Online processing for Forward Tracker in PANDA

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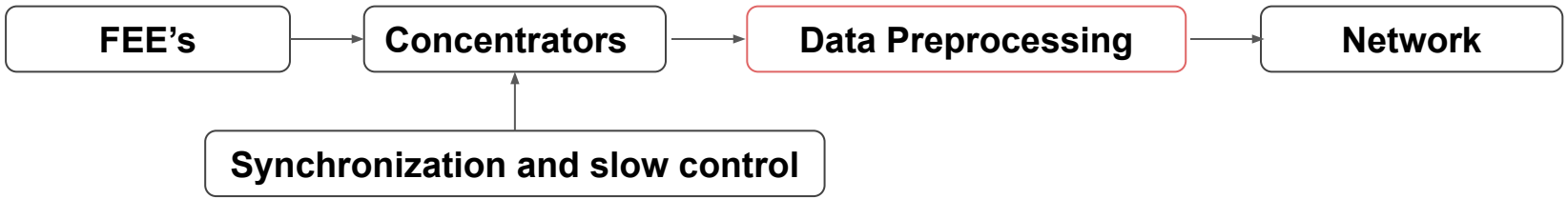
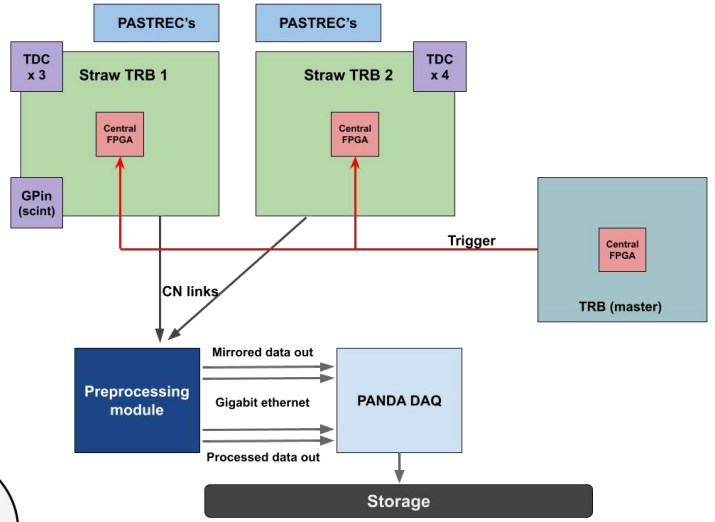
DAQ in PANDA

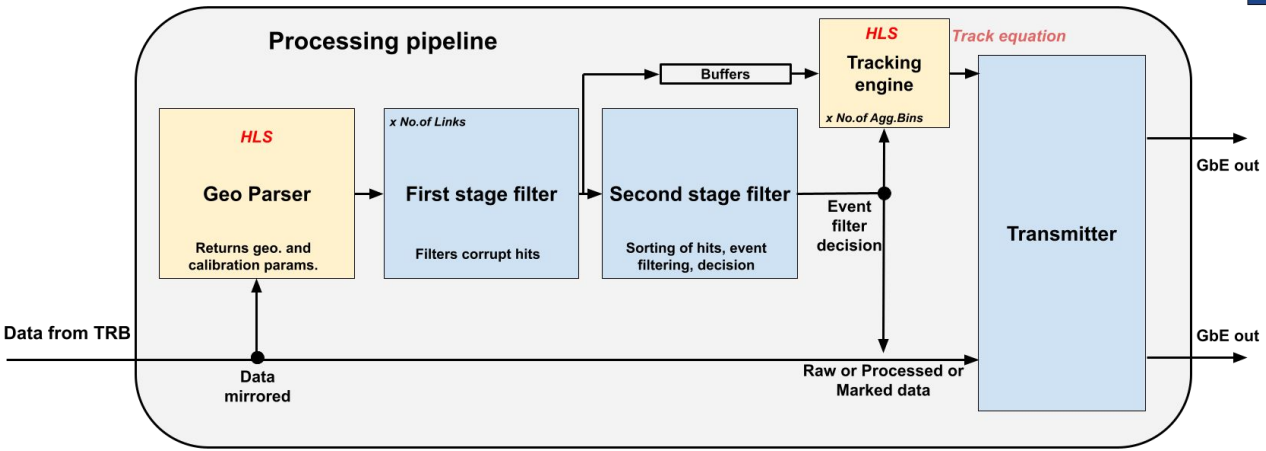
- The PANDA DAQ with self triggering detector systems.
- The physics events of interest are identified by an online event selection
- Tracking information is a one of the key input to distinguish signal events from background in FT.
- FT data inflow from 64 TRB's (upto 2.9 GBps)
- Data volume reduction by eliminating background
- FPGA based compute nodes for online data processing.
- Abundant time b/w triggers to filter events before entering the network.

