Cut-based Beam Selection

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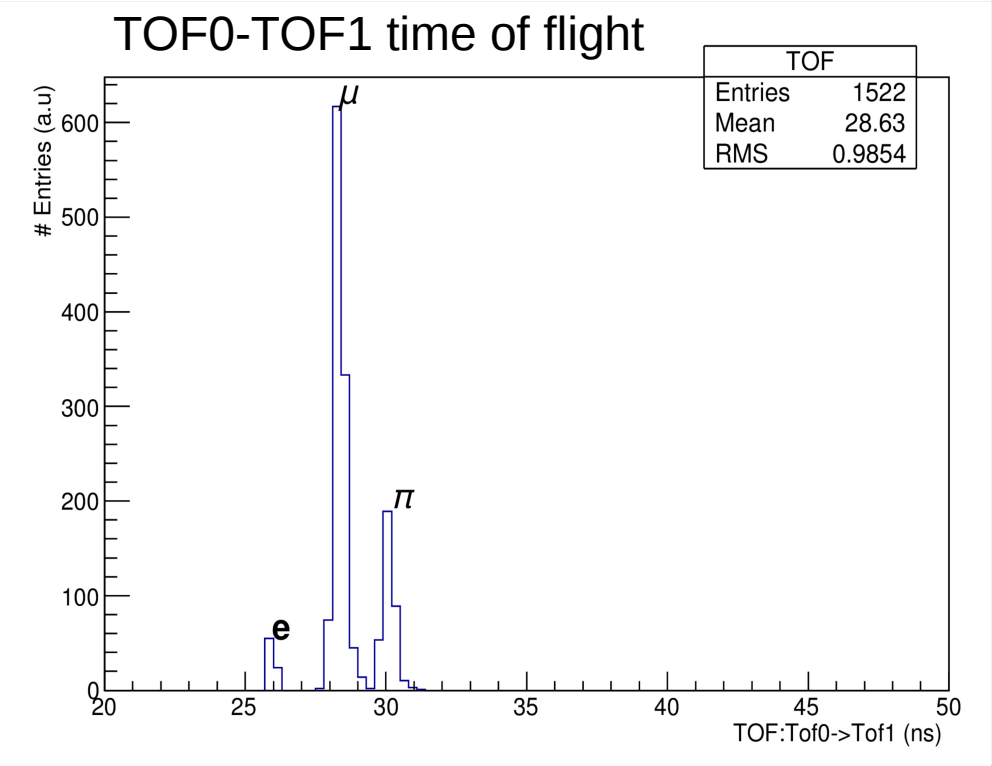
Motivation and Process

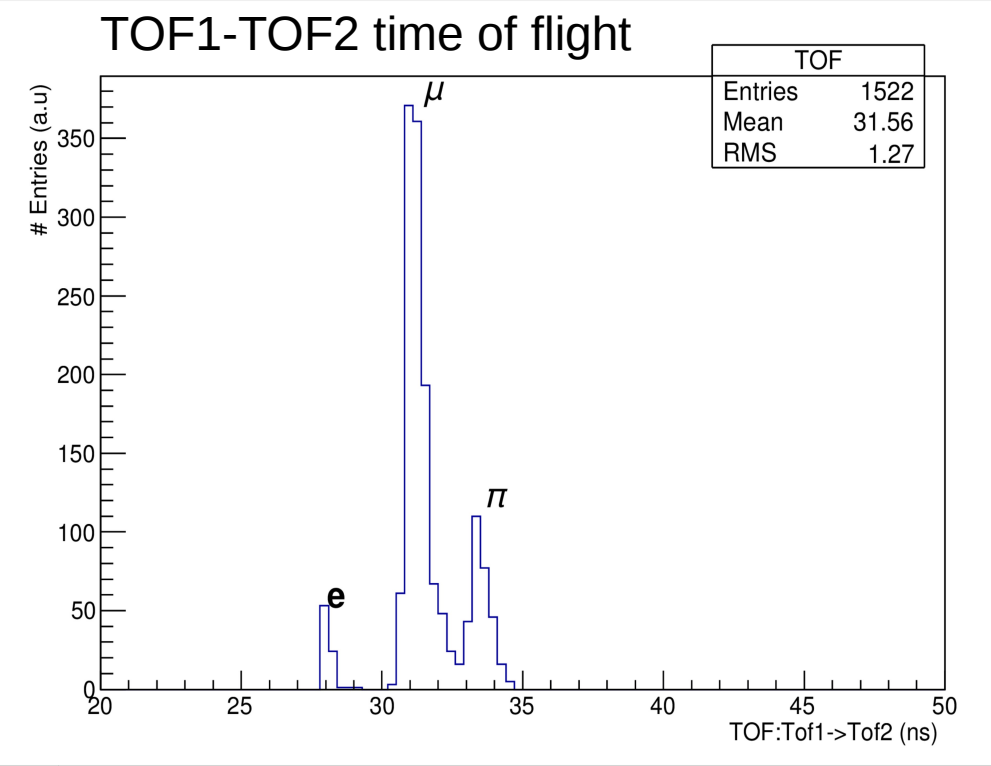
- Recognize and reject pions and electrons in MICE muon beam.
- Evaluate and validate the performance of PID detectors and their corresponding PID variables.
- Analyzed the “official” GRID-reconstructed data.
- A subset of the data presented here: runs 7475, 7290, and 7469.
- Analysis is preliminary and on-going.

Run 7475 – Run Conditions and Cuts

- Run 7475:
  - User cycle 02; October 7 run.
  - (3,200) pion reference run without DS.
  - SSU at full current; no current in SSD.
  - TOF1 trigger with 2102 spills.
  - P_{target} = 300 MeV/c
  - P_{D1} = 268.7 MeV/c
  - P_{D2} = 266 MeV/c.
- Single spacepoint cuts on all TOFs.
- ~10% of events report multiple ADC products in KL.
- CkovA and CkovB report NPEs for below-threshold particles.
- ~23% of the EMR events not reconstructed.

