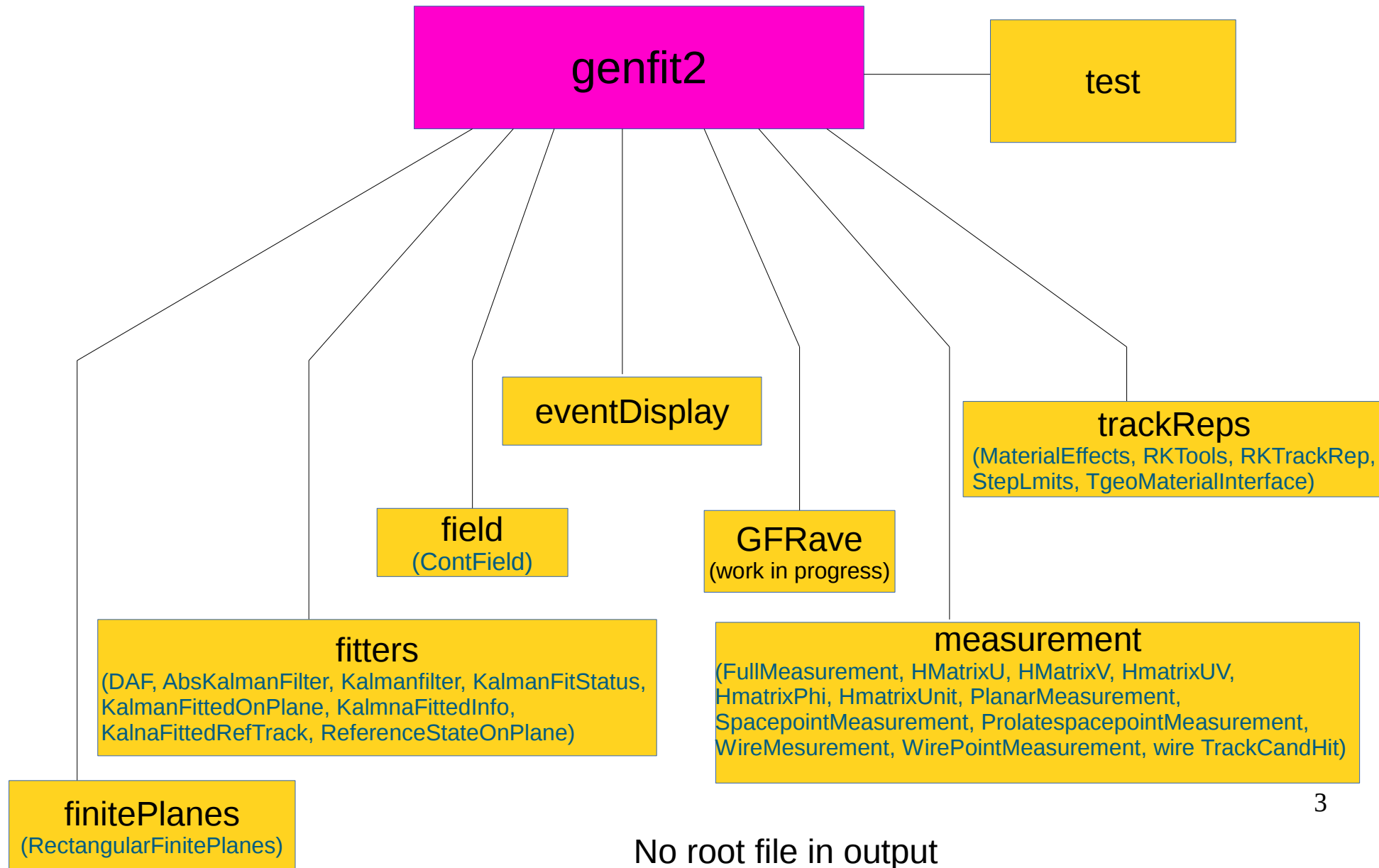# Implementation of Genfit2 in PandaRoot: first results

XLIX $\overline{P}$ANDA Collaboration Meeting

Elisabetta Prencipe | 10 June 2014 | Forschungszentrum Jülich
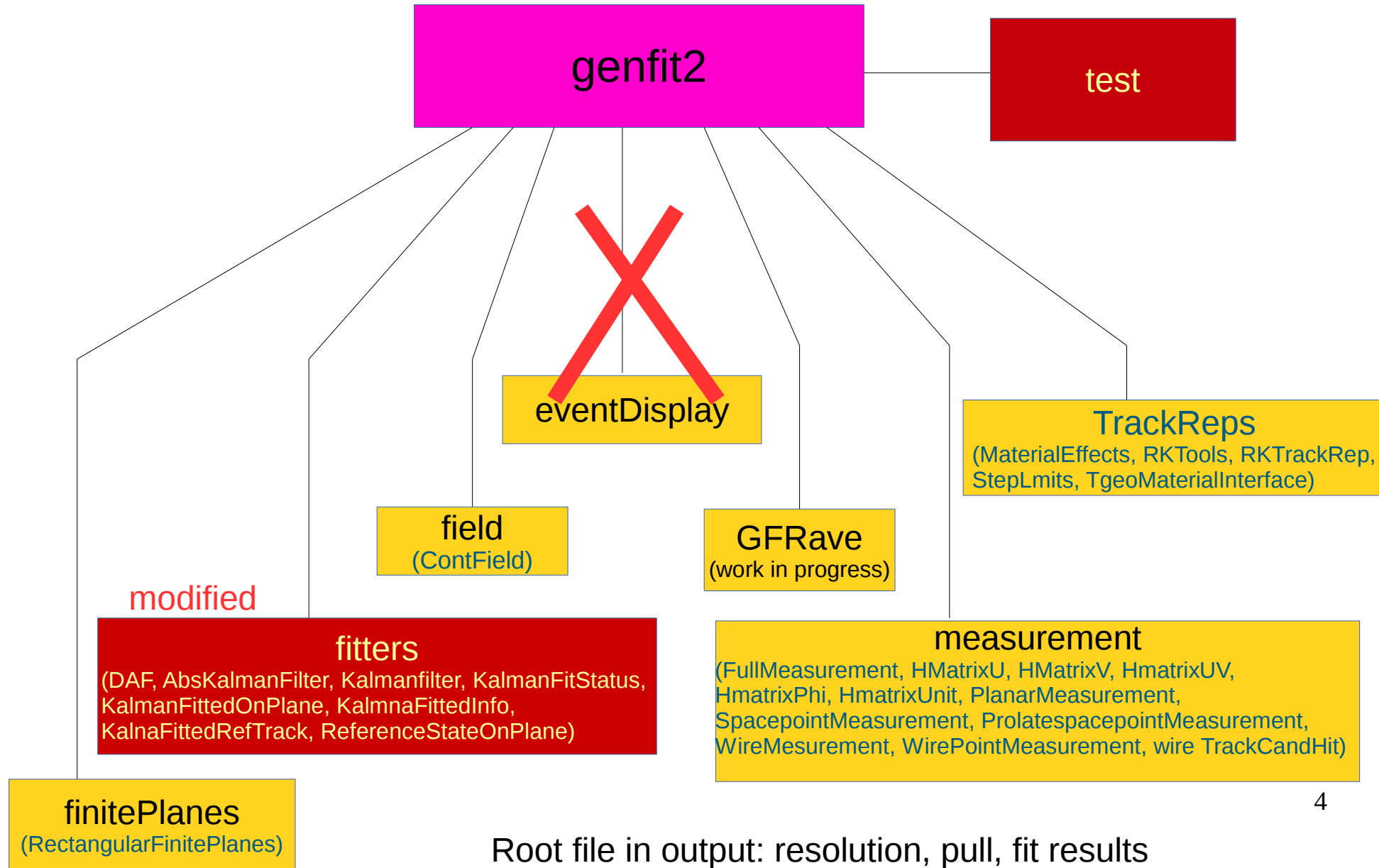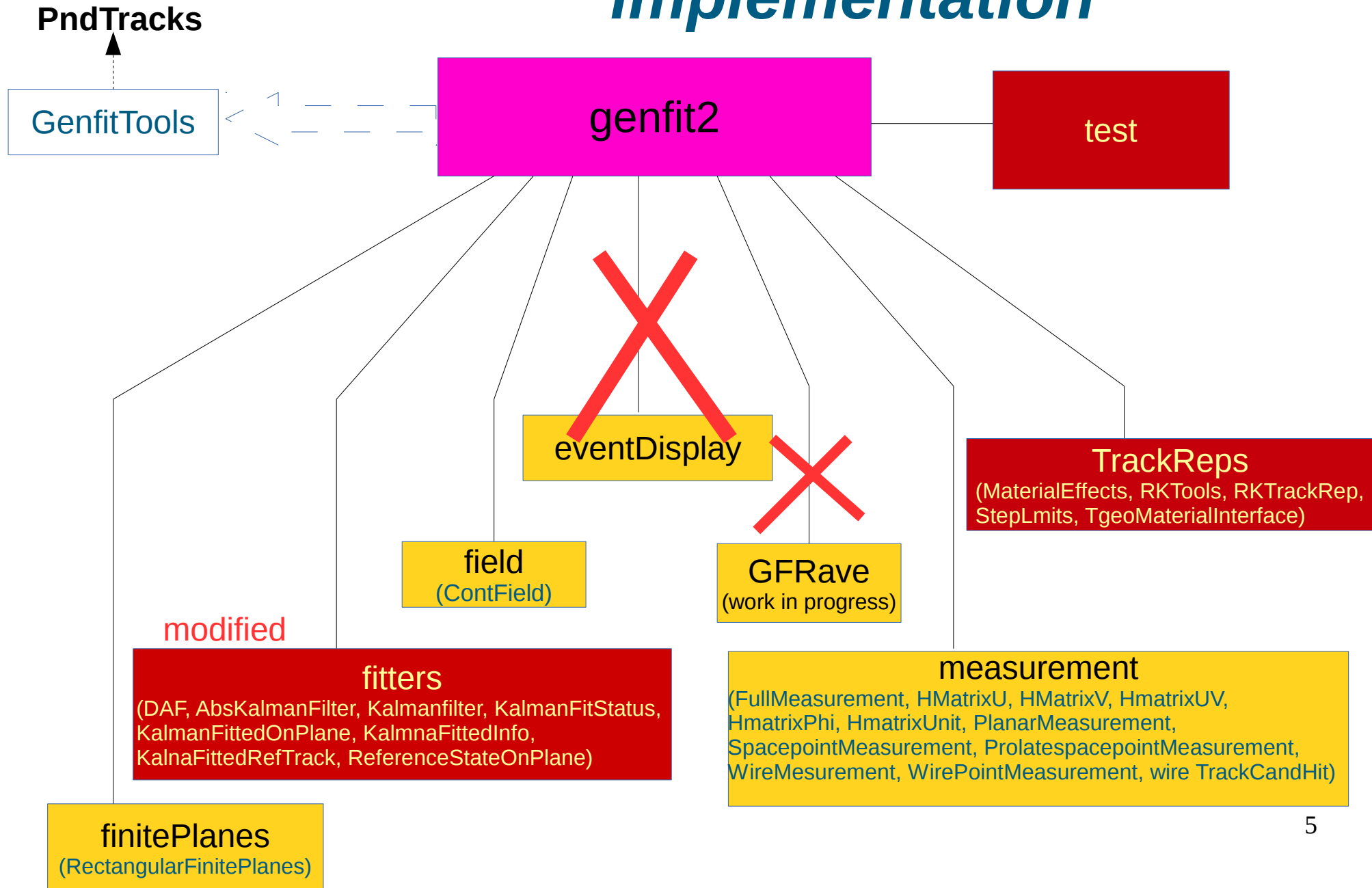
Status and perspectives

