

 <b>Lawrence Berkeley National Laboratory</b>	<b>Magnet Measurement Protocol</b>	<u>Undulator</u> <b>HXU-32</b>	<u>Run #</u> <b>9</b>	<u>Page</u> 1 of 16
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## 1 Introduction

The measurements and tuning of the HXU-32 was carried out in the Undulator Measurement Facility (UMF) at the Lawrence Berkeley National Laboratory (LBNL) from July to September 2015. A description of UMF can be found in [1].

The HXU-32 was assembled and ready for tuning in July 2015. An initial set of measurements on the status of HXU-32 before tuning was carried out on July 31, 2015, and the results are given in [2].

After the first tuning iteration the magnetic fields were measured on August 24, 2015, and the results can be found in [3].

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After the second tuning iteration the magnetic fields were measured on September 2, 2015, and the results can be found in [4].

After the third tuning iteration the magnetic fields were measured on September 3, 2015, and the results can be found in [5].

After the fourth and final tuning iteration the magnetic fields were measured on September 10, 2015, and the results can be found in [6].

This summary report will focus on the changes at the undulator gap 10 mm during the tuning process while the detailed results after each tuning iteration are given in [2]- [6]. The plots interest for the tuning process are the first field integrals averaged over one period, i.e. the averaged angles of trajectory, and the field integrals over the horizontal aperture of the undulator.

## 2 Methods for tuning

To be written by Diego Arbalaez

## 3 Temperature during the tuning process

The climate control of the UMF is designed for maintaining the temperature  $20 \pm 0.1$  °C averaged over every hour during the entire time of the tuning process. The temperature is recorded by 12 temperature sensors. There are 4 temperature sensors along the walls of the UMH. There 2 temperature sensors on the Granite block of the Kugler bench, one in the upstream end and one in the downstream end. There are 6 temperature sensors mounted on the strongbacks, 3 on the lower and 3 on the upper. The 3 temperature sensors on each strongback are distributed to the upstream end, the center, and the downstream end. Figure 1 shows the recorded temperatures of the 12 temperature sensors during the tuning process.

As can be seen in Figure 1 the temperature in UMF was stable during the tuning process but the set temperature of the climate control was about 0.3 °C lower than 20.0 °C. It can also be seen that one of the signals probably has an unstable output value, probably because of a bad connector.

The following points of improvement will be implemented before next measurement campaign in UMF:

- The temperature sensors will be calibrated by exposing all sensors to the same temperature in a controlled way so the individual offset between the different temperature sensors can be established.
- The set temperature in UMF will be increased 0.3 °C.
- All connectors will be verified.



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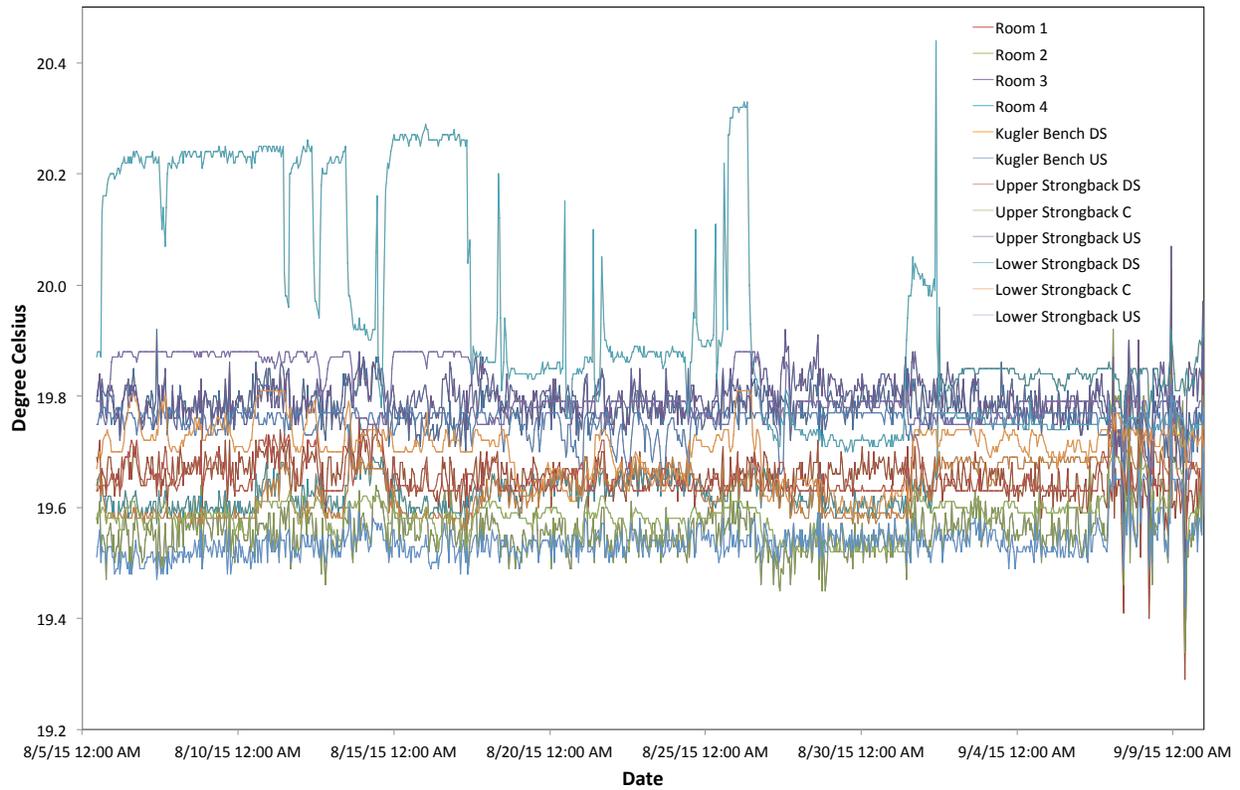


Figure 1: The recorded temperatures of the 12 temperature sensors recording the temperature in the UMF.