Run 7475 - TOF

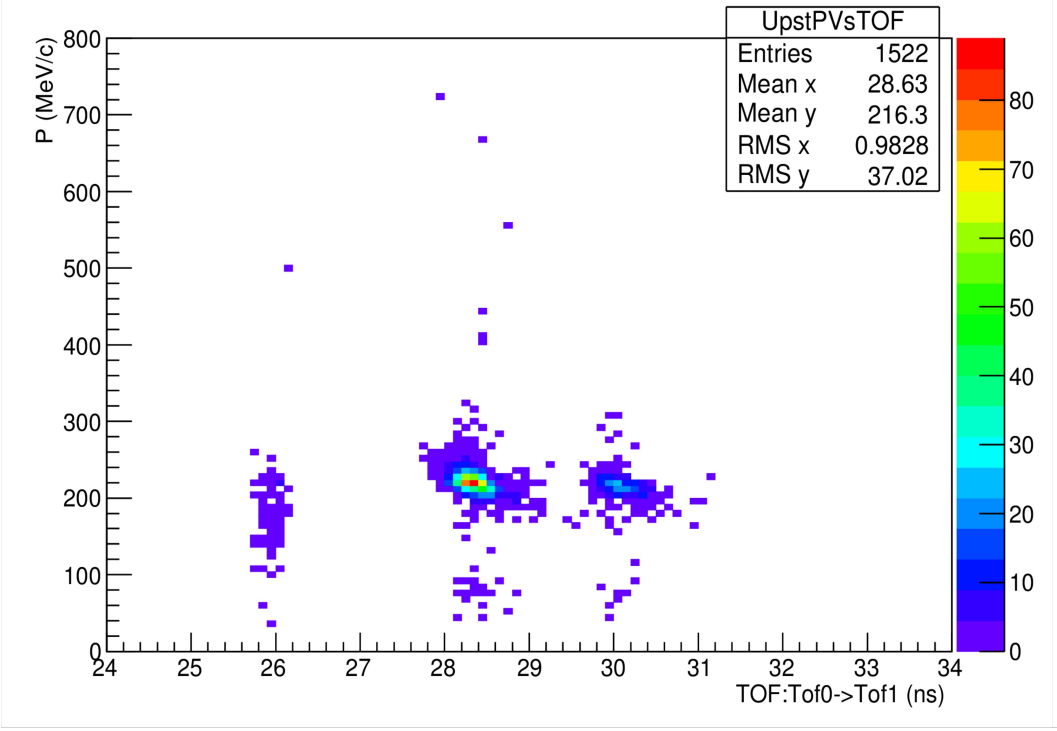




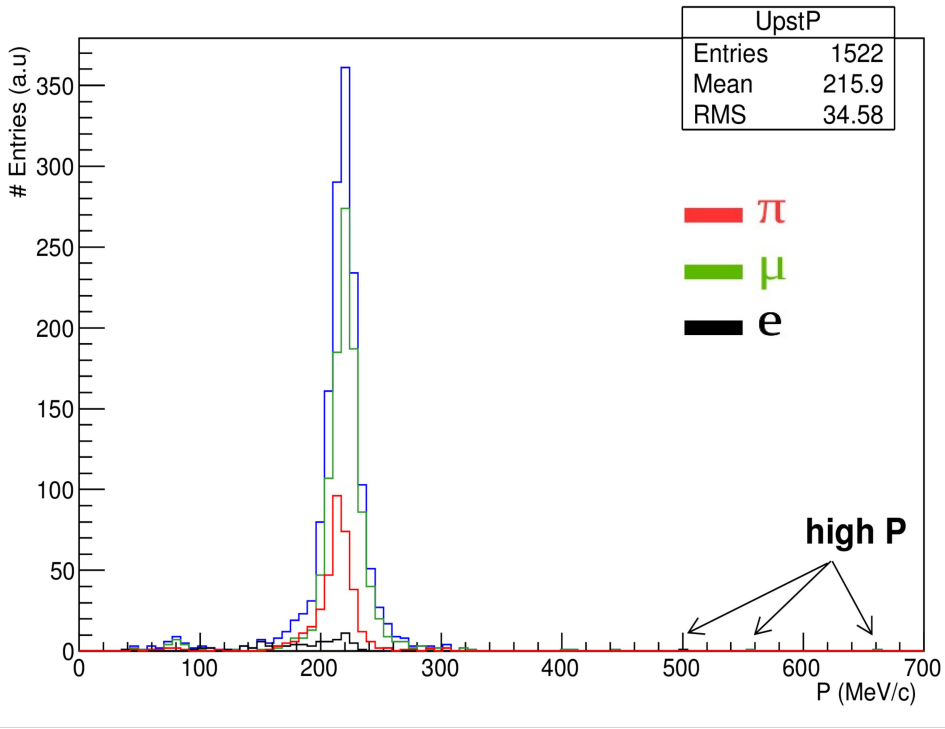
- Clean electron, muon and pion peaks.
- TOF1 and TOF2 further apart (than TOF0 to TOF1) by ~580 mm.
- Used TOF0-1 as reference in other PID plots.
- Discarded the ~23% of particles with improperly reconstructed EMR variables, here and on the subsequent plots.
- KL cuts not implemented until the KL plots.

Run 7475 – P vs. TOF

Upstream momentum vs. TOF0-TOF1 time of flight



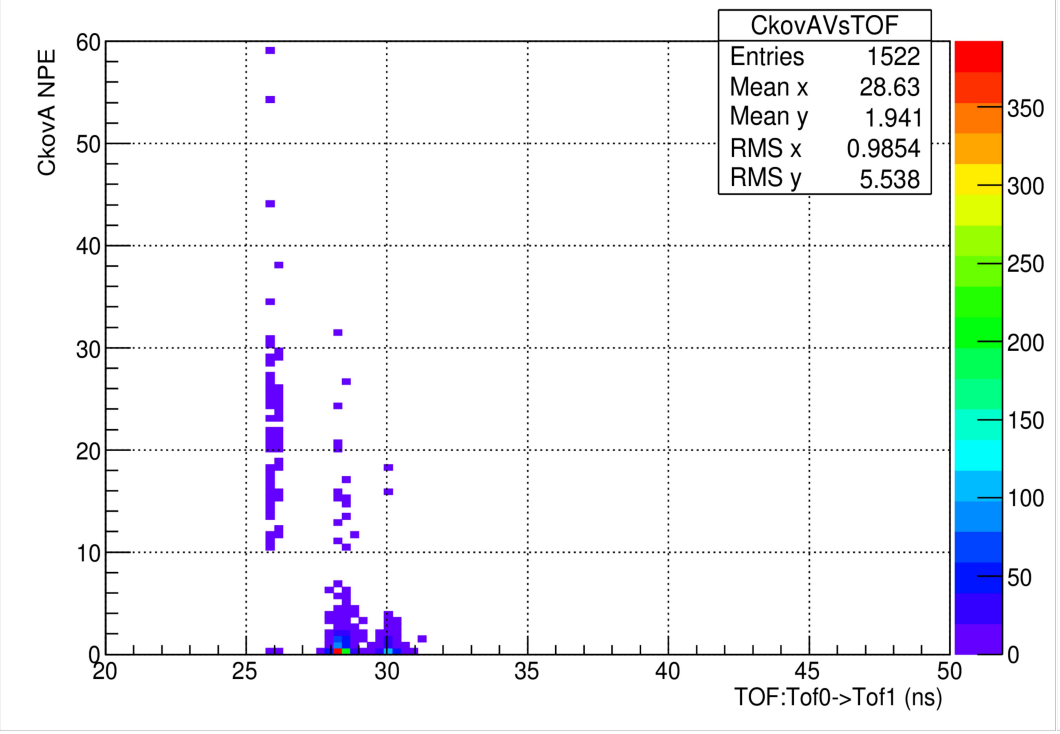
Upstream momentum



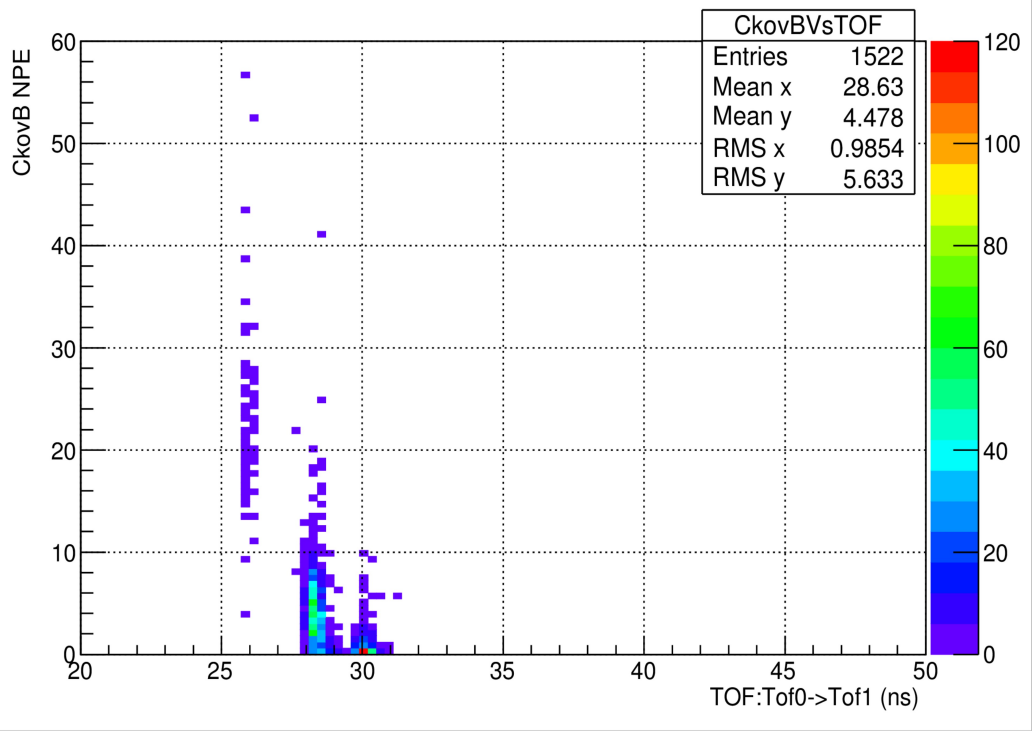
- P as reconstructed in upstream tracker.
- ~1% of events with P > 300 MeV/c.
- ~2% of events with P < 100 MeV/c
- P distribution selection on the right obtained from applying cut on TOF0-1 time of flight info of each particle.
- Indistinguishable range of momenta for electrons, muons, and pions.

