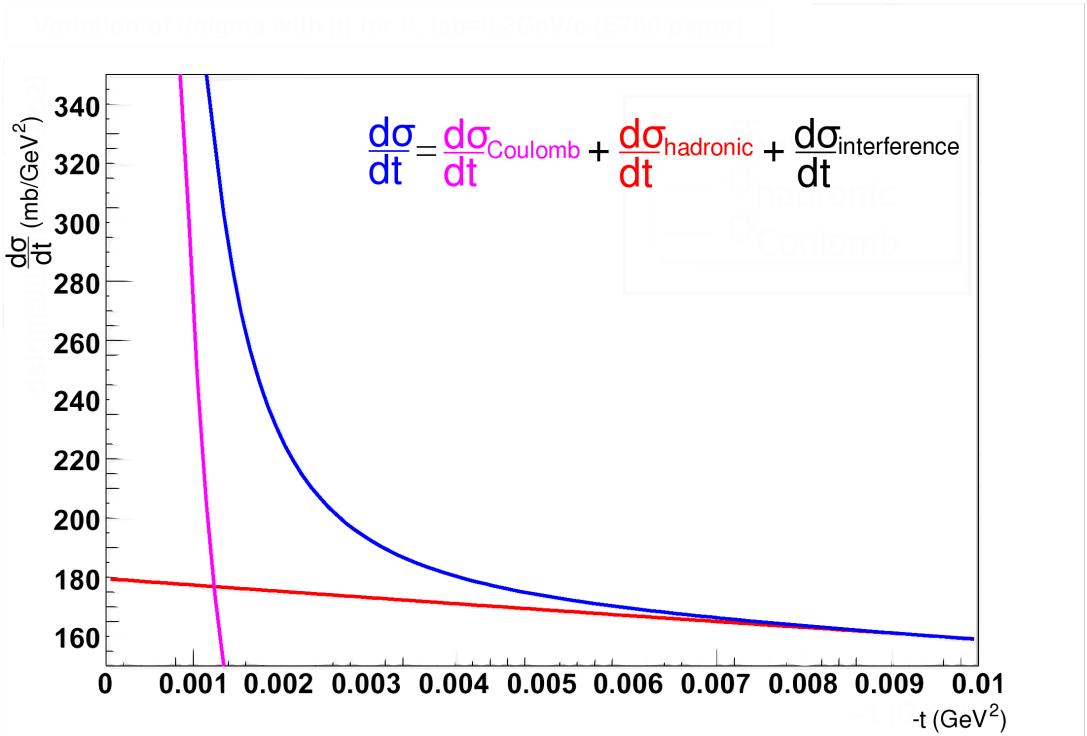
LMD results for back propagation

Anastasia Karavdina
on behalf of the Luminosity Detector group

KPH, Uni Mainz

26 June 2013

Reminder: L extraction from $p\bar{p}$ el. scattering

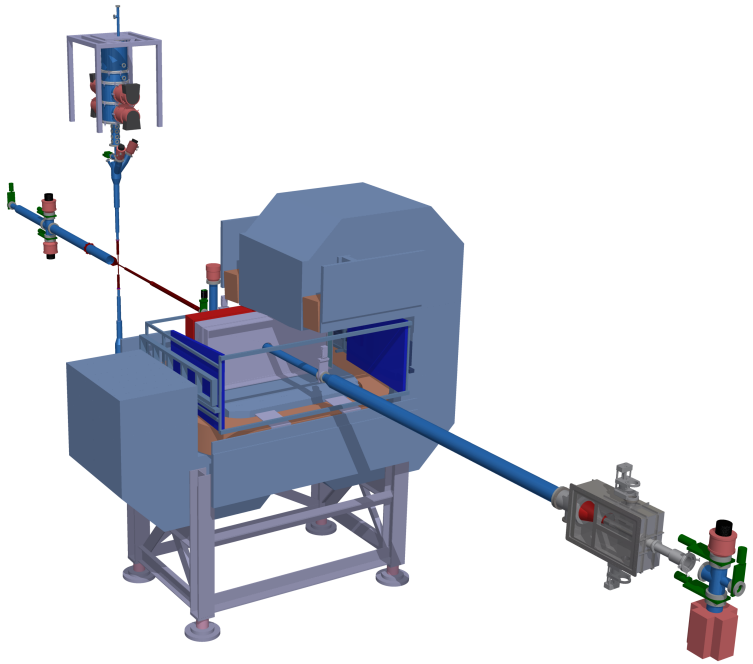


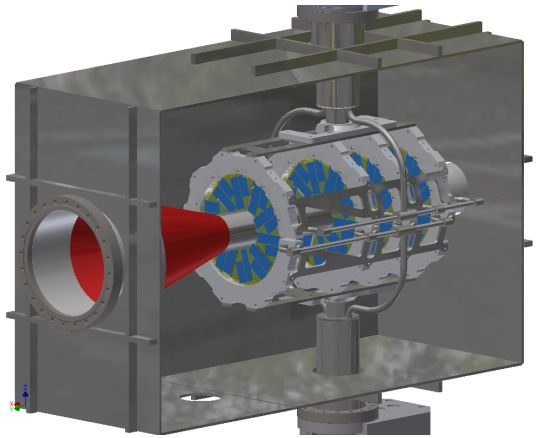
- coulomb part: can be calculated from QED
- hadronic part: measurement+models

measurement at small momentum transfer
$t = 2p_{CM}^2(1 - cos\theta_{cm}) \rightarrow$ small θ (3-8 mrad)

Luminosity extraction by the fit of θ distribution

Reminder: LMD Design





- measurement at small θ (3-8 mrad)
- position downstream from IP ($\sim$ 11 m)
- placed inside vacuum box to minimize scattering of antiprotons

