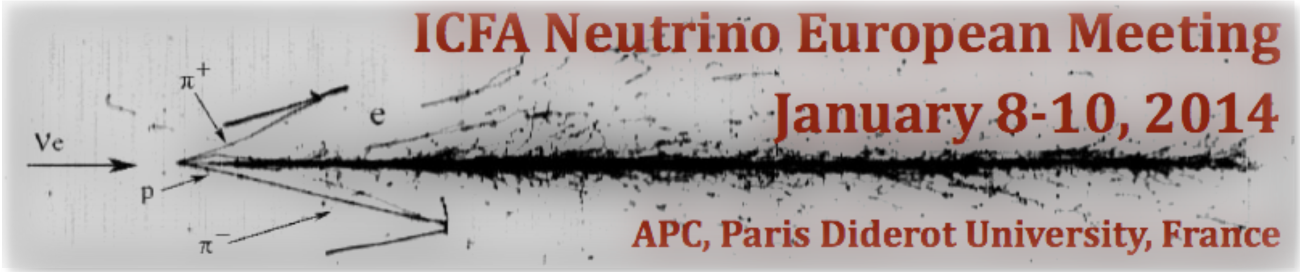


-The CERN neutrino platform-

WA104 – NESSiE Air Core Muon spectrometers

Laura Patrizii (INFN – Bo)
on behalf of the NESSiE Collaboration

CERN Neutrino "Platform"

- enable large scale detector development and tests for neutrino detectors:
  WA104 refurbish ICARUS T600
  R&D on new Large LAr detector ("ICARUS++")
  R&D for air core muon detector
  WA105 R&D on 2-phase LAr prototype

- study for a neutrino (test)beam in the North Area started

- …

WA104 - Air Core Magnet Spectrometer

- Aims
- Design
- Magnetic fields
- Expected Performances
- Prototyping and Tests

Aims

Momentum measurement and charge Id of muons from CC ν interactions (in LAr) in sub-GeV $< E <$ 10 GeV range

(relevant to disentangle the nu anomalies in nu, anti-nu channels)

R&D focused on:

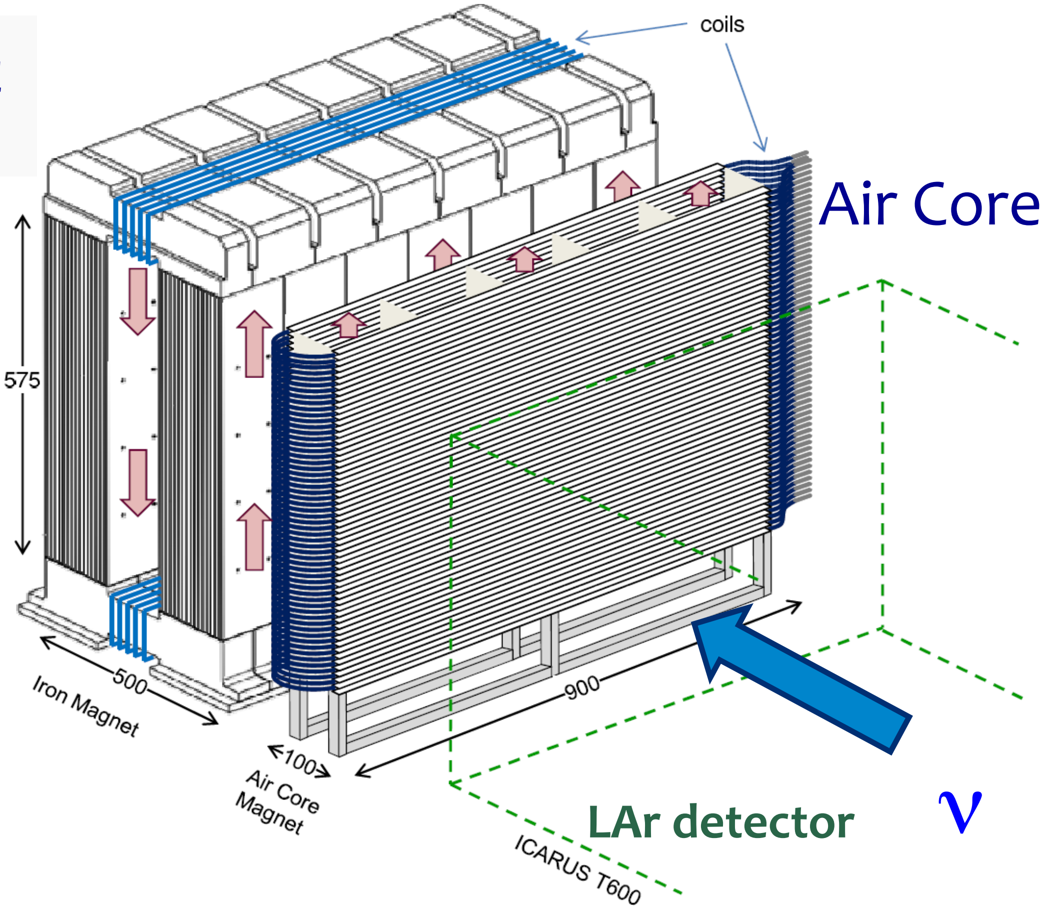
•LAr detector magnetization: the best way- not discussed here, but part of the R&D program

•The "realistic, conservative" approach : an Air Core Magnet spectrometer coupled to multi-layer Iron Core Magnet spectrometer

The NESSiE way

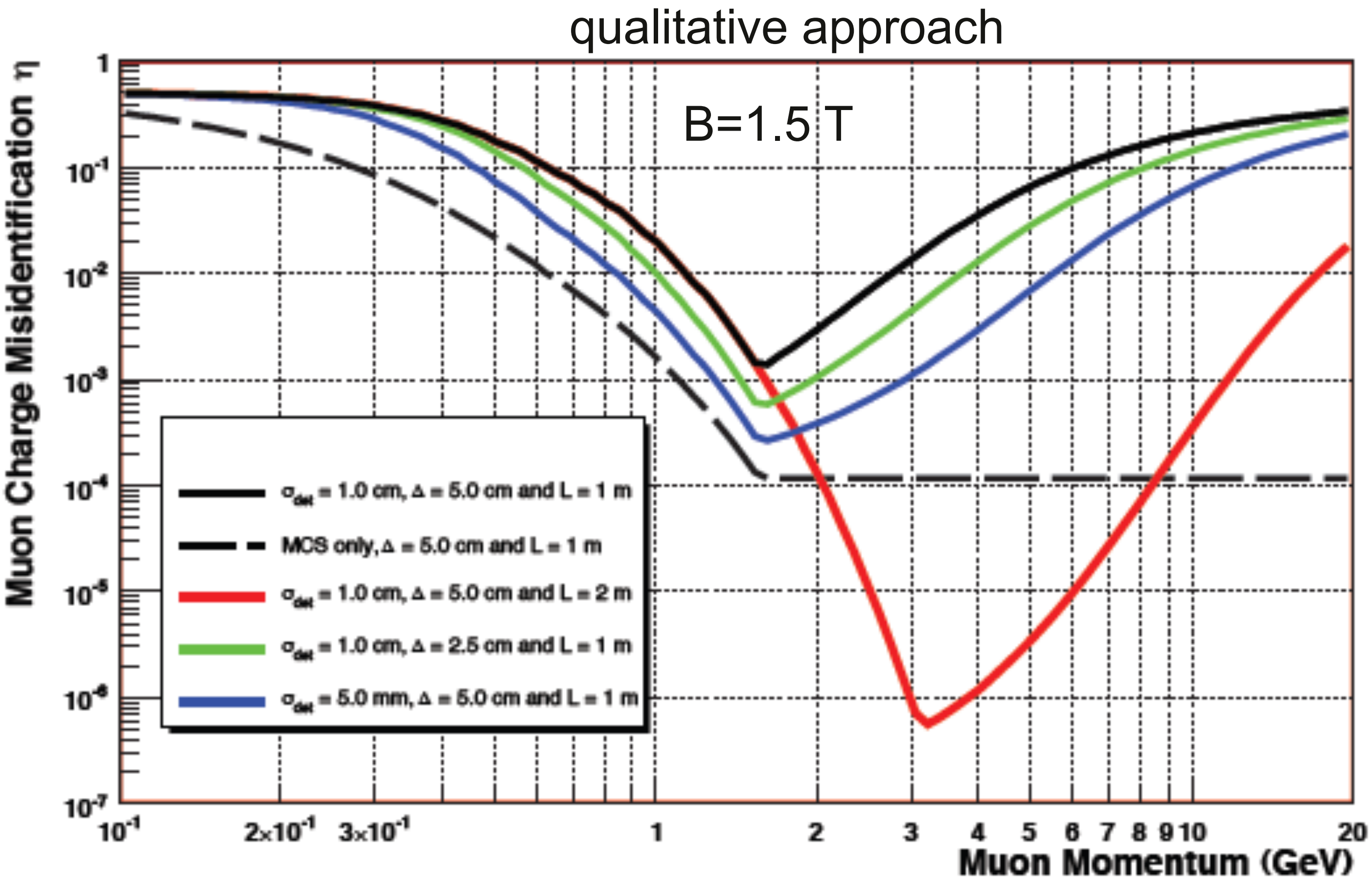
A system of Light & High density Muon Spectrometers downstream an (active) target

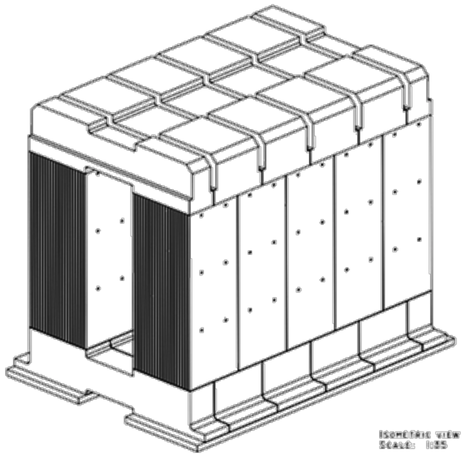
Iron Core Magnet
(à la OPERA)



The issue at low energy (0.5÷1 GeV)

Iron Core Spectrometer





The ACM design/1

Main goal

- charge mis-identification better than 3% at 0.5 GeV

Main Assumed Constraints:

- Power Consumption
- Amount of Material in the Beam Direction
- Costs

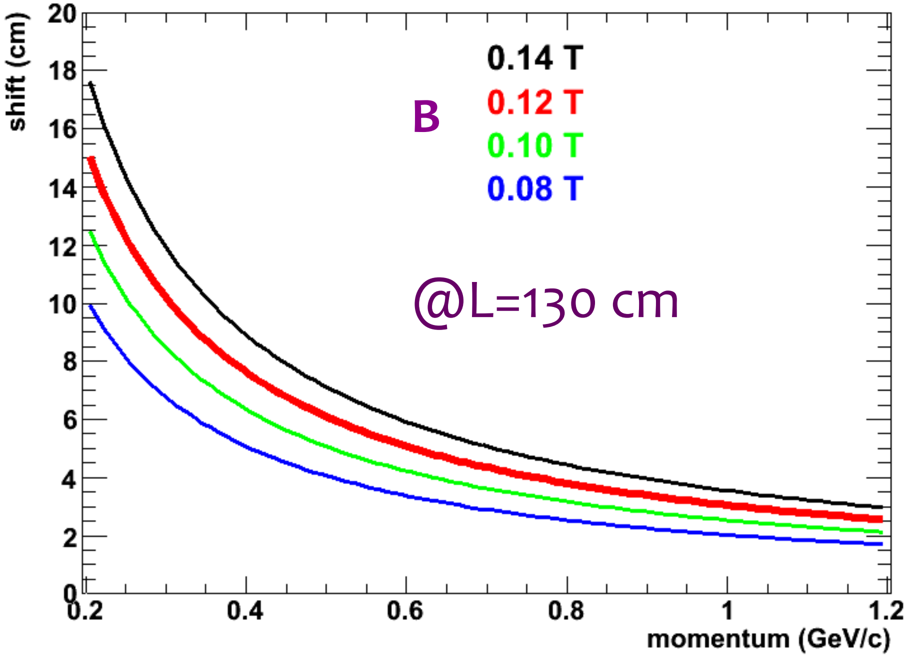
Relevant Parameters Optimization:

