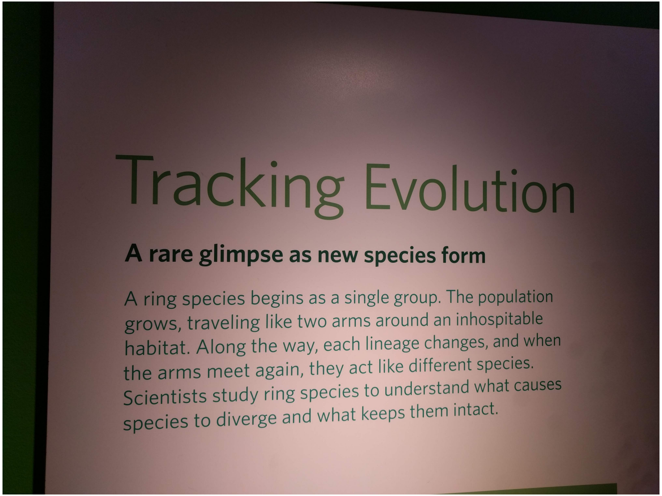
why, what, how

TRACKING AT BELLE II

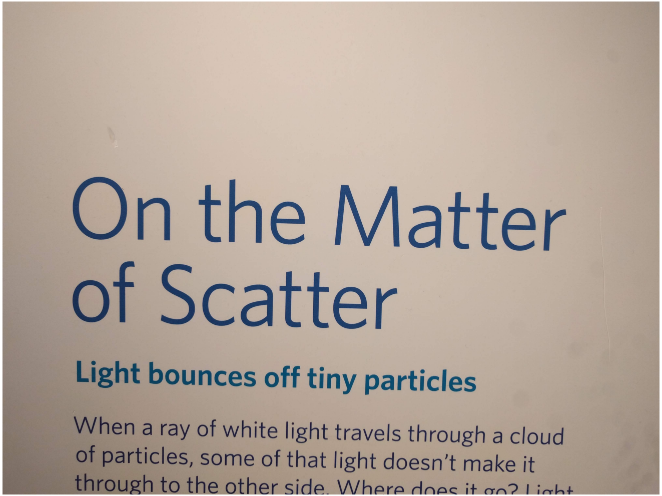
2019, January 17th

Nils Braun | IETP - KIT

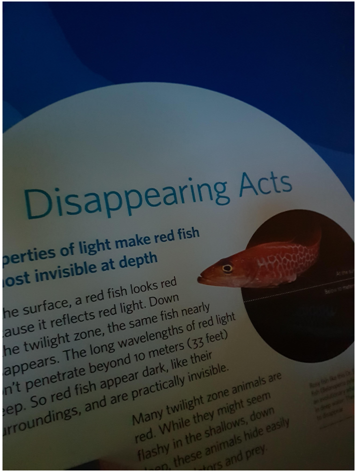
TRACKING IN BERKELEY



TRACKING IN BERKELEY



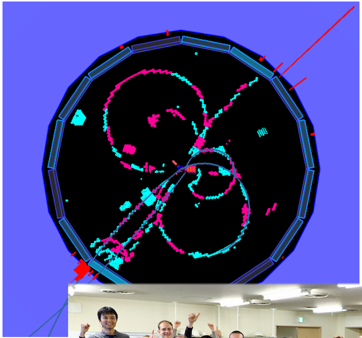
TRACKING IN BERKELEY

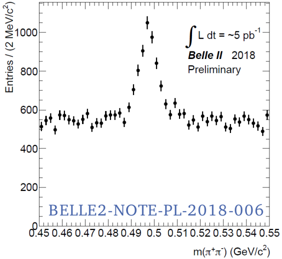


1.

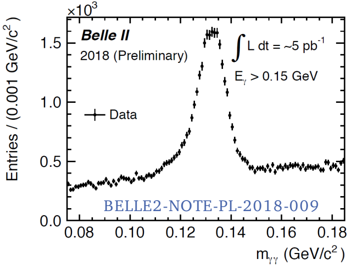
WHY IS BELLE II INTERESTING?

