Impact of SCE on Reconstructed π^0 Mass

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ProtoDUNE EM Shower Task Force Meeting

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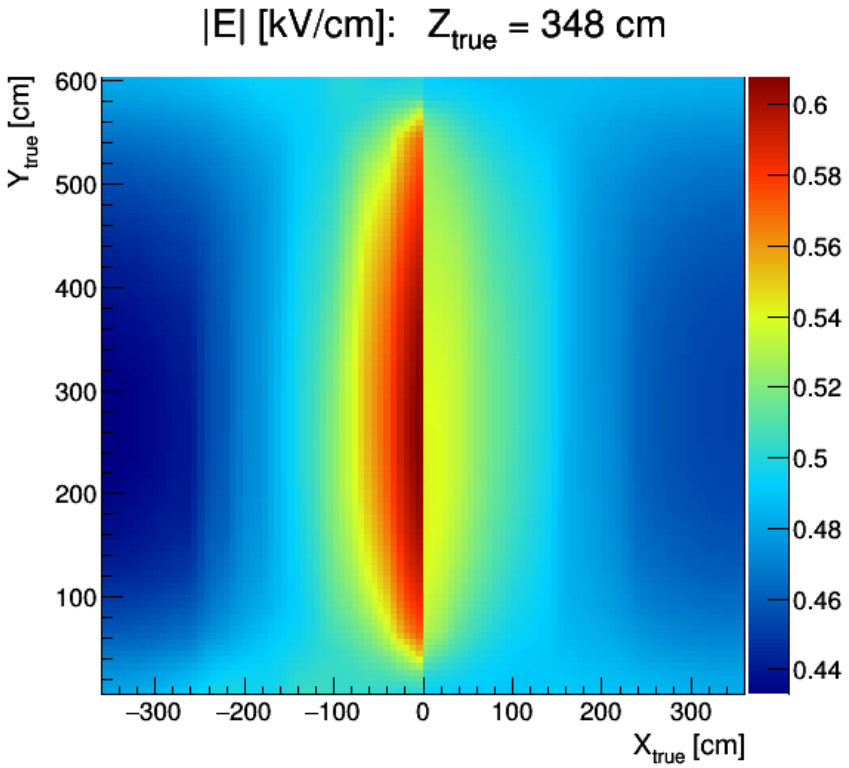
Overview

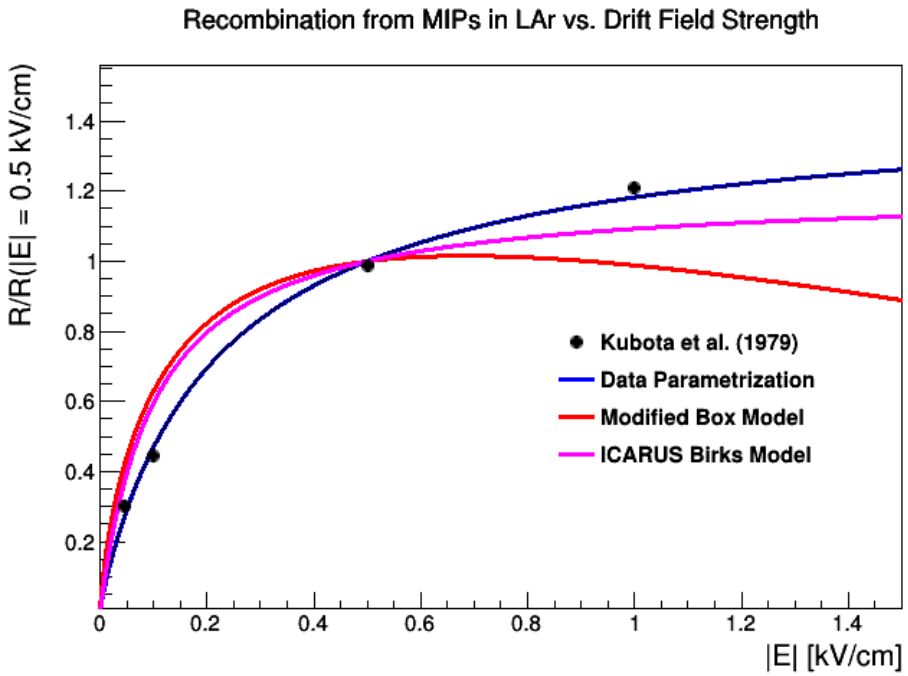
- Two space charge effect (SCE) corrections should be made to our π^0 events:
  - Spatial correction: impacts angles of photons (thus π^0 opening angle), photon dE/dx
  - E field correction: impacts photon energy (through recombination)
- Explore potential recombination models we might want to use in π^0 analysis
  - Different implications for EM shower energy scale
- Also discuss first studies of impact of SCE on reco. π^0 mass
  - Assumes we are using knowledge of π^0 decay point and photon shower start points to detetermine opening angle (should give best mass resolution)

Methodology

- Making use of a sample of roughly 2300 π^0 events (from beam π^+ interactions), including location of π^0 decay, location of each photon interaction start point, and energy of each photon
  - Select only candidates with exactly two photon daughters
- Reconstruct π^0 mass for four cases:
  - No SCE simulation included
  - Only E field SCE simulation included (impacts photon energies)
  - Only Spatial SCE simulation included (impacts opening angle)
  - Full SCE simulation included (impacts both)
- Repeat above study for three different recombination models:
  - Modified box model
  - ICARUS Birks model
  - Scaling from Kubota data (charge yield from ~1 MeV beta decays)

