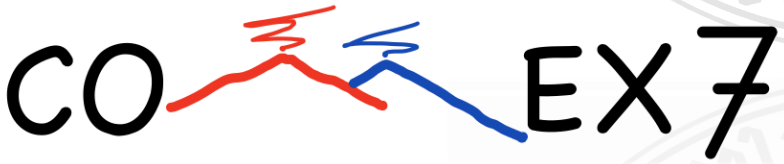
The Many Faces of the Pygmy Dipole Resonance in ^{120}Sn

M. Weinert, E. G. Lanza, M. Müscher, G. Potel,
M. Spieker, N. Tsoneva, A. Zilges,
and the CAGRA+GR collaboration



Catania, Sicily, June 2023

Universität zu Köln

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Complementary Information on the PDR

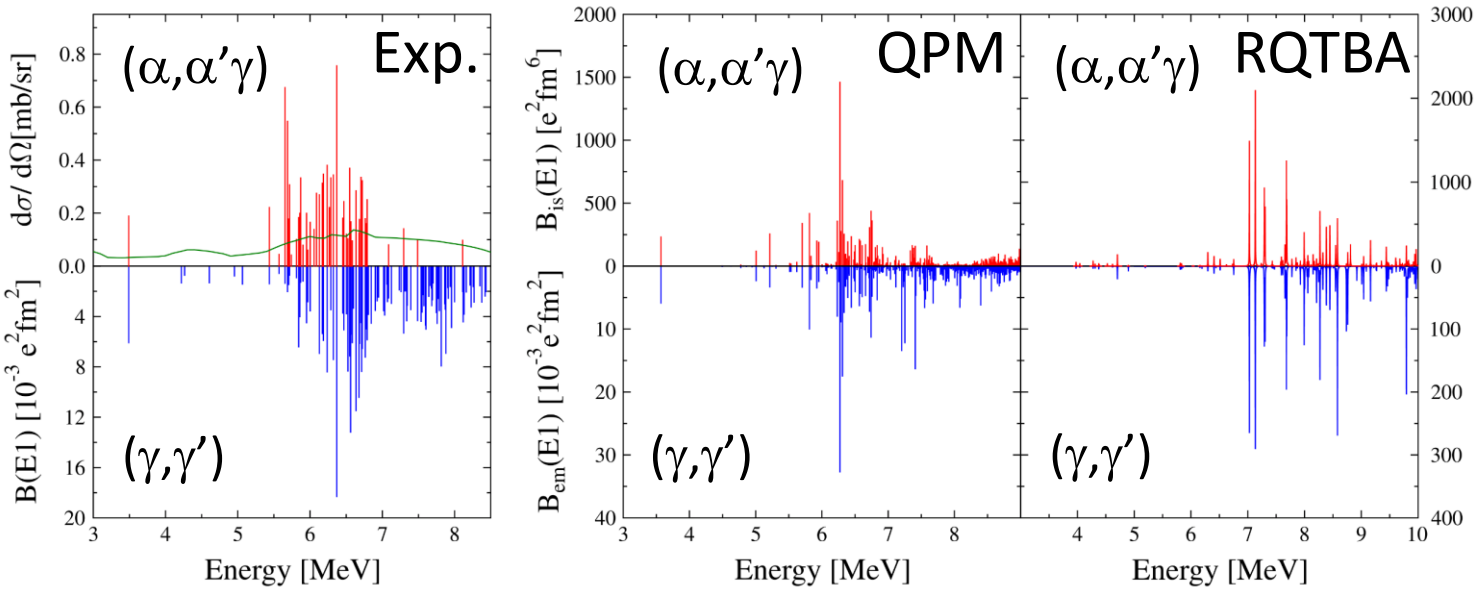
EM response
(isovector)
(γ,γ'), CoulEx

Surface char.
(isoscalar)
($\alpha,\alpha'\gamma$),
($^{17}O,^{17}O'\gamma$)

1p1h char.
(d,p), (d,pγ)

Decay prop.
(γ,γ'), (p,p'γ)

A short history of ^{120,124}Sn

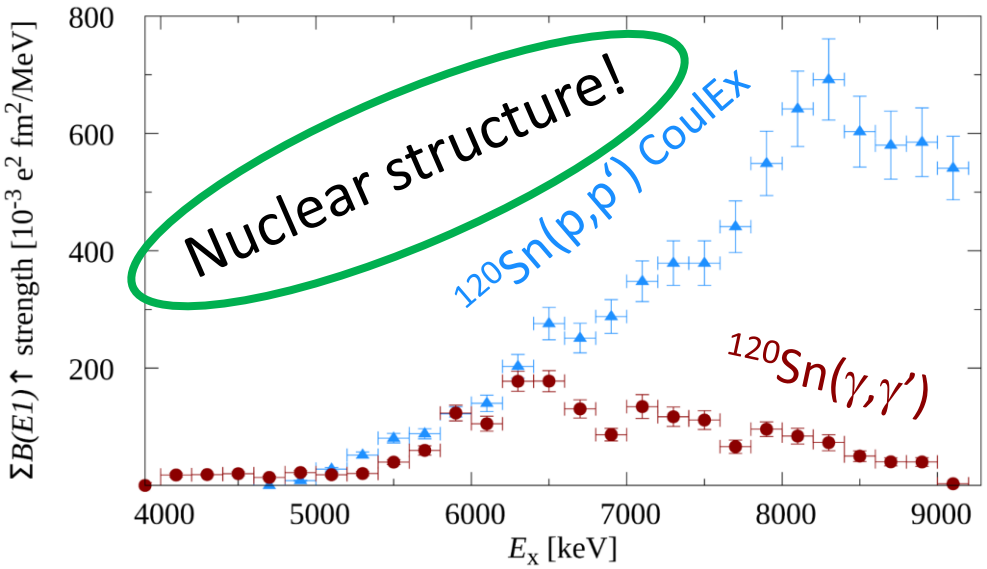


← ^{124}Sn

^{120}Sn ↓

^{124}Sn(α,α'γ), exp. and theory

Splitting of cross sections and *neutron-skin* character in isoscalar part (also in (^{17}O,^{17}O'γ))



J. Endres, E. Litvinova *et al.*, PRL **105** (2010) 212503
J. Endres, D. Savran *et al.*, PRC **85** (2012) 064331
L. Pellegri *et al.*, PLB **738** (2014) 519

A.M. Krumbholz *et al.*, PLB **744** (2015) 7
M. Müscher *et al.*, PRC **102** (2020) 014317

