EUROPEAN
SPALLATION
SOURCE

The ESS Accelerator

Bonn, 22 January 2014

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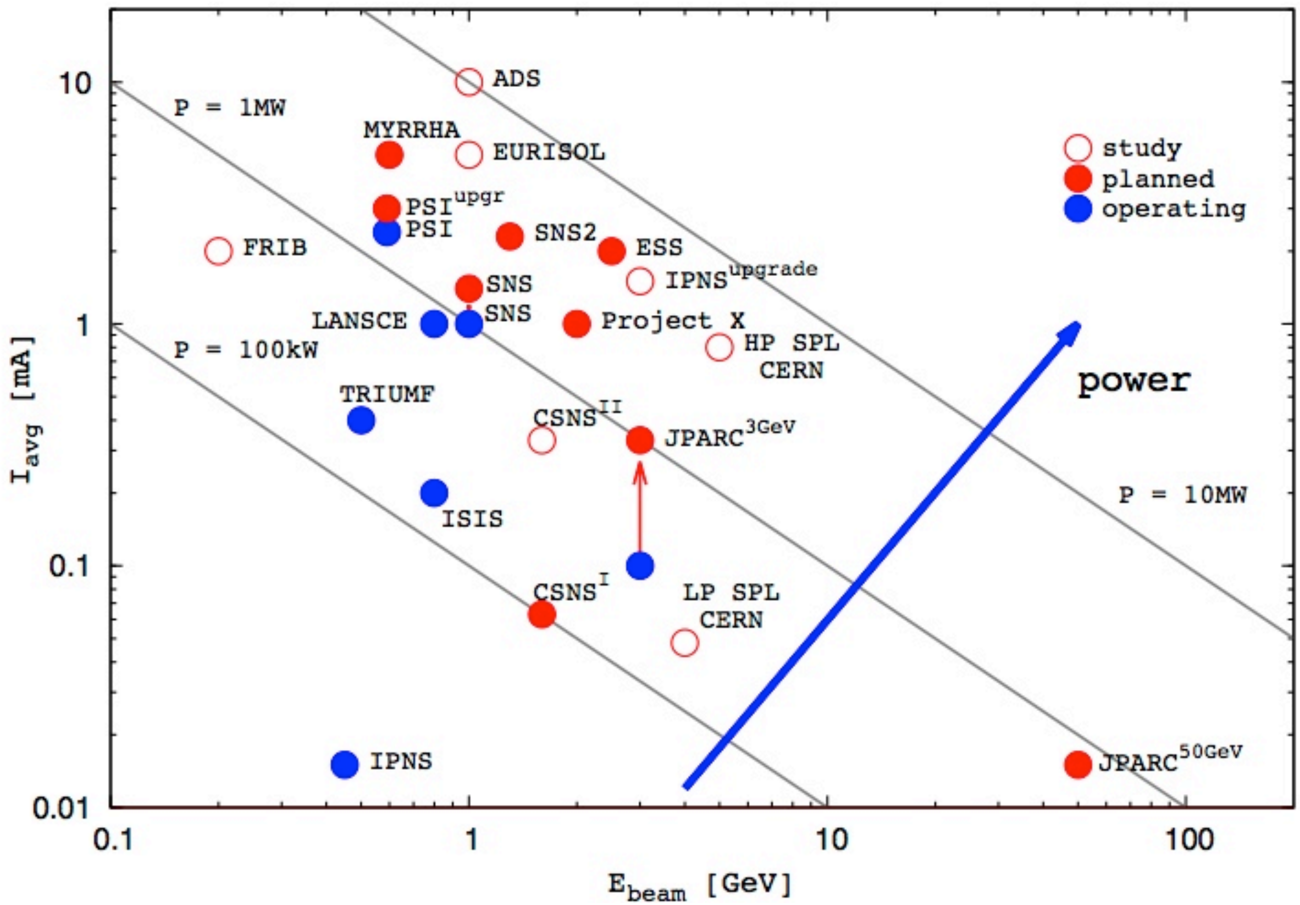
Deputy Head Accelerator Division

