ECAL Alignment with *e* and π data

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Outlook

- Introduction
- Alignment with e data (y dimension)
  - Method
  - Results
- Alignment with π data (x and y dim.)
  - Method
  - Results and comparisons
- Conclusion

Alignment with e^- data

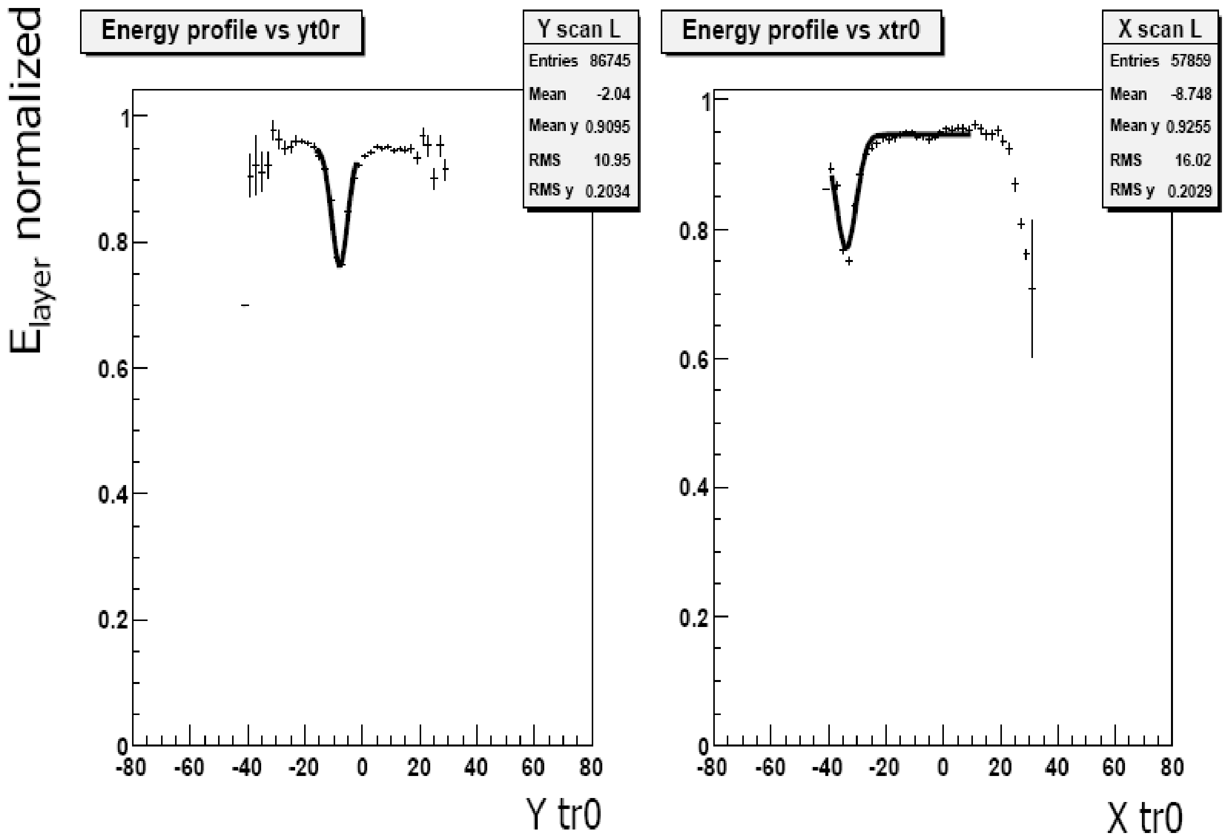
- Aim : To measure the position of the layers w. r. t. the first layer
  - Used data: all 2006 *e* runs
  - Event selection + Fiducial volume (→ no lateral leakage and energy flat beam)

- Method :
  - Measurement of the relative position of the guard rings relatively to the first layer.
  - Guard ring positions extracted from the energy profile.
  - Energy profile :

    Energy in a layer = f^{ct}(track position on first layer)
  - Electron position on the first layer given by the tracking.

