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Accelerator: WP Status & General Issues

J. G. Weisend II and Mats Lindroos

TAC, 1 April, 2015

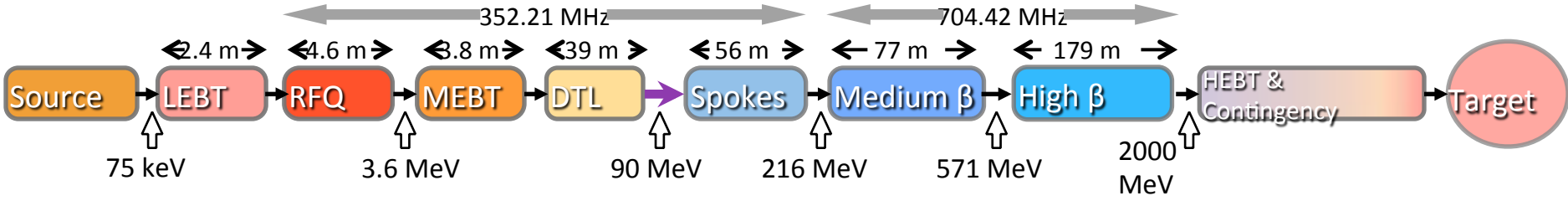
Accelerator Technical performances

Design Drivers:

- High Average Beam Power
  - 5 MW
- High Peak Beam Power
  - 125 MW
- High Availability
  - > 95%

Key parameters:

- -2.86 ms pulses
- -2 GeV
- -62.5 mA peak
- -14 Hz
- -Protons (H+)
- -Low losses
- -Minimize energy use
- -Flexible design for future upgrades



- Describe the scope of activities for which you are responsible. Use a picture or pictures if possible. No more than 1 slide.
- Talk about high-level performance requirements

Accelerator Selected technologies

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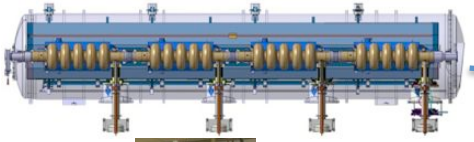



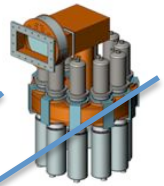

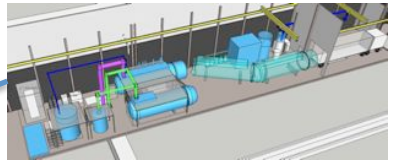
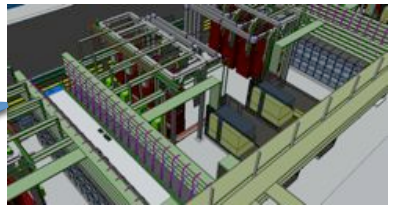
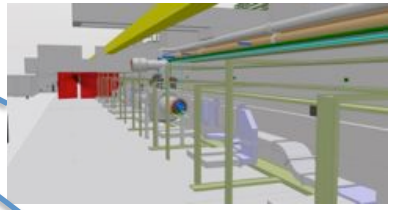
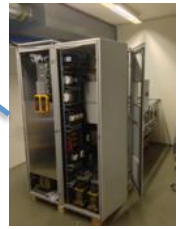

Accelerator Organization

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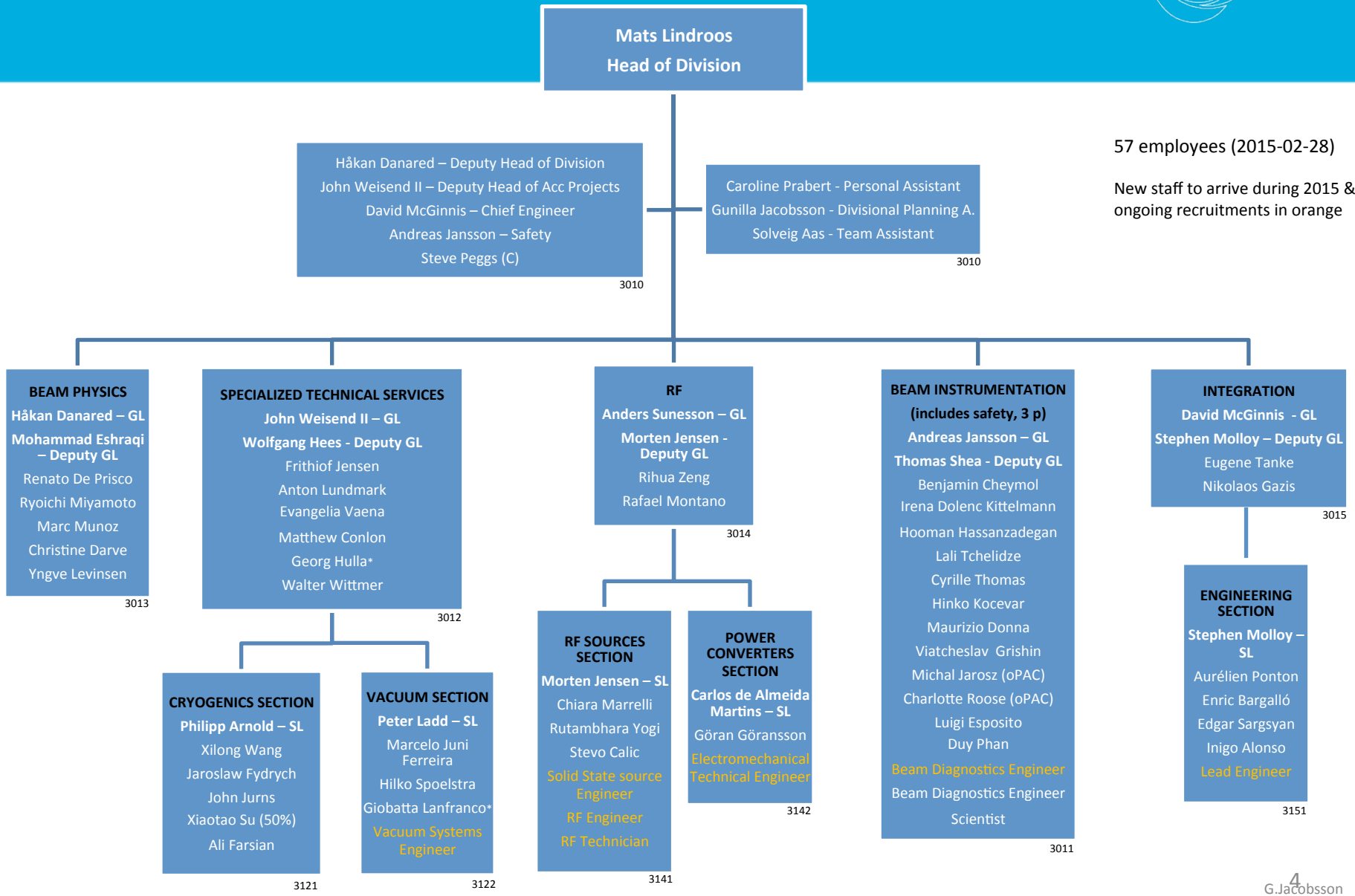

57 employees (2015-02-28)

New staff to arrive during 2015 & ongoing recruitments in orange

* N.B. Transfer not yet formally approved

Accelerator Project organization

WP#	WP TITLE	WP LEADER	EXT. WP?	DEPUTY WP LEADERs FOR EXTERNAL WPs
WP01	MANAGEMENT	J.G. WEISEND II	NO	
WP02	ACCELERATOR PHYSICS	M. ESHRAQI	NO	
WP03	NORMAL CONDUCTING FRONT END	S. GAMMINO	YES	M. CONLON
WP04	SPOKE CRYOMODULES	S. BOUSSON	YES	C. DARVE
WP05	ELLIPTICAL CRYOMODULES	P. BOSLAND	YES	C. DARVE
WP06	BEAM DELIVERY SYSTEMS	S. MØLLER	YES	P. LADD
WP07	BEAM DIAGNOSTICS	A. JANSSON	NO	
WP08	RF SYSTEMS	A. SUNESSON	MIX	A. SUNESSON
WP99	ACCEL INFRASTRUCTURE & INSTALLATION	D. MCGINNIS	NO	
WP10	TEST STANDS	W. HEES	MIX	W. HEES
WP11	CRYOGENICS	P. ARNOLD	NO	
WP12	VACUUM	P. LADD	NO	
WP13	SAFETY	L. TCHELIDZE	NO	
WP14	ACCELERATOR INTEGRATION	S. MOLLOY	NO	
WP15	ELECTRICAL SUPPORT	F. JENSEN	NO	
WP16	COOLING SUPPORT	A. LUNDMARK	NO	
WP17	POWER CONVERTERS	C. MARTINS	NO	

Collaboration Board:

1. ESS Technical Director
2. Project leader
3. Representatives of all contracted institutes (one elected as chair)

Quarterly Technical Board:

1. Weekly ESS management team
2. All WP leaders and deputies
3. Representatives of all contracted institutes if not already a WP leader

Weekly ESS management team:

1. Mats Lindroos, Project leader
2. John Weisend, Deputy project leader
3. David McGinnis, Chief engineer
4. Håkand Danared, In-kind manager
5. Lali Tchelidze, Safety including radiation safety
6. Anders Sunesson, RF systems
7. Luisella Lari, Head planner
8. Andreas Jansson, Beam instrumentation
9. Matthew Conlon, QA/QC

Accelerator Schedule ("easier to see" version)

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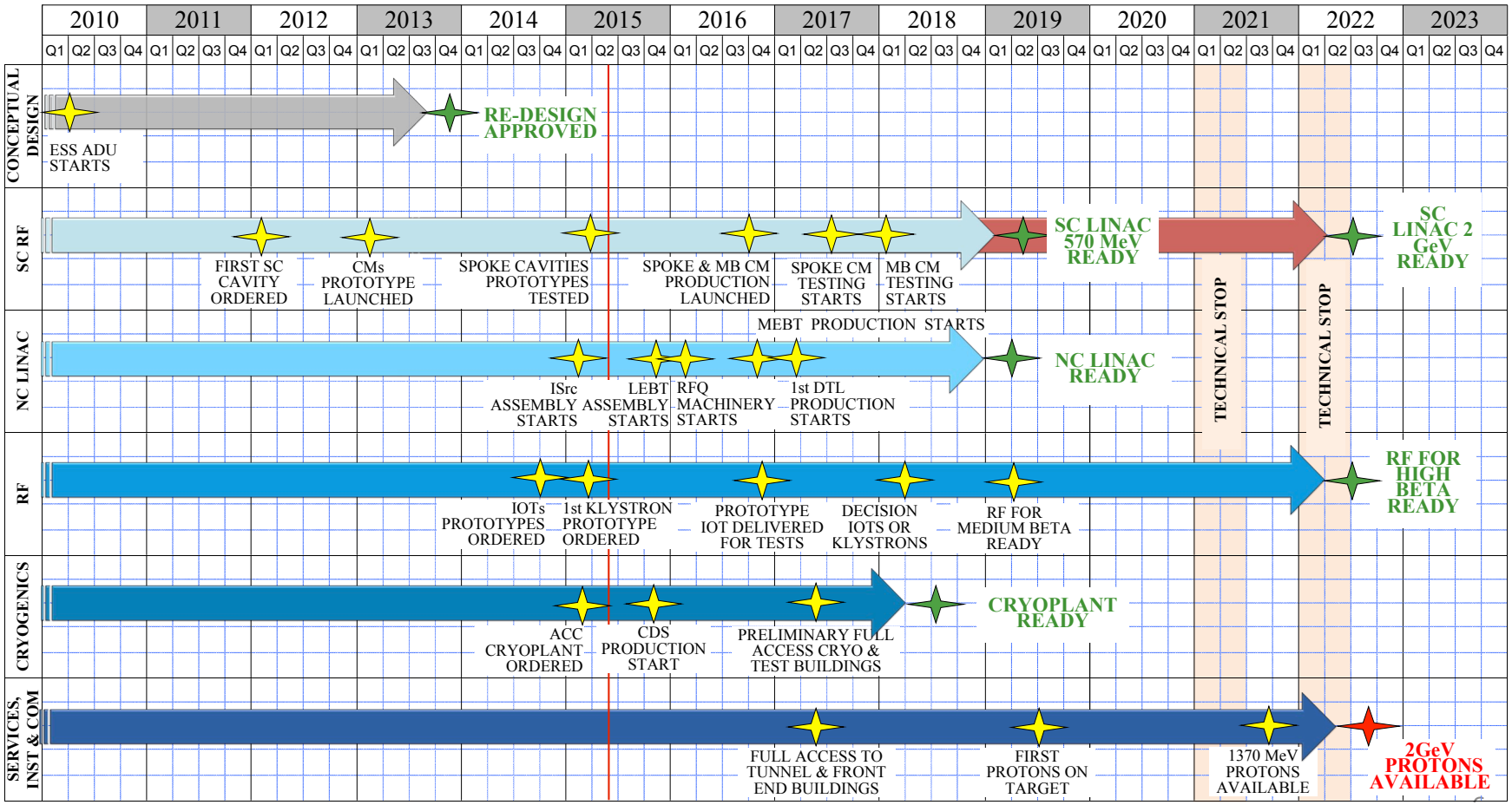
HIGH LEVEL SCHEDULE - ESS ACCELERATOR



