CALICE
Calorimeter for ILC

Royal Holloway
University of London

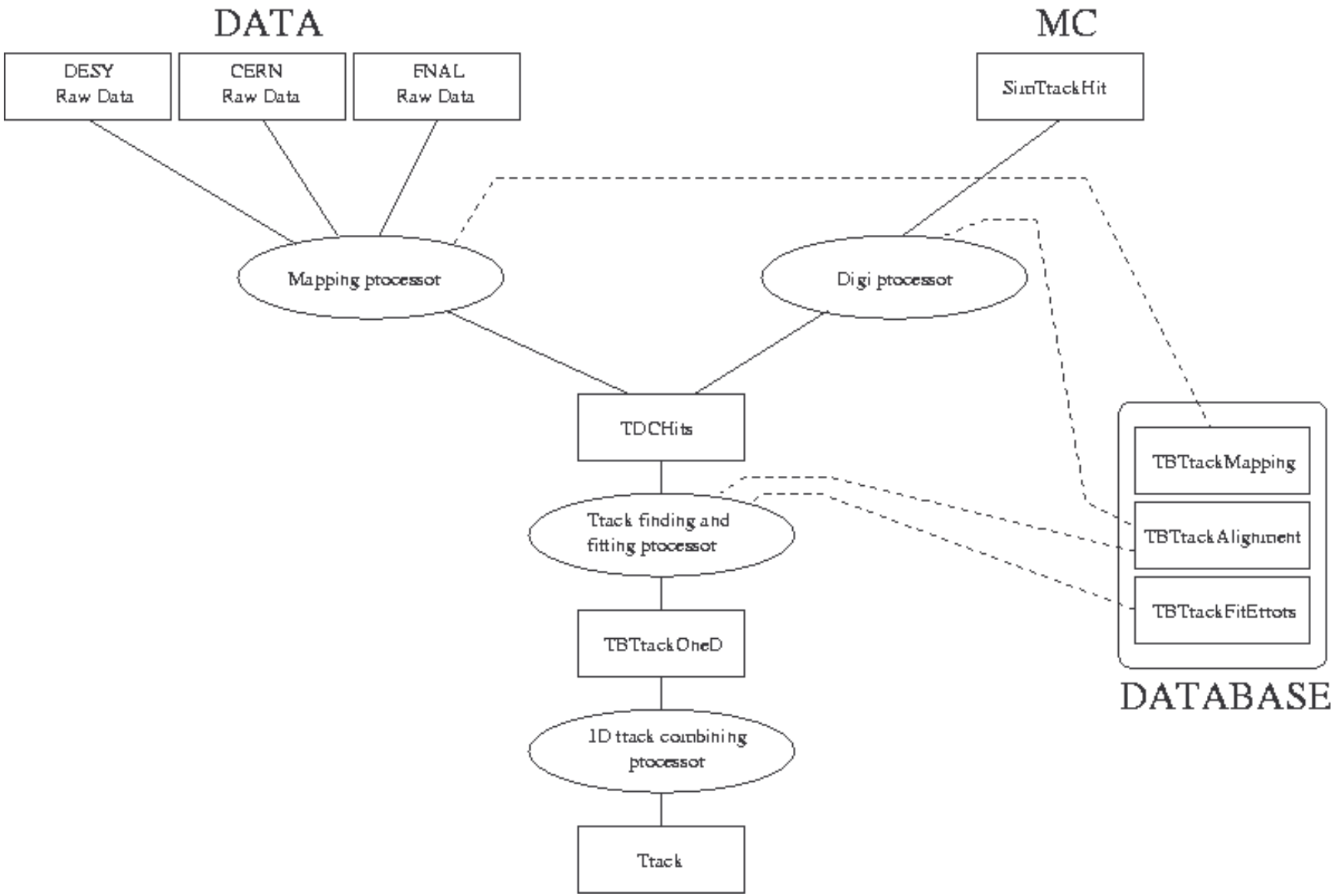
Status of Tracking at DESY

Paul Dauncey, Michele Faucci Giannelli, Mike Green, Hakan Yilmaz, Anne Marie Magnan, George Mavromanolakis, Fabrizio Salvatore

Outline

- New software structure:
  - Include DB interaction
- Measurement of drift velocity and DC off sets
- Intrinsic chamber resolution in the MC
- Comparison of MC with Data

The tracking software



Drift velocity

- Several suggestion, no definitive answer.
  - Scatter plot
  - Ratio
  - Sum of consecutive chambers
  - Recursive methods
  - …
- The fact is we lack of external constraint. Some approximations are needed.

Results

- First method abandoned
  - fit a 2D Gauss and take the axis.
- Second method (X only)

Run	Energy	DC1	DC2	DC3	DC4
230097	3	0,0305	0,0284	0,0346	0,303
230098	1	0,031	0,0282	0,0386	0,0292
230099	2	0,0305	0,0284	0,035	0,0303
230100	4	0,0305	0,0282	0,0345	0,0302
230101	**6**	**0,0303**	**0,0282**	**0,0342**	**0,0301**
230104	5	0,0301	0,0278	0,034	0,0299
230255	1,5	0,0299	0,0278	0,0339	0,0294

- Third method, v1=v2 and v3=v4 (Y too)

DC1-2 X	0,0296
DC1-2 Y	0,0303
DC3-4 X	0,0327
DC3-4 Y	0,0273

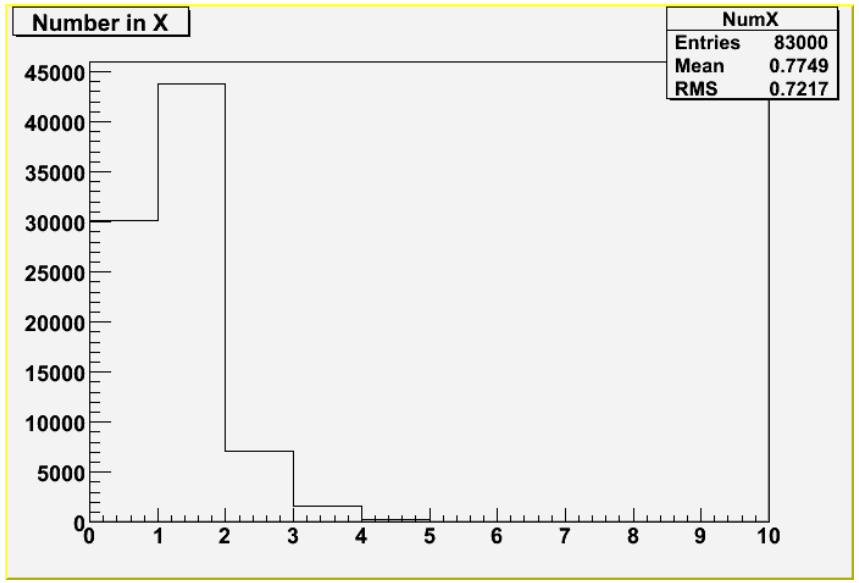
DC1-2 average = 0.0300

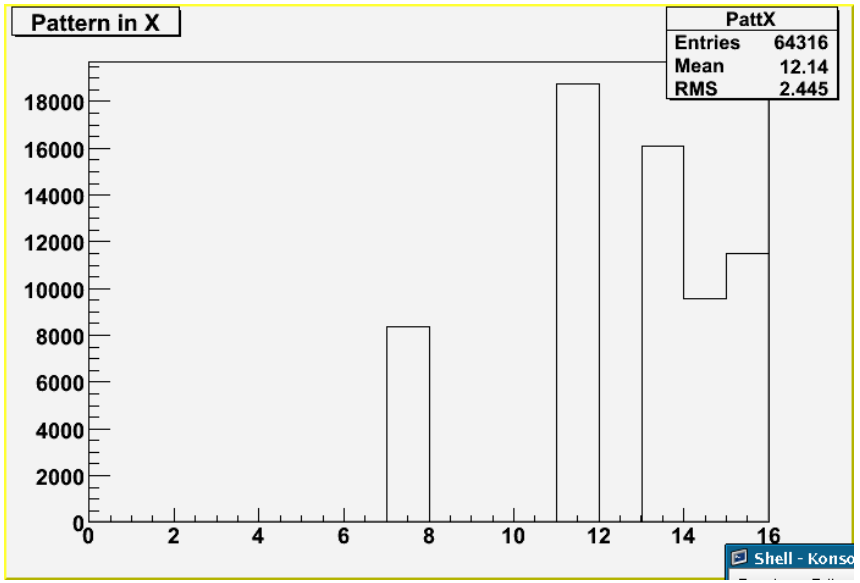
DC3-4 average = 0.0300

Track reconstruction

- Error matrix calculated from MC events to evaluate the multiple scattering,
  - intrinsic error is set to 0.4 mm for the moment
- Try assuming layer 0 and 3 have the same drift velocity
  - Start assuming drift velocity of 0.03mm/ns in each
- Interpolate inwards to determine constants of layers 1 and 2
  - Use full fit and shift offsets and drift velocities to get best probability values
  - Effectively gives relative drift velocities to average of layer 0 and 3
- 1D Track can extrapolate the point at any Z
  - Error is propagated using the error matrix from MC

