

NEST: the powerful tool for simulating low-energy processes in noble elements

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# NEST collaboration

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# About NEST

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- ▶ C++ package with Python equivalent (nestpy)
- ▶ Optional GEANT4 and ROOT integration
- ▶ Simulates the scintillation, ionization, and electroluminescence processes in xenon and argon
- ▶ Github: <https://github.com/NESTCollaboration>
- ▶ Collaboration Website: <http://nest.physics.ucdavis.edu/>

# Low-energy NR in xenon

- ▶ Total quanta  $N_q$  (light+charge) is a power law

$$N_q = \alpha E^\beta$$

- ▶ Charge and light are not anticorrelated at low energies

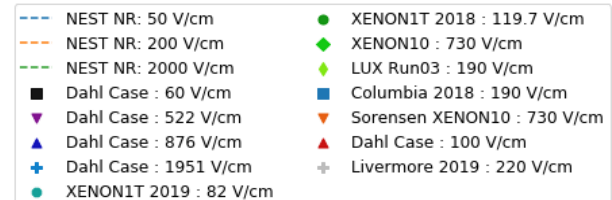
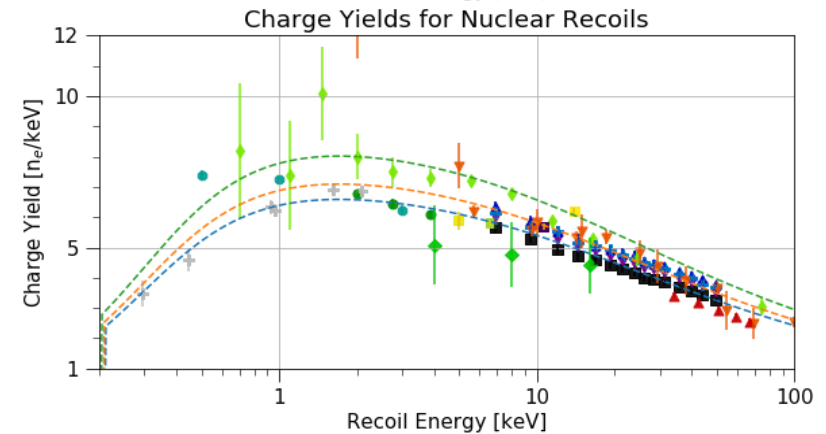
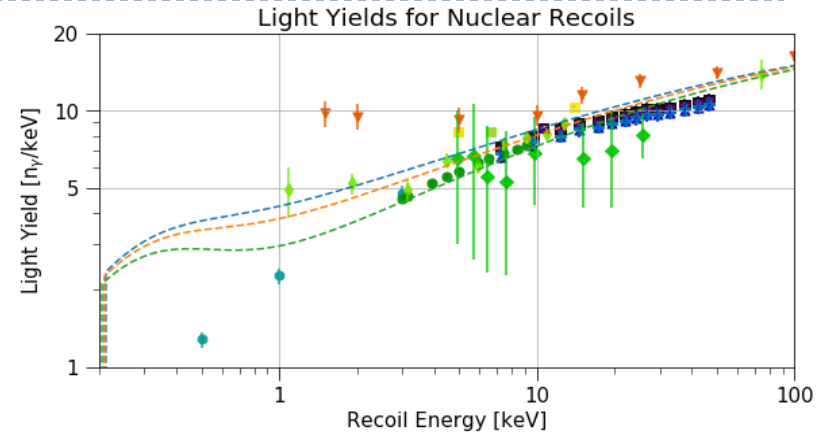
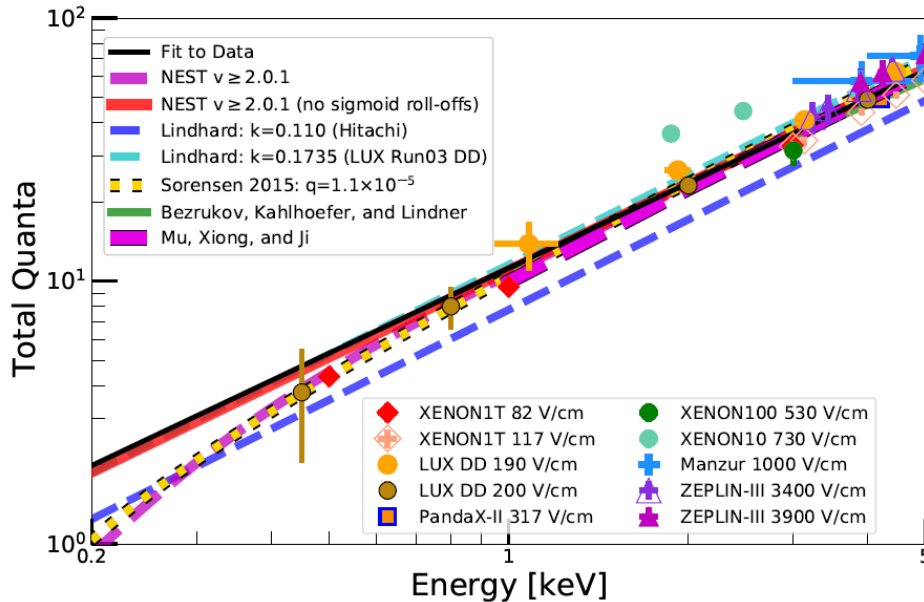
$$N_e = \frac{E}{TIB * \sqrt{E + \varepsilon}} * \left(1 - \frac{1}{1 + (\frac{E}{\zeta})^\eta}\right)$$

