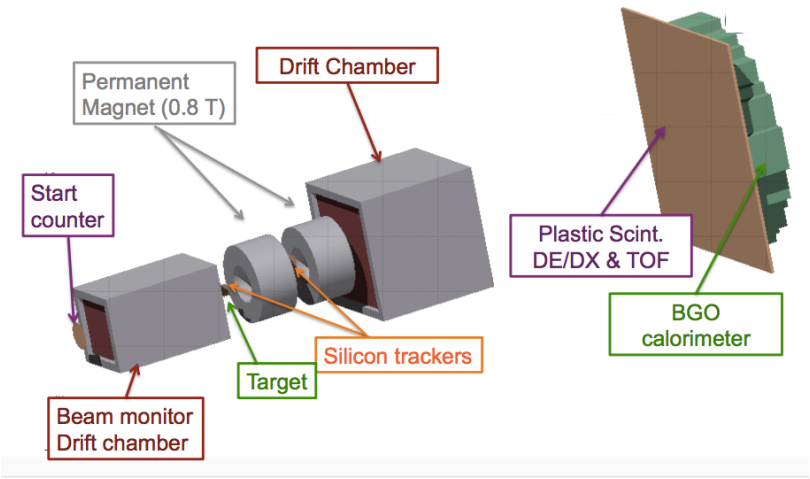
Drift Chamber:
where we are, where we go

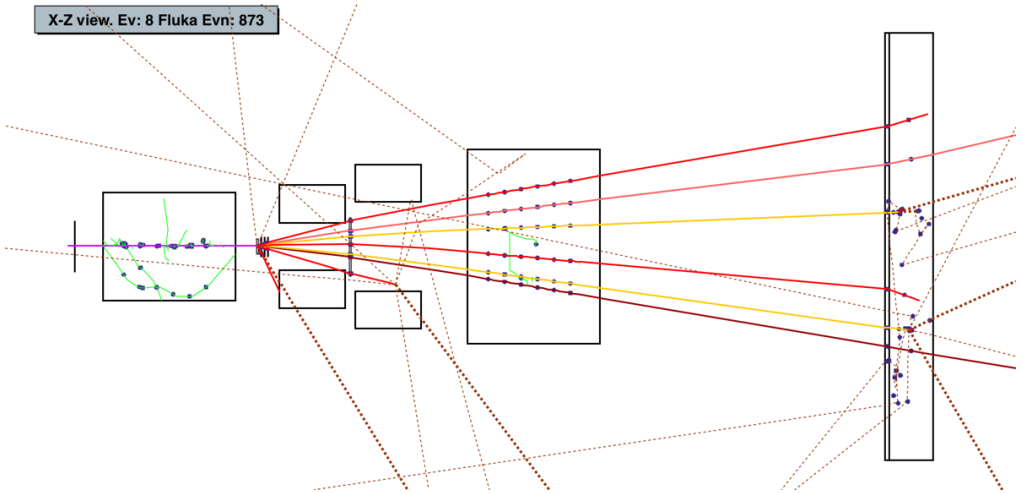
Trento + Milano + Roma



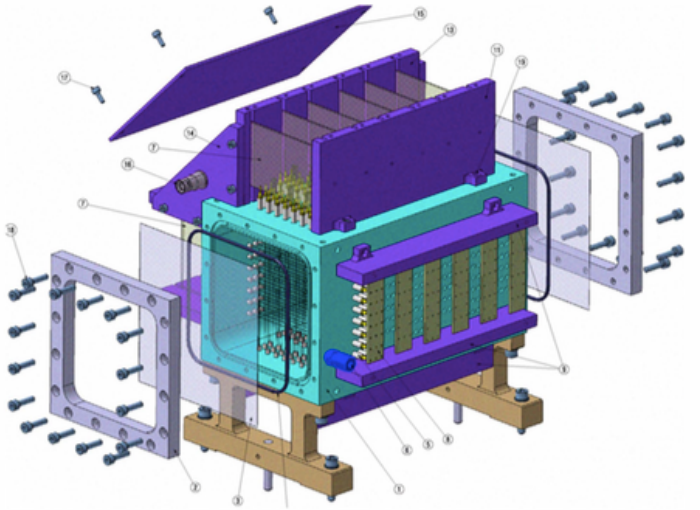
- Essential for tracking after magnetic field (p measurement, matching with scint + calorimeter)
- A DCH capable of providing many points along a track appears to be important
- Gas detector: optimal choice to minimize material

Basic Requirements:

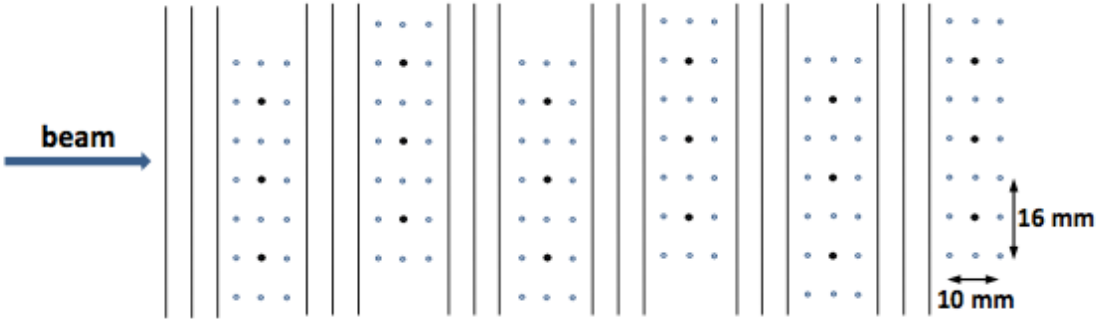
- ≤150 μm spatial resolution
- Low density material
- Multi-track/multi hit



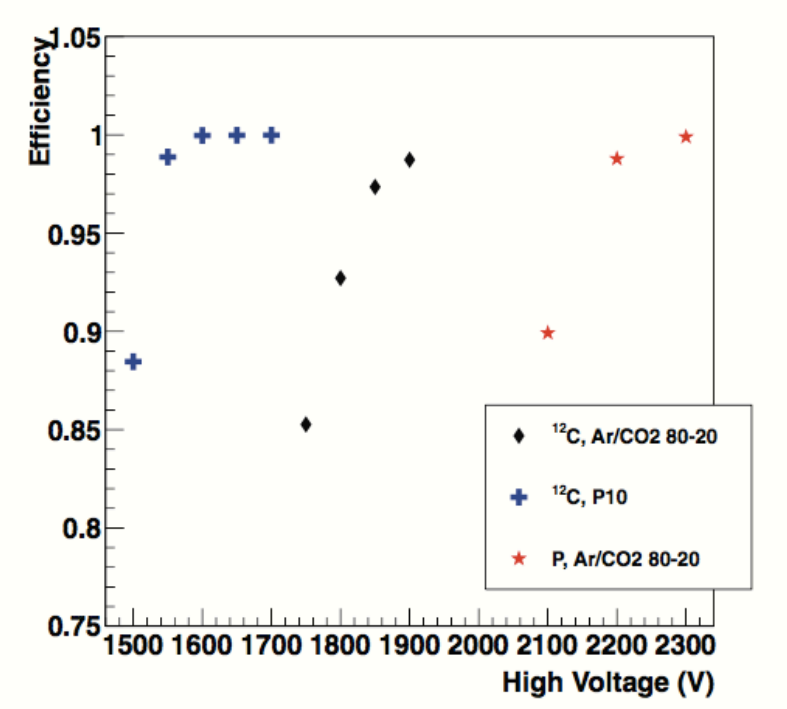
Performances of FIRST DC (now to be adopted as beam monitor)

