NESSIE

SPECTROMETER(S) Proposal for a New Neutrino CERN-SPS Experiment:

Neutrino Experiment with SpectrometerS in Europe

on the quest for STERILE neutrinos

CdS, 2 July 2013
Luca Stanco for NESSiE

Status of the experiment at CERN

To make a long history short:

- ✓ January 2013: Approval by SPSC after first submission in October 2011 (!) pending the beam approval by CERN
- ✓ March 2013: Research Board, no outcome..
- ✓ April 2013: SPC Board, no outcome…
- ✓ May 2013: European Strategy support neutrino physics (4th item)
- ✓ June 2013 Middle Term Plan, MTP for 2014-2018. Outcome ?

- ✓ Working groups at CERN on weekly or bi-weekly basis
- ✓ Marzio Nessi (Cern CENF Project Leader), Sergio Bertolucci (Director Research), Carlo Rubbia (Icarus Spokeperson), myself (for NESSiE): lot of pressure on CERN boards and DG, R. Heuer *

- Letter to CERN DG on April 19th
- Paper on June 13th

"Extrapolated" conclusions from the Council:

- ✓ CERN decided NOT to go for a SBL neutrino beam, by now
- ✓ However, it is willing to invest on Neutrino (4th priority of ESG):
  - 2.7 MCHS in 2013 for Neutrino studies
  - Icarus refurbishing
  - Nessie test-integration
  - Laguna R&D

To be FORMALLY confirmed middle next week

What about INFN and CSN2 ?

- ✓ CTS evaluation on going (from March 2013)
- ✓ To evaluate:
  - CERN involvement
  - different beam possibilities (e.g. FNAL)
- ✓ Requests for 2014 still under evaluation…

Outcome 108th SPSC, 16 January 2013

Approval

The SPSC **supports** the physics cases of both projects and **recognises** their timely relevance in the rapidly evolving neutrino physics landscape. In this context the SPSC **considers** it important to strengthen neutrino activities at CERN in order to help focus those future European contributions to neutrino physics extending beyond the ongoing approved programmes. The SPSC **considers** that a new short baseline neutrino beam at the SPS could be an adequate facility to foster this focus in the near future, provided that the beam operation, in addition to making progress on the sterile neutrino question, can also contribute significantly to the preparation of the future long baseline neutrino projects.

Liquid Argon issue

The SPSC **supports** the focus of the European neutrino community on the LAr TPC technology, for which it has a unique expertise worldwide from the operation of the largest underground LAr detector by the ICARUS Collaboration. This technology is well suited for the search for sterile neutrinos, as well as for very long baseline neutrino experiments if it can be scaled to the large masses required by the measurement of CP violation. It is complementary to the large Water Cerenkov detectors developed in Japan, which are better adapted to shorter baseline neutrino beams and which compensate for a more difficult control of fine systematic effects by an easier scalability to very large masses. The SPSC **notes** that the US neutrino community has a similar technological focus as Europe. The SPSC therefore **recommends** that future European R&D for neutrino beam physics at CERN should be made in close contact with the US groups in anticipation of cooperation on future projects.

Detailed recommendations. A

The SPSC **encourages** the ICARUS+NESSIE Collaboration and the LBNO consortium to set up a joint working group (SBL-LBL) in order to identify all potential synergies between the two projects, including for example Near Detectors, LAr TPCs and their event reconstruction software, muon spectrometers and extended SBL physics reach with e.g. measurements of neutrino cross sections.

Detailed recommendations. B

The SPSC **recommends** that the ICARUS+NESSIE Collaboration optimise its experimental setup for beam conditions and costs, using inputs of the SBL-LBL joint working group. In particular the collaboration should investigate the possibility to re-use the OPERA spectrometers and to build some of its new components (spectrometers, Near Detector, …) in cooperation with LBNO. Particular attention should be paid to the adequacy of the Near Detector for the expected beam and background conditions. For further review of the project the SPSC **requests** a comprehensive TDR document for the final detector configuration and expected physics reach. This TDR should include a detailed breakdown of the work packages and associated responsibilities, costs and financial resources.

CERN DG requested a detailed document in November, Ready on February 7th.

Letter of Intent for the new CERN Neutrino Facility (CENF)

7th February 2013 *

CERN Neutrinos study group, ICARUS-NESSiE Collaborations, LAGUNA-LBNO Consortium

ABSTRACT:
The nature and characteristics of neutrinos still represent one of the most intriguing questions of modern particle physics. This Letter of Intent presents a plan to build at CERN a Short Baseline Neutrino Facility capable to meet this challenge. The new beam line will make use of the SPS beam, it will be located in the CERN North Area of the Prevessin site and will comprise in a first step 2 experimental halls (far and near) which will host the detector facilities. The beam layout will be compatible with a long neutrino baseline which might be constructed in a second stage.

KEYWORDS: Neutrino, Short-baseline, Long-baseline, Sterile Neutrinos, ICARUS, NESSIE, LAGUNA, LBNO, CERN.

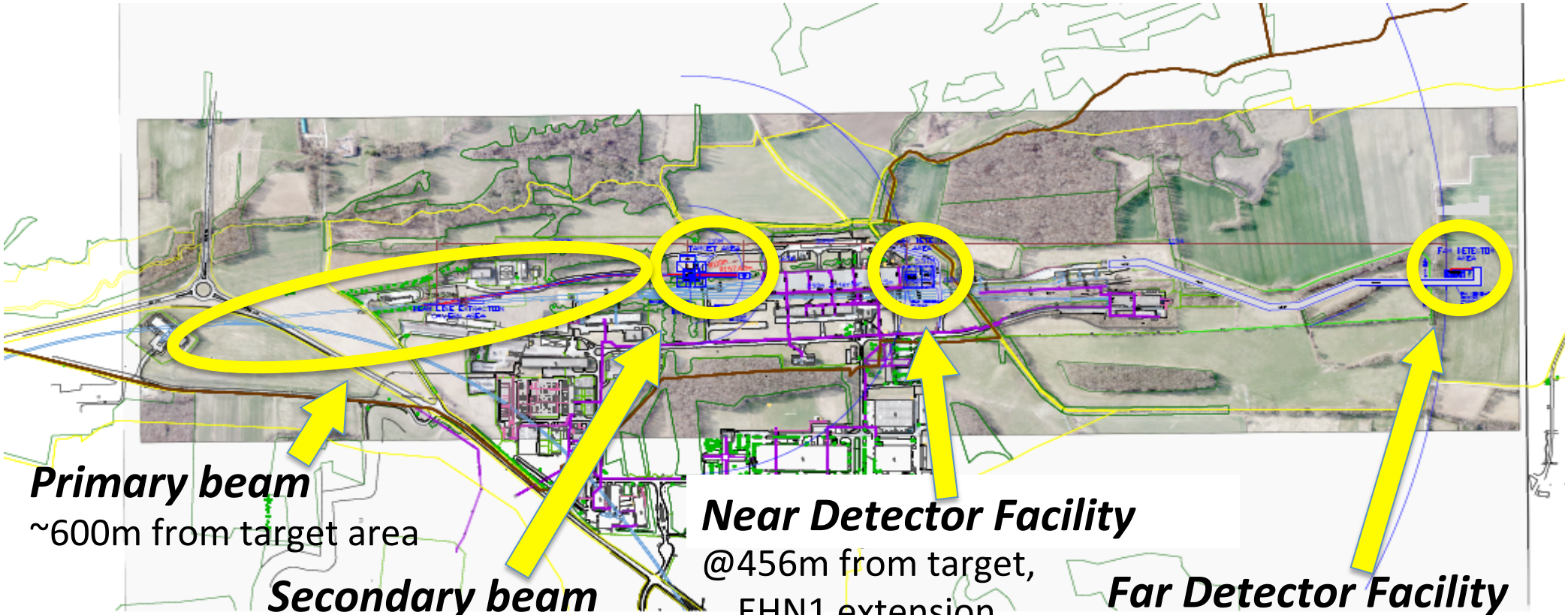
*EDMS link: https://edms.cern.ch/nav/P:CERN-0000096725:V0/P:CERN-0000096728:V0/TAB3

Leader Project:
Marzio Nessi (Cern)

Deputy:
Rende Steerenberg (Cern)

- **200 pages for 5 Work-Packages,**
- **a TDR for Beam, Infrastructures and Experiments**

- 200 pages for 5 Work-Packages,
- a TDR for Beam, Infrastructures and Experiments

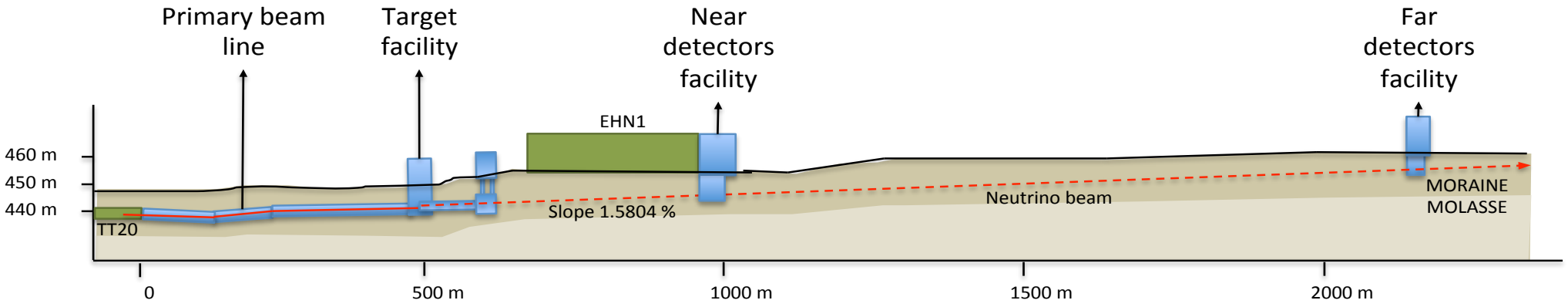


Primary beam
~600m from target area

Secondary beam
In front of EHN1

Near Detector Facility
@456m from target,
EHN1 extension

Far Detector Facility
@1600m from target



Needed Resources

Items	Core costs (KCHF)	possible additional costs
Civil Engineering (all projects)	53054	14995
Primary beam line instrumentation and services	20315	310
Secondary beam line instrumentation and services	17940	1685
Far detector facility instrumentation and services	2095	0
Near detector facility instrumentation and services	3865	0
Project technical coordination	3345	0
Total (KCHF)	100613	16690