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#### 4 The HXU-32 at the gap 10 mm before tuning

Figure 2 shows the field integrals measured with the flip coil at the gap 10 mm after assembly and before the tuning process has started. Figure 3 shows the integrated first field integral averaged over 1 period at 10 mm gap along a 4.4 m long Hall probe scan of the undulator. Note that the Hall probe scan is longer than the flip coil that is 3.735 m long.

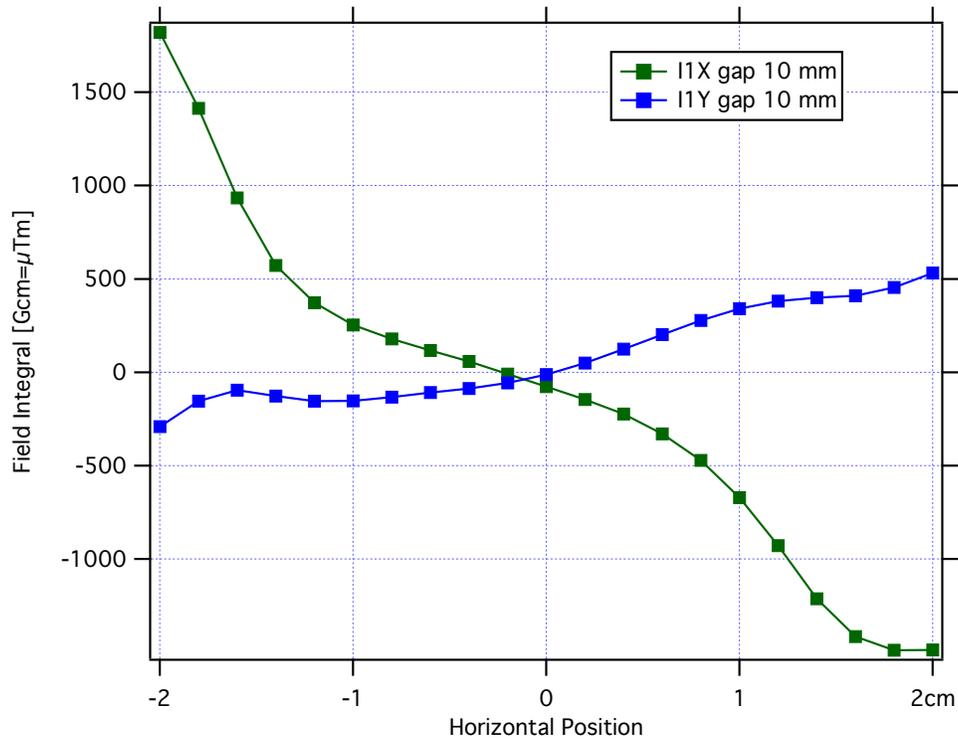


Figure 2: The field integrals measured with flip coil at 10 mm gap.



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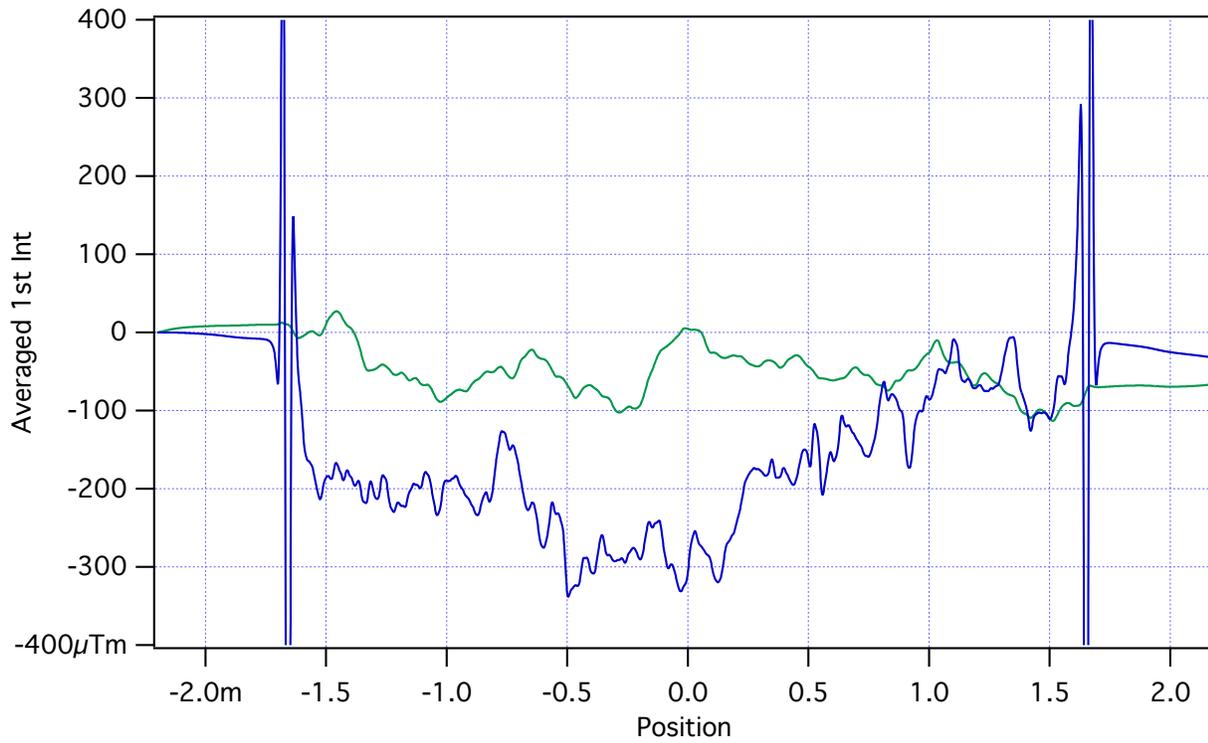
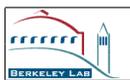