Mitglied in der Helmholtz-Gemeinschaft

Structure of the tool

Structure of the tool - modification

JÜLICH
FORSCHUNGSZENTRUM

genfit2

test

eventDisplay

TrackReps
(MaterialEffects, RKTools, RKTrackRep, StepLmits, TgeoMaterialInterface)

field
(ContField)

GFRave
(work in progress)

modified

fitters
(DAF, AbsKalmanFilter, Kalmanfilter, KalmanFitStatus, KalmanFittedOnPlane, KalmnaFittedInfo, KalnaFittedRefTrack, ReferenceStateOnPlane)

measurement
(FullMeasurement, HMatrixU, HMatrixV, HmatrixUV, HmatrixPhi, HmatrixUnit, PlanarMeasurement, SpacepointMeasurement, ProlatespacepointMeasurement, WireMesurement, WirePointMeasurement, wire TrackCandHit)

finitePlanes
(RectangularFinitePlanes)

4

Root file in output: resolution, pull, fit results

Structure of the tool – modification implementation

JÜLICH
FORSCHUNGSZENTRUM

PndTracks

GenfitTools

genfit2

test

eventDisplay

TrackReps
(MaterialEffects, RKTools, RKTrackRep, StepLmits, TgeoMaterialInterface)

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finitePlanes
(RectangularFinitePlanes)

5

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@ THIS collaboration meeting

- Trunk rev-20185 was tested (standard revision)
- *genfit2* has been introduced in the rev 20185 (branch development).
  New update------>**rev-20295**
- Preliminary, <u>stable</u> branch development:

  https://subversion.gsi.de/trac/fairroot/browser/pandaroot/development/prencipe
  work in progress - last fixes are in the branch development:

  https://subversion.gsi.de/trac/fairroot/browser/pandaroot/development/genfit2
  where Johannes Rauch (TUM) and me have committed the code

- Main change: /GenfitTools/trackrep is not there any further
  /genfit2/trackReps is used instead
- State vector is not anymore in trackReps/RKTrackRep
- Track follower is part of the genfit2 tool, now
- Different genfit tool structure
  It required changes in the pandaroot packages:
  /lmd/, /hyp/, /hypGe/, /stt/, /mvd/, /GenfitTools/, and few other small changes...

- Gentif2 provides the Kalman equations & the track representation

- /genfit/ (rev 400) and /genfit2/ (rev 1731) are not compatible
  the current branch developed does not provide a switch to run both versions
  genfit2 is ported into pandaroot as external packages

- **First tests in trunk rev 20185 w/o *genfit2* are presented**

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Testing the standard trunk rev-20185....

- Many informations are accessible by mean of /rho/ classes
- Basic variables to check: px, py, pz, e, x, y, z
- Need to test:
  - reconstructed variables
  - true values
  - error distributions

- Kalman filter applies to reconstruction
- The equation of the motion of a charged particle (track) in a magnetic field is linear in 5 parameters:
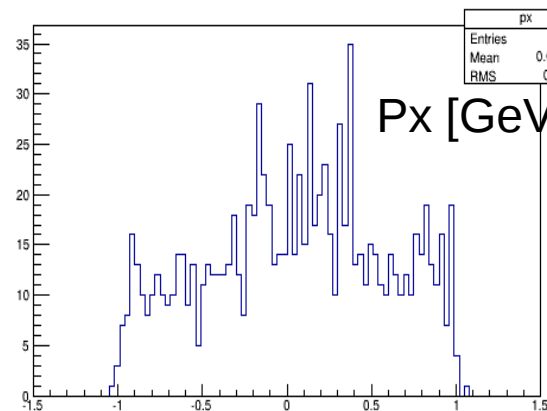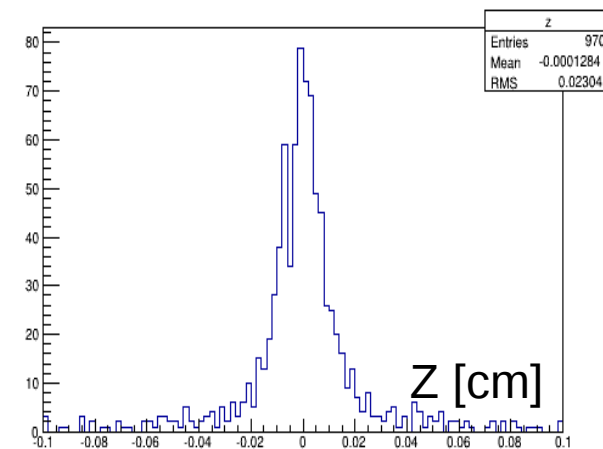
  $z0$, $d0$ = Sqrt(x2 + y2), curvature ($\propto$ Q/pt), $\tan\lambda$ (p$\cdot$cosλ = pt), ϕ

- These parameters refers to the POCA:
  - Tracking parameters are built
  - Error propagation: information accessible by RhoError/Cov7(i,j)

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Testing the standard trunk rev-20185....

- Easy test: p =1.0 GeV/c, test every track hypotesis: μ, π, K, p ,e
- BoxGenerator, multiplicity =1: 1000 generated events
- PID = "best"

The Good!
(supposed to be...)

970/1000, hyp: muon
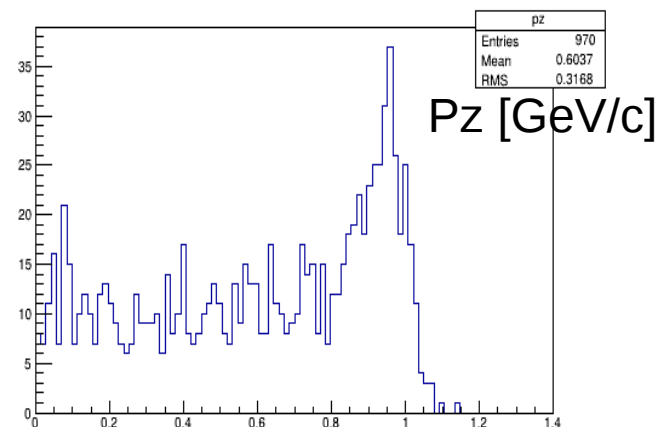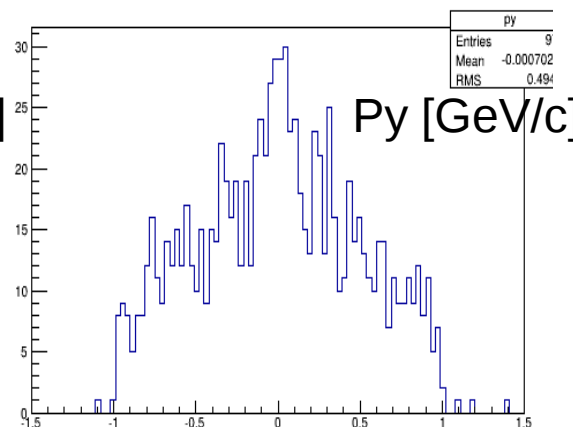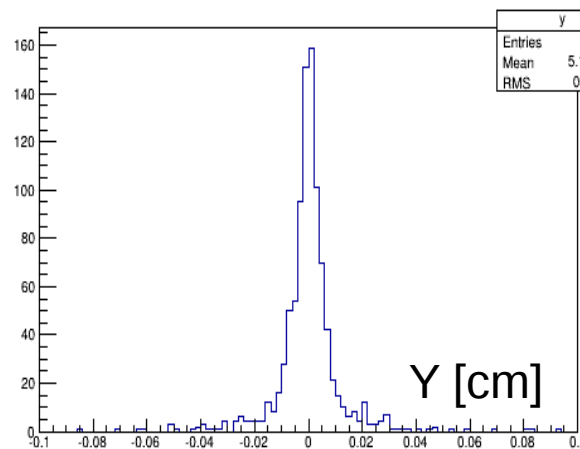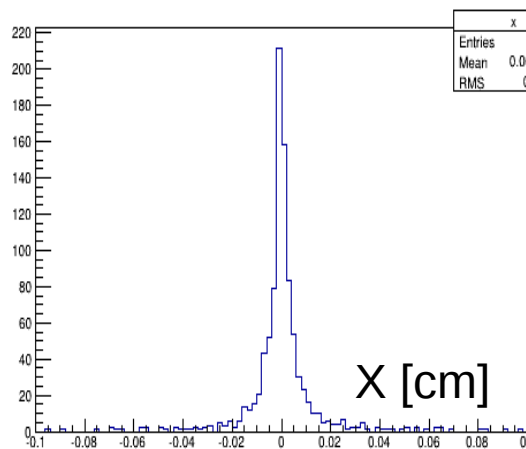
Testing the standard trunk rev-20185....

SPACE RESOLUTION: true – rec, single muon, p = 1 GeV/c

res X [cm]

Muon, 970 entries

~50 μm

Mean	8.799e-06
RMS	0.01651
χ^2 / ndf	228.3 / 65
Constant	113.9 ± 7.7
Mean	-0.0001375 ± 0.0001882
Sigma	0.005049 ± 0.000286

res Y [cm]

Muon, 970 entries

~50 μm

Mean	0.001331
RMS	0.01666
χ^2 / ndf	183.5 / 66
Constant	120.2 ± 6.5
Mean	-1.613e-05 ± 1.891e-04
Sigma	0.005301 ± 0.000216

res Z [cm]

Muon, 970 entries

~100 μm

Mean	0.0003148
RMS	0.02377
χ^2 / ndf	170.3 / 78
Constant	56.04 ± 3.17
Mean	3.726e-06 ± 3.764e-04
Sigma	0.009891 ± 0.000415

- Statistics here is limited
- Gaussian is not the optimal parameterization: it give a qualitative idea of the performance of PndRecoKalman task in the standard trunk rev-20185

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Testing the standard trunk rev-20185....