Table 6.38: CORE Cost table

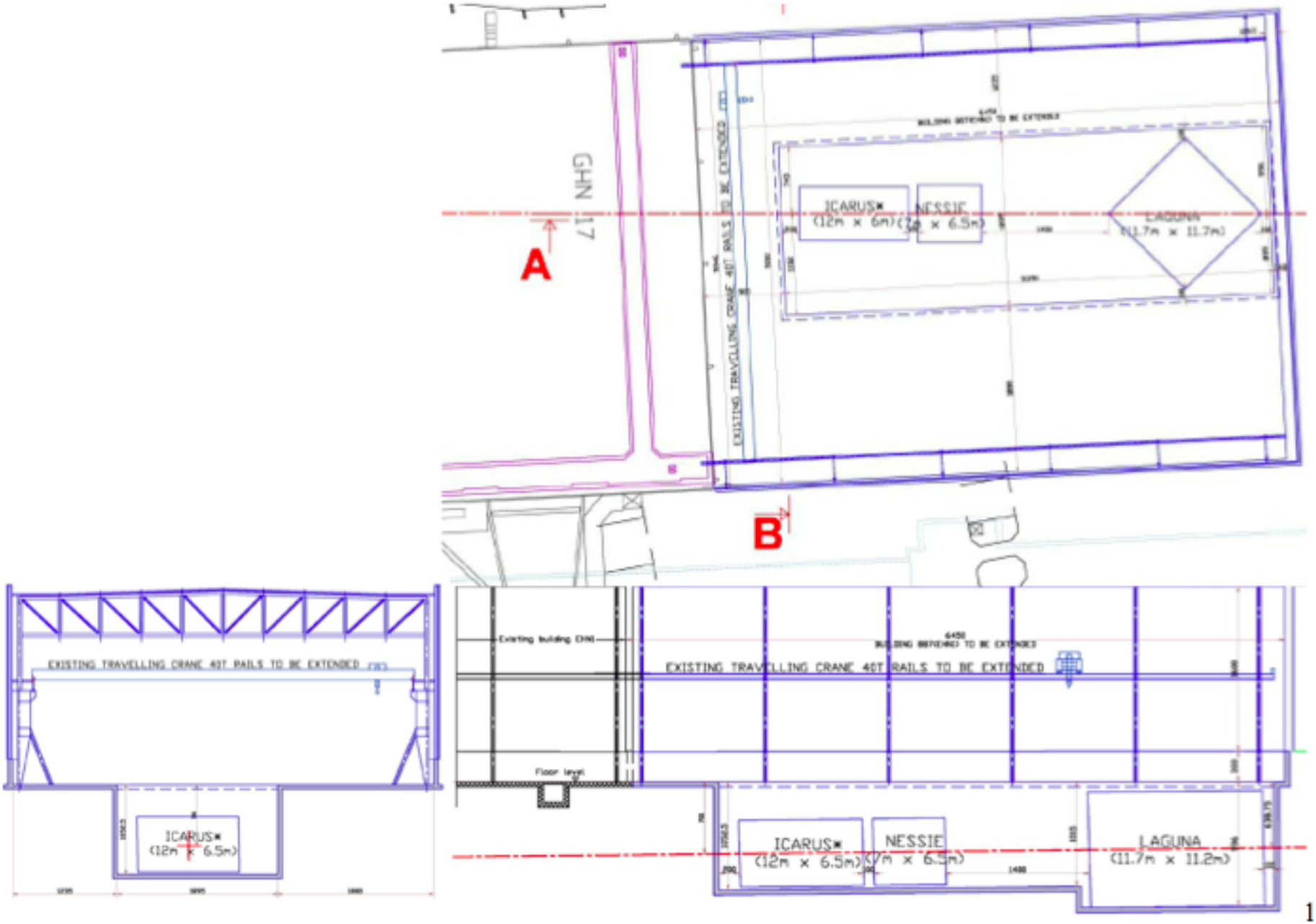
Table 6.38 shows the cost of the various main components as defined in this LOI, for all what concern the new CENF facility (experiments responsibilities excluded)

A more detailed cost table, with a break down item by item can be found through the following WWW-address: https://edms.cern.ch/document/1260767/1.

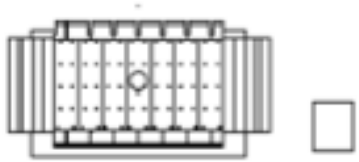
The cost figures quoted in this LOI are in 2012 Swiss Francs. No possible contingency figures

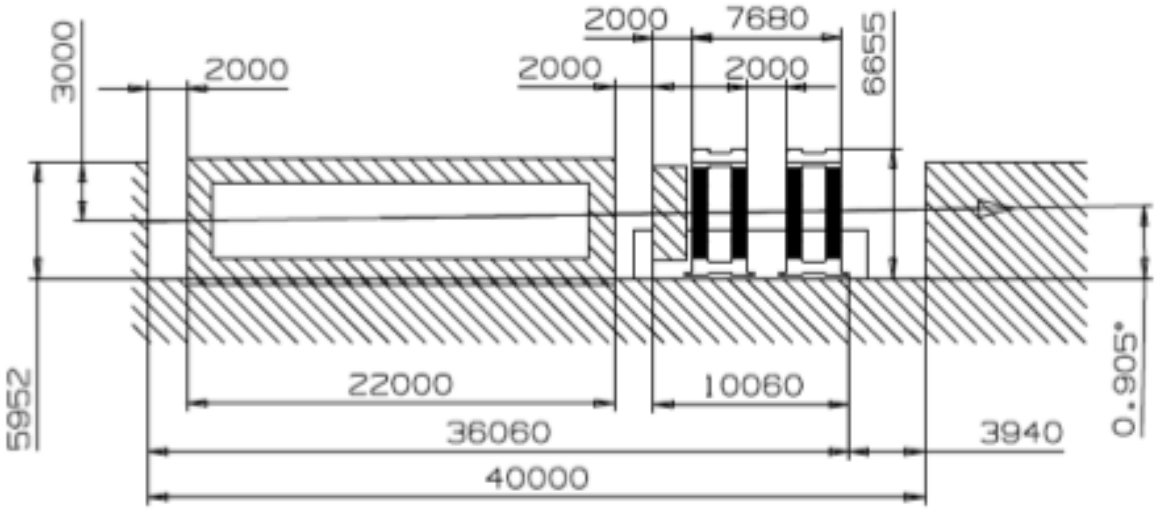
Dedicated MOU's with the individual detector collaborations will be prepared such to define the boundary of responsibilities between the various actors and provide a financial frame for the operation of the facilities and the detectors.

CERN proposal: NEAR site



FAR site

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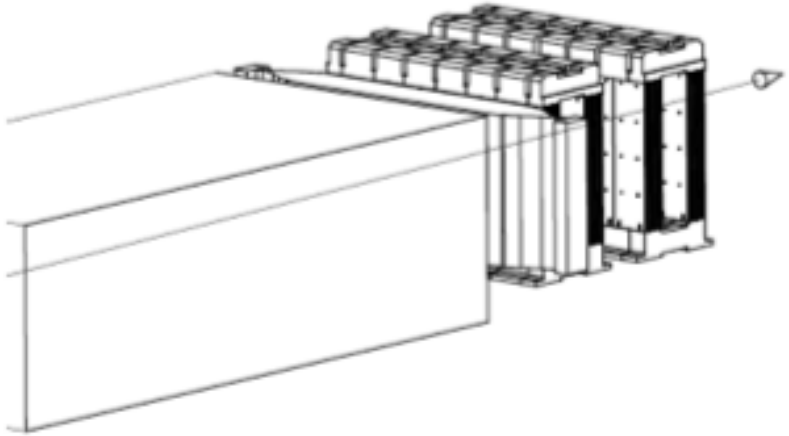
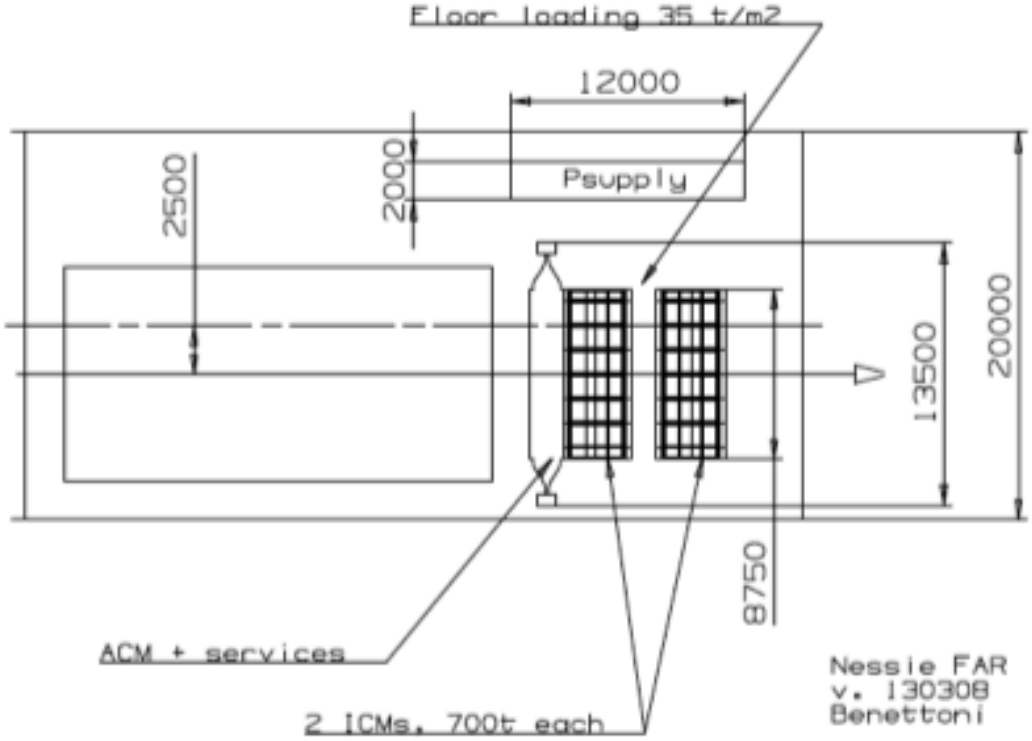



Floor loading 35 t/m2
12000
2000
Psupply
2500
20000
13500
8750
ACM + services
2 ICMs, 700t each
Nessie FAR
v. 130308
Benettoni

NESSiE Initial Design

- Two Iron spectrometers (**ICM**), 1500 + 800 t, composed by:
- 48 yoke blocks, , 4.5 x 0.6 x 1 m, 25t
- 480 slabs, 2 – 3 t, 1.25m x 3.5–6 m
- 1800 + 700 m^2 of RPC
- «sandwich style» assembly to be made in situ, one piece per time

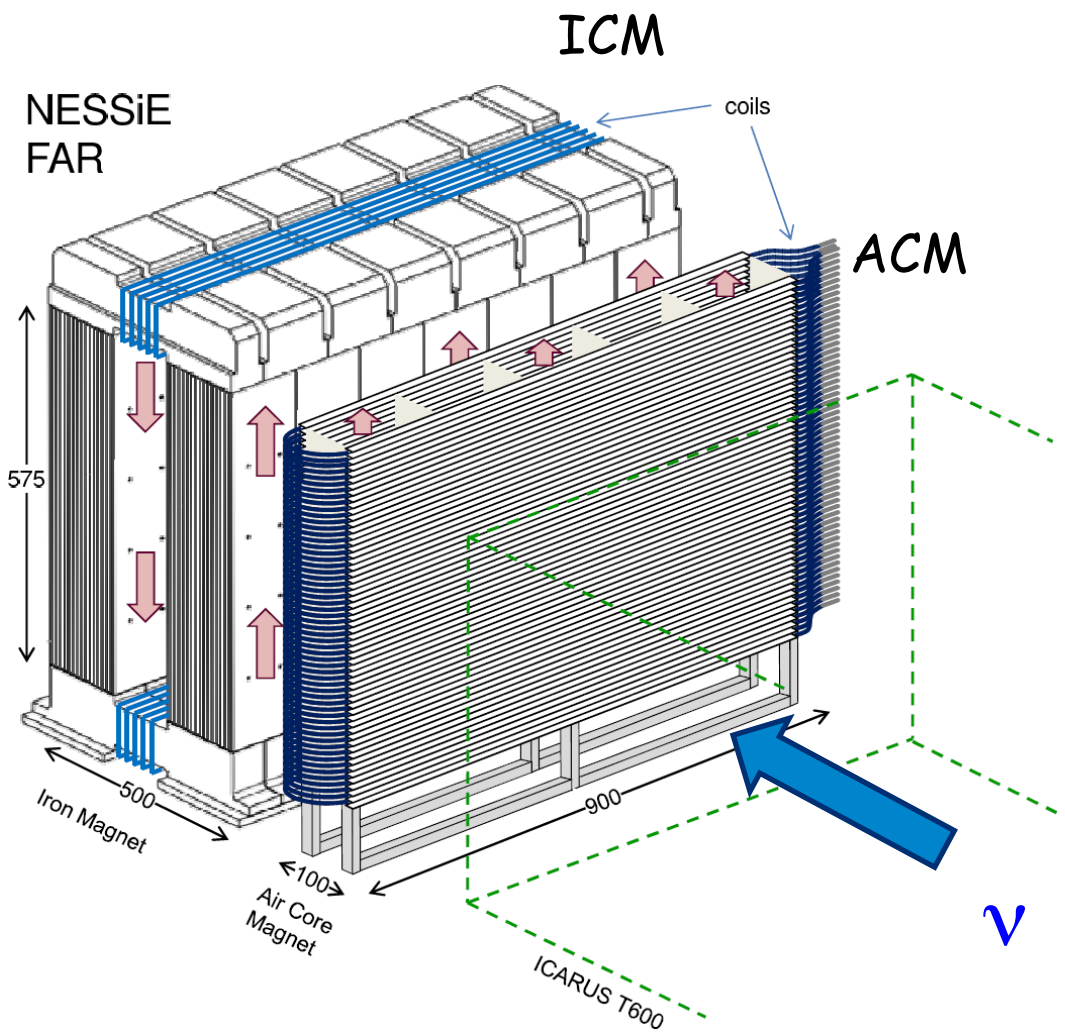
- 20,000+12,000 digital channels

- Two **ACM** preassembled and installed in one shot
- Precision Trackers preassembled and installed in one shot

