

Beam parameters for the Hall-B RG-M run during November 2021 through January 2022

October 30, 2021

Hall-B Run Group M is scheduled to run from November 10, 2021, to January 31, 2022, in experimental Hall B. The CLAS12 is a multipurpose detector system based on a toroidal (forward detector) and a solenoid (central detector) superconducting magnets. The detector system includes Cherenkov Counters, Drift Chambers, Scintillator Counters, Silicon-strip detectors, Micro-mega gas detectors, and Calorimeters. In this run period CLAS12 will be used in its standard detector and shielding configuration with the Forward tagger off and the Large Moller cone installed. RG-M run will use up to 6 GeV (3 passes) electron beam, with currents up to 300 nA (up to 500 nA on empty target). This run will use several different targets ranging from cryogenic, liquid targets, to heavy solid targets. Targets will be located inside the vacuum scattering chamber that is installed inside the central detector in the center of the 5 T solenoid magnet.

The target system used for RG-M is the Saclay cryo-target. This target system has been used in Hall B throughout the 6 GeV and 12 GeV era. RG-M will use the following liquid targets using the Saclay cryo target system (H_2 , D_2 , 4He , Ar), and also solid targets (^{120}Sn , C). This target system will be able to support all the targets of interest, except for $^{40,48}Ca$ which will require encapsulation and will need to be mounted separately. The targets are housed in a vacuum vessel along with the cryogenic system. A scattering chamber is installed around the target cell area. This is made from Rohacell foam with a wall thickness of 6.5 mm. Aluminum windows are used at the entrance and exit of the liquid cells, and at the exit of the scattering chamber.

The details of all components, such as windows and cells, are shown on the beam line drawing, including thicknesses and locations. The beam line layout is shown in Figures 1 - 4.

Table 1: Target configurations that will be used in RG-M where liquid targets are denoted by "L" and soild targets are listed just as the chemical composition.

Energy (GeV)	Target	Thickness (cm)	Density (g cm^{-3})	Areal Density (mg cm^{-2})	T/X_o^1 (%)	Beam Current (nA)	Luminosity ² (10^{35} $\text{s}^{-2} \text{cm}^{-2}$)
6.6	LH	5	0.071	355	0.6	80	1
	LD2	5	0.164	820	0.7	70	2
	LHe	5	0.125	625	0.7	90	2
	LAr	0.5	1.396	698	3.6	80	2
	C ³	0.2	2.20	440	1.0	130	2
	¹²⁰ Sn ³	0.03	7.31	205	2.3	277	2
	^{40,48} Ca	0.13	1.55	200	1.2	280	2
	Empty	—	—	—	—	525	—
4.4	LH	5	0.071	355	0.6	108	1.5
	LAr/C	0.5/0.2	1.396/2.20	698/440	3.6/1.0	110/175	3
	Empty	—	—	—	—	450	—
2.2	LH	0.5	0.071	35.5	0.06	50	0.06
	LAr/C	0.5/0.2	1.396/2.20	698/440	3.6/1.0	5/8	0.13
	Empty	—	—	—	—	380	—

¹ Total thickness (T) per radiation length (X_o)

² per nucleon.

³ 4-foil target cell.

The requirements for beam parameters for RG-M run are summarized in Table 2

Table 2: Required beam parameters.

Parameter	Requirement	Comments
Energy (GeV)	6, 4, 2	3, 2, 1 pass
$\delta p/p$	$\sim 2 \times 10^{-4}$	
Current (nA)	≤ 300	up to 500 nA on empty target
σ_{xy} (μm)	< 200	As measured by 2H01 harp
Position stability (μm)	< 100	On 2H01 and 2H00 ($> 30\text{nA}$) BPMs with feedback
Divergence (μrad)	< 100	
Beam Halo ($> \pm 5\sigma$)	$< 10^{-5}$	As measured by 2H01 harp
Long term current stability	$< 5 \%$	For > 30 nA, integrated over minutes
Short term beam intensity stability (60 Hz harmonics)	$< 10\%$	of the total power, measured with SLM and halo rates
Bunch charge fluctuations	$< 10 \%$	Measured with DAQ

For initial beamline tuning and after extended down time (≈ 8 hours) the electron beam will be dumped in the tagger dump. After that the beam will be sent to the Faraday Cup and centered on the target. For beam currents for which beam power exceeds 175 W on the Faraday Cup (30 nA at 6 GeV, 44 nA at 4 GeV and 87 nA at 2 GeV) the beam blocker will be inserted upstream of the Faraday Cup.

