RF Timing Studies/Misc PID

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Intro

- Trying to use RF timing in the same way SIDIS group are
  - They have had some success in using the RF timing info for PID
- Whilst looking, I've also modified how I select prompt/random events in my script
- Produced some other interesting PID plots

Selected Setting

- Want to see if RF timing can be used for PID
- Tested a set of runs from the spring
  - $Q^2 = 4.4\ GeV^2c^{-2}$, $W = 2.74\ GeV^2$, x = 0.4, centre setting, low ϵ
  - $P_{SHMS} = 5.389\ GeV/c$, $E_{Beam} = 8.2\ GeV$
  - Runs 7978–8002 (Excluding dummy)
- Chained all runs
  - Stats for proton are too crappy without doing this
- This run had lots of "odd" kaon events with missing mass $\sim 0.85\ GeV/c^2$
  - Made some new PID plots to look into this a little more
- Applied fairly standard cuts to select particles

Common Cuts

- Have some cuts common to all particle types in SHMS
- Want events with e^- in HMS and a hadron in SHMS

Table: Common cuts before PID, events *not* in the range shown are removed.

Cut	HMS	SHMS
δ	$< \lvert 8 \rvert$	$-10 < \delta < 20$
θ	$< \lvert 0.08 \rvert$	$< \lvert 0.06 \rvert$
ϕ	$< \lvert 0.045 \rvert$	$< \lvert 0.04 \rvert$
$E_{TotNorm}$	> 0.7	N/a
HMS Cer NPE	> 1.5	N/a

PID Cuts - Detectors

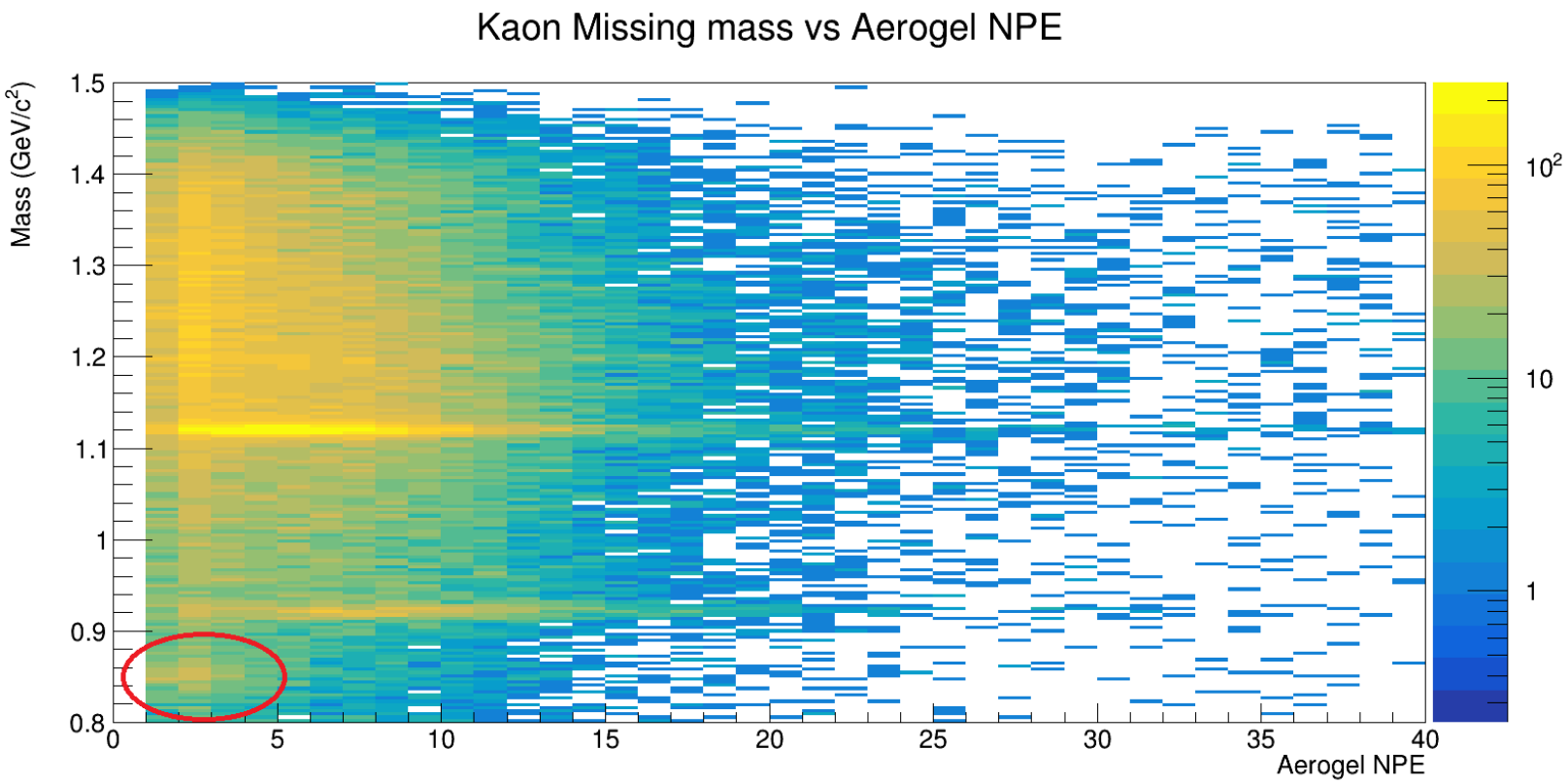
- PID is by detector hits, namely the Aerogel and HGC
- Requirement for a 'hit' in the detector is that there is > 1.5 NPE for the event
- Hit combinations for π, K and p are summarised below

