STATUS AND PERSPECTIVE OF AVAILABLE BEAMS AT LABORATORI NAZIONALI DEL SUD

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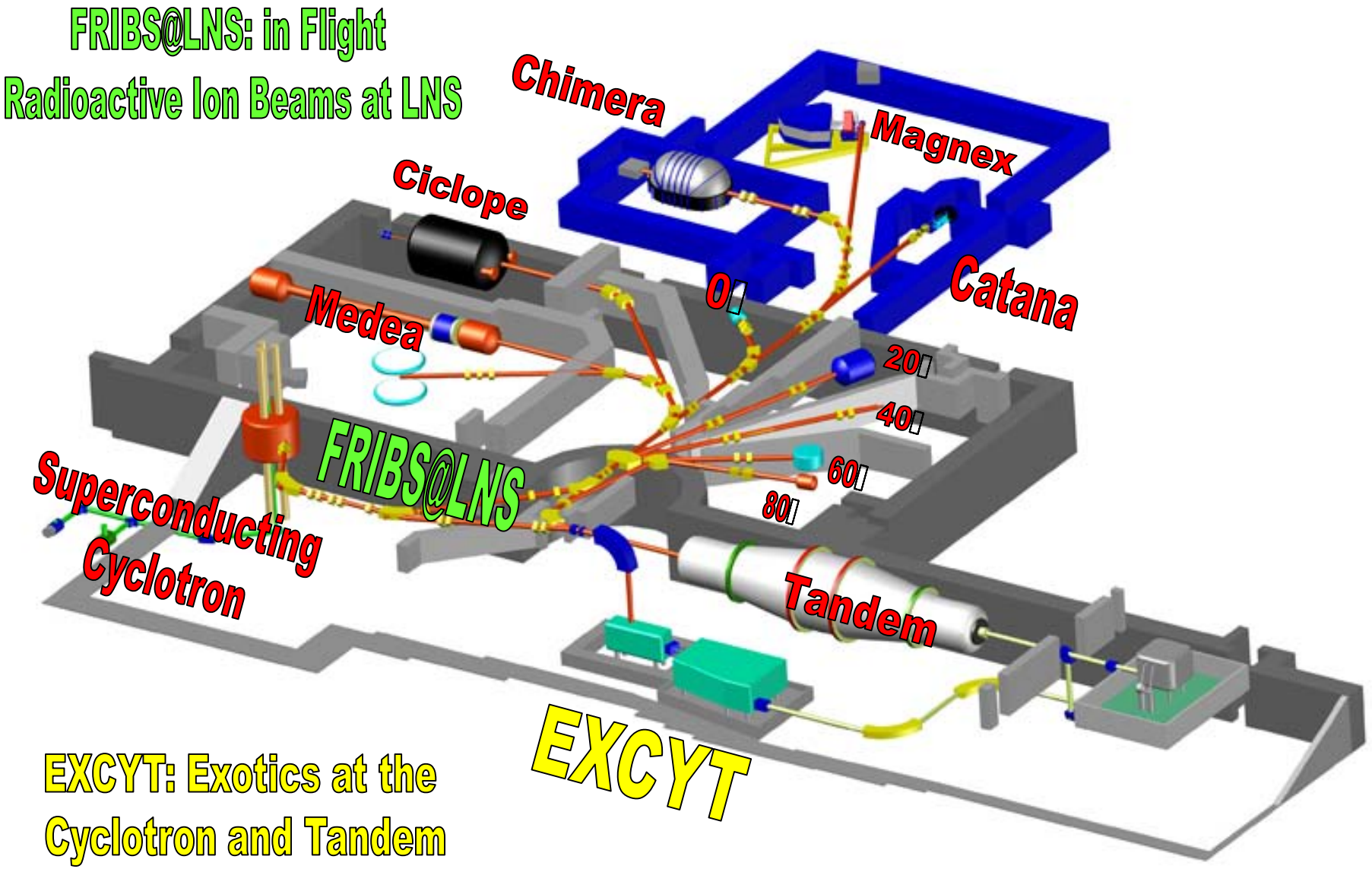
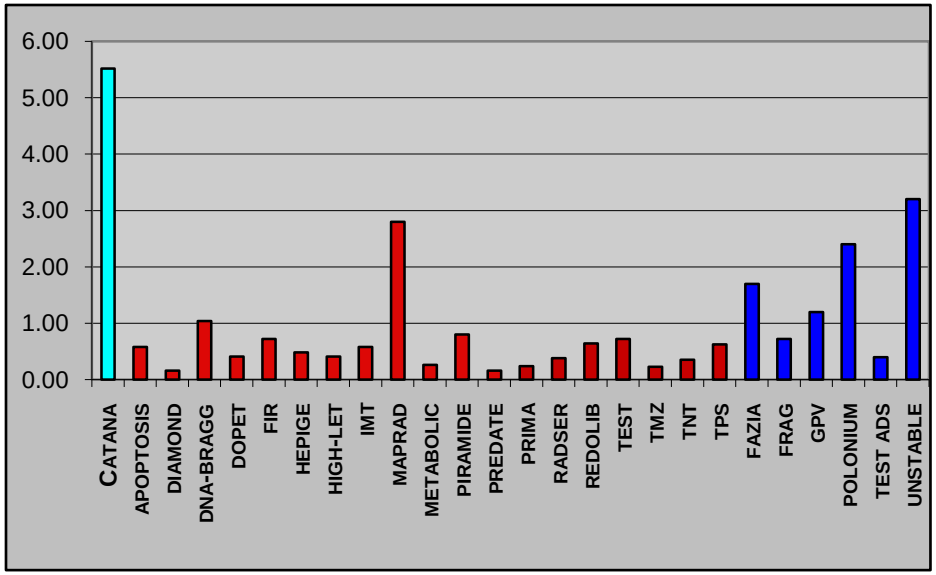
ECOS-ENSAR Workshop, Menaggio, 18-21 Juin 2012

LNS lay-out: accelerators and experimental halls



Use of the Cyclotron and Tandem beams in 2011

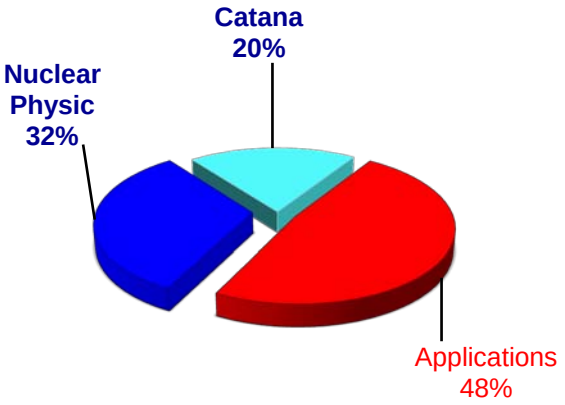


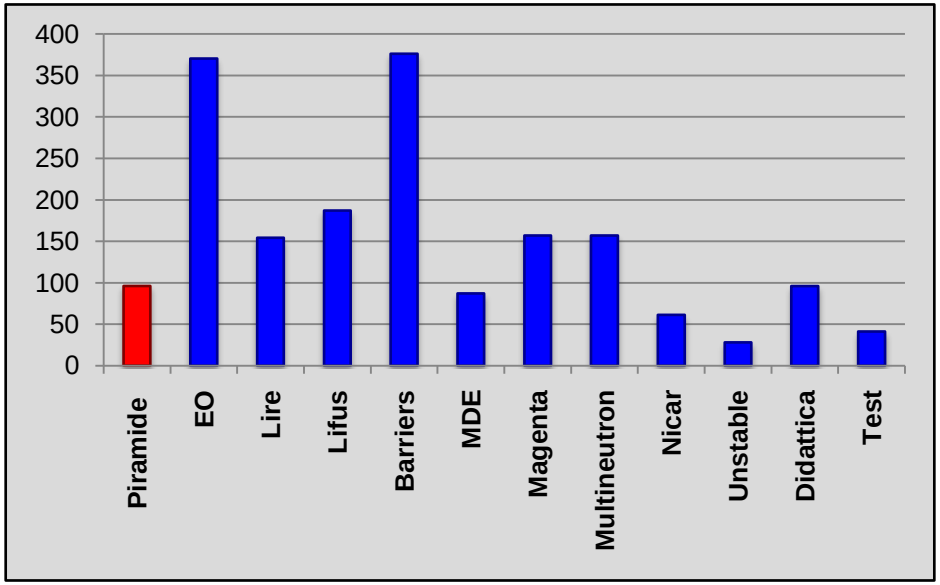
Cyclotron 2665 h

32% Nuclear Physics

20% Catana

48% Applications

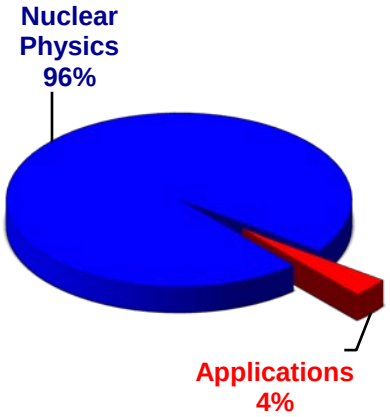




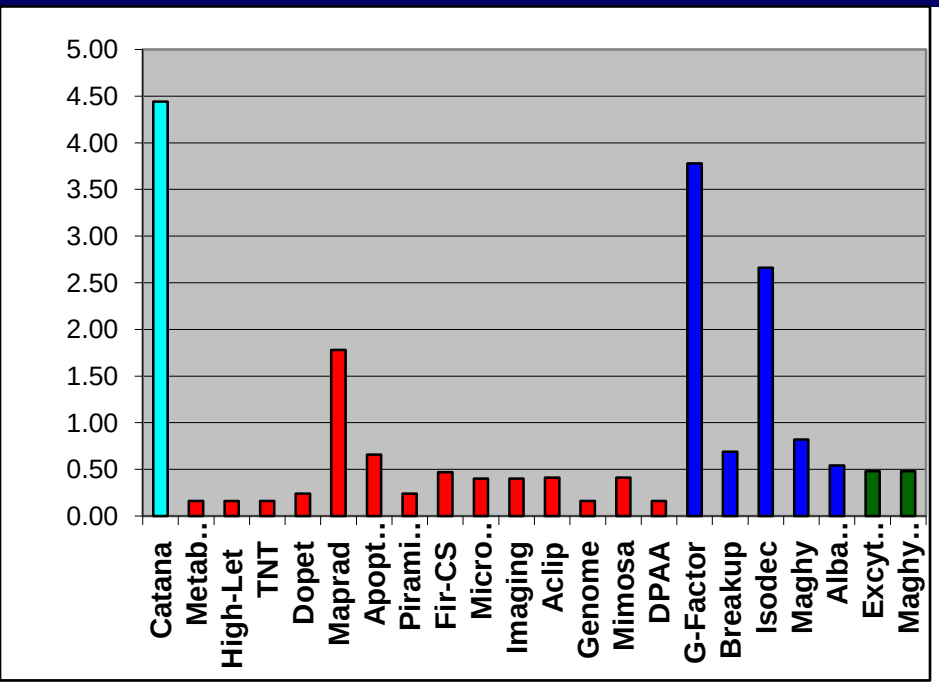
Tandem 1810 h

96% Nuclear Physics

4% Applications

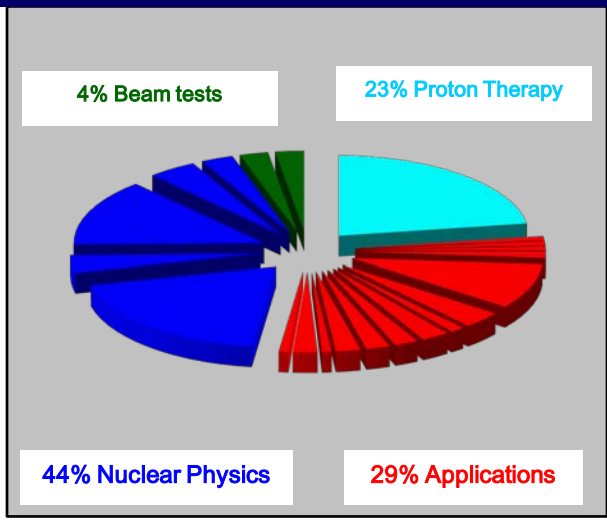


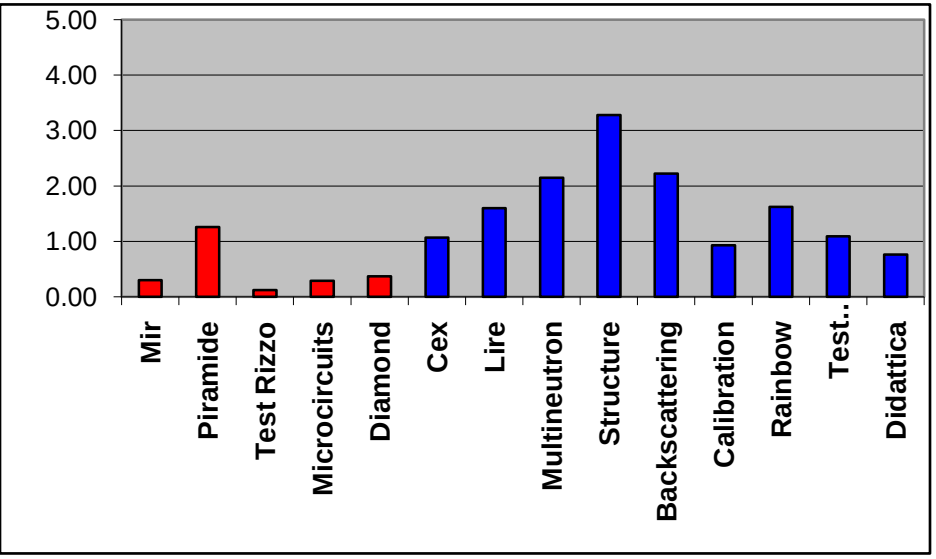
Use of the Cyclotron and Tandem beams in 2010



