APEX (A' EXperiment): *LHRS PID for optics optimisation purposes*

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General aims

- investigate general track cuts particularly for optics optimisation purpose

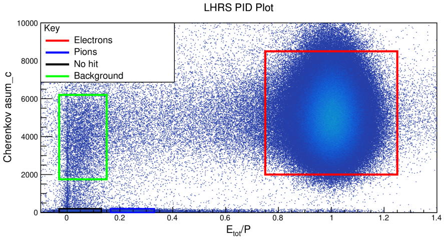
- to optimise PID cuts for Cherenkov and Calorimeters (PRLs) for LHRS optics specifically but also to prepare scripts for later PID optimisation

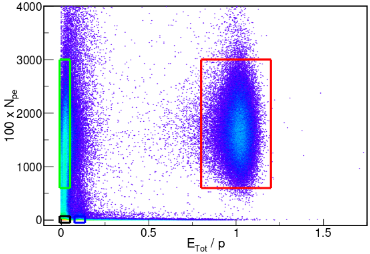
General track cuts

- Set of 'sanity' cut on track properties: number of VDC tracks, track theta(θ), phi(ϕ), beta ($\beta = v/c$), dp (δp)
- idea from Barak Schmookler thesis (GMP) tested where different kinds of events (electron, pion etc) have distinct distributions in these properties: cuts can reduce undesired background to electron ratio

General track cuts

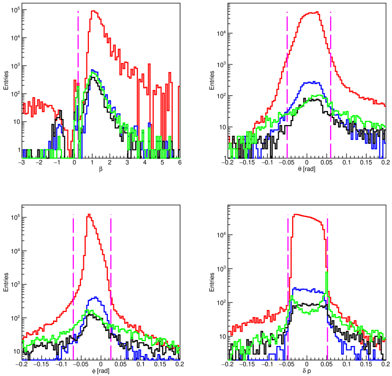
- To separate different types of events plot Cherenkov (Ch) sum against Total energy in Calorimeters (Cals) (for left-arm this is PRL1 + PRL2 energy (normalised to track momentum))
- Top plot from APEX, LHRS run 4179 (optics run with LHRS negative polarity), bottom plot from Barak Schmookler thesis
- Red area: electrons (strong sig in Cals and Ch), blue area: pions (weak Ch and $\sim$0 sig in Cal), black area: no signal in either, green area: background (strong Cher sig but $\sim$0 in Cals)



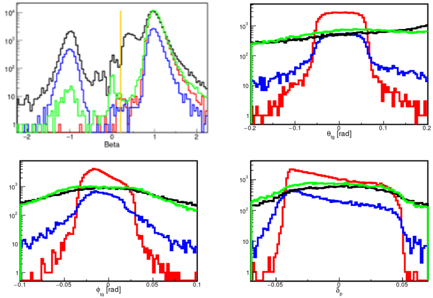


- Plot these different species of events against track properties...
- Red: electrons, Blue: pions, Black: no signal in both, Green: Cherenkov background

APEX

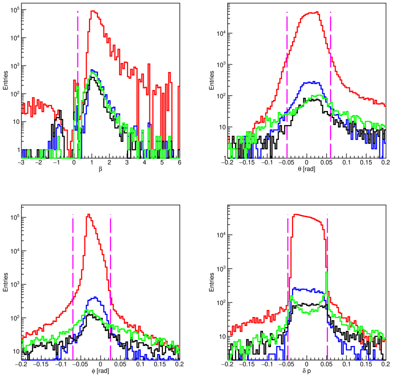


GMP (Barak Thesis)



- Pink lines for APEX indicate where cuts are placed
- $\beta > 0$, ensures forward tracks. Cuts on θ,ϕ and δp increase electron to bg ratio (and ensures sensible tracks)

APEX



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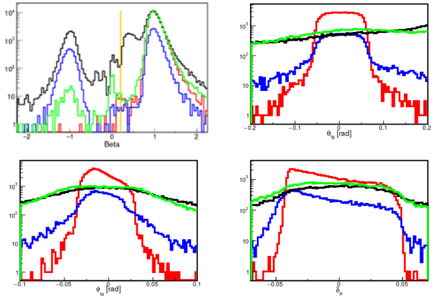
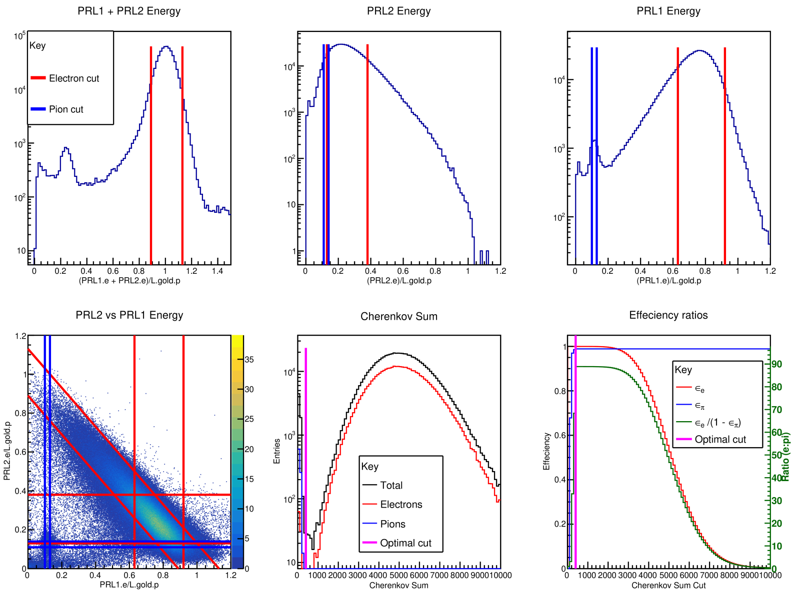


