

Outcome from DESY-TB February 2017

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PXD BPAC Pre-Meeting

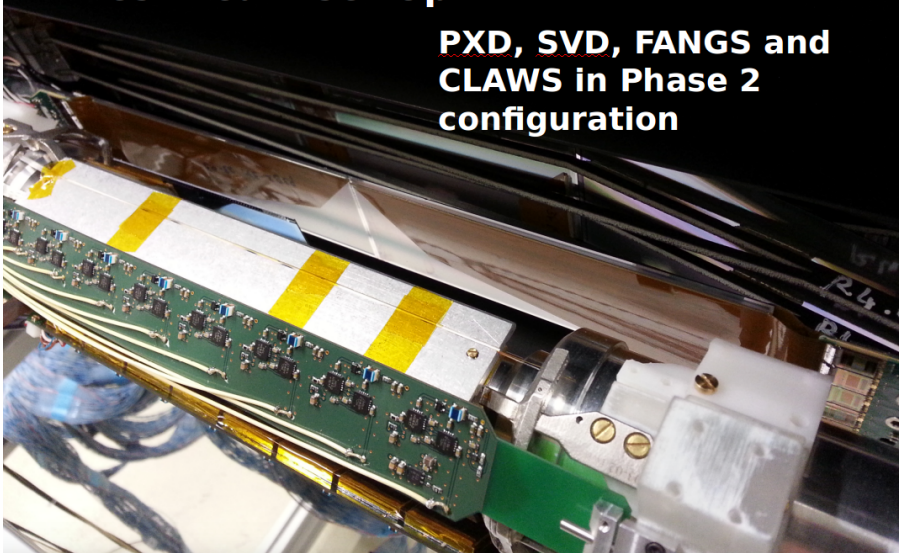


GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN



Test Beam Set Up

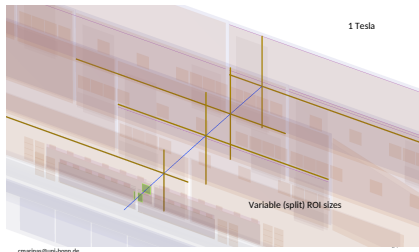
PXD, SVD, FANGS and CLAWS in Phase 2 configuration



Track finding used for data reduction

- Belle II has two trigger stages:
 - hardware based trigger L1
 - High Level Trigger (HLT): software based trigger
- track finding algorithm will be used on the HLT to reduce the amount of data read out by the PXD
 - find tracks in the SVD
 - extrapolate found tracks to the PXD
 - define Regions Of Interest (ROI) on PXD sensors
 - read only PXD - hits found in ROI (data reduction factor $\approx 10\%$)

VXDTF2 Online ROI Selection



Definition of the Observables

- **efficiency**: measurement of the fraction of Particles (with at least an associated RecoTrack and a PXDDigits) that have at least one PXDDigit inside and ROI

$$\epsilon_{PTD} = \frac{\# \text{ Particles with at least one related RecoTrack and one related PXD Digit inside a ROI}}{\# \text{ Particles with at least one related RecoTrack and one related PXD Digit}}$$

PTD = Particle with Track and Digit

- **data reduction factor (drf)**: measurement of the fraction of activated PXDDigits that are selected with ROI finding and that will be available for offline reconstruction

$$\text{drf} = \frac{\# \text{ PXDDigits inside the ROIs}}{\# \text{ PXDDigits}}$$

PXDDigits are intended over threshold

- **execution time**: time reported by the statistics at the end of the basf2 execution (ms/call)

DRF with Run 111

Run number	RUN/TEST	Beam	Beam Energy [GeV]	Magnet	Magnet Field [T]	Cooling	Nominal CO2 temperature [°C]	Geometry	Track finder	Trigger rate (in/out) [Hz]	Rotation [°]
111	COMBINED RUN	ON	5.0	OFF	NO	ON	-15	2 PXD	VXDTF	120	0

→ data reduction factor

- choose a run with no ROI Finding running on HLT → Run111
- run tracking, ROI Finding and PXDDigit filtering *offline*

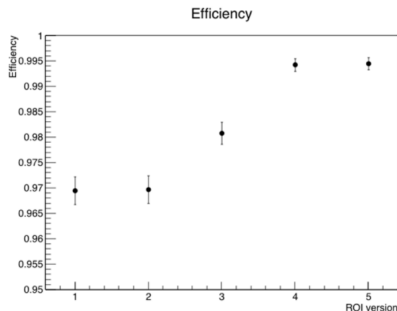
data → offline tracking → offline ROI finding

- 10k analysed events
- only PXD layer 1 data available
- average of 0.5 tracks per event
- average of ~1 intercepts per event (two per tracks)
- average of ~ 1 ROI per event, depending on ROI size