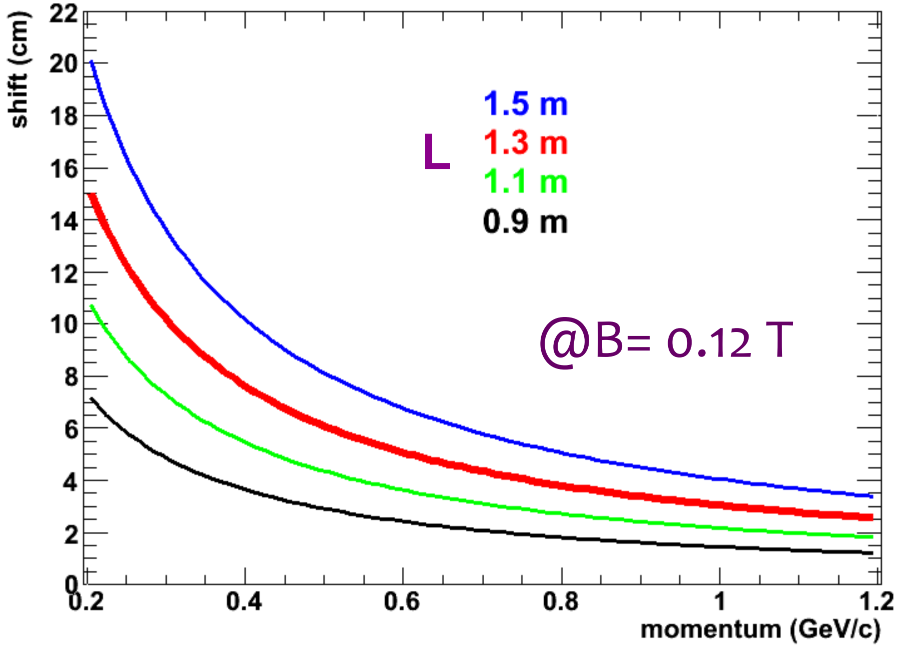
L : Magnetic Volume Depth L = 130 cm

B: ~ 0.1 T

Conductor : Aluminum

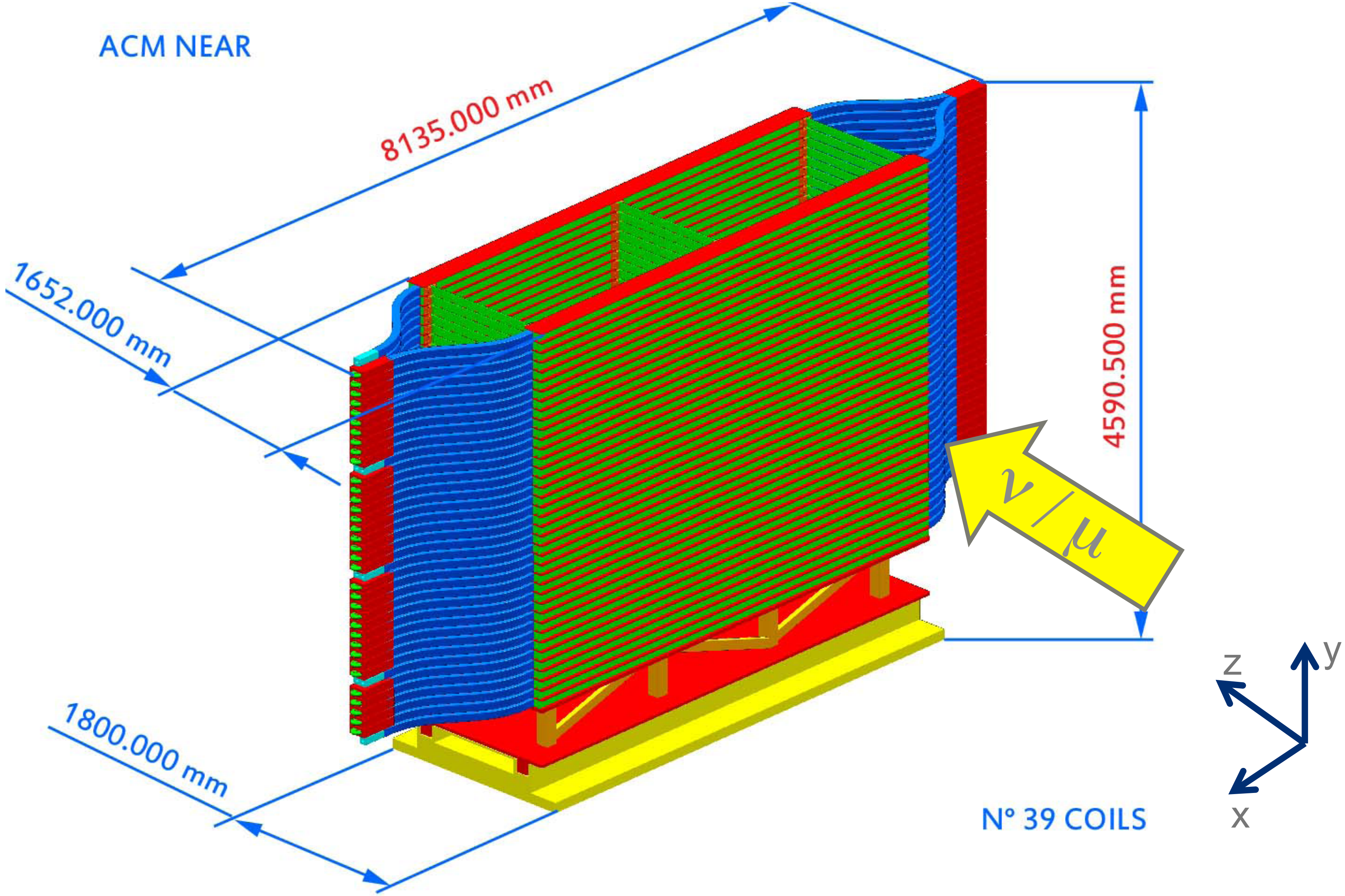
Detector resolution ~ 1 mm





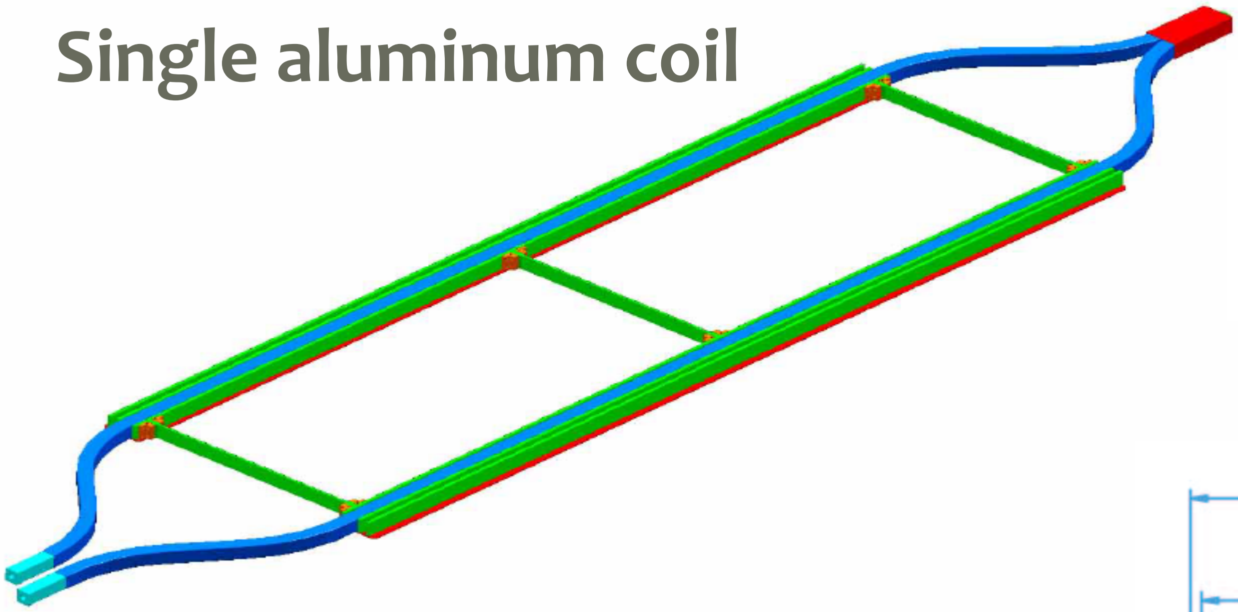
Displacement of muon trajectory in the bending plane

The ACM design/2



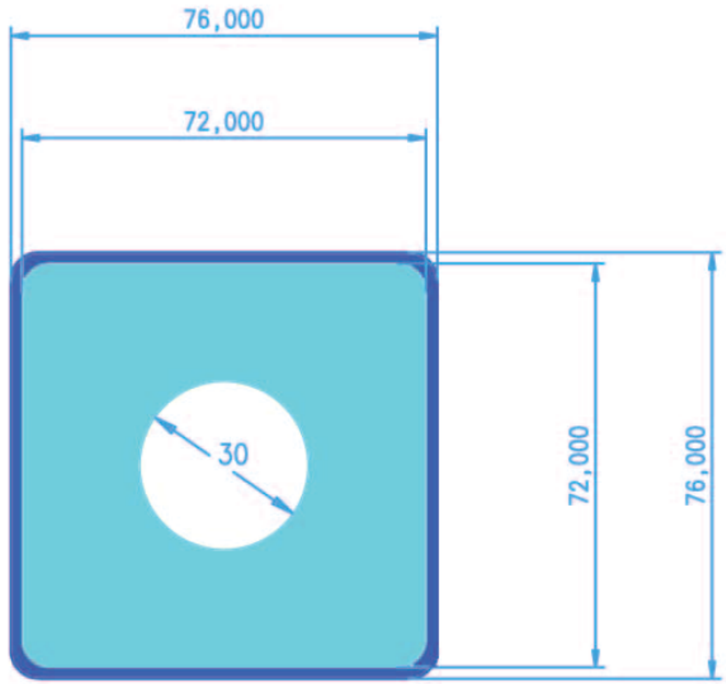
The ACM design/3

Single aluminum coil



Conductor: Al
Coil Cross Section 72x72 mm²
Hole (cooling) = 30 mm Ø

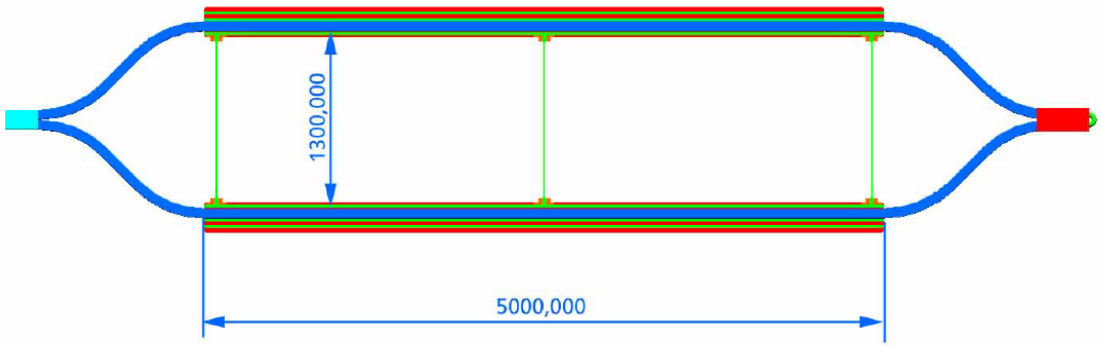
Cross-section

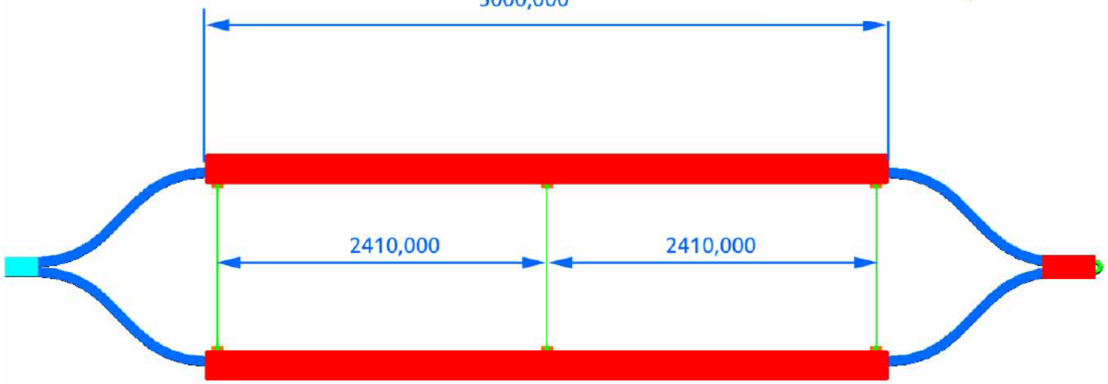


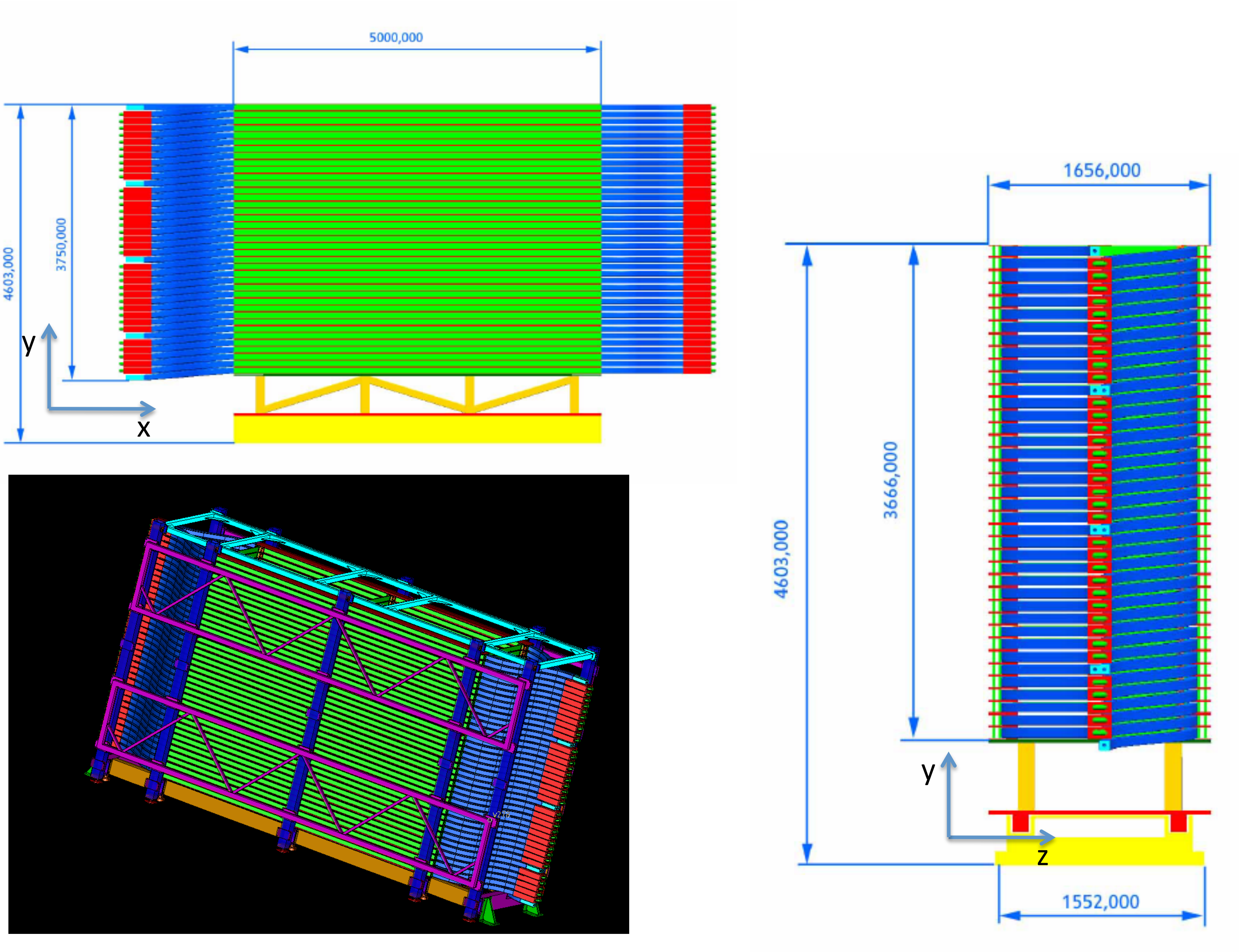
NESSiE ACM	
Nb of coils	**39**
Conductor Length/coil	14,8 m
Current density	2 A/mm^2
Total power	**250 kW**

