Comments by Lilian on the alignment

http://www.star.bnl.gov/public/ssd/STAR_online/STAR_Calibrations.html#Alignment

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Some Notes

- Lillian summarized the alignment process
- I have done some editing and highlighting of his document.
  - For brevity
  - Some wordsmith
- Most of the highlighting is done by me
- I hope that I am interpreting work correctly
- Green comments are mine

Hardware

PART I

Ladder Assembly Survey
Part I

- Each of the 16 modules was placed on an individual support and as close as possible from its nominal location. Some modules were intentionally shifted from their nominal location because of the geometrical extend of the previous module. Some modules shifted due to a bad orientation of the module during the phase of landing on its support.
- The mechanical support for the ladder was installed on top of the modules and the modules were glued to the support. During that step, all four aluminum pins on the module had to fit within holes performed in the ladder support. Some modules went in contact to the support and moved despite the vacuum pump.
- The modules were glued and untouched for 24 hours in order for the glue to cure. The vacuum was then turn off.

Ladder Assembly Survey
Part II

- The first survey was then done in that situation: the ladder still in place on the marble bench.
- Then the ladder was lifted up and stored.
- The first ladders were surveyed again on a dedicated support. The support was supposed to mimic the final support of the ladder and was rotating to place the ladder at a tilt close to the final orientation of the ladder.
- The hardware survey is a mixture of the two surveys

Conclusions from Ladder Assembly Part I

- This support was not really suited for this type of accurate measurement.
  - Especially nominal attachment conditions (orientation and strength) of the ladder to the support were very difficult to reach and reproduce.
    - This means that ladder positions were different from final.
  - For that reason, the data obtained from these surveys have to be carefully evaluated.

Conclusions from Ladder Assembly Part II

- On the other hand, the data measured while the ladder was still on the bench are useful. In that situation, the modules are all in the same plane (the ladder plane).
  - They do not include possible variation due to the ladder sagitta but at first order they give accurate measurement along the ladder axis and in the direction perpendicular to the ladder radius.
  - From these measurements, for every module in each ladder, shifts along the ladder axis (module small edge) and perpendicular to it (module large edge) are calculated. The rotation of the module around its normal direction is also determined.

Module	DBX - mm	DBY mm	DPSI - degrees
1	0.03	-0.07	0.00
2	0.02	-0.03	0.00
3	0.02	-0.03	-0.01
4	0.02	-0.03	-0.01
5	0.00	0.03	0.03
6	0.01	-0.02	0.00
7	0.01	-0.05	0.00
8	0.01	-0.01	-0.01
9	0.02	0.04	0.00
10	-0.15	0.04	0.00
11	0.01	-0.03	0.00
12	0.01	-0.03	0.00
13	0.01	-0.02	0.01
14	0.01	0.14	0.00
15	0.01	-0.01	-0.02
16	0.02	-0.03	-0.02

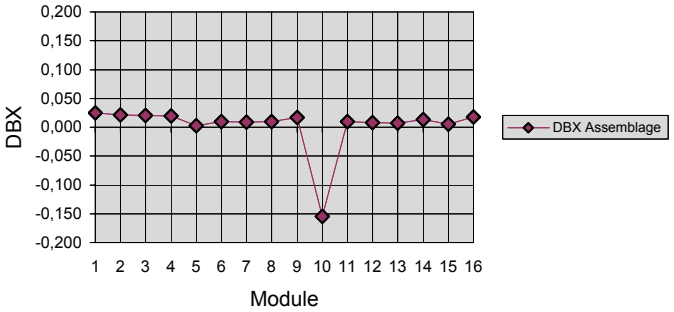
Data for this Ladder

Assembly Order 16
Ladder 22
Position
Run IV XX
Run V 18
Run VI 18

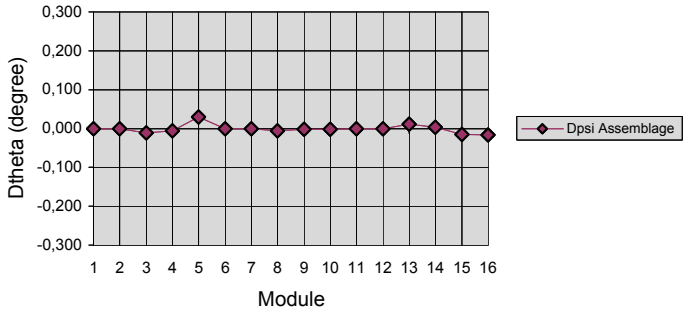
Module 1 was not measured with others.
Its value was taken from the bench.

Ladder 16

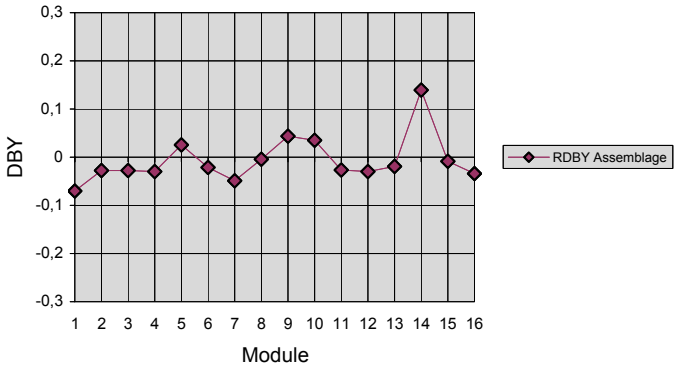
DBX (large edge)



Rotation in the wafer plane



DBY (small edge)



Ass. Order		16
Lad		22
Position	Run IV	XX
	Run V	18
	Run VI	18

Module 1 not measured (position taken when the module was installed on the bench)
Module 14 shifted by 400 microns in Y (?)

