

Il contributo tecnologico dell'INFN

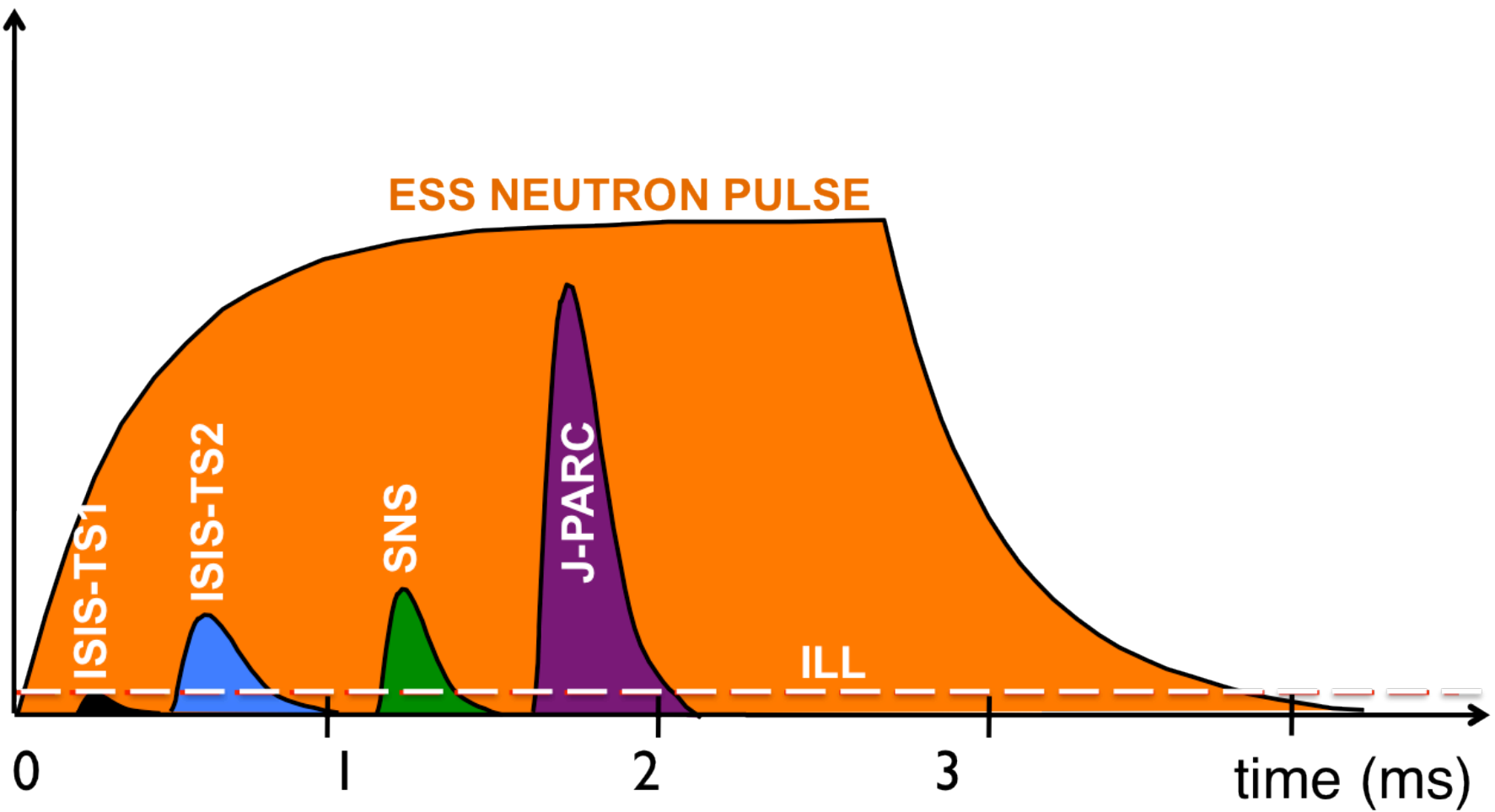
S. Gammino

Roma, 6 Dicembre 2013

ESS - General

- * The ESS will be a multidisciplinary Research center where the most powerful neutron source (30 times more than the today's leading facilities) will be available
- * ESS will be constructed in Lund, hosted by Sweden and Denmark but realized by at least 17 European countries
- * It will be based on a superconducting linear accelerator where high intensity protons will be accelerated
 - Average proton beam power: 5MW
 - Protons pulse current of 62.5 mA in 2.86 msec at 2.0 GeV
 - Repetition rate of 14 Hz
 - ***High reliability (95%) is a challenge for the Front End (under INFN responsibility)***
- * Protons will reach a single neutron target section from which the neutron flux will be produced (spallation reactions)

Brilliance





CONFIDENTIAL

X
3,6 MeV

X
93 MeV

28(165)

X
2000 MeV

ESS - The INFN contribution

* INFN has been involved in the Design Update phase (2011-12), for several components of the LINAC, and it is involved in the next phase, aimed to the construction of prototypes

— The Proton source

— The LEBT

— The Drift Tube Linac

— The Superconducting elliptical cavity @ high energy section

Preconstruction phase

1st ESS Steering Committee

22nd & 23rd October 2009 Copenhagen

strong support from 13 (now 17) countries to:

- to engage in the ESS Design Update
- to prepare organisation aimed for construction



INFN contribution started in 2009 and followed during the revision of the baseline (Accelerator Design Update 2011-12) until the issue of the

ESS Technical Design Report



ACCSYS redesign impact

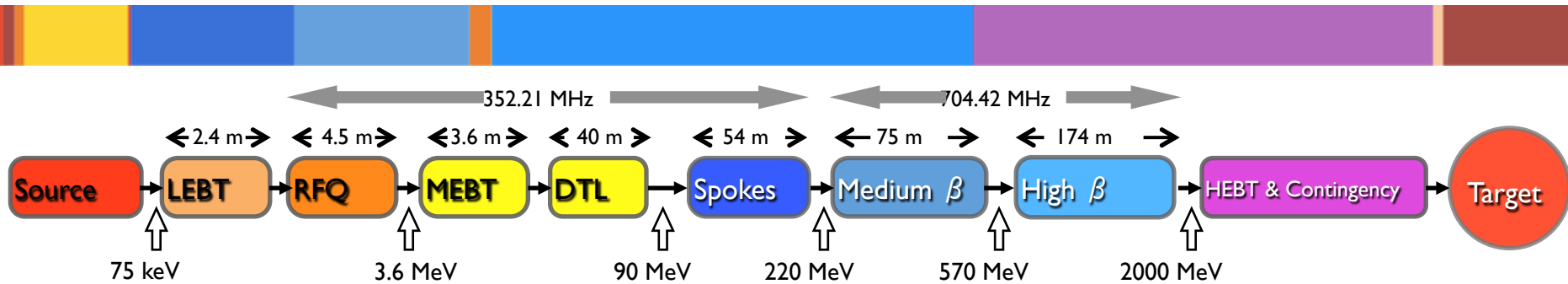
In order to minimize the cost of the accelerator (down to 497 M€) a redesign was necessary after the Technical Design Report presentation, to decrease the energy (2.5 GeV to 2.0 GeV) and to increase the current (50 to 62.5 mA).

