Work Summary

Liverpool FASER Meeting

April 4, 2025

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Updates this Month

- MC Production for Dark Higgs
  - Reprocessed Dark Higgs samples at Liverpool
  - Able to generate samples on fasermc
- First look at Dark Higgs Samples/Muon-Pion Selection
  - Gave talk at Analysis meeting this week
  - Follow up with a selection criterion
  - Get better Neutrino background

MC Production

- Calypso branches currently in use
  - centos7-legacy – Simulation/Digitization works here
  - master – Reconstruction works here
  - torrence-calonu – Calibration fixes + 2024 reprocessing
- master/torrence-calonu are alma9 based
- In general simulation/digitization broken in alma9
  - Trying to run and assimilate issues

Generation - Using Liv-HEP Cluster

- master branch
  - Sim/Digi/Reco works now – Probably Carl's fixes
  - NTuple Generation fails due to weird database error
- torrence-calonu branch
  - Simulation/Digitization broken
  - Reconstruction works
  - Reconstructed Dark Higgs samples currently in use – No Database issue here?
- Need to formalize the workflow here for validation

My attempts at Generation - Using lxplus

- Submitting jobs to lxbatch – from fasermc account
  - Able to Generate Dark Higgs samples using centos7 containers
  - Updated Reconstruction needs to run separately in alma9
  - Working on combining a centos7 simulation with alma9 reconstruction
- Submitting jobs to lxbatch – from my account
  - Releases held at fasermc/work directory – permissions messy
  - Need to build my own release – eos does not play well with large files being written rapidly
  - Directory structure is hard coded to work very specifically within the fasermc directory

First (1.5) look at Dark Higgs Samples

- Shifting code is likely correct - Sorry Carl!
- Timing Cut Inadquate for extended decays
- Preshower Studies for PID Selection/Background
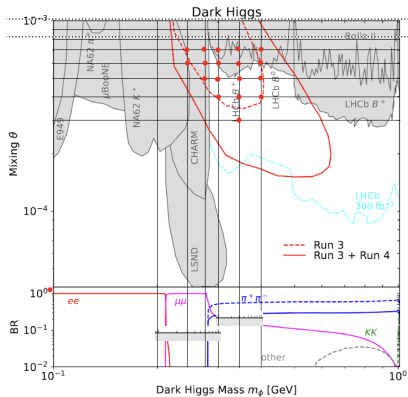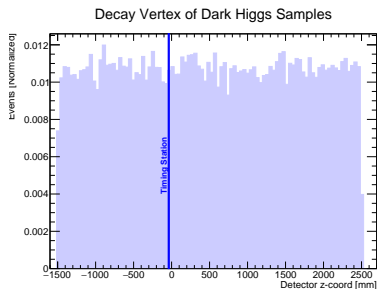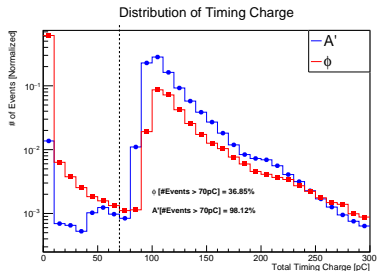- Calostudies for PID Selection/Background

Figure: Dark Higgs Grid

- 18 new samples here in extended decay volume

Timing Cut for an Extended Decay Volume

Distribution of Timing Charge


Decay Vertex of Dark Higgs Samples

- Conclusion : Decays after timing station will not be picked up by the timing station
- Sorry, but I had the plots and I needed to show them

