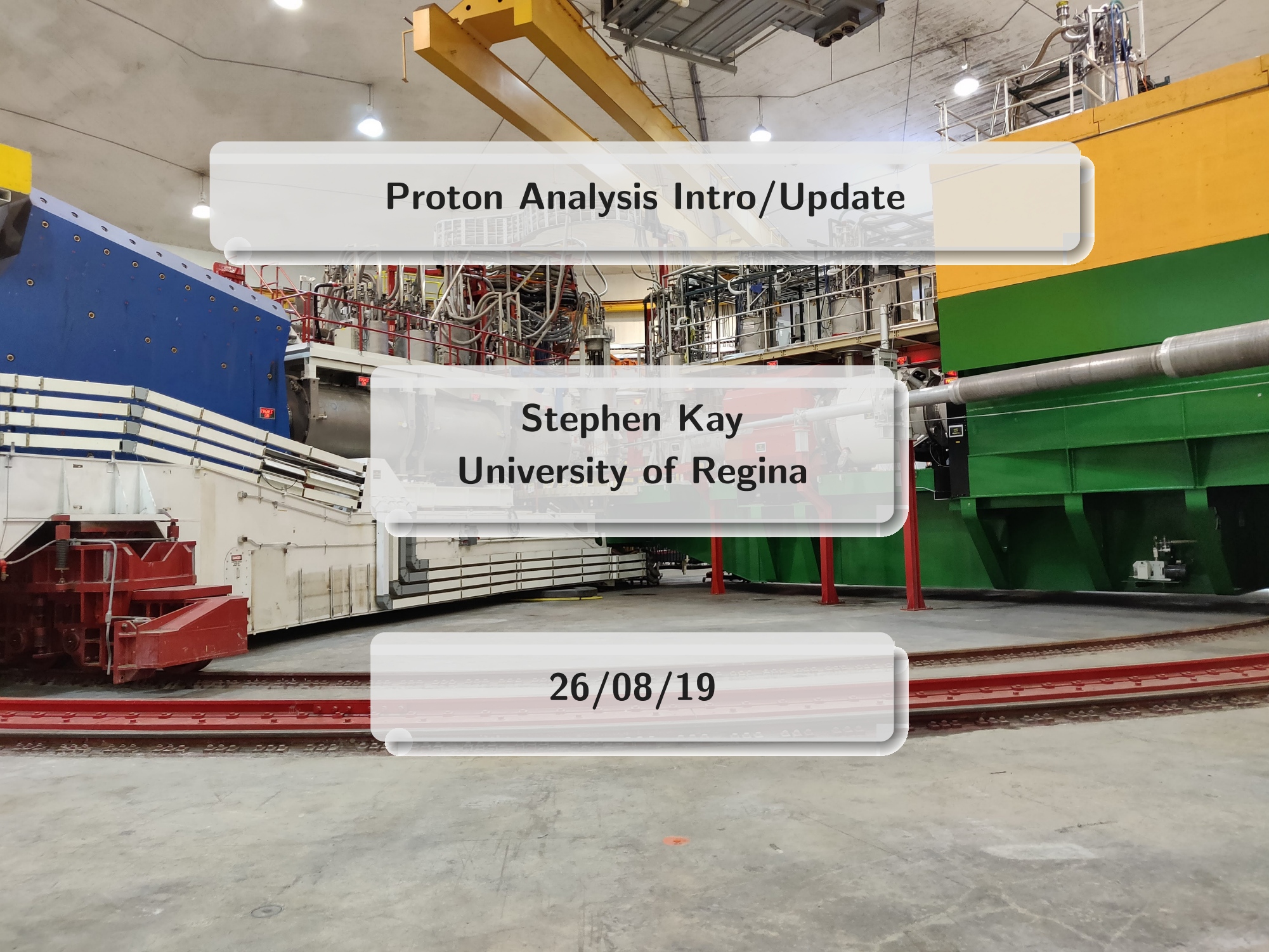

Proton Analysis Intro/Update

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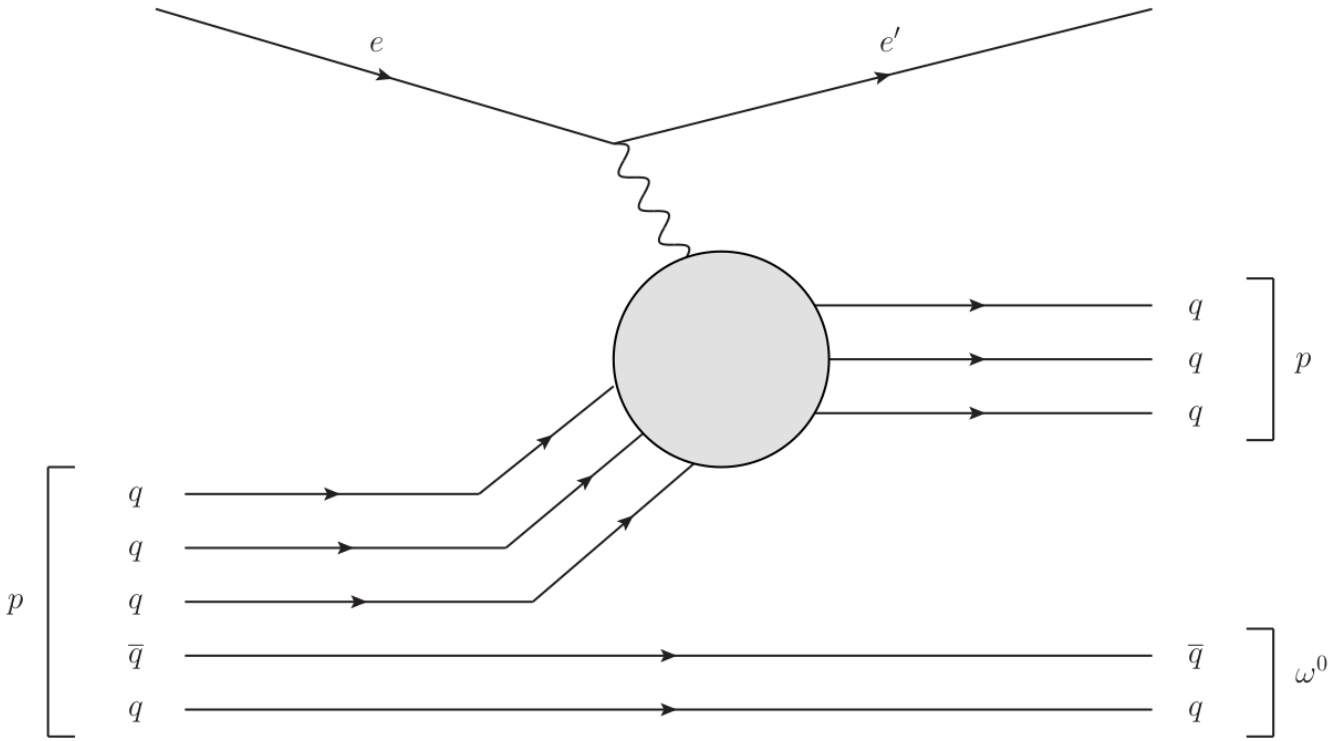
Introduction

- In addition to the π and K analysis, can also analyse proton events in the data
- Similar motivation to the work Bill did, u channel is largely ignored
- Want to try and get some initial results before May next year, in time for a workshop Bill is organising
- As a start, need to check PID of proton events and see if there are any issues

u-Channel Events



An example u-channel process, here we have backward angle ω production. [1]

[1] - W.Li. PhD Thesis, University of Regina 2017

Physics Channels

- Of course, other neutral mesons can be produced
- Numerous physics channels to examine
- Ratios of various neutral meson production channels at different ϵ values - e.g. ϕ to ω ratio
- ω L/T ratios as a function of $-u$ with the eventual aim of separated cross sections where possible
- Q^{-n} dependence of ω $L/T/LT/TT$ cross sections
- For now though, need a clean sample!

Selection Cuts

- Want events with e^- in HMS and p in SHMS
- Various cuts in both detectors used for *all* events before PID,