(conditionally) funded Prototype 13 coils

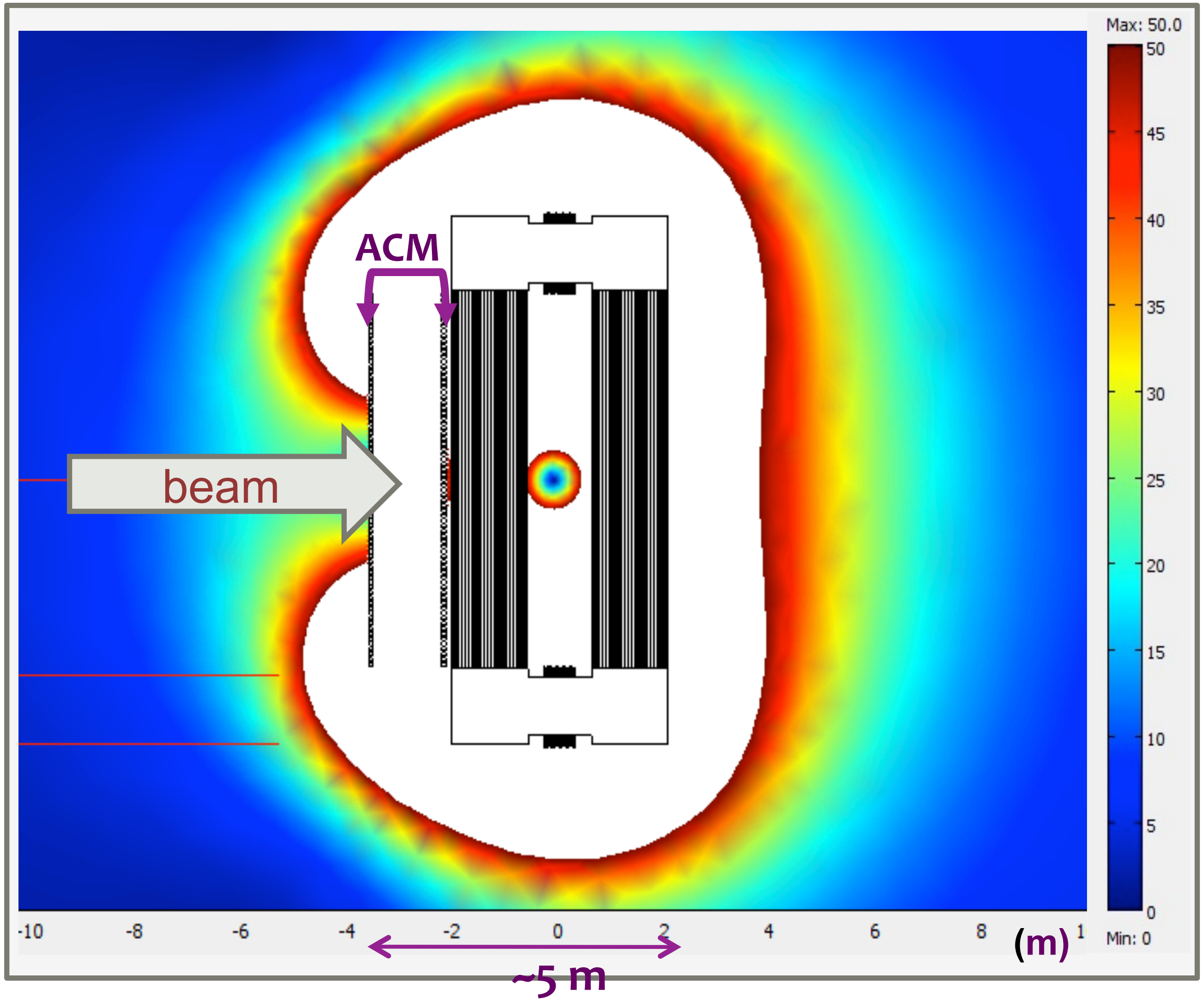
Internal area for detectors
130 cm x 241 cm x 2






