EUROPEAN SPALLATION SOURCE

The European Spallation Source

Steve Peggs,
for ESS/AD & the ADU collaboration

Neutrons in 2019 !

5	MW	beam power
2.5	GeV	protons (H+)
2.0	ms	pulses
20	Hz	rep rate
704	MHz	RF frequency
< 1	W/m	beam losses
> 95%		availability
7.5	MW	upgradabilty?

http://esss.se/linac/Parameters.html

ESS on the ADS roadmap

Finding #5: "The missions for Accelerator Driven Sub-critical (ADS) technology lend themselves to a technology development, demonstration & deployment strategy in which successively complex missions build upon technical developments of the preceding mission." U.S. Dept. of Energy White Paper (2010).

Table 2: Accelerator Requirements for three reference ADS Designs

	Transmutation Demonstration (MYRRHA [5])		Industrial Scale Facility driving single subcritical core (EFIT [10])	Industrial Scale Facility driving multiple subcritical cores (ATW [11])
Beam Energy [GeV]	0.6	2.5	0.8	1.0
Beam Power [MW]	1.5	5.0-7.5	16	45
Beam current [mA]	2.5	[**50]	20	45
Uncontrolled Beamloss	< 1 W/m	< 1	< 1 W/m	< 1 W/m
Fractional beamloss at full energy (ppm/m)	< 0.7		< 0.06	< 0.02

ESS [**50 mA in 2 ms pulses at 20 Hz]

Technical assumptions

ESS Linac:

- Optimised for 50 mA (not 75 mA / 7.5 MW upgrade)
- Fully non-segmented (continuous cryostat), doublet optics
- 1 cavity per klystron

High Energy Beam Transport (HEBT):

- Linac 10 m below grade (assumed flat), Target 1.6 m above
- Octupolar beam profile flattening

NO second "full power" Target Station !

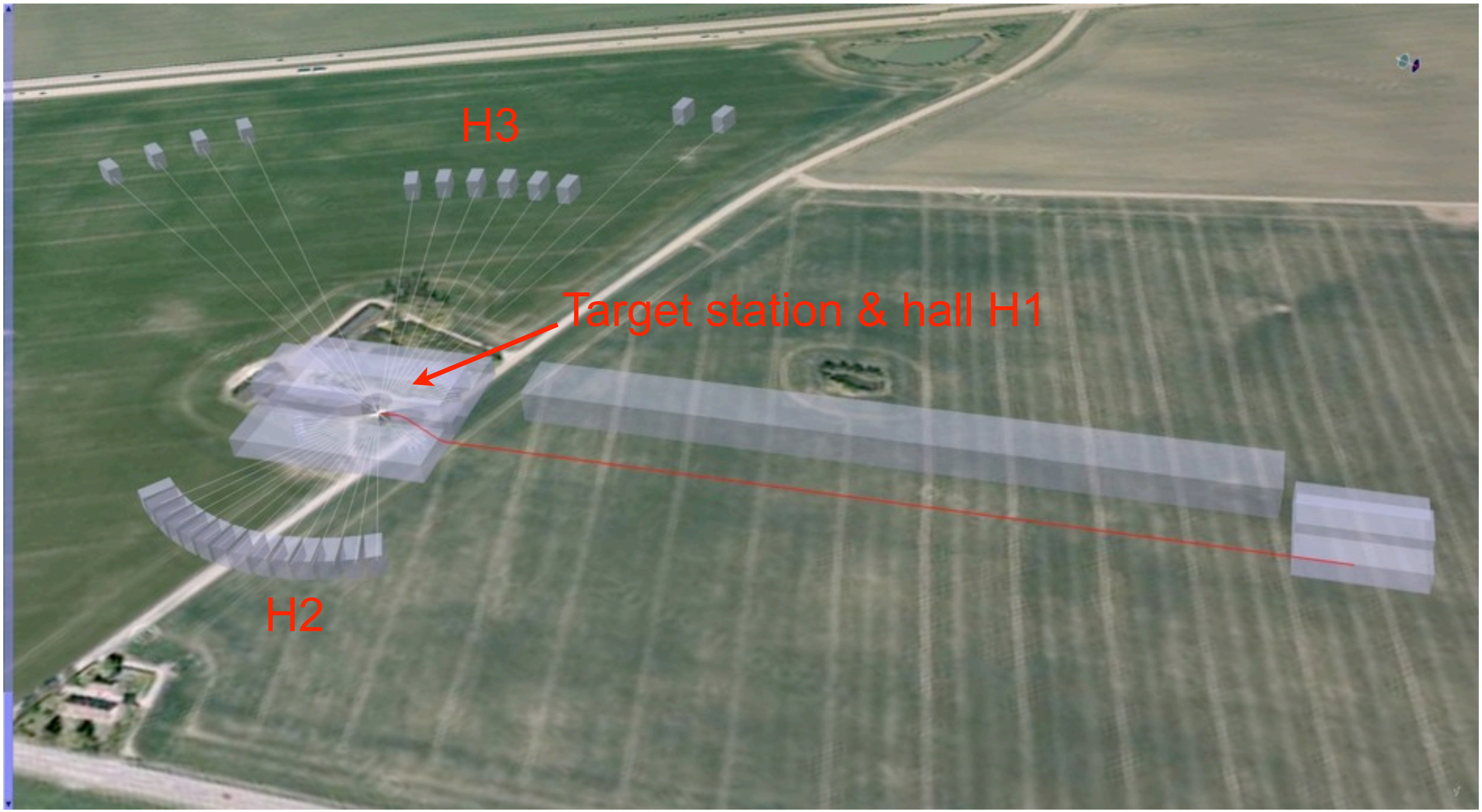
- (but secondary proton extraction lines possible?)

