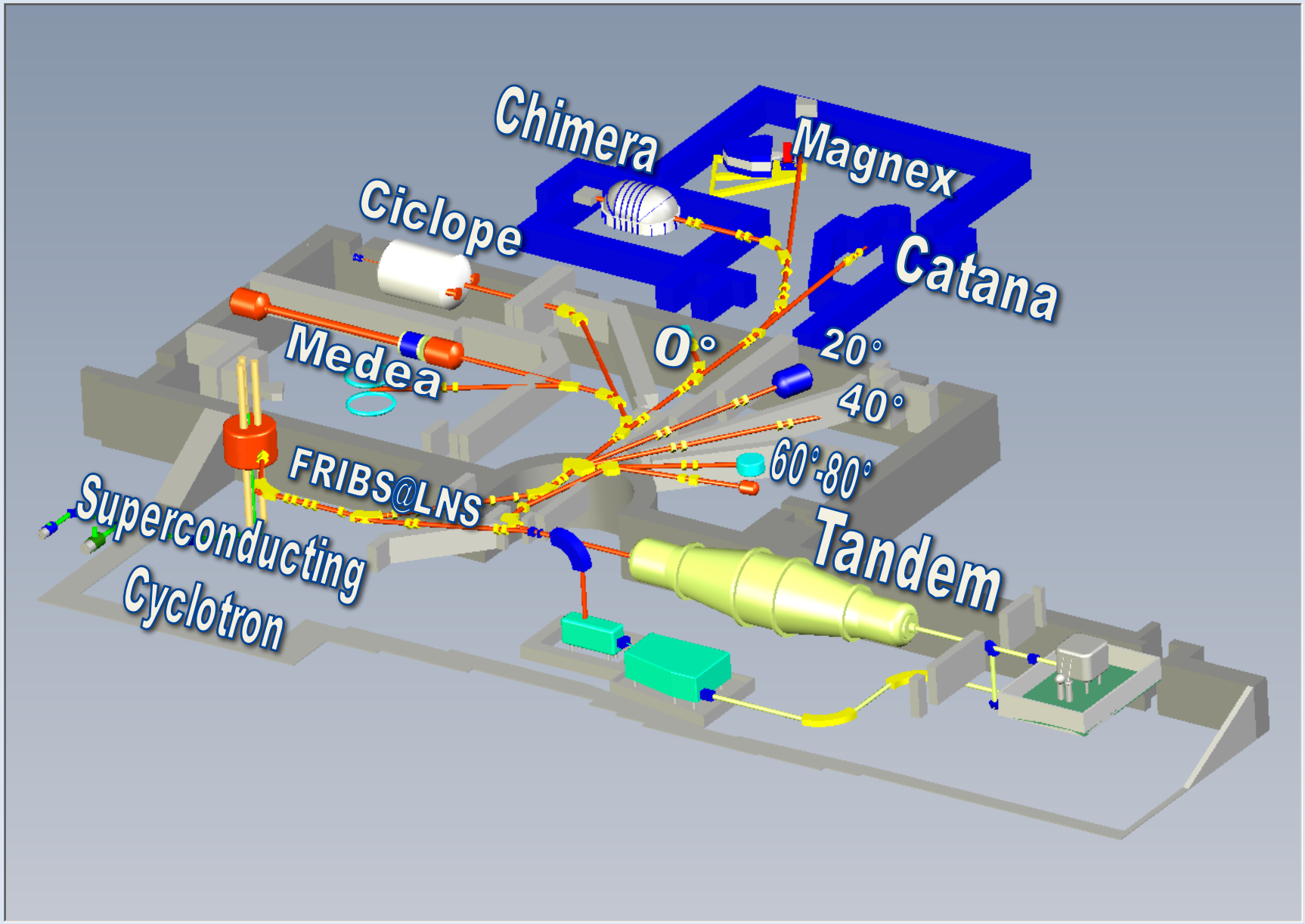
Status of the accelerators and news for the users

