Thoughts on Trigger Design Plan September 2010

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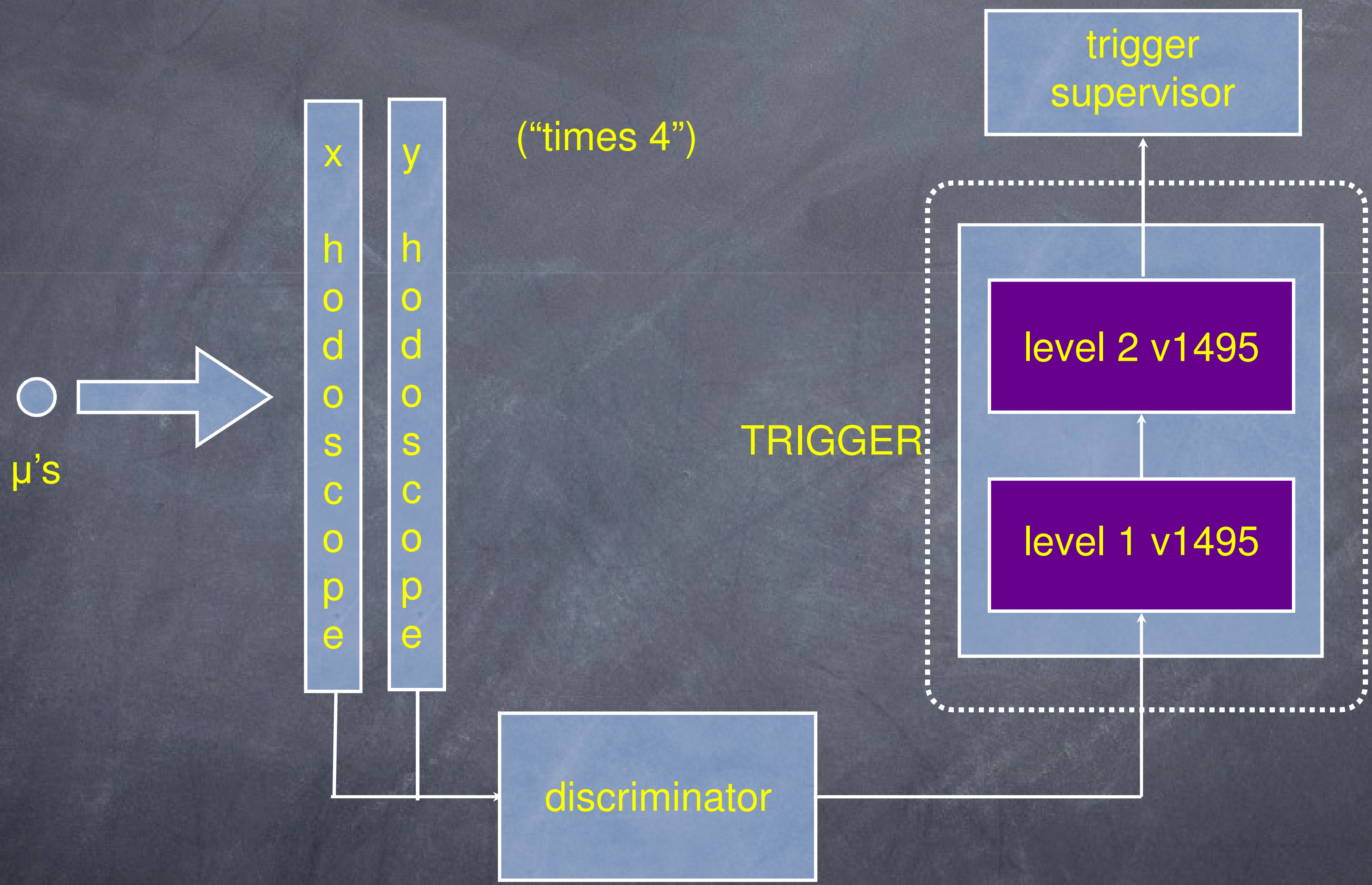
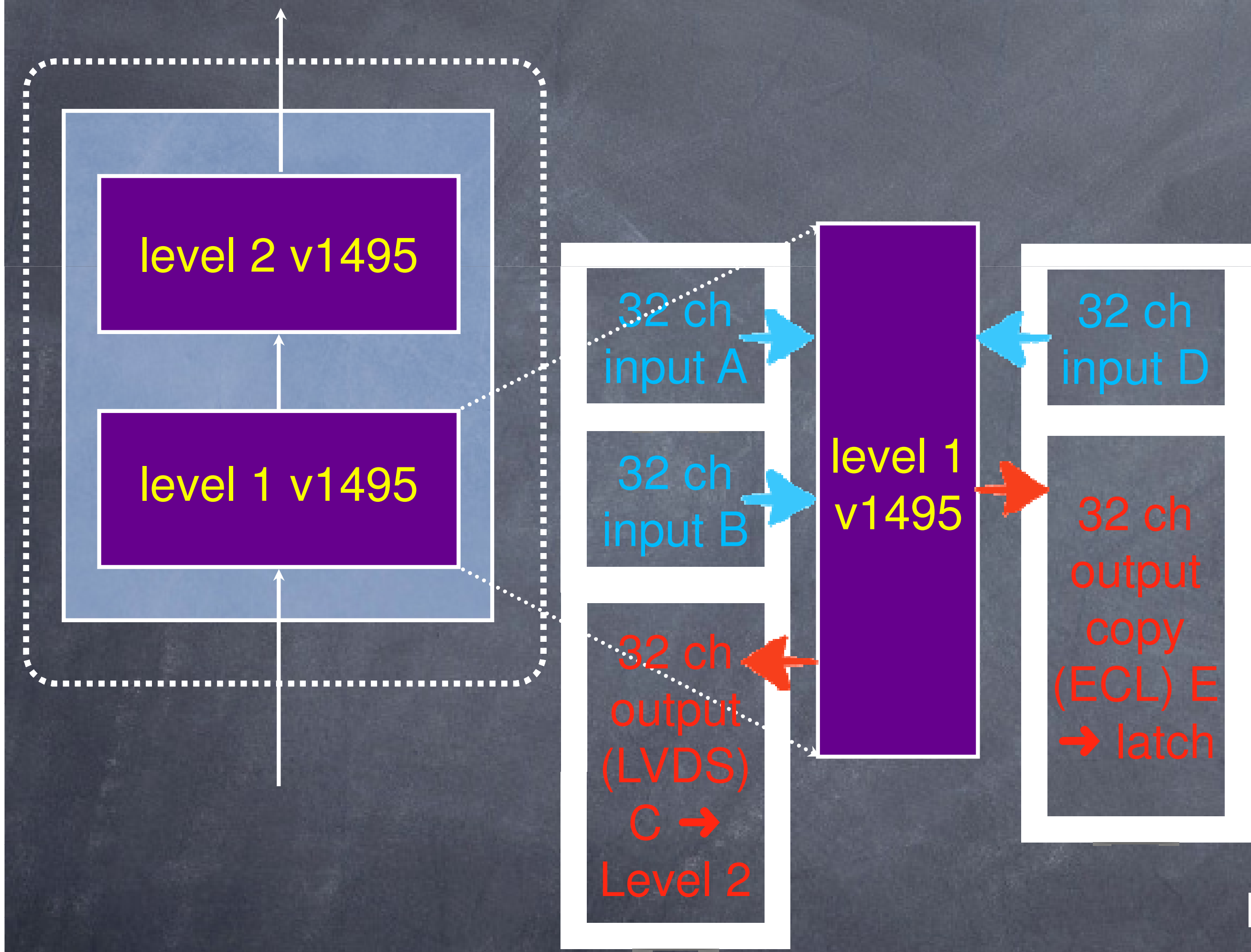
Basic plan for trigger:
high efficiency / selectivity for primary trigger: high p_T opposite sign muon pairs
identification of J/psi → $\mu^+\mu^-$ pairs for prescaling
prescaled readout of other muon pairs
prescaled readout of single track events
prescaled readout of other trigger types