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	✗	✗

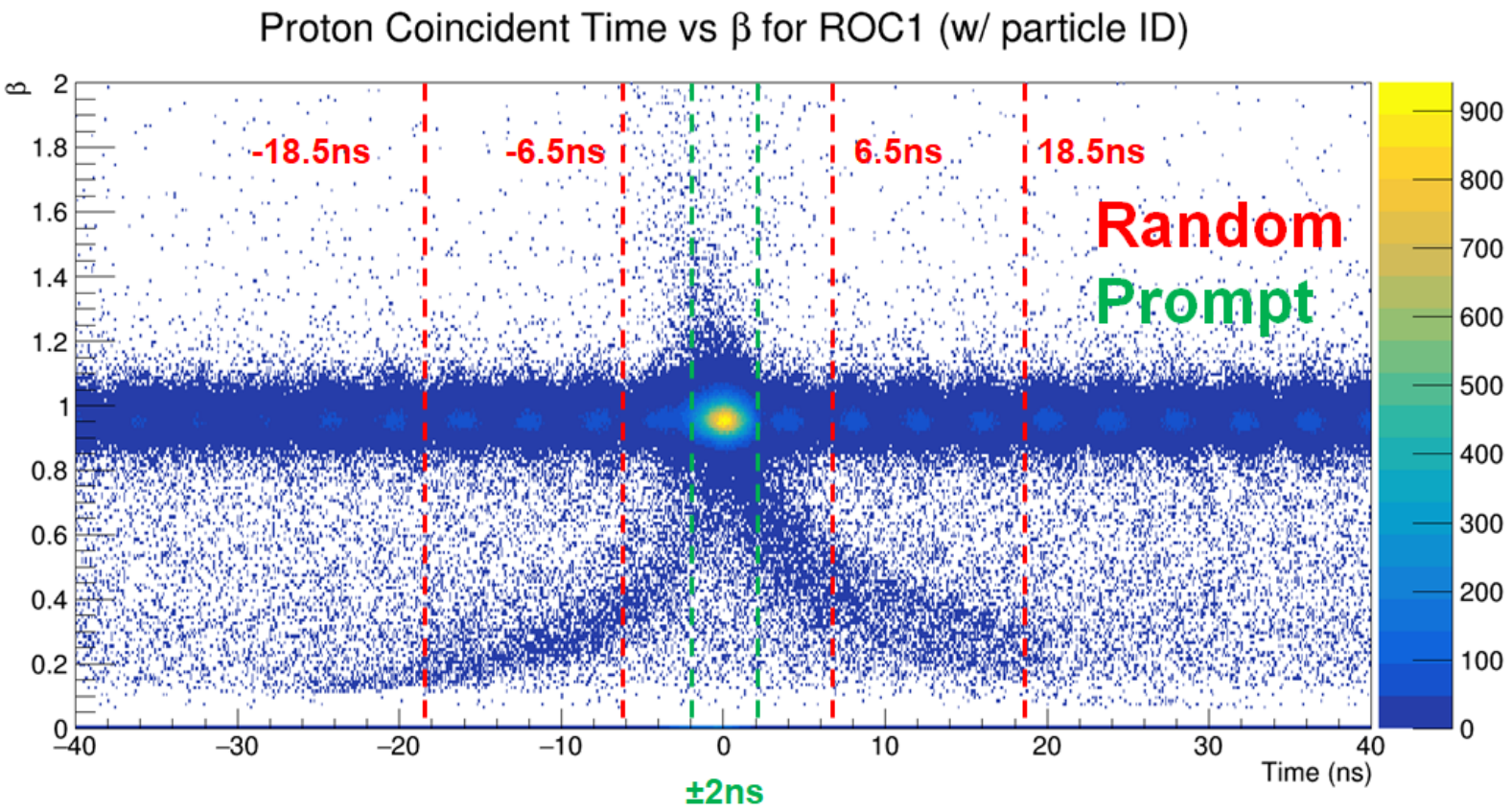
Timing Cuts and Other Comments

- Timing cuts depend upon the kinematic setting, too many to list
- All are done so that *six* random buckets are selected for random subtraction
- Due to the way t and u are defined in hcana, when we select protons, t is actually u and vice versa!
