Reentrant cavity BPM

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Dipolar Higher Order Modes (HOM) of the accelerating superconducting cavities

CARE/SRF Meeting – Frascati

14th November 2006

CARE/SRF WP11 Task 11.1

➢ **Reentrant Cavity BPM program** :

- Design, fabrication and beam tests of a beam position monitor.

- **Reentrant cavity BPM features:**
  - **Compatibility with clean environment**
  - **Operation at room and cryogenic temperature**
  - **Position resolution better than 10 µm**

➢ **Dipolar Higher Order Modes (HOM) program:**

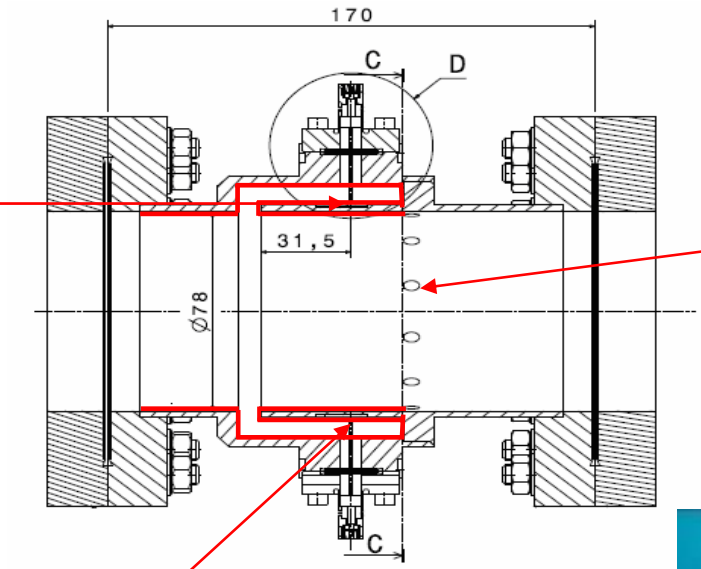
- Prove the potential of the HOM BPM instrumentation
- Measure the cavity centers
- Measure the relative misalignments within the fixe TTF cryomodules

Reentrant cavity BPM

- The cavity is fabricated with stainless steel

length: 170 mm **aperture: 78 mm**

Cu-Be RF contact welded in the inner cylinder of the cavity to ensure electrical conduction.

