Karlsruhe Institute of Technology

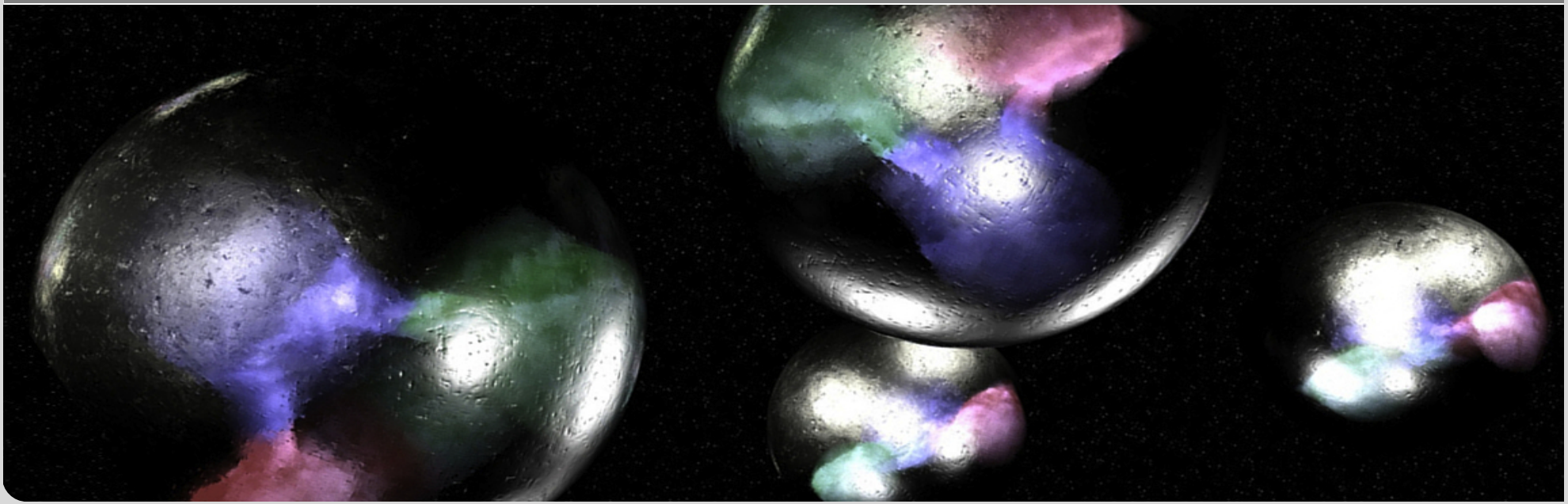
Belle II

Report on the VXDTF2

F2F Tracking Meeting — Pisa 2017

Felix Metzner | 5th December 2017

INSTITUT FÜR EXPERIMENTELLE TEILCHENPHYSIK (ETP)



1. X–Best Candidate Selection
2. Effect of the SVD Timing Cut
3. Remaining Memory Issues
4. Vertex Resolution with the Current Setup

X–Best Candidate Selection

X–Best Candidate Selection

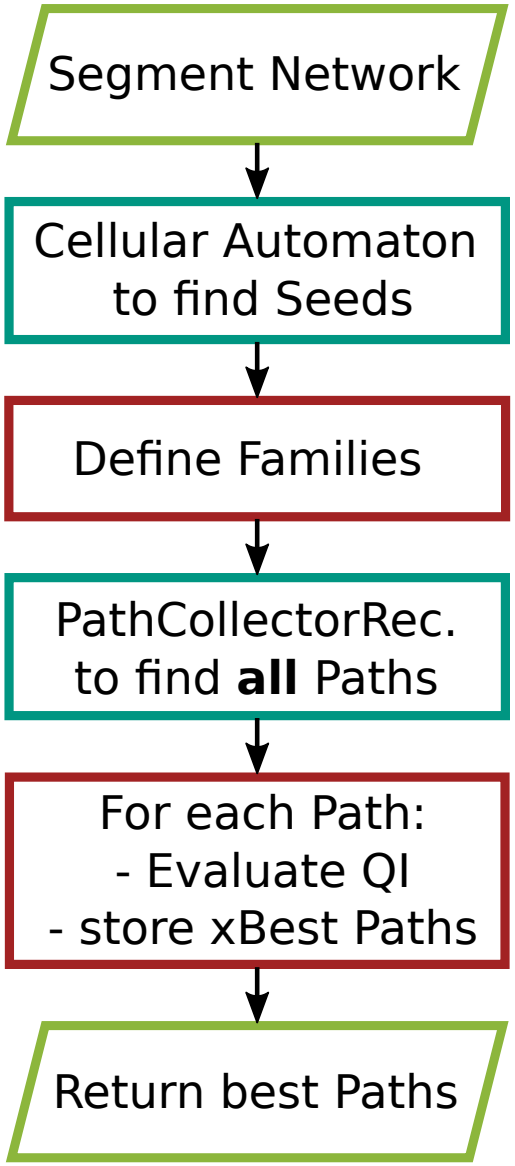
First ansatz to tackle the memory issues:

2–Step Candidate Selection

- define families based on 2-SpacePoint segments
- calculate QI for Candidate
- determine *x* best candidates of a family
- only store these to DataStore

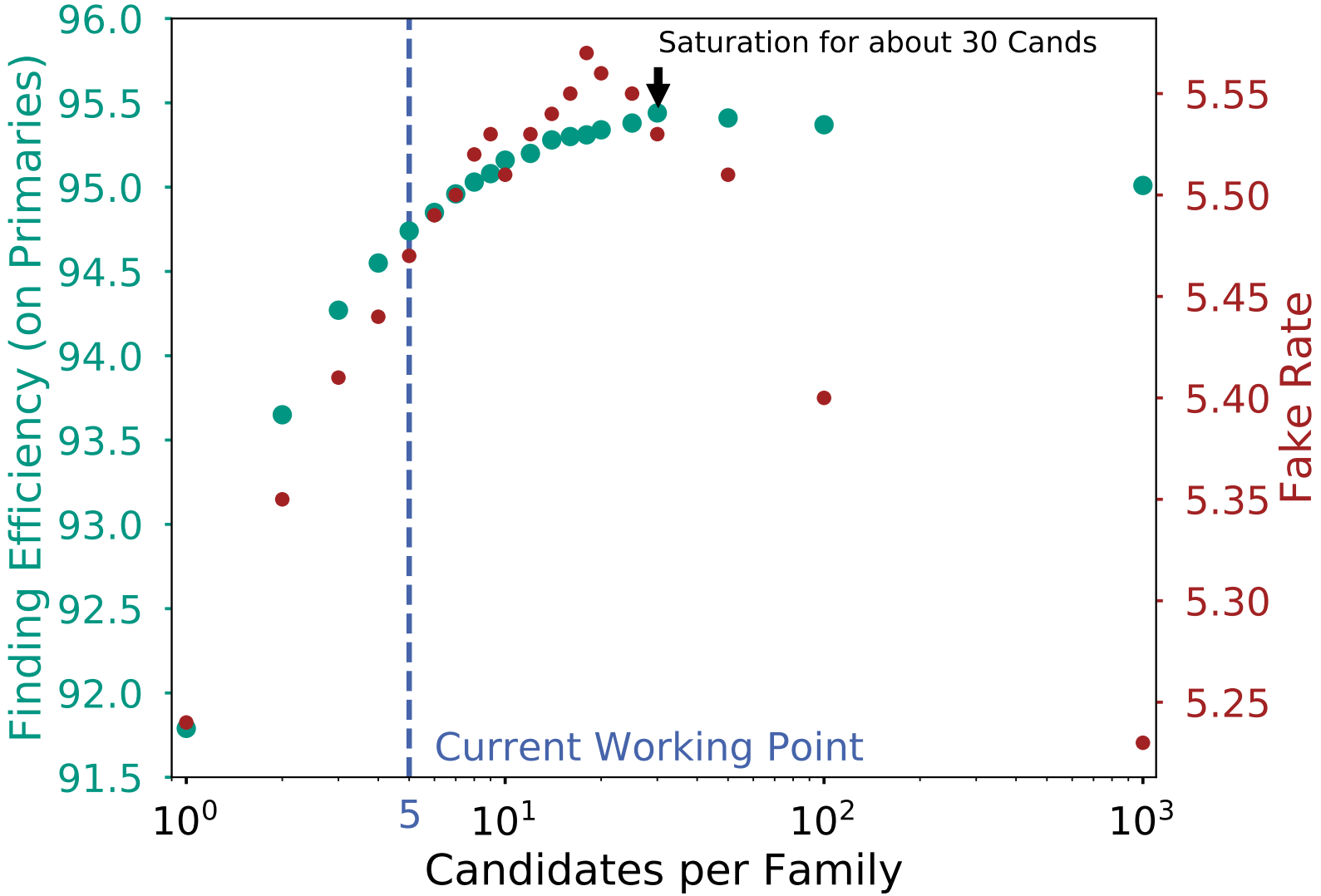
$\Rightarrow$ **Memory usage reduced by factor 10**
$\Rightarrow$ **Improves Finding Efficiency**

Currently we use 5 Candidates per Family, but can we do better?
$\Rightarrow$ Evaluation on 5000 $\Upsilon(4S)$ events with Bkg