Table 3 presents the proposed run plan. Depending on the performance of the experiment and accelerator it will be adjusted.

Table 3: Proposed Run plan

Energy (GeV)	Target	Duration (Hours)	Target Change Date
6.0	H	48	November 10, 2021
	Target change H to D	8	November 13
	D	144	November 13
	Target change D to He	8	November 20
	He	144	November 20
	Target change He to ^{40}Ca	22	November 26
	^{40}Ca	144	November 27
	Target change ^{40}Ca to ^{48}Ca	12	December 4
	^{48}Ca	144	December 4
	Target change ^{48}Ca to C	12	December 4
	C	144	December 10
	Target change C to Sn	1	December 17
	Sn	120	December 17 - December 20
	BREAK		
	Sn	24	January 10
2.1	Target change Sn to Ar	22	January 11
	Ar	152	January 11
	Pass change to 1 pass		January 19
	Ar	40	January 19
	Target change Ar to C	1	January 20
	C	40	January 18
	Target change C to D	22	January 21
	D	40	January 20
	Target change D to H	8	January 23
	H	8	January 23
4.0	Pass change to 2 pass		January 24
	Target change H to Ar	22	January 24
	Ar	40	January 25
	Target change Ar to C	1	January 27
	C	40	January 27
	Target change C to H	8	January 29
	H	32	January 29

