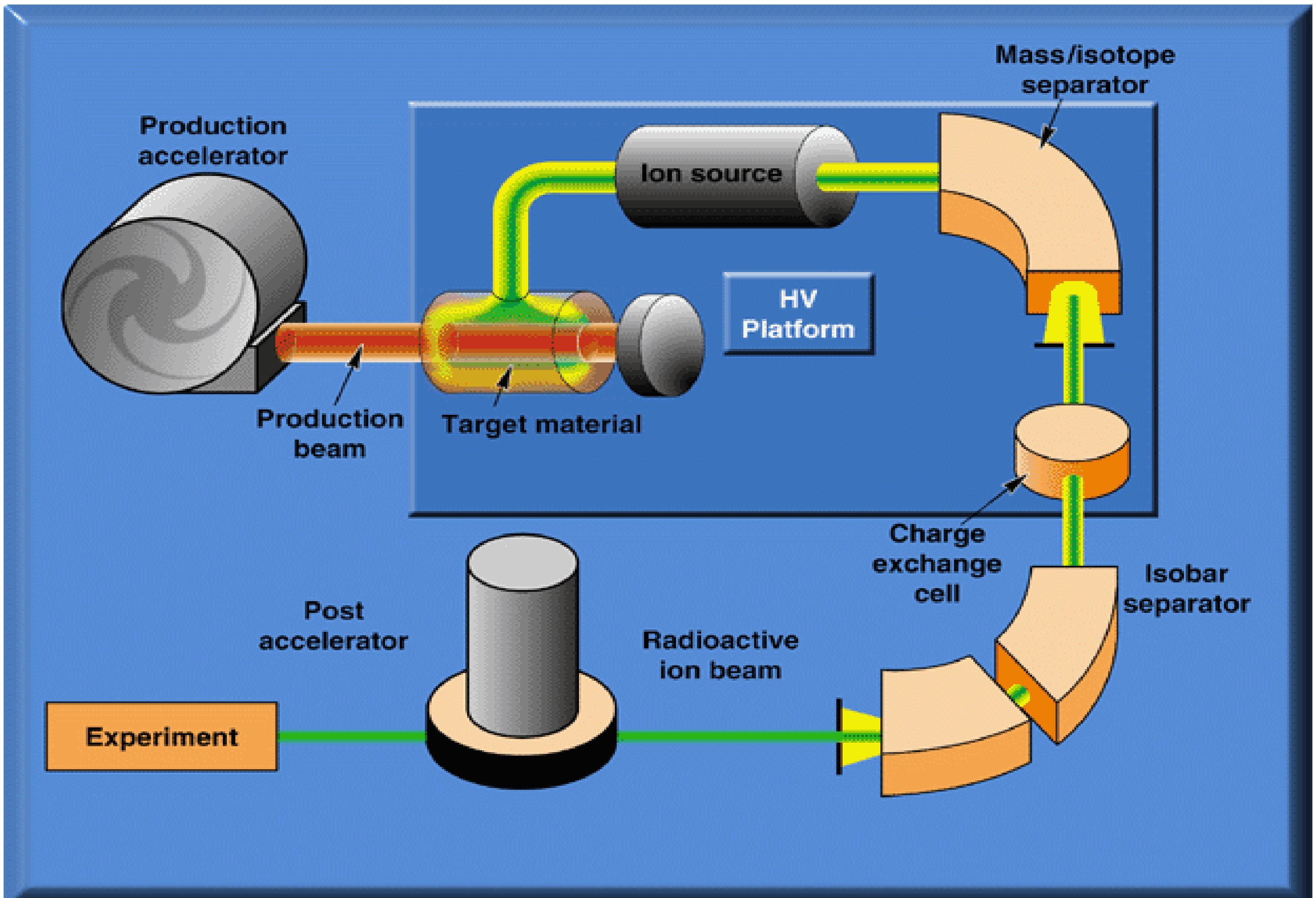
SPES

Una facility di “medio termine”
per fasci radioattivi
ai Laboratori Nazionali di Legnaro

The ISOL concept for RIB production



SPES
INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

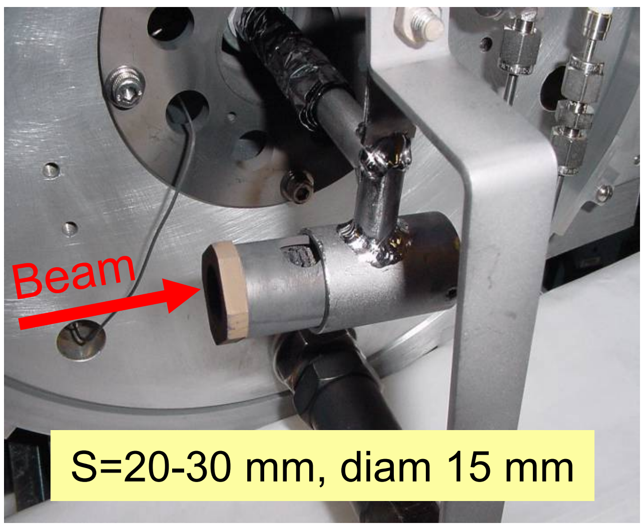
Spiral2
GANIL
GRAND ACCELERATEUR NATIONAL D'IONS LOURDS
LABORATOIRE COMMUN DSM/CEA-IN2P3/CNRS

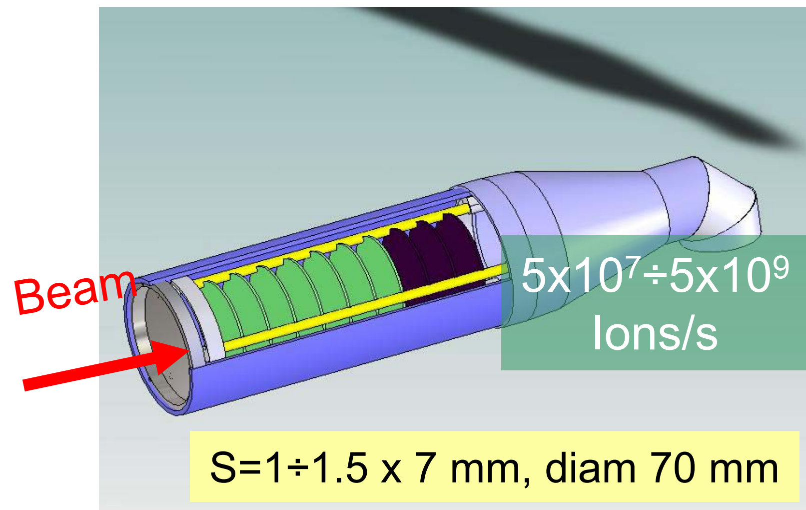
ISOL facilities nel mondo

	Fascio primario	Potenza sul bersaglio	Fissioni al secondo
ISOLDE (CERN)	protoni 1 GeV, 2 μA	0.4 KW	10^{12}
HRIBF (USA)	protoni 40 MeV, 10 μA	0.4 KW	10^{11}
TRIUMF(CANADA)	protoni 450 MeV, 100 μA	25 KW	
EXCYTE (Catania)	^{12}C 45AMeV ^{13}C 45AMeV	0.4 KW 18 W	Fascio prodotto $1.5\ 10^{4}\ ^{8}Li$
SPIRAL2 (Francia)	deutoni 40 MeV, 5 mA	200 KW	10^{13}
SPES (LNL)	protoni 40 MeV, 200 μA	8 KW	10^{13}

