

New Level 1 Track Triggers

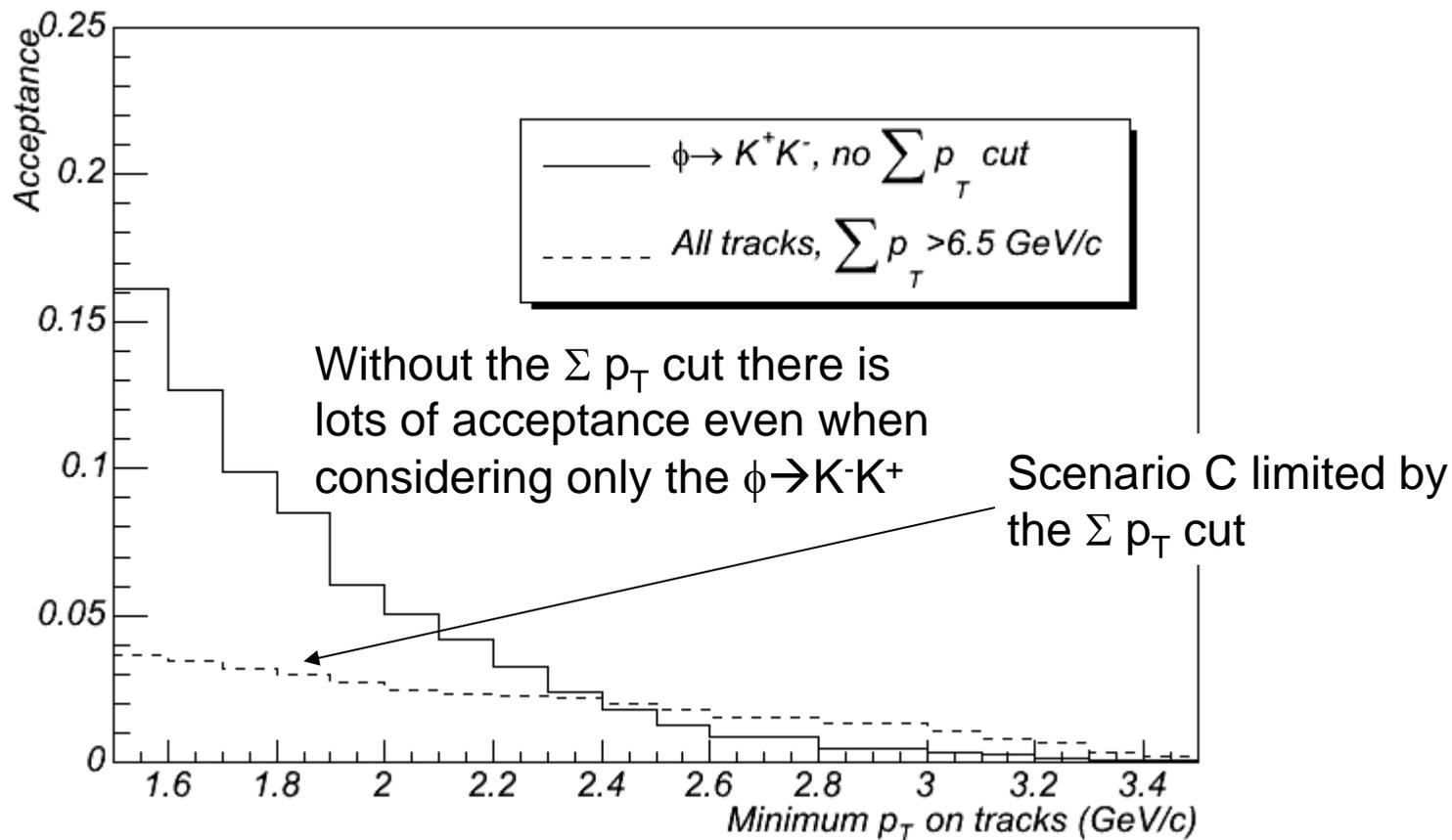
- Outputs from SLAM provide lists of axial tracks plus associated stereo information
- Consider new Level 1 track triggers fed by the SLAM outputs, in addition to existing trigger hardware
- Concentrate on dedicated $\phi \rightarrow K^+K^-$ trigger
 - Compare efficiency and level 1 rate relative to a modified Scenario C trigger
 - Conceptual implementation design

