Aligning the Mutr and MuID globally

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Outline

- **New offline aligning method for the Mutr and the MuID**
- **Simulation results, without field**
  - Without misalignments
  - With random misalignments
- **RealData results, without field**

- **Global Minimisation**

  The **best set of alignment parameters** is calculated by M. Blobel's algorithm for all detectors at the same time.

  Minimisation of the sum of the track χ^2.

- **Tricks**

  The tracks are **independant** one from the other.

  Alignment parameters set is the **same** for all tracks.

- **Fixed detectors to avoid global transformations**

  Changing the fixed detectors can change how the algorithm converges. The set of fixed detectors chosen are:

$$[\text{station, gap}] = [0, 0] \text{ and } [1, 0]$$

- **Cuts on the alignment output**

  We do not use the output misalignments given by the program when:

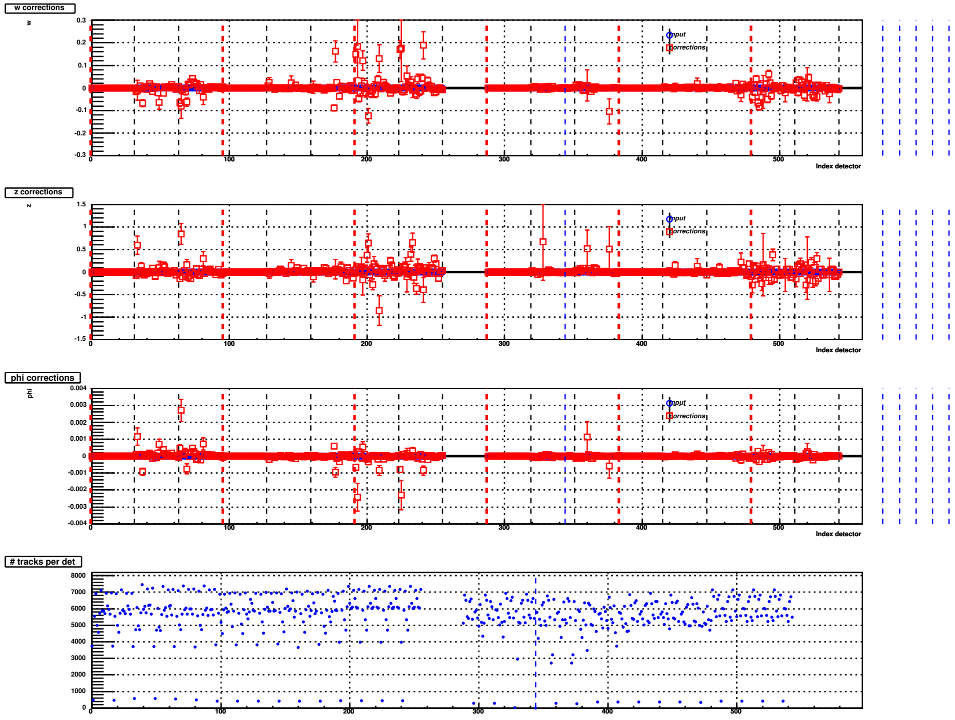
1. The number of tracks in the detector is less then 50, because the algorithm do not have enough inputs to calculate an accurate result.
2. The error of the algorithm output is too big..

Simulation results, without field

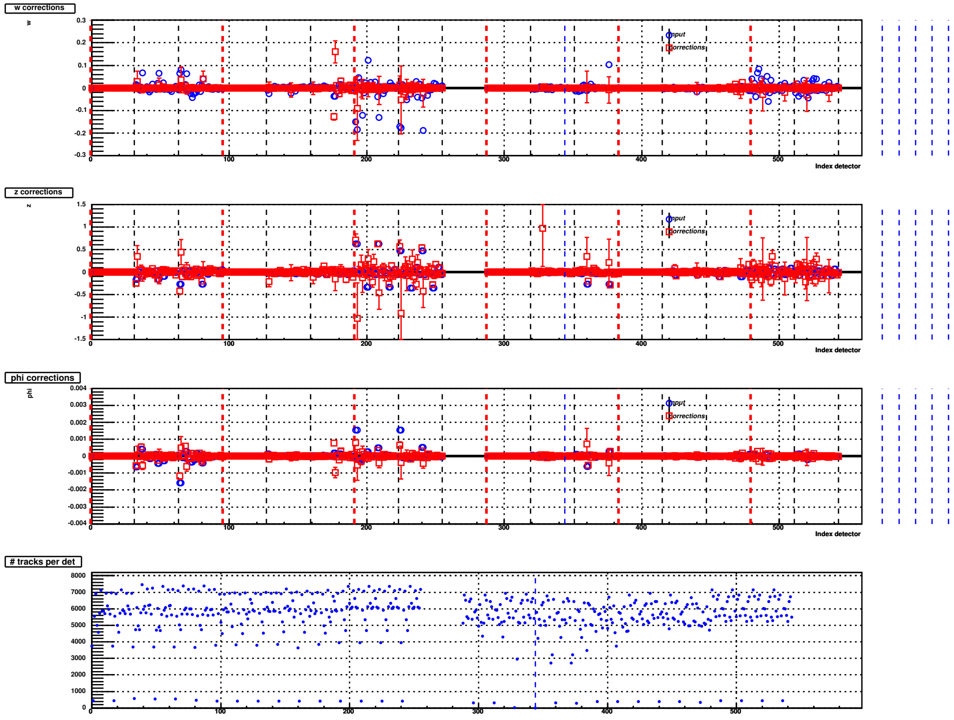
No misalignments - Mutr

Offsets

First reconstruction



Second reconstruction



SCALE

w: [-0.3; 0.3]; z: [-1.5; 1.5]; phi: [-0.004; 0.004]

number of hits (range for both plots): [0; 8000]

w: [-0.3; 0.3]; z: [-1.5; 1.5]; phi: [-0.004; 0.004]

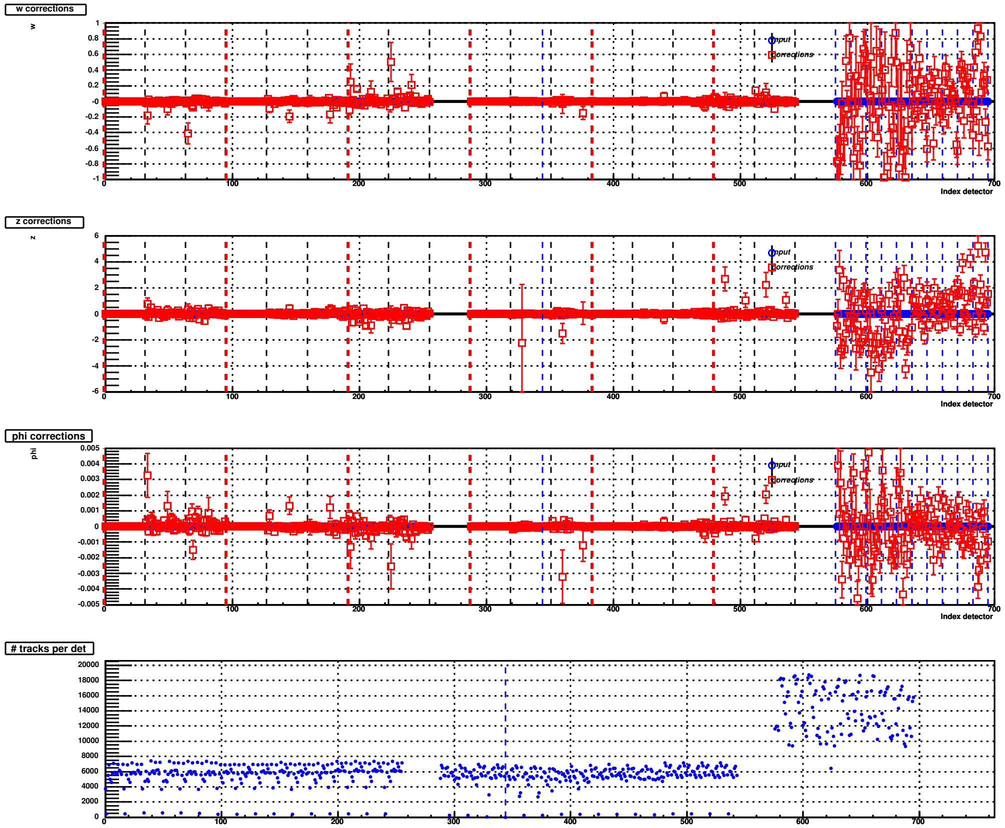
- The absice is the index of each half octant, starting from south arm, station 0 gap 0 (on the left), north arm, station 2 gap 2 (on the right). The stations are divided by vertical red dashed lines.
- In the first plots: the input misalignments are represented in blue (for this first reconstruction there were no misalignments in input); the red dots are the misalignments found by the algorithm.
- The bottom plots represents the number of hits in each detectors.
- The blue dashed lines that can be seen on all the plots indicates that these detectors saw less that 5 hits.

Conclusion : **The alignment does not show incoherent results.**

Status

- The simulation gives good results when alining without magnetic field the Mutr and the MuID together within the error bars.

- However for the MuID, we see wider error bars, maily due to it poor resolution (larger tubes). It could also be due to multiple scattering: to be tested by increasing the particules momentum.