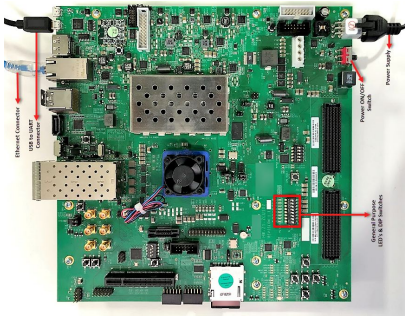


Processing pipeline

- Intermediate data processing stage.
- Push forward pipeline for event filtering and extraction of tracks.
- Tracking engine to complement the filtering.
- Using Xilinx ZCU102.





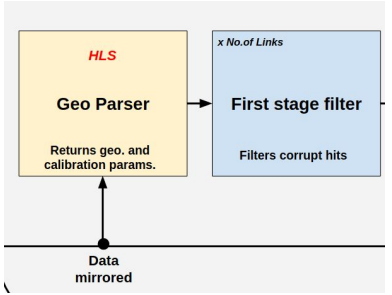


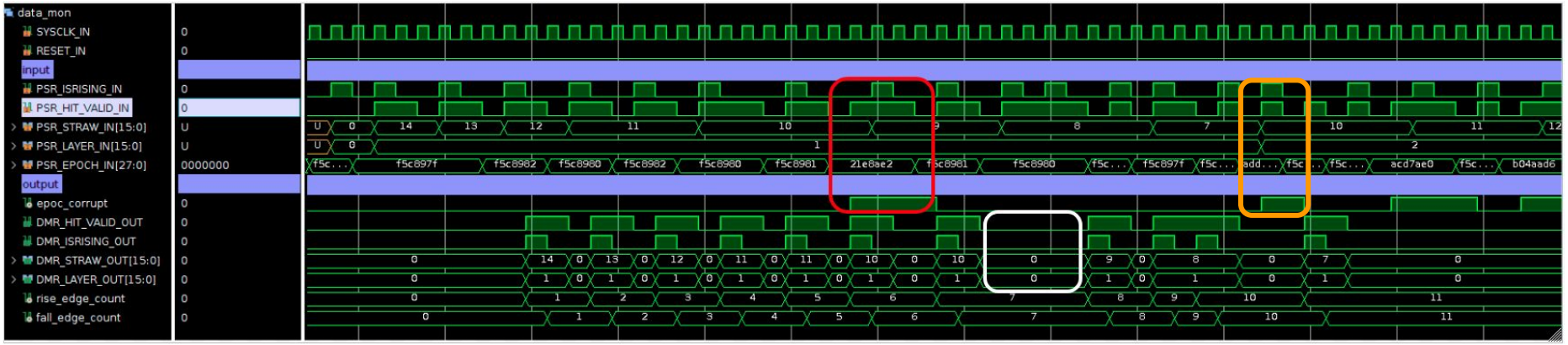
Zynq UltraScale+MPSoC ZCU102

Geo. Parser and First stage filter

Geo.Parser

- Maps TDC channel and returns X, Y, Z and straw, layer, module and time Calib parameter.
- Written in C++ using *HLS.*

