Bleed-through Considerations

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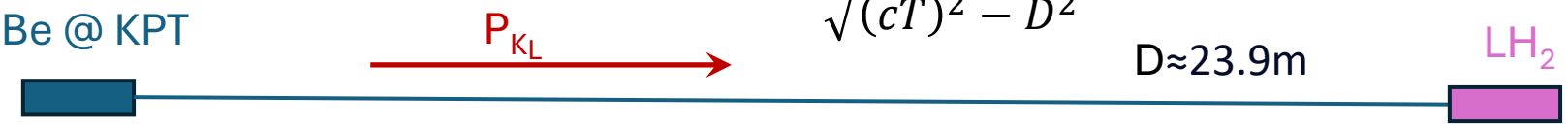
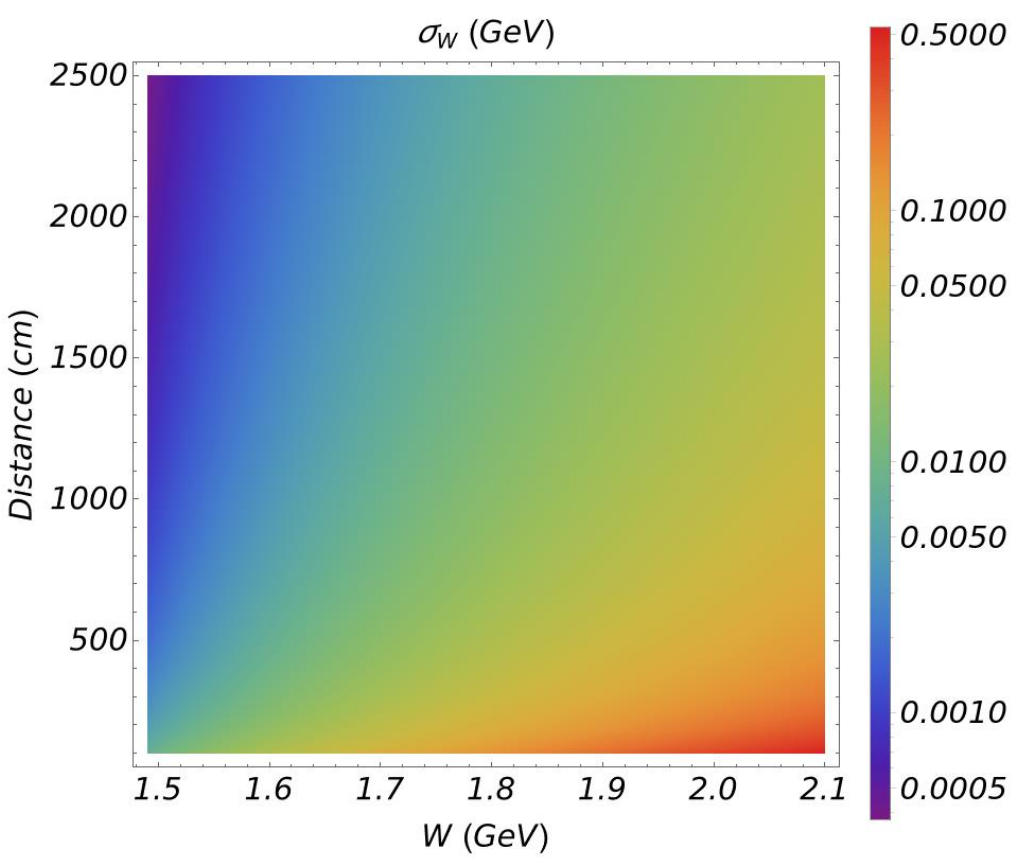
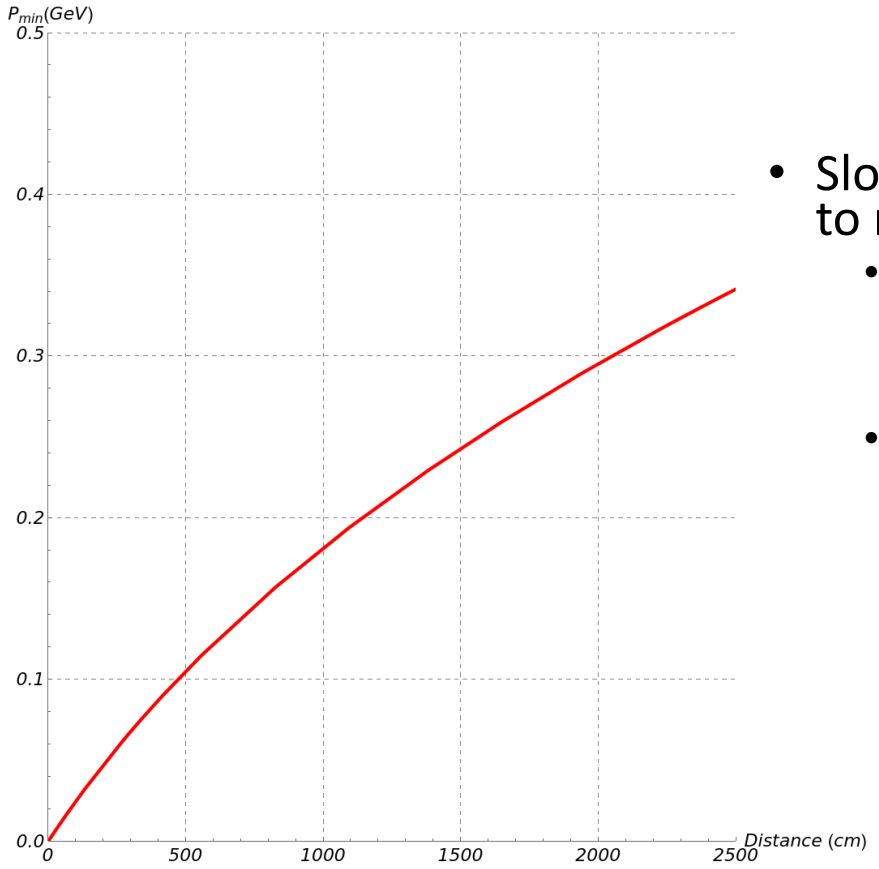
Beam Energy from TOF

