The magnetic spectrometer of the FOOT experiment

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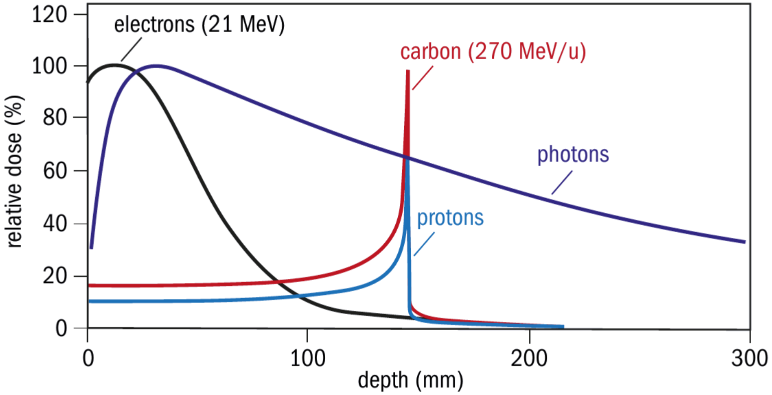
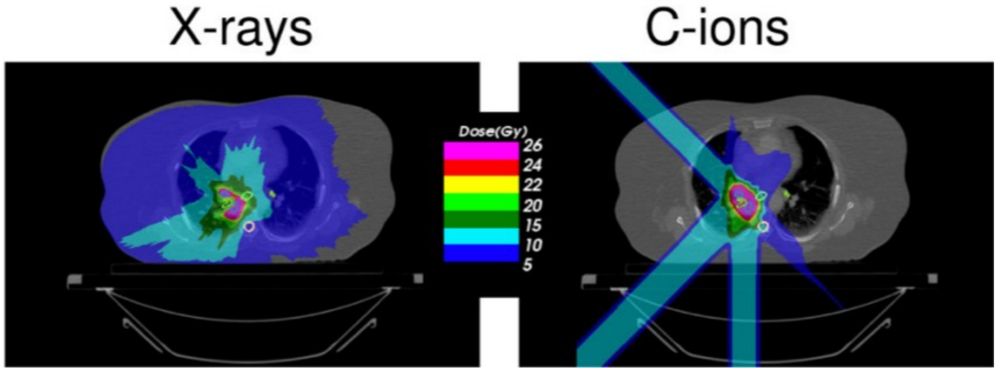
Pros and cons of Hadrontherapy

The magnetic spectrometer of the FOOT experiment

Riccardo Ridolfi

High **conformity** to the tumour volume ✔





Pros and cons of Hadrontherapy

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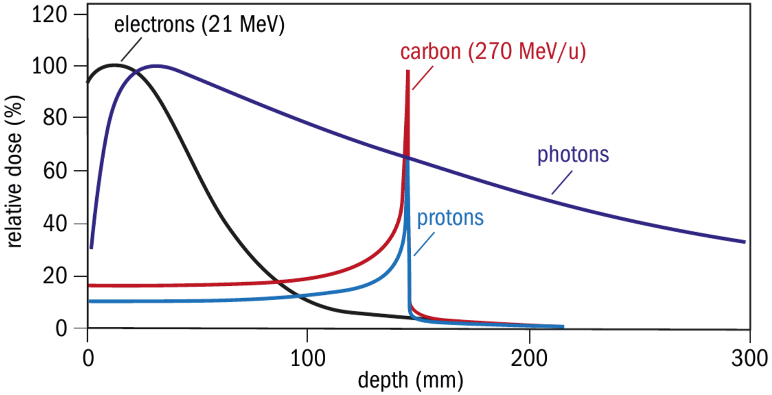
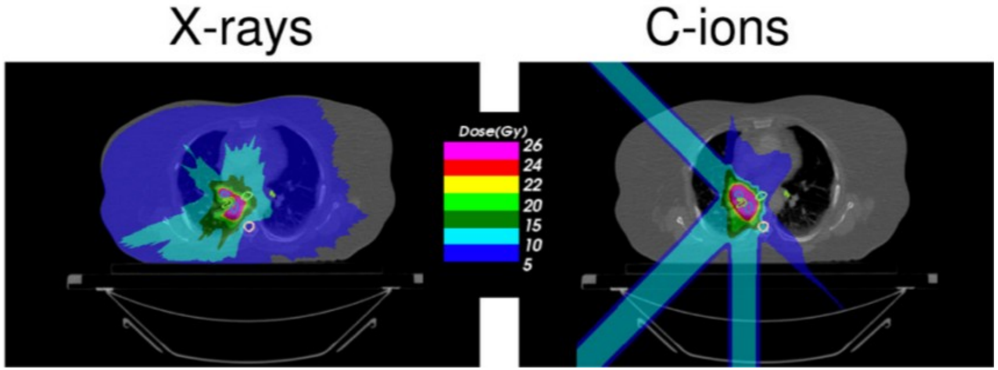
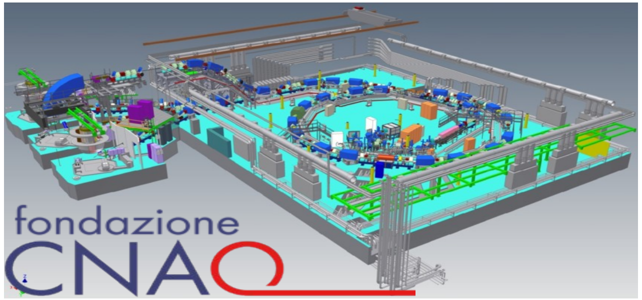
High **conformity** to the tumour volume





High-cost treatment



Space radioprotection

The magnetic spectrometer of the FOOT experiment

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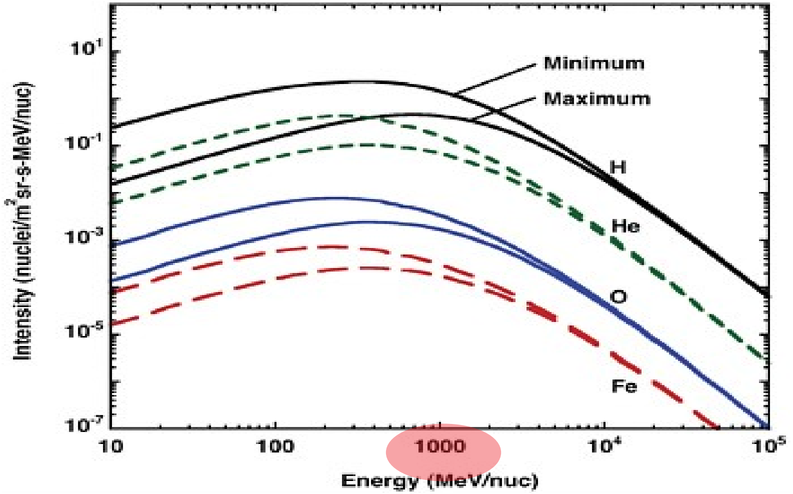
Mars has **NO magnetosphere** and a **very thin** atmosphere → **NO protection** against GCR and SPE

Travel: 1.8 mSv/day (GCR + SPE)
On Mars: 0.64 mSv/day
On Earth: 2.64 mSv/year

→ ~ 1 Sv (increase the cancer probability of ~3%)

Passive shielding is needed as active seems not feasible!



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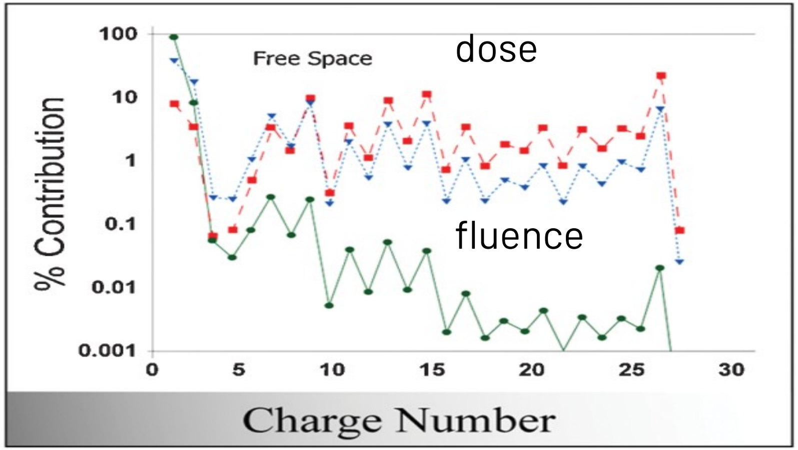

