Summary of PXD Background and ROI / PXD Efficiency Studies

All credits go to Simon and Sally!

PXD Backgrounds

Phase 3 offline results

Slavomira Stefkova

BG meeting, 07.08.2019

Slides can be found here:
https://indico.belle2.org/event/830/contributions/3538/attachments/1815/2772/BG_07_08_PXD_Sally.pdf

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

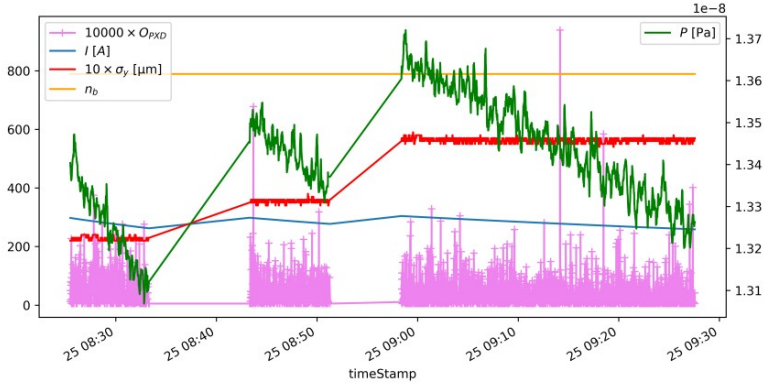
Content

In this presentation, following items will be discussed:

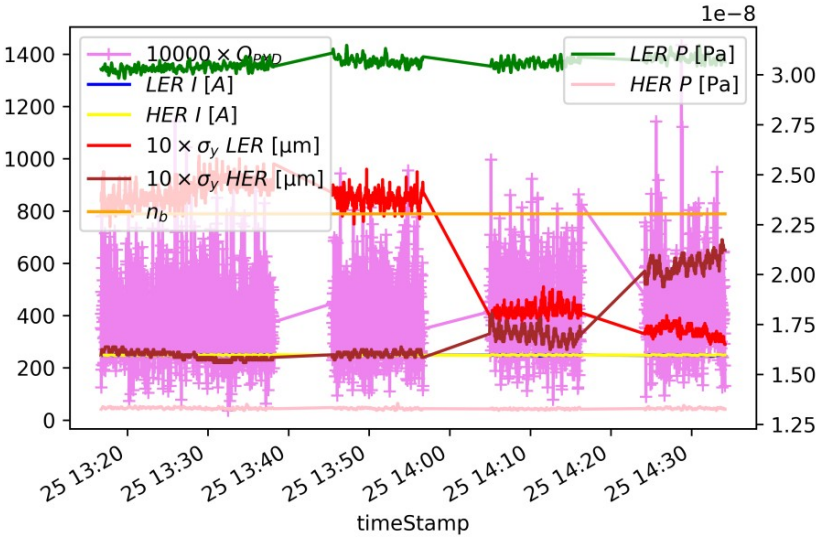
- Measurement of the Luminosity BG
- Update on PXD extrapolations
- Improved fitting strategy

Luminosity BG measurement

- **Data**: Offline data from 25.06.2019
- LER Single-beam runs: 3071, 3074, 3075
- HER Single-beam runs: 3076, 3077, 3078 (see figure)
- Luminosity scans: r3087, r3088, r3089, r3091

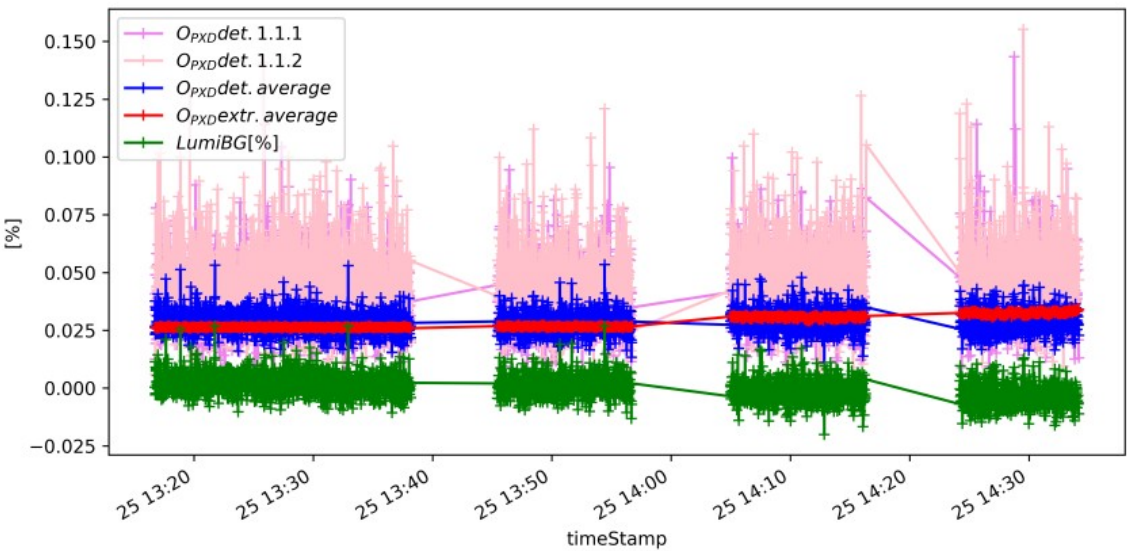


Luminosity scans - Beam parameters



Measurement Strategy

- Perform Touschek and Coulomb decomposition for LER and HER
- Extrapolate to beam conditions in Luminosity scans for L1 and L2
- Lumi-BG O_{PXD} = Measured O_{PXD} − Extrapolated O_{PXD}
- Figure below shows L1 average