MOM. RESOLUTION: true – rec, single muon, p = 1 GeV/c

res	Px
Entries	970
Mean	-9.287e-06
RMS	0.01848

res	Py
Entries	970
Mean	-0.0003709
RMS	0.01765

res	Pz
Entries	970
Mean	0.0001543
RMS	0.02358
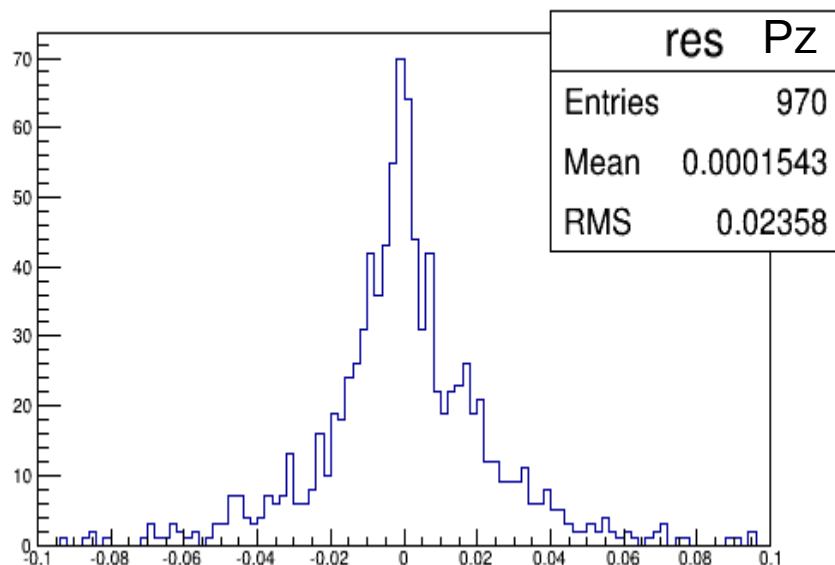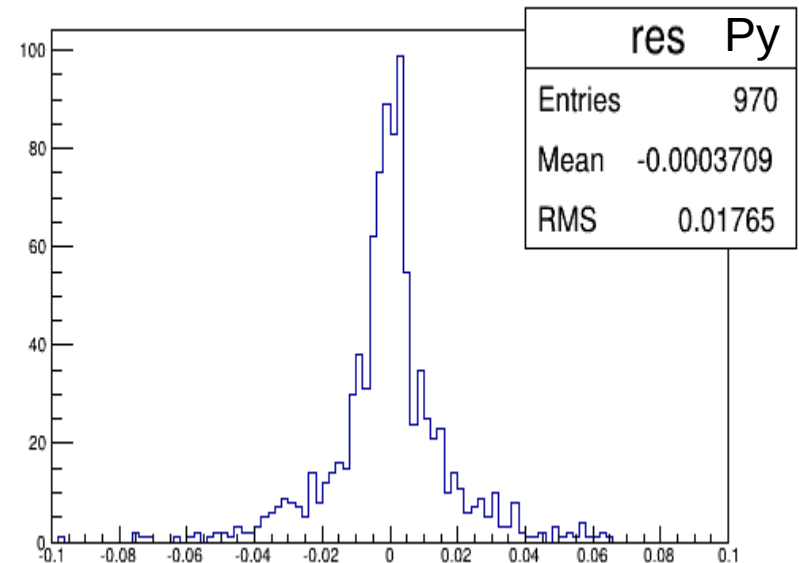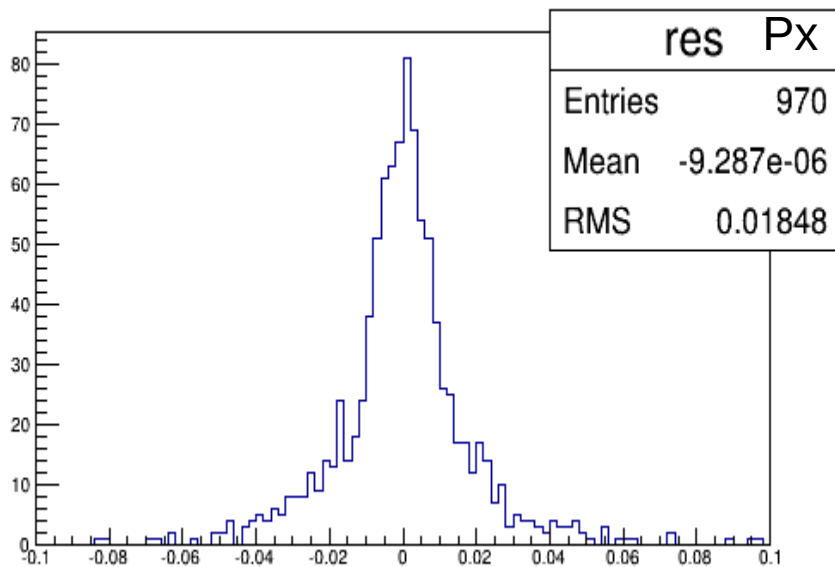
- Not a simple gaussian distribution: resolution seems degraded

- Main problems found, standard trunk:
GF tracks not always converted to PndTrack
Tracks "vertical" to MVD
Track with too many iterations in the fit
Tracks with p(last hit)> p(first hit)

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Testing the standard trunk rev-20185....

Evaluation of the resolution of the 5 parameters as in slide 7:
SPACE RESOLUTION
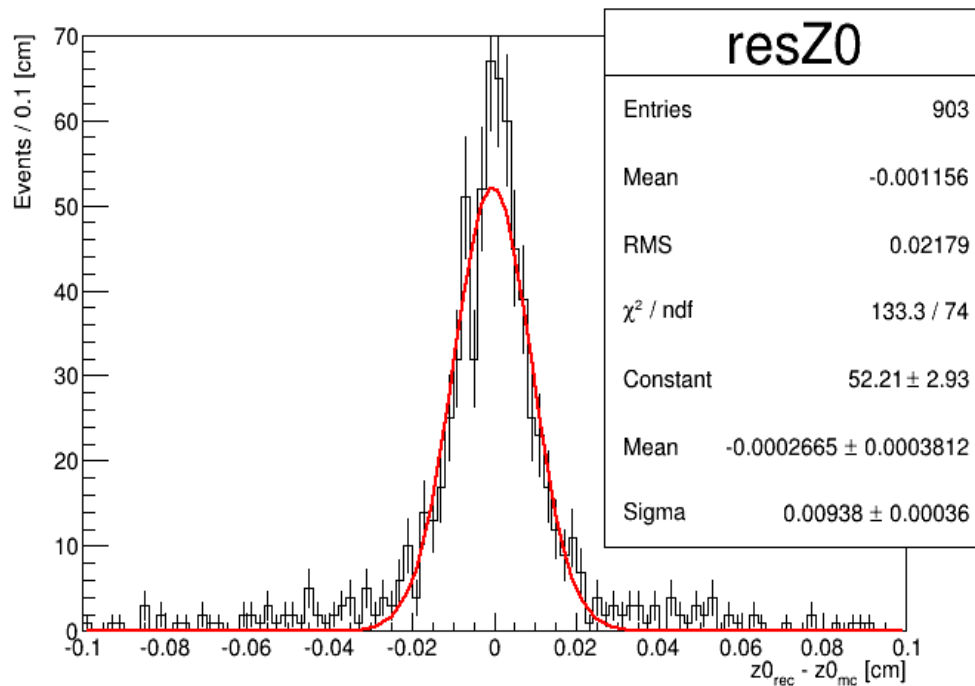
903/1000
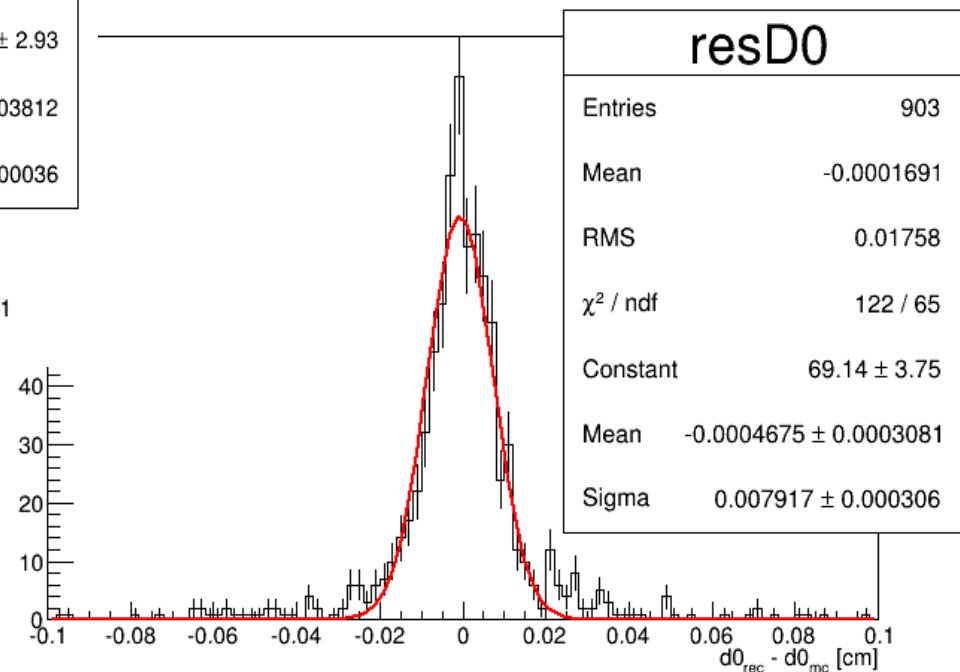
Track: μ-
~70 fake candidates

Testing the standard trunk rev-20185....

Evaluation of the resolution of the 5 parameters as in slide 7:
ANGULAR RESOLUTION
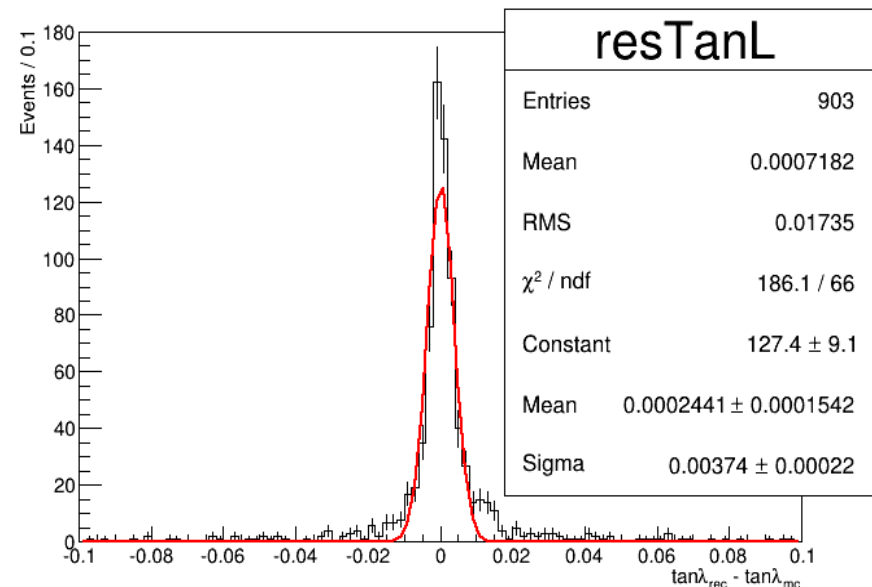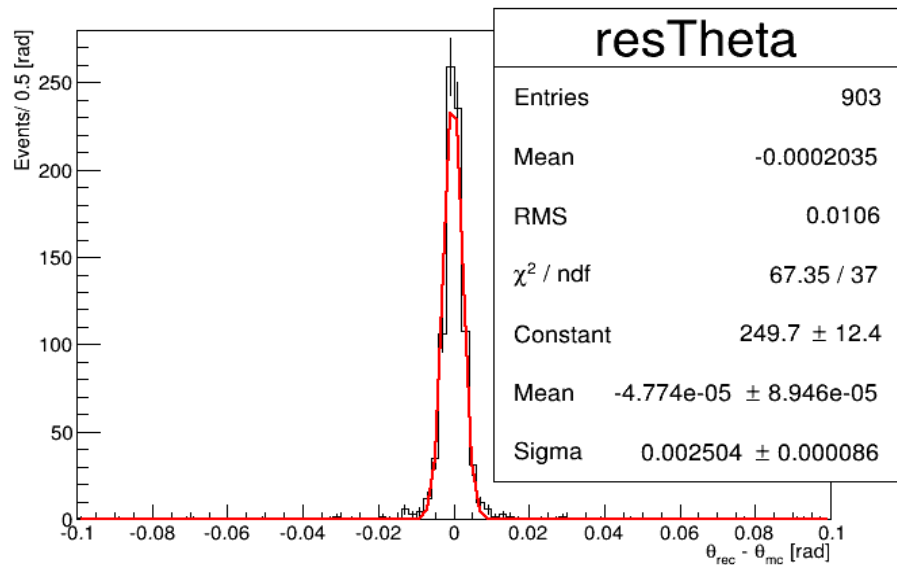
resPhi

Entries	903
Mean	0.0005717
RMS	0.01248
χ^2 / ndf	134 / 53
Constant	183.4 ± 10.8
Mean	0.0001147 ± 0.0001158
Sigma	0.003042 ± 0.000138

903/1000

Track: μ-
~70 fake candidates

resTheta

Entries	903
Mean	-0.0002035
RMS	0.0106
χ^2 / ndf	67.35 / 37
Constant	249.7 ± 12.4
Mean	-4.774e-05 ± 8.946e-05
Sigma	0.002504 ± 0.000086

resTanL

Entries	903
Mean	0.0007182
RMS	0.01735
χ^2 / ndf	186.1 / 66
Constant	127.4 ± 9.1
Mean	0.0002441 ± 0.0001542
Sigma	0.00374 ± 0.00022

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Testing the standard trunk rev-20185....

