# The CERN Neutrino Platform

M.Nessi, 22-10-2018

# … the agreed 2013 European Strategy :

*"Rapid progress in neutrino oscillation physics, with significant European involvement, has established a strong scientific case for a long-baseline neutrino programme exploring CP violation and the mass hierarchy in the neutrino sector. CERN should develop a neutrino program to* ***pave the way*** *for a substantial European role in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan."*

# Our interpretation

- ✓ *no new $\nu$ beams at CERN !*
- ✓ *$\nu$ beams in the US and in Japan*
- ✓ *A structure at CERN to foster an active involvement of Europe and CERN in the US and Japanese new facilities*

→ **Neutrino Platform as a CERN project**

# CERN $\nu$ Platform Mandate (2014)

- Assist the various groups in their R&D phase (detectors and components) in the short and medium term
- *Give coherence to a fragmented European Neutrino Community*
- Provide to the $\nu$ community a test beam infrastructure (charged particles)
- *Bring R&D at the level of technology demonstrators in view of major technical decisions*
- Continue R&D on $\nu$ beam, as a possible base for further collaborations
- *Support the short baseline activities (infrastructure & detectors)*
- Support the long baseline activities (infrastructure & detectors)

# The ν Platform is organized through a system of MOUs

**Memorandum of Understanding**

**for providing a framework for developing a Neutrino Program at CERN**

between

The EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH, an Intergovernmental Organization having its seat at Geneva, Switzerland, ('CERN,'), as the Host Laboratory,

on the one hand,

and

The FUNDING AGENCIES/INSTITUTIONS PARTICIPATING IN THE NEUTRINO PHYSICS RESEARCH PROJECTS AT CERN ('the Neutrino Institutions'),

on the other hand,

(collectively "the Parties")

**Preamble**

(a) As endorsed by the CERN Research Board at its meeting of August 28th, 2013 and detailed in Annex 1, CERN has decided to develop a Neutrino Program at CERN ('the Neutrino Program') to pave the way for a substantial European role in future Long-Baseline Experiments and explore the possibility of major participation of Europe in leading Long-baseline Neutrino Projects in the United States and Japan;

(b) The Neutrino Institutions, including possibly CERN, wish to collaborate in the research and development (R&D) and construction of prototypes, equipment and related infrastructure for the Neutrino Program and have obtained the support of their Funding Agencies to enable them to

How to get in?

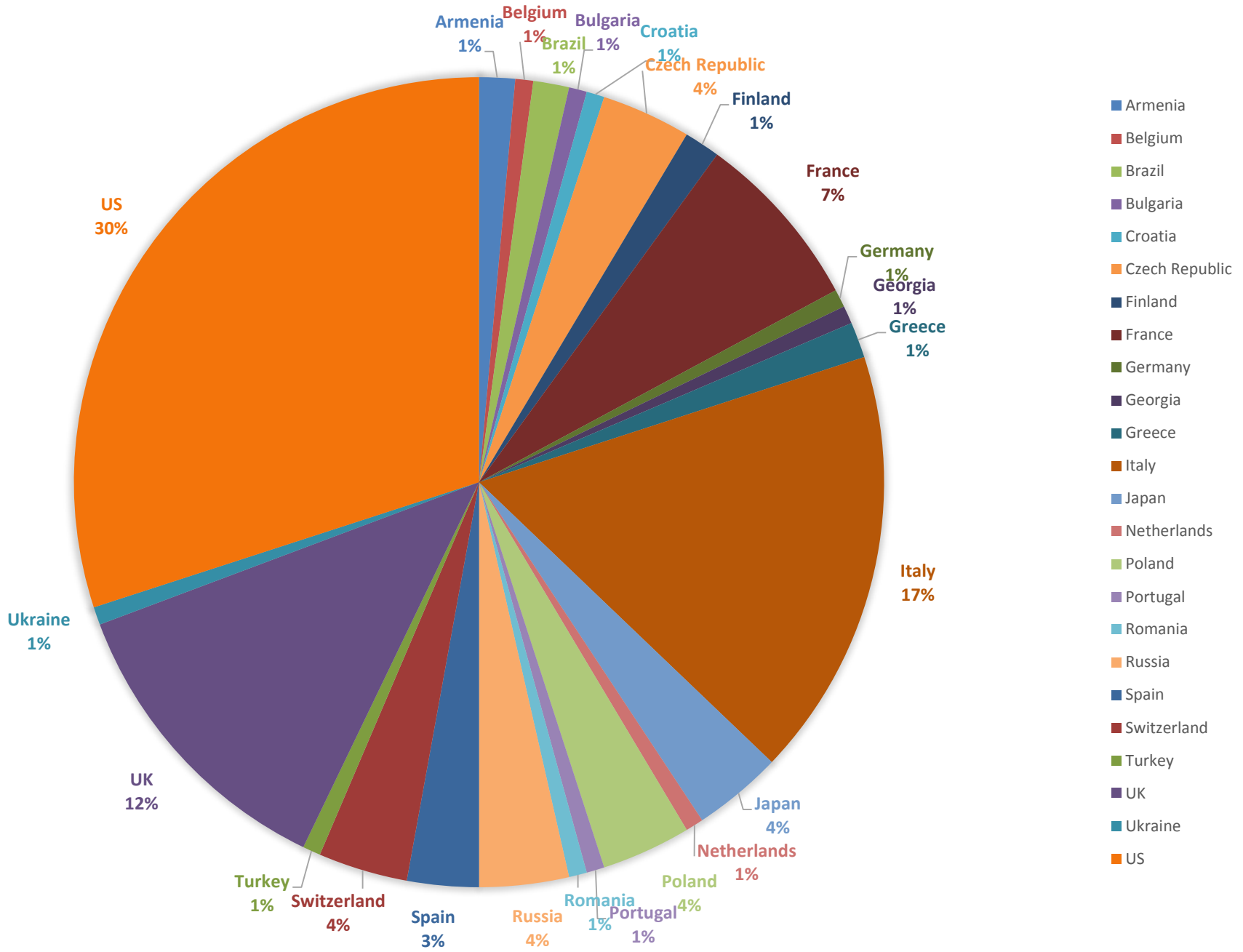
- Present to the CERN SPSC a LOI or an expression of interest
- When approved by the CERN RB, we prepare together an MOU (addendum) which defines all responsibilities and resources needed
- Then a CERN experiment is created (NP01, NP02,NP03, NP04, NP05, …), with all privileges and requirements