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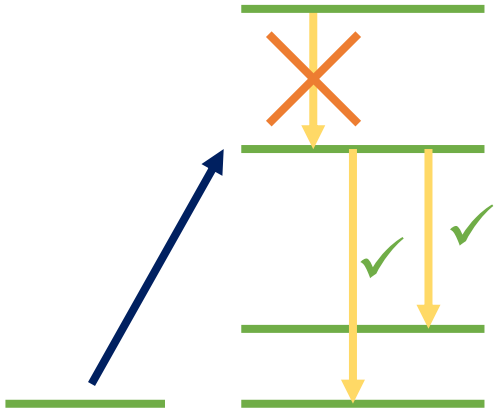
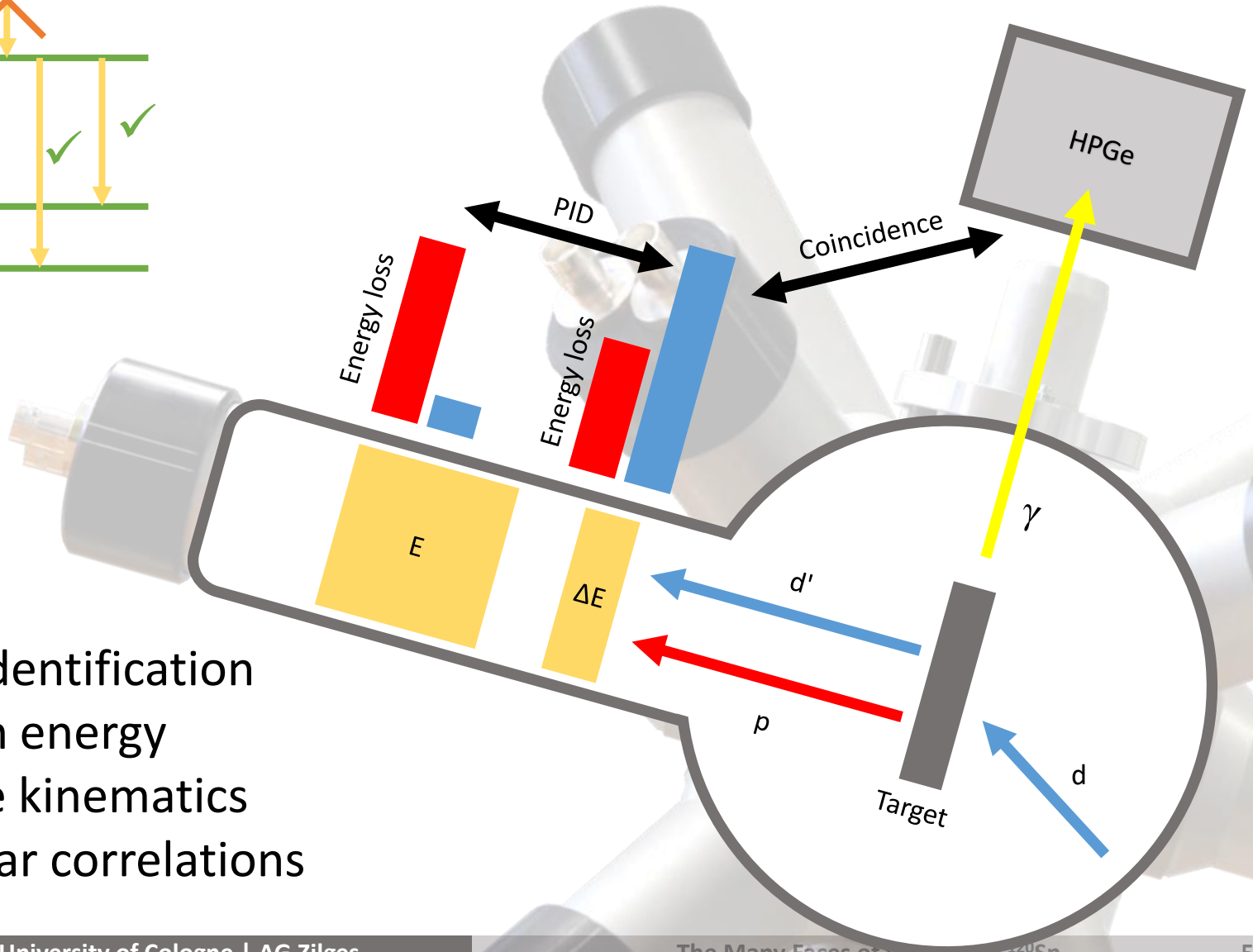
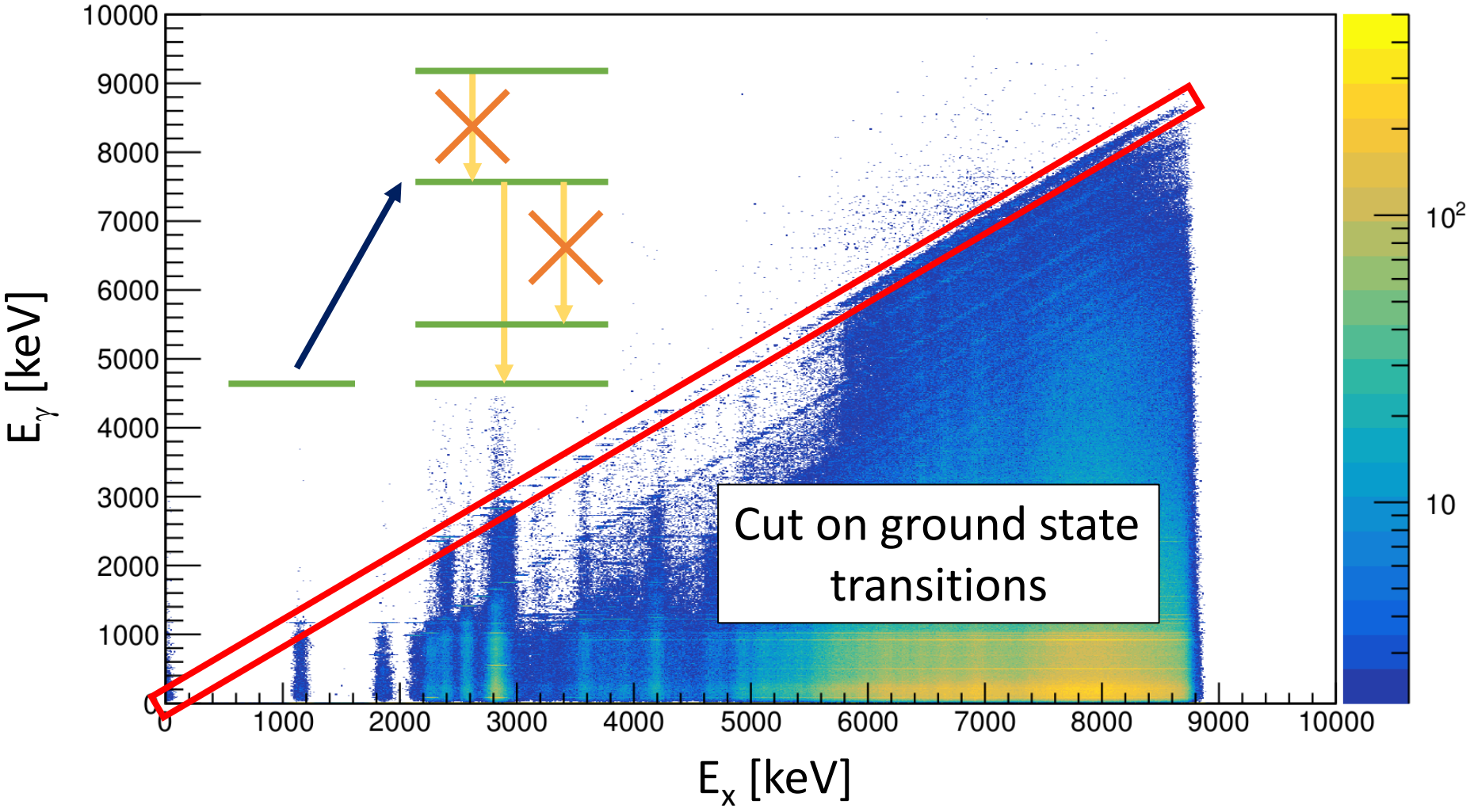
^{119}Sn(d,pγ)@8.5MeV – SONIC@HORUS





- ✓ Particle identification
- ✓ Excitation energy
- ✓ Complete kinematics
- ✓ p-γ angular correlations