$$N_{ph} = (N_q - N_e) * \left(1 - \frac{1}{1 + (\frac{E}{\theta})^\iota}\right)$$

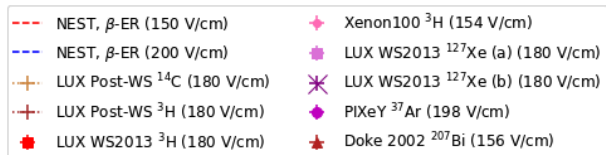
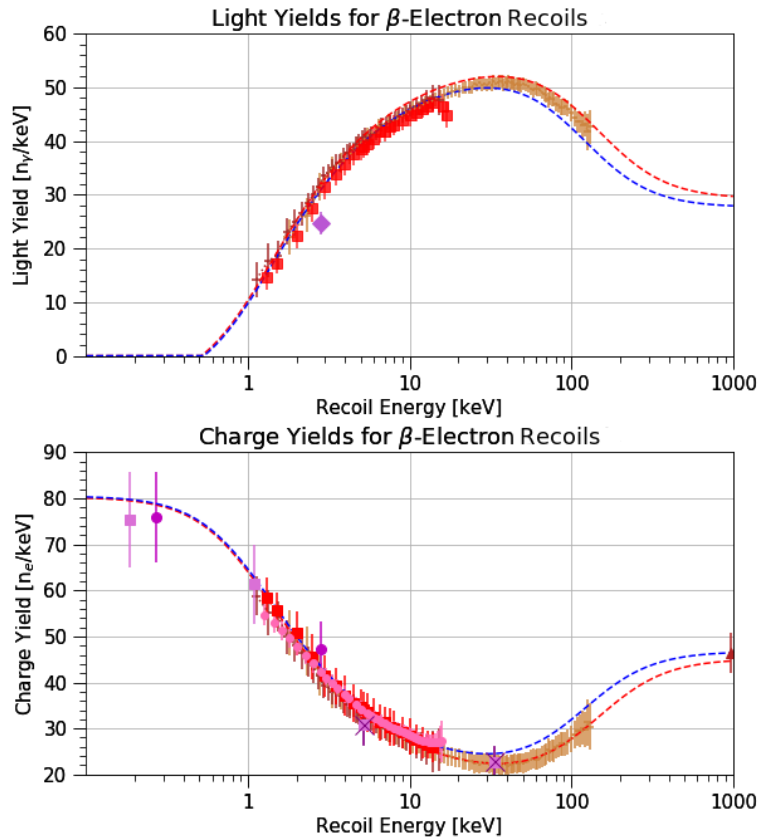
$$TIB = \gamma * Field^\delta * \left(\frac{\rho}{\rho_0}\right)^{0.3}$$

- ▶  $\alpha, \beta, \gamma, \delta, \varepsilon, \zeta, \eta, \theta, \iota$  are free parameters