Cyclotron
1970 h

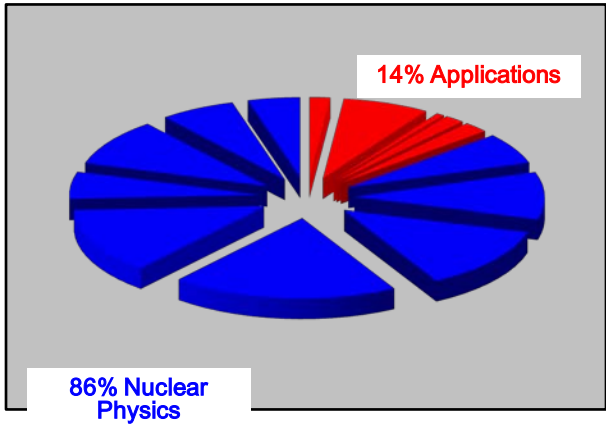
- 44% Nuclear Physics
- 23% Proton-Therapy
- 29% Applications
- 4% Beam tests



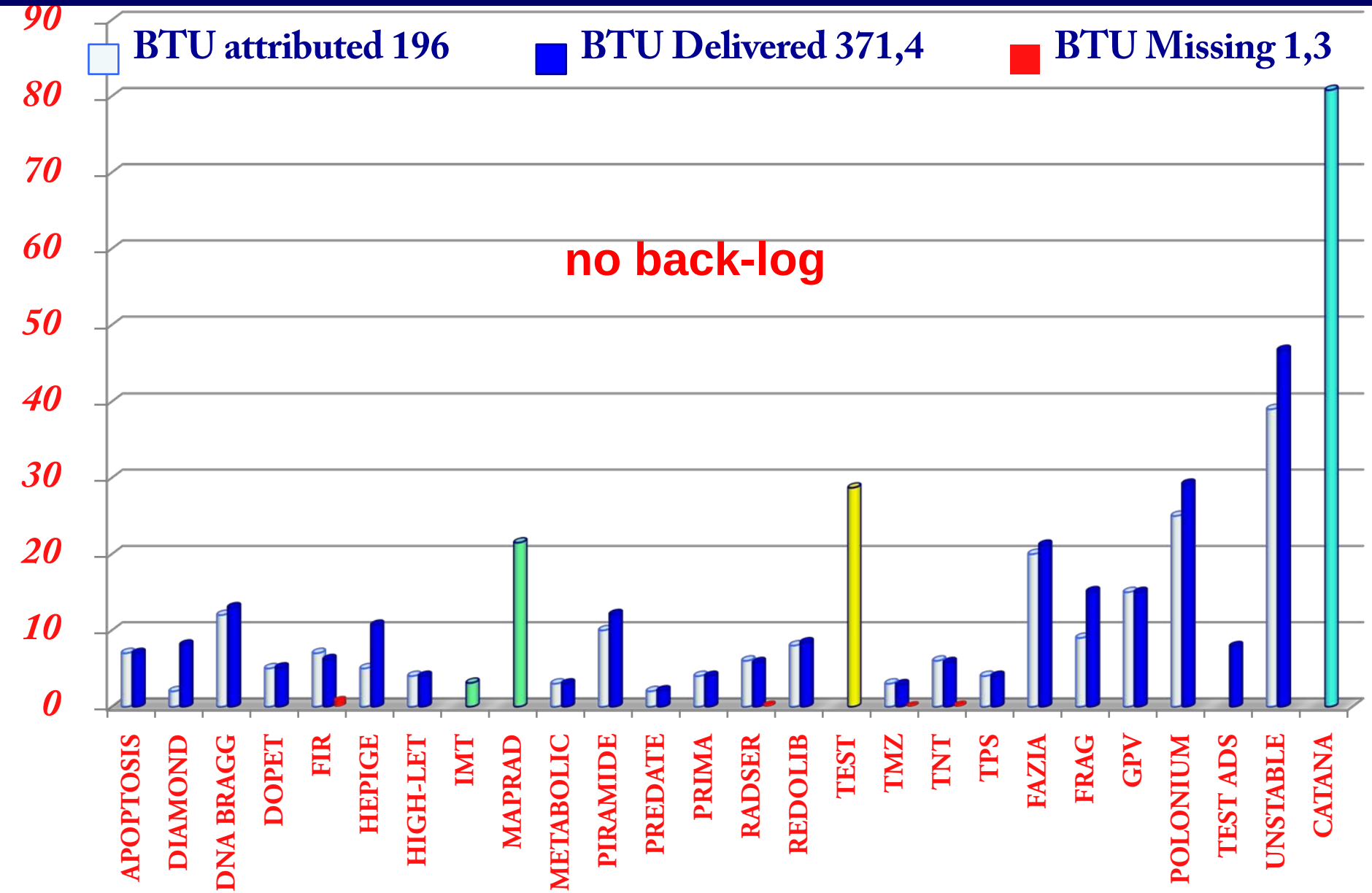


Tandem
1706 h

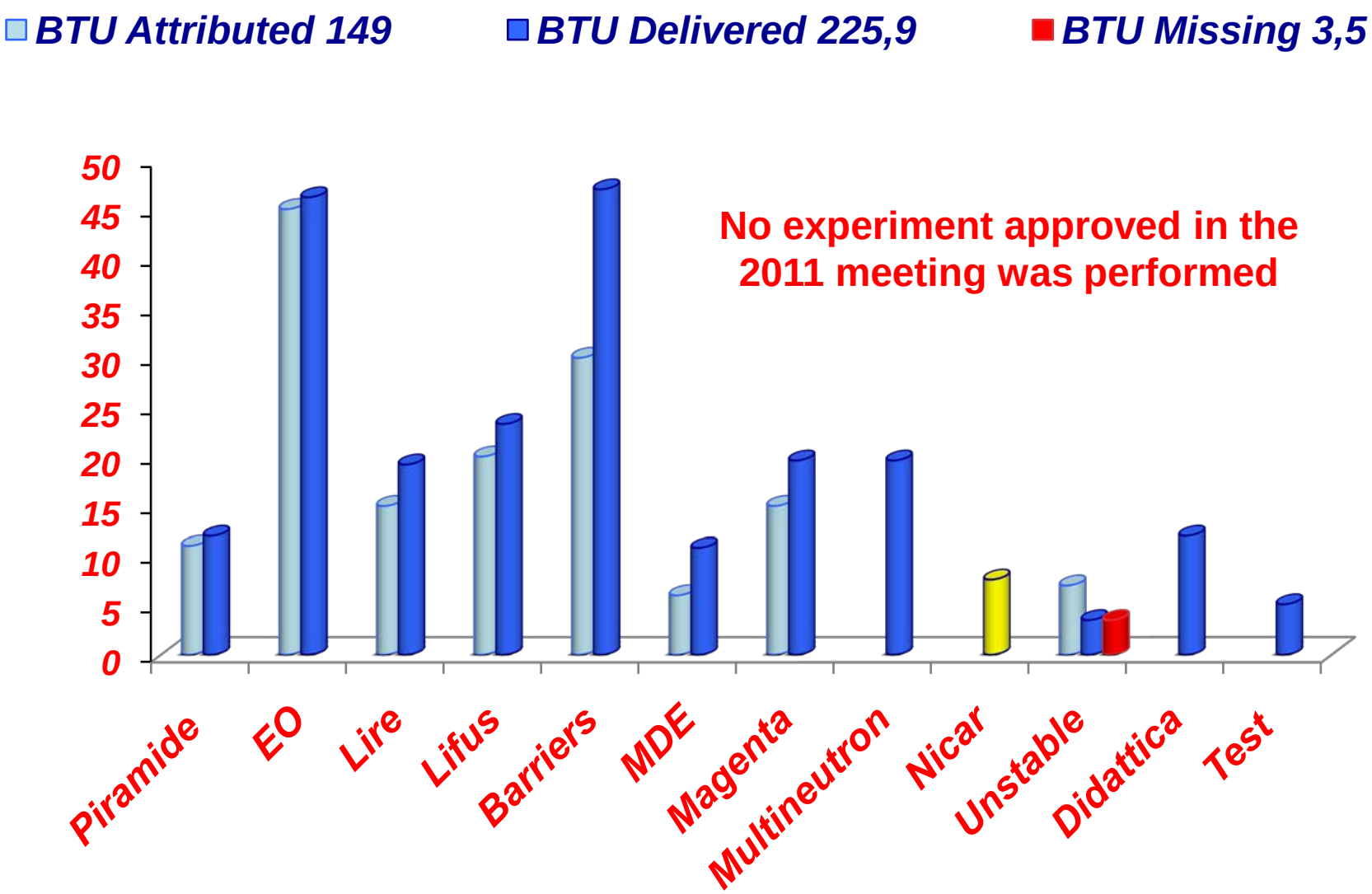
- 86% Nuclear Physics
- 14% Applications



2011 Cyclotron beam delivery



2011 Tandem beam delivery



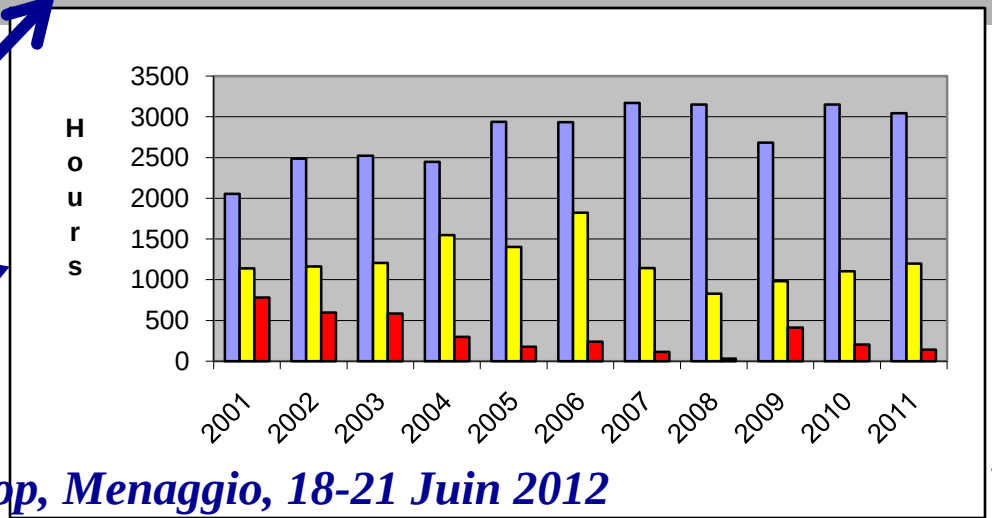
Superconducting Cyclotron status: beam statistics 2001-2011

		Delivered	Setting	Failures
2001	9.5 months	2569	1424	975
2002	8 months	2485	1161	597
2003	8.5 months	2679	1204	587
2004	5 months	1529	944	187
2005	5.5 months	2020	964	122
2006	5.5 months	2017	1252	166
2007	4.5 months	1783	643	65
2008	7 months	2757	740	28
2009	8 months	2683	983	411
2010	5 months	1970	690	128
2011	7 months	2665	1269	125

