Status of LMD software

Anastasia Karavdina

KPH, Uni Mainz

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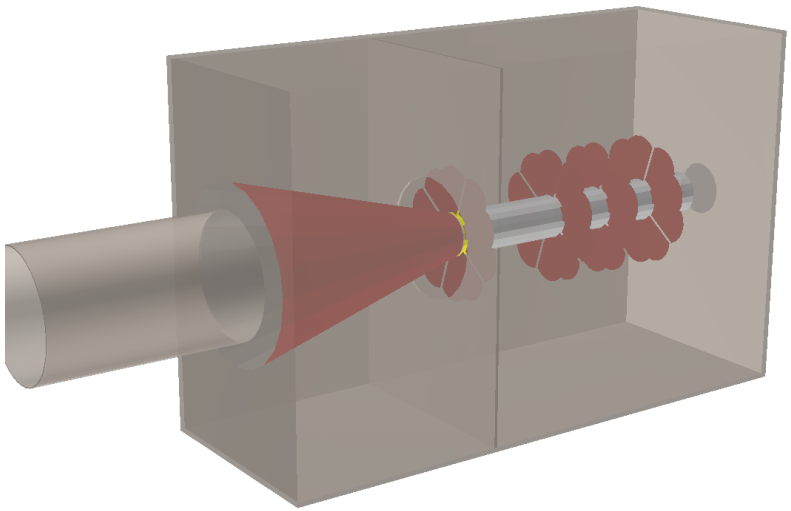
LMD Design



Still missing cooling and support structure

Simulation conditions

- GEANT4
- BOX generator
- Solenoid & Dipole
- beam pipe ver.201303
- the Luminosity Detector

Temporary geometry files

For tests with sensors only

avoid noise tracks from secondaries
e.g used for tuning track reconstruction

macro/lmd/geo/HV_MAPS – Design – SensorsOnly.root

For test with full LMD geometry

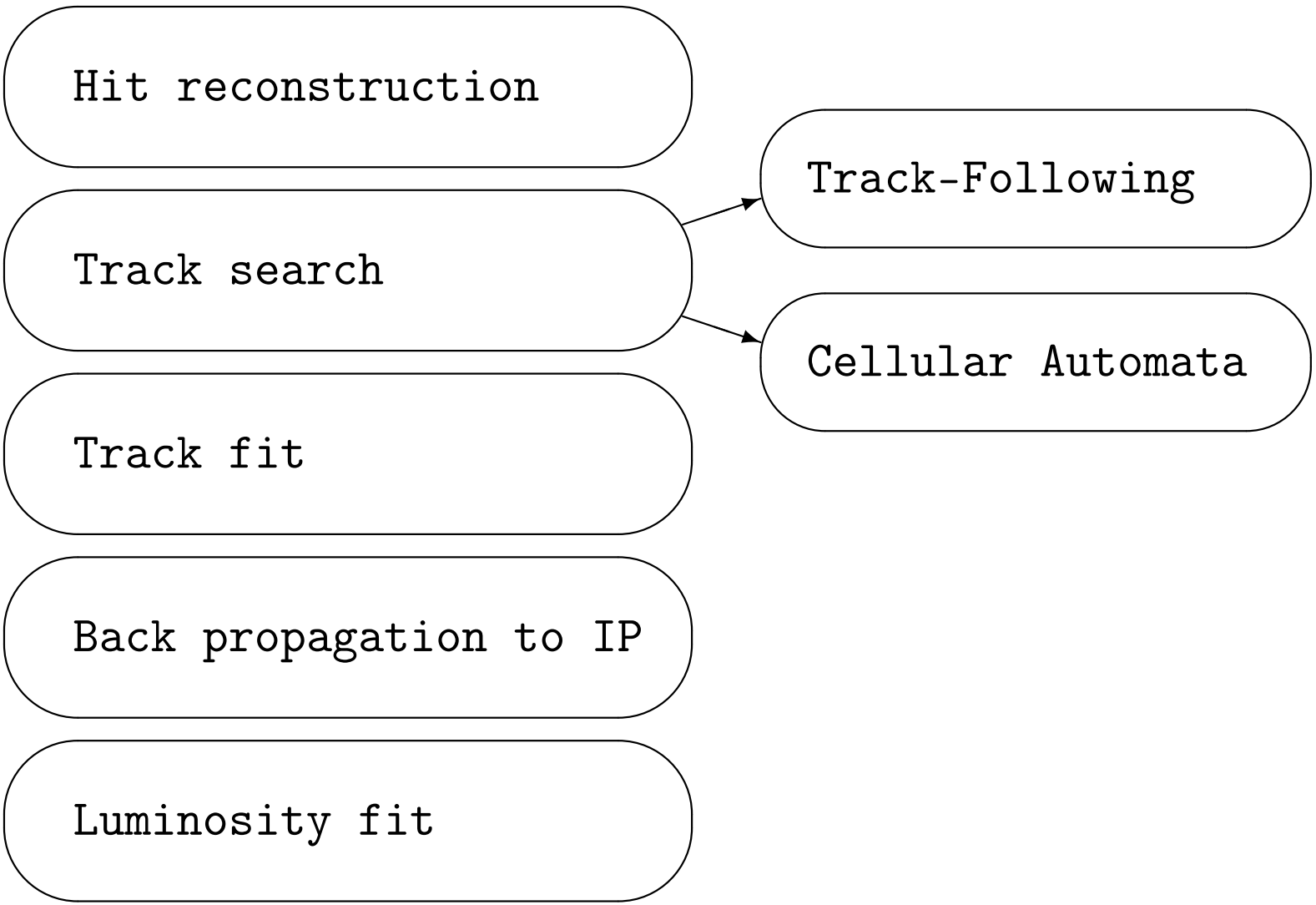
effects due to material
e.g for track reconstruction performance, background, alignment, etc

macro/lmd/geo/HV_MAPS – Design – 29052013.root

Disclaimer

Nobody is responsible for these files
Geometry up to date still can be assured only with macro/lmd/create_Lmd_HV_MAPS.C

Reminder: Track reconstruction chain

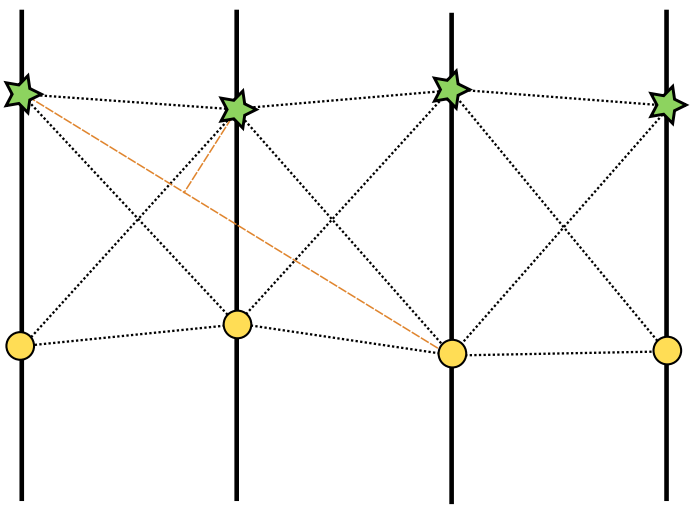


Changes in CA

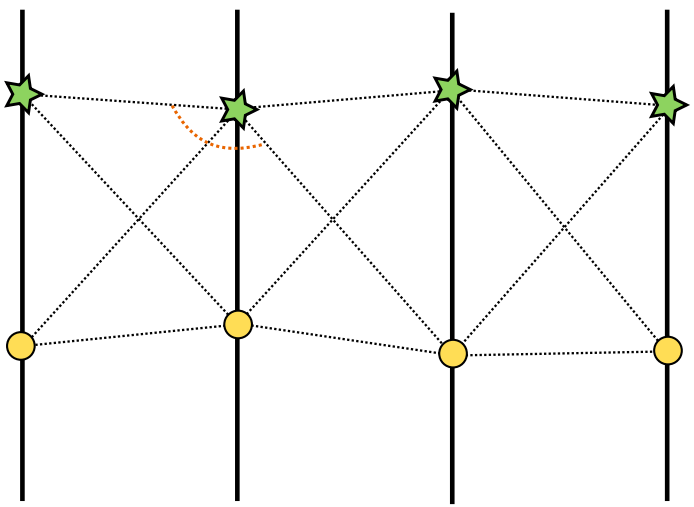
Check neighboring cells by breaking angle

New rule: $(1 - cos\alpha) < \delta\psi$

Seems distance aren't sensitive enough to multiple scattering effect



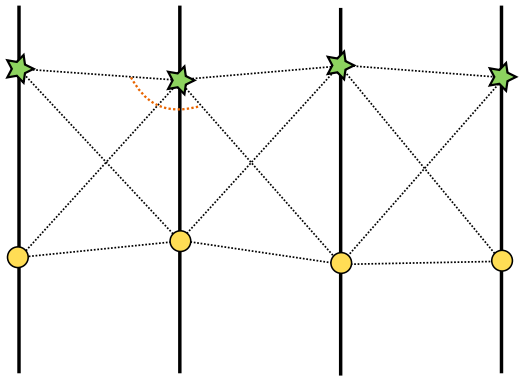
OLD



NEW

CA: $\delta\Psi$ determination & estimation

$$(1 - cos\alpha) < \delta\psi \Rightarrow \delta\psi_{max} = (1 - cos(\sqrt{3}\alpha_0)) \sim \frac{3 \cdot \alpha_0^2}{2}$$

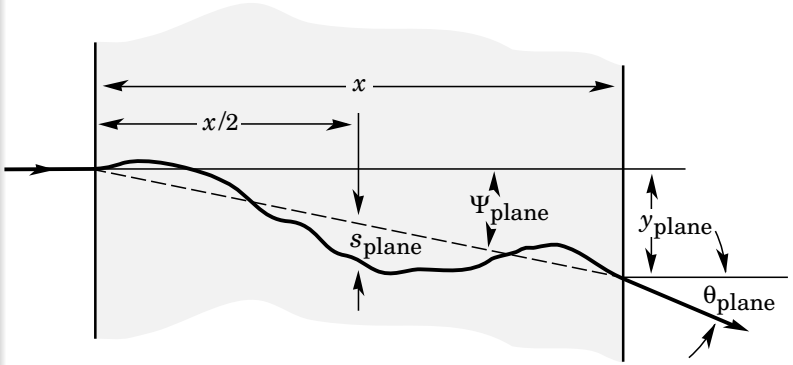


$$\alpha_0 = \theta_{MS} + \alpha_{digi}$$

$$\theta_{MS} = \frac{13.6 \cdot 10^{-3}}{\beta p} \frac{X}{X_0}(1 + 0.038 Ln(\frac{X}{X_0}))$$

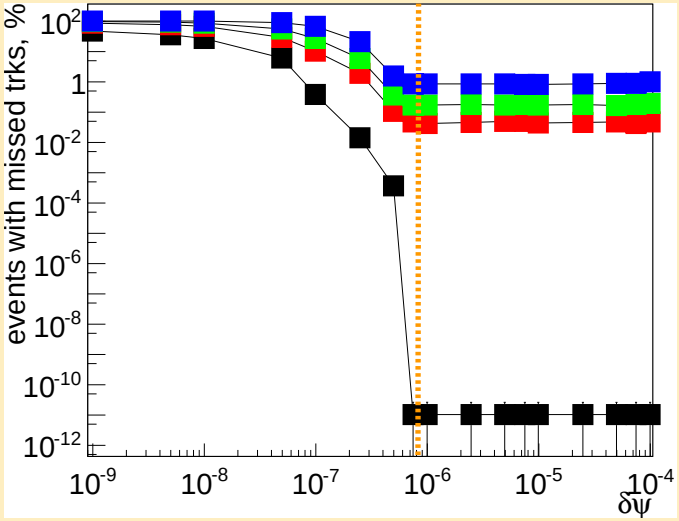
$$\alpha_{digi} = \frac{\sqrt{3} \cdot y_{plane}}{x}(\sim 7 \cdot 10^{-4})$$

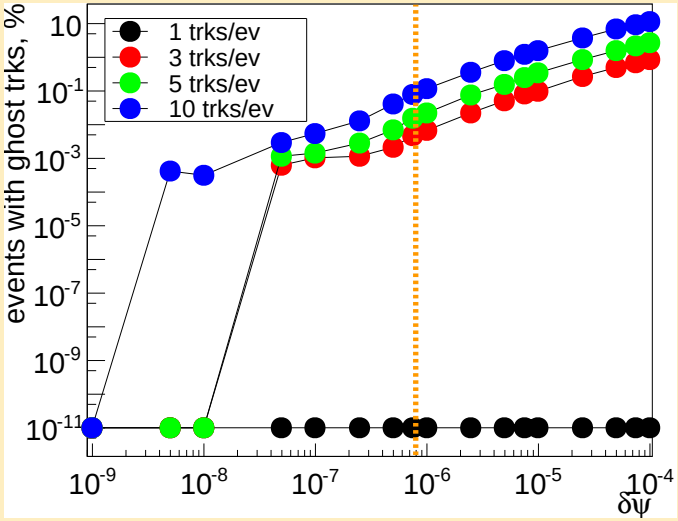
P_{beam} ,	θ_{MS}	$3 \cdot \alpha_0^2/2$
15	$3.1 \cdot 10^{-5}$	$8 \cdot 10^{-7}$
11.91	$3.9 \cdot 10^{-5}$	$8 \cdot 10^{-7}$
8.9	$5.2 \cdot 10^{-5}$	$9 \cdot 10^{-7}$
4.06	$1.2 \cdot 10^{-4}$	$1 \cdot 10^{-6}$
1.5	$3.7 \cdot 10^{-4}$	$2 \cdot 10^{-6}$