- ▶  $\rho_0$  is  $2.9 \text{ g/cm}^3$  for xenon



# Low-energy ER in xenon

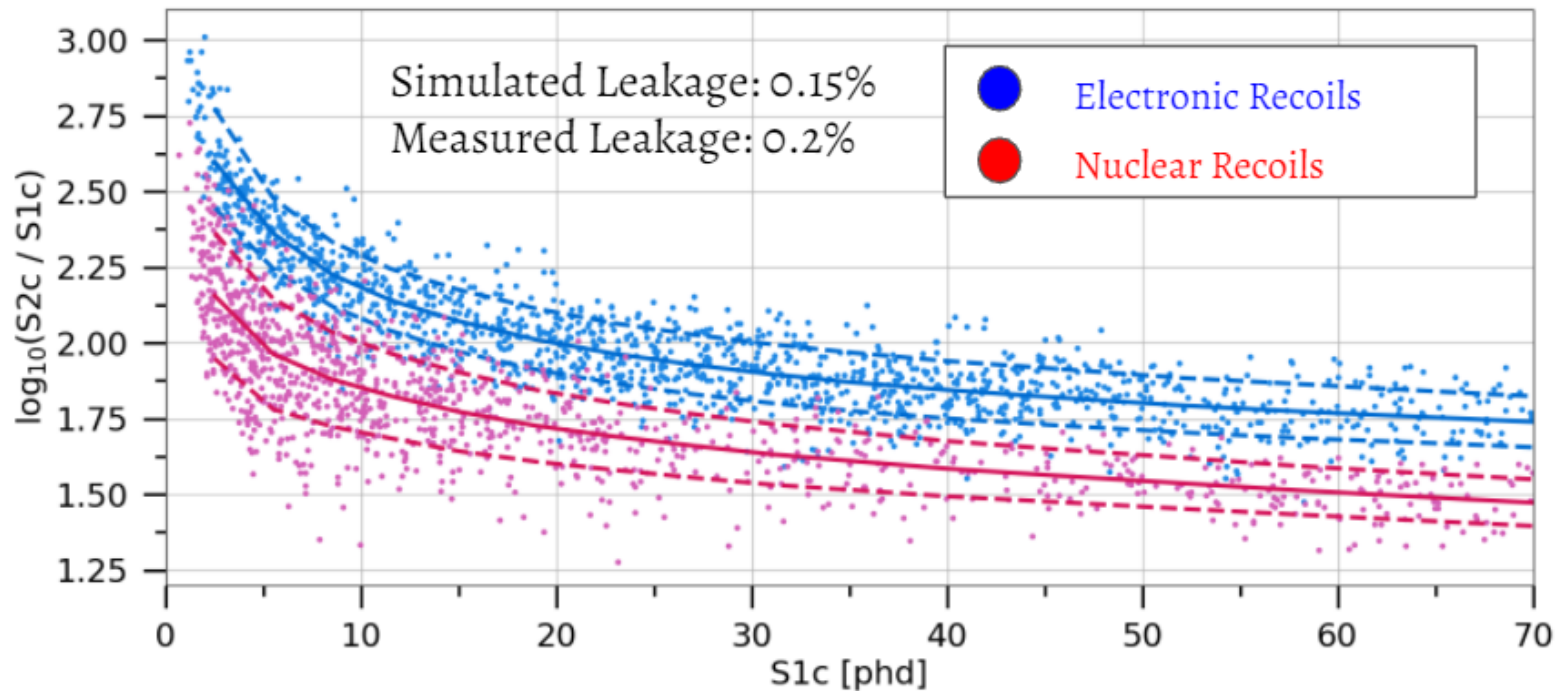


- ▶ NEST offers beta and gamma models that fit to data from sub-keV to MeV energies
- ▶  $L_y + Q_y = \text{const}$

