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

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Instrument Class	Instrument	Costbook Value (M€)	Performance targets (@ 2MW)
Large Scale Structures	LOKI (Broad band SANS)	12.19	5 x D22 & 20 x SANS2D
	SKADI (General Purpose SANS) *(+SONDE funds)*	11.50	4 x D22
	ESTIA (Focusing Reflectometer)	11.80	• Conventional mode: ~ 100 x D17 • High intensity mode: 1cm^2 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: 1mm^3 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**	

With a further ~ 53 M€ investment ESS will more than double the performance of these instruments

NSS Neutron Instrument positions: December 2016

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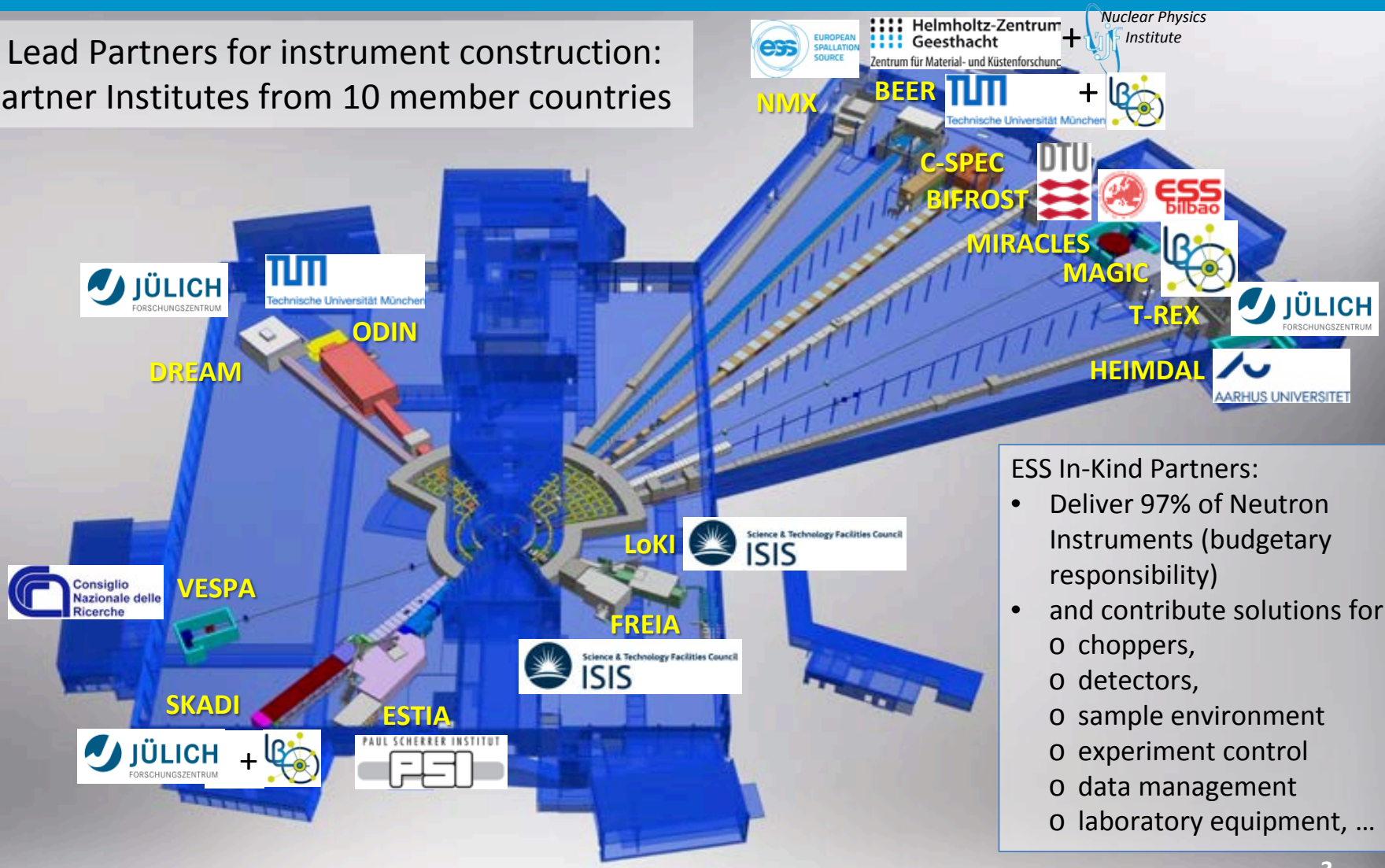
ESS Lead Partners for instrument construction:
14 Partner Institutes from 10 member countries