Run 7475 – Ckov NPE vs. TOF

CkovA number of photoelectrons vs. TOF0-TOF1



CkovB number of photoelectrons vs. TOF0-TOF1



- Muons → trigger more signal in CkovB than CkovA

– expected to be below threshold in CkovA.

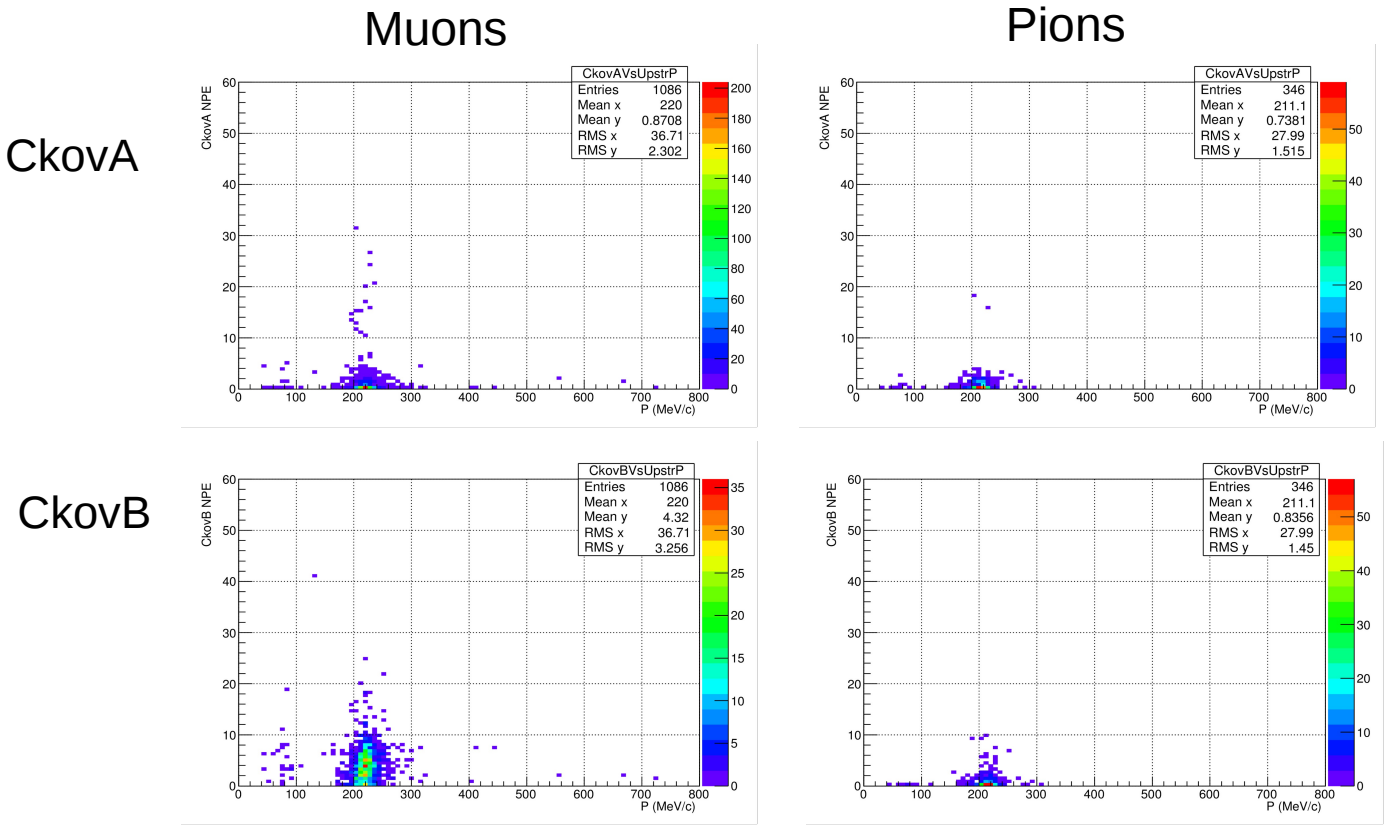
- Pions → same response in both counters

– expected to be below threshold in both Ckov counters.

- Electrons → trigger signal in both Ckov counters

– expected.

Run 7475 – Ckov NPE vs. P

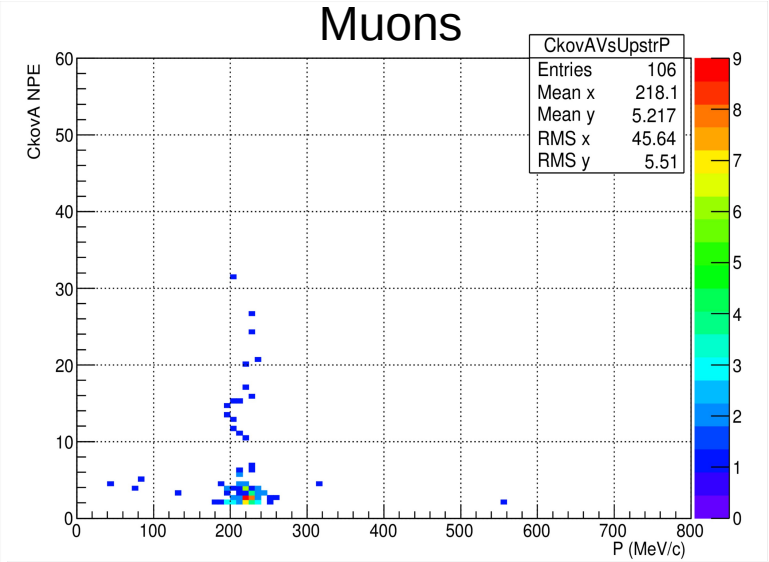


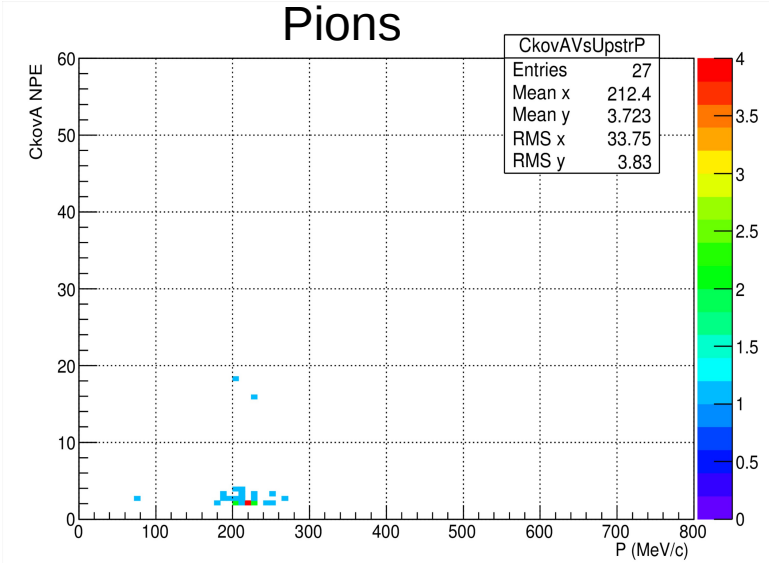
- Muons and pions at below-threshold momenta trigger signal in Ckov counters due to delta-ray electrons (shown above). Muons and pios isolated using TOF0-1 info.
- Types of cuts for vetoing the background delta-ray:
  - Muons: P > 217.9 & 280.5 MeV/c in CkovA & CkovB. Pions: P > 285.8 & 367.9 MeV/c in CkovA & CkovB → on-going investigation by A. Liu and no P cuts yet applied, as result.
  - NPE > 2 & > 10 in CkovA & CkovB for muons and pions (according to Note 473). *Next Page.*