Track reconstruction chain

Hit reconstruction

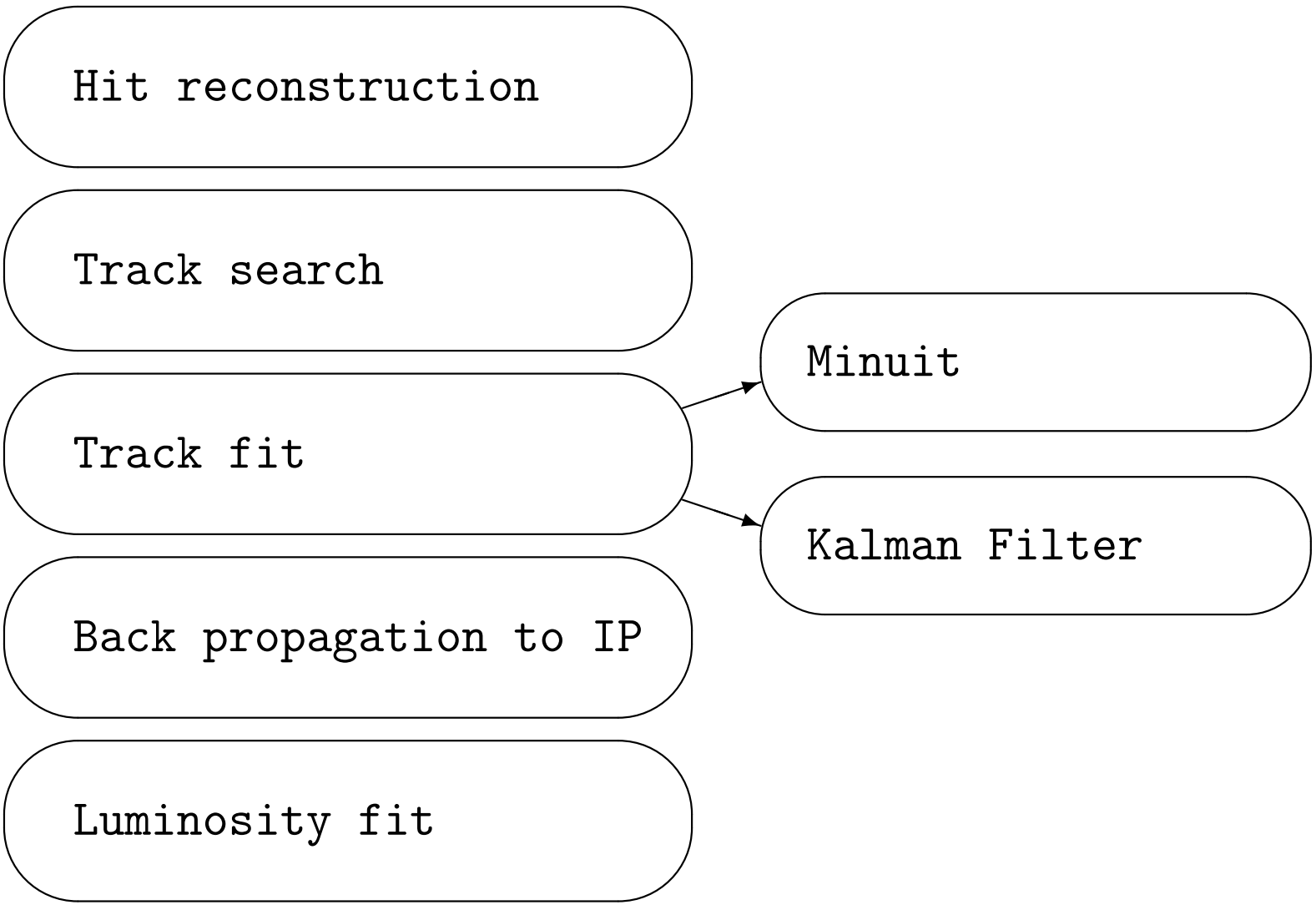
Track search

Track fit

Back propagation to IP

Luminosity fit

Track reconstruction chain



Track reconstruction chain

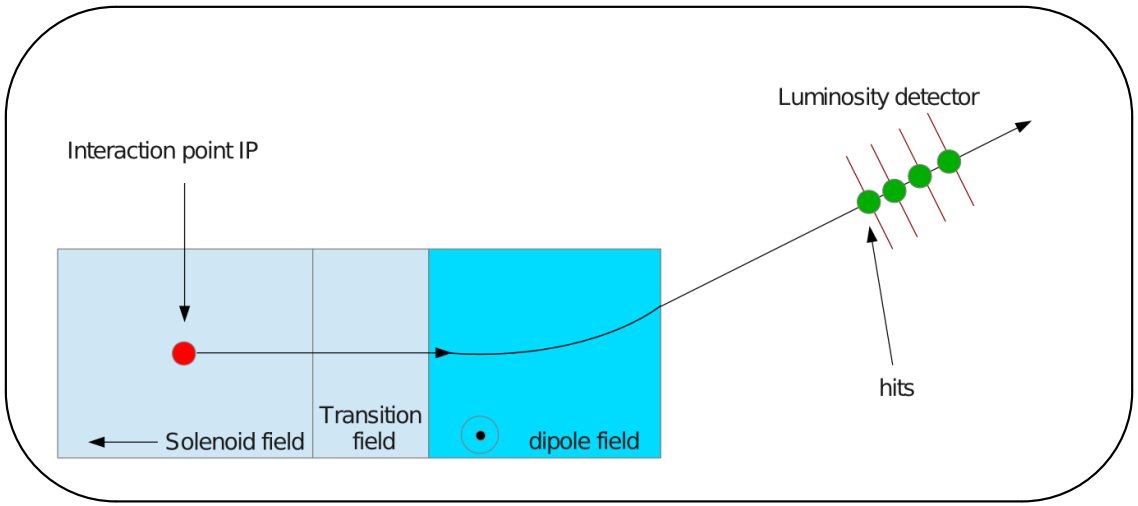
Hit reconstruction

Track search

Track fit

Back propagation to IP

Luminosity fit



Back propagation from LMD (short history)