BELLE II IN THE NEWS

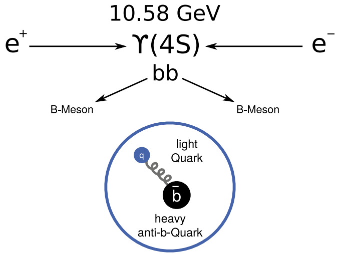


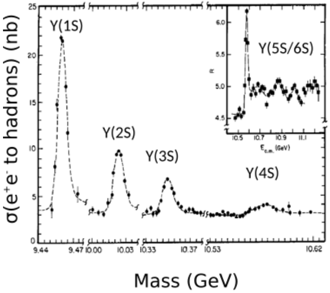


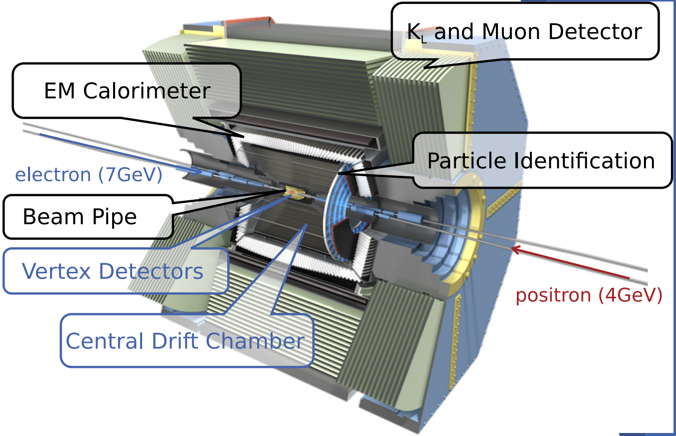
two weeks after first collisions



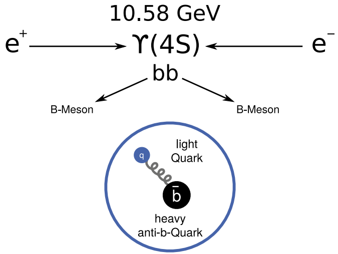
INTRODUCTION TO BELLE II

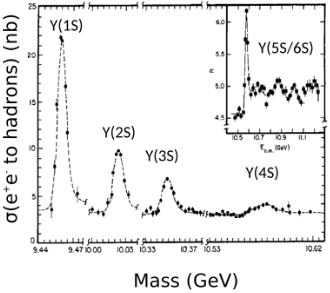


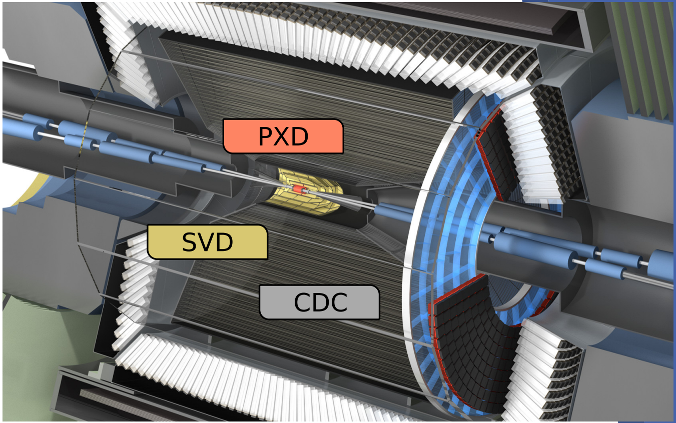




INTRODUCTION TO BELLE II

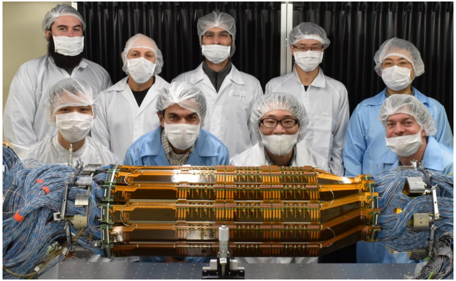


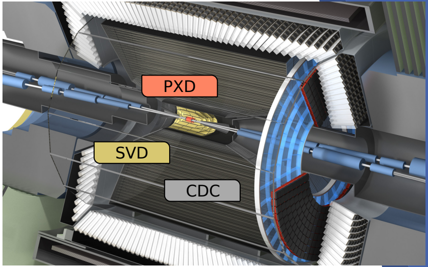




VERTEX DETECTORS

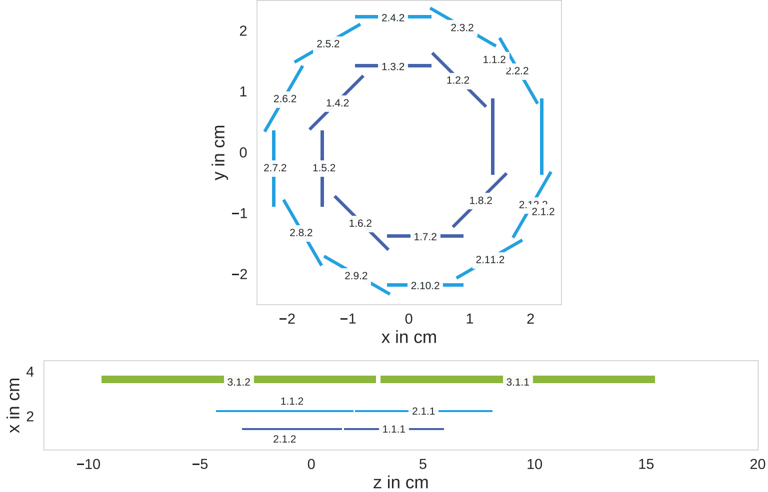
- 2 layers of DEPFET pixel sensors (PXD)