ESS In-Kind Partners:

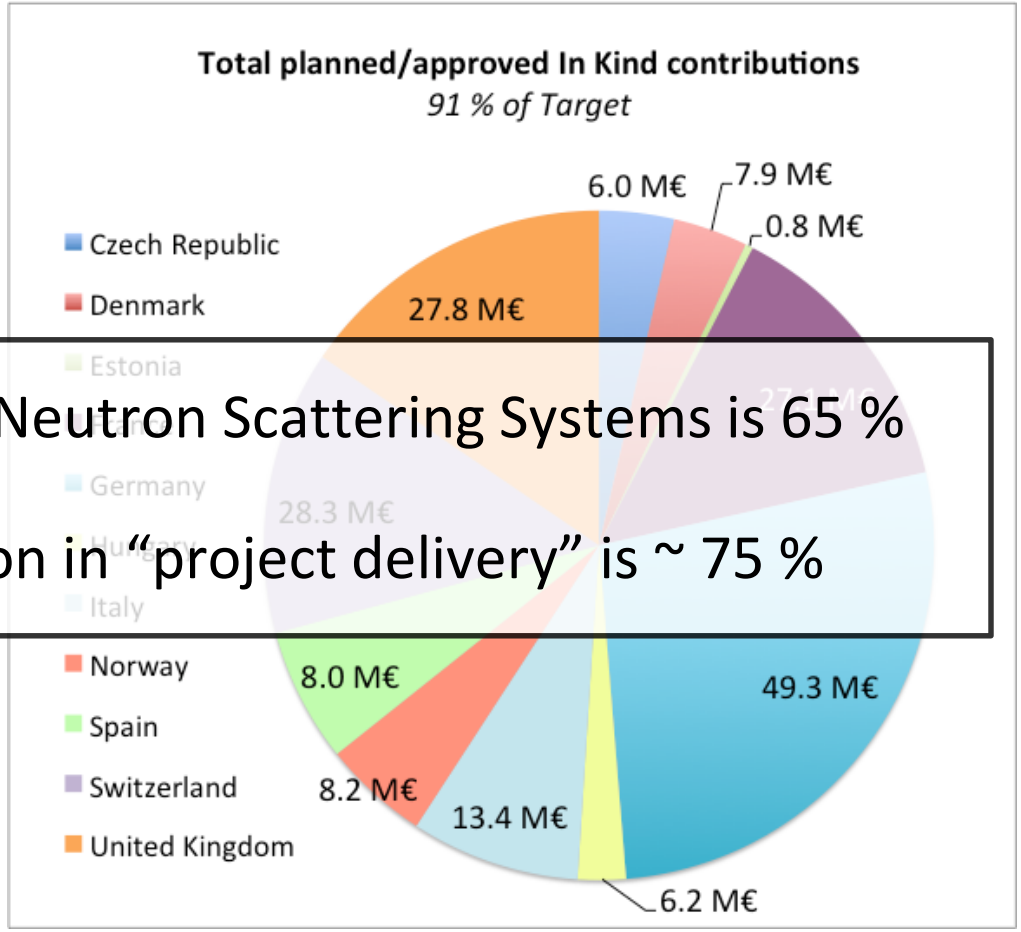
- Deliver 97% of Neutron Instruments (budgetary responsibility)
- and contribute solutions for
  - o choppers,
  - o detectors,
  - o sample environment
  - o experiment control
  - o data management
  - o laboratory equipment, …

ESS Instrument Layout (December 2016)

NSS total In-Kind Contributions
Country Summary

Partner Country	potential value (M€)	Committed to NSS (M€)	% of potential commitment to NSS
Czech Republic	11.25	7.5	67%
Denmark	7.46	7.5	100%
Estonia	0.9	0.8	84%
France	35	28.7	82%
Germany	93	55.4	60%
Hungary	8	6.2	78%
Italy	20.05	16.9	84%
Norway	17	10.6	62%
Spain	8	8.0	100%
Switzerland	41	28.4	69%
United Kingdom	31.4	32.0	102%
total	**297.6**	**205.9**	

