F2F tracking meeting report

https://indico.mpp.mpg.de/conferenceTimeTable.py?confId=2966#20140929

Participants (+ Tobias, Thomas, Doris & CDC team remotely)

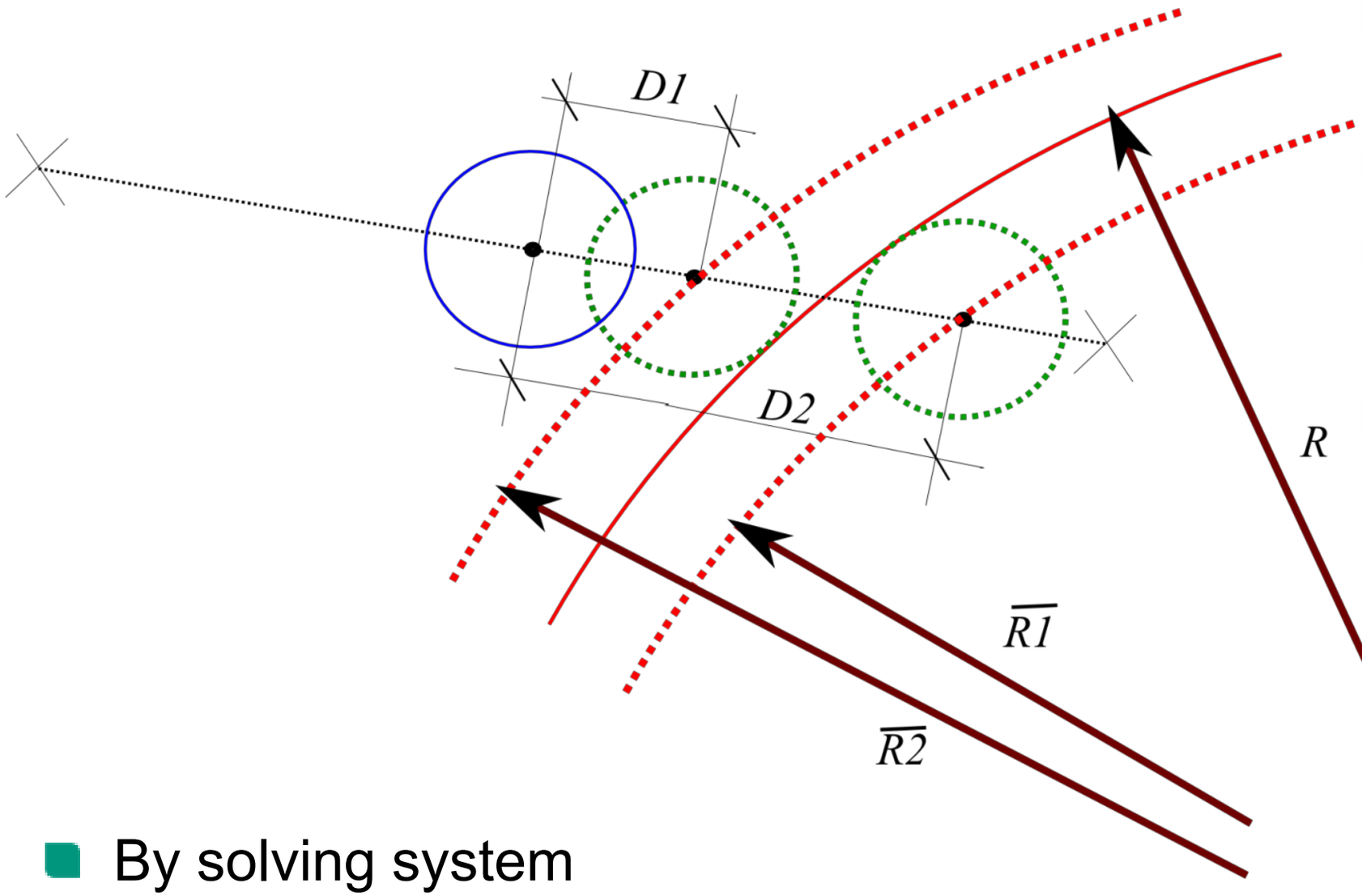
Current registrants (14)

name	institution	city	country/region
BILKA, Tadeas	Charles University Prague	Prague	CZECH REPUBLIC
BOZEK, Andrzej	INP Krakow	Krakow	POLAND
CASAROSA, Giulia	INFN - Pisa	Pisa	ITALY
FROST, Oliver	DESY	Hamburg	GERMANY
FRÜHWIRTH, Rudi	HEPHY Vienna	Wien	AUSTRIA
HECK, Martin	KIT	KA	GERMANY
KODYS, Peter	Charles University	Prague	CZECH REPUBLIC
KVASNICKA, Peter	Charles University in Prague	Prague	CZECH REPUBLIC
LANGE, Sören	University Giessen, II. Physik	Giessen	GERMANY
LETTENBICHLER, Jakob	HEPHY	Vindobona	AUSTRIA
PAOLONI, Eugenio	INFN & University of Pisa	Pisa	ITALY
SCHNELL, Michael	University of Bonn	Bonn	GERMANY
TRUSOV, Viktor	KIT	Karlsruhe	GERMANY
VALENTAN, Manfred	MPP	Munich	GERMANY

Topics covered during the meeting

- CDC:
  - track finders status (Oliver, Viktor),
  - simulation and hit reconstruction (report from the CDC software group).
- Track fitting:
  - Genfit status (Tobias),
  - magnetic field model CPU footprint (Seunguk Cheon , Doris Kim).
- VXD tracking & alignment (Jakob, Rudi, Tadeas, Peter, Peter).
- Software quality assurance.
- PXD data reduction and clusters rescue (Michael, Giulia, Sören + …)

Distance estimation



- R – radius of the track;
- $\overline{R1} = R - driftLenght$
- $\overline{R2} = R + driftLenght$

- We don't know if hit inside or outside of the track, so we have to take into account both possibilities

- By solving system

$$\begin{cases} (x - x_0)^2 + (y - y_0)^2 = \overline{R(1,2)}^2 \\ Ax + By + C = 0 \end{cases}$$

*real* coordinates $(x; y)$ of hit production could be obrained and distances $D1$ and $D2$ could be calculated

Magnetic field CPU consumption in our simulation and reconstruction

- Our present default model is an axial symmetric B field:
  - B has only radial and longitudinal non vanishing components.
  - The radial component is fixed by B_z + Maxwell equations.

