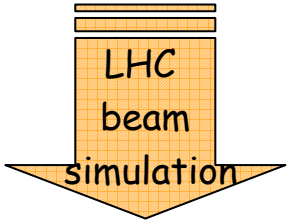
Need for Alignment

Position of off-momentum proton w.r.t. beam

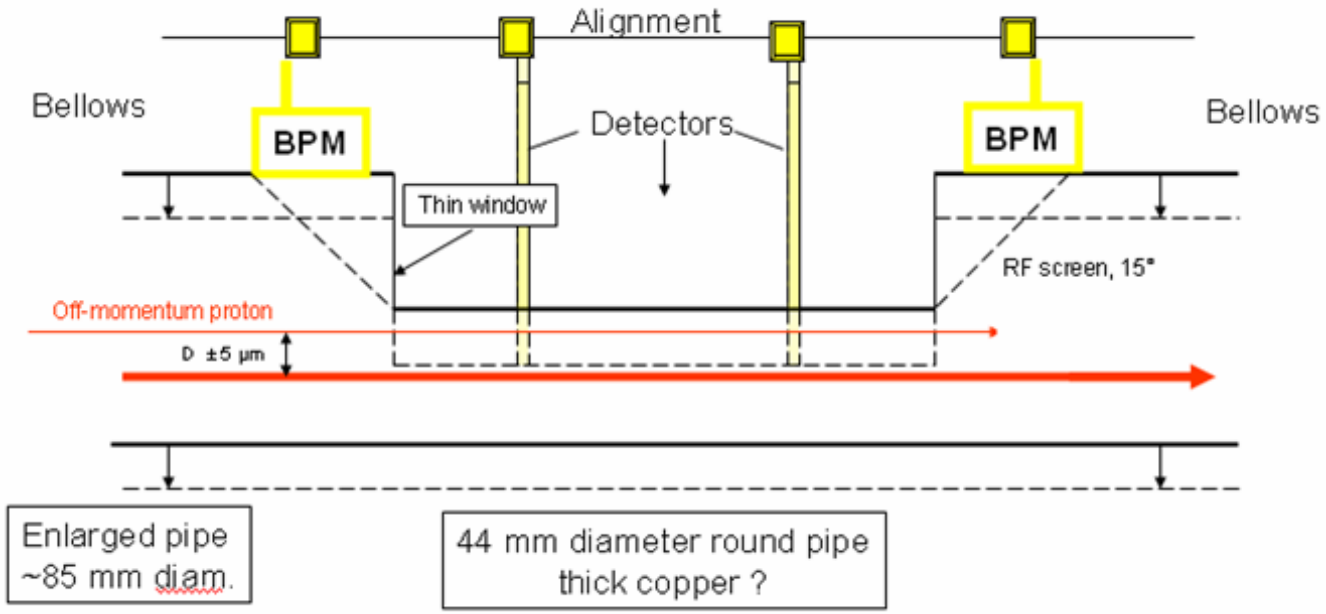


Energy loss of proton

Energy spread of beam → ~50μ position uncertainty at 420m

→ align detectors relative to beam with accuracy ~10(s)μ

One Possibility: a Wire Positioning System

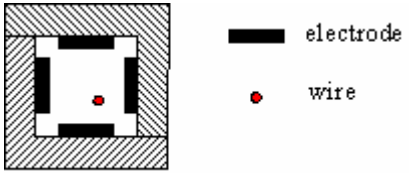


- Alignment wire stretched along length of system, inside connection cryostat
- Beam Position Monitor pick-ups sit around beampipe
- WPS sensors are fixed to the BPMs and detectors

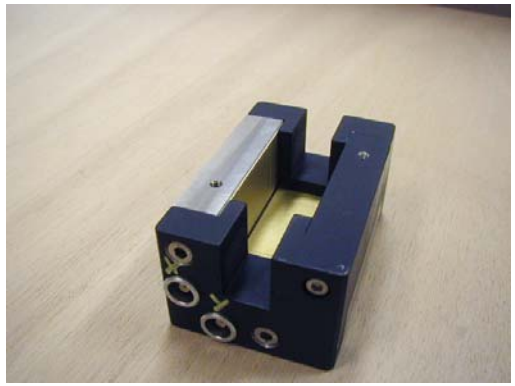
- BPMs measure position of beam (shown in red); WPS measures relative radial alignment of detectors with BPMs
- Picture shows Hamburg Pipe option with all components of alignment system moving together. Other options, e.g. with various components moving independently, may be more complicated.

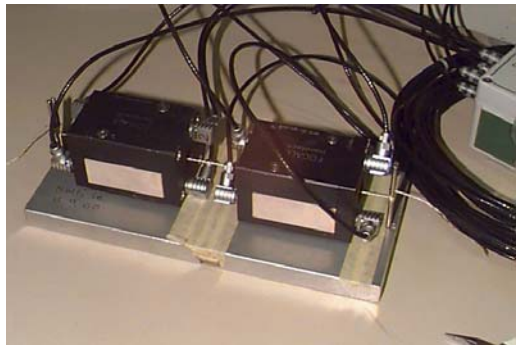
Wire Positioning System

- WPS sensors use a capacitive measurement technique along 2 perpendicular axes.
- They measure the distance between their mechanical axes and a stretched wire which is the reference.
- On each measurement axis, the wire sits between 2 electrodes:



- WPS does not include any electronic components.
- The wire is made of carbon fibers; its geometry is maintained by a sheath of woven PEEK filaments.
- WPS used successfully in LEP energy spectrometer (1999), which required accuracy of 1μm on the beam position.





Resolution: 0.1 μm

Range: 10 mm along two axes

Repeatability: 1 μm

Bandwidth: 0-100 Hz

This slide courtesy of H. Mainaud-Durand

Requirements, Constraints

- Alignment resolution needed ~ 10 μm.
  - Overall precision is:

    BPM precision + alignment BPM →WPS sensor

    + WPS precision + Alignment of system

    + alignment WPS sensor → detector
- Alignment must be stable and low maintenance as well as precise.
- Environment will be harsh: radiation, air currents; variations in temperature, pressure.

Alignment Test Bench at CERN

- Test feasibility & tolerances of a complete chain
- Components and availability:
  - Workspace available in CERN west area
  - Marble bench, 2.5m long, on loan from CLIC
  - WPS components on loan from LHC until end of year:
    - sensors, wire + tensioning/support, readout hardware and software; all fully working.
  - BPM components also on loan from LHC until end of year:
    - One complete pickup, one being finished (ready end of May)
    - Readout software & some electronics available
    - Calibration precision currently 100μm. Needs to be improved!
  - Beam simulation:
    - Wire? Vibrations → hard to calibrate
    - Printed circuit with several traces/embedded wires:
      - Stability
      - Flexibility; could simulate different beam positions

  See Detlef's slides

  - 3 precision positioners available, on loan from CERN & Brunel
  - Initial layout drawings in preparation; may need to make some items.
  - Temperature and humidity monitoring to be arranged
  - Later: something to simulate a detector + fixation to a WPS sensor

Conclusions

- Need very accurate alignment between beam and detectors; ~10s of μm
- One possibility: use a Wire Positioning System to reference detectors to BPMs
- Test bench being set up at CERN, aiming for measurements in June/July.