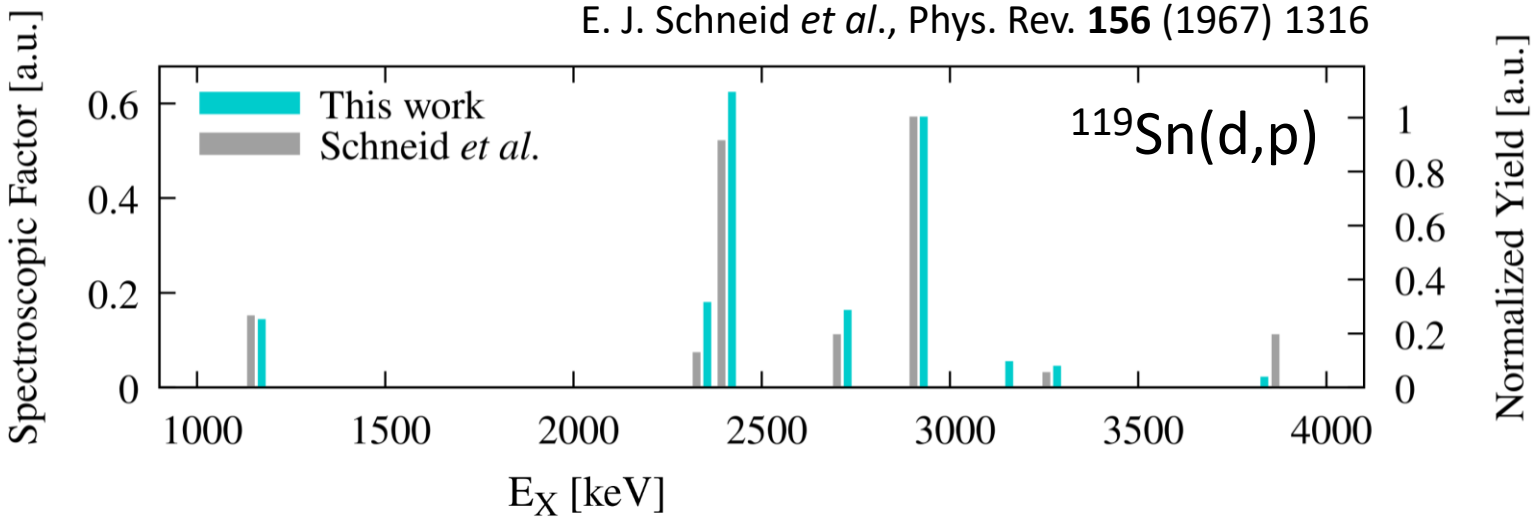
^{119}Sn(d,pγ)@8.5MeV – SONIC@HORUS



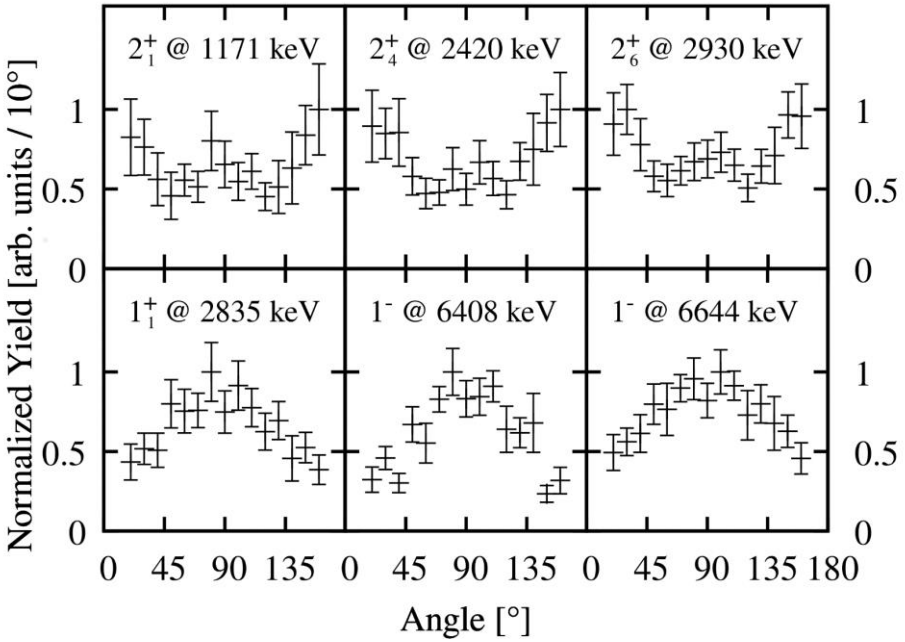
Select direct excitation and decay into specific state in ^{120}Sn

^{119}Sn(d,pγ)@8.5MeV – Additional Information

E. J. Schneid *et al.*, Phys. Rev. **156** (1967) 1316

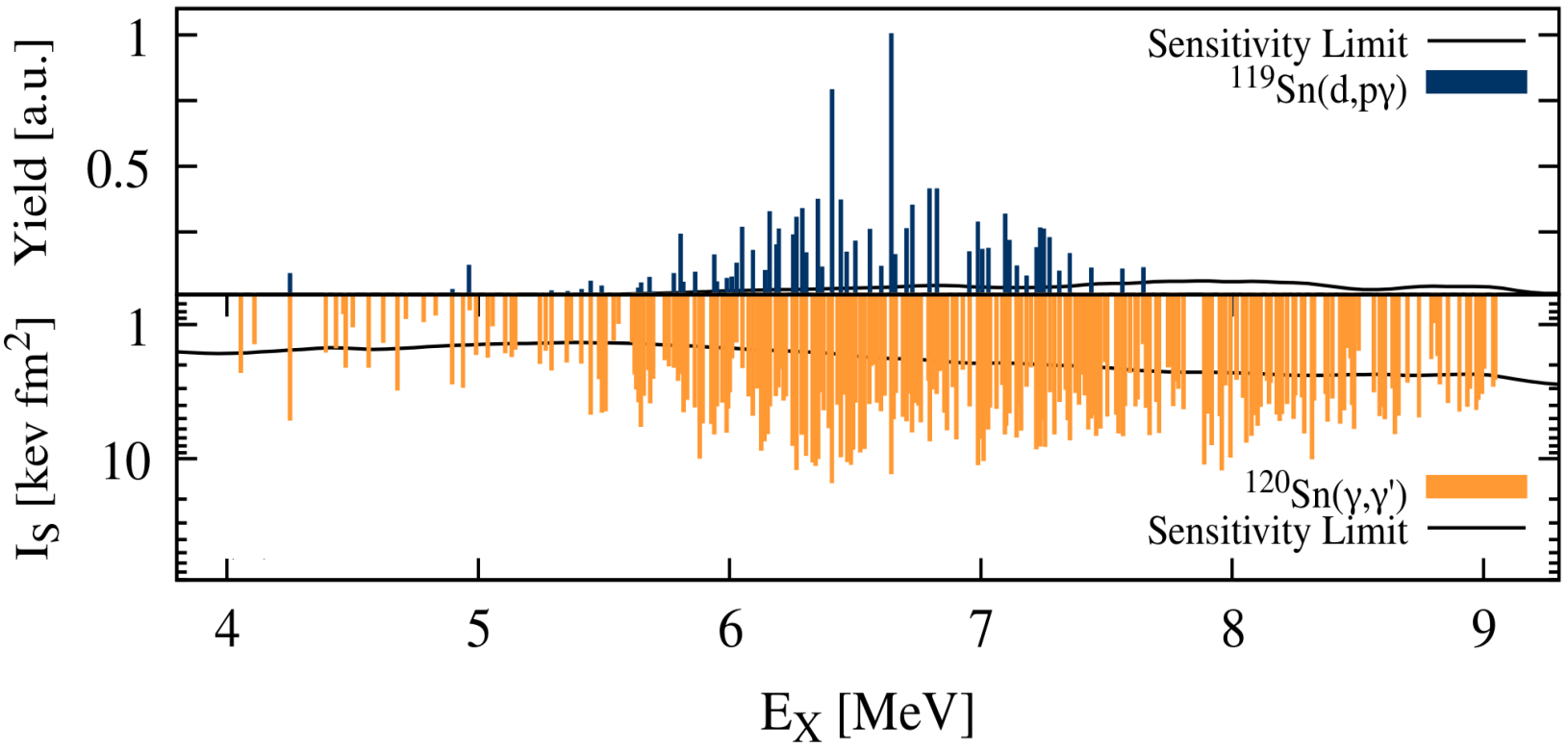


- Direct reaction?
  Normalized (d,p) yield follows spectroscopic factors!
- PDR really populated?
  γ-ray angular distributions identify spin J!