Figure 3: The integrated first field integral averaged over 1 period at 10 mm gap.



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## 5 The change of HXU-32 at the gap 10 mm after 1 tuning iteration

### 5.1 Changes made to the magnetic structure

To be written by Diego Arbalaez

### 5.2 Changes in the field integrals and integrated first field integrals averaged over 1 period

Figure 4 shows the change of the field integrals measured with the flip coil at the gap 10 mm at the tuning iteration. Figure 5 shows the change at the tuning iteration of the integrated first field integral averaged over 1 period at 10 mm gap along a 4.4 m long Hall probe scan of the undulator. Note that the Hall probe scan is longer than the flip coil that is 3.735 m long.

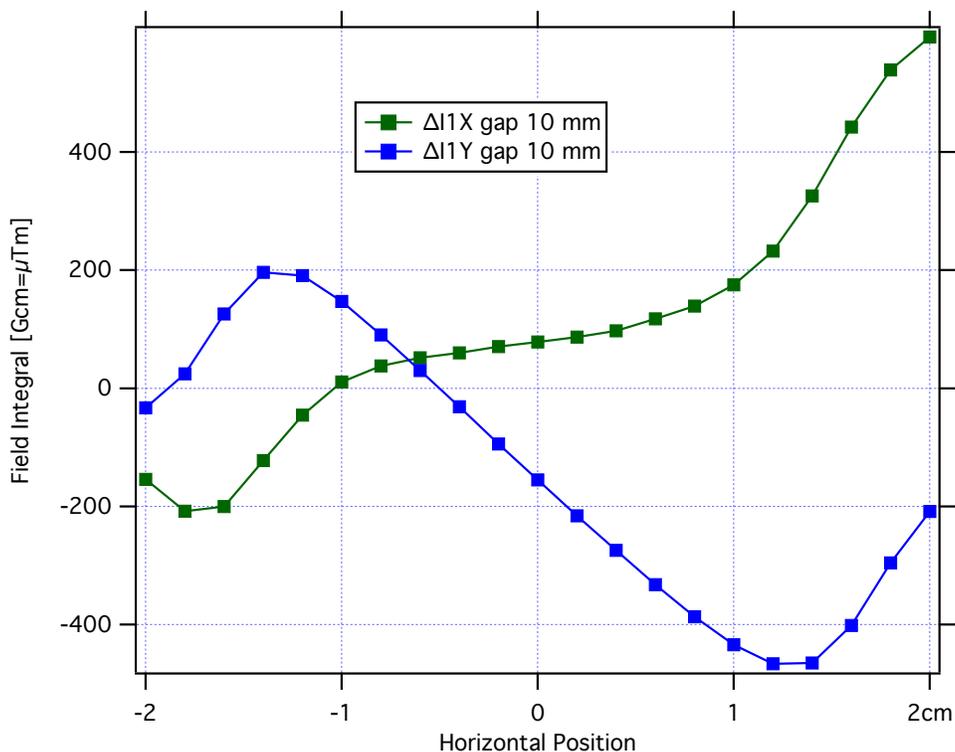


Figure 4: The change of field integrals measured with flip coil at 10 mm gap.