https://edms.cern.ch/document/1353815

Acad. of Sciences of the Czech Rep., Czech Republic, AGH University of Science and Technology, Krakow, Poland, Alikhanian National Science Laboratory (YerPhi), Armenia, Argonne National Laboratory, US, Boston University Study Abroad Program Geneva, Switzerland, Boston University, US, Brookhaven National Laboratory, US, Campinas University, Brazil, CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette - IRFU, France, Centre d'Etudes Nucléaires de Bordeaux-Gradignan, France, Centre National de la Recherche Scientifique - LAPP-Laboratoire d'Annecy-le-Vieux de Physique des Particules, France, Centro de Investigaciones Energéti cas Medioambientales y Tecnológicas (CIEMAT), Madrid, Spain, Charles University, Faculty of Mathematics and Physics, Czech Republic, Colorado State University, US, Czech Technical University, Czech Republic, Dallas University, US, Dipartimento de Fisica e Astronomia, Universita di Roma, Italy, Dipartimento di Fisica E. Pancini, Università di Napoli Federico II, Italy, Dipartimento di Fisica, Universita di Bari, Italy, Dipartimento di Fisica, Universita di Bologna, Italy, Dipartimento di Matematica e Fisica, Universita del Salento, Lecce, Italy, Dipartimento di Matematica e Fisica, Universita Roma Tre, Italy, Drexel University, US, Duke University, US, Eidgenoessische Technische Hochschule Zuerich - ETH Zurich Institute for Particle Physics, Switzerland, European Organiz. for Nuclear Res. (CERN), Switzerland, Federal University of ABC, Brazil, Fermi National Accelerator Lab, US, High Energy Accelerator Research Organization, Tsukuba, Japan, High Energy Physics Institute of Tbilisi State University, Georgia, Imperial College London, UK, Indiana University, Bloomington, US, INFN e Laboratori Nazionali di Frascati, Italy, INFN Milano, Italy, INFN Sezione de Bari, Italy, INFN Sezione di Lecce, Italy, Italy, INFN Sezione di Pavia, Italy, Italy, INFN Sezione di Roma, Italy, INFN, Sezione di Padova, Italy, Institut de Fisica d'Altes Energies (IFAE), Bellaterra, Barcelona, Spain, Institute of Experimnetal and Applied Physics, Czech Technical University in Prague, Czech Republic, Institute of Nuclear Physics, Polish Academy of Science, Poland, Institute of Physics, Acad. of Sciences of the Czech Rep., Czech Republic, Institute of Theoretical Physics, Wroclaw, Poland, Institute of Theoritical Physics and Modeling, Armenia, Iwate University, Japan, Joint Institute for Nuclear Research (JINR), Dubna, Russia, Justus-Liebig-Universität Gießen, Germany, Kamioka Observatory, University of Tokyo, Japan, Kansas University, US, Kyoto University, Japan, Laboratoire de physique nucléaire et de hautes énergies Paris (LPNHE), France, Laboratori Nazionali del Gran Sasso - Sezione di LNGS (INFN), Assergi, Italy, Lancaster University, UK, Lawrence Berkeley National Lab., Berkeley, US, Lebedev Physical Institute of Russian Academy of Science, Moscow, Russia, LIP, Portugal, LNS-INFN, Italy, Lomonosov Moscow State University, Russia, Los Alamos National Laboratory, US, Louisiana State University, US, Michigan State University, US, Middle East Technical University (METU), Ankara, Turkey, National Centre for Nuclear Research, Otwock, Poland, National Institute of Technology Kure College, Hiroshima, Japan, National Taras Shevchenko University of Kyiv, Ukraine, National Technical University of Athens, NTUA, Greece, Nikhef National Institute for subatomic physics, Amsterdam, Netherlands, OMEGA Ecole Polytechnique IN2P3 / CNRS, France, Oregon State University, US, Princeton University, US, Queen Mary University of London, UK, Roma 2, Italy, Royal Holloway, UK, Ruder Boskovic Institute, Zagreb, Croatia, Russian Academy of Sciences - Institute for Nuclear Research, Russia, Russian Academy of Sciences - Institute of Chemical Physics, Russia, SLAC National Accelerator Laboratory, US, South Dakota School of Mines and Technology, Rapid City, US, Southern Methodist University, Dallas, US, State University of New York (Stonybrook), US, STFC - Rutherford Appleton Lab. - Rutherford Appleton Laboratory, UK, Theoretical Nuclear Physics Research Group, Department of Physics and Astronomy, Ghent University, Belgium, Univ. of Valencia and CSIC - Instituto de Fisica Corpuscular (IFIC), Spain, Universita & INFN, Milano-Bicocca, Italy, Università degli Studi e INFN Milano - Sezione di Milano, Italy, Universita e INFN, Bologna - Sezione di Bologna (INFN), Italy, Universita e INFN, Catania - Sezione di Catania, Italy, Universita e INFN, Napoli - Sezione di Napoli (INFN), Italy, Universita e INFN, Padova - Sezione di Padova, Italy, Universita e INFN, Trieste - Sezione di Trieste, Italy, Universitaet Bern - Laboratorium fuer Hochenergiephysik, Switzerland, Universite Claude Bernard-Lyon I - Institut de Physique Nucleaire de Lyon, France, Universite de Geneve - Dept. de Phys. Nucl. et Corpuscul., Switzerland, Universite de Paris VII - Laboratoire APC - Astroparticules et Cosmologie, France, Université Paris Diderot, France, Université Pierre et Marie Curie (UPMC) et Paris Diderot, France, Université Savoie Mont Blanc, France, University of Birmingham, UK, University of Bristol, UK, University of Bucharest, Romania, University of California Davis - Department of Physics, US, University of California Los Angeles, US, University of California, Berkeley, US, University of California, Irvine, US, University of Cambridge, UK, University of Chicago, US, University of Cincinnati, US, University of Edinburgh, UK, University of Genova, INFN, Italy, University of Glasgow, UK, University of Hawaii, Honolulu, US, University of Houston, US, University of Iowa, US, University of Jyvaskyla - Department of Physics, Finland, University of Liverpool, UK, University of London - University College London, UK, University of Manchester, UK, University of Minnesota, Duluth, US, University of Minnesota, US, University of Oulu, Finland, University of Oxford - Particle Physics, UK, University of Peloponesse, Greece, University of Pennsylvania,

- 5 experiment approved, 2 in the pipeline
- 140 cooperating institutes
- 24 countries
- 177 teams
- ~800 registered participants