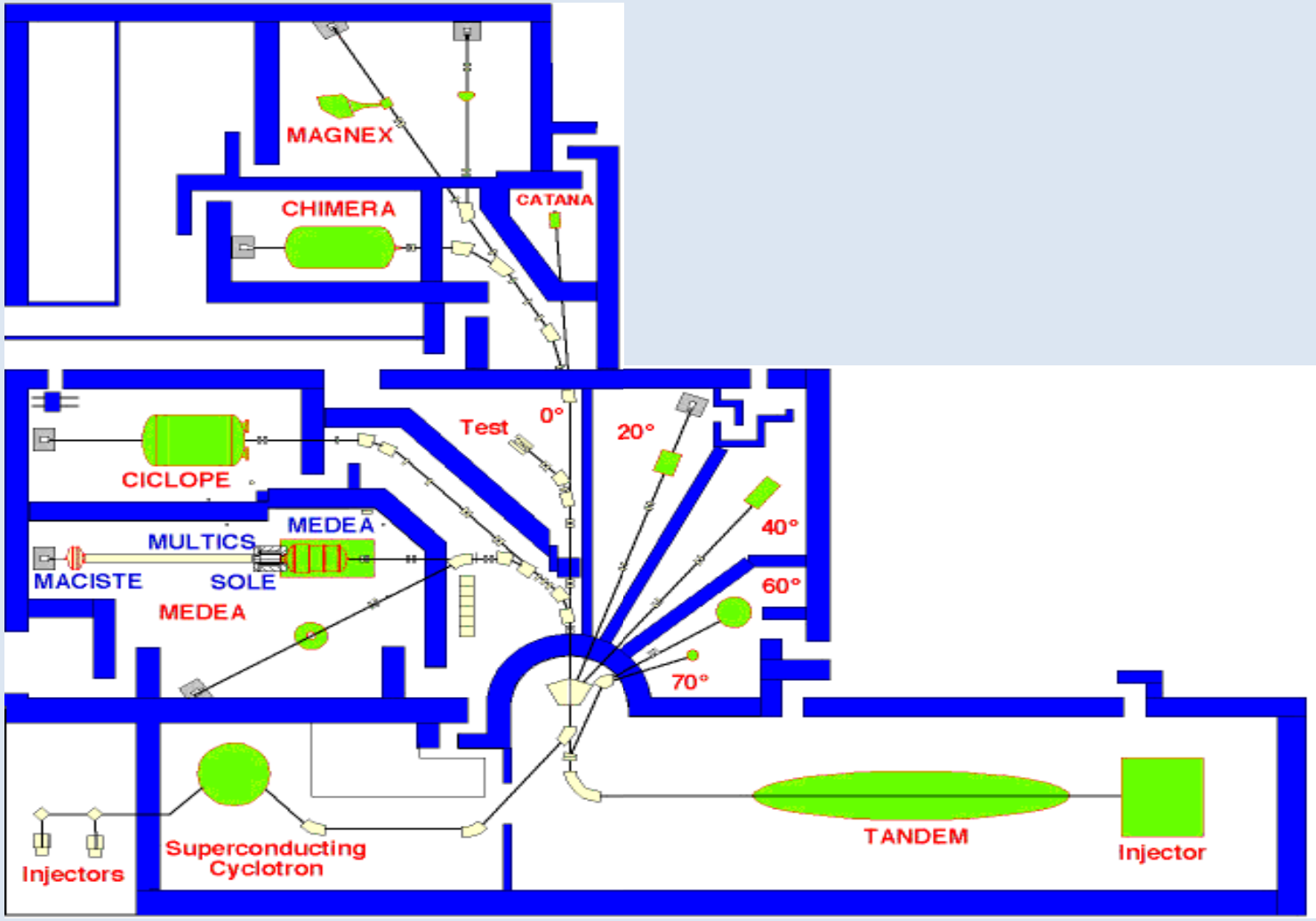
Danilo Rifuggiato

LNS User meeting
December 15, 2015

LNS lay-out: accelerators and experimental halls

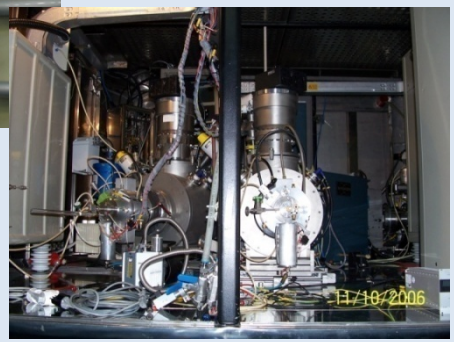


LNS lay-out: accelerators and experimental halls



The LNS accelerators

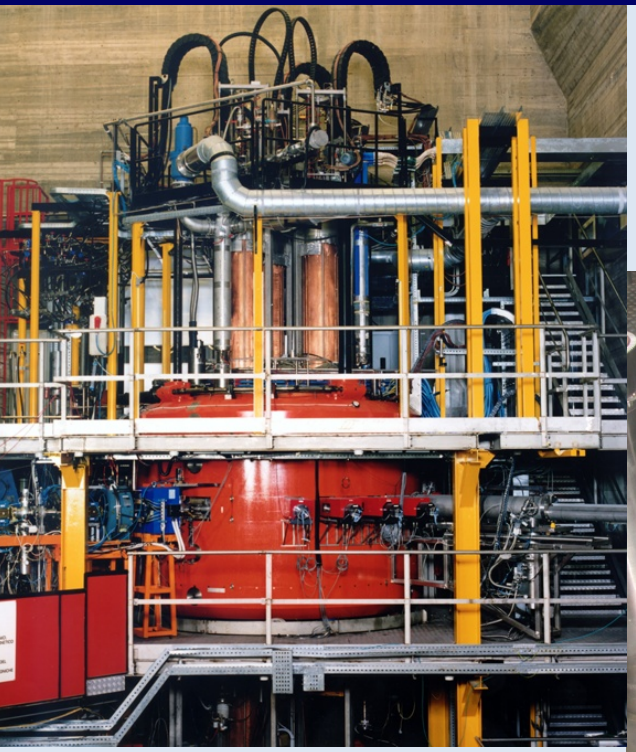
450 KV injector