DATA EXTRACTED BY P6 PLANNING - APRIL 2015

PREPARED BY WP LEADERs & L. LARI
CHECKED BY J. WEISEND
APPROVED BY M. LINDROOS

WP 1: Management and WP 2: Beam Physics

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WP1 Management

- Held Annual Audit on WP11 Cryogenics
- Organized & held CDR for Ion Source & LEBT
- Replanning of P6 in preparation for annual audit to allow for more accurate IKC, program changes and new milestones is almost complete

WP2 Beam Physics

- Follow-up on the preliminary electromagnetic design of pulsed air-cooled quadrupoles for LWU
- The 2014 baseline lattice released
- Definition of RF DTL requirements
- Study of the field map impact on the DTL performance (in progress)
- Study of the HOC in the MEBT steerers on the LINAC performance (in progress)

WP 3: NC front-end

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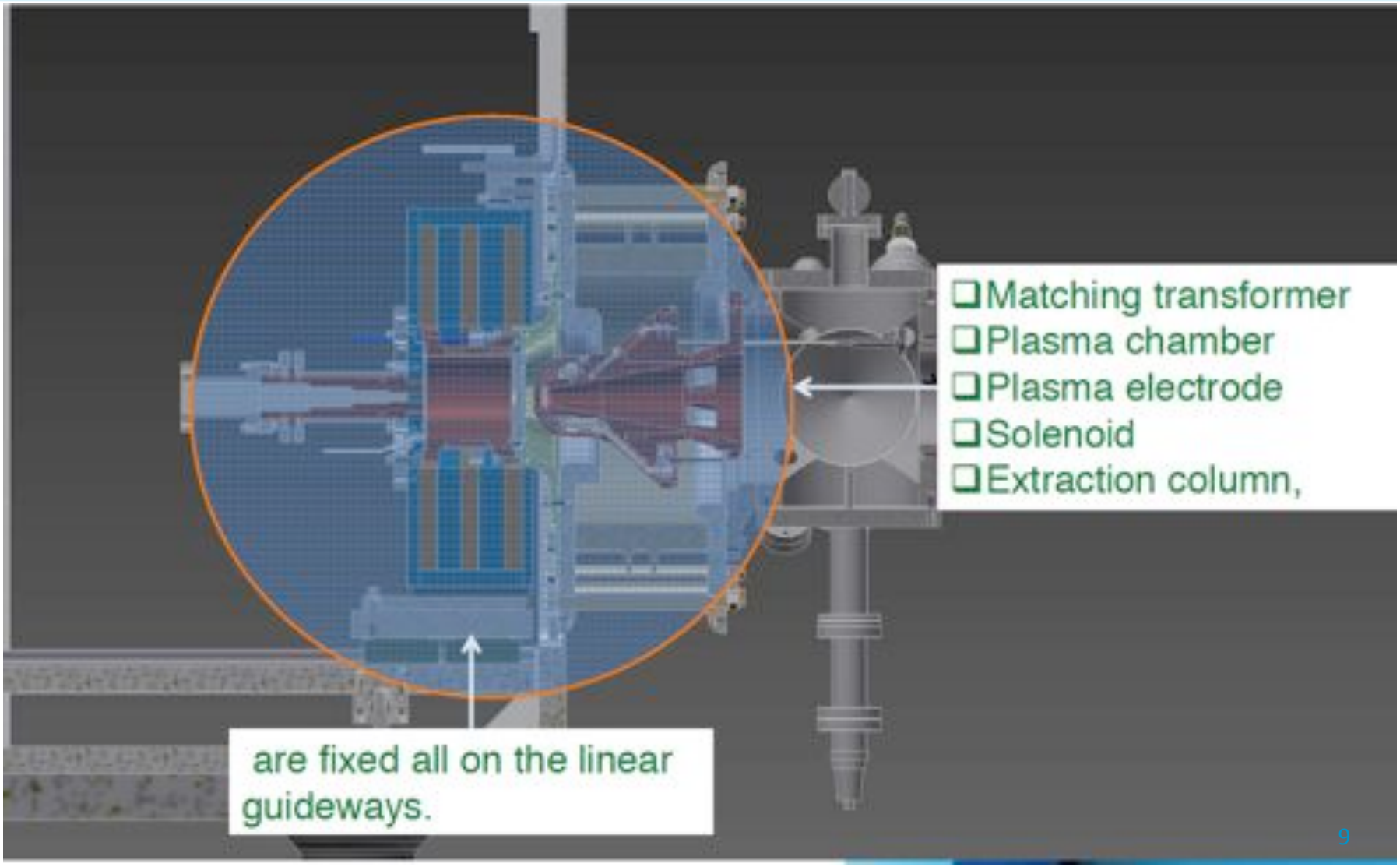
WP3 NCFE

- The tender for procurement of the RFQ copper has been released for quotation
- The layout area for assembly of ESS ISrc and LEBT has been established at LNS, Catania.
- High voltage systems, solenoid, and transformer mounting and insulation equipment for ESS Proton Source (PS)#1 has been procured and delivered. Other PS#1 components are being procured or in the process of being manufactured or delivered.
- The WU team worked during January to document the detailed design so that 3D CAD models, and comprehensive specifications / descriptions were ready for review at Critical Design Review (CDR)
- Detailed design for DTL is progressing, including: positive test of magnets, and progress in definition of the copper plating A visit to GSI copper plating lab verified that DTL design is compliant with main copper-plating requirements

WP3 : Detailed solid models of Proton Source have been created



WP 4 and 5: SRF

For both WP4 and WP5: Results of the study by TUV Nord on pressure vessel issues confirms that both spoke and elliptical CMs fall under section 3-3 of the PED. This should permit Nb procurement in Spring 2015 as planned

WP4 Spoke Cavities & Cryomodules

- 2 prototype Spoke Cavities tested vertically at 2 K
- Results are gratifying - Pictures and data plots are worth a thousand words
- Construction of other subsystems for the prototype CM is well underway

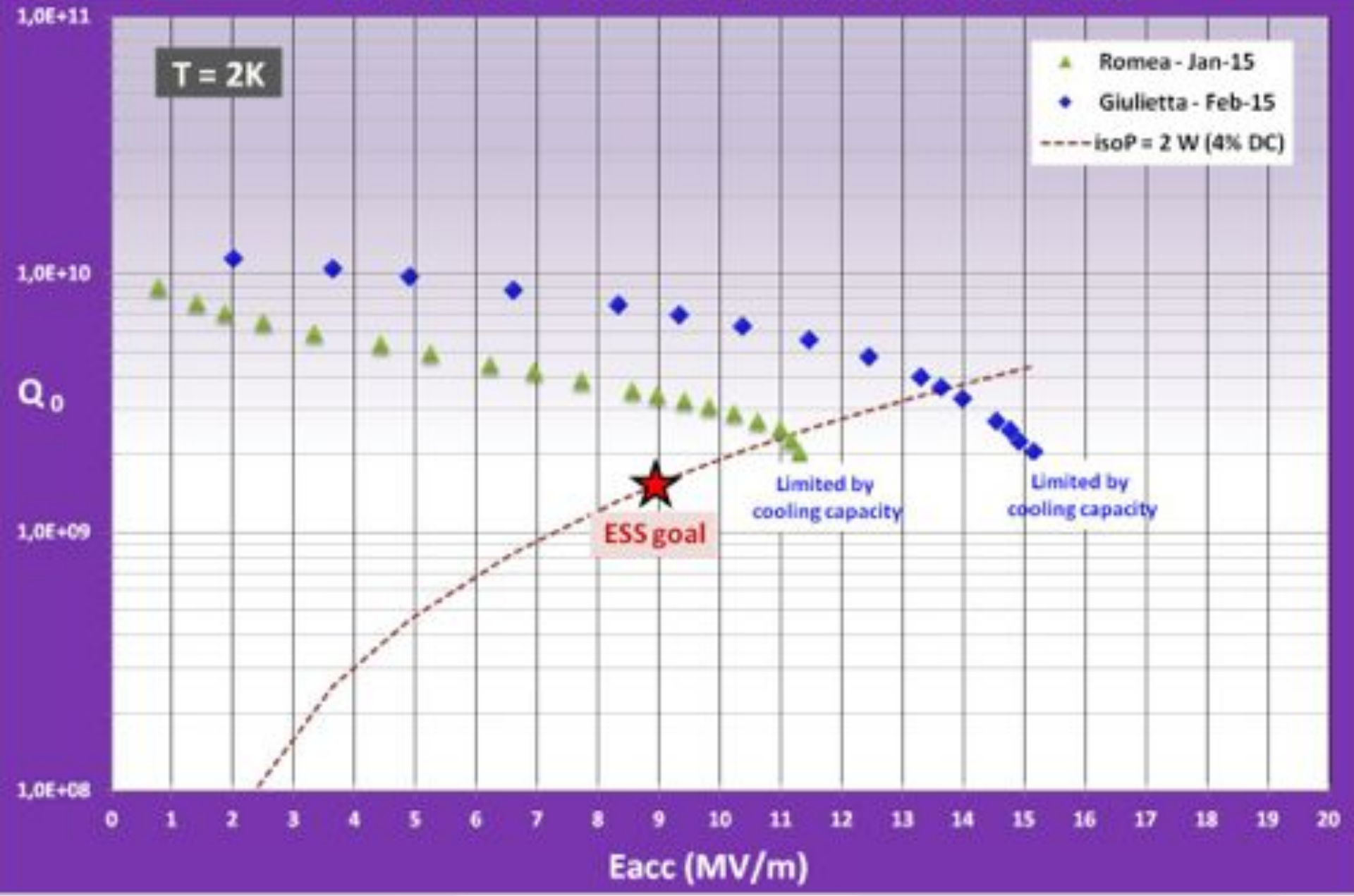
Cavity Prototypes

The 3 spoke cavities prototypes:

named: **Romea, Giulietta and Germaine**

View of the cavity inside: the spoke bars

ESS double-spoke prototype cavities
ZA-01 & 02 - Romea & Giulietta - Feb. 2015



Status of sub-systems fabrication

Cryomodule: vacuum vessel & supporting frame

Power coupler Doorknob

Electronics boards for power coupler conditioning

Cryomodule parts:

Power coupler port/cover

Cold/warm transition

Small closing dished ends

Beam vacuum valve

WP 5: Elliptical SRF

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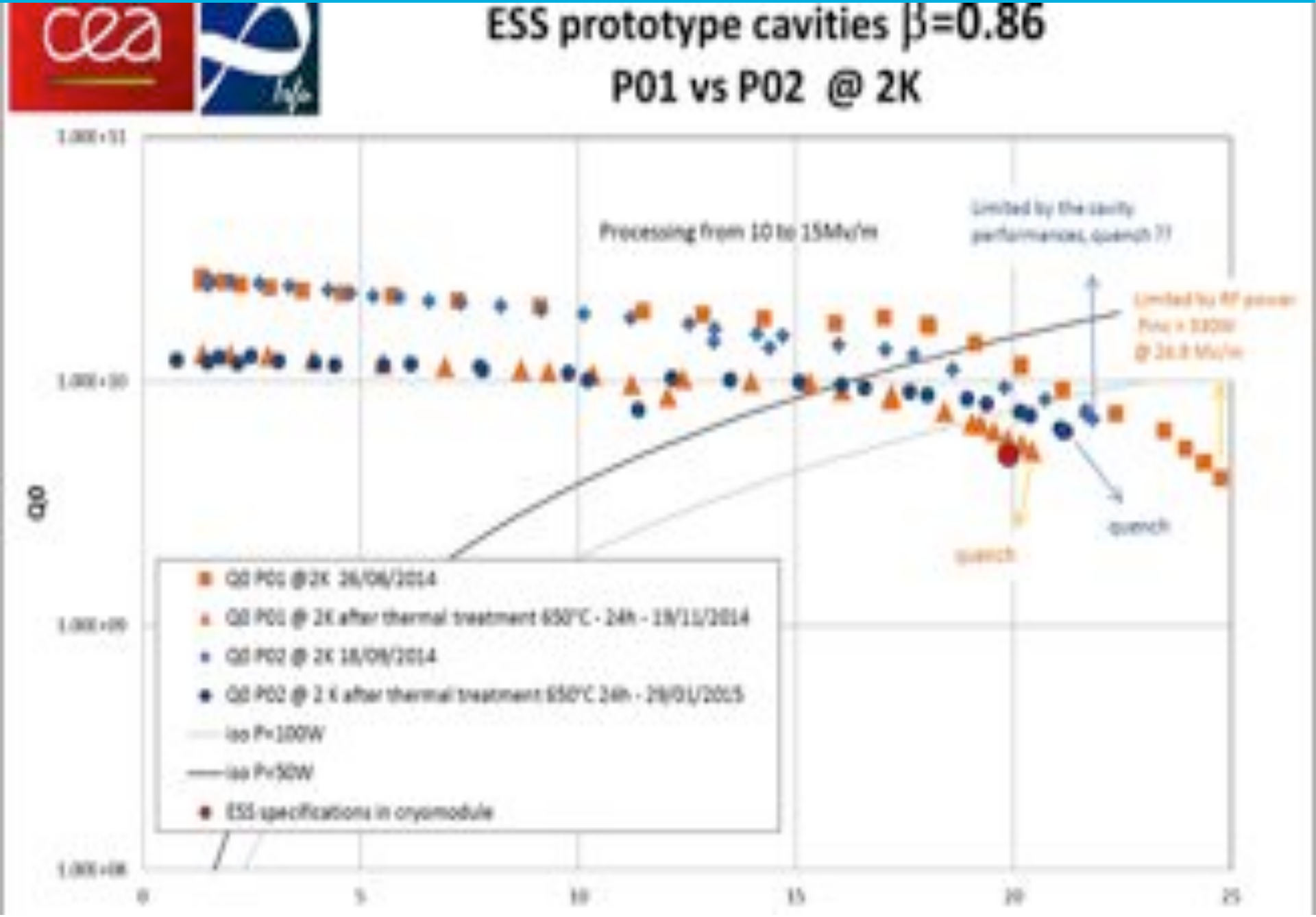
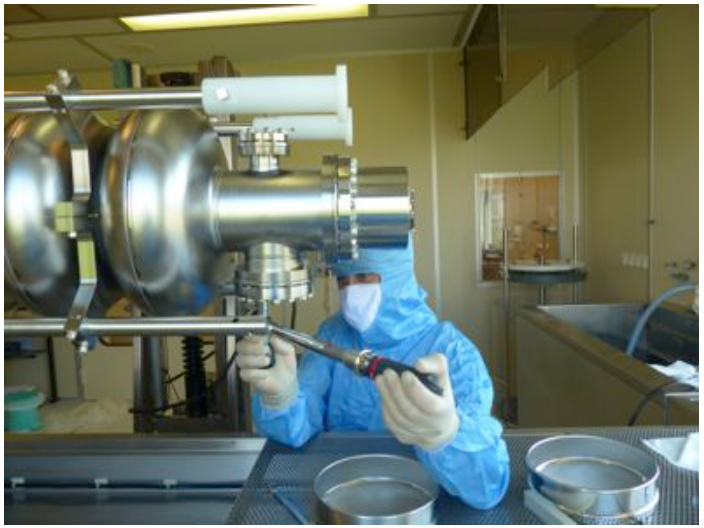
WP5 Elliptical Cavities and Cryomodules

- Cavity P02 from RI has been tested after heat treatment done at CERN for removing the hydrogen from the niobium sheet. The performances of this P02 cavity have been degraded in a similar way than for the P01 cavity with the same amount of Q decrease.
- The cause of the degradation seems to be a pollution of the niobium during the heat treatment in the furnace. This degradation is unusual. The analysis of the RGA monitored during the heat treatment sequence is being done in order to check if some anomalous vacuum quality could be seen.
- A second test of the P02 cavity is scheduled after a deeper chemical treatment to try to remove the pollution from the surface of the niobium. The thickness to remove is being discussed.
- The helium tank of the P01 cavity has been welded at ZANON. Final machining and last fabrication operations are in progress.
- The design of the assembling tooling inside the clean room is almost completed. Good progress has also been made for the tooling outside the clean room.

ESS prototype cavities β=0.86
P01 vs P02 @ 2K



High β Elliptical Cavity Activities in Clean Room



WP 6: Beam delivery

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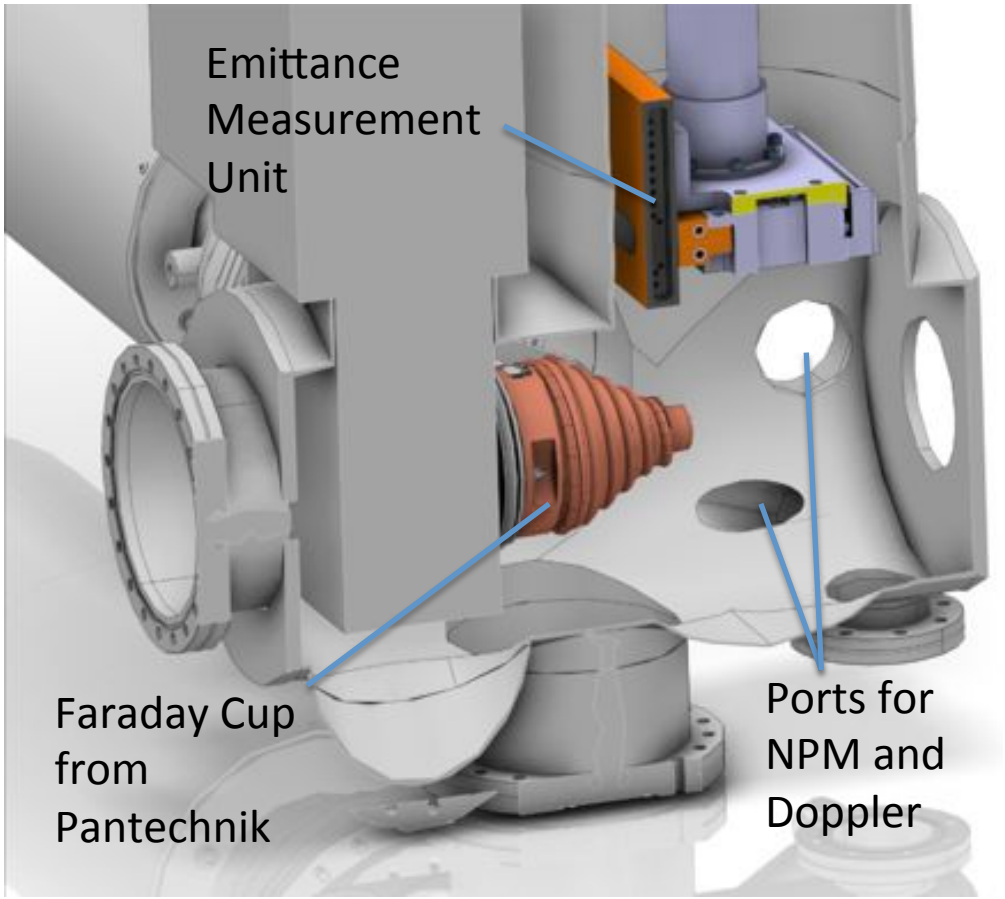
WP6 Beam Delivery Systems

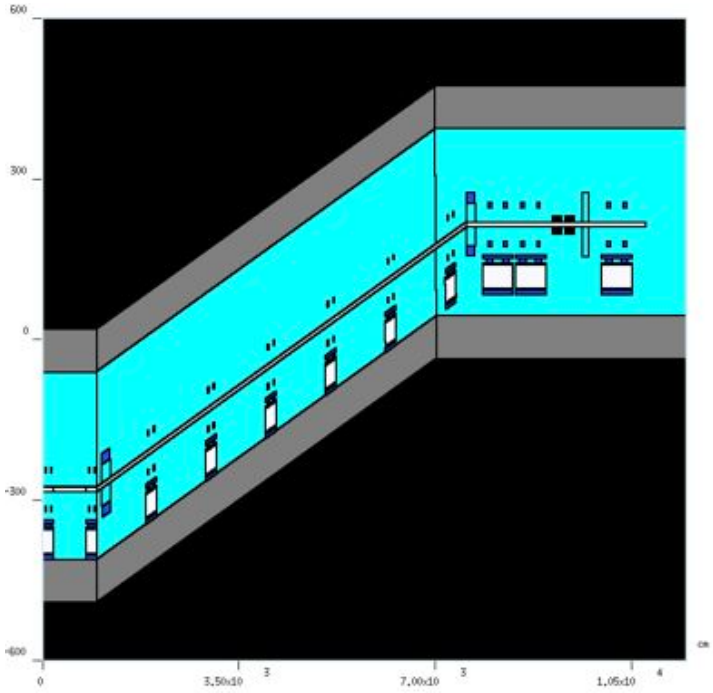
- The WP06 contract between Aarhus University and ESS has been finalized, only signatures pending.
- Work is underway on the requirements of the raster systems. First a prototype raster scanning system with two magnets shall be built and long-term tested before production of the final system.
- In an attempt to prepare component specifications, non-ideal RSM field waveforms, originating from realistic magnet or power supply specifications, have been simulated
- Planning has been updated in P6

WP7: Beam Instrumentation From LEBT to A2T

CATIA Model of
LEBT Diagnostic and Chopper Tank

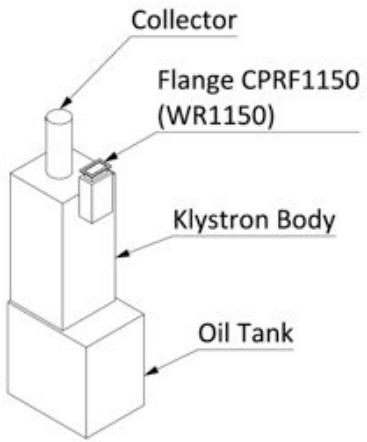


Model of A2T Line for beam loss simulations. Imported from CATIA into MARS Monte Carlo code.