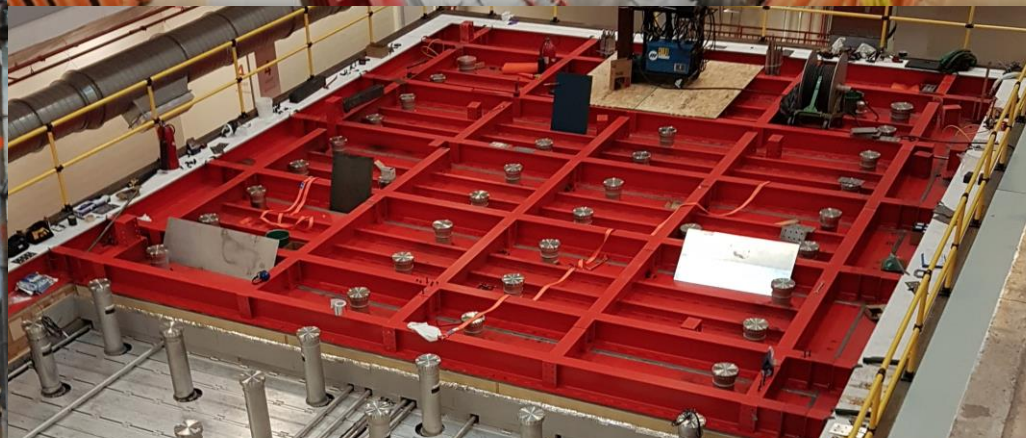
# REPRESENTATION BY COUNTRY

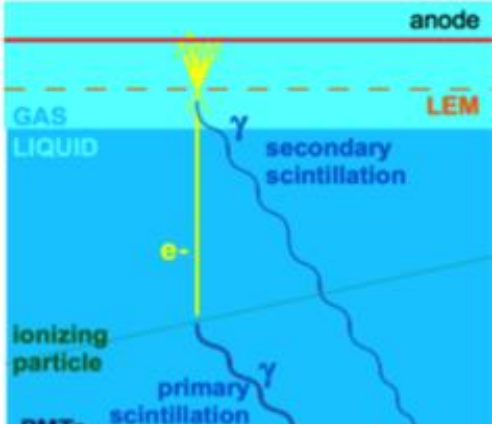


# FNAL SBN: ICARUS detector

Reshaped at CERN, transported to FNAL in 2017. It is now being closed!

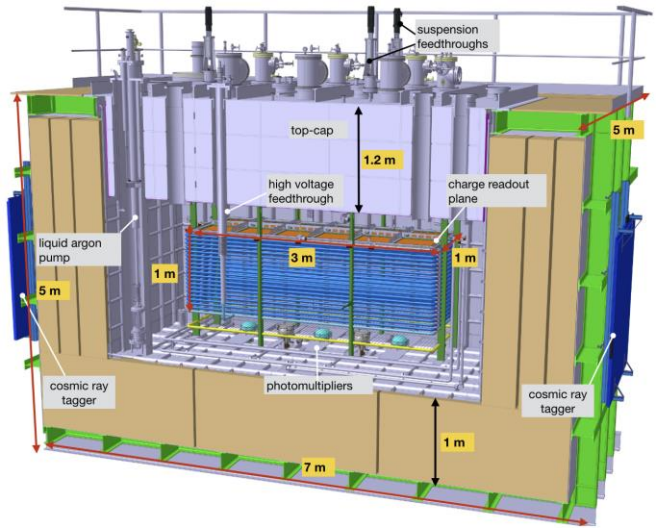
It will be cooled and filled in May 2019 and then the commissioning phase will start

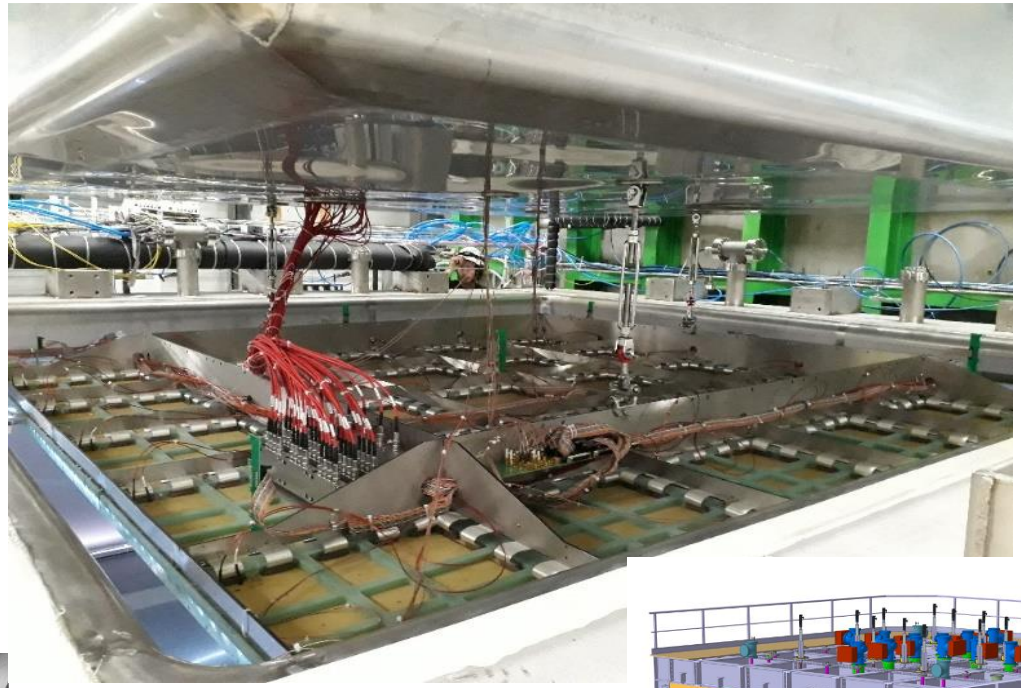





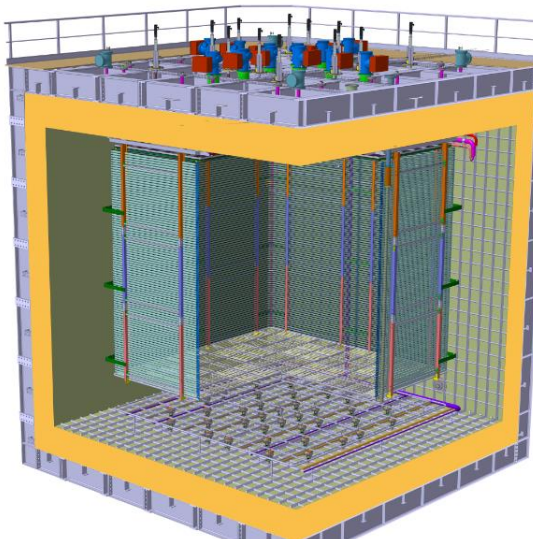

# Double Phase LAr TPC (DUNE far)

3m$^3$ demonstrator constructed and commissioned (JINST_047P_0618)



