# The European Spallation Source Accelerator

J. G. Weisend II
For the ESS Accelerator Collaboration

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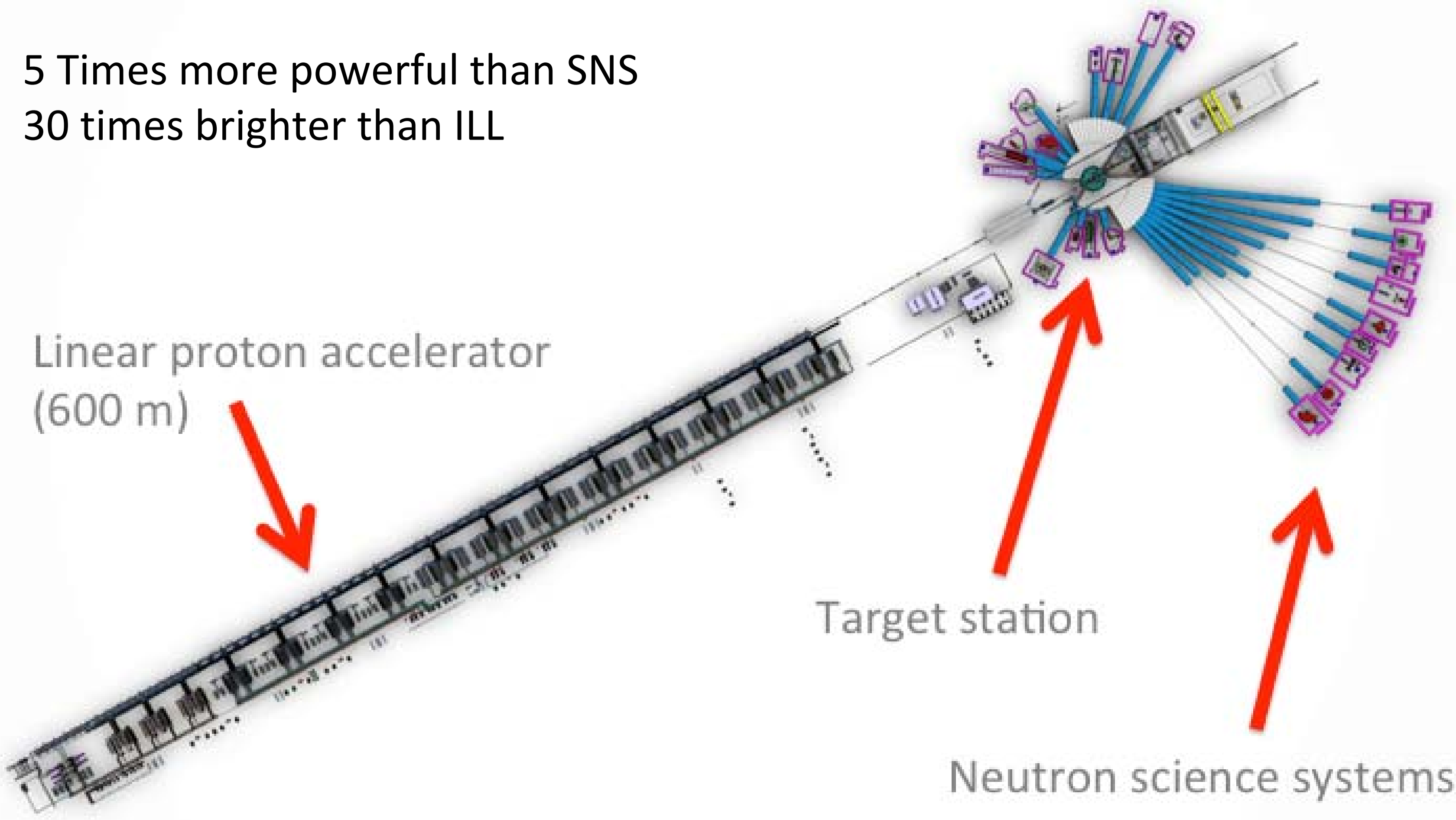
# Outline

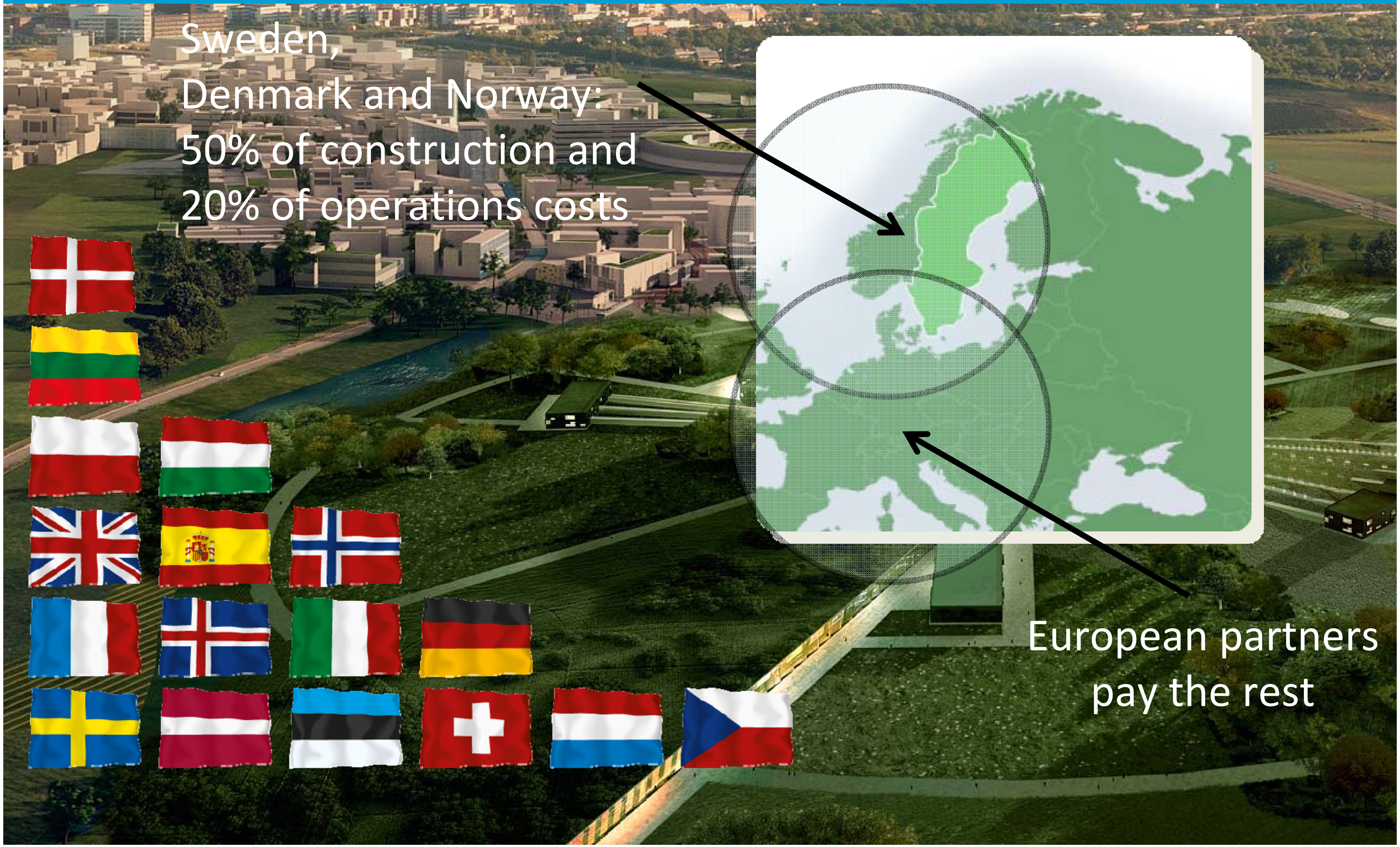
- Introduction to ESS
- Accelerator Overview
- Examples of Accelerator Components
- In-Kind Contributions
- Sustainability at ESS
- High Level Schedule
- Summary

