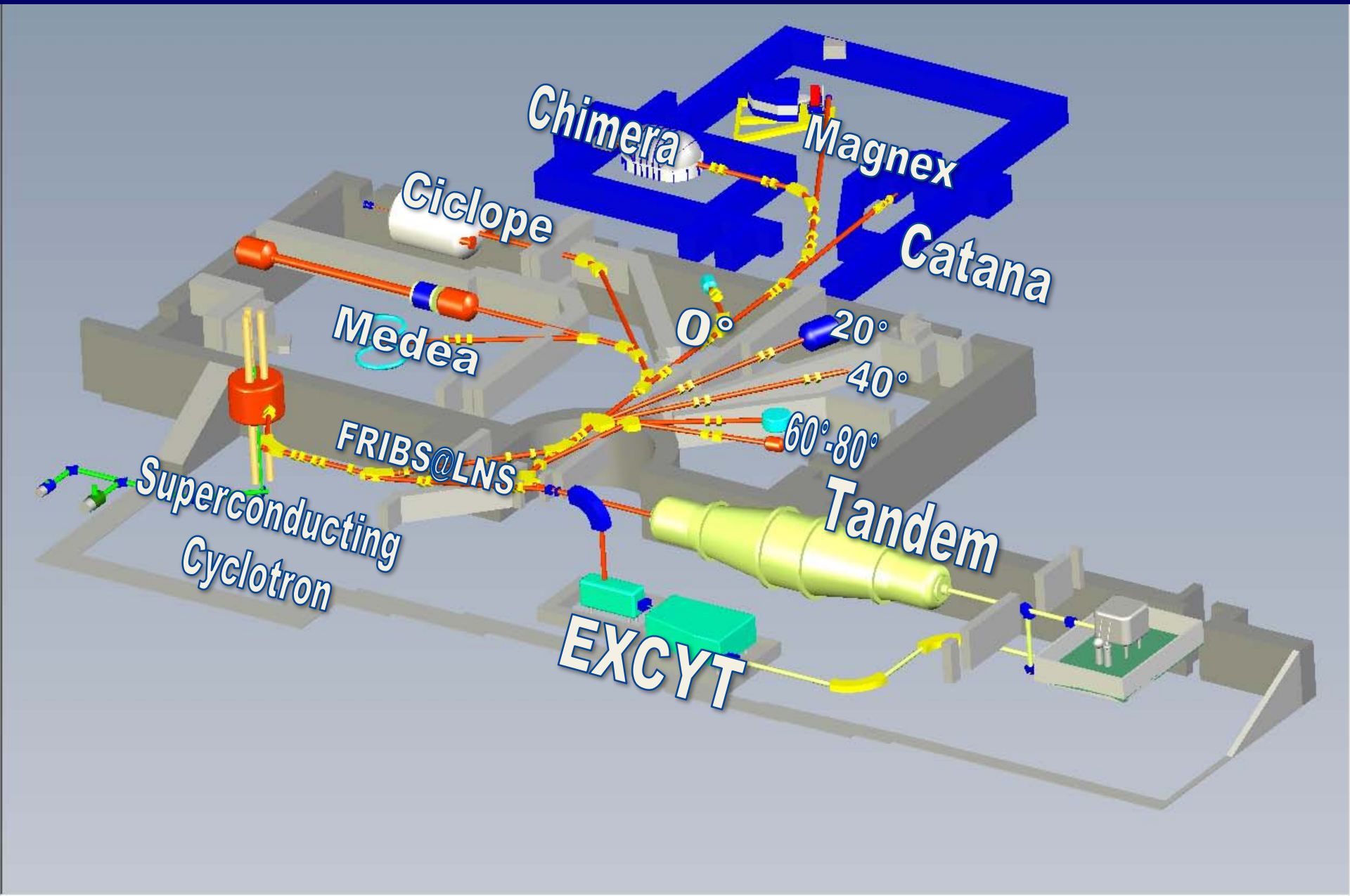
Laboratori Nazionali del Sud: Status and Pespectives

Giacomo Cuttone

INFN – Laboratori Nazionali del Sud, Catania, Italy

CVI Meeting
Catania Oct. 21° 2014

LNS lay-out: accelerators and experimental halls



Superconducting Cyclotron: Helium liquefier revamping

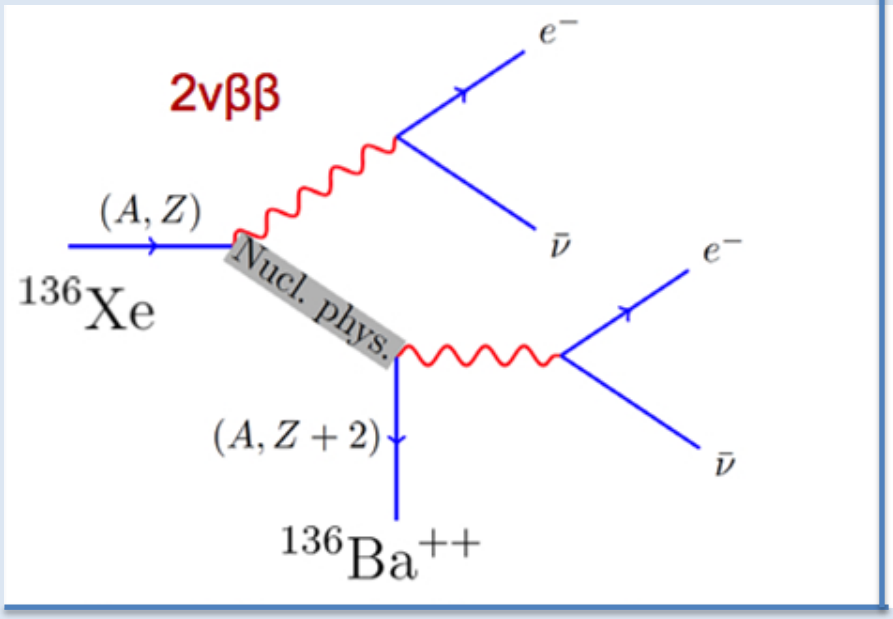
- **January 1st 2013 Breakdown of the helium liquefier: turbine found broken due to impurities (Air Liquide diagnosis) – restart on January 15 - Cyclotron operating on January 25**
- **May 2nd 2013 a new failure! Air Liquide inspection: again problems at the turbine - extraordinary maintenance and upgrade (revamping) needed to restore the reliability grade of the past 20 years**
- **July 8th 2013 Economical offer for the revamping operation produced by Air Liquide after a heavy interaction (around 2 months) Cost: 599.800 € taxes excluded Estimated time: 6 months from the order**
- **July 20th 2013 Contract approved by the INFN Executive Board – performance bond and declarations requested to Air Liquide**
- **October 15th 2013 order issued (Air Liquide Delay in administrative procedure)**
- **End of revamping in Sepetember 2014 (Big Air Liquide Technical Delay)**

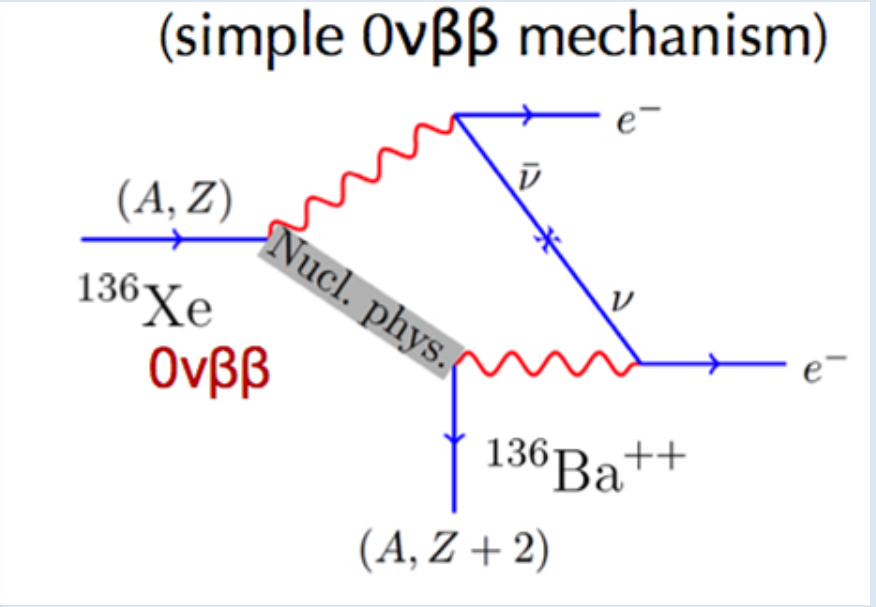
LNS was kept open in August

The Cyclotron cryostat was full of LHe on September 23th

The proton beam was extracted on October 2nd

Physics case demanding high intensity: double β decay





$$1/T_{1/2}^{0\nu}(0^+ \to 0^+) = G_{01}\left|M^{\beta\beta 0\nu}\right|^2\left|\frac{\langle m_\nu \rangle}{m_e}\right|^2$$

