
MAIN COORDINATE SYSTEMS AT THE ESS



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1. INTRODUCTION

Coordinate systems are used for mapping of position and orientation of geometry in a three-dimensional space.

The Primary Coordinate System at the ESS is the Target Coordinate System (TCS). The TCS is the basis for all survey and alignment field activities involving components that must be installed and aligned at ESS. The TCS is also the coordinate system that all the components in the 3D CAD Master Model (also known as EPL) are referred to.

On another level, a set of local coordinate systems are defined and located in respect to the TCS. These coordinate systems locate important systems of the facility, and are widely used at the ESS to attain a better understanding of the position of the systems.

This document defines the TCS and its position within the Swedish National Reference System. It also defines other coordinate systems used at the ESS and their position with respect to the TCS.

2. COORDINATE SYSTEMS

Coordinate systems at ESS are all orthonormal Cartesian systems. Such systems are fully defined once their respective origin and axis orientation are expressed in an already known system. All coordinate systems at ESS follow the right-hand rule.

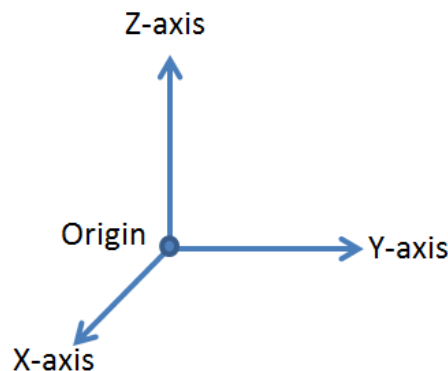


Figure 1: Cartesian Coordinate System

3. SWEDISH NATIONAL COORDINATE SYSTEM

Absolute position of coordinate systems are defined using the Swedish Reference Frame 1999, also known as SWEREF99, and the Rikets Höjdsystem 2000 also known as RH2000.

SWEREF99 13 30 is the Cartesian coordinate system in South West Sweden that determines the absolute East and North of a point. It is used to position the origin of a coordinate system and to orient the axes.

RH2000 is the Sweden's national height system. Zero level is defined as the "Normaal Amsterdams Peil", or NAP. RH 2000 defines the absolute altitude of a point.

4. PRIMARY COORDINATE SYSTEM

The Primary Coordinate System is the basis for all survey and alignment field activities involving components that must be installed and aligned at the ESS. It is also used to define and position all other coordinate systems.

The **Target Coordinate System** is defined and established as the Primary Coordinate System at the ESS.

The origin of the TCS is in the center of the monolith defined as the intersection of the proton beam with common vertical axis of the two moderators. Figure 2 shows a schematic representation of the TCS.

The direction of the axes is defined as follows:

- X axis pointing upstream the proton beam
- Z axis collinear to gravity in the opposite direction
- Y axis is defined following the right-hand rule.