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



Expected I-K contribution to Neutron Scattering Systems is 65 %

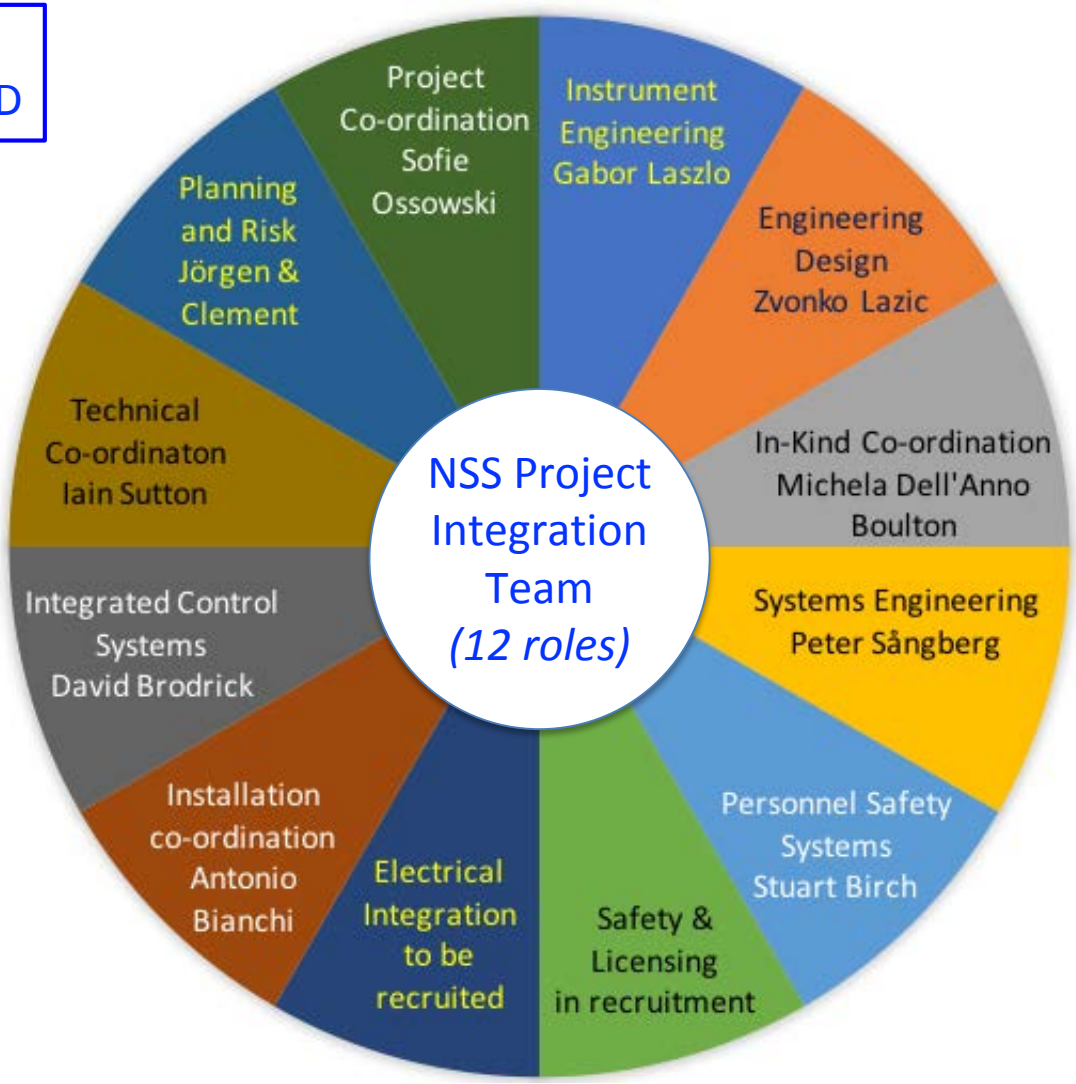
Anticipated I-K contribution in "project delivery" is ~ 75 %

