Report on HLT ROI Finding

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Content

ROI Finding

- ✓ efficiency
- ✓ data reduction factor
- ✓ execution time

Belle II, Phase III

release-00-08-00, VXDTF1

Belle II, Phase II

tracking is not ready . . .

2017 VXD testbeam

feature/DESY_testbeam_Feb2017, VXDTF1

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*

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

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)*

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Physics Processes at $\sqrt{s}$ = 10.573 GeV

- not only Y(4S) @ *BelleII* …
- let's consider the main processes to correctly estimate the observables for *BelleII* runs
- averages shown in the following slides are computed weighting with the cross section of the different processes
- e^+e^- and $\gamma\gamma$ samples are included using the same weight and performance of the $\mu^+\mu^-$ sample
- machine backgrounds considered:
  - noBkg
  - stdBkg: BHWide + Coulomb + RBB + Touscheck
  - stdBkg+QED: BHWide + Coulomb + RBB + Touscheck + QED

Physics process	Cross section [nb]	Reference
$\Upsilon(4S)$	1.05 ± 0.10	[1]
$u\bar{u}(\gamma)$	1.61	KKMC
$d\bar{d}(\gamma)$	0.40	KKMC
$s\bar{s}(\gamma)$	0.38	KKMC
$c\bar{c}(\gamma)$	1.30	KKMC
$e^+e^-(\gamma)$	300 ± 3 (MC stat.)	BABAYAGA.NLO
$e^+e^-(\gamma)$	74.4	-
$\gamma\gamma(\gamma)$	4.99 ± 0.05 (MC stat.)	BABAYAGA.NLO
$\gamma\gamma(\gamma)$	3.30	-
$\mu^+\mu^-(\gamma)$	1.148	KKMC
$\mu^+\mu^-(\gamma)$	0.831	-
$\mu^+\mu^-\gamma(\gamma)$	0.242	-
$\tau^+\tau^-(\gamma)$	0.919	KKMC
$\nu\bar{\nu}(\gamma)$	0.25×10^{-3}	KKMC
$e^+e^-e^+e^-$	39.7 ± 0.1 (MC stat.)	AAFH
$e^+e^-\mu^+\mu^-$	18.9 ± 0.1 (MC stat.)	AAFH

EvtGen used for continuum and Y(4S)

not simulated → prescaled

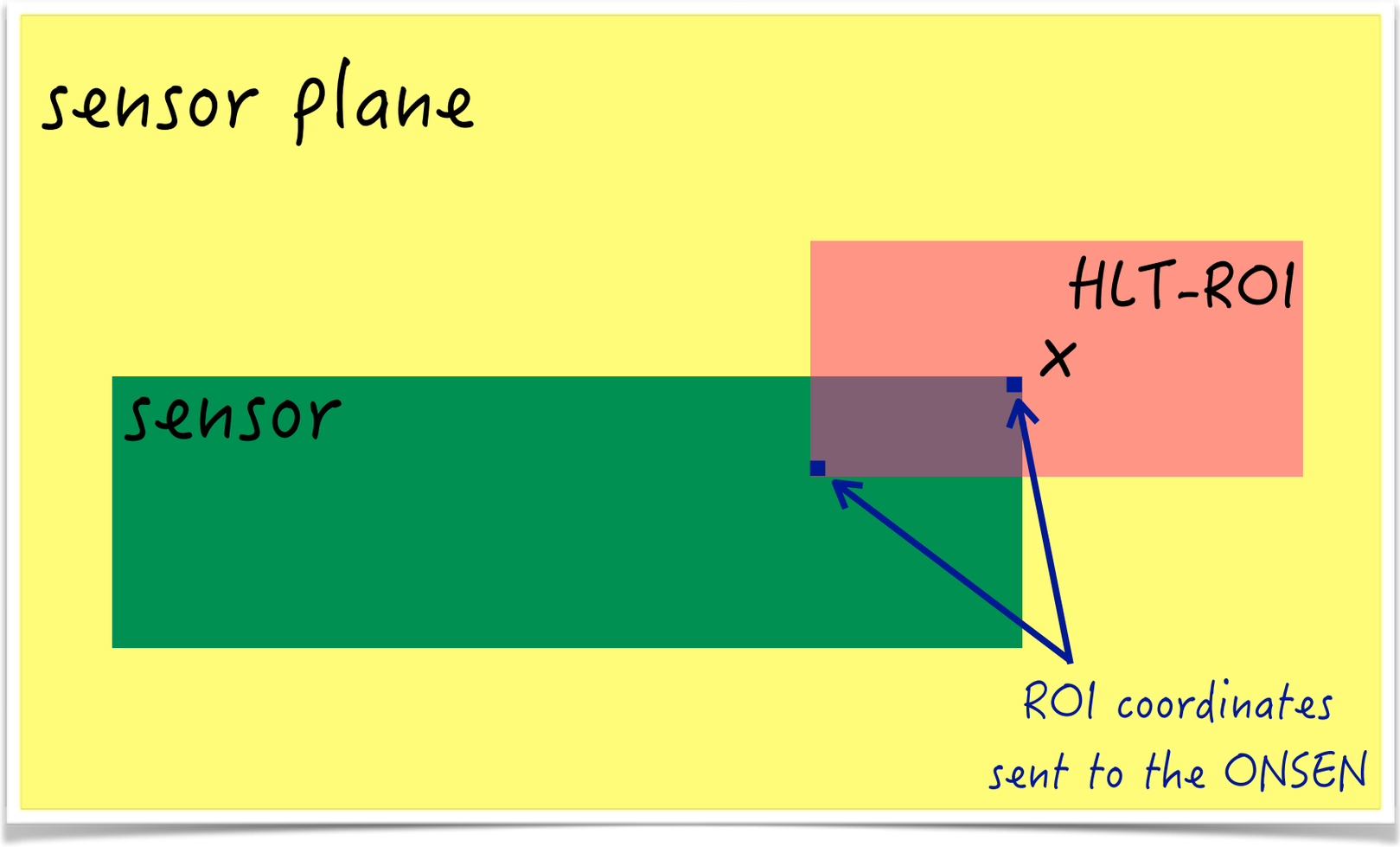
not simulated

not included

ROI Settings

➡ the track is extrapolated only toward a *selection* of sensor planes to reduce the execution time:

- tolerance φ= 0.15 rad
- tolerance z = 0.5cm



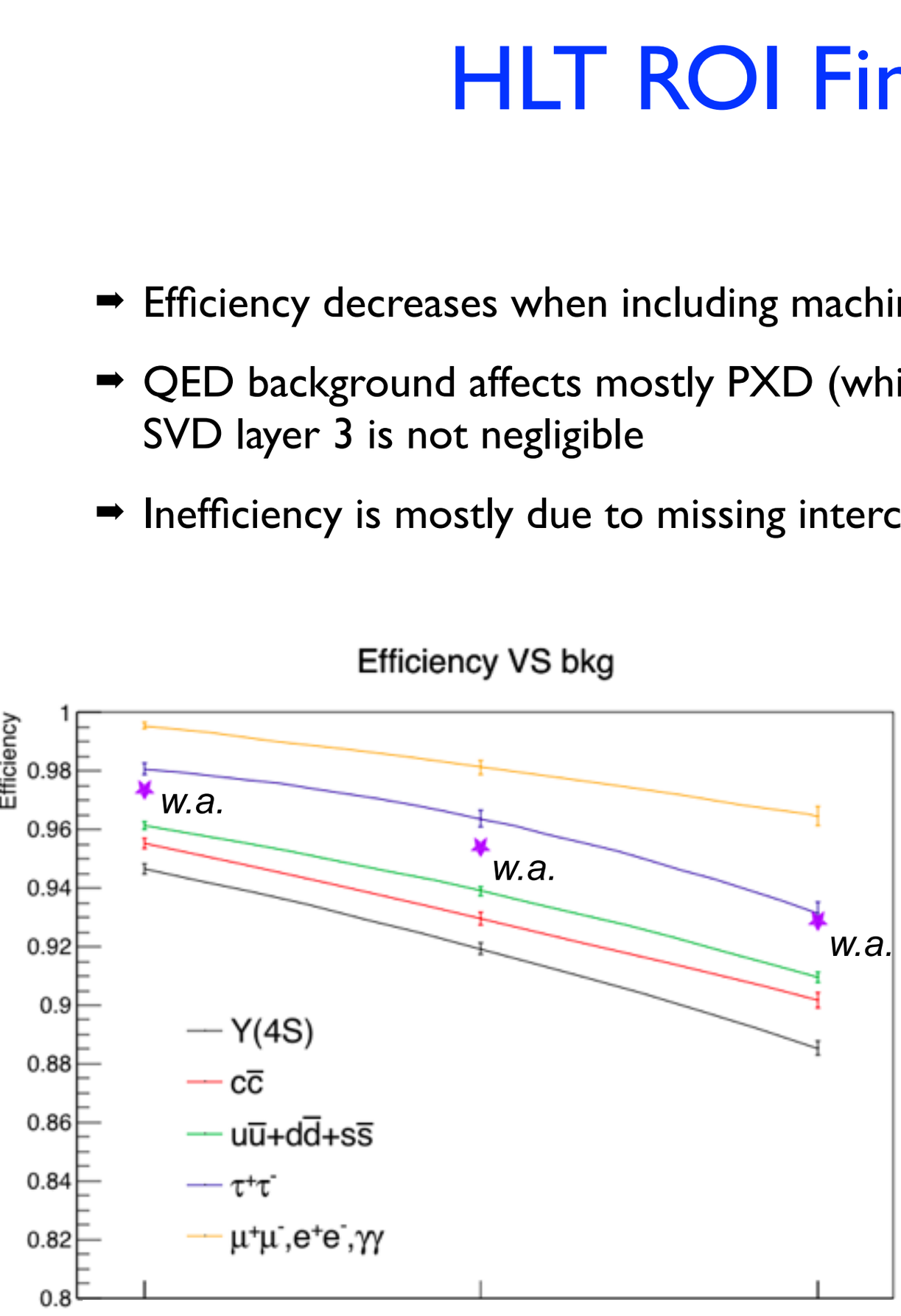
➡ The width of the HLT-ROIs along the two directions is computed as:

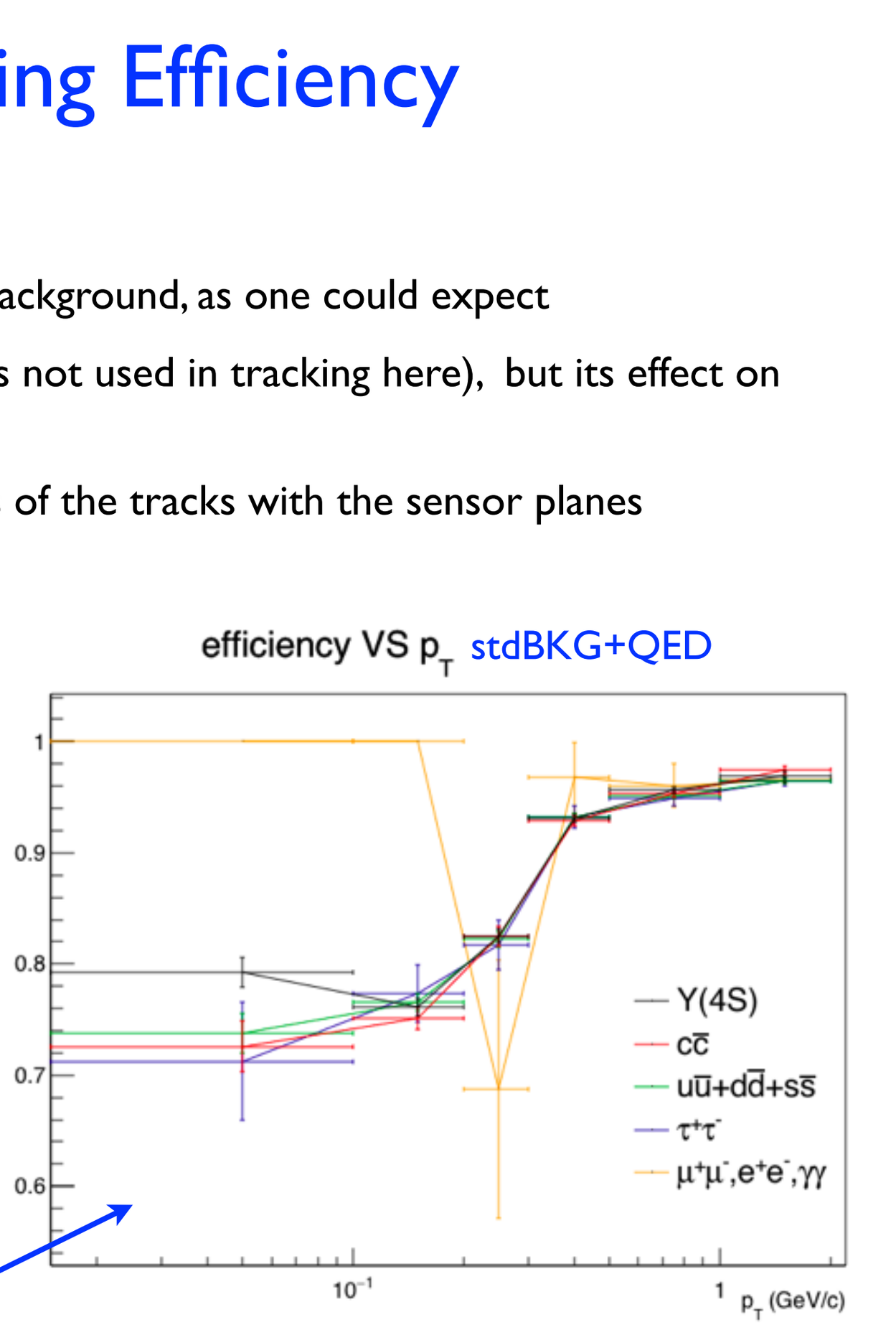
- 10 x $\sqrt{(syst^2 + stat^2)}$
- stat = statistical error of the extrapolation
- syst = 1 mm

➡ HLT-ROIs have also a maximum width of 10 cm in both directions

HLT ROI Finding Efficiency

- Efficiency decreases when including machine background, as one could expect
- QED background affects mostly PXD (which is not used in tracking here), but its effect on SVD layer 3 is not negligible
- Inefficiency is mostly due to missing intercepts of the tracks with the sensor planes