Our present default model

Out[14]=

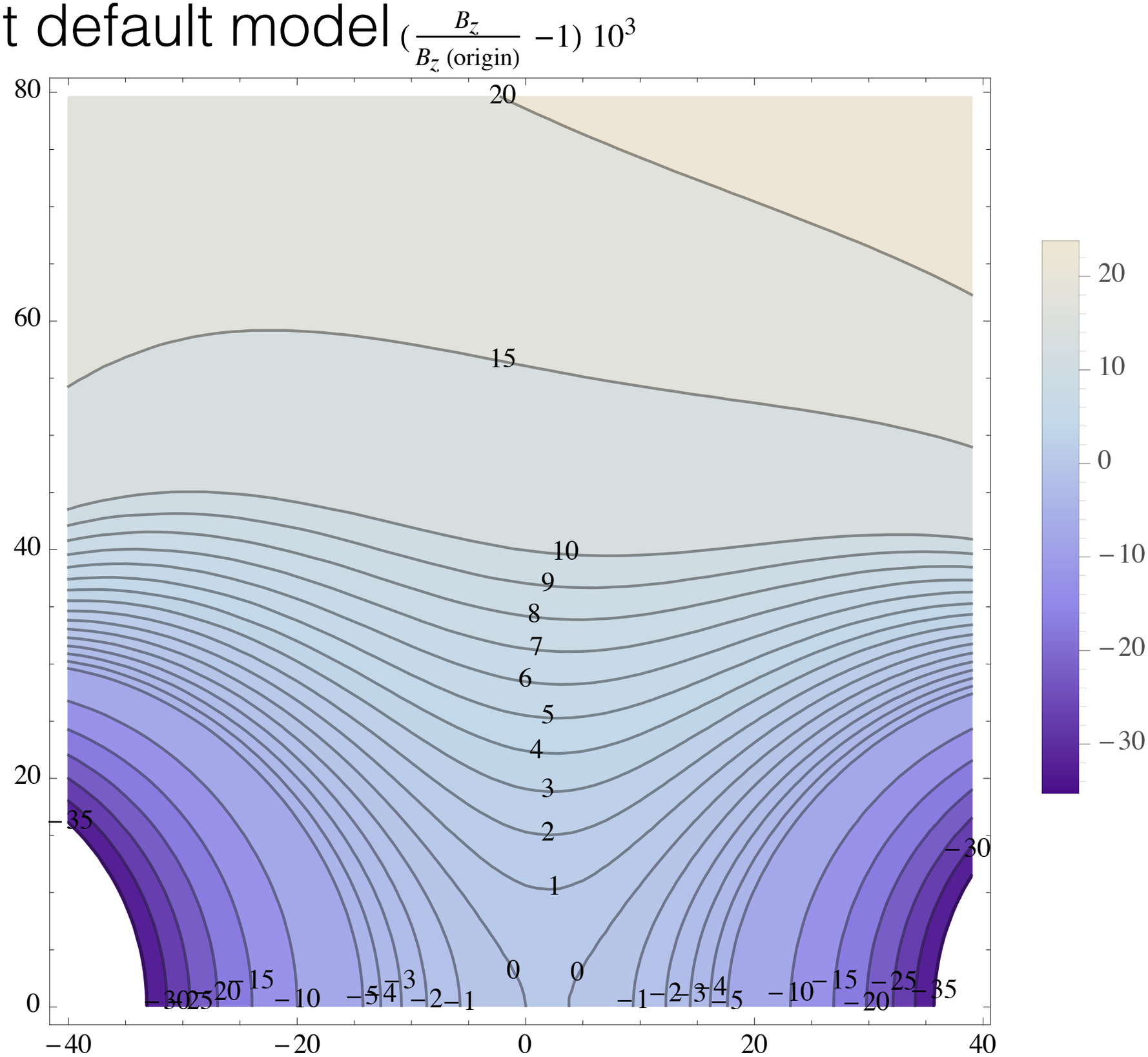


Figure 1: B_z inhomegeneity (‰) as a function of z (cm) and r (cm).

- The B field evaluator caches the previous evaluation point and field.

  - If the the evaluation point distance w.r.t. the previous one exceeds a given threshold the evaluation is performed again.

	Default	0.1cm	0.5cm	1.0cm
FullSim	33.57 ± 31.00	24.30 ± 23.01	25.06 ± 28.36	21.87 ± 14.75
1,000 call				
Total	103.07 ± 34.84	94.49 ± 84.90	99.77 ± 32.55	92.24 ± 18.84
1,001 call				

High momentum sample

	Default	0.1cm	0.5cm	1.0cm
FullSim	401.80 ± 93.94	306.28 ± 63.21	288.53 ± 56.52	265.92 ± 48.95
200 call				
Total	530.55 ± 109.14	437.91 ± 82.42	427.58 ± 76.76	396.96 ± 69.96
200 call				

Low momentum sample

- Main message: we are spending a significant fraction of CPU time in B field evaluation and we should try to optimize the code.

- Seunguk's showed also that 1.0 cm cut is too coarse for precise simulation of soft particles.

