Verifying our Monte Carlo by Using Data From the Past

Matthew Szydagis, UC Davis

LBNE Wed. Simulations Call 01/16/2013

Let's Review

- dQ/dE can be thought of as escape probability, or, one minus the recombination probability. Let's re-derive the ICARUS formula used by default in LArSoft. $\mathcal{R} = Q/Q_0 = 1 - r =$

$$1 - \frac{k_B \frac{dE}{dx}}{1 + k_B \frac{dE}{dx}} = \frac{1 + k_B \frac{dE}{dx}}{1 + k_B \frac{dE}{dx}} - \frac{k_B \frac{dE}{dx}}{1 + k_B \frac{dE}{dx}} = \frac{1}{1 + k_B \frac{dE}{dx}}$$

0.800 in Amoruso

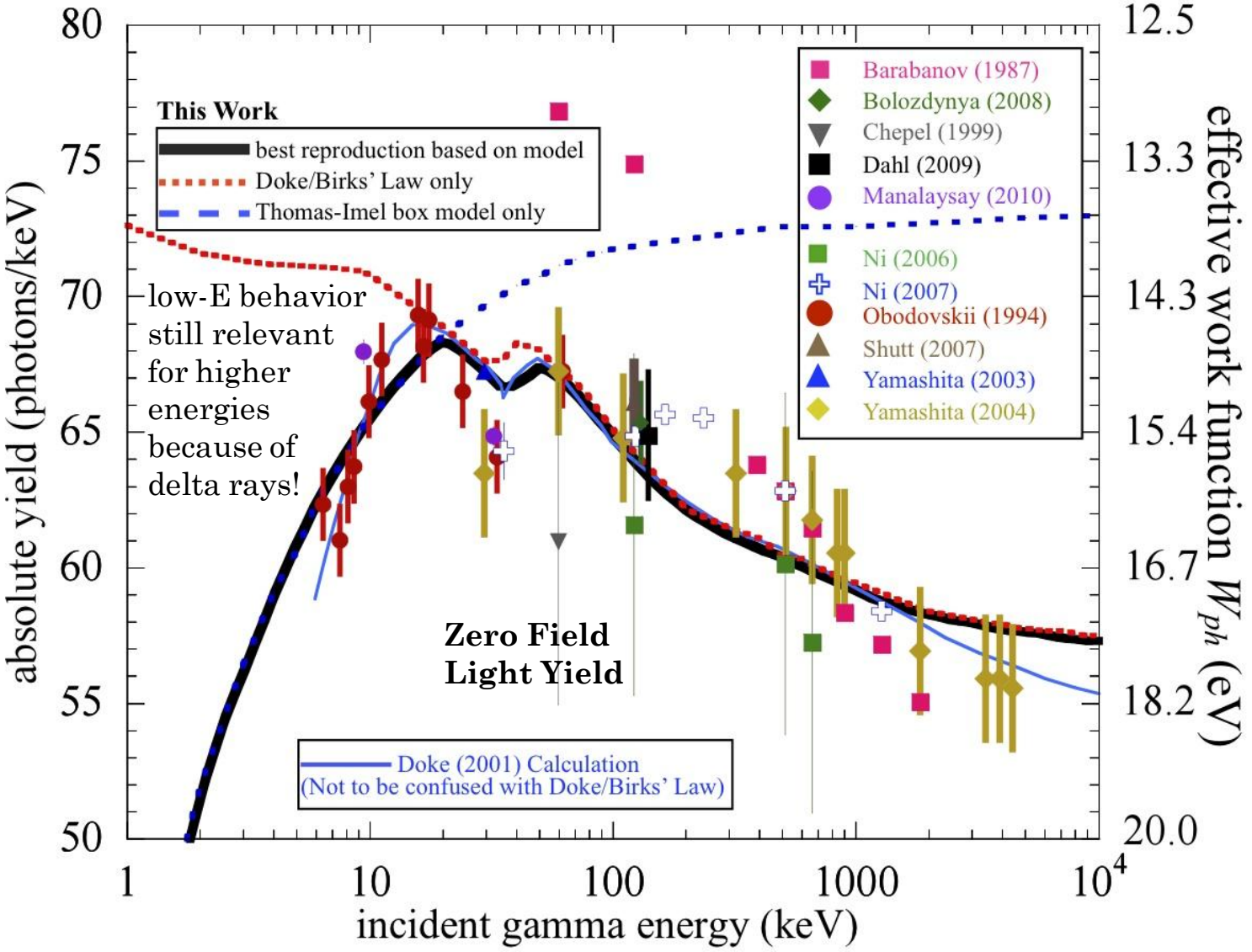
- ICARUS adds a normalization factor, but that breaks the (anti-)correlation between LY, CY. Non-unity normalization can not be easily justified if looking at a dimensionless recombination factor (as opposed to raw charge yield).

