Status of Kalman Filter

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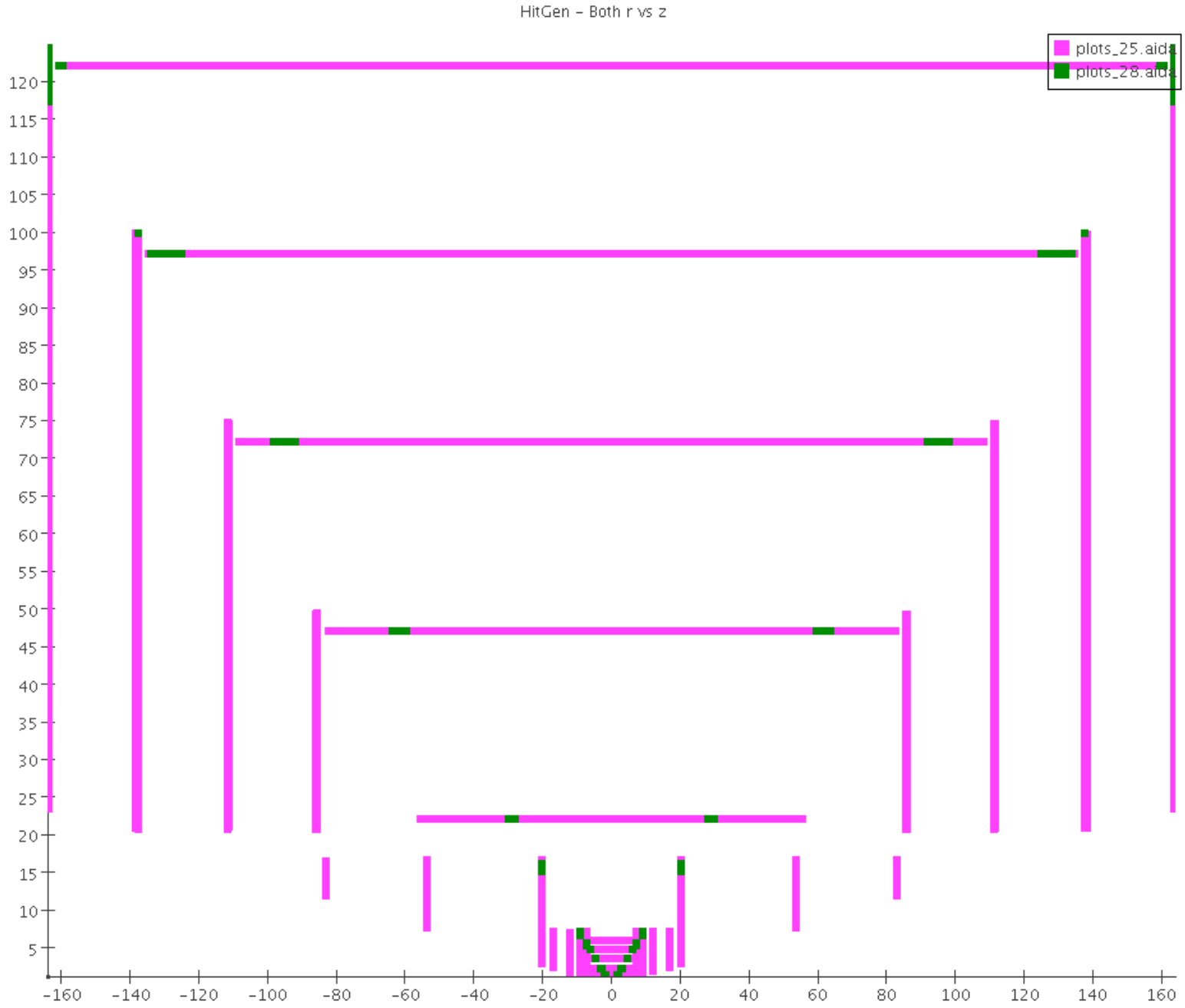
(revised – 12/12/08 2pm)

Where were we before

- Lots of outliers.
  - Traced to long extrapolations which give rise to numerical precision problems.
- The most important subset of these is now solved.
  - All involve long extrapolations with some parameter is poorly measured. This gives rise to numerical precision problems.
- One has an ugly solution.
  - See figure page 4 and notes on page 3.

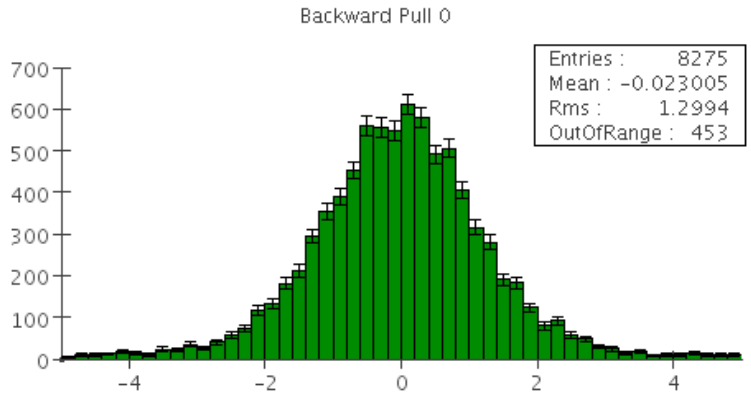
Notes for next page:

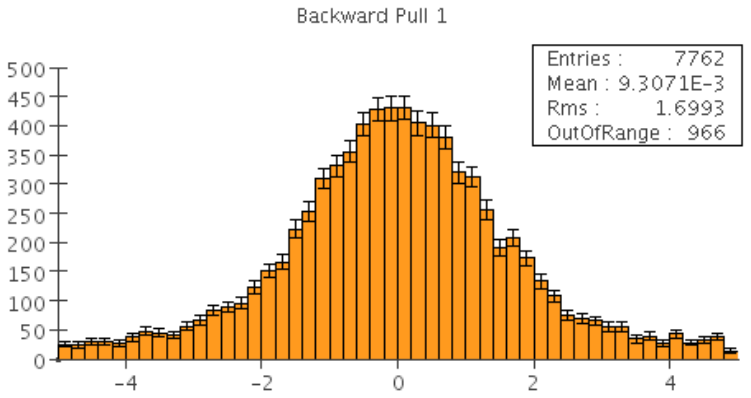
- Magenta points are hits on tracks made by a uniform illumination of the detector.
  - Plot shows r vs z of hits.
  - Tracks are all from the origin.
  - No multiple scattering or eloss in the simulation or fitting.
  - These map out the detector elements.
  - Barrel tracker is axial strips.
  - Tracker zdiscs are x or y measuring strips.
- Green points are from a restricted range of theta.
  - Most tracks have one or two tracker zdiscs at z=160.cm
  - Often next z measurement is forward tracker near z=20 cm.
  - Such tracks have horrible numerical precision problems. They produce plots on page 6.

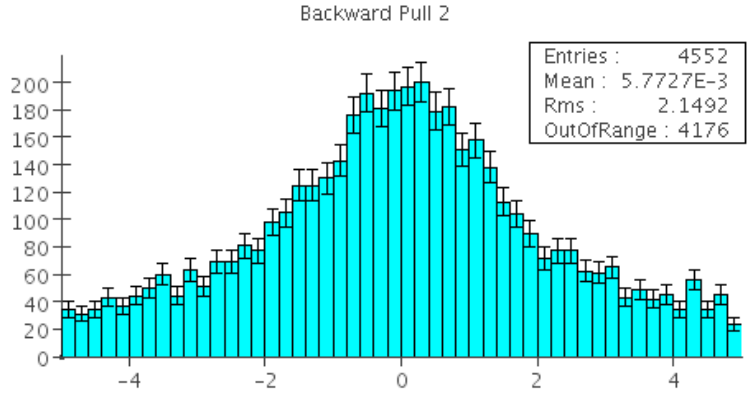

HitGen – Both r vs z
plots_25.aida
plots_28.aida
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
140
160

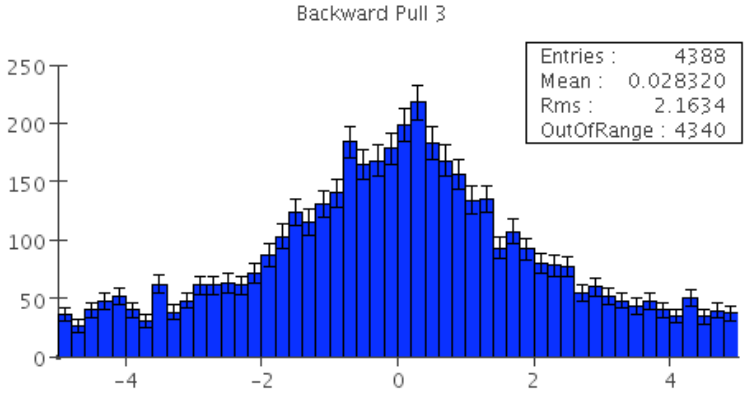
Notes for next page

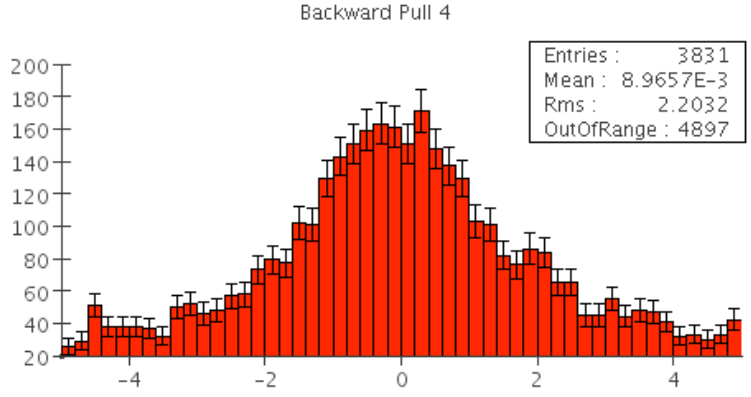
- Pulls and CL for track fits to green points on page 4.
  - All pull distributions are fat and CL has spike at 0.
- Order of parameters for backward fits is TRF DCA track:
  - D0
  - Z0
  - Phi0
  - Tan(lambda)
  - q/pT
- Fit converges without error but gives the wrong answer due to precision problems.
- One answer: remove the outmost zdisc hits. Reduces resolution but gives correct answers: see page 8.