2 sputtering sources



Normal conducting ECR source CAESAR

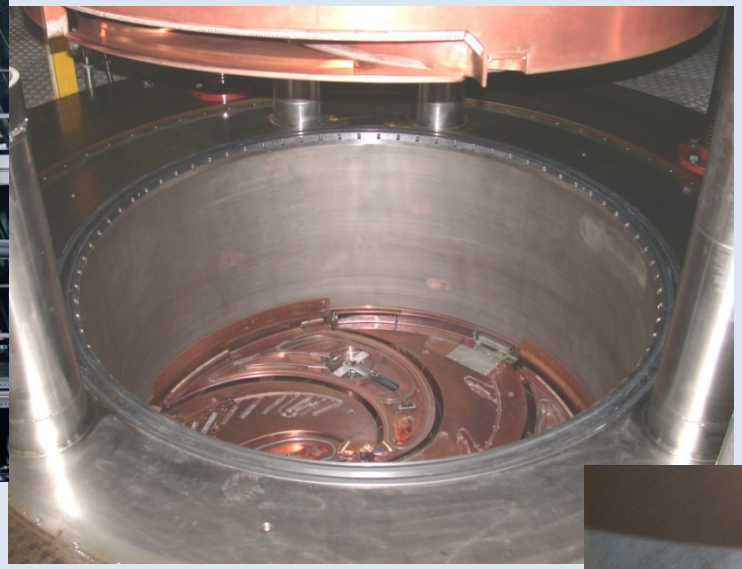
Superconducting ECR source SERSE

The LNS Superconducting Cyclotron



$(T/A)_{max} = K_{bending}\ (Q/A)^2$ ~ 25 AMeV Au36+

$(T/A)_{max} = K_{focusing}\ (Q/A)$ 100 AMeV fully stripped



