Status and Future Perspective of the HIE-ISOLDE Project

International Particle Accelerator Conference, IPAC'12

New Orleans, Louisiana, USA, May 20-25, 2012

Yacine.Kadi@cern.ch

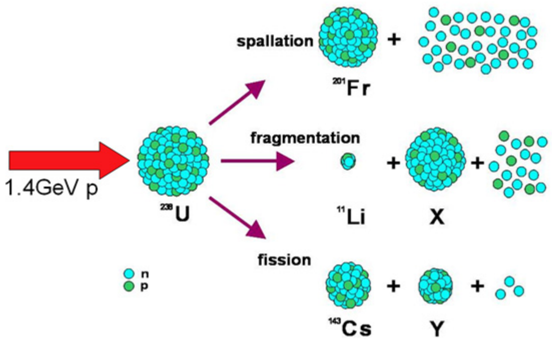
OUTLINE

- **Scope of HIE-ISOLDE**
- Upgrade of ISOLDE Facility: HIE-ISOLDE
- R&D Activities
- Outlook for 2012

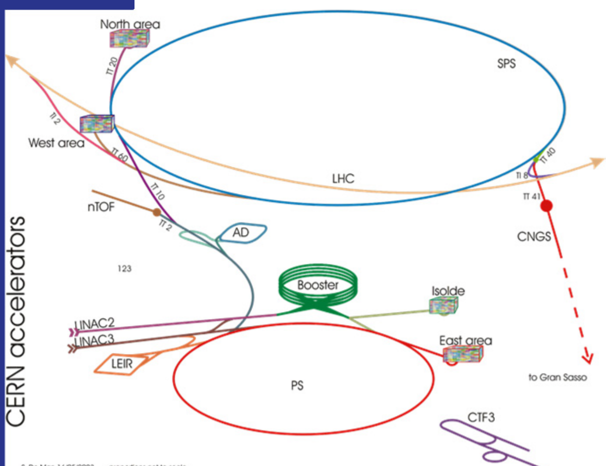
THPPP050: HIE-ISOLDE SC LINAC: OPERATIONAL ASPECTS AND COMMISSIONING PREPARATION

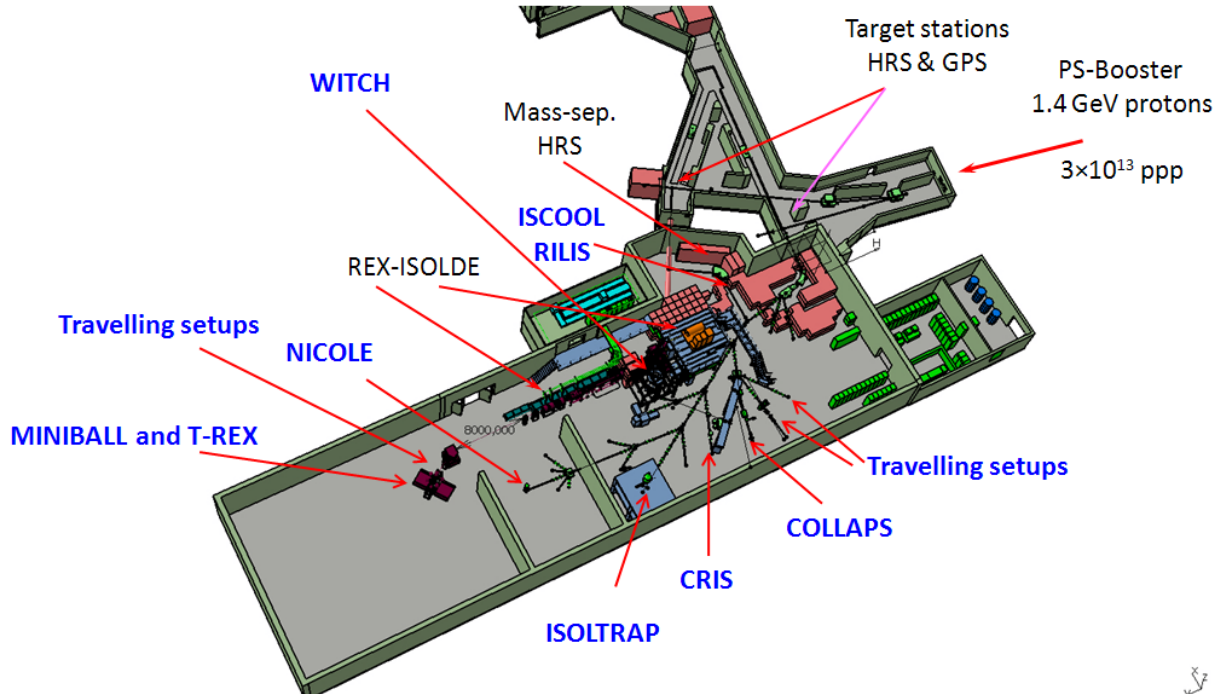
MOPPR048: Beam Instrumentation for the HIE-ISOLDE Linac at CERN

ISOLDE: the ISOL-type RIB facility at CERN



Pulsed 1.4 GeV Proton beam





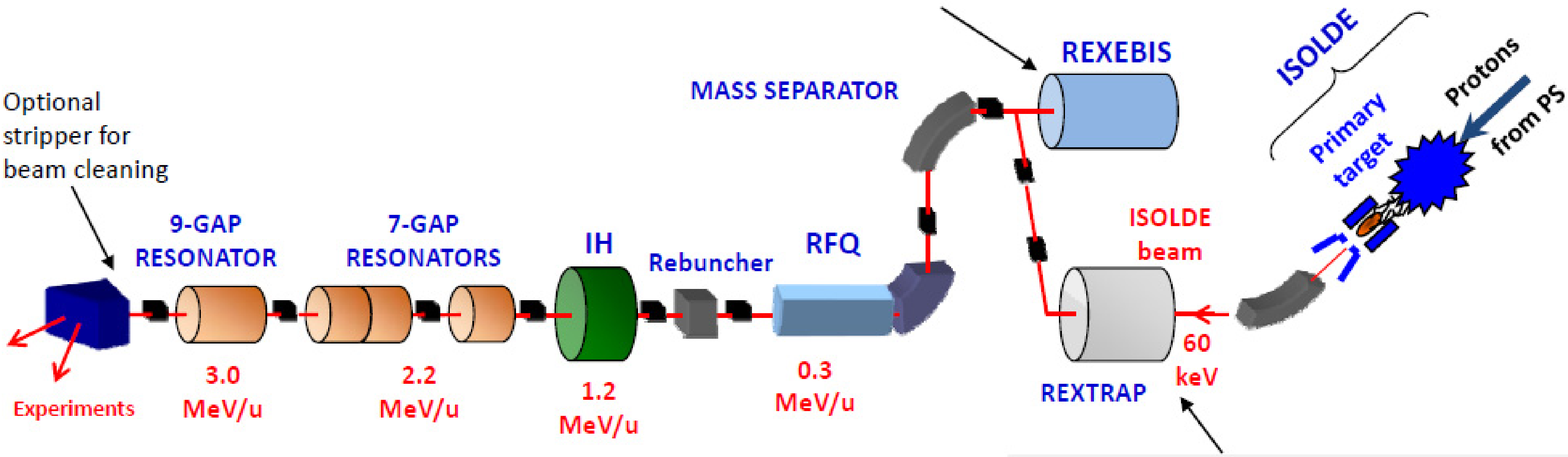
Courtesy D. Voulot

REX-ISOLDE layout

* Energy from 60 kV to few MeV/u
* Operational since Oct 2001
* Until now:
  >30 elements
  close to 100 isotopes

Electron beam ion source

* 1+ ions to n+
* Super conducting solenoid, 2 T
* Electron beam <0.4 A, 3-6 keV
* Breeding time 3 to >200 ms



Linac

Type	normal conducting 6 accelerating cavities
Length	11 m
Freq.	101 MHz (202 MHz for the 9GP)
Duty cycle	1 ms 100Hz
Energy	300 keV/u, 1.2-3 MeV/u (variable)
A/q max.	4.5

Penning trap

* Longitudinal accumulation and bunching
* Transverse phase space cooling
* 3 T solenoid field
  + quadratic electrostatic potential
  + RF cooling
* Buffer gas filled (5E-4 mbar)
* Cooling time ~20 ms