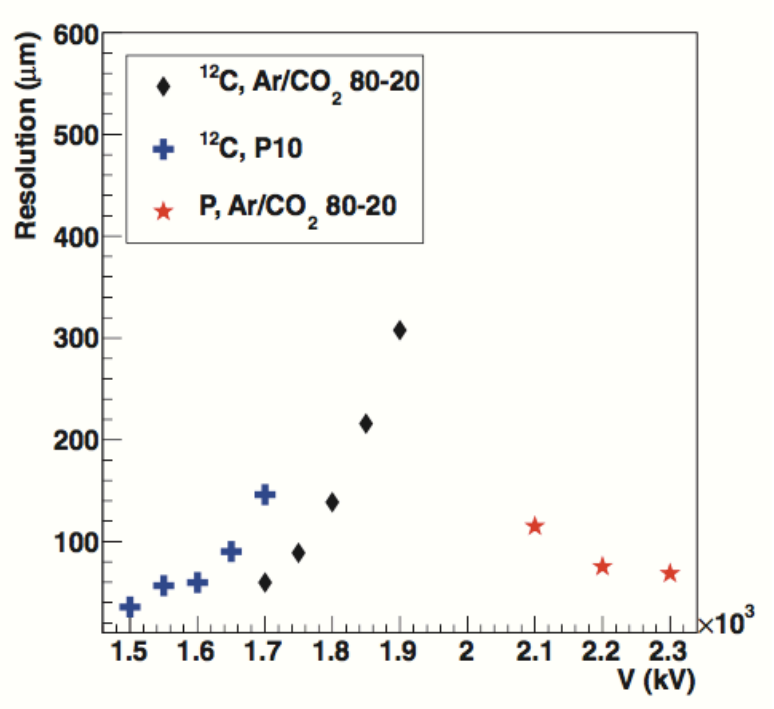


- 12 consecutive layers (alternated horizontal and vertical wire planes)
- Gold-plated tungsten wires
- Each layer: 3 rectangular drift cells (36 sense wires total), each cell 16 mm x 10 mm along beam direction
- Consecutive layers are staggered
- Read-out electronics: factor 10 amplification in signal amplitude



Performances of FIRST DCH

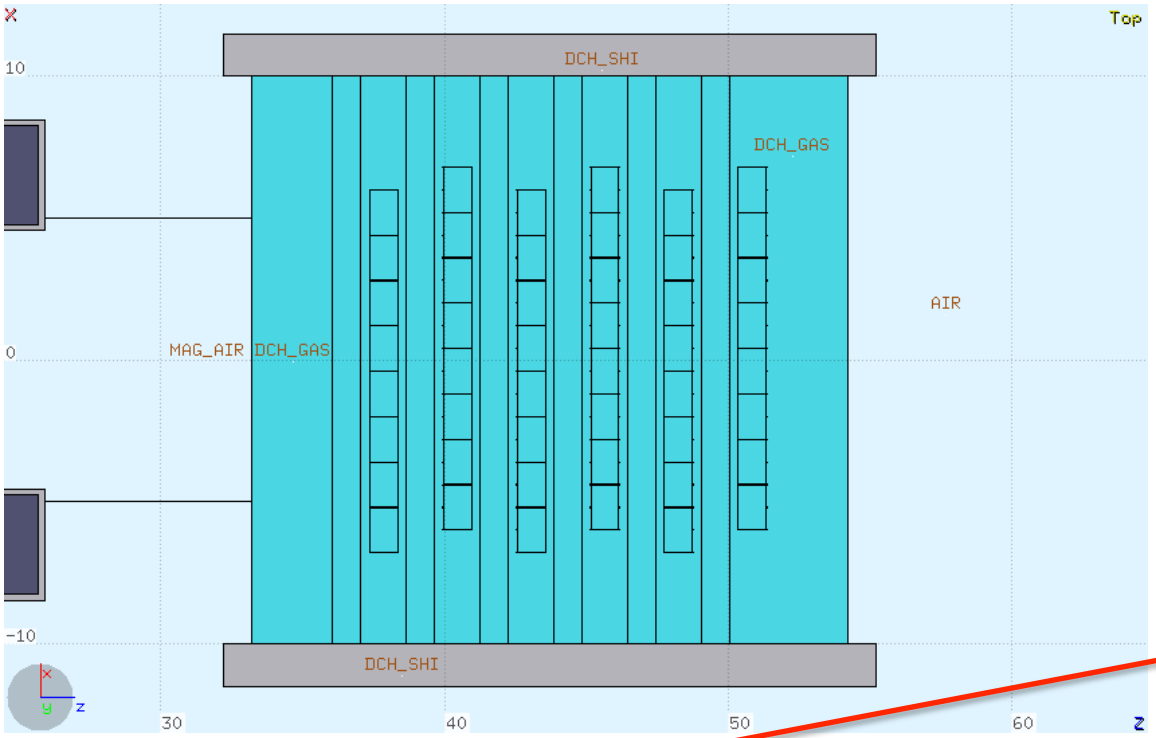


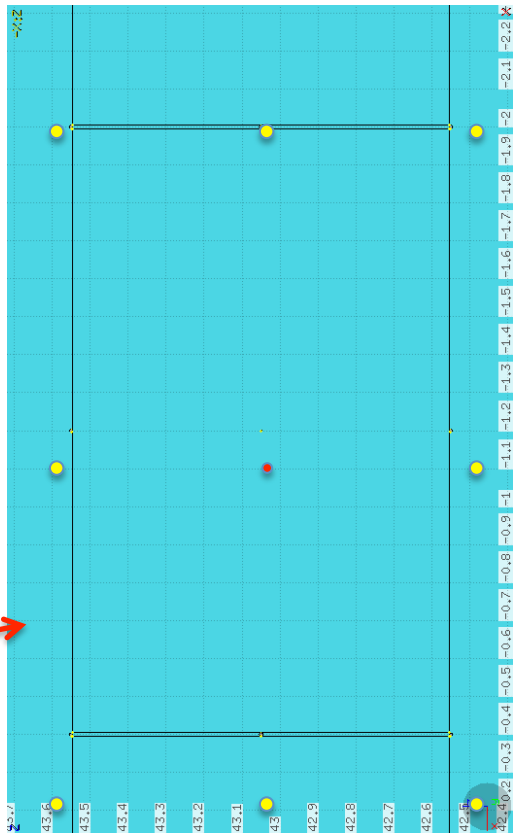


- **80 MeV/u protons and carbon ions:** with Ar/CO2 resolution better than 100 μm at full efficiency for p, about 300 μm for C.