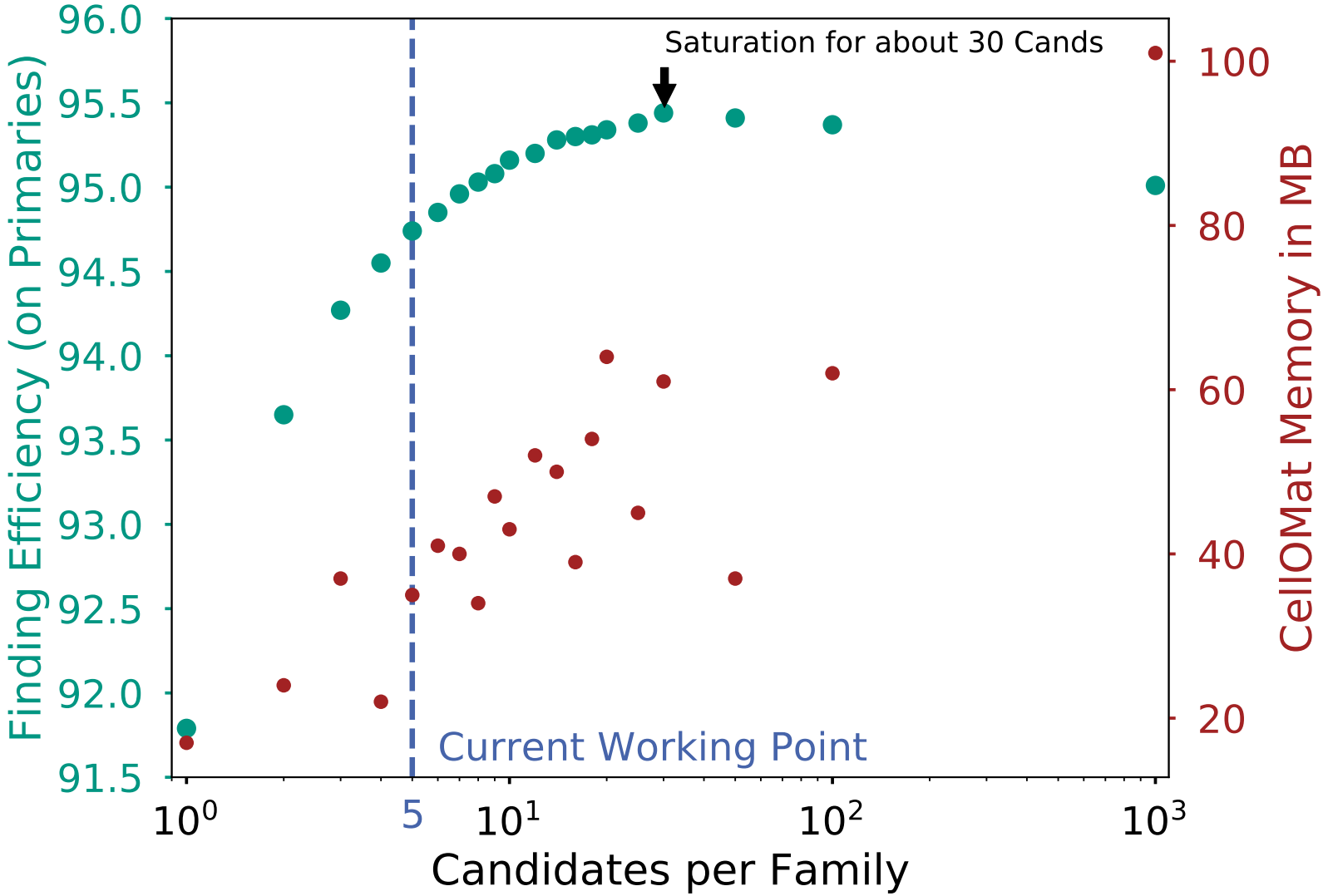
X–Best Candidate Selection

Finding Efficiency and Fake Rate vs. Number of Candidates

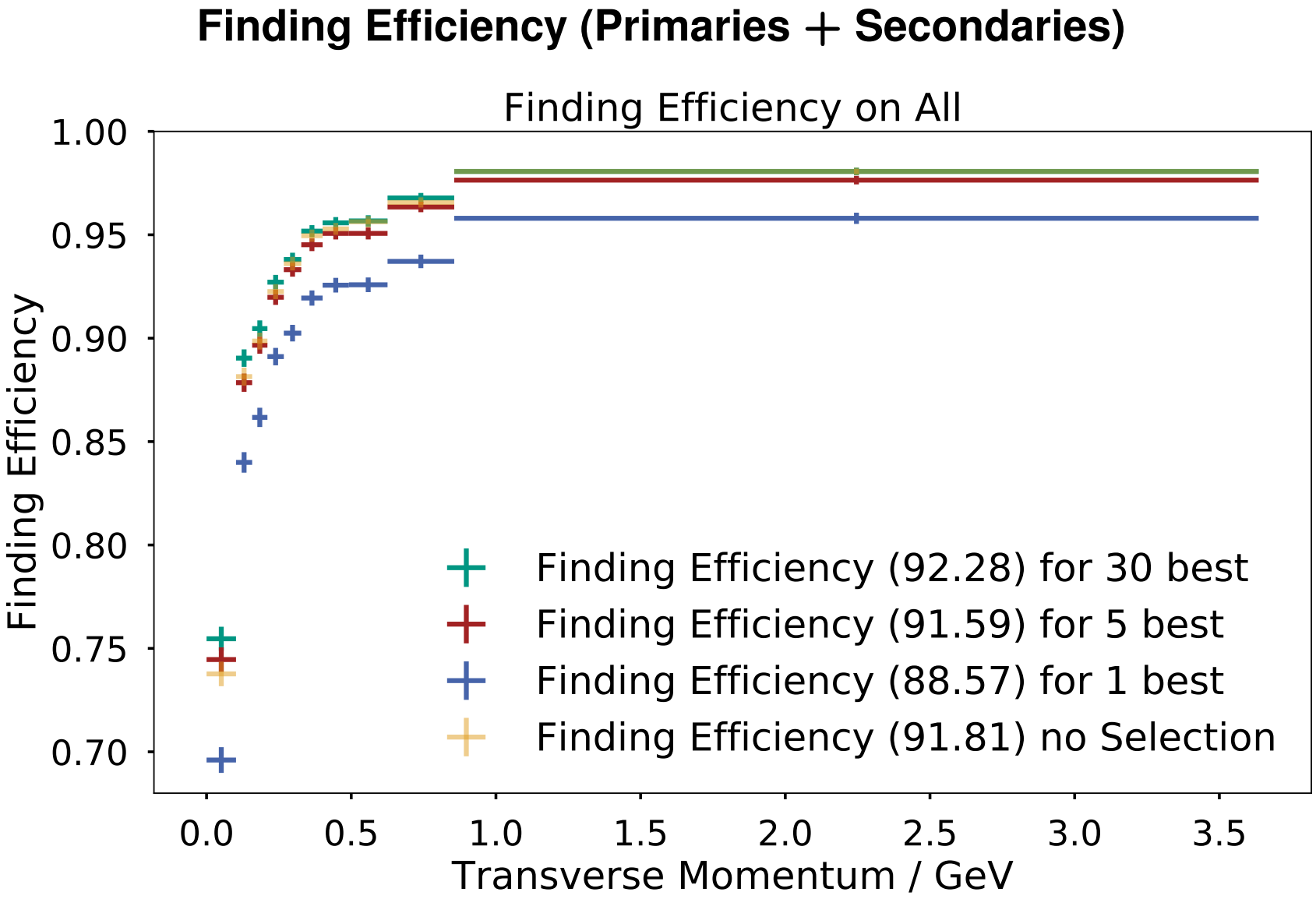


X–Best Candidate Selection

Finding Efficiency and Memory Usage vs. Number of Candidates

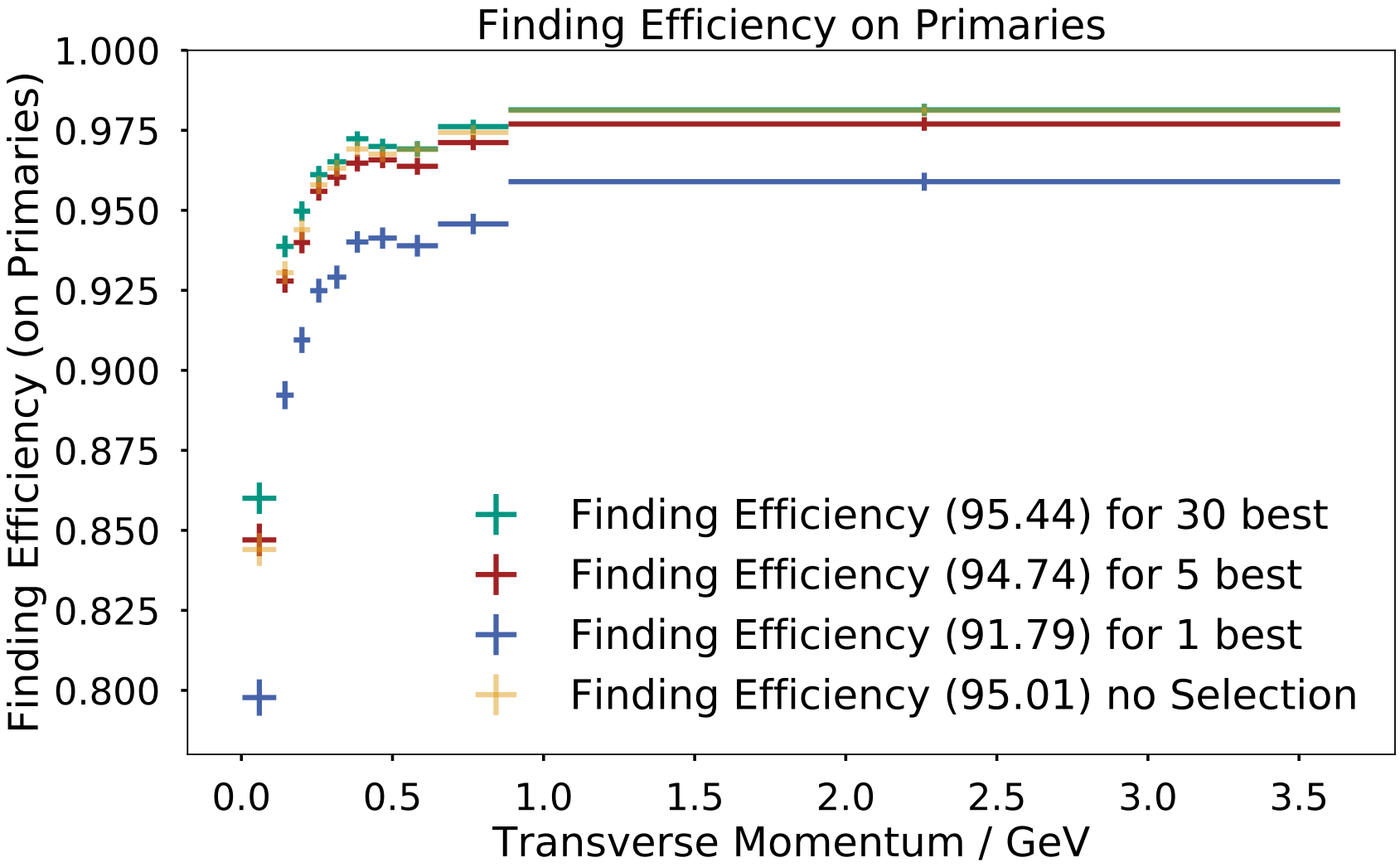


X–Best Candidate Selection



X–Best Candidate Selection

Finding Efficiency (Primaries)



X–Best Candidate Selection

Conclusion

Memory issues are now also partly handled by

- cut on SVD Timing in SpacePoint creation and
- inclusion of SVD Timing into Sector Map,

but 2-Step Candidate Selection still does the heavy lifting!

