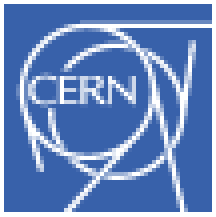


Bunch Charge from Beam Position Monitor

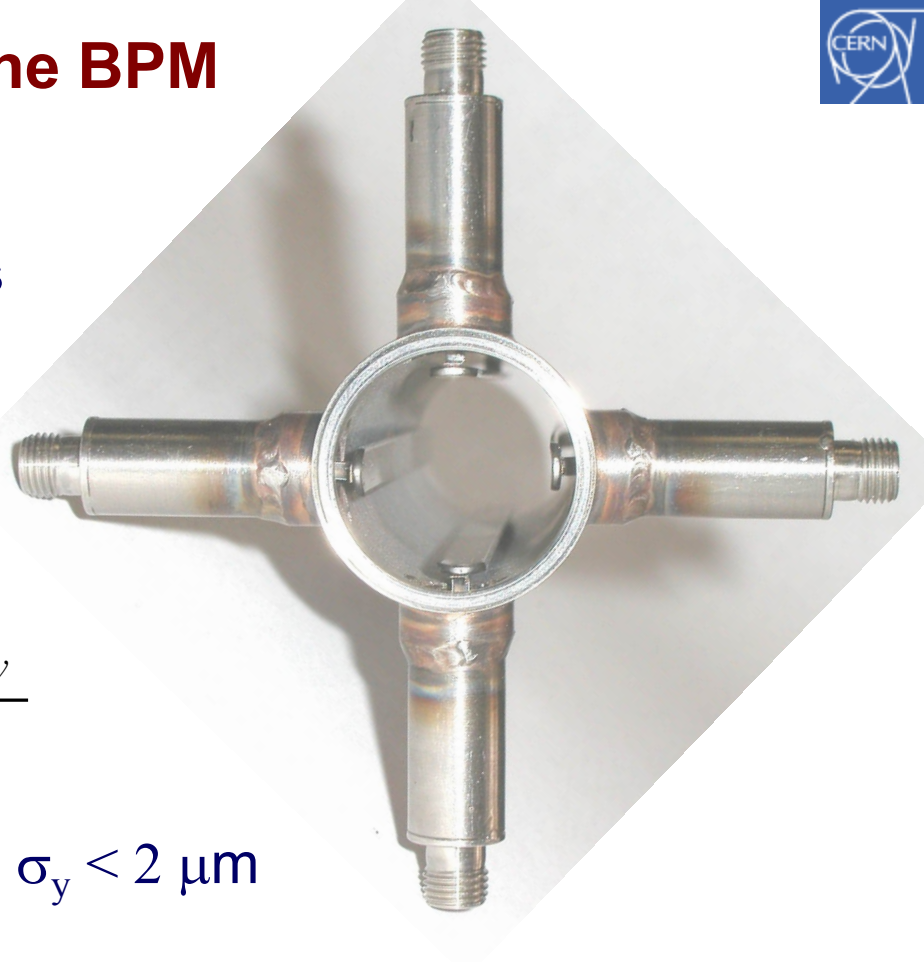
BCT Workshop

Steve Smith
SLAC / CERN
12.01.2011

Beam Position Monitor (BPM)

- Fast
- Linear
  - Essentially no material properties
    - No mu
    - No epsilon
- But:
  - position-dependent
  - Difficult to establish calibration