M. Weinert *et al.*, Phys. Rev. Lett. **127** (2021) 242501

^{119}Sn(d,pγ) vs ^{120}Sn(γ,γ‘)



- Strong state-to-state difference between (d,pγ) and (γ,γ‘)
- Missing strength above 7.5 MeV intriguing…

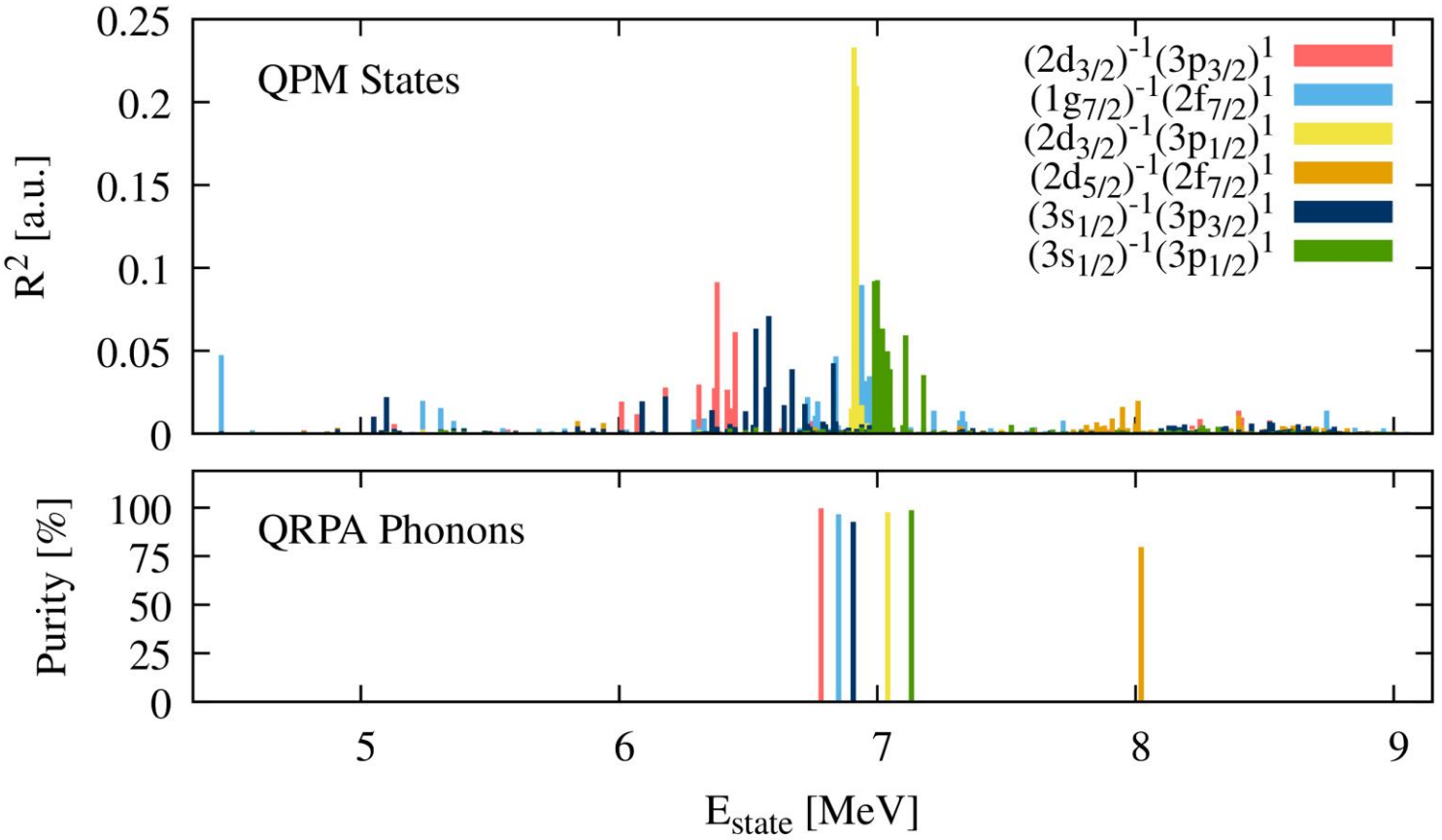
→ Structure reasons?

Theory!

NRF data from: M. Müscher *et al.*, PRC **102** (2020) 014317

^{120}Sn – QPM One-Phonon Distribution

QPM 1ph contributions relevant for ^{119}Sn(d,p)



