

Alignment + run check-up

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FOOT performance meeting

07/09/2022

Detector alignment

- **The alignment is performed on the alignment run (no target) with detectors that reconstruct a particle track: BM, VTX, MSD and IT (IT not included yet)**
- Alignment performed minimizing the residual distribution of the tracks
- Overall process:
 - select the events and tracks suitable for the alignment
(e.g.: events in which TW reconstructed only one hit with Z =nominal beam Z ,
BM with 1 track
VT with 1 vertex and 1 track associated to the vertex
MSD with 1 track)
 - Evaluate the residual distribution of the slope and extrapolate the rotation parameters
 - With the new rotation parameters, evaluate the residual distribution of the detectors projection on the target and extrapolate the translation parameters
 - With the new rotation and translation parameters, evaluate again the residual distributions (both rotation and translation)
- **No rotation around the Z axis is evaluated.
Only slight translation along Z coordinate is given due to the rotation matrix**

FOOT reference system

There are **different possibility to define the FOOT global reference system**.

Where is the global (0,0,0) point and the Z direction?

we need to chose one, two possibility proposed:

1) The beam is centred in (0,0,0) on the target and the beam is along Z axis

This is not the “real” experimental beam condition. (e.g.: in GSI2021 the beam was slightly tilted horizontally, at Trento the beam is slightly tilted vertically)

Probably, this is the simplest way to define the reference system and it is more independent from the run condition.

In this case, activate the “alignStraight” flag in AlignFOOTMain.C (check the “pratical info” slide). The code will print all the alignment parameters in which the detectors will “see” the beam profile at the centre of the target without tilt.

2) Choose a reference detector and align all the others with respect to this one

If the reference detector position and rotations are defined, it is possible to reconstruct a more “realistic” experimental condition.

The reference detector should be the detector with the best performance (e.g.: VT or MSD)

This method can be useful for specific detector studies (e.g.: BM st calibration with VT)

In this case, activate the “alignVs” flag in AlignFOOTMain.C (at the moment the VT is the reference detector, but it is easy to change)

MC studies

We tested the code on MC sample:

- 12C_200new, the MC is produced with everything aligned and without tilt (10k events)
- Test on BM with starting position and rotation parameters:

```
BM starting position and angles:  
PosX: 1.000000 PosY: 0.200000 PosZ: -14.000000  
AngX: 0.000000 AngY: 2.000000 AngZ: 0.000000
```

- Alignment output with method 1:

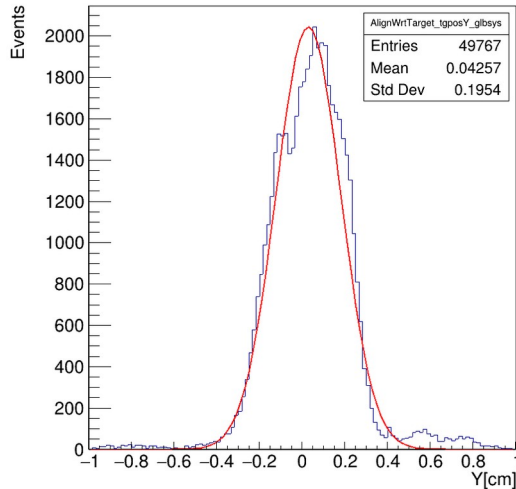
```
AlignWrtTarget::final results for BM  
BMnew position estimate:  
BMPosX: 0.003760 BMPosY: 0.000315 BMPosZ: -14.000296  
BMnew rotation estimate:  
BMAngX: -0.001978 BMAngY: 0.016611 BMAngZ: 0.000000  
residual on traslations with the new geometrical parameters: finalresxtra=0.000598 finalresytra=0.000170  
residual on rotations with the new geometrical parameters: finalresxrot=0.000004 finalresyrot=-0.000002
```

Alignment output with method 2 (BM with respect to VT that is centred without rotations):