The Hadron Intensity Frontier

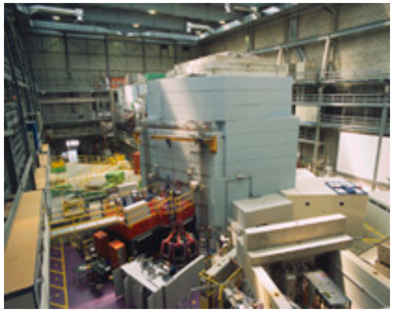


Courtesy of M. Seidel (PSI) and E. Laface (ESS)

Operating Spallation Neutron Sources

LANSCE, USA
1977–
Linac+ring
800 MeV
17 mA in linac
100 kW

ISIS, UK
1984–
RCS
800 MeV
200 mA extracted
160 kW



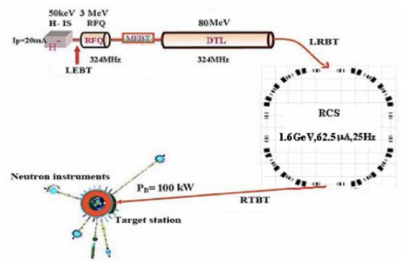
SINQ, Switzerland
1997–
Cyclotron
590 MeV
2.2 mA extracted
1.3 MW

SNS, USA
2006–
Linac+ring
1 GeV
26 mA in linac
1.4 MW

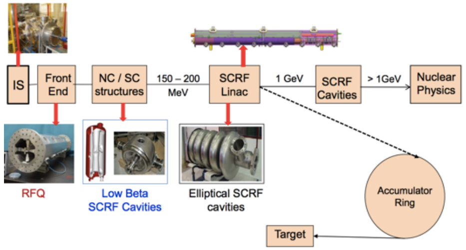
Figure 2 Overall image of J-PARC

J-PARC, Japan
2008–
RCS
3 GeV
330 mA extracted
1 MW (planned)

