

# Activities at Royal Holloway

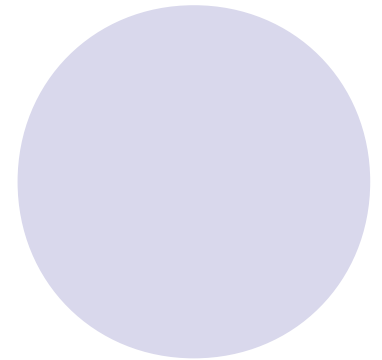
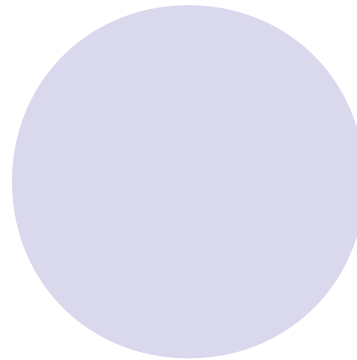
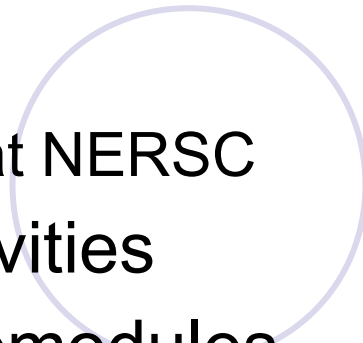


1<sup>st</sup> July 2010

Steve Molloy, Royal Holloway, University of  
London

# Main activities

- **Simulations**
  - ACE3P codes at NERSC
  - Sims of CEA cavities
  - Multi-cavity cryomodules
- **Physical measurements**
  - Bead-pull facility
- **HOM-based diagnostics**
  - Measurements at FLASH & ALICE



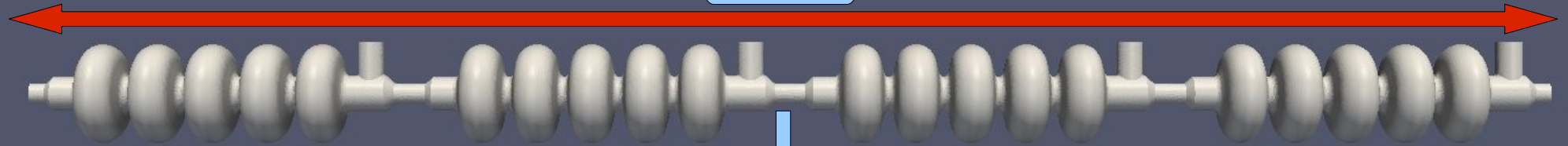
# Heavy duty simulations

- A single cell has the usual mode spectrum
  - $TE_{mnp}, TM_{mnp}$
- Coupled cells (e.g. in a multi-cell cavity)
  - Modes split into passbands
  - Each oscillation characterised by phase advance per cell
- Multicavity installations (i.e. a cryomodule)
  - Modes below beam-pipe cutoff, so disregarded
    - *But this neglects evanescent coupling!*