5000,000
4603,000
3750,000
y
x
1656,000
4603,000
3666,000
y
z
1552,000

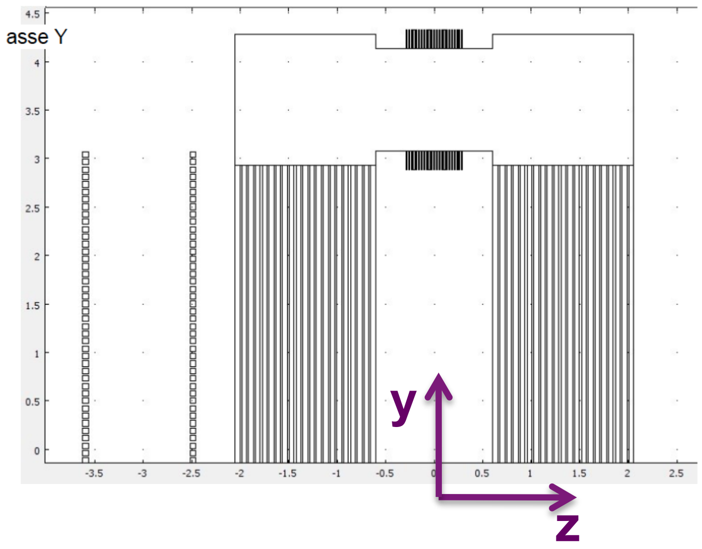
The ACM+ICM magnetic fields



B < 50 G :color scale

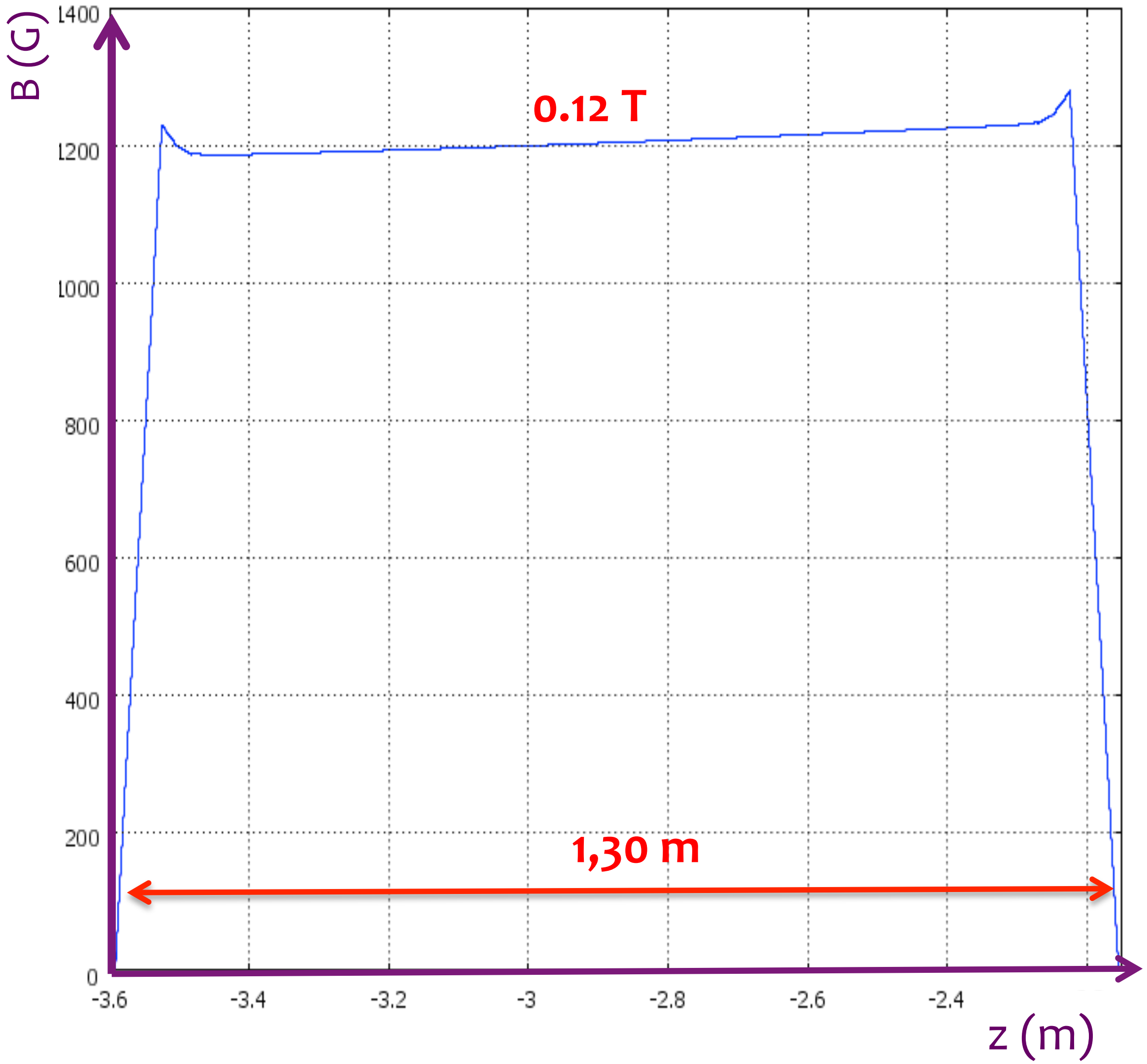
B > 50 G : white

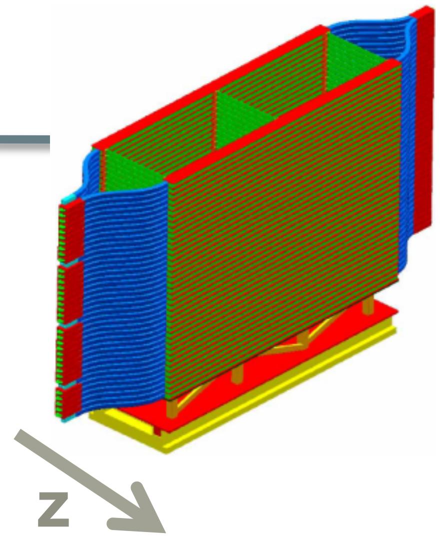
$B_{ICM} = 1.4$ T



The magnetic field in the ACM Volume

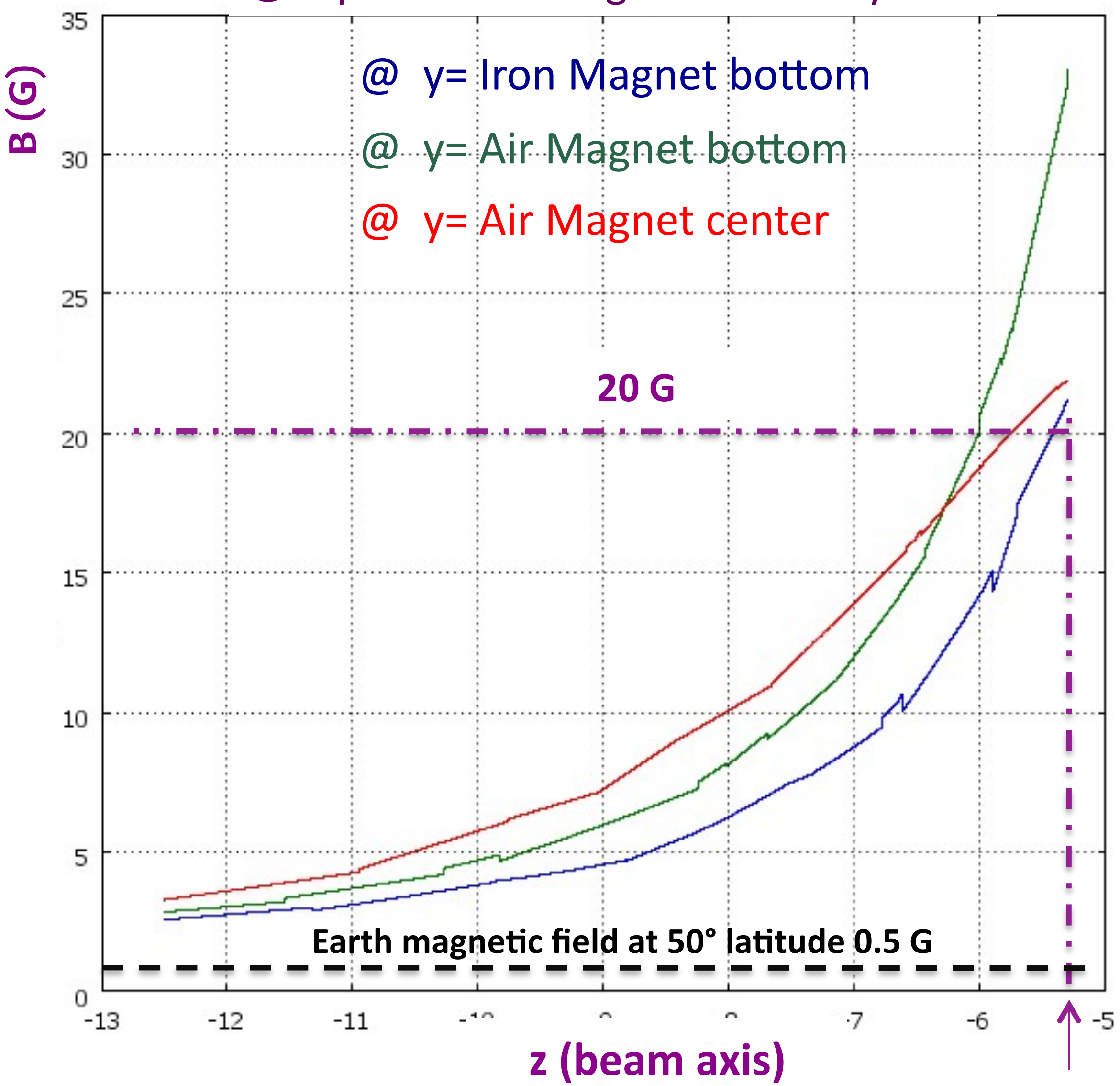
along the z (beam) axis

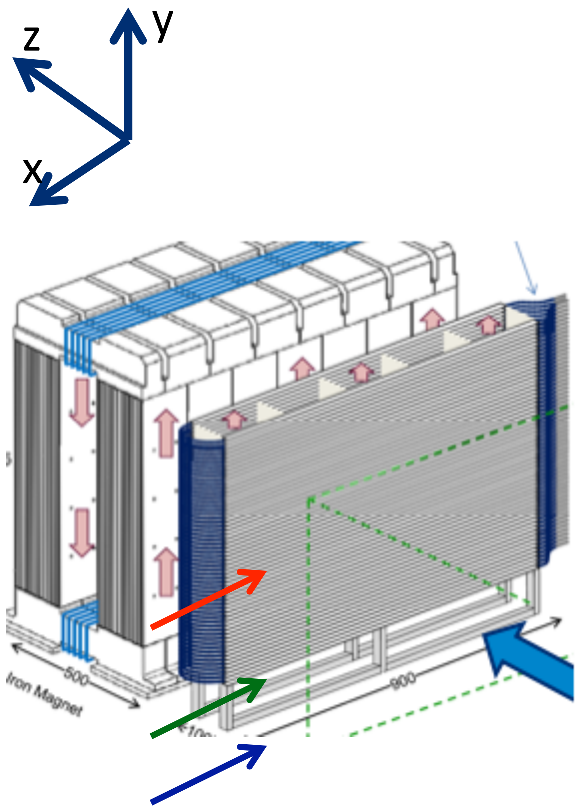




Fringe Field upstream the ACM

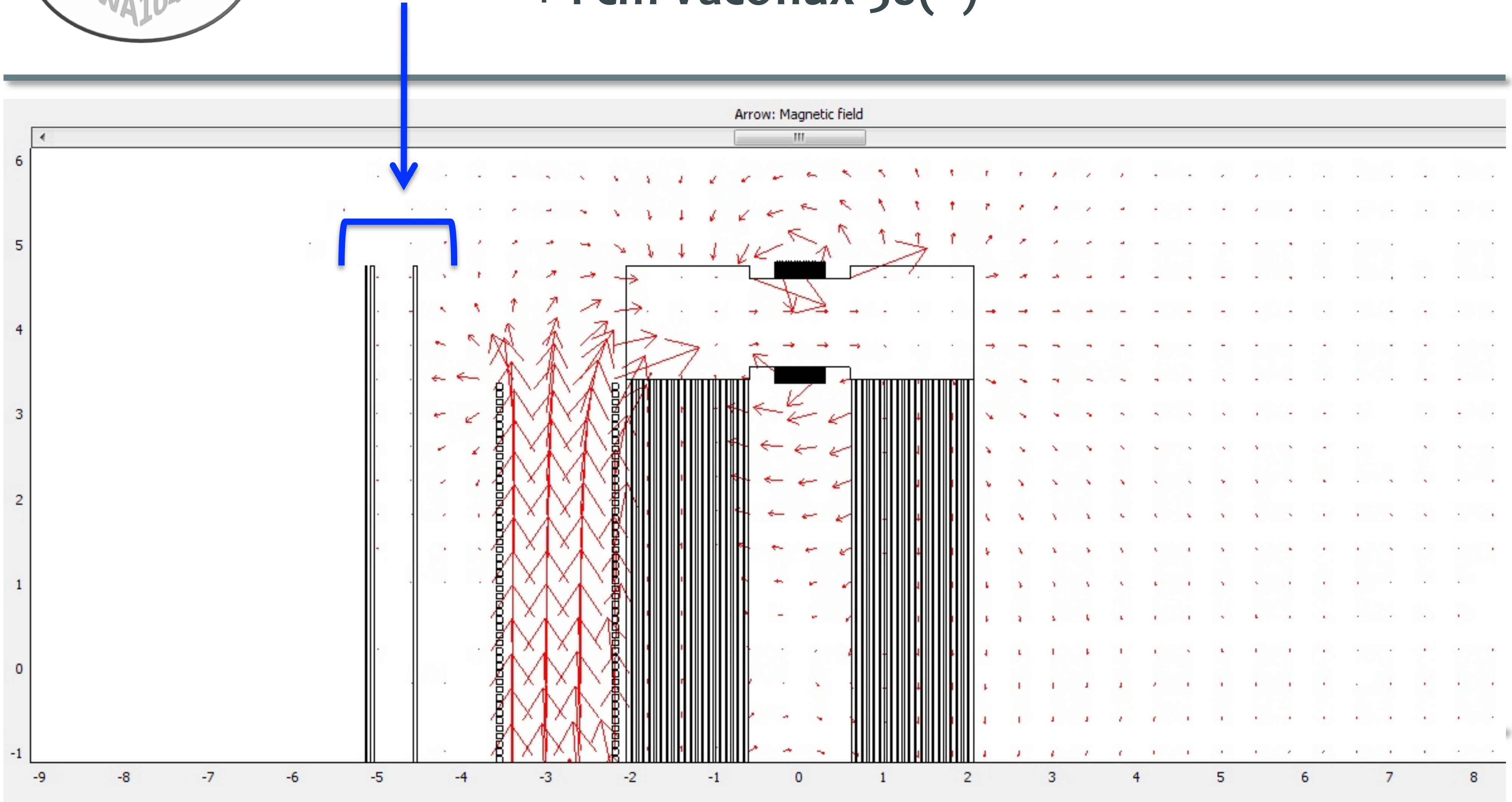
@ 3 positions along the vertical y axis





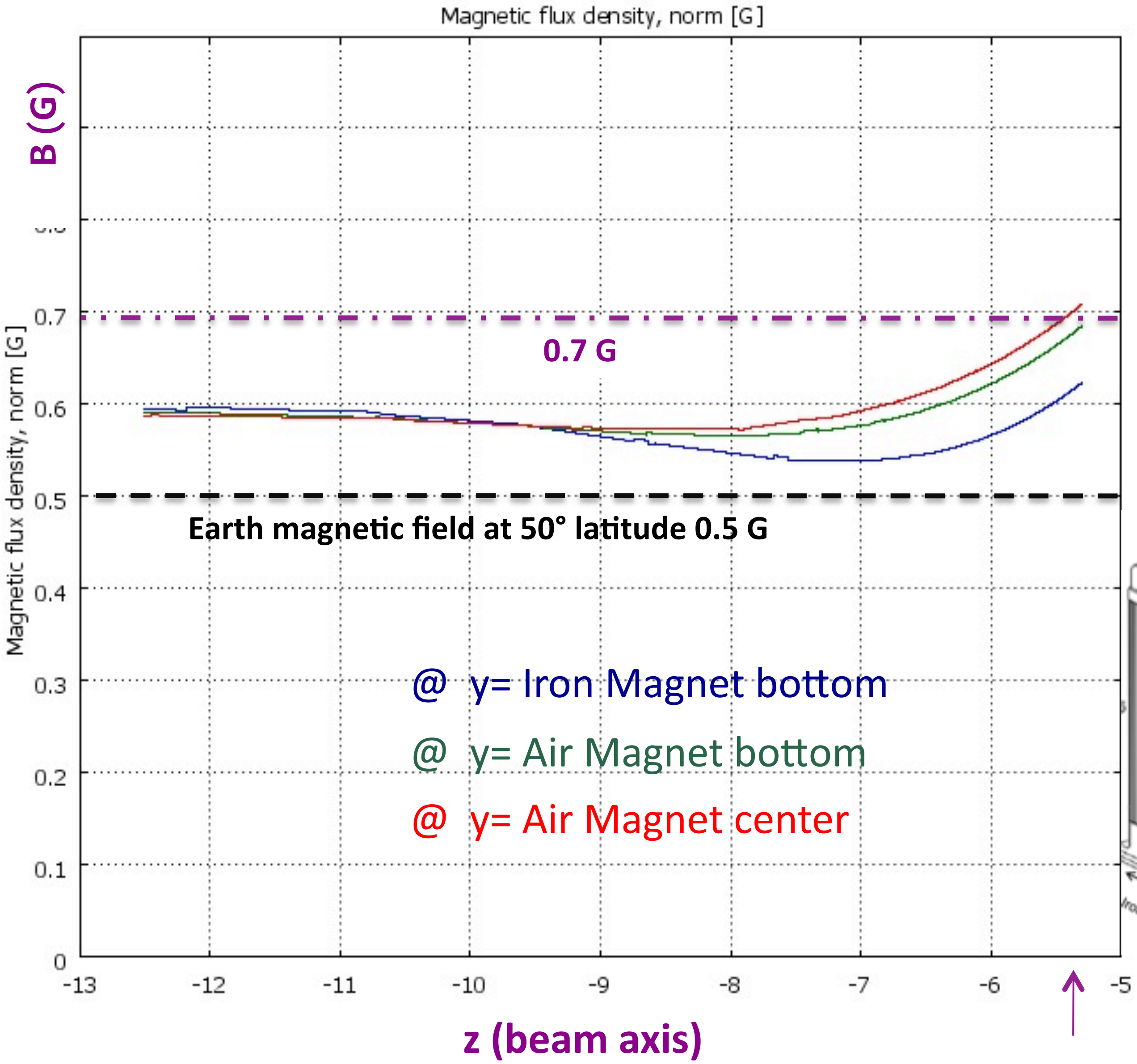
2 m distance from the ACM

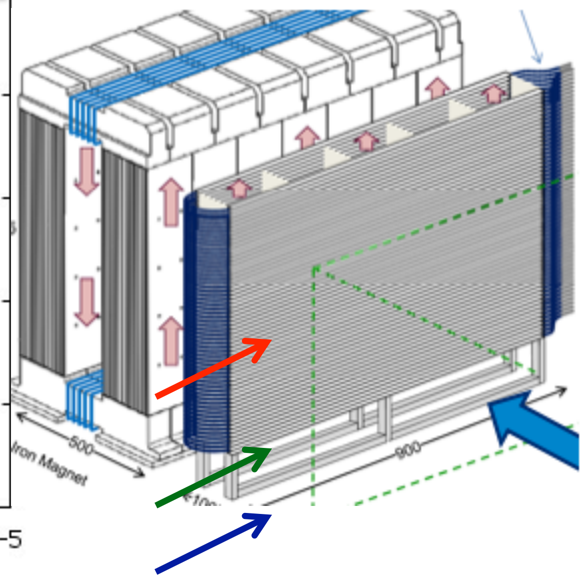
by Shielding with 2 Iron slabs (5 cm thick) + 1 cm Vacoflux-50(*)



(*) Cobalt-Iron Alloy- maximum saturation at 2.35 T –

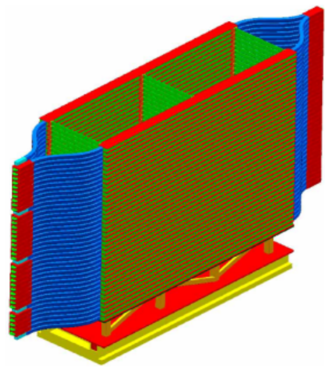
Fringe Field upstream the ACM (by shielding)



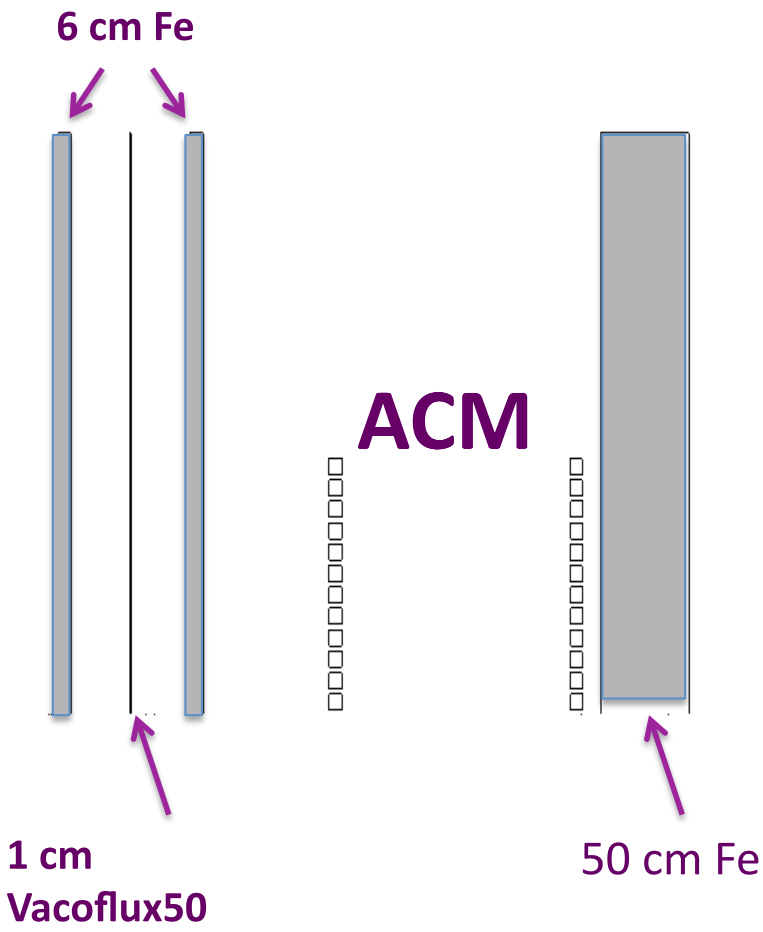


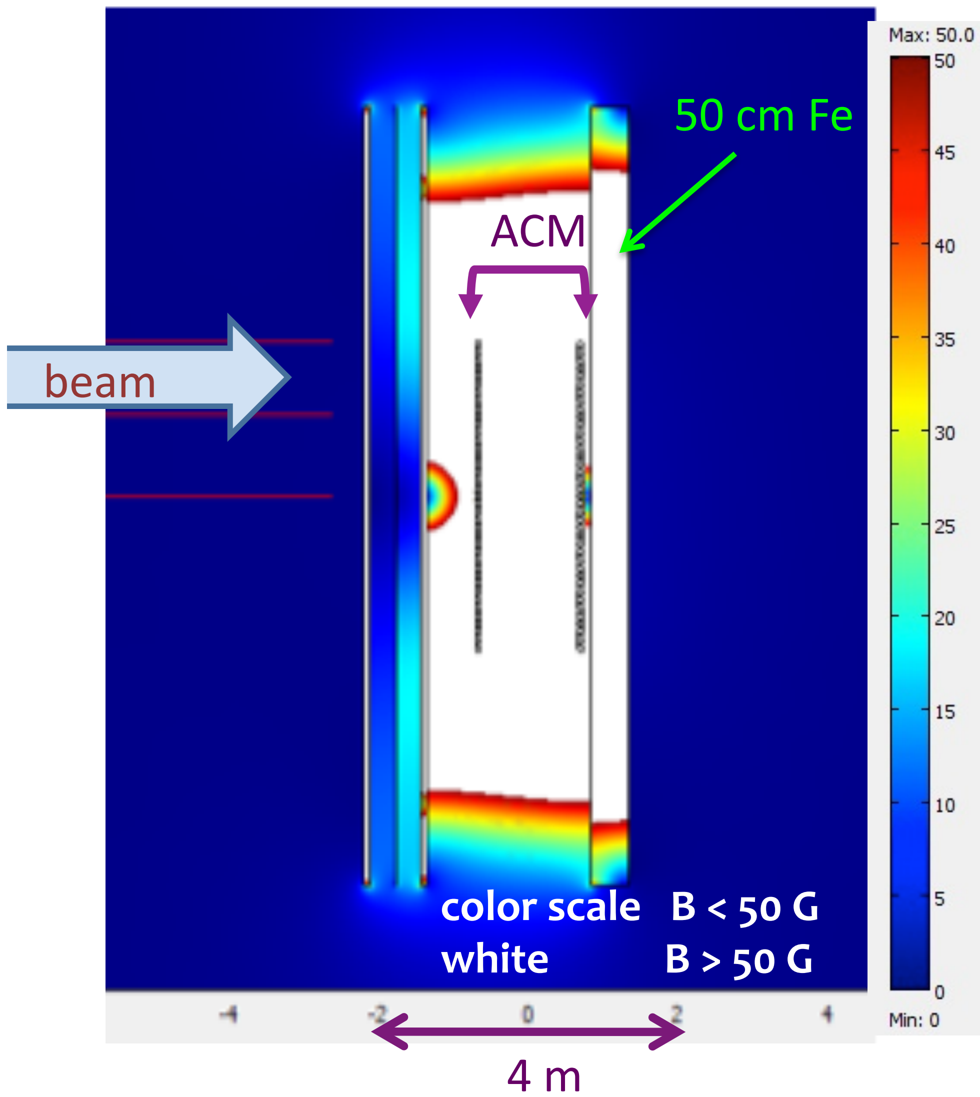
2 m distance from the ACM

The ACM in a “stand-alone” configuration (no ICM)