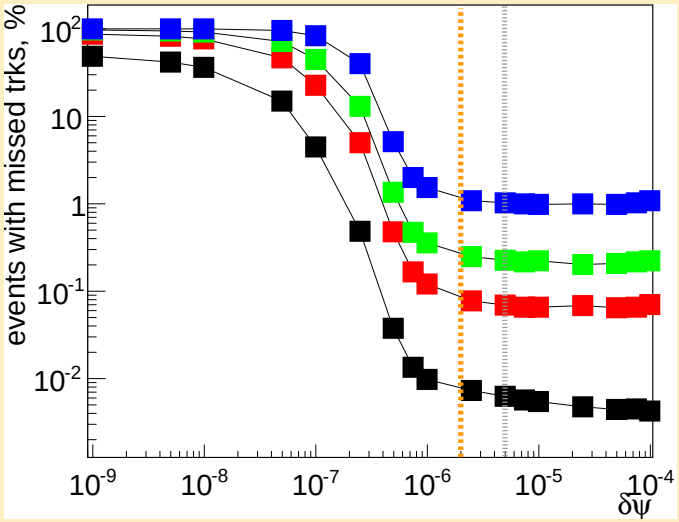
$\delta\Psi$ determination (10^6 events)

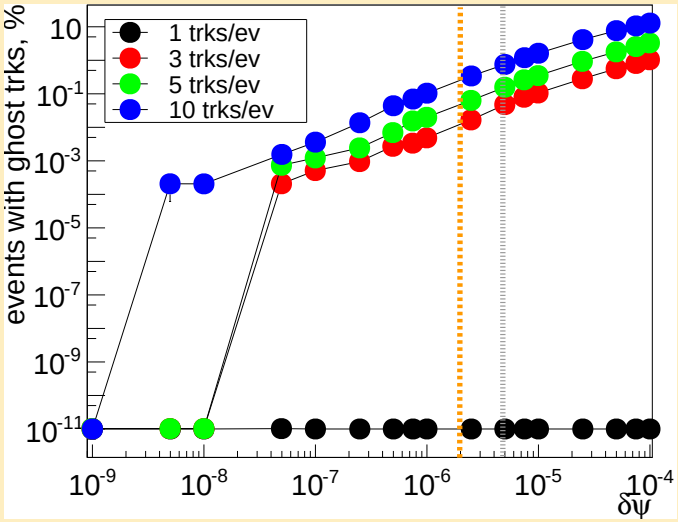
15 GeV/c



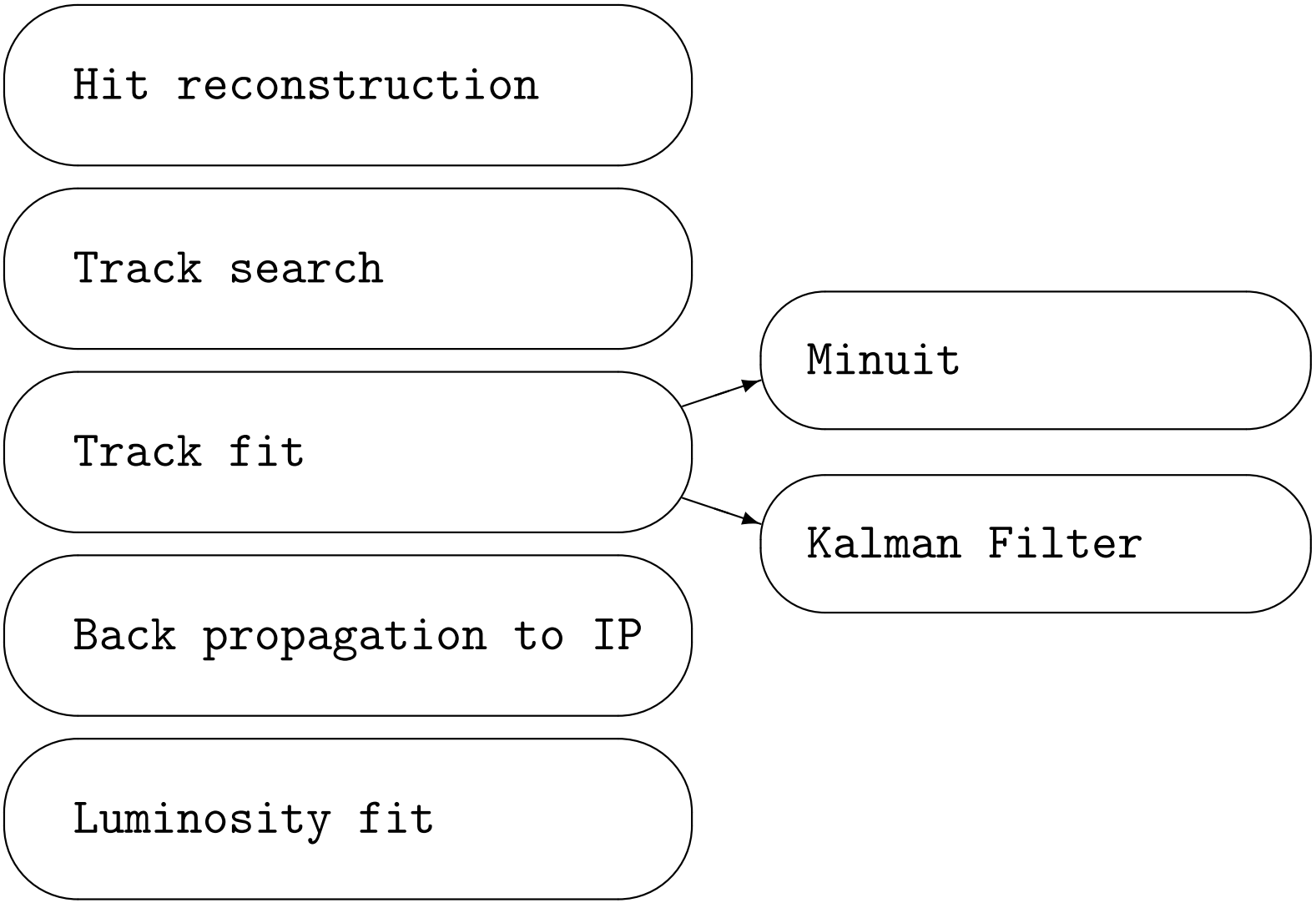


1.5 GeV/c



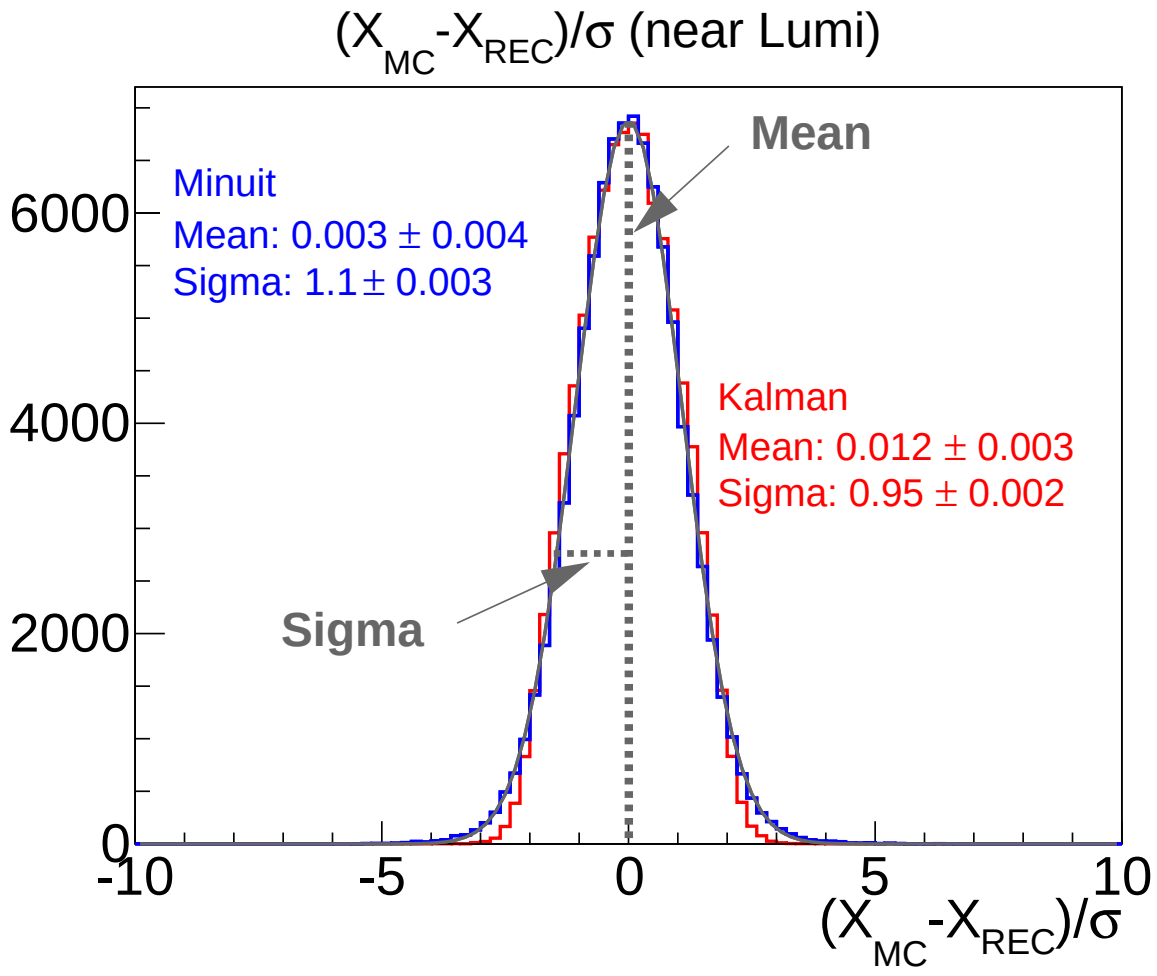


Track reconstruction chain



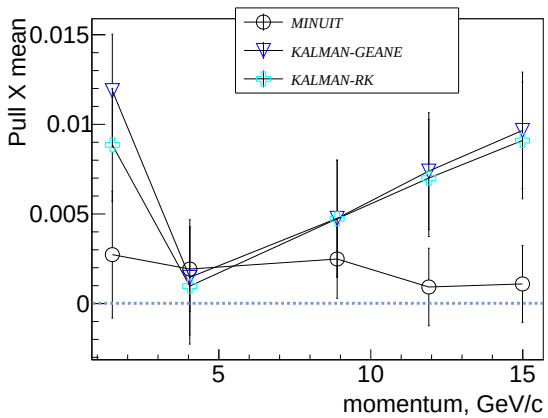
Pull of variable $(X_{REC} - X_{MC})/\sigma_X$

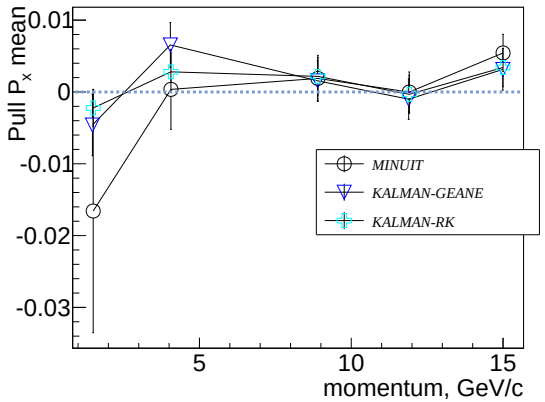
example: pull X_{trk} before back propagation, 1.5 GeV/c

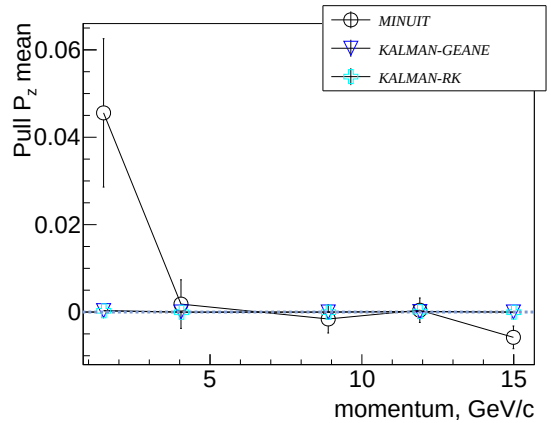


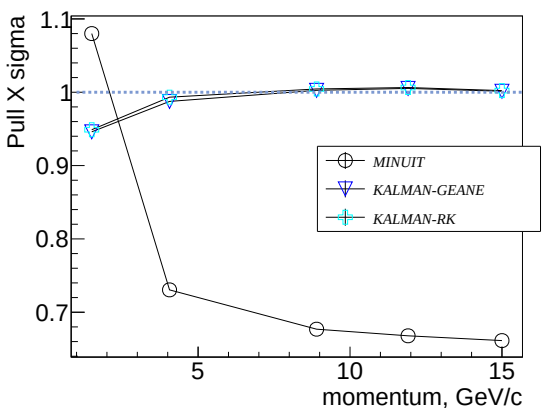
For track description we have 6 variables
(PCA and direction at this point)