The FOOT experiment

The magnetic spectrometer of the FOOT experiment

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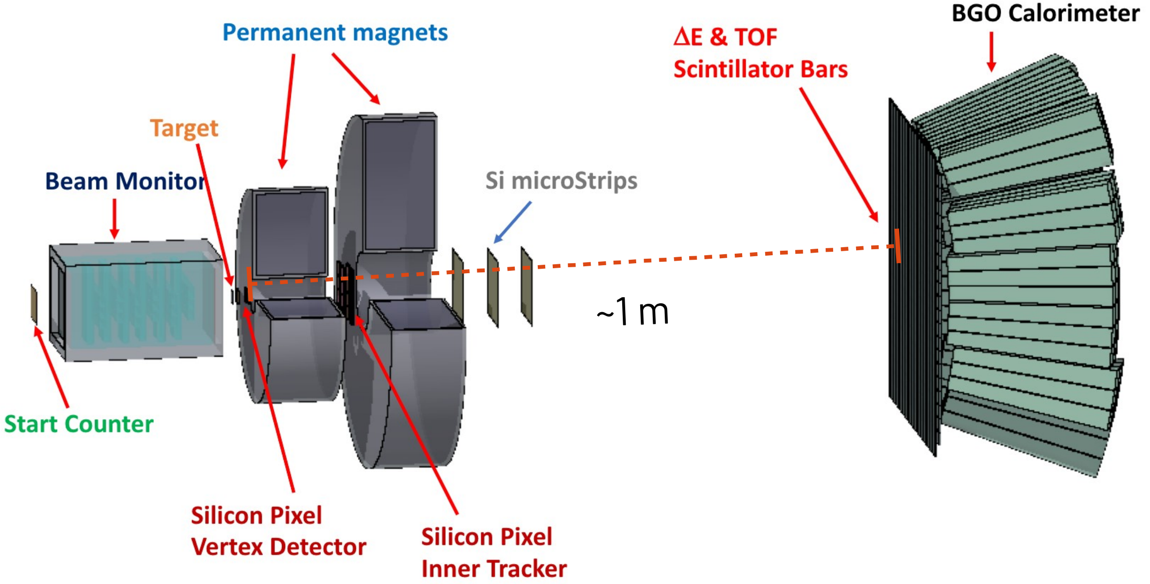

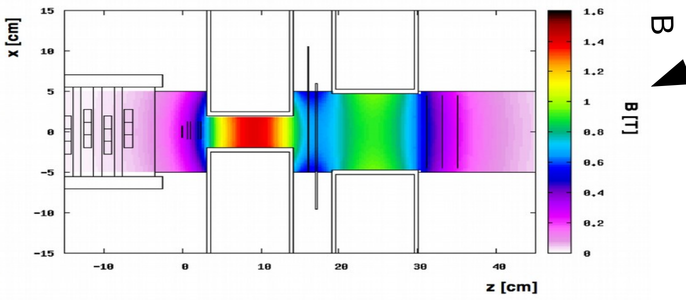

Magnetic field map

FOOT goal:

Fragments **energy spectrum** resolution at the level of **~1-2 MeV/u**

Heavy fragments (Z>2) **cross section** with maximum **uncertainty of 5%**

σ(p)/p at level of 5%

Tracking region

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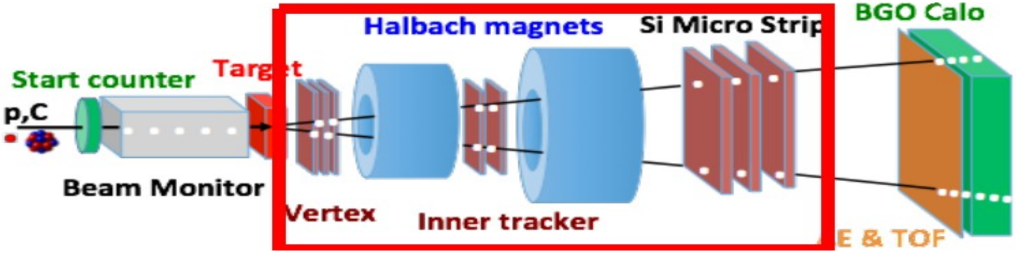
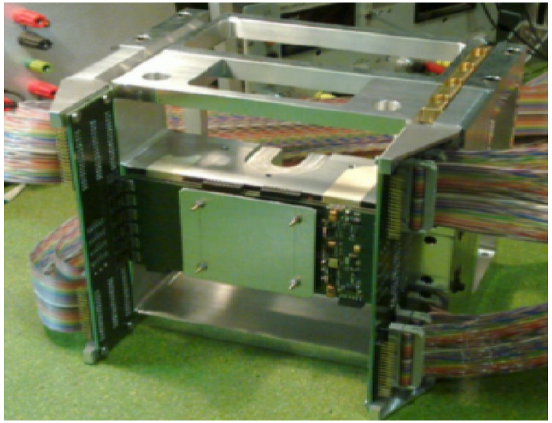
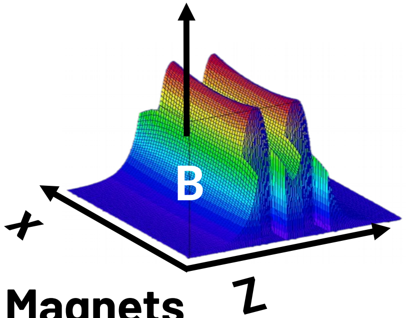
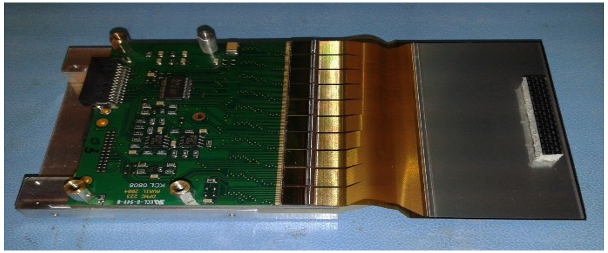




Vertex & Inner Tracker
VTX: 4 layers of Silicon pixels (20x20 μm)
ITR: 2 layers of Silicon pixels (20x20 μm)



Magnets
2 permanent magnets
Hallbach geometry, B field in y direction max 1.4 T



Micro Strip Detector
MSD: 3 layers of Silicon strips (120 μm x 9 cm)

Kalman filter

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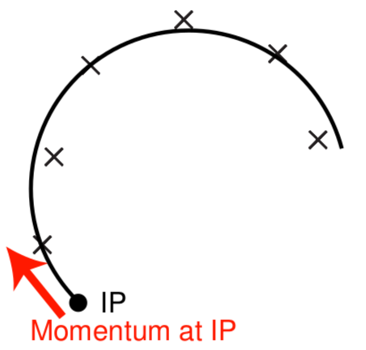
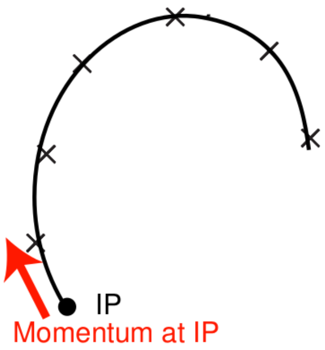
Efficient recursive algorithm, it finds the **best estimate** for the **state** of dynamic system from a set of noisy measurements

a) Normal least square fitting

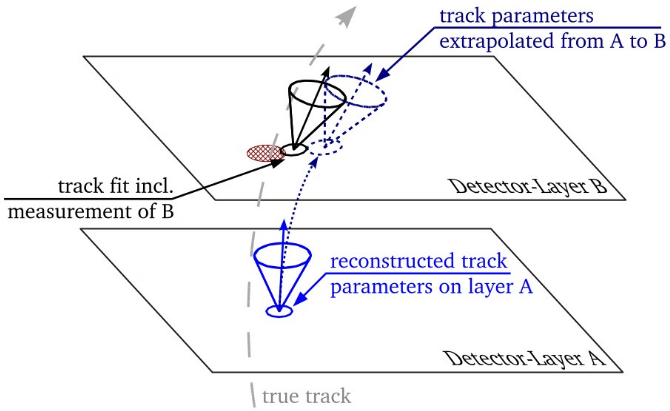


Only one track parameter can be defined

b) Kalman fitting



Track parameters are defined per hit



Genfit package

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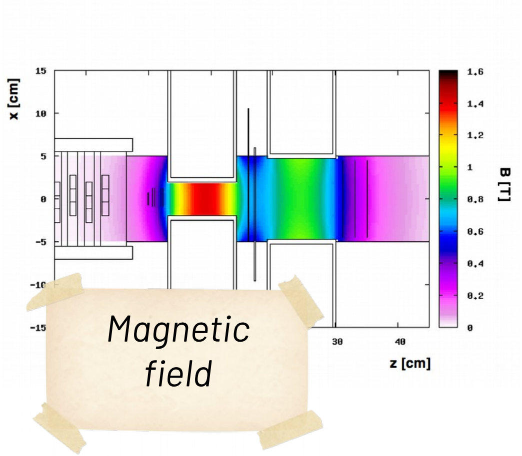
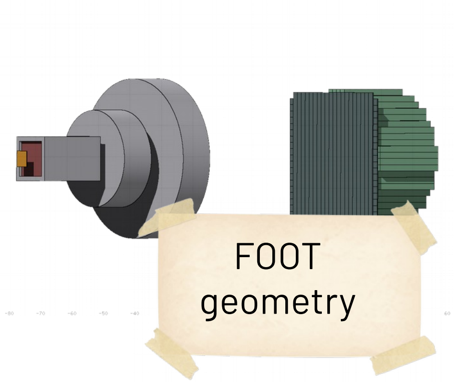
Genfit is based on **three** pillars:

- **measurements**, hit coordinates of the detector (1D, 2D or 3D);
- **track representation**, model of the track (integrated with TDatabasePDG);
- **fitting algorithms**, such as Kalman filter.