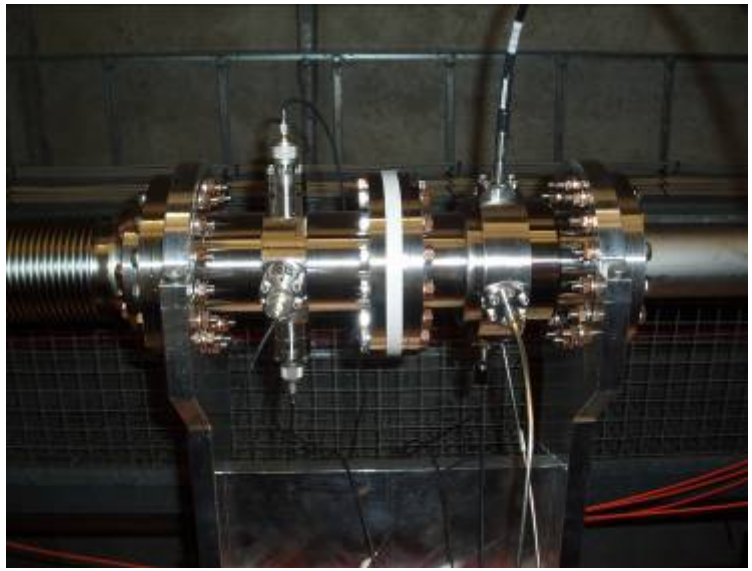


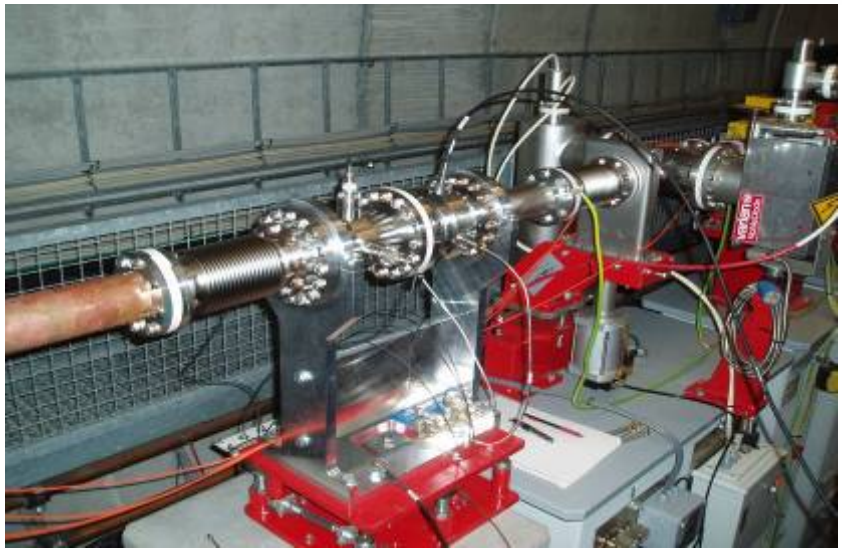
Twelve holes of 5 mm diameter drilled at the end of the re-entrant part for a more effective cleaning.

Feedthroughs are positioned to reduce the magnetic loop coupling and separate the main RF modes (monopole and dipole)

Cavity BPM

Reentrant cavity BPM





Cavity BPM installed on FLASH

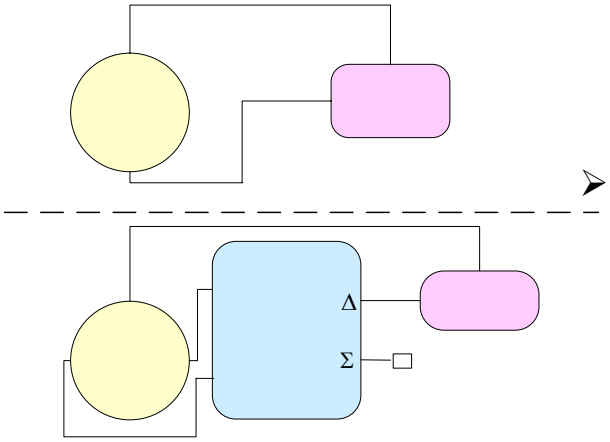
Signal processing system installed in the hall

Reentrant cavity BPM

Eigen modes	F (MHz)			Q_l		
	Calculated	Measured in lab	Measured in the tunnel	Calculated	Measured in lab.	Measured in the tunnel
Monopole mode	1250	1254	1255	22.95	22.74	23.8
Dipole mode	1719	1725	1724	50.96	48.13	59

RF measurements give information on the sensitivity of the RF characteristics to the mechanical mounting and operating environments

- Due to tolerances in machining, welding and mounting, some small distortions of the cavity symmetry are generated. A beam displacement in the 'x' direction gives not only a reading in that direction but also a non zero reading in the orthogonal direction 'y'. This asymmetry is called **cross talk**.



Representation of the cross-talk measurement

- From those measurements, the cross-talk isolation value is estimated:

	Measured in lab	Measured in the tunnel
Cross talk	41 dB	33 dB

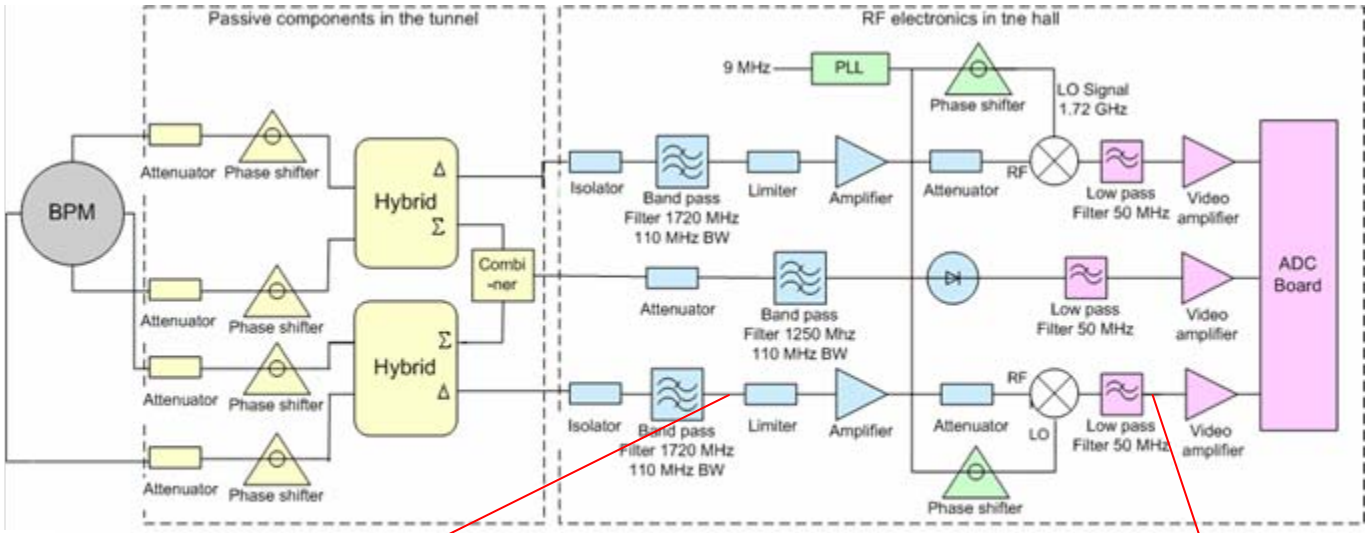
Signal processing

- The signal processing uses a **single stage downconversion** to obtain **Δ/Σ** and is composed of **:**

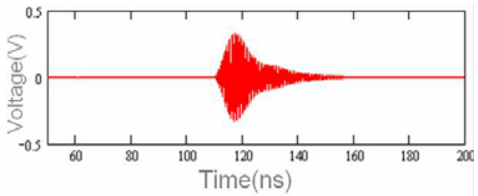
  - hybrid couplers to reject the monopole mode

  - band pass filters

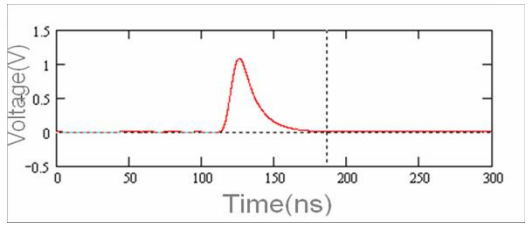
  - synchronous detection



RF signal after Band pass Filter

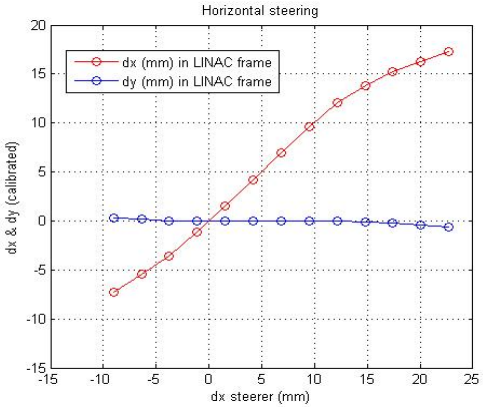


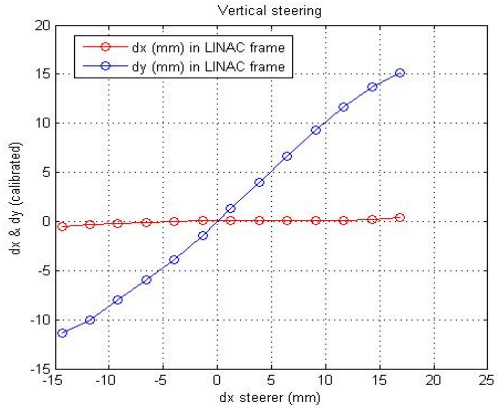
IF signal after Lowpass Filter on channel Δ