Fit of the guard rings positions

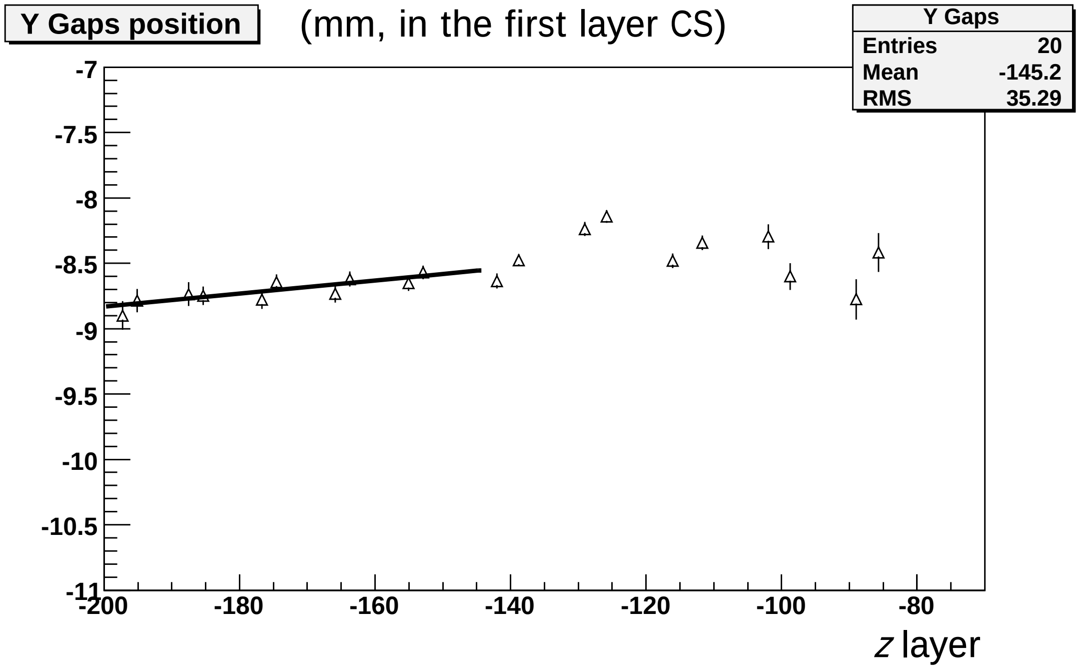
- Usual Gaussian model



Exemple:
layer #12, 20GeV

- The typical precision on the gap centre is 0.1mm / sample

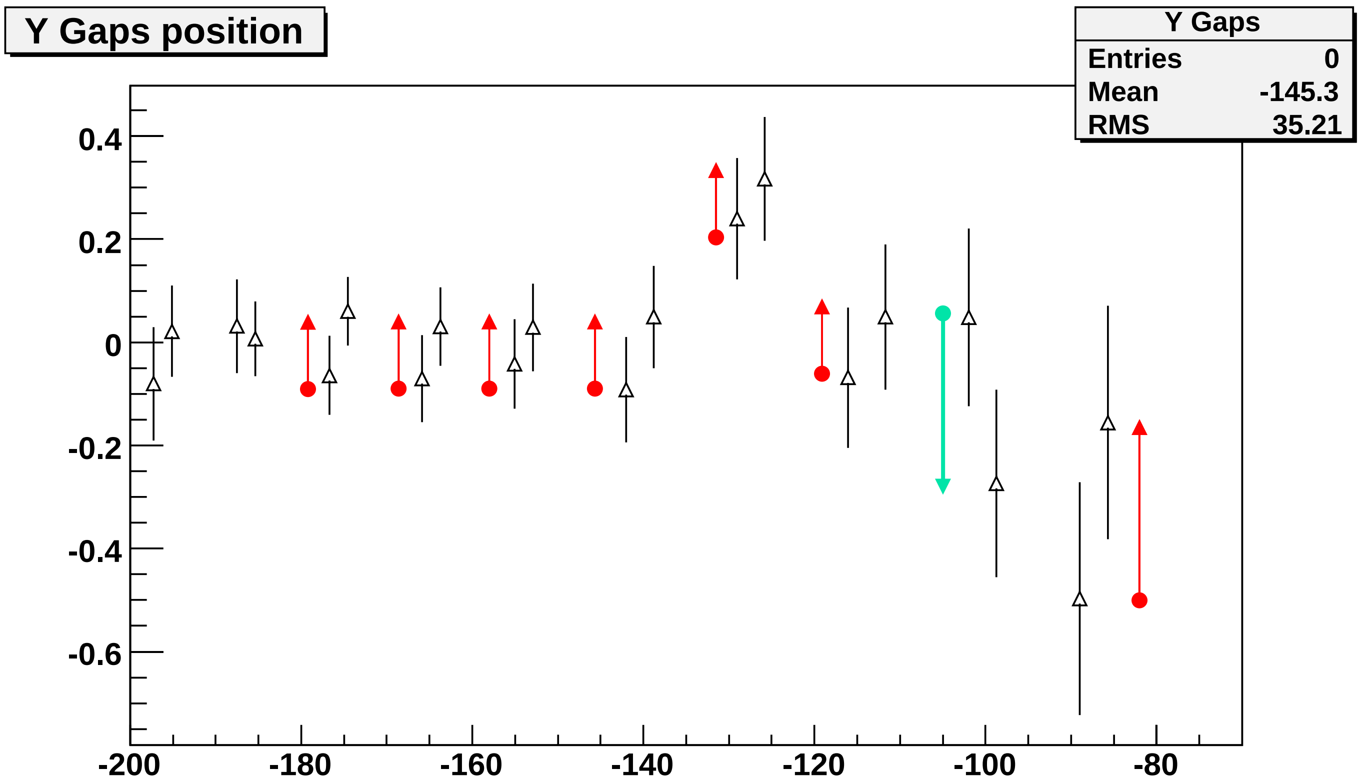
Exemple : the 20 GeV sample of aug. 26th 2006



- Two remarks :
  - The direction can be recontructed from the first 10 layers
  - There is a systematic shift between the two layers of a given slab

Exemple : the 20 GeV sample of aug. 26th 2006

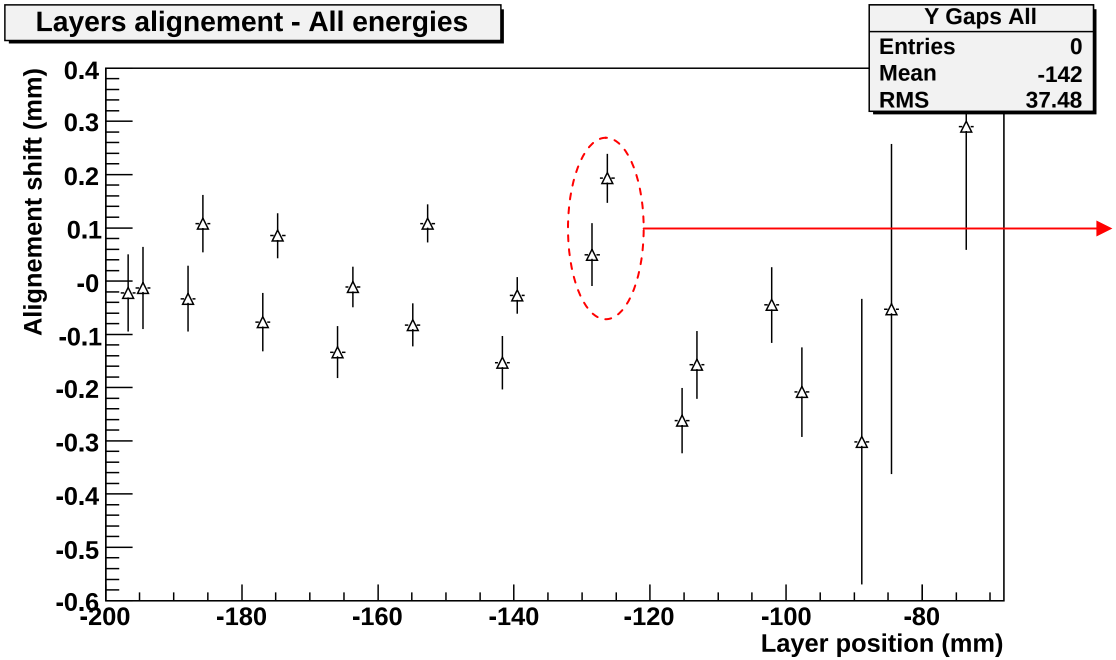
After subtraction of the direction : layers alignment




