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 upgradability?

http://esss.se/linac/Parameters.html
ESS on the ADS roadmap


Table 2: Accelerator Requirements for three reference ADS Designs

<table>
<thead>
<tr>
<th></th>
<th>Transmutation Demonstration (MYRRHA [5])</th>
<th>Industrial Scale Facility driving single subcritical core (EFIT [10])</th>
<th>Industrial Scale Facility driving multiple subcritical cores (ATW [11])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Energy [GeV]</td>
<td>0.6</td>
<td>2.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Beam Power [MW]</td>
<td>1.5</td>
<td>5.0-7.5</td>
<td></td>
</tr>
<tr>
<td>Beam current [mA]</td>
<td>2.5</td>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>Uncontrolled Beamloss</td>
<td>&lt; 1 W/m</td>
<td>&lt; 1 W/m</td>
<td>&lt; 1 W/m</td>
</tr>
<tr>
<td>Fractional beamloss at full energy (ppm/m)</td>
<td>&lt; 0.7</td>
<td>&lt; 0.06</td>
<td>&lt; 0.02</td>
</tr>
</tbody>
</table>

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

Baltic windpower

District heating

Seasonal storage - thermal aquifer
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?)
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

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FIG. 1. (Color) Longitudinal acceptance of the SCL with an average synchronous phase of $-17.4^\circ$ (green squares) for each medium beta cavity and $-20.5^\circ$ (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!