CERN-FNAL meeting, February 16th 2014
***Luca Stanco** for the **NESSiE** Collaboration*

Neutrino Experiment with SpectrometerS in Europe

and

Neutrino Experiment with SpectrometerS in FERMILAB ?

- Interests
- Activities
- Proposals

NESSIE

Collaboration

Currently the following Institutions are members of NESSiE:

- 6 italian groups: Bari, Bologna,Frascati, Lecce, Padova, Roma1
- 2 russian groups: SINP-MSU, Lebedev-LPI
- 1 Zagreb (Croatia)

Around 65 physicists plus engineers and technicians

Observers:

- Strasbourg (France)
- Hamburg (Germany)
- Napoli (Italy)

All these groups have long experience in Neutrino Physics and Hardware (Chorus, Macro, Nomad, Opera, T2K …)

Some facts:

1. Leptonic Flavor investigation should be a MUST for the HEP future
2. CPV is “in our hands” given the ”large” value of θ_{13}
3. It may be a long shot, and it might be difficult to have more than ONE Big Project
4. Contemporary **R&D** and even other **Physics programs** are mandatory
5. An SBL program may be a good possibility, with measurements of
   - ν_e/ν_μ appearance/disappearance and neutrino cross-sections
6. Under Gran Sasso there are equipments 10 M€ valued to be perfectly usable, with a relative modest investment, for Spectrometers

Spectrometers at a neutrino beam. Extended studies:
- SPSC-P-343, arXiv:1111.2242
- SPSC-P347, arXiv:1203.3432
- ESPP, arXiv:1208.0862
- LOI CENF: *https://edms.cern.ch/nav/P:CERN-0000096725:V0/P:CERN-0000096728:V0/TAB3*
- L. Stanco et al., *AHEP 2013 (2013)* ID 948626, arXiv:1306.3455v2

Note: increasing consensus in the Community that Spectrometer(s) are needed either for SBL or LBL

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

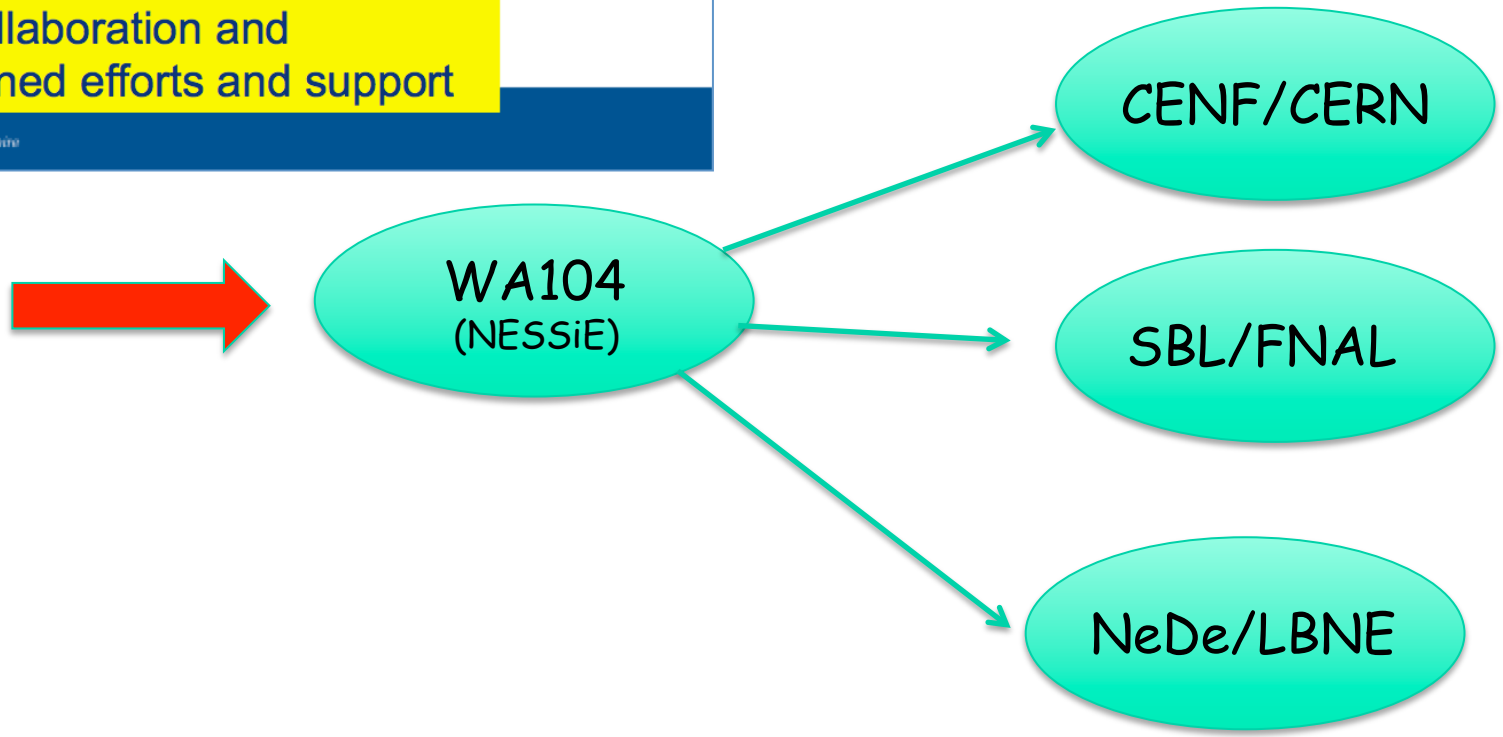
- study for a neutrino (test)beam in the North Area started

- Discussion with US (Fermilab) started concerning LBNE common efforts on detector AND accelerator topics

Needs global collaboration and long-term sustained efforts and support

European Organization for Nuclear Research
Organisation européenne pour la recherche nucléaire

(from November P5 DG presentation)