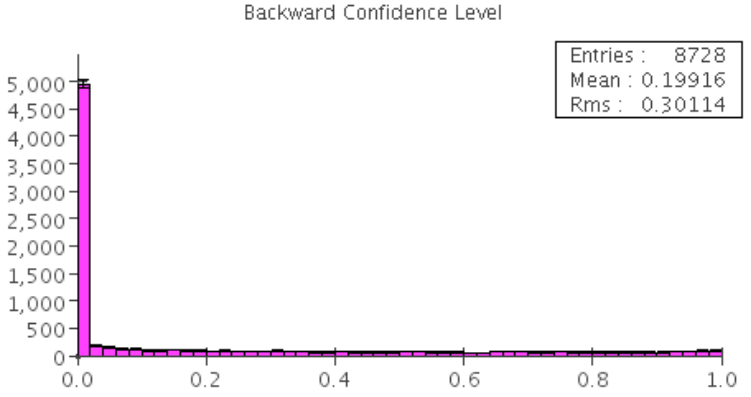

Backward Pull 0
Entries : 8275
Mean : -0.023005
Rms : 1.2994
OutOfRange : 453


Backward Pull 1
Entries : 7762
Mean : 9.3071E-3
Rms : 1.6993
OutOfRange : 966


Backward Pull 2
Entries : 4552
Mean : 5.7727E-3
Rms : 2.1492
OutOfRange : 4176

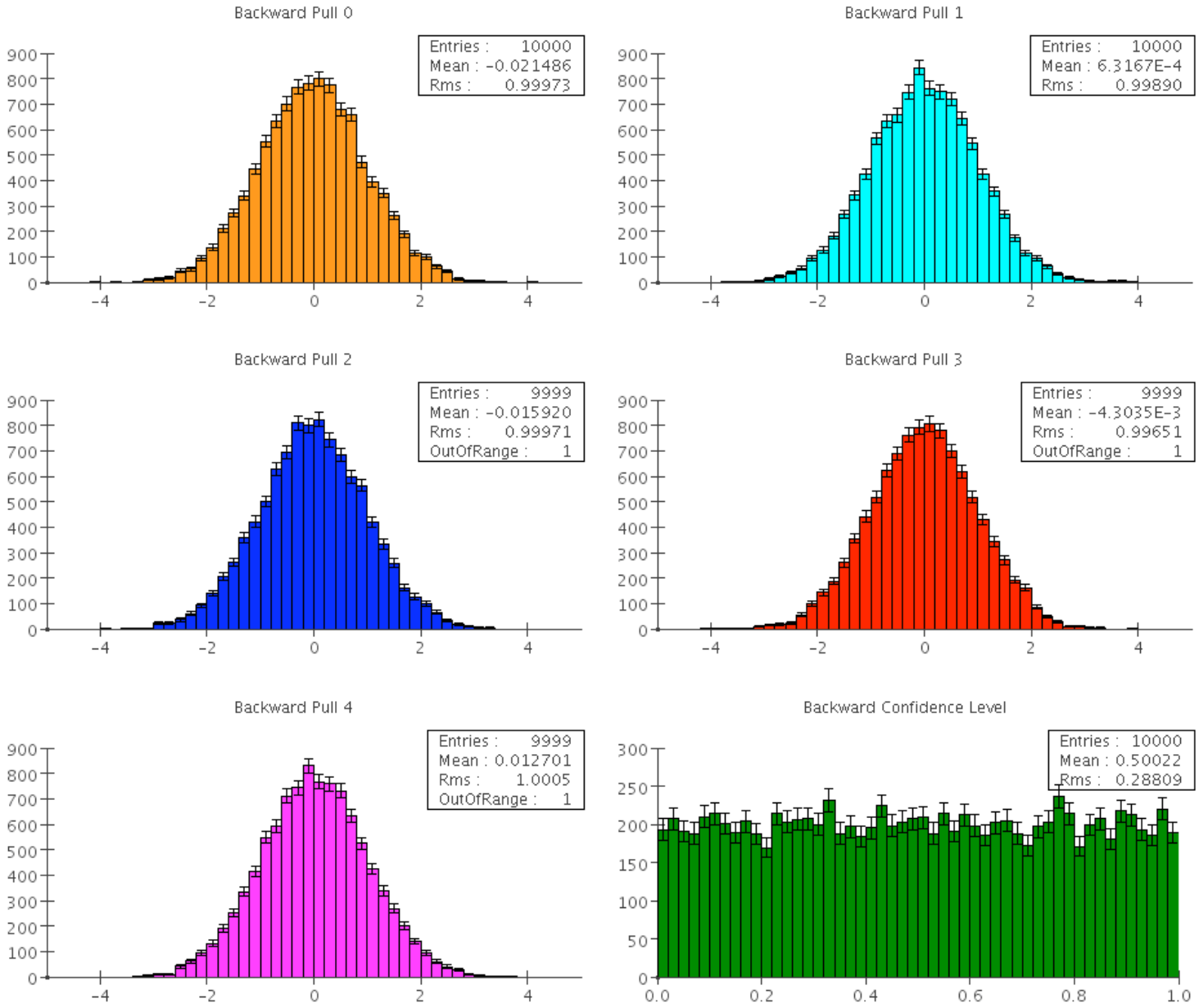

Backward Pull 3
Entries : 4388
Mean : 0.028320
Rms : 2.1634
OutOfRange : 4340


Backward Pull 4
Entries : 3831
Mean : 8.9657E-3
Rms : 2.2032
OutOfRange : 4897


Backward Confidence Level
Entries : 8728
Mean : 0.19916
Rms : 0.30114

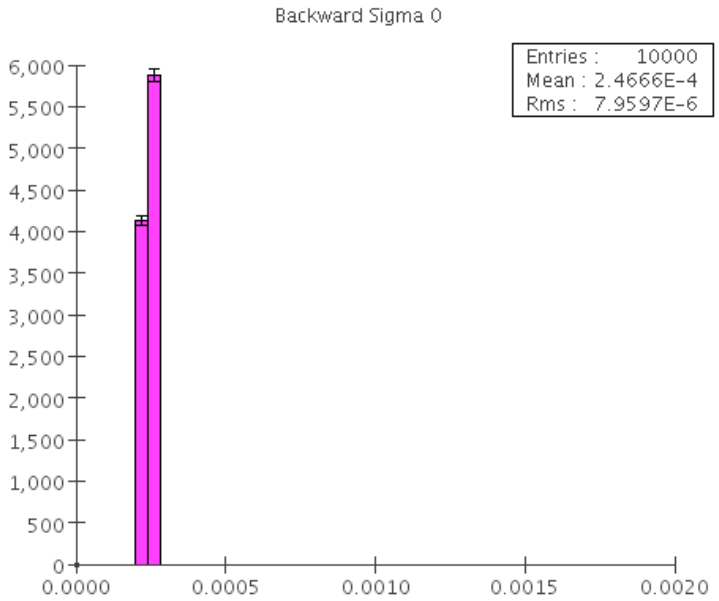
Notes for next slide

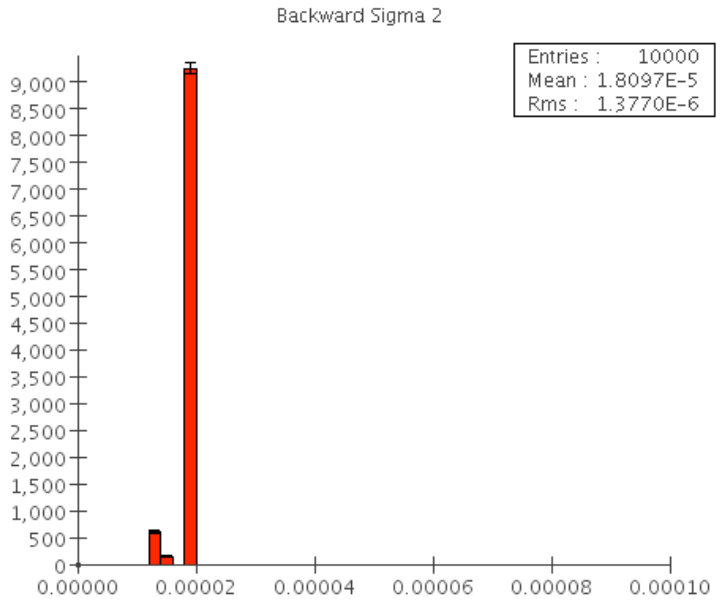
- Same tracks refitted but without zdiscs near |z|=160 cm.
- All pulls look good and CL looks good.

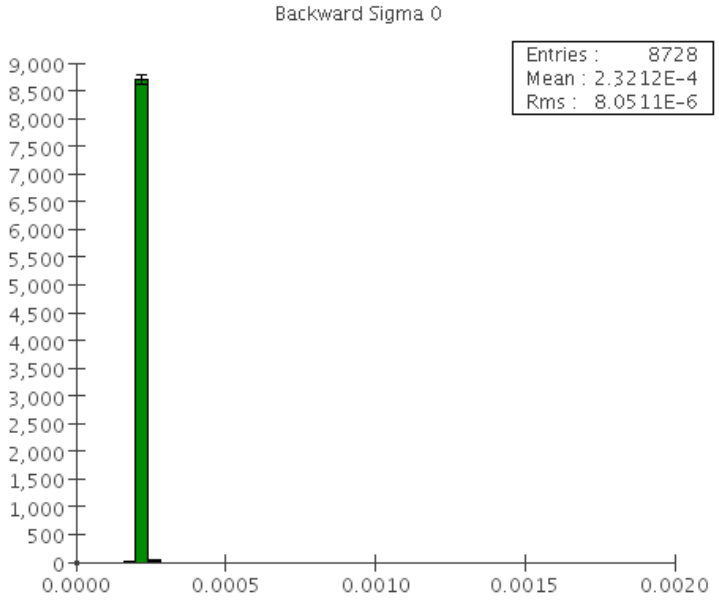

Backward Pull 0
Entries : 10000
Mean : -0.021486
Rms : 0.99973
Backward Pull 1
Entries : 10000
Mean : 6.3167E-4
Rms : 0.99890
Backward Pull 2
Entries : 9999
Mean : -0.015920
Rms : 0.99971
OutOfRange : 1
Backward Pull 3
Entries : 9999
Mean : -4.3035E-3
Rms : 0.99651
OutOfRange : 1
Backward Pull 4
Entries : 9999
Mean : 0.012701
Rms : 1.0005
OutOfRange : 1
Backward Confidence Level
Entries : 10000
Mean : 0.50022
Rms : 0.28809