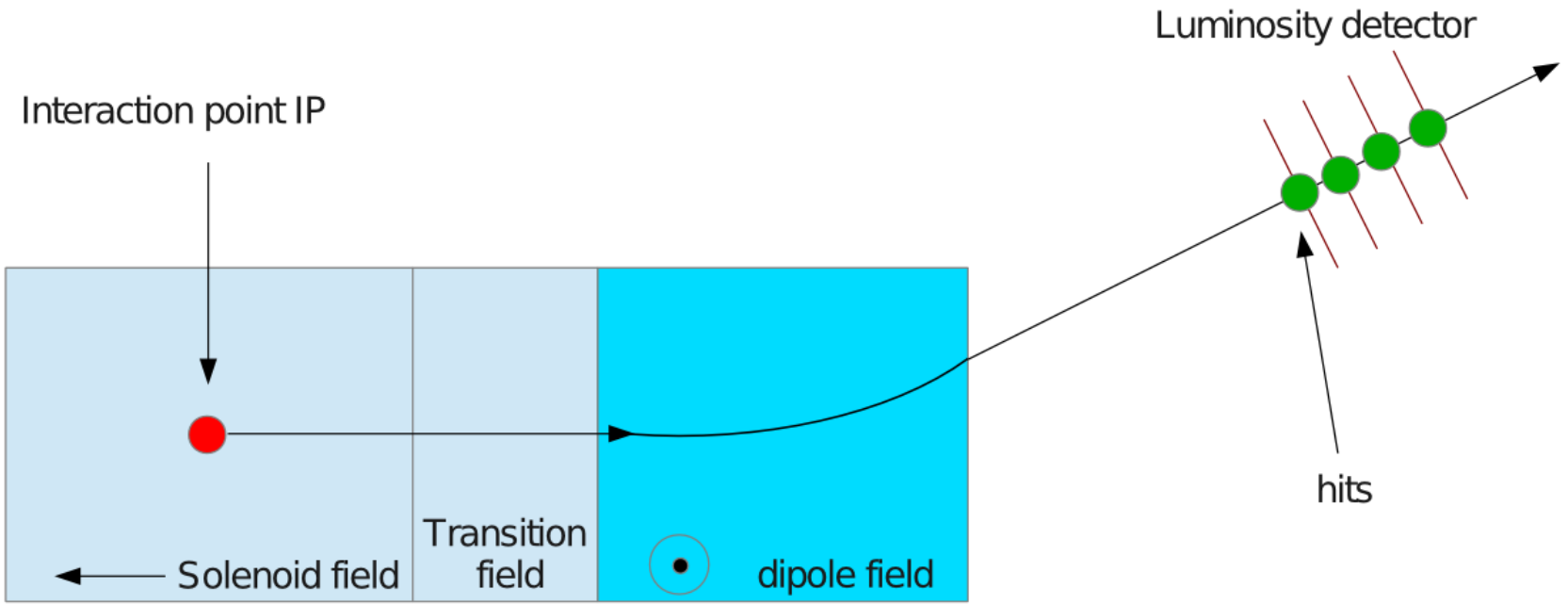
GEANE

- 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

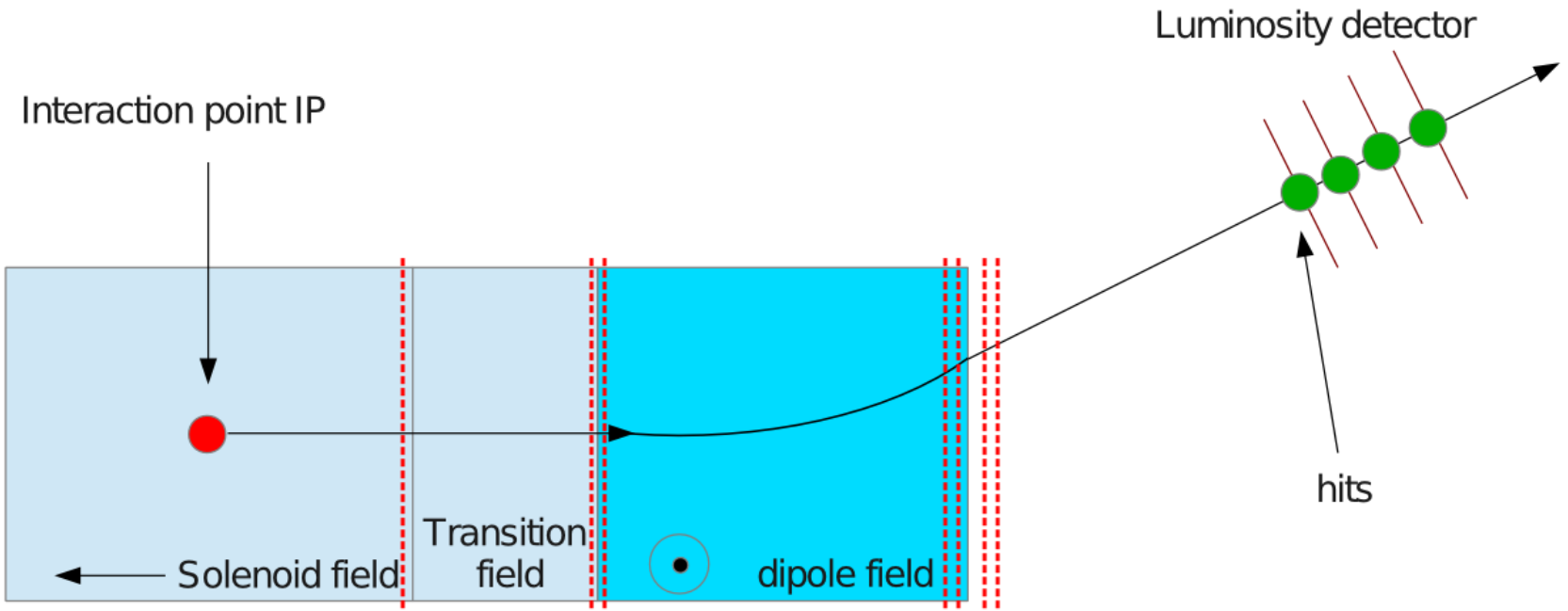
- New option since Apr.2013
- Reason for systematic effects was found quite fast
- Result of error propagation looks strange

