Level 1 $\varphi \rightarrow K^+K^-$ trigger

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(with valuable input from others - apologies to those not explicitly listed)

Physics Motivation

- Level 1 rates for Scenario C based triggers will be too high at luminosities above 10^{32} $cm^{-2}s^{-1}$
- Acceptance limited by p_T and Σp_T cuts
- Proposal:
  - Reduce thresholds to increase acceptance
  - Identify $\varphi \rightarrow K^+K^-$ decay topology to control level 1 trigger rate
- Will improve yields of several B decays:
  - Not only $B^0_s \rightarrow D_s^-\pi^+$, $D_s^- \rightarrow \varphi\pi^-$, but also
  - $B^0_s \rightarrow \varphi\varphi$, $B^+ \rightarrow \varphi K^+$, $B^0_s \rightarrow J/\psi\ \varphi$

Bottom Line

- Physics impact is significant but not overwhelming
- Would improve existing analyses
- Technically feasible: could implement it if there was the desire to do so
- Minimal hardware resources

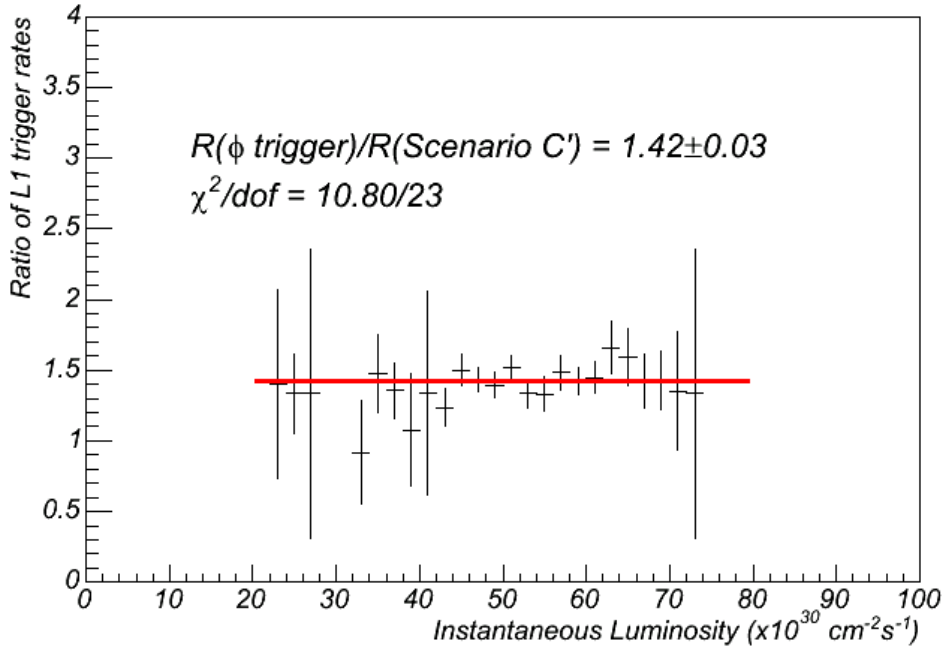
However:

- Less interesting than if, say, $\Delta m_s \sim 30\ ps^{-1}$
- Physics impact might still be optimistic
- Limited manpower may be better used elsewhere

We have decided not to pursue this upgrade at this time.

Physics Motivation

- Original studies done by Jim/Vivek
  - Specified offline cuts that could be applied at Level 1 that are efficient for $\varphi \rightarrow K^- K^+$:
- $\varepsilon(\varphi \rightarrow K^- K^+)/\varepsilon(\text{Scen. C'}) = 6.4 \pm 0.1$
- No evidence for rate growth based on 1.5 GeV two-track test runs
- Control rates further with 3rd track



More Recent 3-track Studies

- Main points from note 8404:
  - Even without stereo information, you can improve B trigger purity
  - Yields of B decays are improved
- Caveats:
  - Projections might still be optimistic
    - XFT, SVT turn on curves
    - Offline cuts needed to extract signals
  - Most of the gain is at high luminosity ($>10^{32}$)
  - Scenario A and Scenario Low are relatively efficient at low luminosity
  - Other ways to improve the existing trigger (eg., reduced SVT p_T thresholds)