That made the low energy section more complex, and the prototype preparation activity was affected.

The entire accelerator's schedule has been revised successfully and after the summer 2013 the activity restarted with the due speed.

A review of the ESS design has been positively carried out in November.

ESS Linac



	Energy (MeV)	No. of Modules	No. of Cavities	βg	Temp (K)	Cryo Length (m)
Source	0.075	1	0	—	~300	—
LEBT	0.075	—	0	—	~300	—
RFQ	3.6	1	1	—	~300	—
MEBT	3.6	—	3	—	~300	—
DTL	90	5	5	—	~300	—
Spoke	220	13	2 (3C) $\times$ 13	0.5 β_{opt}	~2	4.14
Medium β	570	9	4 (6C) $\times$ 9	0.67	~2	8.28
High β	2000	21	4 (5C) $\times$ 21	0.86	~2	8.28
HEBT	2000	—	0	—	~300	—

ESS **NEW** Requirements



- Maximum beam current at the target: 62.5 mA
- Pulse during neutron production: 2.86 ms
- Beam Stability: $\pm 2.5\%$ (I, ϵ) - Beam emittance 0.25π mm mrad
- New RFQ input Twiss parameters
- The peak beam current to be able to be varied from 6.3 mA to 62.5 mA with
a maximum step size of 6.3 mA and with a precision of 1.6 mA.



Proton current needed from the source 70 mA circa and
total drain current above 85 mA is expected

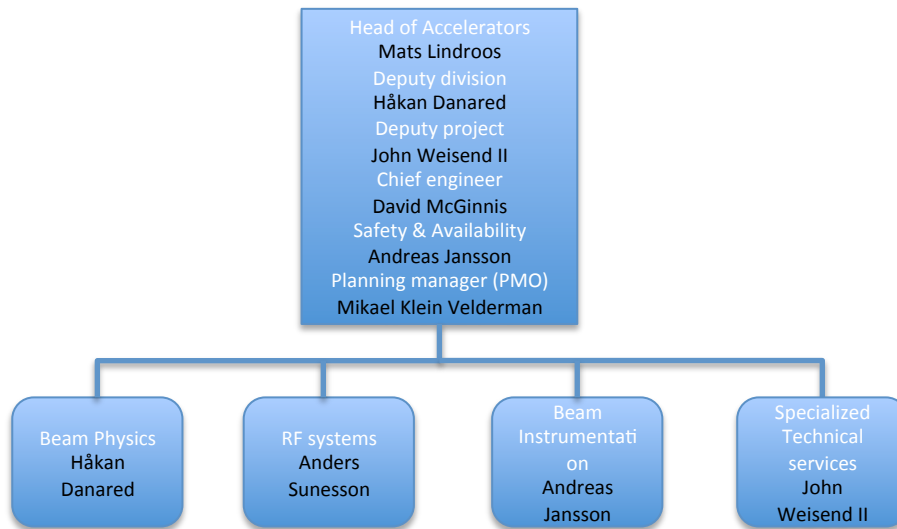
Extraction redesign needed



Huge impact of Mechanical design and beam
dynamics in the low energy part

DTL main changes : 4 → 5 tanks

Details on AD and ACCSYS organization



Lead engineers: Aurelien Ponton, Benjamin Cheymol, Stephen Molloy, Christine Darve, Peter Ladd, Tom Shea

WP#	WP TITLE	WP LEADER	EXTERNAL WP?	LIASON FOR EXTERNAL WP
1	MANAGEMENT	J.G. WEISEND II	NO	
2	ACCELERATOR PHYSICS	M. ESHRAQI	NO	
3	NORMAL CONDUCTING FRONT END	S. GAMMINO	YES	A. PONTON
4	SPOKE CRYOMODULES	S. BOUSSON	YES	S. MOLLOY
5	ELLIPTICAL CRYOMODULES	P. BOSLAND	YES	C. DARVE
6	HEBT & MAGNETS	S. MØLLER	YES	P. LADD
7	BEAM DIAGNOSTICS	A. JANSSON	NO	
8	RF SYSTEMS	A. SUNESSION	NO	
9	ACCEL INFRASTRUCTURE & INSTALLATION	G. LANFRANCO	NO	
10	TEST STANDS	W. HEES	MIXED	W. HEES
11	CRYOGENICS	P. ARNOLD	NO	
12	VACUUM	P. LADD	NO	
13	SAFETY & RELIABILITY	A. JANSSON	NO	
14	REDESIGN EFFORT	D. MCGINNIS	NO	
15	COOLING & ELECTRICAL SUPPORT	F. JENSEN	NO	

- Division and project aligned at high level
 - ✓ WP as groups would make for too big fragmentation
- Weekly or bi-weekly meetings t ESS Accelerator Division
 - ✓ Management board of project and division
 - ✓ WP leaders
 - ✓ Lead engineers
 - ✓ Safety
- Regular meetings for ACCSYS project
 - ✓ Technical board (all WP leaders and reps of labs/uni with contract) as governance and CCB on project level (6 a year)
 - ✓ Collaboration board with reps of director of labs/uni with contracts as oversight committee
 - ✓ Audits yearly of every WP
 - ✓ Reviews (Conceptual, design, ready to build) as required

Prototyping the ESS accelerator



Sebastien Bousson



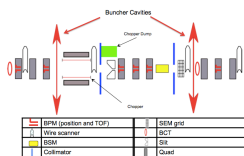
Pierre Bosland



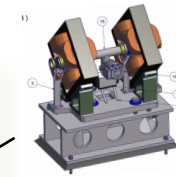
CERN



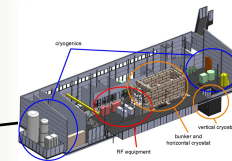
Roger Barlow



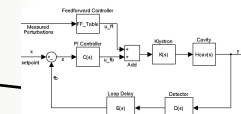
Ibon Bustinduy



Søren Pape Møller



Roger Ruber

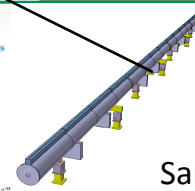
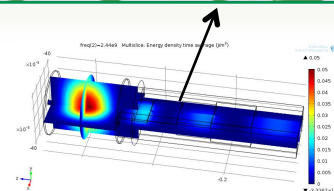


LUND UNIVERSITY



Anders J Johansson

The National Center for Nuclear Research, Swierk



Santo Gammino



The high current proton source will be based on the know-how acquired during the design phase and the construction phase and commissioning of the sources named TRIPS and VIS at INFN-LNS and of the SILHI source at CEA-Saclay.