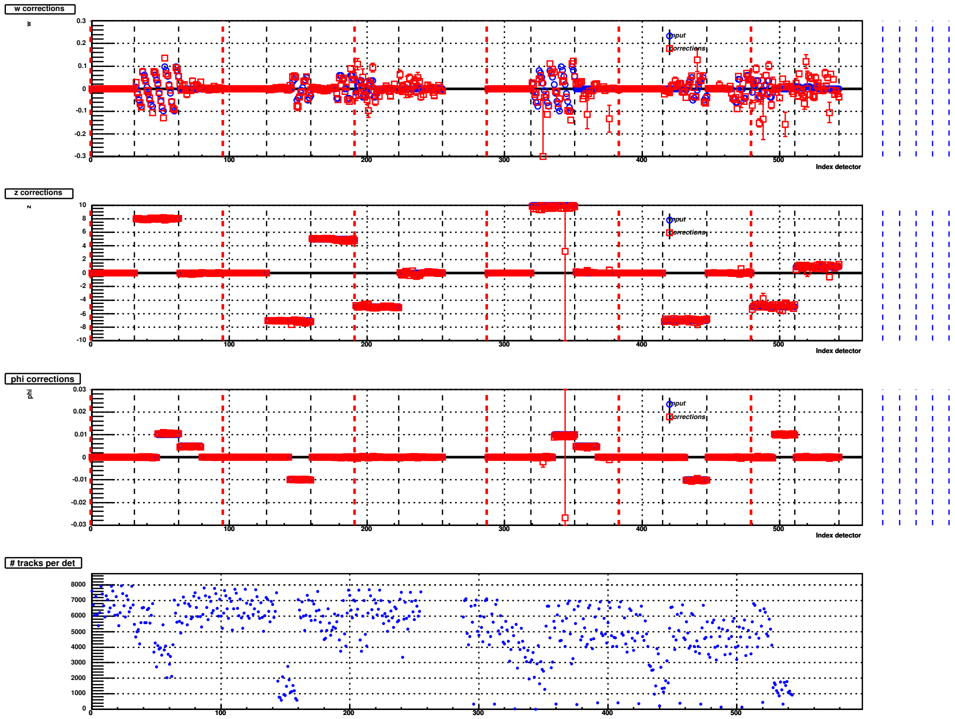
w: [-1; 1]; z: [-6; 6]; phi: [-0.005; 0.005]

Output offsets aligning the Mutr and the Muid together

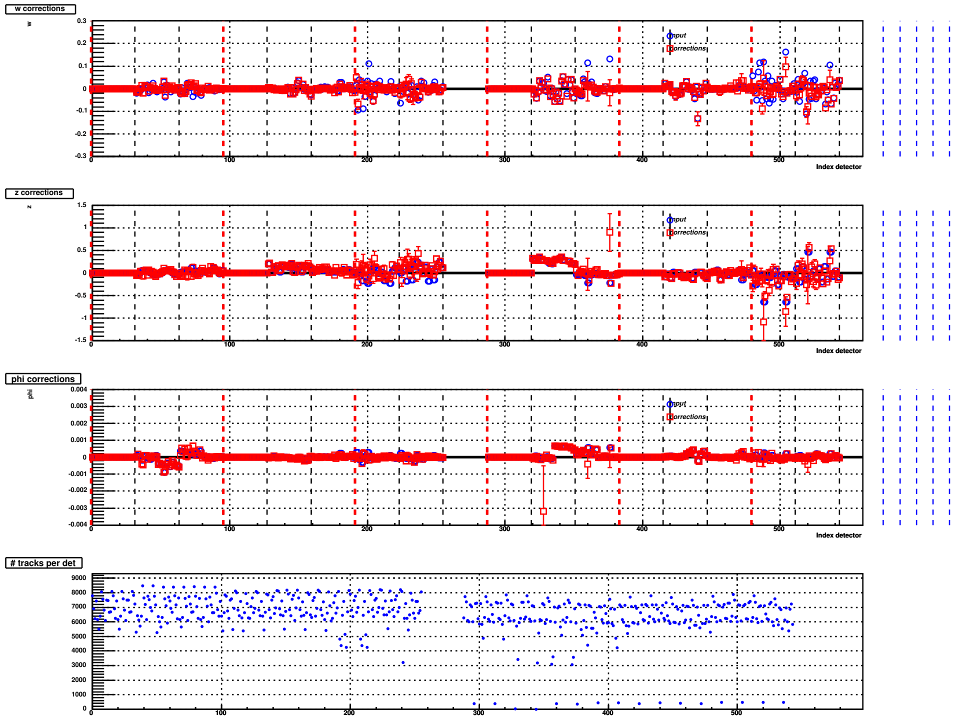
With misalignments - Mutr [1/2]

Offsets

First reconstruction



Second reconstruction



SCALE

w: [-0.3; 0.3]; z: [-10; 10]; phi: [-0.003; 0.003]

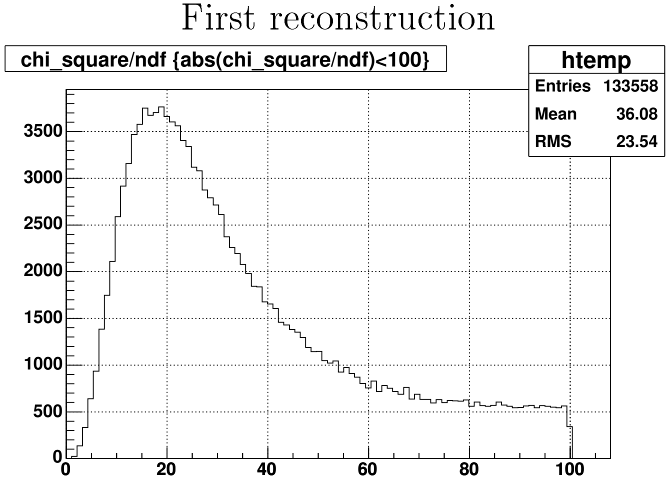
number of hits (range for both plots): [0; 9000]

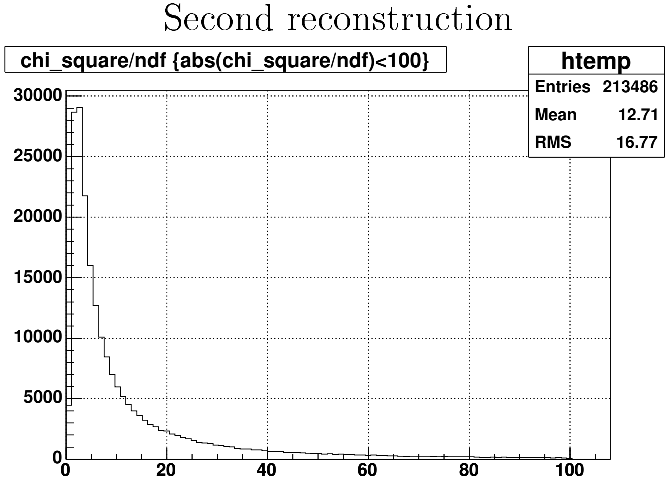
w: [-0.3; 0.3]; z: [-1.5; 1.5]; phi: [-0.004; 0.004]

- The misalignments have been found very acuratly.
- The input of the second reconstruction is the sum of the misalignments first introduced and the ones given by the program (output of the first reconstruction). Therefore, this sum should have been almost 0 if the program had effectivly found the misalignments. The little offsets seen on the right plots (especially for z and phi) indicates that during the first reconstruction the program *had converged towards a wrong value.* This is because the first misalignments were too big. **A third reconstruction confirmed this statement.**

<u>Conclusion:</u> **The alignment is convincing with misalignments for the Mutr alone.**