	Finding Eff.	Memory	Runtime / 5k Events
No 2-Step	95.0%	328 MB	**19 s**
2-Step	**95.4%**	**23 MB**	20 s

Finding Efficiency can be improved by tuning number of candidates

$\Rightarrow$ Saturation for about **30 candidates**.

Effect of the SVD Timing Cut

Effect of the SVD Timing Cut

Evaluation of the Timing Cut introduced by the SVD Software Group

SVD Timing Cut

Reject SVD Clusters with time $< -$**20 ns** during SpacePoint creation.

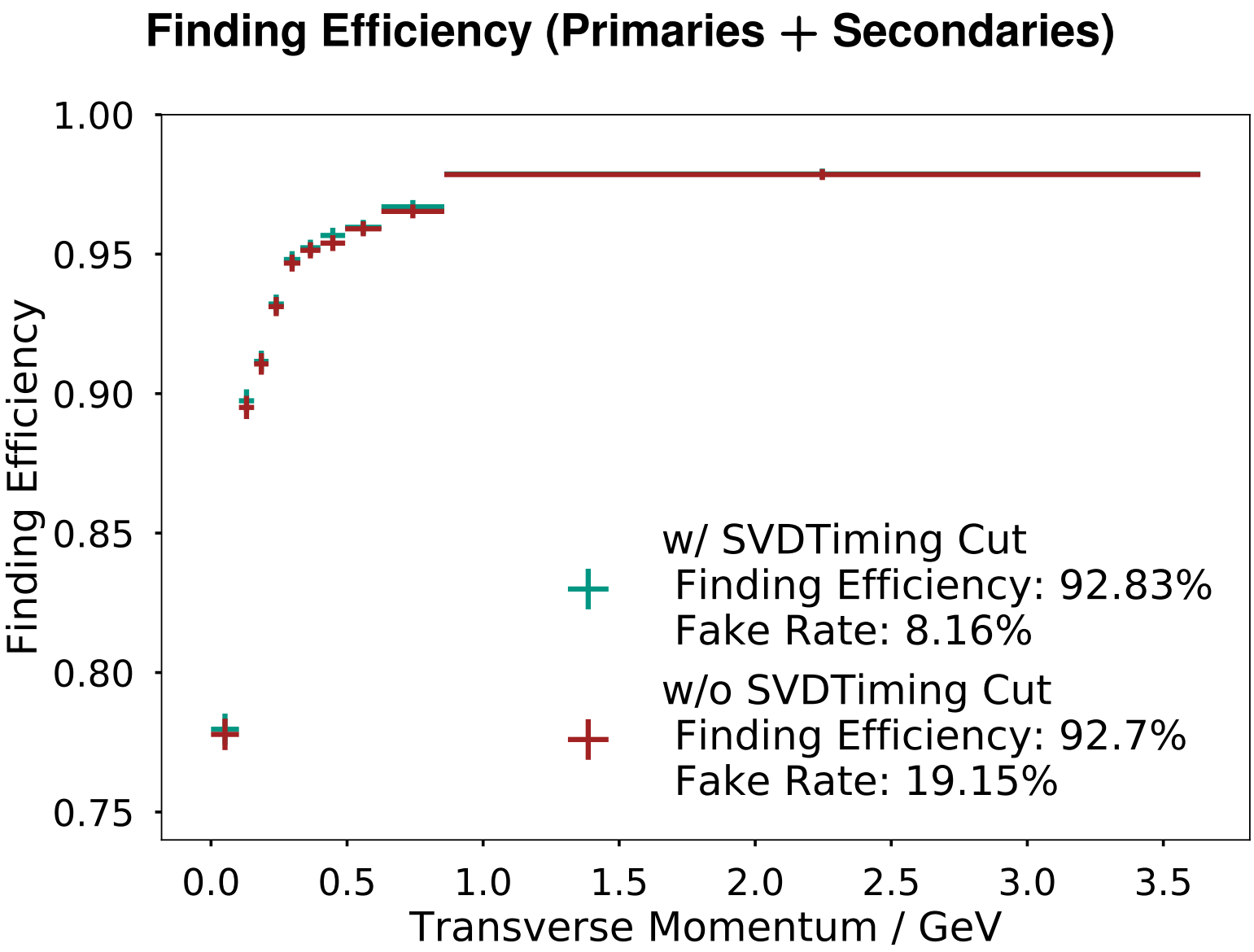
Goal:
- reject fakes
- reduce memory footprint of following modules

But does it affect the Finding Efficiency of the VXDTF2?

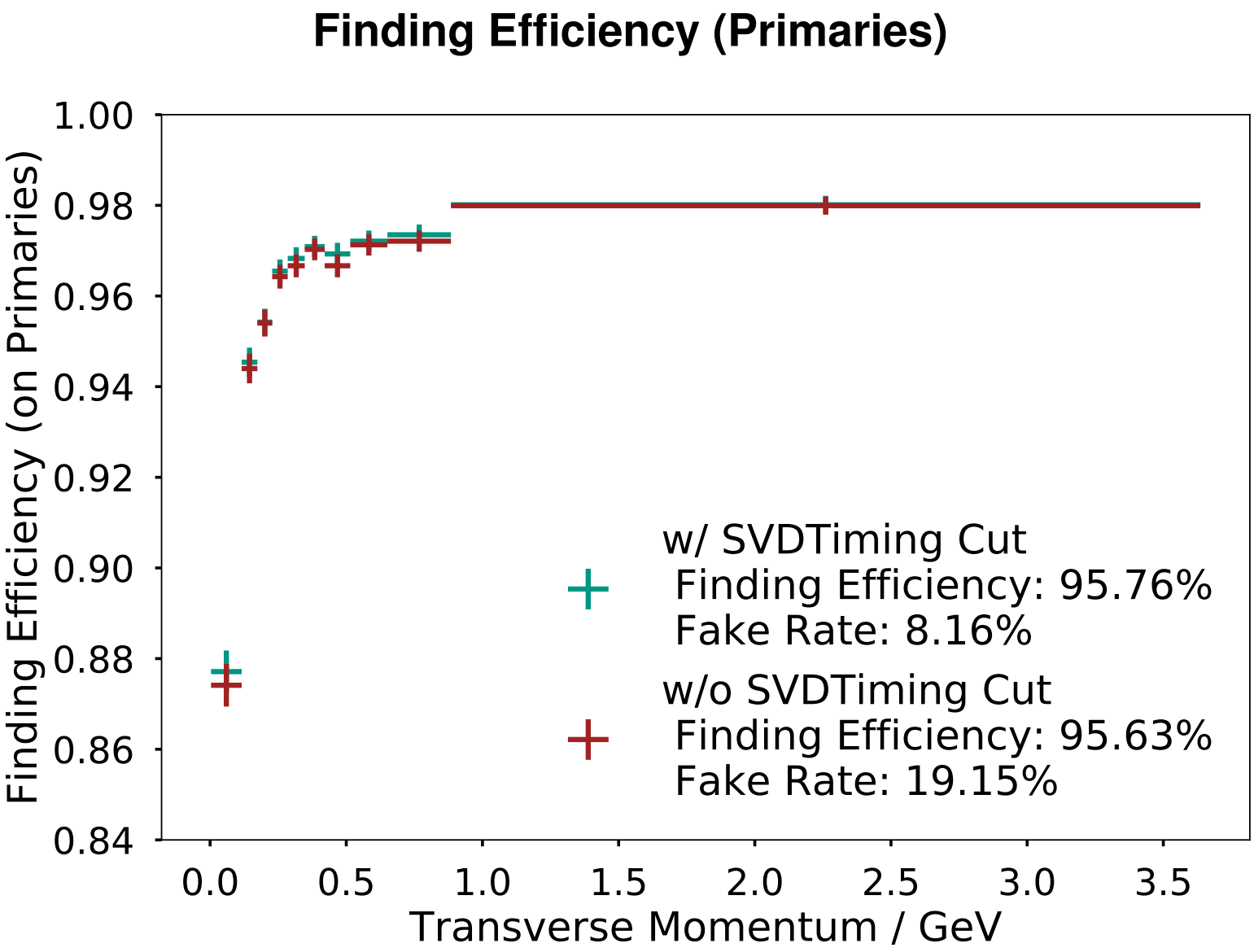
$\Rightarrow$ Evaluation on 5000 Υ(4S) events with Bkg.