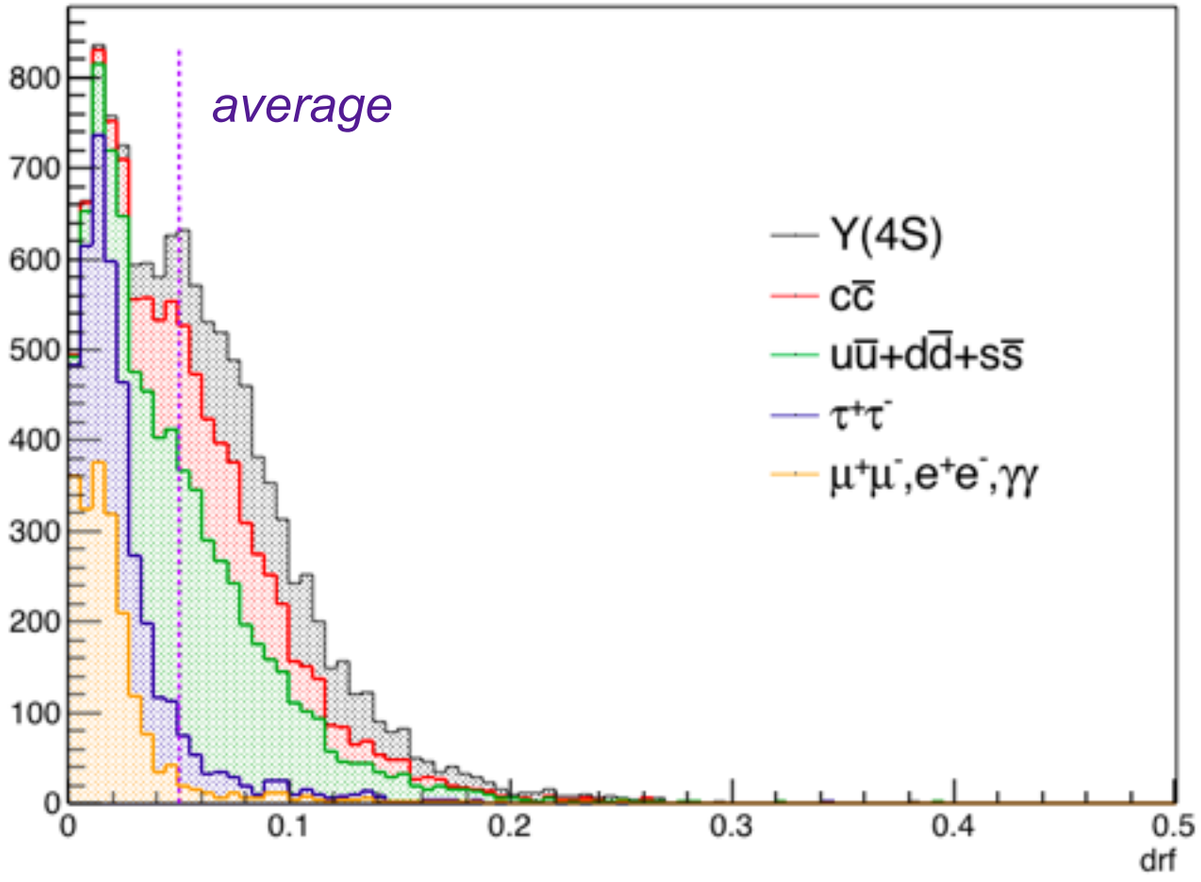
Data Reduction Factor Stacked

- The measurement of the fraction of activated pixels is important for DAQ and storage
- The estimated DRF average shown here assumes that e^+e^- and $\gamma\gamma$ samples have the same DRF and will be pre-scaled to the same cross section as the $\mu^+\mu^-$ sample

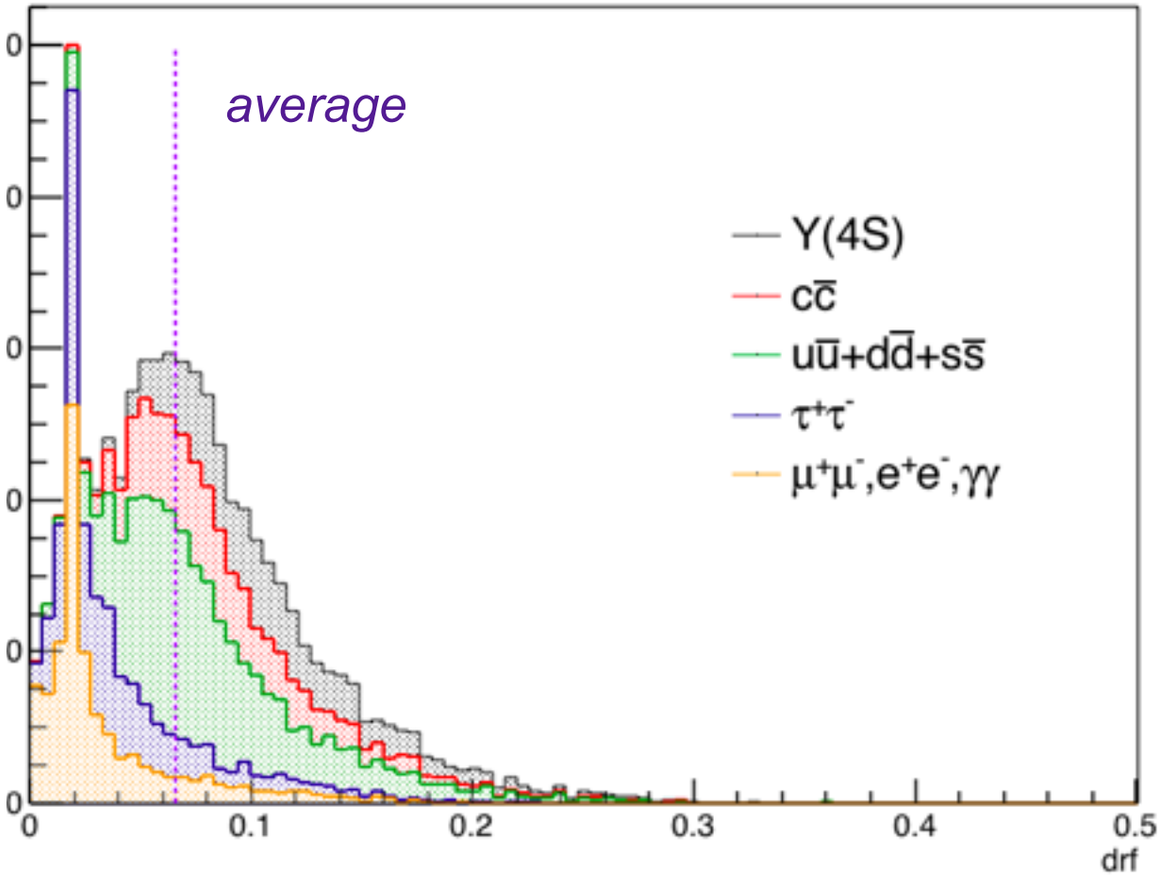
$$drf = \frac{\#\ \text{PXDDigits inside the ROIs}}{\#\ \text{PXDDigits}}$$