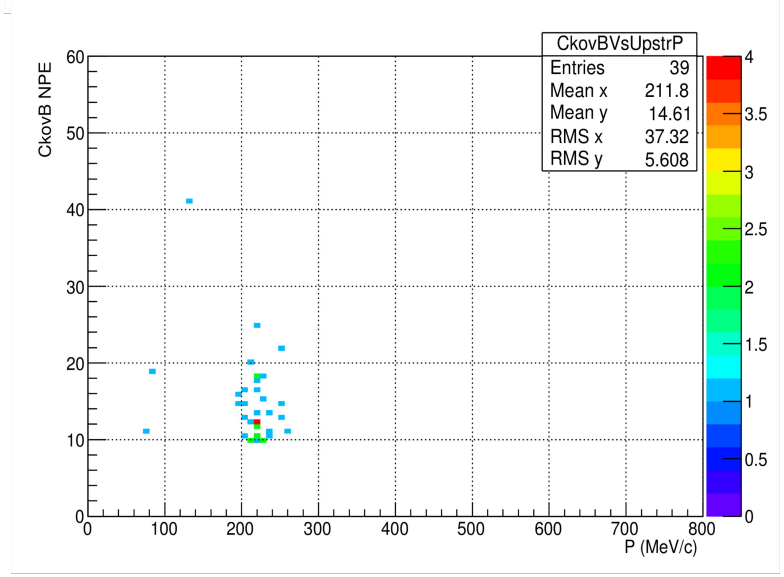
Run 7475 – Ckov NPE vs. P (cont.)

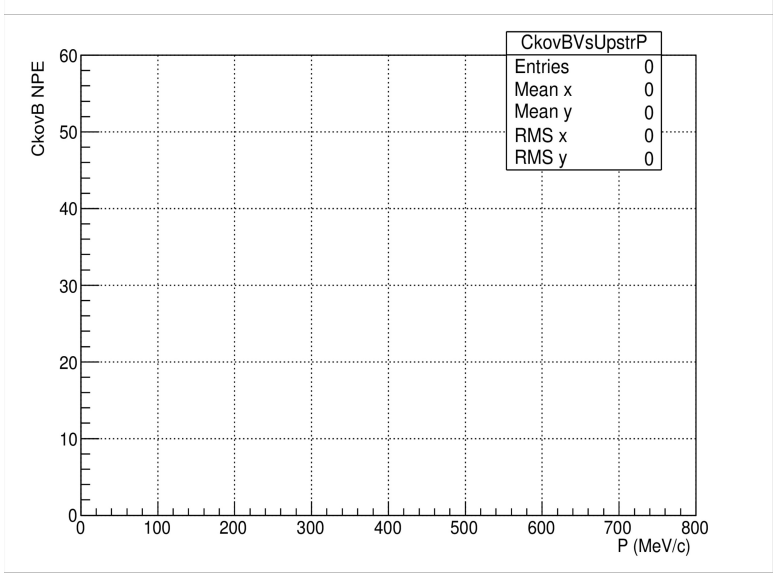
CkovA

CkovB









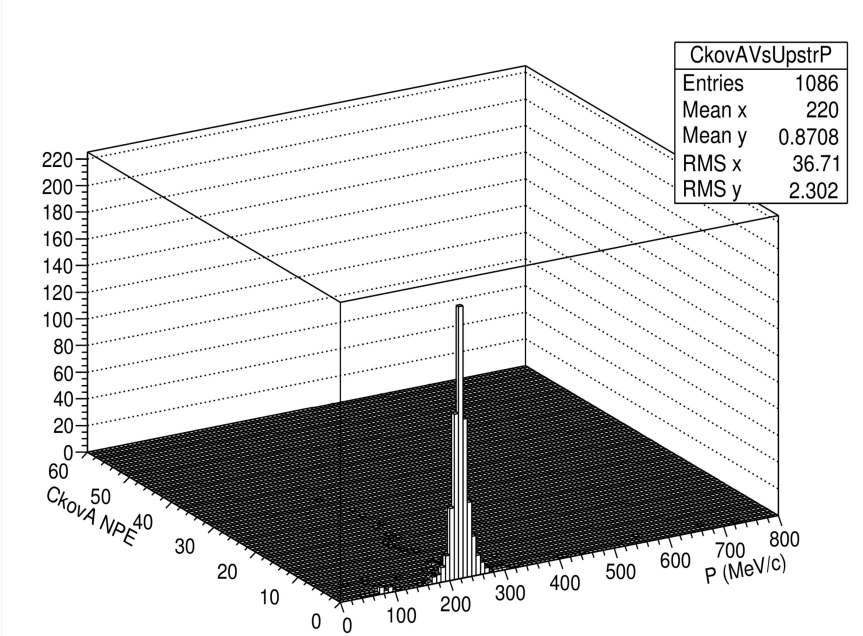
- Some below threshold muons and pions remaining in signal.
- No pions remain in CkovB after the NPE cut.

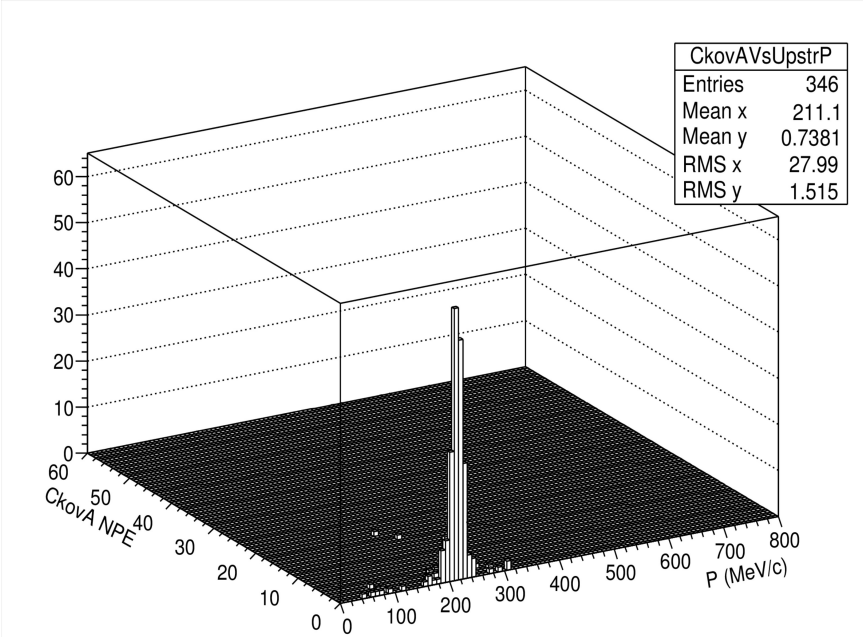
Run 7475 – Ckov NPE vs. P (lego plots)