	Fake Ratte	Memory	Runtime / 5k Events
No Cut	19.2%	87 MB	32 s
> -20 ns	**8.2%**	**23 MB**	**20 s**

Effect of the SVD Timing Cut

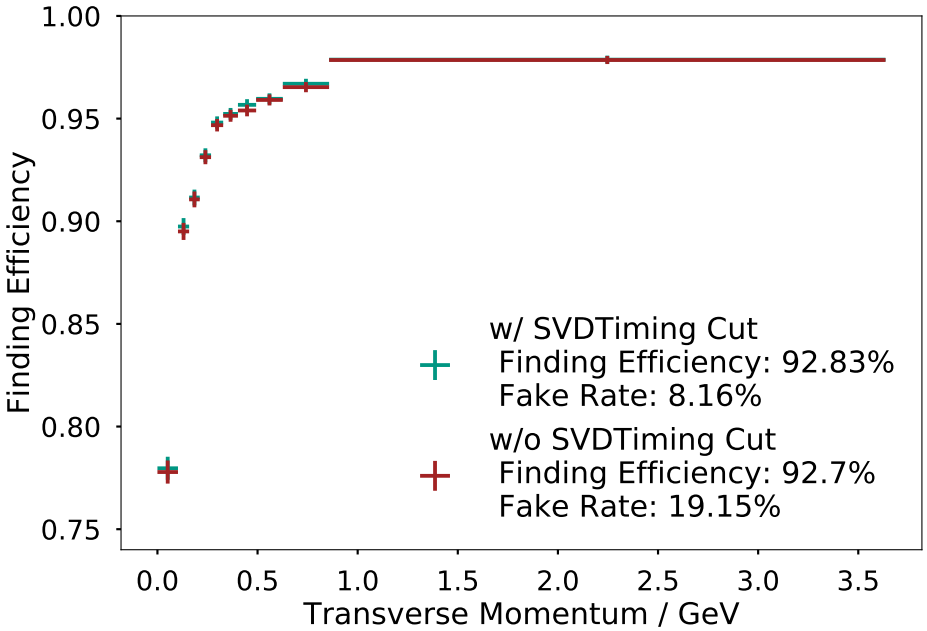


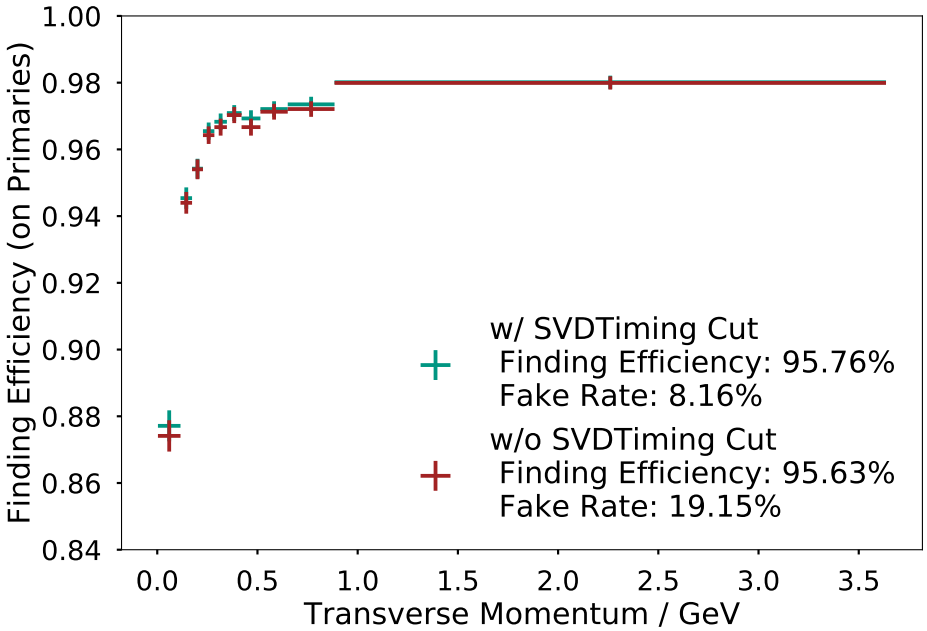
Effect of the SVD Timing Cut



Effect of the SVD Timing Cut

Conclusion





SVD Timing Cut:

- ⇒ **Reduces Fakes while improving the Efficiency!**
- ⇒ **Reduces combinatorics, and thus memory footprint of VXDTF2.**

Remaining Memory Issues

Remaining Memory Issues

Validation run for pre-release 01-00-00b

- 100 jobs, 10k events for each type
- TrackFinderCellOMat exceeds memory limit in several Bhabha jobs

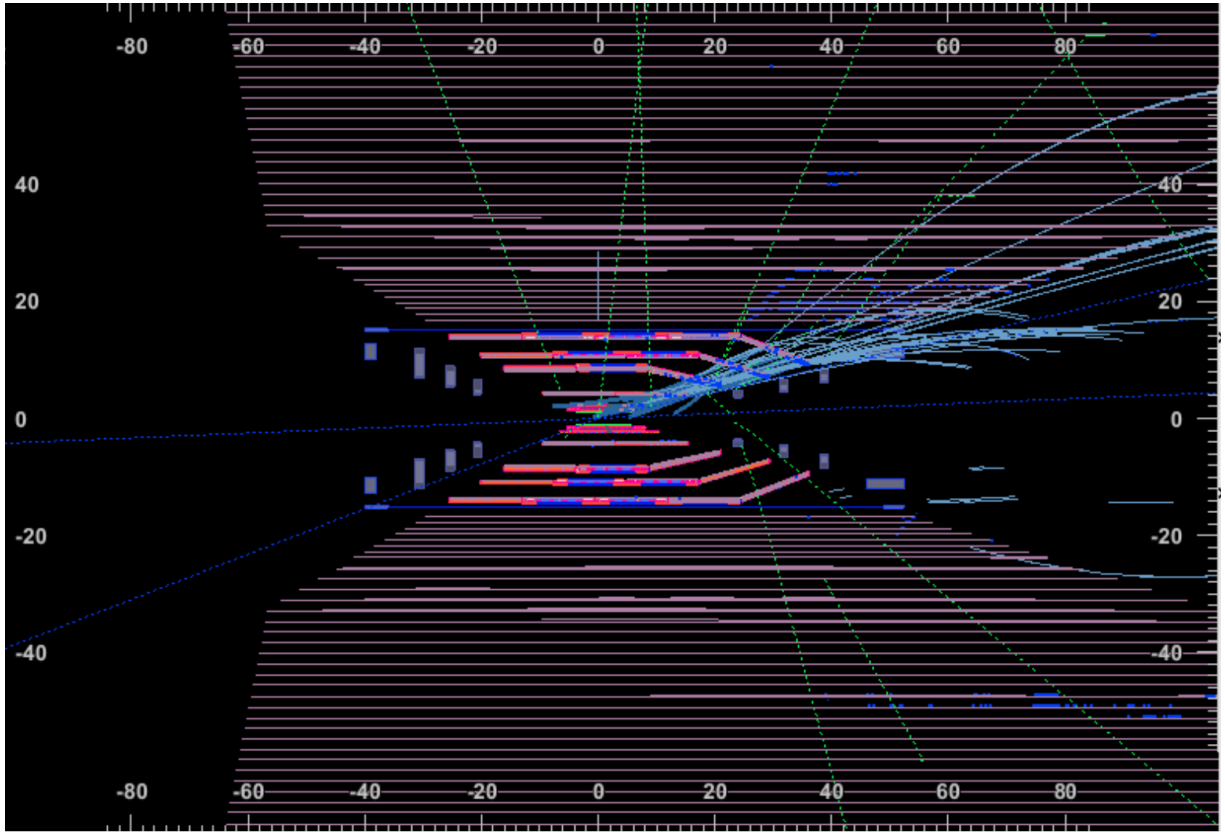
Name	Calls	Memory(MB)	Time(s)	Time(ms)/Call
EventInfoSetter	10001	0	0.11	0.01 +- 0.00
BabayagaNLOInput	10000	11	37.53	3.75 +- 4.29
BGOverlayInput	10000	-18	79.18	7.92 +- 29.13
Gearbox	10000	0	0.04	0.00 +- 0.00
Geometry	10000	0	0.04	0.00 +- 0.00
FullSim	10000	-15	8256.26	825.63 +- 298.95
SVDDigitizer	10000	-0	102.74	10.27 +- 7.52
CDCDigitizer	10000	0	39.85	3.98 +- 3.01
PXDDigitizer	10000	-0	7.20	0.72 +- 1.02
TOPDigitizer	10000	0	5.63	0.56 +- 0.43
ARICHDigitizer	10000	0	0.47	0.05 +- 0.04
ECLDigitizer	10000	0	139.30	13.93 +- 2.24
BKLMDigitizer	10000	0	0.19	0.02 +- 0.04
EKLMDigitizer	10000	0	0.39	0.04 +- 0.09
BGOverlayExecutor	10000	1	14.46	1.45 +- 1.11
PXDDigitSorter	10000	2	122.89	12.29 +- 1.73
SVDShaperDigitSorter	10000	0	5.91	0.59 +- 0.27
__ROISVDCoGTimeEstimator	10000	0	8.21	0.82 +- 0.26
__ROISVDSimpleClusterizer	10000	0	15.77	1.58 +- 0.47
SetupGenfitExtrapolationForPXDDataReduction	10000	0	0.04	0.00 +- 0.00
SVDSpacePointCreator__ROI	10000	0	15.82	1.58 +- 1.28
SectorMapBootstrap	10000	0	0.04	0.00 +- 0.00
SegmentNetworkProducer	10000	85	187.87	18.79 +- 230.64
TrackFinderVXDCellOMat	10000	2484	359.20	35.92 +-1132.97
AddVXDTrackCandidateSubSets	10000	0	2.32	0.23 +- 18.82
QualityEstimatorVXD	10000	0	1.22	0.12 +- 0.31
BestVXDTrackCandidatesSelector	10000	0	0.08	0.01 +- 0.04
SPTCvirtualIPRemover	10000	0	0.12	0.01 +- 0.02
SVDOverlapResolver	10000	0	14.67	1.47 +- 3.81

Remaining Memory Issues

Events with high memory consumption:

- large particle showers in slanted sensors,
- seem to be caused by Bhabha scattering products, **not by Background…**