Beam energy 80 keV

Current up to 60 mA

Proton fraction $> 80\%$

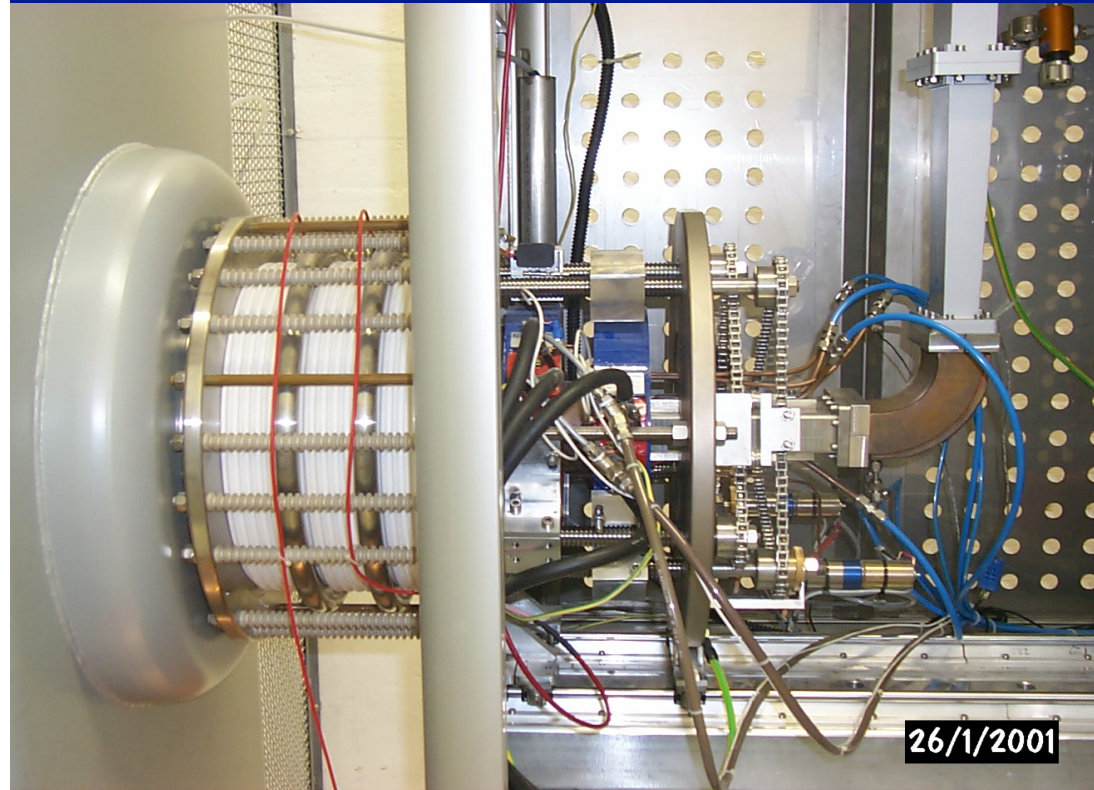
RF power < 1 kW @ 2.45 GHz

CW mode

Reliability 99.8% over 142 h (35 mA)

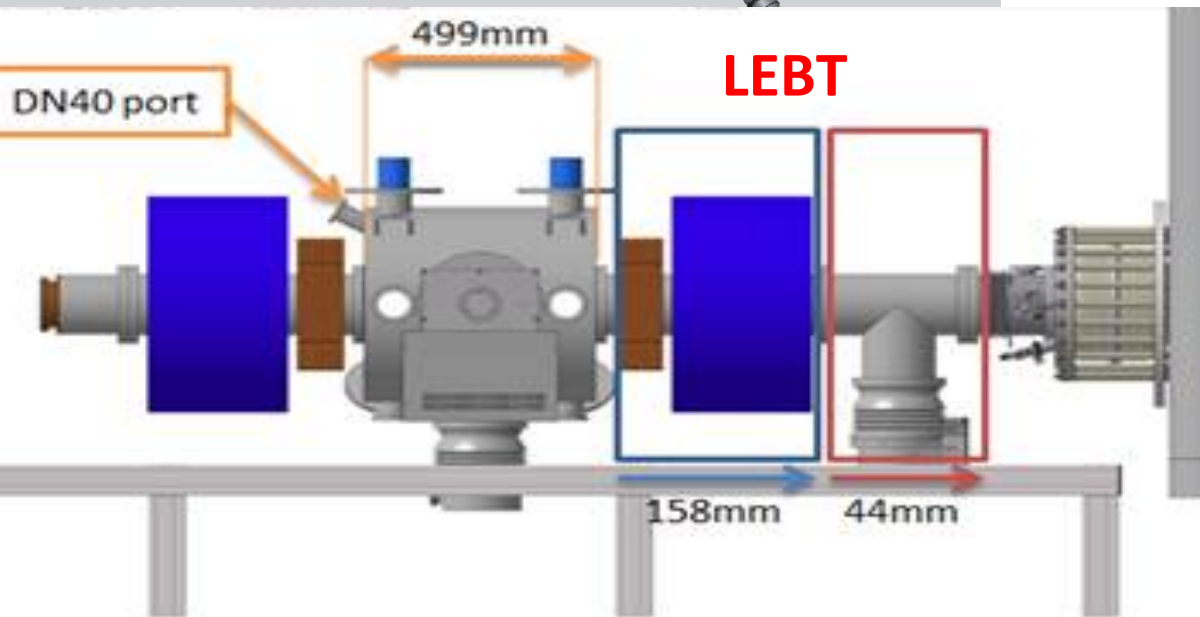
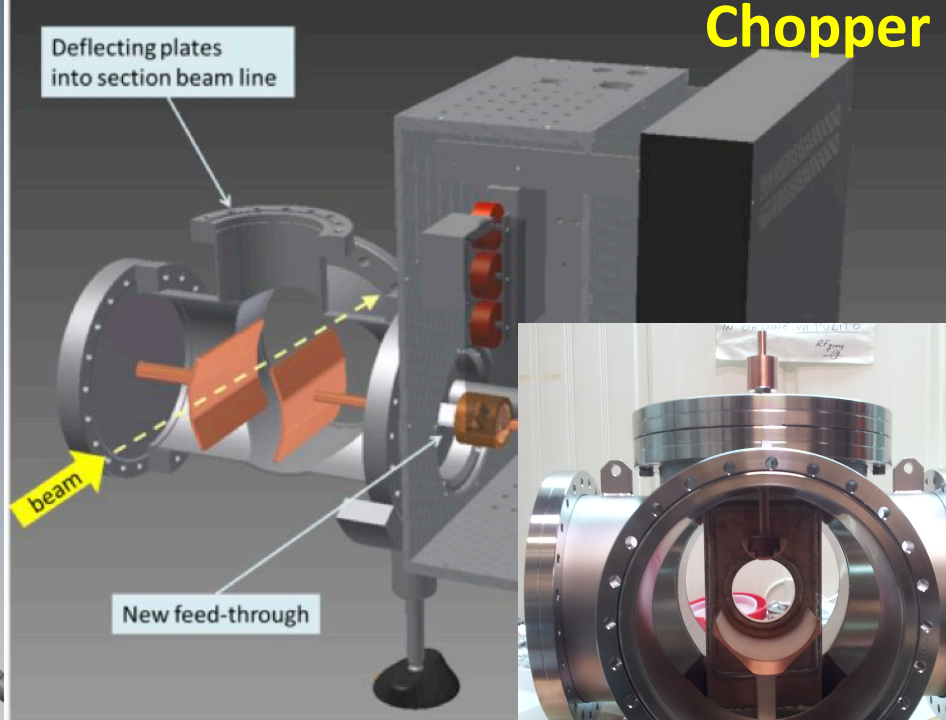
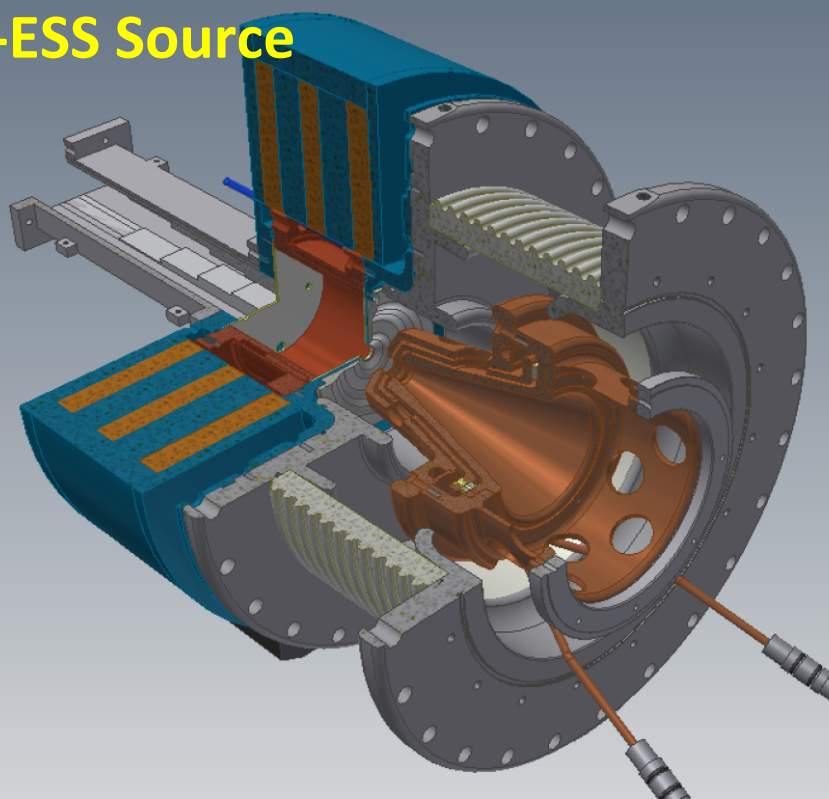
Emittance 0.07π mm mrad (32 mA), 0.15 to 0.25 at max current

