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Baseline for ESS Beamport Allocation

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Executive Summary

A beamport allocation baseline for The European Spallation Source ESS ERIC is presented, with improvements over the existing baseline. The benefits of the proposed layout are brought by having fewer mechanical interference areas, which reduce both complexity and cost during construction phase, and associated costs in the operational phase during maintenance. At the same time, the number of useable beamports for future instruments is maximised in balance with the performance of the suite.

1 INTRODUCTION

The ESS construction project seeks to deploy 16 neutron scattering instruments in the first instance, with a foreseen suite of 22 instruments before 2028. These instruments are to be deployed in four sectors, named after the cardinal directions. The North and East sectors are intended for short instruments, less than 50 metres or so in length. The West sector is reserved for long instruments (about 160 m). The South sector is intended for mostly intermediate-length instruments (50-80 m).

In the North and East sectors, due to the size of the equipment being placed close to the source, it was always foreseen that fewer beam ports could be activated, and the intention in the South and West sectors is that every beam port would be used. In the North and East sectors, the beam ports are separated by 6°. In the South and West, the beam ports are separated by an alternating pattern of 5.3° and 6.7°.

In addition to the boundaries implied by the foreseen neighbours, additional conditions will be imposed. For example, an envelope will be defined by ESS as a boundary for instrument projects, such as a wedge-shaped envelope matching the beam separation, to reduce the potential for disrupting future projects, along with ergonomic conditions [1, 2, 3, 4].

The present baseline is optimised according to the following prioritisation:

1. To provide the best outcome in terms of performance and operability for instruments 1-15, and the two options for instrument 16

2. To provide the best outcome for “guessed” instruments 17-22; and

3. To minimize blocking of unallocated beam-ports, such that 32 instruments (or more) could be installed.

The instruments WANSE, ANNI, SLEIPNIR, NNBAR, Surface Scattering are best possible guesses, and therefore both their geometries and beam port allocations are indicative, and subject to changes once these instruments have been accepted for construction and are better defined.

This baseline is under ESS change control processes after approval.

2 INFORMATION FEEDING THE OPTIMISATION

Two design studies were used to guide this result. A manual study was performed in which the parameter space was explored by hand [5] and a metaheuristic-based computational method [6].

The instrument designs in this report are shown without finalised cave designs. Space will be provided for each instrument during the detailed design phase, and the size and shape of the caves are expected to be defined during Phase 1. Similarly, instrument control hutches are not shown, and will be designed at later stages in the instrument projects.

The information that fed this optimisation was based on the current concepts that have been developed by the instrument teams for the named instruments.

3 BASELINE LAYOUT

3.1 West Sector

The baseline layout for the west sector is shown in figure 1 on page 6, and summarised in table 1 on page 5. This layout allows all instruments to place their choppers in the optimum position for performance, with the exception of MIRACLES, which incurs a small loss of 9.6% bandwidth due to the movement of the pulse-shaping chopper from its currently-planned position at 6.5 m. This is considered to have only a minor impact on performance for MIRACLES [7].

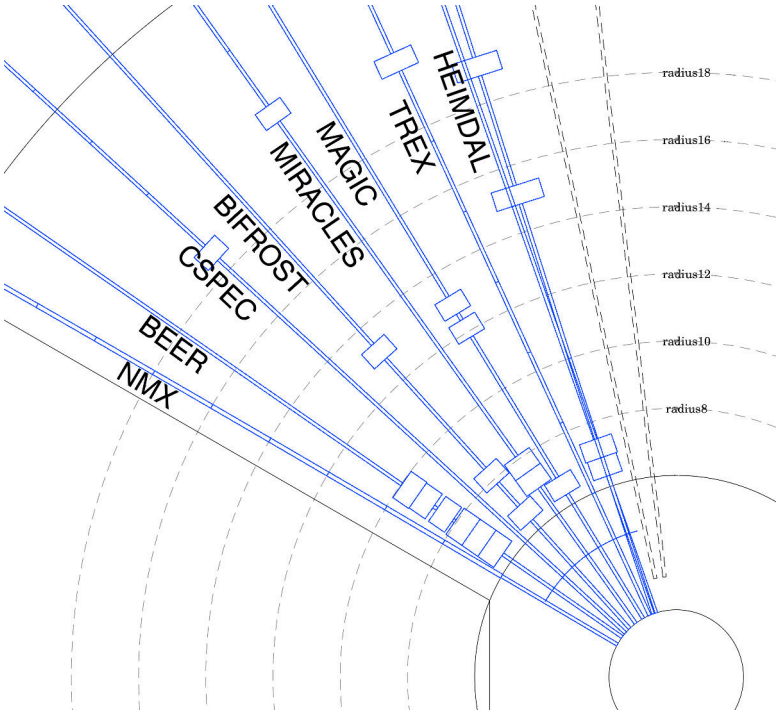
Beam Port	Instrument
W1	NMX
W2	BEER
W3	CSPEC
W4	BIFROST
W5	MIRACLES
W6	MAGIC
W7	TREX
W8	HEIMDAL
W9	—
W10	—
W11	NNBAR/WANSE