Evaluation of the resolution of the 5 parameters as in slide 7:
MOM RESOLUTION

903/1000

Track: μ-
~70 fake candidates

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Testing the standard trunk rev-20185....

PULL: true – rec / error
If tracking algorithms work fine, PULL is supposed to have a gaussian parameterization, with width =1

pull track momentum (all)

hmomtrkPull	
Entries	516
Mean	0.1069
RMS	1.367
χ^2 / ndf	62.3 / 57
Constant	17.6 ± 1.2
Mean	-0.004312 ± 0.062310
Sigma	1.241 ± 0.063

This is OK: with higher statistics it would be exactly =1!

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Testing the standard trunk rev-20185....

PULL: true – rec / error
If tracking algorithms work fine, PULL is supposed to have a gaussian parameterization, with width =1

This is OK: with higher statistics it would be exactly =1!

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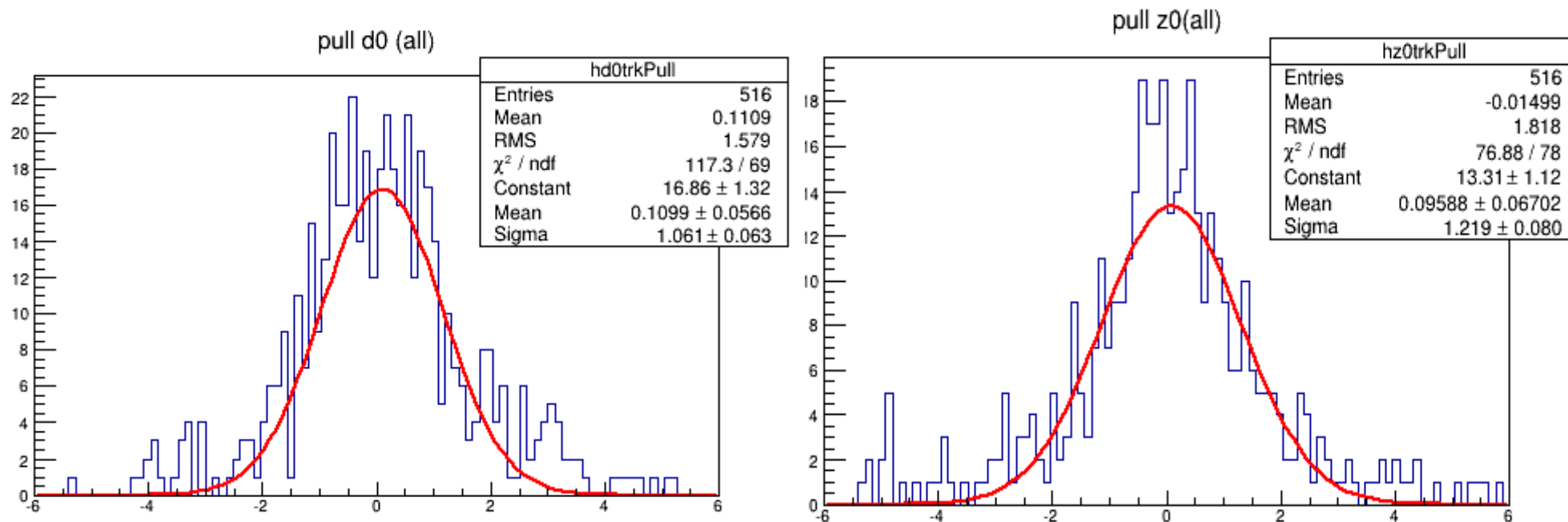
Testing the standard trunk rev-20185....

PULL: true – rec / error
If tracking algorithms work fine, PULL is supposed to have a gaussian parameterization, with width =1

This is OK: with higher statistics it would be exactly =1!

A window of improvement

- Tracking is the core of physics analysis
- Window of improvement in tracking to gain efficiency and better resolution
- Bugs were found in *genfit* (rev 400): need to fix → *genfit2*

- Goal in PANDA: to track low momentum particles with degraded resolution
  ⇨ needed for Charm Physics

- First attempt: to introduce **genfit2** in pandaroot
- Cooperation with genfit-developers at the TUM: no problem!

Testing the modified trunk rev-20185

- /genfit2/ is introduced in pandaroot as external package: rev-1731
- /genfit2/ is currently used in the new Belle2 framework

In this report:

- All track hypothesis checked, p = 1 GeV/c
- Positive and negative tracks are checked
- Study of resolution and efficiency are presented
- Comparison between *genfit* and *genfit2* is shown

Testing the <u>modified</u> trunk rev-20185

with genfit2

RESOLUTION OF THE TRACKING PARAMETERS FOR MUONS, p=1 GeV/c
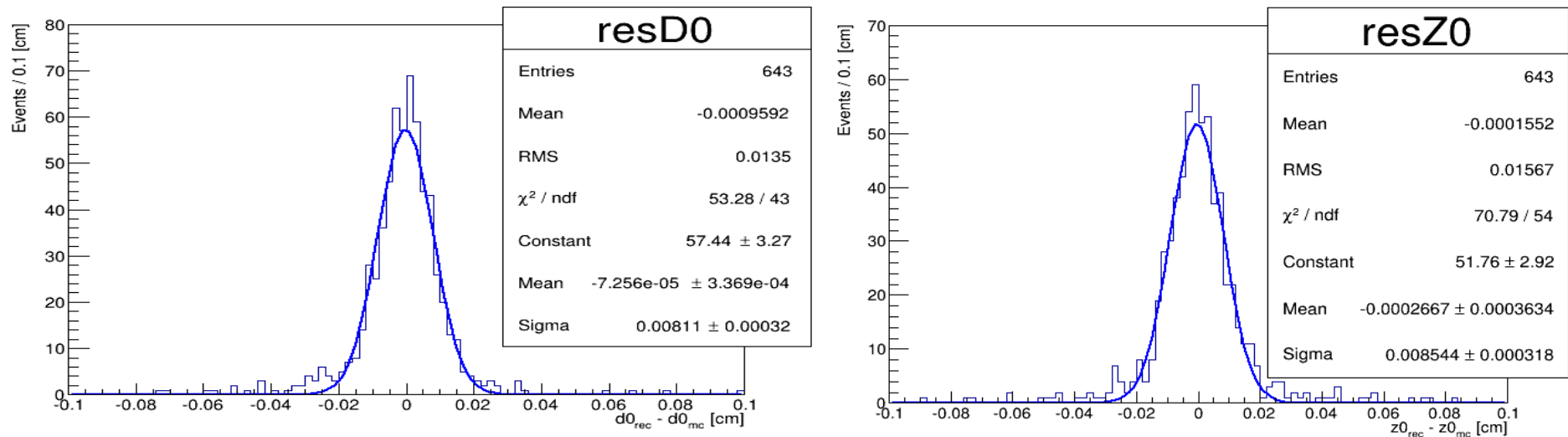
	d0 resolution	z0 resolution
genfit2	81.1+/- 3.2 μm	85.4+/- 3.2 μm
genfit	79.2+/- 3.1 μm	93.8+/- 3.6 μm

This study must be repeated with higher statistics: 1M events

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Testing the modified trunk rev-20185

with genfit2

RESOLUTION OF THE TRACKING PARAMETERS FOR MUONS, p=1 GeV/c
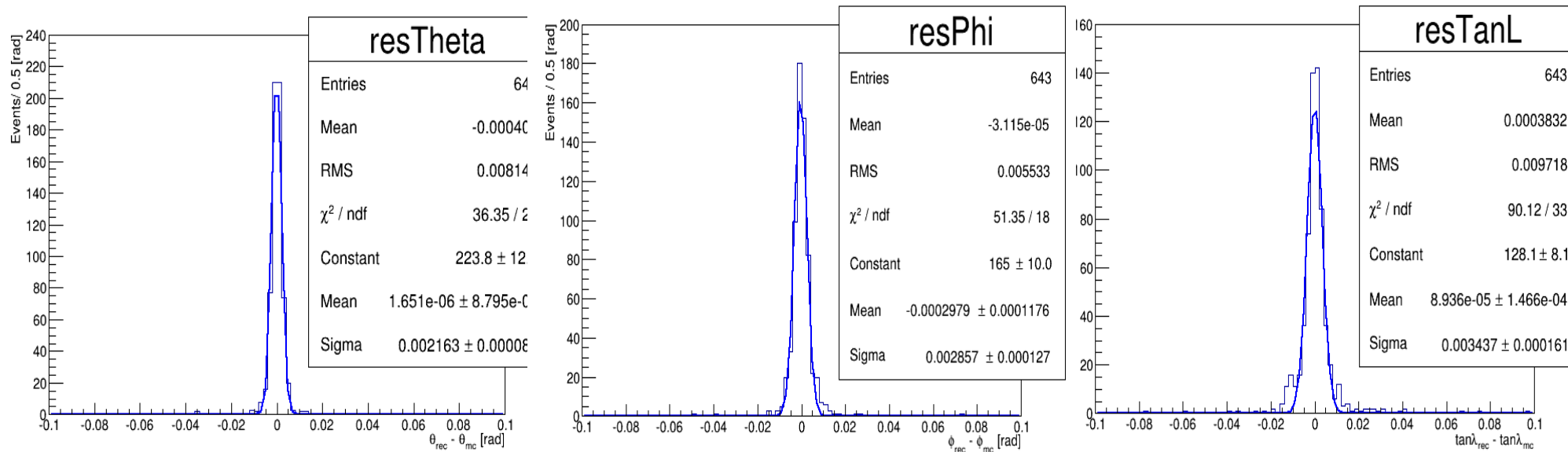
	θ resolution	ϕ resolution	$\tan\lambda$ resolution
genfit2	21.63+/- 0.80 mrad	28.6+/- 1.3 mrad	34.4+/- 1.6
genfit	25.04+/- 0.61 mrad	30.4+/- 1.4 mrad	37.4+/- 2.2