WP 8: 704 MHz klystron prototypes

Nominal output power	1.5 MW
Frequency	**704.42 MHz**
BW	≥ +/- 1 MHz
Pulse width	3.5 ms
Repetition rate	14 Hz
Perveance	$0.6*10^{-6}$
Efficiency	>60%
VSWR	Up to 1.2
Power Gain	≥ 40 dB
Group Delay	≤ 250 ns
Harmonic Spectral content	≤ -30 dBc
Spurious Spectral content	≤ -60 dBc



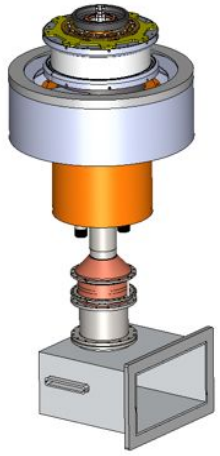
- Open call for tenders started in October 2014 for two prototypes
- Four candidates (Thales, Toshiba, L3 and CPI)
- First contract (**Thales**) signed in December: Thales design is based on the TH2182 successfully built for CERN (but operating in horizontal position)
- Second contract (**Toshiba**) almost in place
- A third prototype will be purchased from **CPI** in the next weeks

TH2182 klystron at CERN

WP8 1.2 MW IOT Prototype Update

Current Status:

- Two contracts place in September 2014
- One contract with Thales/CPI
- One contract with L3
- Delivery in 24 months
- Factory Acceptance at L3 and CERN
- Kick-off meetings and one Preliminary Design Report approved

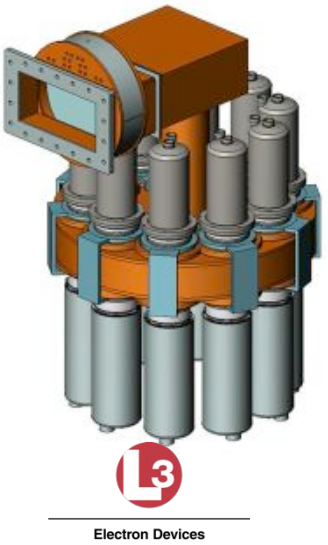


Pre-tender
CPI Cartoon

Next stages:

- Single beam IOTs/beam sticks being developed by both suppliers
- Complete thermal, mechanical and RF modelling
- Complete Preliminary and Final Design Reviews
- Identify auxiliary supplies: Ion pumps, solenoid, filament
- Identify RF drivers (up to 2 kW)

Parameter		Comment
Frequency	**704.42 MHz**	**Bandwidth > +/- 0.5 MHz**
Maximum Power	**1.2 MW**	**Average power during the pulse**
RF Pulse length	Up to 3.5 ms	Beam pulse 2.86 ms
Duty factor	Up to 5%	Pulse rep. frequency fixed to 14 Hz
Efficiency	Target > 65%	



WP10: Test Stands

Temporary RF Lab in LU's M-house:

starting spring 2015, duration 9 months: installation and test run of new topology modulator prototype (WP17) with dummy load

contract for premises about to be signed

minor building modifications necessary – executed by landlord

RF Lab in Utgård facility (Lund):

starting summer / autumn 2015, duration 2-3 years: long term testing of modulator and klystron prototypes as well as RF distribution equipment (WP8 & WP17)

contract for premises about to be signed

minor building modifications necessary – executed by landlord

LCW system being procured by WP10

facility is being shared with Detectors and Sample Environment

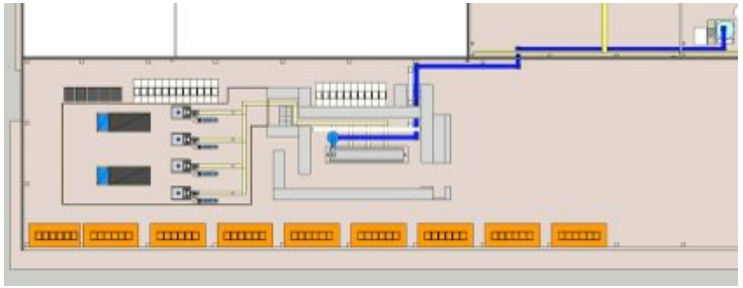
WP10: Test Stands

TS1 in Uppsala:

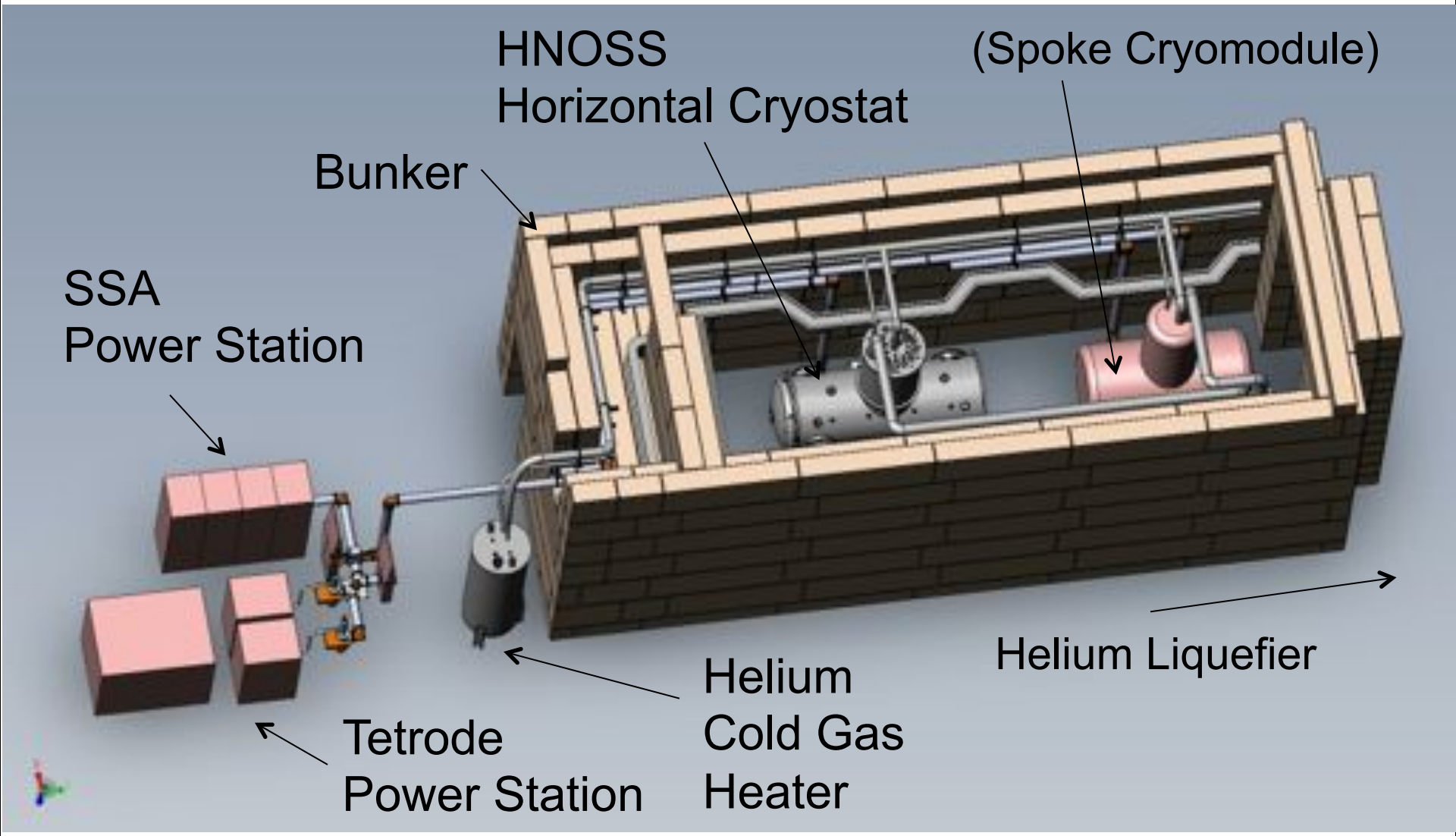
- starting 2016: soak testing of modulator and klystron prototypes (WP8 & WP17) in existing FREIA hall
- contract negotiations ongoing

TS2 in Lund:

- 2018 - 2023: Site Acceptance Tests of elliptical cavity cryomodules (WP5) on dedicated test bench in klystron gallery cont. space
- negotiations about IKC from IFJ PAN (Krakow, Poland) ongoing, DOW (description of work) for testing is under discussion
- conceptual design finished, detailed design to start in 2015



Test Stand Implementation (Phase 1)



WP 11: Cryogenics

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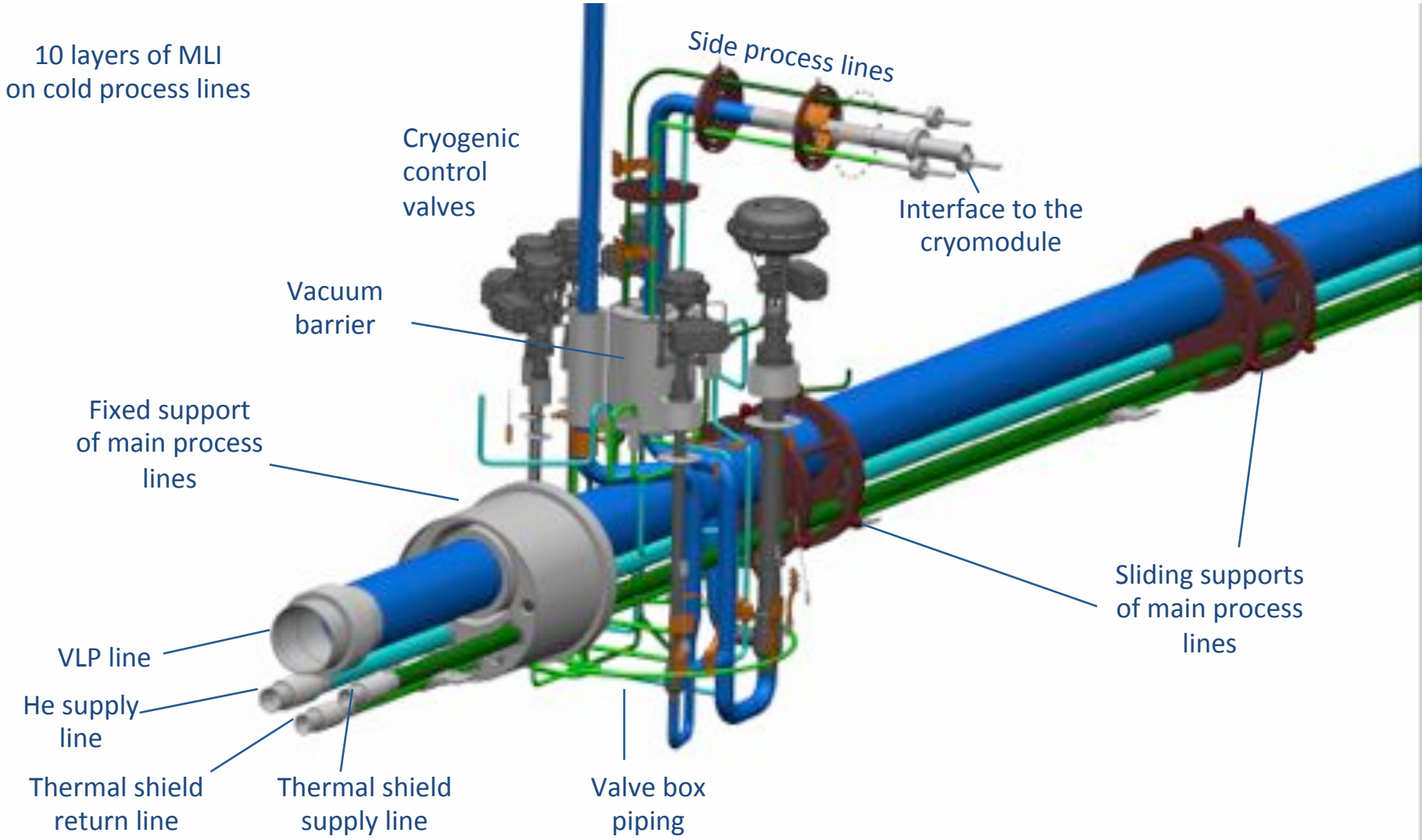
WP11 Cryogenics