Interface Management & Support

Science Divisions:
DMSC, NID, NTD, SAD

Integrated Processes

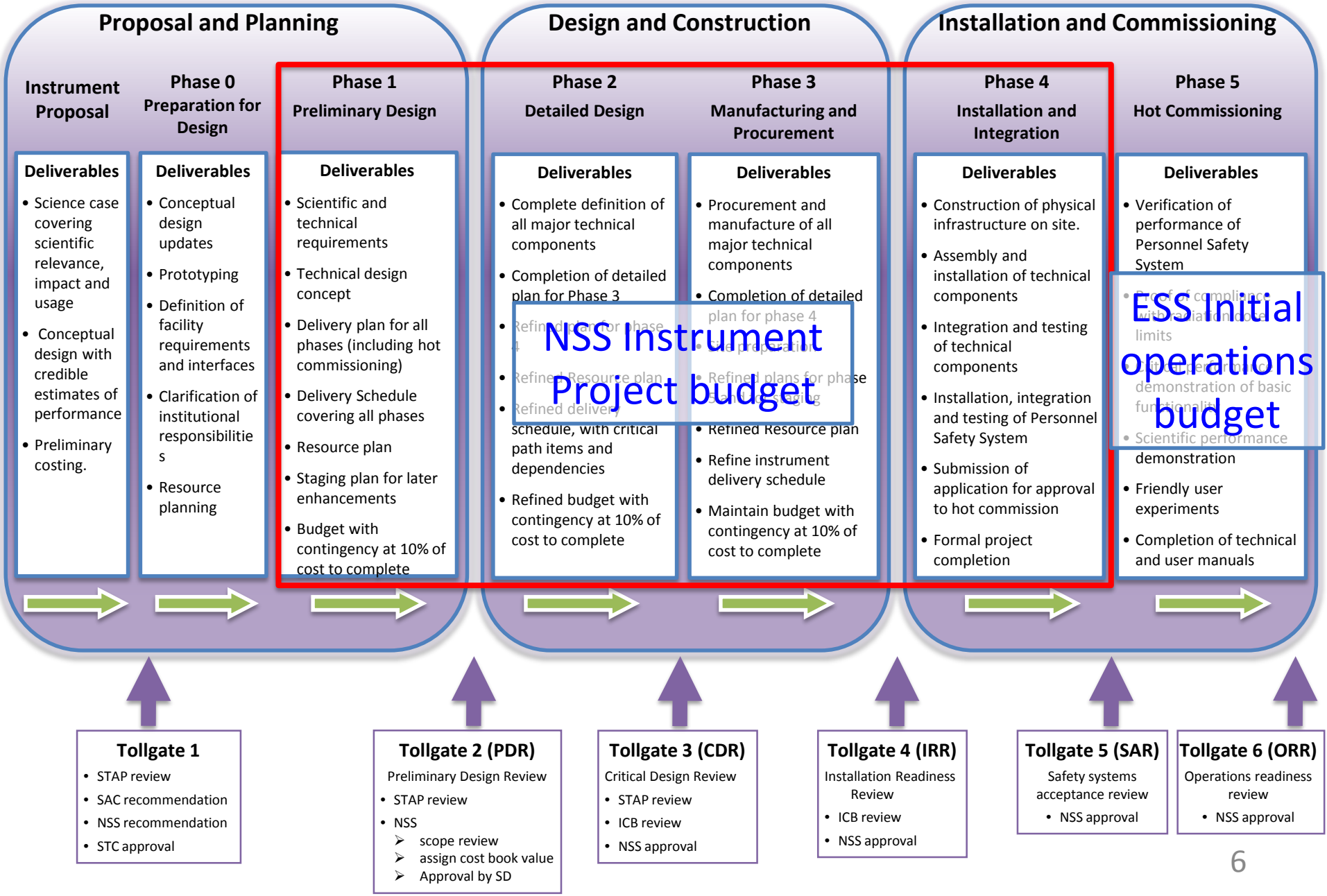
- In-kind agreements
- Installation planning
- Installation co-ordination
- Project Management
  - Tollgates
  - Schedule
  - risk
- Resource management
- Safety management
- Technical annexes



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

NSS Project; Neutron Instrument project phases



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).