Generic Stripline BPM



- Algorithm:
  - Measure amplitudes on 4 strips

$$Y = \frac{R}{2} \cdot \frac{V_U - V_D}{V_U + V_D}$$

- Resolution: $\frac{\sigma_V}{V} = 2\sqrt{2} \cdot \frac{\sigma_y}{R}$

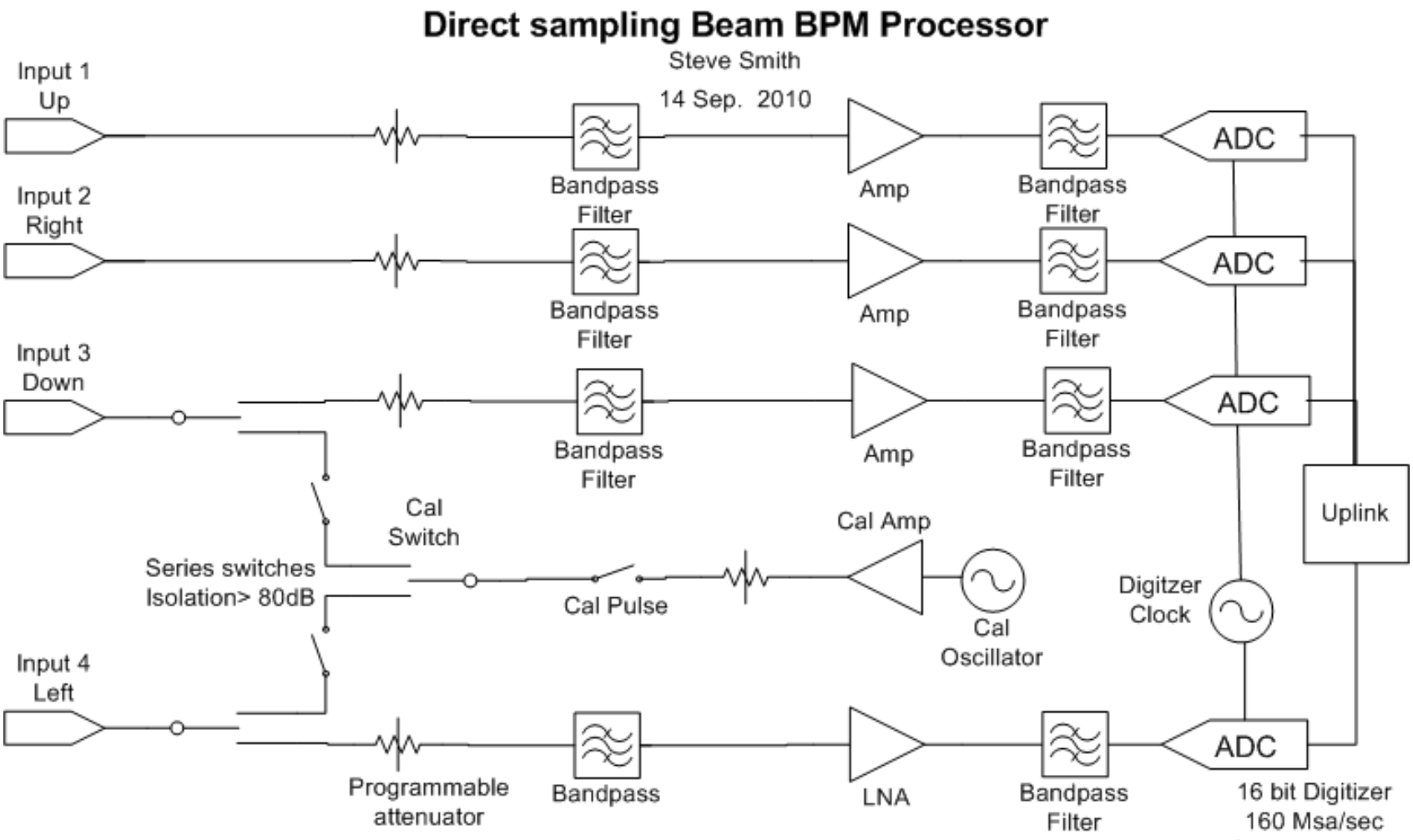
Given: R = 11.5 mm and $\sigma_y < 2\ \mu m$

Requires $\sigma_V/V_{peak} = 1/6000$ ➔ 12 effective bits

- Small difference in big numbers
- **Calibration is crucial!**

BPM as Charge Monitor

- Q ~ (Sum of 4 electrodes)
- Sum is position independent if:
  1. Electrodes all couple equally
  2. Channel gains are equal
     - Cable losses
     - electronic gains
     - …
  3. Electrodes fully cover azimuth