Table: Hit combinations in the HGC and Aerogel for each hadron species

Hadron	HGC Hit	Aerogel Hit
π	✓	✓
K	✗	✓
p	✗	✗

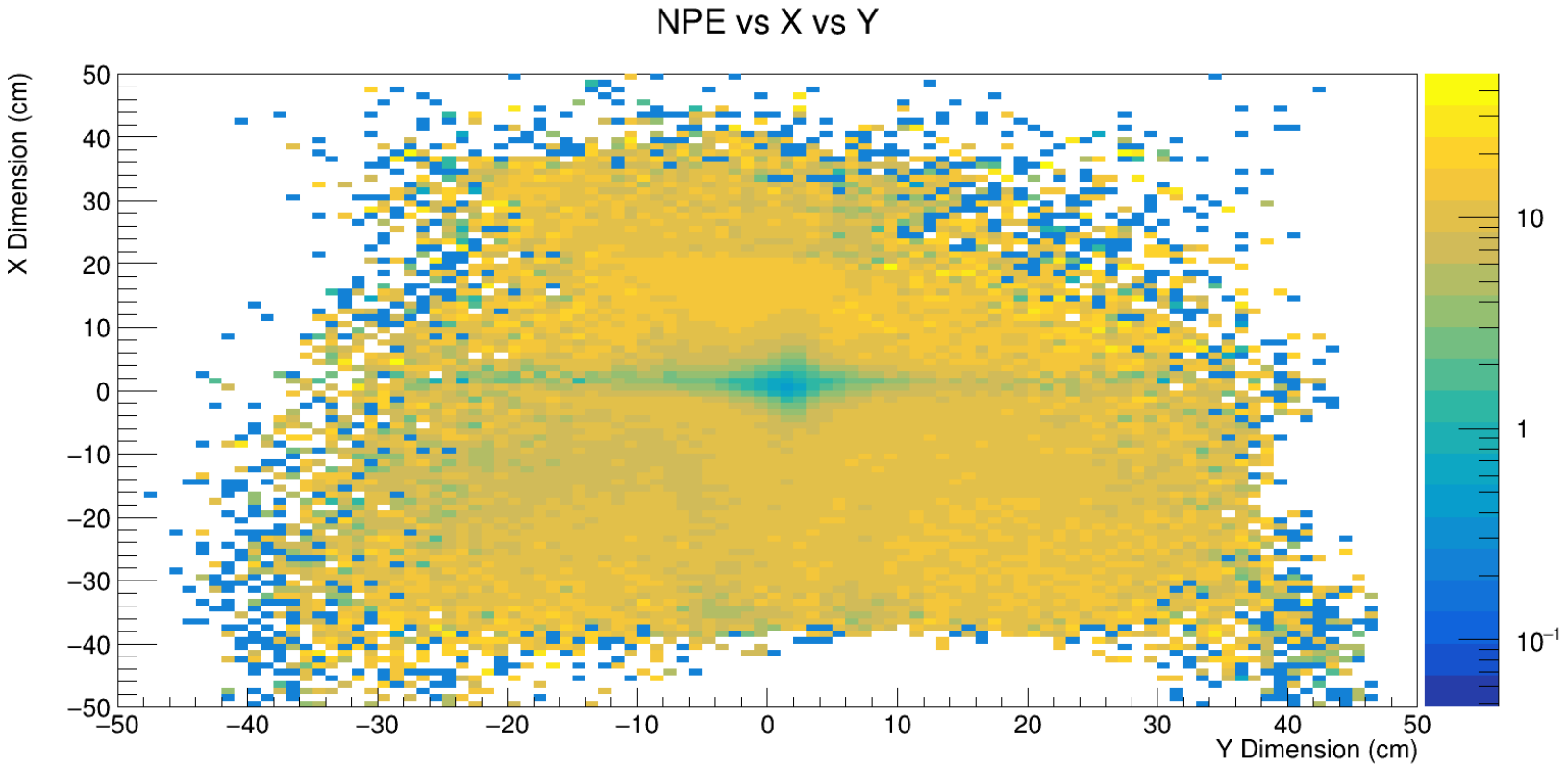
Kaon MM vs Aerogel NPE

- 2D plot of missing mass vs aerogel NPE for "kaon" events
- Low MM events only distributed in low NPE region



