# BPM Calibration

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TeV BPM Upgrade Meeting

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# Ground Rules for Today

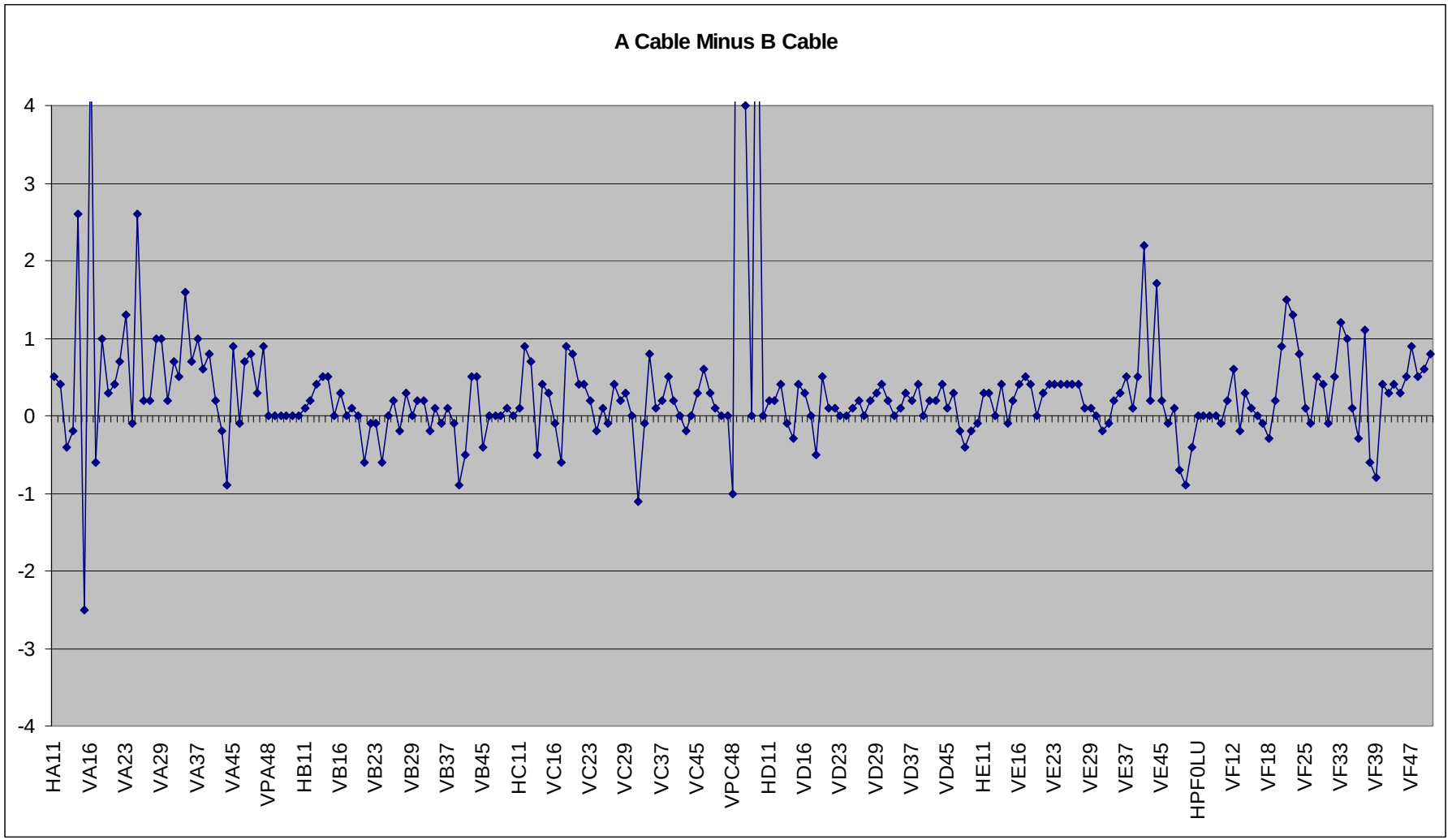
- Limit discussion to closed orbit measurement of 36 proton bunches.
  - First consider proton only
  - Then consider 36 on 36 running.
- Ignore relative phase shifts between A and B.
  - See Beams-doc-1482 (Gustavo Cancelo).
  - The effect is less than 1 micron for the envelope filter. Hard to believe that it is much different for the “recycler” filter.
- Ignore digitizer effects:
  - Beams-doc-812 (Jim Crisp), page 8.
  - $\sigma$(position) = 0.77 $\mu$m for 1 bit noise and full scale signal.
    - Or about 3 $\mu$m for ¼ full scale signal.
- DA = Differential Attenuation

| Source | Error at Source | Position | | Reference |
|---|---|---|---|---|
| | | Scale (mm) | Error (μm) | |
| 1) Error in Quadratic Model | | | ?? | |
| 2) Survey Offset | 1 mil | | 25 | Bob Webber |
| 3) DA Within beam pipe. | “Small” | | 0 | Bob Webber |
| 4) DA in Cables to house. | 0.1/40 mV | 0.2 – 2. | 30 | Note 1. |
| 5) DA in filter board. | | | | |
| 6) DA in Echotek. | 0.001/0.9 | ? | 20 | Note 2. |
| 7) Orthogonal coordinate | | | < 300 | Beams-doc-1076 |
| 8) Effect of Pbars (now) | | | < 170 | Note 3. |
| Total (in Quadrature) | | | | |

- DA = Differential Attenuation

- Note 1.
  - I have a table from Marv Olson which gives measurements of attenuation in proton cable from 1983.
  - Typical values are 40 mV and are quoted with a precision of 0.1 mV. Worst case is 30 mV.
    - Assume that error is the precision with which they are quoted.
  - 20 log ( 40.1/40 ) = 0.02 db
  - 20 log ( 30.1/30 ) = 0.03 db
  - Scale is 150 μm / 0.1 db
  - So position error due to cables is 30 μm, typical and 45 μm worst case.
  - See next page for data.

# From Marv Olson:



- Note 2
  - Spoke with Mark Bowden who reports the following from a conversation with Rick Mahlum who did the tests.
  - For one channel:
    - Typical value of Echotek gain is 0.9
    - Typical error is 1 on third significant figure.
  - Compare two channels: 0.9 + sqrt(2)*0.001
  - 20 log ( 0.90141 / 0.900 ) = 0.0136 db
  - This corresponds to 20 μm.

- Note 3:
- Beams-doc-1059
  - File: bias.ps, page 6.
- Full scale effect is about 170 microns.