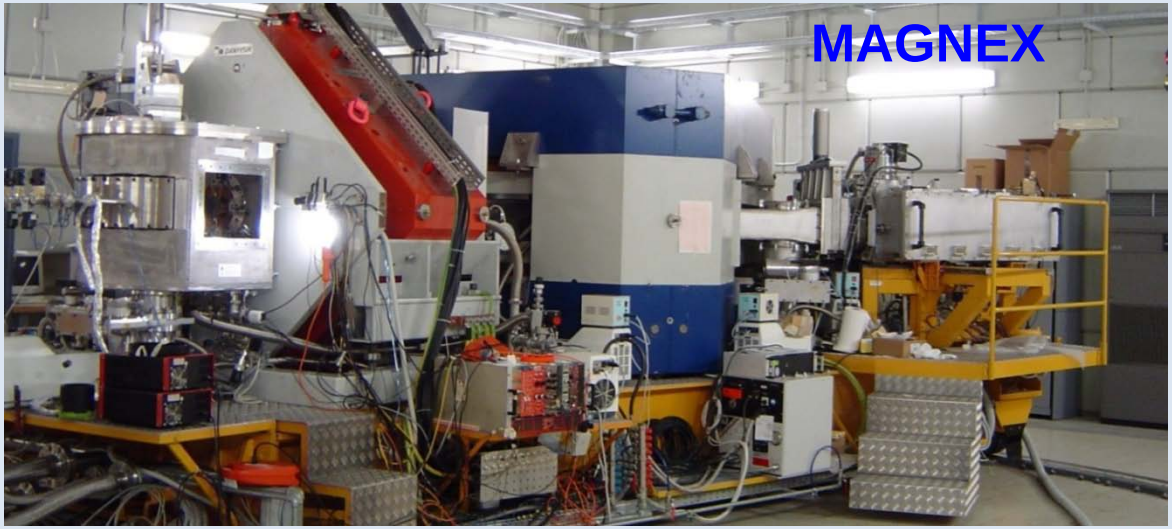
A lot of new physics inside

$$\langle m_\nu \rangle = \sum_i |U_{ei}|^2 m_i e^{i\alpha_i}$$

but one should know **Nuclear Matrix Element** (NME)

$$\left|M_\varepsilon^{\beta\beta 0\nu}\right|^2 = \left|\left\langle 0_f \left\| \hat{O}_\varepsilon^{\beta\beta 0\nu} \right\| 0_i \right\rangle\right|^2$$

Physics case demanding high intensity: double β decay



- Large angular acceptance
- Possibility of measuring at 0°
- Possibility of detection of ^{16}O, ^{18}F, ^{18}Ne, ^{20}Ne
- High resolution spectra
- Angular distributions up to10 nb/sr

Double charge exchange reactions (^{18}O,^{18}Ne) and (^{20}Ne,^{20}O) towards the determination of the nuclear matrix element of the double β decay

$^{40}Ca(^{18}O,^{18}Ne)^{40}Ar$ – exp. DOCET nov.2012

Major upgrade of LNS facilities

- The **CS** accelerator current upgrade (from 100 W to 5-10 kW);
- The **MAGNEX focal plane** detector will be upgraded from 1 khz to 100 khz
- The **MAGNEX** maximum magnetic **rigidity** will be increased
- An **array of detectors for γ-rays** measurement in coincidence with MAGNEX will be built
- The **beam transport line** transmission efficiency will be upgraded from about 70% to nearly 100%
- The **target** technology for intense heavy-ion beams will be developed

The whole upgrade

Looking for intensity

- New s.c. magnet: cryostat with coils
- Stripper system
- Magnetic channels
- New liner
- Source-Cyclotron matching
- Cyclotron-Magnex beam line

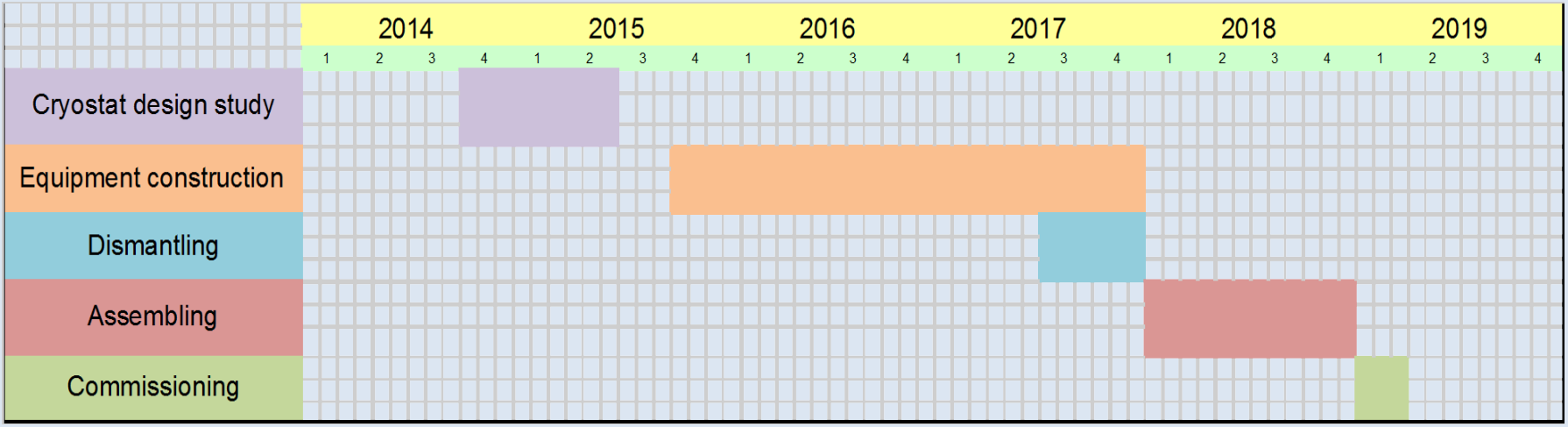
Looking for reliability

- New trim coils
- RF cavities insulators
- New power supplies
- New Helium liquefier

Roughly estimated cost

Superconducting magnet	6 M€
“Intensity” equipment	2.2 M€
“Reliability” equipment	4.5 M€
Total	12.7 M€

Estimated time

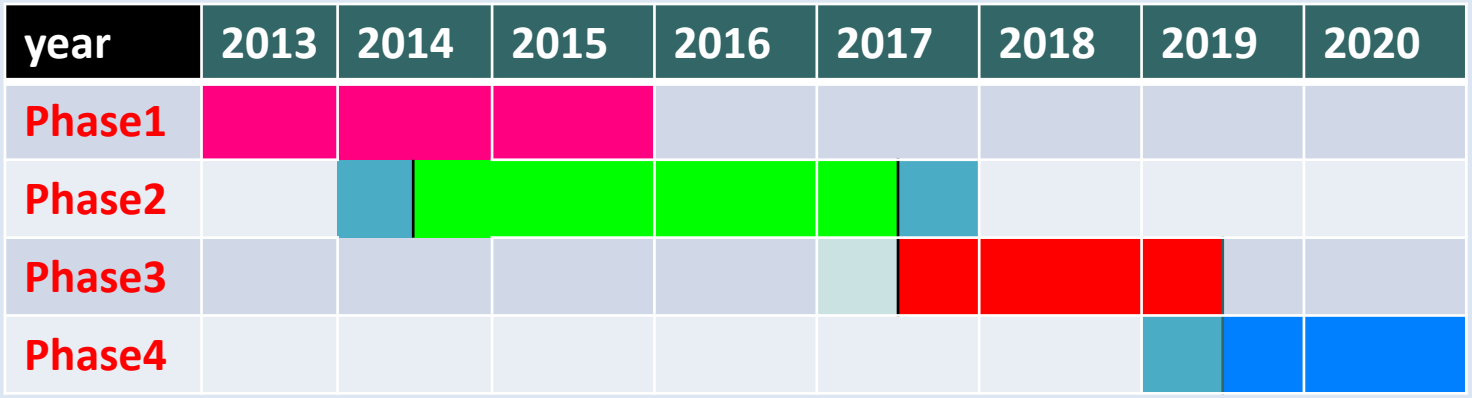


	Start	End
Cryostat design study	09/2014	06/2015
Equipment construction	10/2015	12/2017
Dismantling	07/2017	12/2017
Assembling	01/2018	12/2018
Commissioning	01/2019	04/2019