- Vendor selected for Accelerator Cryoplant (ACCP).
  - 2 tenders were received, both within the budget. Selected vendor is Linde. The contract language has been finalized and final signatures are expected within a few weeks. Starting the effort this month will meet the project schedule for ACCP commissioning
- Agreements reached with both WrUT in Poland (Elliptical CM Distribution line & CTS) and IPN Orsay in France (Spoke CM Distribution line) on providing these IKC. Written agreements should be signed shortly and work at this institutions has already begun
- Significant work completed on the layout of warm piping in the Compressor facility and tunnel
- Ongoing work for the Test & Instruments cryoplant, Target Moderator cryoplant and ancillary systems (storage, recovery, purification)
- 2 new staff members have joined us: X. Su and A. Farsian

Valve box – process lines, supports and vacuum barrier



WP 12: Vacuum

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WP12 Vacuum Systems

- The vacuum test facilities; vacuum integration, material test and calibration test stand to be supplied by STFC Daresbury under a IKC are now in fabrication with delivery schedule for the Q2/ Q3 2015.
- The technical requirements for the particle test facility also being supplied by STFC were finalized in preparation for the meeting with potential supplies of the clean rooms to be held in Lund early in February 2015. This will allow these facilities to be order and delivered during Q3 of this year.
- Technical discussions have now started with STFC to define the first phase of work covering the supply of the LEDP, HEDP and LWU's as apart of the planned UK IKC in the vacuum area.
- Work continues in developing the L3 and interface requirements for the accelerator vacuum systems.

WP 12: Vacuum

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WP12 Vacuum Systems

- Preliminary discussions were held with the WP4 and WP5 team to establish the preliminary requirements for the vacuum insulating system required for the cryomodules.
- On going discussion continue with CEA Saclay to finalize the vacuum layout for the RFQ and with INFN on the ion source and LEBT with regard to vacuum instrumentation and the mechanical layout of the LEBT and LEBT to RFQ interface.
- Interconnection diagrams for the Ion source, LEBT vacuum system and Ion source LEBT control system have been prepared and forward to INFN for comment.
- On going discussions continue with the Bilbao vacuum team on vacuum design requirements, fabrication processes and testing requirements fro the MEBT and the vacuum layout for this system.
- On going work in support of the ICS VIT (vertical integration test) project continues.
- Work continues on cables, racks, controllers etc. for the accelerator vacuum systems.

WP16: Reduced Scale Modulator Prototype - Testing of Low Voltage stage at full power

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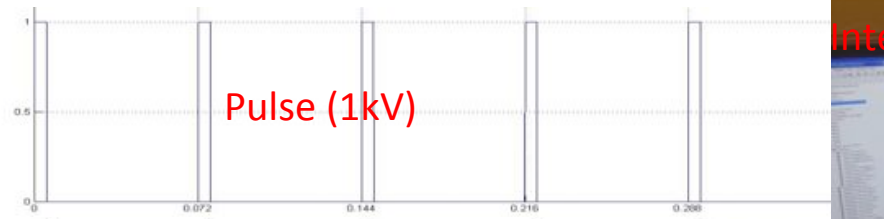
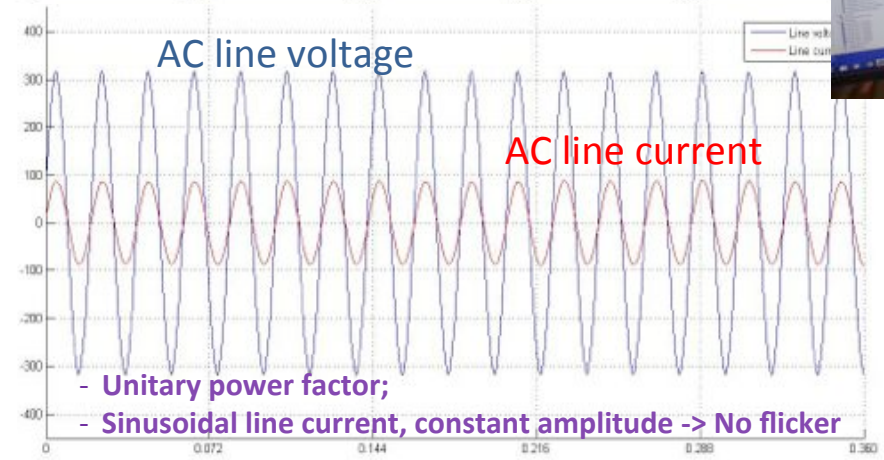
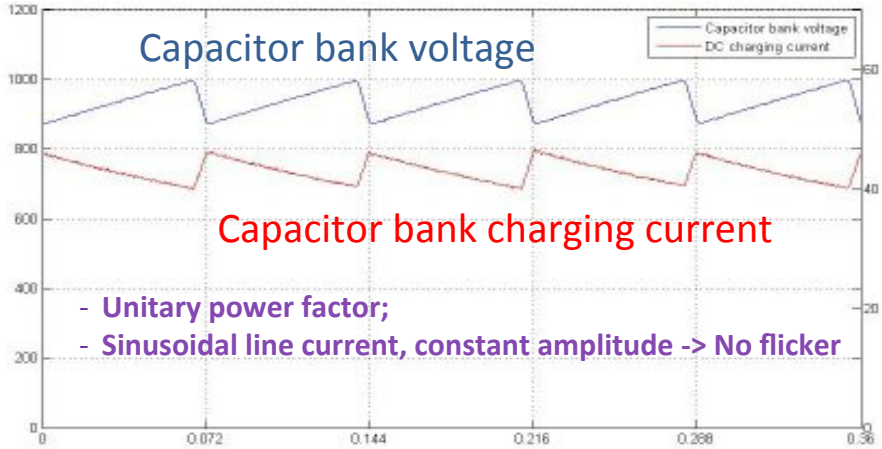
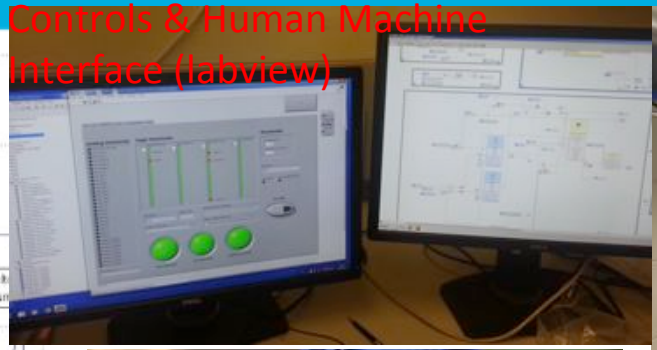


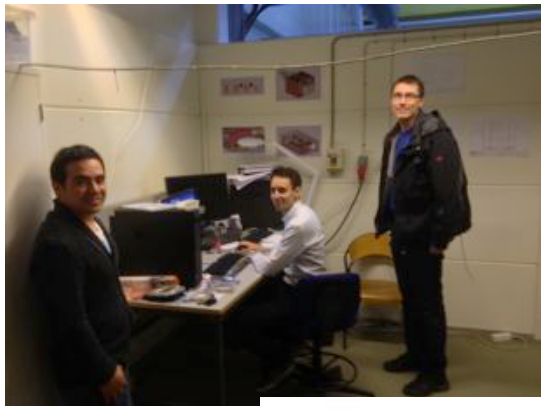


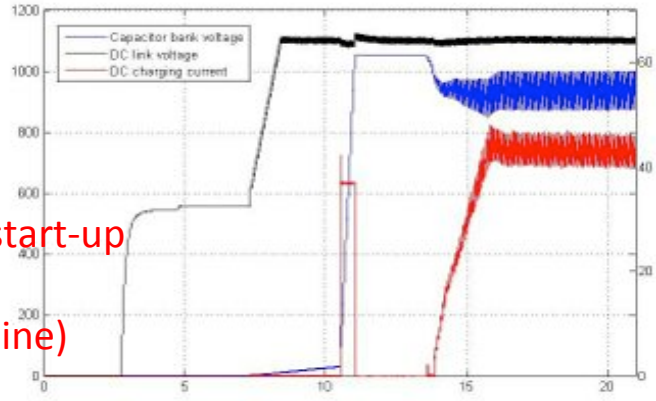
- Unitary power factor;
- Sinusoidal line current, constant amplitude -> No flicker



- Unitary power factor;
- Sinusoidal line current, constant amplitude -> No flicker

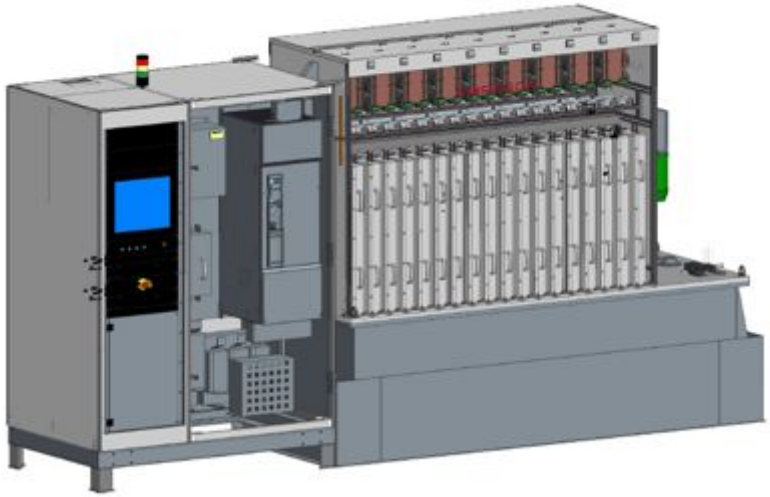






WP16: Status of 330 kVA modulator contract

- 1st version of Technical Design Report (TDR) sent to ESS for approval in end October 2014
- Meeting for discussion the TDR held at CERN on mid November 2014. The 1st version of TDR was not approved as major modifications and additional information was needed;
- Meeting for detailed discussion on some design issues in view of preparation of the 2nd TDR version held at the contractor premises on mid Dec. 2014;
- Major redesign of the High Voltage transformer undergoing (insulation distances needed to be reviewed);
- 2nd version of TDR is about 1 month late wrt last agreed deadline (end January);



Work Package Audits

- Since the last TB Annual Audits were held on WP3 (NCFE) and WP11 (Cryogenics)
- WP3 Audit included outside chair: P. Bertrand (GANIL)
- No technical showstoppers were found in WP11, Concern was raised about the MEBT fast chopper design in WP3 as well as the need to finalize requirements and interfaces.
- WPs have completed most of the previous year's recommendations
- Lists of recommendations have been developed
- Audit reports have been released or are in final preparation

Accelerator Integration and Verification

- The **chief engineer** is responsible for the technical design and leads the integration group. He also leads the weekly Physical Plant Working Group (PPWG) meeting
- **LinacLego** is an important tool for parameters and **DOORS** the tool to manage requirements (time stamped DOORS report saved in **CHESS**):

https://aig.esss.lu.se:8443/LinacLegoWebApp/

- **Lead engineers** sets requirements to level four after discussions with partners and designers
- **Installation plan** developed by the chief engineer in close collaboration with system engineer and chief planner
- A schedule in P6 set by AD QA/QC responsible for reviews at different levels: Preliminary Design R, Critical Design R (ready to order), …
  - Reviews chaired by **Deputy head of accelerator project** with independent experts in the review committee

Ion Source & LEBT CDR

- The CDR for the ION Source and LEBT was held on Feb 10 in LNS Catania
- The team has done a great deal of work and advanced designs exist. Hardware for PS 1 has started to arrive.
- The final report of the committee is still being written
- It was clear that there are a number of undefined requirements and interfaces. A solution to fixing this issue prior to future CDRS will be given In the Chief Engineer's talk today.

