Some comments on CYGNO and slides about reconstruction

Cosmin Deaconu

UChicago/KICP

March 6, 2019

Disclaimers

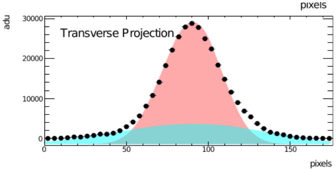
- I'm a bit rusty since I have been doing other things for almost 4 years now!
- All I know about CYGNO is from Elisabetta's slides at the CYGNUS emails and two papers Davide sent me ("Combined readout of a triple-GEM detector" and "Study of the performance of an optically readout triple-GEM")
- Most of what I know is in my thesis (https://dspace.mit.edu/handle/1721.1/99314?show=full, also http://cosmogenic.uchicago.edu/~cozzyd/thesis.pdf if you want clickable links)

Light yield

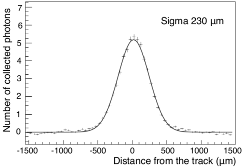
- *ab initio* acceptance calculation is very hard, we never got it to match expectations for DMTPC detectors with CCD's (always had to add a fudge factor into simulations)
- Suspicion that a lot of it is due to the optical transparency of the lens, which is probably not high (typically lenses have lots of elements!)
- Also have to consider image vignetting (maybe not relevant for your prototype)
- Suggestion: Use PMT's for light yield measurement? (acceptance still hard, but fewer unknowns...)

Non-Gaussian tails at high gain?

- When running a prototype detector in a cascaded mode (two micromesh amplification regions back to back, gas gain $\mathcal{O}(10^6)$) we saw evidence of non-gaussian tails.



- Not present in Garfield++ simulations of amplification region... suspicion is that it is related to UV photons, but not confirmed
- Am I reading too much into this image (if I squint, I can see an "extra" tail)?

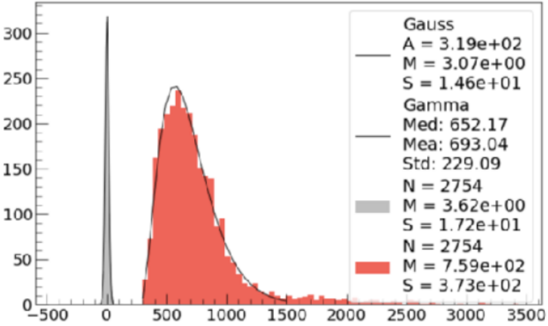


PMT timing

- The "Combined readout" paper talks about "absolute z-position," I think this must be relative z position, right? Unless you can detect the prompt scintillation light?
- I would naively think that the scintillation decay time, which I thought was $\mathcal{O}(10ns)$ for CF_4 would limit Δz resolution from PMT's
  - At 72 μm/ns, this naively limits to about 1 mm resolution in Δz.
  - Maybe this value is old (can't find a reference right now)/superceded?
  - Or maybe shorter with He or in the presence of a large field?
  - Probably multiple components to this decay time (different excitation products with different lifetimes). It might be possible, with suitable filters, to find the shortest timescale.
- Measuring the current on the electrode can give you better resolution, provided that capacitance is low (probably requires segmentation?).

CYGNO Energy Reconstruction

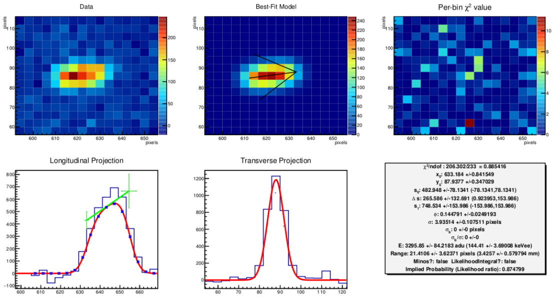
- Reconstructed energy distribution looks a bit funny to me

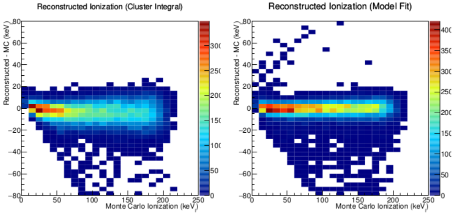


- Reconstruction inefficiency would tend to systematically underestimate rather than overestimate?
- Could this driven by extreme per-electron gain variations or spatial non-uniformity?

My reconstruction algorithm

1. Do image cleanup
2. Use a accepting clustering algorithm to find areas of interest (first blur the image, then look for elevated regions with an adaptive threshold)
3. Perform a maximum likelihood fit of pixels to to a very simple track model:
    - x_0, y_0, the start position
    - ϕ, 2D angle
    - E, "energy" (really just a normalization factor)
    - σ^2, σ is width
    - s_0, ionization density at start of track
    - Δs, change in ionization density from start to end





My Reconstruction Code

- I promised I'd share my reconstruction code...
- ...but I haven't had a chance yet to sit down and extract it out properly (so it doesn't rely on our data formats, etc.)
- If you think you'd find it useful, I'll go through that effort... or I could send you big archive (but that's not very friendly)
- What I think might be useful:
  - Clustering algorithms (although these have things you probably don't need, like dealing with dead regions in the detector)
  - Fitting code (`Minuit2`-based)
  - Maybe some image cleaning code? Not sure how transferrable that is to your cameras...