# ARIS: The Argon Response to Ionization and Scintillation Experiment

**B. Schlitzer**

*On behalf of the ARIS collaboration*

*<aris.in2p3.fr>*

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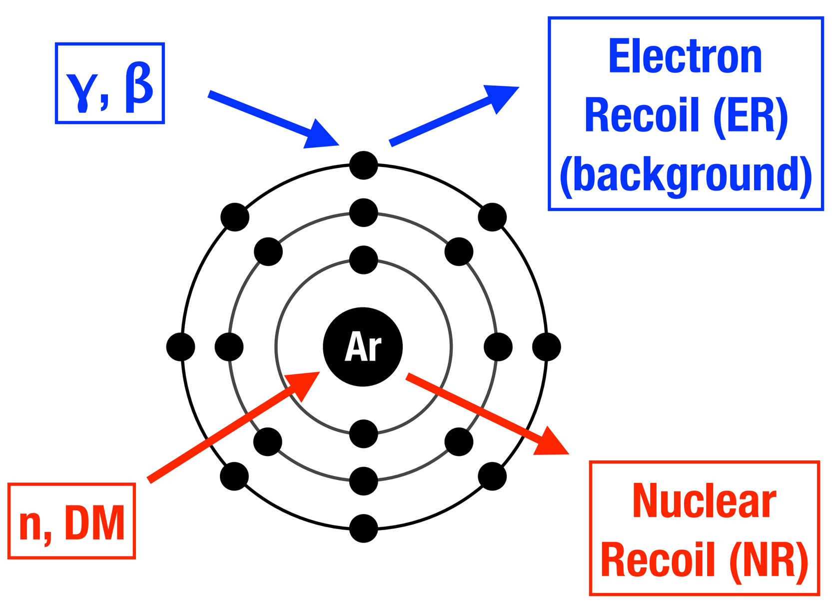
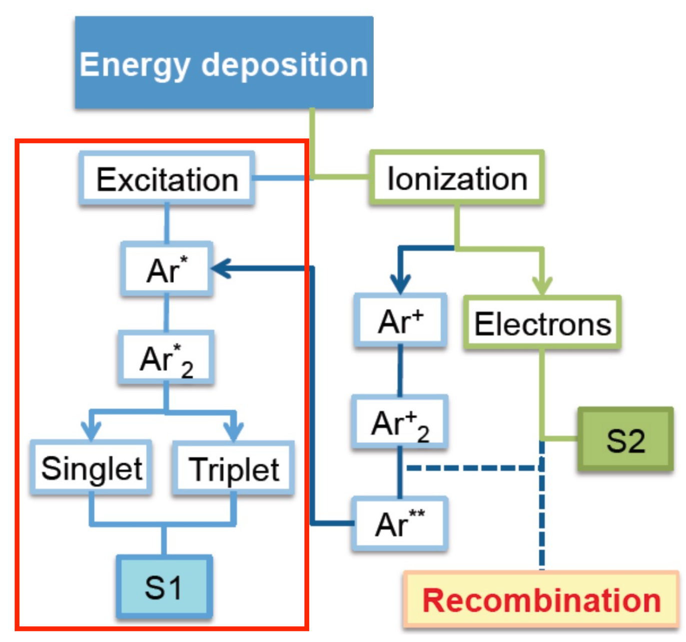
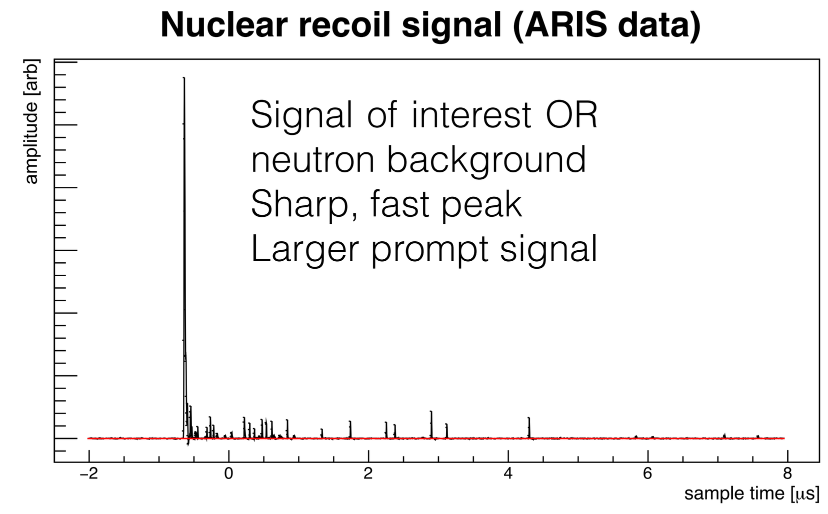
## Nuclear and Electronic Recoils