- **400 MeV/u carbon:** with Ar/CO2 about 140 μm resolution at 97% efficiency

FOOT DCH: initial design



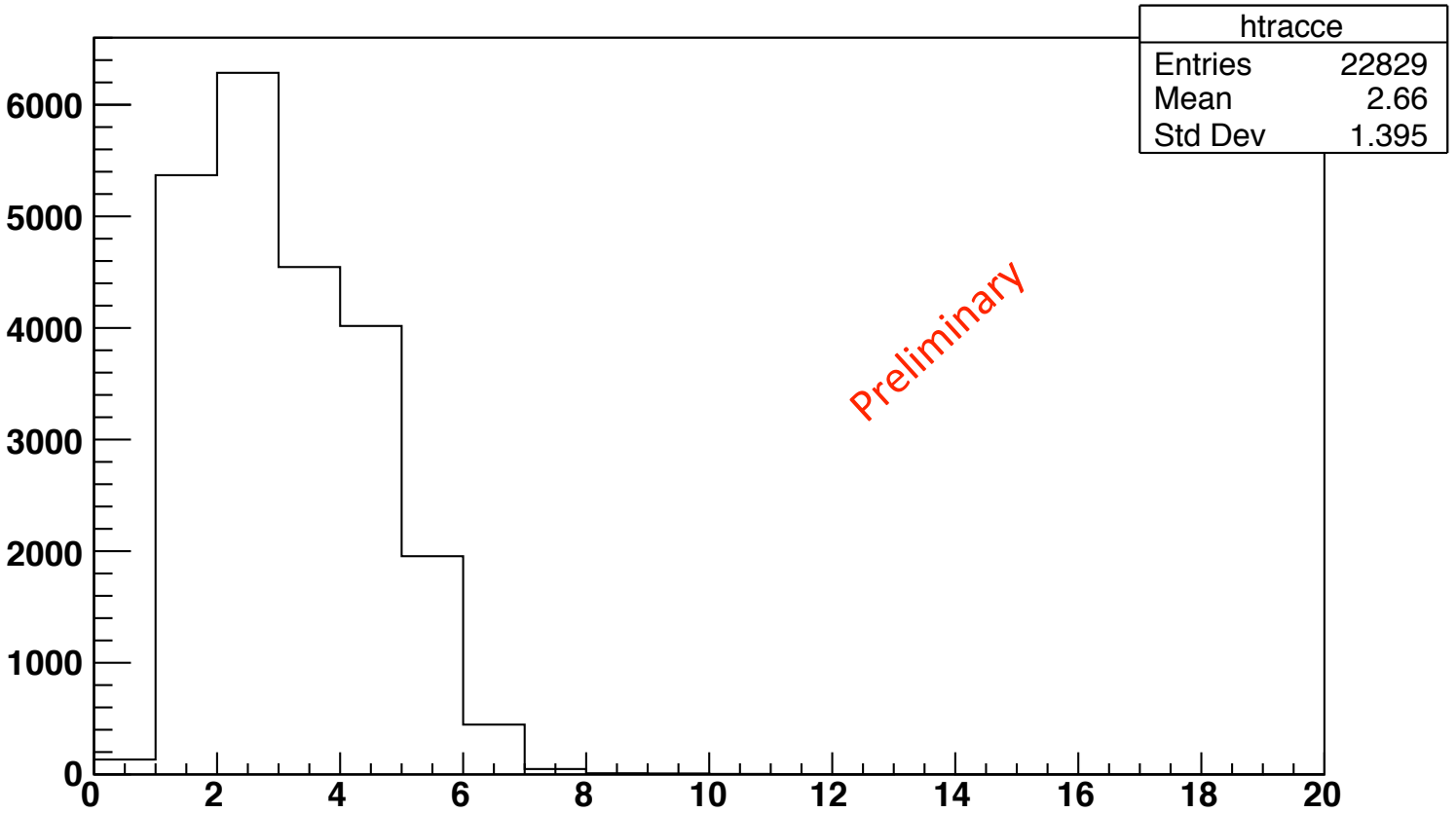


cell size 1.6 x 1 cm

8 filed wires + 1 sense wire/cell

6 X+ 6 Y layers

Track multiplicity in DCH (^{16}O events with fragm. in target)



Challenges

- Actual capability of **multi-track** performance.

Parameters to play with:

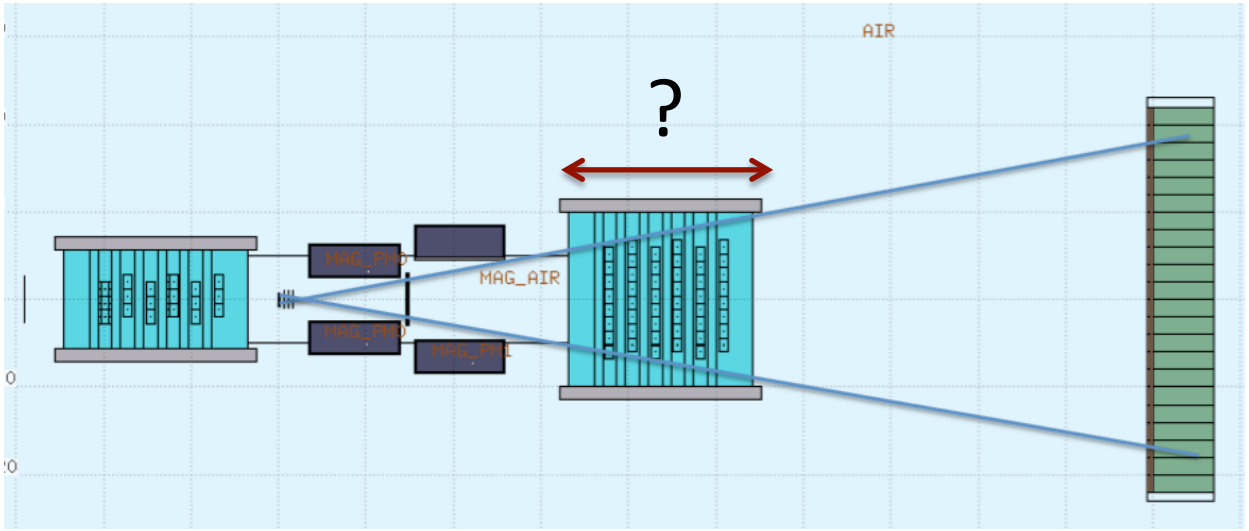
- **Cell size and structure** -> E_{field}, Efficiency
- Choice of **gas mixture** (the lowest possible V_{drift})
- Pulse shape
- **Multi-hit** electronics
- Software for **multi-track reconstruction**
- **Position in the FOOT layout**: how close to the magnets? Effect of fringe field?