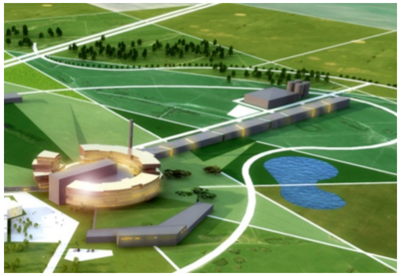
Planned Spallation Neutron Sources



CSNS, China
2018-
RCS
1.6 GeV
15 mA in linac
100 kW

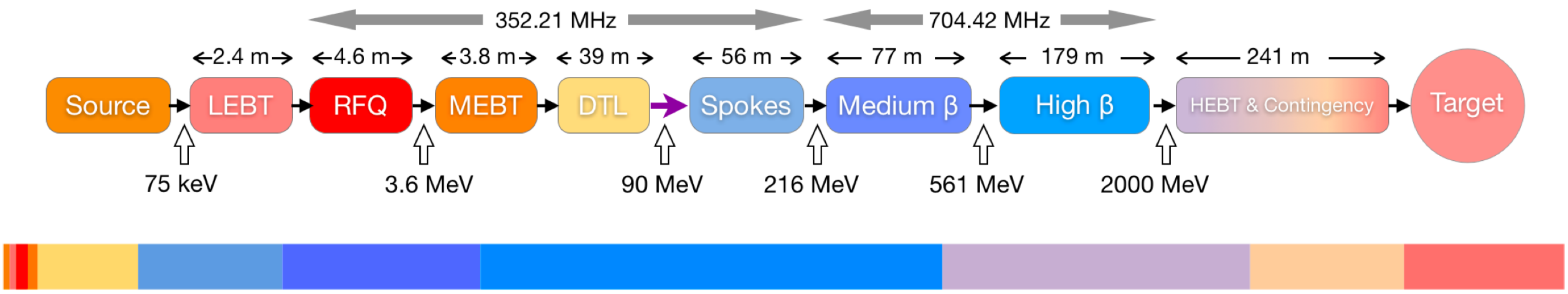


ISNS, India
Linac+ring
1 GeV
20-50 mA in linac
1 MW

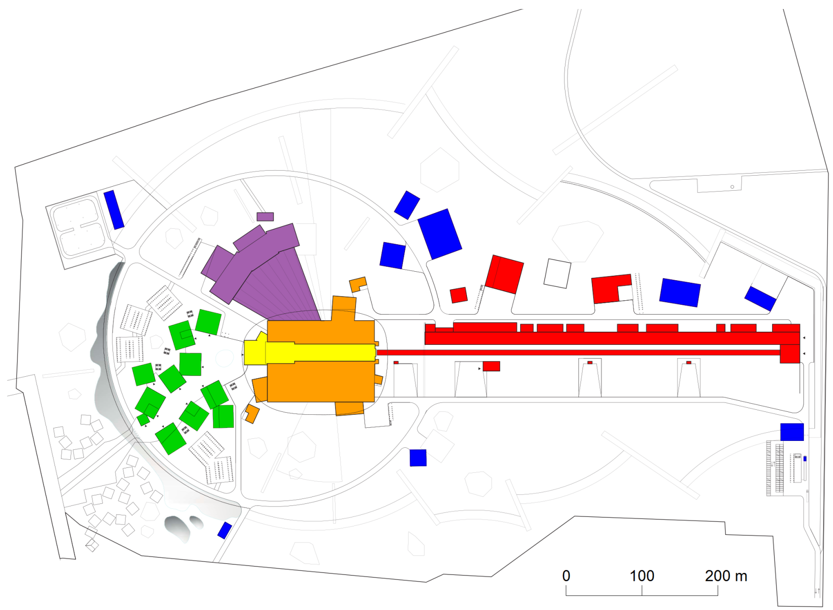


ESS, Sweden
2019-
Linac
2 GeV
62.5 mA
5 MW

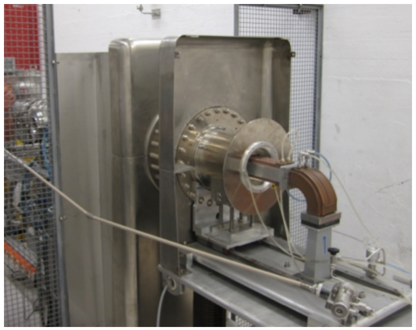
ESS Linac Parameters



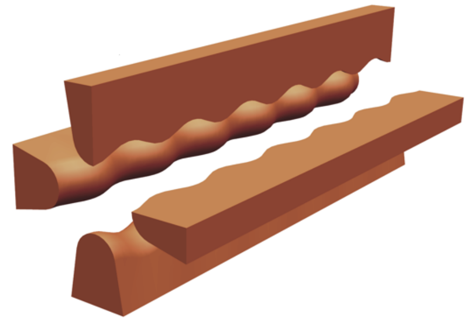
Particle species	p
Energy	2.0 GeV
Current	62.5 mA
Average power	5 MW
Peak power	125 MW
Pulse length	2.86 ms
Rep rate	14 Hz
Max cavity surface field	45 MV/m
Operating time	5200 h/year
Reliability (all facility)	95%



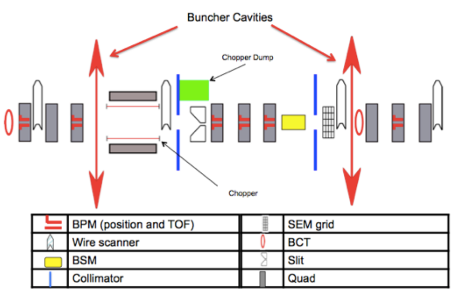
Ion Source and Normal-Conducting Linac



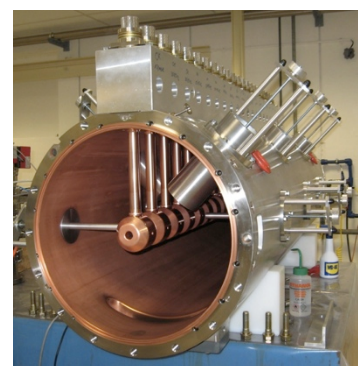
Prototype proton source operational, and under further development, in Catania. Output energy 75 keV.