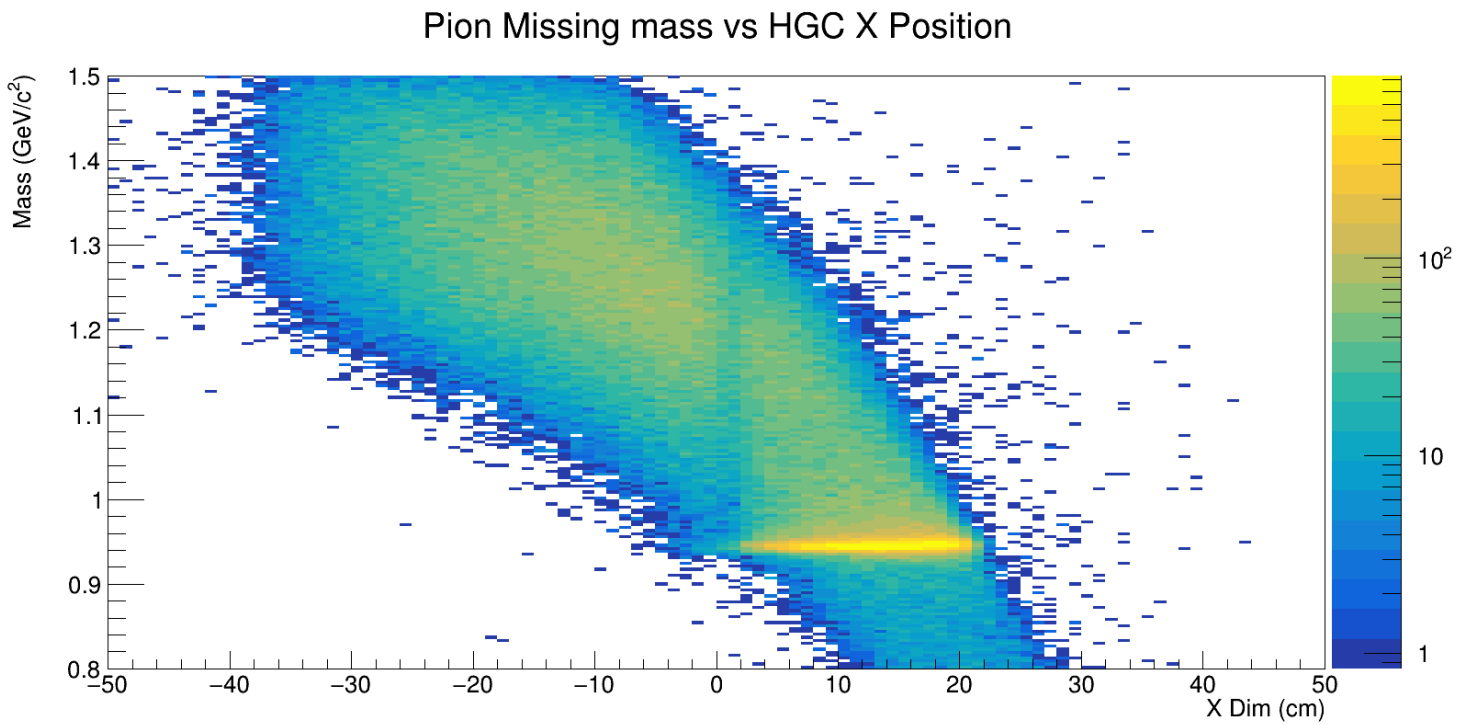
MM vs HGC X Position 1/3

- Know hole region will be problematic
- Looking at HGC NPE distribution in X and Y shows the hole clearly