Systematic shift in a slab


The 9th slab : singularity

Mean positions over all 2006 data

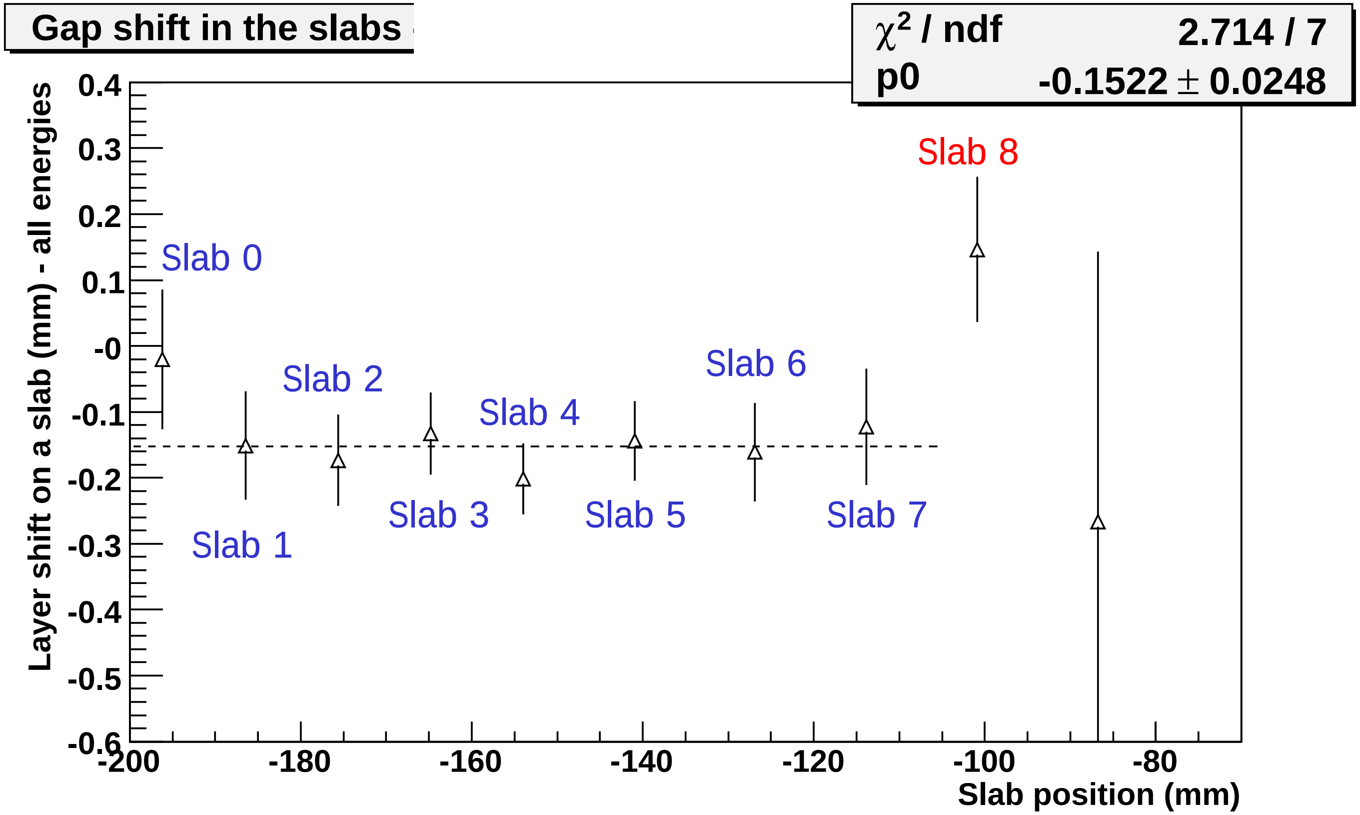


The most misaligned slab ! @ +0.1mm

(in first 2 stacks)

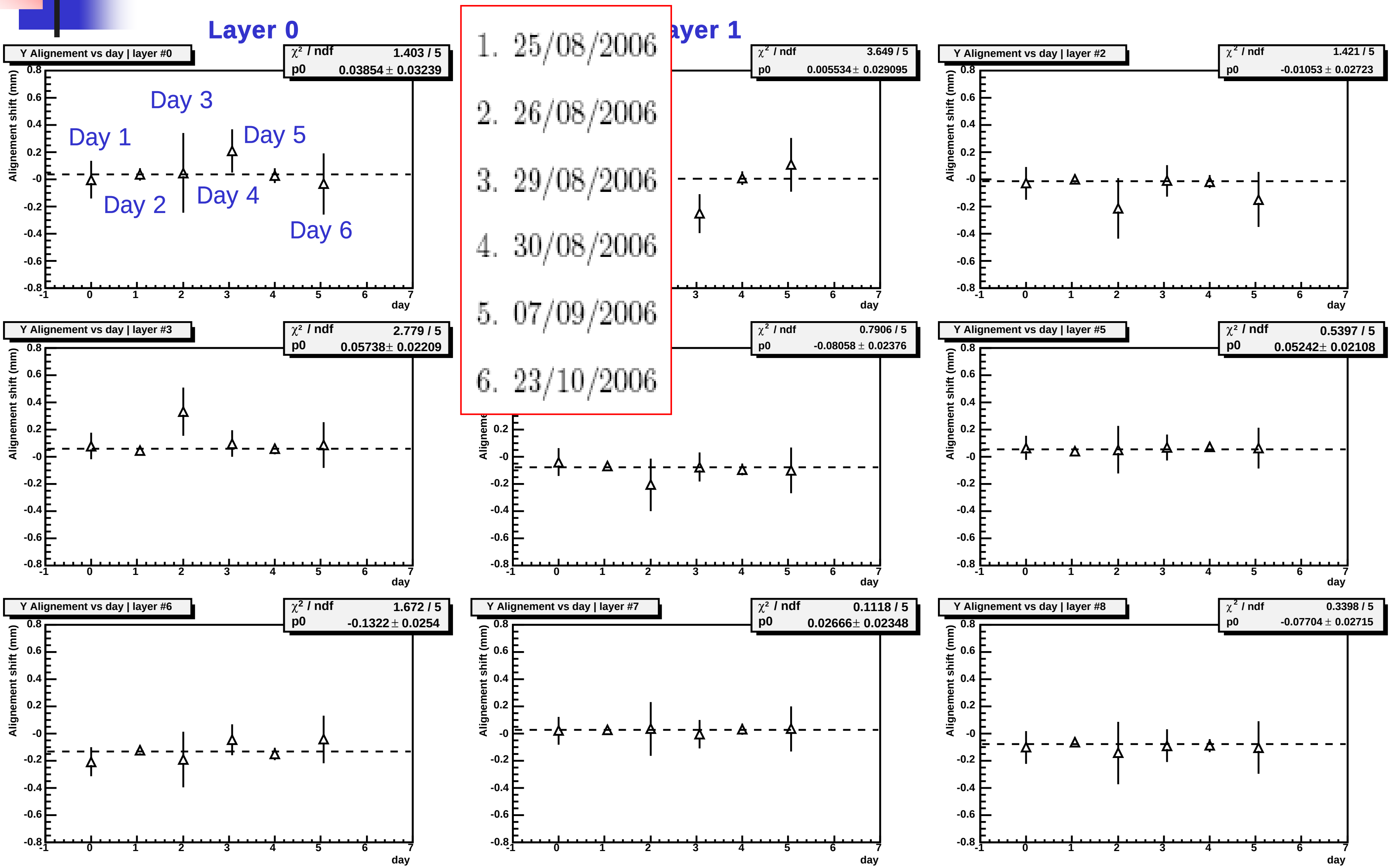
- **Remarks :**
  - Not large misalignment.
  - Systematic shift between two layers of the same slab (with the exception of the 9th slab) confirmed
  - Can be refined by splitting the measurement over different periods (alignment per run / per day)