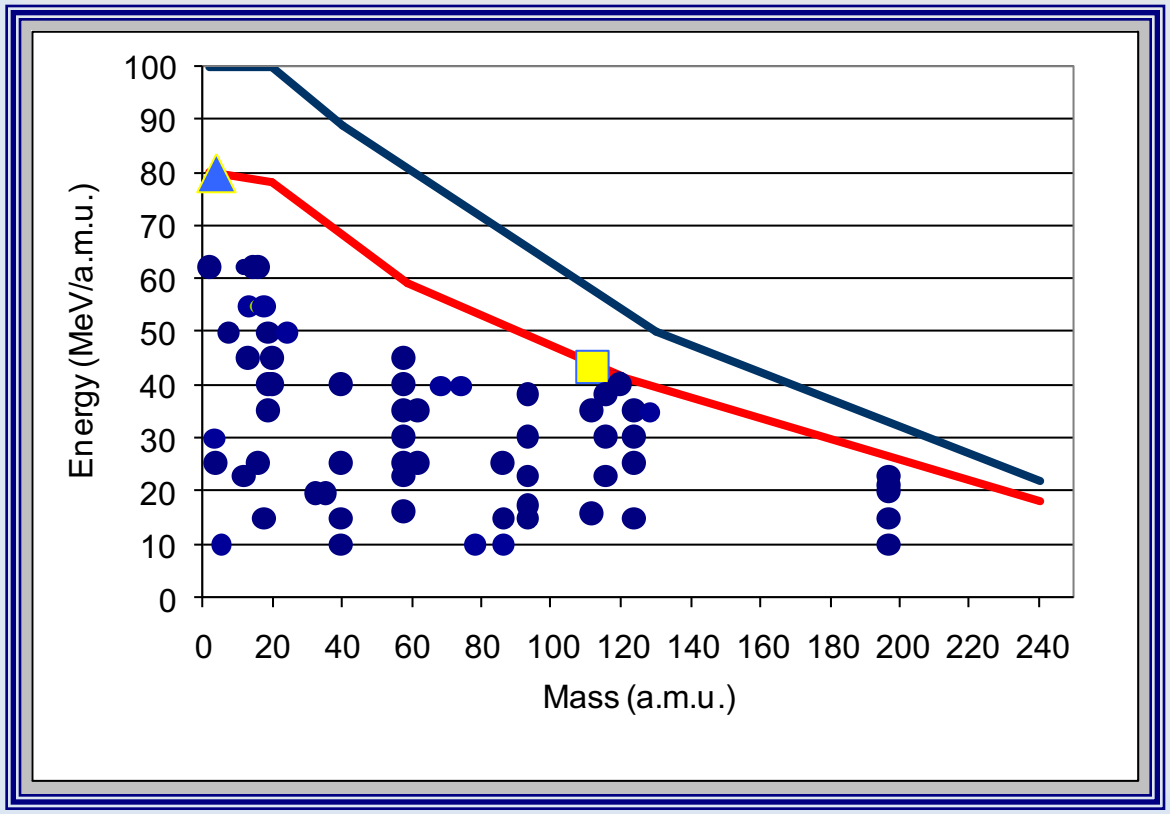
Bending limit	**K=800**
Focusing limit	**Kfoc=200**
Pole radius	**90 cm**
Yoke outer radius	**190.3 cm**
Yoke full height	**286 cm**
Min-Max field	**2.2-4.8 T**
Sectors	**3**
RF range	**15-48 MHz**

Versatility (performance)

Reliability (protontherapy)

High intensity (radioactive beams)