- 4 layers of double-sided silicon strip sensors (SVD)



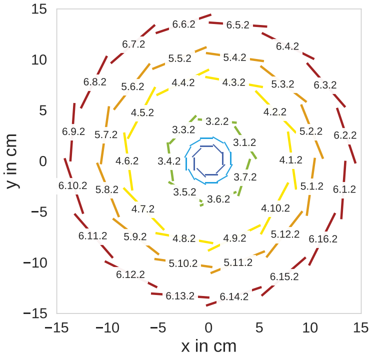


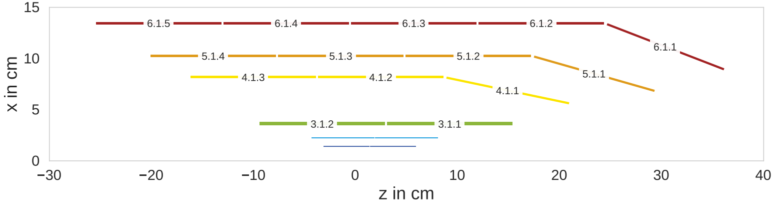
	Acceptance in θ	$17^\circ - 150^\circ$
PXD	Layer Radii	14, 22 mm
	Channels	7,680,000 Pixles
SVD	Layer Radii	38, 80, 104, 135 mm
	Channels	224,000 Strips

VERTEX DETECTOR: PXD



VERTEX DETECTOR: SVD

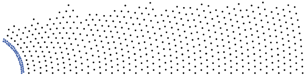




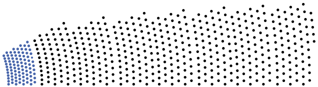
CENTRAL DRIFT CHAMBER

magnetic field	1.5 T
gas mixture	helium, ethane
radius	160 mm – 1130 mm
acceptance	17° – 150°
layers	56
stereo and axial wires	14336
radiation length	680 m