Muons

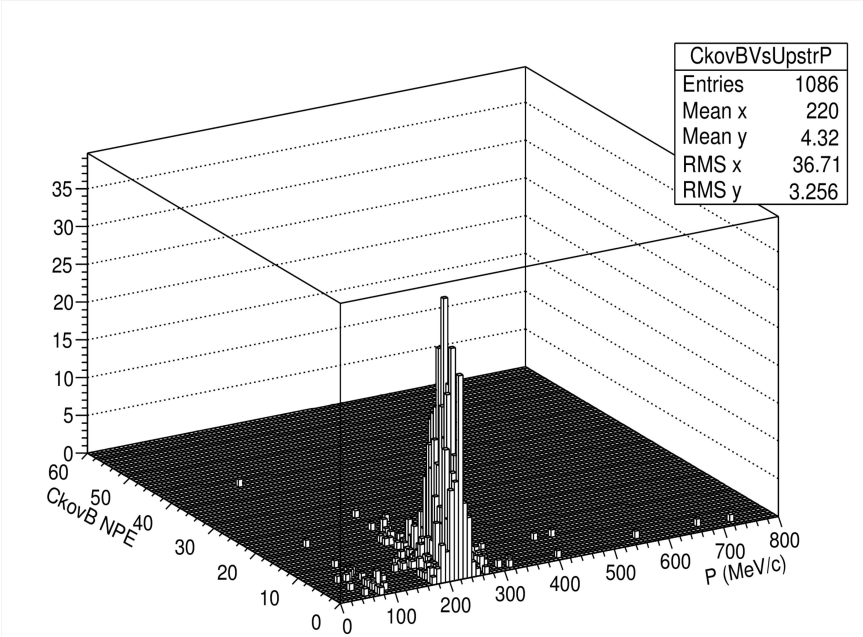
Pions

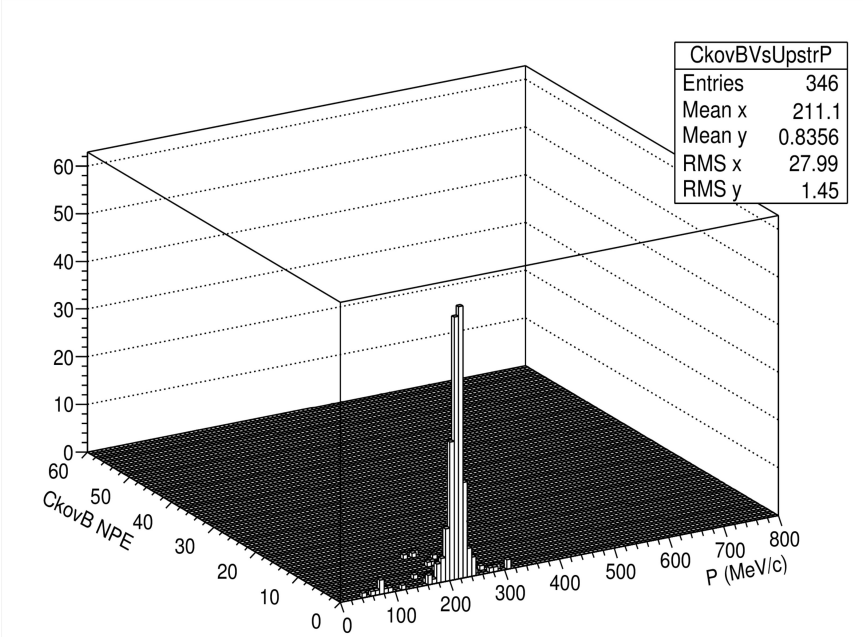
CkovA





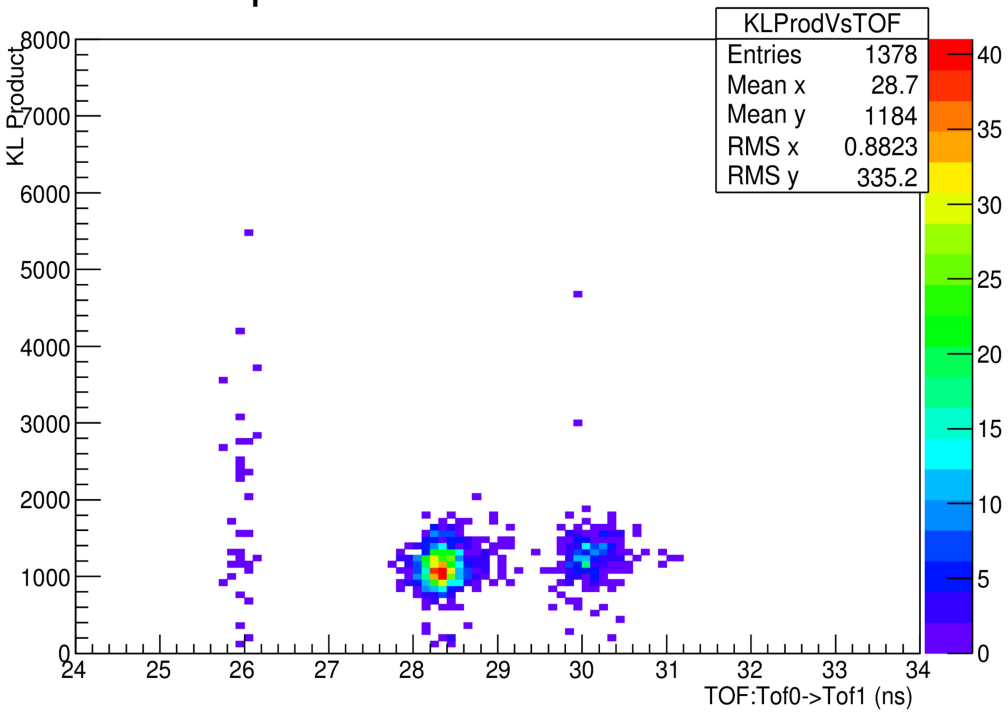
CkovB



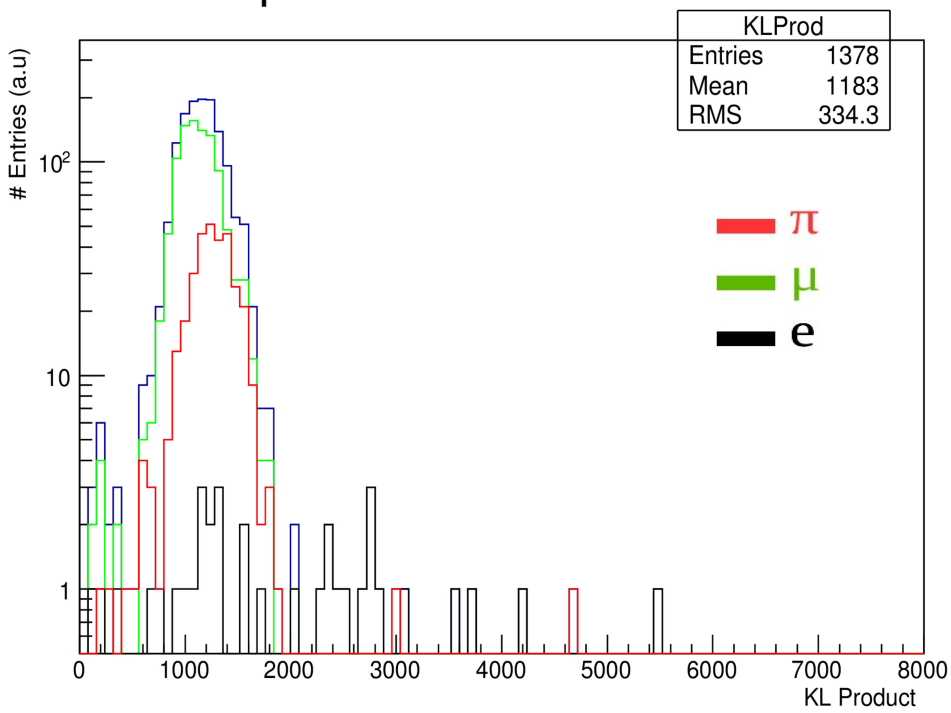


Run 7475 – KL vs. TOF

KL ADC product vs. TOF0-TOF1



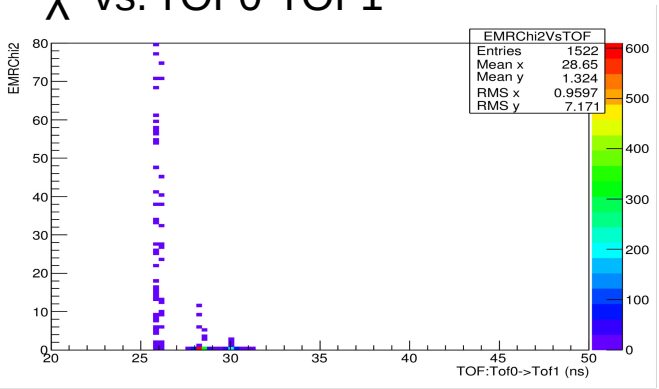
KL ADC product



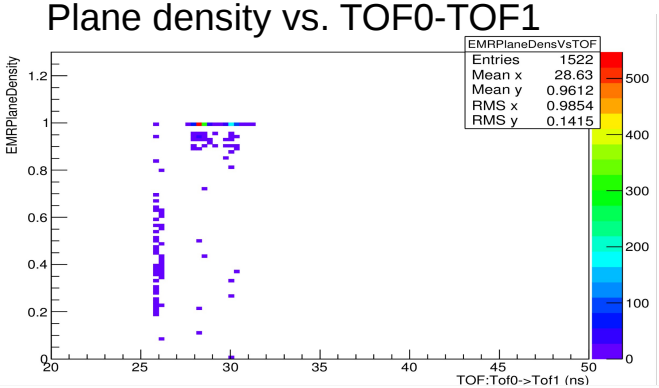
- ~10% of events tend to repeat in the KL sample, each time with a different KL ADC product value → they are rejected from the above plots. EMR cuts still applied.
- KL ADC product spectrum (right plot) → spread-out for electrons and well-defined for muons.
- KL response for pions with longer tail compared to muon peak due to hadronic interactions.

Run 7475 – EMR vs. TOF

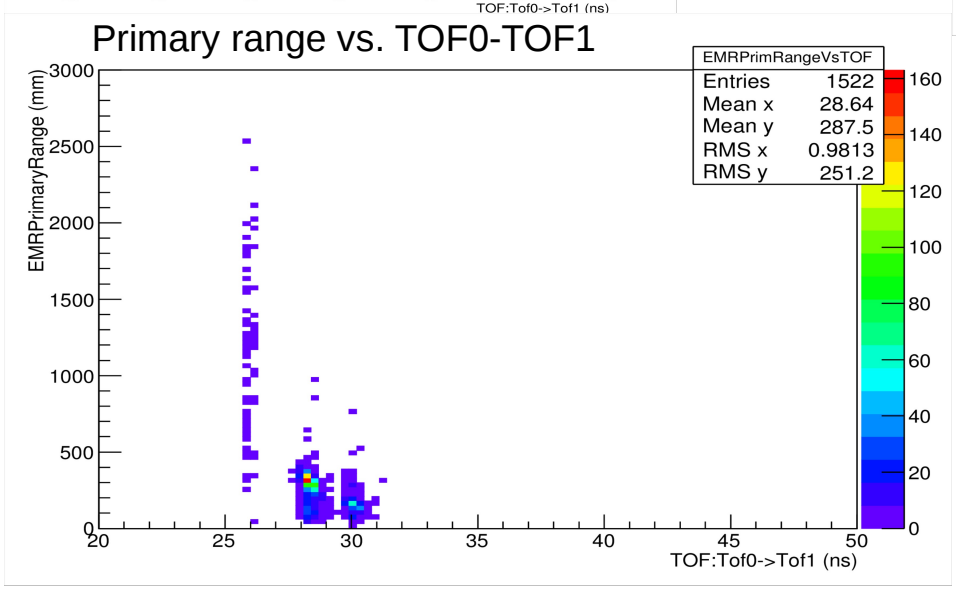
χ^2 vs. TOF0-TOF1



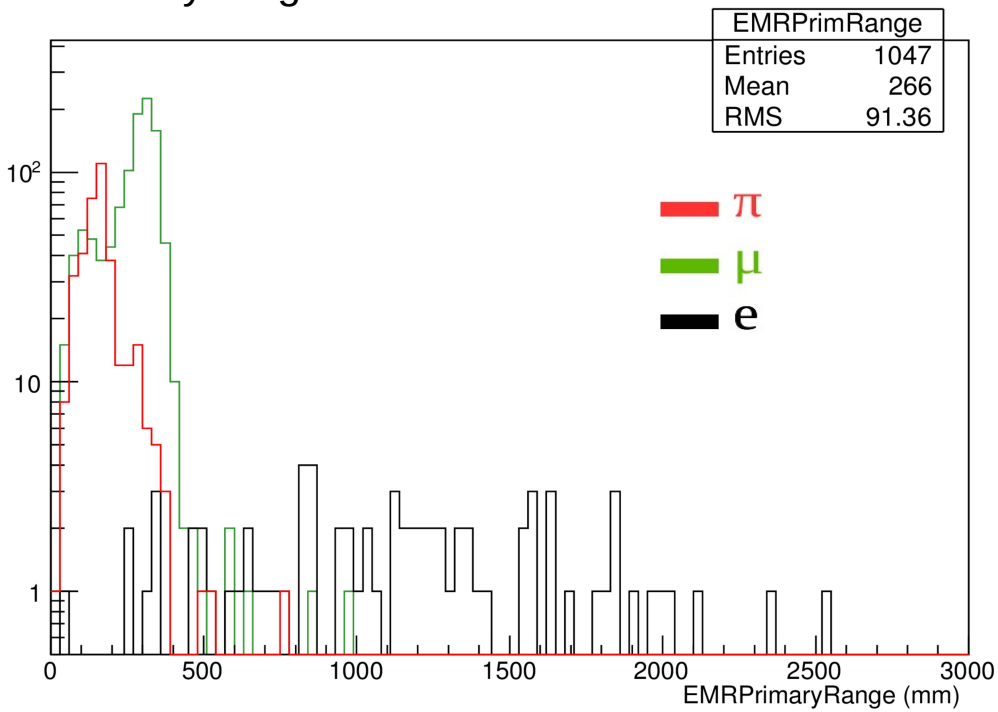
Plane density vs. TOF0-TOF1



Primary range vs. TOF0-TOF1