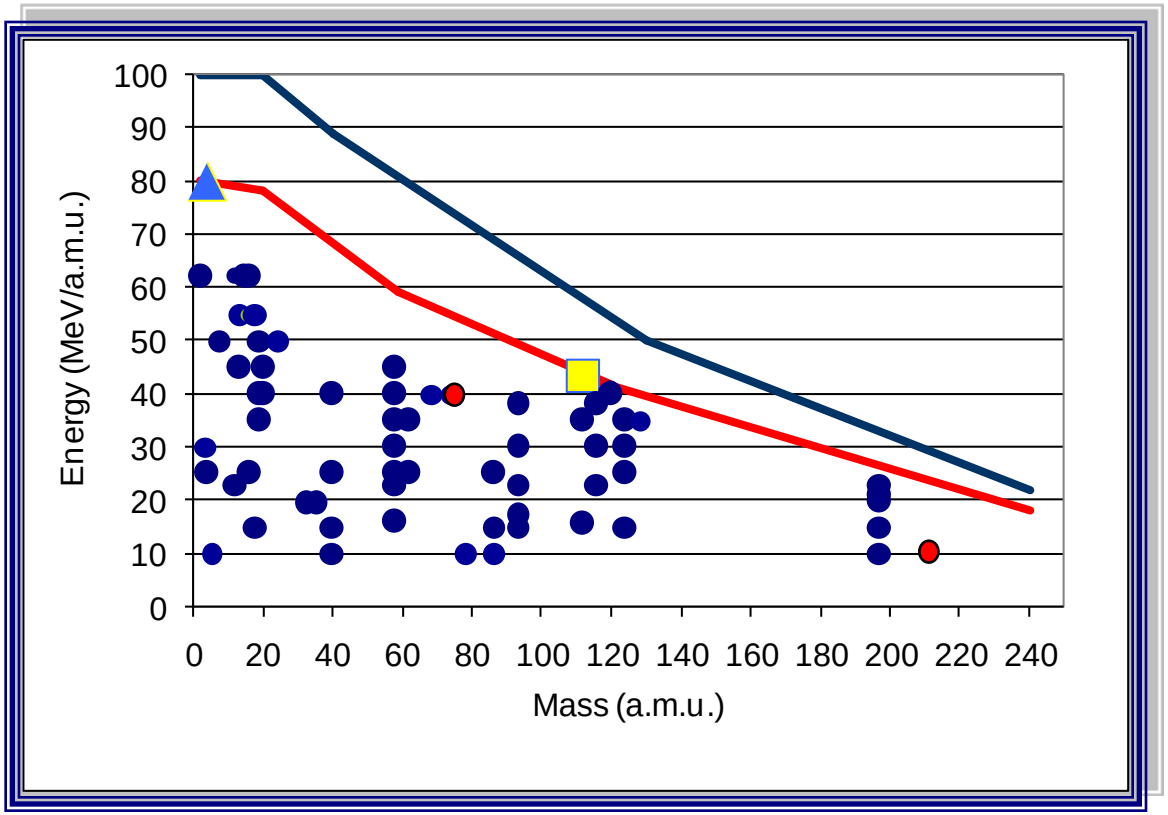
Extraction beam line upgrading

CAESAR ions source upgrading
80 BTU Tandem beam at MAGNEX

Data normalized for 8 months



Superconducting Cyclotron status: beams developed



^{4}He 80 MeV/a.m.u.

^{112}Sn 43.5 MeV/a.m.u.

^{A}X	E (MeV/a.m.u.)
H_2^+	62,80
H_3^+	30,35,45
$^{2}D^+$	35,62,80
^{4}He	25,80
He-H	10, 21
^{9}Be	45
^{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
^{36}Ar	16,38
^{40}Ar	15,20,40
^{40}Ca	10,25,40,45
^{48}Ca	10,45
^{58}Ni	16,23,25,30,35,40,45
^{64}Ni	25,35
^{68,70}Zn	40
^{74}Ge	40
^{78}Kr	10
^{84}Kr	10,15,20,25
^{93}Nb	15,17,23,30,38
^{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

Improvements on ECR sources: cryogenics of Serse and new injection system of Caesar

Serse cryogenics critical from the operating point of view:

1. **the system is quite complex and the path of LHe is long from the liquefier to the cryostat (many dewars): a lot of losses**
2. **priority is given to the Cyclotron in case of failure**

Autonomous system based on Helium recondensation and replacement of current leads with superconducting high Tc ones

a) Design : the new system has been dimensioned and designed by a French company close to CEA Grenoble, who made the source - done

b) Realization : Cost defined to be around 300 k€ : a call for tender will be launched based upon the executive drawings of a) - waiting for funding

CAESAR new injection system has been assembled at the beginning of 2012

New beams will be available:

1)metallic species through the implementation of an oven in 2013

2)The MIVOC method is exploiting for production of "difficult beams", i.e. ^{11}B

for production of ^{8}He with FRIBS@LNS tests are in progress

Tandem status

January – May 2012 stop

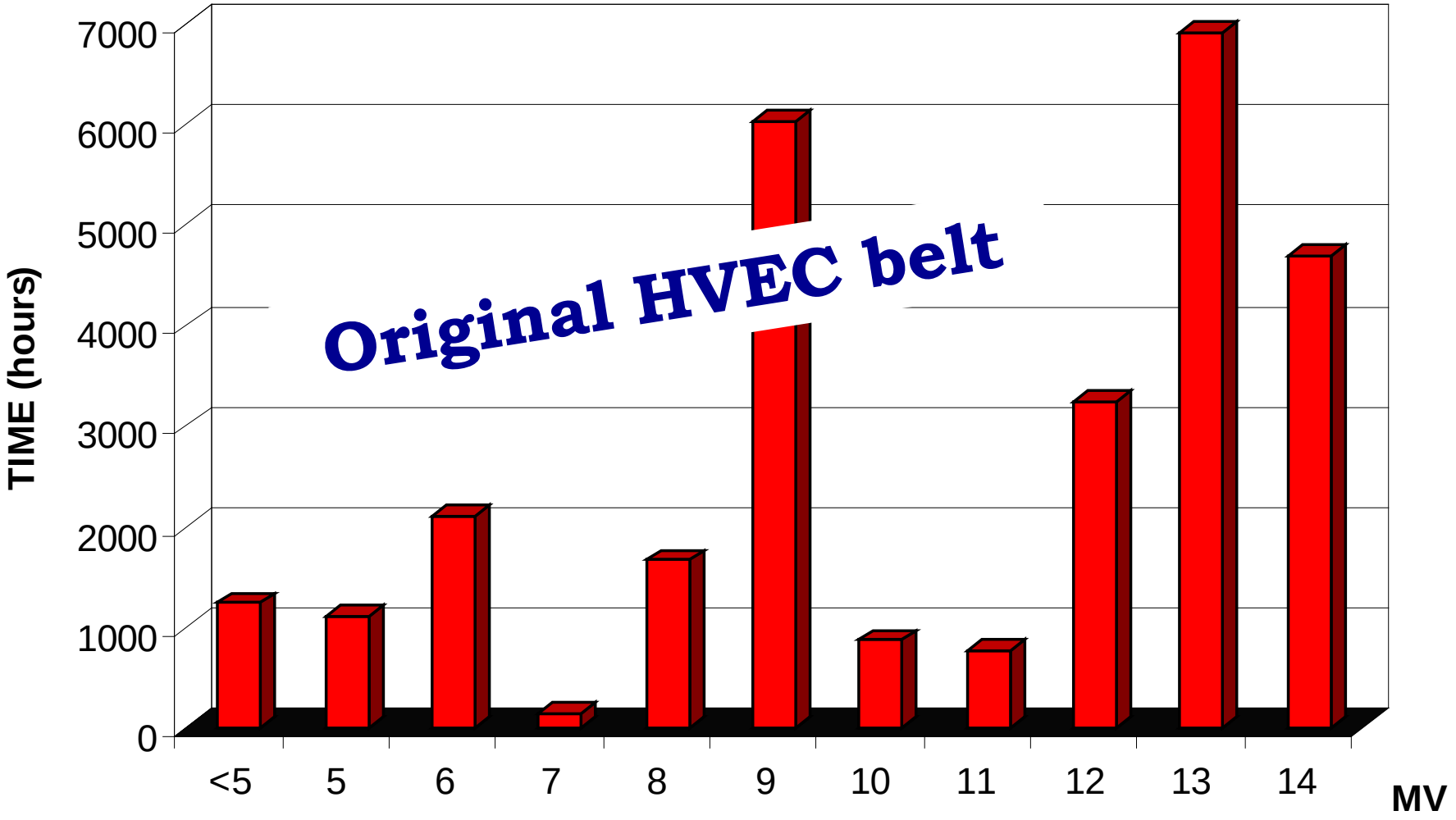
a) maintenance operation on the SF6 plant
b) repairing of the first accelerating tube by means of a special vacuum leak sealant
the residual pressure is now around the operating value

c) assembling of a new belt type and first tests of its mechanical and electrical properties
our conclusion is that the new belt needs to be improved: the tested prototype was not enough stiff and, more important, the insulating material does not resist to temperature and discharges

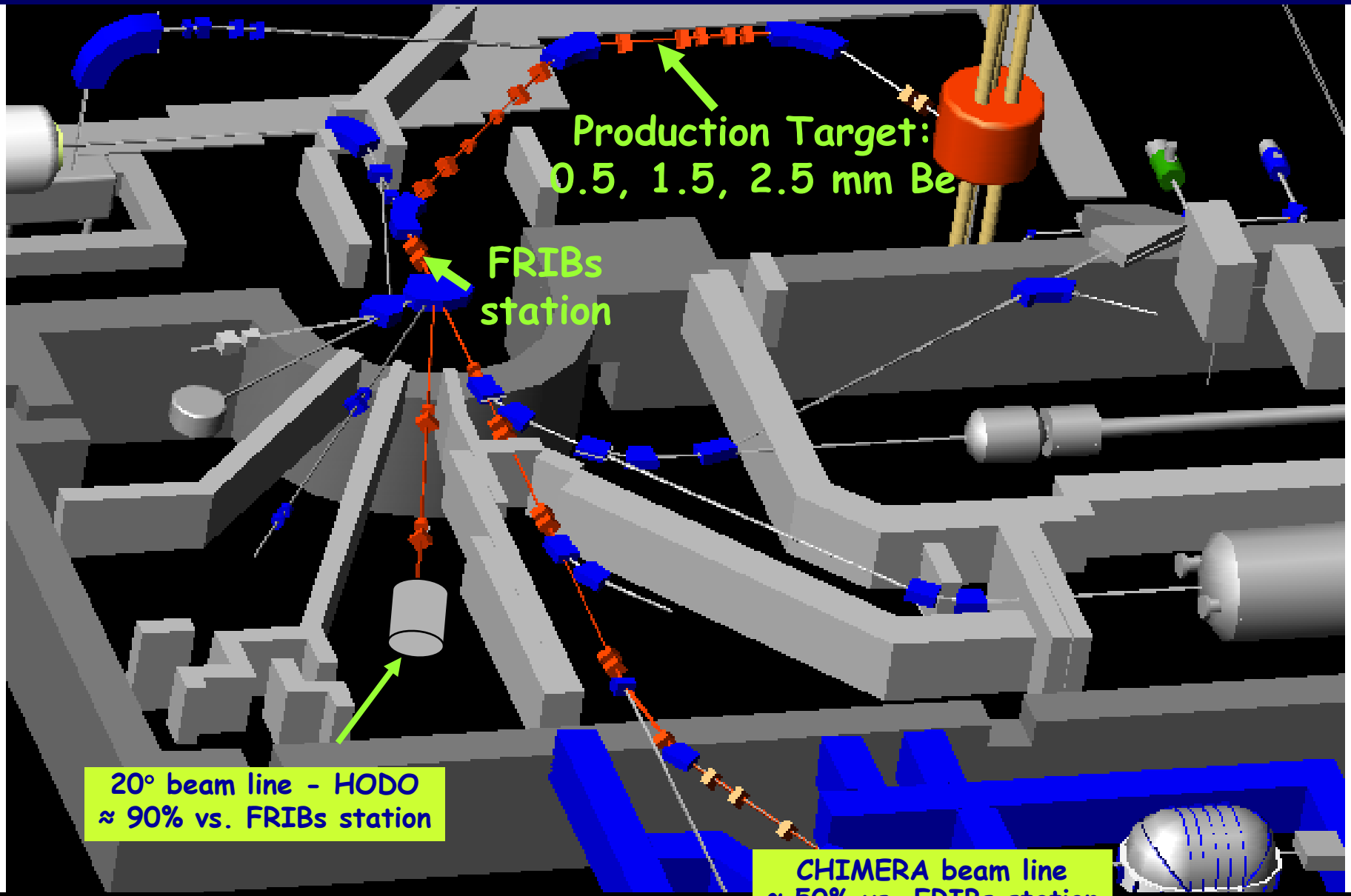
1) Alternative to the belt : Pelletron (NEC) cost 725.000 US$ excl. installation - Time: 2 months, but not before 2014 – funding

