

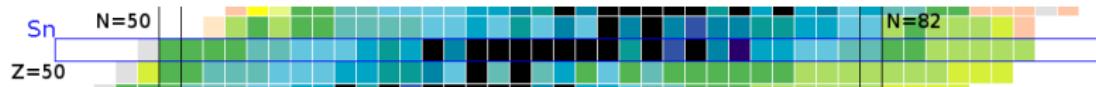
Spectroscopic studies of $^{116,118,120}\text{Sn}$ through thermal neutron induced reactions using FIPPS

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Undergraduate

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CAP Congress

SFU

Motivations



Tin?

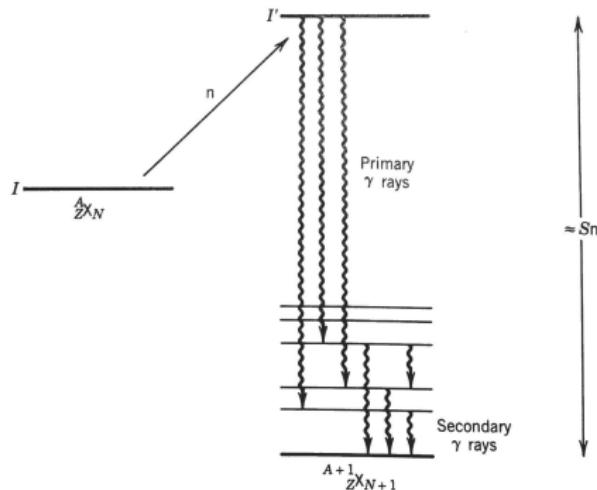
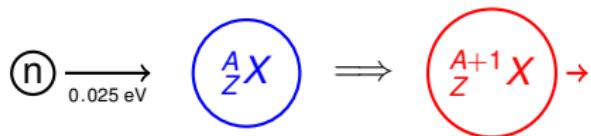
- ▶ Situated on proton magic number 50
- ▶ Studying tin nuclei near stability useful for constructing more accurate models for exotic tin isotopes

Neutron Capture?

- ▶ Complimentary to similar experiments on tin conducted using β^- - decay of indium at TRIUMF using GRIFFIN
- ▶ Provides an additional picture of the level scheme of a nucleus

Neutron Capture Reactions (n, γ)

For S-Wave Capture (Thermal Neutrons)



Spin:
 $I' = I \pm \frac{1}{2}$

Parity:
 $\pi' = \pi$

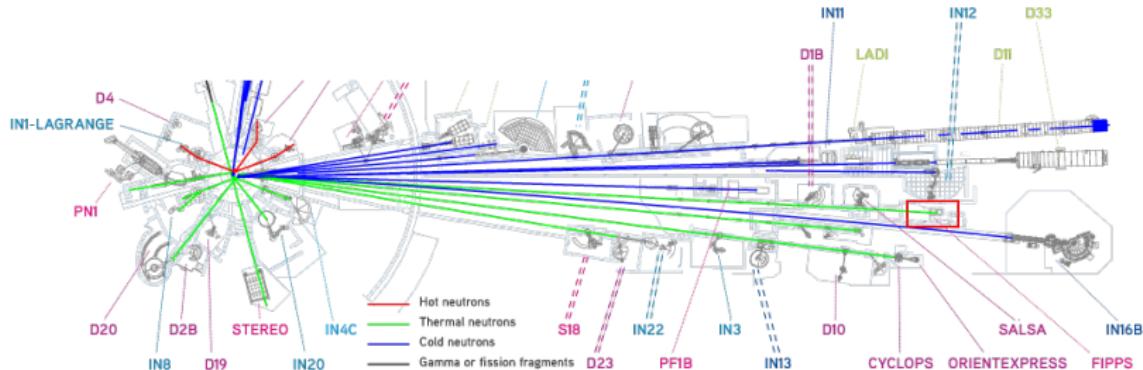
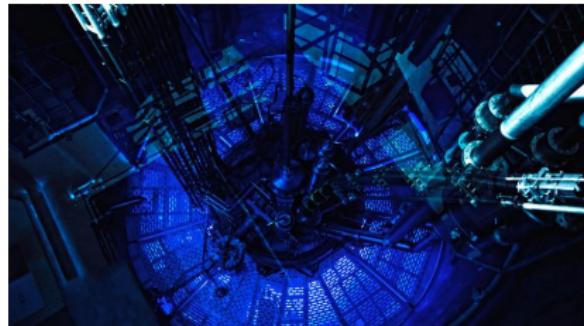
Tin Isotopes:

A	S_n [MeV]
116	9.56
118	9.32
120	9.10

ILL Grenoble

Institut Laue-Langevin

- ▶ Constant $10^8 \text{ neutrons} \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$ thermal neutrons produced by 57 MW research reactor
- ▶ Collimated neutron beam of 1.5 cm at target

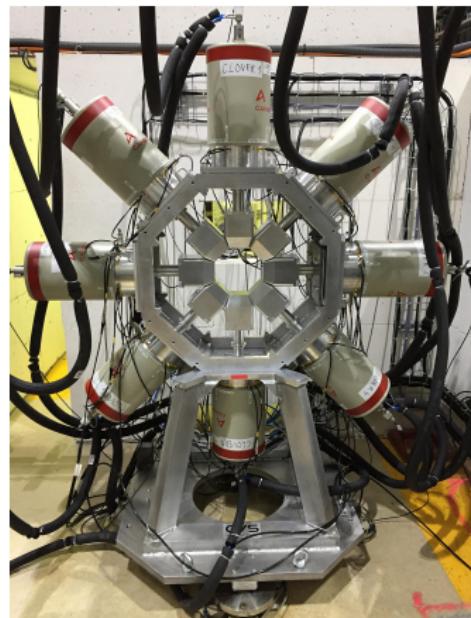


FIPPS Array

Phase 1

Array Parameters:

- ▶ Large n-type HPGe crystals
- ▶ 8 Clover detectors
- ▶ $d_{\text{D-to-T}}$ distance $\approx 9 \text{ cm}$
- ▶ Energy Res. @ 1.4 MeV $\approx 2.3 \text{ keV}$
- ▶ Data acquisition with CAEN V1724 ADC's

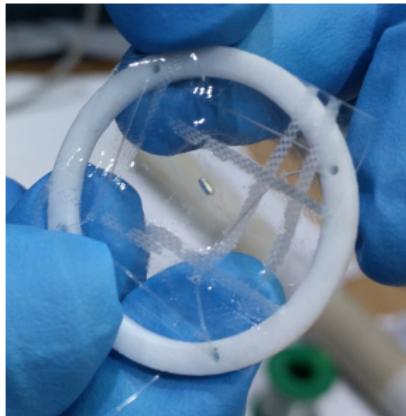


Tin Experiments at ILL

Conducted in 2018

EXP 3-17-9

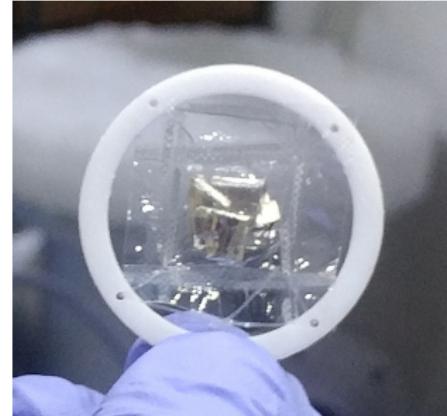
- ▶ $^{115}\text{Sn}(n,\gamma)^{116}\text{Sn}$
- ▶ 10 mg 50% enriched target
- ▶ 16 ancillary $\text{LaBr}_3(\text{Ce})$
- ▶ TAC's for fast timing measurements



Courtesy of FHG

EXP 3-17-20

- ▶ $^{117}\text{Sn}(n,\gamma)^{118}\text{Sn}$
 - ▶ 300 mg target with 92.8% enrichment
- ▶ $^{119}\text{Sn}(n,\gamma)^{120}\text{Sn}$
 - ▶ 500 mg target
- ▶ 8 additional HPGe clovers