No Z variation measured

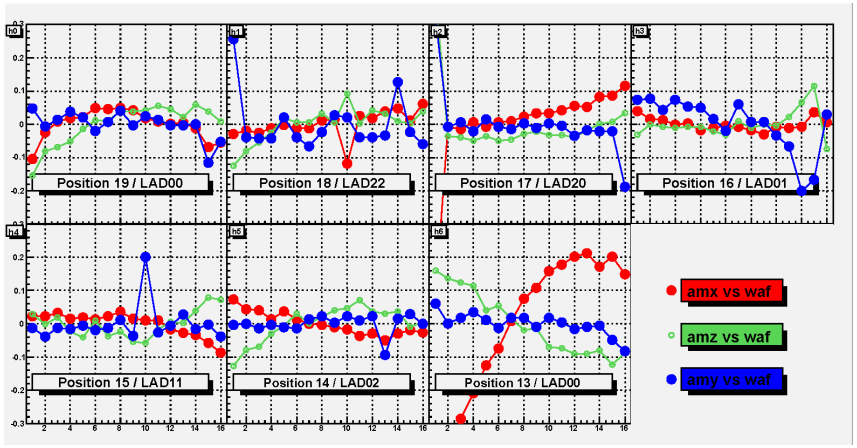
Conclusions for Ladder 22

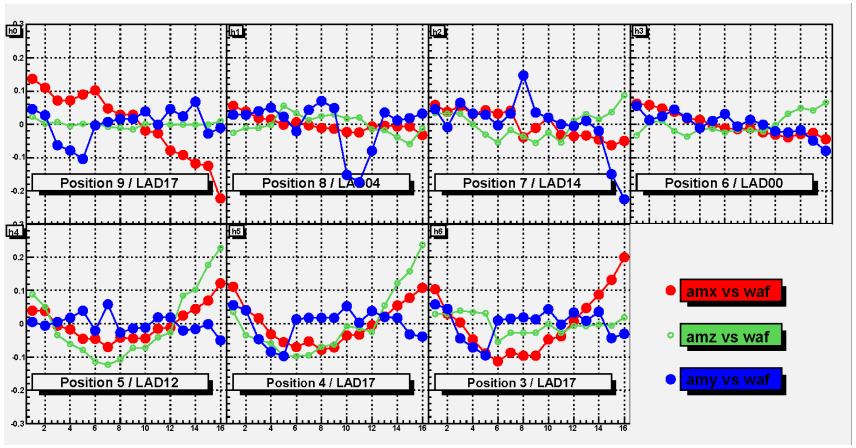
- This ladder shows two particular defects
  - Module 10 is shifted by 150 µm in X
  - The position of the modules is irregular in Y with a maximum shift of 140 µm for module 14.
- Must correct for individual modules
  - In the X direction 20 µm is expected

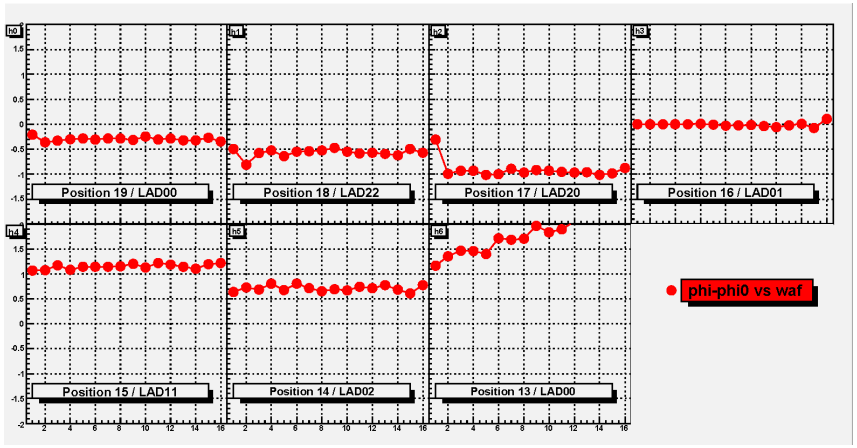
Sector Assembly Alignment

- Once assembled, the ladders were installed on the SSD sectors.
- A survey of the ladders installed on the small sectors exists but it is quite limited.
- The data taken on the rotating support were supposed to be reliable.
- The ladders installed on the sides were never surveyed on their final mechanical support.
- Finally, survey data exist for the 10 ladders installed at the 5 central position of the large sectors
- We are missing final survey for 10 ladders (HM)

