The Noble Element Simulation Technique v2

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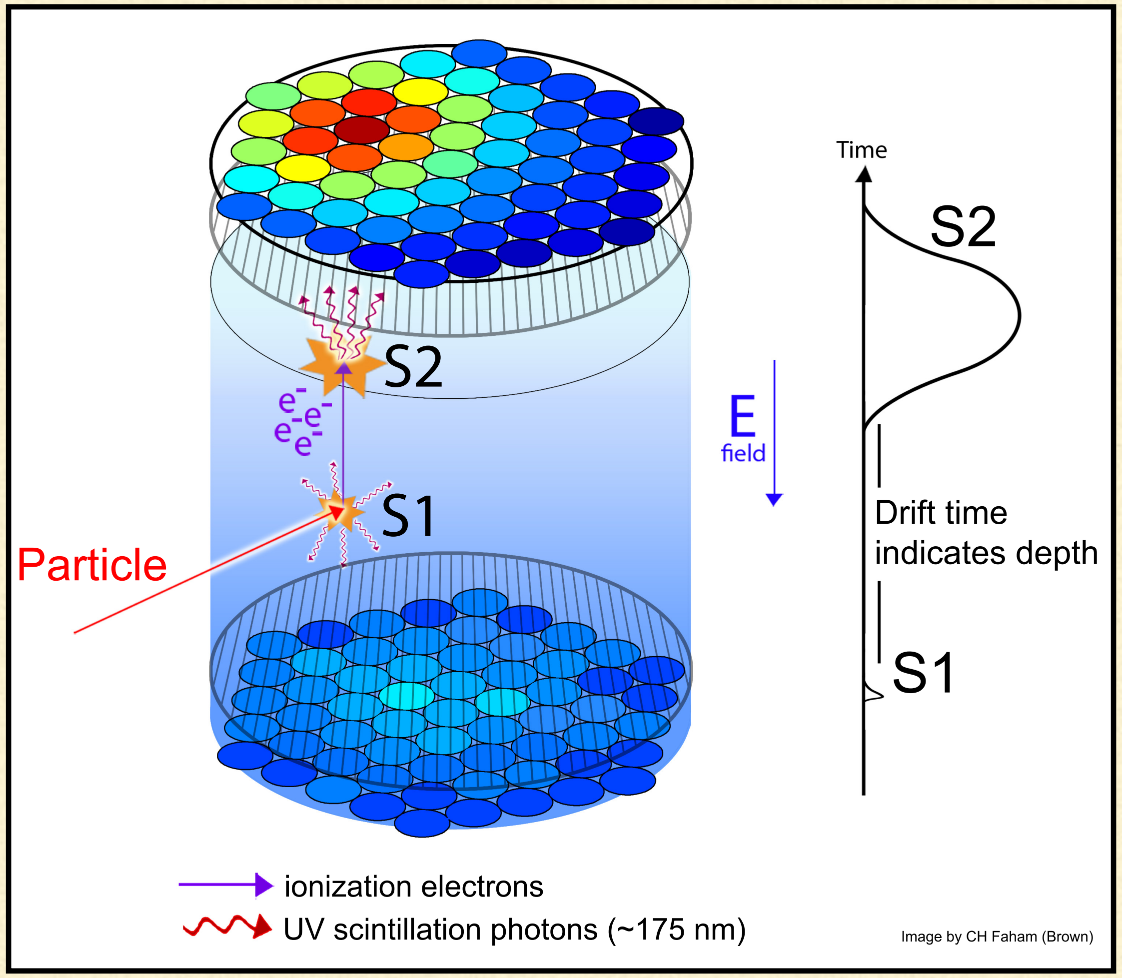
Noble Element TPCs