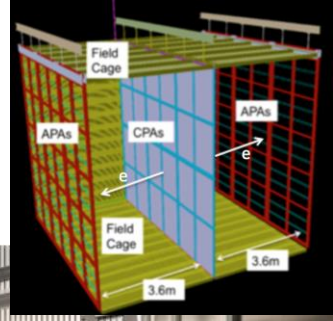



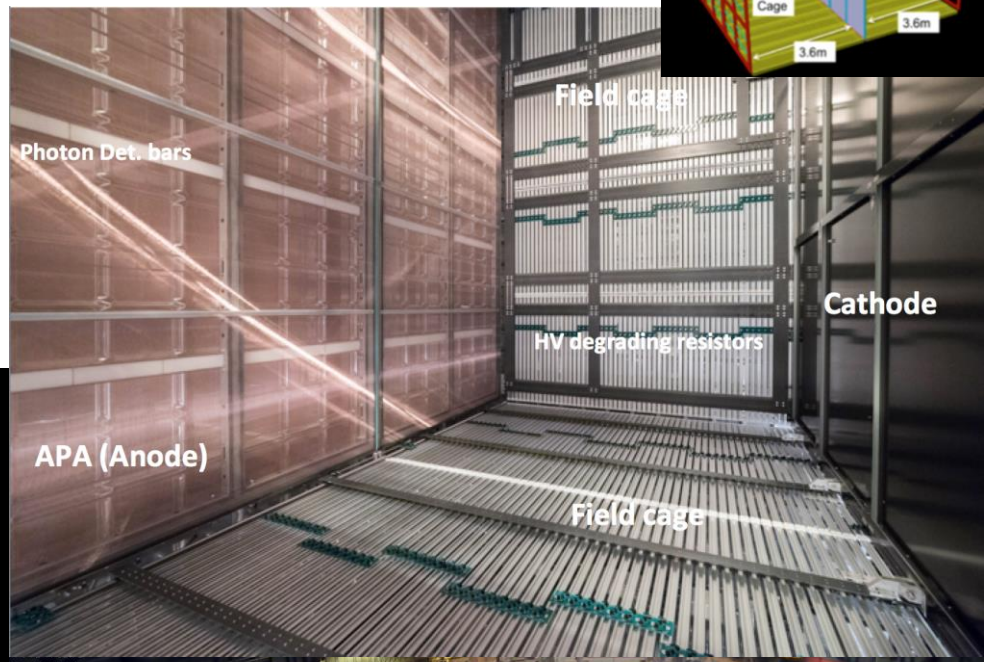
6x6x6 m$^3$ large prototype is being assembled, it will be closed in January 2019 and operated in Spring 2019 in the CERN nord area (EHN1)

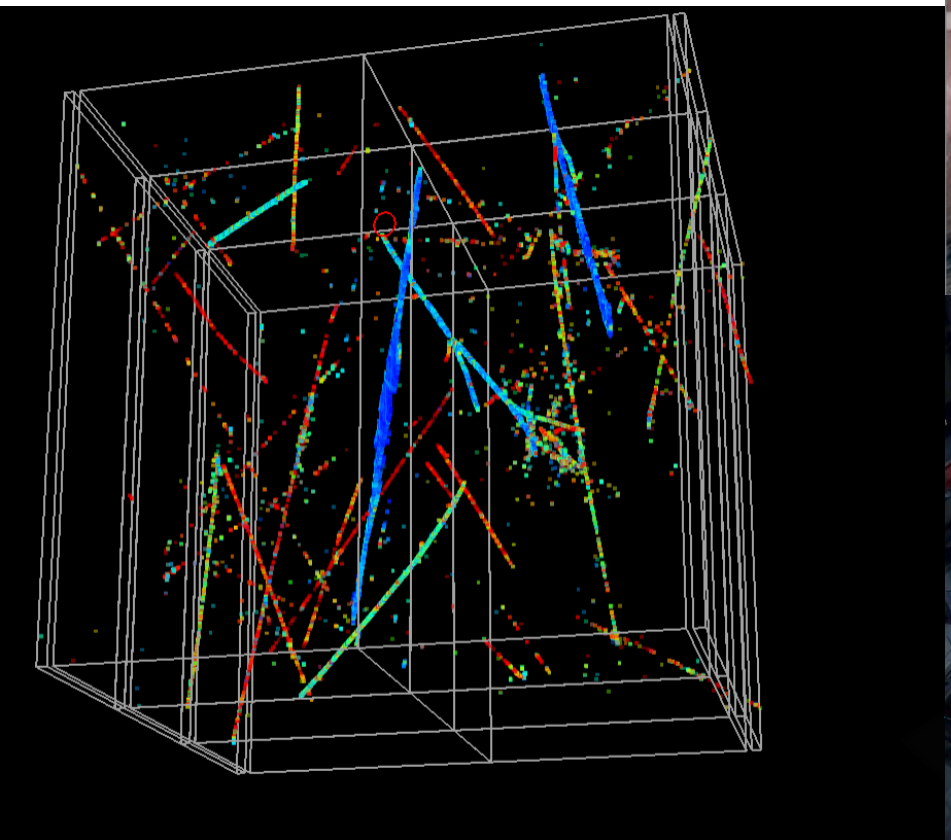


# Single Phase LAr TPC (DUNE far)

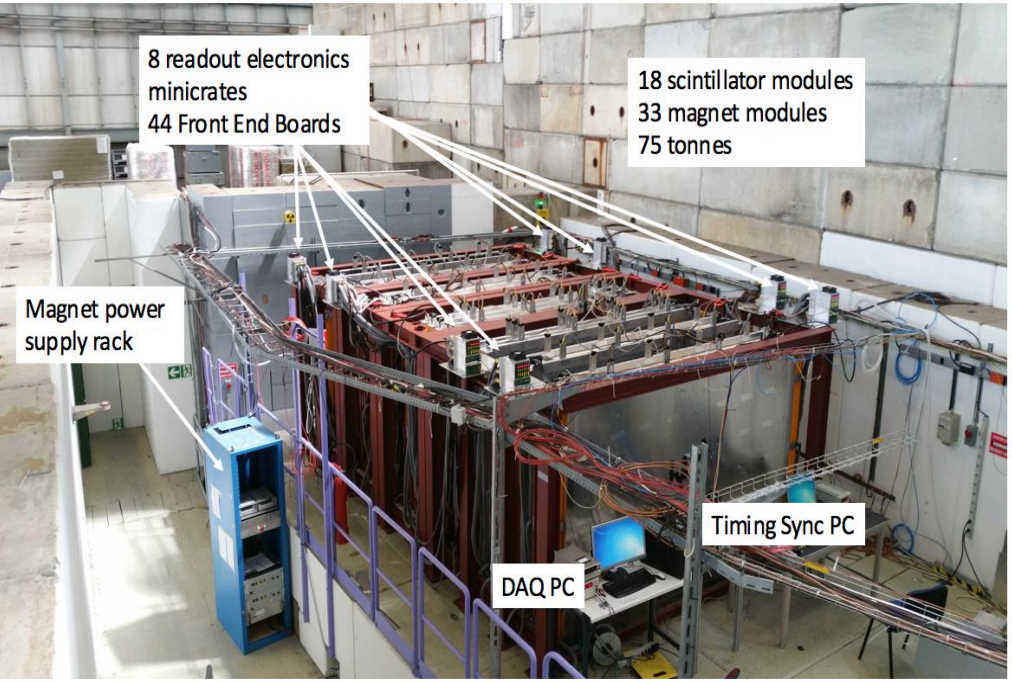
Installed, cooled, filled and now in operation on the SPS test beam since mid September 2018



