TRIUMF Beam Physics Note
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Cyclotron Machine Development in 2023

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Abstract: In this note, we summarised the outcomes of cyclotron beam development in 2023.

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1 Ion Source and Injection Line

1.1 ISIS 5:1 selector

Rick developed an ISIS tune for the 5:1 selector. The operational procedure for the 5:1 selector has been reinstated. By employing the 5:1 selector, BL1B was used for pion life measurement. The details of the ISIS tune with the 5:1 selector running are summarized in beam note TRI-BN-23-17: `http://lin12.triumf.ca/text/design_notes/2023_5-to-1_selector_operation/note.pdf`

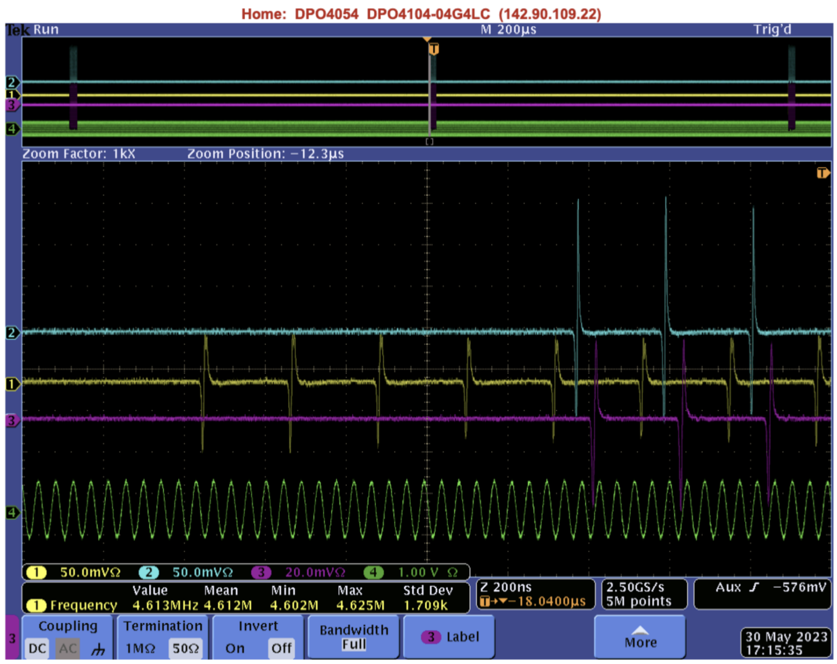

Figure 1: The signal from the the capacitive probes in ISIS downstream the 5:1 selector. Green line is the reference 23 MHz signal.

1.2 New skimmer bias method

Marco tested the new high voltage power supply designed to bias the skimmer plates, intended as a replacement for the battery bias.

1.3 Time structure measurement of bunched beam

The time structure of the injection beam at the location of slit 146 was measured by scanning the phase of the 5:1 selector.