2) New first (and eighth) tube – 300 k€ - not a trivial task

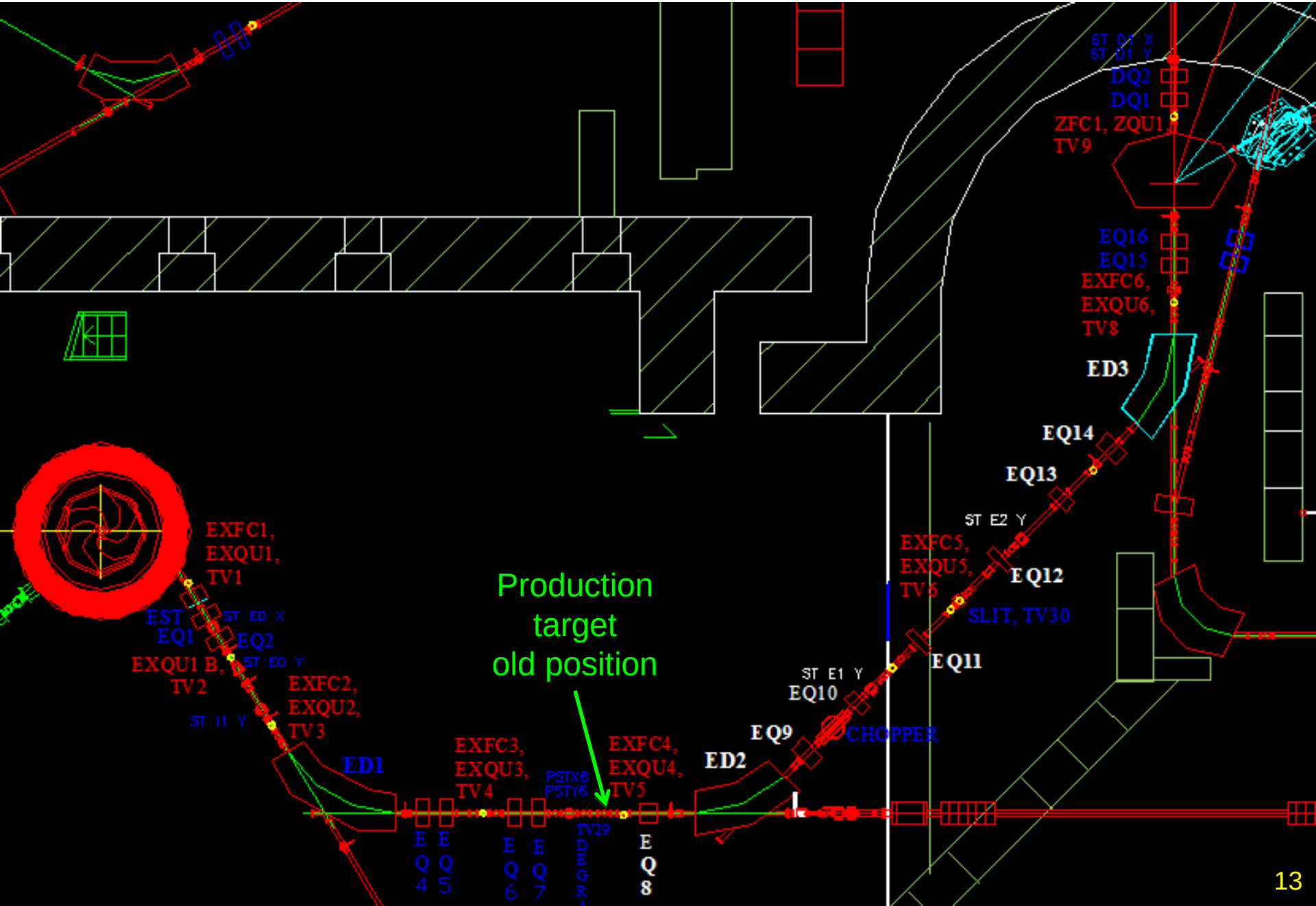
VOLTAGE DISTIRIBUTION OF THE TANDEM DURING THE OPERATIONS WITH THE PREVIOUS BELT
YEARS 1994/2000, TOTAL 28710 h



FRIBS@LNS: in Flight Radioactive Ion BeamS

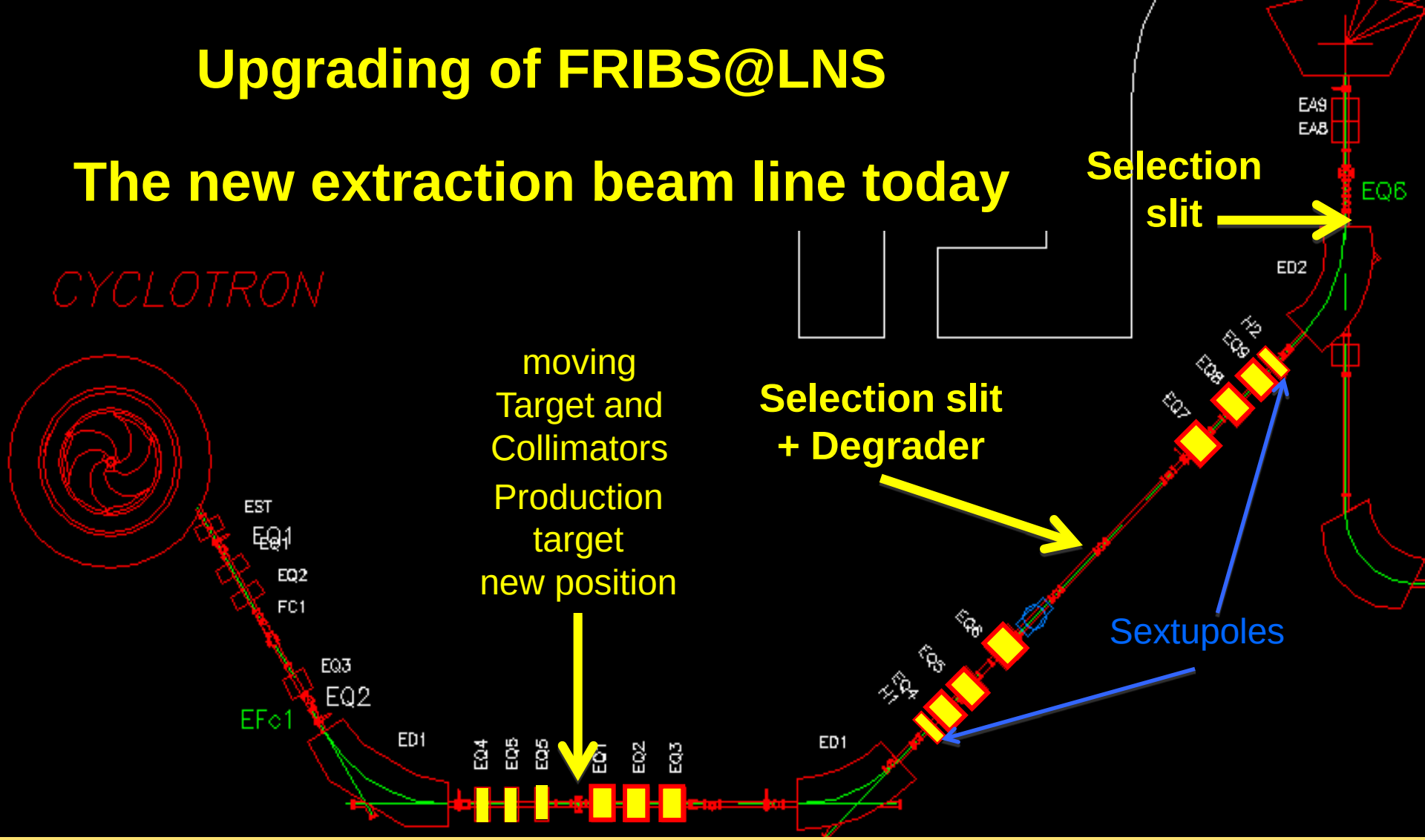


The extraction beam line until July 2010



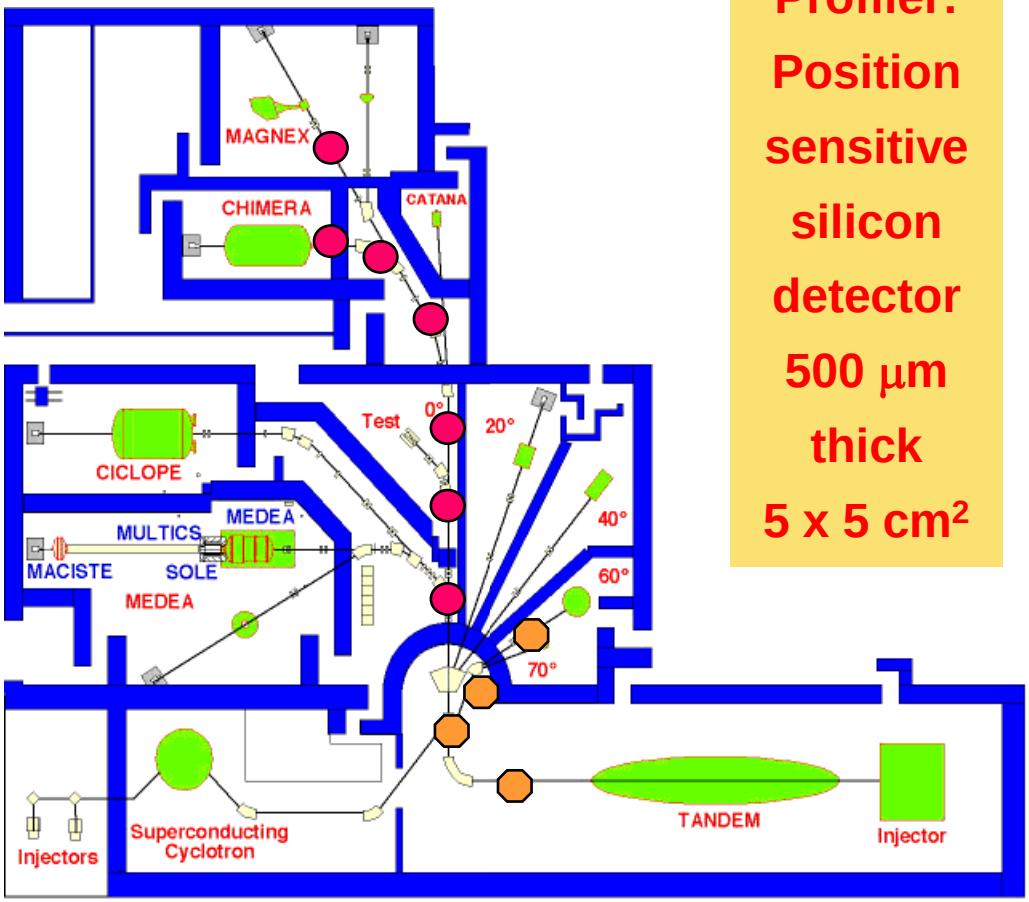
Upgrading of FRIBS@LNS

The new extraction beam line today

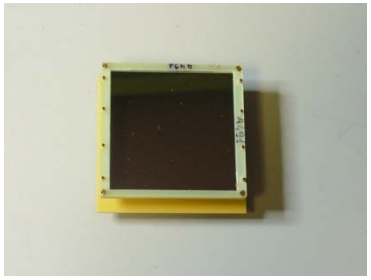


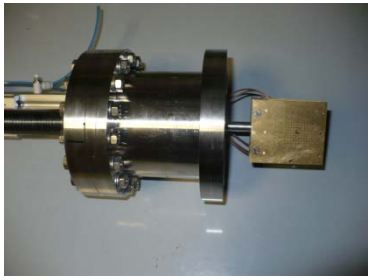
- More (and more powerful) quadrupoles (differently located)
- New position of the production target
- 2 sextupoles

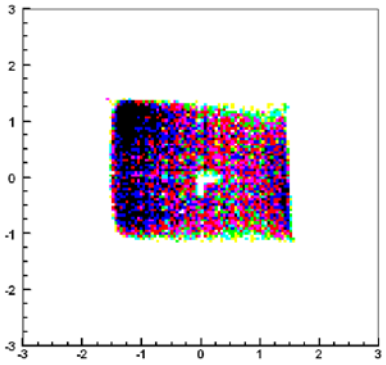
Low intensity diagnostics in the Chimera and Magnex beam lines



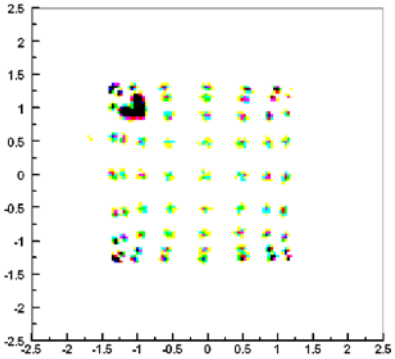
Profiler: Position sensitive silicon detector 500 μm thick 5 x 5 cm²





