Cavity BPM for Spectrometry: progress and plans

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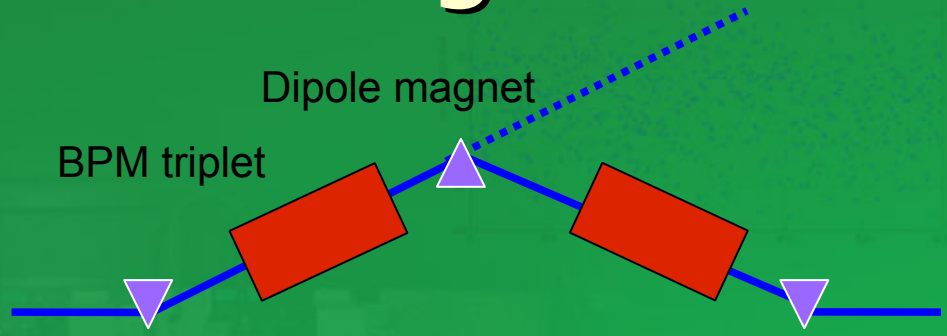
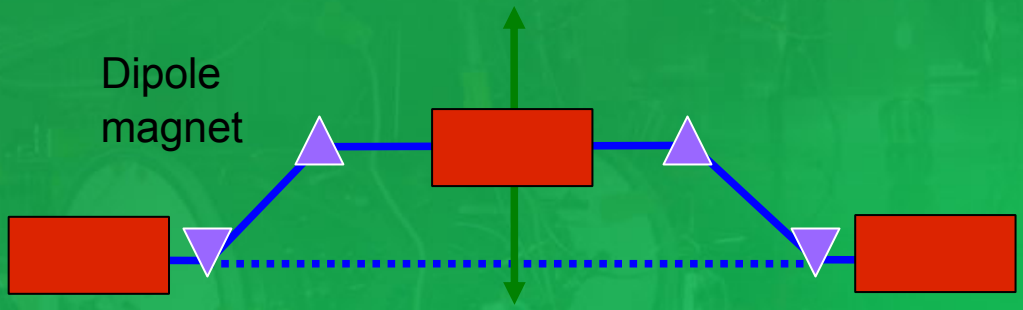
Spectrometer design

- Possible 3/4 magnet spectrometer designs



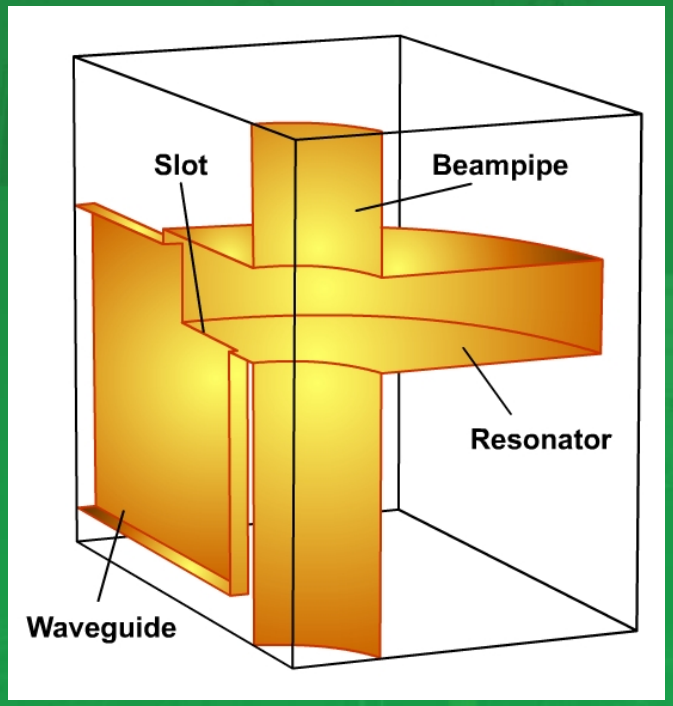
- 3 Magnets
  - Deflection angle measured from offset and distance
  - Beam incline influence on BPM measurements

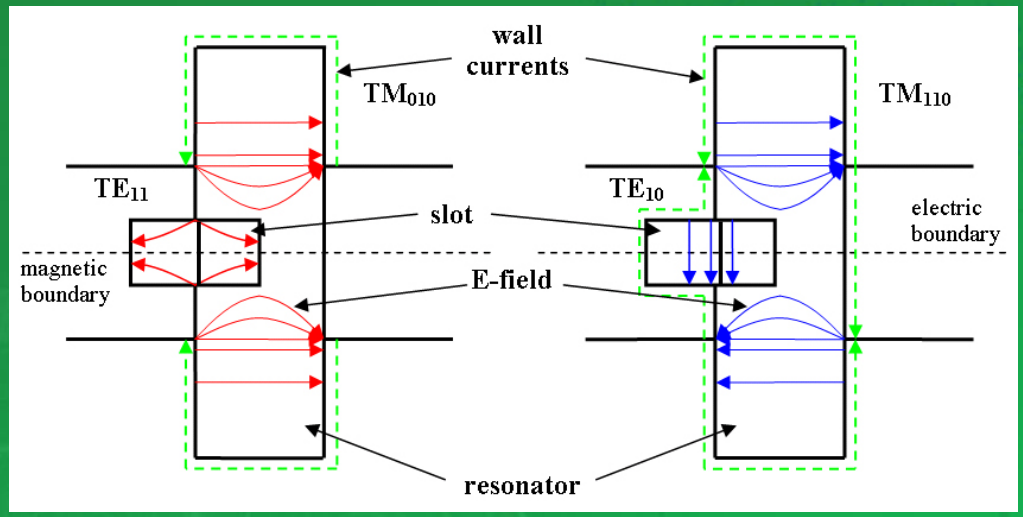


- 4 Magnets
  - Translation of beam
  - Extra precision dipole required
  - Simple translation of BPMs for maximum sensitivity