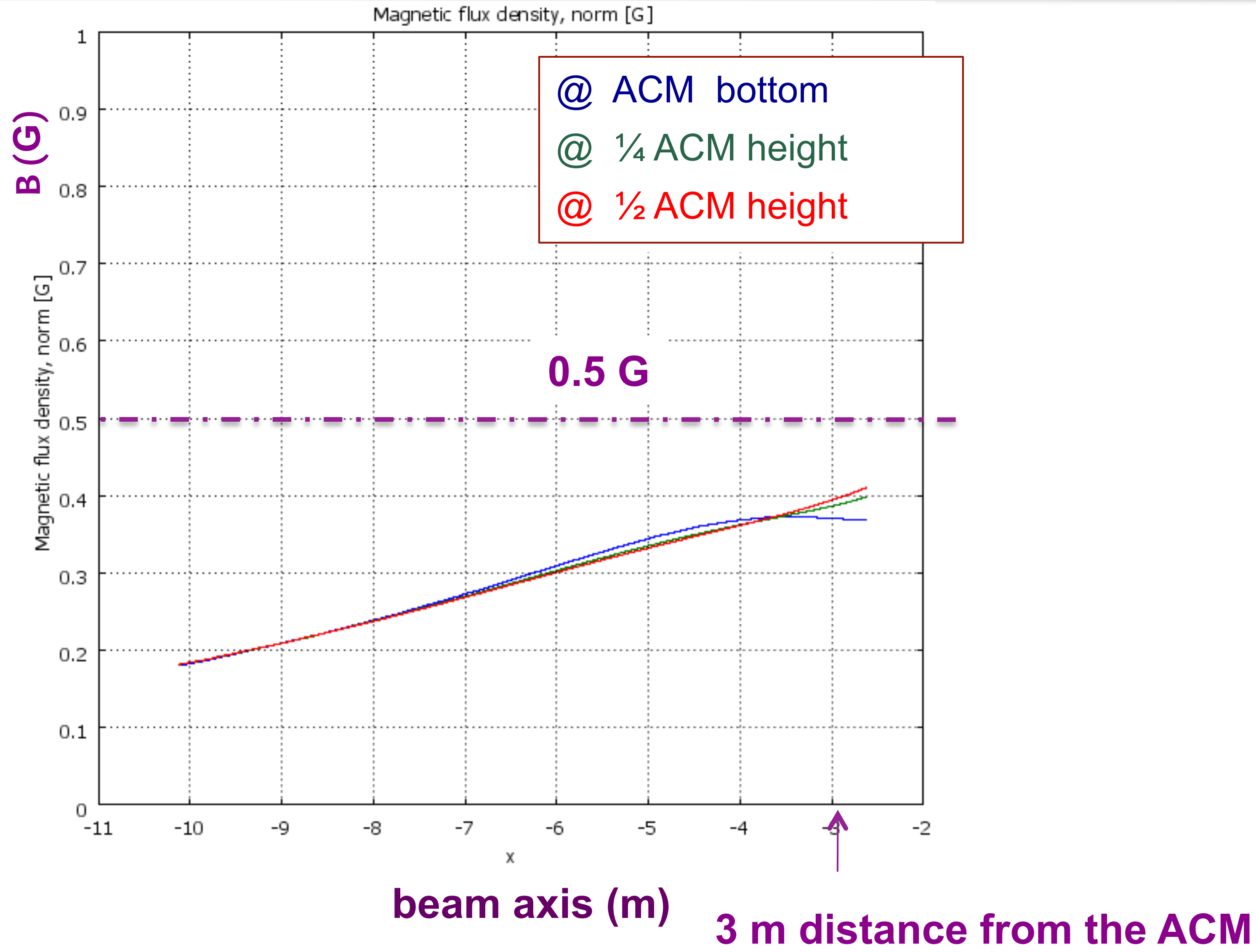


NESSiE - ACM

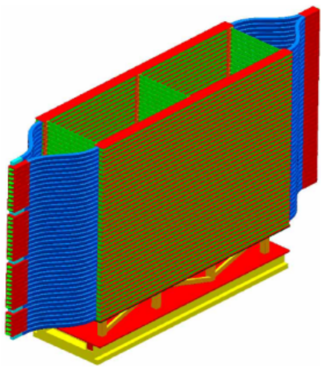




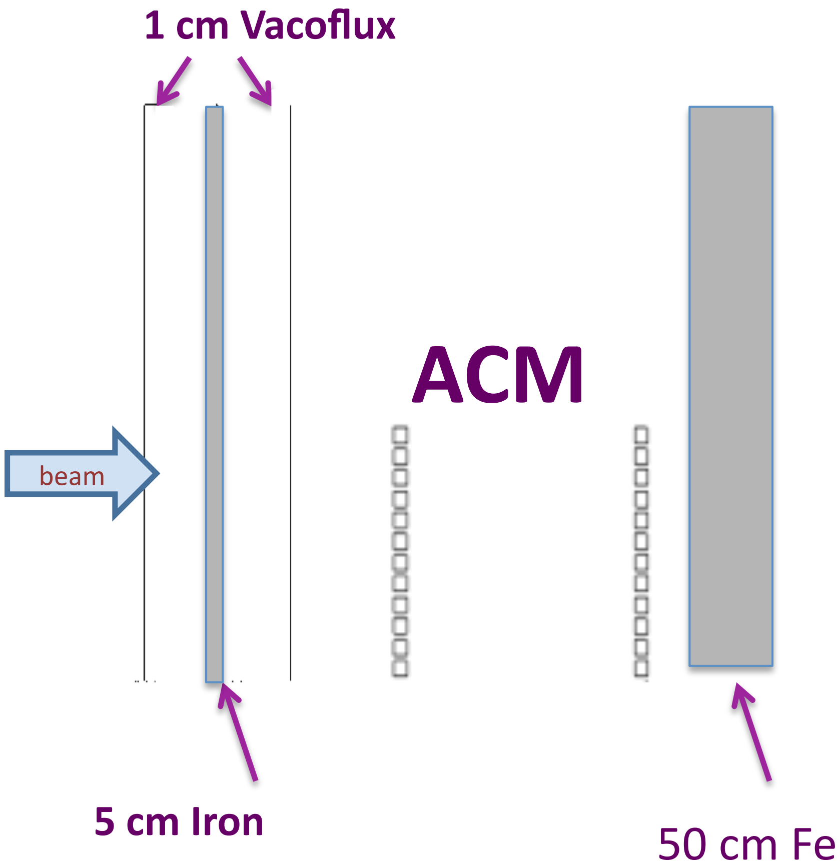
Fringe Field upstream the ACM (standalone)