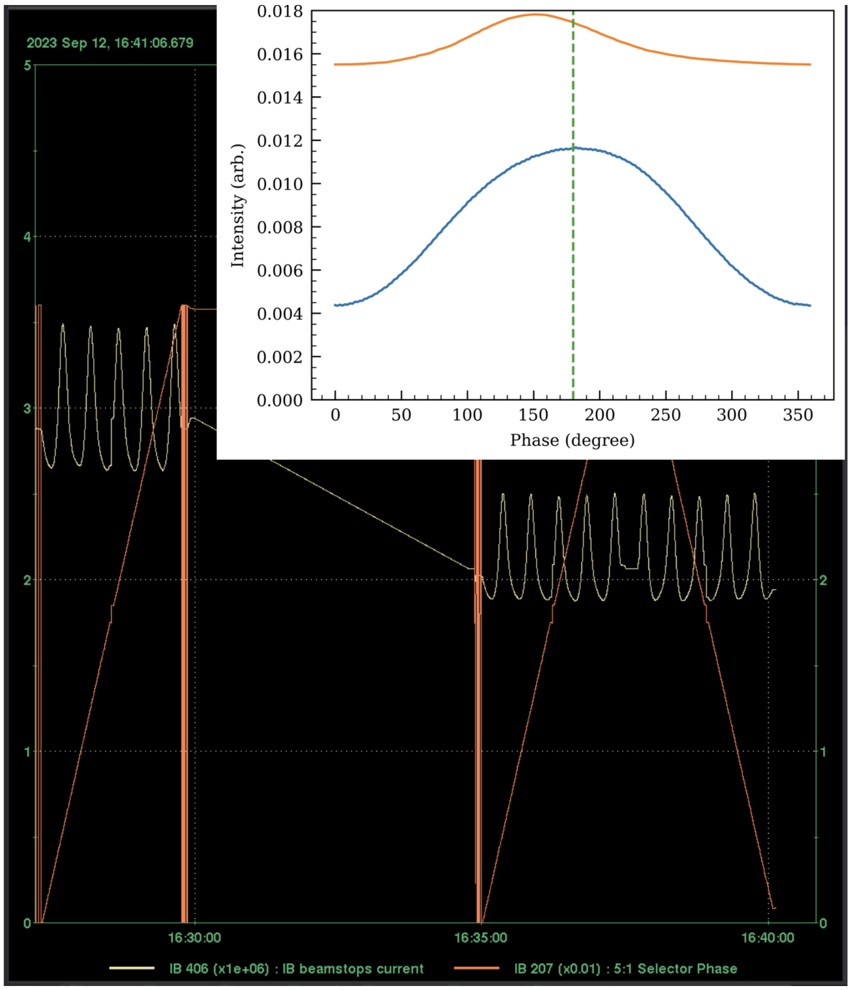

Figure 2: The raw data of the target current reading was obtained while scanning the phase of the 5:1 selector. The blue line shows the time structure of the bunched beam reconstructed from the raw data.

2 Cyclotron

2.1 New main magnet ramp-up procedure

The magnetic field of the optimized ramp-up procedure shows improvement of the field reproducibility as compared to the conventional method. Thomas and etc. summarized the new ramp-up study in a beam note:

`https://gitlab.triumf.ca/beamphys/mmrampup-apr2023/-/jobs/313259/artifacts/file/beam-note.pdf`.

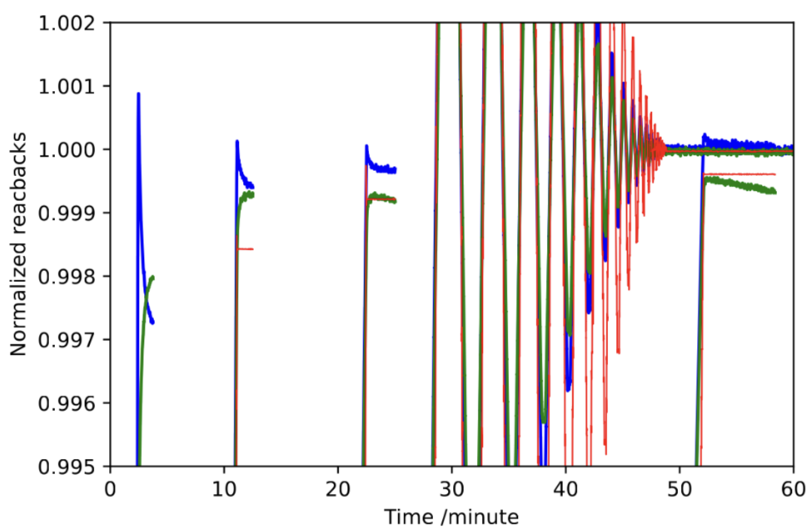

Figure 3: Different ramp-up procedure.