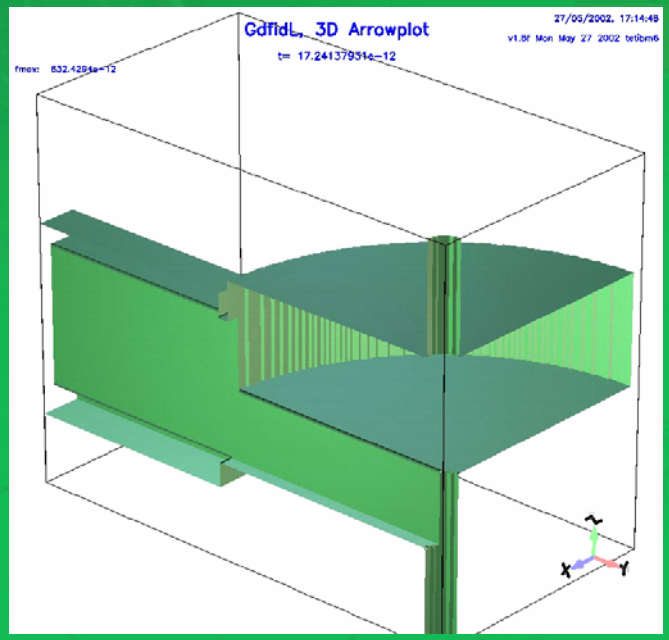
BPM resolution and stability are critical for both designs. Need experience in BPM design, calibration and operation.

Reminder on cavity BPMs





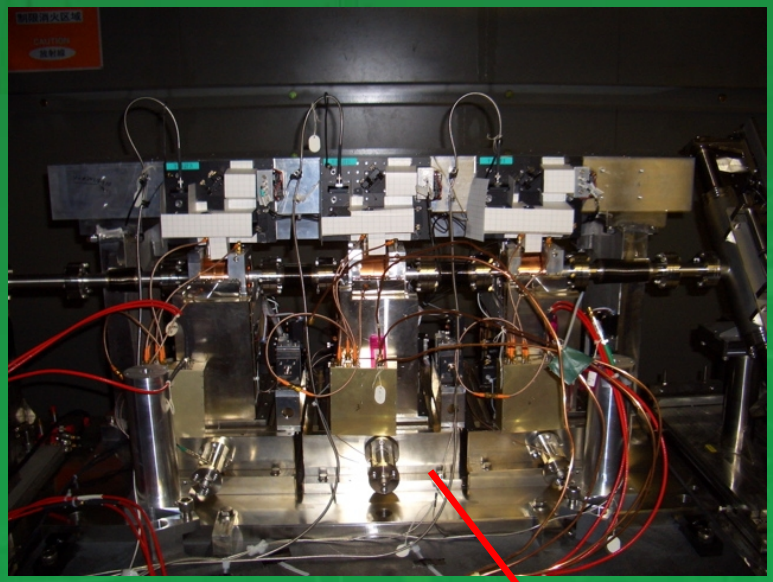
$$V_{out} = \frac{\omega}{2}\sqrt{\frac{Z}{Q_{ext}}\left(\frac{R}{Q}\right)_{fix}}\,\frac{x}{x_{fix}}\,q$$



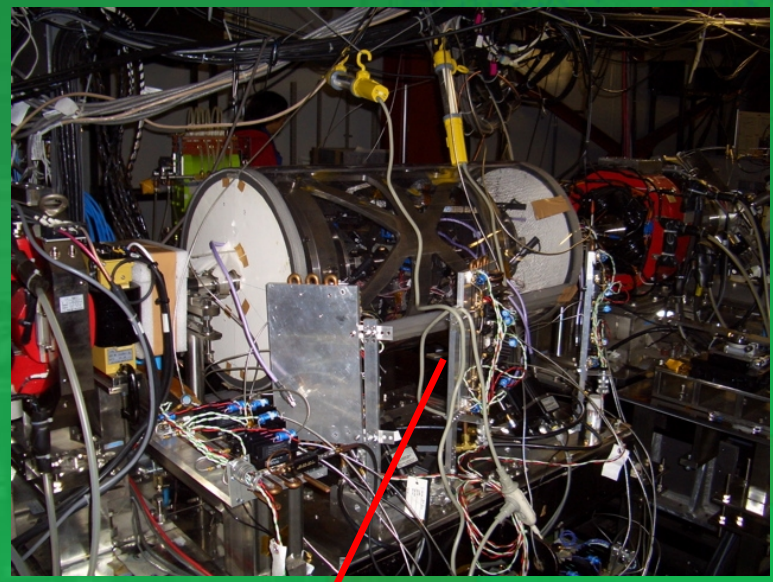
Asymmetric mode output depends on beam position and bunch charge. Symmetric mode (charge dependence only) used for the charge measurements

