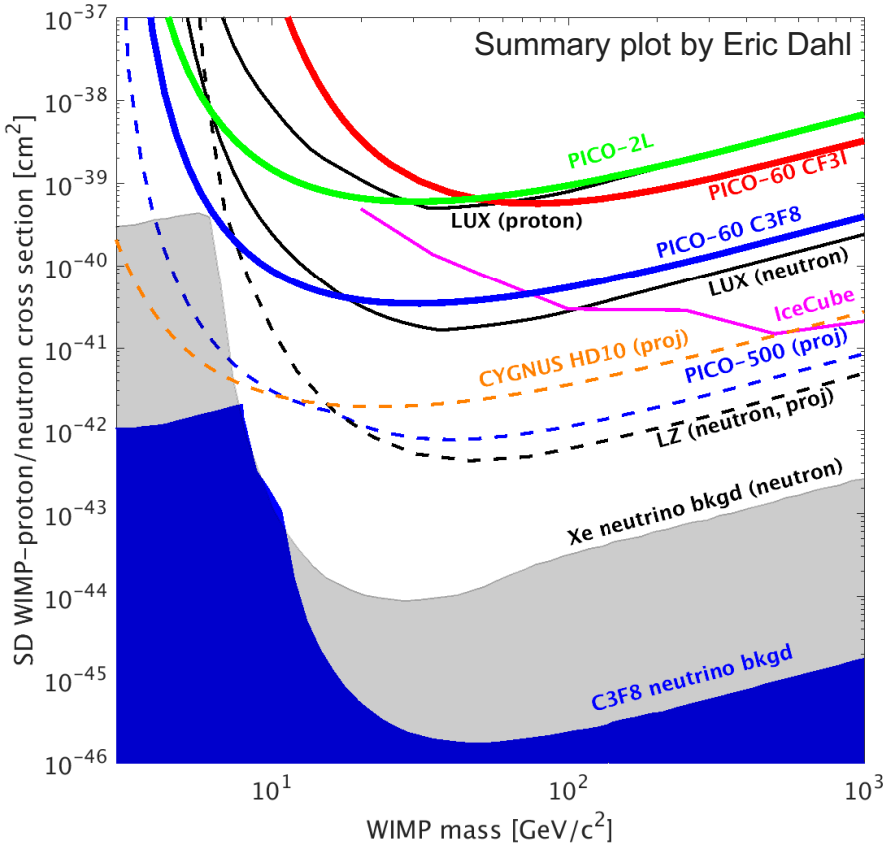
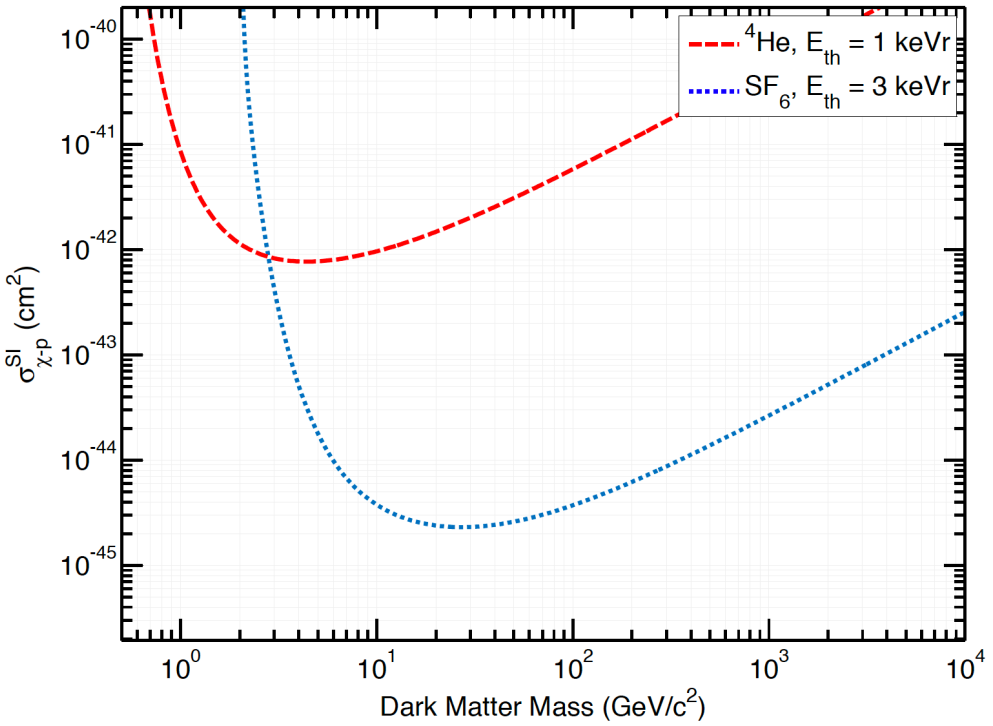
Technology Comparison: brief update

