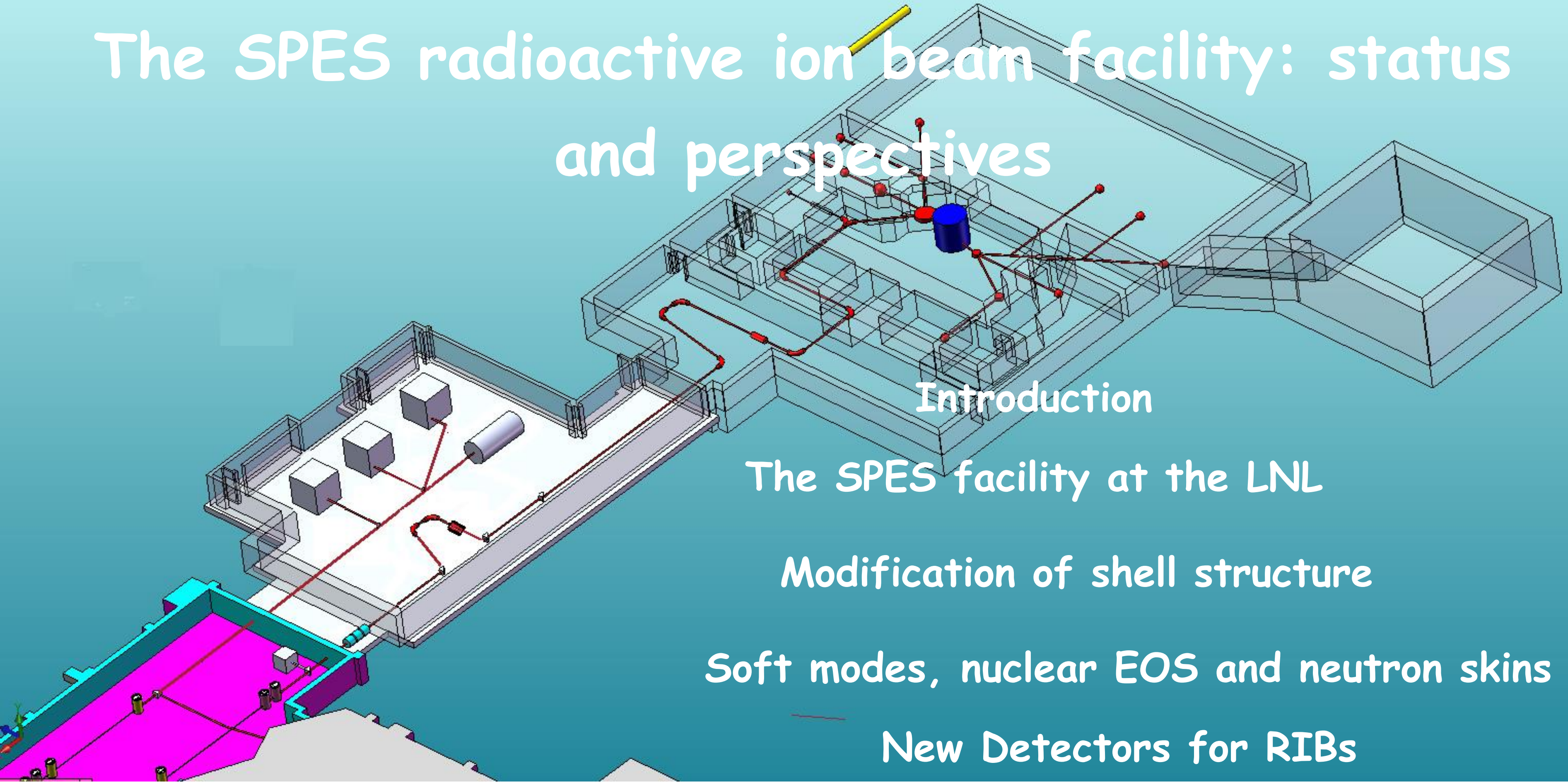
The SPES radioactive ion beam facility: status and perspectives



Introduction

The SPES facility at the LNL

Modification of shell structure

Soft modes, nuclear EOS and neutron skins

New Detectors for RIBs

Giacomo de Angelis

INFN Laboratori Nazionali di Legnaro

for The SPES collaboration

The goal of SPES

- **S**elective **P**roduction of **E**xotic **S**pecies

production of re-accelerated neutron-rich exotic beams
10^{13} fission/s in-target production, and re-acceleration at 10*A MeV (A=132)

- Optimized use of the two exits high current proton driver

Radioisotope production & Medical applications
innovative radiopharmaceuticals (e.g. Sr-82, Cu- 64, Cu-67)

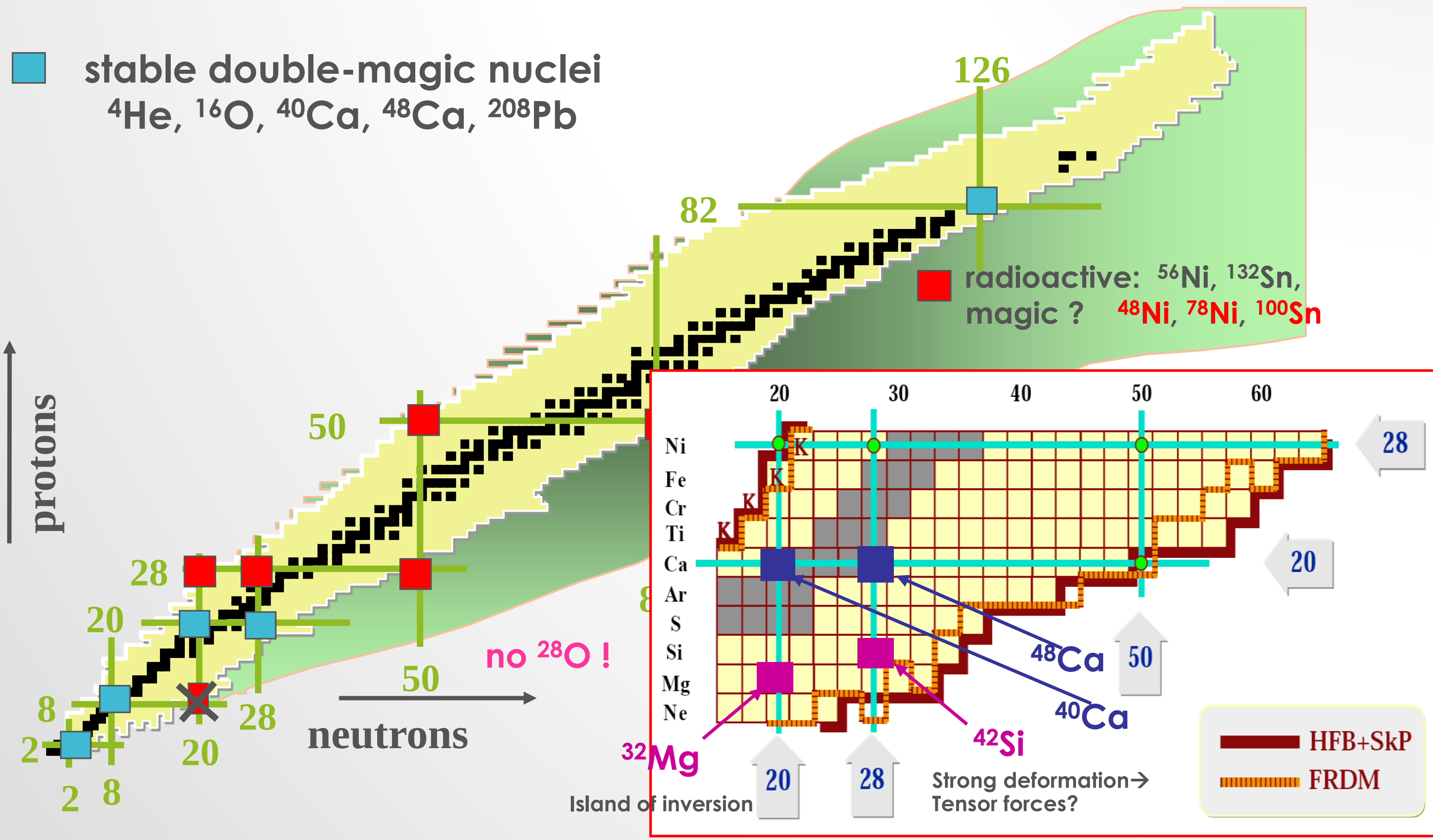
Fast neutron production & material applications: Atmospheric neutron spectra, QMN
Single Event Effect, neutron capture cross sections

SPES CHALLENGES

- Development of a comprehensive model of atomic nuclei – Do we understand the structure and stability of the nuclear systems?
- Understanding the origin of the elements and modeling of the extreme astrophysics enviroments
- Test of fundamental symmetries
- New applications of isotope science

One of the challanges: New magic numbers?

SPES exotic beams for science



LETTER

doi:10.1038/nature12522

Evidence for a new nuclear 'magic number' from the level structure of ^{54}Ca

D. Steppenbeck[1], S. Takeuchi[2], N. Aoi[3], P. Doornenbal[2], M. Matsushita[1], H. Wang[2], H. Baba[2], N. Fukuda[2], S. Go[1], M. Honma[4], J. Lee[2], K. Matsui[5], S. Michimasa[1], T. Motobayashi[2], D. Nishimura[6], T. Otsuka[1,5], H. Sakurai[2,5], Y. Shiga[7], P.-A. Söderström[2], T. Sumikama[8], H. Suzuki[2], R. Taniuchi[5], Y. Utsuno[9], J. J. Valiente-Dobón[10] & K. Yoneda[2]

Atomic nuclei are finite quantum systems composed of two distinct types of fermion—protons and neutrons. In a manner similar to that of electrons orbiting in an atom, protons and neutrons in a nucleus form shell structures. In the case of stable, naturally occurring nuclei, large energy gaps exist between shells that fill completely when the proton or neutron number is equal to 2, 8, 20, 28, 50, 82 or 126 (ref. 1). Away from stability, however, these so-called 'magic numbers' are known to evolve in systems with a large imbalance of protons and neutrons. Although some of the standard shell closures can disappear, new ones are known to appear[2,3]. Studies aiming to identify and understand such behaviour are of major importance in the field of experimental and theoretical nuclear physics. Here we report a spectroscopic study of the neutron-rich nucleus ^{54}Ca (a bound system composed of 20 protons and 34 neutrons) using proton knockout reactions involving fast radioactive projectiles. The results highlight the doubly magic nature of ^{54}Ca and provide direct experimental evidence for the onset of a sizable subshell closure at neutron number 34 in isotopes far from stability.

The shell structure of the atomic nucleus was first successfully described more than 60 years ago[1]. However, the question of how robust the standard magic numbers are in unstable nuclei with a large excess of neutrons—often referred to as 'exotic' nuclei—has been one of the main driving forces behind recent nuclear structure studies that focus on changes in the shell structure, called 'shell evolution'. A noteworthy example is the disappearance of the $N = 28$ (neutron number 28) standard magic number in ^{42}Si (ref. 4), a nucleus that lies far from the stable isotopes on the Segrè chart. On the contrary, exotic oxygen isotopes[3] provide evidence for the onset of a new shell closure at $N = 16$, one that is not observed in stable nuclei. In both cases, the tensor force, a non-central component of the nuclear force, has a key role in describing the experimental spectra[5].

The region of the Segrè chart around exotic calcium isotopes has also contributed valuable input to the understanding of nuclear shell evolution over recent years owing to experimental advances. Enhanced excitation energies of first $J^{\Pi} = 2^+$ states (spin, J; parity, Π) and reduced γ-ray transition probabilities, which are good indicators of nuclear shell gaps, for ^{52}Ca (refs 6, 7), ^{54}Ti (refs 8, 9) and ^{56}Cr (refs 10, 11) provide substantial evidence for the onset of a sizable energy gap at $N = 32$. This result was recently confirmed by high-precision mass measurements on neutron-rich Ca isotopes[12]. In the framework of tensor-force-driven shell evolution[5], the $N = 32$ subshell closure is a direct consequence of the weakening of the attractive nucleon–nucleon interaction between protons (π) and neutrons (ν) in the $\pi f_{7/2}$ and $\nu f_{5/2}$ single-particle orbitals (SPOs) as the number of protons in the $\pi f_{7/2}$ SPO is reduced and the magnitude of the $\pi f_{7/2}$–$\nu f_{5/2}$ energy gap increases (Fig. 1a–c).

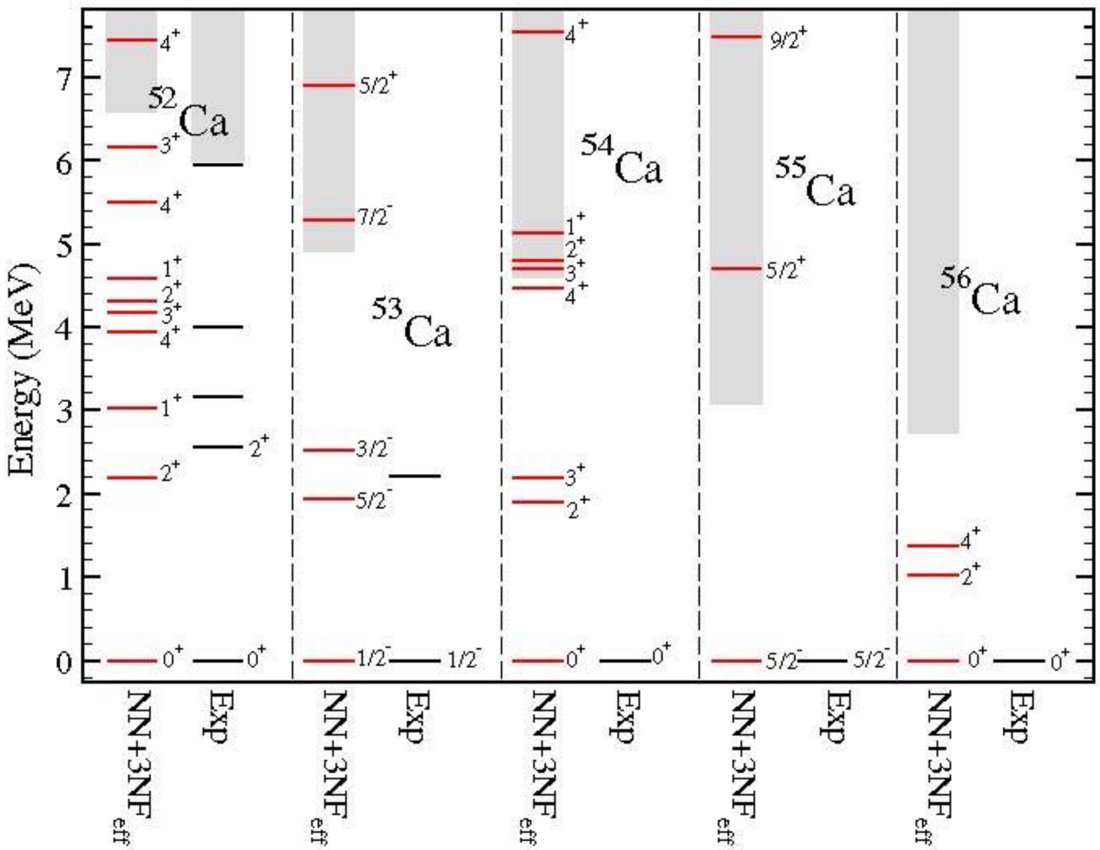
A question that has been asked frequently over recent years is whether or not the onset of another subshell gap occurs in exotic $N = 34$ isotones, which was suggested qualitatively more than a decade ago[13] on the basis of the general properties of nuclear forces. The onset of an appreciable subshell closure at $N = 34$ is illustrated in Fig. 1d, indicating an energy gap between the $\nu p_{1/2}$ and $\nu f_{5/2}$ SPOs in ^{54}Ca that is comparable to the separation of the $\nu p_{3/2}$ and $\nu p_{1/2}$ spin–orbit partners, which is also implied by recent theoretical results; see, for example, ref. 14. We stress, however, that no $N = 34$ subshell closure was reported in the experimental investigations of ^{56}Ti (refs 9, 15) or ^{58}Cr (refs 11, 16), and notable doubt on this magic number for Ca isotopes has been raised[17,18]. Indeed, as indicated in Fig. 2a, theoretical predictions of the energy of the first $J^{\Pi} = 2^+$ state for ^{54}Ca vary considerably, ranging from ~1 MeV in some cases to as high as ~4 MeV in others[14–16,19–24], despite exhibiting close agreement for lighter isotopes; for example, the predictions of the same theories lie within only 0.4 MeV of the empirical result for ^{52}Ca. Such stark discrepancies at $N = 34$ reflect the need for direct experimental input on the matter.

To address this issue, we report on an experimental study of ^{54}Ca to clarify the strength of the $N = 34$ subshell gap in nuclei farther from stability. The energies of nuclear excited states were investigated using proton knockout reactions involving ^{55}Sc and ^{56}Ti projectiles on a Be target at the Radioactive Isotope Beam Factory, Japan, operated by the RIKEN Nishina Center and the Center for Nuclear Study, University of Tokyo. Experimental details are provided in Methods Summary. Particle identification plots indicating the radioactive species transported through the BigRIPS separator and ZeroDegree spectrometer[25], which were used to select and tag radioactive beam projectiles and reaction products, are presented in Fig. 3a and Fig. 3b, respectively. We emphasize that the intensity of the radioactive beam reported here, which was critical to the success of the experiment, is unique to the Radioactive Isotope Beam Factory. Excited-state energies were deduced using the technique of in-beam γ-ray spectroscopy.

The γ-rays measured in coincidence with ^{54}Ca projectiles produced through the one- and two-proton knockout reaction channels are presented in Fig. 4a. The γ-ray energies measured in the laboratory frame of reference have been corrected for Doppler shifts, and so the transitions appear at the energies they would in the rest frame of the nucleus. The most intense γ-ray line in the ^{54}Ca spectrum, the peak at 2,043(19) keV (error, 1 s.d.) in Fig. 4a, is assigned as the transition from the first 2^+ state (2_1^+) to the 0^+ ground state. In addition, two weaker transitions are located at 1,656(20) and, respectively, 1,184(24) keV. Figure 4b shows a γ-ray spectrum obtained with the condition of a prompt coincidence ($\lesssim$10 ns) with the 2,043-keV γ-ray, indicating that the weaker transitions were emitted in decay sequences involving the $2_1^+ \rightarrow 0^+$ ground-state transition. On the basis of the γ-ray relative intensities, the 1,656-keV transition is proposed to depopulate a level at 3,699(28) keV, as presented in the ^{54}Ca level scheme in the lower-right section of Fig. 4a. Placement of the 1,184-keV transition in the

[1]Center for Nuclear Study, University of Tokyo, Hongo, Bunkyo, Tokyo 113-0033, Japan. [2]RIKEN Nishina Center, 2-1, Hirosawa, Wako, Saitama 351-0198, Japan. [3]Research Center for Nuclear Physics, University of Osaka, Ibaraki, Osaka 567-0047, Japan. [4]Center for Mathematical Sciences, Aizu University, Aizu-Wakamatsu, Fukushima 965-8580, Japan. [5]Department of Physics, University of Tokyo, Hongo, Bunkyo, Tokyo 113-0033, Japan. [6]Department of Physics, Tokyo University of Science, Noda, Chiba 278-8510, Japan. [7]Department of Physics, Rikkyo University, Toshima, Tokyo 171-8501, Japan. [8]Department of Physics, Tohoku University, Sendai, Miyagi 980-8578, Japan. [9]Japan Atomic Energy Agency, Tokai, Ibaraki 319-1195, Japan. [10]Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Legnaro, Legnaro 35020, Italy.