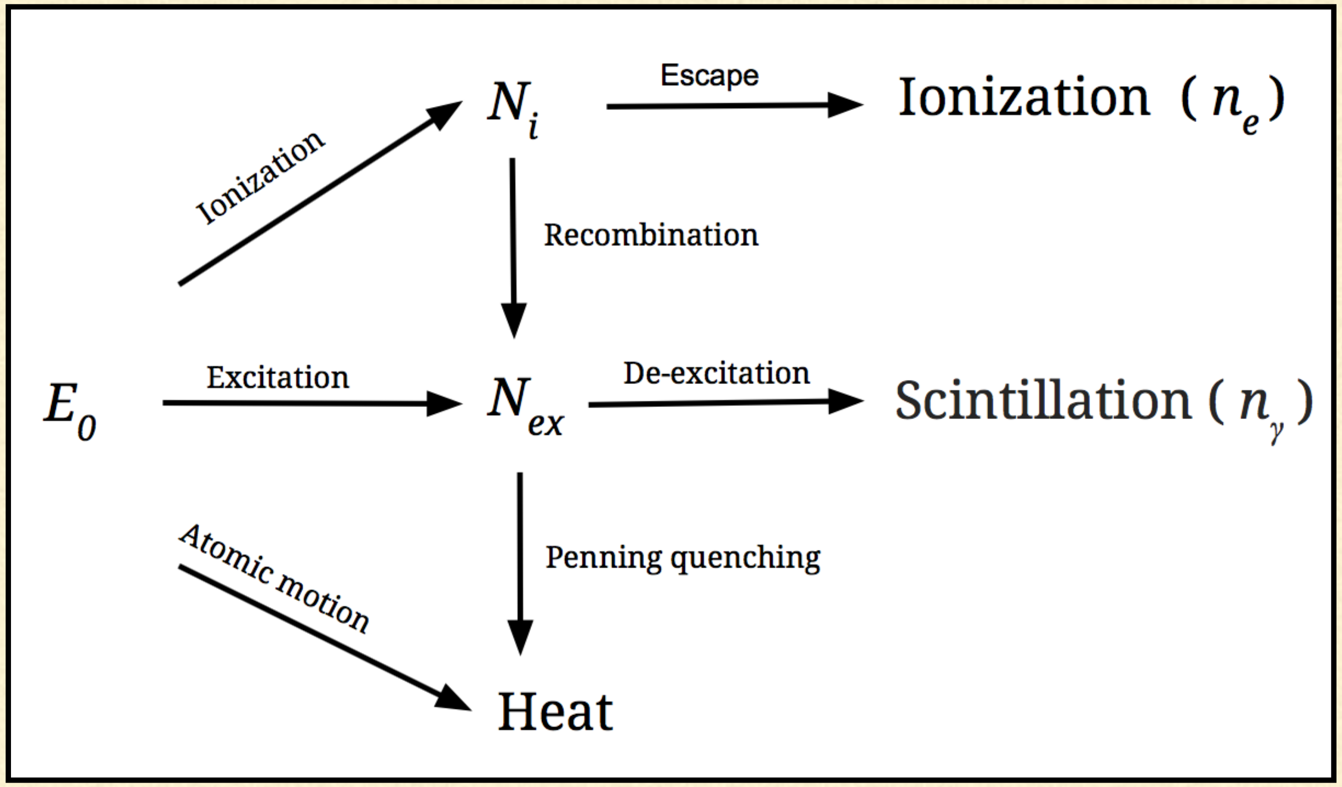


- Noble elements such as **xenon (Xe)** serve as high quality detection media for reconstructing particle interactions.
- **Dual-phase time projection chambers (TPCs)** are a common example, where energy reconstruction is done using both scintillation and ionization channels.
- It is important to model light and charge yields for a variety of interaction types.

Light and Charge Production in Xenon

- The actual microphysics of scintillation and ionization pathways is complicated, and for Xe we cannot completely track the recoil cascades from first principles.
- NEST (**N**oble **E**lement **S**imulation **T**echnique) began as a semi-empirical model that traced these pathways.
- Precision data has constrained the model to purely empirical fits of yield data.

