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Magnetic Field Mapper

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Abstract

The scientific program at the Integrable Optics Test Accelerator (IOTA) ring depends on a variety of specialized magnets, and validation of their field quality is important for ensuring proper performance. Many of these magnets have small physical aperture which makes the magnetic field hard to map. Solutions to this problem have not been readily available in house or with external vendors. To solve this problem, a new magnetic-field mapping device was built. This new Magnetic Field Mapper (MFM), shown in Figure 1, will be capable of quickly mapping a wide variety of magnets to high precision while staying in house.

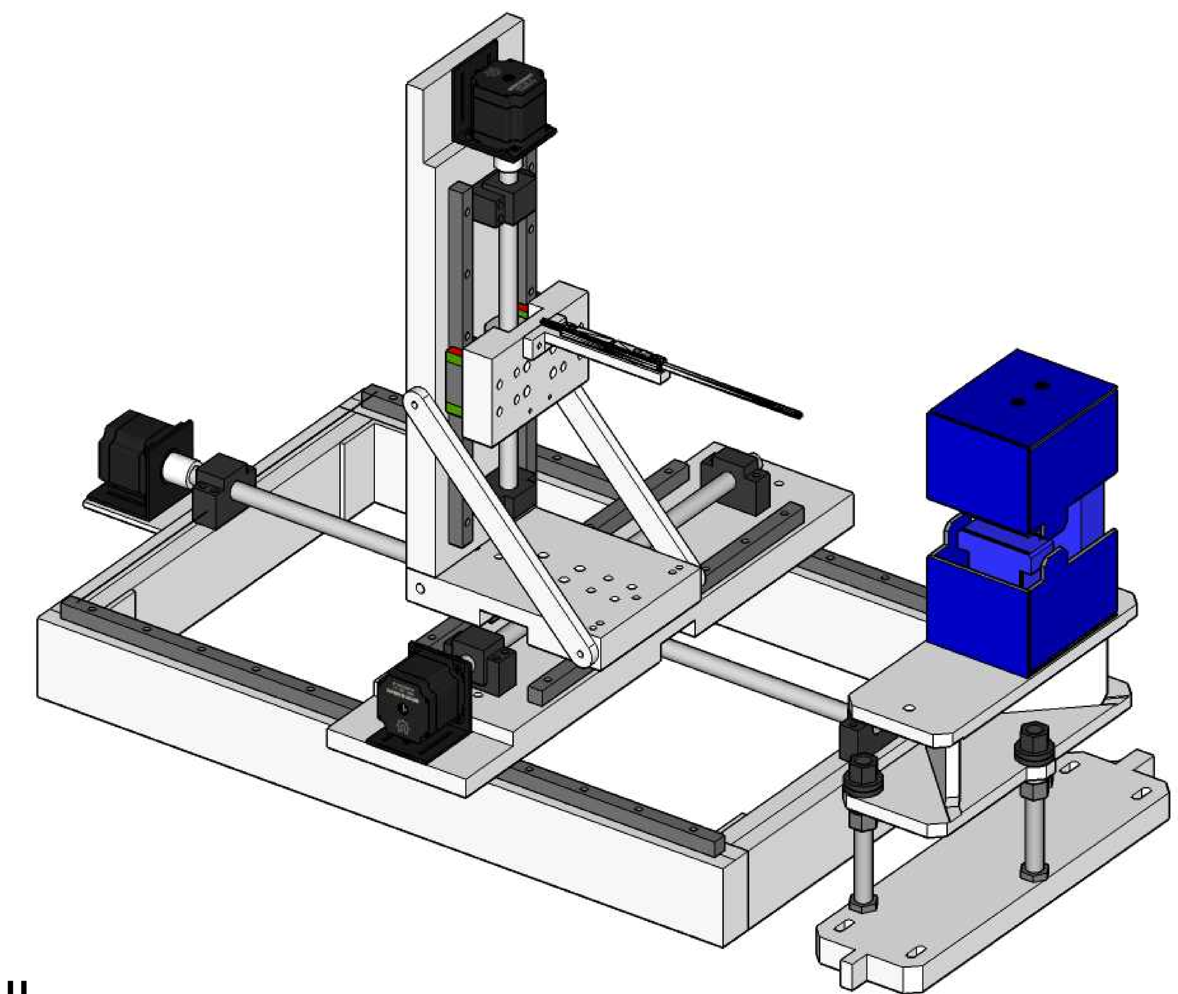

Figure 1. Solid model of the MFM with an optical stochastic cooling chicane dipole for scale. The longitudinal axis of the system is ~0.6 m in length.

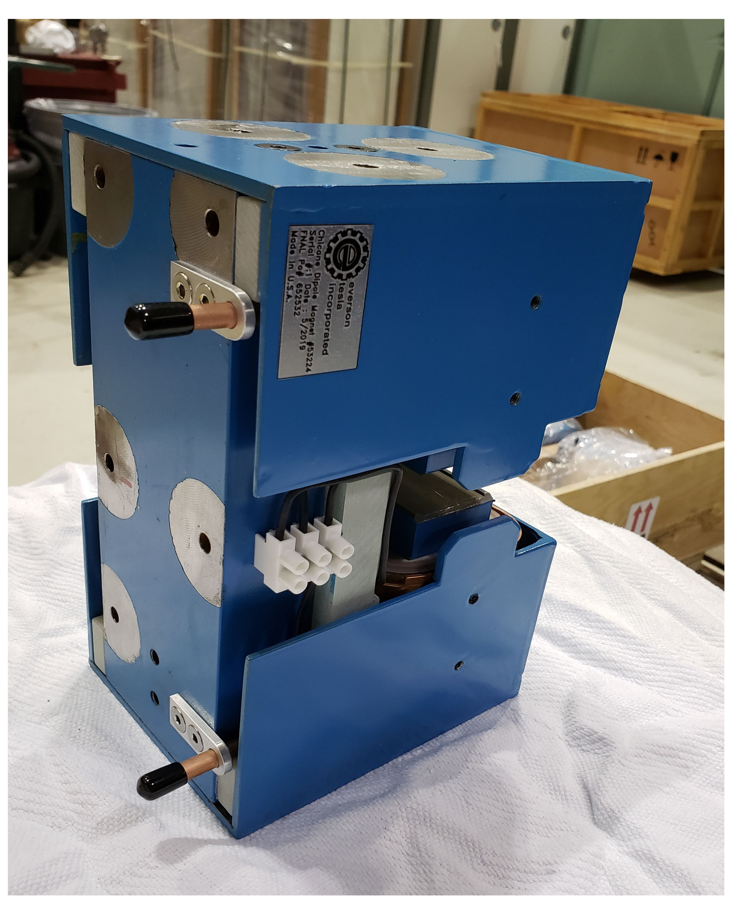

Figure 3. Optical Stochastic Cooling (OSC) Magnet

Controls

The motion and measurement systems will be connected to a Raspberry Pi for control and acquisition of data. Using custom Python scripts all subsystems can be operated as follows:

- A mesh grid of varying density is created
- Stepper motors moves to a location
- The Teslameter reports data at that point
- The process is repeated until complete and the space is mapped
- Taking ~0.5 seconds a point