Courtesy F. Wenander

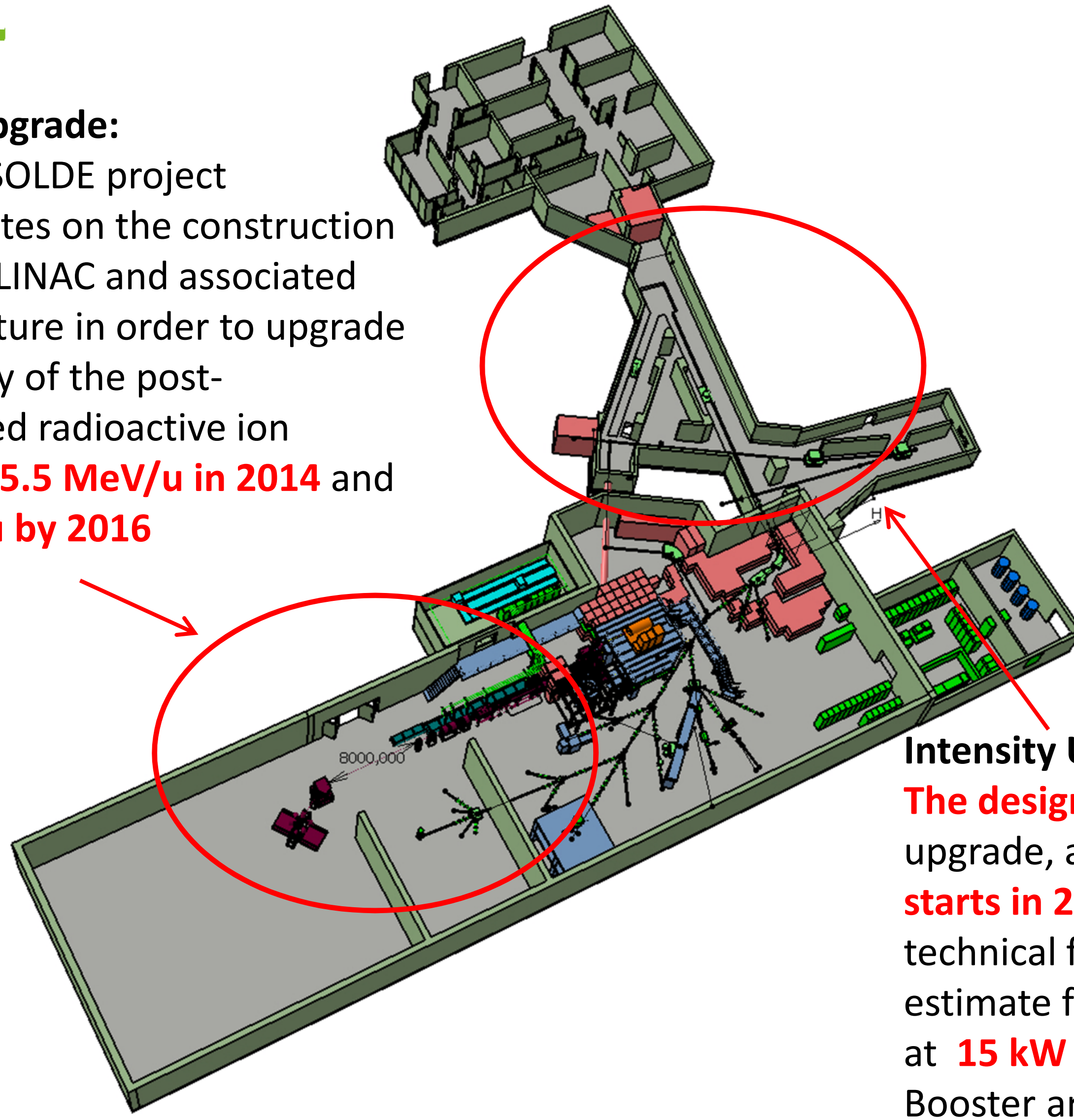
Motivation

The High Intensity and Energy (HIE) ISOLDE project builds on the success of the REX-ISOLDE post-accelerator and will focus on the upgrade of the REX facility but also aims to improve the target and front-end part of ISOLDE to fully profit from upgrades of the existing CERN proton injectors (LINAC4 and PSB Upgrade):

- ✓ Higher energy for the post-accelerated radioactive beam
- ✓ More beams (Intensity wise and different species)
- ✓ Better beams (High purity beams, low emittances, more flexibility in the beam parameters)

HIE-ISOLDE aims at increasing the energy of these RIB up to 10A MeV and their intensity by a factor 10

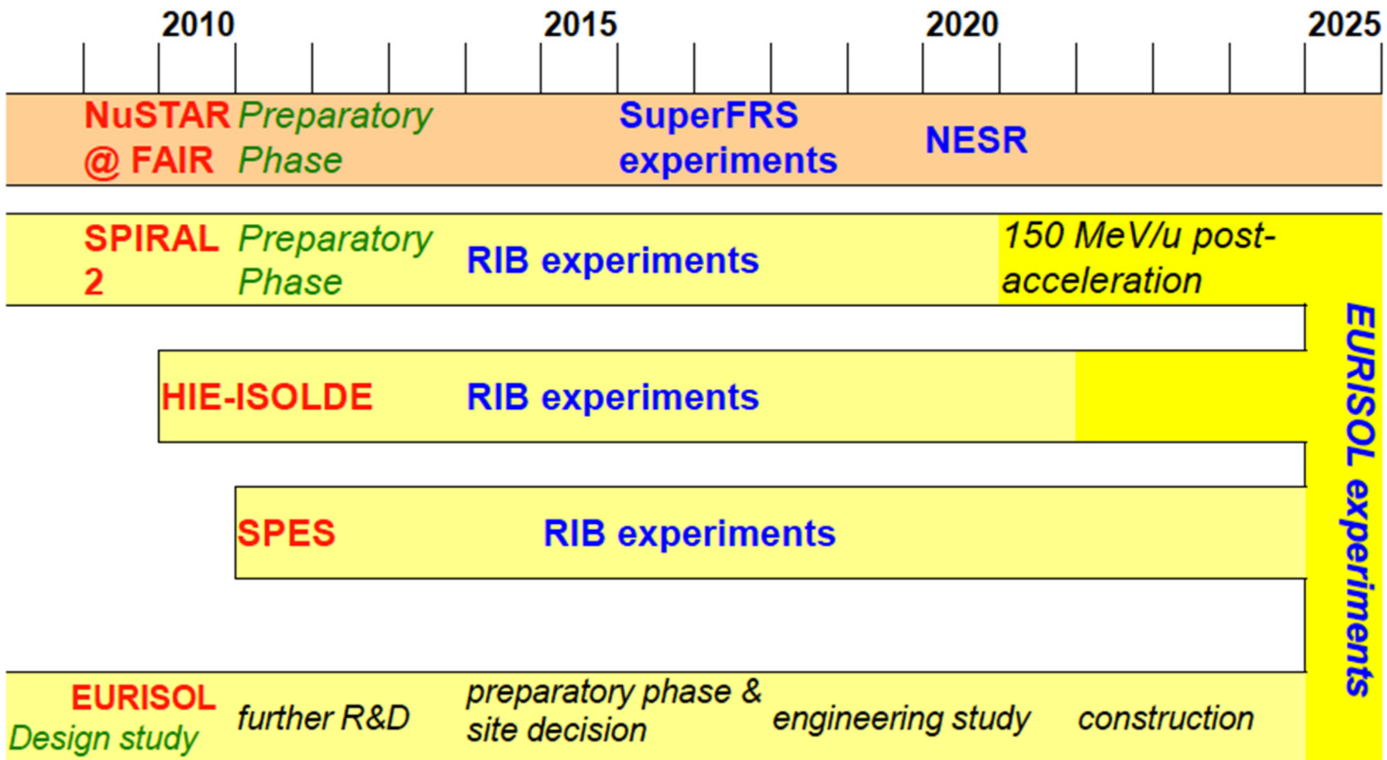
Energy Upgrade:
The HIE-ISOLDE project concentrates on the construction of the SC LINAC and associated infrastructure in order to upgrade the energy of the post-accelerated radioactive ion beams to **5.5 MeV/u in 2014** and **10 MeV/u by 2016**



Intensity Upgrade:
The design study for the intensity upgrade, also part of HIE-ISOLDE, **starts in 2012**, and addresses the technical feasibility and cost estimate for operating the facility at **15 kW** once LINAC4 and PS Booster are online.

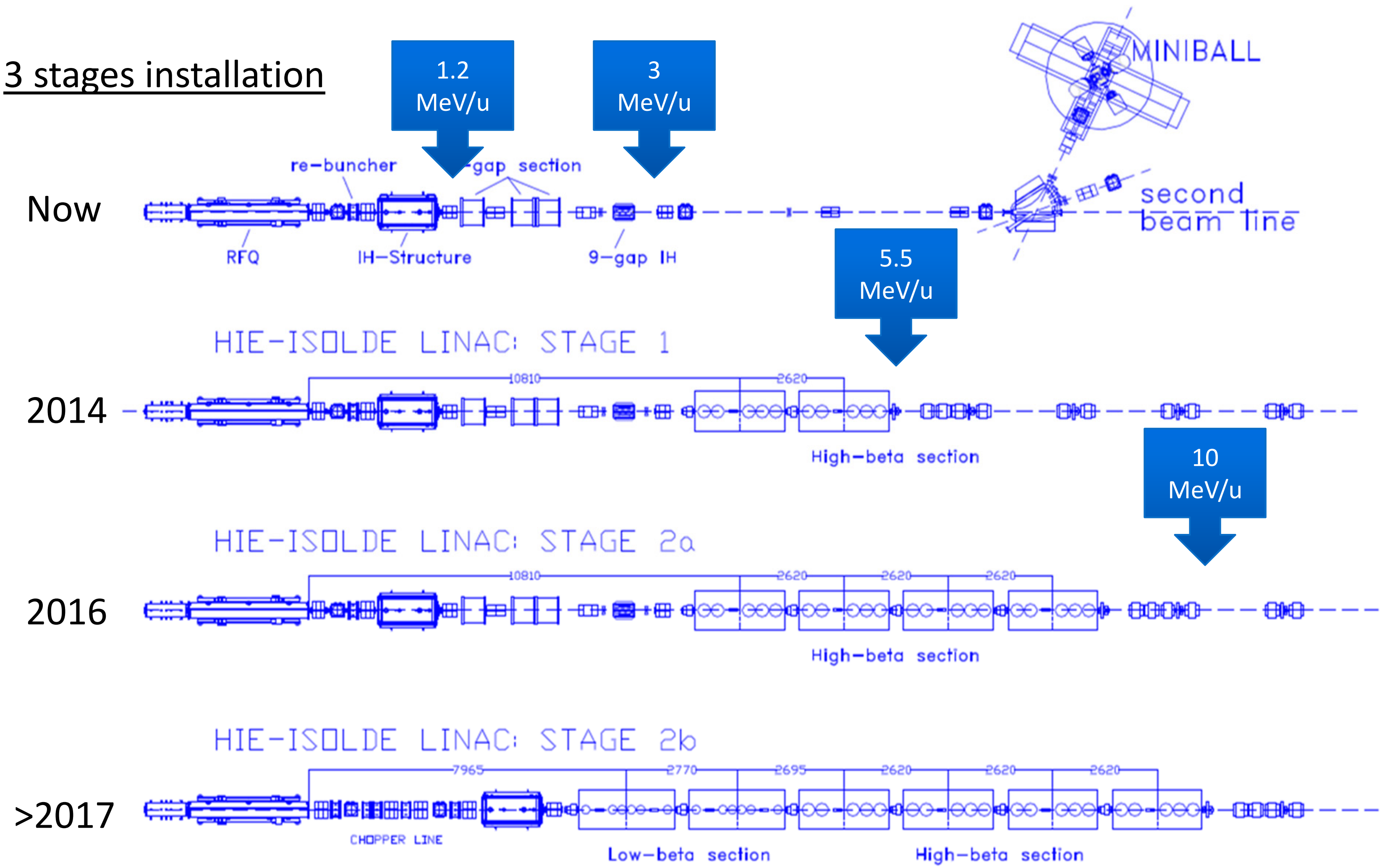
NuPECC Long Range Plan 2010
Timeline for RIB Facilities

