

The Search for Lightly Ionizing Particles Using Data from the 90-Day Run of the LUX Detector

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LUX Collaboration

APS April Meeting

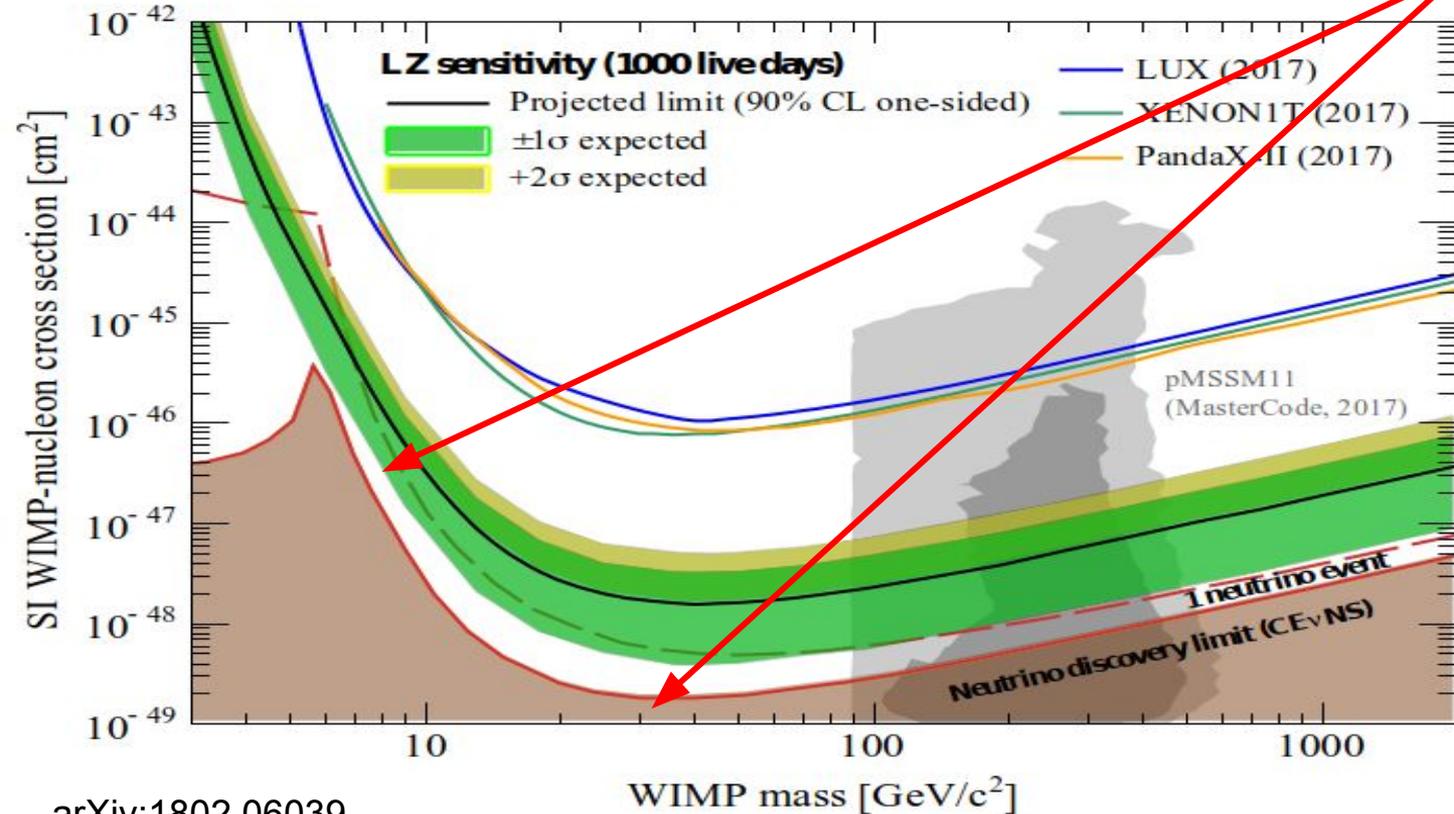
Motivations for LIPs

- Monopole theories - Witten Effect
- String Theory, multidimensional scenarios.
- Hidden U(1) sector - as dark paraphoton.
 - The paraphoton will have an apparent small electric charge due to the kinetic mixing between EM photon and the hidden sector, in a massless scenario
- Charge quantization questions within the SM
- Leave no stone unturned (WIMP parameter space problem)