- People contributing: Ciaran, Cosmin, Kentaro, S.V.
- Running a bit late… (Spent most of my time writing code, instead of text for paper.)
- Simulation framework mostly completed now
  - Recoil generator: SRIM
  - Electron generator: CASINO
  - Detector + readout simulation: own code in python
- First results for neutrino/WIMP discrimination with 1D readout shown at CYGNUS2017 (see slides attached to this agenda).
- Today, focusing on
  - Cosmic visions white paper
  - Electron discrimination at low recoil energy. This is a key issues we need address for coming funding proposals and in our paper.

CYGNUS HD10: Sensitivity for Cosmic Visions

(estimated by Nguyen Phan)

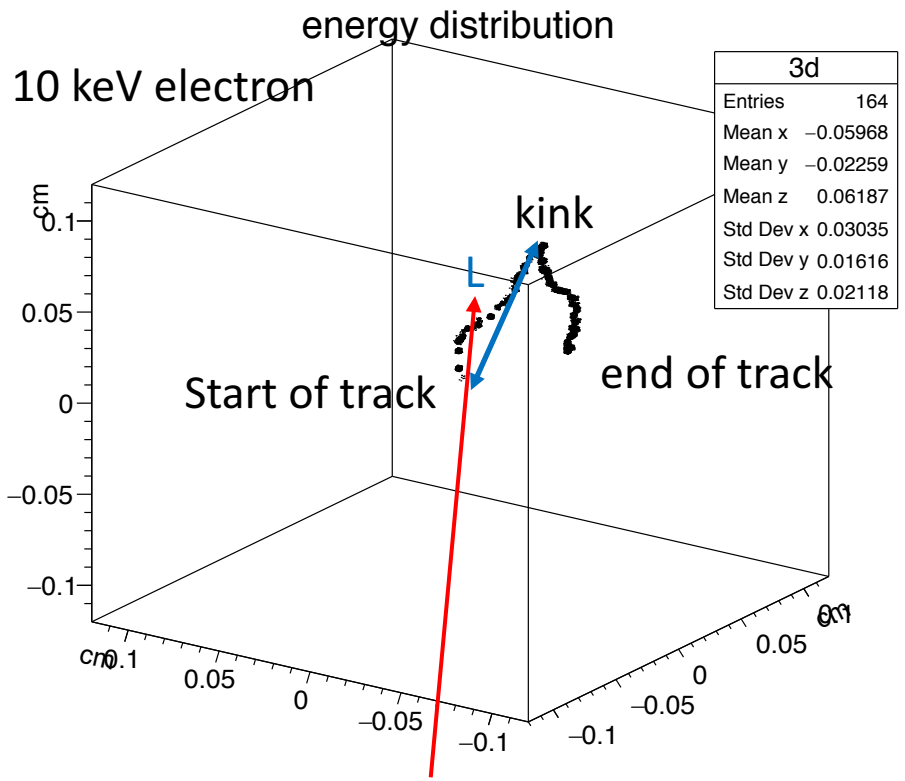


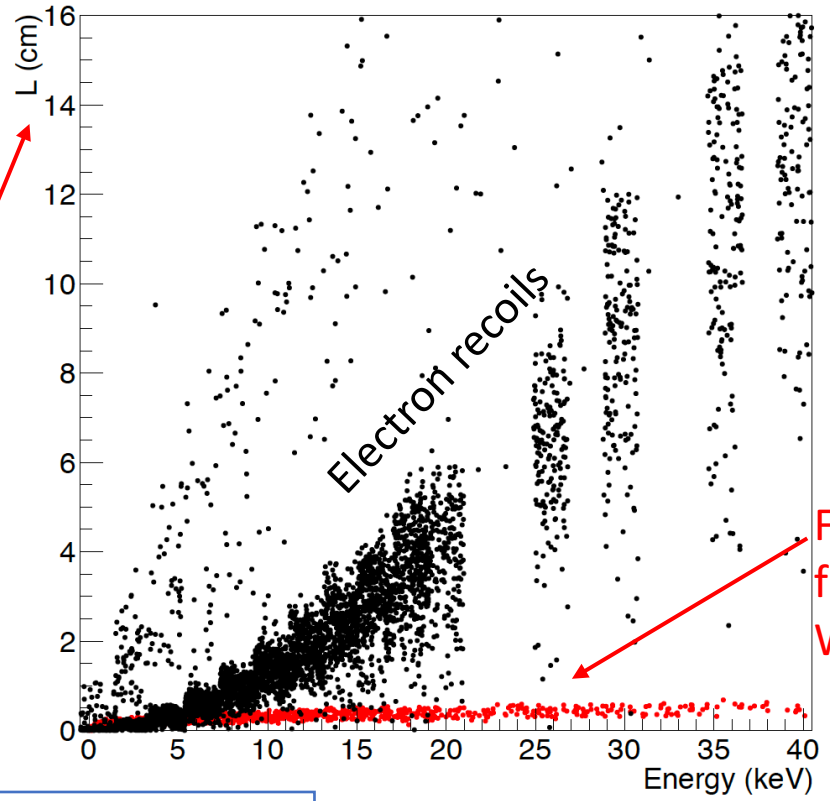


10 m^3 w/ 3-years of running. Competitive sensitivity.
Could be a step towards a large CYGNUS observatory.

New Results (post CYGNUS2017): Electron discrimination in 20 torr of SF_6

- L versus E: definition of L is important





L = distance from start to to ionization furthest away

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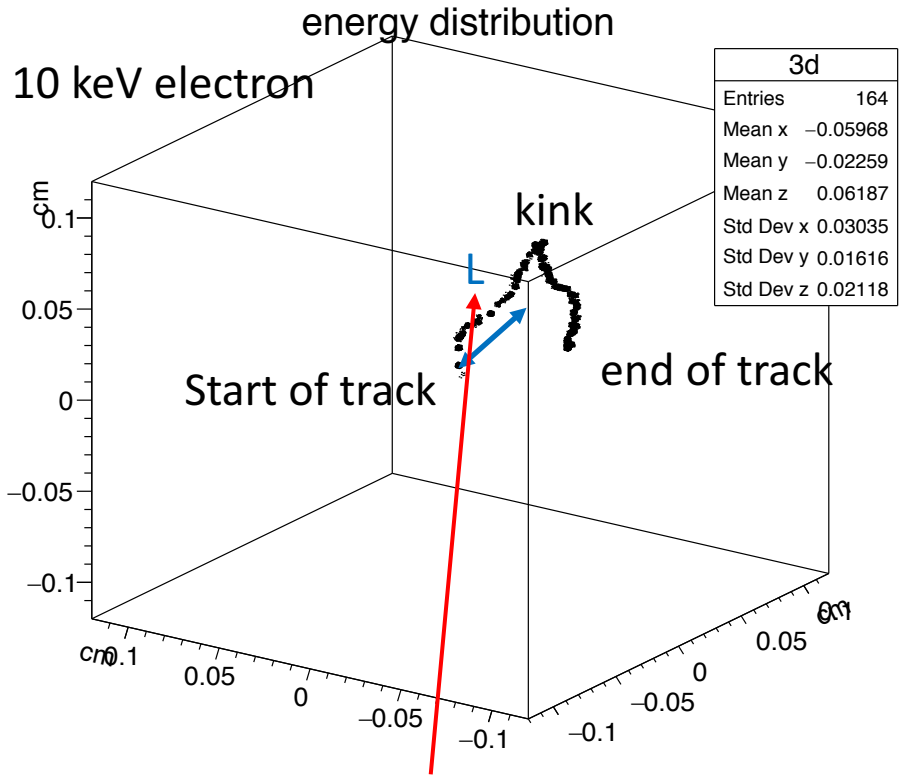
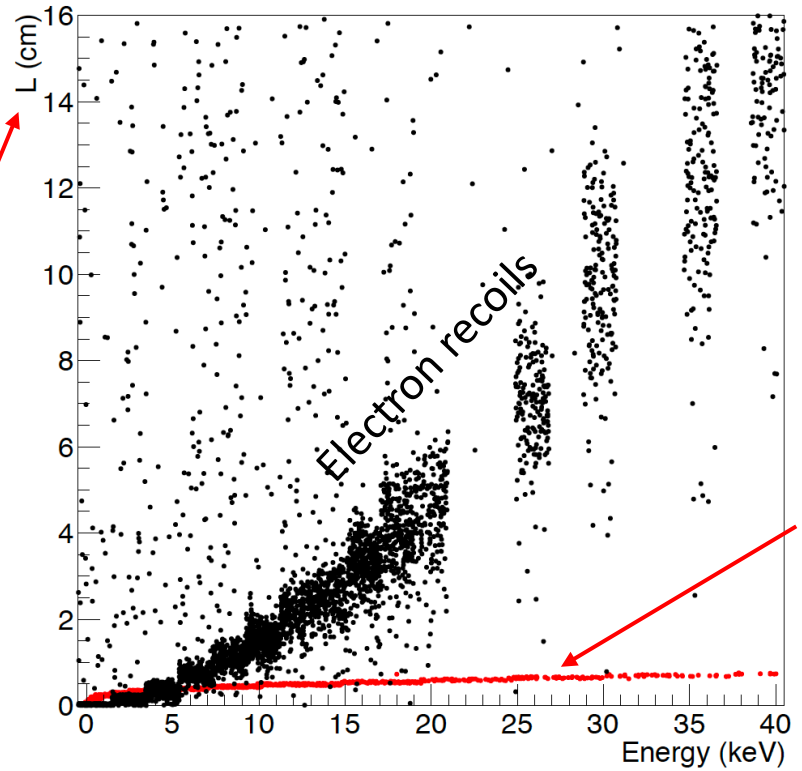
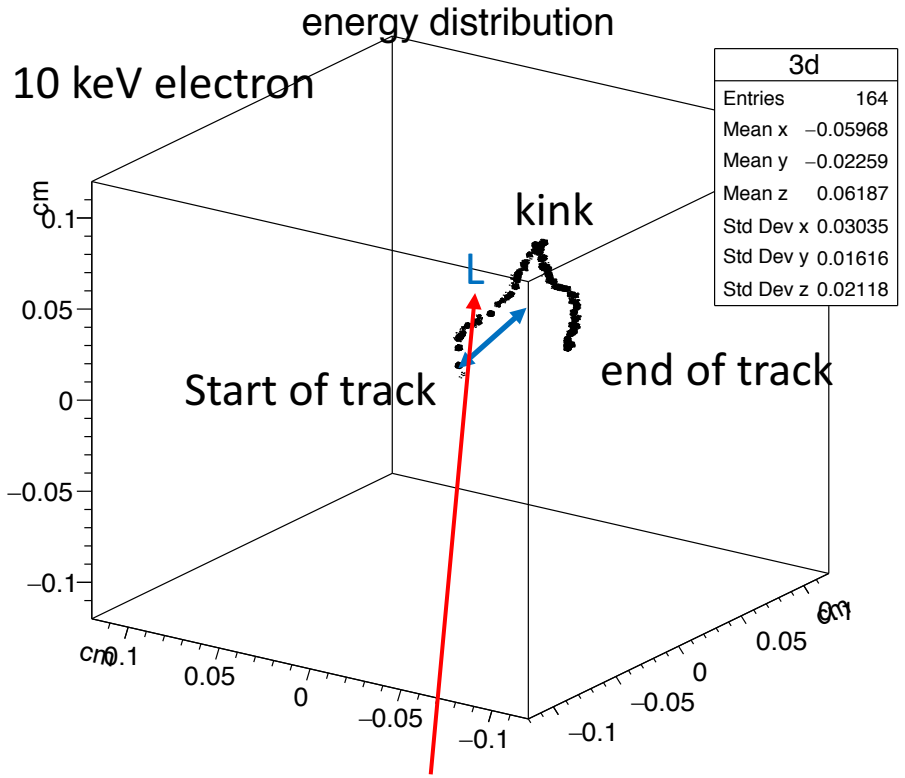