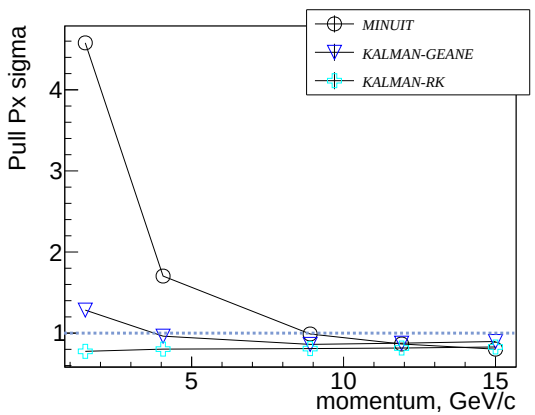
Pulls of variables after track fit

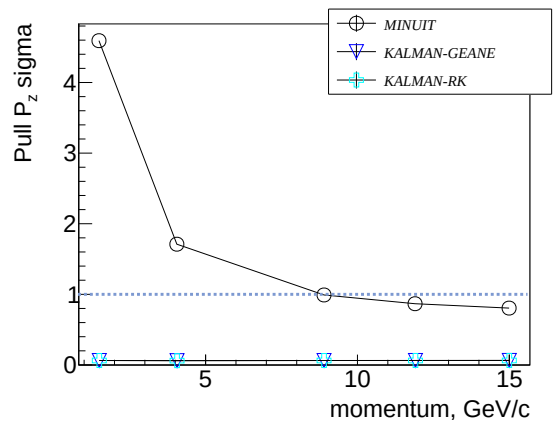








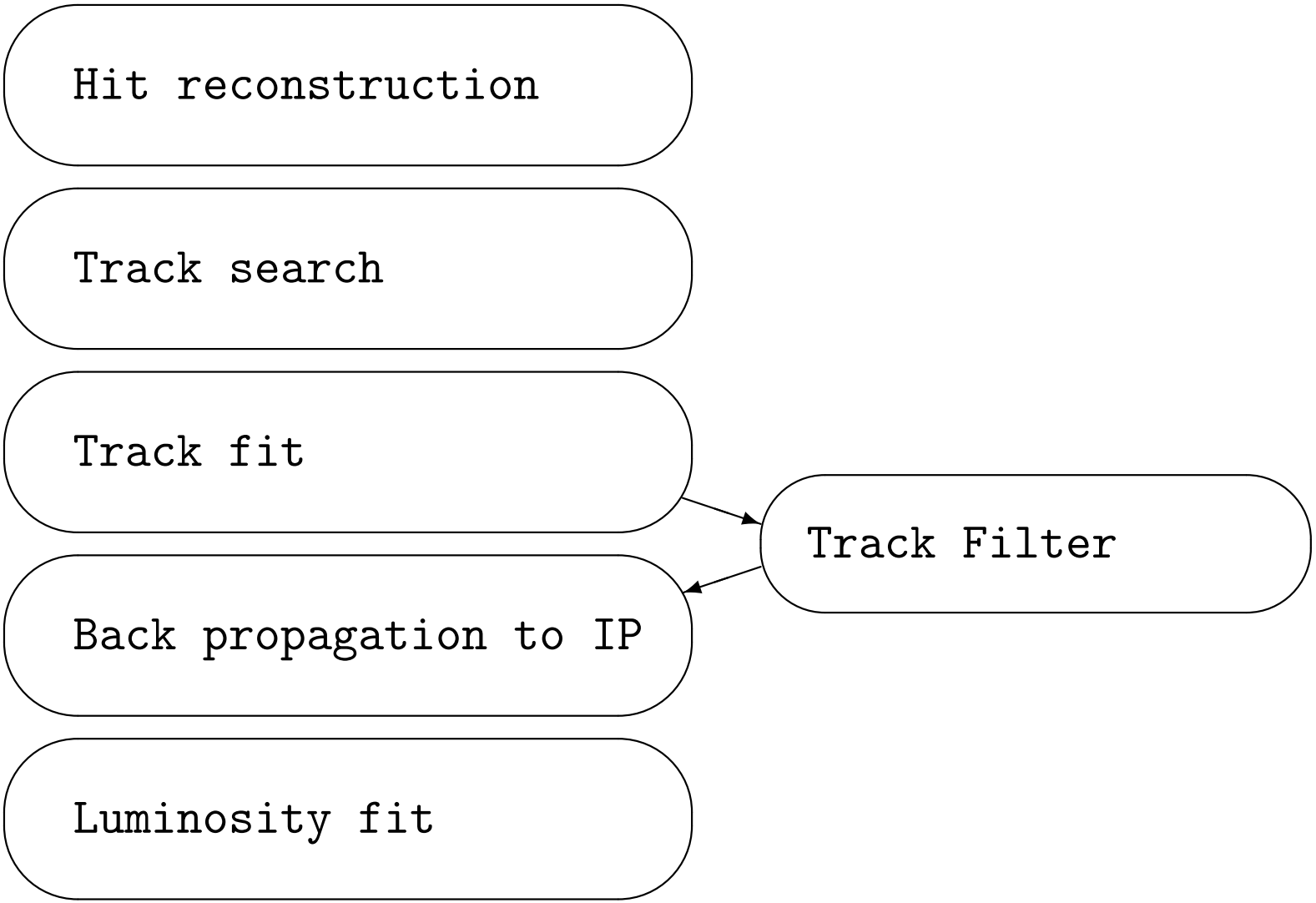




error of P_z overestimated for Kalman Filter

But in general Kalman Filter gives better results

Track reconstruction chain

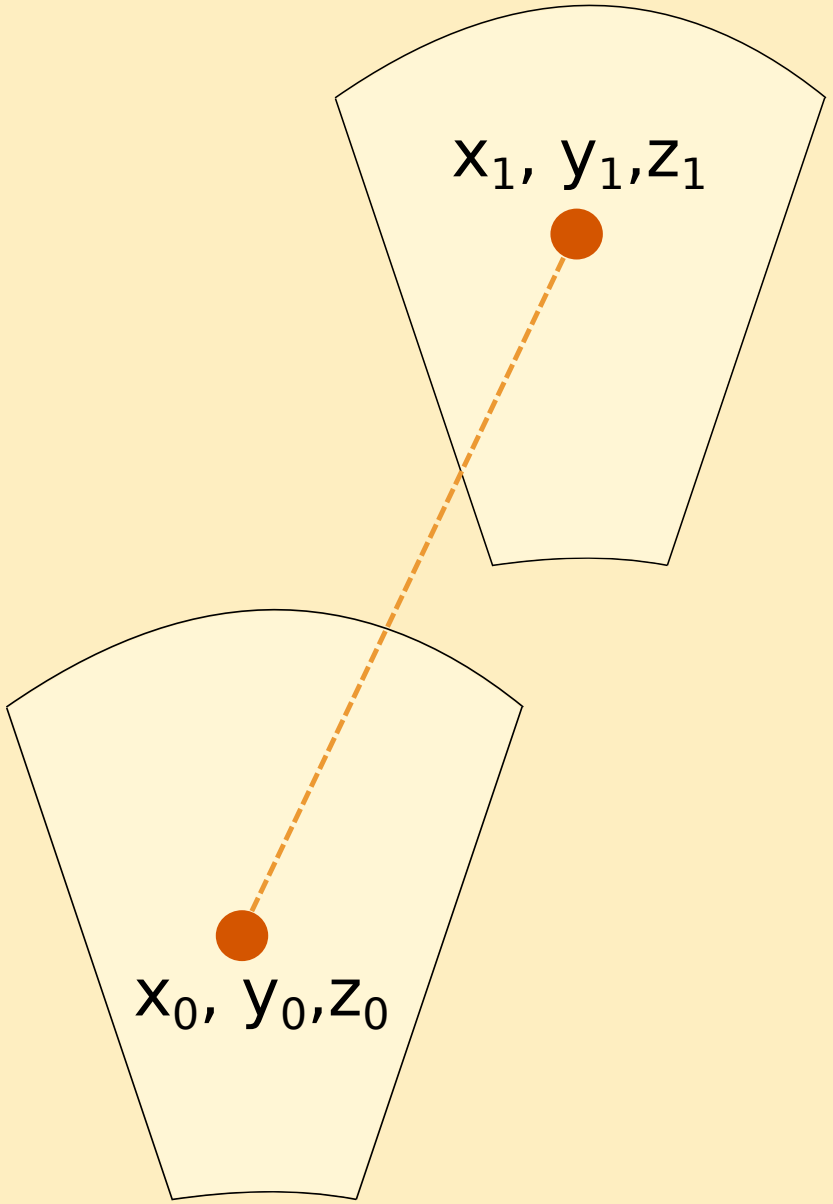


Track filter

- Compare two tracks between each other
  $\rightarrow$ if they contain 2 common hits
  $\rightarrow$ save with higher number of hits or smaller χ^2
- Cut tracks by $\hat{\theta}$, $\hat{\phi}$

Track filter

Cuts on track in LMD



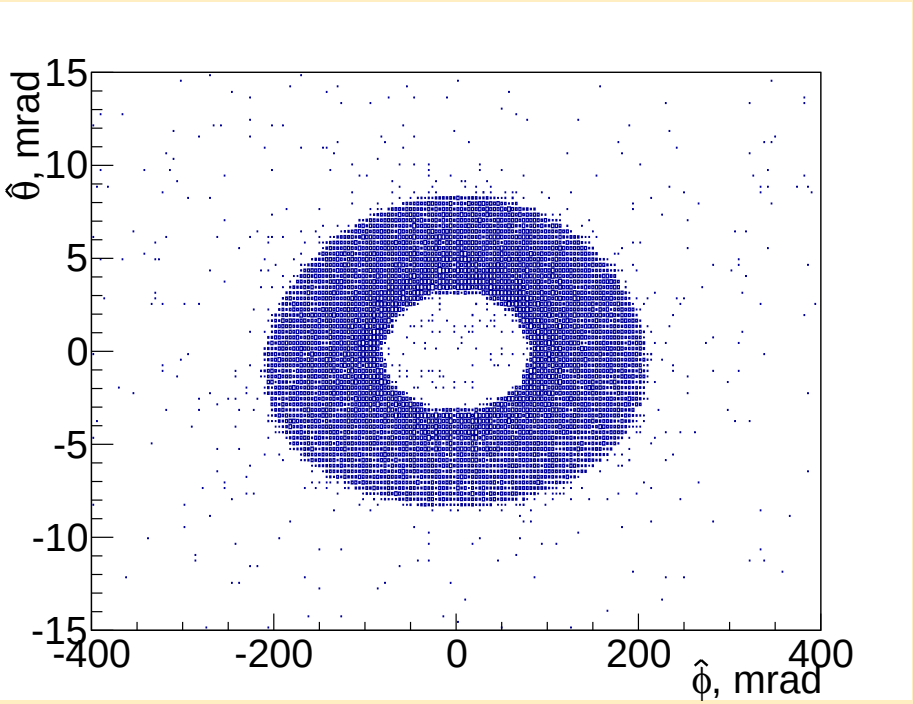
$$d_x = x_1 - x_0$$
$$d_y = y_1 - y_0$$
$$d_z = z_1 - z_0$$

$$tg\hat{\phi} = \frac{d_y}{d_x}$$

$$tg\hat{\theta} = \frac{\sqrt{d_x^2 + d_y^2}}{d_z} - 0.040$$

Track filter

Cuts on track in LMD



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Track filter

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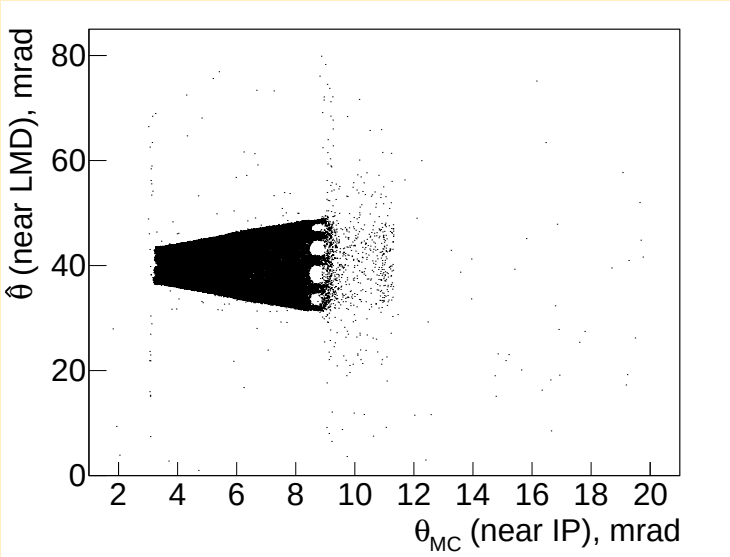

