Alignment of $\mathcal{TWIST}$ Experiment Components

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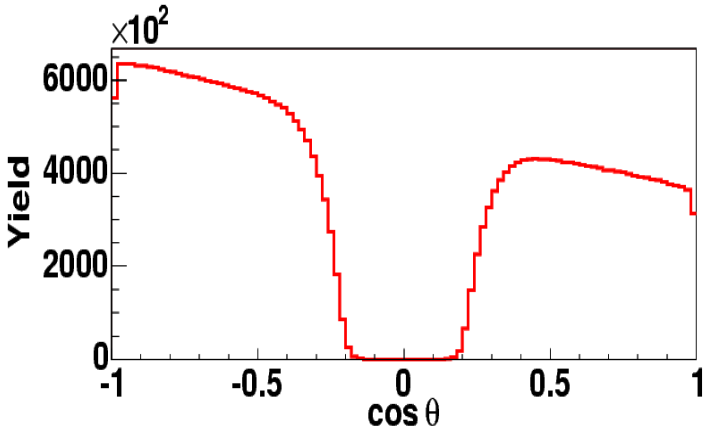
Muon Decay

The muon decay spectrum is parametrized by the four Michel parameters

- $P_\mu \xi$ describes the asymmetry of the spectrum
- In the SM : $P_\mu \xi = -1$