Evolution of the ORNL DT Approach

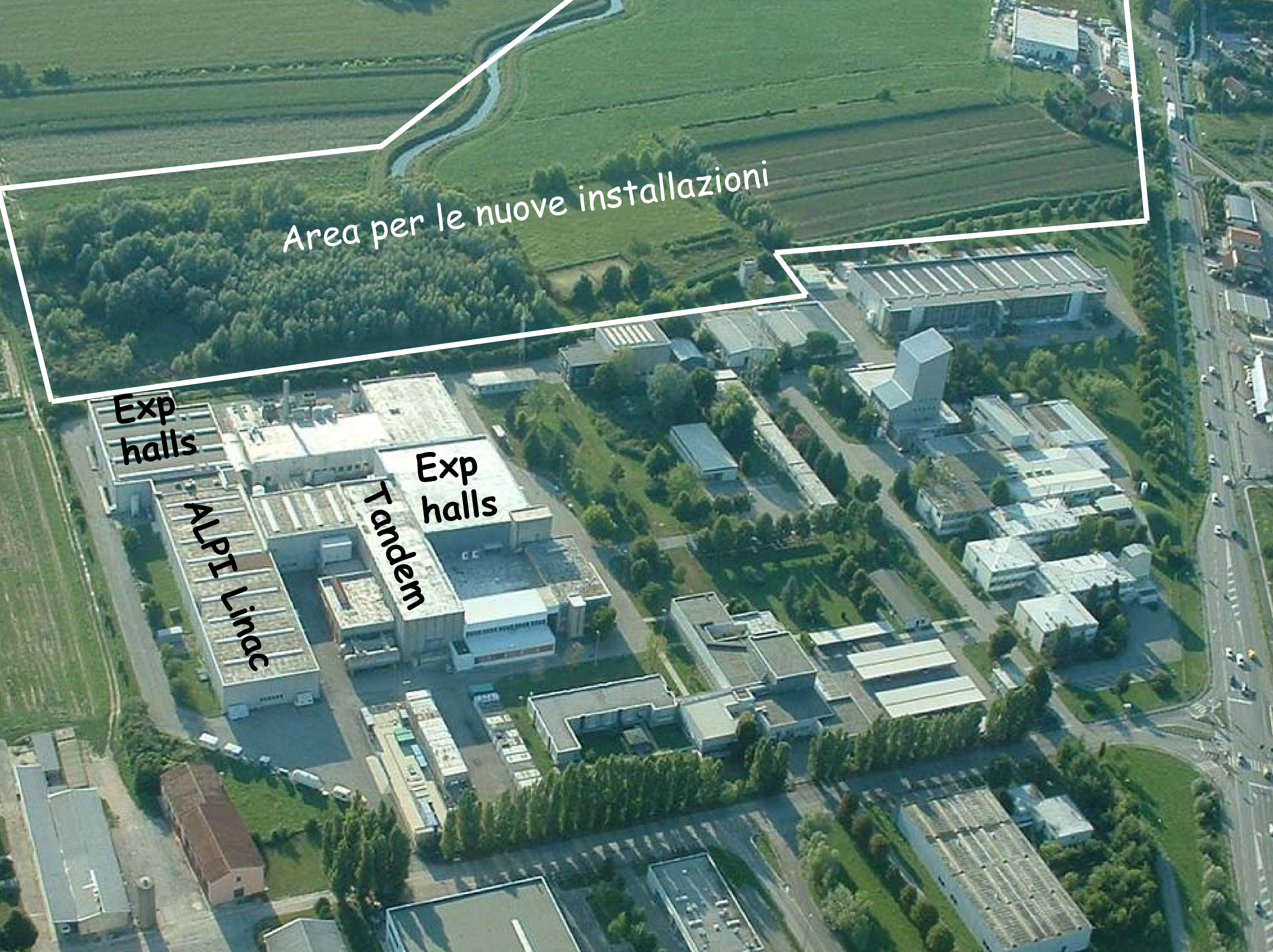
ORNL	**p, 42 MeV, 10÷12 μA**	→	**^{238}U (UC_x)**	→ **FF**	**~ $4x10^{11}$**
LNL	**p, 40 MeV, 200 μA**				**~10^{13}**

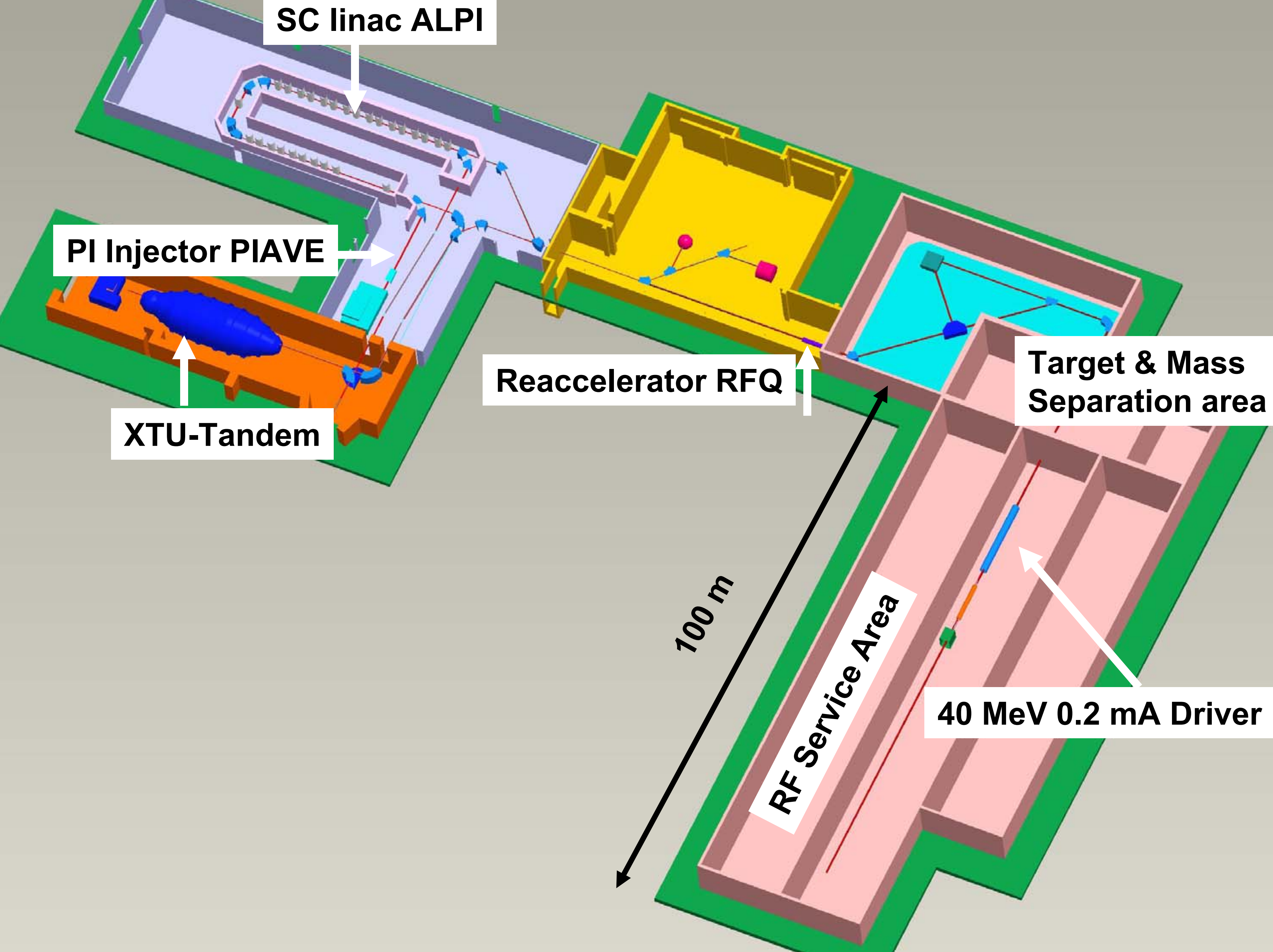




- Total of 1200 hours operation with 10-12 μA of 42 MeV protons
- More than 120 different radioactive beams extracted
- 400 W deposited in target (power density is 97 W/g, as LNL-project)

ORNL is an ideal test-bench for the LNL multi-slice target


Area per le nuove installazioni
Exp halls
Exp halls
ALPI Linac
Tandem


SC linac ALPI
PI Injector PIAVE
XTU-Tandem
Reaccelerator RFQ
Target & Mass Separation area
100 m
RF Service Area
40 MeV 0.2 mA Driver