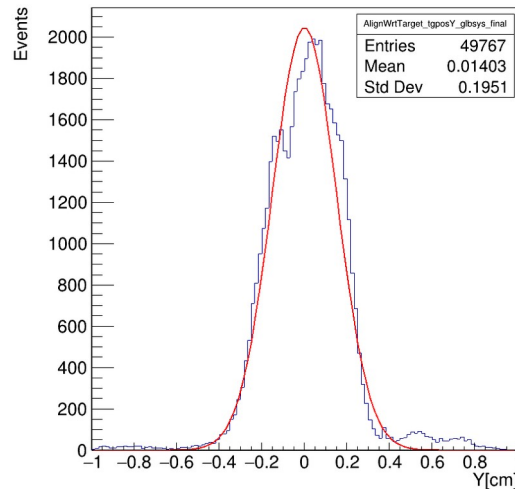
```
BMVT AlignDataVsDetb analysis done  
Detector A new position parameters:  
BMVTPosX: -0.006569 BMVTPosY: 0.000482 BMVTPosZ: -13.996382  
Detector A new rotation parameters:  
BMVTangX: -0.005619 BMVTangY: -0.207037 BMVTangZ: 0.000000  
residual on traslations with the new geometrical parameters: finalresxtra=0.000018 finalresytra=-0.000054  
residual on rotations with the new geometrical parameters: finalresxrot=0.000009 finalresyrot=0.000013
```

GSI2021 method 1 results

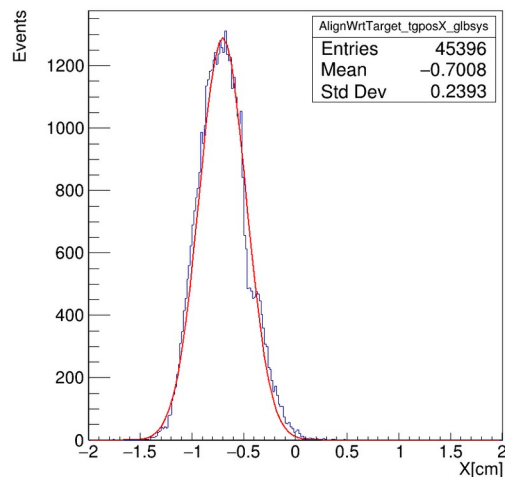
BM projection on target Ypos before align



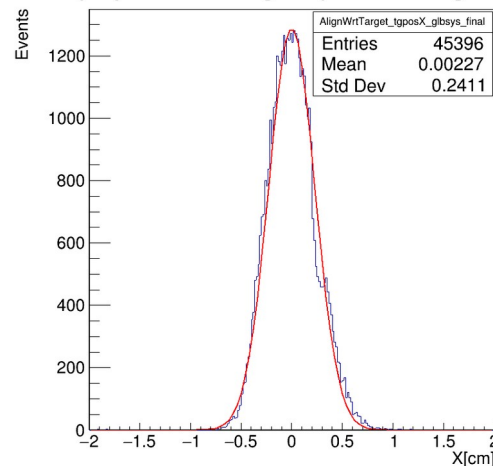
BM projection on target Ypos after align



MSD projection on target Xpos before align



MSD projection on target Xpos after align

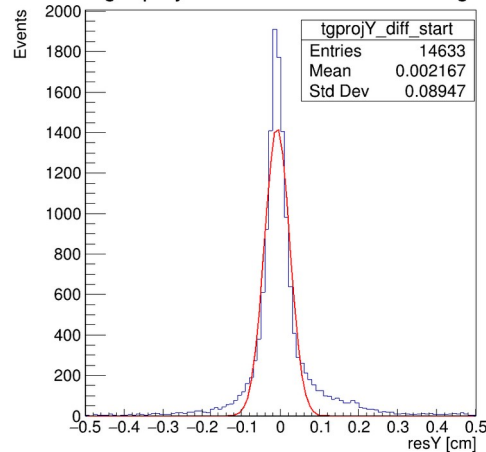


The code has been tested on GSI2021 alignment run without target 4313. Results for BM and MSD alignment with the method 1:

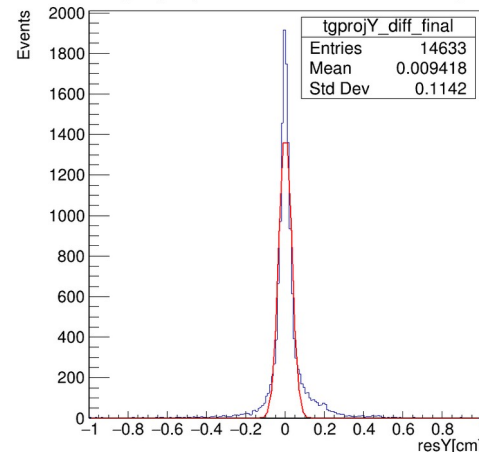
- BM initial beam profile distribution X coordinate mean: 0.03
- BM final beam profile distribution X coordinate mean: $2e-6$
- Difficulties for the BM since the reconstructed beam profile is not Gaussian due to the BM reduced spatial resolution at the cell border
- MSD initial beam profile distribution X coordinate mean: -0.7
- MSD initial beam profile distribution X coordinate mean: -0.0001