On each slab



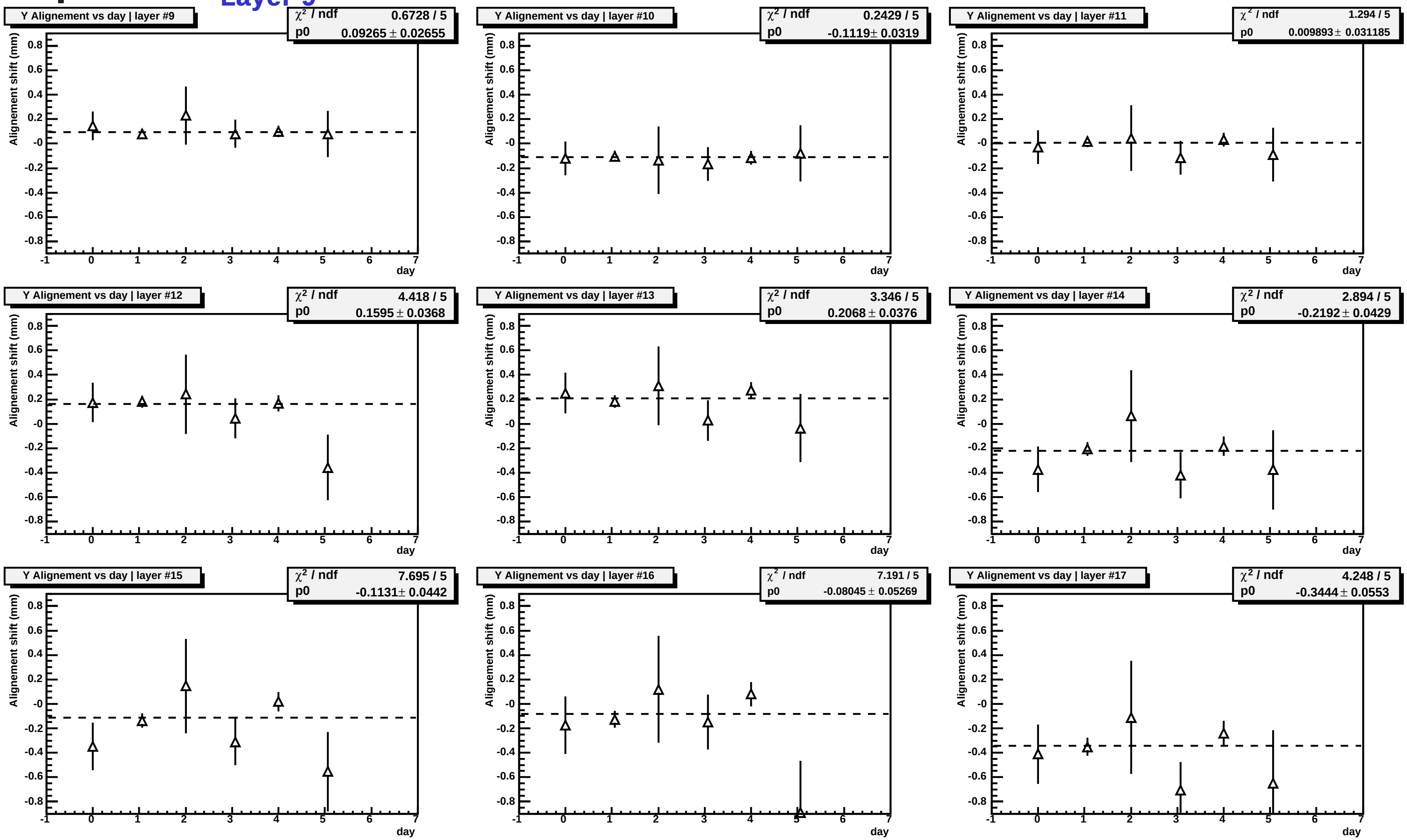
Gap shift in the slabs
χ² / ndf 2.714 / 7
p0 -0.1522 ± 0.0248
Slab 0
Slab 1
Slab 2
Slab 3
Slab 4
Slab 5
Slab 6
Slab 7
Slab 8
Layer shift on a slab (mm) - all energies
Slab position (mm)
0.4
0.3
0.2
0.1
-0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-200
-180
-160
-140
-120
-100
-80

Layer positions per day (ly # 1 to 8)