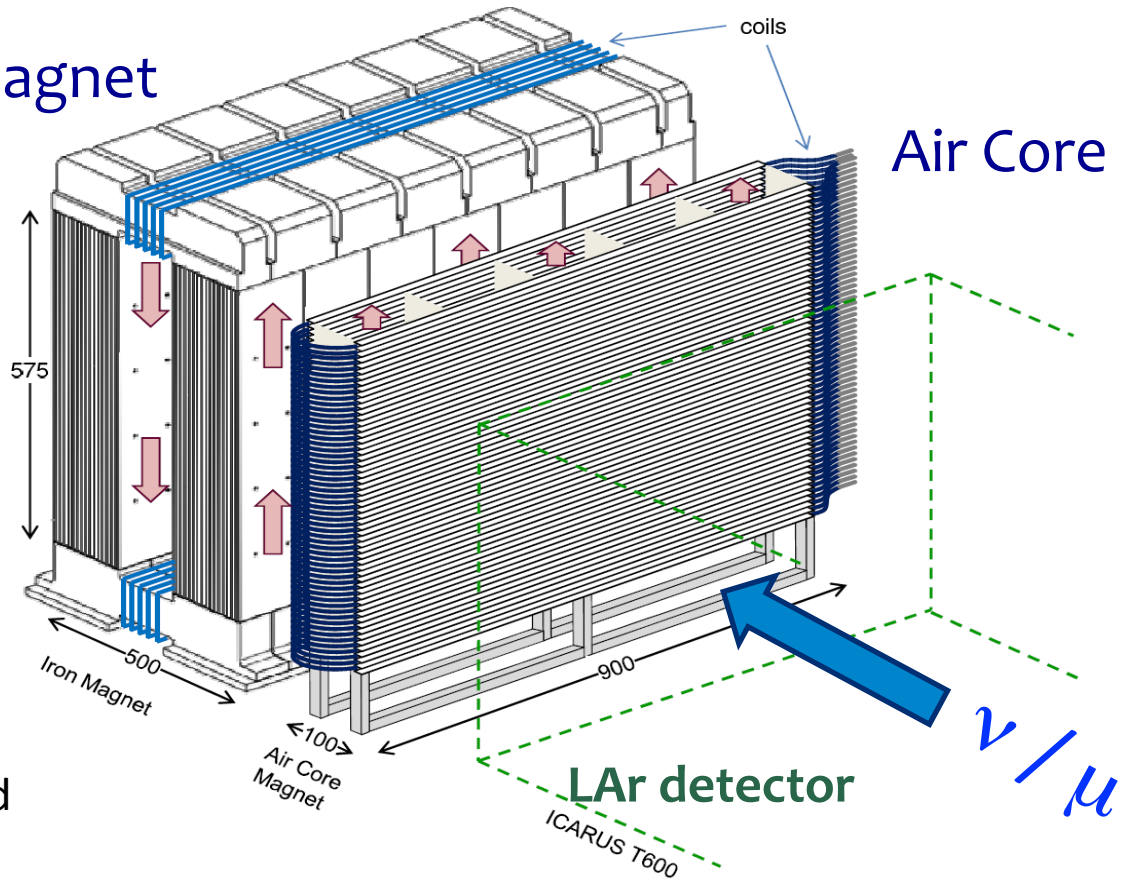


The NESSiE way

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

Iron Core Magnet
(à la OPERA)

Air Core Magnet



- Two Iron spectrometers (**ICM**), 1500 + 800 t, composed by:
- 1800 + 700 m^2 of RPC
- Two **ACM** preassembled and installed in one shot
- Precision Trackers preassembled and installed in one shot

First Goal

SBL ν_μ disappearance search(*)

- Focus the physics goal to gain an order of magnitude in ν_μ disappearance limit at eV scale for Δm^2
- Set the issue of using only iron magnets, with a small scintillator target to disentangle NC
- Define a way to extract oscillation by using a new variable

(*) *LS et al.: AHEP 2013 (2013)* ID 948626, *arXiv:1306.3455v2.*

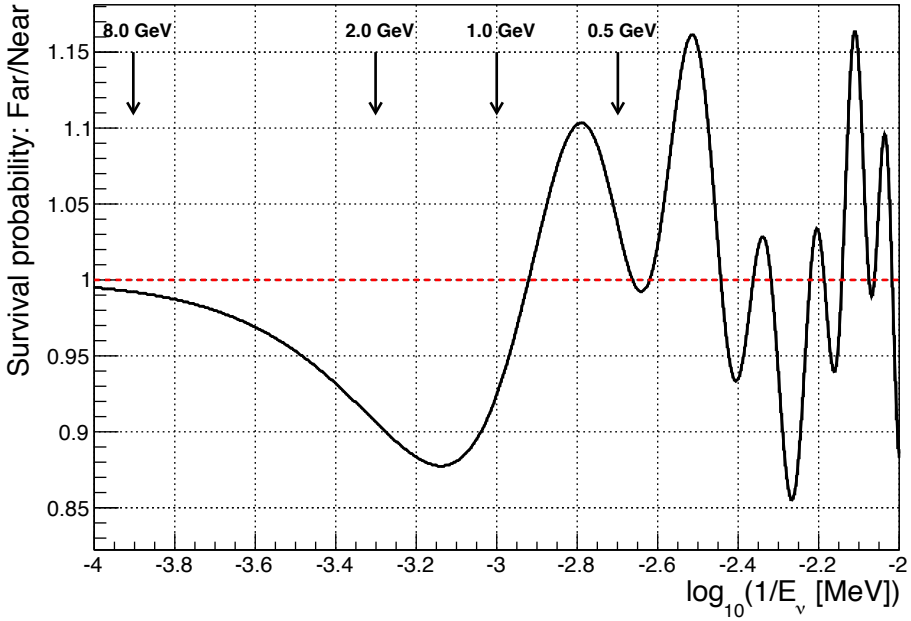
SPECTROMETERS ONLY…

Double ratio $(F/N)_{data}$ / $(F/N)_{no\text{-}osci}$

$$P_{\nu_\mu \to \nu_\mu} = 1 - \sin^2(2\theta)\sin^2(1.267\Delta m^2 \frac{L}{E})$$