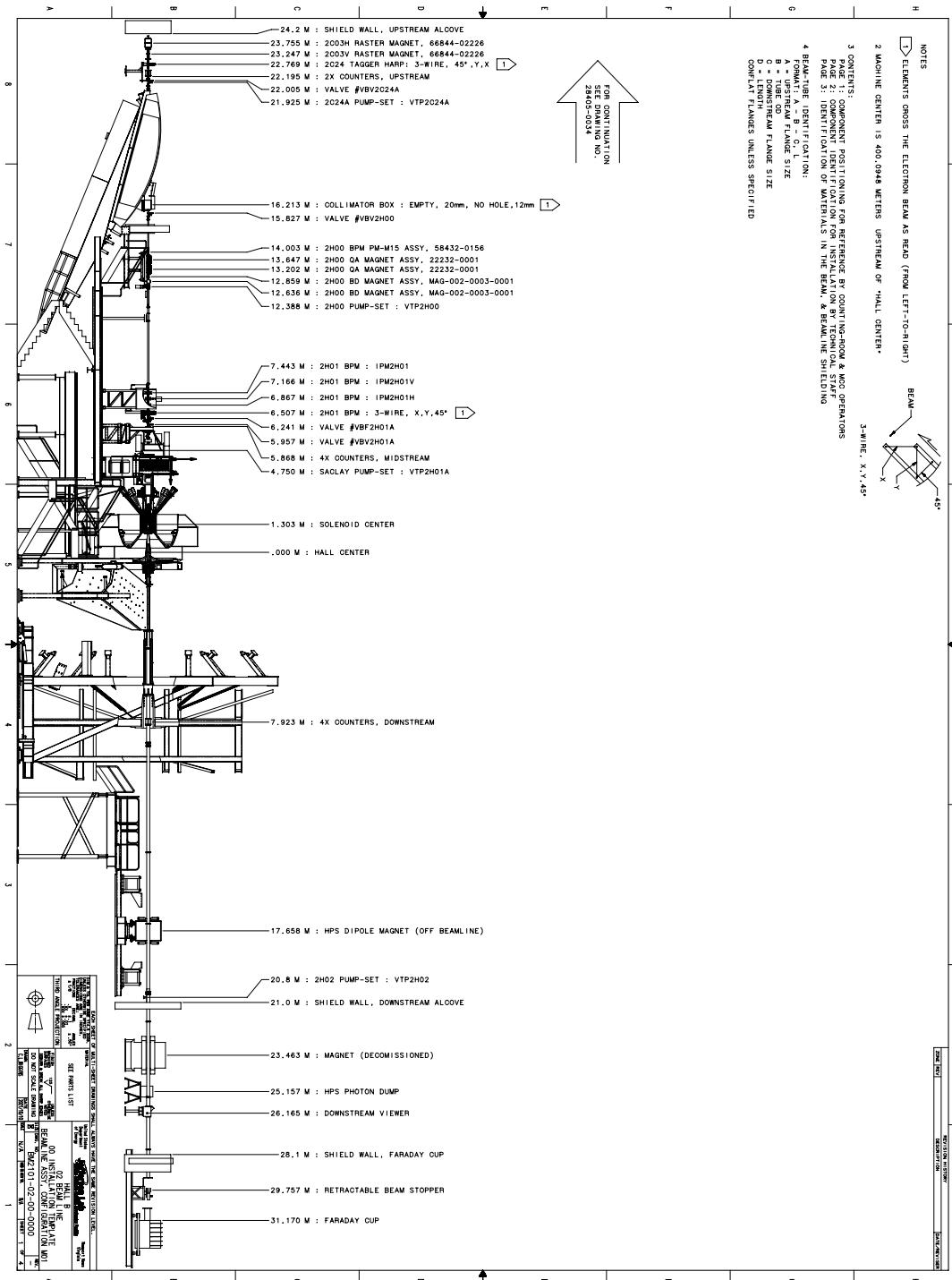


Figure 1: The layout of the RG-M beamline.