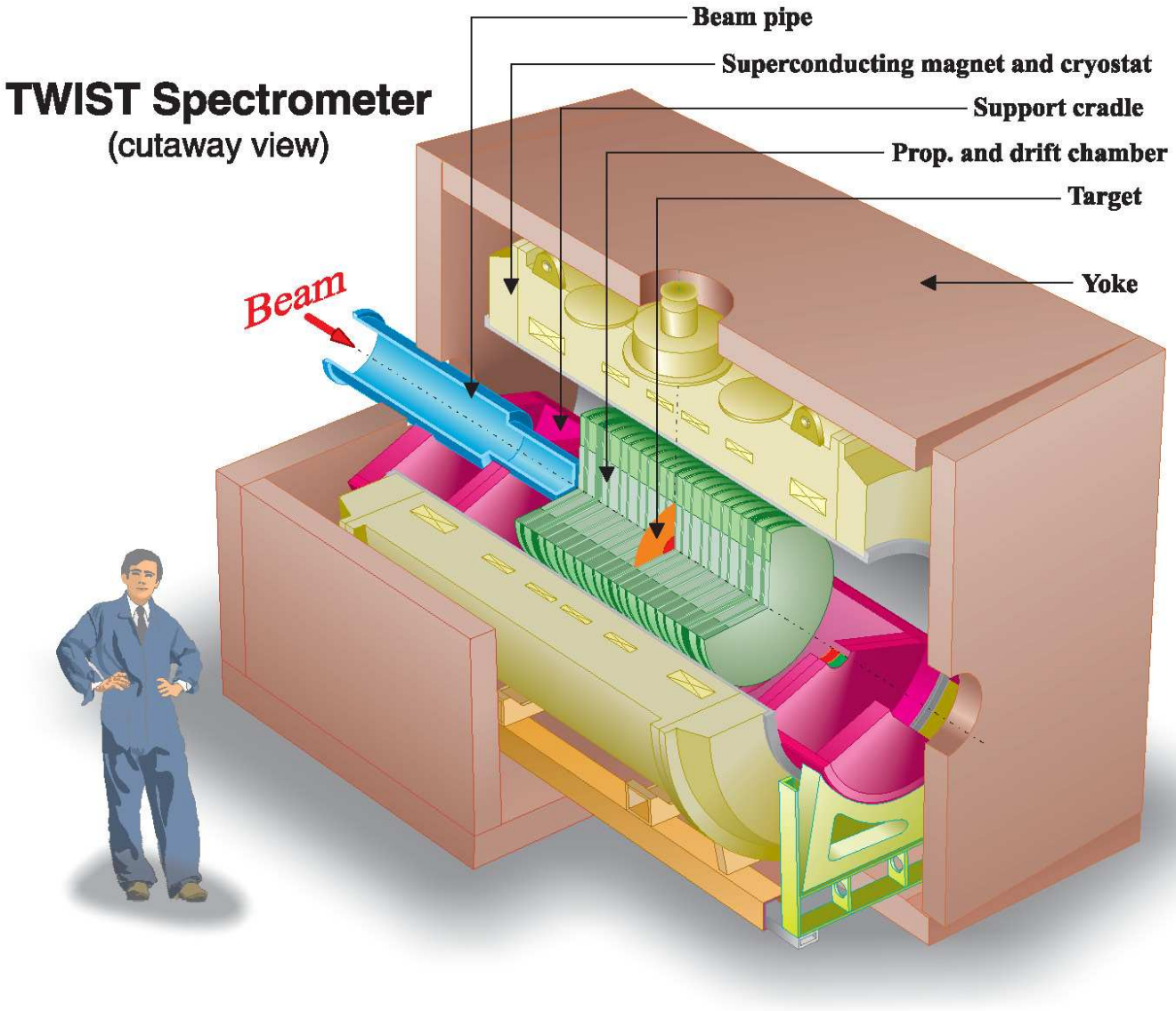


The beam depolarization is the major systematic uncertainty of TWIST last measurement of $P_\mu \xi$ (Blair Jamieson's UBC doctoral thesis, 2006)

Total systematic uncertainty : $3.8 \cdot 10^{-3}$

Depolarization systematic uncertainty : $3.4 \cdot 10^{-3}$

TWIST Spectrometer



Depolarization Sources

The muons arriving in the spectrometer undergo three effects that reduce the polarization :

- The multiple scattering
- The entrance in the 2T magnetic field

Those two effects can be simulated.

But the fringe field effect is dependent on the position and the angle of the muons.

$\Longrightarrow$ The beam characteristics have to be known as well as possible.

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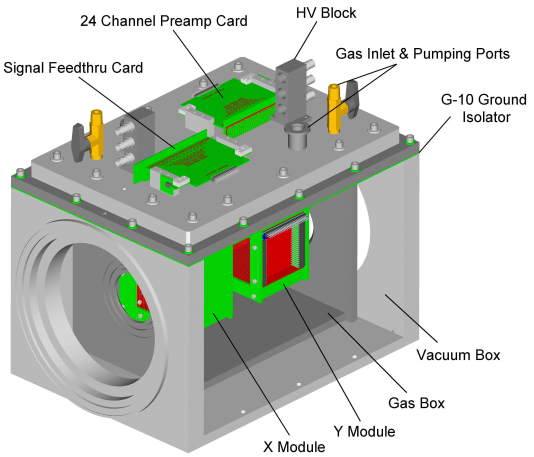
Beam characterization

A Time Expansion Chamber (TEC) is installed before the spectrometer on the beamline.

- 2 modules for X and Y
- Low mass detector
- Operating at low pressure (80mbar)



Beam characterization

A Time Expansion Chamber (TEC) is installed before the spectrometer on the beamline.

- 2 modules for X and Y
- Low mass detector
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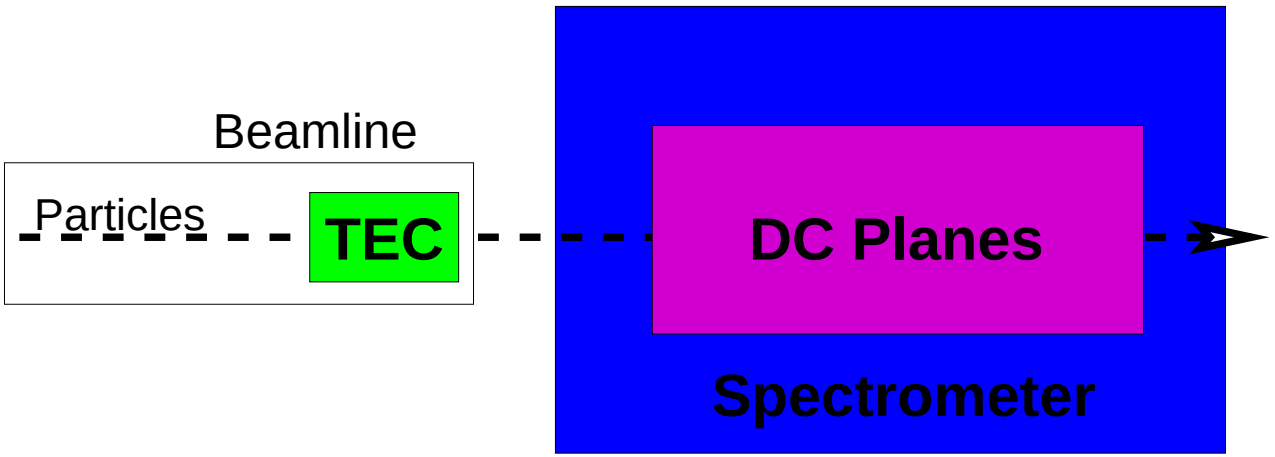
- TEC box installed in the beam vacuum
- Beam characterization before the fringe field