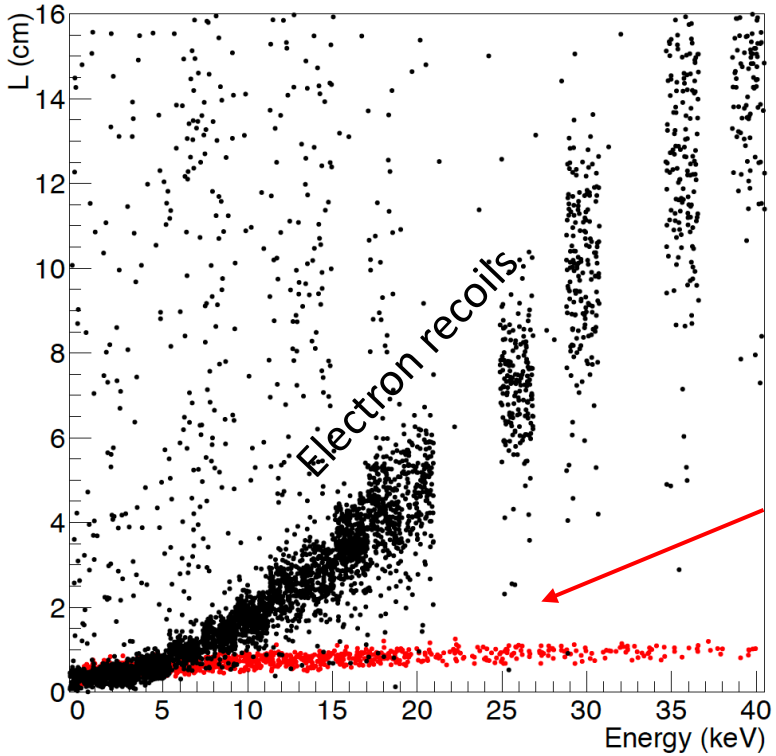


L = 2*distance(center of charge cloud to point furthest from center)

With diffusion included. 0-50 cm driftlength.