$$\mathcal{L}_{\text{MIX}} = \frac{\chi}{4} F^{\mu\nu} F'_{\mu\nu}$$

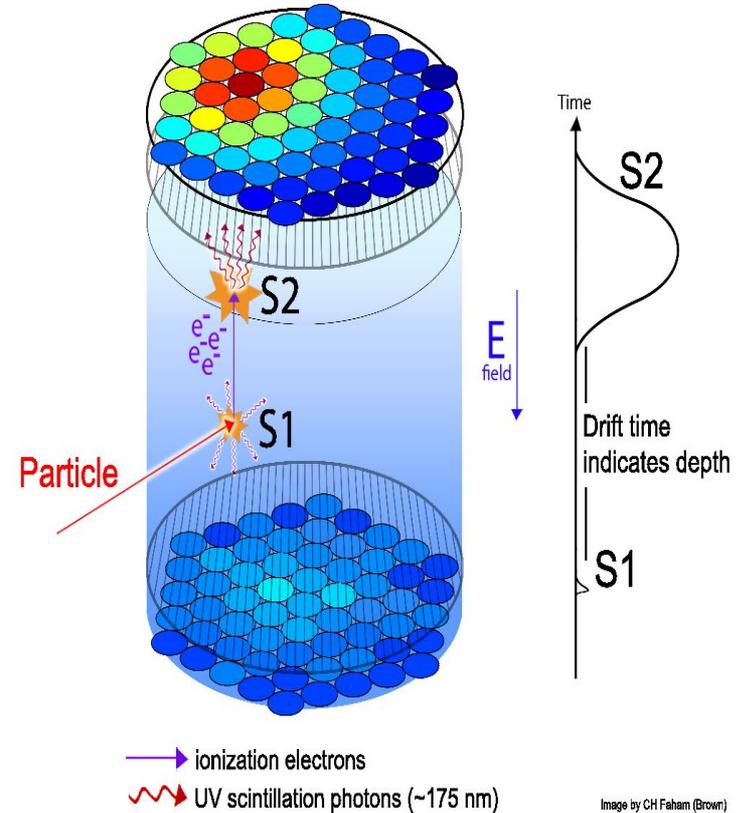
Running out of Room to Find WIMPs

If we hit the Neutrino Floor, neutrinos would look like WIMPs. Then a WIMP search becomes more problematic.



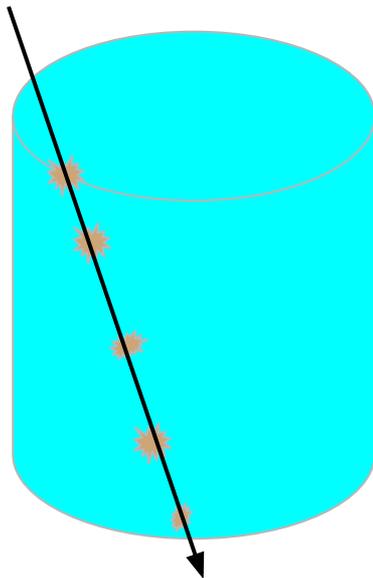
The LUX Detector

- 370 kg Xe
 - 250 kg active region
 - Effective self shielding
- Dual phase gas-liquid Time Projection Chamber (TPC)
 - Using scintillation and ionization
- Located at SURF, South Dakota, USA
 - 1478 m underground
- Designed and optimized for WIMP search
 - But can use data for other physics results

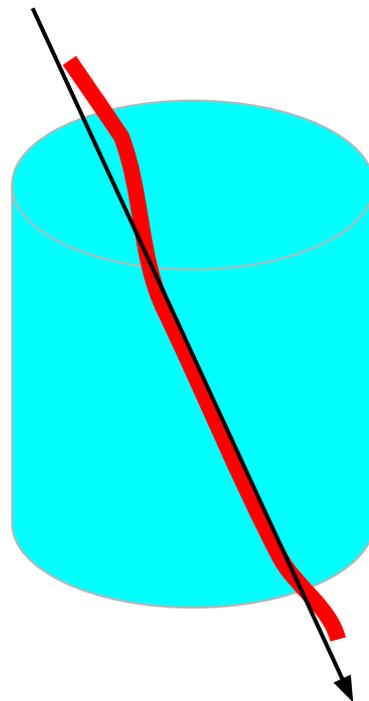


What might a LIP look like? -

Tracks - two types



We expect there to be many (more than 10 in many cases) hits along the detector forming a track line. These hits can be very small and there can be a lot of them. This is important from the perspective of data processing framework and reprocessing data.