- hcana defines them as follows

$$\mathrm{MandelT} = (PQ - fX)\,.M2()$$
$$\mathrm{MandelU} = (PQ - fB)\,.M2()$$

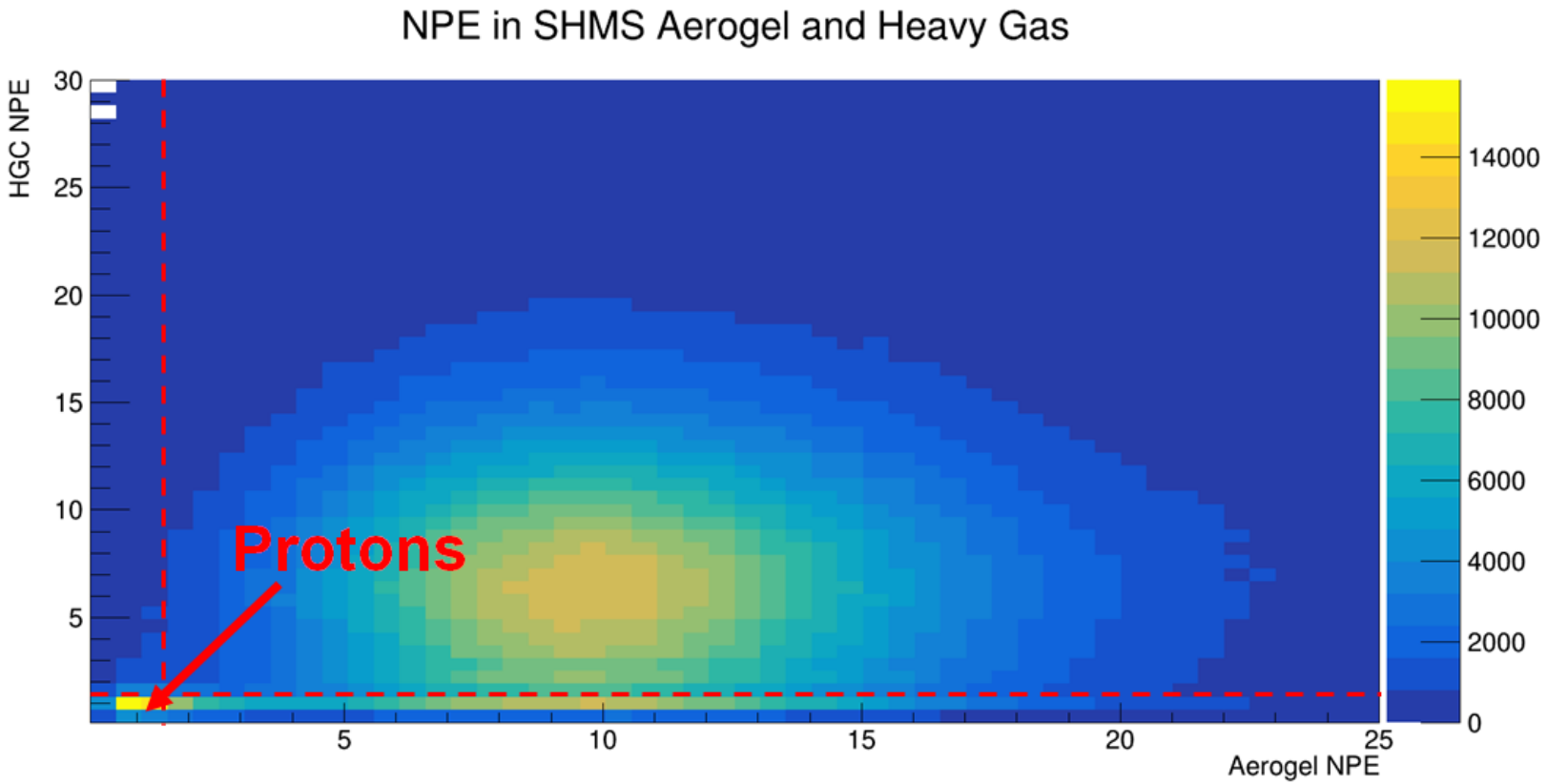
- $PQ \rightarrow$ q Vector, $fX \rightarrow$ 4 momentum of secondary particle, $fB \rightarrow$ 4 momentum of undetected recoil
- Assumes secondary particle is the one being detected, not the recoil