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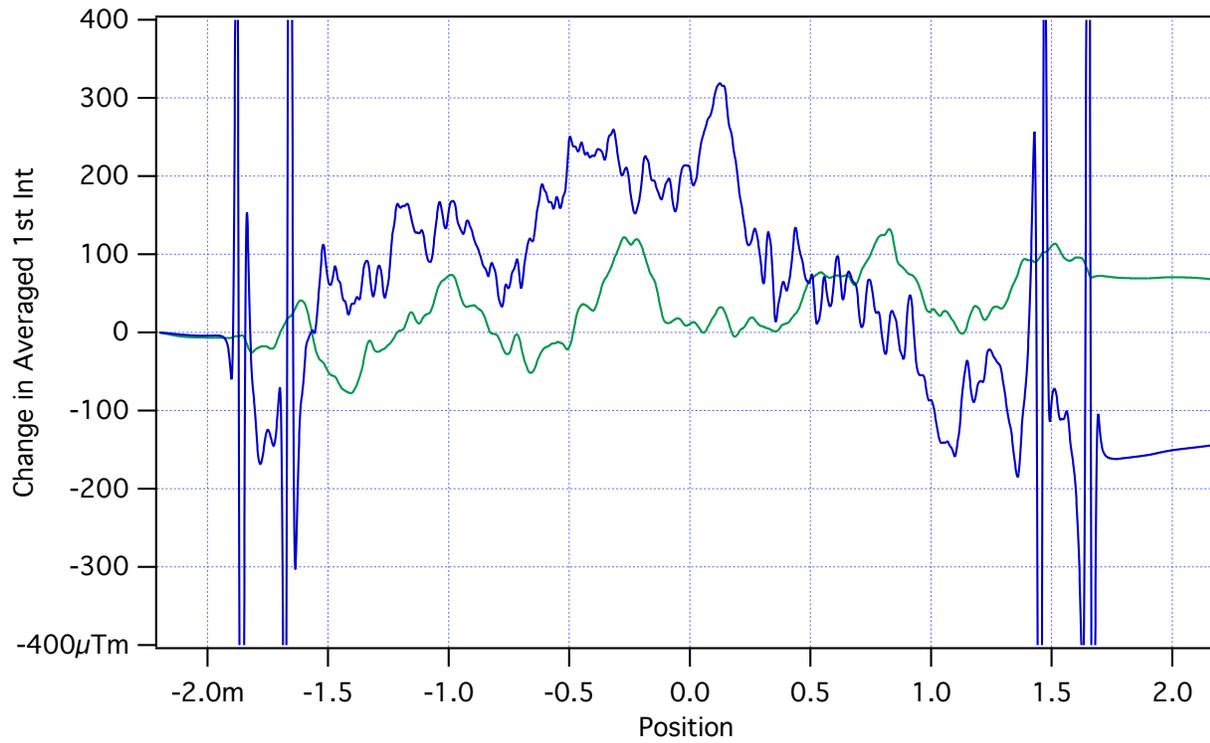


Figure 5: The change of integrated first field integral averaged over 1 period at 10 mm gap.

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## 6 The change of HXU-32 at the gap 10 mm after 2 tuning iterations

### 6.1 Changes made to the magnetic structure

To be written by Diego Arbalaez

### 6.2 Changes in the field integrals and integrated first field integrals averaged over 1 period

Figure 6 shows the change of the field integrals measured with the flip coil at the gap 10 mm at the tuning iteration. Figure 7 shows the change at the tuning iteration of the integrated first field integral averaged over 1 period at 10 mm gap along a 4.4 m long Hall probe scan of the undulator. Note that the Hall probe scan is longer than the flip coil that is 3.735 m long.

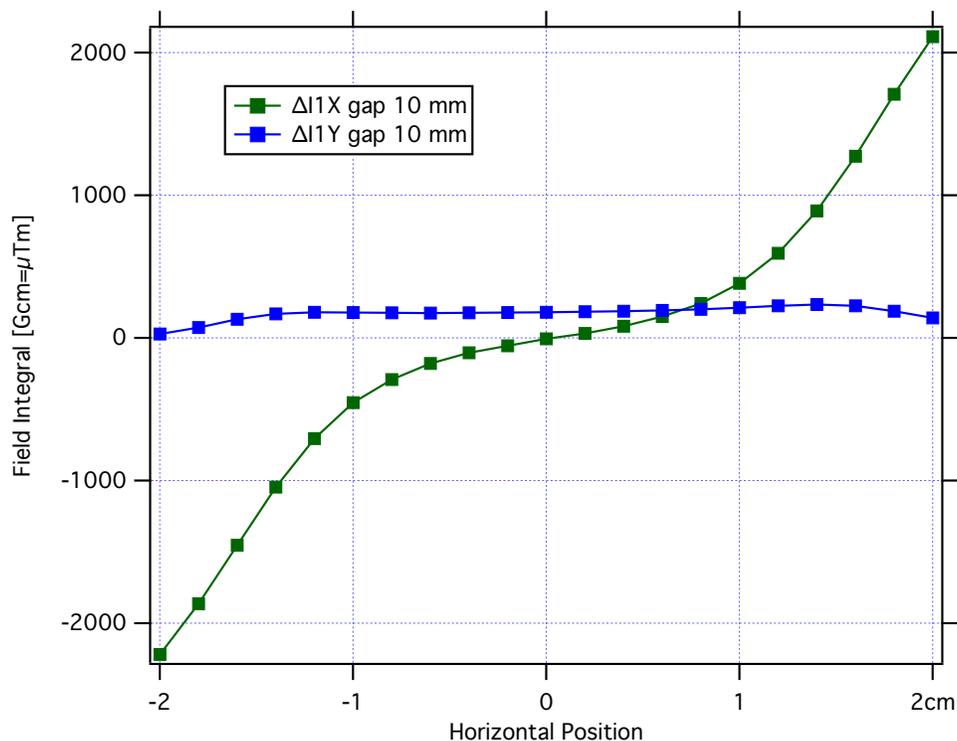


Figure 6: The change of field integrals measured with flip coil at 10 mm gap.



