Update on GRINCH NIM – T. Averett 3/4/2026

Title: *A Gas Cherenkov Counter for a Large Angular Acceptance Magnetic Spectrometer in a High Background Environment*

- Design: high-rate environment - segmented PMT array, large angle side, timing based - VETROC
- The online and offline work was largely done by Maria Satnik (Now at LBNL) – Thank you !!

- Status: First draft 80% complete

- Based on GMn, SBS-9, below pion threshold

- Gas: C_4F_8 – 1atm, pion threshold 2.7 GeV

SBS Config.	Q^2 (GeV/c)^2	d_{BB} (m)	θ_{BB} (deg)	Solid Angle (mSr)	Beam Current (μA)	E_{beam} (GeV)	$\langle p_{scatt} \rangle$ (GeV)	p_{scatt} range (GeV)	Trigger Threshold (GeV)
SBS-8	4.5	1.97	26.5	59	5	5.98	3.58	3.09 - 4.14	2.65
SBS-9	4.5	1.55	49.0	95	12	4.03	1.63	1.43 - 1.86	1.38

Missing or In-progress Items

Thanks: Lots of information from Eric is mostly in my hands, just not included yet

- Abstract, Conclusion – Todd

- Clarification of Rates – Todd/Eric
    - Scalers - not on all runs
    - Number of events in VETROC per trigger – threshold dependent
    - Timing background in LE timing

- Some geometry information from simulation – Todd, Eric

- Clarification of coordinate systems - Todd, Eric

- NINO threshold in volts, % of spe – Todd

- Additional DAQ details, – Alex

- Simulation details – Eric/Andrew

Missing or In-progress Items, con't

- pi/e ratios – Eric

- Clarification of clustering algorithm – Andrew

- Heat map of event rate at entrance window – Eric

- Add simulated track matching plots – Eric

- Estimate of false events in cluster, timing window – Todd/Eric/Andrew

Largest Remaining Item: Analysis plots and efficiency calculations need to be redone using updated timing calibration – Andrew, on his (enormous) to-do list