1-step vs 2-step

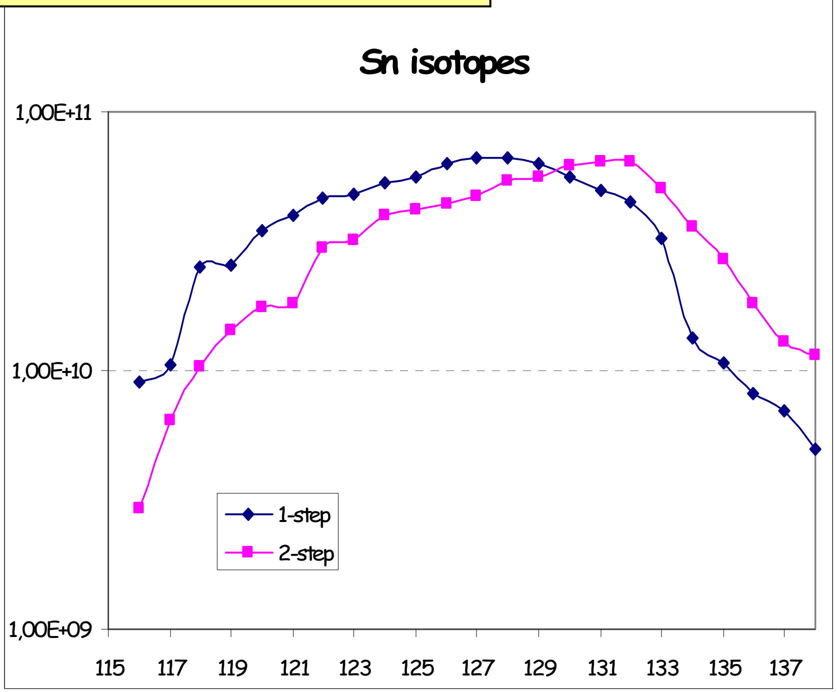
1-step: p 40 MeV 200μA on multi-slice direct target (60gr UCx)

2-step: d 40 MeV 5mA on thick ^{12}C converter + UCx target (800 gr)

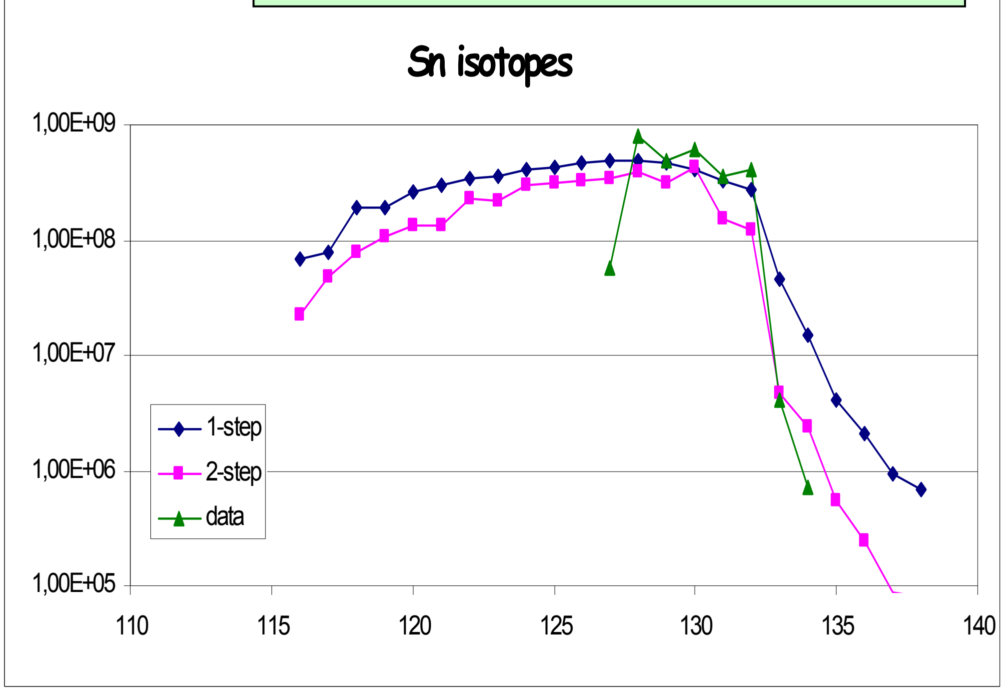
10^{13} fissions/sec

Release times considered:
1-step 2 sec, 2-step 40 sec

In-target production



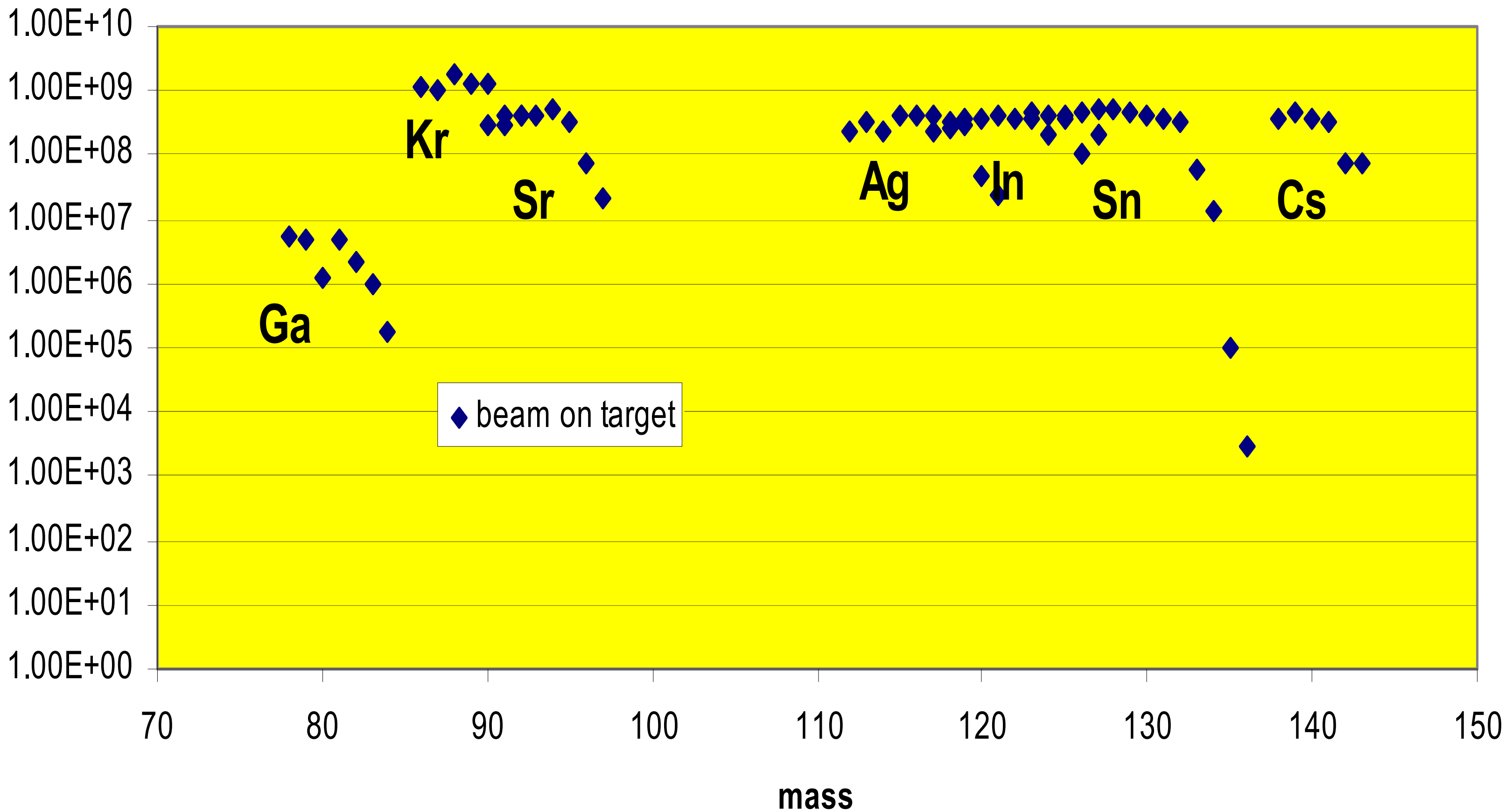
Intensities after acceleration



Evaluated beam intensities

Beam evaluated with the following efficiencies

1+ 30%, n+ 5%, acc. 50% = 0.75%
1+ 90%, n+ 12%, acc. 50% = 5.4% Xe, Kr



SPES-DirectTarget: Strategic Plan

DRIVER — **ISOL RIB SOURCE** — **RI Beam Accelerator** — **EXPERIMENT**

40 MeV, 200 μA protons

RIB production and selection (The core of the machine): Target, +1 source, Charge breeder, Isotope Separator
Authorization