Design exists for ESS RFQ similar to 5 m long IPHI RFQ at Saclay. Energy 75 keV->3.6 MeV.



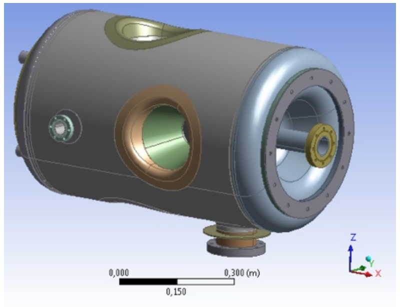
Design work at ESS Bilbao for MEBT with instrumentation, chopping and collimation.



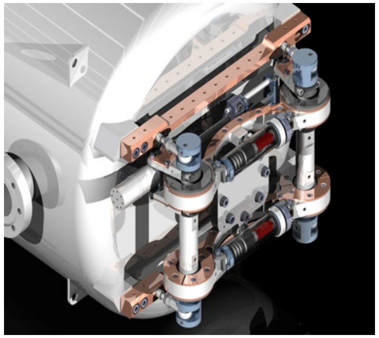
DTL design work at ESS and in Legnaro, 3.6 ->90 MeV.

Picture from CERN Linac4 DTL.

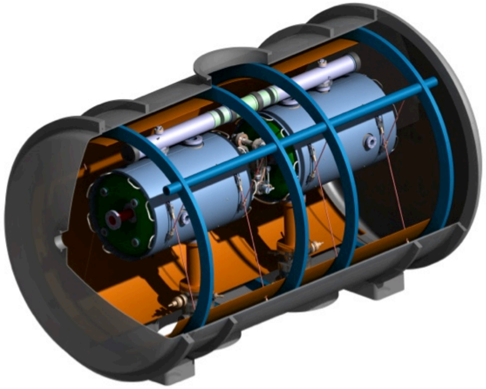
Spoke Cavities and Cryomodules



Superconducting double-spoke accelerating cavity, for particles with beta = 0.5, energy 90->216 MeV.



Cold tuner, to mechanically fine-tune the 352 MHz resonance frequency.



Cryomodule, holding two cavities at 2 K with superfluid helium. Length 2.9 m, diameter 1.3 m.

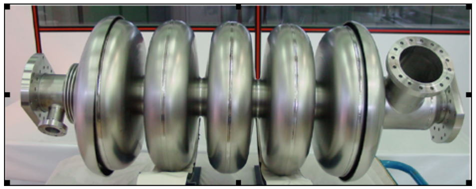
Power coupler, the antenna feeding up to 300 kW RF power to the cavities.

Single-spoke prototype for EURISOL

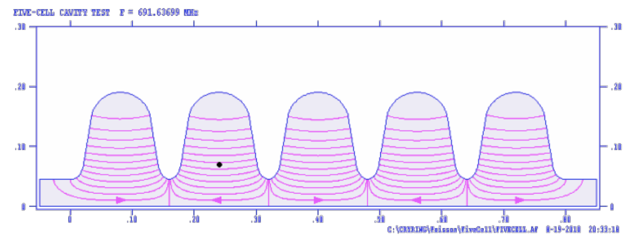
Cavity design done at IPN, Orsay, and prototype cavity has been ordered. Niobium procured and sent to manufacturer.

Cryomodule design highly advanced but not complete.

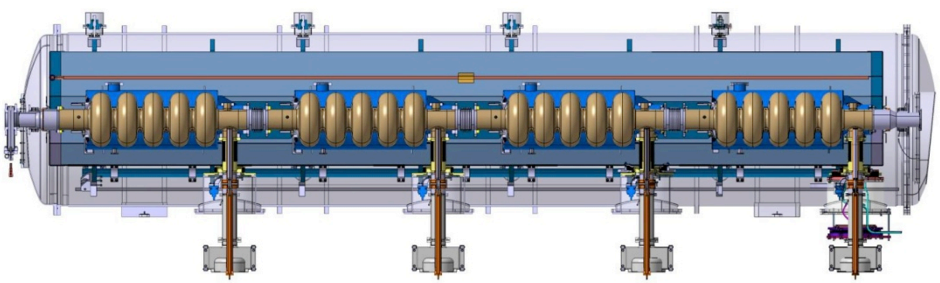
Elliptical Cavities and Cryomodules



Superconducting five-cell elliptical cavity (not ESS). Two families, for beta = 0.67, energy 216->561 MeV and beta = 0.86, energy 561->2000 MeV.