Electronics Overview



Level 1 v1495 I/O



Up to 5*32+2=160 inputs with 32 outputs.

Input signals can be LVDS/ECL/PECL. Built-in output is LVDS only, except for 2 NIM/TTL channels and optional 32 channel A395C ECL card.

The v1495 can operate in synchronous or asynchronous mode.

We had a plan for synchronous mode, sampling inputs in time with the 53 MHz beam RF.

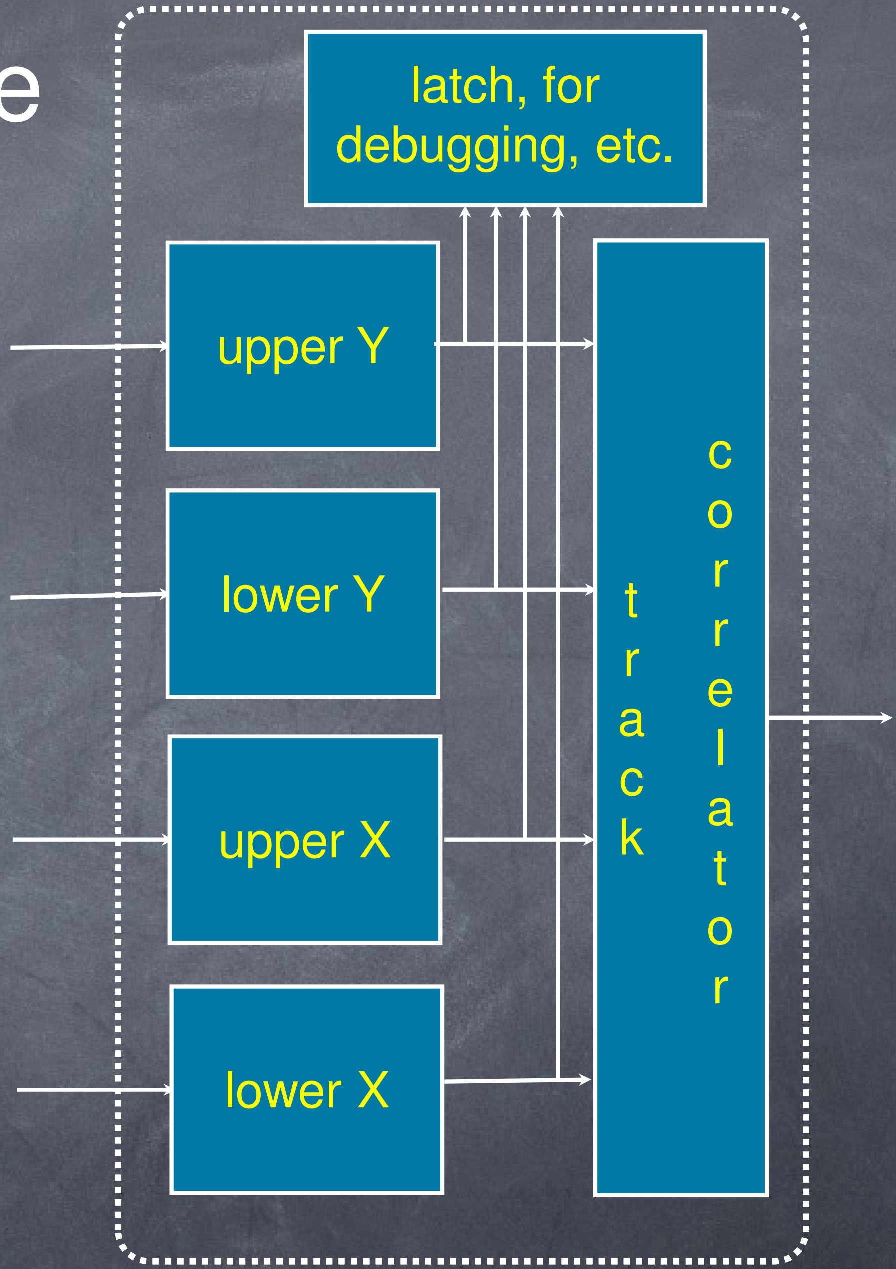
Now planning on asynchronous mode, using internal clock and PLL to sample inputs at 1 GHz. Will need to retime trigger with RF before going to readout electronics.