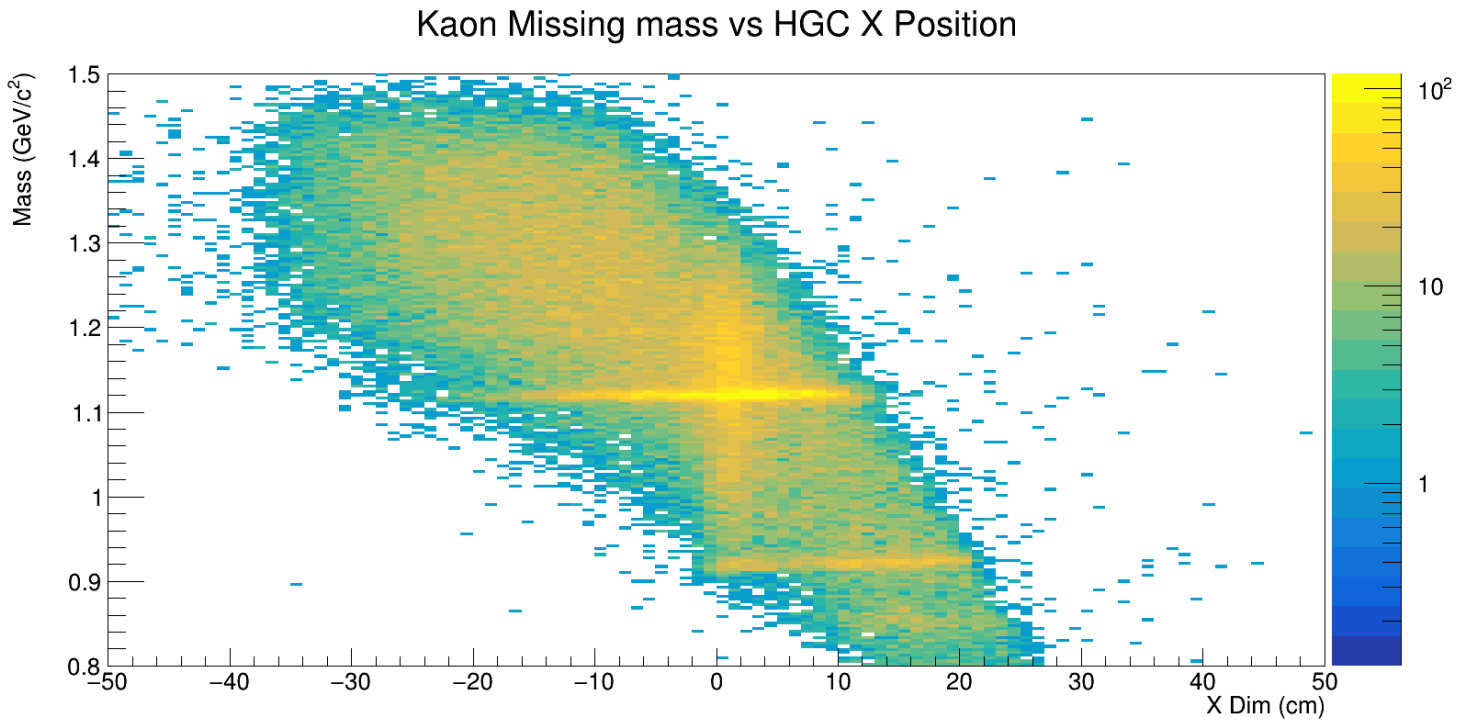
MM vs HGC X Position 2/3

- Plotted missing mass vs HGC X position for pions and kaons
- In pion plot, see clear vertical band of "missing" events at around the position of the hole
  - Implies they potentially look like they do *not* pass the HGC cut, treated as kaons



MM vs HGC X Position 3/3

- For the kaons, see an enhanced vertical band at x = 0, likely the pions leaking in



RF Timing - Overview

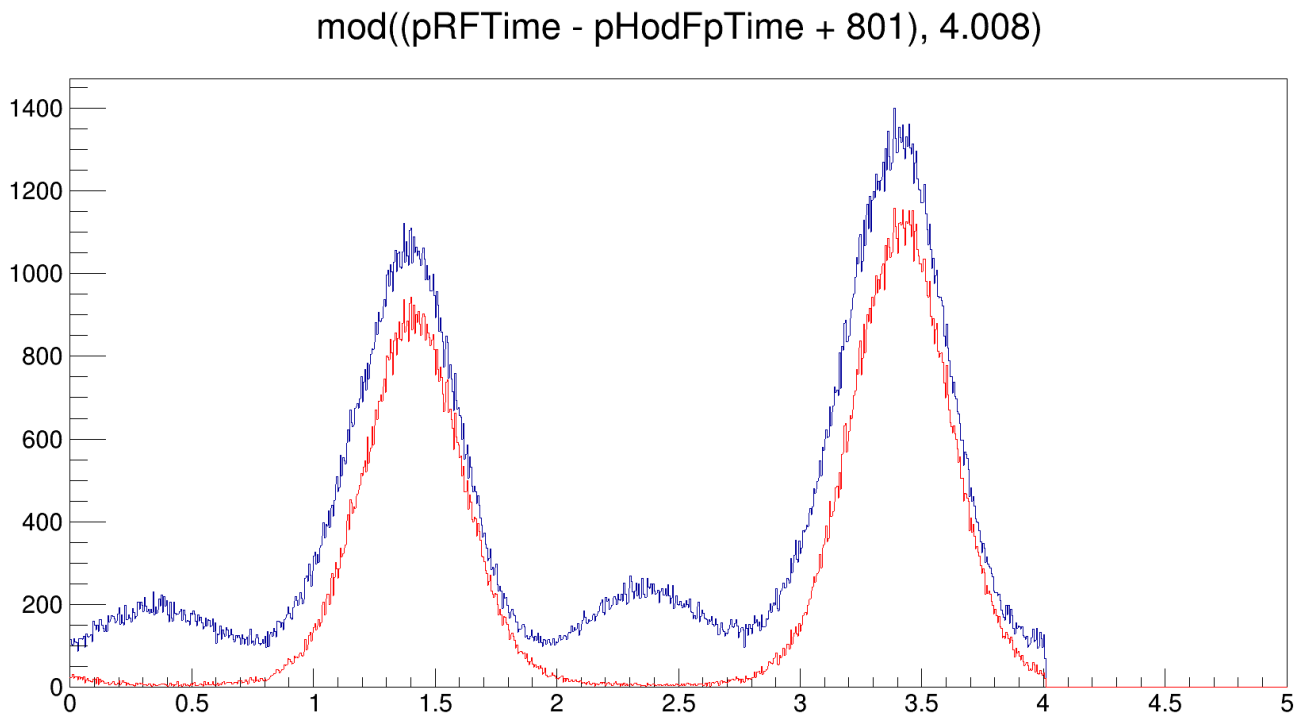
- From discussion with Peter Bosted and Hem, need to take difference between RF time and hodoscope start time
- Need to add an offset this difference, then take modulo
  - Take mod 4.008 $\rightarrow$ from bunch spacing for this run set
  - Found that offset of 801 worked best
- Value plotted as time difference is -

$$\mathrm{fmod}(\mathrm{P.hod.fpHitsTime}[0] - \mathrm{T.coin.pRF\_tdcTime} + 801, 4.008)$$

- **Reminder -**
  - $Q^2 = 4.4\ GeV^2c^{-2}$, $W = 2.74\ GeV^2$, x = 0.4, centre setting, low ϵ
  - $P_{SHMS} = 5.389\ GeV/c$, $E_{Beam} = 8.2\ GeV$