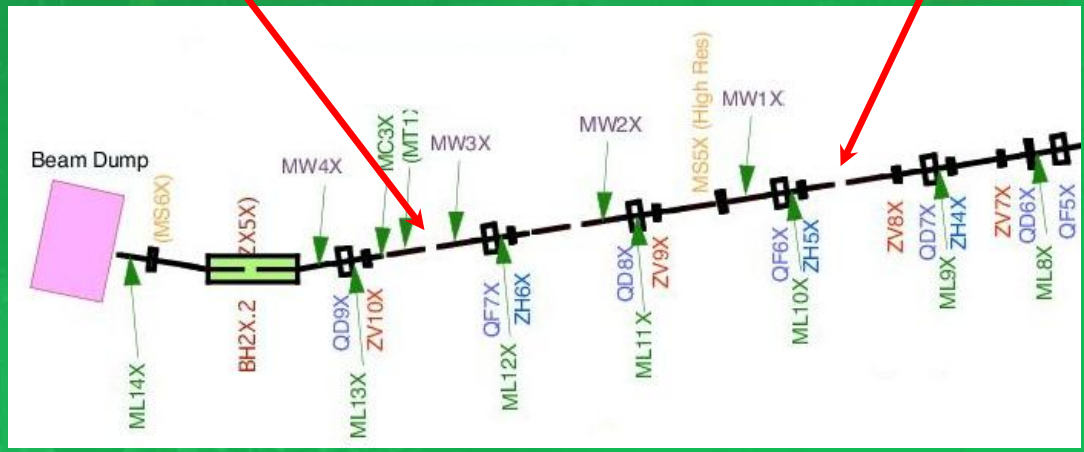
NanoBPM work at ATF

KEK BPMs on flexure piezo movers

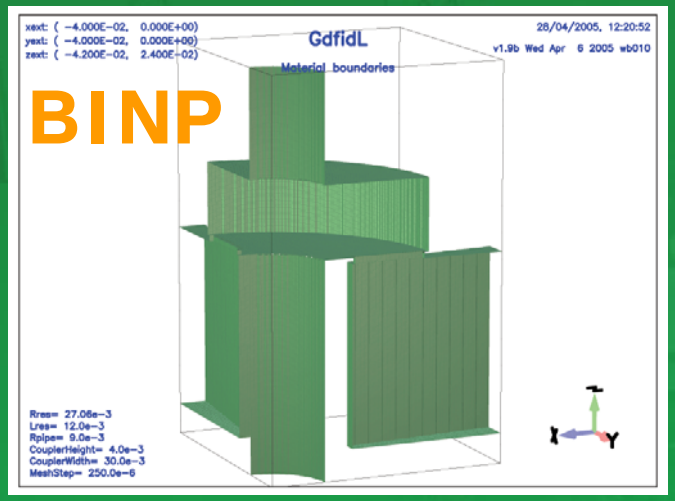


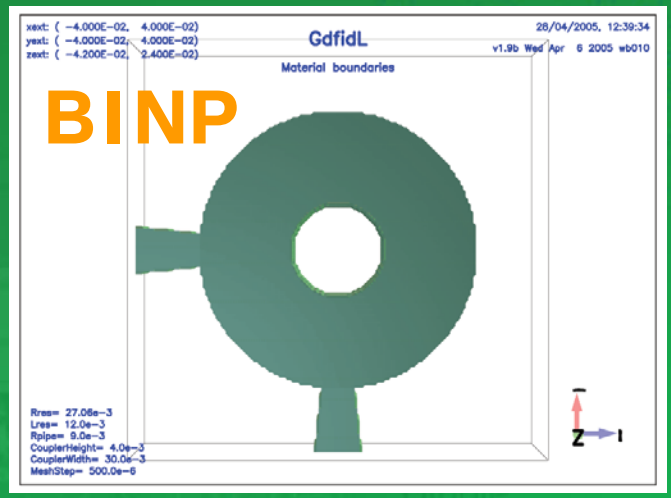
BINP BPMs in SLAC/LLNL frame

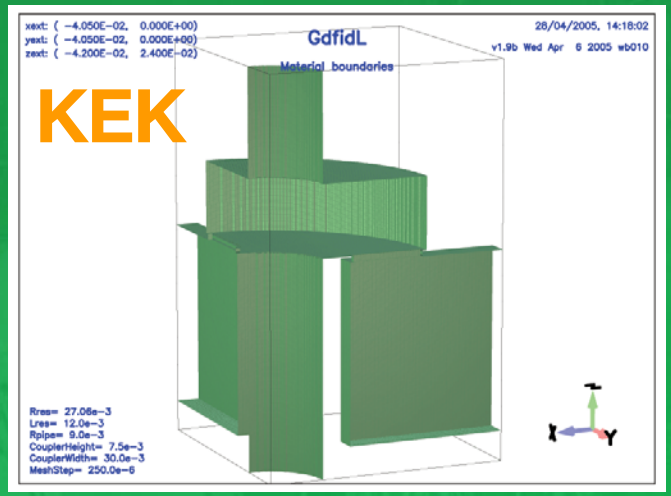