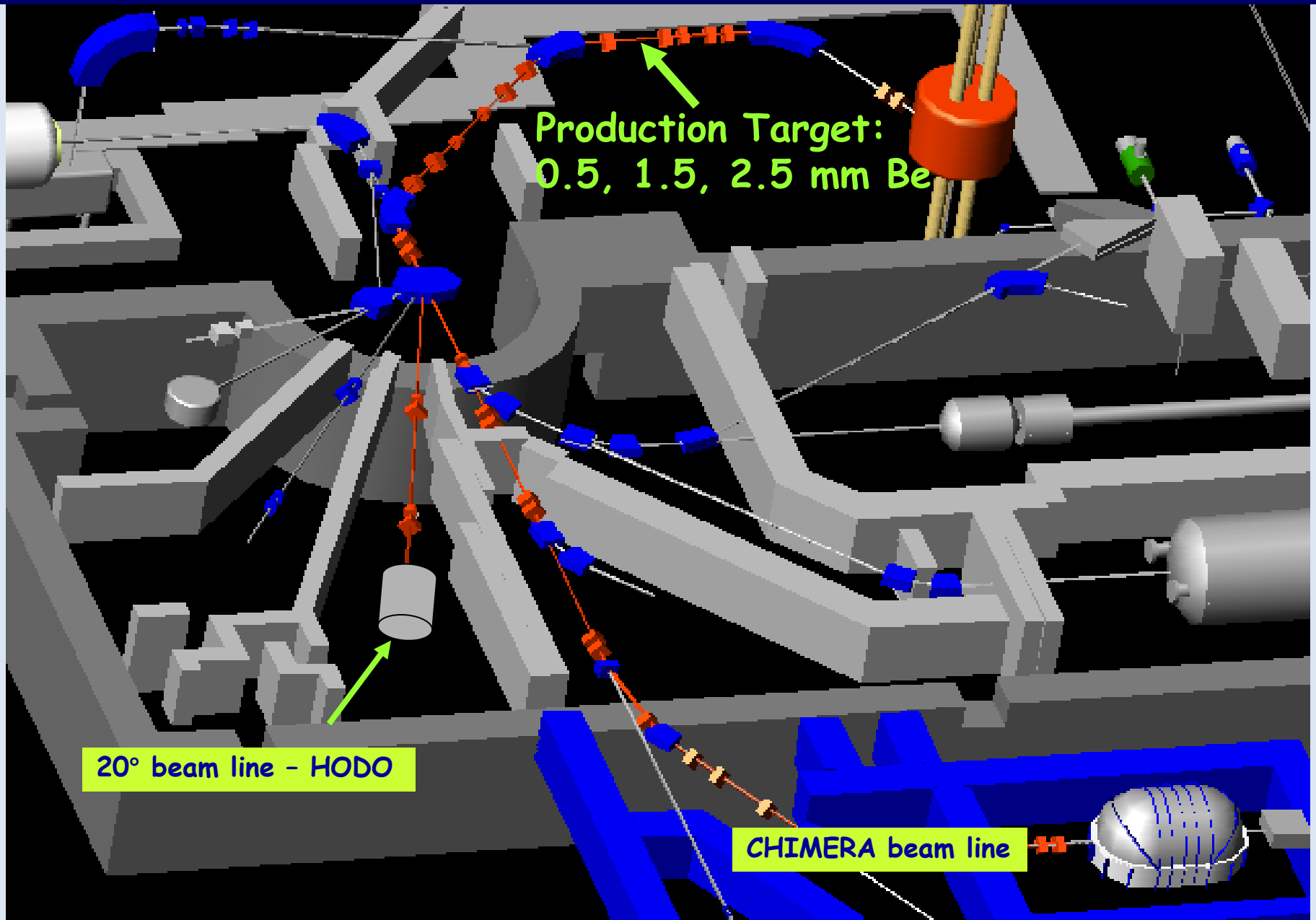
The Phases of NUMEN project

- **Phase1**: The experimental feasibility
- **Phase2**: "hot" cases optimizing the set-up and getting first results
- **Phase3**: The facility Upgrade (Cyclotron, MAGNEX, beam line, …..):
- **Phase4** : The systematic experimental campaign

Preliminary time table



FRIBS@LNS: in Flight Radioactive Ion BeamS



Beams developed at FRIBS@LNS

primary beam	beam	intensity (kHz/100W)
18O 55 AMeV	16C	120
setting 11Be	17C	12
	13B	80
	11Be	20
	10Be	60
	8Li	20
18O 55 AMeV	14B	3
setting 12Be	12Be	5
	9Li	6
	6He	12
13C 55 AMeV	11Be	50
setting 11Be	12B	100
36Ar 42 AMeV	37K	100
setting 34Ar	35Ar	70
	36Ar	100
	37Ar	25
	33Cl	10
	34Cl	50
	35Cl	50
20Ne 35 AMeV	18Ne	50
setting ne18	17F	20
	21Na	100
70Zn 40 AMeV		
setting 68Ni	68Ni	20

Beams to be delivered in 2014-2015 to approved experiments

^{16}C (CHIMERA)

^{68}Ni (CHIMERA)

^{8}He (CHIMERA) new

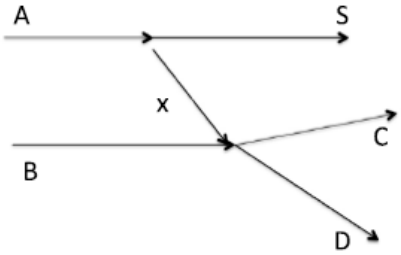
^{14}Be (test experiment) new

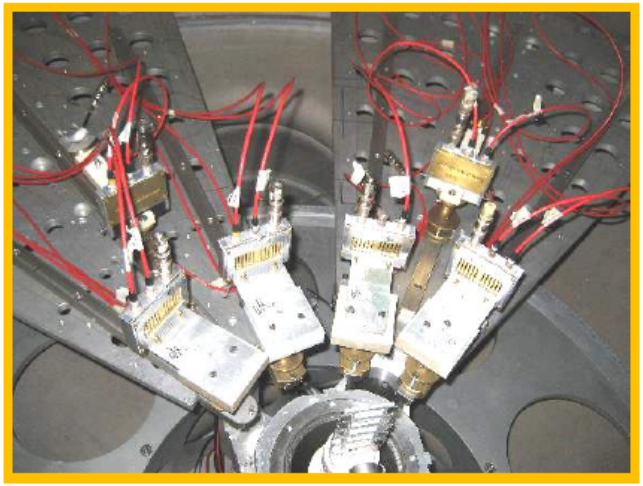
^{38}S (MAGNEX) new

Unique facility in Europe

The Trojan Horse Method

The Method determines the S(E) factor of a charged particle reaction **B+x→C+D** selecting the Quasi Free contribution of an appropriate **A(x+S)+B→ C+D+S** reaction