NO H- injection (or short pulses, or accumulator ring) !

2009 - Artists concept

March 2011 wireframe

22 neutron lines, keeping the target on the slight ridge through the farm

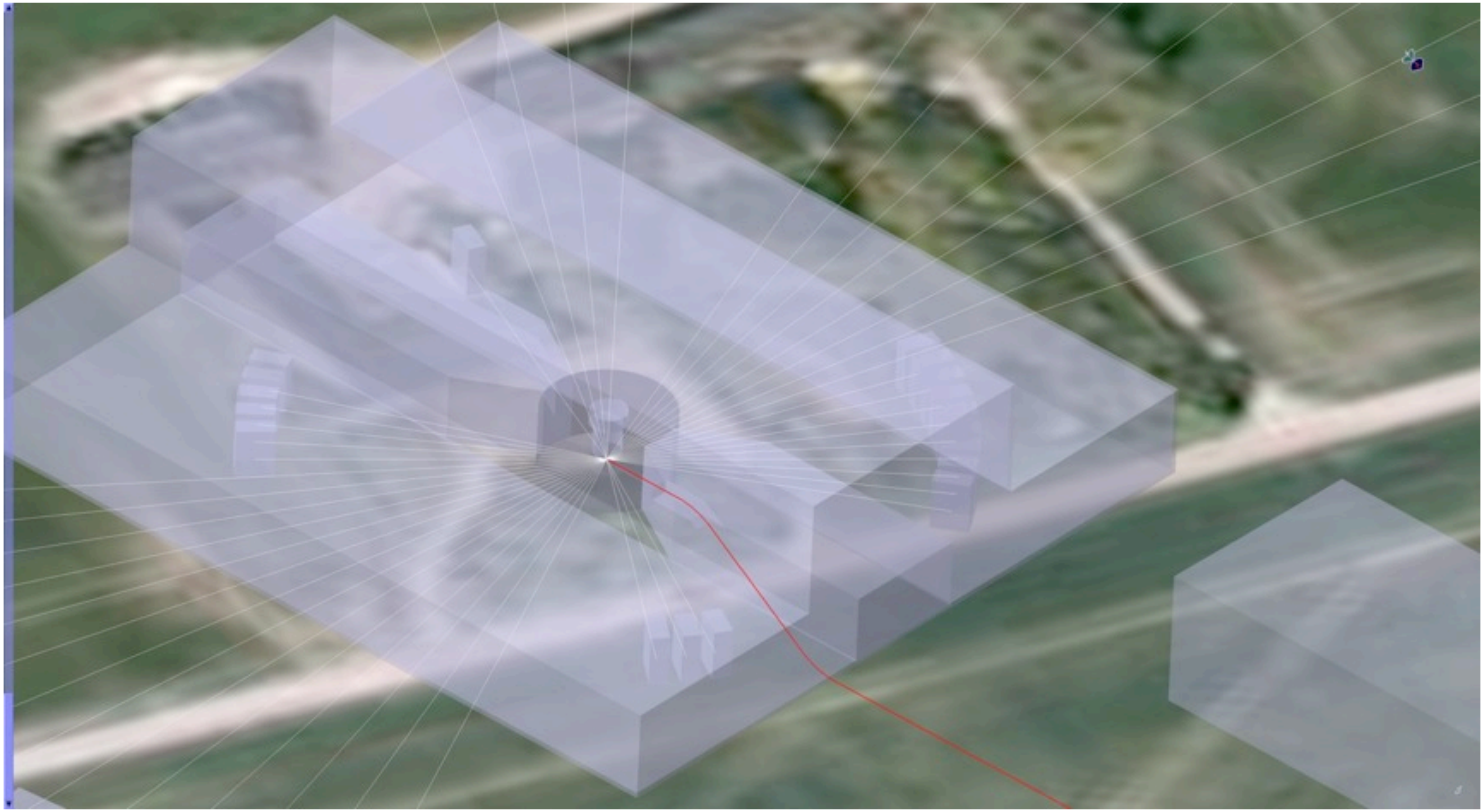


