Tracking in the Belle II Vertex Detector
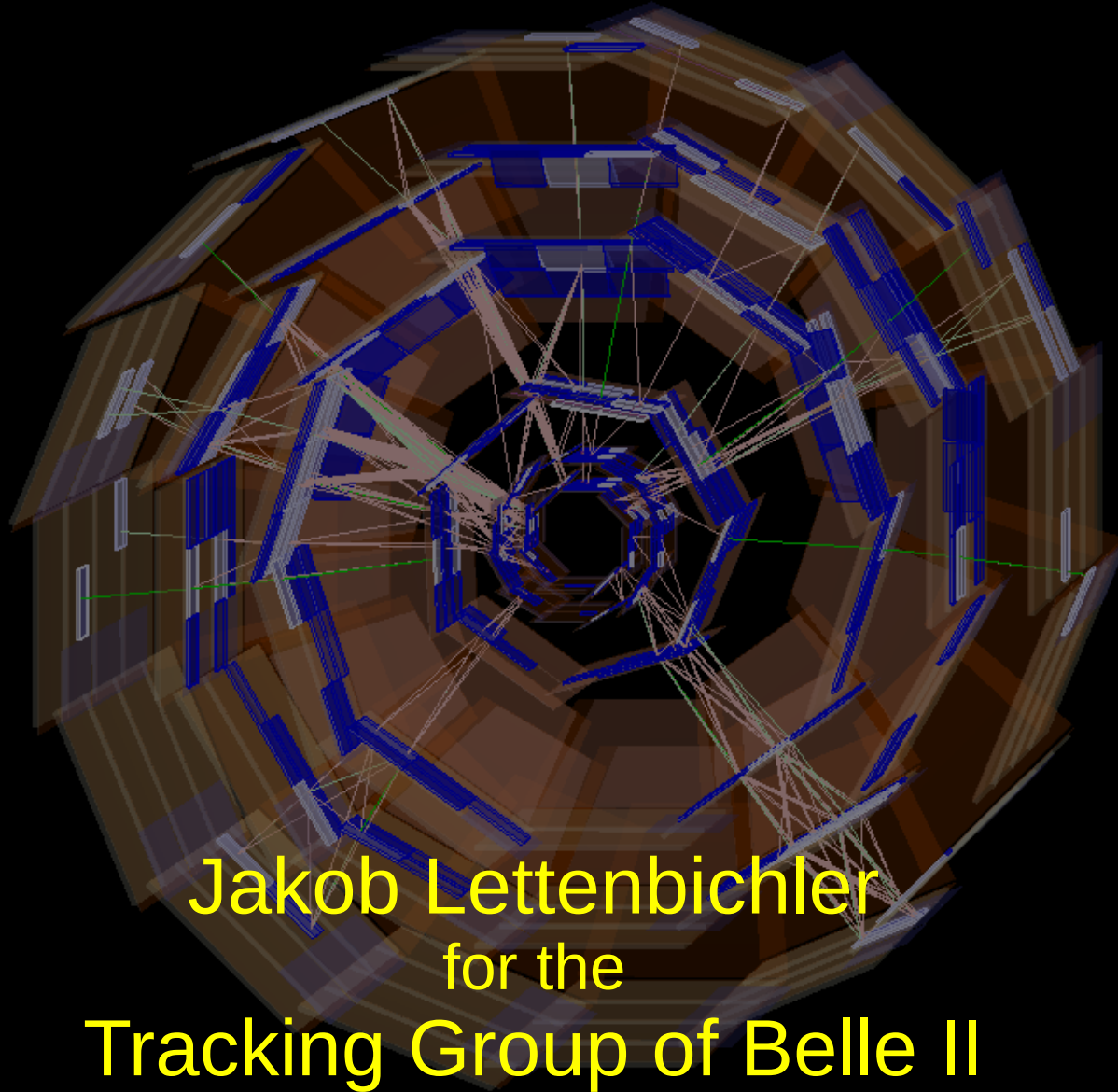## - current status -

Jakob Lettenbichler
for the
Tracking Group of Belle II

What to expect today:

- Last week was **Connecting the Dots** workshop and I think it was a successful advertisment for our TrackFinders

