

# Laboratori Nazionali del Sud: Status and Perspectives

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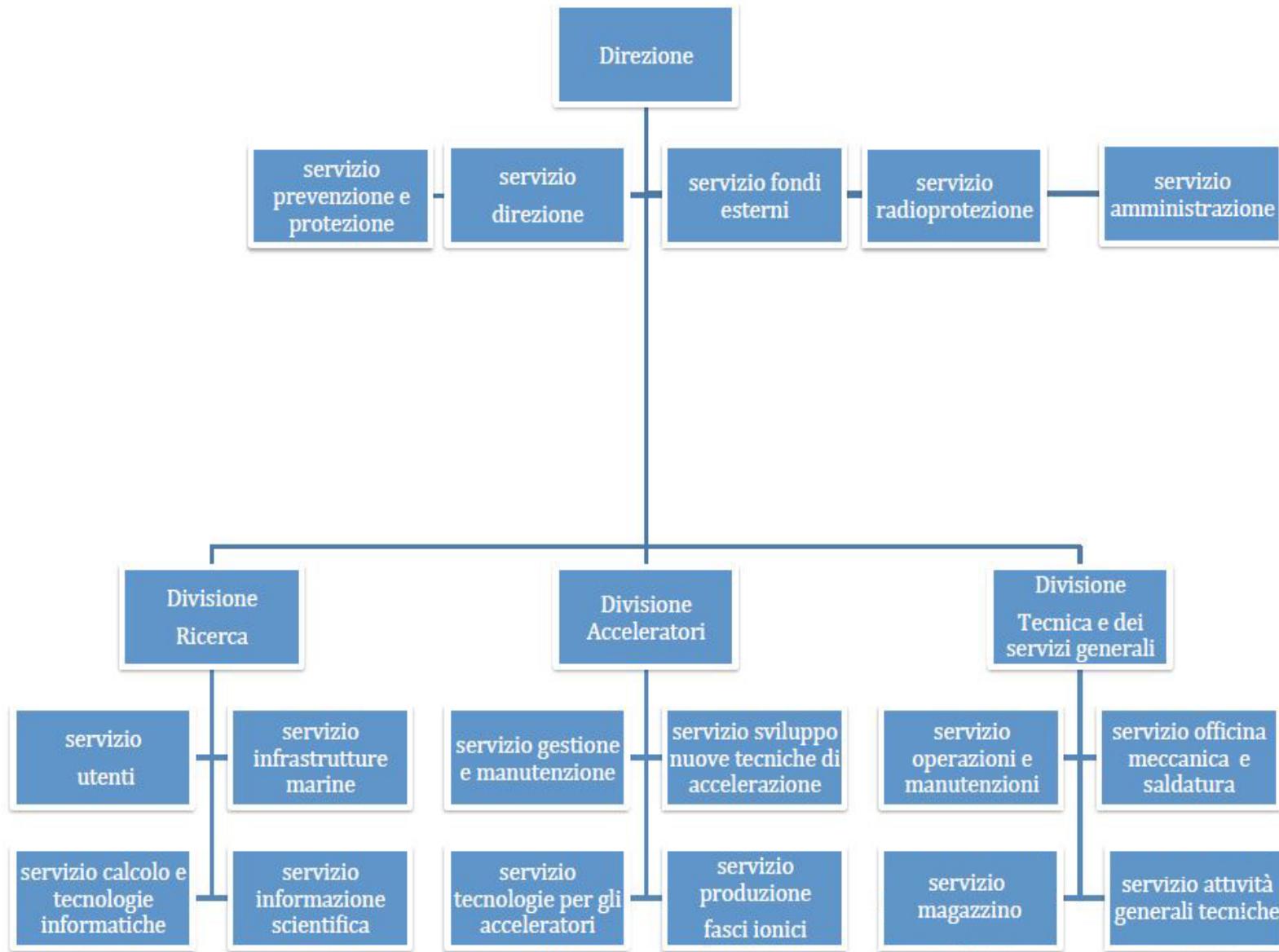
*LNS User Meeting  
Catania Dec. 15th, 2015*

## I Laboratori Nazionali del Sud dell'INFN



Laboratori Nazionali del Sud (LNS) is the most southern laboratory of [INFN](#) and with the wider spectra of research activities. Founded in **1976**, nowdays are constituted by **250** people (**104** permanent staff) including researchers, technicians, doc and post-doc, undergraduate, etc. LNS are an advanced technological and research pole in Italy. Budget 11 M€ per year (exc. Salaries)

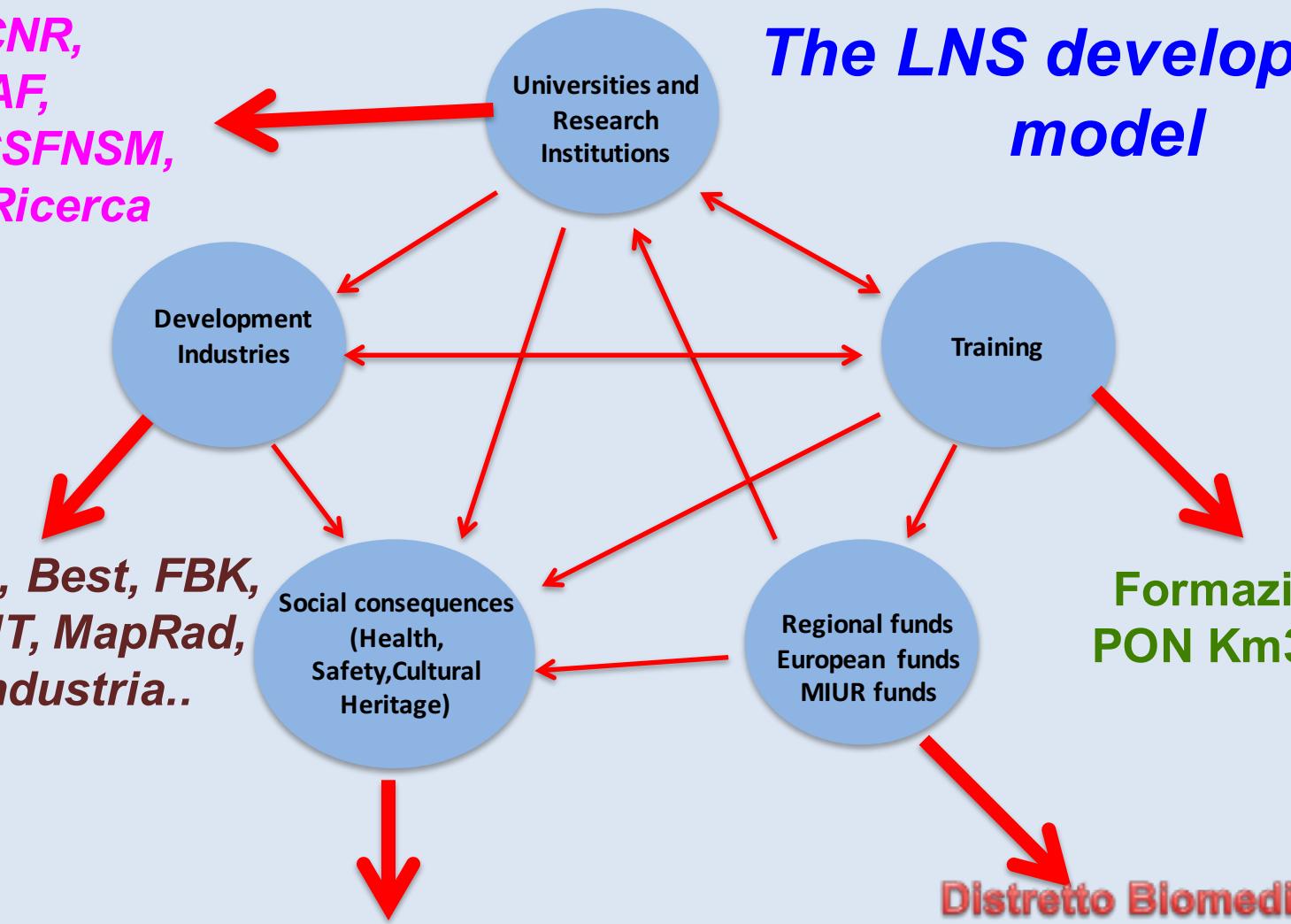
The research and development activities find applications in **medicine**, **biophysics**, **photonics** and **cultural heritage**. About 400 external users per year.



# The LNS development model

Uni CT, CNR,  
INGV, INAF,  
ISPRA, CSFNSM,  
Catania Ricerca

STM, IBA, Best, FBK,  
Caen, IMT, MapRad,  
Confindustria..



- CATANA: 300 patients, 95% success
- LANDIS: Coll. with CNR-IBAM (Misurata Coins, Dead Sea Scrolls...)
- Radioactive Waste Management: Sogin
- Environmental Radioactivity Lab
- Radiobiology Lab

## Distribuzione dei finanziamenti annuali dell'INFN

Anno		Fondi Funzionamento	Fondi esperimenti				Totale
			CSN 2	CSN 3	CSN 4	CSN 5	
2014	Assegnazione iniziale (k€)	5.150,00	199,00	525,00	35,00	355,50	6.264,50
	Assegnazione totale	6.302,00	197,50	502,88	39,01	214,20	7.255,59
	Impegno (k€)	5.092,98	197,38	495,27	37,91	213,28	6.036,82
	Residuo (%)	19,18	0,06	1,51	2,82	0,43	16,80
2013	Assegnazione iniziale (k€)	5.288,00	16,00	268,00	26,50	301,50	5.900,00
	Assegnazione totale	5.341,43	14,23	284,78	39,35	272,90	5.952,68
	Impegno (k€)	5.320,88	14,22	284,54	39,31	270,07	5.929,01
	Residuo (%)	0,38	0,09	0,08	0,10	1,04	0,40
2012	Assegnazione iniziale(k€)	5.069,60	348,50	515,00	31,00	316,50	6.280,60
	Assegnazione totale	5.217,53	128,50	509,50	43,10	319,50	6.218,13
	Impegno (k€)	5.074,85	123,88	501,21	41,71	314,11	6.055,76
	Residuo (%)	2,73	3,60	1,63	3,22	1,69	2,61