TRASCO INTENSE PROTON SOURCE

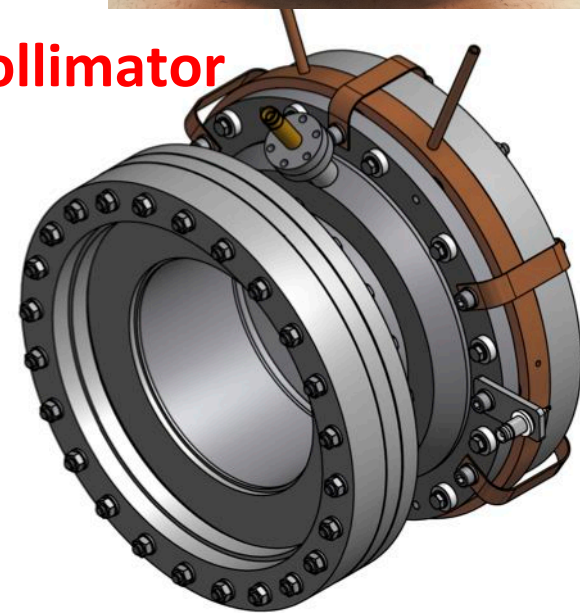


Test benches available at INFN-LNS and at CEA-IRFU

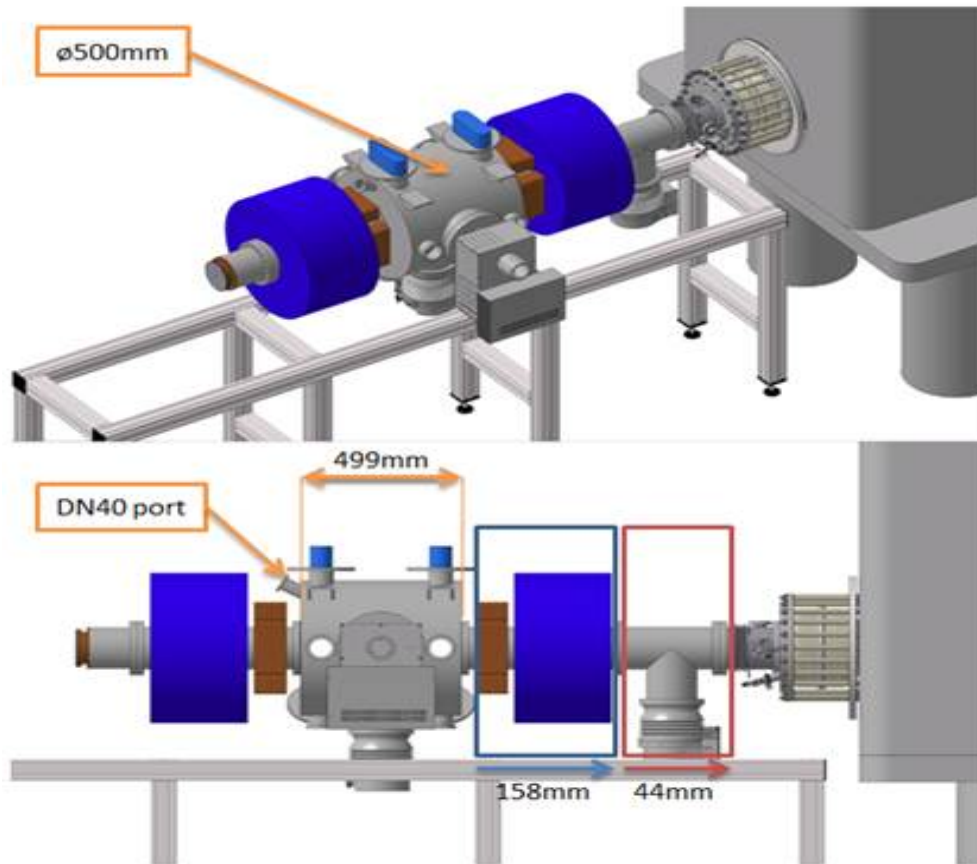
PS-ESS Source



Collimator



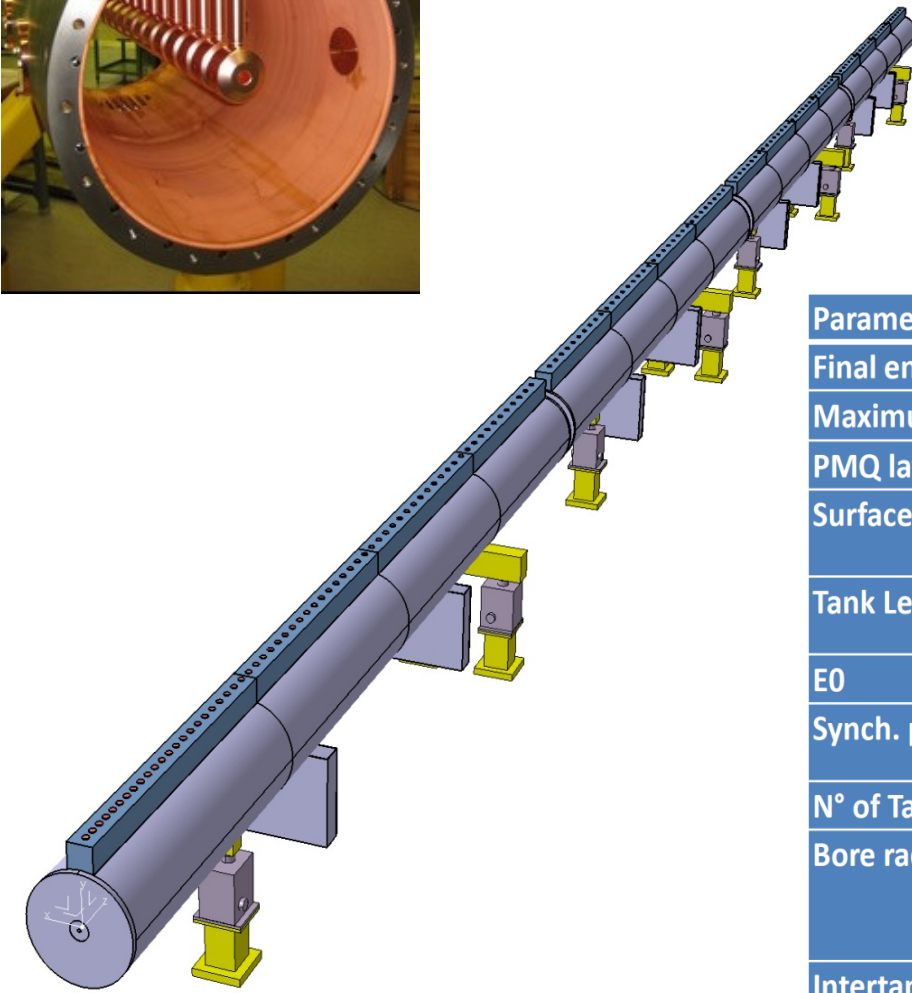
LEBT Beam Instrumentation conceptual design



To be determined:

- Total number of diagnostic instruments
- Length needed for the three instrumentation regions
- Position of the steerers with respect to the solenoids
- Total length of the LEBT

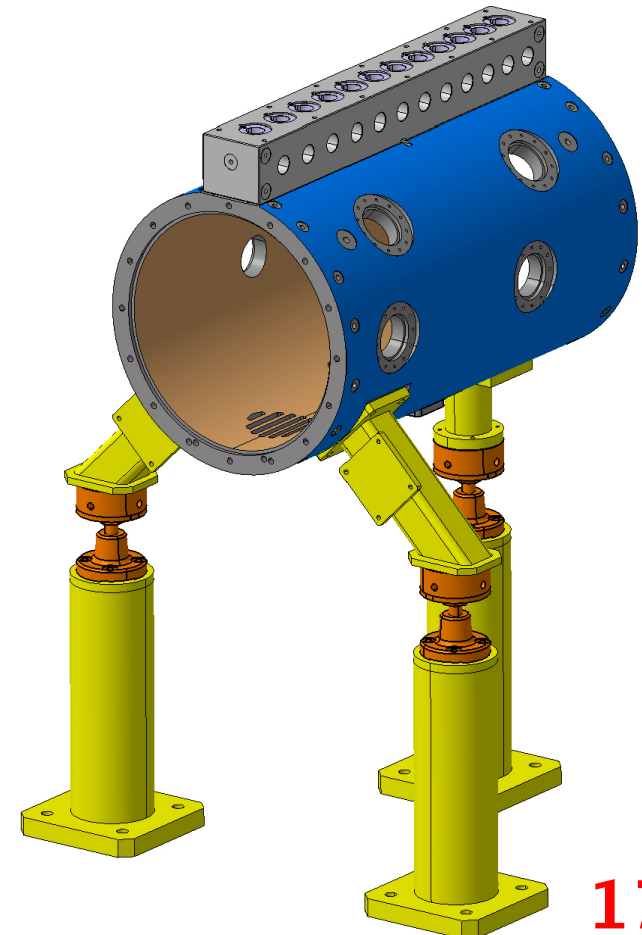
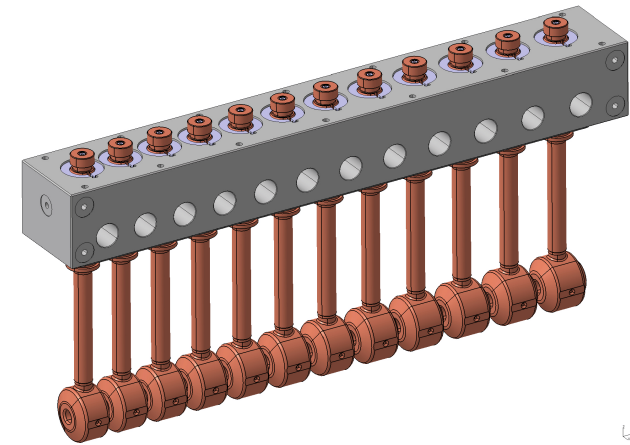
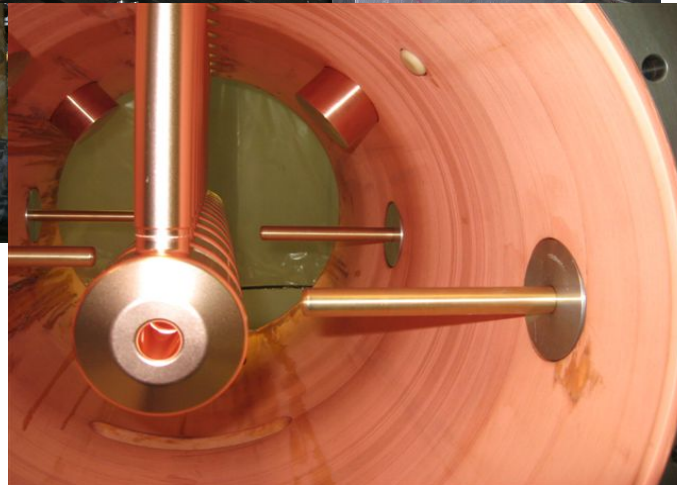
Drift tube Linac (DTL)