ALPI is ideal for the re-acceleration of RIBs.
Its features determine the type of Physics with RIBs at LNL

INFN-LNL
+
NFN sections /Labs
+
…

Direct Target Development

Computing (Thermo-mechanical, Diffusion-Effusion, on-target production…)

INFN-LNL
ENEA-Bo
Uni-PD Mech

Pellet (LaC-SiC-UCx pellets, binder materials, Carbide Foam…)

Uni-PD, Chem & Mech Eng

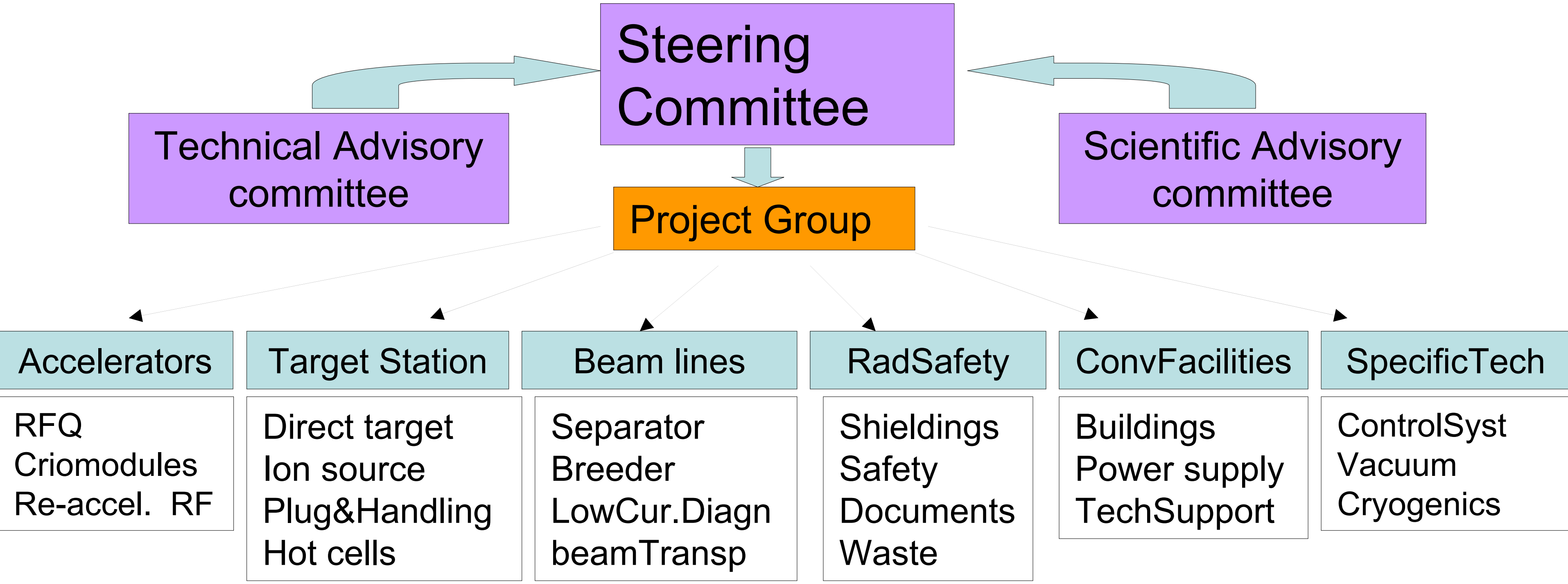
Prototype (Full engineering , Test of the P-dissipation, Test of C-window, …)

INFN-LNL& LNS, Material Res. Lab (UniPD-LN

Agreement with ORNL being signed

SPES-Direct Target
Work Package Structure

Hypothesis: to be defined asap (before fall)



Organizzazione dei LNL e Servizi

Progetto SPES_DT

P-Driver e ALPI

Divisione Acceleratori

BersaglioDiretto

Servizio Bersaglio Diretto

Servizio Utenti

Servizio sorgenti

Linee di trasporto

Divisione Acceleratori

Sicurezze e radioprotezione

Servizio Dosimetria

Servizio sicurezze

Edilizia e servizi convenzionali

Divisione Tecnica

Tecnologie Specifiche

Sistemi di controllo

Vuoto

Criogenia

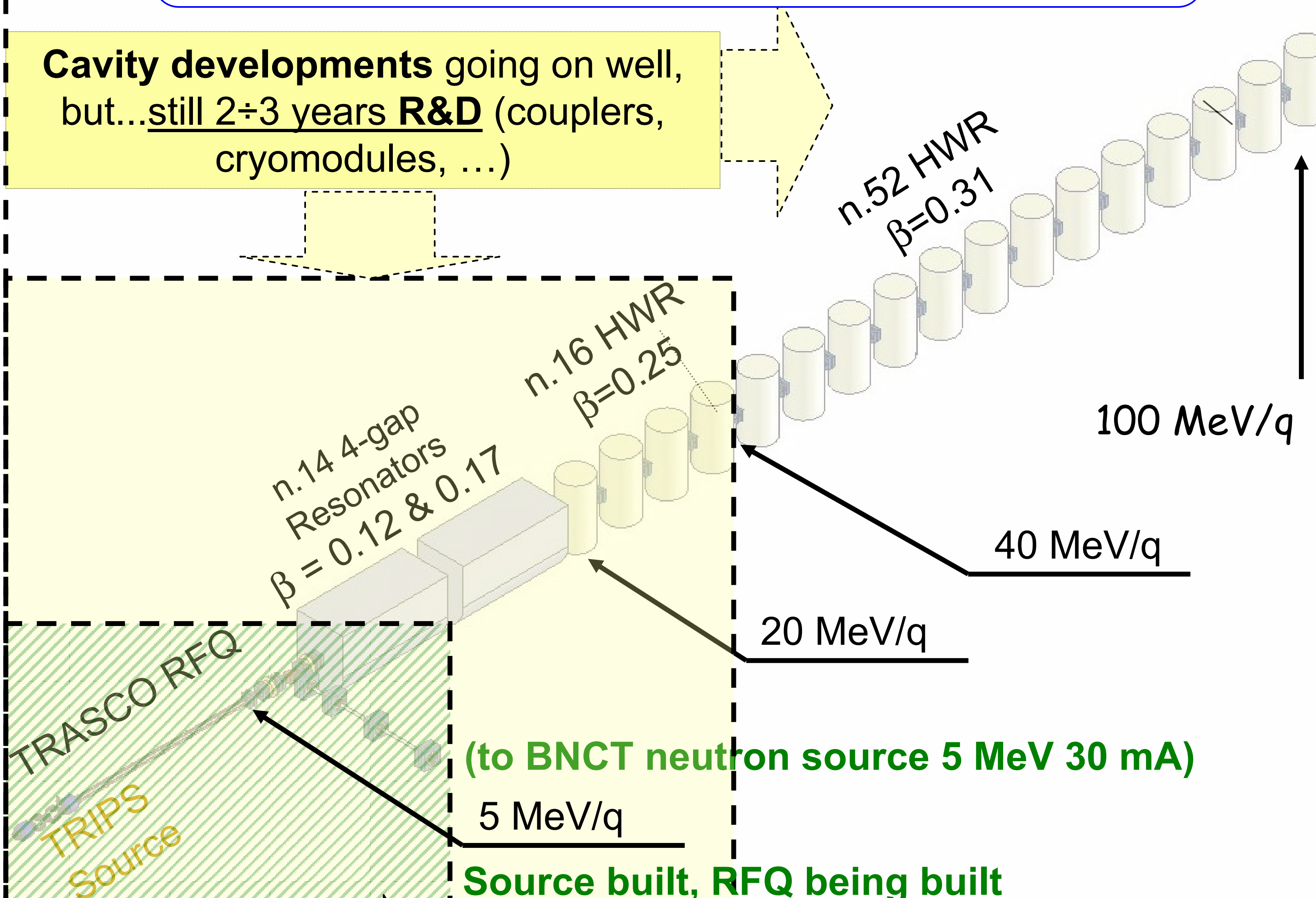
Servizi critici:

- Servizio BersaglioDiretto
- Servizio Dosimetria
- Servizio Edilizia
- Servizio sicurezze
- Controlli

Necessaria una Analisi delle attività e una riorganizzazione dei servizi

Proton Injector: the original layout

Cavity developments going on well, but...<u>still 2÷3 years **R&D**</u> (couplers, cryomodules, …)

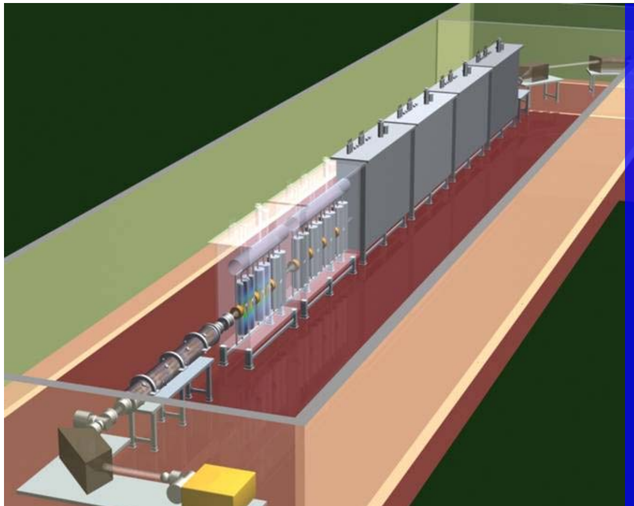


(to BNCT neutron source 5 MeV 30 mA)

Source built, RFQ being built

a quicker-to-build Driver is necessary

Two options for: 40 MeV, 200 μA with little or no R&D

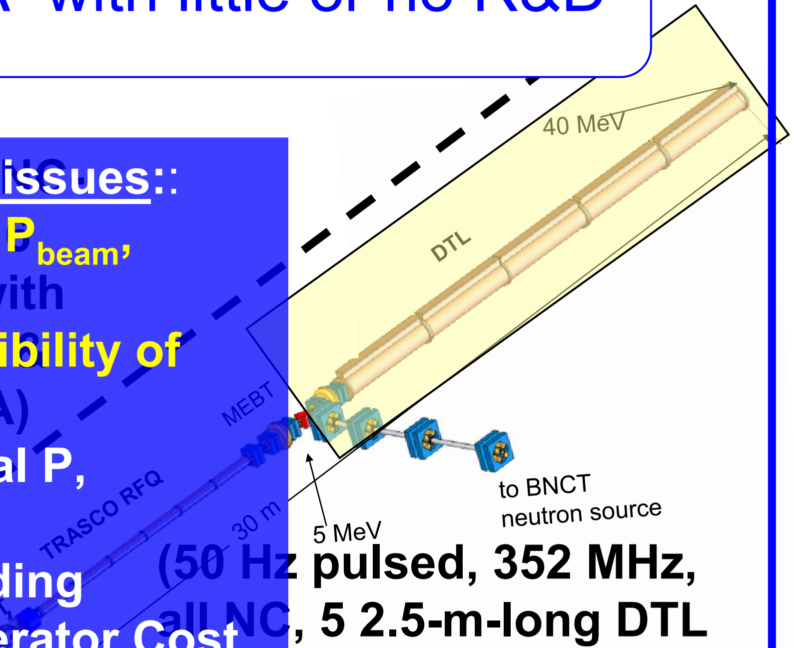


(the whole Linac can be bought turn-key from industry)

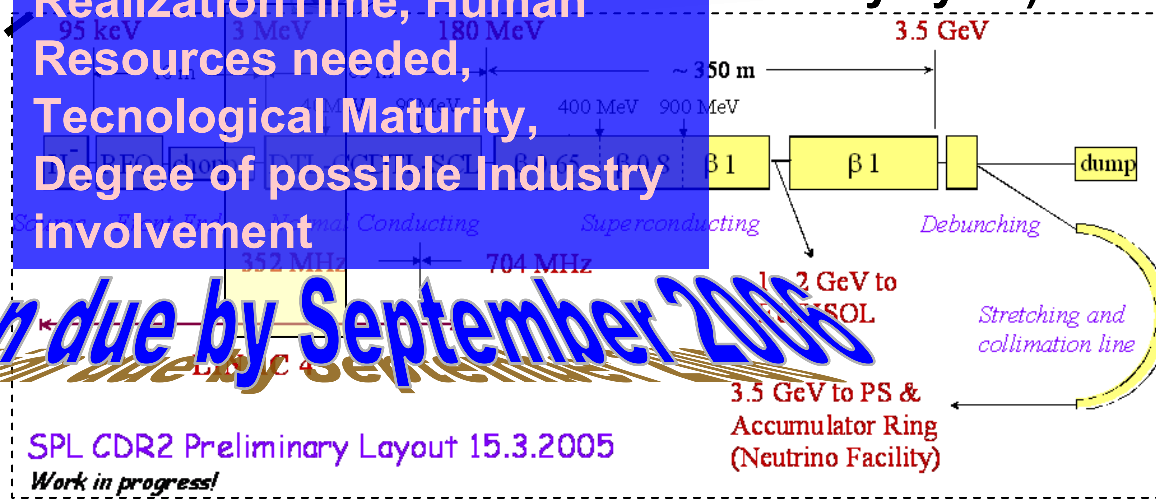
(being built for SPL, prototyped)

<u>Being compared issues</u>::

Beam Species, I, P_{beam},
Beam Losses,
Modularity, Possibility of Upgrade,
Installed electrical P, Operation electrical P, Building Size/Cost, Accelerator Cost,
Further R&D needed, RealizationTime, Human Resources needed, Tecnological Maturity, Degree of possible Industry involvement