$$|P| = \frac{D\, M_{K_L}}{\sqrt{(cT)^2 - D^2}}$$







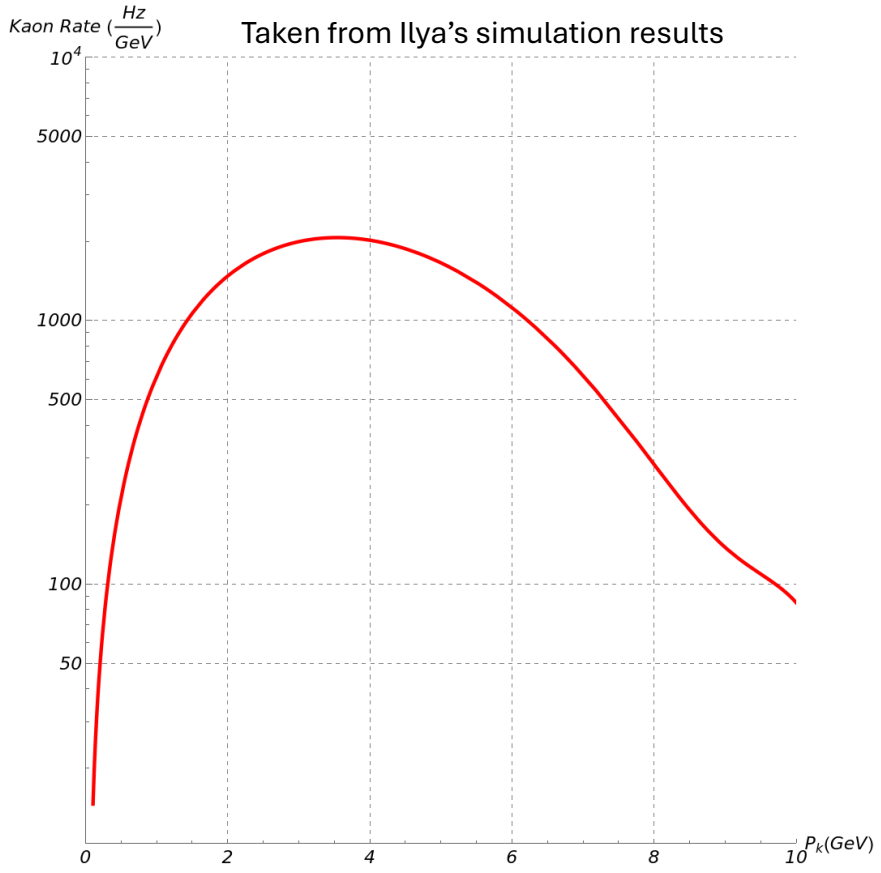
- KLF will measures K_L energy by measuring their TOF from KPT to the interaction vertex in LH_2 target.
  - Use accelerator RF to identify the time photon reaches KPT.
  - This necessitates a long flight path for K_L-s to achieve a good momentum resolution.
  - Current design calls for a ~23.9m between the centers of the targets.
    - LH_2 design is in progress.