It is possible that there could be a continuous or mostly continuous line of ionization in the detector, similar to a muon track. -pulse chopping can help this.

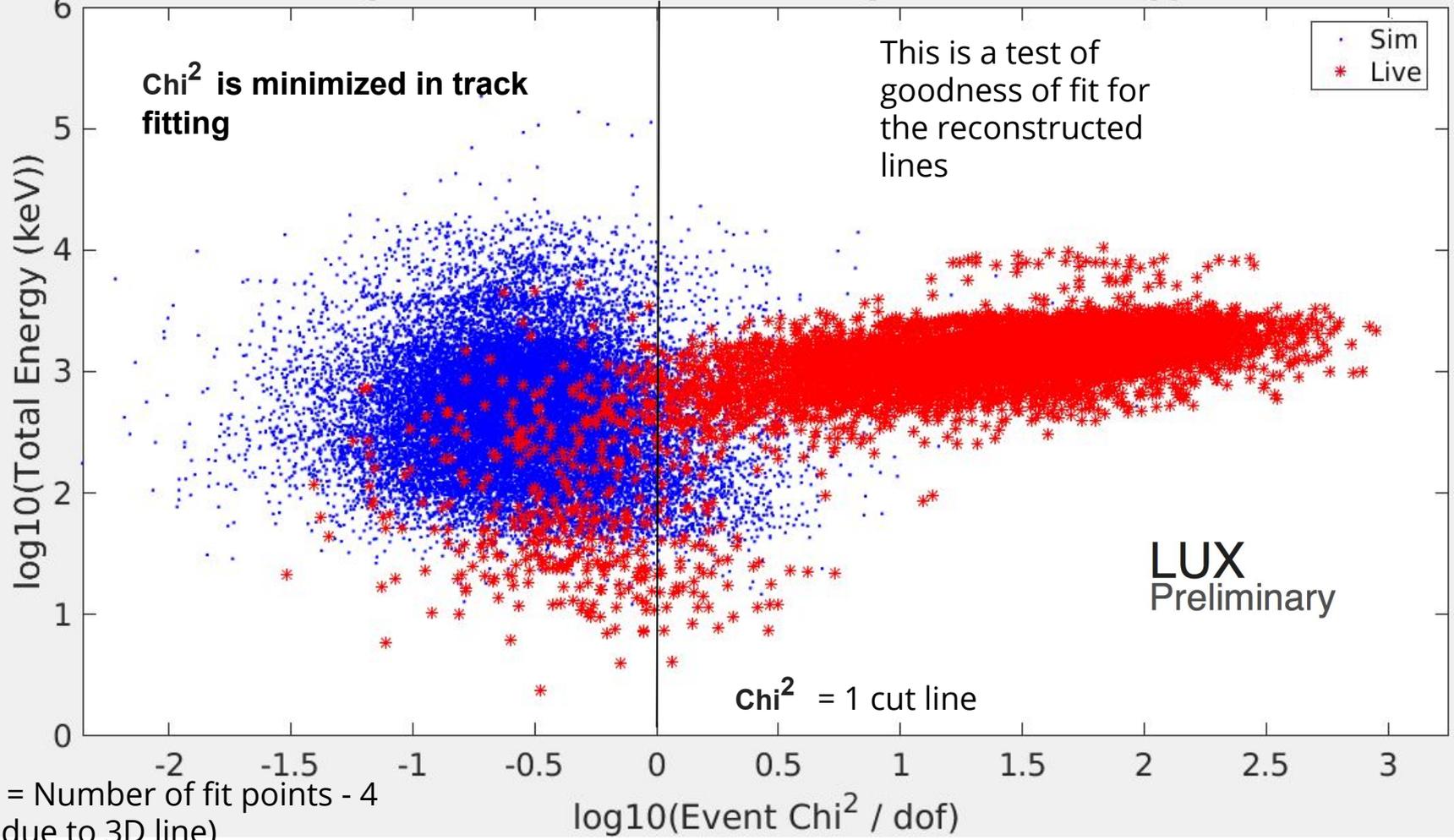
For simulation use the Geant4 monopole class in LUXSim
magnetic charge = 0
Electric charge can be varied

These pose interesting problems for simulation and data processing.

