Hot Commissioning of ESS Neutron Instruments and lead up to User Operations

Shane Kennedy
Deputy Director for Science and NSS Project Leader

www.europeanspallationsource.se
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# The 15 NSS Project Instruments

*All are planned to be world leading at 2 MW*

<table>
<thead>
<tr>
<th>Instrument Class</th>
<th>Instrument</th>
<th>Costbook Value (M€)</th>
<th>Performance targets (@ 2MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Large Scale Structures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOKI (Broad band SANS)</td>
<td>12.19</td>
<td>5 x D22 &amp; 20 x SANS2D</td>
</tr>
<tr>
<td></td>
<td>SKADI (General Purpose SANS) (+SONDE funds)</td>
<td>11.50</td>
<td>4 x D22</td>
</tr>
</tbody>
</table>
| | ESTIA (Focusing Reflectometer) | 11.80 | • Conventional mode: ~ 100 x D17  
• High intensity mode: 1cm² samples = seconds |
| | FREIA (Liquids Reflectometer) | 13.2 | 30 x FIGARO, INTER |
| **Diffraction** | | | |
| | DREAM (Bispectral powder diffractometer) | 13.66 | > 10 x POWGEN or WISH |
| | HEIMDAL (Hybrid diffractometer) | 13.55 | > 50 x GEM, ~ 8 x new POLARIS |
| | MAGIC (magnetism single crystal diffractometer) | 13.10 | Cold: > 100 x worlds best,  
• Thermal: 1mm³ crystals = 10 min |
| | NMX (Macromolecular crystallography) | 11.67 | > 10 x LADI & Biodiff |
| **Engineering & Industrial** | | | |
| | BEER (Engineering diffractometer) | 14.99 | world leading in strain scanning, unique flexibility |
| | ODIN (multi-purpose imaging) | 11.60 | world leading for high resolution, > 10 x best for TOF methods |
| **Spectroscopy** | | | |
| | BIFROST (extreme environment spectrometer) | 13.45 | > 10 x THALES & MACS |
| | C-SPEC (cold chopper spectrometer) | 16.50 | 100 x IN5 (w RRM) |
| | T-REX (bispectral chopper spectrometer) | 16.85 | 3 x 4-SEASONS, 3 x IN5 |
| | VESPA (vibrational spectroscopy) | 12.0 | 10 x VISION (ΔE = 130 meV) |
| | MIRACLES (backscattering spectrometer) | 13.53 | 2 x BASIS and DNA |

Total cost book value: 199.59
ESS Lead Partners for instrument construction:
14 Partner Institutes from 10 member countries

ESS In-Kind Partners:
- Deliver 97% of Neutron Instruments (budgetary responsibility)
- and contribute solutions for
  - choppers,
  - detectors,
  - sample environment
  - experiment control
  - data management
  - laboratory equipment, ...
NSS total In-Kind Contributions
Country Summary

<table>
<thead>
<tr>
<th>Partner Country</th>
<th>potential value (M€)</th>
<th>Committed to NSS (M€)</th>
<th>% of potential commitment to NSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Czech Republic</td>
<td>11.25</td>
<td>7.5</td>
<td>67%</td>
</tr>
<tr>
<td>Denmark</td>
<td>7.46</td>
<td>7.5</td>
<td>100%</td>
</tr>
<tr>
<td>Estonia</td>
<td>0.9</td>
<td>0.8</td>
<td>84%</td>
</tr>
<tr>
<td>France</td>
<td>25</td>
<td>28.7</td>
<td>82%</td>
</tr>
<tr>
<td>Germany</td>
<td>93</td>
<td>55.4</td>
<td>60%</td>
</tr>
<tr>
<td>Hungary</td>
<td>8.0</td>
<td>7.9</td>
<td>99%</td>
</tr>
<tr>
<td>Italy</td>
<td>20.05</td>
<td>16.9</td>
<td>84%</td>
</tr>
<tr>
<td>Norway</td>
<td>17</td>
<td>10.6</td>
<td>62%</td>
</tr>
<tr>
<td>Spain</td>
<td>32.5</td>
<td>13.4</td>
<td>41%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>41</td>
<td>28.4</td>
<td>69%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>31.4</td>
<td>32.0</td>
<td>102%</td>
</tr>
<tr>
<td>total</td>
<td>297.6</td>
<td>205.9</td>
<td></td>
</tr>
</tbody>
</table>