Genfit is an experiment- independent modular framework for **track fitting** and other related tasks





Kalman filter

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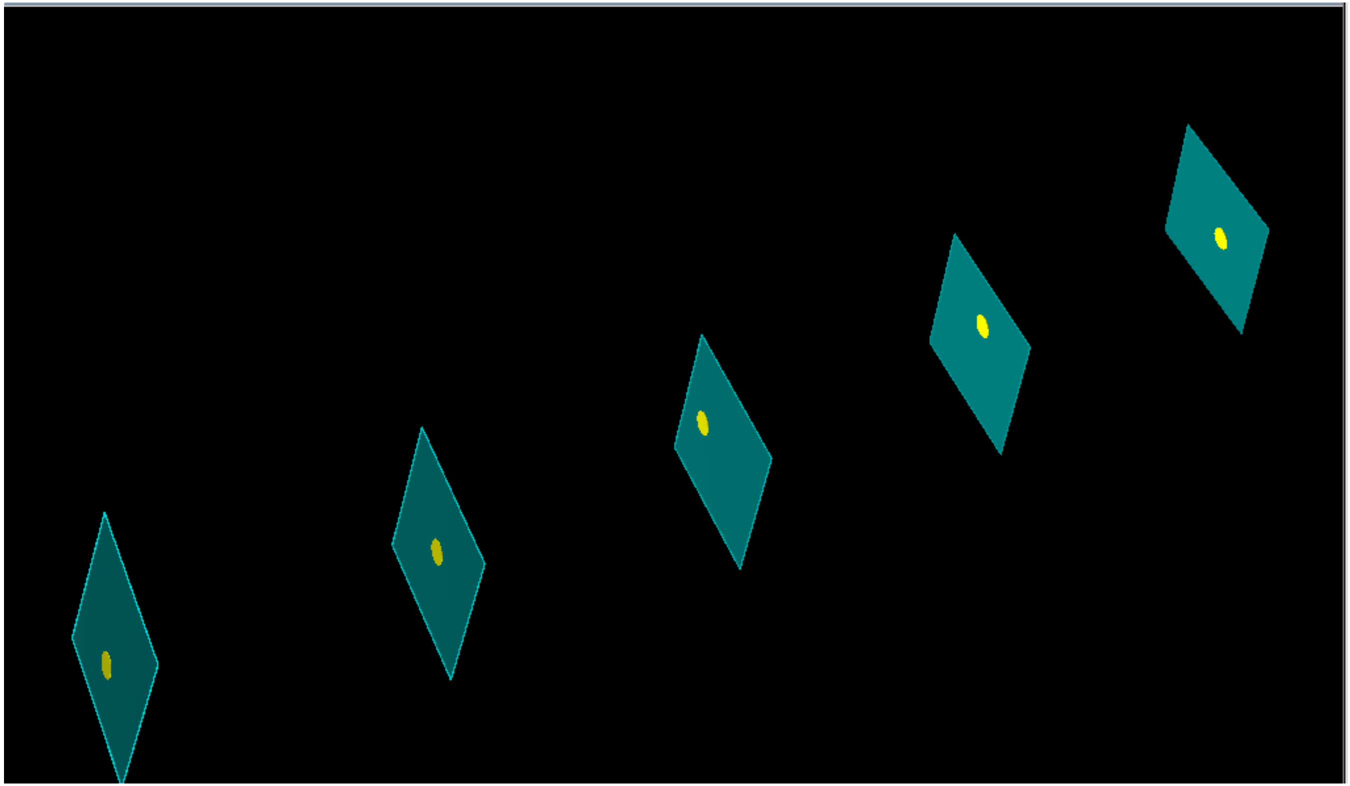

Set of noisy **measurements** (this is a test, not FOOT geometry)

Kalman filter

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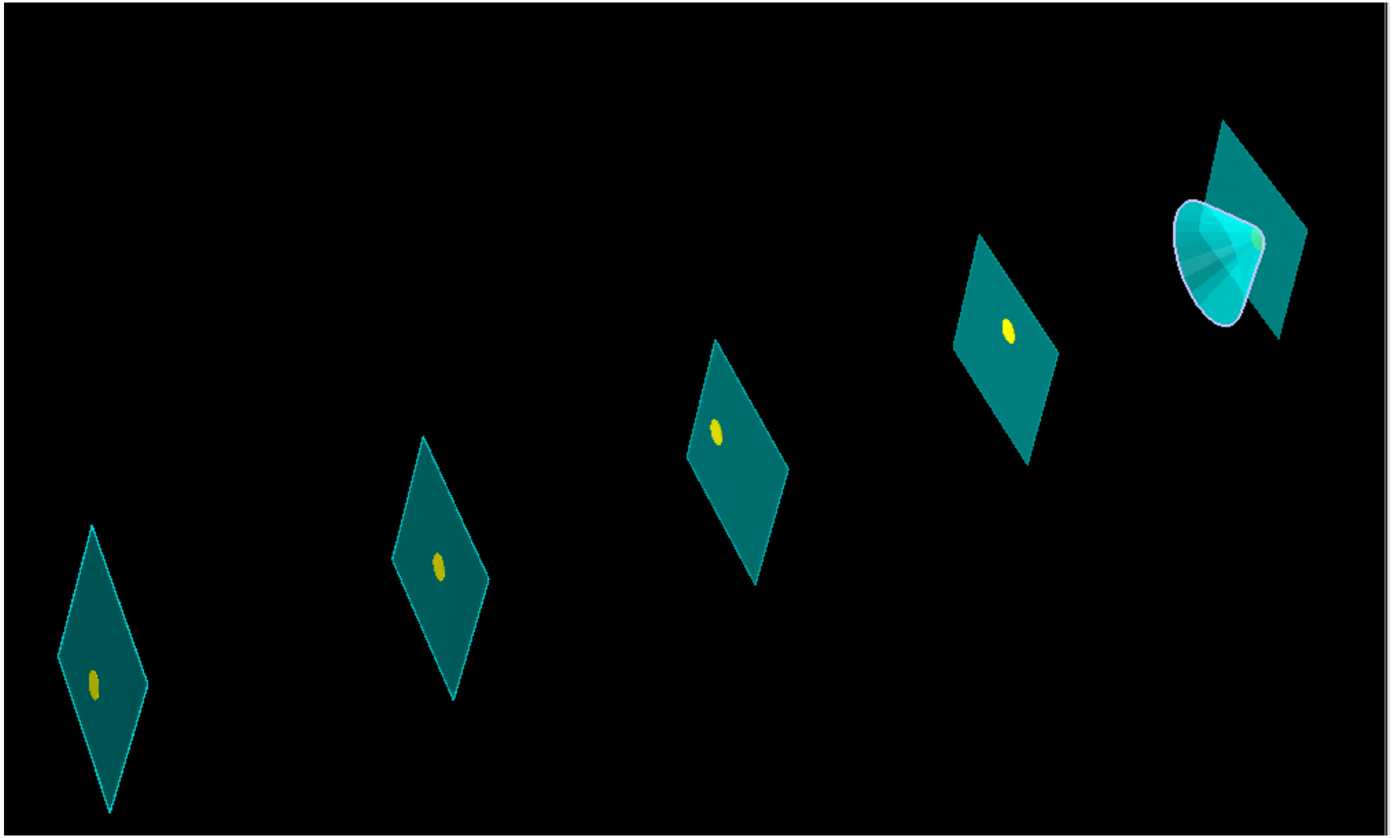
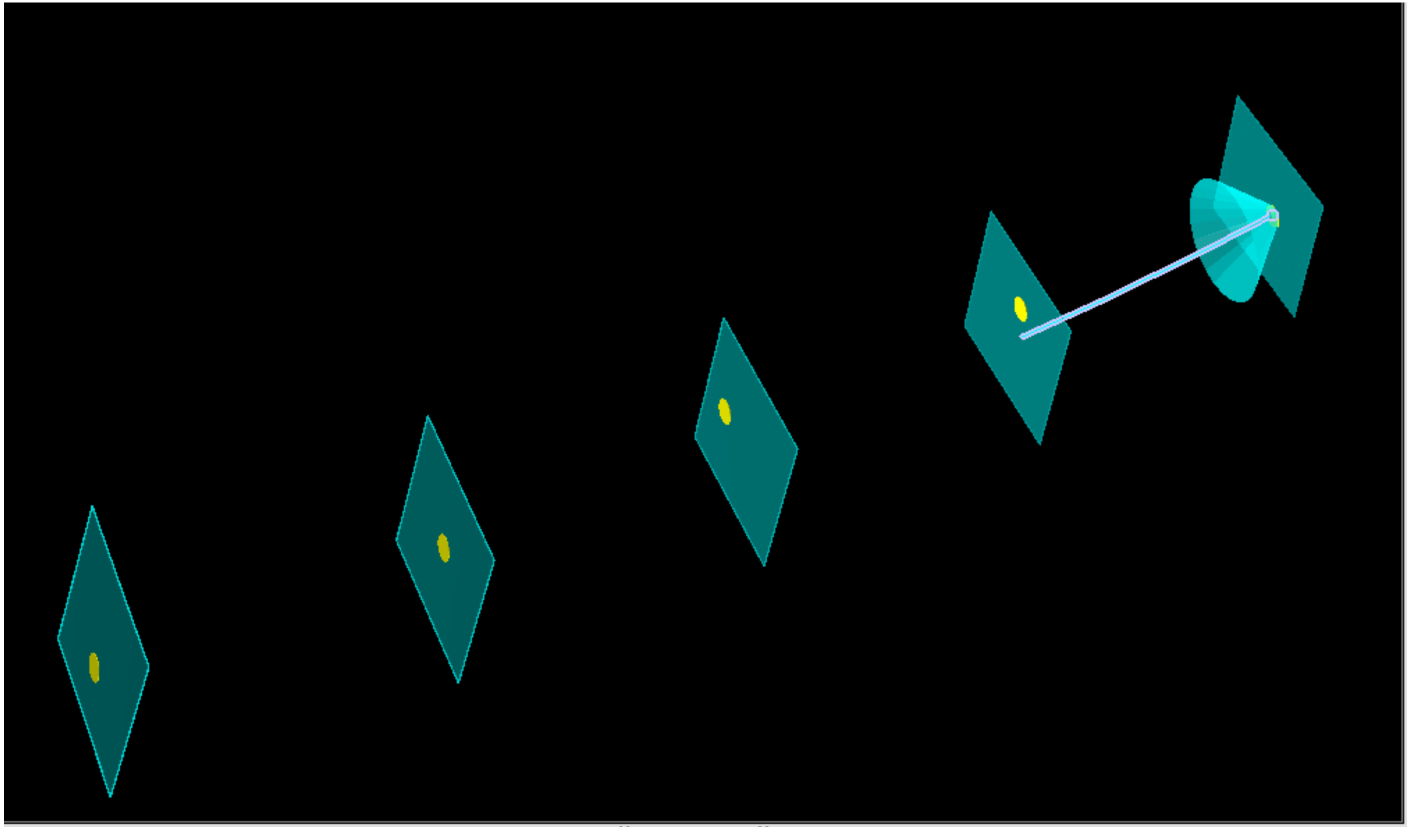