Electrical field lines in ESS-like 5-cell cavity, 704 MHz, with cross section constructed from ellipses and straight lines.

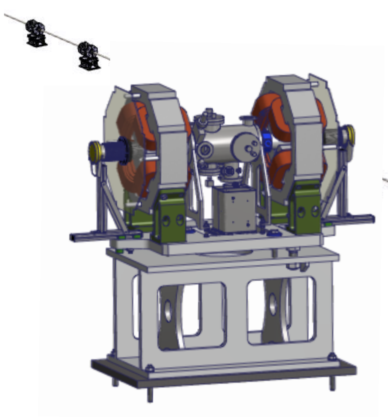


ESS elliptical cryomodule (not final) with 4 5-cell cavities and 4 power couplers for up to ~1 MW peak RF power.

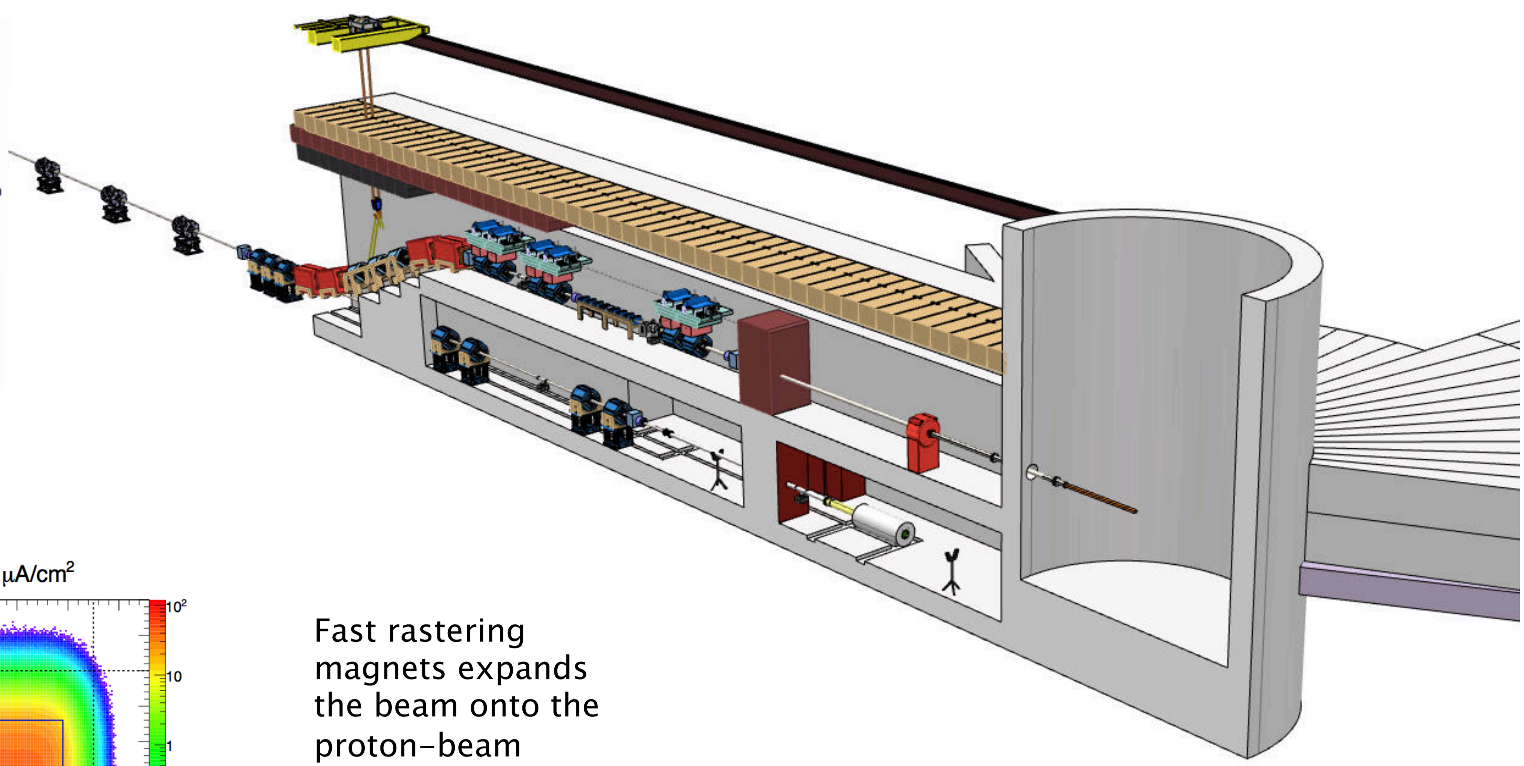
Cavity and cryomodule design well advanced at Saclay.

