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SI LAB
Silizium Labor Bonn

Slow Control for DATCON

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Content

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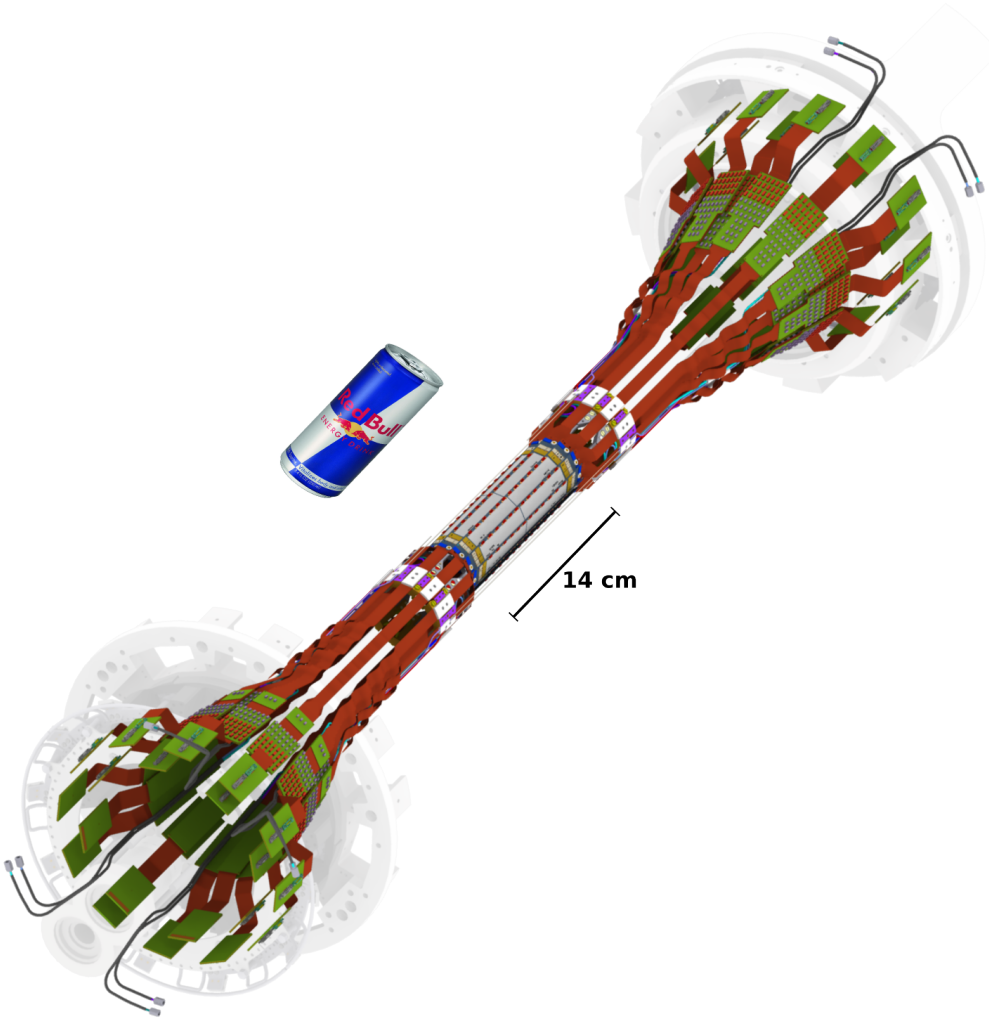
Belle II Vertex Detector



- 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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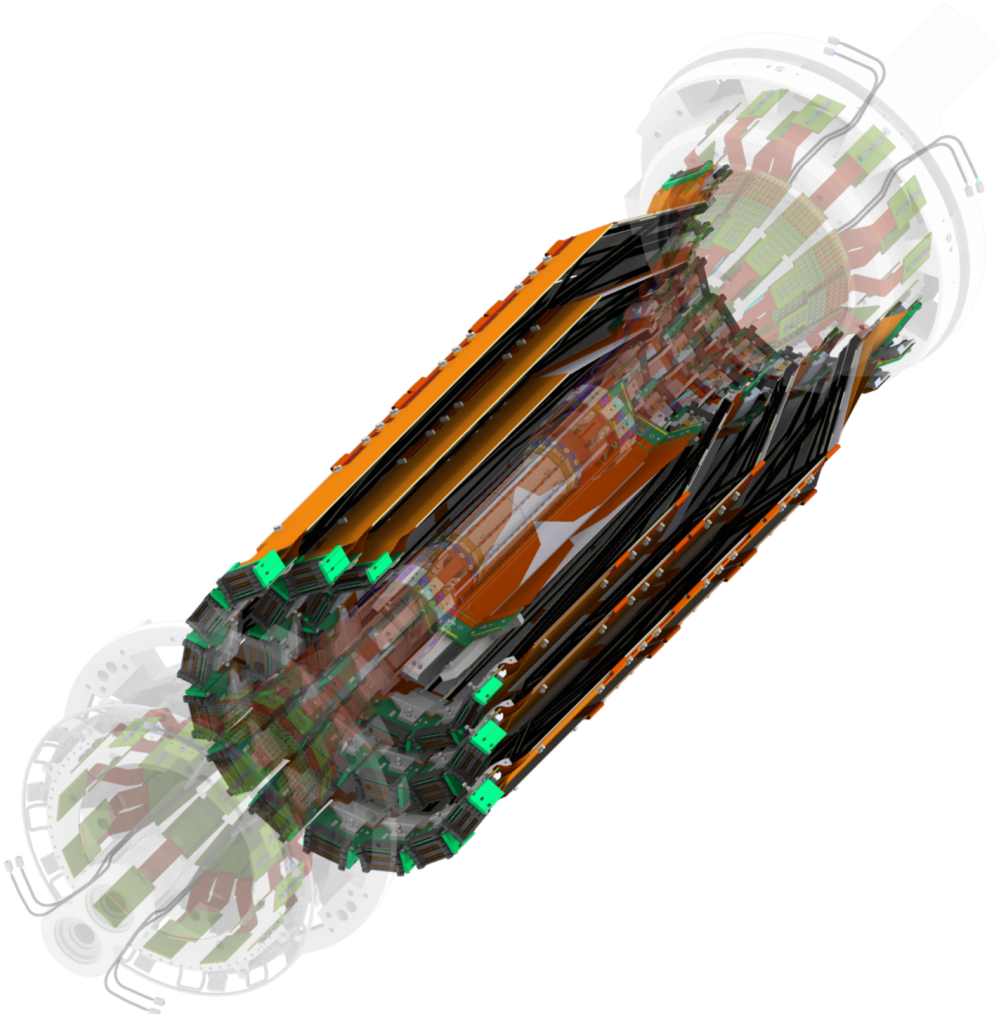

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Data Reduction Idea with SVD Tracking

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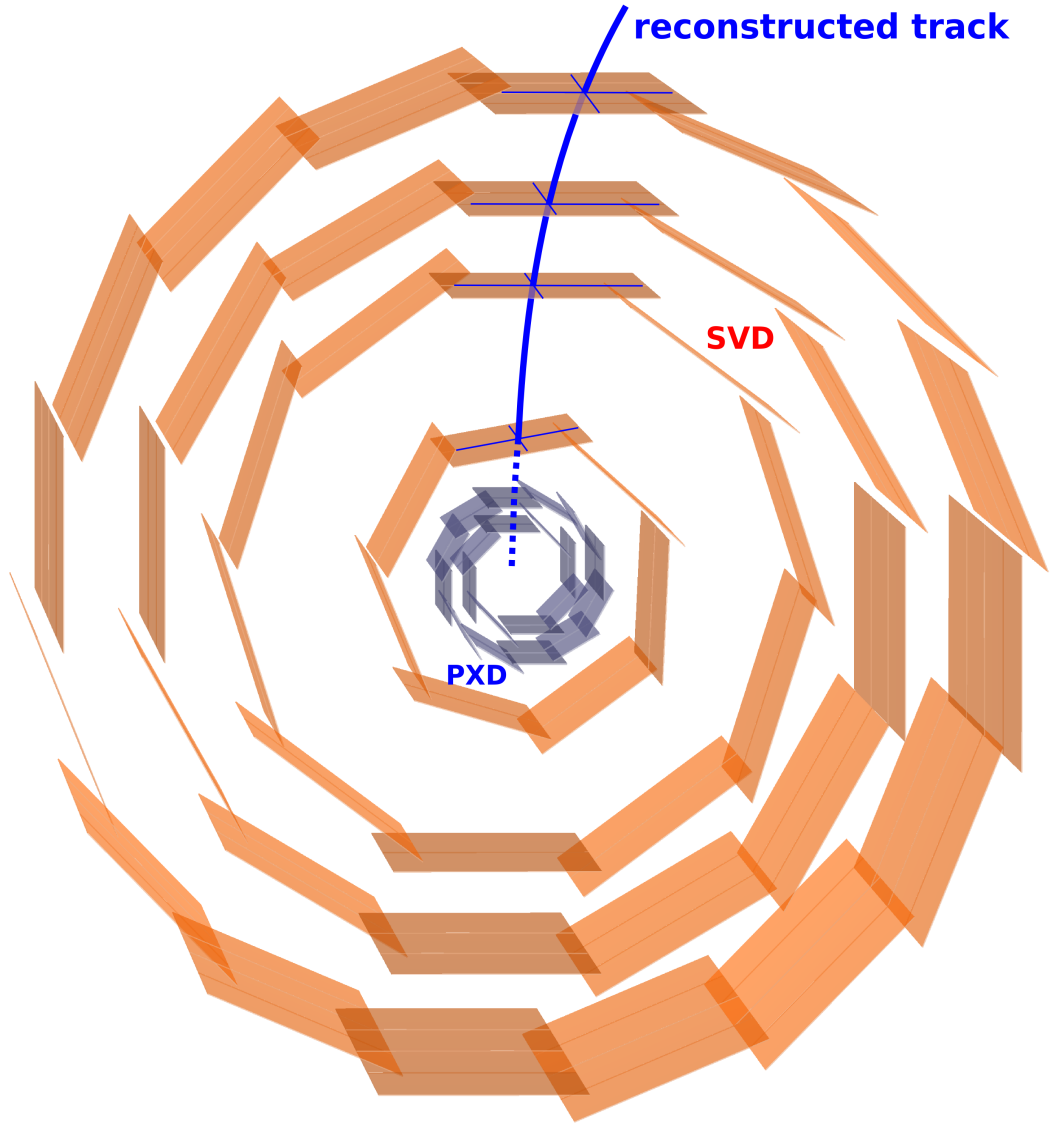
- Complementary approach with two systems to save as much physics data as possible
- HLT: Track reconstruction based on sector-neighbour finding and neural network
- DATCON: Fast FPGA-based track reconstruction system using the Fast Hough Transformation