N=34 subshell closure due to the effects of three body forces driving the monopole part of the nuclear Hamiltonian



Beta delayed
n spectroscopy
n-γ coincidences

LOI SPES A. Gottardo IPN Orsay

Shell model calculations with effective interaction based on chiral Effective field theory and three body forces (G. Hagen PRL 109 2012)

Evolution of the single-particle states around ^{132}Sn

$$\bar{\varepsilon}_{j_\nu} = \varepsilon_{j_\nu} + \sum_{j_\pi} V^M(j_\nu j_\pi) N_{j_\pi}$$

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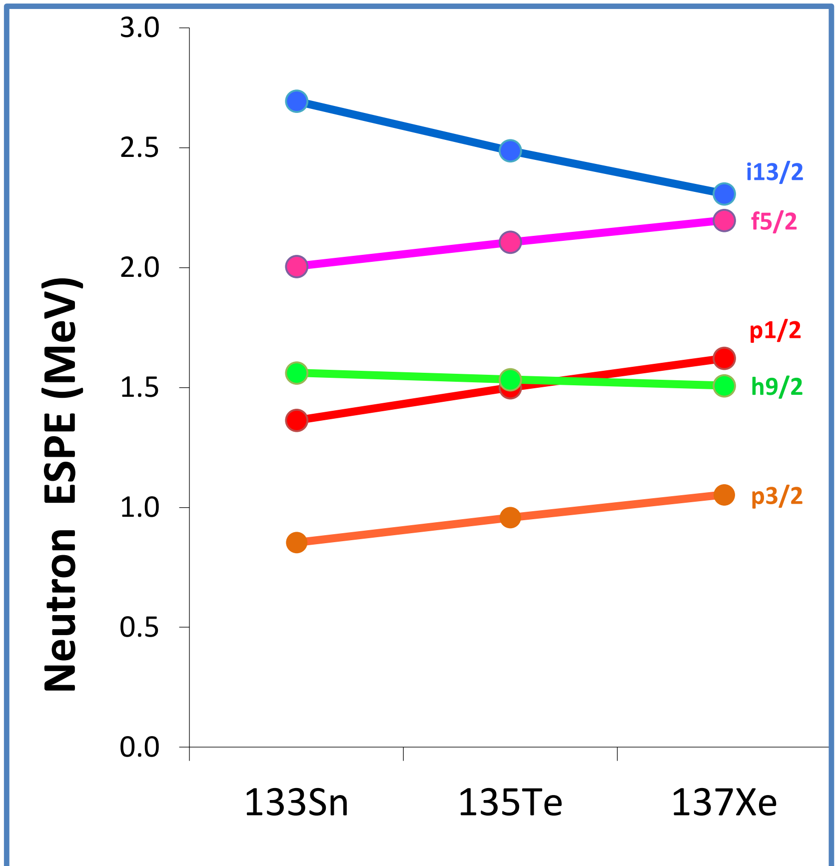
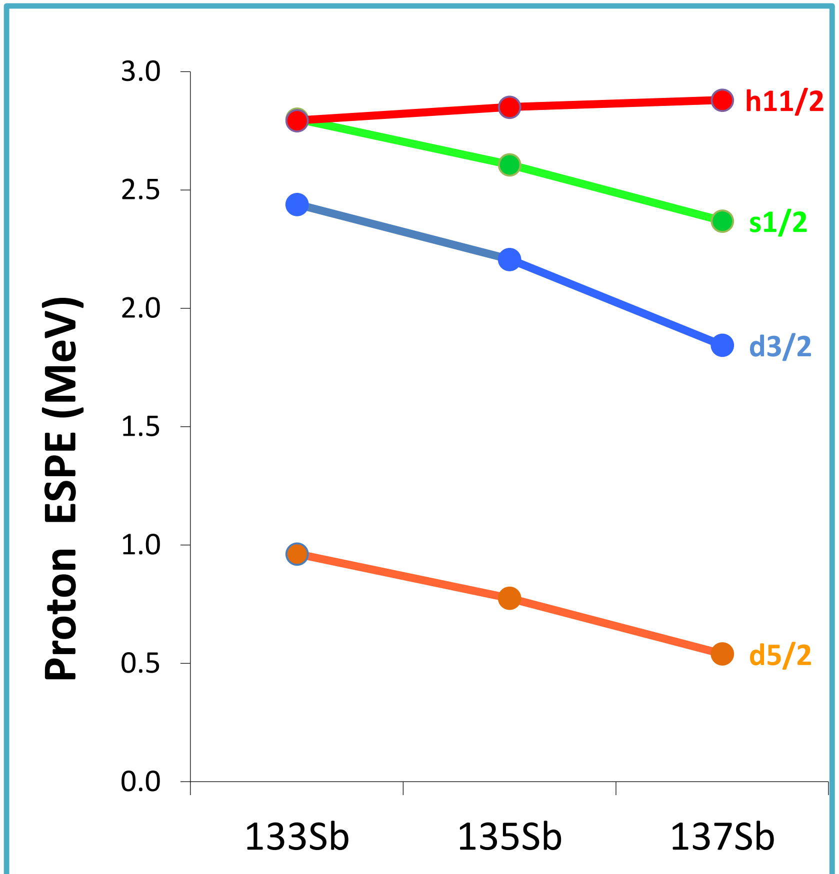


Courtesy of A. Gargano



LOI SPES D. Mengoni (Uni. Pd)

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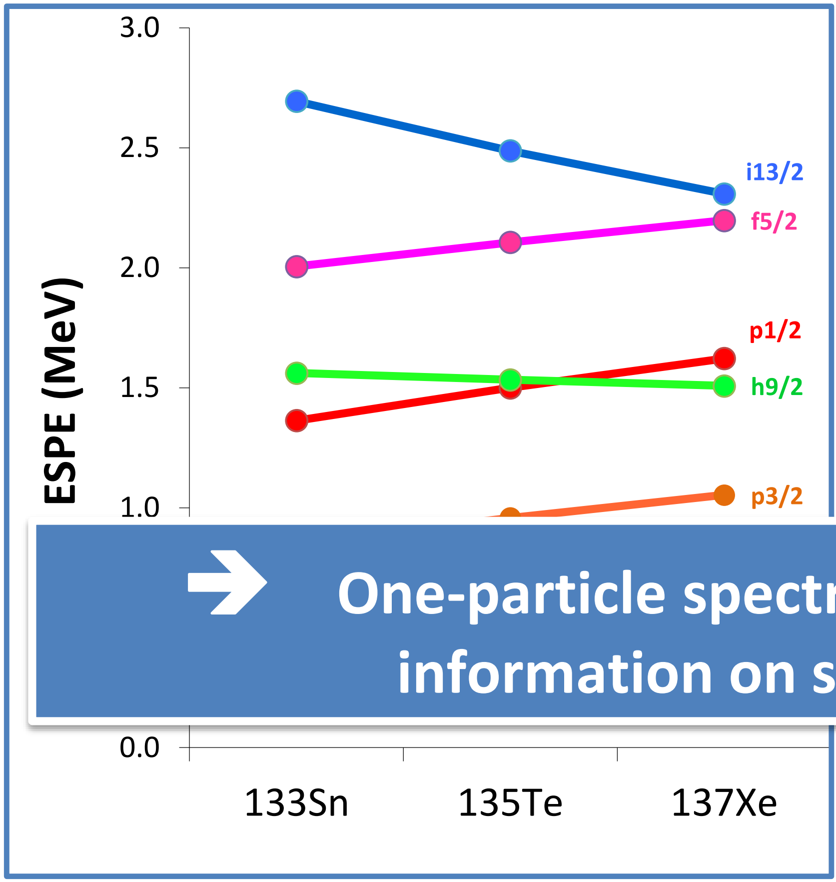
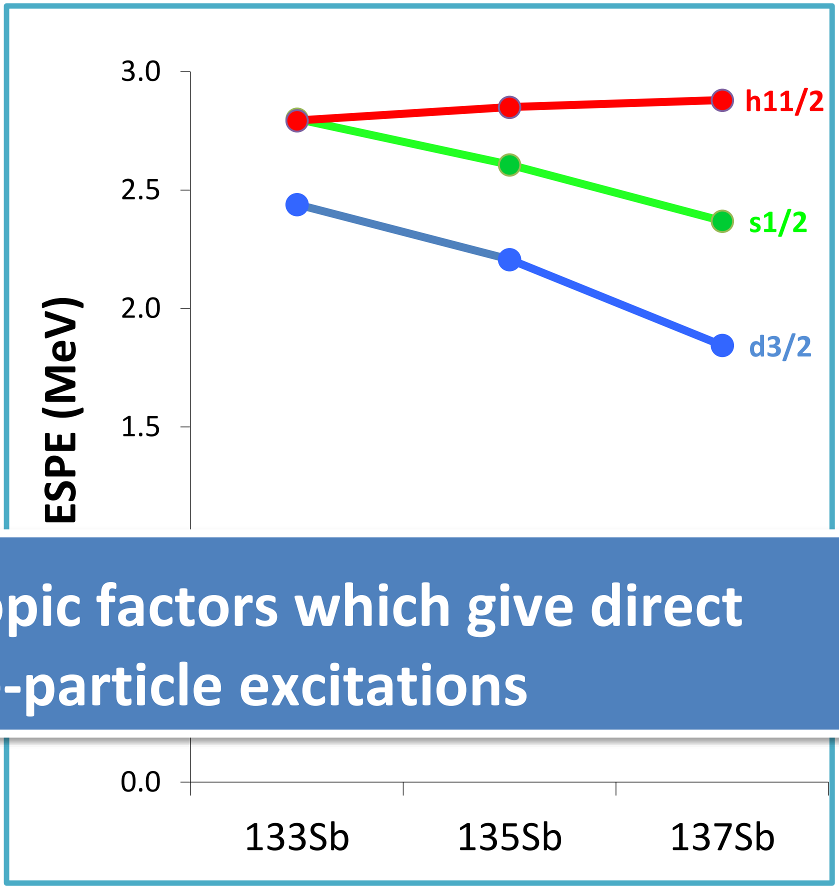




→ **One-particle spectroscopic factors which give direct information on single-particle excitations**

Courtesy of A. Gargano

LOI SPES D. Mengoni (Uni. Pd)

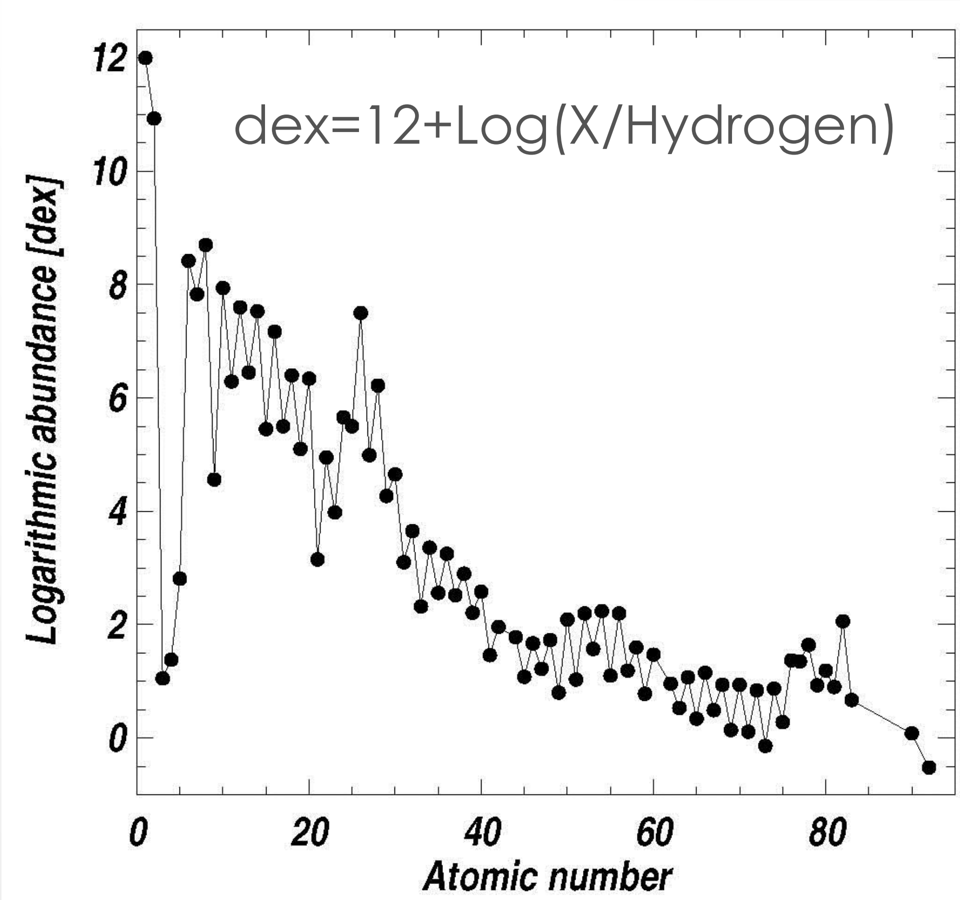
ONE OF THE CHALLENGES: ORIGIN OF THE ELEMENTAL ABUNDANCES IN THE SOLAR SYSTEM

Stars are mostly made of hydrogen and helium, but each has a fairly unique pattern of other elements

The abundance of elements tells us about the hystory of events prior to the formation of our Sun

The plot shows the composition of the Sun Photosphere

How are these elements created prior to the formation of the Sun?



Asplund M. et al.
Ann. Rev. Astr. 47, 481 (2009)

INFN
Istituto Nazionale
di Fisica Nucleare

r-process nuclei:
β-decay and isomer spectroscopy

SPES exotic beams for science

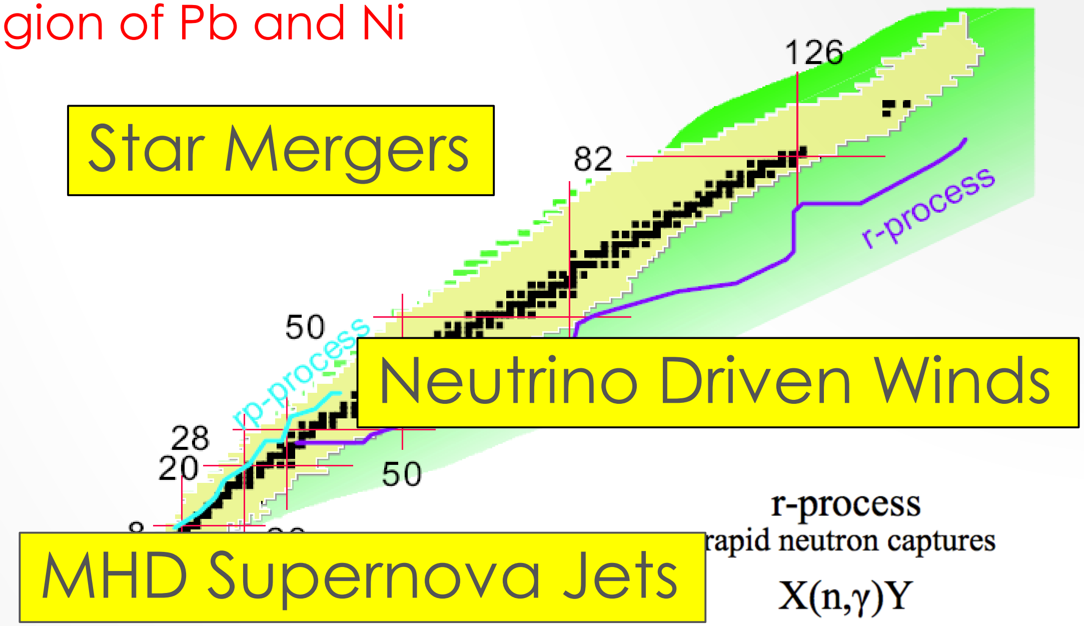
n-rich region of Pb and Ni

– β-decay half-lives
– neutron emission probabilities

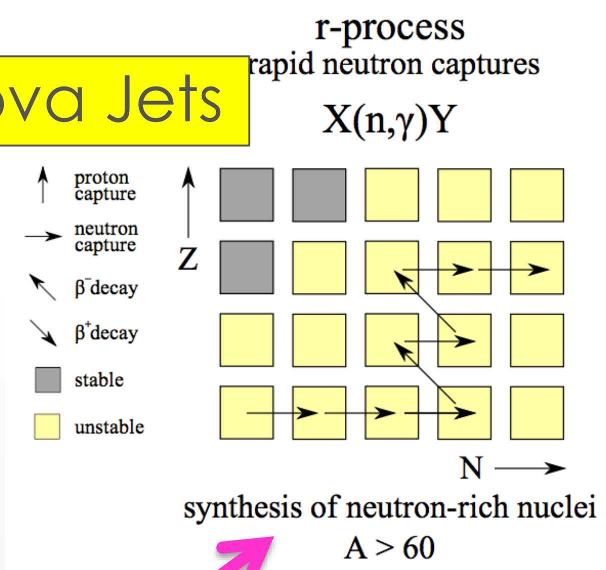
different in **DEFORMED** and **SPHERICAL** nuclei

$$\tau_{\beta\,SPH} \sim 10 \times \tau_{\beta DEF}$$

$$P_{nSPH} \sim 0.5 \times P_{nDEF}$$



→ Large uncertainty in r-process location
→ difficulty to extrapolate to more exotic regions



Importance of Nuclear Structure studies in the vicinity/towards r-process path:

… first excited states
... Isomeric states
... β decay lifetimes

LOI SPES D. Mengoni (Uni. Pd)

ONE OF THE CHALLENGES: REFLECTION ASYMMETRIC NUCLEI AND STATIC ELECTRIC DIPOLE MOMENT

The lopsided nuclei, described today (May 8) in the journal Nature, *could be good candidates for researchers looking for new types of physics beyond the reigning explanation for the bits of matter that make up the universe* (called the Standard Model), said study author Peter Butler, a physicist at the University of Liverpool in the United Kingdom.

The findings could help scientists search for physics beyond the Standard model, said Witold Nazarewicz. *An electric dipole moment would provide a way to test extension theories to the Standard Model, such as supersymmetry, which could help explain why there is more matter than antimatter in the universe.*

ONE OF THE CHALLENGES: REFLECTION ASYMMETRIC NUCLEI AND STATIC ELECTRIC DIPOLE MOMENT

V Spevak, N Auerbach, and VV Flambaum
PR C **56** (1997) 1357

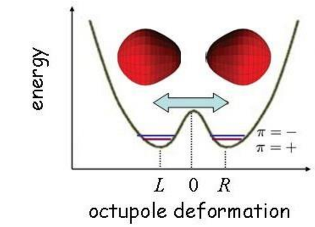
Schiff moment:

related to Q_3

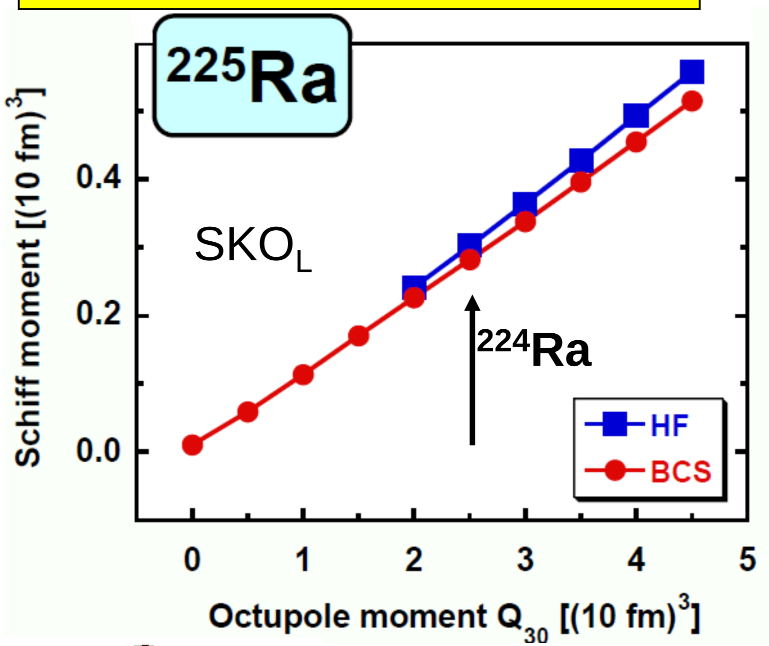
P,T-violating n-n interaction

$$S = -2\frac{J}{J+1}\frac{<\hat{S}_z><\hat{V}_{PT}>}{\Delta E}$$

energy splitting of parity doublet

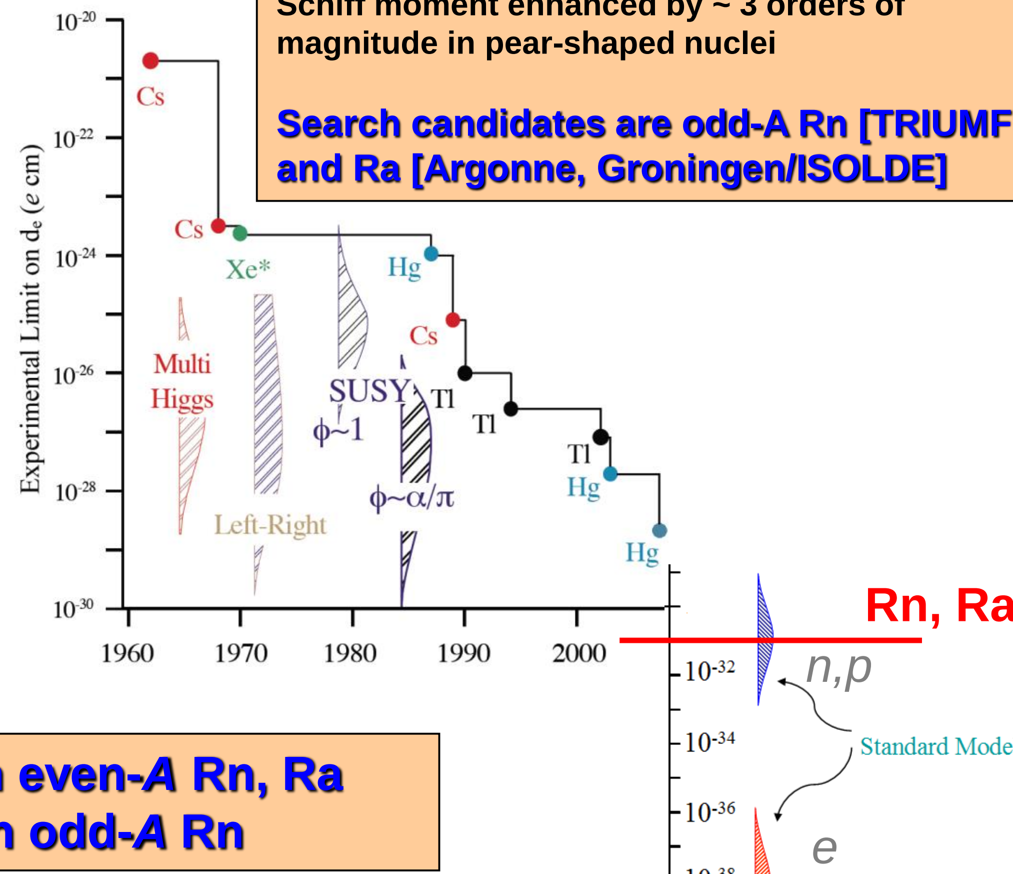


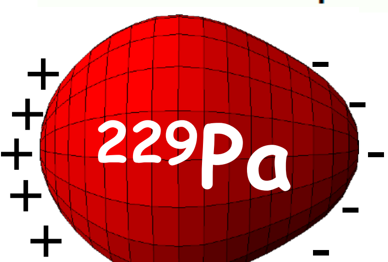
J Dobaczewski (Trento, 2010)



Schiff moment enhanced by ~ 3 orders of magnitude in pear-shaped nuclei

Search candidates are odd-A Rn [TRIUMF] and Ra [Argonne, Groningen/ISOLDE]