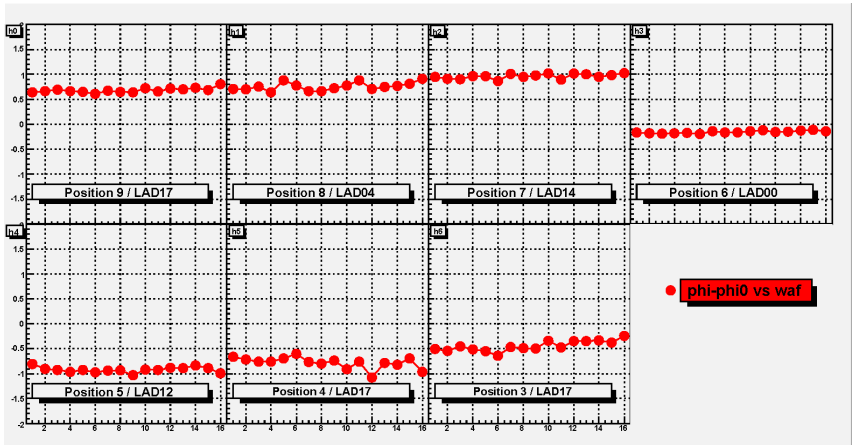
Results for the 10 sectors





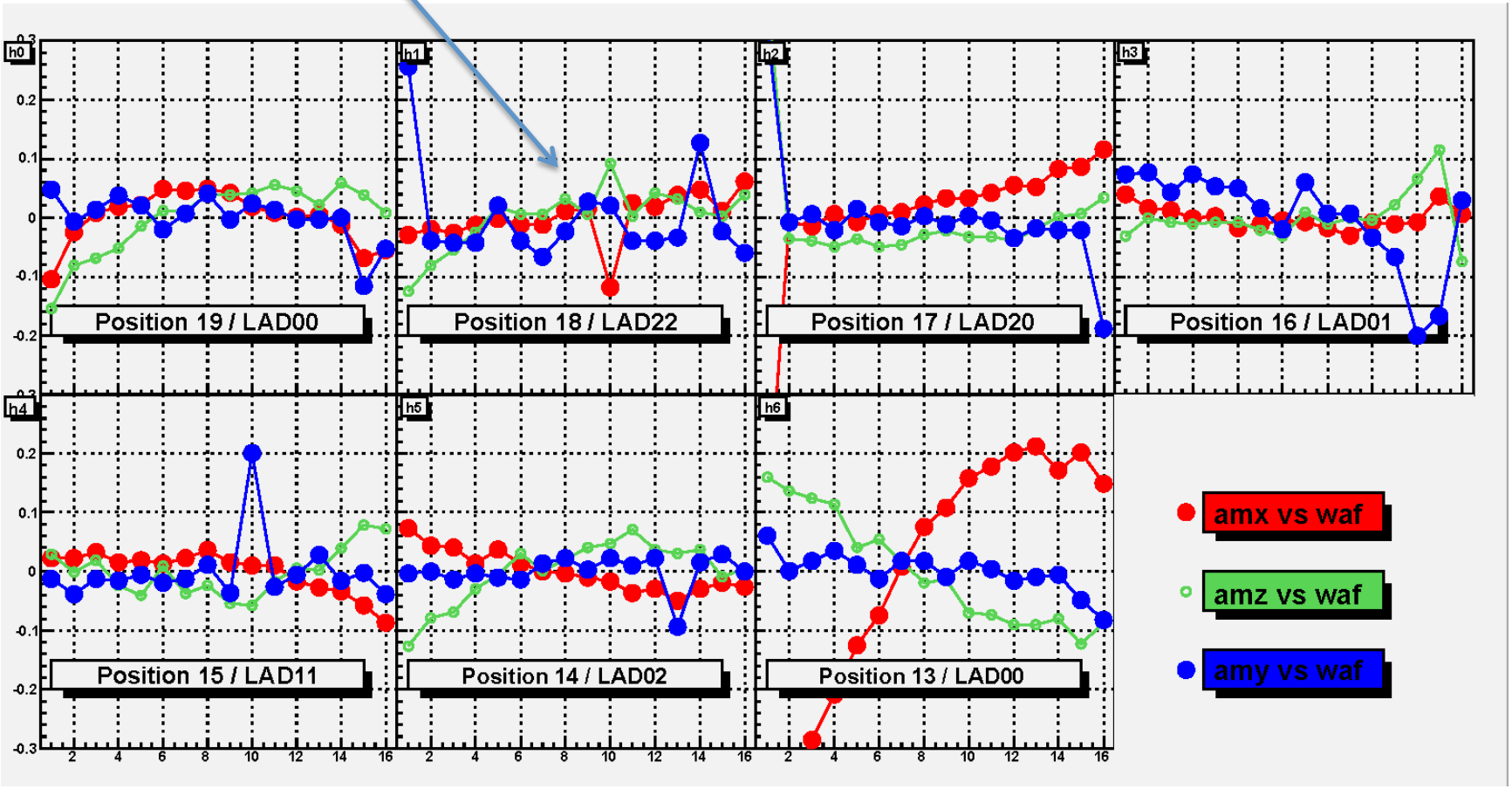


Sector 1



Sector 2

Ladder 22 – Looks different from before



SSD Fixture on the Cone (comments by HM)

- Do not see a reference to alignment of the mount.
- How well is the physical mount mounted on the cone?
- What is the accuracy of positioning the four sectors on the cone?
- How was the alignment done to the rest of STAR?
- Eric has provided us with a completely new system which is much superior than before

