TRT Alignment Status Report

ID Week, 2/5/2007

Andrea Bocci (Duke University)

Outline:
- Activity I: L2 Alignment (J. Alison et al. @Penn)
- Activity II: Integration With ID and FDR Preparation (Andrea)
- Plan and To Do List
Introduction

- Big effort during last year to exercise the TRT alignment algorithm on CSC misaligned multimuon sample.

- End of last year the first set of alignment constants for the Inner Detector was released in time for the detector paper.

- Old scheme used for the occasion: align Si first and then TRT.
  - Step 1: After the Si was aligned standalone we align TRT @L1
    - L1 == TRT barrel (endcap) as a whole
  - Step 2: Once TRT was aligned w.r.t. Si we align the TRT internally (L2)
    - L2 == TRT modules are aligned individually

- Although the first set of constants are quite good, studies to further improvement the TRT alignment are underway.
  - Main Focus: Improve the L2 alignment!
    - John Alison and colleagues from Penn have been working on this.
The CSC misalignment in the TRT (barrel)

There is a global shift (L1) and module movements mainly along R (L2)

Module displacements w.r.t. ideal

The L1 misalignment has been masked

This is if we do not provide any alignment constants for the TRT at L2

Random shifts along (x,y) prompt a "clocking effect"
Displacement after alignment

L2 TRT with TRT+Si tracks with Si ideal

Module displacements w.r.t. ideal

Clocking effect reduced
but not eliminated
Impact of the TRT

Black: Ideal
Blue: After TRT align
Red: After Si align

Improvement mainly due to the L1 alignment
Interplay between Si and TRT clocking effect

$P_T$ reco. bias in multimuons

Using Cosmics in Si (Barrel)

First Pass

Without using Cosmics in Si (Barrel)

No cosmics

• In “No Cosmics” case clocking of L2 TRT cancelled by clocking of Si.
TRT Alignment Plan - New People

Black: Si only
Blue: Si+ TRT aligned @L1 + TRT aligned @L2
Red: Si + TRT aligned @L1 + TRT misaligned @L2

Δ Q/P_T, Barrel Tracks only

pT(Rec/truth) vs. pT truth (Barrel)
TRT Alignment Plan - New People

Black: Si only
Blue: Si+ TRT aligned @L1 + TRT aligned @L2
Red: Si + TRT aligned @L1 + TRT perfect @L2
L2 Studies

Dedicated effort to understand (and improve) the TRT L2

Clocking Effect in TRTAlignAlg

John Alison
Andrea Bocci
Aart Heijboer
Joel Heinrich
Joe Kroll

- Mainly 13.0.30
- Si in perfect position
- L1 TRT done
- Run L2 alignment with full tracks

TRT software meeting 1/24/8
L2 Studies

Clocking Effect

• Basic idea — an incorrect residual minimum is found by systematically shifting modules around the beam axis leading to a biasing of the track Pt.

• Hard to detect in real data b/c
  • residuals are minimized
  • Effect tends to cancel in processes with opposite charged tracks (eg: Z→mumu)
L2 Studies

- Incomplete list of the studies have been performed
  - Impact of statistics
    - 5K vs 50K events
    - Multiple independent samples
  - Radial study (no random x,y displacement)
  - Alignment starting from Ideal position
  - Impact of poorly constrained DoF
  - Use global chi2 method instead of local chi2
  - Align only 1 or 2 layers at the time
  - Etc...

- Another maybe correlated problem is the error calculated by algorithm
  - Off by a factor 4-5, somehow not a surprise but probably too much

I will show few plots from these studies in the following slides (thanks John!)
L2 Studies: Radial Study

Radial Study

Initial displacements

Residual displacements

Initial displacements are radially only

alignment recovers radial displacements while introducing clocking

Alignment done for 9 iterations using 5000 multi-muon events

Software meeting 1/24/08
Global Chi2 Method

- Ran alignment using the Global chi2 method in TRTAlignAlg to solve for the alignment constants.

Residual misalignments

-9 iterations of 5000 events, starting from ideal alignment

Phi Pulls of residual misalignments
L2 Studies: Start from Ideal Geometry

the perfect study

Initial misalignments

typical residual misalignments

- Translation x500 - Layer 0
- Translation x500 - Layer 1
- Translation x500 - Layer 2
- Projection of the translation along z and z' x500

Alignment introduces clocking

No Initial Clocking effect.
L2 Studies: Start from Ideal Geometry

Low Pt

High Pt

Ideal Geom.