Results

- Lumi-BG measurement for L1 and L2 is shown below
- Lumi-BG component is negligible w.r.t the single-beam background component

Run Number	Luminosity	trigger	Extrapolated O_{PXD} [%]	Measured O_{PXD} [%]	Lumi BG [%]
3087	30×10^{32}	physics	0.0263 ± 0.0002	0.0283 ± 0.0046	0.002 ± 0.0046
3088	30×10^{32}	physics	0.0266 ± 0.0002	0.0278 ± 0.0045	0.0012 ± 0.0045
3089	15×10^{32}	physics	0.0307 ± 0.0005	0.0292 ± 0.0047	-0.0015 ± 0.0048
3091	3×10^{32}	beam	0.0325 ± 0.0006	0.029 ± 0.0048	-0.0035 ± 0.0049

Run Number	Luminosity	trigger	Extrapolated O_{PXD} [%]	Measured O_{PXD} [%]	Lumi BG [%]
3087	30×10^{32}	physics	0.0176 ± 0.0001	0.0143 ± 0.004	-0.0032 ± 0.004
3088	30×10^{32}	physics	0.0177 ± 0.0001	0.0143 ± 0.0044	-0.0034 ± 0.0044
3089	15×10^{32}	physics	0.0193 ± 0.0002	0.015 ± 0.0043	-0.0043 ± 0.0043
3091	3×10^{32}	beam	0.02 ± 0.0003	0.0147 ± 0.0044	-0.0053 ± 0.0044

Update on PXD extrapolations

- Last time: PXD occupancy extrapolations were shown with constant pressure
- Today: account for pressure increase
- The old rate:

$$O_{PXD} = \frac{TI^2}{n_b \sigma_y} + (BIP_0 \times \frac{\beta_{old}}{\beta_{new}})$$

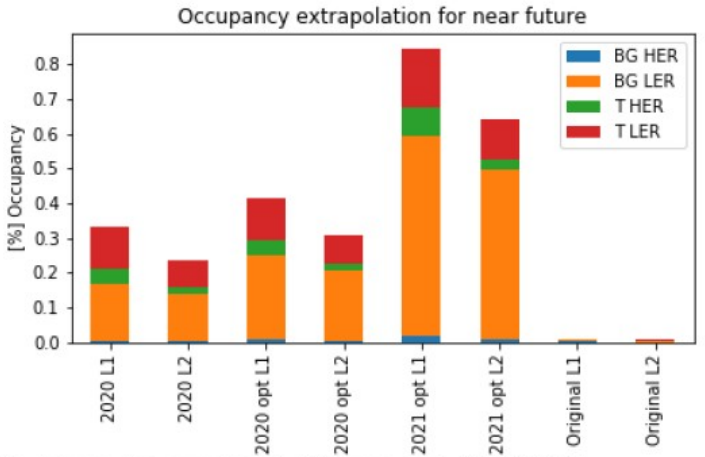
- The new rate:

$$O_{PXD} = \frac{TI^2}{n_b \sigma_y} + (BI(P_0 + \frac{IdP}{dI}(1 - imp(dp\_di))) \times (\frac{\beta_{old}}{\beta_{new}})$$

Extrapolations: Average Sensor

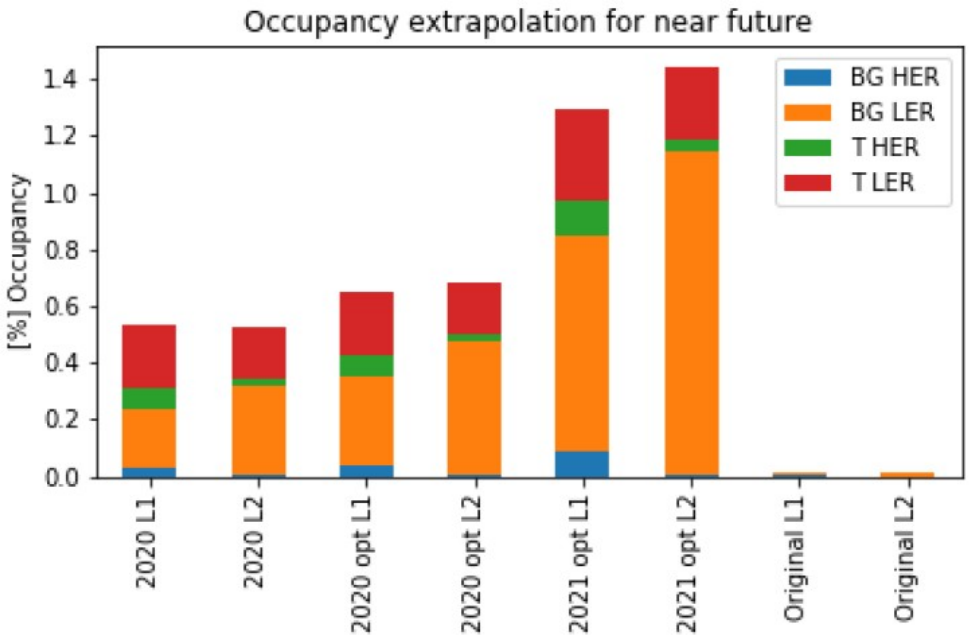
- Using 12 (HER), 14 (LER) May Fit Average Sensor Results
- Reaching $O_{PXD} = 0.8\%$ in 2021 $\rightarrow$ still safe