SVD hit handling

Ever since we switched to the DAF as default, SVD hits were not dealt with correctly:

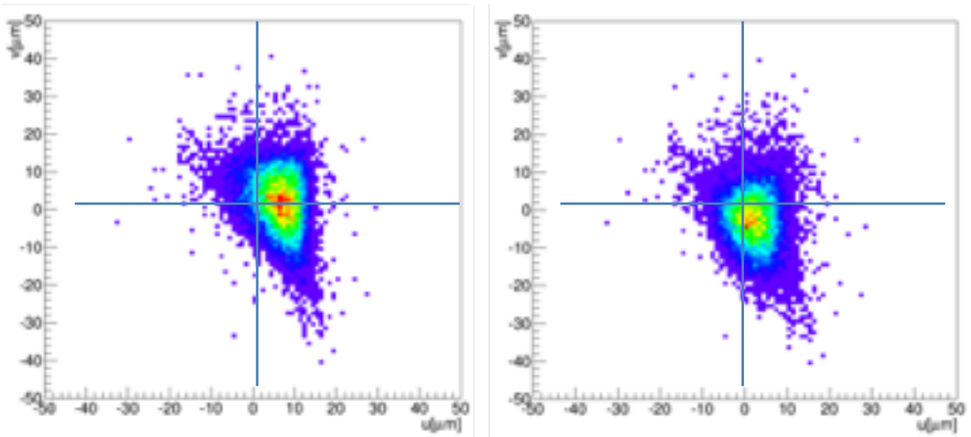
- U and V hits were combined and thus competing
- therefore we used only half the information: essentially the direction with the higher residual was thrown out

In the process of dealing with this, I found an error in the handling of the wedged sensors (double counting of angle of wedged strips, present since the switch to GENFIT2), which didn't have an effect until I un-combined U and V hits.

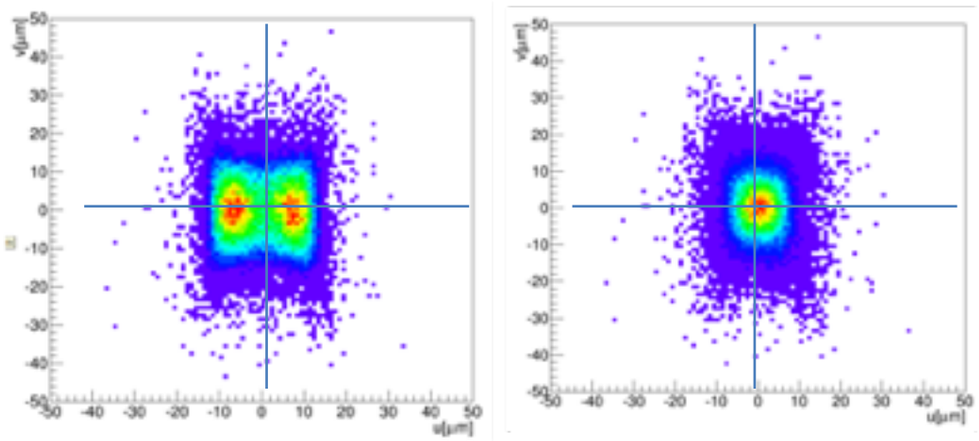
- I fixed both issues
- the fix for the DAF is not yet live, because Tadeas needs to update the GBL interface, and his master's exams were more important

Using cluster shape to improve of hit position

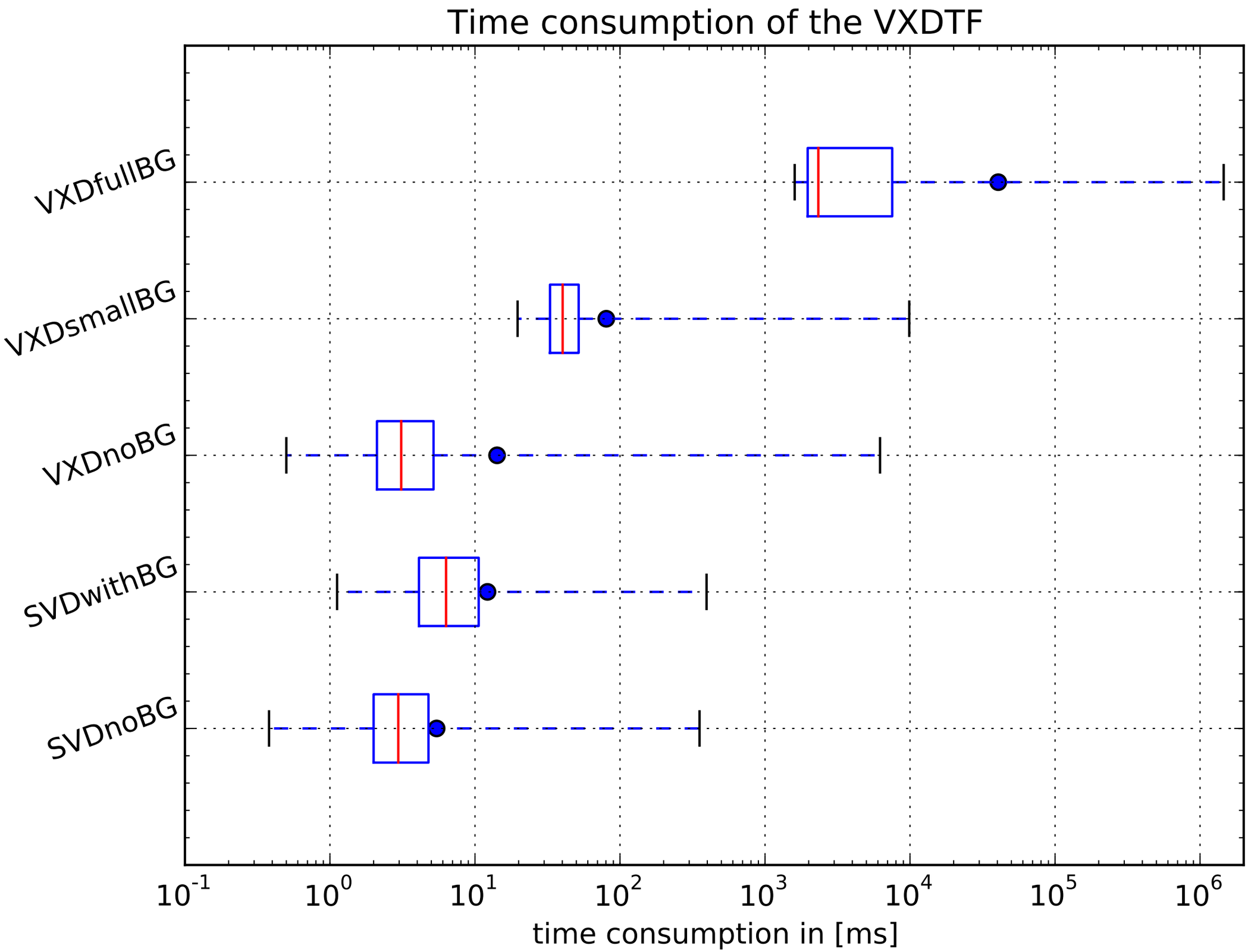
- The 3-pixel “L”-shaped clusters are the simplest and most common case where such a bias correction would be desirable.
- For these clusters, the center-of-gravity estimate is biased by about 10% of pixel size, comparable to the typical RMS error of the position estimate. Therefore, correction of the bias highly desirable.
- We show that adding a fixed (pixel noise dependent) charge to the pixel with zero signal in the 2x2 matrix can significantly improve the center-of-gravity estimate of hit position for such clusters. Adding the fourth pixel with the signal of 1.3 x ENC improved position RMS error from 7.4 microns to 4.7 microns in R-phi, and reduced position from 5 to 2 microns.