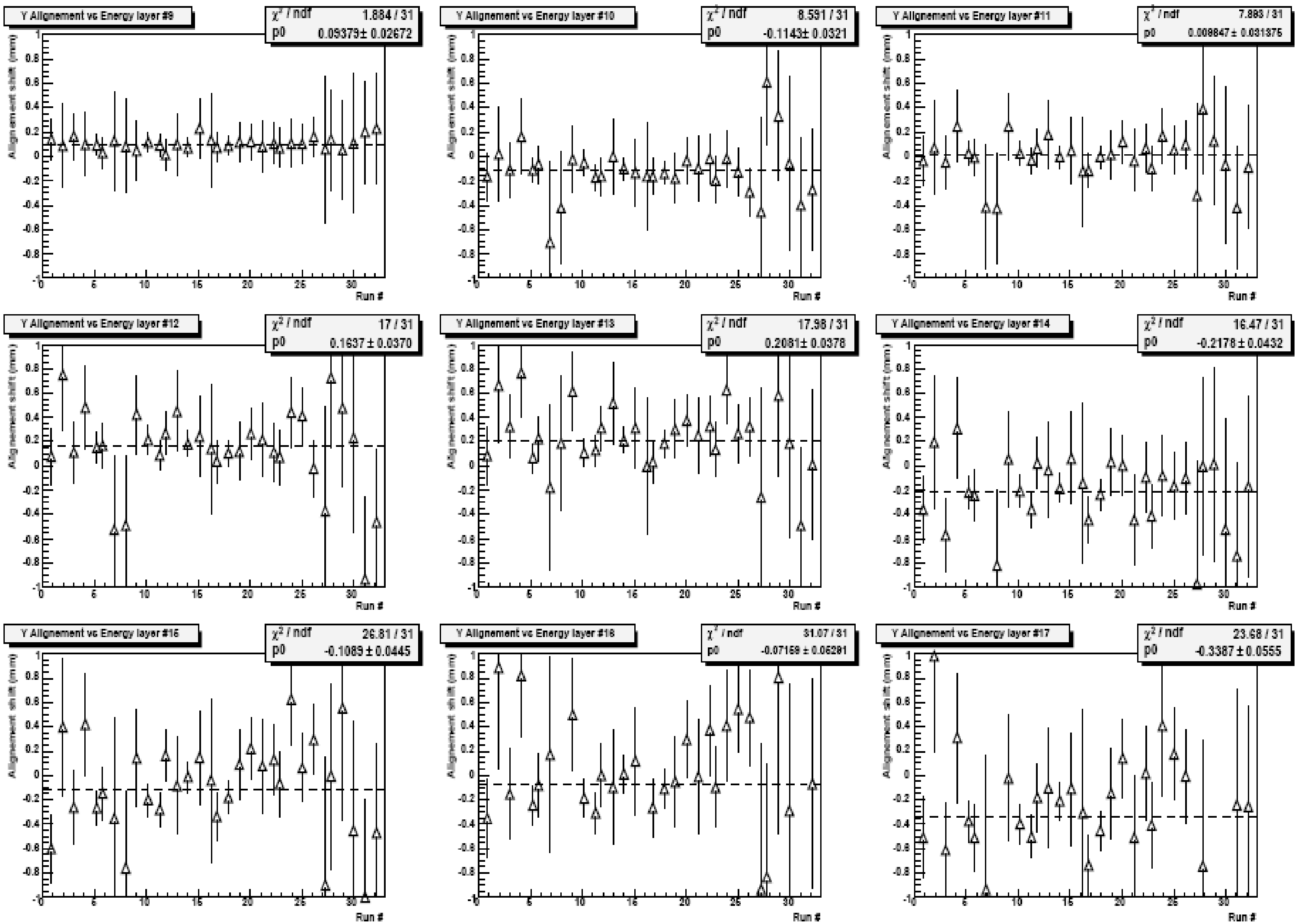


Alignment per day (ly # 9 to 17)

Layer 9



Example : alignment per run. Ly #9 to 17



Mean positions over all 2006 data

Layer number	Layer position (mm) (no direction error)	Layer position (mm) (with direction error)
0	0.035 ± 0.036	0.035 ± 0.036
1	-0.026 ± 0.032	-0.026 ± 0.032
2	-0.008 ± 0.029	-0.008 ± 0.029
3	0.053 ± 0.023	0.053 ± 0.024
4	-0.072 ± 0.023	-0.072 ± 0.025
5	0.054 ± 0.020	0.054 ± 0.022
6	-0.143 ± 0.022	-0.143 ± 0.027
7	-0.032 ± 0.019	0.032 ± 0.025
8	-0.074 ± 0.020	-0.074 ± 0.029
9	0.092 ± 0.017	0.092 ± 0.028
10	-0.118 ± 0.019	-0.119 ± 0.034
11	0.014 ± 0.014	0.014 ± 0.033
12	0.177 ± 0.017	0.178 ± 0.039
13	0.232 ± 0.016	0.241 ± 0.040
14	-0.232 ± 0.017	-0.219 ± 0.047
15	-0.153 ± 0.016	-0.109 ± 0.047
16	-0.126 ± 0.025	-0.056 ± 0.056
17	-0.369 ± 0.027	-0.321 ± 0.058
18	-0.505 ± 0.038	-0.444 ± 0.070
19	-0.403 ± 0.039	-0.323 ± 0.072
20	-0.39 ± 0.078	-0.340 ± 0.104
21	-0.564 ± 0.074	-0.552 ± 0.104
22	-1.048 ± 0.150	-1.012 ± 0.171
23	-0.953 ± 0.144	-0.917 ± 0.166
24	-0.539 ± 0.245	-0.531 ± 0.278
25	-1.105 ± 0.295	-1.102 ± 0.309
26	-1.218 ± 0.531	-1.251 ± 0.543