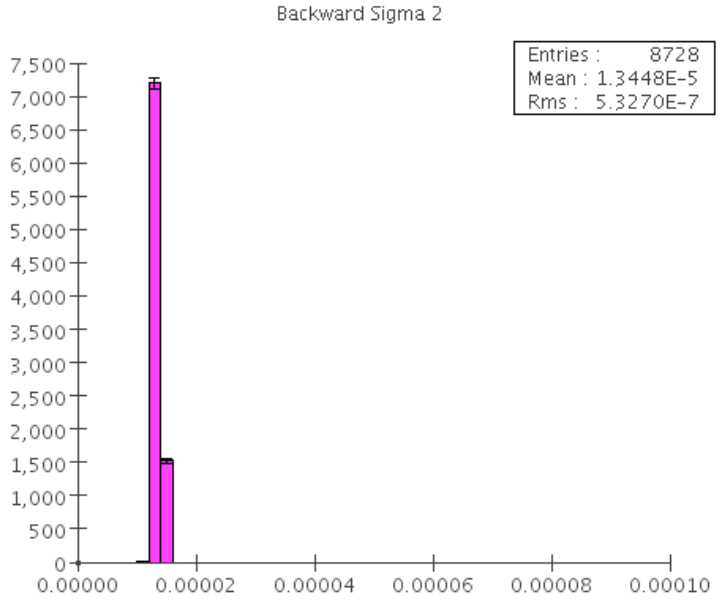
Notes for pages 10…12

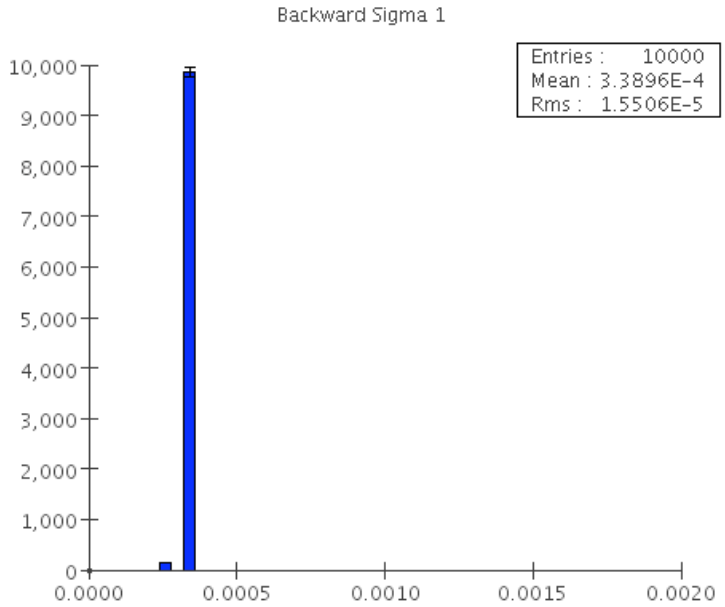
- Columns show distributions of parameter errors for two different fit variants (tracks making green hits on page 4).
  - No MS or eloss in simulation or fits. Perfectly gaussian measurement errors. This is done to isolate problems in the fitter.
- Parameter order as described earlier.
- Top row: fit with outermost zdiscs removed
- Bottom row: fit with all hits included.
  - Fit gives smaller sigma (which is good) but the fit results are not reliable (bad).
  - The effect is most evident in tan(lambda) parameter 4, because of the long lever arm.

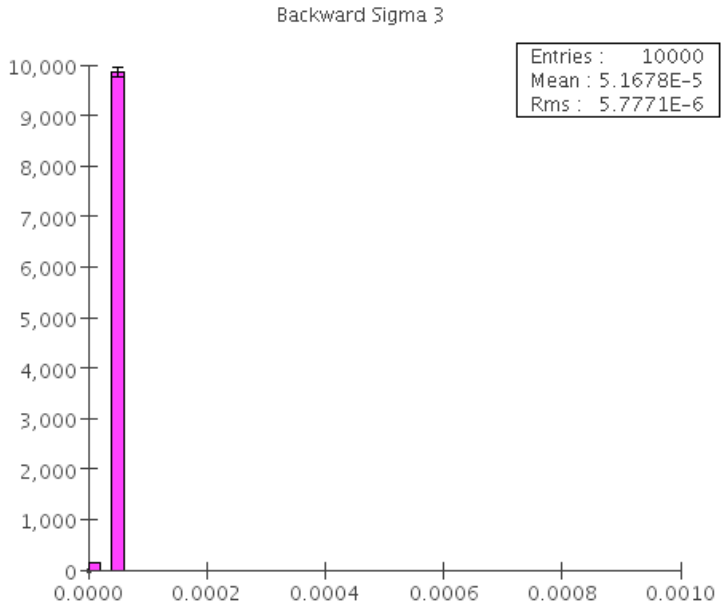

Backward Sigma 0
Entries : 10000
Mean : 2.4666E-4
Rms : 7.9597E-6
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0000
0.0005
0.0010
0.0015
0.0020

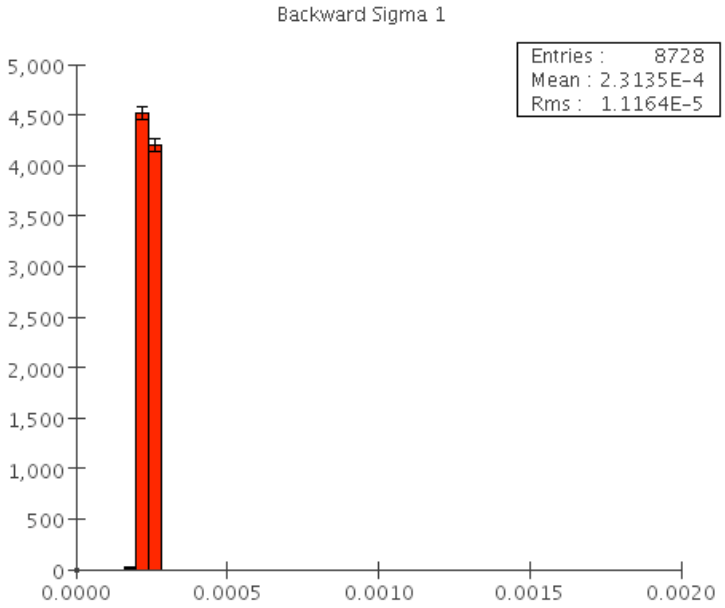

Backward Sigma 2
Entries : 10000
Mean : 1.8097E-5
Rms : 1.3770E-6
9,000
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.00000
0.00002
0.00004
0.00006
0.00008
0.00010

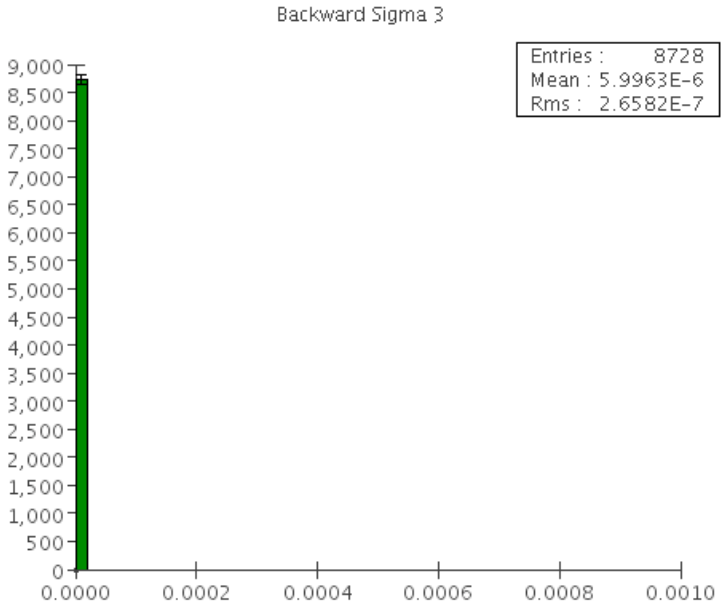

Backward Sigma 0
Entries : 8728
Mean : 2.3212E-4
Rms : 8.0511E-6
9,000
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0000
0.0005
0.0010
0.0015
0.0020

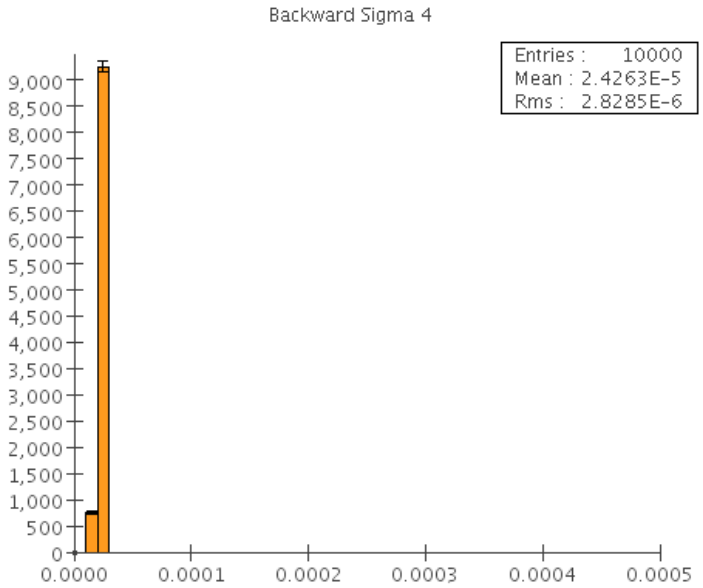

Backward Sigma 2
Entries : 8728
Mean : 1.3448E-5
Rms : 5.3270E-7
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.00000
0.00002
0.00004
0.00006
0.00008
0.00010

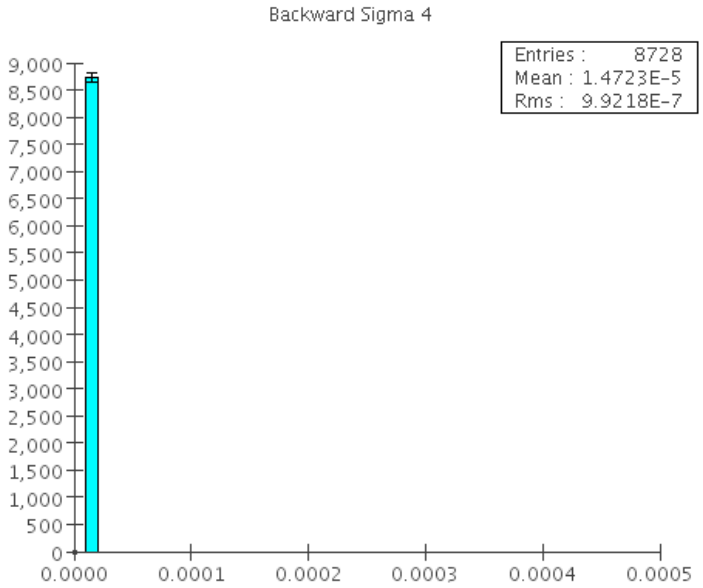

Backward Sigma 1
Entries : 10000
Mean : 3.3896E-4
Rms : 1.5506E-5
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0000
0.0005
0.0010
0.0015
0.0020


