S01020500-IS0023-R00

# SECOND TARGET STATION (STS) PROJECT

# Interface Sheet for Moderator Reflector Assembly and Instrument Systems


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**5/2/2022**


OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

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| Revision | Description |
|---|---|
| 00 | Initial Release |
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# 1. PURPOSE

This document defines the Neutron Beam layout and characteristics of the interfaces between Moderator Reflector Assembly and Instrument Systems neutron scattering instruments and bunker. The interface described in this document will provide guidance to the designs of the Moderator Reflector Assembly, neutron scattering instruments and Bunker Systems. Moderator locations and neutronic characteristics are all key inputs into the design and optimization of the neutron scattering instruments.

# 2. SCOPE

The scope of this document is the Neutron Beam layout and characteristics interface between Moderator Reflector Assembly and Instrument Systems as identified in the parent Interface Control Document S01020500-IC0004 [1] between Target Systems and Instrument Systems. The scope of this document does not include the physical hardware connections such as the core vessel seal between Target Systems and Instrument Systems.

## 2.1 INTERFACING PARTS OR COMPONENTS

| No. | Components (Moderator Reflector Assembly) | | Components (Instrument Systems) | |
|---|---|---|---|---|
| | Name | Functional reference Number | Name | Functional reference Number |
| 1 | Moderator Reflector Assembly | S03040000-M8U-8800-A001 | Instrument Systems | S04000000-M8U-8800-A10000 |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

# 3. ACRONYMS AND DEFINITIONS

| | |
|---|---|
| ICD | Interface Control Document |
| IS | Interface Sheet |
| MRA | Moderator Reflector Assembly |
| SSC | Structure, System or Component |
| STS | Second Target Station |
| WBS | Work Breakdown Structure |

# 4. REFERENCES

## 4.1 DOCUMENTS APPLICABLE TO THE INTERFACING SSCS

| Ref | Document Titles | Document Control System Location |
|---|---|---|
| [1] | S01020500-IC0004 | |
| [2] | Second Target Station Conceptual Design Report | |
| [3] | Second Target Station Neutron Beam Size Report | |
| [4] | Preliminary Moderator Optimization Report | |
| [5] | Moderator Selection Report | |

# 5. INTERFACE DEFINITION

## 5.1 TECHNICAL DESCRIPTION OF THE INTERFACE

In the STS design, a pulsed proton beam is converted to pulsed high brightness cold neutron beams optimized for neutron scattering experiments. The Target Systems group is responsible for designing a Target Assembly to produce neutrons from the pulsed proton beam and a Moderator Reflector Assembly to convert the neutrons emitted from the target to cold neutron beams useful for neutron scattering experiments on the instruments designed by Instrument Systems group. The Instruments Systems group is responsible for the design of the neutron optics modules within the target monolith and all beamline components outside the monolith.

The number of moderators, number of beamlines, and angular orientation of the beamlines to be included in the STS design have been determined during the conceptual design phase of the project [2] while the characteristics of those neutron beams such as the size of the viewed area of the moderator [3], the maximum acceptance aperture of the guide entrance, the distance of the guide entrance from the viewed face of the moderator, and the desired neutron beam characteristics have been determined by the Instrument Systems group in collaboration with the Target Systems group during early preliminary design.

The two moderator types under consideration provide opportunity to best match moderator neutronics performance to neutron instrument requirements. Relevant moderator figures-of-merit continue to be peak brightness, time-averaged brightness, and the time distribution of neutrons emitted from the moderator face typically provided as FWHM (neutron pulse widths) for initial evaluation. Optimizing each moderator for both peak and time-average brightness separately has established useful bounding performance values, while middle configurations balance performance between the two [4]. Optimizing moderator geometry for maximum time-average brightness comes at the expense of broader neutron time distributions and consequently lower wavelength resolution, while optimizing for peak brightness comes at the expense of flux on sample.

Early in preliminary design, the Neutronics Team has completed a moderator optimization which determined optimal MRA configurations for peak brightness, time-average brightness, and a middle configuration between the two for each moderator [4]. Source files for all configurations for both moderators were supplied to the Instrument Systems group for further evaluation. After detailed analysis on representative instruments, the Instrument Systems group decided that the middle configuration the best instrument performance for both the upper, cylinder moderator and lower, tube moderator [5].

## 5.2 INTERFACE DATA

### 5.2.1 Moderator Performance Parameters

The neutron beam characteristics of the chosen configuration are illustrated below as a series of emission time distributions (ETD), peak and time-averaged brightness, and ETD FWHM plots. Additionally, the source files from the neutronics simulation of the chosen configuration are attached.

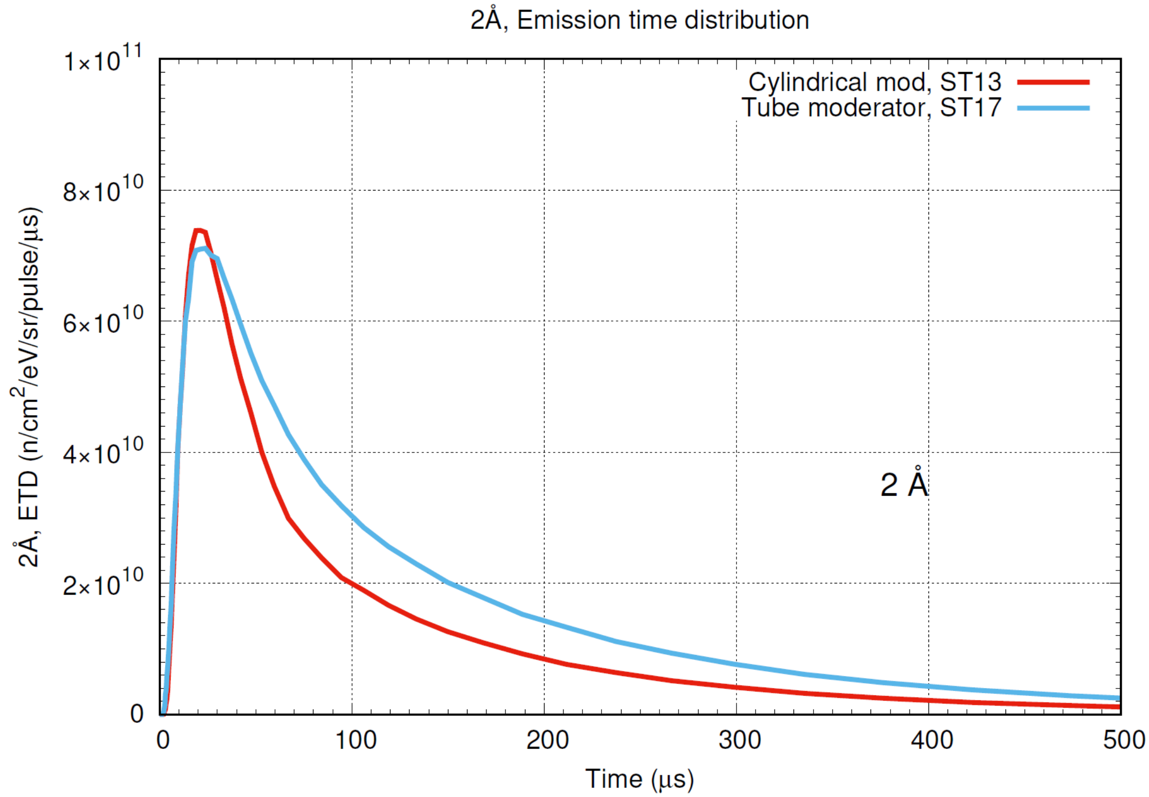


Figure 1. Emission time distribution for the chosen optimized configurations of the 2 moderators at 2Å.