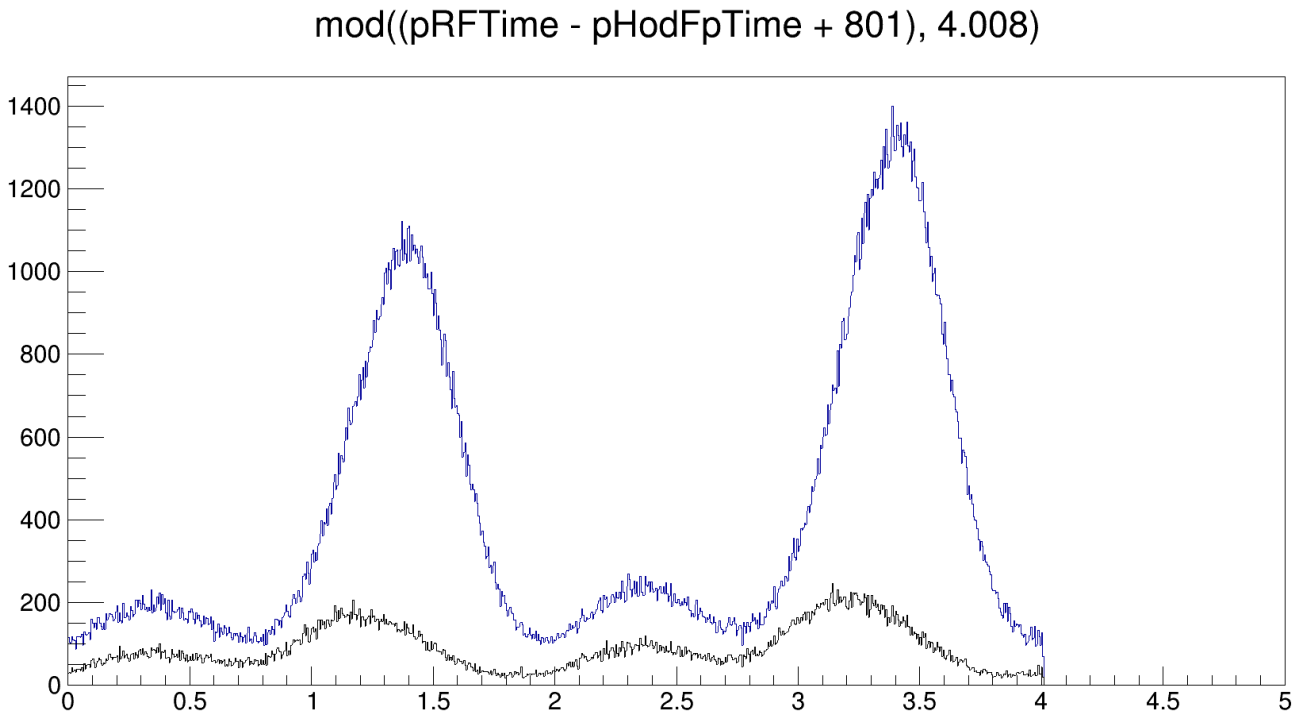
RF Timing - Pions

- RF time differences, after common cuts, shown in blue
- Events with pion PID cuts applied shown in red
- Can clearly distinguish pions from *some* other particle



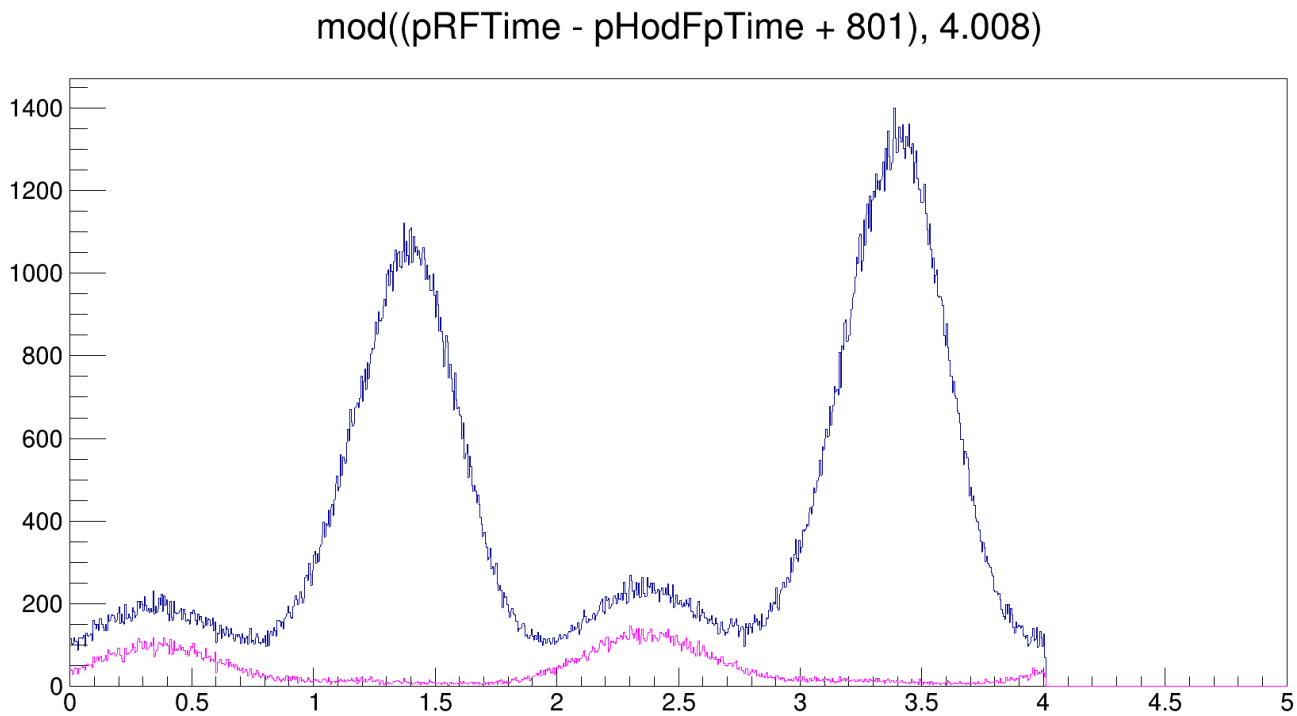
RF Timing - Kaons

- RF time differences, after common cuts, shown in blue
- Events with kaon PID cuts applied shown in black
- Kaons harder to disentangle