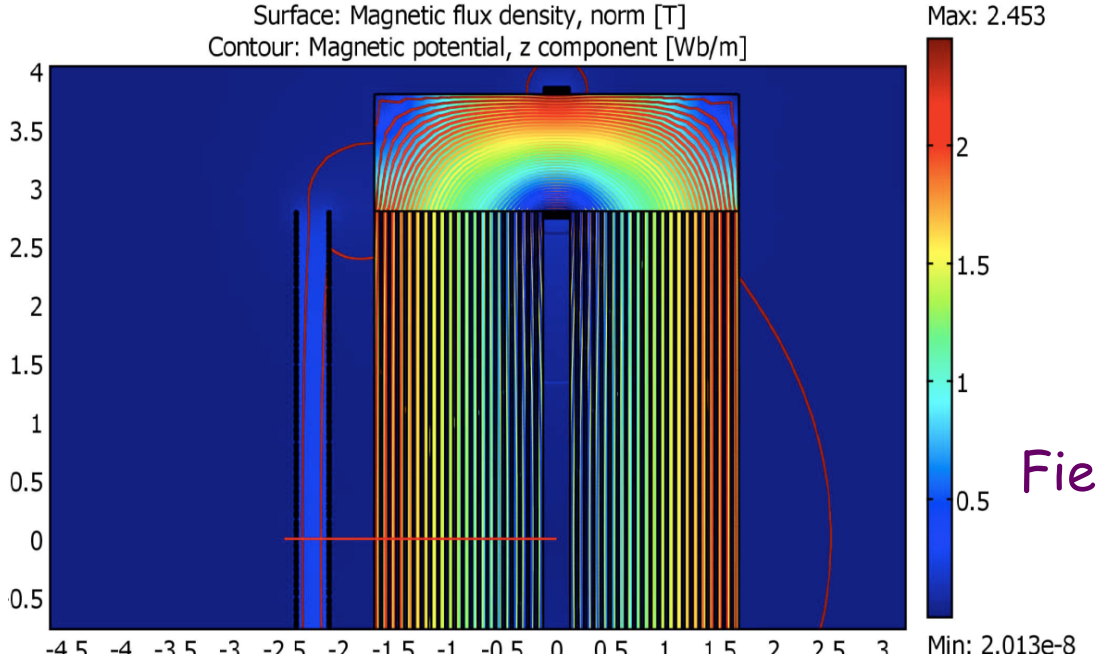
- Near Nessie movable aside on air-pad

- 1 + 0.5 MW , 10 kA, power (summed up for ACM and ICM)

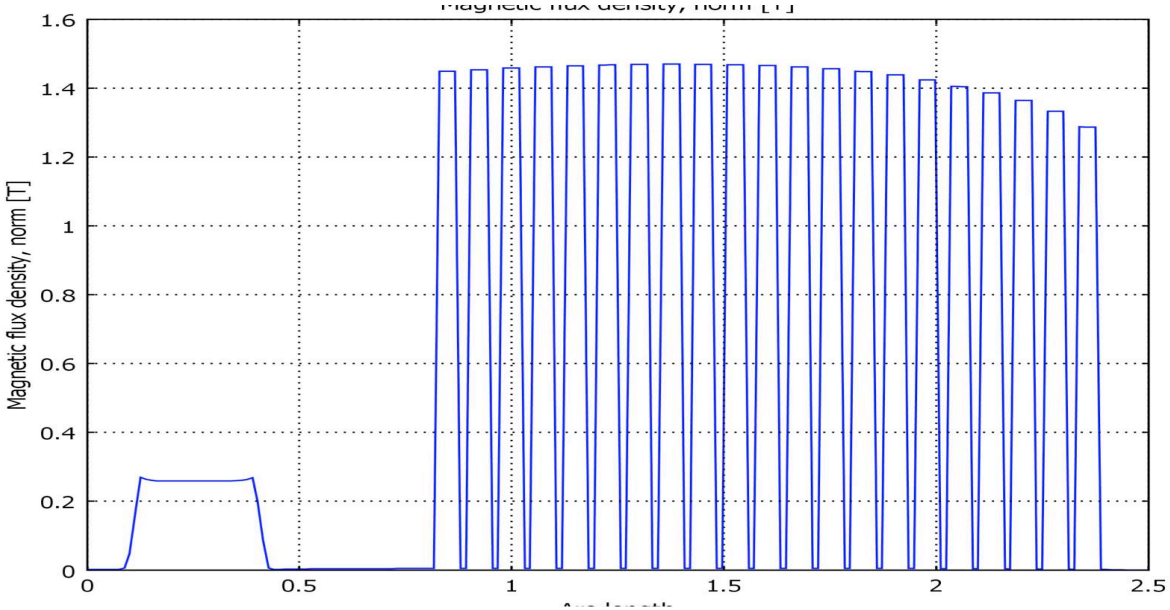
Optimized ! Reduced by almost a factor of 2 !!!



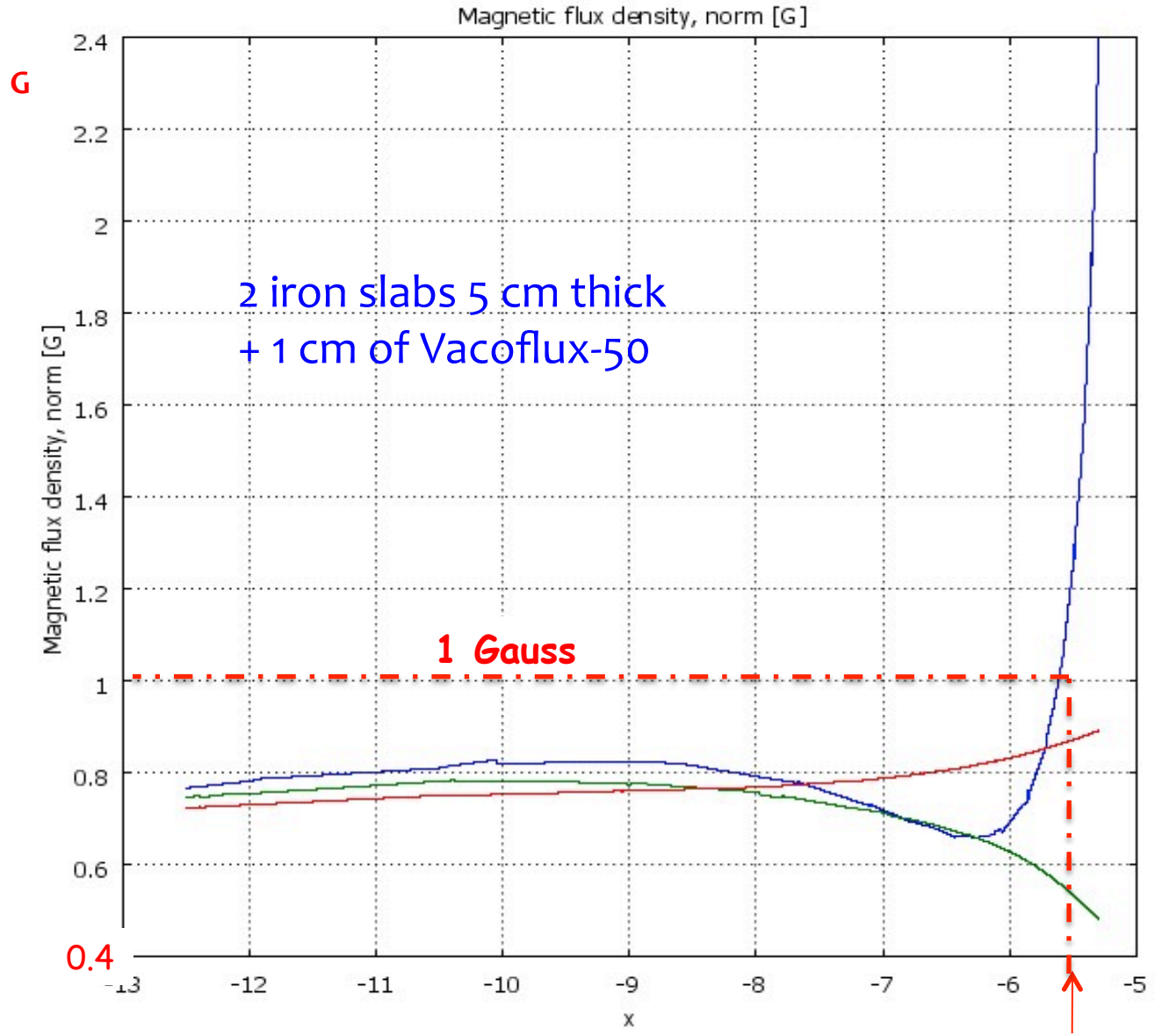
Magnetic Field Simulation



Field in Iron and in Air (2-D)