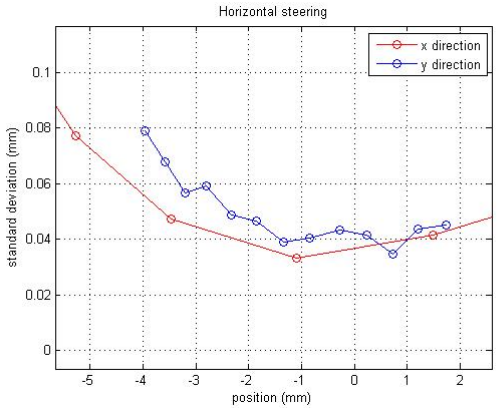
First Beam tests on BPM system

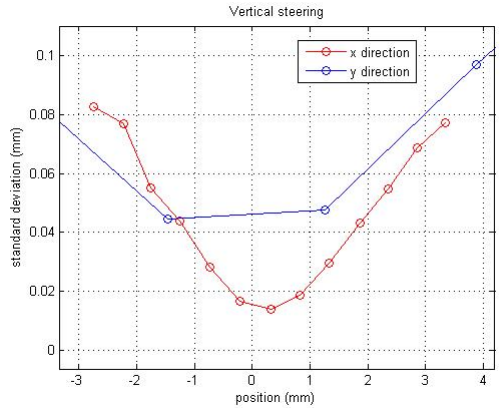
- **Summer 2006, the first beam tests were carried out (at room temperature) and are encouraging.**
- **The BPM was calibrated to have a good measurement dynamics**





Calibration results in LINAC frame from horizontal (left) and vertical (right) steering





Standard deviation of the position measurement (calibrated)

- **Good linearity in a range +/-5 mm**
- **RMS resolution <40 µm with beam jitter**

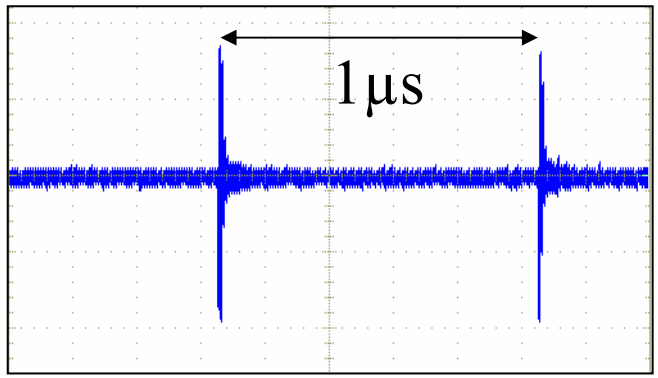
Reentrant BPM characteristics

- To assess the system performance, a model (cavity+signal processing) was elaborated with a Mathcad code based on Fourier transforms.
- Signal given by the model (cavity+signal processing) simulation
- **Noise** determined by the thermal noise and the noise from signal processing channel

  - Resolution results **<1 µm** (Simulation with a range of +/-100µm)

- Time resolution ~ 40 ns -> Possibility for measurements in multi-bunch mode

RF signal from one pick up



Need of new measurements to know the resolution of the BPM and to confirm the simulations

Rentrant cavity BPM Plans

- Winter 2006-2007, new beam tests and resolution studies :

  - gain, on each channel, will be changed to improve the resolution and confirm the simulated performances.

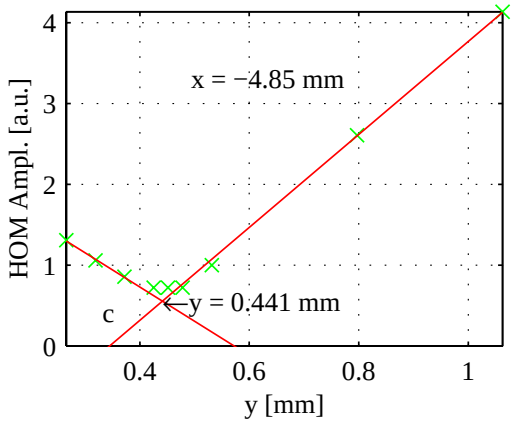
  - the mixer used in the electronics will be replaced by a new one which accepts a high power RF input (around 16 dBm instead of 0 dBm)