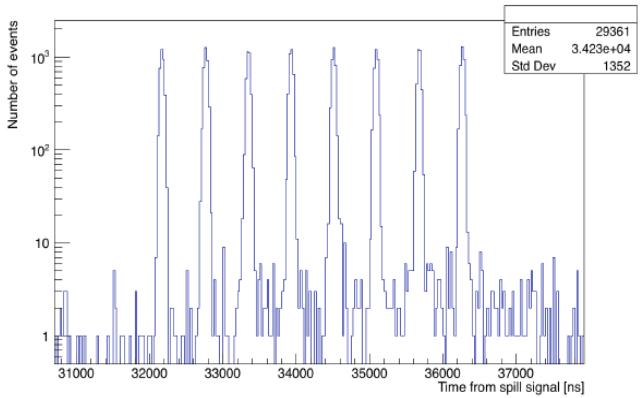



# WAGASCI/Baby Mind muon detector



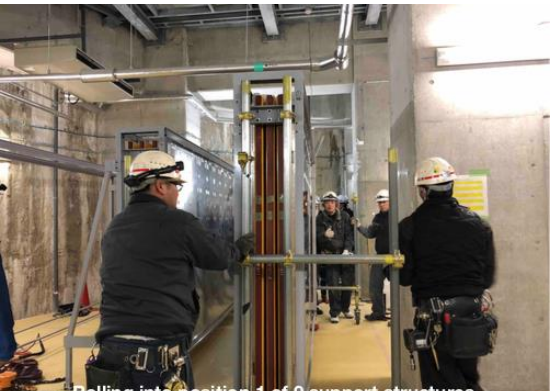

**Commissioning with beam in anti-neutrino mode at J-PARC: 9 March - 31 May 2018**

**8-bunch beam structure clearly seen in neutrino interactions recorded by Baby MIND**
**(J-PARC nu beam spill has 8 bunches)**

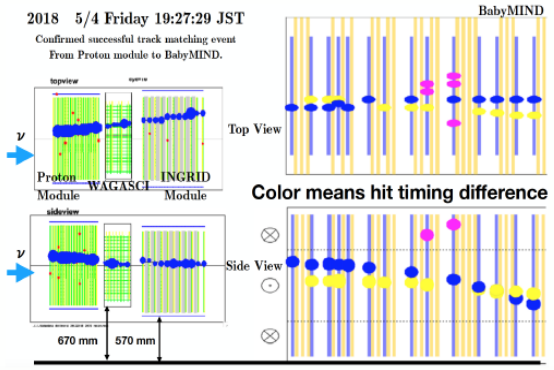


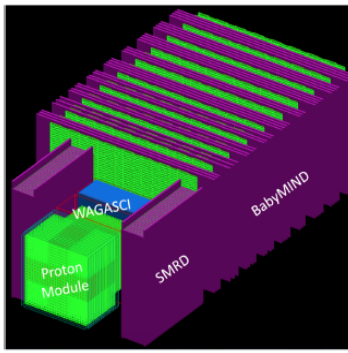

Assembled and tested in the SPS test beam in 2017

**Event rate measured by Baby MIND:**
**~ 5.246 +/- 0.656 (stat.) $10^4$ events/1500 Kg (Fe)/$10^{21}$ P.O.T.**



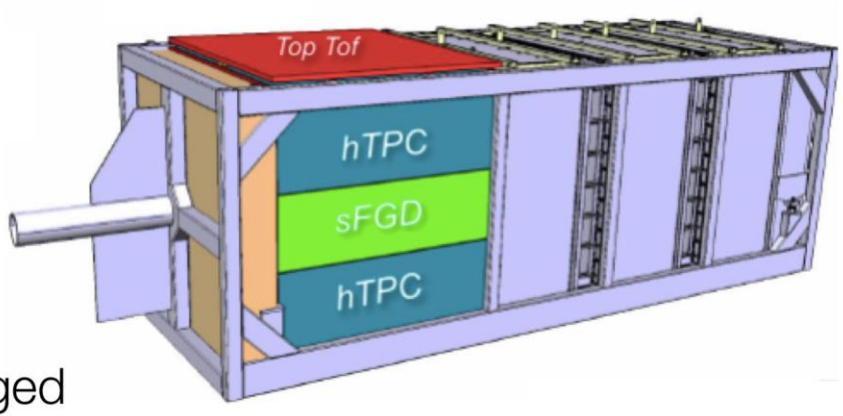
Transported and reassembled at J-Park in February 2018



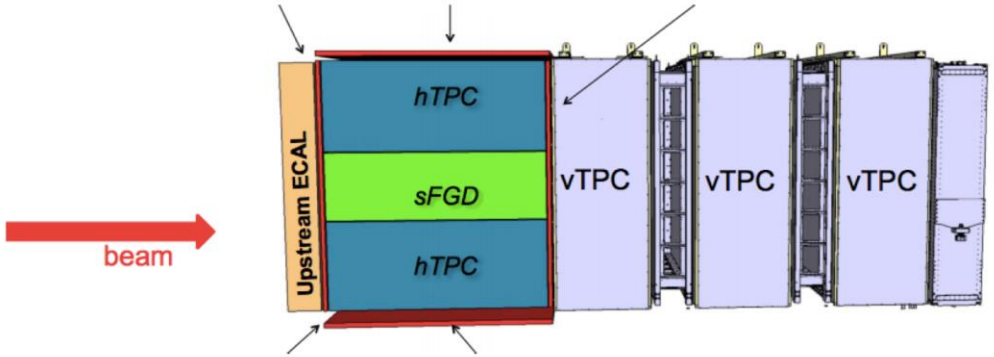



# T2K Near detector upgrade (ND280)

## CERN SPSC P357




- Re-design of the upstream part of ND280
- Down-stream tracker (FGD+TPCs) unchanged
  - 2 tons plastic scintillator target : super-FGD (sFGD)
  - two horizontal TPC (hTPC)
  - Time-of-Flight (ToF) all around



# T2K near detector upgrade : High Angle TPC

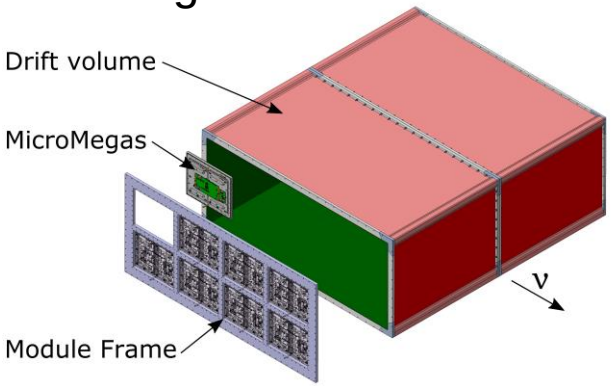


## Design based on the successful operation of the existing TPCs

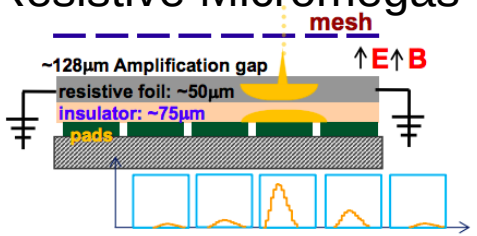
Two new horizontal TPCs with :