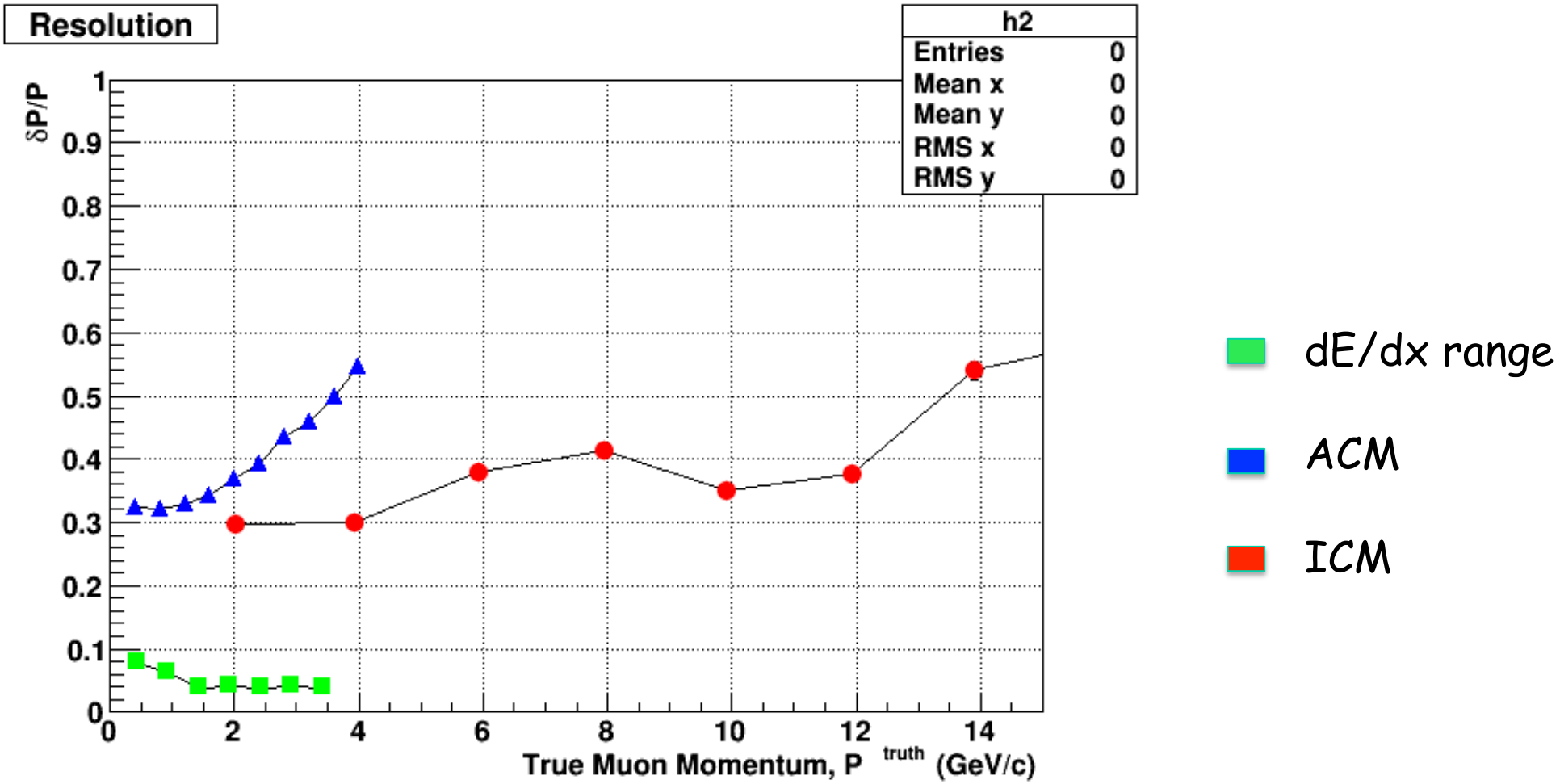
and the fringe field may be under control



(latest optimization)

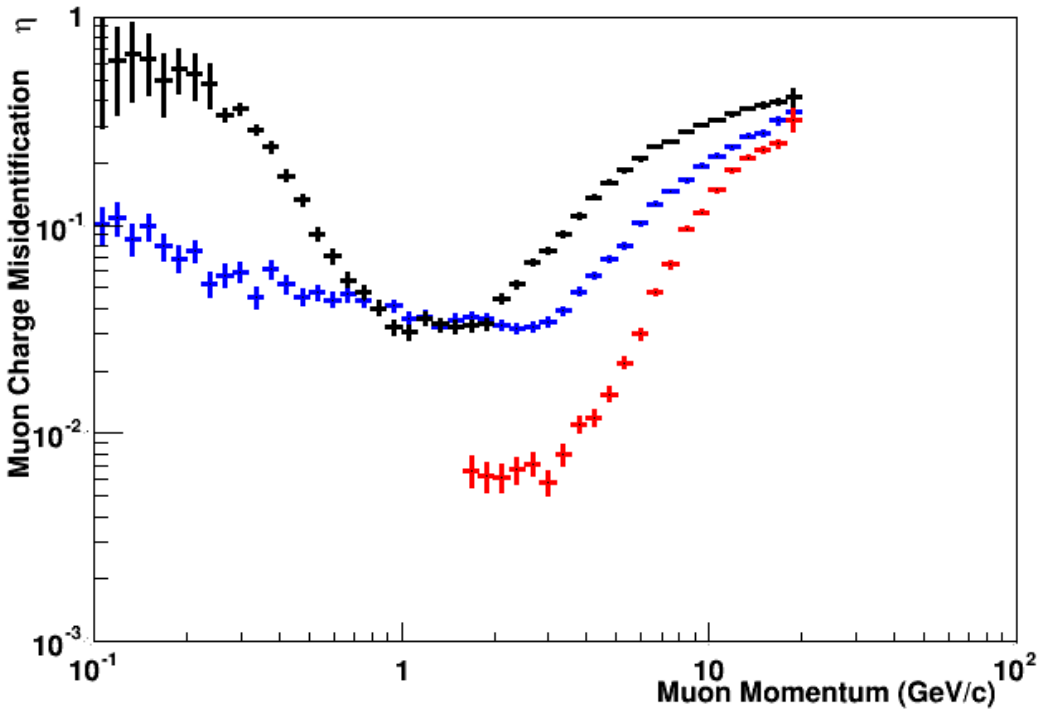
... and the Power Supplies (almost) as well:
230 kW (Near)
450 kW (Far)

Momentum measurement at 4% with dE/dx up to 3.5 GeV
At 30% with Prec.Tracker above 3 GeV
At 30% with ACM below 1.5 GeV



Latest configuration (OPERA-2), algorithms not optimized …

Muon mis-ID

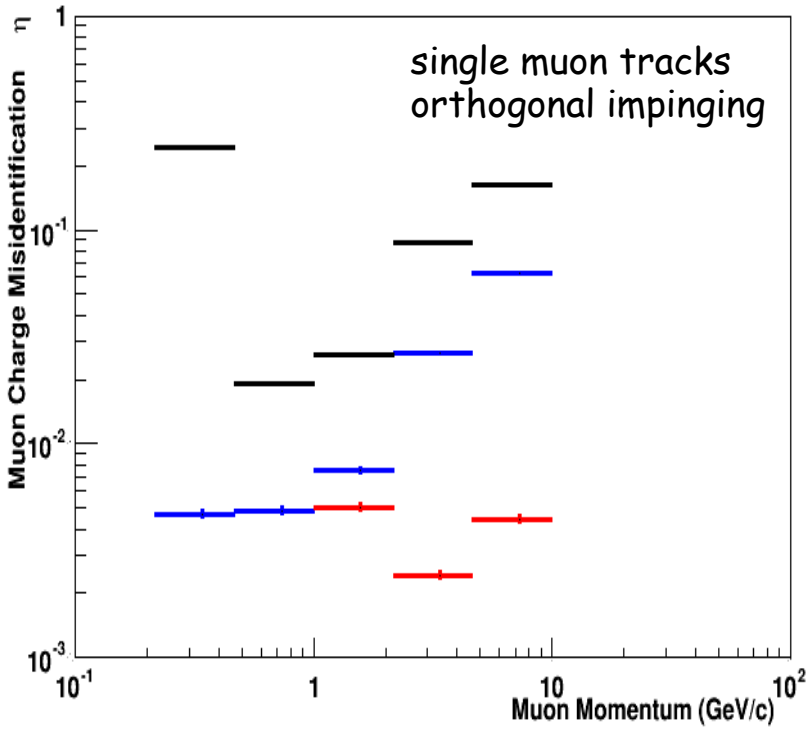


Charge mis-reconstruction at few percent level in all dynamical range of interest (full simulation including selection, efficiency and reconstruction)

one spectr.

ACM

two spectr.



Cost estimation (original, no OPERA, by now obsolete)

RPC-Iron	**1.5 K€/camera -> 2500 mq => (inclusa contingenza)**	**1.5 M€**
	0.1 K€/mq copper strips -> 5000 mq =>	**0.5 M€**
	10 €/dig-channel -> 32,000 digital channels =>	**0.32 M€**
	Supplies (about)	**0.15 M€**
	DAQ (about)	**0.1 M€**
	cabling (about)	**0.1 M€**
	Gas system (about)	**0.2 M€**
	Test stand	**0.1 M€**
Total-RPC-Fe	***available: 1.0 M€, OPERA: 0.9 M€ ? new needs: 1.1-2.0 M€***	***3.0 M€***
Air-Tracker	***300 mq => 0.2 M€ (detector) + 0.1 M€ (elects) + 0.2 M€ (R&D +supplies)***	***1.0 M€***
Magnet-Iron	***1.5 M€ (FE) + 2.0 M€ (Treatments) + 1.0 M€ (Supplies)***	***4.5 M€***
Magnet-Air		***1.5 M€***
GRAND TOTAL	***available: 1.0 M€, OPERA: 3.4 M€ ? new needs: 4.1-8.5 M€***	***10. M€***
Installation	***(about)***	***0.5 M€***

10 M€

Running costs	**gas**	**0.3 M€/year**
	maintenance	**0.15 M€/year**
	Shifts	**0.30 M€/year**
	Powering (CERN), pending air-B optimization	**≤ 1 MCHF/year**

0.5 M€

Opera re-use

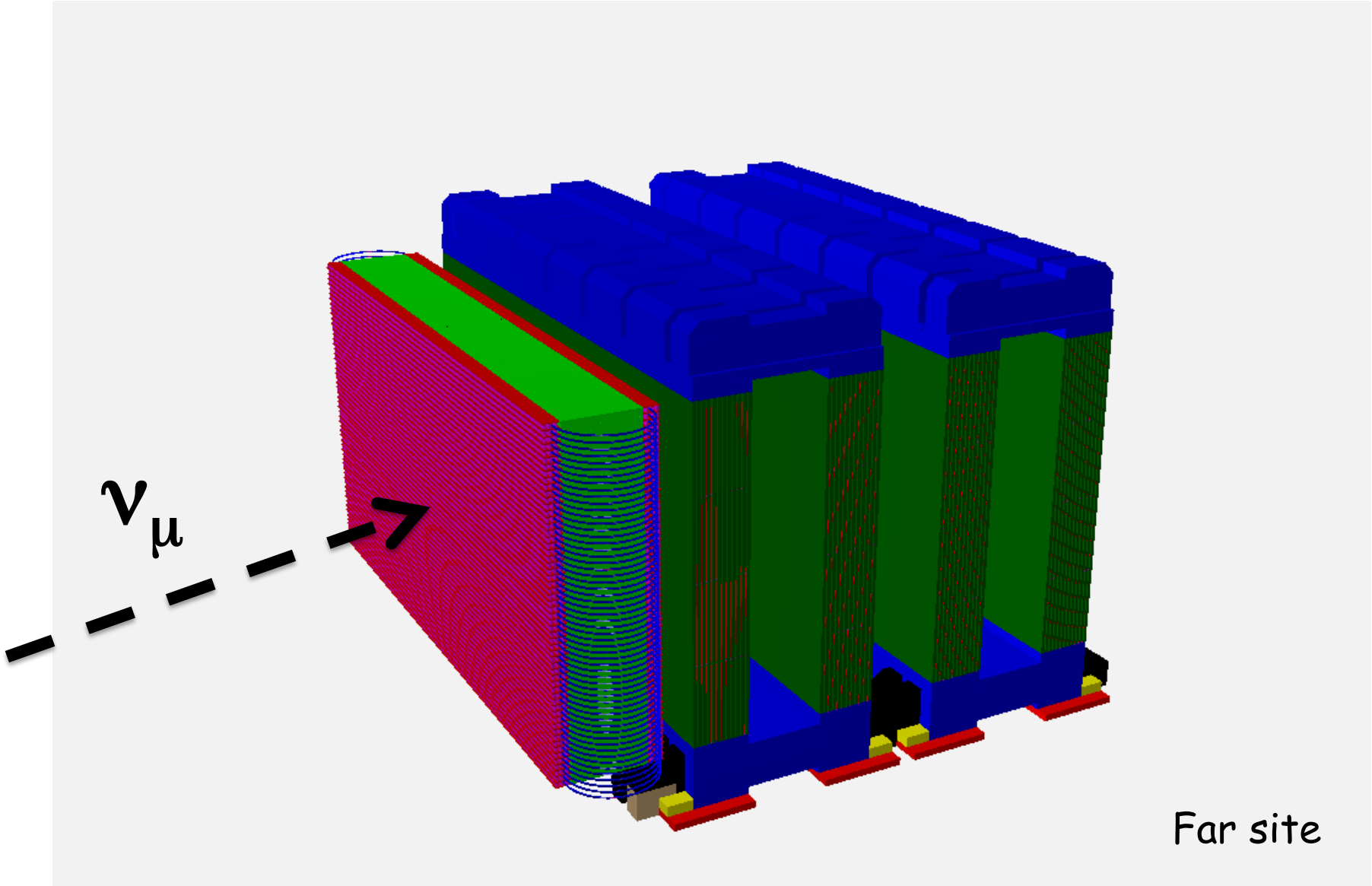
- 2 Spectrometers "available", with Detectors and Servicing
- Possibility to full re-use for Far AND Near ICM
- Need two new sets of Yokes (Top & Bottom)
  new Electronics for RPC
  Mechanical Tools
  PT detectors
  Scintillators
- Other: ACMs