HIE-ISOLDE will play an important role in the network of ISOL facilities preparing EURISOL (with SPIRAL2 and SPES)

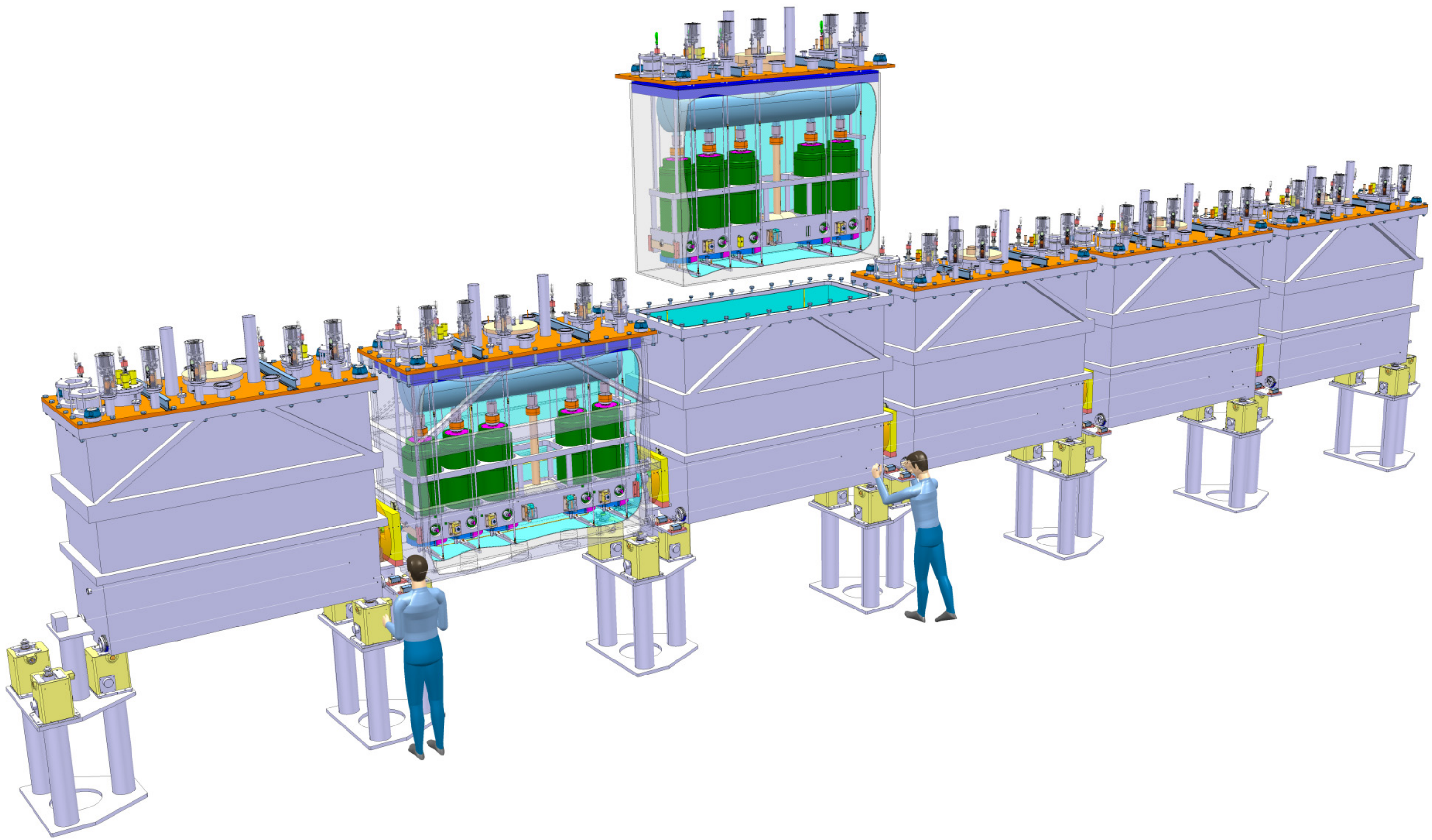


Superconducting LINAC installed in Three Phases

3 stages installation

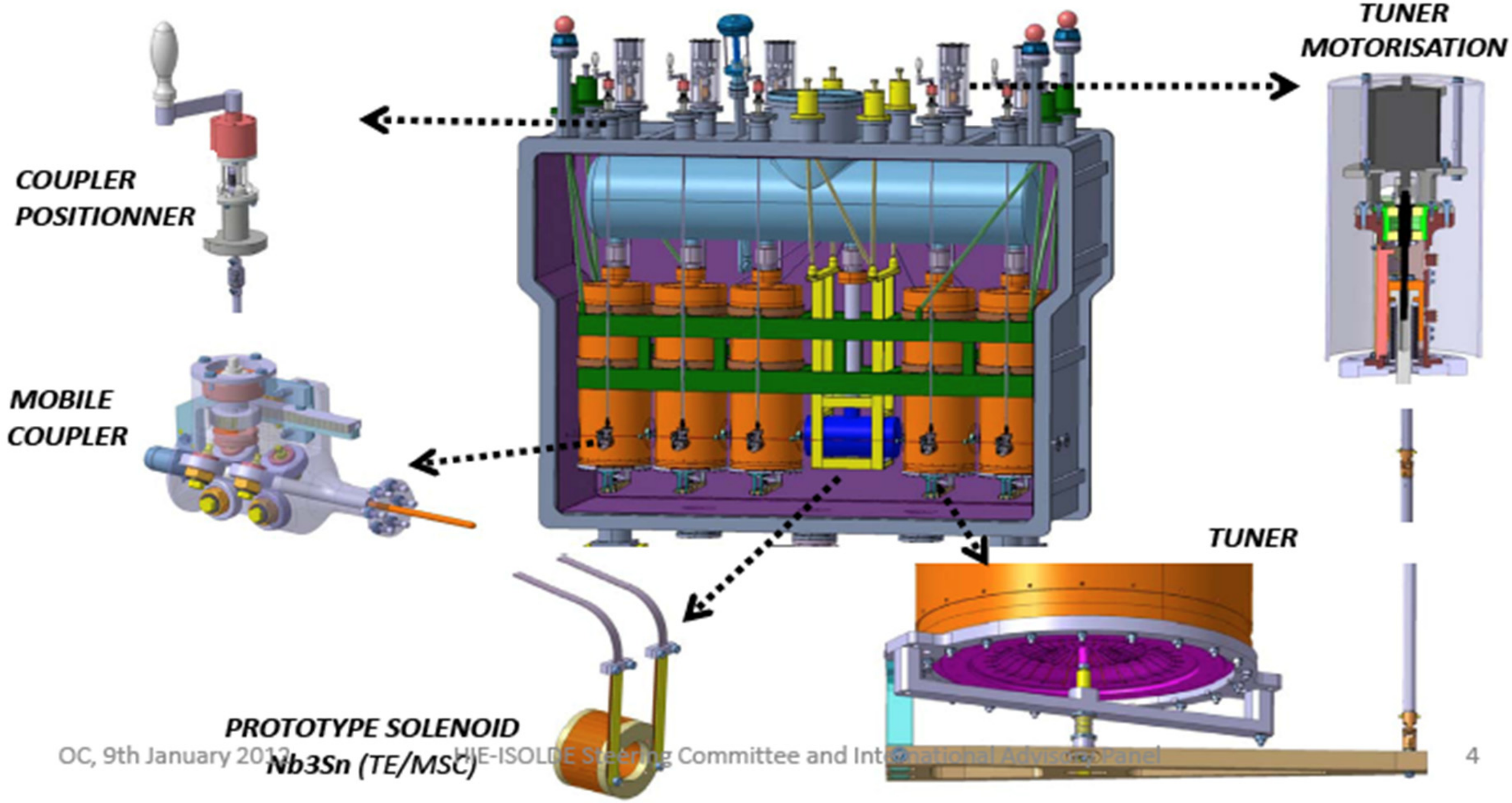


HIE-ISOLDE SC LINAC



R&D activities (2008 – 2011)