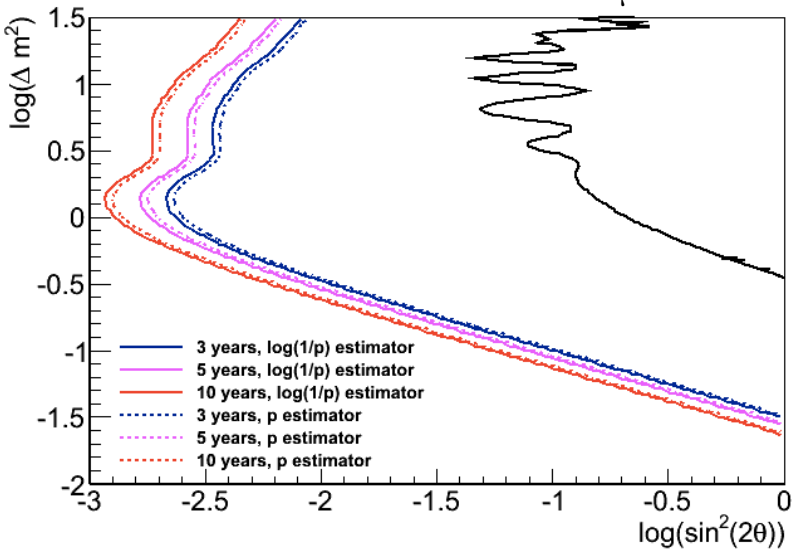
$$\sin^2(2\theta) = 0.146$$

$$\Delta m^2 = 1eV^2$$

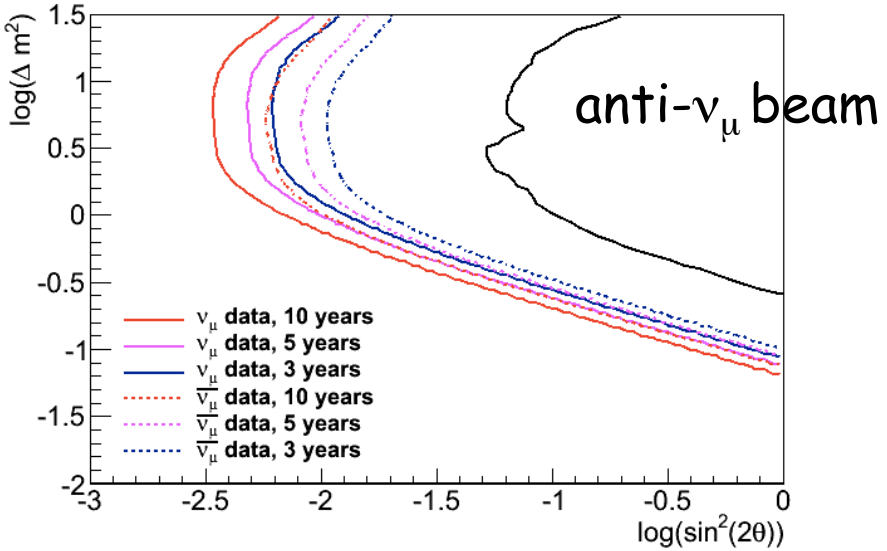


New variable: $\log_{10}(1/E)$

ν_μ beam



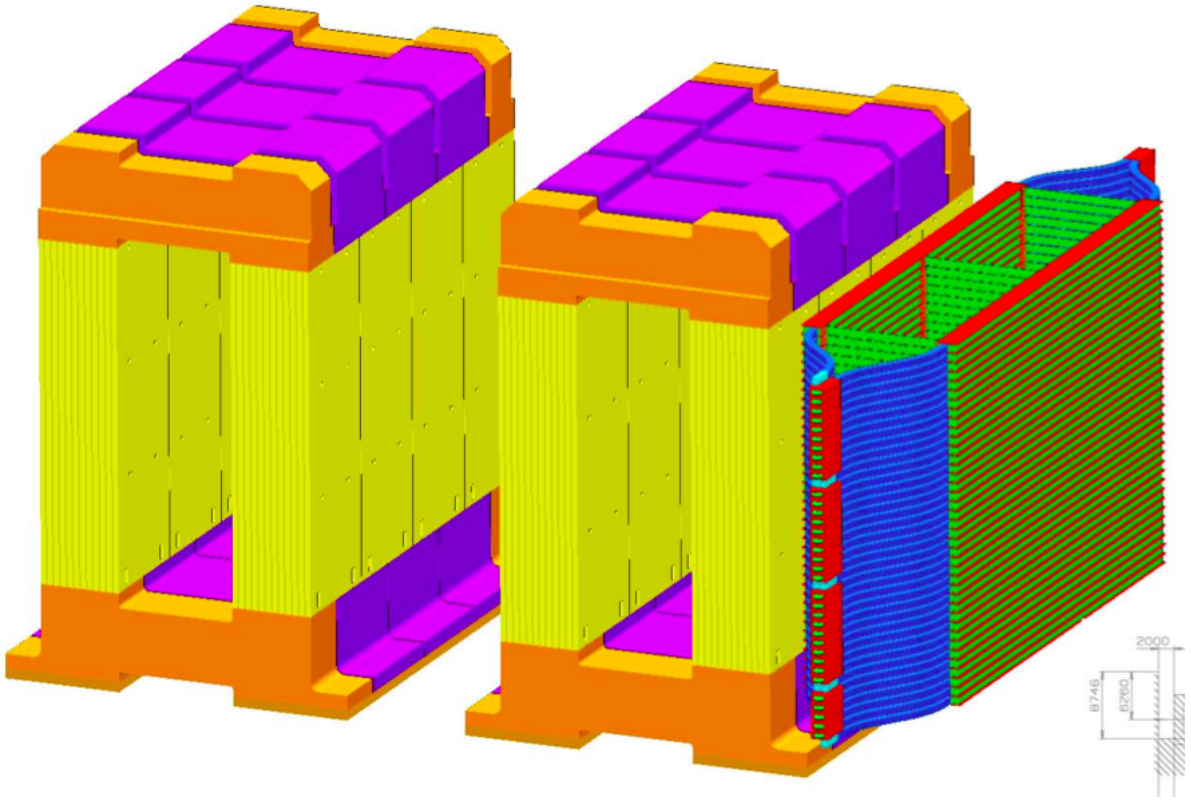
anti-ν_μ beam

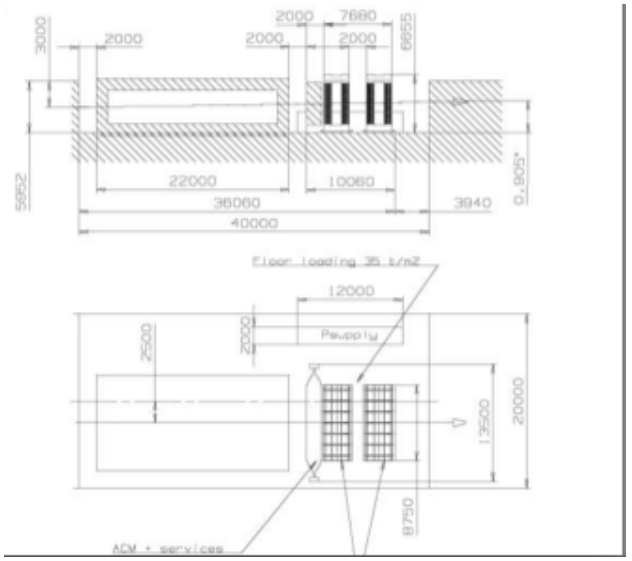


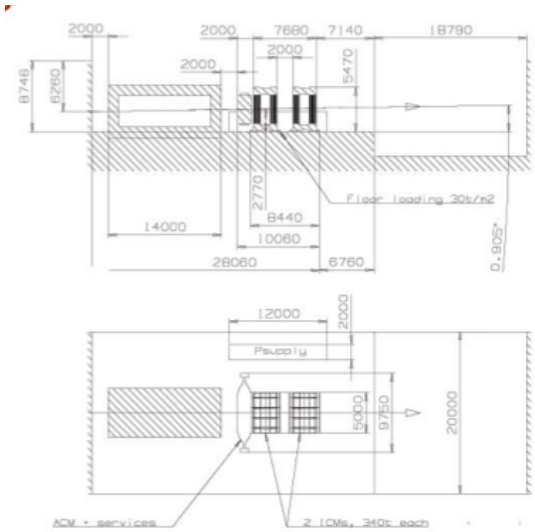
Non oscillation hypothesis is tested with a χ^2 test to a flat (= 1) distribution