First **update** of the forward fit.
Position determined by first measurement.

Kalman filter



Prediction

Kalman filter

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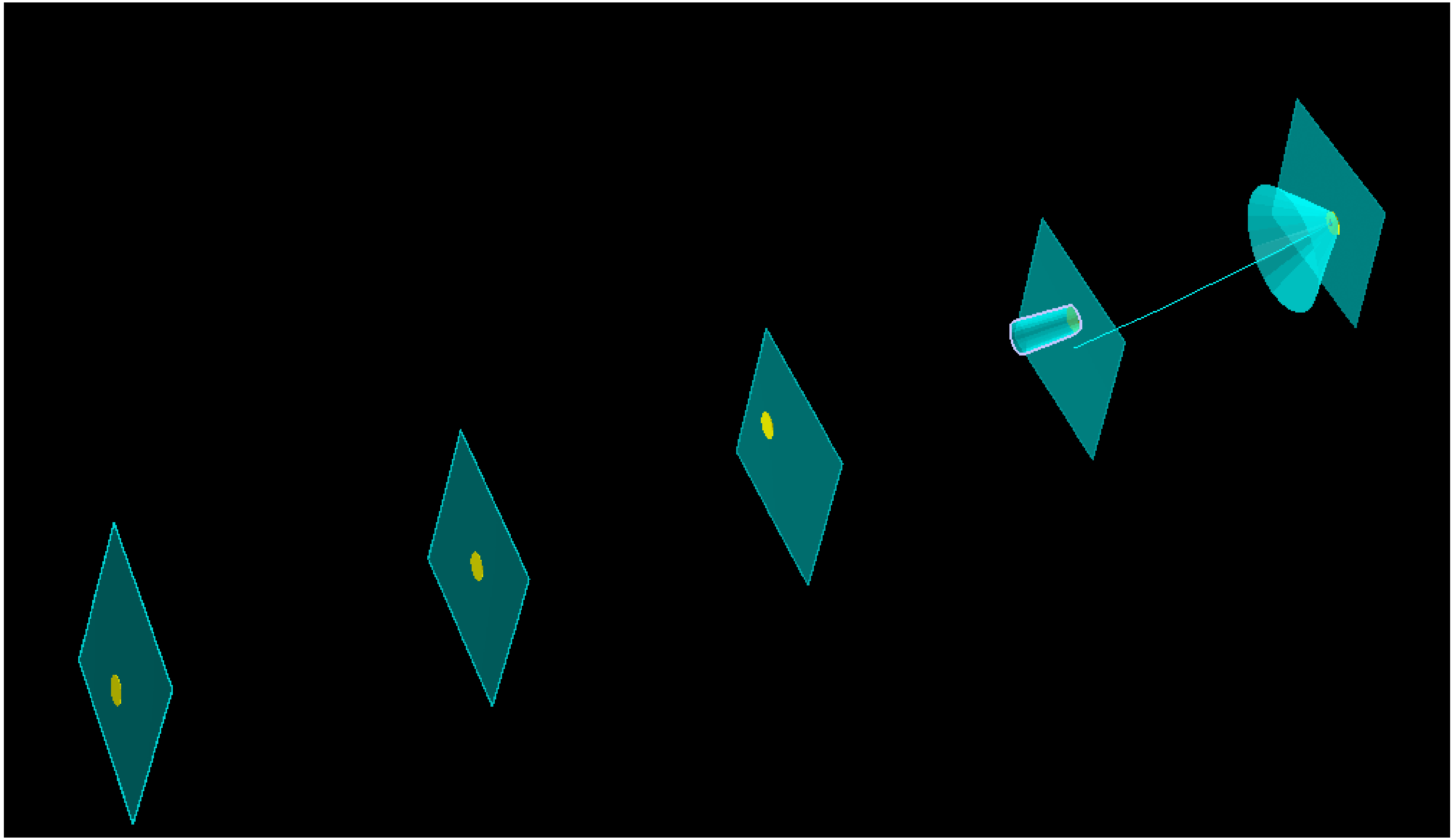

Update

Kalman filter

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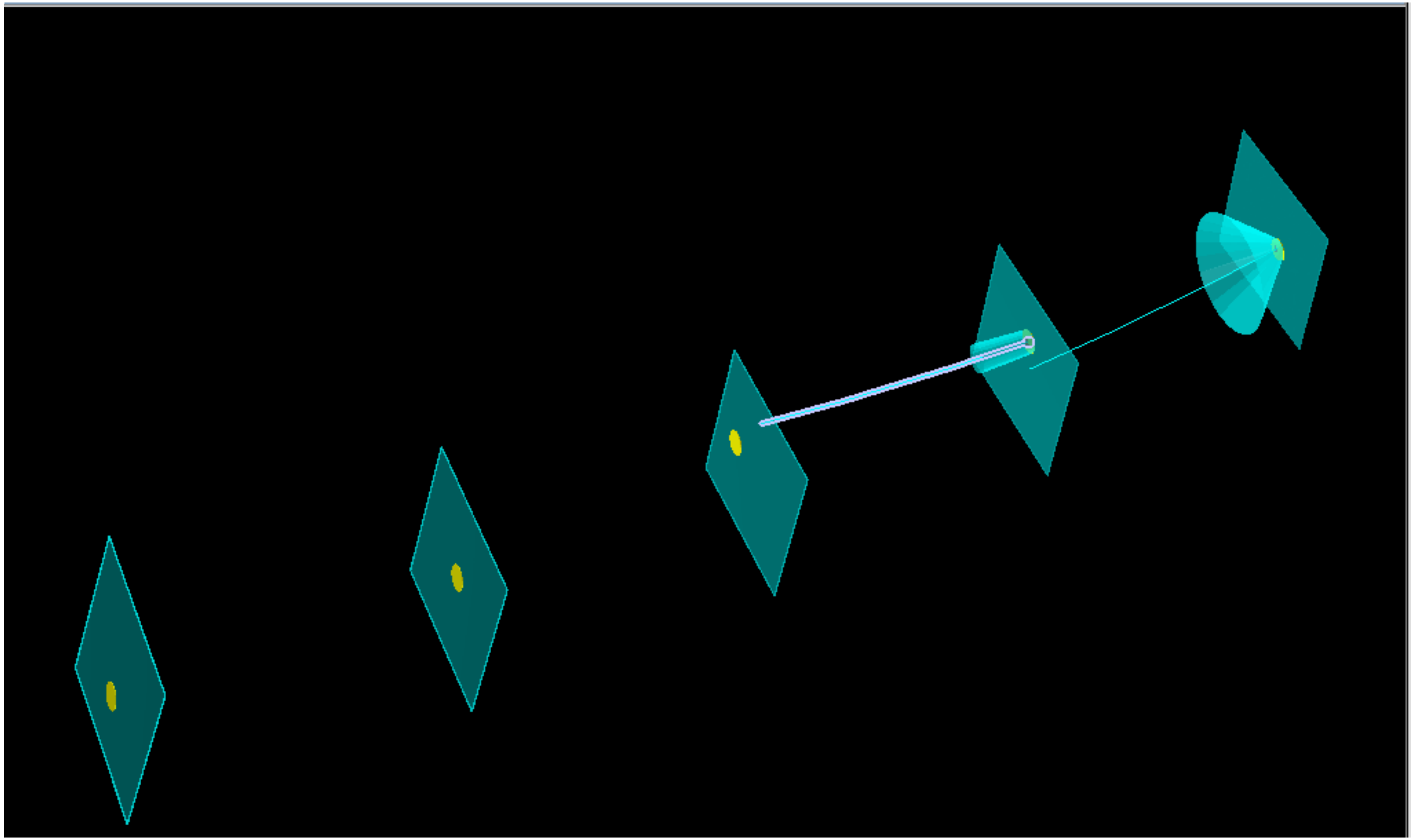