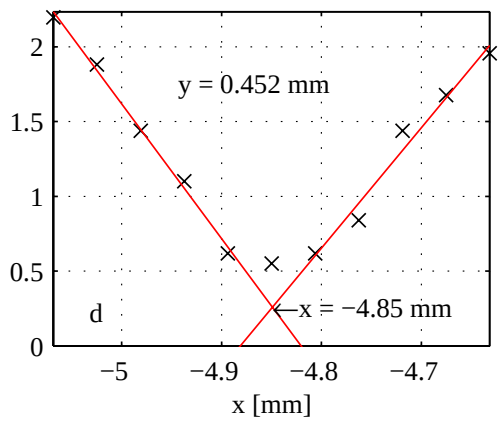
  -> resolution will be improved and dynamics range will be around +/-5mm,

- Tests in multi-bunch mode

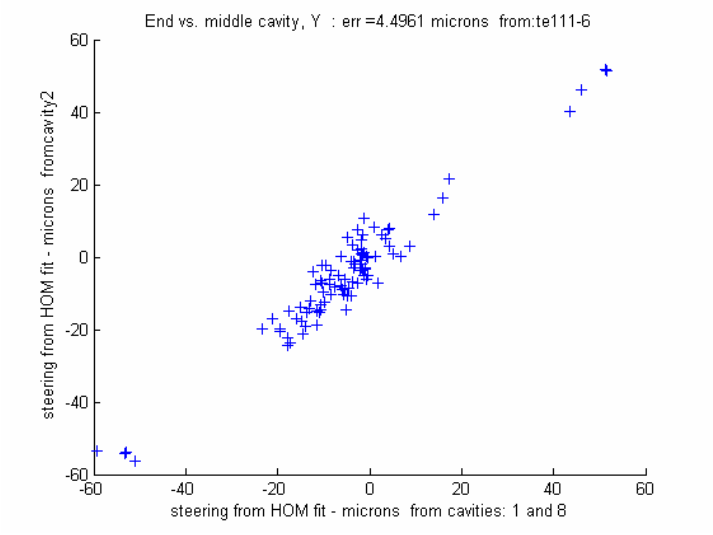
HOM

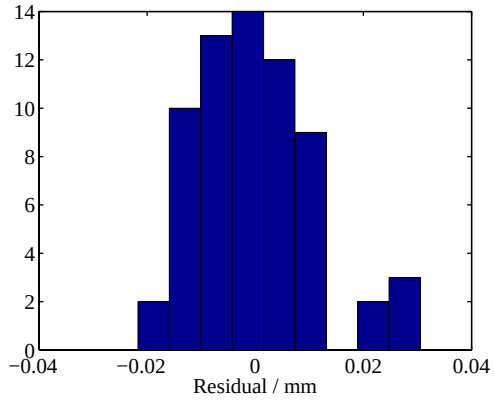
- Beam-based resolution on the position of the electric center of the mode TE111-6 < 50 µm





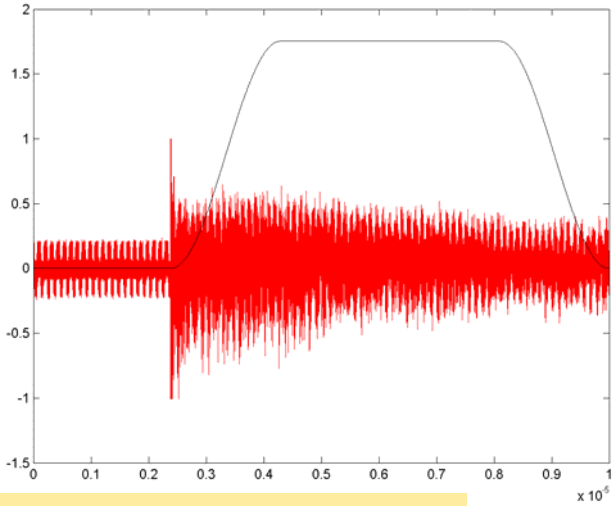
- Resolution 5 µm on beam position estimated from the linear regression residual





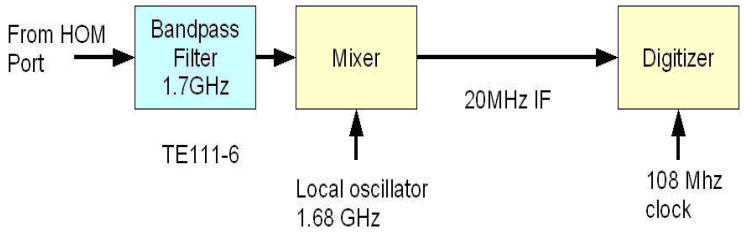
By Courtesy of Rita Pararella and Olivier Napoly