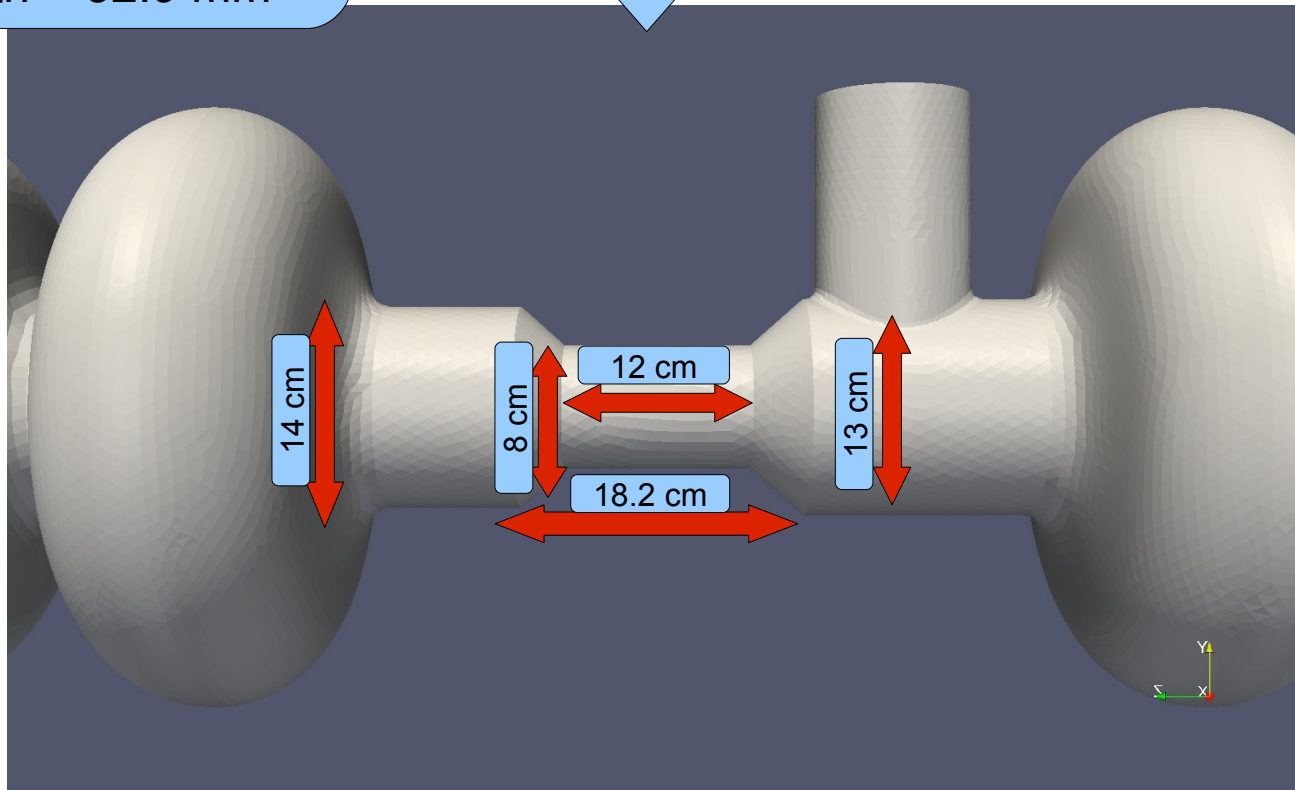


# Eigen solve 4 full cavities

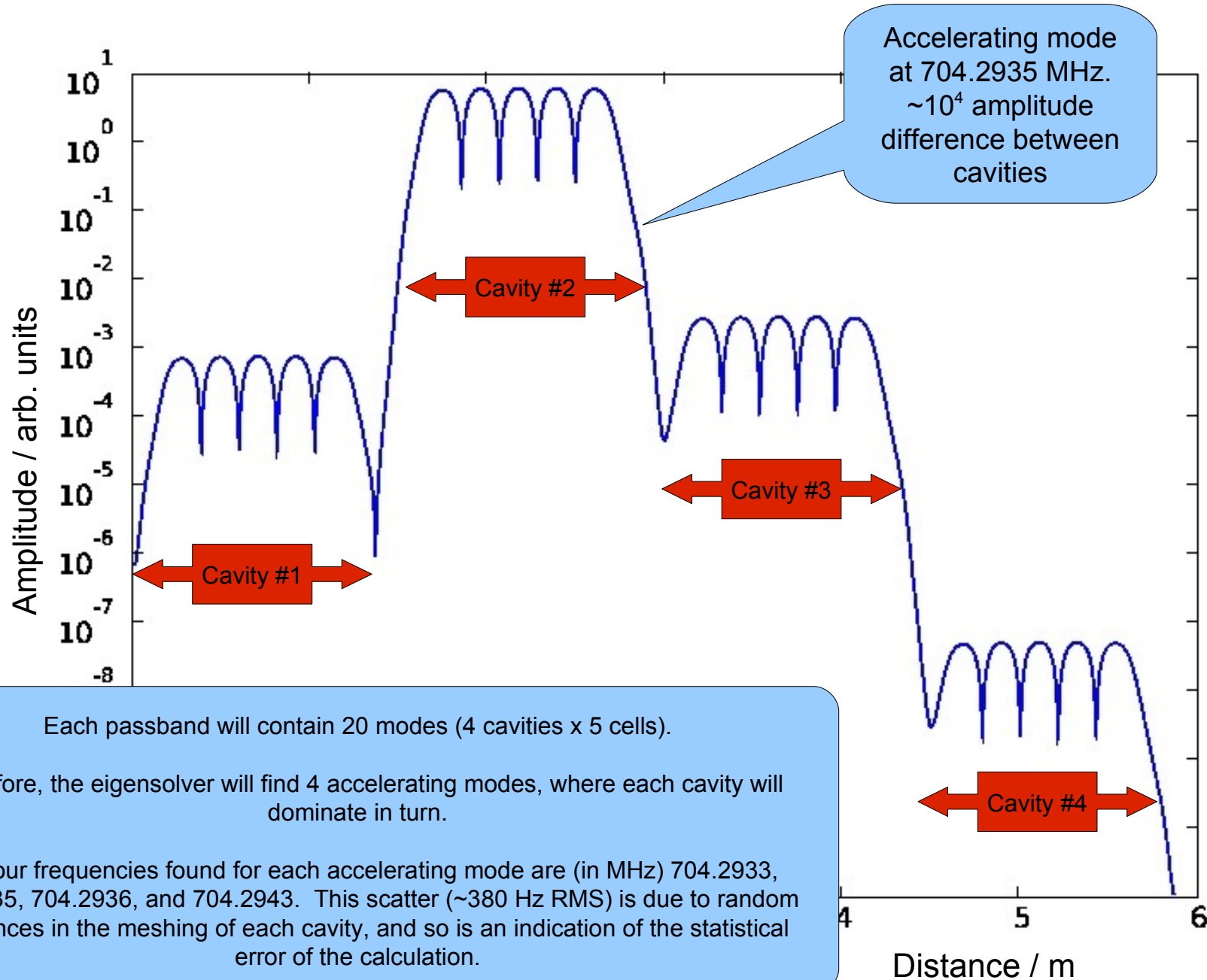
~6 m long



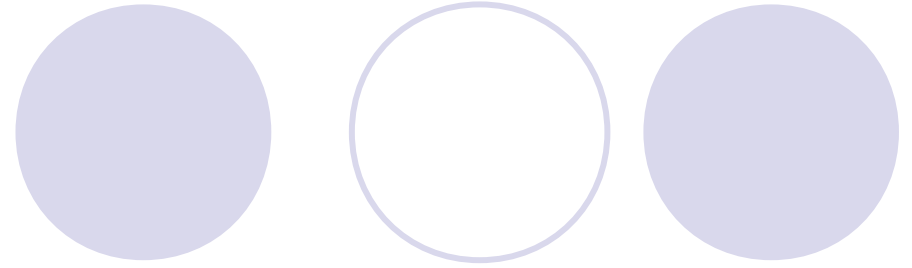
~760k elements  
Average volume =  $4.5 \times 10^{-7} \text{ m}^3$   
Min edge length = 1.4 mm  
Max edge length = 32.9 mm



# Eigenmodes exist in **all** cavities



# Intra-cavity coupling



- Each cavity mode will be found four times
  - One for each cavity
  - A single cavity will dominate each mode, however the evanescent field allows coupling.
    - Beam → Field coupling in one cavity will excite fields in all others.
    - Expect coupling to increase (non-trivially) with frequency
- Extract intra-cavity coupling from simulation
  - Ratio of field amplitude between each cavity and its neighbour



