CHEP 2018
23RD INTERNATIONAL CONFERENCE ON COMPUTING IN HIGH ENERGY AND NUCLEAR PHYSICS
9-13 July 2018
National Palace of Culture
Sofia, Bulgaria

Track Fitting for the BELLE II Experiment

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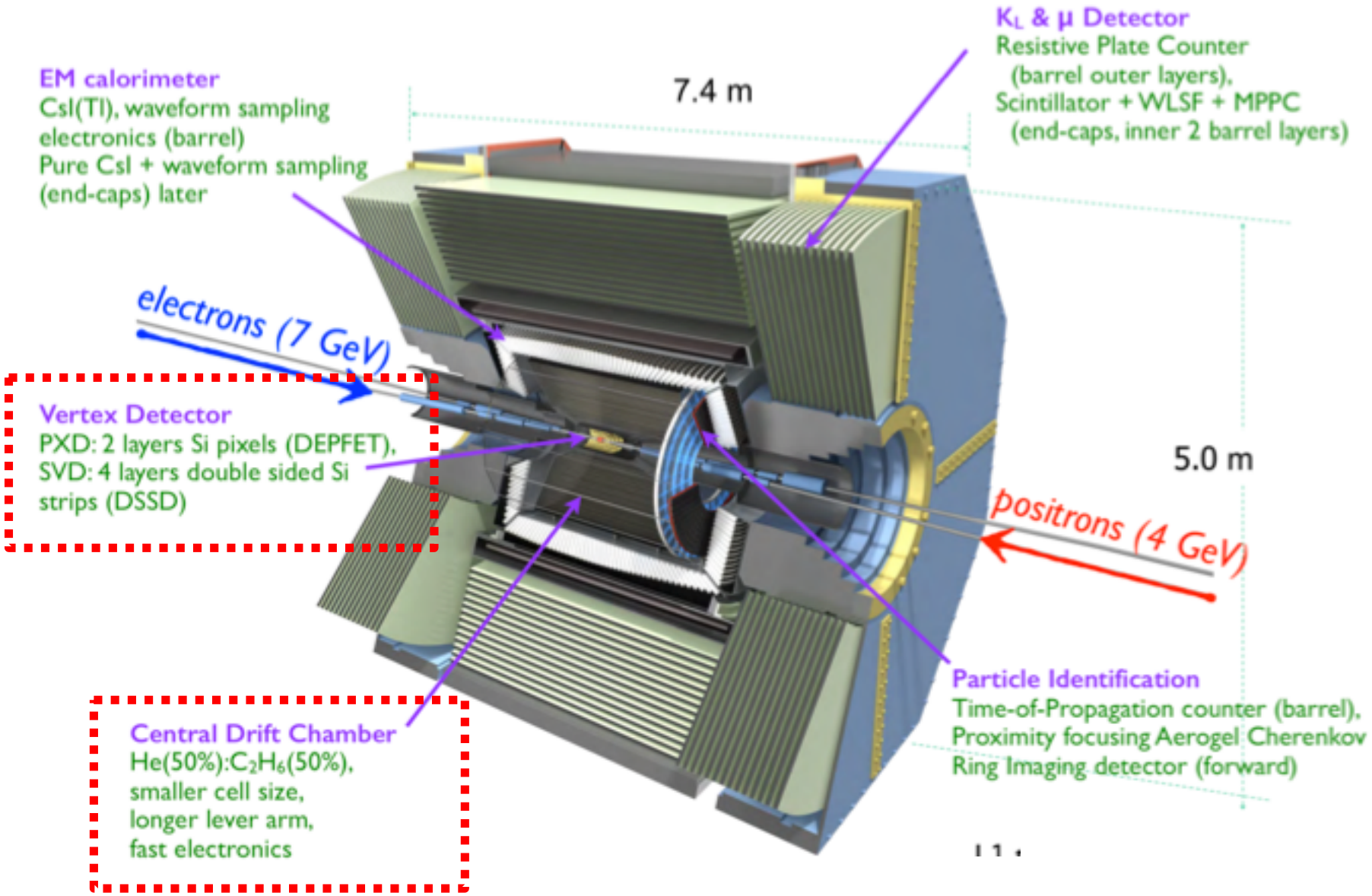
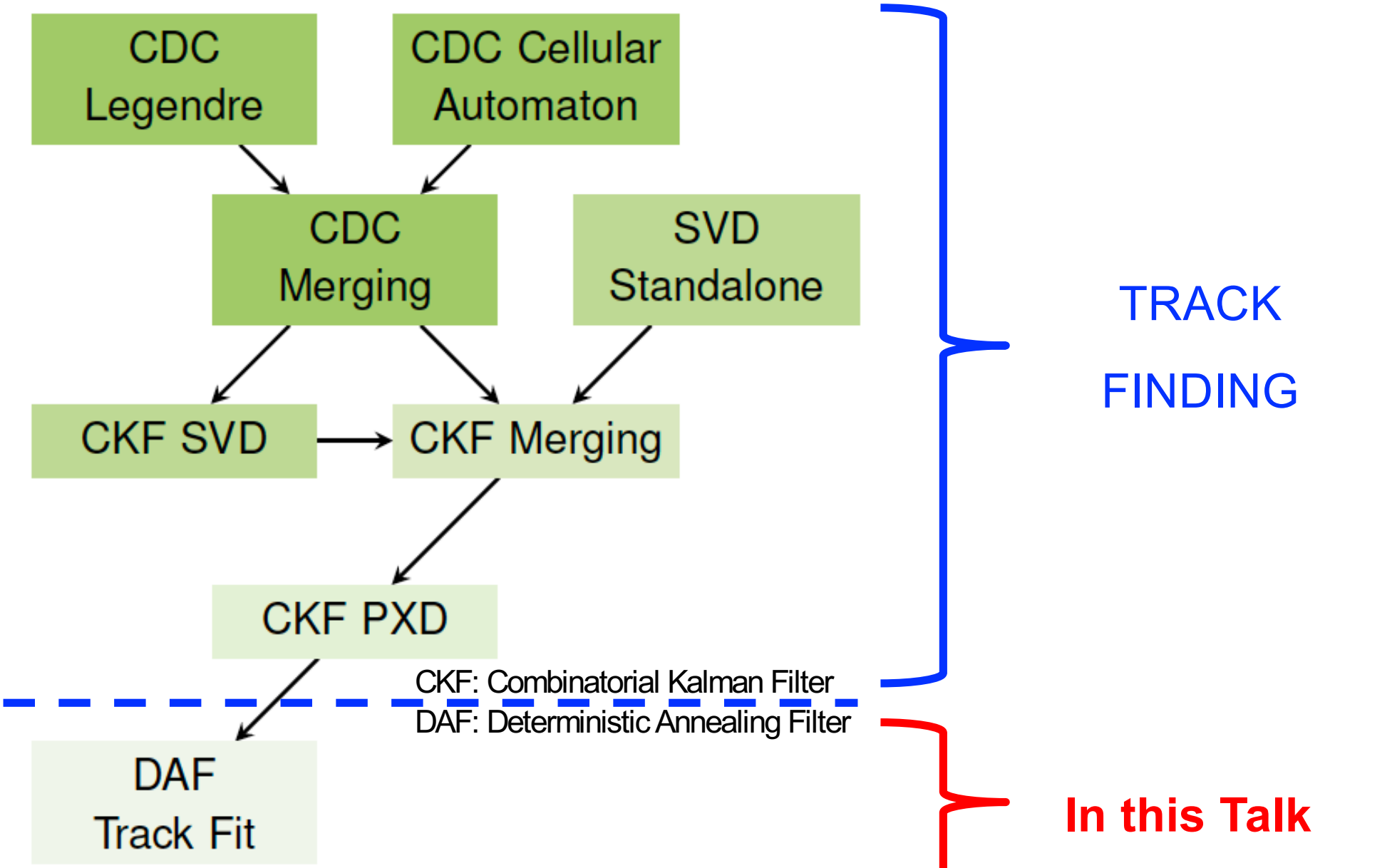
Tuesday, 10th July 2018