Beams developed at the Superconducting Cyclotron



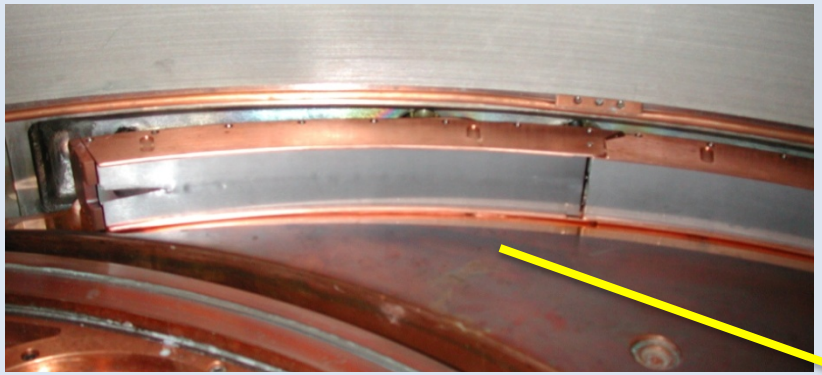
^{4}He 80 AMeV

^{112}Sn 43.5 AMeV

In red beams with intensity 10^{12} pps

^{A}X	E (AMeV)
H_2^+	62,80
H_3^+	30,35,45
$^{2}D^{+}$	35,62,80
^{4}He	25,62,80
He-H	10, 21
^{9}Be	45
^{11}B	55
^{12}C	23,62,80
^{13}C	45,55
^{14}N	62,80
^{16}O	21,25,55,62,80
^{18}O	15,55
^{19}F	35,40,50
^{20}Ne	20,40,45,62
^{24}Mg	50
^{27}Al	40
^{36}Ar	16,38
^{40}Ar	15,20,40
^{40}Ca	10,25,40,45
^{42,48}Ca	10,45
^{58}Ni	16,23,25,30,35,40,45
^{62,64}Ni	25,35
^{68,70}Zn	40
^{74}Ge	40
^{78,86}Kr	10
^{84}Kr	10,15,20,25
^{93}Nb	15,17,23,30,38
^{107}Ag	40
^{112}Sn	15.5,35,43.5
^{116}Sn	23,30,38
^{124}Sn	15,25,30,35
^{129}Xe	20,21,23,35
^{197}Au	10,15,20,21,23
^{208}Pb	10

Increasing the Cyclotron beam intensity



Septum: directly cooled

New septum material: W vs. Ta

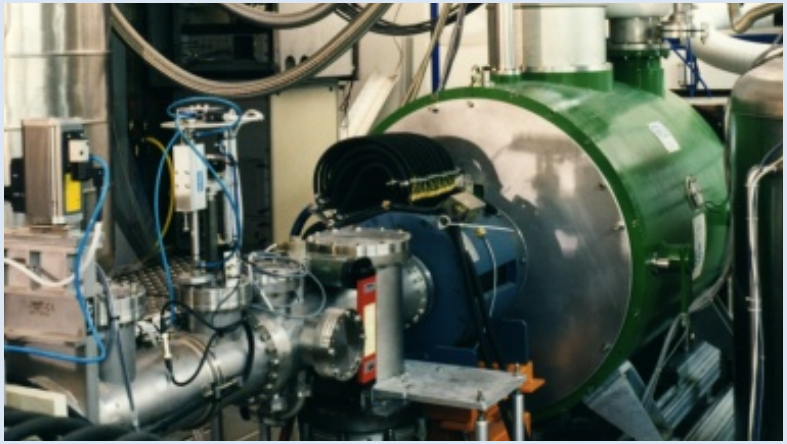
Bigger thickness: 0.3 vs. 0.15 mm

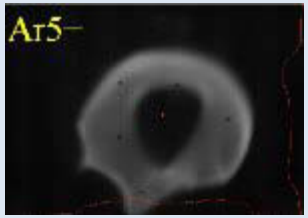
⇨extraction efficiency 63% vs. 50%

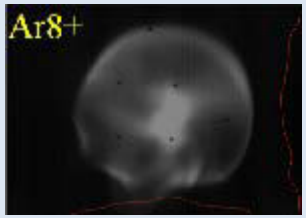
$^{13}C^{4+}$ @ 45 AMeV

Pextr = 150 watt I=1020 enA=

$1.5x10^{12}$ pps







The source-cyclotron matching needs to be improved

Beam transport along the injection line is now being considered, following the MSU, JYFL, KVI methods

Superconducting Cyclotron: highlights

RF

Upgrade of the 100 kW amplifiers: replacement of an obsolete tetrode with a solid state system

ECR sources

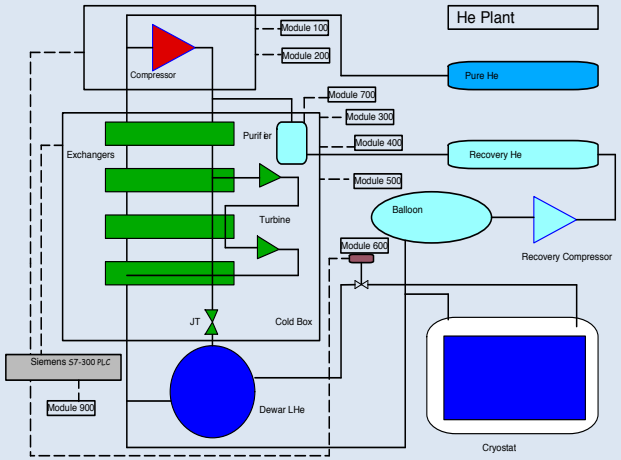
SERSE : Autonomous cryogenic system based on 2 cryocoolers – installation complete – under test