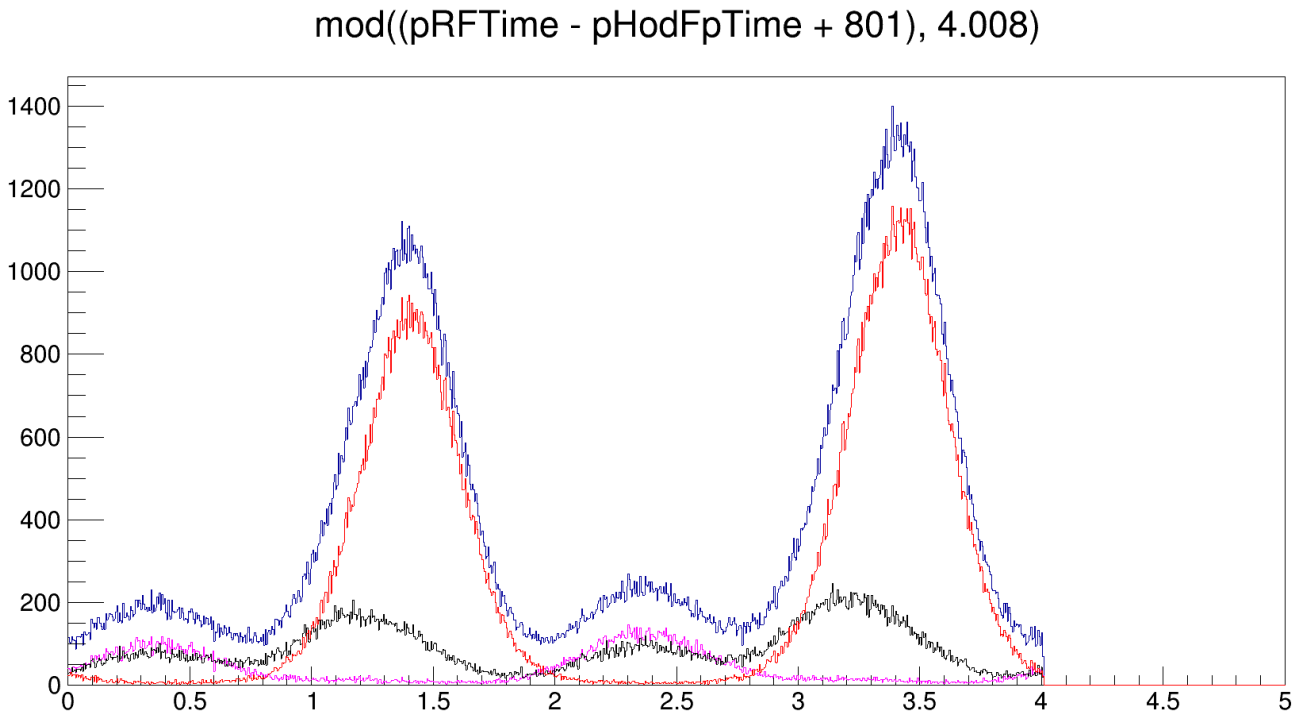
RF Timing - Protons

- RF time differences, after common cuts, shown in blue
- Events with proton PID cuts applied shown in magenta
- Other particle appears to be protons
  - This is also what we were seeing previously