Trick for Runge-Kutta in LMD usage



Step size with knowledge of magnetic field changes

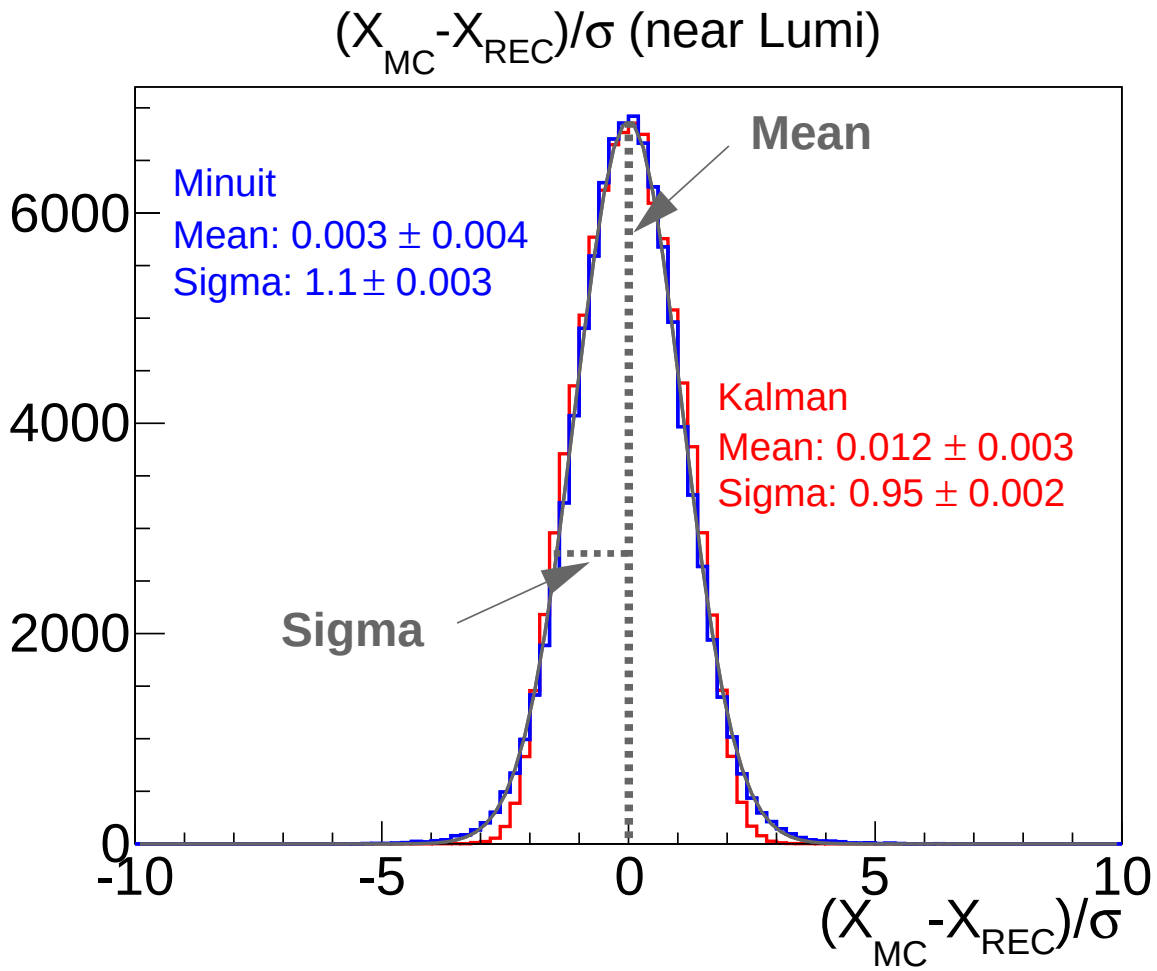
Trick for Runge-Kutta in LMD usage



Step size with knowledge of magnetic field changes

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

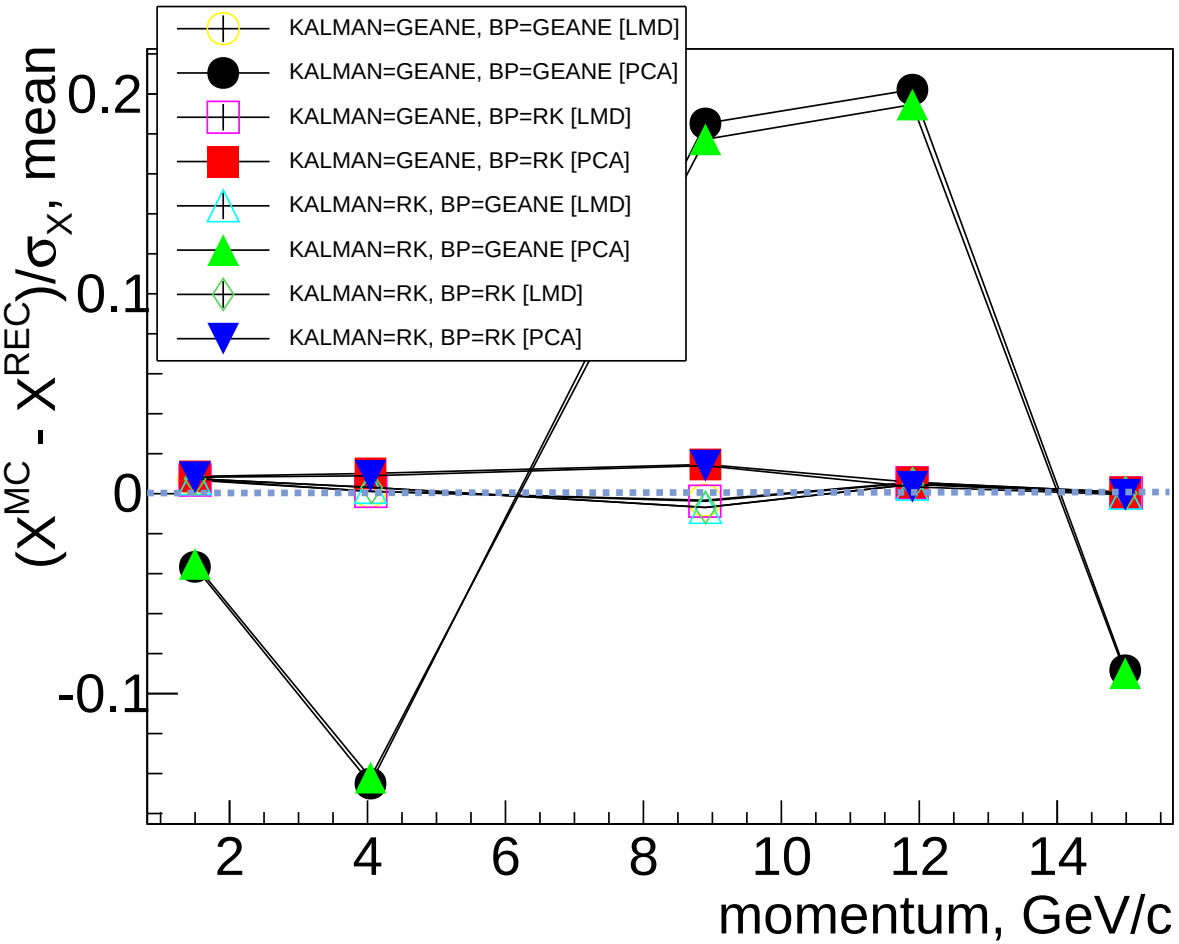
example: pull X_{trk} before back propagation, 1.5 GeV/c