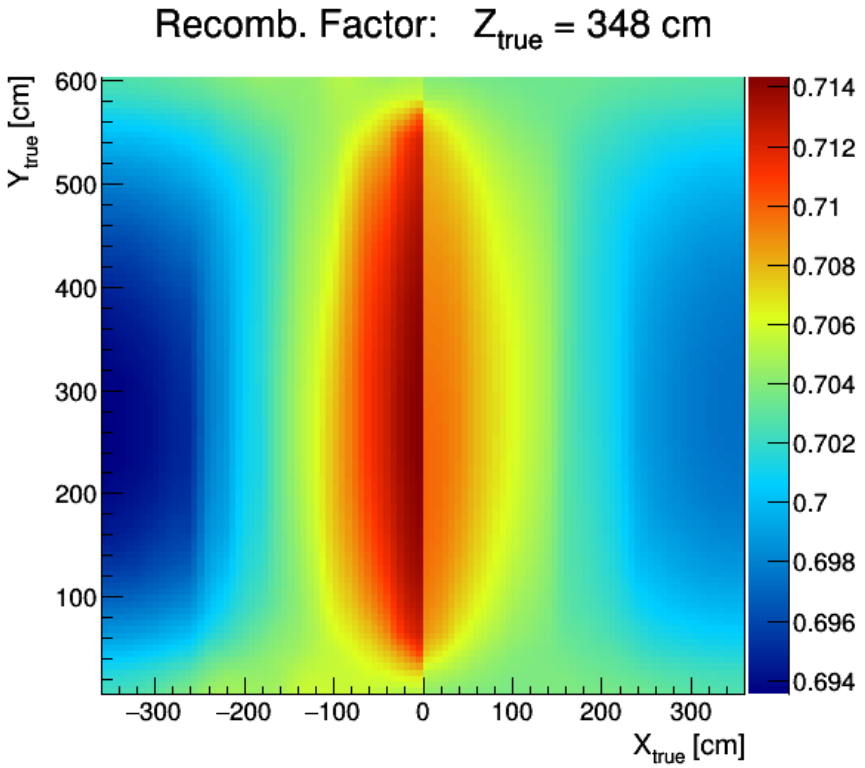
E Field SCE Corrections

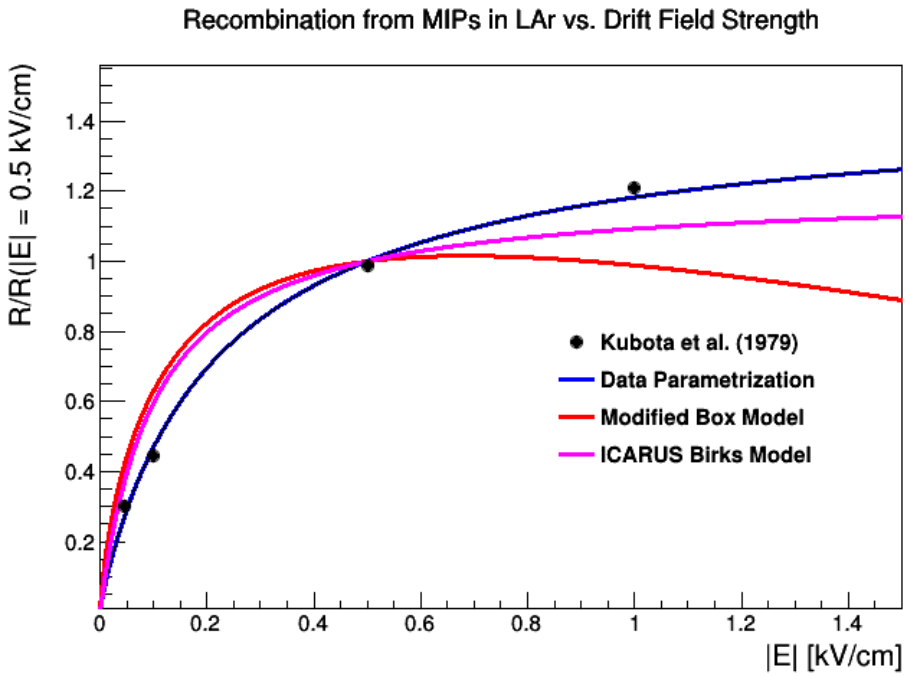




- Can both simulate and correct for impact of E field through recombination → impacts charge/energy scale
  - However… which recombination model to use?
  - Complicated question… use different models for different parts of shower, based on topology?