Upshot: Quite good electron rejection (>~ 10^3) looks feasible above 20 keV (in 3D)
Still need to properly quantify, but for reference, there are 500 electrons in each energy bin



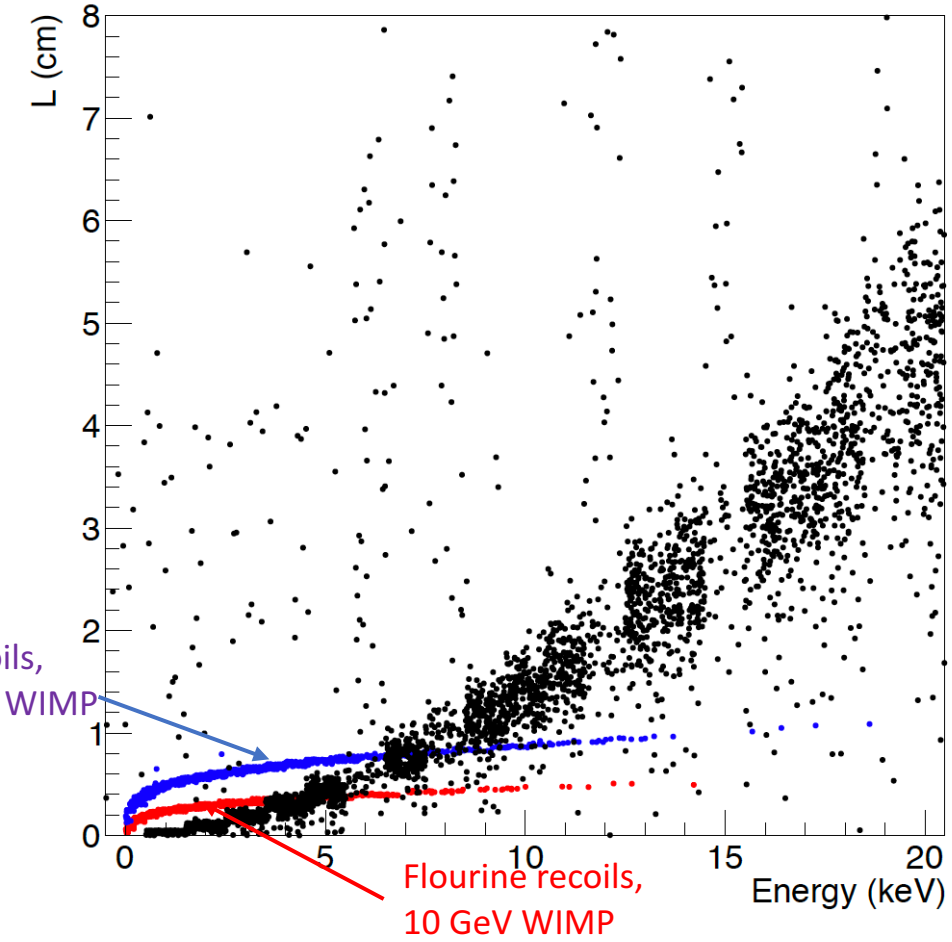


Flourine recoils, from 100 GeV WIMP

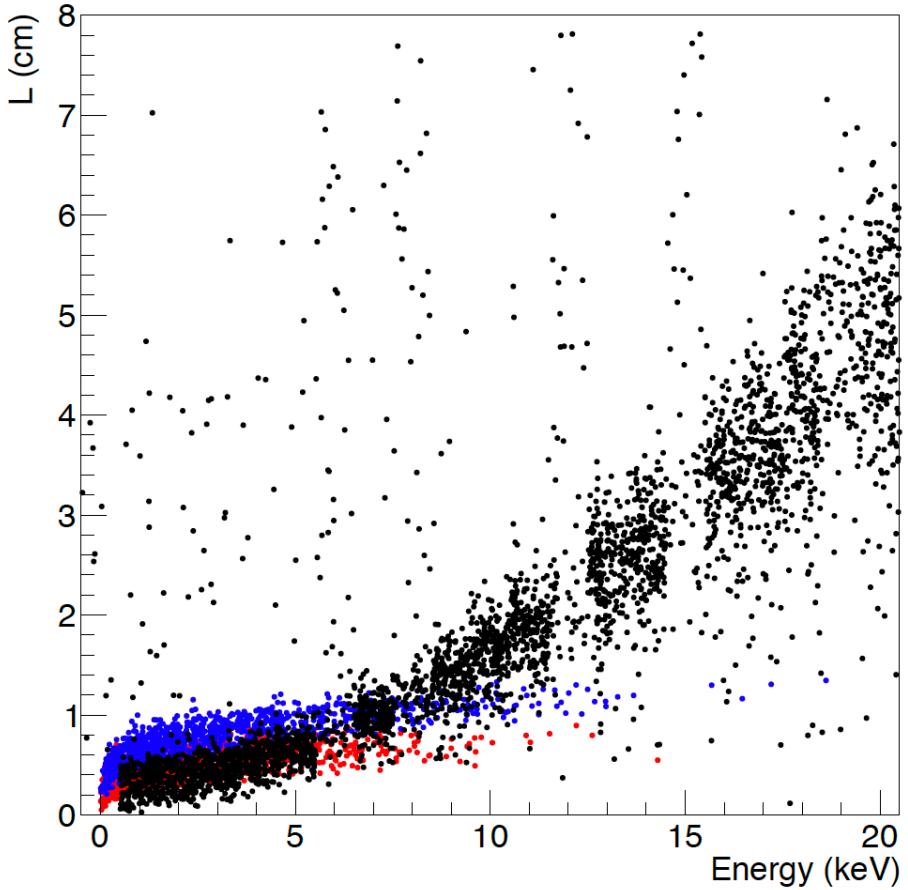
L = 2*distance(center of charge cloud to point furthest from center)

Discrimination at low E < 20 keVee: 10 GeV WIMPs

- w/o diffusion



- With diffusion



Below 5 keV, electron discrimination improves again! Particularly for He recoils! Limited by diffusion.
Next steps: validate w/ DEGRAD, include effect of charge readout and post-detection track reconstruction.

Outlook

- Most hard work done now, but still need significant time to analyze results and write text.
- Planning two types of crosschecks of existing simulations
  - Simulate nuclear recoils both with
    - 1D SRIM dE/dX (done) and
    - Cosmin's 3D recoil library (have a first version, not tested yet)
  - Simulate electrons both with
    - CASINO (done)
    - DEGRAD (CERN packge). Have a summer student will do this in July.
- We all need to agree on gas mixtures presented in different parts of the CYGNUS paper. Proposal:
  - 600 torr He + 200 torr SF6 [CYGNUS HD-10 mixture]
  - 60 torr He + 20 torr SF6 [candidate for large directional CYGNUS]
- I can't promise that I will do any useful work in July. I will be back and free to resume work July 28th.
- Can we finish the draft by mid August, and submit to Journal by August 31?
  Ambitous, but possible?

Input parameters used to simulate ionization, drift, gas gain

Disclaimer: highly preliminary -- needs more work!

- Gas mixture: SF_6
- Pressure: 20 torr
- W: 35.45 eV per ion pair [Hilal and Christophorou, alpha particles]
- Gas gain: 9000 (A. Scarf)
- Gain resolution: $\frac{\sigma_G}{G} = 20\%$ (A. Scarf, Sheffield)
- Diffusion: 116.2 $\frac{\mu m}{\sqrt{cm}}$
- Drift velocity: 140 μm/μs

[from D. Loomba, New Mexico: for 600-800 V/cm which gave minimum diffusion at 20 Torr]