How to Fix That

- Replace $k_B = k\,F^{-1}$ with $k_B = k\,F^{-p}$ (where p = 0.85, nearly the same power used for liquid xenon, 0.83)
- Allows for preservation of the more fundamental physical principles (like the anti-correlation)
- Second, do not rely solely on Birks' Law: recall the Thomas-Imel "box model" of recombination
- Mistake: I originally thought Thomas-Imel wasn't relevant for our energy regime, or redundant

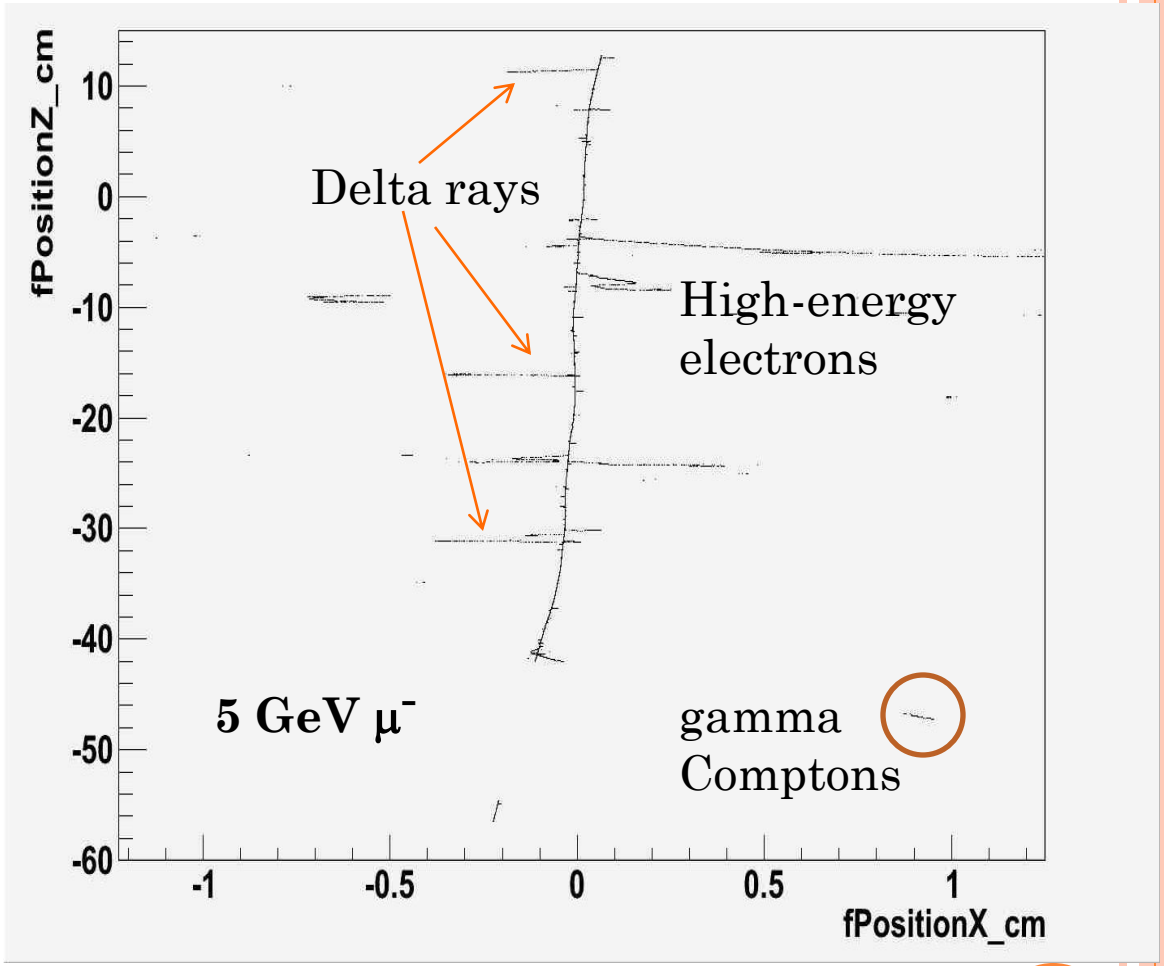
Example From Xenon

Szydagis et al., **NEST: A Comprehensive Model for Scintillation Yield in Liquid Xenon**, 2011 JINST 6 P10002; e-Print: arxiv:1106.1613 [physics.ins-det]