Modified Box Model





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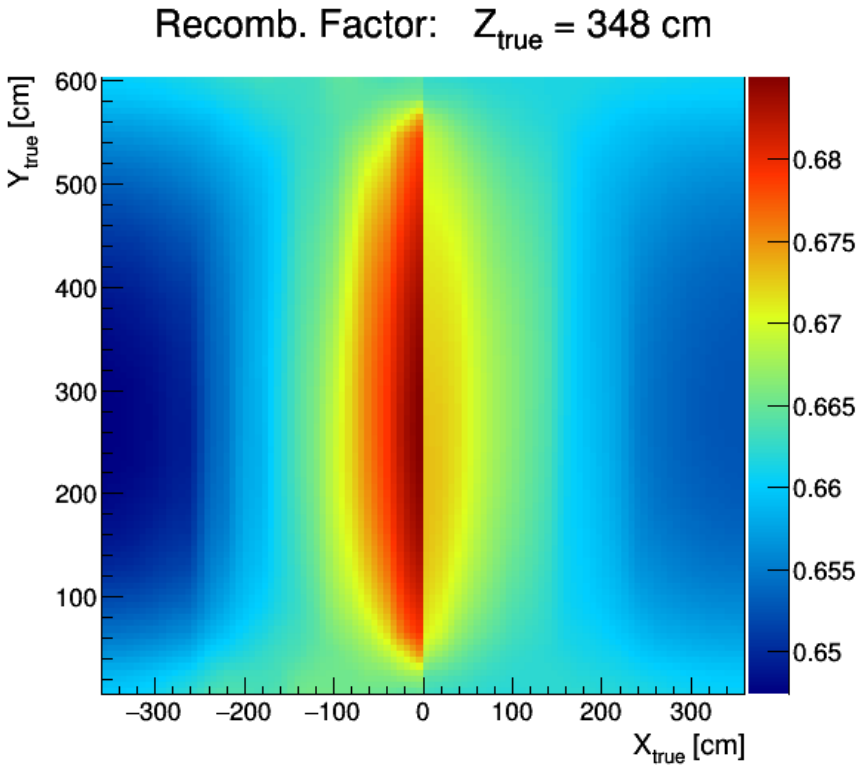
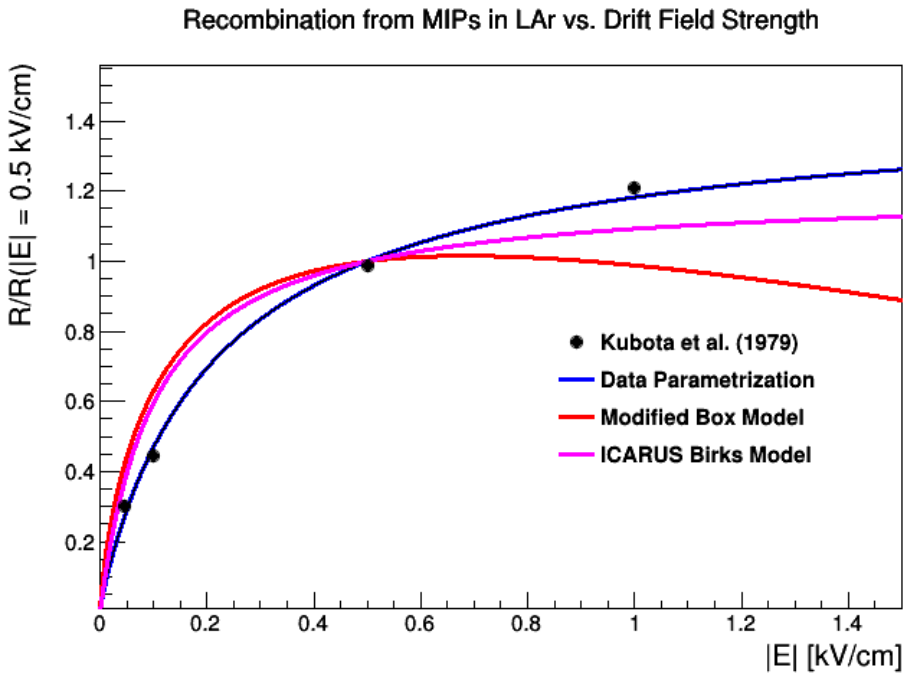
ICARUS Birks Model





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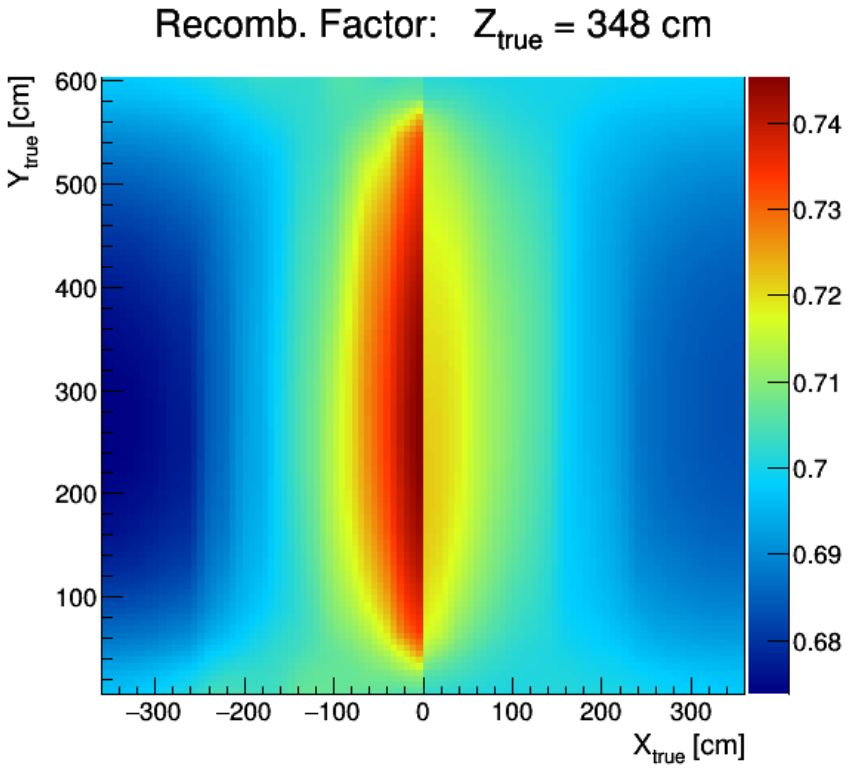
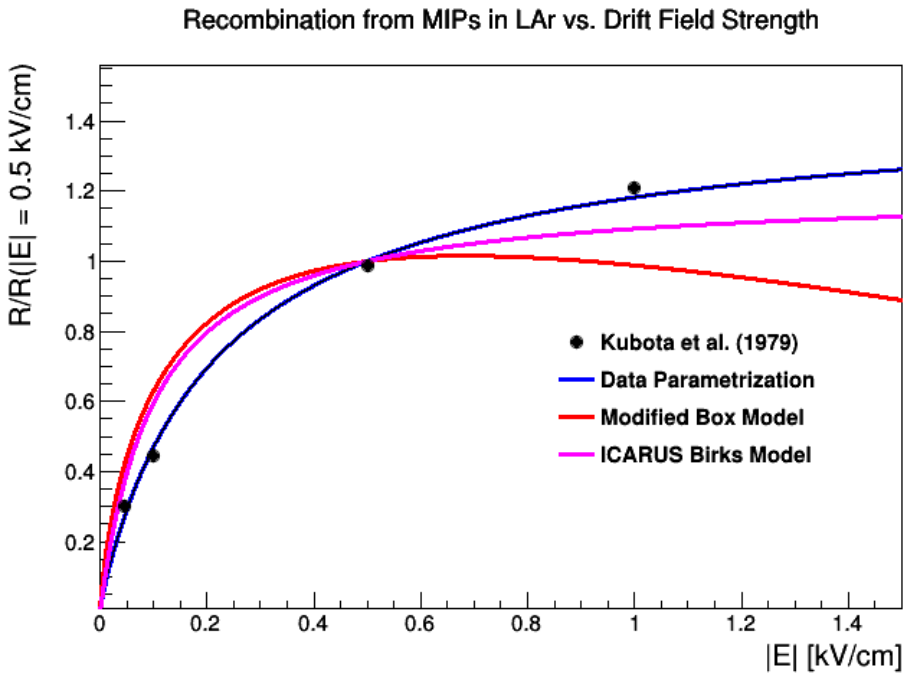
Mod. Box w/ Kubota Scaling