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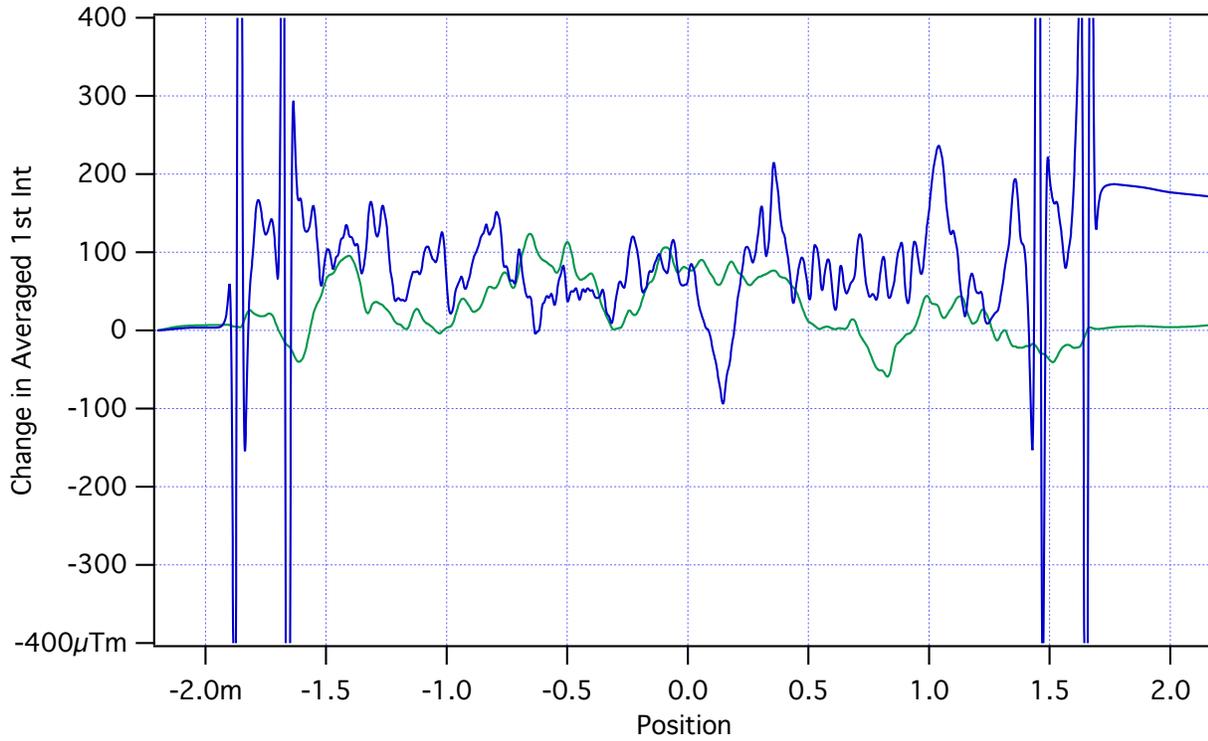
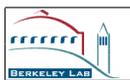


Figure 7: The change of integrated first field integral averaged over 1 period at 10 mm gap.



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## 7 The change of HXU-32 at the gap 10 mm after 3 tuning iterations

### 7.1 Changes made to the magnetic structure

To be written by Diego Arbalaez

### 7.2 Changes in the field integrals and integrated first field integrals averaged over 1 period

Figure 8 shows the change of the field integrals measured with the flip coil at the gap 10 mm at the tuning iteration. Figure 9 shows the change at the tuning iteration of the integrated first field integral averaged over 1 period at 10 mm gap along a 4.4 m long Hall probe scan of the undulator. Note that the Hall probe scan is longer than the flip coil that is 3.735 m long.

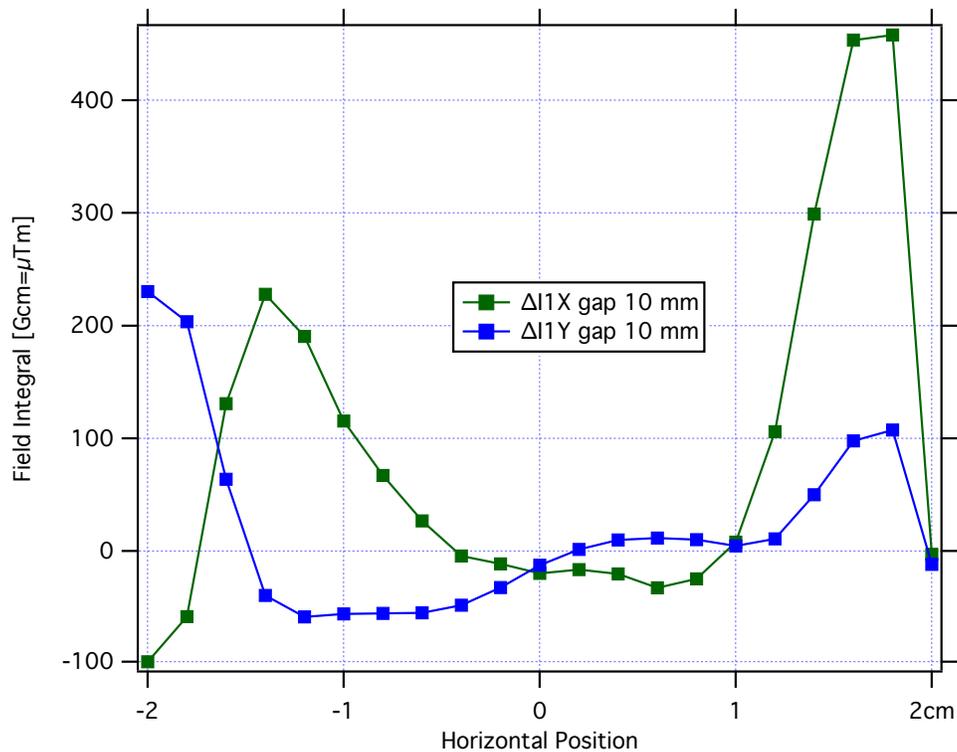


Figure 8: The change of field integrals measured with flip coil at 10 mm gap.