ROI Finding Efficiency at DESY

simulation

- ➔ **Efficiency** above 97% even for small ROIs
 - geometry is simple, high momentum tracks, low track multiplicity
 - inefficiencies due to:
 - lack of intercepts for v4, v5 (large ROIs)
 - too small ROIs for v1, v2, v3 (small ROIs)
- ➔ **Execution Time** evaluated on simulated events at KEK, *not equivalent to the HLT*
- ➔ **Tracking + PXD Data Reduction Execution time** < 5ms/call, with large fluctuations (15ms/call)
 - included modules: pattern recognition (VXDTF1), track fitter, PXDDataReduction



small
ROIs
sides
40-50
pixels long

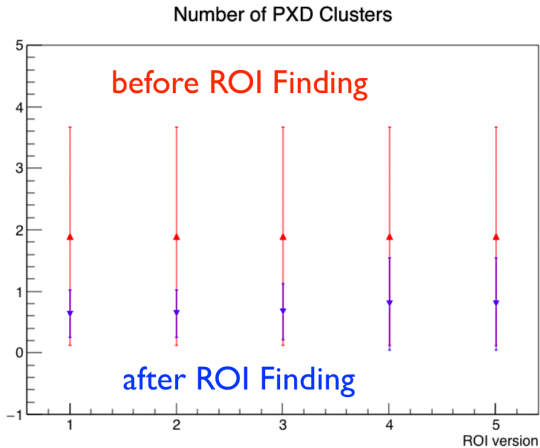


large
ROIs
full-frame
ROIs

Number of PXD Clusters

Run111

- Evaluated with testbeam data: the number of clusters is reduced, but most important the long tails of the number of clusters distributions are cut away



Detail of analysis

- Analysis done on master branch with PXDEfficiency module modified to accept 4 PXD module geometry.
- Offline Analysis Chain: Unpacker → DigitSorter/RawHitSorter → Clusterizer → VXDTF1/2 → DAFRecoFitter → TrackCreator → PXDEfficiency.
- Use only runs with alignment included in *beamtest_vxd_april2017_rev1*, available since 27.06.17.
- All runs taken from the list of long, stable runs, processed up to the first 10,000,000 events for each, if available.
- <https://confluence.desy.de/display/VBTA/Description+of+runs>

Uwe Gebauer

PXD Hit Efficiency

$$\epsilon = \frac{\text{\#Matched track intersection inside ROI}}{\text{\#Track intersection inside ROI}}$$

- Require events with exactly one fitted track with $1 \text{ GeV} < |p_{fit}| < 8 \text{ GeV}$ and fitted p-value $p > 0.01$.
- Require exactly one ROI on module in question, and require track intersection to lie inside.
- Match track intersections to hits with a distance of less than $400 \mu\text{m}$ on the PXD.

Comments

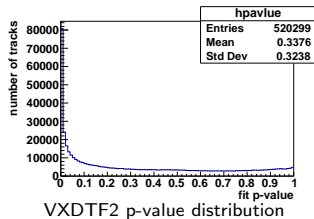
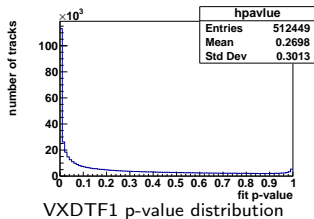
- Analysis can be performed on any run, observing a decrease in efficiency shows the particular run being problematic.
- Alignment used on HLT and during offline analysis different.
- Offline-tracking can produce more/different tracks than online-tracking. Ignore tracks outside ROIs.

Run 176

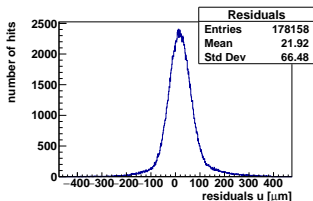
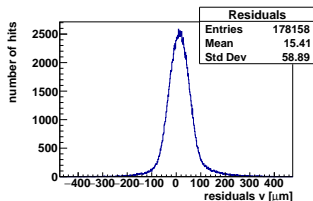
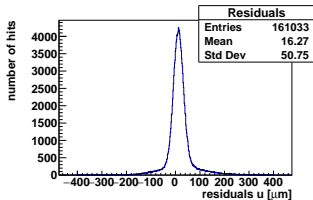
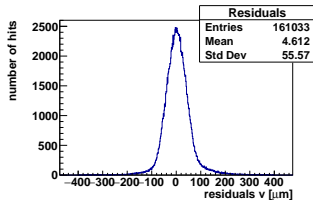
- Magnetic field 0.5T, beam energy 2.4 GeV

Comments

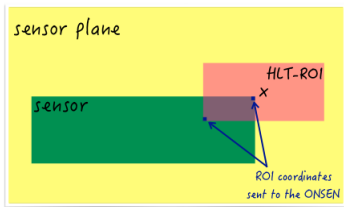
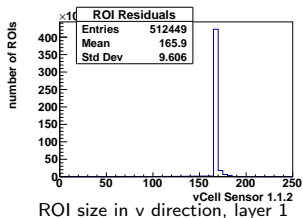
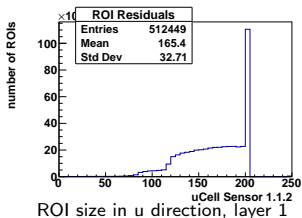
- Earlier analysis greatly hindered by alignment being available only with great delay.
- Did all analysis with VXDTF version 1 and 2.