Results after alignment

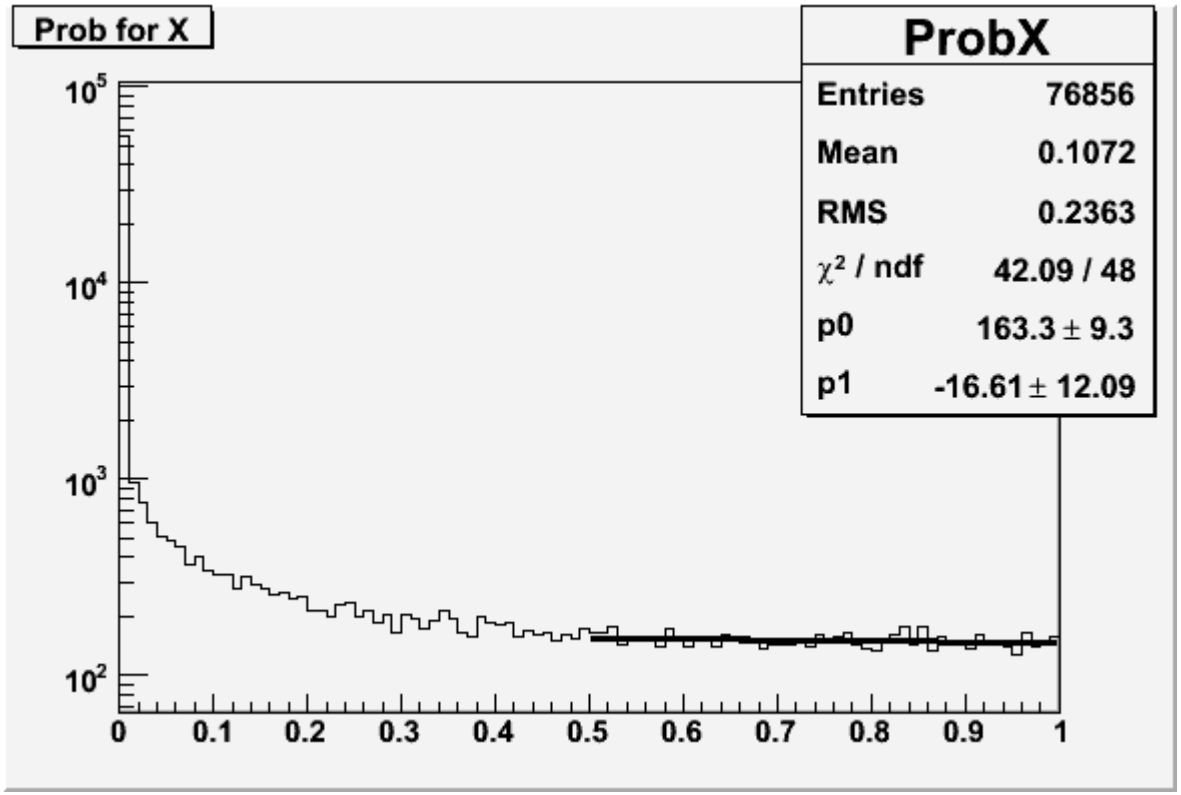




- ~40% of events have no track
  - How much is due to noisy beam conditions at DESY?
  - Need to compare with ECAL energy next
- ~20% of tracks have four hits
  - For efficiency see later

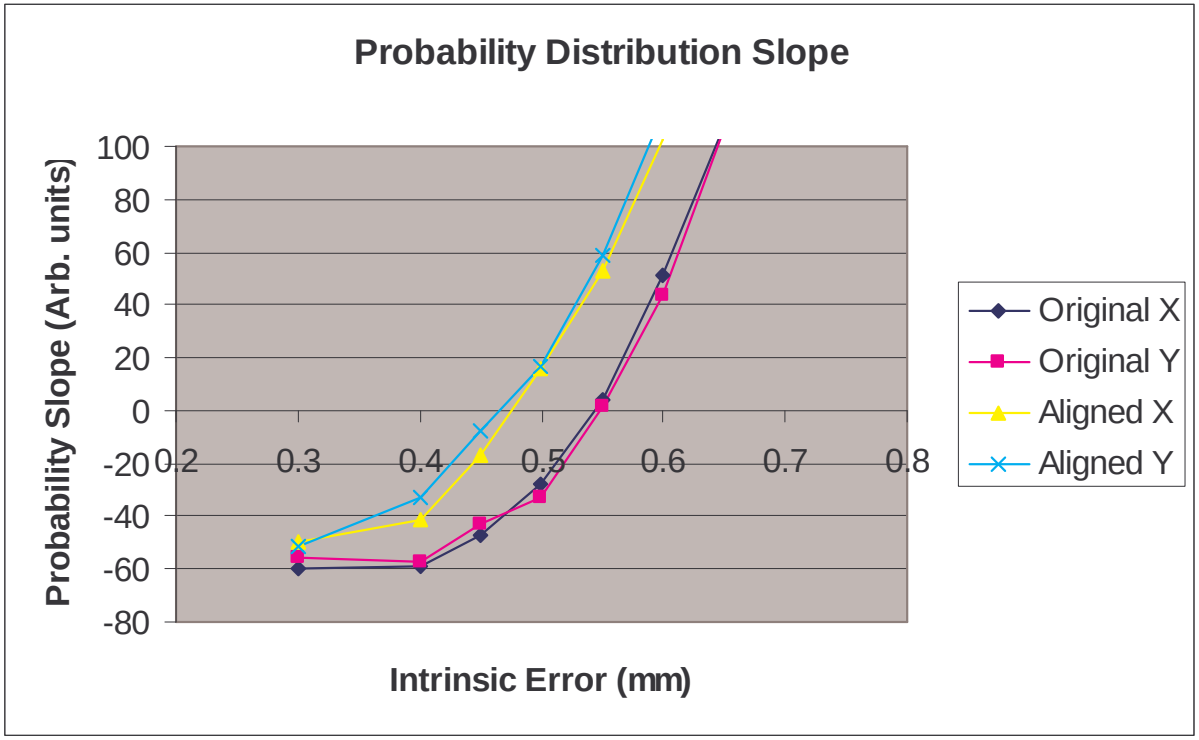
Intrinsic resolution

- It is possible to evaluate the intrinsic resolution constraining the Chi probability to be flat.