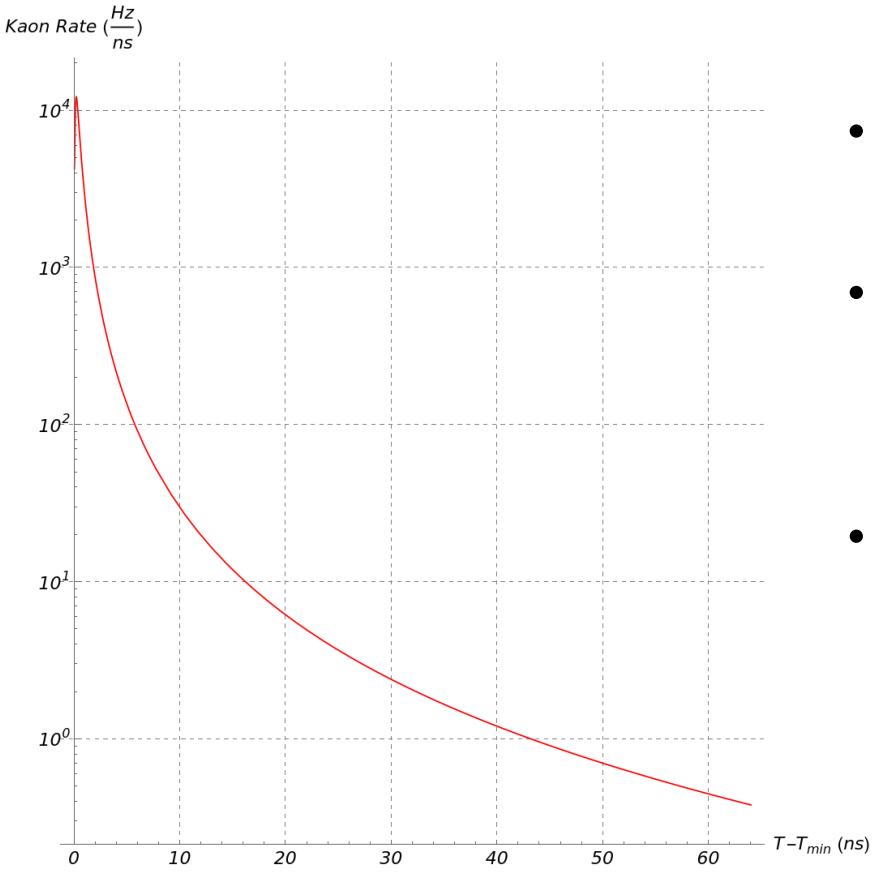
- Slow kaons take longer time to reach the LH_2 target
  - KLF needs less frequent beam bunch spacing for the K-longs to clear the distance between the targets.
  - For any beam bunch spacing there will be where the momentum of the beam Kaon cannot be trusted.
    - For the current design and 64ns bunches,