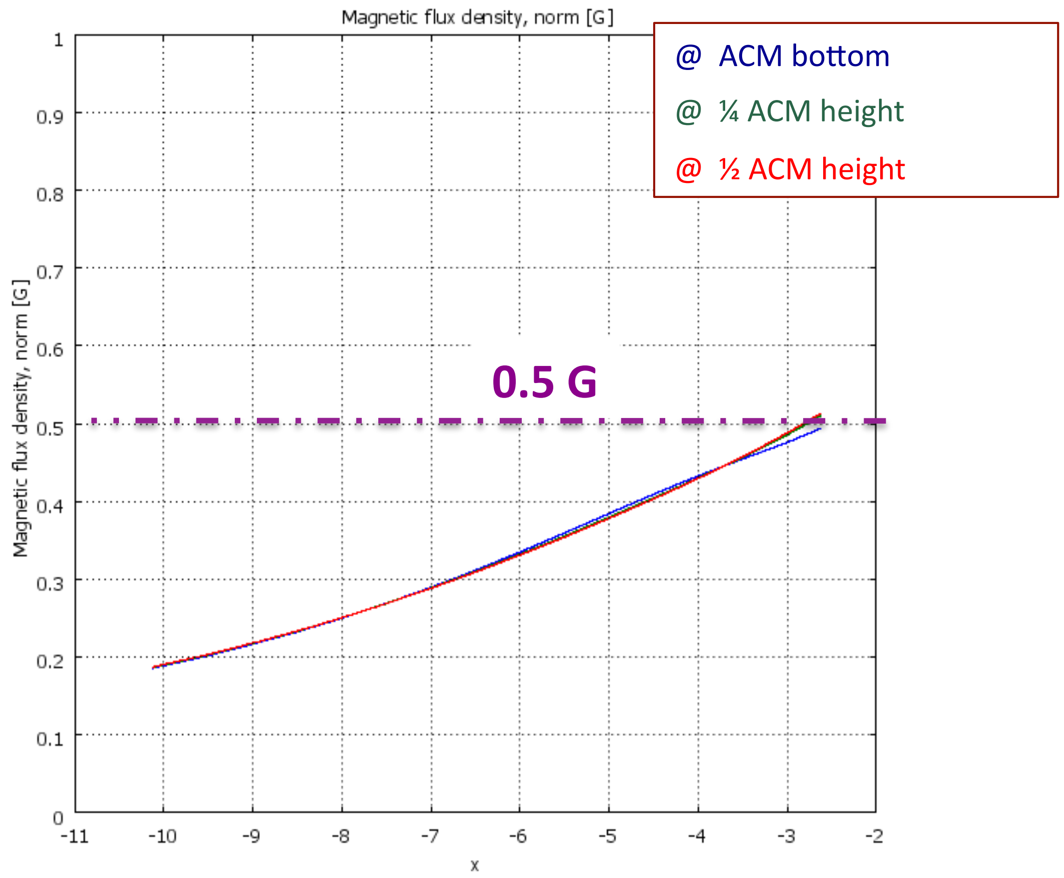
another shielding set-up



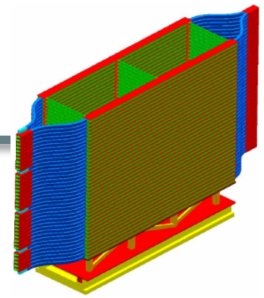
NESSiE - ACM

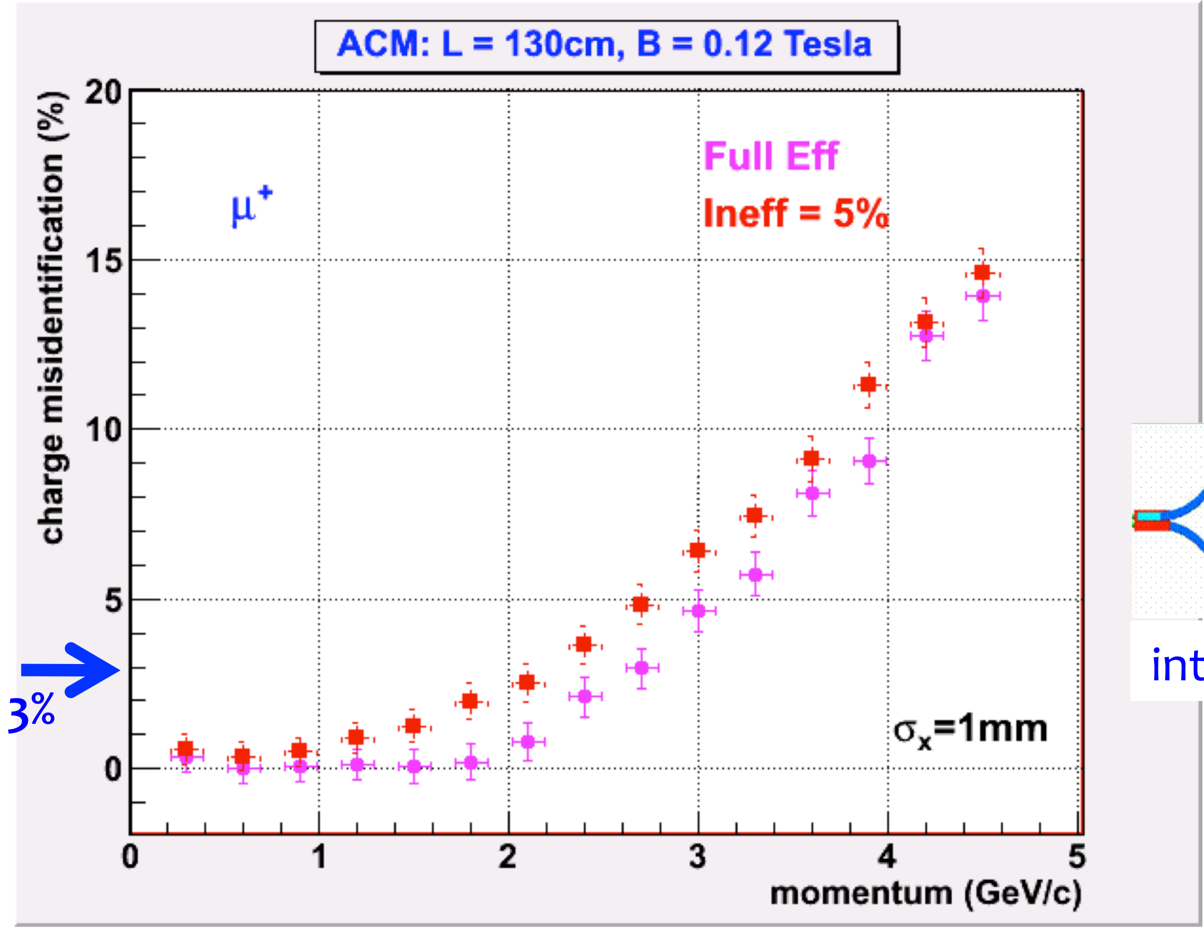


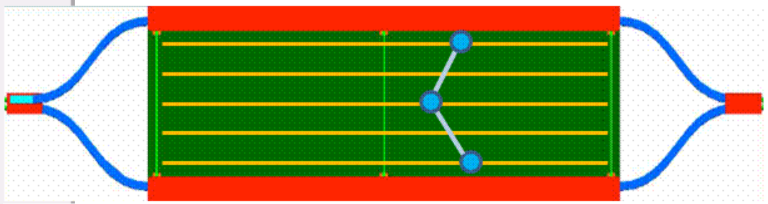
Fringe Field upstream the magnet



Charge Mis-Id with the ACM

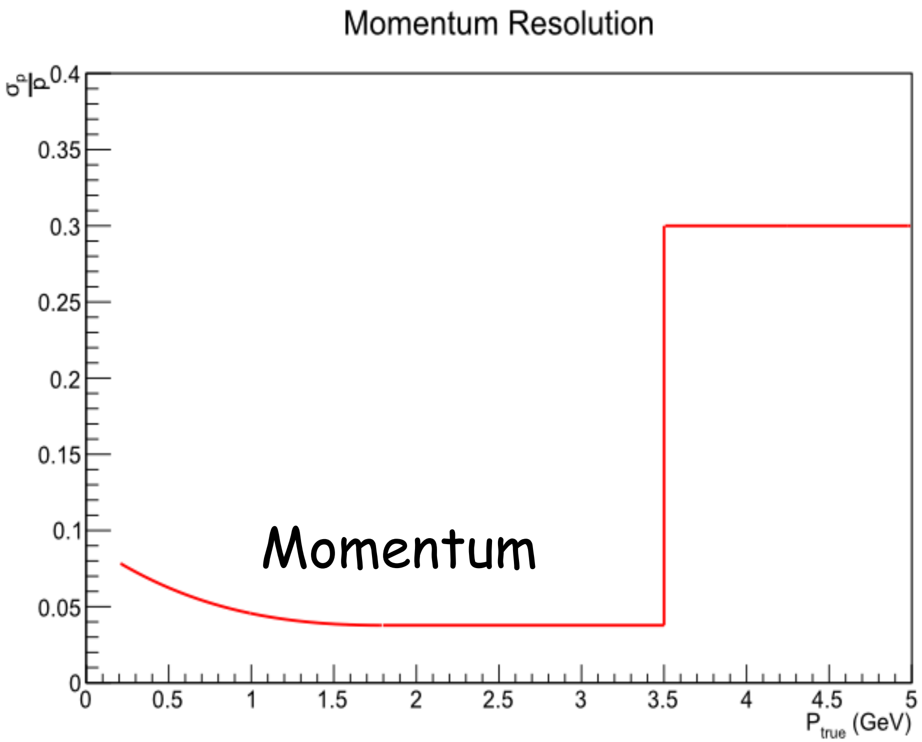


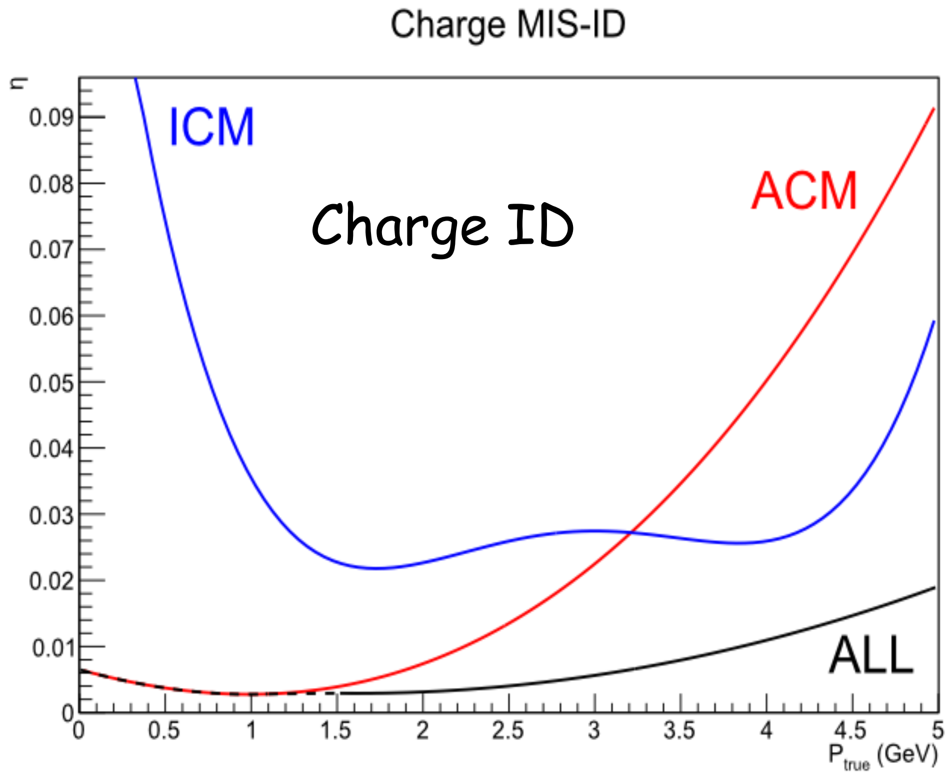


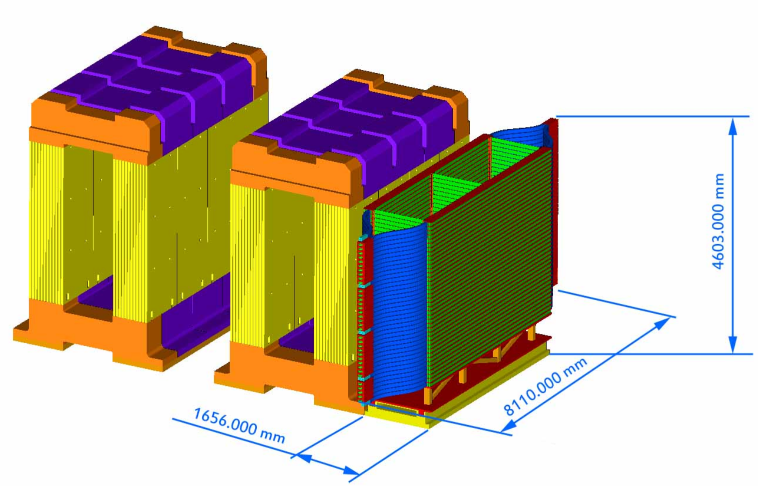


internal detector planes, $\sigma_x \sim 1$ mm

Best, ever, sensitivity for μ detection with similar apparata over large area

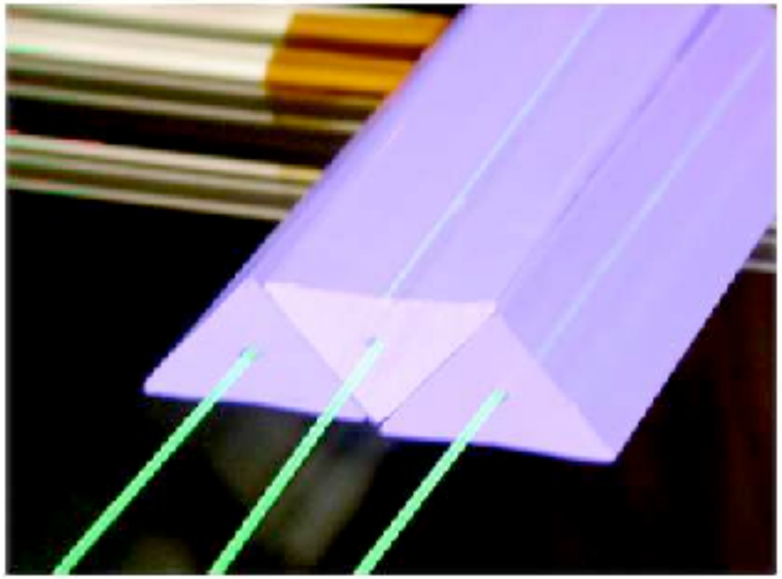






Momentum measured by range (ICM) up to 3.5 GeV,
then ACM and ICM provide ≈30%

R&D on High Precision Detectors



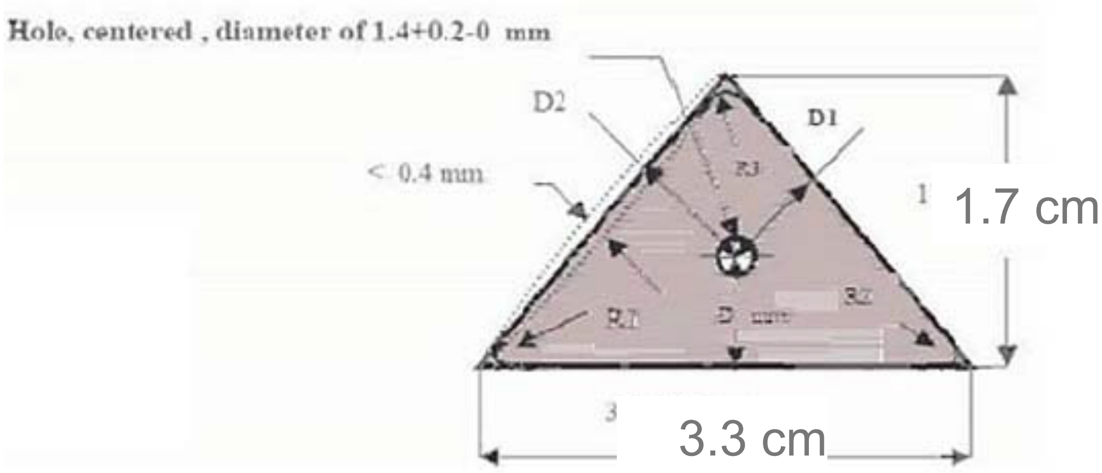


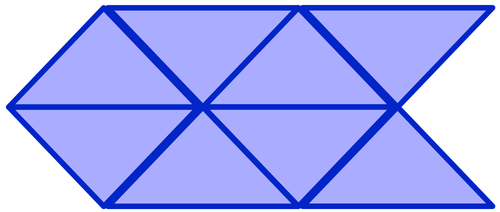
Figure 51: Specification for MINERνA's inner-detector scintillator extrusions.

AIM: ~1 mm resolution

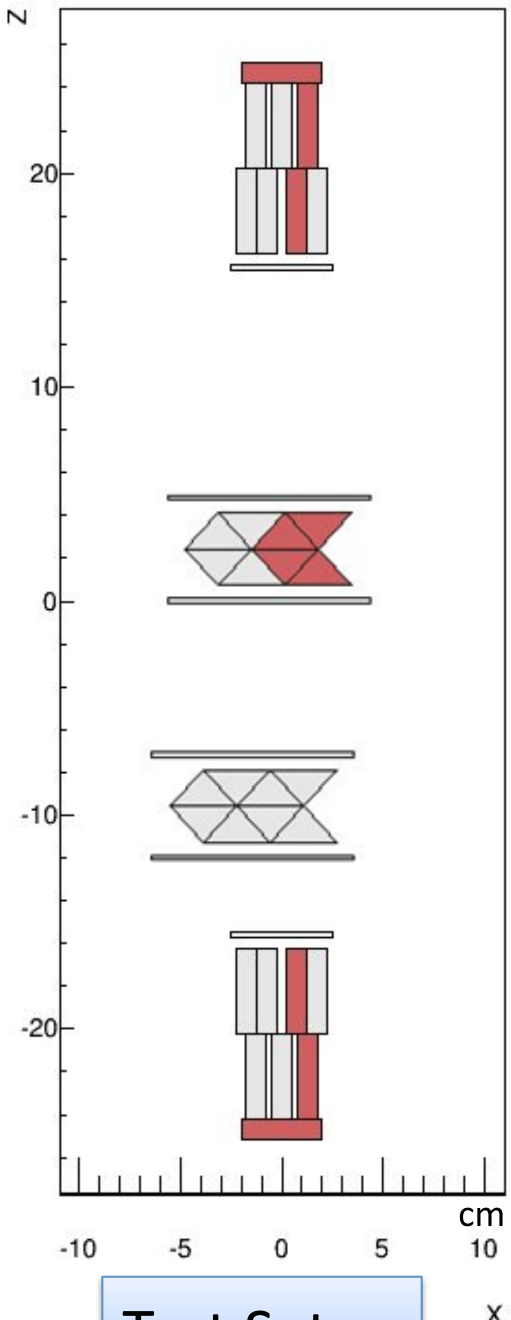
-extruded triangular scintillator bars (à la Minerva)

-embedded WLS fibers

-SiPM SenSL in analog readout

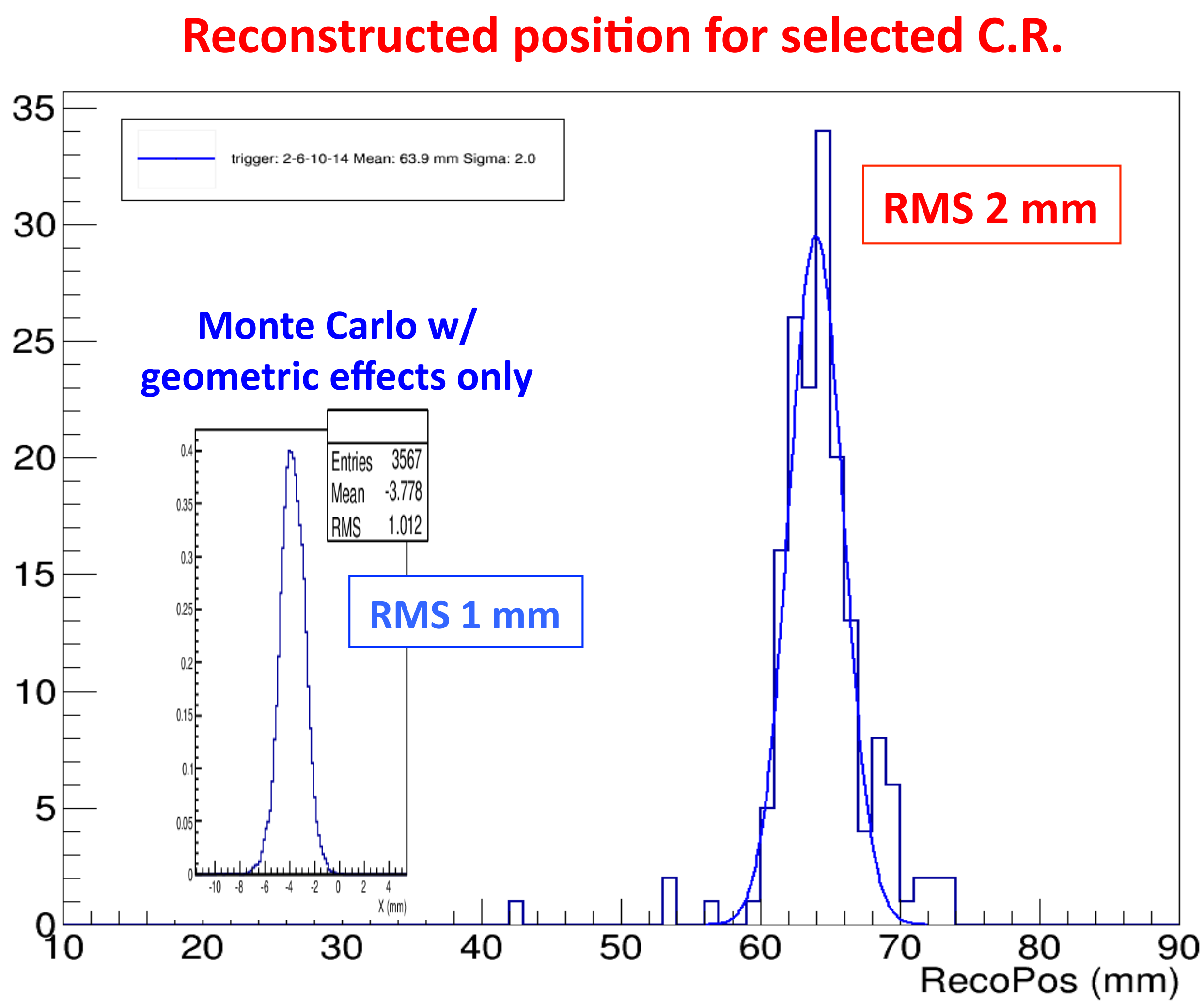


tests with 8 channel module



Test Setup

Cosmic ray tracks selected within a 2.5 mm wide area



More tests and improvements in progress...