Note hodoscope signals vary by up to ≈±9 ns due to scintillator length, and can have 10s of ns offsets between different elements. Code worked out to set offsets in v1495.

Minimum overlap of input signals needs to be determined?

v1495 Trigger Architecture

- Treating multiple scattering as small, individual tracks go into either top or bottom of detectors, but do not cross over. The vertical B field can move them between left & right quadrants
- A few thousand of the ~20k logic elements in each v1495 are typically sufficient to do all tracking in one direction for 1/2 of detector, so 4 level 1 FPGAs will find tracks in upper Y's, upper X's, lower Y's, lower X's
- Leads to horizontal, high-rate plane loss of trigger efficiency, but maybe no vertical plane loss of trigger efficiency (more on this later)
- 5th, 2nd level FPGA is a track correlator, we will also have a 6th FPGA as a spare (currently at JLab)

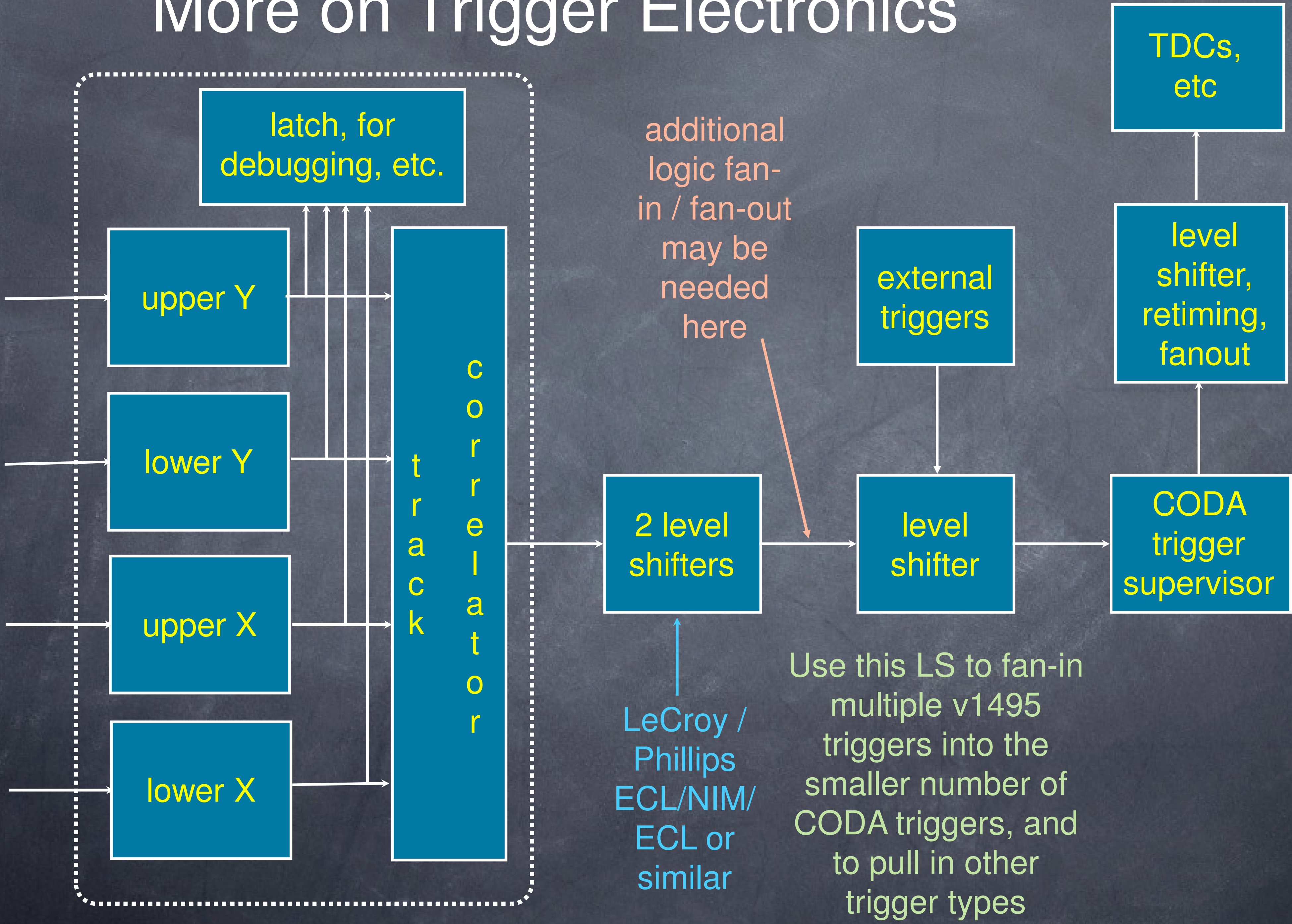


(40+38+32+32)/2 = 71 Y inputs

(46+32+32+32)/2 = 71 X inputs

One optional input card needed per 1st level v1495

More on Trigger Electronics



Y input to Track Correlator

- Track correlator (TC) can only have 32 bits input from each 1st level FPGAs, so 4*32 = 128 inputs and 2*32=64 outputs.
- In y direction, use 3 of 4 tracking to give 16 bits indicating y at last plane. This leaves 32-16=16 spare bits.
  - If 4 hits, all 4 found tracks probably lead to same 4th-plane bit set, but particularly in case of hitting overlapping paddles in the same plane, it may look like two tracks hit adjacent paddles in last plane (1 mm / 7 cm effect?).
- Spare bits proposal (from D Christian): 3 bit hit multiplicities for each of 4 planes, 4 bits unused
- Initial low luminosity data or prior knowledge needed to be smart about other 1st-level input to TC

X Input to Track Correlator

- X direction measures (ignoring multiple scattering) curved tracks, indicating angle and momentum, or $p_{Tx} = p \sin\theta_x$
- 23+16+16+16 paddles in each X half
- No easy way to encode (correlation of) > 1 of the 3 variables, if multiple tracks
- Encoding p_{Tx} is sufficient for tracks scattered close to horizontal
- p_{Ty} usefulness remains uncertain, but for single tracks scattered in vertical direction, $p_{Tx} \approx 0$, so also encoding p will along TC to find high vertical p_T