Typical digital BPM processor

Replace BPF with gaussian LPFs

Perhaps use 240 Msample/sec ADC

Process digitized waveform upstairs

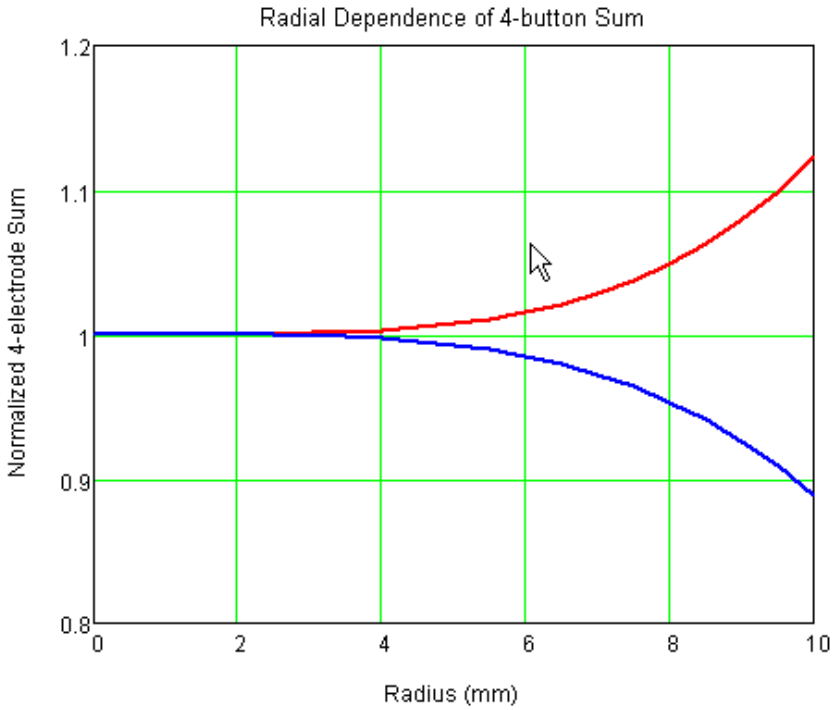
Position Dependence due to Partial Coverage

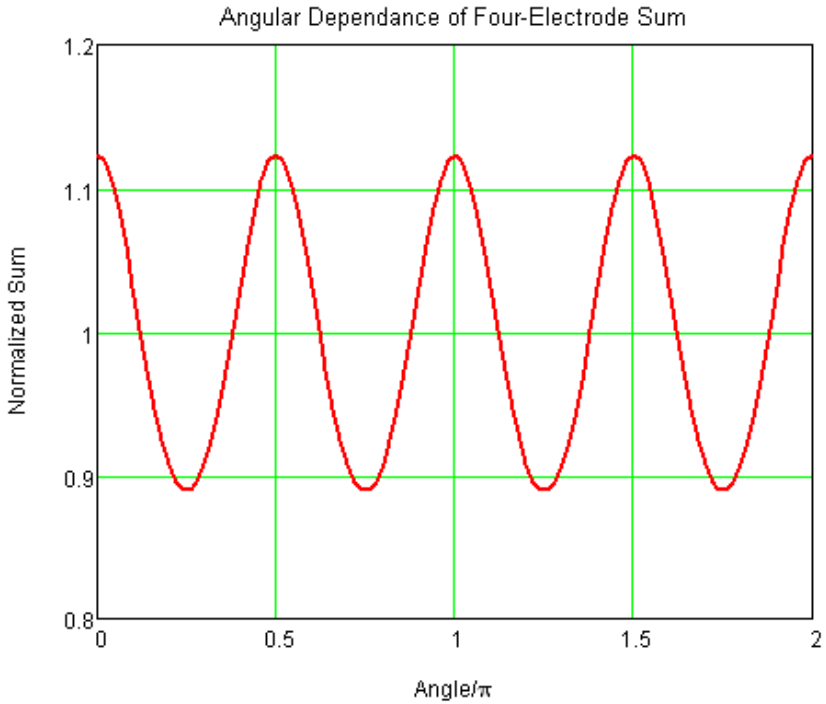
Model Stripline BPM

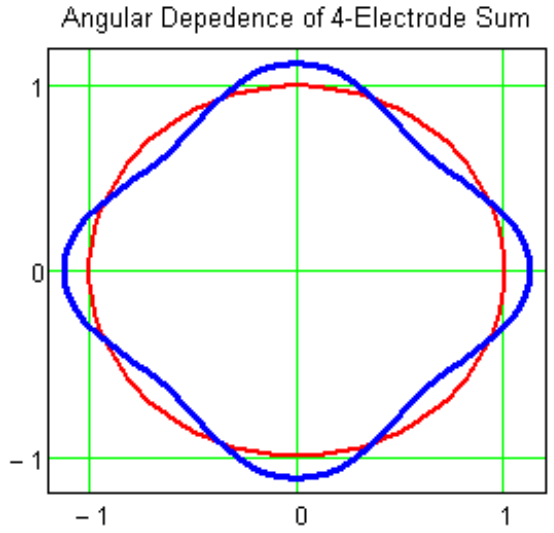
- 5% angular coverage per strip
- Radius 20 mm