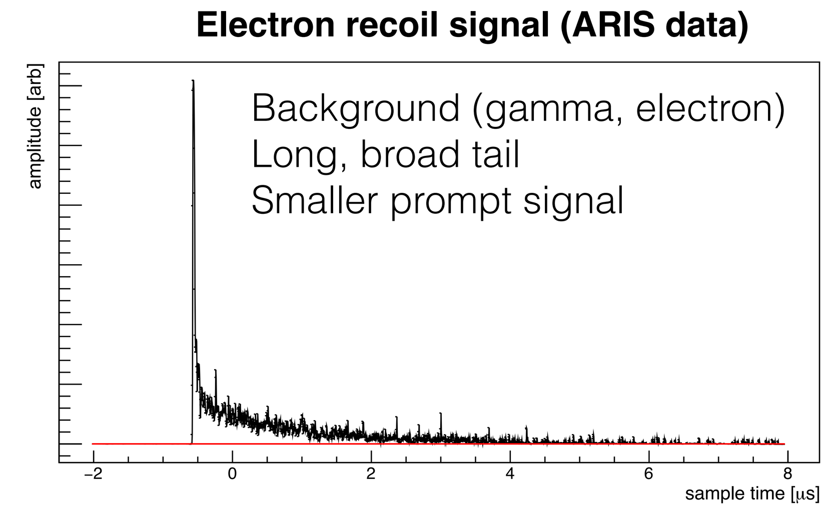
Liquid noble elements like xenon and argon are attractive options for a low energy particle search medium. One of the most powerful properties of liquid argon is its ability to discriminate between a signal of interest and background signals.