GSI2021 method 2 results

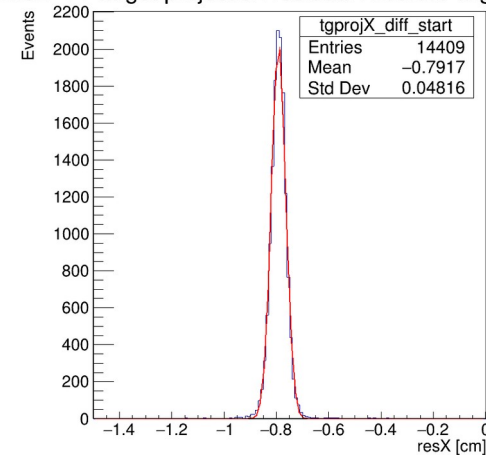
BM-VT target projection residual Y before align



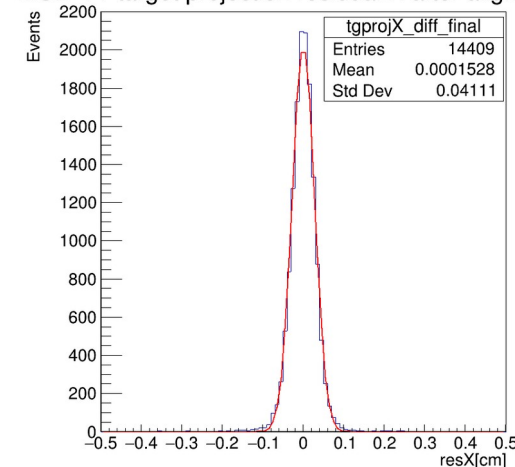
BM-VT target projection residual Y after align



MSD-VT target projection residual X before align



MSD-VT target projection residual X after align



The code has been tested on GSI2021 alignment run without target 4313. Results for BM and MSD alignment with the method 2 exploiting the VT as reference:

- BM initial fitted residual distribution mean for the translation on the Y axis: -0.01
- BM final fitted residual distribution mean for the translation on the Y axis: 4e-5
- For the BM-VT the residual distribution is not Gaussian due to the BM low resolution at the cell border
- MSD initial fitted residual distribution mean for the translation on the X axis: -0.8
- MSD final fitted residual distribution mean for the translation on the X axis: 3.e-5

Run check-up

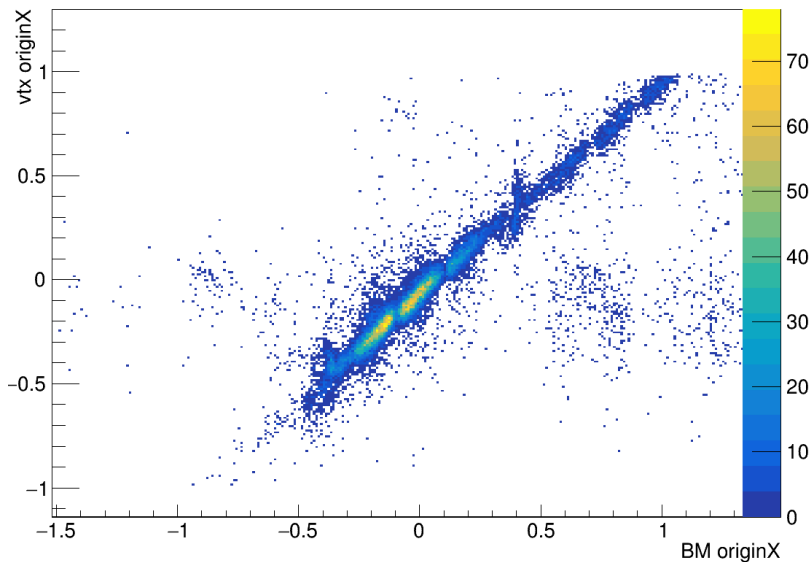
- The detector performances are run dependent (e.g.: BM space-charge effect, VT synchro)
- **This macro can be useful to check the status of each detector and print a recap of the performances for a given dataset.
A sort of quality control code**
- At the moment there are only a couple of checks on the BM performances (not finished)

```
CheckUp file status:  
BM status:  
The fraction of evts in which the number of hits is less than 6 is:1230/57135=0.021528  
The number of events with one BM reco track is:52022/57135=0.910510
```

