ESS Plans and Synergies with CERN

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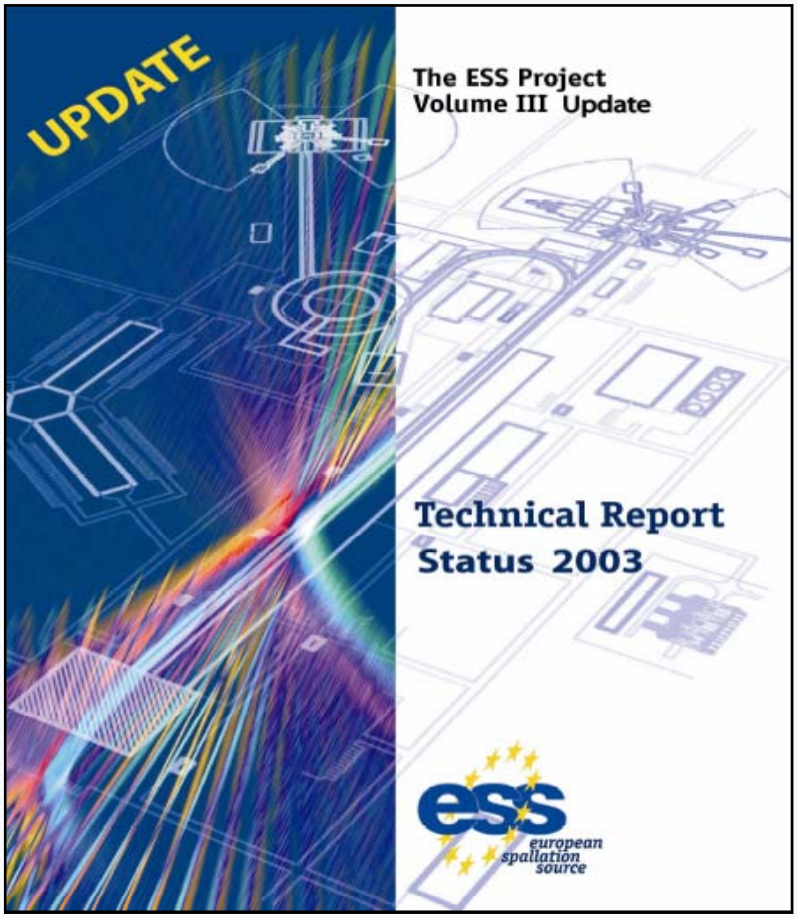
ESS plans and synergies with CERN

- ***ESS Update Report, Dec 2003***
  - Full ESS facility: 5 MW SP & 5 MW LP Hg targets with 2 compressor rings & 114 mA, 1.334 GeV H^- linac
  - Scientific relevance of SP & LP target
  - 15 MW LP Target: Scientific relevance & 3 GeV H^+ linac
- ***ESS-I and the 5 MW LP ESS***
  - ESS-I
  - 5 MW LP ESS, upgradeable: Accelerator, target options, 1 MW PbBi MEGAPIE target, scientific relevance and instruments
- ***Current situation***
  - ESFRI and UK
  - Sites
  - FP7 preparatory study
- ***Synergies with CERN***

ESS Update Report, Dec 2003

- ‘The European Spallation Source (ESS) project, as defined by the four volumes ESS Report 2002, was presented to the public, the general neutron user community and European decision makers at a meeting in the former house of parliament in Bonn, May 2002.
- In January 2003 it became clear, that a decision to built ESS would not be likely forthcaming by the end of early 2004. The ESS council therefore decided to wind down all technical & project planning activities and limit the ESS efforts to documenting the technical and planning status.
- The ESS Update Report, Dec 2003, is a summary of the amount of work, technical definition & progress achieved during the period from May 2002 to early 2003.‘