# ESS Overview

5 Times more powerful than SNS
30 times brighter than ILL



# A European Science Project



Sweden,
Denmark and Norway:
50% of construction and
20% of operations costs

European partners
pay the rest

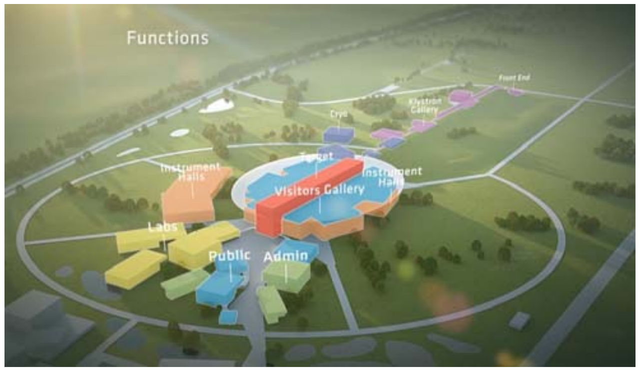
# The view of the Southwest in 2025

- MAX IV – a national research facility, under construction, opens up in 2016
- Science City – a new part of town
- ESS – an international research facility

# ESS accelerator

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
- -14 Hz
- -Protons (H+)
- -Low losses
- -Attention is paid to cryoplant turn down capabilities to minimize use of electrical heaters at low temperatures and proper cryogenic design techniques to minimize static heat leaks
- -Flexible design for future upgrades

# Target Station

Helium-cooled rotating tungsten target

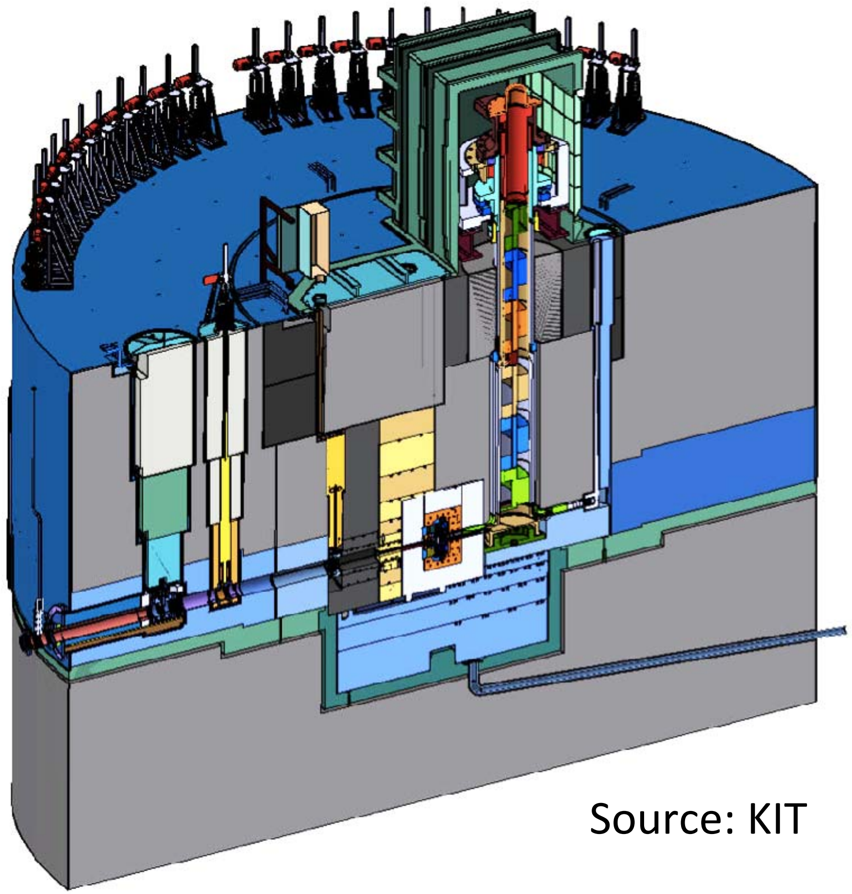
Nearly 5 MW of heat carried away by cooling systems

Entombed in 5 m of steel

Critical components become highly activated, requiring remote handling for servicing

Supercritical $H_2$ (20 K) moderators delivery cold neutrons to the instruments

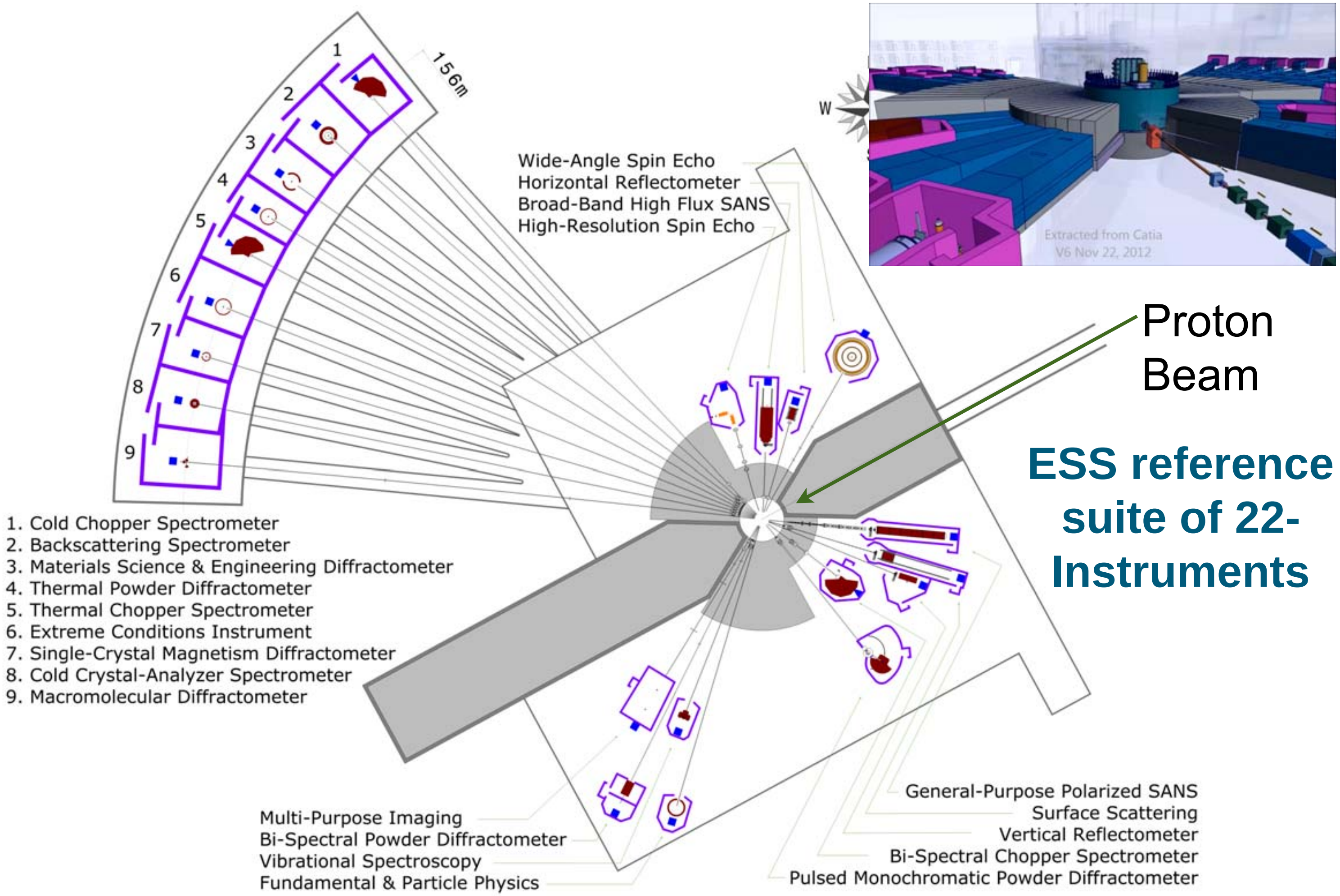
Moderator design is under optimization



Source: KIT

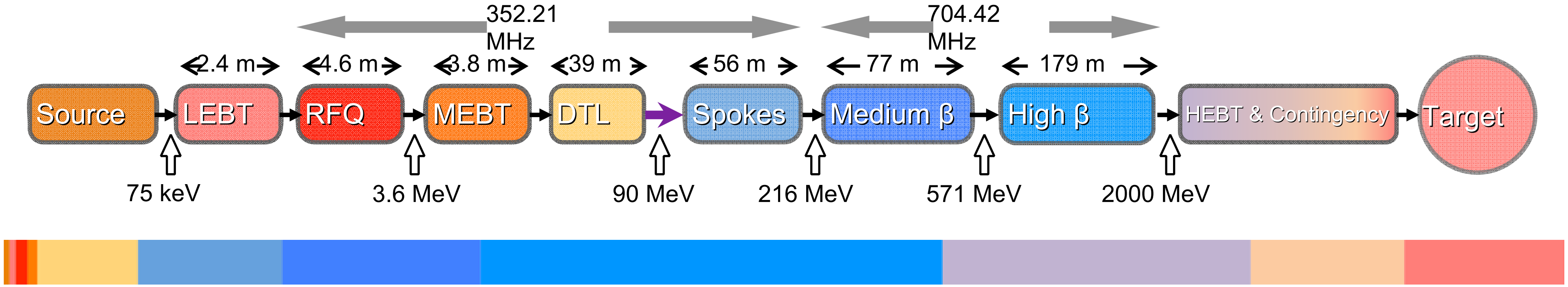
ESS Technical Design Report, ESS-2013-001, April 22, 2013, available at http://eval.esss.lu.se/cgi-bin/public/DocDB/ShowDocument?docid=274 .