## Pulse Shape Discrimination



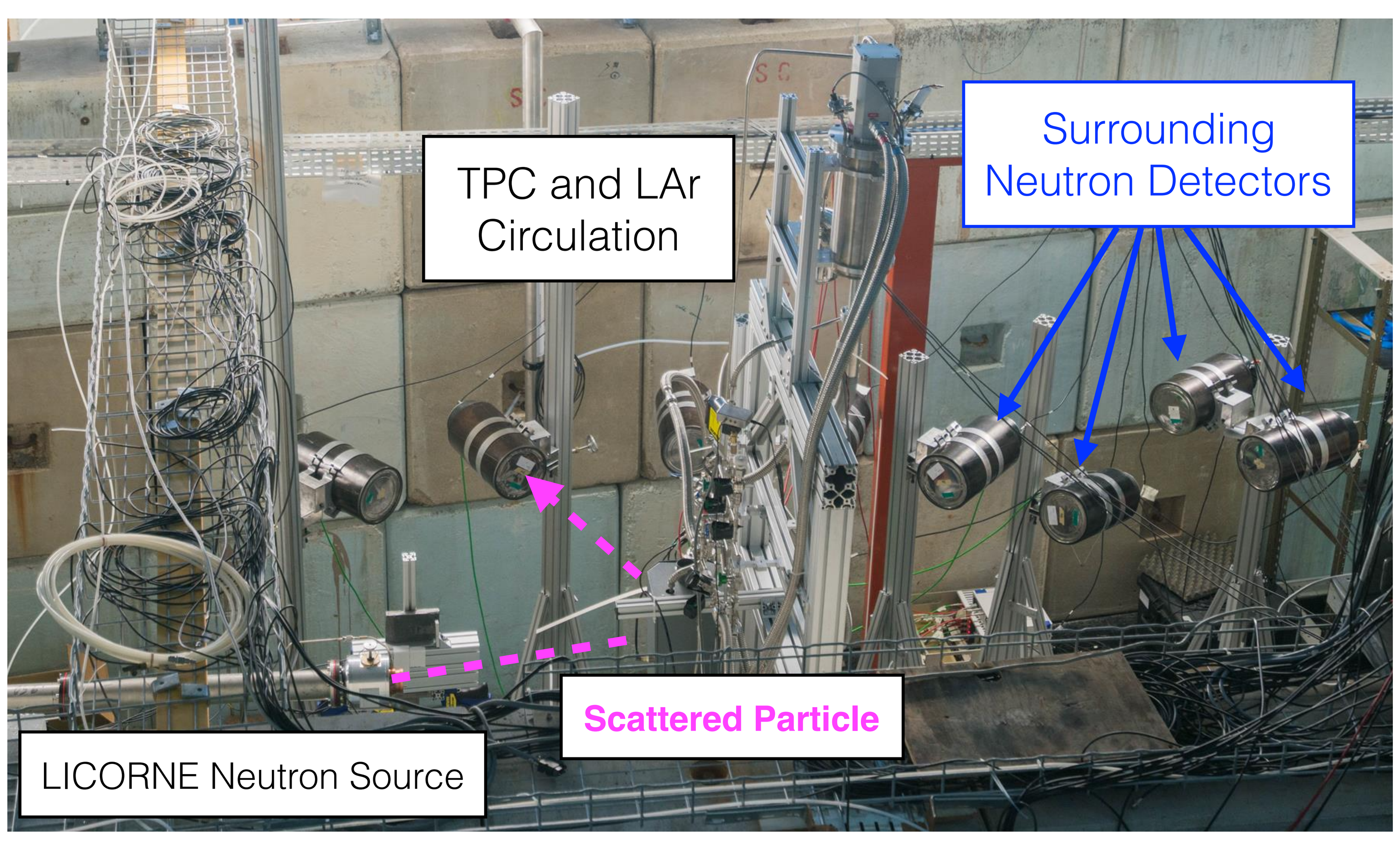

$Ar_2^*$ dimers decay and emit scintillation light with two characteristic time constants:

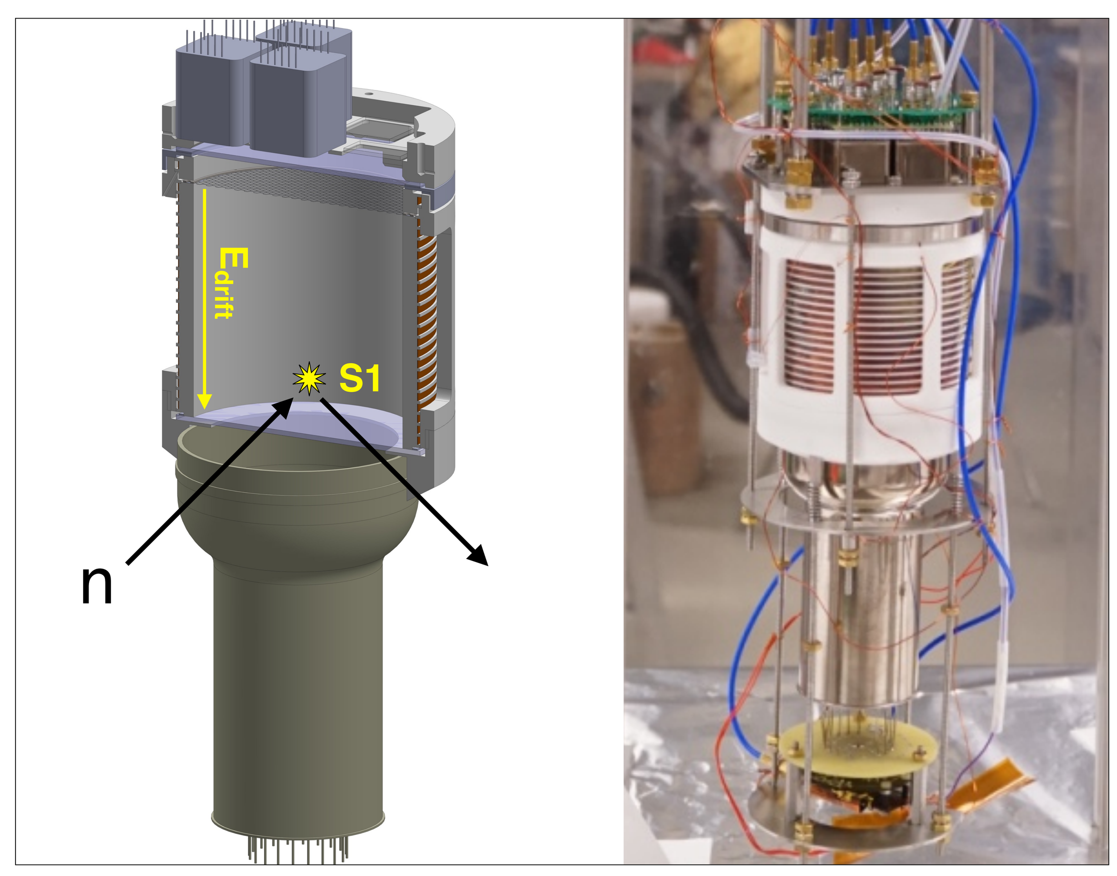
$\tau_{fast}$ = 7.0 ns $\tau_{slow}$ = 1.6 μs [1]

