

Slow Control for DATCON

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Performance of the Tracking Unit and ROI Calculation



Belle II Vertex Detector





- 2 layers DEPFET Pixel Detector (PXD) with 8 million pixels (avg: 60 Gbps, max 256 Gbps)
- Data reduction required for PXD data (factor ~ 10)
- 4 layers Silicon strip Vertex Detector (SVD)
- Idea: Use hits in the surrounding strip detector, and extrapolate them to the PXD to select usable Pixels

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Data Reduction Idea with SVD Tracking

- Complementary approach with two systems to save as much physics data as possible
- HLT: Track reconstruction based on sector-neighbour finding and neural network
- DATCON: Fast FPGA-based track reconstruction system using the Fast Hough Transformation

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Data Reduction Idea with SVD Tracking

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Hardware: Advanced Mezzanine Card



- Virtex 5 FPGA with 4 optical 6.25 Gbps transceivers
- Backplane with 6 ports and 1x Gbit Ethernet port
- 128x DSPs and 4 GB external memory



DATCON Connection





- Data Acquisition Tracking Concentrator Online Node (DATCON)
- 48 optical links from the SVD Front End Electronics (FEE)
- Average expected data rate: 6 Gbps
- 12x AMCs for data acquisition and preprocessing
- 2x AMC for Tracking and ROI calculation

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7/23



- Concentrator (12 AMCs):
 - Acquire data from the SVD FEE (over Finesse Transmitter Board (FTB))
 - Decode SVD Data (4 run modes possible)
 - Noise filter (only in run mode 2)
 - Clustering
 - Coordinate translation and transmitter to tracking AMC(s)
- Tracking (one maybe two AMCs):
 - Reconstruct helix track parameters (with Fast Hough Transformation)
 - Extrapolation to PXD planes
 - Create ROIs, size depending on several criteria (e.g. track radius, number of iterations...)
 - Transmit ROIs to ONSEN



Hough Transformation Basics

- Tracking is based on Fast Hough Transformation
- Hough Transformation is able to find and fit straight tracks



 Also works for arc tracks after conformal transformation

Conformal Transformation

$$\begin{aligned} x' &= \frac{x}{(x - x_n)^2 + (y - y_n)^2} \\ y' &= \frac{y}{(x - x_n)^2 + (y - y_n)^2} \end{aligned}$$





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Conformal Transformation



Real Hough Space Example



Fast Hough Transformation (colors represent depth of iteration)



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Visualization: One Track @500 MeV





Corresponding Hough Space









2 Performance of the Tracking Unit and ROI Calculation





- Constant high efficiency in r-φ @
 0.98 % down to 40 MeV
- Theta efficiency falls under r-φ-efficiency at 300 MeV
- Caused by linear fit of sine-shape like function in z-direction



Total efficiency limited by theta (later compensated in ROI extrapolation, small but long ROIs)



 Average fake hits constant at 60 hits/event

- High number of fake hits caused by high occupancy events
- Or by close tracks events



- Caused by the TC merger algorithm (lots of combinatorics in hits)
- Should be fixed with new Hough Space clustering algorithm and cut-off threshold



- 640 million events (10 tracks per event), Momentum from 50 MeV to 3 GeV and Background (QED, RBB, Toushek, Beam-Gas)
- Flexible ROI size from (8x16 px) up to (12x160 px) (depending on momentum estimated by r)
- Total ROI efficiency (number of primary track hits on the PXD inside ROI): 95.2 percent
- Curler extrapolation still missing! (only two MPH per track)
- Data Reduction Factor (DRF): 45





Performance of the Tracking Unit and ROI Calculation





- Present system based on UDP protocol and a custom status 16 Byte long vector payload transmitted over Gbit Ethernet
- Optical and backplane (Aurora) link status: channel up, PLL status, hard, soft and CRC errors
- Concentrator: run mode of the SVD, number of clusters found, storage status: full, empty, (maybe: number of events stored)
- Tracking: number of tracks processed and ROI found, triggers, some statistics about ROI size
- Switch to IPBus possible (also used in DHH)





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SC: What We Need

- DATCON is passive system, when SVD data arrives it is immediately processed without delay (no timing and control signals required)
- Load of FPGA firmware over JTAG chain (same requirements as ONSEN system)
- Reset signals to get the system back to the normal operating state in case of failures
- Monitoring of temperature and voltages of all FPGAs
- Update of several LUTs
 - Alignment constants for all 12 Concentrating AMCs
 - Some settings for the tracking unit
 - Programming the adaptive ROI size registers
- Power cycle and crate monitoring (temperature, fan speed, other health parameters) over IPMI

Present Slow Control: Concentrator



urxvt										
tp ~/prog/datcon/trunk/tools/concentrator_ctrl > ./control										
Concentrator Control Panel										
ΓMD > s										
Info: Send 1 packet(s) with request										
Cont mode: off										
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	SFP 0	SFP 1	SFP 2	SFP 3						
Lane:	up	up	up							
Channel:	up	ир	up	down						
PLL:	locked	locked	locked	locked						
Frame Err:	0	0	0	0						
Soft Err:	0	0	0	0						
Hard Err:	0	0	0	0						
CRC Err:		0								
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Lanes	down	doup	doup	doup						
Channel.	down	down	down	down						
PLL:	looked	locked	locked	looked						
Storage Status										
	Coord0	Coord1								
Empty:										
Full:										
cun > ∏										

Present Slow Control: Tracking



tp ~/prog/datcon/trunk/tools/tracking_otrl > ./control Tracking Control Panel CMD > s Info: Send 1 packet(s) with request test 0 Info: Receiving Message from 10.0.0.1:54345 16 Bytes received now, 16 Bytes total Status word: SS80 0000 0000 4055 18DC 9505 0000 0000 valid SFP 0 SFP 1 SFP 2 SFP 3 Lane: up down up down Channel: up down up down PLL: locked locked locked locked Frame Err: 0 0 0 0 0 Hard Err: 0 0 0 0 Storage Status Coord ROI 1 ROI 2 Empty: 0 0 0 CRC Err: 0 CRC Err: 0 CRC Num: 0 Rate: 0/s @ 1408713125 Back 0 Back 1 Back 2 Back 3 Lane: down down down down PLL: locked locked locked locked Frame Storage Status Coord ROI 1 Back 2 Back 3 Lane: down down down down PL: locked locked locked locked Frame Storage Status CRC Err: 0 CRC Err: 0 CRC Num: 0 Rate: 0/s @ 1408713125 Tracking Stats Total: 23517 tracks Rate: 290.333 tracks/s Ray: 0.599 tracks/event Trage m 415.100 tray?s	urxvt _ u										
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CMD > [Trg: CMD > []	415.100 trg/s									



- Monitoring of the Finesse Transmitter Board (FTB)
- B2link register access done by Katsuro
- FADC slow control?

Thank you for your attention!

Testbeam Layout









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PXD ROI: 1066 Hits, 26 ROIs Reduction: 75 universitätbonn



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