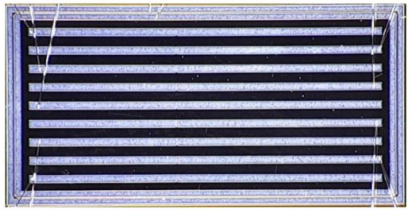
Luminosity Pair Spectrometer Data Rates

- The Pair Spectrometer has 2 detector components: Tracking planes + CALs
- The tracking plane readout granularity is finer than the CALs,
  so this focuses only on the tracking planes.

Dhevan Gangadharan & Nick Zachariou
DAQ meeting Feb 22 2024

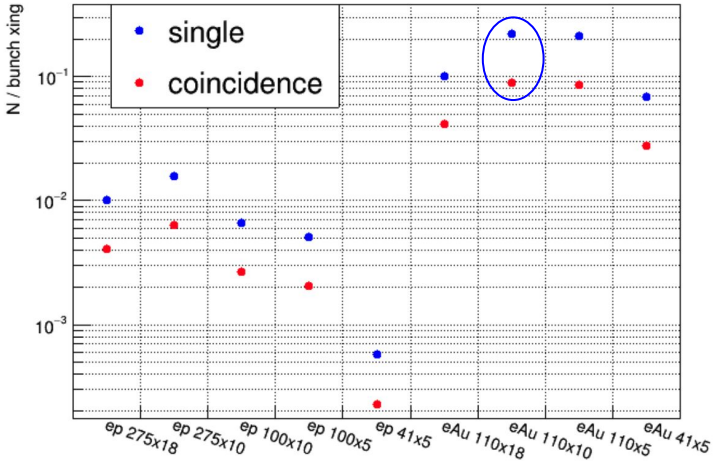
Pair Spectrometer Trackers - AC-LGAD strips

HPK Strip Sensor (4.5x10 mm²)

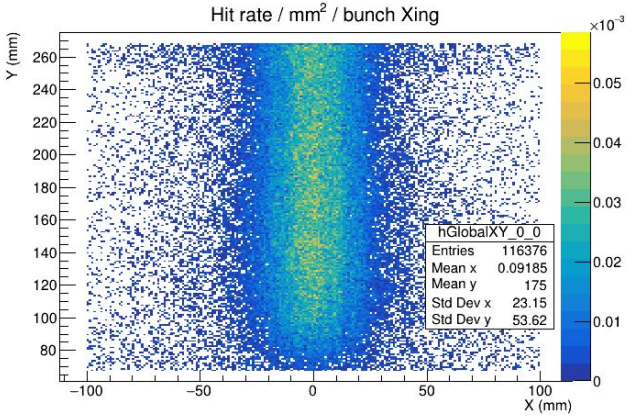


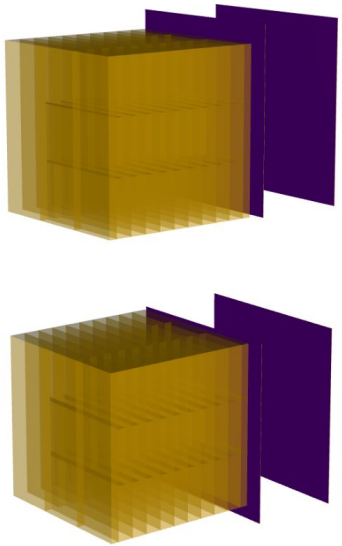
Strip pitch = 0.5 mm

Electron rates per bunch crossing



Tracker occupancy





e+

e-

Analyzer
B field

Each tracking layer:

- 20 cm x 20 cm –> 20*20 / (0.05*1) = 8000 strips (read out on 1 side)
- Average channel rate = 0.2 / 8000 / 10 nsec = **2.5 kHz**
- Peak channel rate (central 1 cm) ~ 0.2 / 400 / 10 nsec = **50 kHz**

Total Data Rate (peak bremsstrahlung in eA):

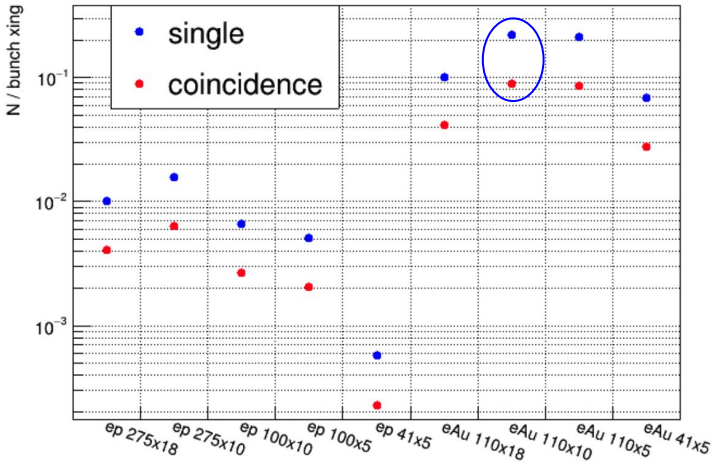
- Charge sharing ~ central strip + nearest neighbors = x3
- 8 layers in total (4 on top/bottom with alternating X/Y strip orientation)
- 2.5 kHz / channel * (8000 * 3 * 8 channels) * 32 bits = **15 Gb/sec**

Data Rate Reduction

15 Gbit/sec is a lot.

Need ways to “summarize” the data.

