The Radiabeam Steerers

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Some history

At the start, I used Radiabeam data and concluded that in ELBT, we would need aircore steerers. These aircore steerers were never used in VECC, because as you know they wrap tightly around the beam pipe and as built were too small wrong I.D.

I guess because we were pressed for time, we gave up on these too early. Under our supervision, they came up with a workable design with NO hysteresis.

Secondly, I noted that even for EMBT and higher, the remanent field of their standard steerers was too large: it seemed to be about ± 3.5 Gauss which is an uncertainty of 93 G-cm since the effective length is 13.3 cm. See Fig.1.

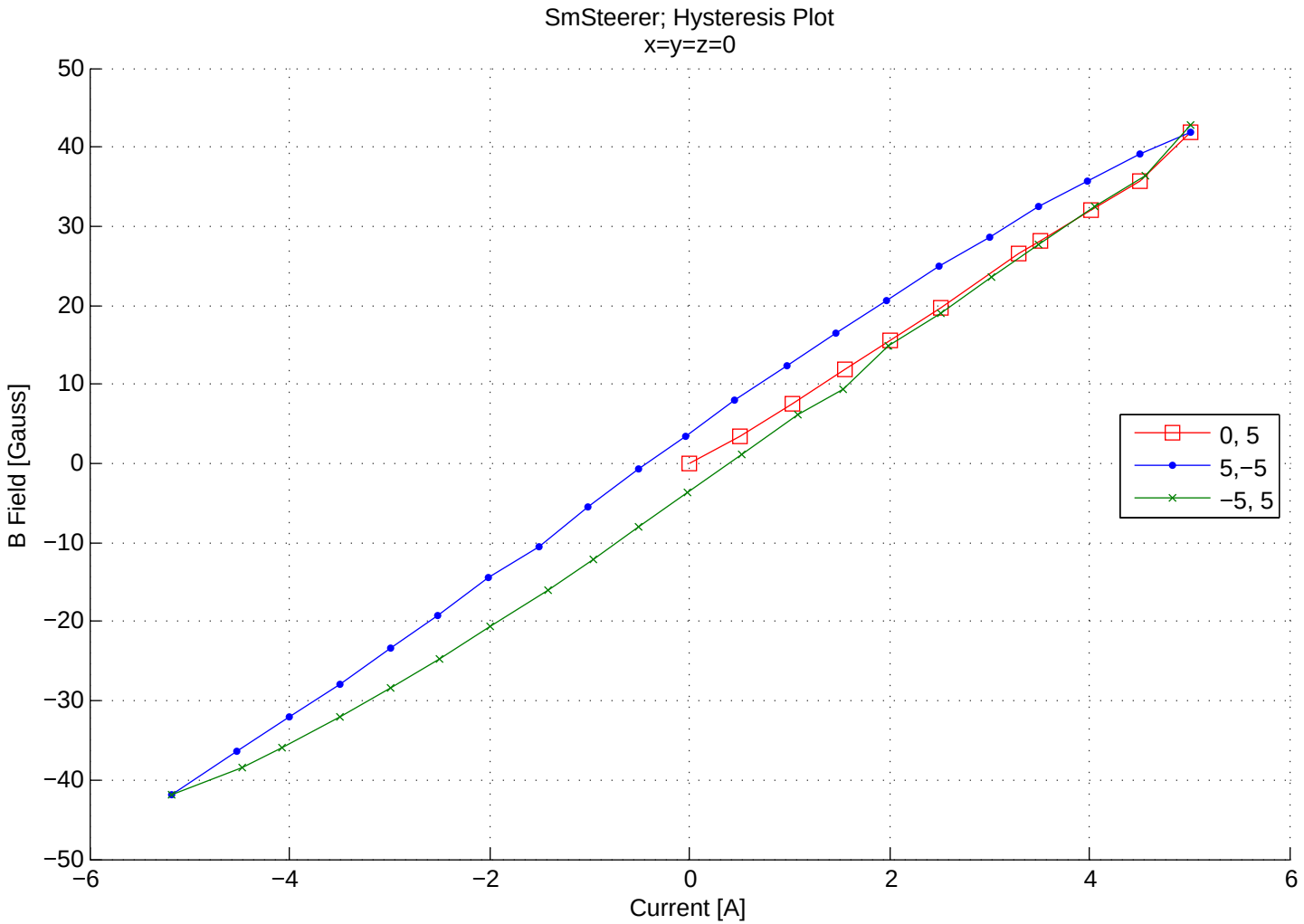

Figure 1: Hysteresis curve supplied by Radiabeam, 7 Oct 2010. Central field versus current.

I specified therefore that reproducibility be better than 5 G-cm. They agreed and checked it off.

IV. **Requirements Type B**

Requirement	Conformance Type B
Steerers to fit around a 3.5 inch OD bellows.	✓
Maximum permissible X and Y dimensions shall be 7 inches.	✓
Steerers' physical (Z) length to be no larger than 1.1 inches.	✓
Maximum capable integrated transverse field of 500 G-cm without exceeding a temperature rise of 30 degrees C.	✓
Maximum current required to reach 500 G-cm: 5 Amperes.	✓
Reproducibility: The integral of the transverse field along Z is to be reproducible to better than 5 G-cm for a given current.	✓
90% of the total integrated transverse field to be confined to less than 20cm along Z.	✓

Figure 2: Requirements in RFQ document, checked off by Radiabeam.