ESS Update Report, Dec 2003

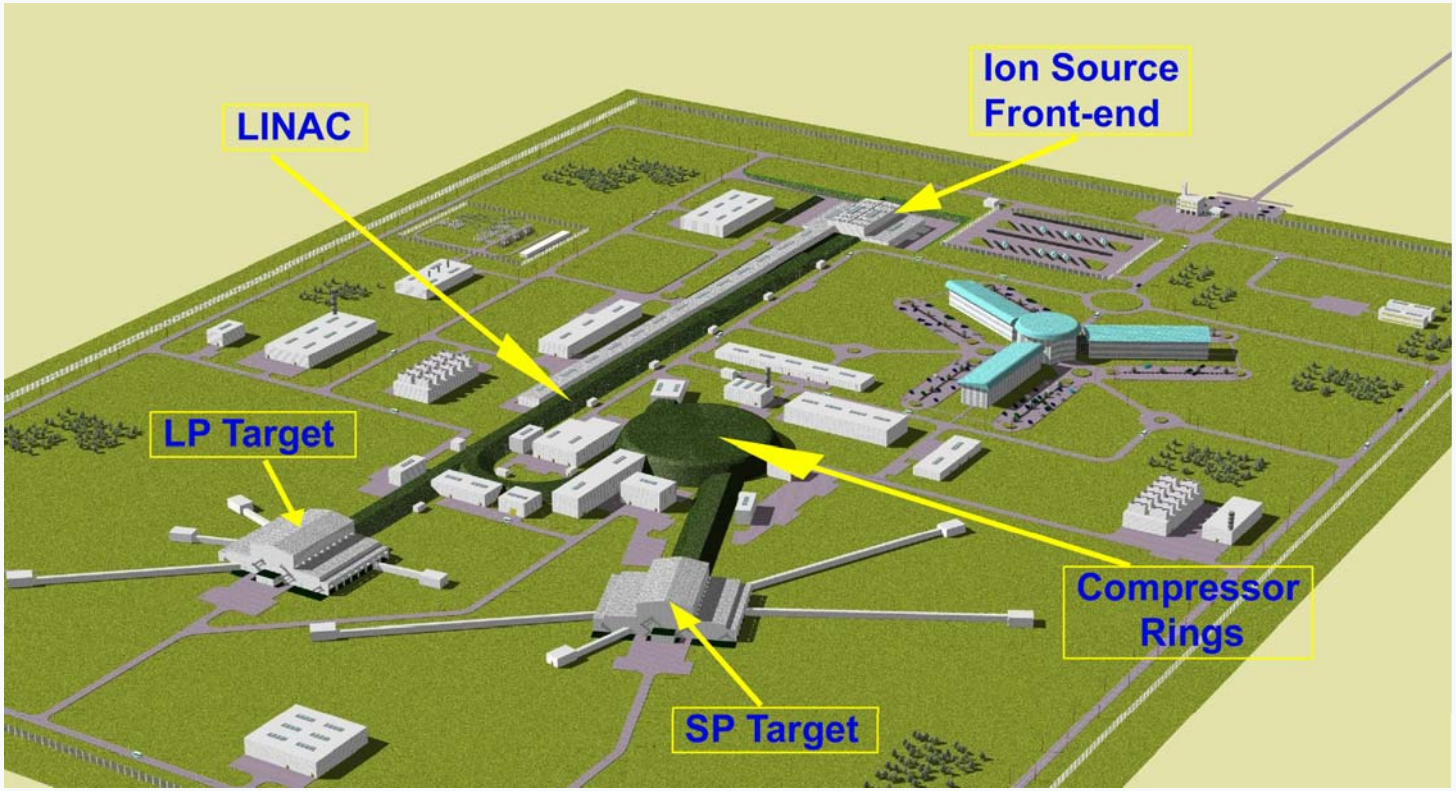


New items, compared to ESS Project Report 2002, Vol 1-4 are mainly in:

- *Chapter 1*:
  SC Reference linac
- *Chapter 5*:
  Instruments & scientific use
- *Chapter 8*:
  Safety & licensing

ESS Update Report 2003: http://neutron.neutron-eu.net/n_documentation/n_reports/n_ess_reports_and_more/106

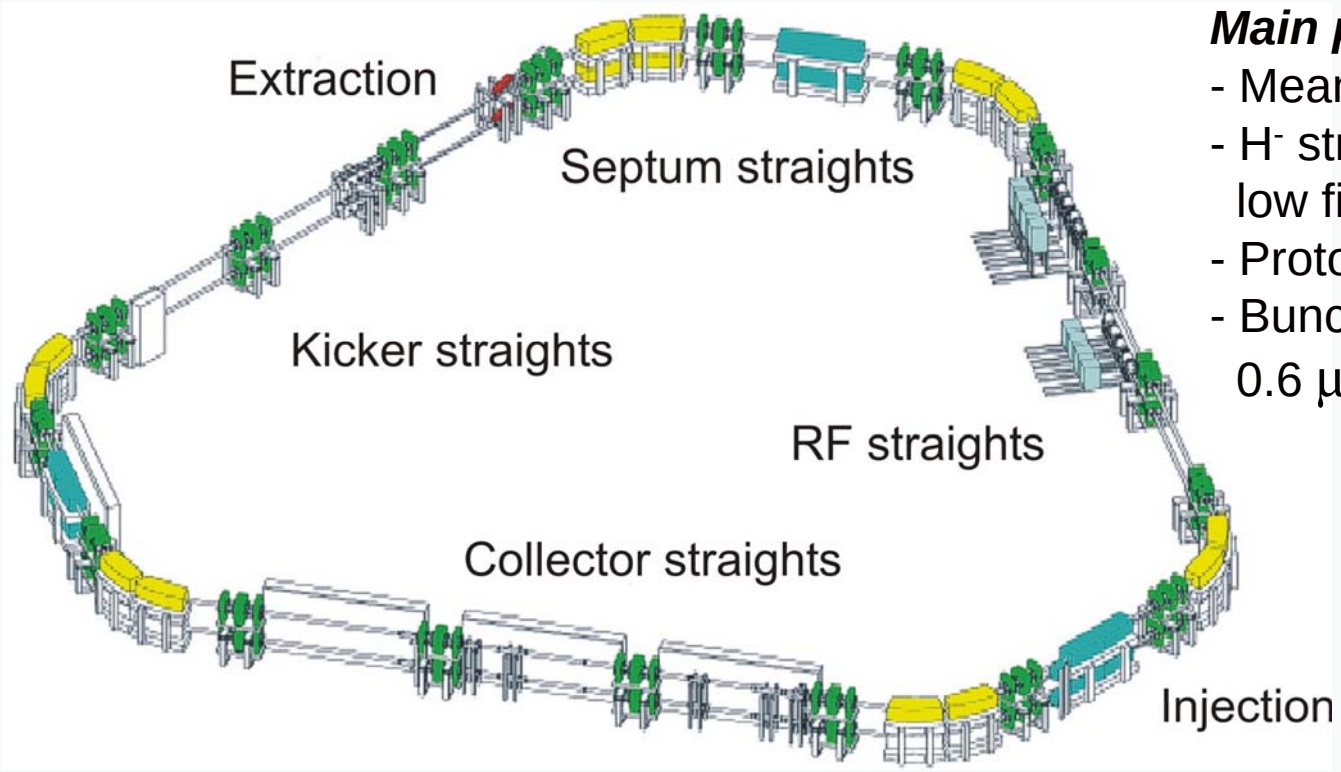
Full ESS Facility: 5 MW SP & 5 MW LP target