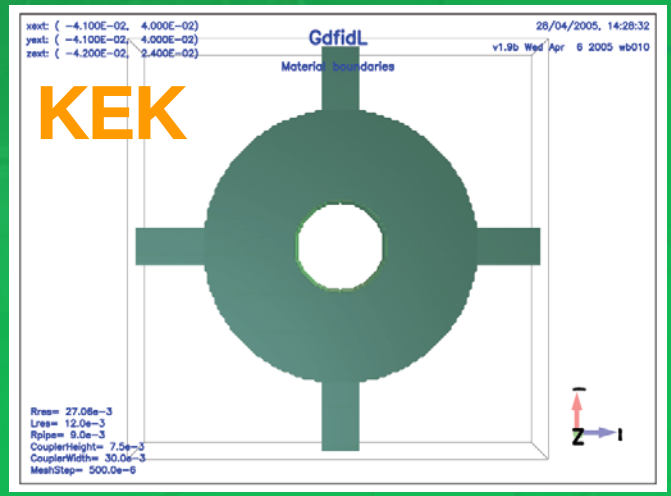


The two existing BPMs



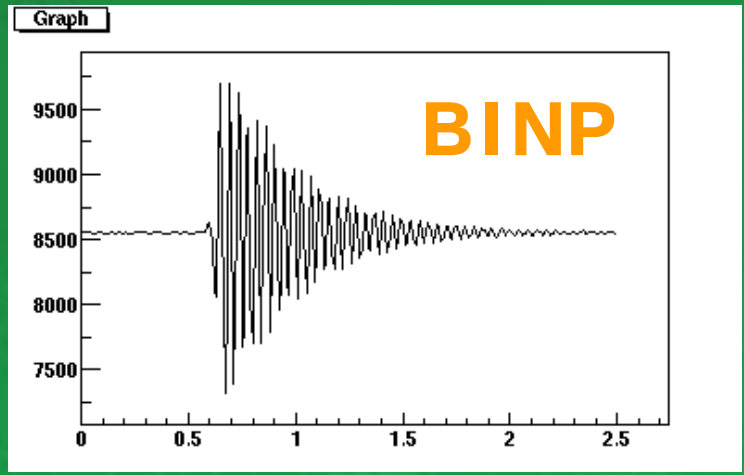




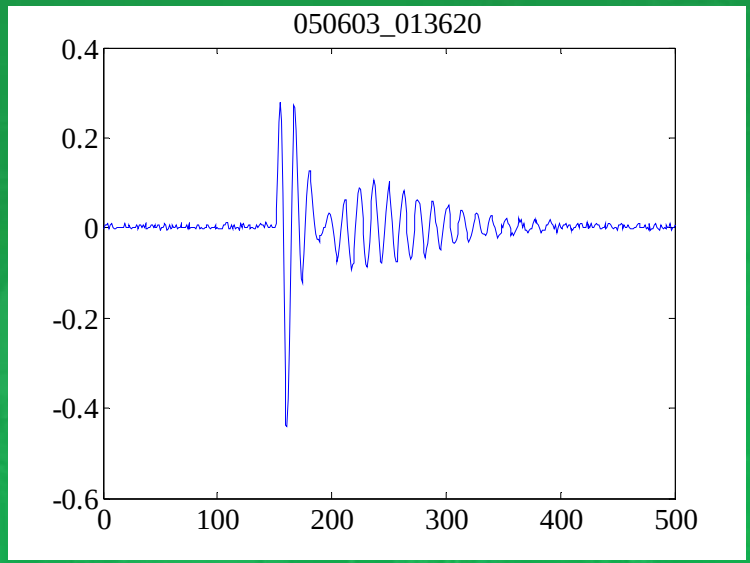


Despite of a very similar structure the performance is very different!