Residual plot of “L” shape in one orientation before (left) and after (right) correction



Residual plot of “L” shape in all orientation before (left) and after (right) correction

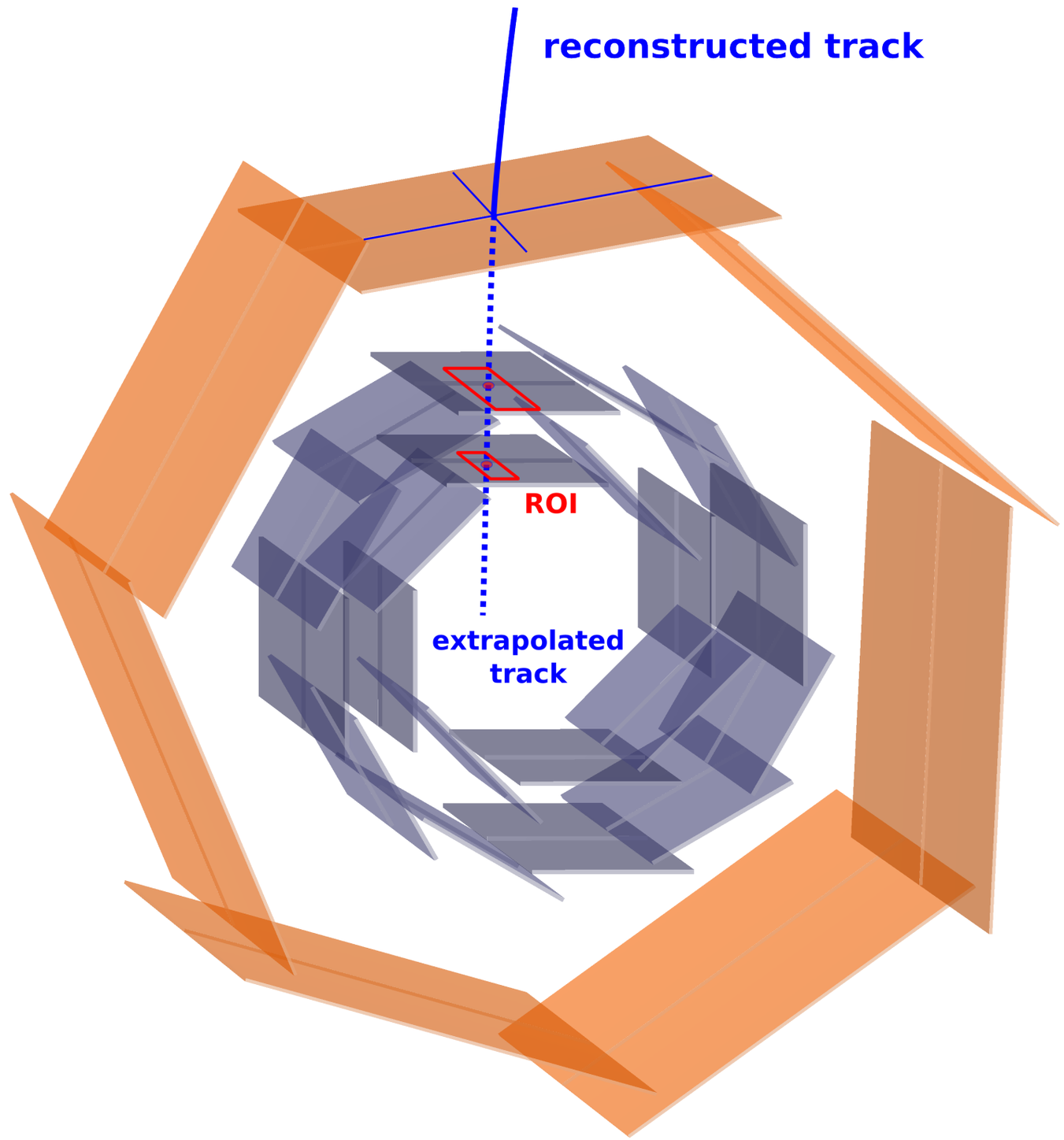

Time consumption of the VXDTF
VXDfullBG
VXDsmallBG
VXDnoBG
SVDwithBG
SVDnoBG
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
time consumption in [ms]