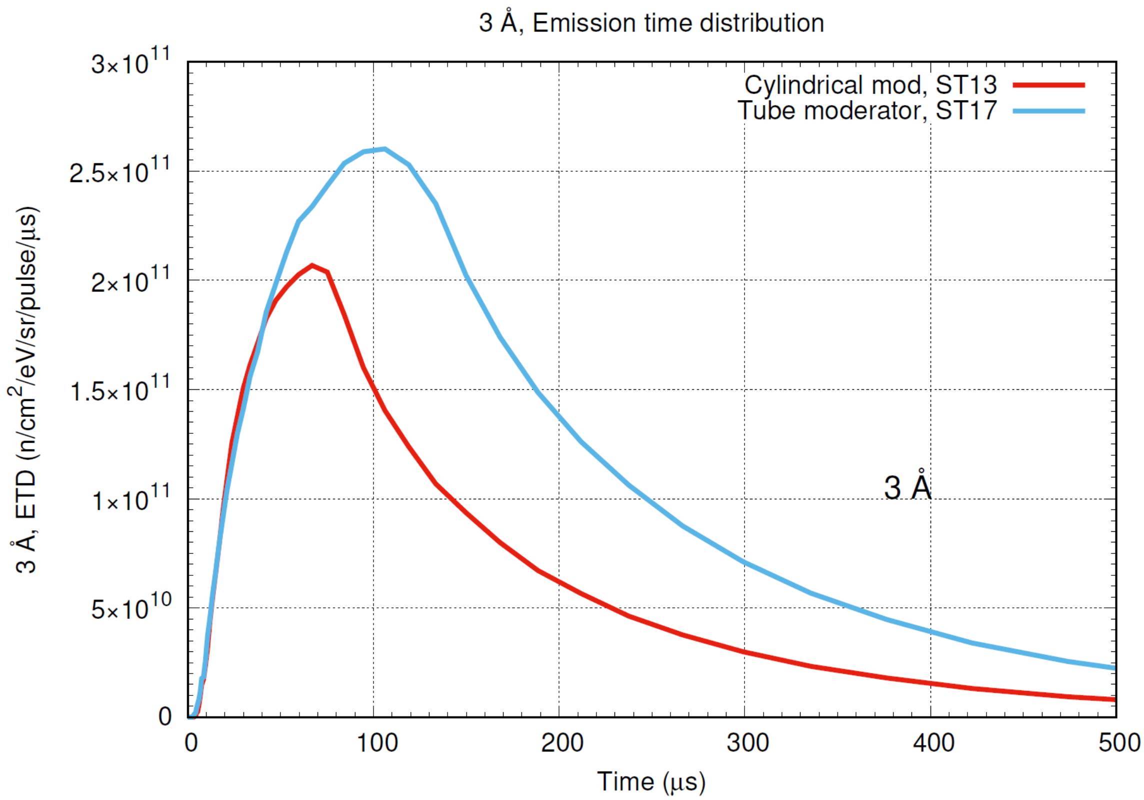


Figure 2. Emission time distribution for the chosen optimized configurations of the 2 moderators at 3Å.

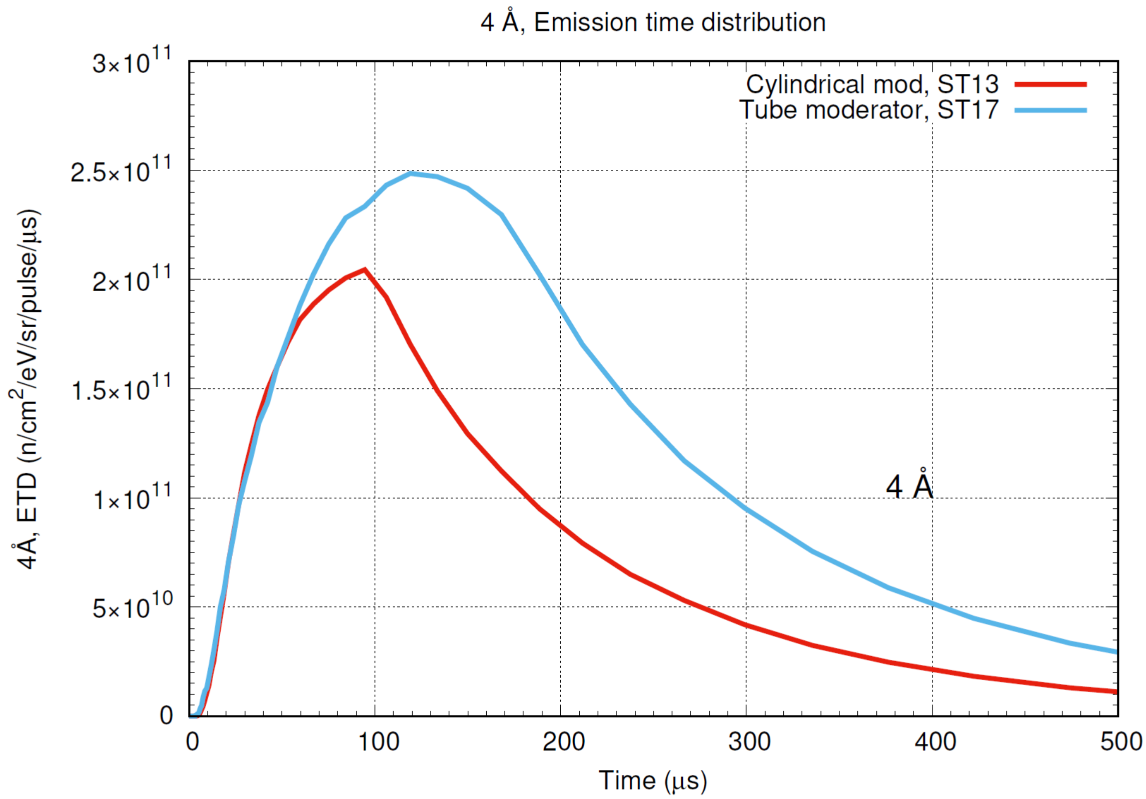


Figure 3. Emission time distribution for the chosen optimized configurations of the 2 moderators at 4Å.

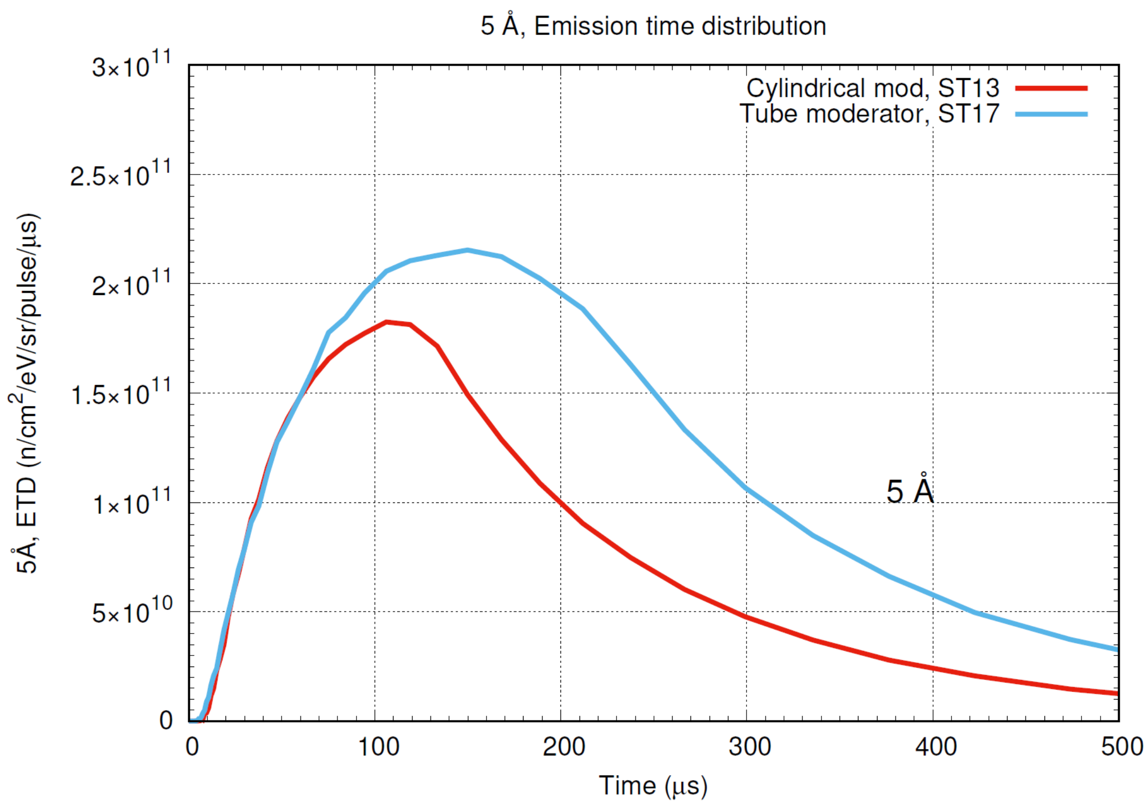


Figure 4. Emission time distribution for the chosen optimized configurations of the 2 moderators at 5Å.