Trigger Efficiency

- What offline criteria to use?
 - Can't study with data since current triggers have higher thresholds
 - First attempt with 4 offline tracks with $p_T > 1$ GeV/c, ≥ 20 COT hits, ≥ 3 Si r- ϕ hits.
 - Presumably would end up with worse S/N than B^0_s reconstructed in Scenario C trigger
- Compare efficiency with modified Scenario C (SLAM confirmation, $90^\circ \Delta\phi_6$ cut and $m_T < 4$ GeV/c²)

Trigger Efficiency

- Basic efficiency comparison:



Basic ϕ -trigger Implementation

- Start with [Jim/Vivek's criteria](#):
 - $1.5 < p_T < 5$ GeV/c on both tracks
 - Opposite charge
 - $2.5^\circ < \Delta\phi_6 < 25^\circ$
 - $\Delta\phi_0 < 10^\circ$
 - $m_T(\pi^+\pi^-) < 0.3$ GeV/c²
 - $|\Delta z_7| < 34$ cm (sort of)
 - SLAM confirmation on both tracks
- Use [CMU's](#) MC samples of $B_s^0 \rightarrow D_s^- \pi^+$ decays to evaluate efficiency. mj2
- $\epsilon(\phi \rightarrow K^- K^+)/\epsilon(\text{Scen. C}') = 6.4 \pm 0.1$

Slide 4

mj2

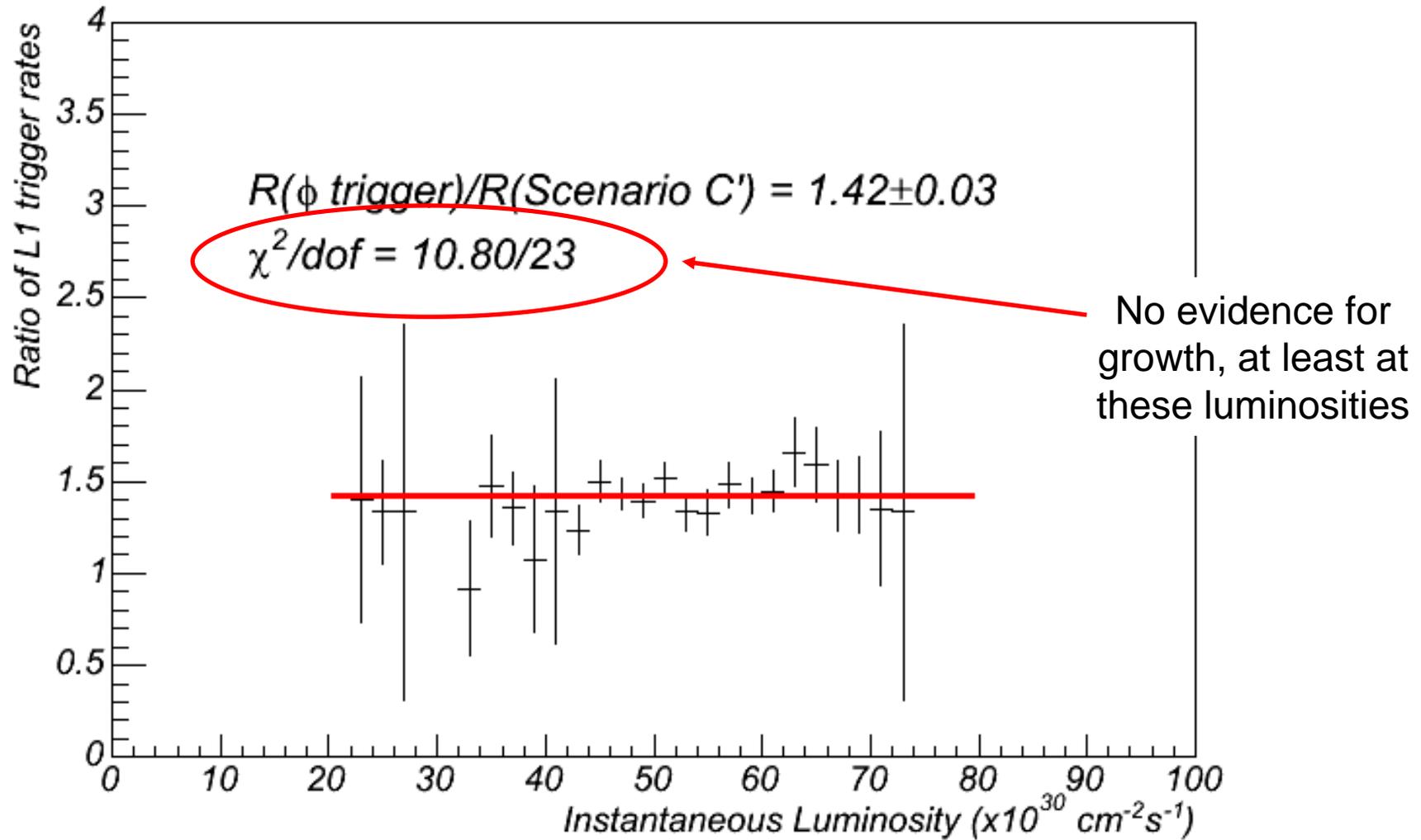
Carnegie Mellon University... not Central MUon!