Scenario	$\beta_y^*[mm]$	I HER [mA]	I LER [mA]	$\sigma_y[\mu m]$	n_b	dP/dIimpr.
Original	3.0	171	141	38	1576	1.0
2020	3.0	1000	1500	38	1576	0.5
2020 opt	2.0	1000	1500	38	1576	0.5
2021 opt	1.4	1300	1800	38	1576	0.333



Extrapolations: +X Sensor

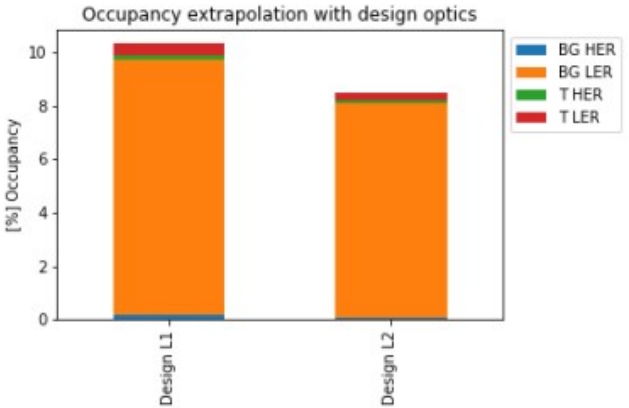
- Highest BG at +X direction
- Using 12 (HER), 14 (LER) May Fit +X Sensors
- $O_{PXD}^{+Xsensor} \approx 2 \times O_{PXD}^{average}$



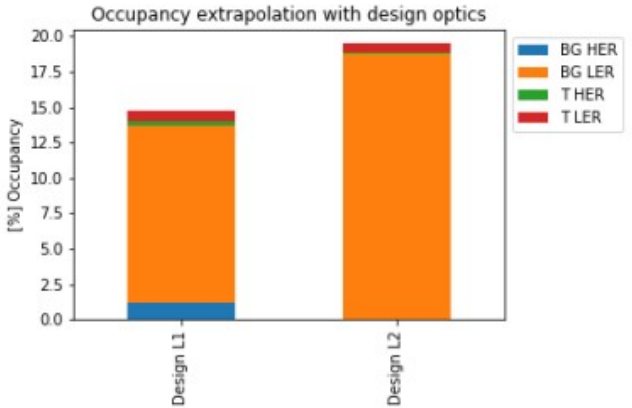
Extrapolations - Design Optics

- Using 12 (HER), 14 (LER) May Fits with Average and +X sensor
- Surpassing O_{PXD} limit (3%)

Scenario	β_y^* [mm]	I HER [mA]	I LER [mA]	σ_y[µm]	n_b	dP/dIimpr.
design	0.3	2600	3600	38	2500	0.333



Average



+X sensor

Update on Single-beam studies

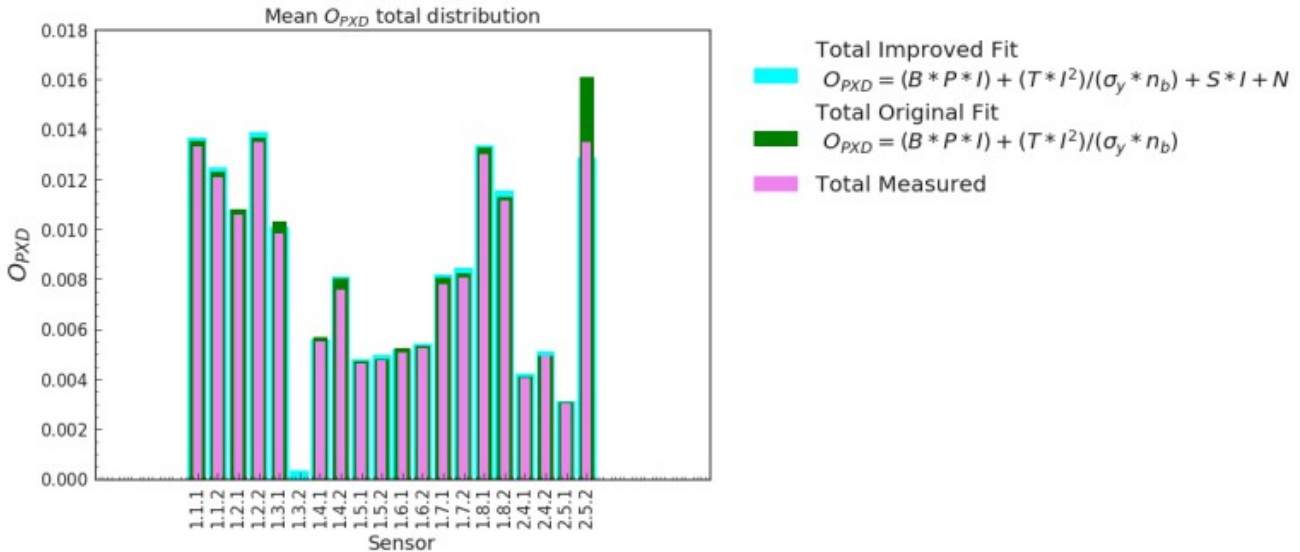
- Usual decomposition assumes only two bkg components to the O_{PXD}: Touschek and Beam-Gas
- In PXD, need to account also for synchrotron radiation and noise
- PXD rate:

$$O_{PXD} = BPI + \frac{TI^2}{\sigma_Y n_b} + N + SI,$$

  where B, T, N, S are the 4 fitting parameters
- In order to achieve fit stability following strategy is used:
  - Fit the data using standard heuristic approach to obtain T and B sensitivities
  - Set bounds on T and B parameters from this fit
  - Refit the data using full fit strategy with all the components

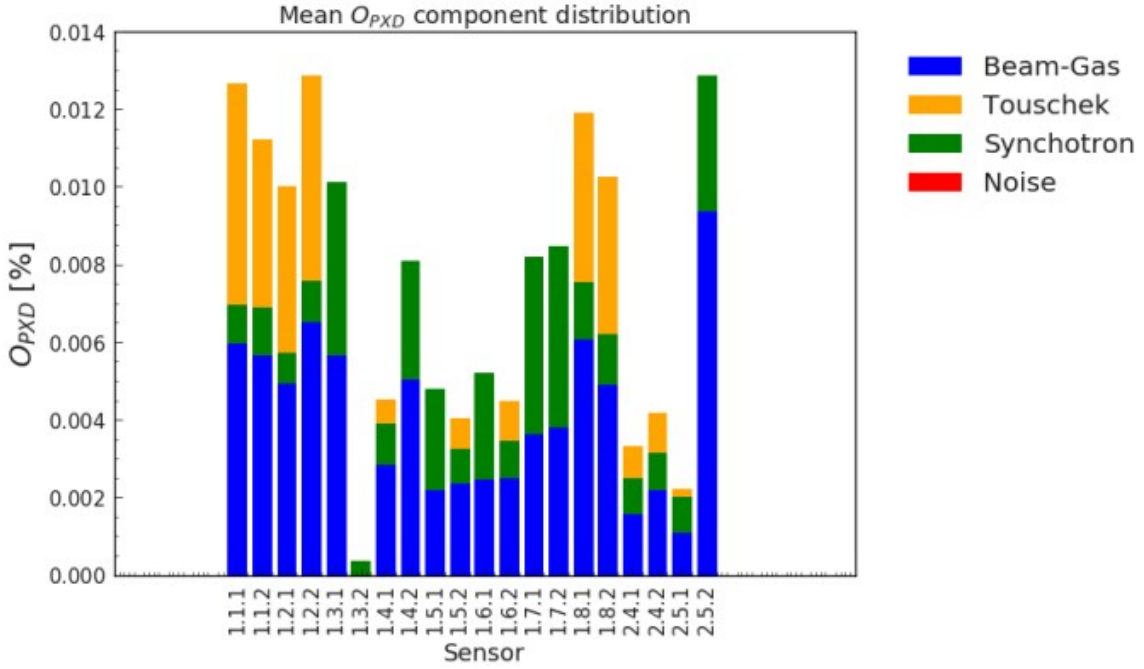
LER 14.05.2019: Fit comparison

- Offline calibrated data: 14.05.2019 LER
- Comparison of the two fits overlayed with measured O_{PXD}
- Both fits agree well with the measured O_{PXD}
- **To do:** check quality of the fits