Intrinsic resolution

- Try different intrinsic resolutions in fit and compare slopes
  - Both before and after realignment (reevaluation of drift velocity and misalignment)



- Value for zero slope approx 0.55mm before, 0.45mm after

Intrinsic resolution (2)

- It is possible to evaluate the intrinsic resolution plotting the errors as a function of the energy.
  - The errors are evaluated using the formula

$$\hat{\sigma} = \frac{\text{mode}[S]}{\sqrt{n_d - 1}}$$

  - With S defined as

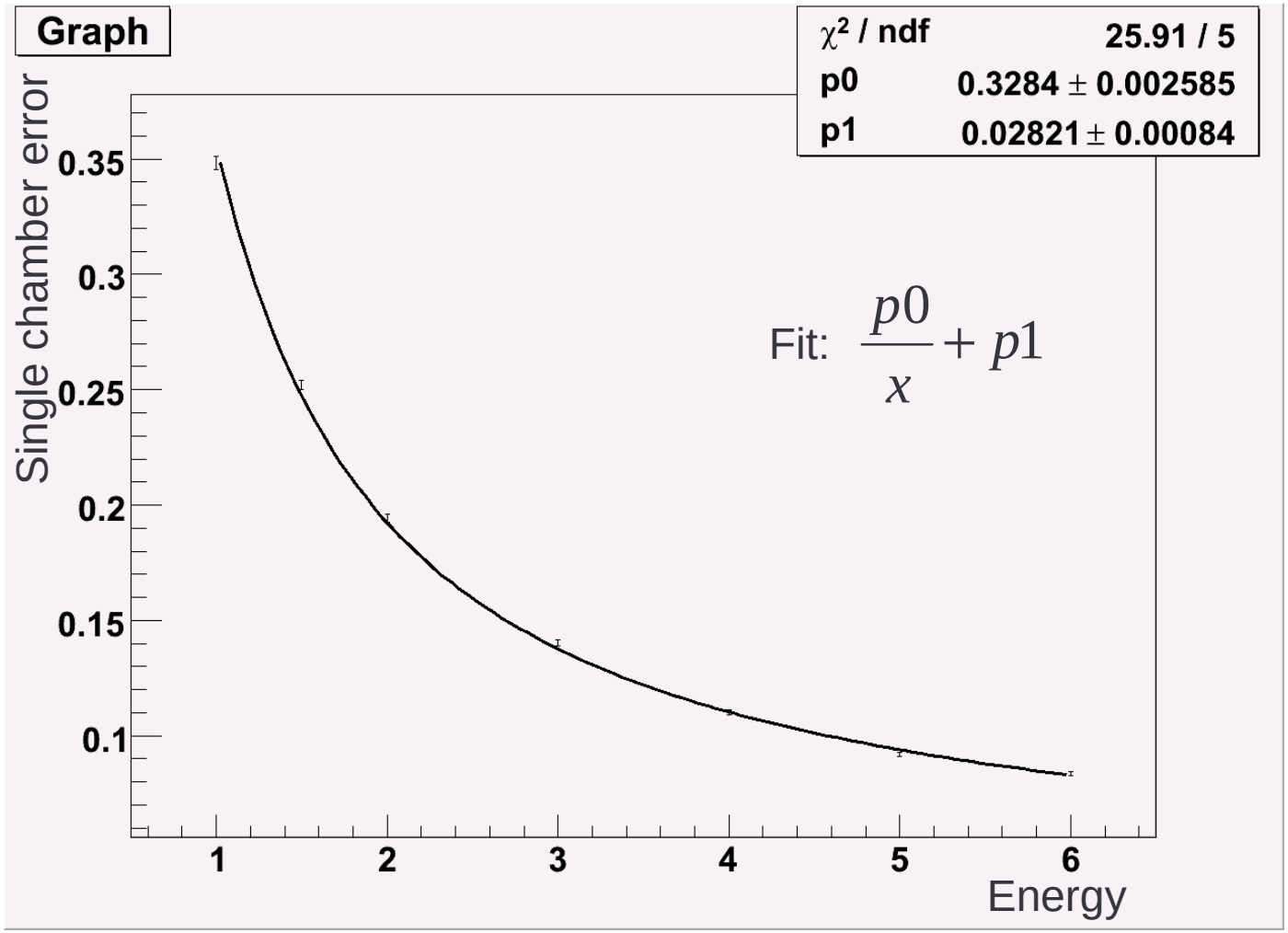
$$S = \sqrt{\sum_{i=1}^{n} (y_i - f(x_i;\theta))^2}$$

  - χ^2 cannot be used since n_d is 2

$$\hat{\sigma} = \sqrt{\frac{\text{mode}[S^2]}{\sqrt{n_d - 2}}}$$

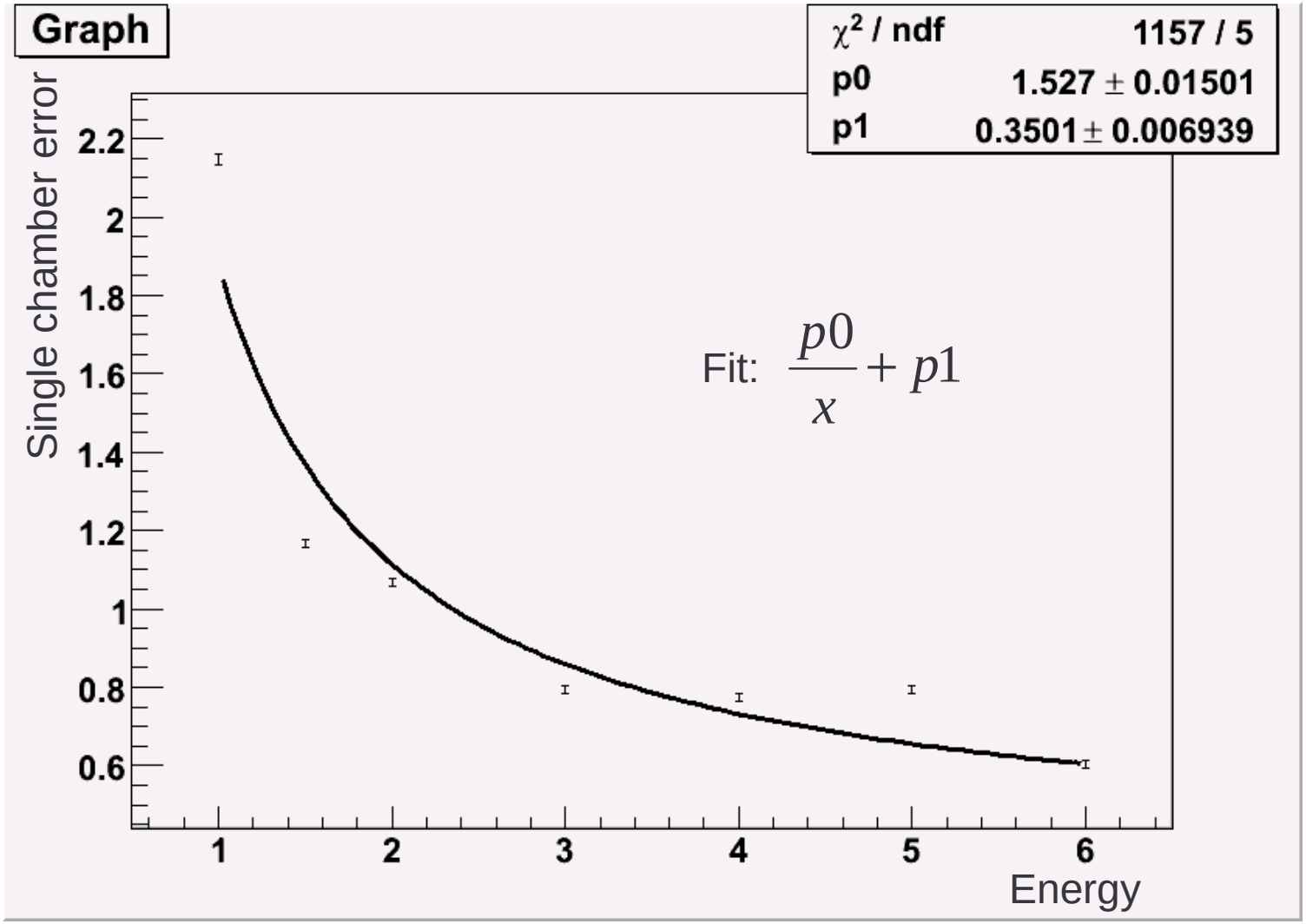
Intrinsic resolution (2)

