Jefferson Lab Hall A Beamline Instrumentation and Calibration for GMP experiment

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Outline

- Introduction to GMp Experiment
- Hall A beamline
- Beam Position Calibration
- Beam Charge Calibration
- Conclusion

Introduction to GMp Experiment

- Form factors characterize the spatial distribution of electric charge and magnetization current in the nucleon.

  $$|\text{Form Factor}|^2 = \frac{\sigma(\text{Structured object})}{\sigma(\text{Point like object})}$$

- Types of form factors:

  G_M^P → Magnetic form factor

  G_E^P → Electric form factor

- Important input to all form factor experiments, and many of the other experiment where elastic scattering is used for normalization.

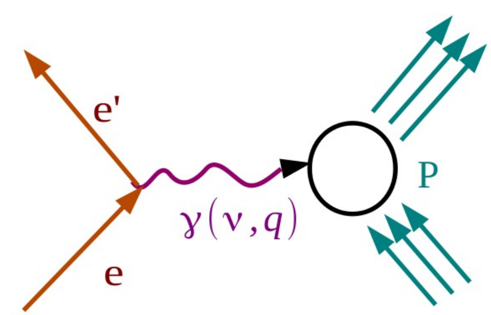
Methods of measurement

- **Rosenbluth separation method**: Measuring cross-section at several values of beam energy and scattering angles for constant Q^2.
- **Polarization transfer:** Measuring the ratio of electric to magnetic form factors by determining the polarization components of recoiling proton.

In OPEA approximation the cross-section in ep scattering when written in terms G_E^P of G_M^P and takes the following form:

$$\frac{d\sigma}{d\Omega} = \sigma_{Mott} \frac{\epsilon (G_E^P)^2 + \tau (G_M^P)^2}{\epsilon (1+\tau)}, \sigma_{Mott} = \frac{\alpha^2 \cos\frac{\theta^2}{2}}{4E^2 \sin^4\frac{\theta}{2}} \frac{E'}{E}$$

Reduced Cross section



Where,

$$\tau = \frac{Q^2}{2M^2}, \ \epsilon = [1 + 2(1+\tau)\tan^2(\frac{\theta}{2})]^{-1}$$

ϵ - Virtual Polarization

Goals of GMP experiment

- To accurately measure the elastic ep cross-section in the Q^2 range of 7-14 GeV^2 with an accuracy better than 2%.

- Determine the magnetic form factor, with an accuracy several times better than previous measurements.

Expected Precision

Goal: 2 % or less total uncertainty

Syst: 0.5-0.8%

Point to point: 0.8-1.1%

Need a good control on:

- Beam energy
- Target density
- Scattering angle

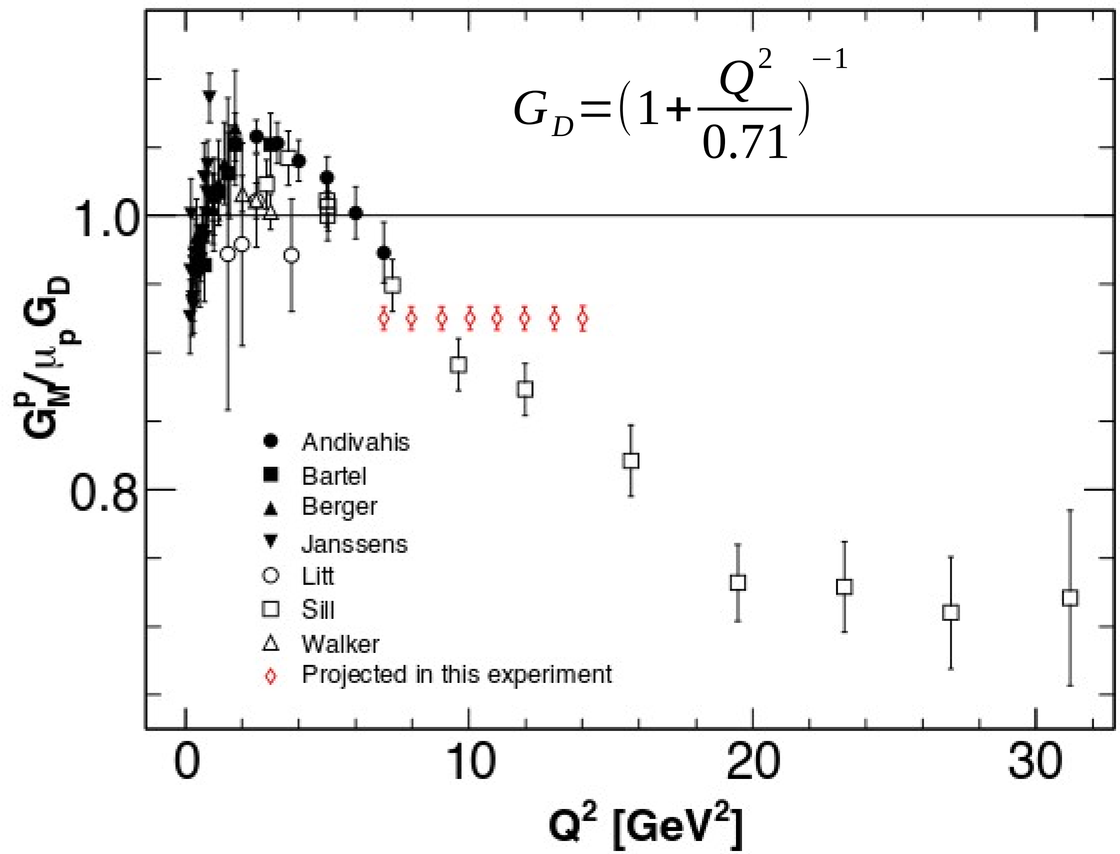