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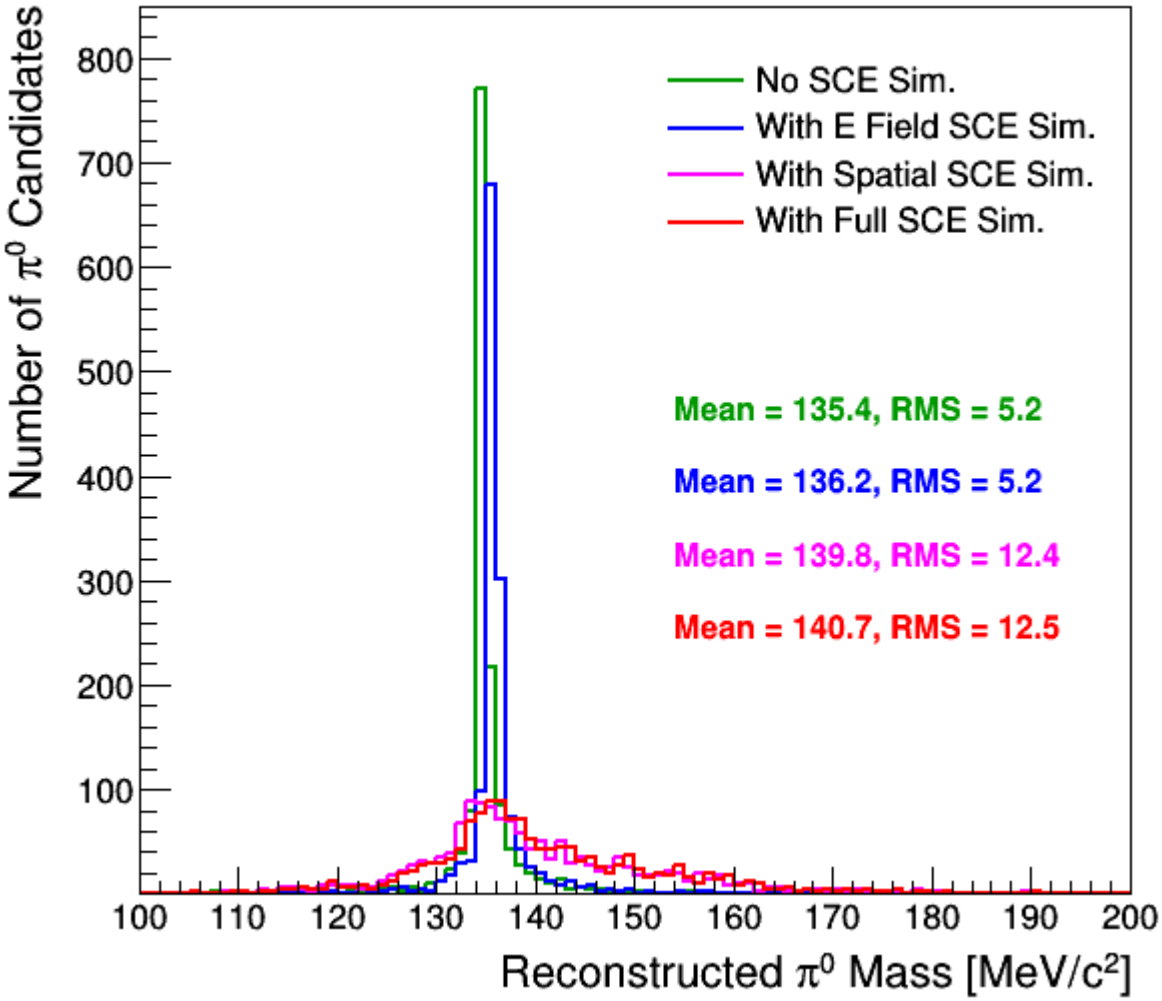