Backward Sigma 3
Entries : 10000
Mean : 5.1678E-5
Rms : 5.7771E-6
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010


Backward Sigma 1
Entries : 8728
Mean : 2.3135E-4
Rms : 1.1164E-5
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0000
0.0005
0.0010
0.0015
0.0020


Backward Sigma 3
Entries : 8728
Mean : 5.9963E-6
Rms : 2.6582E-7
9,000
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010


Backward Sigma 4
Entries : 10000
Mean : 2.4263E-5
Rms : 2.8285E-6
9,000
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0000
0.0001
0.0002
0.0003
0.0004
0.0005

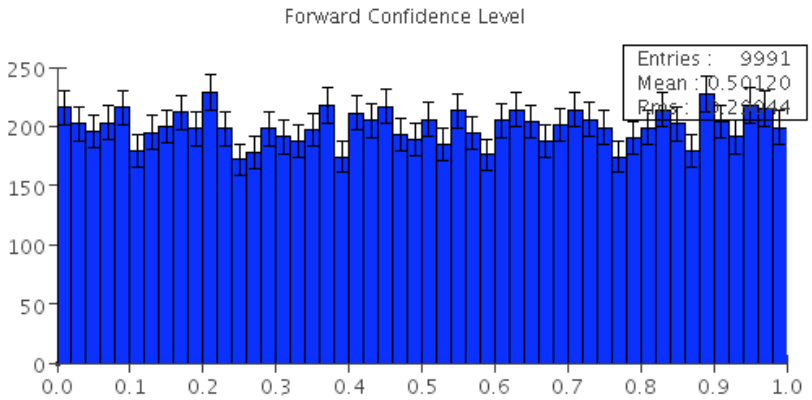

Backward Sigma 4
Entries : 8728
Mean : 1.4723E-5
Rms : 9.9218E-7
9,000
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0000
0.0001
0.0002
0.0003
0.0004
0.0005

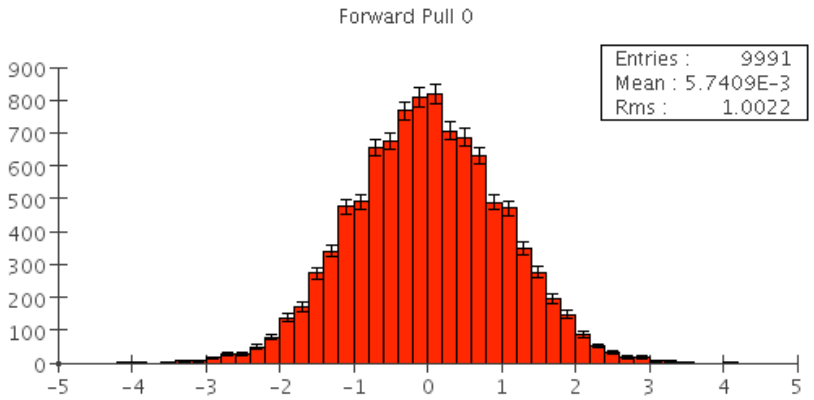
Notes for pages 15, 16

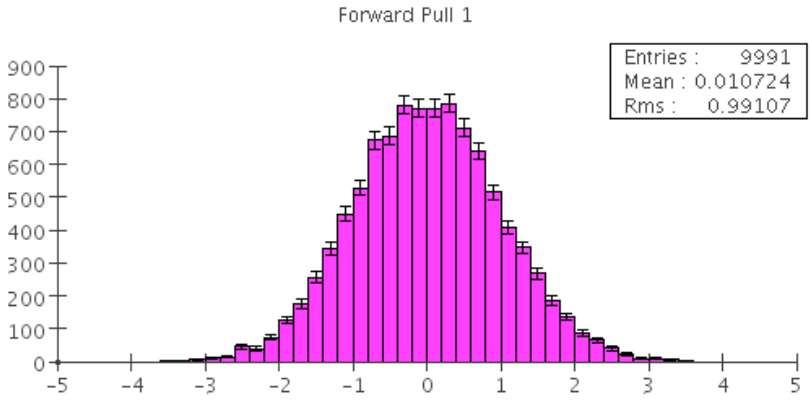
- Both pages show pulls and CL for:
  - -0.991 < cos(theta) < 0.991
  - Pt =1.25 GeV
  - Tracks from origin. Flat in azimuth.
  - Outermost zdiscs removed if and only if next z measurement is more than 1m away.
  - Has gaussian multiple scattering and has energy loss with gaussian straggling.
- Forward fits are essentially perfect, as they should be for this toy model.
- The backward fits have O(5) outliers in the pull distributions (in 10000) fits; ignorable for now.

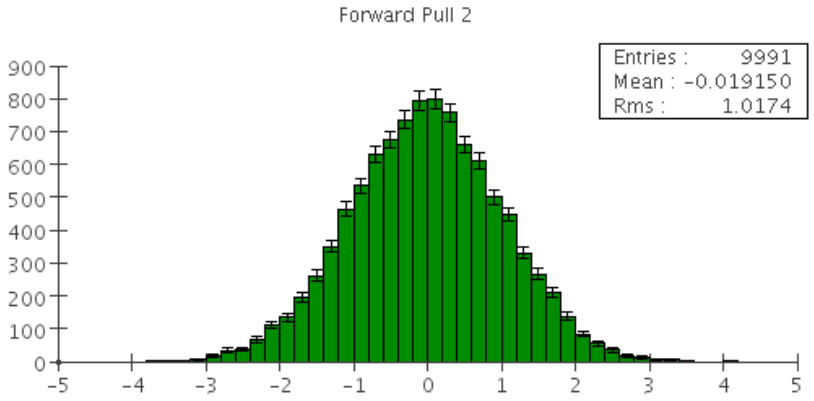
Notes on pages 15, 16

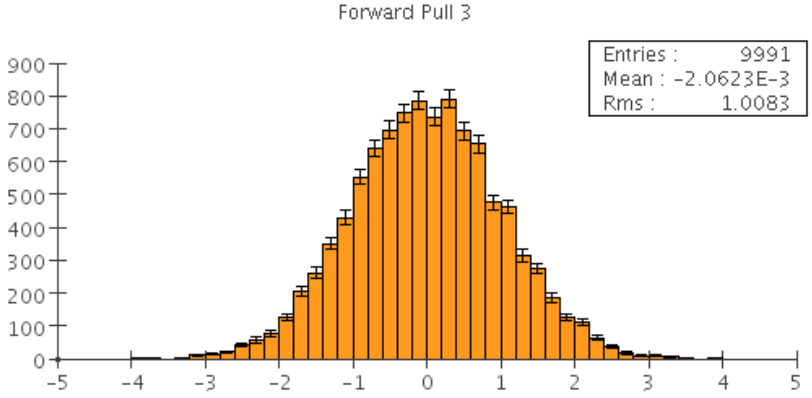
- For forward fits, the parameters are either the TRF cylinder parameters or the TRF zplane parameters.
  - Depends on the type of the outermost measurement.
- Cylinder:
  - Azimuth of hit
  - Z0
  - Alpha = (Azimuth of Pt) – (Azimuth of hit)
  - Tan(lambda)
  - q/pt
- Zplane: (x, y, xslope, yslope, p).

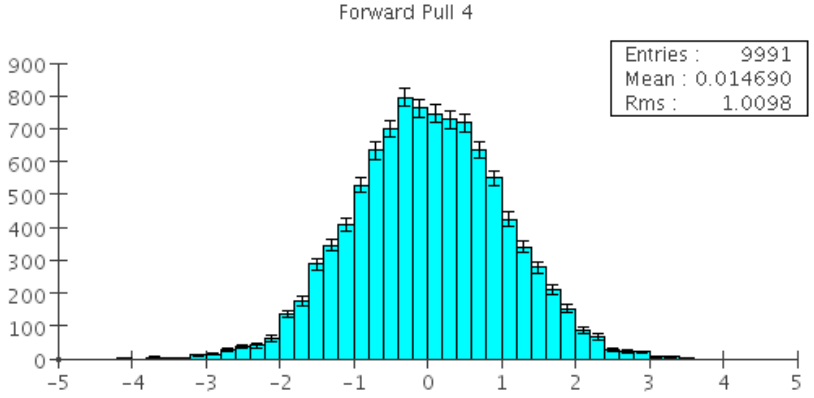

Forward Confidence Level
Entries : 9991
Mean : 0.50120
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
0 50 100 150 200 250

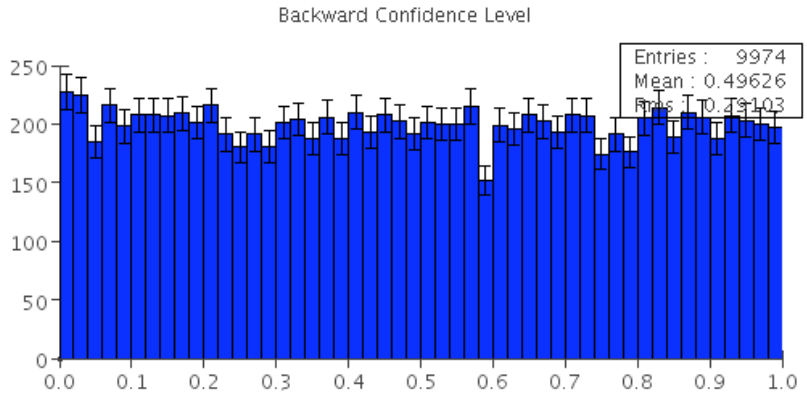

Forward Pull 0
Entries : 9991
Mean : 5.7409E-3
Rms : 1.0022
-5 -4 -3 -2 -1 0 1 2 3 4 5
0 100 200 300 400 500 600 700 800 900