Table 1: Port allocations for West sector.

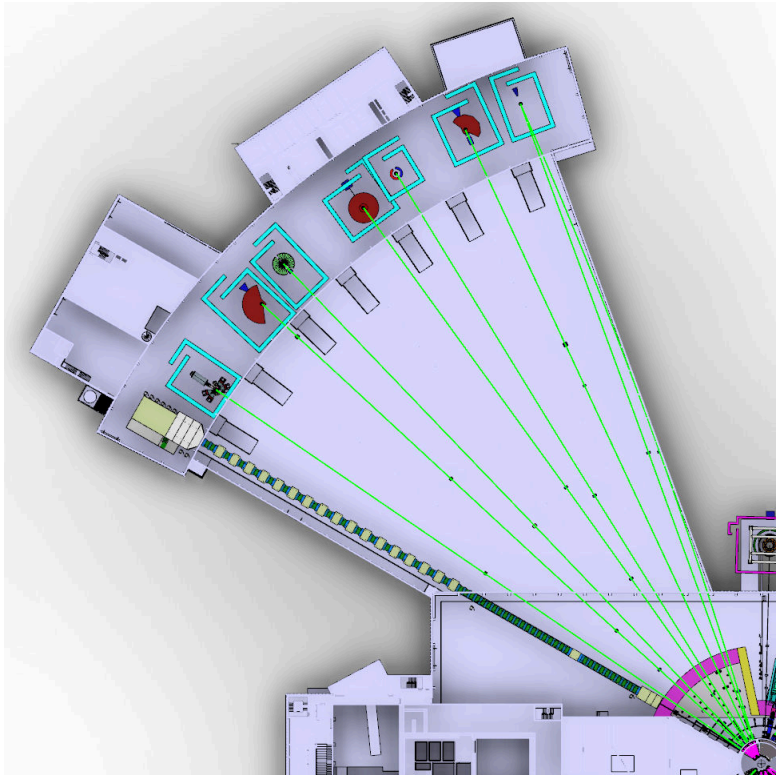
NMX has been fixed on beamport W1, so as to allow space in the main instrument hall for future installation of instruments with crystal monochromators, viewing the bottom moderator. BEER has been constrained to the beamports which allow convenient access between the instrument and its intended sample preparation lab.

Note that NNBAR, and possibly WANSE, make use of the area around the 90° beam port on this sector. This may also block a beam port in the North sector (see section 3.2 on page 6).

Care should be taken to minimise background radiation due to neutron scattering from neighbouring instruments. This is particularly important for the spectrometers (CSPEC, BIFROST, MIRACLES and TREX) where the signal strength is lower. Additional shielding between neighbouring instruments adjacent to sample areas, or tailoring of curvature of beamlines to maximise distance from “noisier” instruments, could help in this respect.