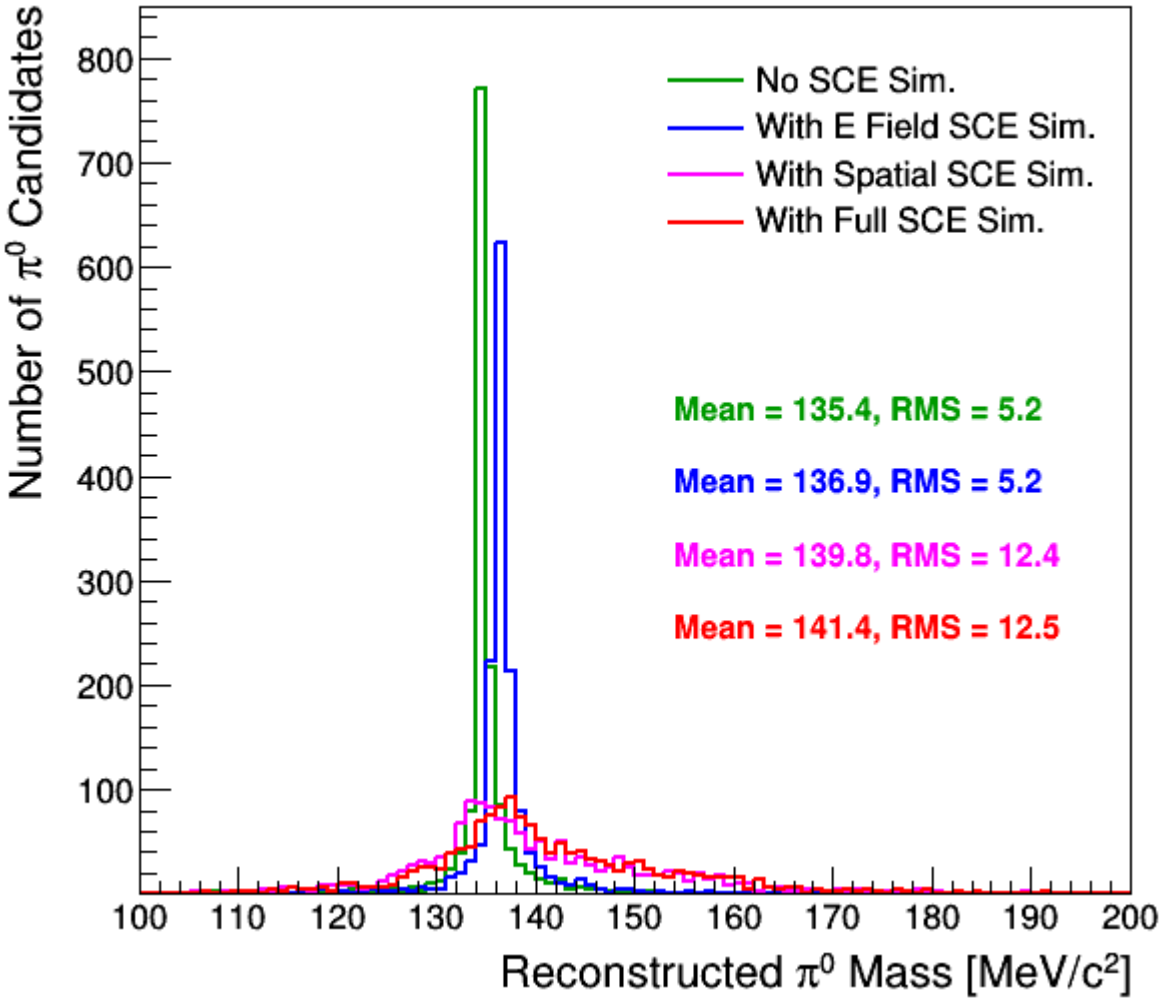
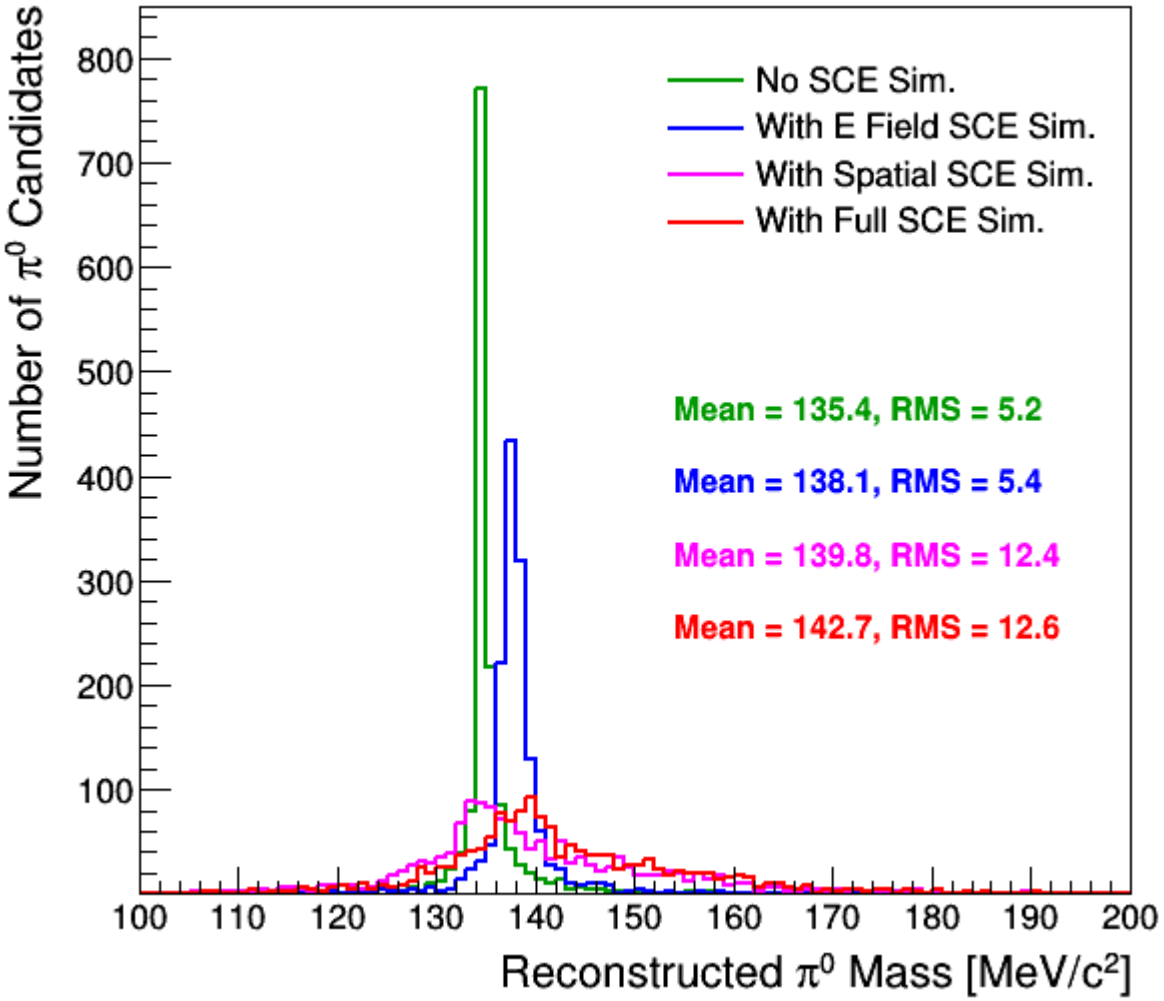
Results: Mod. Box Model