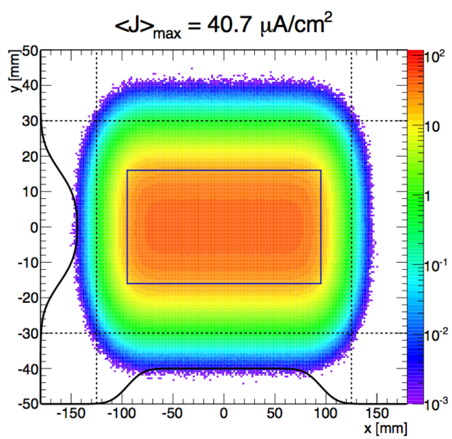
Elliptical Cavities Cryomodule Technology Demonstrator, ECCTD, to be ready 2015.

High-Energy Beam Transport



Quadrupole doublet for linac and HEBT





Fast rastering magnets expands the beam onto the proton-beam window and the 250 mm × 60 mm beam entrance window on the target wheel

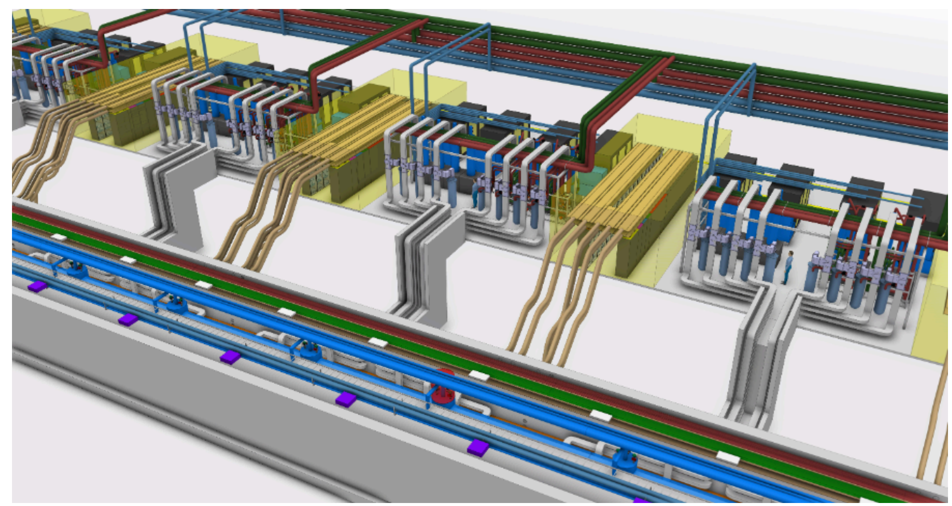
The HEBT design is a contribution from ISA, Århus.