Detailed numbers and figures are given in

CALICE Int. Note CIN-003

Precision better than

30 µm in first stack

100 µm in second stack

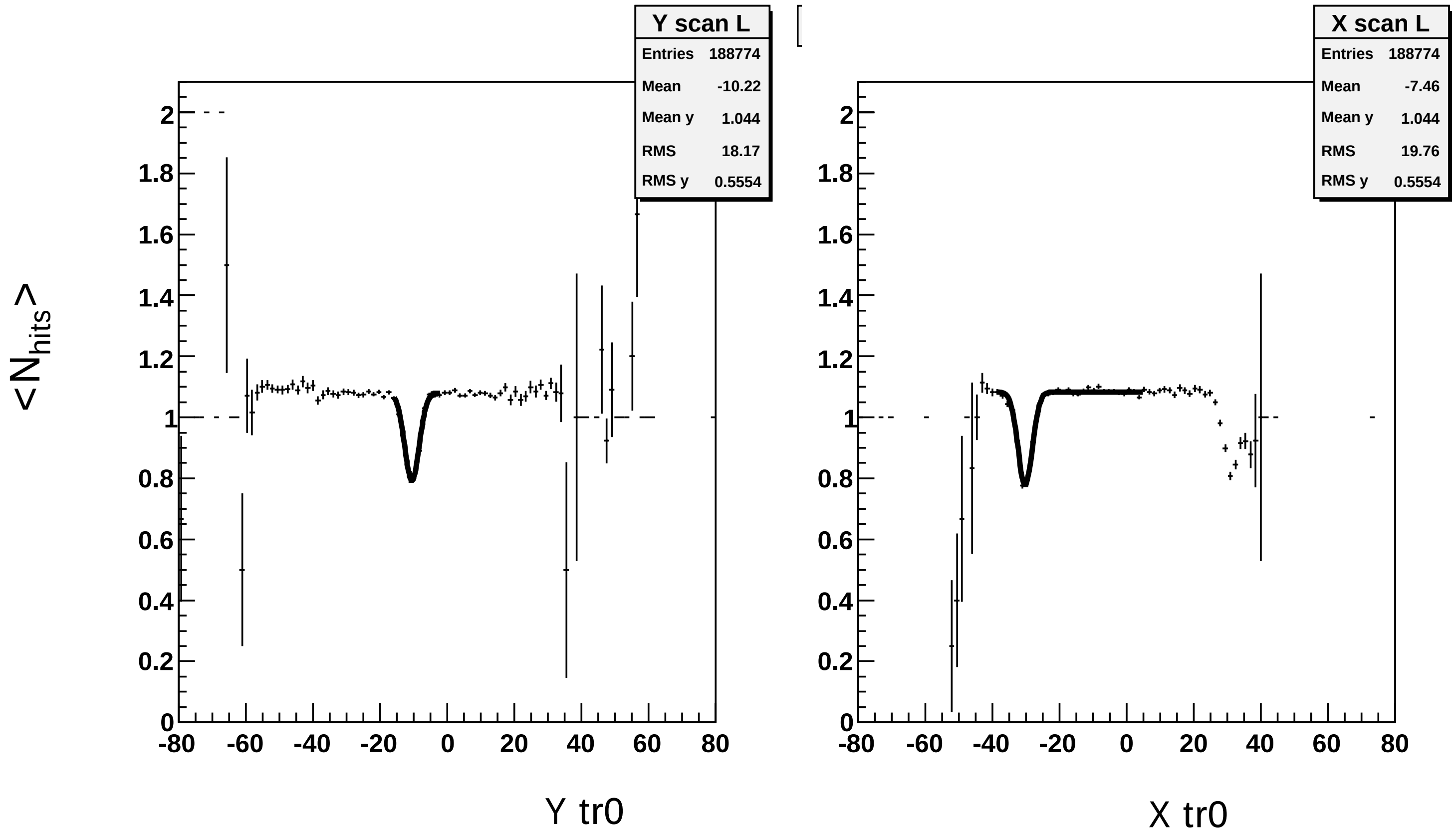
550 µm in third stack

Alignment with π data

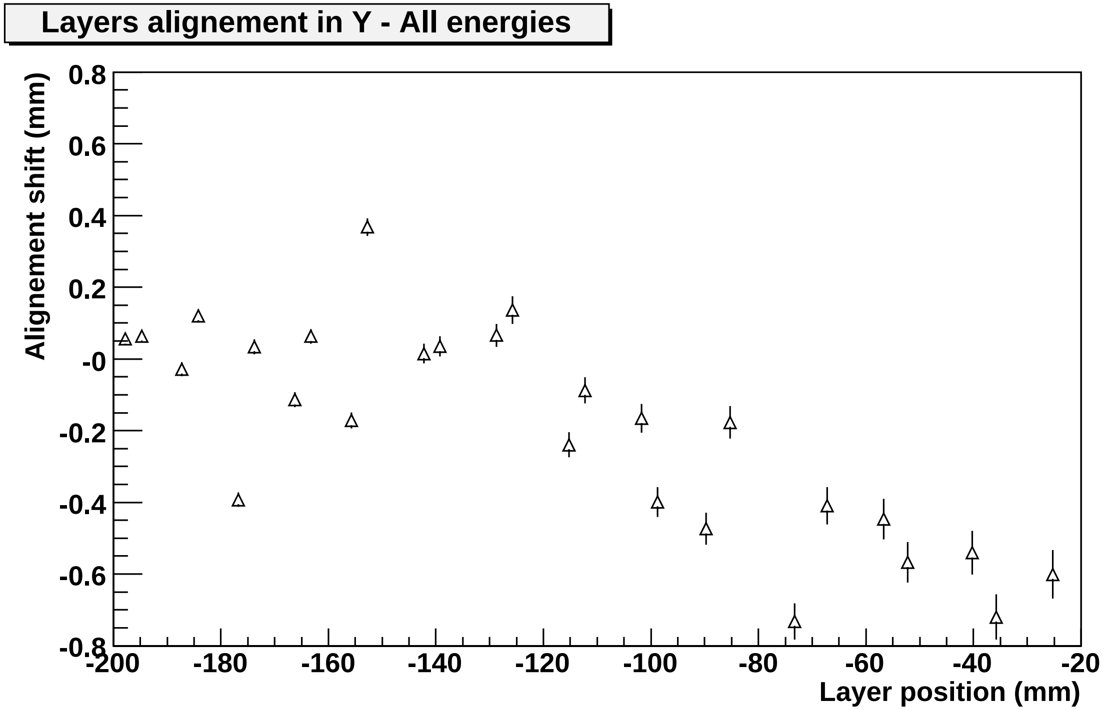
- Aim : measurement of the *x* and *y* position of the layers w. r. t. the first layer
  - Used data: 2006 π runs (6, 17, 30, 40 and 50 GeV)
  - Event selection :
    - Cut on a "MIP χ^2" (event / event basis)
    - Consider layers with $N\text{Hits}_{\text{layer}} < 5$ (layer / layer basis)

- Method :
  - Measurement of the relative position of the guard rings relatively to the first layer.
  - Guard ring positions extracted from the profile of the number of hits in the layer vs. the track position on first layer (*cf. David WARD talk Ph. Meeting 31/10/07*)
  - Electron position on the first layer given by the tracking.