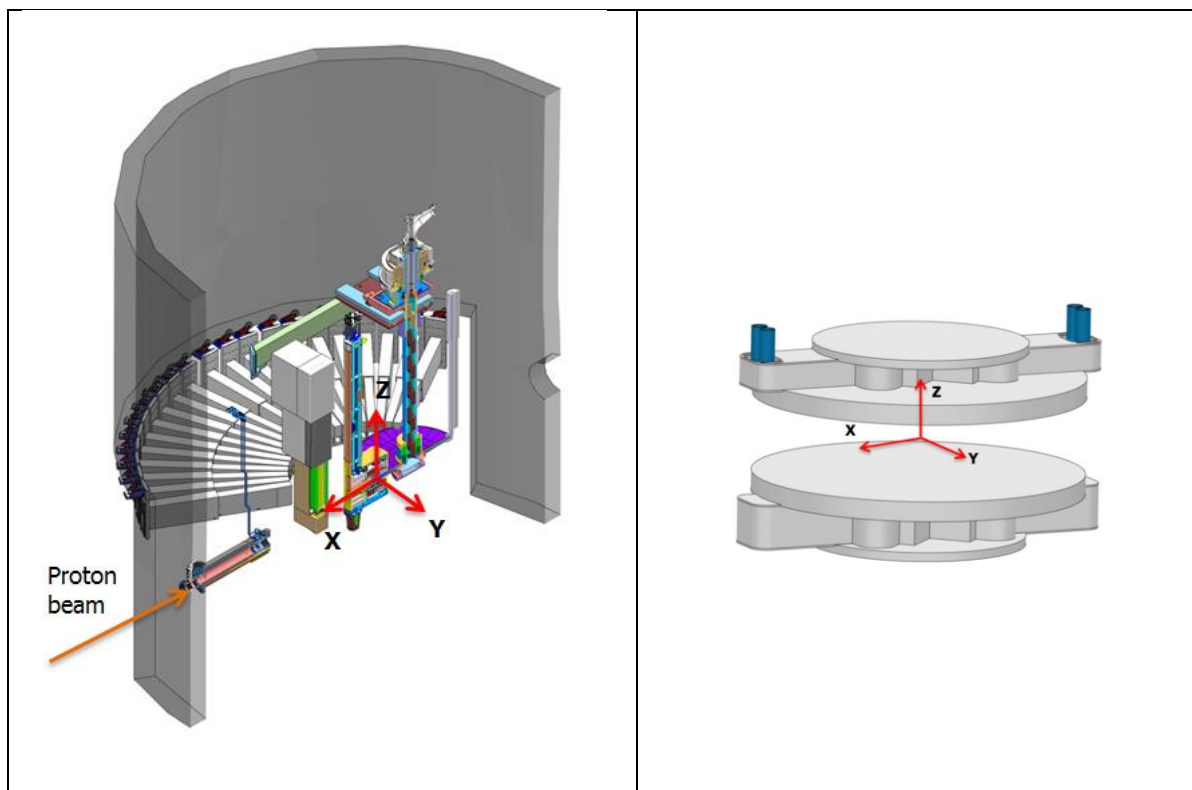


Figure 2: Cut views showing the target coordinate system. Some parts have been hidden for a better view

Location of the TCS origin is specified in Table 1.

SWEDISH NATIONAL COORDINATES			ESS PRIMARY COORDINATES		
SWEREF-99 13 30		RH2000	X [m]	Y [m]	Z [m]
East Coordinate [m]	North Coordinate [m]	Height [m]			
134180,000	6179019,000	81,400	0	0	0

Table 1 Absolute and local coordinates of the origin of the TCS

Absolute orientation of the TCS axes is defined as follows:

- Z-Axis: Collinear to local gravity in opposite direction
- X-Axis: Oriented positive in the east direction, making an angle of 28.5 degrees with the East SWEREF 99 13 30 grid
- Y-Axis: right hand rule.

Figure 3 shows a view of the TCS on the ESS site.

5. SECONDARY COORDINATE SYSTEMS

Other coordinate systems are defined and located with respect to the TCS. These coordinate systems are widely used at the ESS to attain a better understating of the position of some systems. They shall be positioned and oriented respect to the TCS.

The unit system is the metric system.

5.1. Machine Coordinate System (MCS)

The MCS is the Machine Coordinate System. The origin is located in the interface between the ion source and the Low Energy Beam Transport (LEBT) in the front-end section of the accelerator. The X axis is pointing downstream the proton beam, Z is collinear to Z in the TCS and Y is defined with the right-hand rule.

Figure 3 shows a view of the MCS on the ESS site.

Transformation to obtain coordinates of a point in the MCS system can be found in the appendix.

