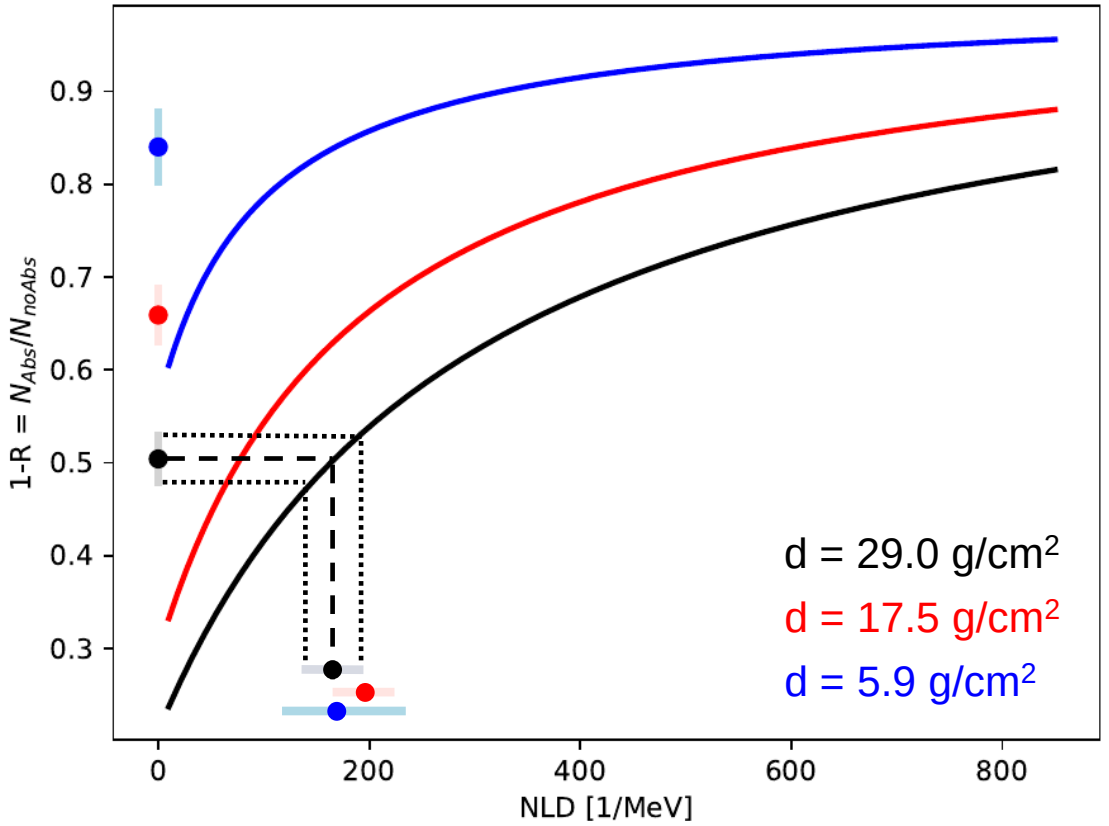

(PRELIMINARY) RESULTS | THE CASE OF ^{88}SR