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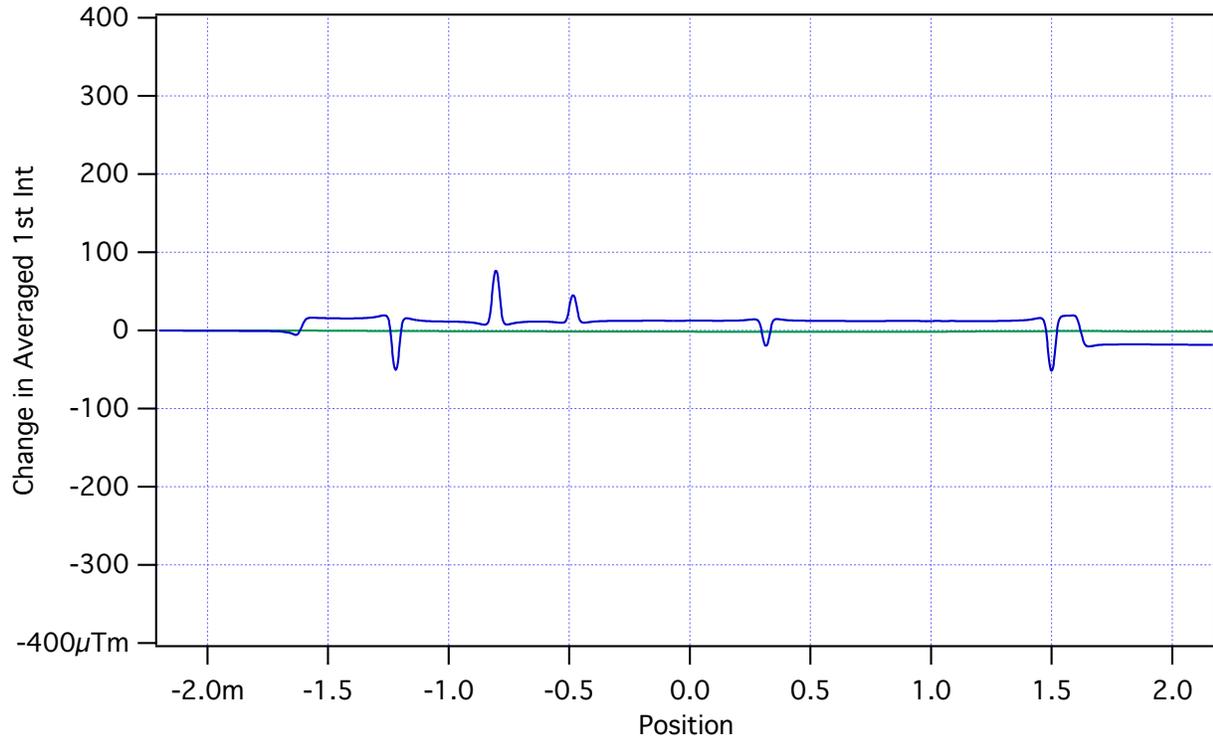
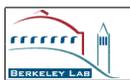


Figure 9: The change of integrated first field integral averaged over 1 period at 10 mm gap.



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## 8 The change of HXU-32 at the gap 10 mm after the 4th and final tuning iteration

### 8.1 Changes made to the magnetic structure

To be written by Diego Arbalaez

### 8.2 Changes in the field integrals and integrated first field integrals averaged over 1 period

Figure 10 shows the change of the field integrals measured with the flip coil at the gap 10 mm at the tuning iteration. Figure 11 shows the change at the tuning iteration of the integrated first field integral averaged over 1 period at 10 mm gap along a 4.4 m long Hall probe scan of the undulator. Note that the Hall probe scan is longer than the flip coil that is 3.735 m long.