Size of 850 m x 1150 m

ESS facility consists of a 10 MW, H^- accelerator capable of delivering 5 MW, 1.4 μs pulses to a short pulse (SP) target at 50 Hz & 5 MW, 2 ms pulses to a long pulse (LP) target at 16 2/3 Hz. Both targets have 22 beamlines & liquid Hg is choosen as material.

Two stacked 1.334 GeV accumulator rings

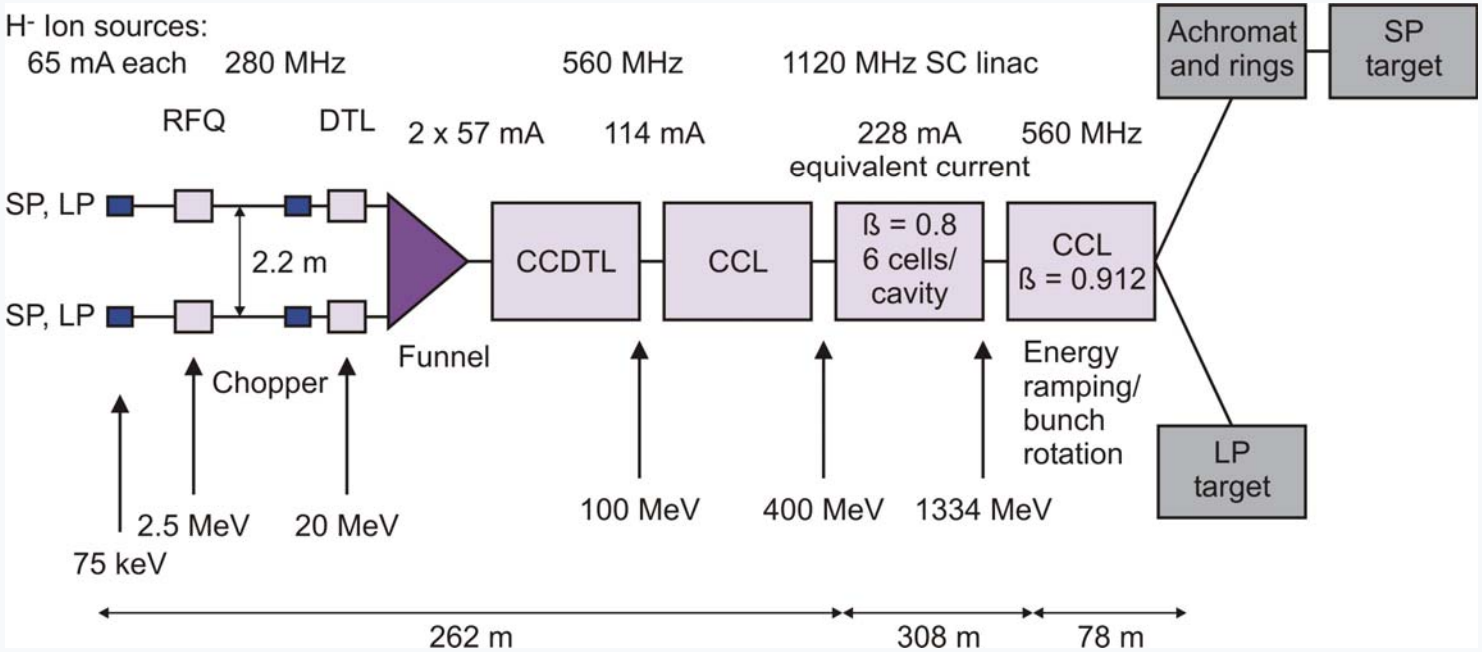


Main parameters:

- Mean radius 35m
- H^- stripping foil inside low field dipol
- Protons/ring 2.34 x 10^{14}
- Bunch, pulse at target 0.6 µs, 1.4 µs