- What has been done
  - Ancillaries: one of each has been designed and manufactured
  - SC cavities: two designs high beta, several cavities manufactured



QWR cavities (Nb sputtered)

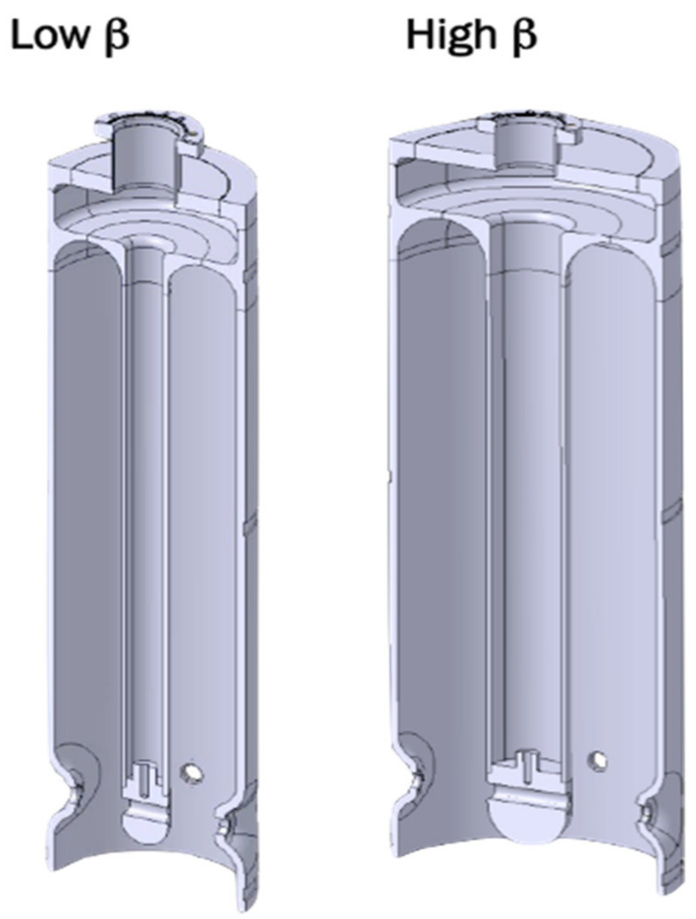


Table 1: Cavity design parameters

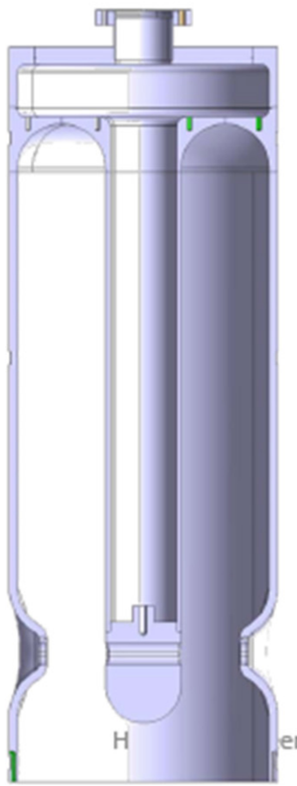
Cavity	Low β	highβ
No. of Cells	2	2
f (MHz)	101.28	101.28
β_0 (%)	6.3	10.3
Design gradient E_{acc}(MV/m)	6	6
Active length (mm)	195	300
Inner conductor diameter (mm)	50	90
Mechanical length (mm)	215	320
Gap length (mm)	50	85
Beam aperture diameter (mm)	20	20
$U/E_{acc}{}^2$ (mJ/(MV/m)^2	73	207
E_{pk}/E_{acc}	5.4	5.6
H_{pk}/E_{acc} (Oe/MV/m)	80	100.7
R_{sh}/Q (Ω)	564	548
$\Gamma = R_s \cdot Q_0$ (Ω)	23	30.6
Q_0 for 6MV/m at 7W	$3.2 \cdot 10^8$	$5 \cdot 10^8$
TTF max	0.85	0.9
No. of cavities	12	20

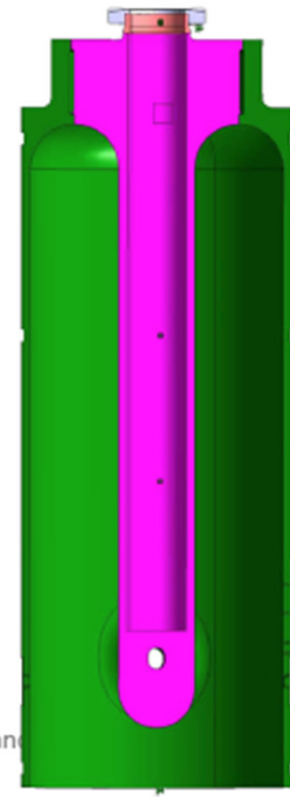
QWR cavities (Nb sputtered)

- Cavity design
  - Only high-beta cavities have been designed so far
  - Very tight geometrical tolerances required
  - Two versions were designed

OLD VERSION

- Rolling, Deep-drawing, EB welding



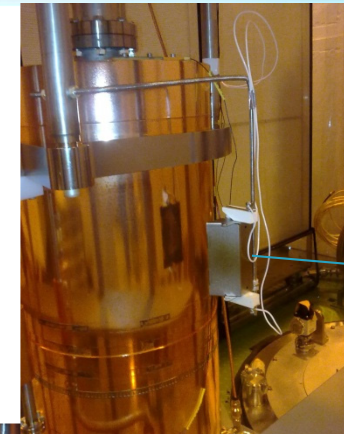


NEW VERSION

- Machining bulk copper, EB welding

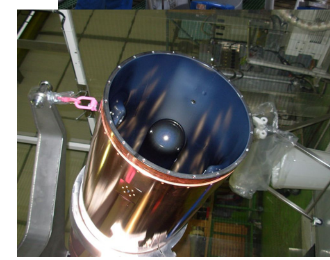
OC, 9th January 2012 H ering Committee an Panel 5

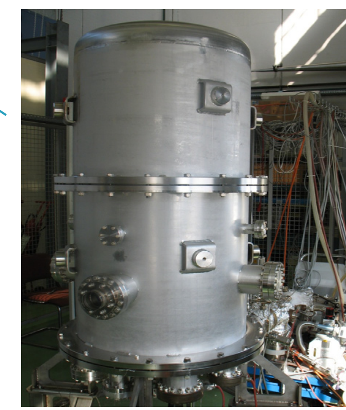
RF tests in 2012



Cavity loop

- Stripping
- NEW) metrology
- Chemistry
- Clean Room Assembly
- Coating
- Rinsing & Clean Room Assembly
- Insertion in cryostat
- Cool Down
- RF Conditioning, RF Measurements
- Warm Up, Venting
- Metrology





RF Test Q2-6

RF Test Q2-6 bis (3 K)