$Q^2 = 3, W = 2.32$ Centre, High ϵ Plots - Timing



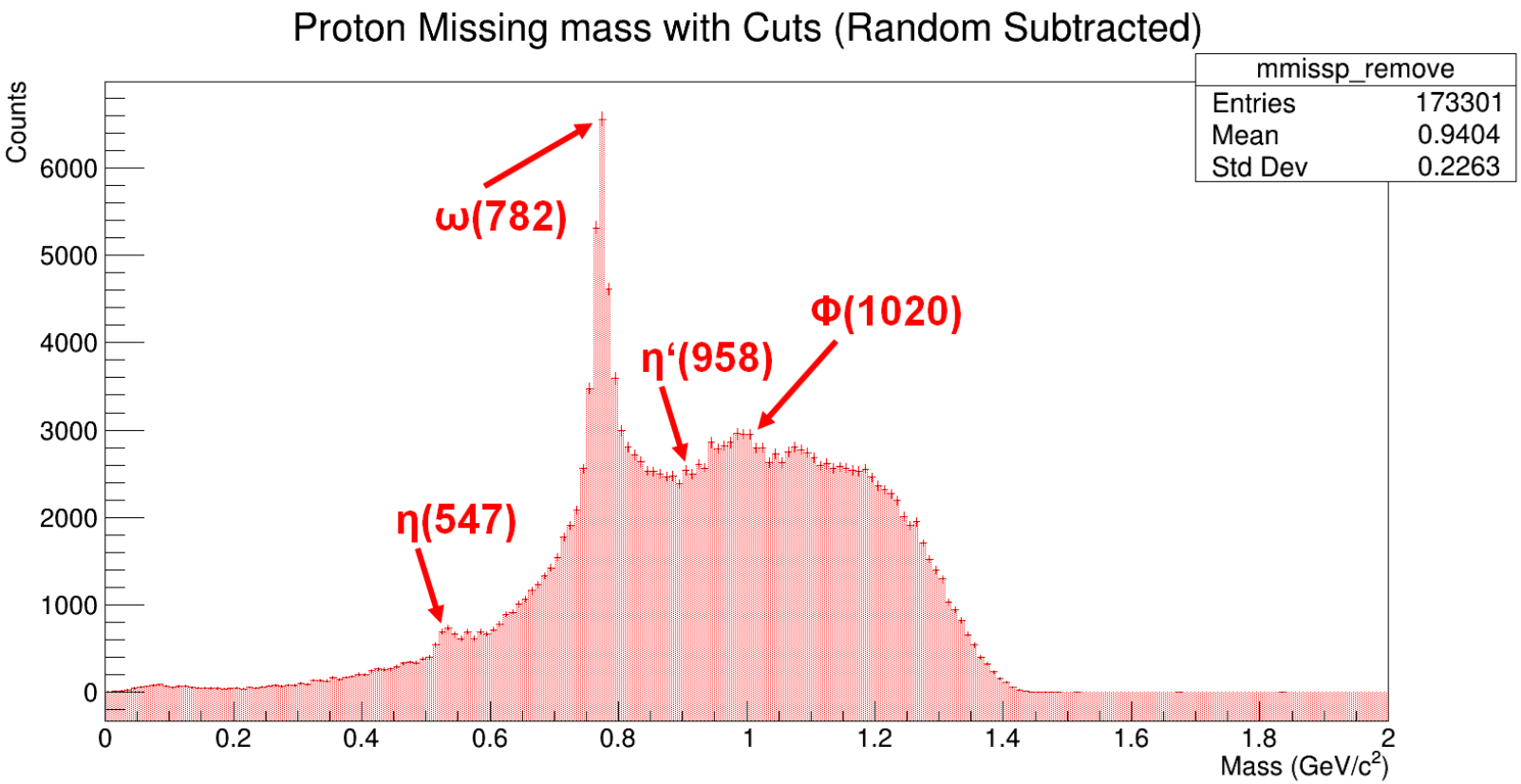
Coincidence time as a function of β for protons. Note that β is slightly low implying hodoscope calibration is probably off.