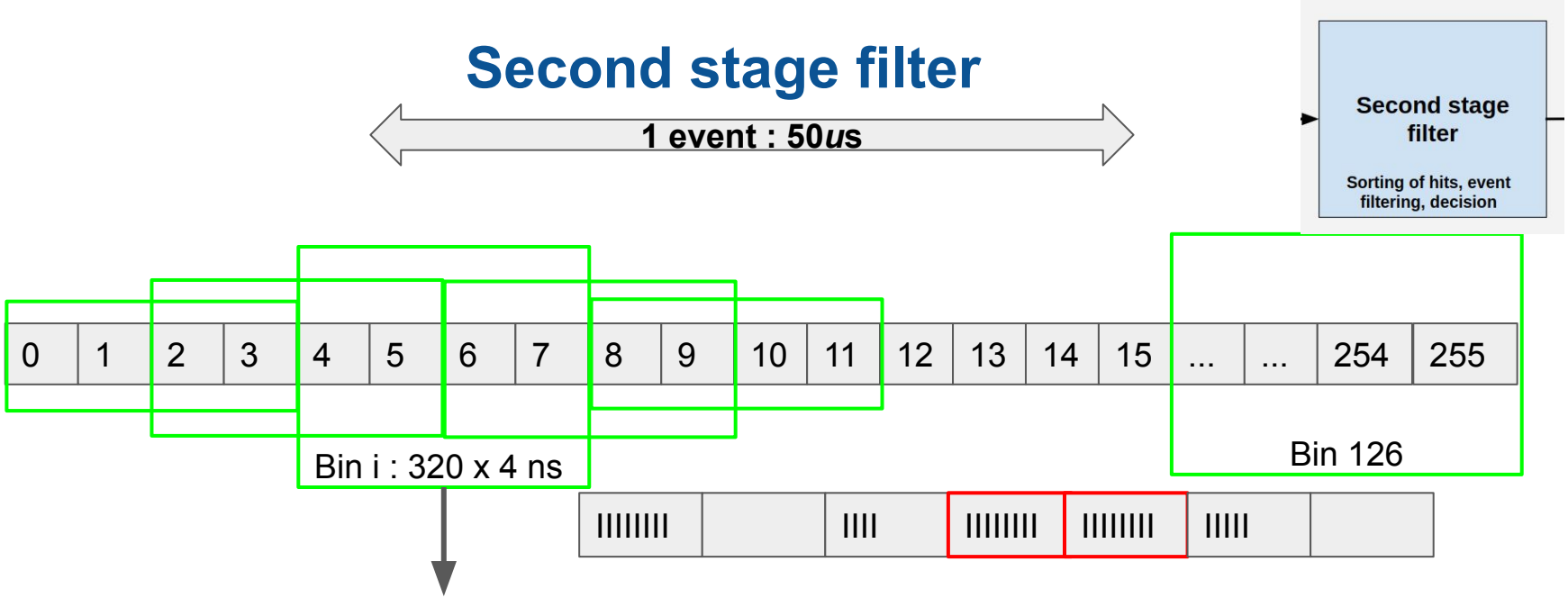




Filtering corrupt time

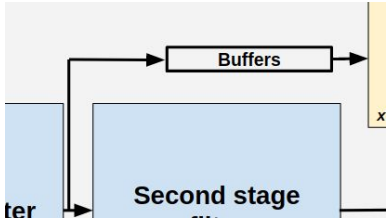
- No.of instances = No.of input links
- Artifacts of tdc implemented like missing edge ,corrupt time
- By comparing the epoch time of the straw hit with the epoch ref. time

Second stage filter



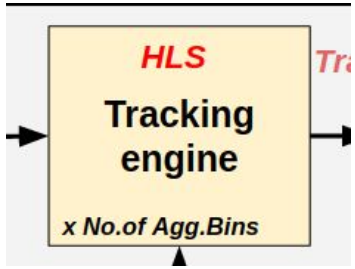
- Data from all Links accumulated
- Time bin based sorting (256 bins in a trigger window and overlap to avoid loss of hits).
- Check
  - if there is a hit from the reference detector (optional)
  - if all the layers have a hit (to form a complete track)
  - if each hit has a pair (hits from neighbouring channels is a must for a track)
- Output decision on conditions begin met and agg.Bin No of potential track