Some Backgrounds & Mitigation

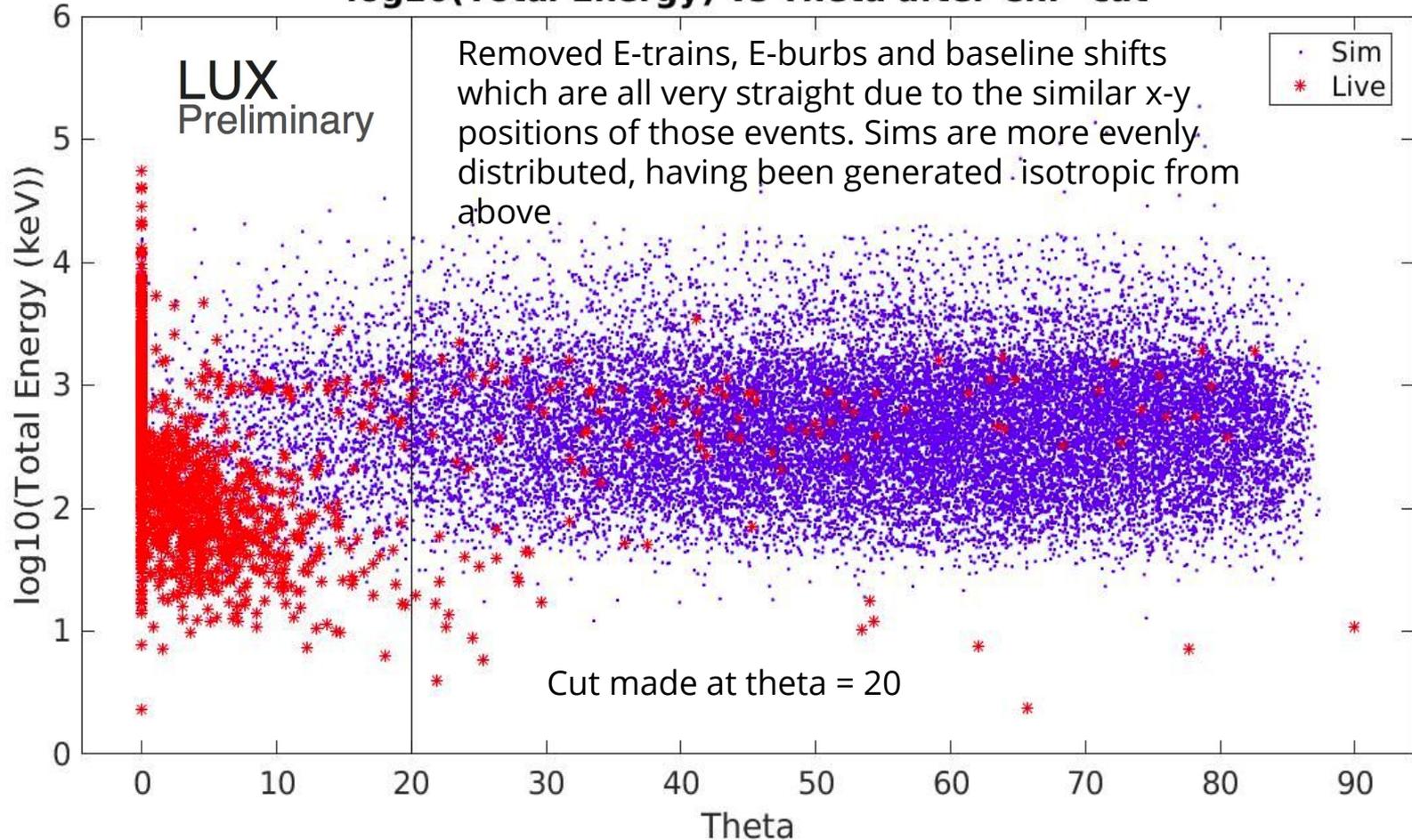
- Some of the more prevalent backgrounds include: baseline shifts, pulses resulting from built up charge, and photo-ionization on bulk impurities.
 - These backgrounds will have same/similar x-y position
- For pulse chopping require minimum pulse height in various parts of a merged/long pulse
- Require 1 phe/sample height on all pulses
- Cuts
 - Energy consistency cuts
 - to avoid high energy events that are depositing energy only in part of the event
 - Muons cut due to PMT saturation leading to inconsistent energy depositions and poor tracks.
 - Track goodness of fit to avoid compton scatters
 - Theta cut to avoid baseline shift and e-train

