**Background**

- Muon g-2 measures the muon magnetic moment anomaly by relating spin precession frequencies to magnetic field strength.
- Every aspect of the magnetic field must be investigated to reach the uncertainty goal of 140 ppb.
- These kicker plates set the muon beam trajectory with a fast magnetic pulse.
- Induced eddy currents in the surrounding metal create a lingering **kicker transient magnetic field**.
- Measurements of the **kicker transient field** have several unique requirements:
  1. No added metal.
  2. MHz bandwidth and mG sensitivity.
  3. Resistance to vibrations and HV.
  4. This demanded an alternative to the usual NMR approach.

**Methodology**

- Three teams designed **Faraday Magnetometers** to measure the kicker transient field for Muon g-2.
- When a laser travels through TGG crystals, the polarization angle rotates in accordance with the **Faraday Effect**:
  \[ d\phi = V_{TGG} \times B \times L \]
- These magnetometers direct lasers into and out of the kicker region, measuring the change in polarization while the field is present.
- The UMass team uses fiber optics to aim the laser, while the INFN and KAIST/FNAL teams align the laser through free space.
- Lasers lose their collimation and polarization in fiber optics. The UMass magnetometer includes internal optics to restore these qualities.
- After Faraday rotation, the beam is split into components to preserve its polarization information on the return trip.

**Results**

- Preliminary results under full field conditions are currently available from the UMass magnetometer. Partial-field data from the INFN and KAIST/FNAL magnetometers show general agreement. The three teams are preparing to collect new data in July 2022.
- ~1.3 million kicker transient field measurements were averaged together to produce the data pictured above.
- UMass result: Kicker transient effect is -18 ppb, with uncertainty +/- 17 ppb.

**Vibration Suppression Techniques**

UMass (left): silicone bands cushion fibers.
INFN (near right): sorbothane pillar secures in place.
KAIST/FNAL (far right): bridge isolates from kicker cage.

**Uncertainty Source**

<table>
<thead>
<tr>
<th>Source</th>
<th>Contribution (UMass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>15 ppb</td>
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<tr>
<td>Spatial Dependence</td>
<td>7 ppb</td>
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<td>Baseline Subtraction</td>
<td>3 ppb</td>
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<tr>
<td>Calibration</td>
<td>0.5 ppb</td>
</tr>
</tbody>
</table>

**55th Annual Fermilab Users Meeting**

**June 13th, 2022**