Track reconstruction in the VXD

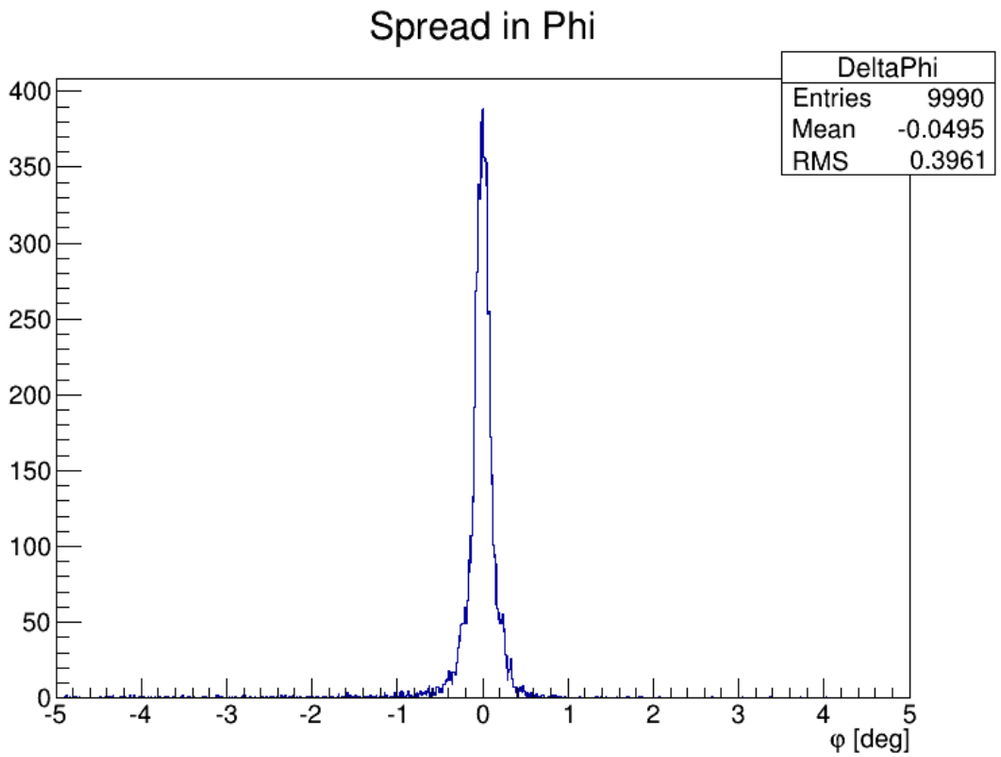
- Jakob is the main player: development, test, debug.
  - Jakob is a PhD student (exams, PhD thesis due in ~ 1 year from now)
  - We do need someone taking responsibility for this crucial part of the reconstruction.
  - The software is not going to stay forever without someone taking care of it.
  - By the way the same do apply for 99% of our tracking software.

Data Reduction Idea with SVD Tracking

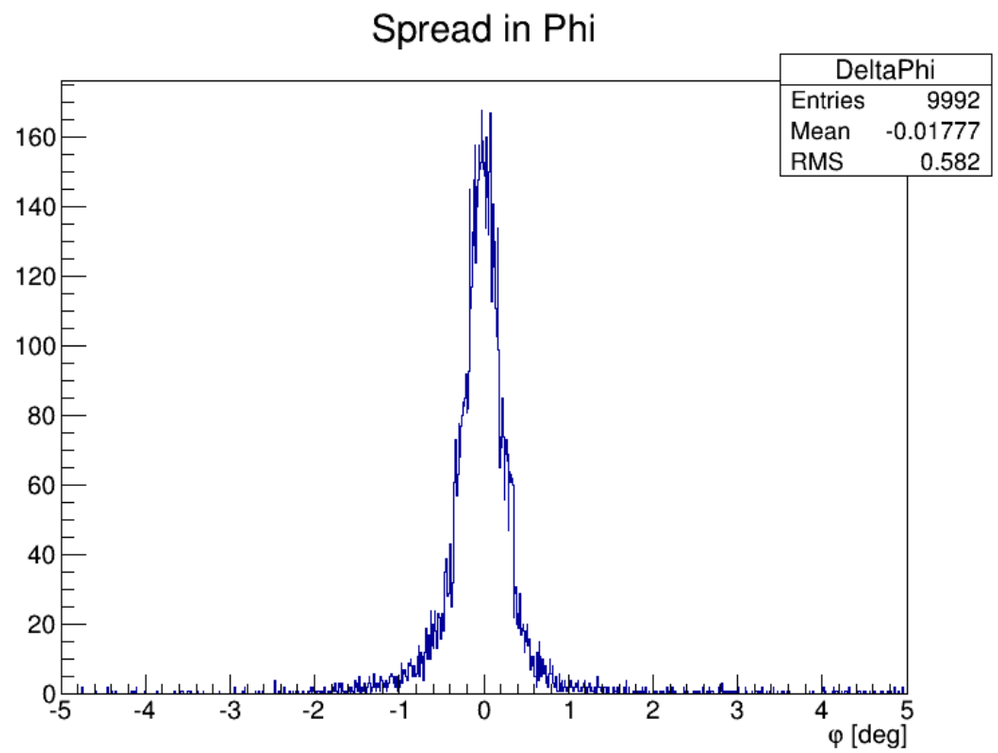
- Complementary approach with two systems to save as much physics data as possible
- HLT: Track reconstruction based on sector-neighbour finding and neural network
- DATCON: Fast FPGA-based track reconstruction system using the Fast Hough Transformation