Back to the Dark Higgs

| Cut	Dark Higgs				Dark Photons				Neutrinos [Genie]			
	Input	Pass	Eff (%)	CumEff (%)	Input	Pass	Eff (%)	CumEff (%)	Input	Pass	Eff (%)	CumEff (%)
Colliding BCID	134583	134583	100.000	100.000	718000	718000	100.000	100.000	30653	30653	100.000	100.000
Timing Trigger	134583	134583	100.000	100.000	718000	718000	100.000	100.000	30653	30653	100.000	100.000
Timing Not Saturated	134583	120108	89.245	89.245	718000	714896	99.568	99.568	30653	29734	97.002	97.002
VetoNu_raw_charge ≤ 40	120108	120092	99.987	89.233	714896	714845	99.993	99.561	29734	29728	99.980	96.982
VetoSt_raw_charge ≤ 40	120092	119746	99.712	88.976	714845	712584	99.684	99.246	29728	29584	99.516	96.513
Timing_raw_charge > 70	119746	117218	97.889	87.097	712584	699050	98.101	97.361	29584	7841	26.504	25.580
Preshower_raw_charge > 2.5	117218	117199	99.984	87.083	699050	698928	99.983	97.344	7841	7508	95.753	24.494
At least one good track	117199	98361	83.926	73.086	698928	637986	91.281	88.856	7508	673	8.964	2.196
At least two good tracks	98361	78282	79.586	58.166	637986	461878	72.396	64.328	673	142	21.100	0.463
Exactly two good tracks	78282	72030	92.013	53.521	461878	398820	86.347	55.546	142	95	66.901	0.310
Track_R < 95	72030	62662	86.994	46.560	398820	362750	90.956	50.522	95	56	58.947	0.183

- Dark Higgs have been pre-filtered to decay in the decay volume
- Timing Saturation is worse for the Dark Higgs?
- Two Track cut performs better at the cost of one good track performing worse
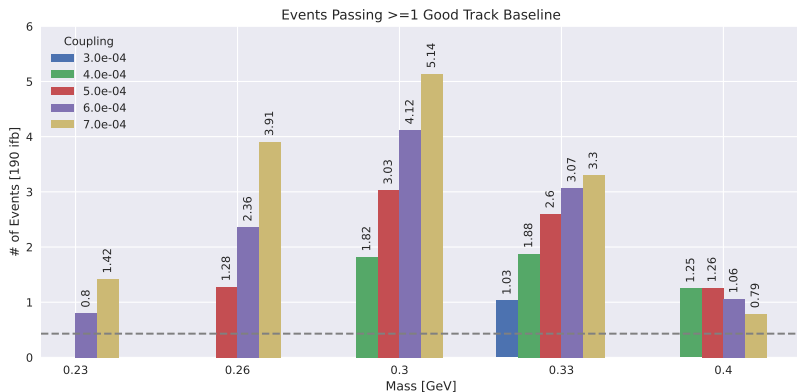
How many Events pass the Entire Cut-Flow ?

Events Passing 500 GeV Calo Baseline
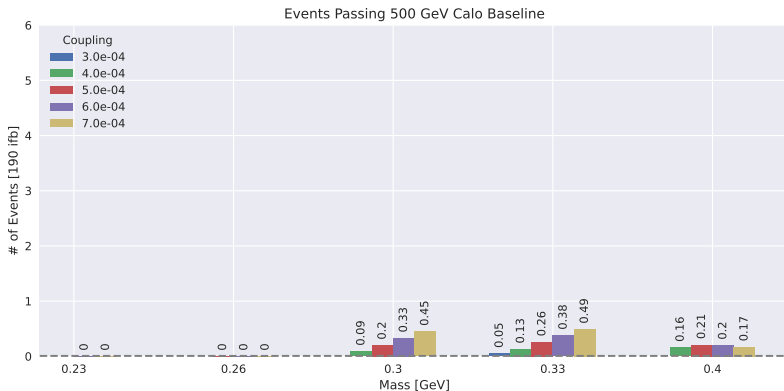
- Almost None – Calo requriement kills all Muons and Pions

Events Passing 2 Good Track Baseline
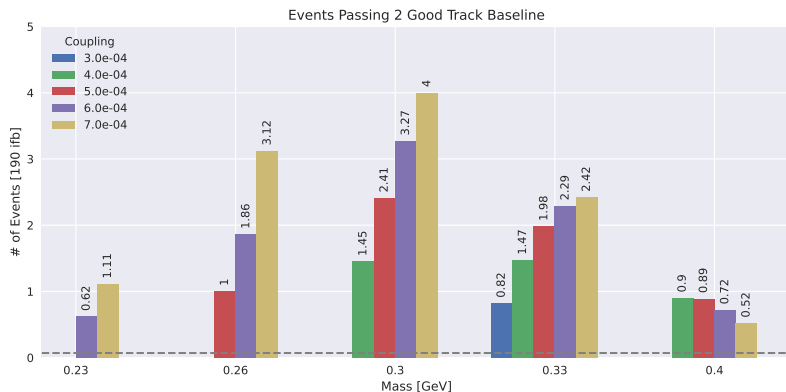
- Just having two tracks is good enough for some samples
- Although background needs to be studied a bit more carefully