$Q^2 = 3, W = 2.32$ Centre, High ϵ Plots - PID



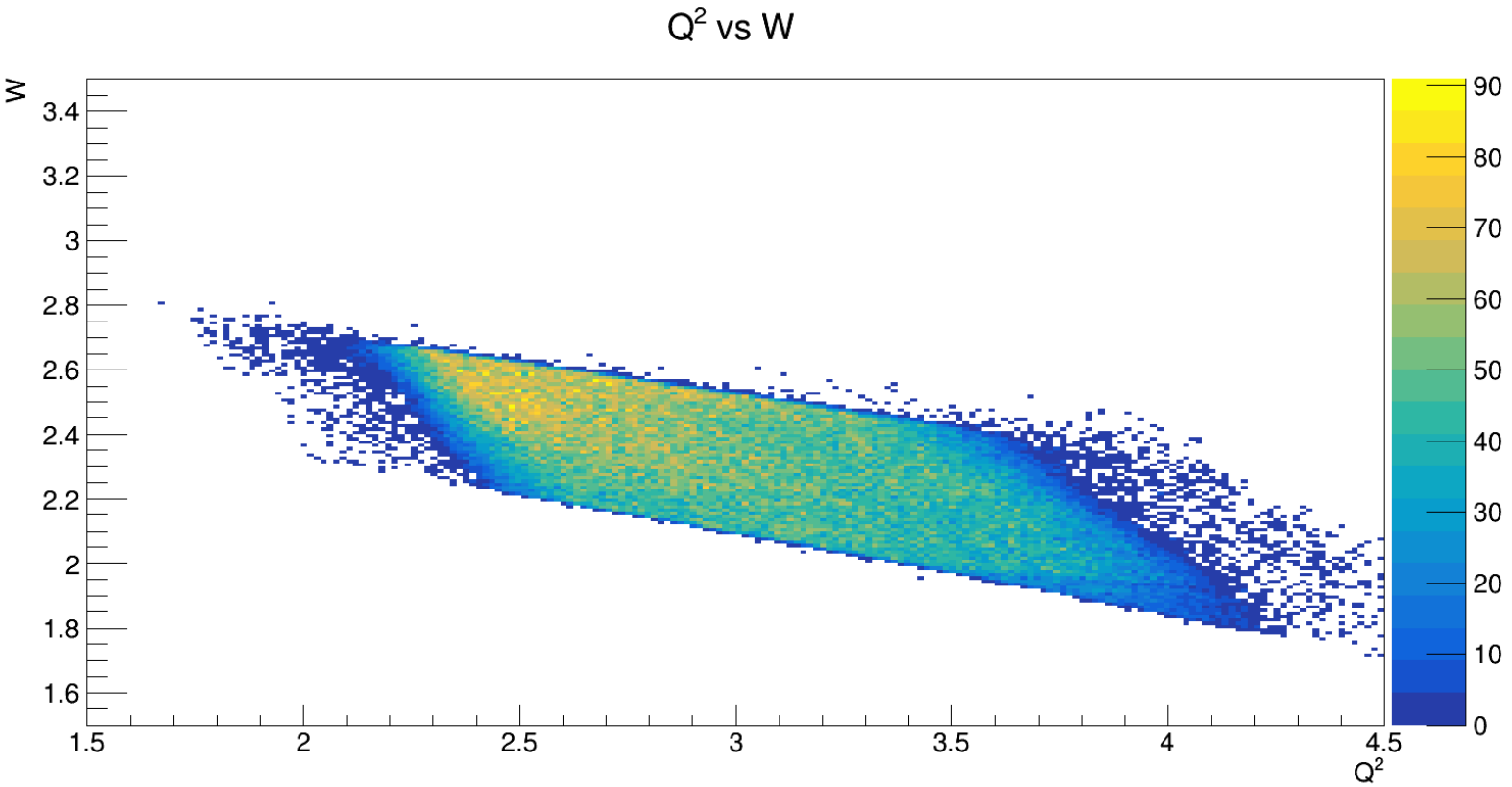
NPE in Aerogel Cherenkov vs NPE in HGC for all events. Red lines illustrate 1.5 NPE cuts.