Buffering stage

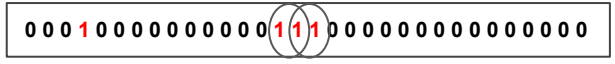


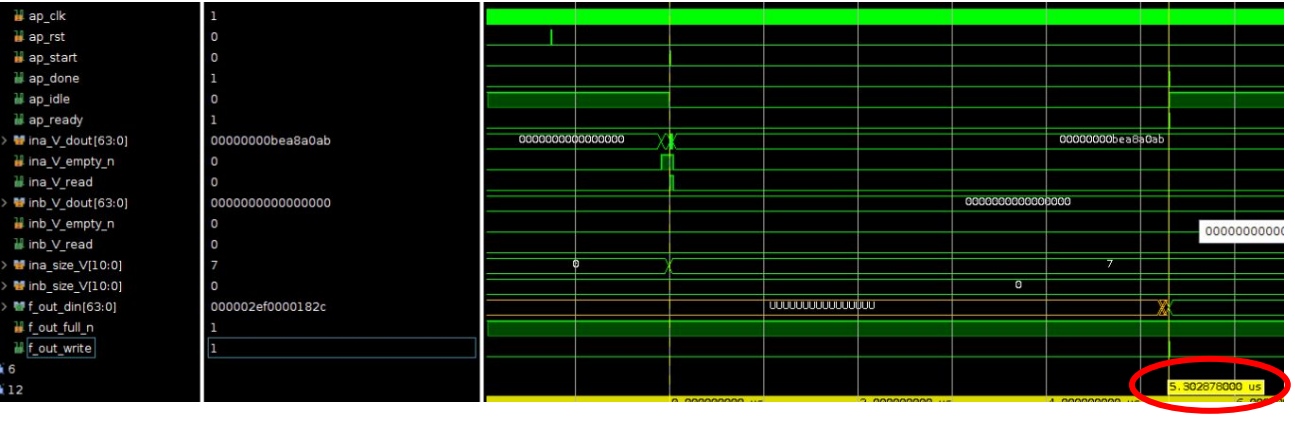
- Data from first stage filter buffered for the track engine.
- No. Links = No.of instances
- No of fifo's = No.of agg.time bin's
- Upon decision from second stage filter hits stored in potential timebins / fifo is read to track engine.

Track engine



- Written in C++ using HLS
- Primitive tracking using straw no.
- Constructs pairs & clusters of hits
- Best combination of straw pairs with least χ^2 selected
- Latency of ~6*us*
- Disadvantage : High resource consumption of upto 6% / inst.





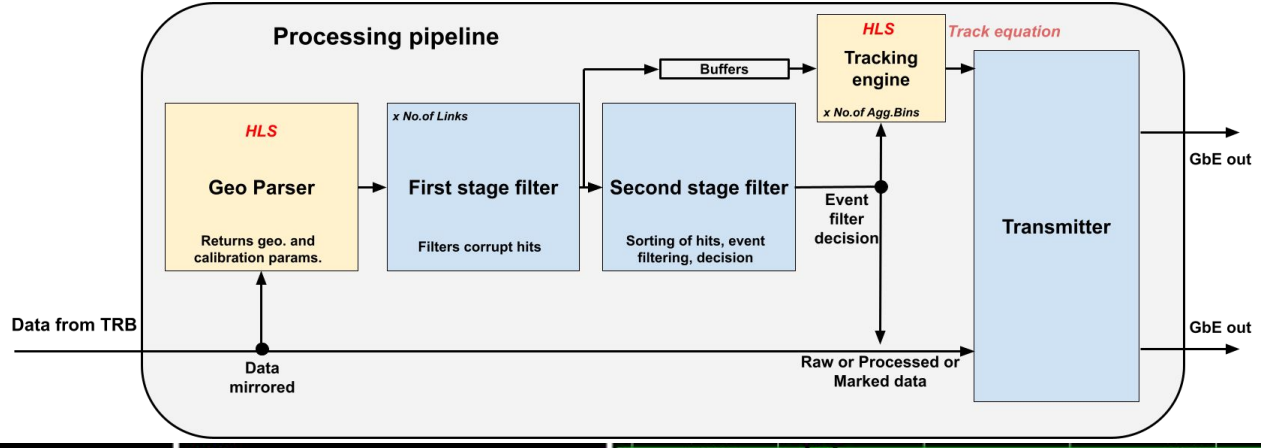
Utilization Estimates

Summary

Name	BRAM_18K	DSP48E	FF	LUT	URAM
DSP	-	-	-	-	-
Expression	-	-	0	1501	-
FIFO	-	-	-	-	-
Instance	20	32	13069	14392	0
Memory	6	-	0	0	0
Multiplexer	-	-	-	597	-
Register	-	-	2383	-	-
Total	26	32	15452	16490	0
Available	1824	2520	548160	274080	0
Utilization (%)	1	1	2	6	0