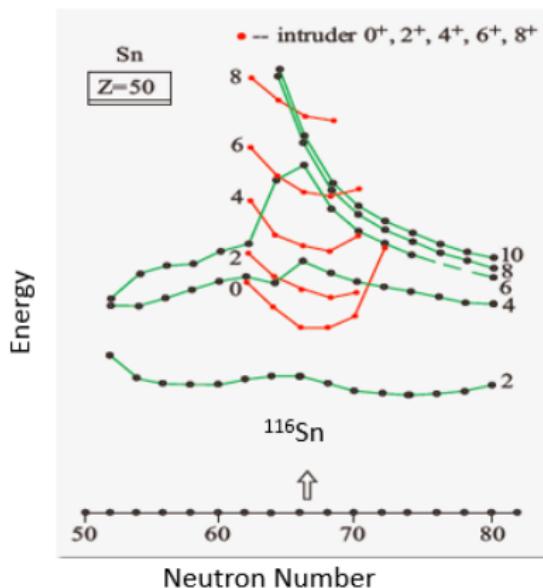
Courtesy of K. Ortner

Experiment 3-17-9

^{116}Sn

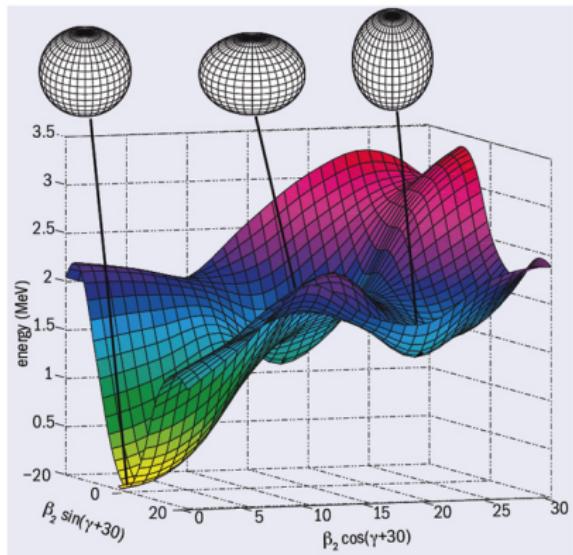
Shape Coexistence

^{116}Sn Experiment



J. Pore M.Sc. Thesis (2013) SFU

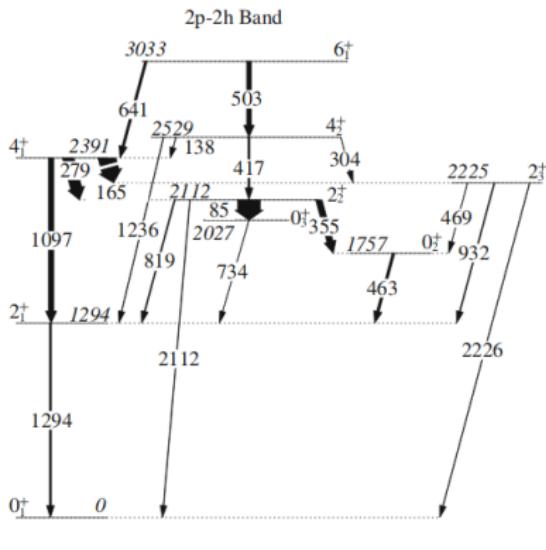
^{186}Pb Textbook Example



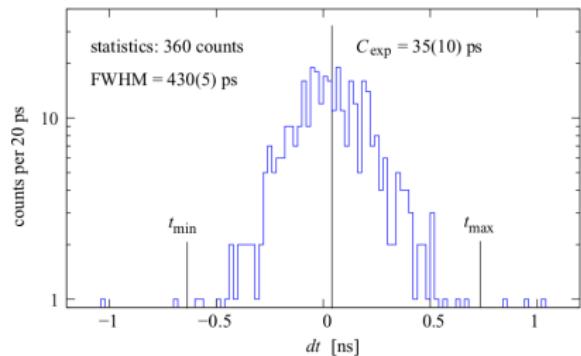
Cern Courier Feature: Exotic lead nuclei get into shape at ISOLDE

$\text{LaBr}_3(\text{Ce})$ Fast Timing

^{116}Sn Experiment



- ▶ Half-life of 4_2^+ state previously postulated to be $\sim 10 \text{ ps}^1$
- ▶ Measurements from ^{116}Sn experiment confirm $T_{1/2} = 29(10) \text{ ps}^2$



Time difference spectra from $\text{LaBr}_3(\text{Ce})$ Array

¹J. L. Pore *et al.*, Eur. Phys. J. A **53**, 27 (2017)