4-electrode sum:

- 4^{th} order in radius
- +-12% error at R/2
- ➔ < 1% at R/4 (!)
- ~ cos(4θ) dependence



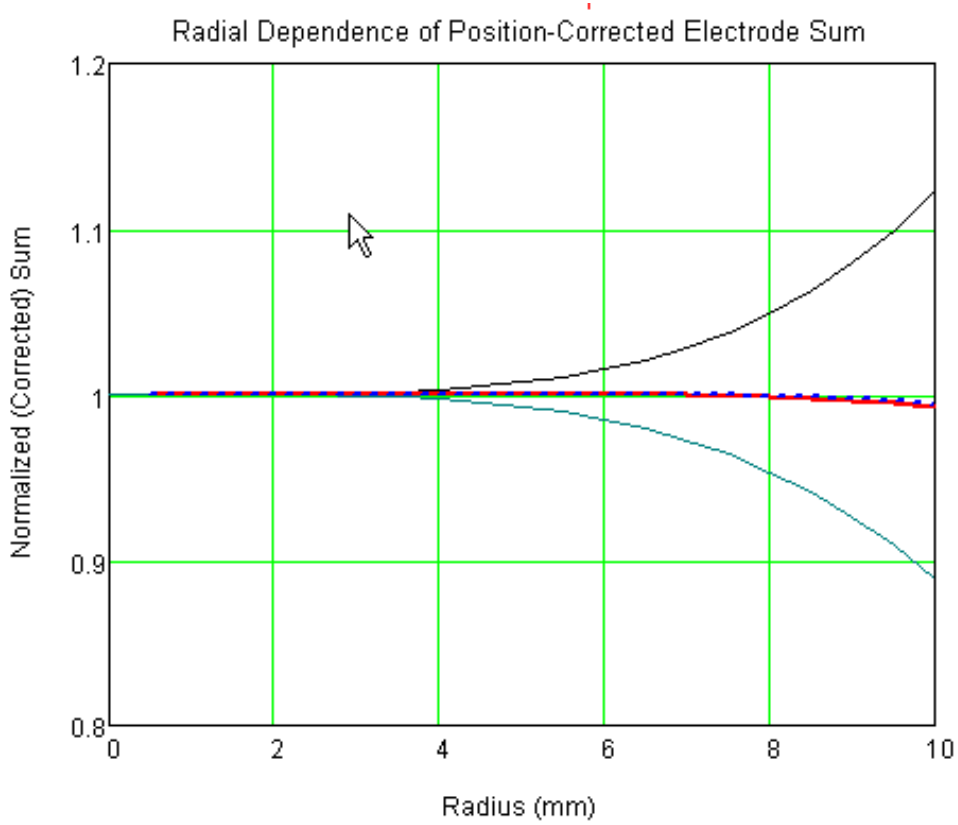


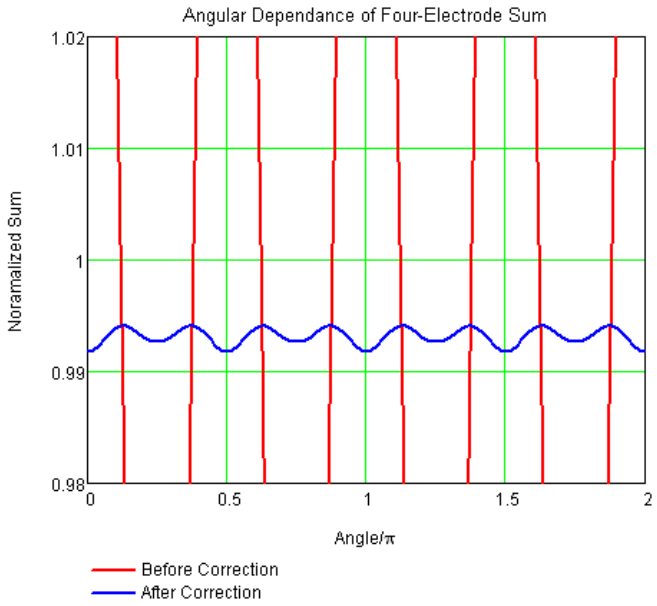


4th Order Correction

- But it is a position monitor!
- Estimate (X,Y) or (r, θ)
- Correct position sensitivity
- Add an octopole term:

$$\Sigma = \left[1 - \frac{\sin(2\phi)}{\phi} \left(\frac{r}{R} \right)^4 \cos(4\theta) \right] \cdot \sum_1^4 V_i$$