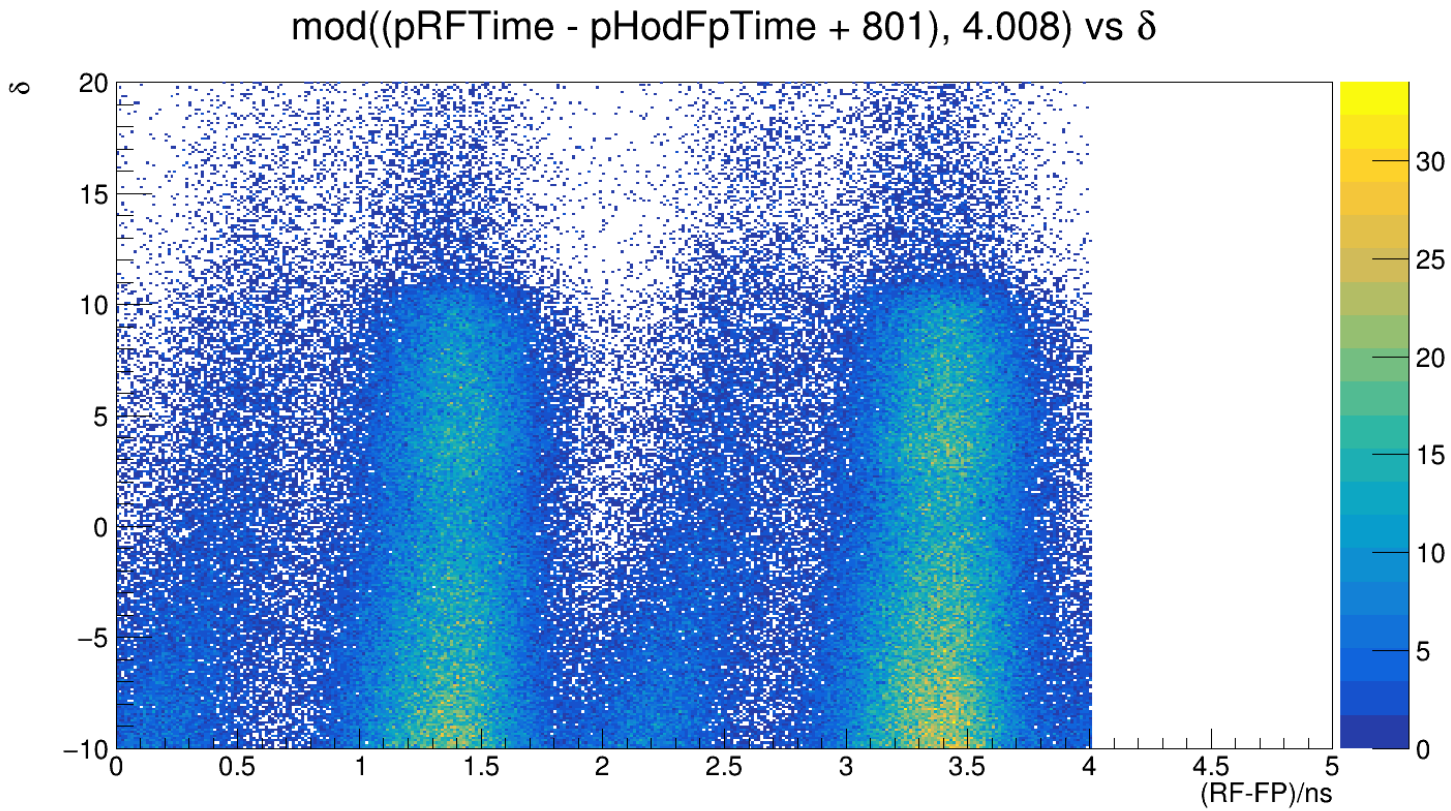
RF Timing - All Particles

- All events, overlaid with pions, kaons and protons
- Proton separation from pion/kaon seems easy
- Distinguishing kaons and pions harder



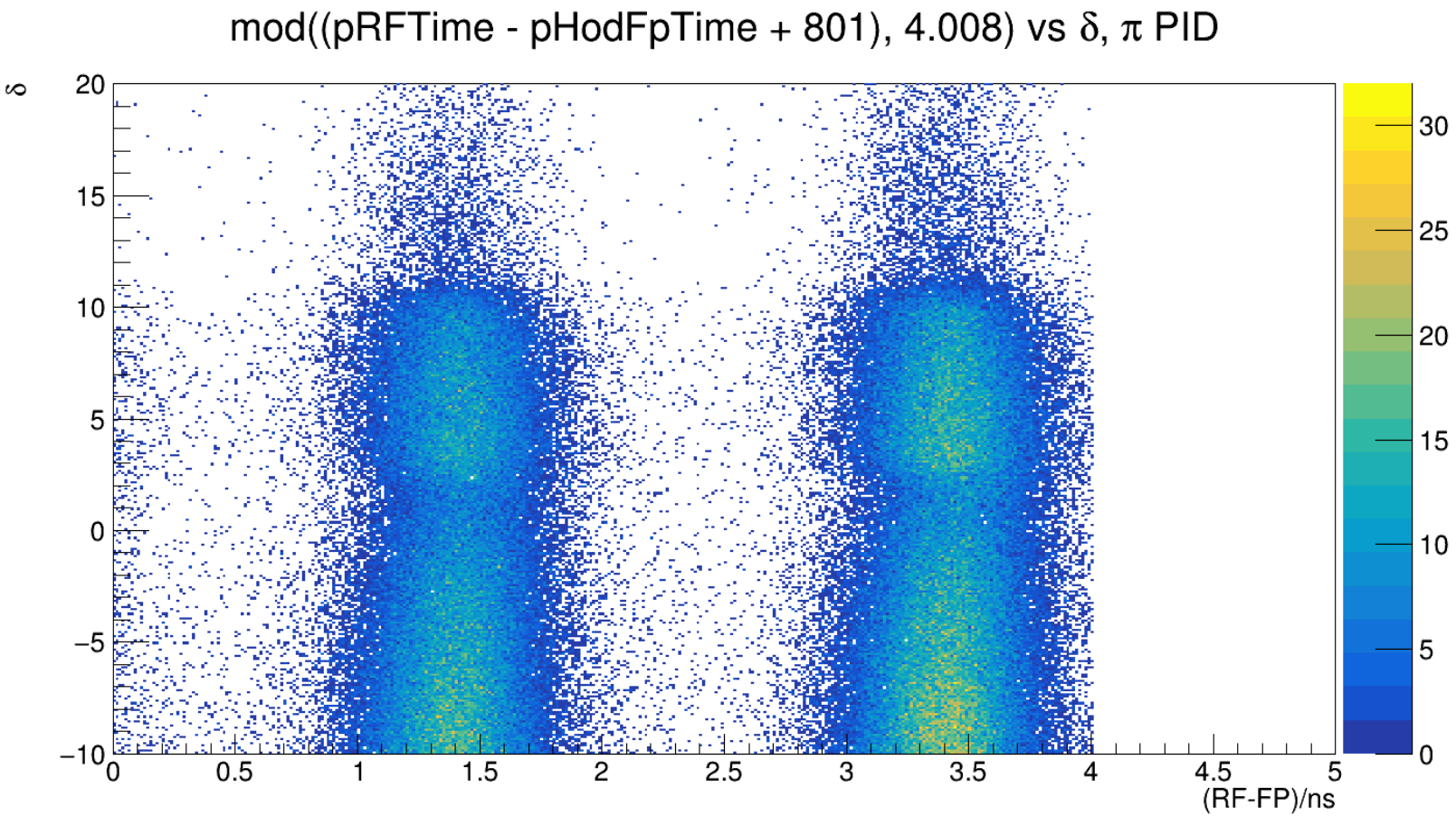
RF Timing vs δ 1/3

- Looking at the RF time vs δ, we can again see how clear the pion/kaon vs proton separation is
- Shown in the plot below is the distribution for all events, after common cuts