log10(Event Chi² / dof) vs log10(Total Energy)

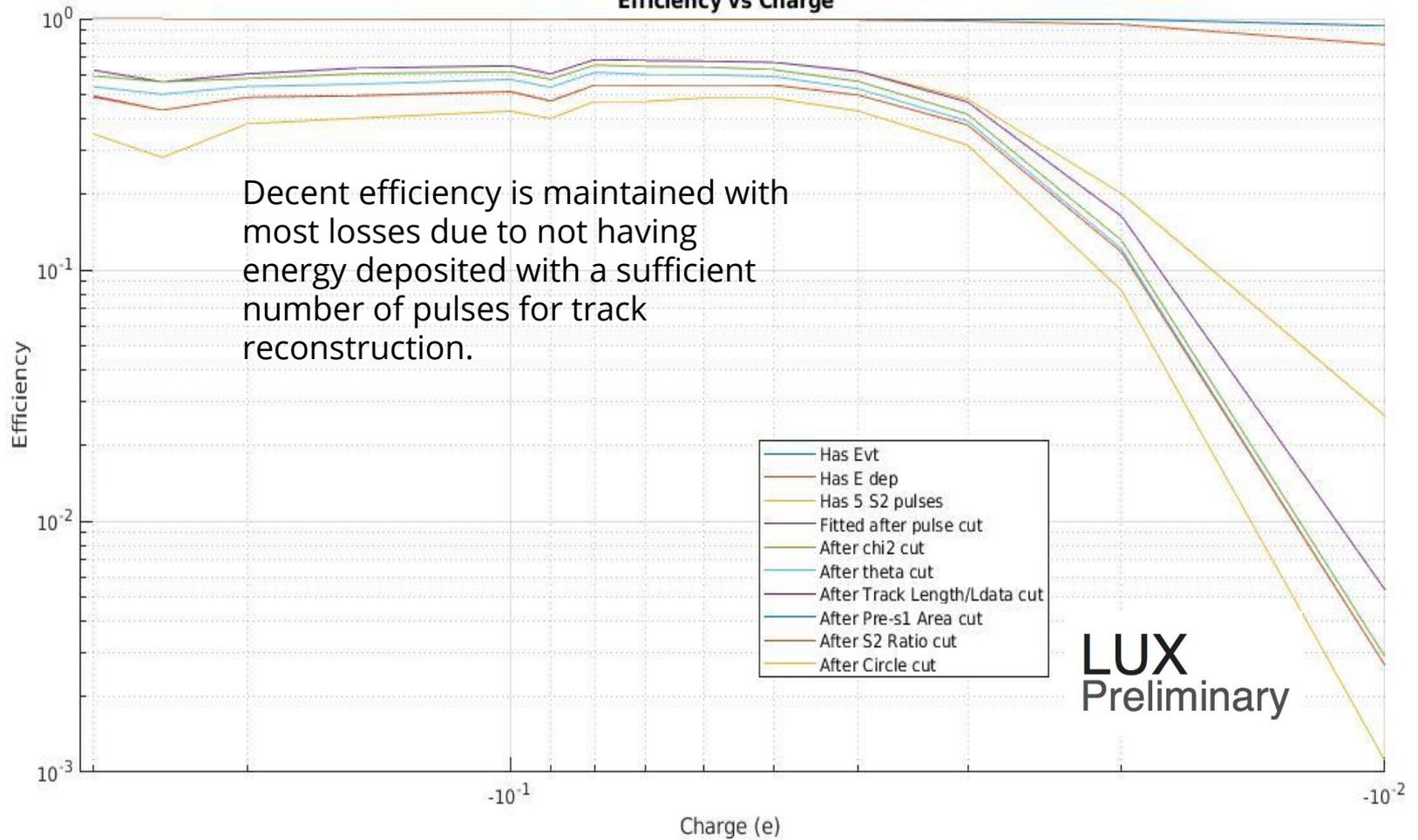


DOF = Number of fit points - 4
(4 is due to 3D line)