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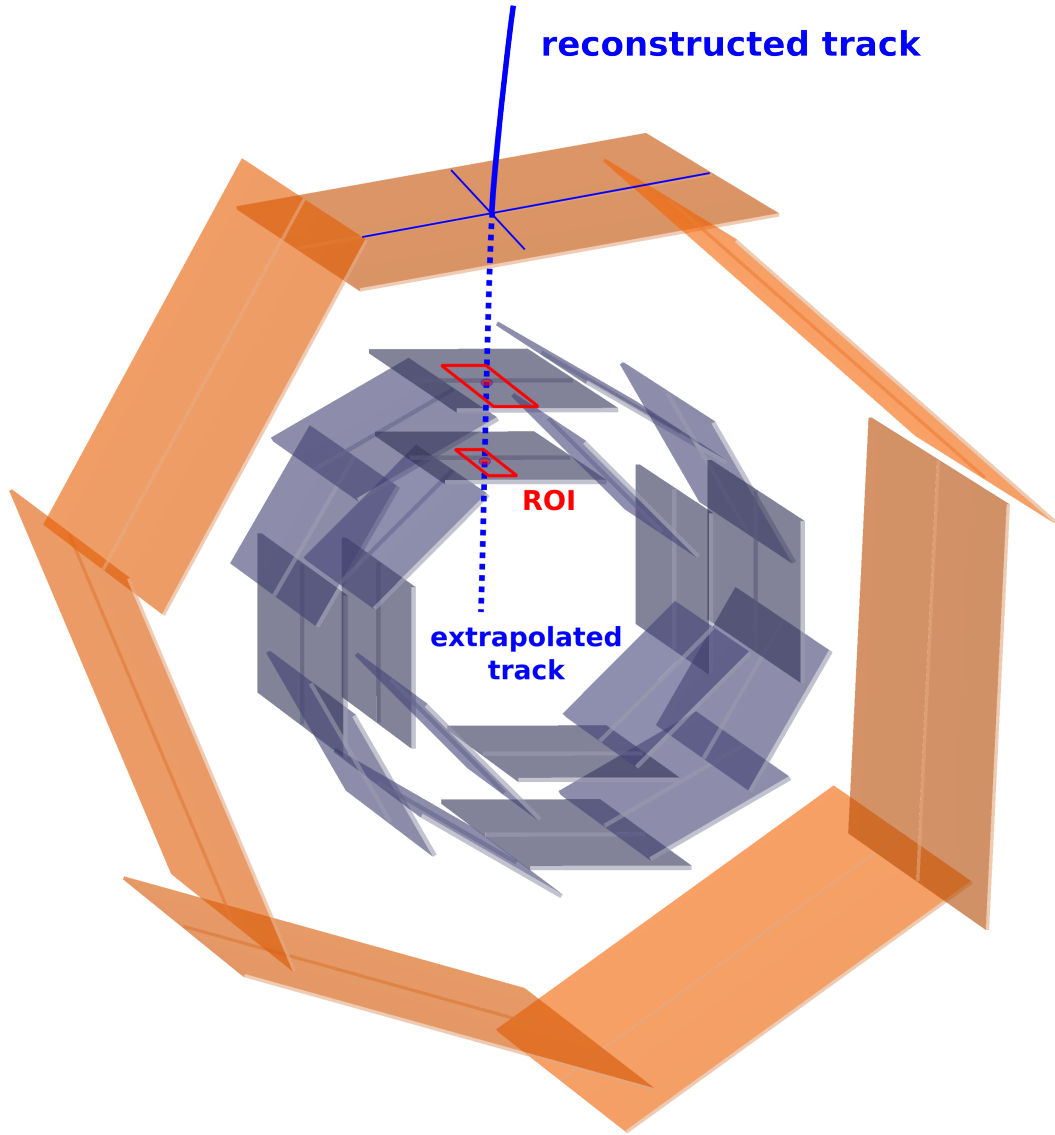
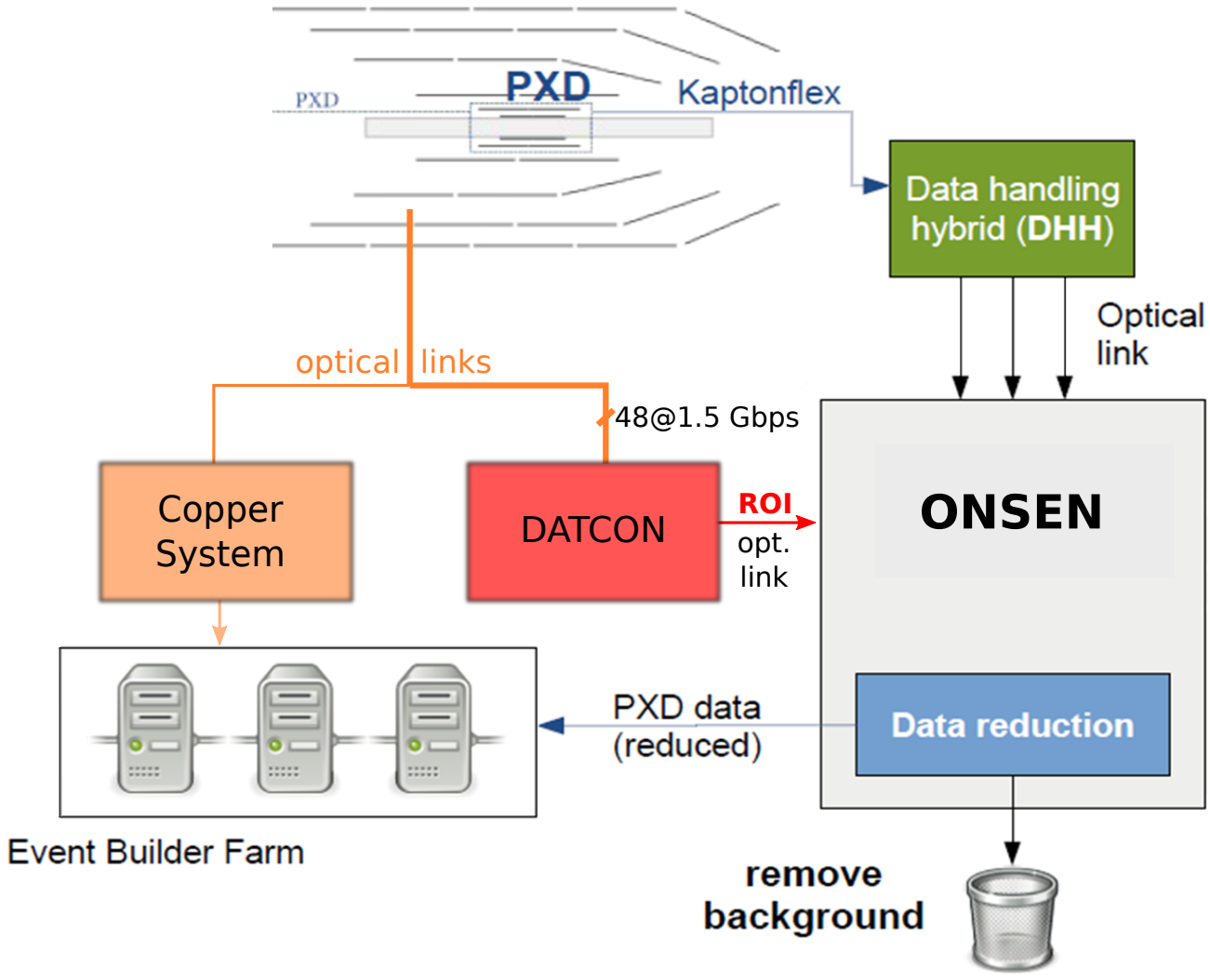