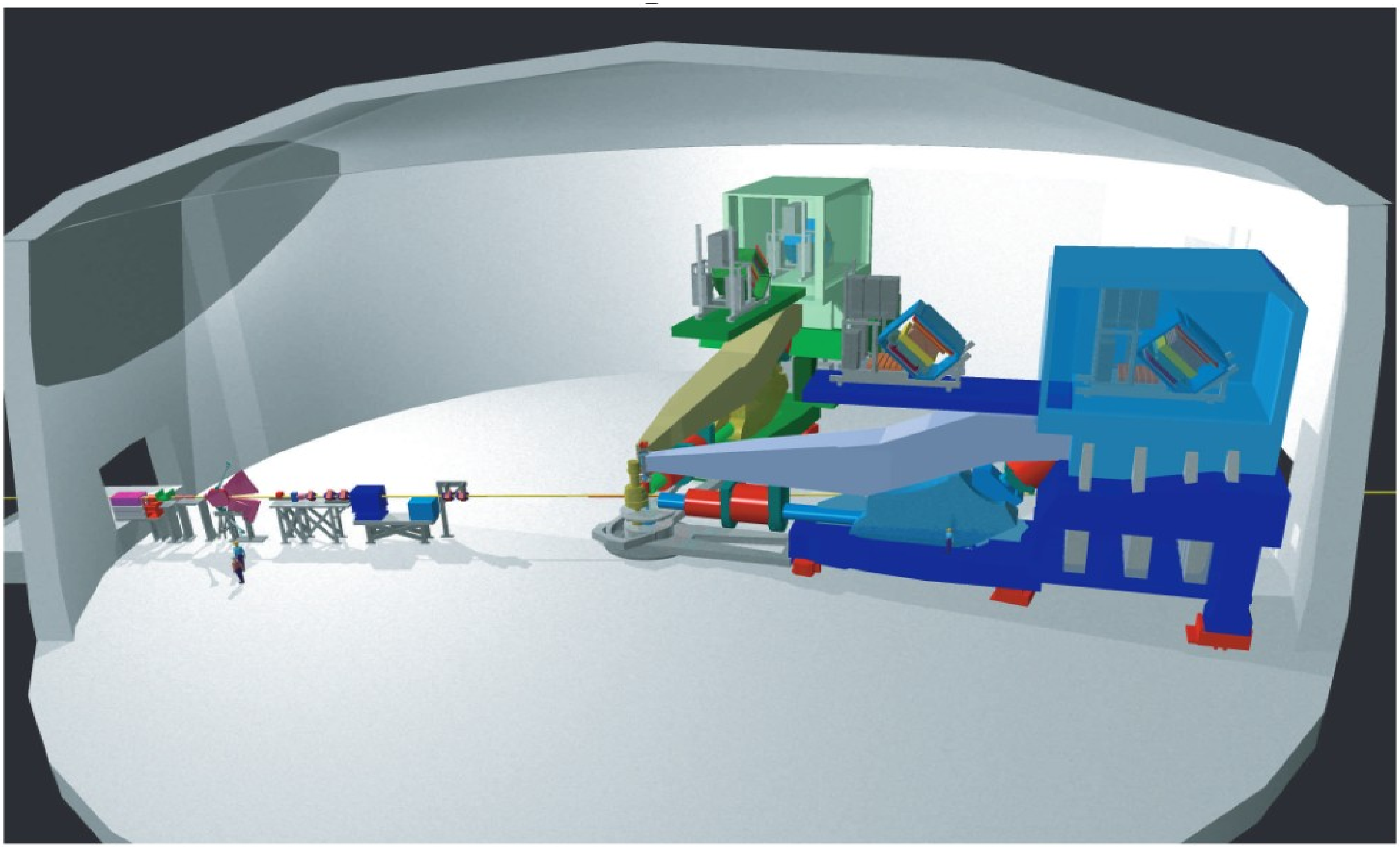
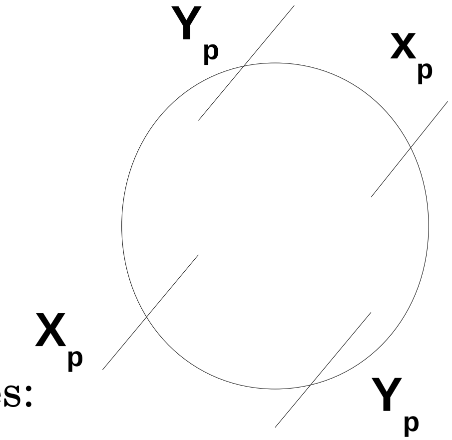