NOTA:

- 1) il residuo del 2014 si riferisce a una quota di finanziamento dedicata a interventi della Divisione Tecnica per il rifacimento della cabina elettrica, non impegnata entro il 31 dicembre 2014 e riassegnata per il 2015;

**Finanziamenti relativi a progetti particolari (Quota ESFRI sul FOE e Progetti Premiali), espressi in k€.**

Anno	ESS	ELI_NP	ASTROFISICA NUCL. MIUR	INFN-E	IRPT MIUR	Totale
2014	1.045,92	178,23	1.384,46	43,73	610,00	3.262,33
2013	573,43	72,00	2.953,82	40,00		3.639,24
2012	593,00	80,00	2.986,00	38,00		3.697,00

**Finanziamenti relativi a terzi (PON, POR, UE, FIRB, ...) espressi in k€. Nelle note sono riportati i periodi di riferimento.**

Anno	kM3Net-Italia	AISHA	Emso.Medit	Ensar	Firb 1	Firb 2	TENDER ESA	Totale
2014				59,86				59,86
2013		1.279,61	2.860,00	114,58			60	4.254,19
2012	20.800,00			148,58	359,20	258,00		21.565,78

**Finanziamenti complessivi espressi in k€.**

Anno	Fondi INFN	Altri fondi	Fondi EU	Totale
2014	7255,59	3262,33	59,86	10577,79
2013	5952,68	3639,24	4254,19	13846,11
2012	5541,89	3697,00	21565,78	30804,67

# LNS and Regional Strategy

We are part of 3 new “Distretti Tecnologici” (Technological District) together 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)**

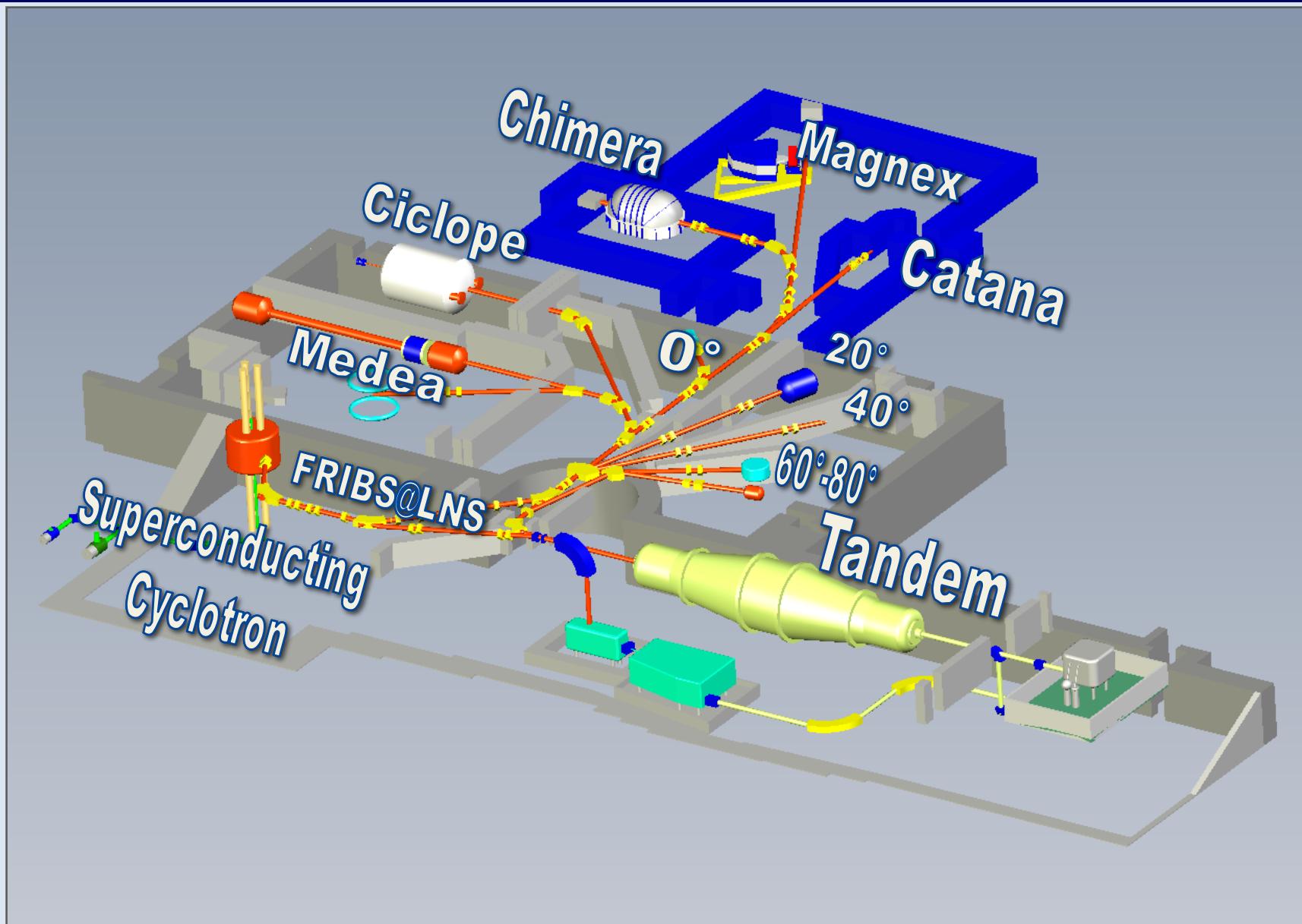
**Distretto Beni Culturali: application of nuclear technology at cultural heritage (Coirich, CNR)**

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

**Energy Saving at LNS: A New LNS (**POR 1.820 M€ in 2015 and 20% as INFN**)**

**We are going to sign specific agreement with Assessorato Attività Produttive**

# LNS lay-out: accelerators and experimental halls



# The $\beta\beta$ decay

## 1) $2\nu$ double $\beta$ -decay

- 1) Does not distinguish between Dirac and Majorana
- 2) Experimentally observed in several nuclei since 1986



## 2) $0\nu$ double $\beta$ -decay

Neutrino has mass

Neutrino is Majorana particle

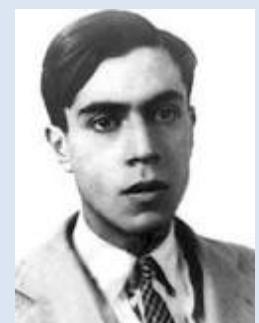
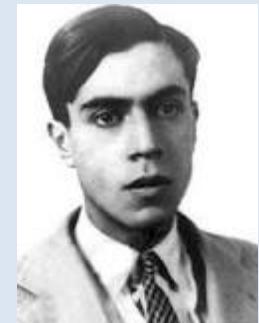
Violates the leptonic number conservation