Theory provided by N. Tsoneva

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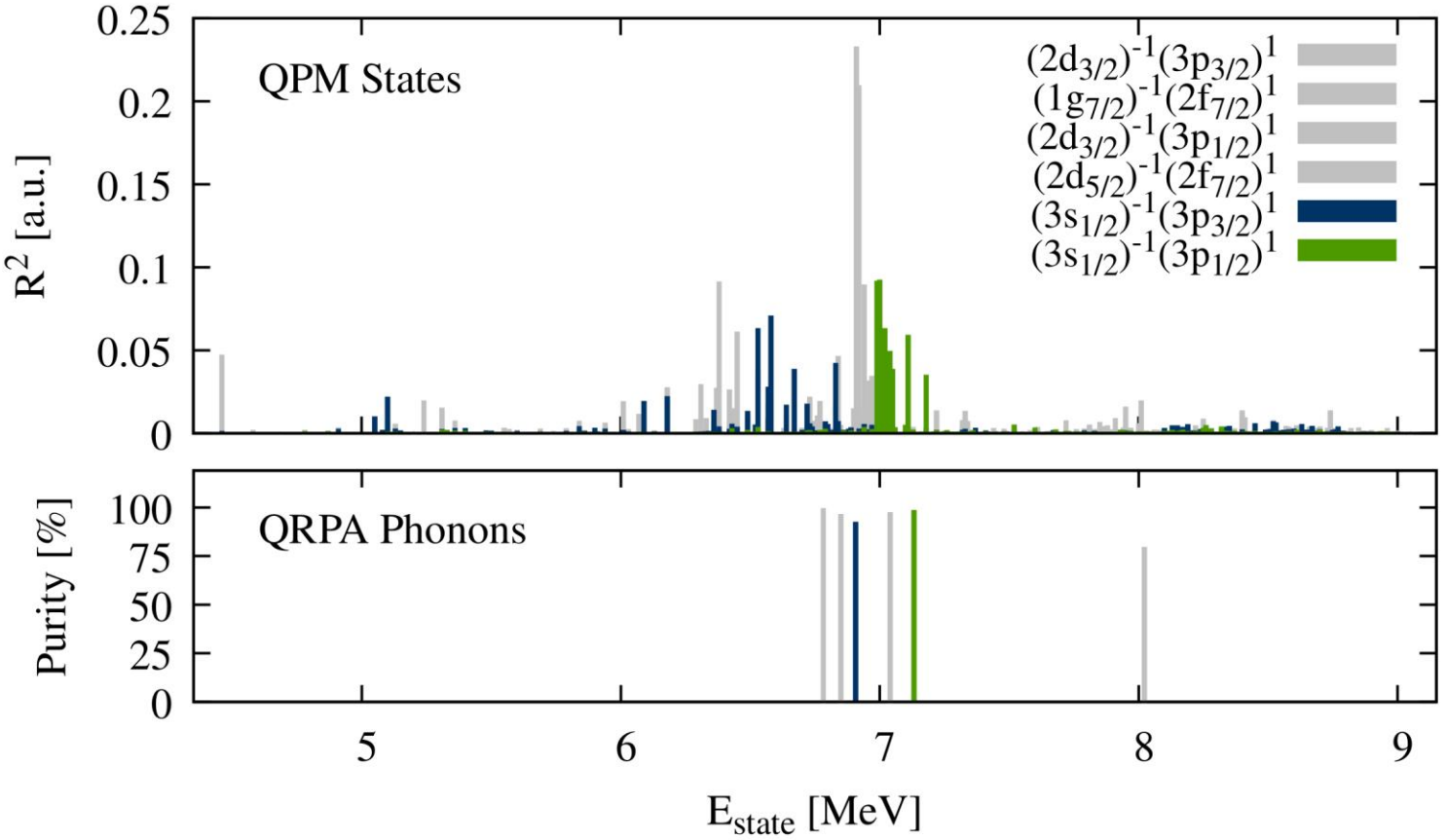
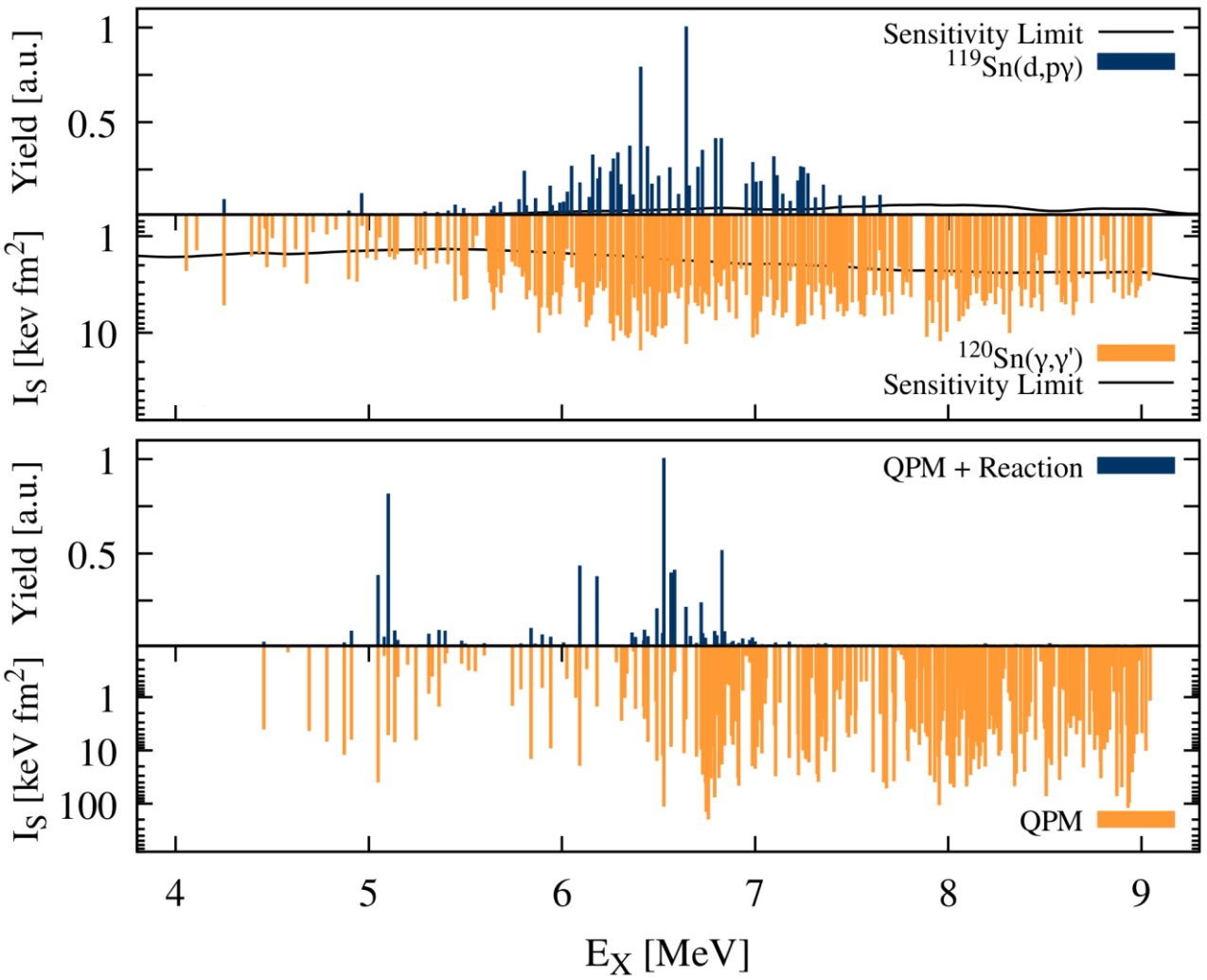