Track chi-square / ndf



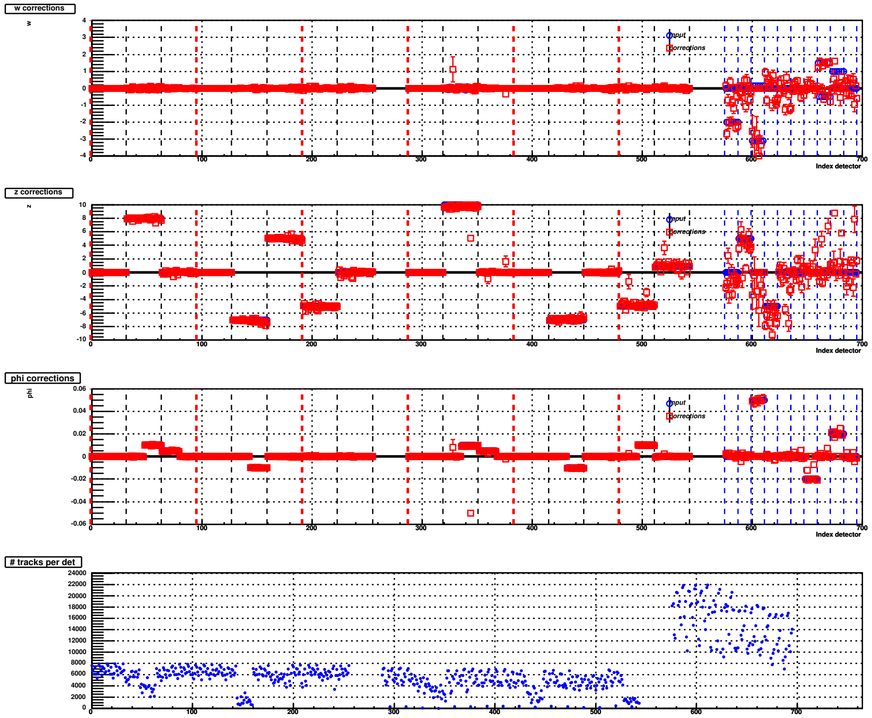


Mutr alone

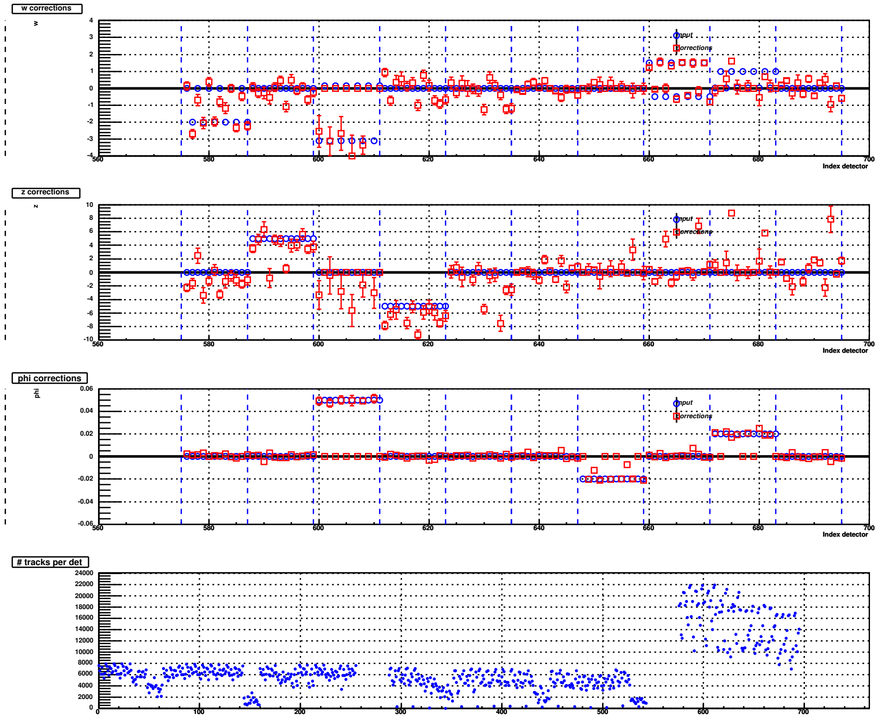
- The track chi square obvious improvement with and without the MuID confirmes the good working of the algorithm to align the detectors globally.

Offsets

First reconstruction



Zoom on the MuID



SCALE

w: [-4; 4]; z: [-10; 10]; phi: [-0.6; 0.6]

number of hits (range for both plots): [0; 8000]

w: [-4; 4]; z: [-10; 10]; phi: [-0.6; 0.6]

- The program is not as successfull with the MuID alignment, but close.
- For the Mutr, it shows results as good as on the previous slides.
- This zoom on the MuID reveals a problem with finding the right misalignment for phi, for one orientation out of the two, when a plane has been misaligned.

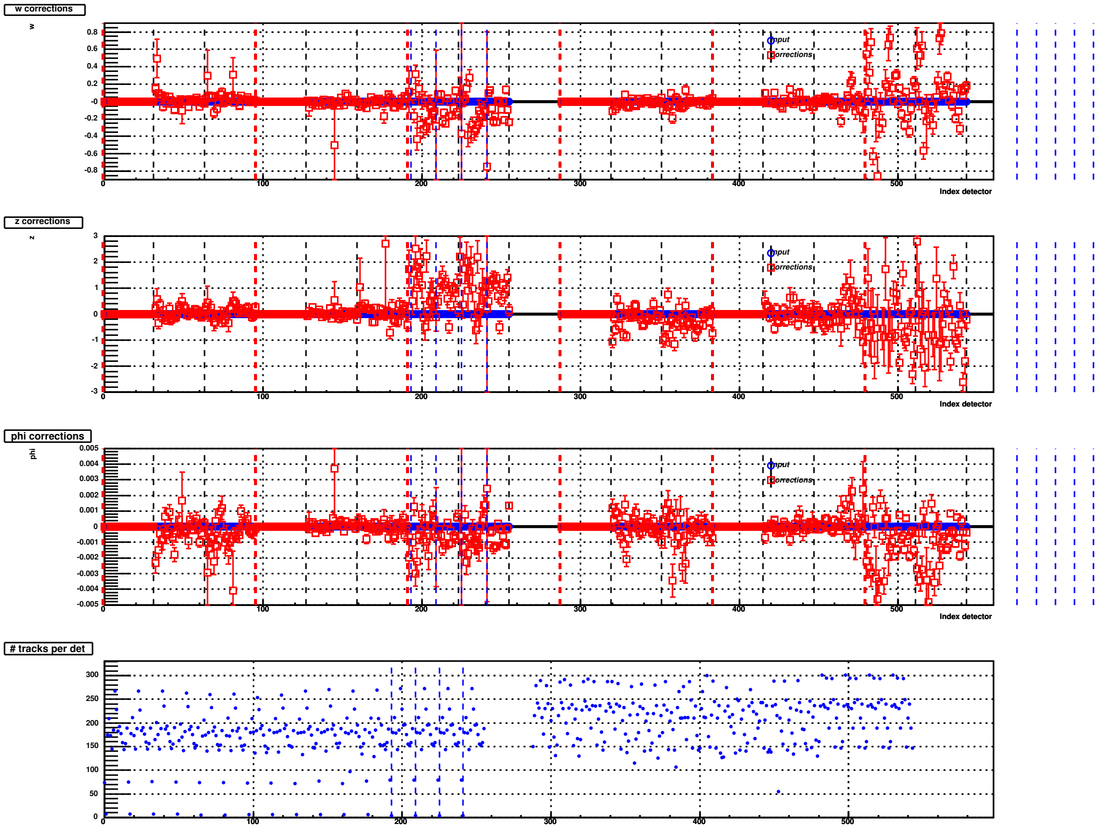
  After more studies, it seems that when misaligning too much MuID orientations, the alignment program is not able to invert the matrix for those orientations. *There might be a problem with the residuals calculation in the program, or the way the misalignments are used in the track fit (look at the angles)*

Conclusion : Work in progress.

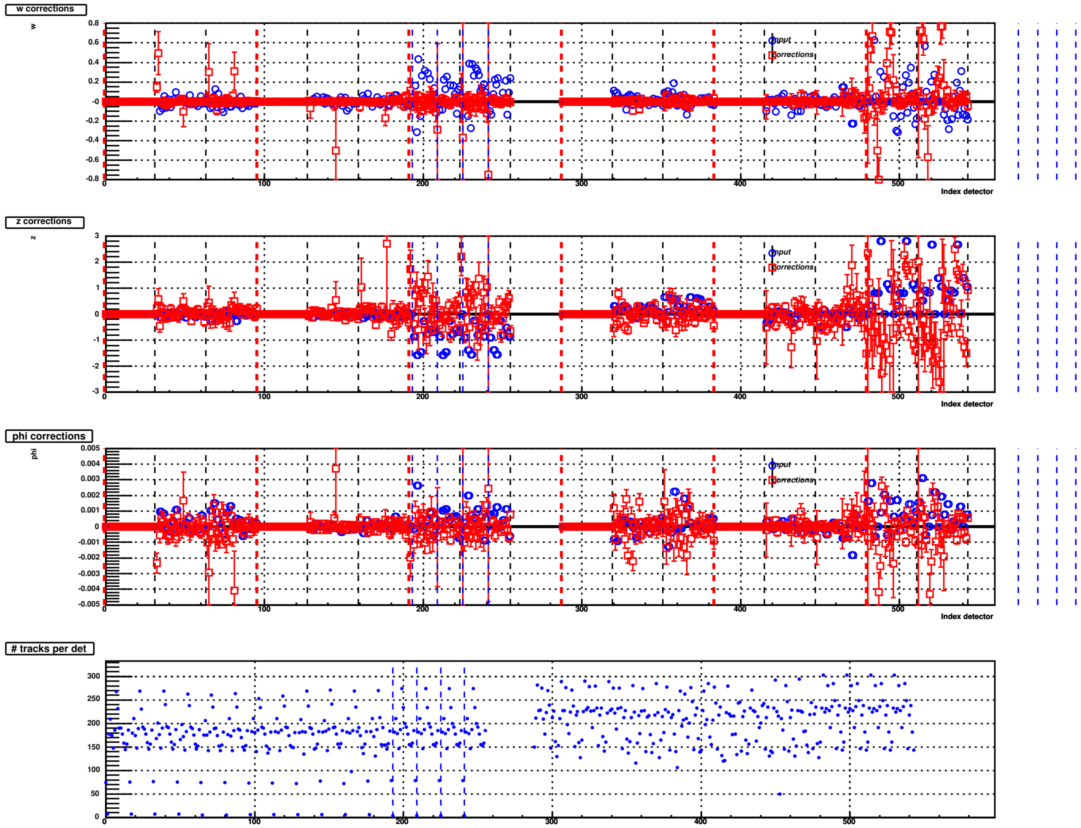
Results on RealData (no field)

Results on RealData [1/2]

First reconstruction



Second reconstruction



SCALE

w: [-0.8; 0.8]; z: [-3; 3]; phi: [-0.006; 0.006]

number of hits (range for both plots): [0; 300]