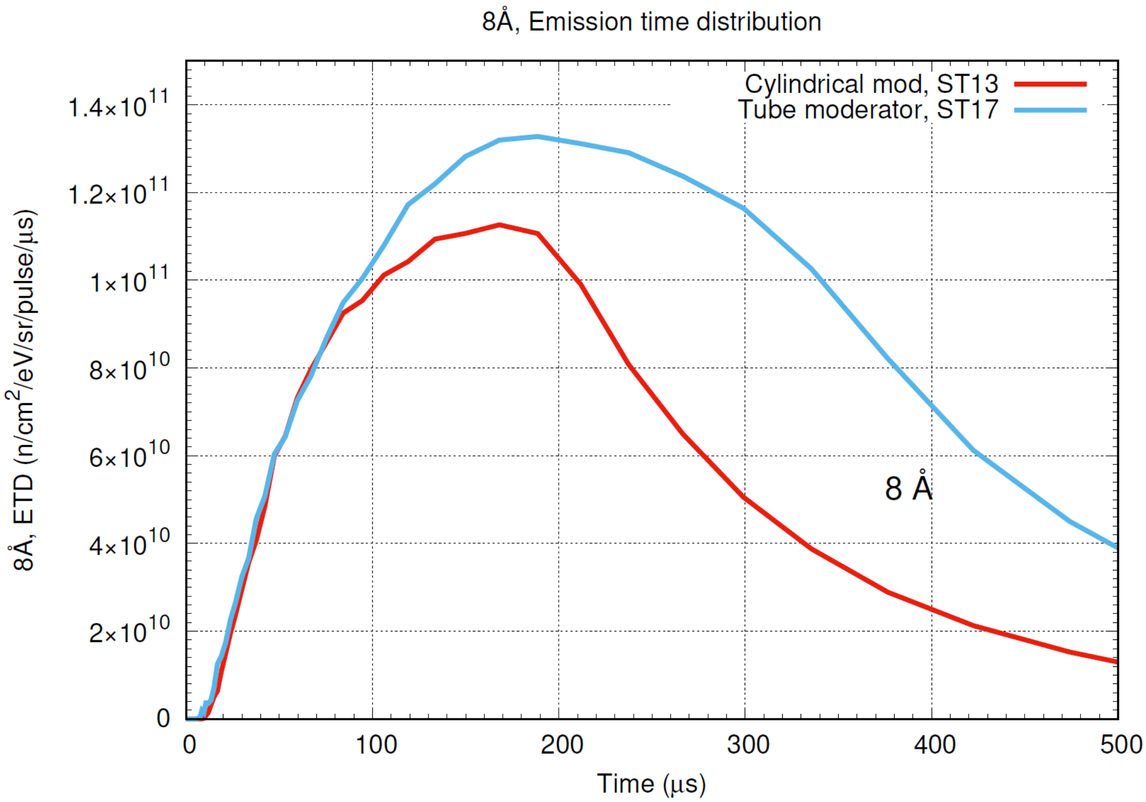


Figure 5. Emission time distribution for the chosen optimized configurations of the 2 moderators at 8Å.

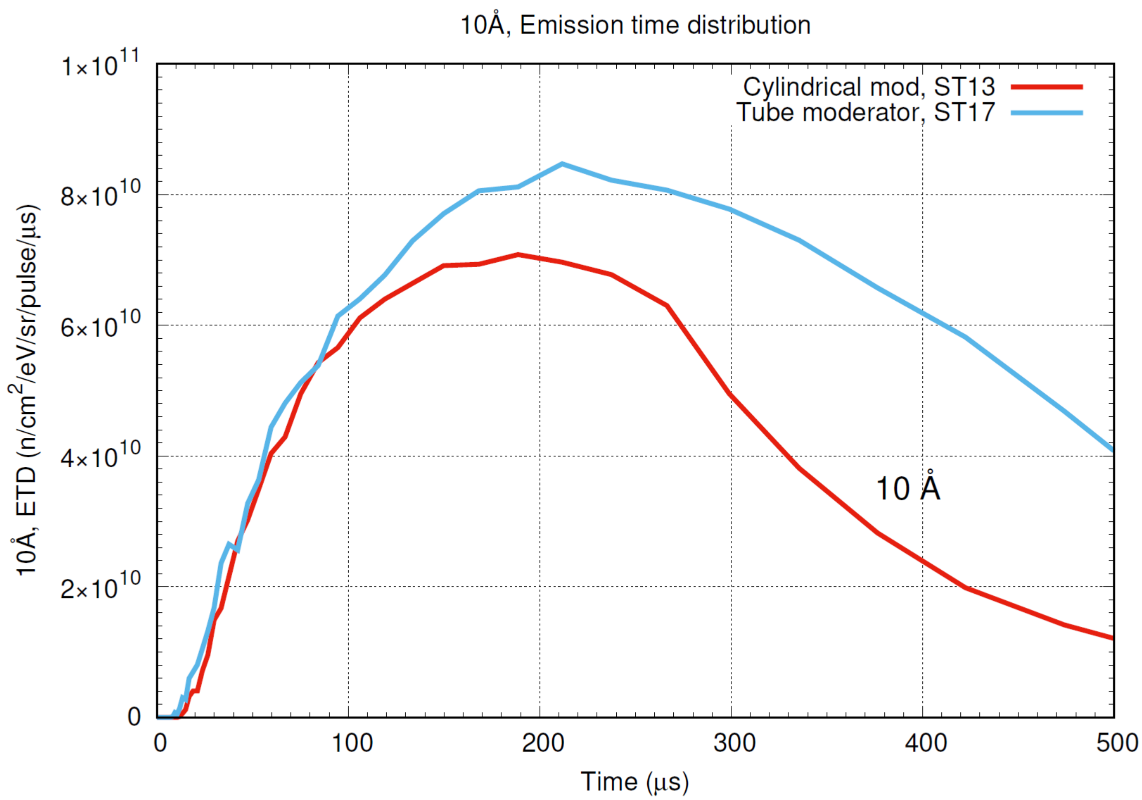


Figure 6. Emission time distribution for the chosen optimized configurations of the 2 moderators at 10Å.

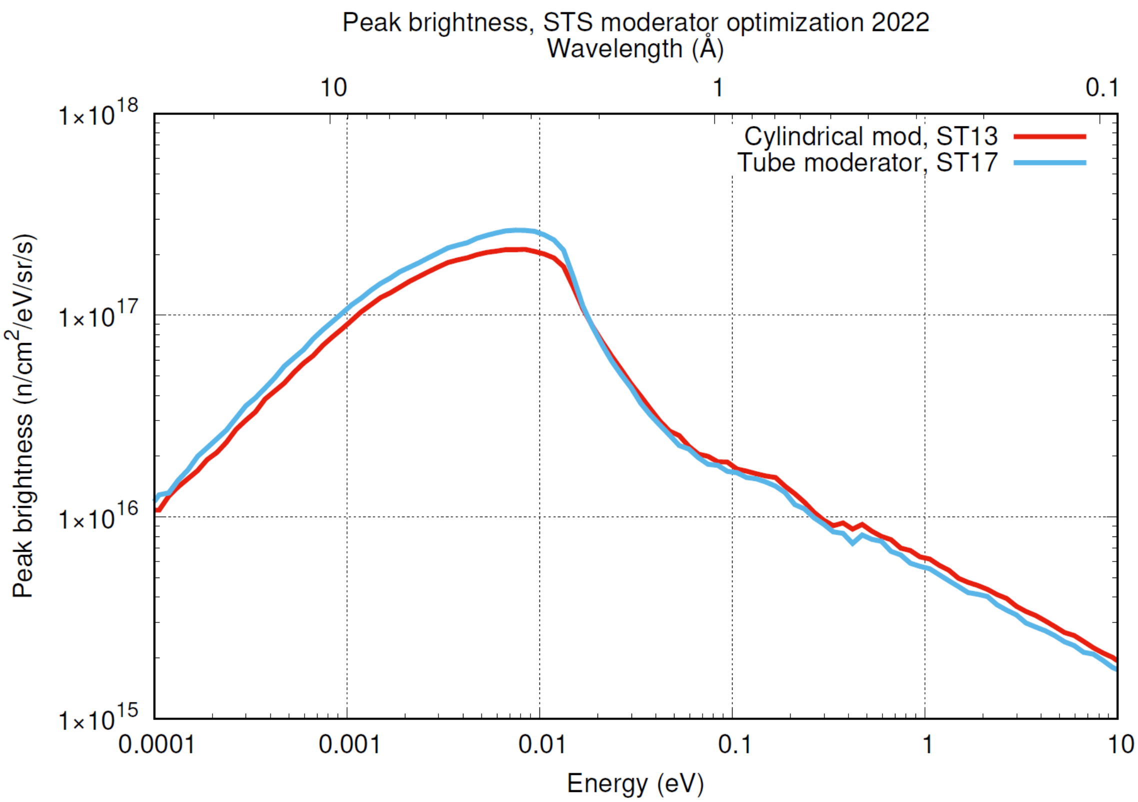


Figure 7. Peak brightness for the chosen optimized configurations of the 2 moderators (log scale).