Matthew Jones, 12/12/2005

Trigger Rate Estimates

- Apply basic $\varphi \rightarrow K^-K^+$ criteria
- Use low p_T two-track trigger test data to determine level 1 rate
- Test run was dynamically prescaled and rate limited – only compare rate relative to modified Scenario C trigger.
- Use this ratio and extrapolations of modified Scenario C rate at high luminosity to estimate level 1 rate from $\varphi \rightarrow K^-K^+$ trigger.

Rate Estimates



Projected Trigger Rates

- Assuming we prescale or apply other criteria to achieve the same level 1 rate, the increase in acceptance is increased by a factor of $6.4/1.4 = 4.6$
- In practice, we want to apply other criteria, like a third track within 90°
- Attempting to quantify this using existing samples

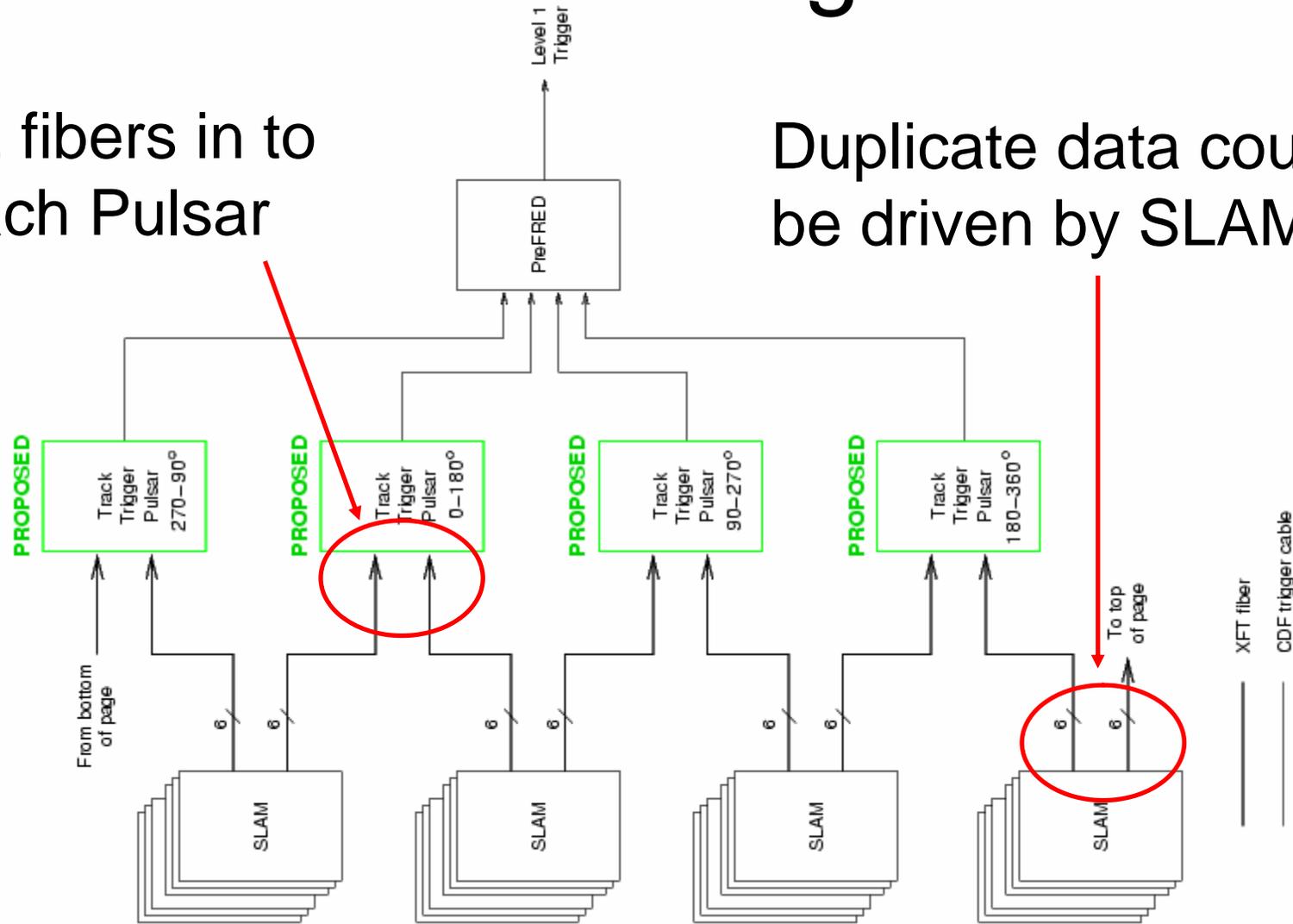
Implementation

- Consider multi-track correlations only within 90° in phi
 - Requires 4 overlapping regions of 180°
 - Each implemented using a Pulsar module
- Best use of stereo information is estimate of z at superlayer 7 encoded in 16 bits.
- Target specific decay topologies rather than arbitrarily configurable trigger cuts for any n-track combination.