RF Systems

SNS klystron gallery

Main features:
- One RF power source (klystron, IOT, ...) per resonator
- Two klystrons per modulator for ellipticals
- Pulsed-cathode klystrons for RFQ, DTL
- Gridded tubes (tetrodes or IOTs) for spokes
- Klystrons for medium-beta ellipticals, and as backup for high-beta
- Developments with industry for high-power IOTs

	Frequency (MHz)	No. of couplers	Max power (kW)
RFQ	352.21	1	900
DTL	352.21	5	2150
Spokes	352.21	26	350
Medium betas	704.42	32	900
High betas	704.42	88	1100



Layout of ESS linac tunnel and klystron gallery

Cryogenics

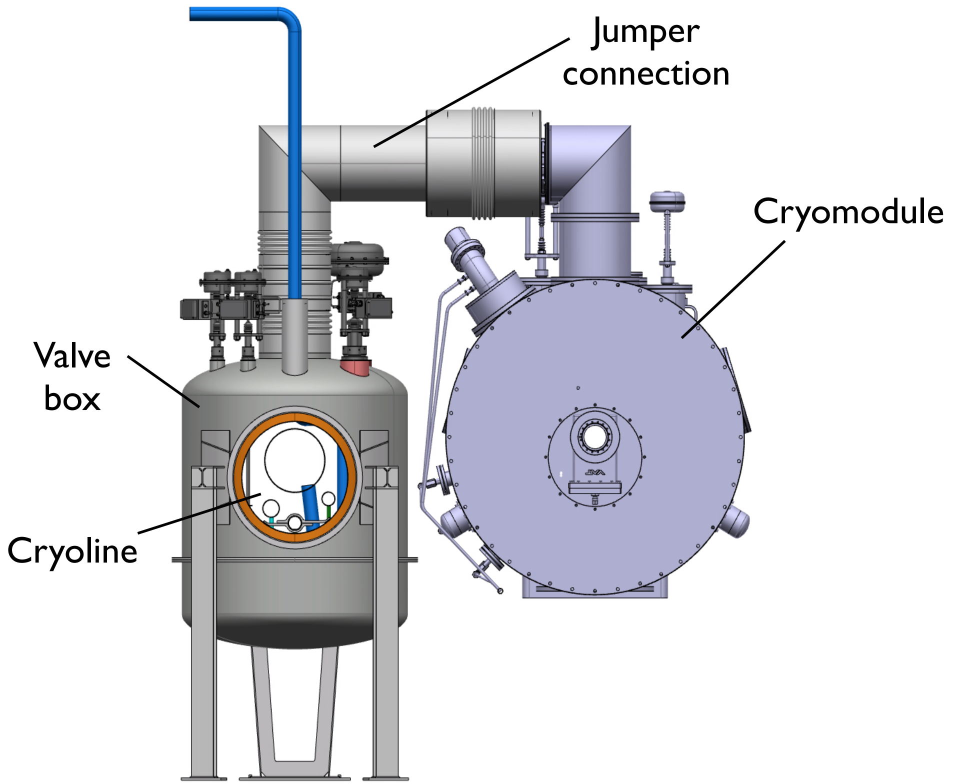
Three cryogenic plants

- Accelerator: 3.1 kW @ 2K, 12.8 kW @40 – 50 K plus 8 g/s helium liquefaction
- Target: ~ 20 kW @ 16K
- Test & Instruments ~ 250 W@ 4.5 K and 200 W @ 40K

Distribution system

- Permits independent cool down & warm up of cryomodules, likely IKC

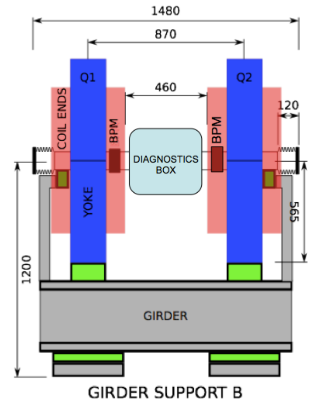
Cryoplant orders to be placed in 2015 with operations starting in 2017 – 2018



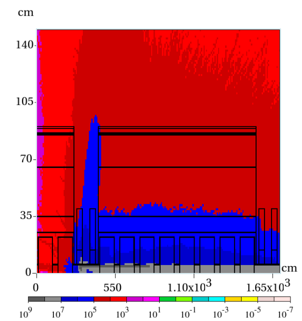
Further Components and Challenges…

… not mentioned for lack of time

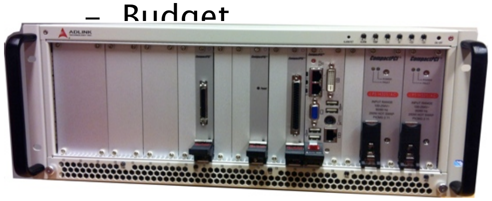
- *Beam instrumentation*
- Control system (ICS)
- Machine protection
- *Personnel protection*
- Vacuum
- *Test stands*
- Cooling, electricity
- Installation
- Logistics
- Safety
- Reliability
- System engineering
- In-kind
- Time schedule
- Budget