After align.

From Ideal

Nominal
L2 Studies: Pulls

Sigma ~ 4 - Errors are overestimated

module pulls along phi

- **Pulls for all layers**
  - Entries: 864
  - Mean: 2.634
  - RMS: 3.724
  - $\chi^2$/ndf: 33.6/29
  - Constant: $79.03 \pm 3.52$
  - Mean: $2.55 \pm 0.12$
  - Sigma: $3.398 \pm 0.098$

- **Pulls for modules in layer 0**
  - Entries: 288
  - Mean: 1.305
  - RMS: 2.471

- **Pulls for modules in layer 1**
  - Entries: 288
  - Mean: 3.61
  - RMS: 3.563

- **Pulls for modules in layer 2**
  - Entries: 288
  - Mean: 2.988
  - RMS: 4.468
L2 Studies: Layer correlations

Layer 2

translation x 500 - Layer 0

translation x500 - Layer 1

δ pulls for layer 2

Entries 32
Mean 1.264
RMS 3.144
χ²/ndf 5.133 / 9
Constant 3.311 ± 1.083
Mean 0.9233 ± 1.0299
Sigma 3.724 ± 1.750

translation x500 - Layer 2

Projection of the translation along #5 x 1000

η pulls for layer 2

Entries 32
Mean 0.598
RMS 4.552
χ²/ndf 6.964 / 15
Constant 1.763 ± 0.564
Mean 4.445 ± 5.071
Sigma 9.324 ± 6.747
L2 Studies: Layer correlations

Layers 1 and 2

translation x 500 - Layer 0

translation x500 - Layer 1

Entries 64
Mean 3.378
RMS 3.706
χ² / ndf 16.38 / 15
Constant 3.488 ± 0.628
Mean 4.089 ± 1.209
Sigma 5.841 ± 1.396

translation x500 - Layer 2

Projection of the translation along δx x 1000

Entries 64
Mean 1.082
RMS 4.407
χ² / ndf 12.39 / 21
Constant 3.641 ± 0.711
Mean 0.389 ± 0.822
Sigma 5.041 ± 0.919
L2 Studies (Just Off the Press!)
L2 Studies (Just Off the Press!)

13.0.X

13.X.0

translation x 500 - Layer 0

projection of the translation along f1 x 500

translation x 500 - Layer 1

projection of the translation along f1 x 500

translation x 500 - Layer 2

projection of the translation along f1 x 500
L2 Studies (Just Off the Press!)

13.0.X

Pt Pulls (After Alignment From Nominal)

Entries 4639
Mean -0.2008
RMS 1.324

Entries 4606
Mean 0.2916
RMS 1.333

13.X.0

Pt Pulls (After Alignment From Nominal)

Entries 9245
Mean 0.04442
RMS 1.351

Entries 12034
Mean 0.03347
RMS 1.343

Entries 6032
Mean -0.118
RMS 1.315

Entries 6002
Mean 0.1863
RMS 1.353
L2 Studies - Plans

- Still work to do to understand the source of clocking effect
  - Part is introduced by the algorithm
  - Part is a residual of the initial clocking configuration

- Several tests performed. No smoked gun yet

- More tests to come with the simplest configuration to single out problems. Other ideas:
  - Single module alignment (cannot do simpler than that!)
  - Distant modules alignment
  - Smart track selection
  - All of the above using cosmics

- Try to find the limitations of the L2 alignment and needs for the best performance
  - How many tracks? We need cosmics? How many?

- The TRT L2 is an essential step for the entire tracking performance
  - It has a huge impact in the momentum resolution
**FDR Challenge**

1. The ID is supposed to run over the FDR calibration stream
   - Basically single tracks with only ROI

2. For FDR-I no iteration procedure was foreseen at Tier0
   - It makes run alignment impossible

3. Still want to test the whole chain
   - From BS data to final alignment constants in the DB

4. Very useful to coordinate Si and TRT alignment. We run sequentially but TRT needs Si aligned before start

5. I’m running the TRT software over a (pre-)sample of FDR calib stream as I speak. More complete tests this week and following week

6. More details in alignment sessions tomorrow and Thursday
   - Restructure of ID alignment SW
   - Calibration/Alignment operations
   - FDR-II
   - ....