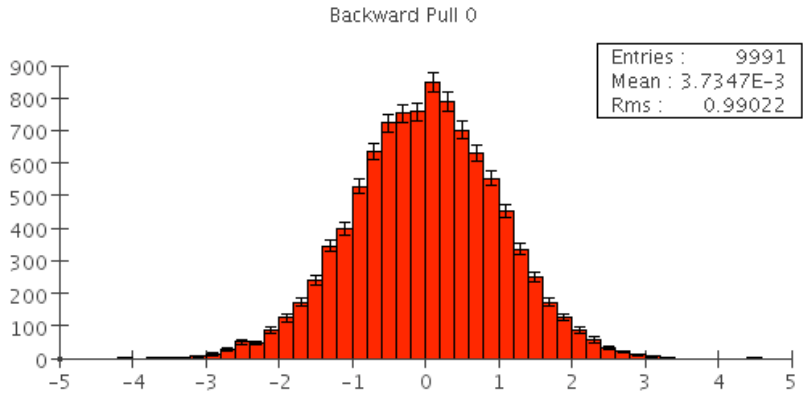

Forward Pull 1
Entries : 9991
Mean : 0.010724
Rms : 0.99107
-5 -4 -3 -2 -1 0 1 2 3 4 5
0 100 200 300 400 500 600 700 800 900

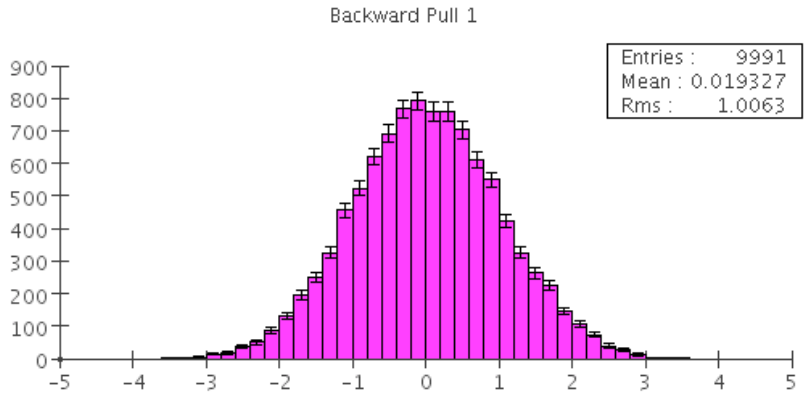

Forward Pull 2
Entries : 9991
Mean : -0.019150
Rms : 1.0174
-5 -4 -3 -2 -1 0 1 2 3 4 5
0 100 200 300 400 500 600 700 800 900

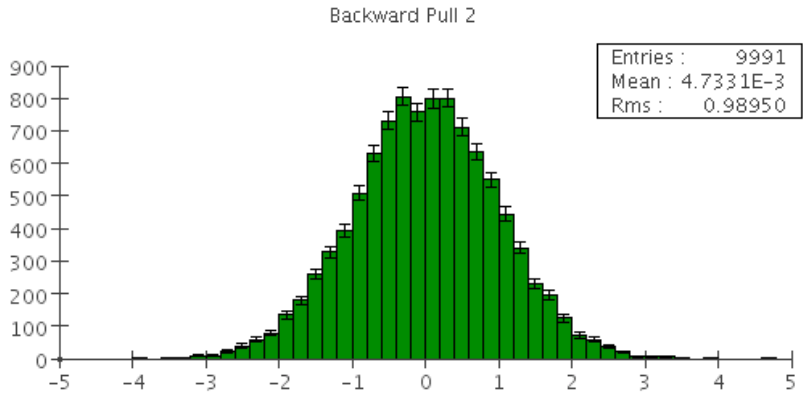

Forward Pull 3
Entries : 9991
Mean : -2.0623E-3
Rms : 1.0083
-5 -4 -3 -2 -1 0 1 2 3 4 5
0 100 200 300 400 500 600 700 800 900

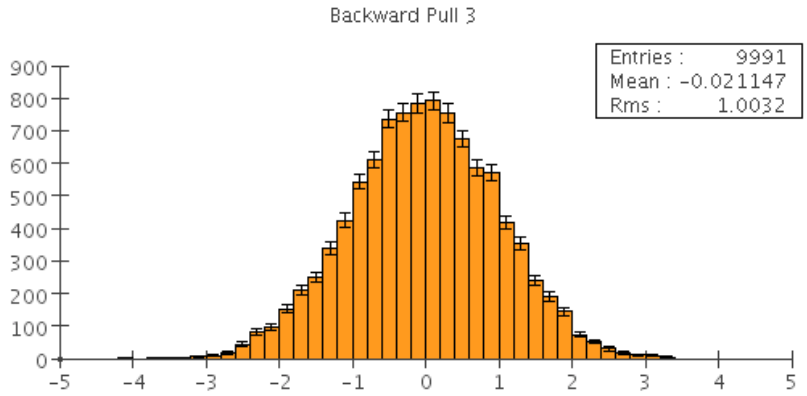

Forward Pull 4
Entries : 9991
Mean : 0.014690
Rms : 1.0098
-5 -4 -3 -2 -1 0 1 2 3 4 5
0 100 200 300 400 500 600 700 800 900

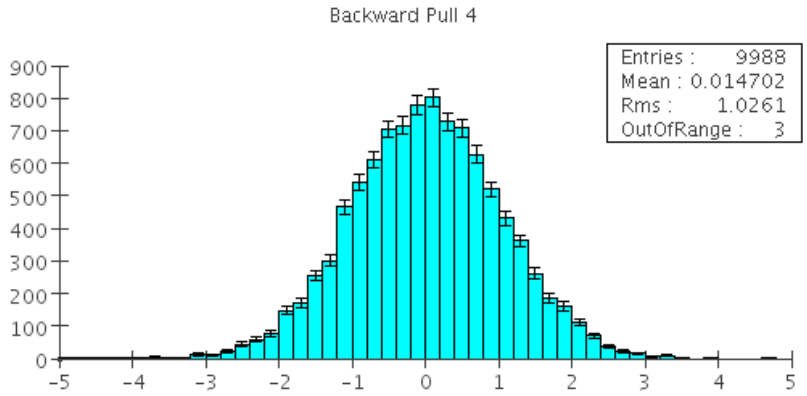

Backward Confidence Level
Entries : 9974
Mean : 0.49626
Rms : 0.29103


Backward Pull 0
Entries : 9991
Mean : 3.7347E-3
Rms : 0.99022


Backward Pull 1
Entries : 9991
Mean : 0.019327
Rms : 1.0063


Backward Pull 2
Entries : 9991
Mean : 4.7331E-3
Rms : 0.98950


Backward Pull 3
Entries : 9991
Mean : -0.021147
Rms : 1.0032


Backward Pull 4
Entries : 9988
Mean : 0.014702
Rms : 1.0261
OutOfRange : 3

Notes on Previous Page

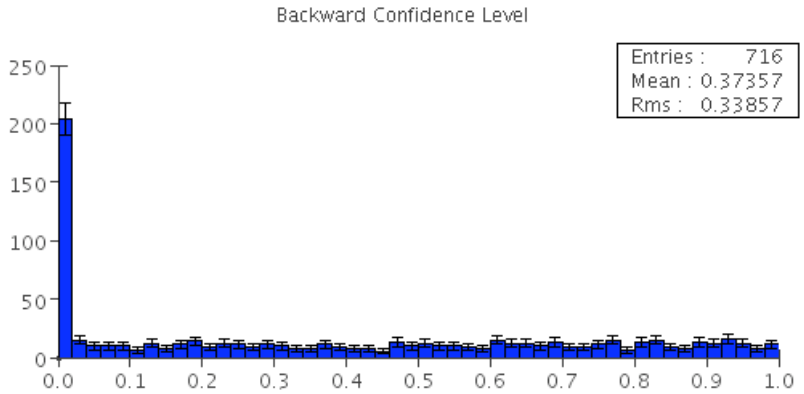
- Tim noticed that on pages 15 and 16, all histograms have 9991 entries (including out of range entries) except for CL on page 16, which has 9974.
- I added printout to the code and it is filled 9991 times!
  - I have no idea why the plotted histogram does not say that.
  - I hand binned the contents into: (cl<0.0), (cl==0.), (0.<cl<1.), (cl==1.0) and (cl>1.0).
    - All 9991 entries in between 0 and 1 with no goal posts.
- No idea what's happening here.

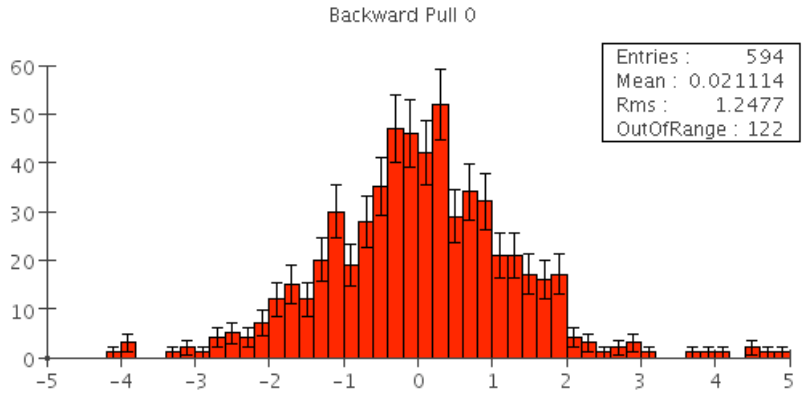
What's Next

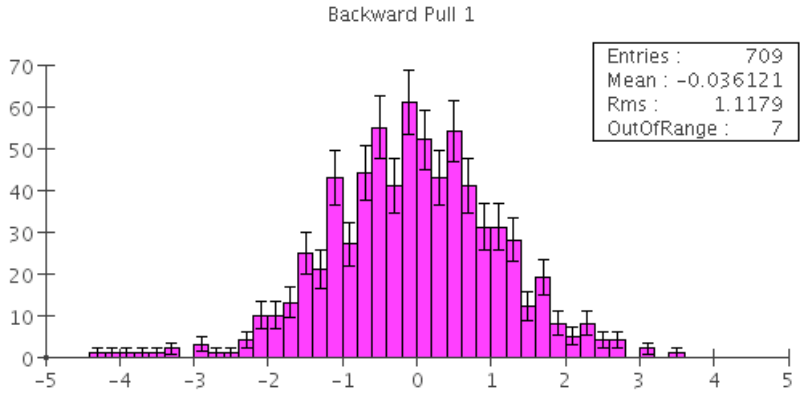
- Almost there.
  - Technology is done.
  - Bookkeeping remains.
- I can have it done by mid Jan (I am away Dec 17 to Jan 7).
- An idea:
  - If we extend the tracker endcap discs near |z|=140 cm to slightly larger radius the problem goes away.
  - Way may need also to extend the discs near |z|=120 cm slightly larger radius to avoid a similar problem.
  - This probably makes extrapolations short enough that the others do not need to be extended.