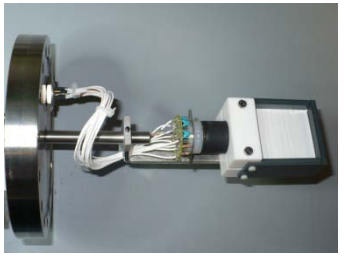


Cyclotron beam

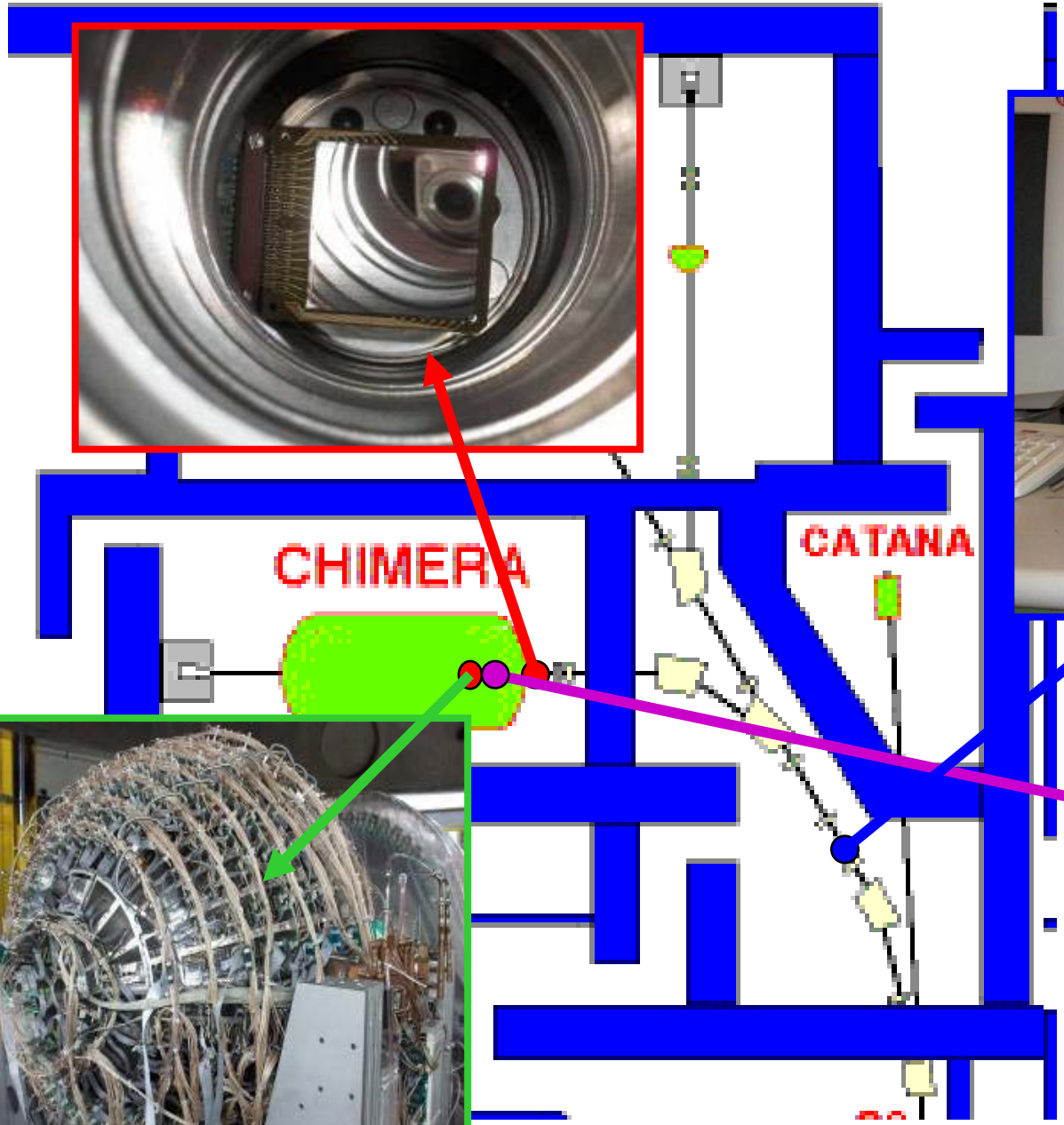


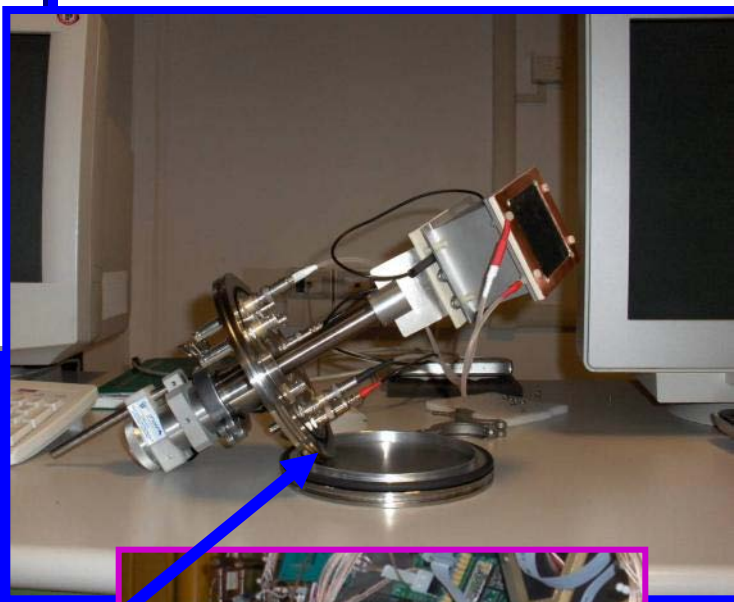
Tandem beam

Counter: plastic scintillator BC408 + PM



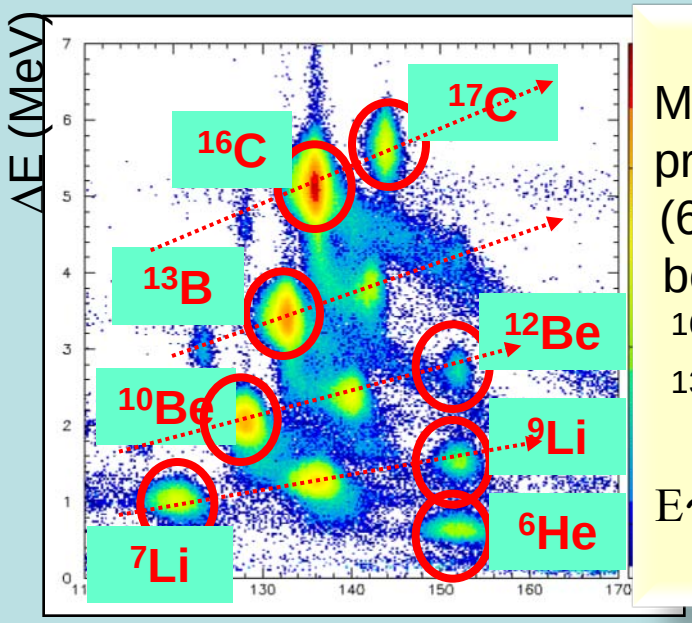
FRIBS@LNS Tagging system





Another DSSSD to measure trajectory

Intensities of some beams available in the CHIMERA Hall

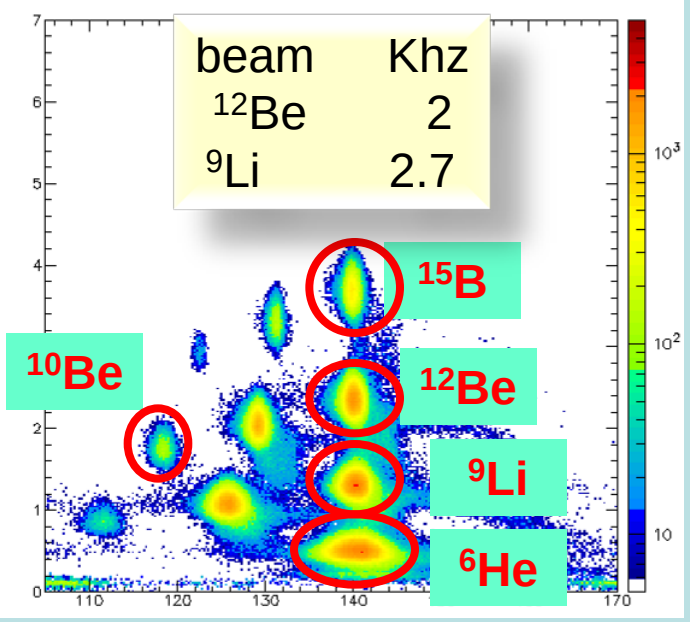


^{18}O 55 MeV/A 100 W primary beam (6.3×10^{11} p/s)

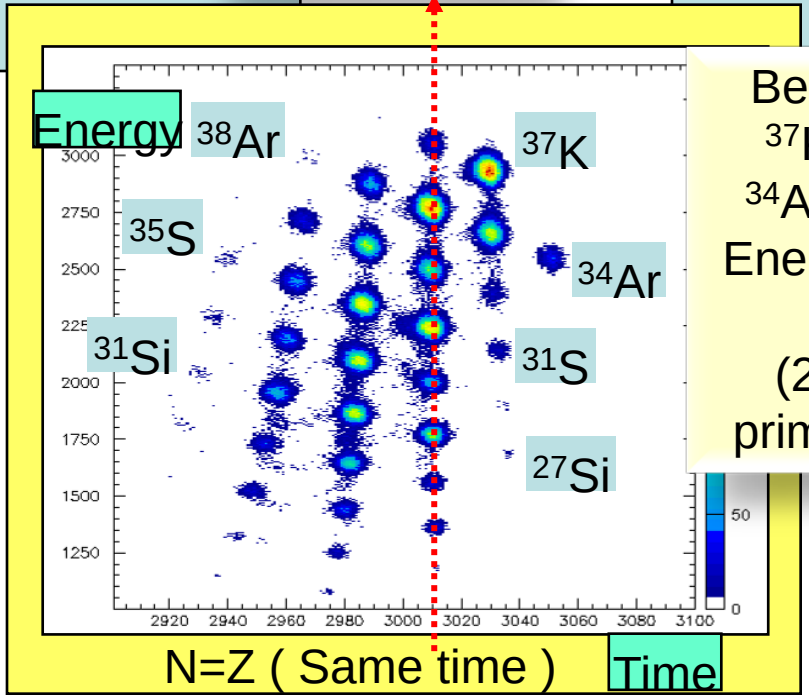
beam	Khz
^{16}C	60
^{13}B	40

E~50 MeV/A

ΔP/P <1%



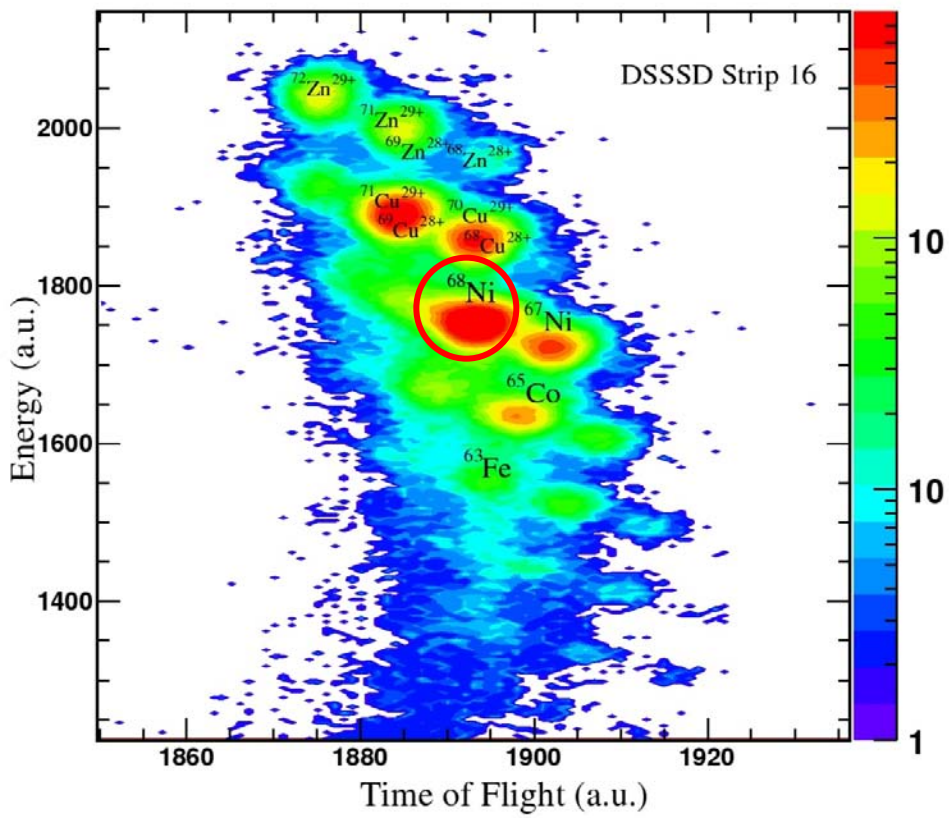
beam	Khz
^{12}Be	2
^{9}Li	2.7



Beam	Khz
^{37}K	14
^{34}Ar	1.8

Energy ~ 20-25 MeV/A (25 W ^{36}Ar primary beam)

NEW – MARCH 2012 : ^{68}Ni production with ^{70}Zn primary beam



Production of a ≈30 A.MeV ^{68}Ni beam at LNS (Time Scale Zn test)

We used a $^{70}Zn^{19+}$ (40 A.MeV) primary beam impinging on a 250 µm ^{9}Be target. The maximum intensity obtained for the primary beam was ≈300 enA (30 W)

Beams identification was obtained using the CHIMERA-IFEB tagging system constituted by a large surface MicroChannel plate followed by a Double Side 32x32 Silicon Strip Detector (DSSSD)

The production rate was 7 KHz / 30 Watt; reaching 100 Watt of primary beam current, we could obtain 2x10^4 pps rate (Lise++ prediction is 5x10^4 pps / 0.1 kW)

We verified that contamination due to not fully stripped ions can be neglected due to the low probability of charge state <27+ (<10%) and to the stripping effect of the MCP foil