CAESAR: new controls system and new oven for metallic low energy beams

Helium liquefier

September 2013 – September 2014 Revamping of the helium liquefier to recover the high reliability level of the past 20 years. Cyclotron not operating 1.5 y. Restart: October 2014

Turbine fixed, PLC replaced, software updated,
New valves, pressure devices, filters, gaskets, actuators installed

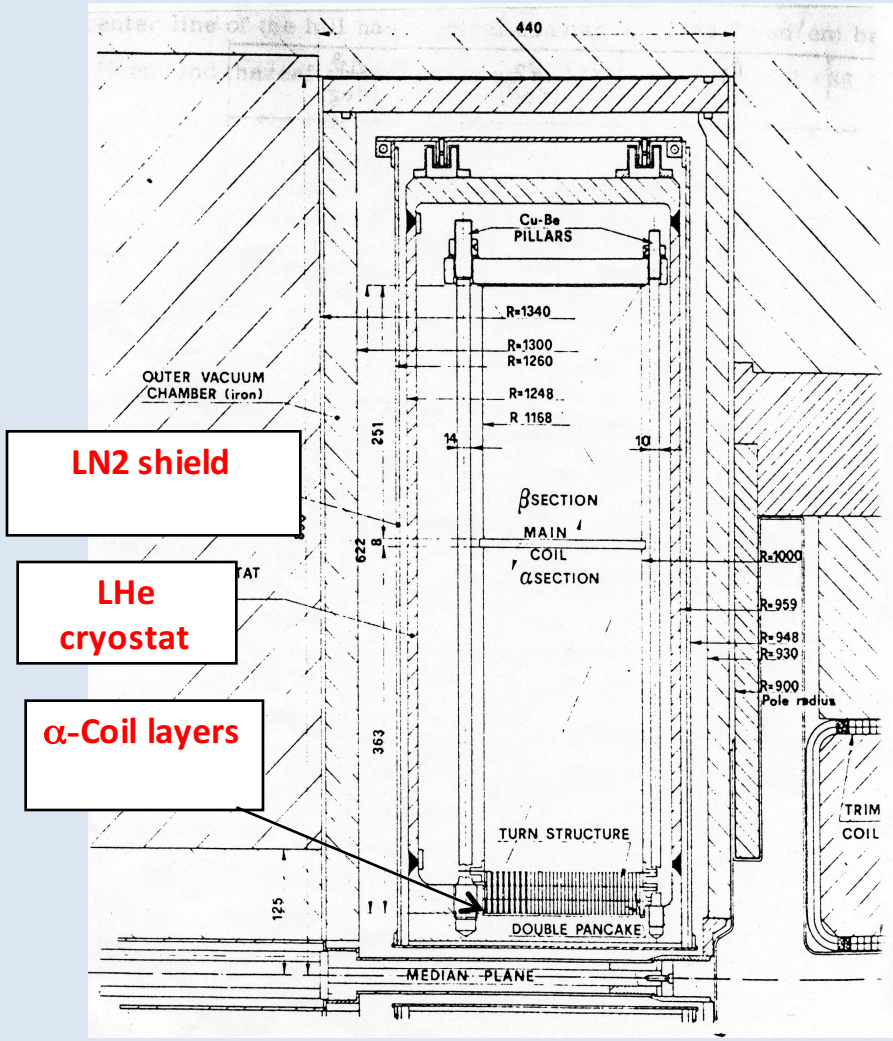


On June 27 another stop occurred due to a failure in the helium compressor, where a heat exchanger was corroded by water. The new exchanger was installed in September, but only 1 month of beam time was lost

Superconducting Cyclotron reliability

A weak point: the Liquid Nitrogen shields

After the warm-up operations (2 since the first cooldown in 1992) LN2 losses have been detected in the LN2 shields of the cryostat.
One of the three shields – named virola interna – has already been closed, but some smaller losses have already been detected in the other big shield – named virola esterna – which cause some problems to the cryostat vacuum.
LN2 shields cannot be fixed nor replaced.