Experimentally not observed

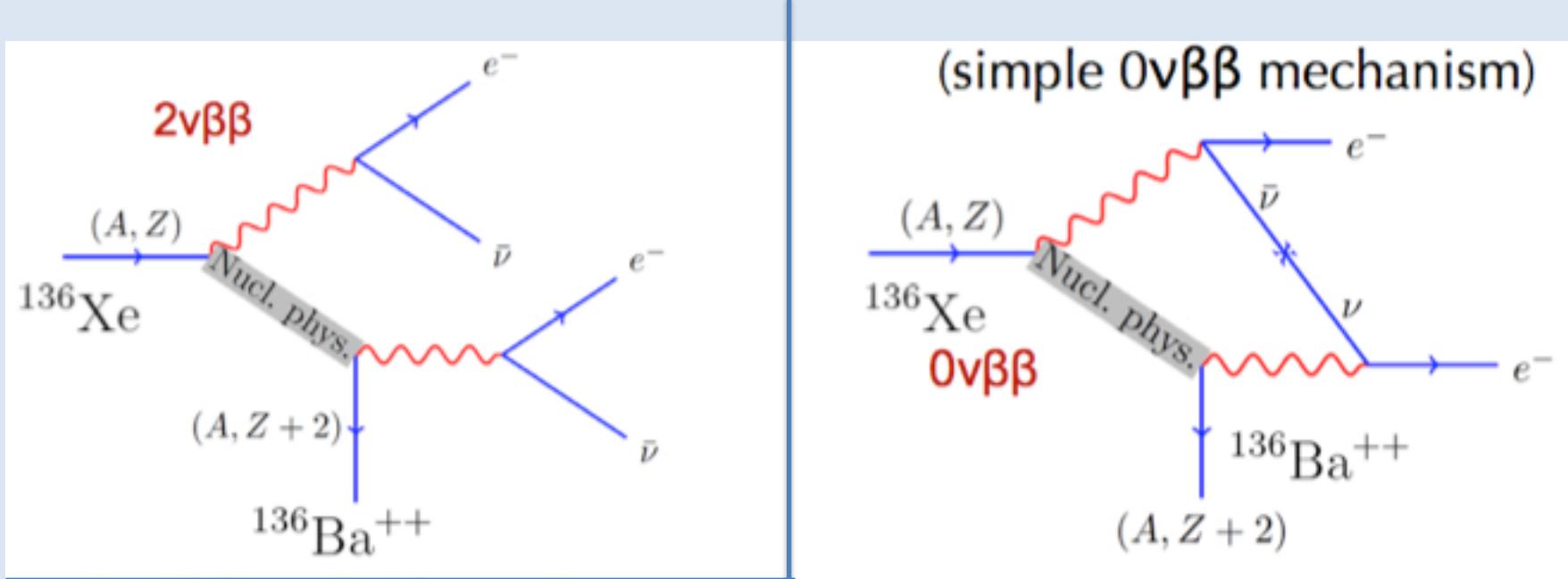
Beyond the standard model

$\nu$  and anti- $\nu$  can  
be distinguished

$\nu$  and anti- $\nu$   
are the same



# Physics case demanding high intensity: double $\beta$ decay



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

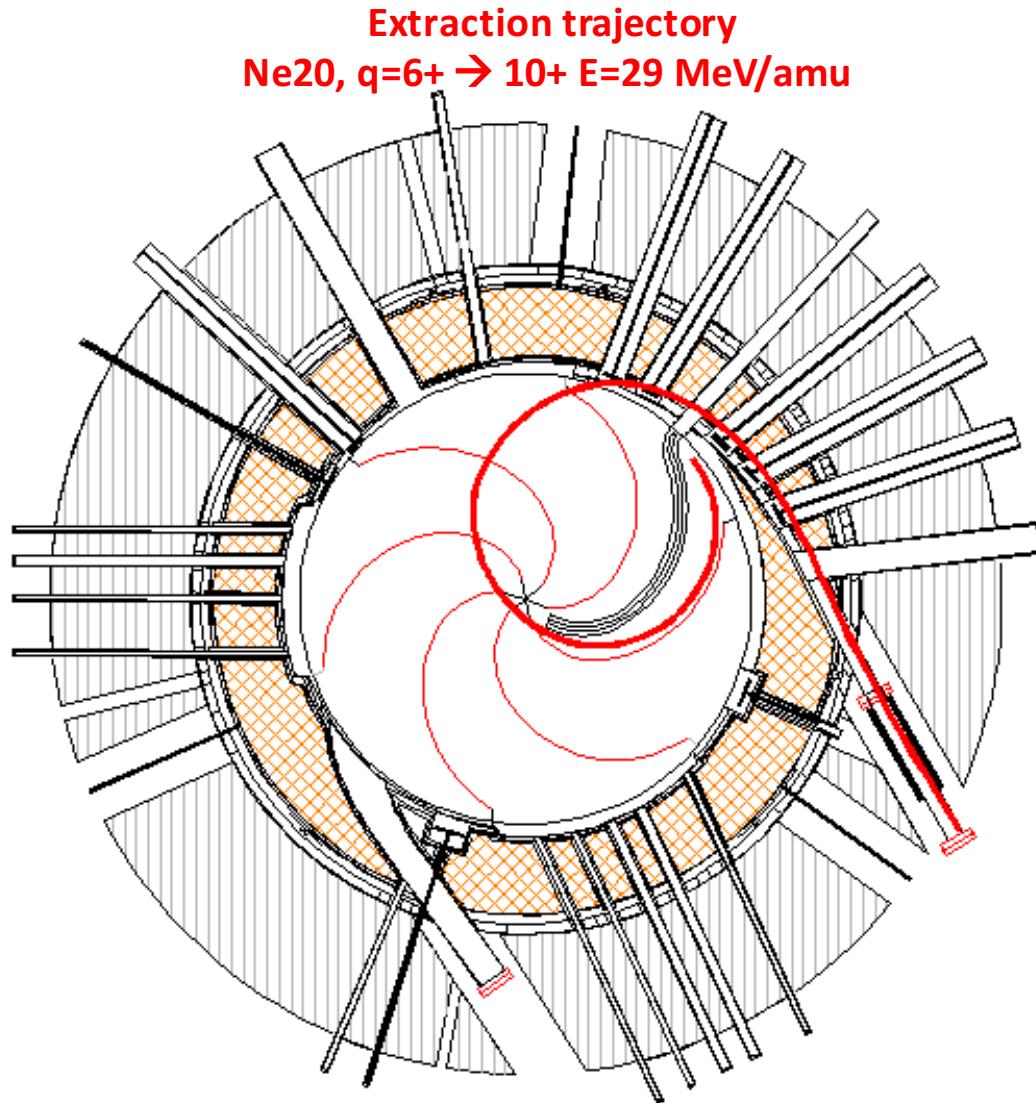
**A lot of new physics inside**

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

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

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

# Extraction by stripping: high efficiency



Extraction by stripping is based on the reduction of **magnetic rigidity** of the accelerated ion, caused by an increase of **charge state** or decrease of mass, after crossing a thin carbon foil (stripper).

For light ions at high energies the charge state fraction for  **$q=Z$**  after a stripper with thickness bigger than the equilibrium thickness is >99%

# Superconducting Cyclotron upgrade: Technical Design Report

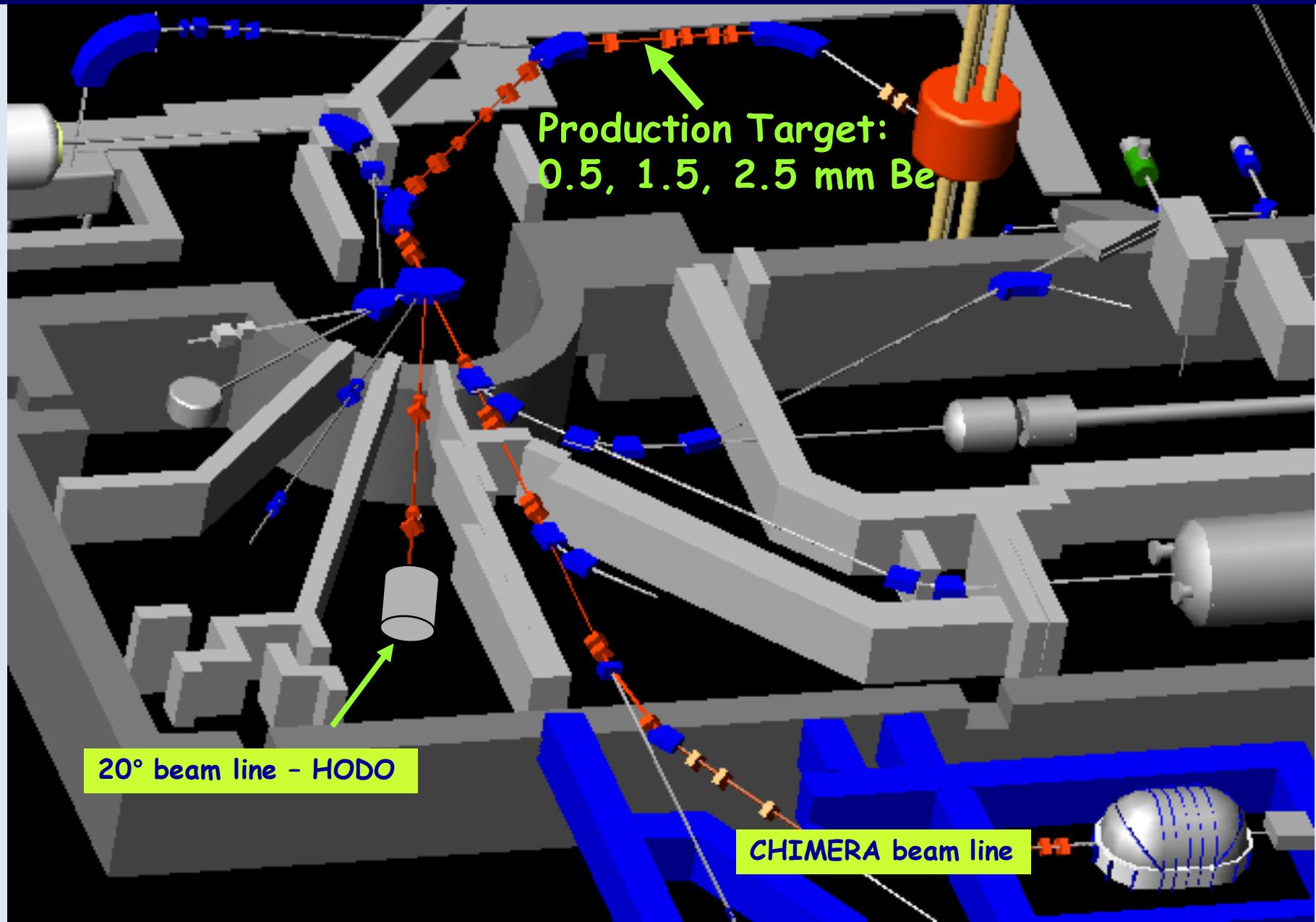
A Technical Design Report has been presented to the INFN MAC on November 12

- Technical and functional analysis of the Superconducting Magnet (Cryostat and superconducting coils) produced by ASG Superconductors, Genova – Estimated costs and time schedule
- First technical choices of the modifications to be introduced:
  - extraction by stripping
  - magnetic channels
  - liner
  - pumping system
  - RF
  - trim coils
  - beam line
  - power supplies
  - radioprotection
  - logistic aspects

Estimated costs and time schedule

capitolo	dettaglio	keuro	parziali keuro
Allegato 3	Magnete+Criostato	4078	5094
	torretta Criogenica	1006	
	QDS	10	
1.1	camera estrazione per stripping	40	39.6
	movimentazione stripper	30	
	controlli e diagnostica	16.8	
1.2	modifiche meccaniche al deflettore	10	39.6
	controlli e diagnostica per il nuovo deflettore	29.6	
1.3	canali magnetici nuovo canale	20	110
	canali magnetici canale esistente	30	
	controlli e diagnostica canali magnetici	60	
2	manifattura nuovo liner	350	390
	lucidatura e pulizia in bagno con ultrasuoni	25	
	verifica dimensionale	4	
	prova da vuoto	2.5	
	trasporto assemblaggio	8.5	
3	vuoto cs	90	224
	vuoto nuova linea di estrazione	134	
4	modifiche ai dee	10	40
	raffreddamento sistema RF	30	
5	trim coil avvolgimenti	360	881
	TC convertitori	450	
	quadro elettrico e linee	40	
	concentratore allarmi e pc	31	
6	N° 1 Dipolo 90°	229	1265
	N° 1 Switching magnet	188	
	N° 2 Dipoli 45°	298	
	N° 2 Dipoli 10°	120	
	N° 8 Quadrupoli	176	
	N° 2 Quadrupoli	54	
	vuoto	200	
7	TPS	13.1	55.6
	Beam losso monitor	42.5	
8	Alimentatori bobine principali	100	420
	Alimentatori della linea di fascio	320	
9	monitoraggio per neutroni e gamma in sala CS	60	967
	sistema di sicurezza sala CS e locali attigui	100	
	schermatura ECR	10	
	impianti idrici per il raffreddamento acqua CS	156	
	monitoraggio per neutroni e gamma in sala Magnex	90	
	Modifiche al sistema di sicurezza	50	
	schermature	421	
	impianti idrici per il raffreddamento beam dump o altro in sala Magnex	80	
10	ribaltatore	250	836.15
	nuova impalcatura per il nuovo magnete di estrazione	25	
	meccanica protezione vitoni	15	
	interfaccia camera pulita	15	
	movimentazione schermature	12.3	
	manpower esterno per smontaggio/rimontaggio	150	
	locale di sgombero	368.85	
		<b>TOTALE</b>	<b>10361.95</b>