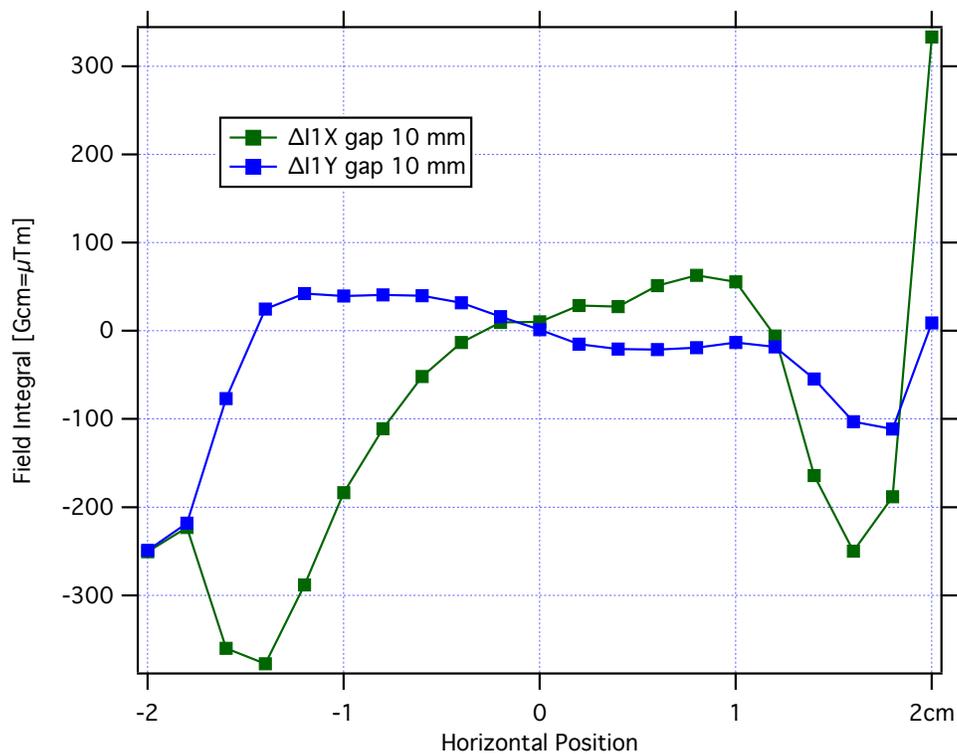


Figure 10: The change of field integrals measured with flip coil at 10 mm gap.



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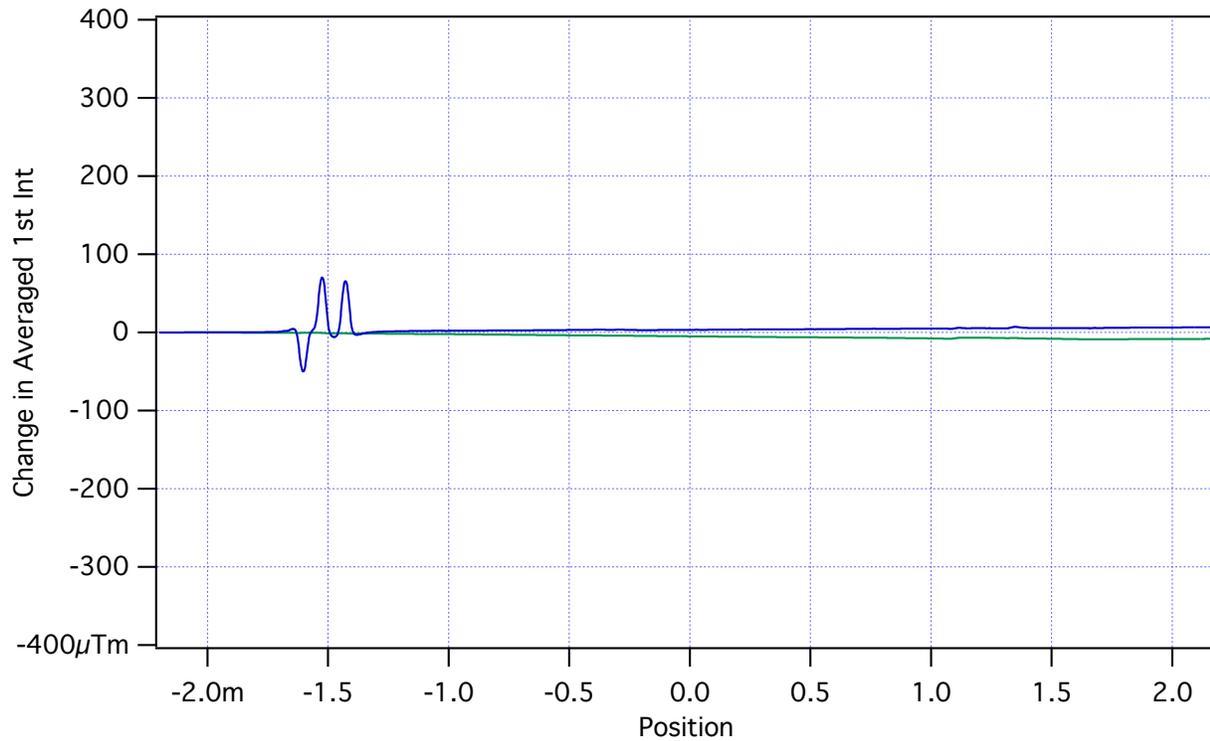
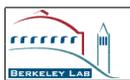


Figure 11: The change of integrated first field integral averaged over 1 period at 10 mm gap.



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## 9 The HXU-32 at the gap 10 mm after tuning

Figure 12 shows the field integrals measured with the flip coil at the gap 10 mm after the tuning process has finished. Figure 13 shows the integrated first field integral averaged over 1 period at 10 mm gap along a 4.4 m long Hall probe scan of the undulator. Note that the Hall probe scan is longer than the flip coil that is 3.735 m long.