Nb hits vs. track position



Mean *y* positions from 2006 π data



Précision better than

30 µm in first stack

50 µm in second stack

80 µm in third stack

Mean y positions from 2006 π data

Layer number	Layer position (mm)
0	0.0215 ± 0.0147
1	0.0424 ± 0.0151
2	-0.0144 ± 0.0193
3	0.0561 ± 0.0174
4	-0.208 ± 0.0198
5	0.0194 ± 0.0208
6	-0.0621 ± 0.0212
7	0.0252 ± 0.0207
8	-0.085 ± 0.0228
9	0.199 ± 0.0246
10	0.00577 ± 0.0275
11	0.0232 ± 0.0282
12	0.0435 ± 0.032
13	0.084 ± 0.038
14	-0.109 ± 0.0353
15	-0.0333 ± 0.0364
16	-0.0773 ± 0.0401
17	-0.173 ± 0.0418
18	-0.215 ± 0.0441
19	-0.06 ± 0.0456
20	-0.359 ± 0.0508
21	-0.167 ± 0.0519
22	-0.196 ± 0.056
23	-0.264 ± 0.0569
24	-0.228 ± 0.0606
25	-0.326 ± 0.0631
26	-0.266 ± 0.0678
27	-0.164 ± 0.0697
28	-0.129 ± 0.0741
29	-0.36 ± 0.0765

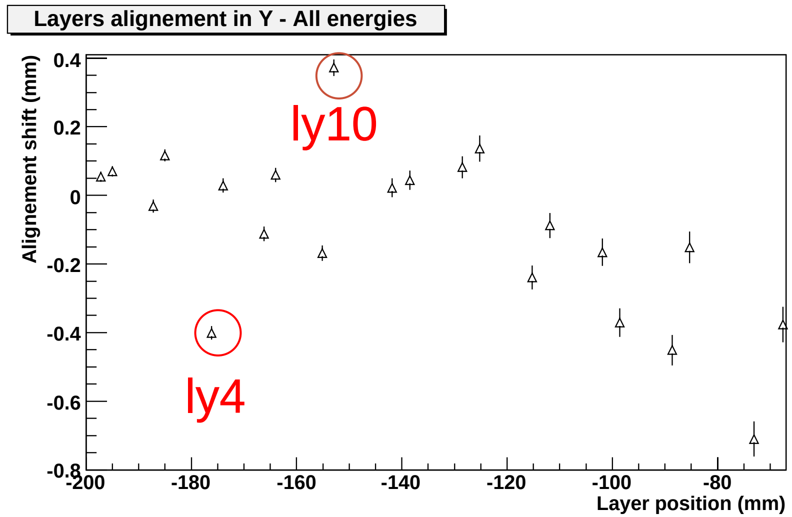
Comparison with e^- based alignment :

- Same precision in the first stack
- 2 times better in the second stack
- 6 times better in the third stack
- Position of layers 27 to 29 accessible

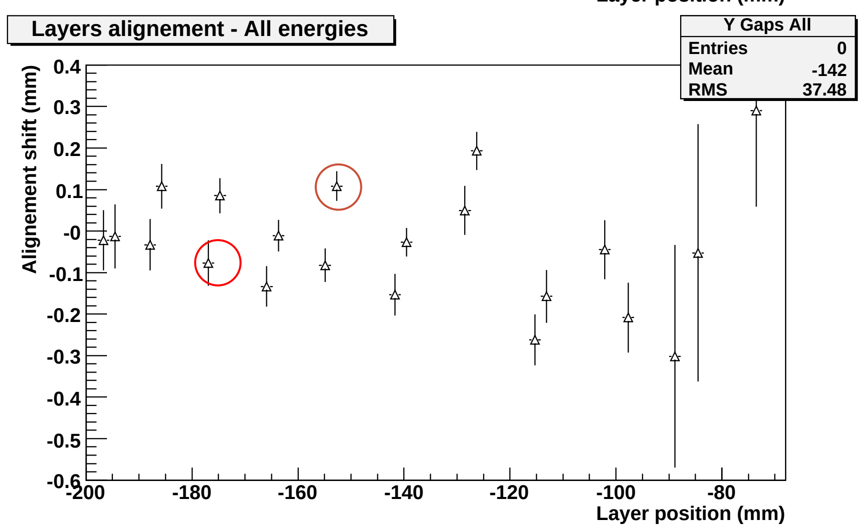
But …

Mean y positions over different 2006 π data

π data

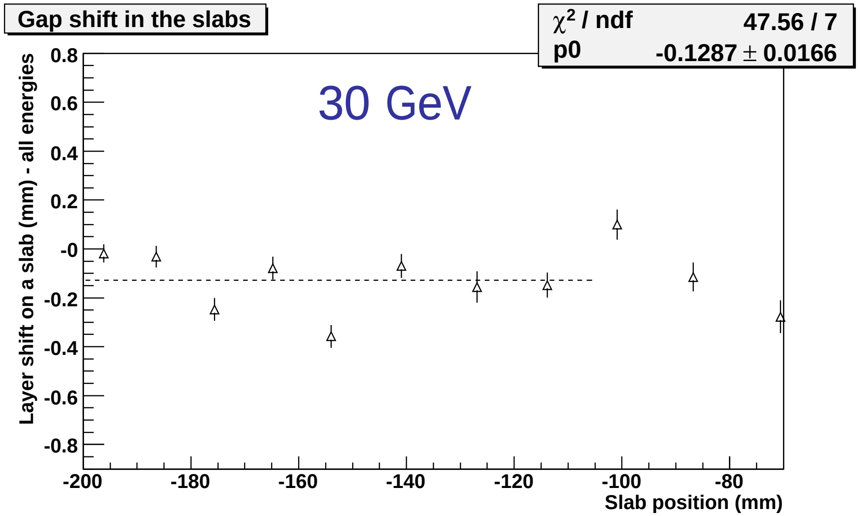


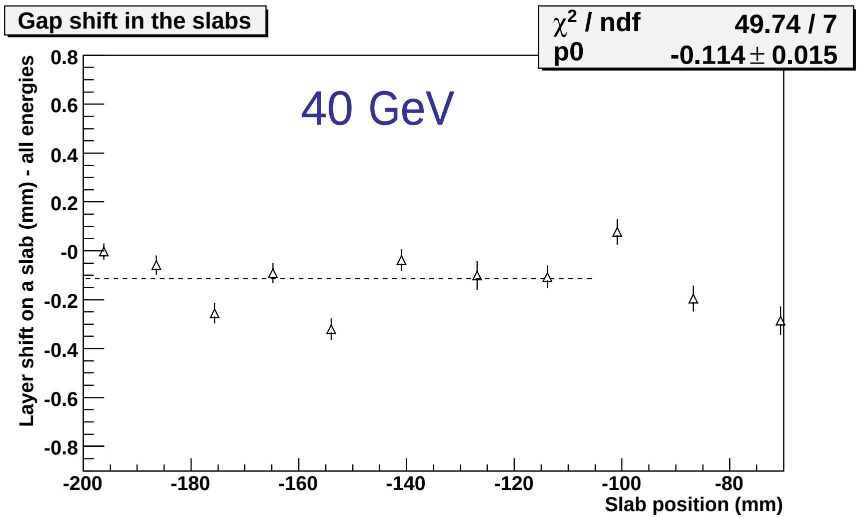
e^- data



- ly4 & 10 : to be understood
- Need to be refined : position per day

On each slab (π samples)