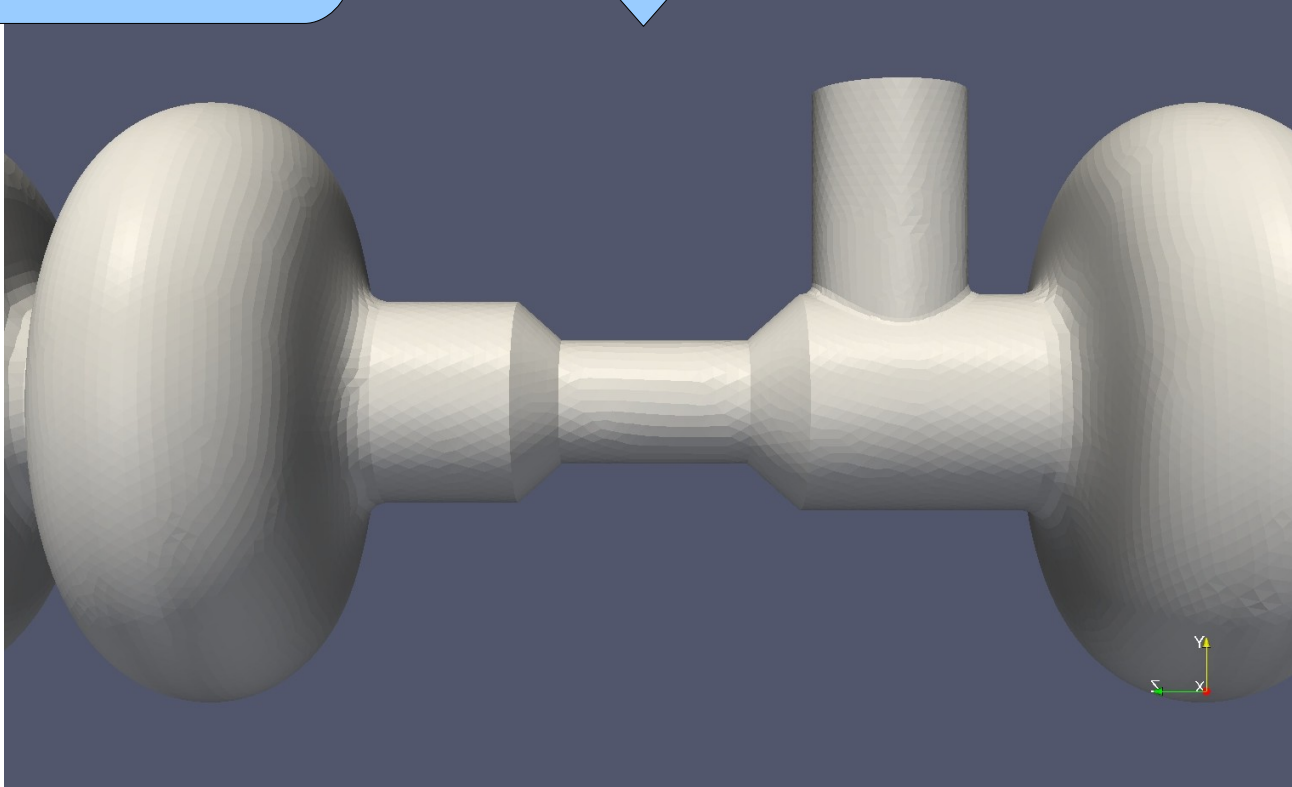


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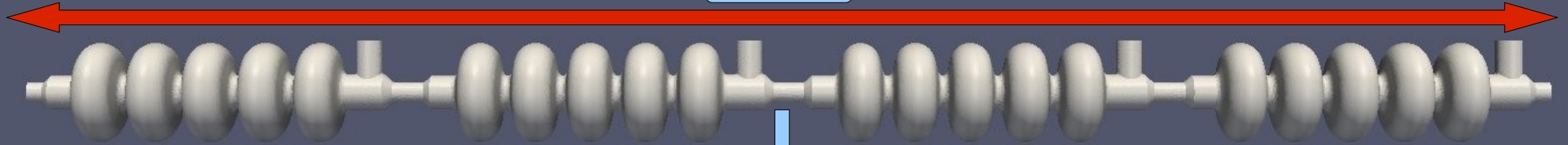
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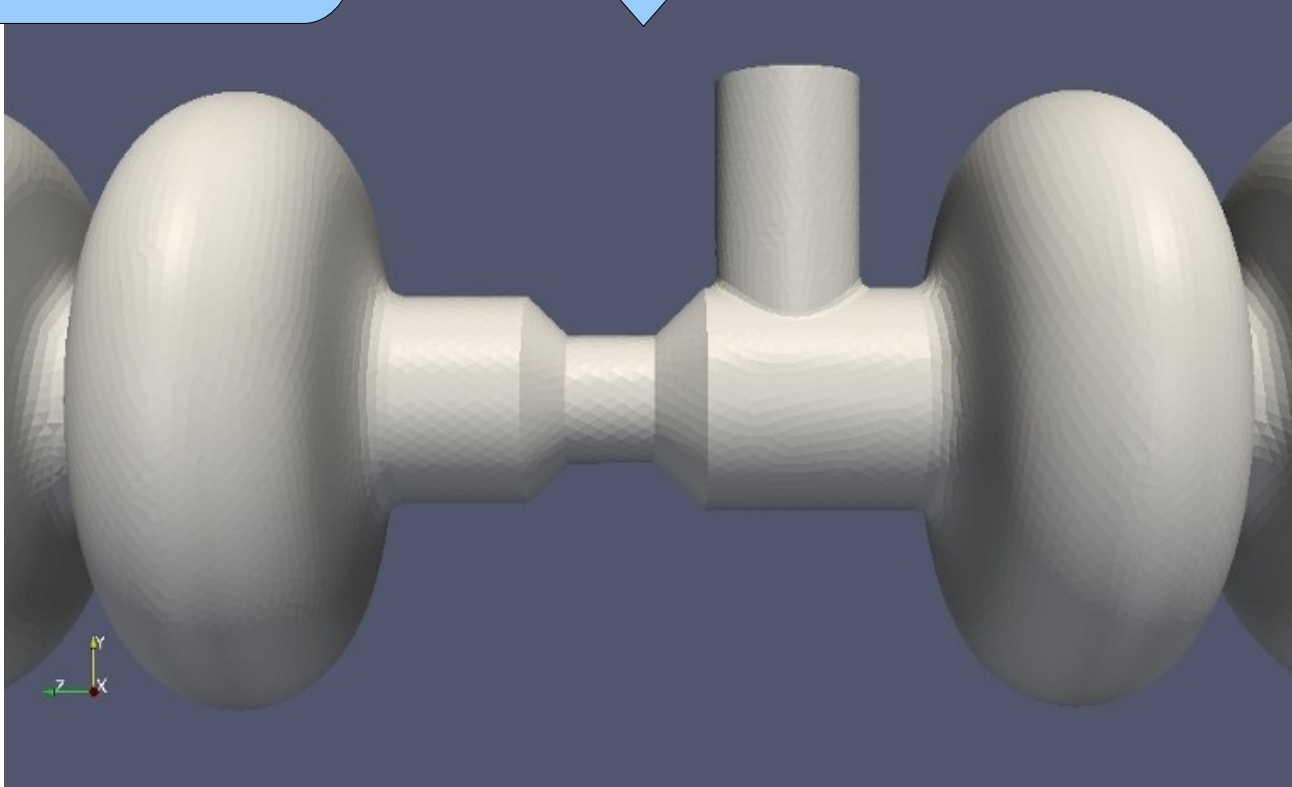


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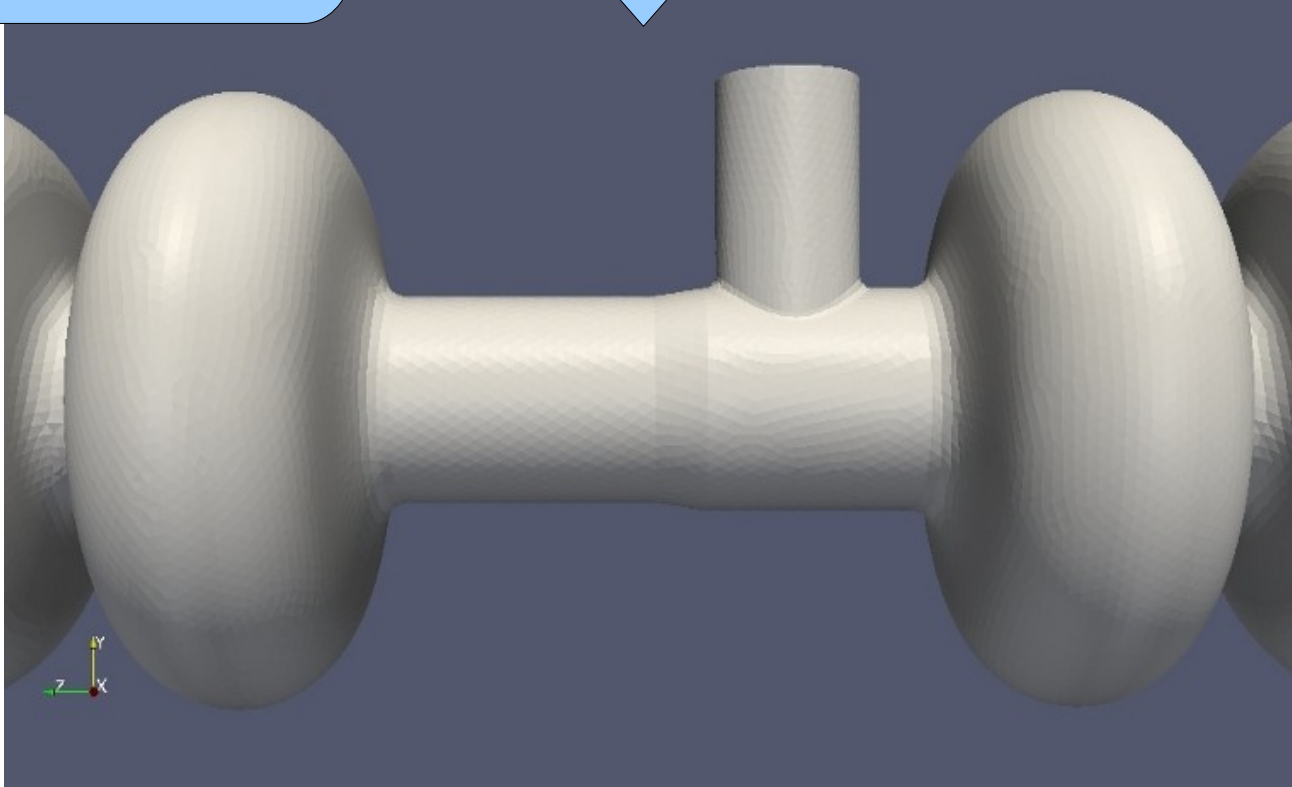