- 2 volumes of 2.0 (w) x 0.8 (h) x 2(drift) $m^3$
- 8 resistive MMs per volume
- cathode voltage at 25kV (E field of 275 V/c
- T2K gas : 95% Ar, 3% CF4, 2% Isobutane
- ~ 4% $X_0$ material budget
- momentum resolution better than 10% at 1 GeV

single-volume box field cage

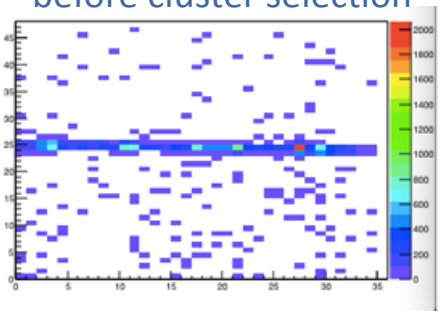



Resistive Micromegas

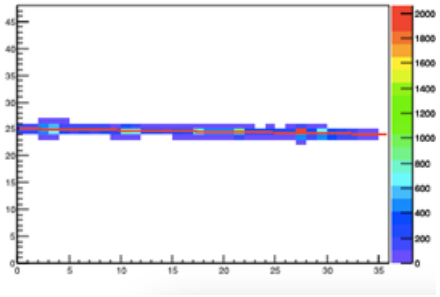



## Muon track

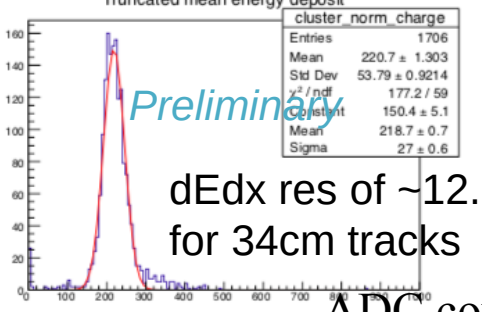
before cluster selection



after cluster selection



## Muons dEdx

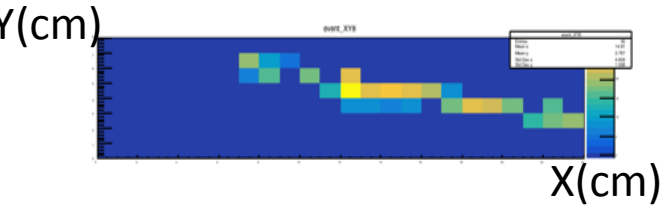