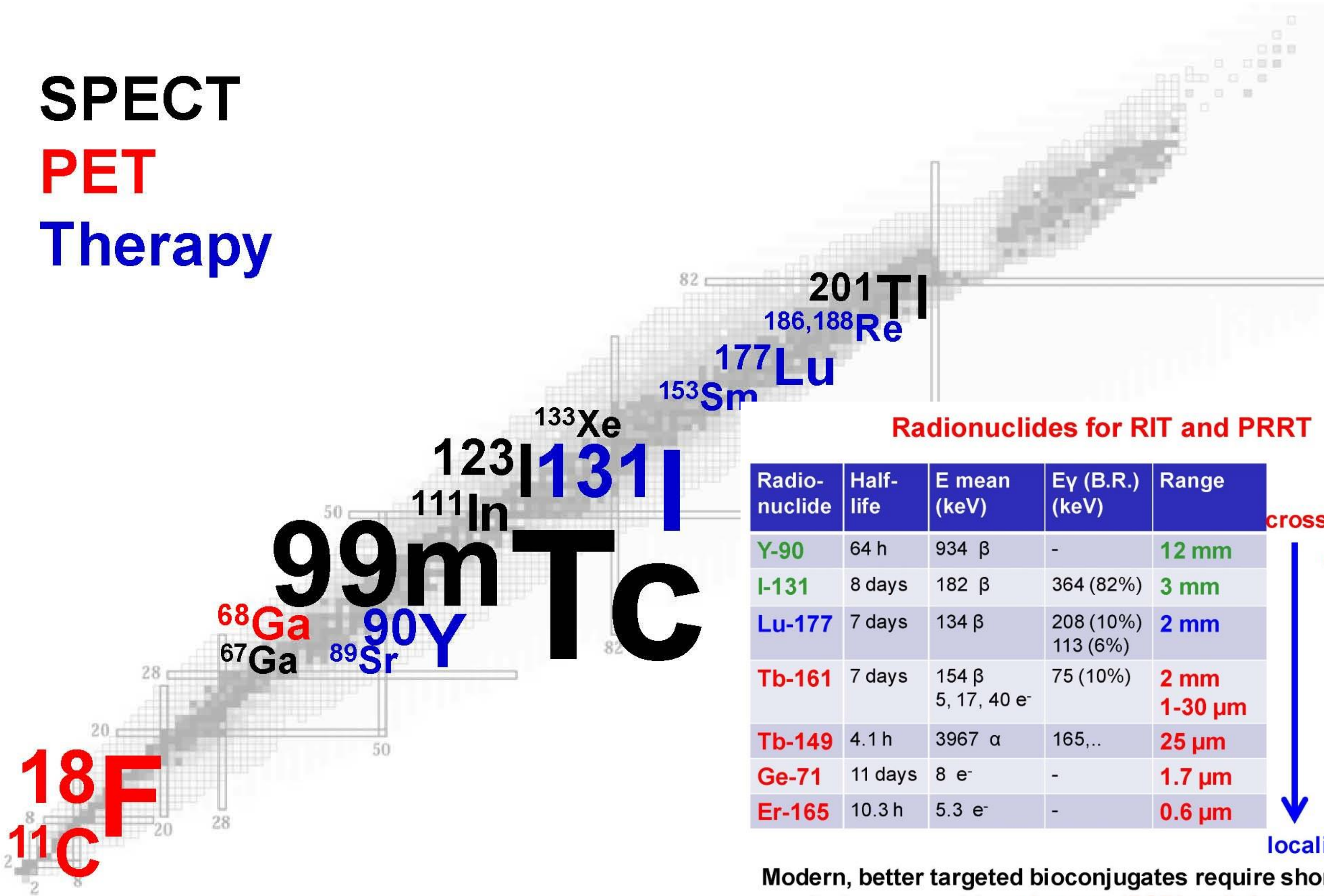


Measure: Q_3 in even-*A* Rn, Ra
ΔE in odd-*A* Rn

ONE OF THE CHALLENGES: RADIONUCLEI FOR MEDICINE

The chart of nuclides – nuclear medicine perspective

SPECT
PET
Therapy



Radionuclides for RIT and PRRT

Radio-nuclide	Half-life	E mean (keV)	Eγ (B.R.) (keV)	Range
Y-90	64 h	934 β	-	12 mm
I-131	8 days	182 β	364 (82%)	3 mm
Lu-177	7 days	134 β	208 (10%) 113 (6%)	2 mm
Tb-161	7 days	154 β 5, 17, 40 e⁻	75 (10%)	2 mm 1-30 µm
Tb-149	4.1 h	3967 α	165,..	25 µm
Ge-71	11 days	8 e⁻	-	1.7 µm
Er-165	10.3 h	5.3 e⁻	-	0.6 µm

cross-fire ↓ localized

Established isotopes

Emerging isotopes

R&D isotopes: supply-limited!

Modern, better targeted bioconjugates require shorter-range radiation ⇒ need for adequate (R&D) radioisotope supply.

Europe/Rome English Login

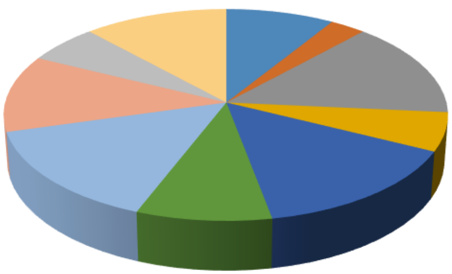
Second SPES International Workshop

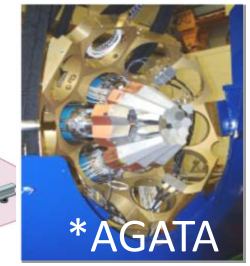
26-28 May 2014 *INFN Laboratori Nazionali di Legnaro*
Europe/Rome timezone

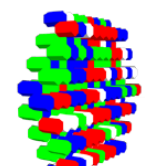
Presented 37 Letters of Intents

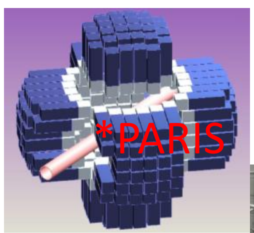
SPES2010 Workshop
(LNL- November 15th-17th, 2010)
24 LoI's for reaccelerated exotic beams

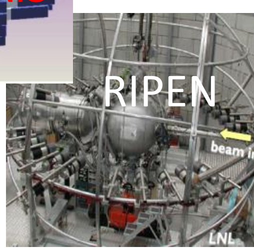
SPES LOIs Topics

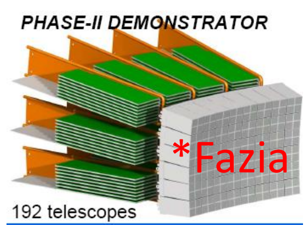




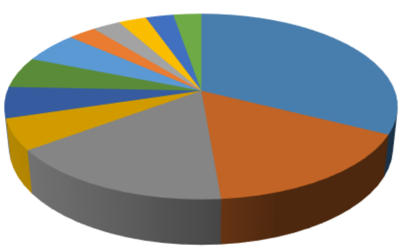


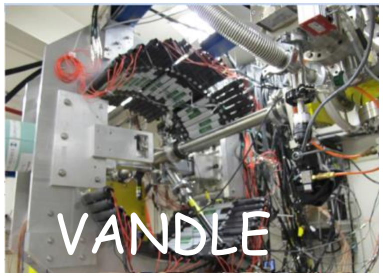


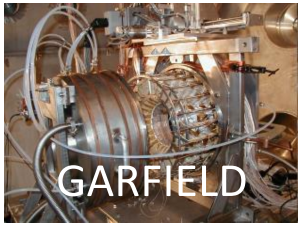




SPES LOIs Spokespersons







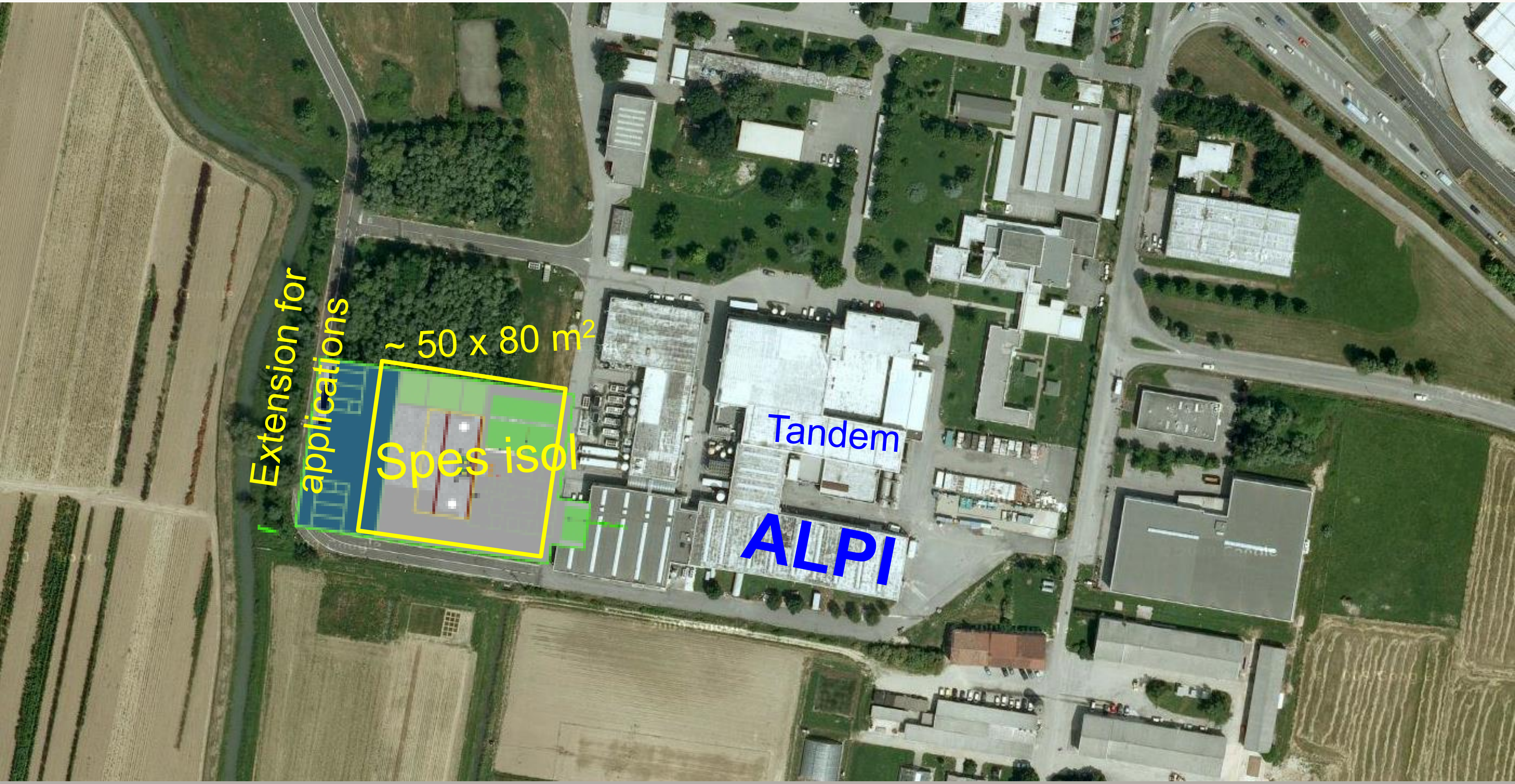
LOIs at ISOL Facilities

	SPES	SPIRAL2 Phase 2	HIE-ISOLDE
Decay Studies	4	20	Not Applicable
Elastic	2	4	3
COULEX	7	2	13
Transfer	8 (3HI)	7	16
Deep Inelastic/ MNTR	5	1	0
Fusion/Fission	11	3	2
New instrumentation	4	NA	5
Astrophysics	3	6	4

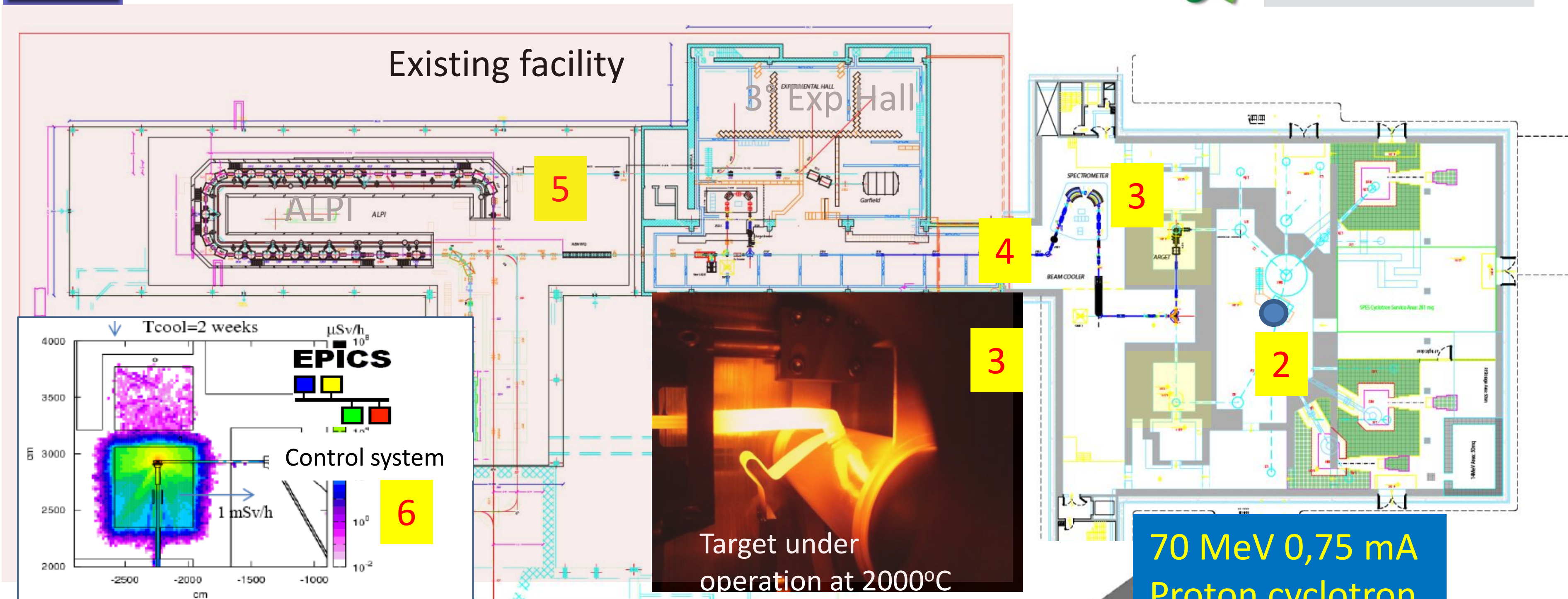
The LNL area

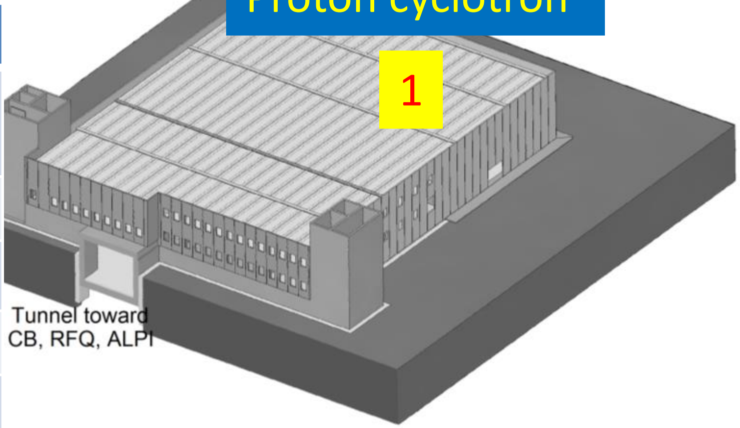
SC_LINAC ALPI & TANDEM XTU 16MV
SPES
INFN-Laboratori Nazionali di Legnaro
200m
Chioggia-Venice
Van de Graaff Accel. 7MV & 2MV
Padova
AREA:
more than 200.000 m²
1/3 present situation **occupied**
2/3 **available** for upgradings

SPES Facility @ LNL



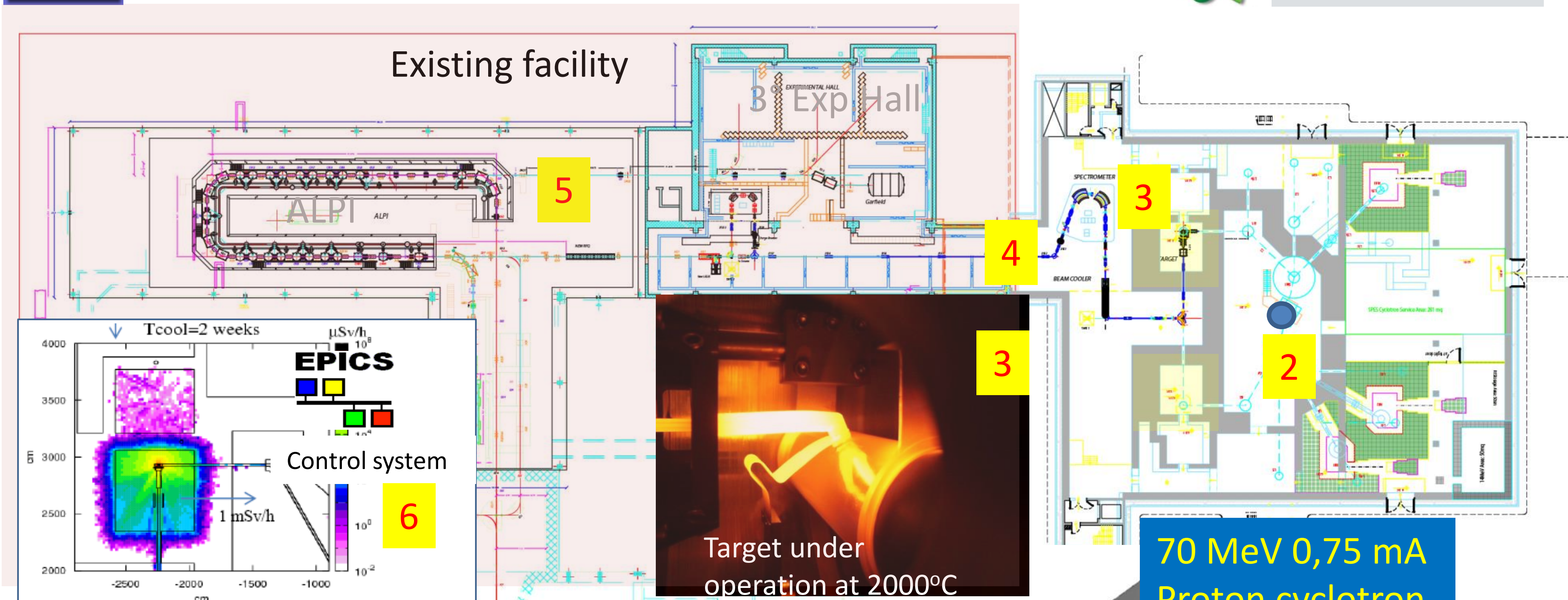
SPES Facility Layout

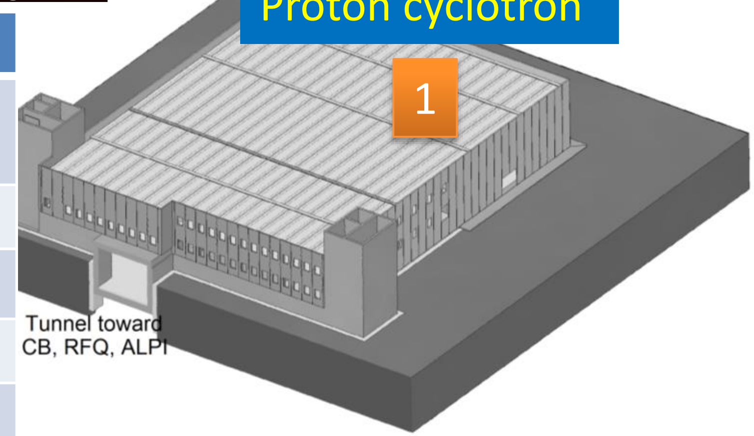




	SPES sub-systems
1	Building and infrastructures with 2 ISOL bunkers for radioactive beam and application area for radioisotopes and neutrons
2	Cyclotron 70 MeV protons with 2 independent exits
3	ISOL UCx target designed for 10^{13} f/s
4	Beam transport with High Resolution Mass Separation
5	Reacceleration with ALPI superconducting linac (10A MeV A=130)
6	Radioprotection, safety & controls

SPES Facility Layout





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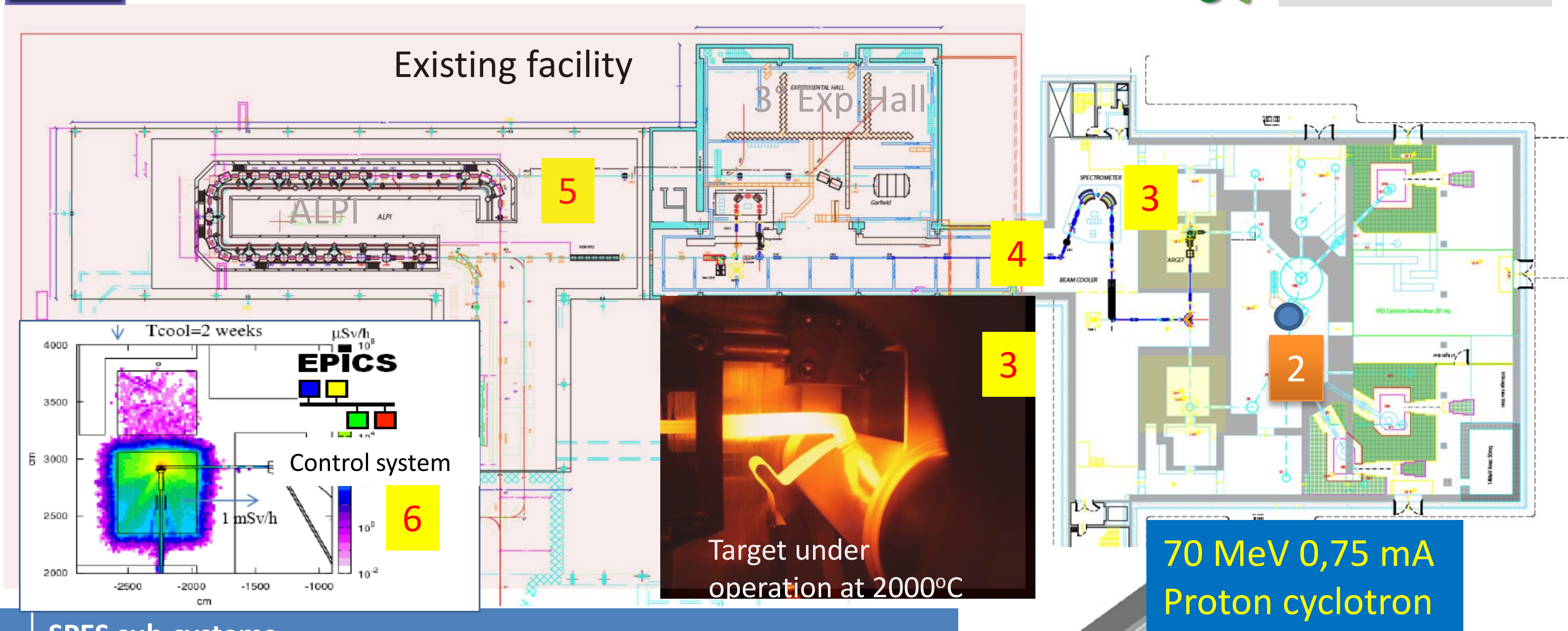
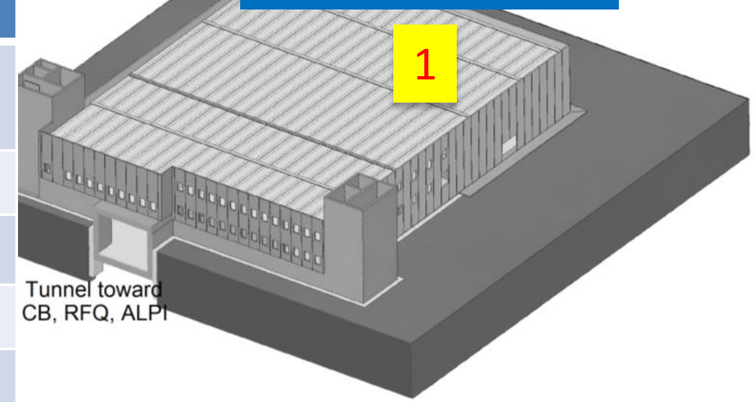
http://www.lnl.infn.it/~gestimp/speslive.jpg