Theory provided by N. Tsoneva

^{119}Sn(d,pγ) – Experiment and Theory



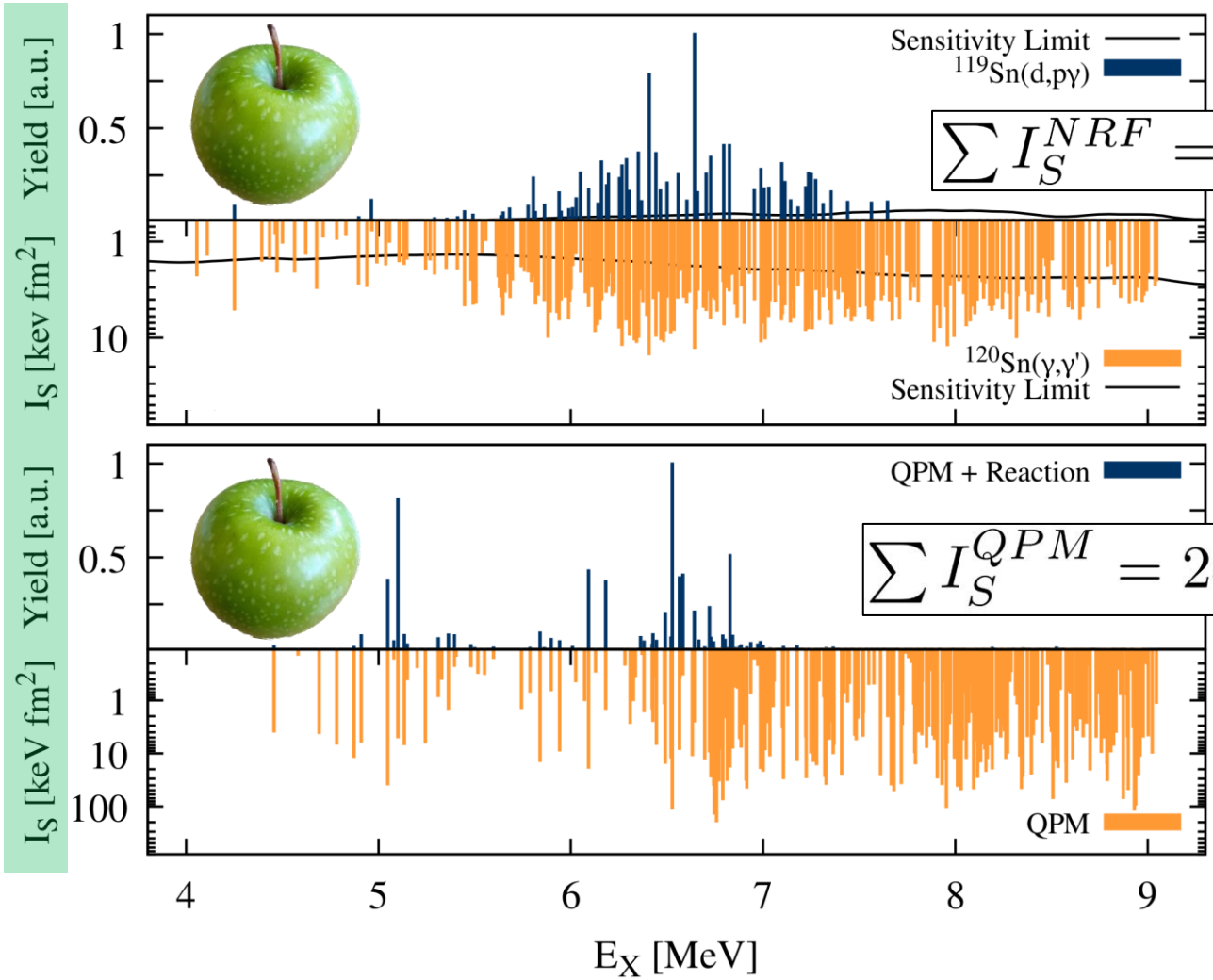
Experiment

Theory

Theory provided by N. Tsoneva and G. Potel

M. Weinert *et al.*, Phys. Rev. Lett. **127** (2021) 242501

^{119}Sn(d,pγ) – Experiment and Theory



$$\sum I_S^{NRF} = 337(21)\,\text{keV fm}^2$$

for states seen in both experiments

$$\sum I_S^{QPM} = 243 - 360\,\text{keV fm}^2$$

for states above experimental sensitivity limit of 1.0 - 0.5 %

Theory provided by N. Tsoneva and G. Potel

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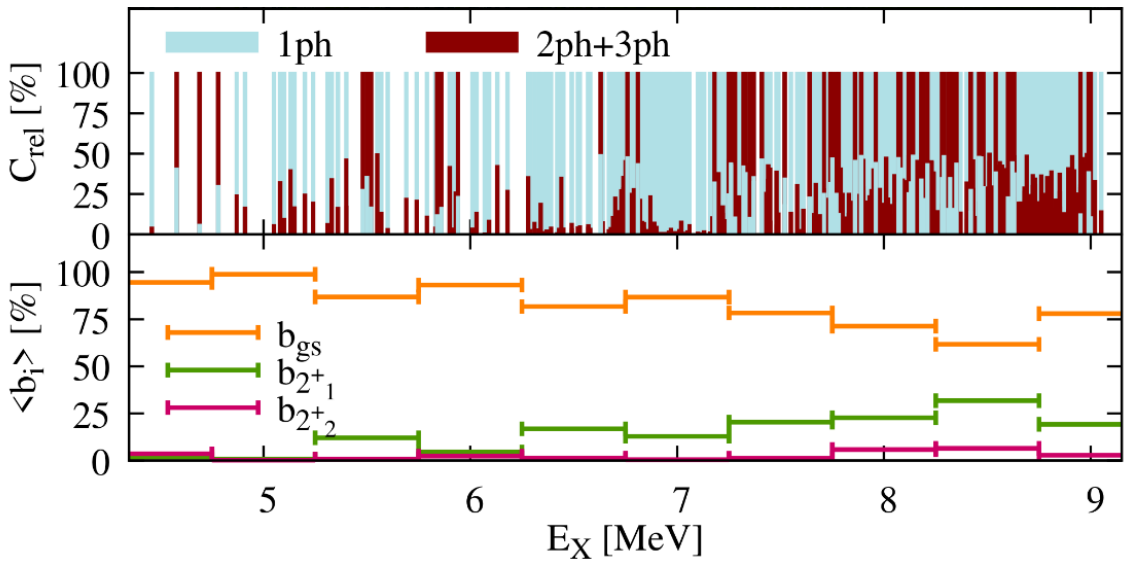
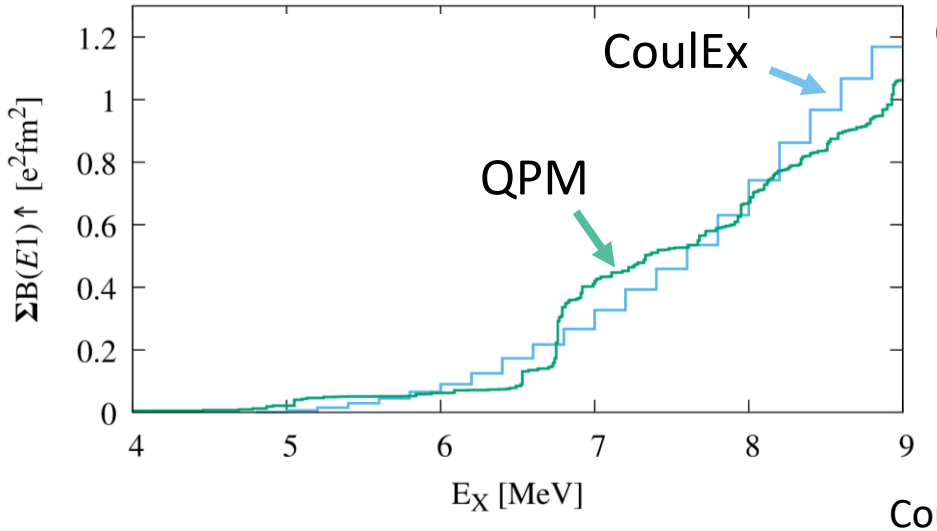
^{120}Sn QPM – Structure and total B(E1)↑

Theory provided by N. Tsoneva



1p1h character and **increasing complexity** at the right excitation energies!



CoulEx: 1.169(12) e^2fm^2

QPM: 1.066 e^2fm^2

M. Weinert *et al.*, Phys. Rev. Lett. **127** (2021) 242501

CoulEx: A.M. Krumbholz *et al.*, PLB **744** (2015) 7

(γ,γ'): M. Müscher *et al.*, PRC **102** (2020) 014317

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CAGRA+GR Campaign @ RCNP, Osaka