Hardware Configuration

12 fibers in to each Pulsar

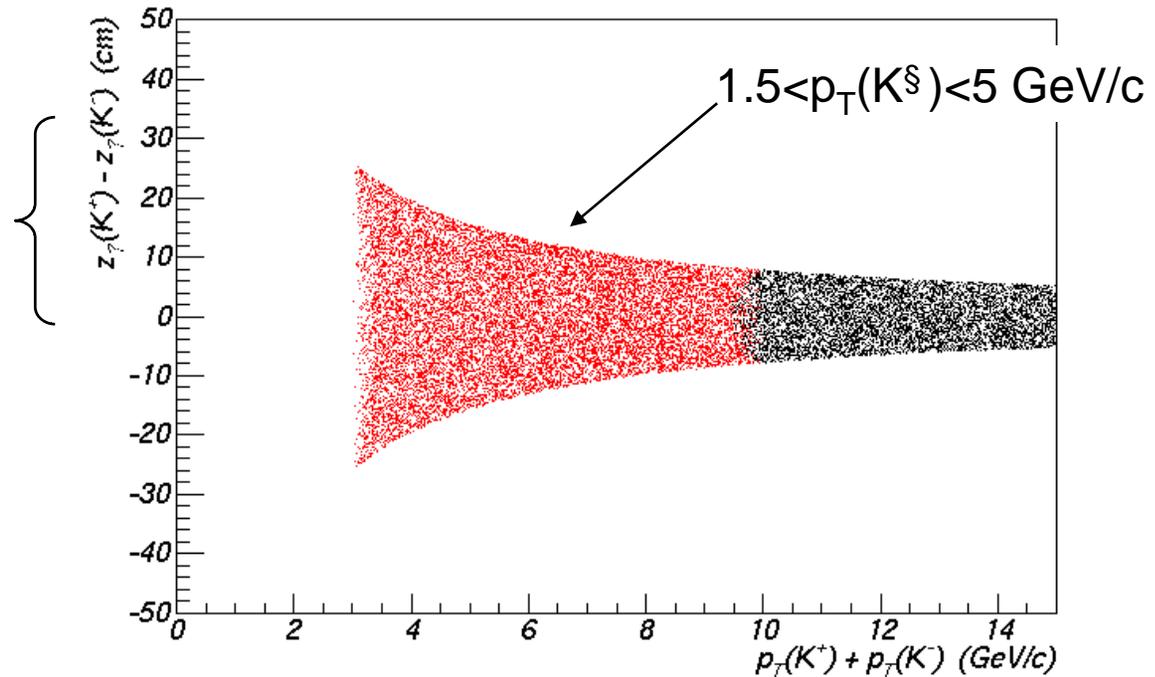
Duplicate data could be driven by SLAM



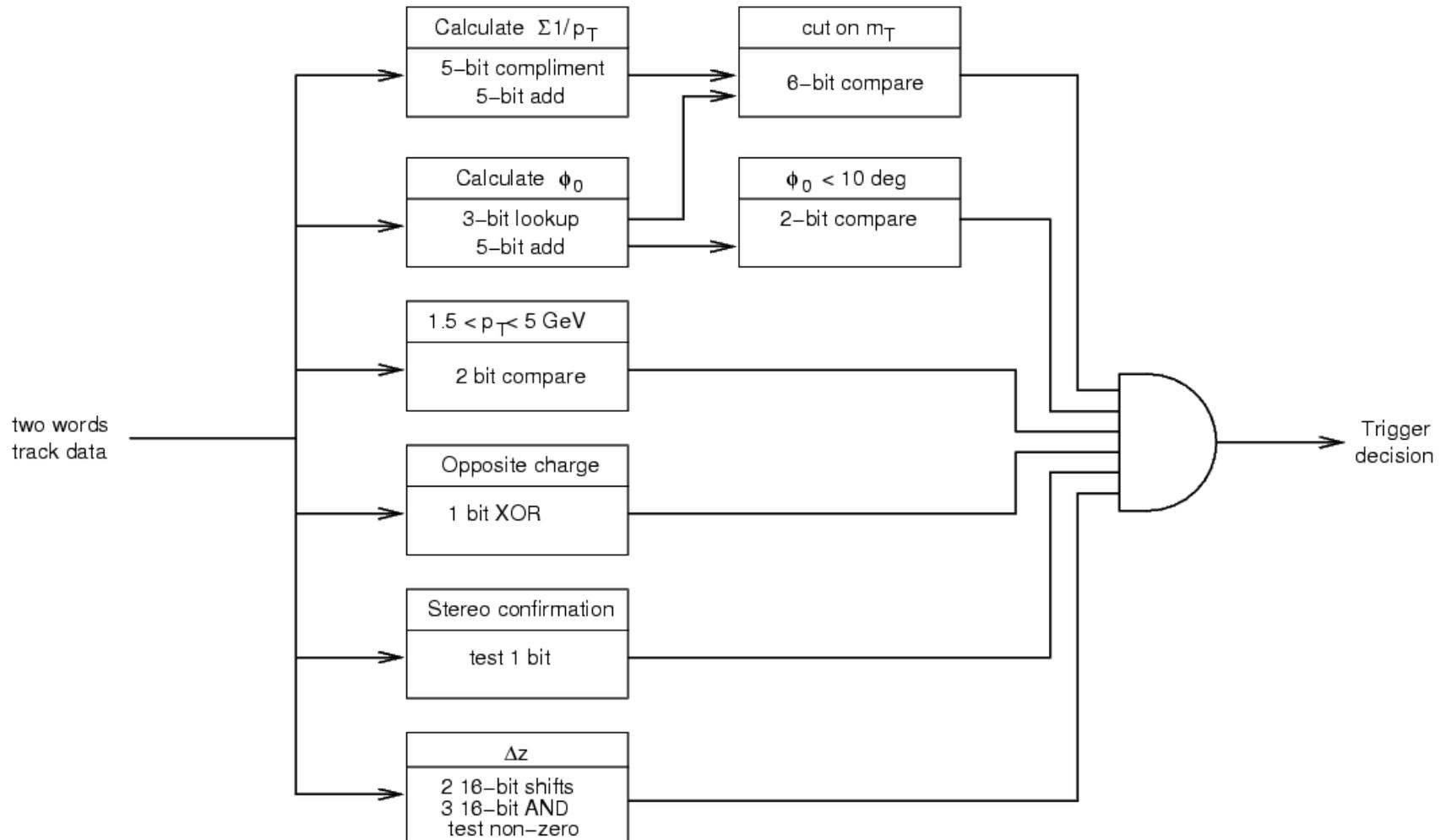
Use of z Information from SLAM

- Divide 300 cm length into 18 equal bins.
- Encode with 16 bits by merging first and last bin
– resolution is $\sim \frac{(17 \text{ cm})}{\sqrt{12}}$

2 bins will be fully efficient for $\phi \rightarrow K^+K^-$



Possible Logic Implementation (1)