7

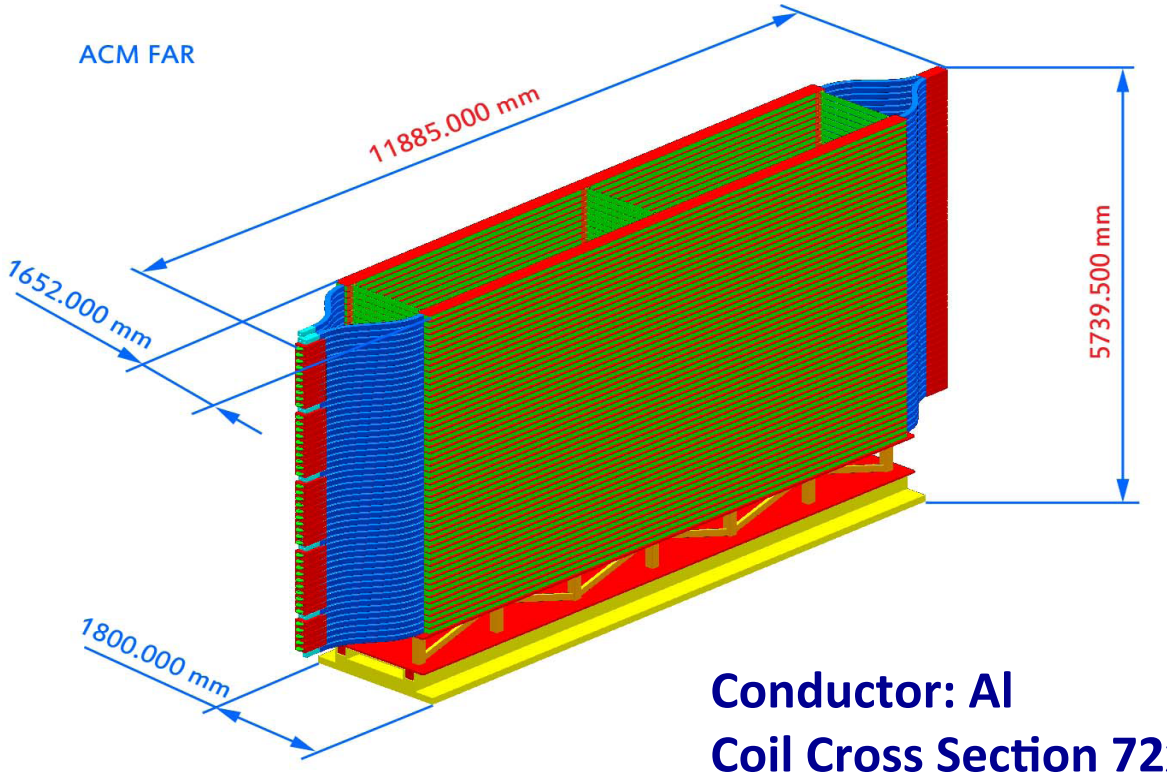
Re-arrangement using OPERA Spectrs

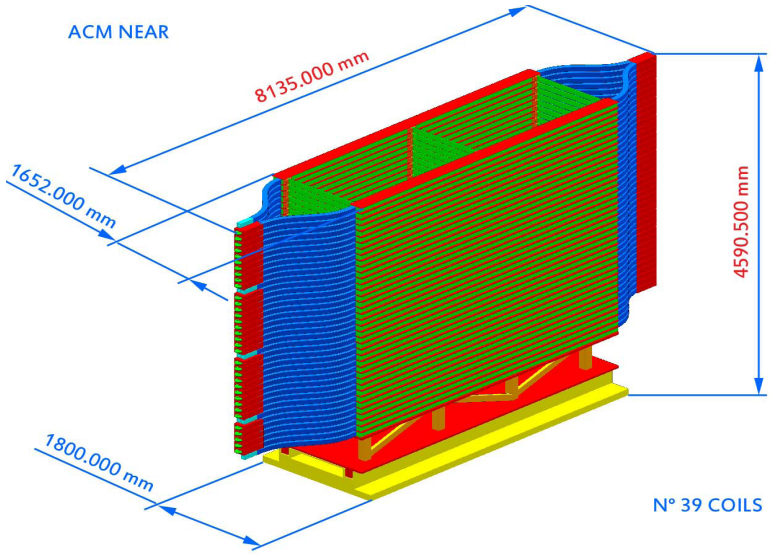






NESSiE Footprints	NEAR Site	FAR Site
Height (along y)	5.47 m	6.65 m
Length (along z)	10.06 m	10.06 m
Transverse (along x)	9.75 m	13.5 m





Conductor: Al

Coil Cross Section 72x72 mm²

Hole (cooling) = 30 mm Ø

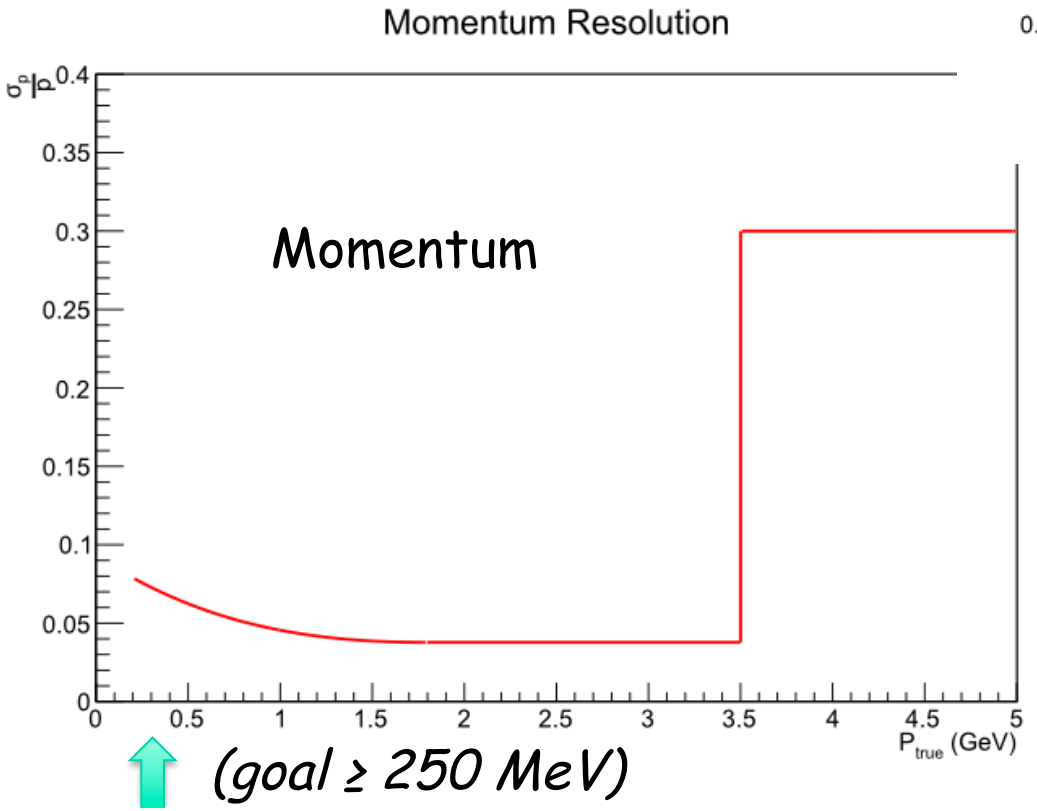
B=0.12T

NESSiE ACM	NEAR Site	FAR Site
Nb of coils	39	51
Conductor Length/coil	14,8 m	22,3 m
Power	230 kW	450 kW