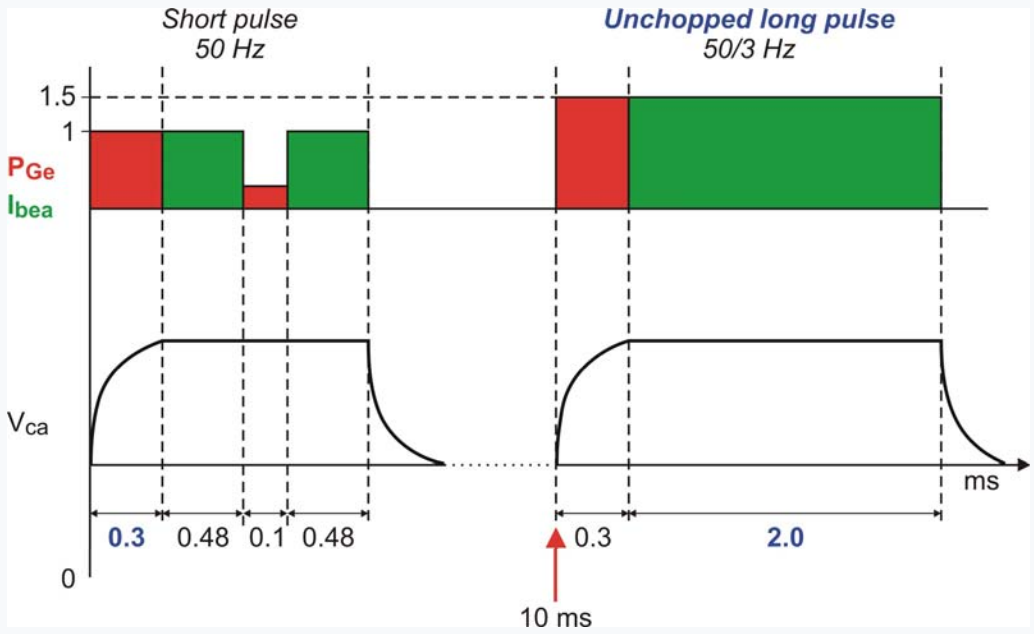
- Chopping the incaming beam at 2.5 MeV helps minimizing the ring beam losses and reduces radiation damage.
  Transverse & longitudinal profiles of injected H^- beam are cleaned by stripping foils in large 180 ° achromatic bending section.

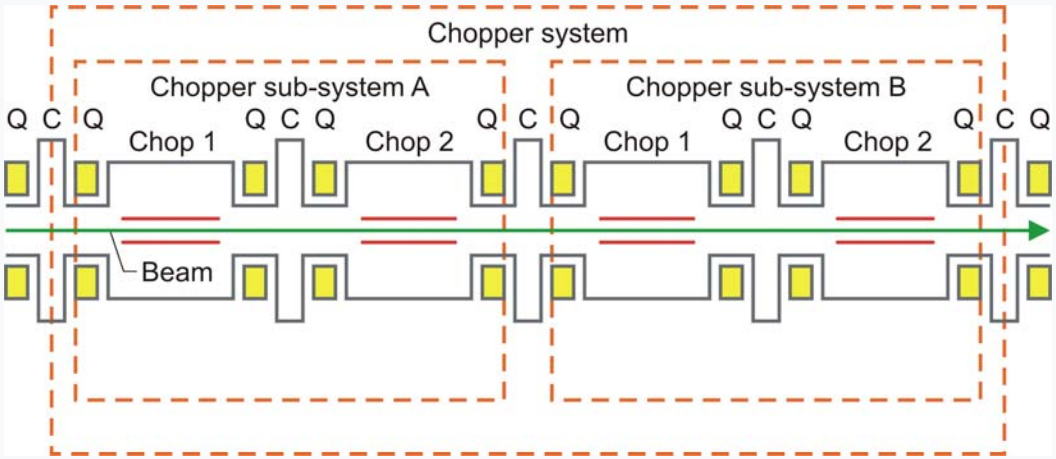
ESS SC Reference Linac: 114 mA H^- beam, 1.334 GeV



- Short description: 2 x 65 mA H^- beams are combined together at 20 MeV in a funnel section. High frequency Superconducting (SC) cavities accelerate the beam from 400 MeV on. Moderate gradient of 10 MV/m in SC linac is used to keep RF power couplers within reasonable limits. After reducing energy spread by bunch rotation (BR) to ± 2 MeV, halo scraping in large 180 ° achromatic section.

ESS SC Reference Linac: Double pulse & chopping





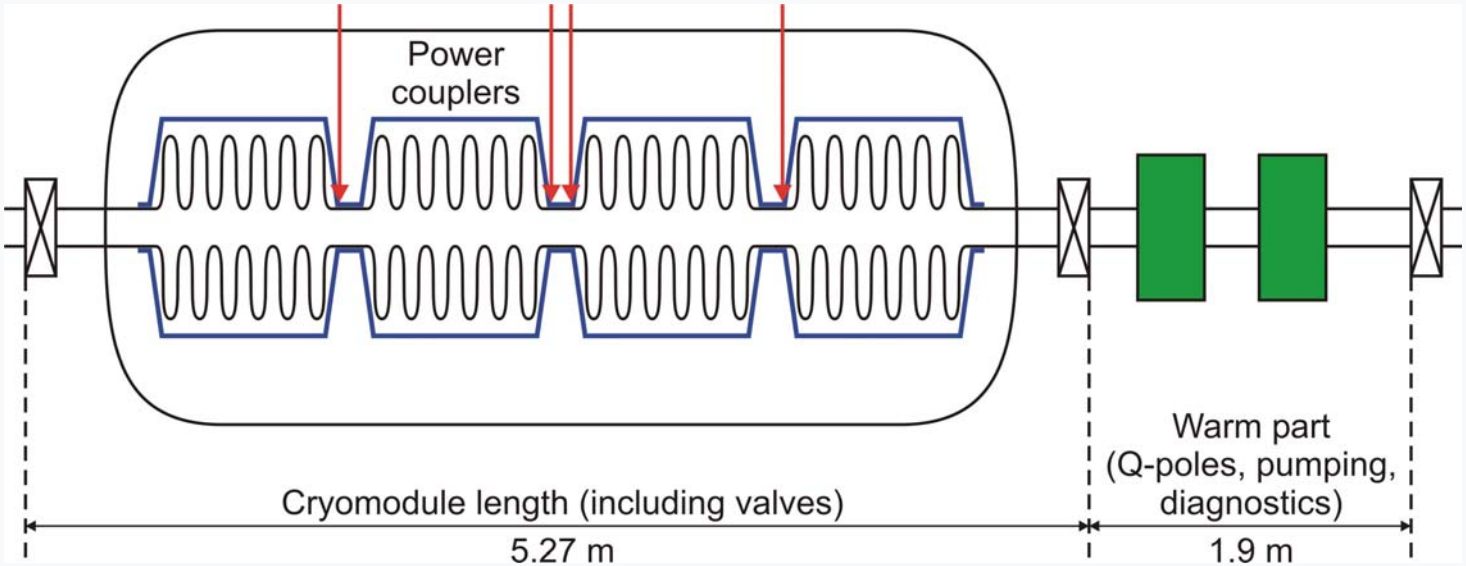
Double pulse:

- Compressor rings get 2 x 0.5 ms long pulses, 70 % chopping
- LP target get 2 ms pulse, no chopping, but 50 % more power in SC

3.5 m chopper line:

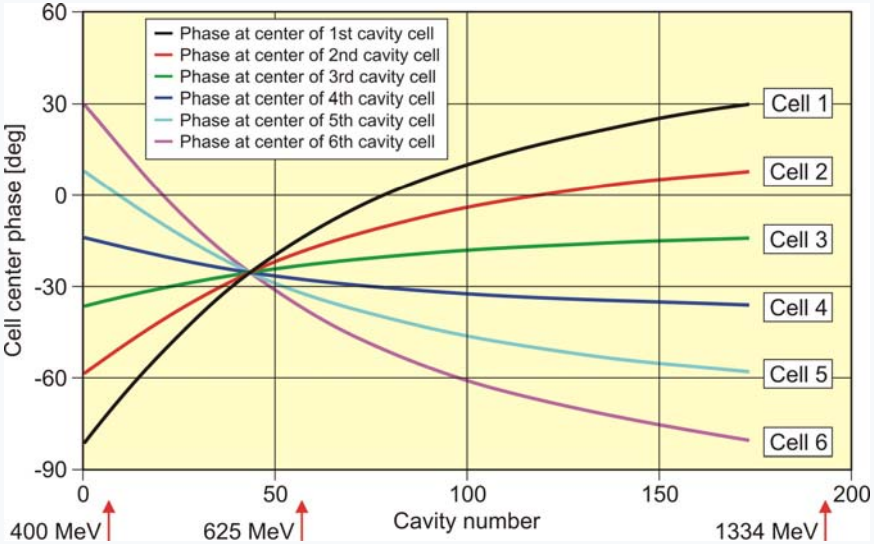
- 2 deflecting sections to absorb < 5 kW
- 2 ns rise,100 us flattop
- 5 combined focusing elements
- Little filamentation in 20 MeV ESS front end

ESS SC Reference Linac: 1120 MHz SC high ß linac



- ***Main parameters of 308 m long 1120 MHz SC linac***
  - 43 cyromodules, each housing 4 elliptical bulk Nb cavities, 6 cells at ß = 0.8, equipped with one SC main coupler
  - As overall ESS RF d.c. is about 11 %, we limited ourself to only 0.85 MW peak power for unchopped LP pulse
  - Only 10 MV/m accelerating gradient at $Q_0 = 10^{10}$ is assumed: Peak magnetic field well blow 50 mT & large ± 2 kHz 3 db bandwidth for unchopped 114 mA beam

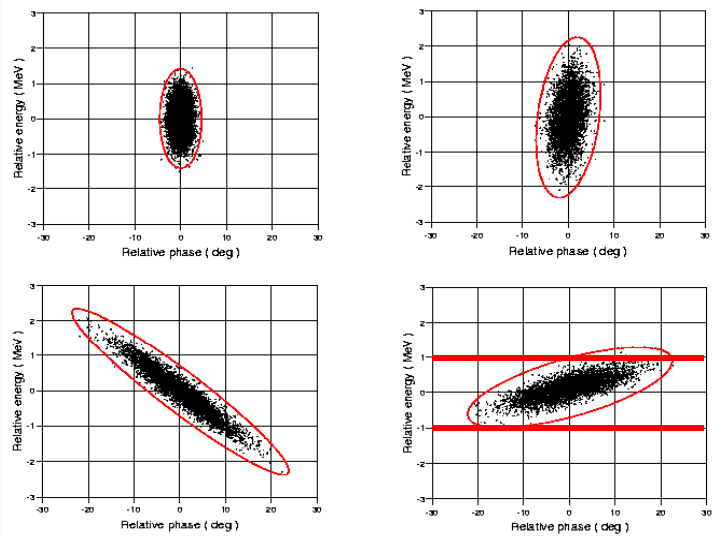
ESS SC Reference Linac: Particle tracking in SC linac



Phase slip along SC linac:
Bunch centre is always between ± 90 °, energy gain in every cell. Results are stable synchrotron Oscillation & small filamentation, obtained by 3 d tracking with 228 mA bunch. After BR, ***energy spread*** < ± 1 MeV.