Belle

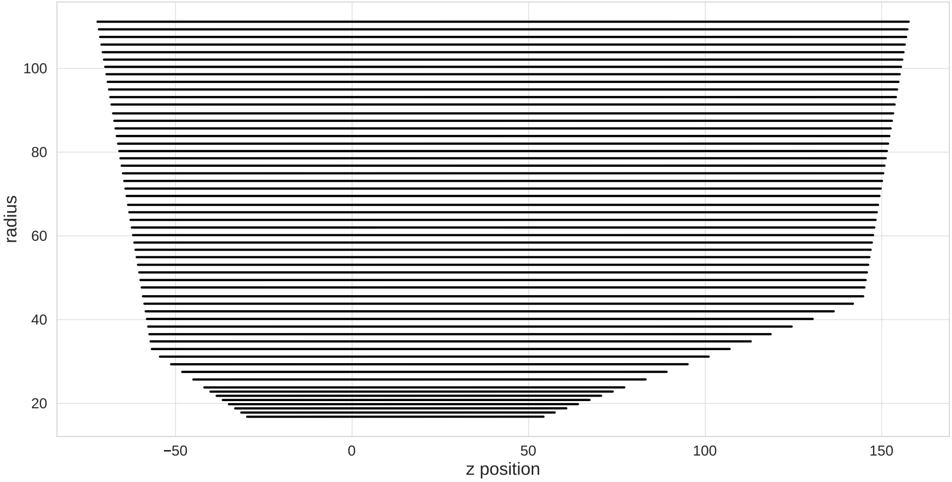


Belle II

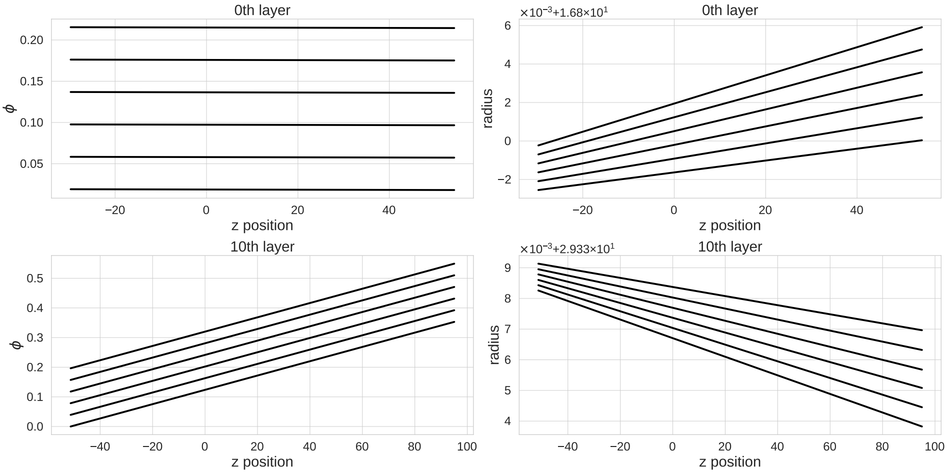


October 2016: CDC Installation

CDC



CDC

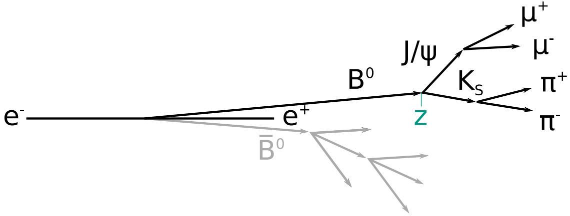

0th layer
0.20
0.15
0.10
0.05
ϕ
−20
0
20
40
z position
0th layer
×10⁻³+1.68×10¹
6
4
2
0
−2
radius
−20
0
20
40
z position
10th layer
0.5
0.4
0.3
0.2
0.1
0.0
ϕ
−40
−20
0
20
40
60
80
100
z position
10th layer
×10⁻³+2.933×10¹
9
8
7
6
5
4
radius
−40
−20
0
20
40
60
80
100
z position

2.

WHAT DO WE WANT TO TRACK?

THE CHALLENGES OF TRACKING AT BELLE II

On average 11 tracks per event...
We want all of those, but not a single fake!

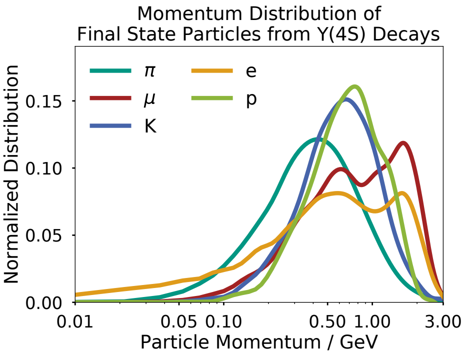


THE CHALLENGES OF TRACKING AT BELLE II

On average 11 tracks per event…
We want all of those, but not a single fake!