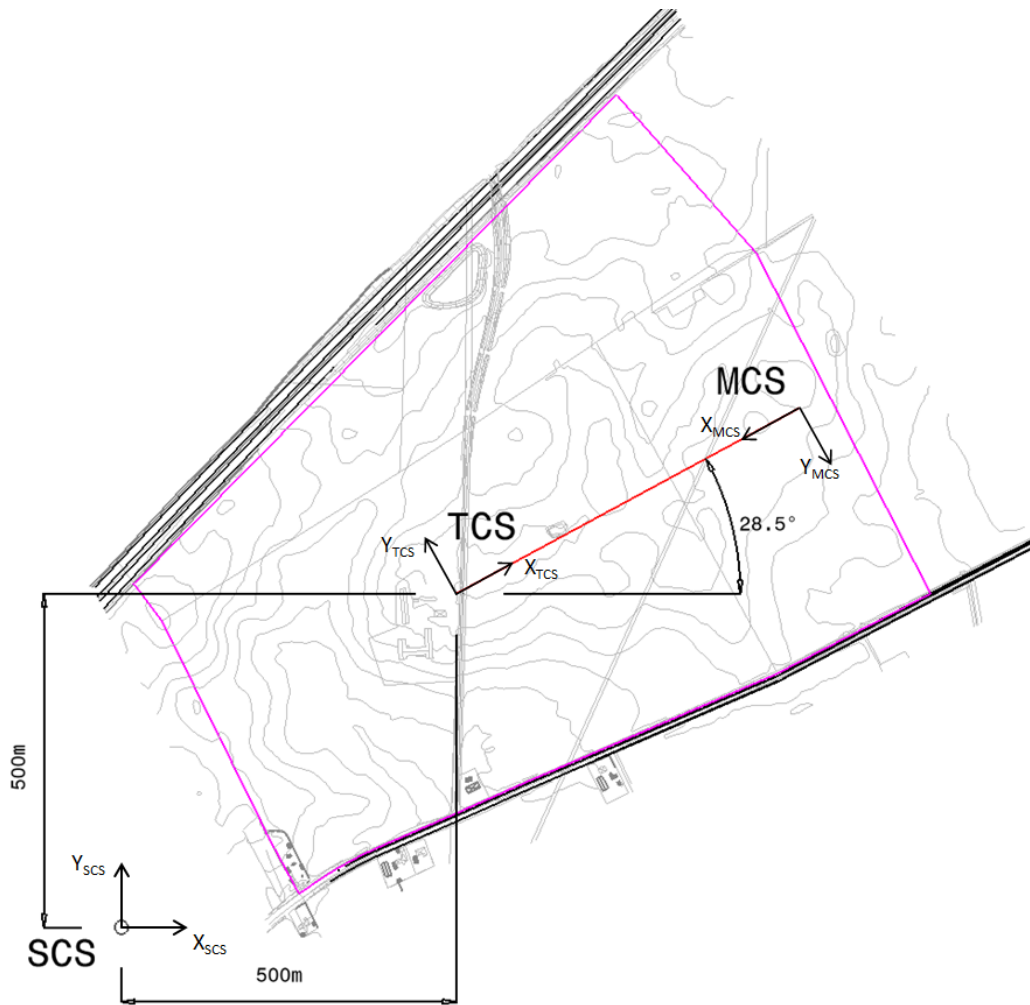


Figure 3 View of the TCS, the MCS and the SCS on the ESS site

5.2. Beam Port Coordinate System (BPCS)

The BPCS is the Beam Port Coordinate System. It is used to define each one of the neutron beam ports inserts within the Monolith Assembly in the Target Station. There will be a total of 42 neutron beam port inserts each one with a central axis and a BPCS. Each insert can be with or without a neutron guide. The wedge, which determines the space which can be occupied by a given instrument, is positioned by the BPCS.

The Moderator Focal point is driven by the design and configuration of the moderators. There will be in total eight moderator focal points: 4 in the top moderator and 4 for in the bottom moderator. The sector that the instrument resides in will determine which moderator focal points are available to that instrument. The location of the moderator focal points relative to the TCS is defined in drawing ESS-0032315.3 [1] and shown in Table 2.