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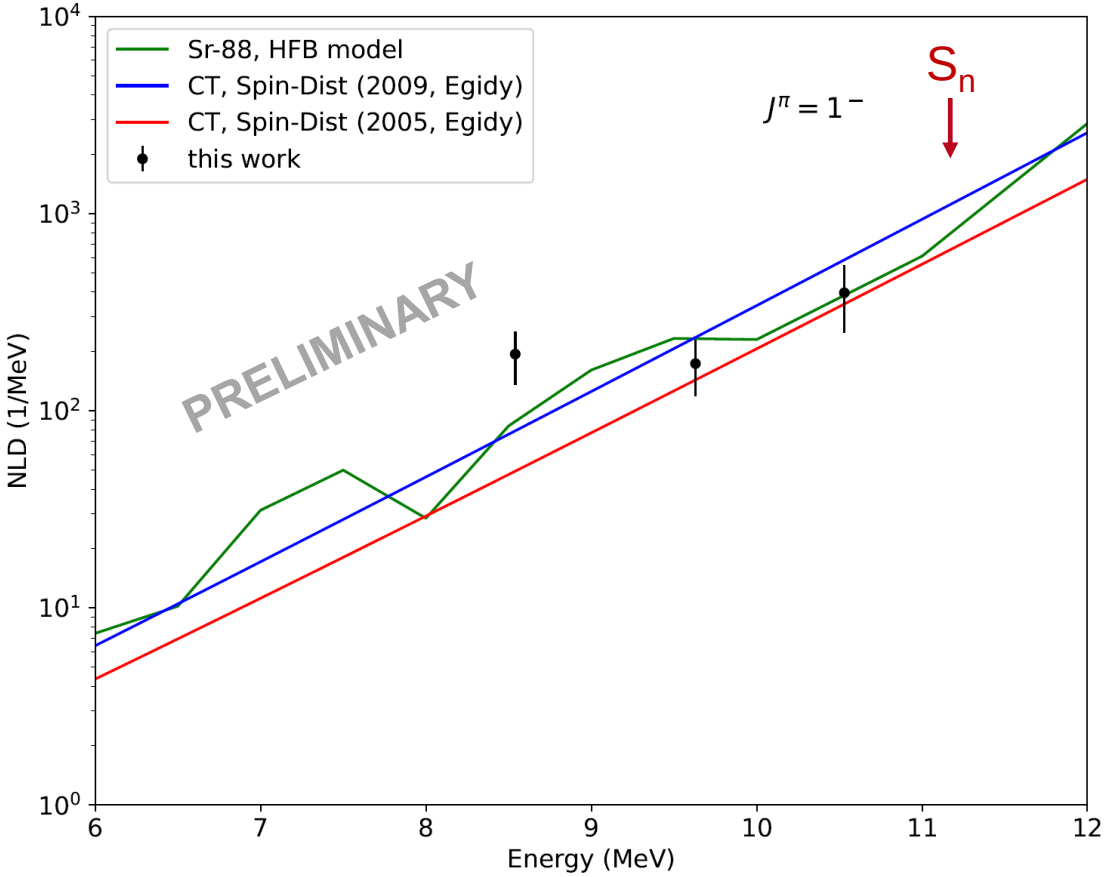