Primary range



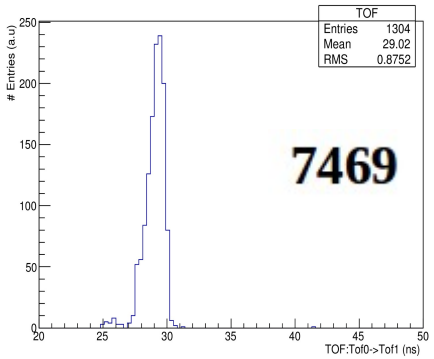
- χ^2 small for muons and large for electrons.
- Plane density ~1 for muons and < 1 for electrons.
- Range for muons well-defiled and for electrons more spread-out.

Run 7469 – Run Conditions and Cuts

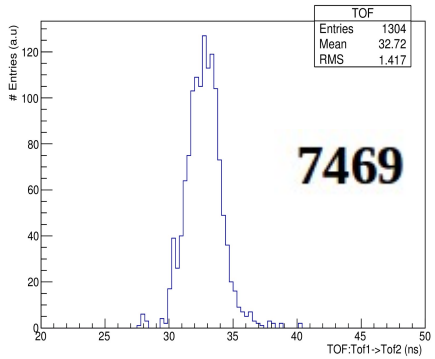
- Run 7469:
  - User cycle 02; October 7 run.
  - (3,140) muon run with DS.
  - SSU at full current; no current in SSD.
  - TOF1 trigger with 3214 spills.
  - P_{target} = 409 MeV/c
  - P_{D1} = 335 MeV/c
  - P_{D2} = 195 MeV/c
- Single spacepoint cuts on all TOFs.
- An unidentified sample of particles between electron and muon peaks in TOF0-1.
- CkovA and CkovB report NPEs for below-threshold particles.
- Cross checked with **run 7290** from user cycle 01 – (6,140) muon run taken on July 24 with 6130 pulses and P_{target}, P_{D1}, and P_{D2} respectively at 327, 324, 189 MeV/c.