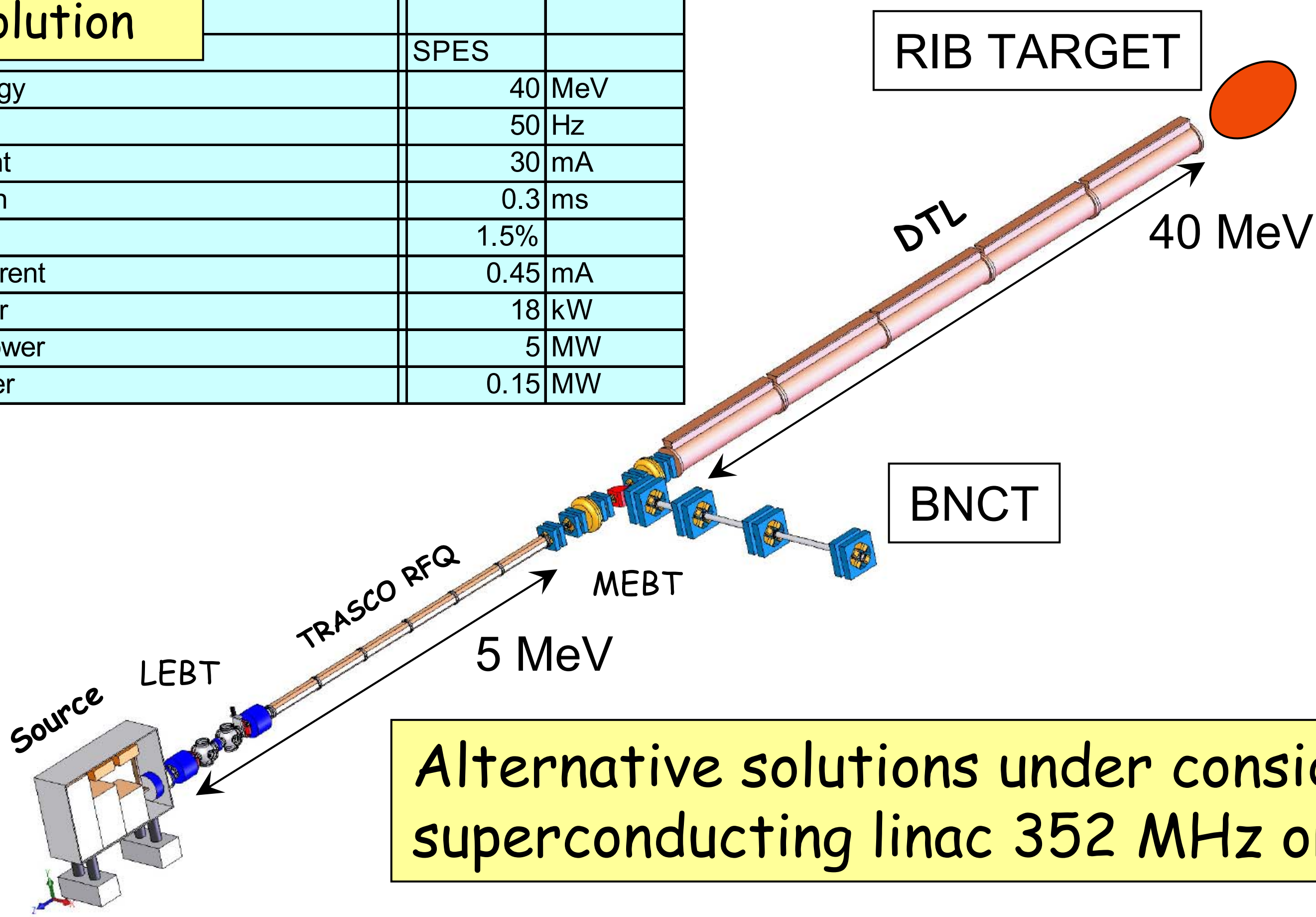
(50 Hz pulsed, 352 MHz, all NC, 5 2.5-m-long DTL units, β = 0.09 & 0.15, 3 mA 1.5% duty cycle)



Decision due by September 2006

The Proton Driver

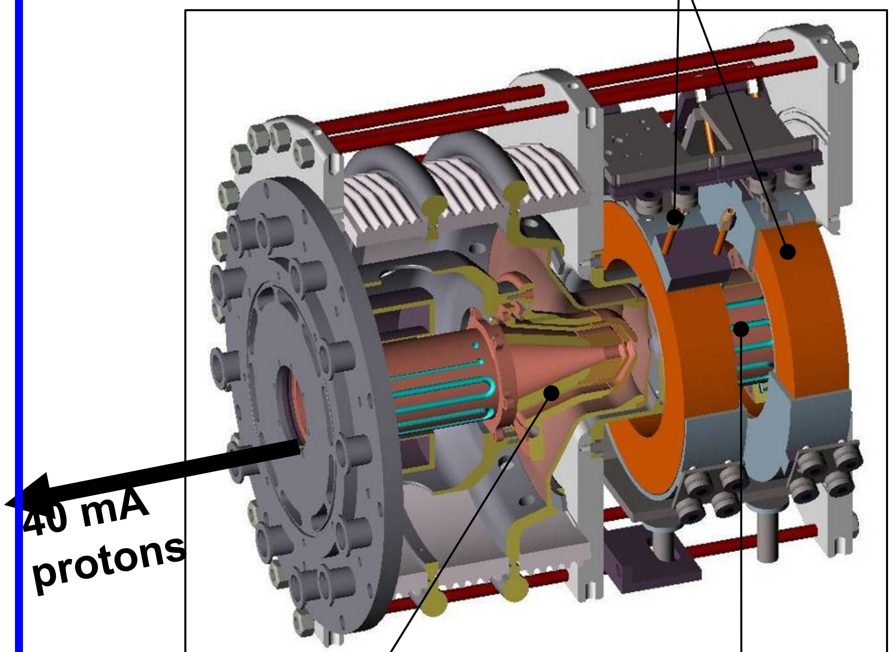
DTL solution	SPES	
proton energy	40	MeV
rep rate	50	Hz
peak current	30	mA
pulse length	0.3	ms
duty cycle	1.5%	
average current	0.45	mA
beam power	18	kW
RF peak power	5	MW
mains power	0.15	MW



Alternative solutions under consideration: superconducting linac 352 MHz or 176 MHz

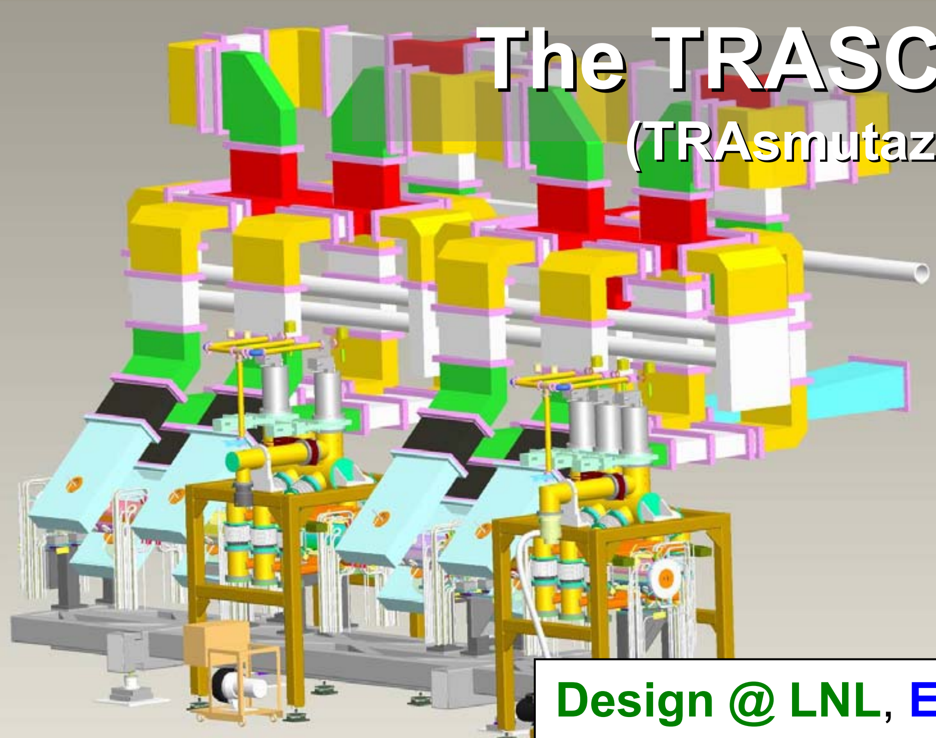
Final decision due in September 2006

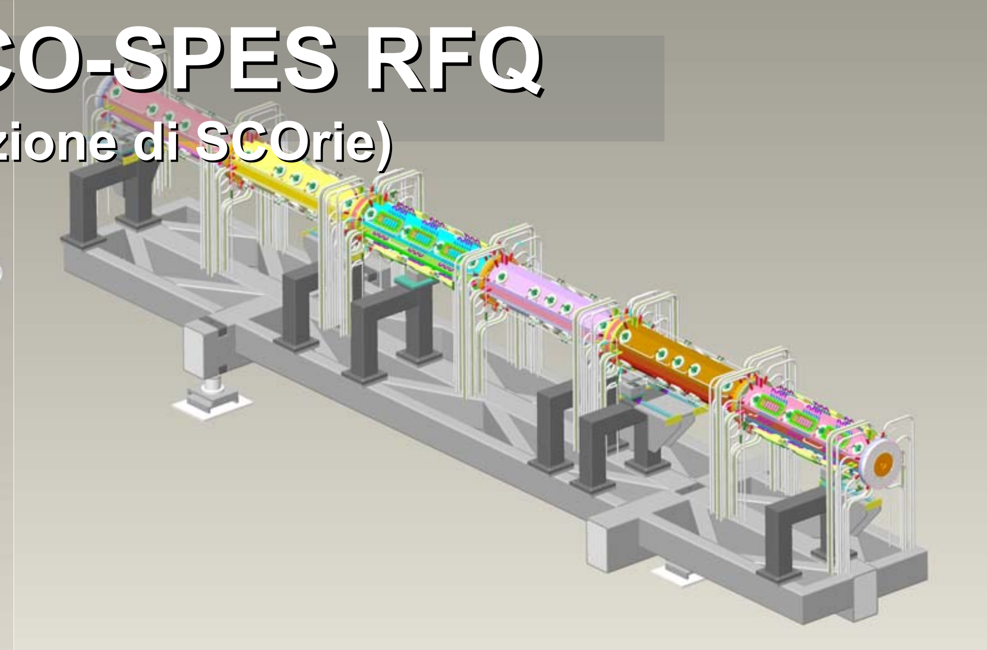
The TRASCO Ion Source TRIPS (built by INFN-LNS)