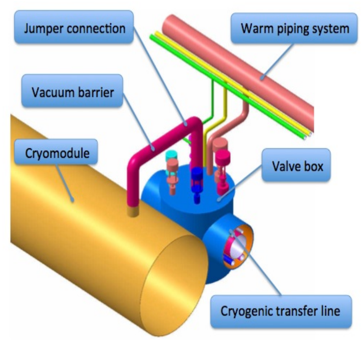
Quadrupole doublet on girder with BPMs and diagnostics box



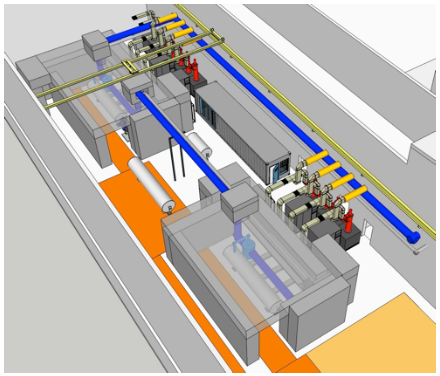
Beam-loss simulations



Control-box prototype



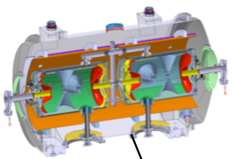
Cryogenic distribution

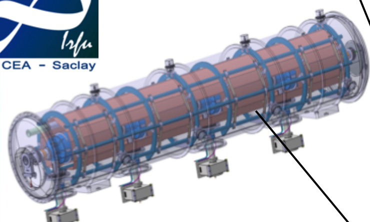


Cryomodule test stand

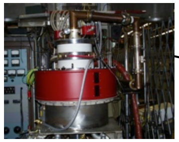
Collaboration During Pre-Construction

Sebastien Bousson



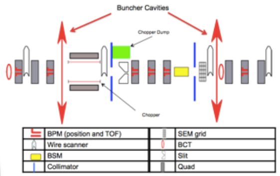


Pierre Bosland

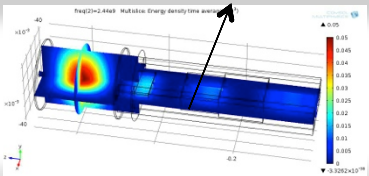


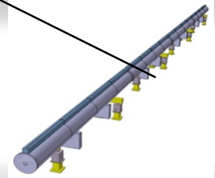
CERN

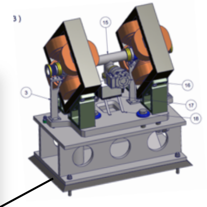
Roger Barlow



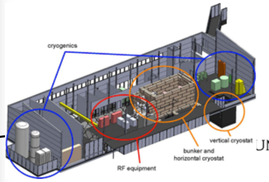
Ibon Bustinduy



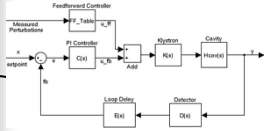




Søren Pape Møller



Roger Ruber



Anders J Johansson

The National Center for Nuclear Research, Swierk

Santo Gammino

Collaborations for Construction

- Partners from Accelerator Pre-Construction expected to continue through Construction
- Need for many additional partners in Construction
- Expressions of Interest for accelerator received from 17 organizations and 41 companies
- Meetings with new potential partners from Italy, Switzerland and Poland within next 6 weeks
- Participation of German labs essential, with their expertise and resources in super-conducting accelerating structures, RF sources, low-level RF, cryogenics, beam instrumentation, personnel safety system and many other areas
- We look forward to collaborating with German accelerator labs and German industry!

Thank you.