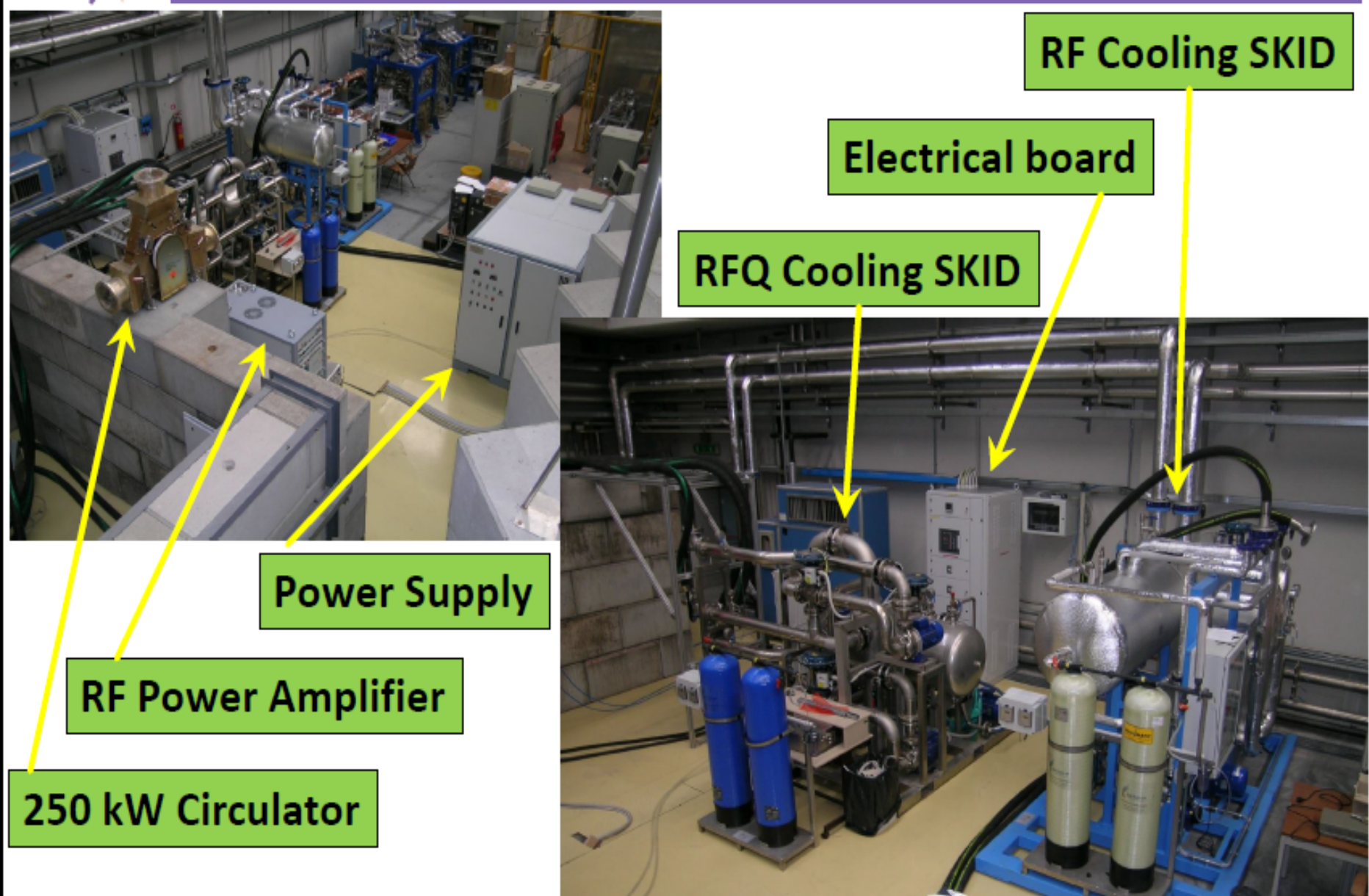
Parameter	Value or Range	Notes
Final energy	75MeV to 85 MeV	
Maximum RF power/tank	2.15 MW	Including 1.25 margins.
PMQ law	Equipartitioned	
Surface E field limit	At 3MeV:1.39 kp Absolute max: of 1.6 kp	"Moretti" limit for 70 T/m PMQ
Tank Length	<8m	Mechanical modules of max 2 meters.
E0	2.8 to 5.0 MV/m	Linearly ramped
Synch. phase	-35° to -20°	Keep large longitudinal acceptance
N° of Tank	4 or 5	
Bore radius	Tank1 and 2=10 mm; Tank3=1.1 mm; From Tank4= 1.2 mm	
Intertank space	1 $\beta\lambda$	

With 5 tanks, about 2.1 MW per each, the maximum energy may reach 93 MeV

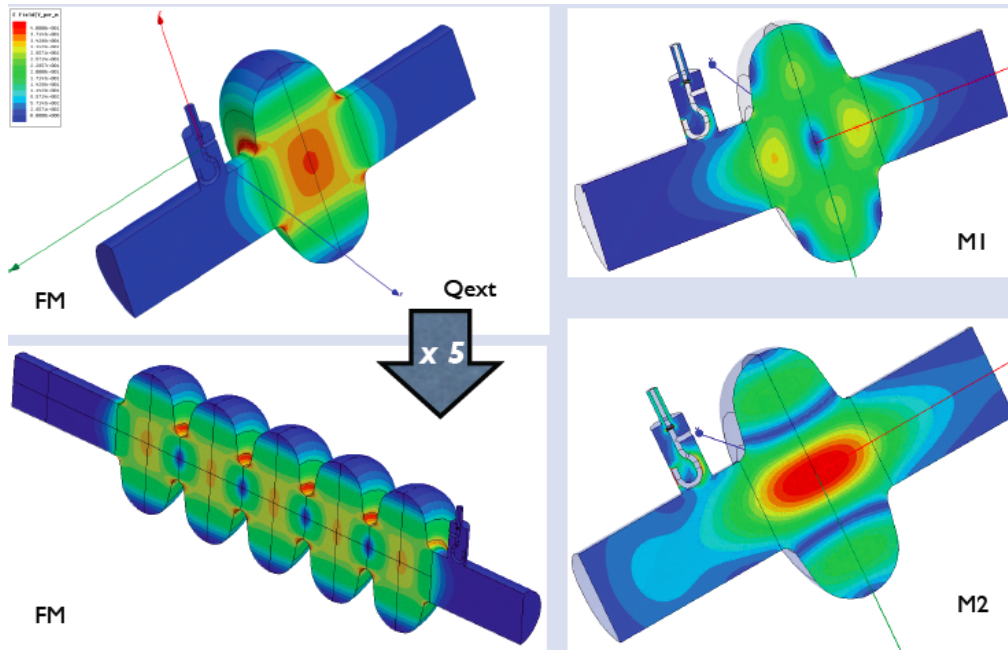
CERN-INFN DTL prototype, based on CERN design



Tank
machining at
Cinel
(Vigonza-Italy)