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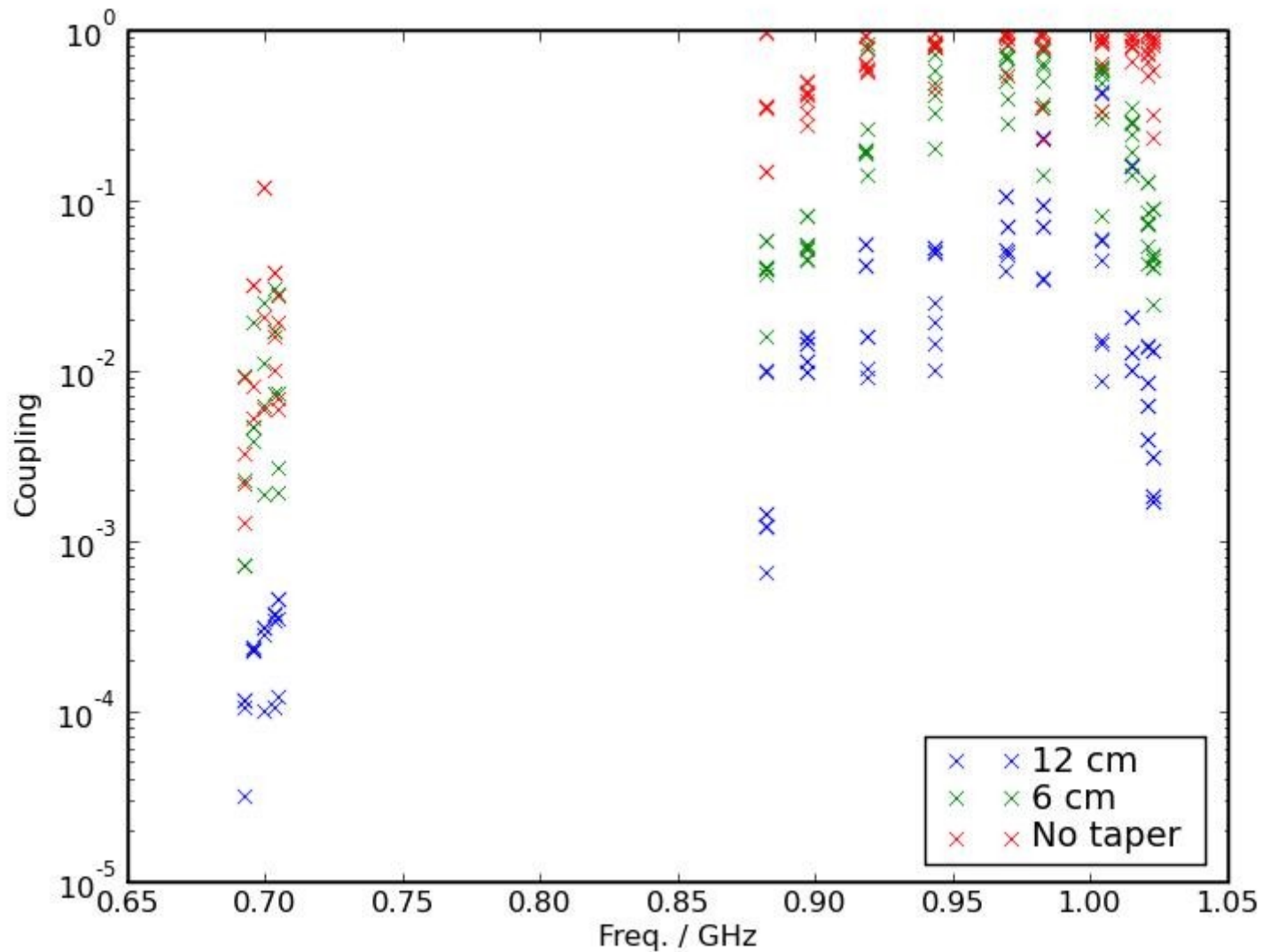
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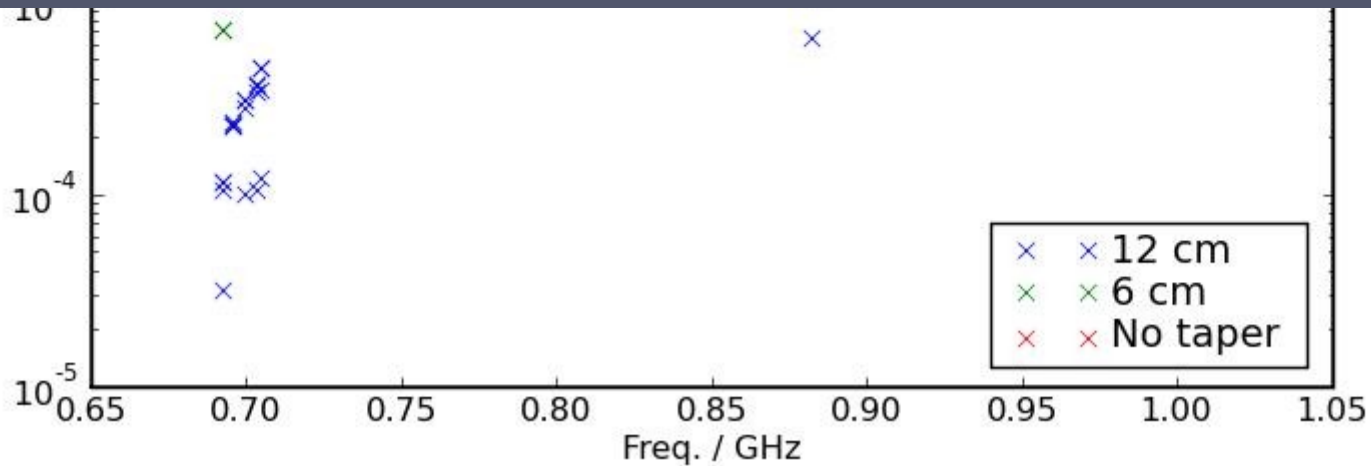
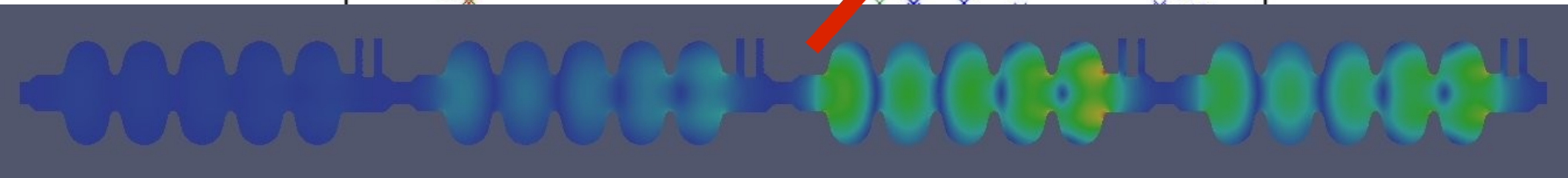
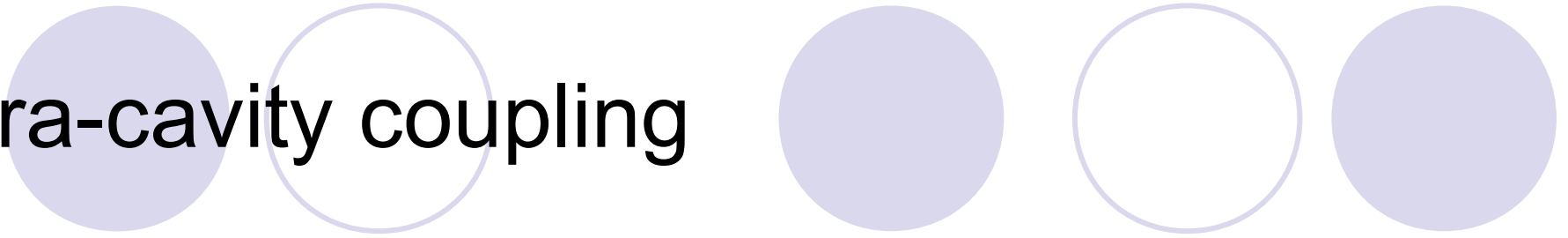
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# Intra-cavity coupling



# Intra-cavity coupling

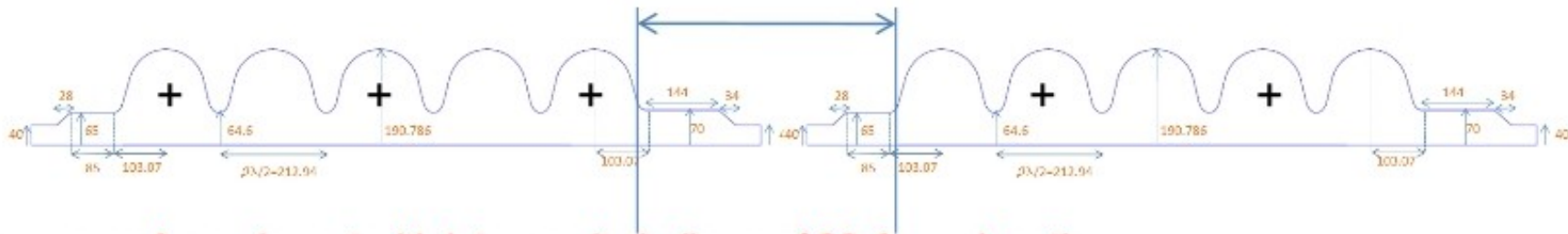


# Cavity geometry 2/5

## phase relation between string of several cavities ( $\pi$ - mode)

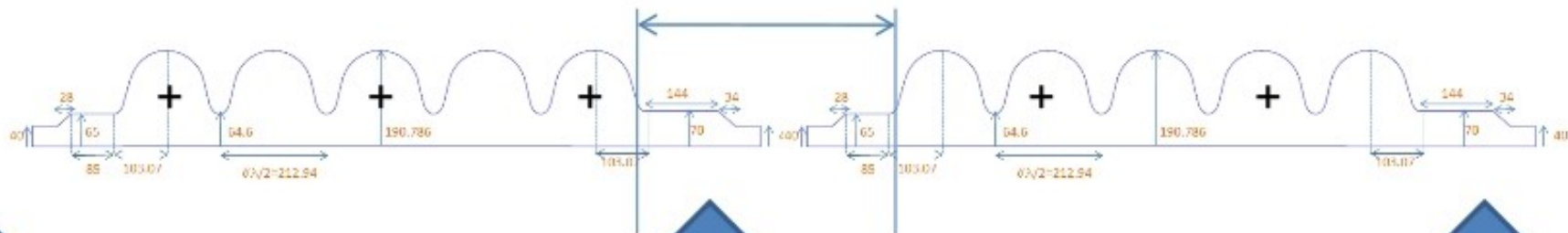
present layout with inter-cavity bellows of **100 mm** length