Neutron beamlines

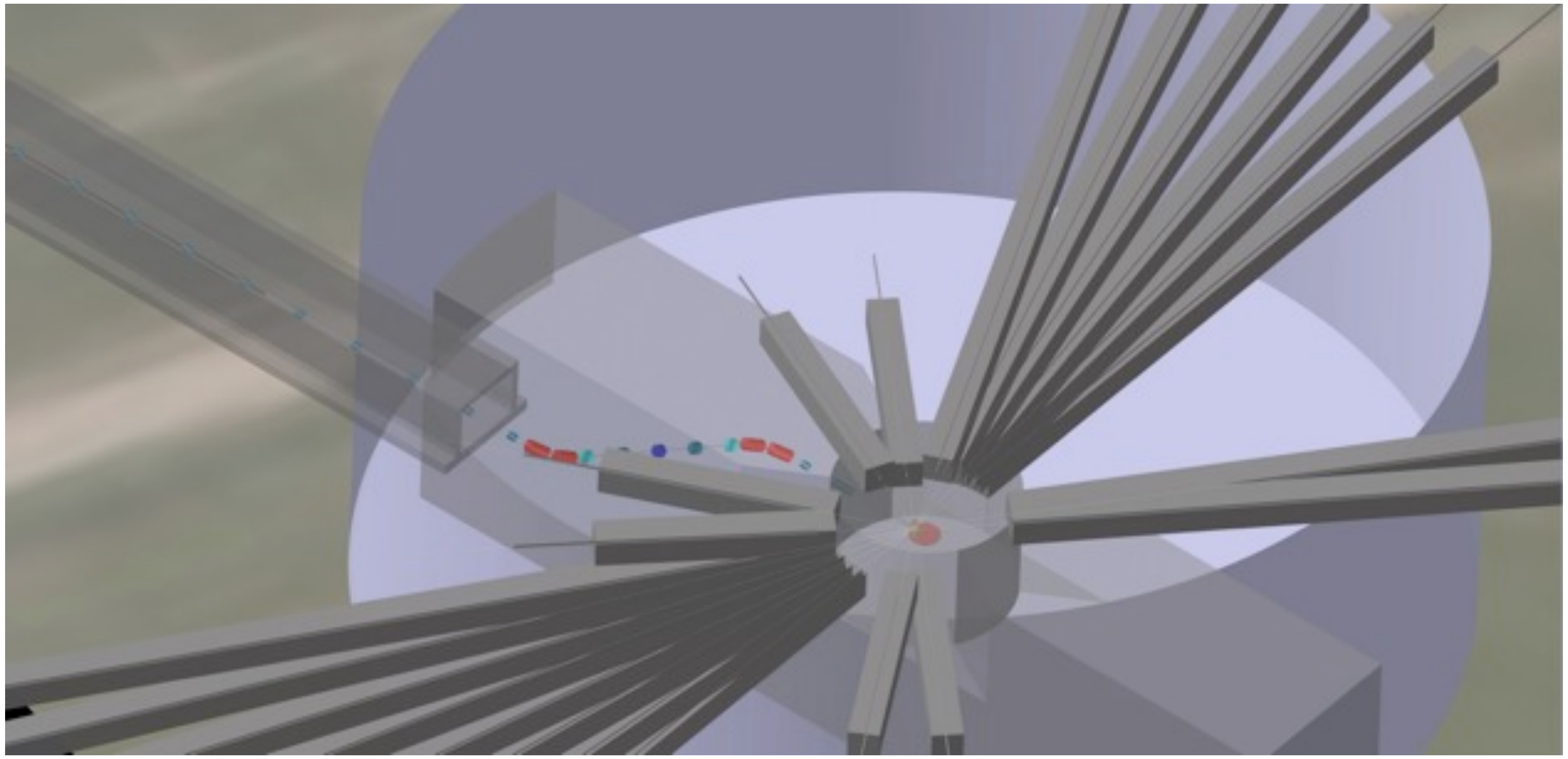
Moderators are placed +/-10 cm above/below the proton beamline

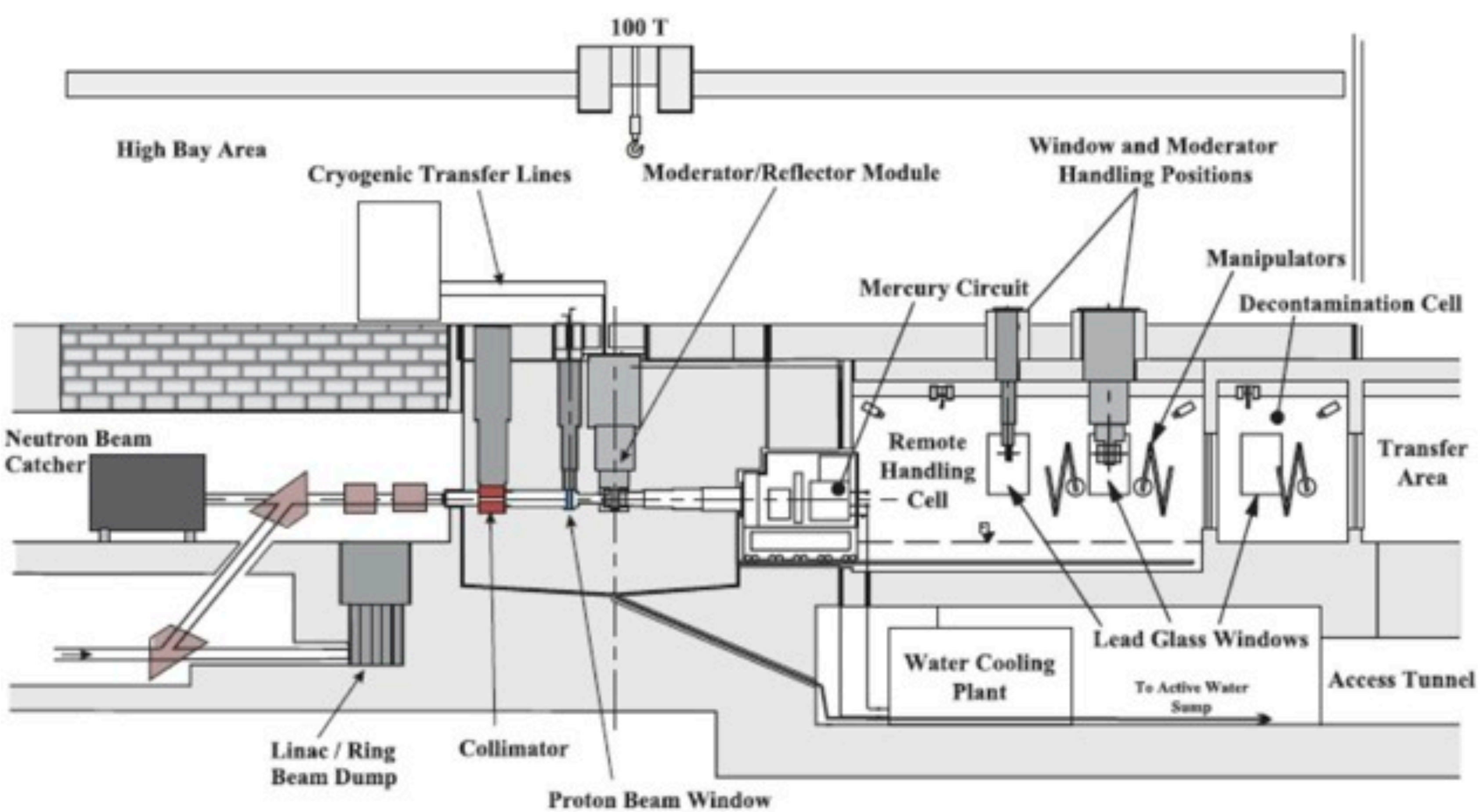
Neighbouring neutron beamlines are above/below the target

