BPM requirements for energy spectrometry

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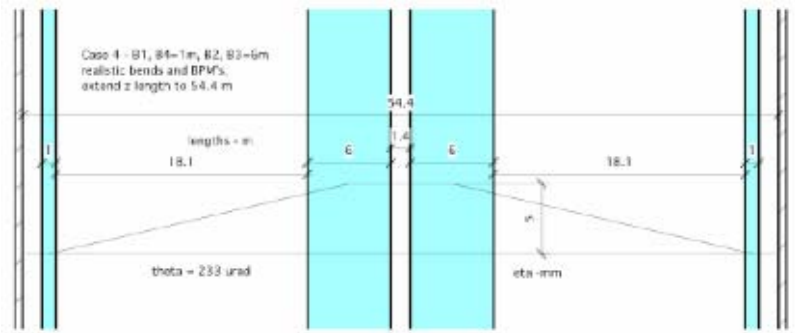
Overview

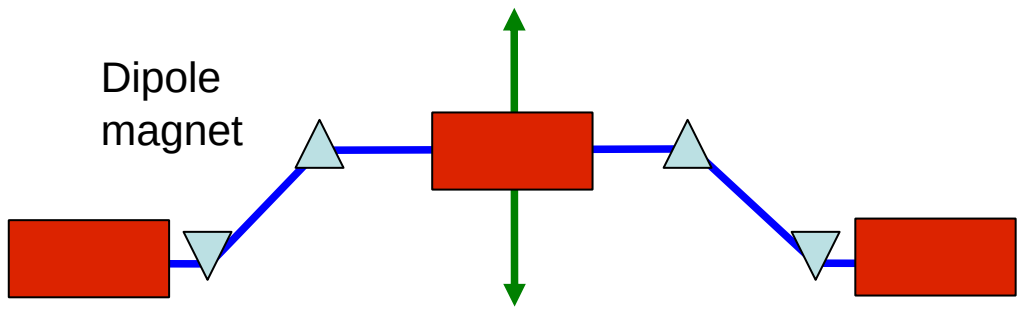
- Spectrometer essential diagnostic for ILC
  - 9 bpms per spectrometer x 4 beam lines ~36 BPMs
  - Requirements different from linac/BDS BPM requirements

- Talk outline
  - Spectrometer requirements
  - Spectrometer BPM requirements
  - Quick overview of existing efforts
    - ATF nano BPMs
    - End station A chicane tests
  - Other BPM development
  - What should be done here at Snowmass
  - Summary

Chicane spectrometer requirements

- Beam energy measurement requirement of 1 part in 10^4
- Assume chicane as proposed by PT and RA
  - 4 magnets
  - 5 mm maximum deflection
  - Bipolar operation
- Measurement time
  - Single bunch
  - Bunch train
  - 1 hour / 1 day
- Mode of operation effects BPM design
  - Operation of chicane (frequency of ramping)
  - Frequent return to low energy?
  - Essential design beam energies
    - 175, 250 & 500 GeV
  - Move BPMs to null dipole signal