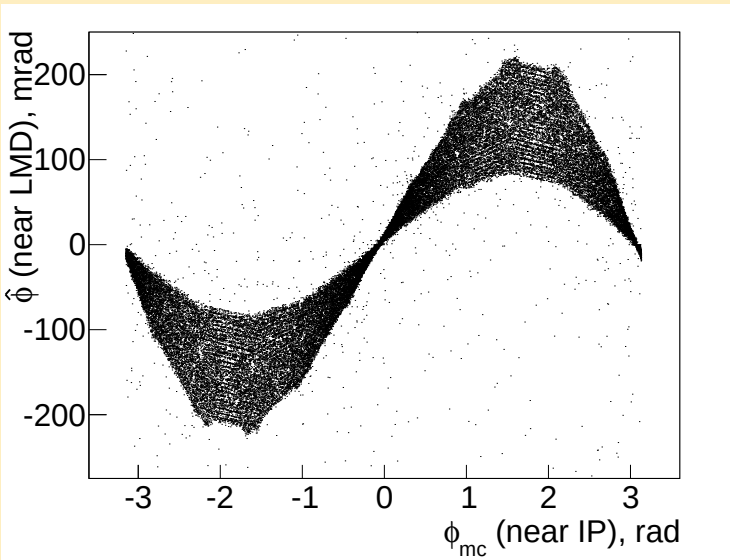

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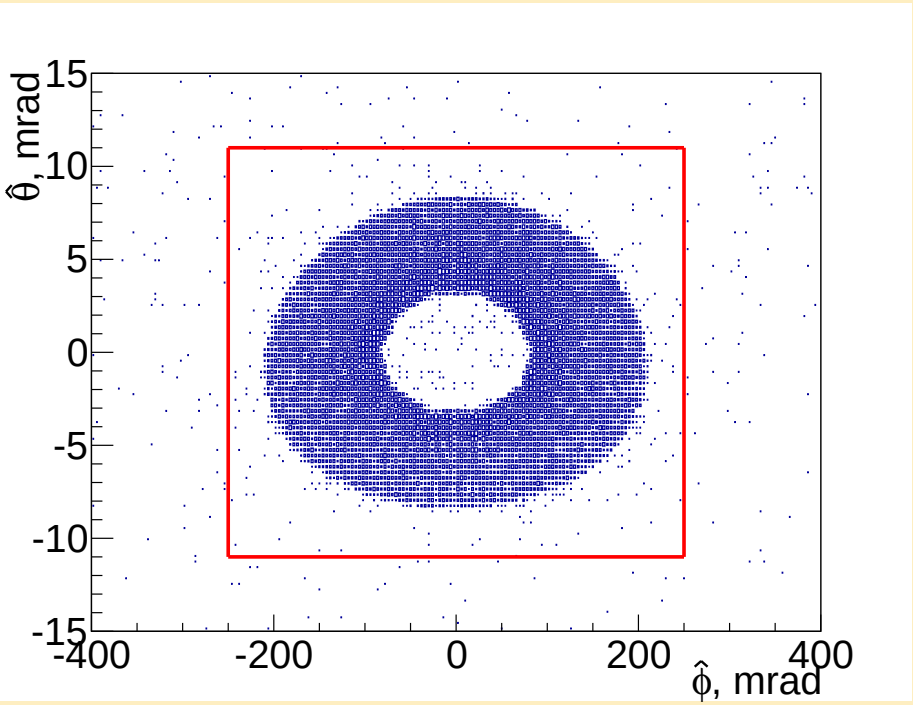
Track filter

Cuts on track in LMD



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$$d_y = y_1 - y_0$$
$$d_z = z_1 - z_0$$

$$tg\hat{\phi} = \frac{d_y}{d_x}$$

$$tg\hat{\theta} = \frac{\sqrt{d_x^2 + d_y^2}}{d_z} - 0.040$$

Full LMD, beam pipe, θ_{MC}=2-11 mrad, 1e5 events

cut $|\hat{\theta}| \leq 11$ mrad, $|\hat{\phi}| \leq 250$ mrad

	Before	After	
P_{beam}	N_{rec}/N_{prim}	N_{rec}^{left}/N_{prim}	$N_{second}^{left}/N_{prim}$
15	103.04 ± 0.07	100.20 ± 0.07	0.62 ± 0.03
11.91	102.16 ± 0.06	99.97 ± 0.06	0.43 ± 0.03
8.9	101.46 ± 0.05	99.77 ± 0.05	0.25 ± 0.02
4.06	100.68 ± 0.03	99.37 ± 0.04	0.09 ± 0.02
1.5	100.77 ± 0.03	99.04 ± 0.05	0.08 ± 0.02

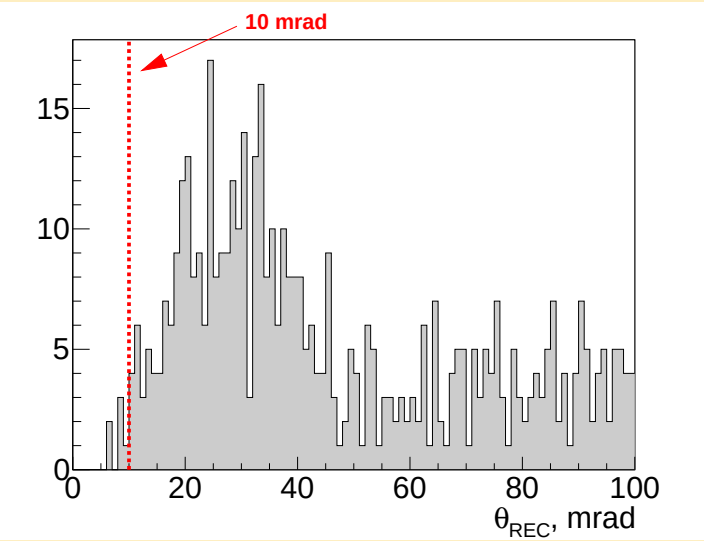
- N_{rec} - number of pure reconstructed tracks

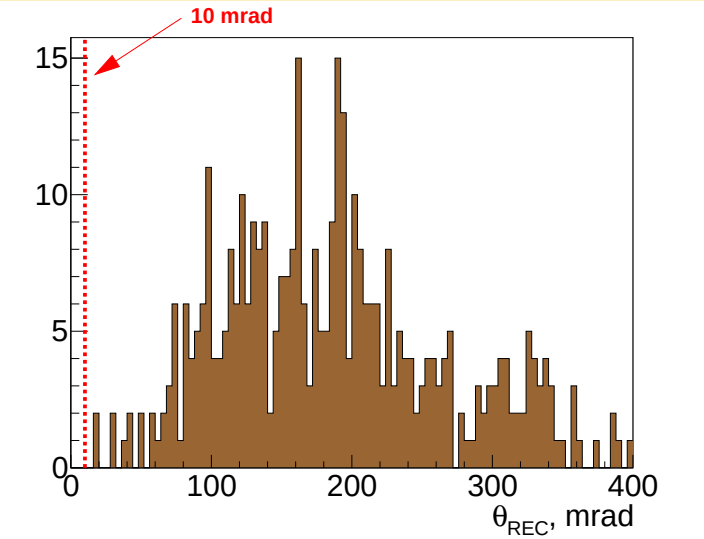
  (hits mixture tracks rejected for simplicity)
- N_{prim} - number of reconstructed primaries $\bar{p}$
- N_{second} - number of reconstructed secondaries
- N_i^{left} - number of tracks which is left after cut

θ of cut tracks after back propagation

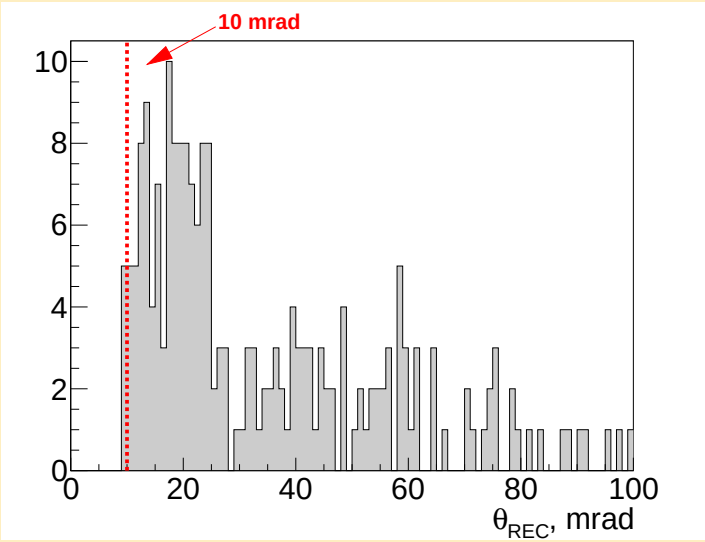
Primaries & Secondaries

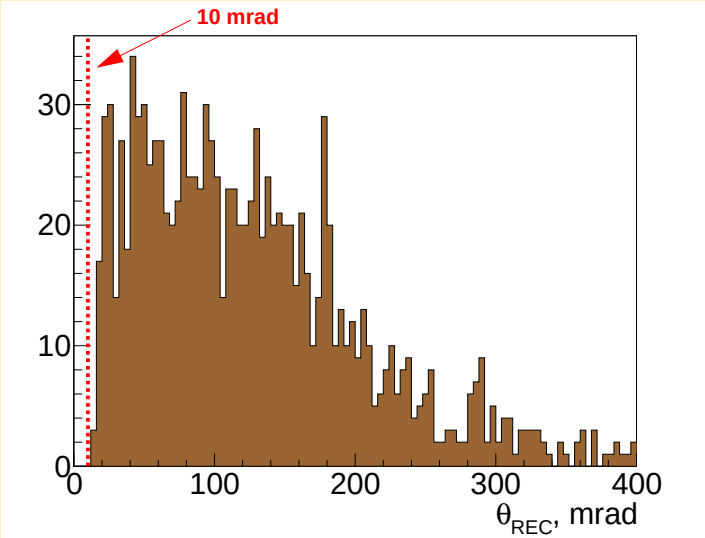
1.5 GeV/c





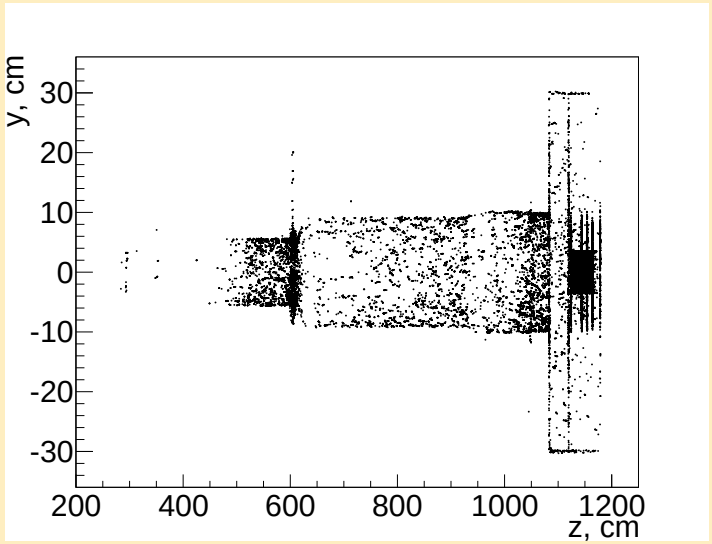
15 GeV/c

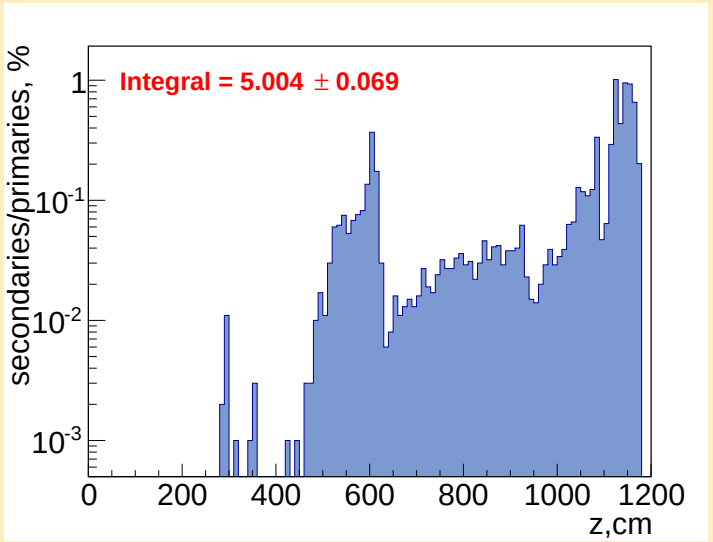




Summary for secondaries study (10^5 events)

Example: 15GeV/c





θ : 2-11 mrad

P_{beam},	z=0-12m	z=10-12m
15	5.01 ± 0.07	4.37 ± 0.06
11.91	4.31 ± 0.06	3.90 ± 0.06
8.9	3.88 ± 0.06	3.62 ± 0.06
4.06	3.43 ± 0.06	3.37 ± 0.06
1.5	3.57 ± 0.06	3.54 ± 0.06

