

DE LA RECHERCHE À L'INDUSTRIE



The NEVFAR project:

New Evaluation of  $\nu$  Fluxes At Reactors

# Revisiting the summation calculation of reactor antineutrino spectra

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**[16th Applied Antineutrino Physics workshop](#)**

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# EXPERIMENTAL CONTEXT

## Reactor anomalies

- Tensions with respect to Huber-Mueller model
- Experimental anomalies
  - ▶ Reactor  $\bar{\nu}_e$  anomaly (RAA):  $\sim 6\%$  deficit of measured IBD rates significant at  $2.5\sigma$
  - ▶ Change in measured IBD rates with respect to fuel composition incompatible with model
  - ▶ Shape of measured IBD spectra incompatible with model
- Can be explained by a bias in Huber-Mueller model or by underestimated model uncertainties

## Summation method

- Prediction  $\forall$  energy,  $\forall$   $\beta$  emitter
- Mandatory (eg activation spectra, CEvNS, geo)



- Uncomplete/biased nuclear database
- Modeling approximations



- **Uncertainties very complex to estimate**

**Need improved evaluation of summation prediction & uncertainties**

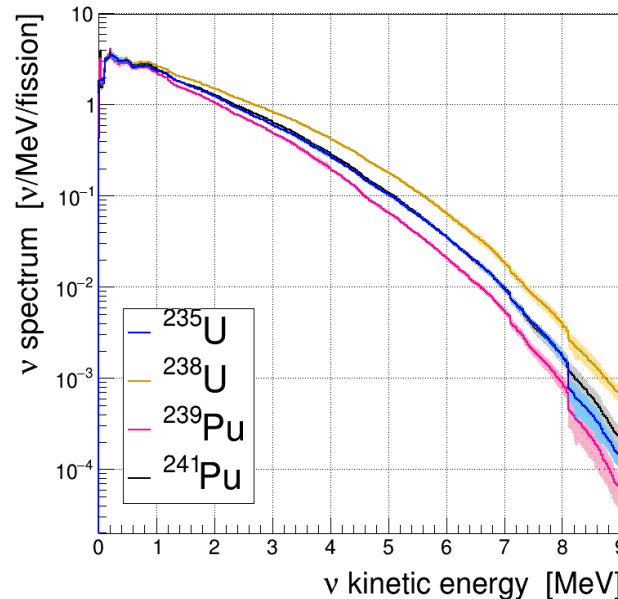
# THE NE $\nu$ FAR PROJECT

(New Evaluation of  $\nu$  Fluxes At Reactor)



## Revise summation method with BESTIOLE code

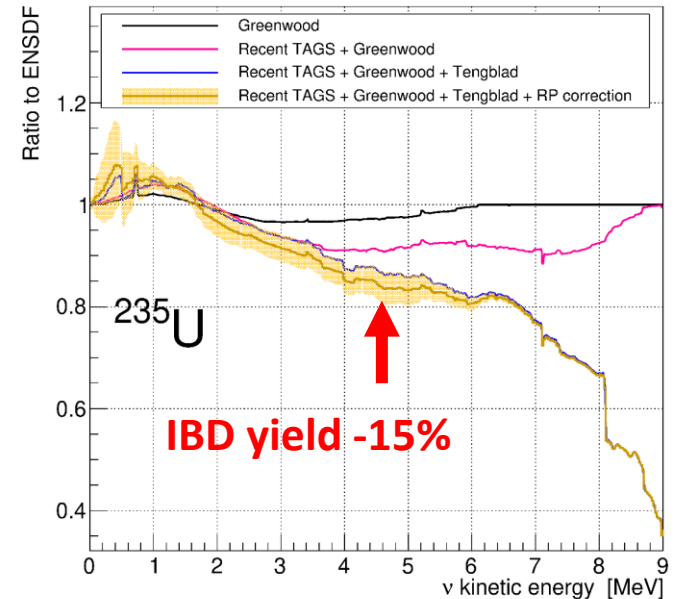
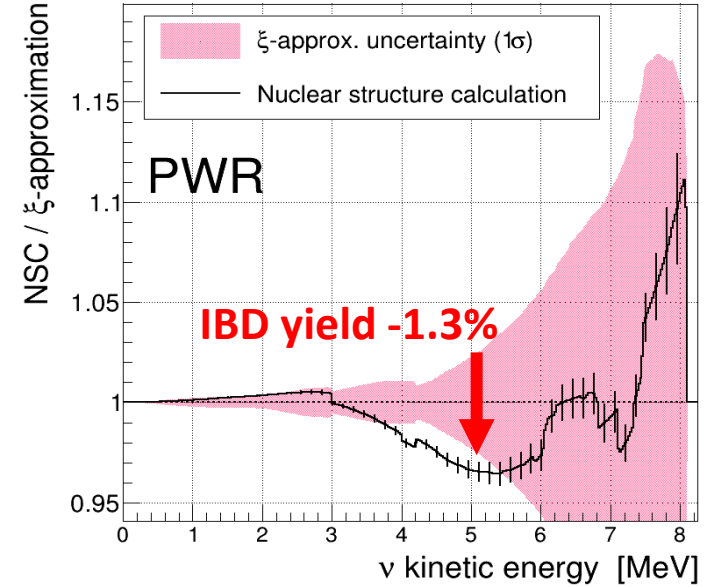
- Improve  $\beta$ -decay modeling
  - ▶ Refined **non-unique forbidden transition** using nuclear structure calculation for 23 transitions
    - ⇒ **Decreases IBD yield by  $(1.3 \pm 0.2)\%$**
- Impact of database incompleteness and quality
  - ▶ Modeling of nuclides with no data
  - ▶ Include **Pandemonium-corrected data**
    - ⇒ **Decreases IBD yield by  $(15 \pm 3)\%$**
- Build **comprehensive uncertainty** budget
  - ⇒ **Led by uncertainty for Pandemonium effect**