Neutron lines have a radius of curvature ~5 km



Target interfaces





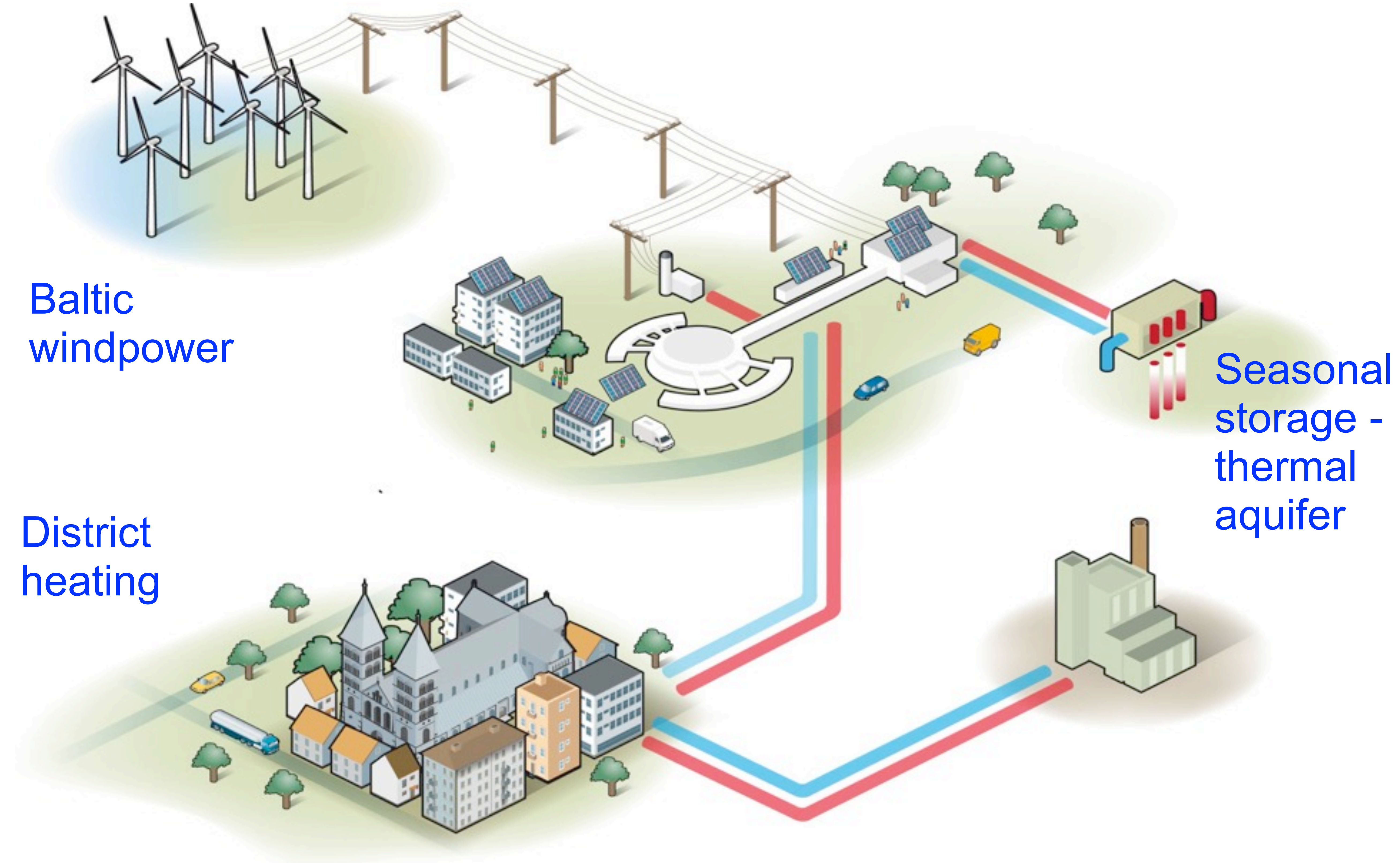
The 1-D wireframe does not address the complex target interfaces:

Accelerator-to-Target
- Controls
- Naming Convention
- Co-ord. systems
- Beam diagnostics
- Distributed systems
- Beam windows
- Beam optics
- Tune-Up Dump
- Protection systems

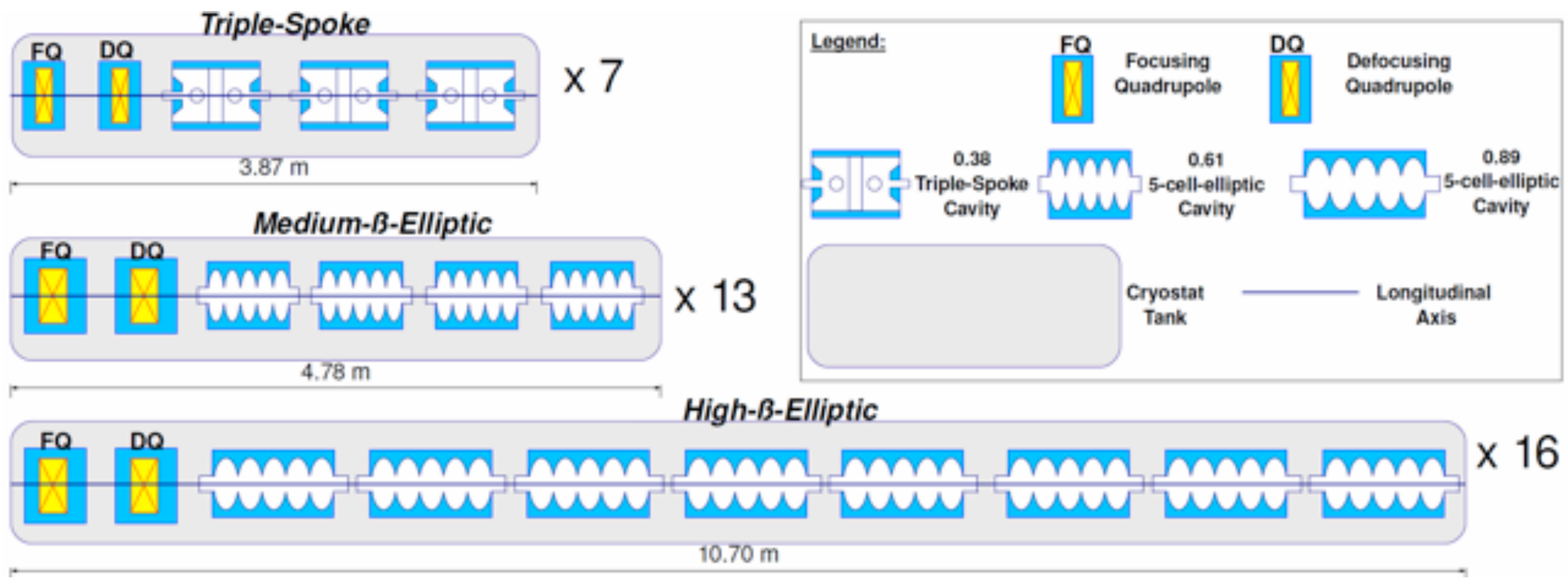
Target-to-neutron-lines
- et cetera

A carbon neutral laboratory?