Reminder: Track reconstruction chain

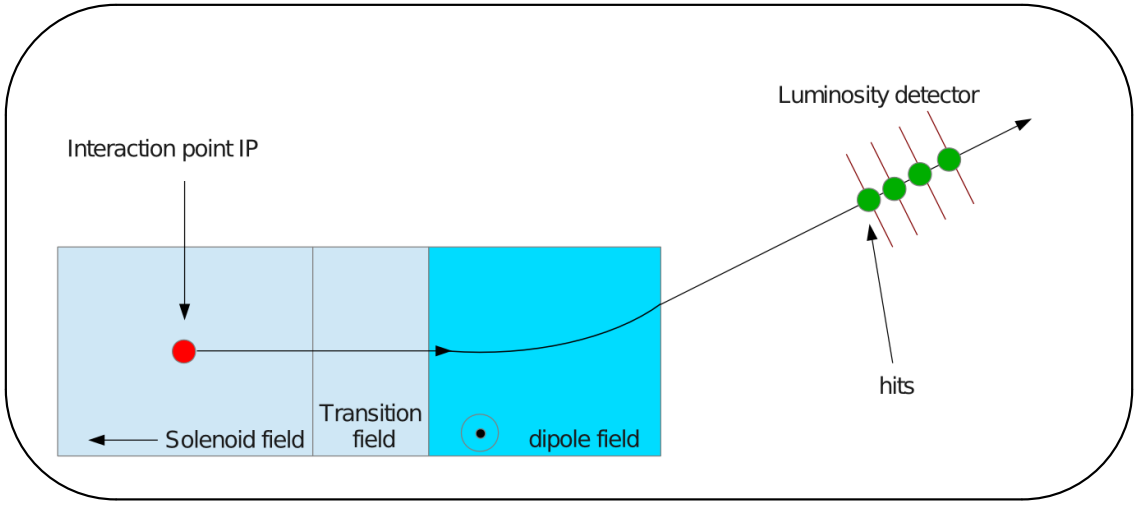
Hit reconstruction

Track search

Track fit

Back propagation to IP

Luminosity fit



Back propagation from LMD (short history)

GEANE

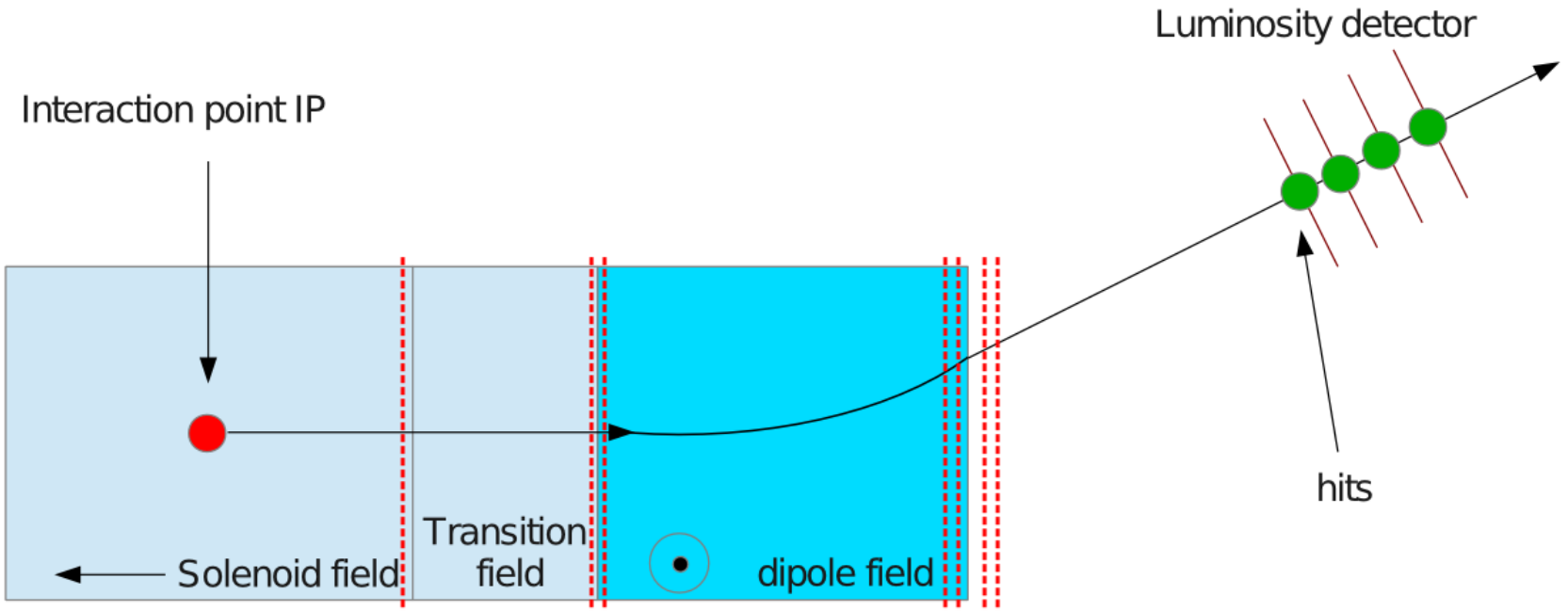
- Was the only one option before Apr.2013
- Problems with error propagation
- Strange behavior for parameters propagation (Different for different beam momentum $\Rightarrow$ wasn't clear is it GEANE problem or mag.field effect)

Runge-Kutta

- New option since Apr.2013
- Reason for systematic effects was found quite fast
- Result of error propagation looks strange

Tomorrow more detailed talk on computing session

Trick for back propagation with Runge-Kutta in LMD usage



Step size with knowledge of magnetic field changes

Back propagation results

- Back propagation in one global step $\rightarrow$ shifted PCA
  Geane: due to large bending angle (20°)
  Runge-Kutta: due to large step size ($\sim$ 100 cm)

- Change number of global steps
  $\rightarrow$ shifts aren't so significant in both cases

σ_{pull} ($P_{beam} \geq$ 4.06 GeV/c)

- Geane:
  $\sigma_{pull}^{PCA} \sim 0.8$ $\sigma_{pull}^{Px,Py} \sim 0.9$
  $\sigma_{pull}^{Pz} \sim 0.1$
  (errors overestimation)

- RK:
  $\sigma_{pull}^{PCA} \sim 1.5$ $\sigma_{pull}^{Px,Py} \sim 0.9$
  $\sigma_{pull}^{Pz} \sim 1$
  (errors underestimation for PCA)

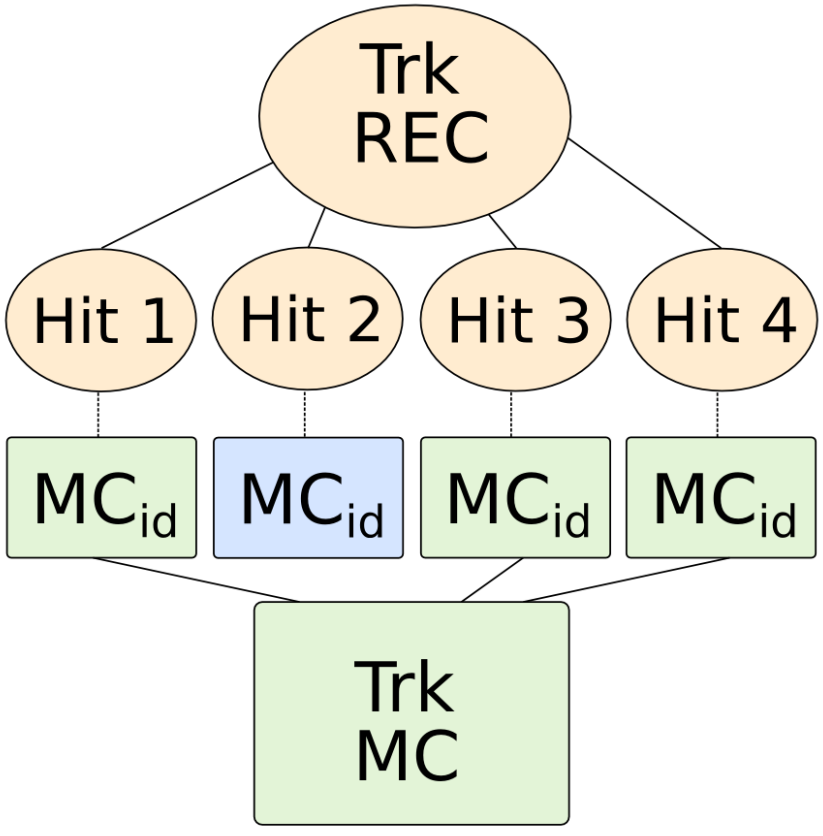
σ_{pull} ($P_{beam} =$ 1.5 GeV/c)

- Geane:
  $\sigma_{pull}^{x} \sim 0.8$ $\sigma_{pull}^{y,z} \sim 0.6$
  $\sigma_{pull}^{Px} \sim 1.3$ $\sigma_{pull}^{Py} \sim 1$
  $\sigma_{pull}^{Pz} \sim 0.1$
  (errors overestimation for PCA)

- RK:
  $\sigma_{pull}^{x} \sim 1.5$ $\sigma_{pull}^{y,z} \sim 1.2$
  $\sigma_{pull}^{Px} \sim 1.4$ $\sigma_{pull}^{Py} \sim 1.1$
  $\sigma_{pull}^{Pz} \sim 1.2$
  (errors underestimation for PCA)

PndLmdTrkQTask

Assignment of reconstructed tracks to simulated (good/ghost/missed)



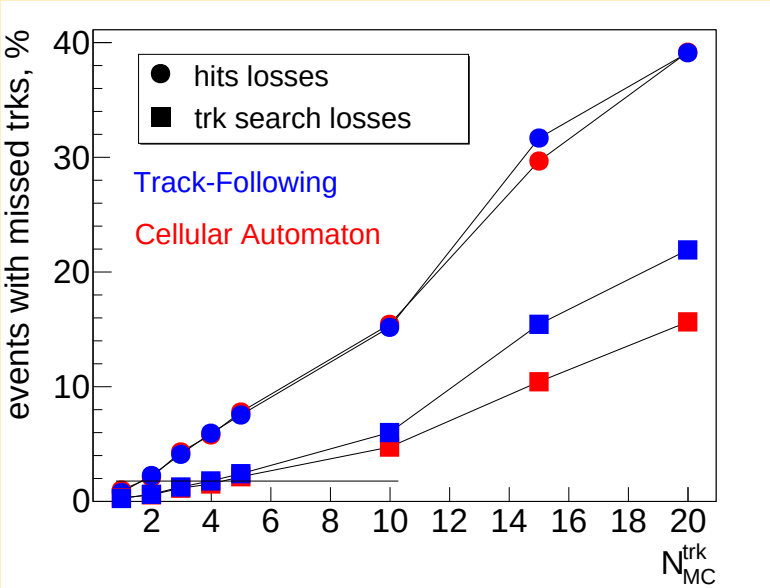
PndLmdTrackQ

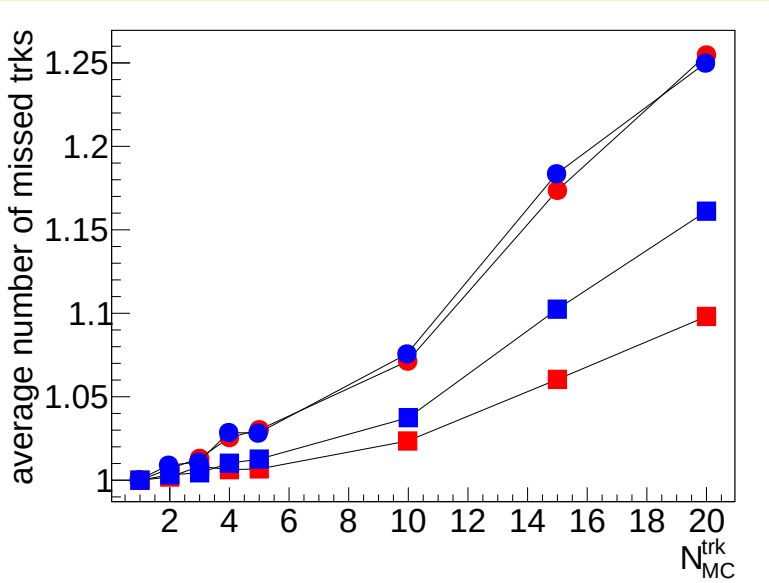
contains true & reconstructed information
(with trk quality flag → reason for ghost/missed)

Missed & Ghost tracks ($2 \cdot 10^5$ events)

Definitions

- *good* contains 65% hits from one MC track
- *missed* wasn't found
- *ghost* was found twice or contains mixture of hits