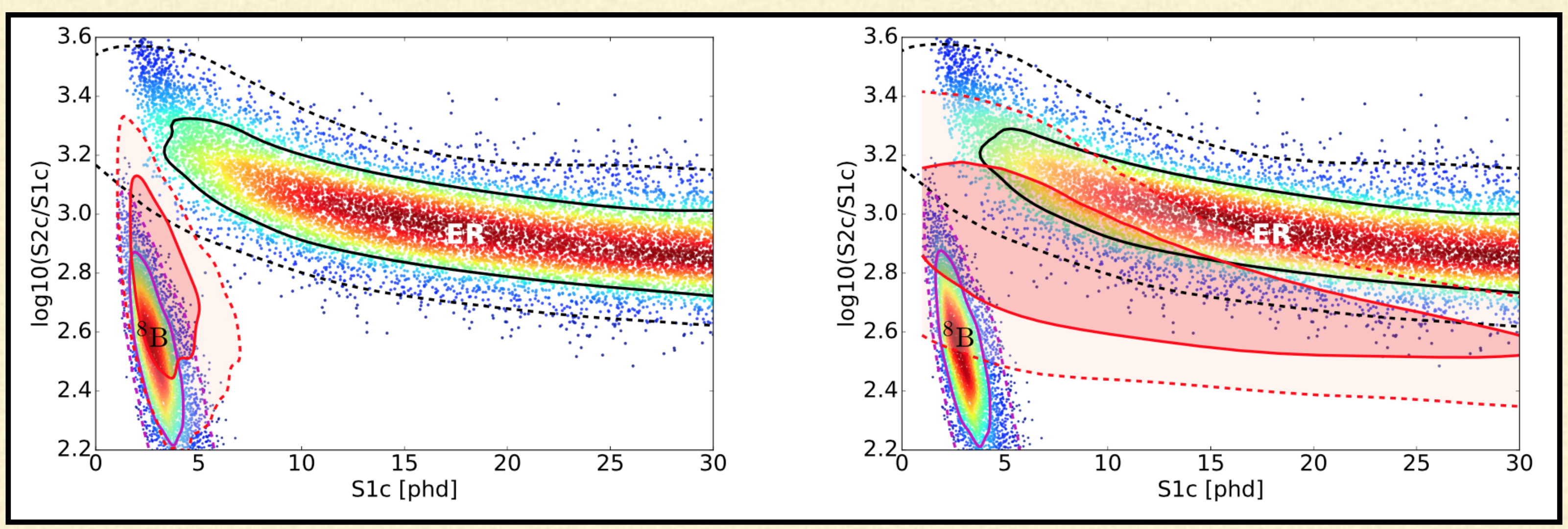
Lenardo et al.



Motivations for NEST

- Having simulations of yields as a function of electric field is crucial for optimizing detector designs and operational parameters.
- NEST guides not only the process of detector planning, but also informs the data analysis during runs and provides crucial cross-checks.
- Having well-understood background and signal models is crucial for low background experiments and rare event searches.

10 GeV/c^2 WIMP   1000 GeV/c^2 WIMP



LZ TDR (Mount et al.)