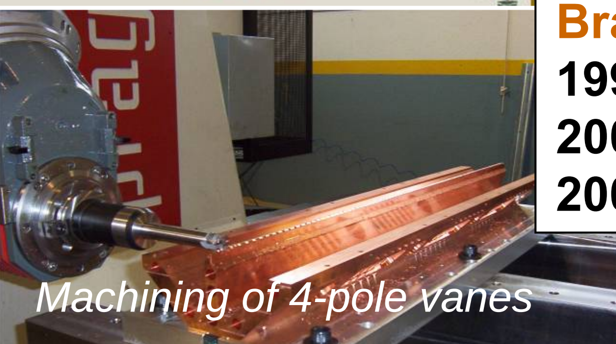
Nominal current (**40 mA**) at low emittance (~ 0.1 mm mrad rms)
has been measured (LNS)

The TRASCO-SPES RFQ
(TRAsmutazione di SCOrie)

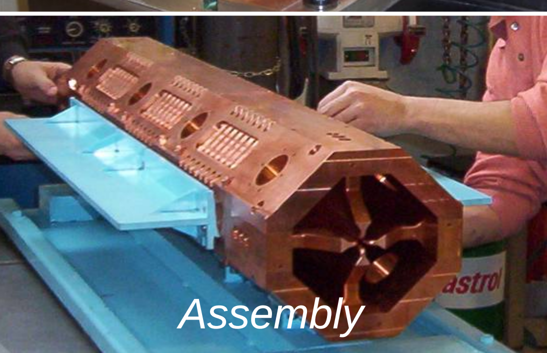




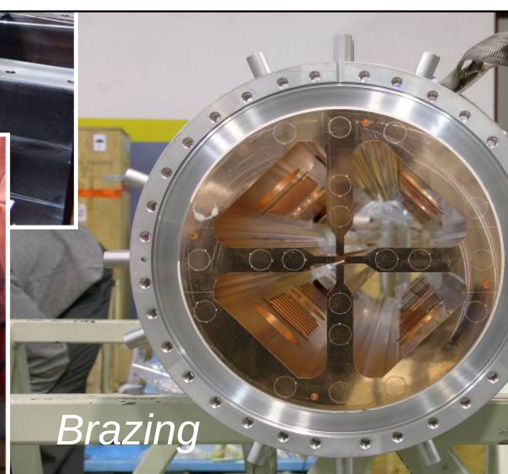
Design @ LNL, **Engineering and construction @ Industry**
Brazing @ CERN, **Measured by LNL at the company**
1999-2002: 2 Modules (R&D TRASCO activity)
2004-2007: construction of modules 3÷6
2008: low-P tests of each module, high P test of the whole RFQ



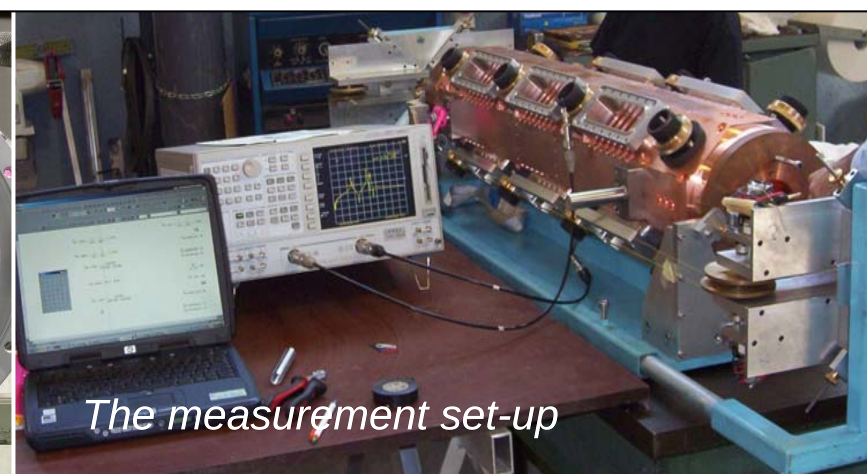
Machining of 4-pole vanes



Assembly



Brazing



The measurement set-up

Preliminary shielding calculation for the driver linac

LABORATORI NAZIONALI DI LEGNARO
Servizio di Radioprotezione

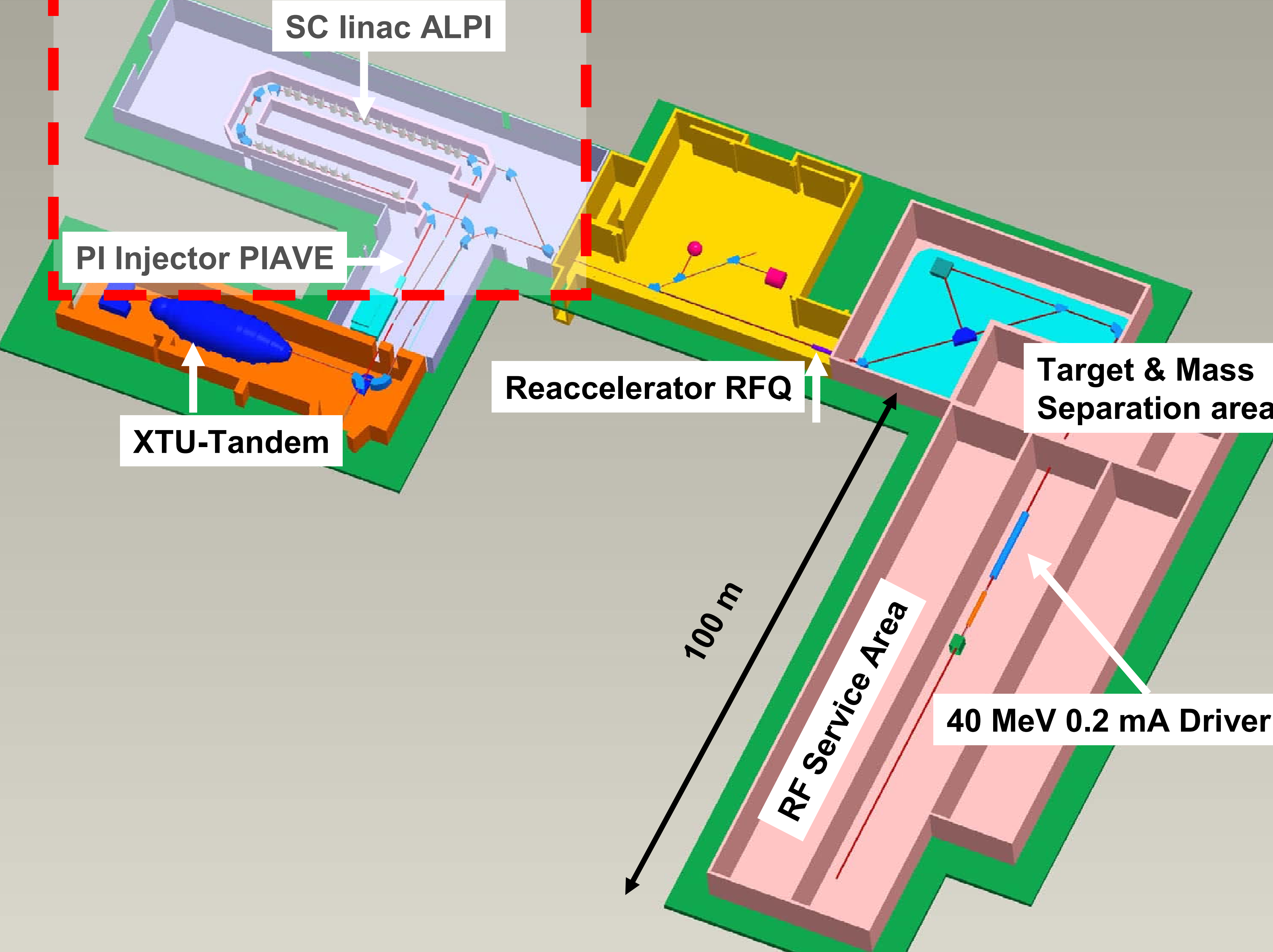
ROUGH SHIELDING CALCULATIONS

- Lateral shielding (90°) of the LINAC tunnel in the following conditions
  - beam: protons
  - Energy: 40 MeV final
  - beam losses: 1 W/m continous
  - target: Iron or copper
  - Desired RDAE: 0.1 µSv/h