Alignment Procedures

- Absolute optical alignment with a theodolite :
  - The yoke
    Cross-hairs on upstream and downstream
  - The magnetic field
    Mapping with a reference line
  - The TEC
    Wires of drift field planes on each module
- Relative alignments with particles :
  - The DC planes and the yoke
    Collimators installed upstream and downstream of the yoke
  - The DC planes and the magnetic field
    Decay positron helix fitted with an angle
  - The TEC and the DC planes

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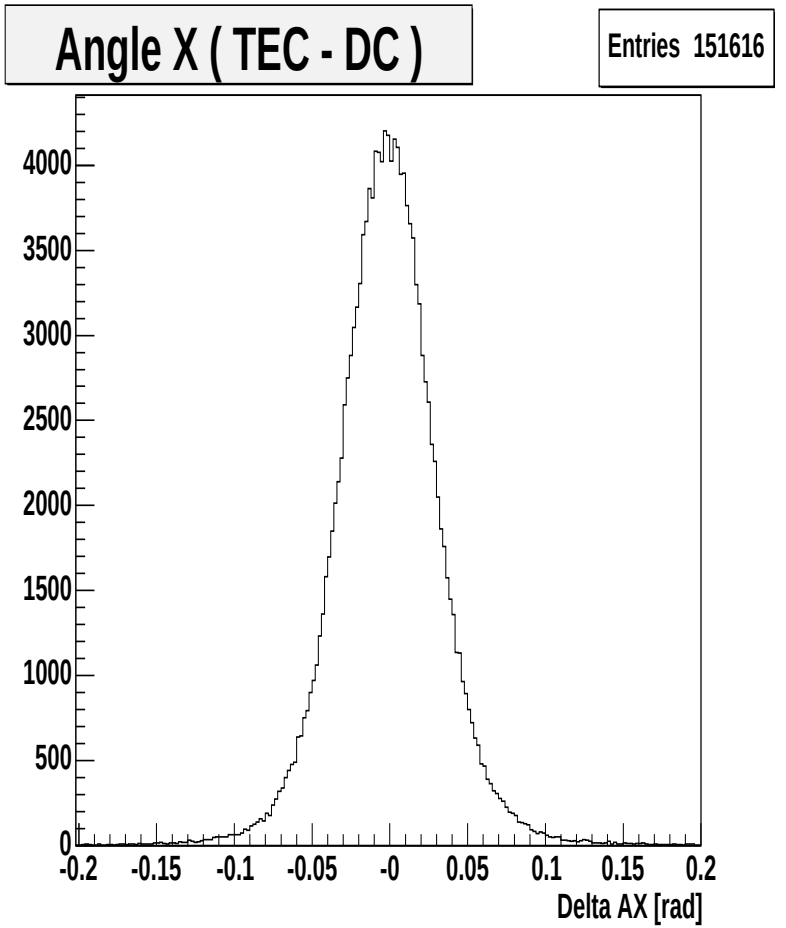
Angular Relative DC/TEC Alignment

Comparison between the TEC and the DC angle measurements

- Straight tracks reconstruction in DC planes
  $\Longrightarrow$ No magnetic field
- Reduced multiple scattering
  $\Longrightarrow$ 55MeV/c pions

For each track

The difference of the angle measurement of the 2 devices is calculated.