Moderator position	X offset (mm)	Y offset (mm)	Z offset (mm)
Upper Moderator North Sector	54	89	137
Upper Moderator East Sector	54	-89	137
Upper Moderator South Sector	-54	-89	137

Upper Moderator West Sector	-54	89	137
Lower Moderator North Sector	54	89	-152
Lower Moderator East Sector	54	-89	-152
Lower Moderator South Sector	-54	-89	-152
Lower Moderator West Sector	-54	89	-152

Table 2 Location of the eight Moderator Focal points respect the TCS

The central axis of a beam port is oriented towards one of the moderator focal points. The angular orientation of the BPCS is defined in drawing ESS-0050727.2 [2] and shown in table 3. The origin of each BPCS is located across the central axis of a beam port and at a distance of 5500mm from the TCS. Both the central axis and the BPCS lie in the plane defined by the X and Y axis of the TCS, at a height of Z=0mm.

Sector	Beam Port #	Angle around Z axis	Sector	Beam Port #	Angle around Z axis
North	1	30.0°	East	1	-30.0°
North	2	36.0°	East	2	-36.0°
North	3	42.0°	East	3	-42.0°
North	4	48.0°	East	4	-48.0°
North	5	54.0°	East	5	-54.0°
North	6	60.0°	East	6	-60.0°
North	7	66.0°	East	7	-66.0°
North	8	72.0°	East	8	-72.0°
North	9	78.0°	East	9	-78.0°
North	10	84.0°	East	10	-84.0°
West	1	150.0°	South	1	-150.0°
West	2	144.7°	South	2	-144.7°
West	3	138.0°	South	3	-138.0°
West	4	132.7°	South	4	-132.7°
West	5	126.0°	South	5	-126.0°
West	6	120.7°	South	6	-120.7°
West	7	114.0°	South	7	-114.0°
West	8	108.7°	South	8	-108.7°
West	9	102.0°	South	9	-102.0°
West	10	96.0° ¹	South	10	-96.7° ¹
West	11	90.0°	South	11	-90.0°

Table 3 Angular orientation of the BPCS respect to the TCS.

The direction of the axes of the BPCS is defined as follows:

- X is pointing downstream of the central axis of a given neutron beam port.
- Z is parallel to Z in the TCS.

¹W10 and S10 locations are not symmetric over TCS XZ plane

- Y defined following the right-hand rule.

Transformation to obtain coordinates of a point in any of the BPCS systems can be found in the A

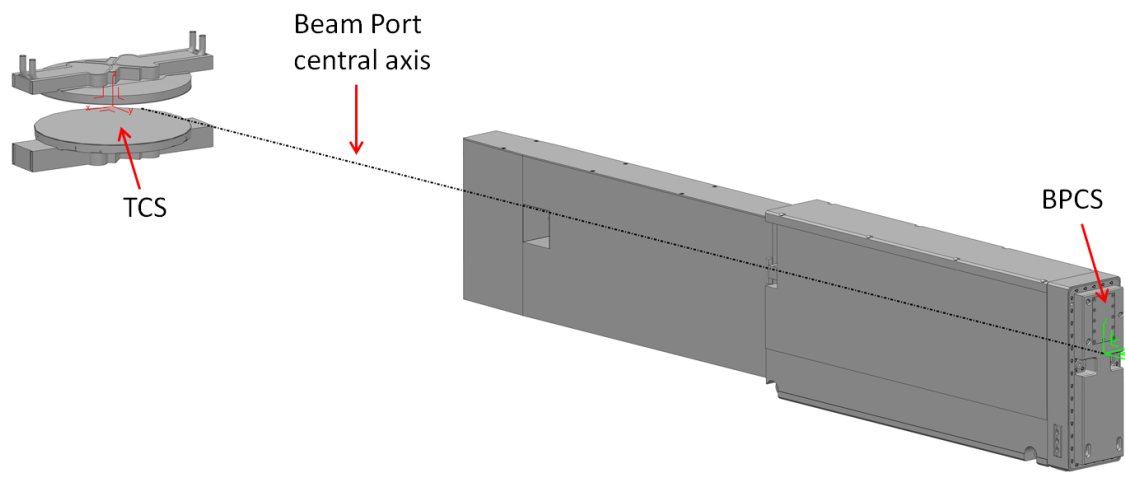


Figure 4 View of the moderator with the TCS, the BPCS and the central axis for a given beam port.