The WA104 R&D program

- Prototyping:
  a reduced size (1/3 nb of coils) of the ACM to be constructed
- Testing:
  magnetic field
  structure (mechanical, magnetic stress)
  cooling

- R&D on Tracking Detectors in Magnetic Field :
  Scintillator bars + SiPM in analog and digital mode
  Other tracking devices

Timescale 2014-2015

MoU under evaluation at CERN

The WA104 R&D program

Activity on the Charged beam

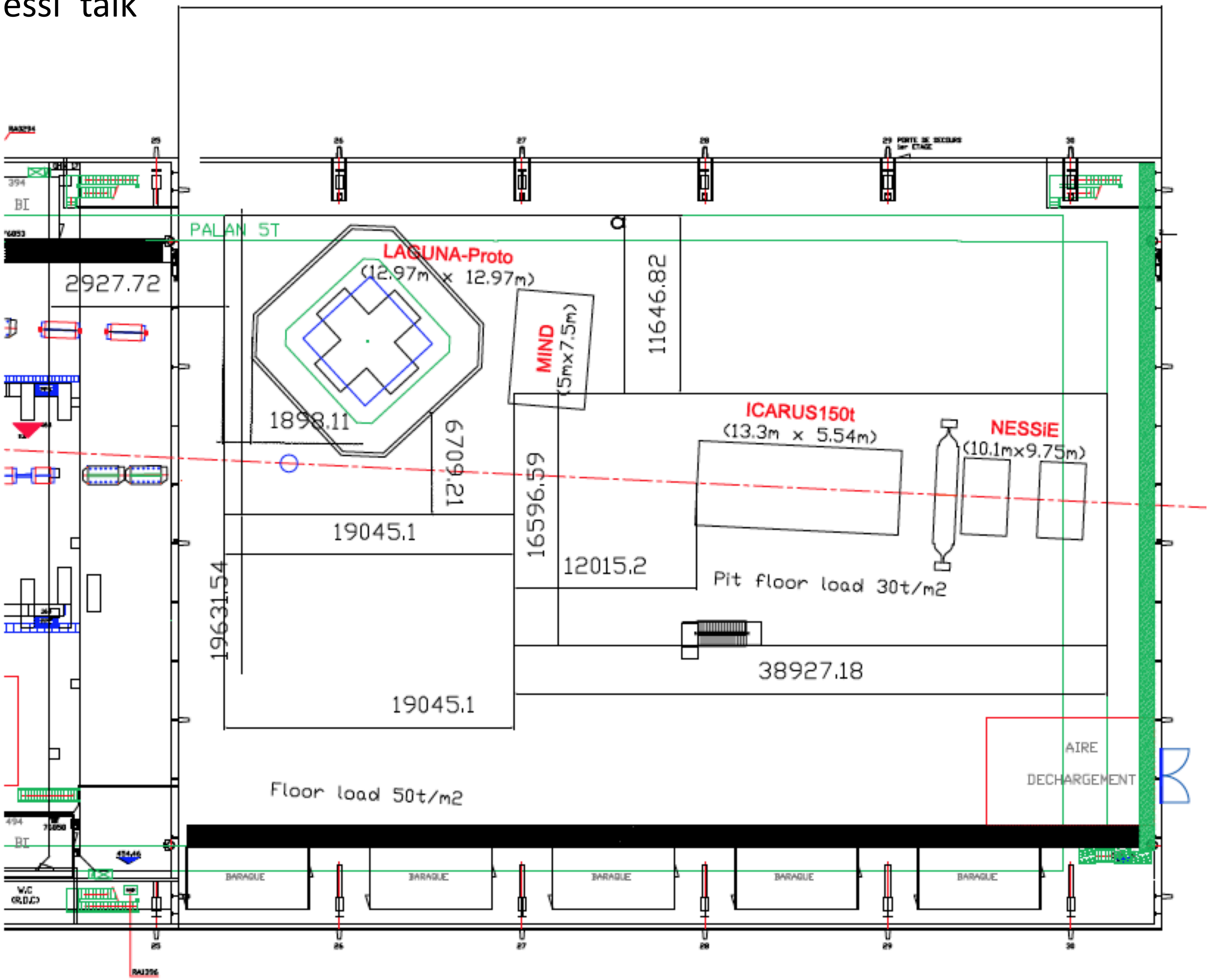
-**Testing ACM performances on charge and momentum measurement**

- **Tracking capabilities and angular resolution of the ACM detector** with high energy muon penetrating LAr-TPC and entering the ACM. Tracking and matching capabilities, angular accuracy, comparison with the measurements performed in LAr-TPC

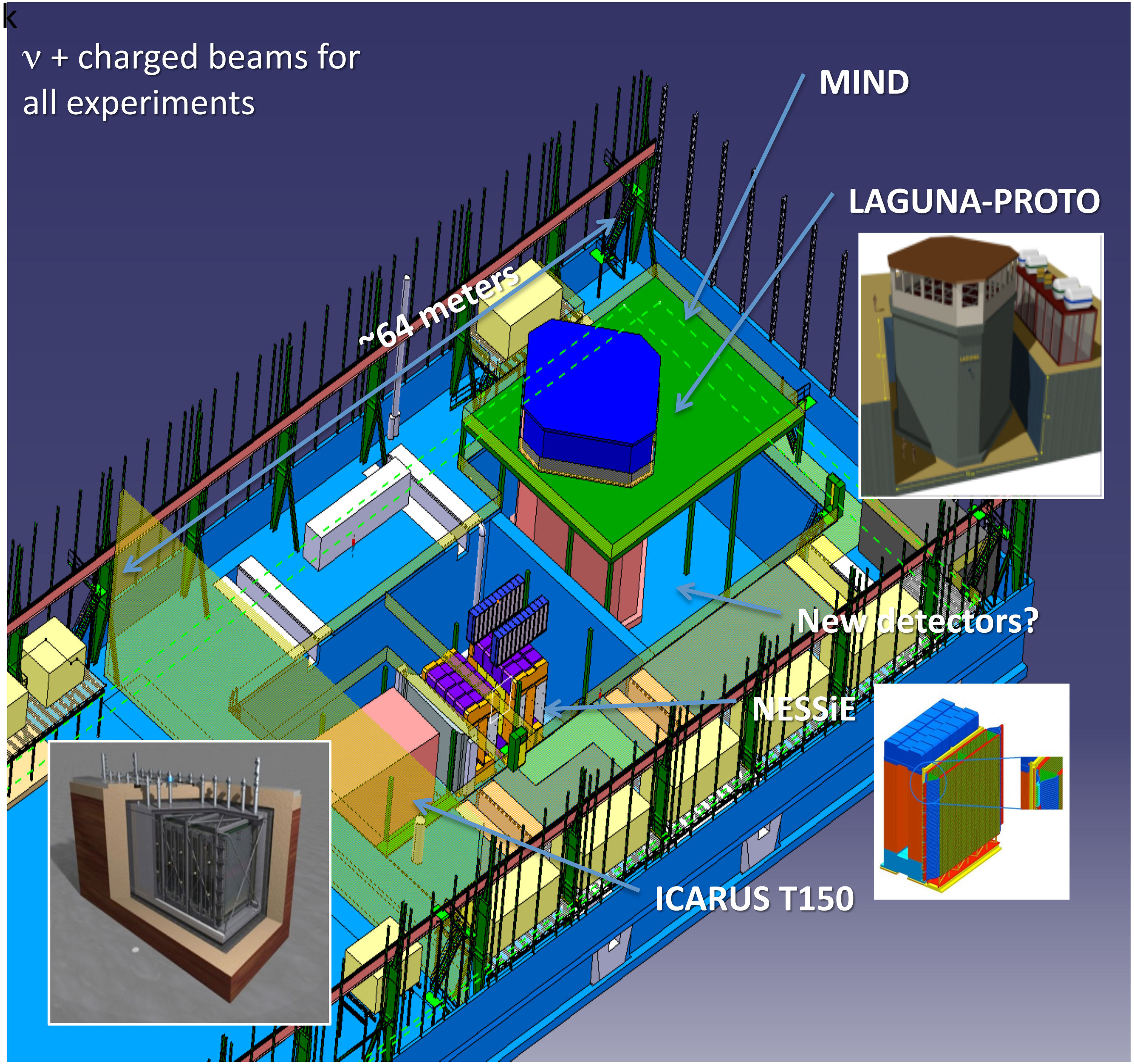
- **Testing fringe field effects on the LAr-TPC detector**