$$2.05 \cdot \lambda/2$$



proposed new layout with inter-cavity bellows of **89.4 mm** length

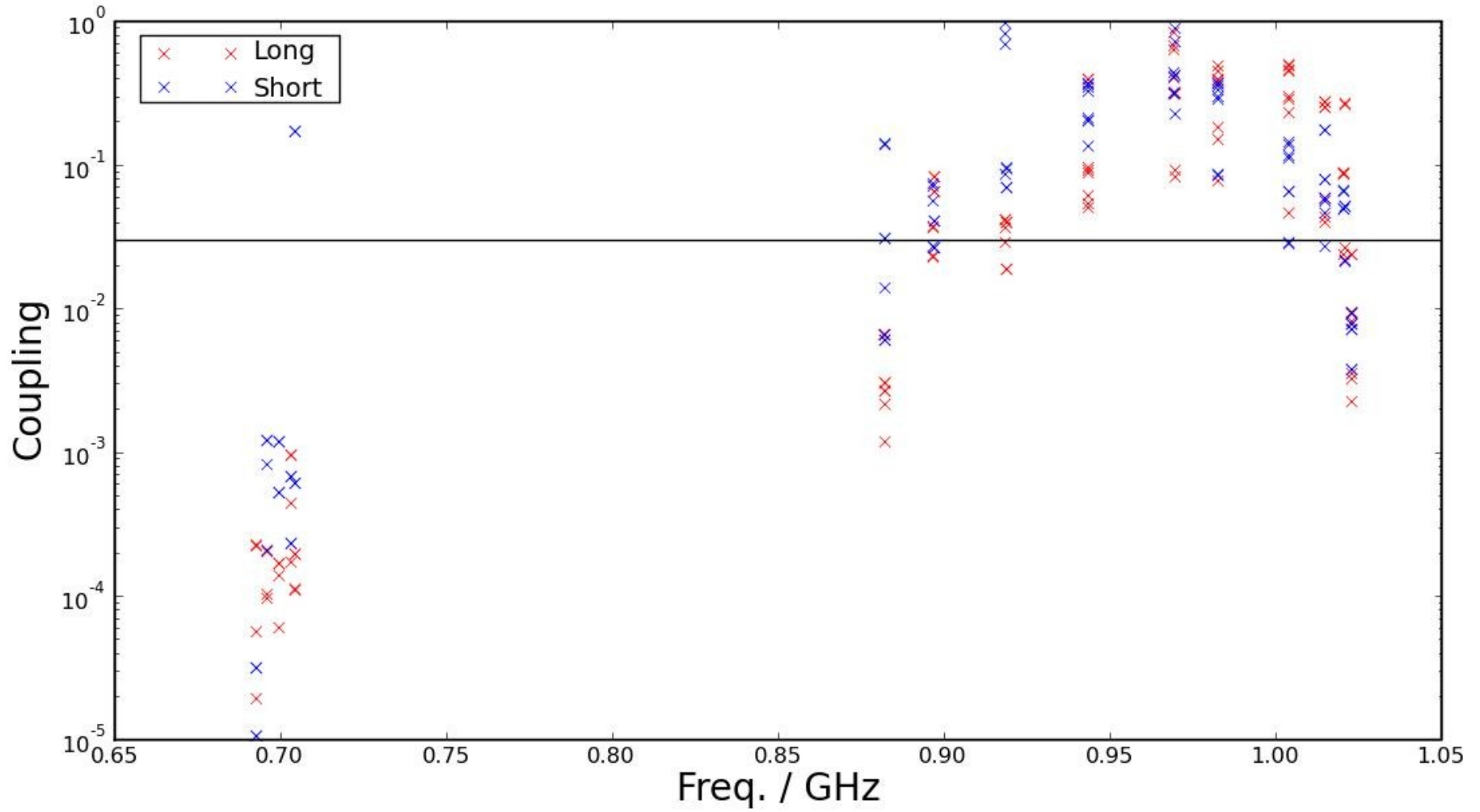
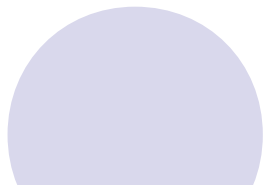
$$2 \cdot \lambda/2$$

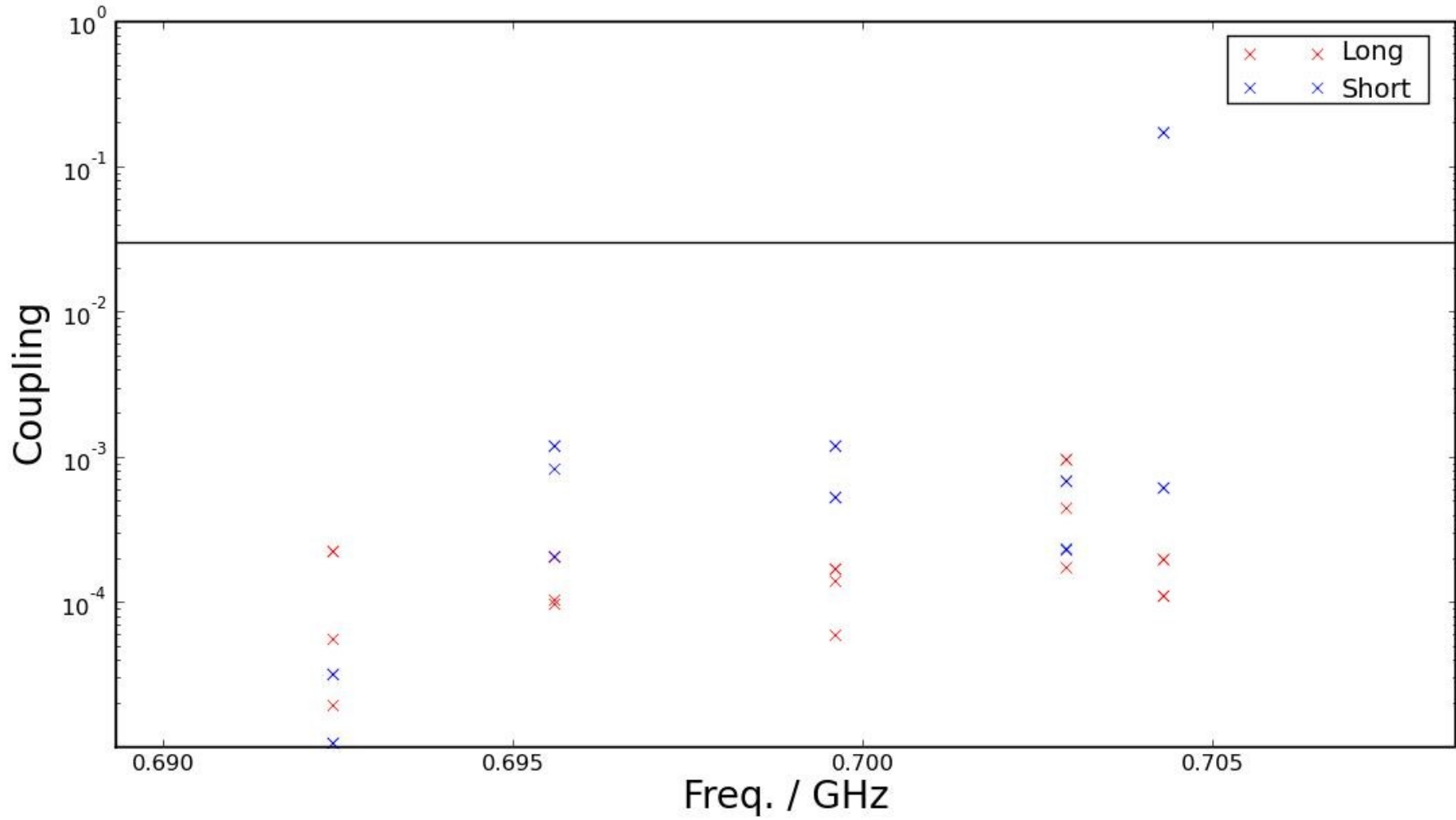
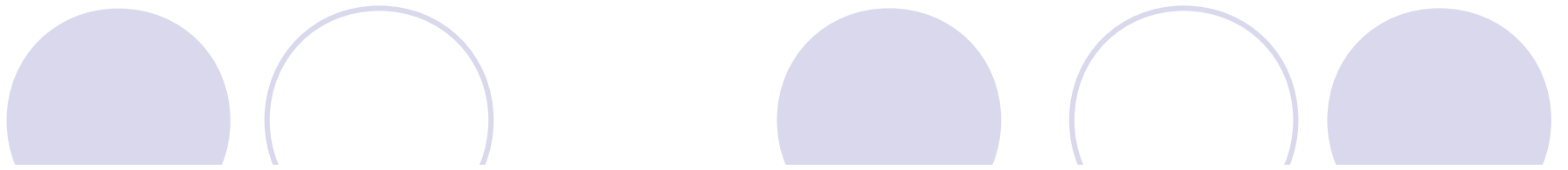