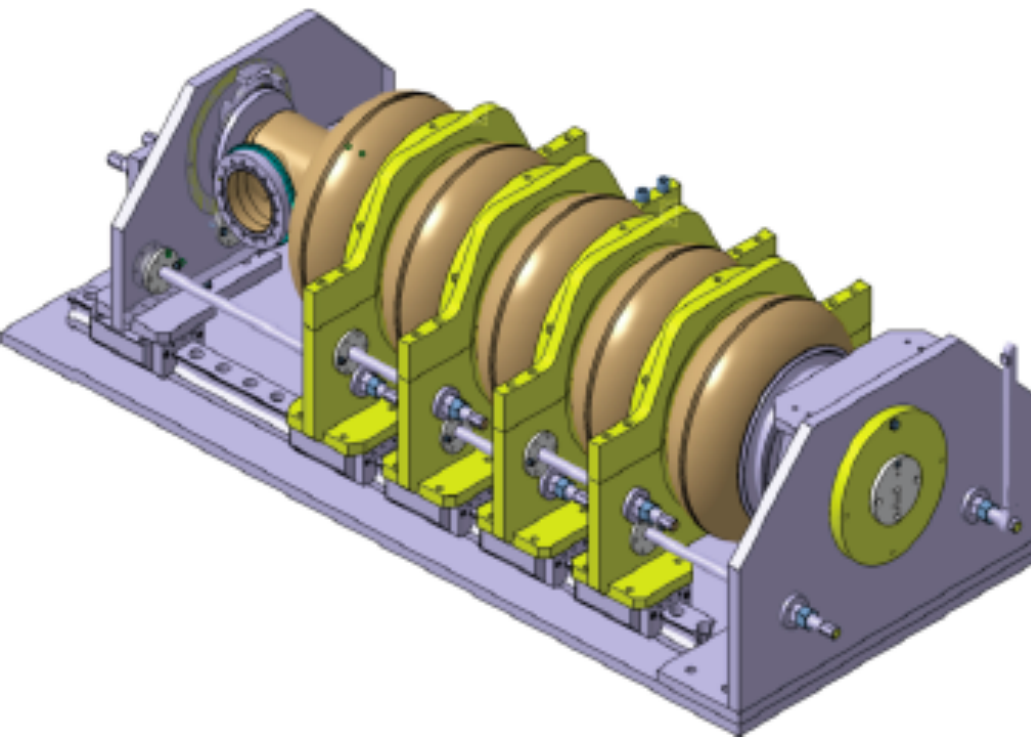


**RF test stand at LNL (used now for IFMIF RFQ)
will be available since 2015**



Elliptical cavities for the high energy section (superconducting)

French WP, it may be provided partially as in-kind from Italy



Redesign and pre-construction phase

- PS-ESS proton source & LEBT
 - Construction of the source started in 4th quarter 2013 (coils, power supplies, RF and high voltage components have been ordered)
 - Mechanics of the PS-ESS source to be ordered in January 2014
 - Chopper tests have been postponed because of the redesign (Dec. 2013 and spring 2014)

Redesign and pre-construction phase

- Drift Tube Linac

- The DTL technical design is sound and mature enough to proceed to engineering design and prototyping.
- The redesign has driven the choice of a higher injection energy (3.6 MeV instead of 3.0) and a higher final energy (above 90 MeV)
- The DTL team has begun prototype programs to develop drift tube along with permanent quadrupole, beam position monitor (BPMs) and steering corrector, to be located inside drift tubes.

Redesign and pre-construction phase

- Superconducting cavities
 - The Milan-LASA team expertise is available for the ESS with a growing rate since 2013 and a stronger cooperation in the field is expected in the next years, when the engagement with the XFEL project will be accomplished.
 - Prototype activity is going to start.

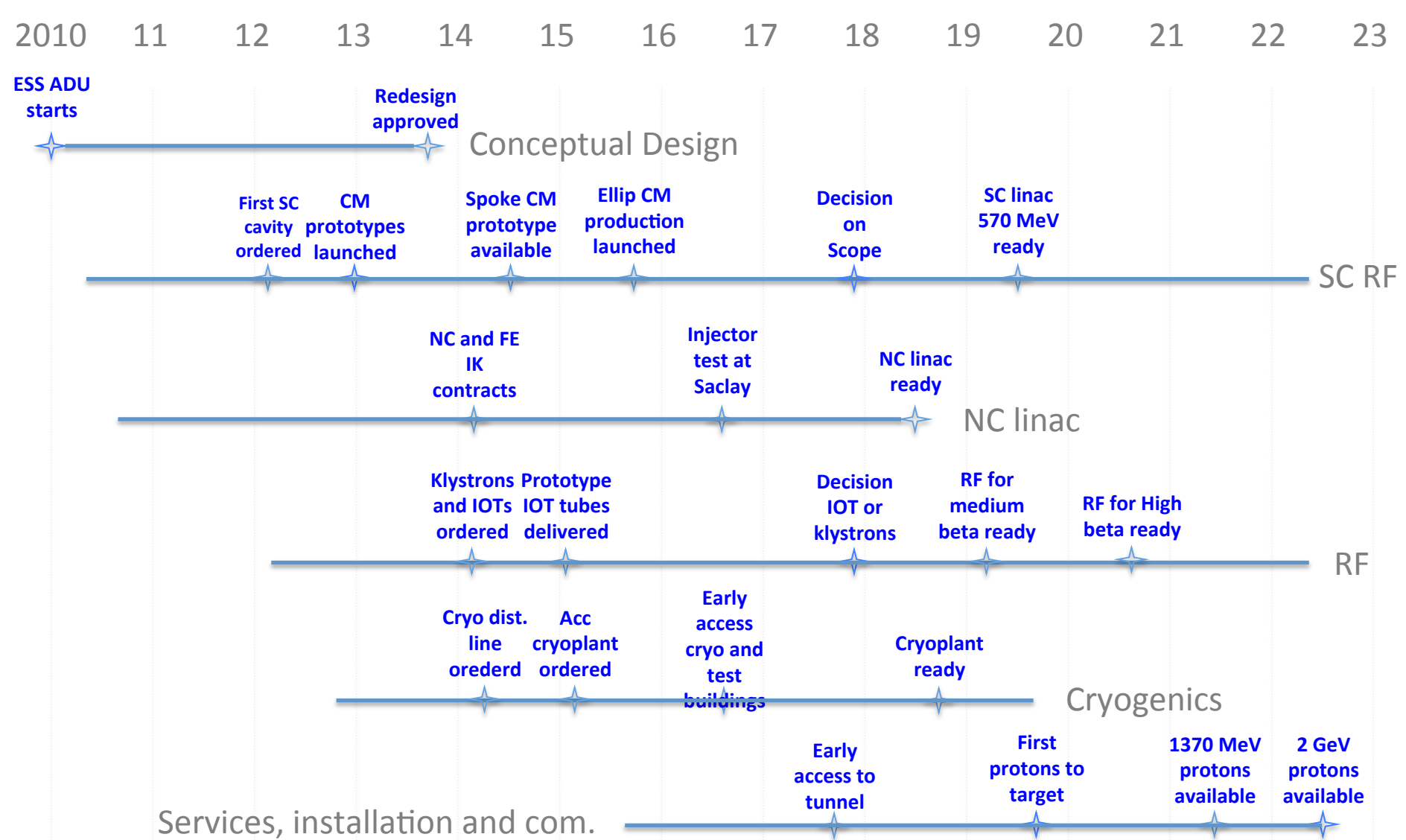
First impressions of Review committee

- The first ESS annual review took place at LUND the 12th-14th November 2013
- Present : ESS project team, 33 members of the review team organized in 7 subcommittees and 7 observers

First impressions:

- The review committee congratulates the ESS team and its management for the quality of the material and presentations submitted to the reviewers
- **The ESS is now a real project from all points of view, well shaped and well organized. ESS is now managing to the established baseline.**
- A big effort was made in the last 10 months to build up an organization structure with names and clear responsibilities attached to it
- The management of the project is strong, well determined, motivated and success oriented. The ESS overall schedule foresees first protons on target in December 2019. The cost cap has been fixed to 1.843 Beuro (year 2013).
- **ESS will start real construction work in June 2014 (ground break)**

Very high level Schedule



State of the art

- INFN is engaged in the preconstruction phase of ESS (LNS for WP3 management and Proton Source&LEBT, LNL for the DTL, Milan-LASA for the SC cavities; minor contributions from other INFN sections)
- The schedule for prototypes' construction is maintained, after the redesign
- The possible in-kind contribution for the construction phase has been proposed and it is under consideration at ESS-AB
- The preparation of the interfaces is an urgent duty before the ground break scheduled in June 2014
- The schedule for the construction is aggressive but reasonable

INFN contribution to the European Spallation Source is one of the most recent contributions of our Institute to Science using Neutrons.