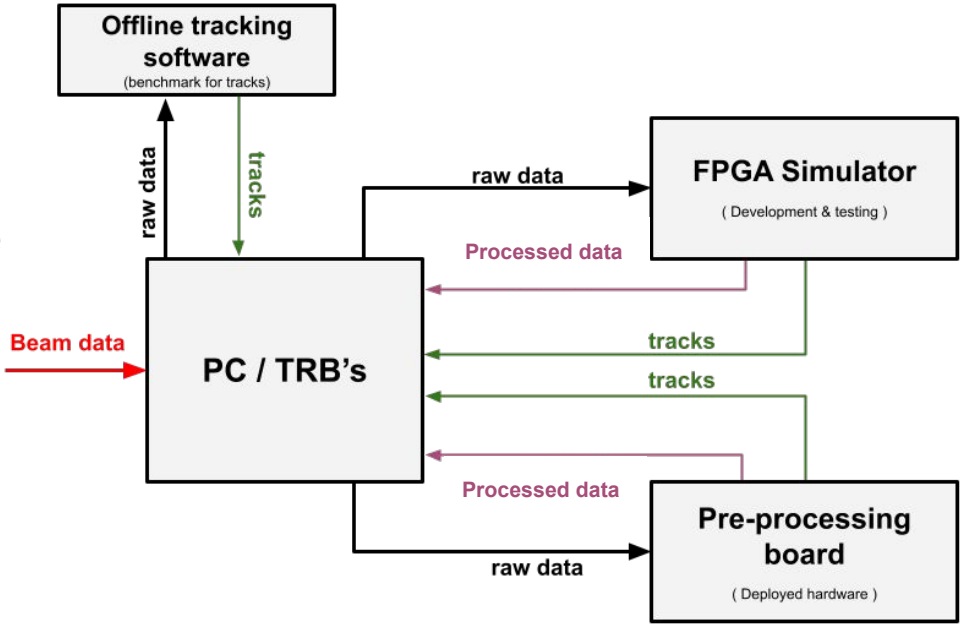
Modes of Op. and Transmitter

- Modes
  - Filtering : Only filtered events are forwarded to the event builder
  - Marking : Events satisfying the filtering conditions and having potential tracks are marked and all events are forwarded to the event builder
  - Bypass : All data from the TRB's is forwarded to the event builder
- Transmittes track data and raw / processed / filtered data to dedicated ports



Development and Testing scheme

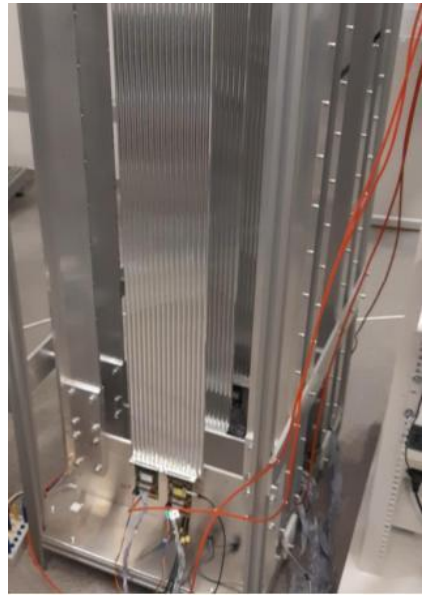
- A flexible development cycle
  - Development by streaming stored FT data from the PC to FPGA simulators
  - Or by streaming stored FT data to the hardware
  - Analyze the outputs stored in PC
- Testing of the module
  - Stream data to the hardware from TRB's connected to the detector
  - Compare output file with the developed offline tracking software.

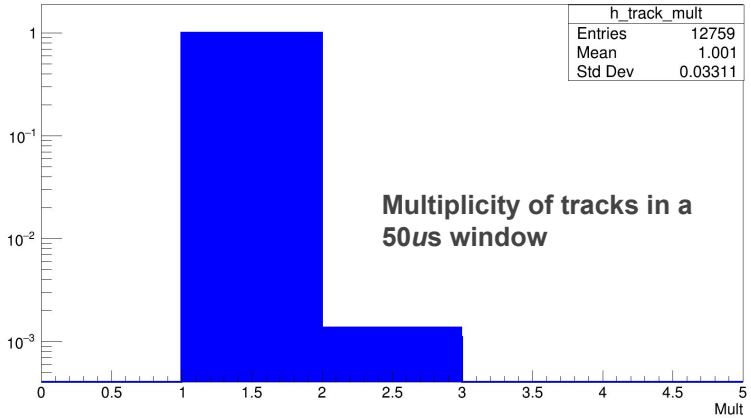


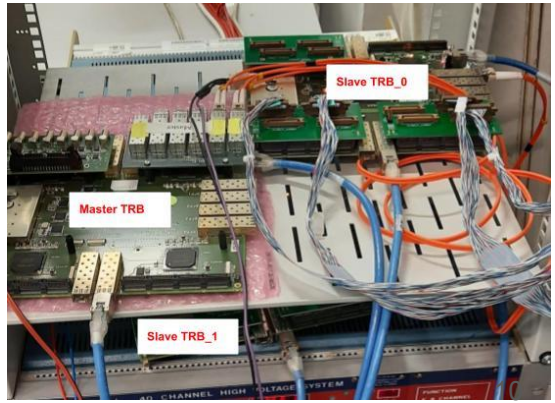
- Event filtering and tracking in hardware must be in agreement with the offline software analysis of the data.