      P_{min} = 0.332 GeV

      W_{min}=1.498 GeV

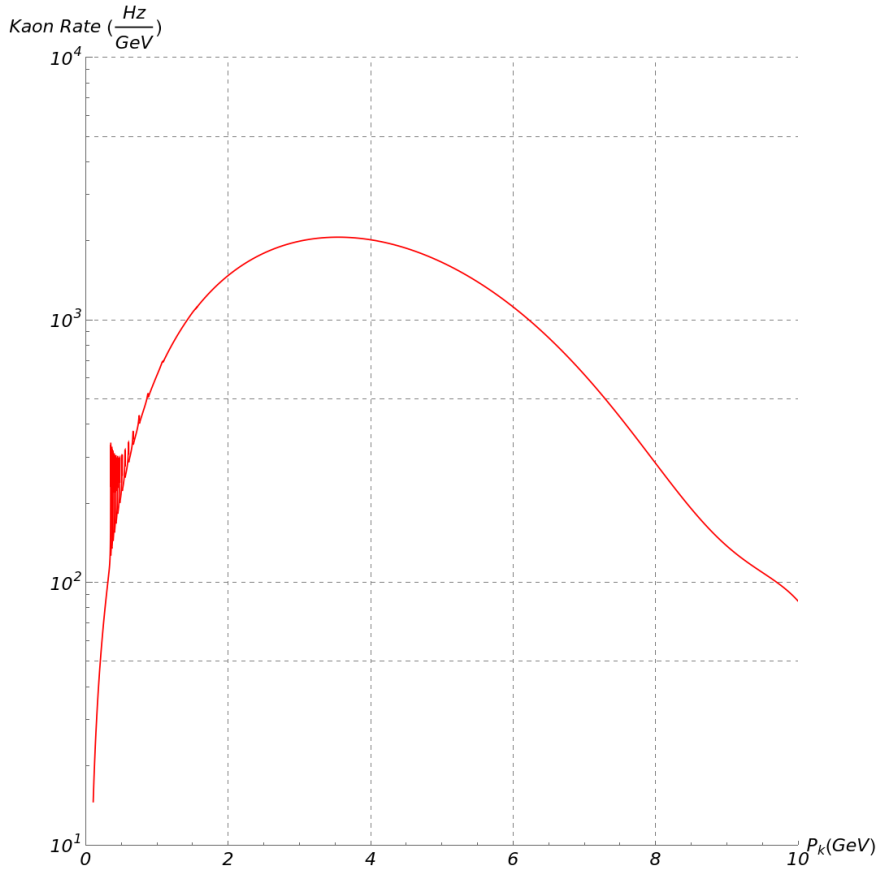
Assumed Beam Conditions

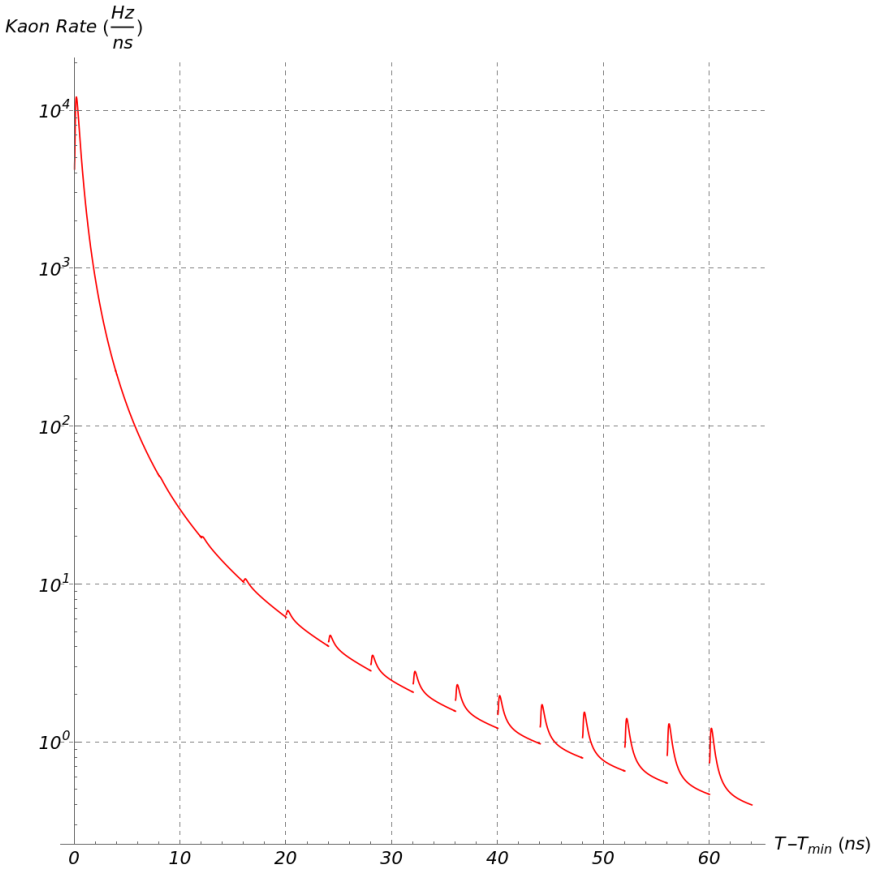




- Calculations are done analytically (numerically when necessary).
- Distance between LH_2 and KPT target centers L=23.9 m.
  - It takes a kaon with P_K=10GeV a T_{min}=80.7ns to travel between the two targets.
- Momentum spectrum is a fit to Ilya's spectrum. The total kaon rate is ~10 KHz.
- Assume 64ns KLF beam bunching, 4ns bleed-though bunching.
  - There are 15 bleed-through bunches within a single KLF bunch interval.
- Assume that there 5nA bleed-through from out-of-time bunches when we have 5μA beam with correct timing.
  - That is 0.1% background in the integral.
  - That is 0.006% for each individual peaks to the main peak.