PXDDigits are intended over threshold

data reduction factor STACK stdBKG

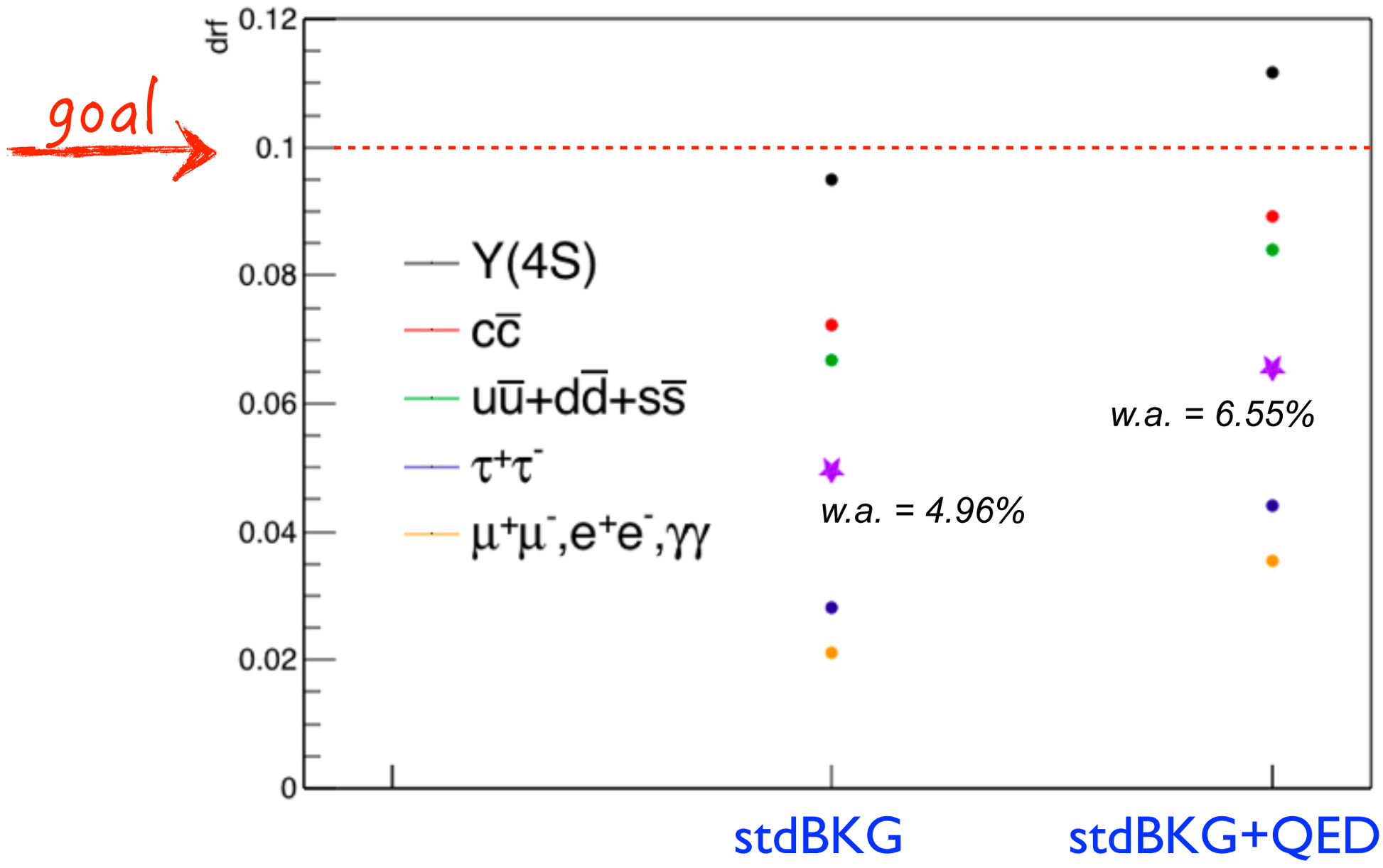


data reduction factor STACK stdBKG+QED

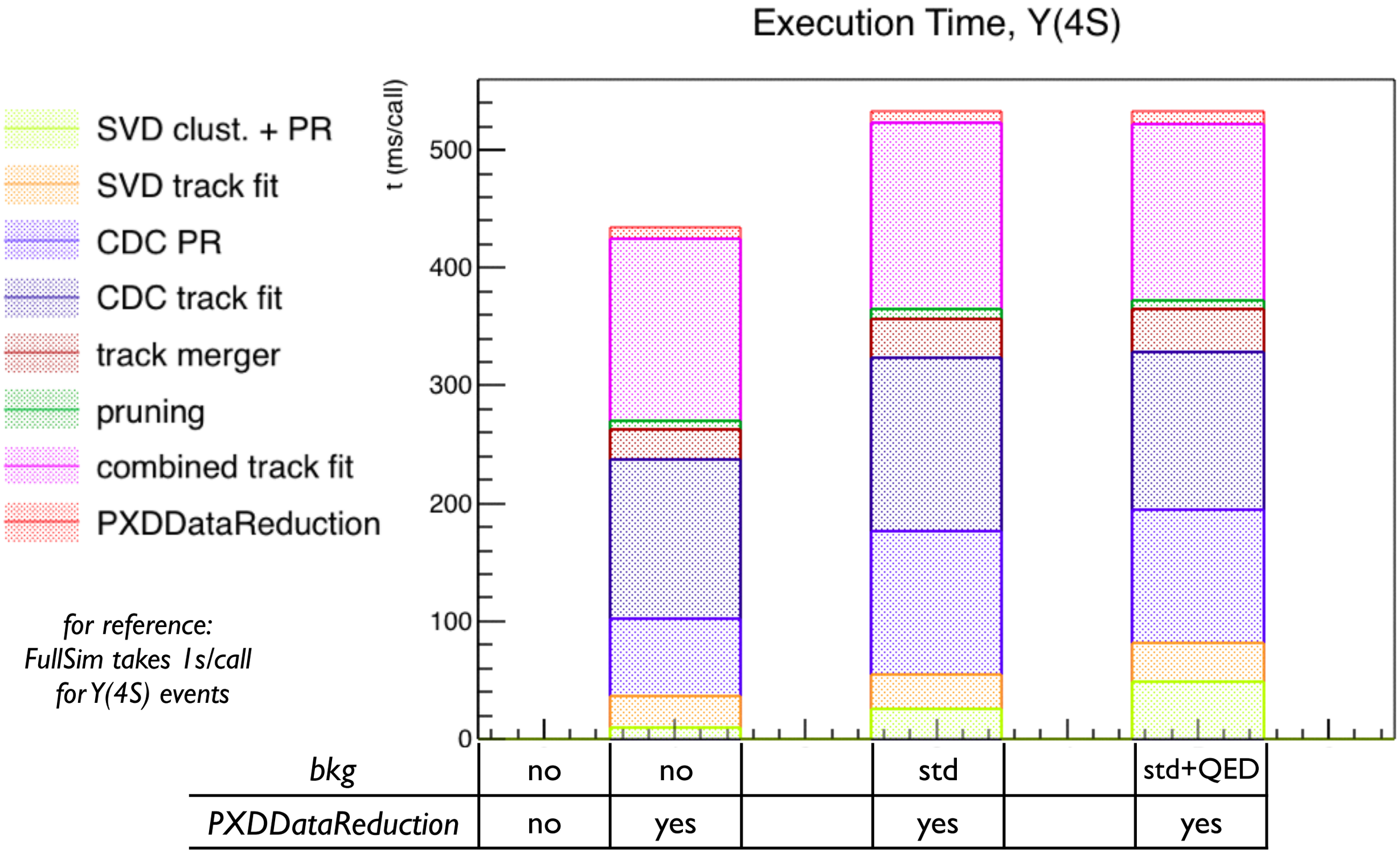


Data Reduction Factor

- e^+e^- and $\gamma\gamma$ are included with the same weight and performance of $\mu^+\mu^-$
- the limit of 10% is the maximum drf that *BelleII* can stand including all sources of pixel rescue (HLT ROIs, DATCON ROIs, PXDDigitRescue)



Estimated HLT Execution Time on Y(4S)