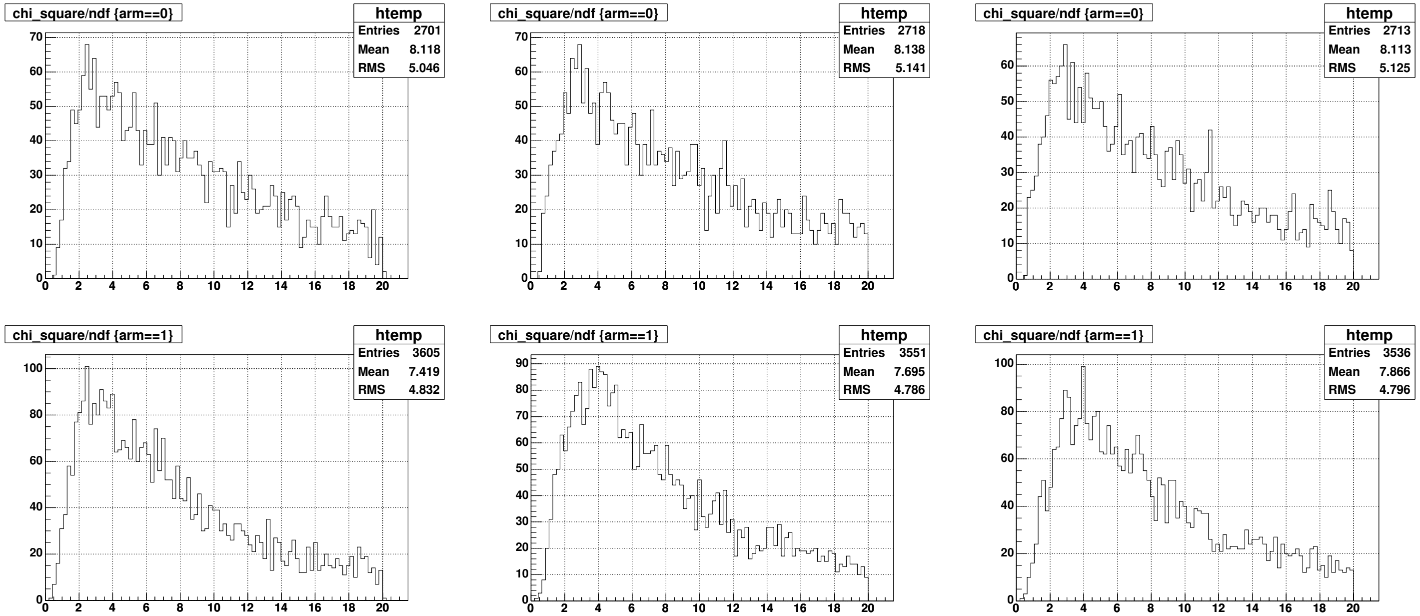
w: [-0.8; 0.8]; z: [-3; 3]; phi: [-0.006; 0.006]

- Last stations have systematics offsets, especially in z.

- The second reconstruction align the detectors more homogenously around 0. However, if we look at the residuals in each half octant, the improvement is not so obvious.

RealData - Track Chi Square [2/2]

If the aligment of the MuTr was working well, we should see an improvement in the track chi-square from the 1rst reconstruction to the second one.



South Arm

North Arm

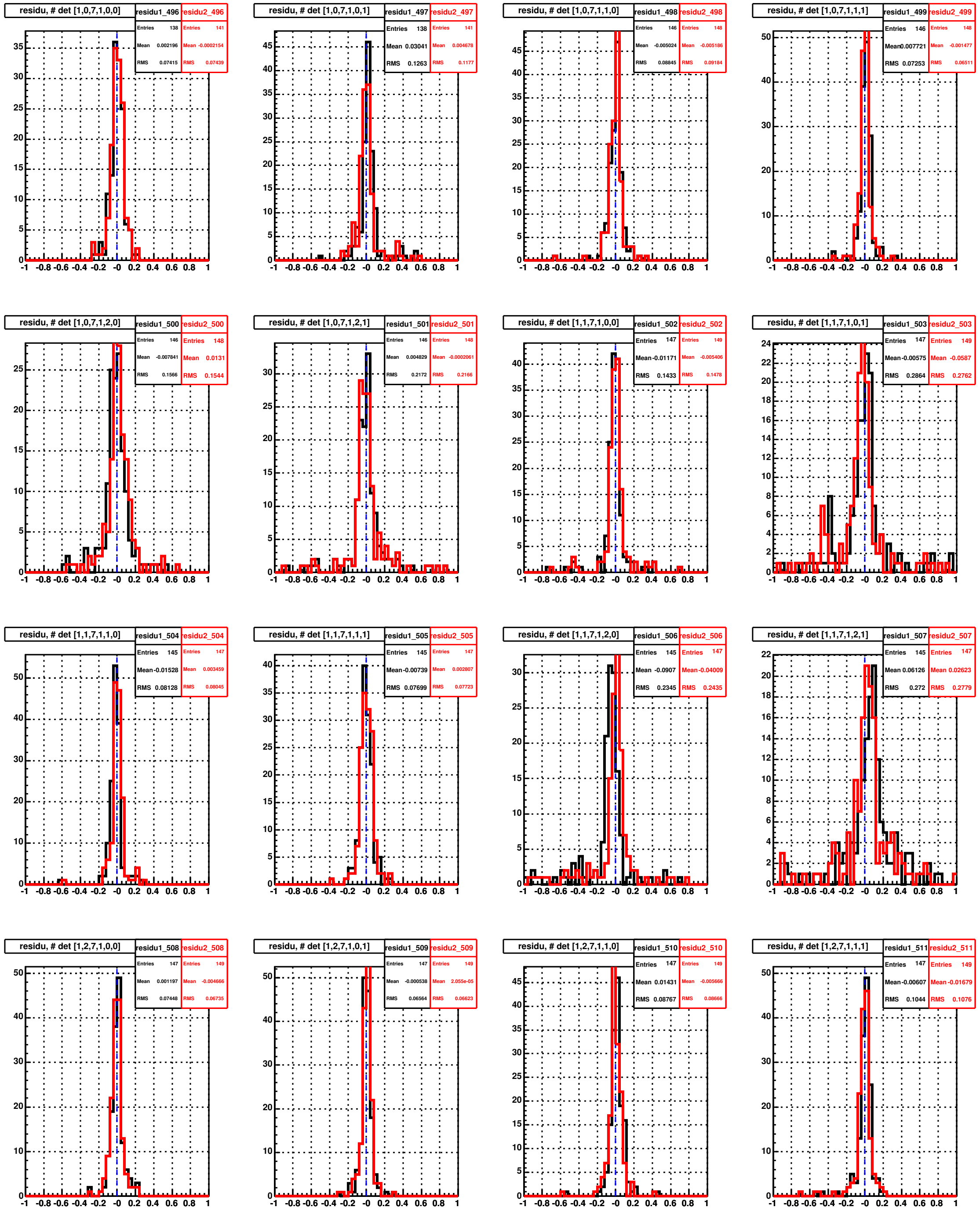
- After the second reconstruction, the track chi square shows increasement of the number of tracks for the south arm (positiv result). However we loose 50 tracks in the north arm (the alignment did not improve the quality of the tracks).A third reconstruction was turned and shows worse results for both arm.
- Something is strange with the realdata alignment since it should improve as in simulations but does not. In fact, it looks like it doesn't affect the tracks much to align or not: **no real changes in the tracks...**

  Closer study: look at the alignment for each parameter.

Results on RealData - Residuals vs parameters

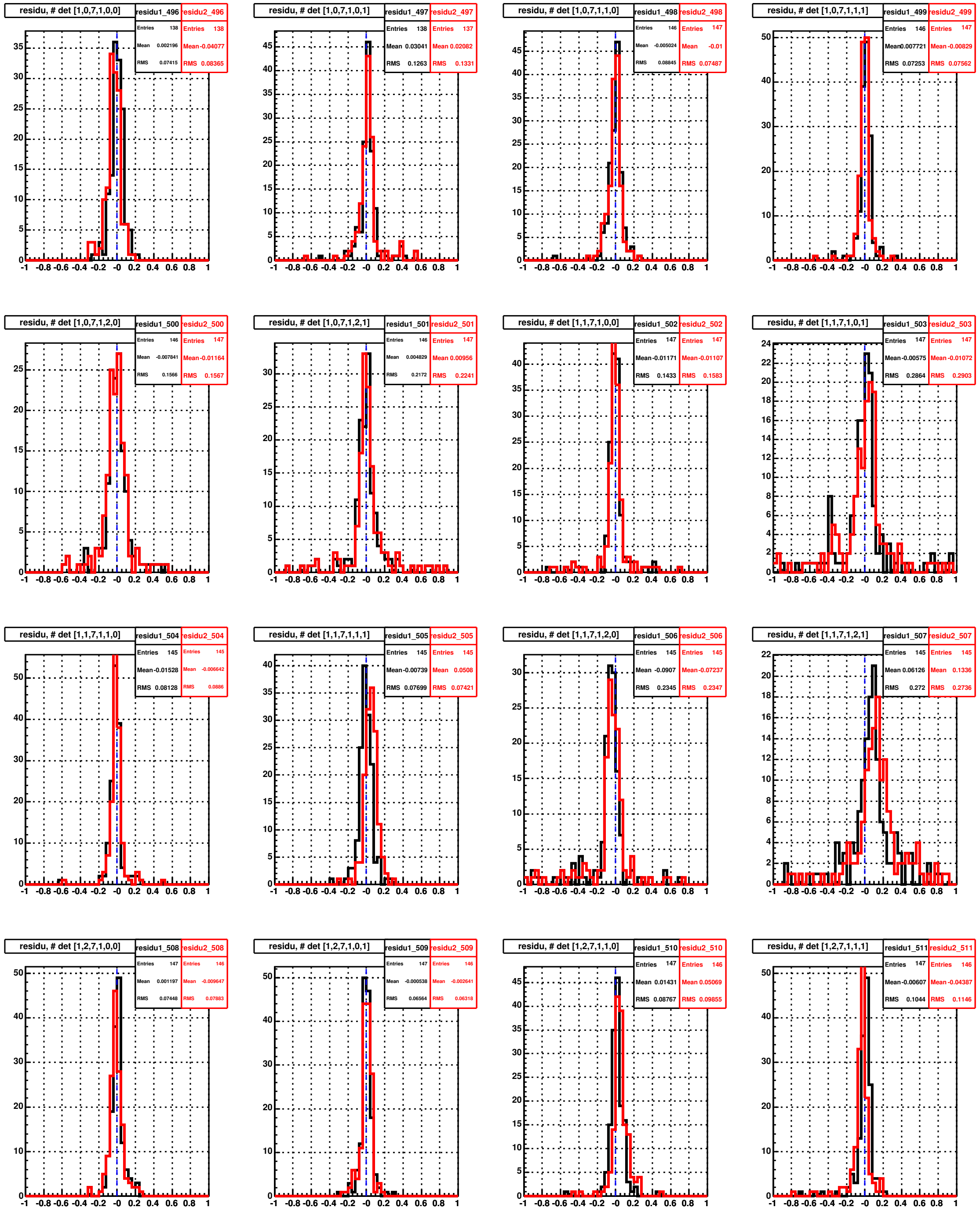
Residuals aligning W only

The red residuals comming from the 2nd reconstruciton are on the whole more centered around 0. Therefore, we can say that the alignment works for W.