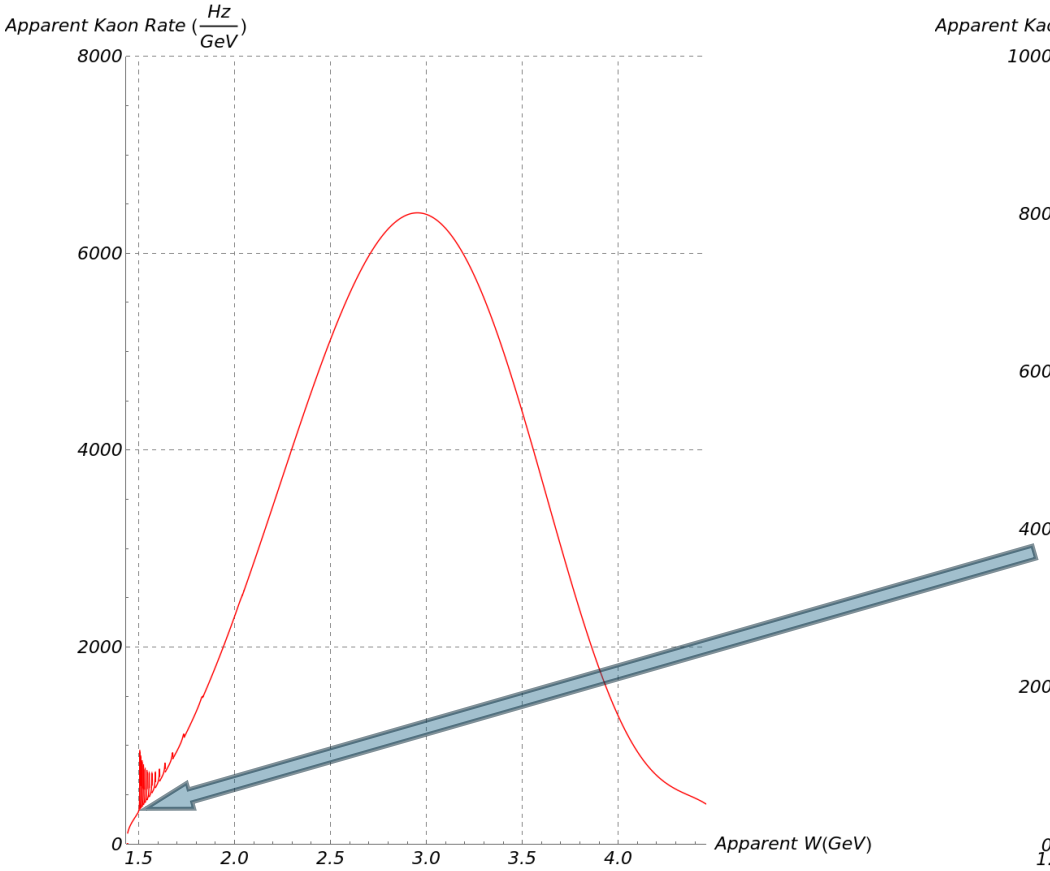
Apparent Reconstructed Spectra

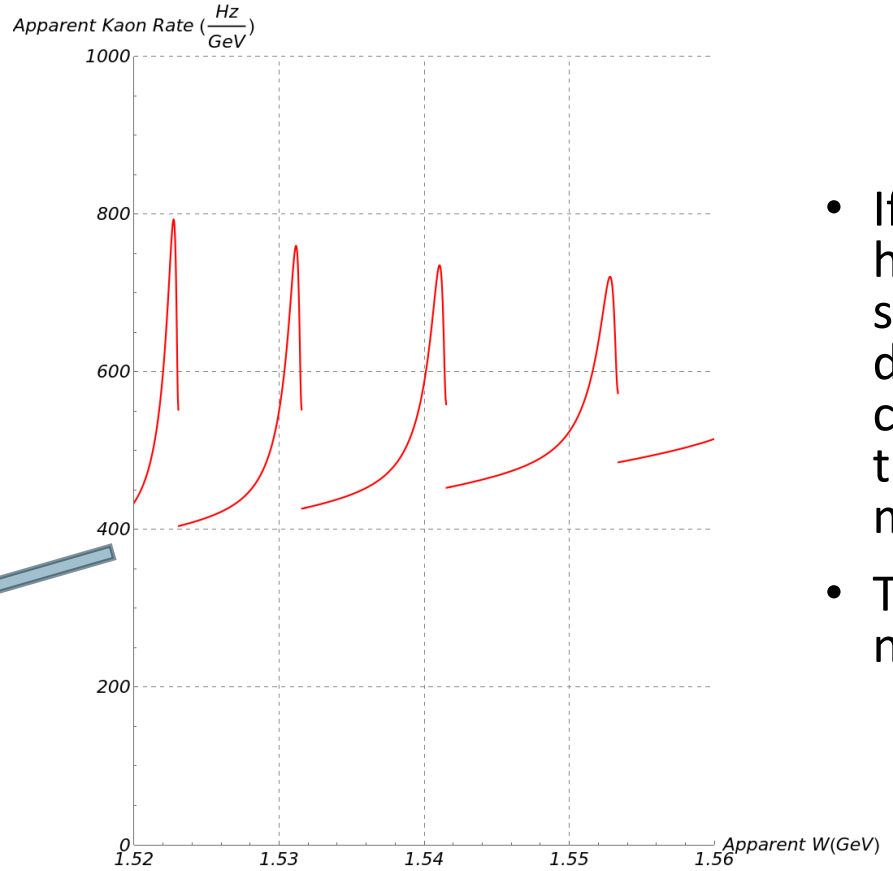




- The spectrum distortions happen only at lower apparent kaon momenta $P_K < 2$ GeV
  - Very narrow bumps
  - Taller bumps at lower momenta.
- The shape of the individual bleed-through peak is defined by the beam kaon momentum spectrum.
- The right-most peaks on the momentum spectrum (left-most peaks on the momentum spectrum) have more restricted true P_{min}.
- Timing resolution is not taken into account here.
  - Peaks will become lower but wider when timing resolution is included.