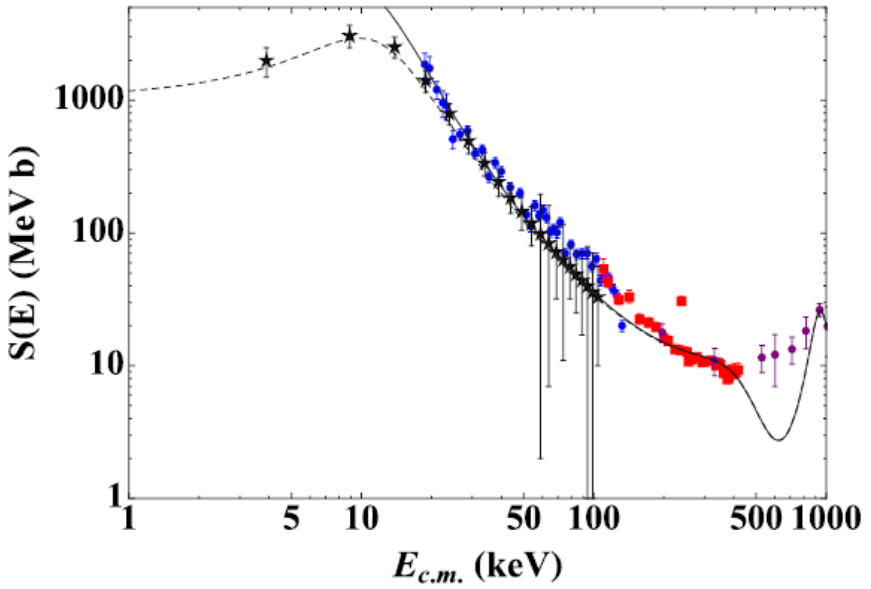




The experimental setup - LNS

Measurement of the 10 keV resonance in $^{10}B(p,\alpha_0)^7Be$

Performed reaction: $^2H(^{10}B,\alpha_0{}^7Be)n$ at 24.5 MeV

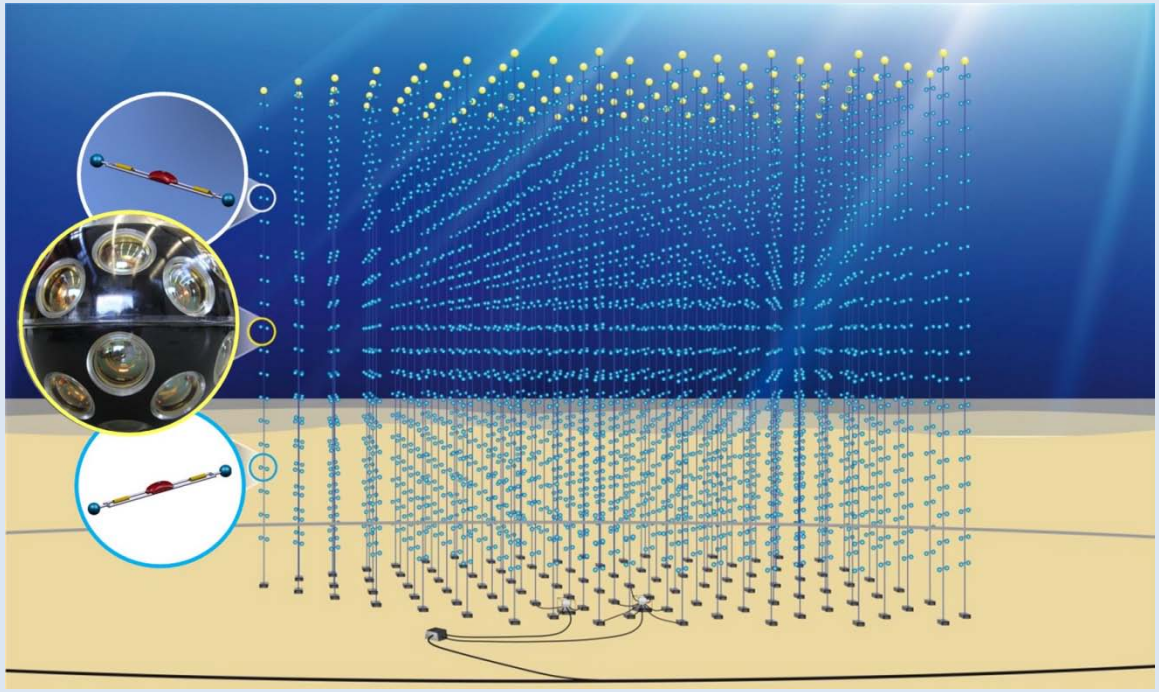


C. Spitaleri et al. PRC 90, 035801 (2014)

For a comprehensive review on indirect techniques: **R. Tribble, C. Bertulani, M. La Cognata, A.M. Mukhamedzhanov and C. Spitaleri, Rep.Prog.Phys. 77, 106901 (2014)**

The giant-scale detector KM3NeT

Faintness of neutrino fluxes and small interaction probabilities oblige to use large natural target such as sea-water: a volume of 5 km^3 of seawater will be instrumented with optical detectors.

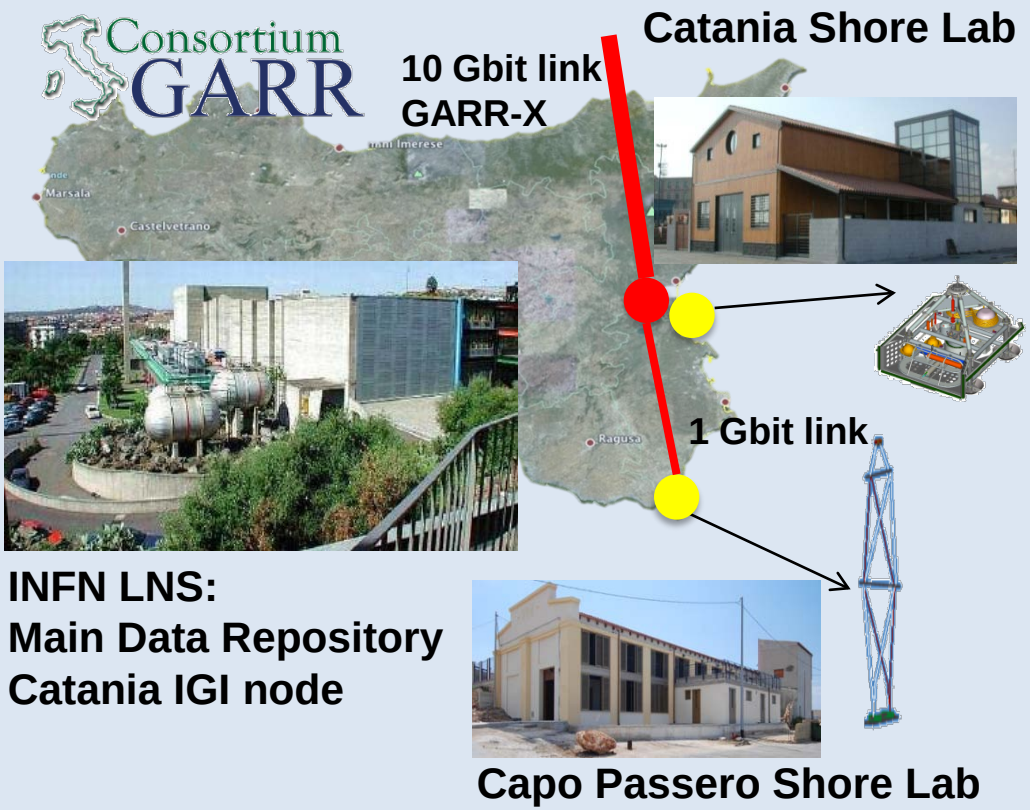


5 building blocks
120 Detection Units (DU)
750 m DU height
180m DU distance
5 km^3 volume
Budget 210 M€

KM3NeT-It is funded by INFN since 1999 (NEMO)
In 2012 the project was awarded with a
PON grant of 21 M€

KM3NeT is a EU funded ESFRI Infrastructure since 2006.
INFN leaded the Prparatory Phase