Location in the DAQ Chain



Hardware: Advanced Mezzanine Card

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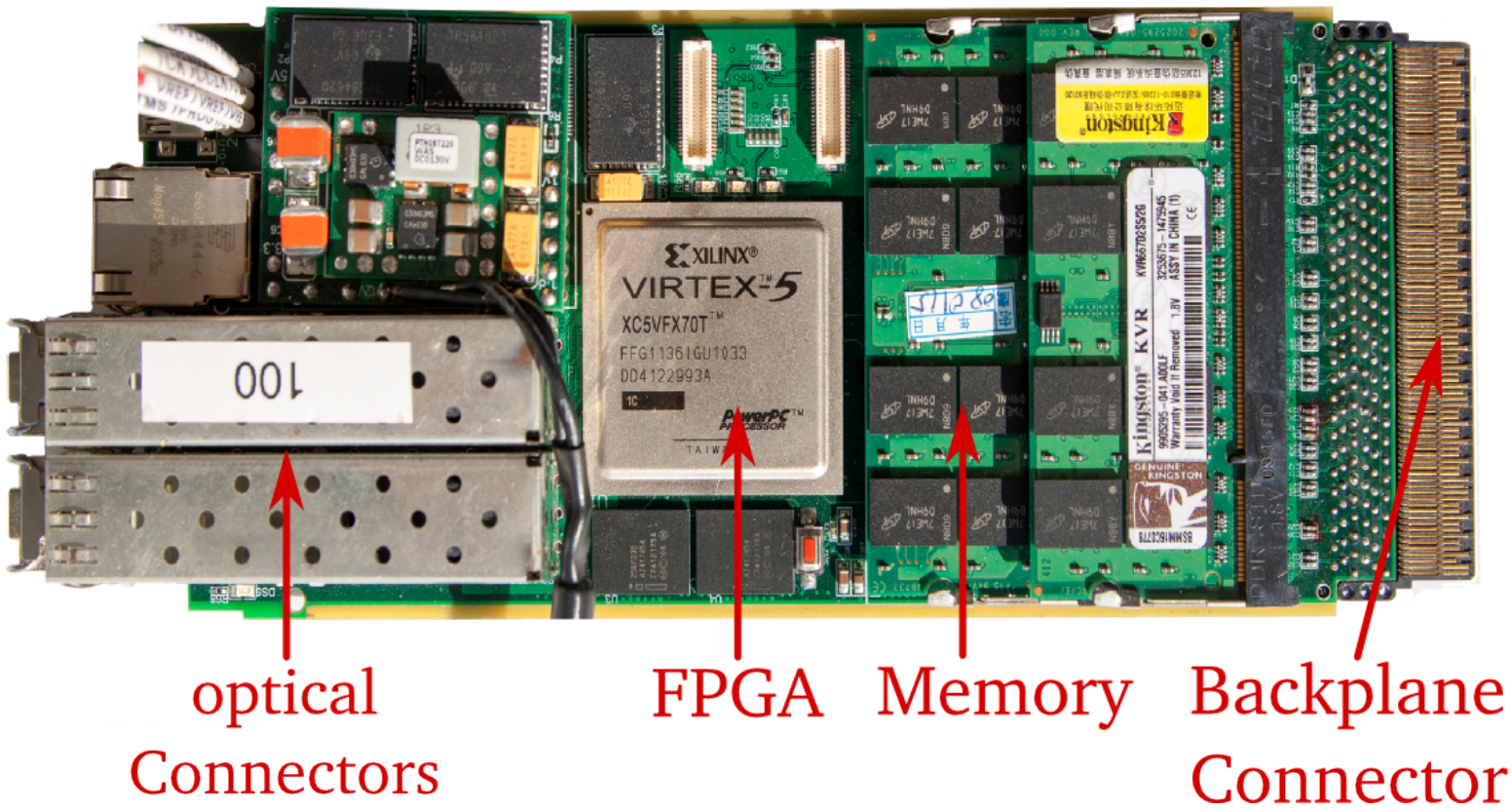
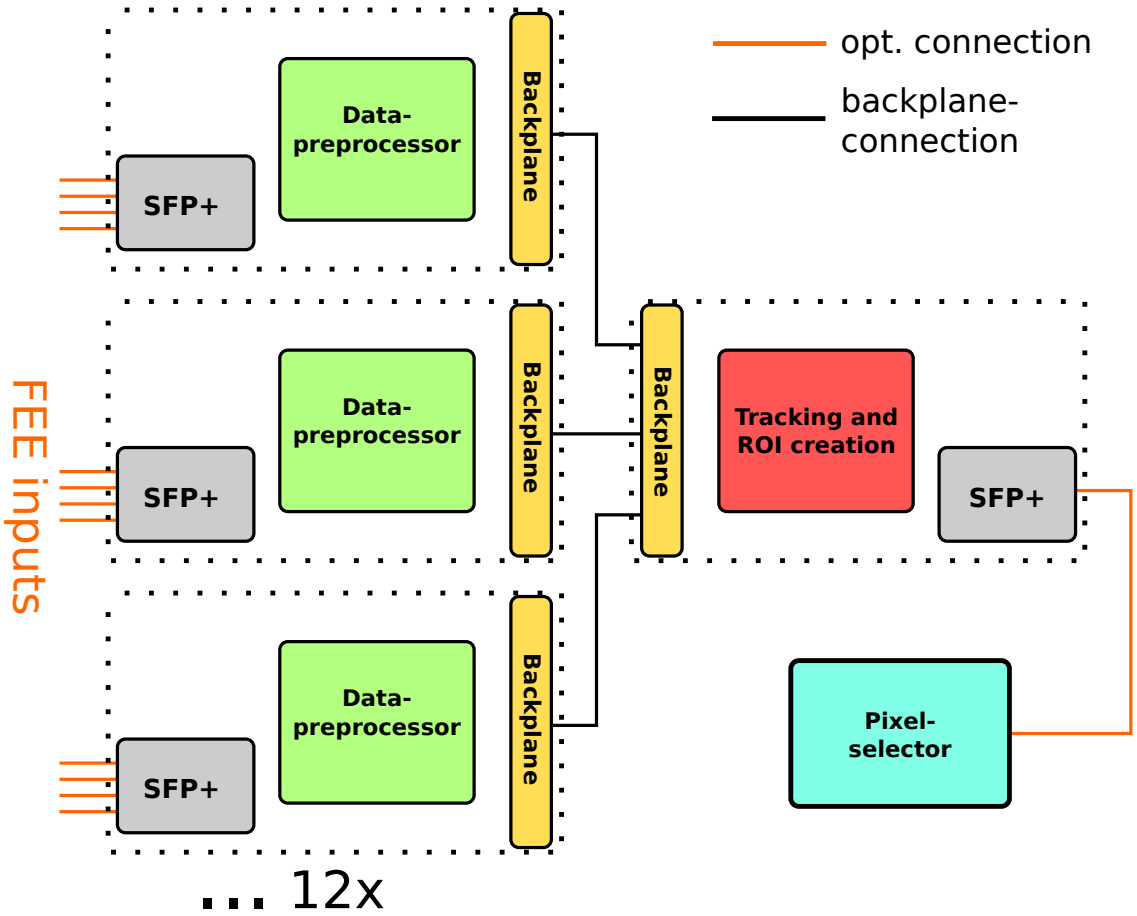
- Virtex 5 FPGA with 4 optical 6.25 Gbps transceivers
- Backplane with 6 ports and 1x Gbit Ethernet port
- 128x DSPs and 4 GB external memory

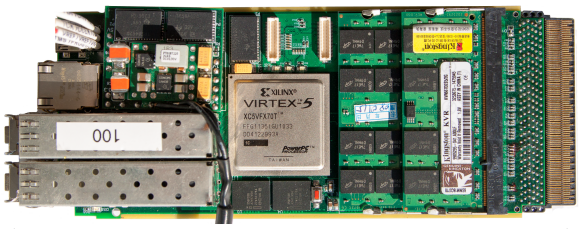


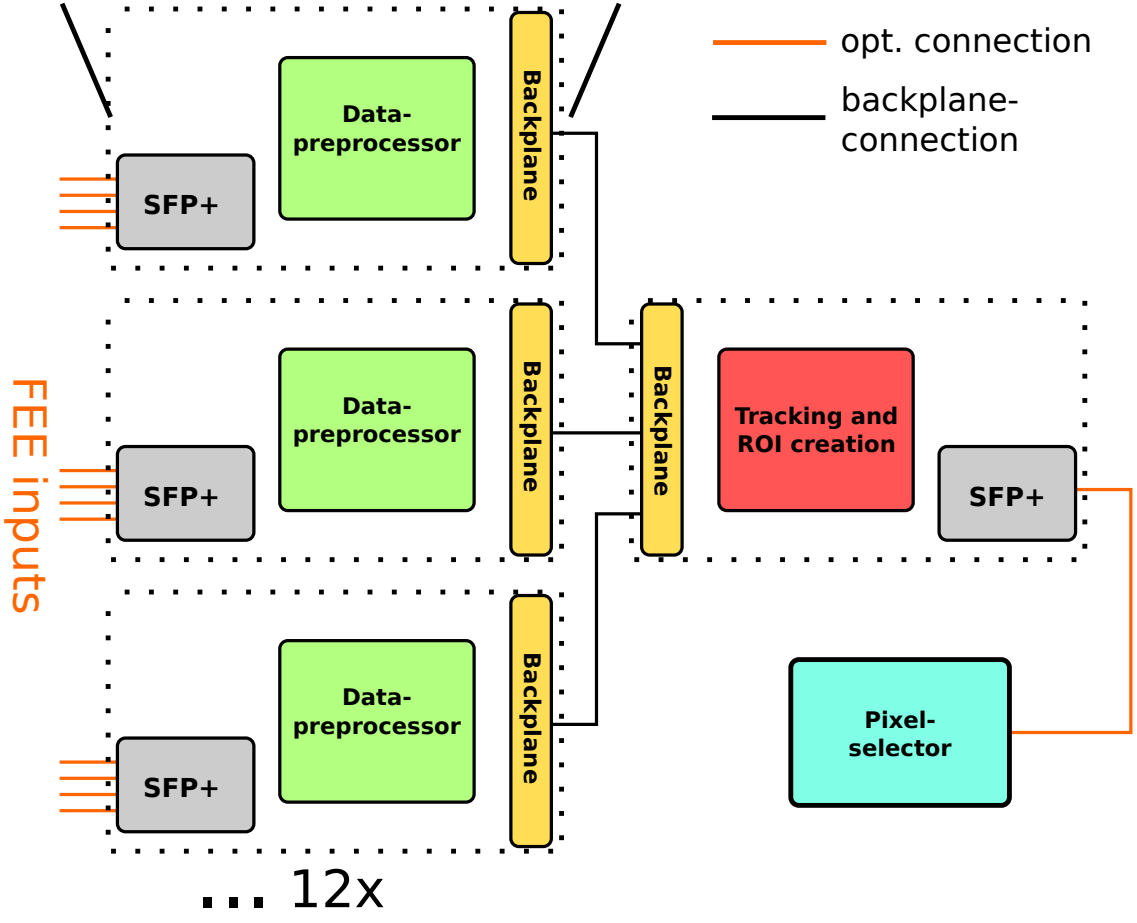
DATCON Connection



- 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

DATCON Connection





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Tasks of the Two Types of AMCs