Overview of Sections

1) **Introduction**: SBS program – large luminosity, background drives design
   1. 510 PMT, 1" diameter" array located on large angle side
   2. "non-focusing" design w/ cylindrical mirrors
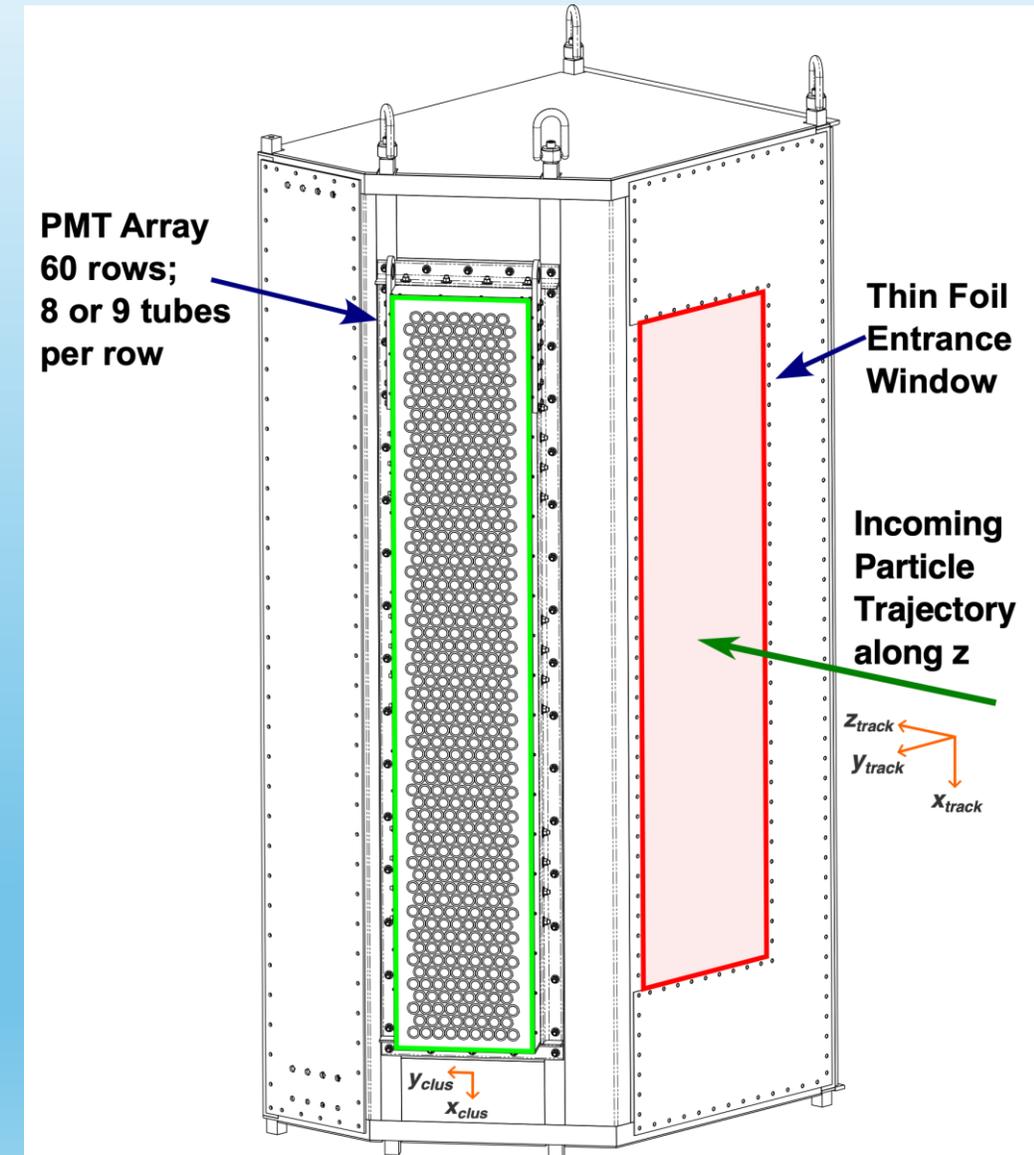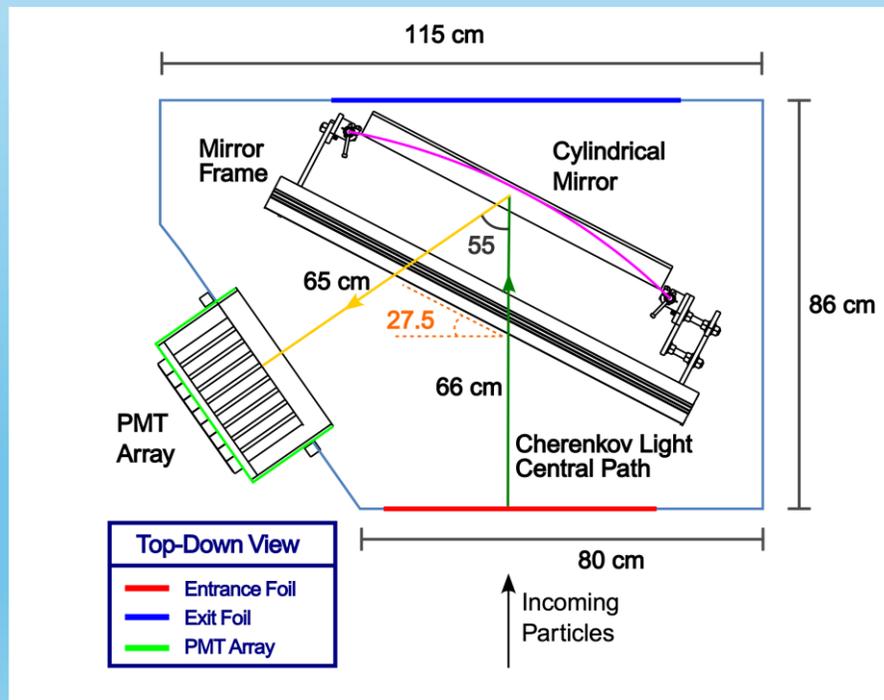   3. Timing-based analysis
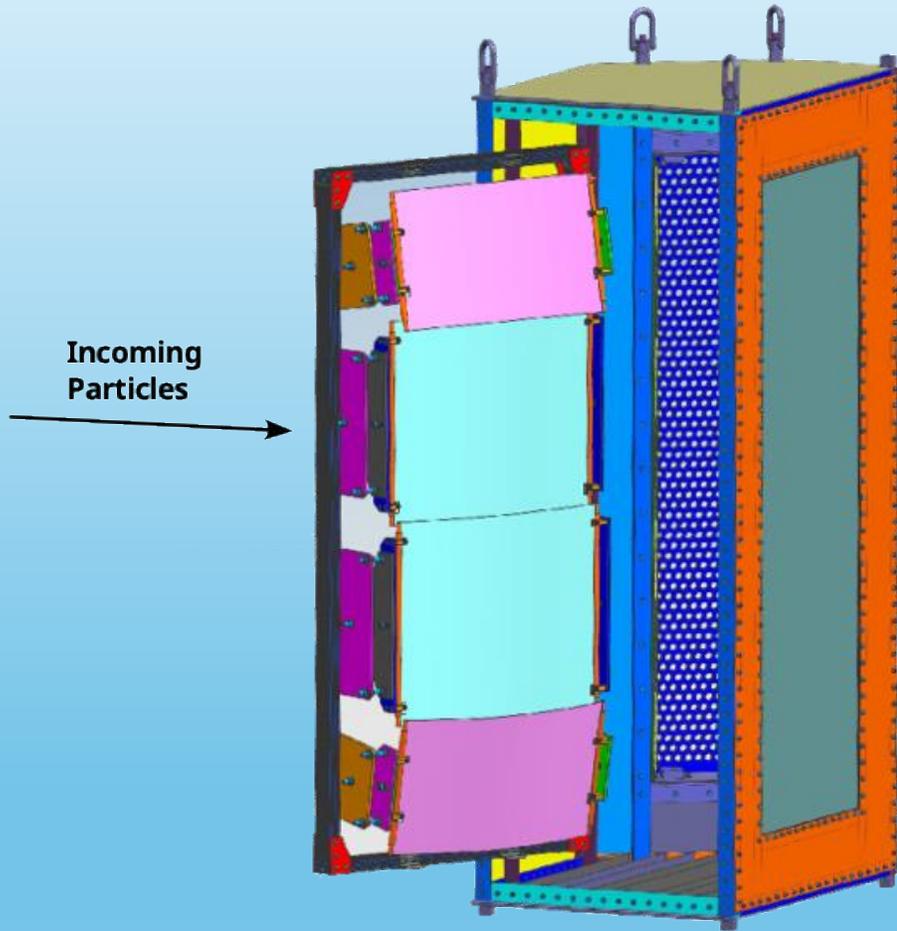
2) **BigBite Spectrometer overview**
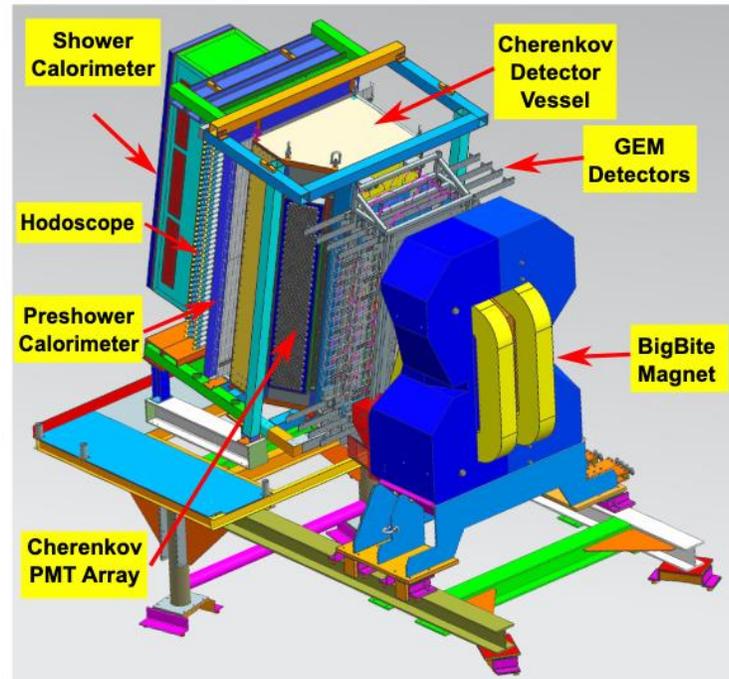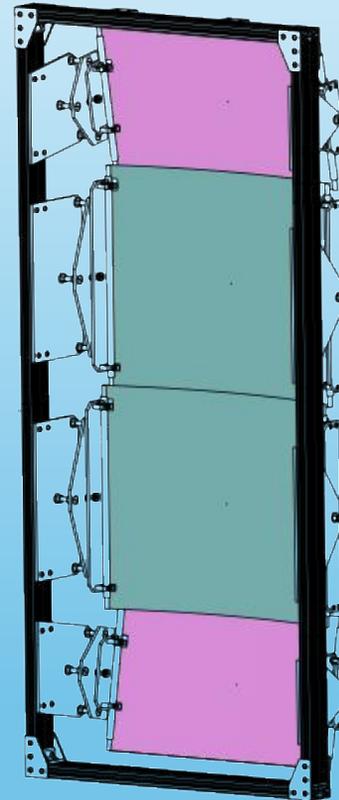