Steel Type

In further discussion, and after also getting advice from George Clark, it was realized that 5 G-cm would be difficult to achieve, but therefore we urged Radiabeam to at least use the best steel, which we thought was 1006. Since that time, it has come to our attention (through Andy Miller) that far softer steels are available, but for now this is beside the point.

Magnet Measurements – Orange Steerers

These were the ones used on the VECC test. Thomas and Kevin (helped by Controls and machinist Marco) have developed a measurement system and have measured the quadrupoles, the dipoles and most recently the steerers, shown below.

Notice that this represents an uncertainty of $+4.5$ to -3.0 or 7.5 G, agreeing with the original curve supplied in 2010. The total integrated field uncertainty is $7.5 \times 13.3 = 100$ G-cm. This is too large!

Secondly, this curve is very irregular. There is for example a jump of more than a Gauss (15 G-cm) at a low excitation where we would typically operate for ELBT.

We should not use these Orange steerers any further. But Chao might be able to use these new measurements to help interpret his VECC data. In hindsight, it's really too bad Chao had to struggle with these steerers.

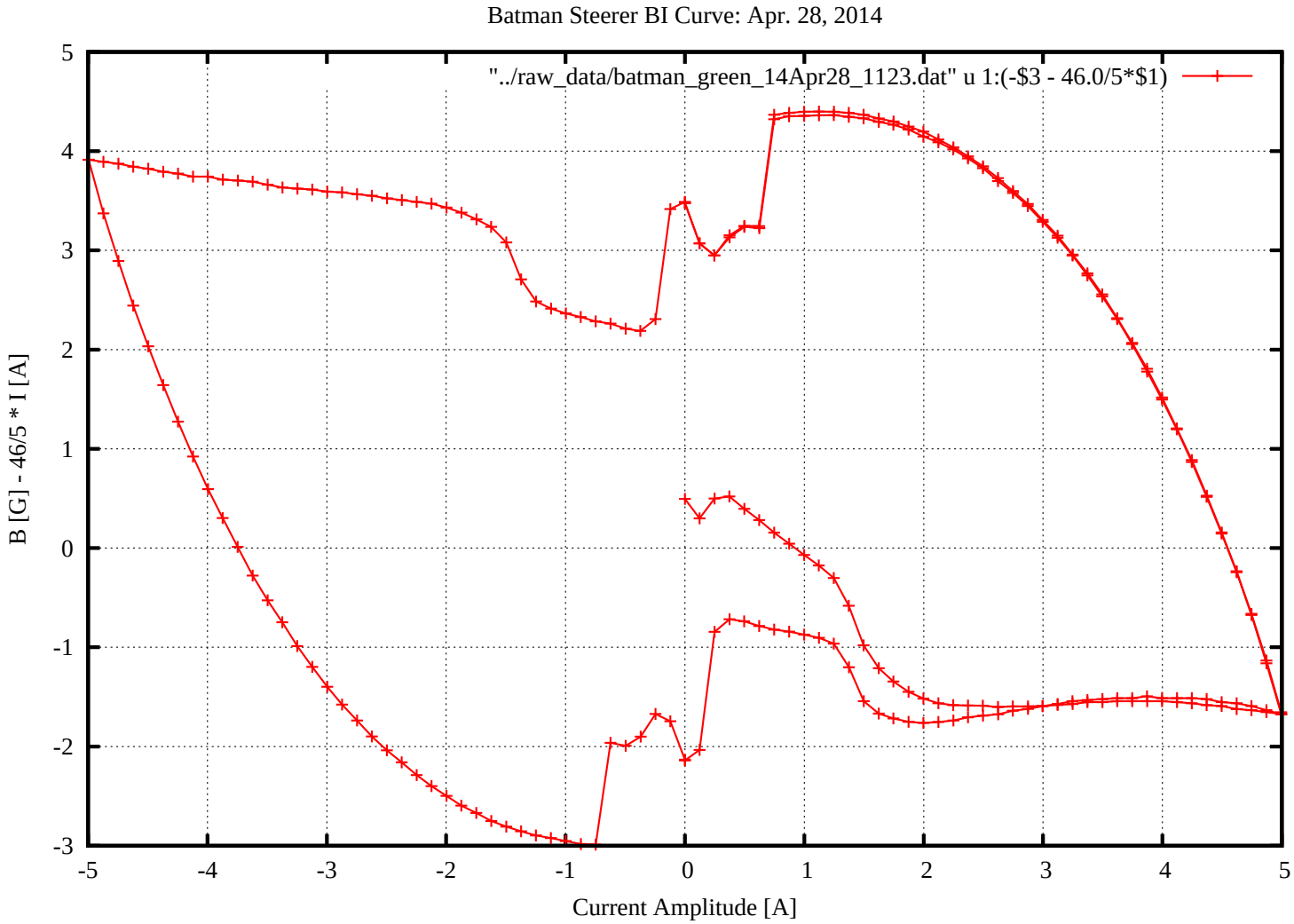

Figure 3: B-I curve of Orange steerer measured at TRIUMF. Linear part has been subtracted in order to show only the hysteresis.