(a) 2D view

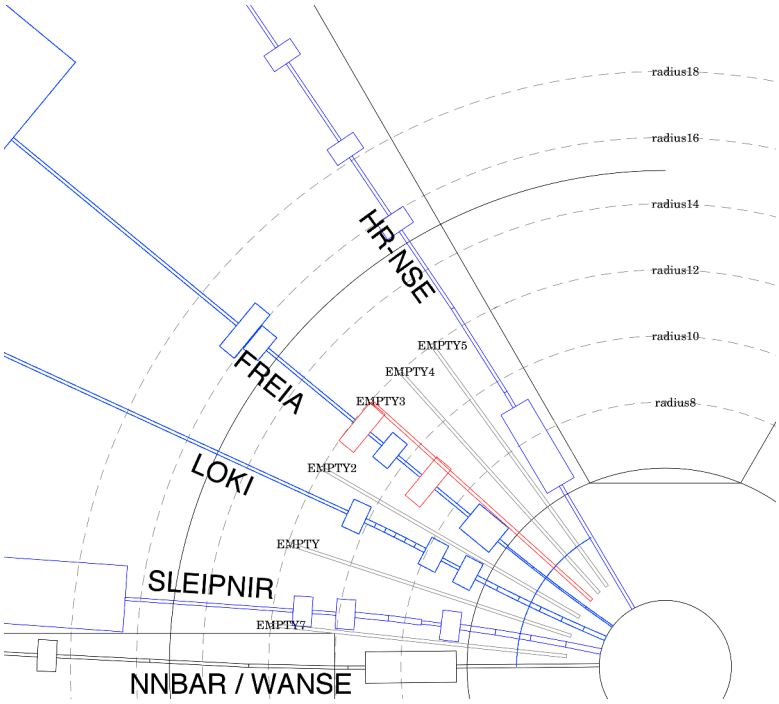


(b) CAD view

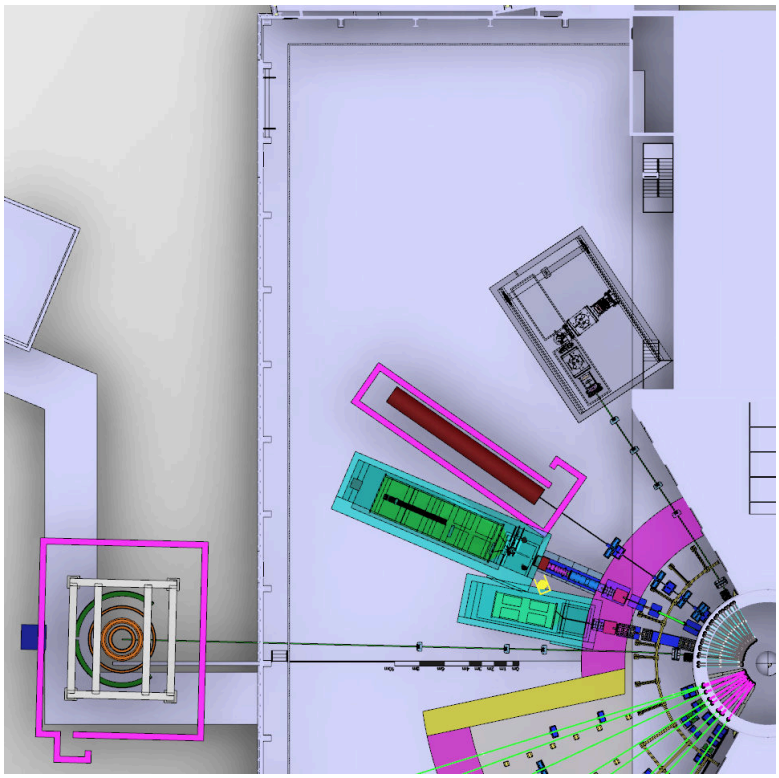
Figure 1: Baseline layout for West sector. Please note that the sample position for CSPEC has moved 10 m in order to fit into the experimental hall.

3.2 North Sector

The layout for the north sector is shown in figure 2 on page 7, and summarised in table 2 on page 8.



(a) 2D view



(b) CAD view

Figure 2: Baseline layout for North sector. The only potential interference highlighted in Fig 2(a) is between a FREIA chopper and an empty beam port. This should be considered in Phase 1 design of FREIA, whether or not to keep the possibility of later use of beamport N4.

Features of design:

- Neither WANSE nor NNBAR instruments are approved or funded at this time. The choice of this beam port allocation will be made later.

Beam Port	Instrument
N1	HR-NSE
N2	—
N3	—
N4	—
N5	FREIA
N6	—
N7	LOKI
N8	—
N9	SLEIPNIR
N10	—

Table 2: Port allocations for North sector.

- Increased space between instruments, without sacrificing future beam ports.

Note that the empty space between instruments is not necessarily useable by each instrument project.