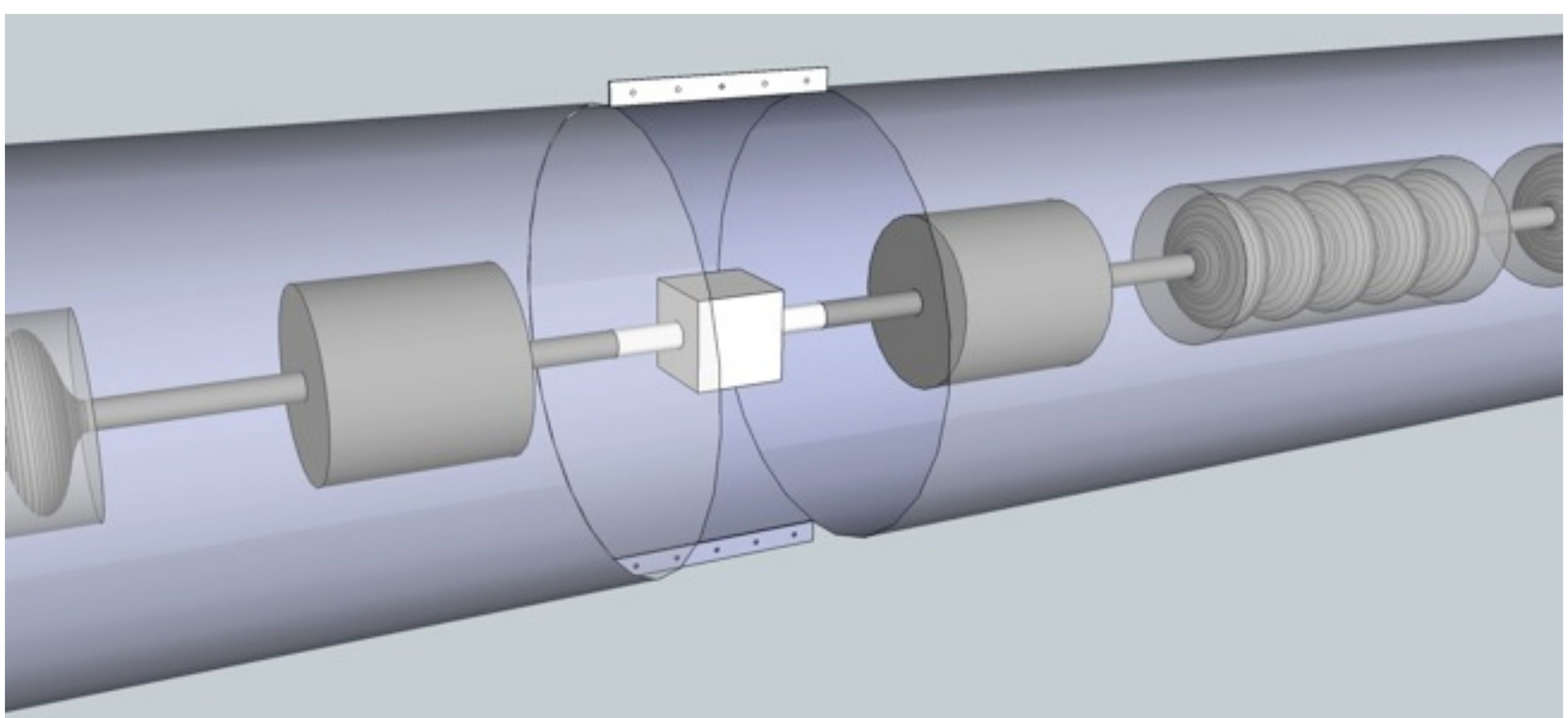
32 – 38 MW site power



Green cryomodules:
continuous, segmented .... or hybrid?



CONTINUOUS cryomodules were assumed in the *Baseline-2010* design.



HYBRID cryomodules are under evaluation.

Short connecting utility modules contain beamline instrumentation at about 50 K.

Beam losses

Excessive radio-activation from losses larger than about 1 W/m can hinder hands-on maintenance.

Intra-beam stripping is plausibly an important source of beam losses in H- linacs like the SNS (0.2 W/m), but not in the H+ ESS.

Other potential beam loss sources are 1) space charge resonances, 2) transverse overfocusing, 3) uncollimated low energy beam halo.

Attaining the ability to confidently predict the relative importance of loss mechanisms is a fundamental challenge to our ability to design multi-MW proton linacs.

Resolve this situation, by:

a) Simulation and theory
b) Experiment (at SNS?)

SNS: simulations & experimental data !

PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS **11**, 104001 (2008)

Measurement of longitudinal acceptance and emittance of the Oak Ridge Spallation Neutron Source Superconducting Linac

Y. Zhang,* J. Galambos, and A. Shishlo

Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831-6461, USA

(Received 19 May 2008; published 8 October 2008)