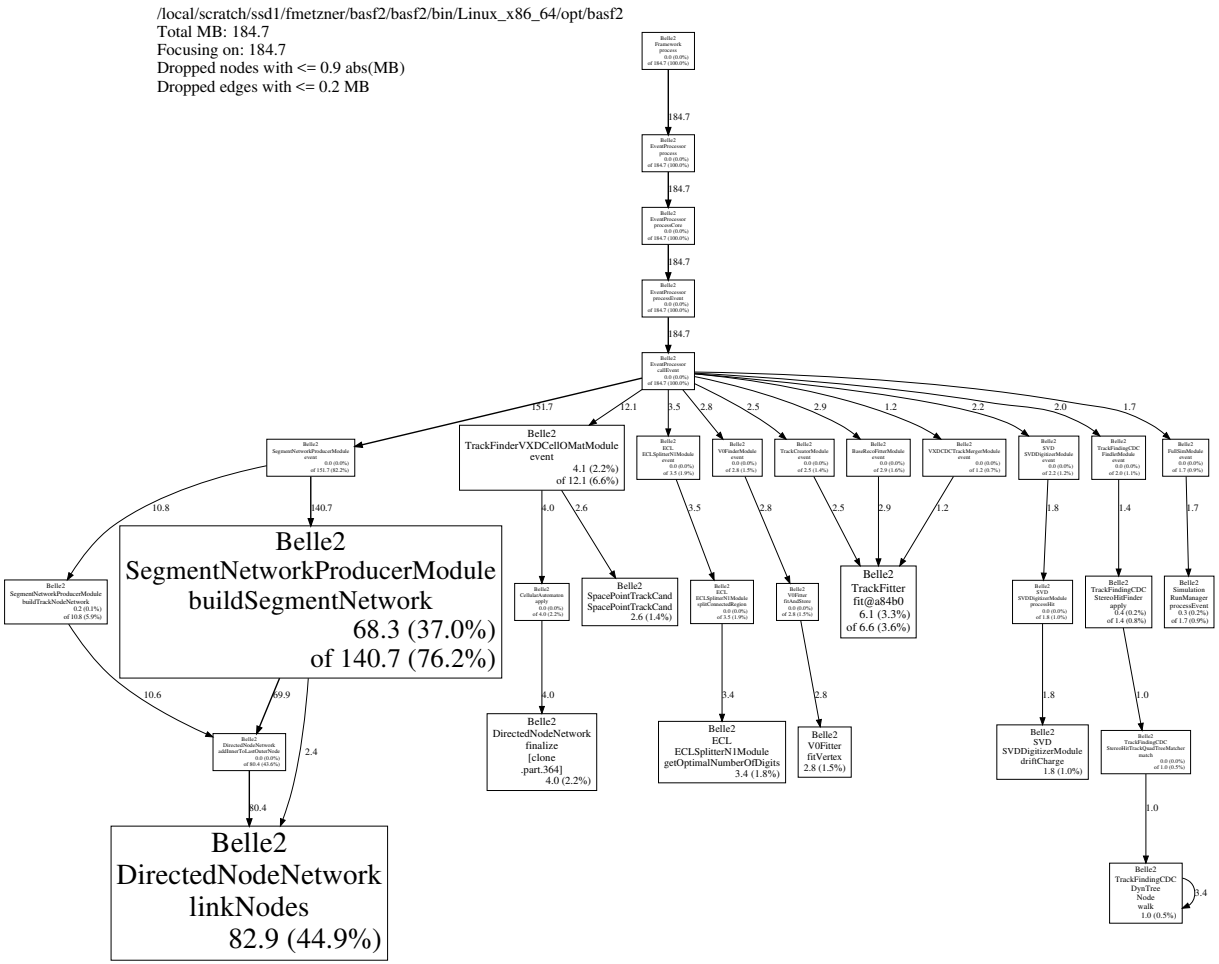
Name	Calls	Memory(MB)	Time(s)	Time(ms)/Call
EventInfoSetter	10001	0	0.11	0.01 +- 0.00
BabayagaNLOInput	10000	11	37.53	3.75 +- 4.29
BGOverlayInput	10000	-18	79.18	7.92 +- 29.13
Gearbox	10000	0	0.04	0.00 +- 0.00
Geometry	10000	0	0.04	0.00 +- 0.00
FullSim	10000	-15	8256.26	825.63 +- 298.95
SVDDigitizer	10000	-0	102.74	10.27 +- 7.52
CDCDigitizer	10000	0	39.85	3.98 +- 3.01
PXDDigitizer	10000	-0	7.26	0.72 +- 1.02
TOPDigitizer	10000	0	5.63	0.56 +- 0.43
ARICHDigitizer	10000	0	0.47	0.05 +- 0.04
ECLDigitizer	10000	0	139.36	13.93 +- 2.24
BKLMDigitizer	10000	0	0.19	0.02 +- 0.04
EKLMDigitizer	10000	0	0.39	0.04 +- 0.09
BGOverlayExecutor	10000	1	14.46	1.45 +- 1.11
PXDDigitSorter	10000	2	122.89	12.29 +- 1.73
SVDShaperDigitSorter	10000	0	5.91	0.59 +- 0.27
__ROISVDCoGTimeEstimator	10000	0	8.21	0.82 +- 0.26
__ROISVDSimpleClusterizer	10000	0	15.77	1.58 +- 0.47
SetupGenfitExtrapolationForPXDDataReduction	10000	0	0.04	0.00 +- 0.00
SVDSpacePointCreator__ROI	10000	0	15.82	1.58 +- 1.28
SectorMapBootstrap	10000	0	0.04	0.00 +- 0.00
SegmentNetworkProducer	10000	85	187.87	18.79 +- 230.64
TrackFinderVXDCellOMat	10000	2484	359.28	35.92 +-1132.97
AddVXDTrackCandidateSubSets	10000	0	2.32	0.23 +- 18.82
QualityEstimatorVXD	10000	0	1.22	0.12 +- 0.31
BestVXDTrackCandidatesSelector	10000	0	0.08	0.01 +- 0.04
SPTCvirtualIPRemover	10000	0	0.12	0.01 +- 0.02
SVDOverlapResolver	10000	0	14.67	1.47 +- 3.01



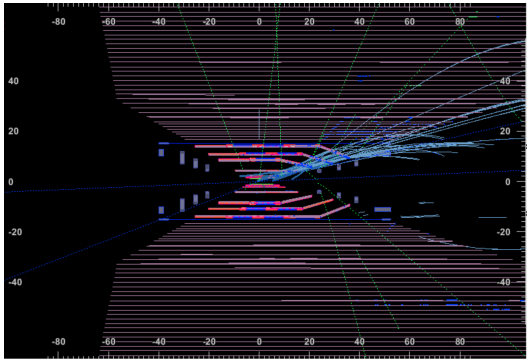
Remaining Memory Issues

First evaluations with **jemalloc**:

- SegmentNetworkProducer causes issues?
- however, overall memory does not fit. . .



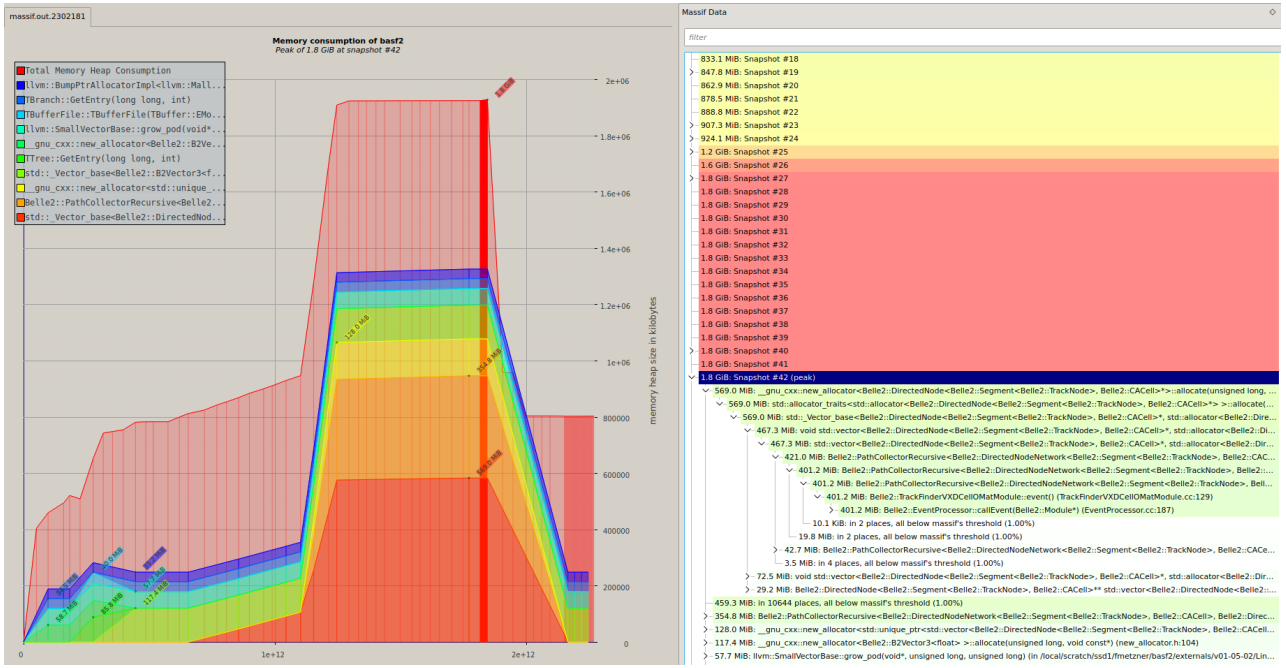
Name	Calls	Memory(MB)	Time(s)	Time(ns)/Call
EventInfoSetter	10001	0	8.11	0.01 +- 0.00
BabayagaNLOInput	10000	11	37.53	3.75 +- 4.29
BGOverlayInput	10000	-10	79.58	7.92 +- 29.13
Gearbox	10000	0	8.04	0.00 +- 0.00
Geometry	10000	0	8.04	0.00 +- 0.00
FullSim	10000	-15	8256.26	825.63 +- 298.95
SVDDigitizer	10000	-0	102.74	10.27 +- 7.52
CDCDigitizer	10000	0	39.85	3.98 +- 3.01
PXDDigitizer	10000	-0	7.20	0.72 +- 1.82
TOPDigitizer	10000	0	5.63	0.56 +- 0.43
ARICHDigitizer	10000	0	0.47	0.05 +- 0.04
ECLDigitizer	10000	0	139.30	13.93 +- 2.24
BKLMDigitizer	10000	0	0.19	0.02 +- 0.04
EKLMDigitizer	10000	0	0.39	0.04 +- 0.09
BGOverlayExecutor	10000	1	14.46	1.45 +- 1.11
PXDDigitSorter	10000	2	122.89	12.29 +- 1.73
SVDShaperDigitSorter	10000	0	5.91	0.59 +- 0.27
__ROISVDCoGTimeEstimator	10000	0	8.21	0.82 +- 0.26
__ROISVDSimpleClusterizer	10000	0	15.77	1.58 +- 0.47
SetupGenfitExtrapolationForPXDDataReduction	10000	0	0.04	0.00 +- 0.00
SVDSpacePointCreator__ROI	10000	0	15.82	1.58 +- 1.28
SectorMapBootstrap	10000	0	0.04	0.00 +- 0.00
SegmentNetworkProducer	10000	85	187.87	18.79 +- 230.64
TrackFinderVXDCellOMat	10000	2484	359.20	35.92 +-1132.97
AddVXDTrackCandidateSubSets	10000	0	2.32	0.23 +- 18.82
QualityEstimatorVXD	10000	0	1.22	0.12 +- 0.31
BestVXDTrackCandidatesSelector	10000	0	0.08	0.01 +- 0.04
SPTCVirtualIPRemover	10000	0	0.12	0.01 +- 0.02
SVDOverlapResolver	10000	0	14.67	1.47 +- 3.81