**IBD yields**  
( $10^{-43}$  cm $^2$ /fission)

$^{235}\text{U} = 6.25 \pm 0.21$   
 $^{238}\text{U} = 10.01 \pm 0.32$   
 $^{239}\text{Pu} = 4.48 \pm 0.15$   
 $^{241}\text{Pu} = 6.58 \pm 0.21$

**IBD yield uncertainty**  
 $\sim 3\%$



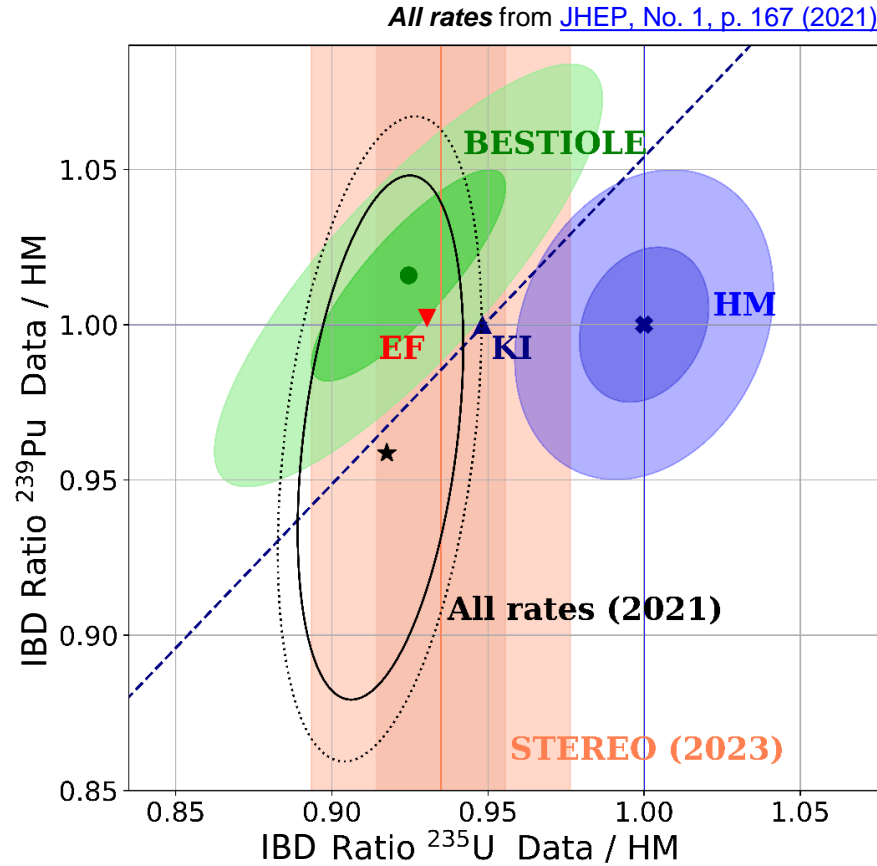
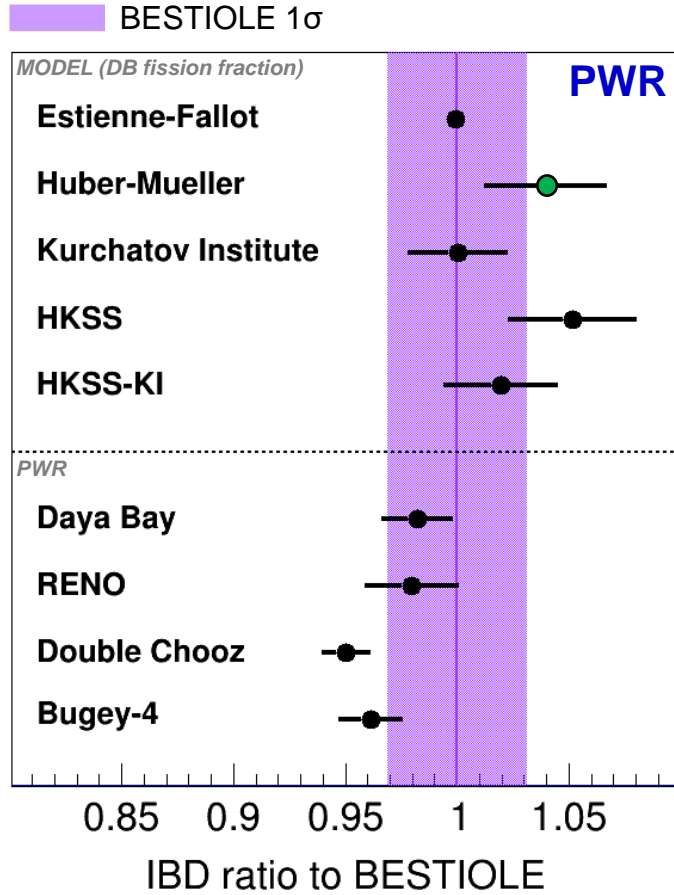
## RESULTS: INTEGRAL MEASUREMENTS