# 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

**<sup>16</sup>C (CHIMERA)**

**<sup>68</sup>Ni (CHIMERA)**

**<sup>8</sup>He (CHIMERA) new**

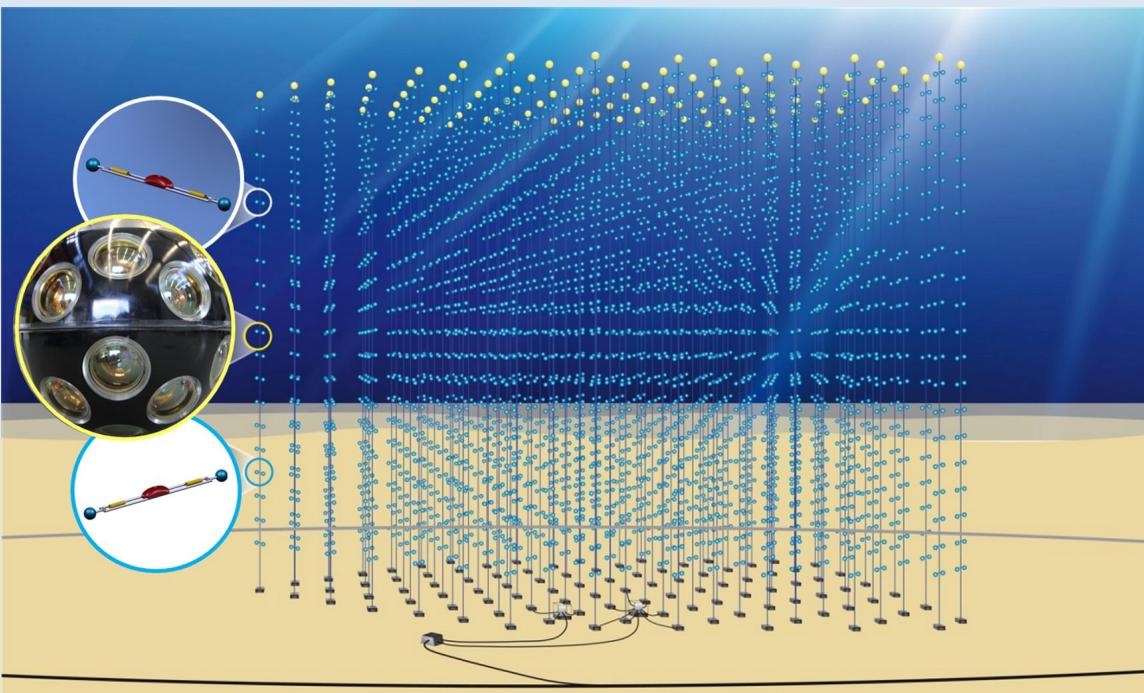
**<sup>14</sup>Be (test experiment) new**

**<sup>38</sup>S (MAGNEX) new**

**Unique facility in Europe**

# 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<sup>3</sup> of seawater will be instrumented with optical detectors.



5 building blocks  
120 Detection Units (DU)  
750 m DU height  
**180m DU distance**  
**5 km<sup>3</sup> 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

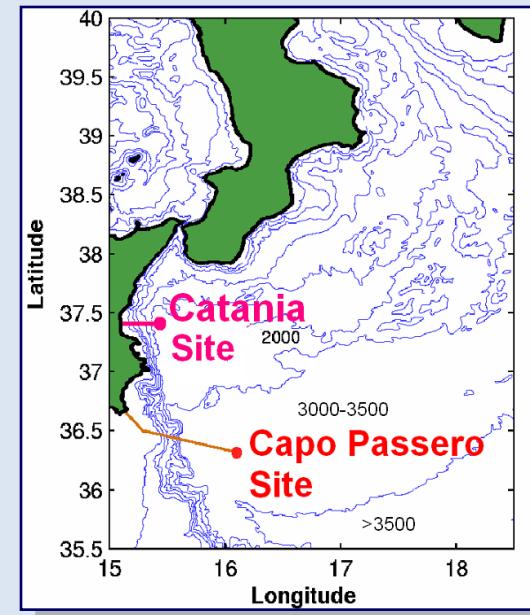
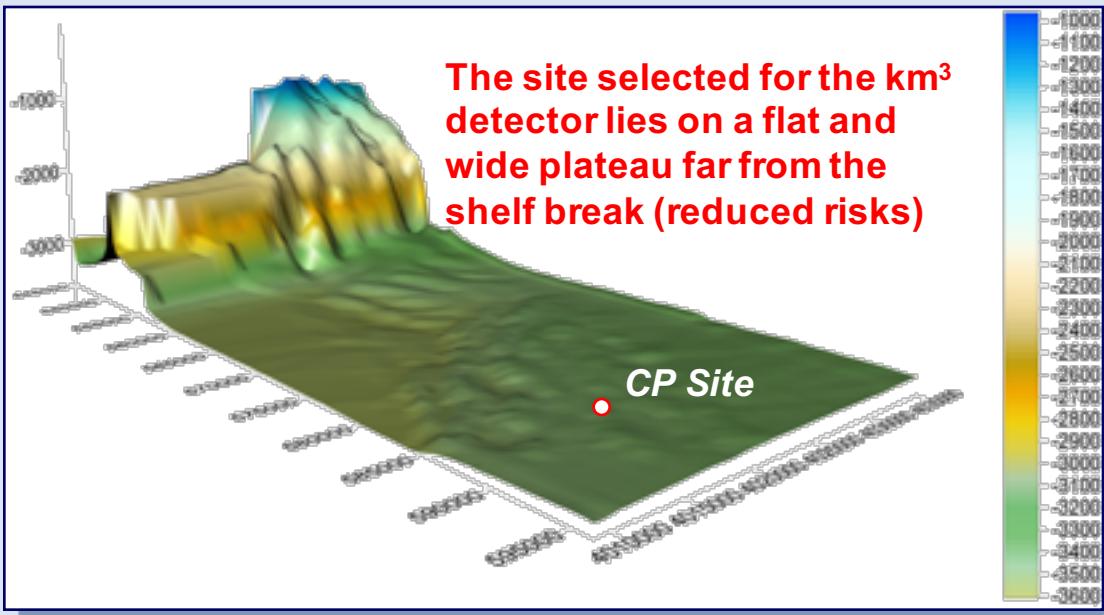
# News

- **ESFRI road map 2016 approved**
  - hearing 8 September 2015, Brussels
  - Inserted in December 2015
- **Interest from Hyper-K**
  - will present draft Memorandum of Understanding for co-operation to RRB on 23 November 2015
- **New web pages coming up soon**
  - stay tuned

# The Capo Passero Site

More than 30 naval campaigns seeking deep sea sites in the Mediterranean Sea. Capo Passero is an optimal site.

- Depth >3500 m, 90 km distance from the shore
- Excellent water optical properties ( $L_a \approx 70 \text{ m} @ \lambda = 440 \text{ nm}$ )
- Optical background from bioluminescence extremely low
- Deep sea water currents are low and stable (3 cm/s avg, 10 cm/s max)
- Wide abyssal plain: large extension of the detector



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



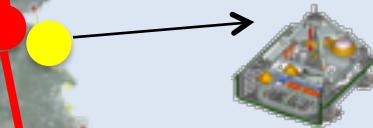
**INFN LNS:**  
**Main Data Repository**  
**Catania IGI node**



**Capo Passero Shore Lab**

10 Gbit link  
GARR-X

**Catania Shore Lab**



1 Gbit link



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



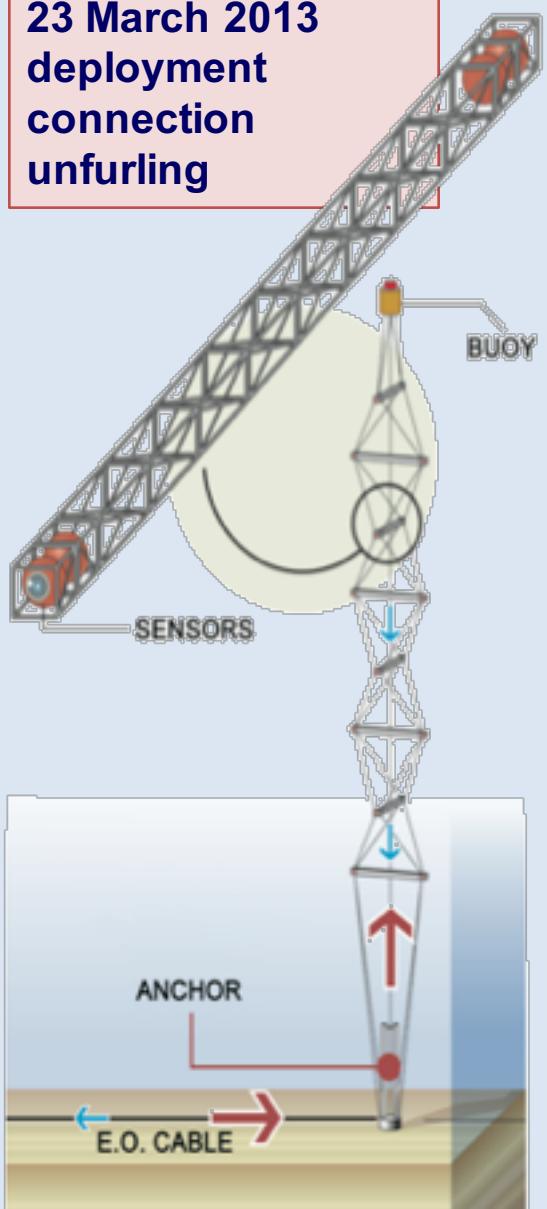
**RECAS**

**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**

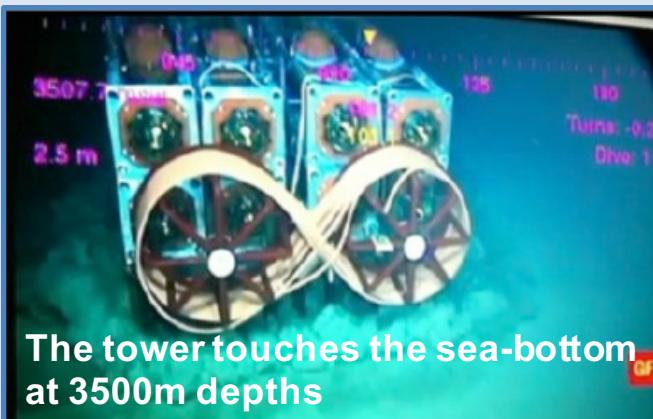
**INFN Catania is a major site of the Italian GRID**