Low momentum particles

- Non-negligible fraction
- Multiple scattering

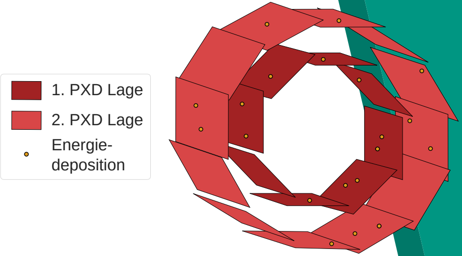


THE CHALLENGES OF TRACKING AT BELLE II

On average 11 tracks per event...
We want all of those, but not a single fake!

Low momentum particles

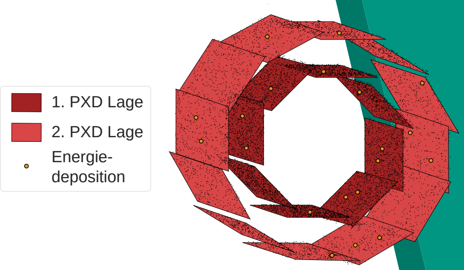
- Non-negligible fraction
- Multiple scattering



- Synchrotron radiation
- Touschek scattering
- Beam-gas scattering
- Radiative Bhabha scattering
- e^+e^- pair production

THE CHALLENGES OF TRACKING AT BELLE II

On average 11 tracks per event...
We want all of those, but not a single fake!



Low momentum particles

- Non-negligible fraction
- Multiple scattering

Beam-induced background High occupancy due to background hits:

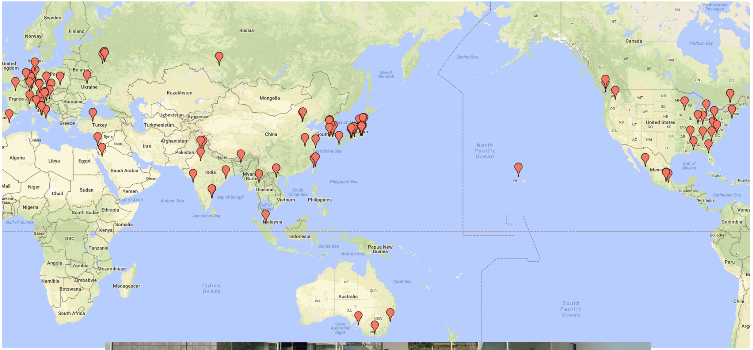
11 tracks $\rightarrow$ 10^2 signal hits
vs. 10^4 background hits

- Synchrotron radiation
- Touschek scattering
- Beam-gas scattering
- Radiative Bhabha scattering
- e^+e^- pair production

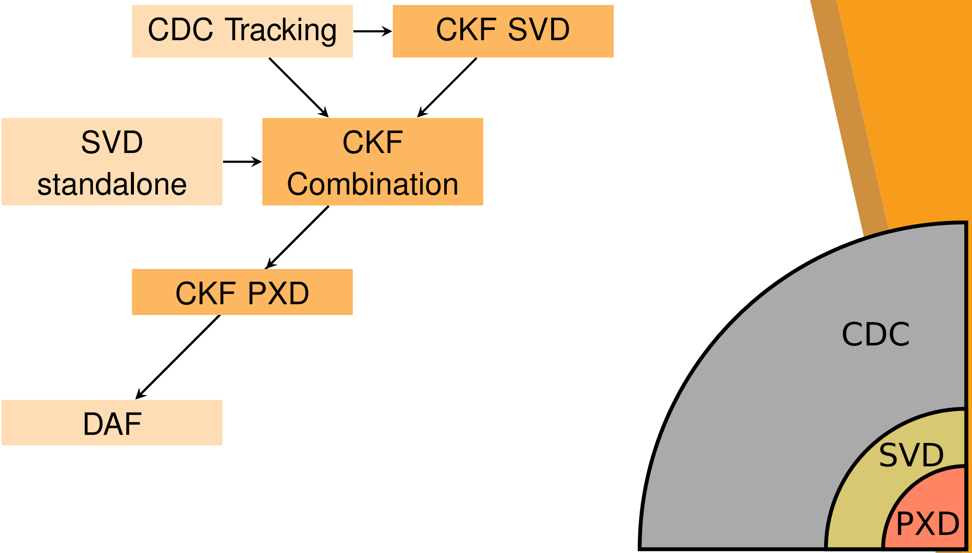
3.

HOW DO WE DO THIS?