1. Only record coincidences at full lumi in eA: **x2 reduction.**

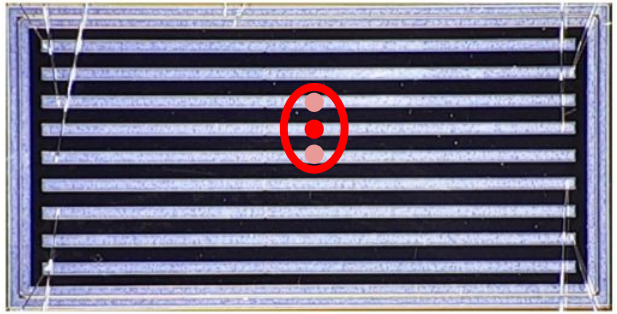


Data Rate Reduction

15 Gbit/sec is a lot.
Need ways to “summarize” the data.

1. Only record coincidences at full lumi in eA: **x2 reduction.**
2. Preprocess signals from clusters of strips and merge into single hits (charge sharing): **x3 reduction.**
   With this done, do we need 32 bits per “channel”? Just need a local X and Y coordinate
   Tracking plane is 20 cm wide. Expected pos res = 0.003 cm. 20 / 0.003 = 6666 divisions
   2^16 = 65536. Would a 16 bit word be enough?: **x2 reduction.**

HPK Strip Sensor (4.5x10 mm^2)



Data Rate Reduction

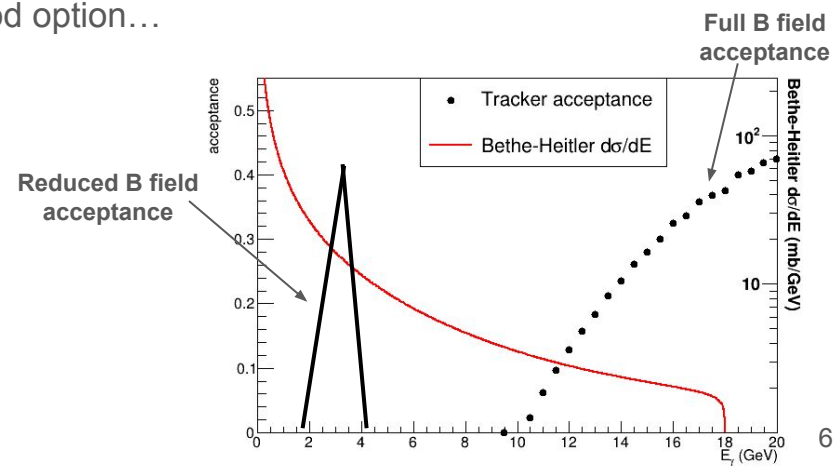
15 Gbit/sec is a lot.
Need ways to “summarize” the data.

1. Only record coincidences at full lumi in eA: **x2 reduction.**
2. Preprocess signals from clusters of strips and merge into single hits (charge sharing): **x3 reduction.**
   With this done, do we need 32 bits per “channel”? Just need a local X and Y coordinate
   Tracking plane is 20 cm wide. Expected pos res = 0.003 cm. 20 / 0.003 = 6666 divisions
   2^16 = 65536. Would a 16 bit word be enough?: **x2 reduction.**
3. Perform tracking in realtime and only store track parameters. 2 tracking planes per direction (X,Y oriented strips) requires consideration of all combinatorial pairs with tracking cuts.
   Potentially dangerous to only have this info (may need to tune cuts).

Data Rate Reduction

15 Gbit/sec is a lot.
Need ways to “summarize” the data.

1. Only record coincidences at full lumi in eA: **x2 reduction.**
2. Preprocess signals from clusters of strips and merge into single hits (charge sharing): **x3 reduction.**
   With this done, do we need 32 bits per “channel”? Just need a local X and Y coordinate
   Tracking plane is 20 cm wide. Expected pos res = 0.003 cm. 20 / 0.003 = 6666 divisions
   2^16 = 65536. Would a 16 bit word be enough?: **x2 reduction.**
3. Perform tracking in realtime and only store track parameters. 2 tracking planes per direction (X,Y oriented strips) requires consideration of all combinatorial pairs with tracking cuts.
   Potentially dangerous to only have this info (may need to tune cuts).
4. Lower our analyzer B field → squeezes acceptance to a narrow region at low Eɣ. However, the CAL E resolution is much worse there: 10% / sqrt(E). Not a good option…



Data Rate Reduction

15 Gbit/sec is a lot.
Need ways to “summarize” the data.

1. Only record coincidences at full lumi in eA: **x2 reduction.**
2. Preprocess signals from clusters of strips and merge into single hits (charge sharing): **x3 reduction.**
   With this done, do we need 32 bits per “channel”? Just need a local X and Y coordinate
   Tracking plane is 20 cm wide. Expected pos res = 0.003 cm. 20 / 0.003 = 6666 divisions
   2^16 = 65536. Would a 16 bit word be enough?: **x2 reduction.**
3. Perform tracking in realtime and only store track parameters. 2 tracking planes per direction (X,Y oriented strips) requires consideration of all combinatorial pairs with tracking cuts.
   Potentially dangerous to only have this info (may need to tune cuts).
4. Lower our analyzer B field → squeezes acceptance to a narrow region at low E_γ. However, the CAL E resolution is much worse there: 10% / sqrt(E). Not a good option...

With options 1 and 2 we have a x12 reduction.
Is this reasonably achievable?
Is 15 Gb/sec / 12 = **1.25 Gb/sec** low enough?