2.2 Vertical tune

Following the implementation of the new ramp-up procedure, we noticed a distinct vertical tune at a radius just before the first crossing of the linear coupling resonance.

2.3 Coupling resonances

The oscillations persist at the radius where we initially corrected the B_r first harmonics. The wiring of HC 8 was confirmed by conducting HE1 and HE2 scans at various phase settings of B_r. We also attempted correction using HC 9, but it did not solve the problem. Further investigation is required to address the resonance at the first crossing.

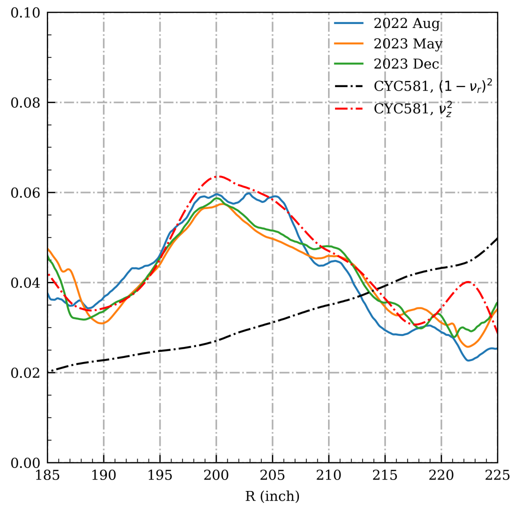

Figure 4: Documented vertical tune.

2.4 None interception phase excursion measurement

We measured the cyclotron phase excursion using the Time-of-Flight (ToF) signal in BL1A, which could be valuable for online isochronism optimization.

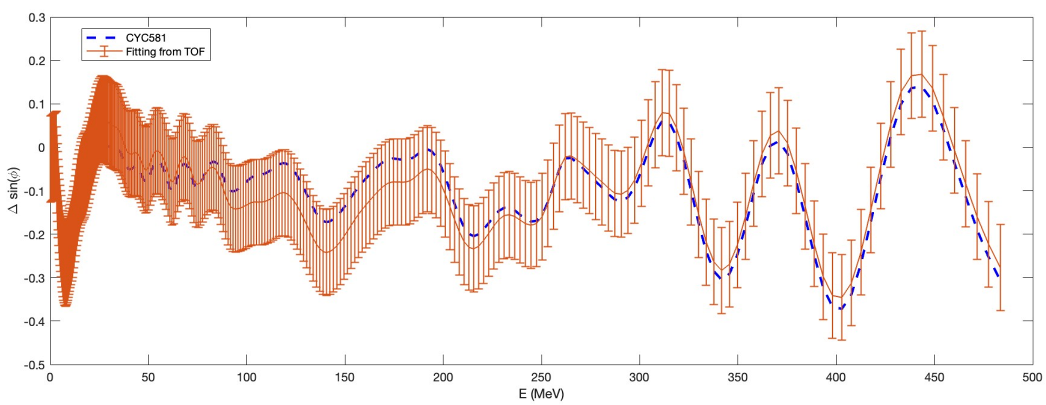

Figure 5: Measured phase excursion compared with the thoretical one calculated from the field survey map.

3 BL1A

3.1 Improve BL1A model using the new BPMs

We measured the transfer matrix elements of BL1A using the new BPMs. The non-zero correlation terms in the measured matrix indicate a potential alignment error in 1AQ6.