RF Test Q1-9

RF Test Q2-6 LNL coupler Indium joint

RF Test Q1-10

RF Test Q1-10 CERN coupler

RF Test Q2-6

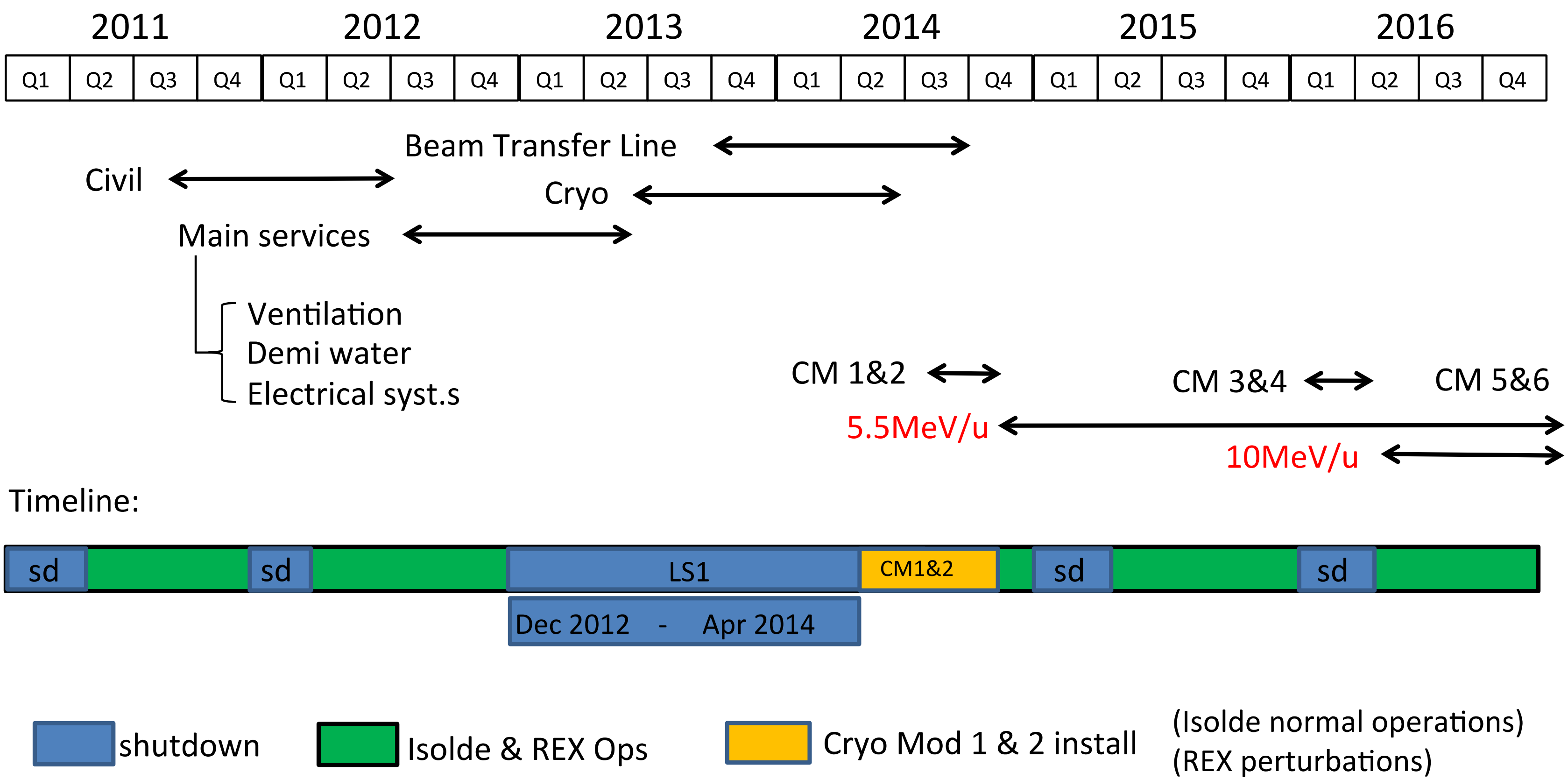
IAP

Dec11 Jan12 Feb12 Mars12 Apr12 May11

3 weeks turnaround steadily confirmed in 2012

HIE-ISOLDE PLANNING

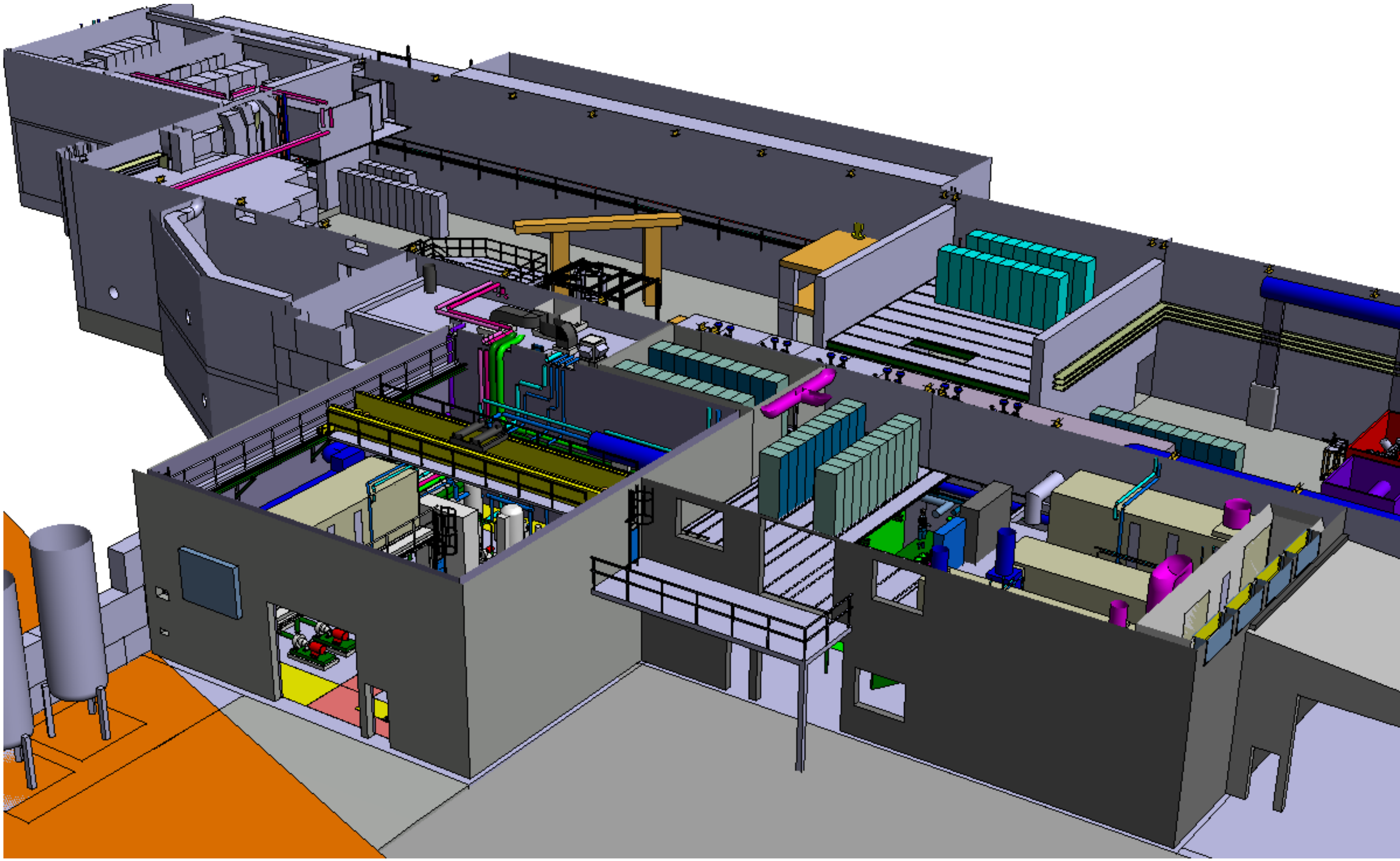
A simplified presentation of the different stages:



CIVIL ENGINEERING

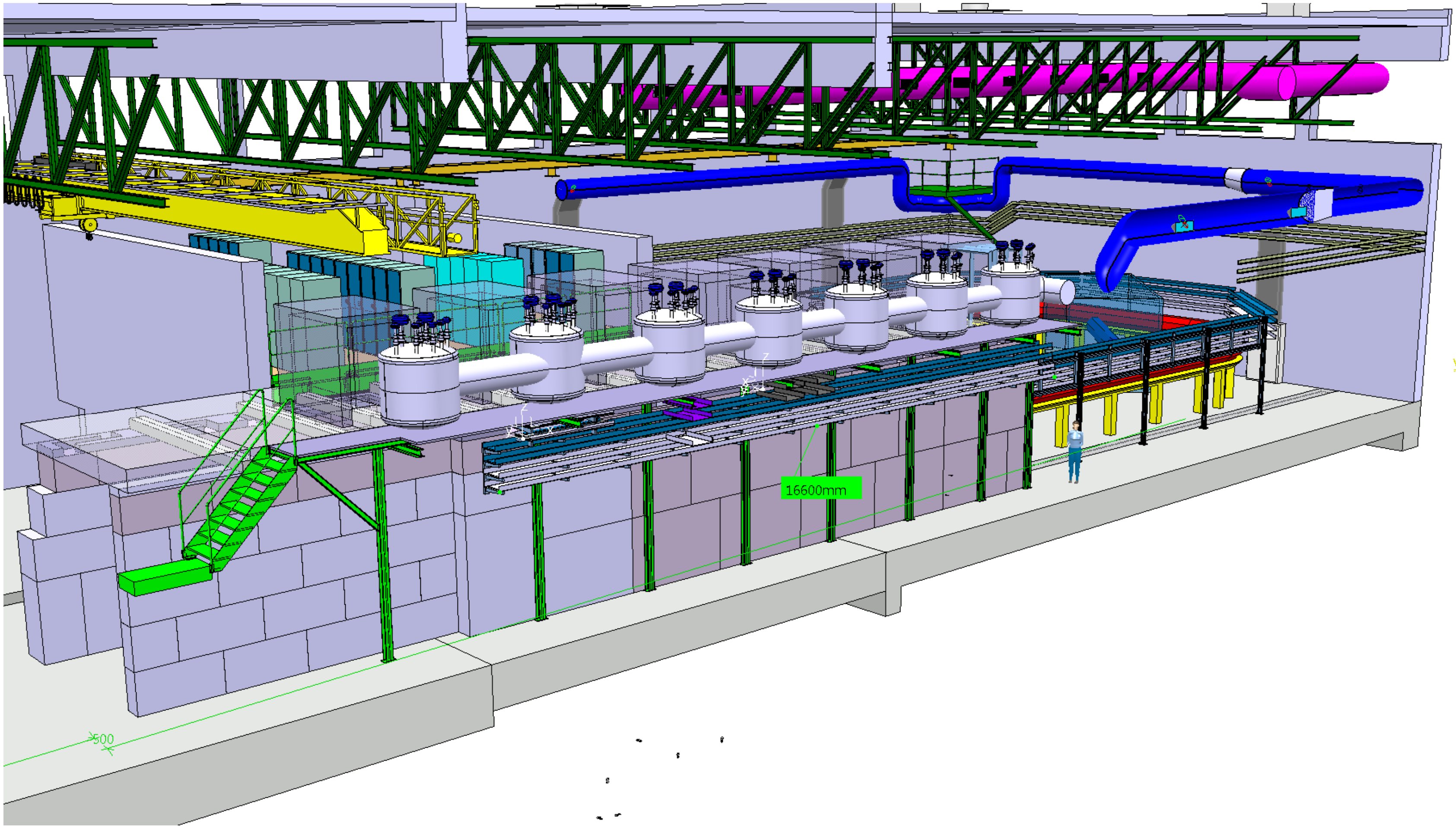
Compressor and Cold Box buildings

MAIN SERVICES



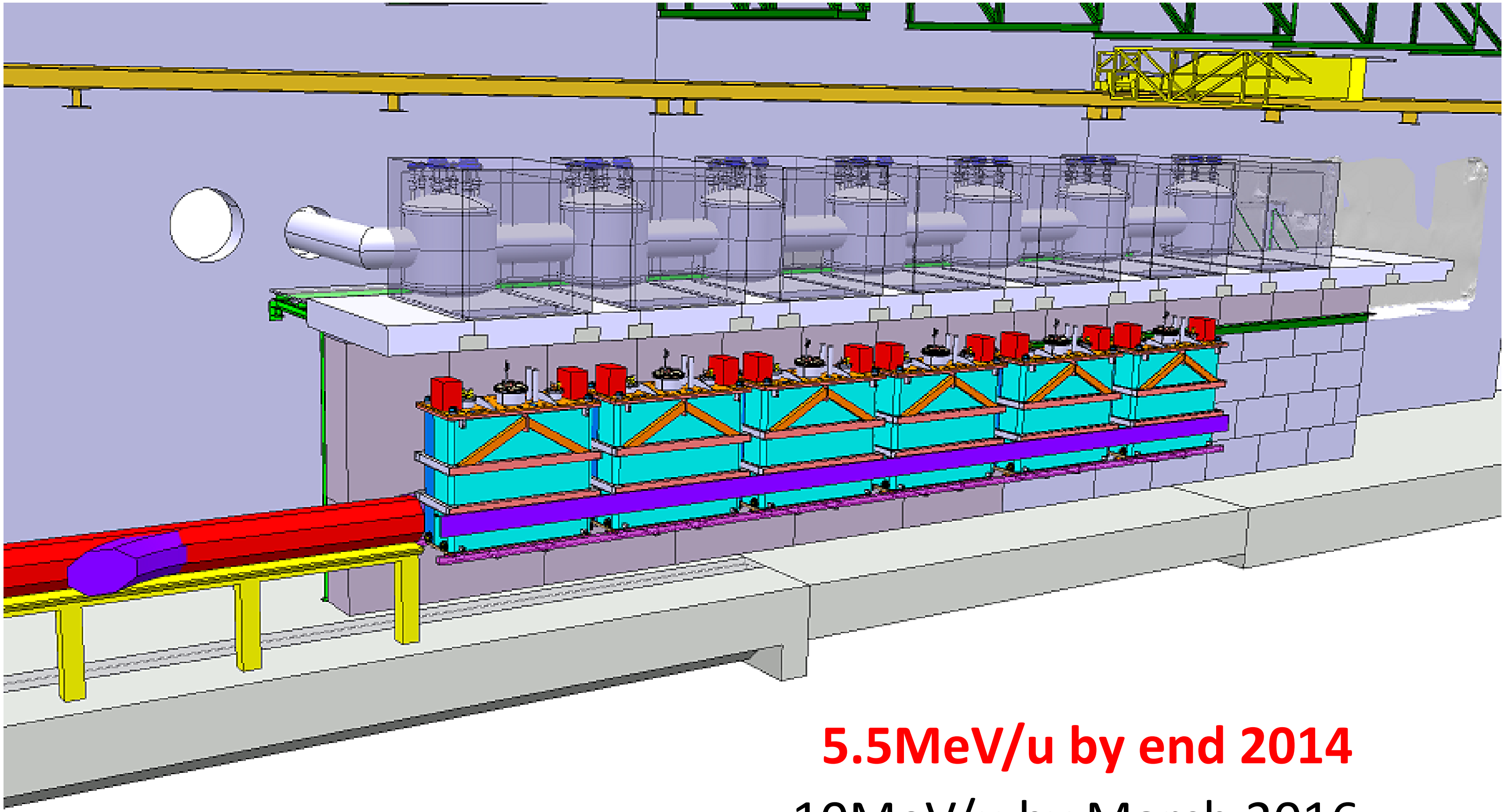
Start installation Main Services July 2012

TUNNEL & CRYO LINE



Installation tunnel: Sep 2013 - LS1
Cryo Cold Line: January 2014 – June 2014

HIE-ISOLDE SC LINAC

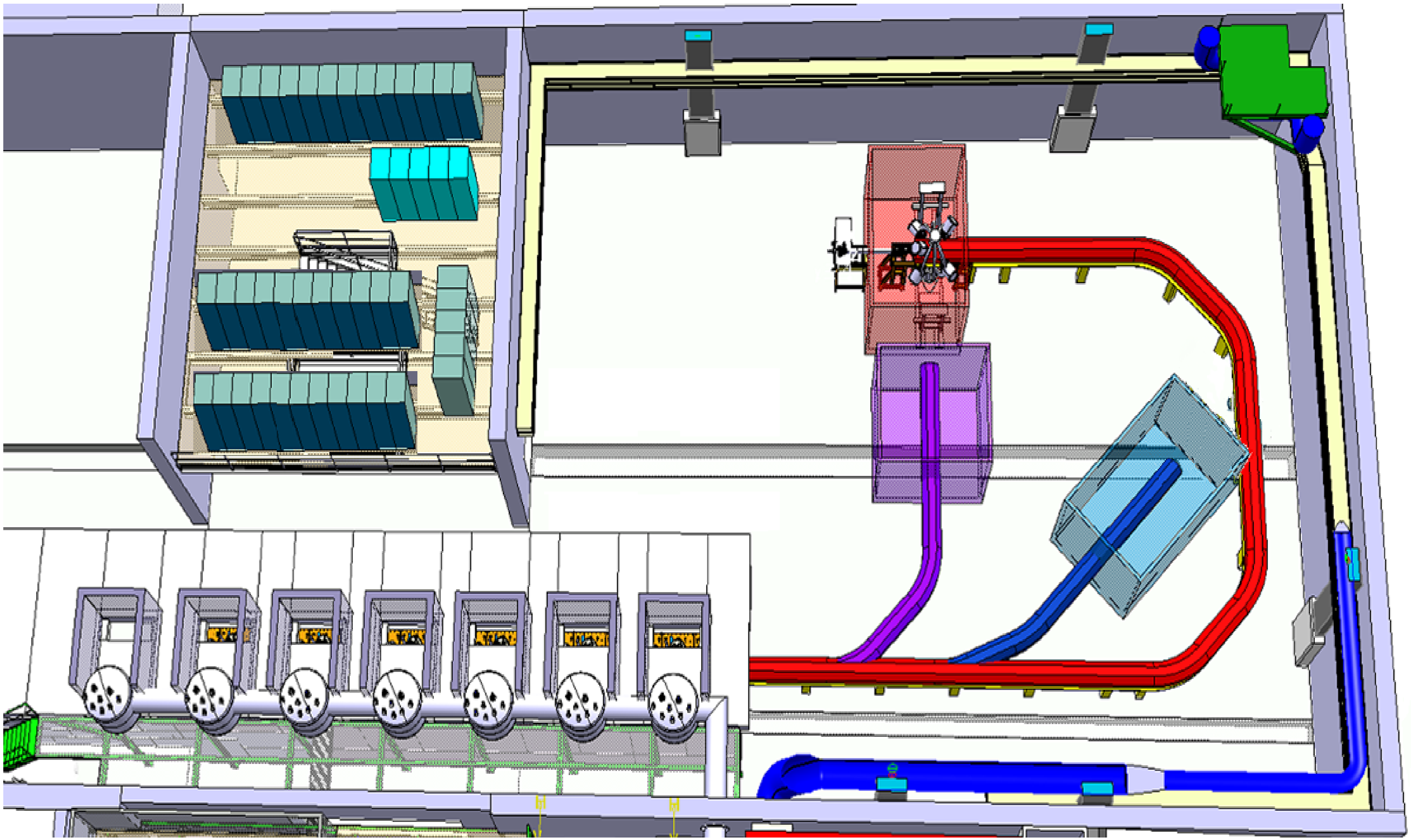


5.5MeV/u by end 2014

10MeV/u by March 2016

Bunched beam by 2018

HIGH-ENERGY BEAM TRANSFER



Call for Letters of Intent

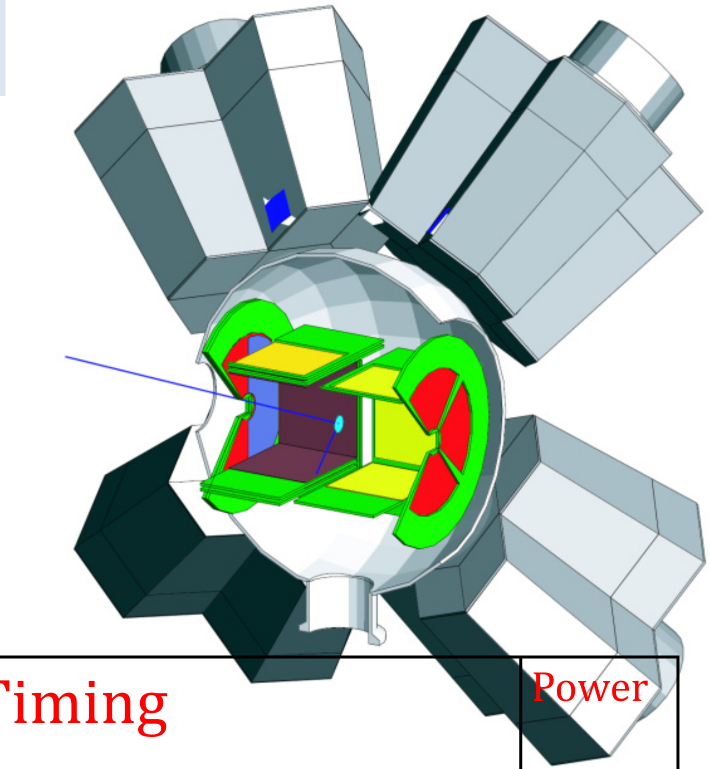
(deadline May 21 2010)