Residuals aligning W and Phi

We se that after the alignment, the residuals are worse than before.



Summary for residuals study

- Improvement on the residuals when aligning only W : alignment working for those parameters aligned alone.
- phi and z are not parameters that should influence the residuals.

  It is actually true for z: not changes in the residuals when aligning z.

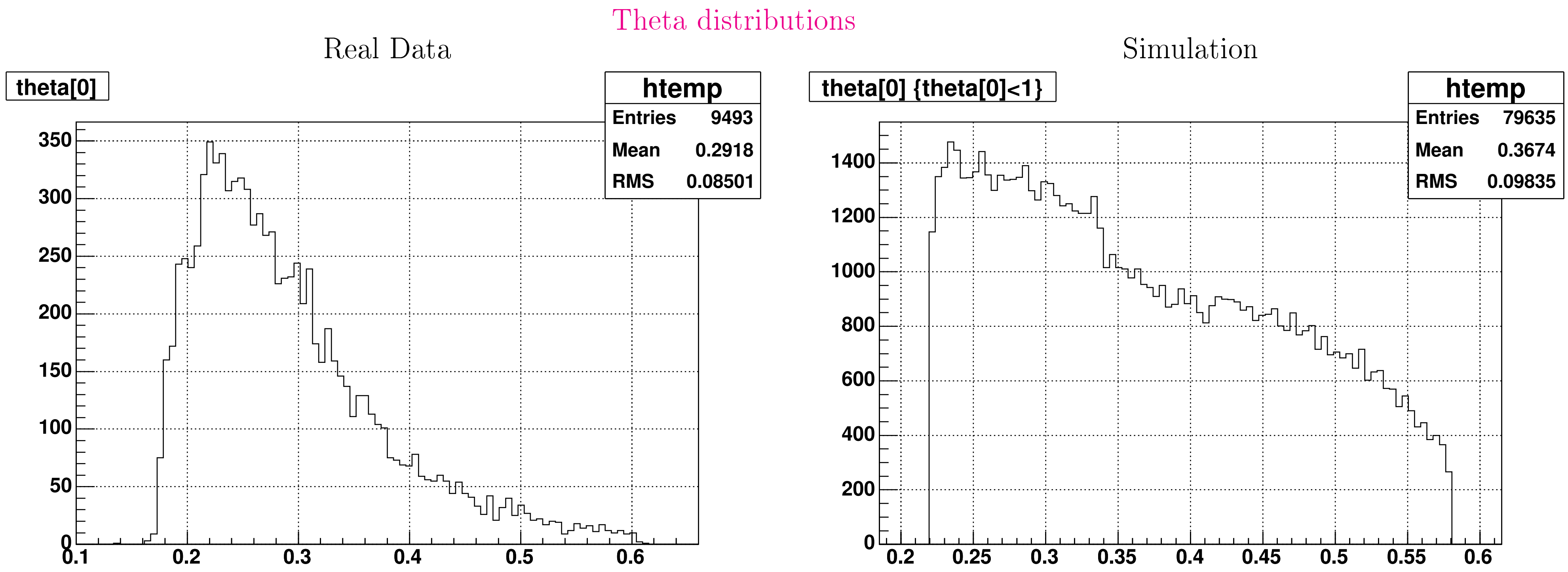
  However, aligning phi do show better residuals. This suggests a correlation between phi and w.
- Poor alignment when aligning w and phi at the same time: this is anonther hint to think that there is an undefinite correlation for those 2 parameters.

Conclusion : **Work on progress**

- w and phi could be more correlated at small angle:

  Put a cut on theta to reduce the tracks close to the beam axis.

  Study the effects on simulations and on RD.

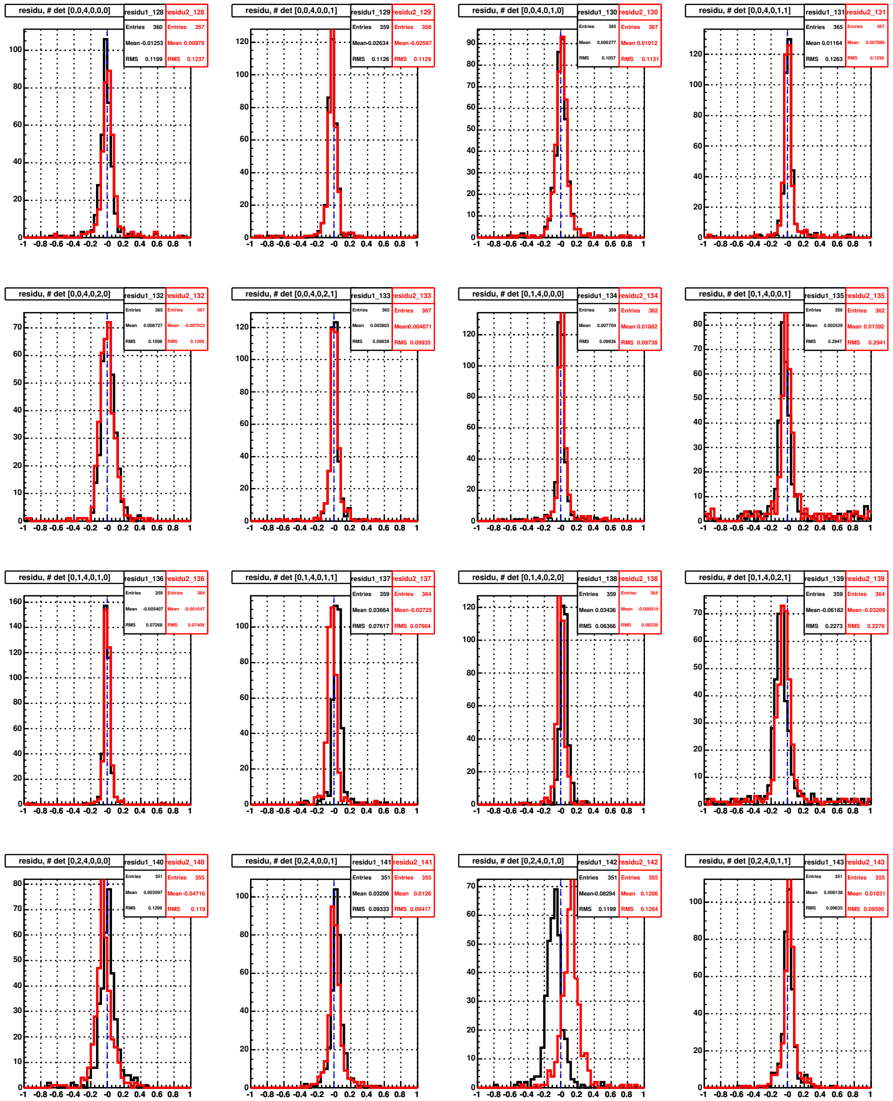


Distribution picked on lower values of theta

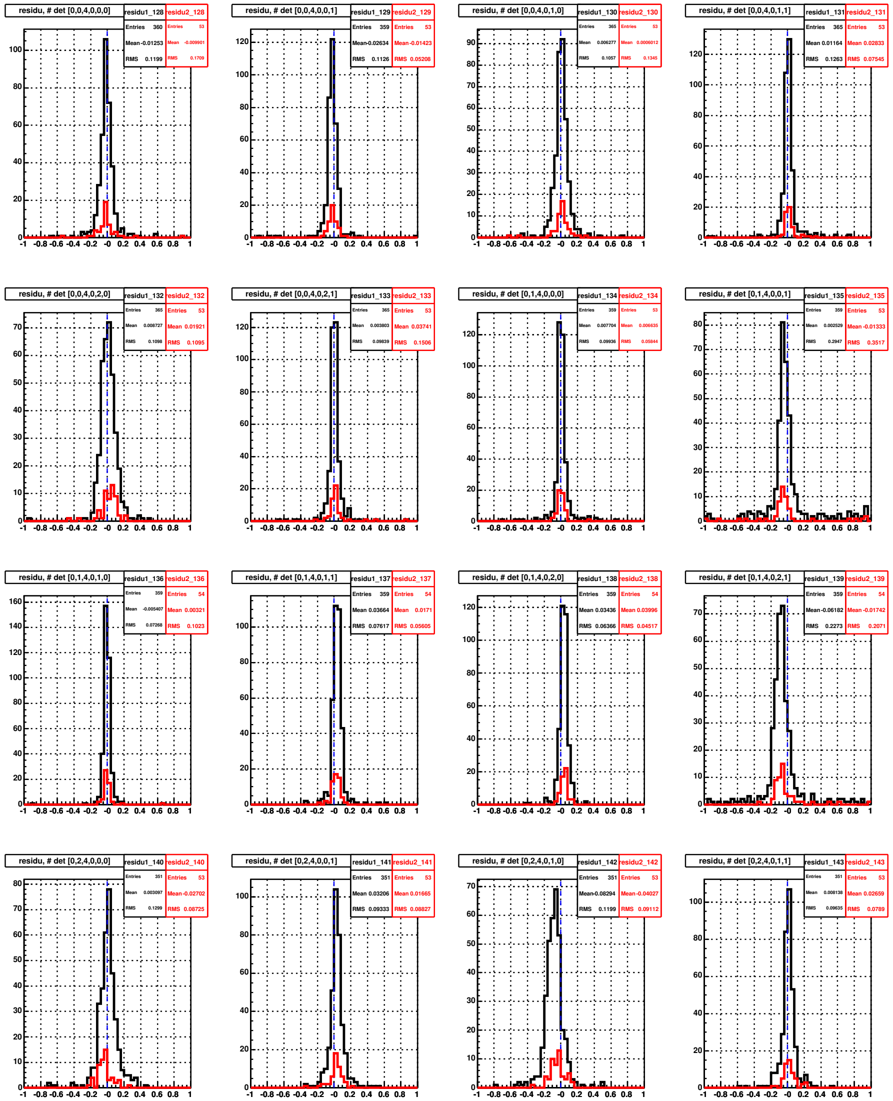
Residuals aligning W, Phi and Z

Almost no theta cut

After the alignment, the residuals are clearly worse than before.