Run 7469 vs. 7290 - TOF

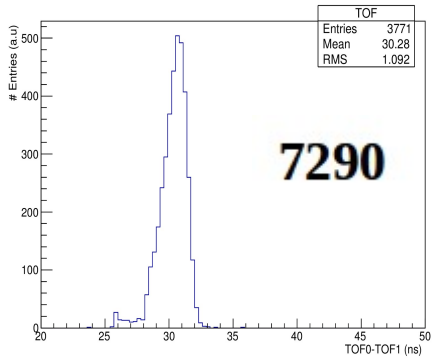
TOF0-TOF1 time of flight



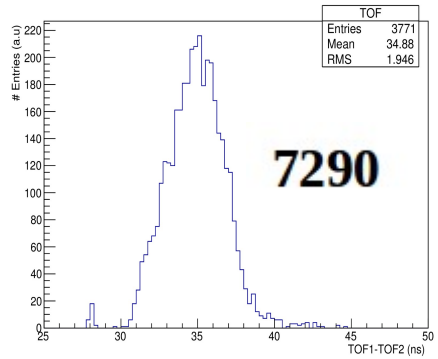
TOF1-TOF2 time of flight



TOF0-TOF1 time of flight

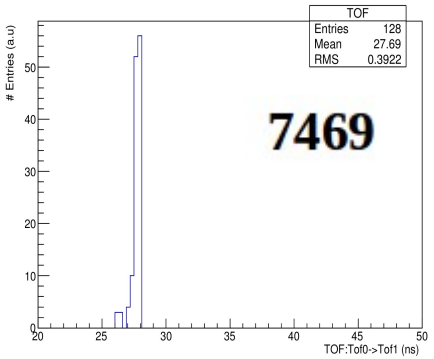


TOF1-TOF2 time of flight

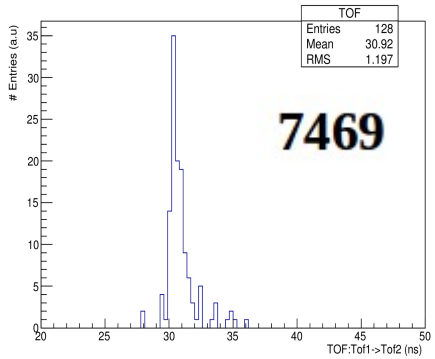


- A broad distribution of particles (~3% of total events in 7290 and 9% of total events in 7469) appearing between electron and muon peaks in TOF0-1 but disappearing from the same region in TOF1-2.
- For 7290, hypothesized as high-P pions → if the case, more triggers in TOF0 outer slabs expected → partly confirmed by S. Wilbur.
- Isolated these particles using TOF0-1 info. Shown below for 7290, they seem to join the muon peak in TOF1-2.