Input, large deviations & linac end

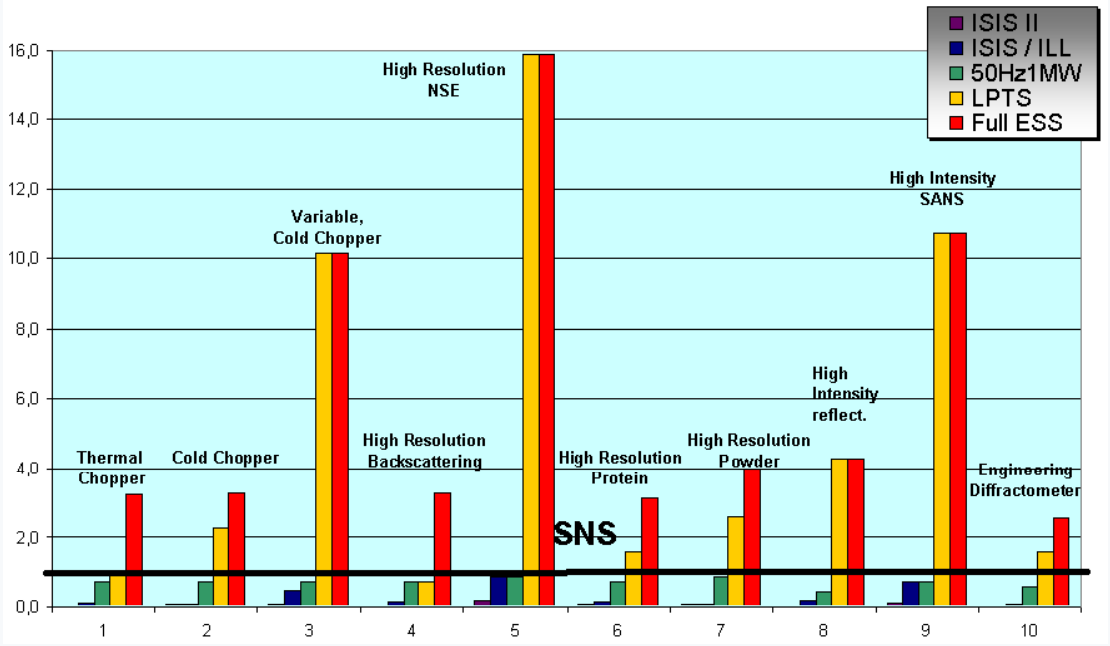
Before & after BR: ***Lines*** are ± 1 MeV



RF amplitude & phase errors:
Field errors along the ESS linac will lead to shift of bunch in energy and time/phase, maybe causing large energy shift after BR. Assuming ± 1 % , ± 1° RF errors in each SC cavity, ***energy shift*** < ± 1 MeV.

Scientific relevance of 5 MW SP & LP targets

A neutron working group under ESFRI (European Strategy Forum for Research Infrastructure) published a report in early 2003, comparing scientific importance of ESS high priority instruments, compared to SNS 1.4 MW SP source.

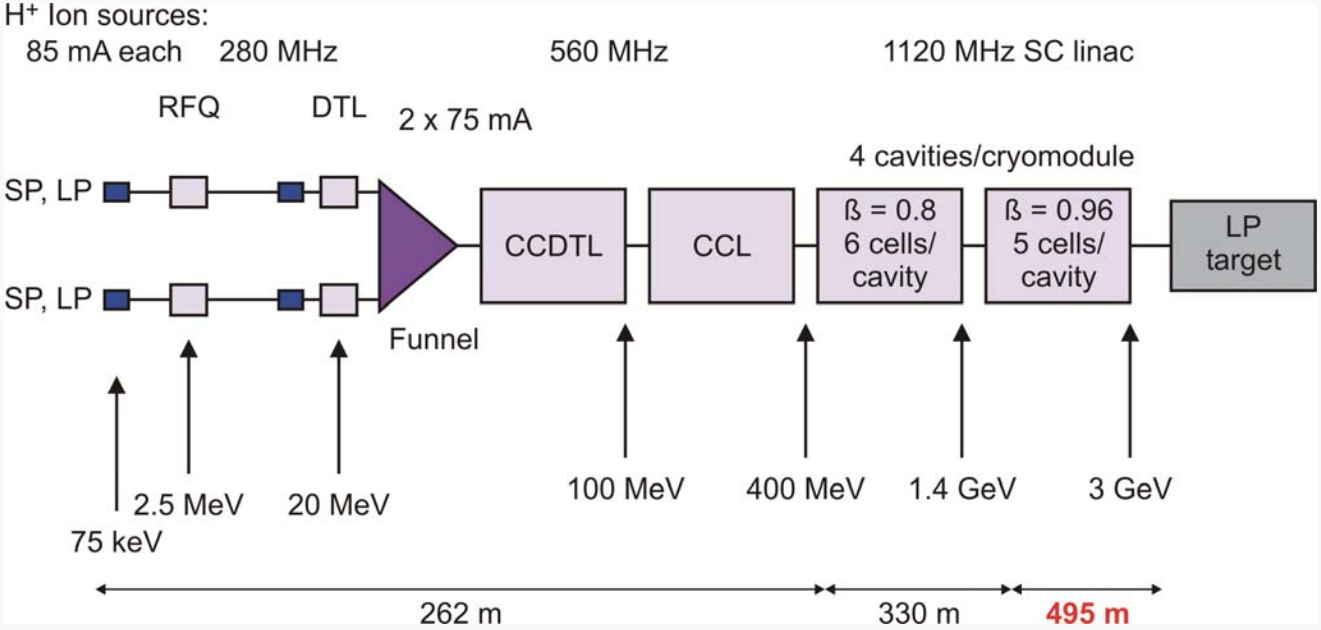


Not visible are low power targets like ISIS 2.TS & proposed SNS LW one. But they are comparable for ***dedicated*** applications.