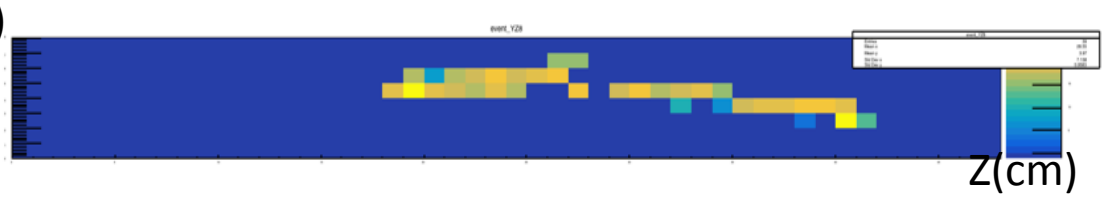

dEdx res of ~12.3%
for 34cm tracks

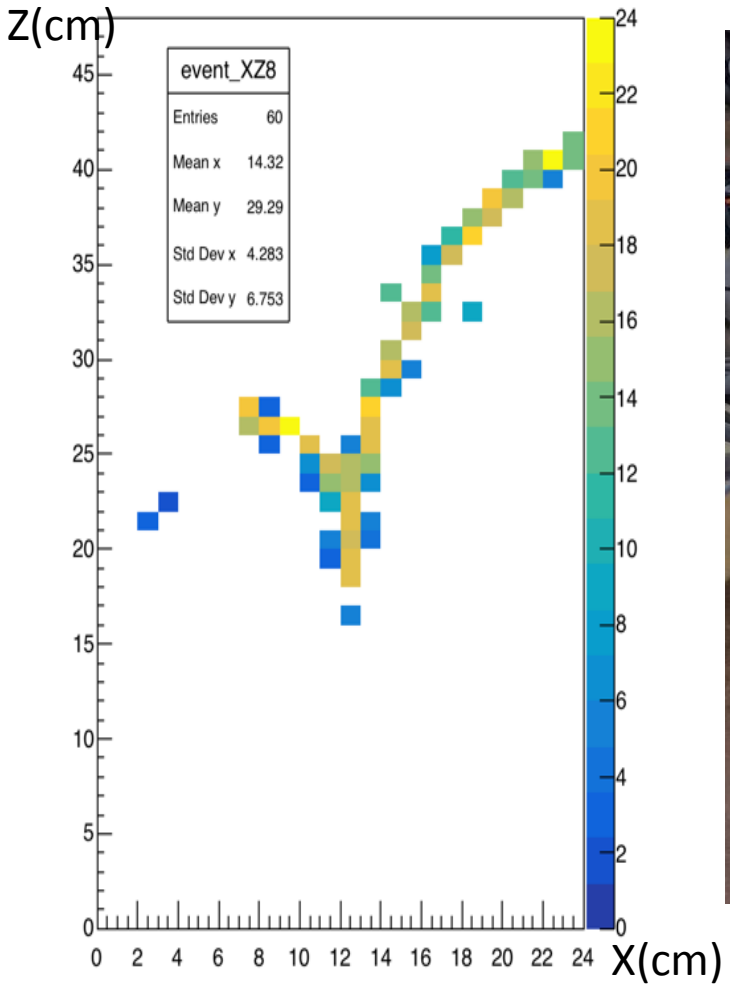
Test beam at CERN this summer

# T2K near detector upgrade : SuperFGD

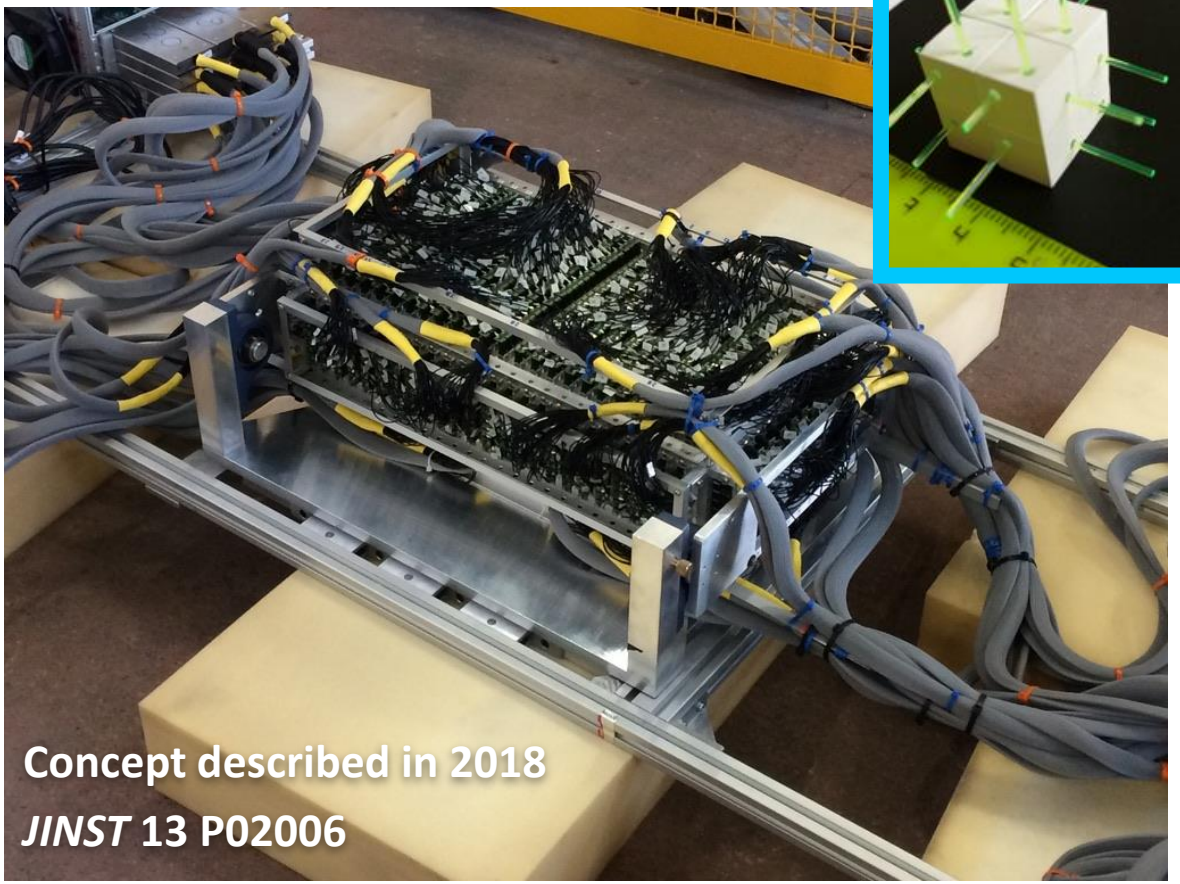
first prototype: 24 cm x 8 cm x 48 cm




9216 cubes, 1728 readout ch.

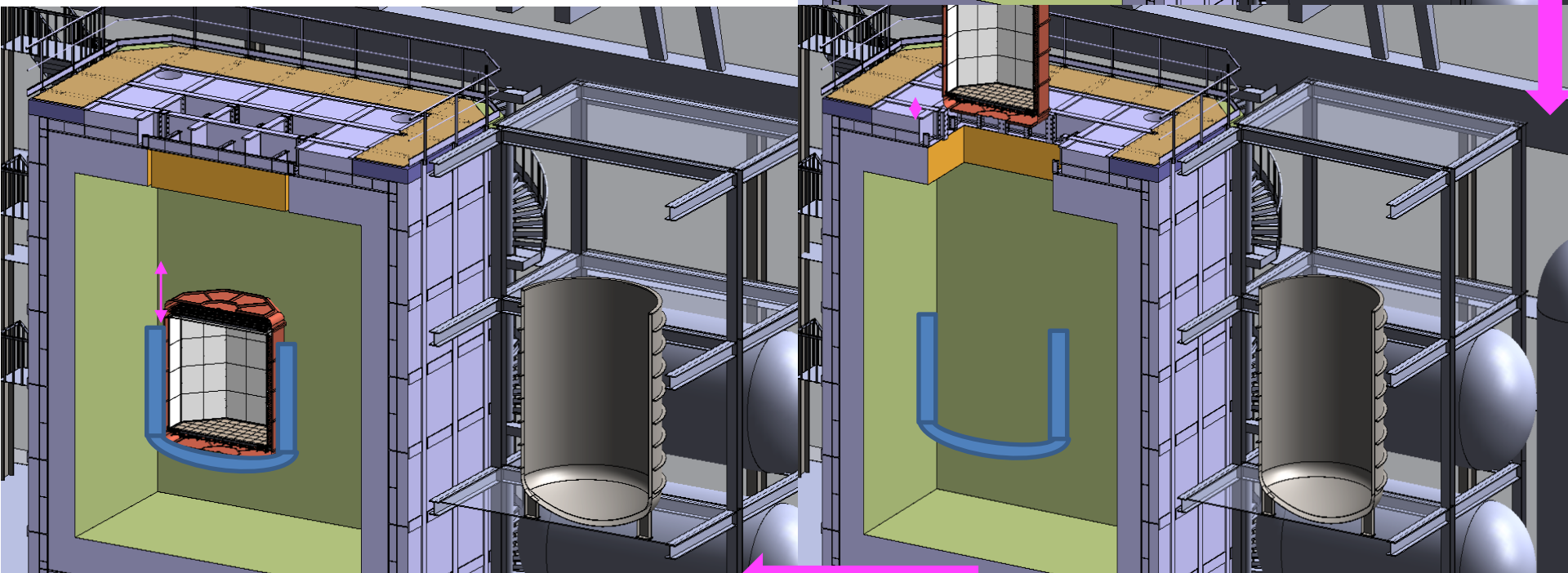


# Darkside 20k

A $LAr^{40}$ TPC (~40tons) in a protoDUNE type of LAr bath

It will be installed in Gran Sasso (It)

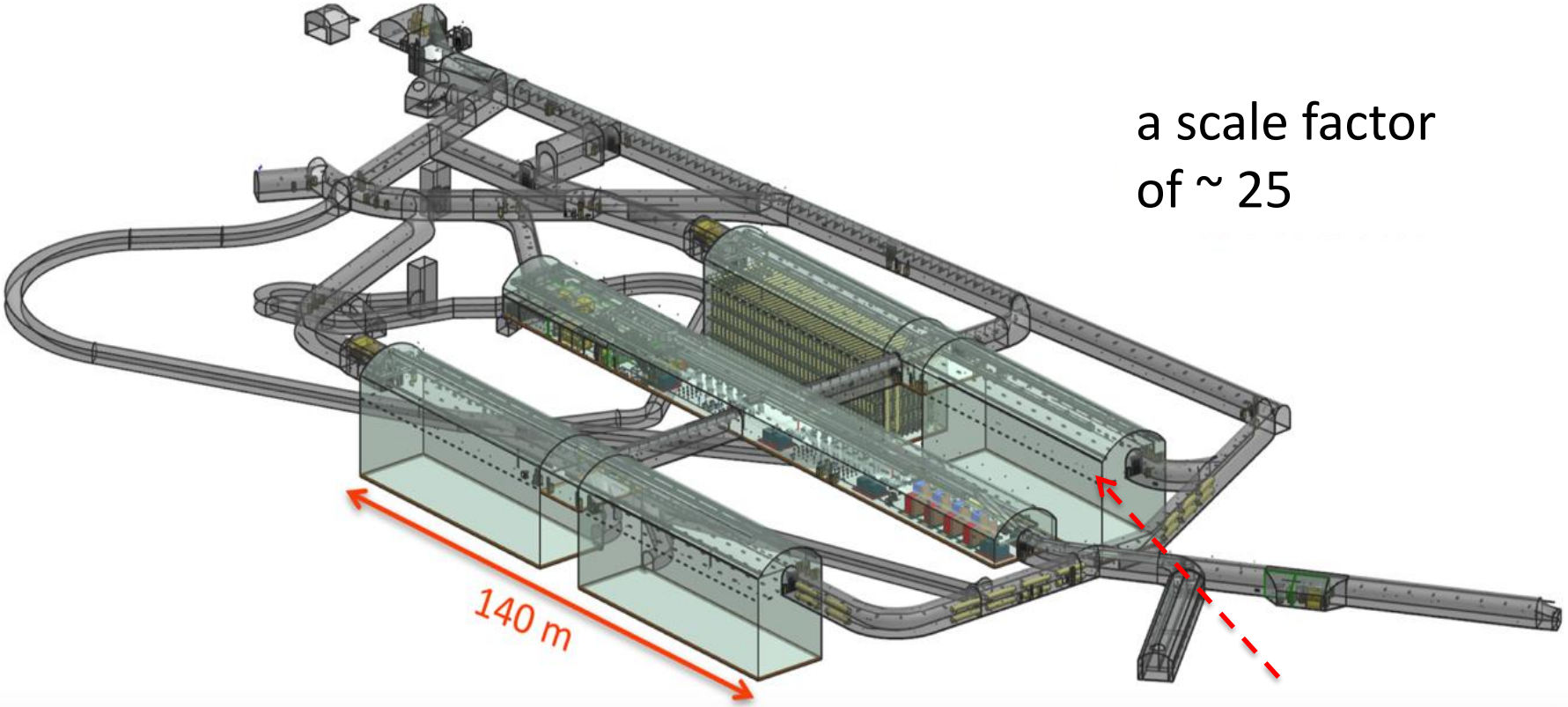
Concept to be extended to 300 tons at SNO Lab