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

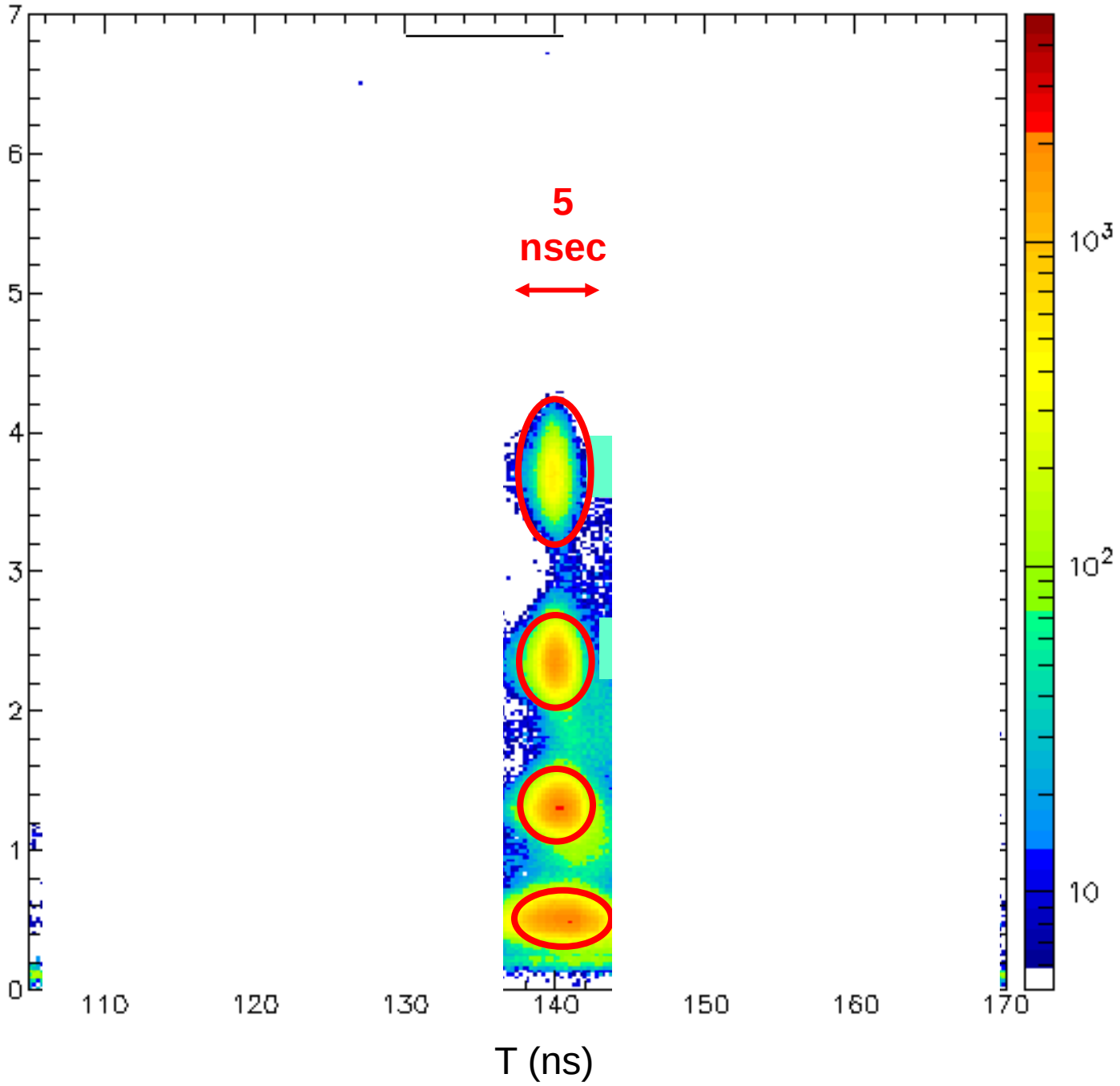
A gain factor > 10 has been found out thanks to the 2010 upgrading

Limiting factors:

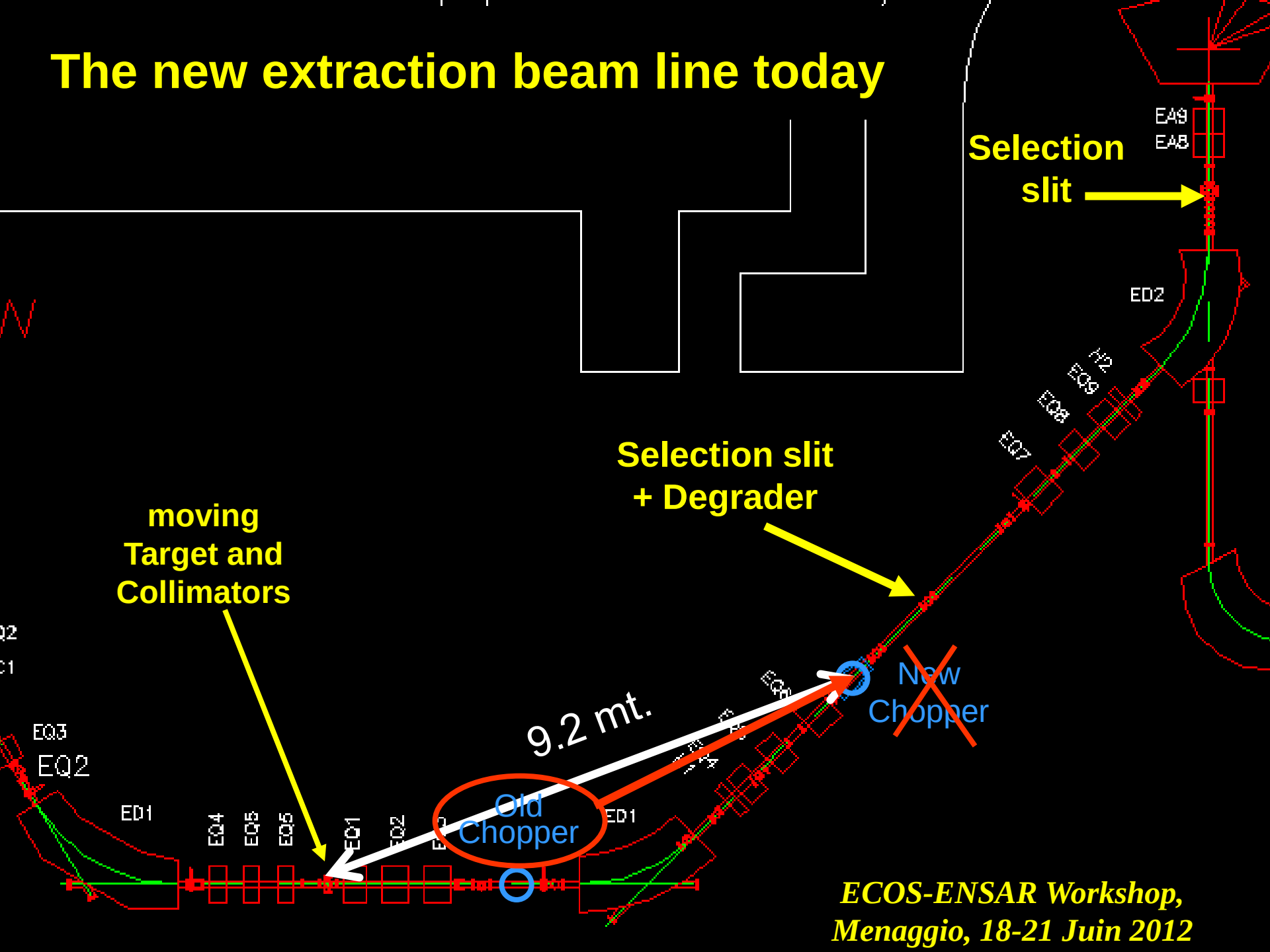
•Primary beam intensity;

•count rate of tagging system, lower than 0.2÷0.3 MHz

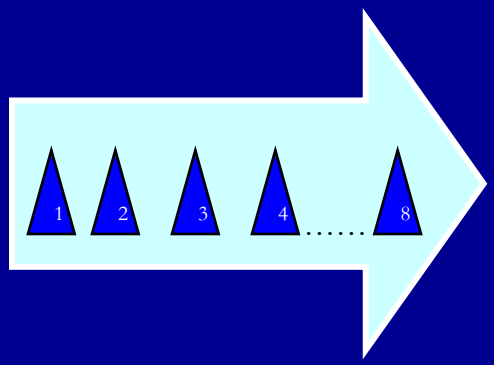
Time of flight measured between MCP placed 13 mt before the CHIMERA strip detector

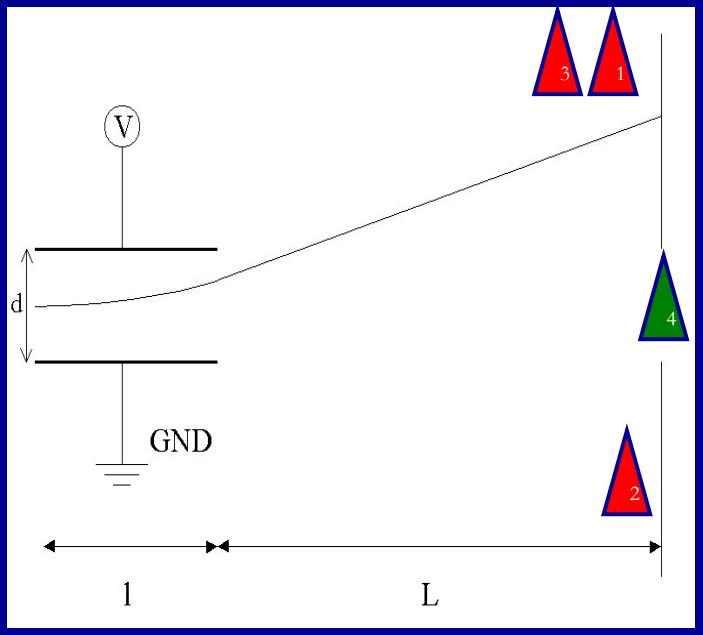


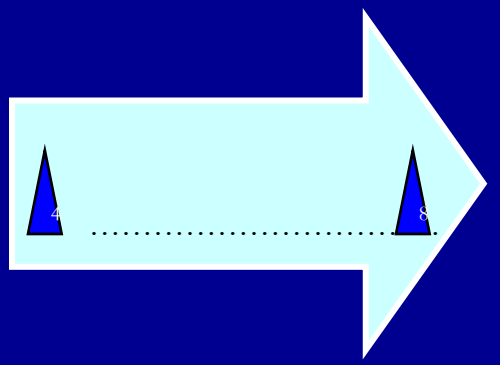
The new extraction beam line today



Chopper-500 basic working principle



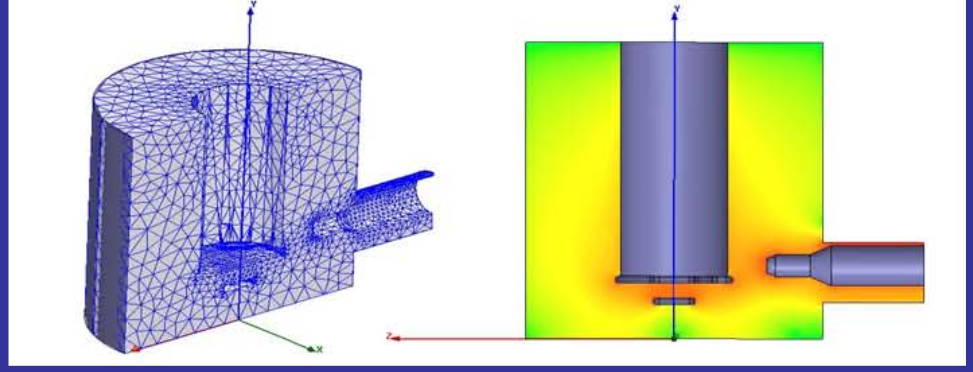




Eight accelerated bunches from the superconducting cyclotron minimum distance among the bunches is 20 nsec.