- MC prediction



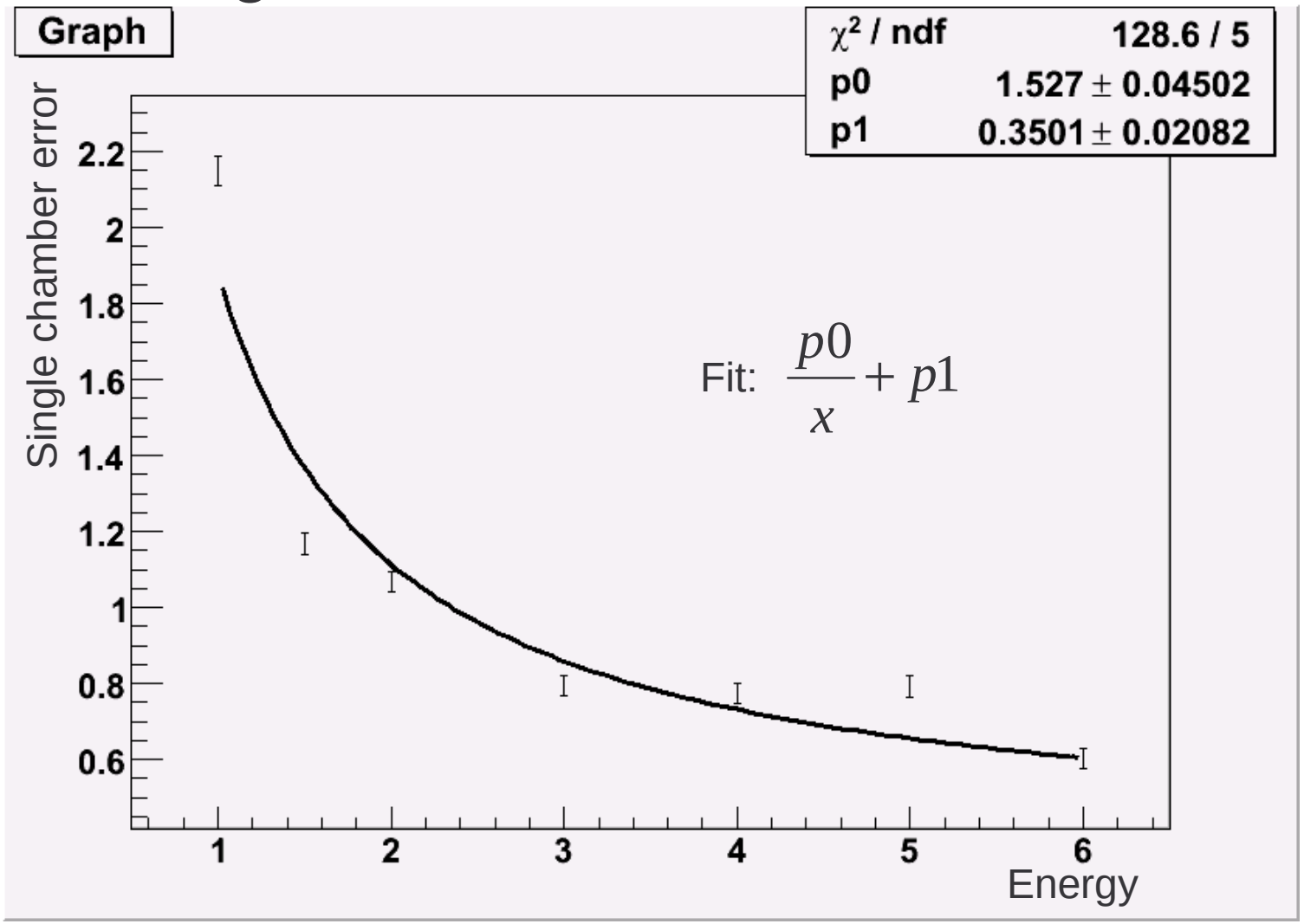
Intrinsic resolution(2)

- Data



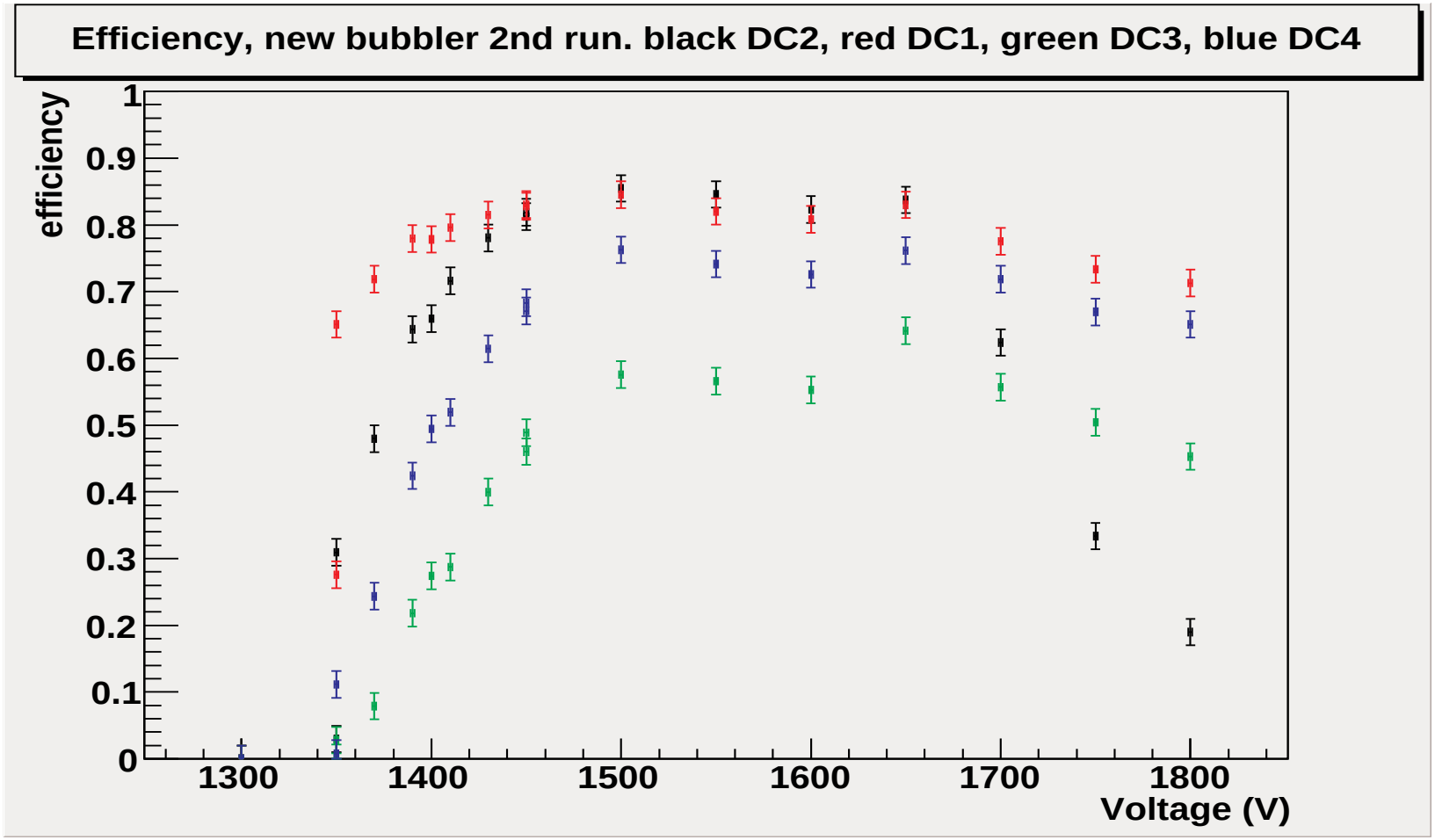
Intrinsic resolution(2)

- Increasing the errors



Efficiency

- Efficiencies have been evaluated last year before the test beams, this is the result