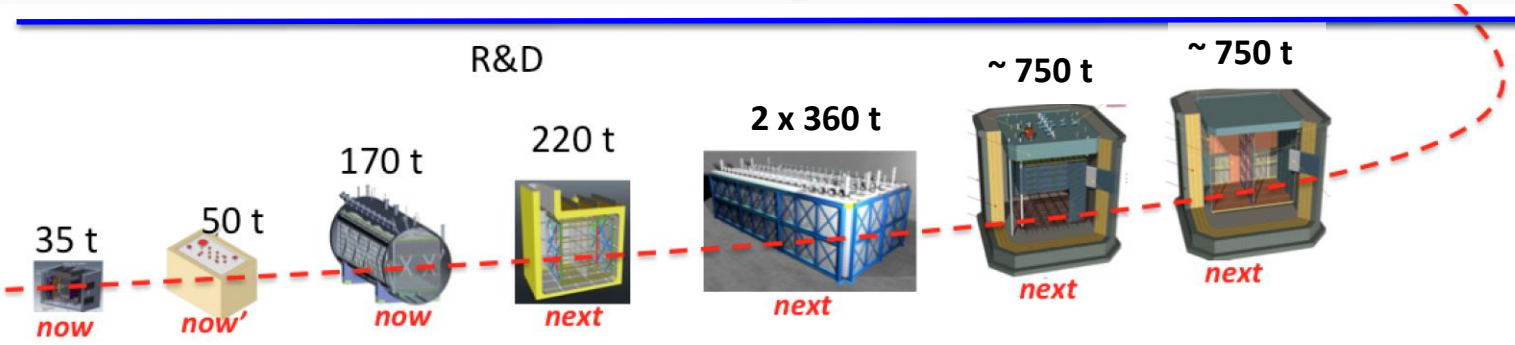
# Sofar very good response and an impressive level of activities

- ✓ Large test beam facility created, with a substantial R&D infrastructure (EHN1 nord area, b185, b182)
- ✓ Most of the initial projects (ICARUS, protoDUNEs, BabyMIND are a success and are or are becoming part of new experiments outside CERN
- ✓ A few more are just starting (T2K near detector upgrade, Darside-20k). A call for new ideas should converge soon
- ✓ A coherent European approach is now visible
- ✓ CERN is now active and visible on several experiments outside CERN
- ✓ The platform concept seems to work

# A step by step approach : "*large demonstrators*"

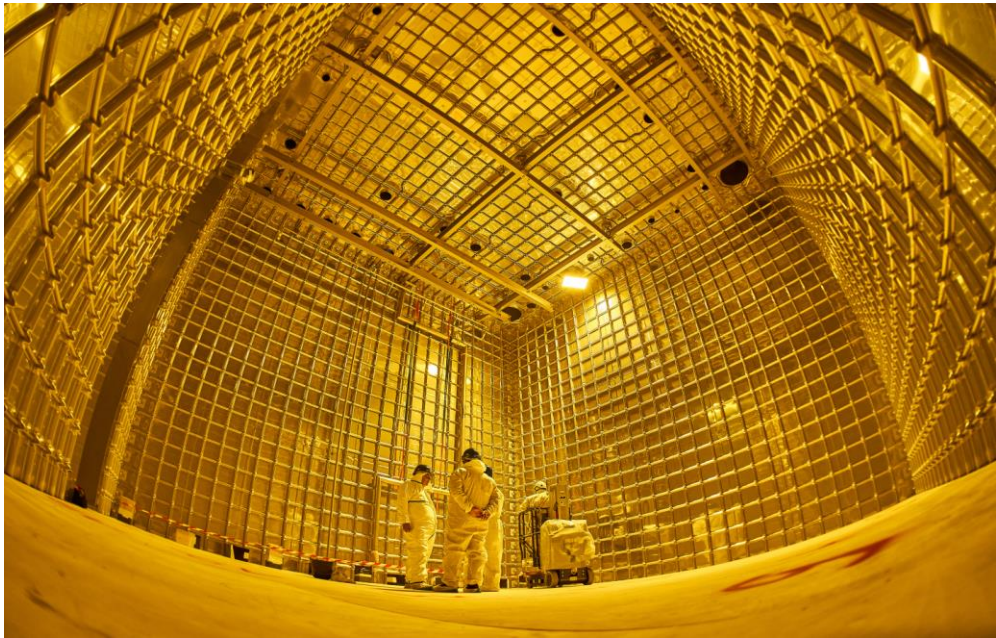



a scale factor
of ~ 25



# Several technical challenges have been approached and solved

- ✓ Large membrane cryostats
- ✓ ppt type of purity LAr cryogenics
- ✓ Large data acquisition systems (in synergy with LHC upgrade)
- ✓ Slow control infrastructure (CERN JCOP type)
- ✓ 300 KV HV system and large field cages
- ✓ Cold front end electronics in LAr
- ✓ Large data handling
- ✓ A new type of warm magnets
- ✓ Integration of large facilities
- ✓ …….



# The Platform concept

- It seems to be effective
- It gives access to external users (not necessarly already at CERN) of CERN infrastructure and specific technical knowhow
- An effective way to bring in new ideas on fundamental research not directly related to the LHC program
- A way to start new collaborations and bring in CERN as a collaborating partner (outside CERN)
- It might extend to other fields of fundamental science in an effective way

**A message to pass to the EU-2020 Strategy ?**