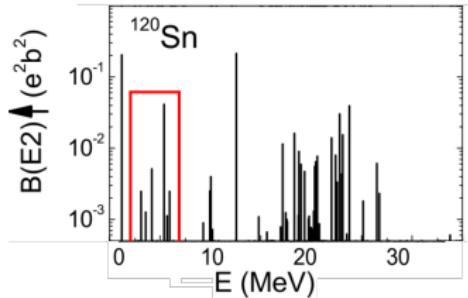
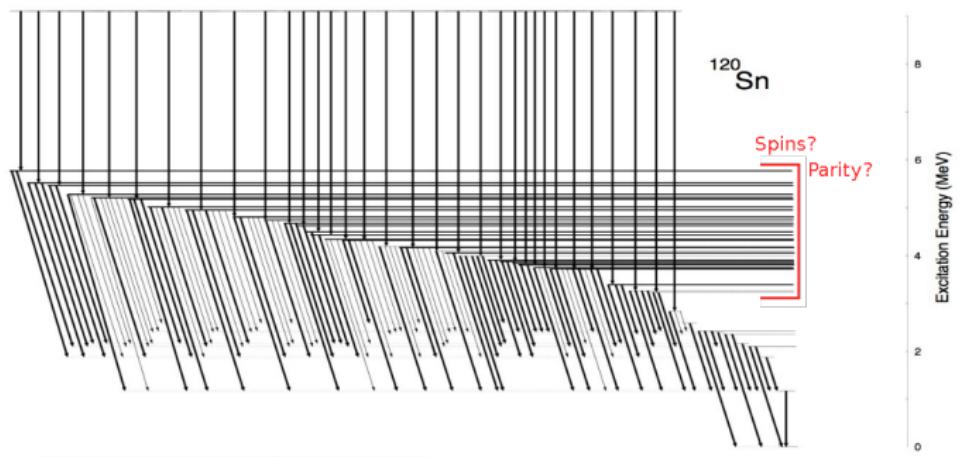
²C. M. Petrache *et al.*, Phys. Rev. C **99**, 024303

Experiment 3-17-20

$^{118,120}\text{Sn}$

Pygmy Dipole Resonances

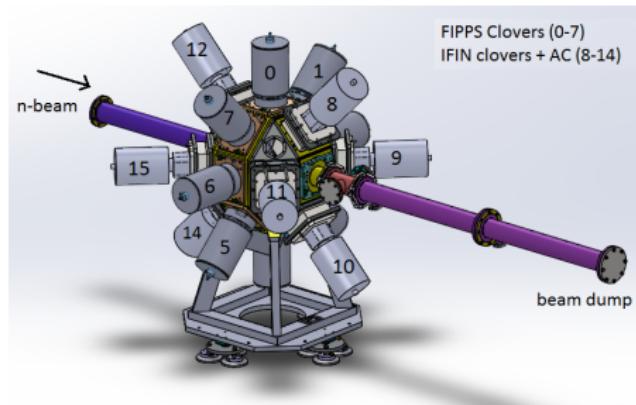
$^{118,120}\text{Sn}$ Experiment



- ▶ Low energy dipole excitations between 3.0-6.0 MeV
- ▶ Spin and parity assignments of closely packed states should be similar

Enhanced FIPPS Array

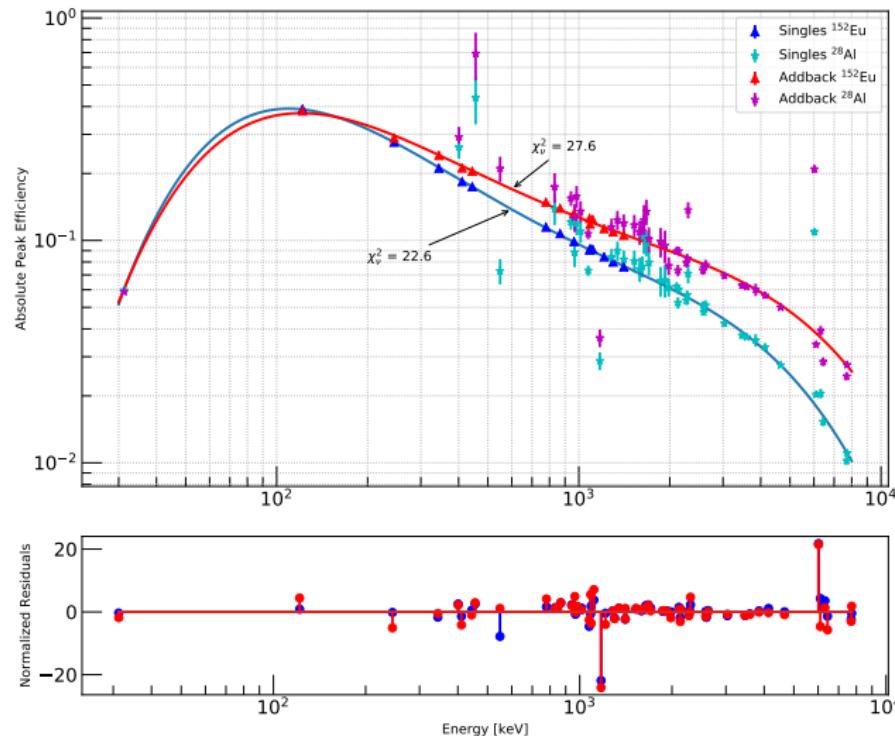
$^{118,120}\text{Sn}$ Experiment



- ▶ An 8 additional BGO Anti-Coincidence HPGe Detectors from IFFIN
- ▶ Improved efficiency
- ▶ Increases the number of unique angles for angular correlation measurements