This study must be repeated with higher statistics: 1M events

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Testing the modified trunk rev-20185

with genfit2

RESOLUTION OF THE TRACKING PARAMETERS FOR MUONS, p=1 GeV/c

resMom	
Entries	643
Mean	-6.672e-05
RMS	0.03756
χ^2 / ndf	61.64 / 44
Constant	37.5 ± 2.3
Mean	0.0002146 ± 0.0013031
Sigma	0.03064 ± 0.00135

resOmega	
Entries	643
Mean	-0.001254
RMS	0.05457
χ^2 / ndf	47.26 / 39
Constant	56.56 ± 3.16
Mean	0.0007701 ± 0.0017159
Sigma	0.04167 ± 0.00158
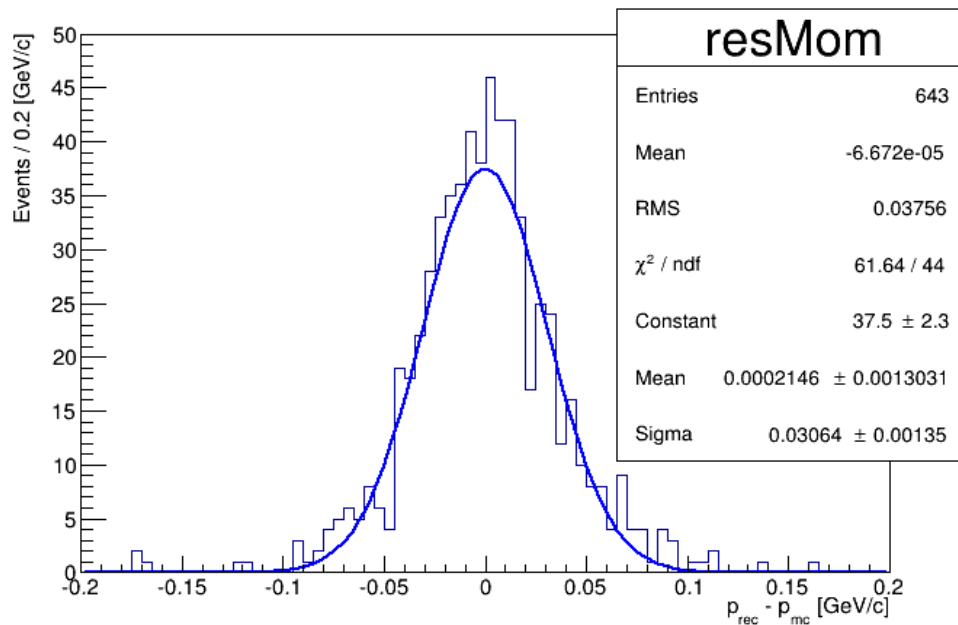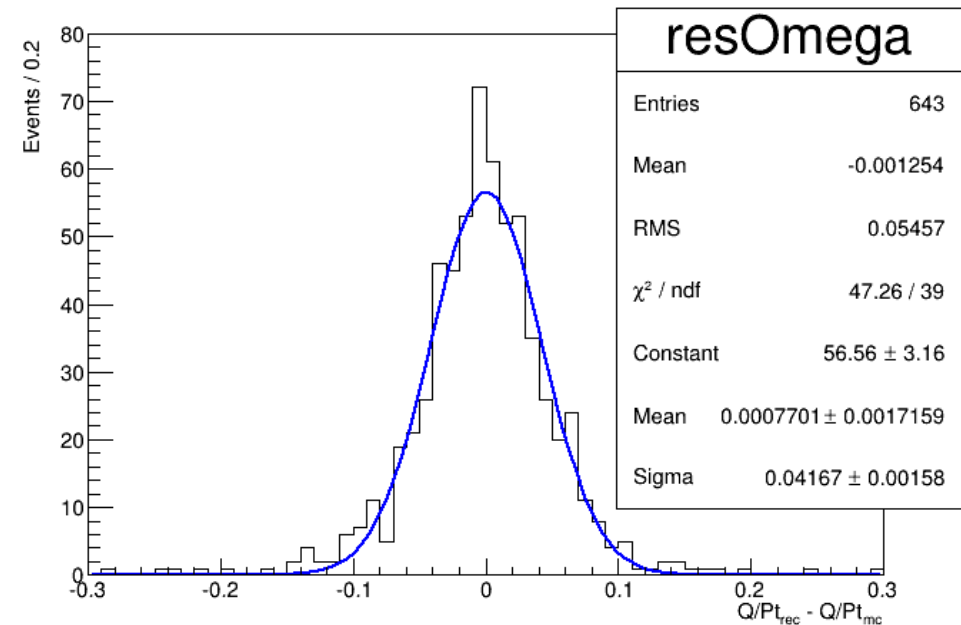
	p resolution	Q/pt resolution
genfit2	30.6+/- 1.4 MeV/c	41.2+/- 1.6 [1/cm]
genfit	31.7+/- 1.0 MeV/c	45.3+/- 1.7 [1/cm]

This study must be repeated with higher statistics: 1M events

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Efficiency

MUONS, p=1 GeV/c

Generated events with BoxGenerator: 1000
Reconstructed, only detector acceptance (genfit): 970
Reconstructed, with correct PdgID, charge, PID requirements (genfit): 903
Reconstructed, with basic selection (p>10 MeV/c, genfit): 516
Reconstucted, with basic selection (p>10 MeV/c, genfit2): 643

improvement

With genfit: trouble to run BoxGenerator with e- only.
With genfit2 all track hypothesis are run smoothly.
Main challenge with genfit2: GetMcTruth() from rho-lists, but the list "McTruth" works good
Several genfit2-tracks fails the MC association: need to be solved

with genfit2

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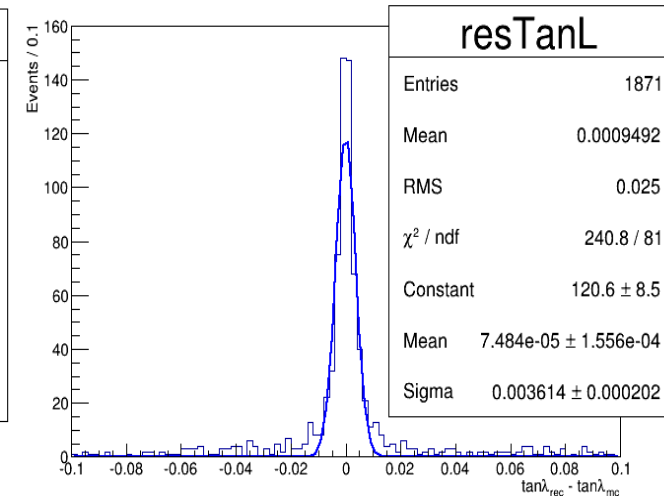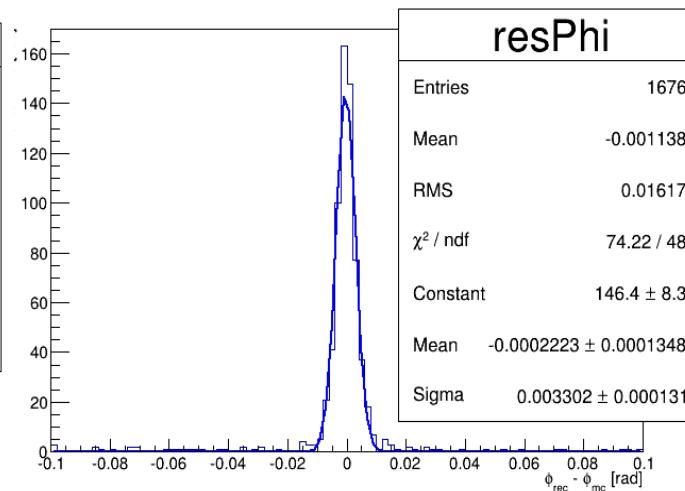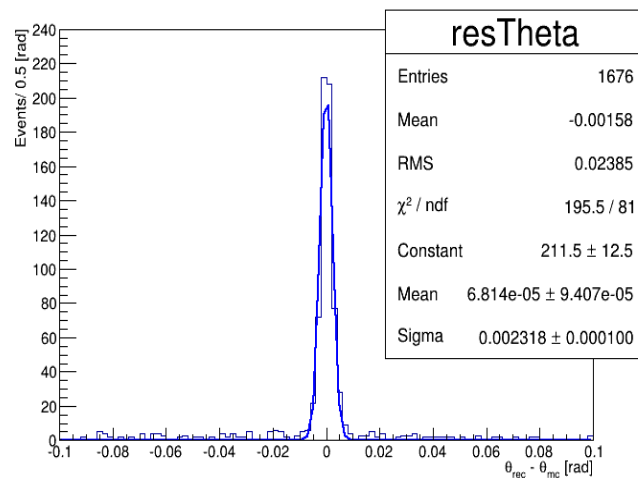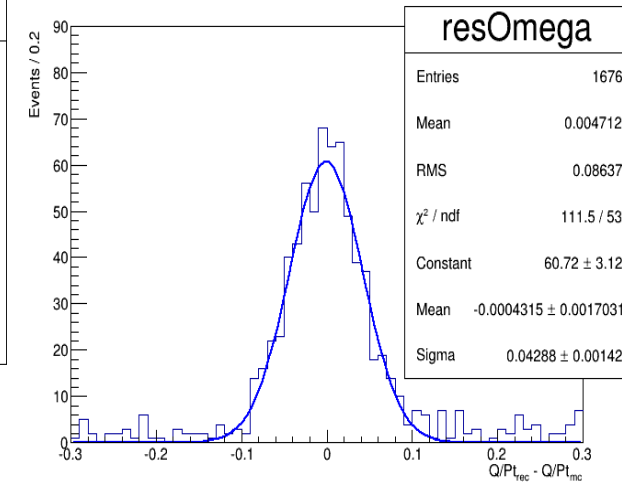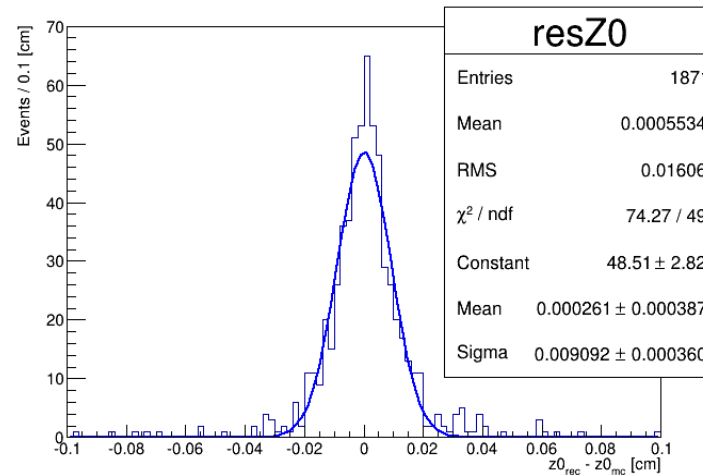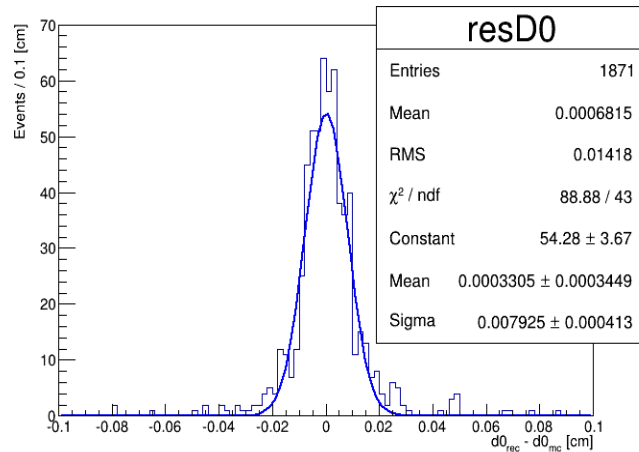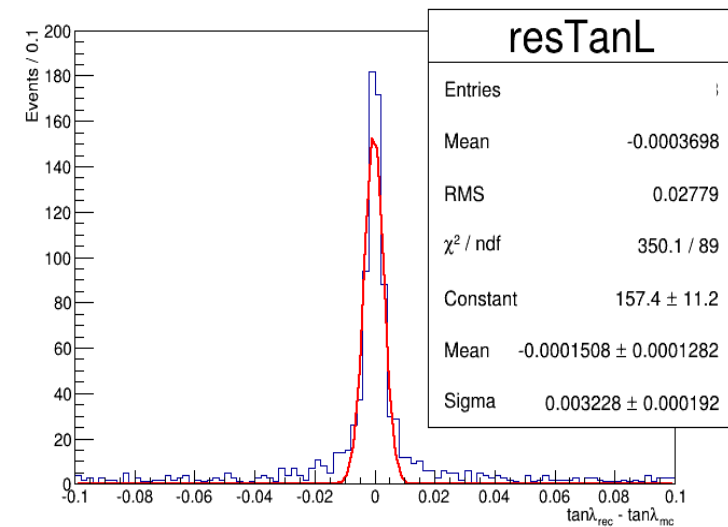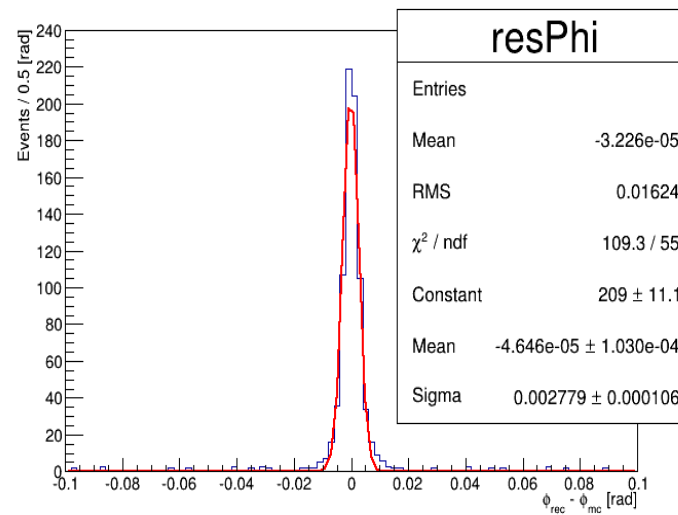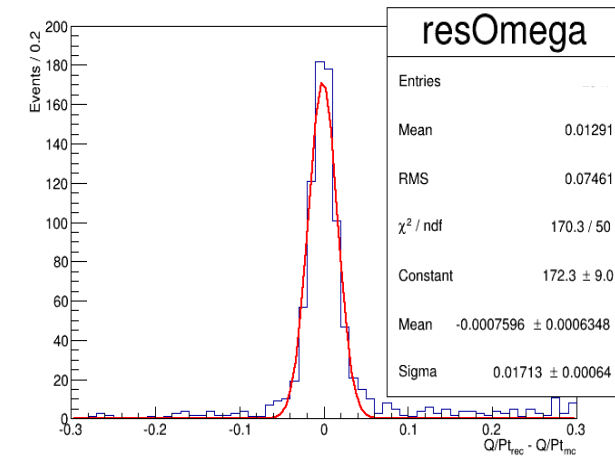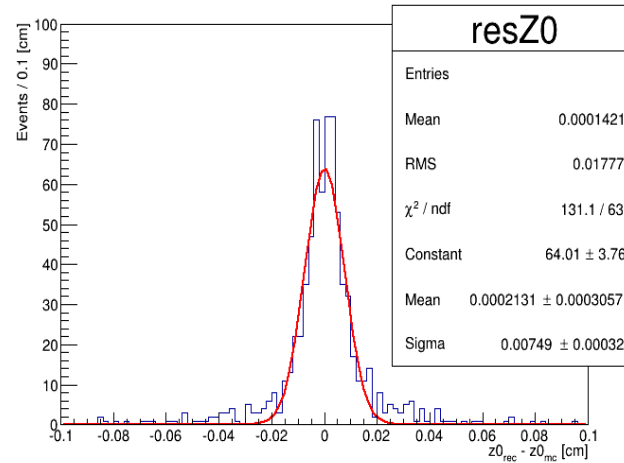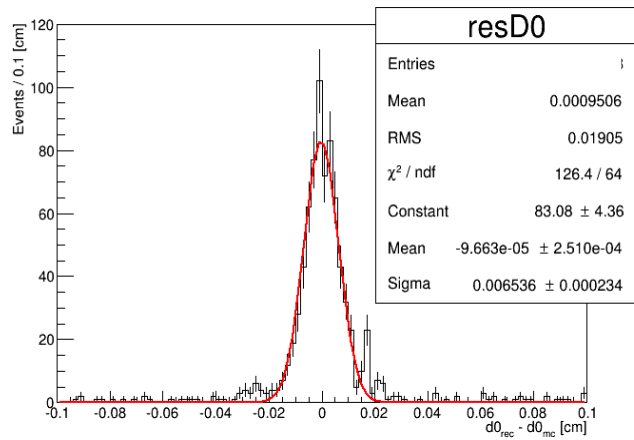
with genfit