Optimizing the design

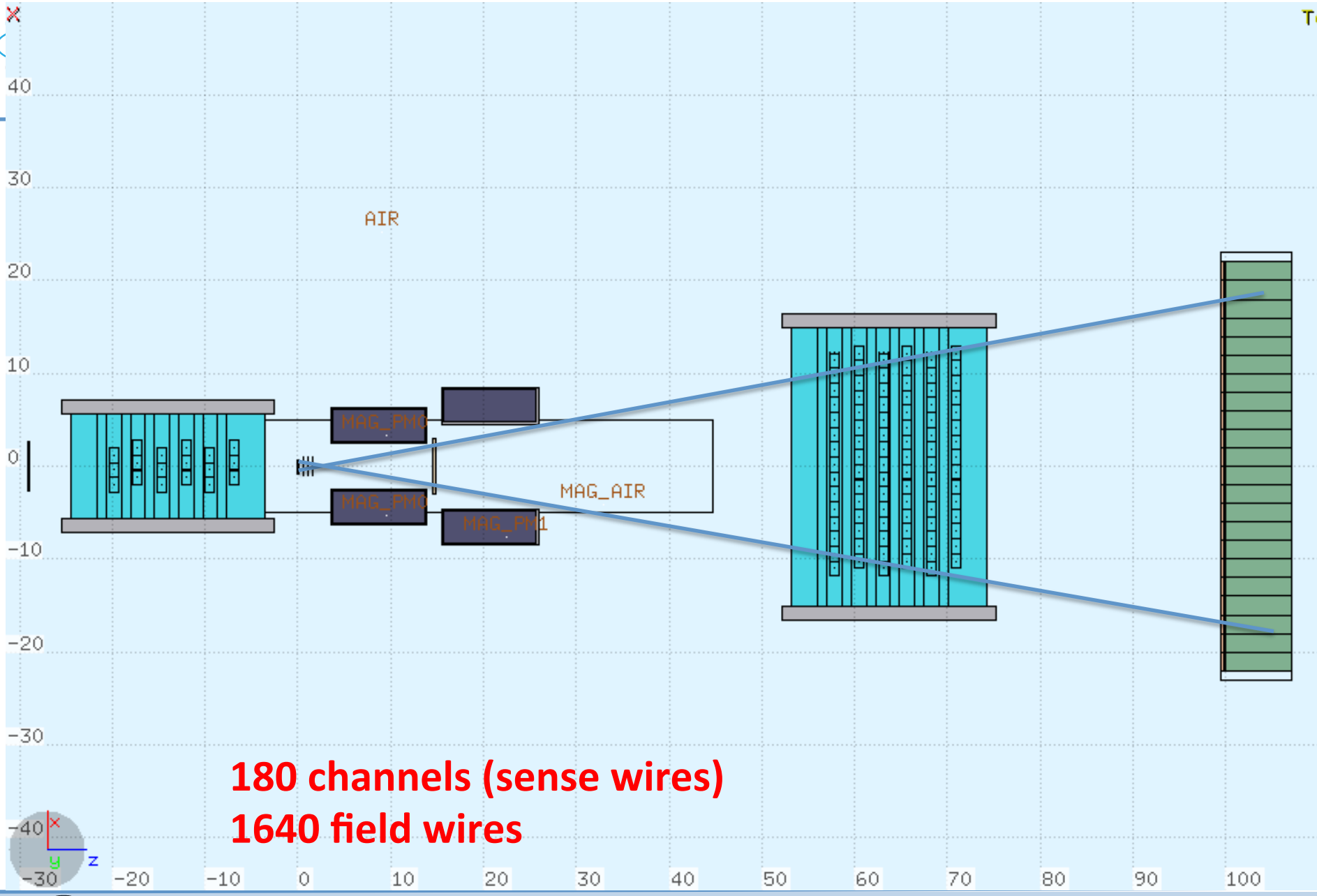
Some help from the DCH position

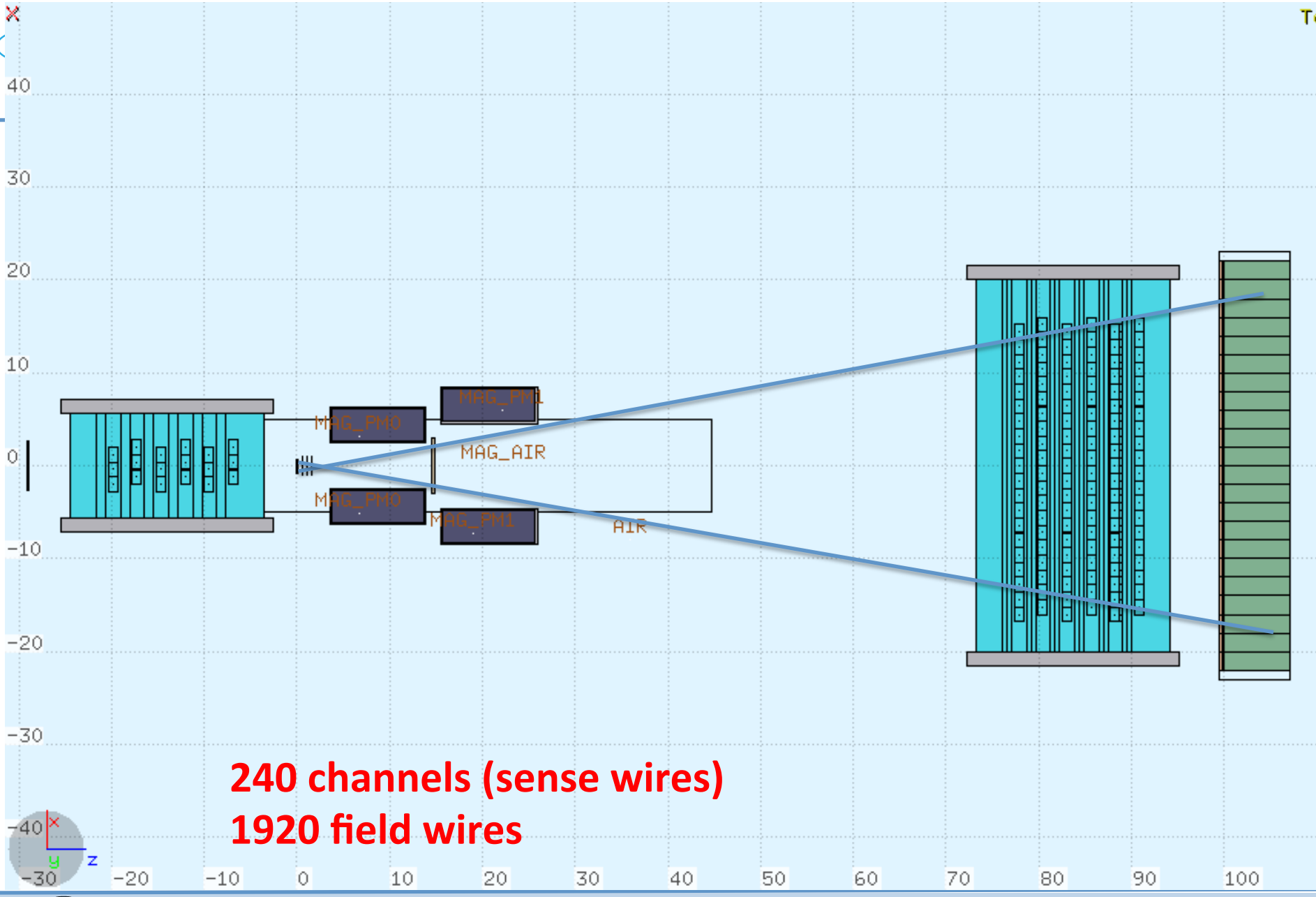
Factors to be considered:

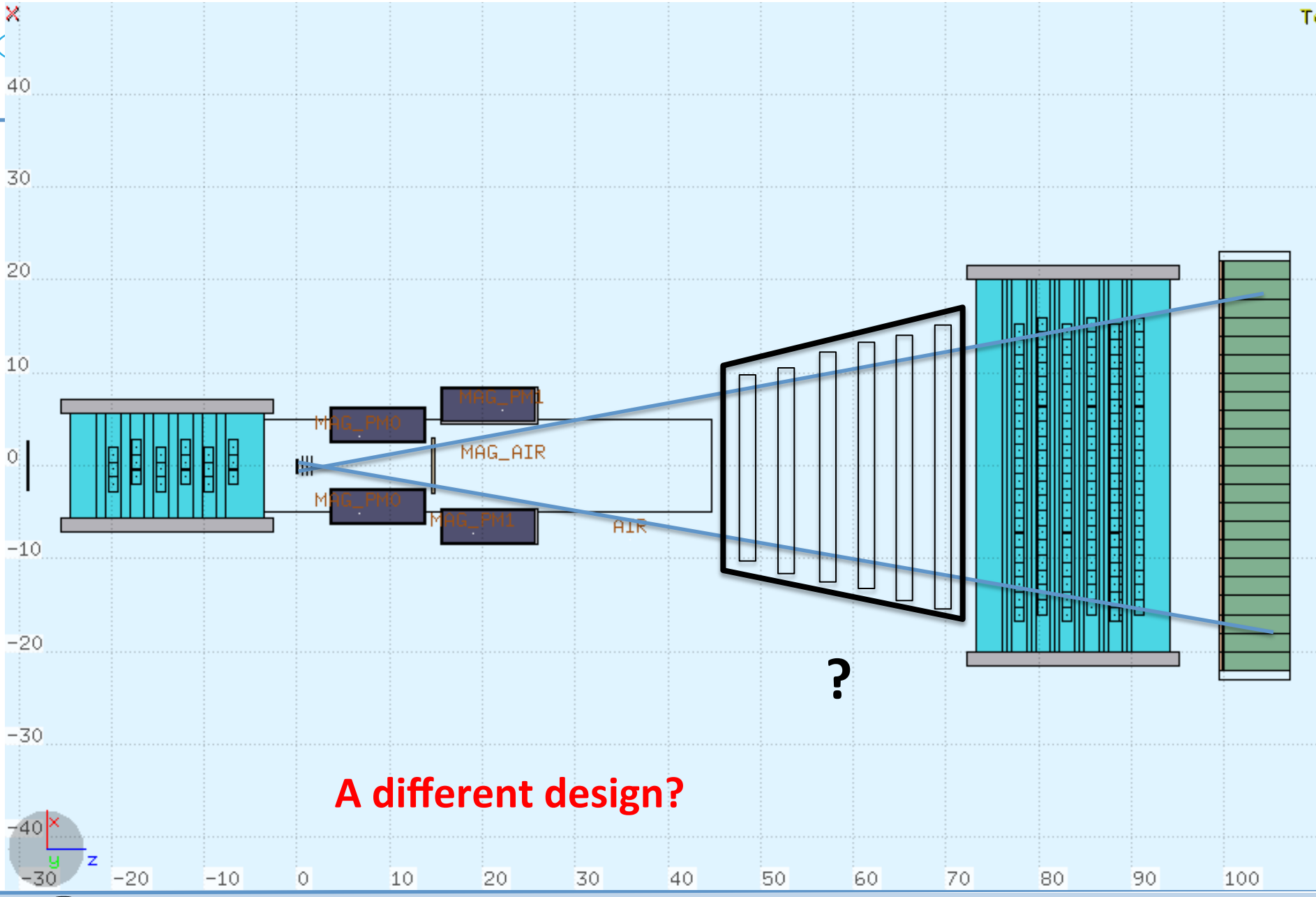
- Fringe field from the magnet
- Solid angle
- Cell size should be compatible with calorimeter pixel
- Total number of channels



Fixing the position will also fix the overall size, cell dimension and channel number


AIR
MAG_PM0
MAG_PM0
MAG_PM1
MAG_AIR
180 channels (sense wires)
1640 field wires

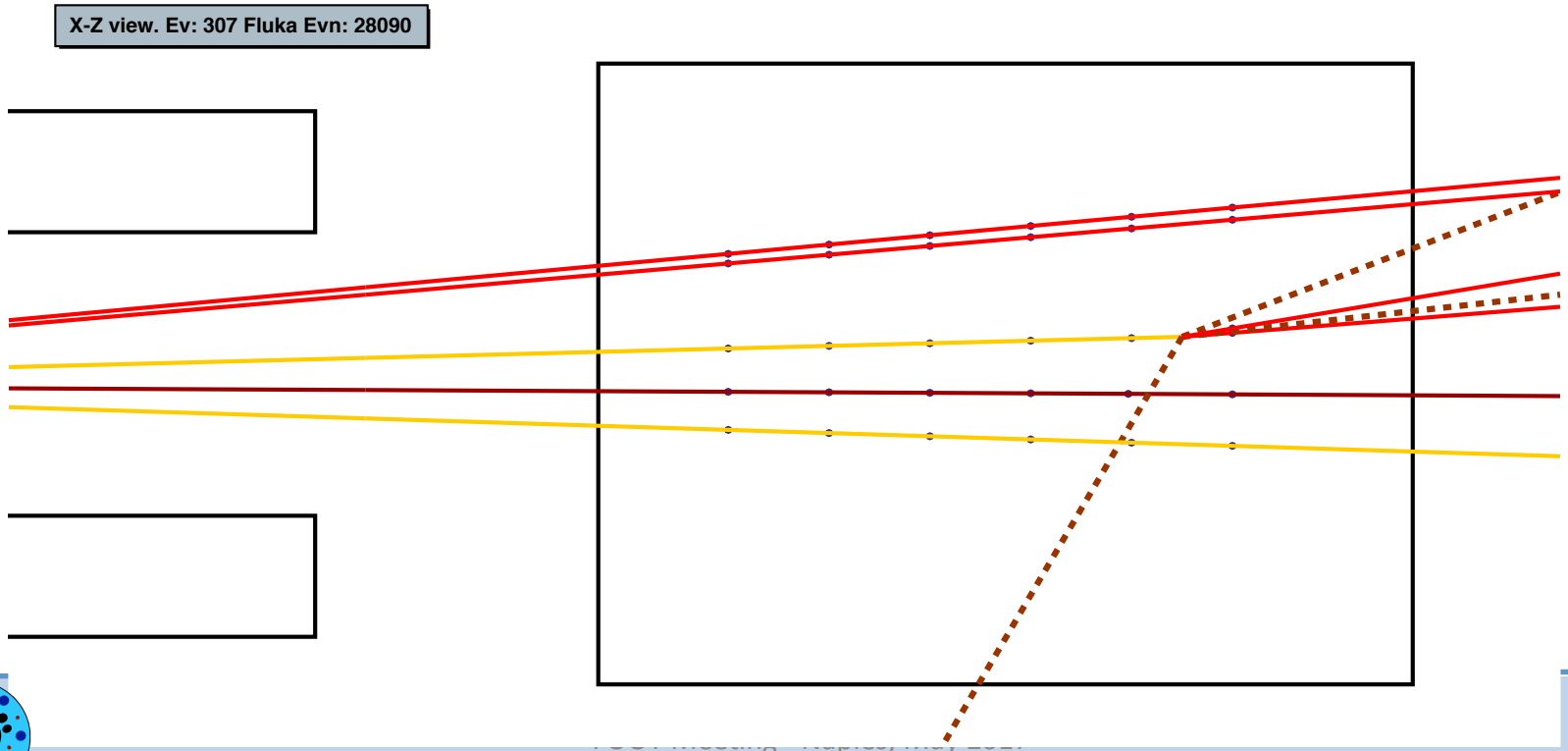

MAG_PM1
MAG_PM0
MAG_AIR
MAG_PM0
MAG_PM1
AIR
240 channels (sense wires)
1920 field wires


MAG_PM0
MAG_PM1
MAG_AIR
MAG_PM0
MAG_PM1
AIR
?
A different design?