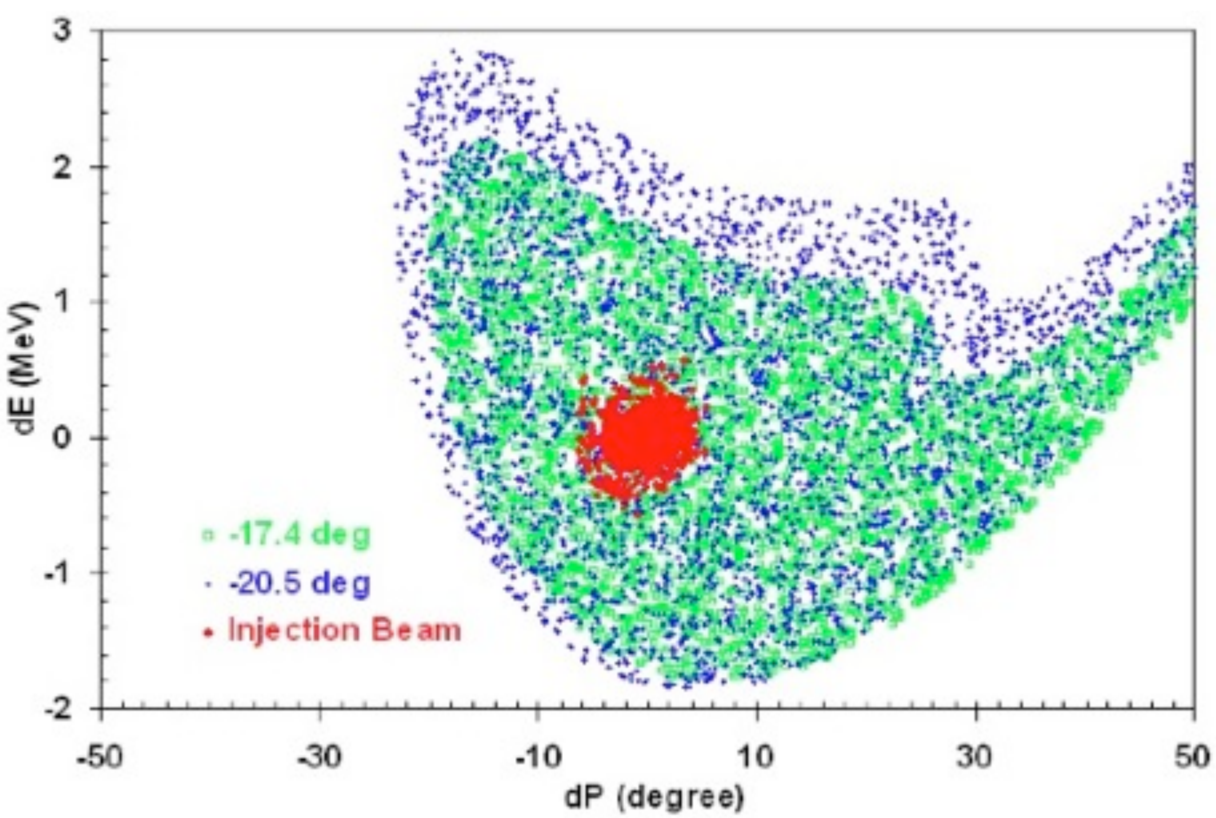


FIG. 1. (Color) Longitudinal acceptance of the SCL with an average synchronous phase of −17.4° (green squares) for each medium beta cavity and −20.5° (blue dots), an injection beam emittance with tails 6 times greater than the nominal beam is shown (red dots) for comparison.

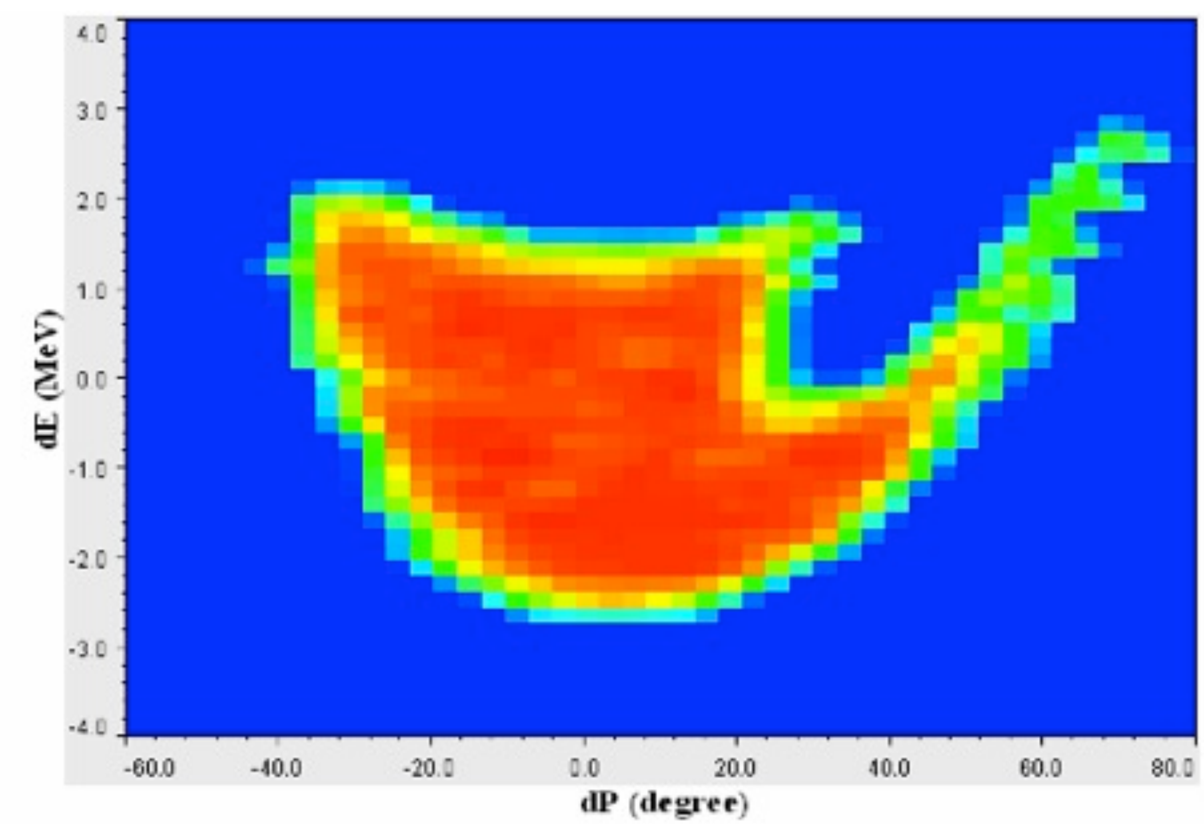


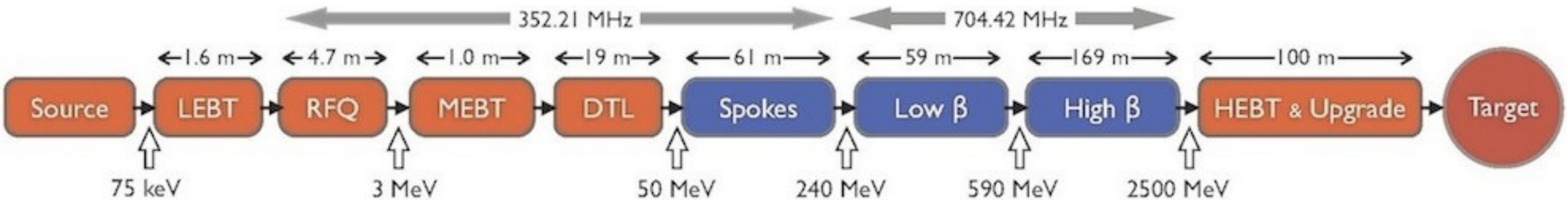
FIG. 7. (Color) Longitudinal acceptance measured at the second SCL cavity with the BCM at the exit of the SCL.

End-to-end simulations

of course, but what is the question?