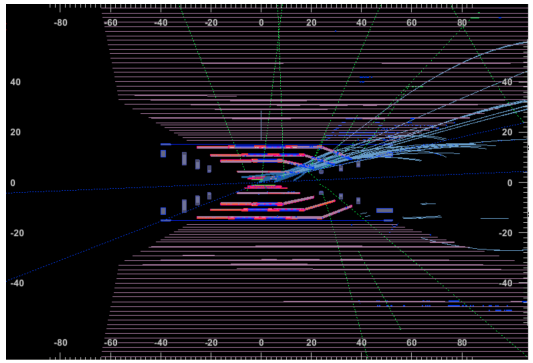
Remaining Memory Issues

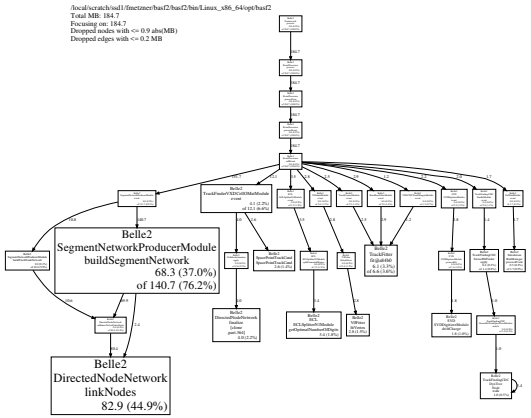
Further tests using **valgrind's massif**

⇒ PathFinderRecursive in CellOMat is the cause!

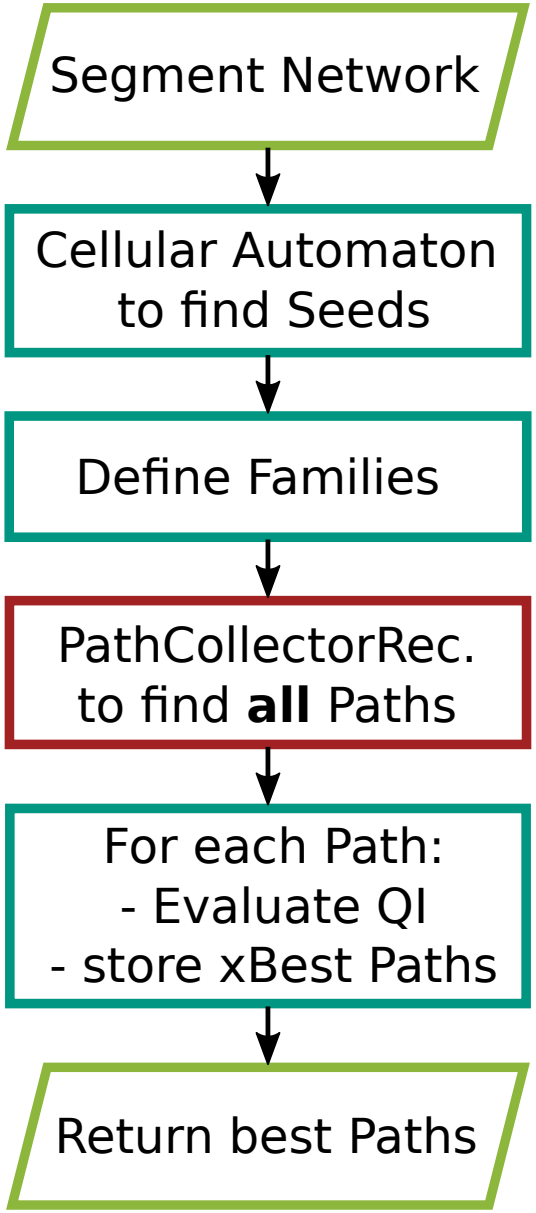


Name	Calls	Memory(MB)	Time(s)	Time(ms)/Call
EventInfoSetter	10001	0	0.11	0.01 +- 0.00
BabayagaNLOInput	10000	11	37.53	3.75 +- 4.29
BGOverlayInput	10000	-18	79.18	7.92 +- 29.13
Gearbox	10000	0	0.04	0.00 +- 0.00
Geometry	10000	0	0.04	0.00 +- 0.00
FullSim	10000	-15	8256.26	825.63 +- 298.95
SVDDigitizer	10000	-0	102.74	10.27 +- 7.52
CDCDigitizer	10000	0	39.85	3.98 +- 3.01
PXDDigitizer	10000	-0	7.28	0.72 +- 1.02
TOPDigitizer	10000	0	5.63	0.56 +- 0.43
ARICHDigitizer	10000	0	0.47	0.05 +- 0.04
ECLDigitizer	10000	0	139.30	13.93 +- 2.24
BKLMDigitizer	10000	0	0.19	0.02 +- 0.04
EKLMDigitizer	10000	0	0.39	0.04 +- 0.09
BGOverlayExecutor	10000	1	14.46	1.45 +- 1.11
PXDDigitSorter	10000	2	122.89	12.29 +- 1.73
SVDShaperDigitSorter	10000	0	5.91	0.59 +- 0.27
__ROISVDCGTimeEstimator	10000	0	8.21	0.82 +- 0.26
__ROISVDSimpleClusterizer	10000	0	15.77	1.58 +- 0.47
SetupGenfitExtrapolationForPXDDataReduction	10000	0	0.04	0.00 +- 0.00
SVDSpacePointCreator__ROI	10000	0	15.82	1.58 +- 1.28
SectorMapBootstrap	10000	0	0.04	0.00 +- 0.00
SegmentNetworkProducer	10000	85	187.87	18.79 +- 230.64
TrackFinderVXDCellOMat	10000	2484	359.20	35.92 +-1132.97
AddVXDTrackCandidateSubSets	10000	0	2.32	0.23 +- 18.02
QualityEstimatorVXD	10000	0	1.22	0.12 +- 0.31
BestVXDTrackCandidatesSelector	10000	0	0.08	0.01 +- 0.04
SPTCvirtualIPRemover	10000	0	0.12	0.01 +- 0.02
SVDOverlapResolver	10000	0	14.67	1.47 +- 3.81