Radiabeam "Type B" Steerers

These are indeed better in terms of absolute hysteresis, but there is both an uncertainty of 1.5 Gauss and a jump of 1.5 Gauss near zero excitation. This is integrated field of 20 G-cm, a factor 5 better than their catalog steerers, but still misses our spec by a factor 4. The spec for ELBT was 10 times better than for EMBT, i.e. 0.5 G-cm; that's why we wanted aircore. These steerers miss the ELBT requirement by a factor 40. We cannot use these in ELBT.

In the EMBT, they could be used if we use the degaussing procedure similar to quads and if we find a way to smooth out the curve near zero. This is under investigation. It may be due simply to poor choice of material for the screws that hold it together.

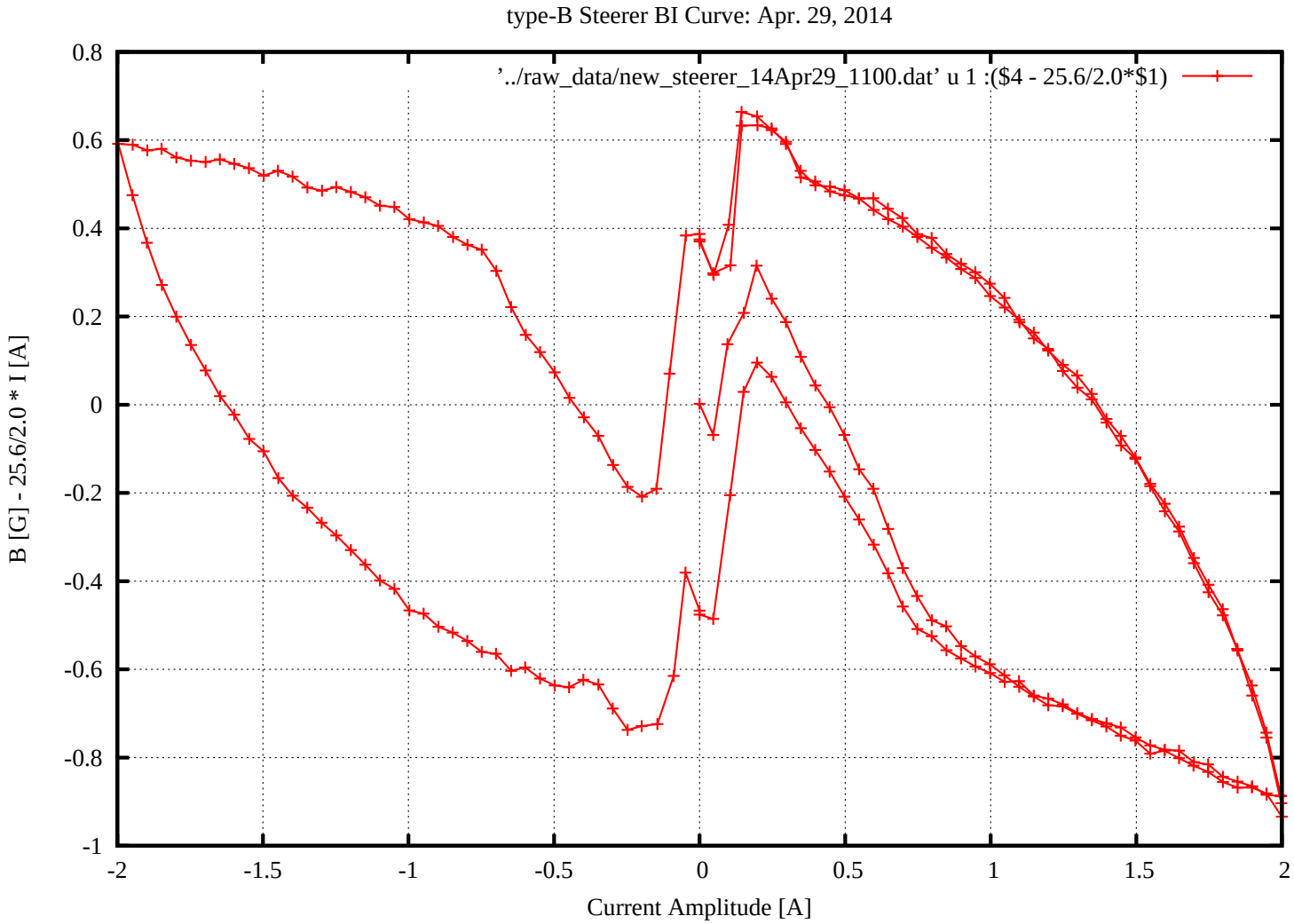

Figure 4: B-I curve of Type B measured at TRIUMF. Linear part has been subtracted in order to show only the hysteresis.