Belle II

The Belle II Experiment



Tracking Design

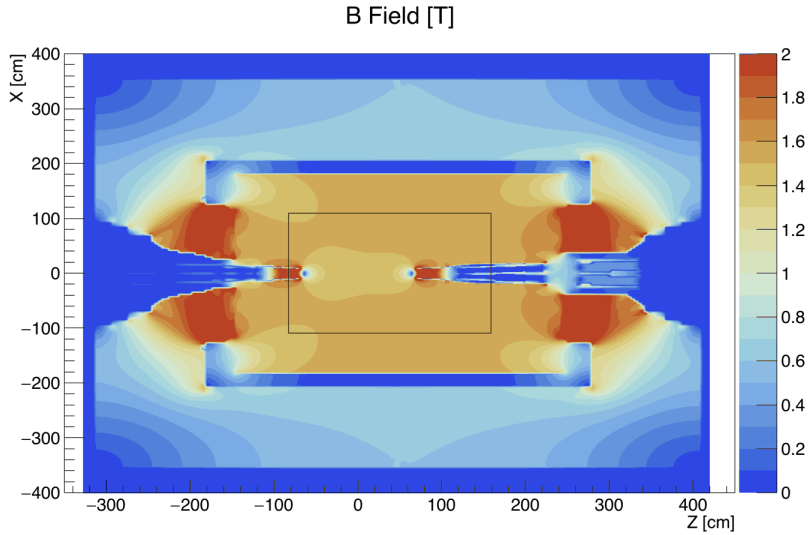


Global Track Fitting

GENFIT: Generic Track Reconstruction Toolkit

Open Source C++ Modular track-fitting framework
Several implemented algorithms inside (DAF is used in our case)

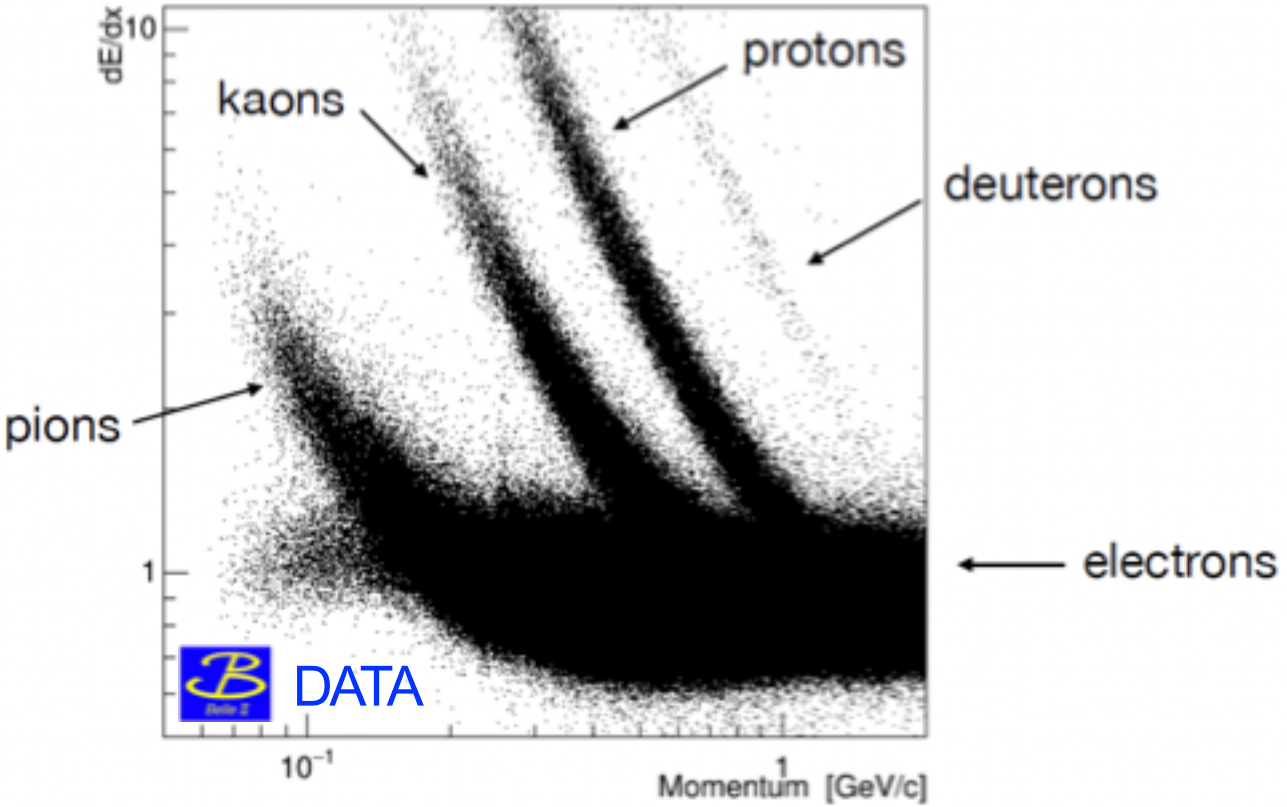
- Not homogeneous Magnetic Field
- Energy loss (different for each particle)
- Different detector hits:
  - CDC: wire + drift time (L/R ambiguity)
  - SVD: position along strips
  - PXD: planar hits (XY)