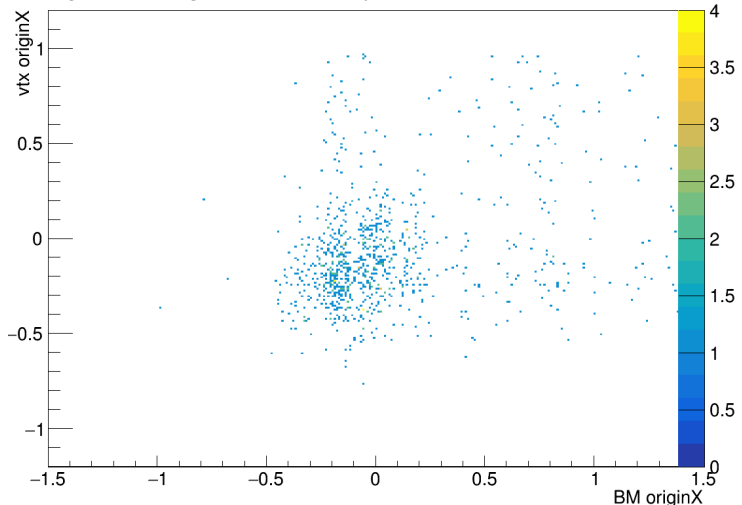
- A check up on the VT synchronization with the BM tracks has been implemented (see next slide)
- **if we think that this could be a good instrument to perform a quality control on the FOOT experimental data, all the sub-detector (or global track) experts should add their specific controls.**

BM-VT synchronization

BM originX vs VTX originX when they are synch till events 134999



BM originX vs VTX originX when start to unsync from events 135000 to events 140000



- **The macro can be adopted to check-up the synchronization status of each run and estimate the event number in which the synch is lost**
- Strategy: plot the BM and VT Origin.X coordinate of the tracks and compute the correlation factor every checkrate events
- Useful also for the future data takings, even if the VT has been updated with the possibility to spot out the unsync event
- Here an example for the run 4327

The correlation between BM and VTX has been maintained till the event 134999 then the synch has been lost some where between event 135000 and event 139999
- The unsync event number is written as output and in the VTXSYNC/* plot title
- N.B.: At the moment the checkrate is every 5k events and the minimum correlation factor is 0.5, but no dedicated studies has been conducted

Practical info

- The code is a shoe macro: AlignFOOTMain.C and AlignFOOTFunc.h
 - As input, it needs a decoded file with TTree containing the subdetector tracks (**the output of DecodeRaw or DecodeMC**)
 - It will read the FOOT.geo file of the exp and run number read from the input file
 - As output it will print (on terminal or in a .txt file) the alignment parameters, the run status information and an “alignout_inputfilename_out.root” file with the fitted plots
 - Example to run the code:
root -l -b -q 'AlignFOOTMain.C+("deco4313_5July_Full.root",3000,false,false,true,false)'

```
// nameFile=Input file name
// entries: number of events to be processed (use 0 to process the whole file)
// alignStraight: calculate the straight alignment parameters
// alignVs: calculate the straight alignment parameters with respect to the VTX (or other fixed detector)
// check: check the sub-detector response for the input file
// printFile: print the alignment and/or the checkup results in an external text file
void AlignFOOTMain(TString nameFile = "", Int_t nentries = 0, Bool_t alignStraight=false, Bool_t alignVs=false, Bool_t check=true,
Bool_t printFile=false)
```

- N.B.: there was an old version of the code with AlignFOOTFunc.C. Probably this file is still present in your builddir/Reconstruction/level0 folder. If AlignFOOTFunc.C is still present, delete or ignore it!

To do

- Decide the FOOT global reference convention
- If we decide to use this method to perform a quality control on the FOOT dataset, all the sub-detector and global track experts should add their specific check up plots
- Add a TW alignment only to estimate the possible X and Y shift (TW rotations would be very tricky... Do we need it?)
- Possibility to check the VT sync in a different way (maybe with VT and DAQ info)?
- Run the macro on data and update all the FOOT.geo files