Fig: Published world data for $G_M^P/\mu_p G_D$ and red data points are our proposed kinematics

Hall A arms and beamline transport



Hall A Beamline



Charge measuring devices:

-Unser

-Beam current monitor

Position measuring devices:

-Beam position monitors

-Harp

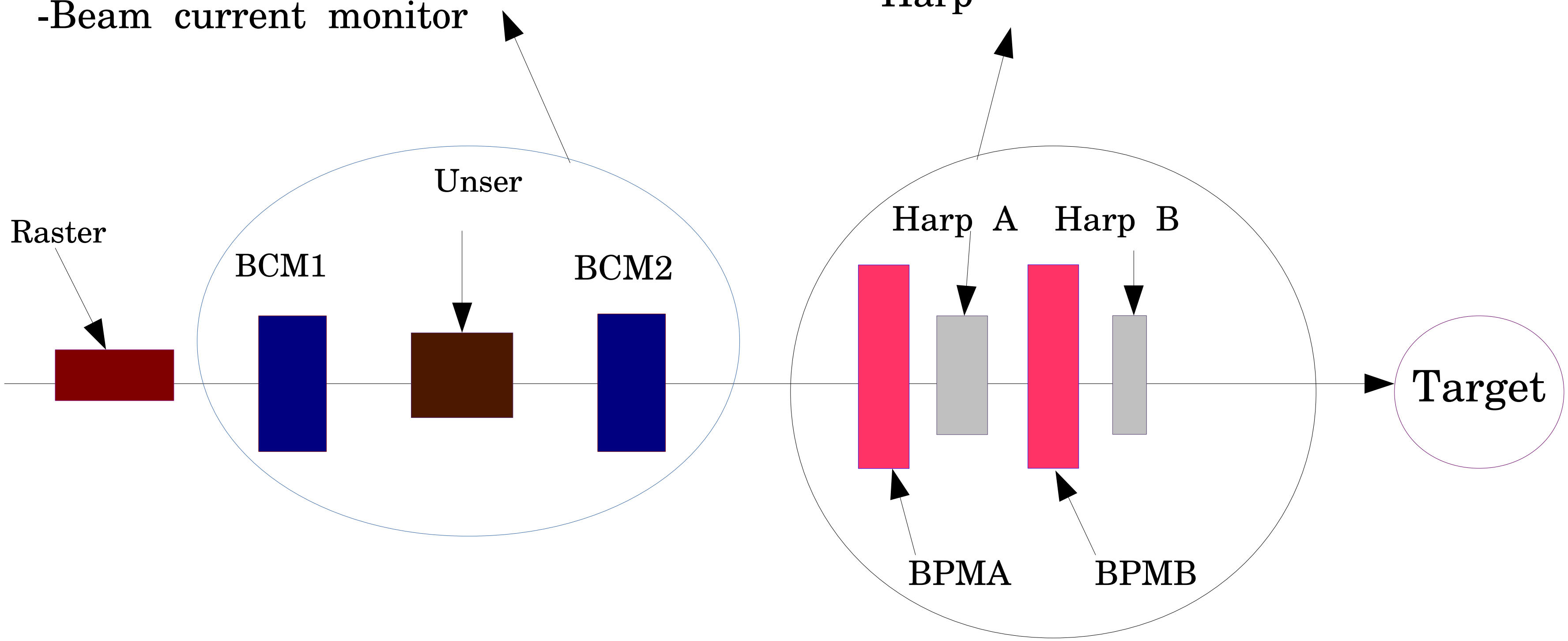
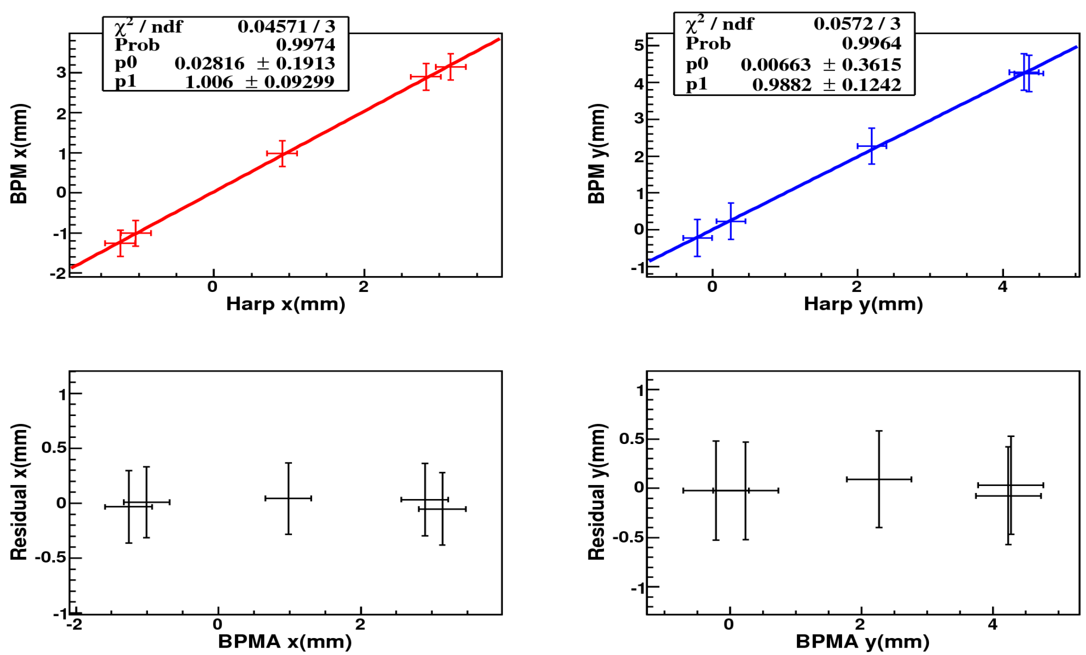