Activity at the Cyclotron October 2014 – December 2015

Just after the mentioned failure in May 2013, the Scientific Committee assigned beam time for 1 year. Therefore after the revamping of the Helium liquefier (1.5 year later), around 15 months had to be recovered.

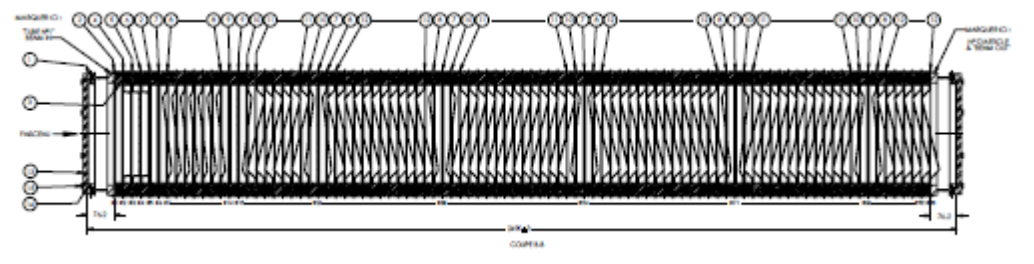
CATANA 4 sessions (Nov. 2014, Feb. 2015, May 2015, Nov. 2015)

INTERDISCIPLINARY PHYSICS	
MAPRAD	0°
RADIOSTEM	0°
HADMAC	0°
MIMOBRAGG	0°
IONMAPS	0°
REDOLIB	0°
PIRAMIDE	0°
WP1-BIOQUART	0°
IRSIDIA	0°
DIAPIX	0°
MITRA	0°
ELIMED	40°
PRIMA	Catana
DNA-Bragg	Catana
DOPET	Catana
ARDENT	Catana
PREDATE	Catana
TERASPARC	Ciclope

NUCLEAR PHYSICS	
CLIR	Chimera
SIKO	Chimera
PIGMY	Chimera
RAINBOW NI	Magnex
Test NUMEN	Magnex
O16-MAGNEX	Magnex
DRIP-LINES	Magnex
AB-INITIO	Magnex
ISOFAZIA	Ciclope
FAZIASYM	Ciclope
FAZIA test	Ciclope

Upgrade of the Tandem – project LNS Nuclear Astrophysics

Tube n. 1 damaged : high residual pressure in the Low Energy section due to the vacuum losses (SF6 inside)
Ordered to VIVIRAD, France, delivered to LNS in May 2014, assembled in the Tandem in July 2014



Replacement from the Low Energy side by means of a dedicated system to minimize stresses

Alternative to the belt: Pelletron by NEC, USA
Ordered in July 2013
Delivered on January 6 2015
Installed on January 19 2015 in 3 weeks

12.3 MV reached at the H.V. Terminal

Activity at the Tandem 2014 – 2015

After the completion of the Tandem upgrade – Tube n. 1 and Pelletron - the following experiments have been performed

INTERDISCIPLINARY

ELIMED	40°-60°
FF-PIXE	60°
LASERDRIVEN	60°
PIRAMIDE	60°

NUCLEAR PHYSICS

LIPMAGNEX	Magnex
COINFUS	40°
ASFIN	60°
E0	60°
NIA	60°
LIFUS	60°
TEST CHIMERA	Chimera
TEST FAZIA	Ciclope

A test for production and acceleration of Mg has been made: 500 enA produced in the source (MgH) and 50 enA q=8, E=80 MeV accelerated and analysed

Beam availability in 2016

Superconducting Cyclotron (including FRIBS@LNS)

Beam Time Units (1 BTU = 8 h) on target per year (9 months):
400 BTU (=3200 h)

Meeting of the PAC on November 16,17

• Protontherapy 5 sessions	-85 BTU
• ELIMED	-45 BTU
• Experiments	270 BTU + 15*
• Backlog	-42 BTU
Total assigned	**228 +15***

* overnight during Catana if p 62 MeV in the Catana hall

Total requested	**390**

Beam availability in 2016

Tandem

Beam Time Units (1 BTU = 8 h) on target per year (9 months): **360 BTU (=2880 h)**

Beam time distribution:

- **ELIMED** **-21 BTU**
- **Backlog** **-12 BTU**

Total available **327**

Total requested and assigned **128**