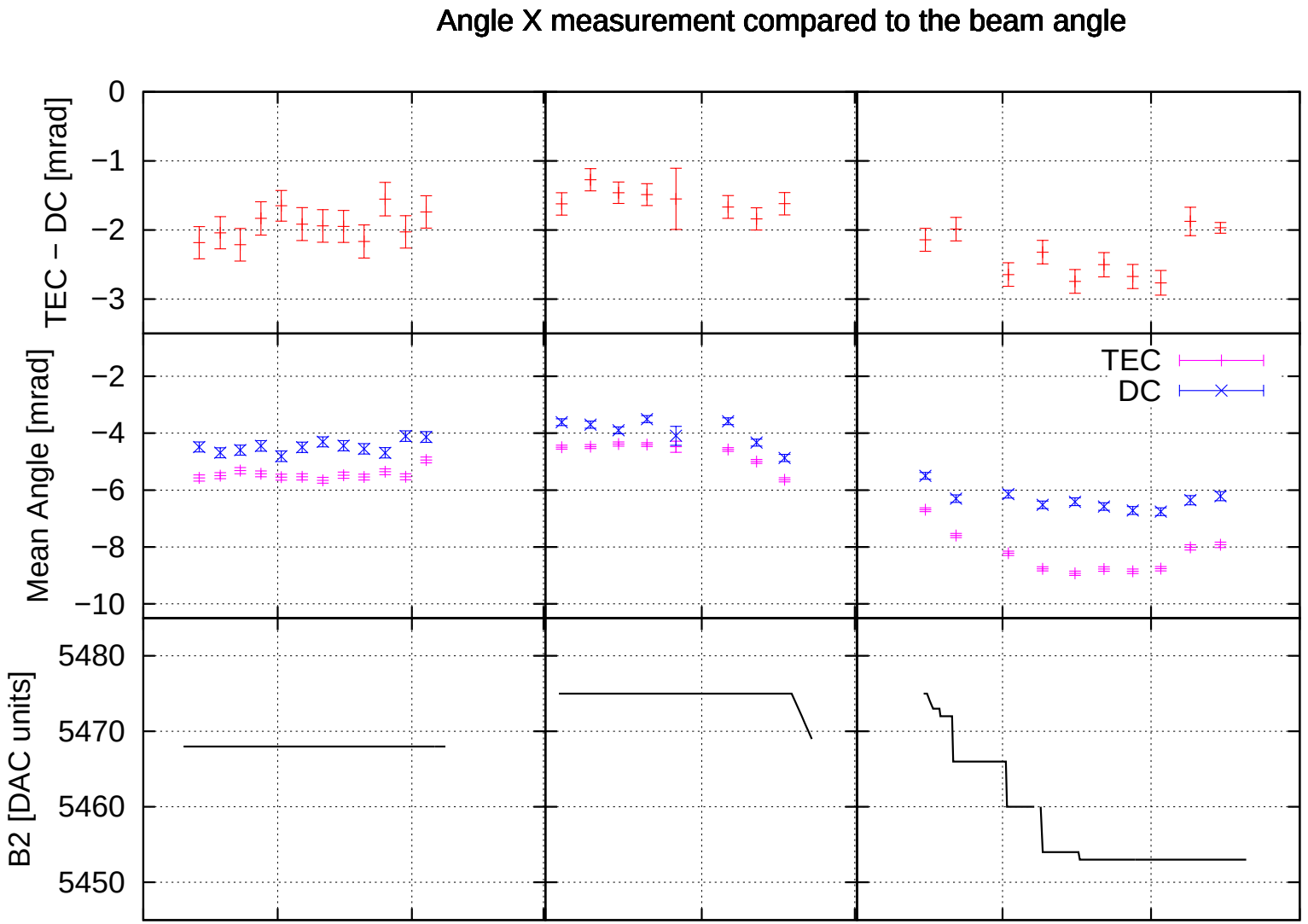
Monte Carlo Study

Monte Carlo simulations are used to validate the procedure and evaluate the precision of the measurement.

DC X rotation	TEC X rotation	Angle X (TEC - DC)
0	0	-0.2 ± 0.7
10	0	9.6 ± 0.5
0	-10	9.5 ± 0.5
-20	0	-21.1 ± 0.5
0	20	-19.5 ± 0.5

Angles in [*mrad*]

The Monte Carlo simulation gives a uncertainty of : $\pm$1mrad


Angle X measurement compared to the beam angle
TEC – DC [mrad]
Mean Angle [mrad]
B2 [DAC units]
TEC
DC
0
−1
−2
−3
−2
−4
−6
−8
−10
5480
5470
5460
5450