Capo Passero: optical fibre link from deep-sea to LNS

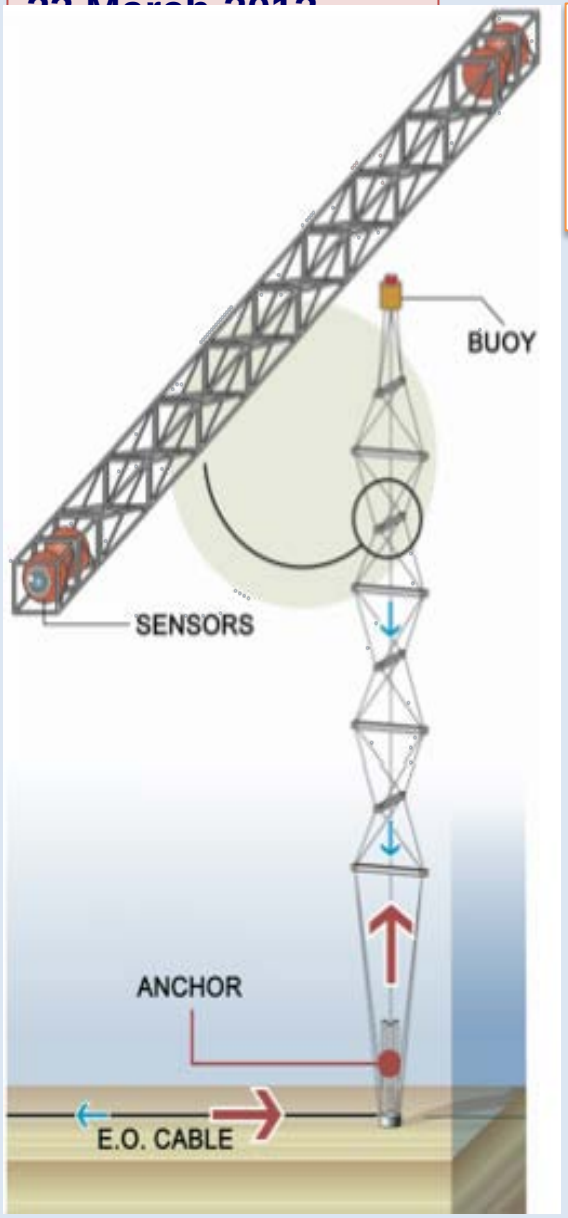


INFN is a main partner of GARR and of the Italian GRID-computing Infrastructure

Capo Passero is the first KM3NeT site with direct optical fiber high speed connection from deep-sea to a node of the European GRID-computing Infrastructure

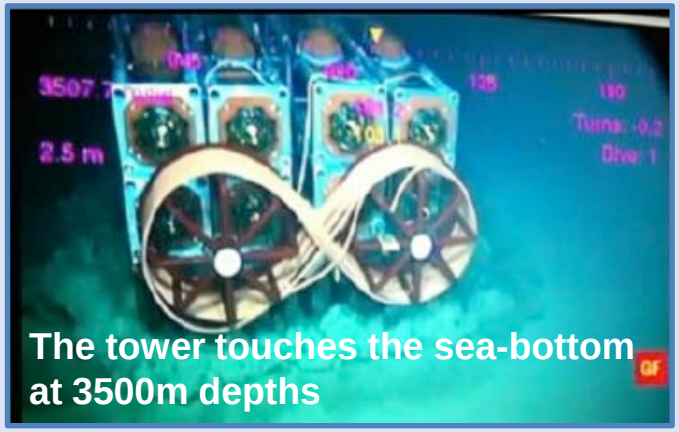
INFN Catania is a major site of the Italian GRID

The KM3NeT Tower Prototype



- 8 floors, 8 m bars, vertical dist. = 40 m, H_{tot} = 450 m
- 32 OM, 12 hydrophones , 2 OAM (opto-acoustic modules)
- CTD, DCS, transmissometer, laser beacon, acoustic beacon


The tower on the “Nautical Tide”

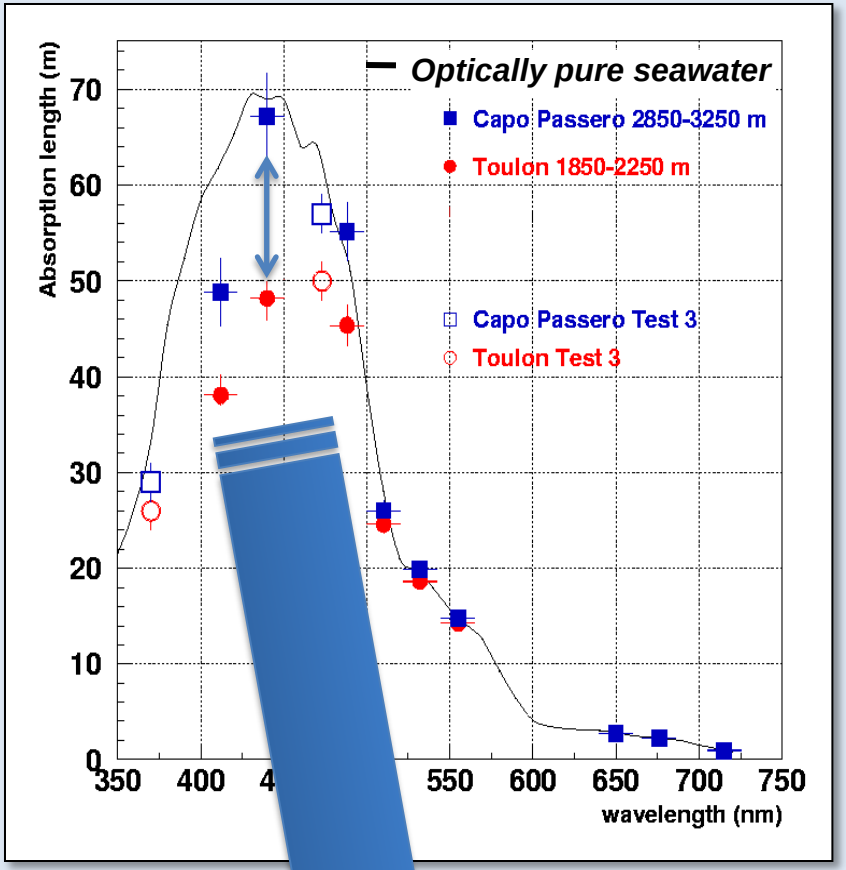


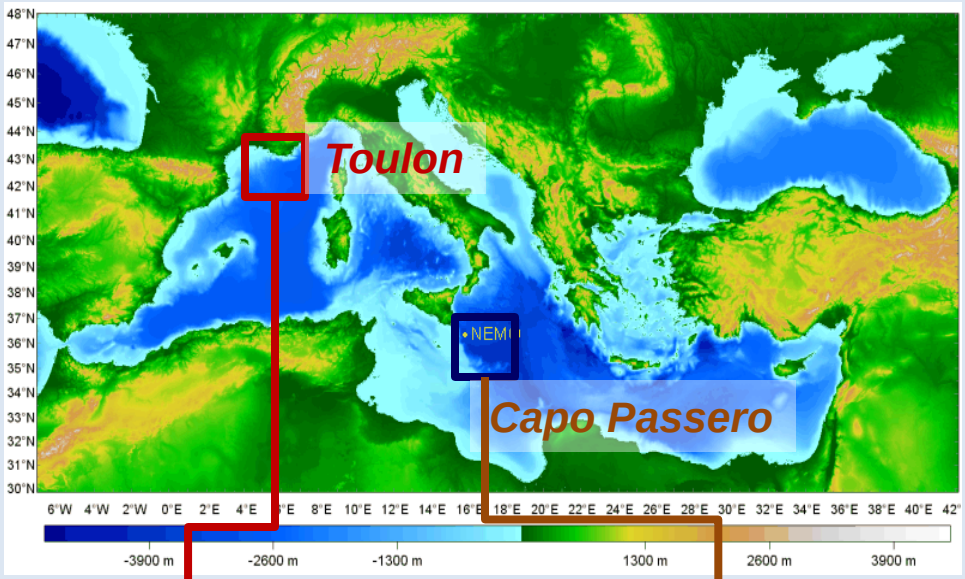
The tower touches the sea-bottom at 3500m depths