# The KM3NeT Tower Prototype

23 March 2013  
deployment  
connection  
unfurling



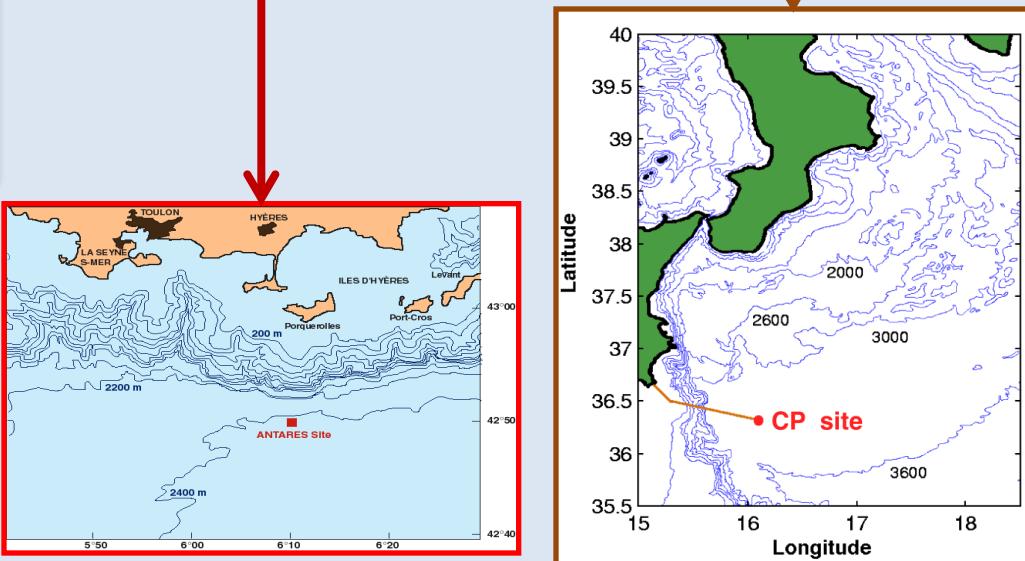
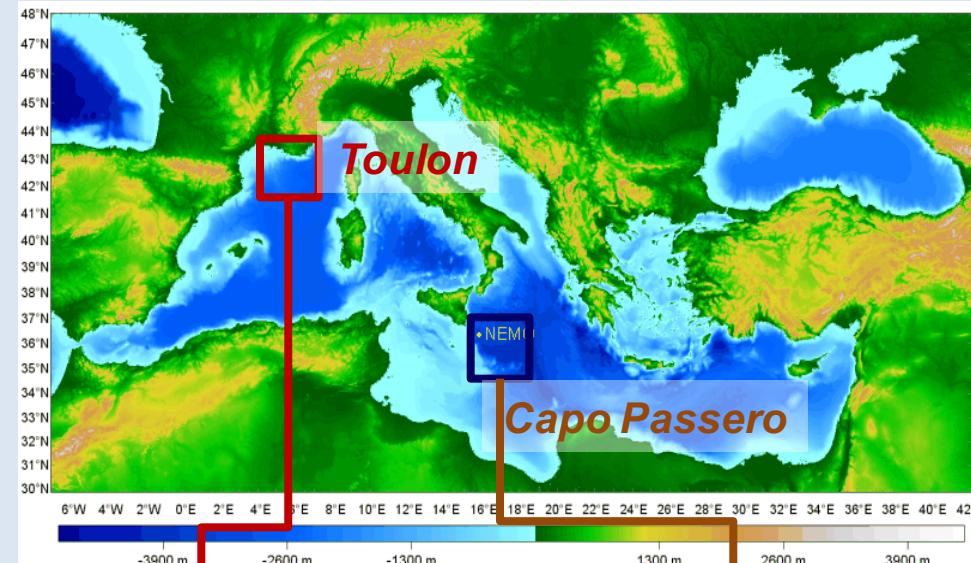
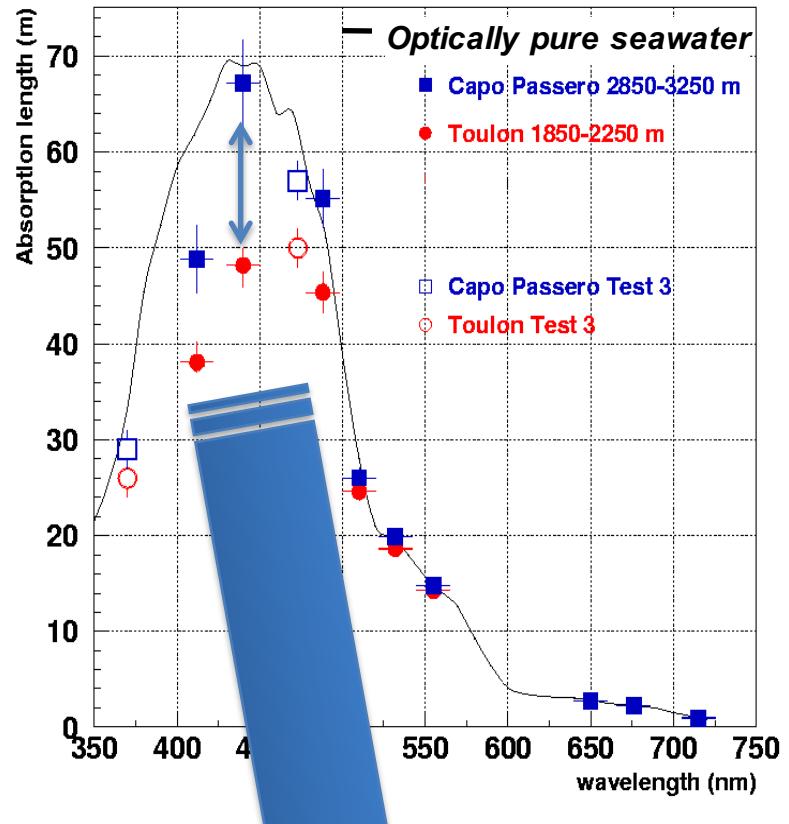
- 8 floors, 8 m bars, vertical dist. = 40 m,  $H_{\text{tot}} = 450$  m
- 32 OM, 12 hydrophones , 2 OAM (opto-acoustic modules)
- CTD, DCS, transmissometer, laser beacon, acoustic beacon



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

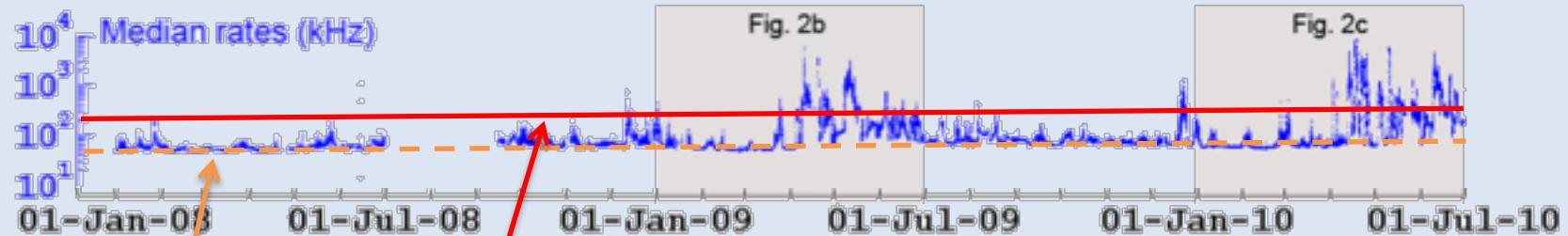


# Light Absorption length

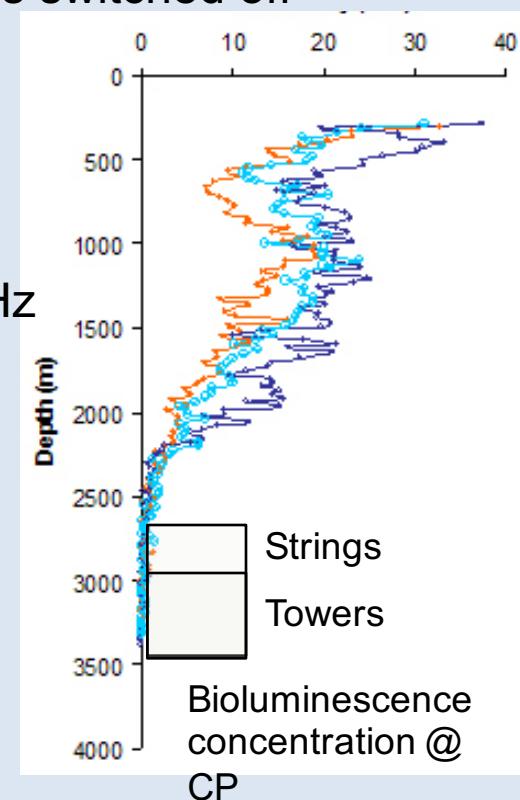
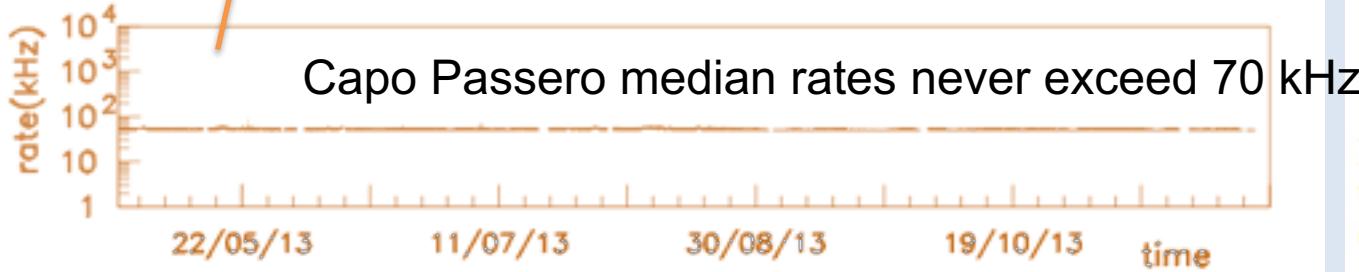


