Readout chip for a Tracking Trigger for CMS at SLHC

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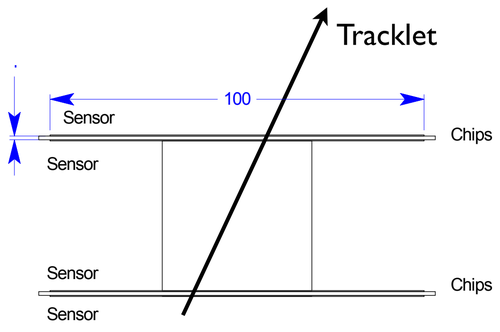
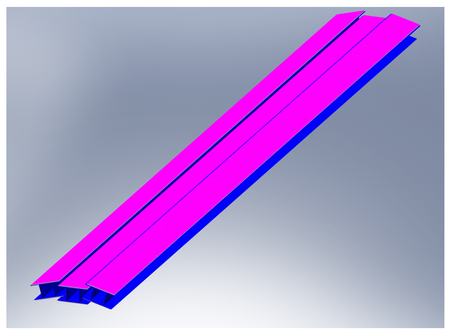
Cross section of a tracker rod assembly



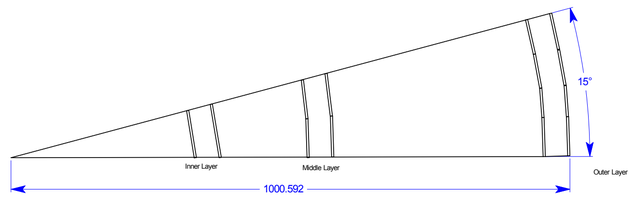
Chips mounted between sensor pairs
Readout both top and bottom sensor
Sensor spacing allows selecting high pt tracks

Combine stubs from top and bottom pairs to form tracklets

3D view of partial assembly of rods

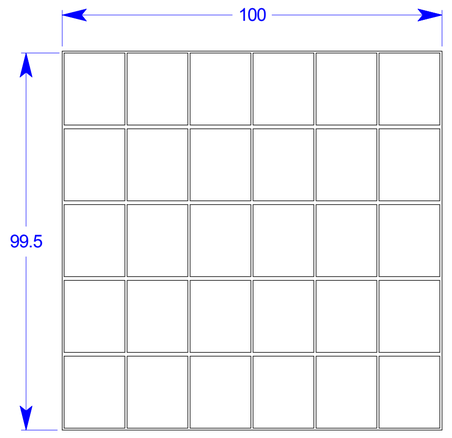


Rod arrangement for a 15 degree sector



Individual rods are assembled into 3 super layers
Minimum Pt is 2.5 GeV/c

Plan view of a sensor with chips



Bottom sensor strip size is 0.1 by 2 mm
Top sensor strip size is 0.1 by 5 mm
30 readout chips per sensor

Main Issues

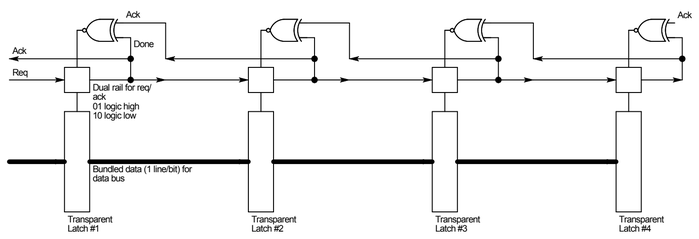
1. Digital noise from chips mounted between sensors
2. Pipe line step must be 25 ns
3. Chip to chip communication required in both directions
4. Trigger and event read out must use the same hardware
5. Large amount of data at SLHC luminosities
6. Chip failure must have small affect on trigger efficiency
7. Many chips to read out at each crossing

Design Choices

1. Completely asynchronous design - the only clock is the crossing clock
2. Use MOUSETRAP micro pipeline for all chip to chip communication and readout
3. Use MEPHISTO encoder for encoding high Pt hits as well as clusters for event readout
4. Maximum event rate is 1/400 of trigger rate so imbed part of an event with every trigger
5. Readout path is reversible so have alternate readout path if a chip fails

MOUSETRAP Pipeline

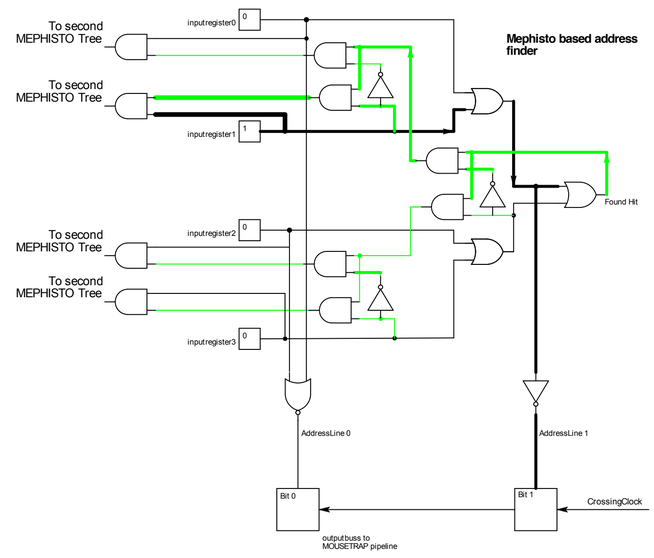
Singh et al.,IEEE Trans. VLSI Systems,15, (2007) 684