FIPPS + IFIN Absolute Efficiency

$^{118,120}\text{Sn}$ Experiment



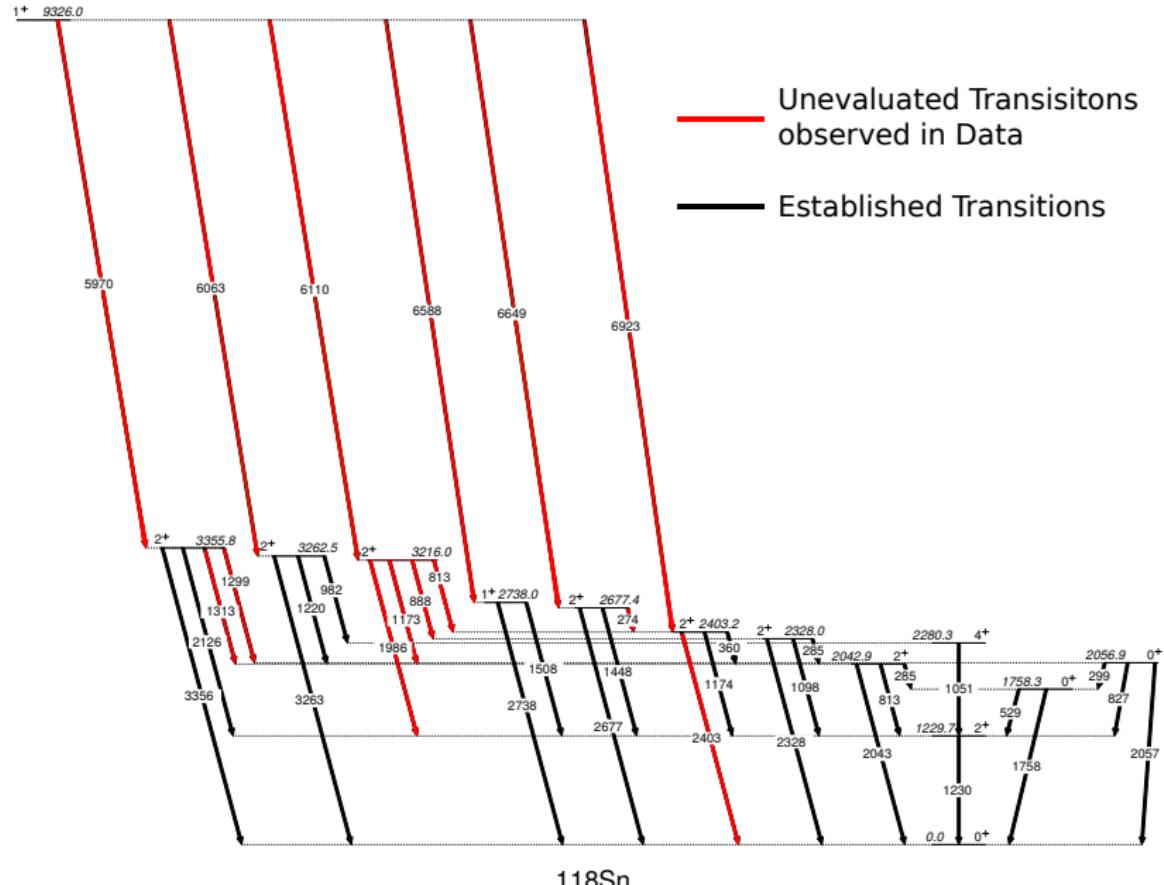
$^{152}\text{Eu}:$

$$E = 0.1 - 1.4 \text{ MeV}$$

$^{27}\text{Al}(n,\gamma)^{28}\text{Al}:$

$$E = 0.0 - 7.4 \text{ MeV}$$

^{118}Sn Partial Level Scheme



Future Work

- ▶ FIPPS is a new setup for us at SFU
- ▶ Behind-the-scenes code writing:
 - ▶ Angular Correlations
 - ▶ Compton Polarimetry
 - ▶ TAC Gating
 - ▶ Empirical 180° Summing Corrections
 - ▶ Correcting Non-Linear Systematic in Energy Calibration
- ▶ Identifying and assigning spin and parity assignments of possible pygmy dipole states and compare to theoretical calculations
- ▶ Performing lifetime measurements of unknown states
- ▶ Complete spectroscopy of $^{116,118,120}\text{Sn}$

Questions?

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Non-Linear Residuals of Detector 0