for reference:
FullSim takes 1s/call
for Y(4S) events

bkg	no	no		std		std+QED
PXDDataReduction	no	yes		yes		yes

Content

ROI Finding

- ✓ *efficiency*
- ✓ *data reduction factor*
- ✓ *execution time*

@ Belle II, Phase III

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@ 2017 VXD testbeam

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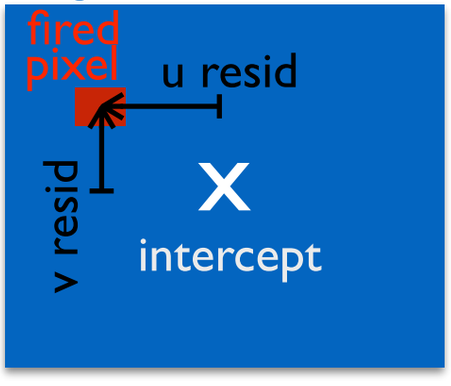
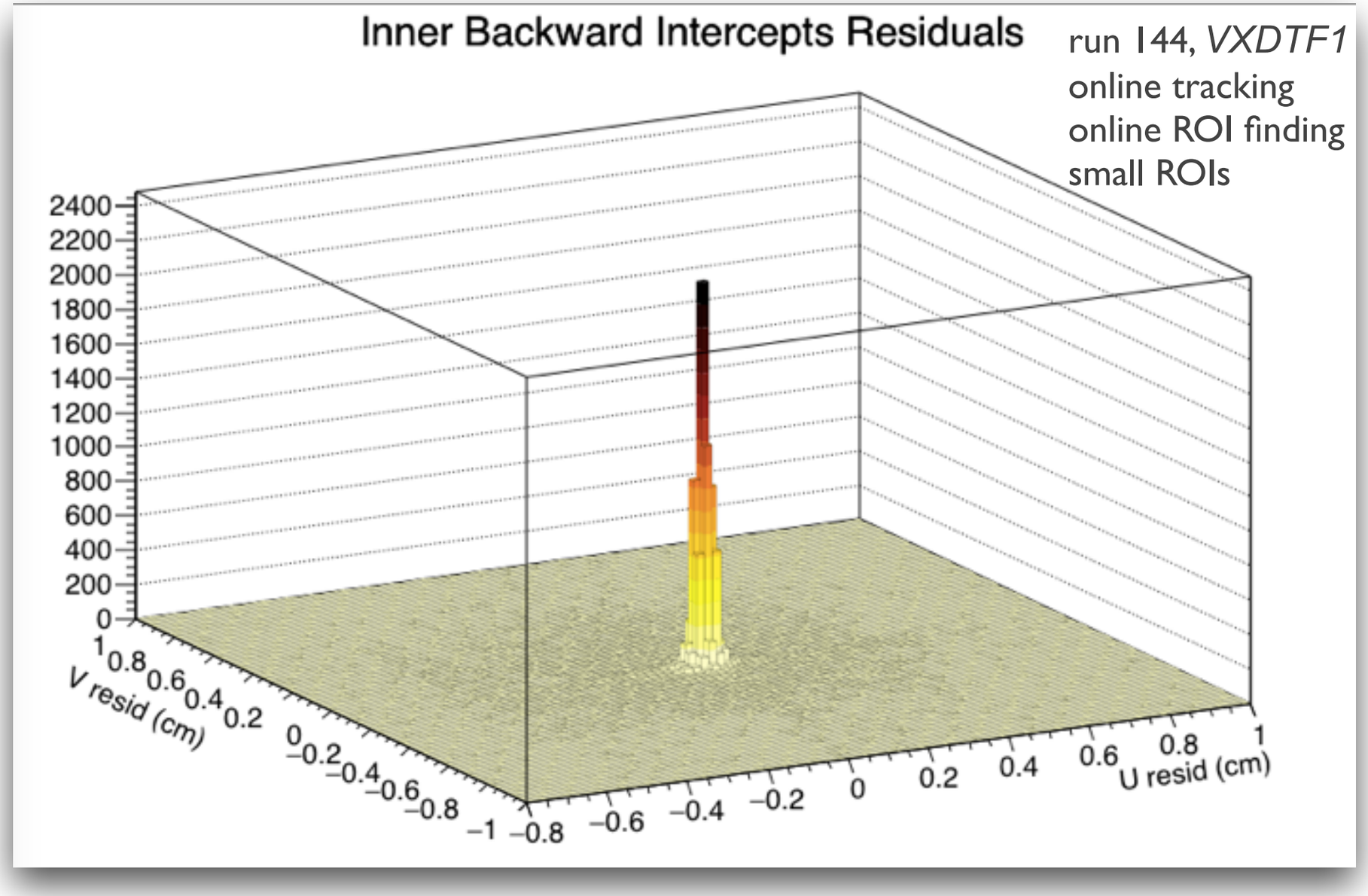
Region of Interest Finding at DESY