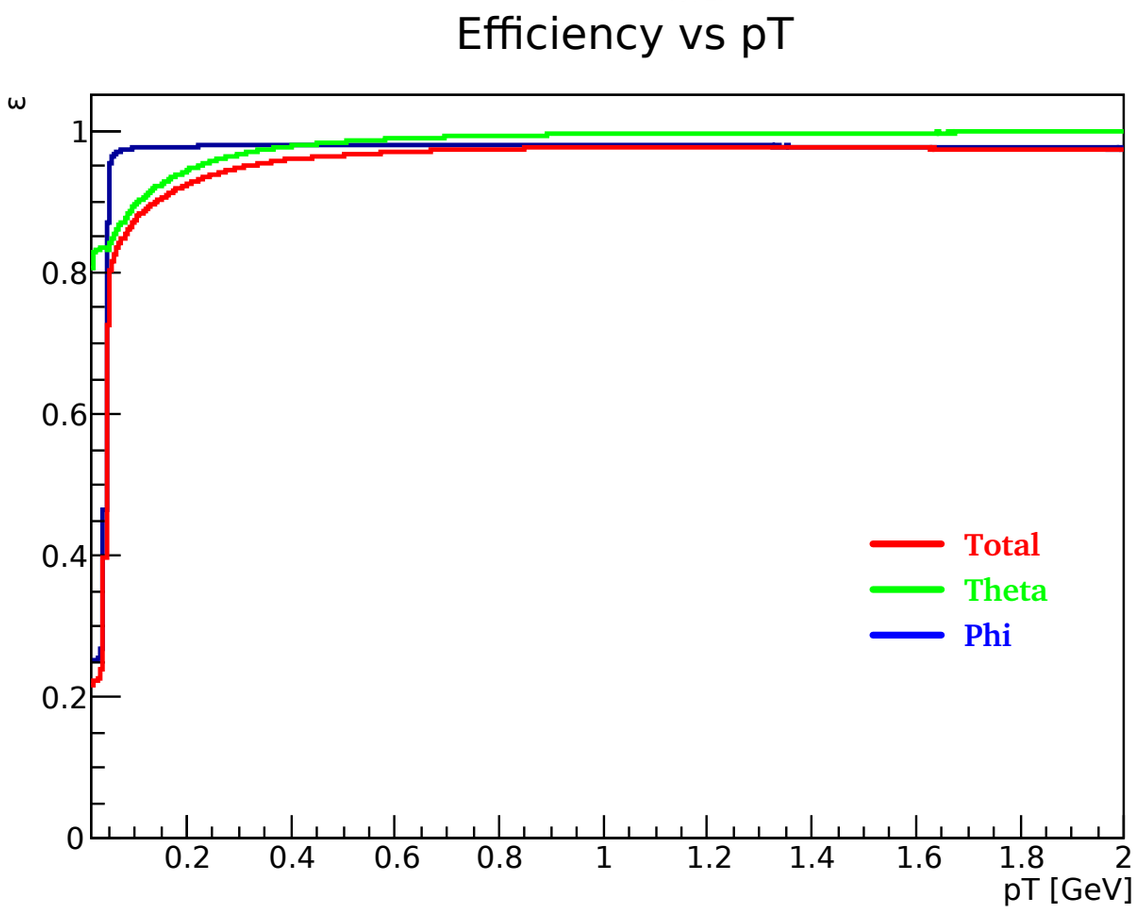


Angle Spread in Phi e^-, e^+ @ 2 GeV



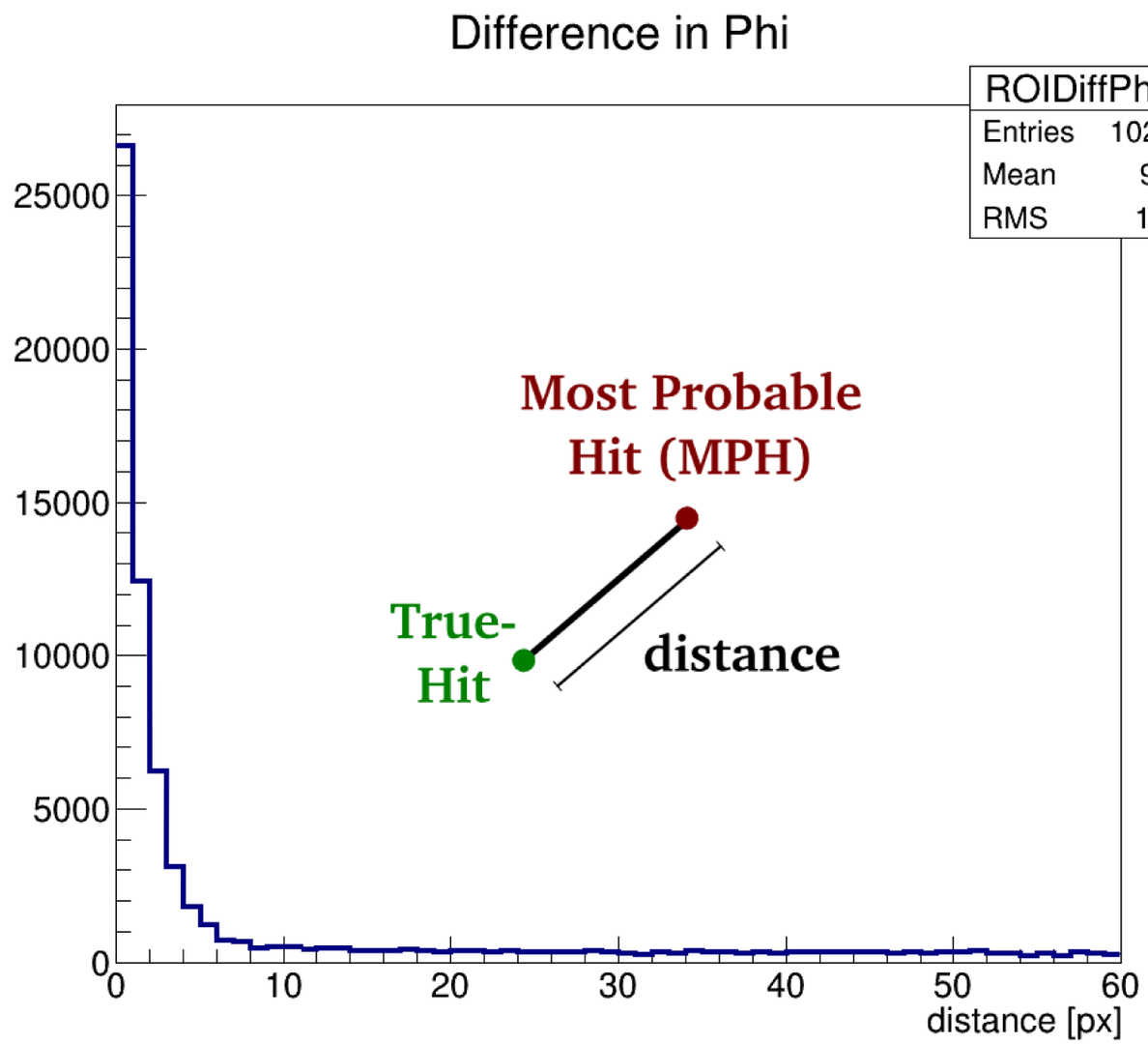
Angle Spread in Phi e^-, e^+ @ 60 MeV





Data Reduction Performance

- Flexible ROI size from 8x16 px up to 12x160 px (depending on momentum estimated by *r*)
- Curler extrapolation still missing! (only two Most Probable Hits (MPH) per track)



- Total ROI efficiency (number of primary track hits on the PXD inside ROI): 95.2 percent
- Data Reduction Factor (DRF): 45

Caveat emptor: flat energy spectrum of the sample (50 MeV-3GeV)

Execution Time

Name	Calls	Memory(MB)	Time(s)	Time(ms)/Call
EventInfoSetter	10001	0	0.18	0.02 +- 0.00
EventInfoPrinter	10000	0	0.48	0.05 +- 0.01
EvtGenInput	10000	-481	16.69	1.67 +- 12.23
Gearbox	10000	0	0.14	0.01 +- 0.00
Geometry	10000	0	0.12	0.01 +- 0.00
FullSim	10000	-997	14165.42	1416.54 +- 397.46
PXDDigitizer	10000	0	108.95	10.89 +- 10.49
PXDClusterizer	10000	0	3.34	0.33 +- 0.05
SVDDigitizer	10000	-120	157.46	15.75 +- 4.31
SVDClusterizer	10000	0	65.26	6.53 +- 1.20
CDCDigitizer	10000	0	69.74	6.97 +- 2.99
TOPDigitizer	10000	0	11.79	1.18 +- 0.56
ARICHDigitizer	10000	0	0.53	0.05 +- 0.03
ECLDigitizer	10000	2	25.76	2.58 +- 0.57
BKLMDigitizer	10000	0	615.85	61.58 +- 36.51
EKLMDigitizer	10000	0	274.72	27.47 +- 36.39
TrackFinderMCTruth	10000	0	4.36	0.44 +- 0.10
VXDTF	10000	9	97.09	9.71 +- 86.97
MCTrackMatcher	10000	0	3.68	0.37 +- 0.09
PXDDataReduction	10000	1799	16890.74	1689.07 +-3551.01
PXDDataRedAnalysis	10000	0	15.14	1.51 +- 0.72
PXDdigiFilter	10000	0	34.32	3.43 +- 0.47
PXDClusterizer	10000	0	2.03	0.20 +- 0.04