Efficiency

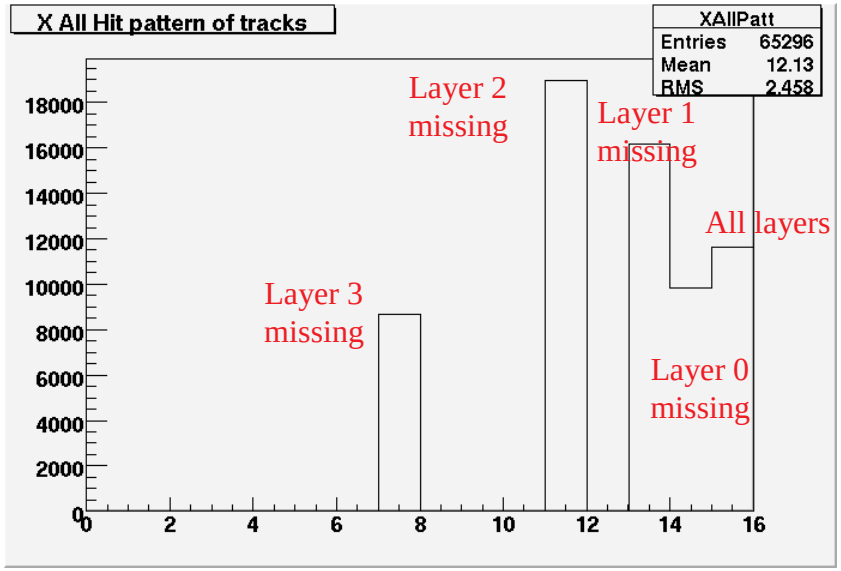
- All chambers have ~75-85% efficiency, this means all wire have an efficiency ~90%
  - Chamber #3 that has 60% efficiency due to the Y wire that is only ~65% efficient
- This result can be compared with the “effective efficiency” from the number of successfully reconstructed tracks

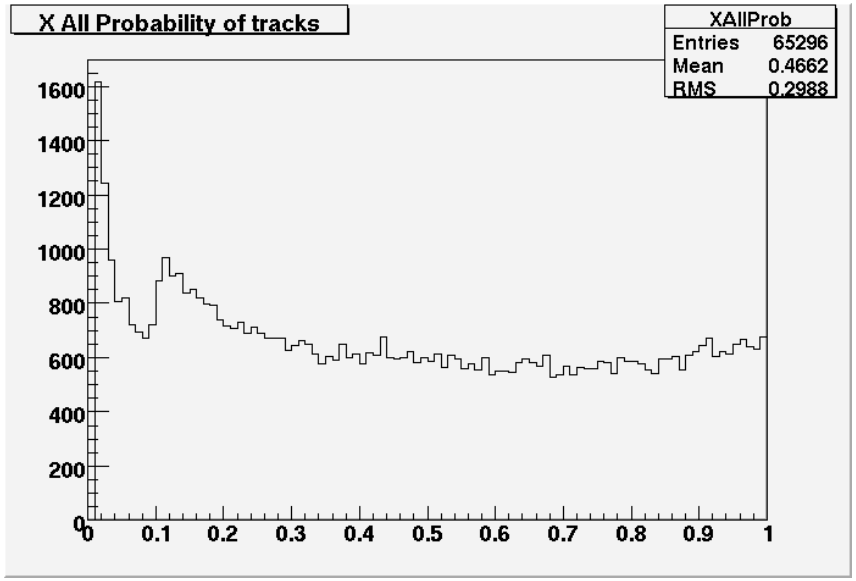
$$\varepsilon^4 = \frac{\#recontructed\_tracks}{\#total\_events} = 20\%$$