RD: Residuals vs theta cut [2/2]



Residuals aligning W, Phi and Z

Big cut on theta: theta $>$ 0.4

No such effect as without any cuts: the alignment is showing better results. However the statistics is too low to conclude clearly.

Conclusion : **Work in progress**

- Alignment working for W alone.
- W and Phi are correlated at small angle:

  The theta cut improves the results for the alignment on RD.

  Try with at looser cut and more statistic to confirm the statement.
- Change to r instead of w

  Indeed, r and phi would not have the same problems as w and phi since r is perpendicular to phi.

- MuID:

  resolve problem (*1 or 2 weeks*)

- Correlation w to phi

  confirm correlation with more stat (*1 week*)

  change to r (*3 weeks*)

- Test with field on (*1 month*)

Conclusion :

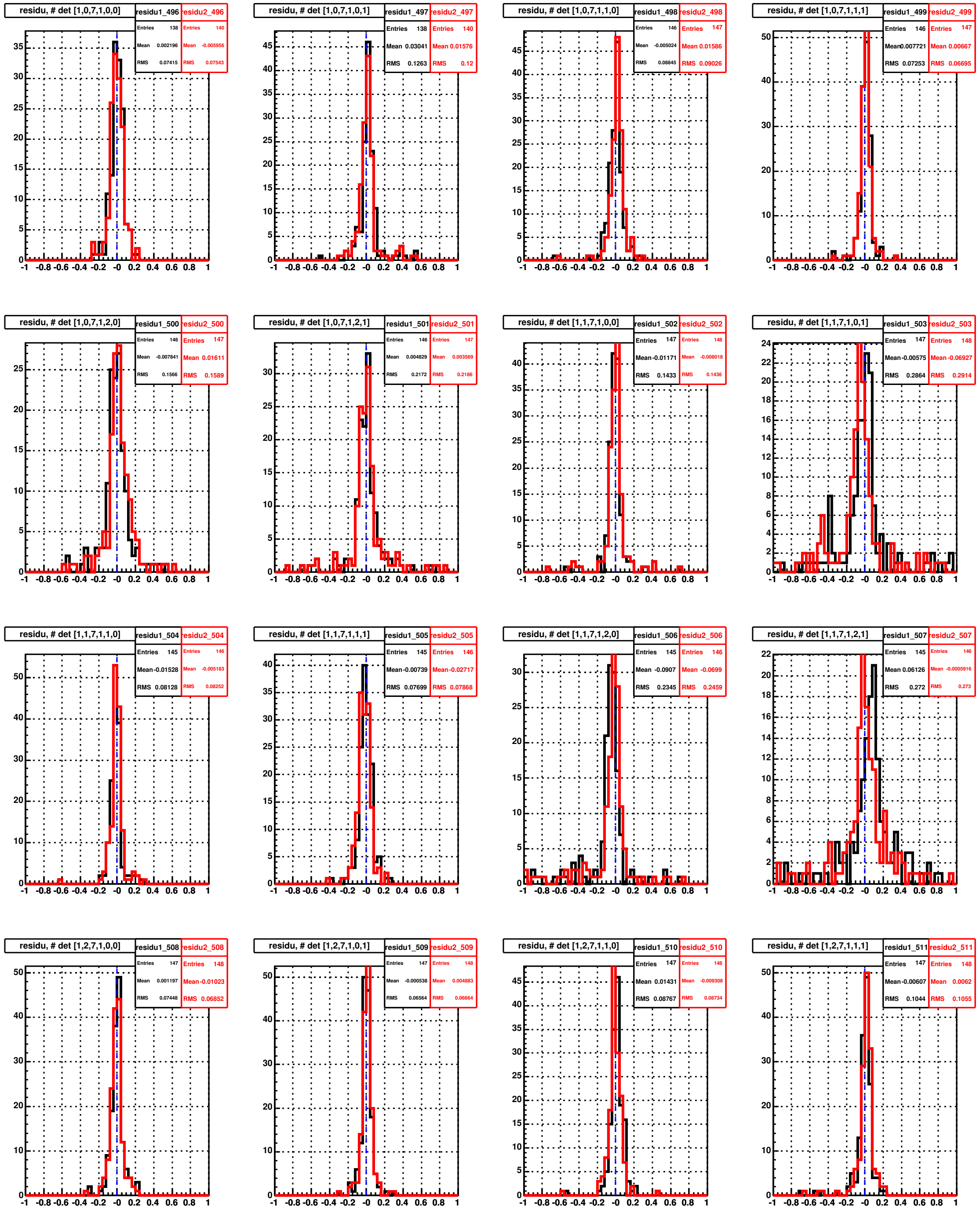
- Hopefully, we'll have results by the end of febuary

Back up slides

Results on RealData (no field)

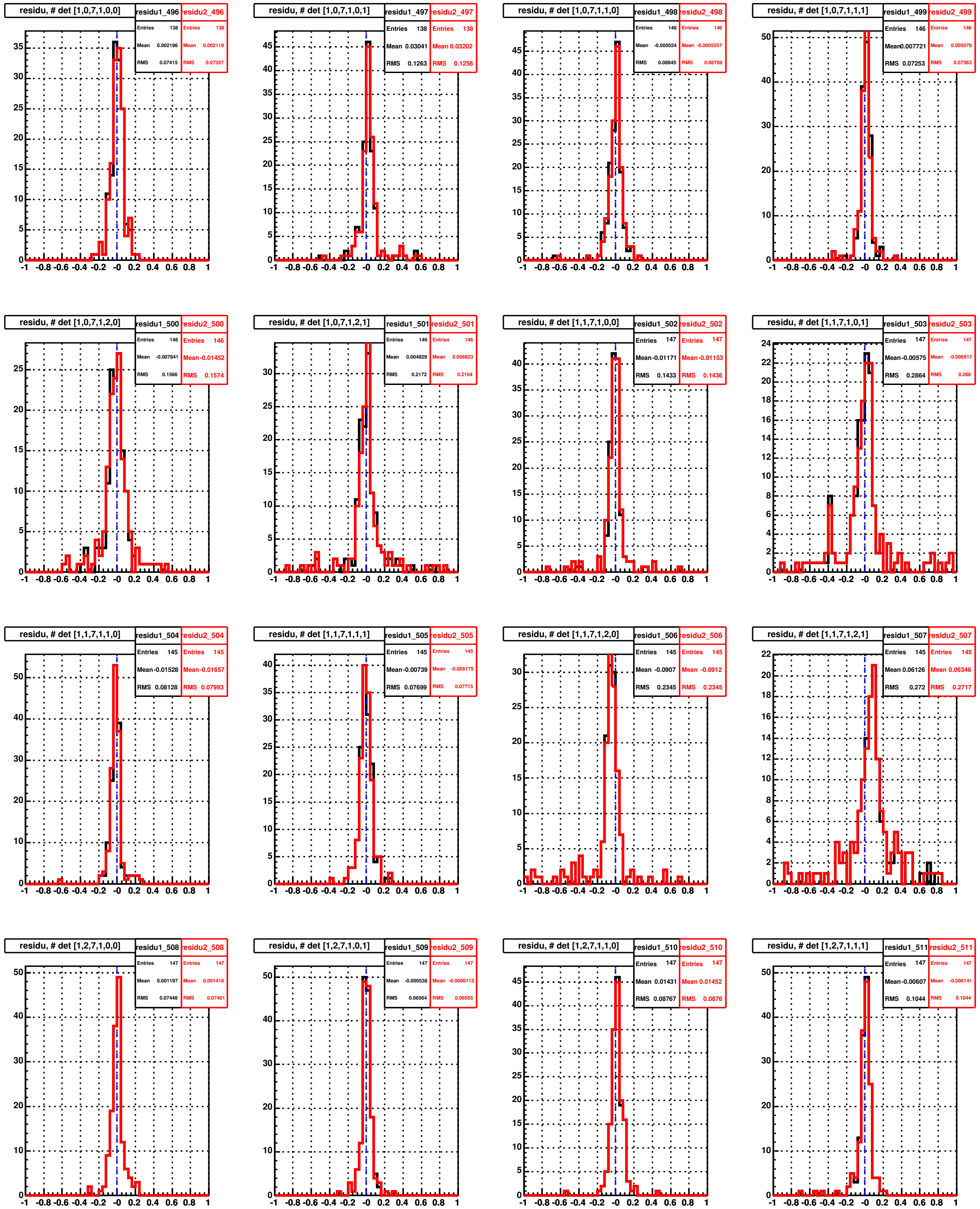
Residuals aligning Phi only

On the whole, after the 2nd reconstruction, the residuals are more centerd. So the alignment works for Phi alone also.