- ROI Finding modules run on HLT as soon as detectors where working
- Different ROI parameters tested (full-frame ROIs, …): no problems encountered

- the finding algorithm was slightly changed in order to cope with different TB geometry wrt *BelleII*

Region Of Interest





The Analyses & the Simulation

➡ *efficiency & execution time evaluated on simulations*

- the telescope was not available → **efficiency evaluated on simulation**
- **t**he hlt log files from the do not contain the execution time, not shown here

➡ *data reduction factor*

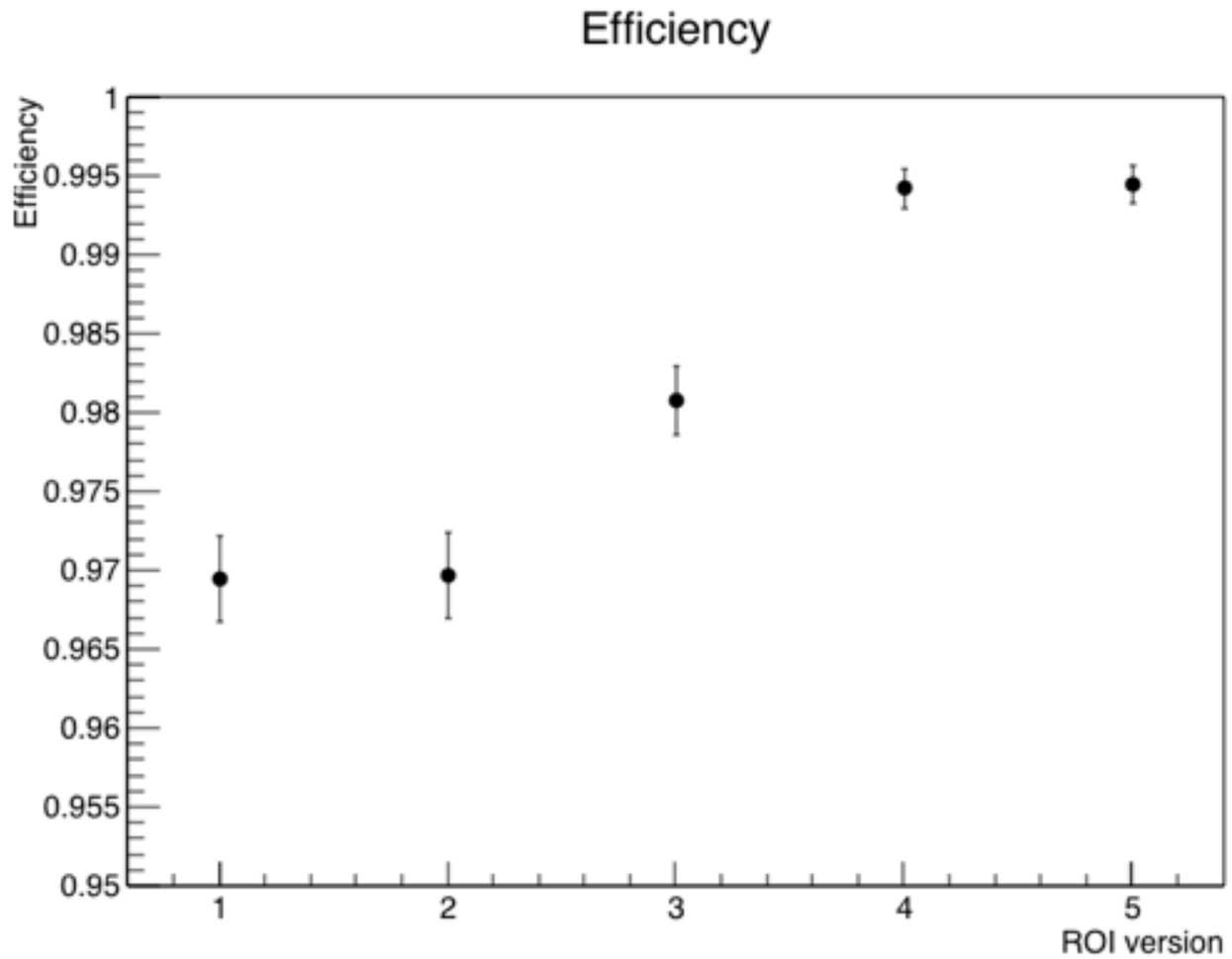
- can be estimated from simulation (same as *BelleII* case)
- can be estimated from **data**
  - choose a run with no ROI Finding running on HLT → Run111, only one working PXD sensor
  - run tracking, ROI Finding and PXDDigit filtering *offline*