Fig: Schematic of Hall A Beamline

Beam Position calibration

- Idea is to convert the relative beam position from BPM to the absolute positions in hall coordinate system using positions determined by the Harp scan.
- Need to find the calibration constants that give positions at BPM close to positions from Harps.



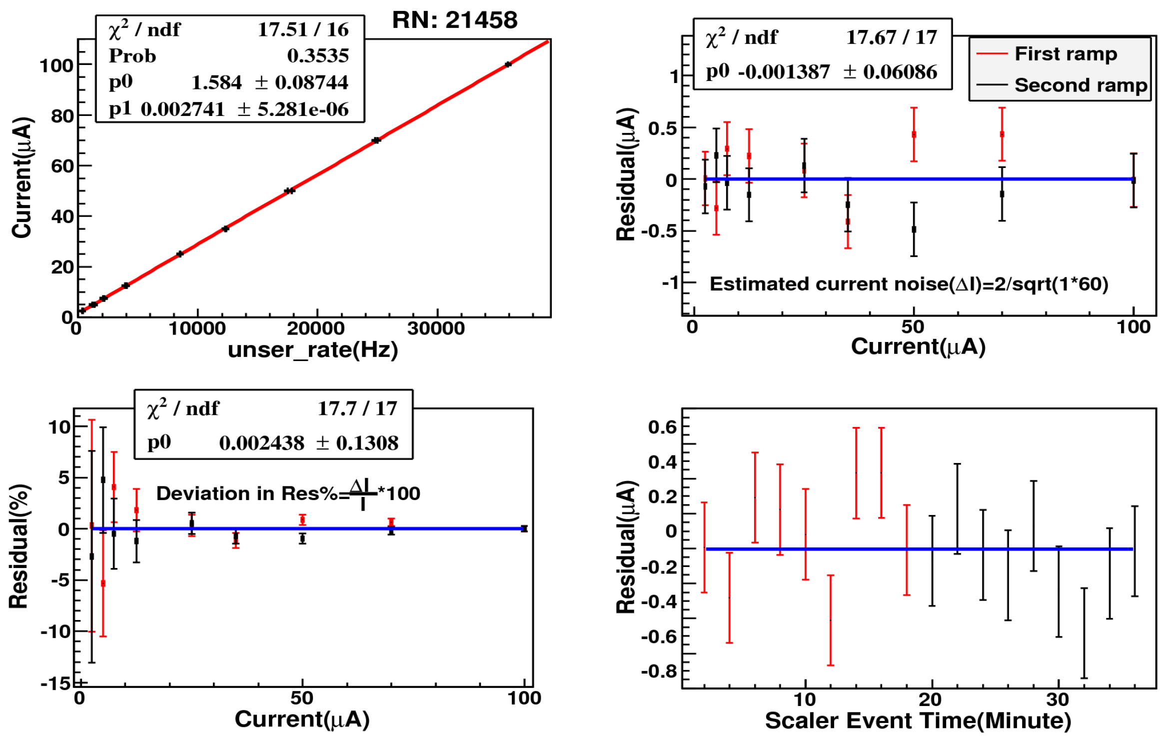
BPM Relative coordinates(x',y')

Hall coordinates (x,y)

$$\begin{pmatrix} x \\ y \end{pmatrix}_{Abso} = \begin{pmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{pmatrix} \begin{pmatrix} x' \\ y' \end{pmatrix} + \begin{pmatrix} x_{of} \\ y_{of} \end{pmatrix}$$