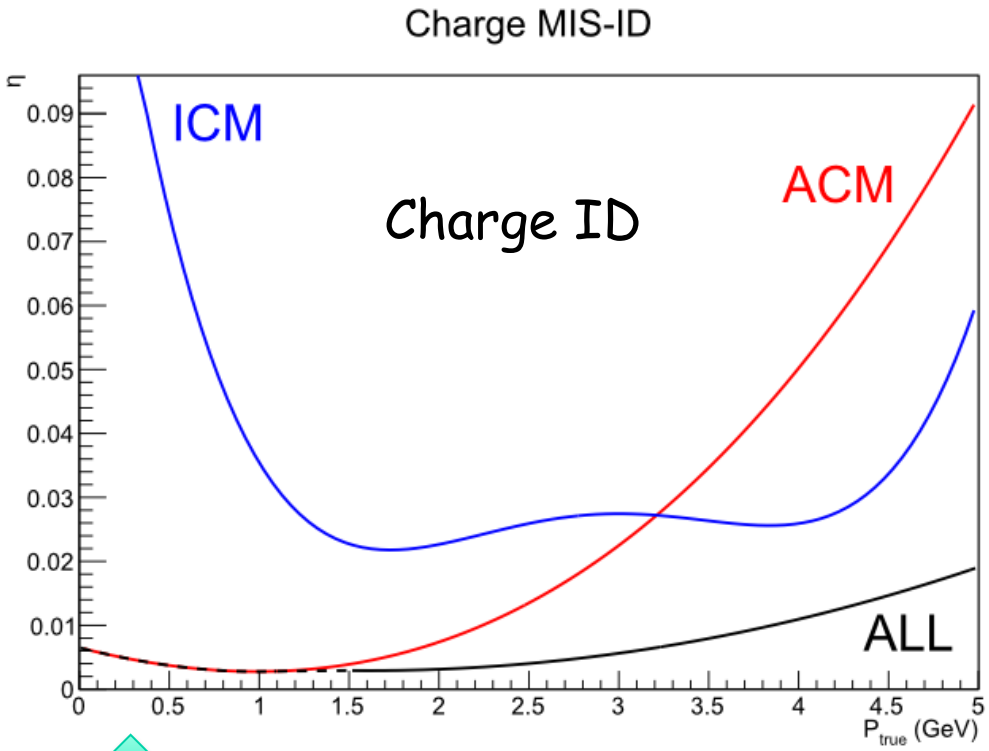
Compare e.g. with ISS-Detectors, http://arxiv.org/pdf/0712.4129v1.pdf

Performances of the present NESSiE configuration
(full simulation, with neutrino beam)

Best, ever, sensitivity for μ detection with similar apparata over large area
(and few MCHF cost)



(goal ≥ 250 MeV)



(goal ≥ 250 MeV)

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

However recent developments on SuperConducting cables or even the use of standard SC coils allow us to think to a different approach in magnetic system.

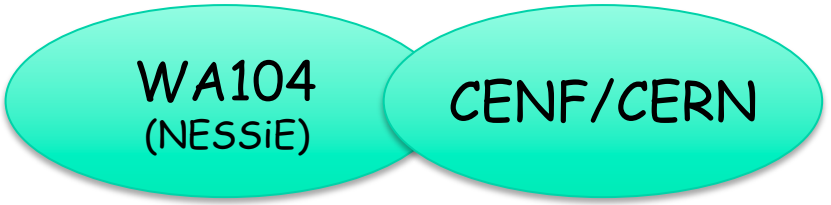
R&D on magnetization of LAr tank:

Pros: - best detector for both muons and electrons
- similar Near and Far detector sites for the LBNE project
- couple ACM with target

Cons: - structural forces (depending of the magnetic field)
- insulation structures
- cost ?
- long way ?

R&D planning for FIRST GOAL

(the plan is to develop activities in line with the CERN-CENF neutrino beam)



1) Prototype ACM-warm (conditionally funded by INFN)
2) Tracking Detectors in Magnetic Field R&D
3) Evaluation ACM-cold
4) Collaboration to R&D for SC on LAr
5) Collaboration with LAr activities/groups

WA104 R&D program - Summary / 1

- Prototyping - a reduced ACM (13 coils) to be constructed

- Testing - measurement of the magnetic field
  - structure (mechanical & magnetic stress)
  - cooling ...

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

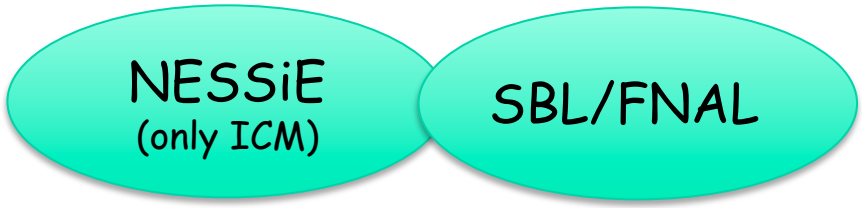
- Activity with the charged beam
  - Testing ACM performances (charge and momentum measurement)
  - Test on tracking capabilities with high energy muons penetrating LAr-TPC and entering the ACM. Matching and comparison with measurement in LAr-TPC

WA104 R&D program - Summary / 2

- Magnetic Field Test
  - Test on fringe field effect on the LAr-TPC detector
- Timescale - 2015-2017

- **TDR to be ready for SPS Committee by the end of February**
- **MoU preparation in progress**