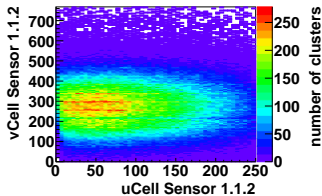
- Residuals for VXDTF2
- Offsets of the mean on the order of 5 – 20 μm

Layer 1 u-direction: $\sigma_{Fit} = 210\mu\text{m}$ Layer 1 v-direction: $\sigma_{Fit} = 170\mu\text{m}$ Layer 2 u-direction: $\sigma_{Fit} = 220\mu\text{m}$ Layer 2 v-direction: $\sigma_{Fit} = 200\mu\text{m}$

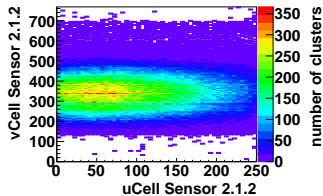
- In u-direction most ROIs lie partially outside the sensor, making the effective ROI smaller.
- For PXD efficiency study no ROIs with intercept outside the sensor area are accepted, limiting how small ROIs can be.



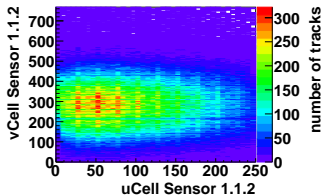
- Magnetic field 0.5T, beam energy 2.4 GeV, VXDTF1
- Beamspot from fitted tracks matches hitmap from sensor very well.



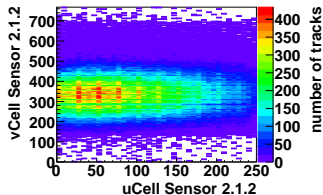
Hitmap of layer 1



Hitmap of layer 2

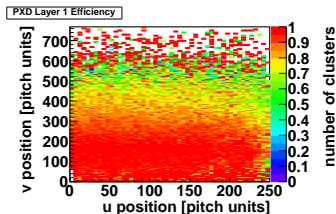


Beamspot from fitted tracks, Layer 1

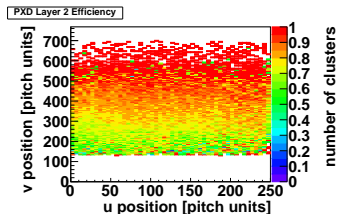


Beamspot from fitted tracks, Layer 2

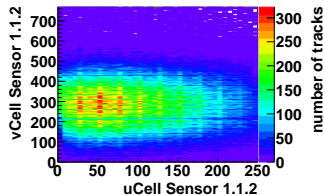
- Magnetic field 0.5T, beam energy 2.4 GeV, VXDTF1
- Efficiency shows gradient in v-direction.



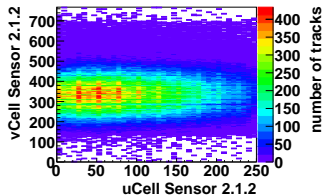
Efficiency on layer 1



Efficiency on layer 2



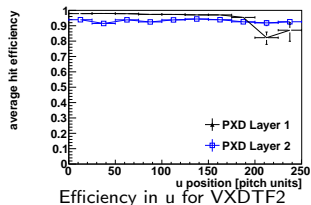
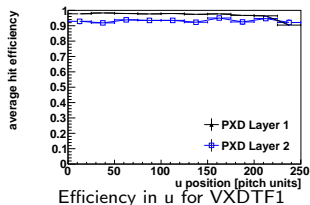
Beamspot from fitted tracks, Layer 1



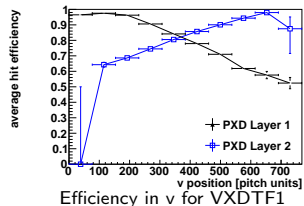
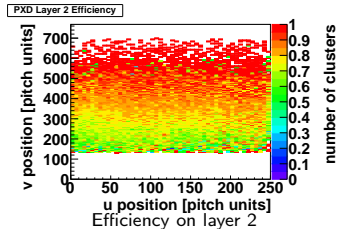
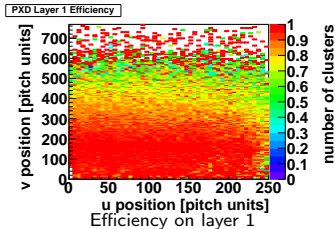
Beamspot from fitted tracks, Layer 2

Run 176

- Projecting the efficiency along the v -direction.
- Constraining the area to sub-range in v -direction:
- Layer 1: $100 < v < 200$
- Layer 2: $500 < v$

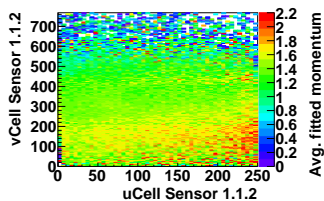


- In v-direction see a linear gradient on both modules.
- Gradient direction opposite between the modules.

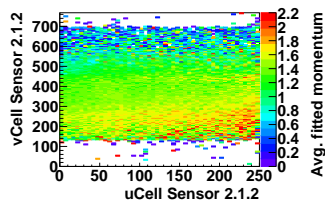


Tracking

- Fitted tracks show no suspicious behaviour.
- Tried both track finders, VXDTF2 shows effect in u-direction, but no change related to the gradient.