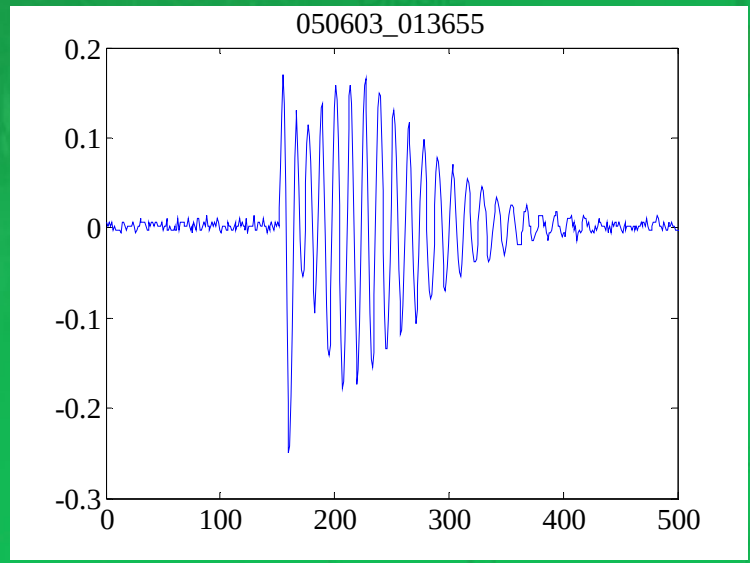
Waveforms



KEK centred

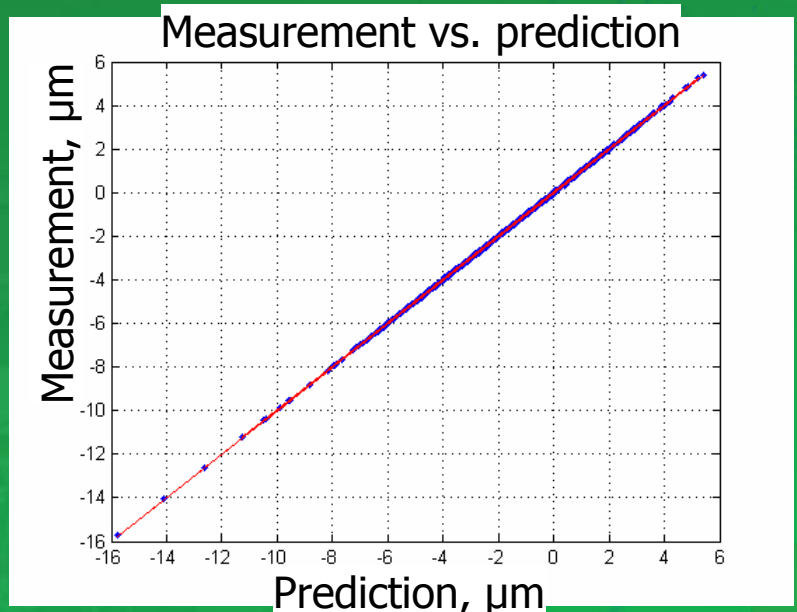


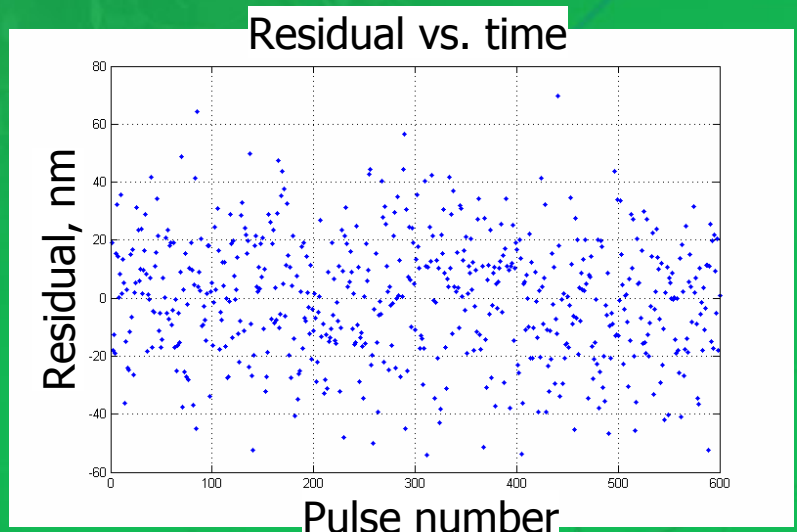
KEK off centre



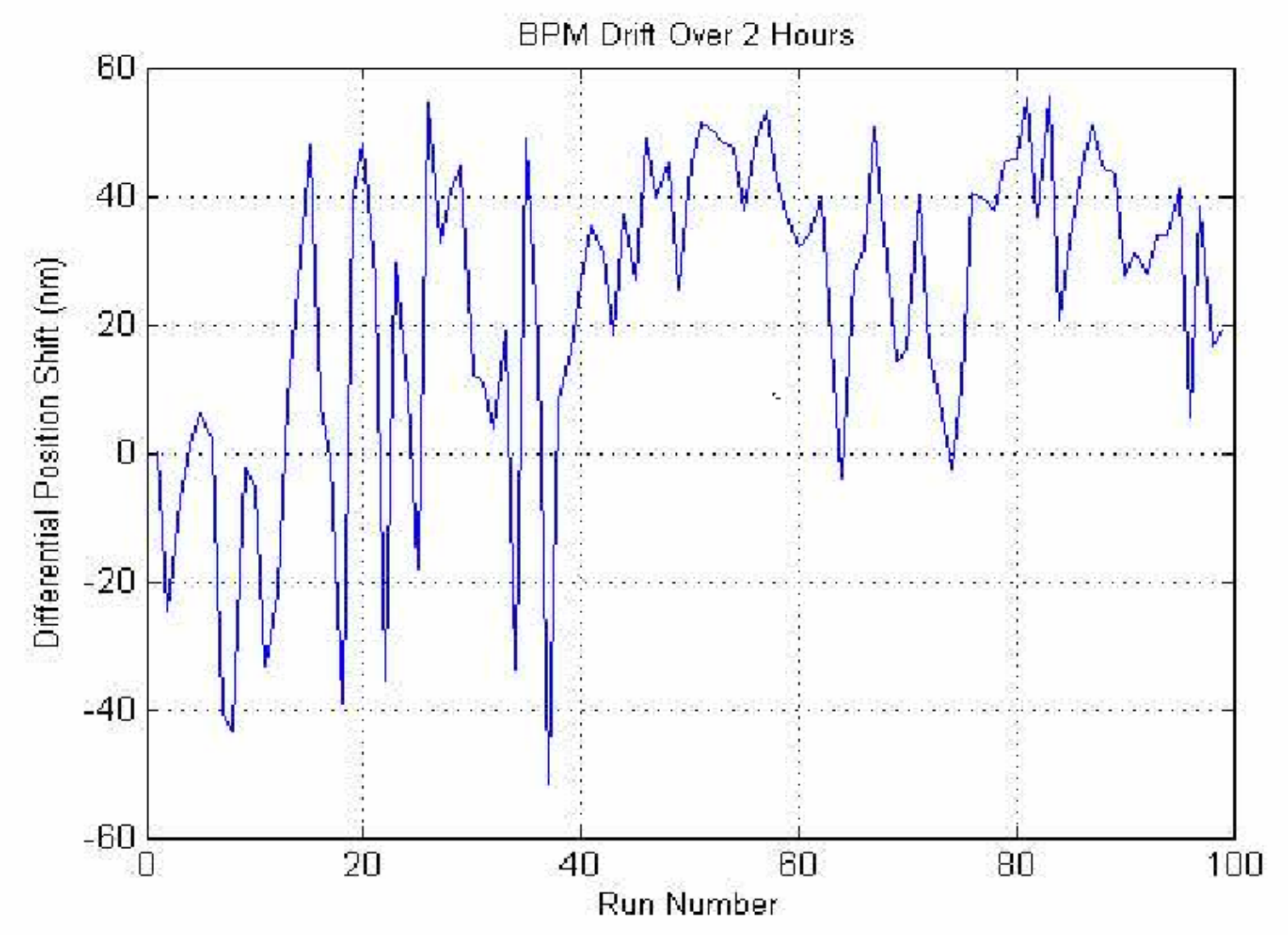
Results from ATF - resolution

- Analysis of 2004/2005 data
  - Steven Smith (SLAC)
  - Digital downconversion
  - Calibration using hexapod movers
  - Resolution ~20 nm
  - Stable: 20 nm drift over 2 hours, ±40 nm jittering over few minutes