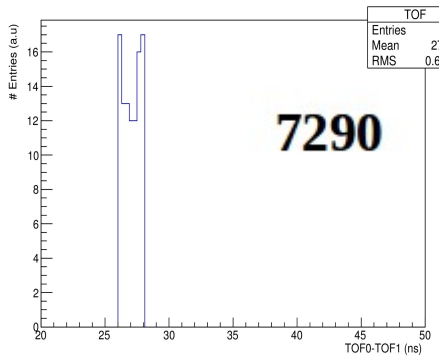
TOF0-TOF1 time of flight



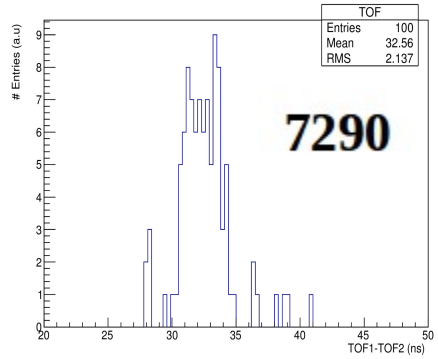
TOF1-TOF2 time of flight



TOF0-TOF1 time of flight

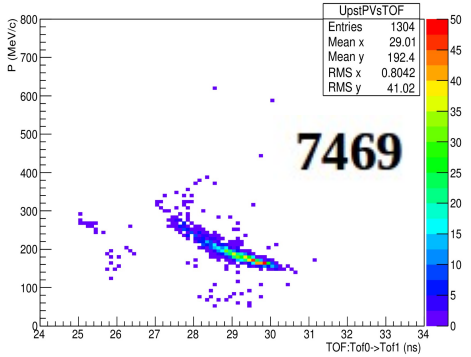


TOF1-TOF2 time of flight

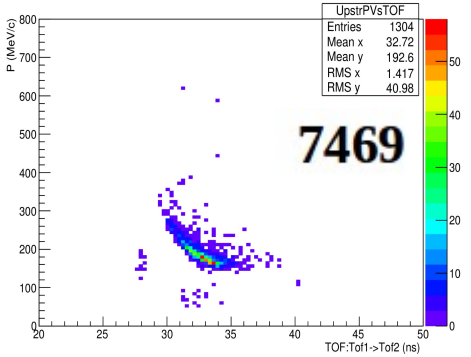


Run 7496 vs. 7290 – P vs. TOF

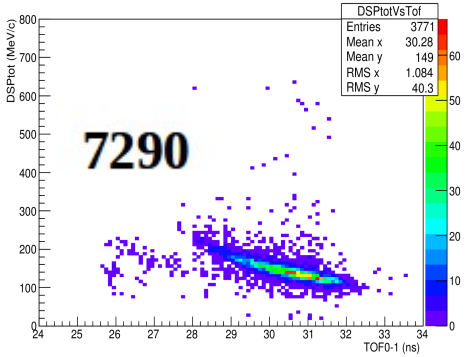
P vs. TOF0-TOF1



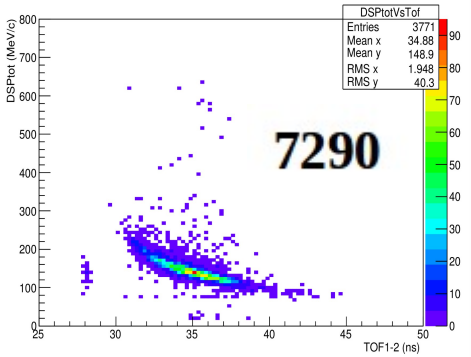
P vs. TOF1-TOF2

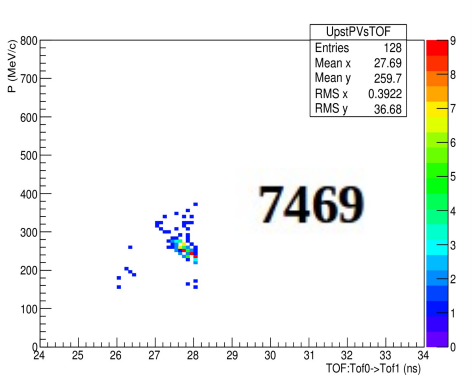


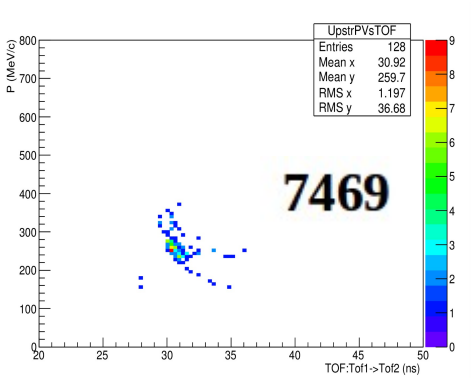
P vs. TOF0-TOF1

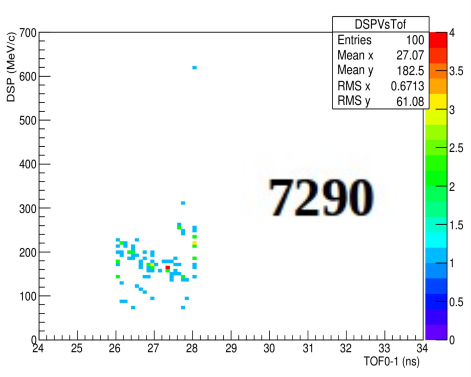


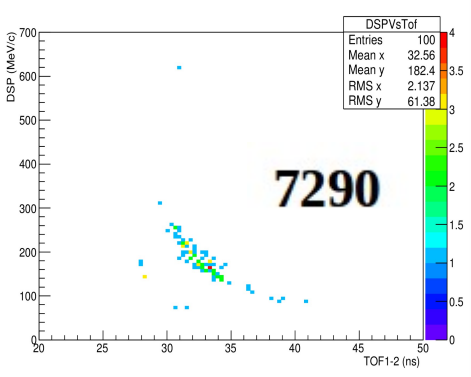
P vs. TOF1-TOF2







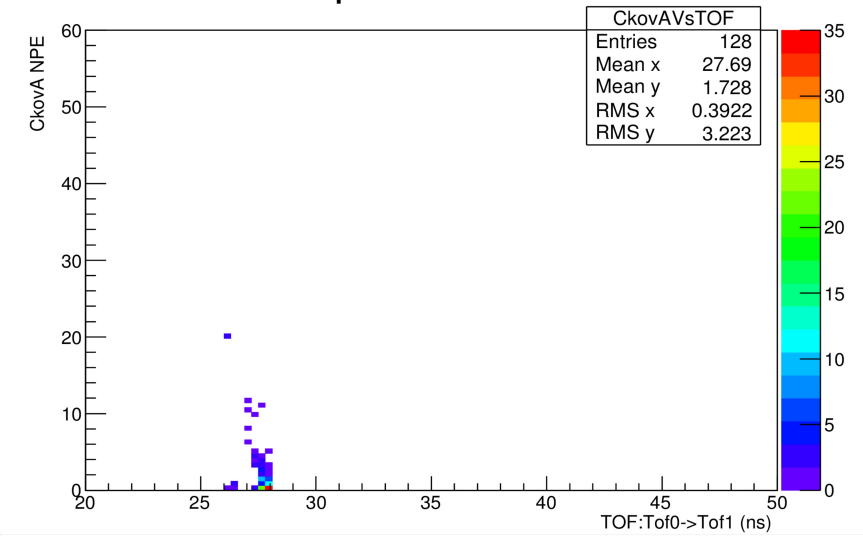




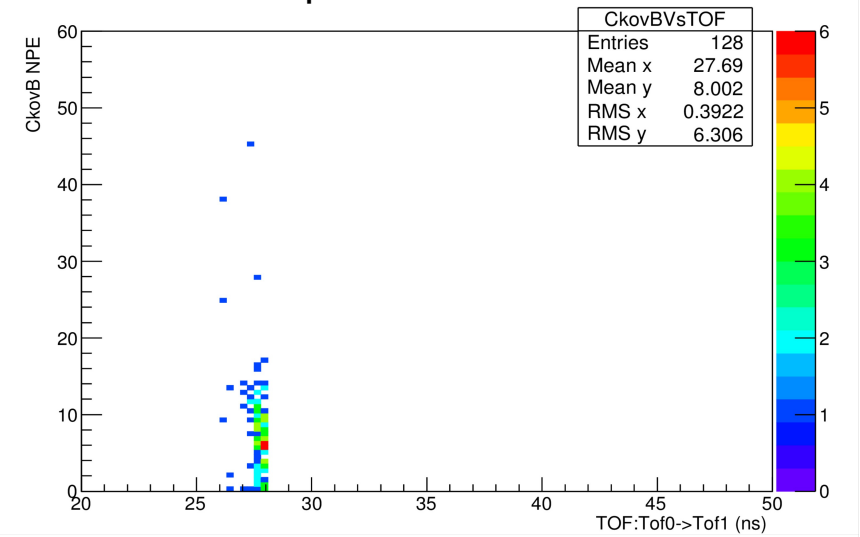
- Second row of plots are the isolated unidentified particles. Isolated using TOF0-1 info.
- In 7469, they have momenta of ~100 to 400 MeV/c.
- In 7290, they have momenta of less than 100 to greater 400 MeV/c.

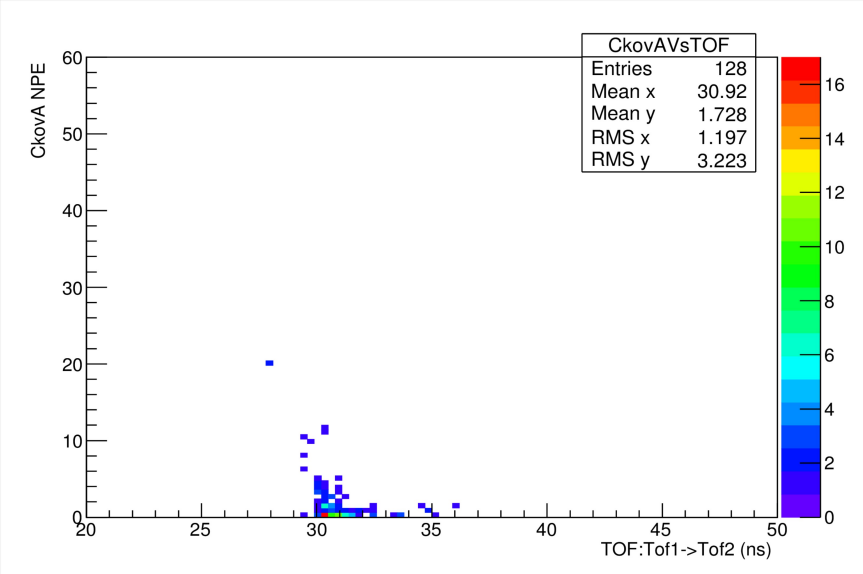
Run 7469 – Ckov vs. TOF

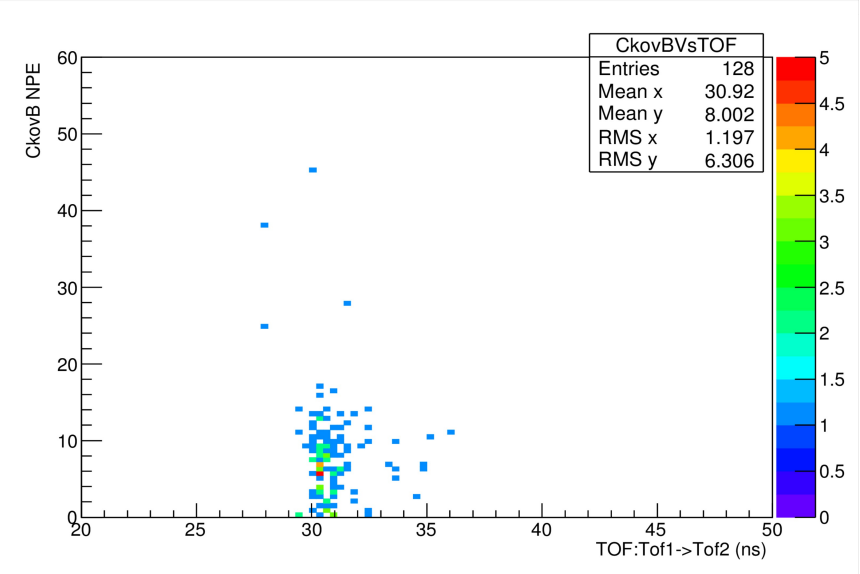
CkovA number of photoelectrons vs. TOF0-TOF1



CkovB number of photoelectrons vs. TOF0-TOF1







- Less response of these unidentified particles in CkovA than CkovB→ characteristic of muons.
- Need more statistics to apply NPE and/or momentum-threshold cuts.

Looking Ahead

- Need higher statistics runs for understanding the unidentified particles and vetoing the background delta-ray electrons using NPE cuts.
- Investigation of unidentified particles in muon runs on-going.
- Need to calculate rate and momentum range of fast pions to form stronger case against the unidentified particles.
- Analysis here can extend to Step IV pion contamination studies.