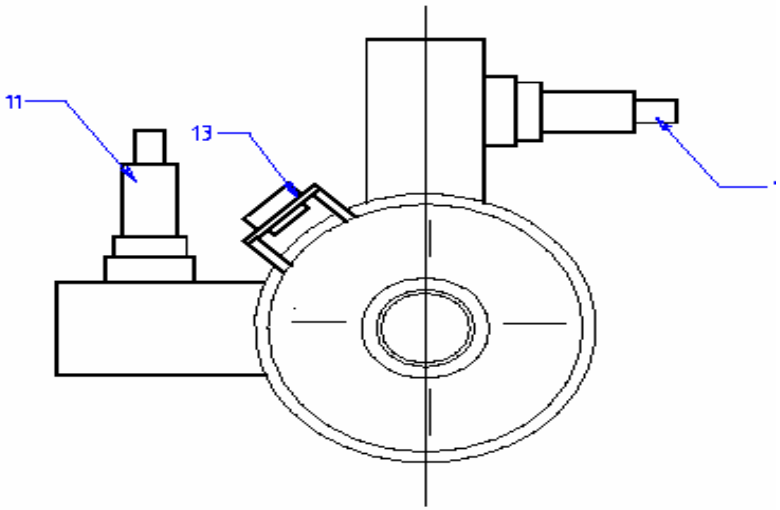


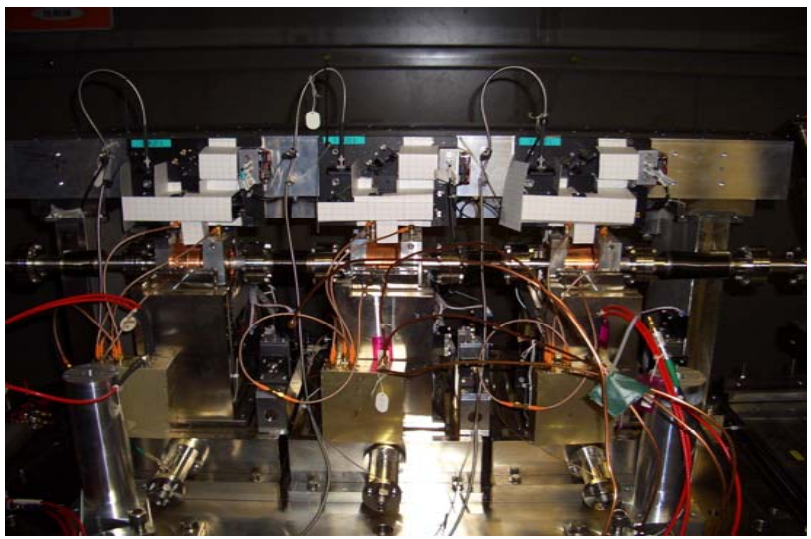


Spectrometer BPM requirements

- Spectrometer BPM will probably set the most stringent requirements on BPM design
  - Aperture
  - **Resolution**
  - Dynamic range (1000:1)
  - **Stability (intrinsic and electronics)**
  - Accuracy
  - Calibration
- Existing BPM designs are far from optimal for an energy spectrometer
  - Button and strip-line not seriously considered
  - ATF/ATF2 - aperture
  - Reentrant resolution/stability?
  - Generic pill box cavity?
    - Cross coupling
- Machine
  - Bunch angle, position & charge jitter
  - Aperture
- Spectrometer
  - Movement range
    - Stray fields
    - Emittance dilution
- BPM
  - Resolution already achieved (See ATF results)
  - Scaling of resolution as function of cavity size
  - Design for stability (monopole rejection)

