

NPS Downstream Beam Pipe

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I. INTRODUCTION

In 2020, Ho San KO created a GEANT4 model of the NPS setup, including scattering chamber, beam pipe, sweep magnet, and calorimeter. This code is available at https://github.com/gboon18/HallC_NPS, with a user's guide for installation and running at JLab at https://wiki.jlab.org/cuawiki/images/f/fa/User_Guide.pdf

There are renewed concerns regarding backgrounds in the NPS experiment, with particular concern for the pre-amplifiers built into the PMT bases. The studies documented by Ho San KO in his Ph.D. thesis: <https://theses.hal.science/tel-02927155v1/document> indicate a significant source of background from beam particles hitting the down stream beam pipe. It was therefore deemed important to update the GEANT4 model to more closely match the final NPS Beam Pipe configuration.

In this note, I summarize information regarding the down stream beam pipe. I have gleaned this information from the following technical drawings provided by Paulo Medeiros:

- 67508-00026: Hall -C NPS Experiment Beamline
- 67173-56159: Spool Piece-A
- 67173-56160: Spool Piece-B
- 67173-56161 Spool Piece-C
- 67110-56841 Corrector Magnet
- 67175-00016 SHMS BeamLine Bellows
- 67503-E-00094 QTOR BeamPipe
- 67175-00009 12 Inch Spool Pipe Section
- 67503-E-00095 18 Inch Downstream Beam Pipe

- 67503-E-00096 24 Inch Downstream Beam Pipe
- 67175-00013 BPM Dummy Spool (2 pieces)
- 67229-56071 G-Zero 24 Inch Beam Line

I have not attempted to give a description of either the mechanical support structures, or the corrector magnet.

II. SCATTERING CHAMBER AND TARGET CELL

I do not have the detailed specs on the scattering chamber. As implemented in the Ho San Ko GEANT4 model, it is a vertical Fe cylinder with inner and outer radii of 20.5 and 22.5 inch, respectively.

The target cell is 150 mm long plus (?) endcap. The length should be changed to 100 mm

III. BEAM PIPE

Unless stated otherwise, all materials are Al

1. Short Connector

Assuming the scattering chamber radius is correct, then from drawing 67508-00026, I conclude that the first downstream beam pipe segment has a length $26.62 - 22.5 = 4.12$ inch. This segment is labelled “Connection Assy-Short Target Chamber Window” and is described in drawing 67153-56037, but I don’t currently have access to that drawing. Based on the mating piece “Spool Piece -A”, I assume that this short piece is a Al-6061 tube with outer diameter 1.5 inch and wall thickness $1/8$ inch (inner diameter 1.25 inch).

The 4.12 inch length of this piece is inclusive of the Al flange (2.75 inch OD) that mates this to Spool Piece-A. This flange has length 0.625 in with OD 3.5 inch.

2. Spool Piece-A, Drawing 67173-56159

This piece (inclusive of flanges) is 66.19 inch long. It consists of a stepped cylinder making a transition from the initial 1.5 inch outer diameter (OD) tube to a 2.0 inch OD tube. For the purposes of the GEANT4 model, I simplify slightly the mechanical design of the stepped structure into two overlapping tubes, with the addition of a small gasket tube.

The initial tube is $(22.26 + 0.62) = 22.88$ inch long, 1.5 inch OD and wall thickness 1/8 inch (1.25 Inch ID). This piece is centered at $z = 26.62 + 22.88/2 = 38.06$ inch.

The second (stepped) tube is $66.19 - 22.26 = 43.93$ inch long, centered at $z = 66.19 - 11.13 = 55.06$ inch, 2.0 inch OD and wall thickness 3/16 inch (1.625 ID).

The two segments of Spool Piece-A overlap by 0.62 inch with a 1/16 inch radial gap. To isolate the vacuum inside from the air outside, an additional tube 0.62 inch long, 1.5 inch ID and 1.625 inch OD should be added, centered at $z = 26.62 + 22.25 + 0.62/2 = 49.18$ inch.

The upstream flange on spool piece-A overlaps the piece by 0.625 inch and has an outer diameter of 3.5 inch. The downstream flange overlaps by 0.875 inch with OD 5.5 inch.

3. Spool Piece-B Drawing 67173-56160

This is a cylindrical piece of three steps. Total length, inclusive of flanges, is 102.31 inch. The following table simplifies the gaskets and flanges. The positions are based on the upstream edge of Spool Piece B at $z = 26.62 + 66.19 = 92.81$ inch downstream of target center.