Fitted momentum on layer 1

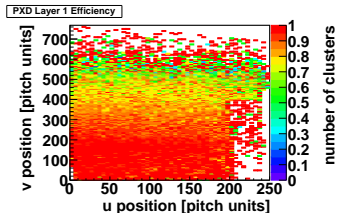


Fitted momentum on layer 2

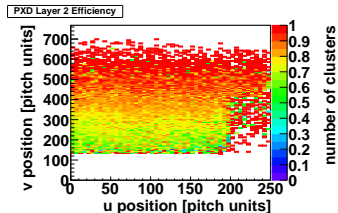
Possible Gradient Cause 1:

Tracking 2

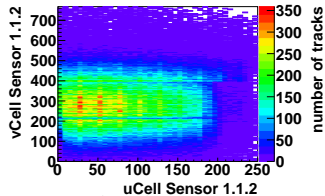
- With VXDTF2 strange area of low efficiency in lower right corner



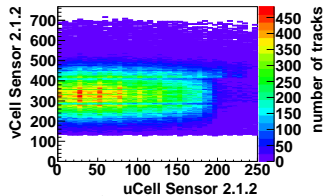
Efficiency on layer 1



Efficiency on layer 2



Beamspot from fitted tracks, Layer 1

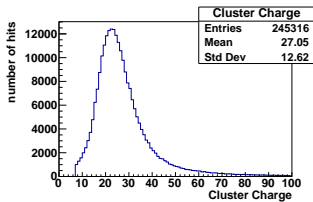


Beamspot from fitted tracks, Layer 2

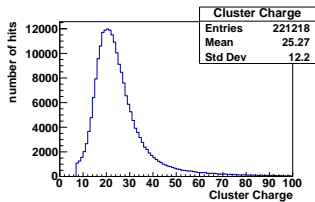
Possible Gradient Cause 2:

Sensors

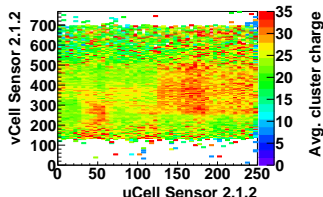
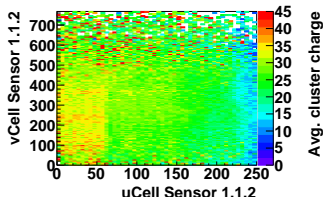
- Small amount of signal cut off at low charges, but not enough to explain gradient.
- Average charge shows some structure on the module, but shape too different as an explanation.



Layer 1 cluster charge



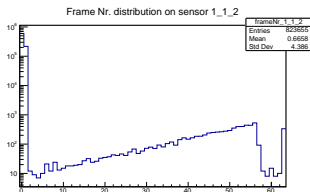
Layer 2 cluster charge



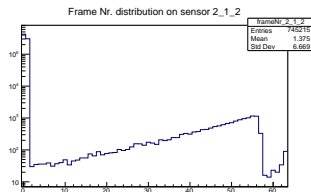
Possible Gradient Cause 3:

PXD DAQ

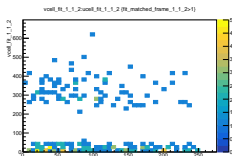
- Some raw PXD hits contain a strange frame number.
- Exact implications still under investigation, but might be related to gradient appearance.



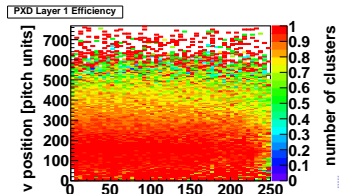
Frame number on layer 1



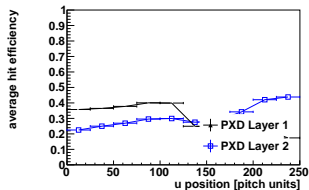
Frame number on layer 2



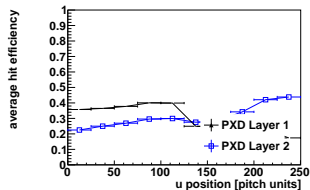
Tracks with matched digit having frame nr. > 1



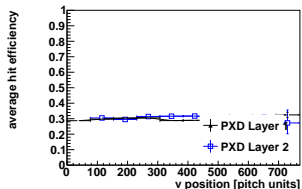
- Magnetic field 1T, beam energy 2.4 GeV
- Many runs are like this: Efficiency much lower.
- Although classified as long and good run, some problem seems to have occurred.



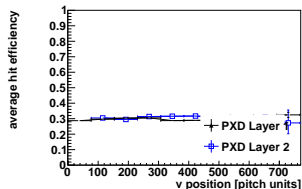
Efficiency in u for VXDTF1



Efficiency in u for VXDTF2

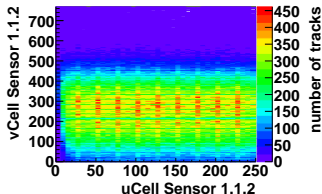


Efficiency in v for VXDTF1

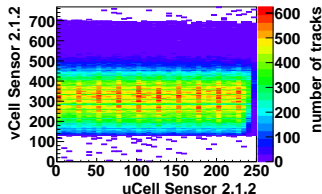


Efficiency in v for VXDTF2

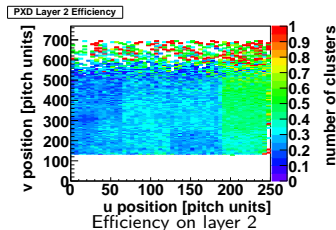
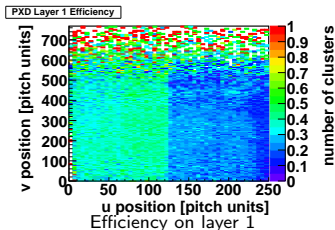
- VXDTF1
- Sharp edge with different efficiency: Problems during module operation?