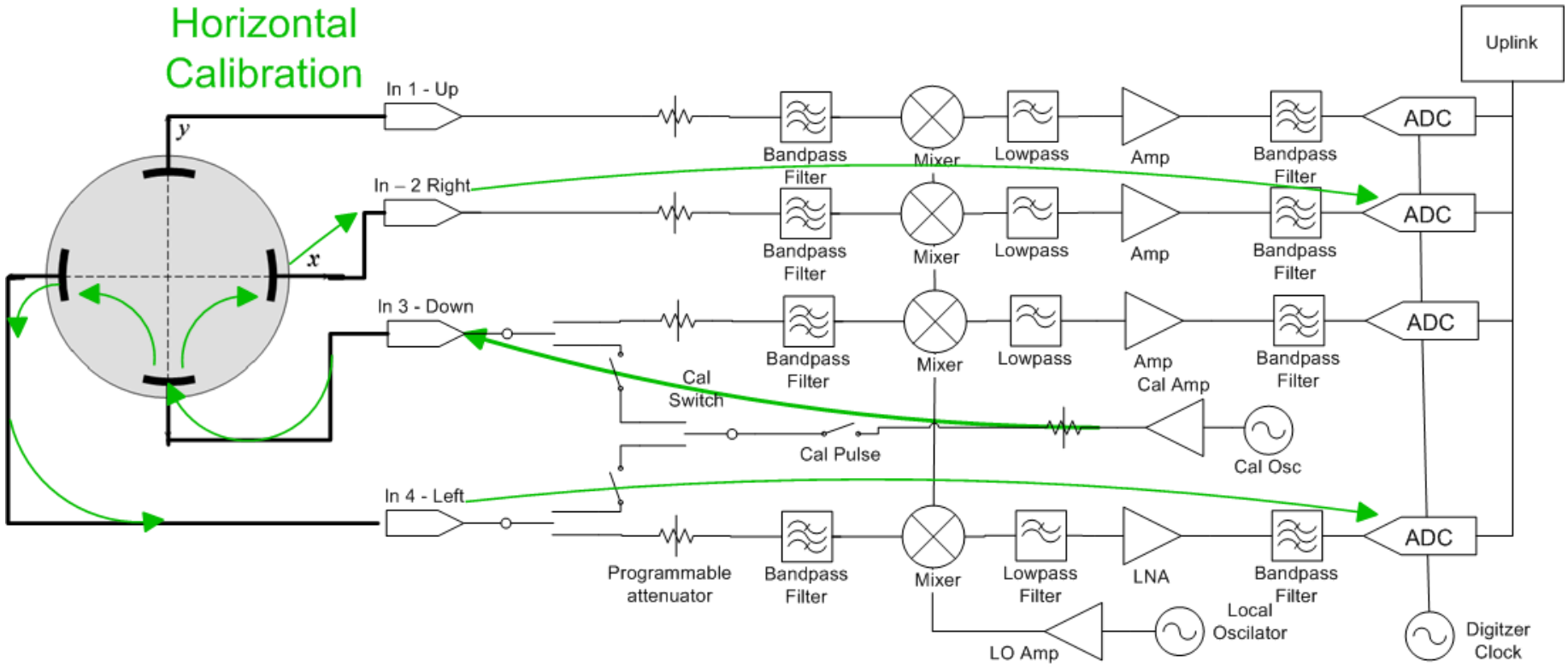


- Now error is < 1% at R/2

Calibration

- Must calibrate relative gains of 4 buttons
- Can calibrate
  - RF source
  - With beam
  - Fit data of 2-D beam motion to 3 gain ratios
    - Up/Down
    - Left/Right
    - UpDown/LeftRight
  - 2-D beam motion from H,V pinger?

Calibration With RF Source



- Transmit calibration from one strip
- Measure ratio of couplings on adjacent striplines
- Repeat on other axis
- Gain ratio ➔ BPM Offset
- Repeat between accelerator pulses