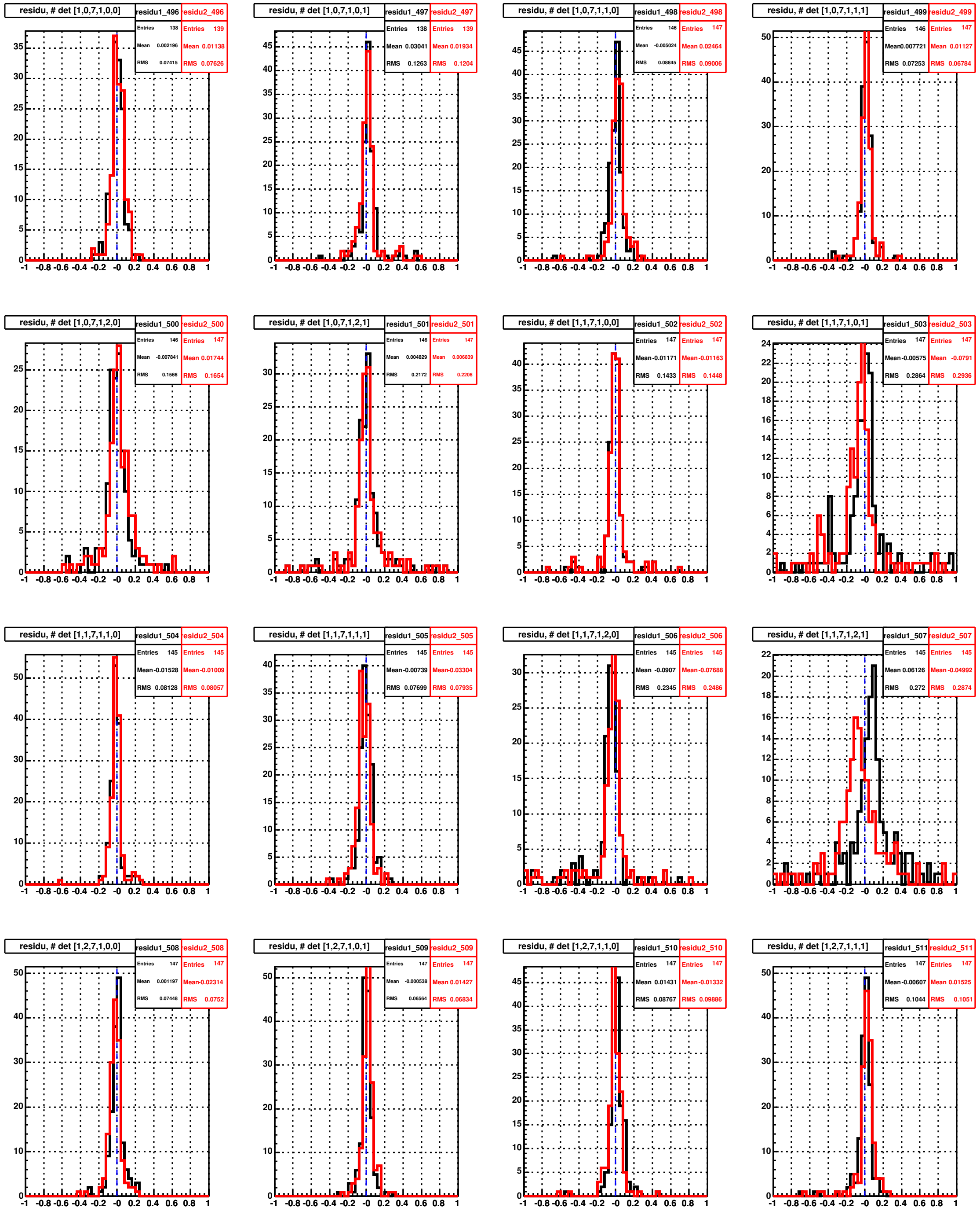
Residuals aligning Z only

There are no real changes between the first reconstruction residuals and the seconde ones.



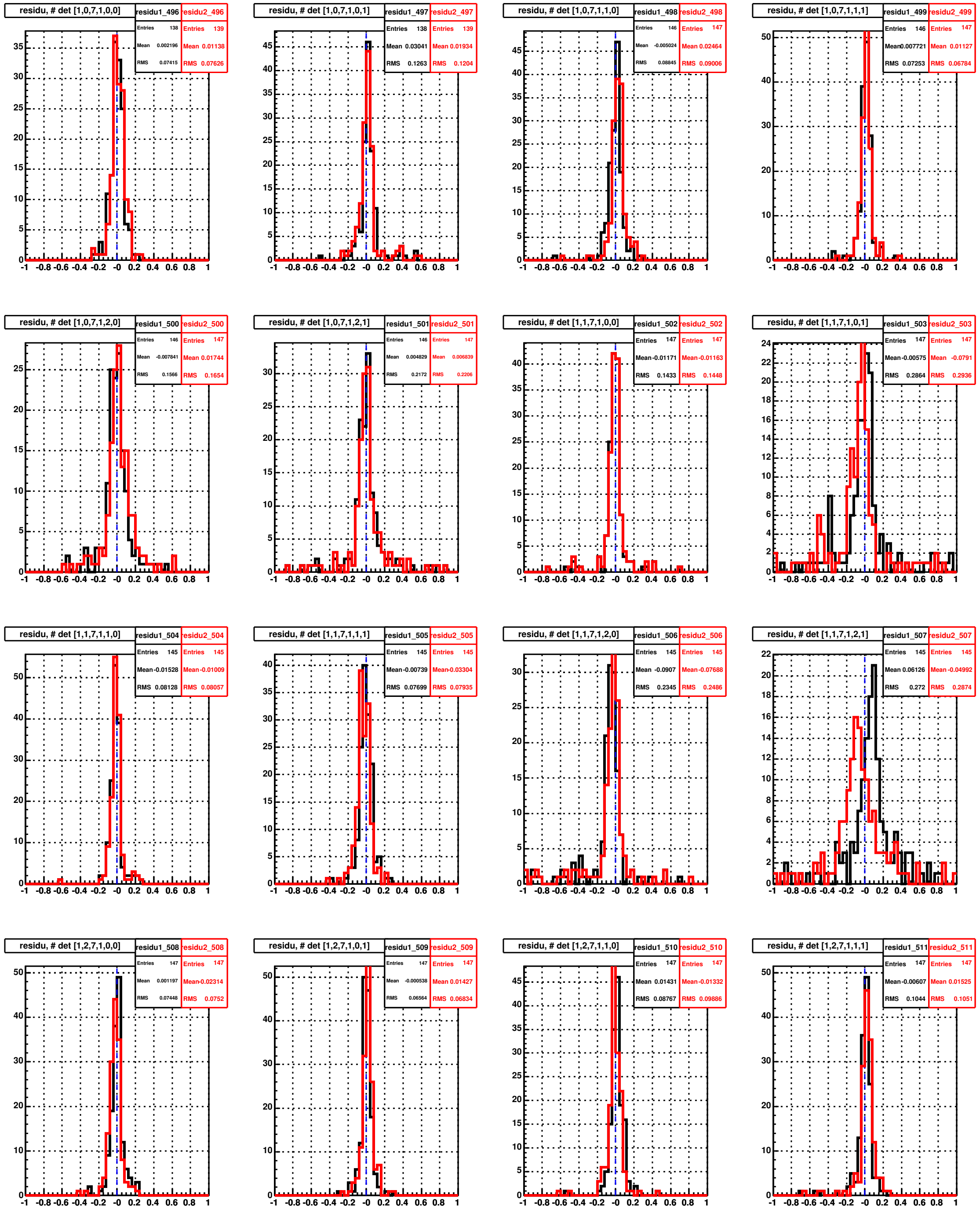
Residuals aligning W and Z

It seems that after the alignment, the residuals are worse than before.



Residuals aligning Phi and Z

It seems that after the alignment, the residuals are a slightly worse than before.