(90°)	SOURCE TERM (0°)	EFFECTIVE SOURCE TERMS
10 MeV	1.2×10^{3} n/p	10^{-18} Sv/p at 1 m
20 MeV	4×10^{-3} n/p	10^{-17} Sv/p at 1 m
30 MeV	1.1×10^{2} n/p	3×10^{-7} Sv/p at 1 m
40 MeV	2.3×10^{2} n/p	3×10^{-7} Sv/p at 1 m

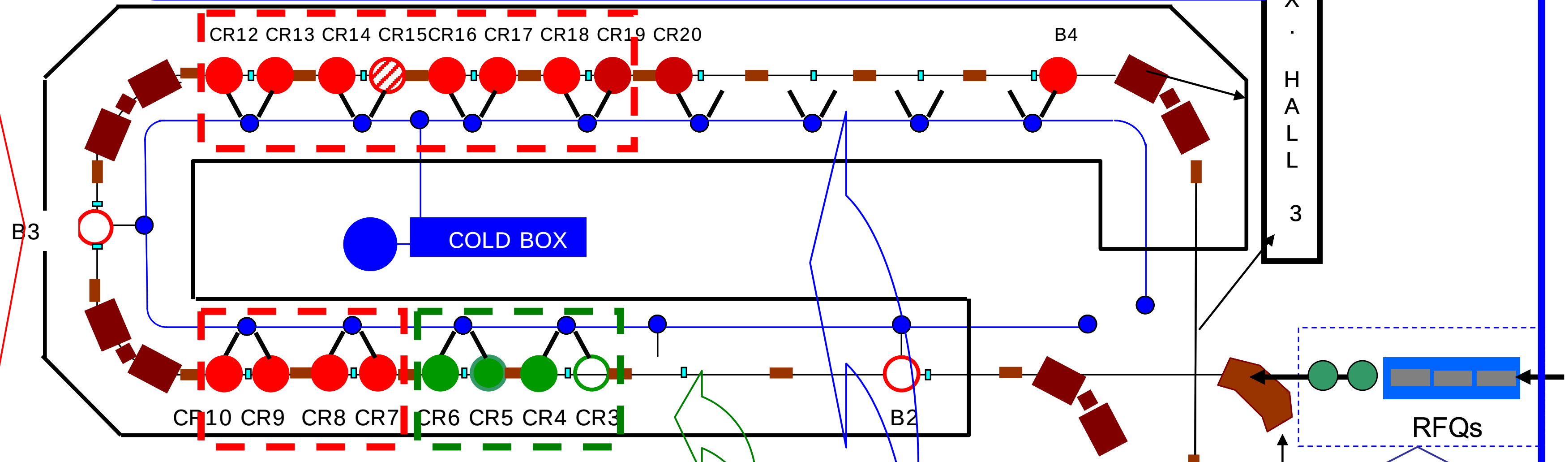
FOR THE DOSE EQUIVALENT RATE OUTSIDE A LATER SHIELD FROM A CONTINOUS LOSS OF PROTONS ALONG A BEAM LINE EQUATION

For the 10÷40 MeV sections, 90÷130 cm of concrete is enough



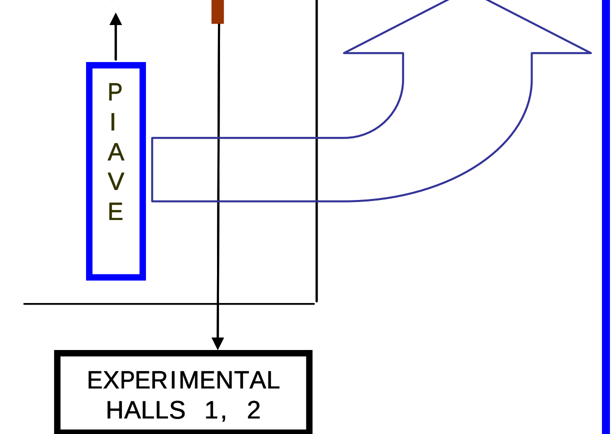
SC linac ALPI
PI Injector PIAVE
XTU-Tandem
Reaccelerator RFQ
Target & Mass
Separation area
100 m
RF Service Area
40 MeV 0.2 mA Driver

Preparation of ALPI as a RNB Accelerator



ALPI Upgrade as a RIB Accelerator

- New or displaced HI Injector
- Full set (n.16) of low beta resonators at > 6 MV/m
- Further upgrade of medium beta resonators (4.3 → 5.5 MV/m)
- Moderate upgrade of the cryogenics system (back to nominal 7 W/cavity)
- Some quads from 20 to 30 Tm
- **New diagnostics (large I and E ranges, RA, sub mm spatial res., few 100 ps,…)**



Schedule

	2006	2007	2008	2009	2010	2011	2012
Target prototypes	■	■	■				
Authorization to construction	■	■					
Facility Design	■	■	■				
Building Construction			■	■			
Completion of driver (1st part-RFQ)	■	■	■				
Installation and commissioning of SPES-1					■	■	
Construction of driver (2nd part-DTL)		■	■	■		■	
Installation and comm. of the full driver						■	
Installation and comm of the target system			■	■			
Alpi preparation for post acceleration	■	■	■	■			
Installation of RIBs transfer lines and spectrom.				■	■		
Complete commissioning							■

<u>Ansatz</u>:
New TDR October 2006
Green light by the end of 2006

Energy profile following possible ALPI Upgrade (Ansatz: full funding today!)

Year		2006	2007		2008		2009
E_{acc} [MV/m]	CR03	0	0	0	6	6	6
	CR04->CR06	3	3,5	3,5	3,5	3,5	6
	CR07->CR20	3,6	3,6	4,2	3,6	4,2	5,5
Energy [MeV/A]	$^{238}U^{28+}$	4,96	5,21	5,84	5,97	6,6	8,64
	$^{132}Xe^{19+}$	6,13	6,39	7,15	7,18	7,94	10,27
	$^{132}Xe^{26+}$			*9,6*			13,2
Energy [MeV/A]	$^{132}Xe^{40÷44+}$	*9,1*		10,6		11,25	15,1
with HE Stripper	$^{132}Xe^{41÷45+}$			*13*		13.04	17.07

1. P_{cryo}/resonator back to nominal value (7 W)
2. Low-beta cavities: higher P amplifiers (3 →3.5 MV/m)
3. Low-beta resonators: CR03 at 6 MV/m, CR04-CR06 3.5 → 6 MV/m
4. Further upgrade of medium beta resonators (4.3 →5.5 MV/m)
5. Operation of the new ECR Ion Source
6. Use of high E stripper (~80% beam loss)

FUNDED

The resonator upgrades apply as well to ALPI as an RNB reaccelerator

Outlook

SPES was originally motivated by the appropriateness of ALPI as RNB Accelerator (Upgrade Programme started – partly funded)

The multislice DT concept allowed focusing onto a 40 MeV 200 μA proton beam driver

Definition of industry-assisted 40 MeV p driver (nc or sc), by September 2006

Decision within 2006 → RNBs in 2012