Test setup

- Processing module tested with
  - Detector prototype with 4 modules in 4 layers (8 FEE's)
  - Scintillator for ref.time
  - Cosmics and ^{90}Sr radioactive source
  - Continuous trigger at 20kHZ
  - 32 time bins of width 2.5us with an overlap of 1.25 us
- Data collected for marking and filtering modes.
- Data collected with a similar prototype in 2019 under beam conditions also used for benchmarking.

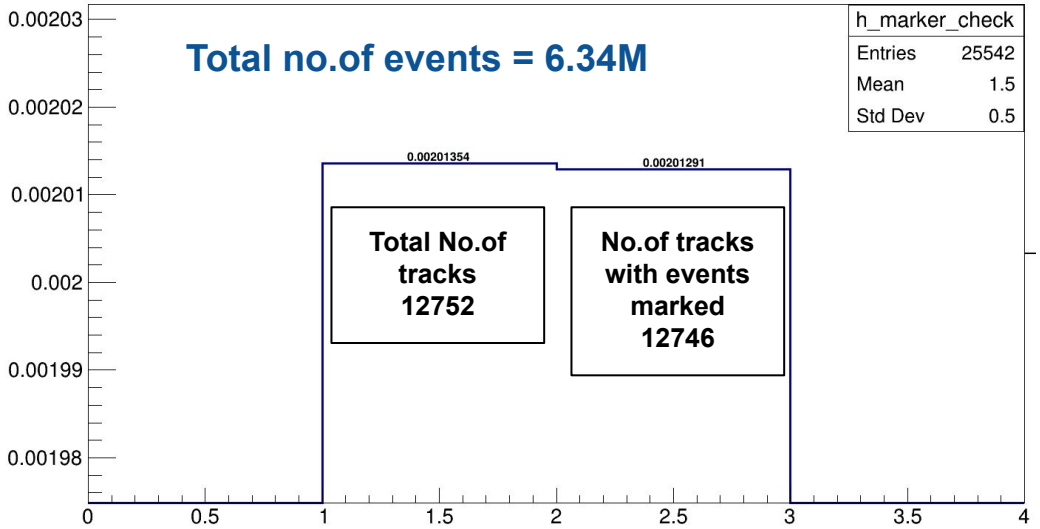






Preliminary results

- Marking : ~99.9% marking accuracy
- Filtering : 123KB/s compared to 350MB/s under ^{90}Sr with 2 TRB's
- Bypass : No data loss
- Analysis of track reconstruction efficiency under progress.



Scope and conclusion

- Tests of the module demonstrates the scope for immense data reduction with accurate filtering procedure.
- Push forward filtering with no latency, tracking with latency of ~ 6 - 7us.
- Optimizations required for PANDA production system
  - Module to process data from a large no of TRB's
  - Time bin width and overlap to meet rates at PANDA production system
  - Instances of Track engine could be minimized and split out into an accelerated platform.
- Serves as a platform for track visualization during online monitoring.

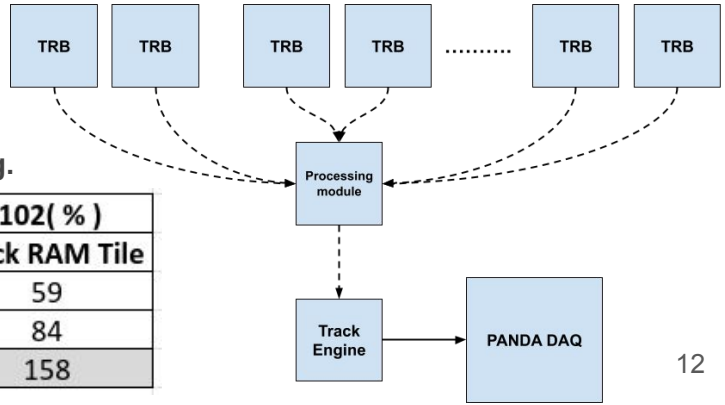


Table1. Preliminary resource consumption projection for FT online processing.

Tracking stations	No of Channels	No. of TRB's	Resources for Preprcessing ZCU102(%)		
			CLB LUTs	CLB Registers	Block RAM Tile
FT 1,2	2304	12	57	47	59
FT 3,4	3328	18	82	68	84
FT 5,6	6592	35	152	126	158

Thank you