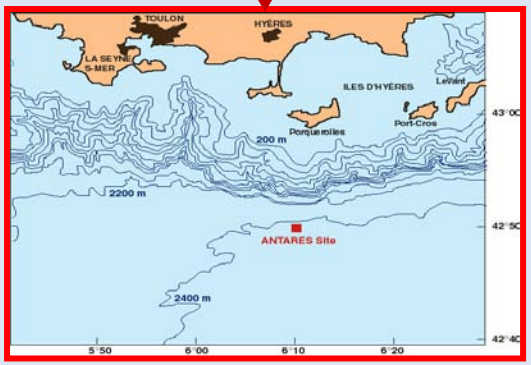

The OM: 10” Hamamatsu R7081, Front End Module, Time Calibration, LED beacons

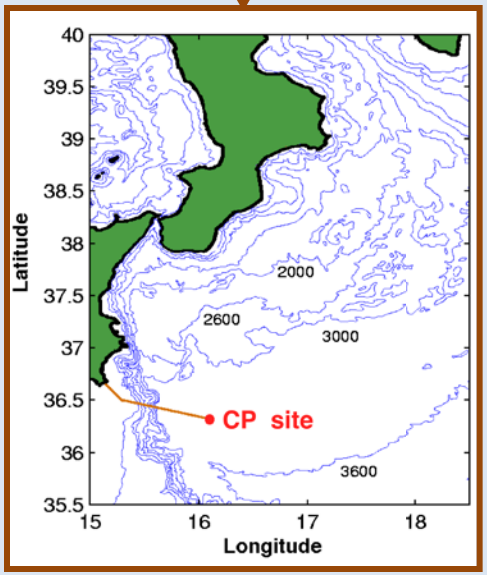

Hydrophones: acoustic positioning and bioacustics (INFN/SMID/NATO)

Light Absorption lenght



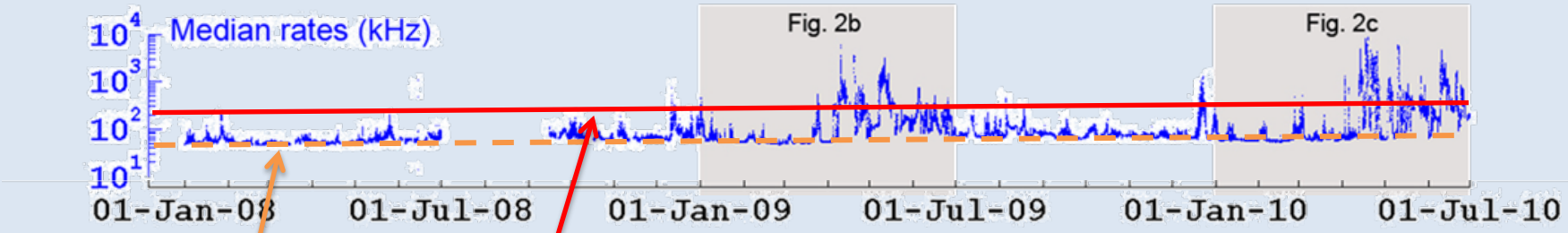






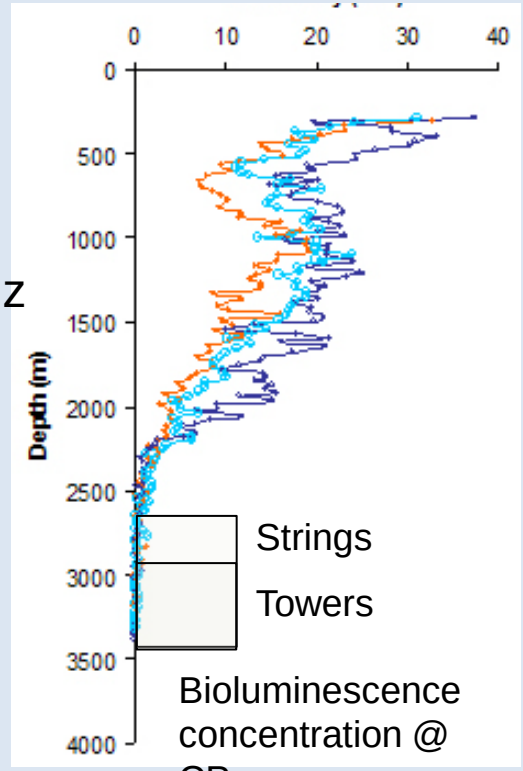
C.P. waters 30-40% more transparent than Toulon ones @lambda Cherenkov

Optical Background median rates at ANTARES and Capo Passero site



Median rate Above 200 kHz: ANTARES DAQ is switched off

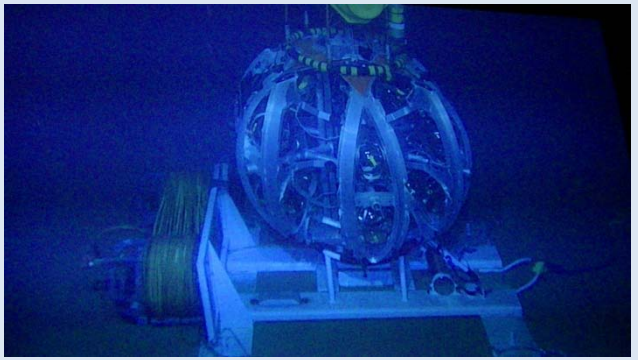
Capo Passero median rates never exceed 70 kHz

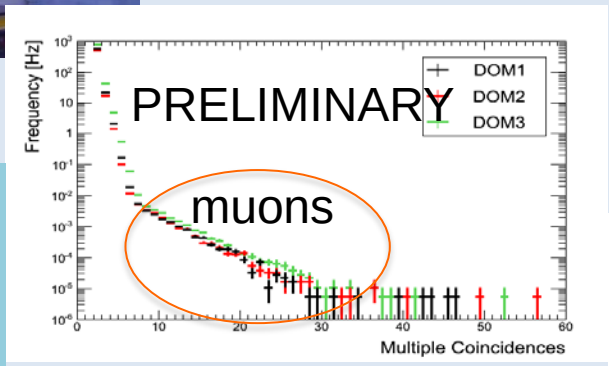


Bioluminescence concentration @ CP

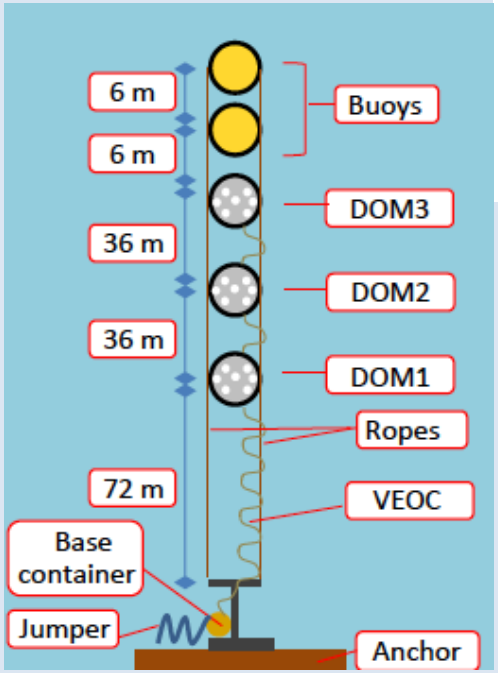
The demonstrators

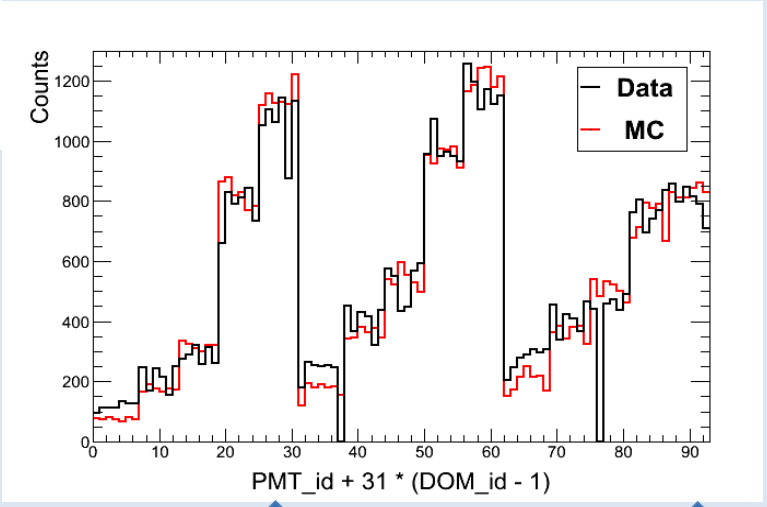
The PPM DU:
deployed May 2014
at Capo Passero Site