3.3 East Sector

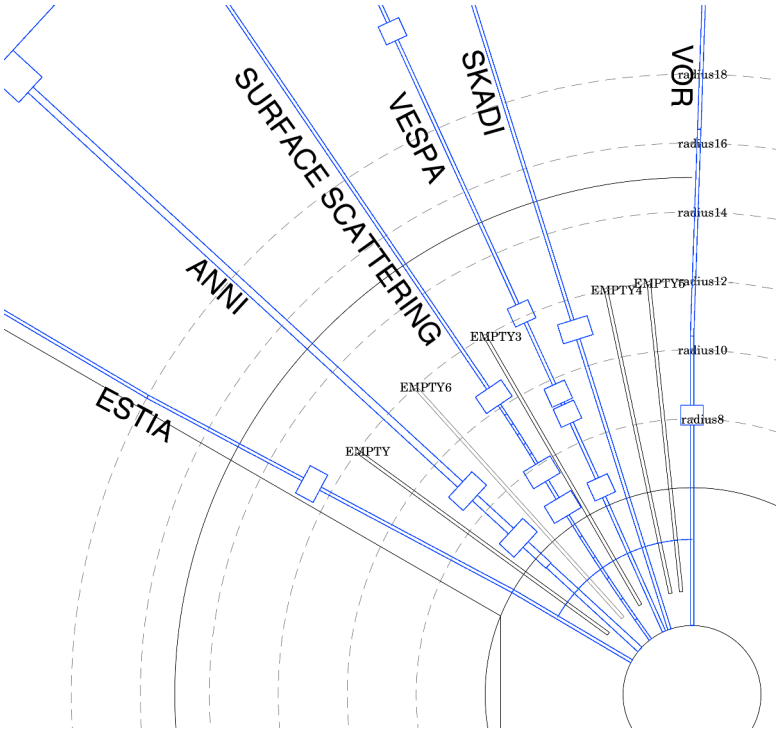
The baseline layout for the East sector is shown in figure 3 on page 10, and summarised in table 3 on page 9. Note that S11 from the South sector is used as an East sector beam port in this layout.

Beam Port	Instrument
E1	ESTIA
E2	—
E3	ANNI
E4	—
E5	SURFACE SCATTERING
E6	—
E7	VESPA
E8	SKADI
E9	—
E10	—
S11	VOR

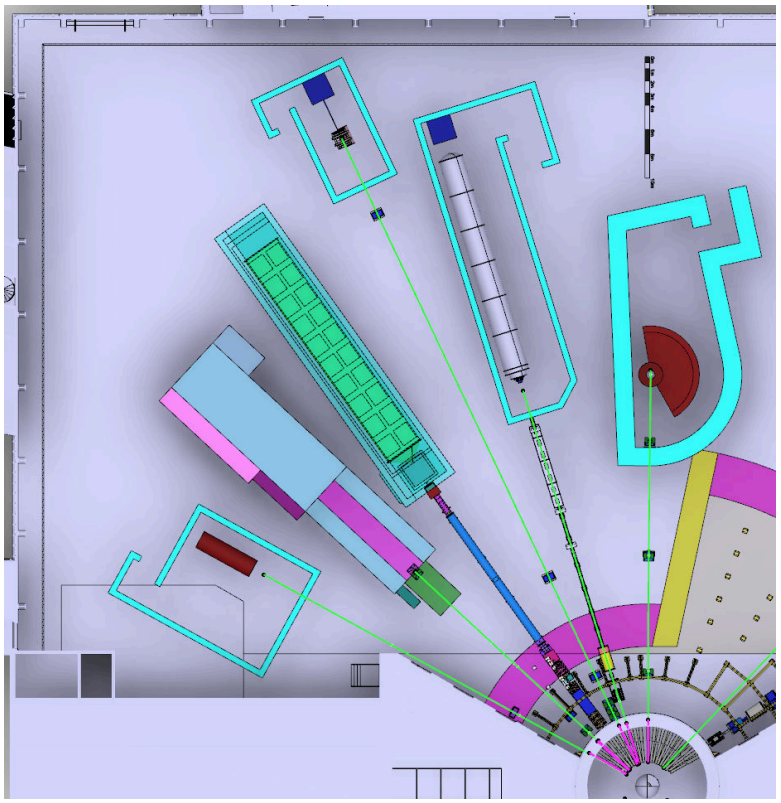
Table 3: Port allocations for East sector.

Features of design:

- VESPA fits into the guide hall by pointing it towards the corner of the building, while avoiding the external doors.
- Other instruments are separated as widely as possible.
- VOR is in the lowest background position for the sector, around 90 degrees.
- ESTIA is along an edge (optimum for ESTIA, due to the beam delivery and shielding concept, even though this was not forced on the algorithm).



(a) 2D view



(b) CAD view

Figure 3: Layout for East sector. Please note that VOR has been moved 4 m away from the target in this figure to remove interference with the bunker in the South sector. An alternative may be to invert the scattering geometry to the left hand side.

3.4 South Sector

The allocations for this sector are illustrated in figure 4 on page 11, and described in table 4 on page 11.