Input parameters for readout plane simulation

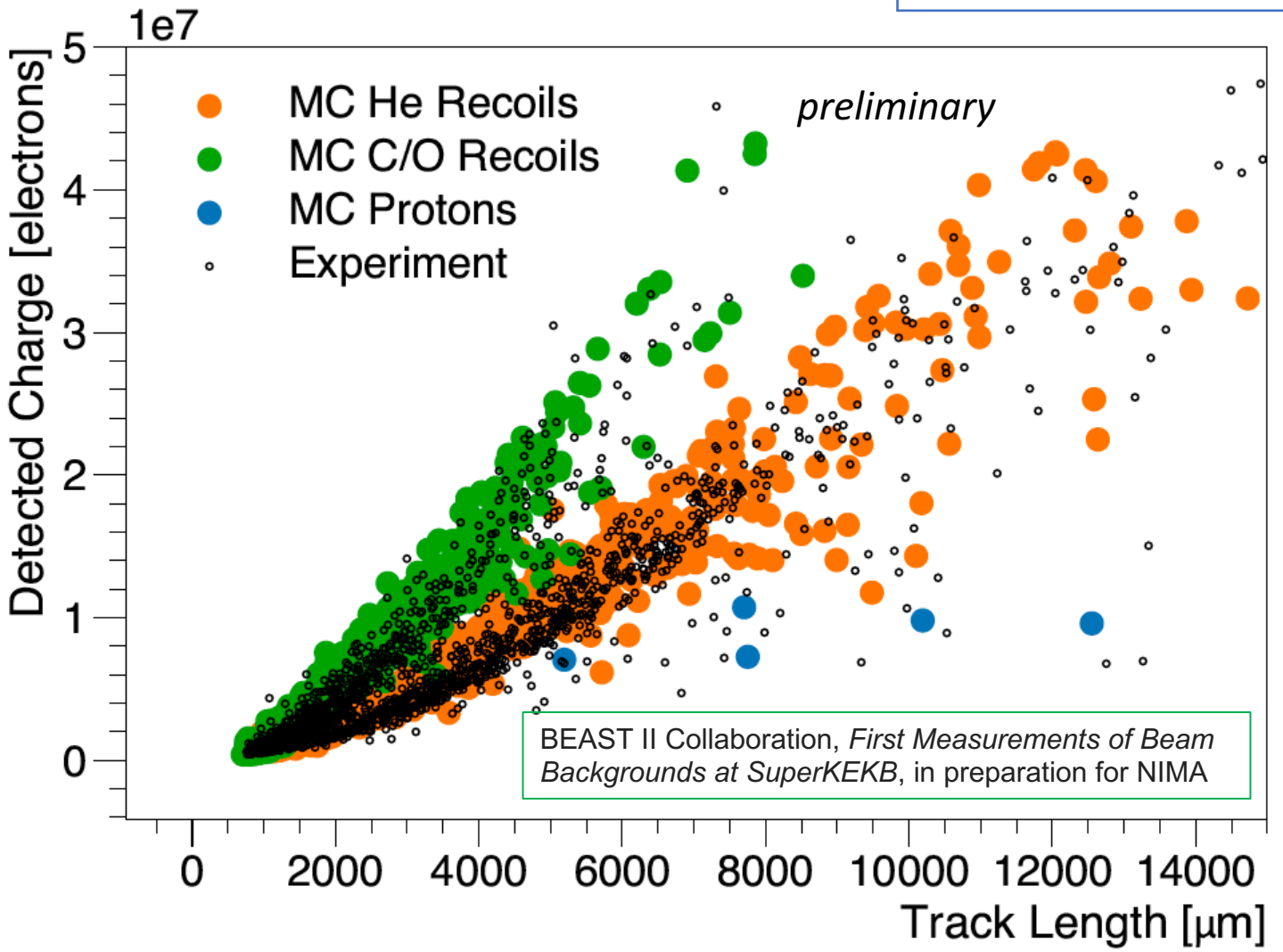
Disclaimer: *highly* preliminary -- needs more work!

Readout type	Dimensionality	Segmentation	Z binning (assume 1MHz sampling)	Detector Element Capacitance	Noise level	Noise level per 1-µs readout clock cycle	Threshold (avalanche charge)
planar	1D (z)	10 cm x 10 cm	140 µm	11,000 pF GEMs: 250pF (3cm*3cm, 100um) **3000pF** (10cm*10cm, 100um) 25000pF (30cm*30cm, 100um)	5400 e^- for 1000 pF, 1µs peaking time	18000 e^-	3 x noise
wires	2D (xz)	1m wires, 2mm pitch	140 µm	?	250e^- in 10 us	800 e^-	3 x noise
CMOS camera	2D (xy)	t.b.d.	n/a	n/a	?	?	?
resistive strip Micromegas	3D (xyz) with coincidence ambiguity	1 m strips, 200 µm pitch	140 µm	50 pF per 10 cm of strip → 500 pF	2800e^- for 1µs peaking time	2800 e^-	3 x noise
pixel ASIC	3D (xyz)	200 µm	140 µm	12-200 fF	~270 e^- (per 25 ns sample)	42 e^-	1500 e^-

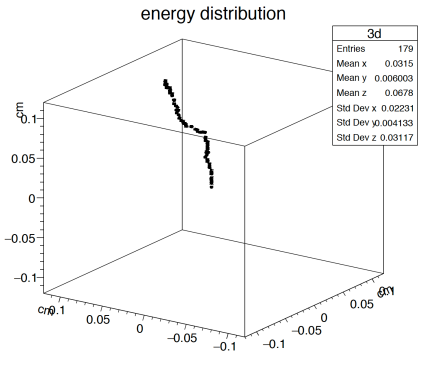
(only charge readout for now. But can probably add 2d optical.)