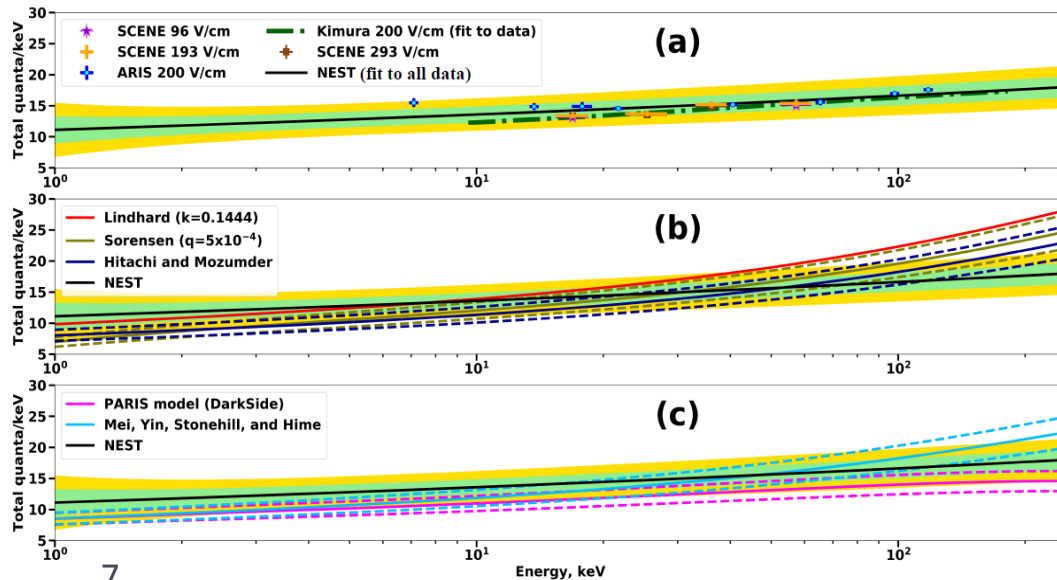
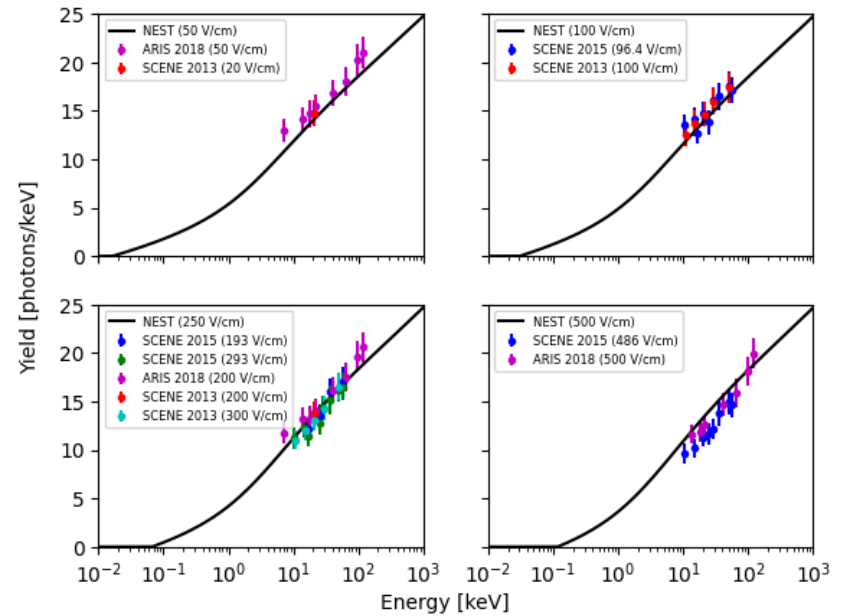
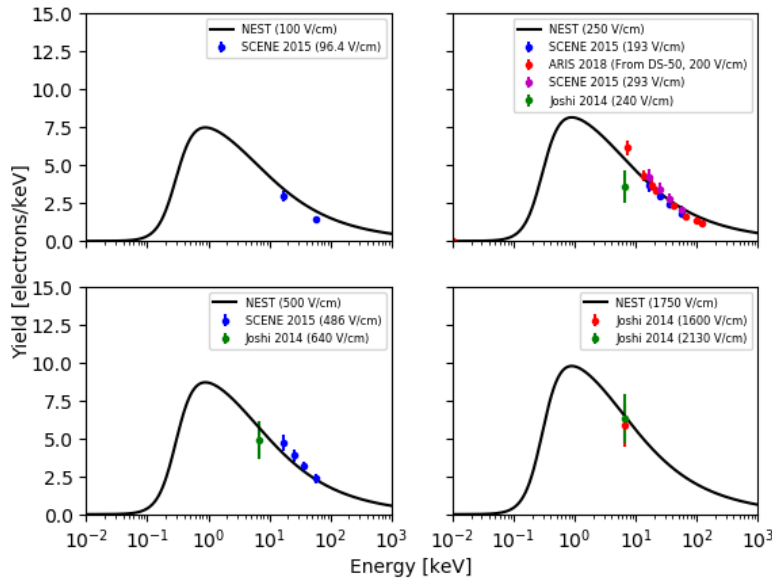
# Discrimination in xenon