Simple, asynchronous pipe line using Non Return to Zero signaling and transparent latches

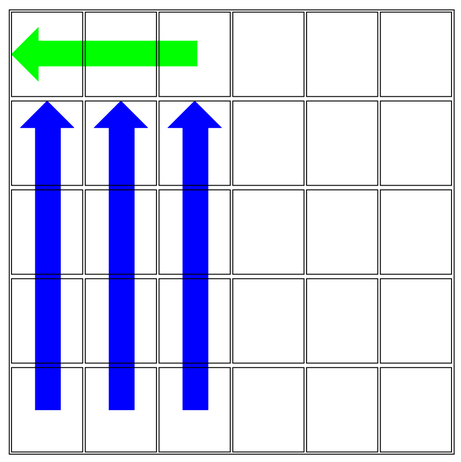
Multiple MEPHISTO address encoders

P. Fischer, NIM A 461 (2001) 499-504



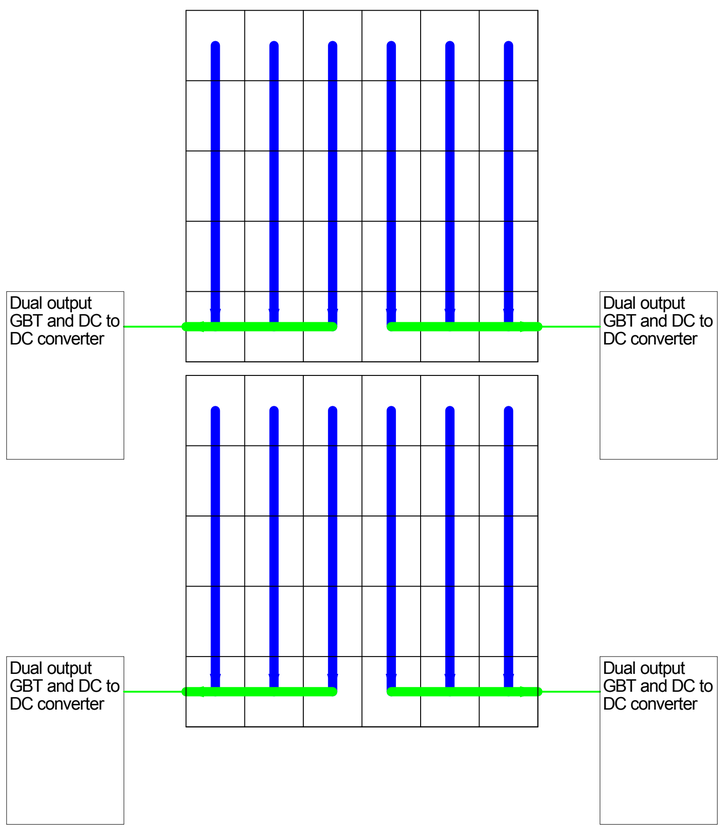
Use two encoders with each one encoding both low to high and high to low addresses to get up to 4 high PT tracks per chip

Sensor Readout



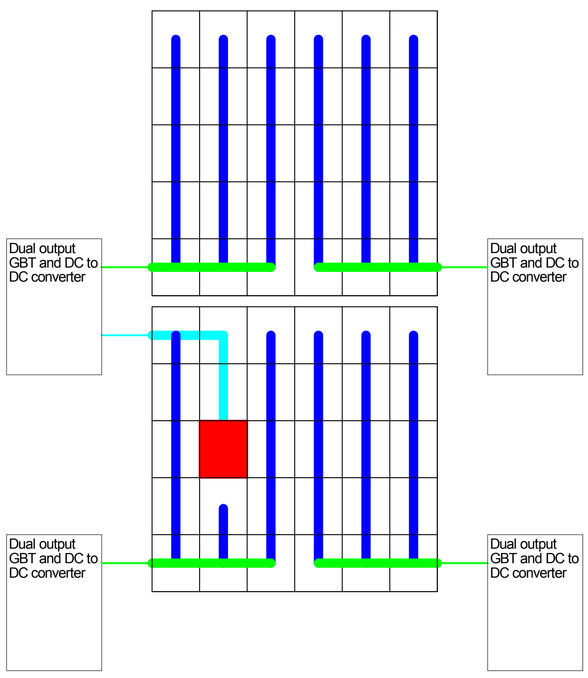
All readout is by MOUSETRAP micro pipelines
Read out each half ot the sensor independently
Read out along blue path to buffers in green chip in one pipe line step
Read out data along green path to a fiber driver in second pipeline step

Multi sensor read using dual output optical drivers



Multiple Sensor readout using dual output DC-DC converters

Chip Failure



Readout Path can be reversed if a chip fails. the auxiliary readout uses the second readout port on the optical driver

Pipeline Steps on the Chip

1. Send phi hit data to neighbor chips in both layers (MOUSETRAP)
2. Find hit cluster centroids (max cluster width is 3 strips)
3. Send cluster centroids in z direction on top layer (MOUSETRAP)
4. Form stubs for high Pt tracks from the 2 sensor layers
5. Encode addresses using MEPHISTO encoders
6. Gather data into reg. for MOUSETRAP pipeline
7. Transmit data along blue lines to chip at end of column
8. Transmit data along green line to optical transceiver.