SPES Facility Layout





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Cyclotron test at BEST Company site (Ottawa)

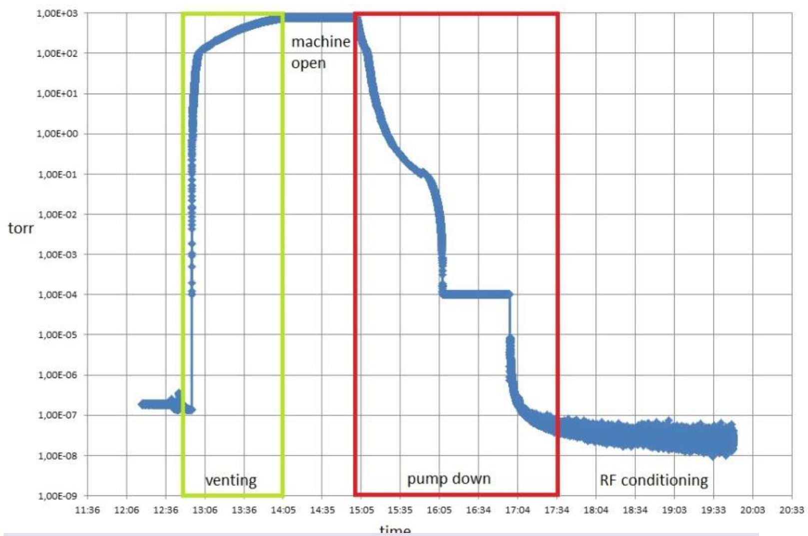
Main Parameters

Accelerator Type	Cyclotron AVF 4 sectors
Particle	**Protons (H^- accelerated)**
Energy	**Variable within 30-70 MeV**
Max Current Accelerated	**750 µA** (52 kW max beam power)
Available Beams	**2 beams at the same energy** (upgrade to different energies)
Max Magnetic Field	1.6 Tesla
RF frequency	56 MHz, 4^{th} harmonic mode
Ion Source	Multicusp H^- I=15 mA, Axial Injection
Dimensions	Φ=4.5 m, h=1.5 m
Weight	150 tons

Cyclotron assembled and operated at 1MeV

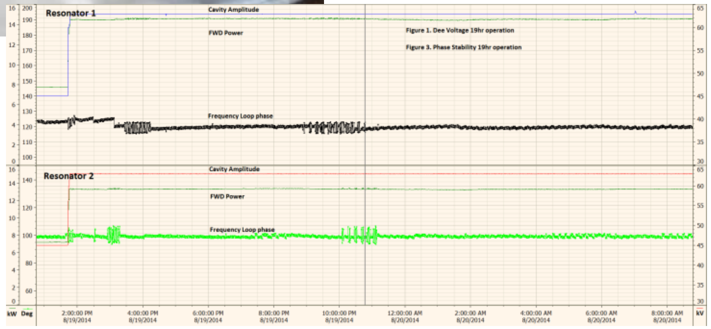
A.Lombardi

Final Fatory Acceptance Test in Ottawa next week



Succesful vacuum test: below 10^{-7} Torr after 2hours pumping

Both cavities with 62 kV voltage and 14 kW FWD RF power each. Amplitude Stability within ± $2.5*10^{-5}$

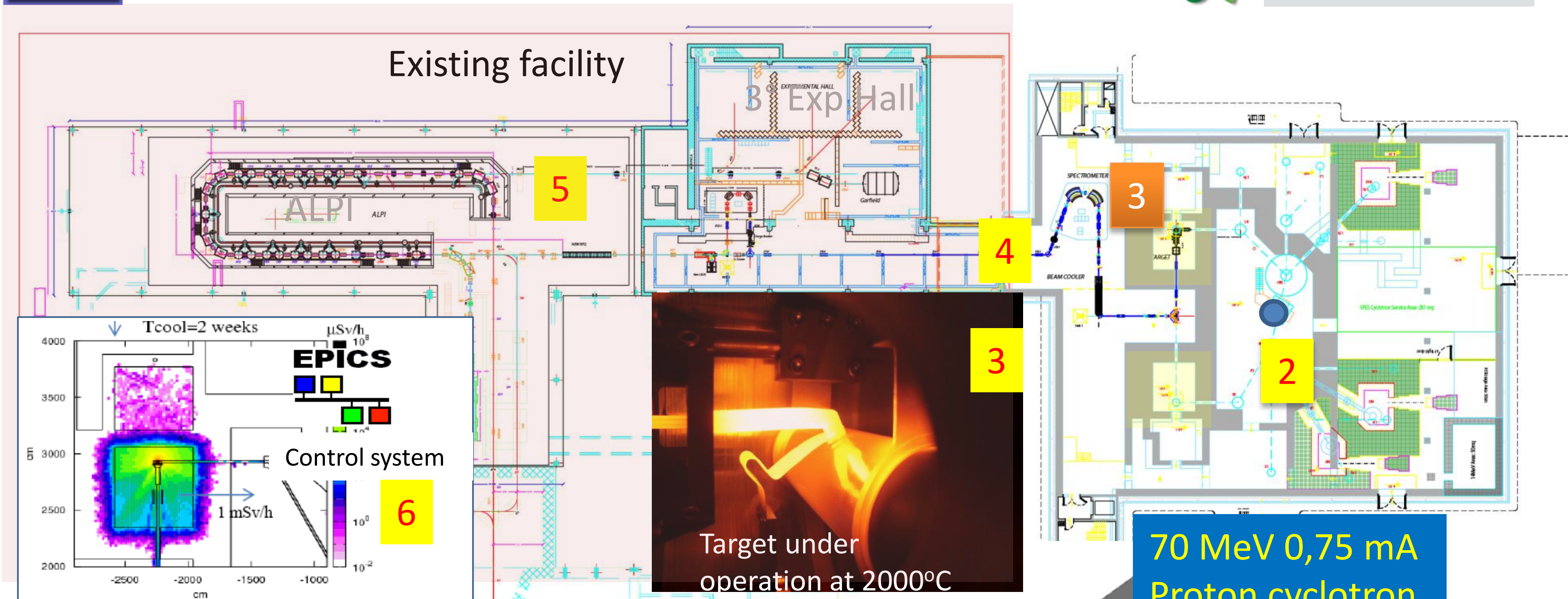


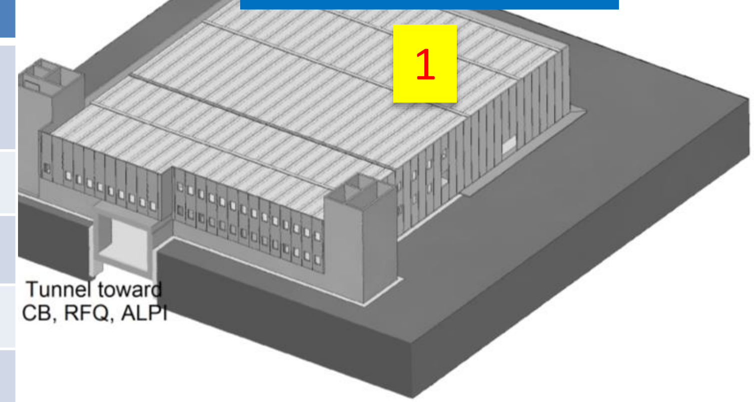
Critical point: maximum current of 800 microA accelerated up to 1 MeV

If test is succesfull, the cyclotron will be dismounted and the transfer to Italy will start.

Cyclotron at LNL: February 28, 2015

SPES Facility Layout





	SPES sub-systems
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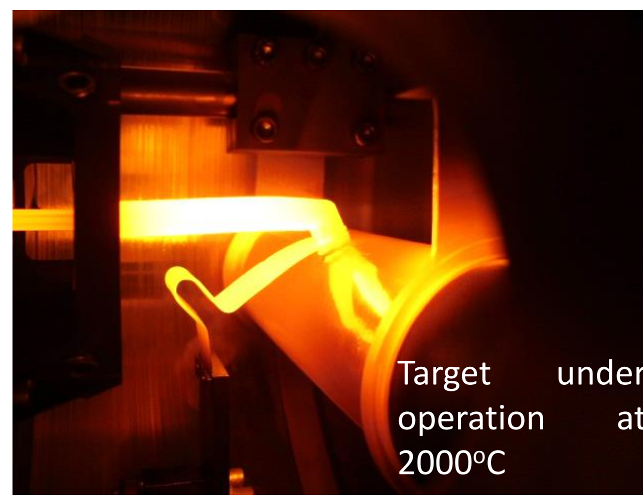
6	Radioprotection, safety & controls

Technical highlights: the production target

SPES DIRECT TARGET CONCEPT to operate with **8 kW** proton beam

(A. Andrighetto et al.)

- Direct Target carefully designed to reach **10^{13} fissions/s** with **8 kW** proton beam (thermo-mechanical considerations);
- **In beam test** performed at **iThemba lab (South Africa)** on May 2014;
- Prototype under operation.
- Fully developed **front-end** following ISOLDE design;



Target Power test @ iThemba Lab

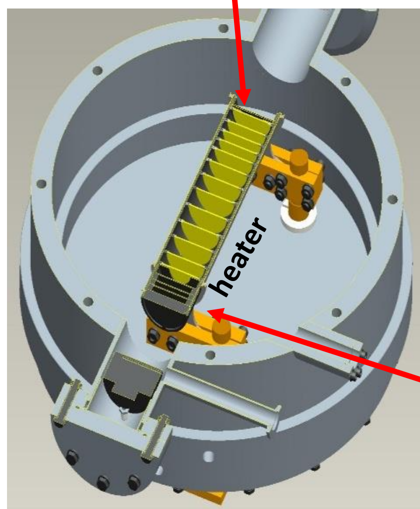
SPES target **in-beam power test** (SiC target)

Heater power compensated by proton beam.

- Up to **4 kW proton beam** in target.
- **Stable temperatures**
- **Stable vacuum** (3 10^{-5} mbar)

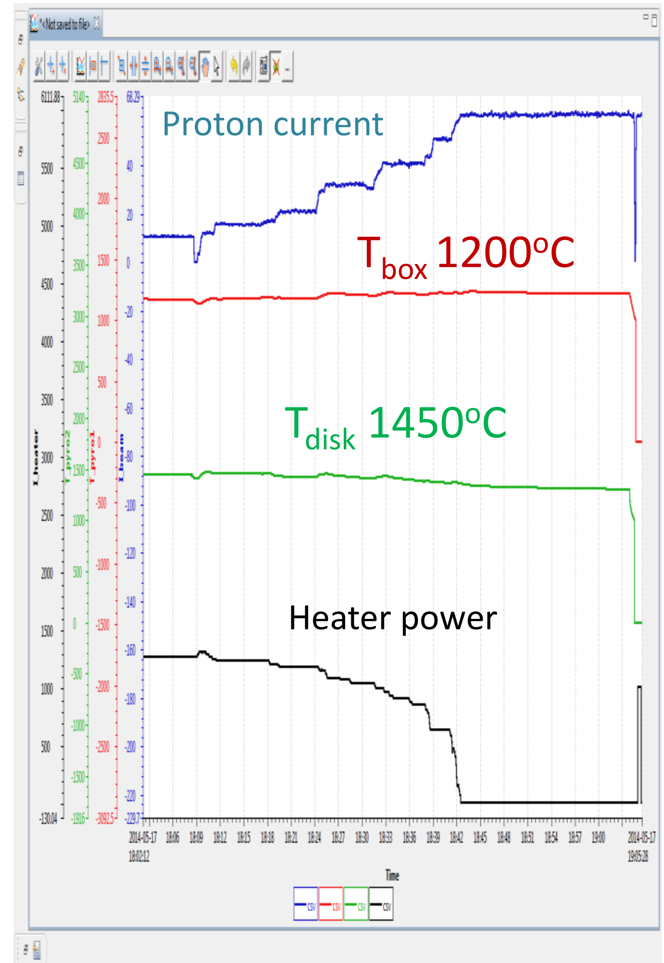
T_{disk}

Proton beam
66MeV 60 μA



T_{box}

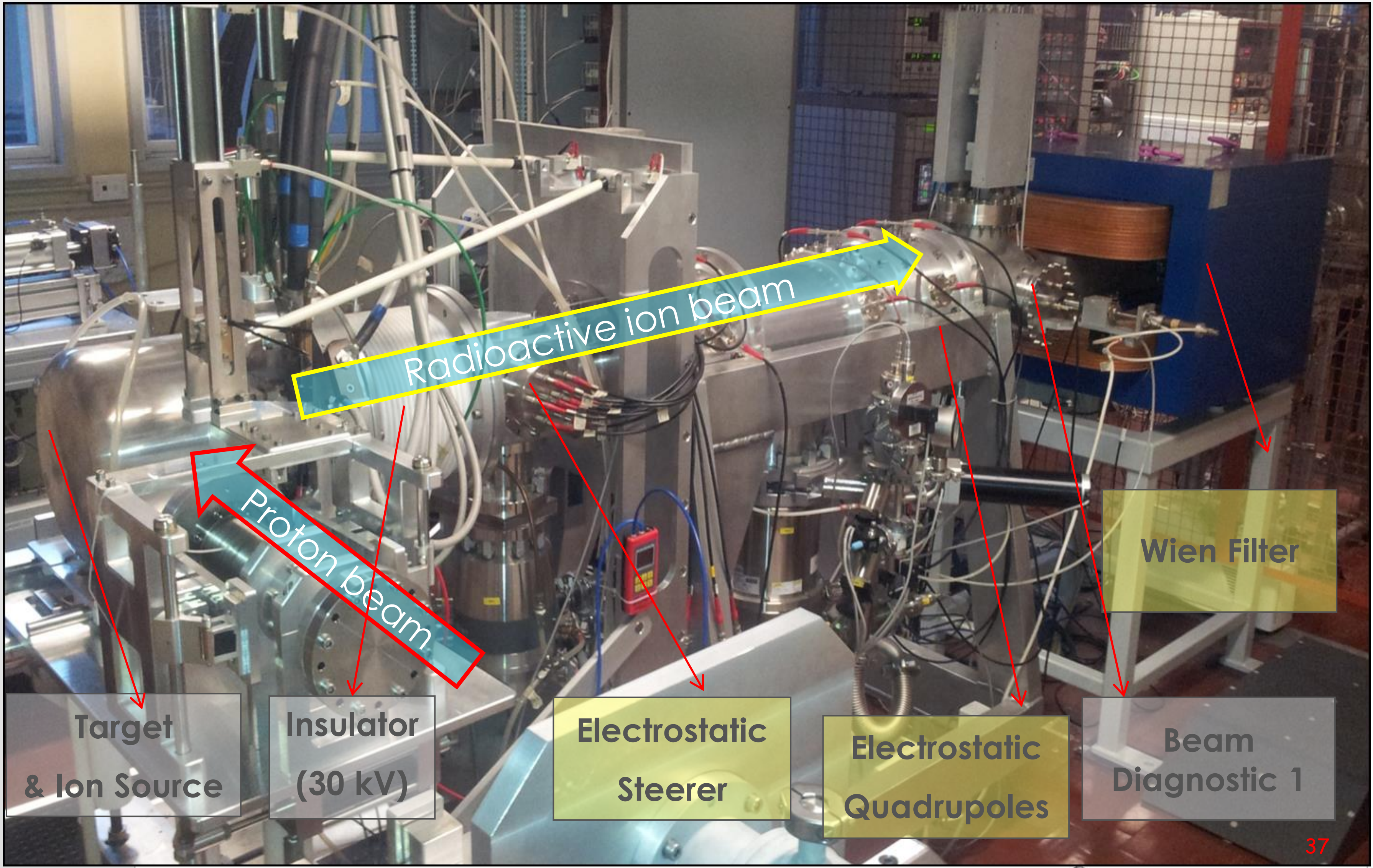
Thanks to Rob, Lowry and all the **iThemba_Labs Cyclotron** staff



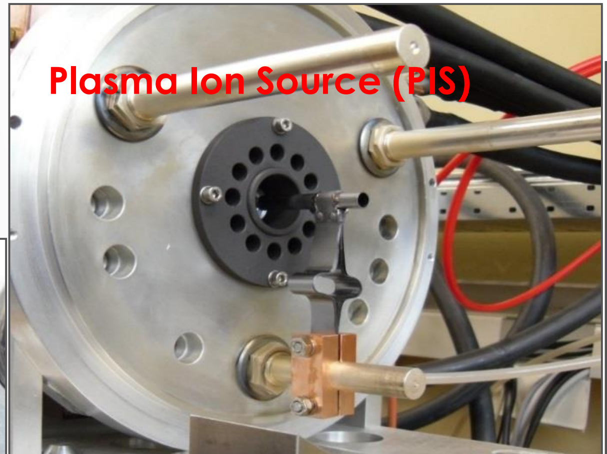
iThemba_Labs, May 17th, 2014

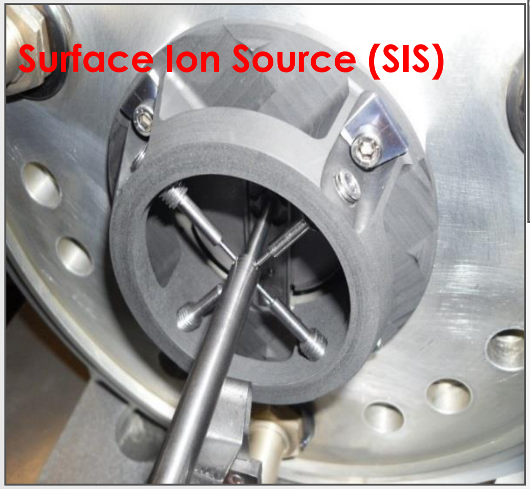
The Front End

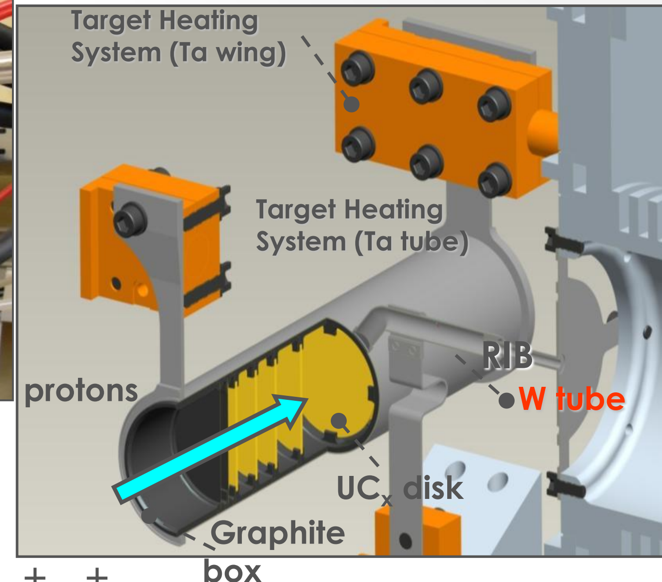
(working since 2010)