- This week we are back to our offices and it's time to put the advertisment aside and focus on reality: what is the current state of the VXDTF2?
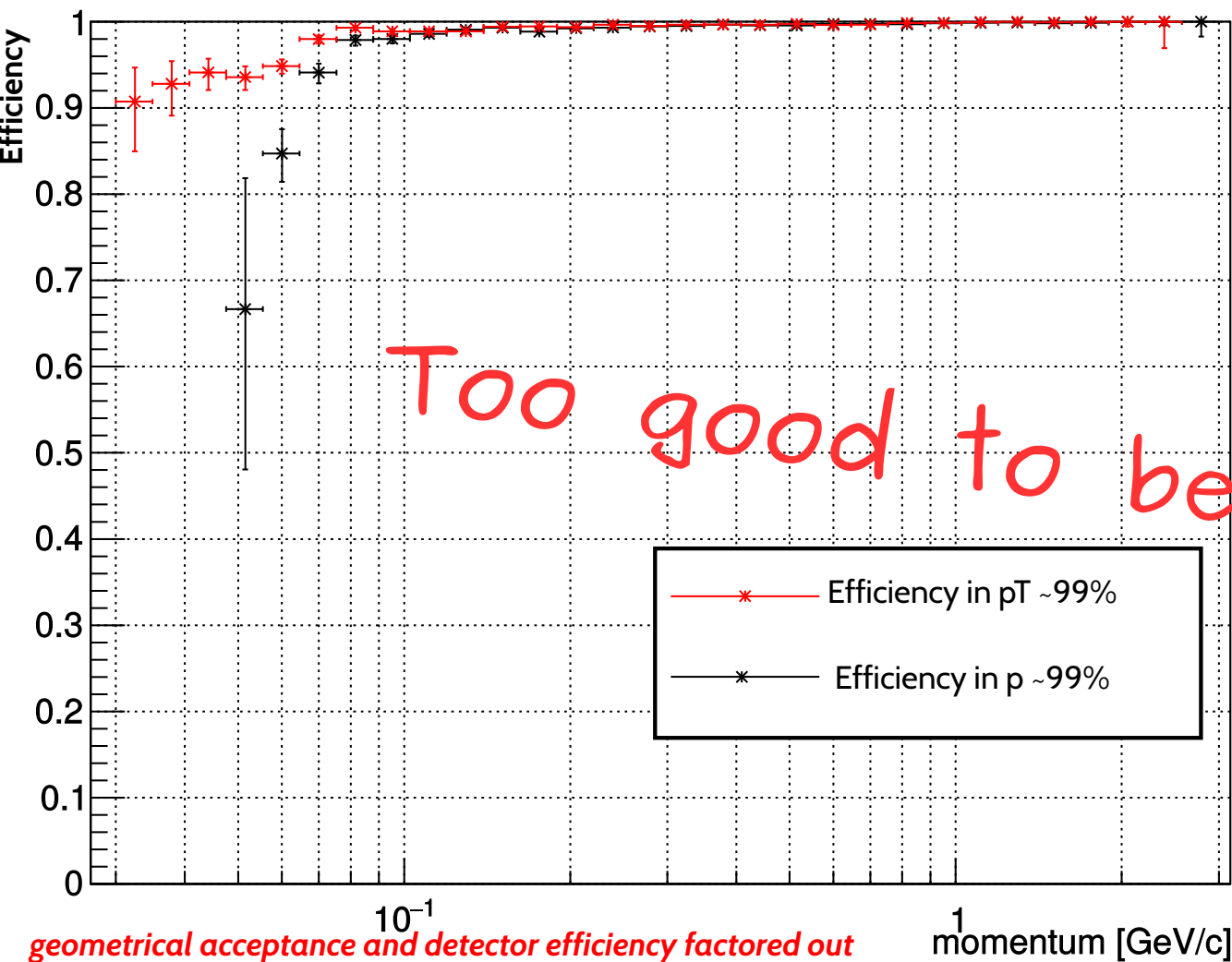
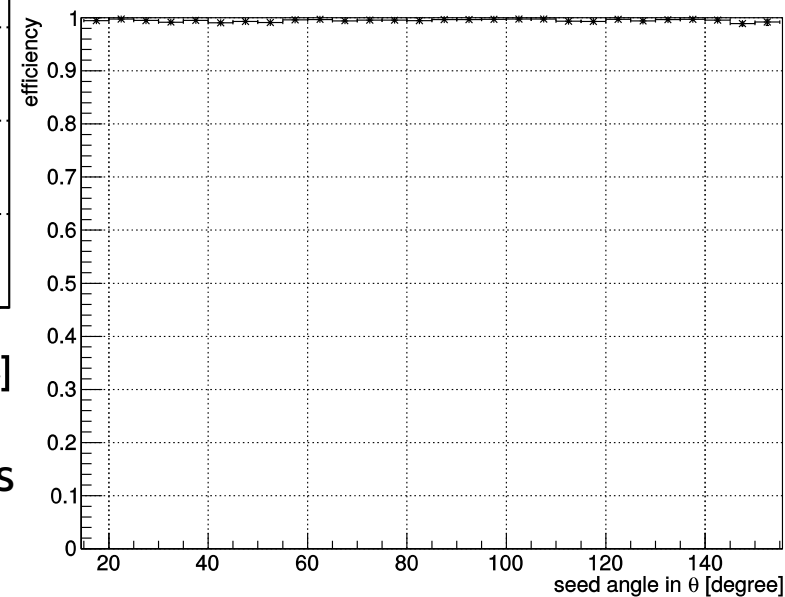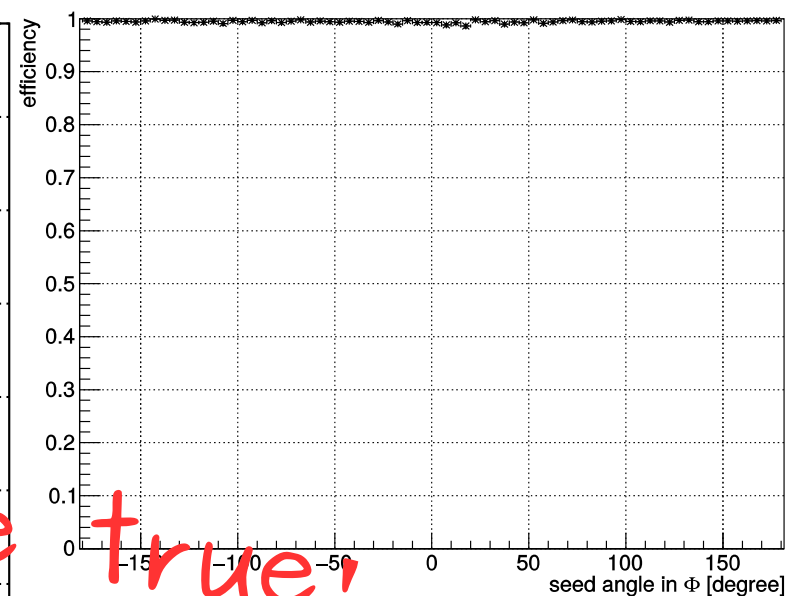# Planned structure for the VXDTF (event-part)
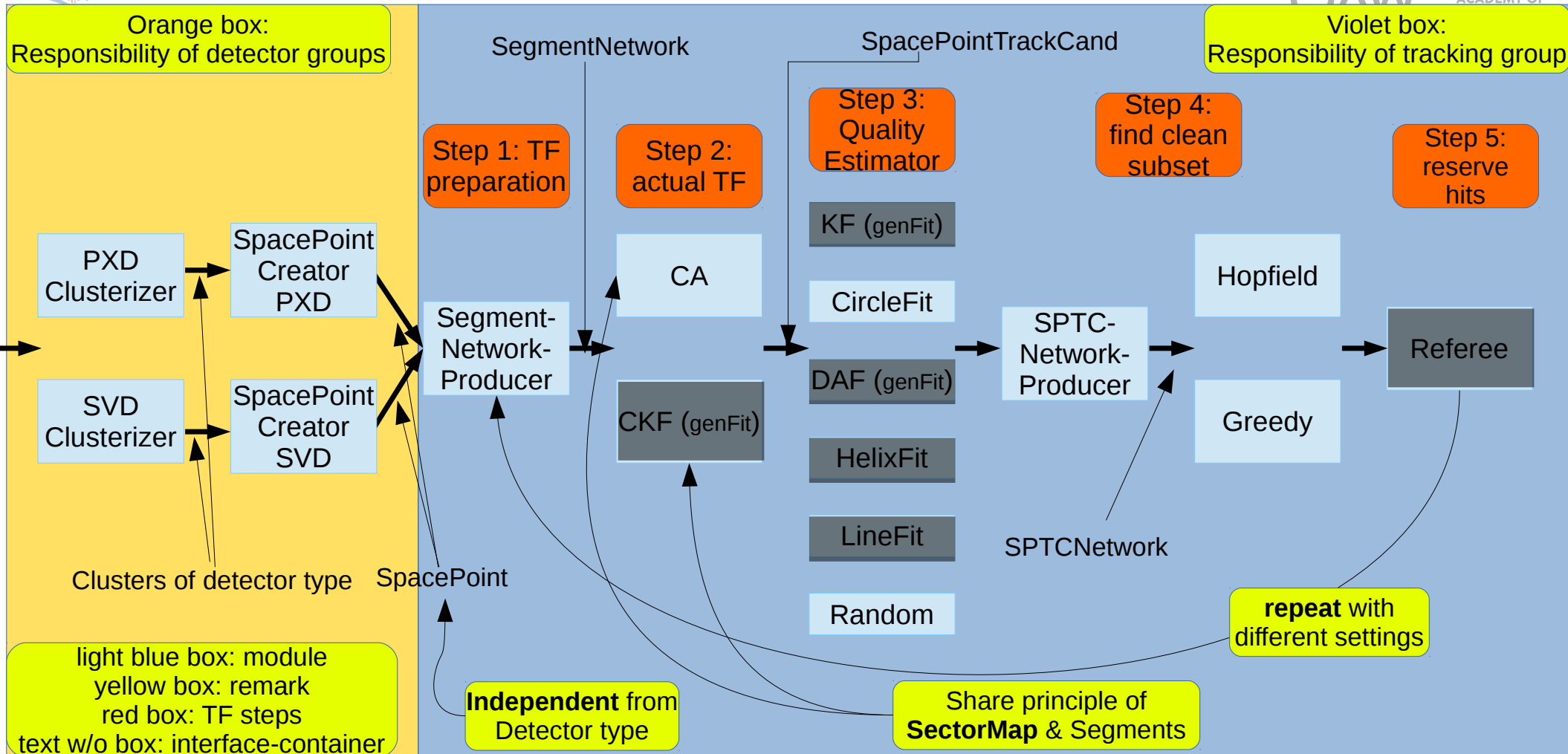
- Modules which are dark are not yet written.
- New module: **_VirtualIPRemover_**, can be placed before or after Fit (or both at once)