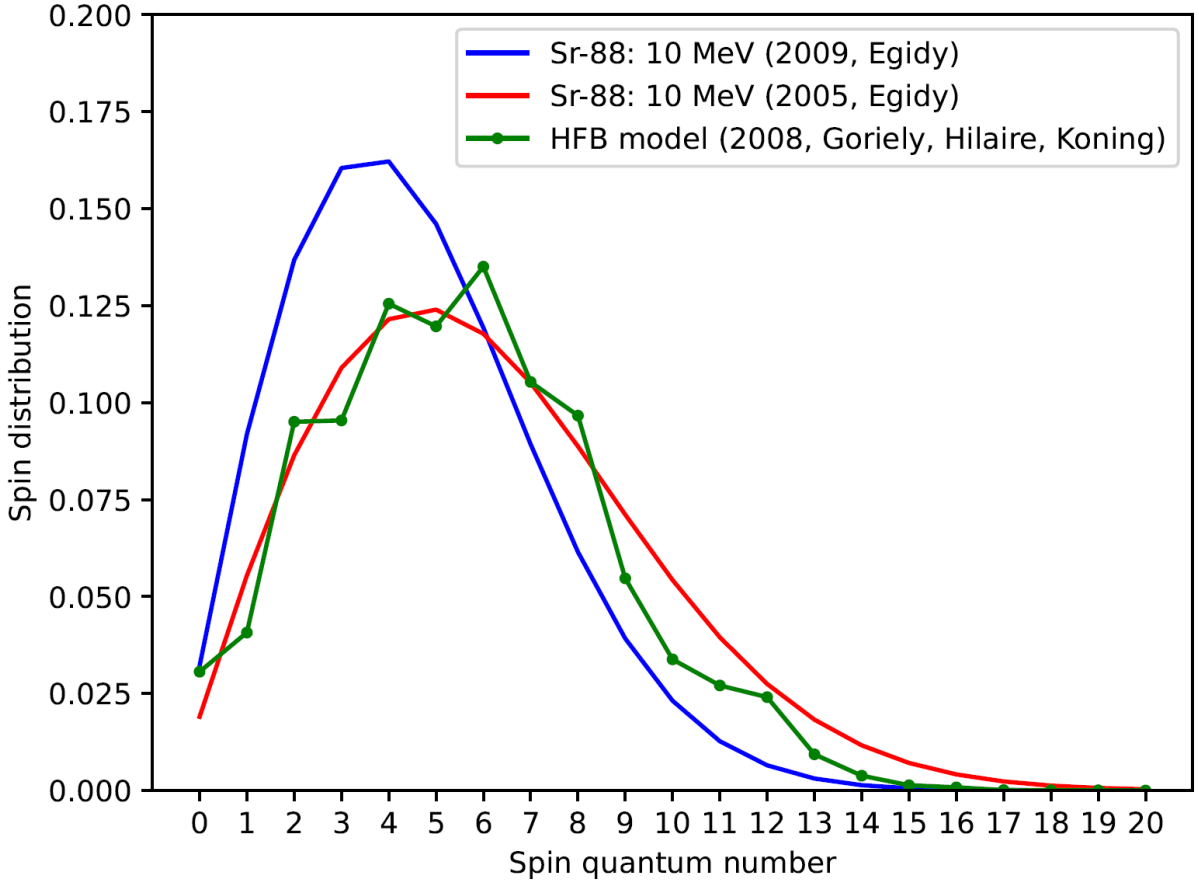
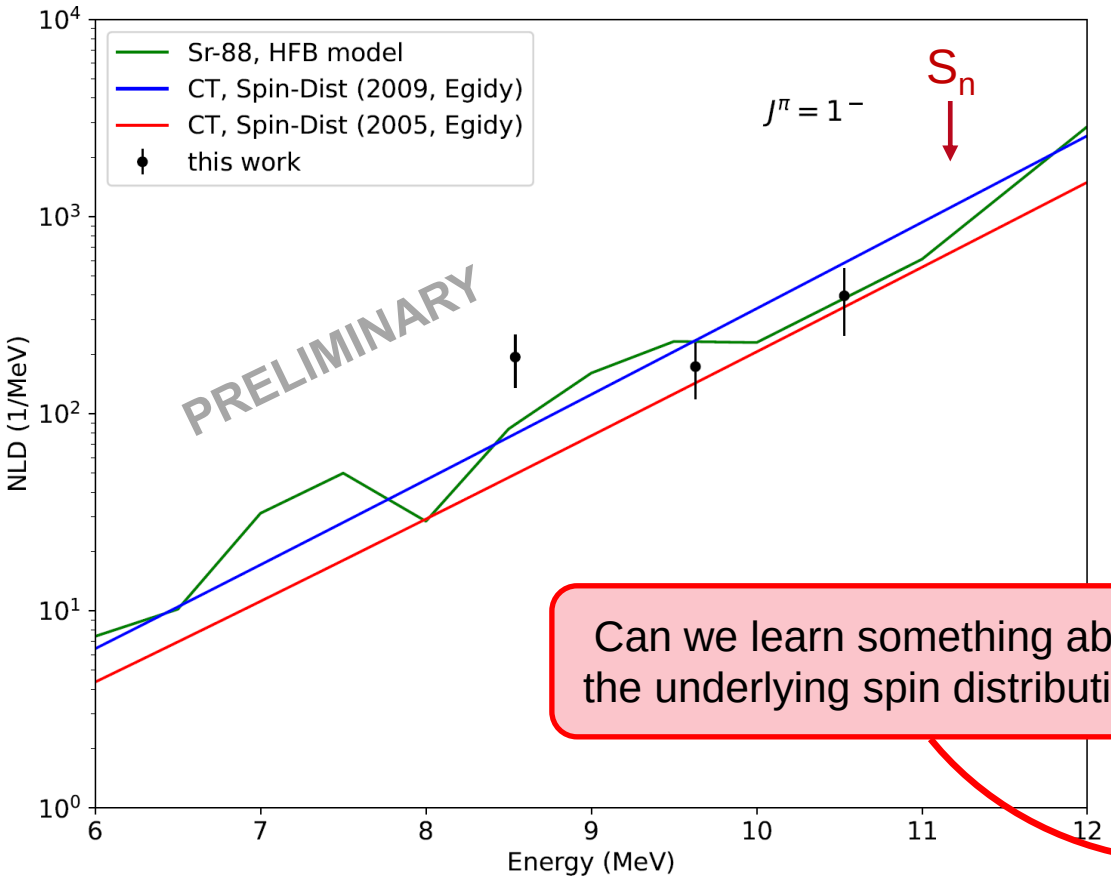