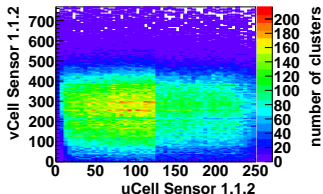
Beamspot from fitted tracks



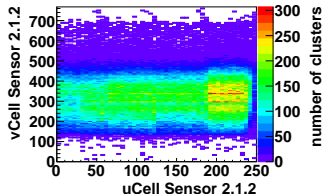
Beamspot from fitted tracks



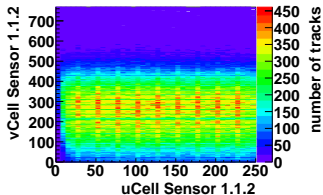
- VXDTF1
- Same effect observed on hitmap



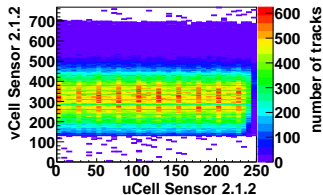
Hitmap on sensor, Layer 1



Hitmap on sensor, Layer 2

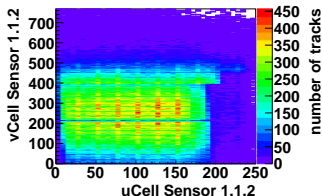


Beamspot from fitted tracks, Layer 1

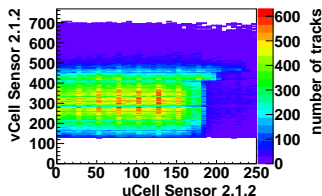


Beamspot from fitted tracks, Layer 2

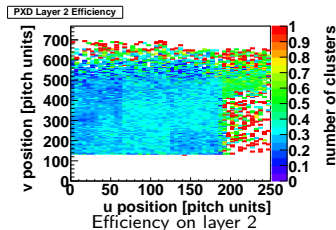
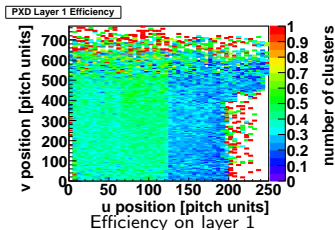
- VXDTF2
- Again observe lower right corner as much less efficient: Some sector-map effect?



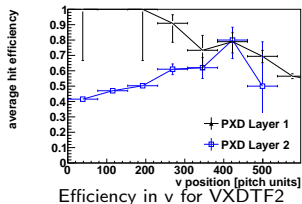
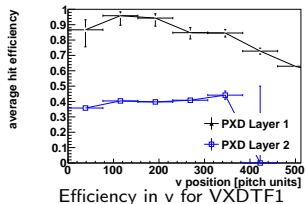
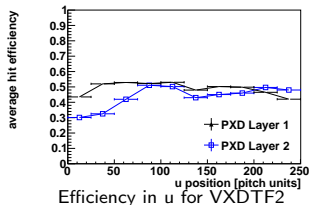
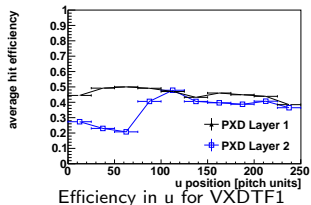
Beamspot from fitted tracks



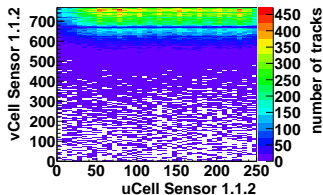
Beamspot from fitted tracks



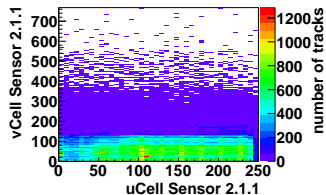
- Magnetic field 1 T, beam energy 4 GeV



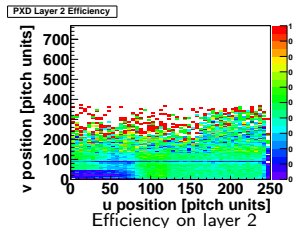
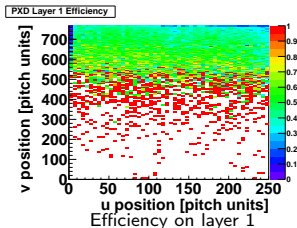
- VXDTF1



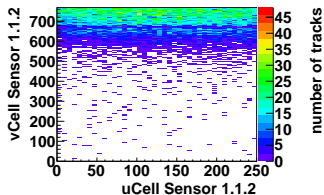
Beamspot from fitted tracks



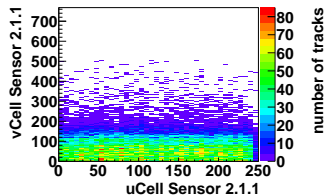
Beamspot from fitted tracks



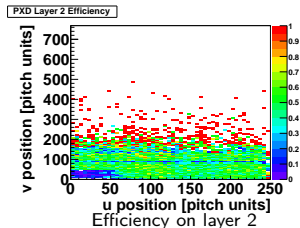
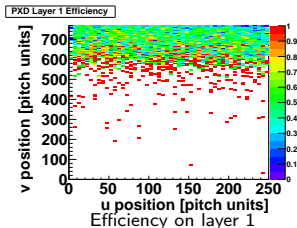
- VXDTF2