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

BP with GEANE in one step

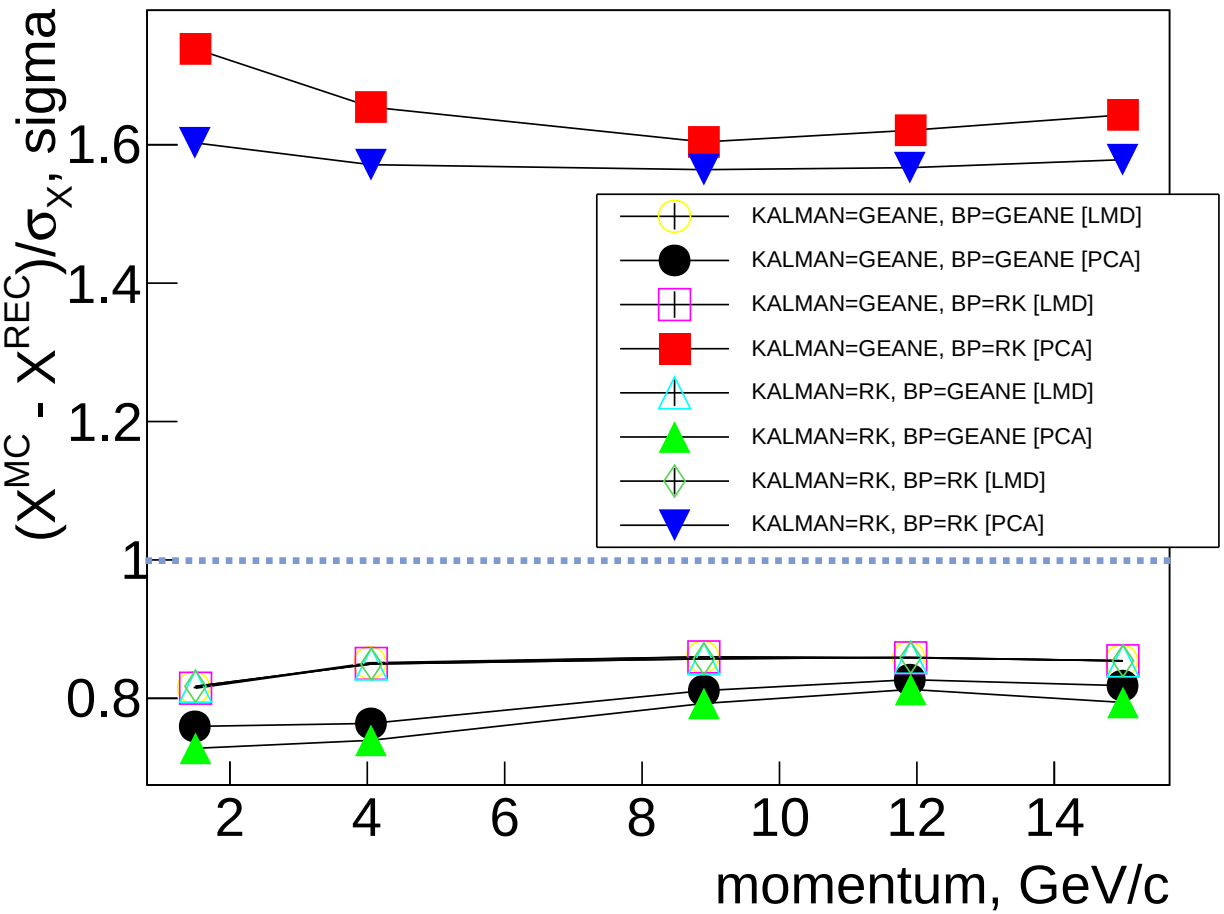
pull X_{PCA}, mean value



For diff. energies GEANE has diff. systematic shifts

BP with GEANE in one step

pull X_{PCA}, sigma value

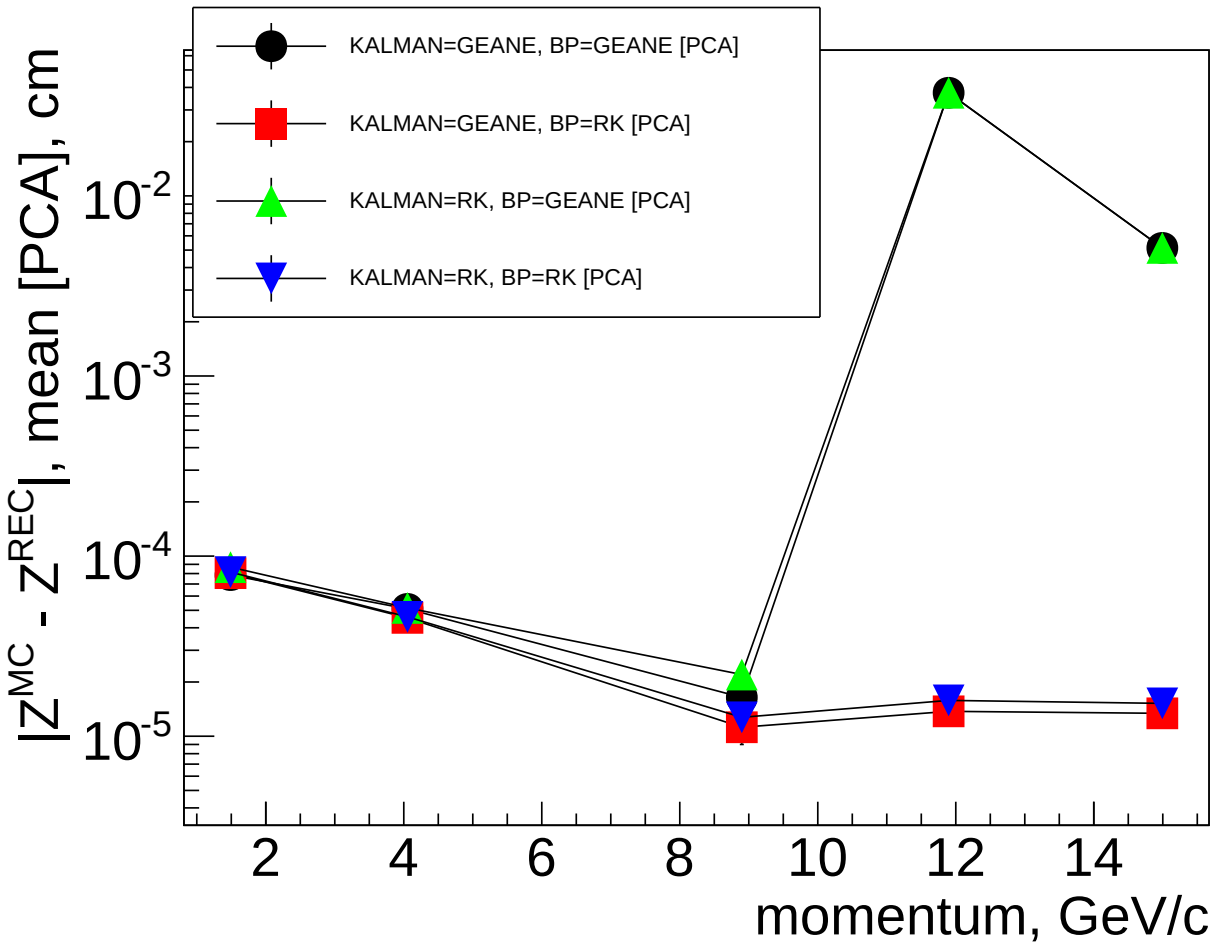


GEANE overestimates errors

Runge-Kutta underestimates them

BP with GEANE in one step

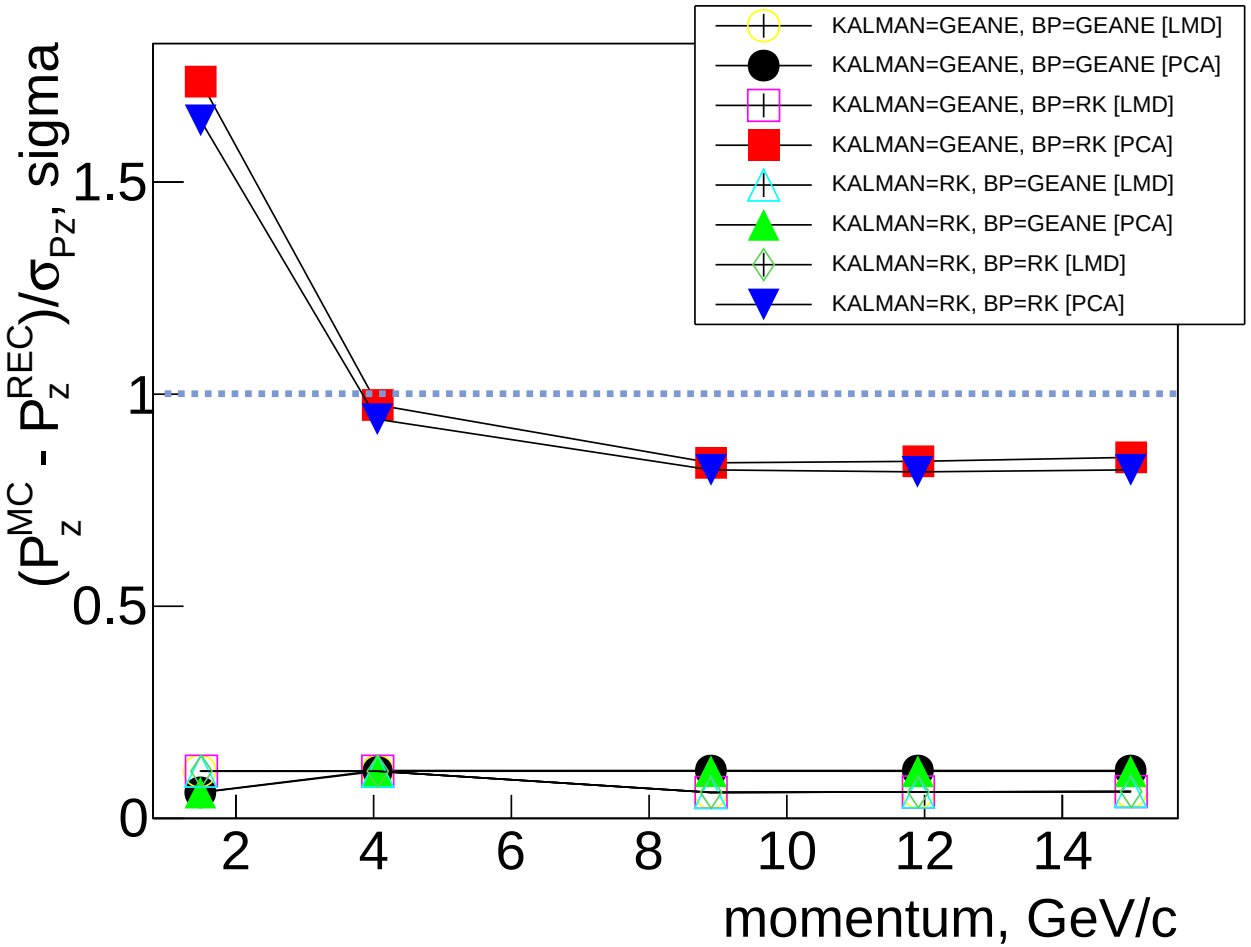
diff. $Z_{MC} - Z_{REC}$, mean value



11.91 GeV/c and 15 GeV/c:
GEANE gives shift $\sim$ 100 μm

BP with GEANE in one step

pull P_Z, sigma value



GEANE overestimate errors

And much more plots tell us...

- With such approach GEANE has problem with parameters propagation
- PCA is shifted!