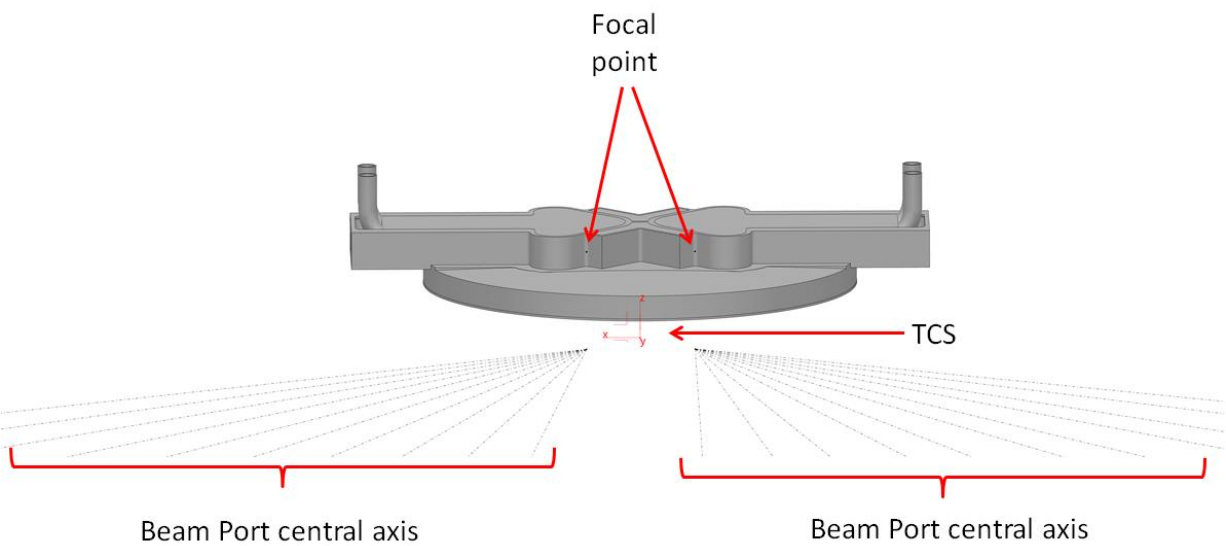


Figure 5 View of the top moderator with 2 of the focal points, the TCS and a set of beam port central axis.