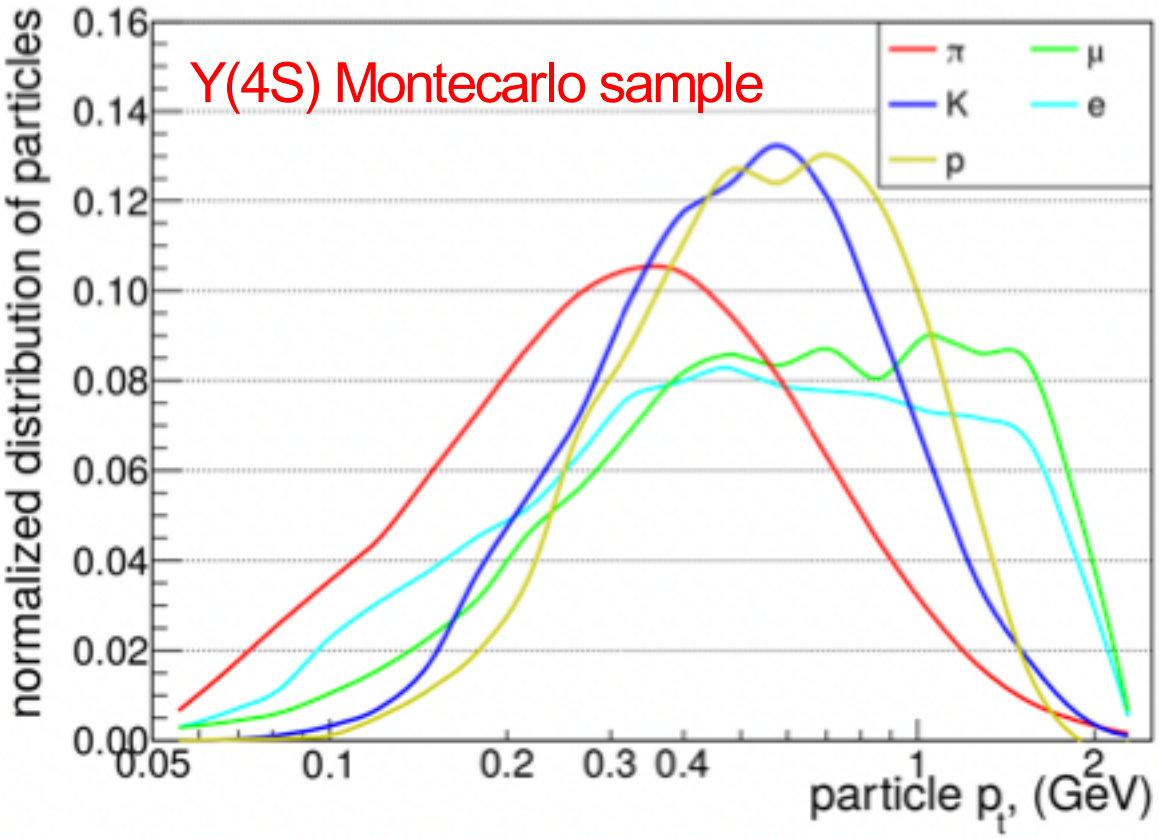
- Originally developed inside PandaRoot framework at TUM
- Major update (GENFIT2) based on acquired experience with Belle II
- Now used by large community (Belle II, PANDA, GEM-TPC, FOPI, SHiP)
- Nucl. Instr. Meth. A 620 (2010) 518-525 – J. Phys.: Conf. Ser. 608 (2015) 012042

Energy Loss Importance

- Different particles, different energy loss
- Different particles, different time of flight, different drift time in CDC
- At high momentum not large differences
- At low momentum, wrong mass hypothesis can lead to wrong results



Our Momentum Range of Interest



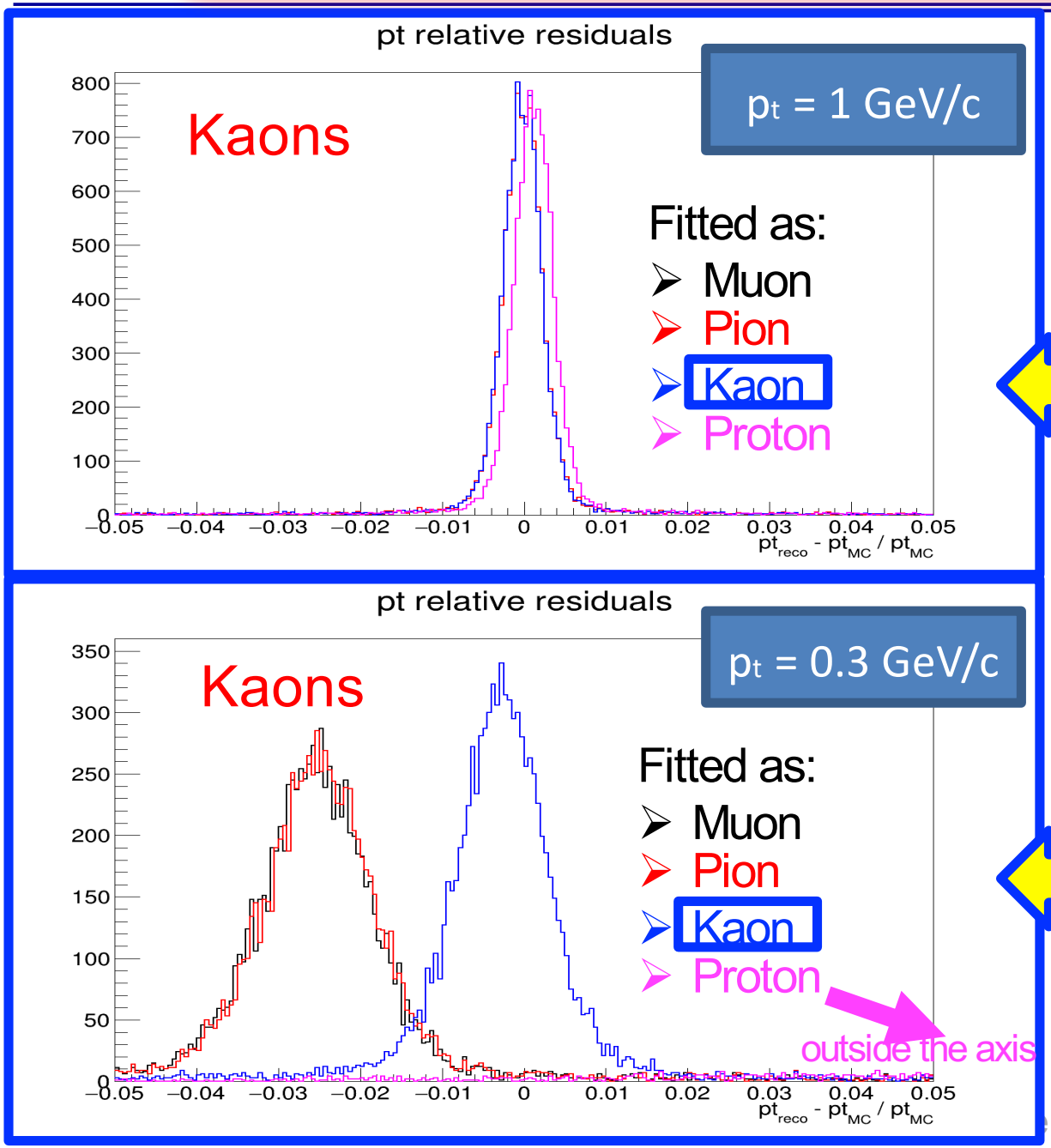
- ✓ Large fraction of pions
- ✓ Particles below 1 GeV/c (mostly)