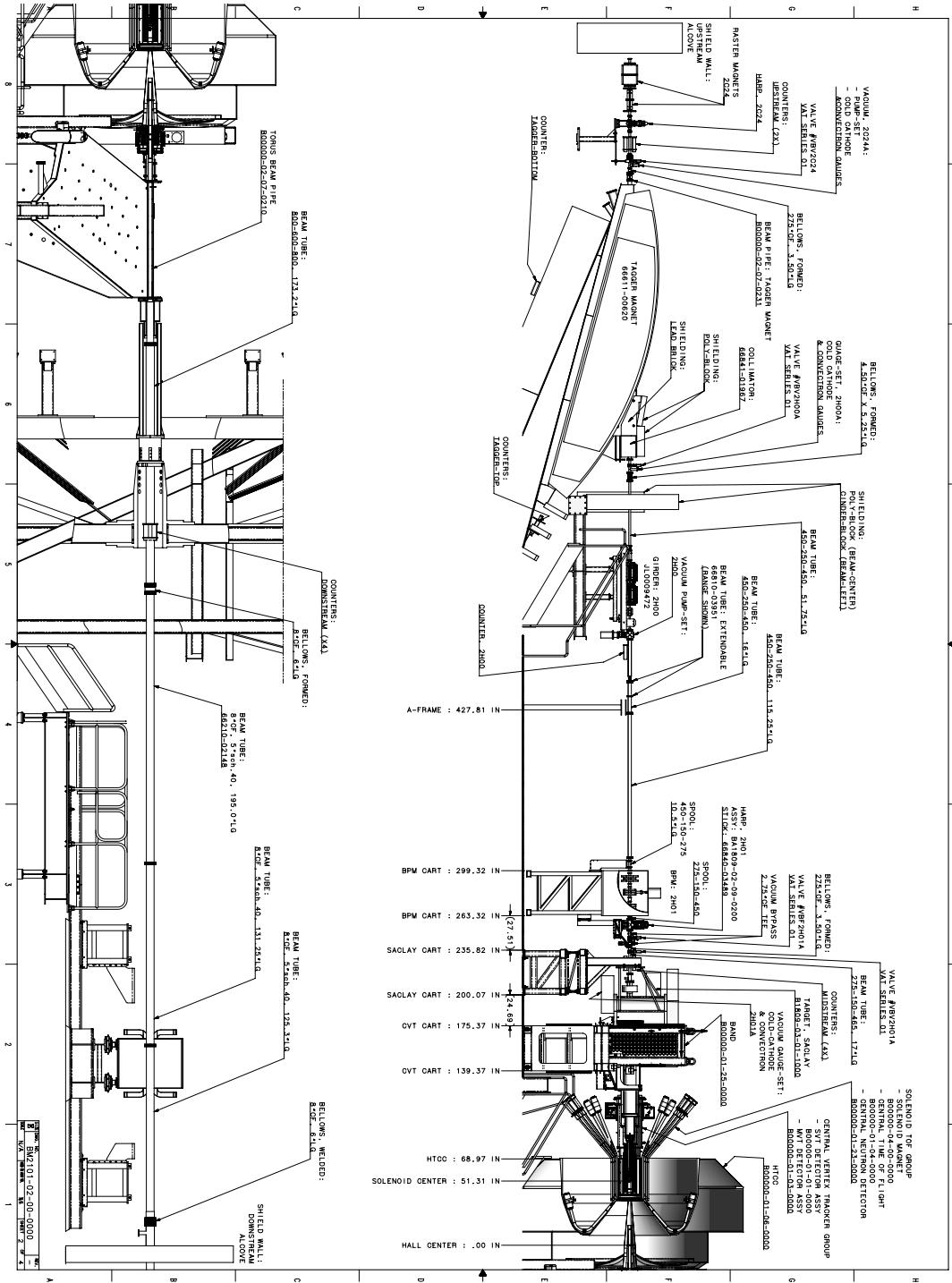


Figure 2: The layout of the RG-M beamline.

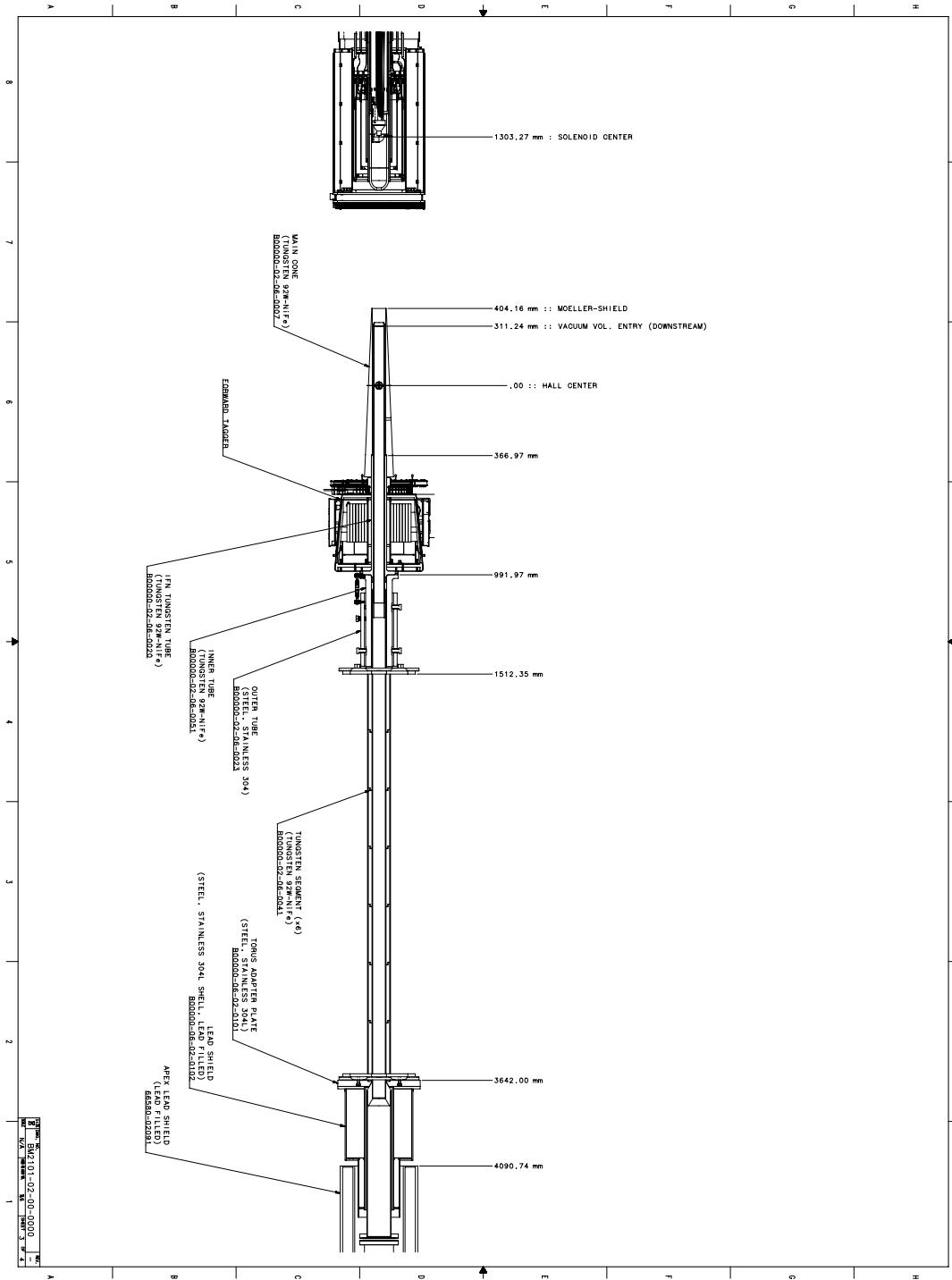


Figure 3: The layout of the RG-M beamline.