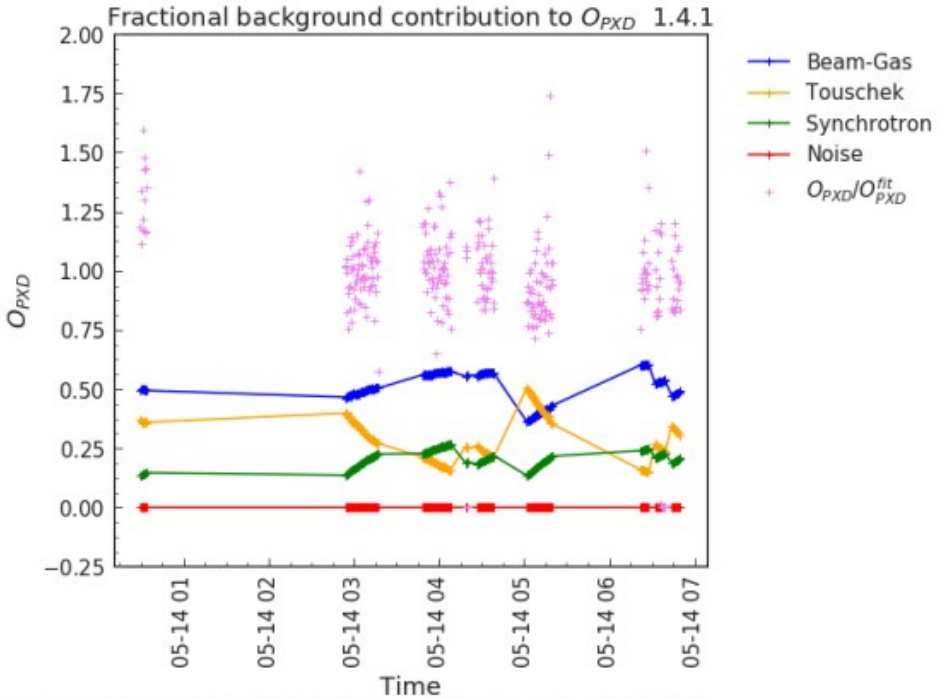
LER 14.05.2019: Mean O_{PXD} contributions

- Check the different contributions of the backgrounds
- Dominated by beam-gas bkg with almost no noise contribution



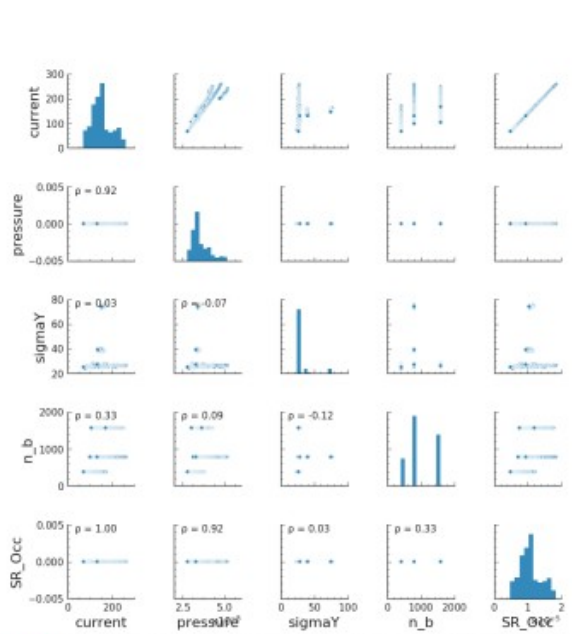
LER 14.05.2019: O_{PXD} contributions

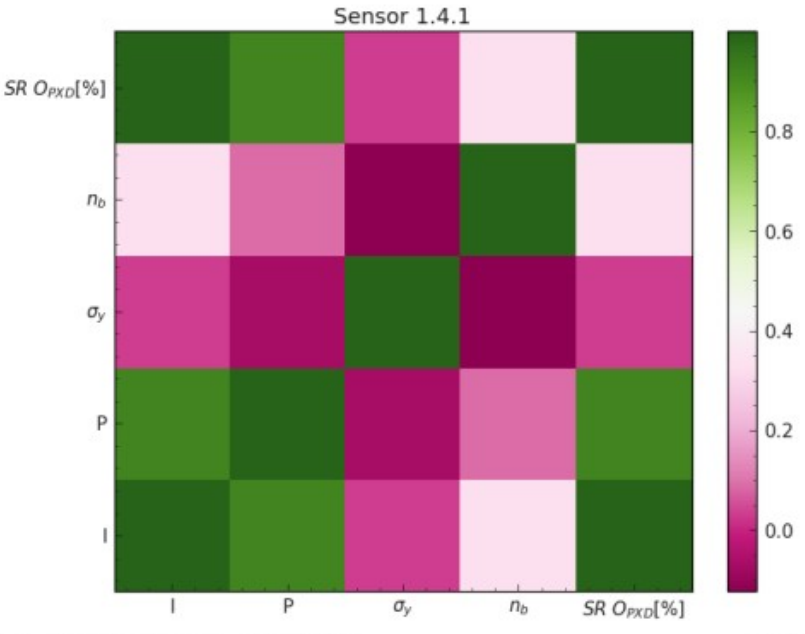
- Evolution of bkg contributions as a function of time
- Example of module 1.4.1
- Dominated by beam-gas



LER 14.05.2019: SR component monitoring

- Want to know what beam/machine parameters are responsible for SR
- Look at correlations with beam parameters
- **To do:** Look at the correlations with HER tunes





Summary

- Lumi-BG measurement was performed using luminosity scans from 25.06.2019
- Lumi-BG is negligible
- PXD extrapolations for near future and design optics with varying pressure were shown
- With design optics $O_{PXD} >> 3\%$ need for background mitigation
- New fitting strategy for single-beam runs accounting also for synchrotron bkg and noise was trialed
- New fits allow for monitoring of all different background components
- Special emphasis on synchrotron radiation and its relationship with beam/machine parameters is/will be studied
- To do: Cross-check synchtron radiation component with cluster data