Particle type	Average fraction
$\pi^{\pm}$	72.8%
$K^{\pm}$	14.9%
$e^{\pm}$	5.8%
$\mu^{\pm}$	4.7%
$p^{\pm}$	1.8%

WARNINGS

- ➢ Low multiplicity samples (e^+e^-, $\mu^+\mu^-$,…) reach larger momentum values
- ➢ Energy loss depends on total momentum (and not on p_t)

Different Particle Hypotheses Fit



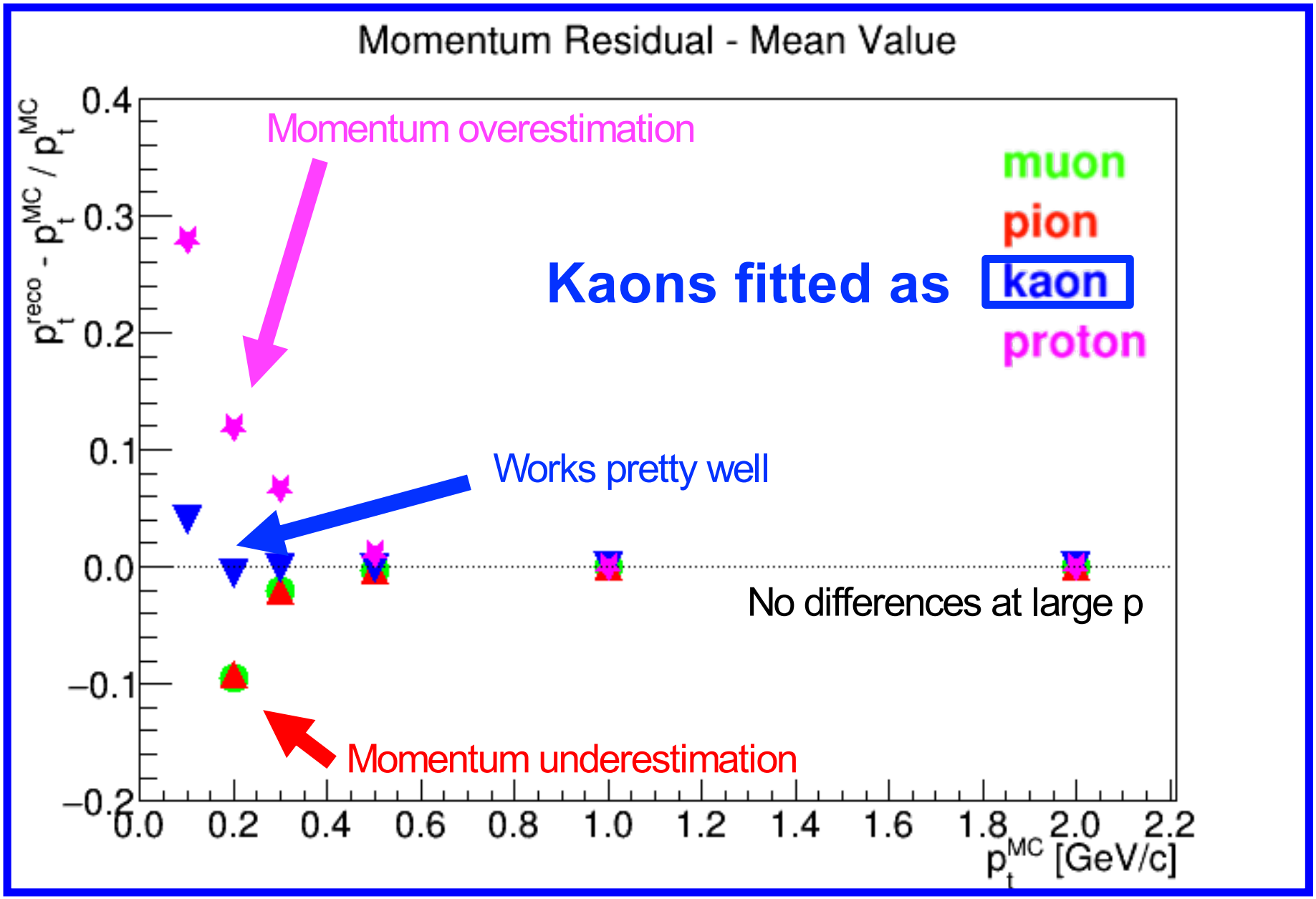
Kaons at θ = 60°

MC particle gun
fixed momentum

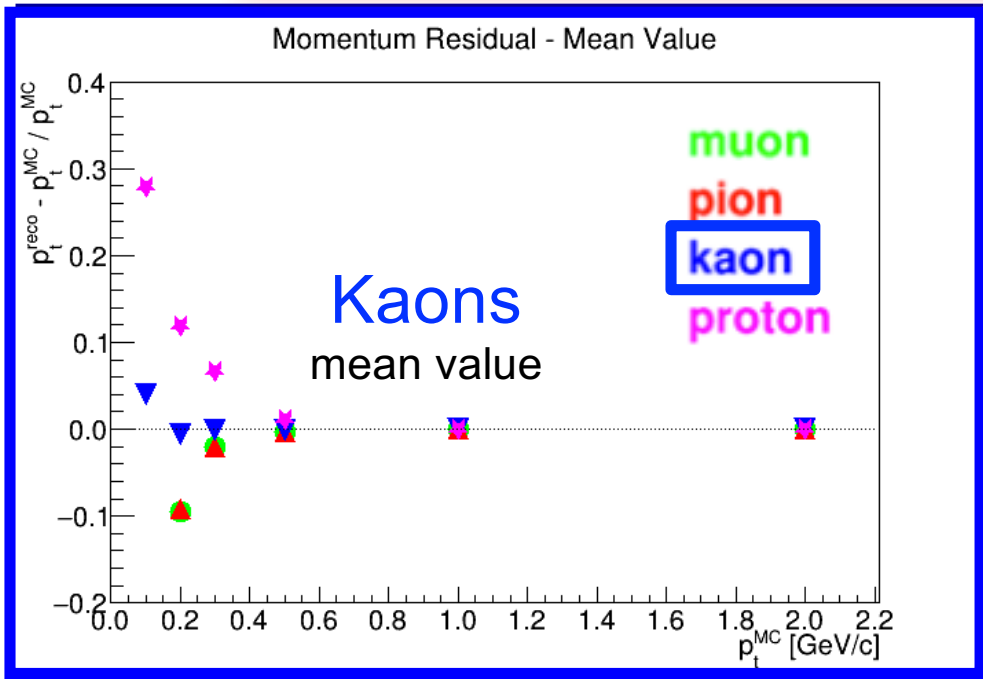
at high momentum
different hypotheses provide
similar results