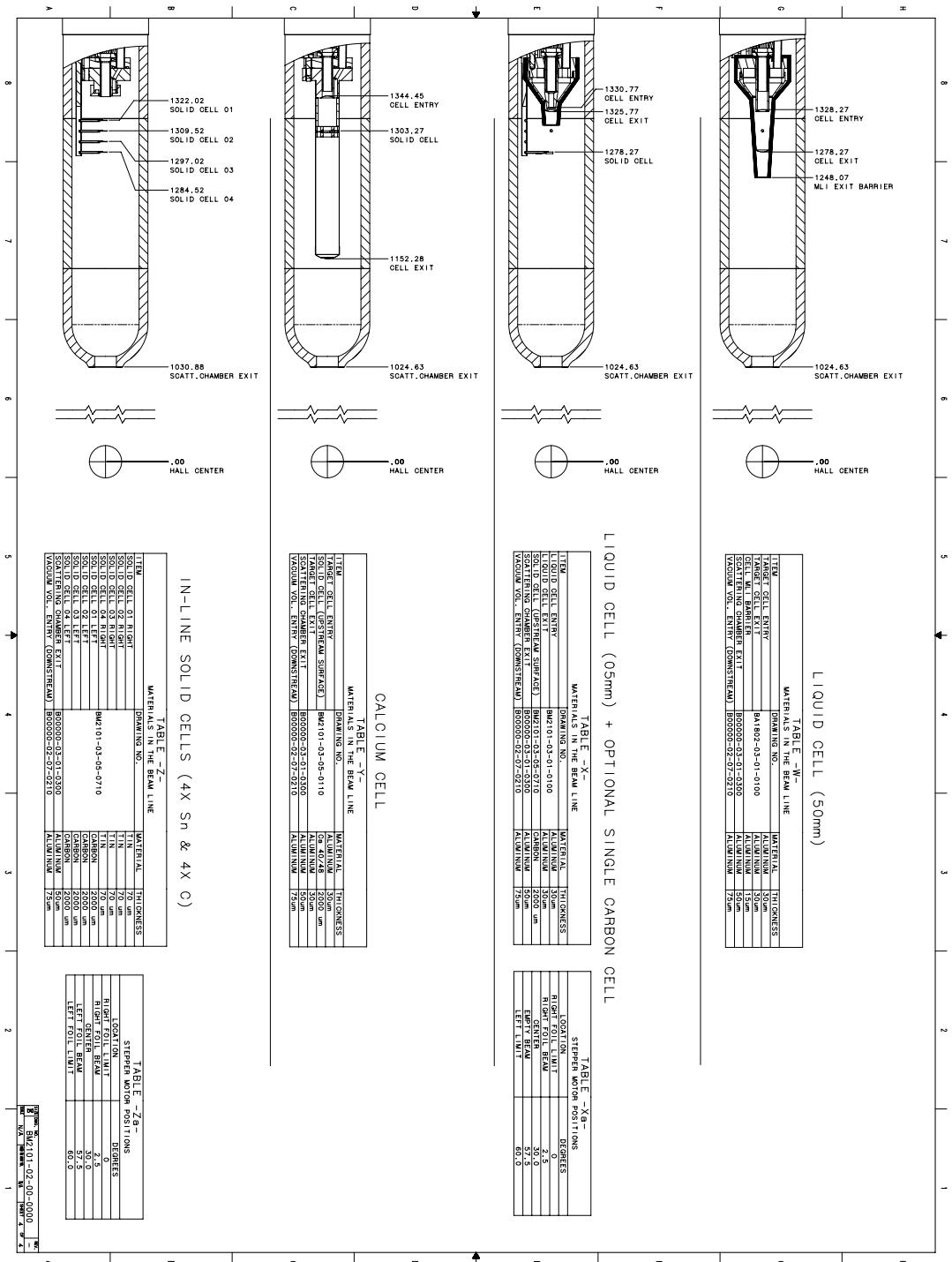


Figure 4: The layout of the RG-M beamline.