Table 1

Steering	BPM	R12 cm/mrad	R34 cm/mrad	Theoretical slope cm/A	Measured slope cm/A
CM1	BPM3-H	-0.498898	0.460247	-1.30268	1.17419 ± 0.04059
	BPM3-V	-0.498898	0.460247	0.	0.00976 ± 0.02450
	M4.7-H	-0.007107	0.711538	-0.01856	-0.01502 ± 0.01734
	M4.7-V	-0.007107	0.711538	0.	0.02252 ± 0.02875
	M6.9-H	1.125711	0.111853	2.93937	-2.70574 ± 0.10861
	M6.9-V	1.125711	0.111853	0.	0.07357 ± 0.01827
1VSM1	BPM3-H	0.201796	0.198411	0.	-0.01173 ± 0.04731
	BPM3-V	0.201796	0.198411	0.35038	0.36692 ± 0.02274
	M4.7-H	0.081518	0.721197	0.	0.05313 ± 0.00780
	M4.7-V	0.081518	0.721197	1.27357	0.73338 ± 0.05556
	M6.9-H	-0.290106	0.251224	0.	0.14071 ± 0.05116
	M6.9-V	-0.290106	0.251224	0.44364	0.41372 ± 0.08331
1VB1	BPM3-H	0.094047	0.093002	0.03689	-0.04395 ± 0.00237
	BPM3-V	0.094047	0.093002	0.	-0.00117 ± 0.00172
	M4.7-H	0.327	0.711828	0.12827	-0.10308 ± 0.00376
	M4.7-V	0.327	0.711828	0.	-0.00499 ± 0.00215
	M6.9-H	0.471981	0.300838	0.18514	-0.17034 ± 0.02587
	M6.9-V	0.471981	0.300838	0.	0.00233 ± 0.00203
1ASM4	BPM3-H	0.	0.	0.	0.00000 ± 0.00000
	BPM3-V	0.	0.	0.	0.00000 ± 0.00000
	M4.7-H	0.	0.	0.	0.00000 ± 0.00000
	M4.7-V	0.	0.	0.	0.00000 ± 0.00000
	M6.9-H	0.636653	0.282253	0.	-0.01897 ± 0.06018
	M6.9-V	0.636653	0.282253	0.49843	0.52509 ± 0.08871
1ASM5	BPM3-H	0.	0.	0.	0.00000 ± 0.00000
	BPM3-V	0.	0.	0.	0.00000 ± 0.00000
	M4.7-H	0.	0.	0.	0.00000 ± 0.00000
	M4.7-V	0.	0.	0.	0.00000 ± 0.00000
	M6.9-H	0.601768	0.278094	1.06267	1.07887 ± 0.06339
	M6.9-V	0.601768	0.278094	0.	-0.02444 ± 0.03939

3.2 Beam profile measurement in BL1

We measured the beam profile using the newly installed wire scanner at the former 1AM3 location. The vertical profile appears good, showing a minimum beam size as expected while scanning the quads. However, the horizontal profile is noisy and exhibits a mysterious double peak. Further efforts are required to enhance the signal and refine our optics model.

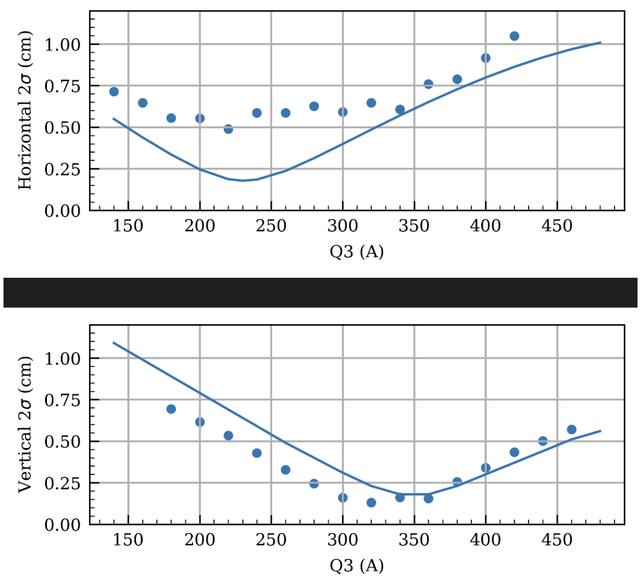

Figure 6: 2σ beam size calculated from the profile.

4 BL2A

No activity for this beamline.

5 BL2C

No activity for this beamline.