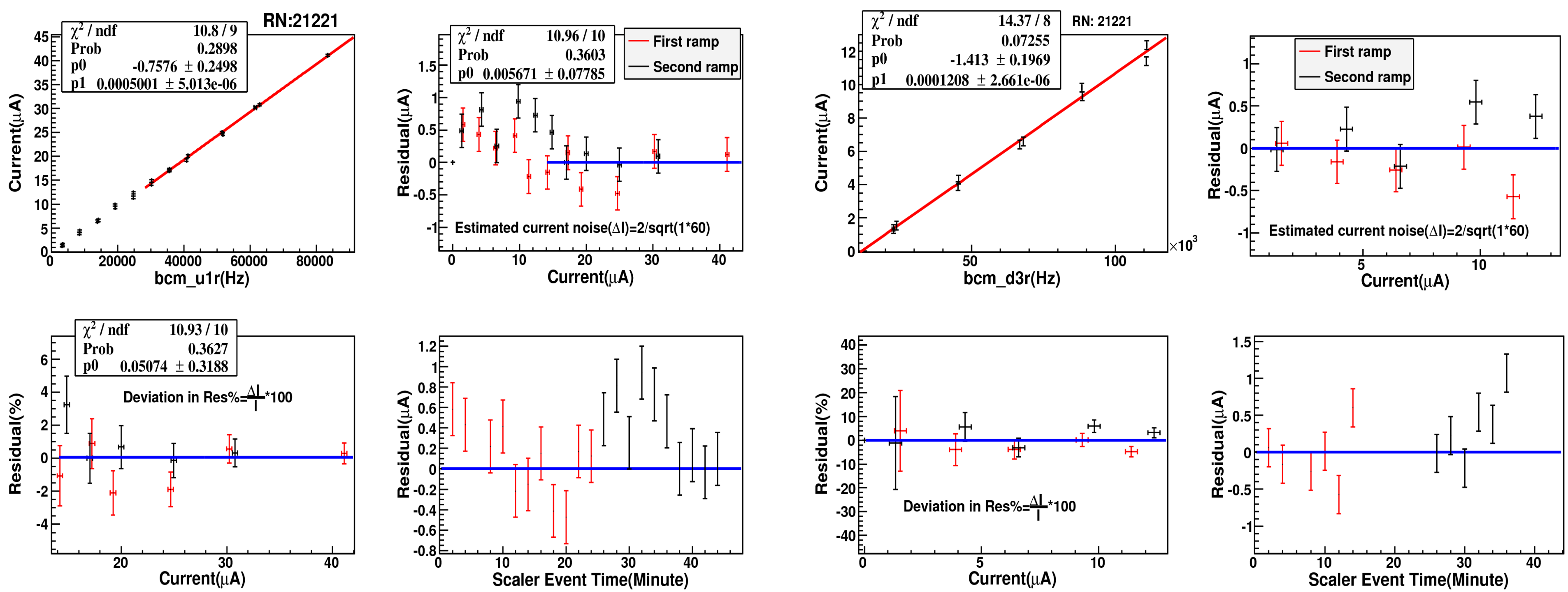
Unser calibration

- Calibrated Unser frequency against known current through a wire.
- Calibrations are done relatively frequently to study stability and drift.
- Gain is found to be stable within 0.4% from Fall14.



BCM Calibration

- Calibrated BCM frequency against unser current to determine $f_{BCM} \rightarrow I_{BCM}$
- Removed current below 15uA from u1 bcm while d3 bcm is saturated above 14uA.
- The overall uncertainty above 15 uA estimated at +/- 0.3uA from x1.



Conclusion

- BPMs are calibrated against harp.
- Current monitors are calibrated frequently from 0-40 uA and found stable.
- We were able to measure the current within the precision of 2.5%.