# ESS Reference suite of instruments



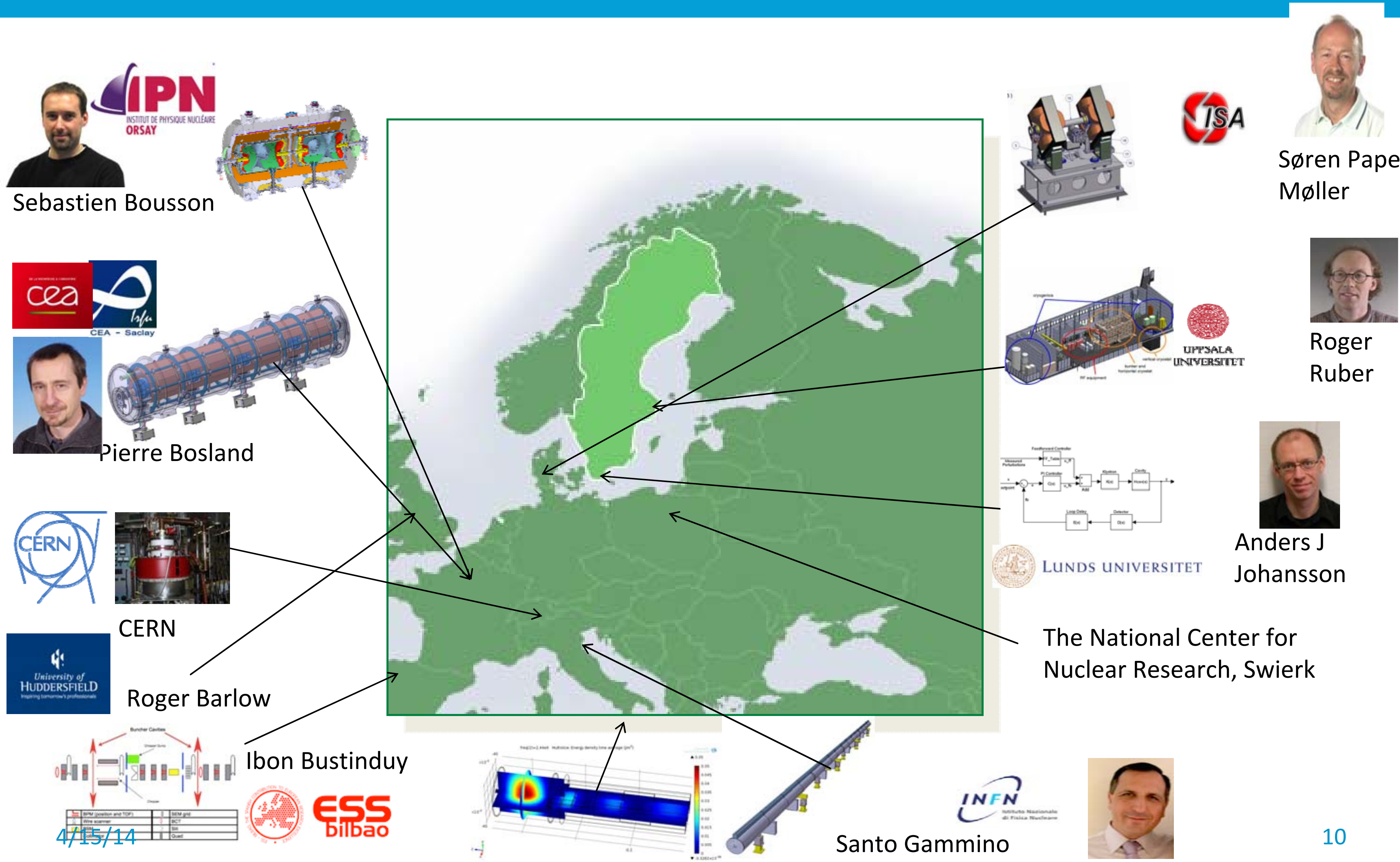

**ESS reference suite of 22-Instruments**

# THE ESS LINAC




| | Length (m) | W_in (MeV) | F (MHz) | β Geometric | No. Sections | T (K) |
|---|---|---|---|---|---|---|
| LEBT | 2.38 | 0.075 | -- | -- | 1 | ~300 |
| RFQ | 4.6 | 0.075 | 352.21 | -- | 1 | ~300 |
| MEBT | 3.81 | 3.62 | 352.21 | -- | 1 | ~300 |
| DTL | 38.9 | 3.62 | 352.21 | -- | 5 | ~300 |
| LEDP + Spoke | 55.9 | 89.8 | 352.21 | 0.50 (Optimum) | 13 | ~2 |
| Medium Beta | 76.7 | 216.3 | 704.42 | 0.67 | 9 | ~2 |
| High Beta | 178.9 | 571.5 | 704.42 | 0.86 | 21 | ~2 |
| Contingency | 119.3 | 2000 | 704.42 | (0.86) | 14 | ~300 / ~2 |
| ~~Upgrade~~ | ~~59.6~~ | ~~2000~~ | ~~704.42~~ | ~~(0.86)~~ | ~~7~~ | ~~~300 / ~2~~ |

# Prototyping the ESS accelerator



# Ion Source

Microwave Discharge Ion Source

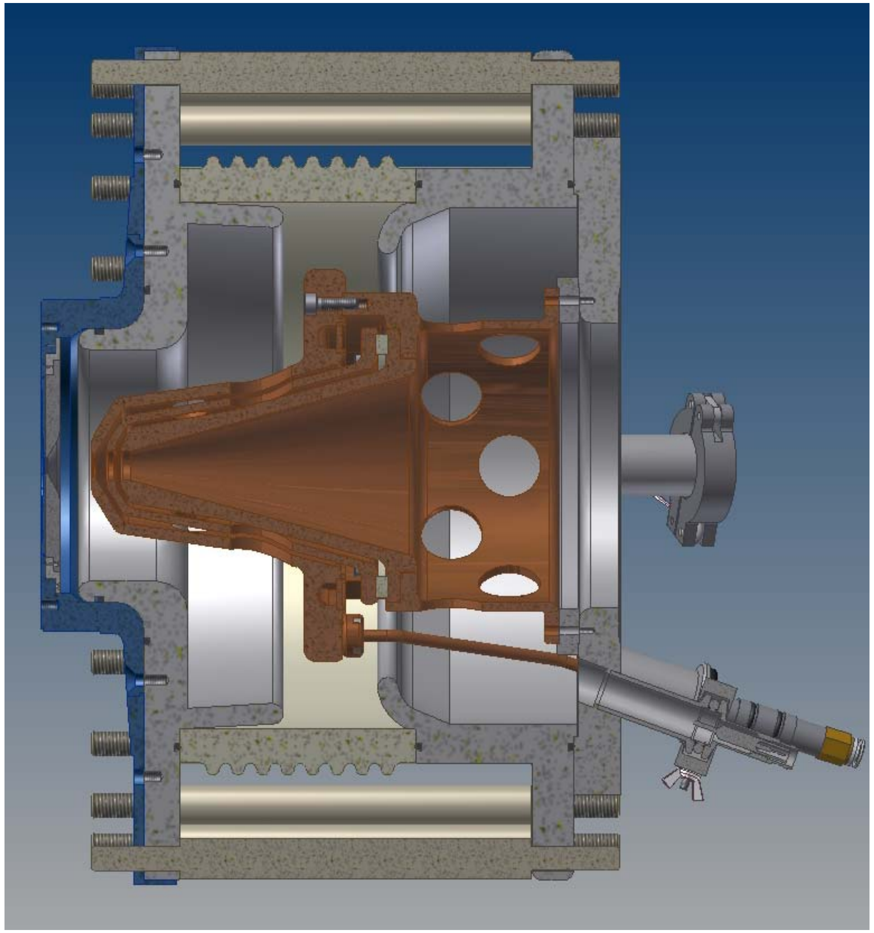
Proton peak current ~75 mA

Total drain current ~100 mA

Output Energy 75 keV

Provided by INFN-LNS, Catania

Experience from TRIPS and VIS ion sources



Extraction system of the ESS ion source
(Courtesy L. Celona)