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- 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

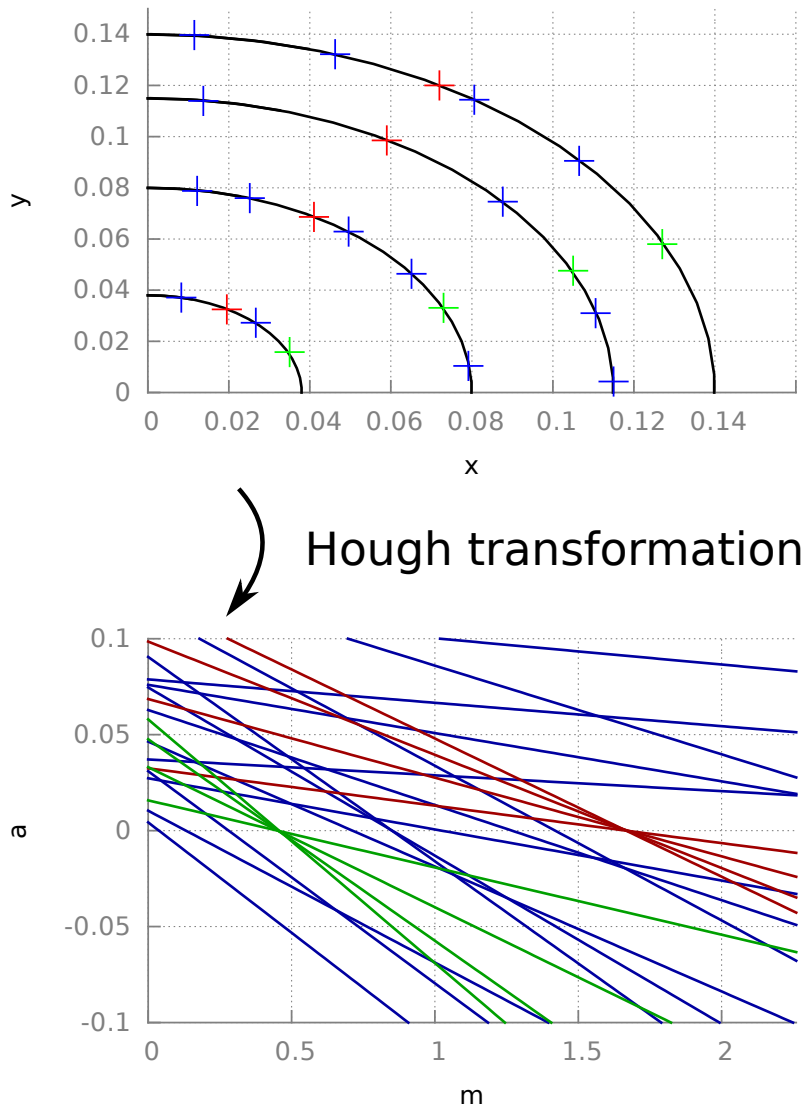
Simple Hough Transformation

$$y_i = m \cdot x_i + a \xrightarrow[trafo]{Hough} a = -m \cdot x_i + y_i$$

- Also works for arc tracks after conformal transformation

Conformal Transformation

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



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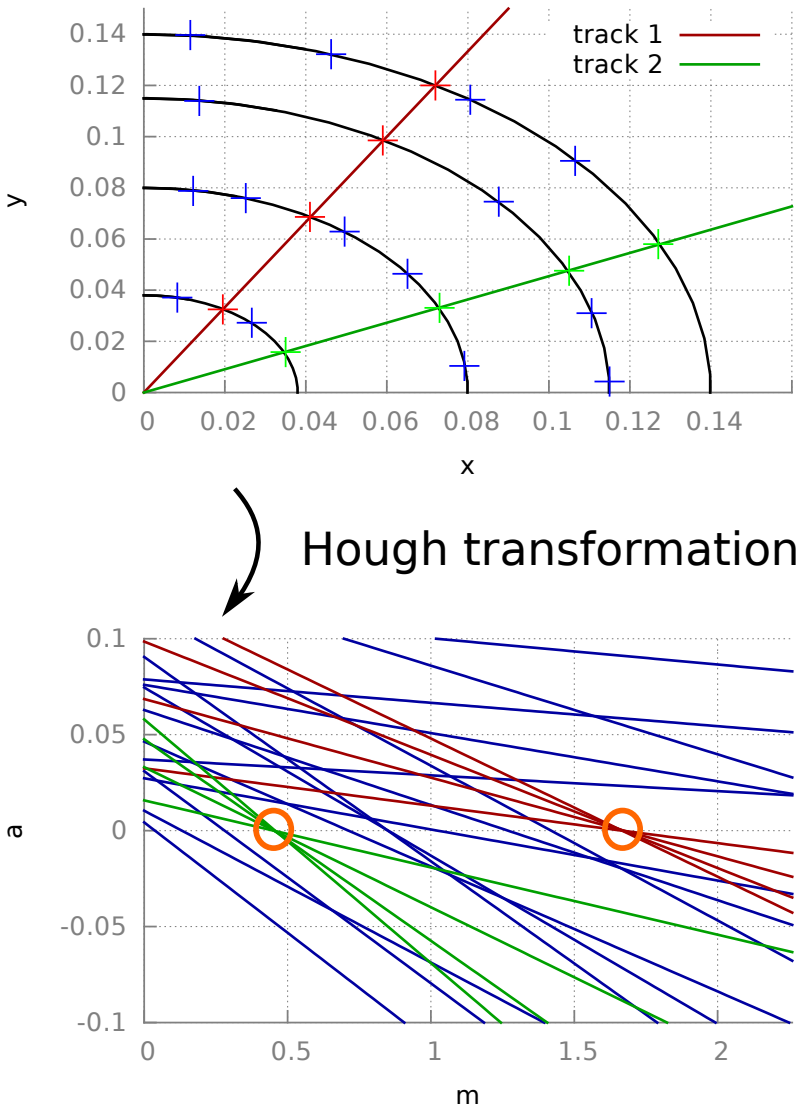

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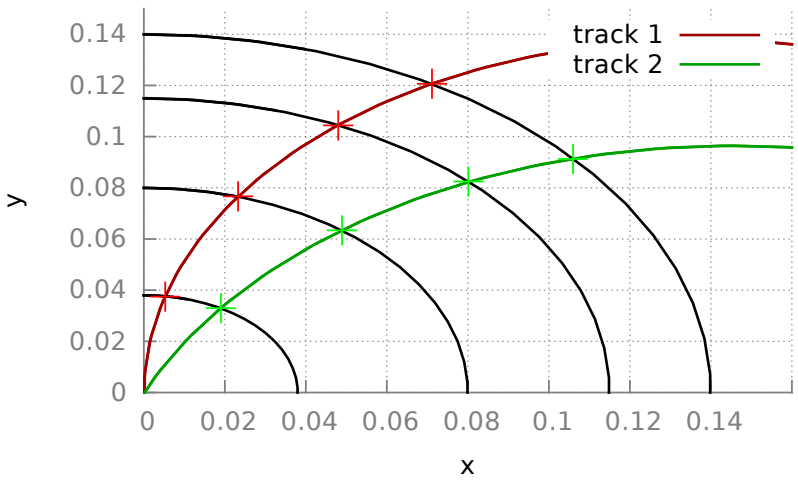

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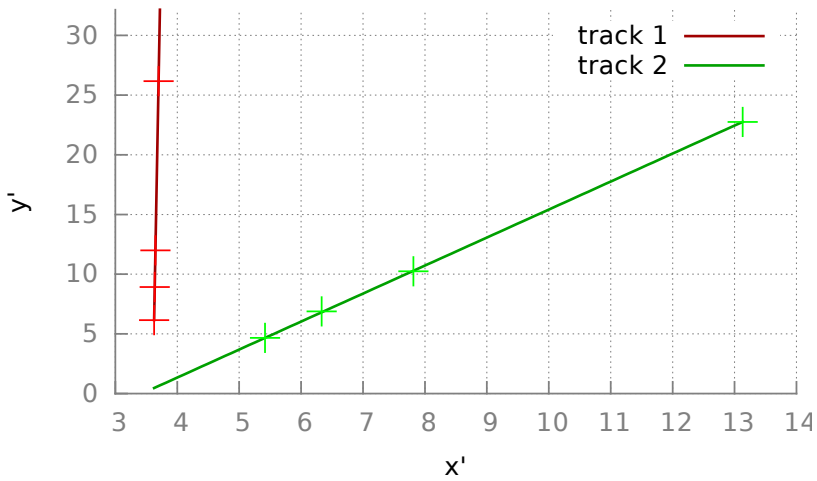