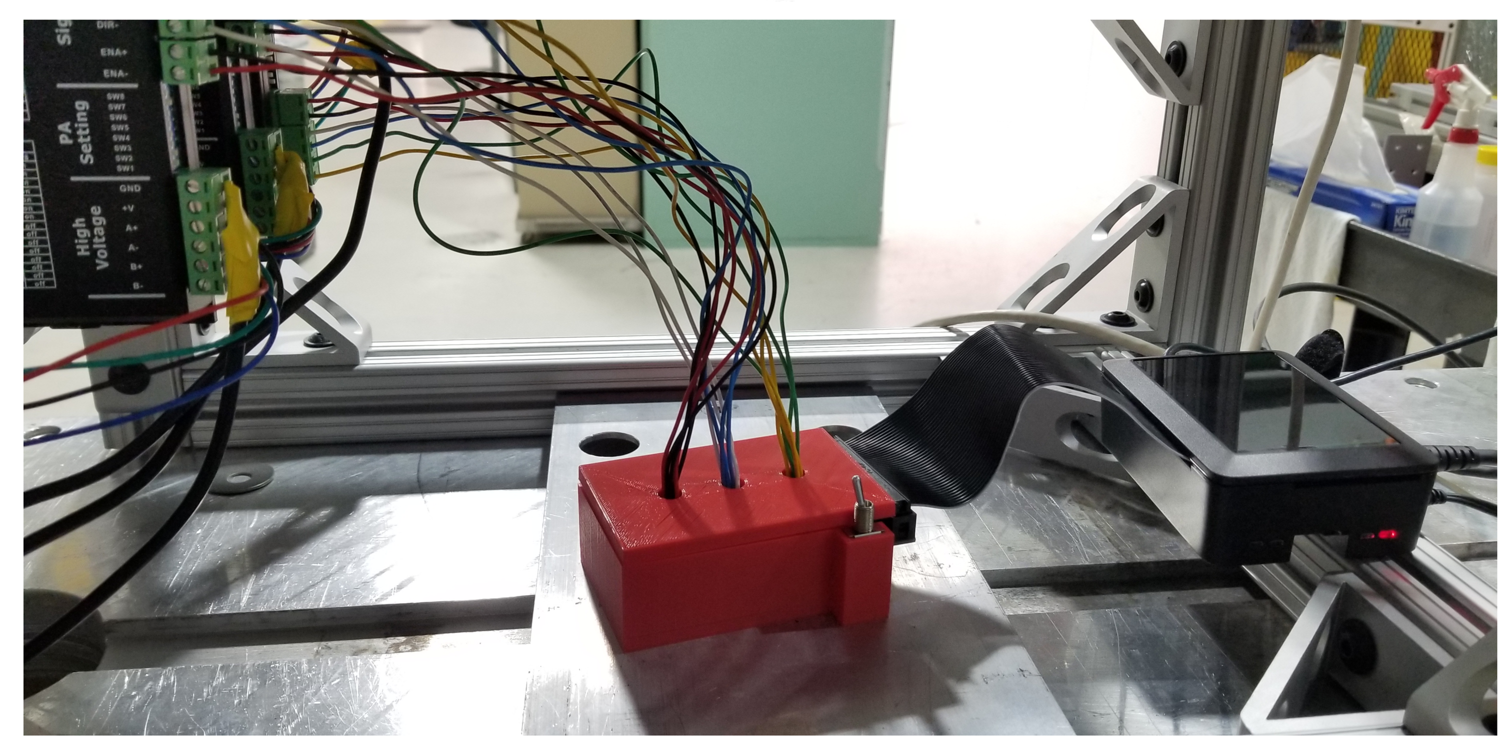

Figure 2. The Raspberry Pi and GPIO Breakout Box and Stepper Drivers

Measurement and Movement

The measurements will be taken using an F71 3 Axis Teslameter.

- Small 3-axis Hall Probe Size, 4mm by 4mm
- Range of measurable fields, 35 mT to 35 T with an error ~±0.25%

The movement of the integrated system will be controlled with a system of stepper motors and high-current stepper drivers.

- Low-cost linear bearings and rails for support
- The system will be mounted on a series of aluminum plates supported on a base of 8020 aluminum.