# LEBT

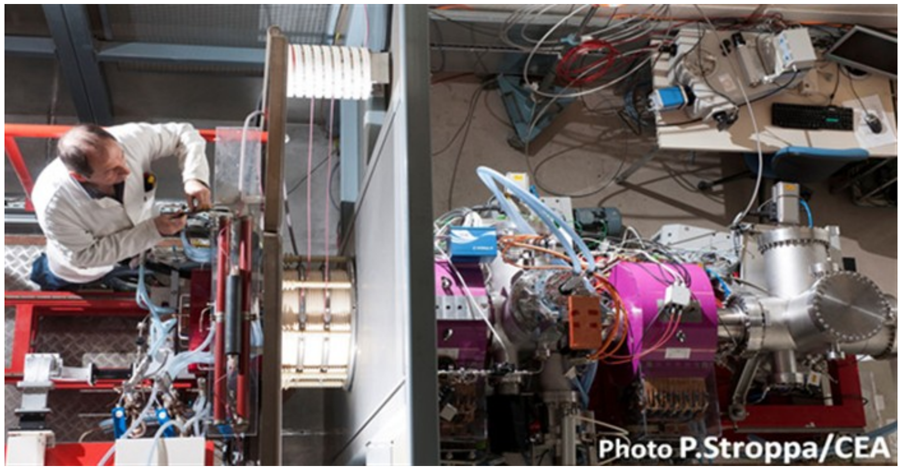
Dual solenoid layout

Functions:

- Transport and match input the RFQ
- Clean the beam pulse from the rise/fall time of the source with a slow chopper
- Provide different level of beam current with an iris

Provided by INFN-LNS, Catania

Design close to the IFMIF LEBT




IFMIF source and LEBT at CEA-Saclay

# RFQ

352 MHz 4-vanes RFQ

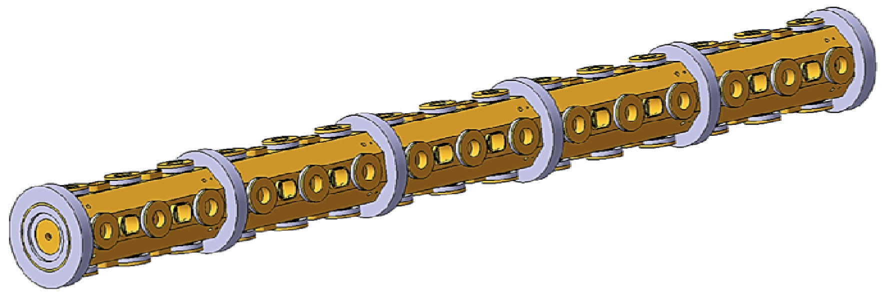
5 segments of ~90 cm

Functions:

- Accelerates
- Bunches the pulse in a train of bunches
- Focuses in the 3 planes

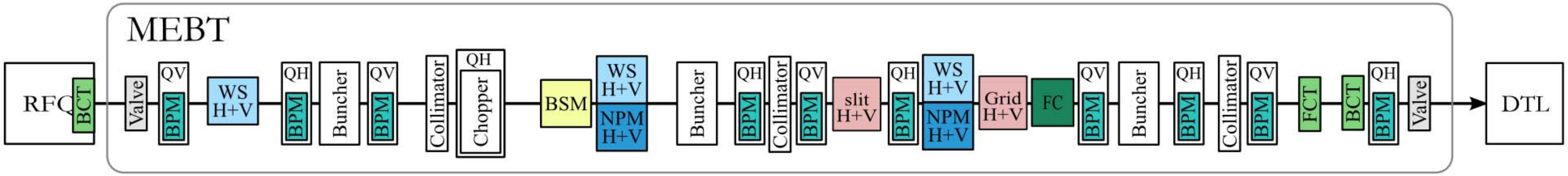
Foreseen transmission > 90 % for 70 mA input beam

Provided by CEA-Saclay



RFQ 3D view (Courtesy N. Sellami)

# MEBT




MEBT layout (Courtesy B. Cheymol)

Fully instrumented MEBT

~ 4.5 m

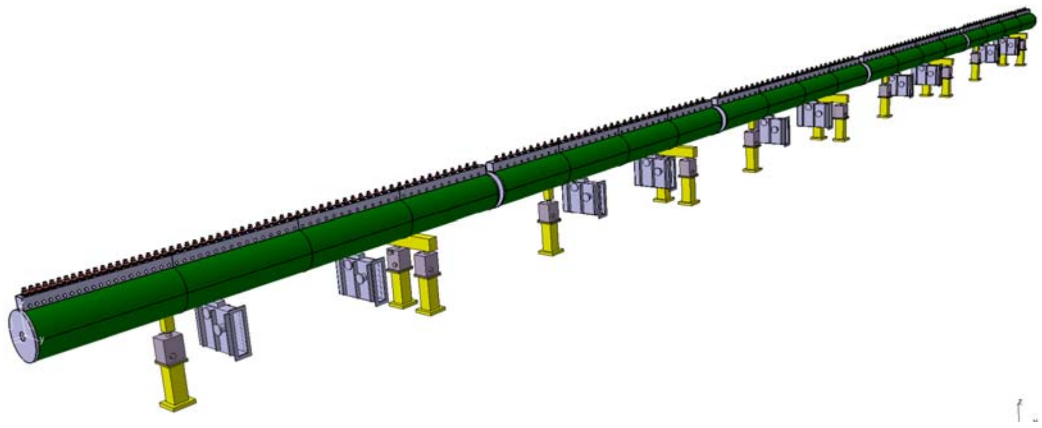
Functions:

- Transport and match into the DTL
- Characterize the beam
- Fast chopping of the beam with rise/fall time ~ 10 ns

Provided by ESS-Bilbao

# DTL

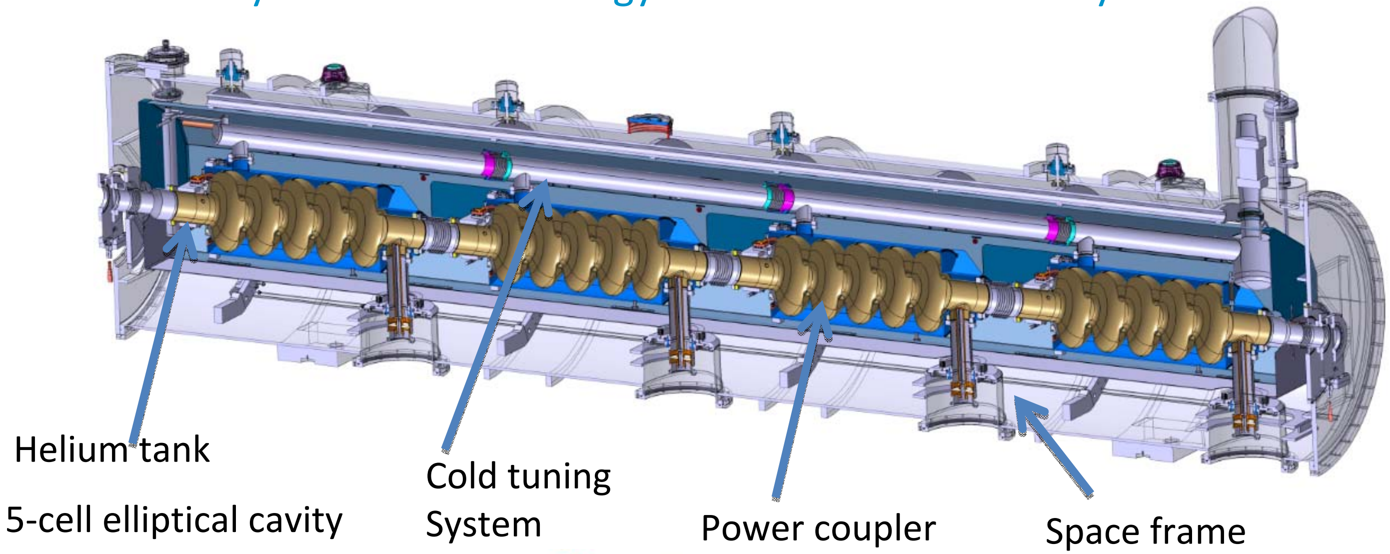
- 352 MHz
- 5 tanks
- Length ~ 40 m
- Output energy: ~90 MeV
- Provided by INFN-LNL, Legnaro