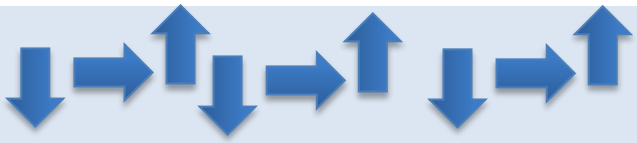


Same as per PPM-DOM





PMT Orientation



Sea Operation: deployment and connection

The DSV Nautical Tide

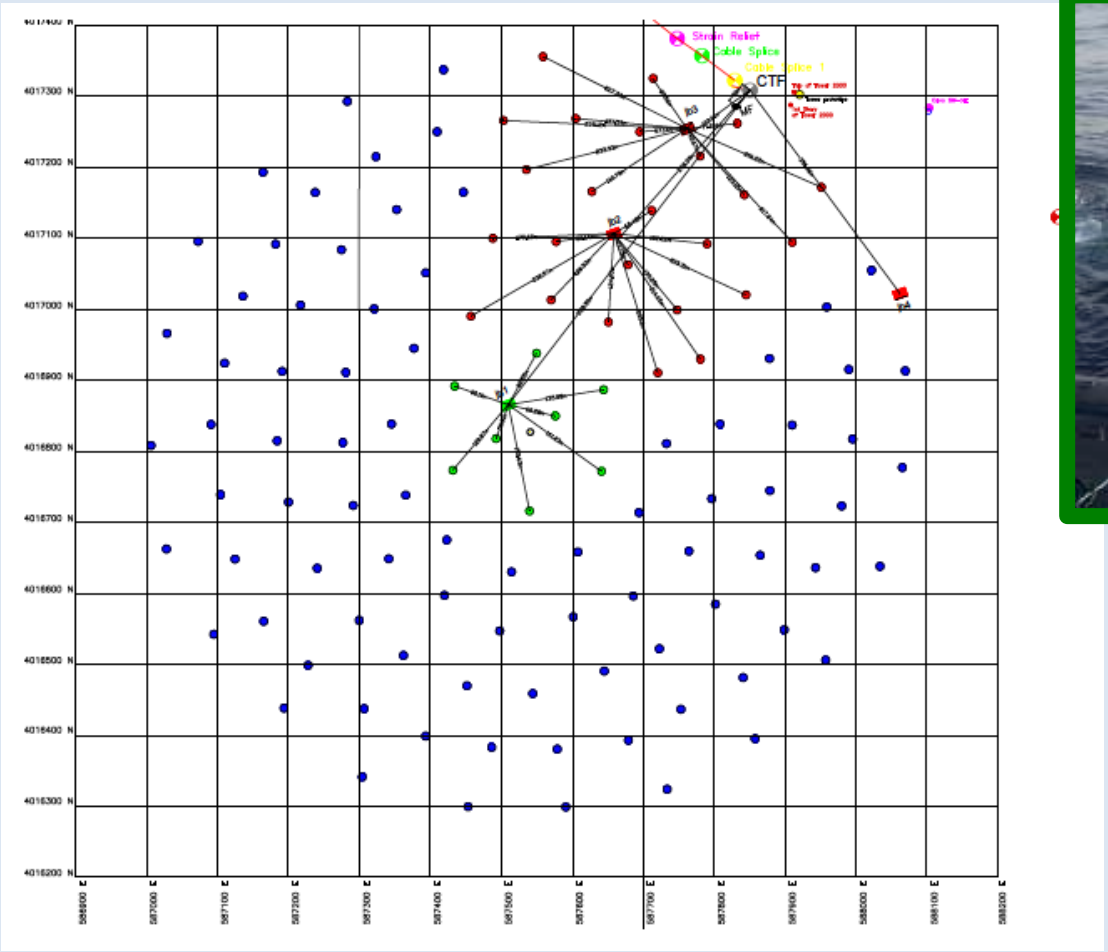

The ROV

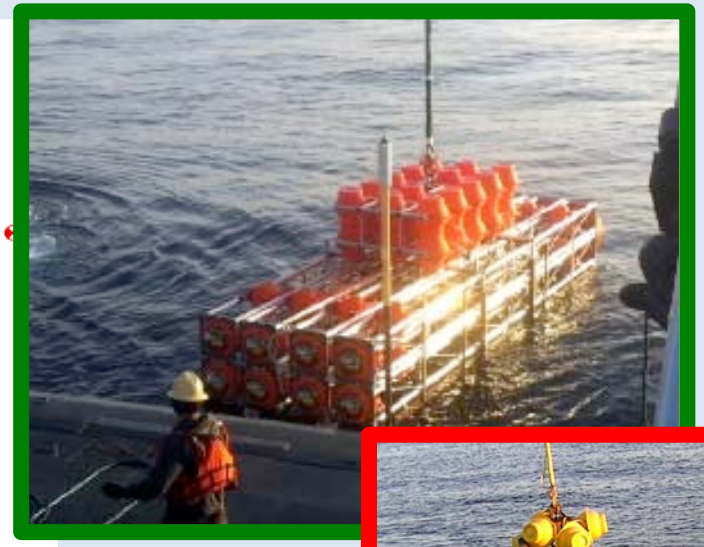
Tower Deployment April 2013


PPM-DI Deployment May 2014

KM3NeT Installation Plan

→ Site full Survey (05/2014) Area Clearance (11/2014) 1 DU (11/2014)
→ 8 **Detection Units 2015** 26 Detection Units in 2015
A full Building Block before 2020





Phased implementation

Phase	Total costs [M€]	Primary deliverable	Status
1	31	Proof of feasibility of network of distributed neutrino telescope ***26 strings+8 Towers in Capo Passero*** ***7 strings in Toulon***	***Funded***
1.5	+(50:60)	Measurement of neutrino signal reported by IceCube ***2 building blocks (> IceCube)***	***Letter of Intent***
2	+(130:160)	Neutrino astronomy ***6 building blocks***	ESFRI road map

Km3NeT perspectives

- **For the completion of the Full Building Block:**
  10 M€ per year in 2015-2019
  Possible Source: EU Regional Funds.

- **FOE: 2 M€ per year in the next 5 yrs as contribution for infrastructure management and temporary position personnel**

International Framework:

- **Greek site is out!**

- **French site will be devoted to ORCA (insidede Km3NeT coll.)**

- **Italian site is the unique for High Energy neutrino telescope (even in collaboration with ICECube)**
- **Km3Net collaboration is moving to a more stable organization (finally)**

KM3NeT and EMSO

Common efforts with the Earth and Sea Science Community

KM3NeT

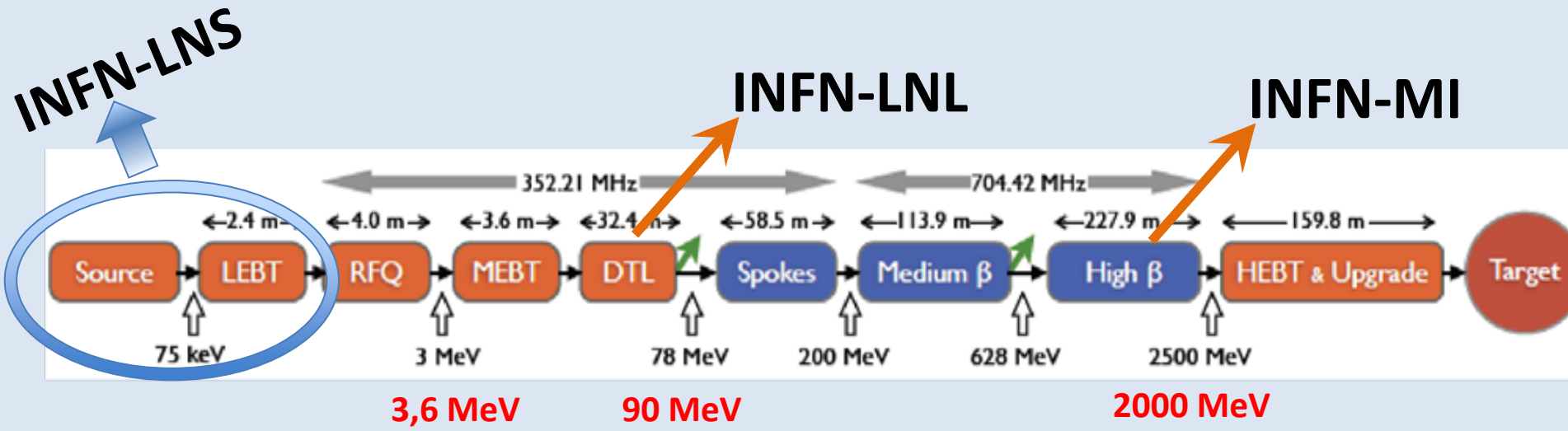
european multidisciplinary seafloor observatory emso

Real Time Environmental Monitoring

Toulon, Sicily and Hellenic: sites of common interest for KM3NeT and EMSO

Oceanography (water circulation, climate change):
Current intensity and direction, Water temperature, Water salinity ,...
Geophysics (geohazard):
Seismic phenomena, low frequency passive acoustics, magnetic field variations,...
Biology (micro-biology, cetaceans,...):
Passive acoustics, Biofouling, Bioluminescence, Water samples analysis,...