Events Passing >=1 Good Track Baseline

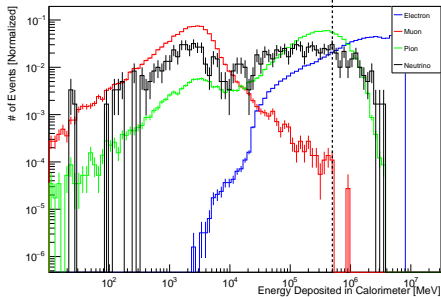# Calo Energy by Track p

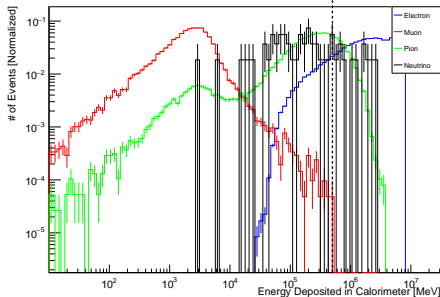**Figure:** Energy Deposited in Calorimeter divide by Sum of Track Momentum at Station 3 [One Good Track]

Figure: Same as left after baseline selection

- Some artifacts (e.g. peak at 1 GeV) could be from the underlying sample from which the particles are drawn

Calo Energy by Track p

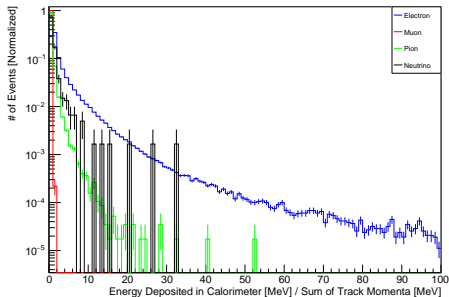Distribution of Energy Deposited in Calorimeter / Track Momenta

Figure: Energy Deposited in Calorimeter divide by Sum of Track Momentum at Station 3 [One Good Track]
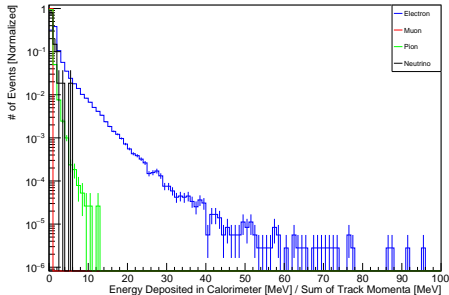
Figure: Same as left after baseline selection

- Might be a better variable to cut on to preserve some Pion events
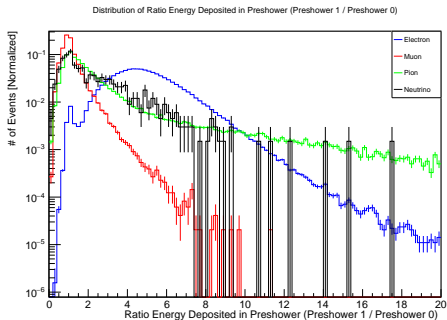
Preshower Ratio

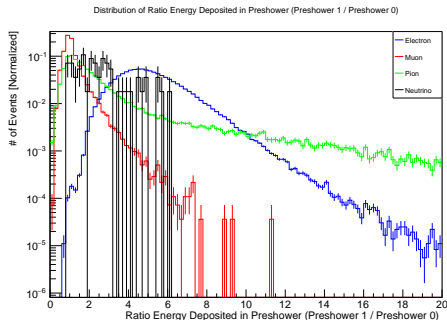**Figure:** Preshower E_dep Ratio post One Good Track Baseline Selection

Figure: Same as left but after complete Baseline Selection

- PID is a possibility but not a clear one.
- Previous study for PID [Link]

Moving Forward

- MC Production
  - Validate Simulation/Digitization in Alma9
  - Investigate the issues with the ChargeMIS-ID for A' samples
  - Investigate 2 track Reconstruction at large separations
- Dark Higgs
  - Investigate the Neutrino Background
  - Attempt a PID using Preshower+Calo
  - Develop a selection criterion for muonic/pionic channels
- Other Bits
  - Start writing up first year report