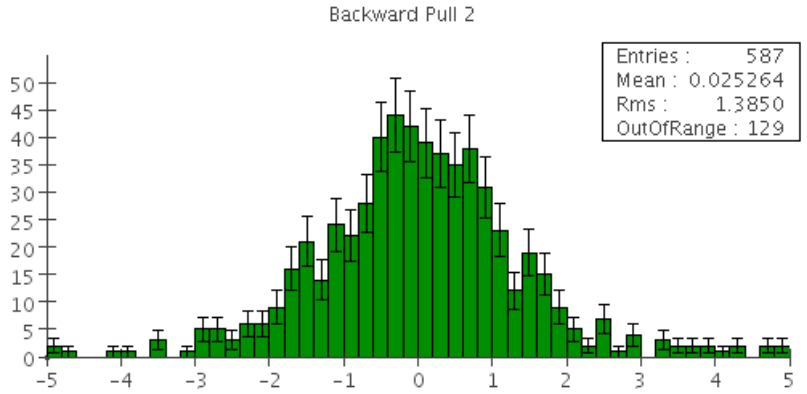
Work After the Meeting

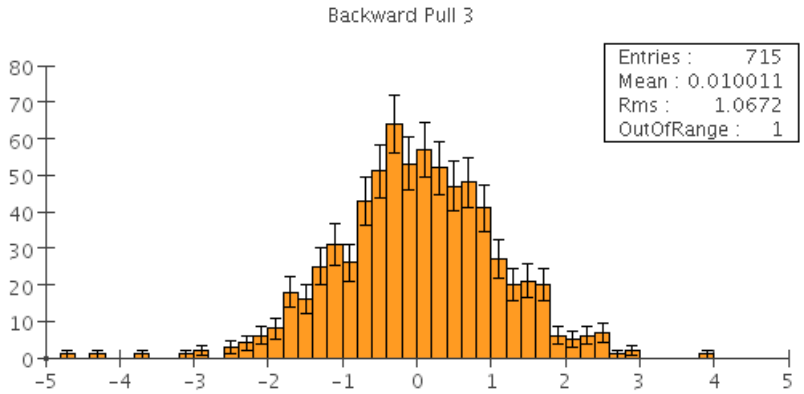
- Pages 20, 21 are redos of pages 6 and 8, but I have enabled energy loss and scattering in both the generation and the fit. (Some of the support material is missing from the material model – so all resolutions are a little too good).
  - The results are the same. When the zdiscs near |z|=160 cm are included, the fits give unreliable results. When the are excluded the first give good results.