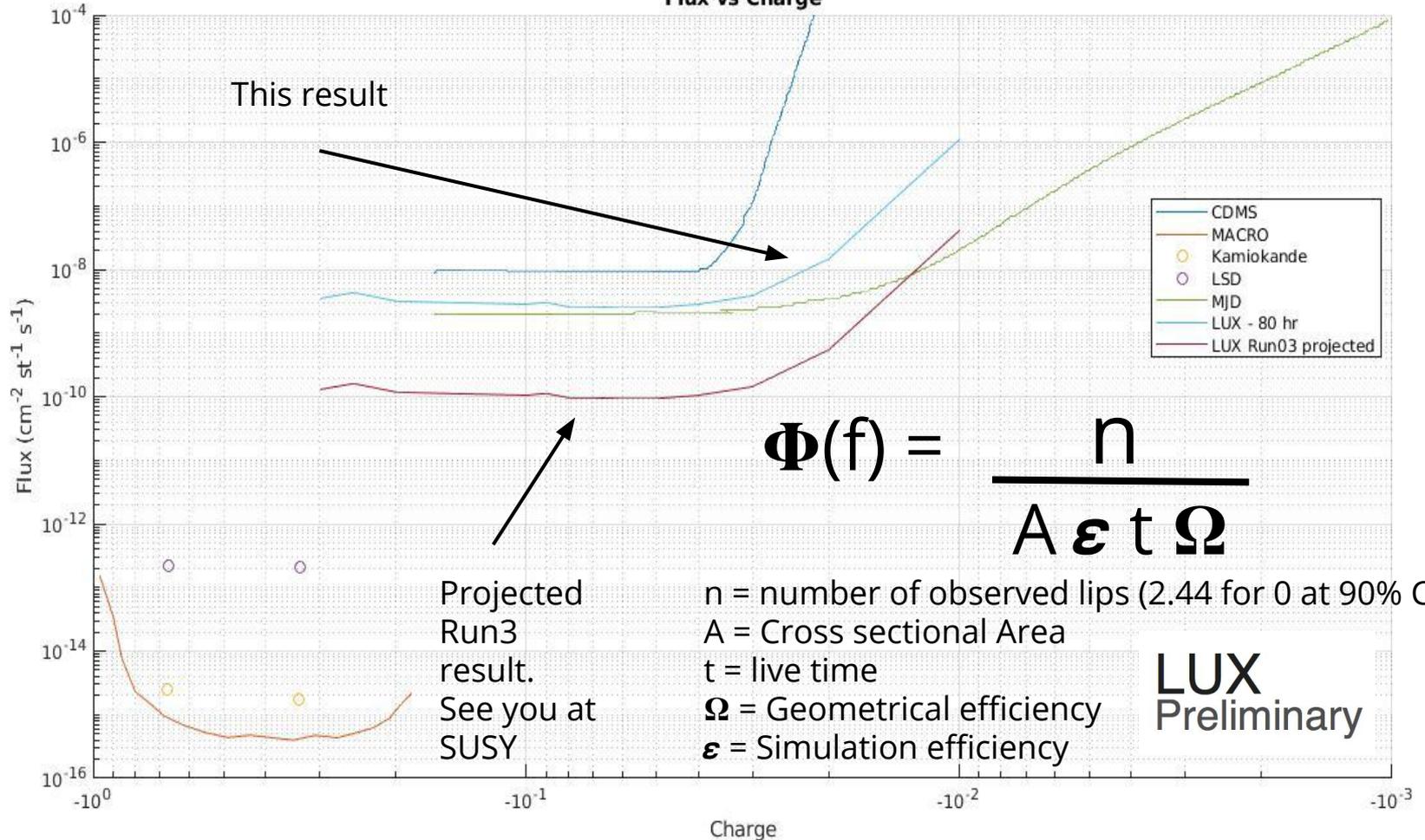
log₁₀(Total Energy) vs Theta after Chi² cut