Credit: Anu

Overview of Sections, con't

3) Cherenkov Design

1. Overview/Geometry/Mirrors – non-focusing vertically
2. PMTs and light catchers
3. Magnetic shielding
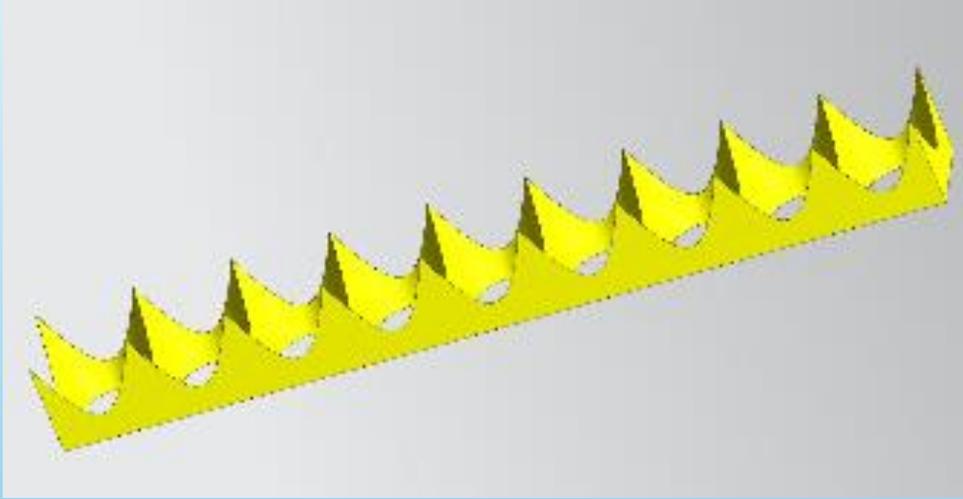4. Radiator gas choice and gas panel
5. DAQ – commissioned VETROC, NINO

Top-Down View diagram labels: 115 cm, Mirror Frame, Cylindrical Mirror, 55, 65 cm, 27.5, 86 cm, 66 cm, PMT Array, Cherenkov Light Central Path, 80 cm, Incoming Particles

Legend:
- Entrance Foil (red)
- Exit Foil (blue)
- PMT Array (green)

PMT Array 60 rows; 8 or 9 tubes per row

Thin Foil Entrance Window

Incoming Particle Trajectory along z

z_{track}, y_{track}, x_{track}

y_{clus}, x_{clus}

Overview of Sections, con't

Incoming Particles

Side/rear view with mirrors out
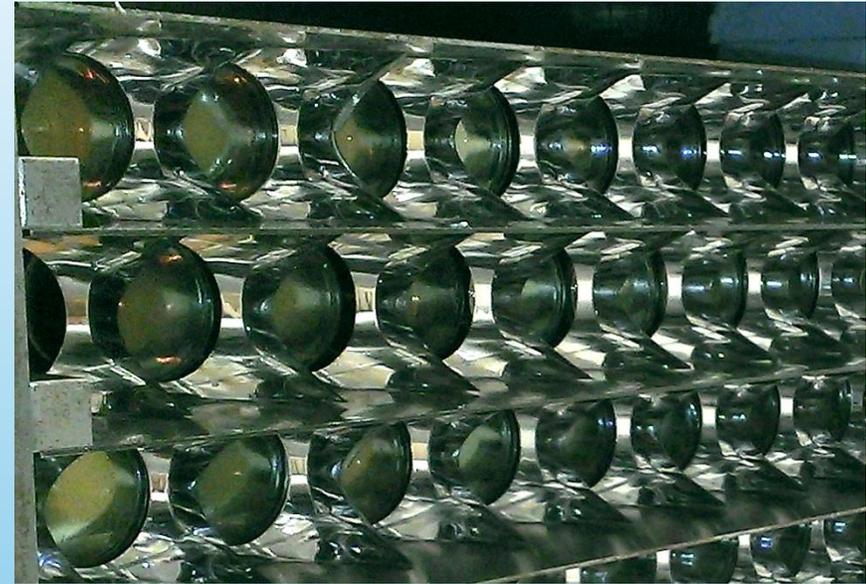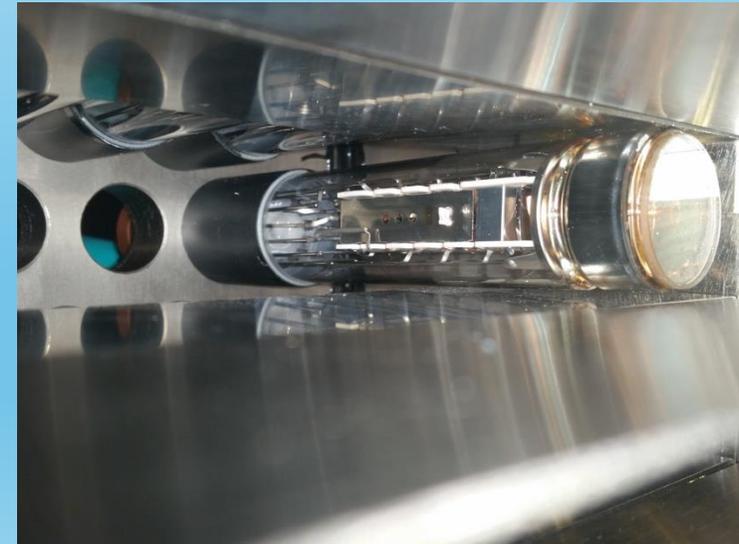
Front view of mirrors

Light catchers


Magnetic shielding

Overview of Sections, con't

Radiator Gas: C_4F_8 at atmospheric pressure, pion threshold 2.7 GeV

1. W&M studies of candidate gases – non-toxic, non-flammable, transparent in UV/VIS, large index, affordable

| Gas	C_4F_8	C_3F_8	CO_2
Atomic Mass (amu)	216	188	44
Vapor pressure at 20°C (bar)	2.7	7.7	58.5
Refractive index n ($\lambda = 405$ nm)	1.00132	1.00111	1.00046
Absorption (280 − 630 nm) (%/m)	5.8	~ 0	~ 0
N_γ/L for $\beta \sim 1$ (photons/m)	240	202	59
Cherenkov cone half-angle (deg)	2.94	2.70	1.74
p_t (MeV) for e^-	9.94	10.84	16.86
p_t (MeV) for π^-	2715	2961	4607