Run number	RUN/TEST	Beam	Beam Energy [GeV]	Magnet	Magnet Field [T]	Cooling	Nominal C02 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

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

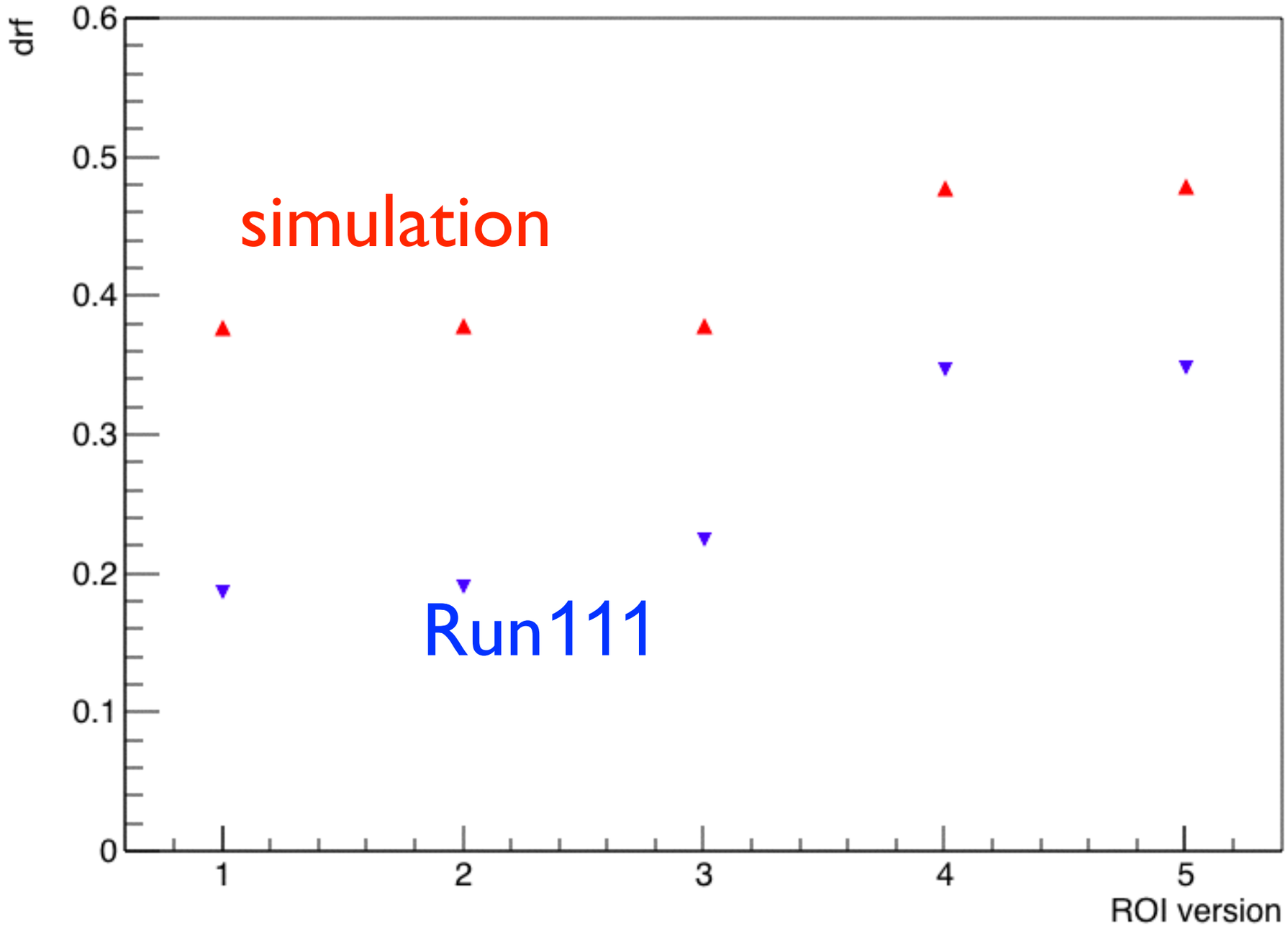
sides 40-50 pixels long

large ROIs

full-frame ROIs

Data Reduction Factor

➡ 20% to 50% disagreement between simulated and measured data reduction factor due to the fact that detector&electronic noise is not included in the simulation



Conclusions

- ROI Finding software is in good shape, the algorithm has been tested on the main physics processes with complete machine background yielding an average:
  - efficiency of 93%
  - data reduction factor of 6.5%
  - execution time < 500 ms/event for SVD clustering, SVD+CDC tracking & PXDDataReduction .This test should be repeated on the HLT itself.
- the analysis of DESY testbeam data has been performed confirming results of past testbeams

Future Plans

1. *BelleII* Note with the results shown, to be used as reference (in preparation)
2. study ROI performances with VXDTF2
   - then re-evaluate the sources of inefficiencies
3. simulations with *PhaseII* geometry