C.P. waters 30-40% more transparent than Toulon ones  
@lambda Cherenkov

# Optical Background median rates at ANTARES and Capo Passero site



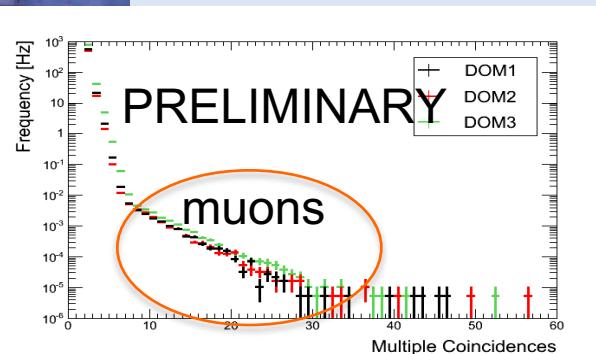
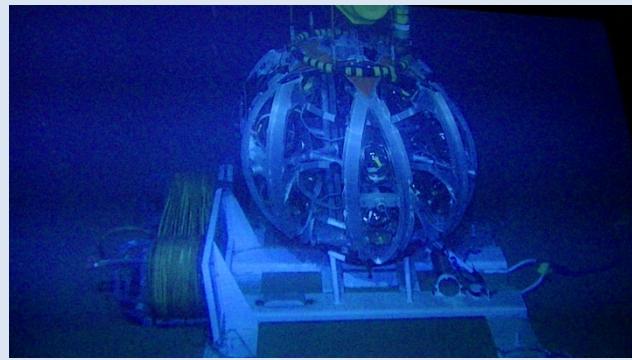
Median rate Above 200 kHz: ANTARES DAQ is switched off



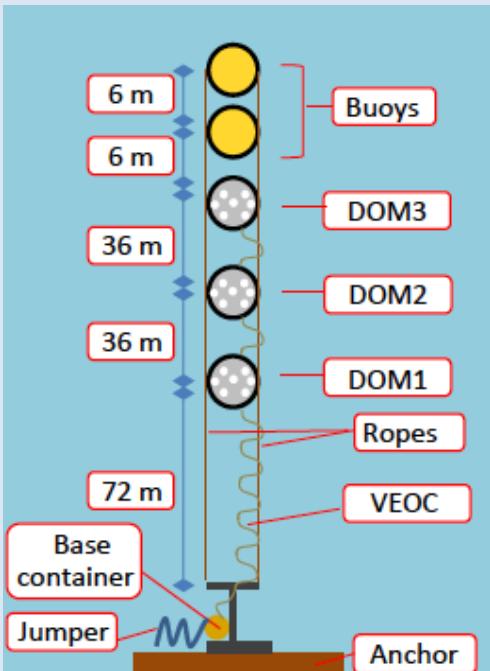
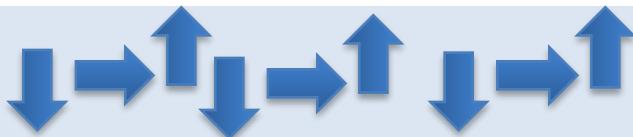
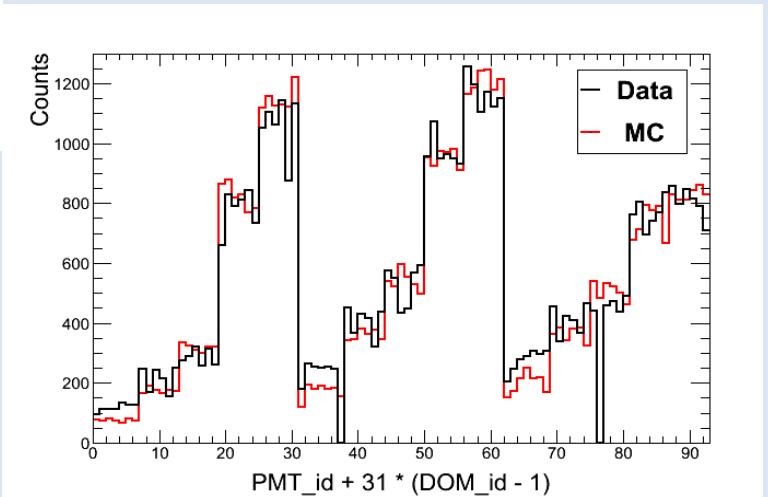
# The demonstrators



The PPM DU:  
deployed May 2014  
at Capo Passero Site



Same as per PPM-DOM



# KM3NeT Installation Plan

→ Site full Survey (05/2014)

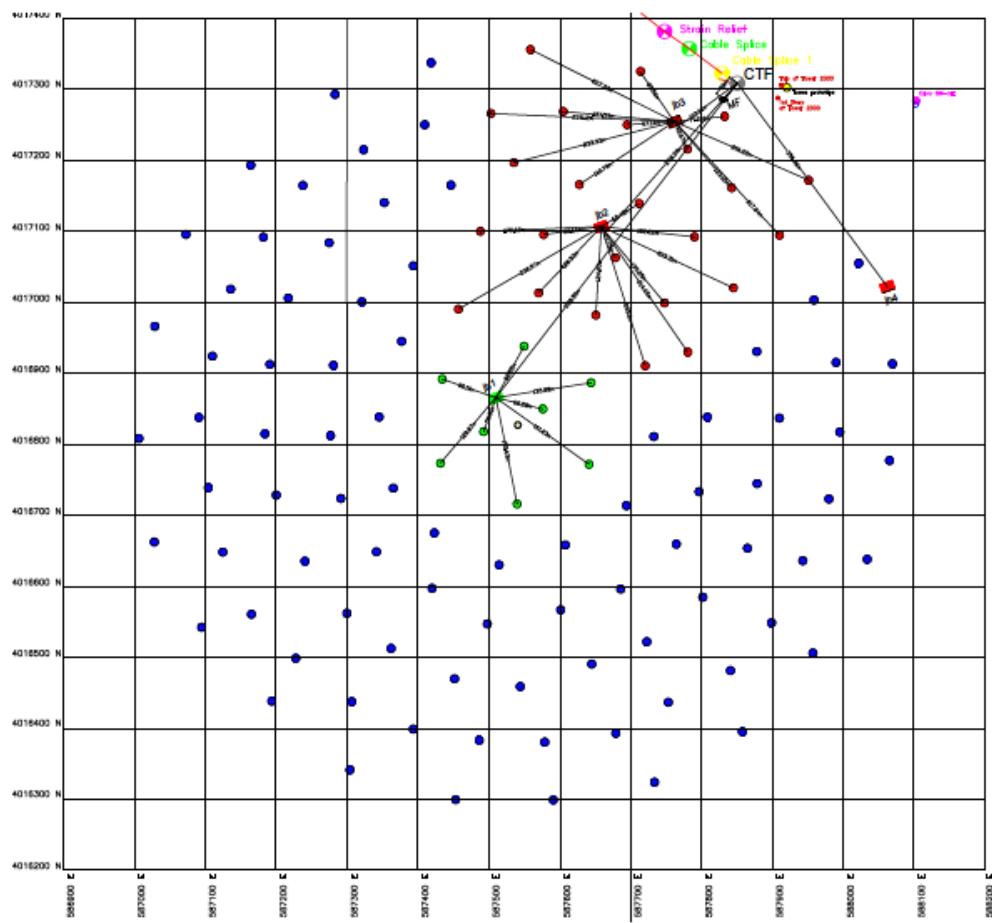
→ 8 Detection Units 2015

A full Building Block before 2020

Area Clearance (11/2014)

26 Detection Units in 2015

1 DU (11/2014)



# Sea Operation: deployment and connection



# Km3NeT Integration sites:

Nikef, Erlangen,  
Naples, Catania,  
Tulon, and Athens

Now DU2 on Fugro  
AT installed at  
CapoPassero site



# Phased implementation

Phase	Total costs [M€]	Primary deliverable	Status
1	31	Proof of feasibility of network of distributed neutrino telescope <i>26 strings+8 Towers in Capo Passero</i> <i>7 strings in Toulon</i>	<b>Funded</b>
1.5	+(50:60)	Measurement of neutrino signal reported by IceCube <i>2 building blocks (&gt; IceCube)</i>	<b>Letter of Intent</b>
2	+(130:160)	Neutrino astronomy <i>6 building blocks</i>	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: 1 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 (ARCA)
- Km3Net collaboration is moving to a more stable organization (finally)

# KM3NeT and EMSO

Common efforts with the Earth  
and Sea Science Community



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):