TO BE CONTINUED TOMORROW IN THE SOFTWARE MEETING

Software

PART 2

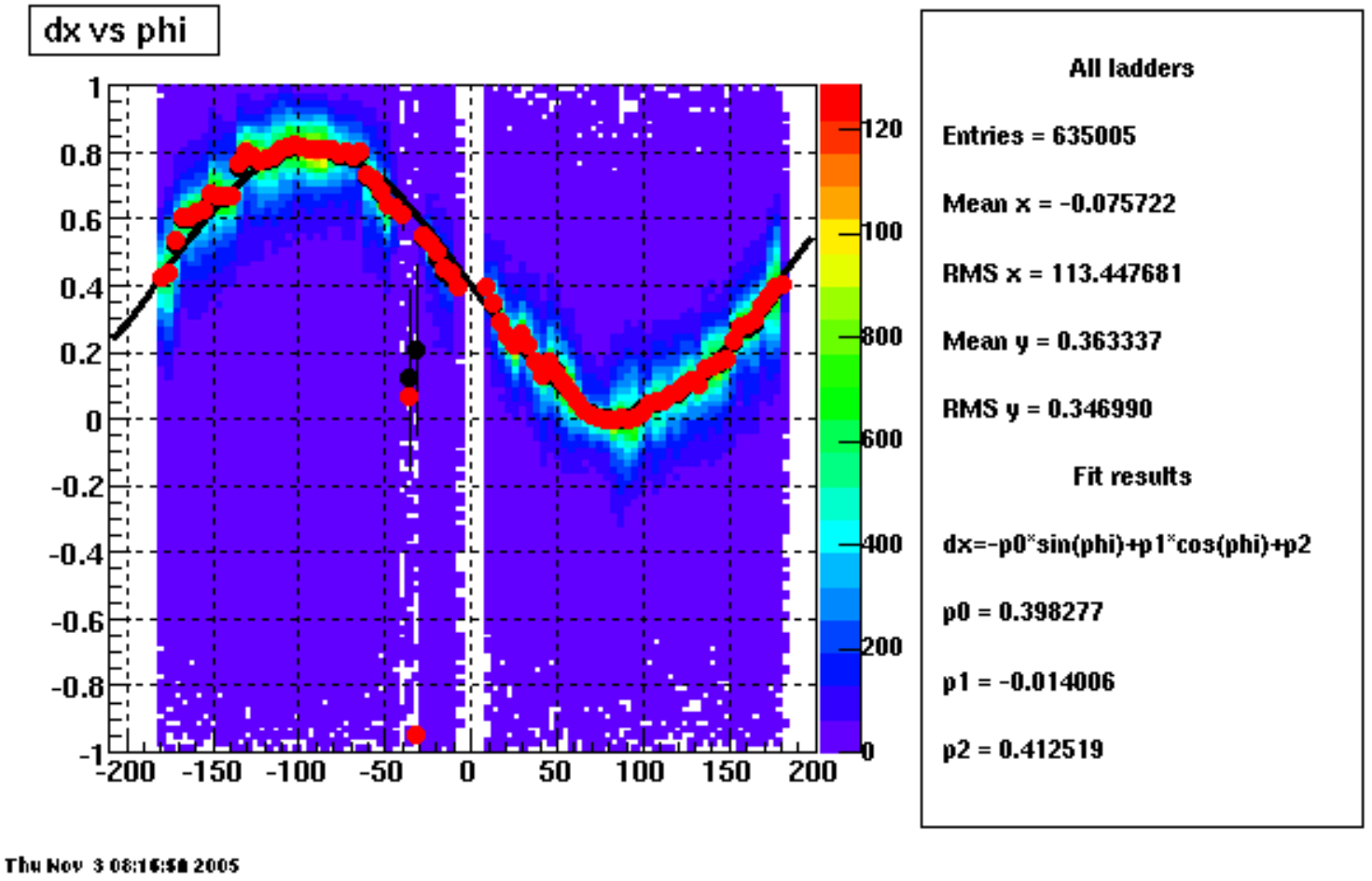
Final alignment by tracks

- The alignment of the SSD has been studied using real data taken during the run.
- Tracks in the TPC (and SVT) and hits in the SSD have been reconstructed.
- From that study, one has found that the SSD in Run V is shifted by about 4 mm in X, 200 µm in Y and 1 mm along the beam axis with respect to the geometrical center reconstructed offline.
- The SSD is also rotated around the beam axis by about 1°.
- This study has been performed on Cu+Cu at 62 GeV/c Full Field data.
- SSD was reinserted when Spiros did the alignment. No knowledge on how much the SSD moved during this time.

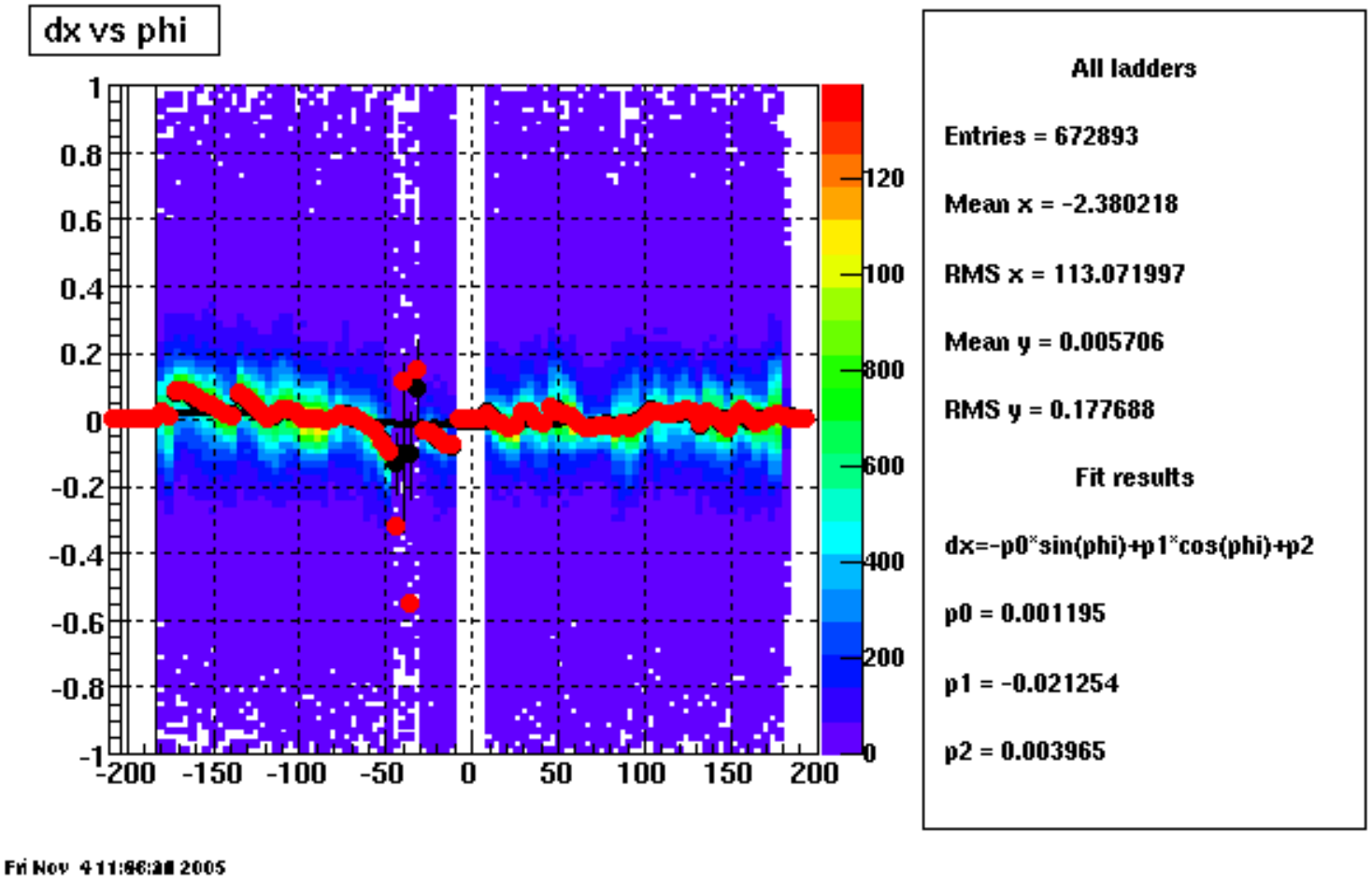
Procedure

- An iterative approach was used
- General corrections were made first
- Then final adjustments were made with and without the SVT
- The final results look the save with and without the SVT
- See www.star.bnl.gov/~lmartin/Alignment/CuCu62FF/AlignmentCuCu62FF.html for more details