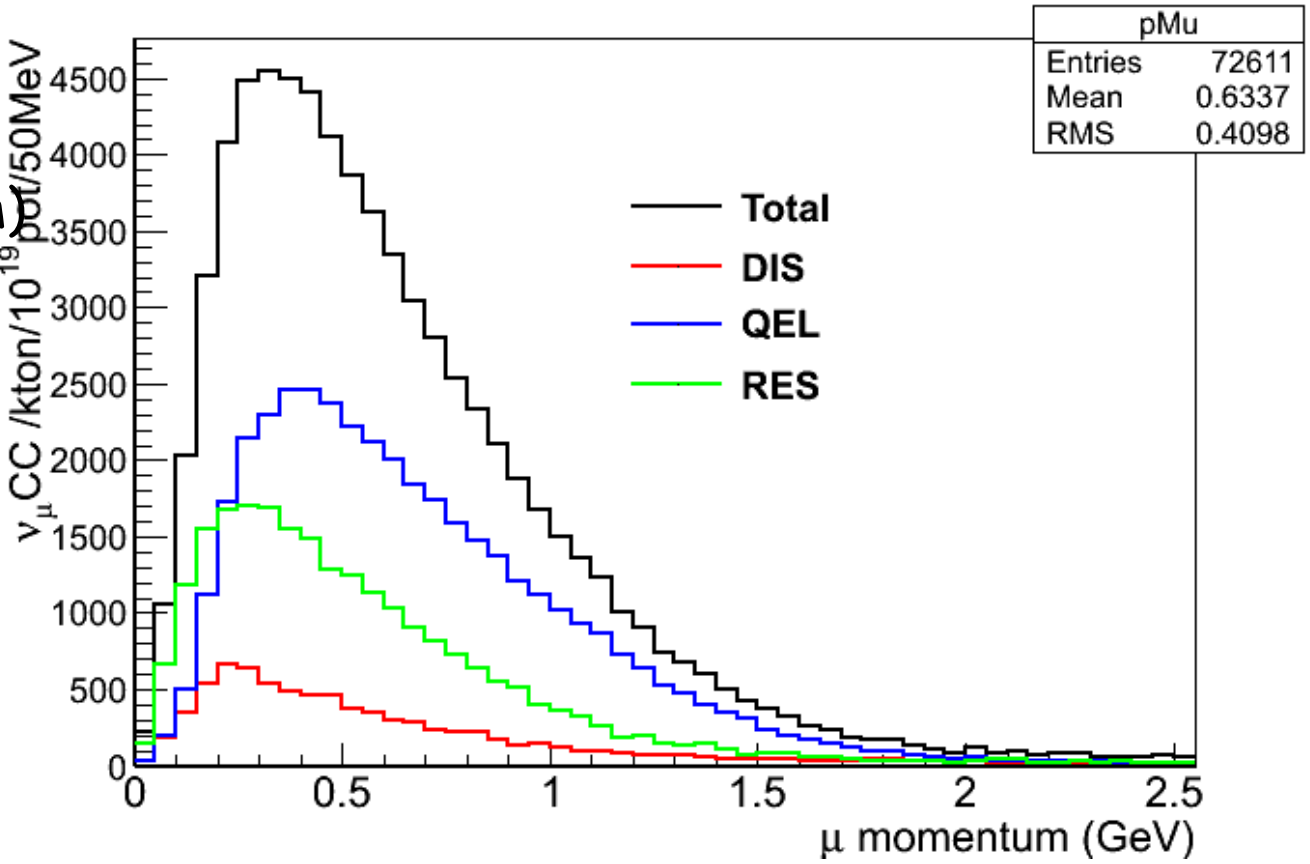
Second Goal



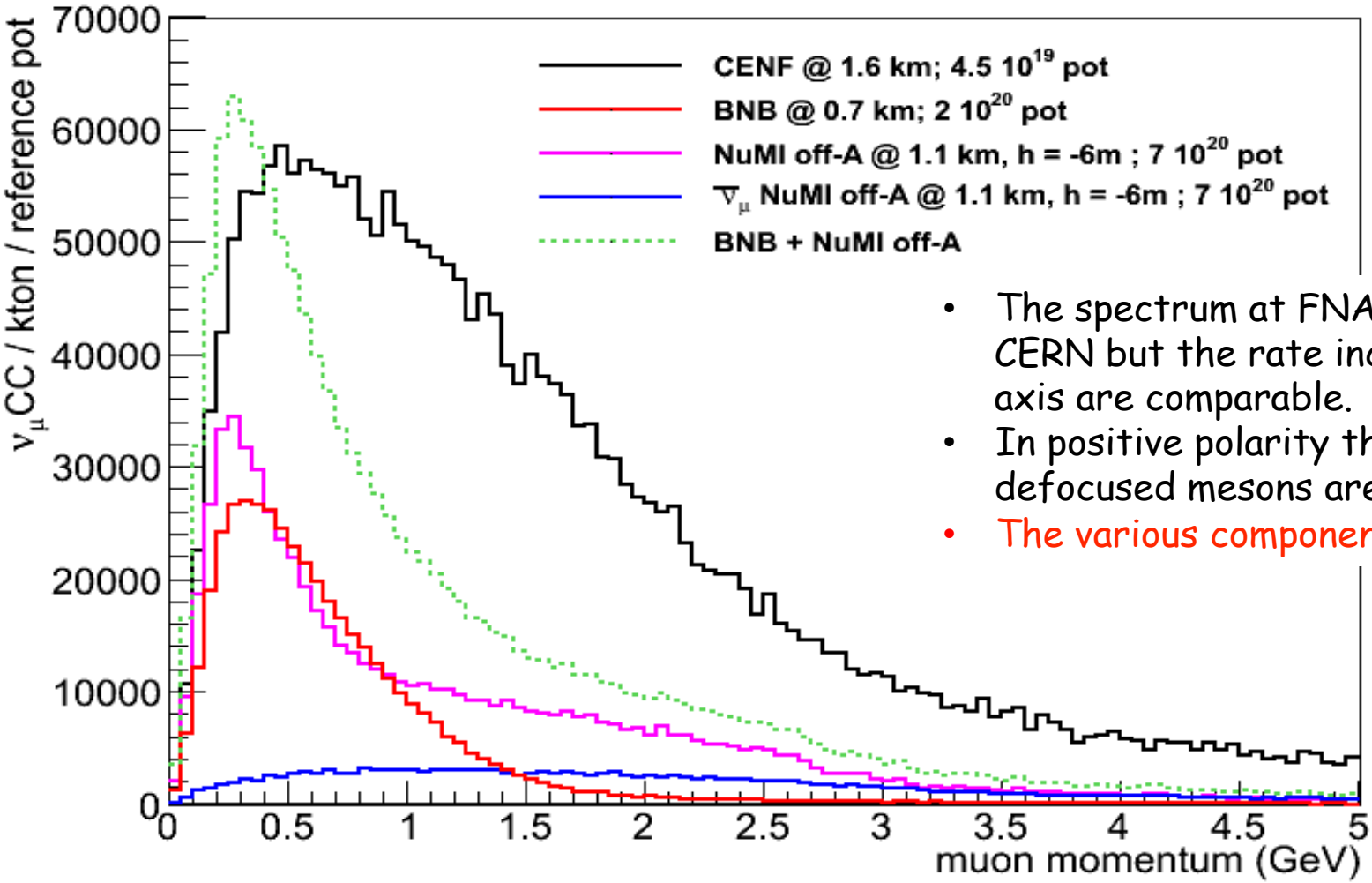
FNAL options under investigation

Booster Beam (at 700 m)

(full simulation with fluxes, cross-sections, GEANI 2.6)