Component	Date
Ion Source & LEBT (CDR)	February 10
MEBT (PDR)	TBD
RFQ (CDR2)	May 26
DTL (CDR)	June 16
ACCP (PDR1)	September 30
ACCP (PDR2)	December 1
LWU (CDR)	Q4 2015

Accelerator Major In-kind

- Since the launch of Expressions of Interest in spring 2013, discussions on in-kind are going on with 26 organizations.
- Possible partners to Accelerator have been identified in Denmark, Estonia, France, Germany, Hungary, Italy, Norway, Poland, Spain, Sweden, Switzerland, UK.
- Value of items discussed with these partners represents 50.4% of the accelerator budget, excluding cash contributions and paid contracts.
- Main task with many partners is to agree on technical details and write specifications.
- At the same time, issues need to be solved concerning cash flow, VAT, etc.
- The ESS aim is to have In-Kind Agreements signed after the ERIC transition, i.e. Technical Appendices should be ready in June.

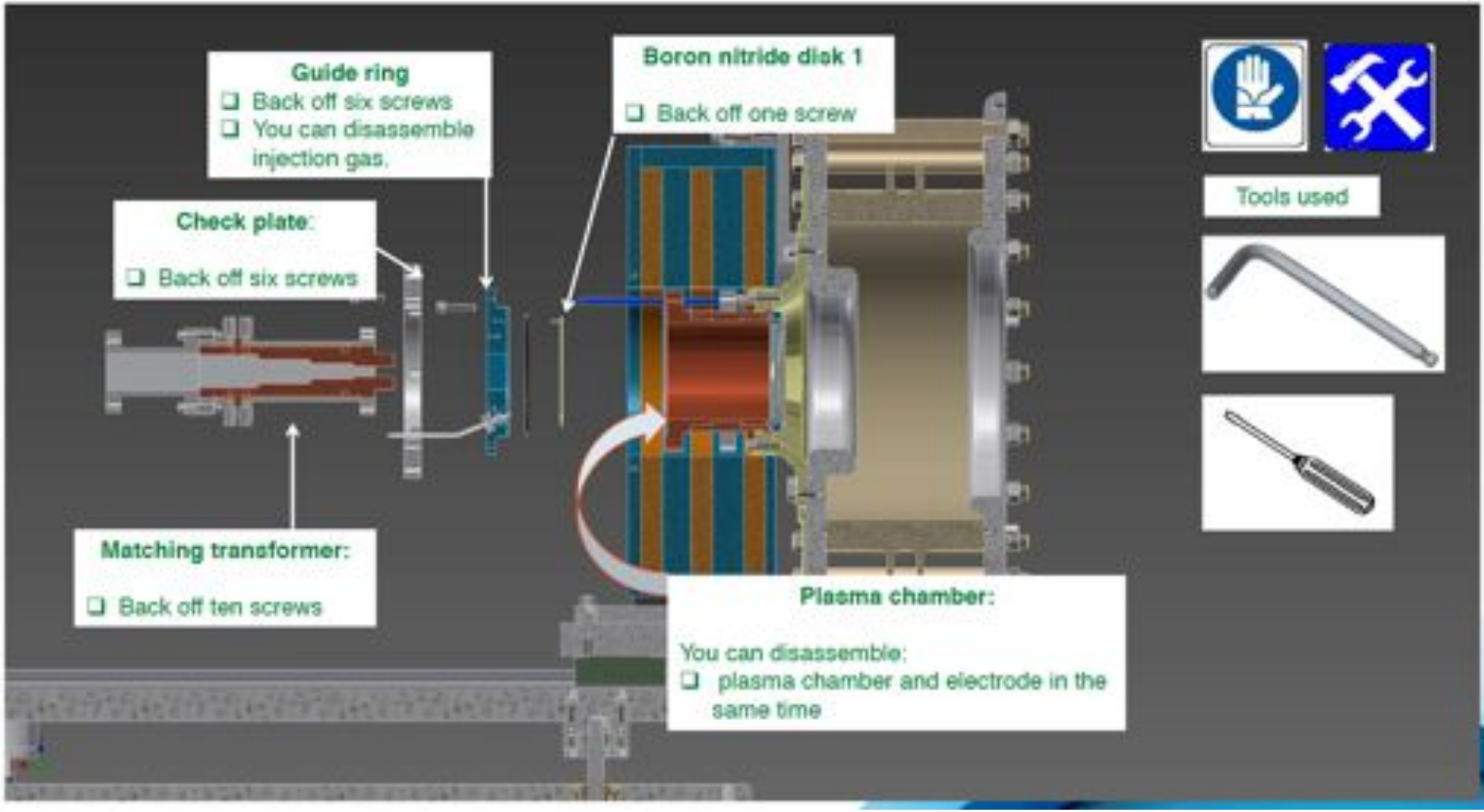
Accelerator Summary

- The accelerator project is in a phase of intense prototyping and reviewing and will soon see most major systems in construction
  - Large part of prototyping and design done by in-kind partners
  - Work on (parts of the) RF design, modulators, beam instrumentation and cryogenic design done in Lund
  - Essential to get in-kind contracts agreed and signed in 2015 to permit construction of all systems to start in earnest
- Coordination, integration and verification represent a major part of the work done today by the accelerator division at ESS in Lund
- The goal is to build and train the accelerator division so that it can assume full responsibility for operation and maintenance of the accelerator systems in 2019

Extra slides:

Here follows extra slides on WP progress

WP3: Attention to maintenance procedures from the start



WP3 : Some equipment for PS has arrived at LNS Catania

Cavity Prototypes

One spoke cavity installed on the cryo-insert for experiment at 2K

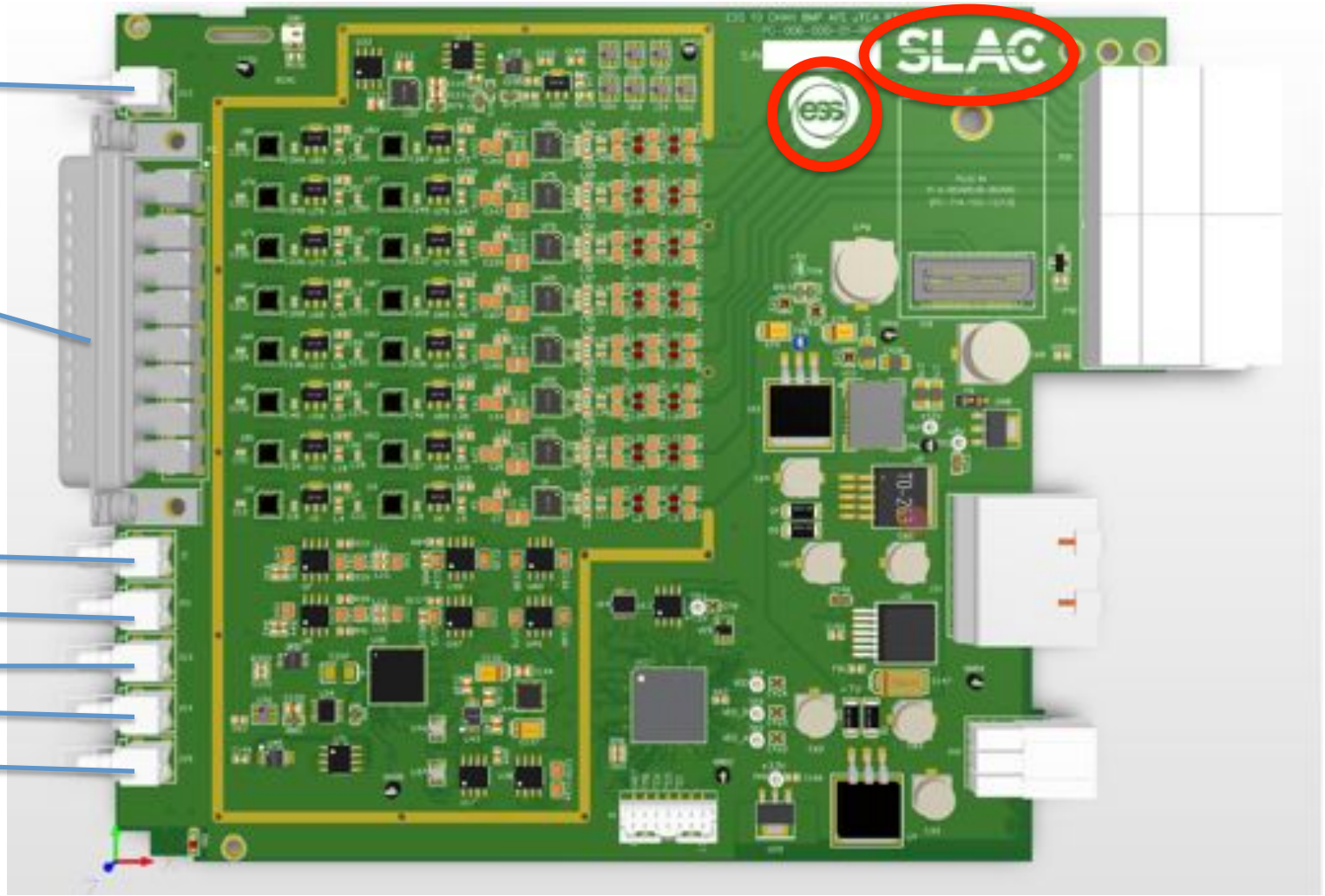
High β Elliptical Cavity Prior to RF Testing

High β Elliptical Cavity installed in Helium Tank

WP7 Beam Instrumentation
Position Monitor Front End Electronics

EUROPEAN SPALLATION SOURCE

Developed through agreement between SLAC and ESS. Incidentally, this agreement recently allowed Controls Division to quickly arrange collaboration with SLAC.



Highlights 2014 (1/2)