Results: ICARUS Birks Model



Results: Kubota Scaling

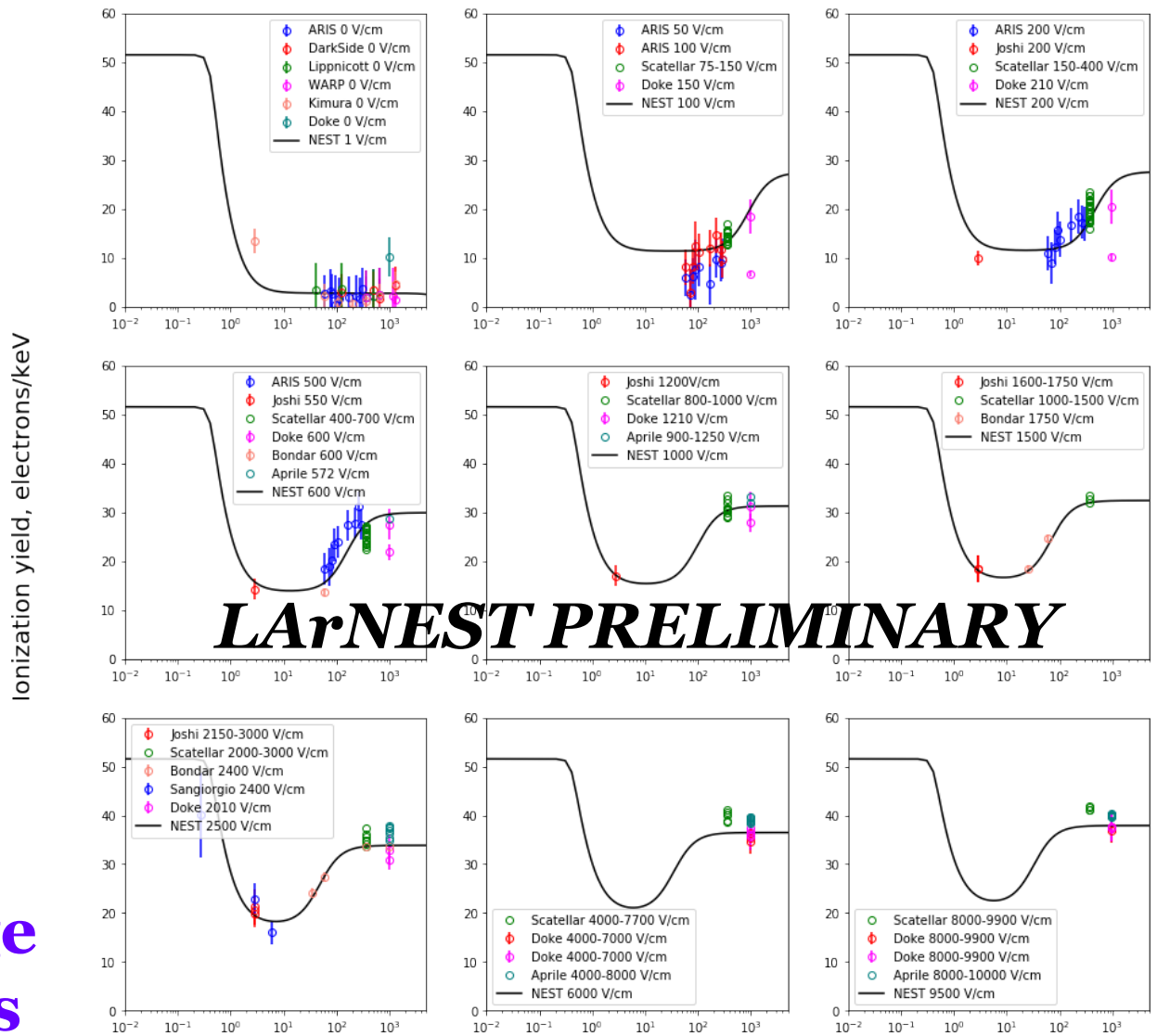


LArNEST for EM Showers?