Expected I-K contribution to Neutron Scattering Systems is 65 %
Anticipated I-K contribution in “project delivery” is ~ 75 %

Assigned value for instruments = 193.4 M€
"of other contributions = 12.5 M€
Total In-Kind Value assigned = 205.9 M€
Interface Management & Support

Integrated Processes
- In-kind agreements
- Installation planning
- Installation co-ordination
- Project Management
  - Tollgates
  - Schedule
  - Risk
- Resource management
- Safety management
- Technical annexes

Integrated Systems
- Neutron Bunker
- Beam inserts
- Choppers
- Transport optics
- Vacuum systems
- Electrical systems
- Shutters
- Shielding
- Cranes
- Penetrations
- Grounding
- Services
- Controls & sensors
- Remote handling
- Safety systems

Science Divisions: DMSC, NID, NTD, SAD
NSS Project; Neutron Instrument project phases

Proposal and Planning

Instrument Proposal

Deliverables
• Science case covering scientific relevance, impact and usage
• Conceptual design with credible estimates of performance
• Preliminary costing.

Phase 0 Preparation for Design

Deliverables
• Conceptual design updates
• Prototyping
• Definition of facility requirements and interfaces
• Clarification of institutional responsibilities
• Resource planning

Deliverables
• Scientific and technical requirements
• Technical design concept
• Delivery plan for all phases (including hot commissioning)
• Delivery Schedule covering all phases
• Resource plan
• Staging plan for later enhancements
• Budget with contingency at 10% of cost to complete

Tollgate 1
• STAP review
• SAC recommendation
• NSS recommendation
• STC approval

Design and Construction

Phase 1 Preliminary Design

Deliverables
• Complete definition of all major technical components
• Completion of detailed plan for Phase 3
• Refined Resource plan
• Refined delivery schedule, with critical path items and dependencies
• Refined budget with contingency at 10% of cost to complete

Tollgate 2 (PDR)
Preliminary Design Review
• STAP review
• NSS
  ➢ scope review
  ➢ assign cost book value
  ➢ Approval by SD

Tollgate 3 (CDR)
Critical Design Review
• STAP review
• ICB review
• NSS approval

Tollgate 4 (IRR)
Installation Readiness Review
• ICB review
• NSS approval

Phase 2 Detailed Design

Deliverables
• Procurement and manufacture of all major technical components
• Completion of detailed plan for phase 4
• Refined resource plan
• Refine instrument delivery schedule
• Maintain budget with contingency at 10% of cost to complete

Tollgate 5 (SAR)
Safety systems acceptance review
• NSS approval

Phase 3 Manufacturing and Procurement

Deliverables
• Construction of physical infrastructure on site.
• Assembly and installation of technical components
• Integration and testing of technical components
• Installation, integration and testing of Personnel Safety System
• Submission of application for approval to hot commission
• Formal project completion

Tollgate 6 (ORR)
Operations readiness review
• NSS approval

Phase 4 Installation and Integration

Deliverables
• Verification of performance of Personnel Safety System
• Proof of compliance with radiation dose limits
• Critical performance demonstration of basic functionality
• Scientific performance demonstration
• Friendly user experiments
• Completion of technical and user manuals

Phase 5 Hot Commissioning

Deliverables
• Procurement and manufacture of all major technical components
• Completion of detailed plan for phase 4
• Site preparation
• Refined plans for phase 5 and for staging
• Refined Resource plan
• Refine instrument delivery schedule
• Maintain budget with contingency at 10% of cost to complete

NSS Instrument Project budget

ESS Initial operations budget
### Planned order of commencement of operation of first 8 instruments (August 2023)

Matching early success in delivery of scientific outputs with the capacity of Lead In-Kind partners to deliver on schedule (ISIS, PSI, FZJ, LLB, HZG/NPI, TUM/PSI, TUM/LLB & DTU lead consortium).