Prediction

Kalman filter

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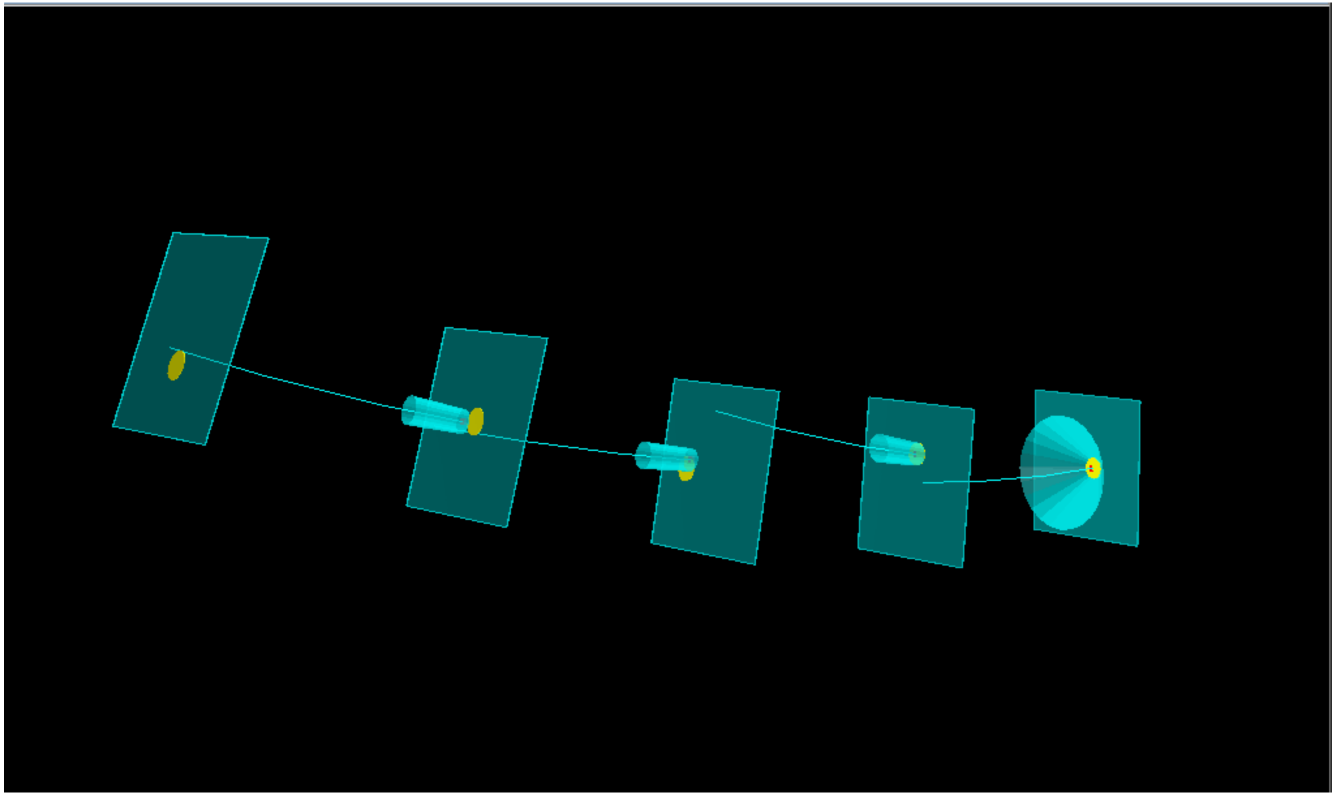

Forward fit

Kalman filter

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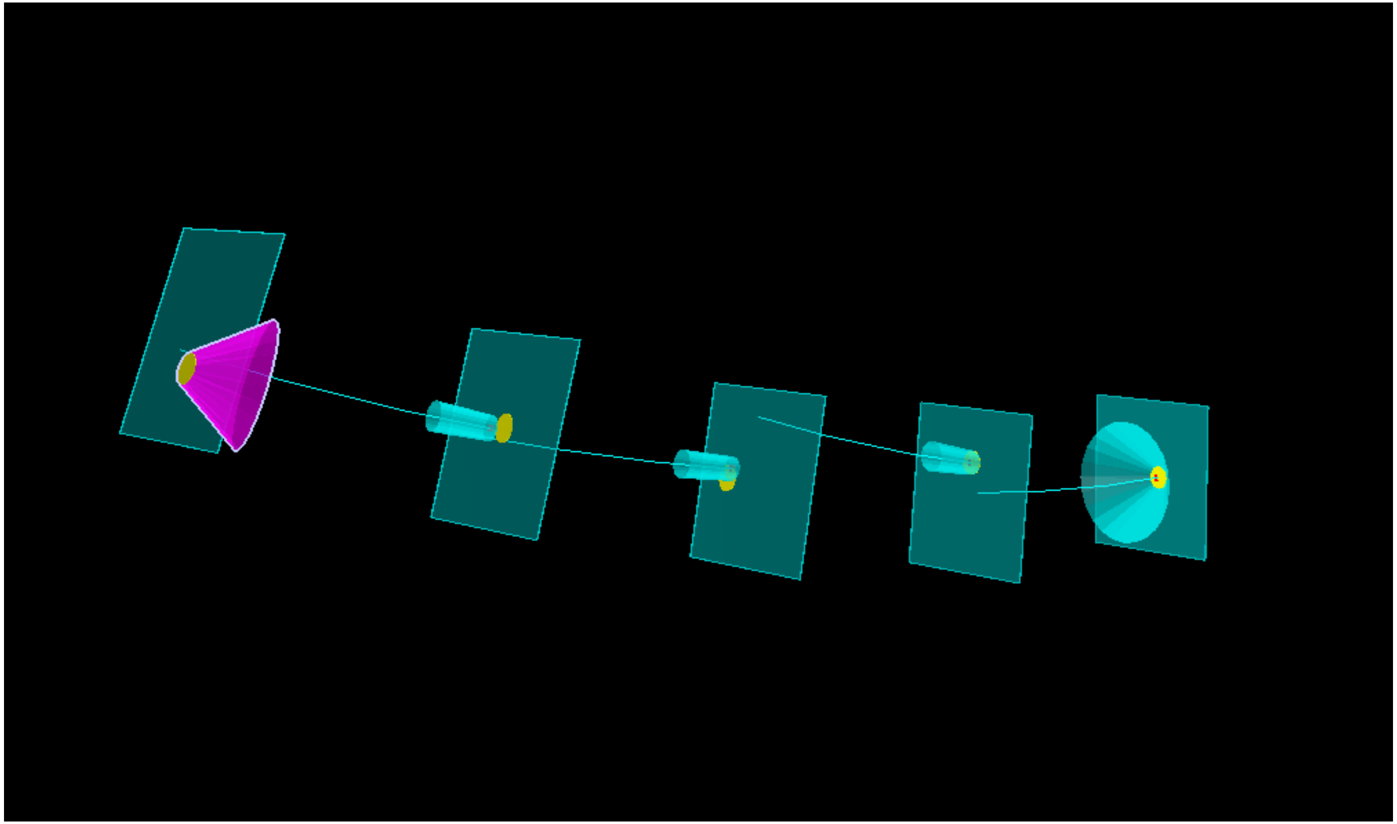
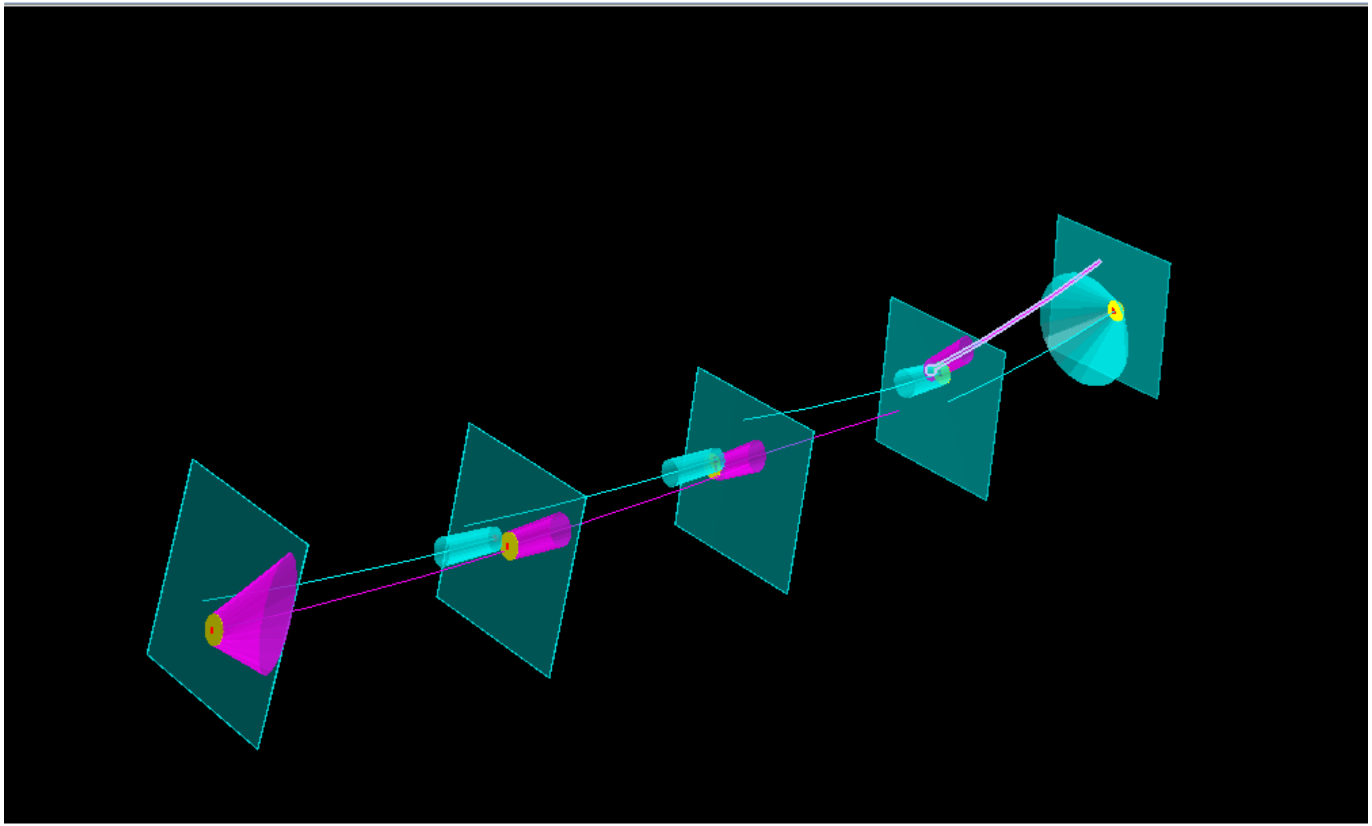