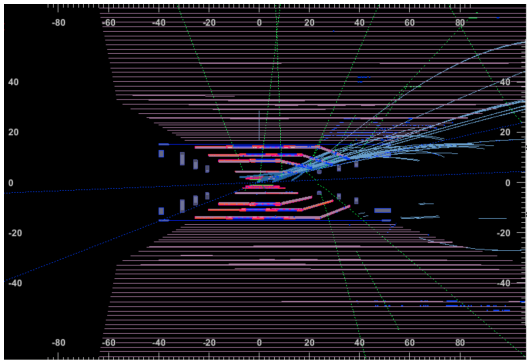
Remaining Memory Issues

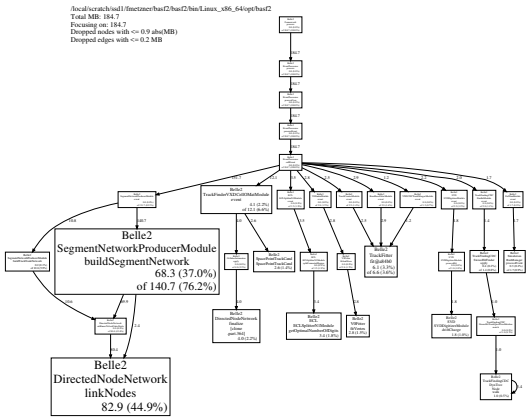


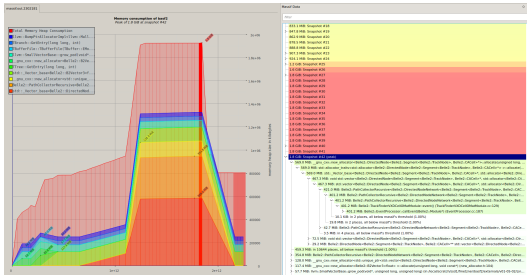
Size for Freak Event 251461

17121110 Calls returning 15626720 Paths

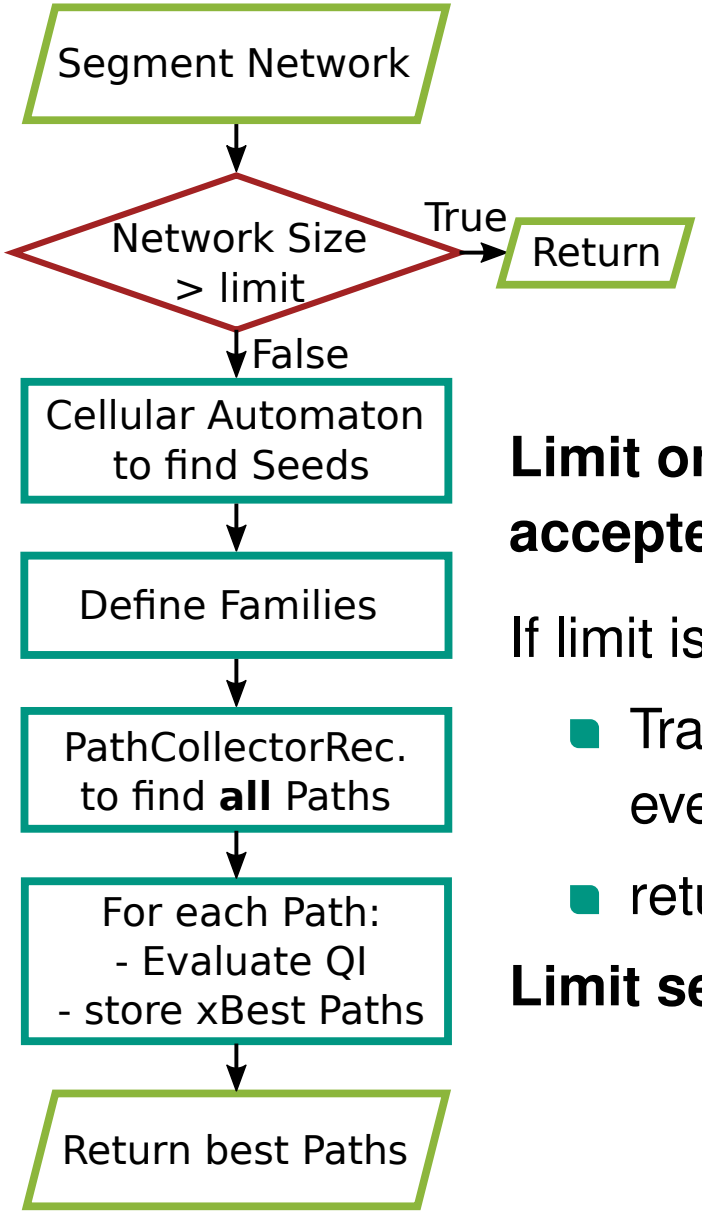
Name	Calls	Memory(MB)	Time(s)	Time(ms)/Call
EventInfoSetter	10001	0	0.11	0.01 +- 0.00
BabayagaNLOInput	10000	11	37.53	3.75 +- 4.29
BGOverlayInput	10000	-18	79.18	7.92 +- 29.13
Gearbox	10000	0	0.04	0.00 +- 0.00
Geometry	10000	0	0.04	0.00 +- 0.00
FullSim	10000	-15	8256.26	825.63 +- 298.95
SVDDigitizer	10000	-0	102.74	10.27 +- 7.52
CDCDigitizer	10000	0	39.85	3.98 +- 3.01
PXDDigitizer	10000	-0	7.28	0.72 +- 1.02
TOPDigitizer	10000	0	5.63	0.56 +- 0.43
ARICHDigitizer	10000	0	0.47	0.05 +- 0.04
ECLDigitizer	10000	0	139.30	13.93 +- 2.24
BKLMDigitizer	10000	0	0.10	0.02 +- 0.04
EKLMDigitizer	10000	0	0.39	0.04 +- 0.09
BGOverlayExecutor	10000	1	14.46	1.45 +- 1.11
PXDDigitSorter	10000	2	122.89	12.29 +- 1.73
SVDShaperDigitSorter	10000	0	5.91	0.59 +- 0.27
__ROISVDCoGTimeEstimator	10000	0	8.21	0.82 +- 0.26
__ROISVDSimpleClusterizer	10000	0	15.77	1.58 +- 0.47
SetupGenfitExtrapolationForPXDDataReduction	10000	0	0.04	0.00 +- 0.00
SVDSpacePointCreator__ROI	10000	0	15.82	1.58 +- 1.28
SectorMapBootstrap	10000	0	0.04	0.00 +- 0.00
SegmentNetworkProducer	10000	85	187.87	18.79 +- 230.64
TrackFinderVXDCellOMat	10000	2484	359.20	35.92 +-1332.97
AddVXDTrackCandidateSubSets	10000	0	2.32	0.23 +- 18.02
QualityEstimatorVXD	10000	0	1.22	0.12 +- 0.31
BestVXDTrackCandidatesSelector	10000	0	0.08	0.01 +- 0.04
SPTCvirtualIPRemover	10000	0	0.12	0.01 +- 0.02
SVDOverlapResolver	10000	0	14.67	1.47 +- 3.81







Remaining Memory Issues

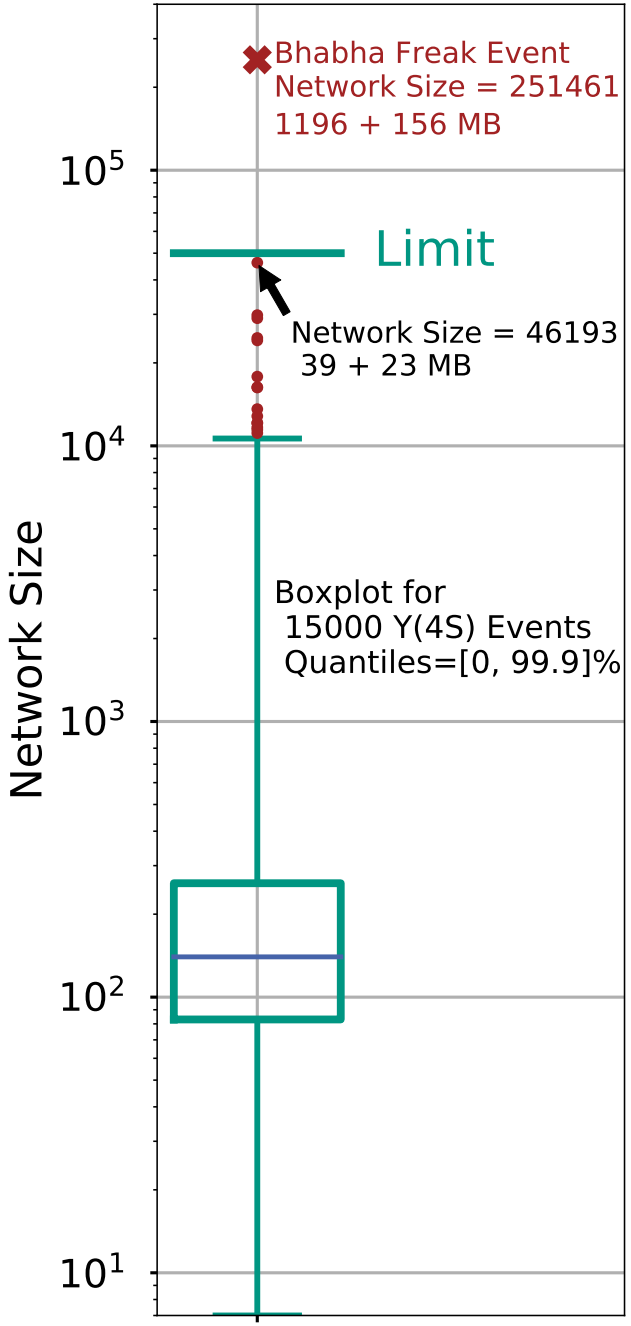


Limit on network size accepted by TrackFinder.

If limit is exceeded:

- TrackFinder skips event,
- returning 0 SPTCs.

Limit set to 50 000.



Vertex Resolution with the Current Setup

Vertex Resolution with the Current Setup

***z*–Coordinate Resolution of Vertex with 4-Layer Tracking + CKF**

- Evaluated on 10 000 B→JΨ K^0_S Events with Bkg Campaign 16
- Vertex fit with Rave
- Resolution calculated only on correctly reconstructed B-Mesons

Resolution calculated with RMS_{90}

$$\mathrm{RMS}_{90} = \frac{1}{n}\sum_i^n z^2_{\mathrm{Res}\ i} \quad \text{and} \quad \sigma_{90} = \frac{\mathrm{RMS}_{90}}{0.79}$$

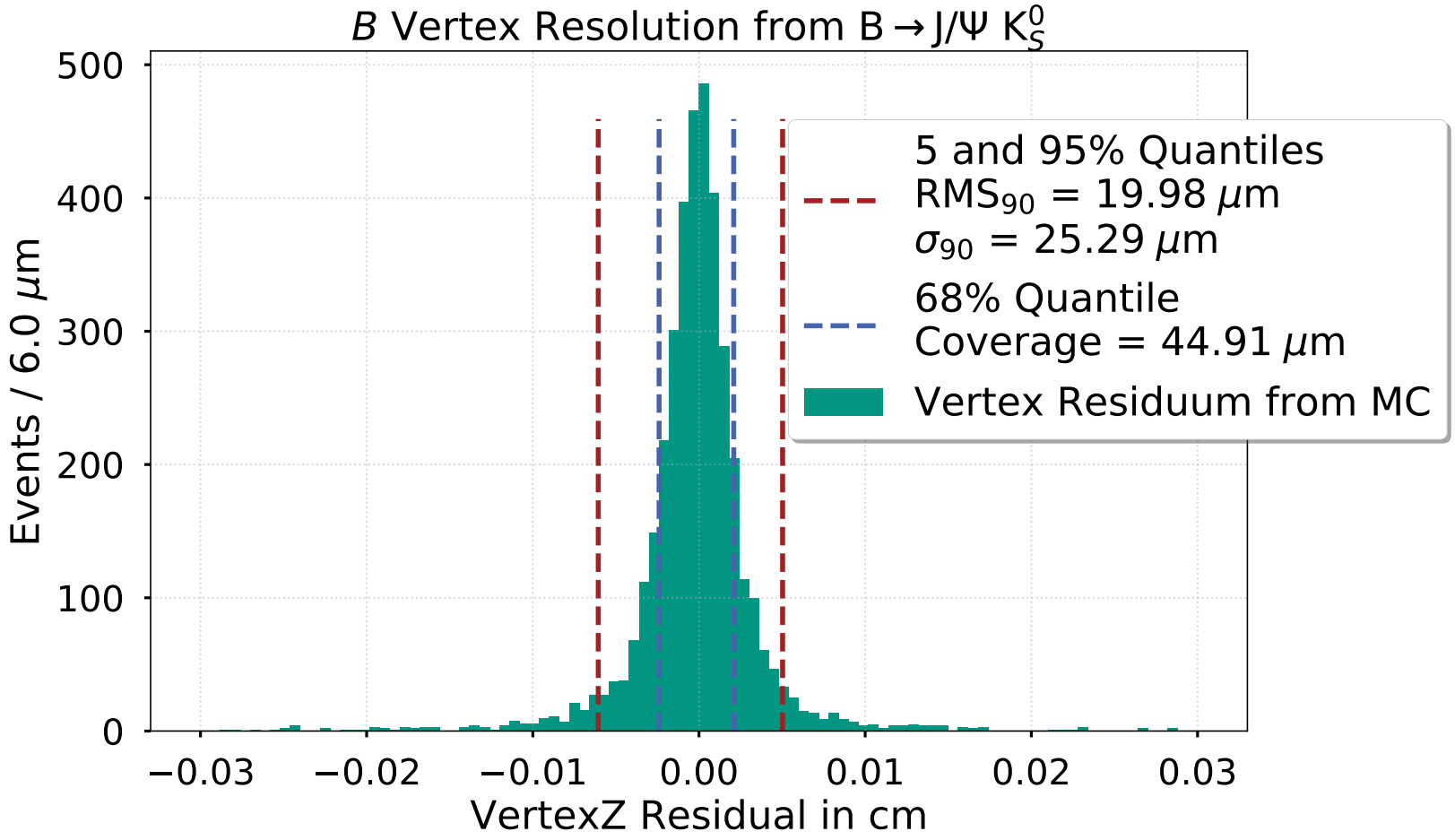
with $z_{\mathrm{Res}\ i} = z_{\mathrm{PR}\ i} - z_{\mathrm{True}\ i}$
and for i with $z_{\mathrm{Res}\ i}$ in 90%-Quantile