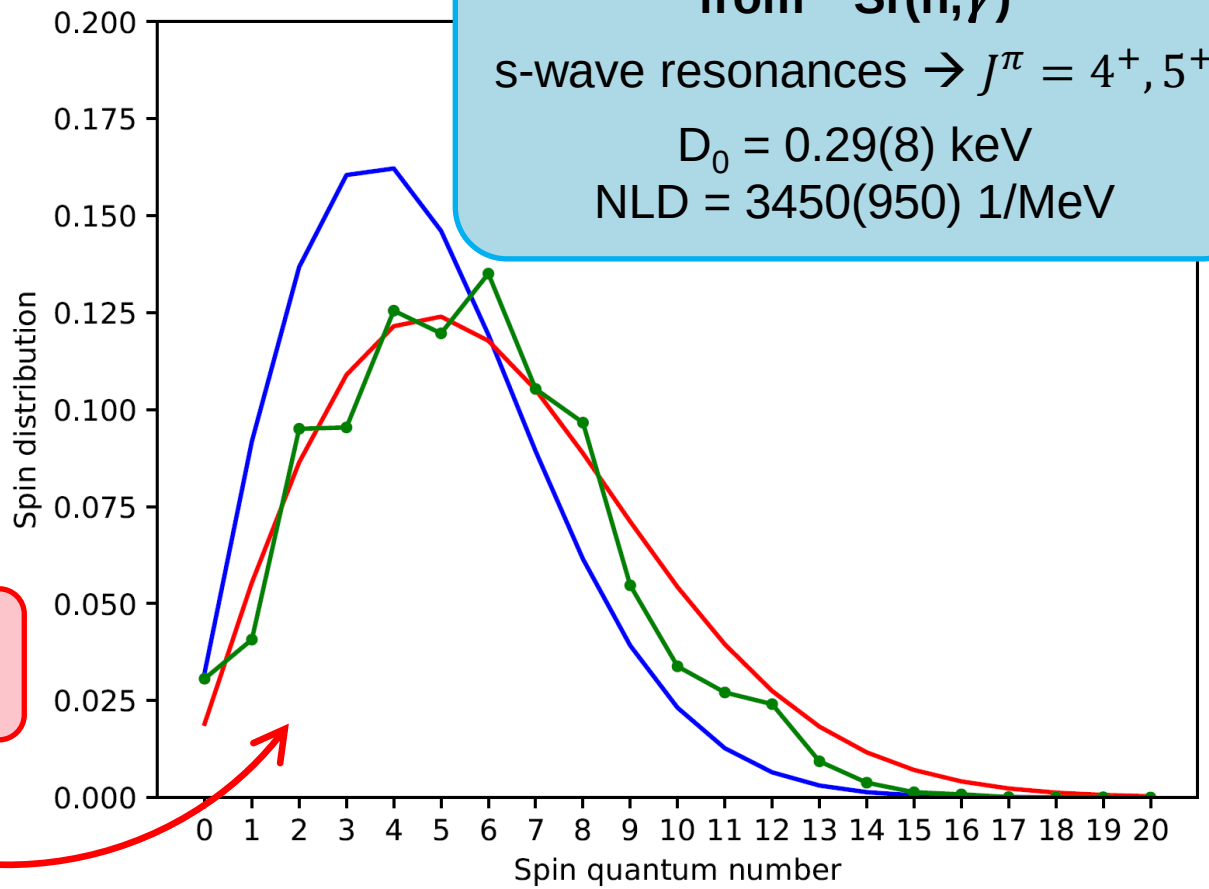


S. Goriely, S. Hilaire, A.J. Koning, PRC 78 (2008) 064307

(PRELIMINARY) RESULTS | THE CASE OF ^{88}SR



Can we learn something about the underlying spin distribution?