↑  
RF power coupler  
phase =  $-180^\circ$

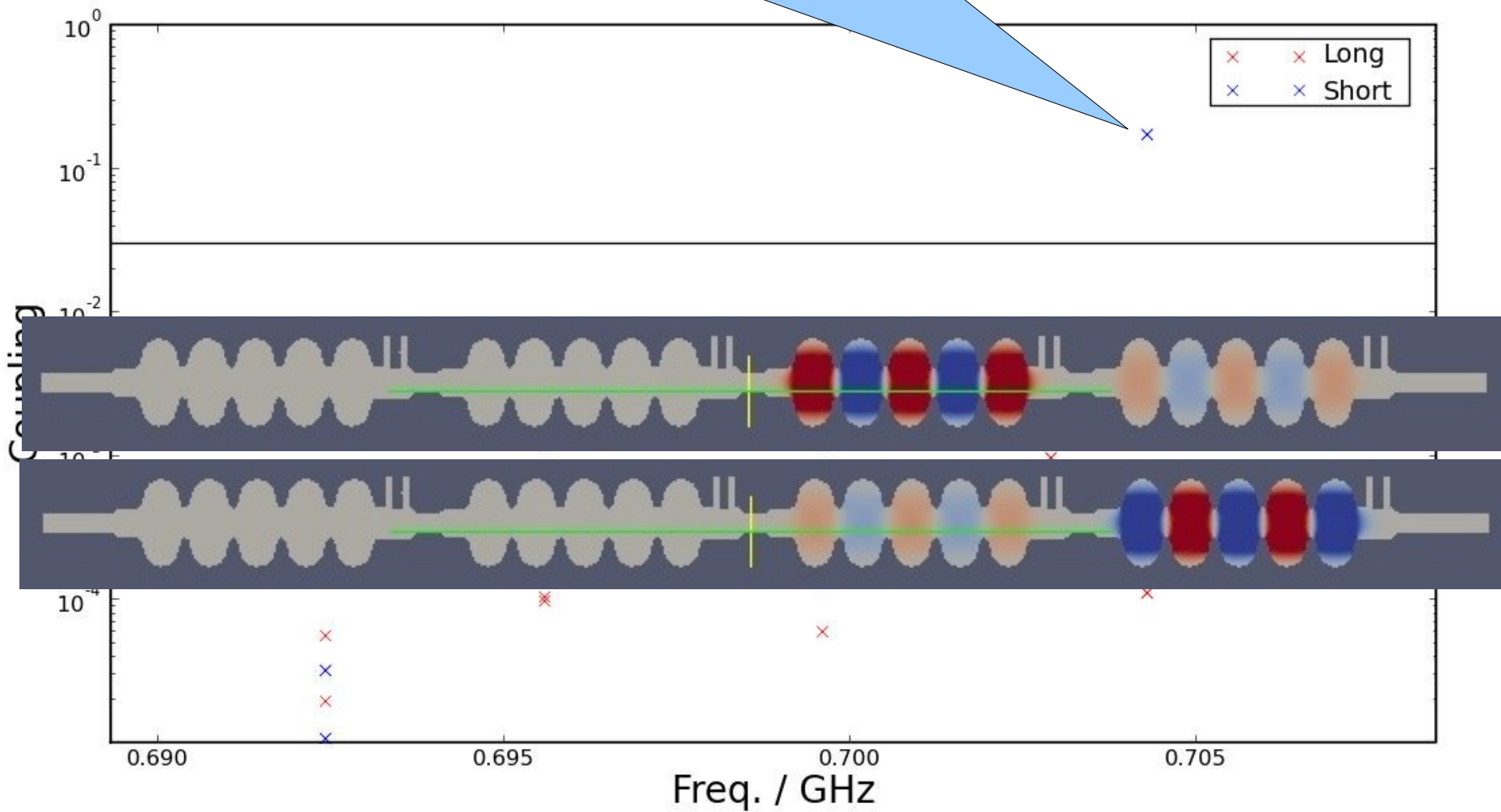
↑  
RF power coupler  
reference phase =  $0^\circ$

↑  
RF power coupler  
phase =  $180^\circ$





Two modes with identical simulated frequencies.  
Orthonormal eigenvectors





# High Performance Computing

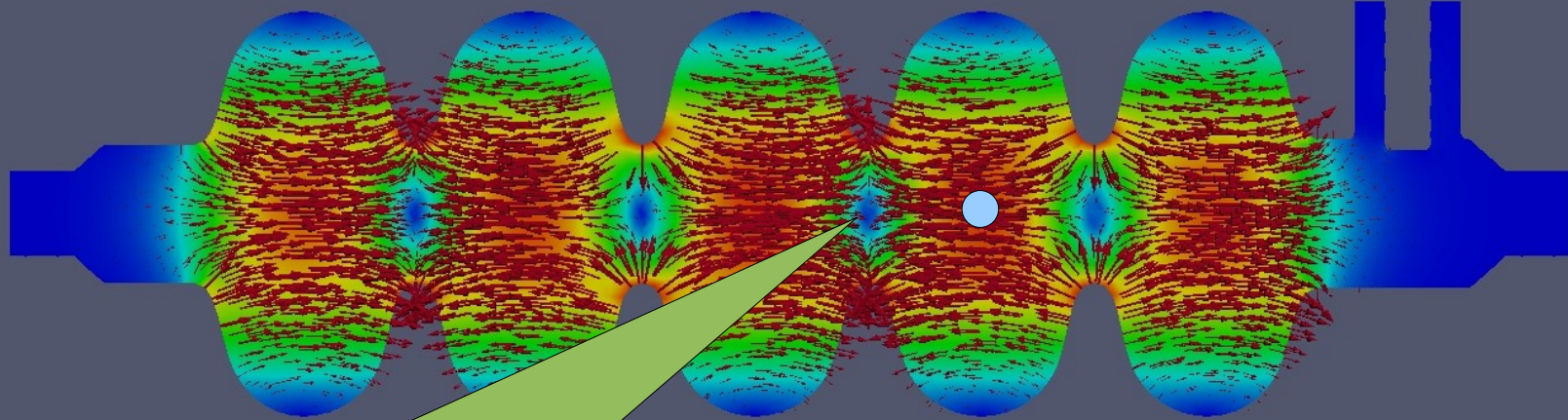
- Access to SLAC simulation codes
  - Limited by export restrictions
    - Highly indebted to Kwok Ko, et al. at SLAC
  - Highly parallelisable EM sim. codes.
- Franklin supercomputer at NERSC
  - 38000 compute cores
    - 11<sup>th</sup> fastest in the world!
  - I have 15% of SLAC's NERSC budget!
    - 150k CPU.hours