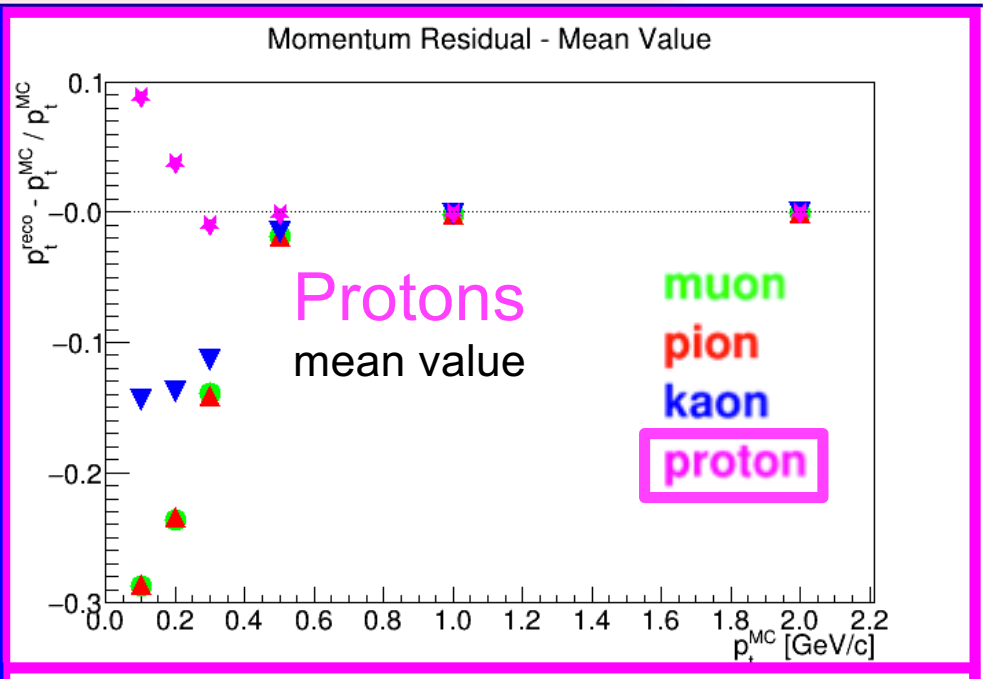
at low momentum
wrong hypotheses provide
large bias in momentum