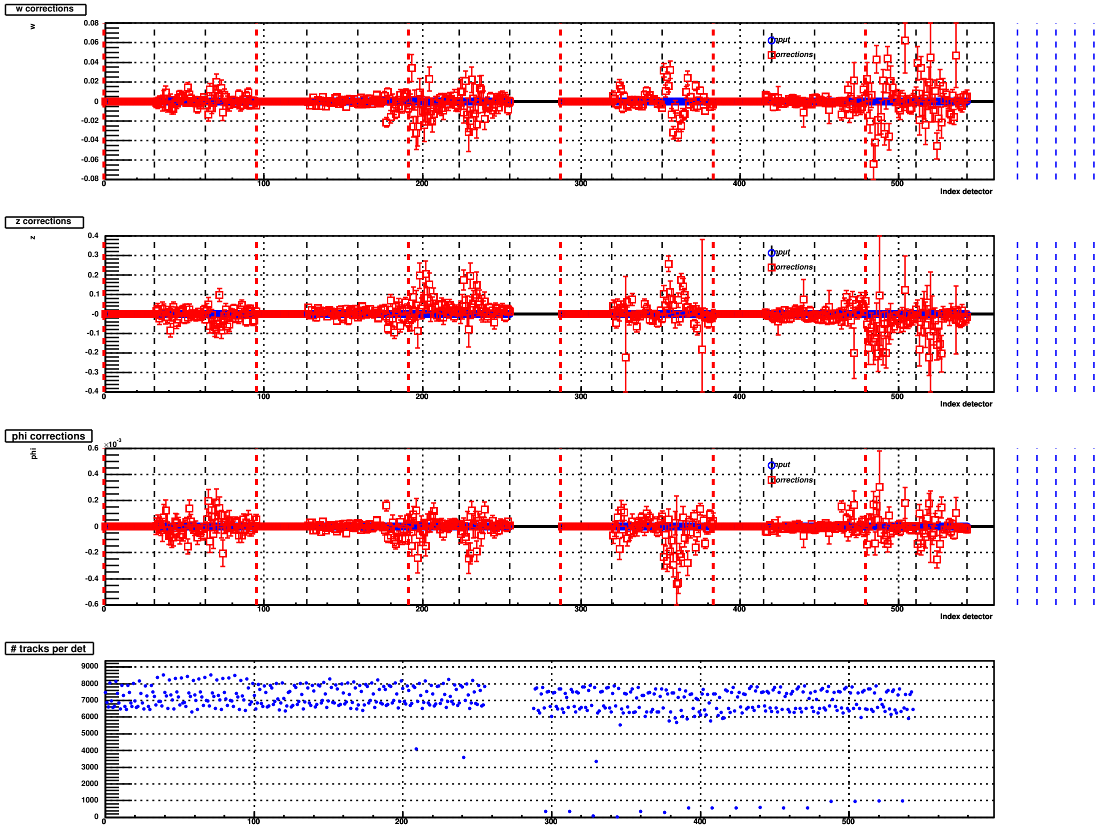


With field ON

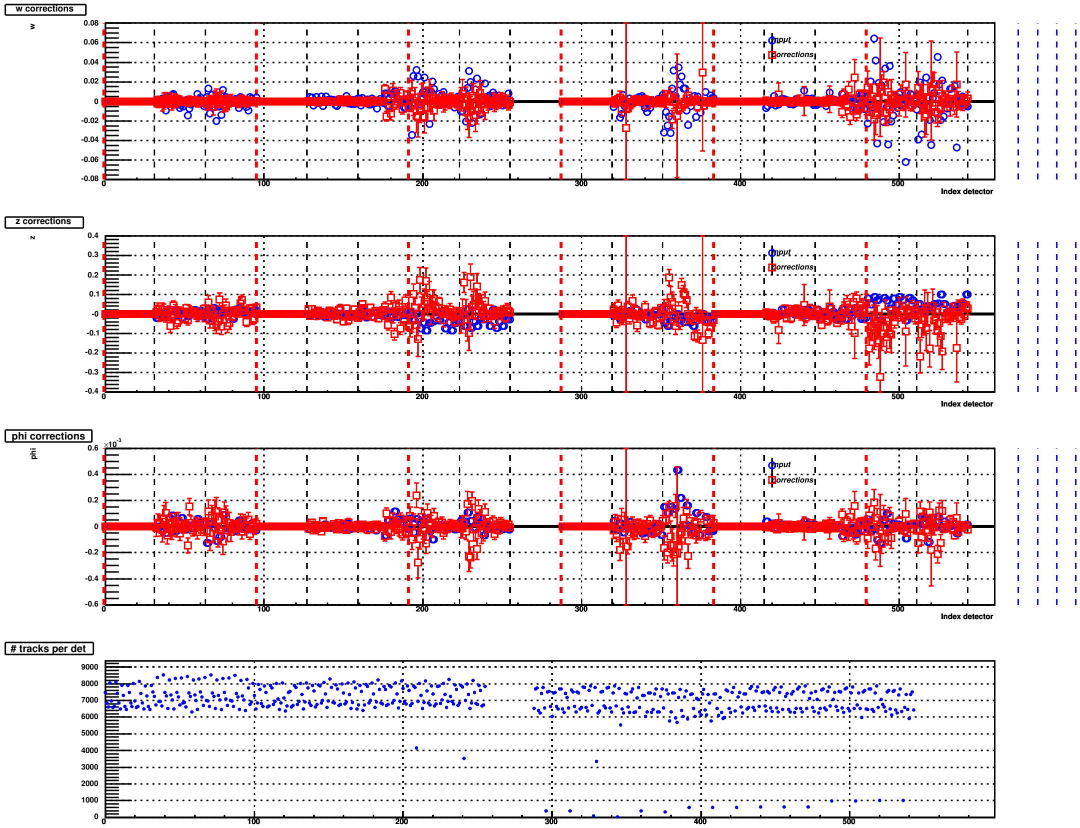
With field ON - Without Misalignments

Offsets

First reconstruction



Second reconstruction



SCALE

w: [-0.08; 0.08]; z: [-0.4; 0.4]; phi: [-0.0006; 0.0006]

number of hits (range for both plots): [0; 9000]

w: [-0.08; 0.08]; z: [-0.4; 0.4]; phi: [-0.0006; 0.0006]

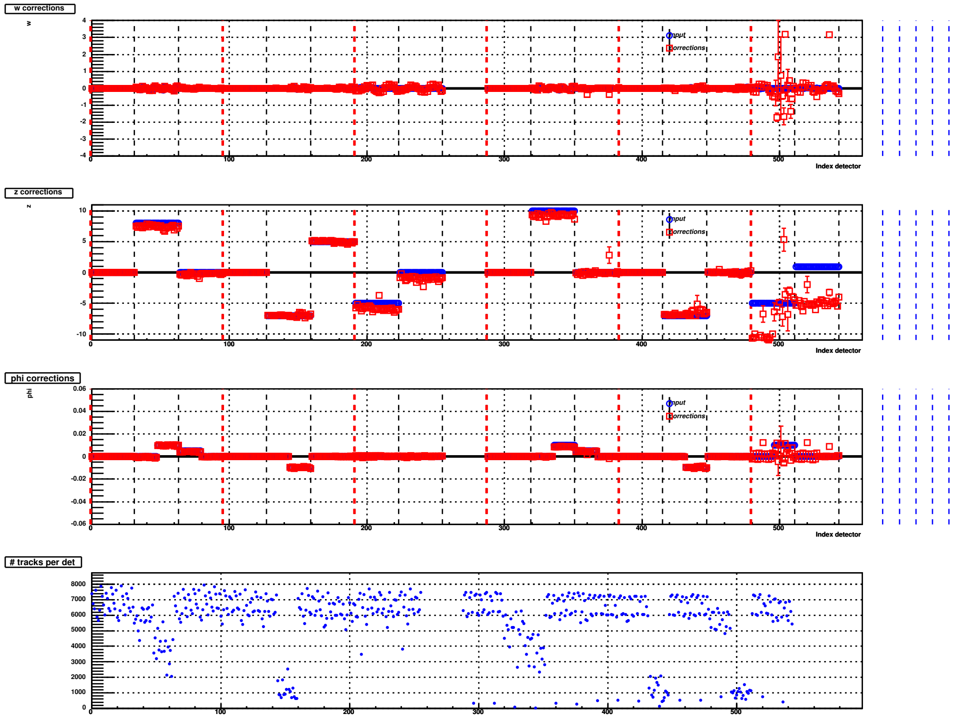
Conclusion :

- The simulations do not show any problems when aligning the Mutr without misalignments inputs.

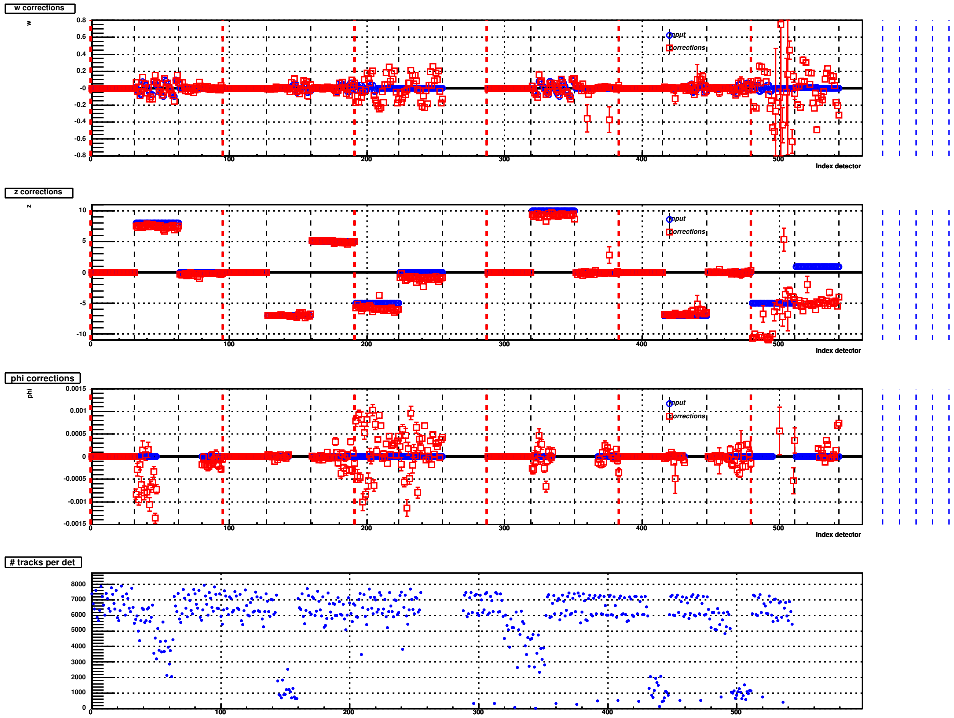
With field ON - With Random Misalignments

First reconstruction

Offsets



Zoomed



SCALE

w: [-4; 4]; z: [-10; 10]; phi: [-0.06; 0.06]

number of hits (range for both plots): [0; 8000]

w: [-0.08; 0.08]; z: [-10; 10]; phi: [-0.0015; 0.0015]

- Strange systematic effect in the last station: founding of wrong misalignments for all parameters.

  May be it is due to some correlations between w and phi when the tracks are too close to the beam axis. Not understood yet.

- Are the input misalignments too big ?

  A second reconstruction has been turned and shows that the misalignments in input were not too big.

  ? Might be due to a prob in the extrapolation with respect to the track shape.

Conclusion : **Understand the systematic offsets of the last station.**

Simulation	
No Field	With Field
No misalignment - Muid *Work on the MuID alignment to solve the bug.* With misalignments - Mutr and Muid *We tried a cut on theta to limit the influence of the corelation between w and phi.*	No misalign - Mutr Slight systematic offsets not understood With misalignments - The program converges towards a wrong value. *Tring less misalignments do not help the algorithm to converge, neither does an itteration.*

Real data

- The program seems to align. However the tracks quality does not improve.
- We are trying to run more stat and to use the theta cut.