# Software – SLAC's ACE3P codes

	Module Name	Description
Frequency Domain	Omega3P	Eigen-solver for resonant modes
	S3P	S-Parameters
Time Domain	T3P	Excitation of fields by relativistic bunch
	Pic3P	PIC code for space-charge dominated devices
	Track3P	Particle tracking for multipacting & dark current
Multi-physics	TEM3P	EM, thermal, mechanical

# Bead-pull technique



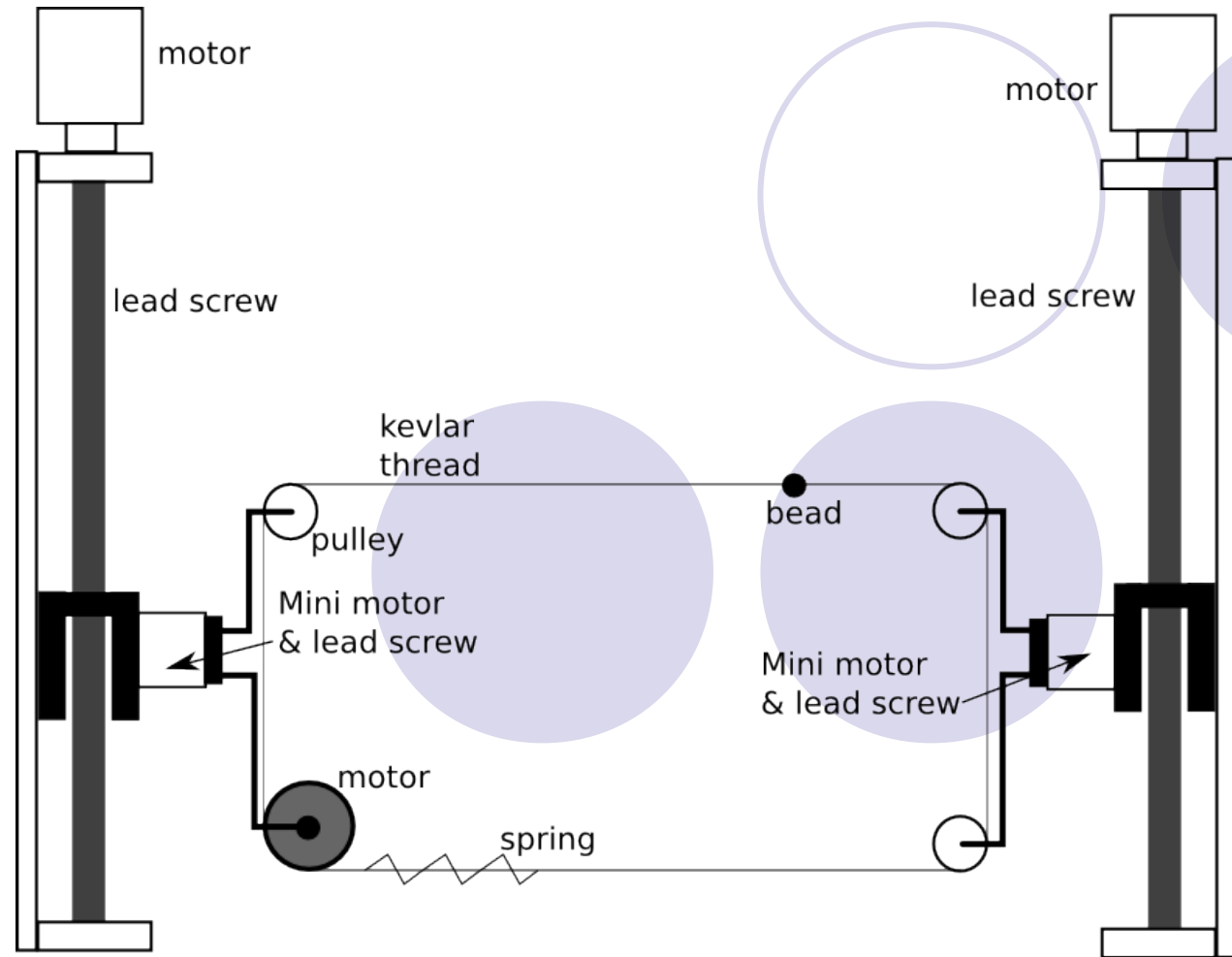
Energy resonantly exchanged between  
E & B fields.

A perturbation affecting the stored energy  
will therefore alter the frequency.

$$\left(\frac{\Delta f}{f}\right) = \left(\frac{k}{4U}\right) \iint (\mu H(x, y)^2 - \epsilon E(x, y)^2) dx dy$$