- CA: Cellular Automaton
- KF: Kalman Filter
- CKF: Combinatorial KF
- DAF: Deterministic Annealing Filter
- Hopfield/HNN: a neural network of Hopfield type
- SPTC: SpacePointTrackCandidate

VXDTF2 – performance shown at CTD

Efficiency vs momentum

Too good to be true!

Efficiency in pT ~99%

Efficiency in p ~99%

geometrical acceptance and detector efficiency factored out

BUT: high fake- and clone rate due to early development status

Y(4s) results with typically 10 tracks per event

Der Wissenschaftsfonds.

VXDTF2 – performance after the CA

Efficiency vs momentum

Efficiency of Φ

No sever issues…

Significant drop:
I suspect some filters

Efficiency of θ

WTF?!?
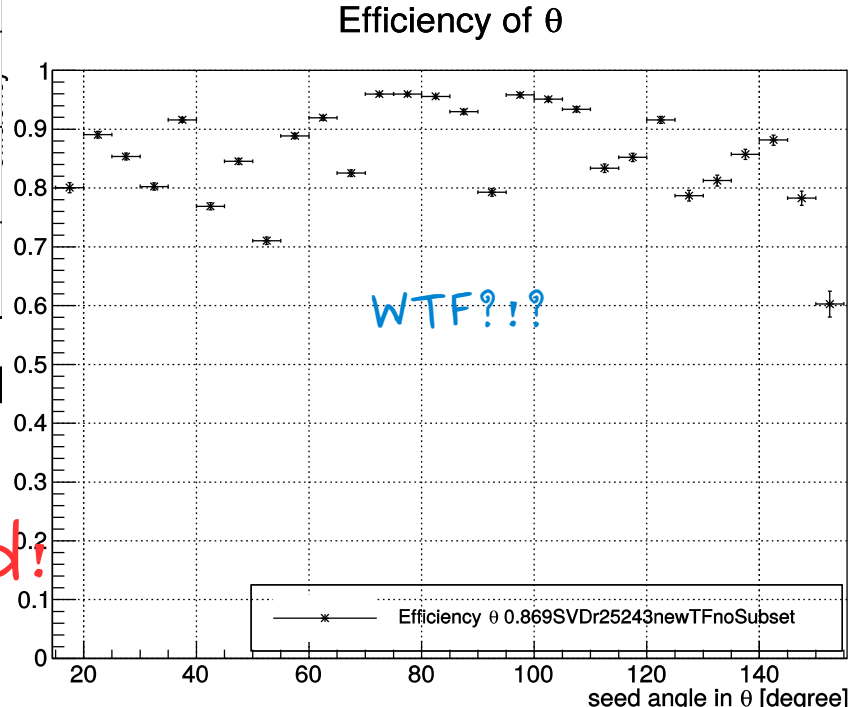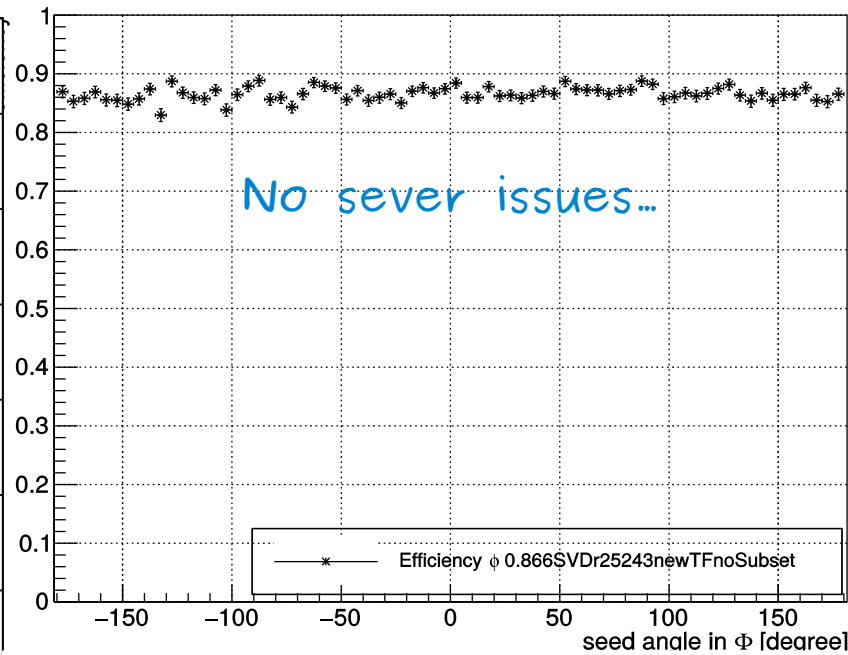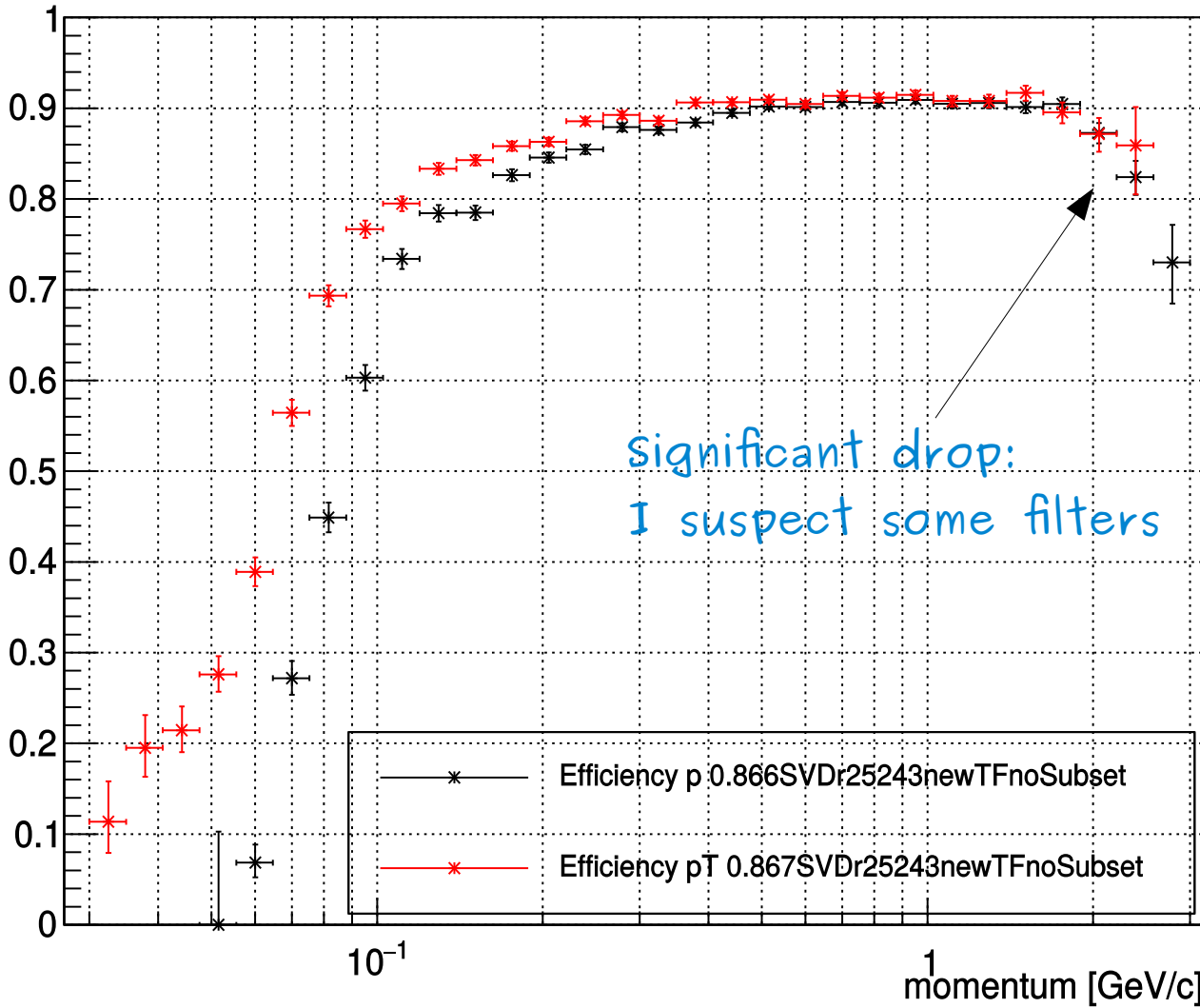
No sub-set-selection, no fitting,
simply all 2- and 3-hit-filters used!
– single pass run –