GrandRaiden Spectrometer

- ➢ High energy resolution under **forward angles** incl. 0°

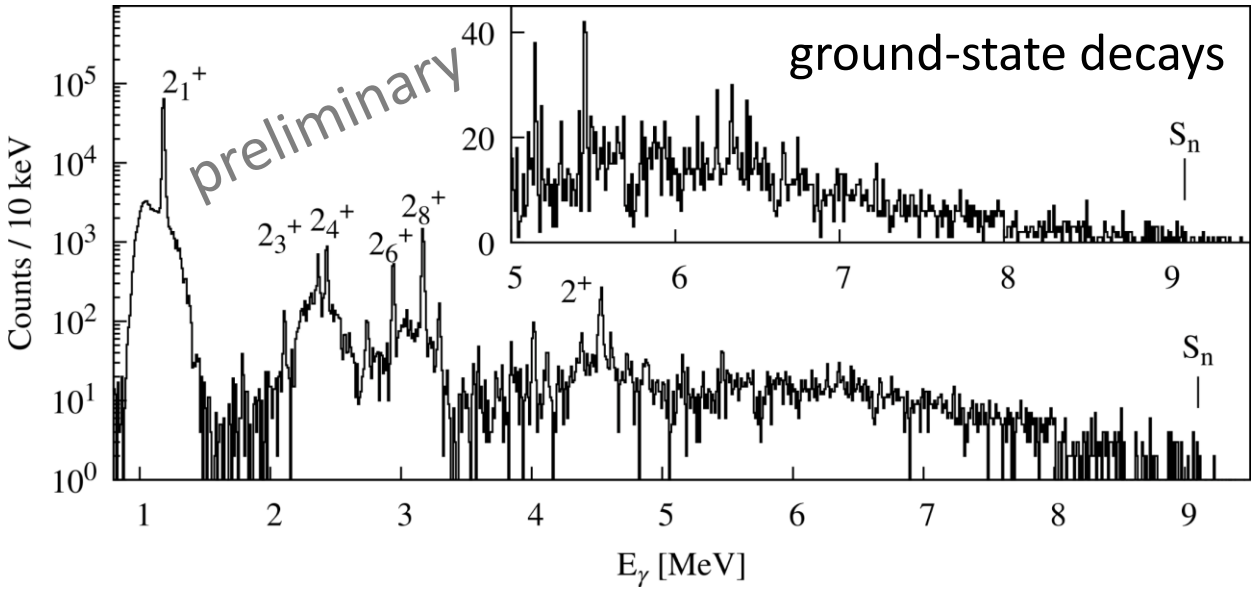
CAGRA Clover array

- 12 clover type detectors + BGO shields
- 4 large volume $LaBr_3$ detectors

$^{120}Sn(\alpha,\alpha'\gamma)$
$E_\alpha = 130$ MeV
$\theta_\alpha = 4.5°$

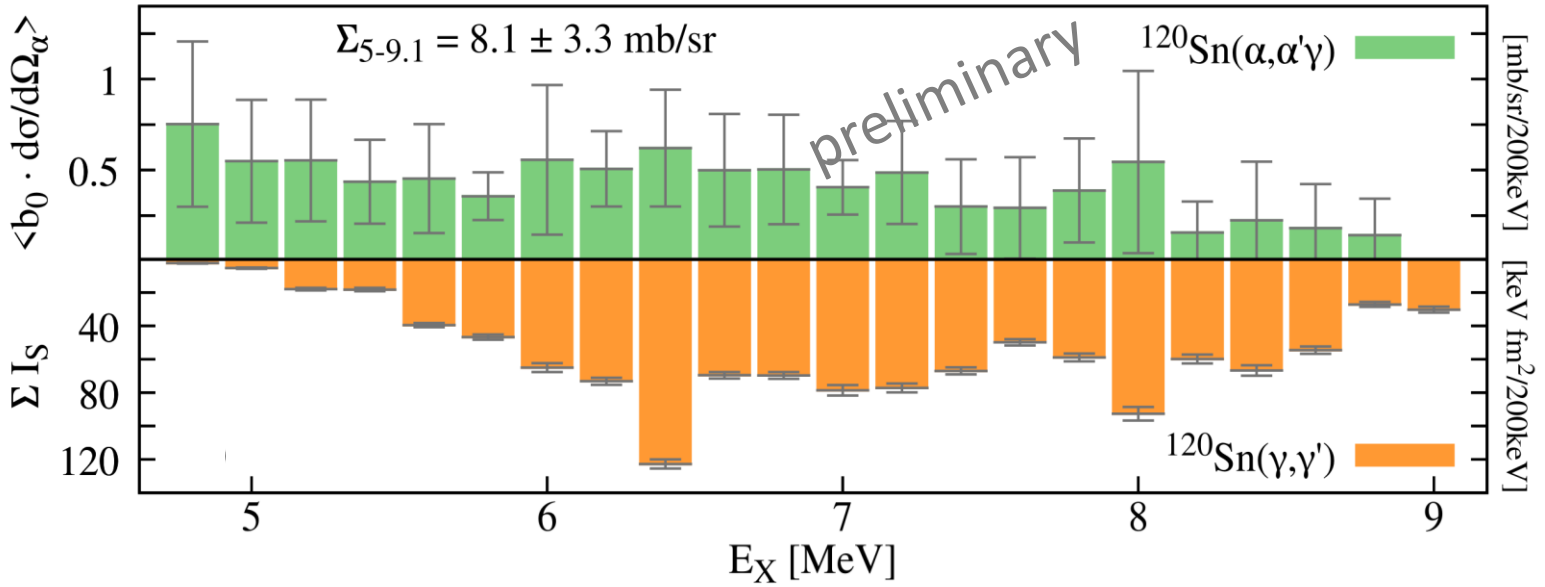
Over **1100 hours** of beam time!

^{120}Sn(α,α'γ) – Ground-State Decay Spectrum



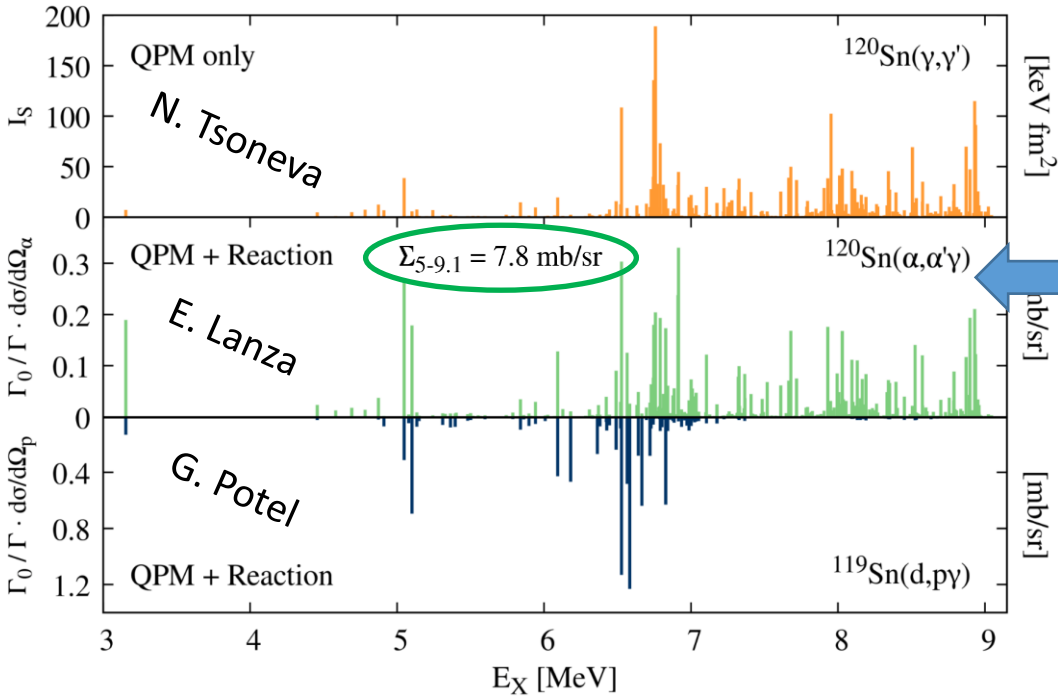
Low statistics, but:

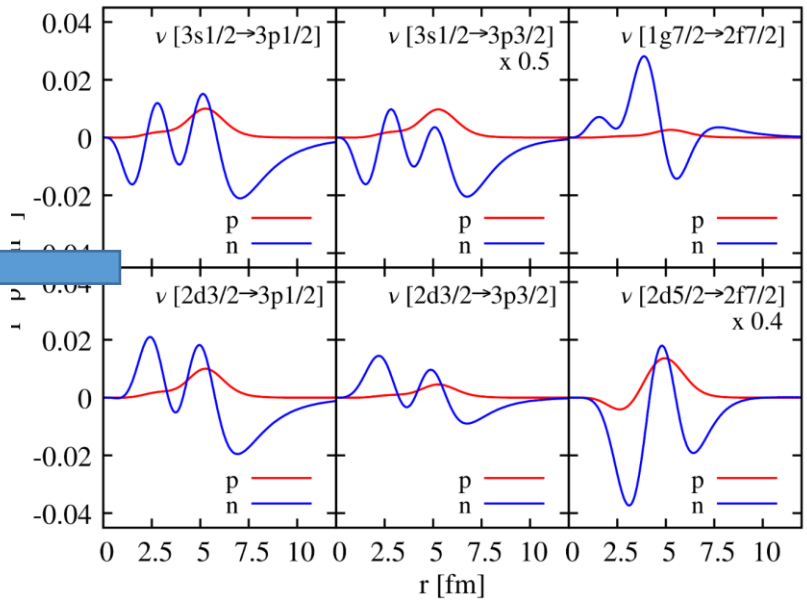
(mostly flat)
isoscalar response evident!