TO availability for dismantling
and transportation at CERN: Autumn 2014

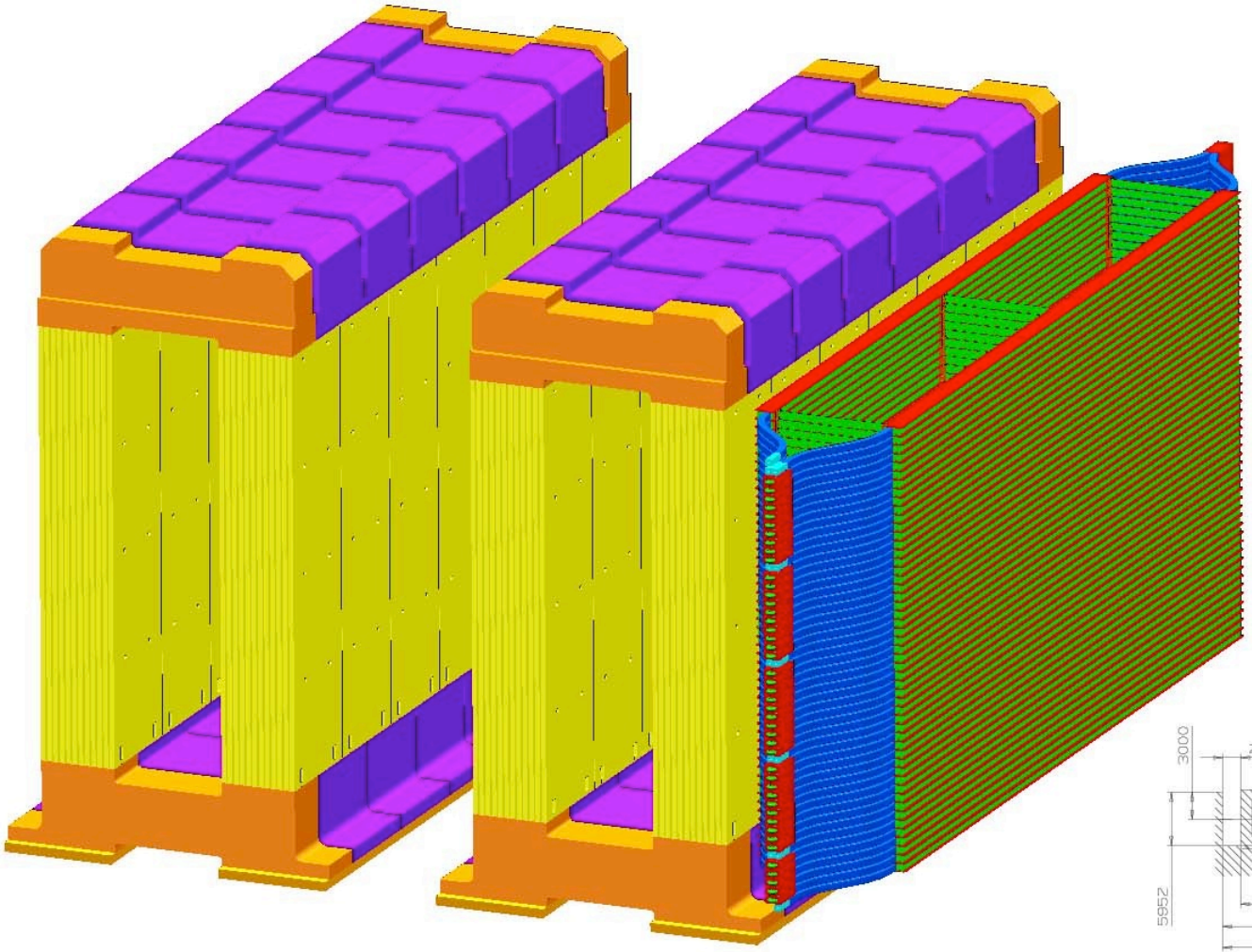
OPERA discussion:
possible start dismantling July-December 2014

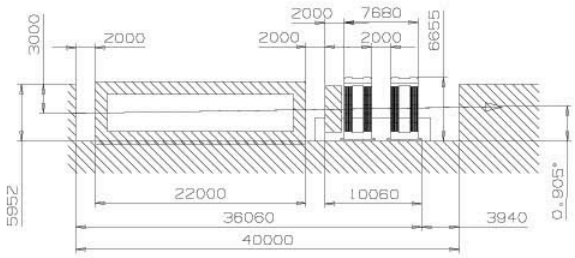
but FIRST 6 months needed for 2nd SM brick taking-out

Arrangement with OPERA Spectrs



Far site

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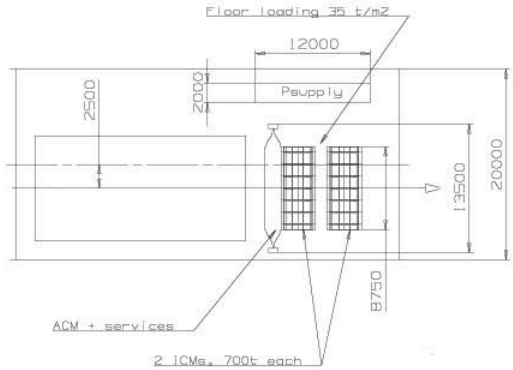
Floor loading 35 t/m2
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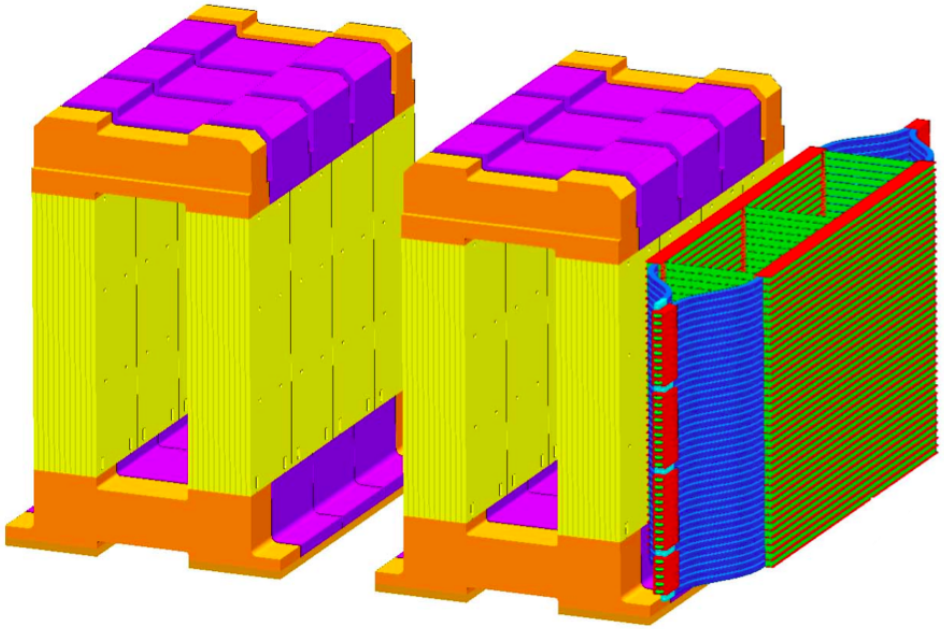
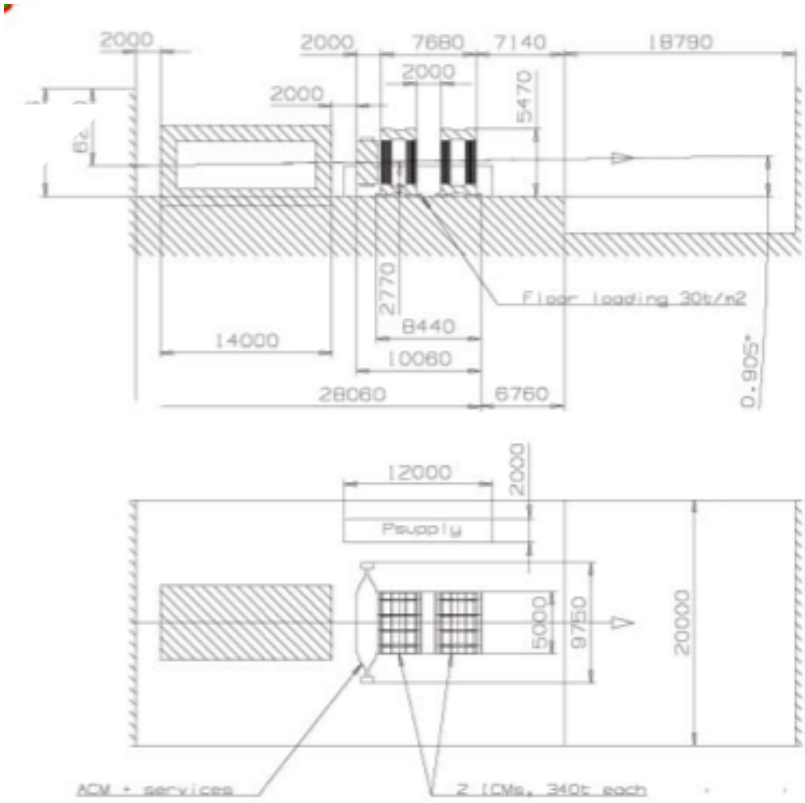
ACM + services
2 ICMs, 700t each