Efficiency vs Charge



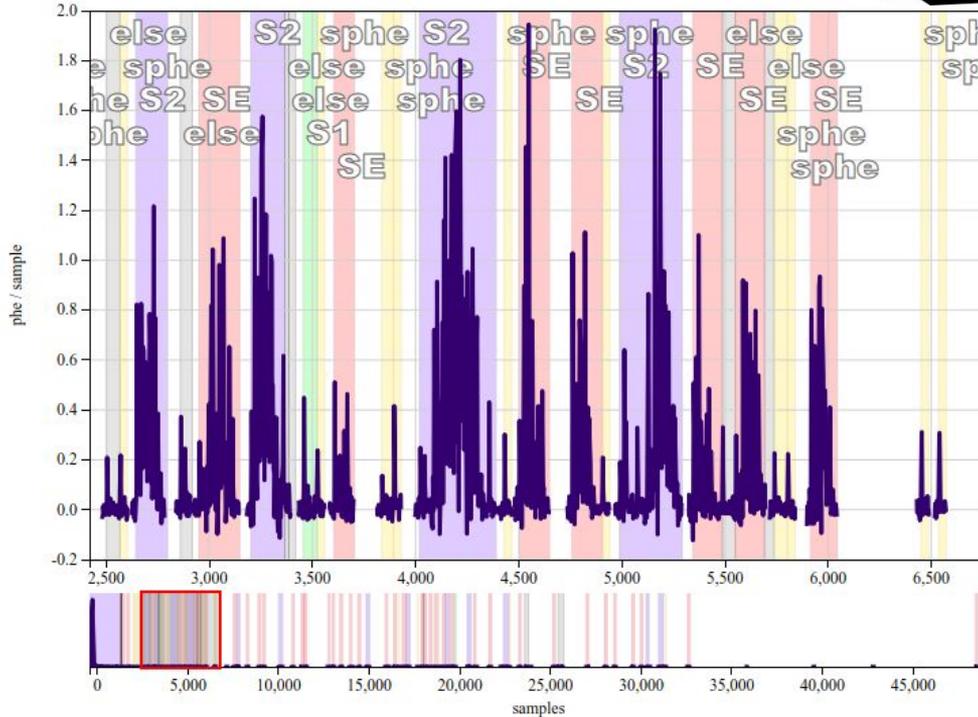
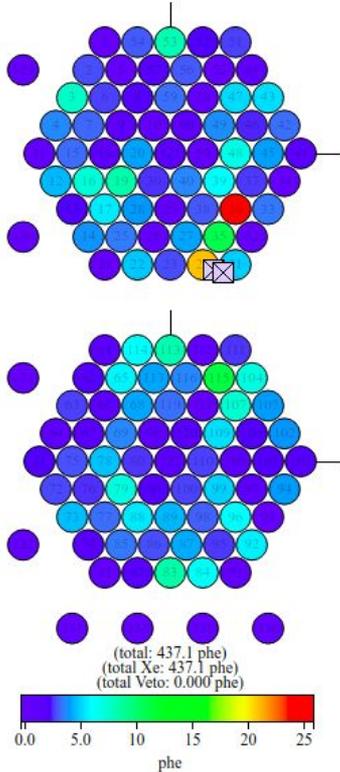
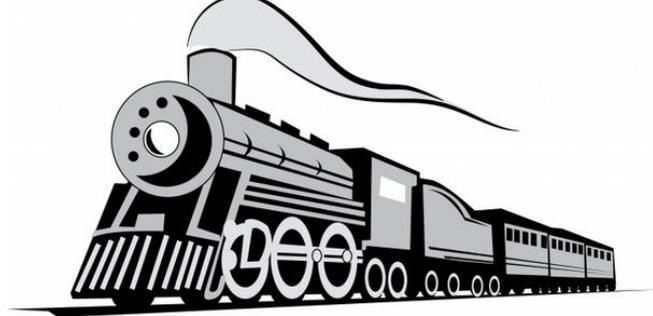
Flux vs Charge



Questions?