- 5 MW SP source is 3 x better than 1.4 MW SNS for all cases. For same instruments, 5 MW LP source is also better than SNS, even better compared to 5 MW SP source.

15 MW LP Source: Scientific relevance & 3 GeV H^+ linac

- Stimulated by the ESFRI 2003 findings, beginning 2003 discussions started about the scienific releavance of 15 MW LP source. In 1. order, relative performance is increased by factor 3, leading to at least same gain factors as full ESS. Open questions by end 2003: Validity of 1. Order scaling & target design.
- In response to these discussions, 3 GeV,15 MW H^+ linac is shown in ESS Update Report 2003, based on SC Reference linac.



No chopper line & no achromatic bending section. Only 4 % RF d.c.
1 GeV, 5 MW H^+ linac requires only 28 SC cyromodules, 201 m in length.

ESS situation 2007, ESS initiative (ESS-I)

Several of following transparencies are based on presentation P. Tindemans, chair of ESS-I, ***http://essi.neutron-eu.net/essi***, at ICANS XVIII, Dongguan, April 2007

- Purpose: Keep ESS on the political tables, and demonstrate to the (young) scientists that the fight to get ESS goes on.
- Members:
  - European Neutron Scattering Association (ENSA)
  - Consortia for site candidatures: Yorkshire, Scandinavia, Hungary, Spain/Basque Country, Sachsen/Sachsen-Anhalt
  - Some labs: ILL, FZ Jülich (after discussing with all German labs)
  - Independent chair

ILL is host

- Looks like we are succeeding!

The ESS 2007 to be built

Arguments

- SNS + 10 (+) years ➔ ESS '5 x SNS' in many areas
- Maintain network of sources
- Cost-effectiveness dictates: Eventually as many instruments as possible
- Start in as complementary a mode as possible

Choice

- Start with 5 MW LP target, 20 instruments:
  - As many ancillary and science facilities as affordable
  - Ready to operate in 'industry-mode' too: Access mode (financial, time), IP arrangements, demonstration experiments, standardised procedures, etc.) and as much as possible upgradeable to:
  - More power
  - More target stations (SP, LP, low power TS for dedicated applications)
  - More instruments

Costs

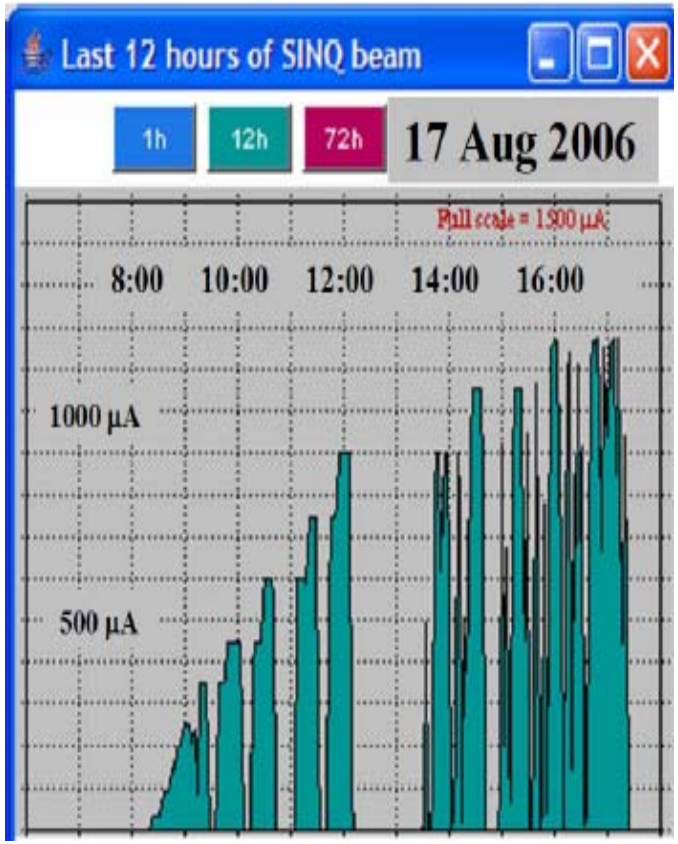
$\geq$1.2 B€$_{2006}$ investment, depending on upgrade possibilities;
100 M€$_{2006}$/y operating

ESS 2007, 5 MW LP target

- Preference is still liquid Hg target, but an alternative solid rotating target was already part of the ESS design study.
- Options compared, including first experience of liquid Hg SNS target, at workshop in Lund in March 2007. Technically and in terms of performance no dramatic difference. So if Hg raises political problems (though e.g. Swedish government does not see problem to license a liquid Hg target) other options exist.
- Liquid Pb/X eutectic suggested as target material to avoid production of long-lived actinides. Consequences like higher melting temperatures must be studied.
- Thermal - hydraulic effects of LP target with 15 MW & 900 kJ/ pulse, e.g. beam window
- Specified must be secure storage of very high activated ***liquid target material*** and transport to solidification plant.

ESS 2007, 1 MW PbBi MEGAPIE target at PSI

Last fall, PbBi liquid metal MEGAPIE target was succesfull commissioned at PSI, reaching about ***1600 MWh*** until planned shutdown in Dec 2006. Typical beam power was about 700 kW.