The relative abundance of these two time constants is uniquely dependent on the particle's energy loss density. Measuring the time-profile of LAr scintillation allows for powerful discrimination between ER and NR interactions.

## The ARIS Experiment

The Argon Response to Ionization and Scintillation (ARIS) experiment aims to characterize nuclear and electronic recoils in liquid argon by exposing 0.5 kg of LAr in front of a neutron beam (with associated gamma flash) at the Institut de Physique Nucleaire d'Orsay in France. Neutron and gamma recoil energies are constrained by one of eight neutron detectors surrounding the TPC.



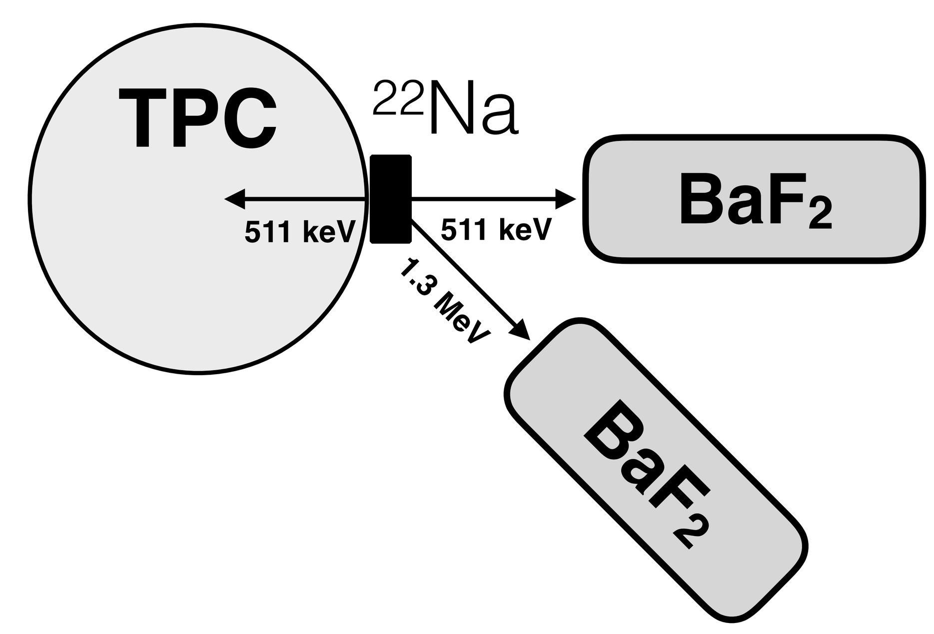




The ARIS Time Projection Chamber (TPC):

- High purity 0.5 kg LAr target
- Seven one-inch photomultiplier tubes (PMTs) view the active volume from the top as well as one three-inch PMT from the bottom
- PTFE reflector with wavelength shifting TPB coated interior surfaces to maximize light collection

We exploit the geometry of $^{22}$Na decay to calibrate the ARIS trigger.