VXDTF	10000	19	99.44	9.94 +- 88.55
RootOutput	10000	22	20.45	2.04 +- 34.58
Total	10001	253	32694.48	3269.12 +-3599.31

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- executed @ KEK
- no parallelisation
- compiled in *opt* mode

~ 76 MCParticles per event
~ 8.9 TrackCand per event

Execution Time With Background

Name		Calls	Memory(MB)	Time(s)	Time(ms)/Call
EventInfoSetter		10001	0	0.18	0.02 +- 0.01
EventInfoPrinter		10000	0	0.75	0.08 +- 0.38
EvtGenInput		10000	0	16.13	1.61 +- 9.69
Gearbox		10000	0	0.14	0.01 +- 0.00
Geometry		10000	0	0.12	0.01 +- 0.00
FullSim		10000	-45	14358.99	1435.90 +- 388.75
BeamBkgMixer		10000	-609	2478.12	247.81 +- 111.88
PXDDigitizer	**X45**	10000	-58	4961.45	496.15 +- 62.86
PXDClusterizer		10000	0	42.53	4.25 +- 0.46
SVDDigitizer	**X15**	10000	-14	2317.87	231.79 +- 27.48
SVDClusterizer		10000	1	121.51	12.15 +- 1.66
CDCDigitizer	**X9**	10000	2	604.39	7+- 6.52
TOPDigitizer		10000	-64	30.05	3.00 +- 0.65
ARICHDigitizer		10000	0	0.85	0.09 +- 0.03
ECLDigitizer		10000	4	690.37	69.04 +- 3.86
BKLMDigitizer		10000	1	1247.49	124.75 +- 41.61
EKLMDigitizer		10000	0	876.91	87.69 +- 41.93
TrackFinderMCTruth		10000	0	5.13	0.51 +- 0.11
VXDTF	**X3.5**	10000	10	364.76	36.48 +- 250.32
MCTrackMatcher		10000	0	5.67	0.57 +- 0.10
PXDDataReduction	**+15%**	10000	1268	19454.87	1945.49 +-3450.45
PXDDataRedAnalysis		10000	0	15.79	1.58 +- 0.71
PXDdigiFilter		10000	0	1704.28	170.43 +- 44.93
PXDClusterizer		10000	0	3.04	0.30 +- 0.08
VXDTF		10000	0	341.27	34.13 +- 219.30
RootOutput		10000	35	57.52	5.75 +- 61.74
Total		10001	532	49721.60	4971.66 +-3533.36