Number of ghost tracks is exactly 0

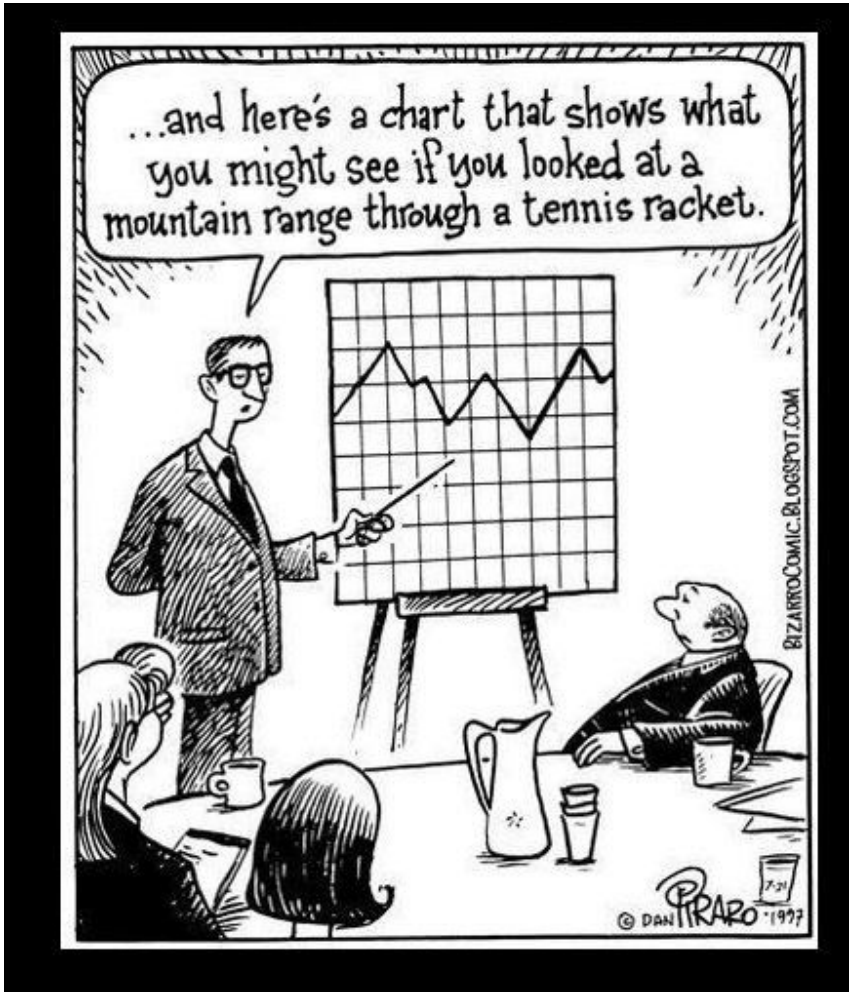
Conclusion

- Cellular Automaton was tuned and tested
- Cuts on tracks before back propagation is moved to track filter task
- Runge-Kutta algorithm from GenFit
  - tested for Kalman Filter and back propagation (additional option to GEANE)
- Back propagation now is done in 7 global steps
  - Parameters propagation is OK for both ☺
  - Error propagation isn't ☹

Plans

- Finalize track reconstruction performance study
- Modules alignment
  (technique approval, limits test)
- Background studies
  (cuts efficiency, influence of beam smearing)

Thank you for attention!

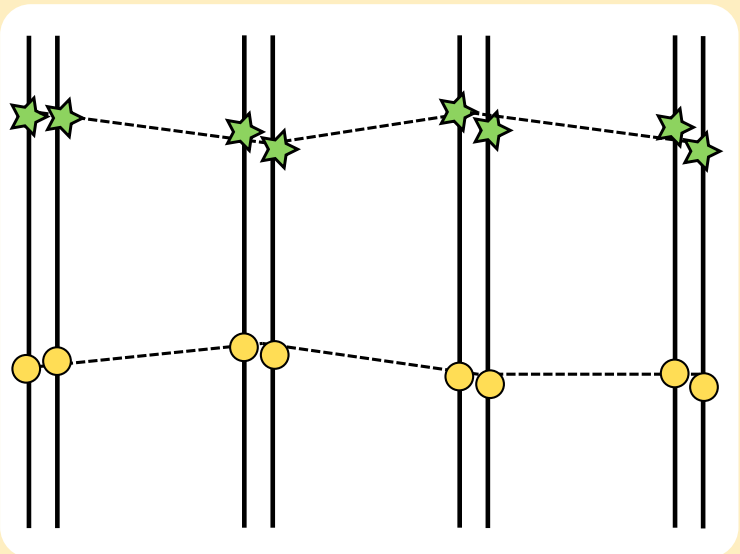


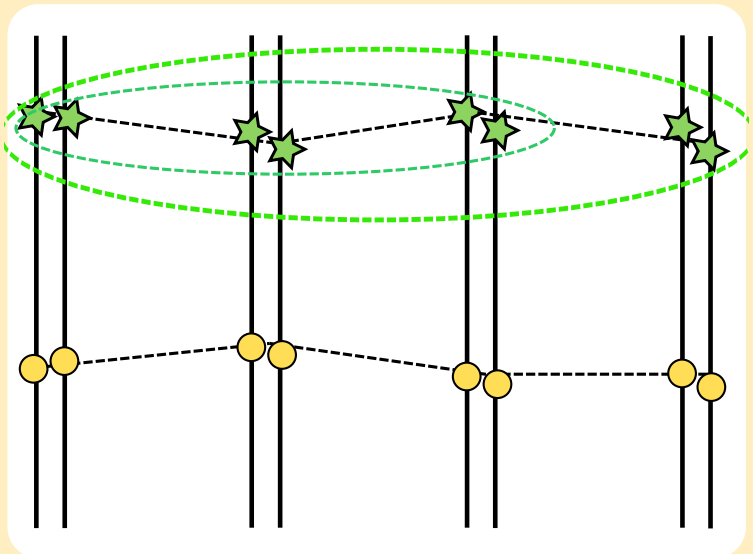
Ghost tracks

Possible reasons to add a track

- double track reconstruction (Ex.1,2)
- wrong hit combination reconstruction (Ex.3)

Example 1





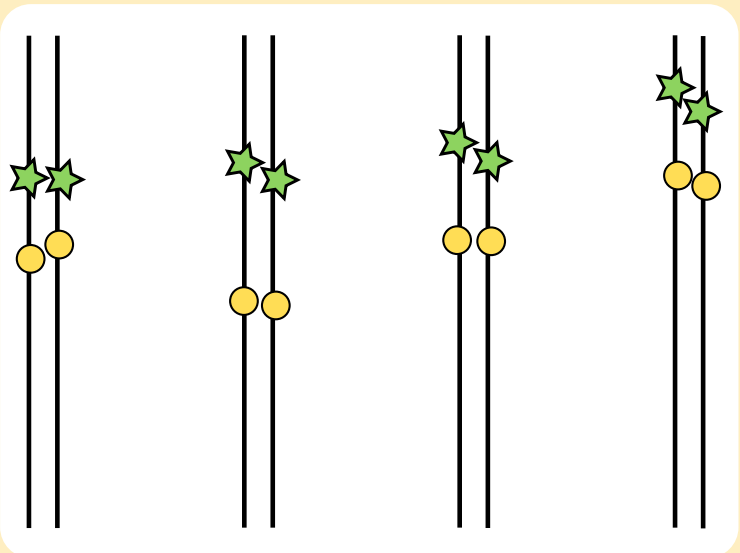
- Prevented by Track Filter task ($2 \geq$ common hits $\rightarrow$ trk with max $\sharp$*hits* or min χ^2)

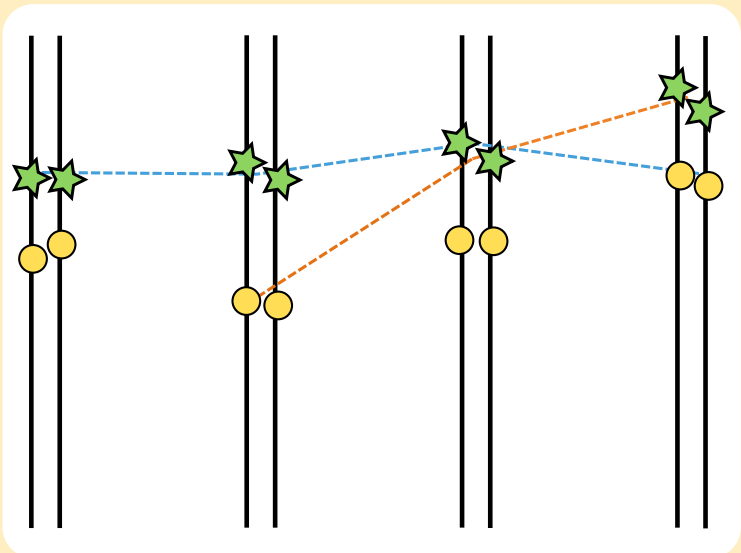
Ghost tracks

Possible reasons to add a track

- double track reconstruction (Ex.1,2)
- wrong hit combination reconstruction (Ex.3)

Example 2





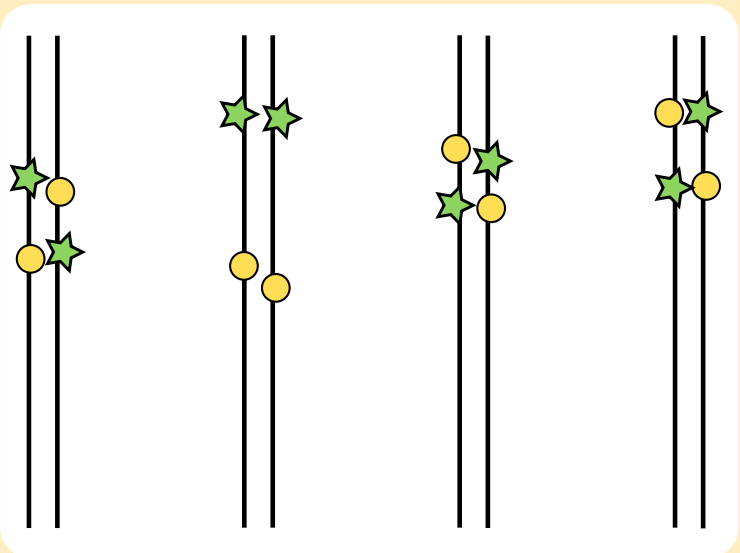
- Can't be resolved by Track Filter task, because there is no 2 $\geq$ common hits

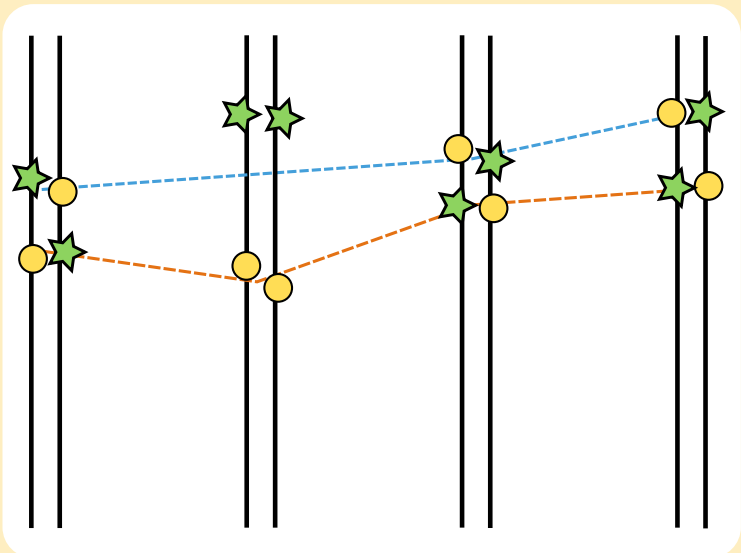
Ghost tracks

Possible reasons to add a track

- double track reconstruction (Ex.1,2)
- wrong hit combination reconstruction (Ex.3)

Example 3





- Blue and orange tracks will be marker as *ghost* (from MC: green and yellow are *missed*)