First **update** of the backward fit.

Kalman filter



Prediction

Kalman filter

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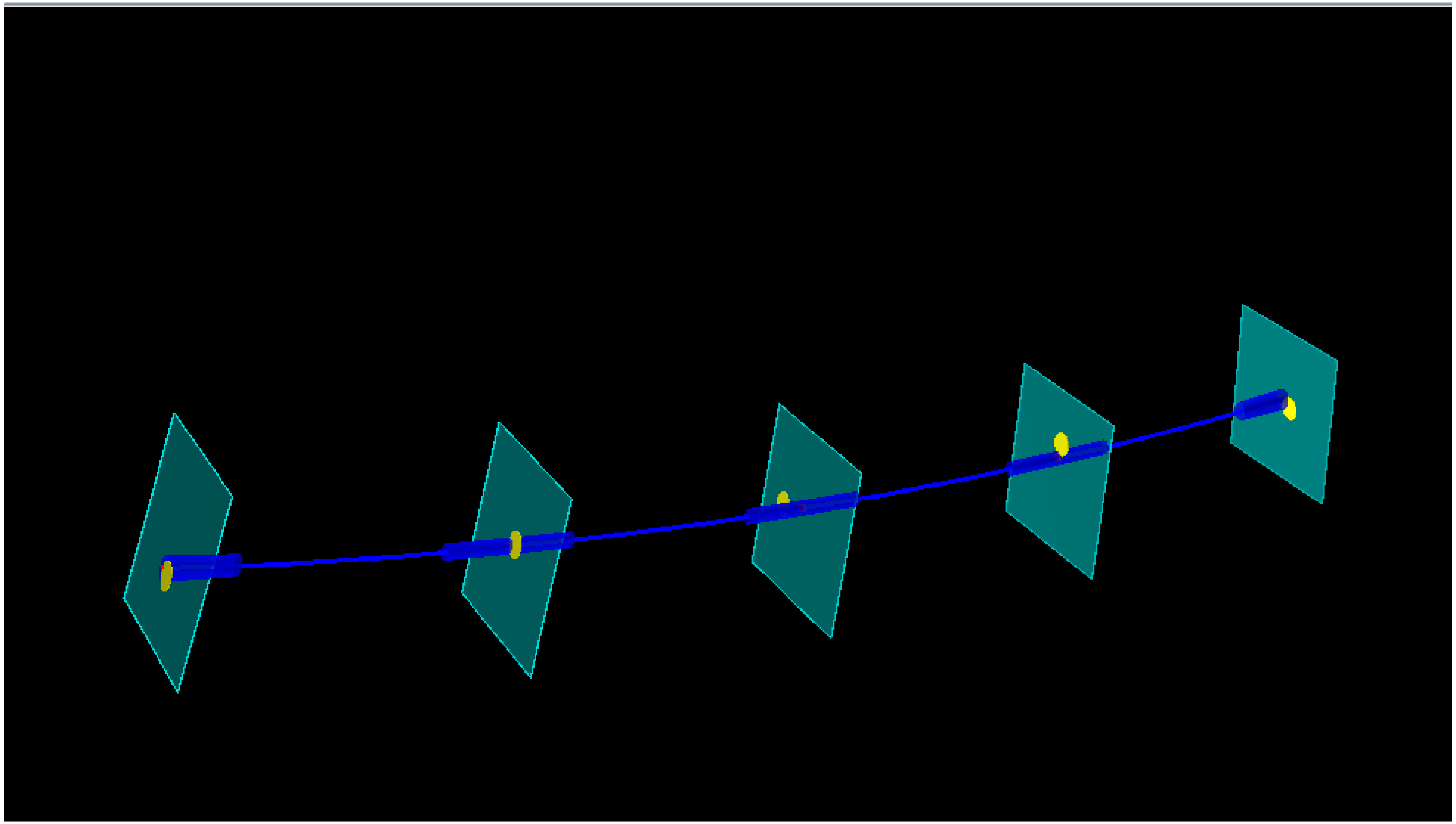

Smoothed track

Track finding strategy

The magnetic spectrometer of the FOOT experiment

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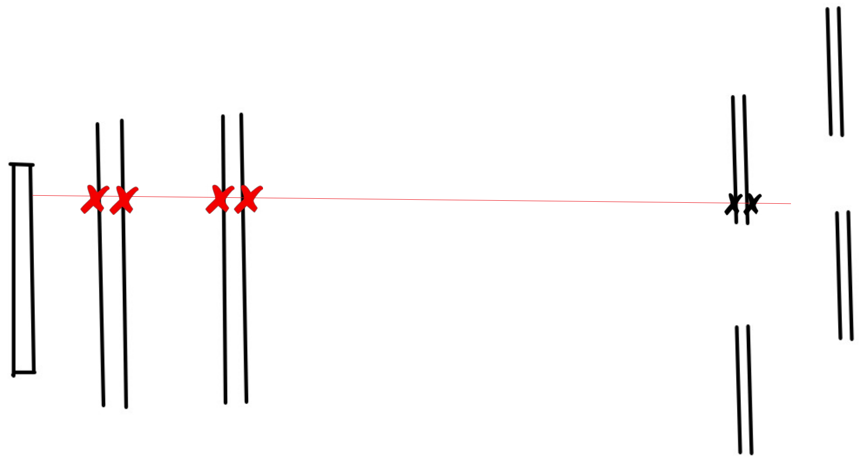
1) Get **information from TW** about **fragment charge**
2) Take all **vertices** found in the **target**
3) Take all VTX tracks
4) Add clusters in the vertex detector to the track candidate
5) Project them with a **straight line** to IT positions (only YZ view)
6) **Add clusters** with minimum distance on IT