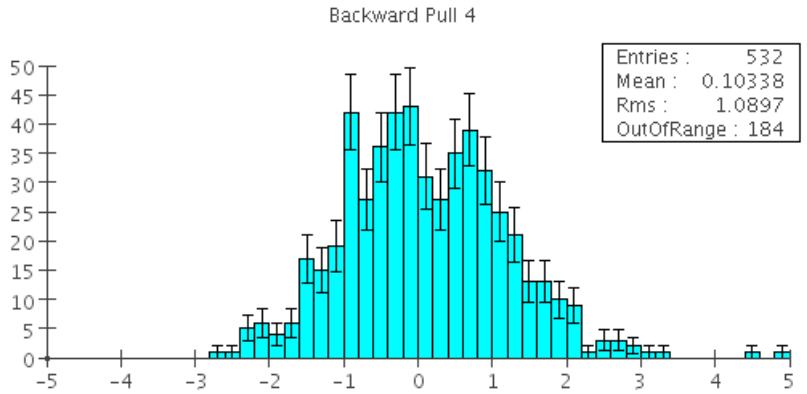

Backward Confidence Level
Entries : 716
Mean : 0.37357
Rms : 0.33857

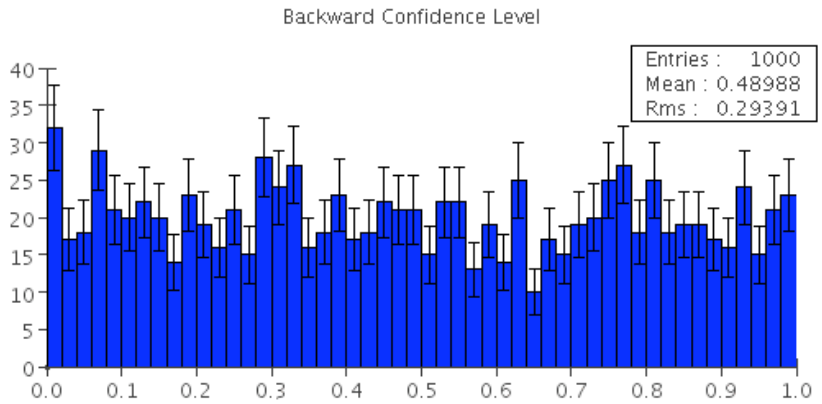

Backward Pull 0
Entries : 594
Mean : 0.021114
Rms : 1.2477
OutOfRange : 122

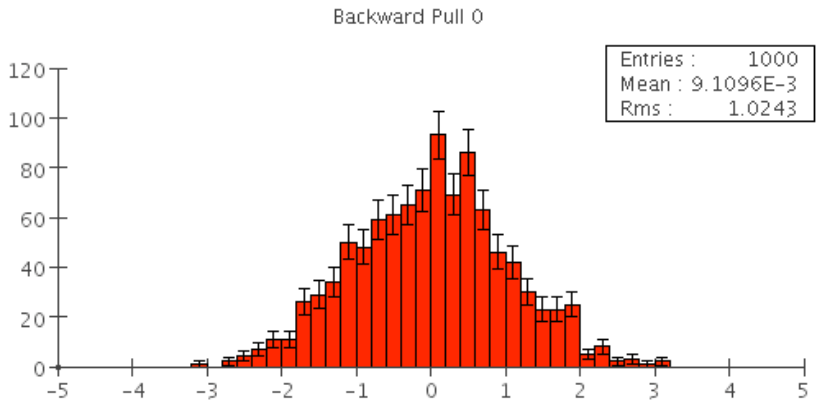

Backward Pull 1
Entries : 709
Mean : -0.036121
Rms : 1.1179
OutOfRange : 7

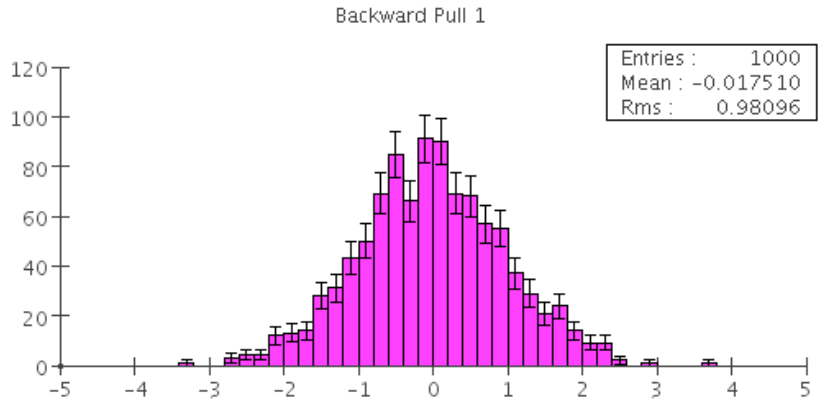

Backward Pull 2
Entries : 587
Mean : 0.025264
Rms : 1.3850
OutOfRange : 129

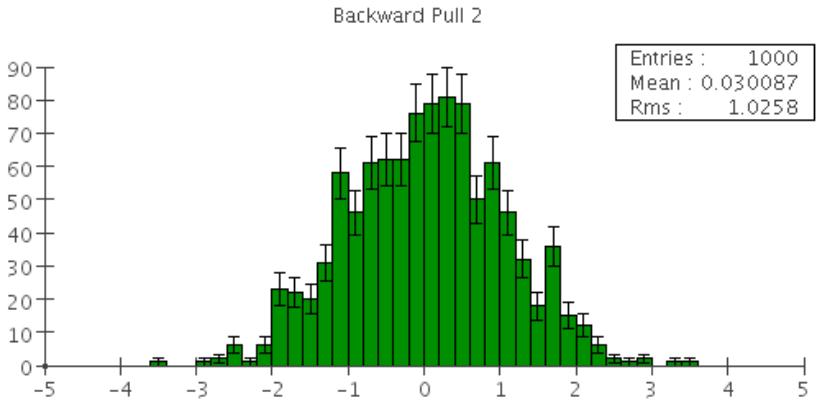

Backward Pull 3
Entries : 715
Mean : 0.010011
Rms : 1.0672
OutOfRange : 1

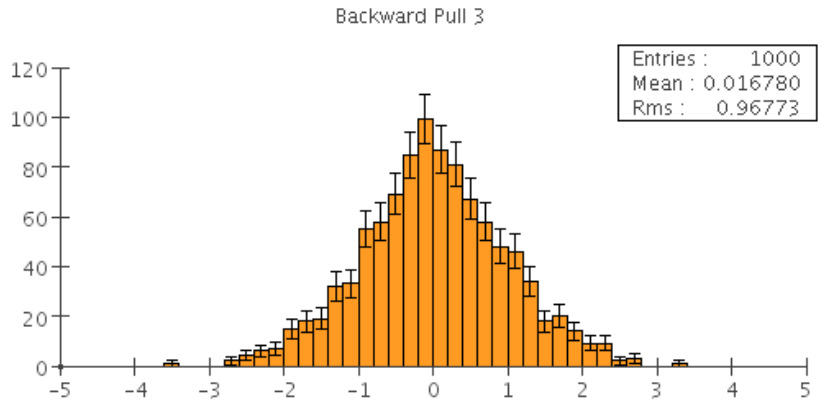

Backward Pull 4
Entries : 532
Mean : 0.10338
Rms : 1.0897
OutOfRange : 184

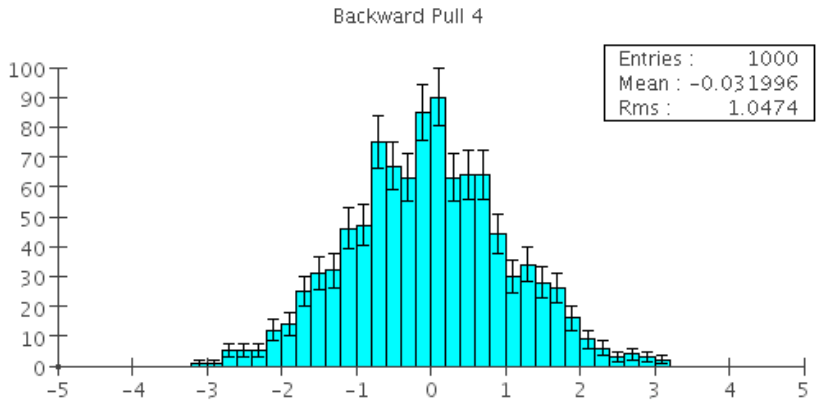

Backward Confidence Level
Entries : 1000
Mean : 0.48988
Rms : 0.29391


Backward Pull 0
Entries : 1000
Mean : 9.1096E-3
Rms : 1.0243


Backward Pull 1
Entries : 1000
Mean : -0.017510
Rms : 0.98096

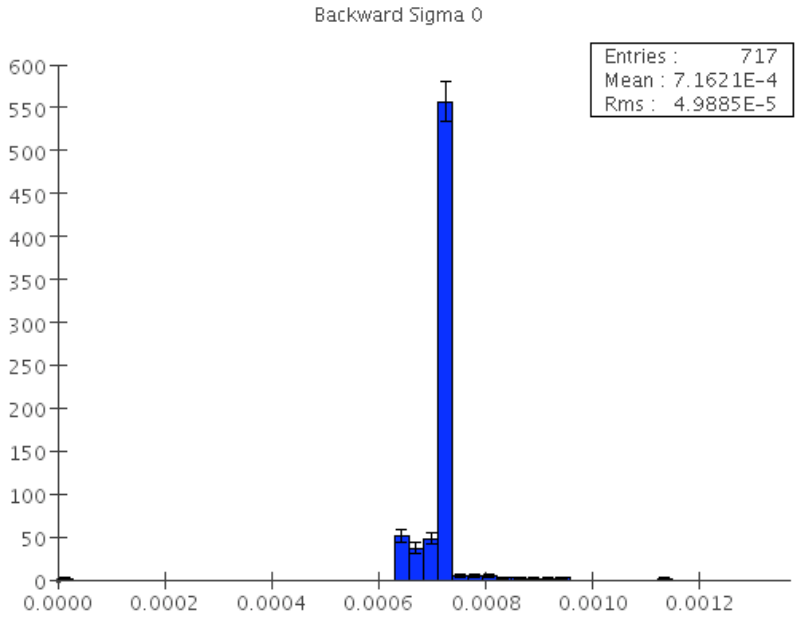

Backward Pull 2
Entries : 1000
Mean : 0.030087
Rms : 1.0258

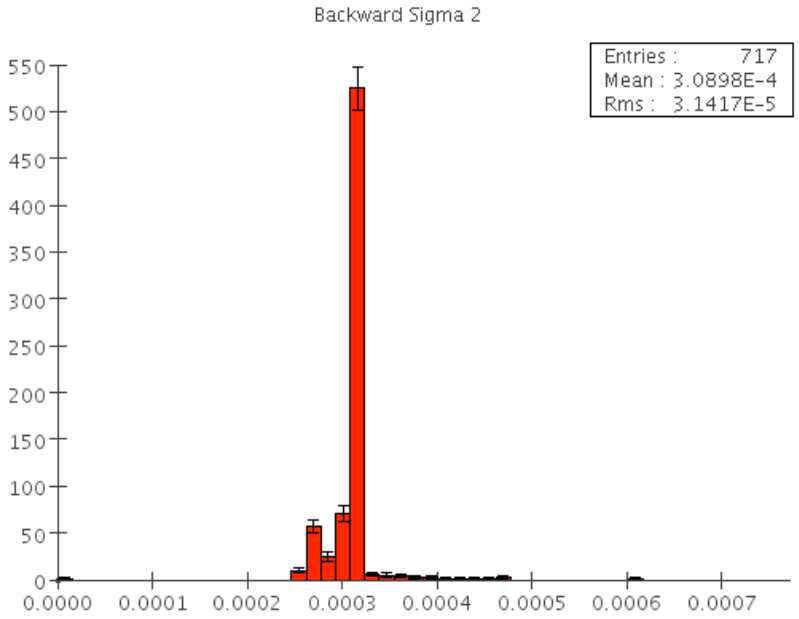

Backward Pull 3
Entries : 1000
Mean : 0.016780
Rms : 0.96773

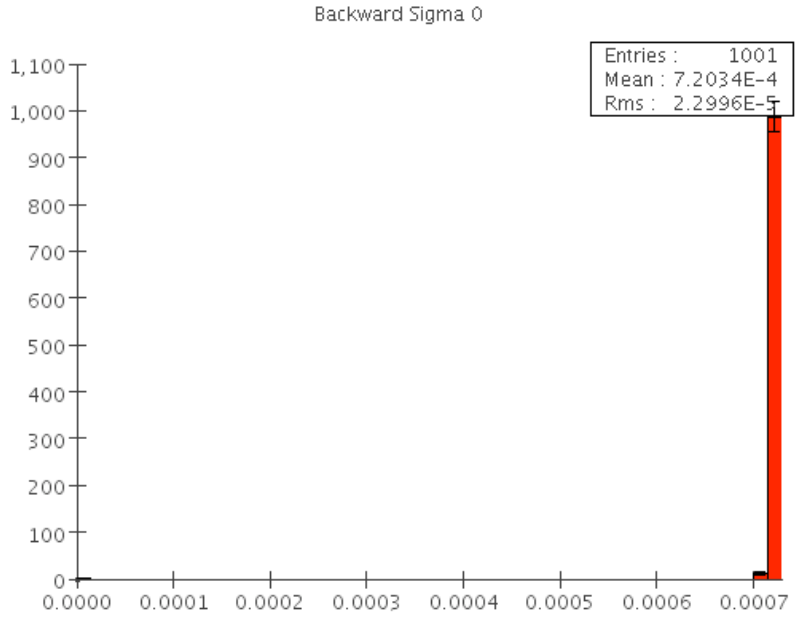

Backward Pull 4
Entries : 1000
Mean : -0.031996
Rms : 1.0474

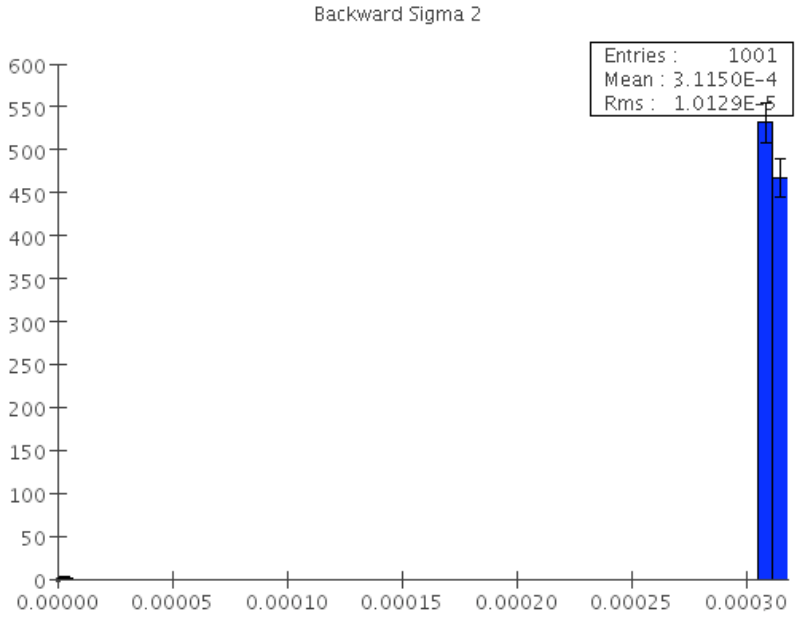
Work After the Meeting

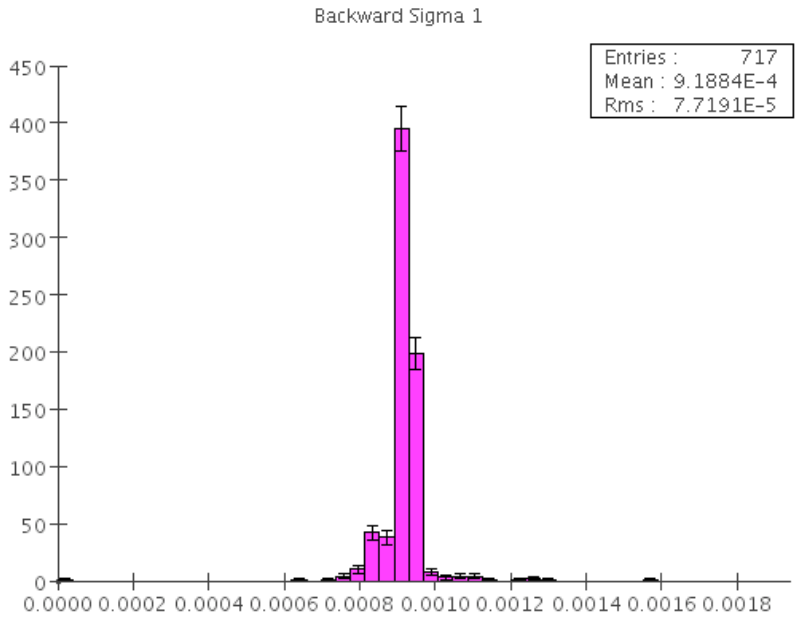
- Pages 22, 23, 24 are a redo of pages 10…12 except that MS and Eloss are turned on in both the fits and the simulation.
  - The top plots are for the fit that includes the distant zdiscs
    - So the errors may be smaller but the results are unreliable.
  - The bottom plots are for the fit that excludes the distant zdiscs.
    - So the results are reliable but the errrors may be larger.
- Be careful: the horizontal scales are not the same within a column!!
- The loss in resolution caused by dropping the distant z hit is very small!
  - So dropping the hit is not a horrible thing to do.