Missed tracks

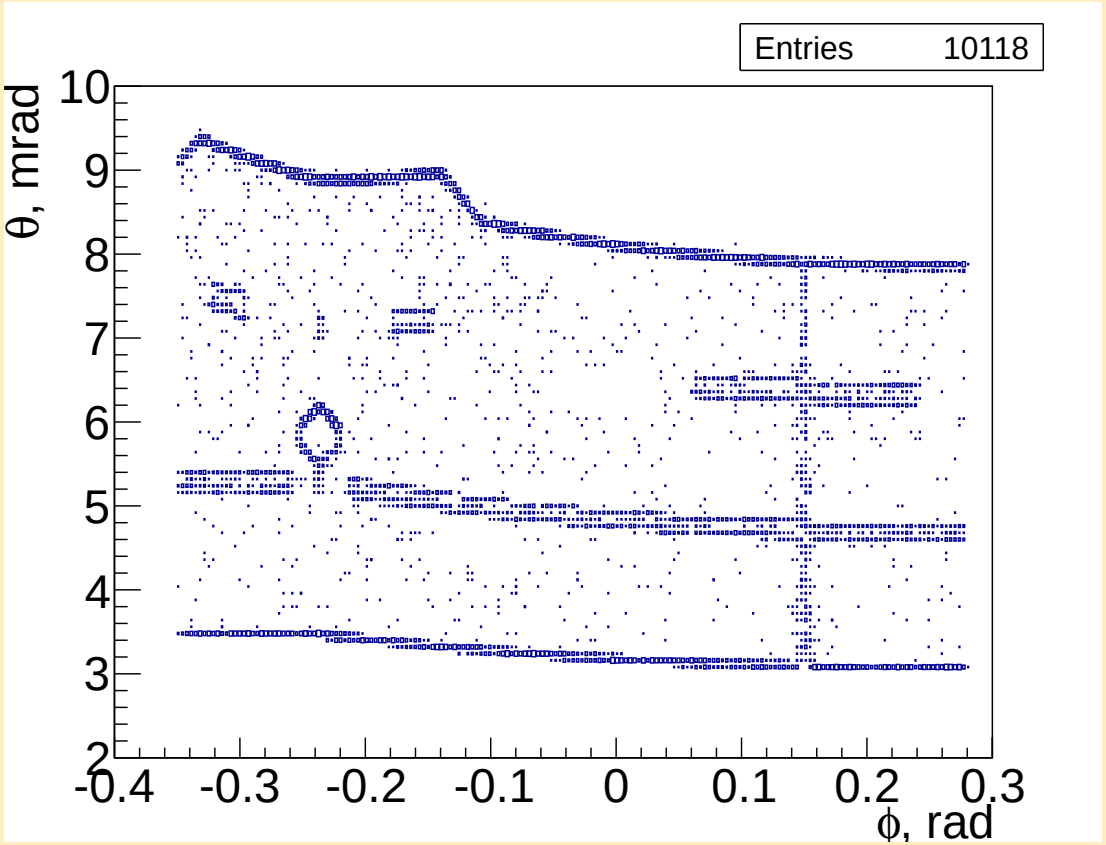
Possible reasons to loss a track

- Small amount of hits $\rightarrow$ min 3 hits for trk-search
- losses during tracks search
- Cut on trk-candidate
- losses during back-propagation