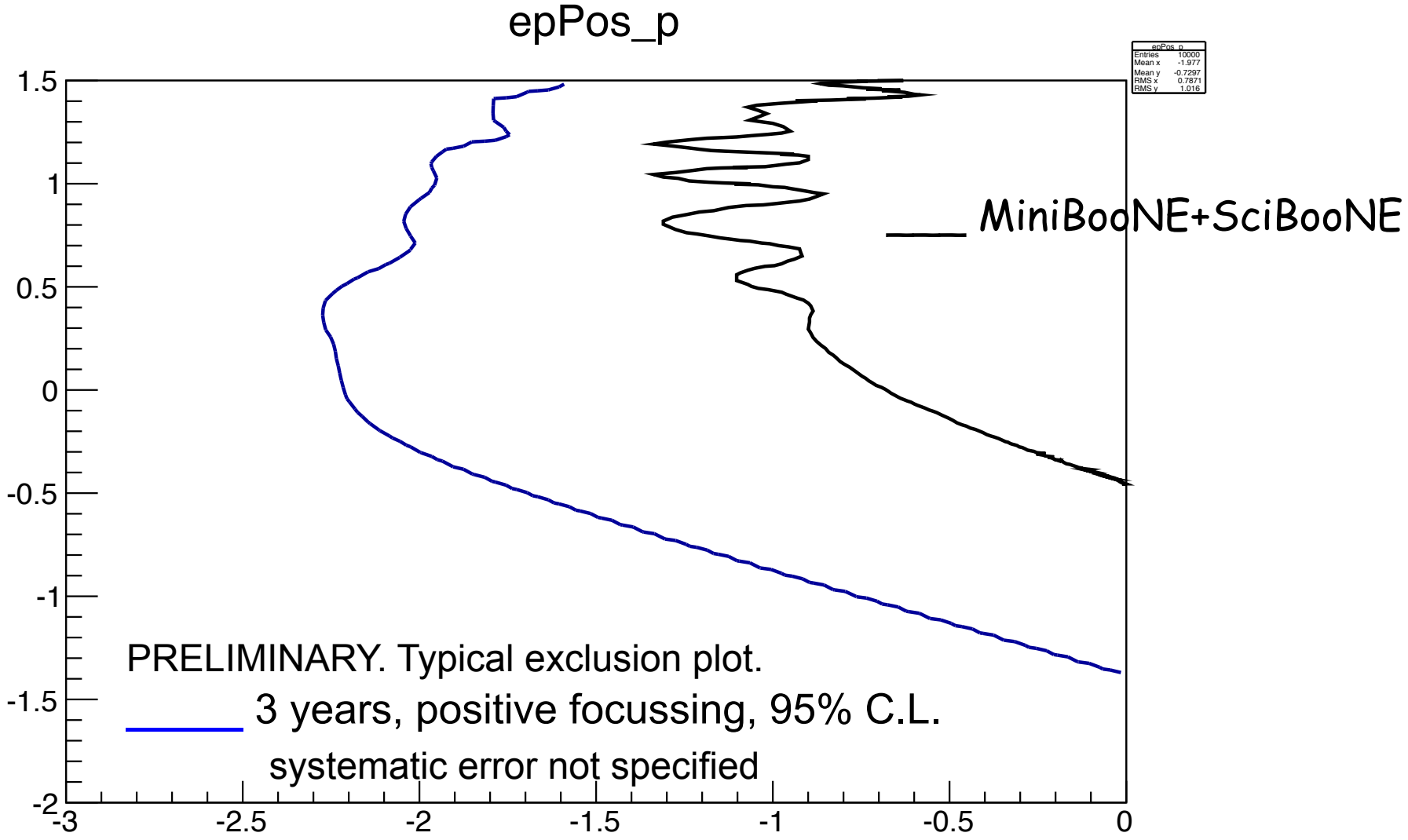


Muon momentum distribution
Positive polarity **(compare all)**



- The spectrum at FNAL is softer than CERN but the rate including the numi off-axis are comparable.
- In positive polarity the anti-nu from from defocused mesons are small
- The various component test different L/E

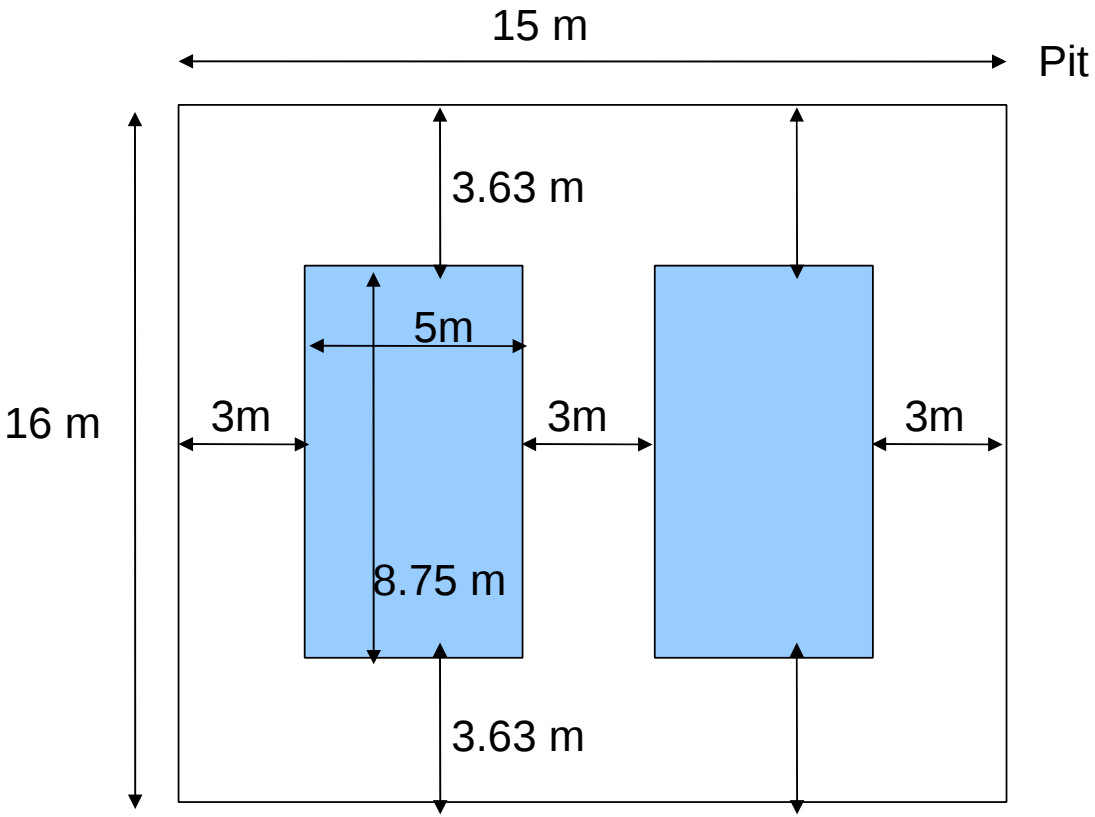
Evaluation of 1 kton size detectors for 2 sites at FNAL/Booster.
Muon disappearance sensitivity (2-flavour limit) at FNAL.