Spool Piece-B. Dimensions in inches.					
Segment	OD	Wall	ID	Length	$z(\text{center})$
Item-1	2.500	1/8	2.25	$36.77+0.62=37.39$	111.505
Item-2	2.875	3/16	2.5	43.62	152.01
Gasket	3.5625	11/16	2.875	0.62	172.95
Item-3	4.000	7/32	3.5625	22.48	$92.81 + 102.31 - 22.48/2 = 183.88$
Flange-1	4.50		2.5	0.72	
Flange-2	8.00		4.00	0.94	

The dimensions of the flanges were measured on the drawing, so may disagree slightly with actual specs.

The downstream face of Spool Piece B is at $z = 92.81 + 102.31 = 195.12$ inch.

4. **Corrector Magnet**

The corrector magnet is mounted on Spool Piece-B, 12" downstream of the upstream flange face and centered at $z = 114.81$ inch. The magnet is described in Drawing 67110-56841.

5. **Spool Piece-C**, Drawing 67173-56161

This is a short, straight, cylinder.

Spool Piece-C. Dimensions in inches.					
Segment	OD	Wall	ID	Length	$z(\text{center})$
Pipe	6.625	9/16	6.0625	23.08	206.66
Flange-1	8.00		6.625	0.94	195.59
Flange-2	10.75		6.625	0.94	217.73

6. **SHMS BeamLine Bellows**, Drawing 67175-00016

This is described as an 8 in bellows. All pieces of flanges on previous drawings were described as Al. In this drawing, The bellows and flanges are described as Stainless Steel. Bellows range is 5.48 inch to 8.70 inch. Nominal length is 7.080 inch. Flanges are 10.75 inch OD, 7.83 Inch ID. Bellows segments are 9.50 inch OD, 8.50 inch ID.

7. **QTOR BeamPipe**, Drawing 67503-E-00094

Assume upstream face of QTOR pipe at $z = 195.12 + 23.08 + 7.08 = 225.28$ inch.

The upstream 'flange' is a welded insert of length 1.12 inch. This is *followed* by 201.13 inch pipe. Flange-2 overlaps the final 1.12 inch of the pipe.

QTOR Beam Pipe Weldment. Dimensions in inches.					
Segment	OD	Wall	ID	Length	$z(\text{center})$
Flange-1	10.75	9/16	8.50	1.12	225.84
Pipe	10.75	3/8	10.00	202.26	327.53
Flange-2	18.00		10.75	1.12	428.10

8. **16 Inch Gate Valve** The exact length along the beam line of this gate valve and its adapter flanges is not completely clear. From the master drawing 67508-00026, I estimate it as 18.75 inch.

9. **12 Inch Spool Pipe Section**, Drawing 67175-00009

Based on the estimate of the Gate Valve, this piece starts at $z = 447.41$ inch. Total length of spool piece is 62.20 inch, centered at $z = 478.51$ inch. OD is 12.75 inch, wall thickness 0.406 inch, ID is 11.938 inch. Flanges are on drawing. At this distance from target, it may not be important to include flanges.

10. **18 Inch Downstream Beam Pipe**, Drawing 67503-E-00095

This piece is 151.50 inch long, centered at $z = 585.36$ inch. OD: 18 inch; Wall thickness: 3/8 inch; ID: 17.25 inch.

11. **24 Inch Downstream Beam Pipe**, Drawing 67503-E-00096

Total length is 97.75 inch.

24 Inch Downstream Beam Pipe. Dimensions in inches.					
Segment	OD	Wall	ID	Length	$z(\text{center})$
Flange-1	24.00	3.00	18.00	2.00	662.11
Pipe	24	3/8	23.25	95.75	710.985
Flange-2	32.00		24.00	2.00	757.86

12. **BPM Dummy Spool**, Drawing 67175-00013

24 Inch BPM Dummy Spool. Dimensions in inches.					
Segment	OD	Wall	ID	Length	$z(\text{center})$
Flange-1	32.00	4.00	24.00	2.00	759.86
Pipe	24	3/8	23.25	63.54	790.63
Flange-2	32.00	4.0	24.00	2.00	821.40

13. **Transition to Beam Dump** The next element is a similar 24 inch OD pipe, 153.12 inch long.

This is followed another piece identical to the ‘BPM Dummy Spool’ above.

The final piece is a large bellows, connected to the Beam Dump Interface.