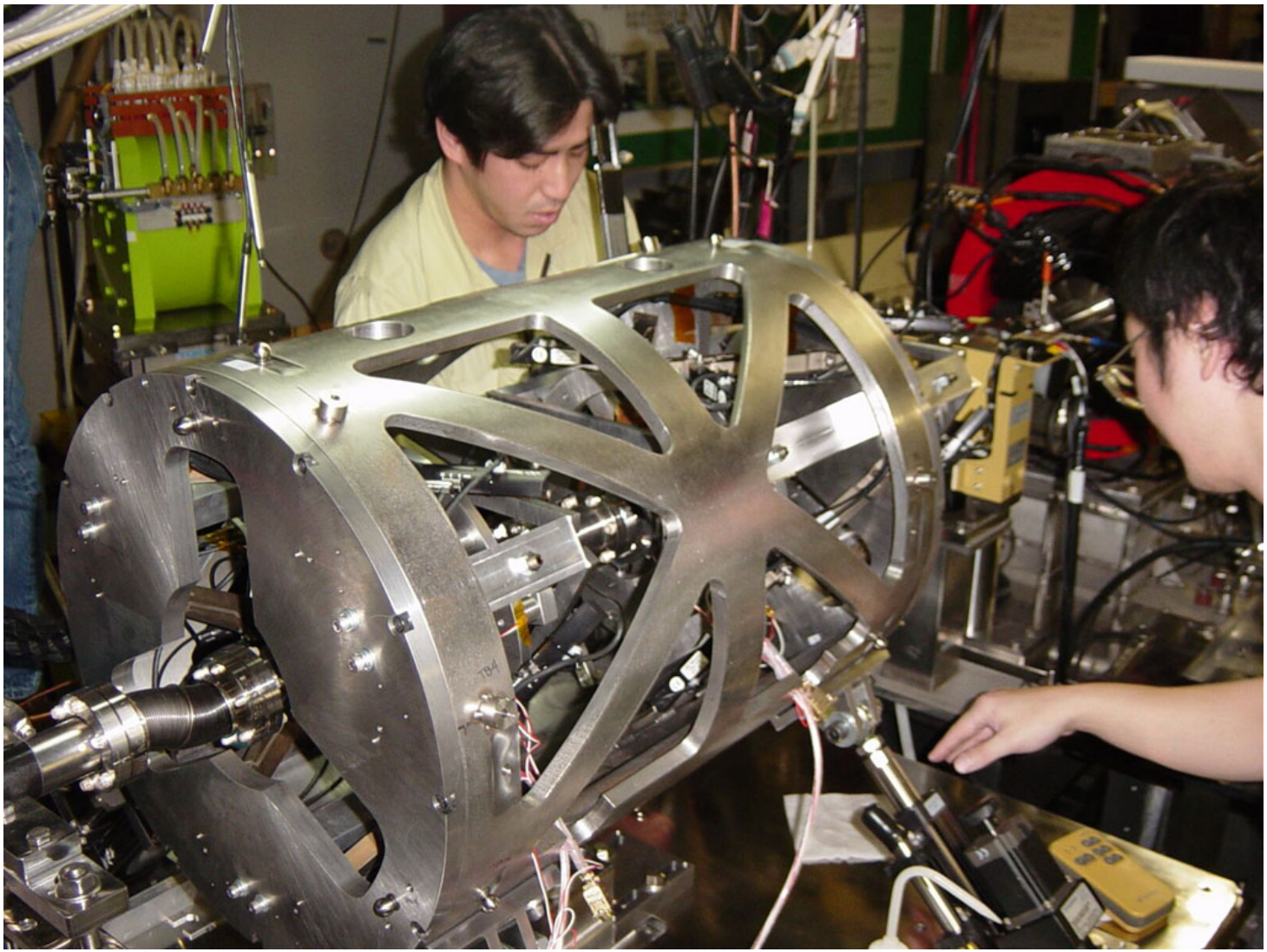
ATF NanoBPM programme





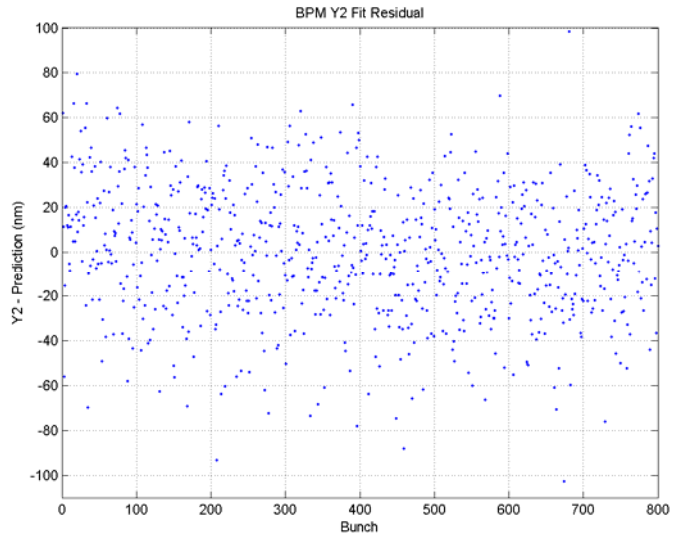
- BINP BPMs (V. Vogel et al)
  - ~2cm diameter
  - Dipole selective waveguide couplers
  - 2 stage down-mixs electronics
- Triplet installed in the ATF extraction line
  - Mechanically stable LLNL “space-frame”
  - Ability to move each BPM
  - Whole triplet together
- Triplet of ATF cavities installed down stream of BINP BPMs
  - Performance not as good
  - Cross coupling
  - Monopole mode rejection