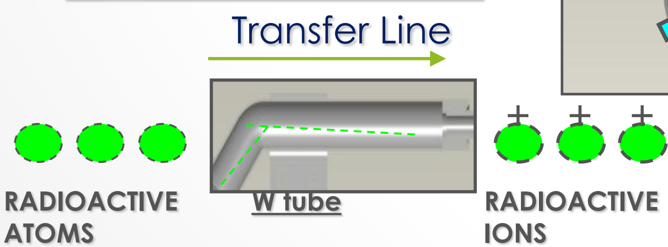
The SPES 1+ Ion Sources

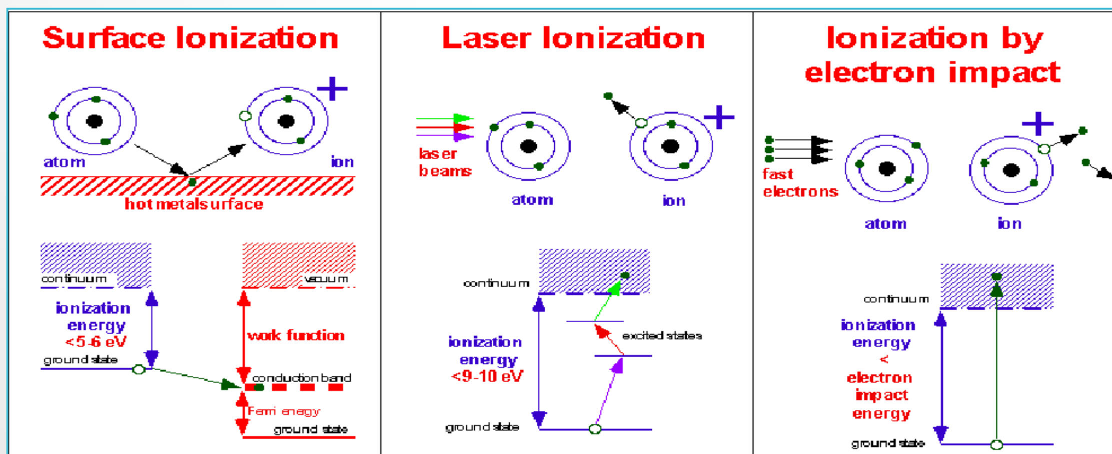




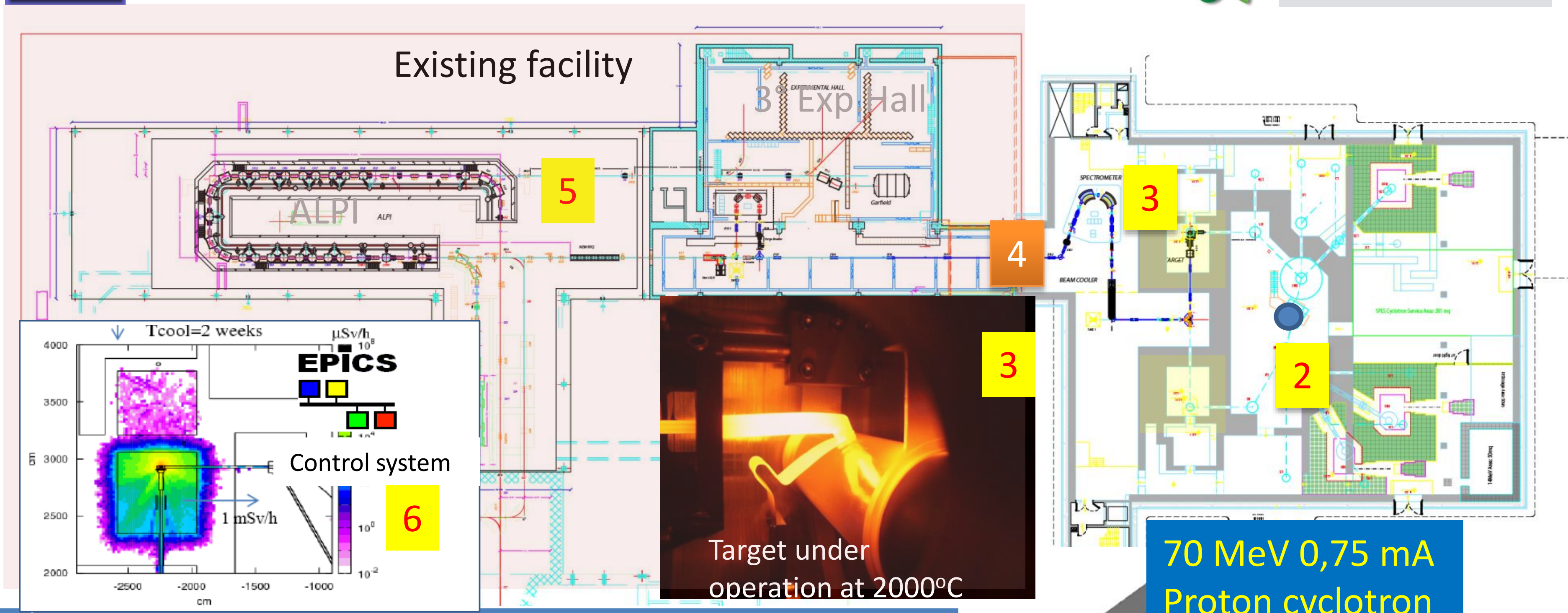


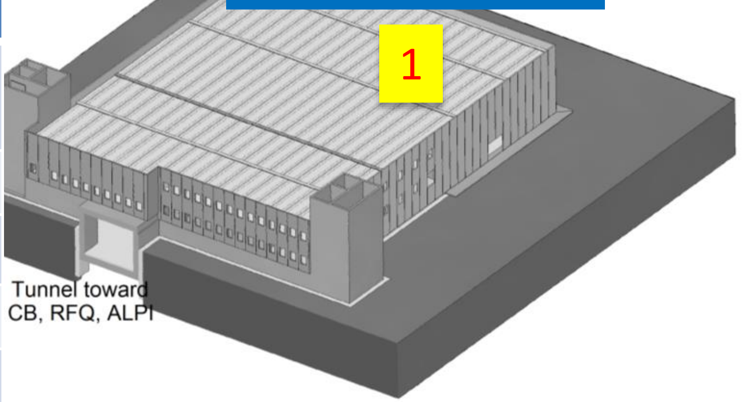
ION SOURCE DEVICE





SPES Facility Layout





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High Resolution Mass Separator & Beam Cooler

L.Calabretta, M.Comunian, A.Russo, L.Bellan

Collaboration SPES – CENBG Bordeaux (SPIRAL2)

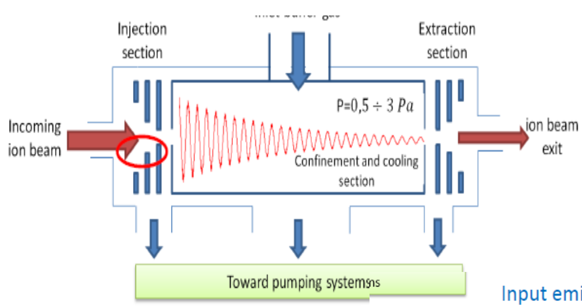
- Scaled-up version of the separator designed by Cary Davids for CARIBU, Argonne
- Mass resolution: 1/40000 (eng. design: 1/25000)

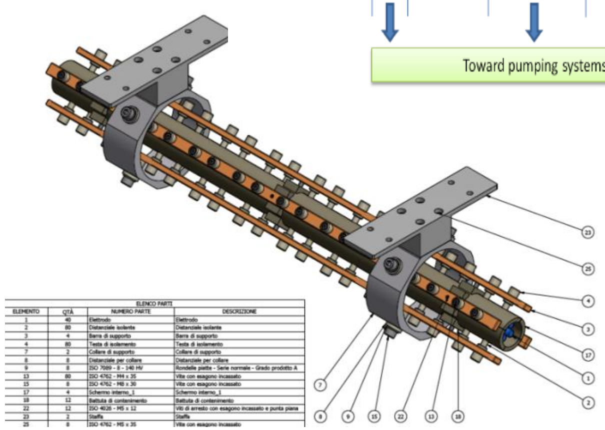
Beam Cooler to match the HRMS input requirements

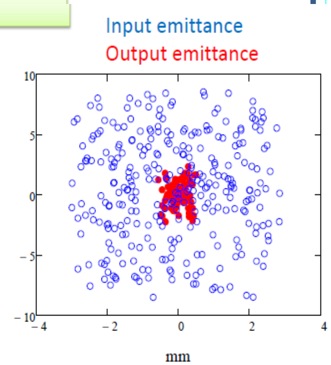
COOLBEAM experiment financed by INFN-CSN5, 2012→2015

Collaboration: LNL-LNS, Mi bicocca

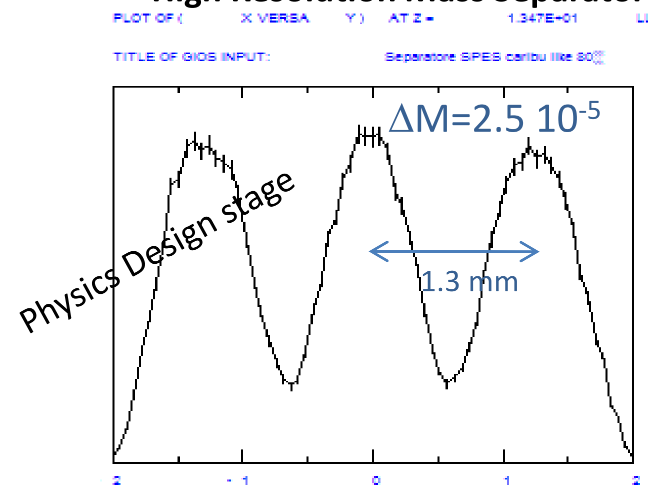
M.Maggiore

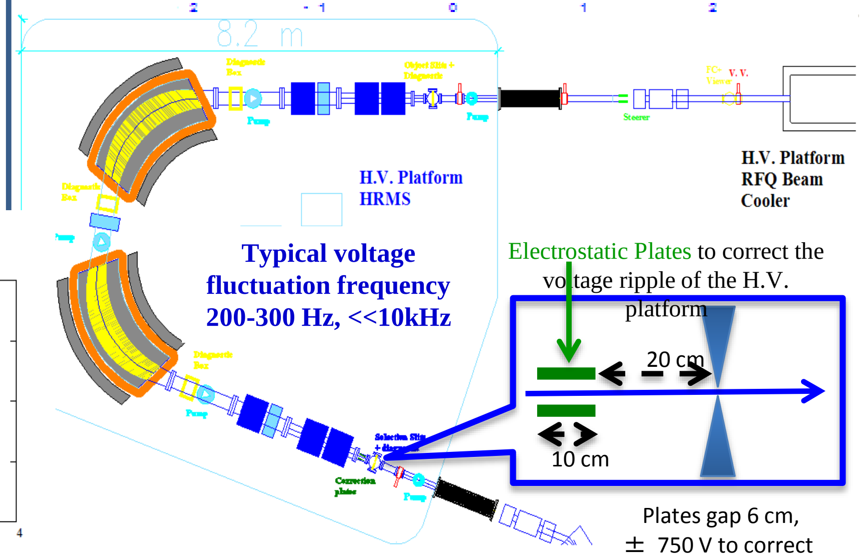






High Resolution Mass Separator

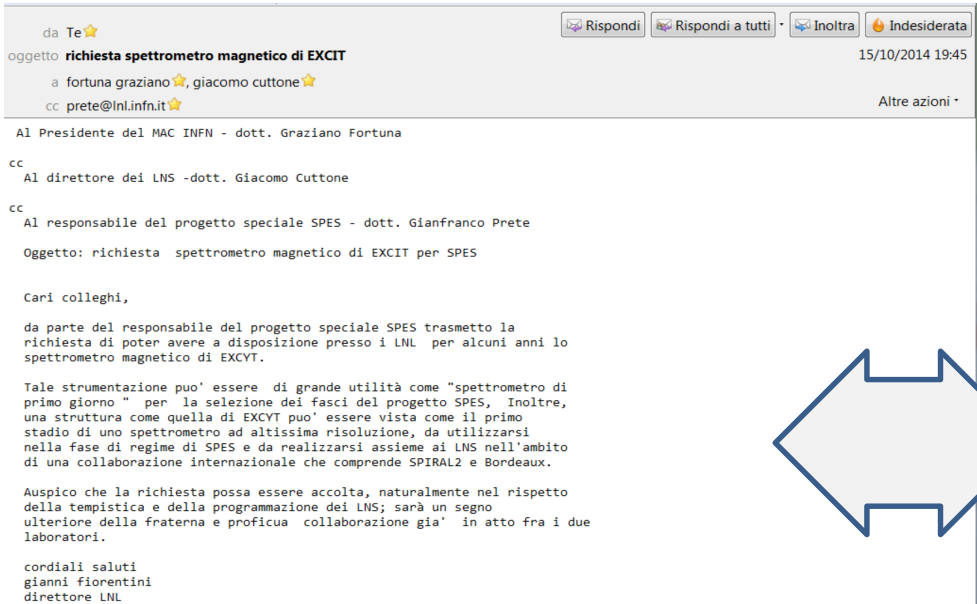




Plates gap 6 cm, ± 750 V to correct ± 5 V platform ripple

High Resolution Mass Spectrometer

INFN-LNS


da Te
oggetto **richiesta spettrometro magnetico di EXCIT**
a fortuna graziano, giacomo cuttone
cc prete@lnl.infn.it
15/10/2014 19:45
Rispondi | Rispondi a tutti | Inoltra | Indesiderata | Altre azioni

Al Presidente del MAC INFN - dott. Graziano Fortuna

cc
Al direttore dei LNS -dott. Giacomo Cuttone

cc
Al responsabile del progetto speciale SPES - dott. Gianfranco Prete

Oggetto: richiesta spettrometro magnetico di EXCIT per SPES

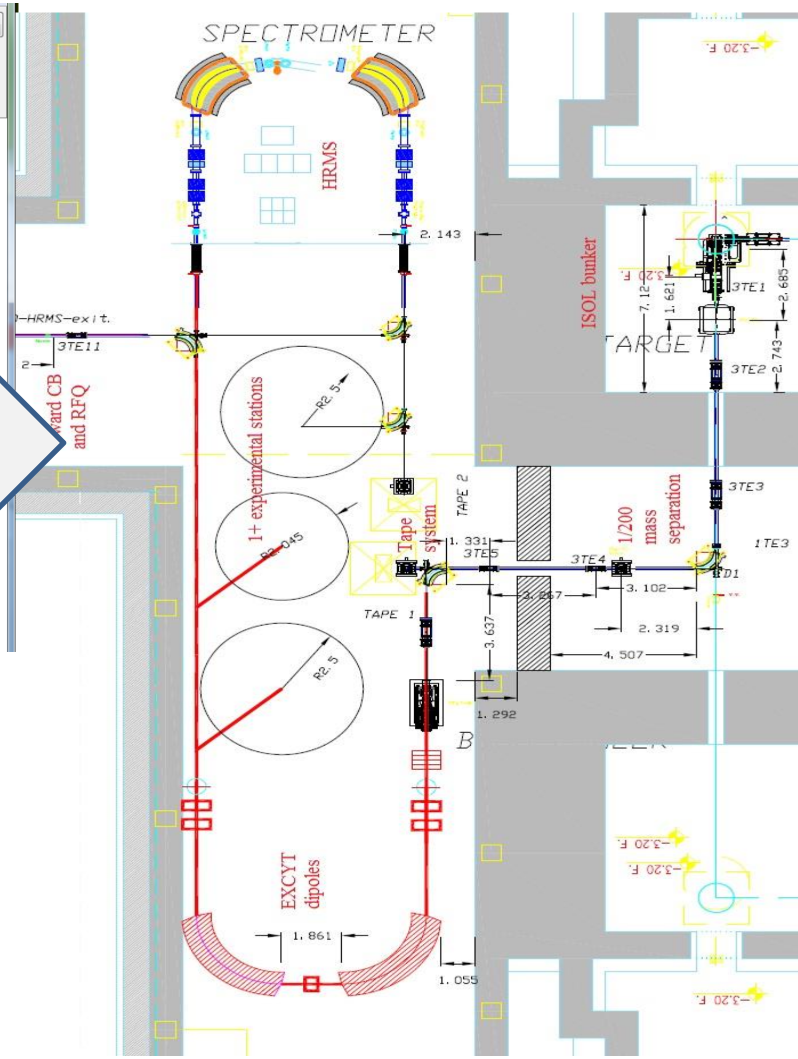
Cari colleghi,

da parte del responsabile del progetto speciale SPES trasmetto la richiesta di poter avere a disposizione presso i LNL per alcuni anni lo spettrometro magnetico di EXCYT.

Tale strumentazione puo' essere di grande utilità come "spettrometro di primo giorno " per la selezione dei fasci del progetto SPES, Inoltre, una struttura come quella di EXCYT puo' essere vista come il primo stadio di uno spettrometro ad altissima risoluzione, da utilizzarsi nella fase di regime di SPES e da realizzarsi assieme ai LNS nell'ambito di una collaborazione internazionale che comprende SPIRAL2 e Bordeaux.

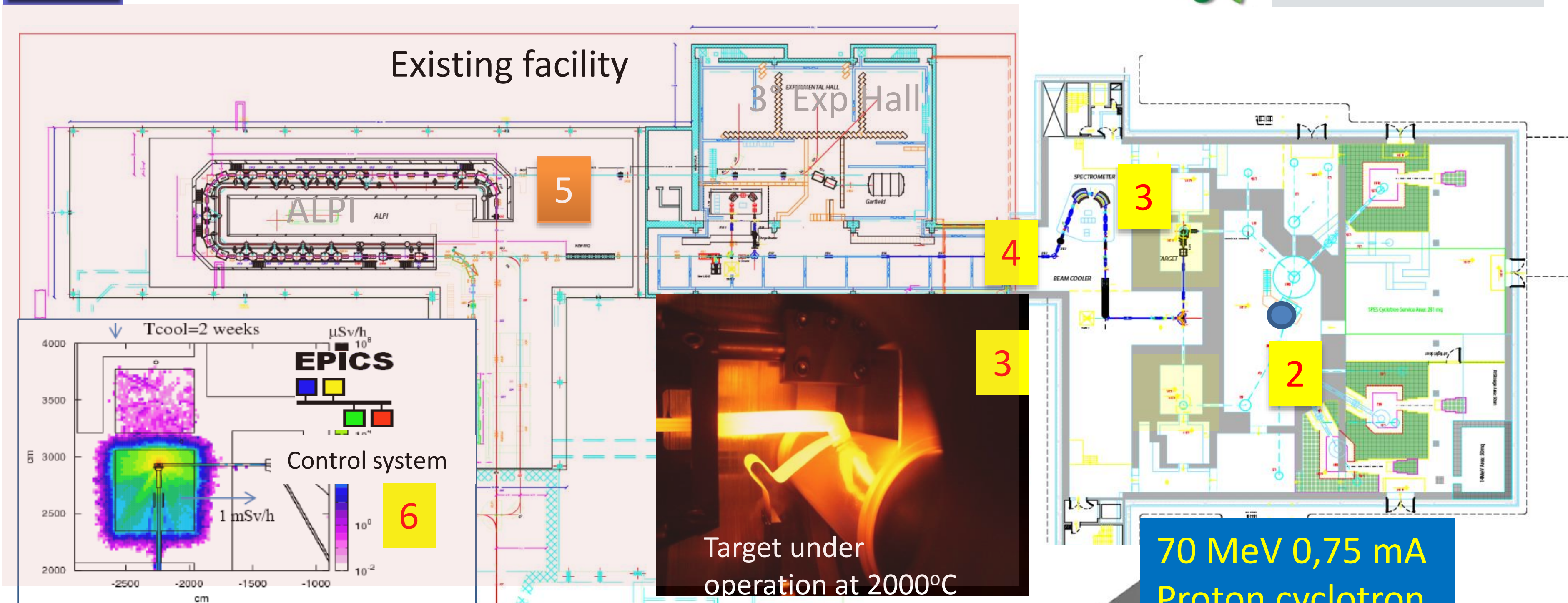
Auspico che la richiesta possa essere accolta, naturalmente nel rispetto della tempistica e della programmazione dei LNS; sarà un segno ulteriore della fraterna e proficua collaborazione gia' in atto fra i due laboratori.