Real Hough Space Example

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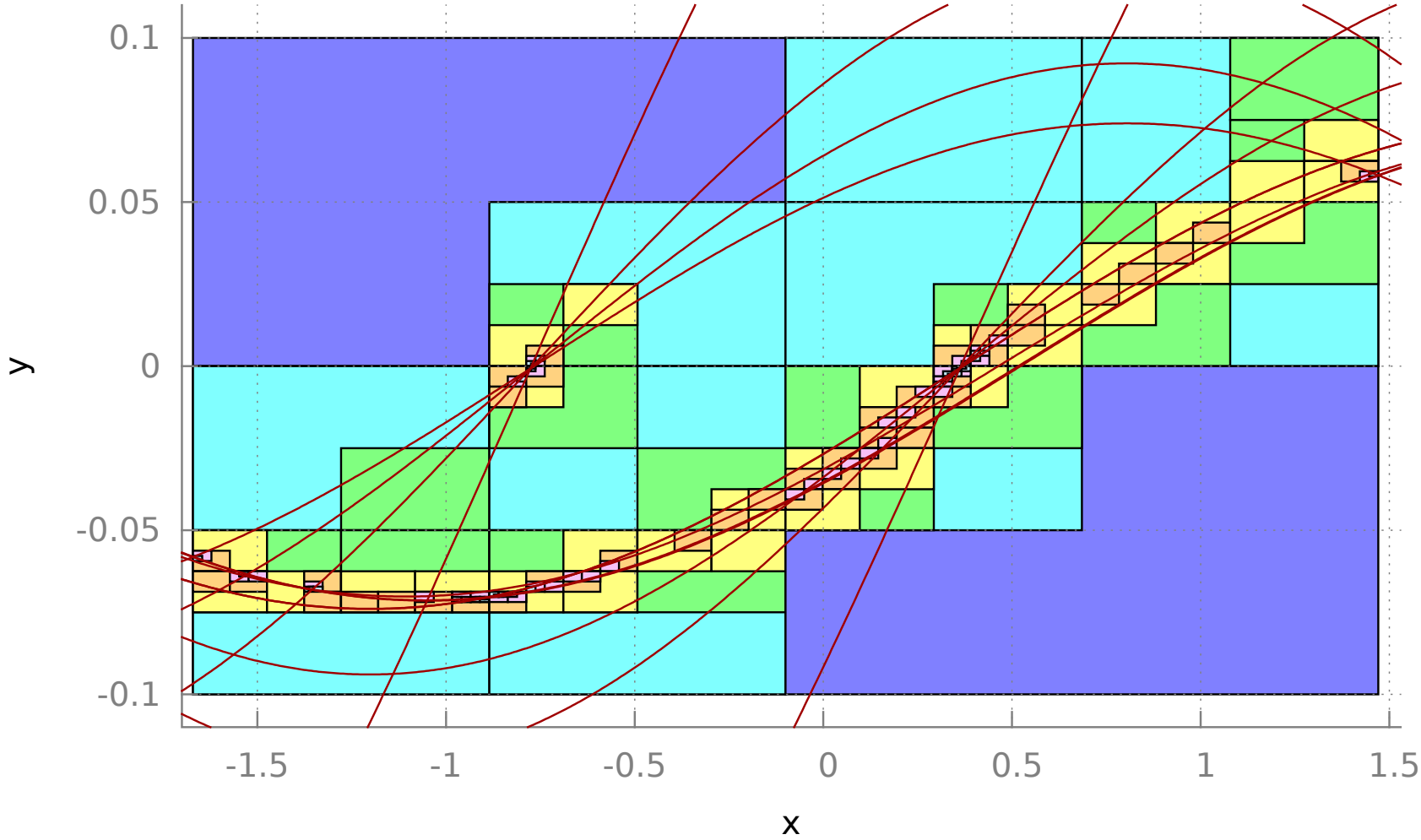
Fast Hough Transformation (colors represent depth of iteration)



Visualization: One Track @500 MeV

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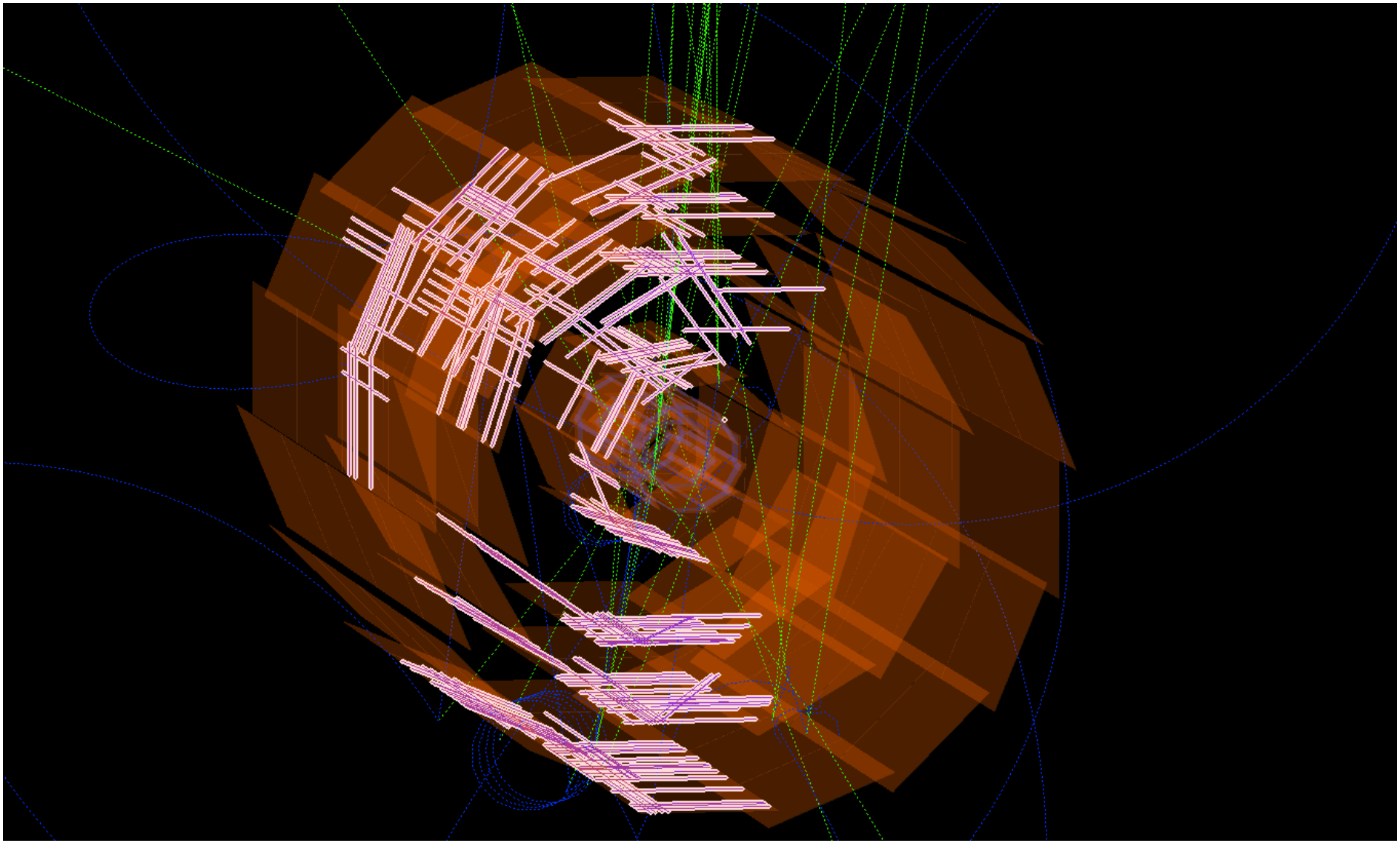

Corresponding Hough Space

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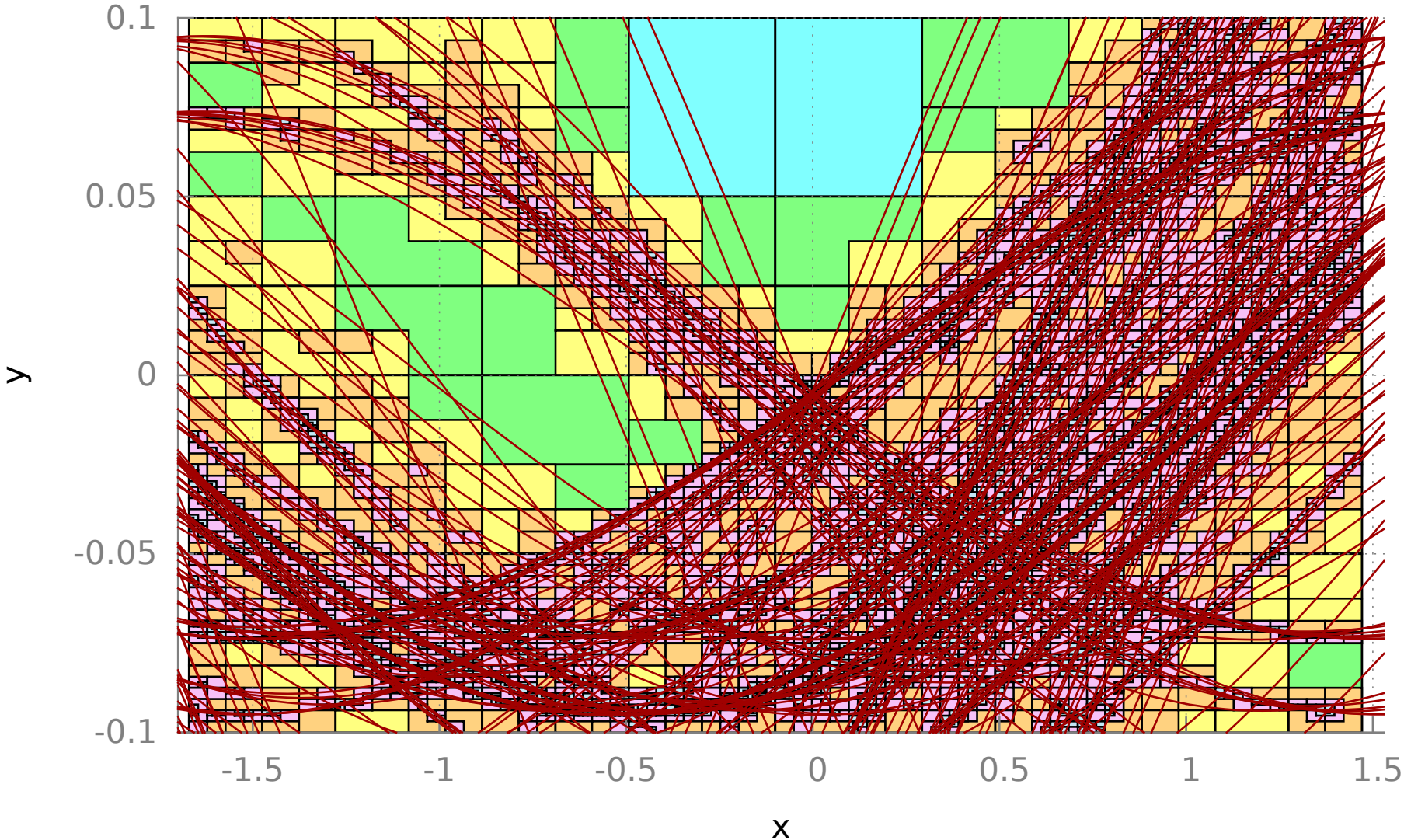