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VXDTF2 – performance after HNN

Efficiency vs momentum

Efficiency of Φ

Basic patterns preserved:
bottleneck are the filters

Efficiency φ 0.839SVDr25243newTFHNN_withVIPfix

seed angle in φ [degree]

Efficiency p 0.839SVDr25243newTFHNN_withVIPfix

Efficiency pT 0.840SVDr25243newTFHNN_withVIPfix

momentum [GeV/c]

Efficiency of θ

Efficiency θ 0.842SVDr25243newTFHNN_withVIPfix

seed angle in θ [degree]
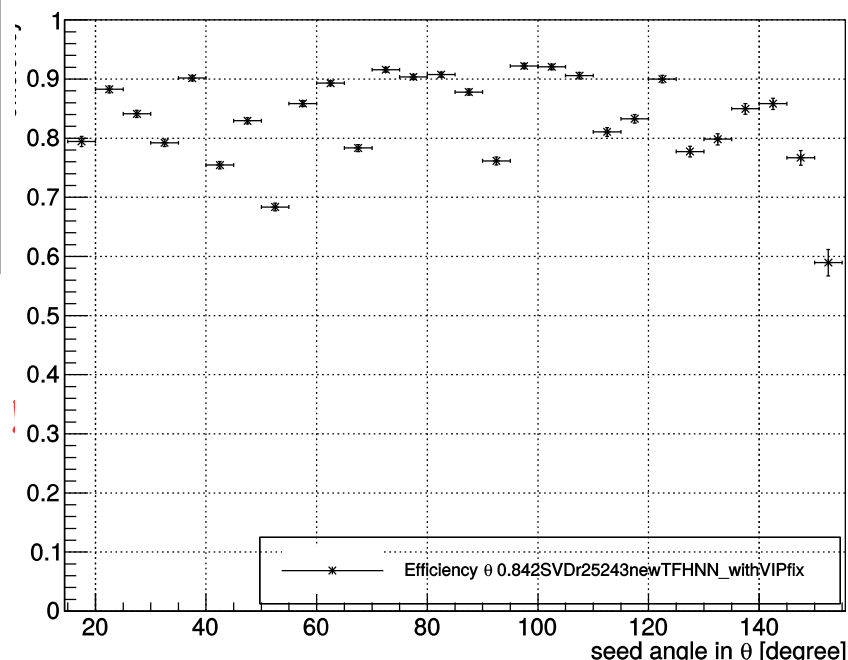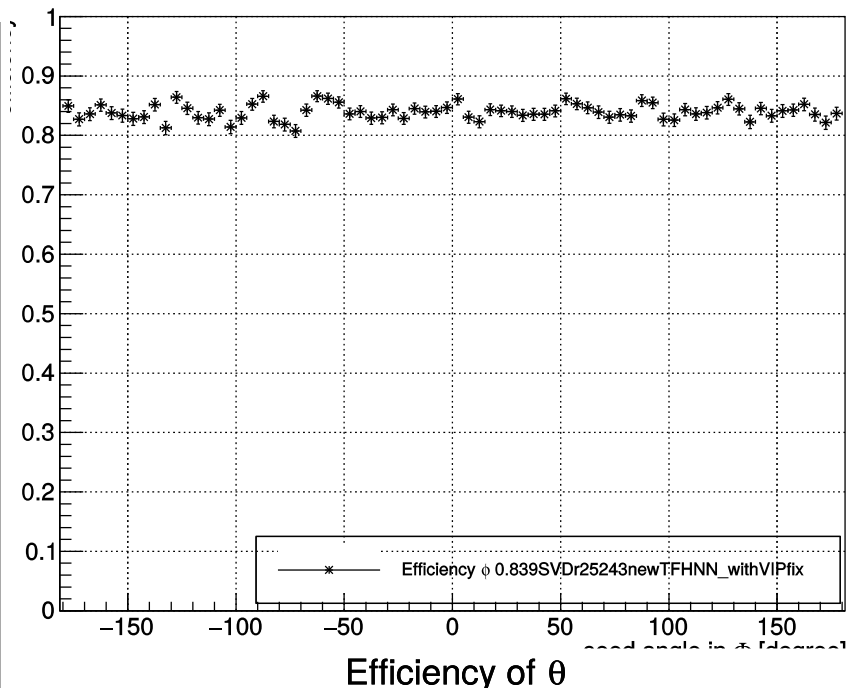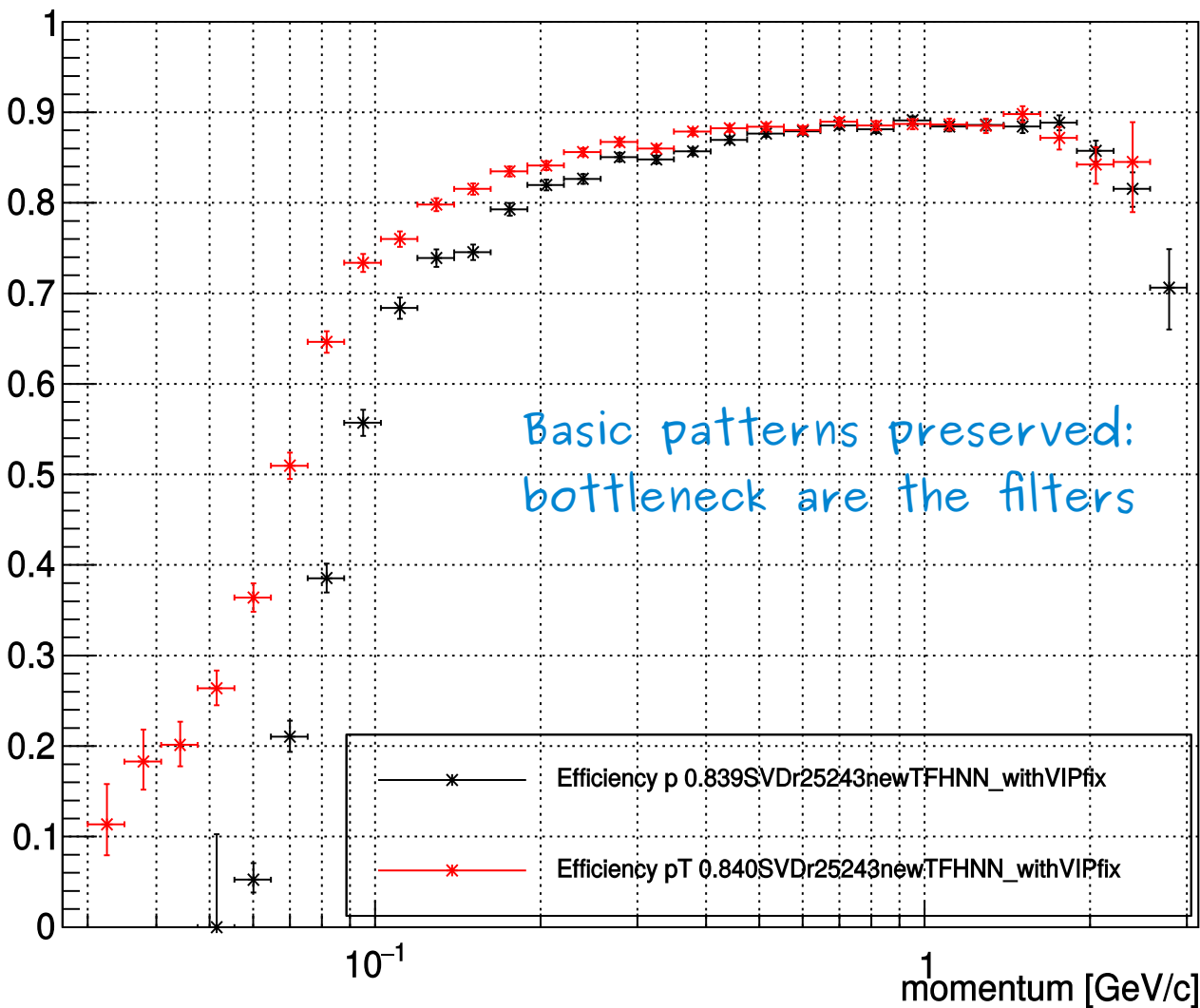
Full single-pass-chain (no referee)!