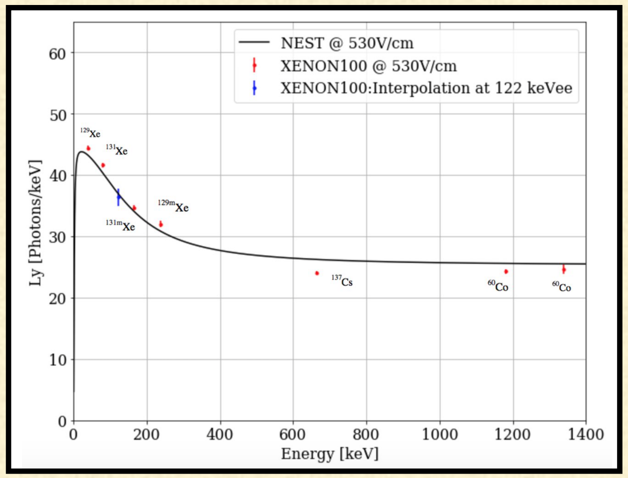
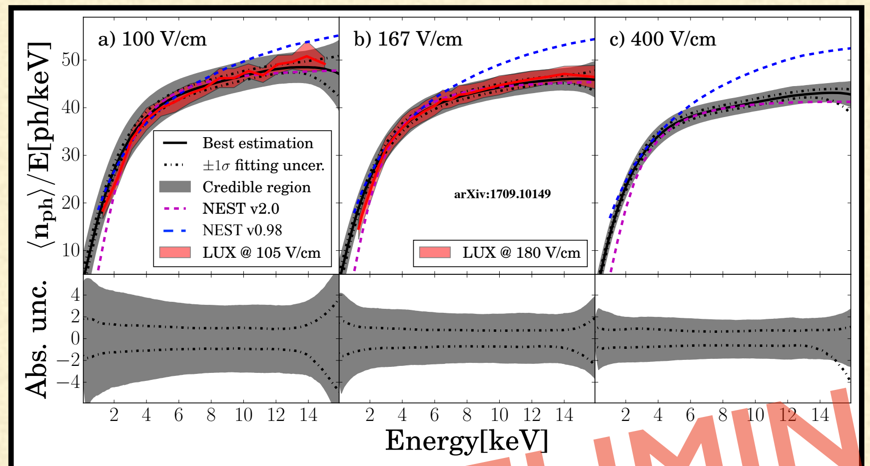
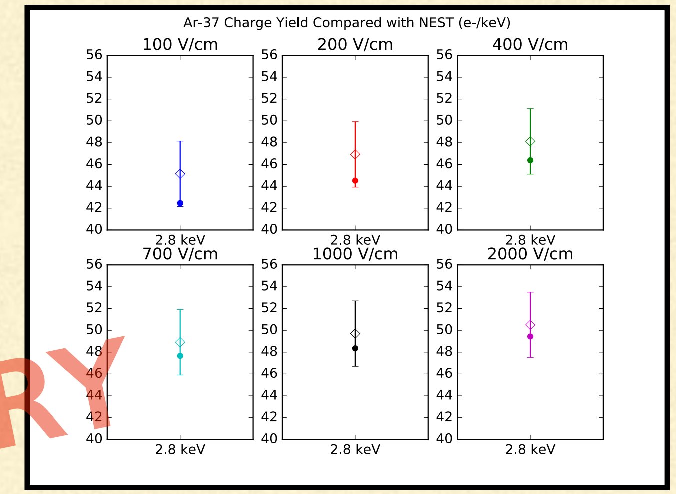
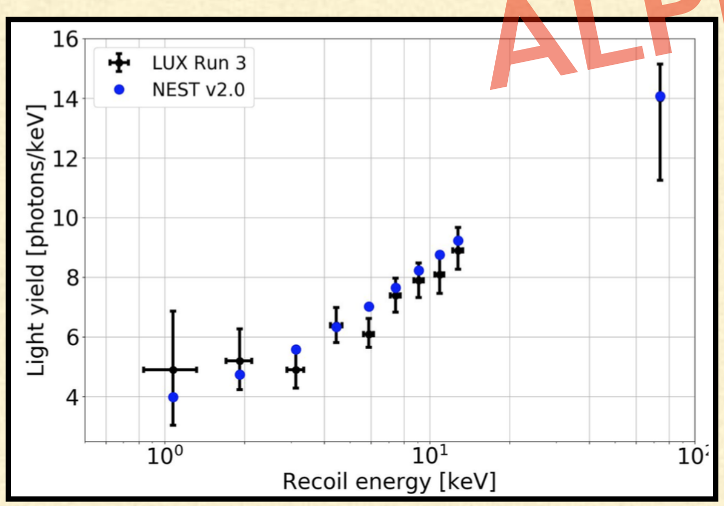
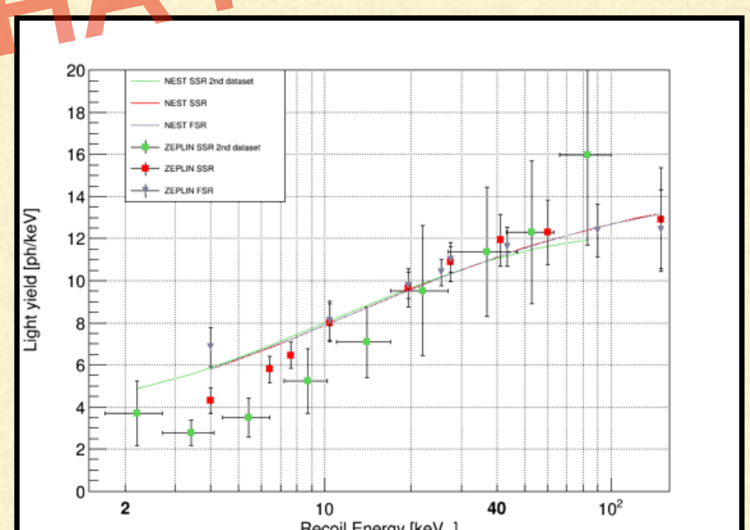
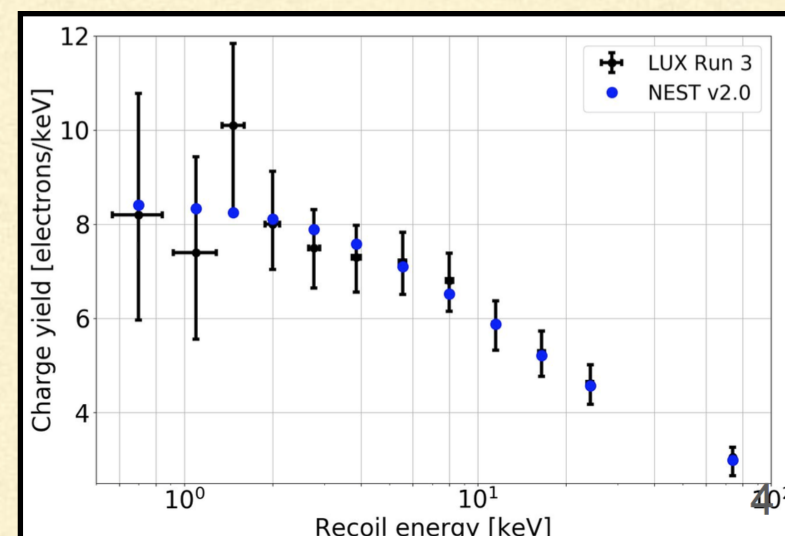
Enter NEST v2.0

- The NEST v2.0 is the latest standalone package, which can be used both as a library and as a command-line tool for quick calculations.
- NEST v2 compiles without dependencies on GEANT4 or ROOT, making it a faster and more accessible tool that works right out of the box.
- There are models for various interaction types (each with a succinct formula):
  - Compton scatters and beta decays
  - Photo-absorption
  - ^{83m}Kr

  } Electron recoils (ER)
  - Xe, other heavy nuclear recoils (e.g. ^{206}Pb)
  - Neutrons
  - Alphas

  } Nuclear recoils (NR)

Validation Campaign

	Light		Charge
ER			
NR			

ALPHA PRELIMINARY

Conclusions

- NEST v2 will be available as a public beta version by the end of this year.
- Future goals include the addition of recombination fluctuations to the physics models, an optional GEANT4 integration for full detector simulations, and a web tool for quick calculations.
- We plan to use the new empirical models as a point of comparison for an eventual first-principles atomic physics model, NEST v3.

NEST Collaboration

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Thank you!

Questions?