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Performance: Efficiency with Bkg

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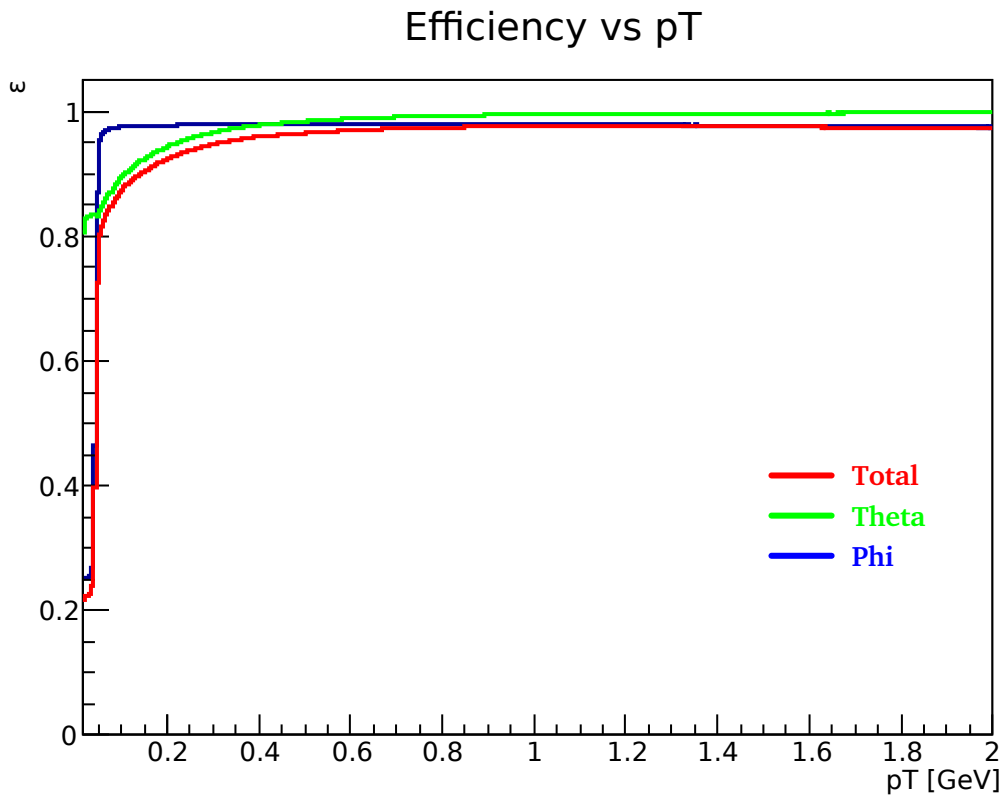
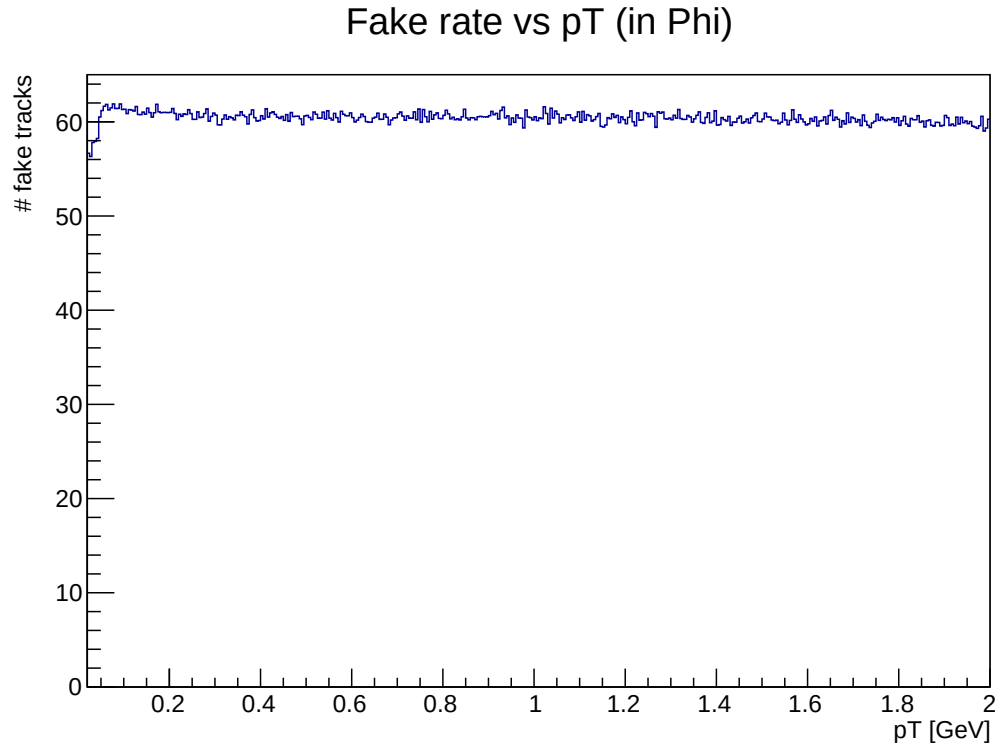
- Constant high efficiency in r-φ @ 0.98 % down to 40 MeV
- Theta efficiency falls under r-φ-efficiency at 300 MeV
- Caused by linear fit of sine-shape like function in z-direction



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

Fake Rate vs pT

- 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

Long Data Reduction Run

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- 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

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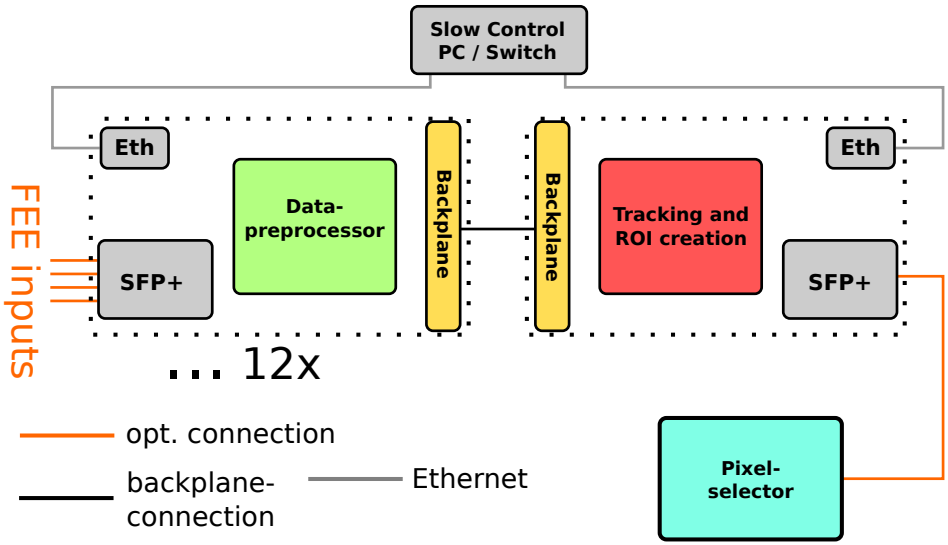
SC: What We Can Provide



- 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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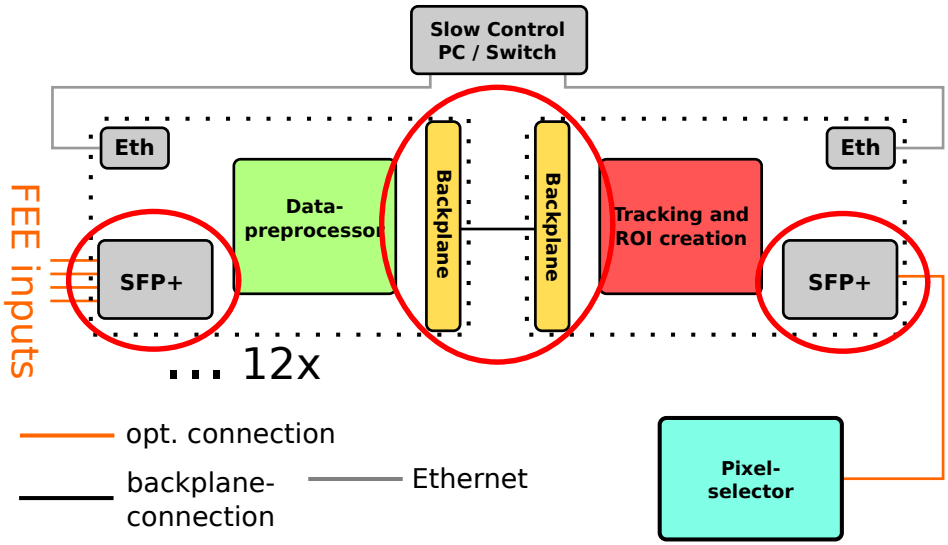

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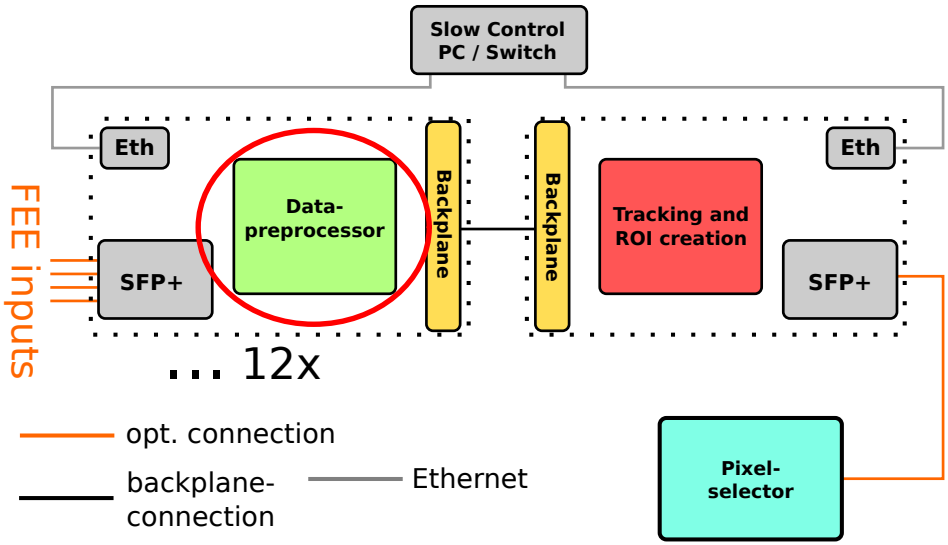