ESS - The INFN contribution



INFN has been involved in the Design Update phase (2011-12), for several components of the LINAC, and it is involved in the next phase, aimed to the construction of prototypes :

- The Proton source
- The LEBT
- The Drift Tube Linac
- The Superconducting elliptical cavity @ high energy section

ESS NEW Requirements

- Maximum beam current at the target: 62.5 mA
- Pulse during neutron production: 2.86 ms
- Beam Stability: ±2.5% (I,ε) - Beam emittance 0.25 π mm mrad
- New RFQ input Twiss parameters
- The peak beam current to be able to be varied from 6.3 mA to 62.5 mA with a maximum step size of 6.3 mA and with a precision of 1.6 mA.

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Proton current needed from the source 70 mA circa and total drain current above 85 mA is expected

Beam extraction redesign

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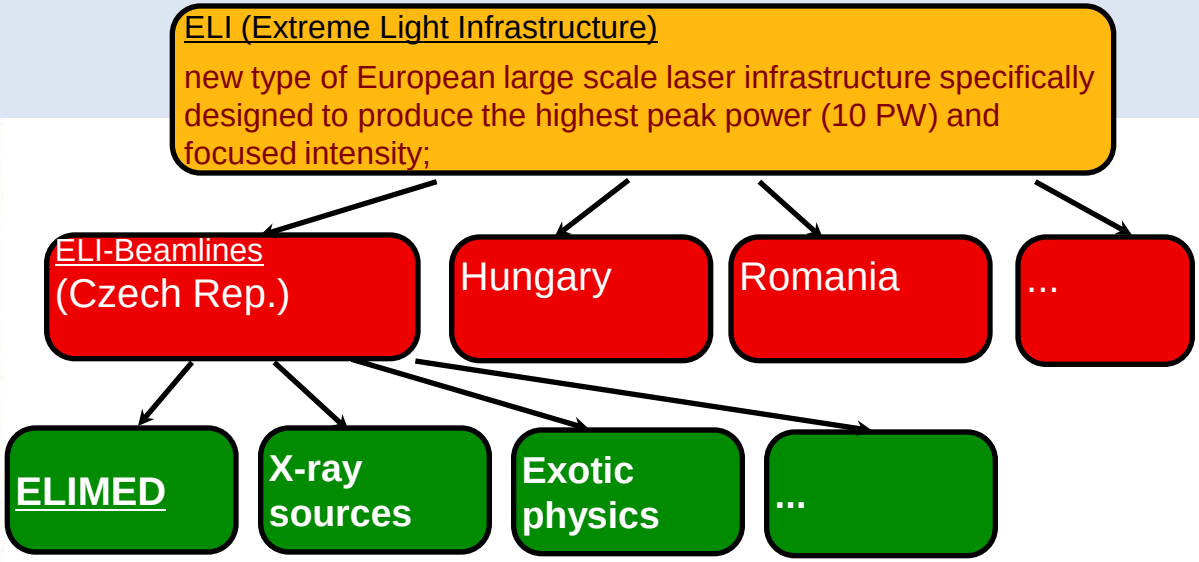
Beam extraction redesign

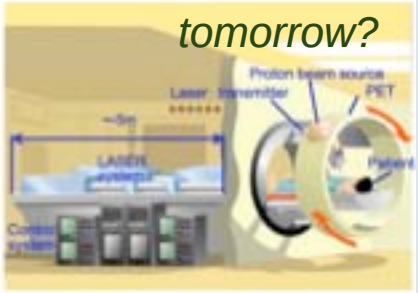
Huge impact of Mechanical design and beam dynamics in the low energy part

DTL main changes : 4 → 5 tanks

ELI-Beams and the ELIMED idea



- Why ELIMED?
  - Realization of a facility at ELI-Beamlines, to *demonstrate the clinical applicability of the laser-driven protons*
  - **Compactness, cost-reduction**, new pioneering treatment modalities



- Why ELIMED at INFN?

-The project we are proposing is related to the preparatory phase of ELIMED (2013-2015): optimisation of the proton beams, transport, diagnostic dosimetric

ELIMED MoU

- It was born by an idea of FZU of Prague and INFN-LNS researchers
- A MoU (Memorandum of Understanding) between INFN-LNS and ELI has been signed and officially started the activity


Fyzikální ústav
Akademie věd ČR, v.v.i.

INFN

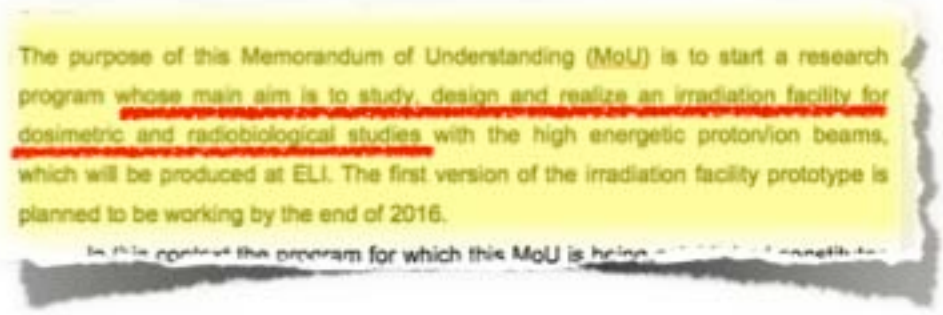
Memorandum of Understanding for a scientific and technologic collaboration towards medical applications at ELI Beamlines

Between the

ELI-Beamlines, Institute of Physics of AS CR, public research institution (FZU),
Prague, Czech Republic

And

Laboratori Nazionali del Sud (LNS), of INFN, public research institution,
Catania, Italy


The purpose of this Memorandum of Understanding (MoU) is to start a research program whose main aim is to study, design and realize an irradiation facility for dosimetric and radiobiological studies with the high energetic proton/ion beams, which will be produced at ELI. The first version of the irradiation facility prototype is planned to be working by the end of 2016.

In this context the program for which this MoU is bring

ELI Tender in progress for ELIMED

European Researchers' night 2014 at INFN - Laboratori Nazionali del Sud

September 26, 2014

Funded by the European Commission's Research and Innovation Framework Programme under the Horizon 2020 (2014-2020) by the Marie Skłodowska-Curie actions. it consists of a pan-European event taking place on the last Friday night of September.

Quantitative impact: number of attendees

More than **2,500** people (certified by enter tickets) made up of children, parents, teenagers, adults took part in the event.
LNS Visits at least 1000 people join the tour of LNS *queuing till 01:30* to enter the Lab! Organized **20** tour of LNS with 45-50 persons each. Even on saturday and sunday LNS opened the door.

Qualitative impact: *several activities addressed to the general public from children to elder persons.*

LNS and Regional Strategy

We are part of 3 new "Distretti Tecnologici" (Technological District) togheter with the sicilian universities (Palermo, Catania and Messina), CNR, INGV, ENEA, SME and large companies (STM, Fidia, Alenia, Farmitalia, …)

Distretto Biomedico: Prototype of Ion Gantry for Hadrontherapy (LNS, CNR-IBAM, Catania Univ, Cometa. Hitec2000, C3SL, Unico)

Distretto del Mare: application of submarine acoustic detectors for marine hazard (LNS, INGV, ENEA, Wass Alenia, SME consortium)

Distretto Beni Culturali: application of nuclear technology (Coirich, CNR)

INFN-LNS is component of the Catania Ricerche consortium together with CNR, Catania Univ. Farmitalia and Camera di Commercio of Catania.

Thank you