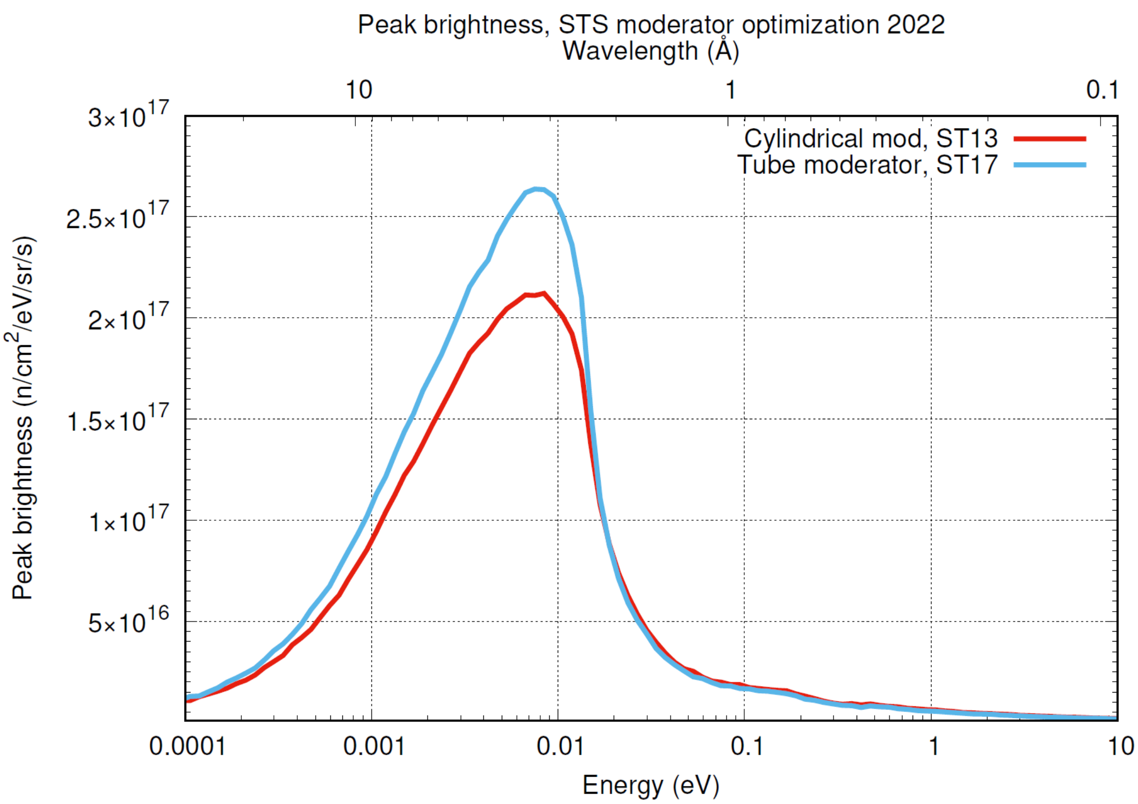


Figure 8. Peak brightness for the chosen optimized configurations of the 2 moderators (linear scale).

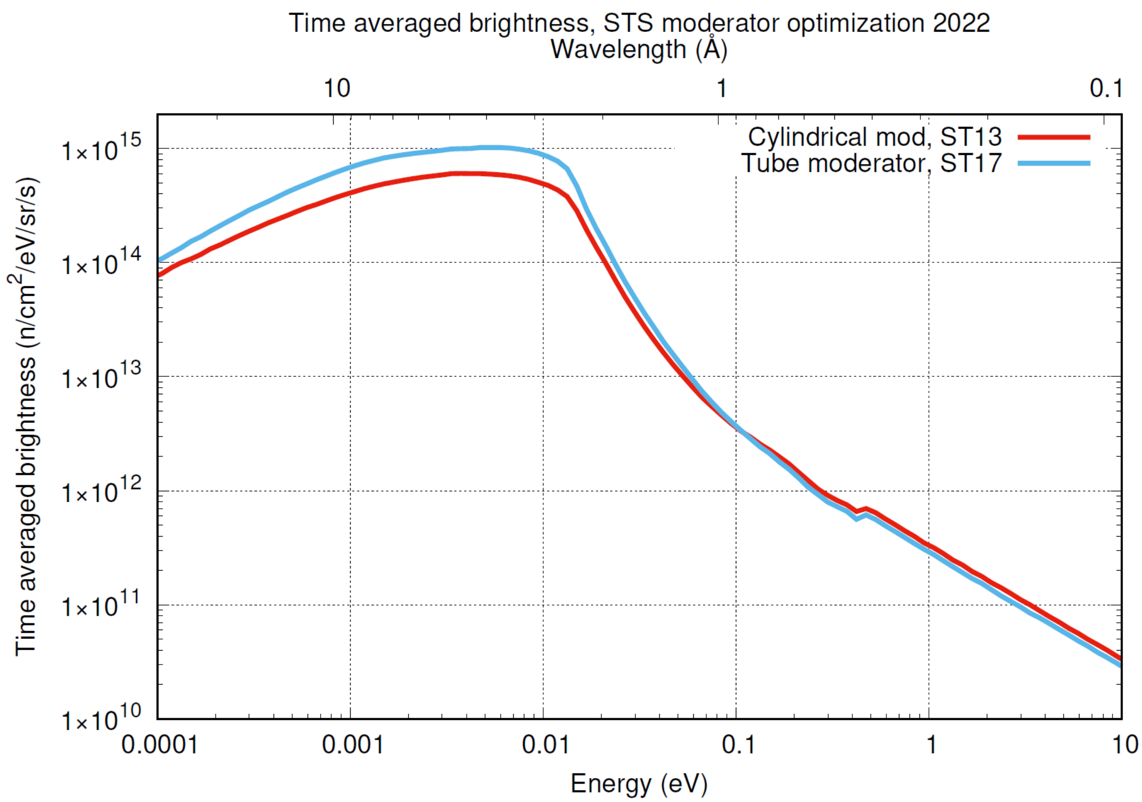


Figure 9. Time-average brightness for the chosen configurations of the 2 moderators (log scale).

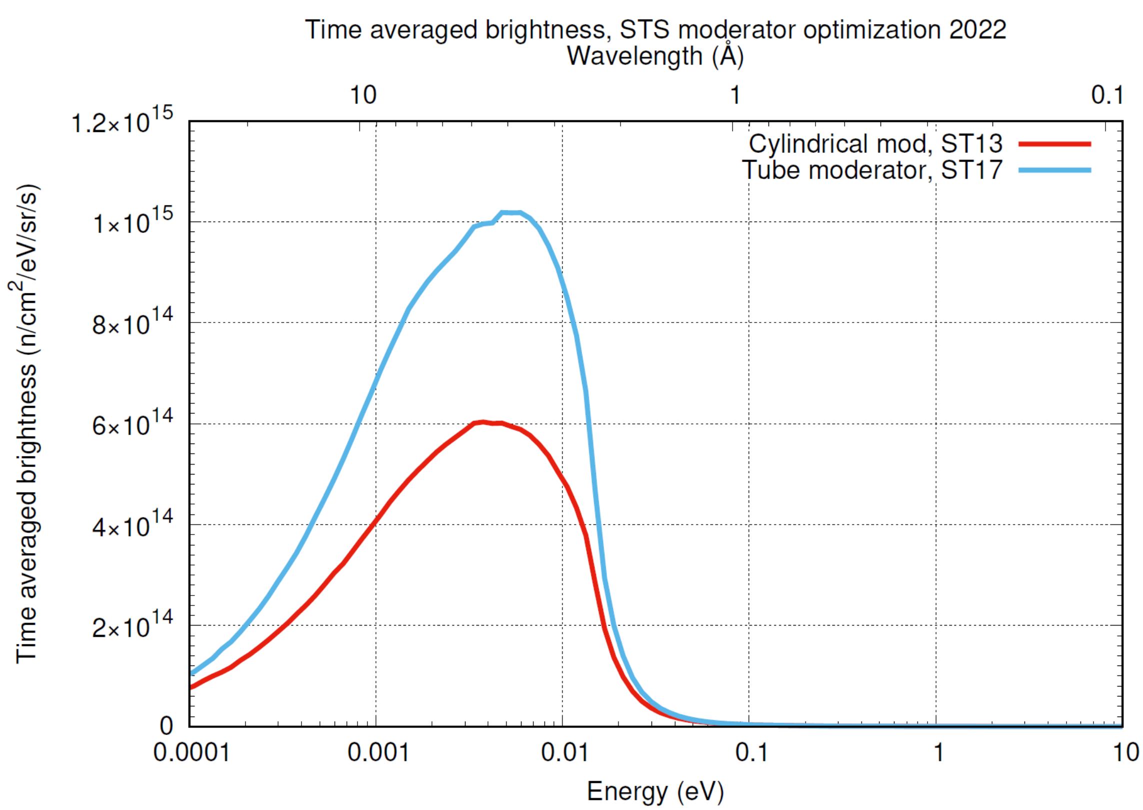


Figure 10. Time-average brightness for the chosen configurations of the 2 moderators (linear scale).