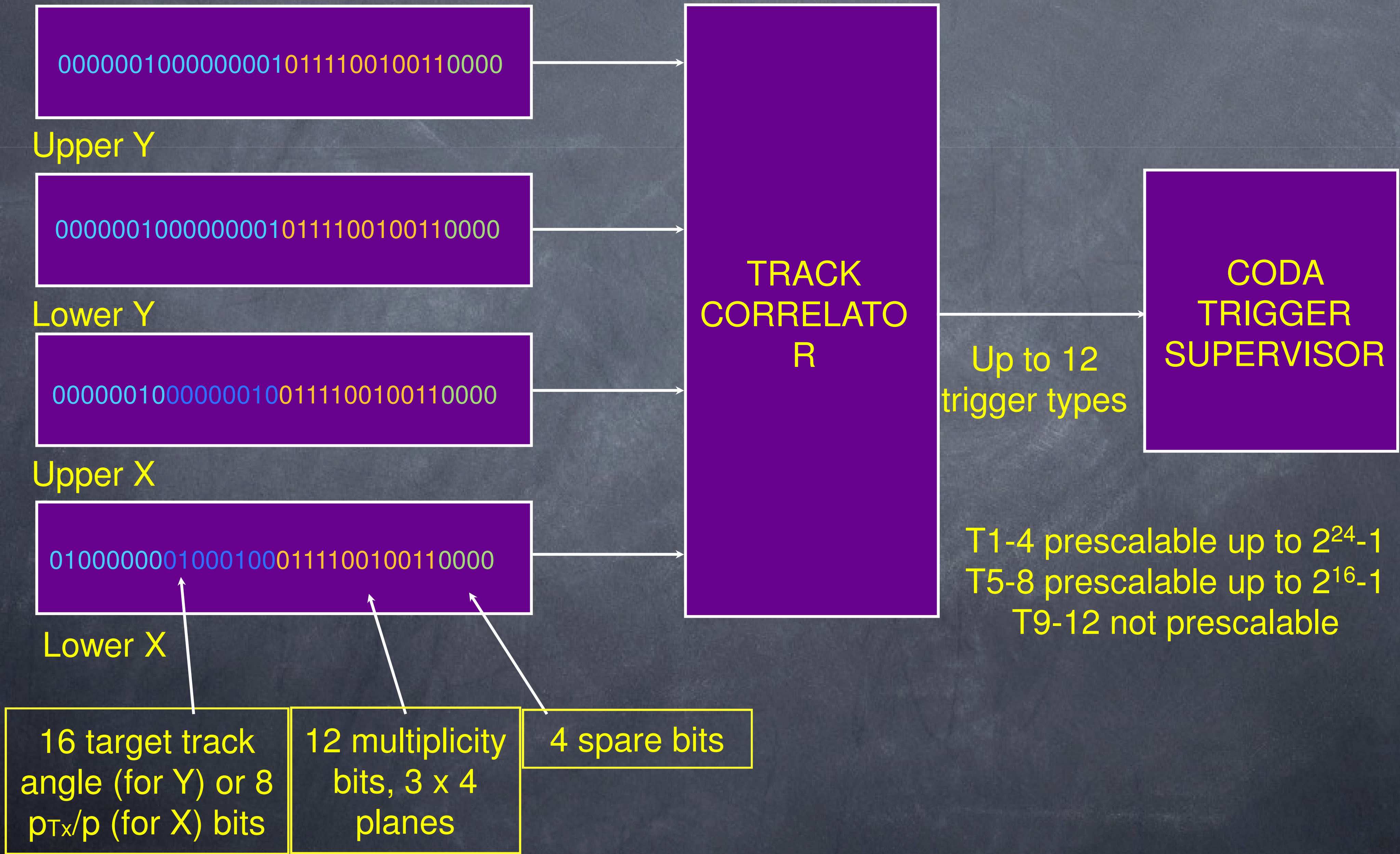
X Bits Input to Track Correlator

- D Christian proposed 20 bits (10+, 10-) for p_{Tx} (probably too many) and 12 bits to give 3-bit multiplicities per plane
  - C Brown points out resolution poor at trigger level for p_{Tx}, and have only a few triggers so only need a few p_{Tx} bins - 8 bits (4+, 4-) proposed, probably bins of 0.5-1 GeV/c, 1-1.5 GeV/c, 1.5-2 GeV/c, and >2 GeV/c (MC needed to check if these ranges are correct)
  - RG suggests using 8 bits to also encode momentum (4+, 4-) for possible use in p_{Ty} trigger
  - 8 bits p_{Tx} + 8 bits p + 12 bits multiplicity leaves 4 spare bits

Are multiple tracks common?

- In reality, I don't know - they can be random or real.
- Assume 5 MHz random singles per scintillator (probably cannot run much hotter than this), 20 ns trigger resolving time. ⇒ 20 ns / 200 ns = 10% random hits, or 1-2 random hits per plane. Leads to of order 50% chance of random track in trigger matrix (MC needed!) or apparent two track event
- Indications of order MHz rate of low p_T single tracks from dump, with about 10% making 3/4 track triggers

Track Correlator Logic



Possible Trigger types

- Triggers to read in with prescale = 1:
  - Start of spill
  - End of spill
  - Scaler? (pulser?)
  - High p_{Tx} opposite-sign muon pair, > 2.5 GeV total (MC needed to check 2.5 as limit)

Possible Trigger types

- Triggers to read in with small prescale (or at several hundred Hz total?)
  - Medium p_{Tx} opposite-sign muon pair, 2.0 - 2.5 GeV total
  - High p_{Tx} same-sign muon pair, > 2.5 GeV total

Possible Trigger types

- Triggers to read in with large prescale (or at few hundred Hz total?)
  - Low p_{Tx} opposite-sign muon pair, < 2.0 GeV
  - Not-high p_{Tx} same-sign muon pair, < 2.5 GeV
  - Single high p_{Tx} any-sign muon
  - Random trigger (beam counter, coincidence between two paddles that should not be in real coincidence, ..)
  - Multiplicity (but no track) trigger
  - NIM trigger (high ps only after v1495 verified)