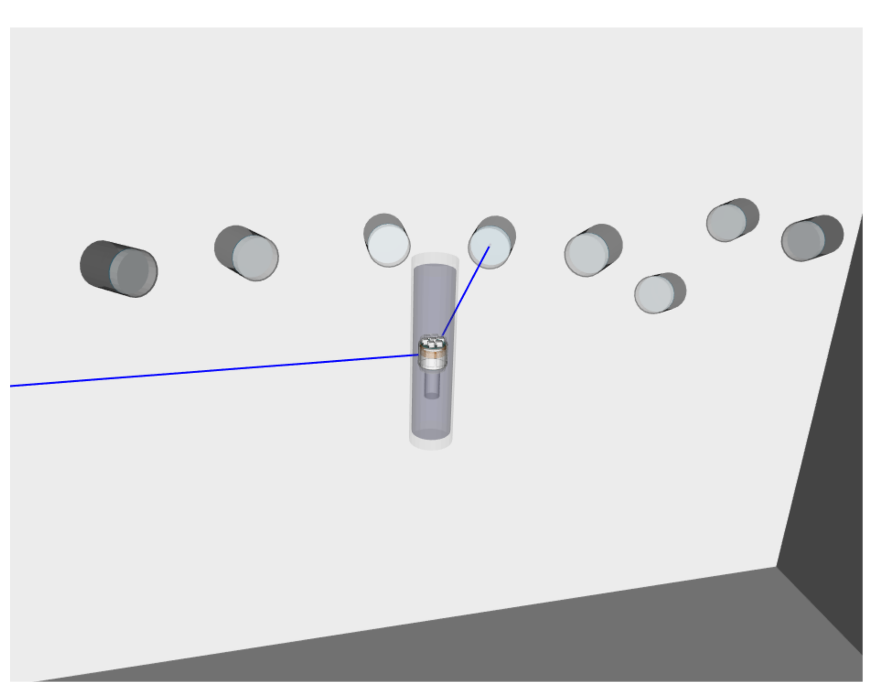
A complete understanding of the trigger efficiency allows accurate simulation of detector response even at low recoil energies.

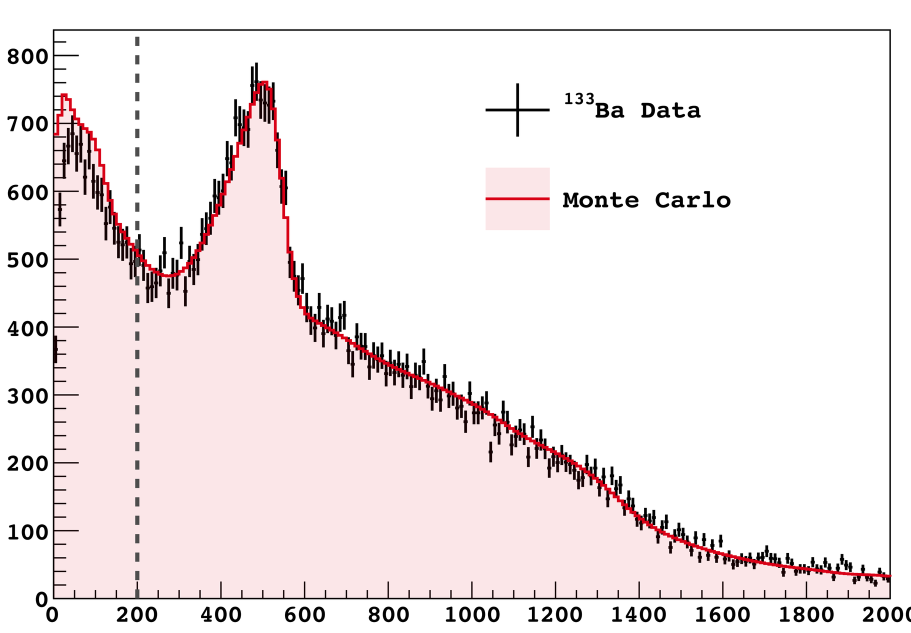



## Monte Carlo Simulations

A full simulation of the TPC geometry with surrounding neutron detectors was produced in Geant4.

Comparing simulated events with ARIS data allows us to extract physics including detector light yield, neutron beam energy and spatial profile, and relative scintillation ratios.






The Monte Carlo provides a spectrum of nuclear and electronic recoil energies for all 8 probed recoil energies.