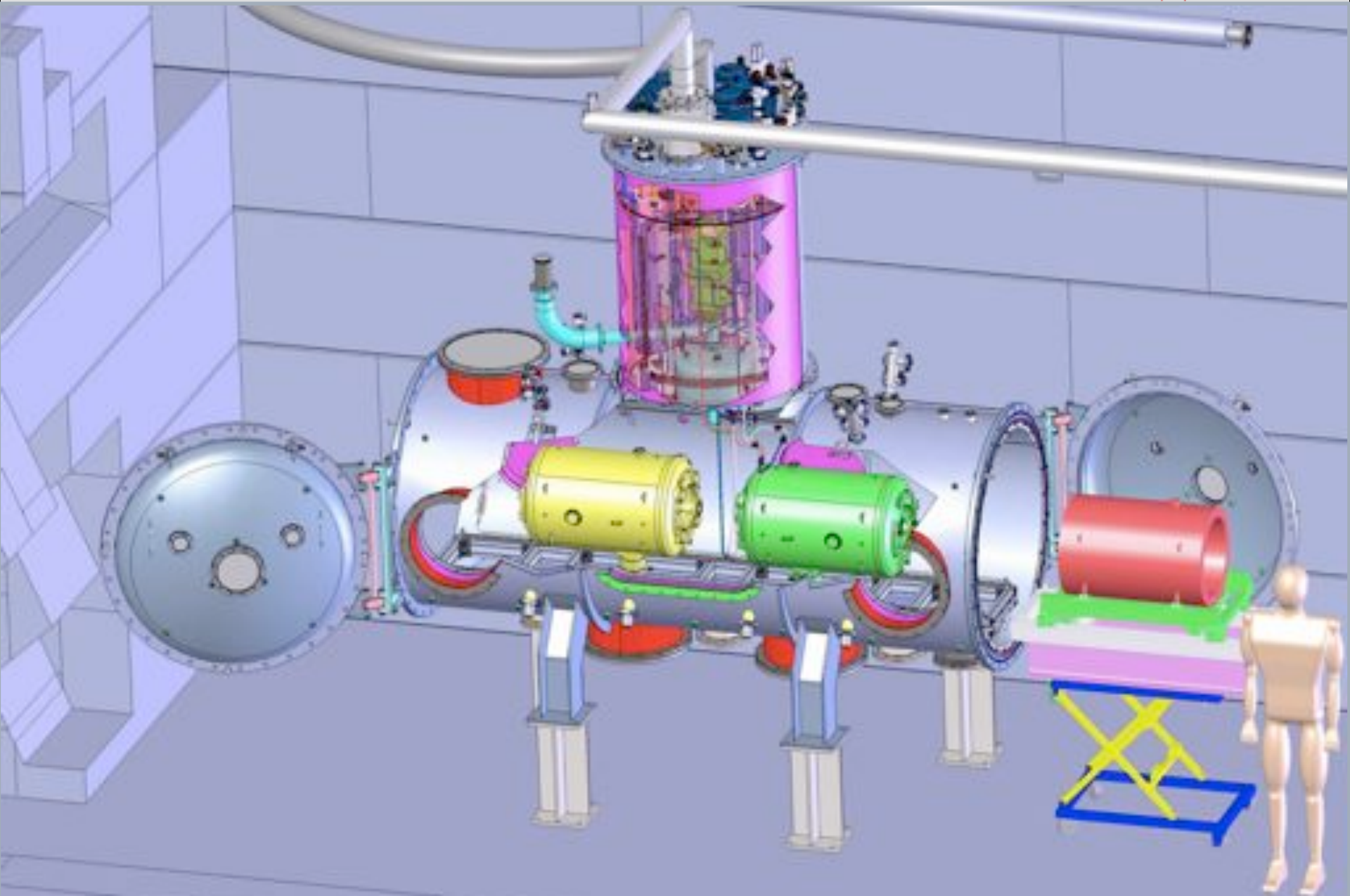
- **Laboratory infrastructure**
  - completed bunker for ESS tests plus 2 smaller bunkers
  - controls and interlock systems development ongoing
    - EPICS as main interface
    - Siemens PLC and Nat.Instr. cRIO hardware
  - (radiation) safety system installation ongoing
    - Rotem MediSmarts hardware
- **Cryogenics and SRF Test Stand**
  - commissioned helium liquefier (14-Mar-2014)
    - now servicing university & UU region with LHe and LN2
  - commissioned HNOSS (09-Dec-2014)
    - dummy volume cooled down to 2 K
    - improving automatic controls, adjusting some hardware
  - prepare for cool down and test with SRF cavity
    - single spoke "Hélène" arrived from IPN Orsay (17-Feb-2015)
    - warm RF testing ongoing (to verify our procedures)

Highlights 2014 (2/2)

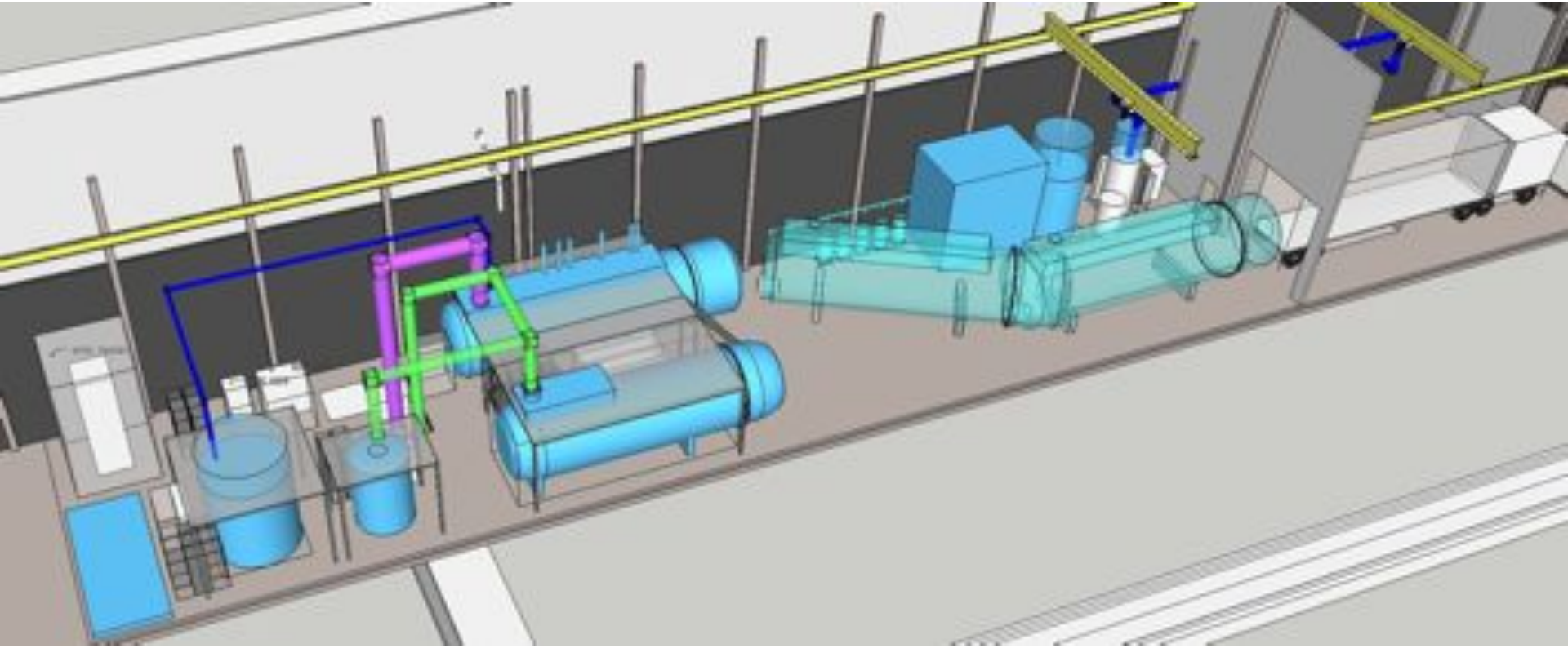
- **High Power RF Systems**
  - **4 systems foreseen to come in operation during 2015**
    - long delays with Electrosys (bankrupt Spring 2014)
      - company has finally restarted (target delivery 31-May-2015)
      - legal problems regarding ownership of Thales tubes (could again delay project)
    - 2nd contract with DB Electronica (target delivery 31-May-2015)
    - borrowed 50 kW amplifier from CERN (arrived 18-Feb-2015)
      - target date for commissioning start mid March
    - Siemens solid-state
  - in-house development solid-state technology demonstrator
    - compact combiner, increased efficiency modules
- **LLRF and Controls**
  - first parts Lund LLRF have arrived
    - control modules only, RF parts to arrive soon (mid-March)
  - in-house development LLRF
    - LabVIEW (Nat. Instr. PXI based)