Phase 3 of beam commissioning:
The third and final phase of the start-up procedure was successfully accomplished on the 17th of August, where the power was stepwise increased to full power 700 kW (1200 µA proton current). After some 10 minutes time with stable proton beam at each step, the beam was interrupted to follow the temperature transients in the target. All systems operated very stable at all power levels.

Startup & operation of CW target is much easier than for SP one.

ESS 2007, Scientific relevance of 5 MW LP target

ESS-I Rencurel workshop, Sep 2006, agreed on better LP performance

Important Contribution to European Priority Research Mission	*Flagship Field of Research*	*Full ESS, 5 MW SP & LP*	*5 MW LP*
Functional Materials, Microsystems and IT, Nanotechnology	**Solid State Physics**	**WL**	**SL**
Microsystems and IT, Functional Materials, Nanotechnologies, Traffic & Transport, Sustainable Development	**Material Science & Engineering**	**WL**	**SL**
Functional Materials, Nanotechnologies, Traffic & Transport, Sustainable Development	**Liquids & Glasses**	**WL**	**SL**
Functional Materials, Nanotechnologies, Traffic & Transport, Sustainable Development	**Soft Condensed Matter**	**WL**	**WL**
Functional Material, Health, Sustainable Development	**Chemical Structure Kinetics & Dynamics**	**WL**	**SL**
Health and Biotechnology	**Biology & Biotechnology**	**WL**	**WL**
Traffic and Transport, Cultural Heritage, Sustainable Development	**Mineral & Earth Science, Environment and Cultural Heritage**	**WL**	**SL**
Cosmology, Origin of the Universe, Education, Public Understanding	**Fundamental Physics**	**WL**	**WL**

ESS 2007, Changes in European Political Landsscape

1. ESFRI Road Map 2006 (modeled after DoE 20-year facilities outlook) + strong desire of European Commission to implement this. ESS is high on this 35-project list – across all fields of science – as one very mature projects.

2. UK Neutron Review March 2006: UK should participate in European next generation project. Decision on feasibility study into 1 MW upgrade of ISIS postponed until European efforts fail.

3. Several very serious site candidates backed by national governments with money; see next slide.

ESS 2007, Serious site candidates

Scandinavia/Sweden: Lund

- Sweden formally proposed March 2007 to host ESS, made a 300 M€ offer
- Swedish government appointed negotiation team led by former finance minister Alan Larson to tour Europe
- Government established ESS project unit at Lund university under Colin Carlile (now professor at Lund University), with budget of several M€ until end 2008
- *22*/23 October 2007, Round Table with interested governments and EU

Spain/Basque Country: Bilbao

- Formal proposal by national government and Basque government: 50-50; 300 + M€ available and 20 M€ for preparations
- When presidents and prime ministers meet… Chirac and Zapatero: 'French support for Bilbao; joint WG to investigate things'
- Bilbao team under Juan Urrutia tours Europe too
- About to appoint international director for ESS-Bilbao

Hungary

- Formal bid May 2007: Site either near Budapest or in Debrecen
- Ministry for Economy and Transport in charge
- Structural Funds EU, European Investment Bank
- Strong regional support
- Equally making the Europe tour

UK: Culham science park (including RAL), Yorkshire ?

ESS 2007, FP7 proposal granted (5 M€ EU support)

(EU FP7 funds ‚preparatory' studies for ESFRI Road Map projects)

- Adressing more in-depth safety issues, socio-economic aspects, regulatory requirements
- Environmental compliance issues different target materials
- Radio-active inventory, emission, handling, storage
- Decommissioning
- Upgradeability
- Novel ideas for user operations, and for governance
- Enhancing support for ESS: Industry, funding agencies, public at large, politics

Overall report 24 months, but specific reports much earlier, and 6- and 12-months intermediary reports to serve governments' decision making.

ESS 2007, Synergies with CERN SPL linac

- Both high currents ESS linacs, either 114 mA H^- one or 150 mA H^+ one uses pulsed high ß SC cyromodules from 400 MeV. Timely construction of choosen ESS linac requires complete cyromodule as full power test-bed of pulsed SC cavities. ***Common interest*** with pulsed CERN SPL linac is evident .
- Depending on choosen ESS upgrade scenario, also low energy chopping line is required, maybe even for 150 mA H^+ linac. If a dedicated low power target station, like ISIS 2. target or planned SNS LW target, becames of interest for ESS upgrade, then beam intensity of 1 ms pulse can by 50 % reduced in low energy chopping line. ***Common interest*** with pulsed CERN SPL linac is evident .

Summary

- Summarized is full ESS facility with 5 MW SP & LP target, as documented in the ESS Update Report 2003. Emphasis is given to the choosen ***ESS SC Reference Linac*** with its low frequency front end, followed by high frequency SC cyromodules. Both pulsed ESS linacs, either 114 mA H^- or 150 mA H^+, use SC cavities > 400 MeV.
- After ending ESS project by end of 2003, ESS-I group succesfully promoted ESS to be in the ***highest category of maturity*** of the European Road Map. Consensus on ESS facility is to start with 5 MW LP target, about 20 instruments, being upgradeable laterly.
- Recently formed FP7 study group will look at accelerator & target problems, associated with various upgrade scenarios.
- Complete cyromodule as full power test-bed of pulsed SC cavities is on ***common interest*** for ESS & CERN SPL linacs. Low energy chopping line could also be of interest, depending on ESS upgrade.