$Q^2 = 3, W = 2.32$ Centre, High ϵ Plots - MM_p



Missing mass for proton events, random background subtracted.

$Q^2 = 3, W = 2.32$ Centre, High ϵ Plots - $Q^2(W)$

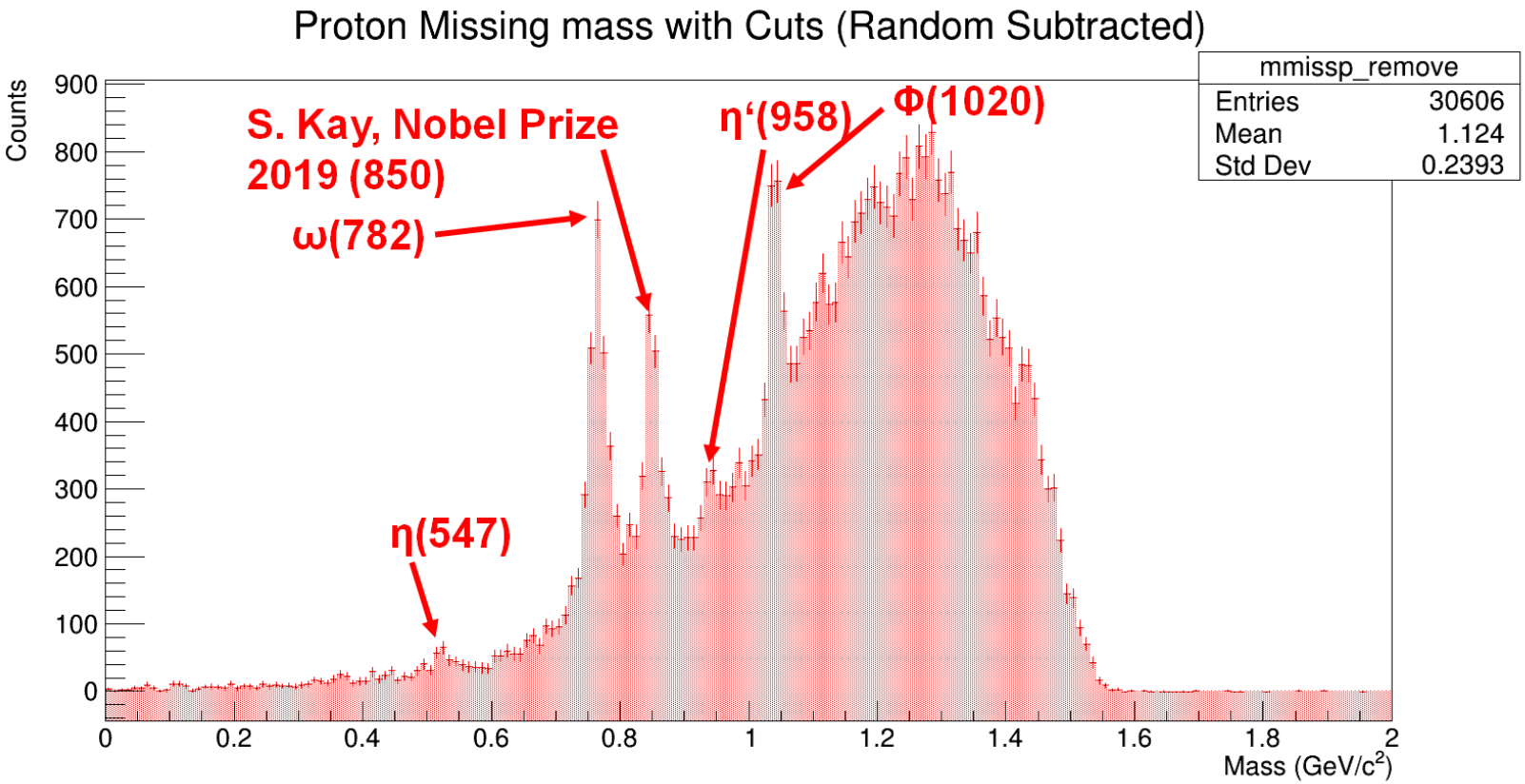


$Q^2(W)$ 'diamond' plot.