- Kubota dataset uses ~1 MeV electrons – is non-MIP-like nature of low-energy electrons contributing to discrepancy?
- **LArNEST** (LAr Noble Element Simulation Technique) developing ionization/scintillation model using "electron recoil" data at various energies and electric fields
  - Would account for non-MIP-like features with energy dependence, which can be translated to a dE/dx dependence
  - If different microphysics at play for EM showers, this model would be more appropriate to use (informed by measurements made actually using electrons/gammas)
- LArNEST being developed by CSU grad. student Justin Mueller
- Some preliminary LArNEST fit results on following slides

Prelim. LArNEST Fit Results

J. Mueller,
E. Kozlova

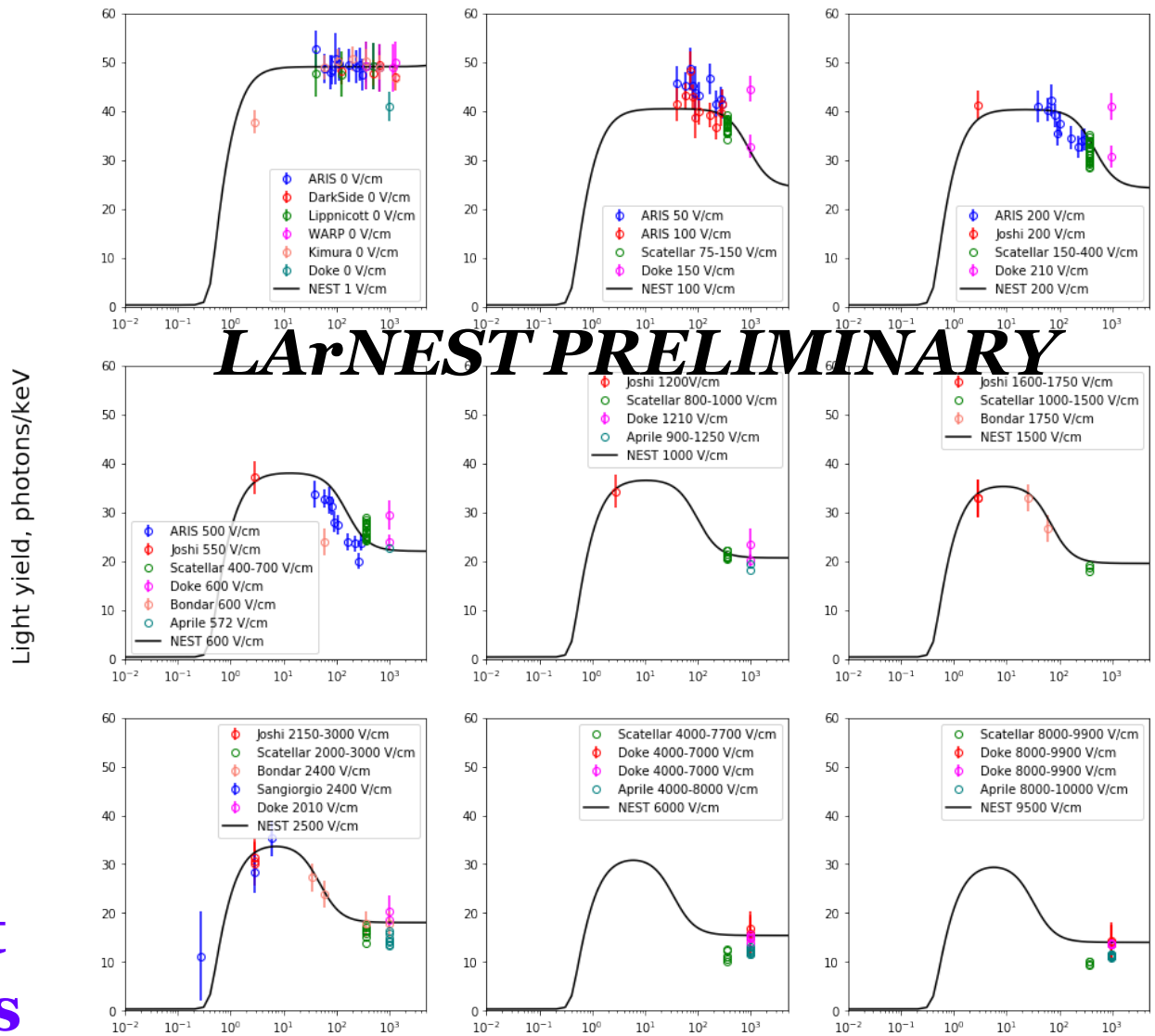