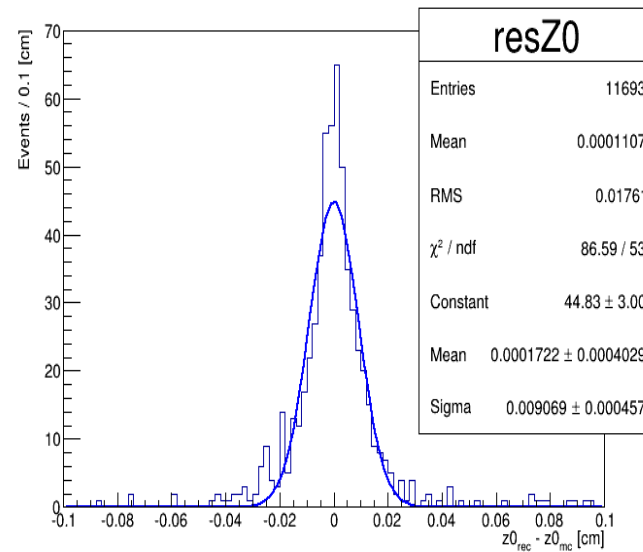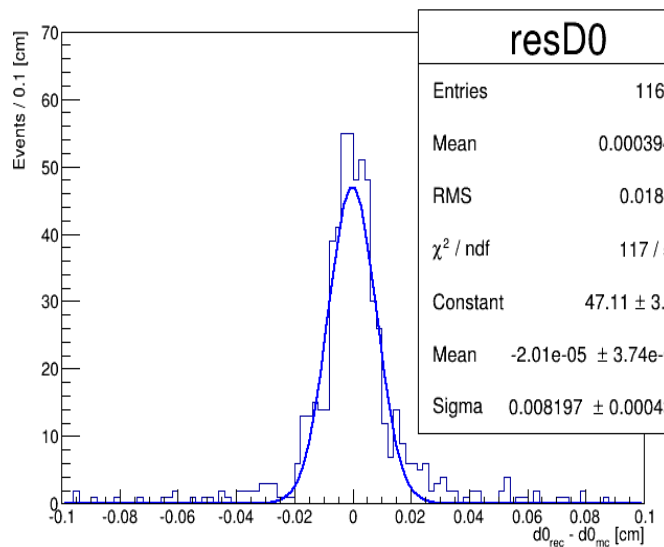# Additional check: resolution of **kaon**, p = 1.0 GeV/c

with genfit2

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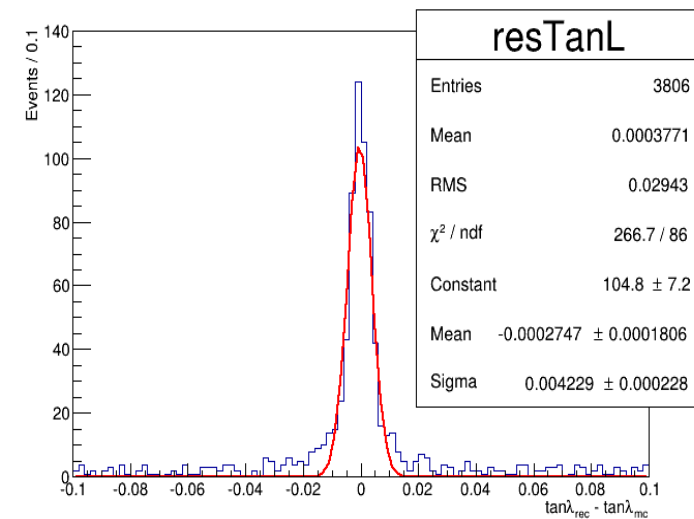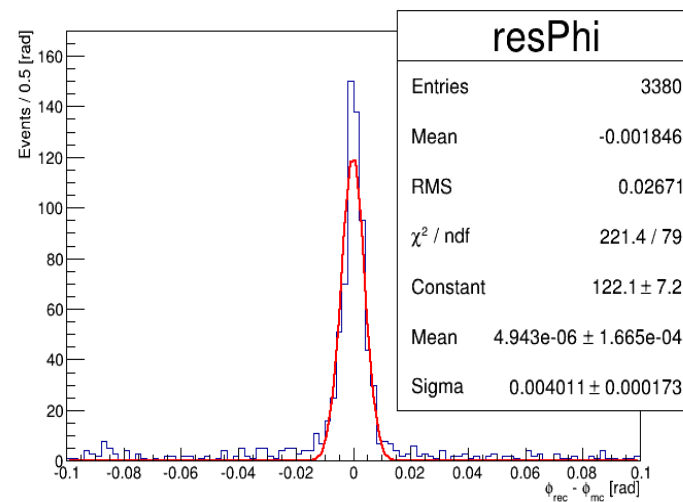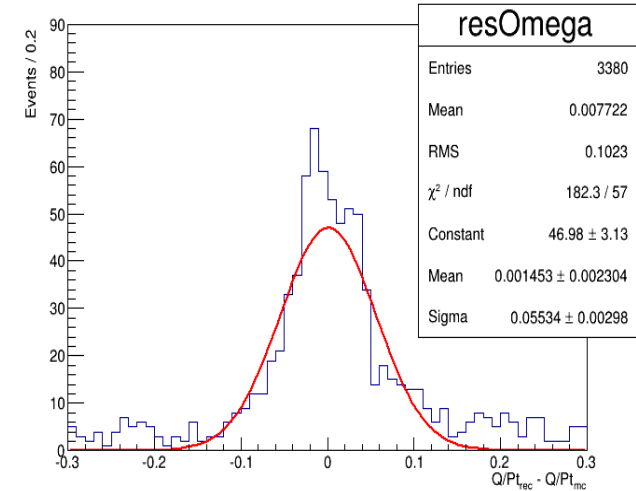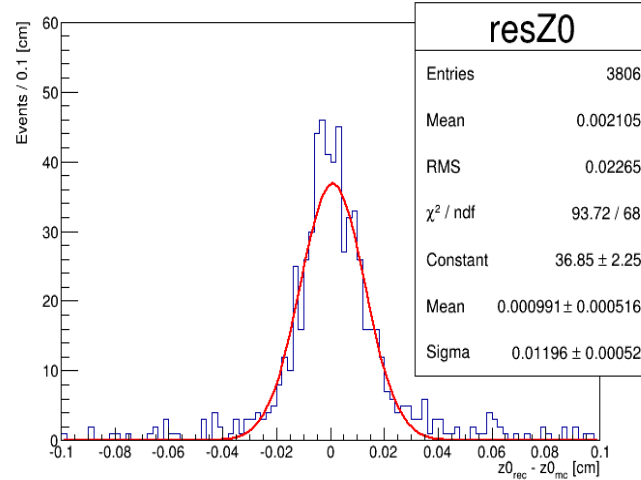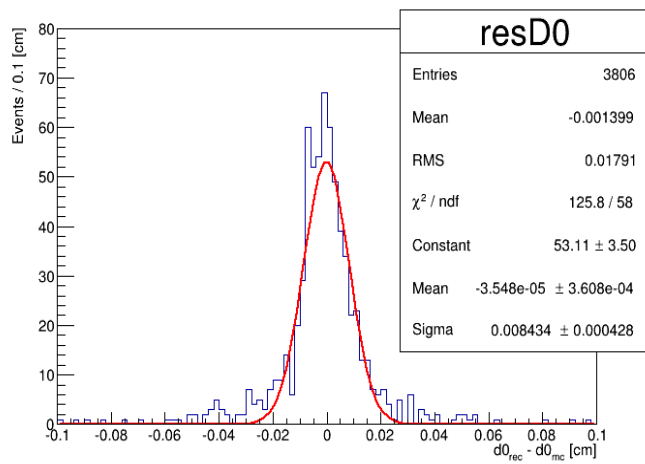
Additional check: resolution of **electrons**, p = 1.0 GeV/c