Measured at W&M
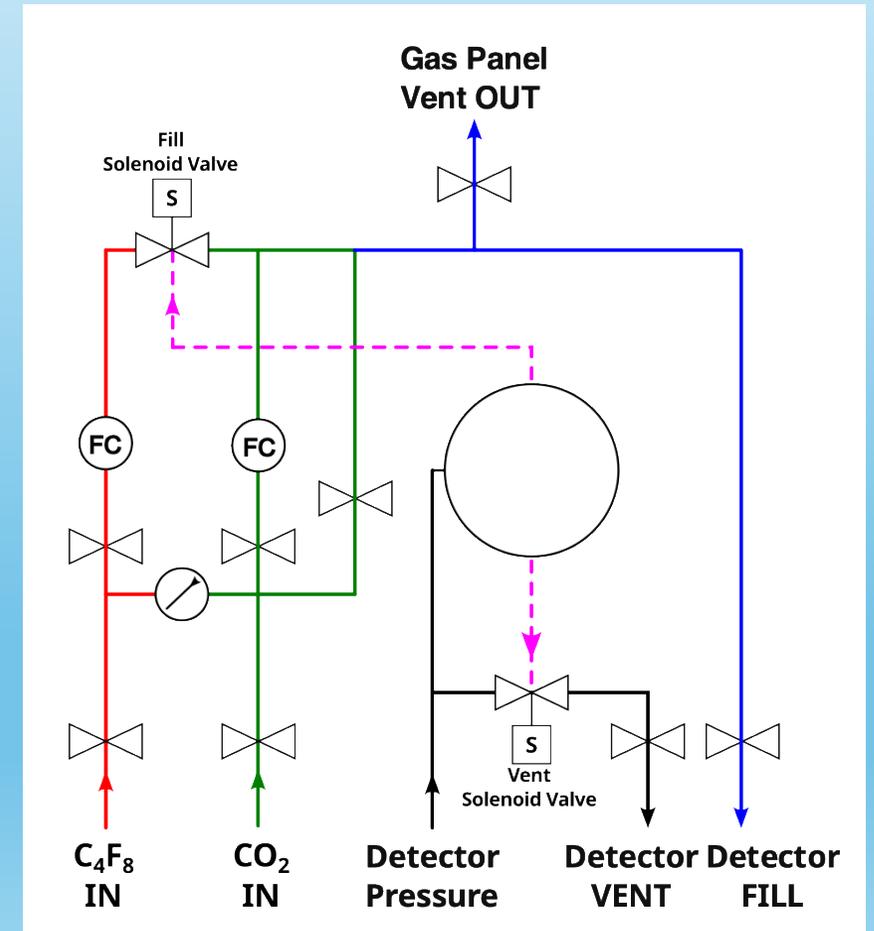
Overview of Sections, con't