Hit finding inefficiency in PXD

PXD Workshop, DESY

Simon Kurz, Cyrille Praz
September 23, 2019

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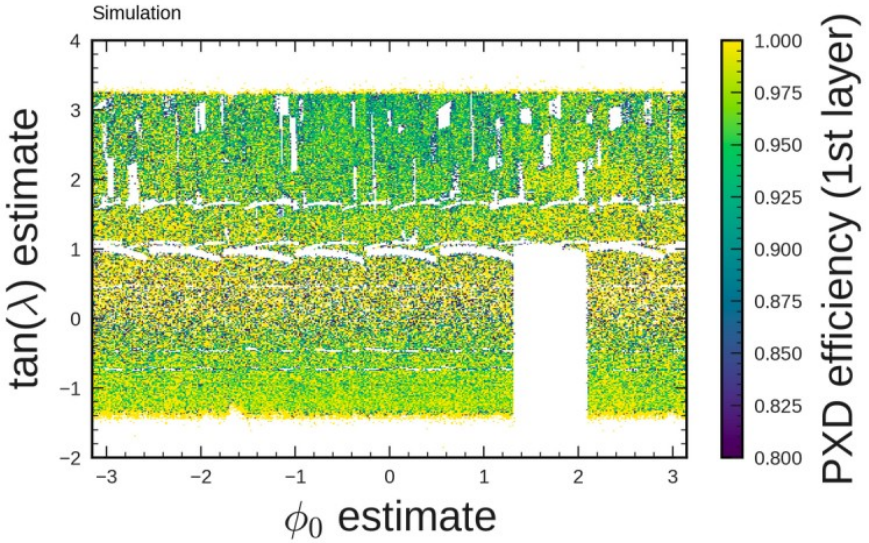
DESY.

Hit patterns

Simulated bhabha events w/o background

- First observed by Cyrille in simulated Bhabha events (no background)
  - Jira issue: https://agira.desy.de/browse/BII-4969

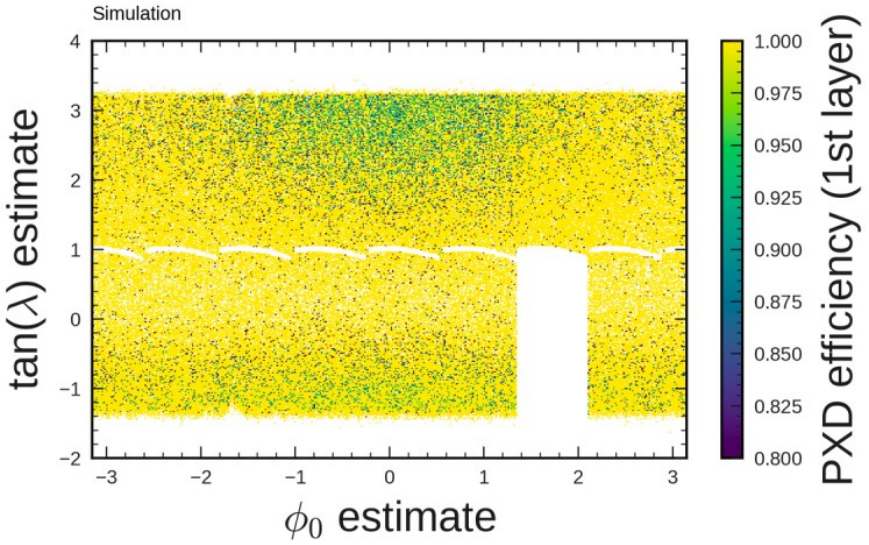
- Only visible at high tan(λ)
  - PXD efficiency degrades to about 40% in these regions



Fixing it..