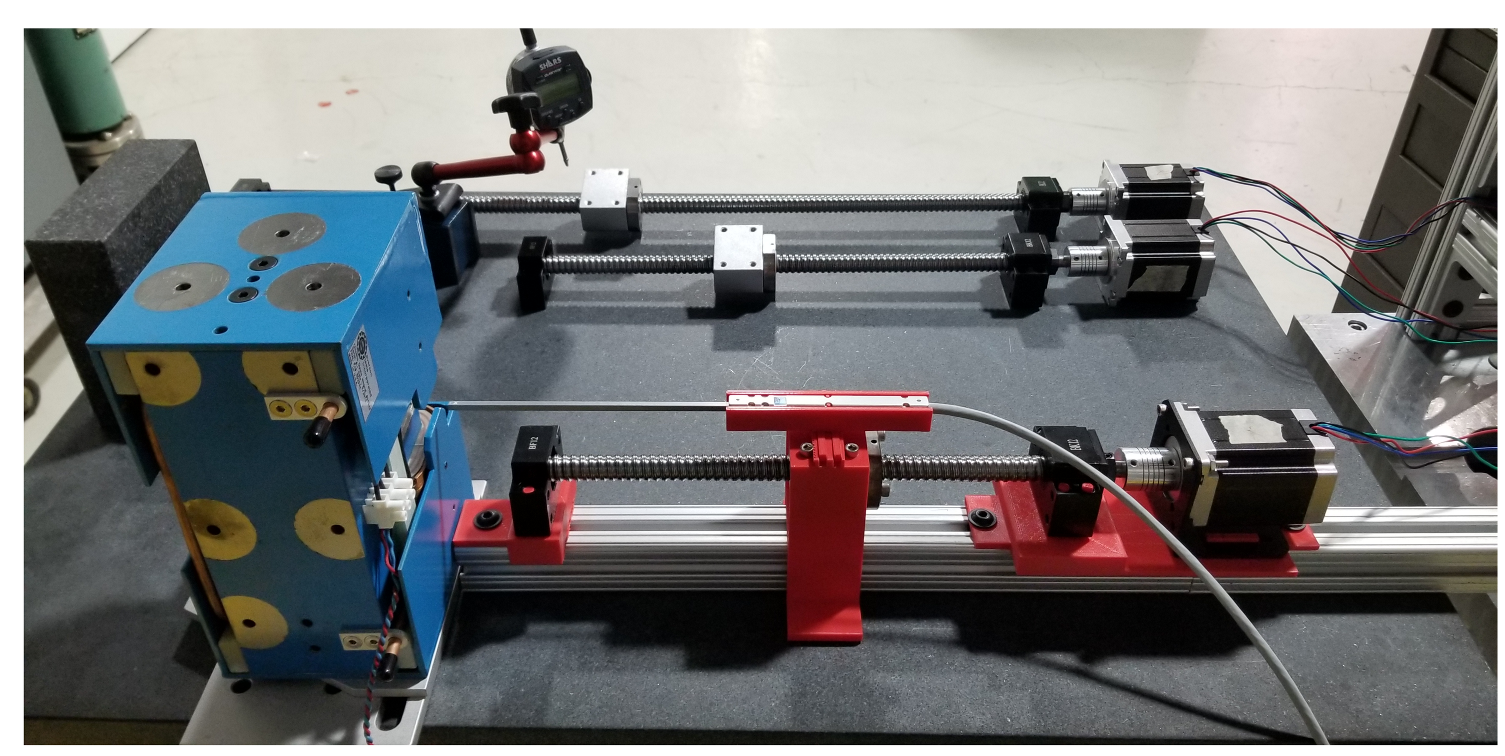

Figure 4. Data Taking Assembly. Includes Stepper motors, Ball screws, 3-Axis Probe, 3D Printed Mount