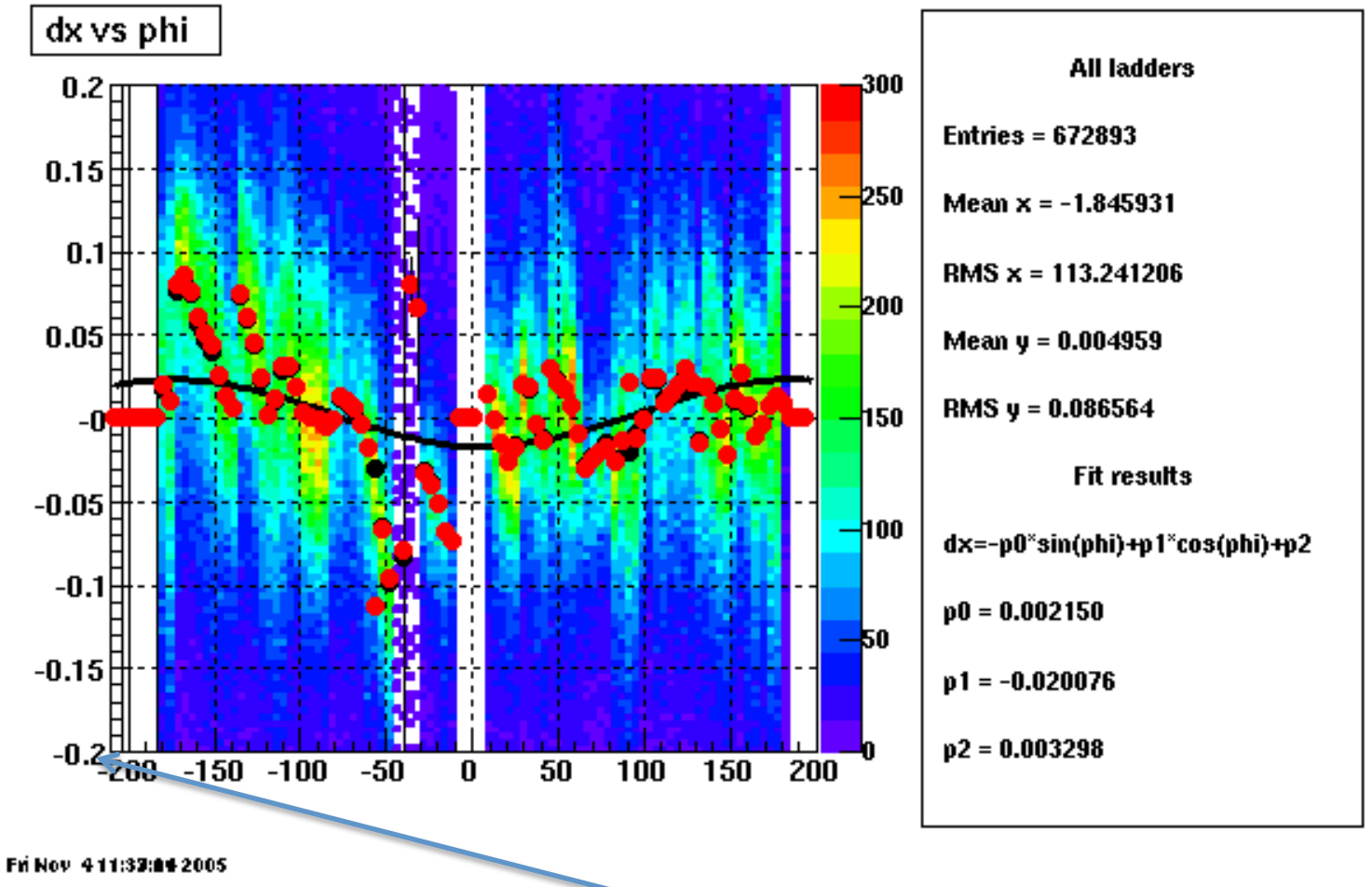
Pass 001 : No corrections



Pass 002 : Global X offset correction

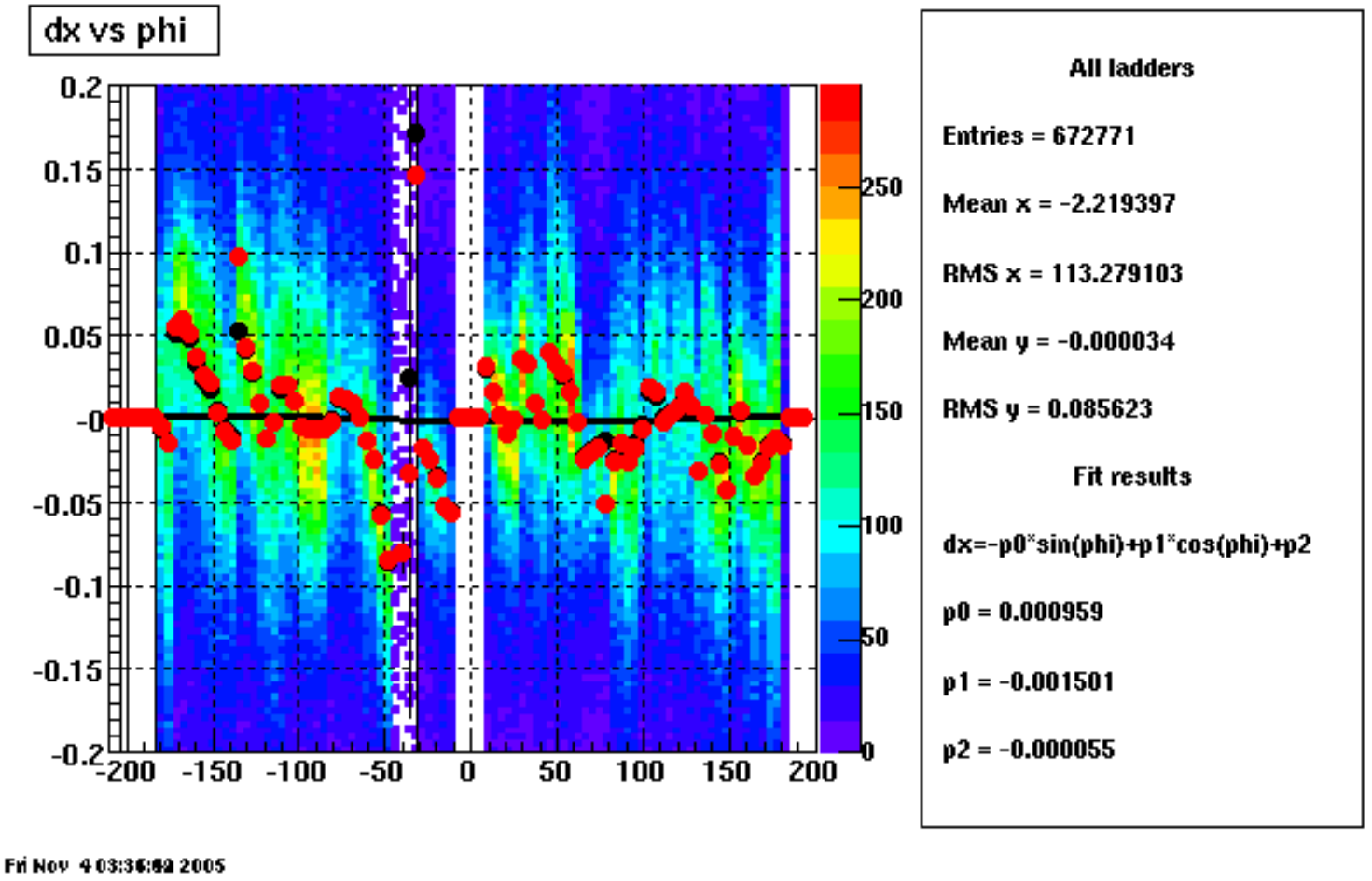


Pass 003 : Global Phi offset correction