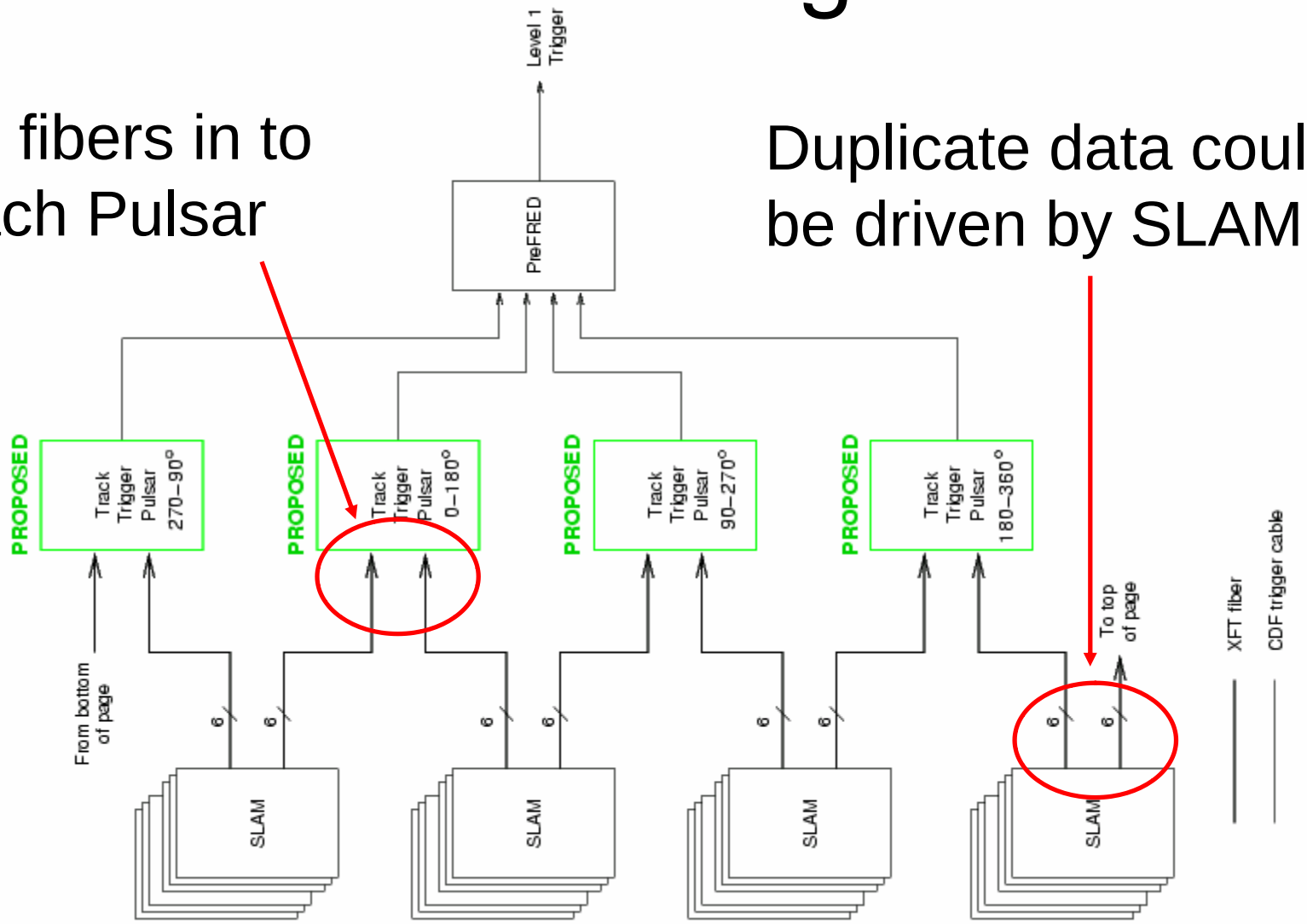
Proposed Implementation

- Axial tracks + stereo information provided on 2 of the 3 SLAM outputs
- Restrict triggers to tracks within 90^o in φ
- Requires 4 Pulsar boards, each covering overlapping regions of 180^o
- Each needs 3 (actually 4) RX mezzanine boards
- Outputs:
  - $\varphi \rightarrow K^+K^-$ trigger
  - $\varphi \rightarrow K^+K^-$+track trigger
  - $\varphi \rightarrow K^+K^-$ multiplicity trigger