$Q^2 = 3, W = 2.32$ Centre, High ϵ - Comments

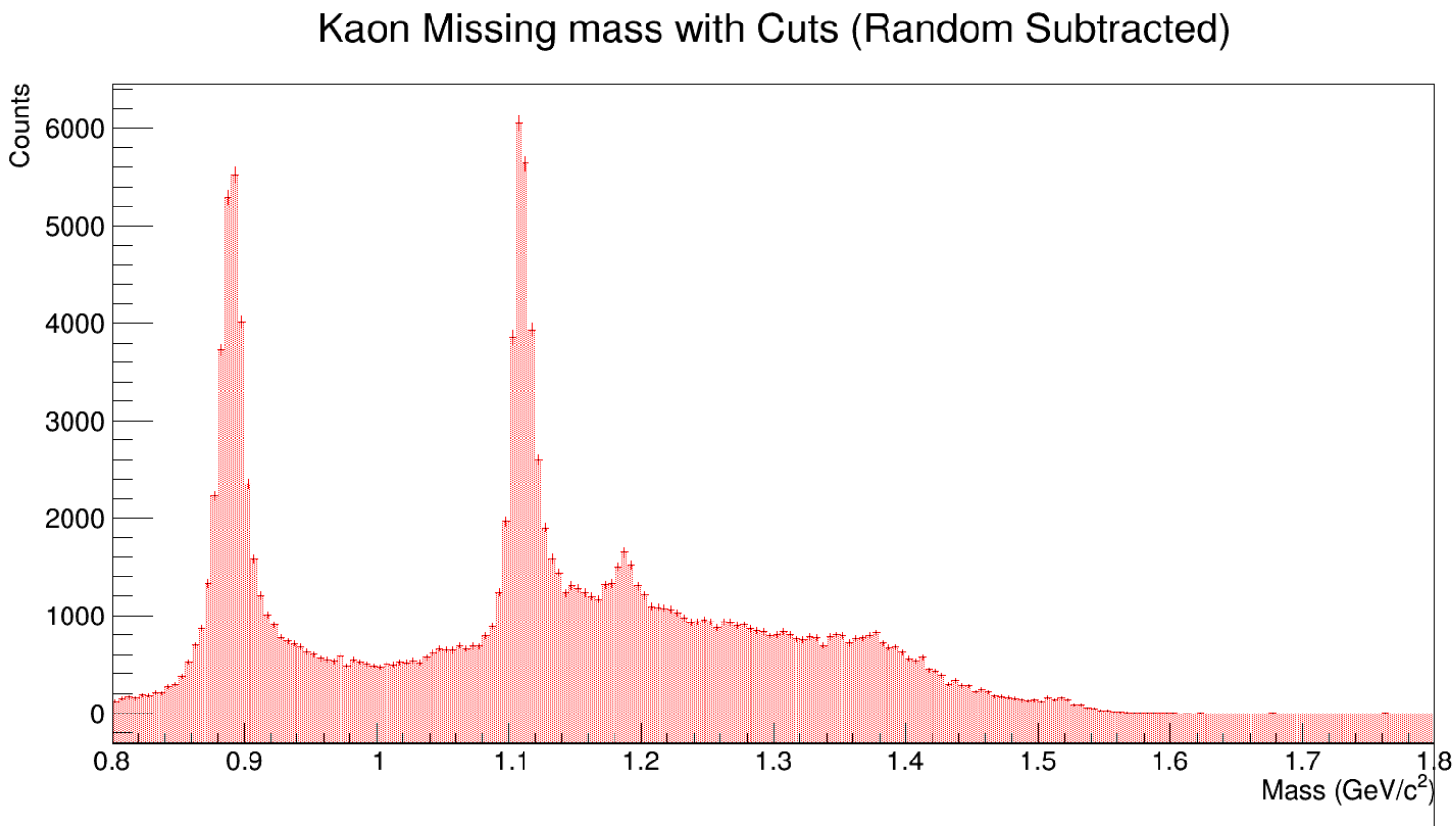
- From timing plot, β looks off
- η' very hard to make out, large physics background or need to clean up PID more?
- However, not seeing any "extra" strange peaks anywhere... for this setting!
- Do on other settings as we will see

$Q^2 = 3, W = 3.14$ Centre, High ϵ Plots - MM_p



Missing mass for proton events, random background subtracted. Note the peak at ~850 MeV which does not correspond to any real flavourless meson.

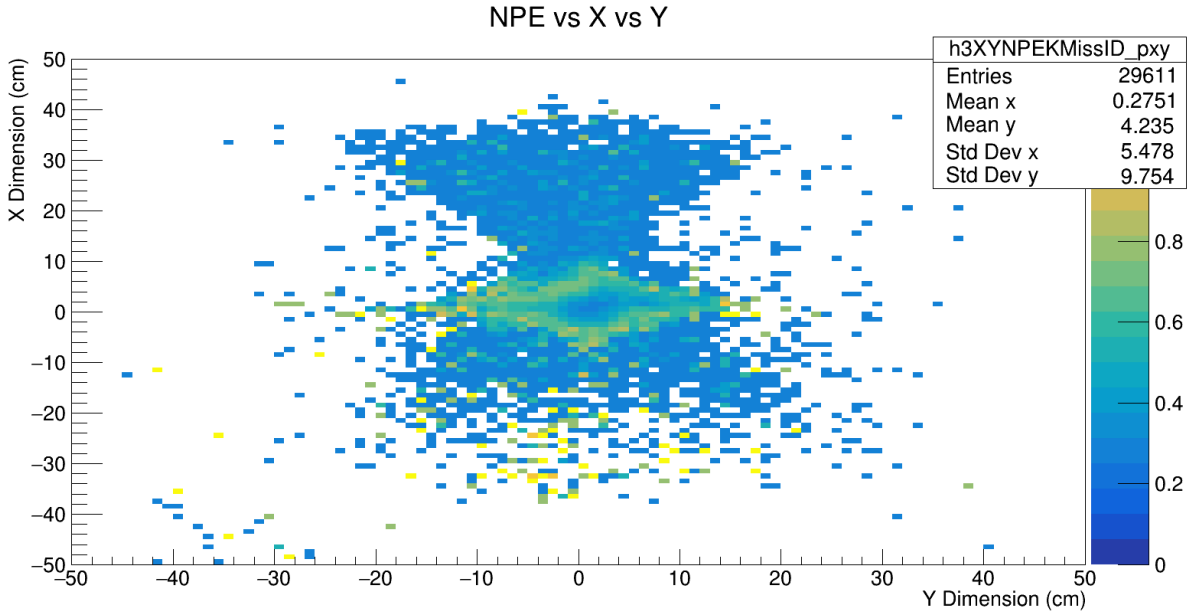
$Q^2 = 3, W = 2.32$ Centre, High ϵ Plots - MM_K