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results

- ## Hard numbers – after the CA:
  Absolute numbers: total/perfect/clean/contaminated/clone/tooShort/ghost: 85601/83491/1345/765/208848/0/40237 efficiency : total/perfect/clean/contaminated/clone/tooShort/ghost: **86.6091%/84.4743%/1.36084%/0.774009%/211.308%/0%/40.7109%**
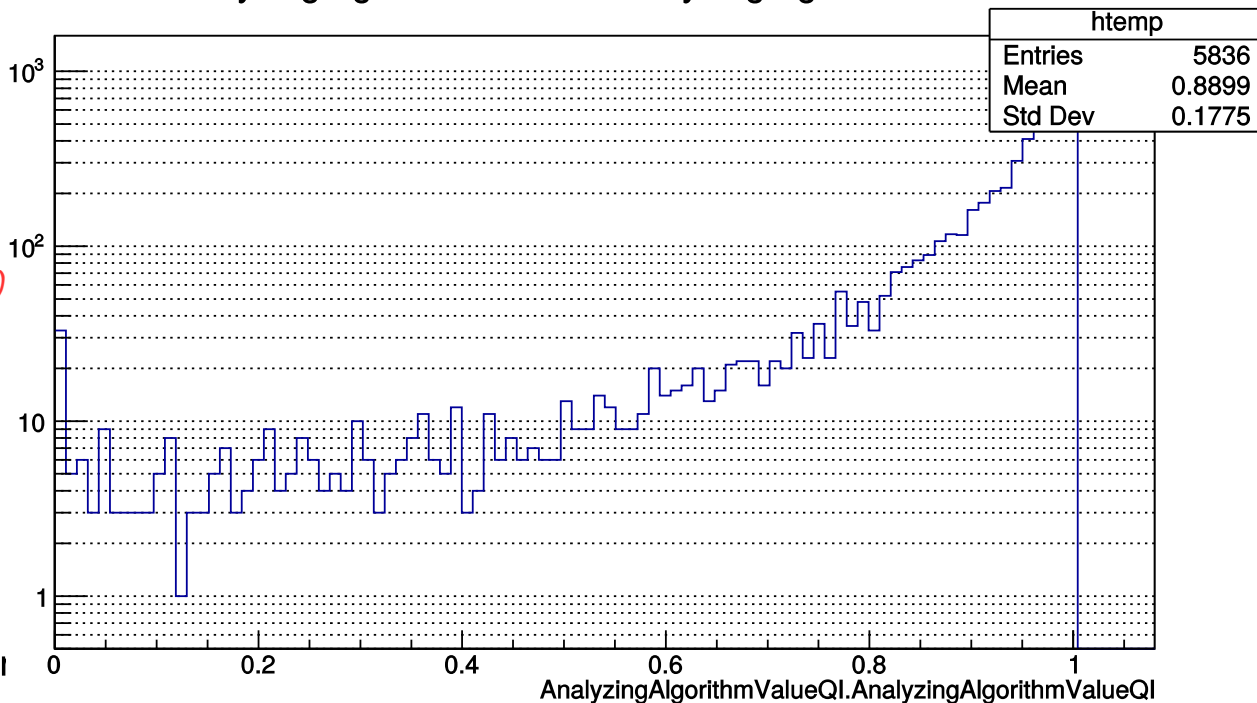
- ## Hard numbers – after HNN:
  Absolute numbers: total/perfect/clean/contaminated/clone/tooShort/ghost: 82965/71344/5785/5836/1/0/4052 efficiency: total/perfect/clean/contaminated/clone/tooShort/ghost: **83.9421%/72.1842%/5.85313%/5.90473%/0.00101178%/0%/4.09972%**