Simulated bhabha events w/o background

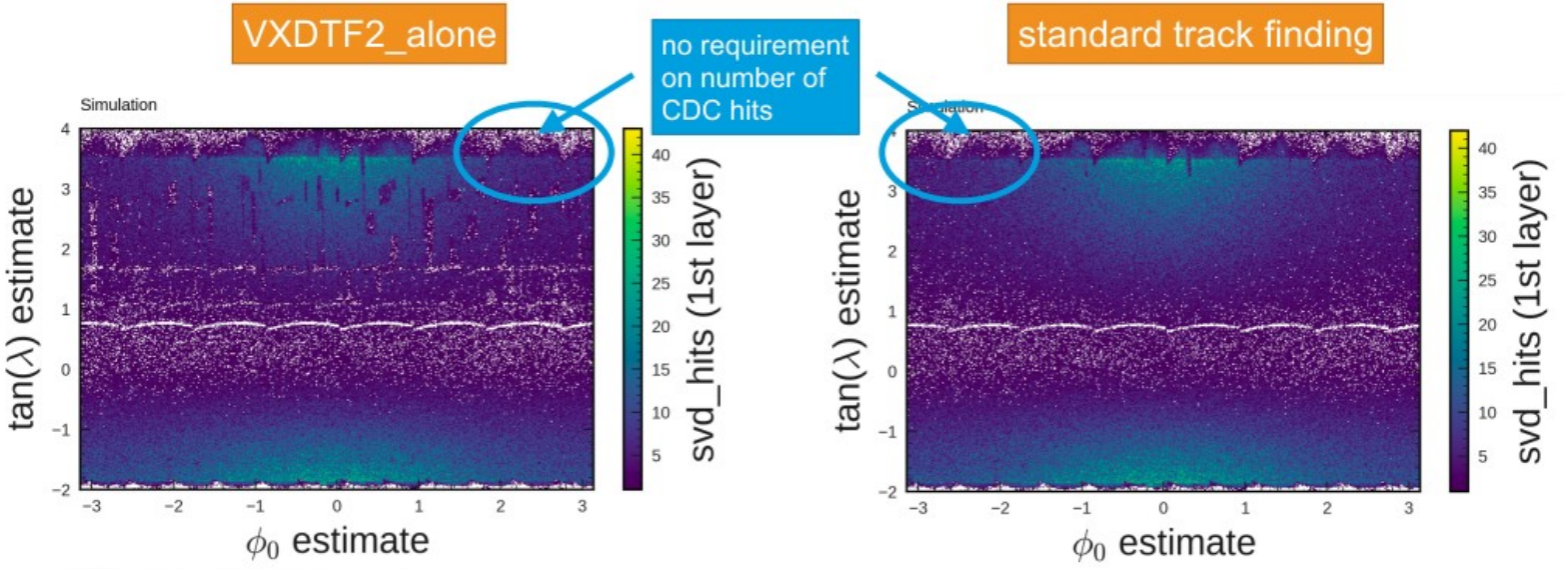
- Realised that *add_PXDDataReduction(…)* is by default turned on in simulation
- **Disable PXDDataReduction for early Phase 3 (exp 1003)**
  - https://stash.desy.de/projects/B2/repos/software/pull-requests/4702/overview
  - **Problem:** ROI selection on HLT is not identical!
    - HLT: full tracking → Simulation: VXD only
- **Fix ROI finding efficiency so that we can turn it on once we actually need it**



VXDTF2 performance

Efficiency of VXD_only tracking

- Test performance of VXDTF2_alone
  - Bhabha events with tracks from IP
  - Check distribution of SVD hits assigned to tracks
- **VXDTF2 seems to have problems finding very forward tracks in some regions**
  - CDC→SVD CKF is able to compensate for that

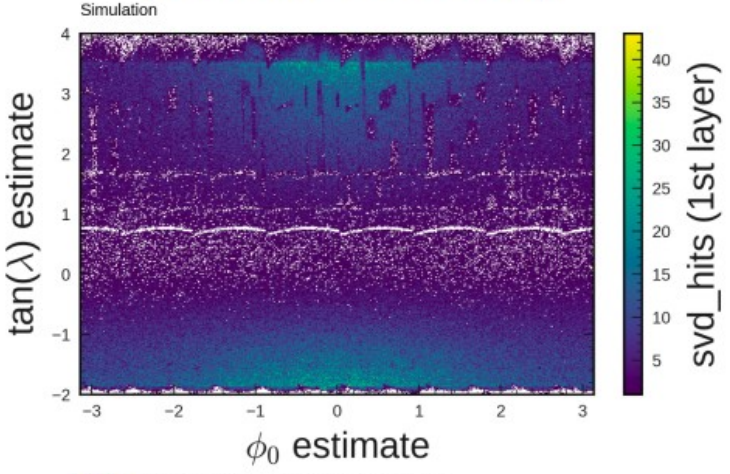


VXDTF2 performance

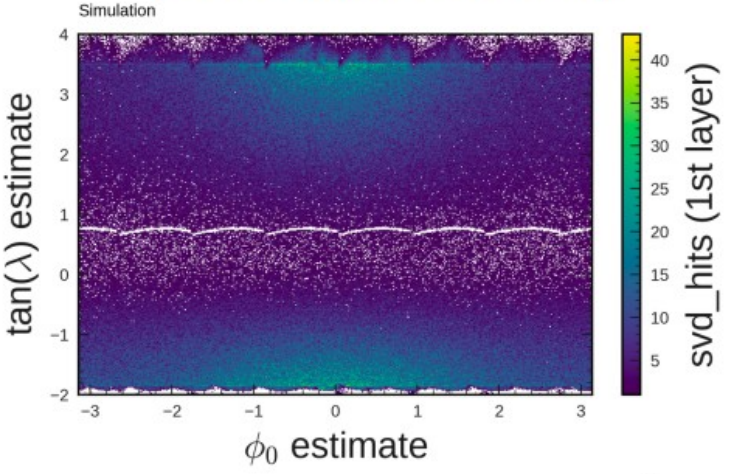
Efficiency of VXD_only tracking

- Thomas produced another sector map to test performance of VXDTF2_alone
  - Trained on 2 million events simulated with BabayagoNLO
  - Added 8 additional tracks from muon gun (flat in p=[0.1, 7] GeV)
  - Thomas: Slightly less efficient on Y(4S) events than standard sector map with about 94.5%
- **Seems to fix low efficiency regions for Bhabha events!**