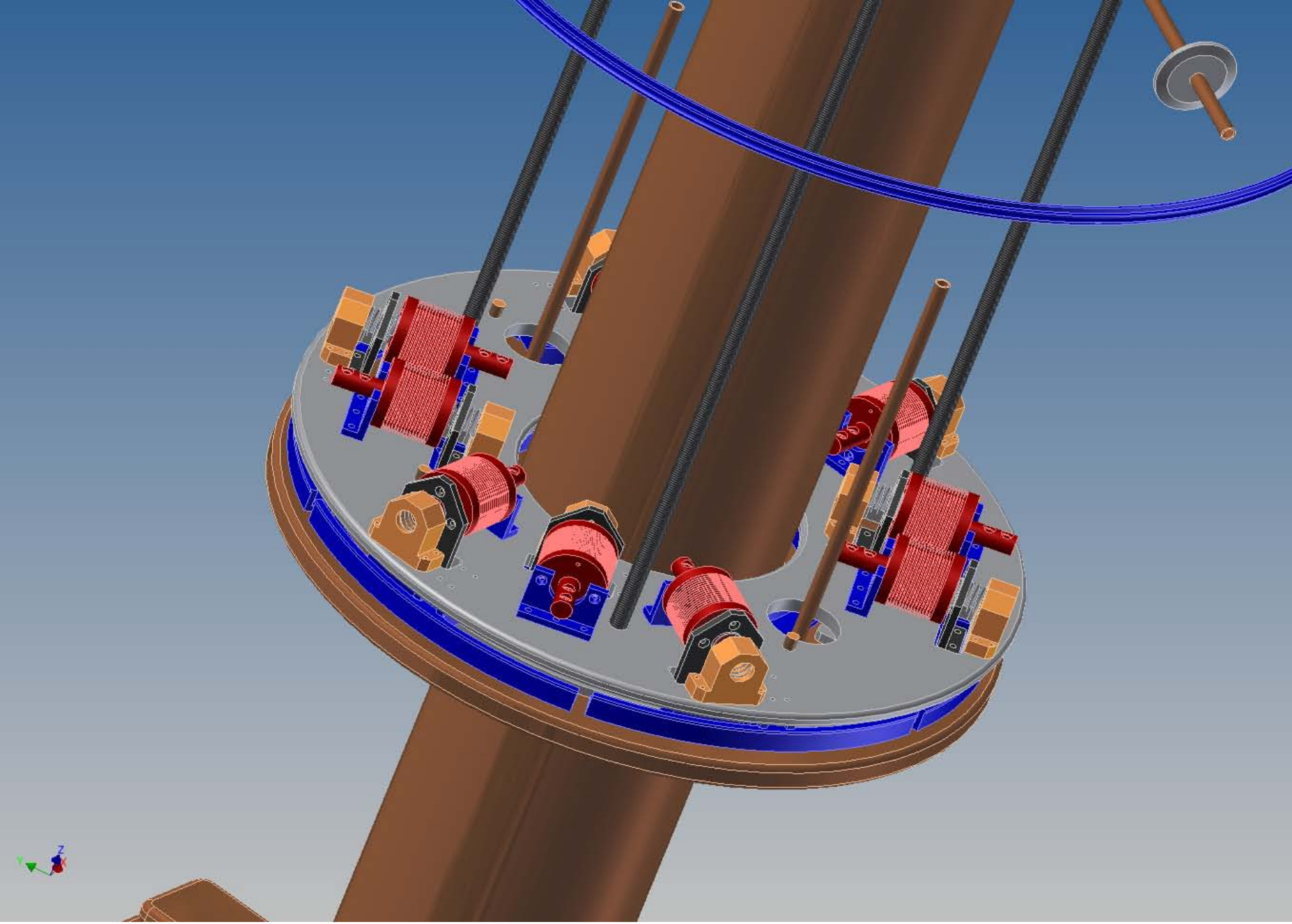
The chopper-500 system suppresses 3 bunches out of 4 and could cut the bunch length from 1÷3 ns to 500ps FWHM.