with genfit2
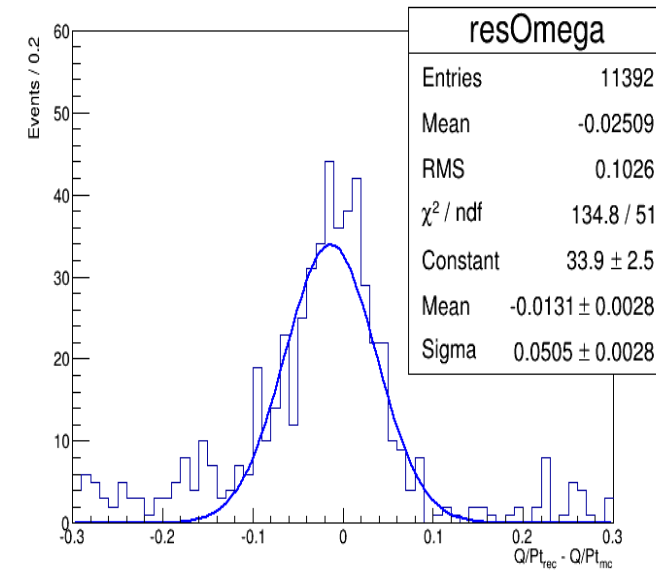
With angular variable resolution
is not good: need to investigate

but....

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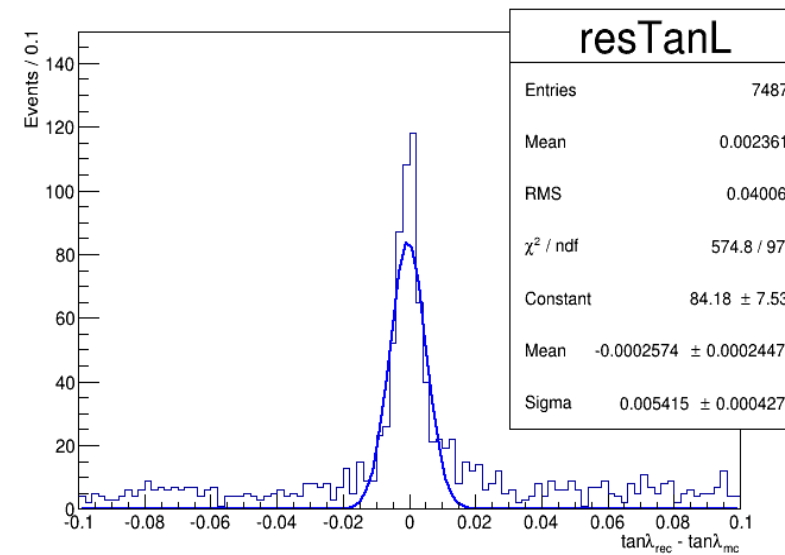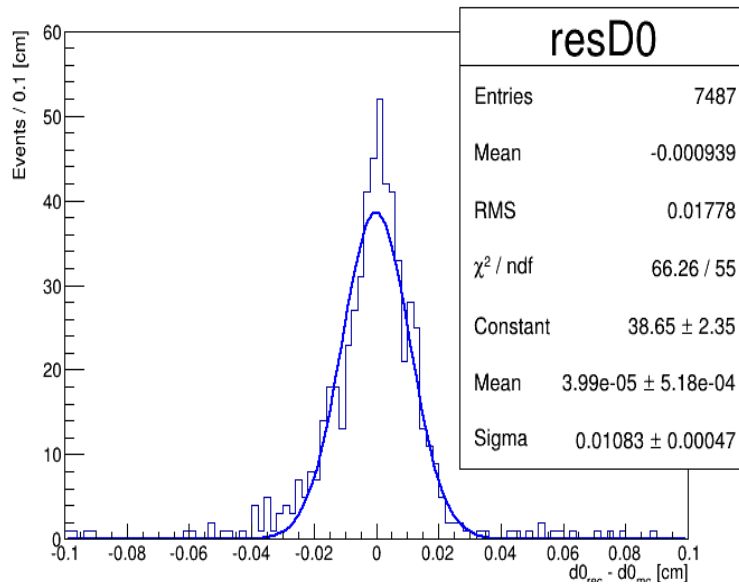
Additional check: resolution of **electrons**, p = 1.0 GeV/c
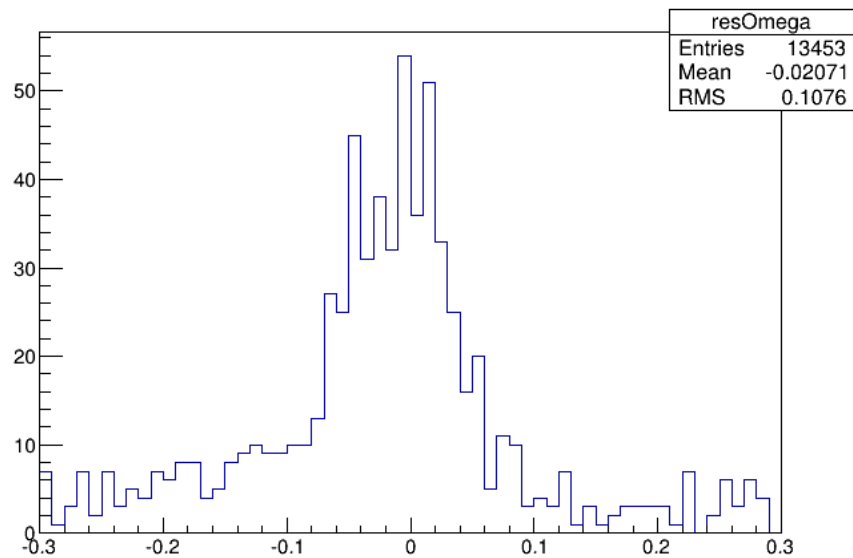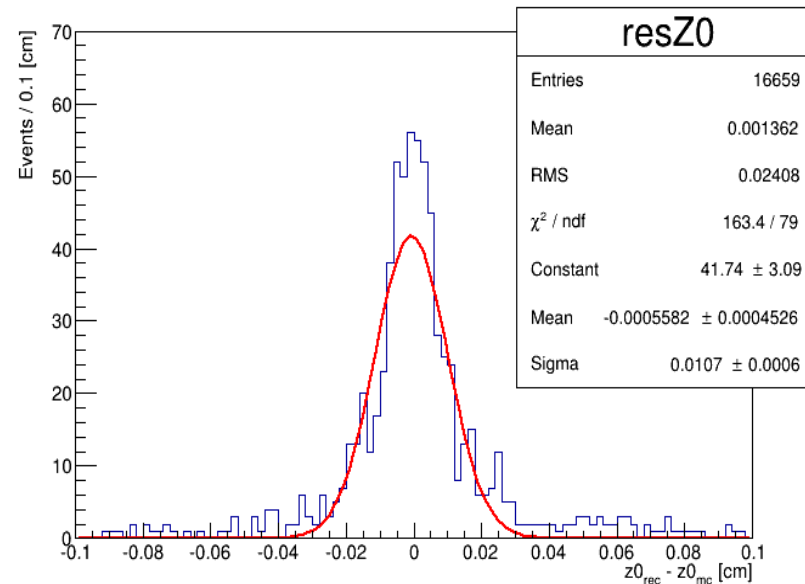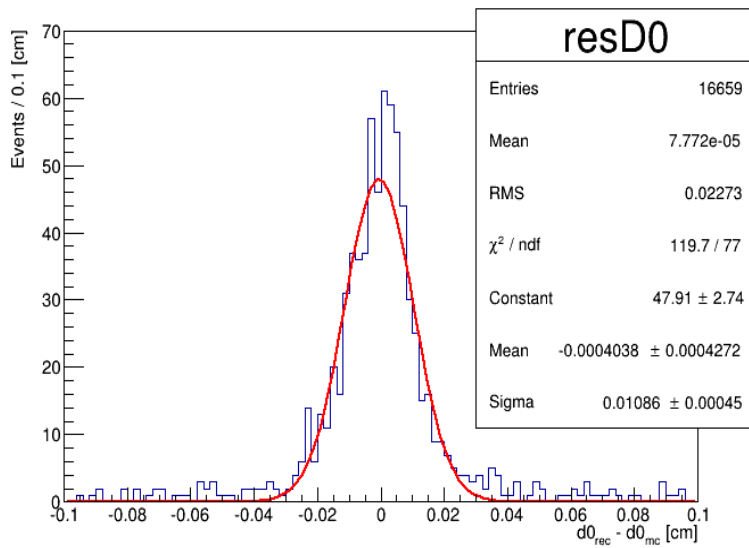
...bad angular resolution
was also with old-genfit.