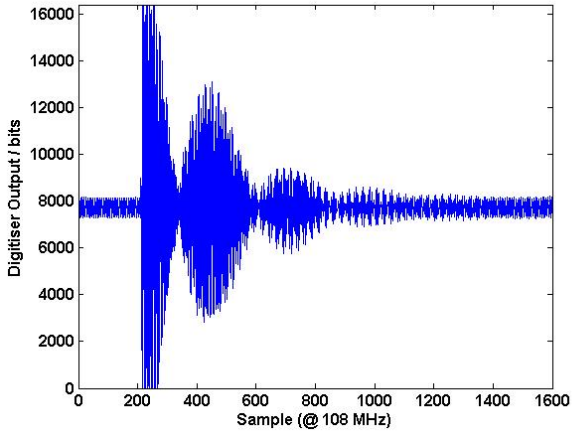
Electronics devices



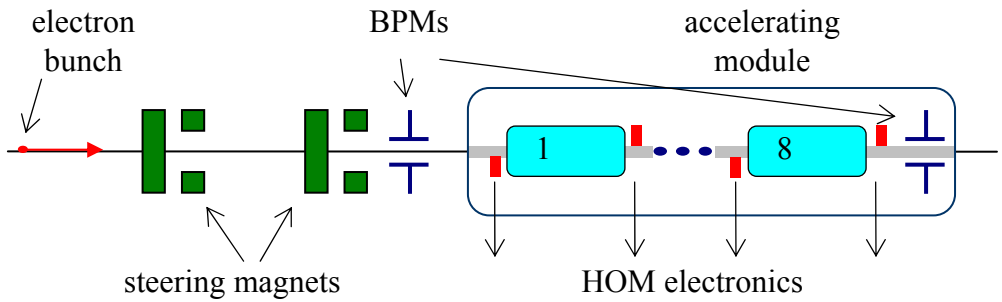
PhD thesis of Rita Paparella

- Multi-channel system capable of simultaneously measuring all 80 of the FLASH HOM channels