1) Optics design & tuning strategies: integration by beam
   - lengths & strengths, optics matching
   - diagnostics & correctors, algorithms
   - on-line & off-line from one single model
2) Multi-particle pushing:
   - does the emittance blow up, do tails grow?
   - collimation
   - Beam losses: fundamental challenge - power limit?
3) Contingency: real-time production line response
   - move risk from manufacturer to ESS (cf XFEL)
4) Upgradability: the cost of preservation
   - Power, non-neutron scattering uses, parasitic extraction
5) Reliability: longer term contingency response
   - Synergy with ADSR?

Design Update collaboration



NC front-end: Ion source (INFN), RFQ (CEA), MEBT (ESS-Bilbao), DTL (INFN)

SC linac: Spoke Cavities (CNRS), Elliptical cavities (CEA)

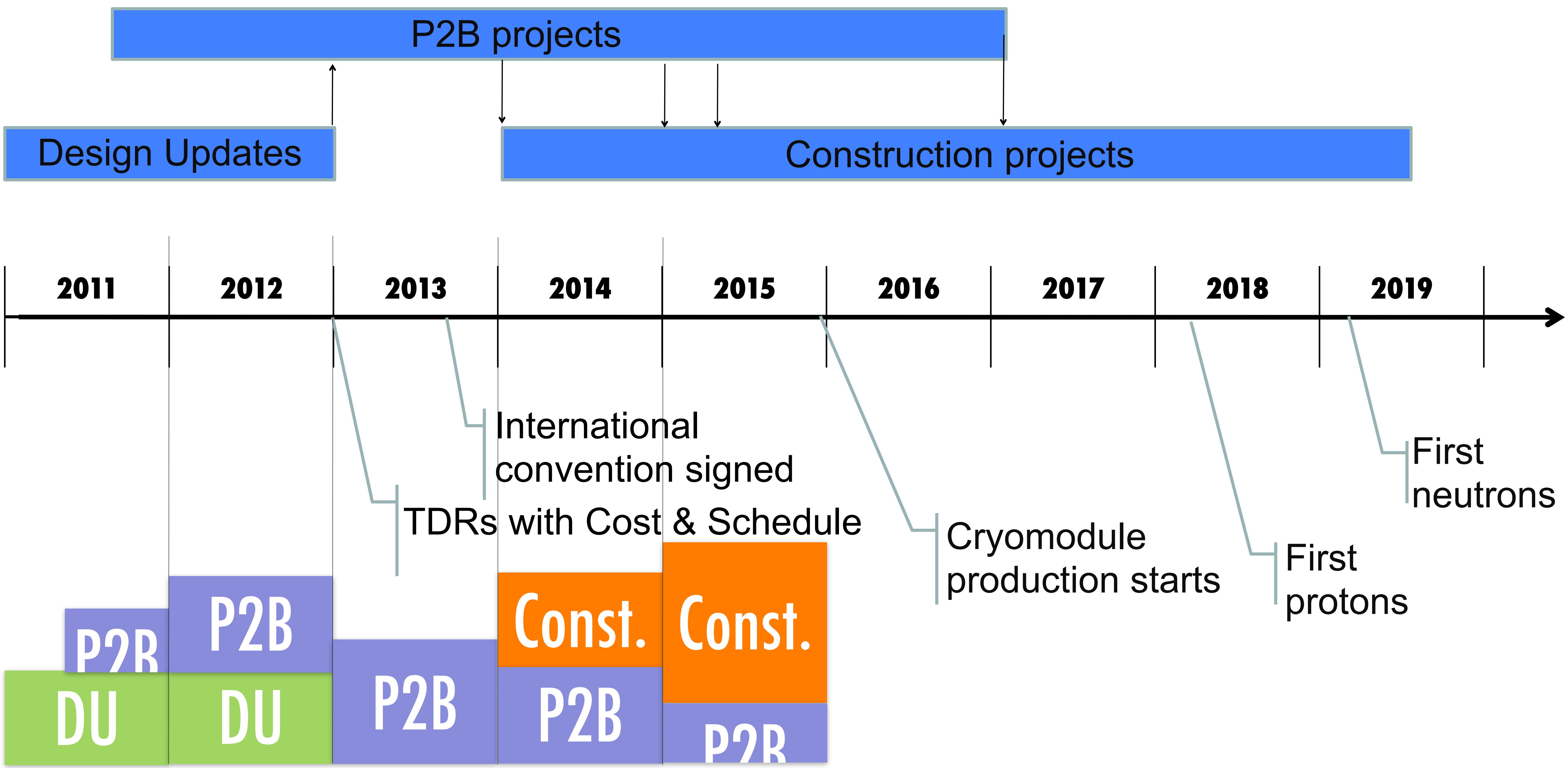
HEBT: Aarhus university

RF sources & controls: High-power (Uppsala U), RF regulation and controls (Lund U)

Utilities: power, network, cooling and cryogenics supplies and distribution and integration (Tekniker)

Overlapping projects

Prepare-to-Build (P2B) provides 1) Prototyping & 2) Engineering Design Reports, in smooth transitions from design to construction.



Accelerator Division expansion

now → end of 2012

Technical staff	**14 → 42**
RF systems & power supplies	2 → 7
Beam Physics & magnets	3 → 5
Beam instrumentation	2 → 7
Vacuum & cryogenics	1 → 5
Controls, databases & scientific computing	3 → 5
Management, admin & Project support	3 → 5
PhD Students	0 → 8

Recruitment is very much in progress!