Beamspot from fitted tracks



Beamspot from fitted tracks



Conclusion

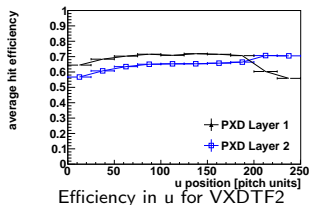
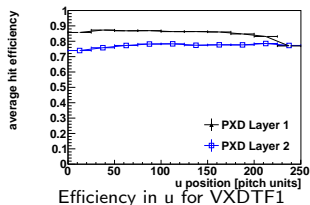
- In some runs and using appropriate cuts, observe high PXD efficiencies ($> 97\%$)
- Measured efficiency is highly run-dependant. Many changes between runs not properly documented.
- VXDTF2 shows problems with memory usage in several runs. Tracking people know and are working on it.
- Big issue: ExpressReco did not produce PXDEfficiency plots. But DAQ problems best visible in bad efficiencies.
 - Planned to help VXD DQM to add these very important histograms
- Big issue: Proper VXD alignment arrived with huge delay .. and delayed efficiency studies here.
 - Alignment responsables aware of this problem. Will not happen again.
- Big issue: Startrow field in data format seems to be not properly filled. Would have been helpful for understanding reason of bad efficiencies.
 - This issue is discussed since TB16. No progress.

Additional runs

Some with less statistic

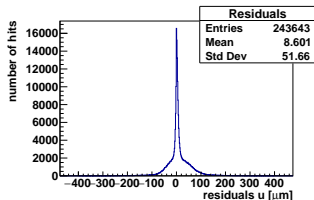
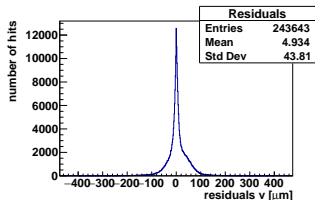
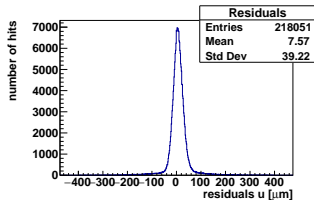
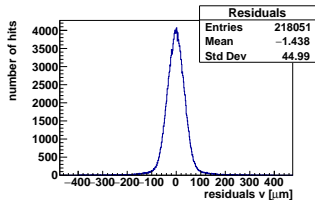
Run 176

- When not requiring the fitted track to lie inside the ROI, measured efficiency with VXDTF2 drops drastically.
- Not applying constraint in v here.

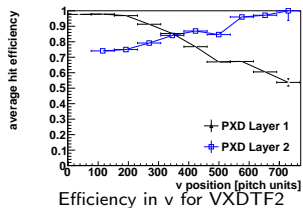
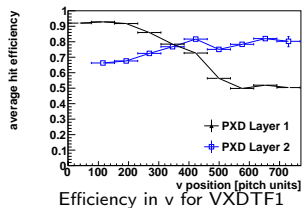
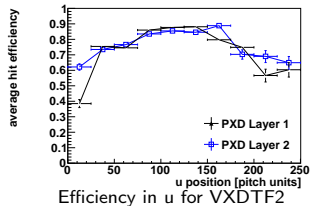
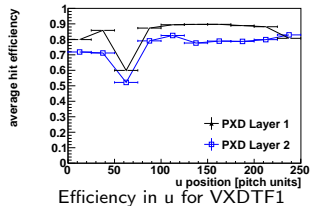


- Even if correct track found, if not passing through a ROI no hit information is saved.
- ROIs are determined with VXDTF1 on HLT, so finds mostly the same tracks as were used there.
- If VXDTF2 finds different tracks than VXDTF1, these will not pass through the ROI and have no chance of being matched.

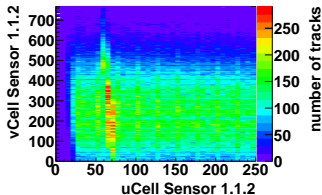
- Residuals for VXDTF1
- Biased residuals
- Cross-check of alignment *beamtest_vxd_april2017_rev1*

Layer 1 u-direction: $\sigma_{Fit} = 210\mu\text{m}$ Layer 1 v-direction: $\sigma_{Fit} = 220\mu\text{m}$ Layer 2 u-direction: $\sigma_{Fit} = 155\mu\text{m}$ Layer 2 v-direction: $\sigma_{Fit} = 195\mu\text{m}$

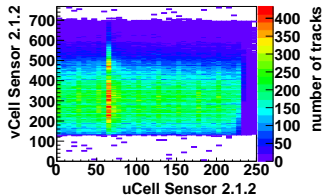
- Magnetic field 1 T, beam energy 1 GeV
- Minimal fitted momentum reduced to 0.5 GeV



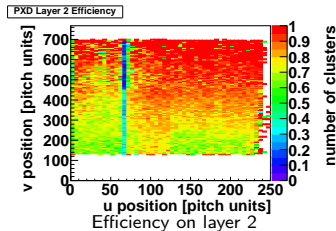
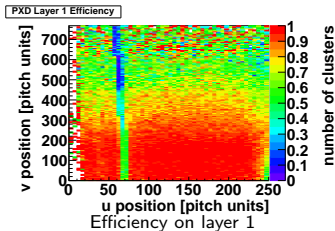
- VXDTF1