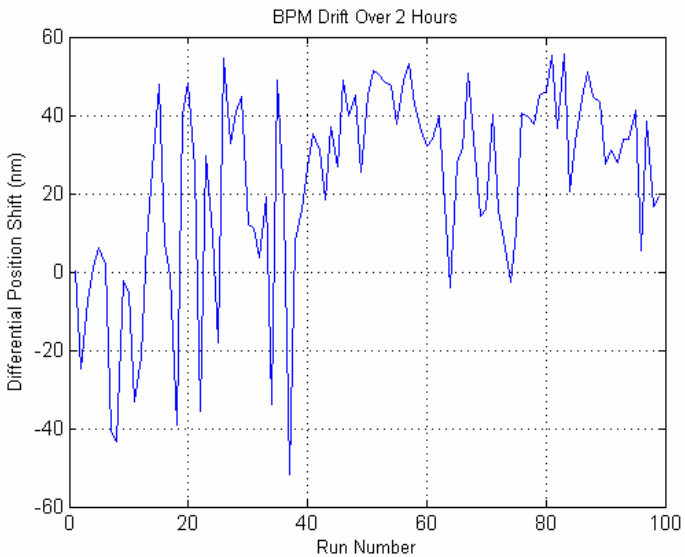
LLNL Spaceframe and BPMs



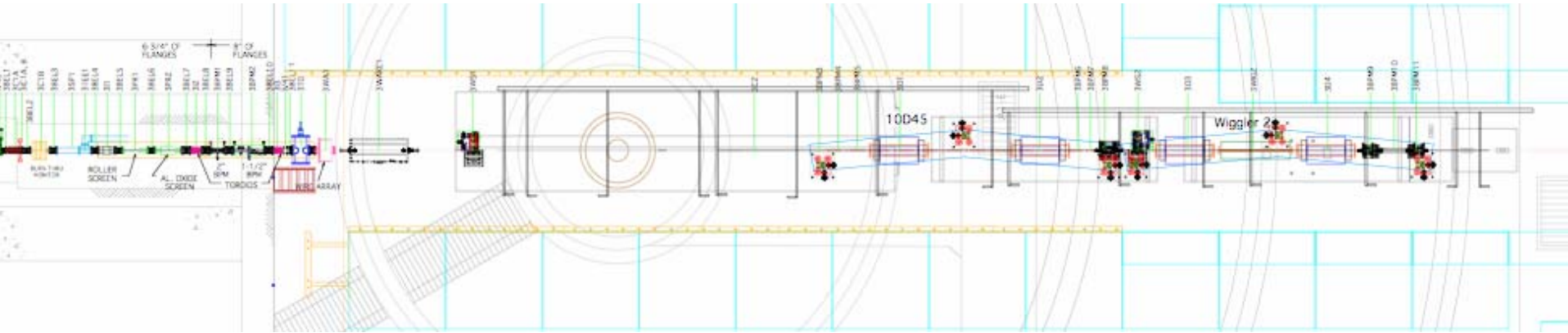
Recent nano BPM results

- Resolution and stability measurements from BINP cavities
- Resolution
  - Long run 800 events ~ 10 minutes
  - **σ ~ 24 nm**
  - Resolution for spectrometer achieved
- Stability
  - Measured drift over 2 hours
  - First 100 events used for calibration
  - Drift <120 nm peak to peak
  - RMS drift **~40nm** over 2 hours
  - Stability already seems promising