VXDTF2 – performance after HNN

"Perfect" Tcs
(perfect: 100% purity and 100% reconstructed)
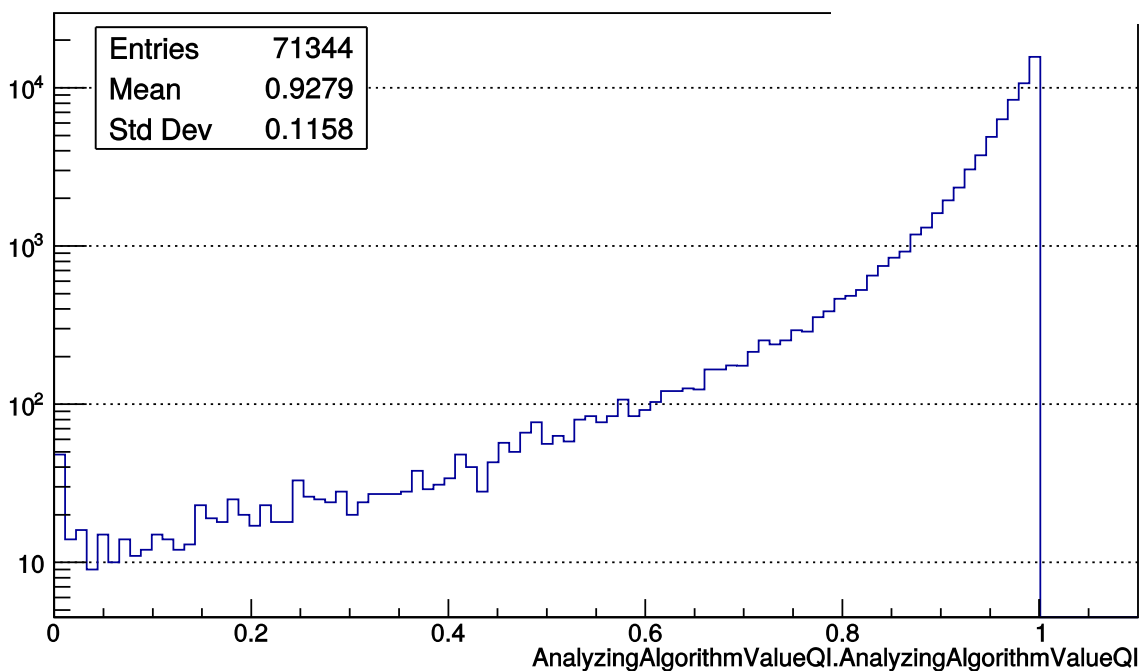
"Contaminated" Tcs
(contaminated: 100% < purity < 70%)

Conclusions

- **Good news everyone** - VXDTF2 is producing results!
  - But: do <u>not</u> let this mislead you to „optimistic" opinions about this project
- **Bad news**: VXDTF is far, far away from its „production quality state"
  - I am sorry, but this is definitively early Alpha-stage
- In practically every module still many little screws and levers have to be tuned – loads of work to be done
- Message for the next time: even for such a small detector like the VXD: tracking is not a one (or two)-man-job...

Der Wissenschaftsfonds.