VXDTF2_alone
Standard sector map



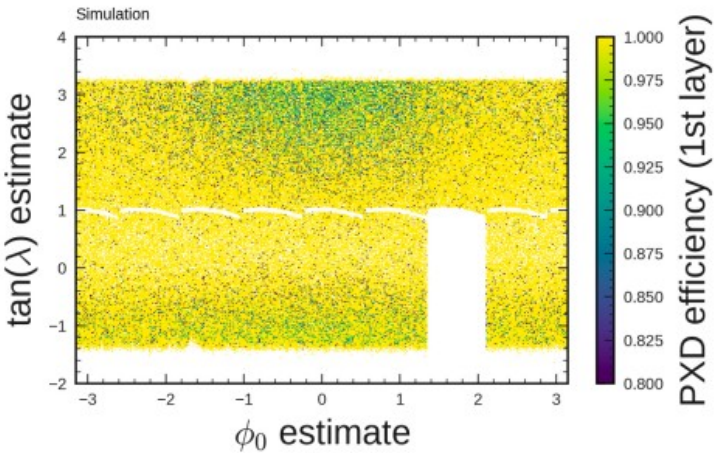
VXDTF2_alone
Sector map with Bhabha



ROI-finding efficiency

New (preliminary) sector maps based on Bhabha events

- No low efficiency regions in PXD visible anymore
  - Even though only VXDTF2 is used for ROI finding (and not full track reconstruction chain)

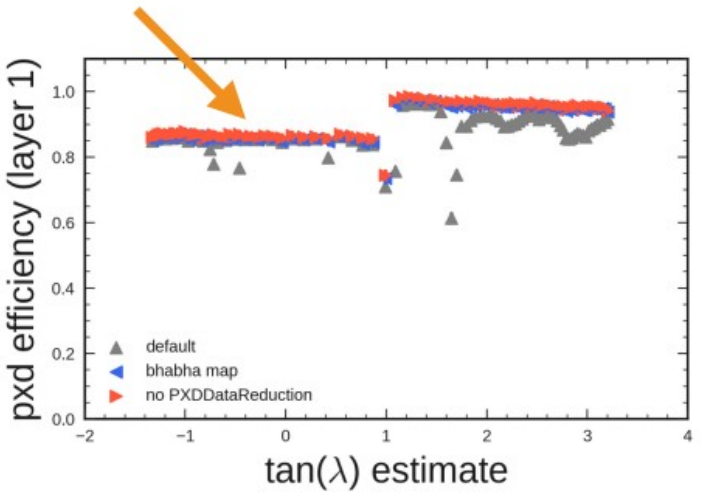


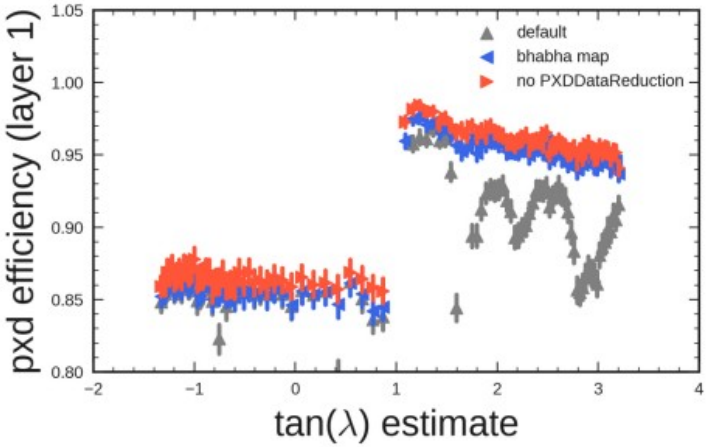
ROI-finding efficiency

New (preliminary) sector maps based on Bhabha events

- Small degradation in the order of 1% visible if directly compared to pxd efficiency without ROI selection

Plateau lower because of missing module in layer 1





Summary

Fix ROI finding and VXDTF2

1. **Disable ROI finding in simulation for early Phase 3 (exp 1003)**
   - https://stash.desy.de/projects/B2/repos/software/pull-requests/4702/overview
   - Currently waiting for some other PR to fix problem with *EventInfoSVD*

2. **Can we improve the track finding efficiency of VXDTF2?**
   - Revise sector maps (Thomas is working on that)

3. **Fix tracking used for ROI finding**
   - Make sure that simulation uses the same track reconstruction chain as HLT
   - **Discussion from the tracking F2F workshop last week:**
     - Make sure that VXDTF2_alone also shows high performance on Y(4S) events using the new sector maps
     - Should then be sufficient to run SVD standalone (+CKF to CDC) on HLT
       - Also reduces CPU time for tracking on HLT (significantly)
       - Downside: we're completely relying on performance of SVD and SVD track finding on HLT