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- executed @ KEK
- no parallelisation
- compiled in *opt* mode

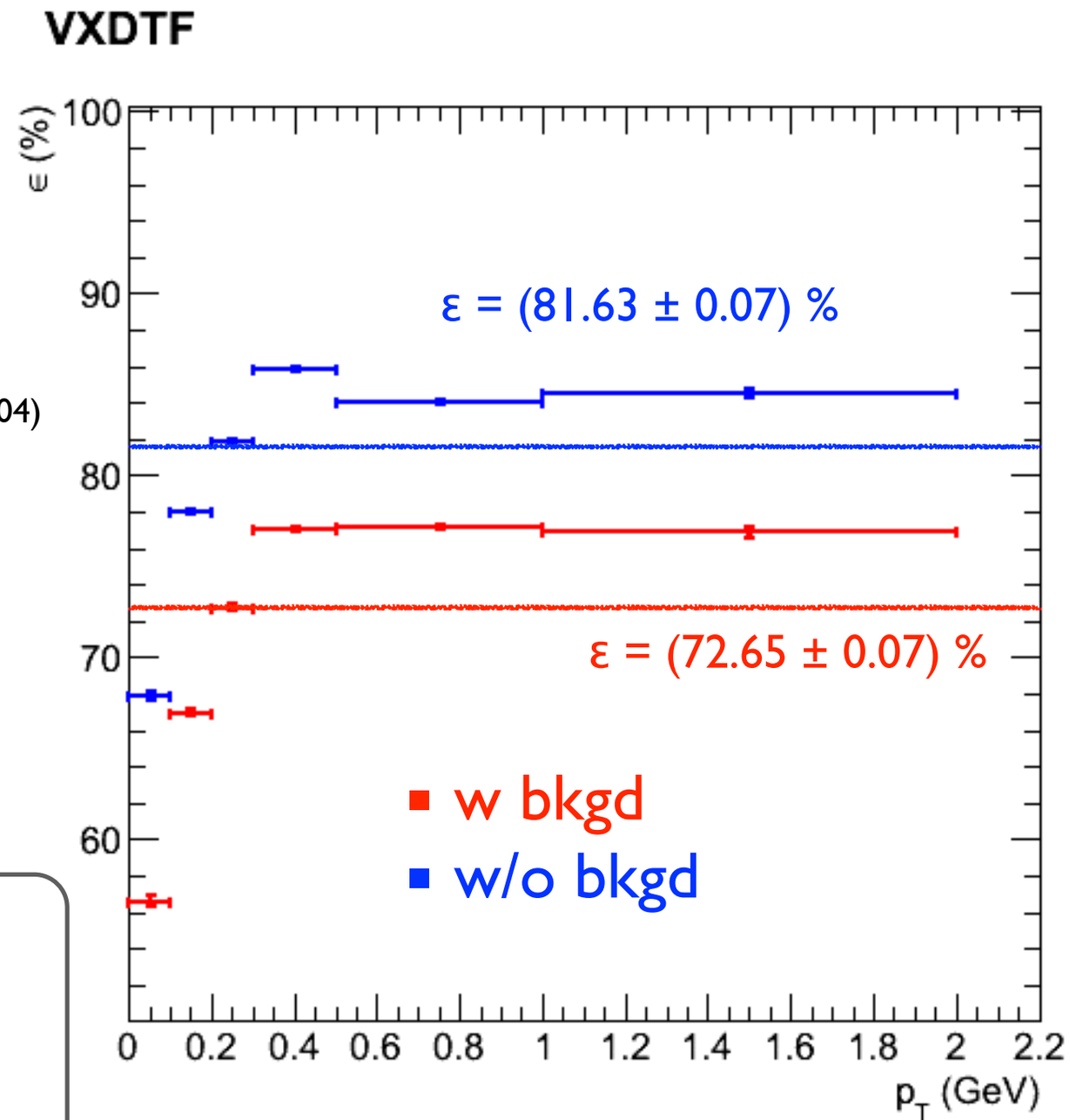
~ 76 MCParticles per event
~ 9.4 TrackCand per event

```
bkgdir = '/sw/belle2/bkg.new/'
bkgFiles = [
    bkgdir + 'twoPhoton_200us.root',
    bkgdir + 'Coulomb_HER_100us.root',
    bkgdir + 'Coulomb_LER_100us.root',
    bkgdir + 'RBB_HER_100us.root',
    bkgdir + 'RBB_LER_100us.root',
    bkgdir + 'Touschek_HER_100us.root',
    bkgdir + 'Touschek_LER_100us.root']
```

ROI Finding Efficiency

ROI finding efficiency evaluated on 10k generic B decays:

- ➡ Efficiency w/o bkg = (81.63±0.07)%
  - increased by ~6.5% w.r.t. previous studies (9th june 2104)
- ➡ Efficiency w bkg = (72.65±0.07)%
- ➡ In both cases inefficiency mostly due to failures in fitting the track and finding an intercept with the sensor planes (as always)



$$\varepsilon = \frac{\text{\# PXDDigits inside a ROI}}{\text{total \# PXDDigits of TrackCand}}$$

inefficiencies of the pattern recognition are factorized,

but the TrackCand quality is not!

Software quality assurance

- We need to sharply improve on this side.
  - Luigi reported a sudden worsening of the vertex resolution and the bug went unnoticed for weeks.
  - Tracking validation plots didn’t help to catch timely the bug:
    - lack of instructions for the software shifters,
    - lack of some key plots
    - lack of effective contact with people doing physics analysis

Conclusions

- We had a very fruitful and pleasant meeting.
- Things are progressing quite well (even if with some delays with respect our schedule).
- Major ongoing efforts:
  - development of a Trasan free CDC track finder,
  - refactoring of the VXDTF.
- Next F2F tracking meeting in Vienna on January Monday the 12th 2014