Optimizing the design

Material choice is also important

First MC estimate: ≈0.2% of useful events have some track interacting in gas+wires+windows; ≈2% in mechanical frame (including neutral particles)



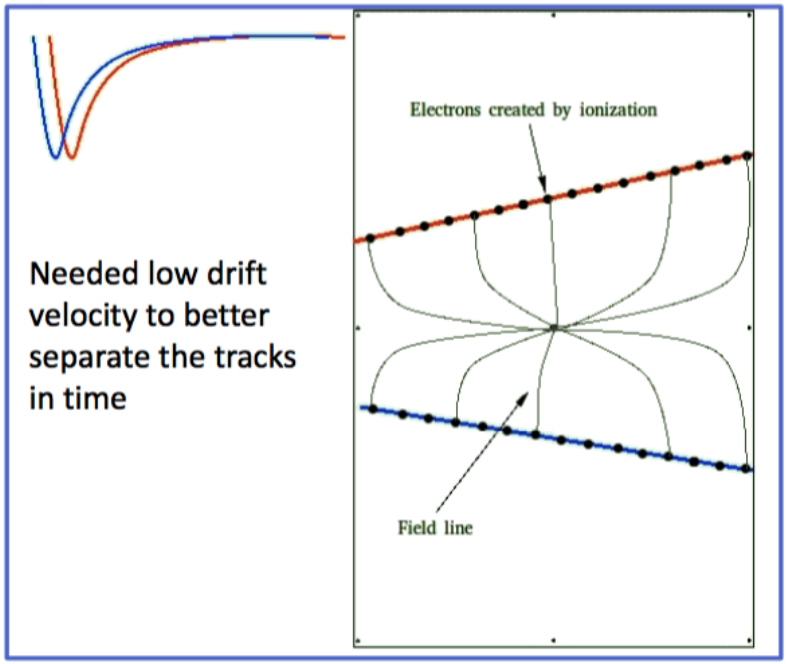
Multi-tracking

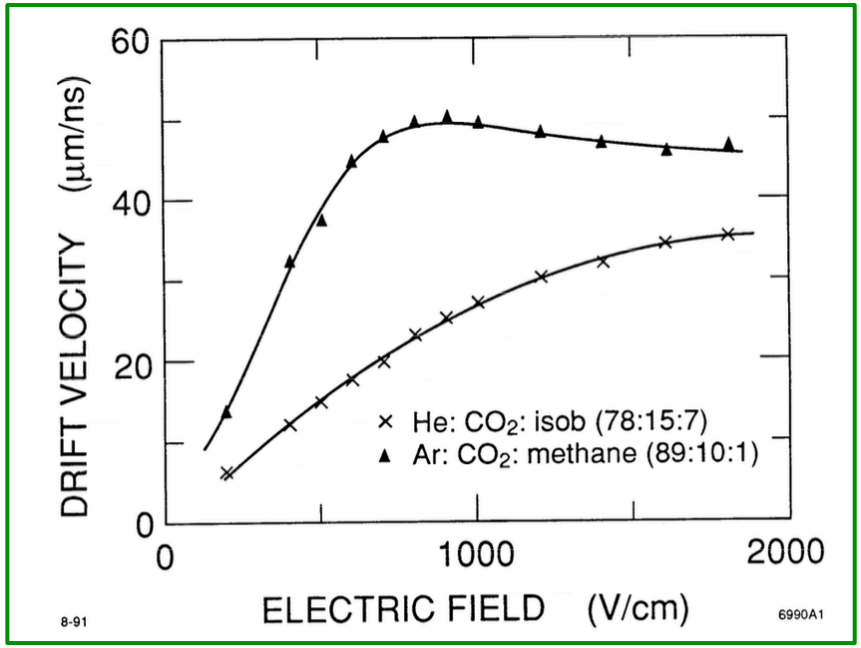
- It was **not a requirement** for FIRST DC

- **Can be optimized** by playing with:
  - Cell dimension and size, E field
  - Cells staggering
  - Gas mixture and pressure
  - TDC multi-hit
  - Reconstruction Algorithm

Multi-tracking

Few Hints on the "ideal" gas mixture
(from previous Serena's talk)

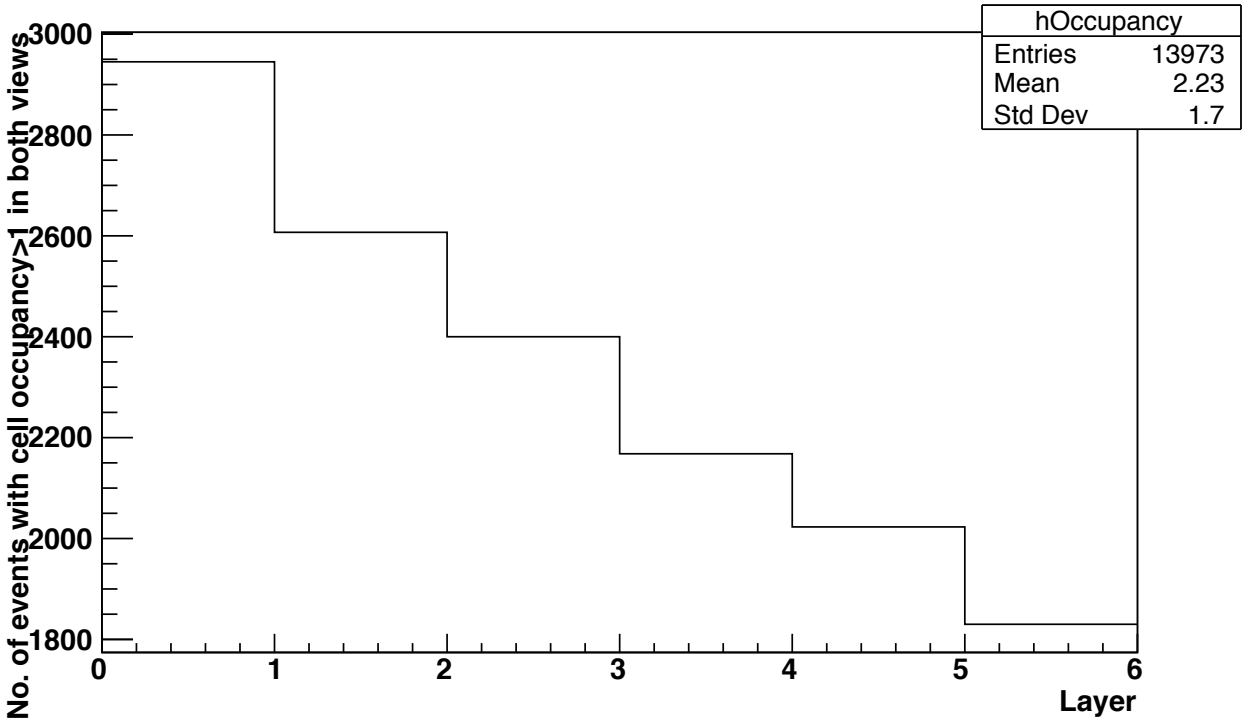




Explore different gas mixtures
- Ar-CO_2 or He-CO_2? Does He minimize fragmentation probability?