- But understanding step size isn't easy
  (Many thanks to *Lia Lavezzi* for helping us with GEANE, including explanation parameters list)

GEANE (external) params for step

Name	Meaning	Value
tmaxfd	max. angular deviation due to field	-1
stemax	max. step size	-1
deemax	max. fractional energy loss	-1
epsil	precision in boundary crossing	0.001
stmin	min. step size	-1

(Value <0 means it will be calculated inside GEANE)

Possible tricks

Change GEANE

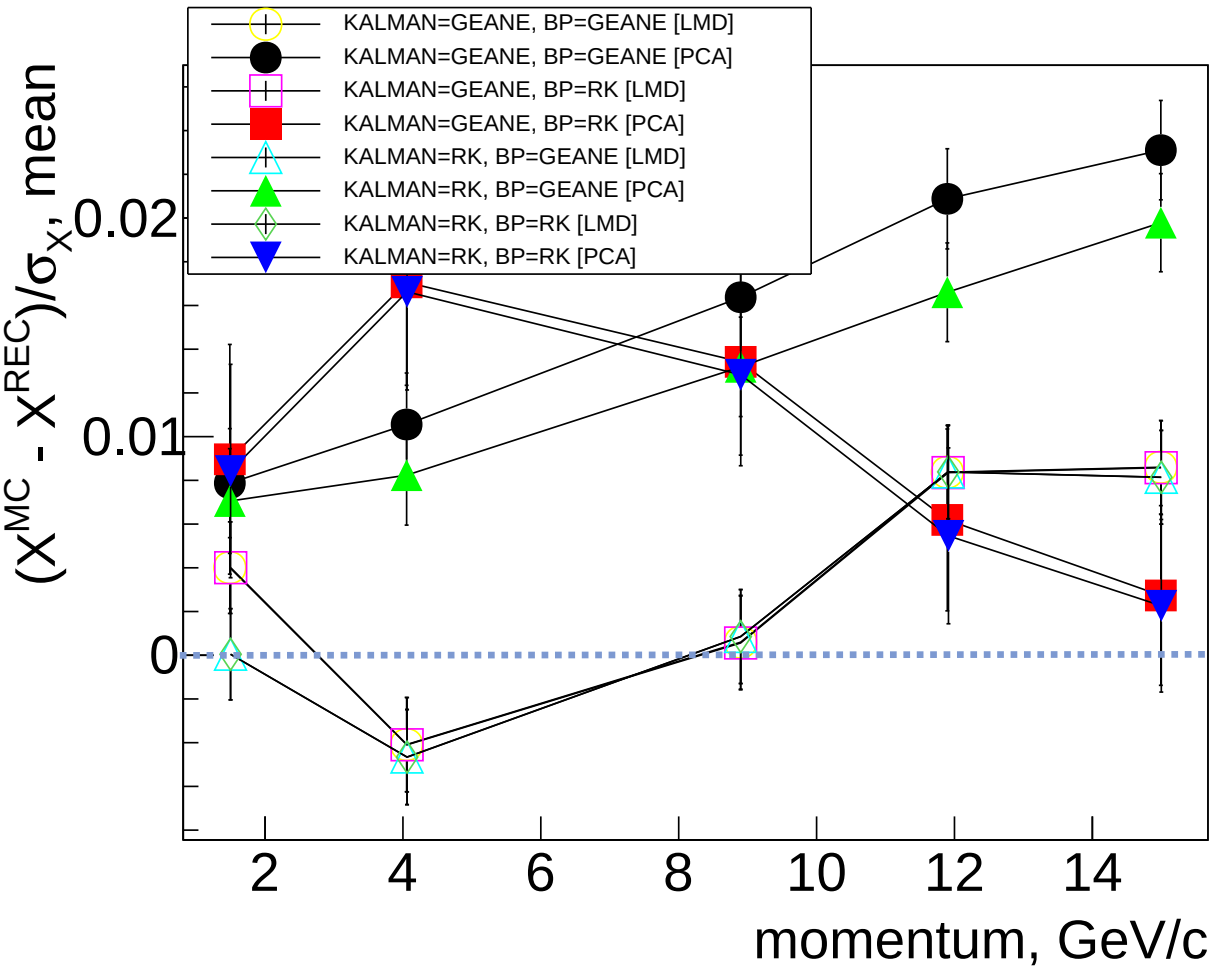
- Change the maximum bending angle allowed within one step (default 20°)
  $\rightarrow$ doesn't work without:
- Change MXNSTP=max.number of steps (default 1000)
  But it's internal parameter in Geant3 $\Rightarrow$ one has to touch external packages