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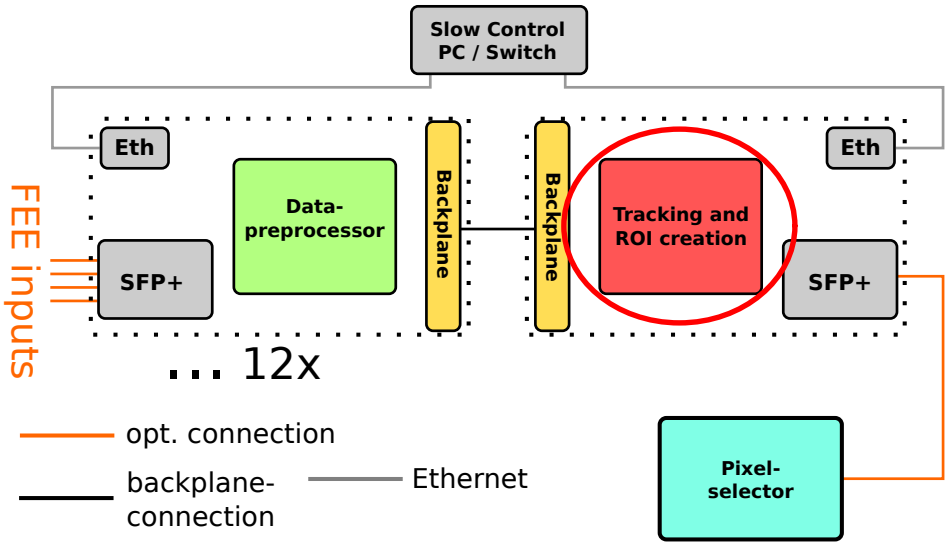

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SC: What We Need

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- 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

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```
urxvt
tp ~/prog/datcon/trunk/tools/concentrator_ctrl > ./control

Concentrator Control Panel

CMD > s
Info: Send 1 packet(s) with request
Cont mode: off
Info: Receiving Message from 10.0.0.1:54345 16 Bytes received now, 16 Bytes total
Status word: 1: 7740 3: 0000 5: 0000 7: 5038 9: 5B1C 11: AB00 13: 0000 15: 0000 valid

                SFP 0           SFP 1           SFP 2           SFP 3
Lane:           up              up              up              down
Channel:        up              up              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               0
Accumulated
CRC errors:     0       Rate: 0/s @ 1408708106
Number of
packet(16 bit): 45957           45509
Run mode:       2               2

                Back  0         Back 1          Back 2          Back 3
Lane:           down            down            down            down
Channel:        down            down            down            down
PLL:            locked          locked          locked          locked

                   Storage Status
                Coord0          Coord1
Empty:          1               0
Full:           0               0
CMD >
```

Present Slow Control: Tracking

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```
urxvt
tp ~/prog/datcon/trunk/tools/tracking_ctrl > ./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: 5580 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
Soft Err:      0               0               0               0
Hard Err:      0               0               0               0
                               Storage Status
               Coord           ROI 1           ROI 2
Empty:         0               0               0
Full:          1               0               1
State:         0
CRC Err:       0
CRC Num:       0       Rate: 0/s @ 1408713125

               Back  0         Back 1          Back 2          Back 3
Lane:          down            down            down            down
Channel:       down            down            down            down
PLL:           locked          locked          locked          locked

                               Tracking Stats
Total:         23517 tracks
Rate:          290.333 tracks/s
Avg:           0.699 tracks/event
Trg:           415.100 trg/s
CMD >
```

SVD Slow Control

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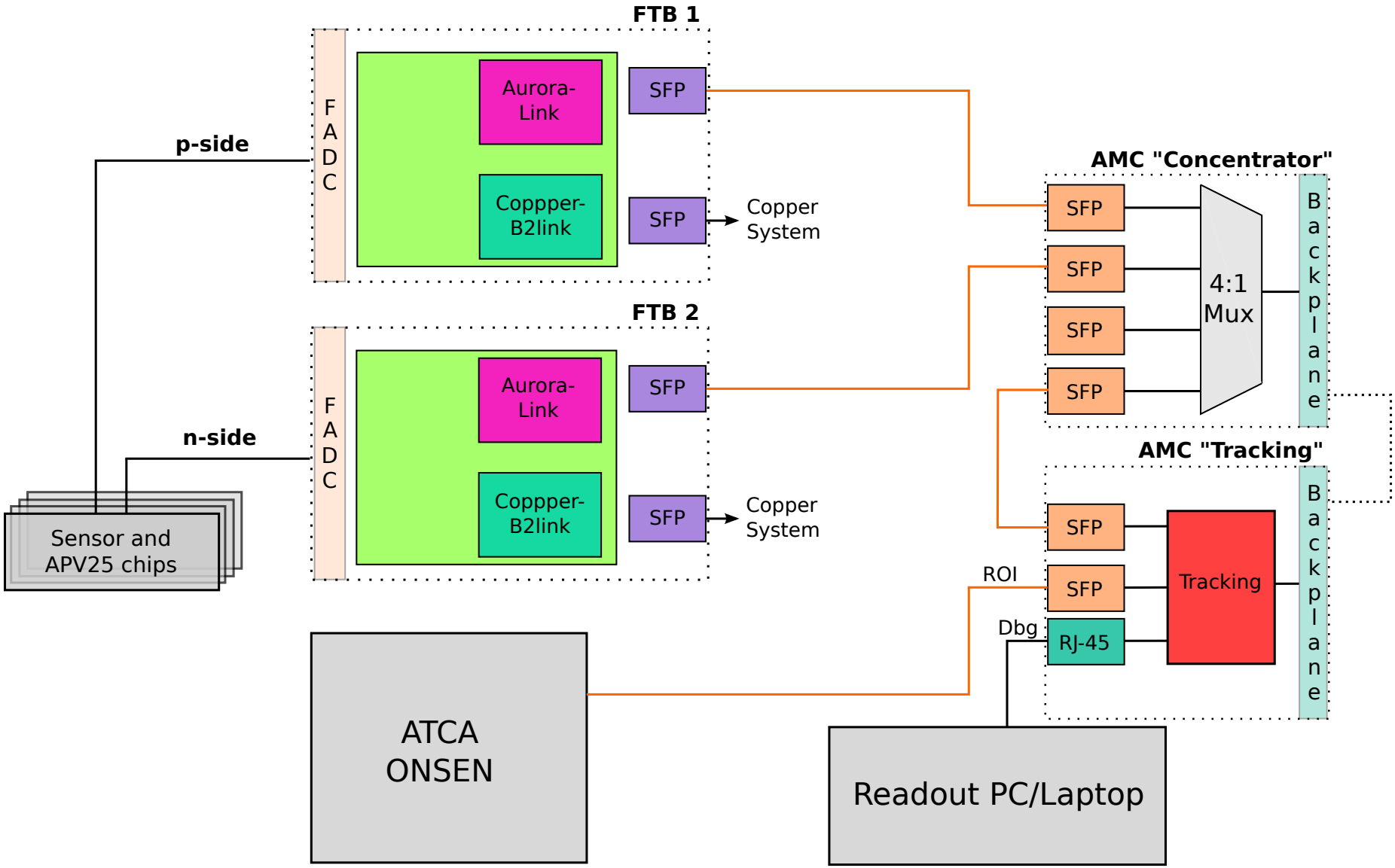
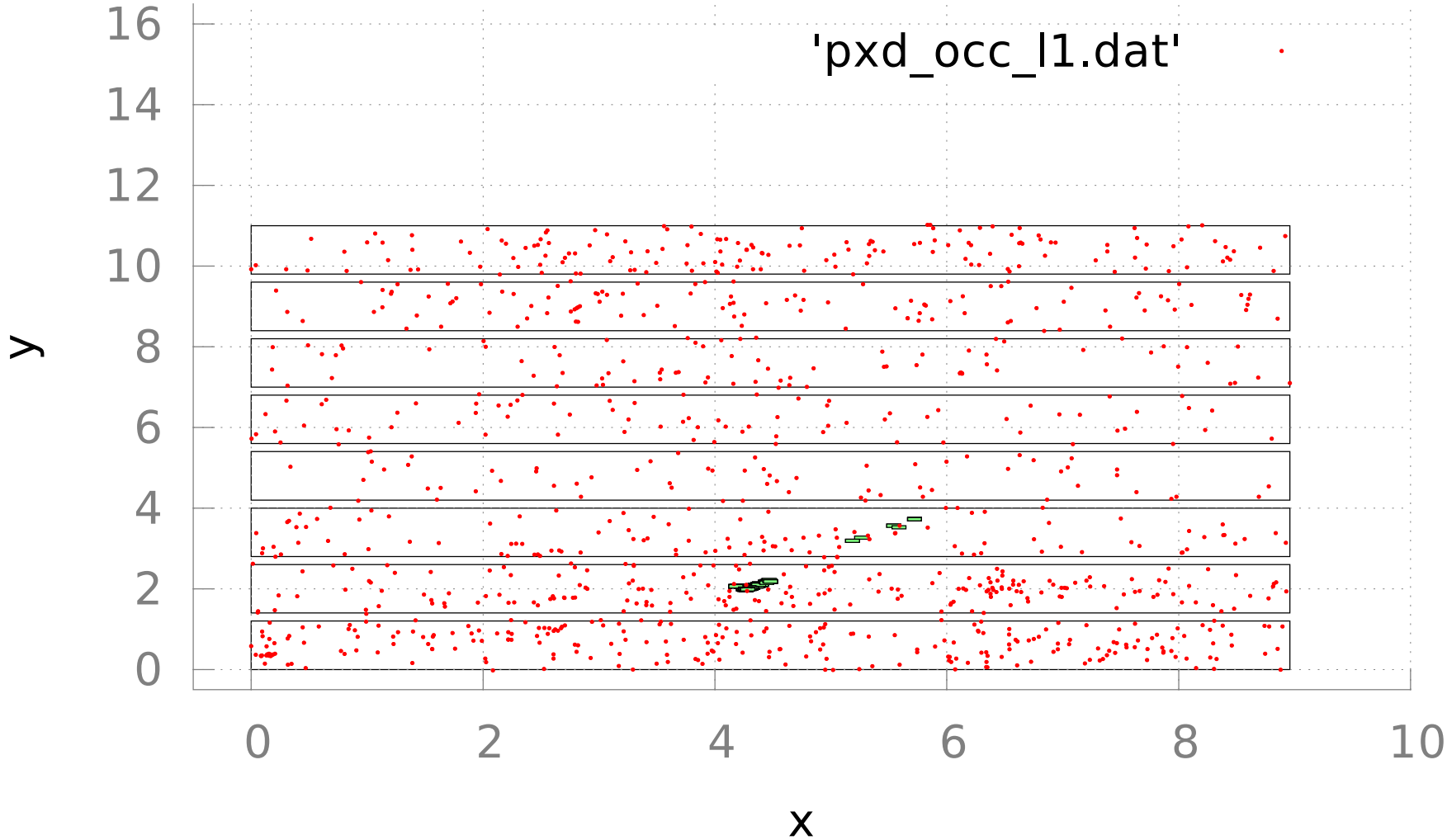
- Monitoring of the Finesse Transmitter Board (FTB)
- B2link register access done by Katsuro
- FADC slow control?