That's all folks!
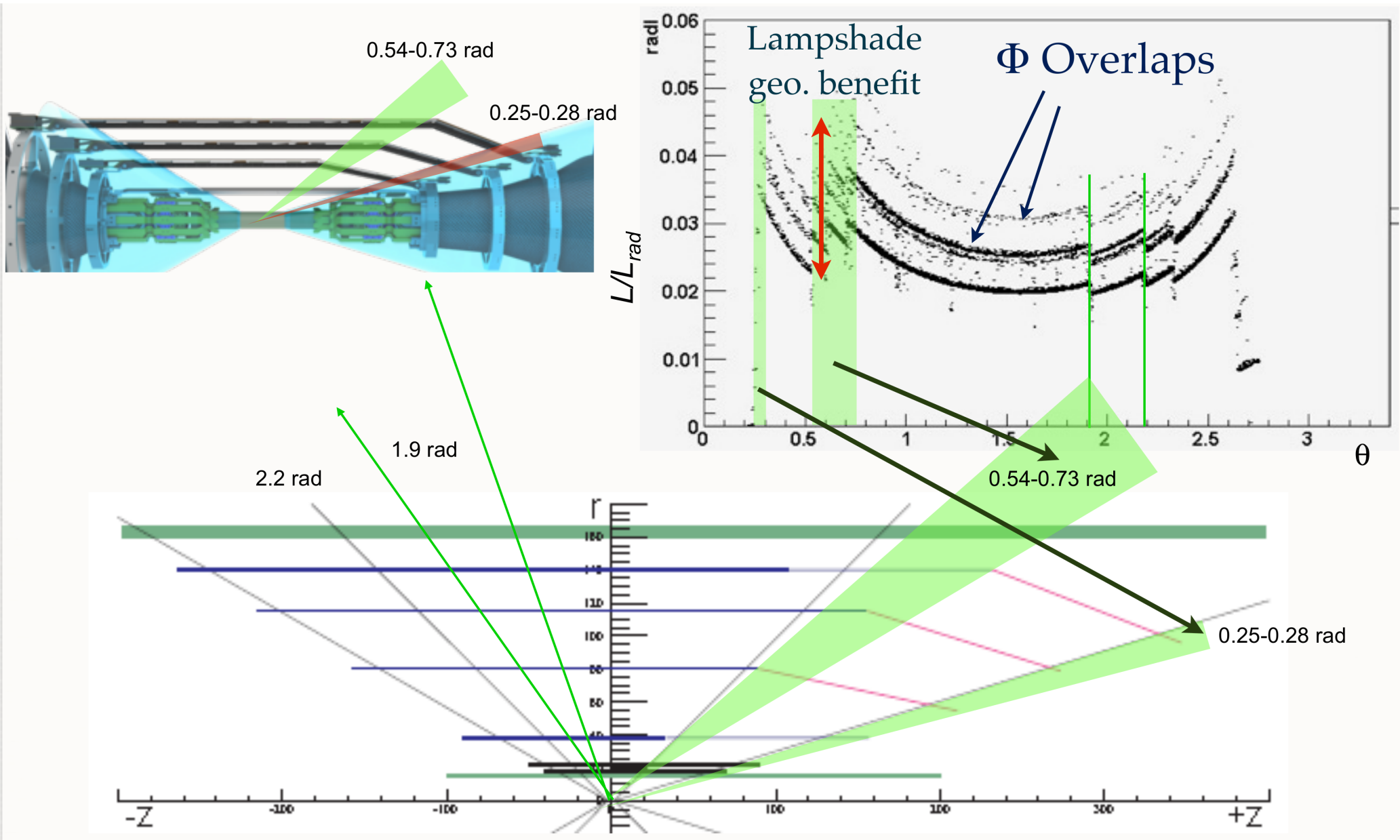
The SVD in detail
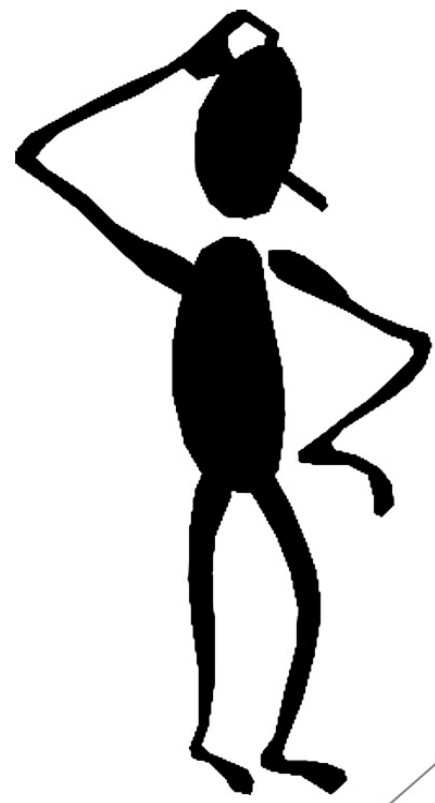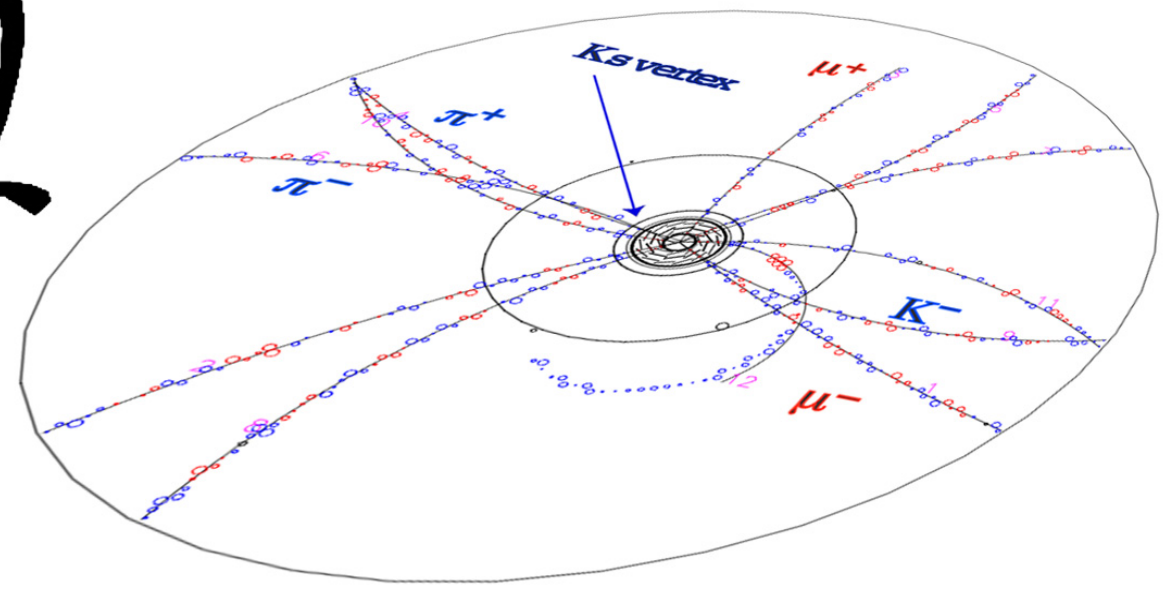
- ◆ 4 layers of double sided silicon strip detectors

- ◆ Lampshade geometry for layers 4, 5 & 6

- ◆ Individual readout on each silicon sensor

- ◆ Very light mechanical structure
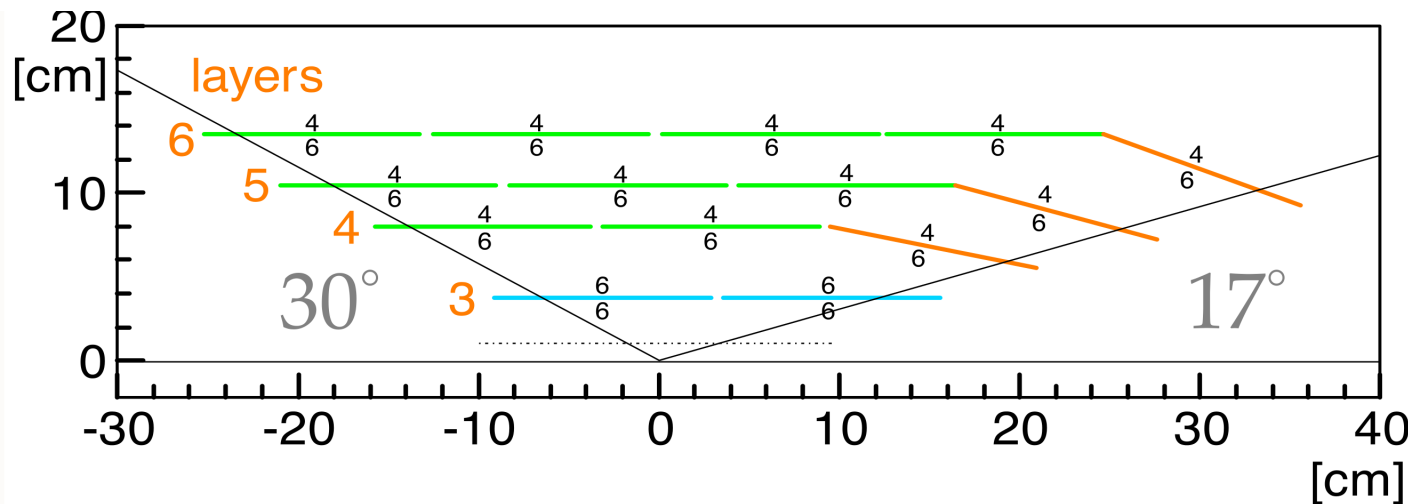
z APVs / rphi APVs — Rect (122.8 x 38.4 mm^2, 160 / 50 um pitch)