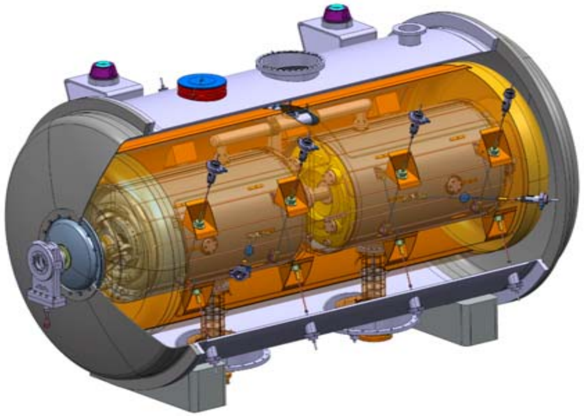


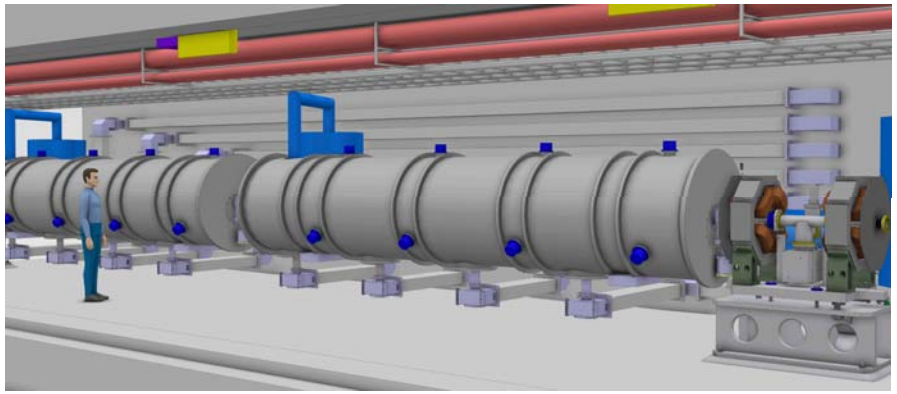
DTL 3D view (Courtesy P. Mereu)

# Cryomodules

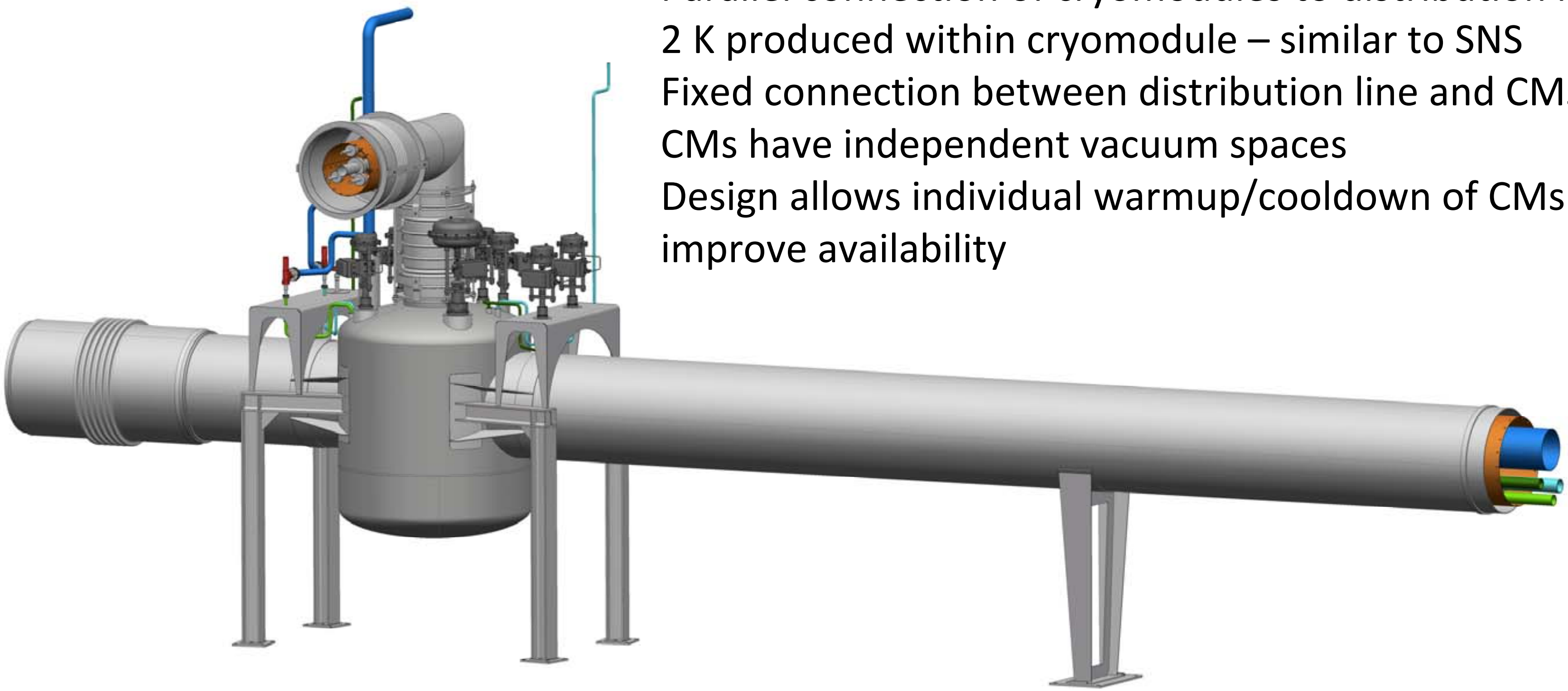
→ Cavities Cryomodule Technology Demonstrator results by 2016



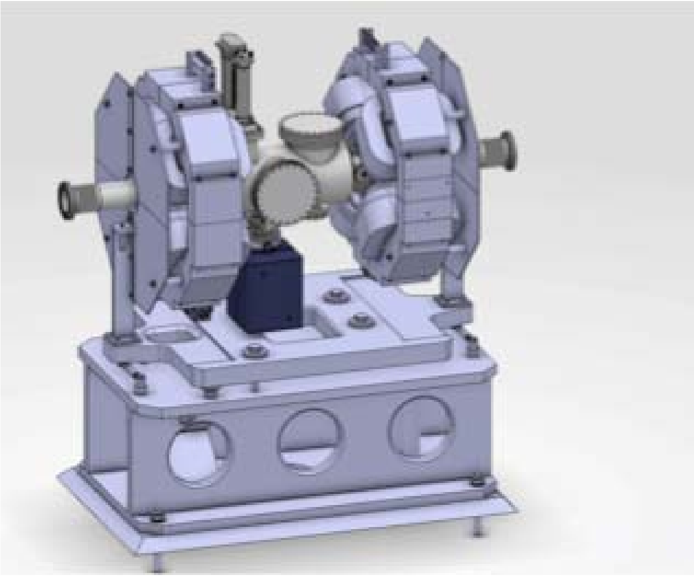


# Cryogenic Distribution Line



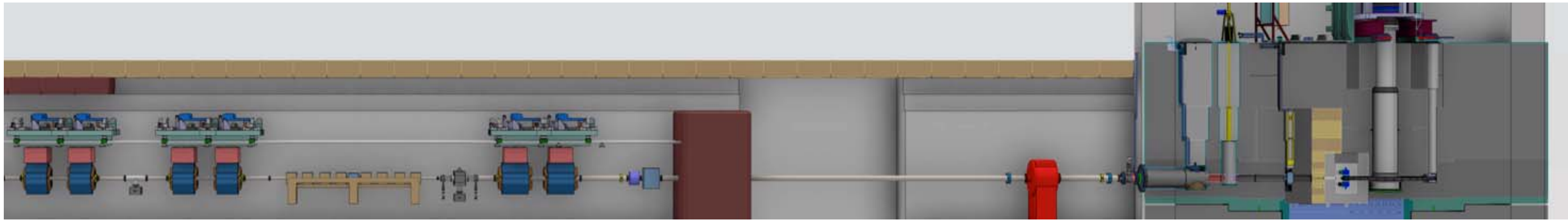
- Parallel connection of cryomodules to distribution line
- 2 K produced within cryomodule – similar to SNS
- Fixed connection between distribution line and CMs
- CMs have independent vacuum spaces
- Design allows individual warmup/cooldown of CMs to improve availability