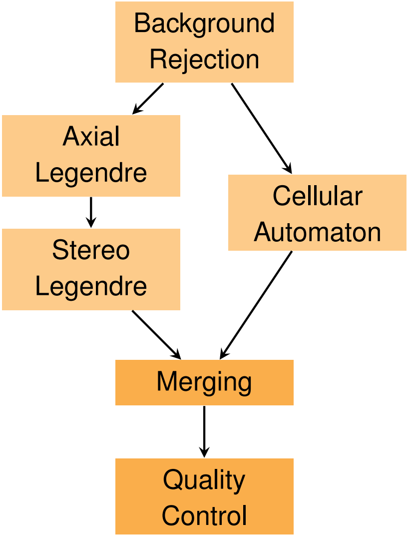
WHO IS WE?



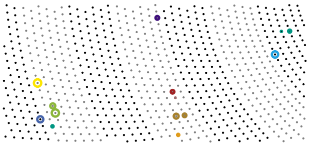
Belle II collaboration: ≈ 800 members, ≈ 30 nations


CDC Tracking
CKF SVD
SVD
standalone
CKF
Combination
CKF PXD
DAF
CDC
SVD
PXD

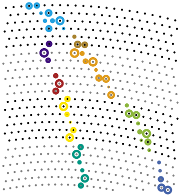
OVERVIEW OF CDC TRACKING



BACKGROUND FILTER



Background

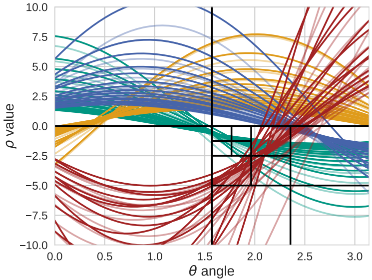


Signal

- using a MVA (FastBDT)
- based on variables from clustered hits
- will be tuned with background-only data from random trigger

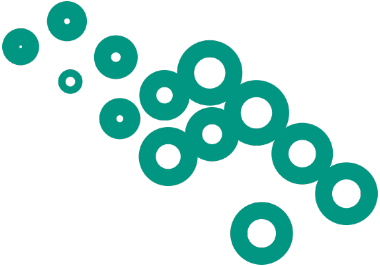
GLOBAL LEGENDRE ALGORITHM

$$\rho_{\pm}(\theta) = x' \cos(\theta) + y' \sin(\theta) \pm d$$



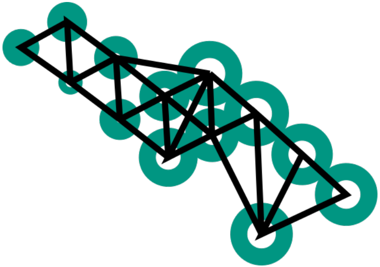
- shifting binary search with re-centering
- ρ dependent maximal level
- multiple passes
- post-processing for curler merging based on fast Riemann fit

LOCAL CELLULAR AUTOMATON



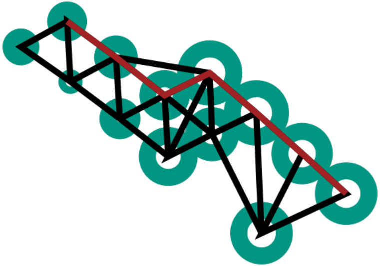
- clusters
- MVA filters or hand crafted features
- hit-bridging
- extension to track finder possible

LOCAL CELLULAR AUTOMATON



- clusters, triplets
- MVA filters or hand crafted features
- hit-bridging
- extension to track finder possible

LOCAL CELLULAR AUTOMATON



- clusters, triplets, segments
- MVA filters or hand crafted features
- hit-bridging
- extension to track finder possible

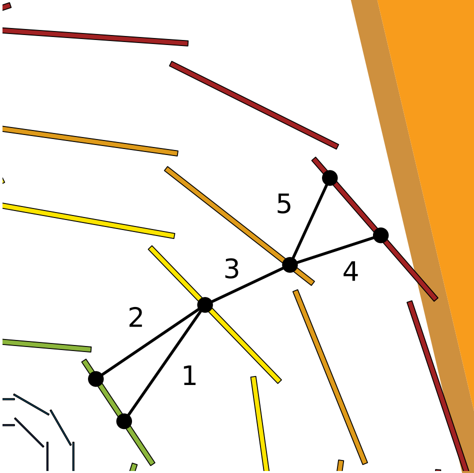
SVD STANDALONE TRACKING

Cellular Automaton collects longest paths beginning with outermost SVD 3D-hits.