Hardware Configuration

12 fibers in to each Pulsar

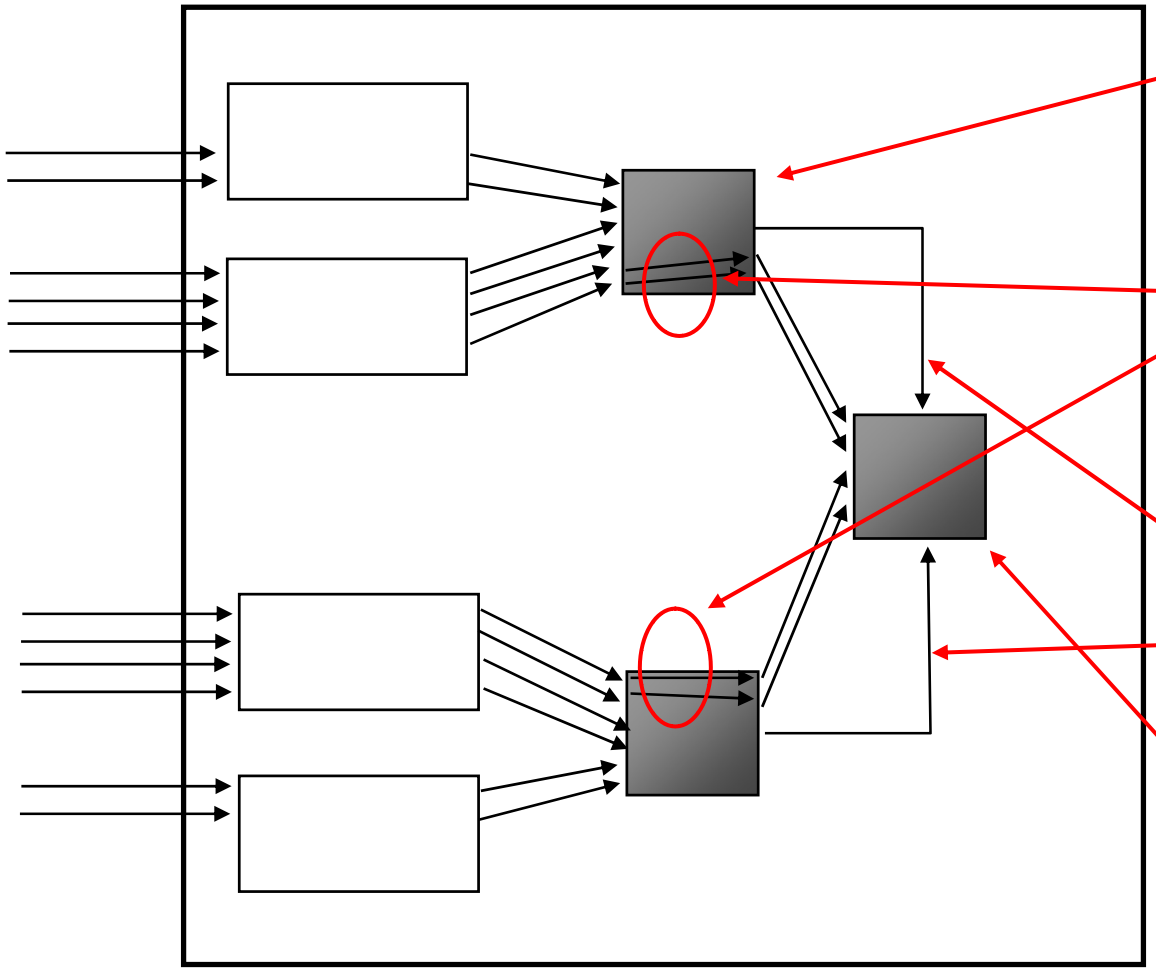
Duplicate data could be driven by SLAM



Timing Budget

- Specified to be same as XTRP path
- First output data from LOM until trigger decision ready to be sent to pre-fred is 967 ns (7.3 CDF_CLK cycles)
- Presumably, some will be taken to serialize/de-serialize/align track data
- Preliminary designs indicate that no fundamental timing limitation exists