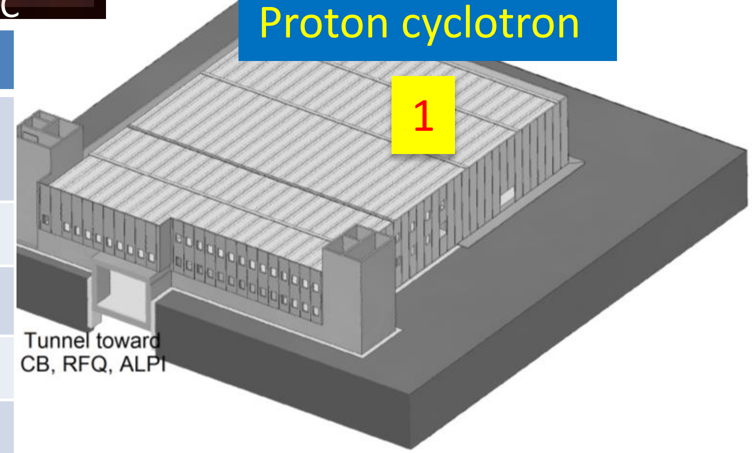
cordiali saluti
gianni fiorentini
direttore LNL



CNRS-CENBG

SPES Facility Layout





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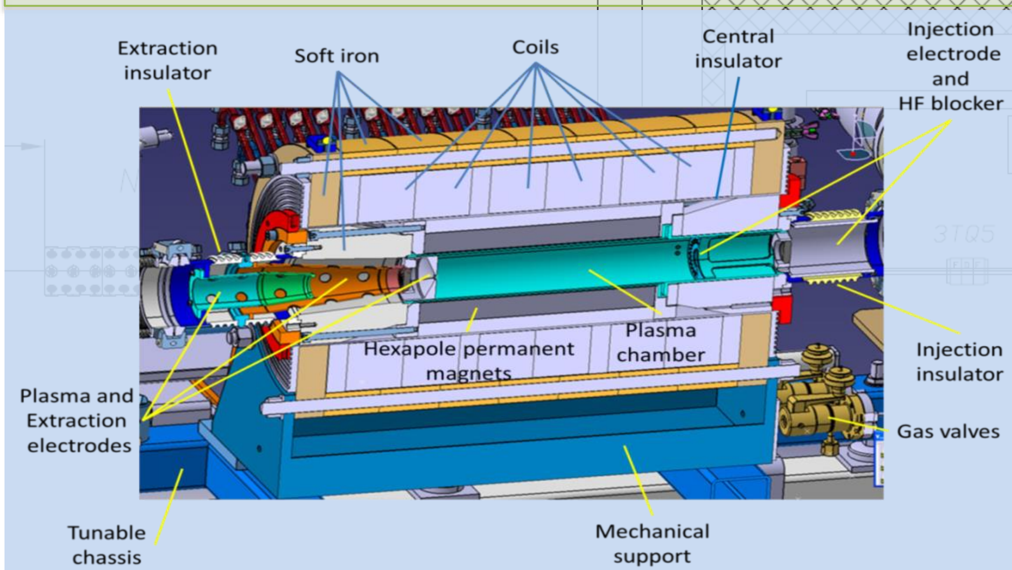
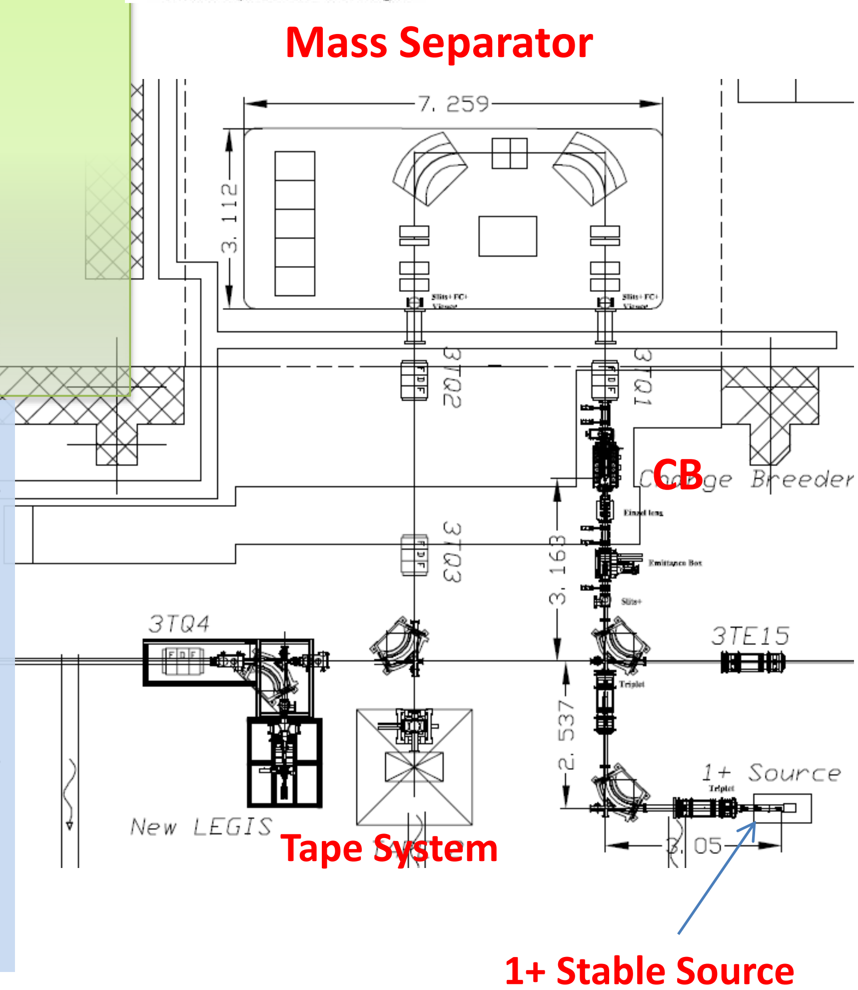
Exotic Beam reacceleration

Collaboration with LPSC (Grenoble) for the SPES Charge Breeder

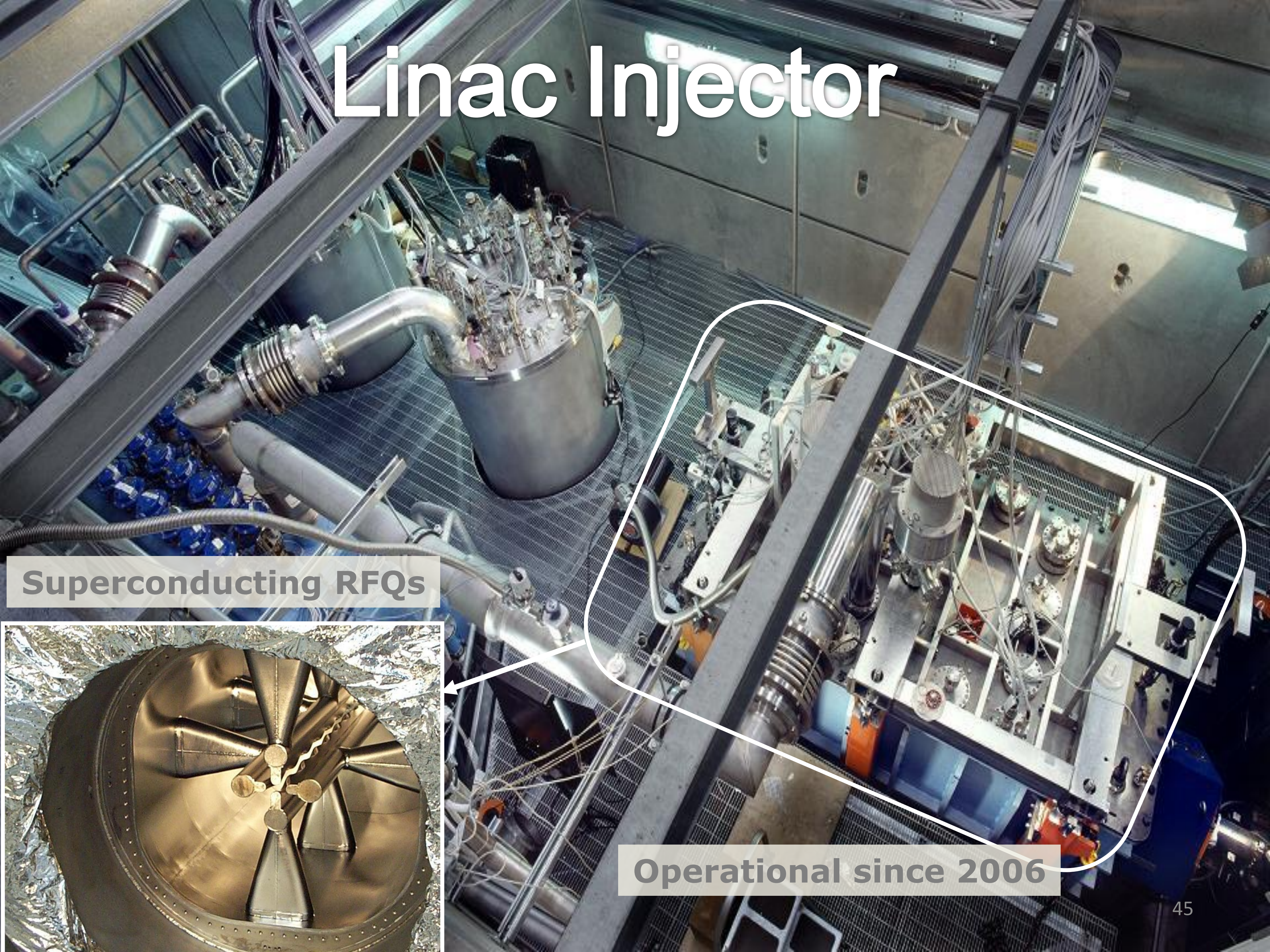
The development of an Upgraded PHOENIX booster is Part of a MoU in the frame of the European Associated Laboratories (LEA-Colliga) with GANIL.
(In exchange: development of SPIRAL2 n-converter by INFN)
Project and construction by LPSC_Grenoble

- 2010 Preliminary measurements
- 2011 Conceptual design and schedule definition
- 2012 Design
- 2013 Agreement definition
- 2014 Construction
- 2015 Commissioning



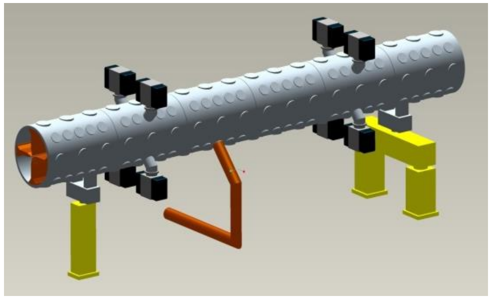


Linac Injector

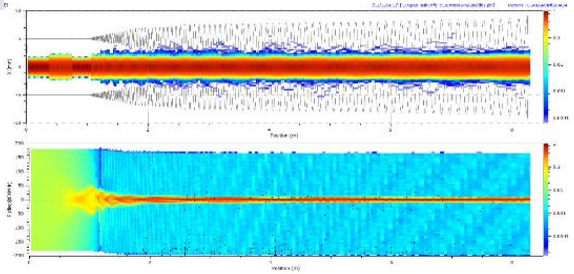


Exotic Beam reacceleration: room temperature RFQ

Mechanical layout of the **RFQ**

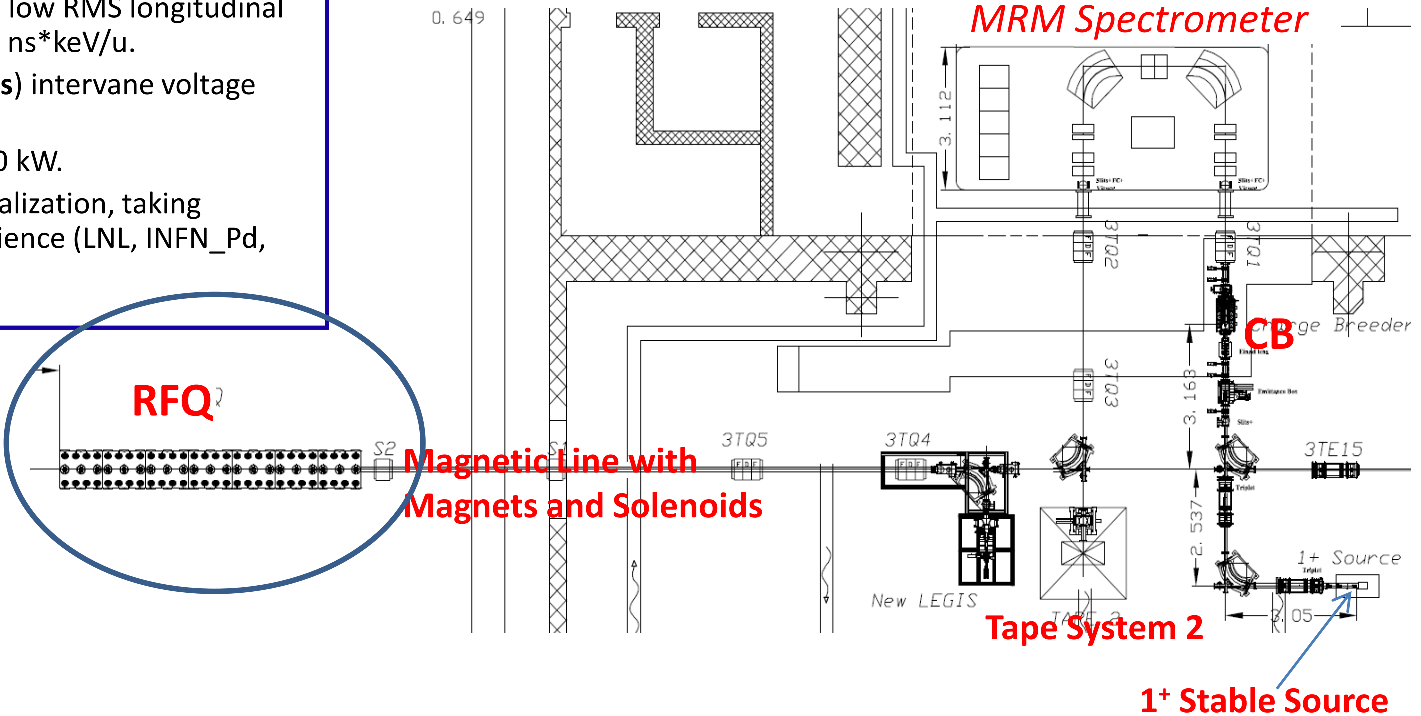


Physics design

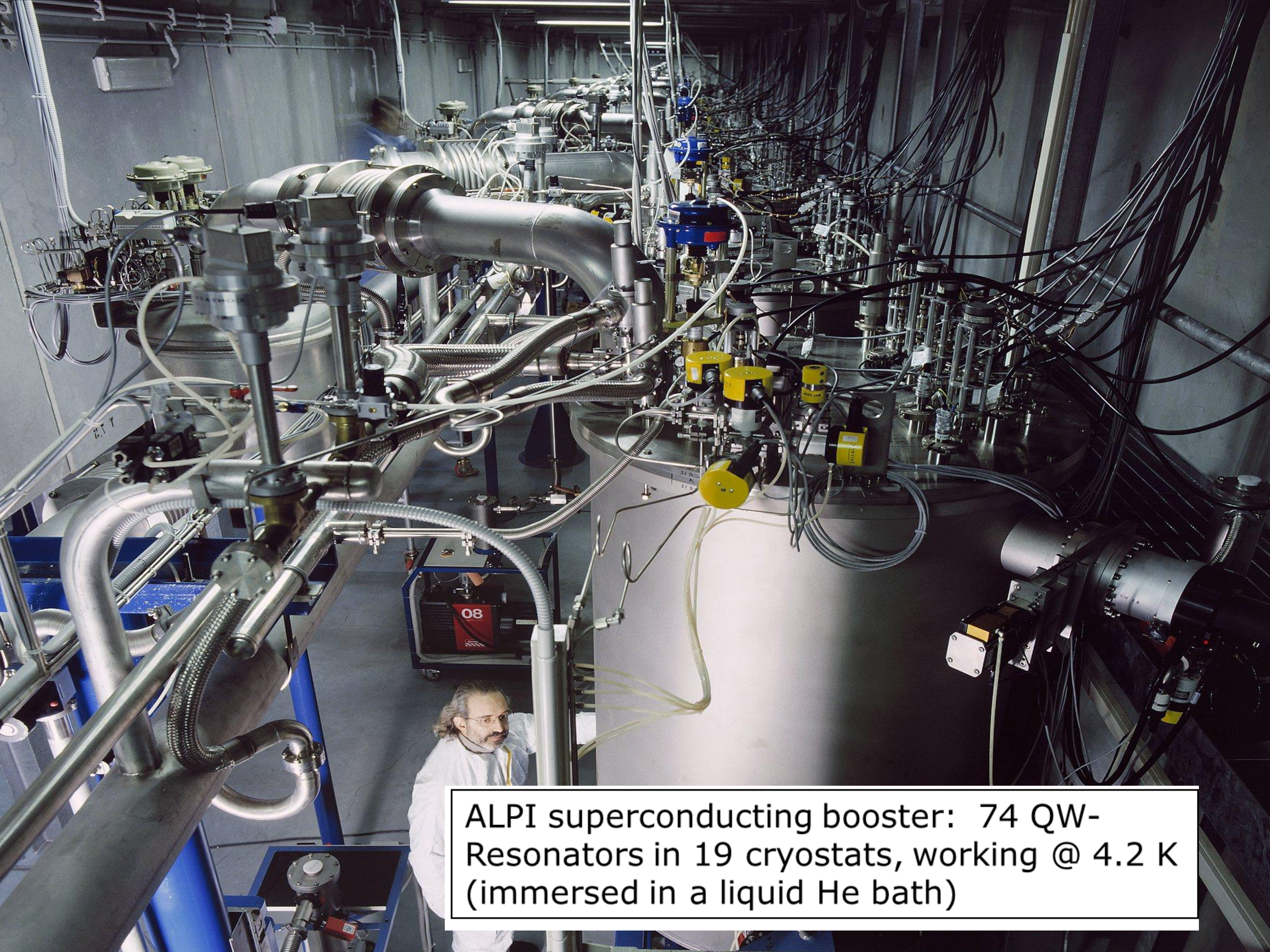


High power RF Coupler 200kW 100% duty cycle

- Energy 5.7 → 727.3 [β=0.0395] KeV/A (A/q=7)
- Frequency 80 MHz
- Beam transmission >95%, low RMS longitudinal emittance at output: 0.15 ns*keV/u.
- Length 695 cm (**7 modules**) intervane voltage 63.8 – 85.8 kV
- RF power (four vanes) 100 kW.
- Mechanical design and realization, taking advantage of IFMIF experience (LNL, INFN_Pd, Bo, To).

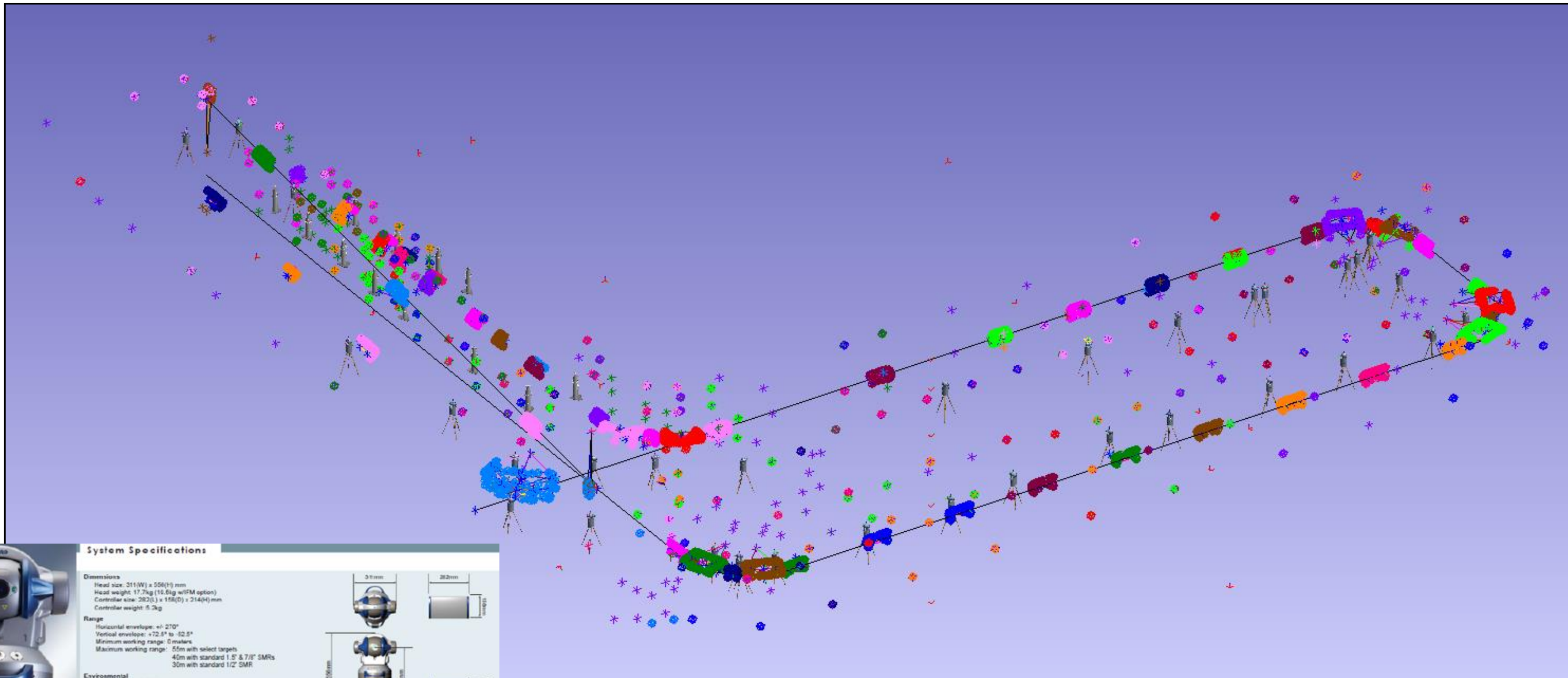


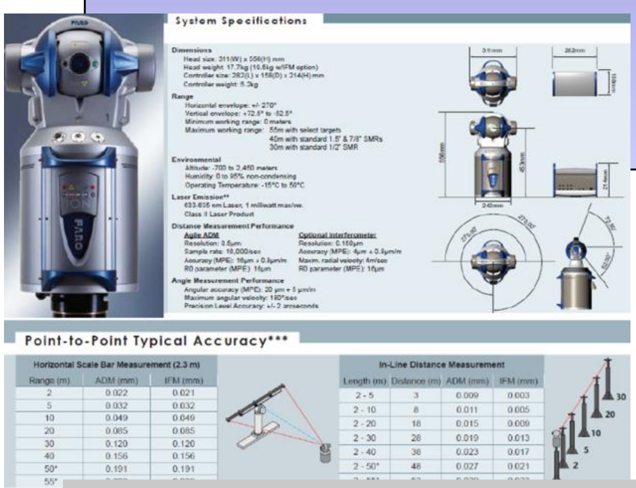
E. Fagotti, A. Pisent



ALPI superconducting booster: 74 QW-Resonators in 19 cryostats, working @ 4.2 K (immersed in a liquid He bath)

OUTPUT OF Fiducialization OF ALL MAGNETS IN ALPI





System Specifications

Dimensions
Head size: 311(W) x 556(H) mm
Head weight: 17.7kg (16.6kg w/IFM option)
Controller size: 282(L) x 158(D) x 214(H) mm
Controller weight: 5.3kg

Range
Horizontal envelope: +/- 270°
Vertical envelope: +72.5° to -52.5°
Minimum working range: 0 meters
Maximum working range: 55m with select targets
40m with standard 1.5" & 7/8" SMRs
30m with standard 1/2" SMR

Environmental
Altitude: -700 to 2,450 meters
Humidity: 0 to 95% non-condensing
Operating Temperature: -15°C to 50°C

Laser Emission**
633-635 nm Laser, 1 milliwatt max/cw.
Class II Laser Product

Distance Measurement Performance

Agile ADM
Resolution: 0.5µm
Sample rate: 10,000/sec
Accuracy (MPE): 16µm + 0.8µm/m
R0 parameter (MPE): 16µm

Optional Interferometer:
Resolution: 0.160µm
Accuracy (MPE): 4µm + 0.8µm/m
Maxim. radial velocity: 4m/sec
R0 parameter (MPE): 16µm

Angle Measurement Performance
Angular accuracy (MPE): 20 µm + 5 µm/m
Maximum angular velocity: 180°/sec
Precision Level Accuracy: +/- 2 arcseconds