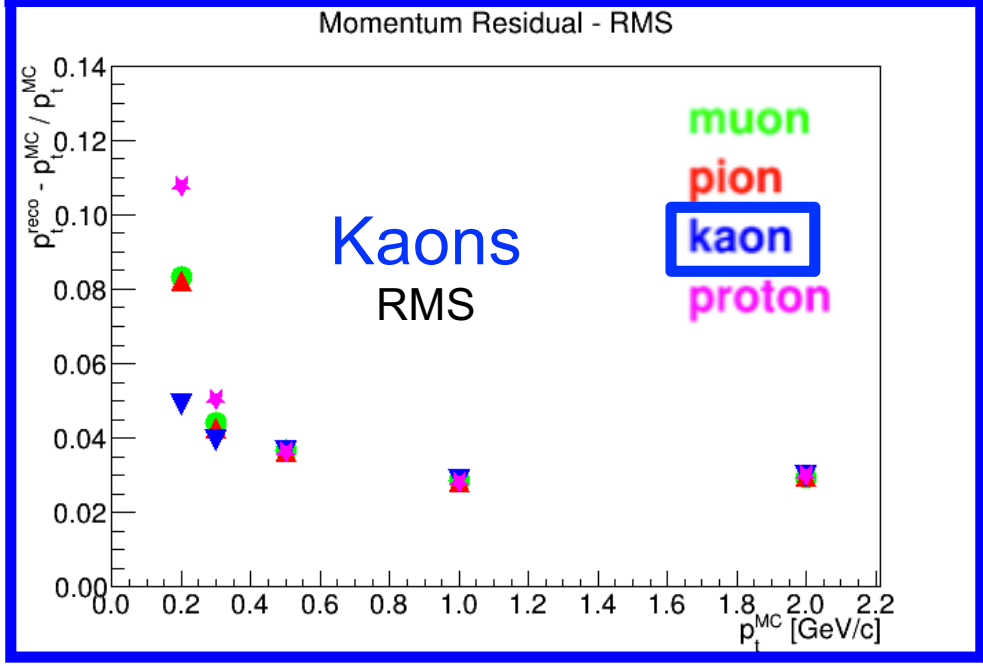
Mean Peak Position for Kaon Tracks

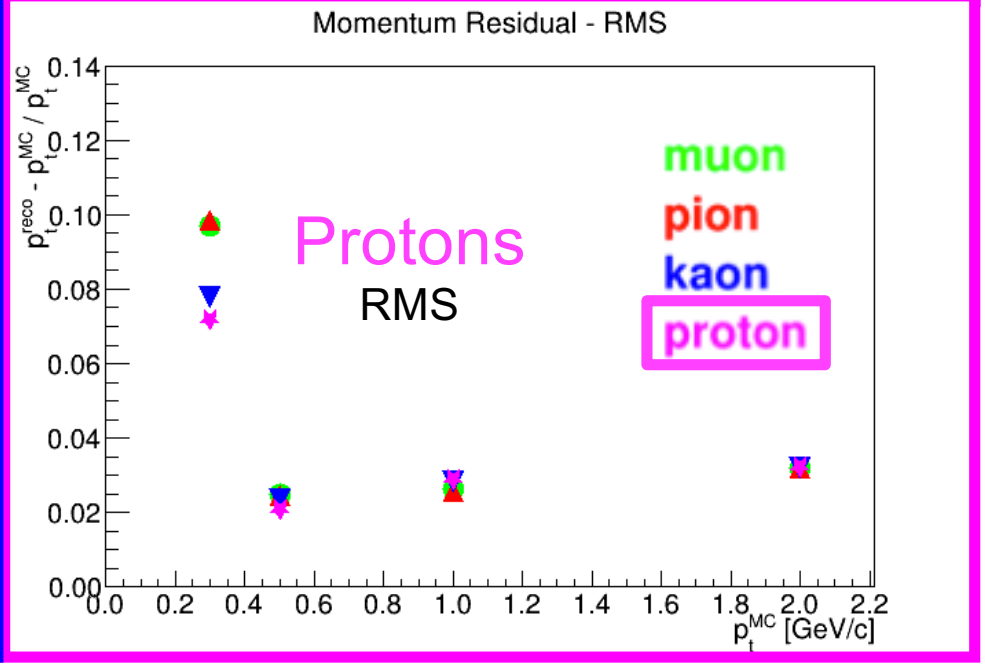


Comparison between different hypotheses









Implementation in Belle II

Determinist Annealing Filter - 3 hypotheses in parallel

- π fit
  - Electrons ← Need dedicated bremsstrahlung handling (ongoing)
  - Muons ← Substantially equivalent to pions
  - Pions
- K fit
  - Kaons
- p fit
  - Protons
  - Deuterons ← Only needed for few analyses, no central production

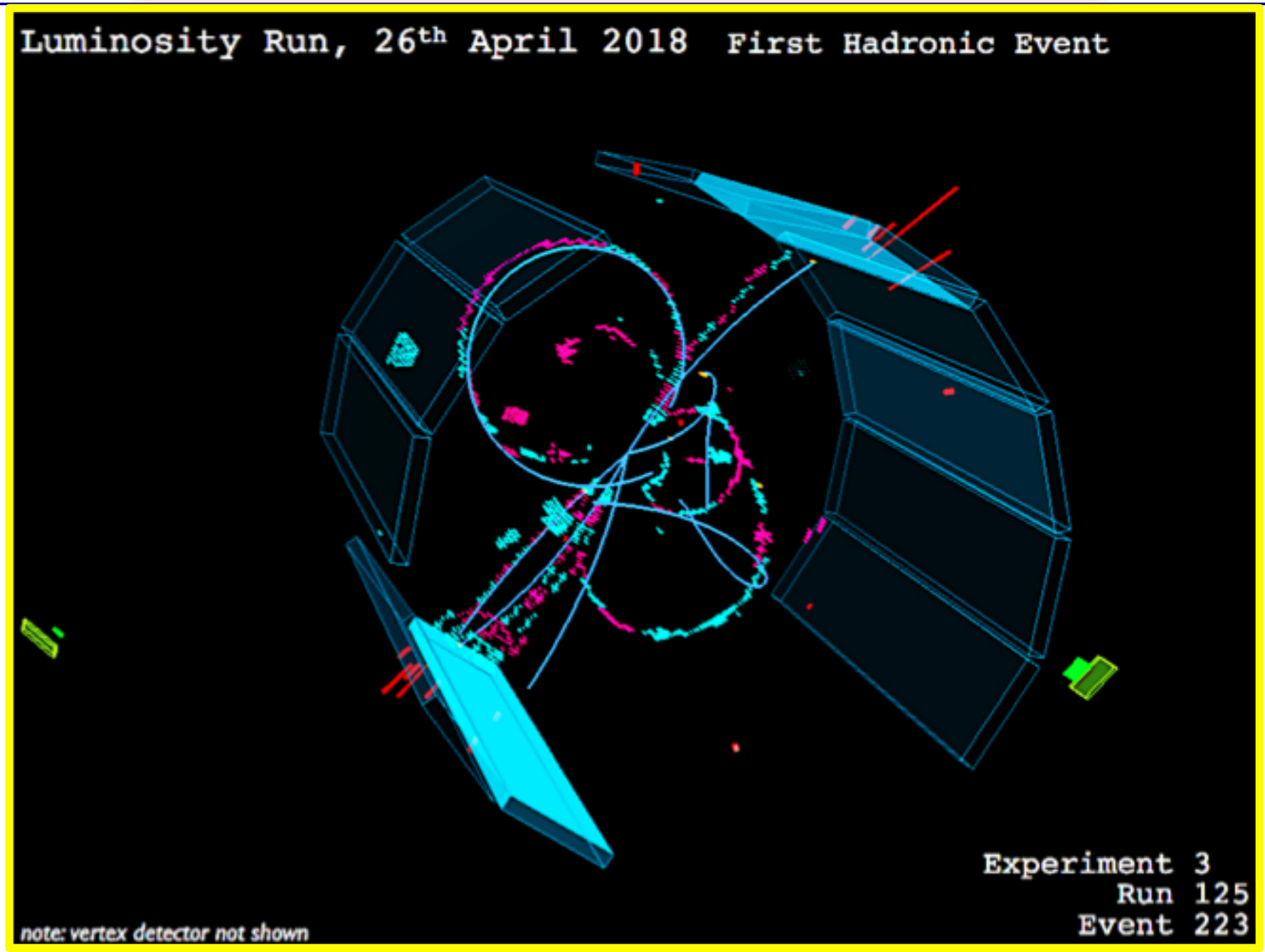
Resources with 3 (π, K, p) and 4 (π, K, p, d) hypotheses compared to only π hypothesis

	Disk Space Ratio		CPU Time Ratio	
	3/1 hyp	4/1 hyp	3/1 hyp	4/1 hyp
Track Fitting	2.59	3.12	2.89	3.75
Global mDST	1.17	1.22	1.07	1.09