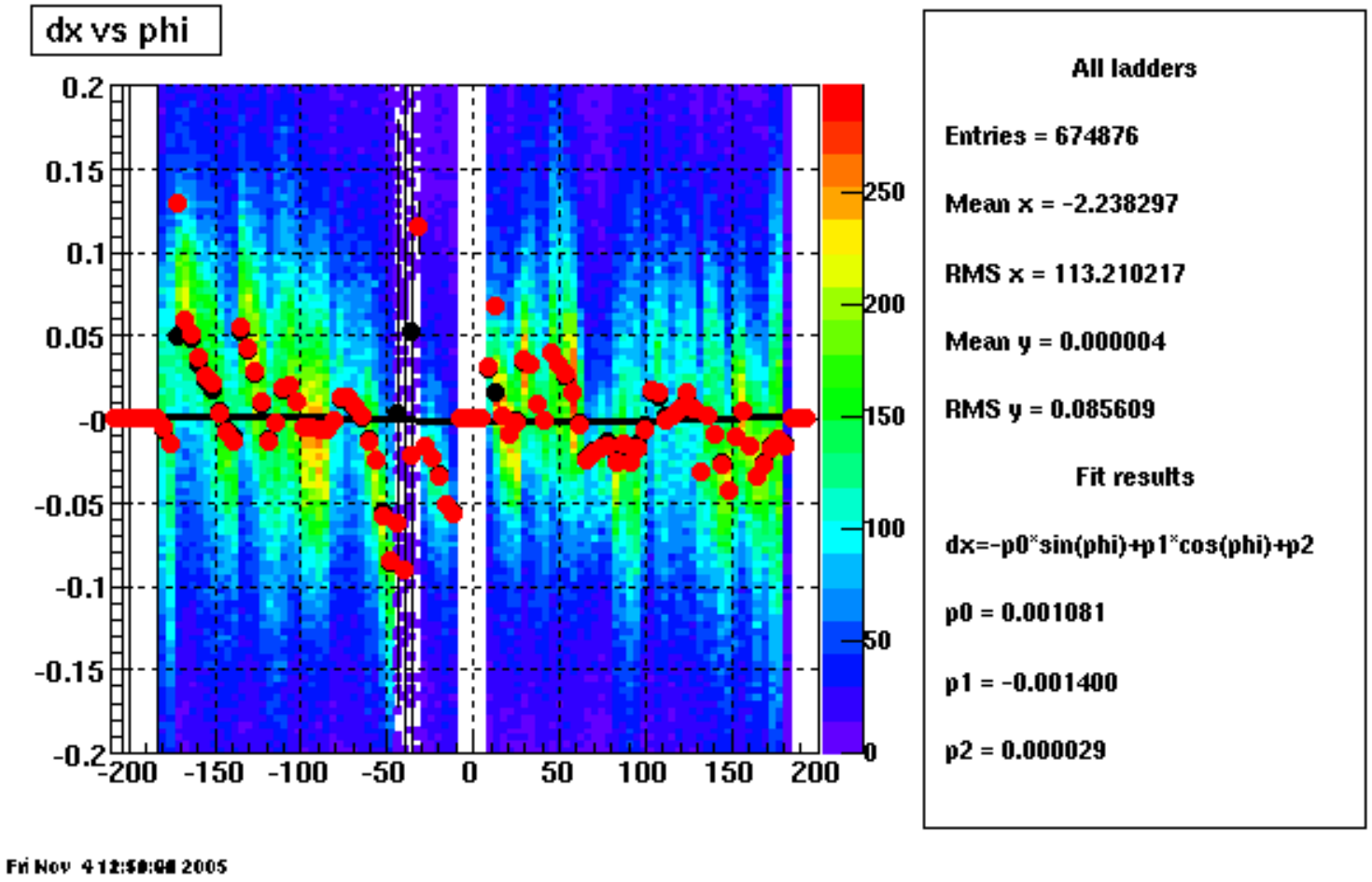


Note new vertical scale

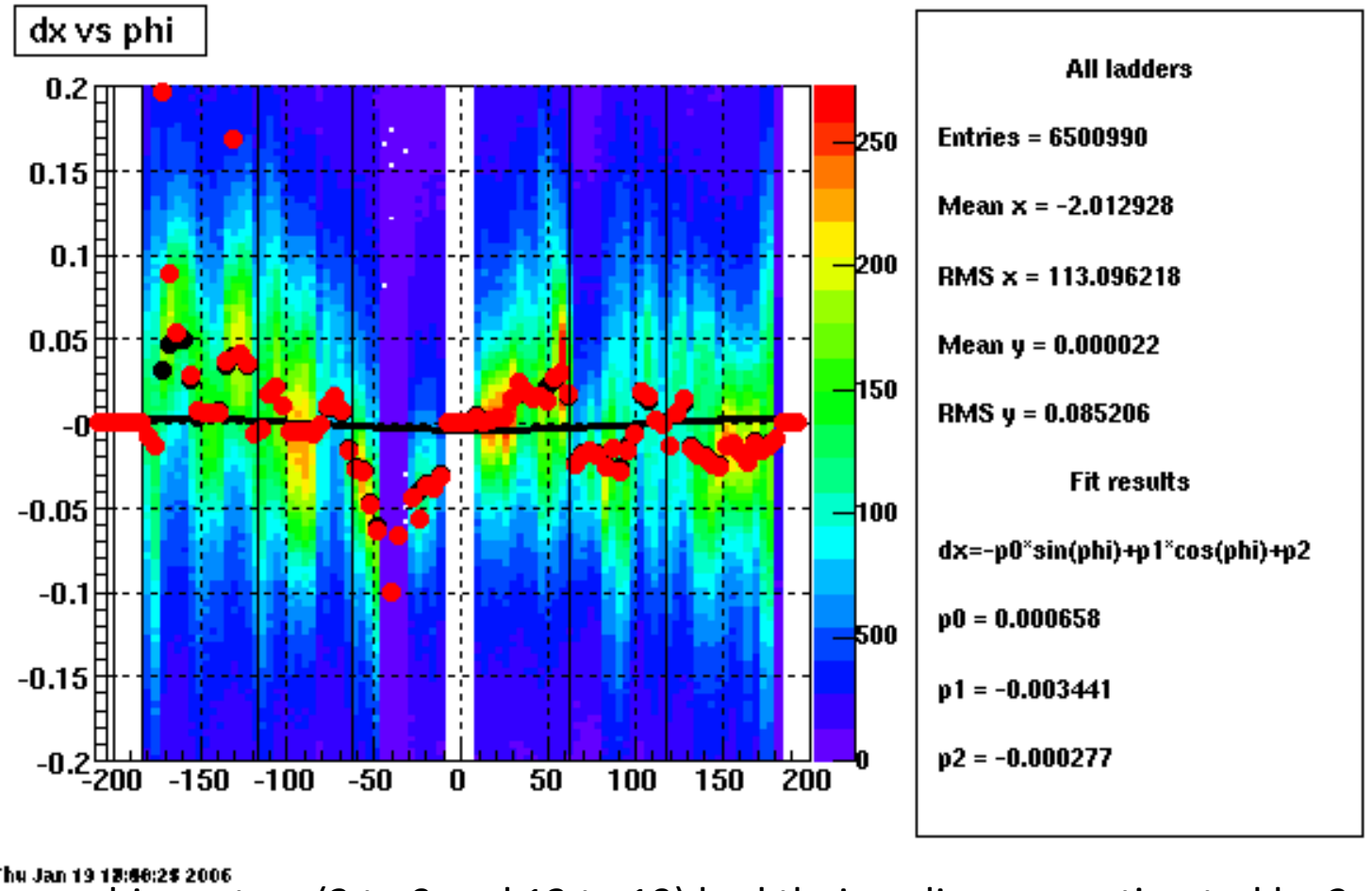
Pass 004 : Global Y offset correction. Small change of the phi and X offsets