LArNEST PRELIMINARY

Charge Yields

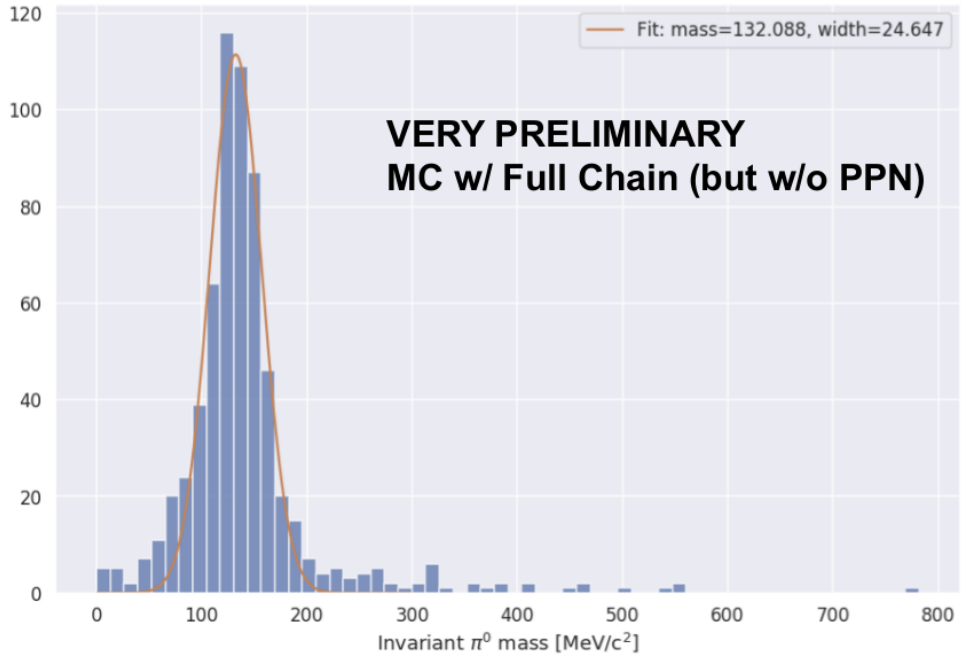
Prelim. LArNEST Fit Results

J. Mueller, E. Kozlova



Light Yields

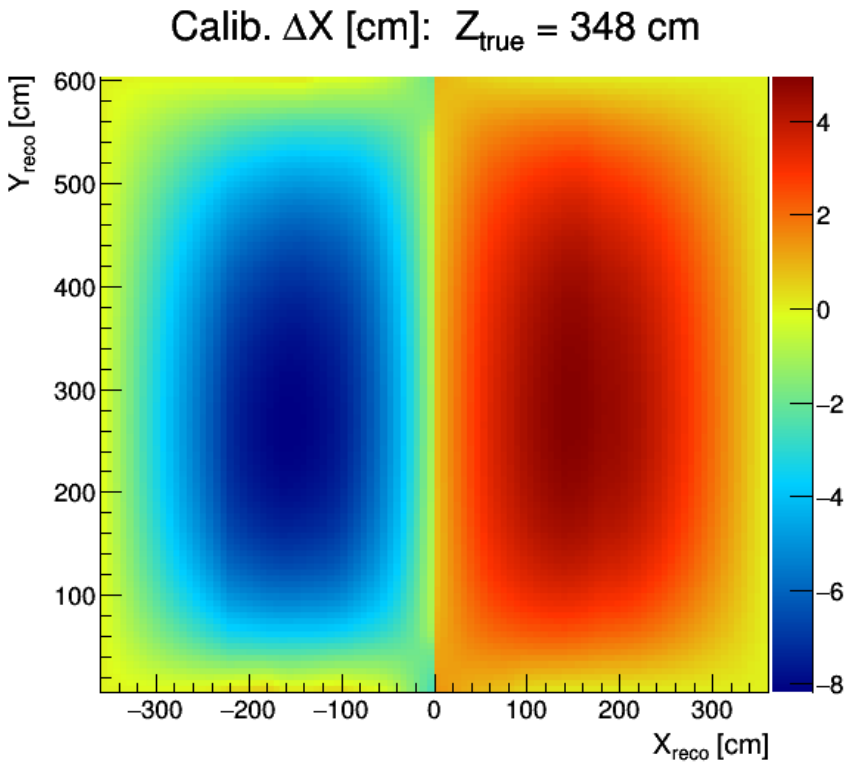
Discussion

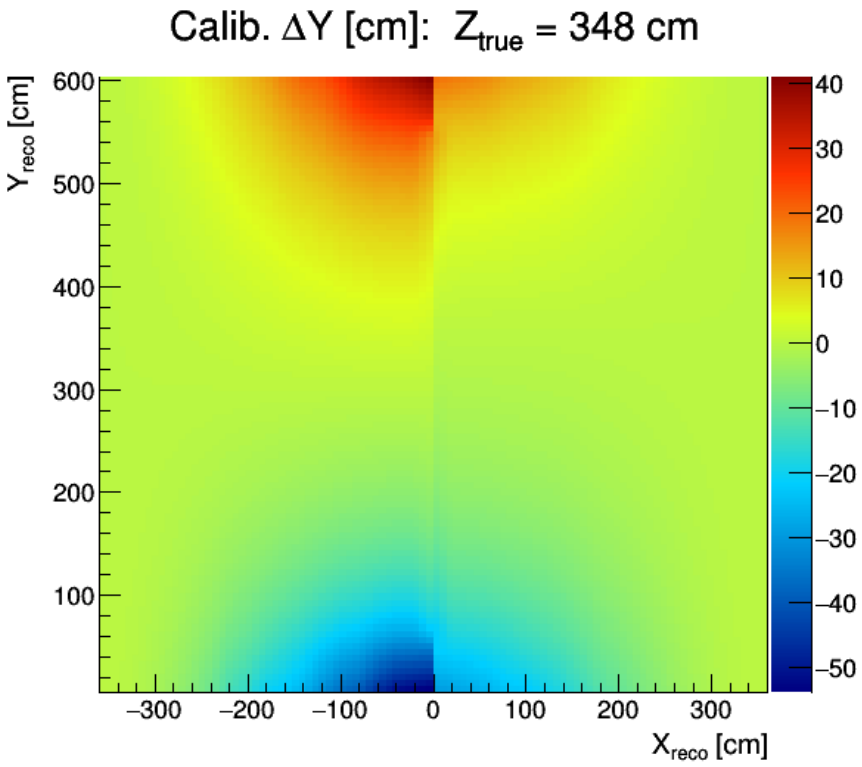


- Impact of SCE non-negligible compared to reco. smearing (see above for previous ML result for reconstructed π^0 mass in MC)
- Spatial SCE impact more important; E field SCE impact becomes more important for certain recombination models (ICARUS Birks model, measurements with beta decays)
- Use LArNEST For electron/photon shower recomb. model?

BACKUP SLIDES

Spatial SCE Corrections





- Can correct position of 3D points using SCE corrections
  - Do this and recalculate photon angles, Needed to improve matching of photon pairs to vertex