Another recent one is the proposed IRIDE facility, which has a different mission than the ESS, but that may be complementary for some applications; e.g. it may be helpful for industrial purposes, in applications already known and in edge-of-technology applications.

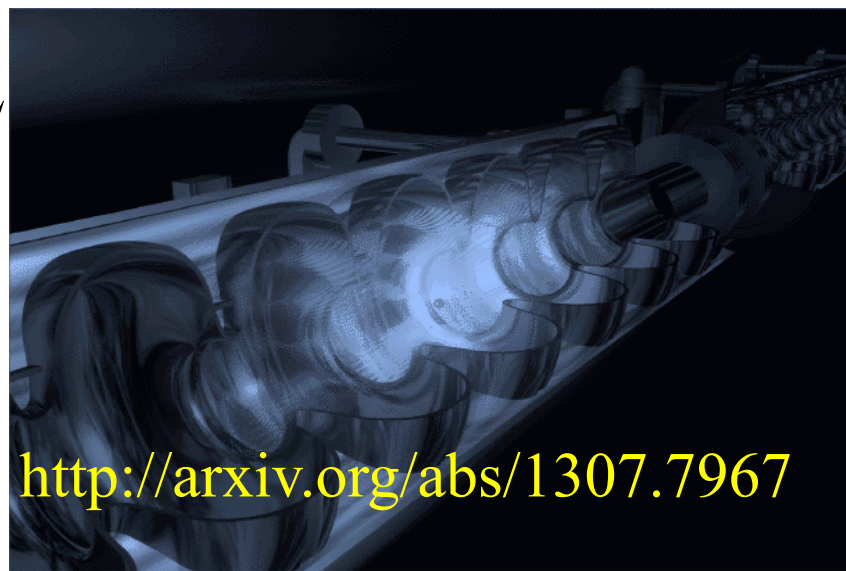
Though the mission of IRIDE is based on a different field, the specific applications to Neutron-based R&D may play a role.

IRIDE aims and potentials

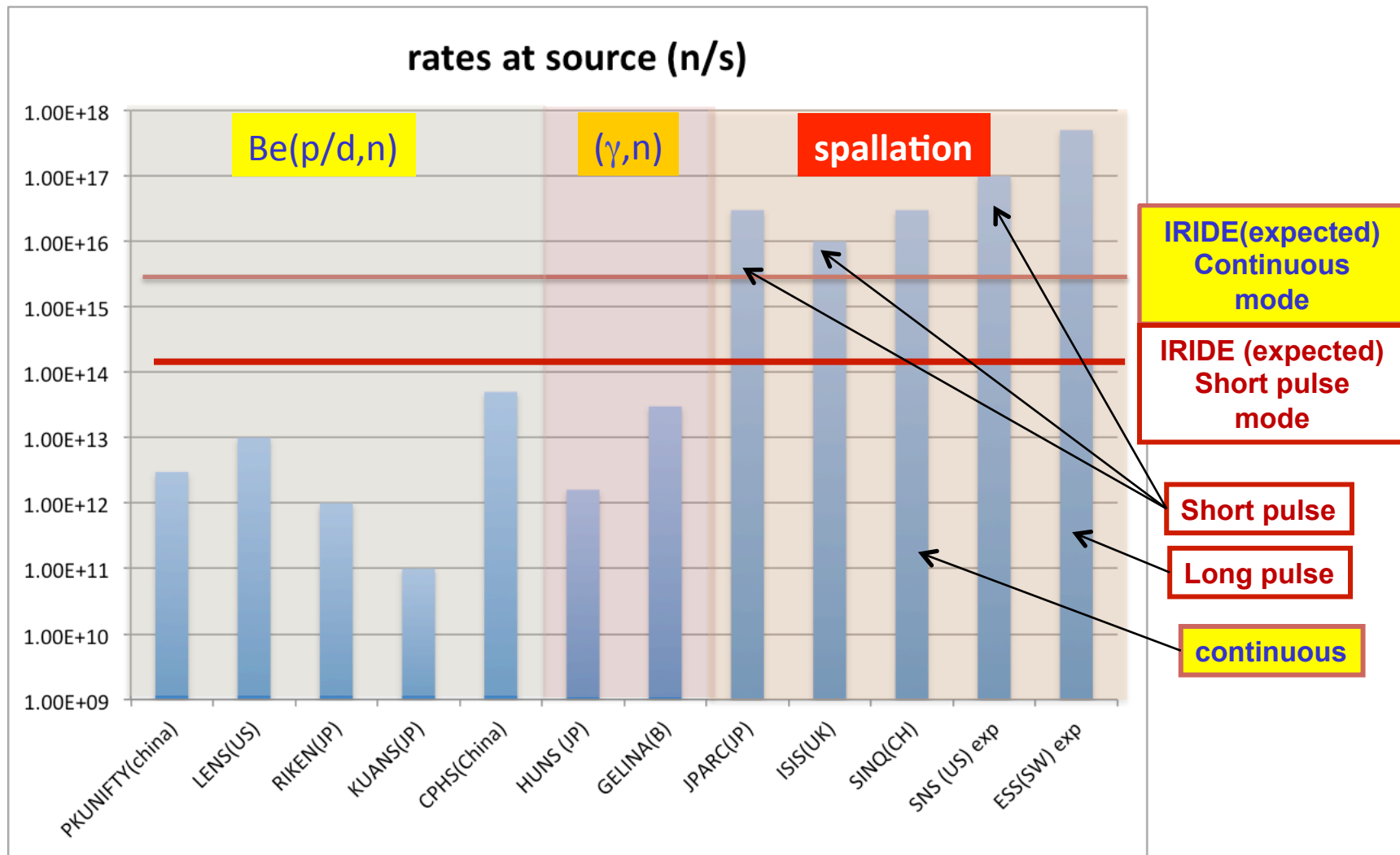
- Science with Free Electron Lasers (FEL) from infrared to X-rays,
- Nuclear photonics with Compton back-scattering g-rays sources,
- Science with THz radiation sources,
- *Advanced Neutron sources by photo-production,*
- Fundamental physics investigations with low energy linear colliders
- Physics with high power/intensity lasers,
- R&D on advanced accelerator concepts including plasma accelerators and polarized positron sources
- ILC technology implementation
- Detector development for X-ray FEL and Linear Colliders
- R&D in accelerator technology and industrial spin – off

Ref. IRIDE White Book:

<http://arxiv.org/abs/1307.7967>



Comparison with some accelerator driven sources



Final remarks

INFN has been involved in the early phase of the ESS Accelerator construction and is expected to play a role also in the following years.

The know-how about High Power Proton Accelerators developed since '90s (TRASCO project, EU FP6, NTA Strategic Project, CSN5, etc) is recognized by the community of accelerators' experts. That expertise was requested by ESS-AB since the Design Update in 2009. Additionally, the synergy with other Research Institutions in Italy and in Europe may drive the use of INFN expertise and facilities in the sense of Neutron-based Sciences.