Missing mass for kaon events. Note the peak at $\sim$0.9 $GeVc^{-2}$.

$Q^2 = 3, W = 2.32$ Centre, High ϵ Plots - HGC X/Y

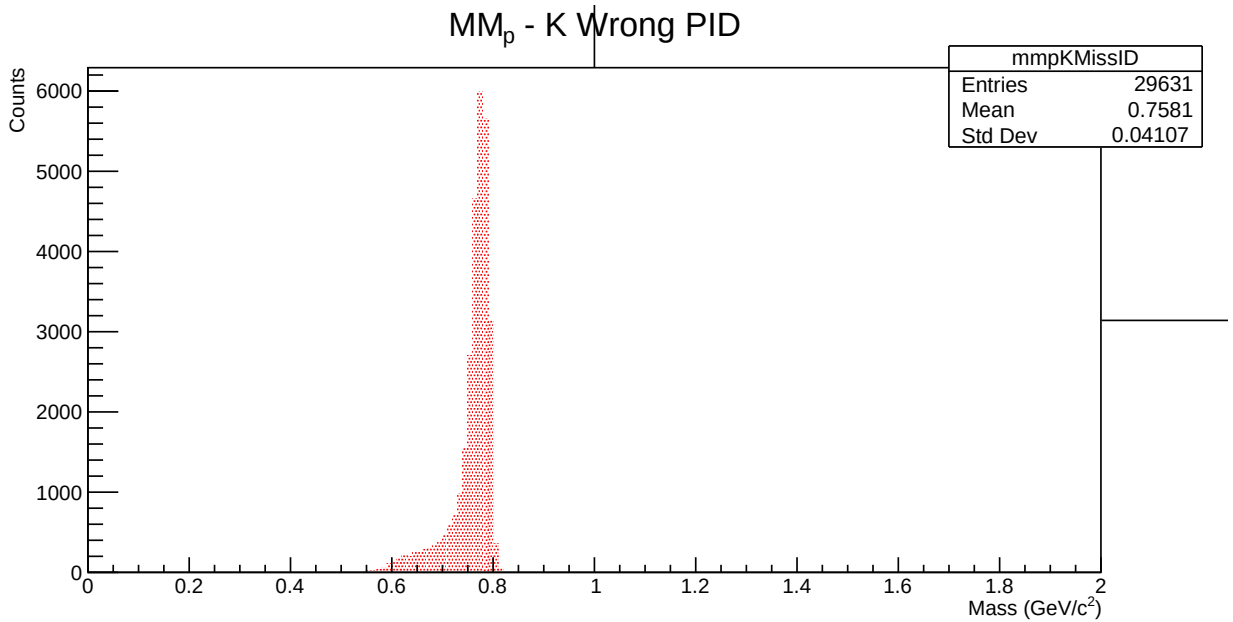
- Where are the events in these extra peaks passing through the focal plane?
- Look at "kaon" events where the missing mass is $0.7 < MM_K < 0.9$



Projection of HGC NPE as a function of X and Y position in the HGC. Only "kaon" events with $0.7 < MM_K < 0.9$ are plotted.

$Q^2 = 3, W = 2.32$ Centre, High ϵ Plots - MM_P for Miss-ID'd Kaons

- What does the proton missing mass value look like for these events?



MM_p distribution for "kaon" events with MM_K that does not correspond to a physical state. The peak shown is at $\sim 0.77 GeVc^{-2}$.

Concluding Thoughts

- Would be naive to conclude that events shown are definitely proton events where we have an ω produced
- Gives a hint in the direction we need to go though, should try to remove background and add further PID cuts where possible
- Add a shower/preshower cut?
- Can easily process all events again and timing windows look OK for now
- Need to focus on kinematics that do *not* look so good
- Will assess each kinematic individually and sort into good/bad categories