Apparent W-spectrum



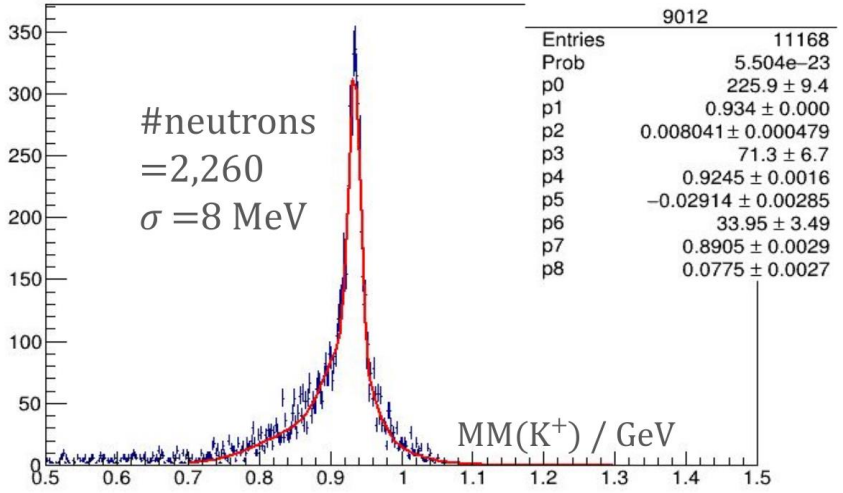


- The distortions happen only at lower apparent invariant mass W< 2.5 GeV
  - Very narrow bumps, ~1.5MeV.
  - Taller bumps at lower momenta.
  - At W=1.522 GeV, the peak height is similar to the level of the smooth distribution.
    - Depends on the true original kaon P-spectrum.
- If a physics reaction does not have strong background suppression procedure, the W-dependent background can cause false peaks because of these shifts in W and shifts in missing masses.
- Time resolutions were not included here.
  - These bumps will get wider when folding in time resolutions due to uncertainty in the KPT position and the intrinsic time resolution of the detector
    - extra contribution to the widths ranging from ~1 MeV at W=1.5 to ~20 MeV at W=2 MeV.

What to do?

- There has always been bleed-through beam in Hall D which could complications with PID in GlueX.
- KLF will be more sensitive to bleed-through as the beam energy is determined from the TOF of K_L-s.
- Bleed-through at the levels seen during GlueX (3nA) already could cause problems in the physics analyses at low invariant masses unless the event selection strongly rejects events from out-of-time beam bunches.
  - Even if there are cuts that are used to select events, like missing mass, the amount of the background and the shape of the background can be strongly affected by the events from the out-time-bunches causing false structures in W-spectrum.
- Some of the physics channels interested in low-W physics should study their physics channels as well the background channels that could populate their events when created by out-of-time bleed-through to determine the acceptable level of bleed-through.
- We need to specify to the accelerator division what level of bleed-through from out-of-time beam bunches KLF can tolerate.
  - Requesting to have less than 3 nA bleedthrough will likely require work on the accelerator side as all attempts to reduce it failed so far.

Example



Missing mass in $K_L\, p \longrightarrow K^+ n$ (by Vitaly)

- This spectrum may get backgrounds from other physics channels due to wrong beam energy reconstruction, with W-dependent shapes.
- Can cause artificial structures in the W-dependence of the K^+n yields.
- It could be very helpful to study the sensitivity of this channel to the bleed-through levels.