Results

Measuring experimental field of OSC Dipole

- Comparing to model field
- Large deviation outside field screens

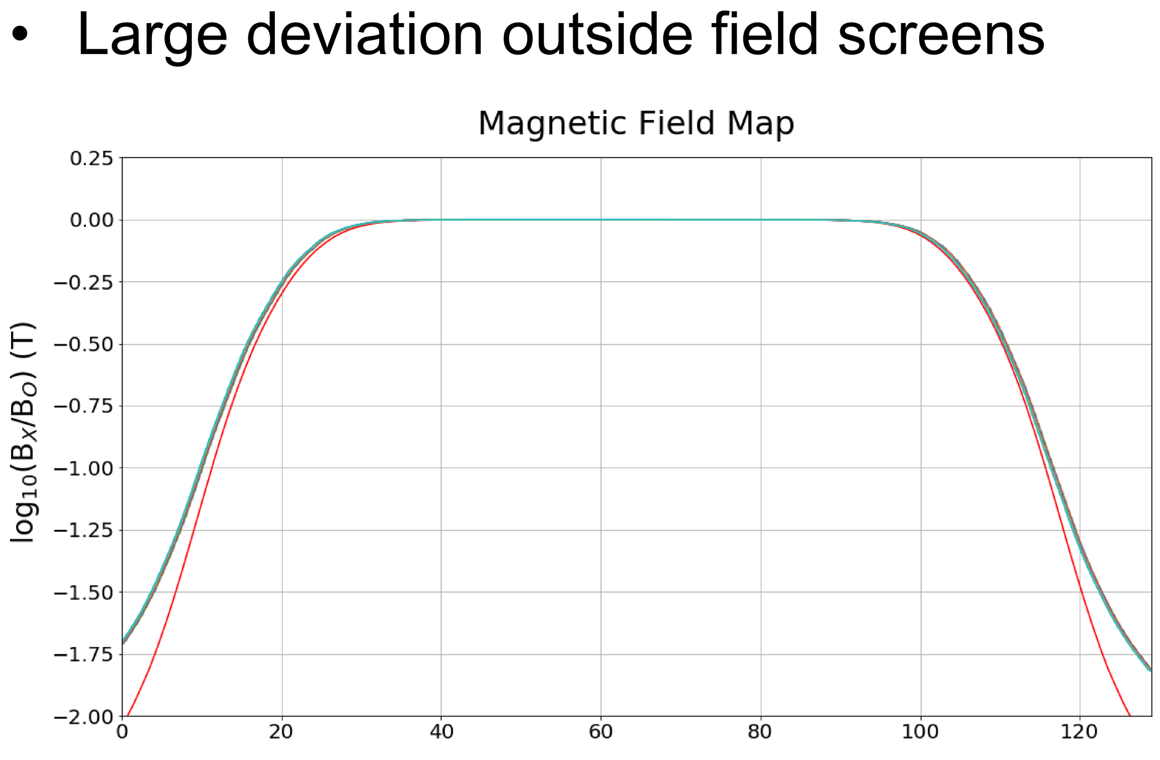

Figure 5. Measured Magnetic Field of OSC Dipole in Longitudinal line scan

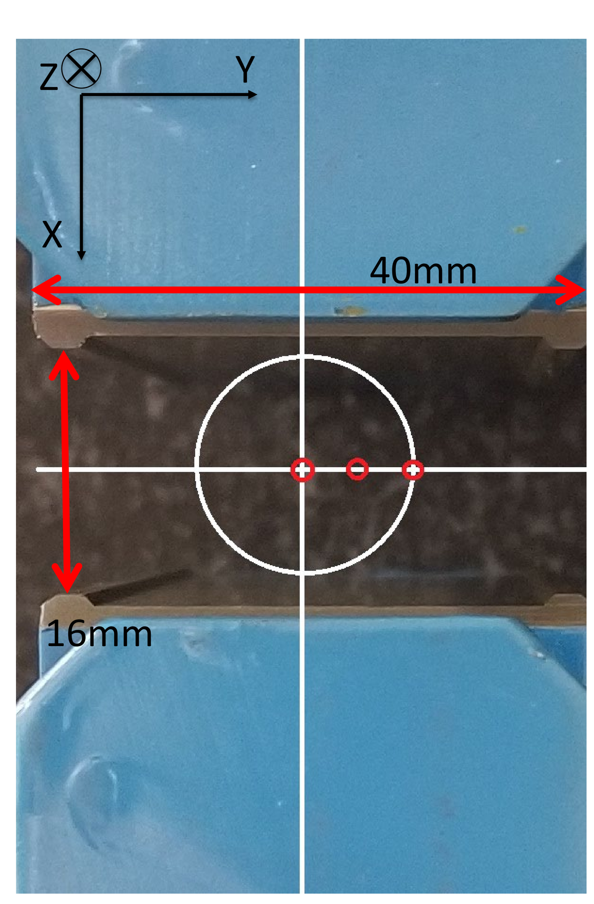

Figure 6. OSC Dipole with markings where scans occurred(0,3mm,6mm)

