Some initial thoughts on calibration for FF detectors

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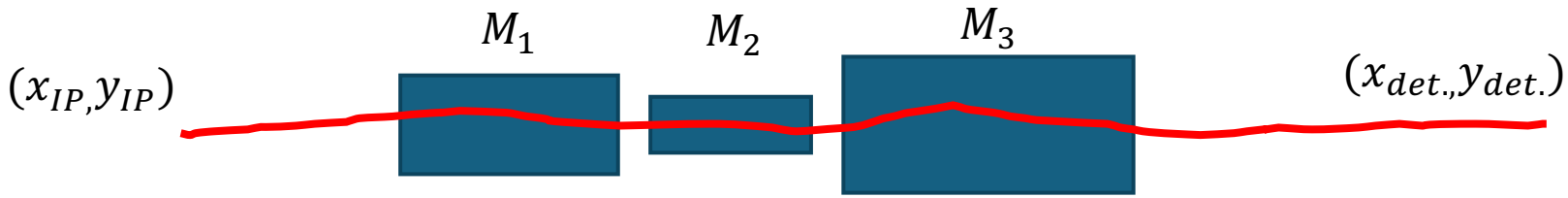
Roman pots and off-momentum detectors

- How do we *use* the Roman pots?
- Momentum reconstruction requires *transfer matrices* to describe particle motion through the magnets.

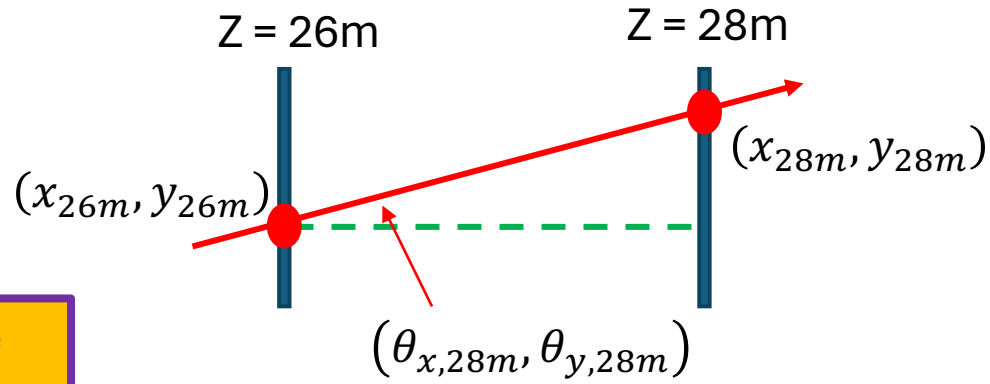


$$M_{transfer} = M_1 M_2 M_3 \ldots$$

$$\begin{pmatrix} x_{ip} \\ \theta_{x,ip} \\ y_{ip} \\ \theta_{y,ip} \\ z_{ip} \\ \Delta p/p \end{pmatrix} = \begin{pmatrix} a_0 & a_1 & a_2 & a_3 & a_4 & a_5 \\ b_0 & b_1 & b_2 & b_3 & b_4 & b_5 \\ c_0 & c_1 & c_2 & c_3 & c_4 & c_5 \\ d_0 & d_1 & d_2 & d_3 & d_4 & d_5 \\ e_0 & e_1 & e_2 & e_3 & e_4 & e_5 \\ f_0 & f_1 & f_2 & f_3 & f_4 & f_5 \end{pmatrix} \begin{pmatrix} x_{det.} \\ \theta_{x,det.} \\ y_{det.} \\ \theta_{y,det.} \\ z_{det.} \\ \Delta p/p \end{pmatrix}$$

- Transforms coordinates at detectors (position, angle) to original IP coordinates.
- Matrix unique for different positions along the beam-axis!

Detector



Precise alignment < 0.1 mm precision crucial for accurate reconstruction of tracks using transfer matrices.

Roman pots and off-momentum detectors

AC-LGAD

Alignment concepts:

- Relative alignment of sensors with respect to one another.
- Absolute alignment of sensor packages with respect to beam.

➢ Survey alignment

- Doesn't require interaction with DAQ.
- Provides ~mm precision, at best → not good enough alone for our needs.

➢ Beam-based alignment

- Beam-based alignment requires use of information from the machine beam position monitors, in combination with detector hit information.
- Requires BPMs before and after Roman pots.
- Goal is to understand the position of the beam with respect to the detectors.
- Also important to understand alignment of sensors in same station.
- Different optical configurations can be requested for calibration runs, as well.

➢ Use of hit information

- Comparing rates in various parts of the detector → beam is Gaussian in x and y, rates in bottom/top and right/left should be the same if the detector is perfectly centered on the beam.
- Useful way for achieving relative alignment as rates are compared in sensors between in different layers.

B0 tracker

AC-LGAD

- Conventional tracker in a magnetic field, normal challenges apply.
- Need to consider absolute alignment of planes and relative alignment with respect to one another.
- Can use cosmics for calibration, as well.
- High rates expected in detector during normal operation (DIS + beam+gas) – could low lumi running be useful for calibration purposes?

B0 EMCAL and ZDC EMCAL

- Both using crystals (PbWO4 or LYSO) + SiPM readout (APDs also being considered).
  - Cosmic rays can be used for calibration (we usually have cosmic running periods before we get beam at RHIC), and to calibrate SiPM gains.
  - LED systems can be employed, as well (but has not been discussed).
  - Standard calibration tools with “real” particles → MIPs and gamma/electrons.
    - B0 calibration will benefit from track information in the case of electrons, but no details ready on this, as of yet.

ZDC HCAL

- Same technology as HCAL insert in forward endcap.
  - Data needed for SiPM gain calibration, LED system for calibration, etc.
- Biggest difference here is the dynamic range → neutrons can have ~ beam energy in ZDC.

Some general notes

- Every ePIC subsystem will need cosmics → expectation for ~ 1 week of cosmic data taking before the run starts seems reasonable.
  - Requires full DAQ operation.
- LED systems will be needed for most calorimetry.
  - Not clear SRO DAQ is needed here, but perhaps some common approaches can be employed.
- Need to be able to use information from the accelerator in real-time.
  - BPM information for RP/OMD alignment.
  - Accelerator clock information.
- AC-LGAD – based detectors will have similar needs (same ASIC, same sensor).
  - ASIC will have obvious needs for measurement of pedestal and noise and calibration of threshold and gains.
  - Radiation damage will accrue over time and affect both the timing resolution, and spatial resolution (for detectors using charge sharing, e.g. B0) → not expected for a significant running time, but needs to be monitored.
- Time synchronization of FF/FB with central detector? Scheme needs to be discussed.
  - Time of the hit @ FF detector needed to associate hit to bunch crossing.
  - Takes about 10 bunch crossings (30 meters/speed of light – 10ns bunch spacing) worth of time to go from IP to Roman pots.