<table>
<thead>
<tr>
<th>Instrument Class</th>
<th>Sub-class</th>
<th>Candidates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Scale Structures</td>
<td>Small Angle Scattering</td>
<td>LOKI (ISIS) or SKADI (FZJ)</td>
</tr>
<tr>
<td></td>
<td>Reflectometry</td>
<td>ESTIA (PSI) or FREIA (ISIS)</td>
</tr>
<tr>
<td>Diffraction</td>
<td>Powder Diffraction</td>
<td>DREAM (FZJ) or HEIMDAL (ÅU)</td>
</tr>
<tr>
<td></td>
<td>Single crystal diffraction</td>
<td>MAGIC (LLB) or NMX (ESS)</td>
</tr>
<tr>
<td>Engineering</td>
<td>Strain scanning</td>
<td>BEER (HZG/NPI)</td>
</tr>
<tr>
<td></td>
<td>Imaging and tomography</td>
<td>ODIN (TUM/PSI)</td>
</tr>
<tr>
<td>Spectroscopy</td>
<td>Direct Geometry</td>
<td>C-SPEC (TUM) or T-REX (FZJ)</td>
</tr>
<tr>
<td></td>
<td>Indirect Geometry</td>
<td>BIFROST (DTU), MIRACLES (Bilbao), VESPA (CNR)</td>
</tr>
</tbody>
</table>

*Instruments in **bold** type to be operational by Aug 2023

*Italic*: backups in case of delays
NOTES:

• Assumes 2MW maximum power until end 2025
• Phases aligned with TG2 reviews on 1st 9 NBIs
• Installation & Integration (TG4) + Hot Commissioning (TG5) for first 8 NBIs aligned with draft BOI plan (schedule match typically within 1 month)

Installation for most instruments begins in Q2/2019 with in-monolith optics
Access to other “instrument construction areas” will be later
Preparing for BOT and first BOI:
In bunker activities

First installations in bunker:
(Feb – Sept 2019)
Neutron Beam Optics in monolith & light shutters

Next installations in bunker:
(from Nov 2019 – May 2020)
Bunker Optics for first 4 – 8 Neutron Beam Instruments

Bunker roof completed:
(from Jun – Aug 2020)
Bunker Optics for first 4 – 8 Neutron Beam Instruments
NOTES:
• Plan aligned with access dates to D & E buildings
• TG4 (Installation & Integration) according to on-site resource plan & aligned with first 8 NBI schedules (schedule match typically within 1 month)
• Alignment with TG5 for NBI 9-15 not yet complete
• On-site Resource plan under development

* BOT still under discussion with ESS-ERIC Council

TG5 (Hot Commission) 12 – 18 months
**PHASE 5 - Neutron Instrument Hot Commissioning**

- **Safety systems commissioning**
  - Personnel safety systems confirmed to be operational.
  - Radiation dose levels verified to comply with operational requirements.
  - Where necessary, corrective measures bring radiation dose levels into compliance.

- **Critical performance verification**
  - Critical performance requirements verified by measurement.
  - Any critical performance shortfalls rectified before moving into operations.

- **Scientific Performance Demonstration**
  - Standard ‘benchmark’ measurements to satisfy expectations of scientific quality.
  - Friendly user experiments test the instrument capabilities, with scientists who have been involved construction. – Any technical problems encountered should be solved.
  - Measurements selected on their potential to produce exciting scientific results.

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**Tollgate 6 – Neutron Instrument Operations Readiness Review**

- All operational documents (technical reports, drawings, user manuals, safety procedures)
- Changes and modifications made during the beam testing phase
- Neutron Instrument operation and maintenance plans.
ESS Proton Production Schedule

DRAFT FOR DISCUSSION

Production 200 days/yr @ 2 MW

Start User program: Aug. 2023
(Level 0 MS)

Production 200 days/yr @ 2 MW

Commission
Accel/Target

Ready for
BOT (L1-MS)

BOI#1 (L1-MS)

BOI#2 & #3

BOI#4 & #5

BOI#6, #7 & #8

BOI#9, #10 & #11

<- (BOI#12 -15) ->