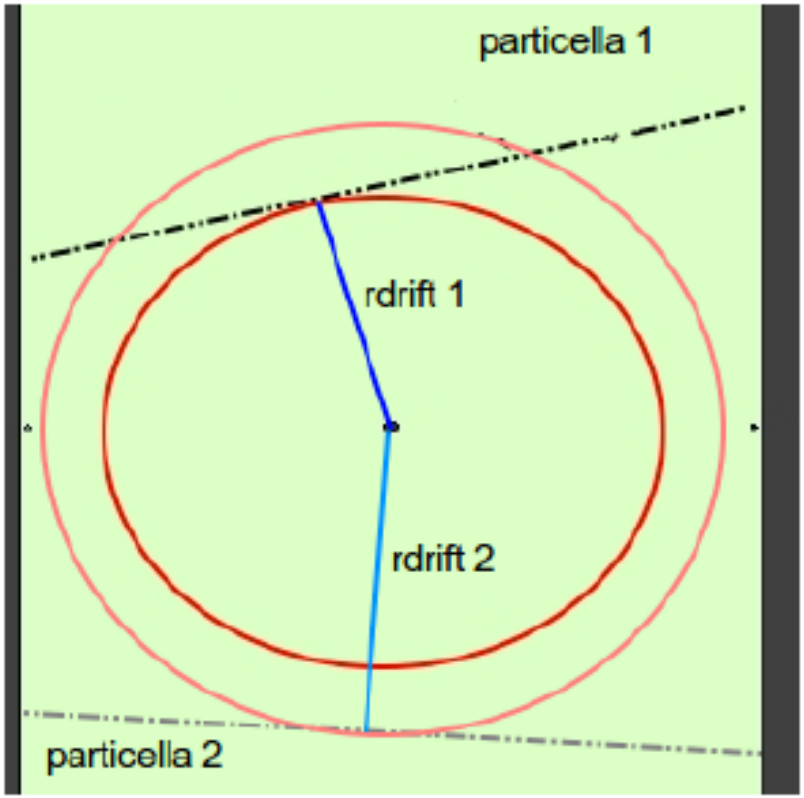
Multi-tracking

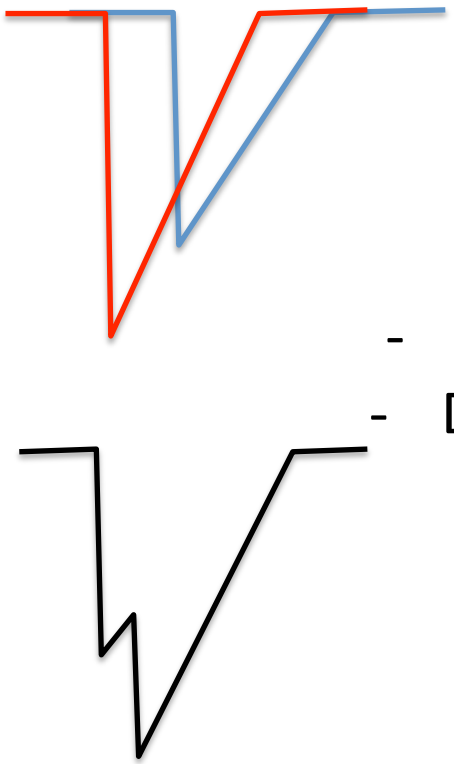
No. of events having occupancy>1 in cells of both X and Y view in the same plane as a function of layer



First rough estimate: we could distinguish multiple tracks with sufficient confidence in at least 75% of events, to be studied.

Multi-hit capability



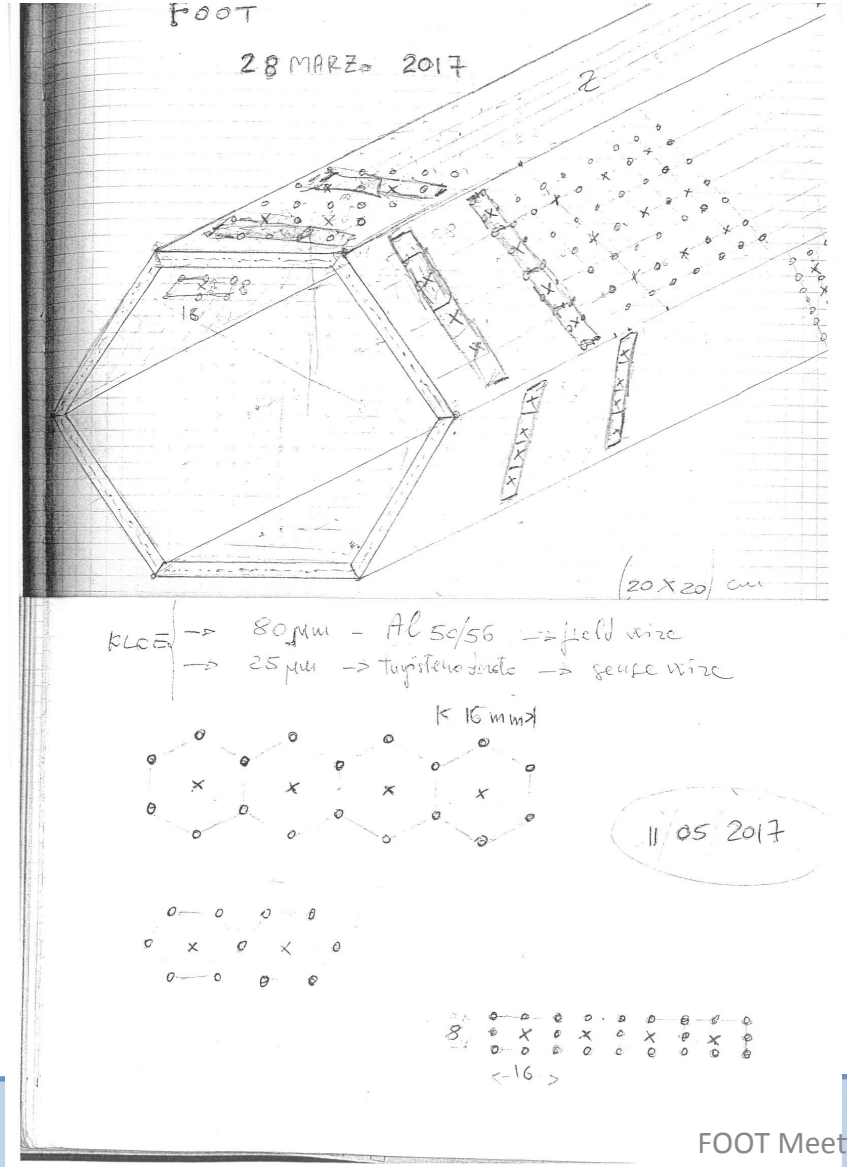


Many variables to be considered:

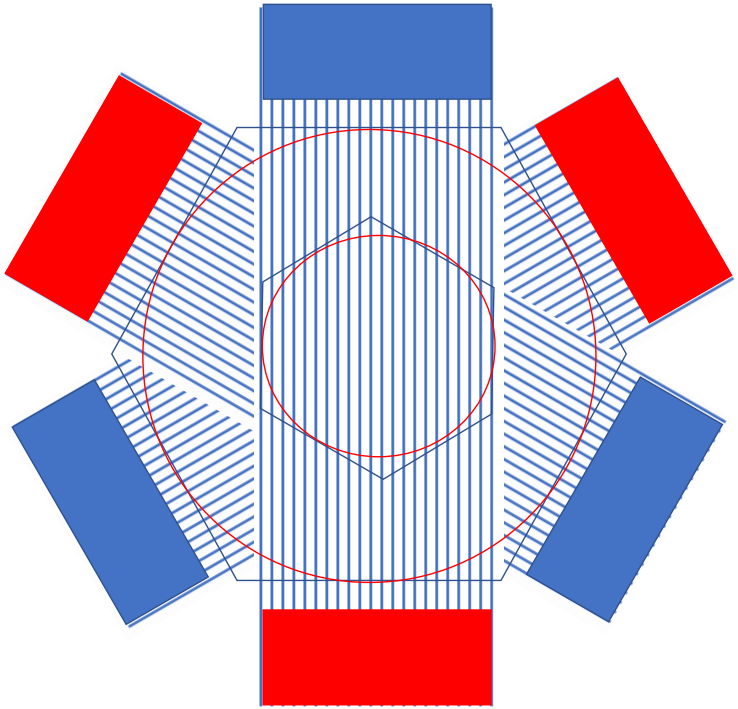
- Cell size
- V_{drift} (gas mixture+field)
- Dynamic range of signals

Not clear if we can manage…

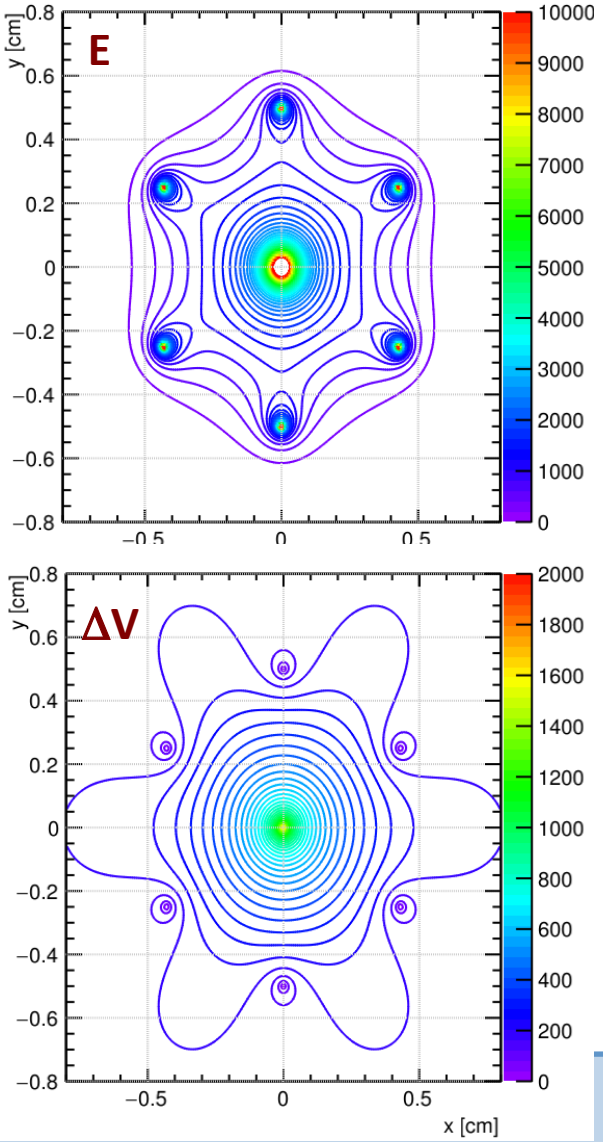
Alternative design



3-view chamber to “ease” multi-track identification



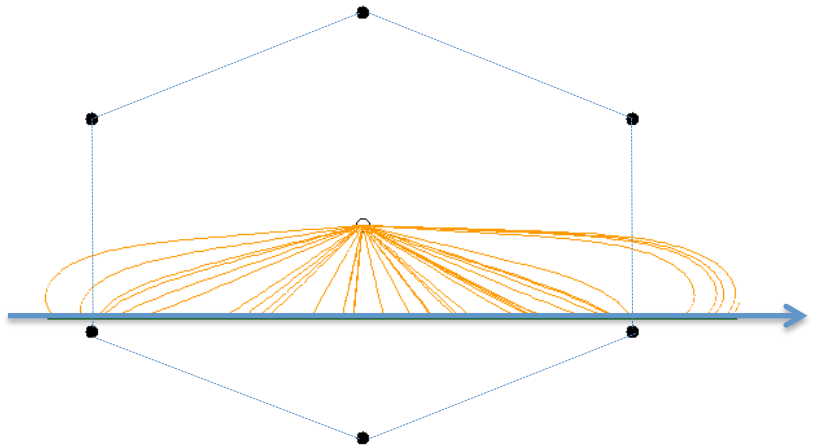
Garfield++



Simulation of ionization processes, electron/ion drift, signal generation…

Example:

- Ar/CO2 80/20
- 2000 V anode potential
- 4 GeV Muon track



Just the first steps:

- Interface with MC for ion tracking
- Play with gas mixture/HV parameters
- Extract ST relations

Conclusions

- We do not need starting from scratch: FIRST DC
- Resolution and efficiency not a big deal; **multi-tracking is an issue**

TO DO LIST:

- Extended Garfield++ studies (gas mixtures, cell geometry, ST-relations)
- Study and design of readout electronics optimized for multi-tracking
- Test beam with FIRST beam monitor (late 2017-early 2018):
  - calibration with different beams (proton, carbon)
  - benchmark of Garfield++ output

Possibile Timeline

Item	Within
Design definition:	July 2017
TDR:	Sept. 2017
Order to purchase base mechanics:	Oct. 2017
Building Mech frame:	Dec. 2017
Test beam FIRST beam monitor	Late 2017
Final Orders:	April 2018
Construction:	Oct. 2018
1st Test Beam:	Dec. 2018

Cost Estimate

1) Mechanics (materials and machining)	4.8 kEuro
2) Tooling for wiring	0.6 kEuro
3) pin + small mech. parts	3.9 kEuro
4) gas system	7.2 kEuro
5) HV power supply	5.2 kEuro
6) cables + connectors HV.	0.5 kEuro
7) front end electronics & protos:3k ; 12+2 schede 16 ch =	8k -12 kEuro
8) digital electronics + crate. 3x 5 k + crate 4k	~22 kEuro
9) Low voltage power supply	1.5 kEuro
10) Other cables (LV, signals, DAQ)	2.4 kEuro
11) Test-beam equipment	5.0 kEuro

Total: ~65 k +VAT

Thank you