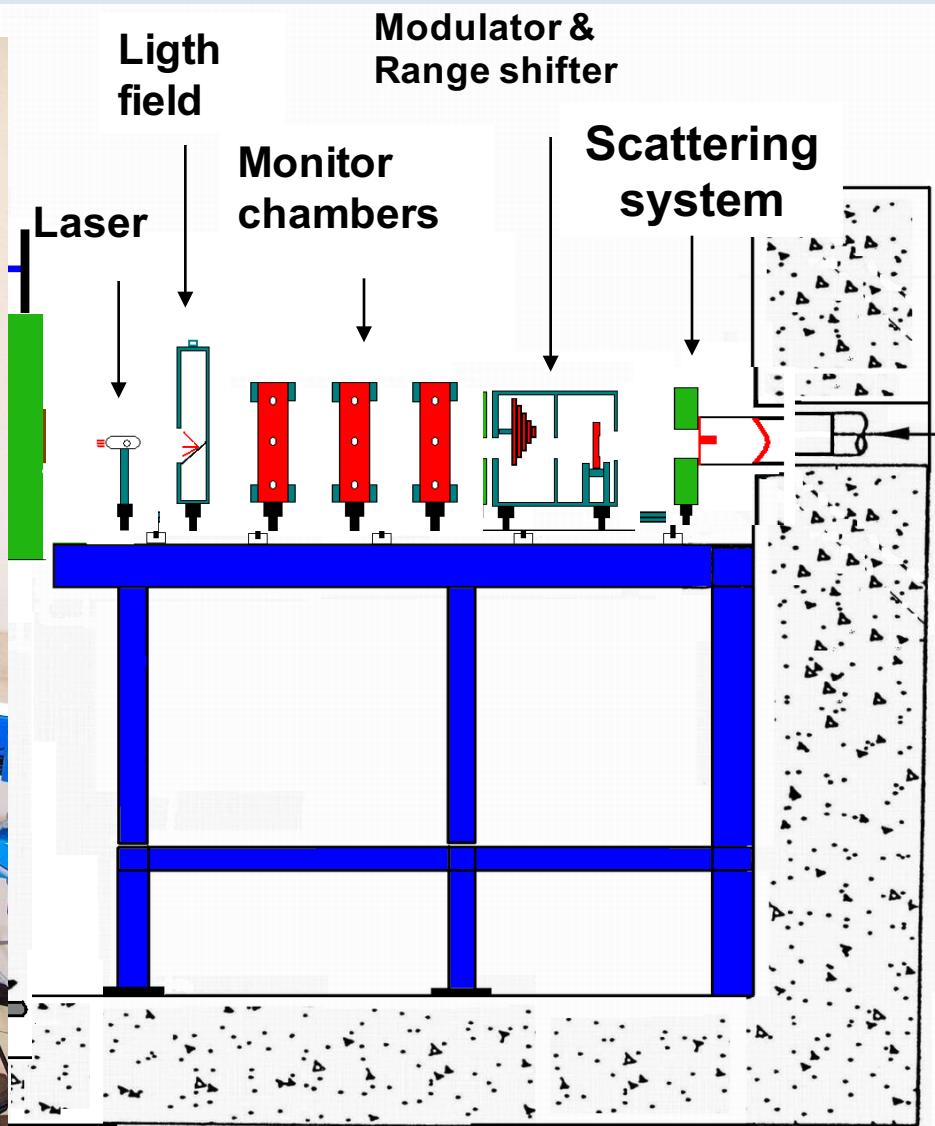
*Seismic phenomena, low frequency passive acoustics, magnetic field variations,...*

Biology (micro-biology, cetaceans,...):

*Passive acoustics, Biofouling, Bioluminescence, Water samples analysis,...*

*In Sicily coordination between Catania, Porto Palo, Capo Granitola and Palermo (INFN, INGV, CNR and university of Catania and Messina).*

# CATANA proton therapy beam line



## SOPRAVVIVENZA

Total Number of patients	363	
Deaths	6	
	Metastasis	5
	Other	1
Eye retention rate	95 %	
Surviving	98 %	
LOCAL CONTROL	95 %	

## Applications for Cultural Heritage

LANDIS (in collaboration with CNR-IBAM) is mainly engaged in the technological development of innovative instrumentation and new methods for the non-destructive characterization artistic and archaeological material of interest in the field of Cultural Heritage. The techniques employed at LANDIS are available in portable version and are mainly based on the use of X-ray beams and charged particles.

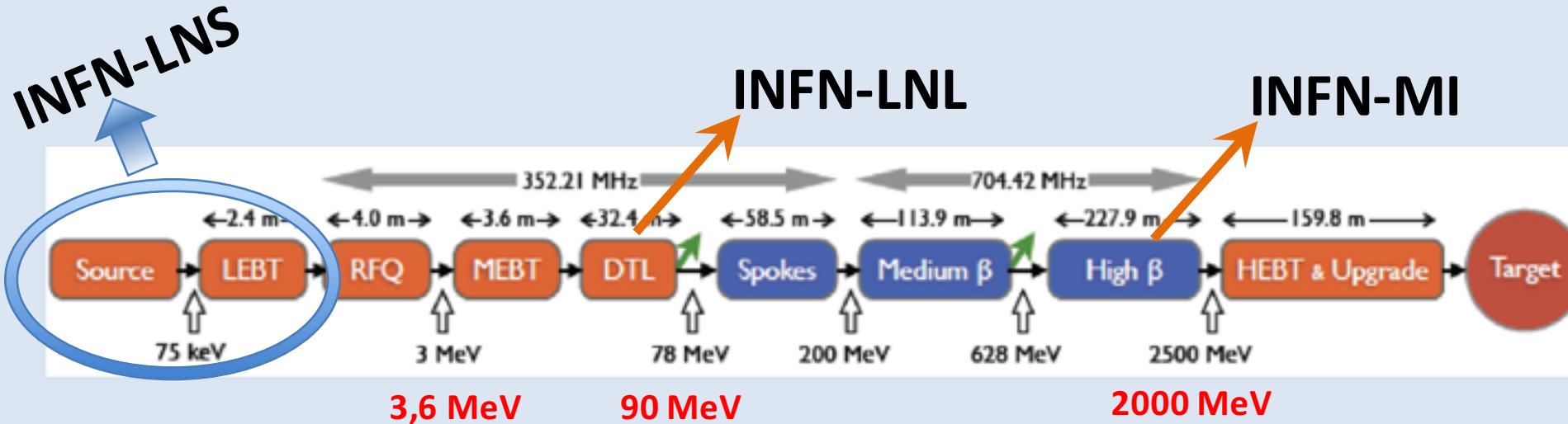


The LANDIS instrumentation used at Paolo Orsi Museum (Sr)

## Activities in Sicily

- *Sicilian local Superintendences Soprintendenze (Catania, Siracusa, Enna);*
- *Archeological Museums (Paolo Orsi Archeological Museum of Siracusa; Salinas Archeological Museum of di Palermo; Archeological Museum of Caltanissetta and Gela)*

# 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

# ELI (Extreme Light Infrastructure)

new type of European large scale laser infrastructure specifically designed to produce the highest peak power (10 PW) and focused intensity;



ELI-Beamlines  
(Czech Rep.)

Hungary

Romania

tbd

ELIMAIA

X-ray  
sources

Exotic  
physics

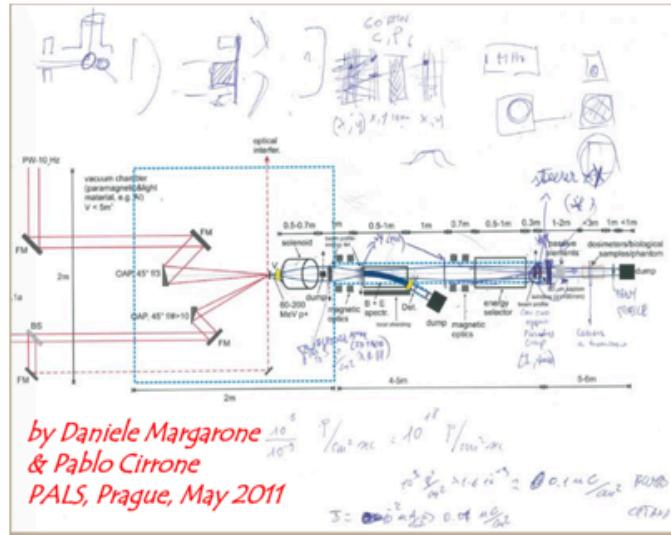
...

## ELIMAIA:

ELI Multisiplinary Applications of laser-Ion Acceleration

- ELIMAIA is an ELI-Beamline facility
- ELIMED ELI-Beamlines MEDical applications
  - is the transport beamline of ELIMAIA
  - will transport and measure laser-driven ions for multidisciplinary applications

# ELIMAIA - ELIMED story



2011

2012



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

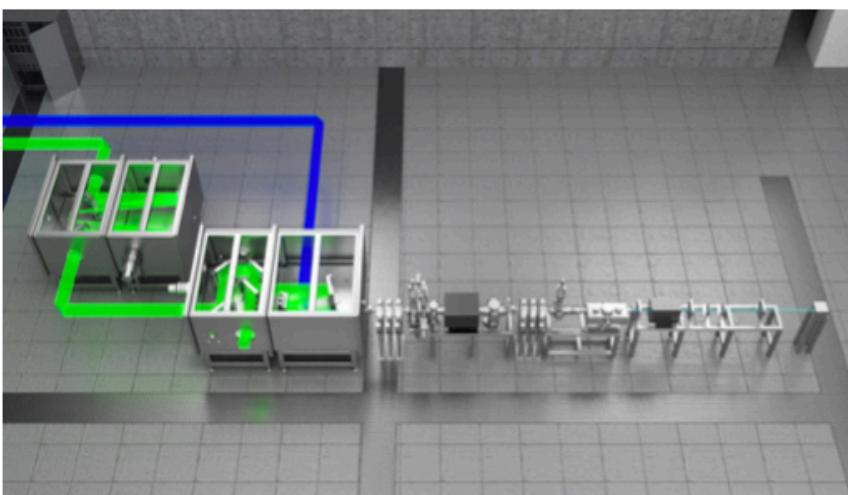
Laboratori Nazionali del Sud |

4. WORK SUBJECT-MATTER; WORK SCOPE

The Contract concerns the design, assembling, performance optimization, and delivering to the Client at the Client's Place of Business of a complete transport beamline and a number of dosimetric endpoints that will enable the users to apply laser-driven ion beams in multidisciplinary fields in accordance with this Contract (hereinafter the "System"). Furthermore, the scope of this Contract mainly encompasses (i) various training services to be provided to the Client's personnel in compliance with Article 13 of this Contract (ii) a royalty free licence, if any according to Article 14, to use the System for the purposes of the use of the ELI-Beamlines Project after completion and (iii) the possible realization of the Additional System, subject to the exercise of the Call Option right by the Client under par. 4.6 (the "Works").