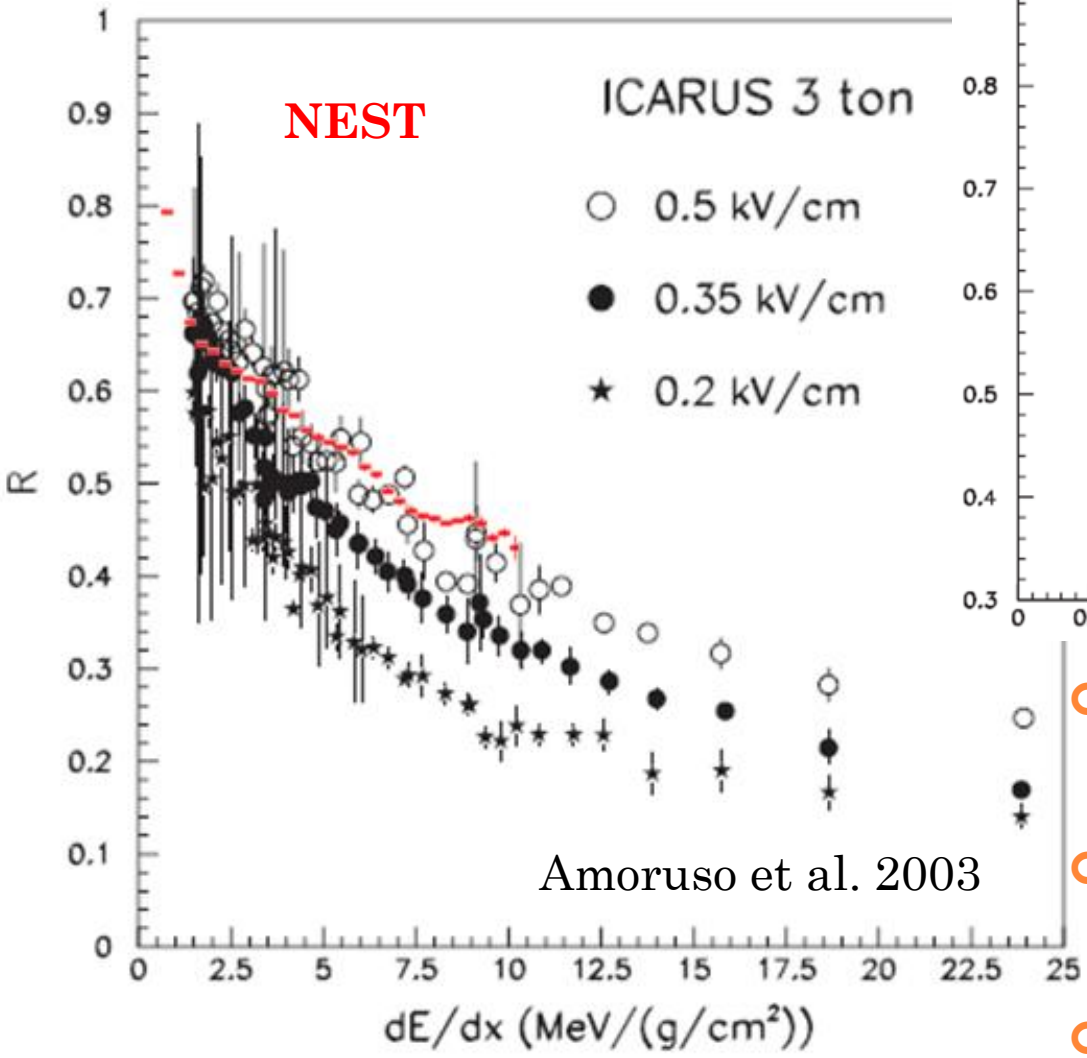
Secret to Success

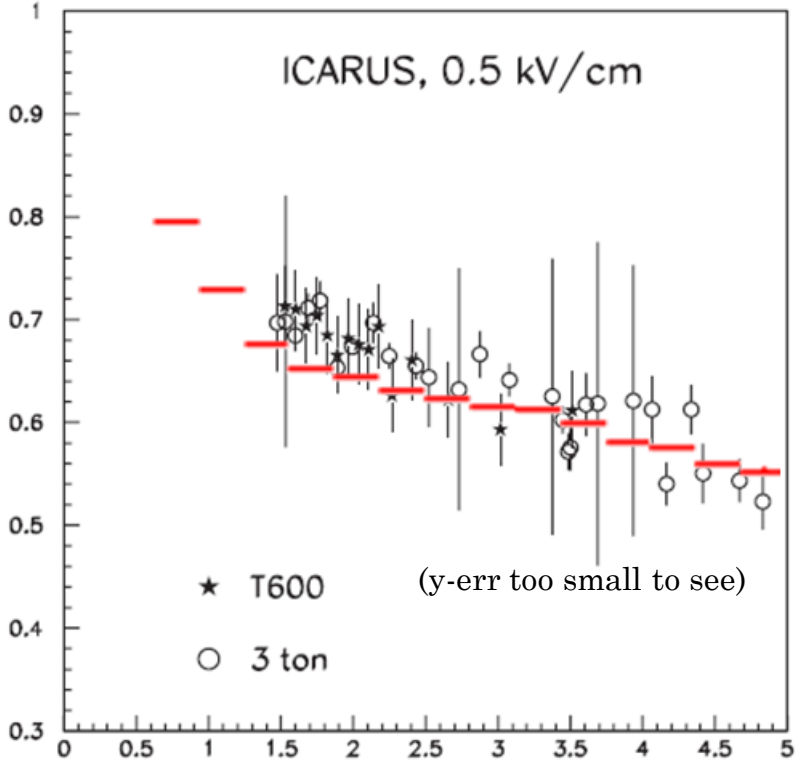
- See Christmas-tree structure of secondary tracks. Many low enough in energy to be governed by T-I
- Using it in concert with Birks eliminates need for artificial re-normalization, and other MC "fudge factors"*



* You also need a short G4 track-length cut-off, something of order um or nm!!

Comparison to Data





- Working on sims out to higher LET
- Following through on other fields
- Doing muons, e-'s

Comparison to Data

- The low-LET region is better off than it looks
- ICARUS Q / Q_0 number of 0.7 for MIPs may be too high: corresponds with 30,000 e-'s per MeV. What happened to ~27,000?
- Strange step-down in data at an LET of ~4 – 5. Undercurrent of lower-charge-yield data points throughout these results…
- NEST can simultaneously match the low and high LET data well (or at least within the 1-sigma error bars) because of the two "tricks" from slide 3. More physical?
- LBNE precursors/prototypes will provide more great data for good model-building