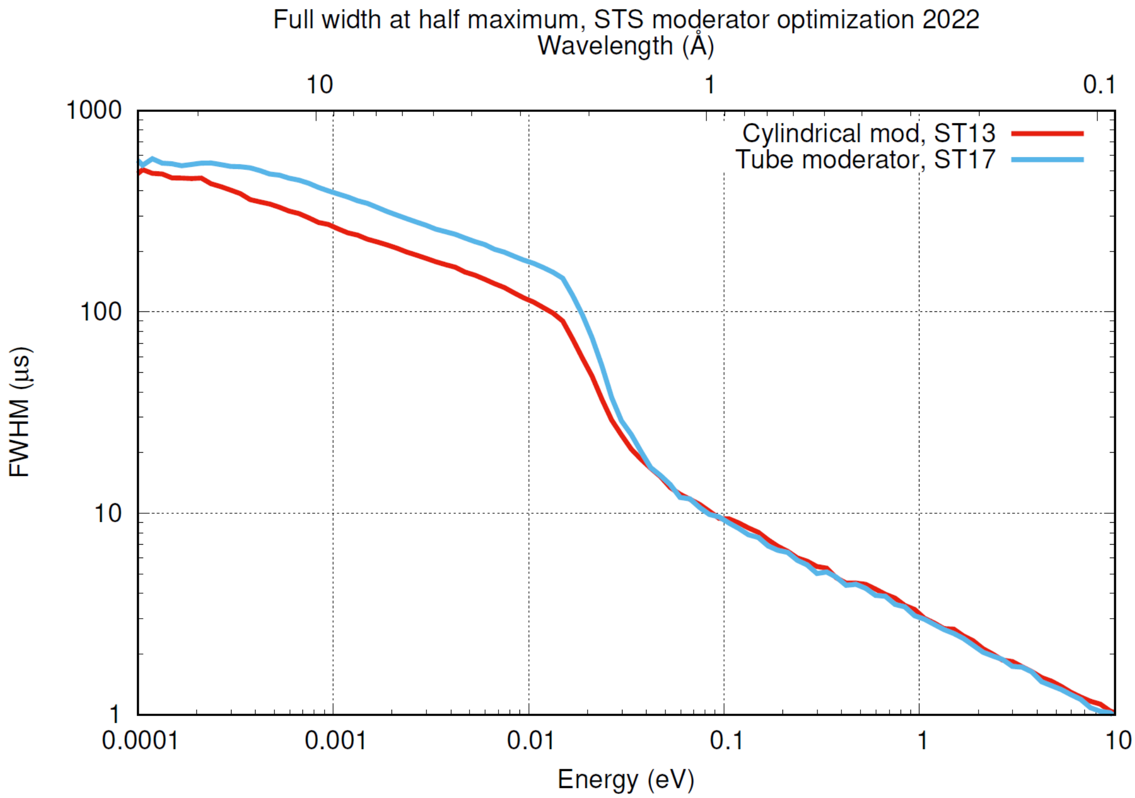


Figure 11. Full Width at Half Maximum for the chosen configurations of the 2 moderators (log scale).

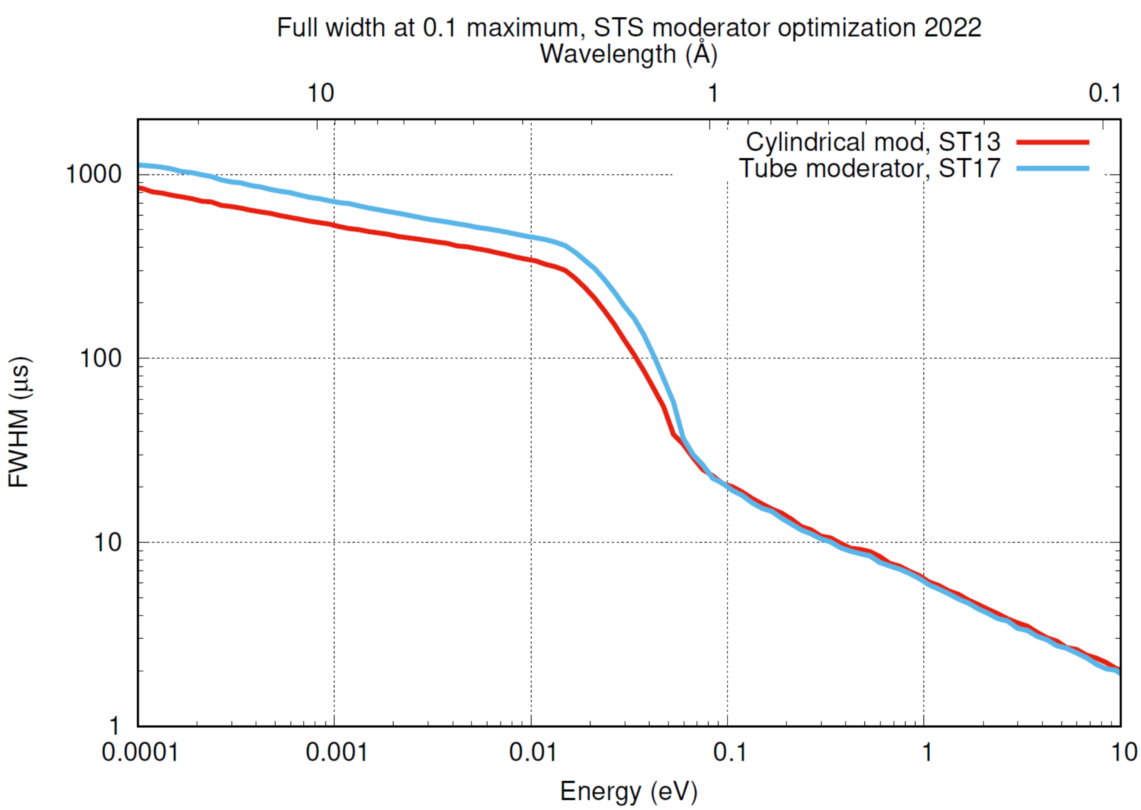


Figure 12. Full Width at 0.1 Maximum for the chosen configurations of the 2 moderators (log scale).