⇒ Track Fitting values scale linearly with number of hypothesis

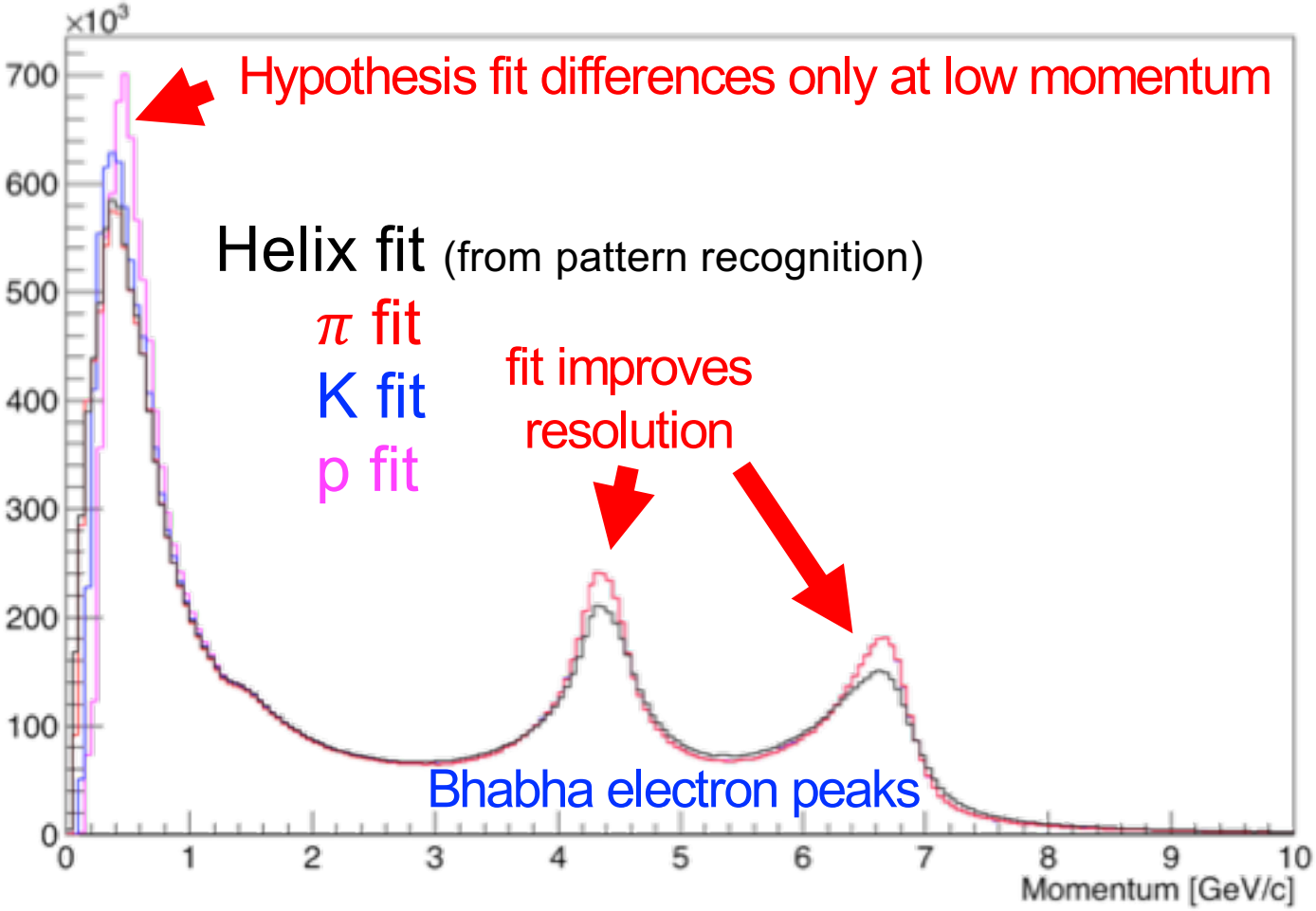
⇒ Global increase of ~10% in CPU time and ~20% in disk space

Does it work also with real data?

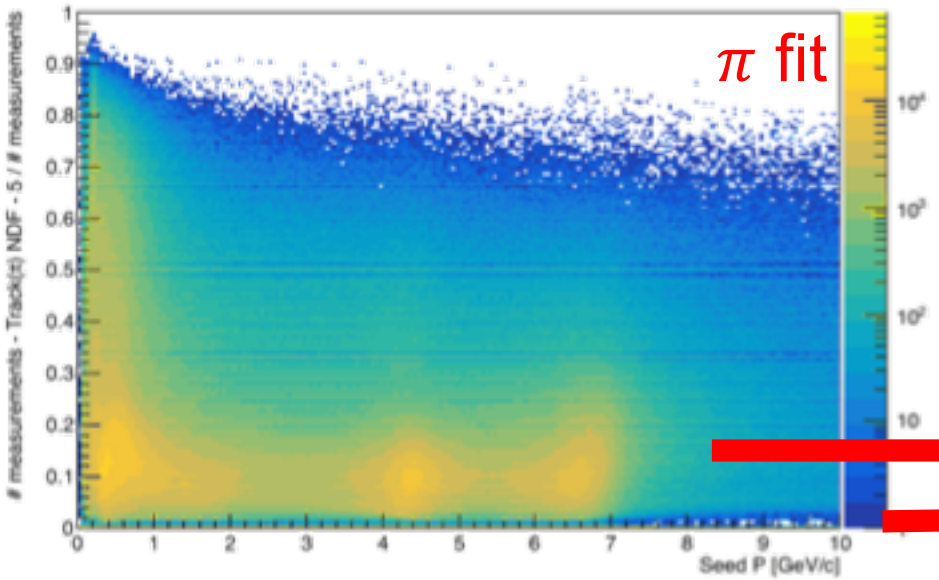


First round of data from collisions

Non optimal beam profile, preliminary detector calibration, SVD+PXD only in a small acceptance, no Bhabha suppression on purpose



What about tracking hits?