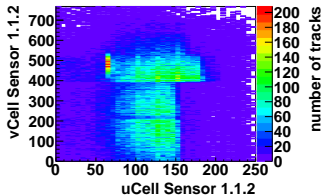
Beamspot from fitted tracks



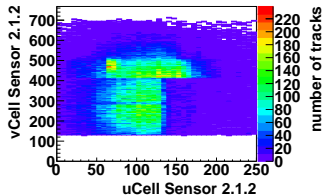
Beamspot from fitted tracks



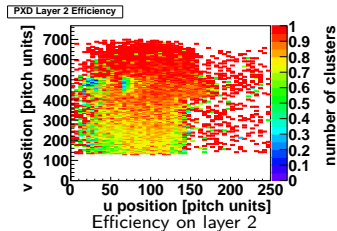
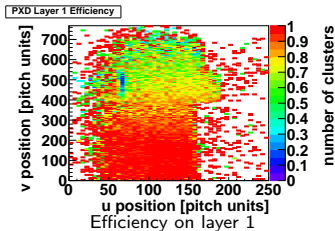
- VXDTF2



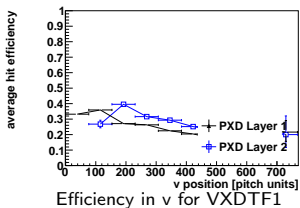
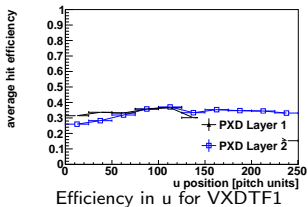
Beamspot from fitted tracks



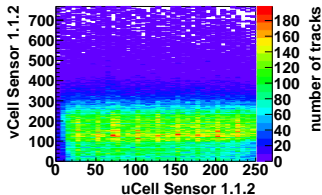
Beamspot from fitted tracks



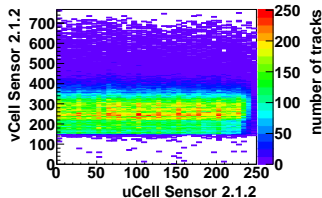
- Magnetic field 1 T, beam energy 2.4 GeV
- Analysis fails with VXDTF2



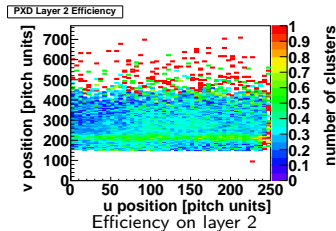
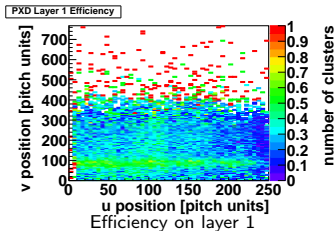
- VXDTF1



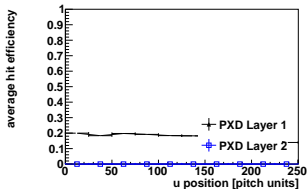
Beamspot from fitted tracks



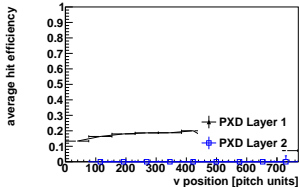
Beamspot from fitted tracks



- No magnetic field, beam energy 5 GeV
- Only layer 1 taking data, full-frame dummy ROIs sent
- BASF2 exhausts all memory on my machine and freezes when using VXDTF2.

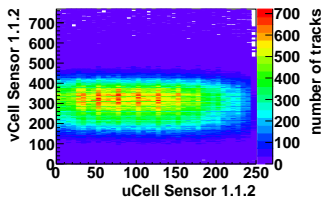


Efficiency in u for VXDTF1

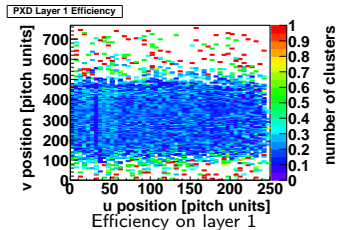


Efficiency in v for VXDTF1

- VXDTF1

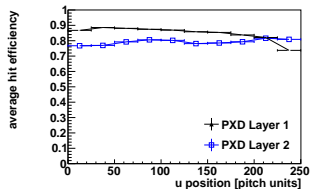


Beamspot from fitted tracks

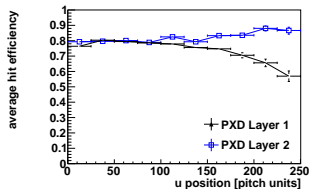


Efficiency on layer 1

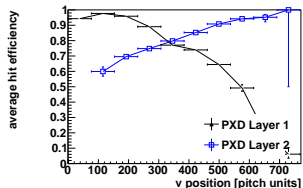
- Magnetic field 0.25 T, beam energy 2.4 GeV