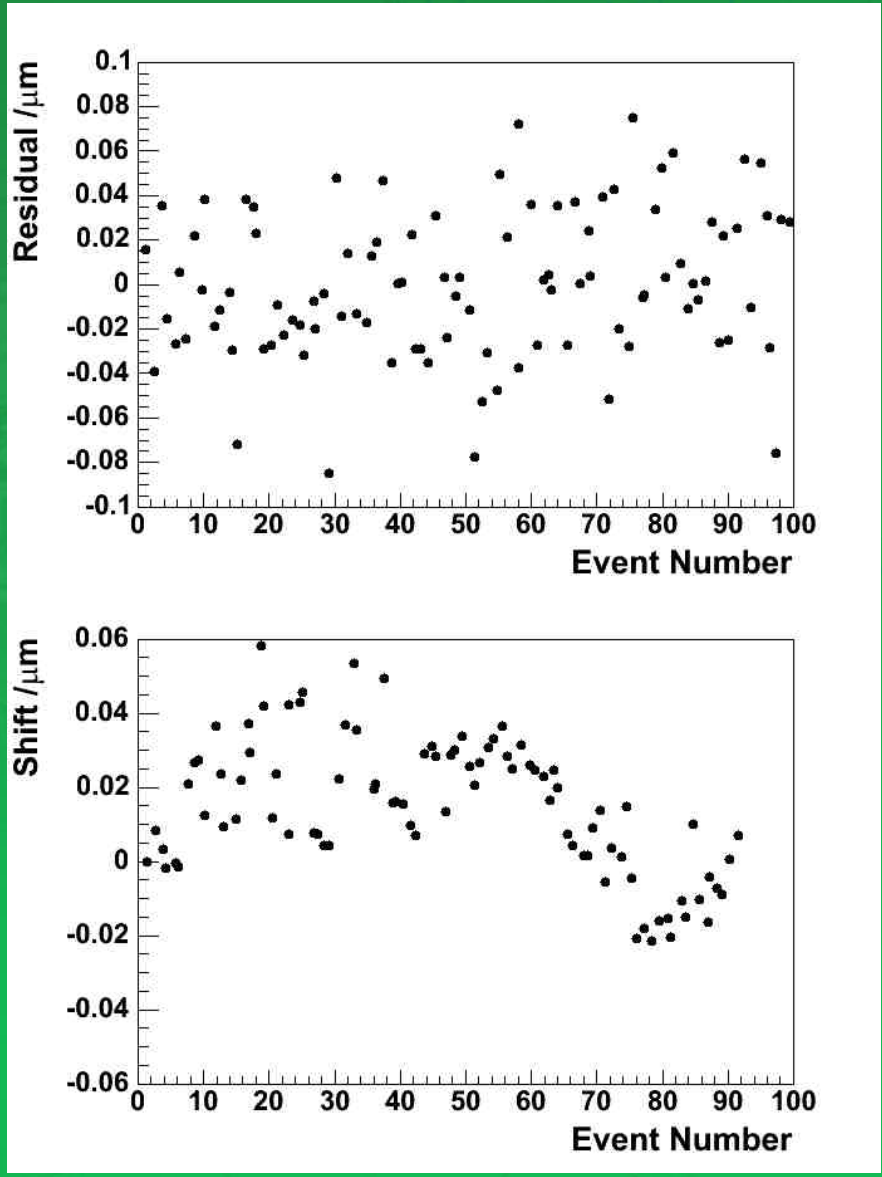


Results from ATF - stability

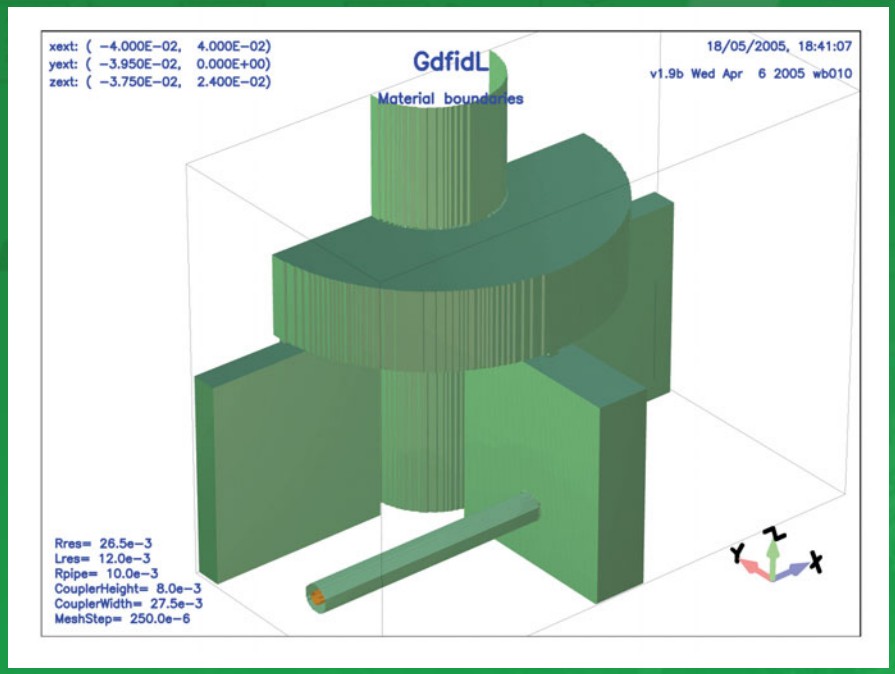


Results from ATF - resolution

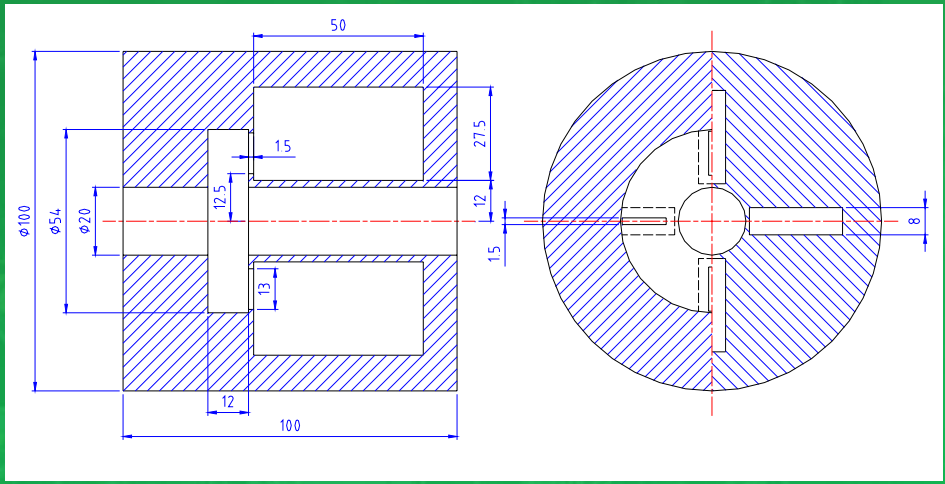
- May 2005 data
  - Fitting algorithm
  - Calibration using hexapod movers
  - Resolution ~ 35 nm
  - Stable: 20 nm drift over 2 hours, around 80 nm of jittering over few minutes