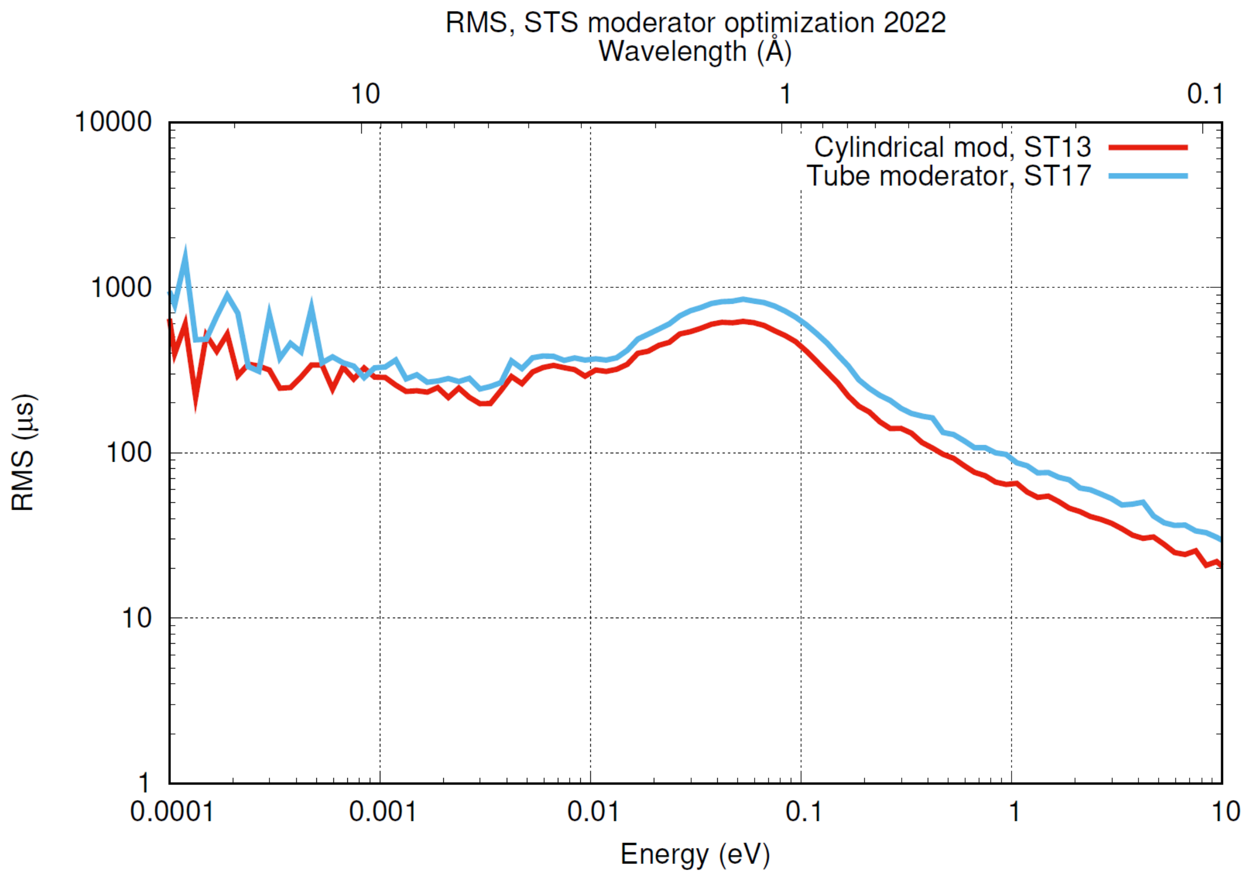


Figure 13. Root mean square for the chosen configurations of the 2 moderators (log scale).

### 5.2.2 Interface Geometry

As described in the Conceptual Design Report [2], the STS design will feature a total of 22 beamlines. The upper moderator, located just above the target, will be viewed by 16 of those beamlines, while the lower moderator, located just beneath the target, will be viewed by the remaining 6 beamlines. The angular orientation of each beamline and which moderator each beamline views is shown in Table 1 and Figure 14 below. The viewed area geometry, guide entrance geometry, and guide entrance distance is also listed in Table 1. The characteristic size of the viewed face of the moderators will be 30 mm, as discussed in reference [3].

Table 1. STS Beamline Geometry

| Beamline | Angle from Proton Beam | Moderator | Viewed Area Geometry | Guide Entrance Geometry | Guide Entrance Distance |
|---|---|---|---|---|---|
| ST01 | -145° | Lower | Ø30mm Circle | 50mm Square | 750mm |
| ST02 | -134° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST03 | -123° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST04 | -112° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST05 | -101° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST06 | -90° | Lower | Ø30mm Circle | 50mm Square | 750mm |
| ST07 | -79° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST08 | -68° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST09 | -57° | Upper | 30mm Square | See 5.2.2.1 | 2000mm |
| ST10 | -46° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST11 | -35° | Lower | Ø30mm Circle | 50mm Square | 750mm |
| ST12 | 35° | Lower | Ø30mm Circle | 50mm Square | 750mm |
| ST13 | 46° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST14 | 57° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST15 | 68° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST16 | 79° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST17 | 90° | Lower | Ø30mm Circle | 50mm Square | 750mm |
| ST18 | 101° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST19 | 112° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST20 | 123° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST21 | 134° | Upper | 30mm Square | 50mm Square | 1000mm |
| ST22 | 145° | Lower | Ø30mm Circle | 50mm Square | 750mm |

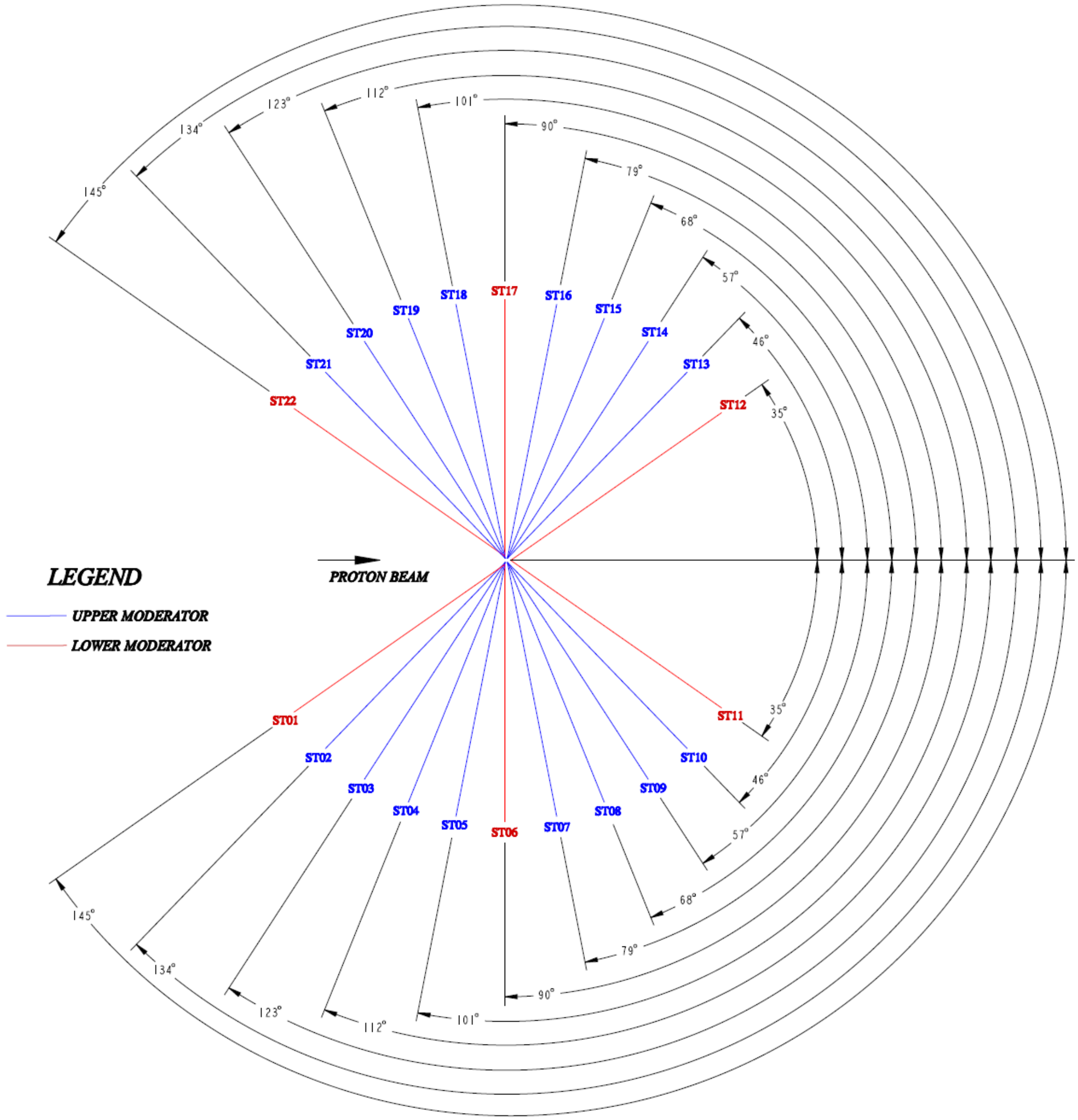


Figure 14. Overall Beamline Angle Layout Plan View. Angles Defined Relative to the Proton Beam Direction.

Figures 15,16, and 17 define the beamline origins on the viewed faces of the hydrogen moderators. The beamline origins are located on the outer surface of the hydrogen. Detailed preliminary engineering of the Target Assembly and Moderator Reflector Assembly has not yet begun; therefore, the proton beam center horizontal plane to moderator center distances depicted in Figure 13 will see minor adjustments in a future revision expected in mid-2022. Guide entrance distances may also change as the design matures.