Change approach to GEANE

- Divide 12m - 2m distance on 7 steps as it was done with Runge-Kutta

BP with GEANE in 7 steps

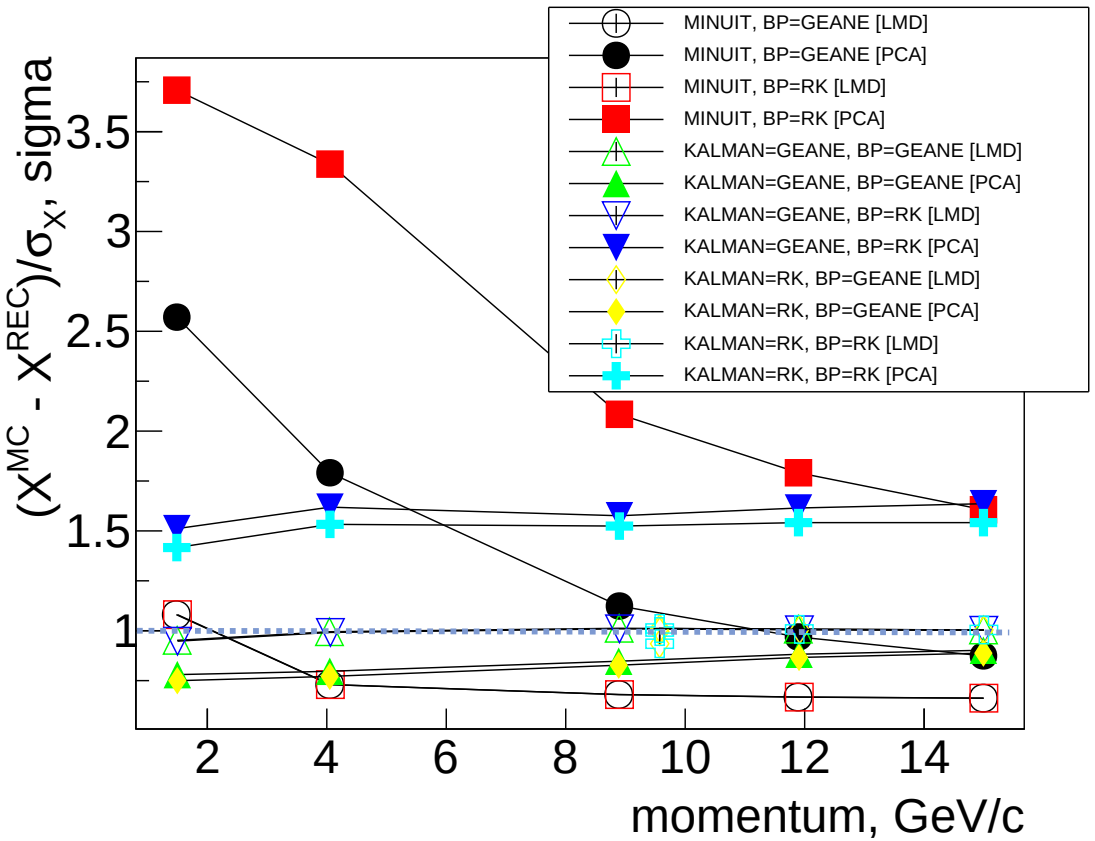
Pull X_{PCA}, mean value



Systematic shift after back propagation is smaller

BP with GEANE in 7 steps

Pull X_{PCA}, sigma value



Kalman

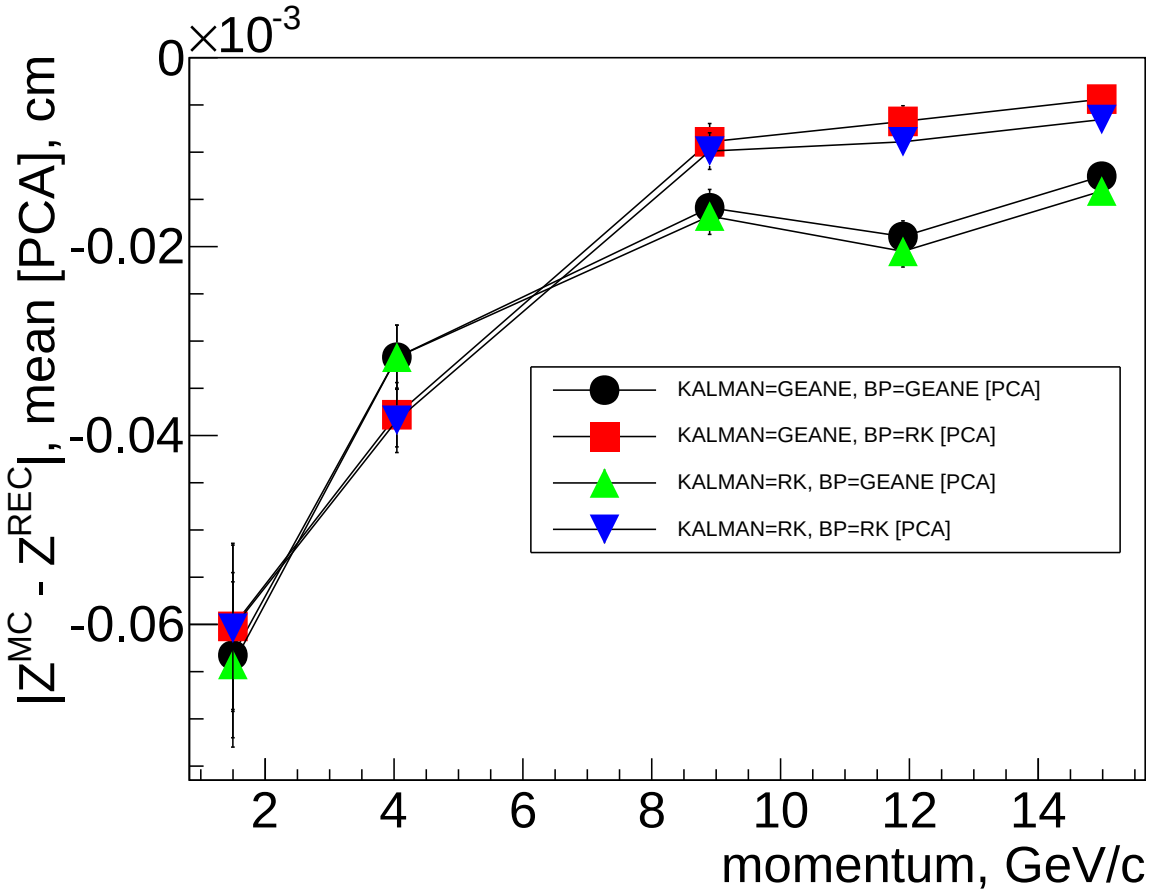
GEANE overestimates errors
Runge-Kutta underestimates
(As before)