Track finding strategy

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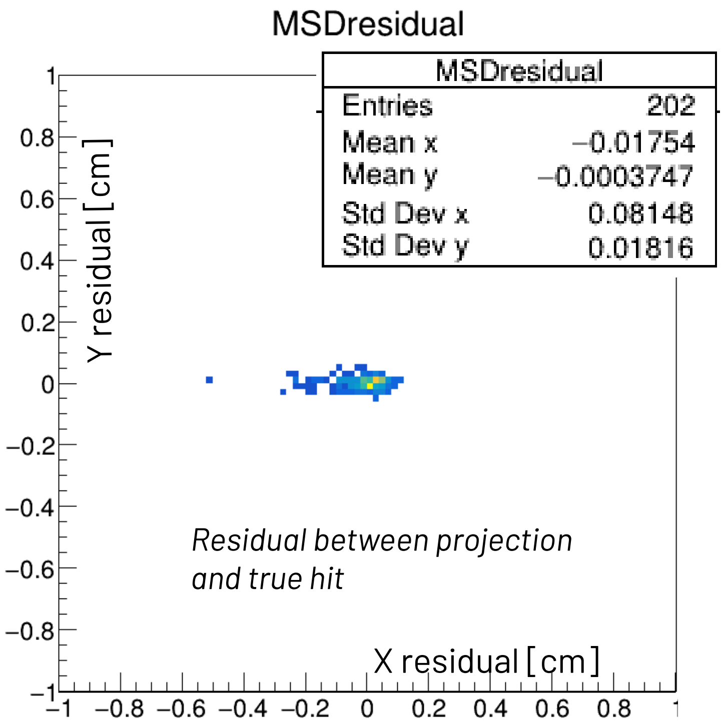
Now **extrapolation to MSD** has to be done

After the IT insertion we have **more "information"** also about the bending, i.e. q/p

Moreover, TW allows us to make a guess about produced fragments:

1) Runge-Kutta extrapolation to MSD (4^{th} order)
2) Add closer cluster to extrapolation
3) Repeat for each MSD layer (1D measurement)
4) Runge-Kutta extrapolation to TW position
5) Calculate residuals with TW points
6) Choose best point and get its charge
7) Set particle type and make the real fit
(for light nuclei H, He all isotopes)



Residual between projection and true hit

Track finding strategy

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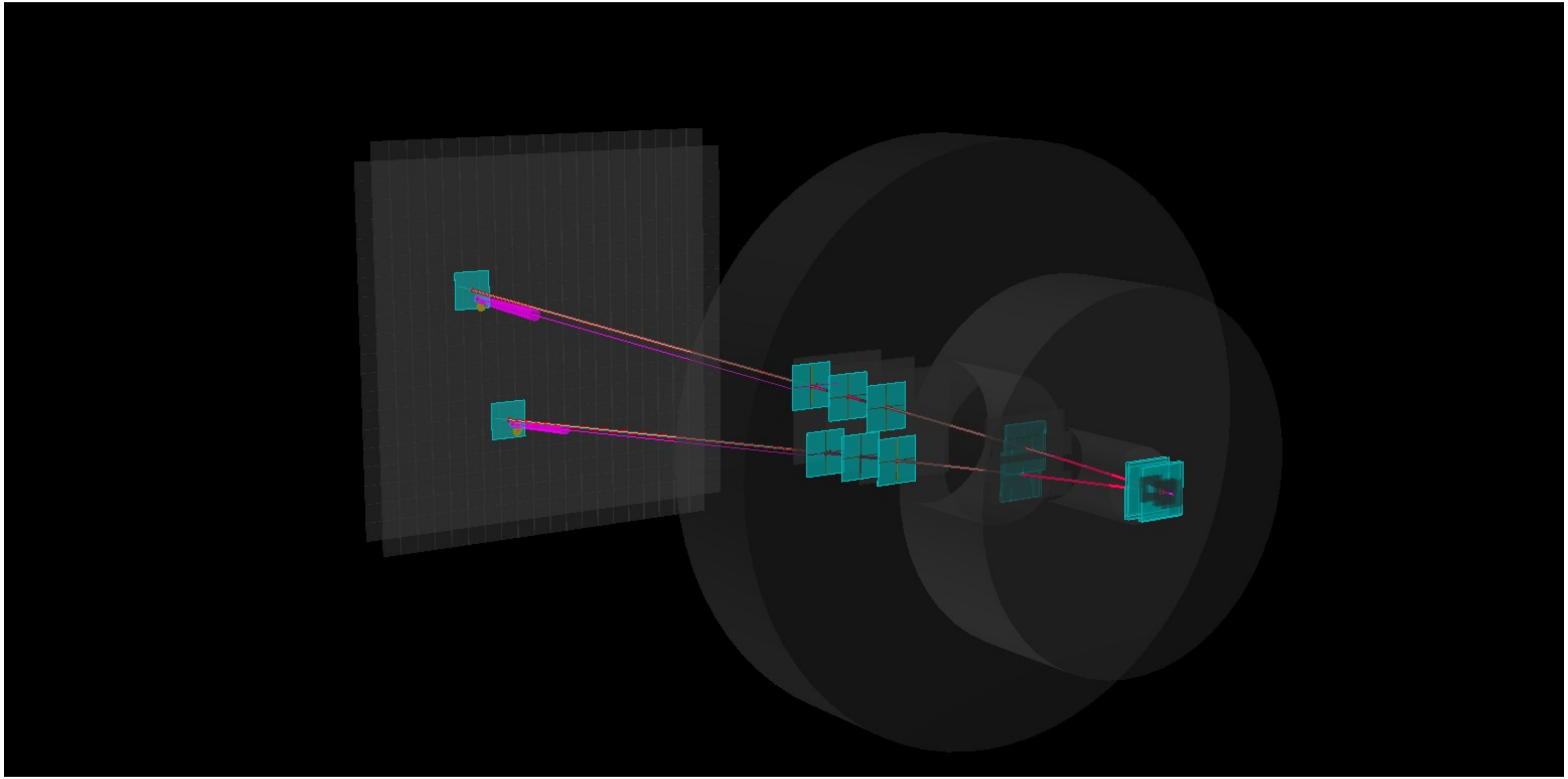

Track finding results

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In the following, simulation 200 MeV/u 16O on Carbon was used (41k events)

reconstruction efficiency

$$\varepsilon_{\mathrm{reco}} = \frac{N^{\mathrm{reco}}_{\mathrm{ref}}}{N_{\mathrm{ref}}}$$

number of fragments reconstructed by at least one track

number of fragments seen by TW originated in the target

Fragments originated in the detector are not handled at this step!

Track finding results

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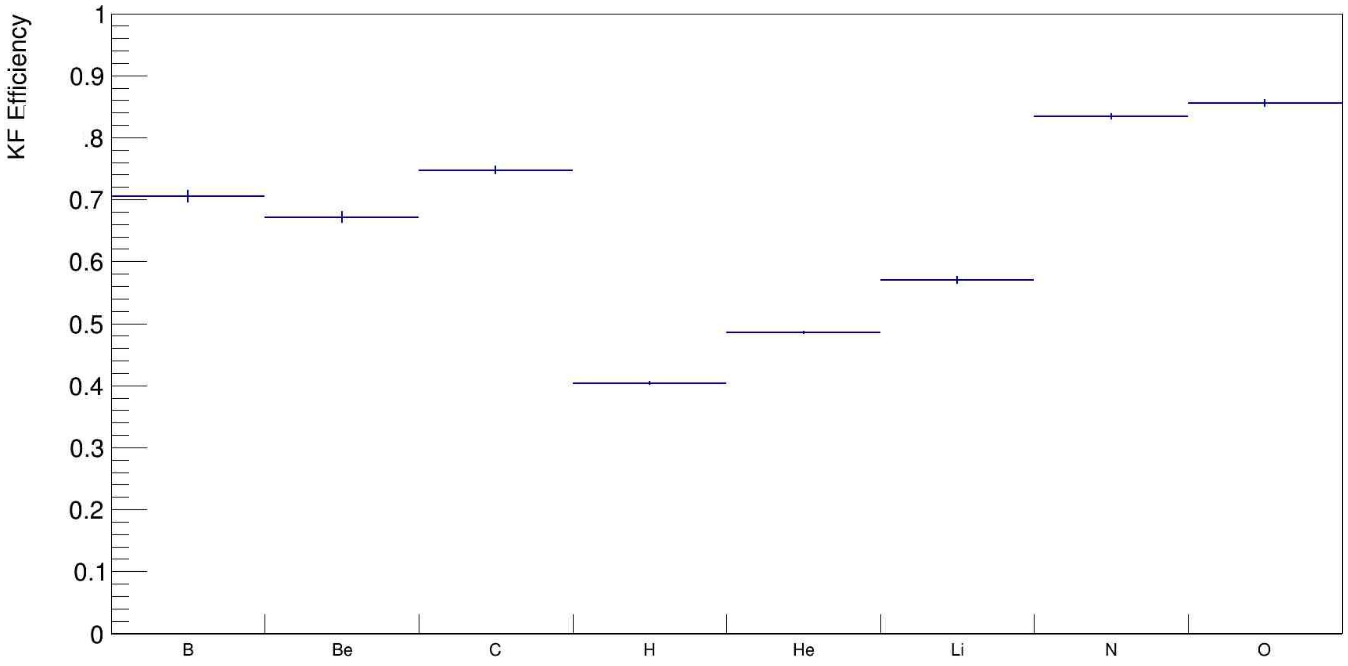