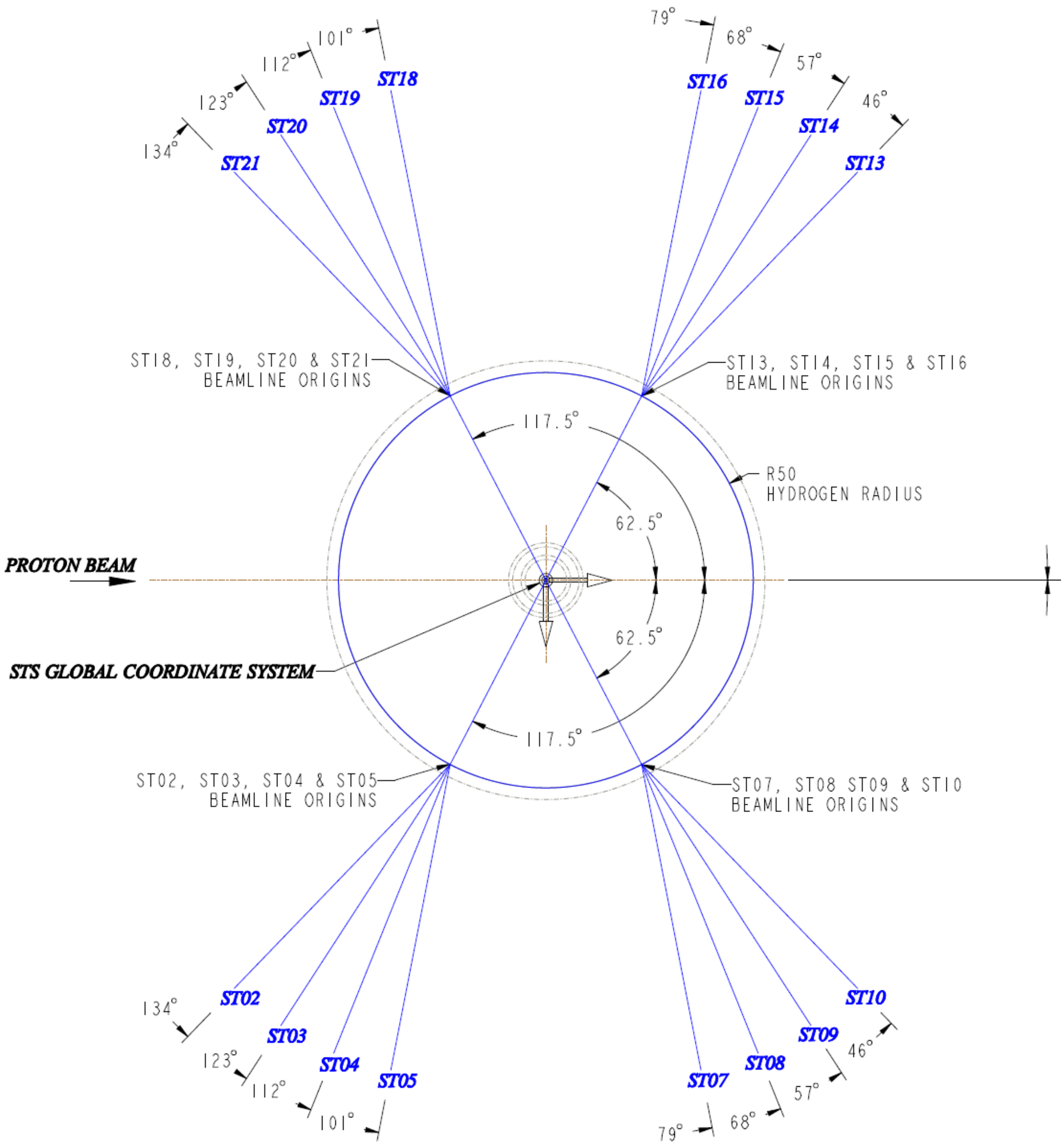


Figure 15. Cylinder Moderator Beamline Layout Plan View (dimensions in mm).
Cylinder Moderator Vertical Axis is Aligned with the STS Global Coordinate System Vertical Axis.
Hydrogen Boundary and Beamlines are Shown in Blue.

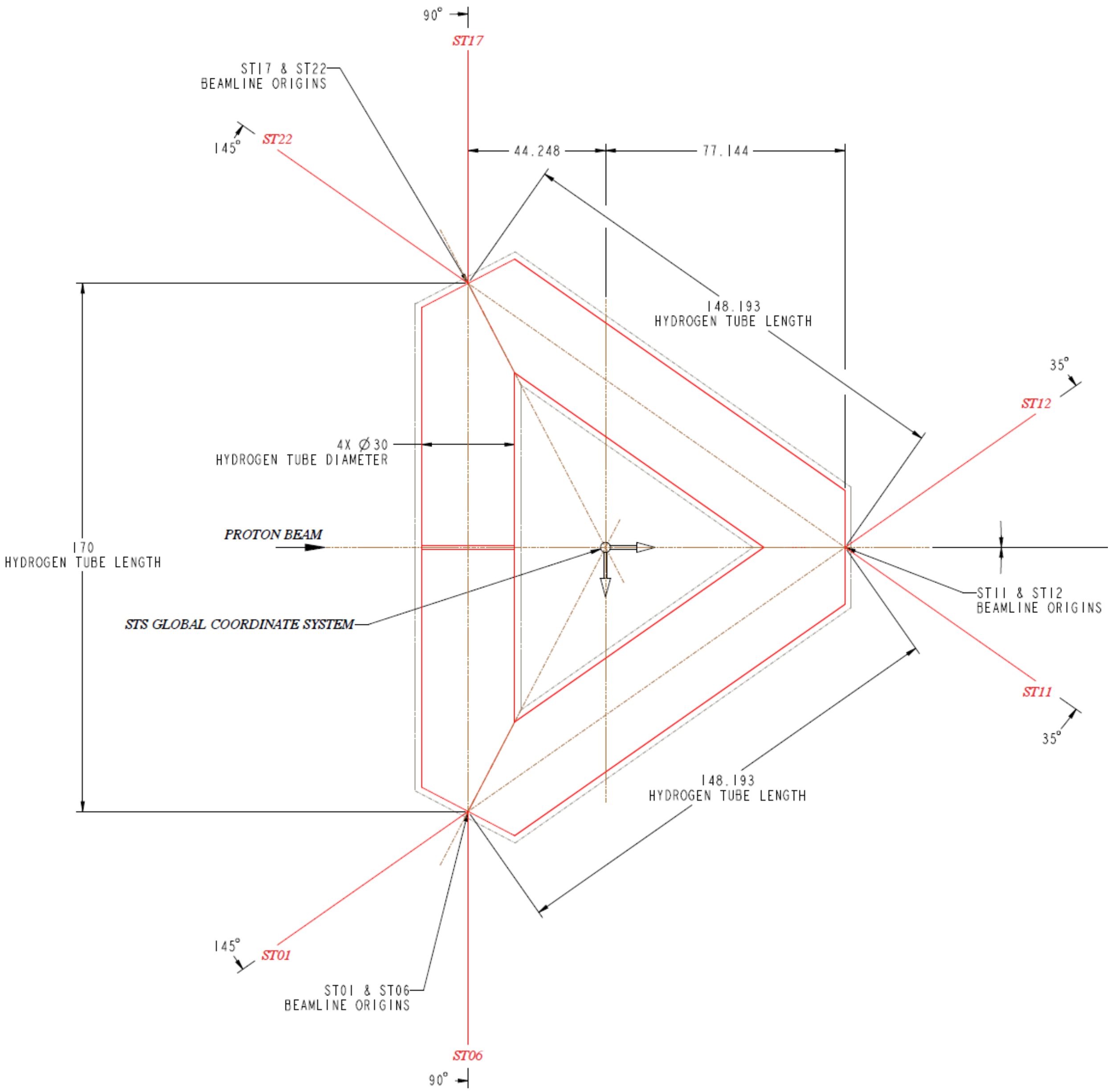


Figure 16. Tube Moderator Beamline Layout Plan View (dimensions in mm).
Tube Moderator Angular Bisector Intersection is Aligned with the STS Global Coordinate System Vertical Axis. Hydrogen Boundary and Beamlines are Shown in Red.