So far there is no cuts on back propagated tracks

1.5 GeV/c, $\delta\psi$=5·10^{-6}: Missed trks

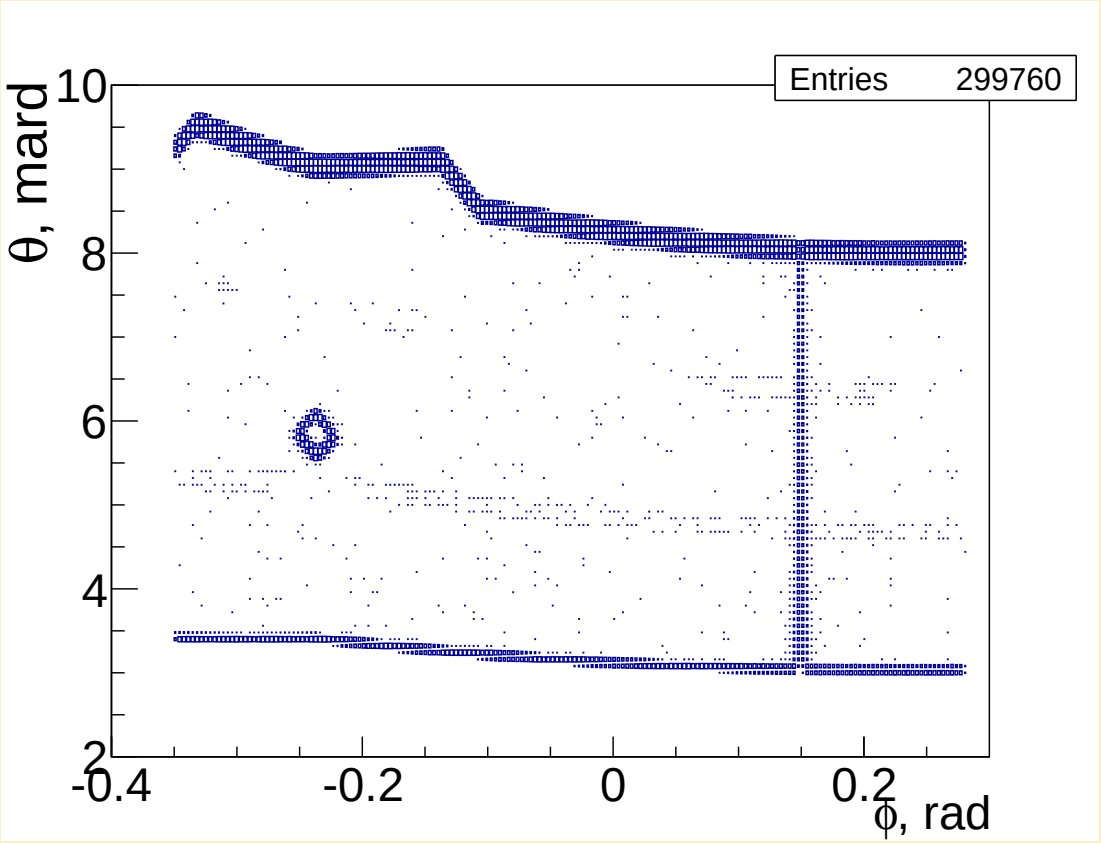
10 trks/ev, 10^6 events



- trk search losses

1.5 GeV/c, $\delta\psi$=5·10^{-6}: Missed trks

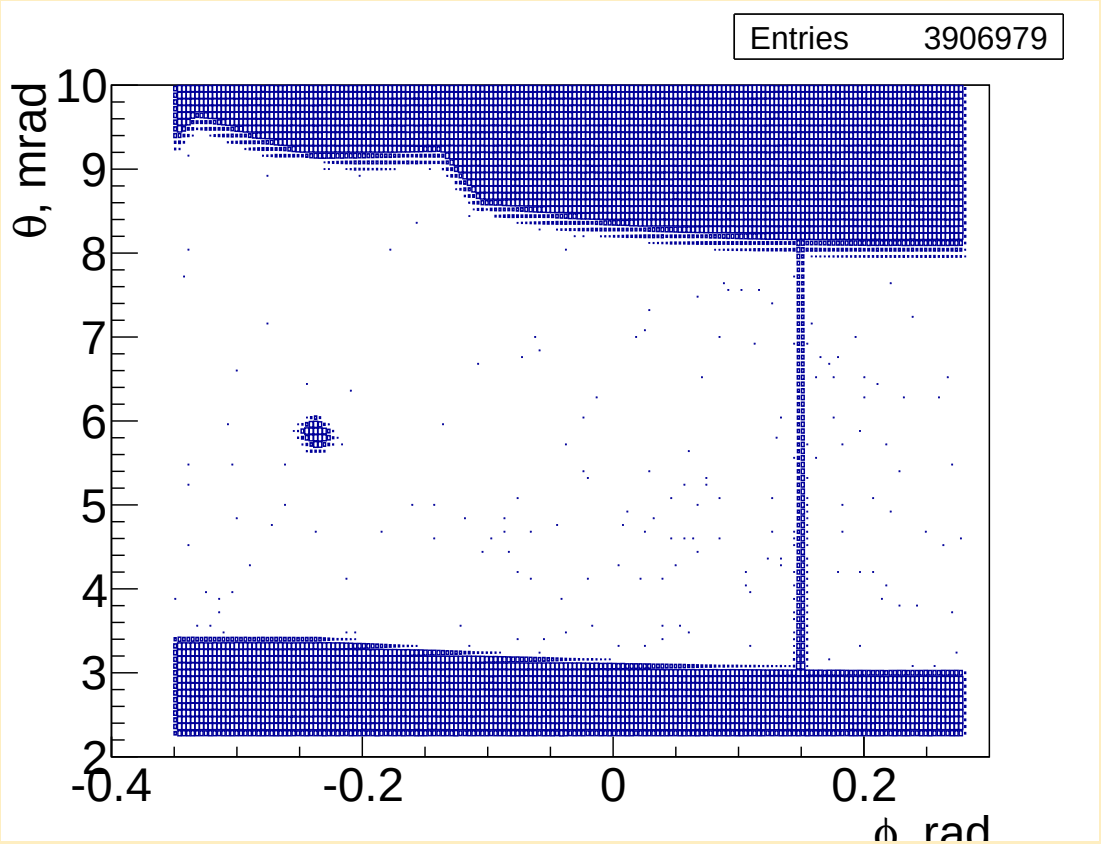
10 trks/ev, 10^6 events



- at least one MC hit

1.5 GeV/c, $\delta\psi$=5·10^{-6}: Missed trks

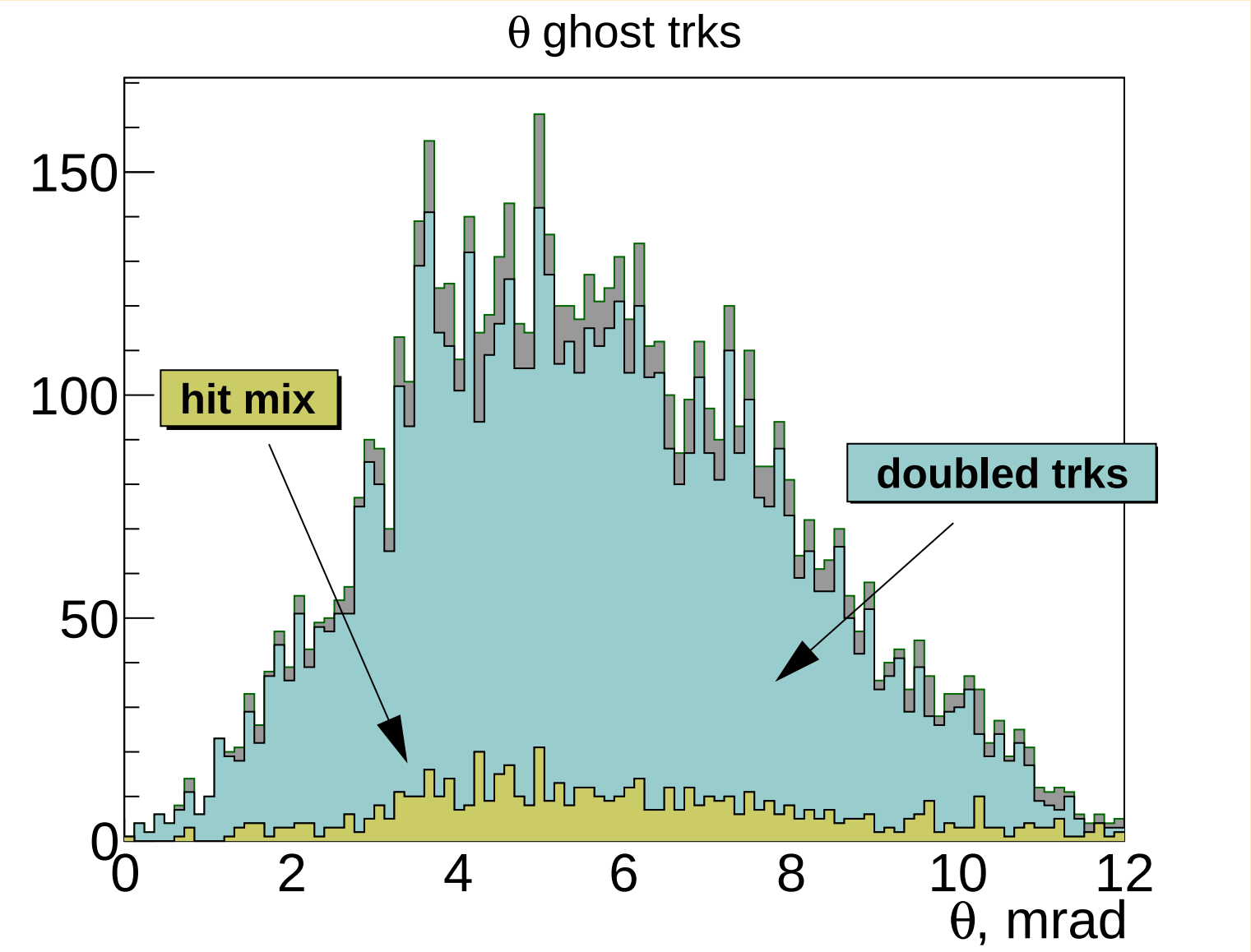
10 trks/ev, 10^6 events



- no MC hits

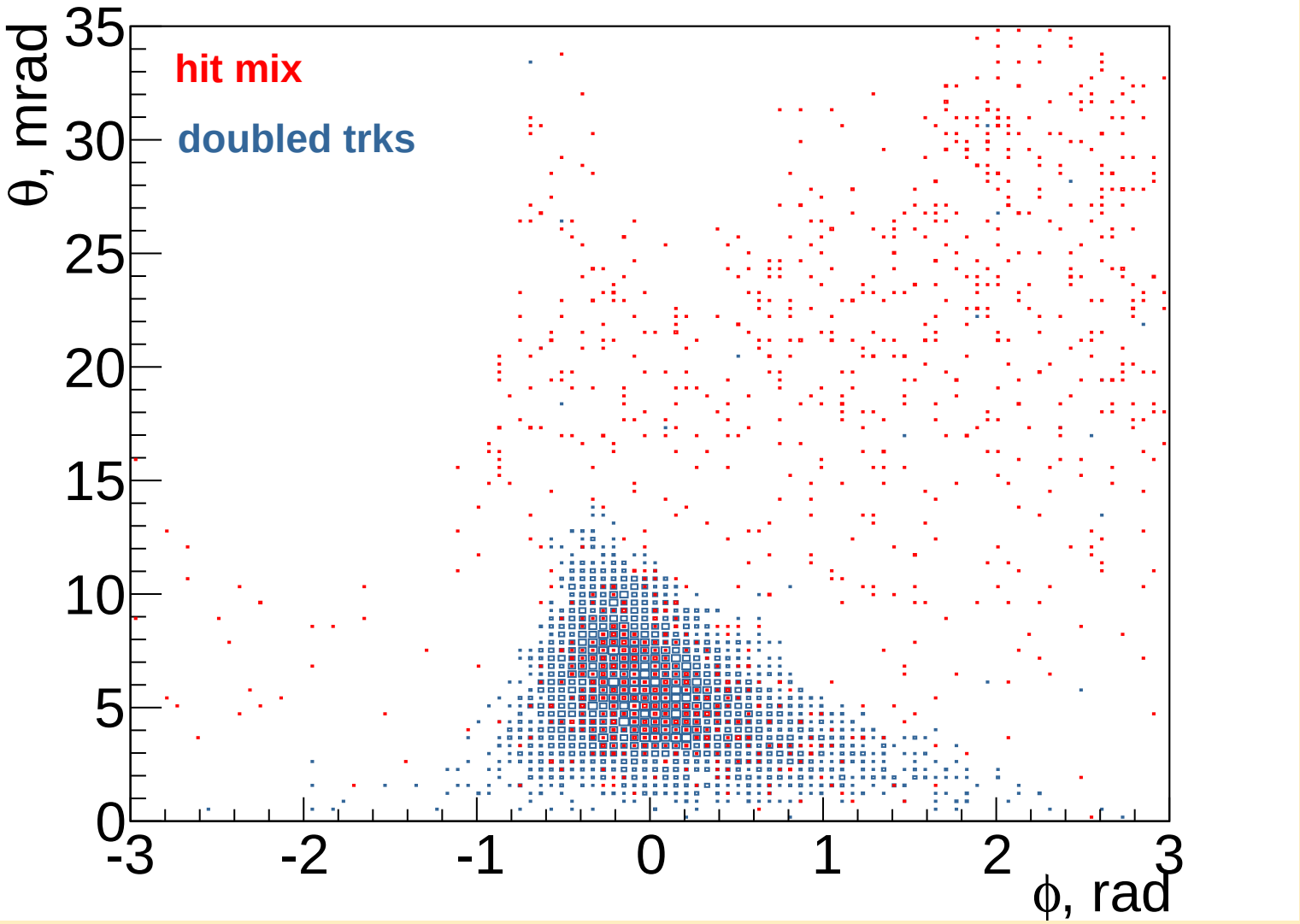
1.5 GeV/c, $\delta\psi$=5·10^{-6}: Ghost trks

10 trks/ev, 10^6 events

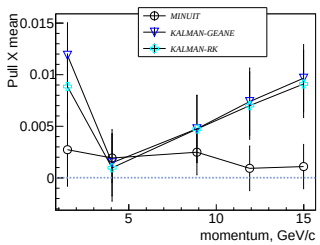


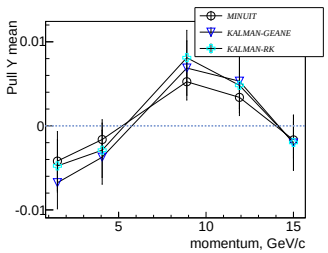
1.5 GeV/c, $\delta\psi$=5·10^{-6}: Ghost trks

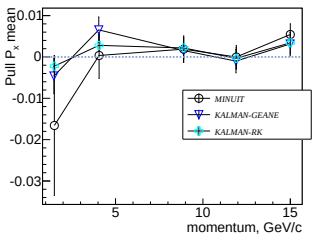
10 trks/ev, 10^6 events

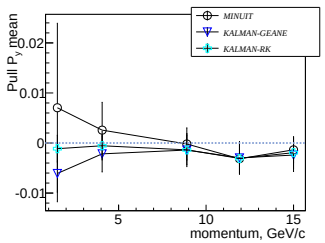


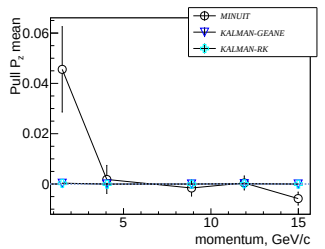
Pulls of variables after track fit

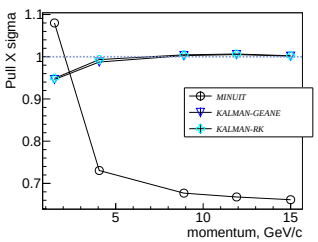


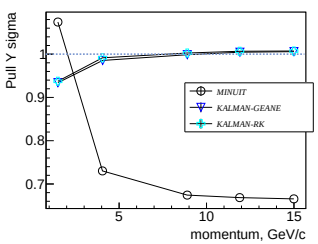


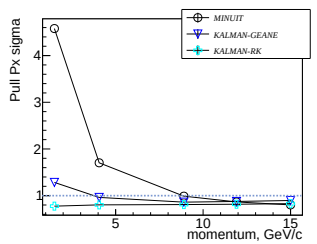


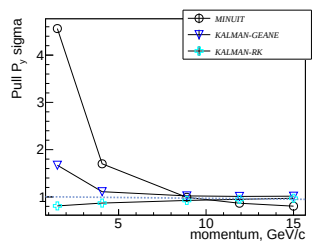


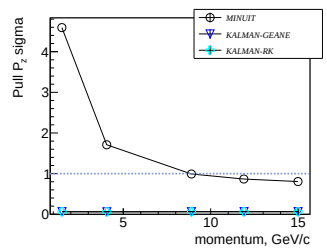






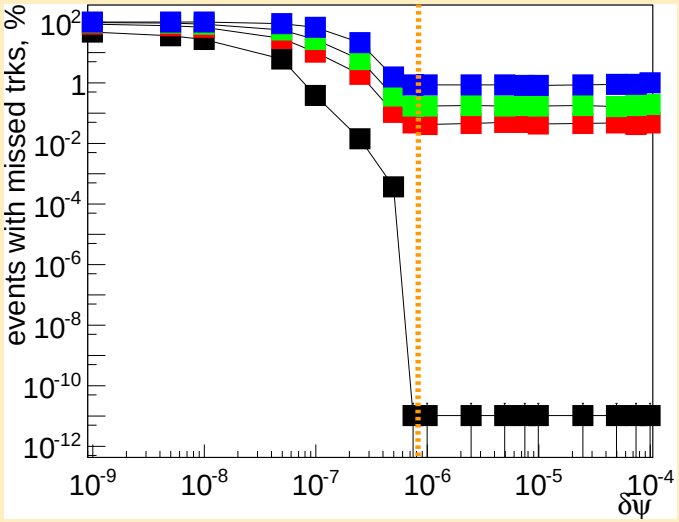


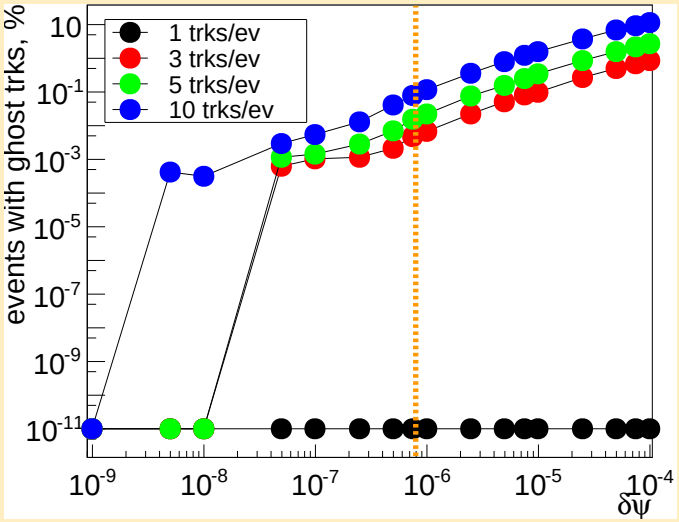




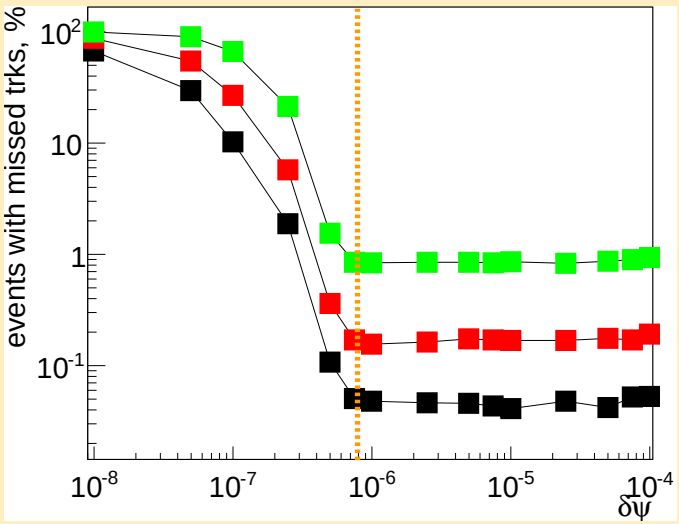
$\delta\Psi$ determination (10^6 events)

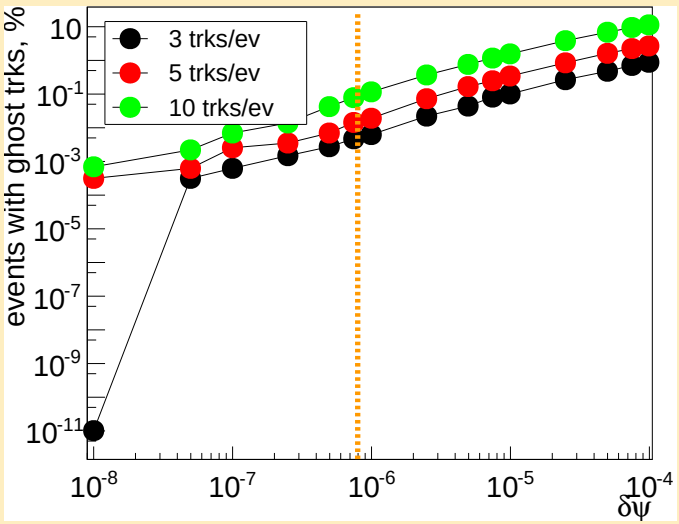
15 GeV/c





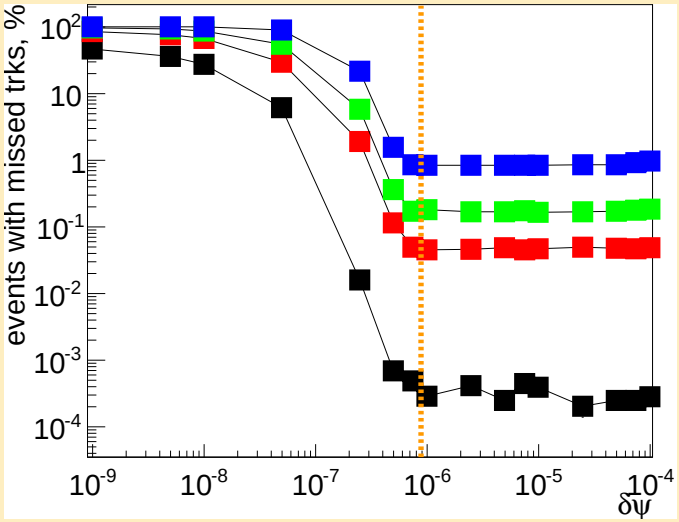
11.91 GeV/c

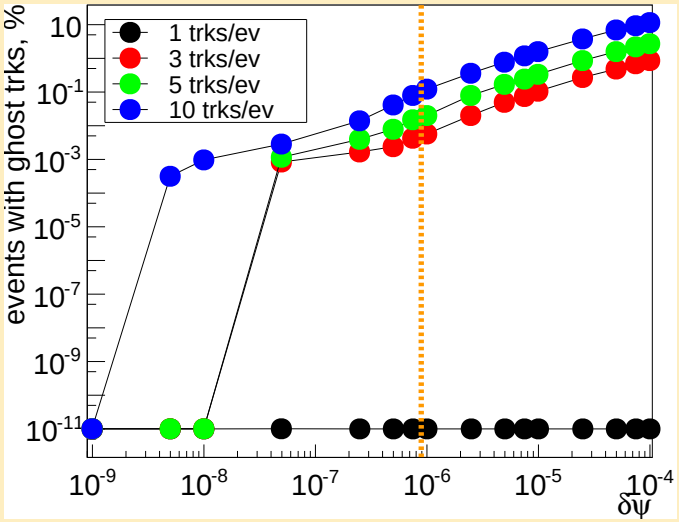




$\delta\Psi$ determination (10^6 events)

8.9 GeV/c





4.06 GeV/c