Neighboring 3D-hits are given by a set of filters:

- Evaluating duplets and triplets of 3D-hits
- Individual for every sensor
- Learned from simulation

$\Rightarrow$ Reduction of combinatorics
$\Rightarrow$ Allows for multiple scattering



SVD STANDALONE TRACKING

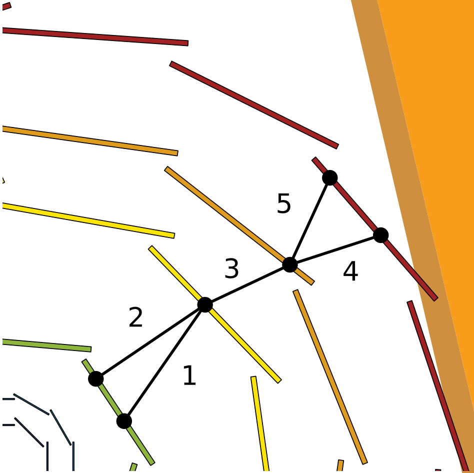
The final set of tracks is chosen from all paths such that no tracks share a SVD hit.

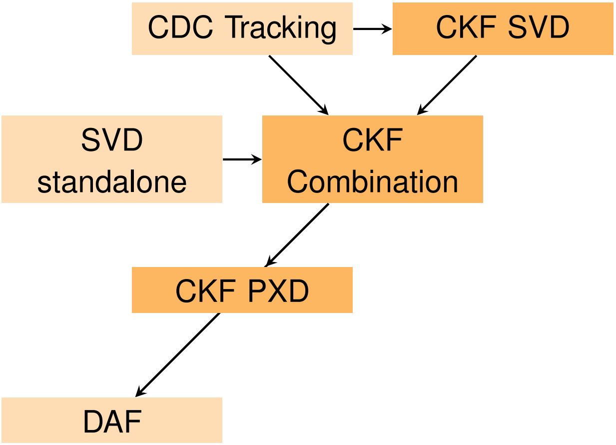
For competing paths a quality estimation is employed:

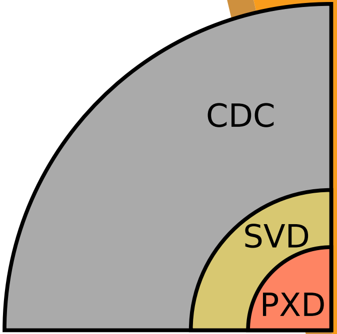
- Based on fitting 3D-hit triplets
  [A. Schöning, arXiv:1408.5536v1]
- Combine fit result with additional detector information via MVA method