z APVs / rphi APVs — Rect (122.8 x 57.6 mm^2, 240 / 75 um pitch)

z APVs / rphi APVs — Wedge (122.8 x 57.6-38.4 mm^2, 240 / 75..50 um pitch)
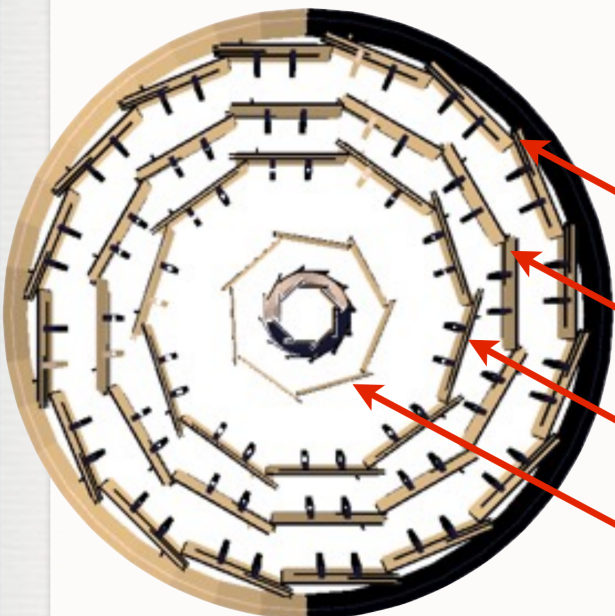
Layer	Avg.Radius (mm)	Ladders	Sensors / Ladder	Slanted?	Windmill angle [°]	Overlap [%]
6	135	16	5	✓	7	10.8
5	105	12	4	✓	5	5.1
4	80	10	3	✓	6	17.6
3	39	7	2	✗	6	5.9

Belle II

0.54-0.73 rad

0.25-0.28 rad

Lampshade geo. benefit

Φ Overlaps

L/L_{rad}

θ

0.54-0.73 rad

0.25-0.28 rad

2.2 rad

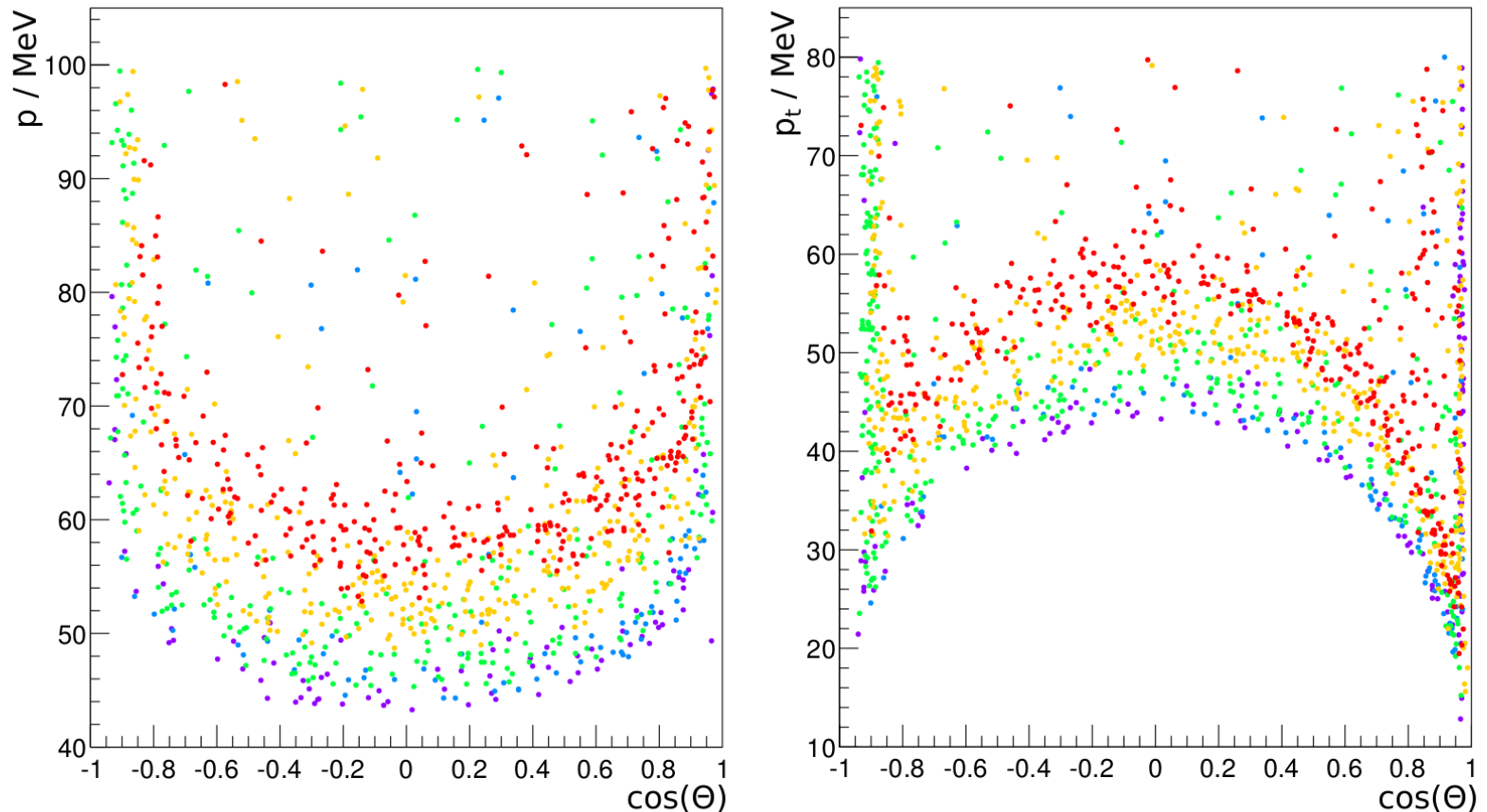1.9 rad

Material effects in Detail

Figure 5.4.: Total and transverse momentum of simulated pions that do **not** reach the last SVD layer, over $\cos\theta = p_z/p$. Colours indicate the outermost layer reached: violet and blue for PXD layers 1 and 2; green, yellow and red for SVD layers 1, 2, and 3, respectively.

Taken from diploma thesis of Christian Pulvermacher

Backup: Distributions of tracks