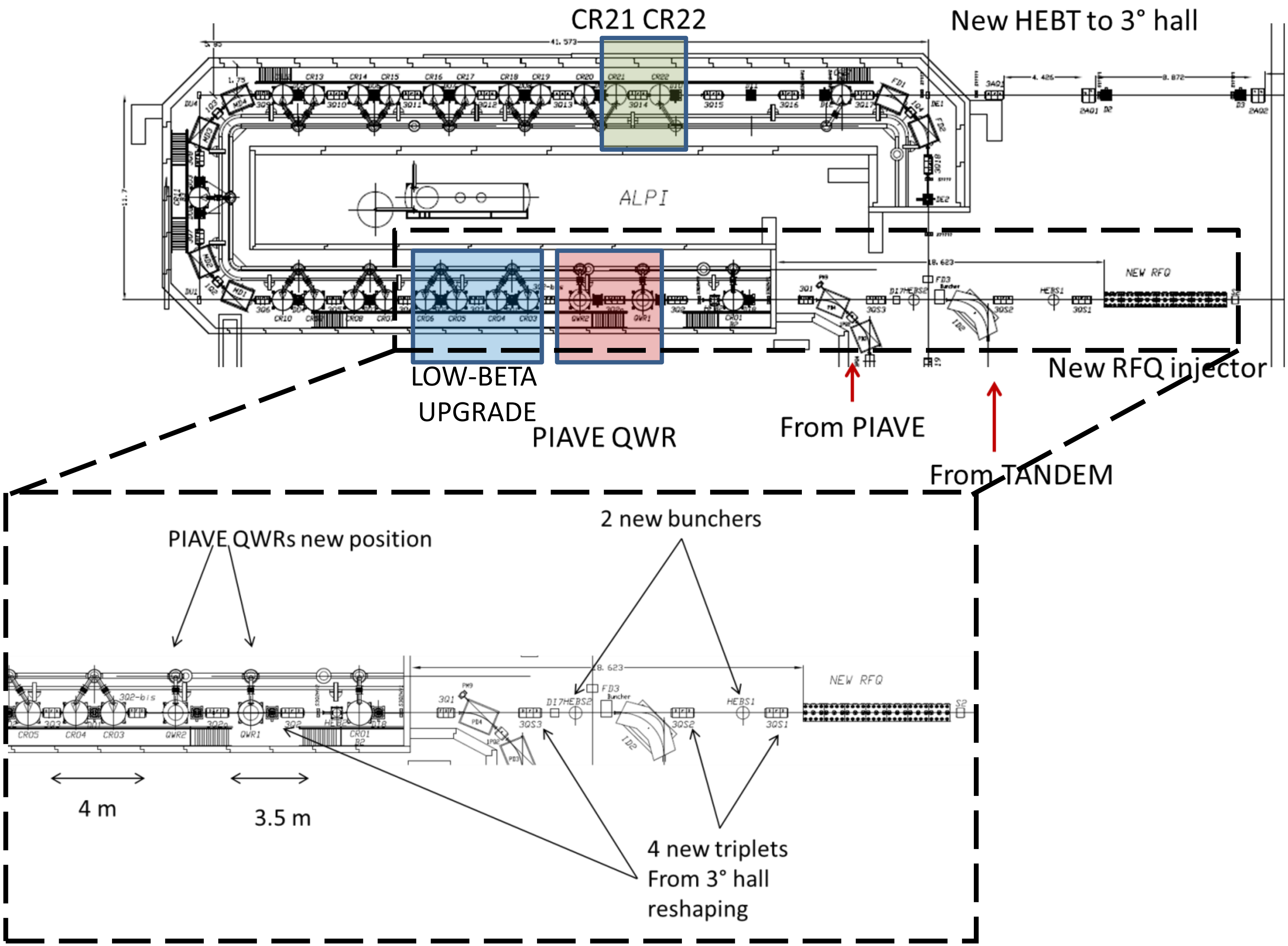
Point-to-Point Typical Accuracy***

Horizontal Scale Bar Measurement (2.3 m)		
Range (m)	ADM (mm)	IFM (mm)
2	0.022	0.021
5	0.032	0.032
10	0.049	0.049
20	0.085	0.085
30	0.120	0.120
40	0.156	0.156
50*	0.191	0.191
55*	[illegible]	[illegible]

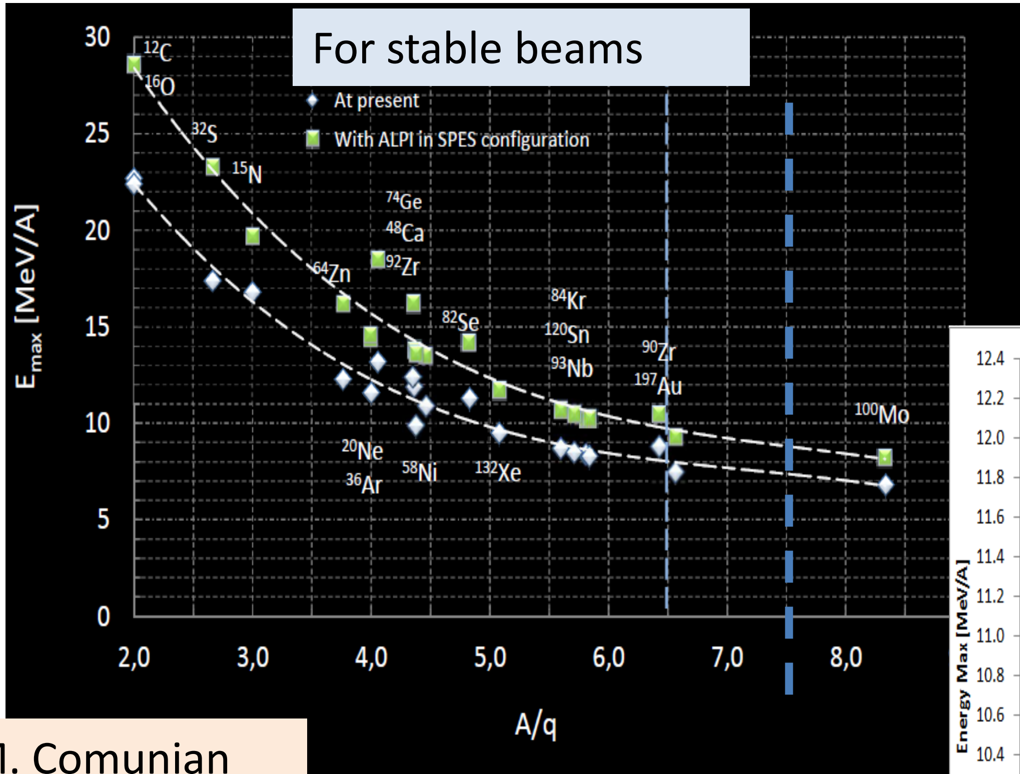
In-Line Distance Measurement			
Length (m)	Distance (m)	ADM (mm)	IFM (mm)
2 - 5	3	0.009	0.003
2 - 10	8	0.011	0.005
2 - 20	18	0.015	0.009
2 - 30	28	0.019	0.013
2 - 40	38	0.023	0.017
2 - 50*	48	0.027	0.021
[illegible]	[illegible]	[illegible]	[illegible]

E. Fagotti et al.

SC Resonator Improvements on ALPI



The Upgraded Alpi post-accelerator

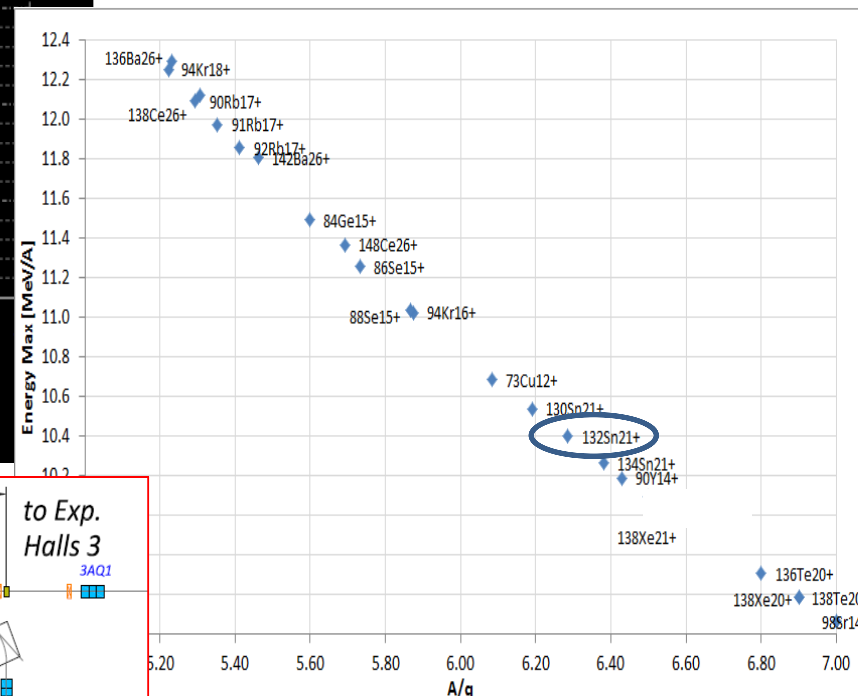


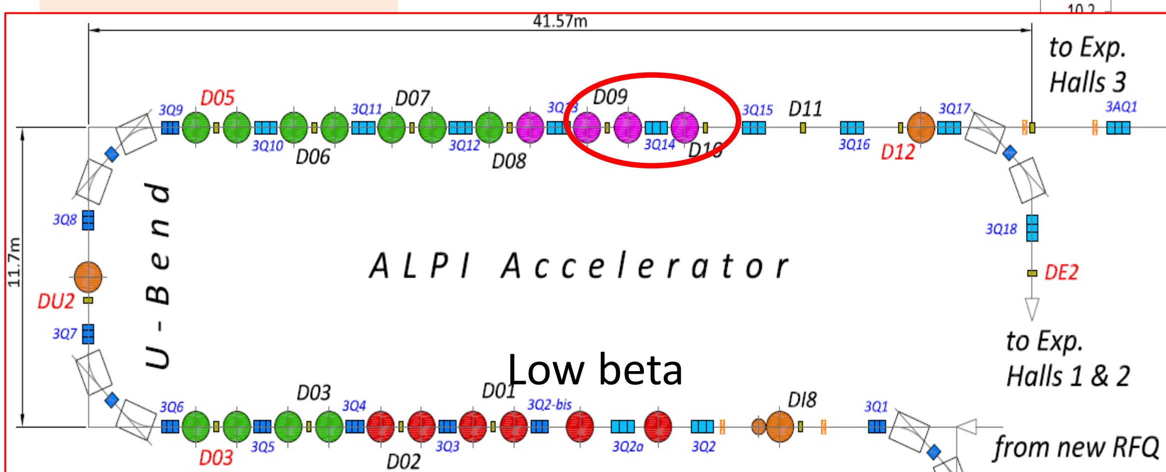
M. Comunian

For exotic beams

Low Beta=5 MV/m, Medium Beta=4.3 MV/m, High Beta=5.5 MV/m

Conservative value: 2 cavities off in the calculation.

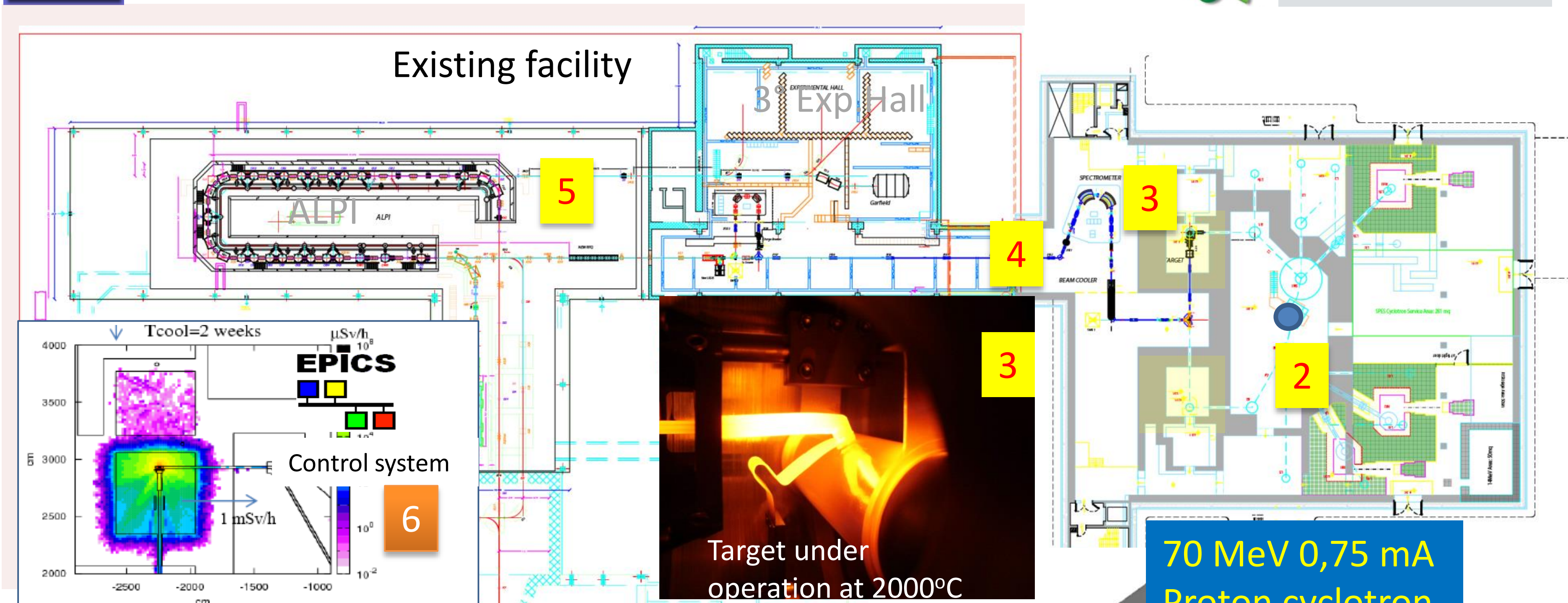


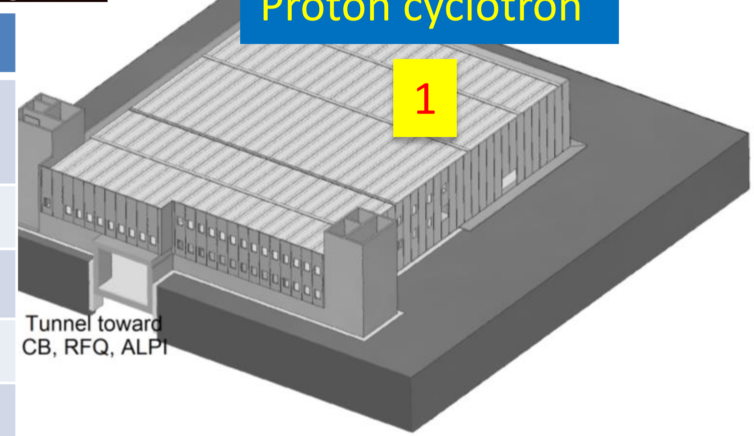


Reshape and improvement of low beta cavities.

Added high beta cryostats to improve the final energy.

SPES Facility Layout





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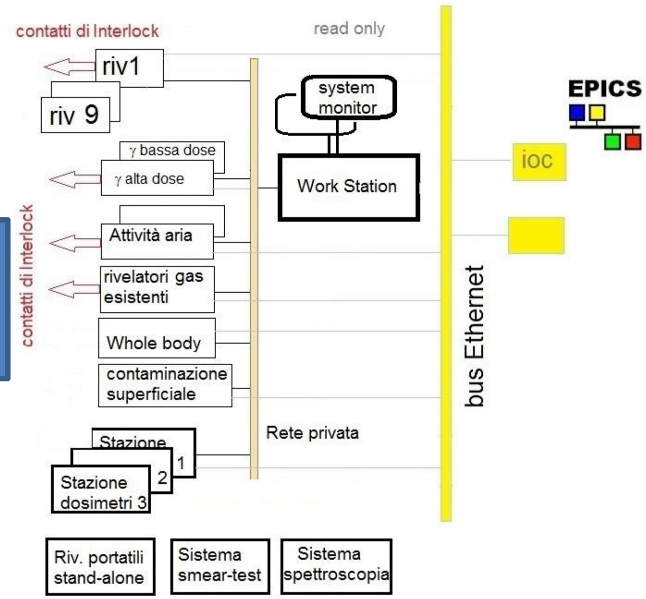
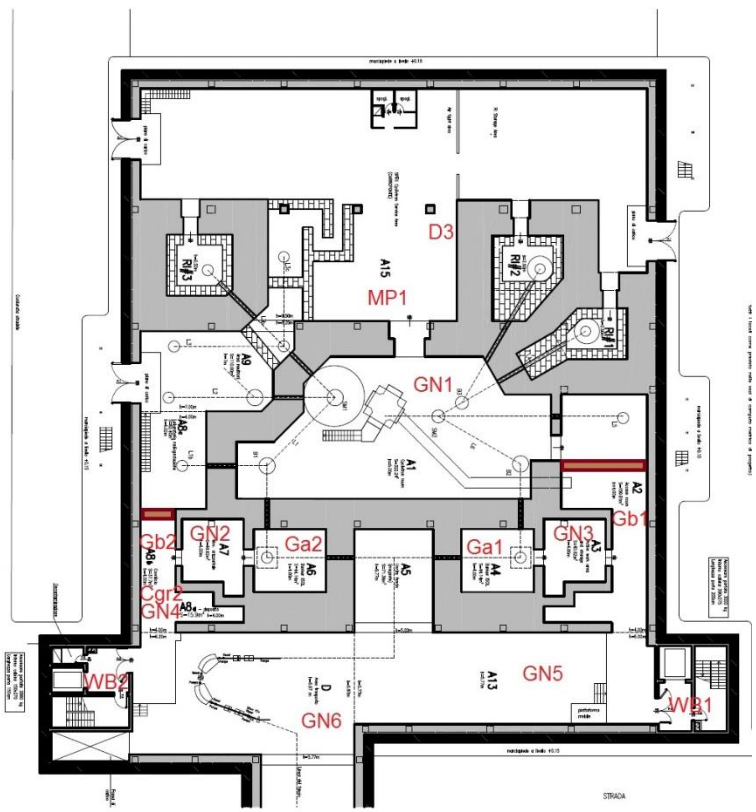
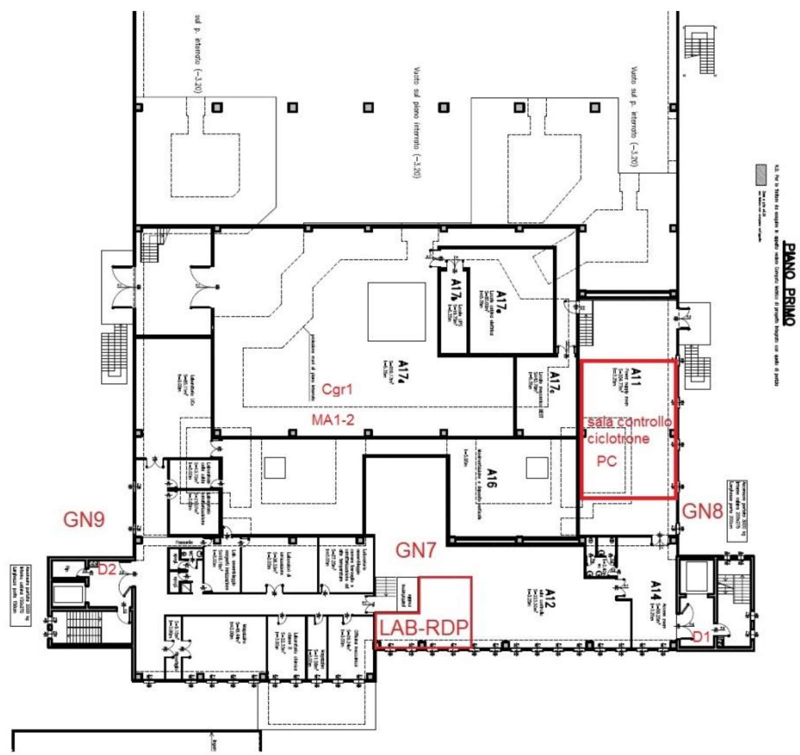
SPES Safety System







Actual status

Already done:

- **Building**: international bid completed, just works starting
- **Cyclotron:** on construction by BEST (Canada)
- **ISOL target:** prototype developed and under operation in lab
- **Safety & control:** authorization to the cyclotron operation just obtained, a Quality and Safety System under implementation

FULLY FUNDED

To be done:

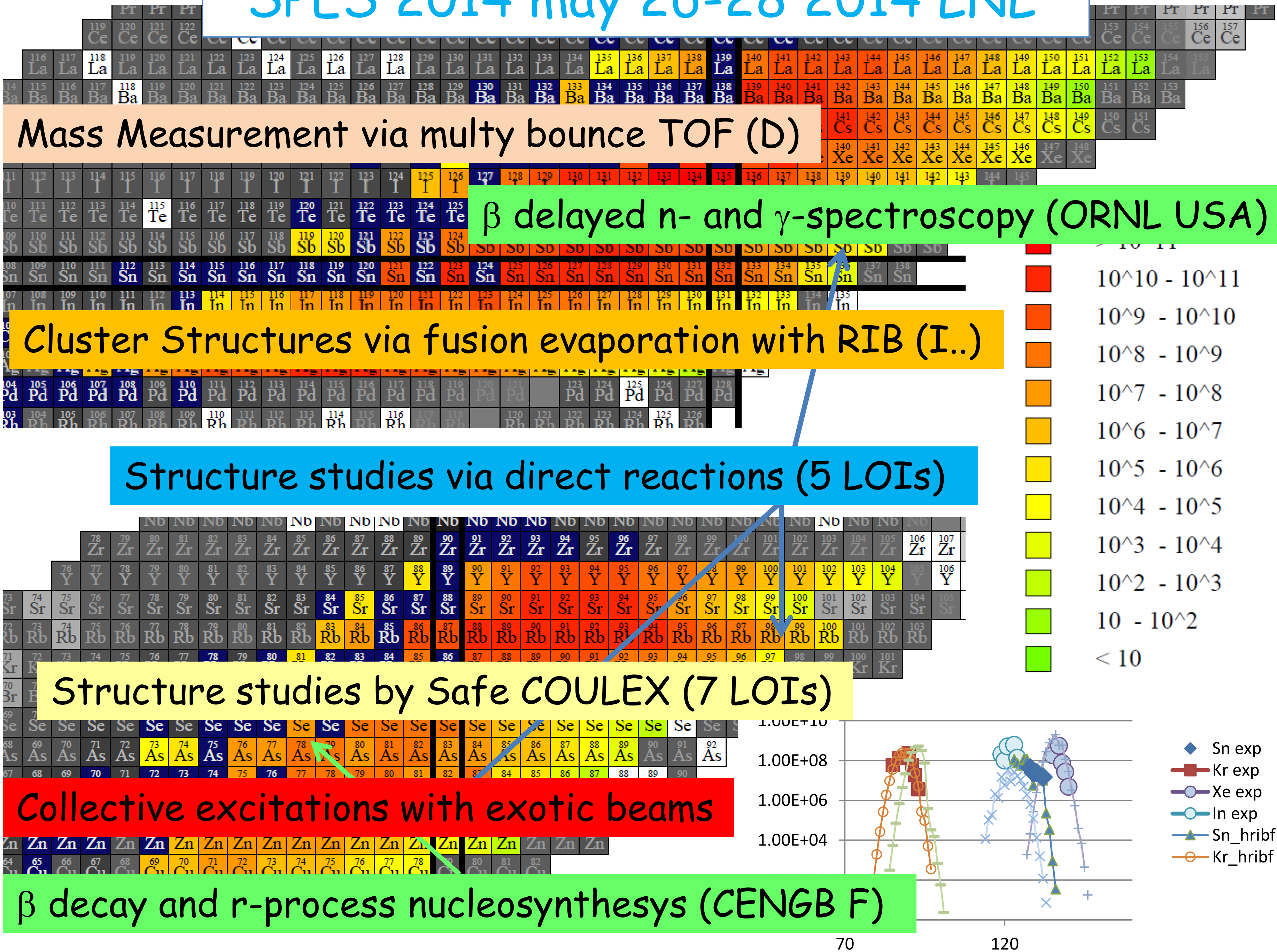
- **Radioactive beam selection and transport** partially FUNDED
- **Charge breeder for increasing the charge state** FUNDED
- **RFQ for pre-acceleration** FUNDED
- **Upgrade of the ALPI superconductive Linac** partially FUNDED
- **General control system and safety** partially FUNDED

Complete funding expected in three years. Total cost: 51 Meuro

SPES general planning

	2012	2013	2014	2015	2016	2017	2018	2019
Authorization to operate and safety	UCx 5microA							
ISOL Target-Ion Sources development								
ISOL Targets construction and installation								
ISOL on-line commissioning								
Building Construction	Executive project	raw building construction						
Cyclotron Construction & commissioning				Cyclotron at LNL				
RFQ development and Alpi up-grade								
Design of RIB transport & selection (HRMS, Charge Breeder, Beam Cooler)								
Construction and Installation of RIBs transfer lines , CB and spectrometers								
Stepwise commissioning and first exotic beam (2018), HRMS in 2019								

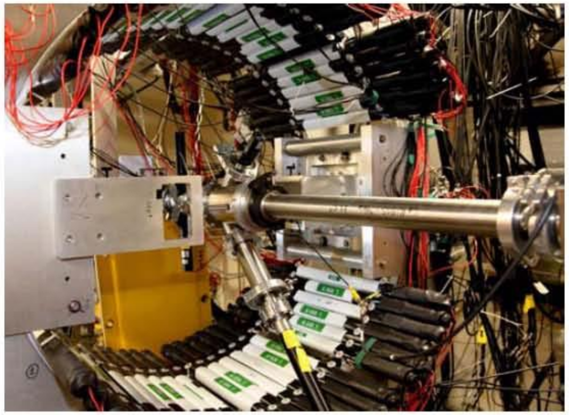
SPES 2014 may 26-28 2014 LNL



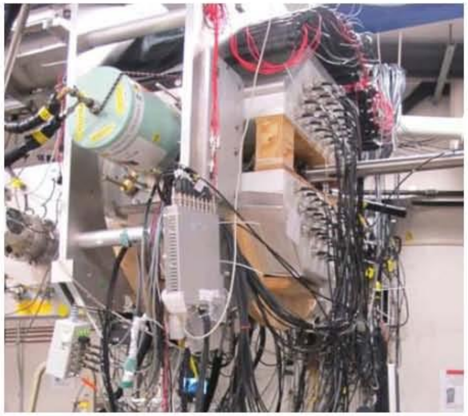
Decay spectroscopy techniques to study neutron-rich fission fragments at SPES

Krzysztof P. Rykaczewski, Robert Grzywacz, Carl J. Gross, Daniel W. Stracener, Yuan Liu
Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831-6371, USA
in collaboration with
C. Mazzocchi, A. Korgul, M. Karny, K. Miernik, U. of Warsaw, Warsaw, Poland
W. Krolas, Institute of Nuclear Physics PAN, Krakow, Poland

MTAS = Modular Total Absorption Spectrometer



VANDLE = Versatile Array of Neutron Detectors for Low Energy



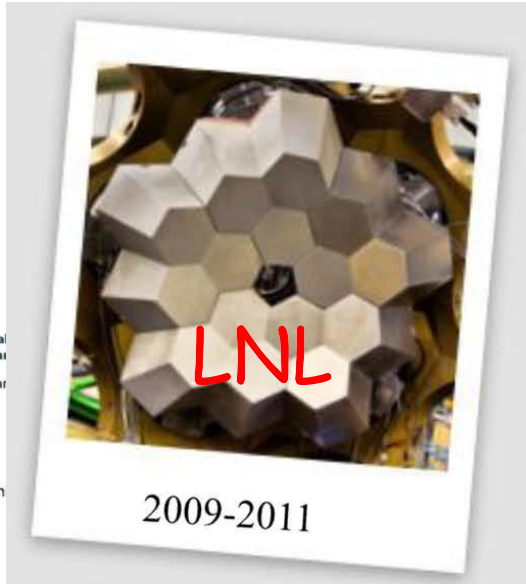
3Hen = Helium-3 Neutron Detectors
Hybrid-3Hen = 3Hen + Clover Ge

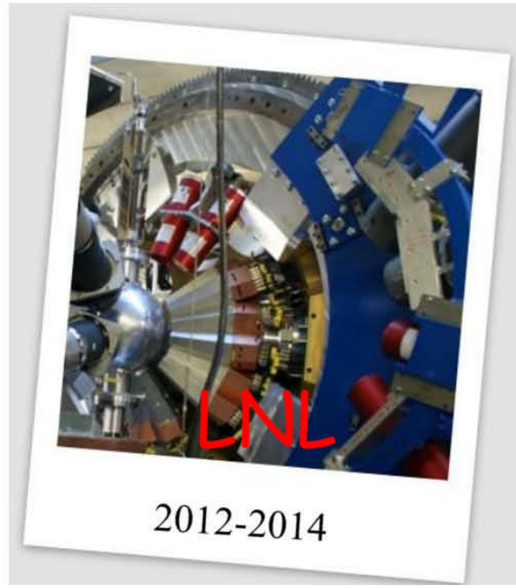
The physics of neutron-rich fission fragments

- nuclear structure evolution as N >> Z
- spectroscopy near and above the neutron separation energy
- rapid-neutron capture half-lives and beta-delayed neutron branchings
- societal impact in better data for modeling neutron-rich environments such as nuclear reactors
- more detailed understanding of the anti-neutrino spectra from reactors

Not riaccelerated radioactive nuclear beams

INFN
Istituto Nazional
di Fisica Nuclear
Laboratori Nazionali di Legnar





To Prof. Giovanni Fiorentin

Director of LNL

Dear Gianni,

Let us first convey to you, on behalf of the AGATA Steering Committee (ASC) and AGATA Collaboration Council (ACC), the message that the full scientific community around AGATA has appreciated the interest of the LNL laboratory in the AGATA physics program and in particular in the scientific potential of the AGATA detector in combination with the exotic radioactive ion beams of the SPES facility. In view of the wide scientific program of AGATA at SPES, already envisaged by the scientific community through the presentation of 15 LOIs, the AGATA Steering Committee has agreed to install the AGATA detector at LNL-SPES for running an experimental campaign in the period 2019-2020.

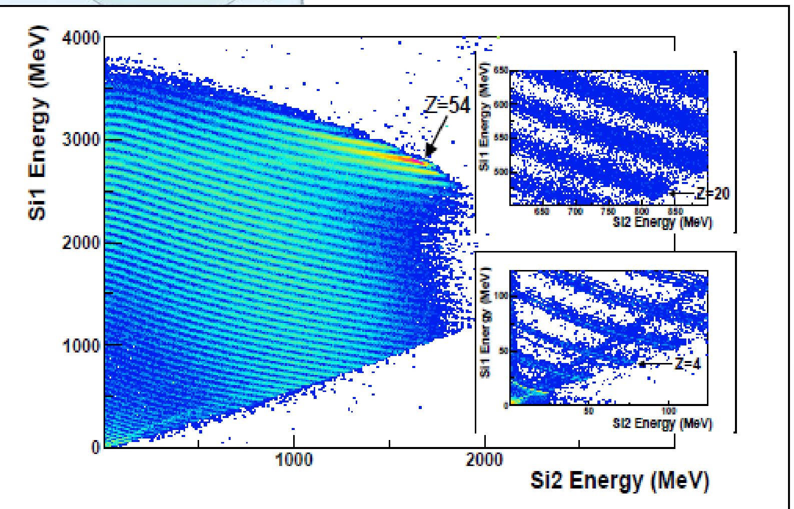
Therefore the AGATA Steering Committee has decided for a commitment of the detector until 2020 (GANIL 2017-2018, LNL 2019-2020).

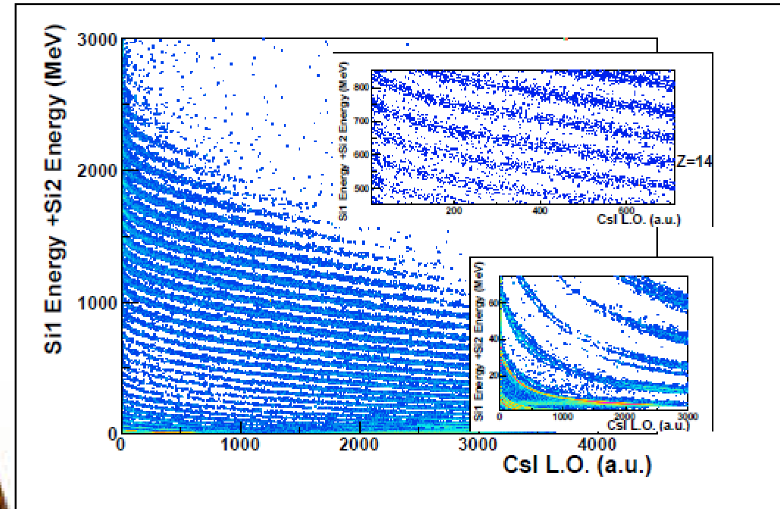
Best Regards,

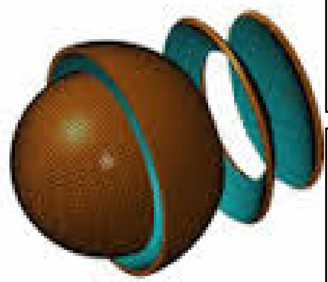
G. de Angelis (ASC Chair) and J. Nyberg (ACC Chair)

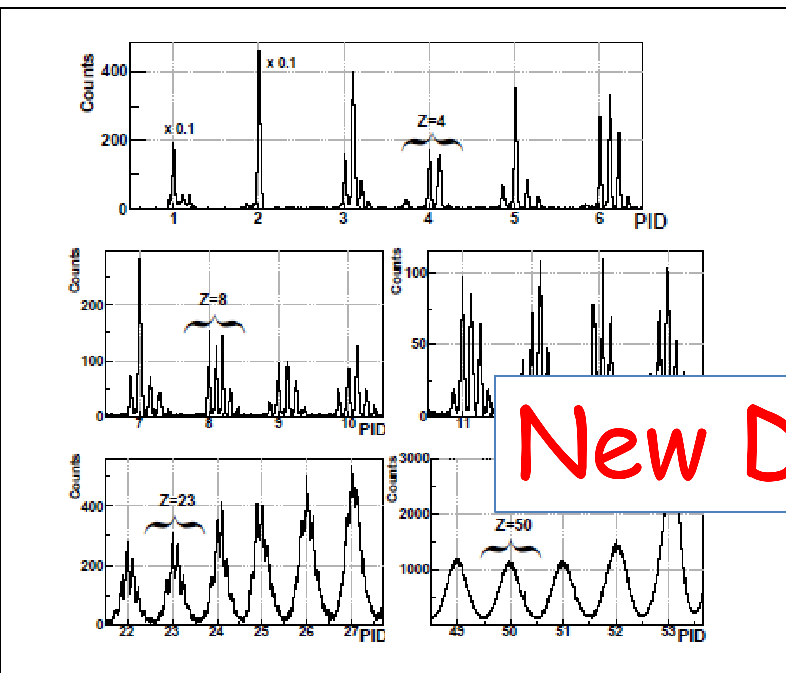
AGATA @ SPES
2019-2020

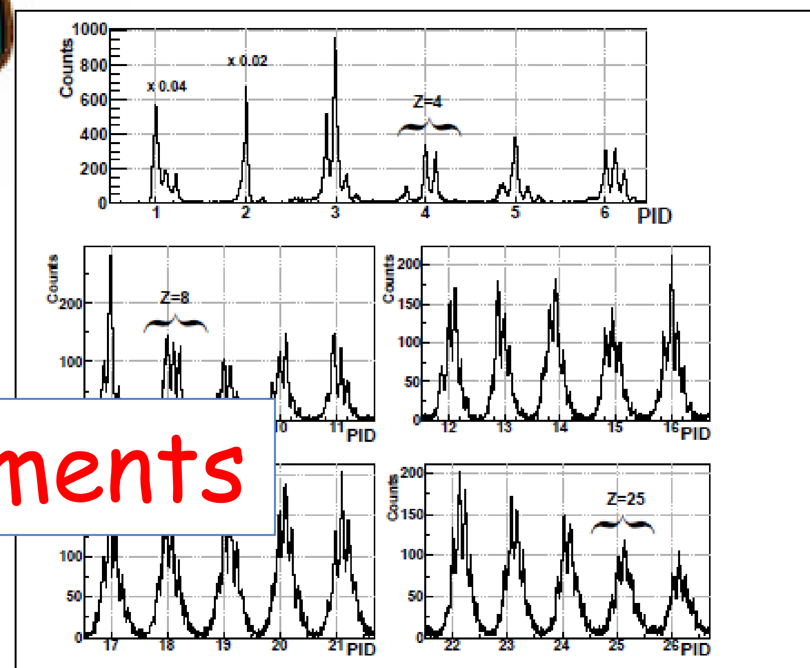
The FAZIA project





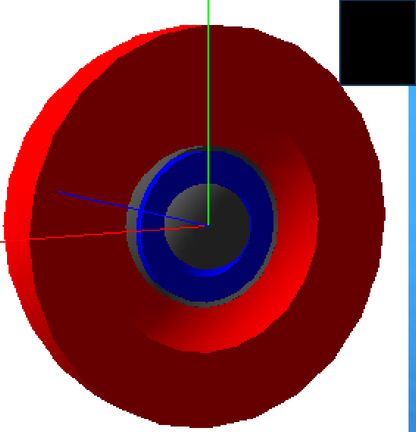


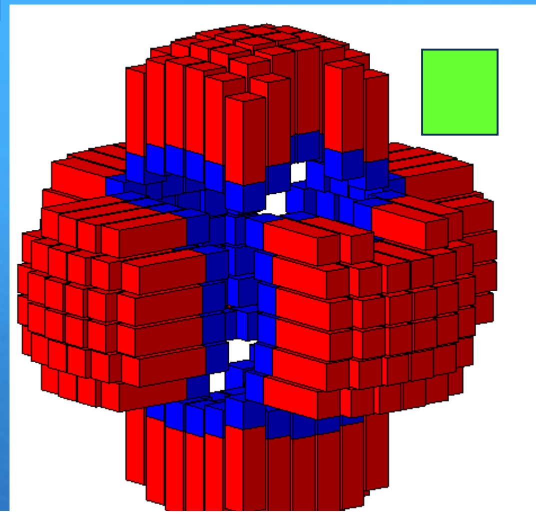


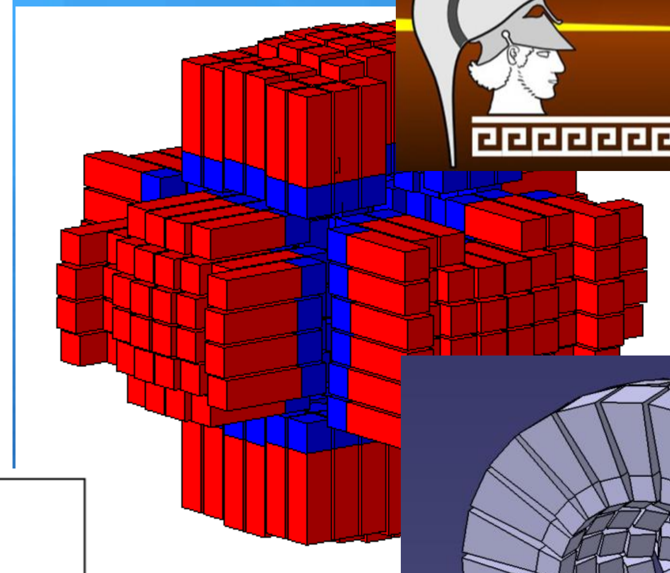


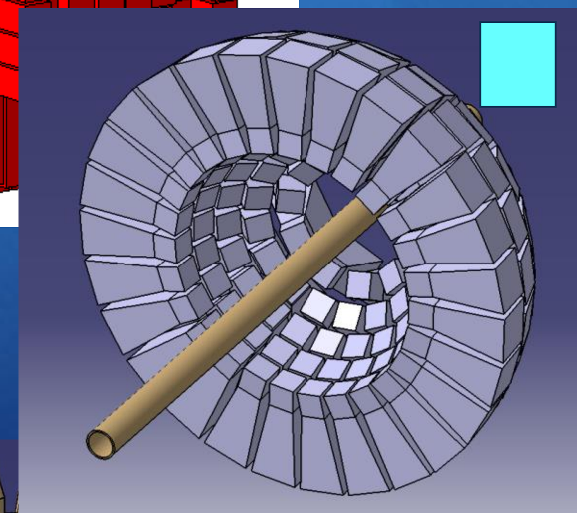
New Developments

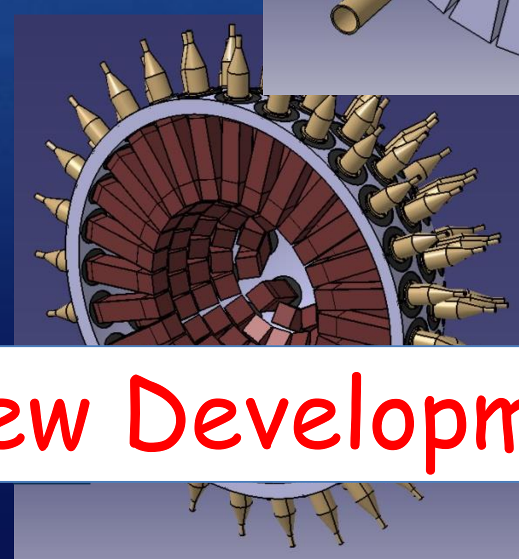
PARIS

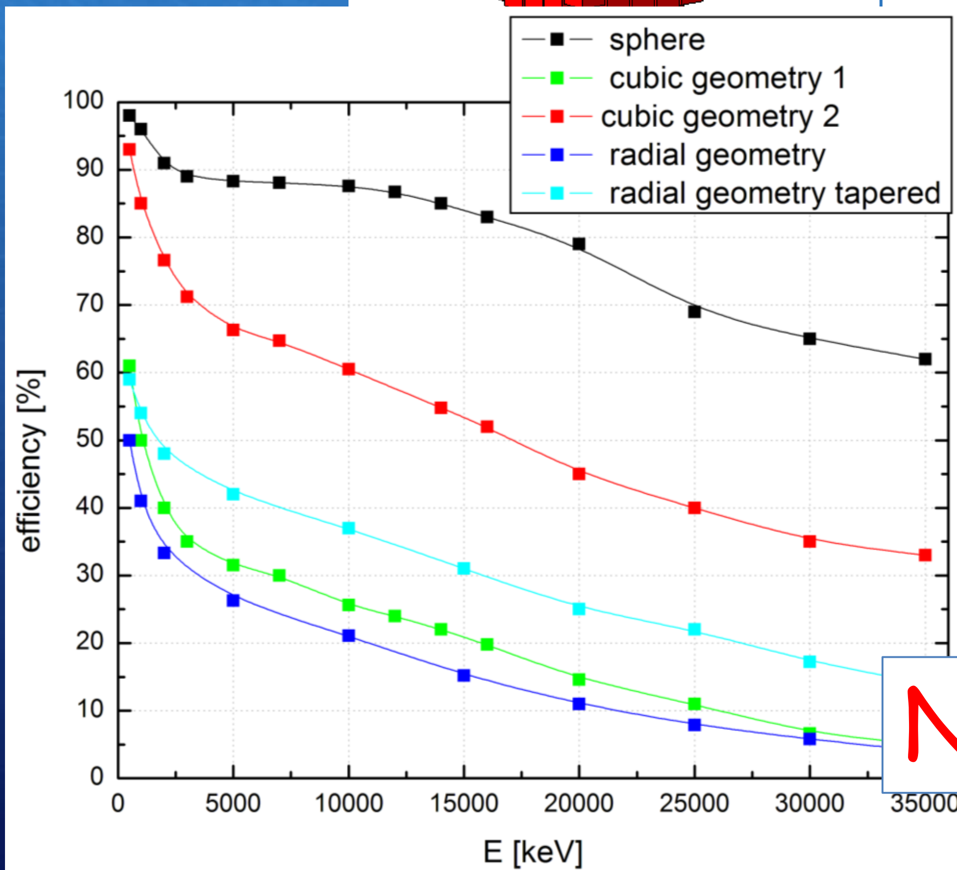












New Developments


INFN
SPES
Thanks for attention
THANK YOU
26/11/2014
13:00