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

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

Italic: backups in case of delays

Internal* Neutron Beam Instrument Schedule

DRAFT FOR DISCUSSION V3.3, 10th June 2017

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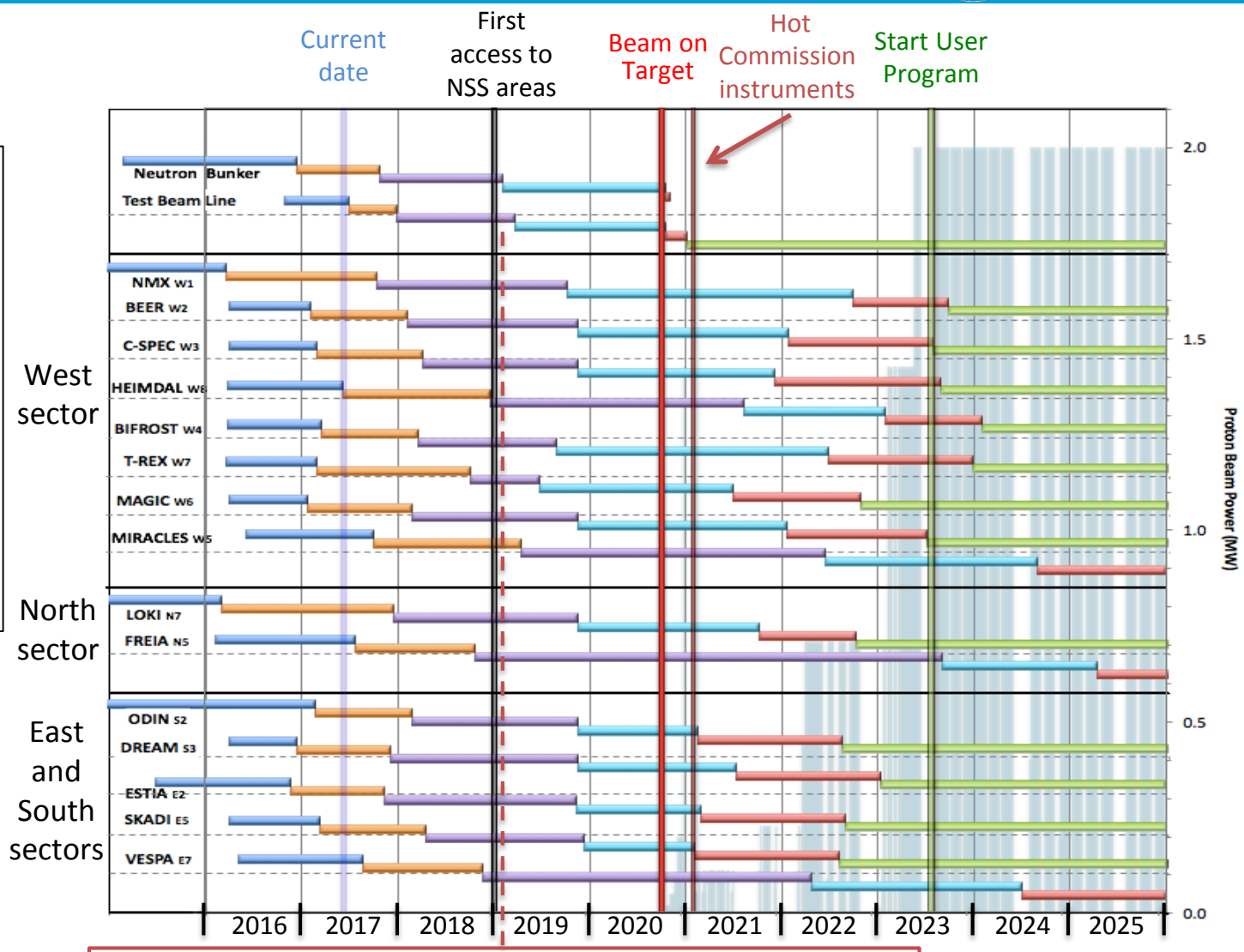
* still under discussion with ESS-ERIC Council

NOTES:

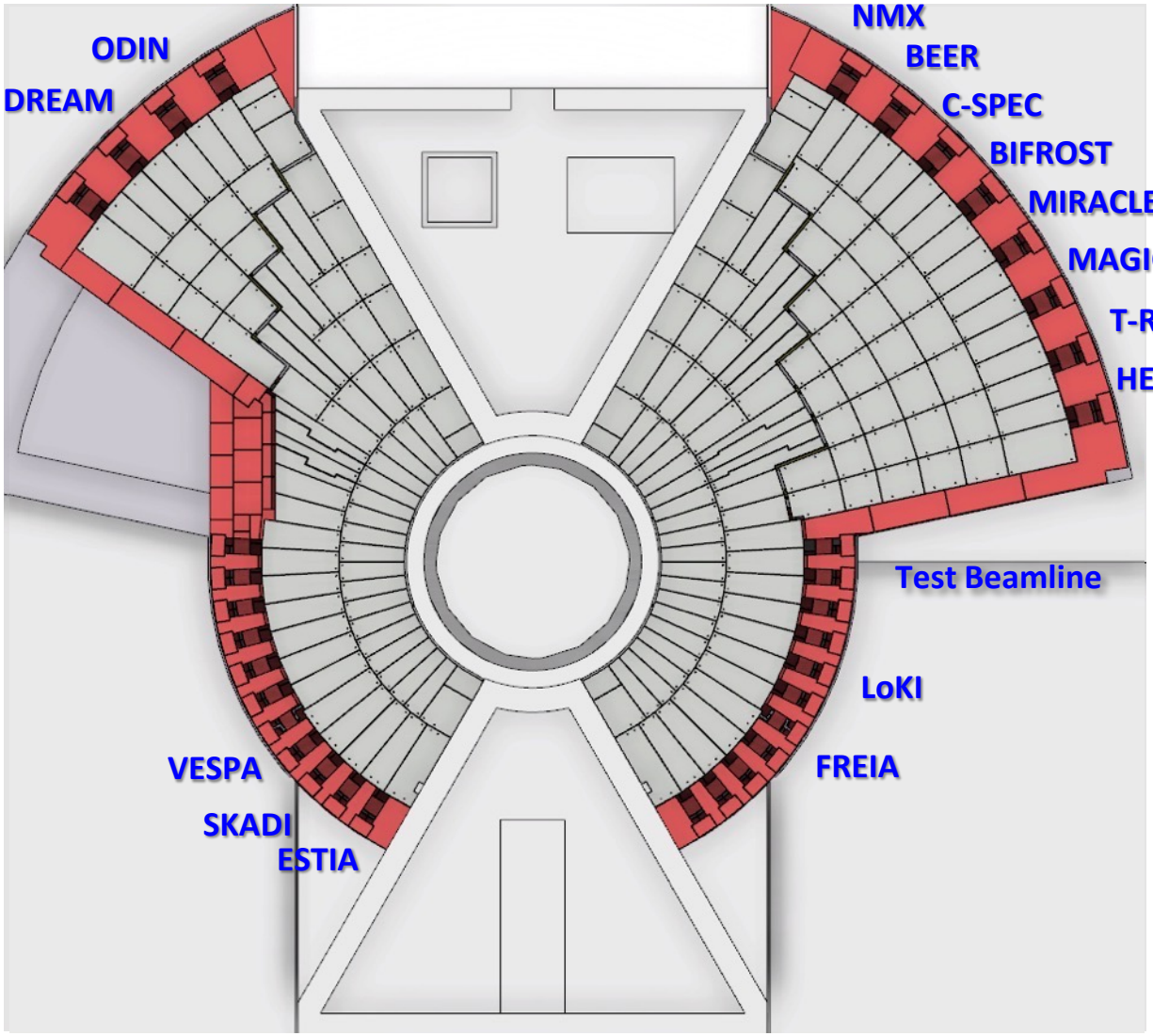
- Assumes 2MW maximum power until end 2025
- Phases aligned with TG2 reviews on 1st 9 NBIs
- Installation & Integration (TG4) + Hot Commissioning (TG5) for first 8 NBIs aligned with draft BOI plan *(schedule match typically within 1 month)*



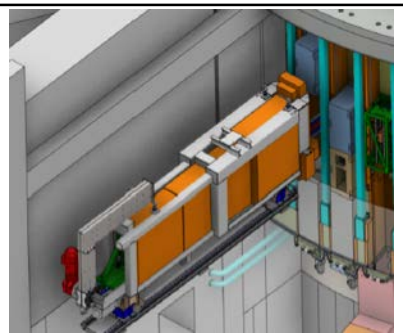
Preliminary Design
Detailed Design
Manufacturing & Procurement
Installation & Integration
Hot Commissioning/Early science
Operation