Pass 005 : Global Z offset correction

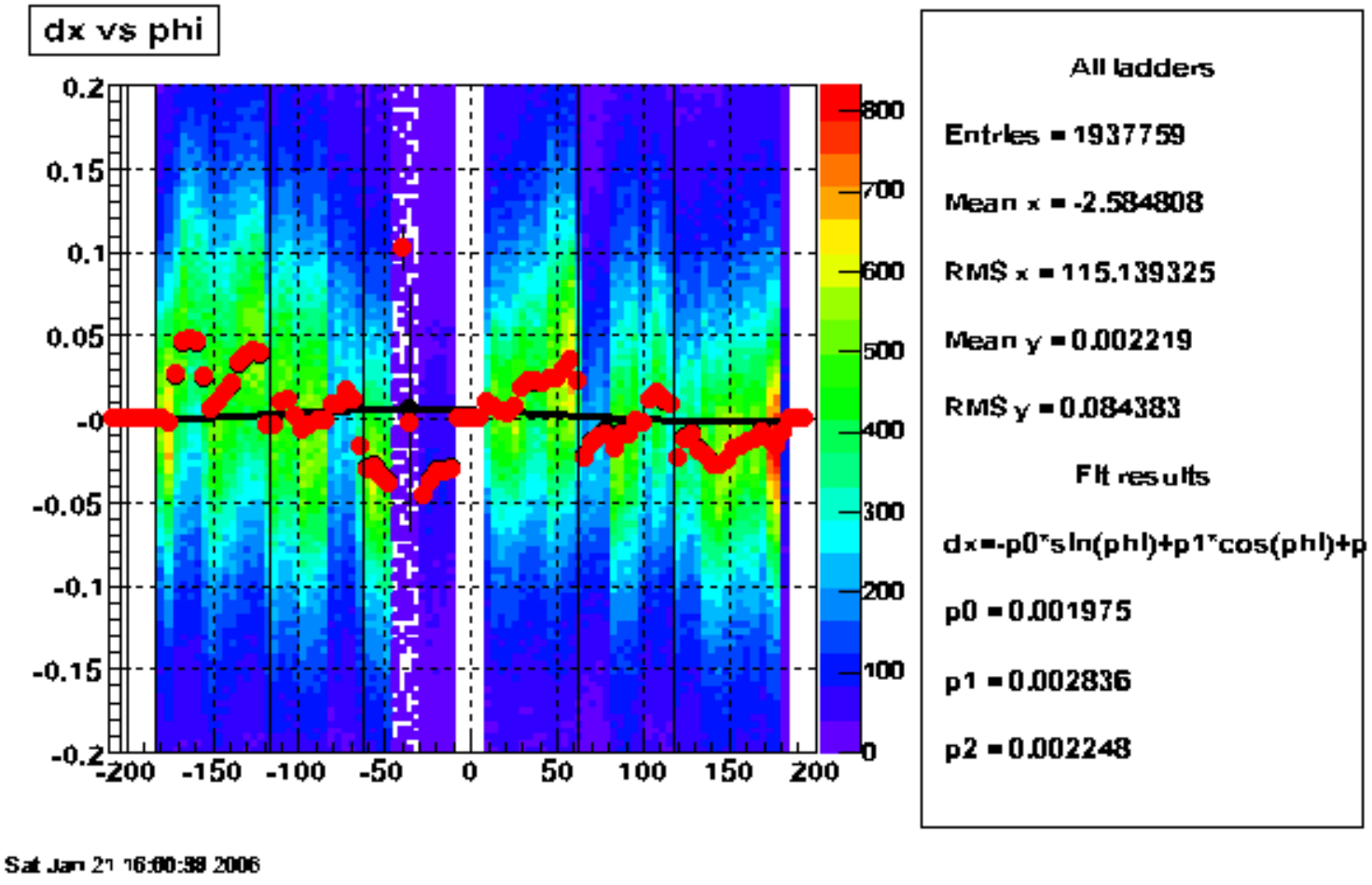


Pass 006 : Ladder radius corrections

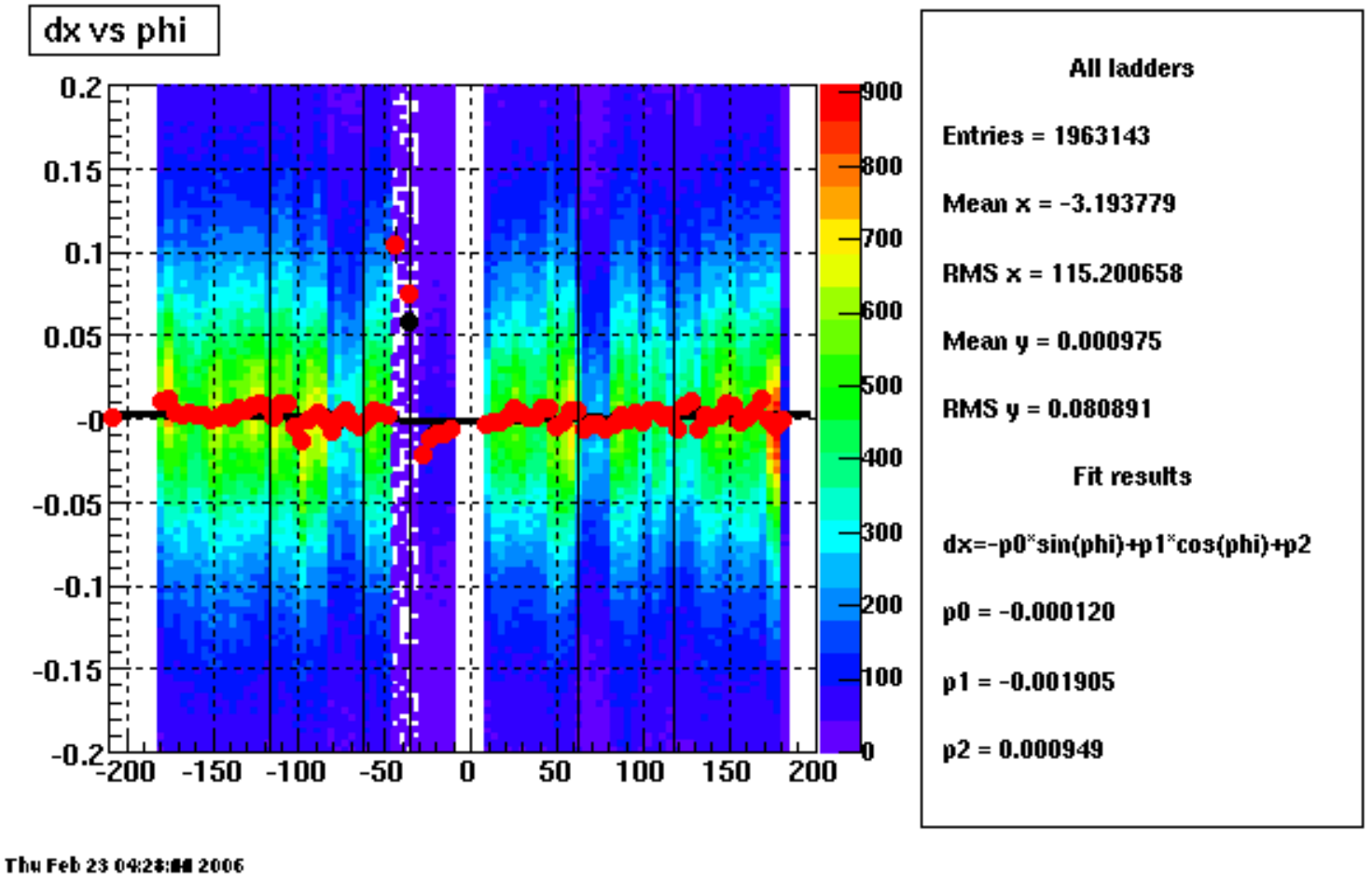


All ladders on big sectors (3 to 9 and 13 to 19) had their radius overestimated by 2 mm except the ladder 16. The radii are corrected in this pass. The SSD geometry in the database matches the geometry obtained after this Pass.

Pass 007 : New processed data



Pass 013 : rotations around the ladder axis



Summary of other passes (these were done with and without the SVT)

- **Pass 008 : Ladder radius corrections improved. The radius corrections were slightly wrong for the big sectors (except for ladders 6 and 16)**
- **Pass 009 : Small wafer relative position corrections. The relative positions of the wafers measured during the ladder assembly survey are included in the geometry**
- **Pass 010 : dx vs z corrections. The sector degrees of freedom (rotation and translation) have been introduced. Corrections for the drift residual (dx) versus z correlations. The full barrel, the bottom sector and some ladders are rotated**
- **Pass 011 : dy vs z corrections. Corrections for the transverse residual (dy) versus z correlations. Individual ladders are shifted along their radius direction**
- **Pass 012 : dx and dy offset corrections. Individual offsets in X (drift) and Y (transverse) local directions are corrected.**
- **Pass 013 : rotations around the ladder axis. The dx versus phi (or local X) correlations are corrected. A small offset in X is also corrected for in the same pass.**

My summary of survey with respect to the HFT

- Iterative alignment processes are dangerous (from experience). You can easily add a tilt or other bias. Procedures are needed to prevent it.
- Ladder survey did have problems. Really need to do proper module survey again. Not all modules were surveyed well.
- The physical mount of the SSD provided displacements that we will never see again.
- Data allows us to look at individual ladders. Will see some correlation between old and new.
- We need to investigate stiffness of ladders.
- However, it will be near impossible to correlate with final survey because of displacements and translations in old SSD mount.

An Alignment Philosophy (This needs to be quantified)

- Internal Alignment
  - Positions of the modules need to be known to a fraction, f, of the width of 95 μm (pitch of the SSD)
    - The resolution of the SSD is 95/√12 μm in x (or better if we do interpolation)
  - Also need to the height, specify how well we need to measure h (this is important to do early as it determines which method we measure flatness).
- External Alignment
  - Need to point tracks to the TPC to the SSD
  - Would need a number n·95 μm
  - We need a requirement on "n"
- We need to specify f, n, h