2013



end 2014

- 5 DIC. 2014

Signed in Prague on 8/12/2014

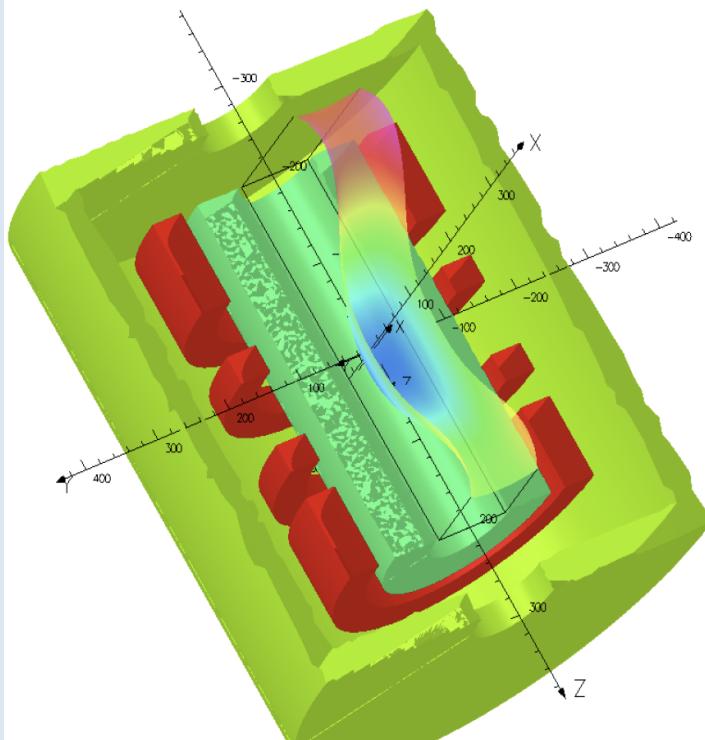
On behalf of: Fyzikální ústav AV ČR, v. v. i.

Signature:   
Name: Prof. Jan Řídký, DrSc.  
Title: the Director

Signed in Rome on \_\_\_\_\_

On behalf of: INFN, Istituto Nazionale di Fisica Nucleare

Signature:   
Name: Prof. Fernando Ferroni  
Title: President  
ISTITUTO NAZIONALE DI FISICA NUCLEARE  
IL PRESIDENTE  
Prof. Fernando Ferroni



# AISHa

## Advanced Ion Source for Hadrontherapy

AISHa is a hybrid ECRIS: the radial confining field is obtained by means of a permanent magnet hexapole, while the axial field is obtained with a **Helium-free superconducting system**.

The **operating frequency of 18 GHz will permit** to maximize the plasma density by employing commercial microwave tubes meeting the **needs of the installation in hospital environments**.

Radial field	1.3 T
Axial field	2.7 T - 0.4 T - 1.6 T
Operating frequencies	18 GHz
Operating power	2 kW
LHe	Free
Iron yoke diameter/length	42 cm / 60 cm
Source weight estimation	480 kg



# AISHa

## Advanced Ion Source for Hadrontherapy

### RELAZIONE SULLO STATO DEL PROGRAMMA DI INVESTIMENTI PO. FESR 2007-2013 - Sicilia - Linea di Intervento 4.1.1.1

Protocollo: 1157

#### DATI PROGETTO

<b>Titolo</b>	AISHa Advanced Ion Source for Hadrontherapy		
<b>Costo del progetto</b>	€ 4.995.000,00	<b>Contributo richiesto</b>	€ 3.400.000,00
<b>Area tematica</b>	Salute e scienze della vita (comprese le biotecnologie d'ambito)		

Soggetto	ISTANZA	AMMESSO	
HITEC2000 srl	752.400,00	22,0%	719.377,95
UNICO srl	745.800,00	21,8%	694.235,87
C3SL srl	435.600,00	12,7%	395.703,35
INFN/LNS	1.484.240,00	43,4%	1.279.611,39
<b>TOTALE</b>	<b>3.418.040,00</b>	<b>100%</b>	<b>3.088.928,56</b>



# *Status AISHA*

## *Advanced Ion Source for Hadrontherapy*

- Capitolato sistema magnetico: inviato a 7 ditte, con possibile opzione di fornitura per SC, per PM o entrambi. Ordine/i atteso/i entro Febbraio.
- RF system: ricevute le offerte informali, in fase di definizione. Ordini attesi entro Febbraio
- Meccanica: Avvio Progettazione Body Source (Divisione Tecnica) e LEBT (PMI). Inizio ordini Body Source entro Marzo.
- Preparazione area: Divisione Tecnica, Servizio Radioprotezione, Servizio Sorgenti.

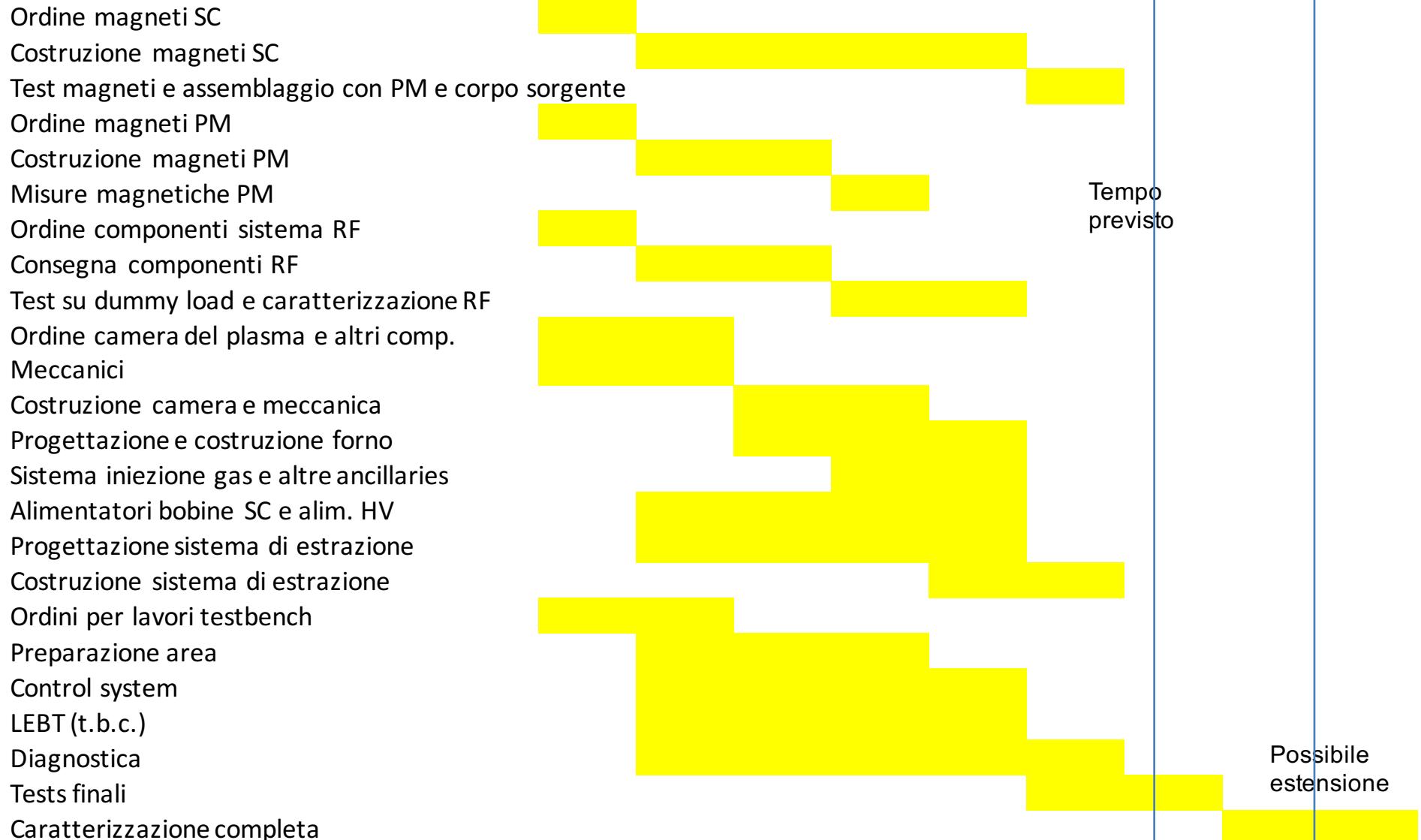
### **Personale**

- **Personale tecnico dei LNS: contributo essenziale di diversi servizi per il raggiungimento degli obiettivi nel tempo prefissato.**
- Un assegnista e un borsista momentaneamente “dirottati” su AISHA.
- Due nuovi assegni di ricerca: procedure in corso.
- Personale ART.23 per un anno: procedure in corso



I Q 2014	II Q 2014	III Q 2014	IV Q 2014	I Q 2015	II Q 2015	II Q 2015	IV Q 2015	I Q 2016
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## AISHA POR



# **AISHa 2 prospettive**

## **Sarà una copia di AISHa 1**

- **Modalità e tempi di realizzazione** *In parte dal premiale in fase di assegnazione (750k€ + personale), il resto del finanziamento dipenderà dagli accordi tra il CNAO e l'INFN, con fondi propri del CNAO e non prima del 2016-17.*
- **Installazione e test preliminari** a Catania o direttamente a Pavia.
- **Installazione e commissioning** in sala Sincrotrone in più fasi successive, minimizzando, ma, ovviamente non annullando, l'impatto con le normali operazioni di trattamento dei pazienti.
- **Opportunità per i LNS** : economie di scala, utilizzo di parte di LEBT e diagnostica di CNAO per AISHA-1, conferma del ruolo rilevante in questo tipo di partenariati (centri di adroterapia stanno per essere avviati in vari paesi).

# Conclusions

- LNS has a scientific program well defined based on 3 pillars: Nuclear Physics and Accelerators, Km3NeT and Applied Physics.
- LNS has a governing system growing up in a well structured context applying modern concepts of scientific management.
- LNS has not a quality control system. We are starting for doing that!
- LNS requires an increment of personnel for the CS upgrading.

*Thank you*