- DAQ: Commissioned VETROC, NINO
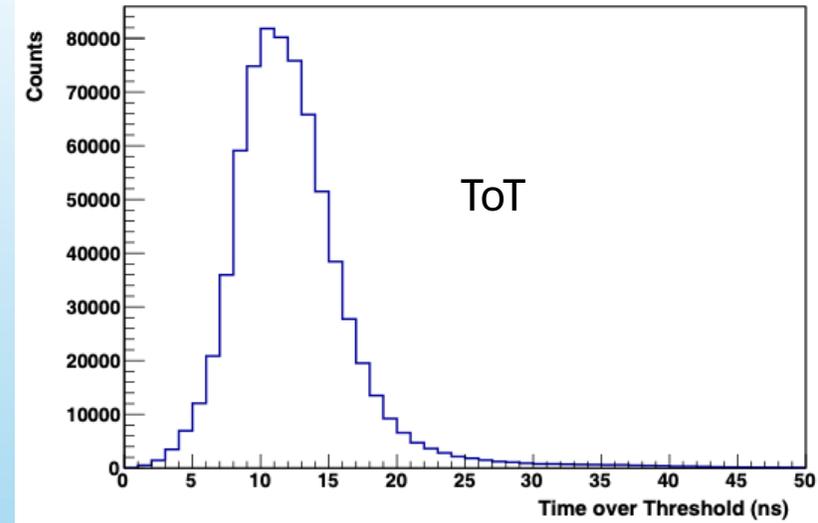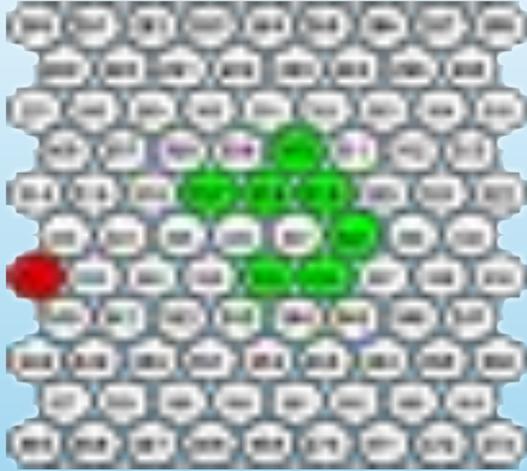 - Sparce in some sections
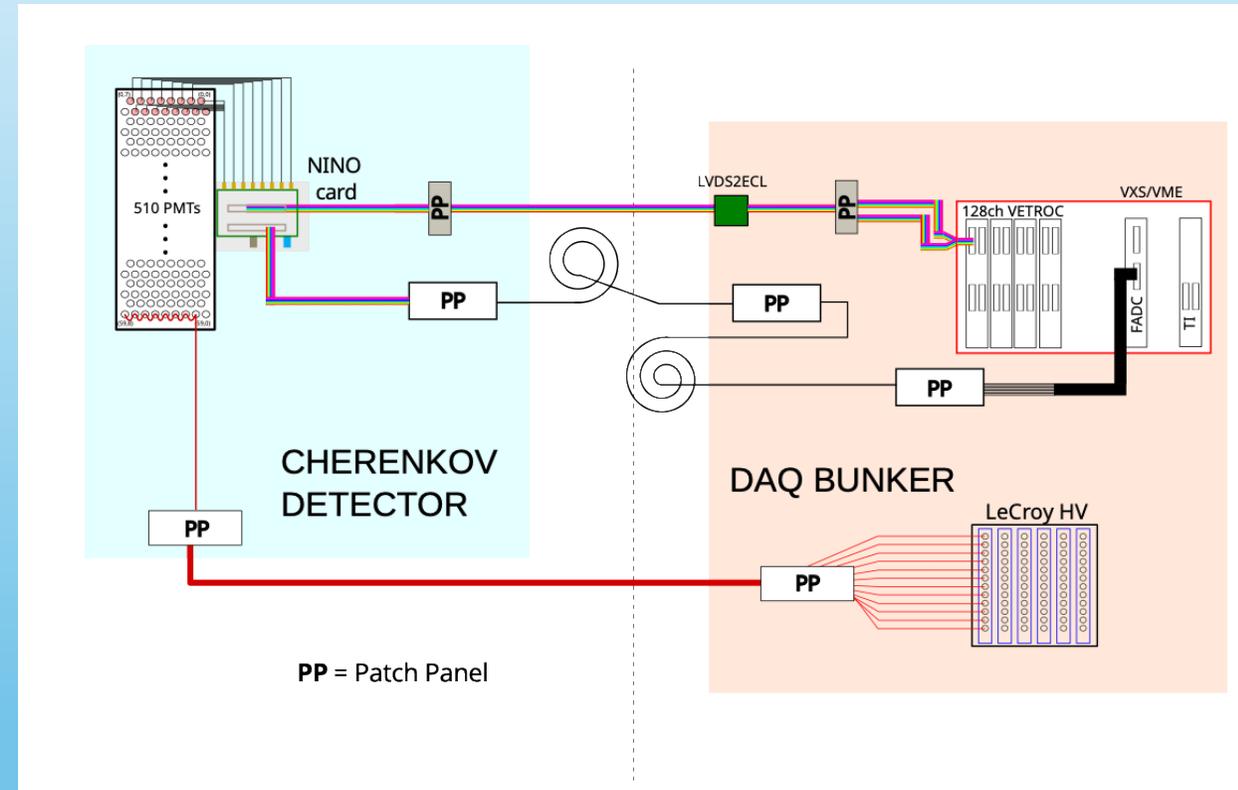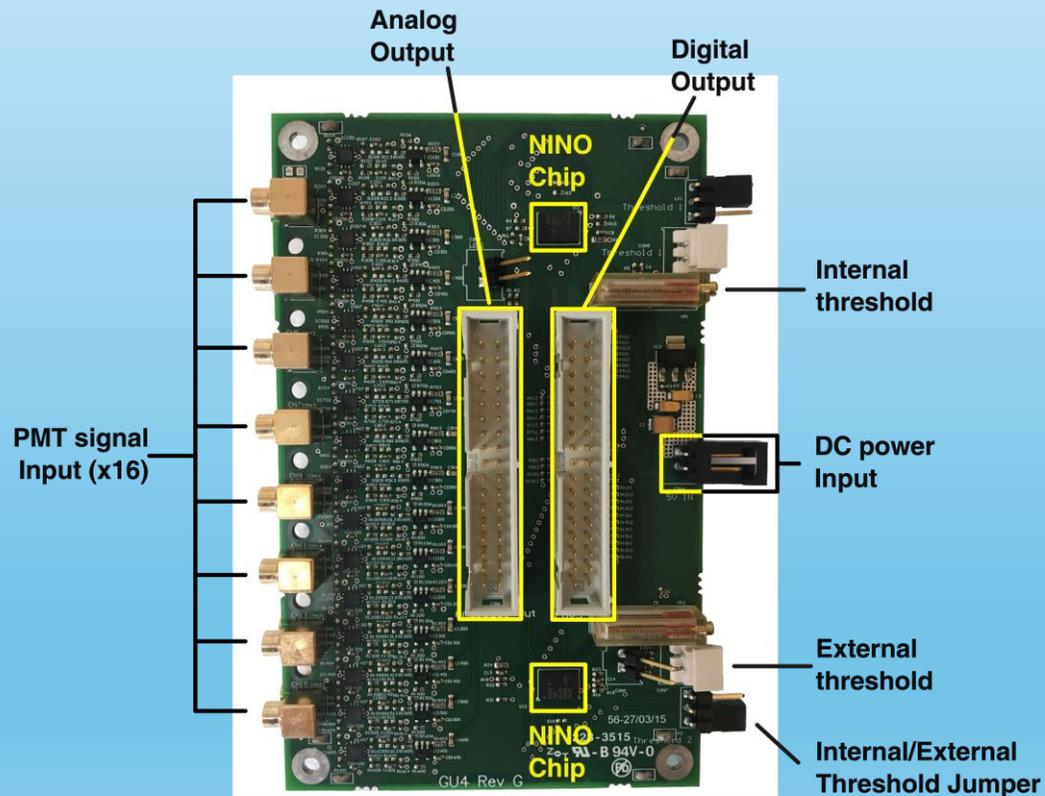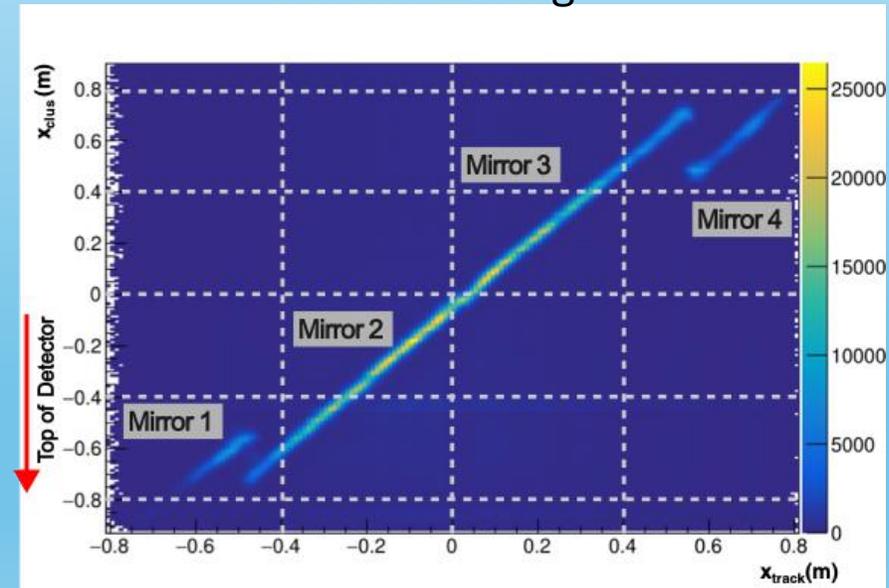
Overview of Sections, con't