Near site

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Psupply
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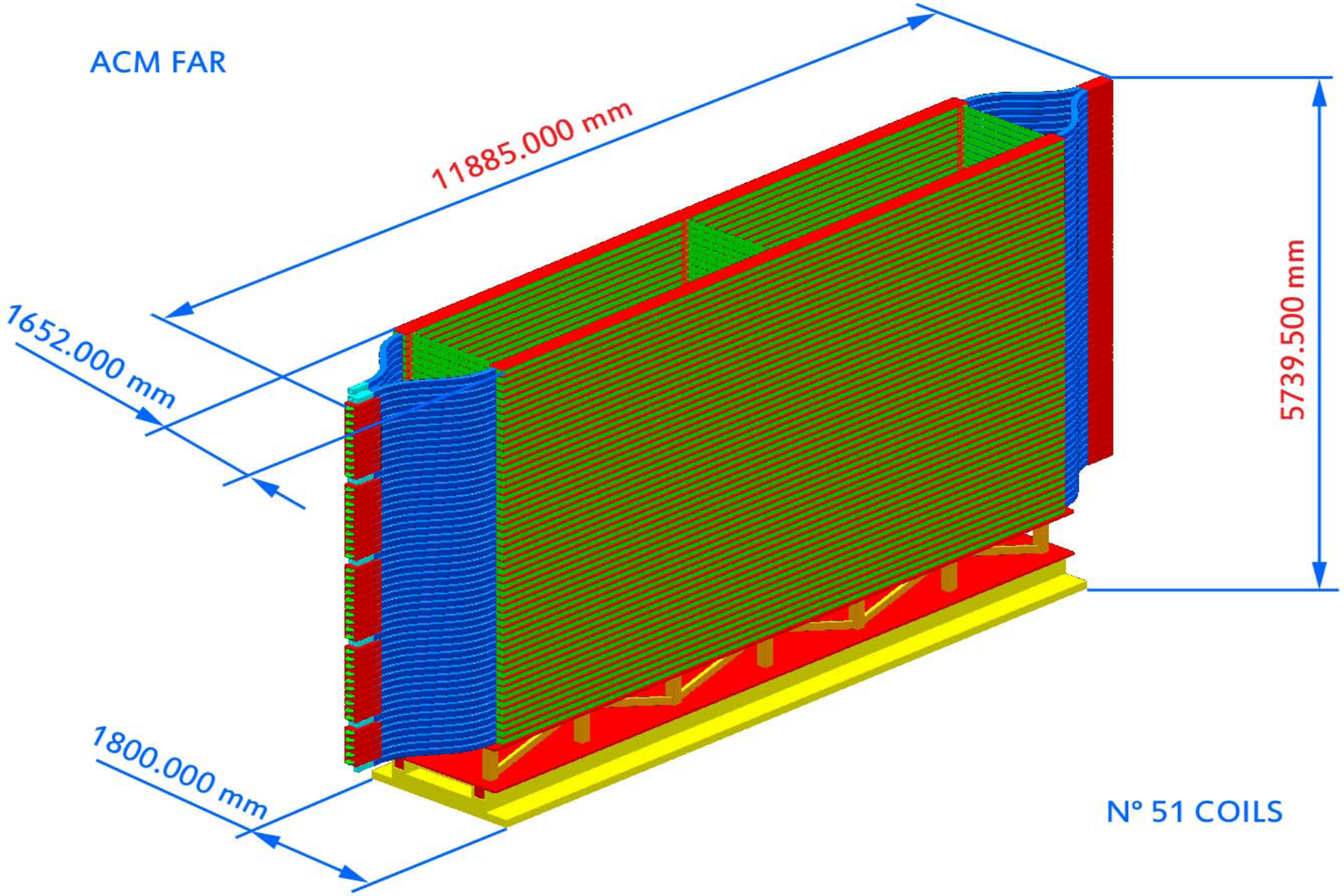
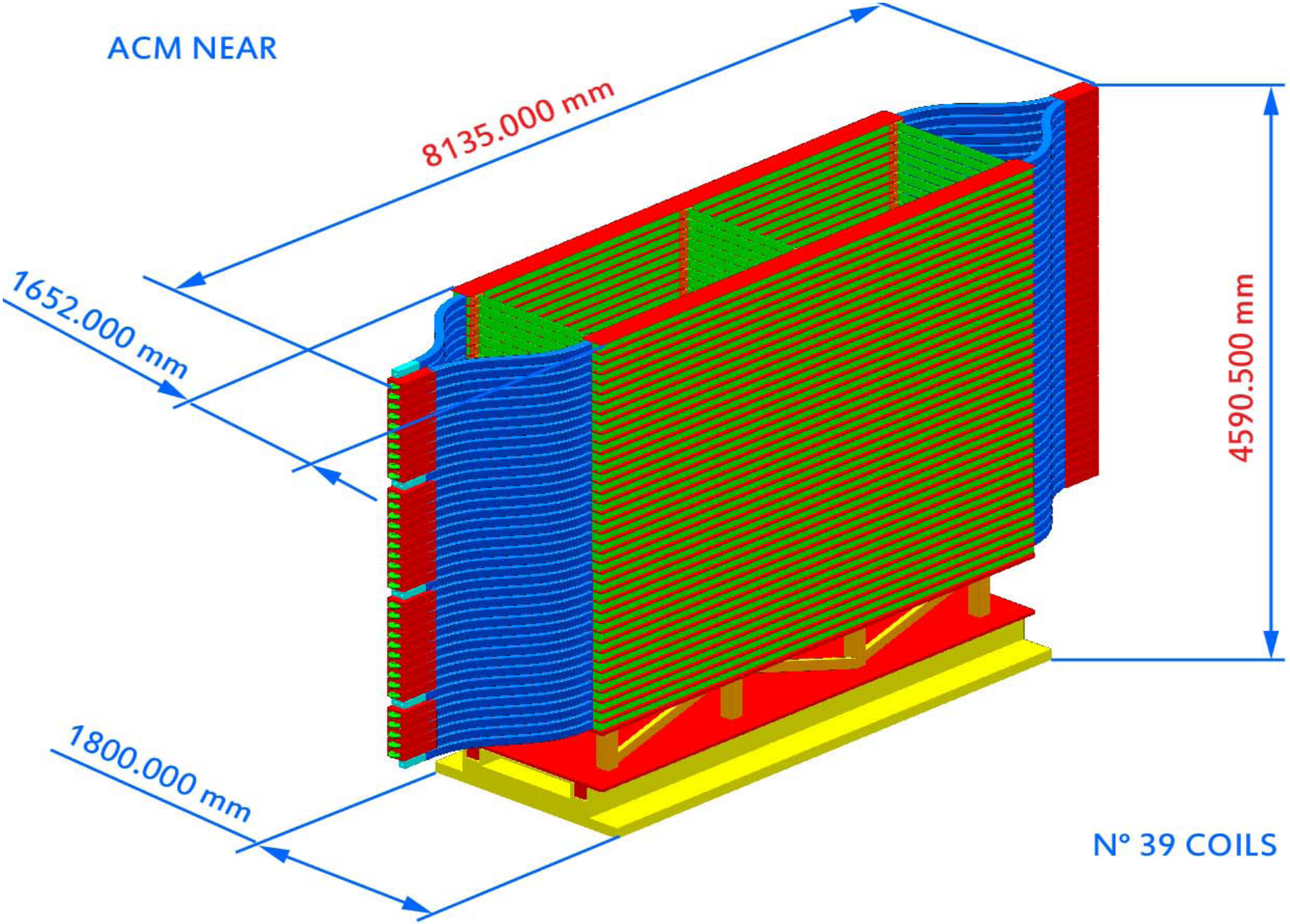
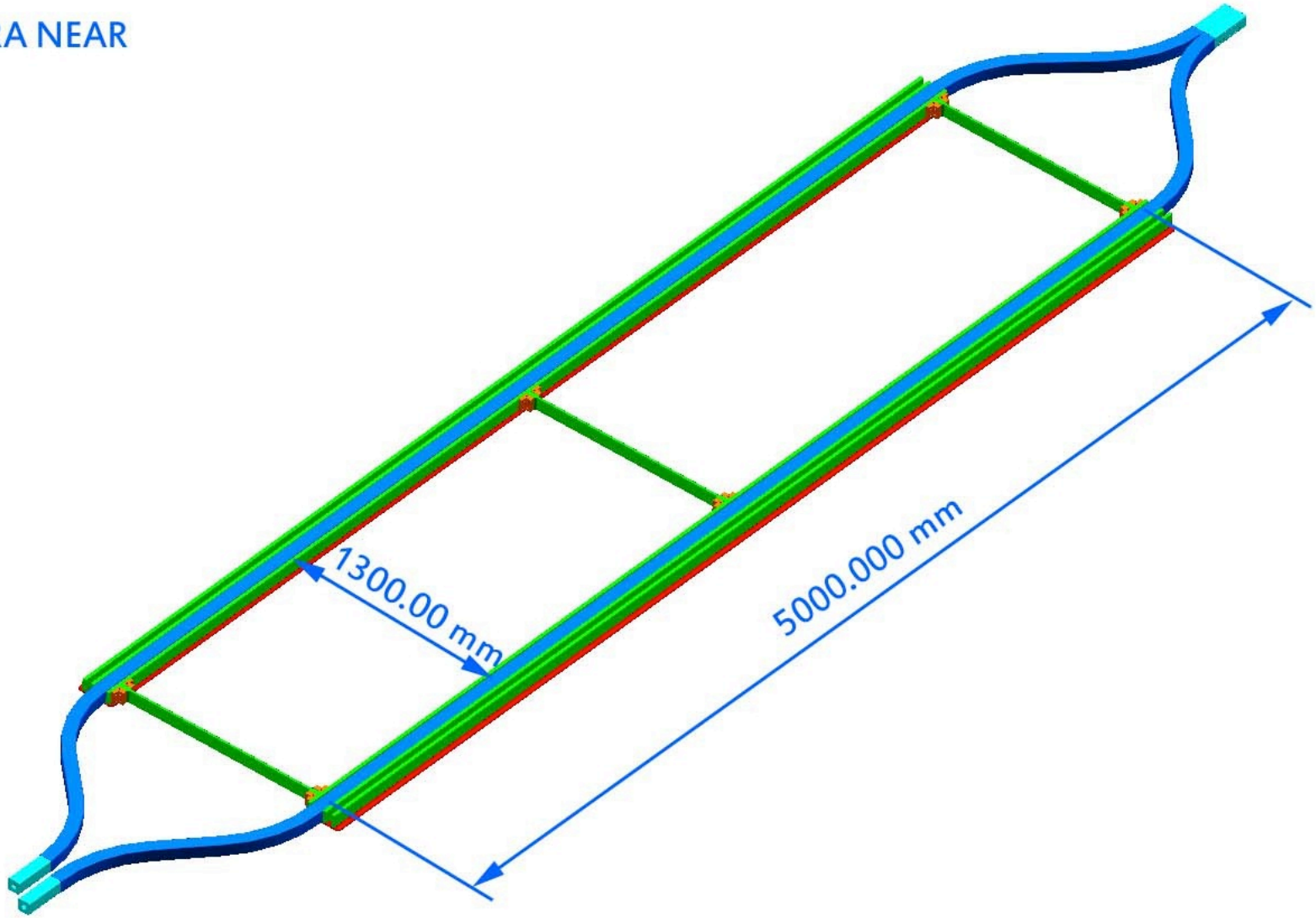
ACM + services
2 ICMs, 340t each