M. Nessi' talk

EHN1 Extension – North Area

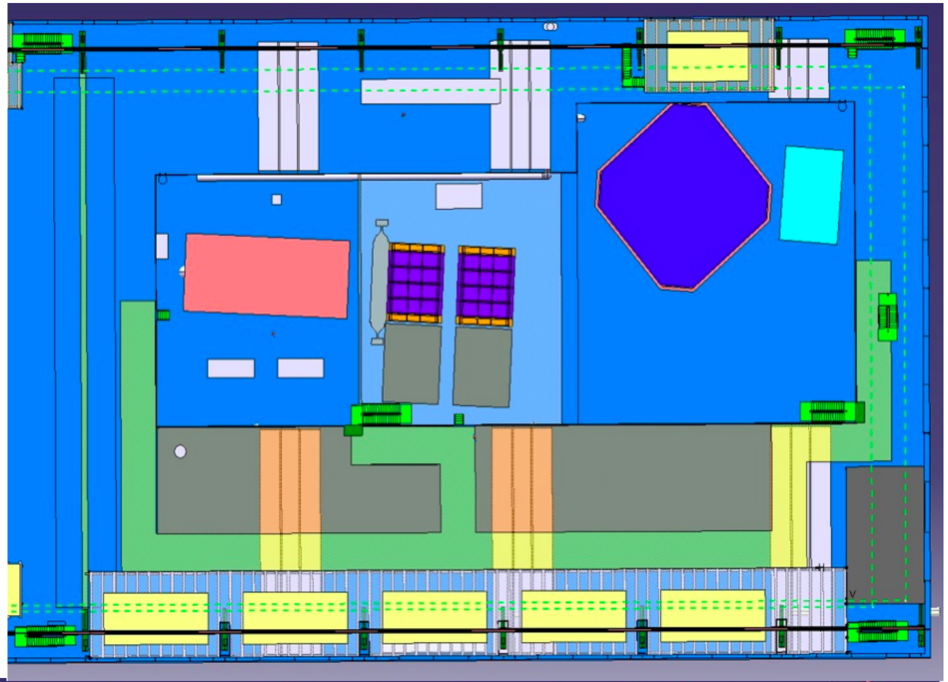


The CERN Neutrino Platform
M. Nessi' Talk

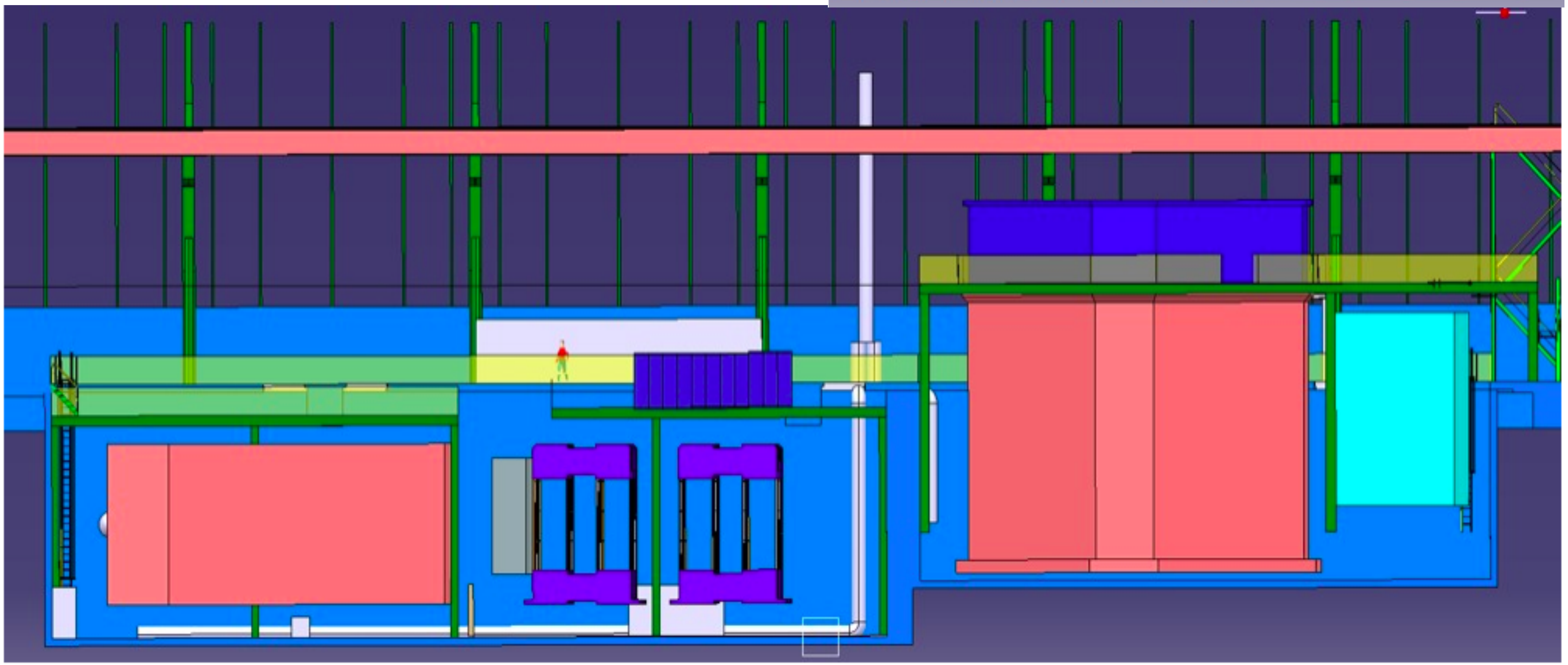


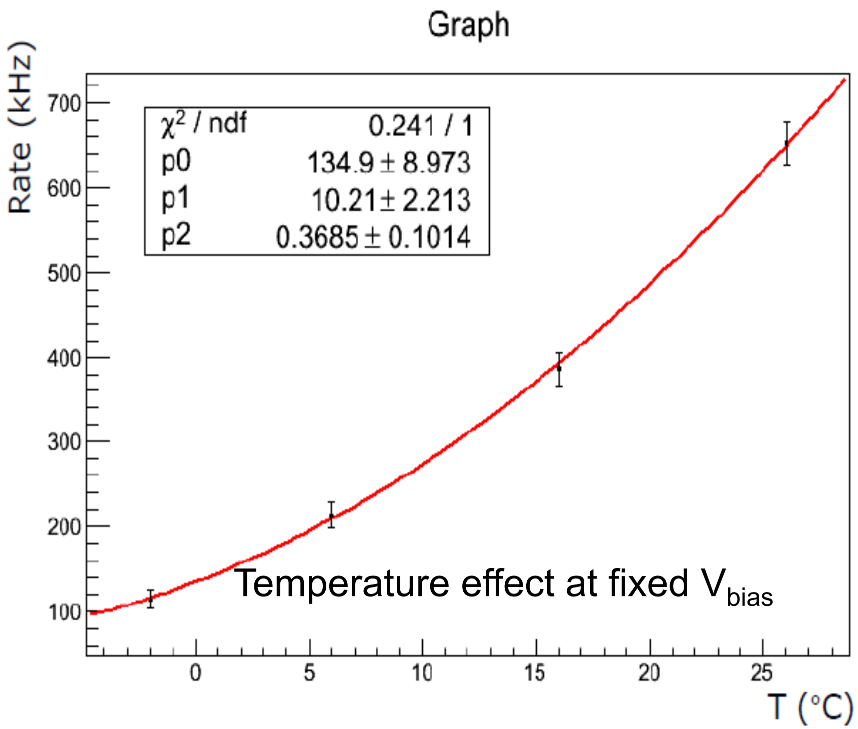
Thank you

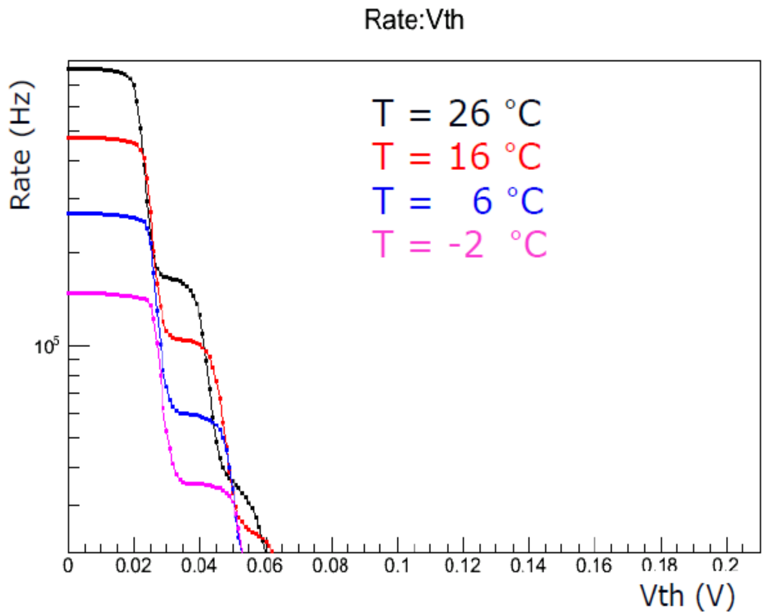
Top view

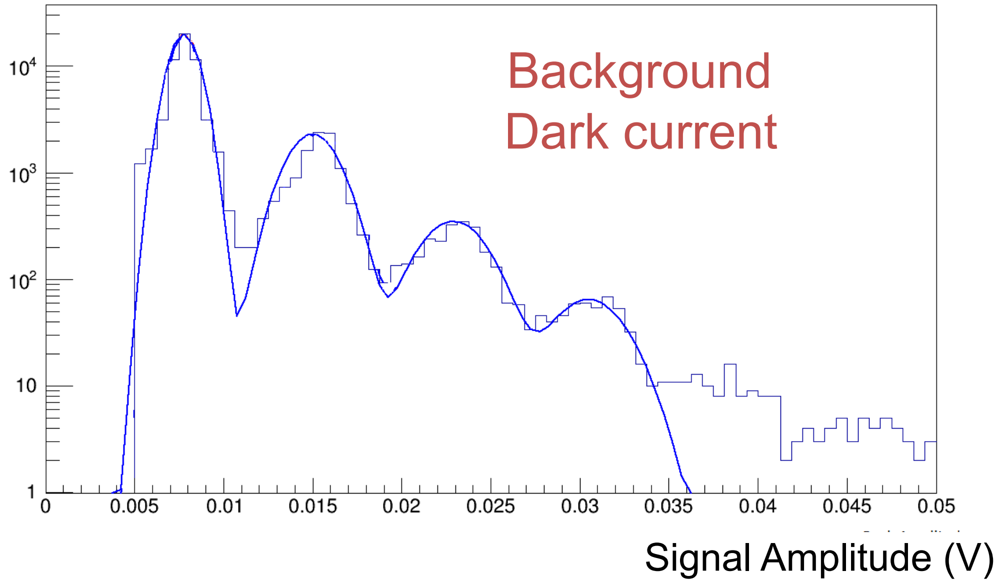


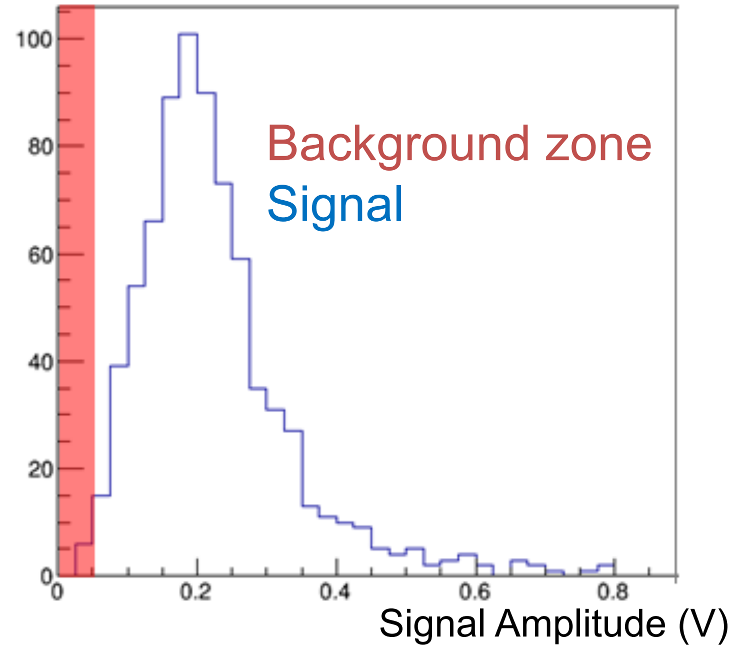
Side view



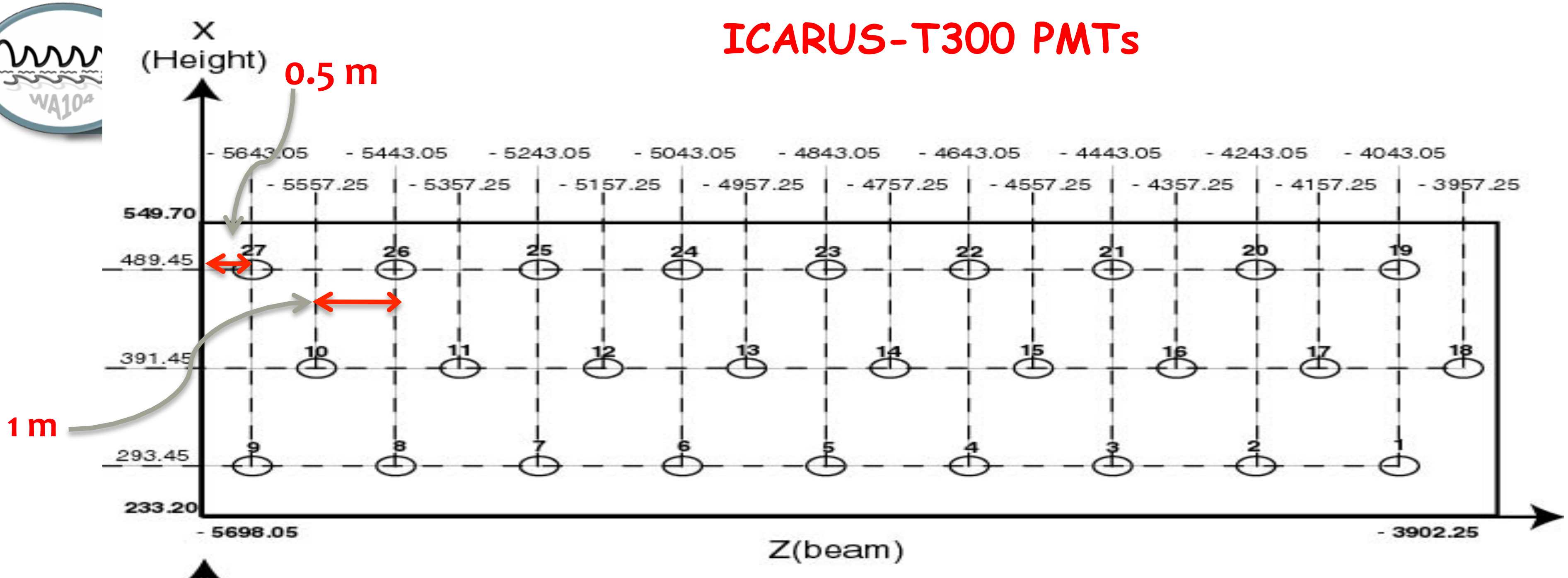

Graph
Rate (kHz)
χ^2 / ndf 0.241 / 1
p0 134.9 ± 8.973
p1 10.21 ± 2.213
p2 0.3685 ± 0.1014
Temperature effect at fixed V_{bias}
T (°C)
100
200
300
400
500
600
700
0
5
10
15
20
25

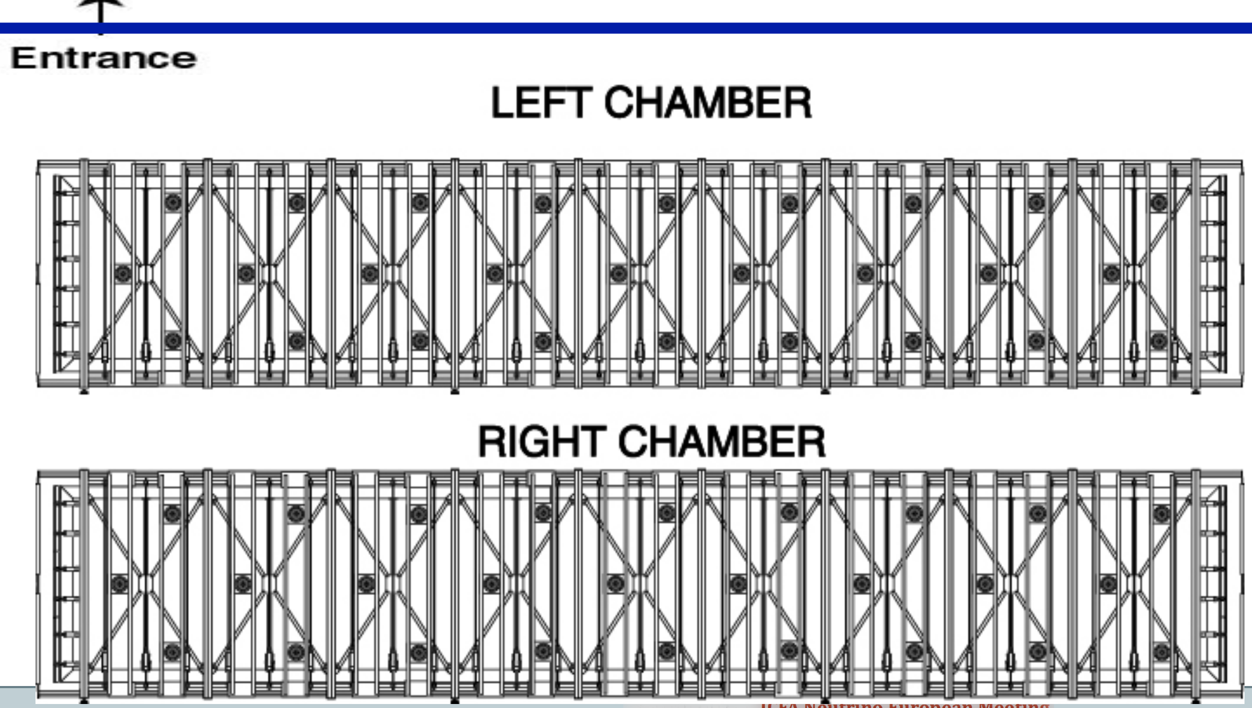

Rate:Vth
Rate (Hz)
10^5
T = 26 °C
T = 16 °C
T = 6 °C
T = -2 °C
Vth (V)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2


Background
Dark current
Signal Amplitude (V)
1
10
10^2
10^3
10^4
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
0.045
0.05


Background zone
Signal
Signal Amplitude (V)
0
20
40
60
80
100
0
0.2
0.4
0.6
0.8

ICARUS-T300 PMTs





27 PMTs

27 PMTs