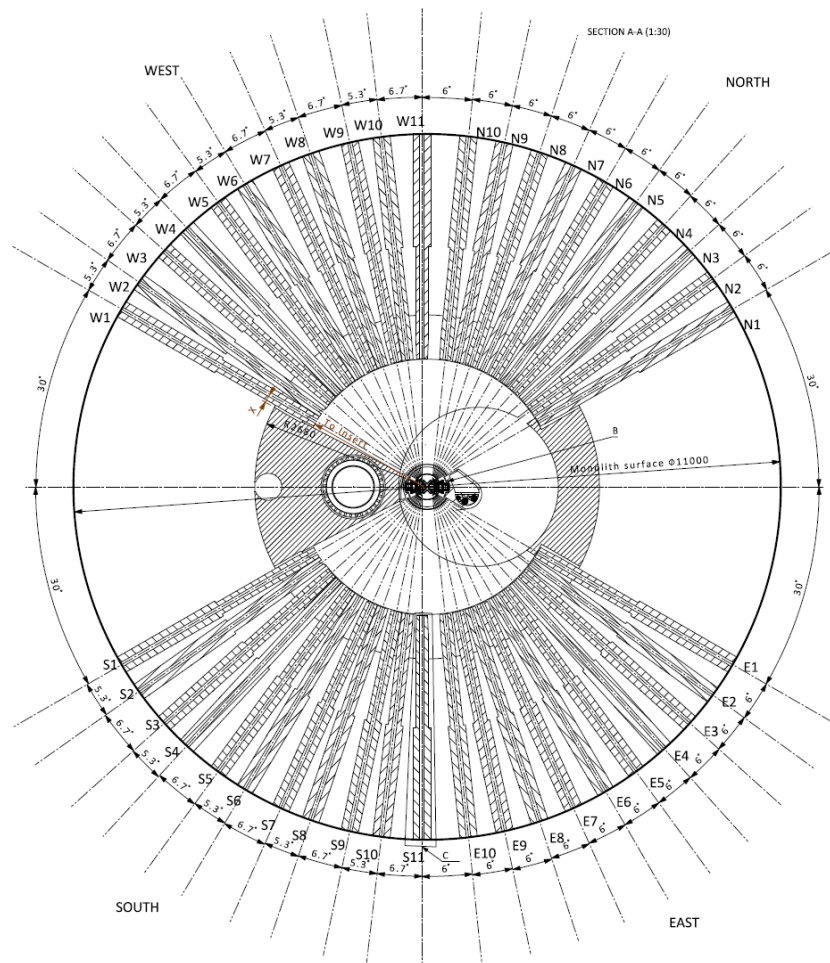


Figure 6: Cut view of the 42 beam ports.

5.3. ISCS (Instrument Source Coordinate System)

The ISCS is the Instrument Source Coordinate System. The origin of the ISCS is the point considered as the neutron source for a given instrument.

The ISCS is specific for every instrument and its position and orientation are driven by the needs of the instrument. It shall be included in the skeleton of any instrument.

The ISCS is usually defined by the scientist responsible for each instrument.

The direction of the axes is defined as follows:

- X is pointing downstream the neutron beam.
- Z is perpendicular to X and shall belong to the plane containing X and the gravity, and opposite to gravity
- Y is defined following the right-hand rule

6. OTHER COORDINATE SYSTEMS

6.1. Site-Wide Coordinate System (SCS)

The SCS is the Site-wide Coordinate System. The origin of the SCS is located underground: 500m south and 500m west of the TCS following the SWEREF grid and at -81.4meters in Z direction. X axis

is pointing East, Y axis is pointing North and Z axis defined with the right-hand rule. SCS guarantees that any ESS system is described by positive coordinates.

Transformation to obtain coordinates of a point in the SCS system can be found in Appendix1.

6.2. Building Coordinate System (BCSA)

The BCSA is the Building Coordinate System. Its origin is located in the same X and Y as the TCS, and at -81,4meters in Z direction. It is used mainly for a CAD translation of models between CF and the Integration Group. The direction of the axes is the same as the TCS.

Transformation to obtain coordinates of a point in the SCS system can be found in Appendix1.

7. GLOSSARY

Term	Definition
BCS	Building coordinate system
BPCS	Beam Port coordinate system
CAD	Computer Aided Design
CF	Conventional Facilities
EPL	ESS Plant Layout
ESS	European Spallation Source
ISCS	Instrument source coordinate system
MCS	Machine coordinate system
SCS	Site-wide coordinate system
TCS	Target coordinate system

8. REFERENCES

- [1] ICD Moderator-NSS, ESS-0032315.3
- [2] BPCSs and R6 roof support pillars skeleton, ESS-0050727.2

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First issue - Moderator position updated	X. Permanyer	2015-08-05
2	Moderator position in Z direction updated	X. Permanyer	
3	BPCS located at 5.5m from TCS. ISCS origin definition updated. New positon of Focal Points	X. Permanyer	
4	Remove false references	F. Rey	2019-03-10

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Revision	Reason for and description of change	Author	Date
5	Change references	F. Rey	2019-03-18
6	Corrected BPCS definition, integrated the change on W10, corrected BPCS locations in embedded files, removed notion of an upper/lower BPCS, released together with skeleton [2], removed old referenced drawing.	J. Koning	2020-05-28

9. APPENDIX

9.1. Coordinate System Transformation



CS_transformation_v
4.xlsx

9.2. Transformation Matrices from TCS

(BPCSs not included, for these refer to the embedded excel file above or [2])



Transformation from
TCS_v3.docx