ACM FAR
11885.000 mm
1652.000 mm
5739.500 mm
1800.000 mm
N° 51 COILS


ACM NEAR
8135.000 mm
1652.000 mm
4590.500 mm
1800.000 mm
N° 39 COILS

SPIRA NEAR

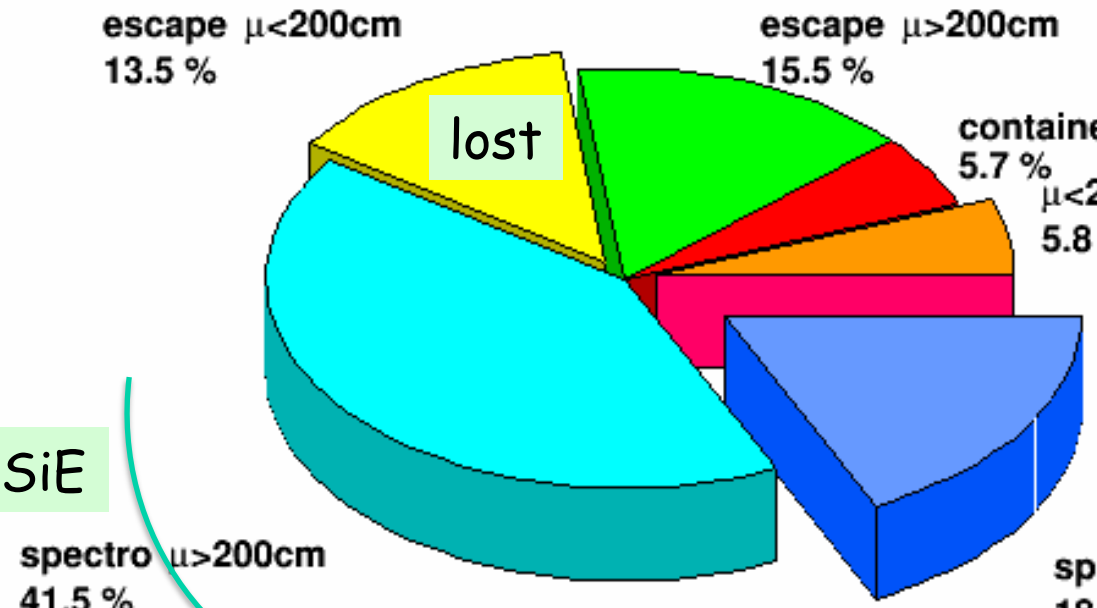


Neutrino Interactions in the Liquid Argon

(accepatances)

NEAR site

Icarus-LAr only

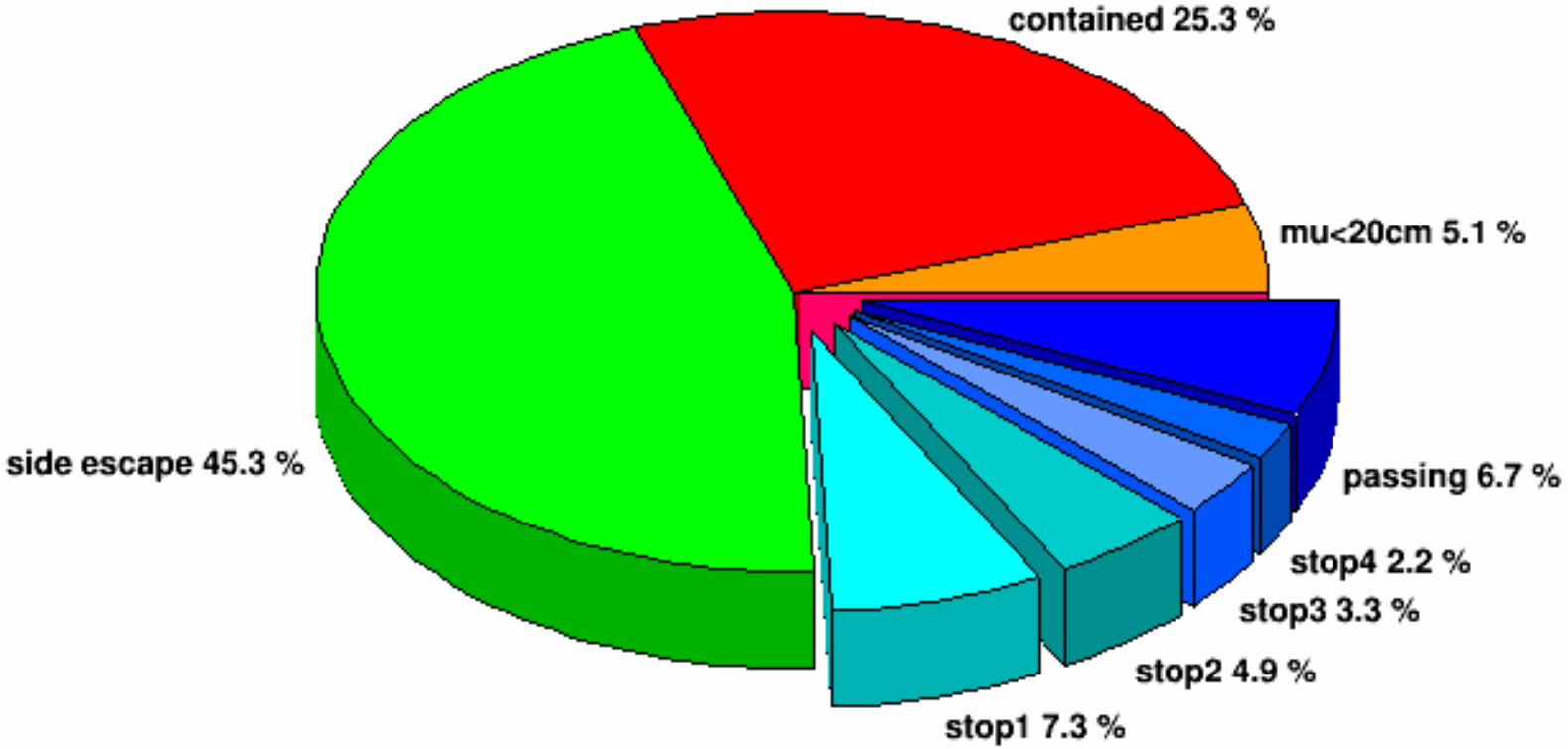


LAr+NESSiE

NESSiE only

muon stopping in the iron spectrometer

FAR site



New paper (L.Stanco et al.): arXiv:1306.3455

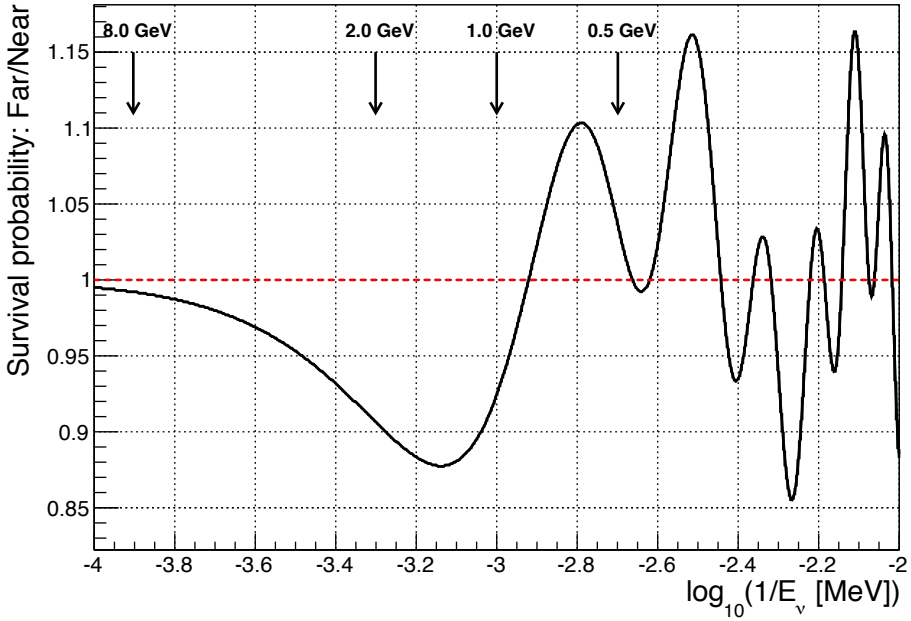
ONLY SPECTROMETERS…

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

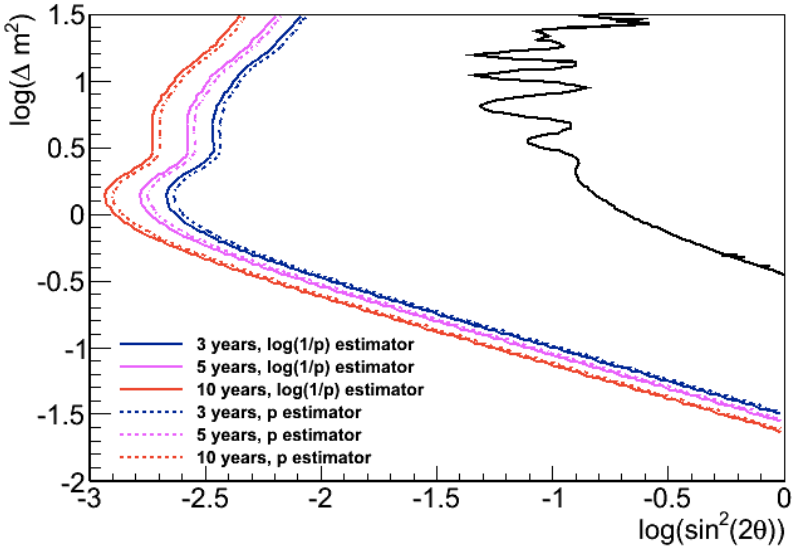
$$P_{\nu_\mu \to \nu_\mu} = 1 - \sin^2(2\theta)\sin^2(1.267\Delta m^2 \frac{L}{E})$$

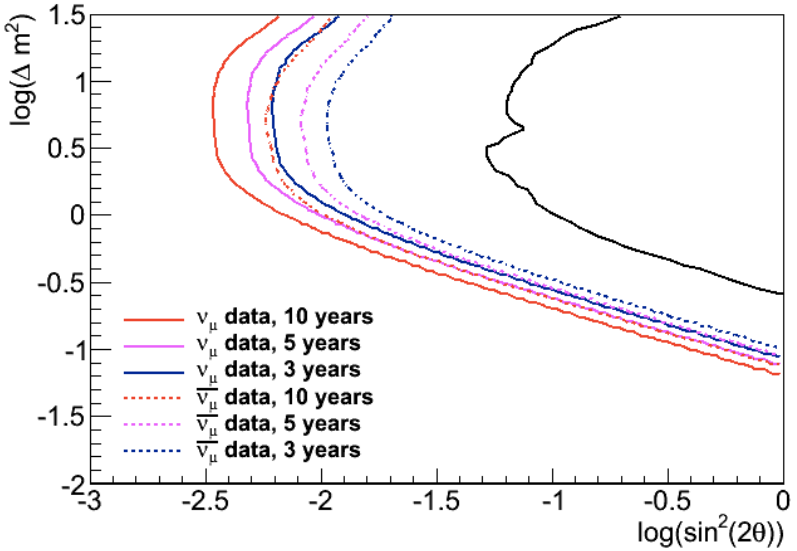
$$\sin^2(2\theta) = 0.146$$

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



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





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

Work Packages (CTS):

1. ICM ← INFN
2. ACM ← common
3. RPC ← INFN
4. Precision Tracker ← Germany
5. Scintillators ← France
6. RPC Electronics ← INFN
7. DAQ &Trigger ← common

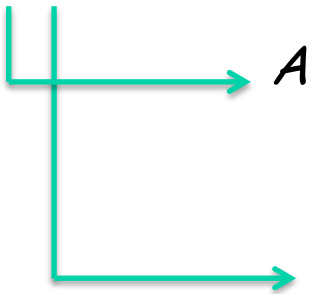
Running

The maintenance costs of the in-kind detectors which are property of different Funding Agencies will be on charge of the Agencies themselves.
The running costs will amount to about 300 Keuro per year, mainly for the gas consumption of RPC and PT.
They will be shared among the Collaboration following membership percentage.
At present we foresee 1 year of running, in 2017, before the Long-Shutdown-2, and 2 year after the LS2.
The cost for Power Supplies of ACMs, when ready, will be taken by CERN.
Shifts for operations will be also shared among the collaborators, following the above rule.