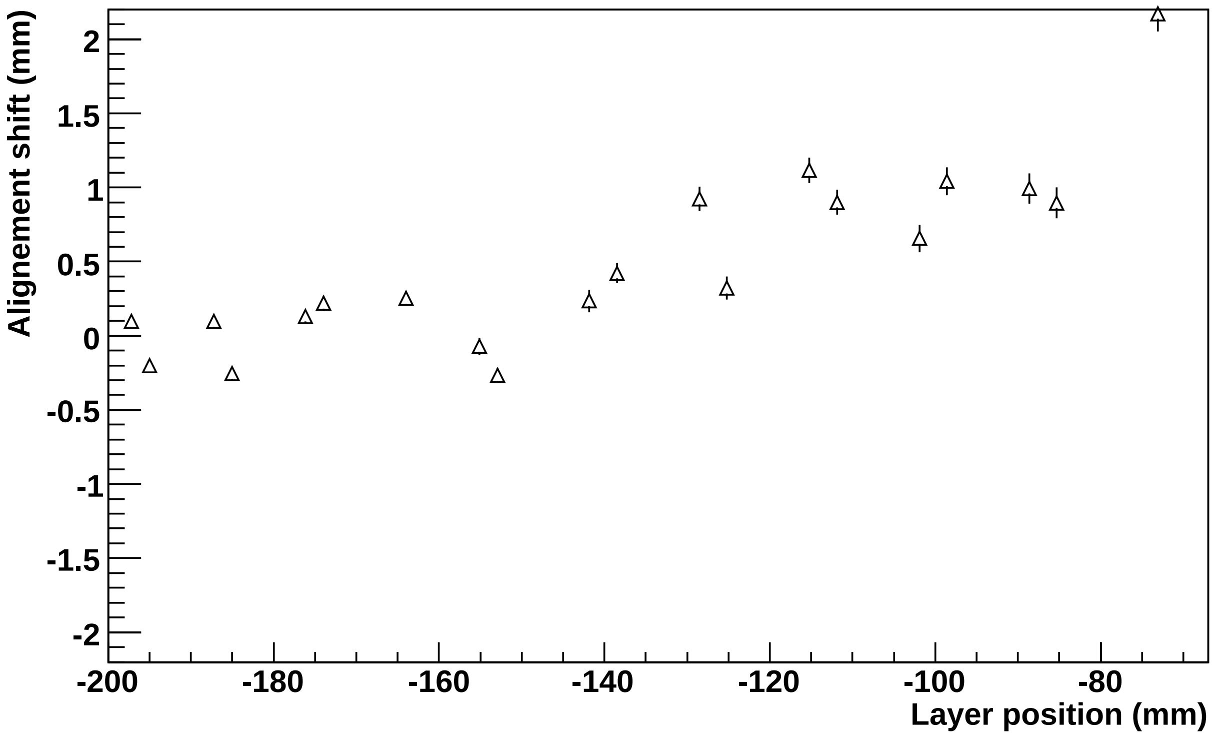




Shift = (-0.13±0.02)mm @ 30GeV
(-0.11±0.02)mm @ 40GeV
(-0.12±0.02)mm @ 50GeV

- The same effect is observed using independent π samples
- Compatible with the shift observed using e^- samples

Mean x positions over 40 GeV π data



The nominal shifts of 2.5mm/slab and 1.3mm layer/layer were subtracted

Mean value of *x* positions from 2006 π data

6, 30 and 40GeV π

Layer number	Layer position (mm)
0	0.115 ± 0.0313
1	-0.13 ± 0.0267
2	0.0905 ± 0.03
3	-0.137 ± 0.0269
4	0.06 ± 0.0309
5	0.0665 ± 0.033
6	0.238 ± 0.0463
7	0.0323 ± 0.0333
8	-0.00459 ± 0.0384
9	-0.119 ± 0.0431
10	0.195 ± 0.0534
11	0.199 ± 0.0483
12	0.344 ± 0.0632
13	0.112 ± 0.056
14	0.539 ± 0.0617
15	0.368 ± 0.0607
16	0.334 ± 0.0665
17	0.416 ± 0.0678
18	0.399 ± 0.0751
19	0.393 ± 0.0761
20	1.02 ± 0.0884
21	1.13 ± 0.086
22	1.19 ± 0.0966
23	1.09 ± 0.0959
24	1.26 ± 0.104
25	1.2 ± 0.106
26	1.74 ± 0.118
27	1.22 ± 0.116
28	1.47 ± 0.124
29	1.45 ± 0.126

Comparison with *y* alignment :

- same precision
- shifts in first stack <0.2mm
- global shift of the 3rd stack ~1mm

Conclusion

- Method :
  - The alignment can be performed using the guard ring positions in the x and y axis
  - In y the precision varies from 30µm to 0.6mm with e- and 20µm to 70µm with π.
  - For x the precision varies from 30µm to 130µm with π.

- Misalignment :
  - The observed misalignment in the y axis is < 1.3 mm (electrons), <0.5mm (pions)
  - The misalignment in x is < 0.3mm in the first stack, <0.5mm in the second stack. The third stack has a global shift of ~1mm
  - Layers of the third stack are the most misaligned both in y and x

- Remarks :
  - The alignment does not have any impact on the resolution/linearity
  - A misalignment may bias (increase) the Molière radius, but the measured values in the x & y axis indicate a negligible effect (< 1 mm).
  - Taking into account the misalignment for the MC simulation should improve the agreement MC/data (interwafer gap description).
  - There is a systematic shift in y axis between the guard rings on two layers of the same slab, except the 9th slab. The shift is 0.13±0.01mm.