Steering Setup for HOM dipole experiment

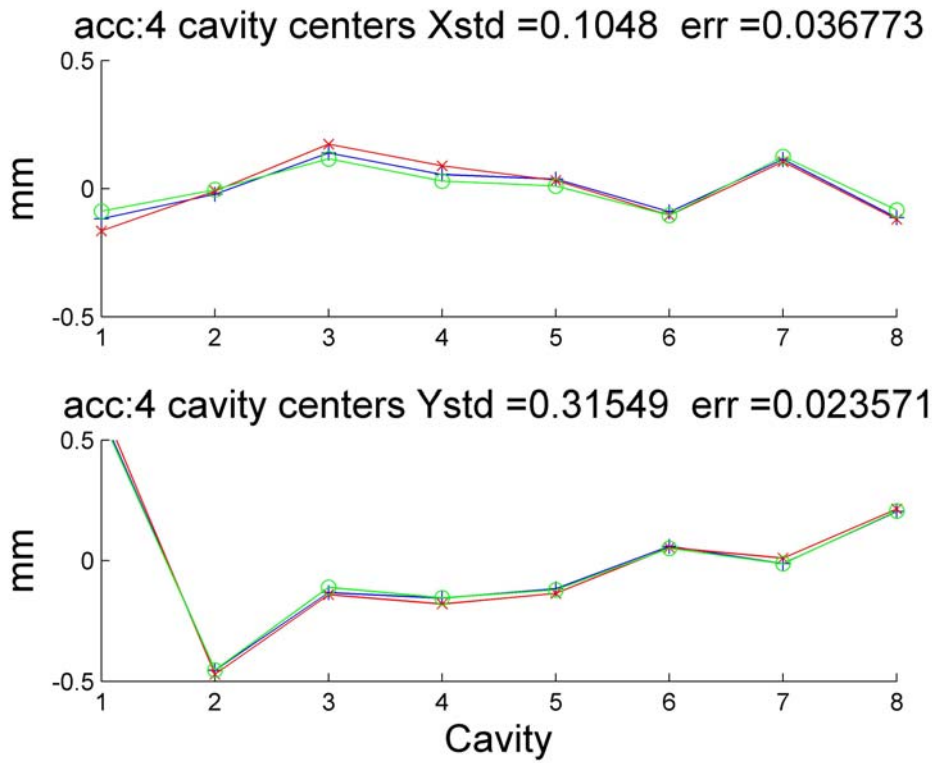


- Experiment purpose: find the centers of cryocavities using the trajectory which is associated with the minimum power output

Cavity Alignment ACC4

- X: 100 microns RMS misalignment, 37 micron measurement reproducibility
- Y: 315 micron RMS misalignment, 23 micron measurement reproducibility

⇒ Standard deviation of the cavity centers in the 4th module from TE111-6 < 350 µm

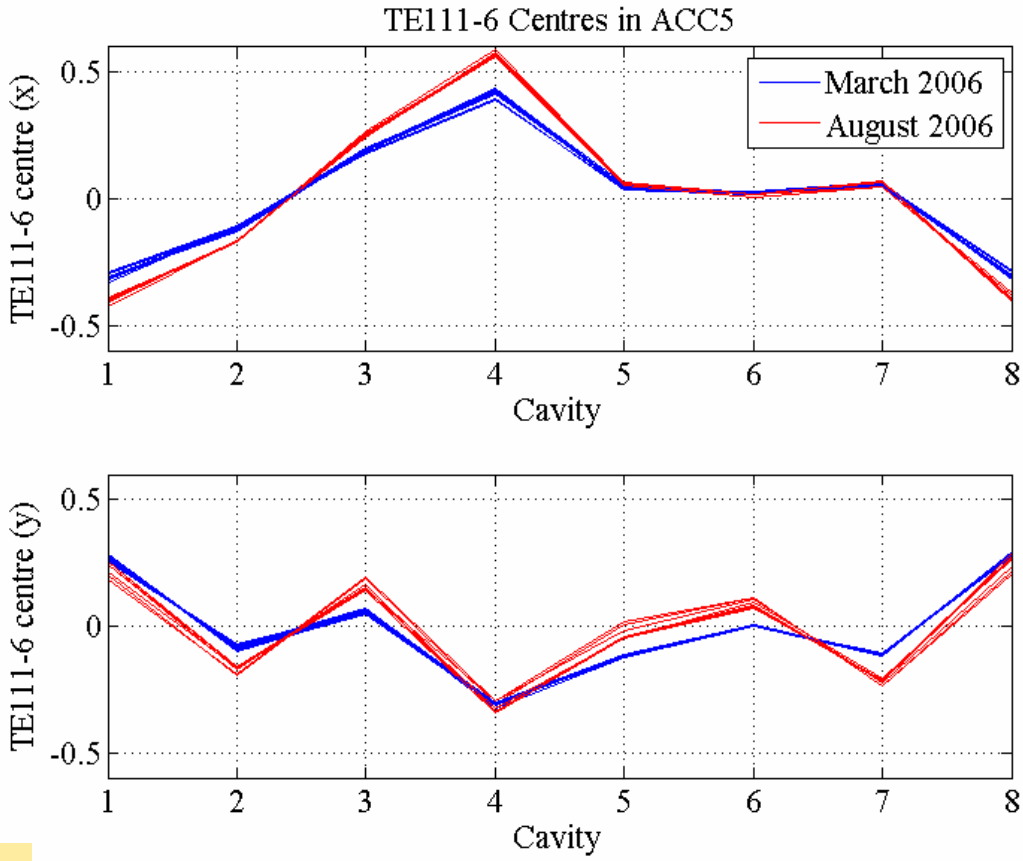


By Courtesy of Joe Frisch

Cavity Alignment ACC5

- X: 240 micron misalignment, 9 micron reproducibility
- Y: 200 micron misalignment, 5 micron reproducibility

⇒ Standard deviation of the cavity centers in the 5th module from TE111-6 < 300 µm



By Courtesy of Joe Frisch

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Thank you for your attention