MONEY estimation

Iron magnets: in-kind value 5940 K€ (from OPERA MoU)
Cost for transportation to CERN and refurbishing: 3000 K€
In-kind value of Precision Tracker: 1900 K€
possible refurbishing: 700 K€
In-kind value of Scintillators: 1900 K€
possible refurbishing: 300 K€
Cost ACM: 1000 (Near) + 1200 (Far)

TOTAL: 3+1+1+1 = 6 M€



ACM-NEAR, including R&D, designs, certifications

ACM-FAR might be staged at 2nd phase (after LS2)

NESSIE Collaboration

In the near future:
- CERN clarification of its willingness
- Search for other neutrino beams

ITALY
- Bari: 0.6 FTE/3
- Bologna: ?/5
- Frascati: 0.5/2
- Lecce: ?/7
- Padova: ?/12
- Roma1: 0.6/3

TOTAL: ? FTE / ? People

t.b.d.

Less FTE than last year, due to the stop of SBL Neutrino Project

Two new groups:
- SINP-MSU, Moscow
  Tatiana ROGANOVA (group leader), Anna Anokhina, Timur Dzhatdoev
- Lebedev, LPI, Moscow
  Natalia POLUHINA (group leader),
  O.Dalkarov, N.Starkov, A.Bagulya, M.Chernyavskiy, M.Vladymyrov

Welcome to four Observers:
Strasbourg(FR), Hamburg(G), Zagreb(KR), Napoli (IT)

INFN involvements in NESSiE :

BARI: Front-End, Simulation, Analysis, Detectors

BOLOGNA: ACM Mechanic, Design, Software, DAQ-ACM, ACM-tracker

FRASCATI: ICM Mechanic, Design, Beam-simulation, Detectors

LECCE: Mechanic, Simulation, Analysis

PADOVA: Infrastructures, Simulations, Analysis, DAQ, Mechanics, Detectors

ROMA-1: Software and Analysis

MOSCOW: Software and Analysis

NESSIE

Gruppo di Padova:

M. Benettoni, Pr.Tecn. (20%)
A.Bertolin. Ric.INFN (20%).
F.Dal Corso, Pr. Tecn. (20%)
S. Dusini , Ric. INFN(20%)
C.Fanin, Pr. Tecn. (20%)
M. Laveder, Ric. Univ. (20%)
I.Lippi, Ric. INFN(40%)
E.Medinaceli, Ass. Univ. (20%)
M.Mezzetto, Dir. Ric. (20%)
M. Roda, Dottorando (20%)
C.Sirignano, Ric. Univ. (20%)
L.Stanco, Dir. Ric. (40%). Responsabile Nazionale e Locale

2.9 FTE + t.d.c.

Riferimenti nella collaborazione

- Stefano Dusini: *Simulazione Detector e DAQ*
- Luca Stanco: *Supervisione Collaborazione*

Nel 2013/14 dovranno definitivamente chiarirsi gli ambiti di lavoro, o al CERN o in un altro sito internazionale.

NESSIE

Richieste finanziarie 2014

(Le richieste dipendono dalle valutazioni in corso)

Missioni Interne: t.b.d

Missioni Estero: t.b.d.

Consumo: t.b.d.

Inventario: t.b.d

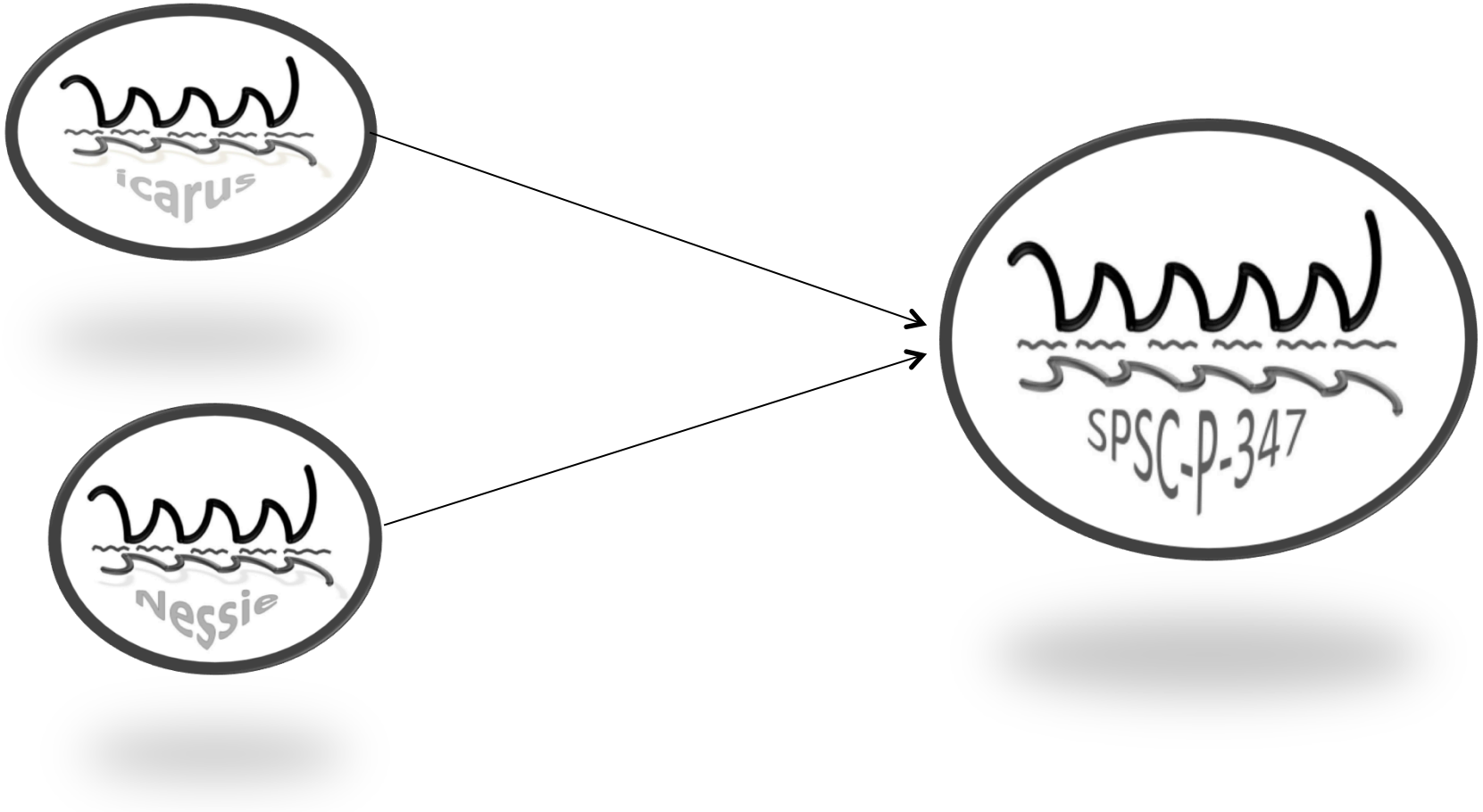
Richieste ai servizi PADOVA per il 2013:

Elettronica: t.b.d.

Meccanica: t.b.d

Uffico Tecnico: 4 m.u. per supporto valutazione sito CERN/FNAL

Thank you !



Backup slides

Conclusive Studies

Oscillation type	Neutrinos	Experiments
θ_{12}	ν_e(solar, reactors)	SNO, SK, Borexino, Kamland
θ_{23}	ν_μ (atmospheric, accelerators)	SK, Minos, T2K
θ_{13}	ν_e(reactors)	Daya Bay, RENO, Double Chooz, T2K
θ_{14}	ν_e(reactors, radioactive sources)	SBL Reactors, Gallex, Sage. **This Proposal**
θ_{24}	ν_μ (accelerators)	CDHS, Miniboone. MINOS+ **This Proposal**

Measure at L/E corresponding to $\Delta m^2 \sim 1\ eV^2$

ν_μ AND $\overline{\nu}_\mu$

AND with ≥ 2 sites

in Appearance (ν_e)

AND

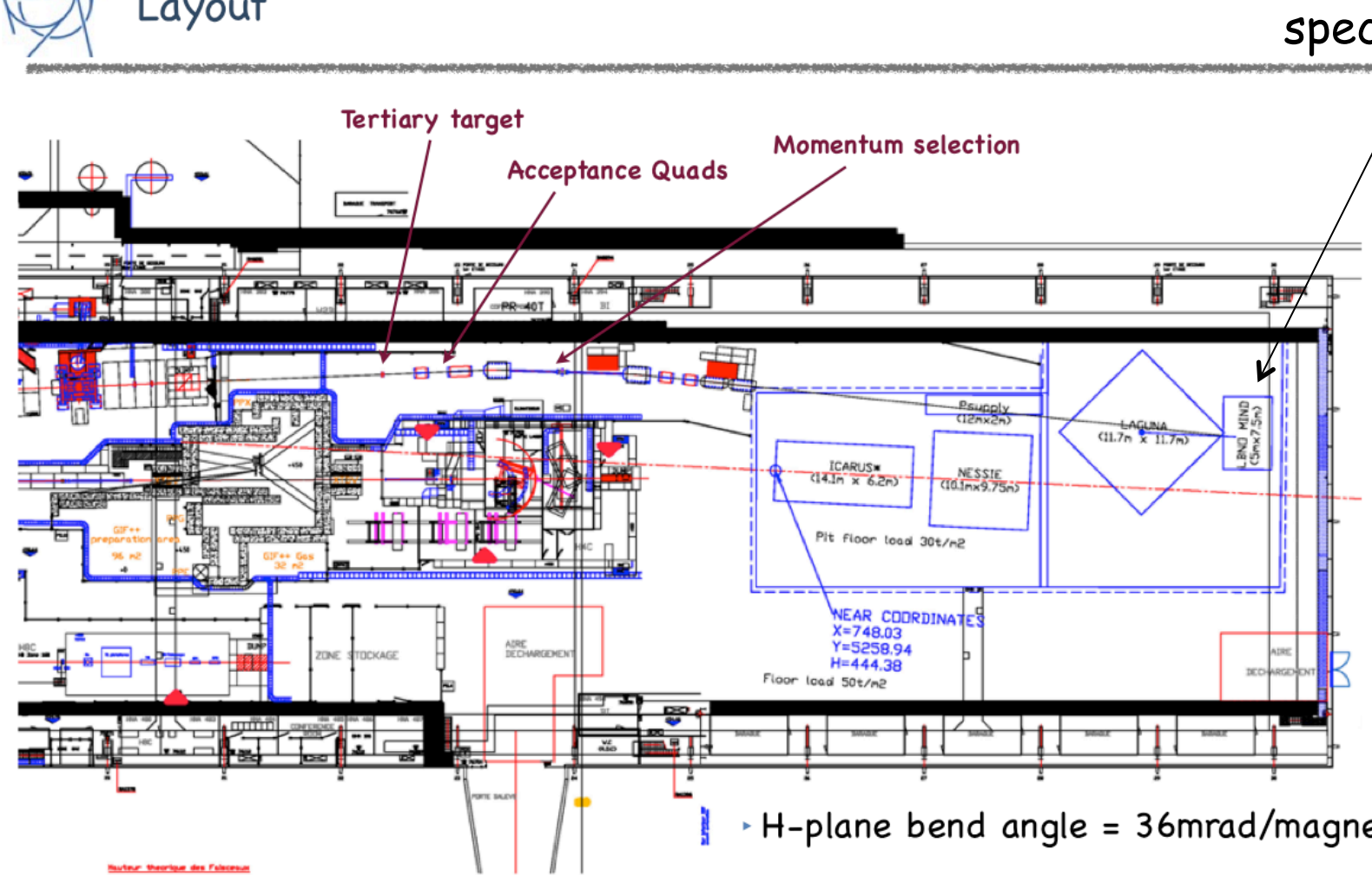
in Disappearance (ν_μ)

2^3 combs

L.Stanco©

Latest CERN designs for the Near site:

Layout



- H-plane bend angle = 36mrad/magnet
- V-plane bend angle = 30mrad/magnet