Thank you for your attention!

Testbeam Layout



Close Tracks Events



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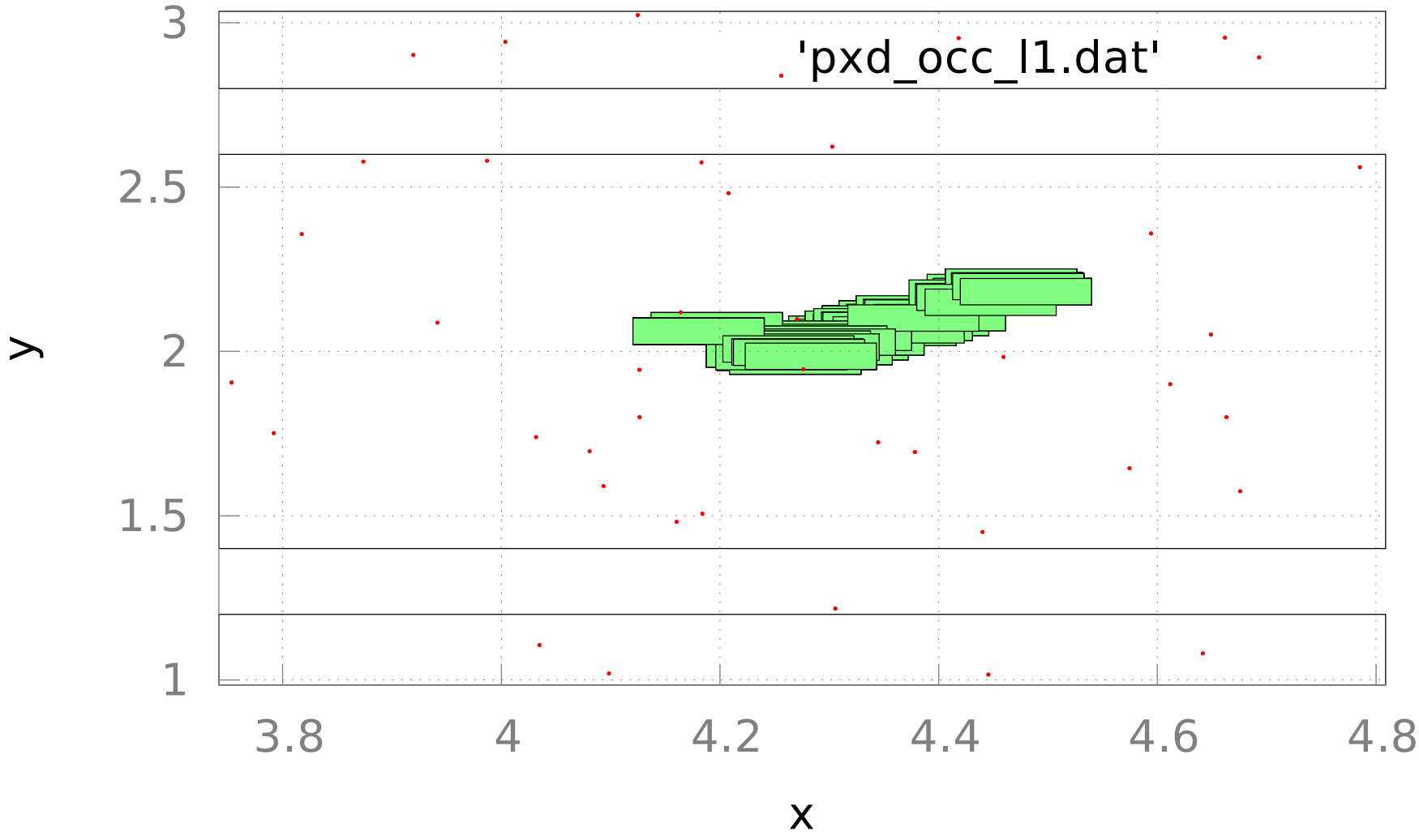
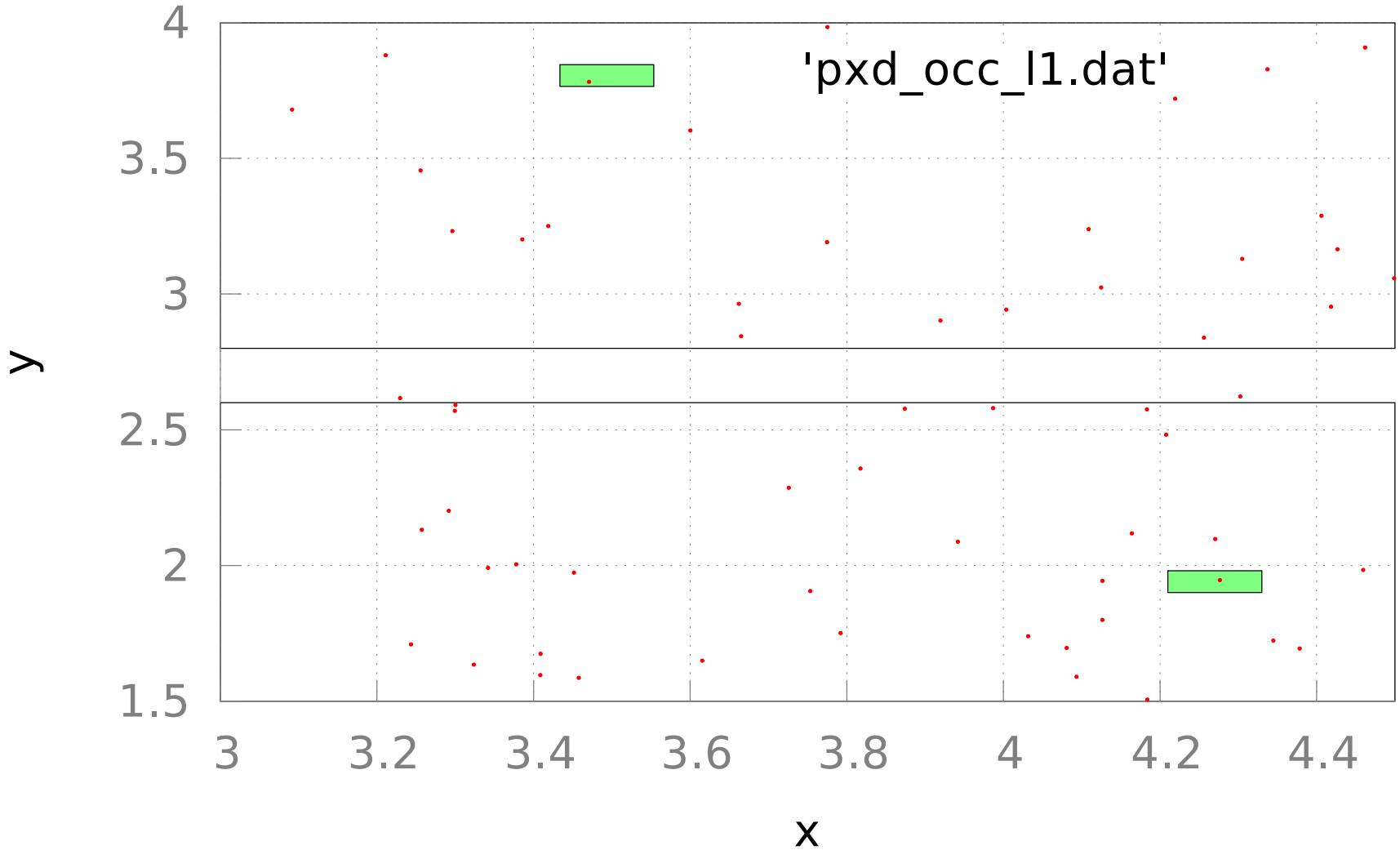


PXD ROI: 1043 Hits, 2 ROIs Reduction: 522



PXD ROI: 1066 Hits, 26 ROIs Reduction: 75