Resolution calculated with 68% Quantile Coverage

$$\text{Coverage} = z_{\mathrm{Res}\ 84\%} - z_{\mathrm{Res}\ 16\%}$$

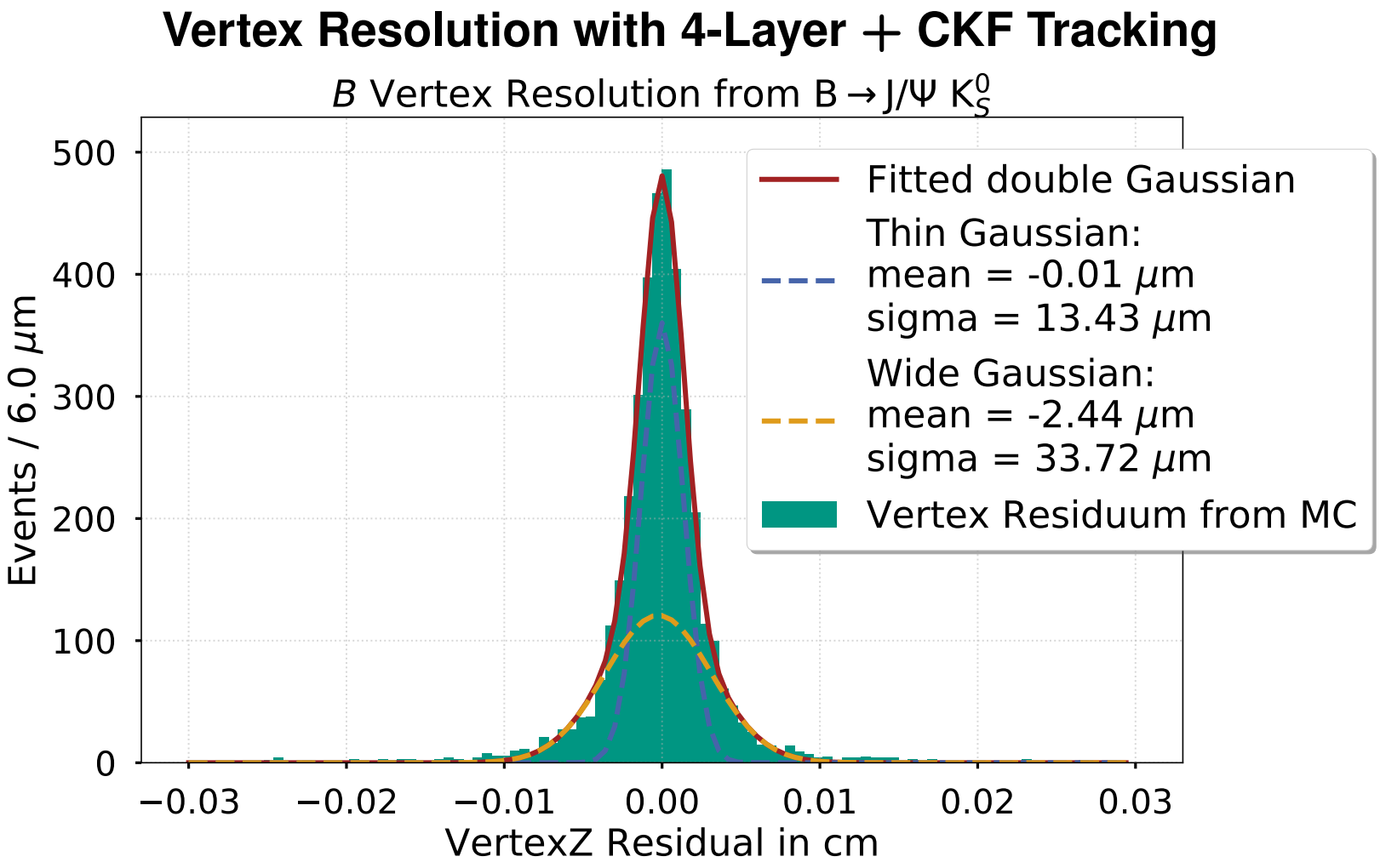
Vertex Resolution with the Current Setup

Vertex Resolution with 4-Layer + CKF Tracking



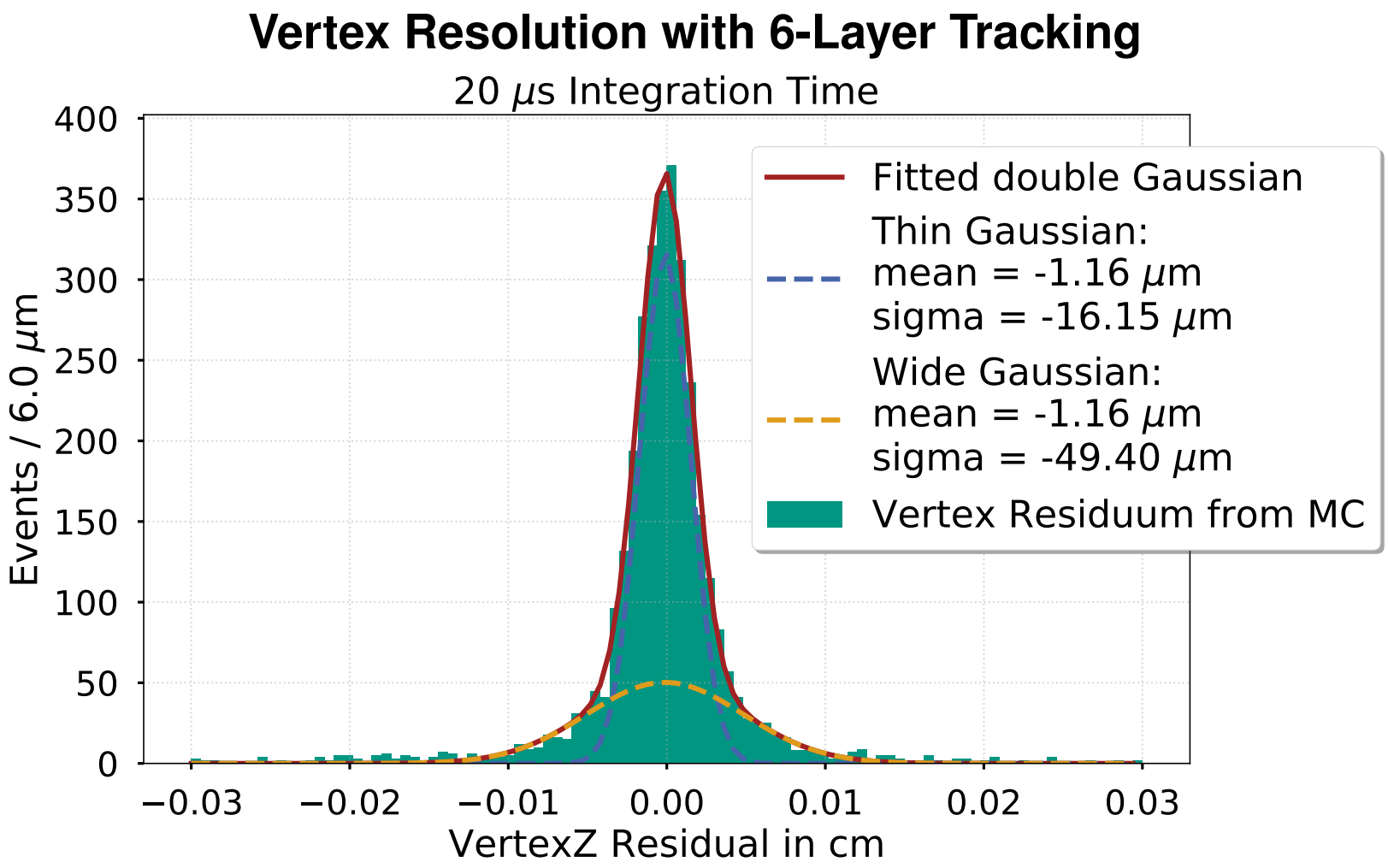
Vertex Resolution with the Current Setup

The old evaluation technique for comparison:



Vertex Resolution with the Current Setup

The old evaluation technique for comparison:



Vertex Resolution with the Current Setup

Conclusion

Vertexing performance with **4-Layer + CKF Tracking** at least as good as with **6-Layer Tracking**.

- unfortunatelly no thorough comparison due to data loss...
- many other changes have been made

Vertexing evaluation can be included into the **Validation**.