Conclusion

TEC/DC angular alignment results

$$\Delta\theta_X(TEC - DC) = (-2 \pm 1)mrad$$

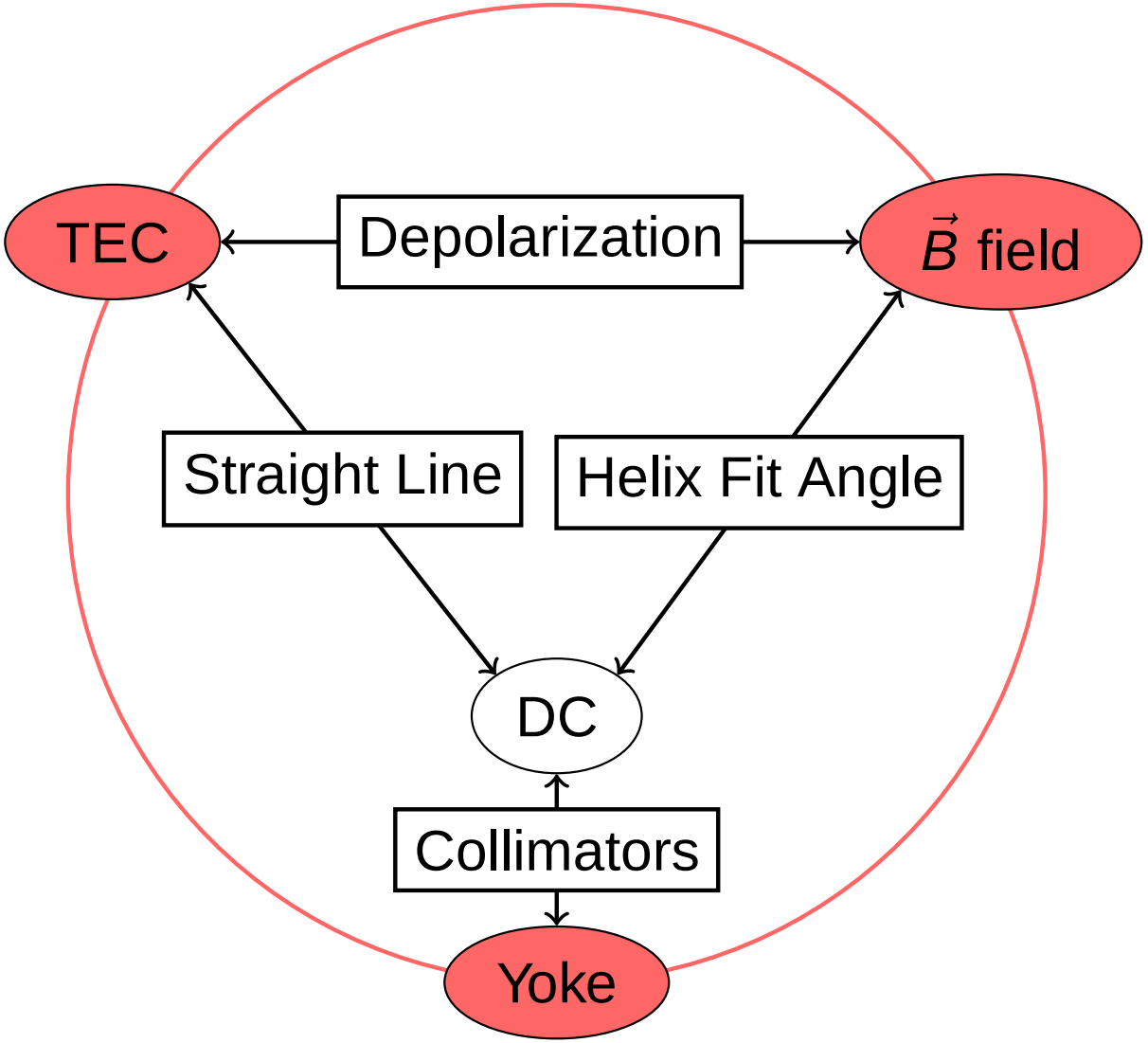
$$\Delta\theta_Y(TEC - DC) = (-1 \pm 1)mrad$$

- The TEC/DC position alignment analysis is the next step.
- The various alignment procedures are complementary.
- A consistency check will be possible with a relative alignment between the TEC and the magnetic field will be available.

Thank you

For you attention
And to Jingliang for his help on this study

TWIST complete alignment scheme



Optical alignment

Straight line event