ATF2 Q-BPM design



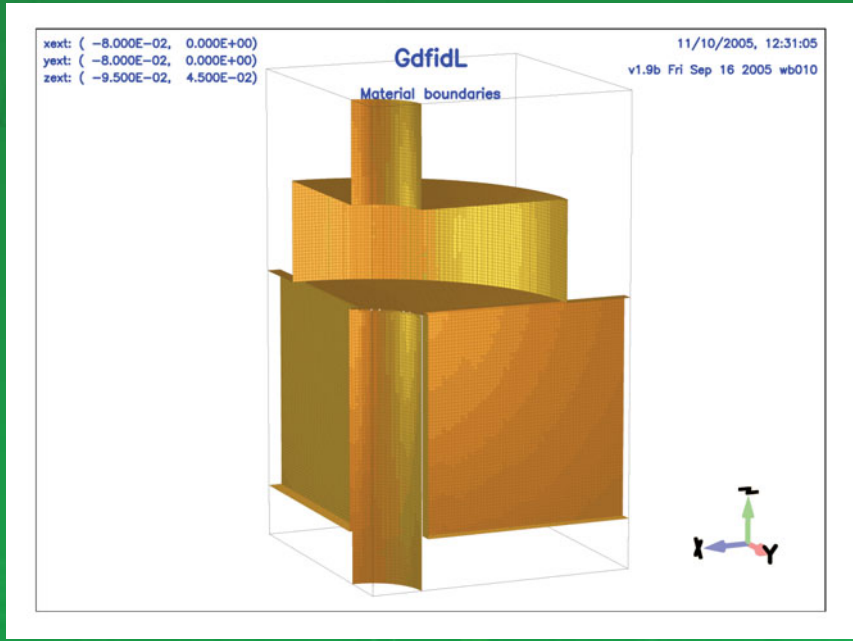
- Successor of previous designs
- "Longitudinal" design
- 4-coupler symmetrical structure
- Beam pipe diameter increased to 20 mm to meet the ATF2 beam optics requirements
- Increased coupling for a higher sensitivity
- Dipole mode frequency 6426 MHz (harmonic of the bunch repetition frequency)

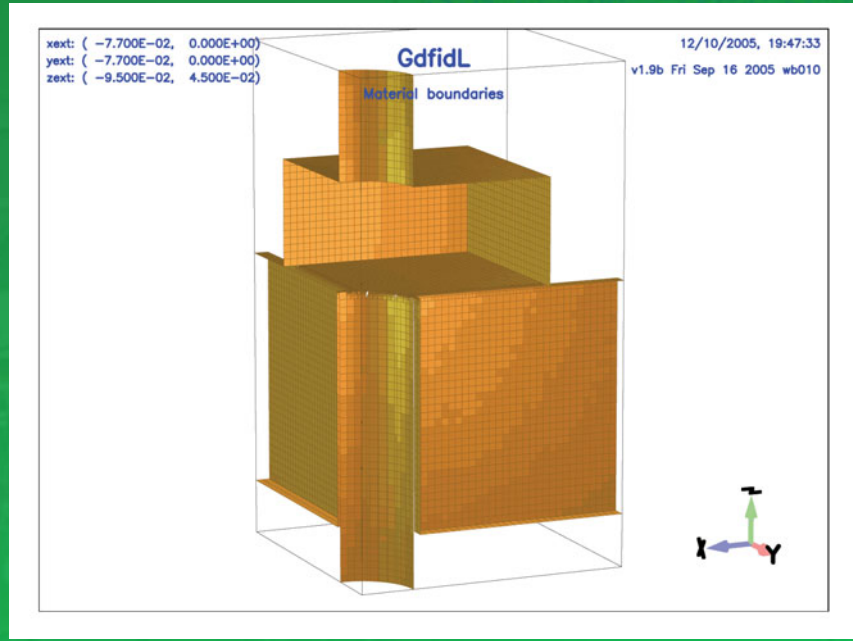


Symmetric mode leakage:
Leakage is less than computation error for the perfect structure
Introducing asymmetries (Slot + wg + feedthrough shifted by 0.5 mm, 0.25 mm meshstep) we get a signal equivalent to 10 μm