Beam Port	Instrument
S1	—
S2	ODIN
S3	—
S4	DREAM
S5	—
S6	—
S7	—
S8	—
S9	—
S10	—
S11	VOR

Table 4: Port allocations for South sector.

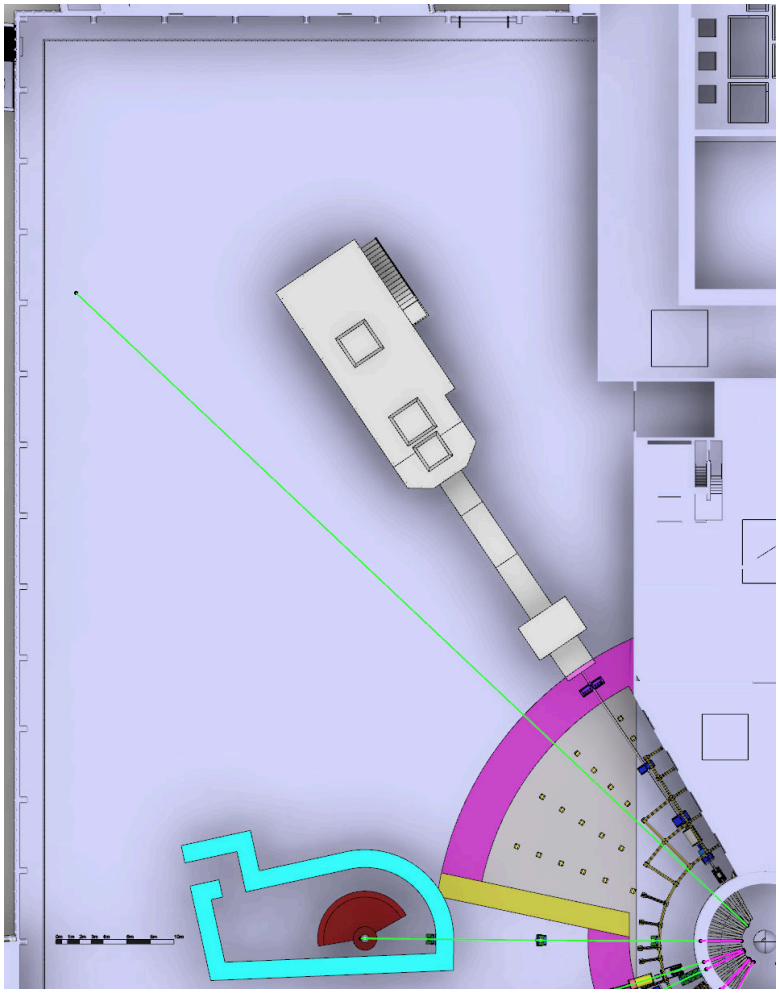


Figure 4: Layout for South sector. Only the trajectory for DREAM is shown in this figure, as there are no detailed engineering drawings available at the time of writing.

The South sector has a space between ODIN and DREAM, but these teams may decide to integrate the two beamlines as neighbours (DREAM moves to S3) if they are satisfied that this holds no significant cost, schedule or operational/maintenance penalty to do so.

Note that VOR, to achieve a 90° angle relative to the proton beam, occupies the S11 beam port.

A test beamline may be deployed in the South sector, but could also be deployed in the other sectors. The beamport chosen will depend on optimising the space, impact on the neighbours, and the view of the moderators.

3.5 Potential Future Beam Ports

In addition to the 22 identified instruments, there appear to be up to 5 useable beam ports in the East sector; up to 3 in the North sector (with a further port reserved for NNBAR or spin echo); and up to 8 available in the South sector, and 2 in the West sector; a total of up to 18 useable ports. The layouts shown here would lead to a suite with:

- 15 early instruments
- 16th instrument (spectroscopy or spin echo)
- 6 further instruments (2^{nd} spin echo or NNBAR, SLEIPNIR, ANNI, Surface Scattering, plus others under discussion) taking the total to 22
- Anticipation of 34 or more instruments. Some of those will in all likelihood need to defer to the footprint of existing neighbours, and identify plans and costs of modifications and integration, in order to be allocated a construction project budget.

Some of the foreseen upgrades include:

- Expansion of South sector to long instruments
- Expansion of West sector to activate W9 and W10
- Upgrades of W1 and S1 to include several instruments on “monochromator farms”
- Possible placements of test beamline(s)

REFERENCES

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[7] K. Andersen and O. Kirstein. Performance losses due to bandwidth changes. Private communication, 8th December 2015.