New: Particle ID

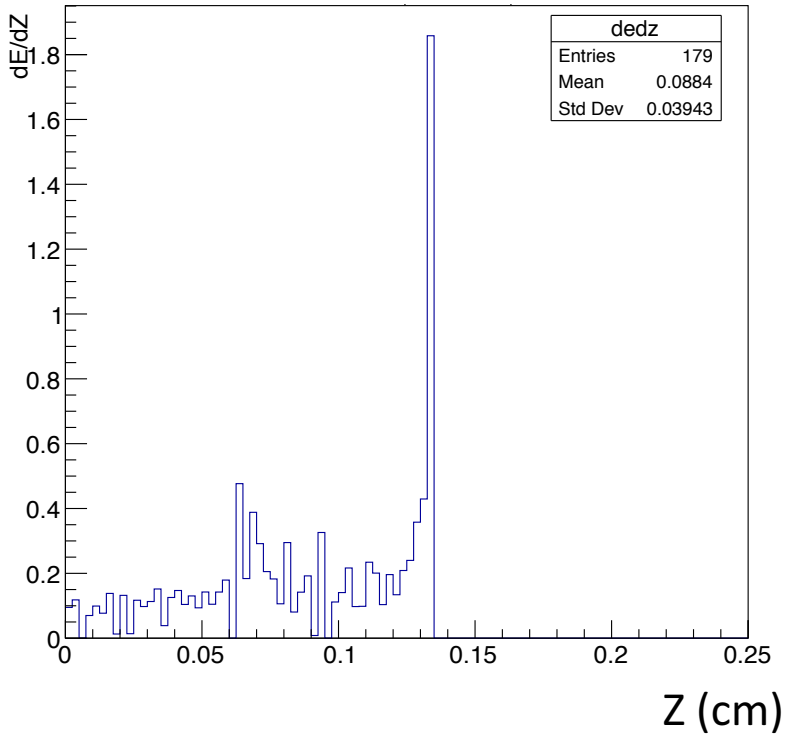
Michael Hedges
TPC Simulation by Igal Jaegle (now at U. Florida)

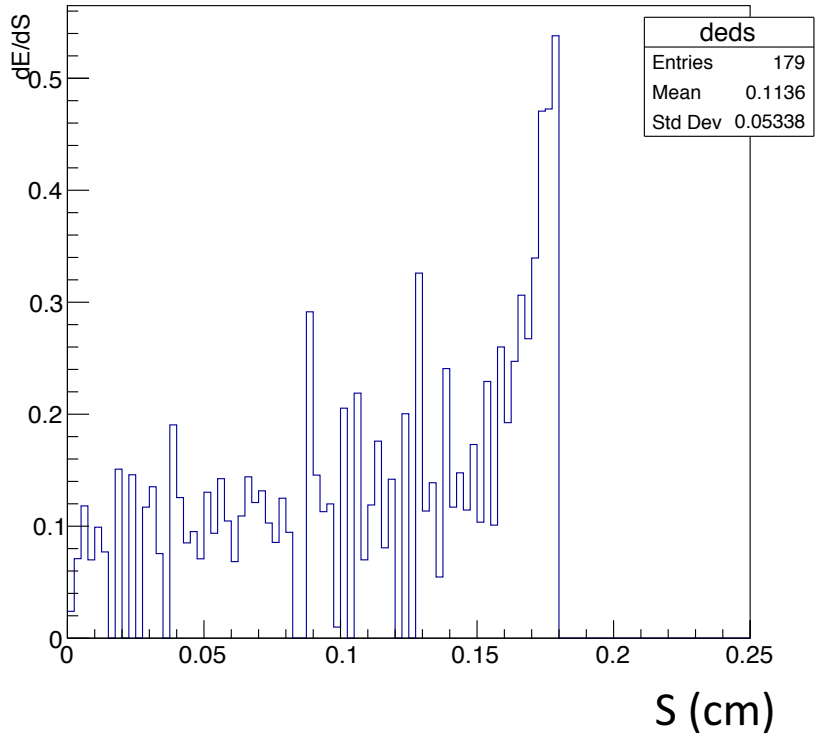


dE/dZ vs dE/dS

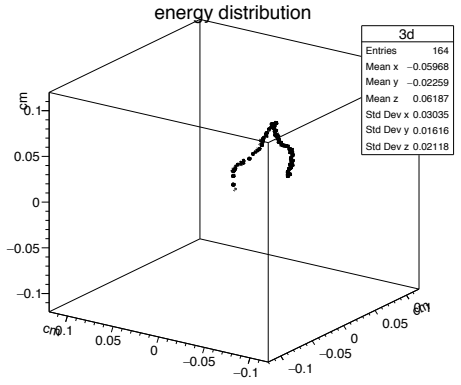


One 10-keV electron





dE/dZ vs dE/dS



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