The Integrated Field Error

- Important figure of merit for accelerator magnets
- OSC dipole integrated field quality is expected to be within 2e-4 of the magnetic center
- Preliminary experimental data the integrated field quality was measured
- At 3 different locations
- Repeated 10 times

$$I(x) = \int B_y(x,z)dz$$

$$\Delta(x) = \frac{I(x) - I(0)}{I(0)}$$

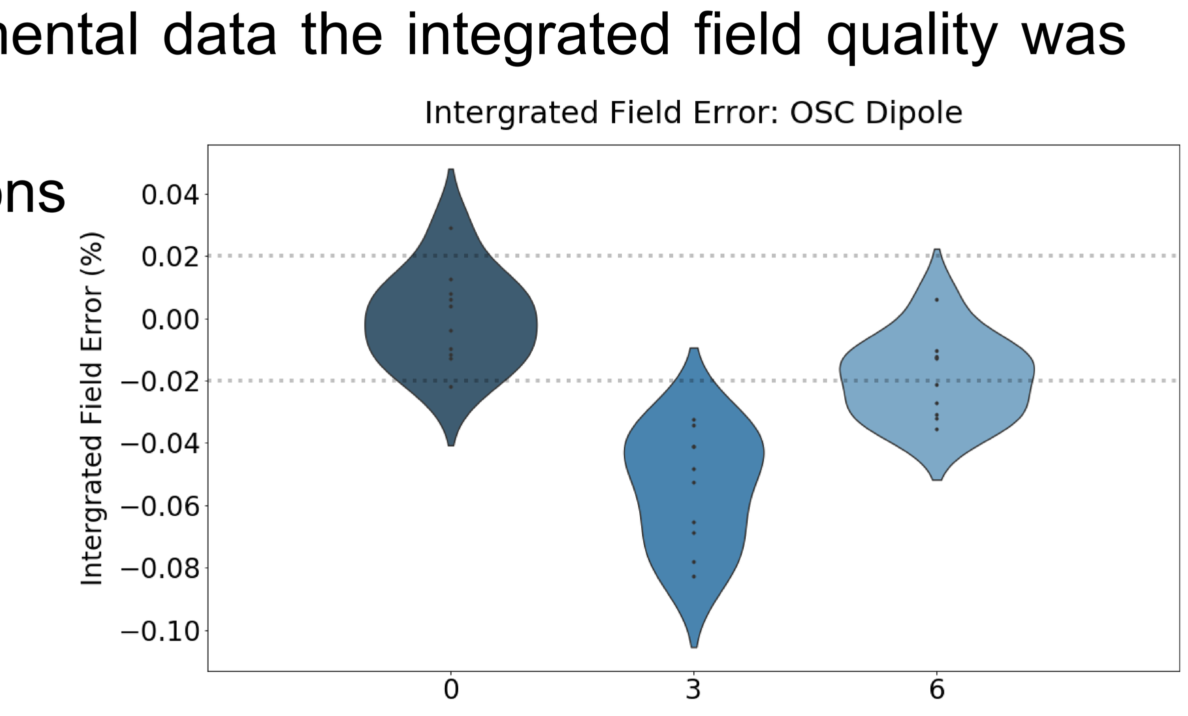

Figure 7. Integrated Field Quality of OSC Magnet

Possible sources of data error include Magnetized Ball Screw, Mount instability, and Bent Ball screw

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