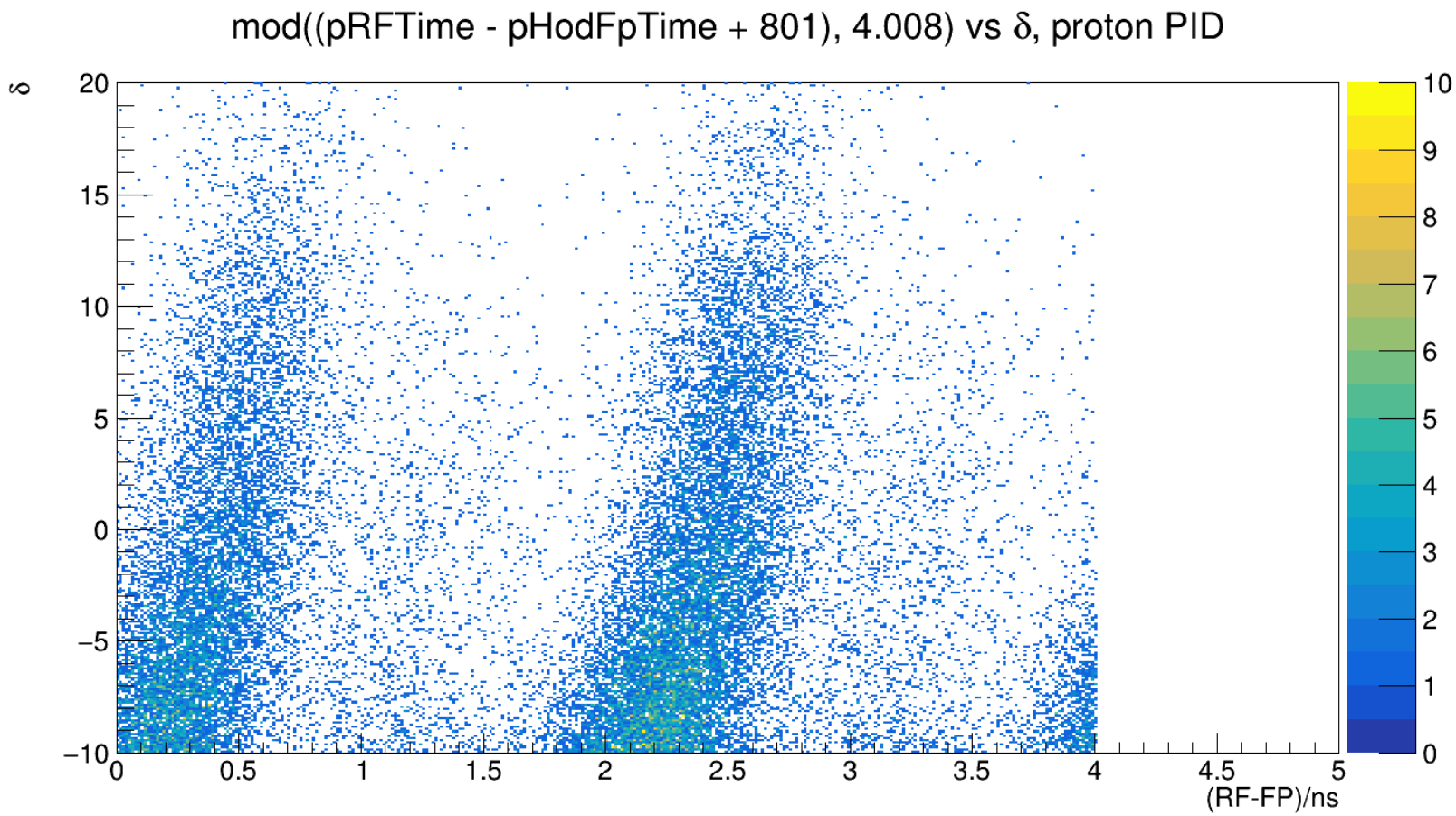
RF Timing vs δ 2/3

- Shown in the plot below is the distribution for all pions
  - Notice the "gap" around $\delta = 0$



RF Timing vs δ 3/3

- Shown in the plot below is the distribution for all protons



Discussion

- Need to look at random subtracted 1D RF diff distributions for kaons/protons
  - Have this for pions, didn't look too different, didn't have time to add it in for others yet
- How can we incorporate this into a wider PID strategy?
  - Can easily be used for pion/proton selection, less obvious that it can be done easily for kaons
- Looks like we can recover "protons" from our kaon event selection with this method, should remove the weird peak at 0.85 GeV/c^2 hopefully
  - Will test this later
- Need to see how this looks for other settings
  - Need to test a 2 ns bunch spacing run too