Hit matching efficiency (purity) ~ **98%**

No request on minimum number of measurements

Chi-square **cut**

Track fitting

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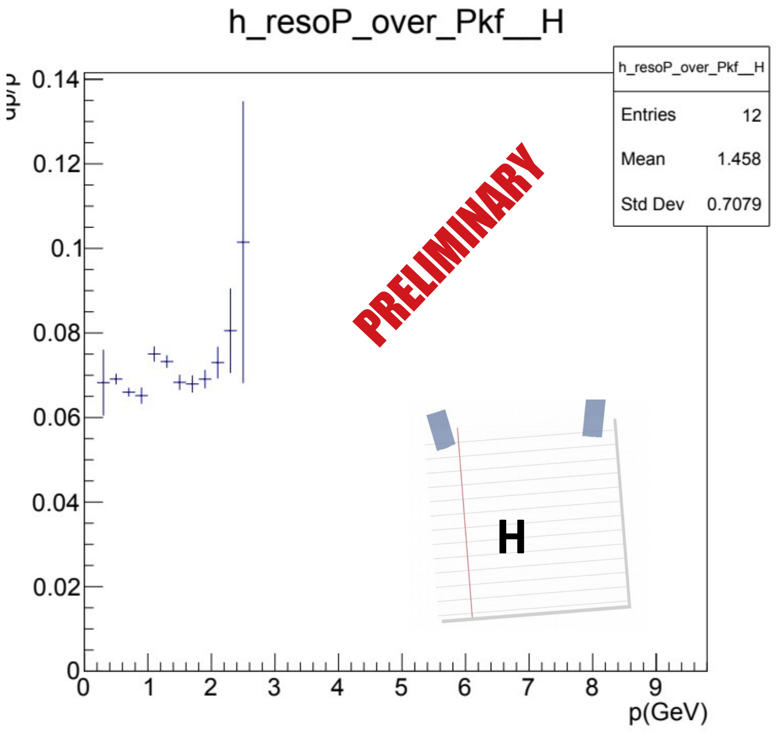
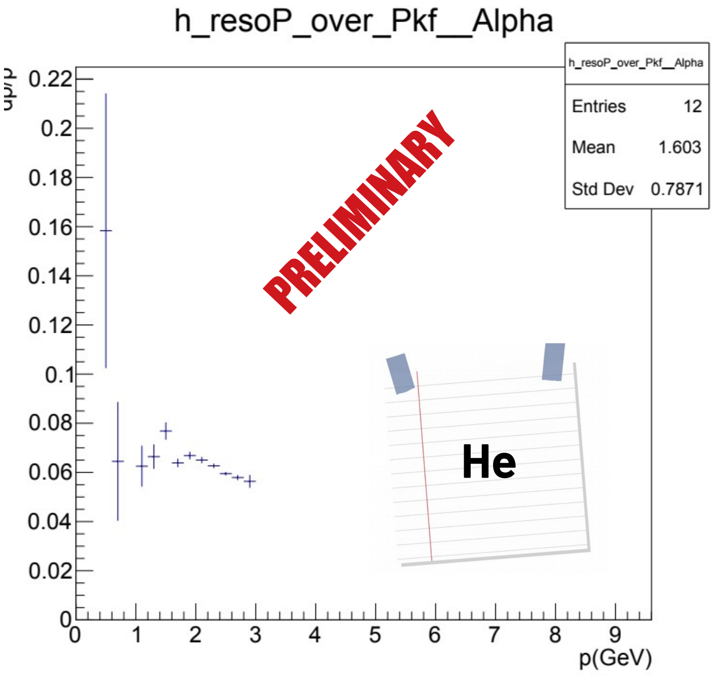
Results are recorded **by fragment** charge;
Momentum axis is divided in bins **200 MeV/c wide**;





Track fitting

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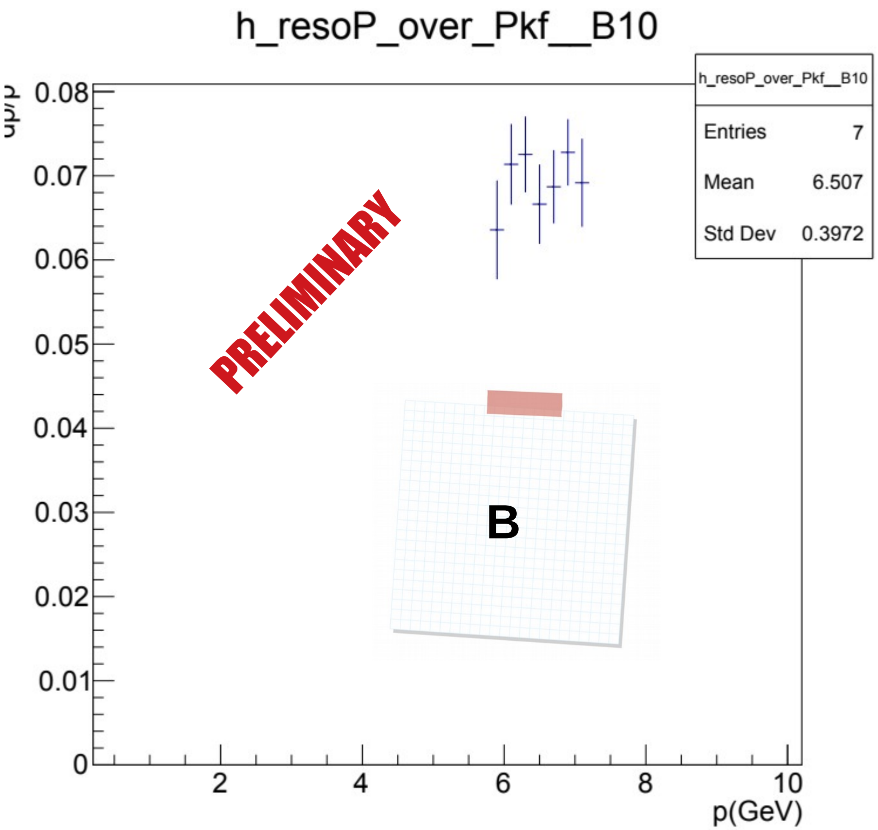

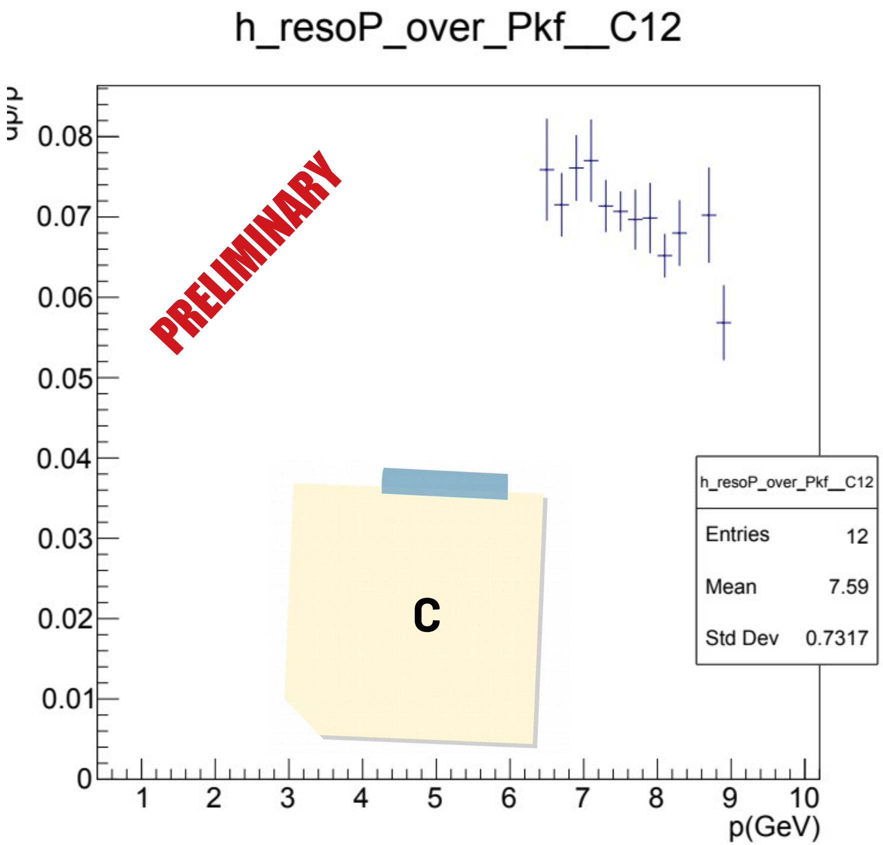

Conclusions

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- First **global reconstruction** strategy for FOOT experiment is set in place;
- Still **room for improvement**, both in track finding and in track fitting;
- Reconstruction efficiency **from 0.4** with Hydrogen to **0.85** with Oxygen;
- Investigate other **reference set** choices;
- Momentum resolution is around **7%** up to now (it was ~4% for heavy fragments with MC truth)
- Several **improvements** already in mind

Thank for your attention!