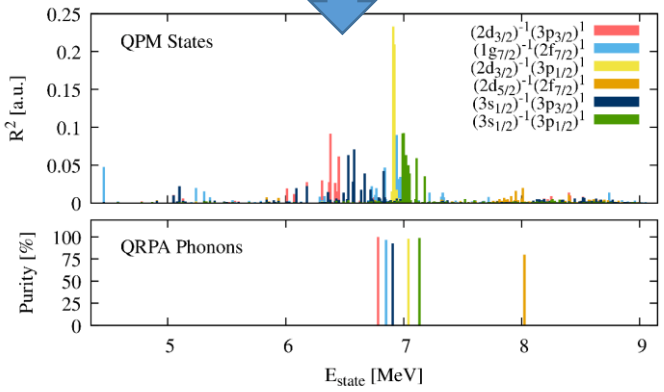


experiment

State-to-State QPM+Reaction Predictions

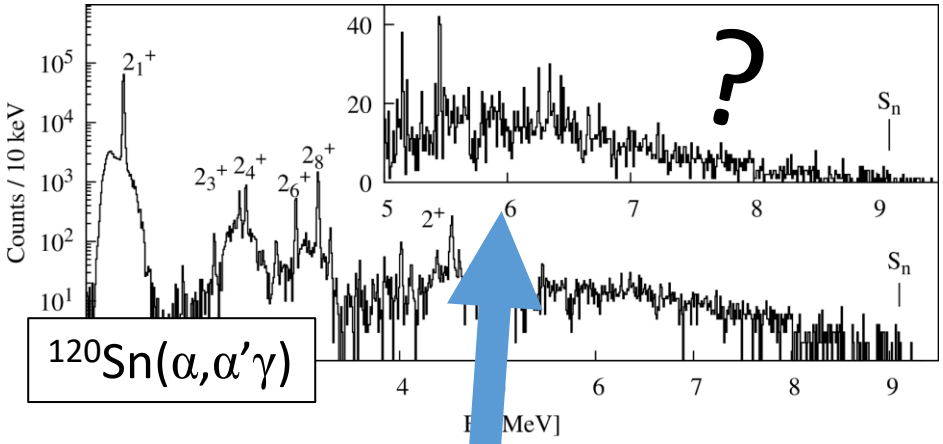


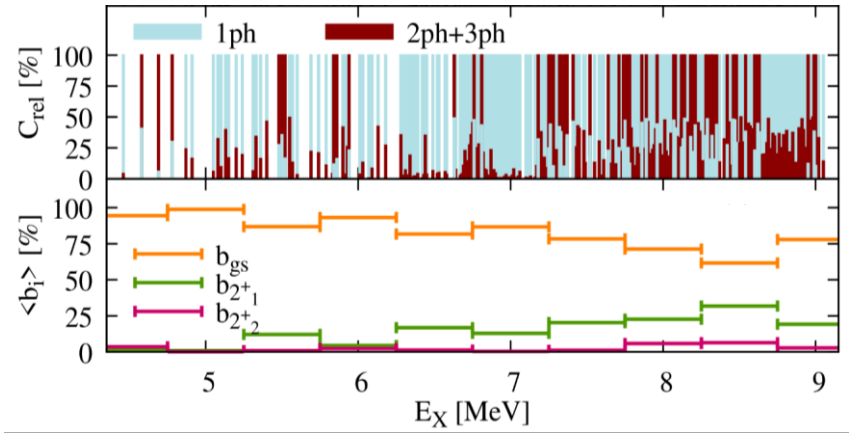


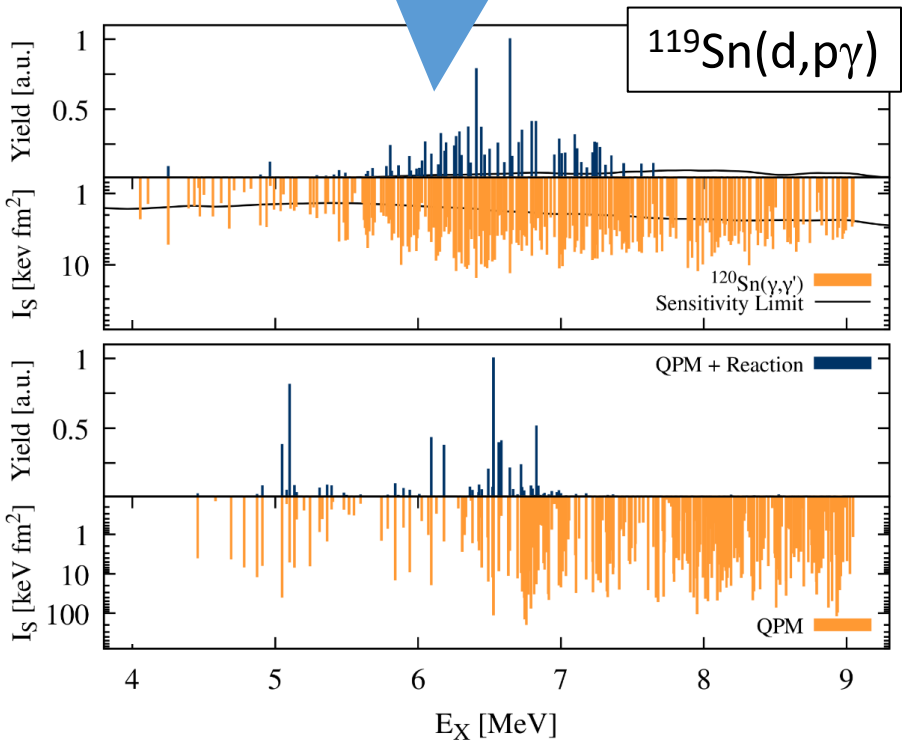


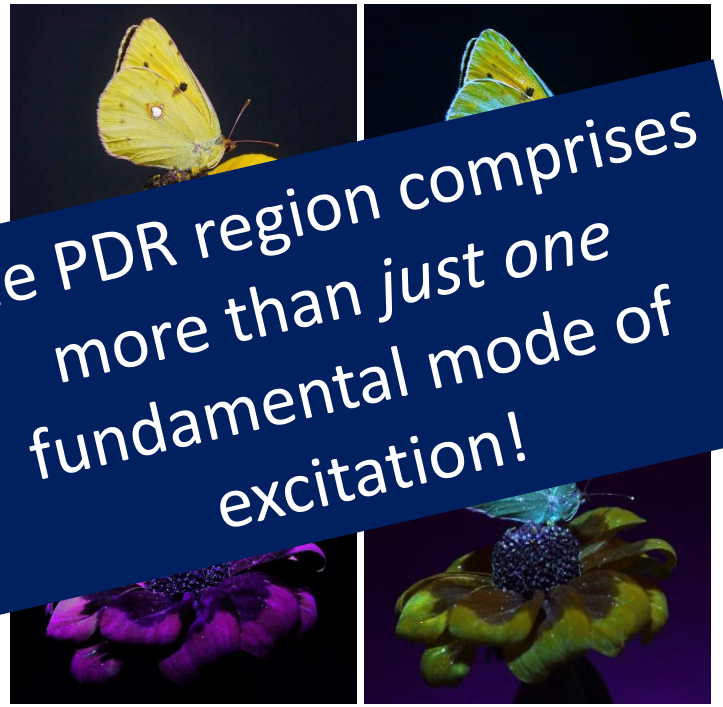
- No pronounced difference between (α,α'γ) and (γ,γ') suggested!
- **Total isoscalar response** reproduced from **only the 1ph TRDs**!
- **Connection** between **1p-1h** structure and ***neutron-skin*** oscillation?

The Many Faces of the PDR in ^{120}Sn









The PDR region comprises more than *just one* fundamental mode of excitation!

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