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

Internal* NBI Installation Schedule (TG4 –> TG5)

DRAFT FOR DISCUSSION (from V3.3, 10th June 2017)

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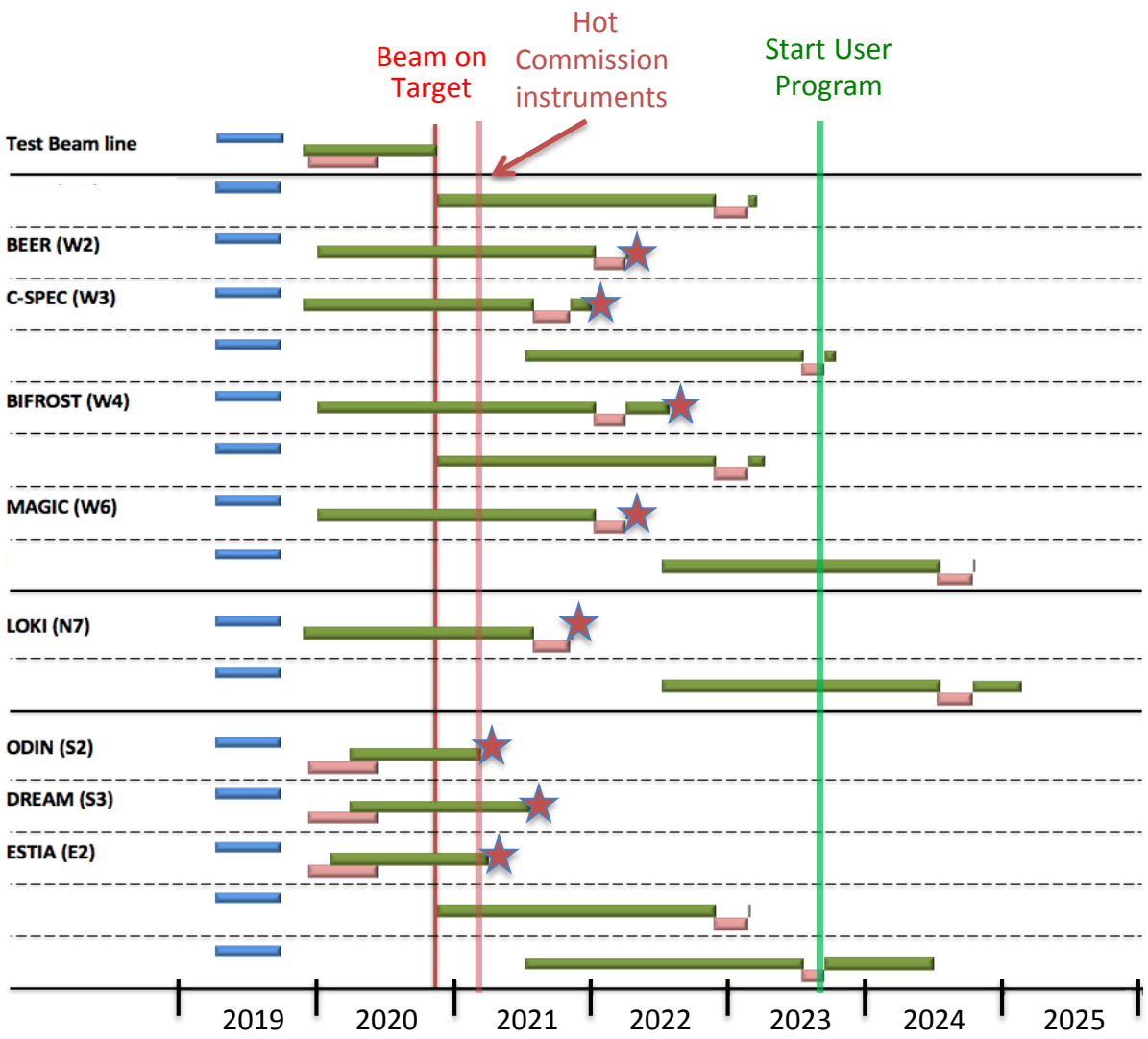
* BOT still under discussion with ESS-ERIC Council

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*

In monolith complete
In bunker complete
Out of bunker

TG5 (Hot Commission)
12 – 18 months



Neutron Instrument Hot Commissioning and Early Science (prior to User Program)

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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.