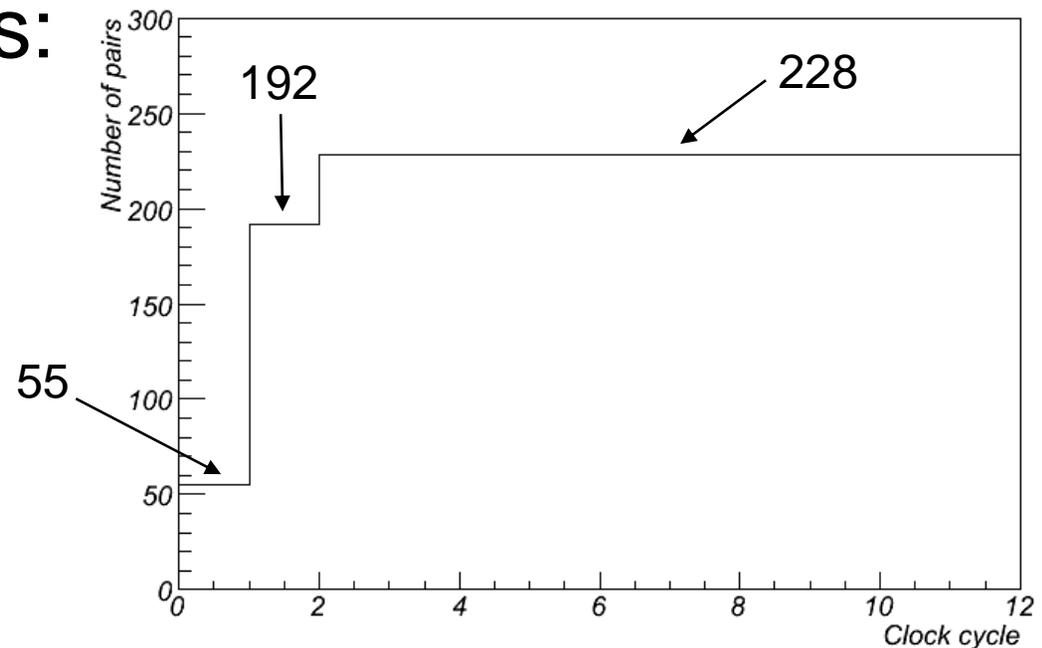


Possible Logic Implementation (1)

- Operations on a pair of tracks can be very fast:
 - Opposite charge: 1 bit XOR
 - Δz cut: 2 shifts, 3 AND, test non-zero (16 bits)
 - Stereo confirmation: test 1 bit
 - $1.52 < p_T < 5.18$ GeV/c: 5-bit compare (alternatively $1.52 < p_T < 5.81$ GeV/c: test 1 bit)
 - Calculate φ_0 : 3-bit lookup, 5-bit add
 - $\Delta\varphi_0 < 10^\circ$: 2-bit compare
 - Calculate $\Sigma 1/p_T$: 5-bit compliment, 5-bit add
 - Calculate “ m_T ”: 6-bit compare (cut on $\Delta\varphi_0$ as a function of $\Sigma 1/p_T$)

Possible Implementation (1)

- The $\Delta\phi_6$ cuts are implemented by the pair sequencing
- 12 track words received every 16.5 ns
- Number of pairs:



Possible Implementation (2)

- If it takes more than 16.5 ns to process one pair, use a pipeline architecture:
 - Process 456 pairs in 33 ns
 - Process 684 pairs in 49.5 ns
 - etc...
- Number of logic elements required seems reasonable...
 - Need to measure timing
 - Need to refine resource estimates
 - Routing of pairs to logic elements might be tricky
 - Additional constraints from connectivity on Pulsar

Final Trigger Output

- Count number of φ candidates in 15 degree wedges
 - Count number of tracks in φ candidate above p_T threshold(s)
- Count tracks with p_T above threshold(s) in each 15 degree wedge
- Form correlations
 - φ +track (reduce rate)
 - φ + φ trigger (targeting $B_s \rightarrow \varphi\varphi$, $B_{d,s} \rightarrow D_s^- D_s^+$)

Next

- Need more TEST_TWO_TRK1.5 triggers
 - Run 205929 had L1 rate of 22 kHz at a luminosity of $50 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$
 - Fixed prescale by about 500 should work at least up to $100 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$
- Would benefit from more Monte Carlo
 - Jim has provided about 20k events, more would be useful
- Need to sort out problems with XFTSim
- 3-track rates and efficiencies
- Related to SF segment finding [efficiency studies](#).

Next

- Planning the firmware would benefit from
 - Timing/resources required by elementary logic operations (Ryan?)
 - Essentially the same input logic as Level 2 interface Pulsars
 - Should get at least 2 Pulsars in a test stand that can be dedicated to this work (Purdue/Wilson Hall/B0?)

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