PID cut scans

- Basic idea: test efficiency of both PID detectors by taking 'clean' sample from one and seeing effects of varying PID cut on electron efficiency, ϵ_e, pion rejection efficiency, ϵ_π, of second detector and final e to π ratio: $= e_e/(1 - e_\pi)$
  - $\epsilon_e =$ ('good' electrons)/('good' electrons after PID cut)
  - $\epsilon_\pi =$ 1 - (initial pions)/(initial pions after PID cut)
- similar process used for initial APEX test run (Eric Jensen thesis [1], pages 74-76), Barak Schmookler thesis [2] (pages 140-153), various tritium elog notes including one from Hanjie Liu [3] and also a technote on the E08-027 experiment[4]

[1] Jensen Thesis
[2] Schmookler Thesis
[3] Liu elog note
[4] E08-027 technote

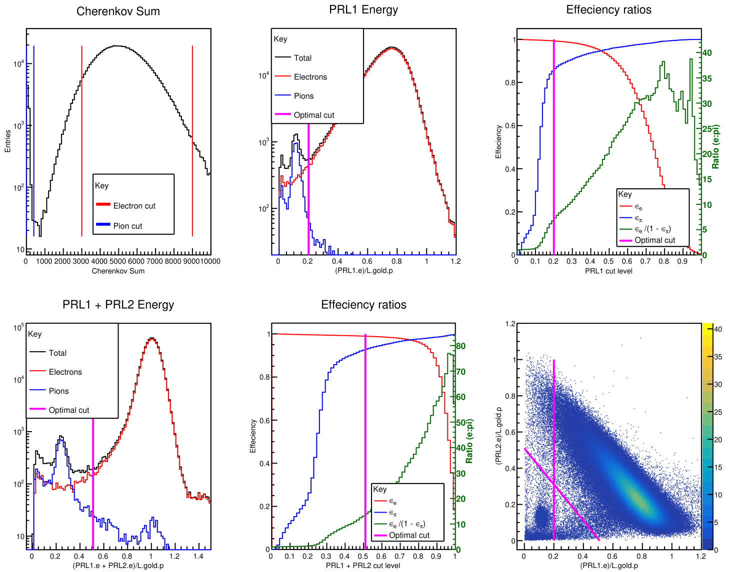
Cherenkov Efficiency



Cherenkov Efficiency

- first four plots show position of cuts from the PRLs to get sample of 'good' electrons and pions to test Cherenkov response (electron cuts are red, pion cuts are blue)
- Fifth plot shows the number of electrons, pions and the total count in the Cherenkov versus the total Cherenkov sum they produce in the detector. From this the sixth plot showing ϵ_e, ϵ_π and $e_e/(1-e_\pi)$ as a function of Cherenkov sum cut can be calculated
- Can be seen that Cherenkov provides a clean cut with a high ϵ_e and ϵ_π

Calorimeter Efficiency



Calorimeter Efficiency

- First plot shows cuts applied to the Cherenkov sum to obtain a sample of 'good' electrons and pions from the Cherenkov
- Second plots shown variation of electrons, pions and total count against the PRL1 energy (normalised to track momentum). Visible is a small peak (log scale) for pions at ~ 0.1 which shows the energy deposition value for real pions.
- The Fourth plot shows a similar histogram where electron, pion and total counts are plotted against the sum of PRL1 and PRL2 energies (normalised to track momentum). Again a peak can be seen for pions (at ~ 0.22).

Calorimeter Efficiency

- The third and fifth plot show the evolution of ϵ_e, ϵ_π and $e_e/(1 - e_\pi)$ as a function of the PRL1 cut and (PRL1 + PRL2) cut respectively.
- As can be seen the calculated $e_e/(1 - e_\pi)$ for both seems to peak at large values of cuts. This is because some of the pion sample selected from the Cherenkov are actually of a different species. In the fifth plot an electron peak at 1 can be seen for the pions (can be explained by one particle leaving small signal in Cherenkov whilst accidental, coincident electron leaves large PRL signals within the trigger window), this contamination results in some 'pions' surviving larger cuts and increases $e_e/(1 - e_\pi)$ at larger values of cut.
- cuts were then chosen visually (as they have been in the other analyses mentioned on slide 6) but for future a peak and background could be fitted to the pion sample to extract true pions and then used to calculate the optimum cut values.

Final cuts

- Final cuts used are:
  - track cuts: $L.tr.n == 1$ && $L.gold.beta > 0.2$ && $L.gold.th > -0.05$ && $L.gold.th < 0.06$ && $L.gold.ph > -0.07$ && $L.gold.ph < 0.025$ && $L.gold.dp > -0.048$ && $L.gold.dp < 0.05$
  - PID cuts: $(L.prl1.e/(L.gold.p * 1000)) > 0.2$ && $((L.prl2.e + L.prl1.e)/(L.gold.p * 1000)) > 0.51$ && $L.cer.asum\_c > 400.0$
- where L.gold is the analyzer determined 'golden track' for each event.

Scripts Used

- Scripts used are in the PID directory (which is in the Calibrations directory) of the APEX offline github repository: `https://github.com/JeffersonLab/HallA-APEX-Offline`
- repository also contains scripts used to calibrate both arm Cherenkovs and Calorimeters (necessary step before PID analysis)