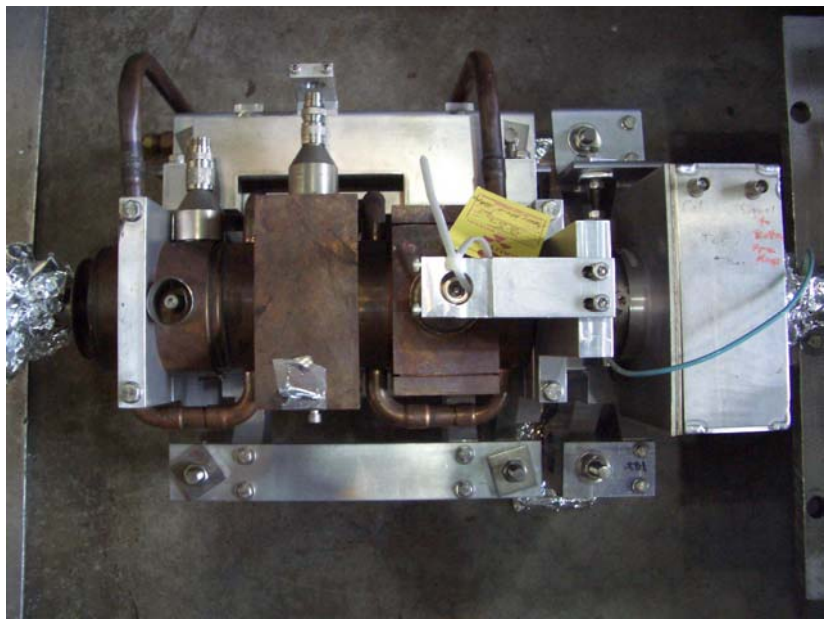




End station A programe

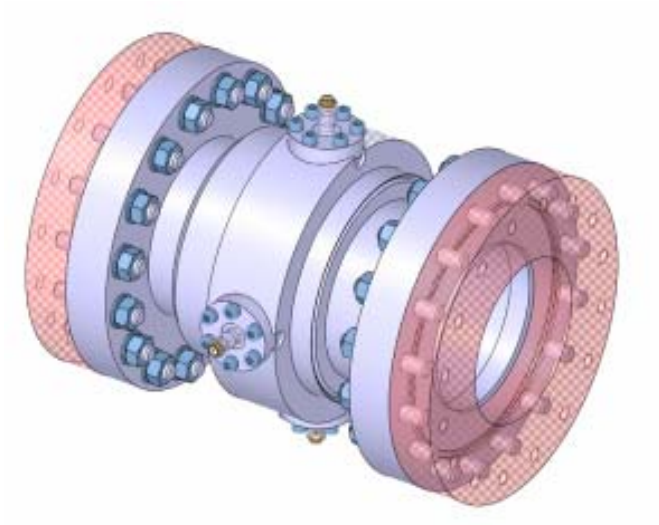


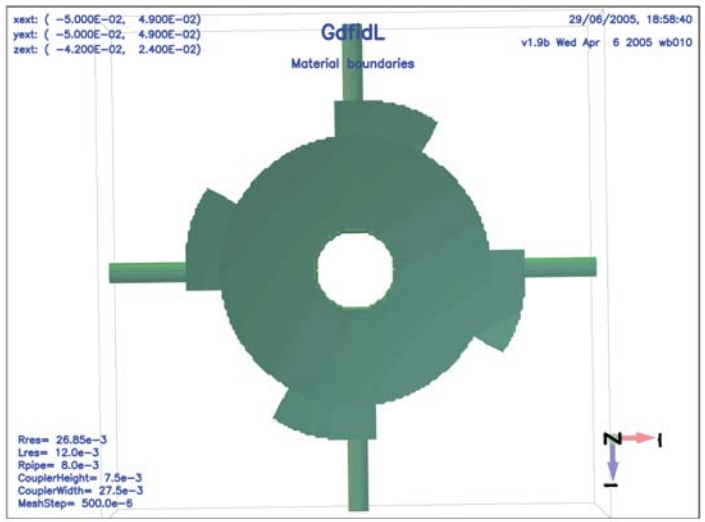
- Plans to test chicane ideas at ESA
  - Using old SLAC cavities
  - Test of chicane ideas and identification of possible problems
  - Test system of other general ILC and spectrometer specificBPM designs
  - New RF electronics
    - Resolution <1μm
- First tests in November 2005, Chicane tests 2006…



Other BPM designs

- Many talks in GG2 regarding BPM design
  - Focus mainly for cold Linac BPMs
  - What about BDS BPMs?
- BPM designs
  - Button
  - Strip line
  - Reentrant cavity
  - **Resonant cavity**
- Specify BPM cavity requirements and select designs which most closely match these requirements





Snowmass 2nd week work/discussions

- Spectrometer
  - Single bunch resolution
  - Bunch train resolution
- Machine
  - Range of possible
    - Aperture
    - Position, angle, charge jitter
- Spectrometer-machine interaction
  - Chicane operation
  - Magnet ramping
  - Possible loss of luminosity?
- BPMs
  - Resolution
    - 100 nm to 1 μm
  - Dynamic range
    - 100 μm to 1mm
  - Stability (thermal, etc)
    - Common mode rejection
    - Mechanical symmetry
    - 200 nm (to 2 μm) many hours/days
  - Cavity Q
    - Implications for single bunch measurement
    - Is it possible to extract single bunch information with large Q
    - Tests at ESA and ATF to verify this
  - Other
    - Reference cavities
    - Mechanics/size

Summary

- Aim for Snowmass
  - Identify key design requirements
    - Discussions with accelerator designers
      - Machine parameters at spectrometer
      - Mode of operation
  - Generate first requirements table (as for linac BPMs) for Spectrometer BPMs
    - Begin design of Spectrometer specific cavities
    - Prototype
    - Timescale
      - Conjunction with spectrometer development work
      - Detector CDR, February 2006
- Propose homework!
  - Machine information required (PT, AS, MW)
  - Spectrometer operation (MW, DM, ET, SB)
  - Cavity design (SS, MR …)
- Generate specifications to pass to Cavity designers