- Giving an efficiency of 70% for each wire

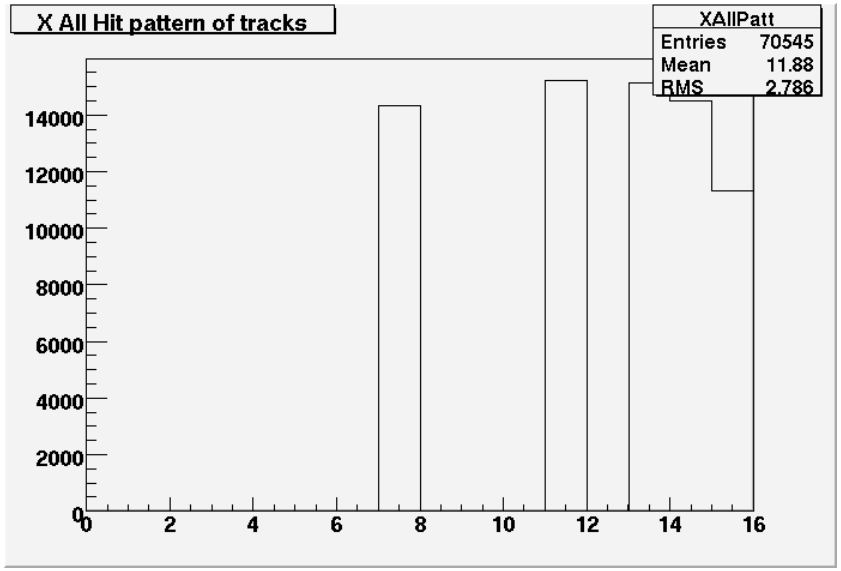
MC-Data comparison

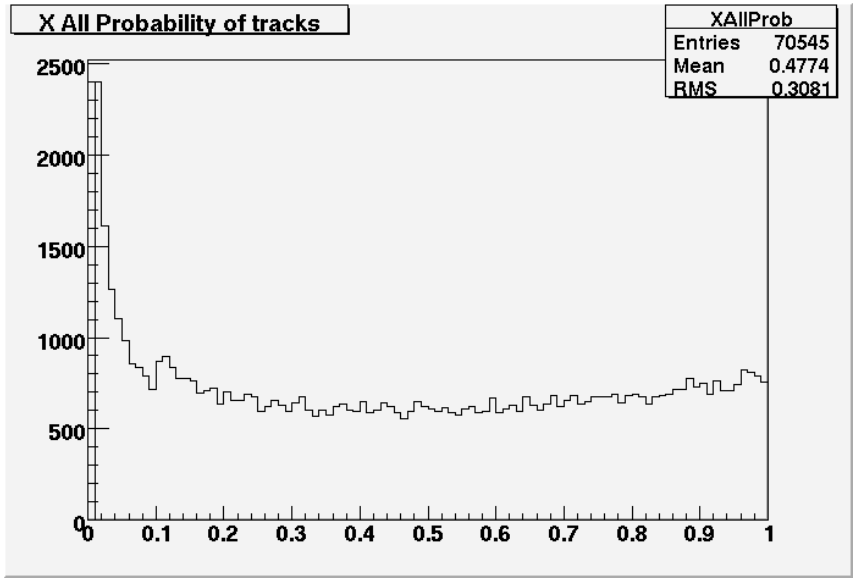
Data





MC



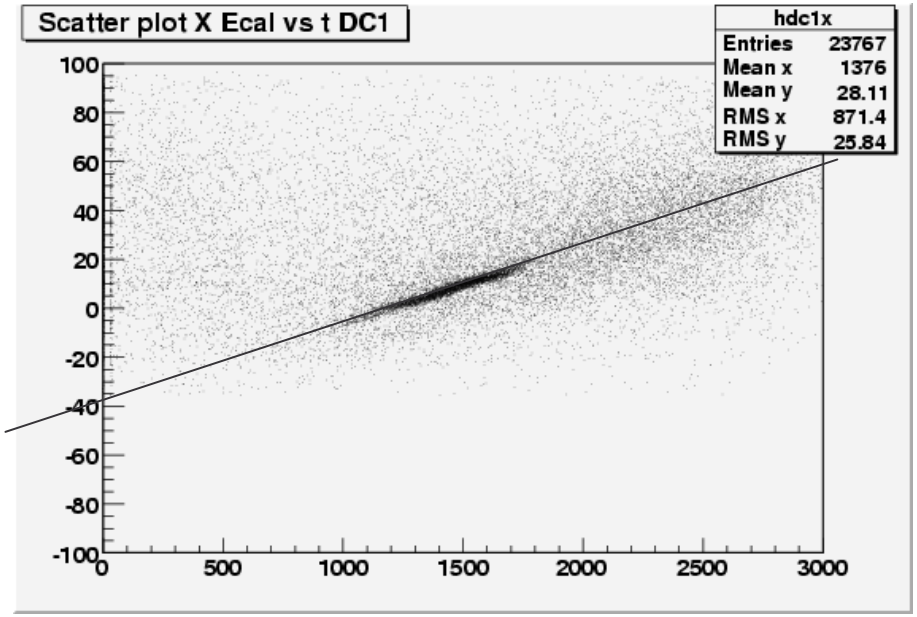


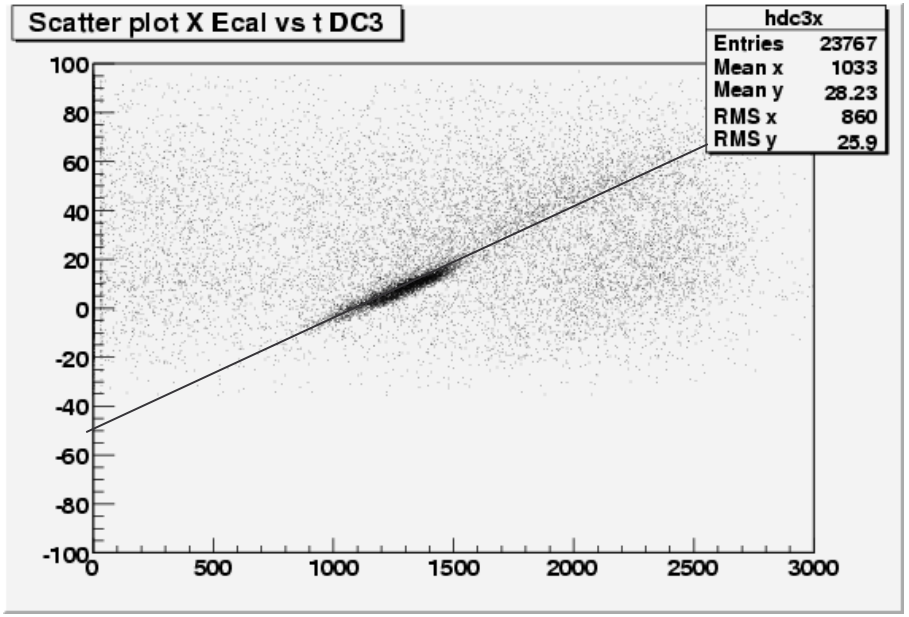
Conclusion

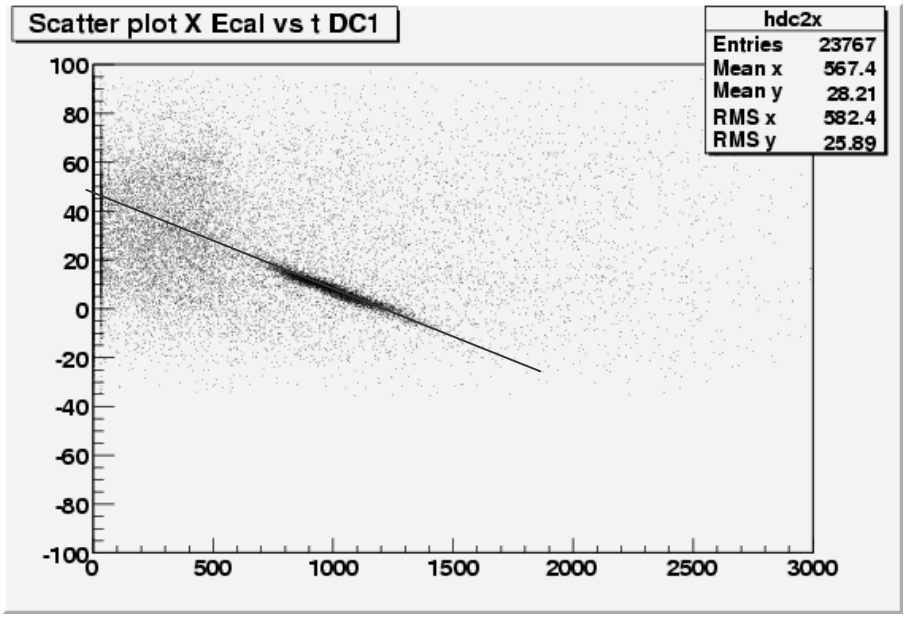
- Software structure is defined, minor issue to be decided.
- MC simulation and digitization is available
- Several method to evaluate drift velocity and other constants
  - All are in good agreement
- More studies are undergoing to improve these values
- Tracking is almost ready,
  - this week last test will be performed to have the tracking installed and debugged on Roman machine

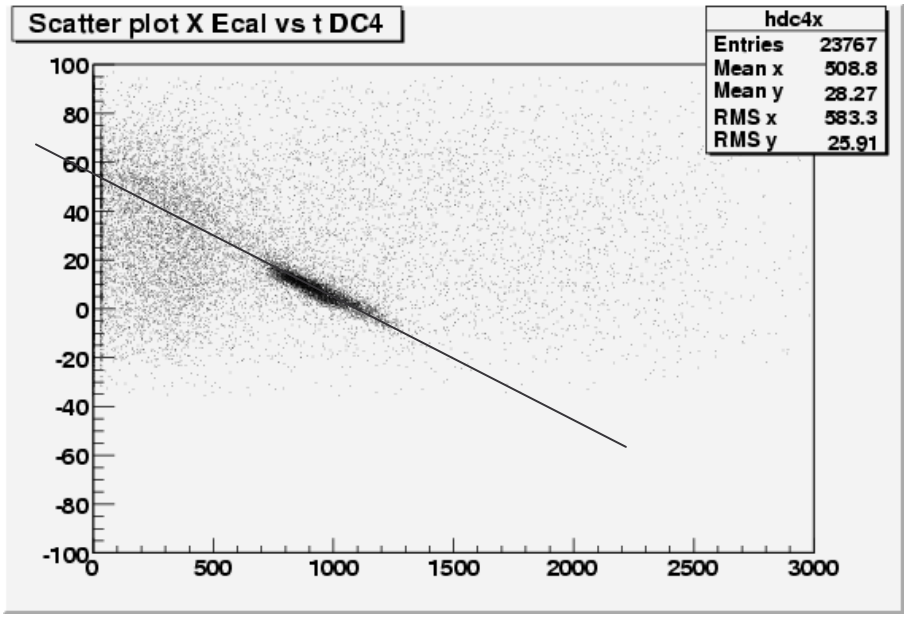
Backup slides

X_{ECAL} vs t_{DC}

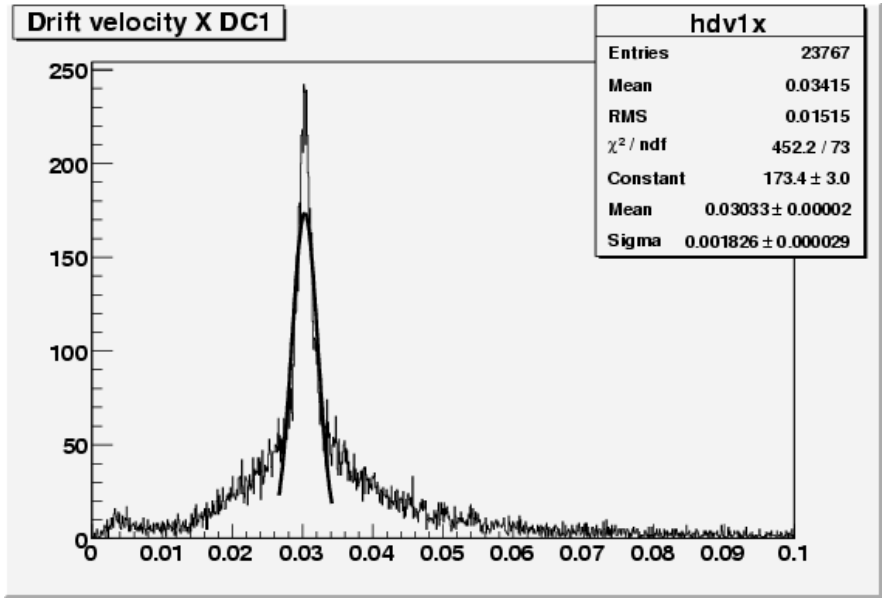

Scatter plot X Ecal vs t DC1
hdc1x
Entries 23767
Mean x 1376
Mean y 28.11
RMS x 871.4
RMS y 25.84