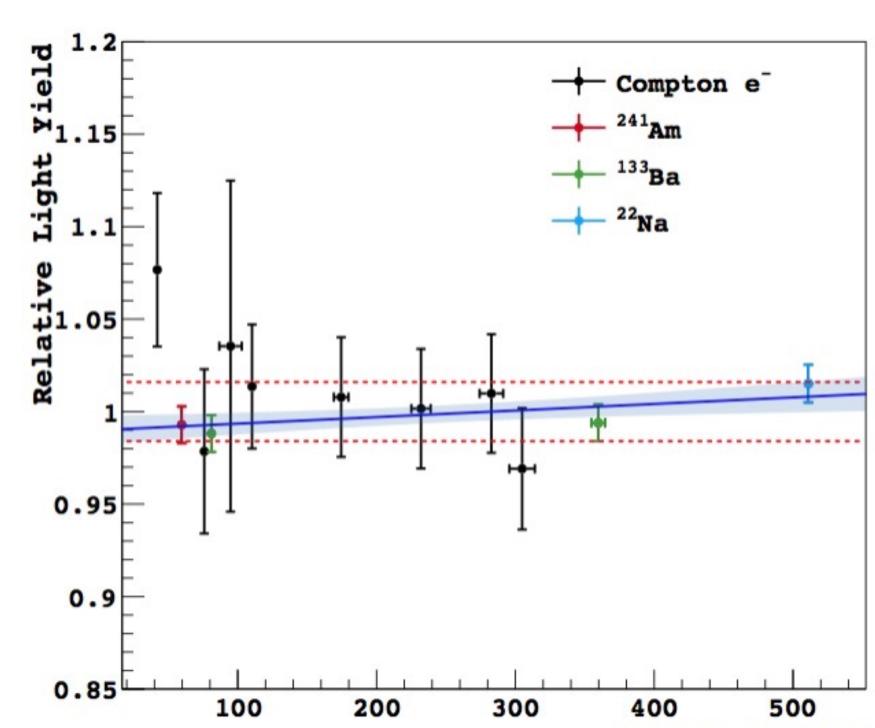
Excellent agreement between simulated events and ER selected ARIS data shows our Monte Carlo accurately accounts for the detector resolution, light yield, and kinematics of beam events.

## Light Yield vs Energy

Results from Compton single-scatter ER events are combined with $^{241}$Am, $^{133}$Ba, and $^{22}$Na source data.

LY in the [41.5, 511] keV range is found to be constant within 1.6% at 1σ CL.

Measuring the light yield to be independent of energy in this range means ARIS results are applicable to many other LAr detectors which may use different calibration energies.

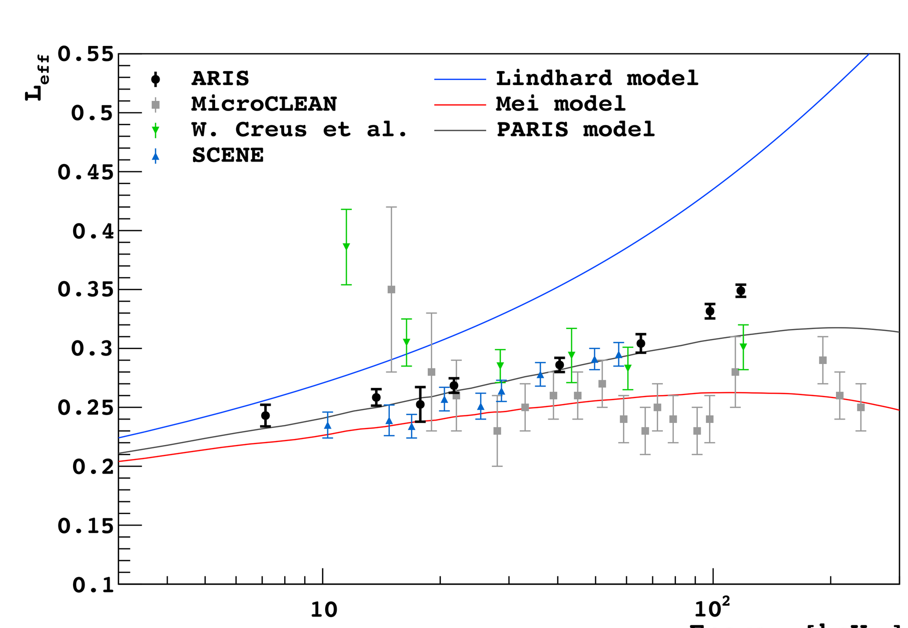



## NR / ER Relative Scintillation

Due to signal quenching, NR and ER events of the same energy produce a different amount of light. We characterize this effect with the effective Lindhard parameter, or $L_{eff}$.

$L_{eff}$ is obtained by measuring the light $S1_{ER}$ from a known source energy $E_{source}$ and comparing to the light $S1_{NR}$ produced in neutron events at a known recoil energy $E_{NR}$:

$$L_{eff}(E_{NR}) = \frac{S1_{NR}/E_{NR}}{S1_{ER}/E_{source}}$$




## References

[1] A. Hitachi, T. Takahashi, Phys. Rev. B 27 (1983) 5279.
[2] arXiv:1801.06653v1. "Measurement of the the liquid argon energy response to nuclear and electronic recoils"