Backgrounds - E - trains



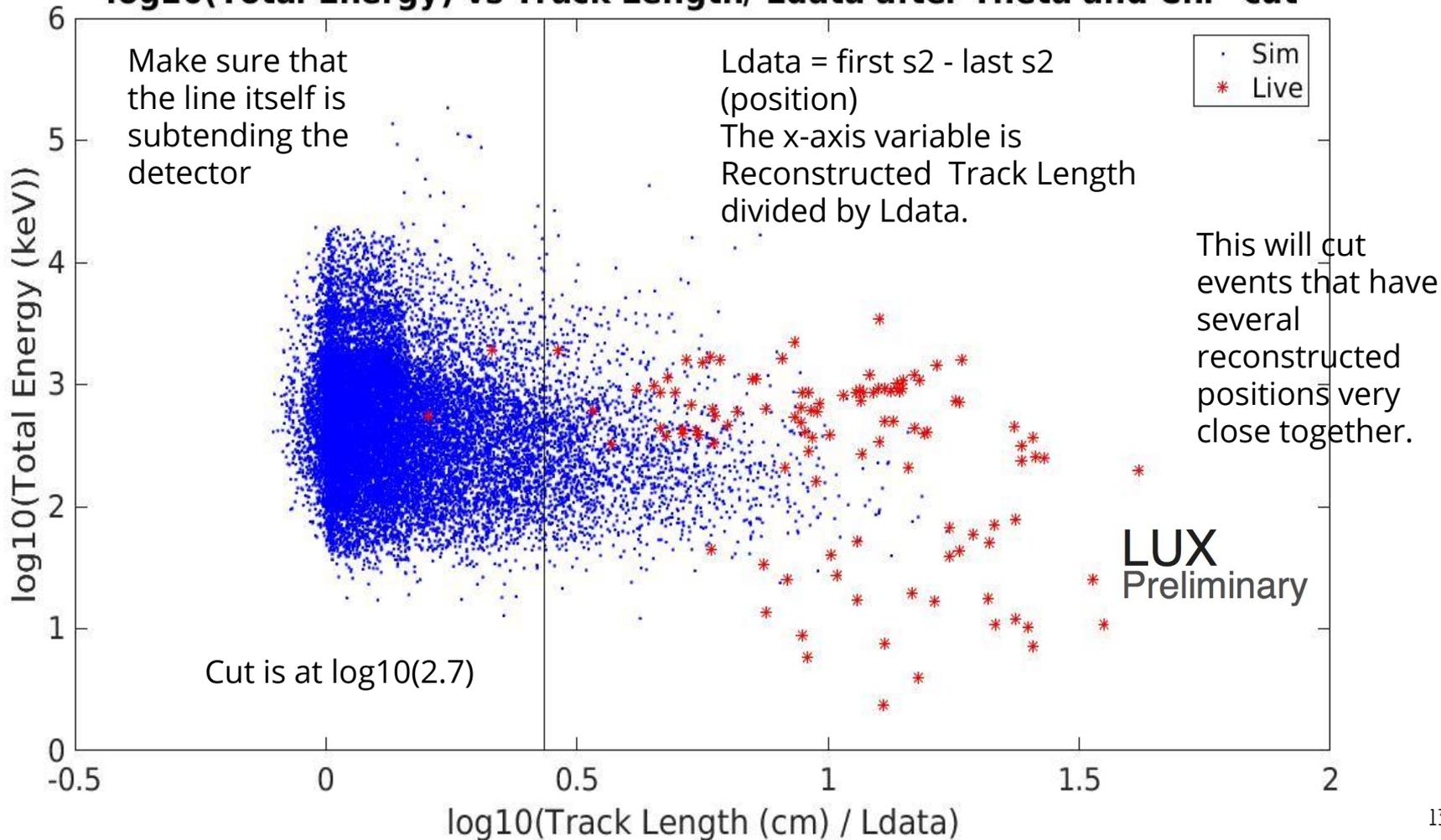
-Often after high Energy event or multiscatter

- Can look like a lot of small impacts often reconstructed in the same x-y position.

-Can trail into the following event and make up an event of only e-train pulses.

LUX
Preliminary

log₁₀(Total Energy) vs Track Length/ Ldata after Theta and Chi² cut



STD S2/Total Energy vs First 2 S2s/ Last 2 S2s After Previous Cuts

LUX
Preliminary