from ^{87}Sr(n,γ)

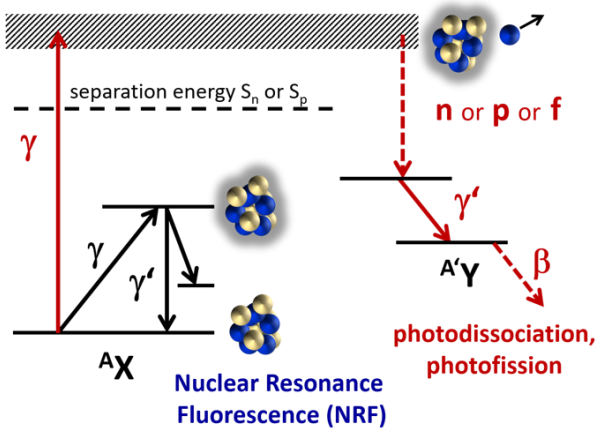
s-wave resonances → $J^\pi = 4^+, 5^+$

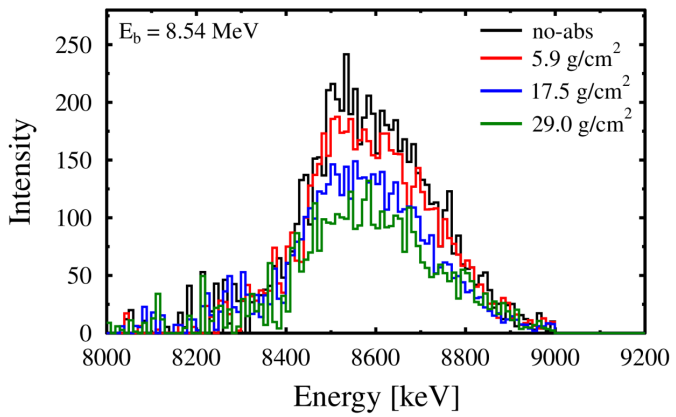
D_0 = 0.29(8) keV

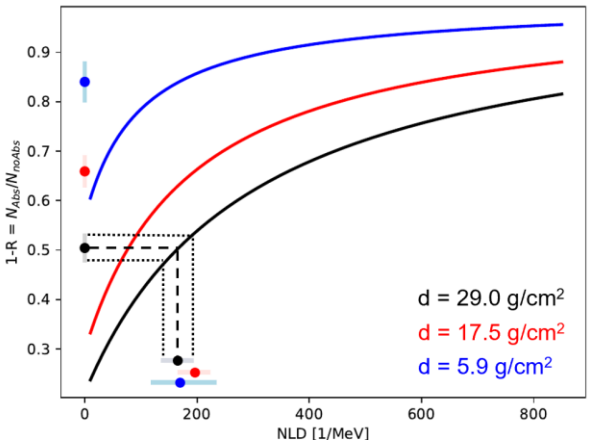
NLD = 3450(950) 1/MeV

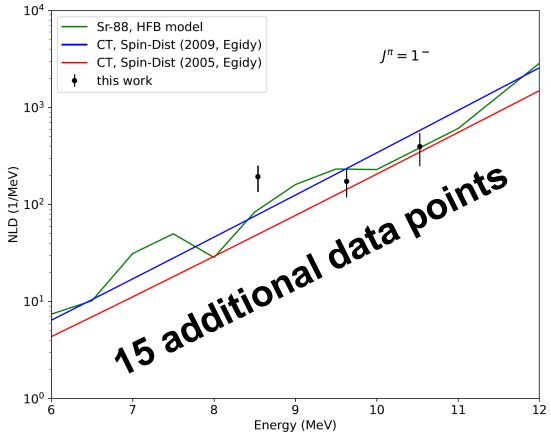
S. Goriely, S. Hilaire, A.J. Koning, PRC 78 (2008) 064307

SUMMARY & OUTLOOK









THANK YOU & COLLABORATION

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