⇒ Successful resolution of hit overlaps

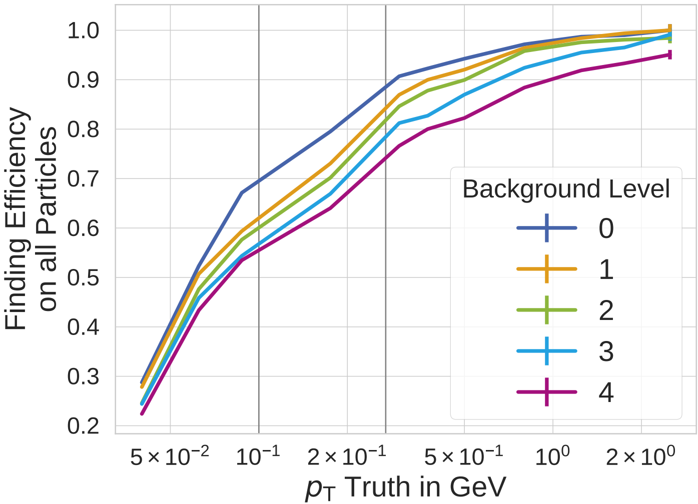
⇒ Discriminator against fake tracks



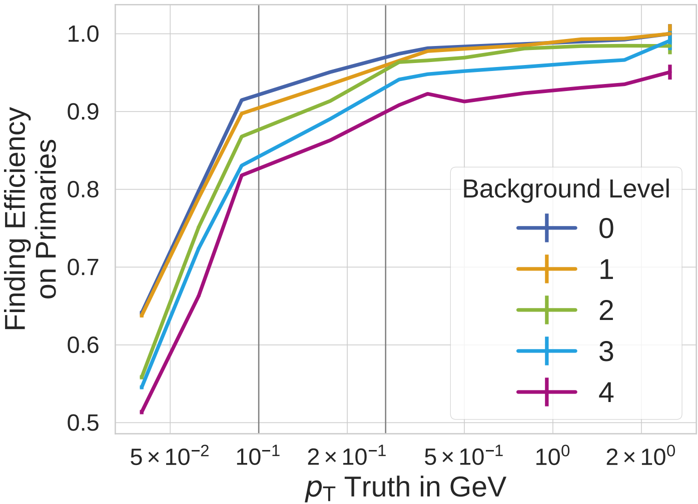

CDC Tracking
CKF SVD
SVD standalone
CKF Combination
CKF PXD
DAF


CDC
SVD
PXD

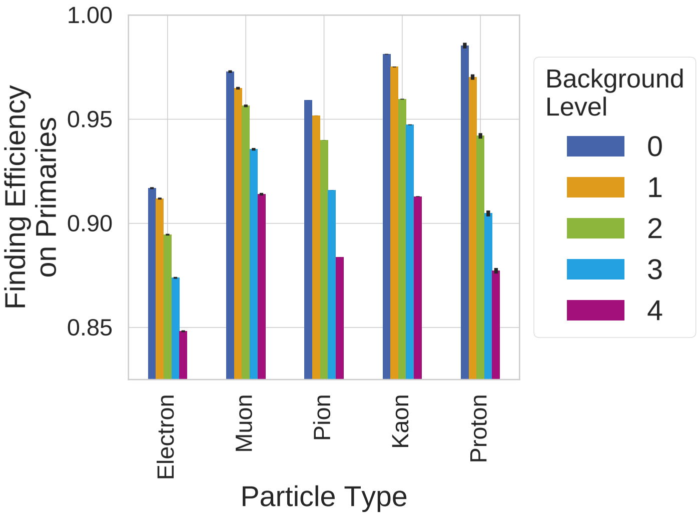
PERFORMANCE



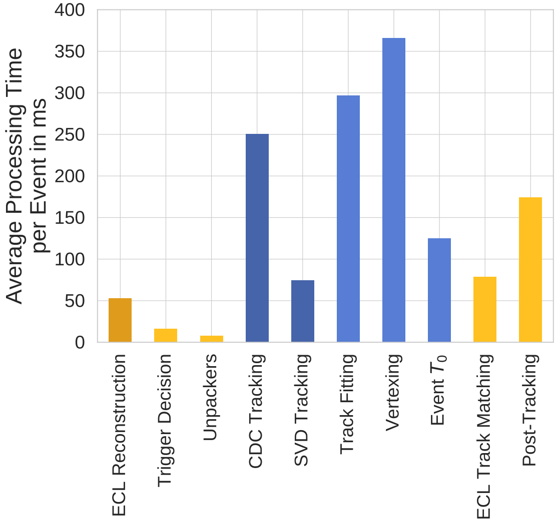
PERFORMANCE



PERFORMANCE



PERFORMANCE



SUMMARY

- What we can give ACTS:
  - Various different tracking and track finding algorithms employed at Belle II.
  - Expertice with low-momentum tracking, drift chambers, non-CERN experiments, github-conveners of GENFIT 2

SUMMARY

- What we can give ACTS:
  - Various different tracking and track finding algorithms employed at Belle II.
  - Expertice with low-momentum tracking, drift chambers, non-CERN experiments, github-conveners of GENFIT 2, Japanese food

SUMMARY

- What we can give ACTS:
  - Various different tracking and track finding algorithms employed at Belle II.
  - Expertice with low-momentum tracking, drift chambers, non-CERN experiments, github-conveners of GENFIT 2, Japanese food
- What we can get from ACTS:
  - Speed. Speed. Speed.
  - Electron hypothesis fit.
  - Contact to the community.