Minuit

GEANE underestimates below 11 GeV/c
Runge-Kutta underestimates errors

BP with GEANE in 7 steps

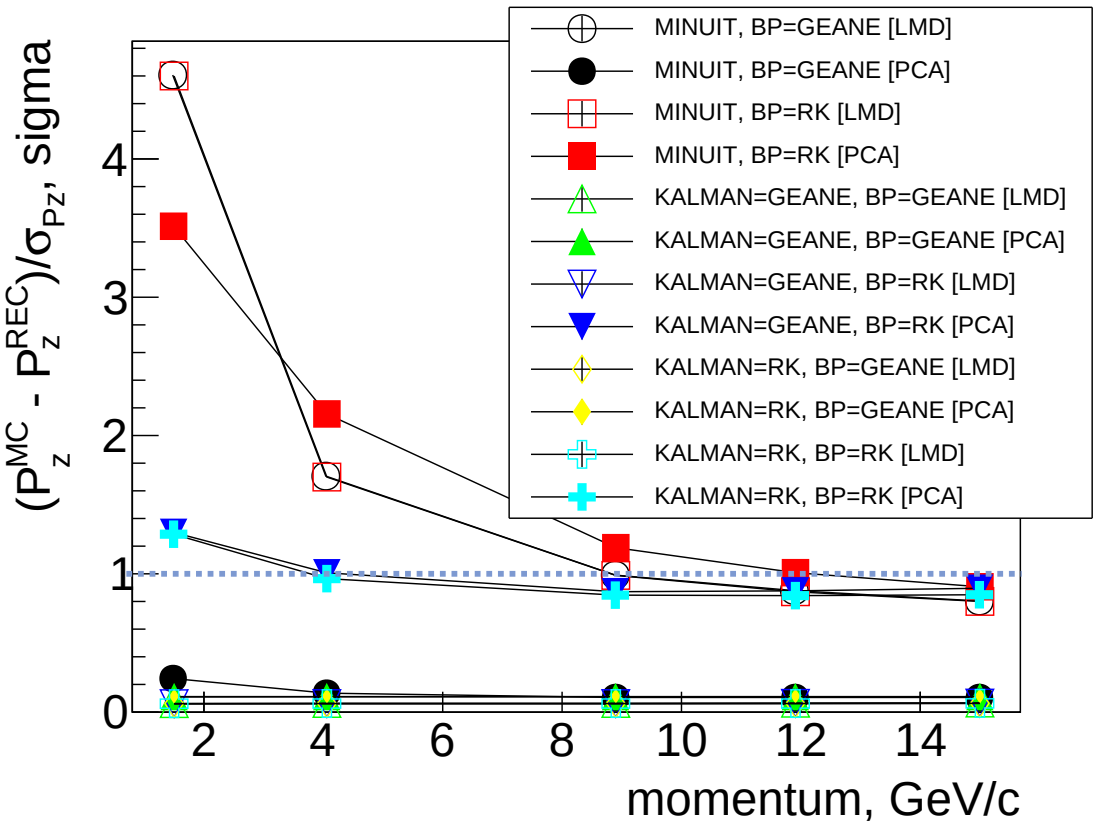
Diff. $Z_{MC} - Z_{REC}$, mean value



Systematic shift is below 1 μm

BP with GEANE in 7 steps

Pull P_Z, sigma value



Kalman

GEANE overestimates errors

Runge-Kutta slightly overestimates

(As before)

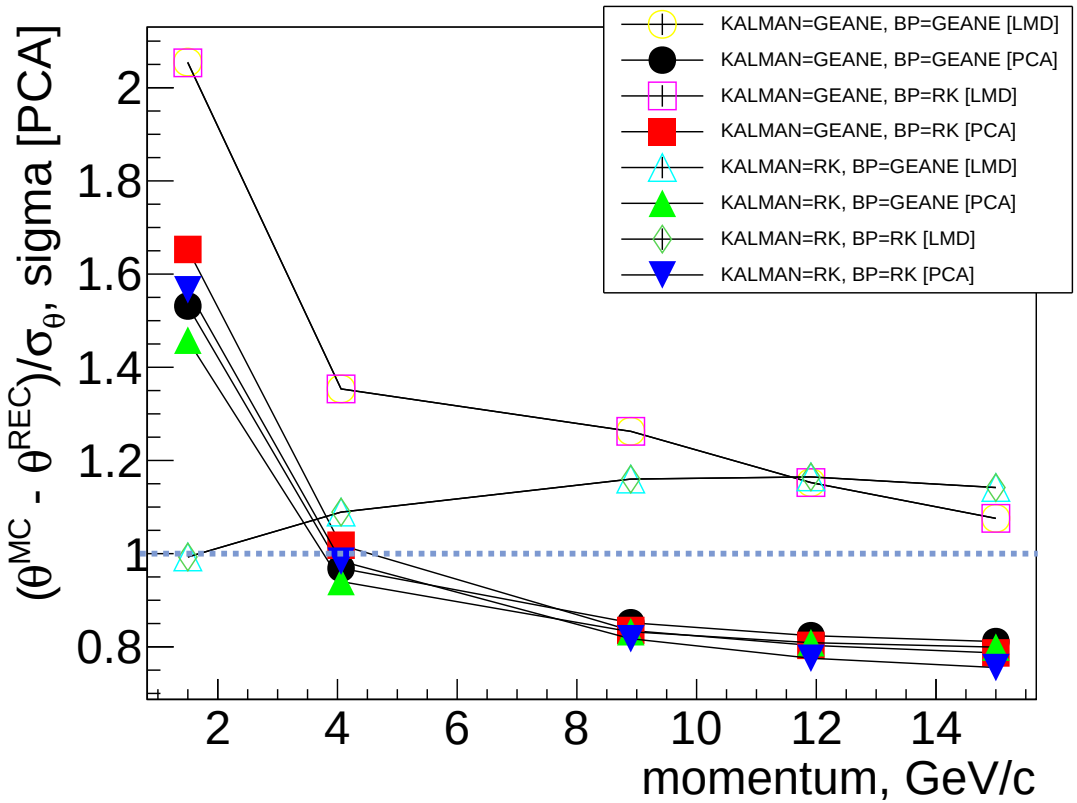
Minuit

GEANE overestimates errors

Runge-Kutta underestimates

BP with GEANE in 7 steps

Pull θ, sigma value



err P_z should directly participate in err θ calculation
Why err θ is OK, while err P_z is so overestimated ?

global steps vs. internal steps for Geane

parameters residuals

Global $\rightarrow$ 7 global steps, bending angle = 20°
Internal $\rightarrow$ 1 global step, bending angle = 0.01°

15 GeV/c	Global		Internal	
Param	Kalman	BP	Kalman	BP
x, cm	0	$2 \cdot 10^{-3}$	$5 \cdot 10^{-3}$	$3 \cdot 10^{-2}$
y, cm	0	10^{-4}	$-5 \cdot 10^{-3}$	$-5 \cdot 10^{-3}$
z, cm	ND	$-2 \cdot 10^{-5}$	ND	$-2 \cdot 10^{-2}$
px, MeV/c	$2 \cdot 10^{-3}$	$-5 \cdot 10^{-3}$	$2 \cdot 10^{-2}$	$-7 \cdot 10^{-2}$
py, MeV/c	10^{-3}	$3 \cdot 10^{-3}$	$2 \cdot 10^{-3}$	10^{-2}
pz, MeV/c	10^{-4}	$5 \cdot 10^{-5}$	$-5 \cdot 10^{-4}$	0

1.5 GeV/c	Global		Internal	
Param	Kalman	BP	Kalman	BP
x,cm	0	$4.5 \cdot 10^{-3}$	$-2 \cdot 10^{-2}$	0
y,cm	0	-10^{-3}	$5 \cdot 10^{-3}$	$-2.5 \cdot 10^{-3}$
z, cm	ND	-10^{-4}	ND	$1 \cdot 10^{-1}$
px, MeV/c	$2 \cdot 10^{-3}$	$-1 \cdot 10^{-2}$	0	$1.5 \cdot 10^{-2}$
py, MeV/c	10^{-3}	$1.7 \cdot 10^{-2}$	$2 \cdot 10^{-3}$	-10^{-2}
pz, MeV/c	$5 \cdot 10^{-5}$	$1.3 \cdot 10^{-3}$	$-5 \cdot 10^{-4}$	$1 \cdot 10^{-3}$

global steps vs. internal steps

time, 1 trk/ev

Global $\rightarrow$ 7 global steps, bending angle = 20°

Internal $\rightarrow$ 1 global step, bending angle = 0.01°

Geane

P, GeV/c	Global		Internal	
	Kalman, ms	BP, ms	Kalman, ms	BP, ms
1.5	5	3	22	616
4.06	5	2	12	400
8.9	5	2	9	266
11.91	5	2	8	227
15	5	2	8	198

Runge-Kutta, 7 gl. steps

P, GeV/c		
	Kalman, ms	BP, ms
1.5	2	3
4.06	2	2
8.9	2	2
11.91	2	2
15	2	2

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)

Conclusion

- 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 ☹