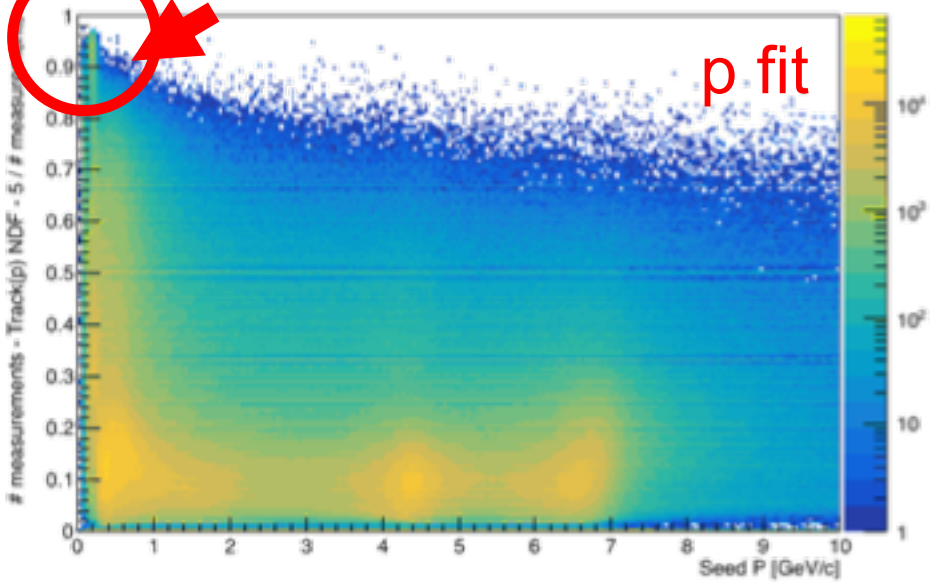
Percentage of removed hits from DAF

measurements – weighted NDF – 5

~10% hits are removed in the fit

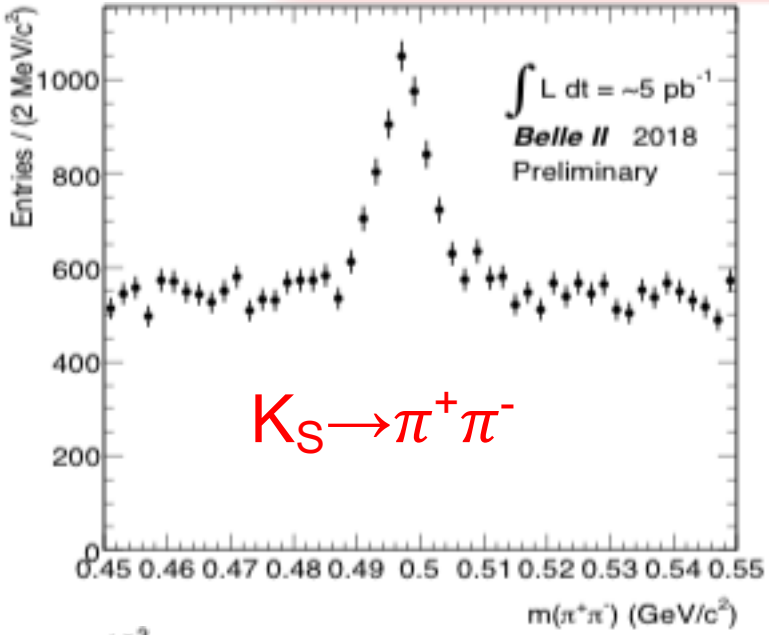
0 → All measurements used in the fit

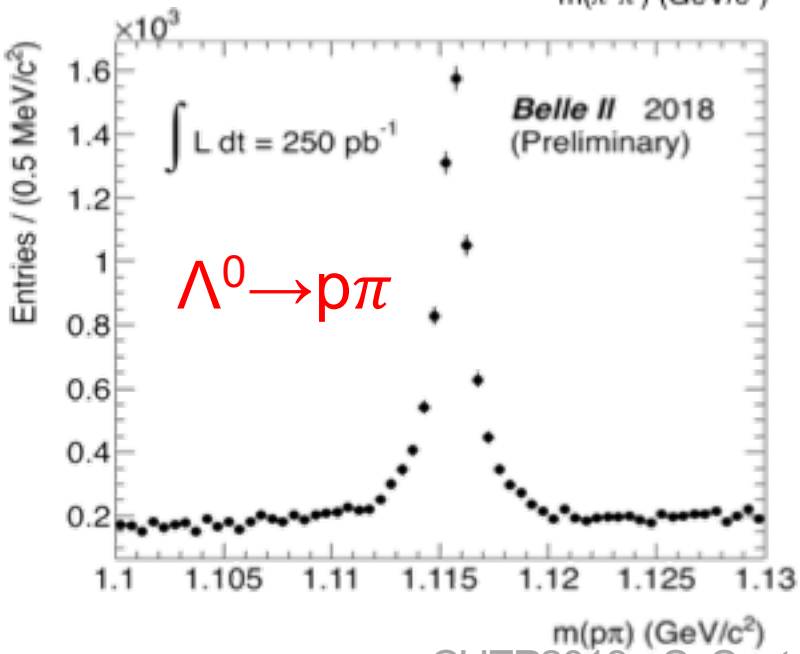
Almost all hits removed in the fit



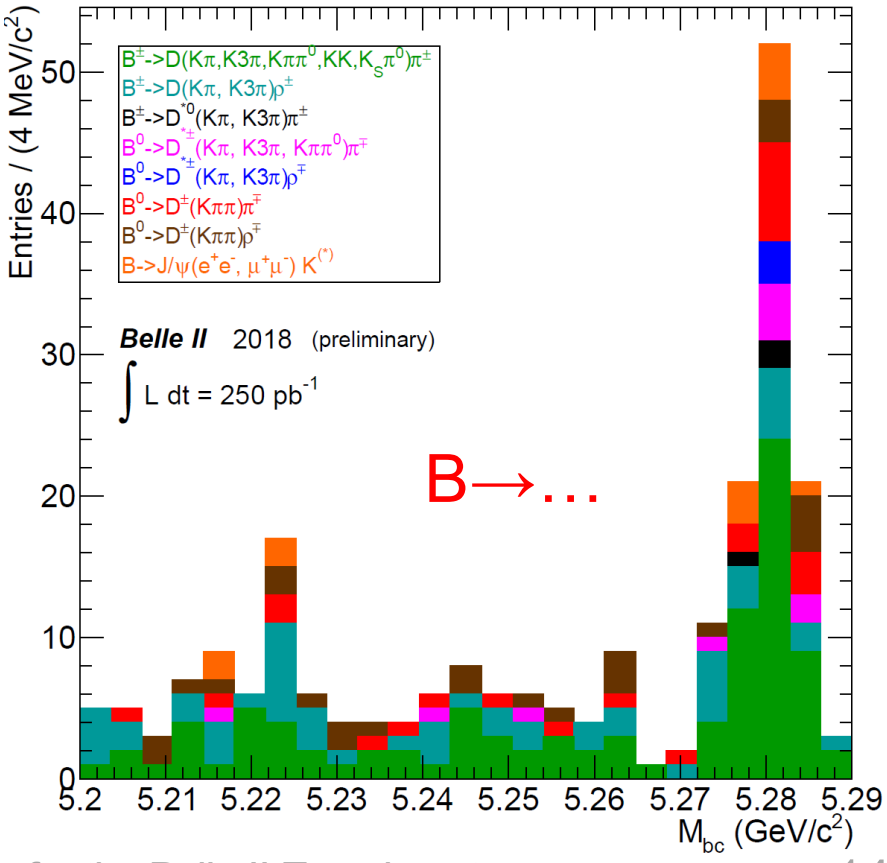
- At very low momentum the proton hypothesis cannot fit the track (too much energy loss)
- DAF set a low weight to almost all the hits

What about particles?





Nice invariant mass peaks at the correct positions!



Summary

In Belle II global tracking is performed my means of the GENFIT2 package

Track Fitting takes into account realistic magnetic field, different kind of detector hits, and energy loss for different particles

Tracks are fitted with three mass hypotheses (π, K, p), a compromise between performances and computing resource consumption

A momentum dependent mass hypothesis in the fit can reduce CPU time and disk usage, in particular for p >1 GeV/c tracks

Determinist Annealing Filter removes outliers and downweighs distant hits, possibility to detect wrong mass hypotheses

Ongoing studies on electron corrections
and optimization of the computing resources for fitting