The selected bunches: 1 bunch out of 4



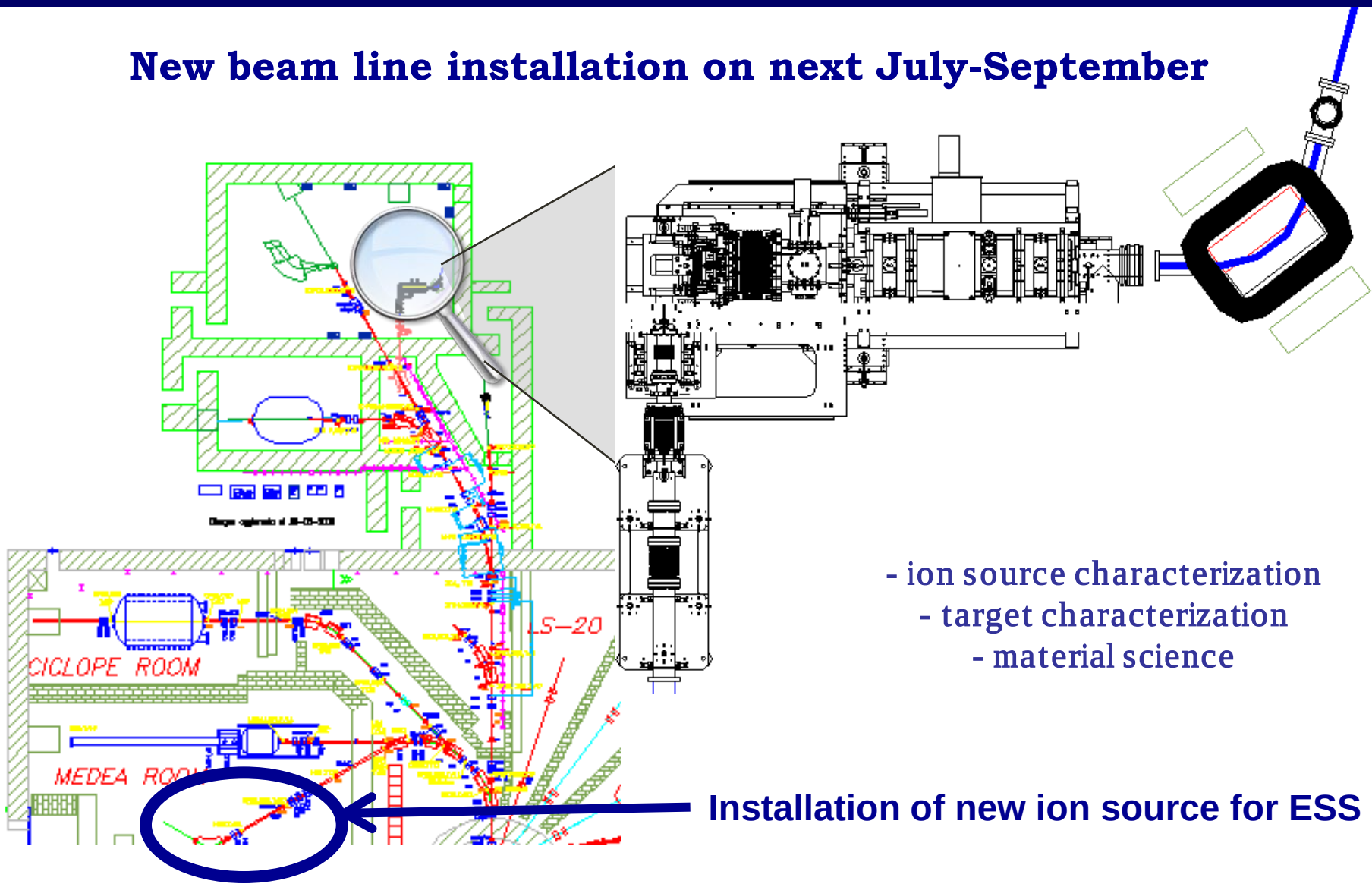
Mesh and distribution electric field

Refurbished sliding short of the Chopper 500



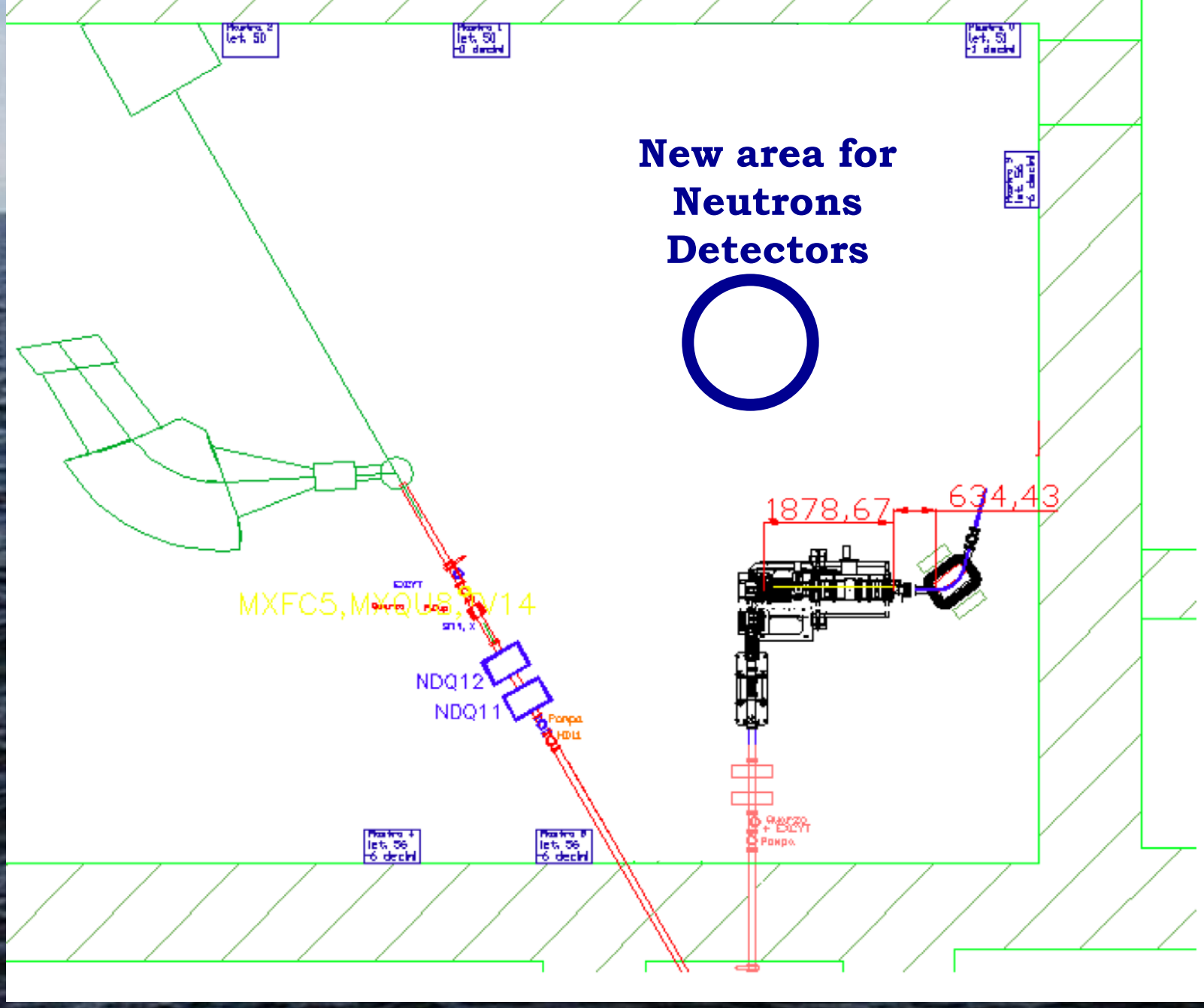
Test bench for EXCYT and SPES

New beam line installation on next July-September

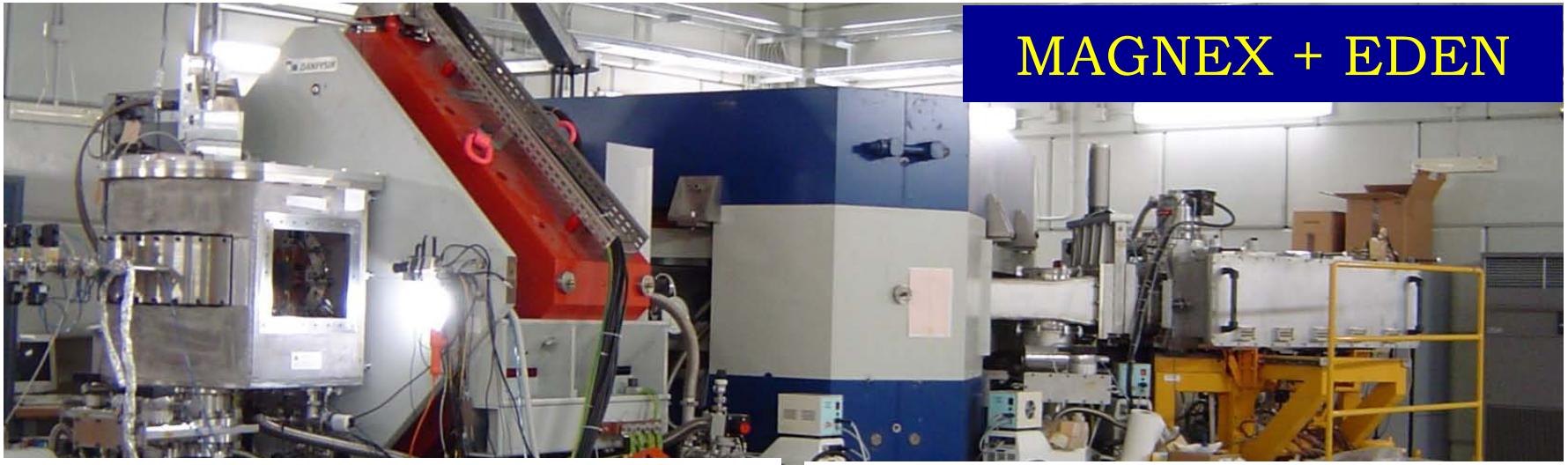


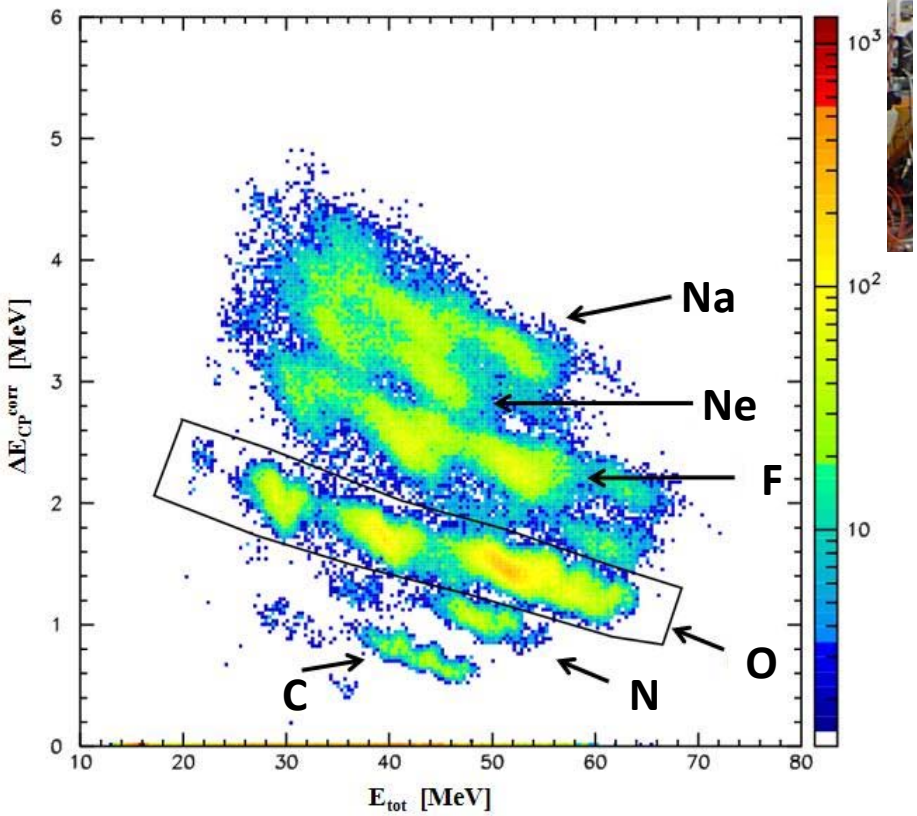
- ion source characterization
- target characterization
- material science

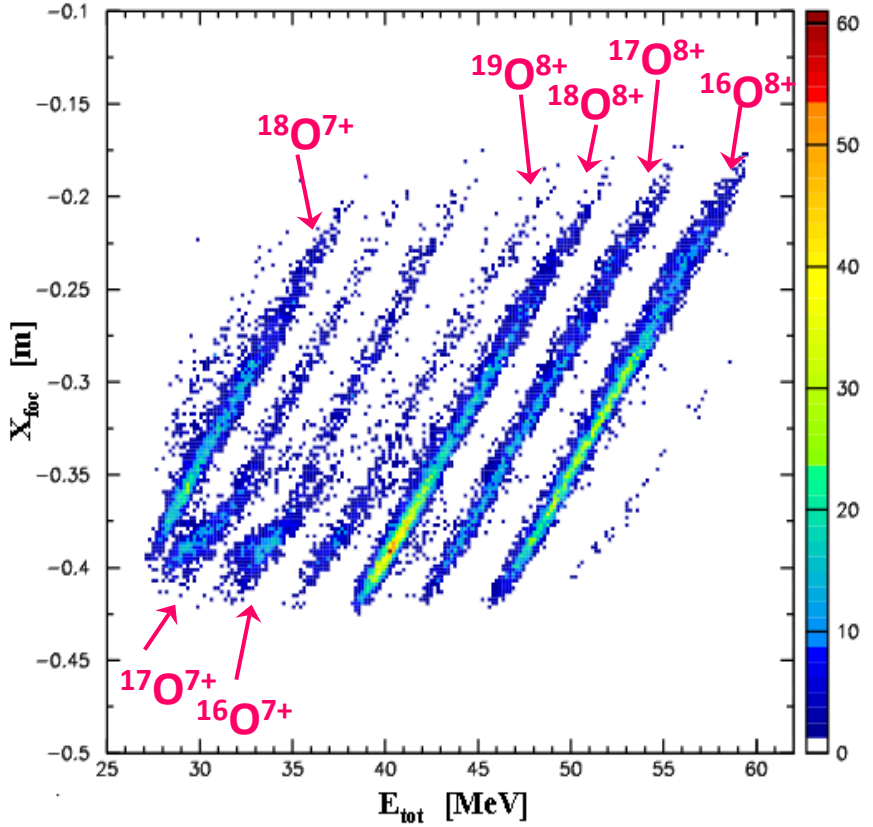
Installation of new ion source for ESS


New area for
Neutrons
Detectors
1878,67
634,43
NDQ12
NDQ11

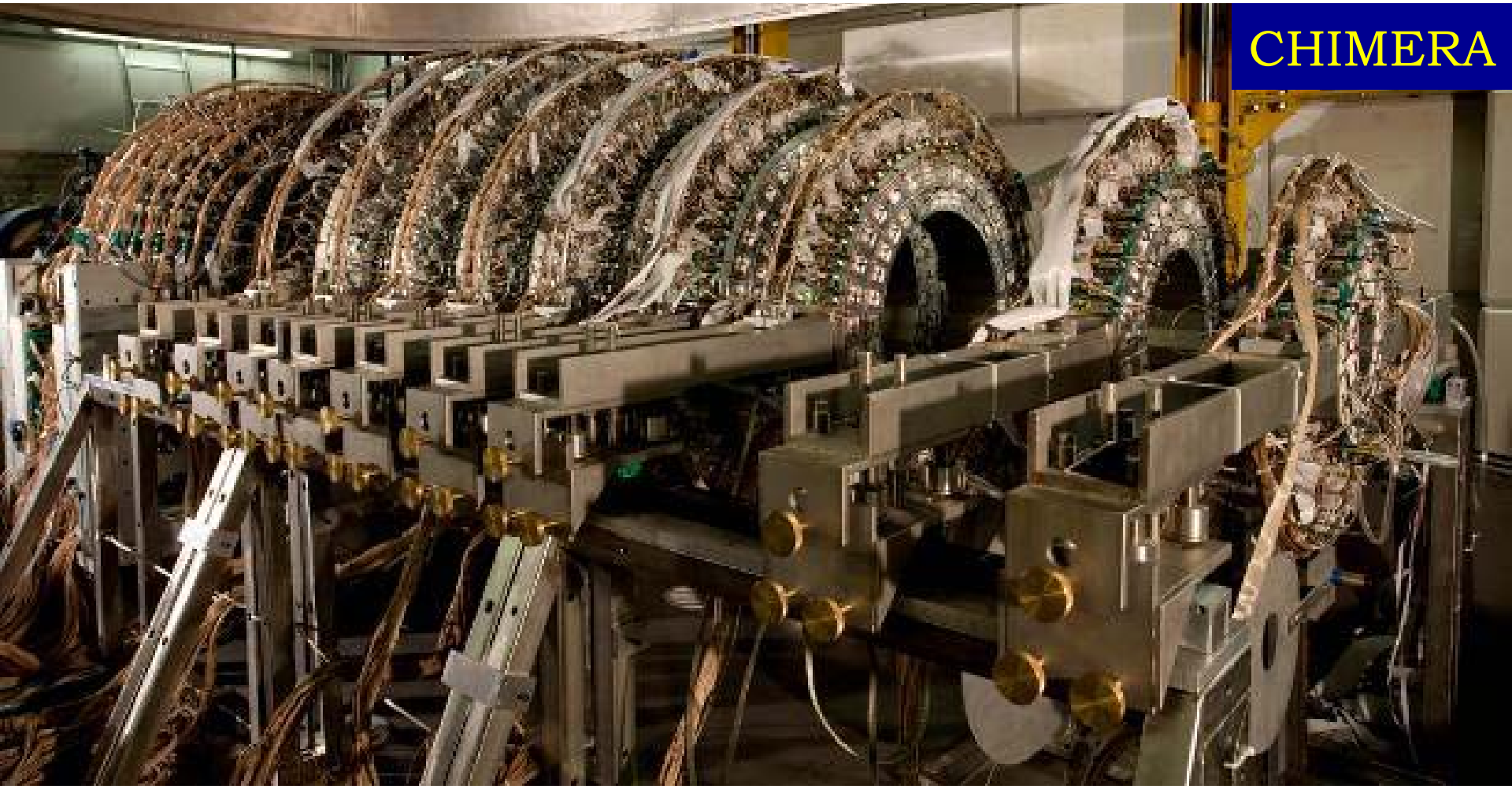
MAGNEX + EDEN




Na
Ne
F
O
C
N
ΔE_{CP}^{corr} [MeV]
E_{tot} [MeV]


$^{18}O^{7+}$
$^{19}O^{8+}$
$^{18}O^{8+}$
$^{17}O^{8+}$
$^{16}O^{8+}$
$^{17}O^{7+}$
$^{16}O^{7+}$
X_{foc} [m]
E_{tot} [MeV]

Main task of LNS accelerators is satisfy the beam request of physics program based on MAGNEX, CHIMERA and Nuclear Astrophysics



Beam availability - October 2012-July 2013

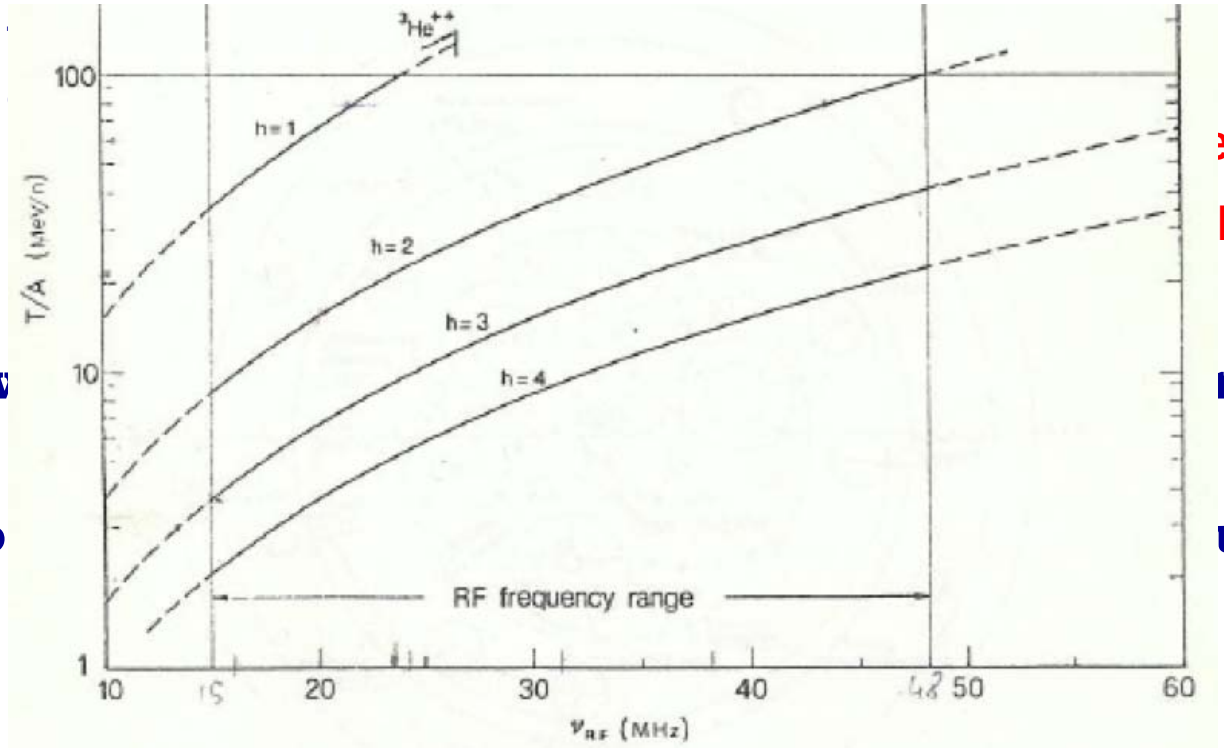
Cyclotron: the estimated amount of available beam time is 270 BTU + 85 for Catana + 60 for private users; research users ask for 494 BTU;

Develop program:

upgrading ECR sources to increase intensities of stable beams;

New central region for the cyclotron, to work in 3rd harmonic and deliver beams at low energy > 4 MeV/amu, very interesting for MAGNEX spectrometer;

Tandem:



to start the experiments eduled

lts produced new call

This year v ron chain

This co uclear

CONCLUSION

- **We have a design project to upgrade the SERSE source and to deliver higher intense stable beams from Cyclotron, but we are waiting for funds;**
- **We have a plan to refurbish the Tandem, but we are waiting for funds;**
- **The upgrading of beam intensity with FRIBS@LNS is in progress, and studies are in progress to increase the beam focusing on the primary target and then to deliver more intensity to the users**

ECOS-ENSAR Workshop, Menaggio, 18-21 Juin 2012