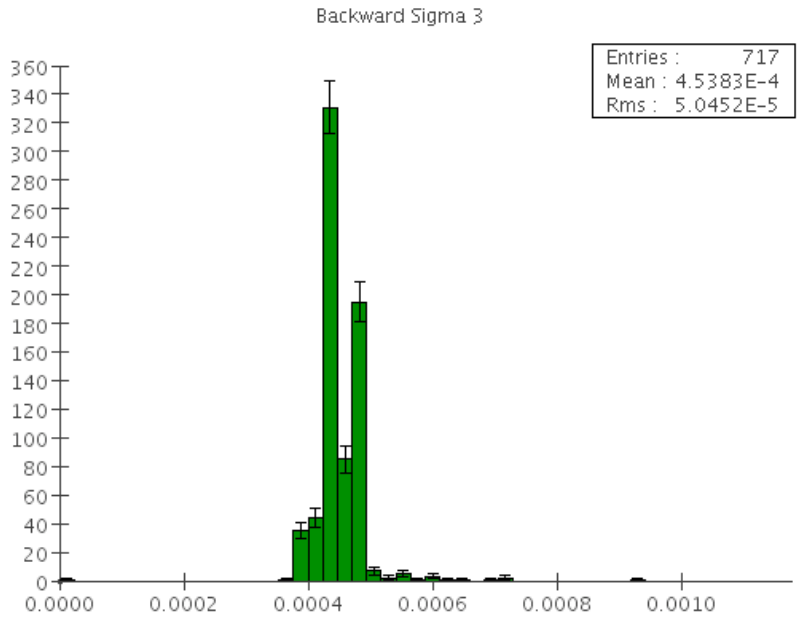

Backward Sigma 0
Entries : 717
Mean : 7.1621E-4
Rms : 4.9885E-5
600
550
500
450
400
350
300
250
200
150
100
50
0
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0.0012

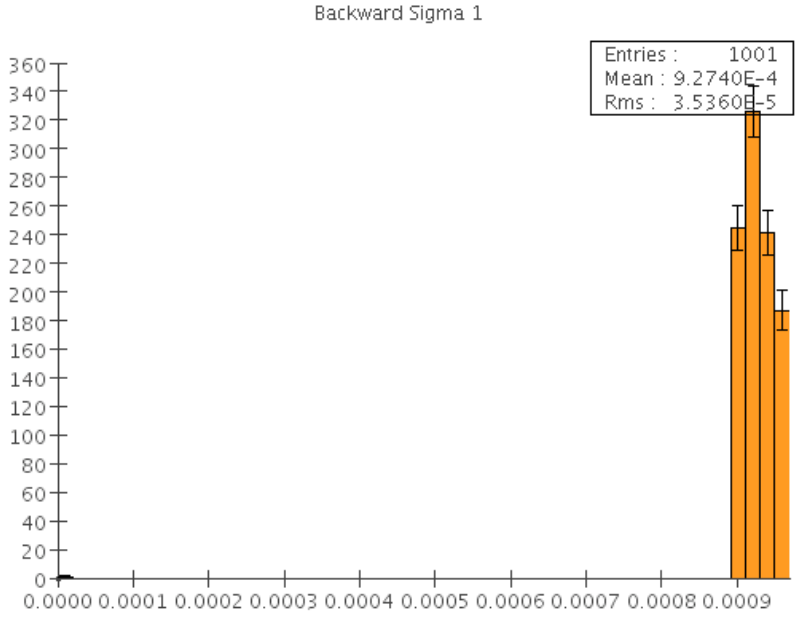

Backward Sigma 2
Entries : 717
Mean : 3.0898E-4
Rms : 3.1417E-5
550
500
450
400
350
300
250
200
150
100
50
0
0.0000
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.0007

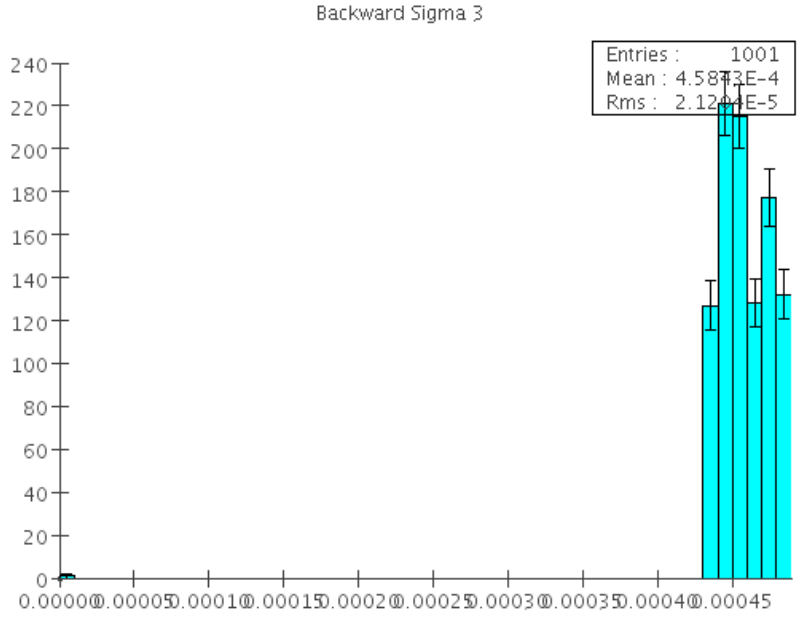

Backward Sigma 0
Entries : 1001
Mean : 7.2034E-4
Rms : 2.2996E-5
1,100
1,000
900
800
700
600
500
400
300
200
100
0
0.0000
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.0007

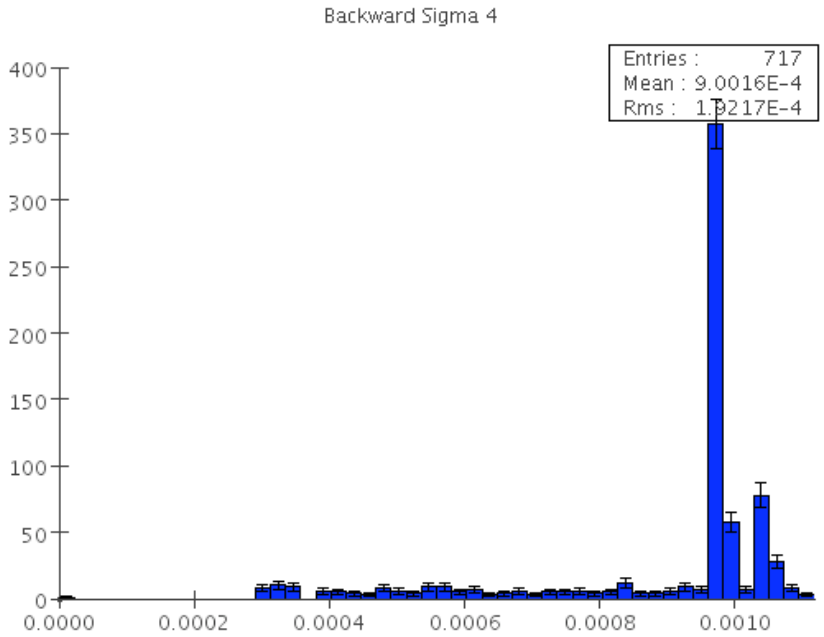

Backward Sigma 2
Entries : 1001
Mean : 3.1150E-4
Rms : 1.0129E-5
600
550
500
450
400
350
300
250
200
150
100
50
0
0.00000
0.00005
0.00010
0.00015
0.00020
0.00025
0.00030

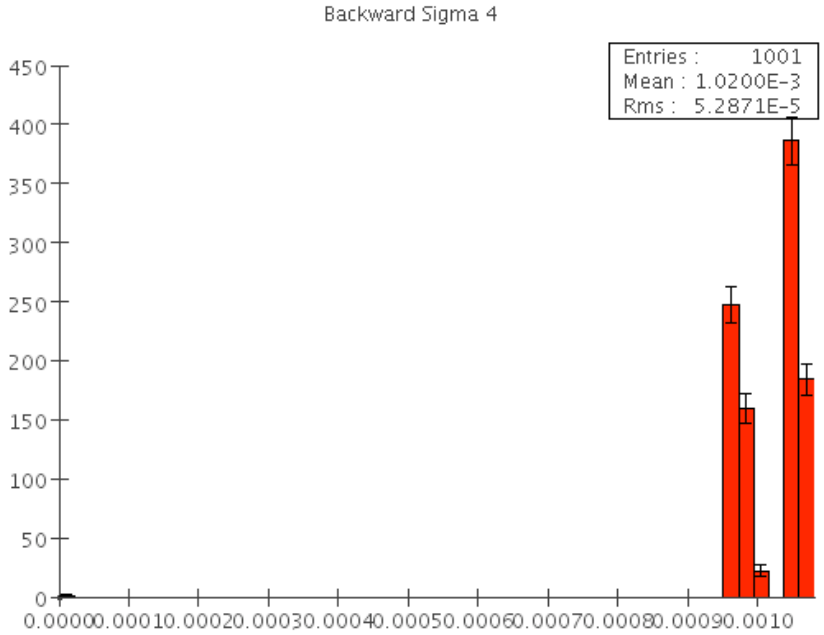

Backward Sigma 1
Entries : 717
Mean : 9.1884E-4
Rms : 7.7191E-5
0.0000 0.0002 0.0004 0.0006 0.0008 0.0010 0.0012 0.0014 0.0016 0.0018


Backward Sigma 3
Entries : 717
Mean : 4.5383E-4
Rms : 5.0452E-5
0.0000 0.0002 0.0004 0.0006 0.0008 0.0010


Backward Sigma 1
Entries : 1001
Mean : 9.2740E-4
Rms : 3.5360E-5
0.0000 0.0001 0.0002 0.0003 0.0004 0.0005 0.0006 0.0007 0.0008 0.0009


Backward Sigma 3
Entries : 1001
Mean : 4.5873E-4
Rms : 2.1204E-5
0.00000 0.00005 0.00010 0.00015 0.00020 0.00025 0.00030 0.00035 0.00040 0.00045


Backward Sigma 4
Entries : 717
Mean : 9.0016E-4
Rms : 1.3217E-4
400
350
300
250
200
150
100
50
0
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010


Backward Sigma 4
Entries : 1001
Mean : 1.0200E-3
Rms : 5.2871E-5
450
400
350
300
250
200
150
100
50
0
0.0000
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.0007
0.0008
0.0009
0.0010