# Only normally conducting magnets are used in the accelerator

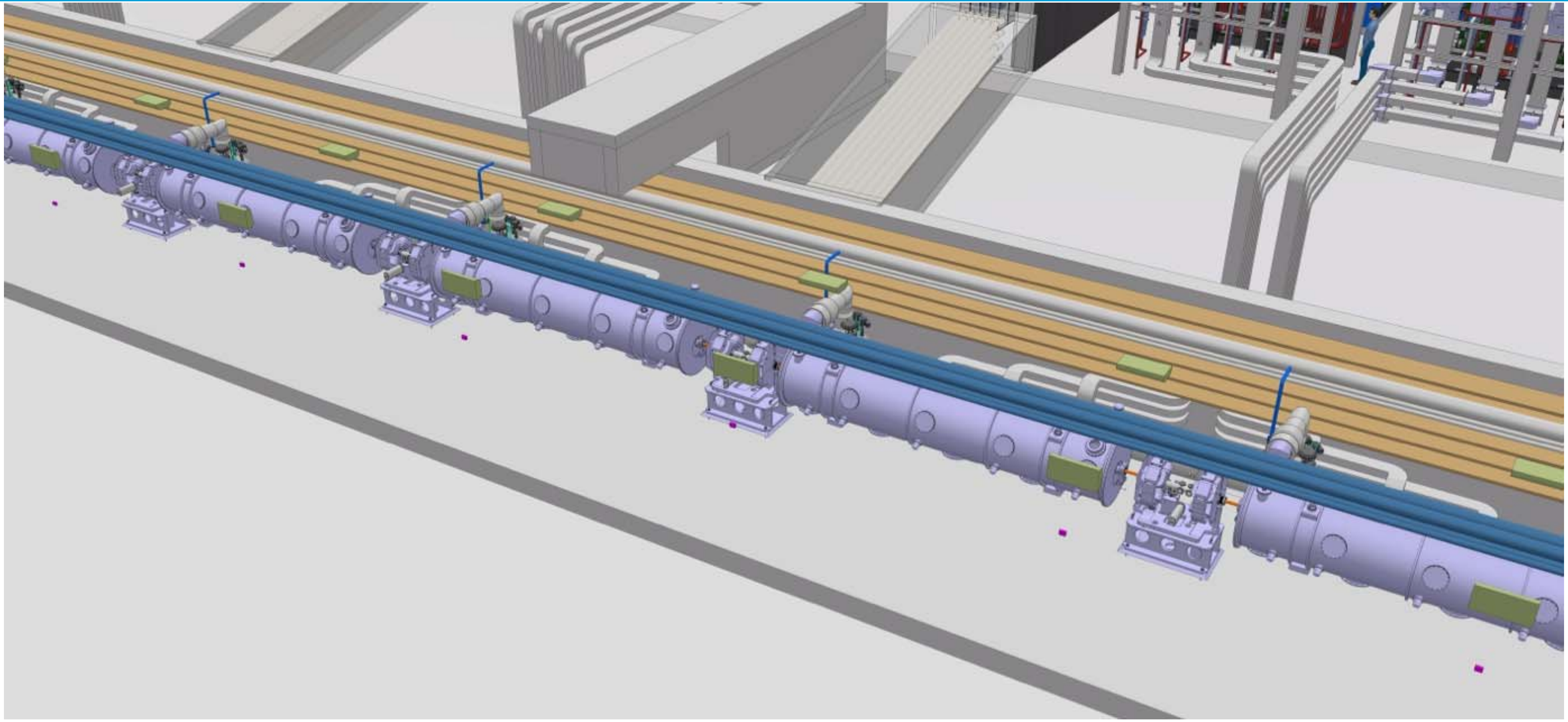


Linac Warm Unit placed between cryomodules and in HEBT

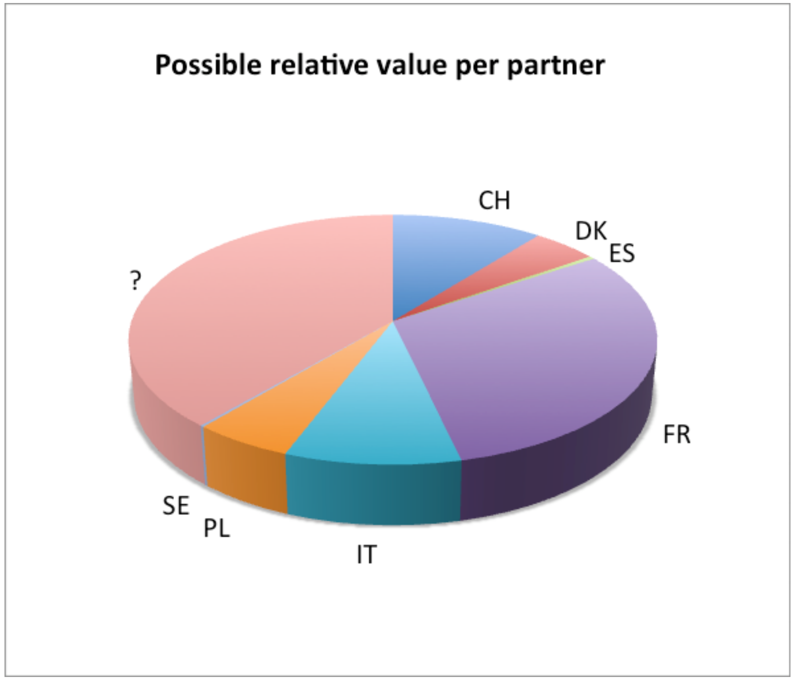
A2T Line

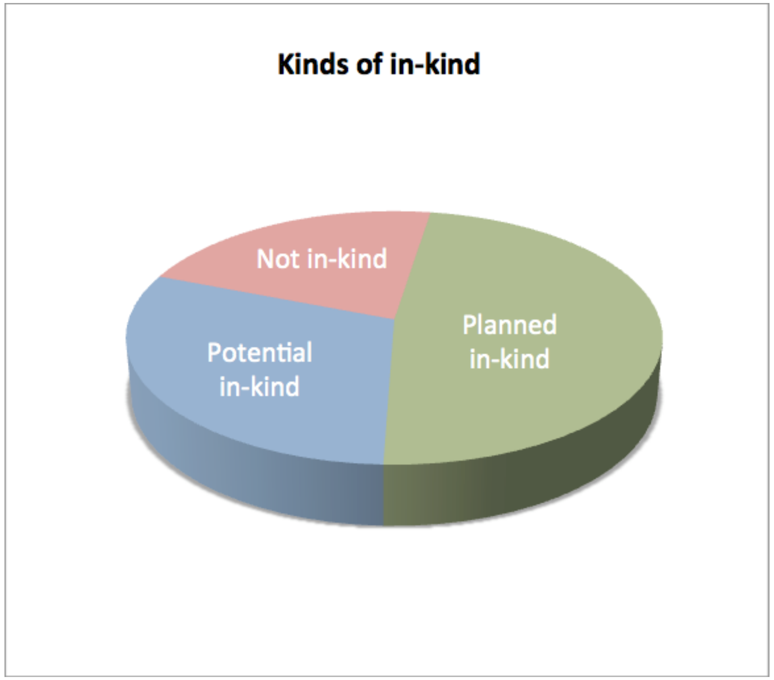


# Conventional Facility Design & Equipment Layout is Moving to Detailed Design



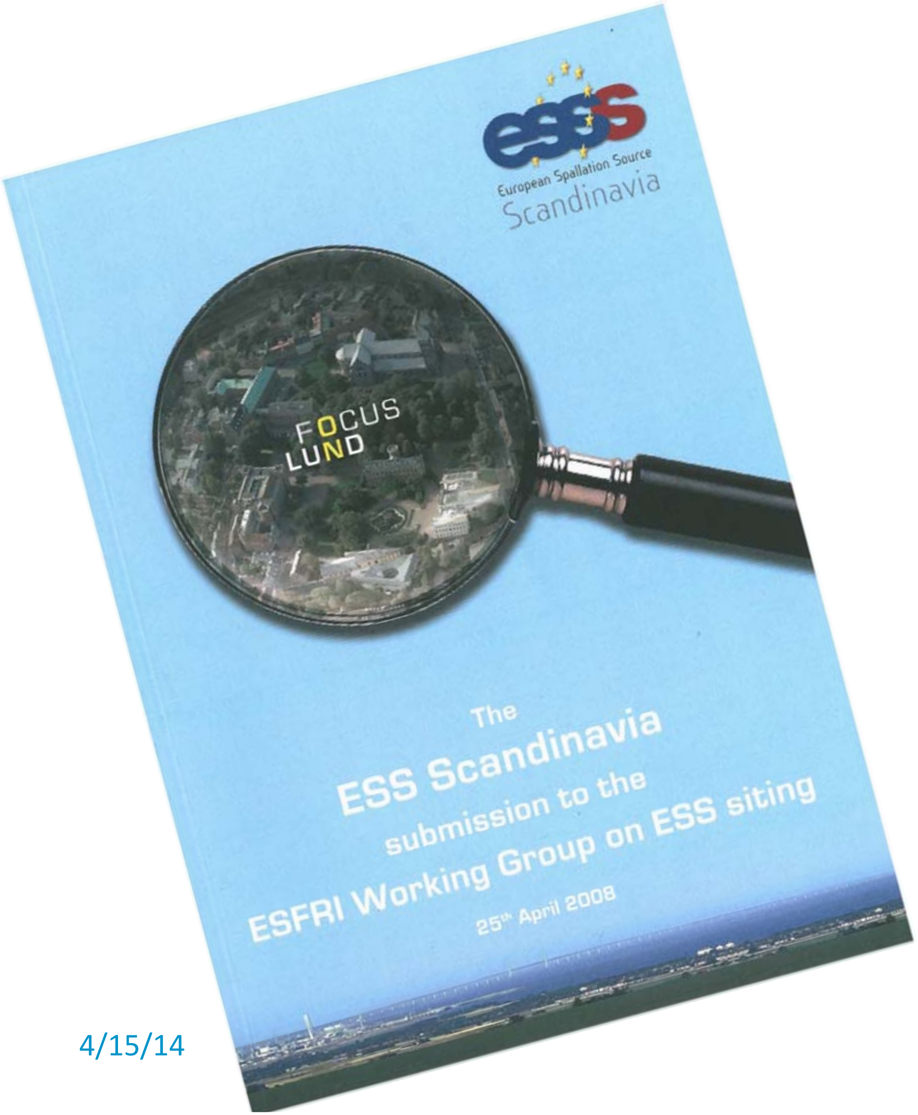
# In-Kind Contributions are well advanced




Planned + potential in-kind is 78% of accelerator budget. Currently, Planned in-kind is 48 % of the accelerator budget