- 34 Letters submitted
- 284 Participants from 76 Laboratories in 22 Countries
- 30 LOIs make use of the Energy and Intensity increases; 4 of the intensity upgrade only
- Major mechanisms are Coulex (13) and transfer(16);

elastic scattering(3); fission(2)

- (3) letters concern masses and moments; (4) astrophysics and (5) major new instrumentation
- Major subjects: Nuclear shapes ; Shell evolution; Halo properties; Nuclear astrophysics

Miniball + T-REX

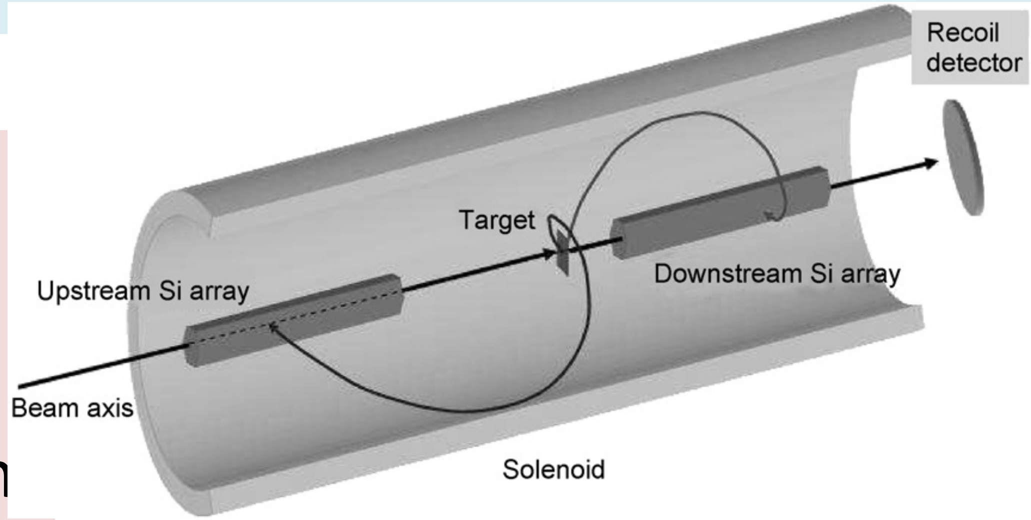


- Segmented Ge array
- Inner Si-strip detection for charged particles (T-REX)
- No show stopping beam requirements but would benefit from slow extraction and buncher/chopper

setup	Geometrical properties	Energy properties (FWHM values)	Timing	Power
MINIBALL (+general purpose reaction chamber)	<3mrad + 2-3mm FWHM diameter (at 5-10 MeV/u energy)*	En. Spread: <1e-3 En. Accuracy: <1% En. Stability: ?	Would profit from microstructure required by HELIOS	About 26 kW

Helios

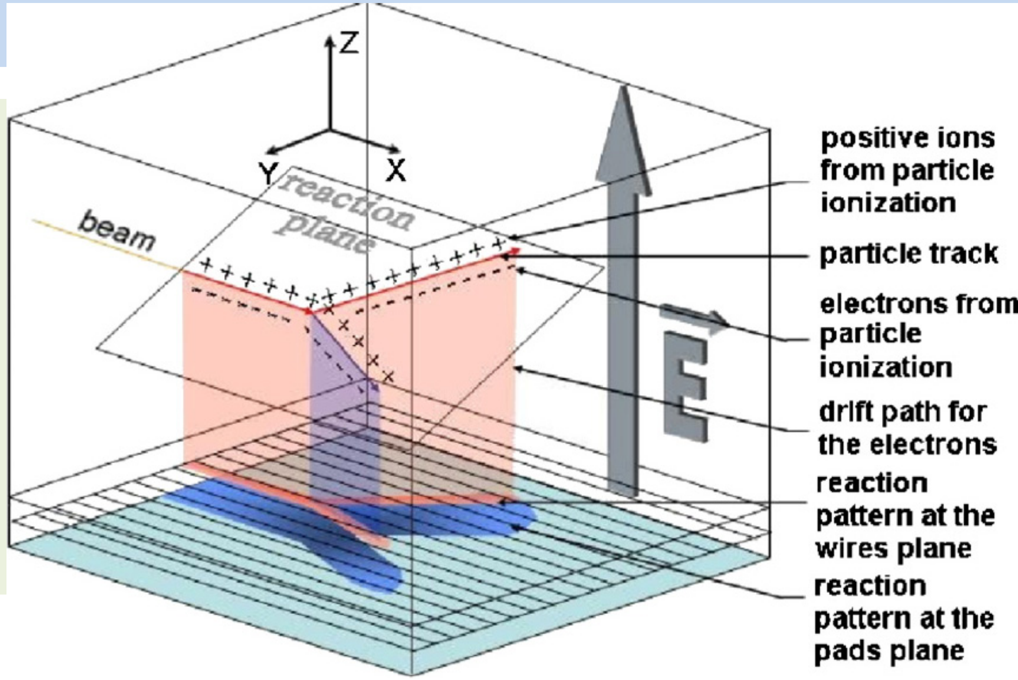
- Solenoid for transfer reactions
- Needs buncher/chopper for TOF measurement with 2 ns resolution



setup	Geometrical properties	Energy properties (FWHM values)	Timing	Power
HELIOS	3mrad + 5mm FWHM diameter at 5-10 MeV/u	En. Spread: <1e-3 En. Accuracy: <1% En. Stability:	Important (for 10MeV/u): resolution <2ns on target repetition rate: 1/100 ns no background (<1% acceptable)	below 25 kW

ACTAR

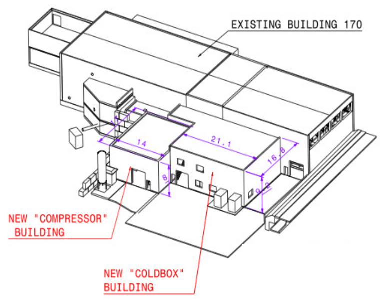
- Active target for resonant scattering and transfer reactions
- Allows to measure with very low intensities



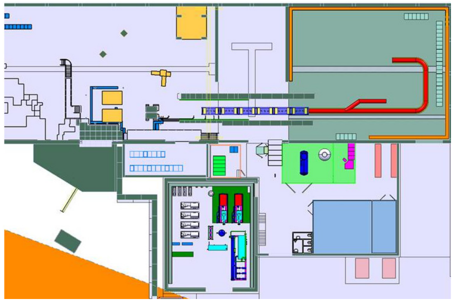
setup	Geometrical properties	Energy properties (FWHM values)	Timing	Power
ACTAR (input: R. Raabe)	<2 mrad + 3mm FWHM diameter at 5-10 MeV/u*	En. Spread: <1e-2 En. Accuracy: En. Stability:		About 25 kW

OUTLOOK

- Completion of Civil Engineering Works by Q3 2012 followed by Installation of Main Services (EL, CV, Transport)
- **Procurement of Cryogenic Plant by Sep. 2012**
- **Procurement of first series of 10 high-beta cavities launched.**
- **Procurement of CM1 and HEBT compponenets by Q3 2012.**