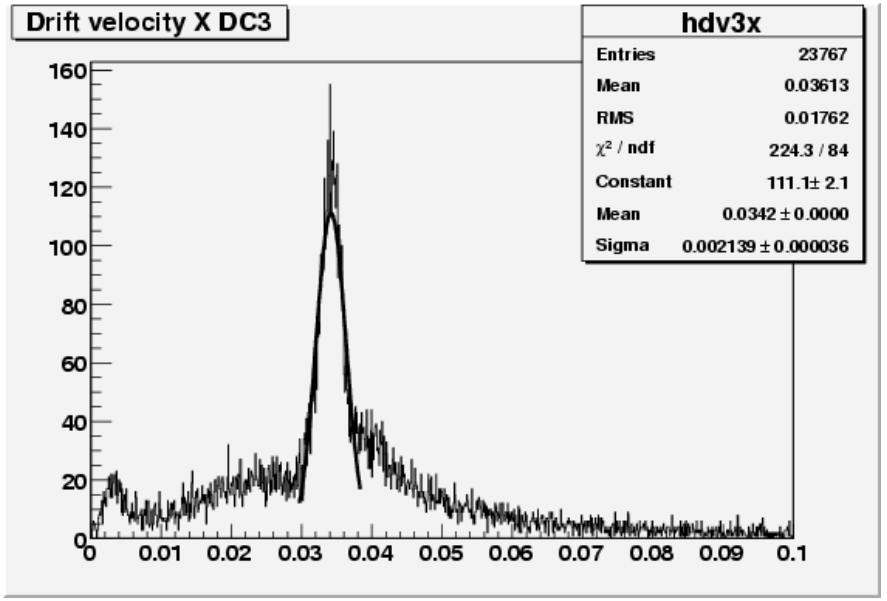

Scatter plot X Ecal vs t DC3
hdc3x
Entries 23767
Mean x 1033
Mean y 28.23
RMS x 860
RMS y 25.9

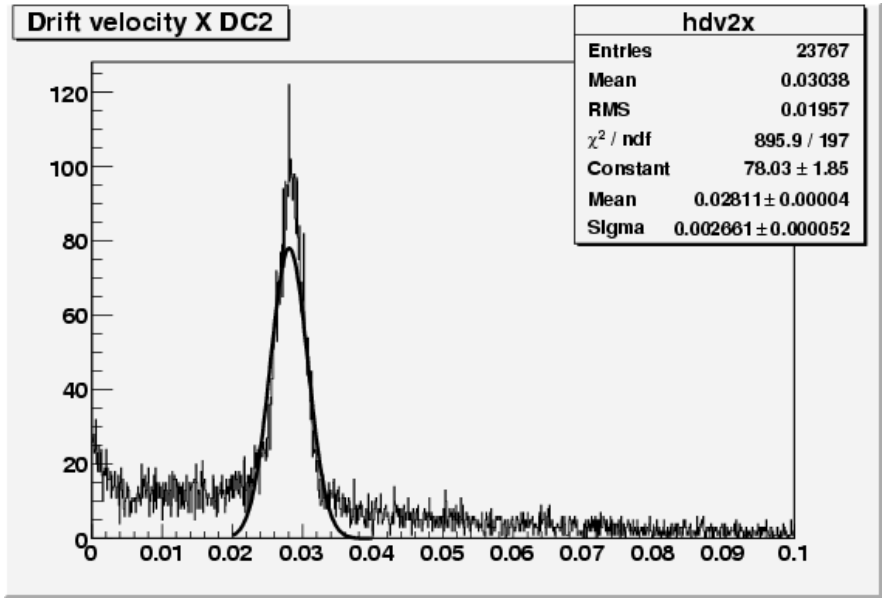

Scatter plot X Ecal vs t DC1
hdc2x
Entries 23767
Mean x 567.4
Mean y 28.21
RMS x 582.4
RMS y 25.89

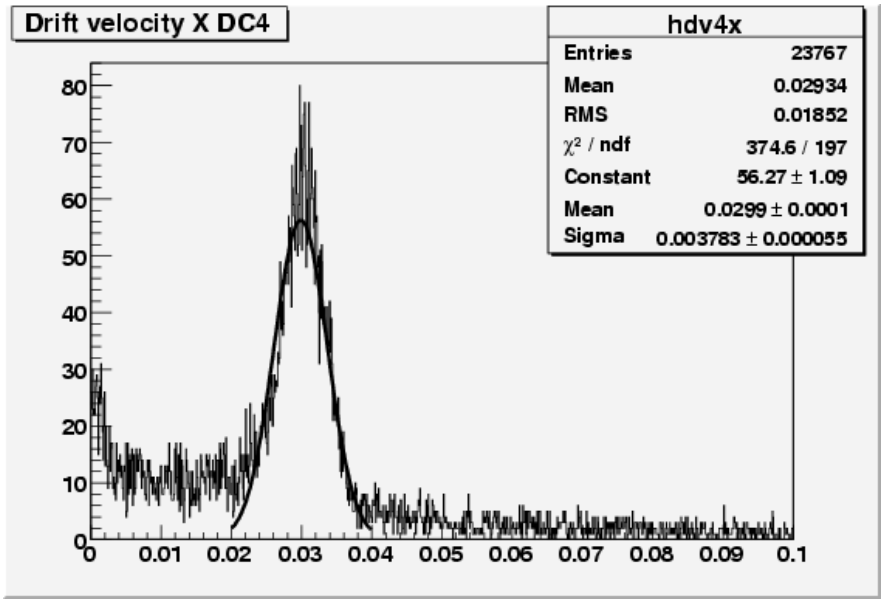

Scatter plot X Ecal vs t DC4
hdc4x
Entries 23767
Mean x 508.8
Mean y 28.27
RMS x 583.3
RMS y 25.91

$(36-X_{ECAL})/t_{DC}$

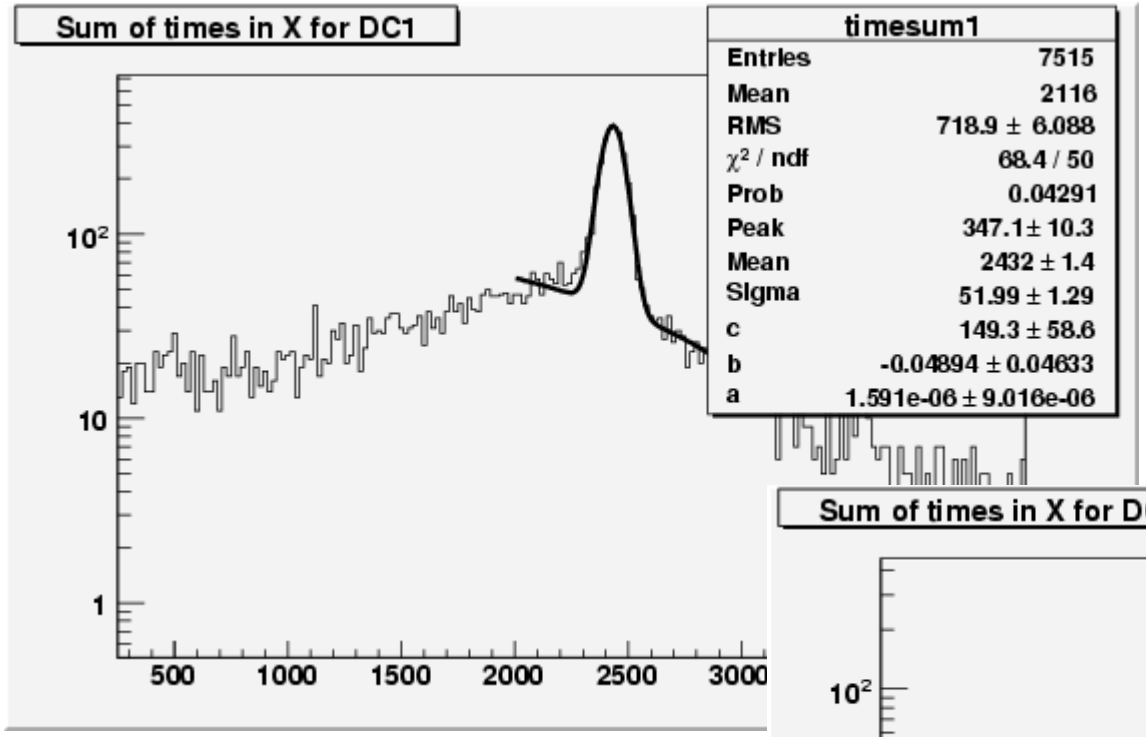

Drift velocity X DC1
hdv1x
Entries 23767
Mean 0.03415
RMS 0.01515
χ² / ndf 452.2 / 73
Constant 173.4 ± 3.0
Mean 0.03033 ± 0.00002
Sigma 0.001826 ± 0.000029