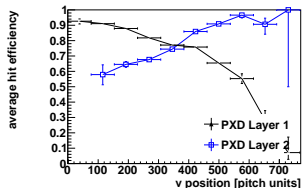
Efficiency in u for VXDTF1



Efficiency in u for VXDTF2

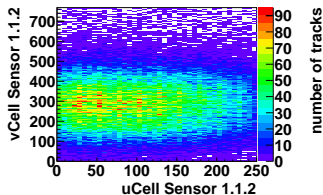


Efficiency in v for VXDTF1

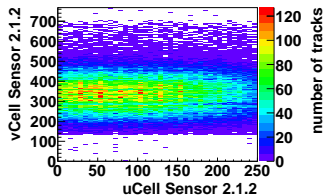


Efficiency in v for VXDTF2

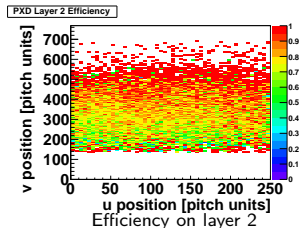
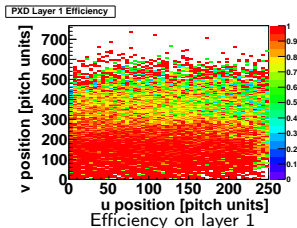
- VXDTF1



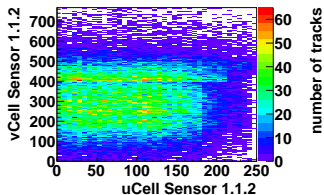
Beamspot from fitted tracks



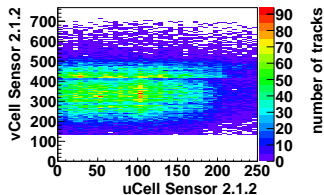
Beamspot from fitted tracks



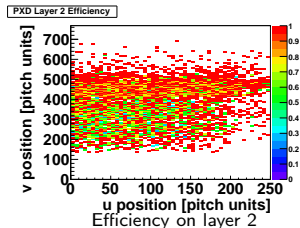
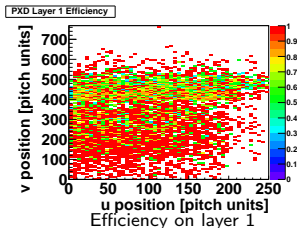
- VXDTF2



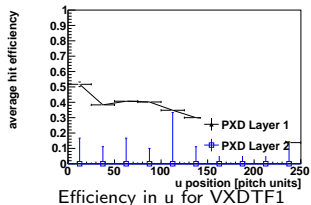
Beamspot from fitted tracks



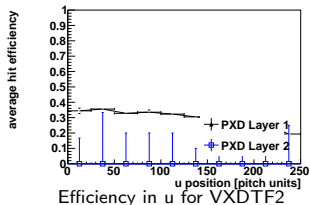
Beamspot from fitted tracks



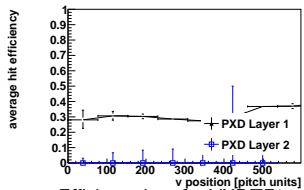
- Magnetic field 0 T, beam energy 5 GeV



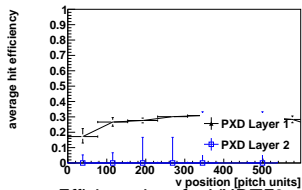
Efficiency in u for VXDTF1



Efficiency in u for VXDTF2

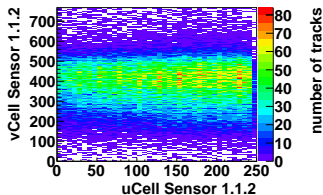


Efficiency in v for VXDTF1

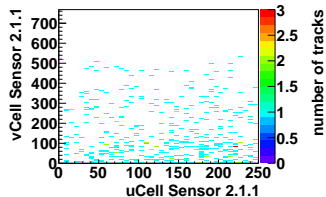


Efficiency in v for VXDTF2

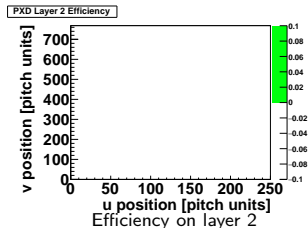
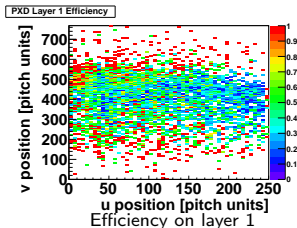
- VXDTF1



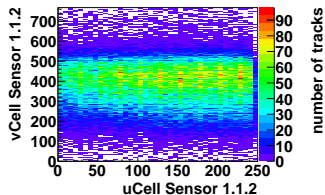
Beamspot from fitted tracks



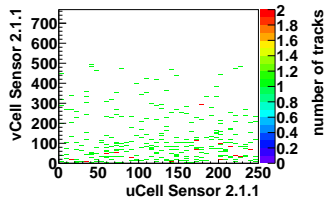
Beamspot from fitted tracks



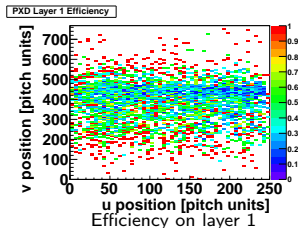
- VXDTF2



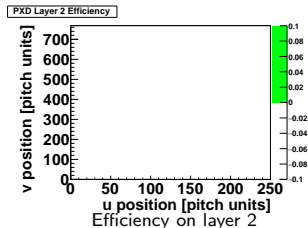
Beamspot from fitted tracks



Beamspot from fitted tracks



Efficiency on layer 1



Efficiency on layer 2