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

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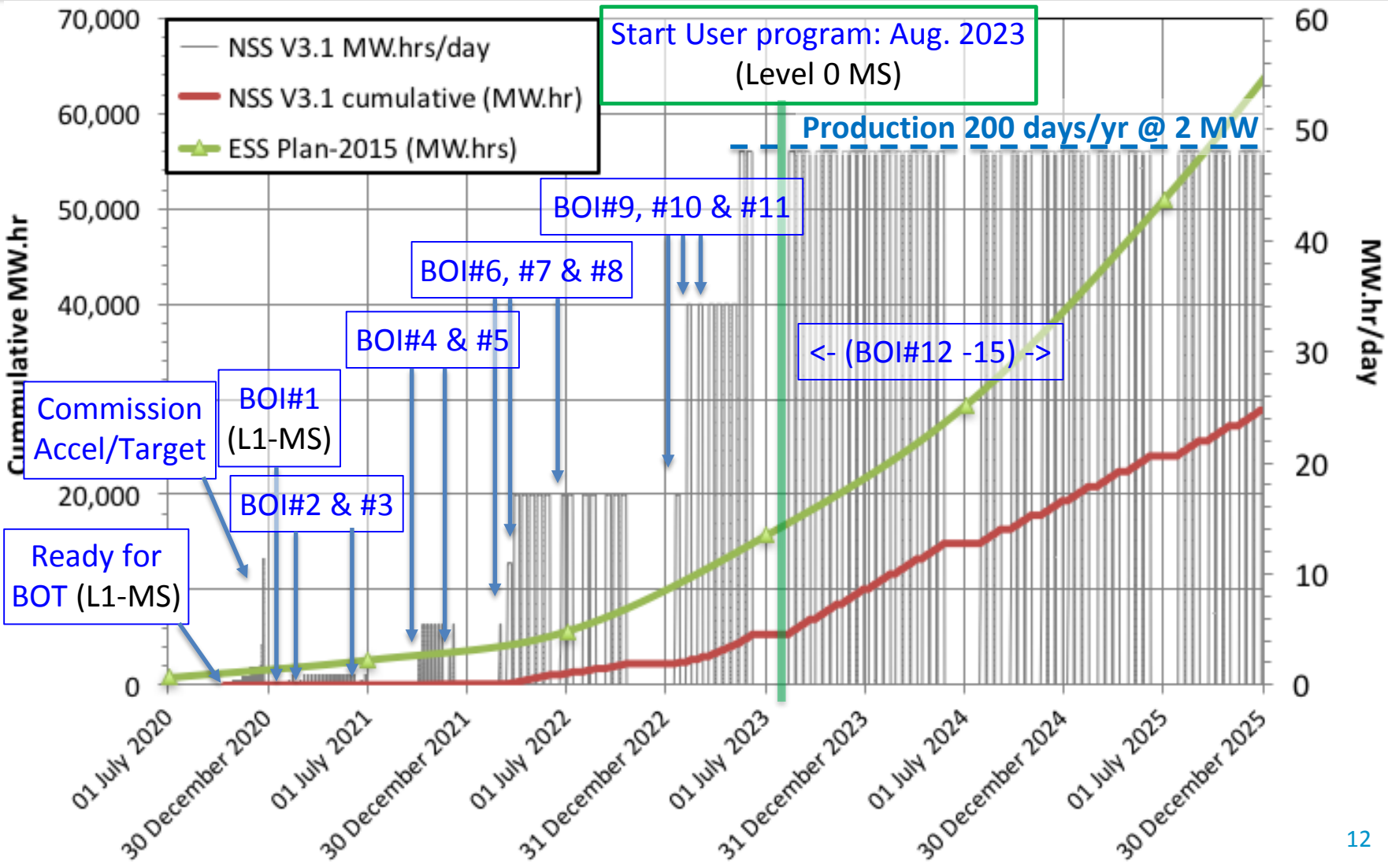

Ref: NSS MS V3.3