# The Scandinavian Commitment: A Sustainable Research Center




- ✓ **Responsible**

  Energy Efficiency

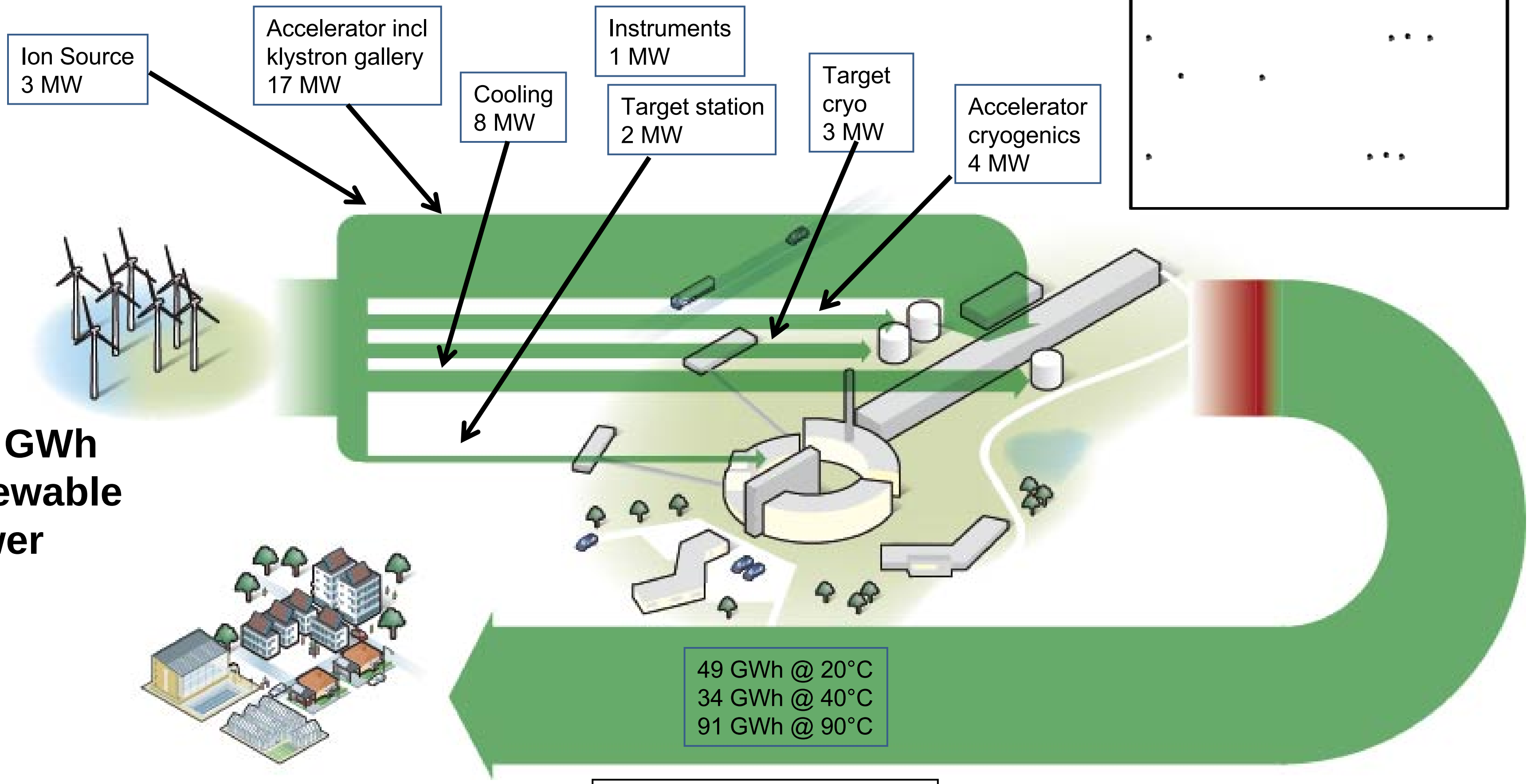
- ✓ **Recyclable**

  ESS's cooling is Lund's heating

- ✓ **Renewable**

  Power from renewable sources

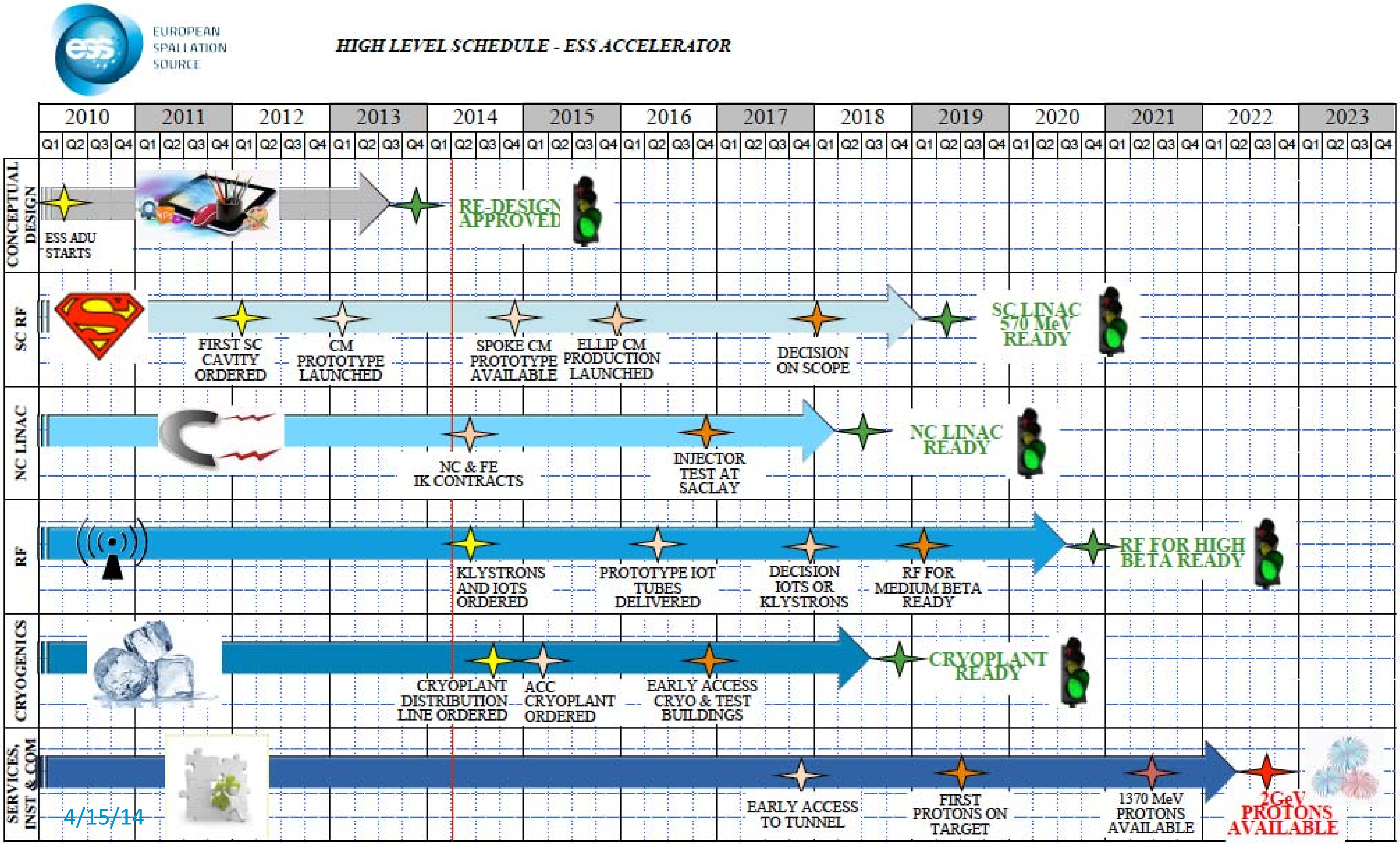
# Energy Inventory ESS 2012




**250 GWh renewable power**

**174 GWh re-used heat = 70% (excluding heat pumps)**

# Very High Level Schedule



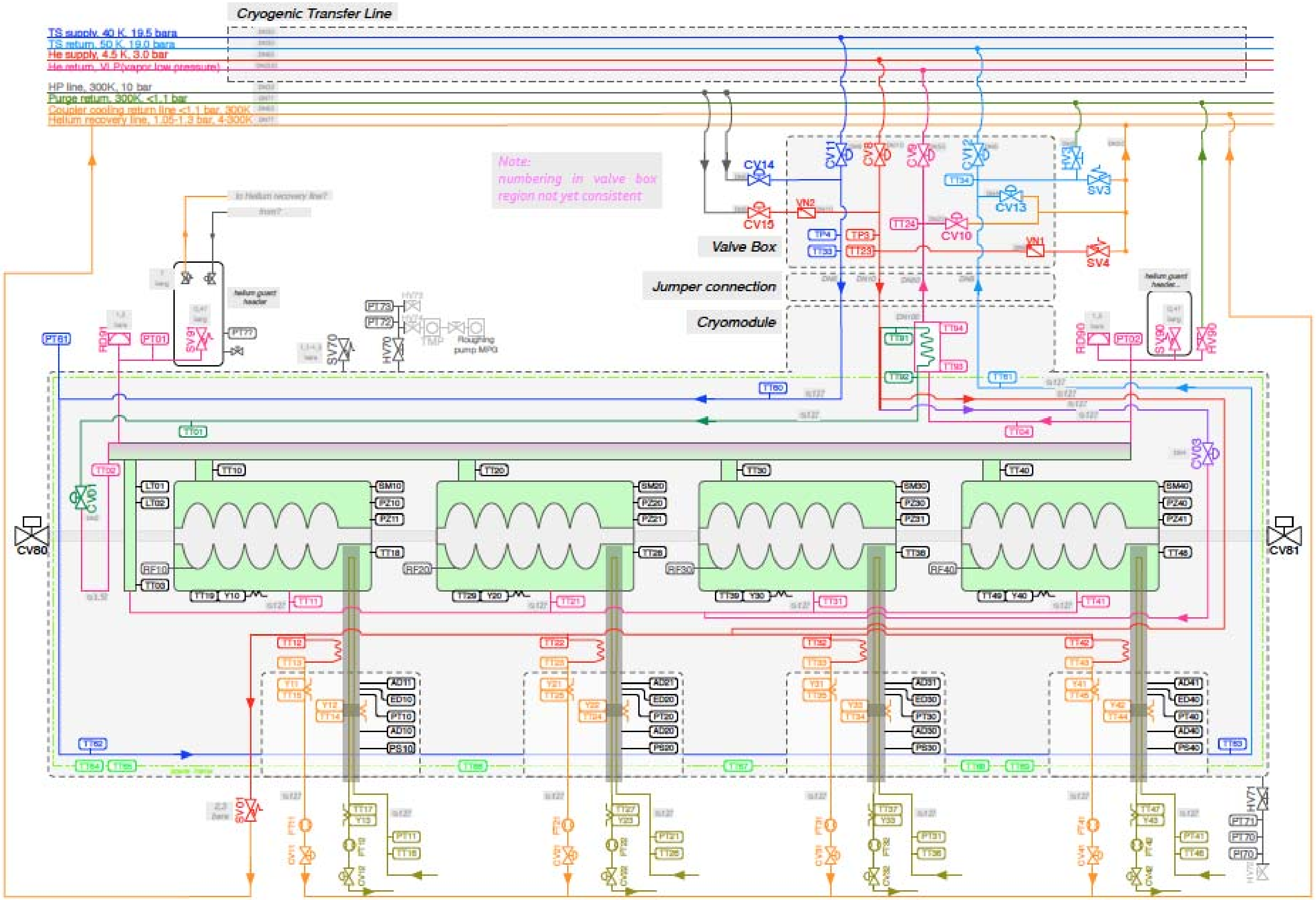
# Summary

- ESS will become the world's most powerful source for neutron science
- Work is well underway
  - A very skilled team has been assembled, both at ESS and at our partner labs
  - Accelerator design update is complete – detailed requirements down to level 4 are almost complete
  - Significant prototyping is underway (modulators, IOTs, ion source, DTL, RFQ, cryomodules)
  - Required buildings and utilities have been defined and are under detailed design
  - Ground breaking in 2014 with sizable procurements in 2014 and 2015
- Significant Opportunities for IKC exist
- 1$^{st}$ beam in 2019 with full power & all instruments in 2023

# BACK UP SLIDES

EUROPEAN SPALLATION SOURCE

# Connection between Elliptical Cavity CM and Cryogenic Distribution Line




Version 20140227a NE

# Conceptual ESS Cold Box Room Layout

EUROPEAN SPALLATION SOURCE