- Simulation
  - Description needed
  - Pi/e ratio, # pe's, cluster size multiplicity, track matching, efficiencies
  - More results?
  - Clustering algorithm
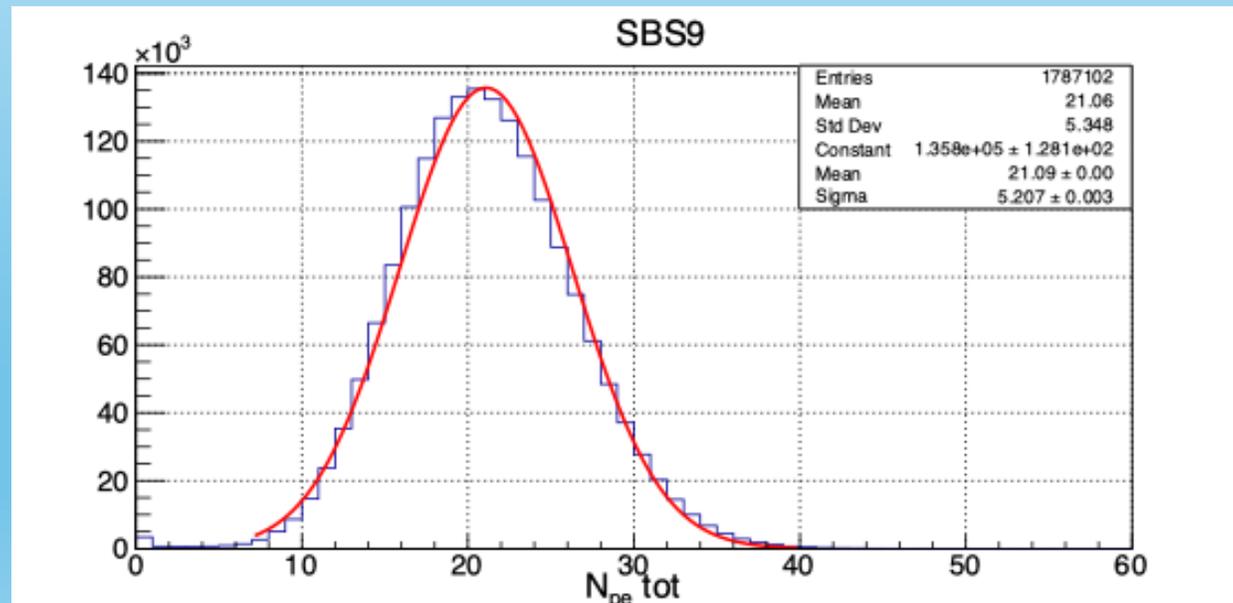
Performance: Maria's Analysis

ToT

Cluster size
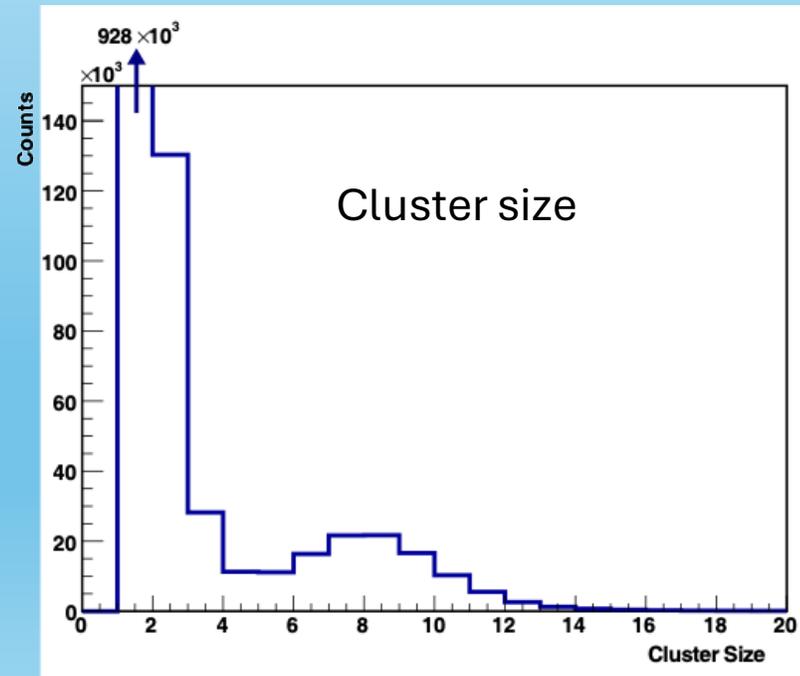
Track Matching

Note: single tube rate 600 kHz – 1 MHz

Money Plots
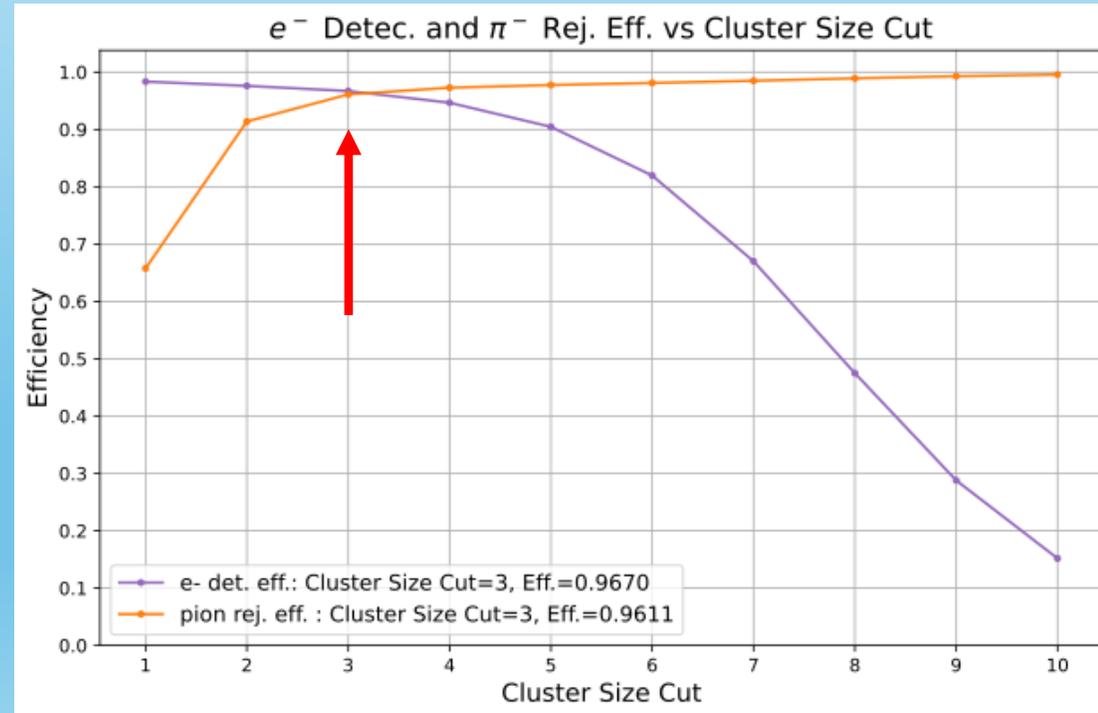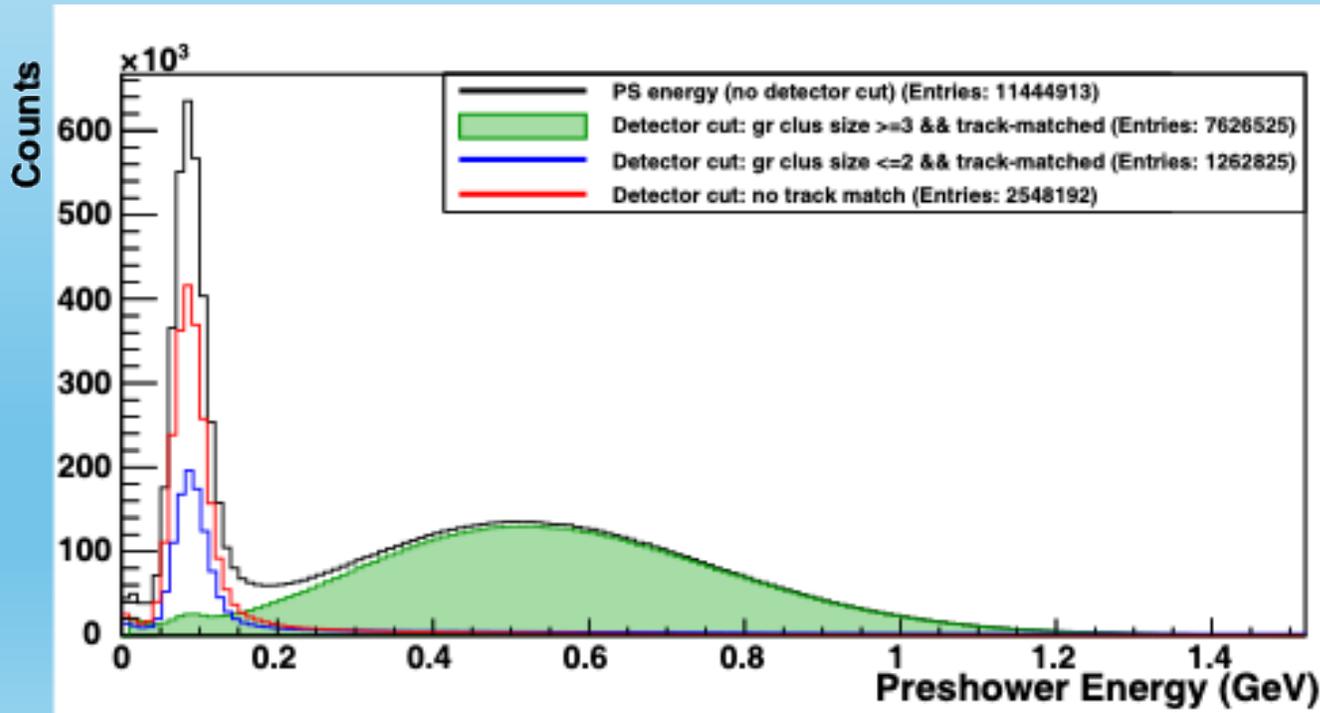
Design requirements:

Electron > 95% detection
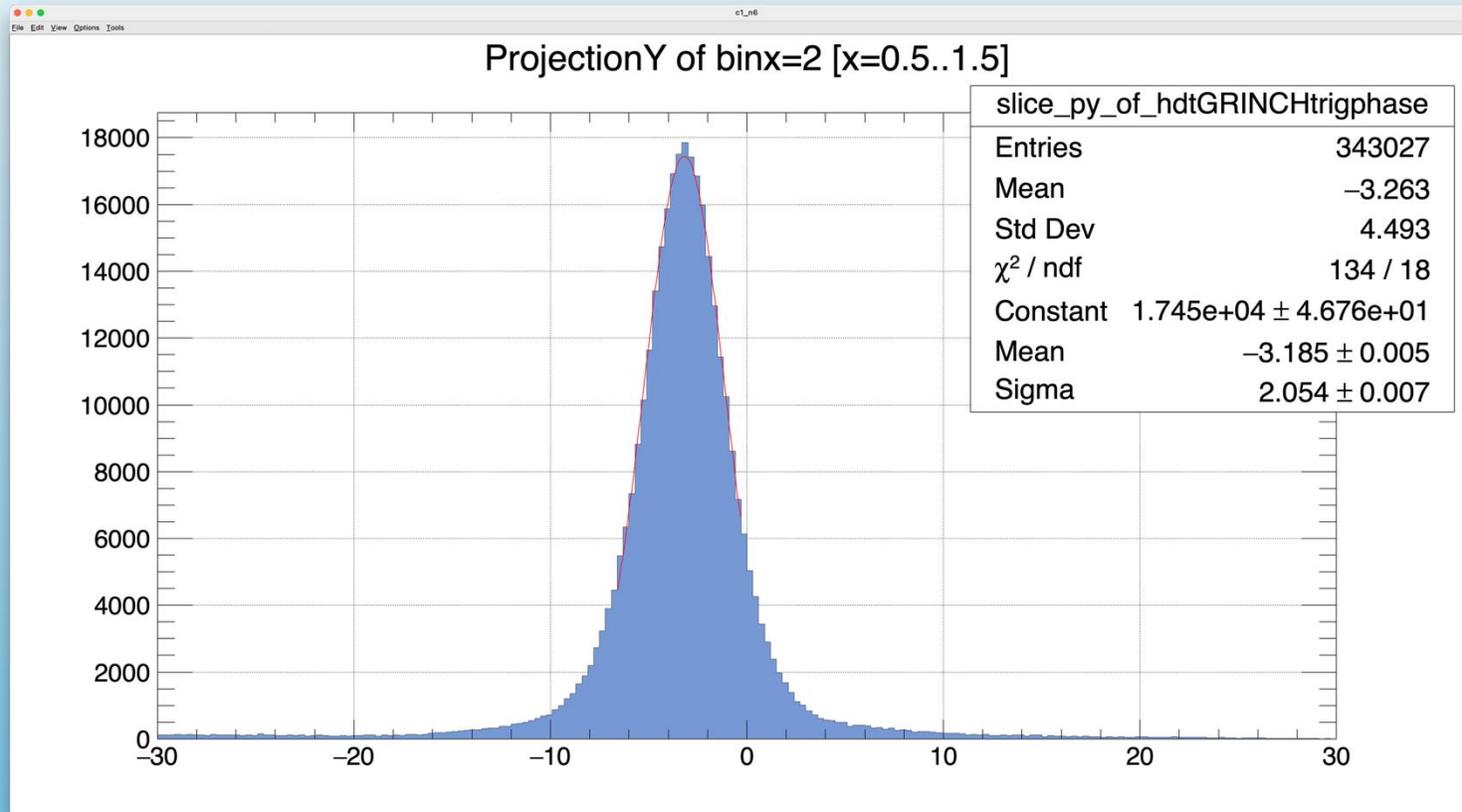Pion > 90% rejection

Maria's Analysis:

>= 3-tube cluster efficiencies:

Electron detection, 97%
Pion rejection, 96%

Upcoming improvement

- This shows the improved timing resolution from Andrew ~ 4x
  - Not used by Maria