- ▶ NEST is also capable of simulating NR/ER leakage
- ▶ Useful feature for signal/background discrimination

Simulation of LUX 2013

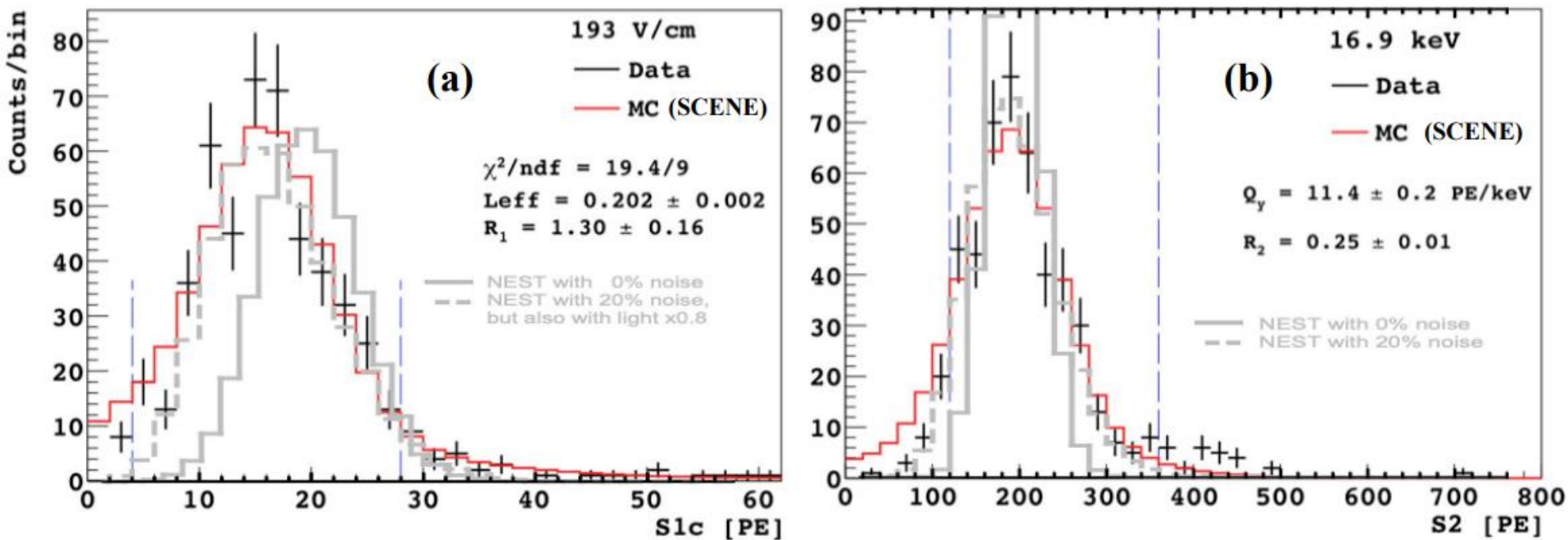


# Low-energy NR in argon



► Models are based on xenon NR model

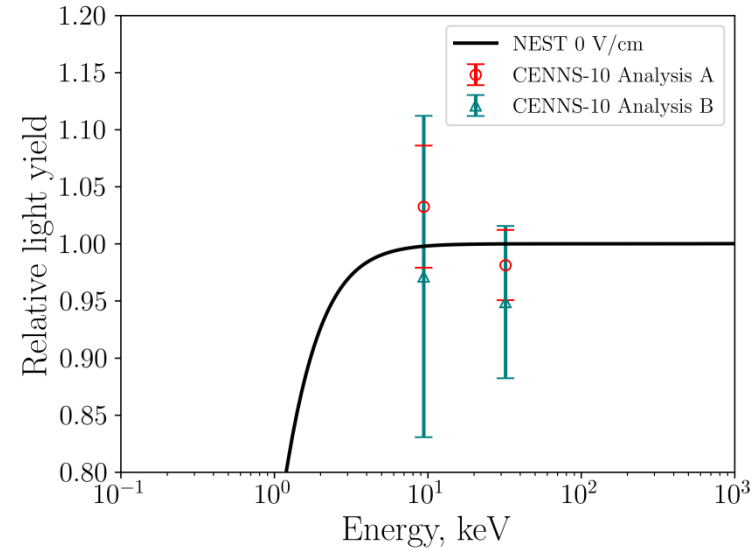
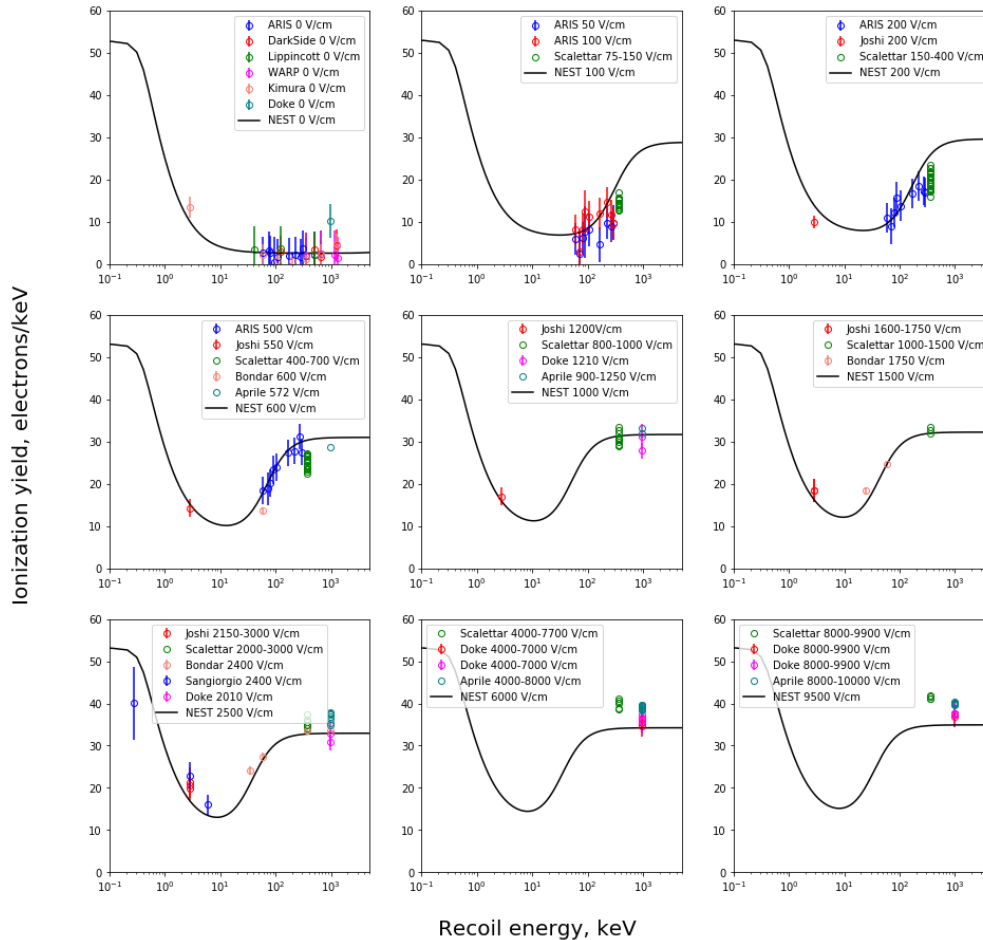
# Low-energy NR reconstruction



- ▶ (a) S1 peak and (b) S2 peak for 16.9 keV NR in LAr by SCENE



# Low-energy ER in argon



Comparison of CENNS-10 results from the two 83mKr component separation analyses compared with the NEST predictions  
 Taken from arXiv:2010.11258

► Models are based on xenon ER beta model

# Conclusion

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- ▶ NEST models the intrinsic physics of noble detectors while maintaining a format that is accessible and customizable for users
- ▶ Accurately simulates many different interactions in all xenon phases (and in liquid phase in argon)
- ▶ Upcoming updates:
  - ▶ Improvements to LAr ER model
  - ▶ Future development of gaseous Ar models
  - ▶ Improvements to LXe ER model
  - ▶ Noise
- ▶ If you want to read more about NEST:
  - ▶ [Review paper](#)
  - ▶ [NEST website](#)

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Thank you for your attention!