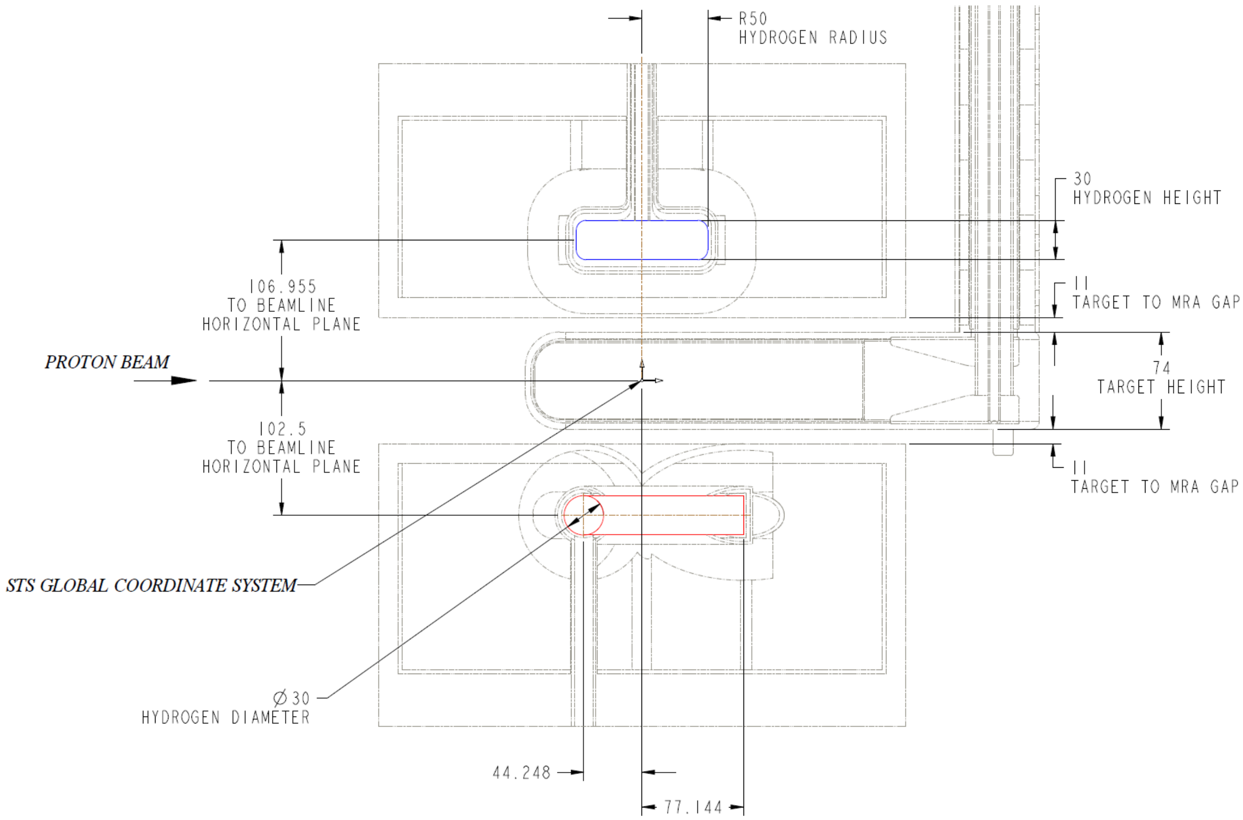


Figure 17. Moderator Vertical Cross-section Along Proton Beam Axis (dimensions in mm). Cylinder Moderator Hydrogen Boundary is Shown in Blue. Tube Moderator Hydrogen Boundary is Shown in Red.

#### 5.2.2.1 Beamline ST09 Geometry

The ST09 beamline will house the QIKR instrument, a horizontal-sample-surface reflectometer, which will feature 2 independent beamlines offset 2.5 degrees from horizontal, one up and one down, as shown in Figure 18. Each beamline is also angled from the nominal beamline angle to allow space for the independent beamlines and sample locations as shown in Figure 19. The dimensions of the rectangular guide entrances at the distance of 2000 mm from the moderator viewed face are shown in Table 2.

Table 2. ST09 Rectangular Guide Entrance Geometry

| Beamline | Guide Entrance Width | Guide Entrance Height |
|---|---|---|
| ST09-U | 30mm | 37mm |
| ST09-L | 30mm | 41mm |

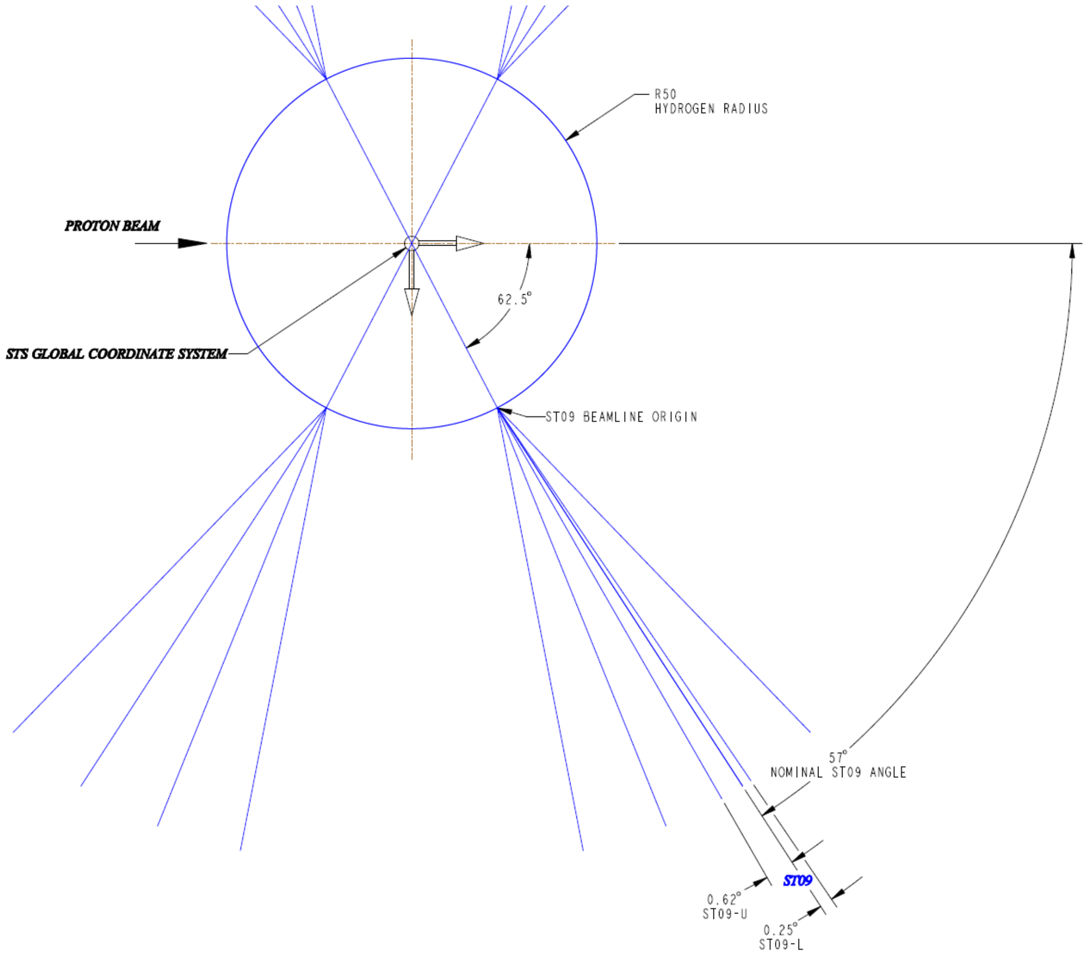

Figure 18. ST09-U and ST09-L Plan View (dimensions in mm, angles are not to scale for clarity).

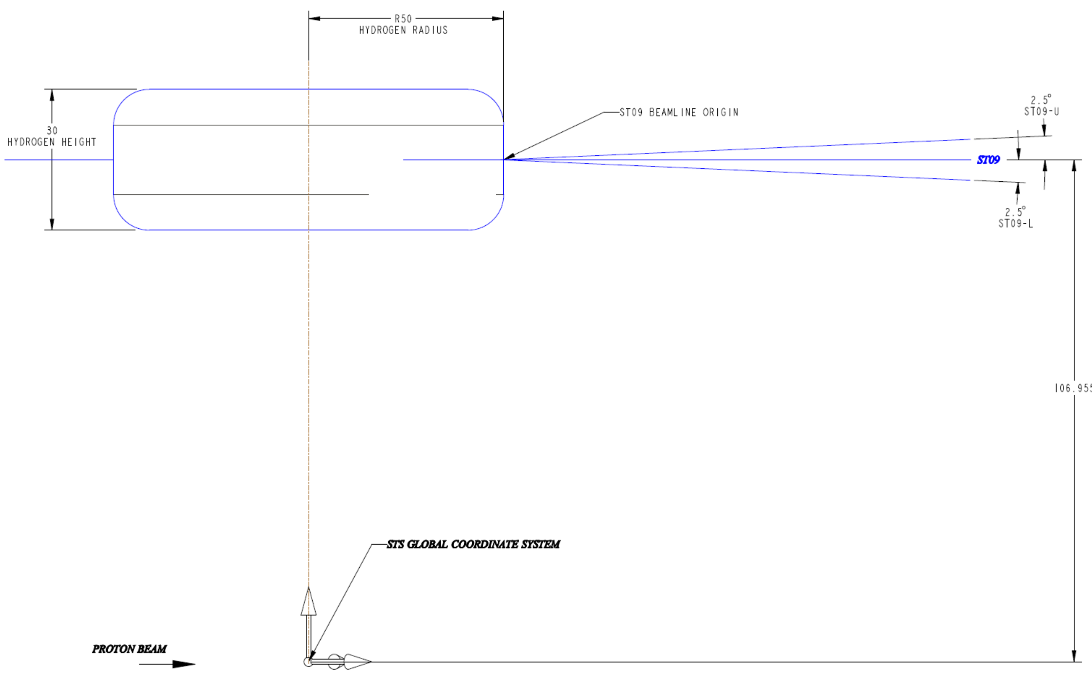

Figure 19. ST09-U and ST09-L Vertical Cross-section through ST09 Layout (dimensions in mm).