Data Flow on Pulsar



Track pair sequencing and φ trigger logic

Data from two fibers passed through to control FPGA

phi/track per 15 degree wedge

global trigger logic: phi, phi+track, n-phi

Firmware Implementation

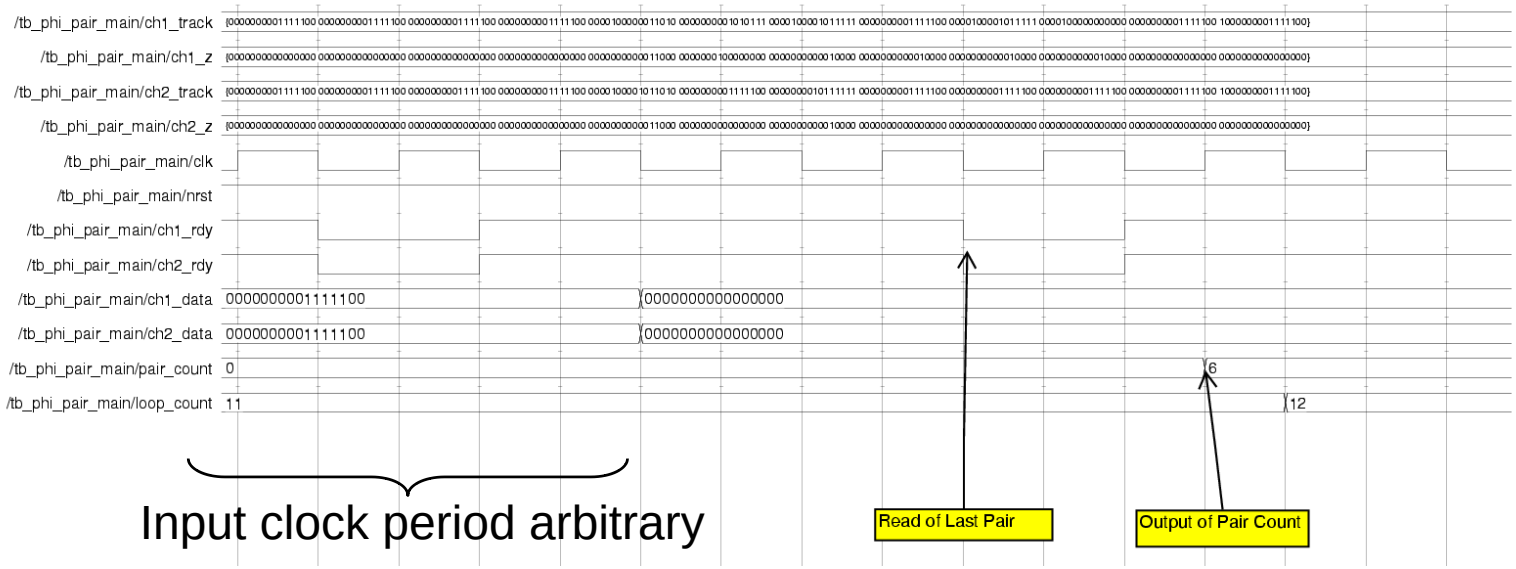
- Combinatorial logic does not appear to be a problem:
  - Problem of routing data to form all possible pairs of tracks handed off to Altera compiler
  - Uses 40% of chip resources (double for pipeline)
  - Latency is about 100 ns after data is loaded
  - This was one of the biggest open question
- More work needed:
  - Adding the third track
  - Need a first order implementation of complete system
  - Some adjustments may be needed to make it fit

Timing/Resource Usage

Flow Status	Successful - Tue Jul 25 21:39:45 2006
Quartus II Version	4.1 Build 181 06/29/2004 SJ Full Version
Revision Name	phitriger
Top-level Entity Name	Phi_Pair_Main
Family	APEX20K
Device	EP20K400BC652-1XV
Timing Models	Production
Total logic elements	1,507 / 16,640 (9 %)
Total pins	52 / 502 (10 %)
Total memory bits	0 / 212,992 (0 %)
Total PLLs	0 / 1 (0 %)

Full implementation needs 4 instances (36%)

~100 ns to process all pairs



People Resources

- Purdue:
  - Matthew, Gene (firmware, commissioning)
  - Some engineering support (Brunjes)
- UIUC:
  - Kevin, Greg, Ben (algorithms)
  - Some engineering support (Ryan)
- Other:
  - Pre-fred firmware (Carla)
  - fibers, cables

Assumptions

1. SLAM produces track list according to specification
   - Z at SL6 probably limited to 8 bits
2. SVT will support patterns for tracks with p_T down to 1.5 GeV/c
3. Level 1 trigger bits are available (probably need 3)
4. Pre-Fred firmware can be reprogrammed

Hardware Requirements

- Proposed trigger hardware:
  - 4 Pulsar modules
  - 12 (more likely 16) RX mezzanine boards (in hand)
  - 48 fibers from SLAM to Pulsars (cost: few k$)
  - Output trigger cables (cost: < 1k$)
  - Crate (space already allocated on 1st floor)
- Development resources at Purdue:
  - 2 Pulsars
  - 4 RX+4 TX mezzanine boards (in hand)
  - 12 fibers
- Development resources at Fermilab:
  - Same

Summary

- Perceived benefits:
  - Increased yields of interesting B decays
  - Parasitic commissioning
  - Minimal impact on activities in physics groups
- Main reasons not to do it:
  - Lack of any overwhelming physics argument
  - Limited manpower resources could have bigger impact elsewhere