- DB / BESTIOLE =  $0.982 \pm 0.015$  (exp)  $\pm 0.031$  (model)
- DB / HM =  $0.945 \pm 0.014$  (exp)  $\pm 0.024$  (model)

⇒ Significance at  $0.5\sigma$  for BESTIOLE and  $1.9\sigma$  for HM

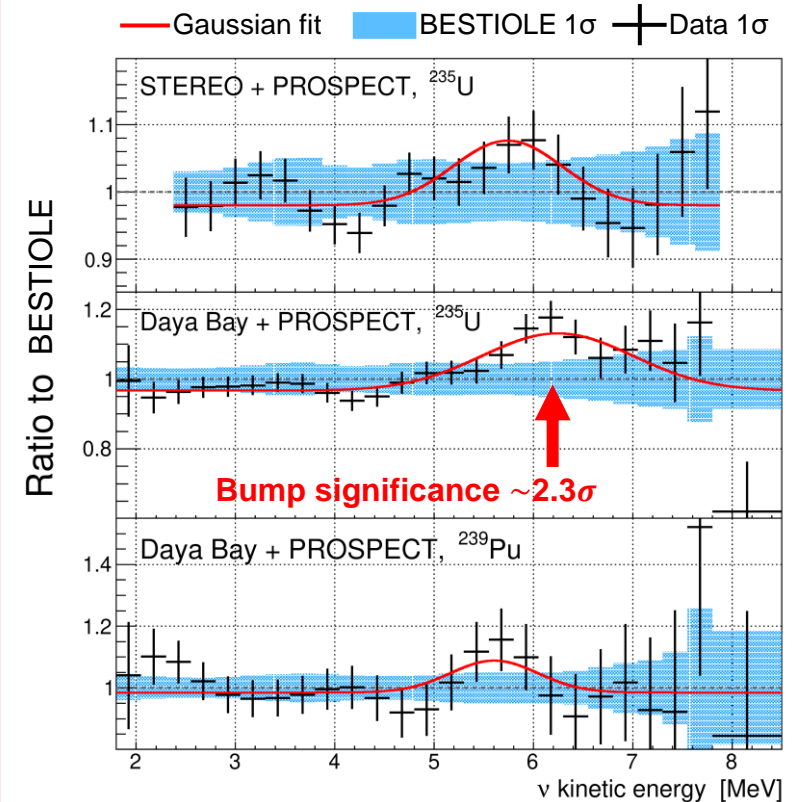
- BESTIOLE consistent within  $\sim 2\sigma$  with global rate analysis

⇒ Discrepancy with HM favors RAA caused by  $^{235}\text{U}$  HM flux



## RESULTS: RATIO OF IBD SPECTRA

- Shape only comparison, predictions normalized to data
- Gaussian distortion not significantly favored in 5-7 MeV
  - ▶ Gaussian bump hypothesis favored by  $\leq 2.3\sigma$



Overall good agreement with experimental IBD spectra

More details in the [associated presentation](#) and in our [article on arXiv](#) !