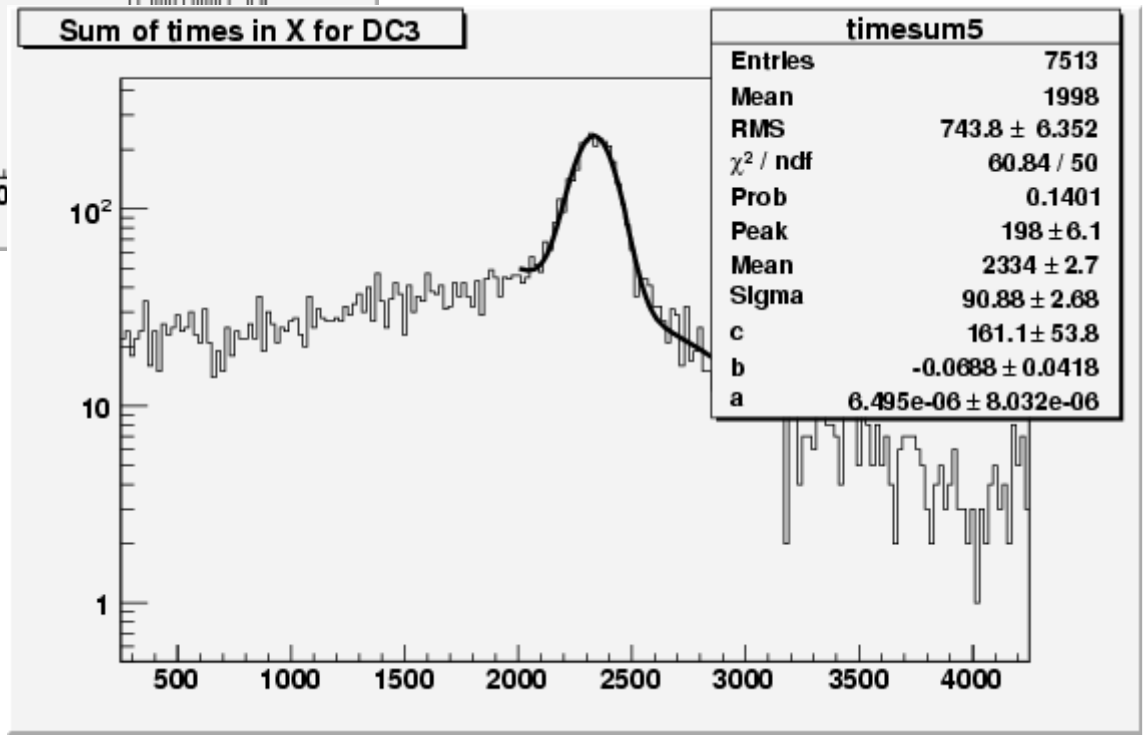

Drift velocity X DC3
hdv3x
Entries 23767
Mean 0.03613
RMS 0.01762
χ² / ndf 224.3 / 84
Constant 111.1 ± 2.1
Mean 0.0342 ± 0.0000
Sigma 0.002139 ± 0.000036


Drift velocity X DC2
hdv2x
Entries 23767
Mean 0.03038
RMS 0.01957
χ² / ndf 895.9 / 197
Constant 78.03 ± 1.85
Mean 0.02811 ± 0.00004
Sigma 0.002661 ± 0.000052

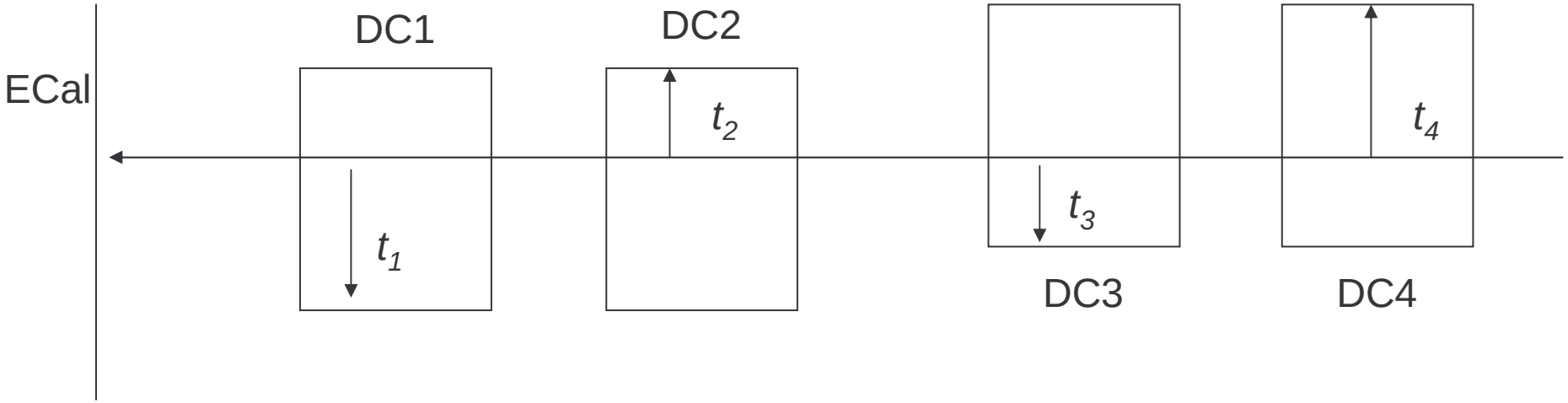

Drift velocity X DC4
hdv4x
Entries 23767
Mean 0.02934
RMS 0.01852
χ² / ndf 374.6 / 197
Constant 56.27 ± 1.09
Mean 0.0299 ± 0.0001
Sigma 0.003783 ± 0.000055

$(T_1+T_2)/L$


Sum of times in X for DC1
timesum1
Entries 7515
Mean 2116
RMS 718.9 ± 6.088
χ² / ndf 68.4 / 50
Prob 0.04291
Peak 347.1 ± 10.3
Mean 2432 ± 1.4
Sigma 51.99 ± 1.29
c 149.3 ± 58.6
b -0.04894 ± 0.04633
a 1.591e-06 ± 9.016e-06
10²
10
1
500
1000
1500
2000
2500
3000


Sum of times in X for DC3
timesum5
Entries 7513
Mean 1998
RMS 743.8 ± 6.352
χ² / ndf 60.84 / 50
Prob 0.1401
Peak 198 ± 6.1
Mean 2334 ± 2.7
Sigma 90.88 ± 2.68
c 161.1 ± 53.8
b -0.0688 ± 0.0418
a 6.495e-06 ± 8.032e-06
10²
10
1
500
1000
1500
2000
2500
3000
3500
4000

Drift velocity



$$\begin{cases} v_1 t_1 + v_2 t_2 = L \\ v_2 t_2 + v_3 t_3 = L - Off_{DC} \\ v_3 t_3 + v_4 t_4 = L \\ v_1 t_1 + v_4 t_4 = L - Off_{DC} \\ X_{ECAL} = v_1 t_1 - Off_{ECAL} \\ X_{ECAL} = v_2 t_2 - Off_{ECAL} \\ X_{ECAL} = v_3 t_3 - Off_{ECAL} - Off_{DC} \\ X_{ECAL} = v_4 t_4 - Off_{ECAL} - Off_{DC} \end{cases}$$

- All quantity have to be considered averaged
- Offset between DC1-DC2 and DC3-DC4 is 0.2mm, negligible on first approximation
- Y should be easier because of the better alignment:
  - $OffY_{DC}$ should be very small

Distributions