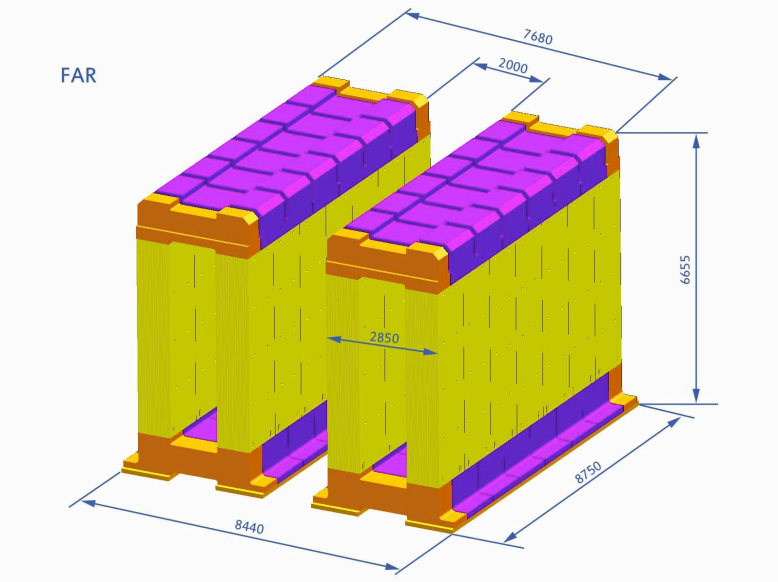


Needed a a careful study on systematics

Pit dimensions for far ICM

FAR

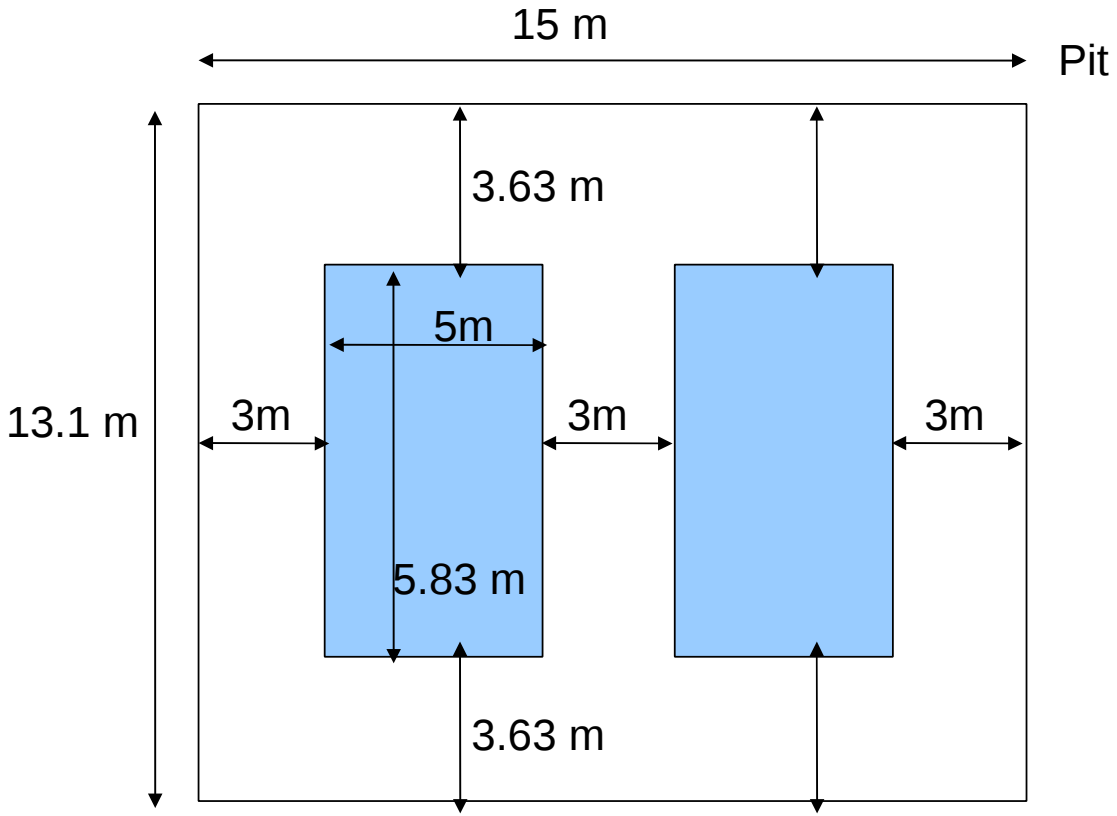


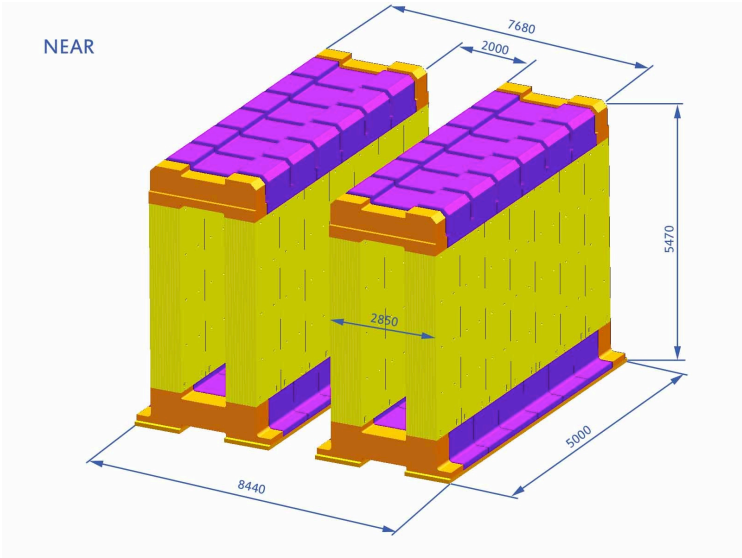


Notes:
3.63 m laterally for the extraction of the internal support structure
3 m on the other direction and between magnets to ease installation
Other 50-100 m2 needed around the pit to keep slabs and to assemble RPCs during installation
For the near, 16 m -> 13 m if two RPC columns instead of three

Pit dimensions for near ICM

NEAR





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For the near, 16 m -> 13 m if two RPC columns instead of three

A proposal is under development, to be shortly released.

With systematics under careful control a gain of ONE order of magnitude can be achieved in ν_μ disappearance measurements at Short-Baseline.

The new CERN-CENF neutrino beam is anyhow needed to get the gain of two order of magnitude and to undergo the anti-ν_μ study.

CONCLUSIONS

1. **Neutrino** Physics is a MUST for Particle Physics
   (neutrino mass, Majorana/Fermi, astroparticle connection, window for BSM)

2. **CERN/Europe** should be a MAJOR actor
   (facilities, past experience, major partner in the Global picture)

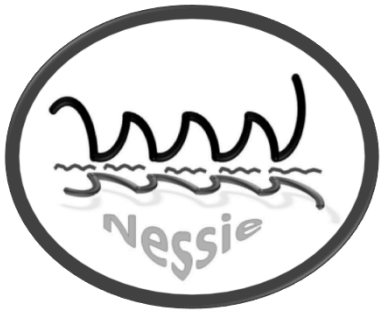
3. Large and experienced **community** from the NESSiE Collaboration
   (knowledge, motivation, largeness)

4. The WA104-NESSiE R&D activity at CERN will be pursued for ACM-like development, together with collaboration with LAr colleagues.

5. A proposal for an experiment at FNAL, to be made in 2015-2019, for ν_μ disappearance searches is going to be released

6. The CERN-CENF neutrino beam is mandatory to complete the SBL studies and the R&D programs.

Thank you !



WA104-NESSiE

NESSiE at FNAL

CERN/CENF

Backup slides