- Need to re-make analysis plots using this information
  - Efficiency likely unchanged

To Do:

- Repeat analysis with improved timing - Andrew
  - Which parts?
    - Timing calibration
    - Number of tubes/per cluster
    - ToT
    - Track matching
    - Efficiencies vs. cluster size, timing window
      - Maria used +/- 30 ns

- Clustering description - Andrew

- Background rates - Todd
  - Scalers – not available for much of kinematics, DAQ threshold?
  - Out of time rates – From analysis, NINO threshold
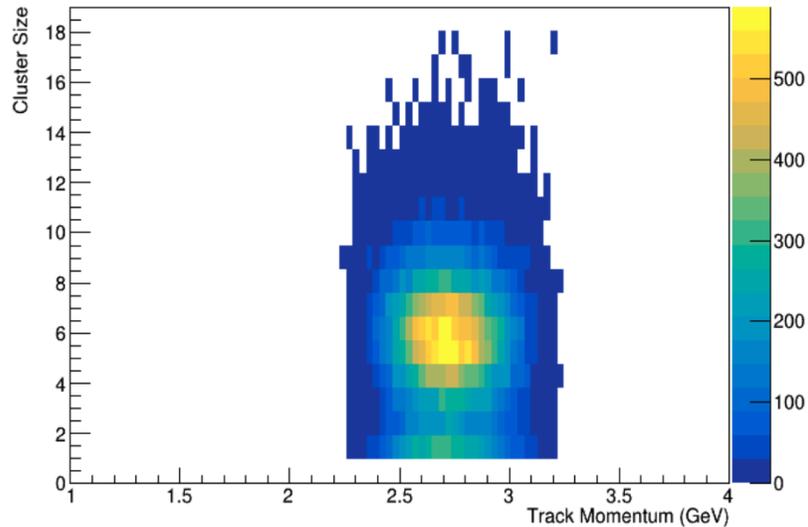 - VETROC – as a scaler ??

- Simulation - Eric/Andrew?
  - Description
  - Compare to final analysis plots
    - N_pe per cluster/tube
    - N_tubes per cluster

- DAQ - Alex
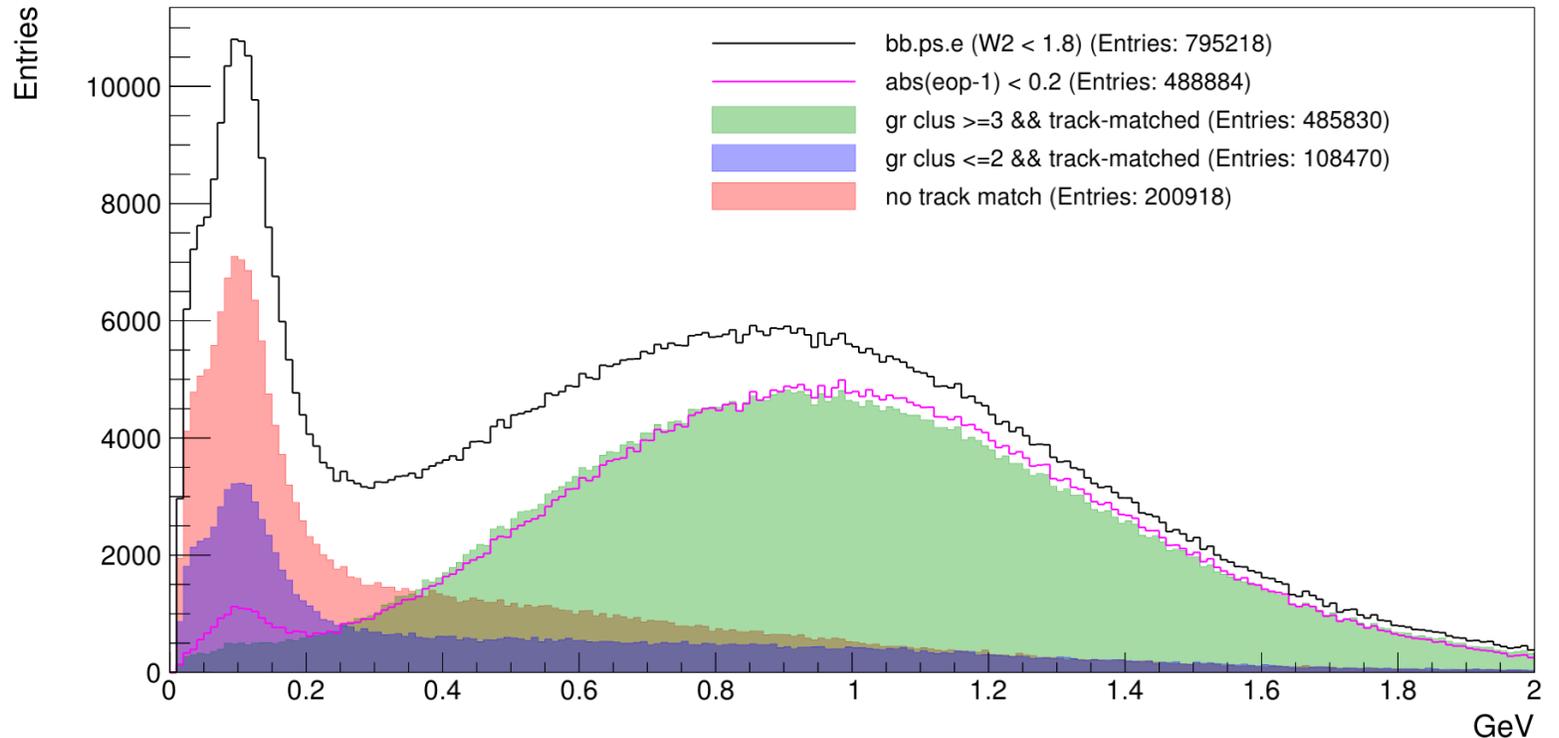 - More thorough description – Alex

Question

- Should we include an analysis from data with events above pion threshold?
- GEn Kin 3 where p_e = 2.2-3.2 GeV
- Results look similar (Jack Jackson's analysis)
- Calculate efficiencies after next pass analysis

Matching GEM Tracks

Kin3 Cluster Size vs. Track Momentum

PreShower Energy W2 < 1.8

bb.ps.e (W2 < 1.8) (Entries: 795218)
abs(eop-1) < 0.2 (Entries: 488884)
gr clus >=3 && track-matched (Entries: 485830)
gr clus <=2 && track-matched (Entries: 108470)
no track match (Entries: 200918)

Hope to finish this semester/summer

Author List: Let me know if you think you should be included

M. Satnik, A. Ahmidouch, B. Aljawarneh, J. Annand, T. Averett, C. Ayerbe,
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