pt distribution is worse than with genfit2

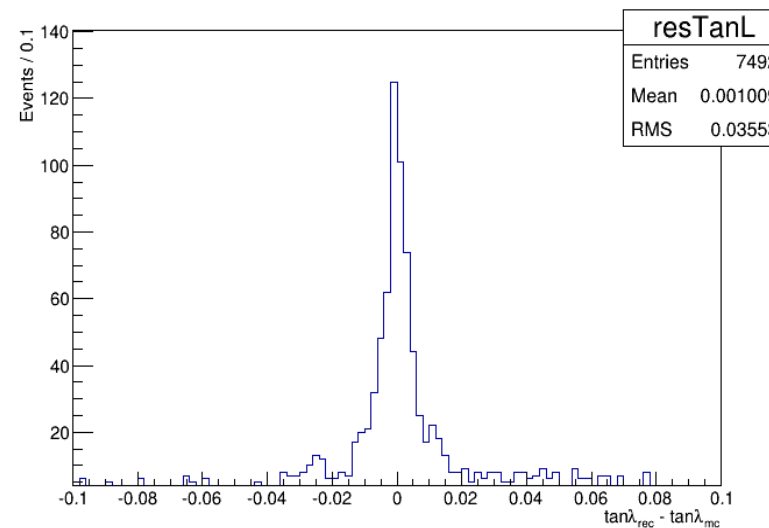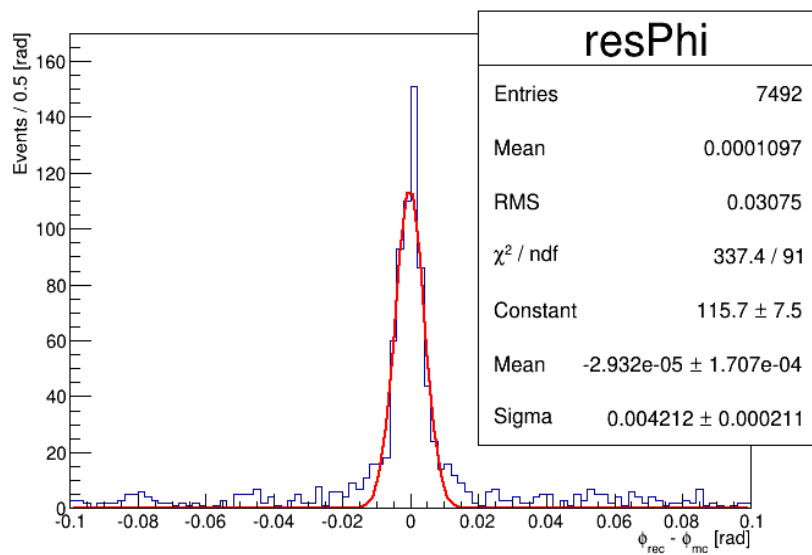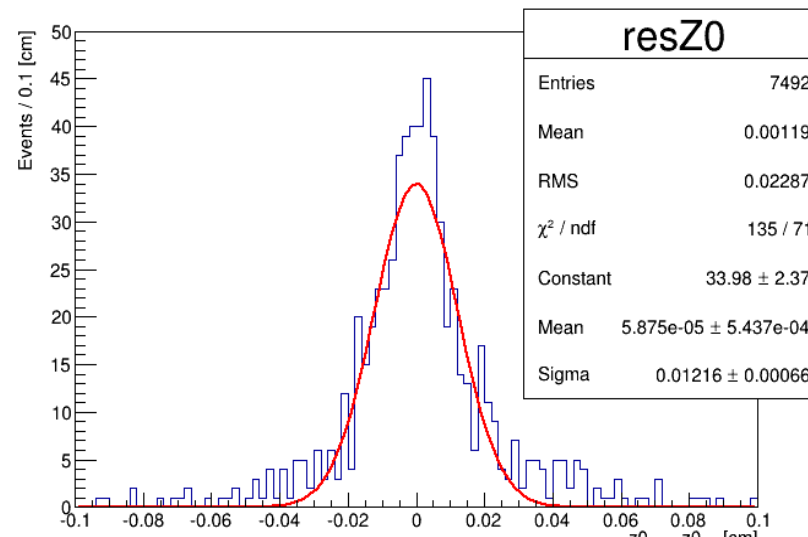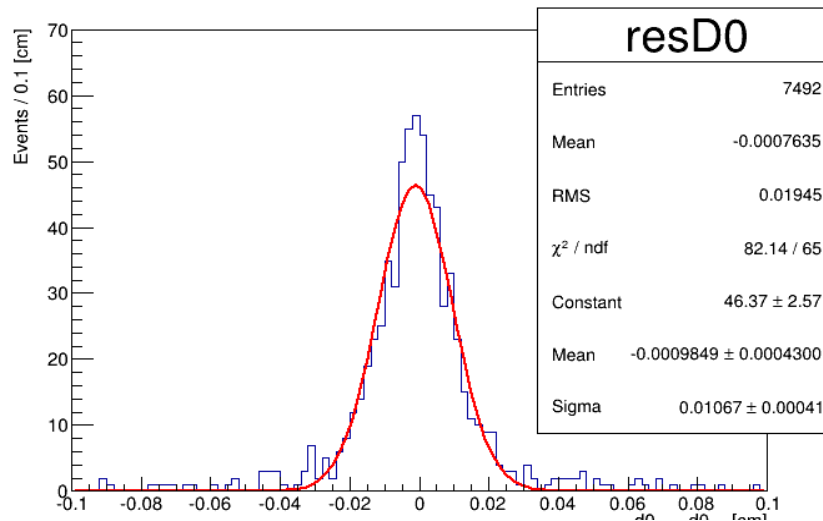Elisabetta Prencipe, XLXI PANDA Coll meeting

with genfit2

Q/pt distribution is not good: need to be understood

Elisabetta Prencipe, XLXI PANDA Coll meeting

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Additional check: resolution of **protons**, p = 1.0 GeV/c

with genfit

Q/pt distribution is not good: need to be understood

Not possible to fit $\tan\lambda$ with a Gaussian
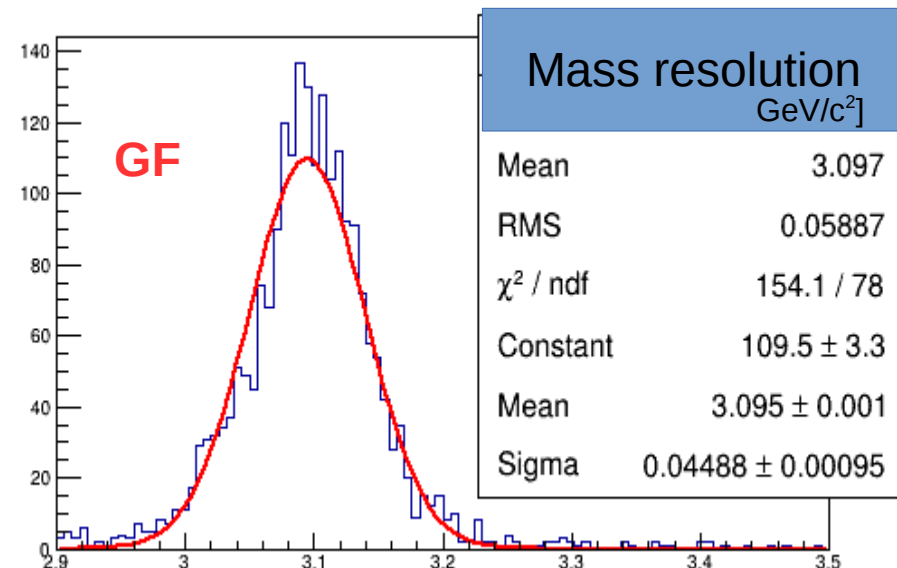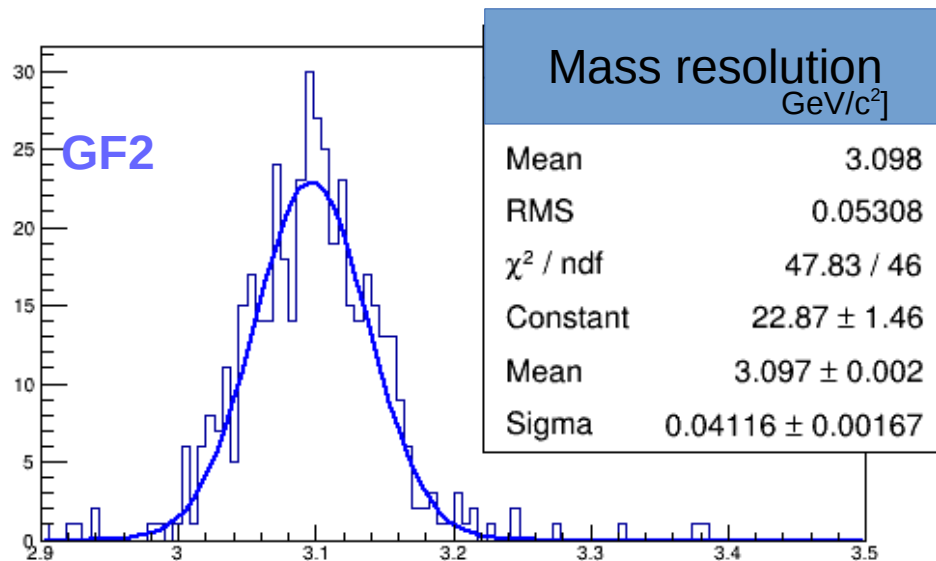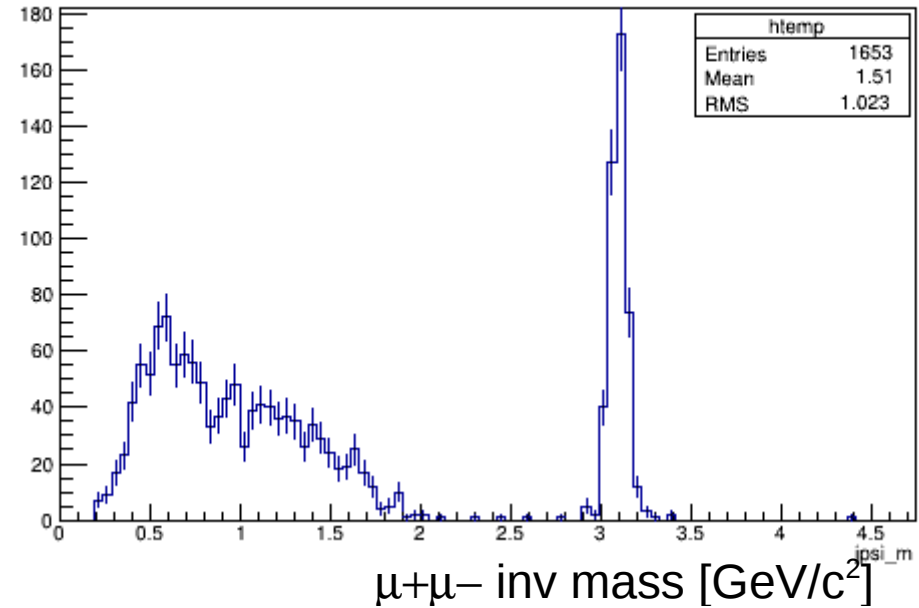
First test with a "standard" analysis channel

$\overline{p}p \rightarrow J/\psi \pi^+ \pi^-$

EvtGen: 2500 events generated
PndVtxFitter is used
No dedicated selection: only det acceptance

	"**best**"	
GF2	1653	
GF	2344	Many candidates/event Only 1 cand/event: <1000

μ+μ− inv mass [GeV/c²]

GF2

Mass resolution	
	GeV/c²]
Mean	3.098
RMS	0.05308
χ² / ndf	47.83 / 46
Constant	22.87 ± 1.46
Mean	3.097 ± 0.002
Sigma	0.04116 ± 0.00167

GF

Mass resolution	
	GeV/c²]
Mean	3.097
RMS	0.05887
χ² / ndf	154.1 / 78
Constant	109.5 ± 3.3
Mean	3.095 ± 0.001
Sigma	0.04488 ± 0.00095

Elisabetta Prencipe, XLXI PANDA Coll meeting

Conclusions

- /genfit2/ has been ported in PandaRoot
- Preliminary comparison with old-genfit has been provided:
  first tests on 1000 (single track) events show improvement
- Very important: to check the pull of tracking distributions
  need to repeat this study with higher statistics, all hypothesis, different p
- One issue still to be tuned: PndMCTrackAssociator
- Fast simulations run smooth: no tracking (except the PndPidCorrelator)
- Please, check your analysis with genfit2 and report troubles in the forum, if any

THANKS!