Sensitivity to the incline component:
7 μm/mrad

BPM for spectrometry



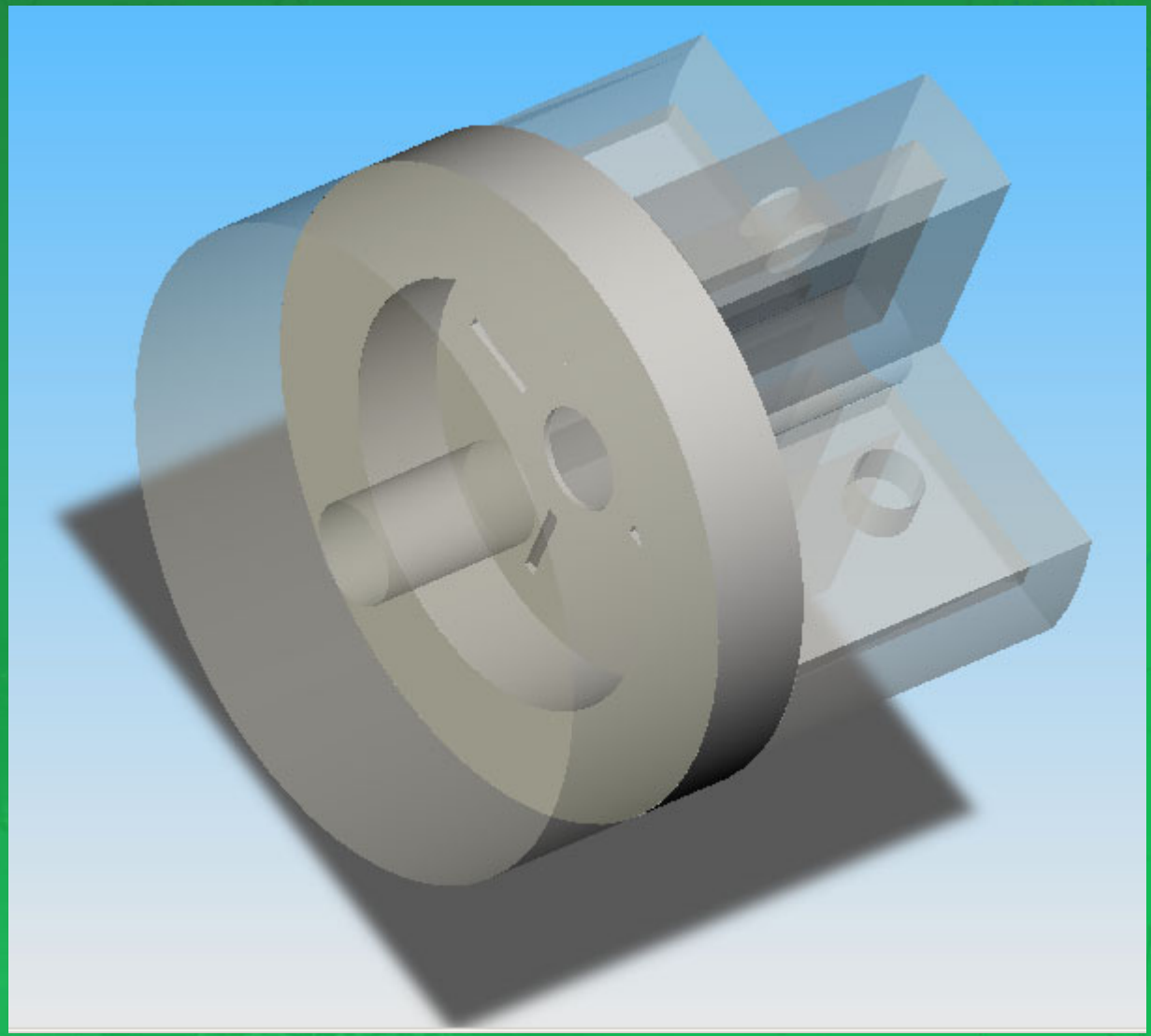


- Base on the existing technologies, proved to provide a high resolution
- Prefer easy production and moderate costs

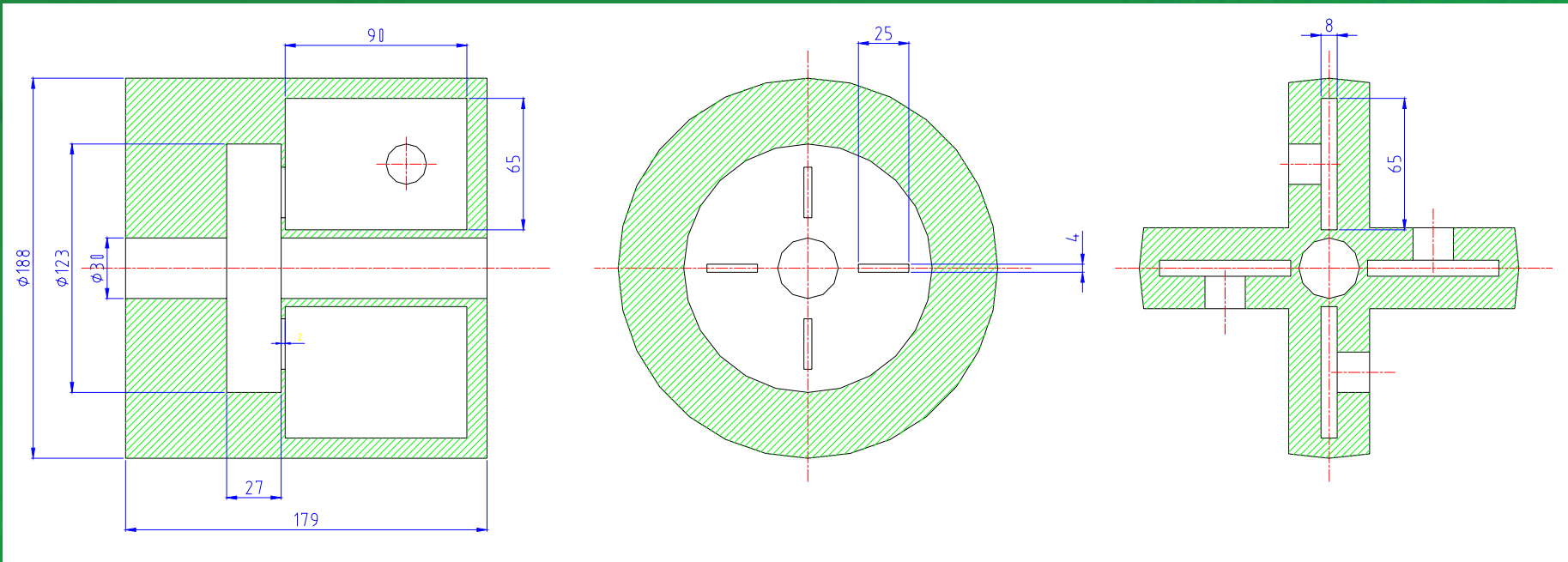
Baseline BPM parameters

- Rectangular waveguides and coupling slots to suppress the monopole mode
- 30 mm beam pipe diameter to allow for higher optics flexibility and safety
- 2.8 GHz cavity to allow beam pipe change and to fit into a well explored frequency range, await a better stability; looser tolerances comparing to 6.5 GHz cavities
- Coupling strength close to 1 to read out enough oscillations for the analysis, but allow for a bunch-to-bunch operation
- Downconversion to 10-30 MHz and digitization at 100-150 MSamples/s
- Both DDC and Fitting algorithms applicable
- One reference cavity per triplet, symmetric output

Cylindrical prototype 3D view



Design in progress



- Tuning to 2876 MHz
- Q=3690 – to be double/triple checked
- τ=250 ns – to keep the same analysis
- R/Q=0.25 Ω – 4 times lower than for BINP structure
- Almost the same sensitivity as for BINP BPMs at ATF beam – no bunch length effects => resolution < 100 nm seem to be no problem

BPMs Schedule

- Electrical design of 2 prototypes
  - Cylindrical is half way through
- 2 prototypes for lab tests
  - Have sketches for cylindrical
  - Looking for feedthroughs
- Electronics design
- Prototype electronics for lab tests (try to recycle in the first vacuum test, design PCB boards afterwards)

Summary

- Independently of the chicane design a careful study of the components and their systematics is needed
- Gained a useful experience on cavity BPMs operation, calibration, design, possible problems, achievable resolution, etc. and working on what we think is an optimal BPM for spectrometry
- Present BPMs already achieved the resolution we need, stability tests are in progress. The repeatability from cavity to cavity is needed.