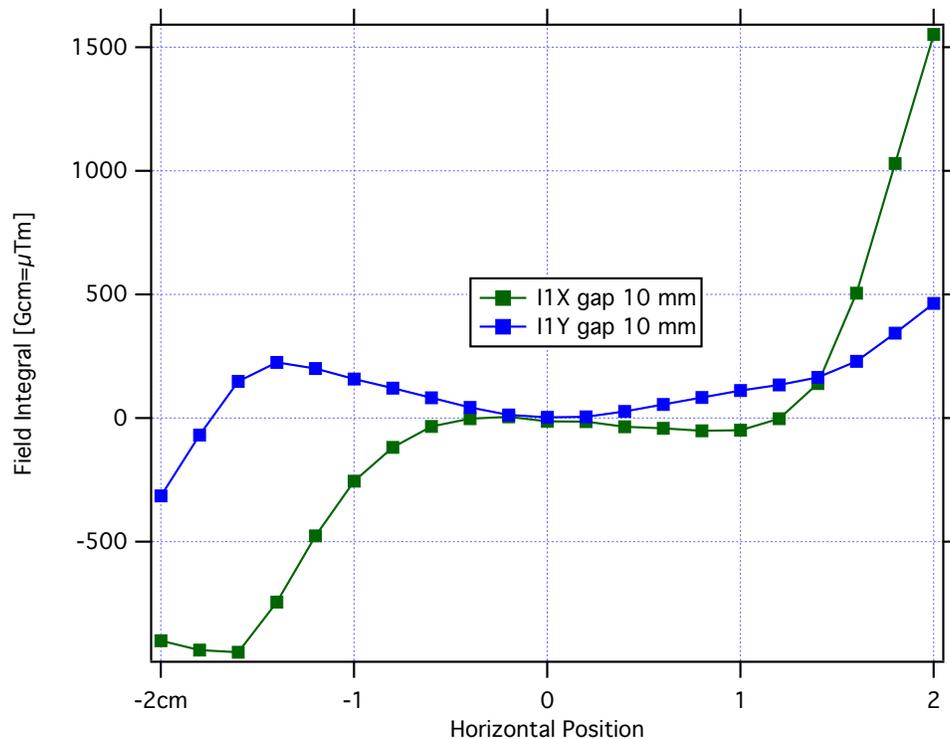


Figure 12: The field integrals measured with flip coil at 10 mm gap.



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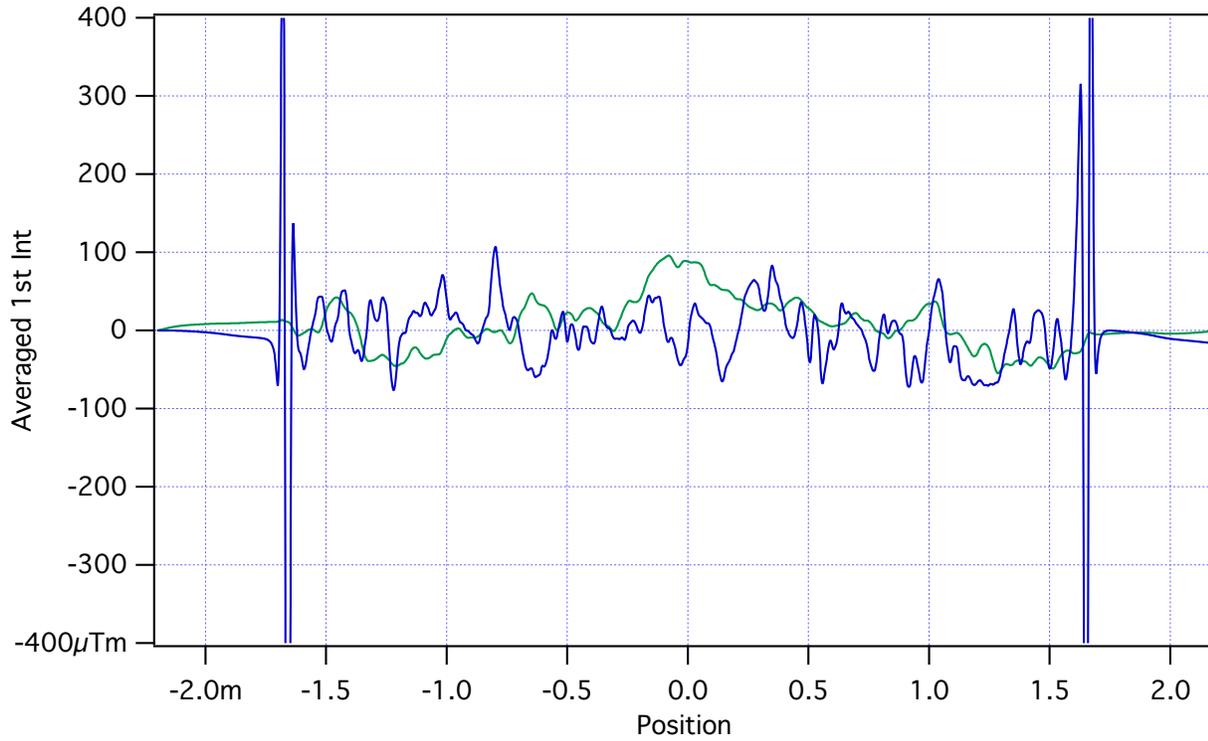


Figure 13: The integrated first field integral averaged over 1 period at 10 mm gap.

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