UPPSALA UNIVERSITET

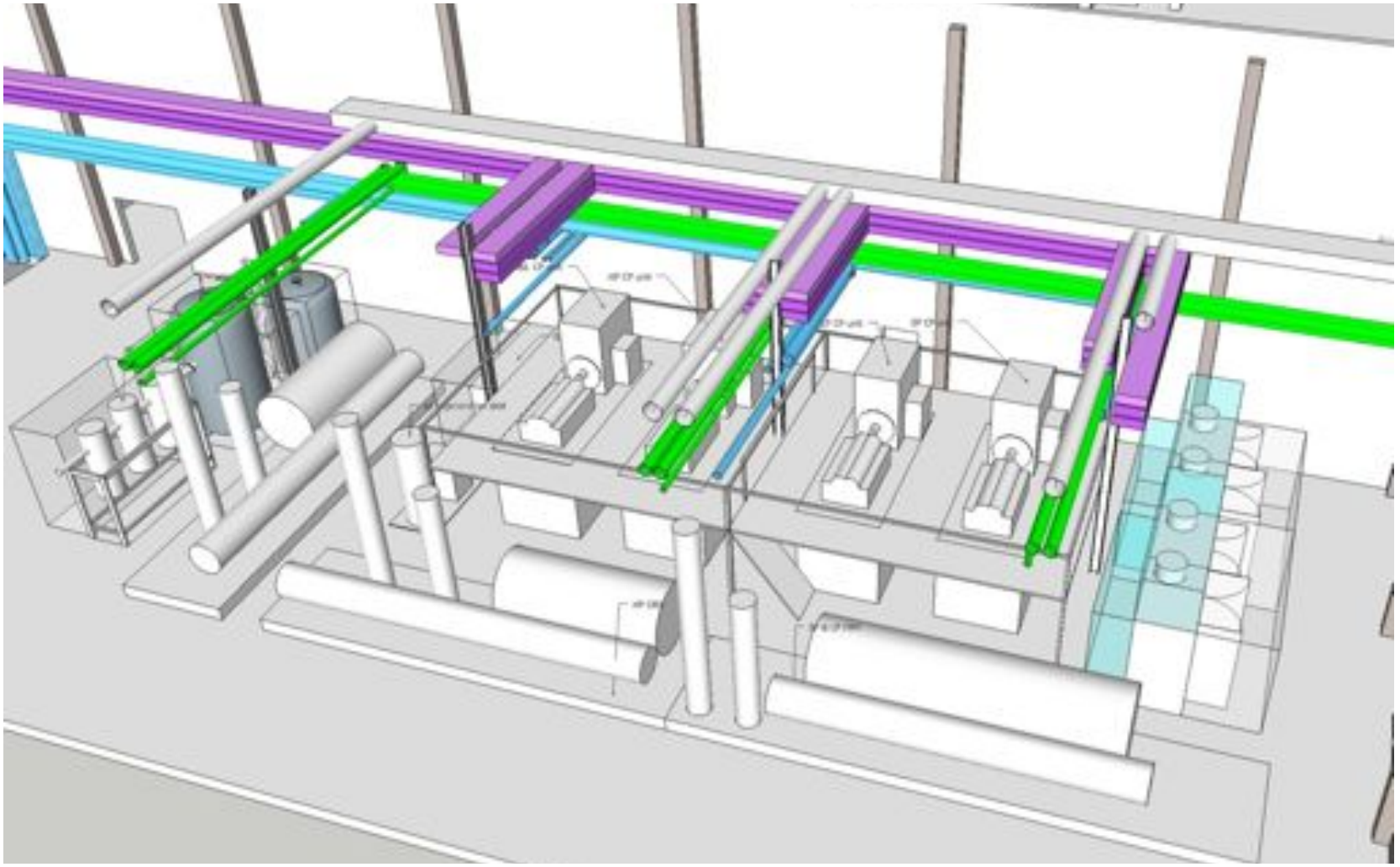
HNOSS



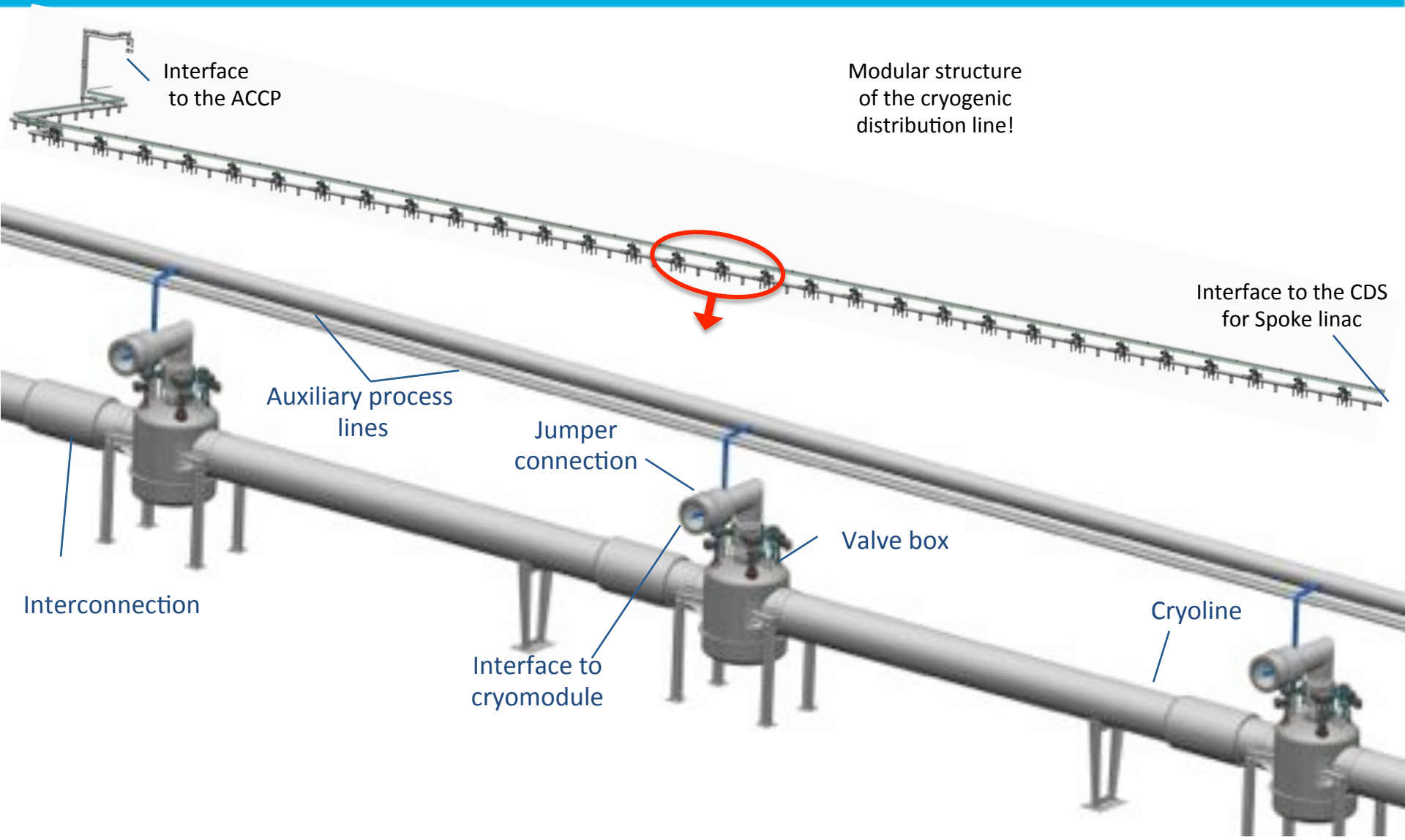
Layout of Cold Box Room



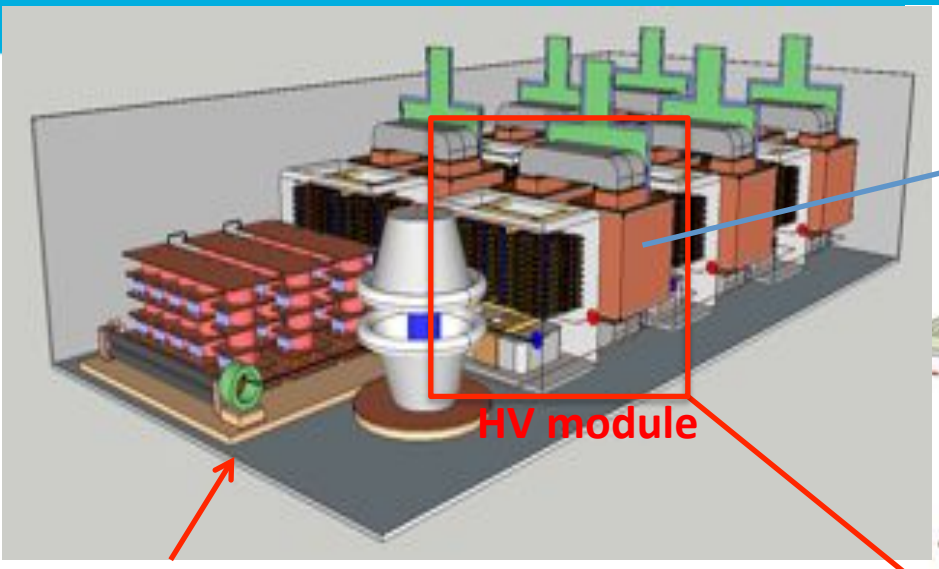
Layout of He Compressors & Ancillary from Linde Tender in ESS Compressor Bldg

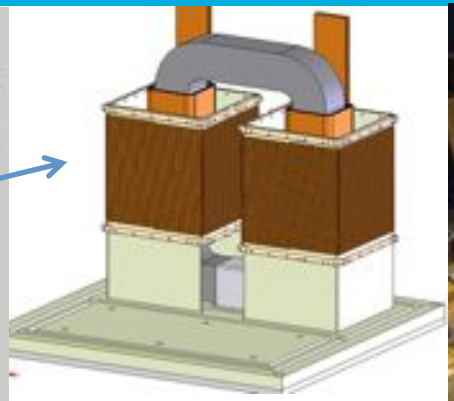


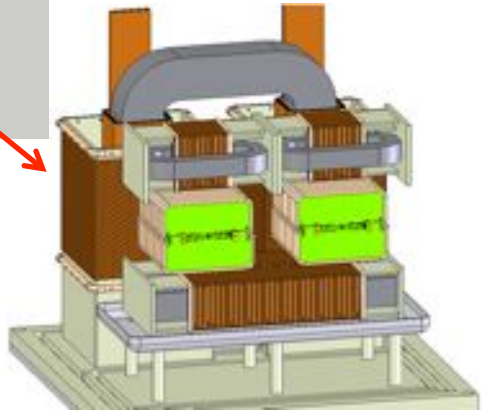
CDS for the elliptical linac – isometric view

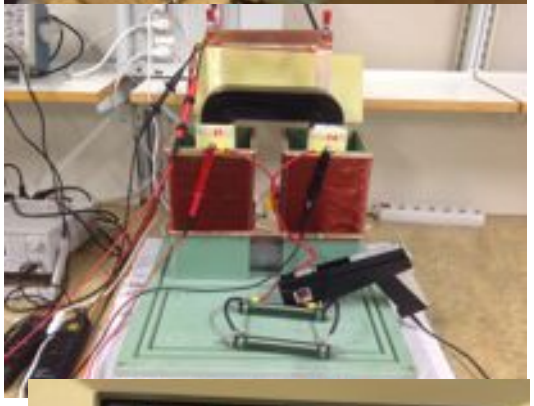


WP16: Design of HV oil tank assembly and components' prototyping









HV oil tank assembly

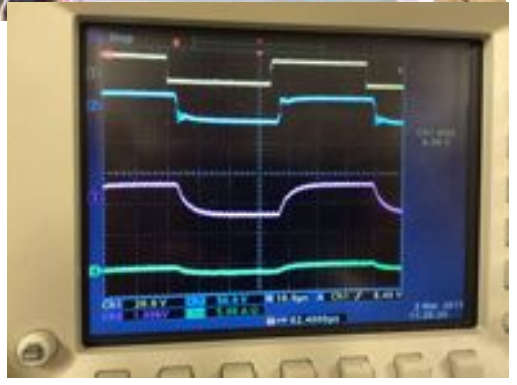
(Collaboration between ESS and LTH)

- Design of the whole system undergoing;

HV module (HV transformer + HV rectifier)

Construction and validation of one HV module prototype is undergoing:

- HV transformer assembled (first test results obtained last Monday);
- HV rectifier is under construction

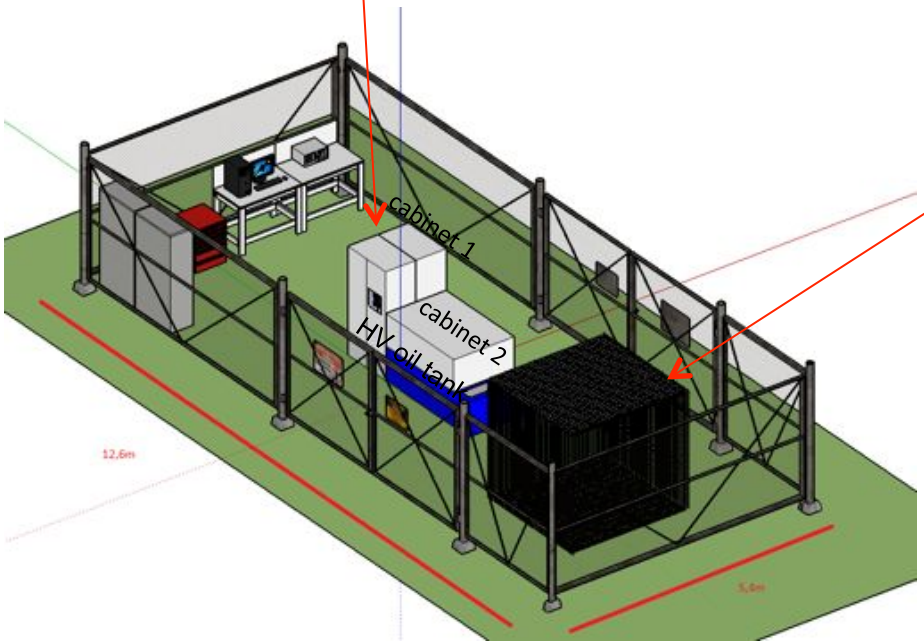


WP16: High Voltage Power Electronics lab - M building of LTH, in Lund

EUROPEAN SPALLATION SOURCE

Modulator

- Low voltage (cabinets 1 &2): Complete and successufly tested on dummy loads;
- HV oil tank: under design and prototyping phase



High Voltage resistive dummy load

(arrived on 25th Feb. 2015)

Work Package Audits in 2015 (Dates may be impacted by Annual Review)

EUROPEAN SPALLATION SOURCE

Work Package	Date
WP15 Electrical Support	March 11
WP16 Cooling Support	April
WP6 Beam Delivery	April
WP12 Vacuum	May
WP10 Test Stands	May
WP99 Integration & Installation	June
WP2 Beam Physics	June
WP8 RF	September
WP17 Power Convertors	September
WP7 Beam Instrumentation	October
WP4/5 Cavities & CMs	October
WP3 NCFE	November
WP11 Cryogenics	December

Accelerator Major In-kind

In-kind

ATOMKI
CEA
CNRS
Cockcroft Inst
Daresbury Lab
Elettra
ESS-Bilbao
GSI
Huddersfield Univ
IFJ PAN
INFN Catania
INFN Legnaro
INFN Milan
NCBJ
RAL
RHUL
Tallinn UT
TU Lodz
Univ Oslo
Warsaw UT
Wroclaw UT

Paid contracts

Aarhus Univ
DESY
Lund Univ
PSI
Uppsala Univ

Accelerator Major In-kind

EUROPEAN SPALLATION SOURCE

Largest IK Packages

Partner	Scope (main)	M€ (prel.)	HoA	Agreed[1]	Signed
CEA Saclay	RFQ, Cryomodules, Diagnostics	70.8	Yes	Yes	No
Daresbury	High Beta Cavities, Vacuum	32.3	No	No	No
Elettra	RF, Magnets, Power Suppl., Diagn.	30.5	Yes	No	No
IPN Orsay	Cavities, Cryomodules, Cryo Distr.	19.9	Yes	Yes	No
IFJ PAN	Installations	18.1	No	No	No
Huddersfield	RF Distribution	17.6	No	No	No
Legnaro	Drift Tube Linac	16.8	Yes	No	No
Bilbao	MEBT, Warm Linac RF, Diagnostics	15.7	Yes	Mostly	Partly
Milan	Medium Beta Cavities	10.1	Yes	No	No

1) Technical scope and cost agreed