Thank you



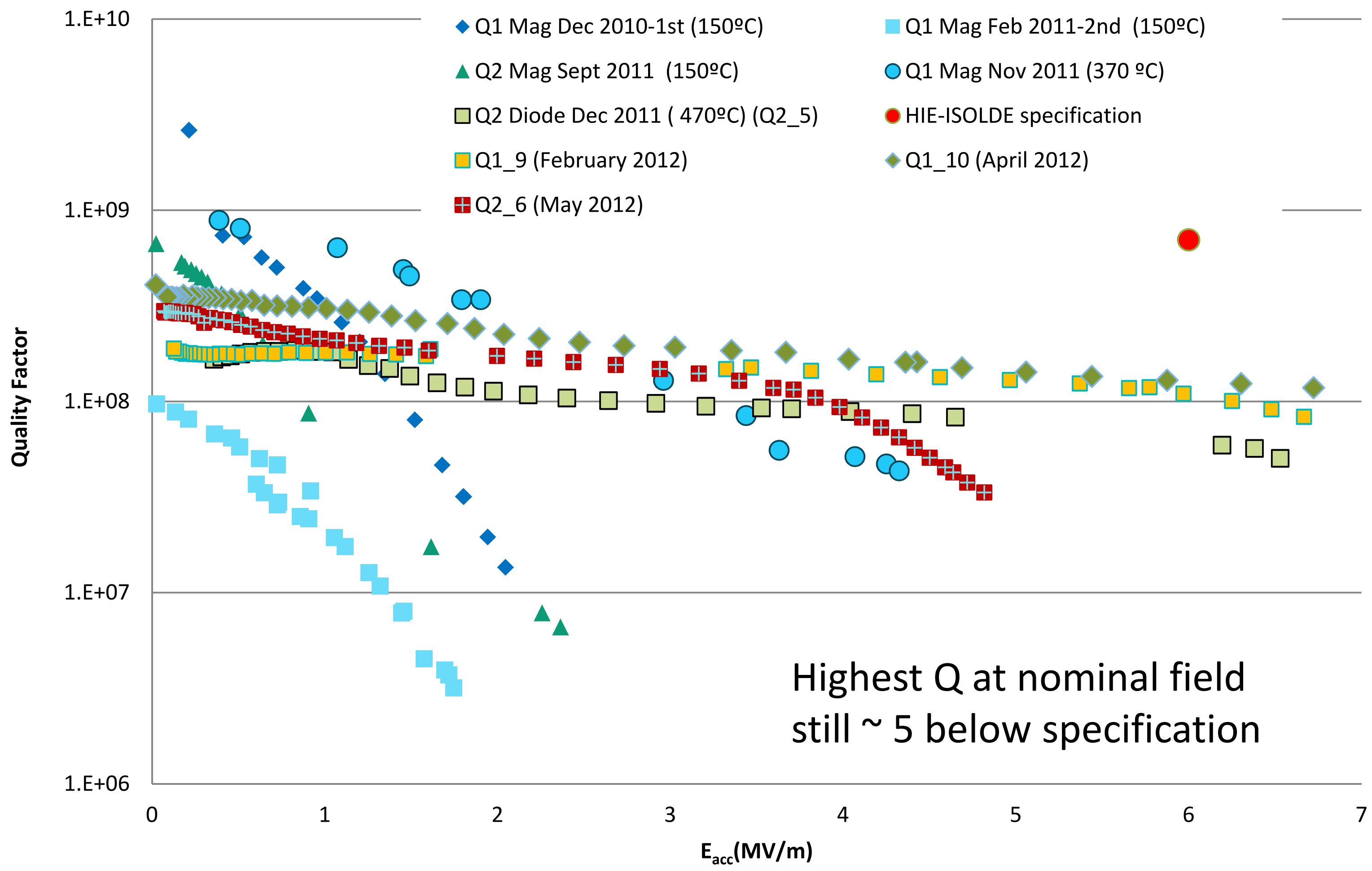
HIE-ISOLDE web site -> http://hie-isolde.web.cern.ch/hie-isolde/

CATHI-ITN web site -> https://espace.cern.ch/Marie-Curie-CATHI/default.aspx

Acknowledgements

- The ISOLDE Collaboration
- The HIE-ISOLDE Project Team and groups within CERN Accelerator and Technology Sector
- The Swedish Knut and Alice Wallenberg Foundation (KAW 2005-0121)
- The Belgian Big Science program of the FWO (Research Foundation Flanders) and the Research Council K.U. Leuven
- The CATHI Marie Curie Initial Training Network: EU-FP7-PEOPLE-2010-ITN Project number 264330.
- The Spanish Programme "Industry for Science" from CDTI

Cavity performance to date



Cavity performance: tree new coatings in 2012

	Q1_9 - diode	Q1_10 -diode	Q2_6- diode
Date of RF Meas.	February	April	May 2
Pressure (mbar)	1.7 10^{-1}	2.2 10^{-1}	2.5 10^{-1}
Discharge mean power (kW)	3.6	3.6	4.5
Deposition energy (kWh)	32	32	33
Coating temp (°C)	109-115→ 508-560	109-113→ 586-594	Likely* > 650
Changes	Higher power and temperatures then Q2_5	SS cavity support Helicoflex gasket Uniform temperature and improved base vacuum	Pre heating with internal heater Leak detected after coating*

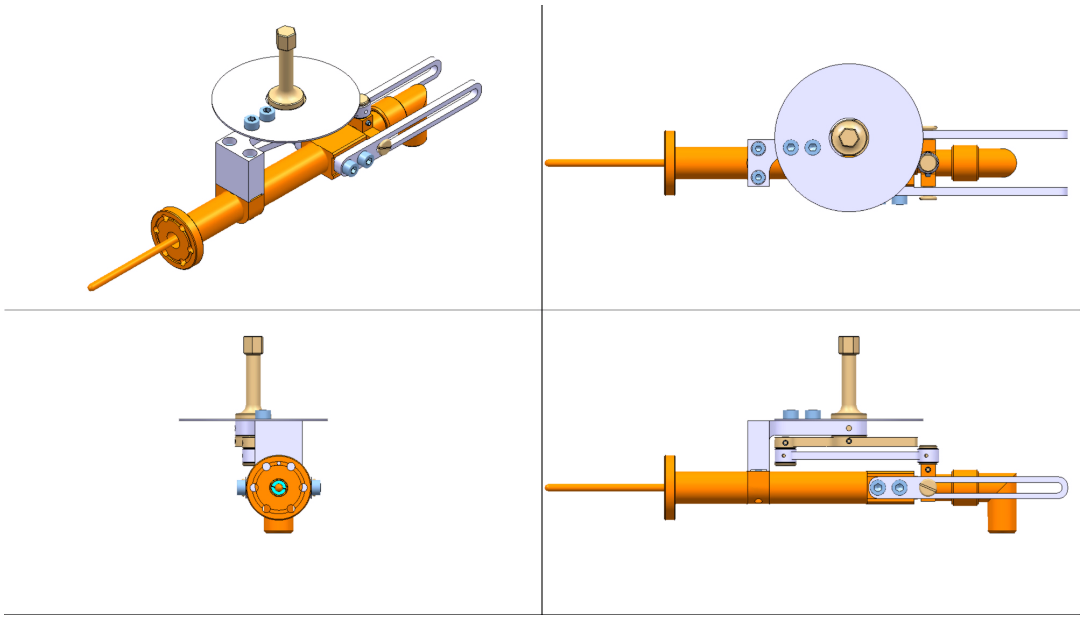
Tests performed alternatively on two copper substrates (cavities) named Q1 and Q2, from the same design, based on the rolled sheet manufacturing method; Third prototype of the same design (Q3) coming on line now

***Details in coating reports issued by S. Calatroni, B. Delaup, P. Garitty, and N.Jecklin On EDMS (1210705, 1210866, 1215502)**

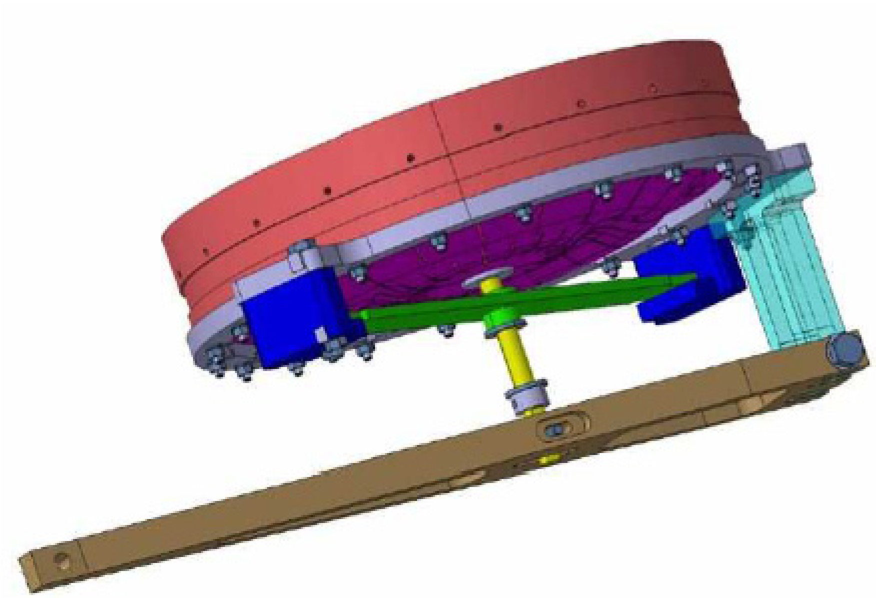
Power coupler

- Old mobile coupler was blocked two times during RF tests in 2011 (after having worked well for several tests)
- We resorted to a fixed coupler as from November 2011
  - Made the measurements more reliable and provided check point as Q_{ext} was known and one could observe when $\beta=1$
  - Slowed down RF processing (1 week to condition a cavity)

- Through the collaboration with INFN-LNL we got a mobile coupler
- New concept design started at CERN end 2011



HIE-ISOLDE tuning plate (2)



Pictorial view of the tuning plate with its actuator

Results of CST simulations: in yellow, nominal value of the tipgap at the present

	Tipgap 70mm	Tipgap 90mm
Position +5	100.684 MHz	101.235 MHz
Position -15	100.929 MHz	101.339 MHz
$\Delta_{\text{tuner plate}}$	12.25 kHz/mm	5.2 kHz/mm

This is a big number: at TRIUMF the main mechanical resonance is at 72Hz giving 0.3Hz RMS detuning ➔need correction better than 0.3Hz. If we apply the same value to our case we need to move the plate of only 0.02μm!! At TRIUMF they reached a resolution of ~0.055μm.

1. Microphonics spectrum measurements are ongoing to fix the minimum detuning we need to correct.
2. We need, anyway, to reduce the sensitivity:
   a) by choosing tipgap of 90mm (What about beam dynamics? Are the fields much different than in the case of 70mm?)
   b) By changing the plate shape with nominal tipgap of 70mm