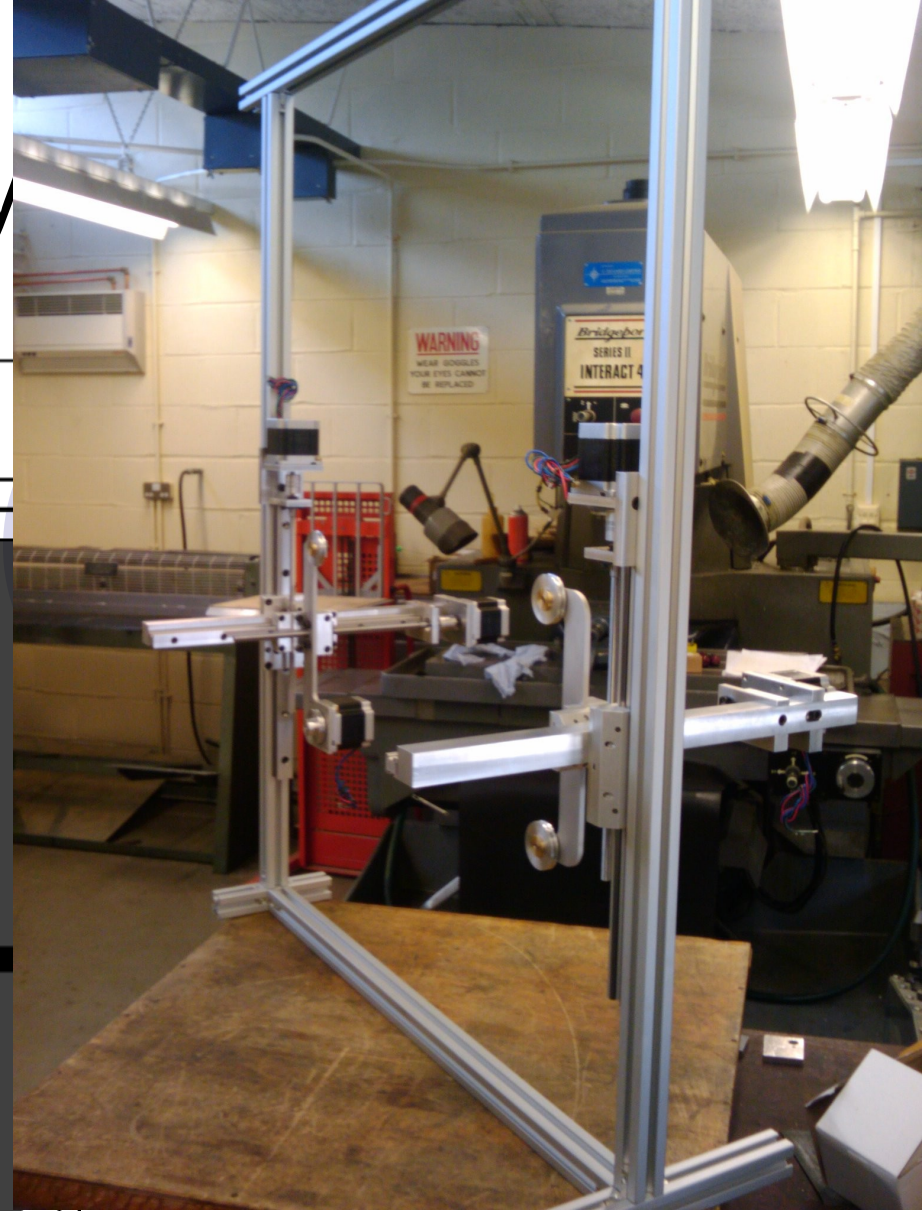
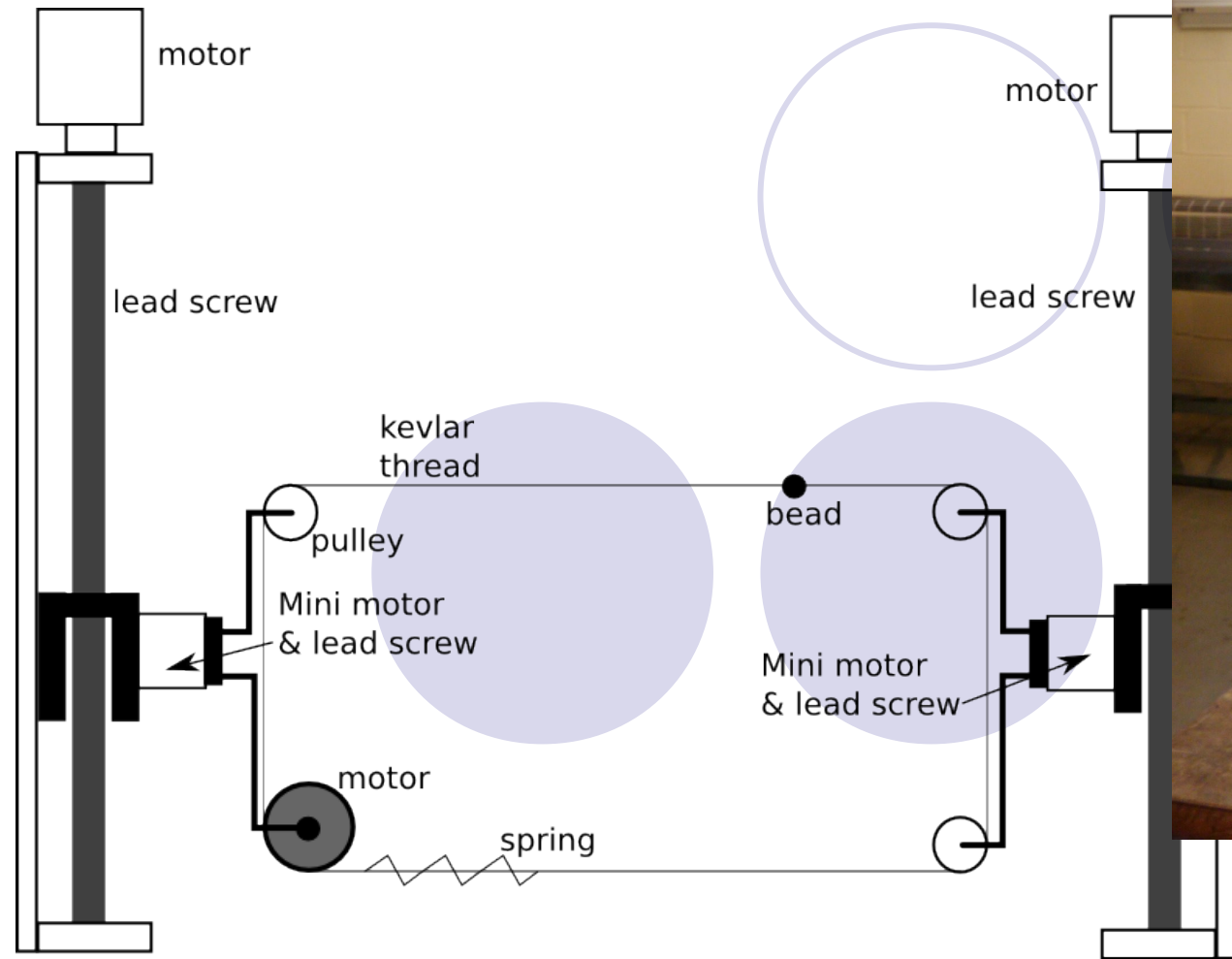
There are many other ways to perform this calculation,  
including observation of phase changes, etc.

# RHUL Bead Pull Facility



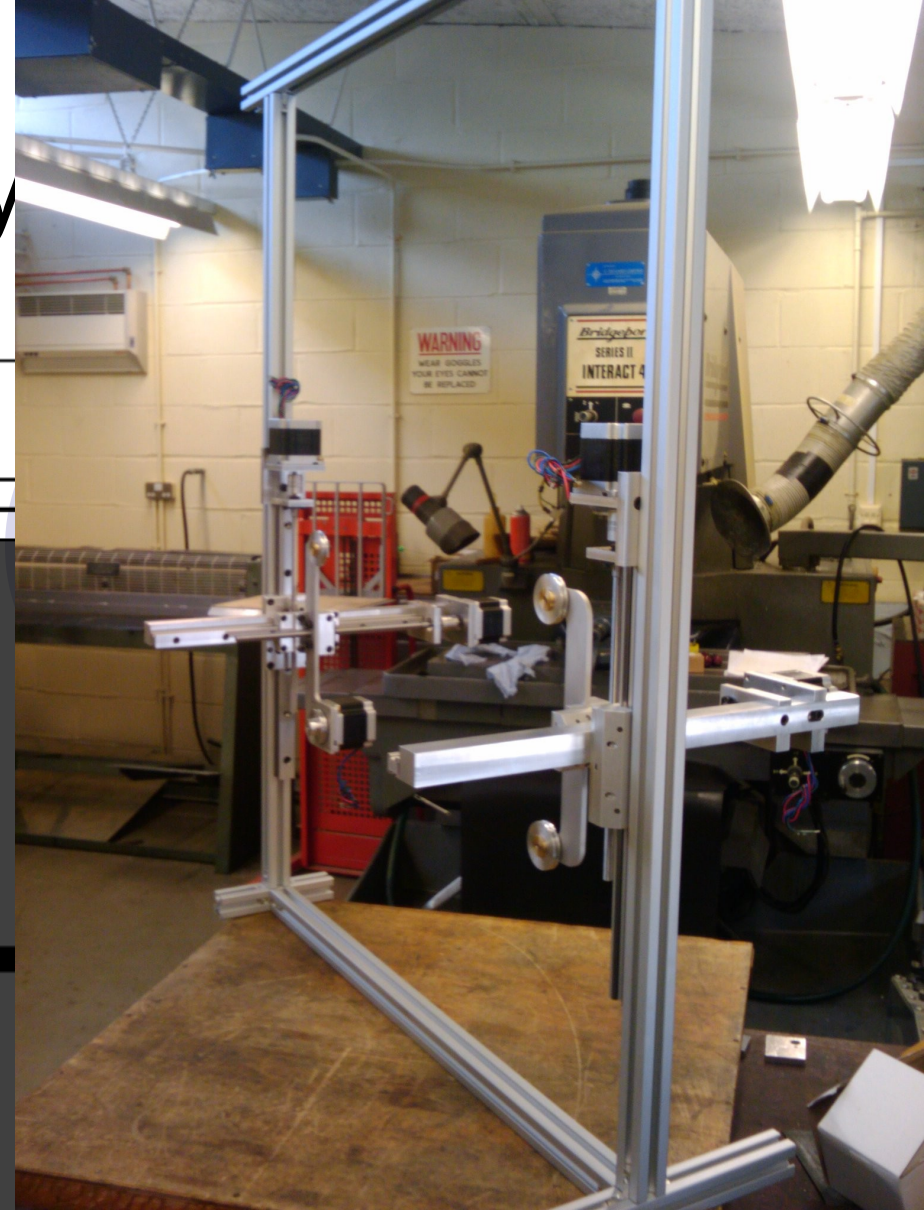
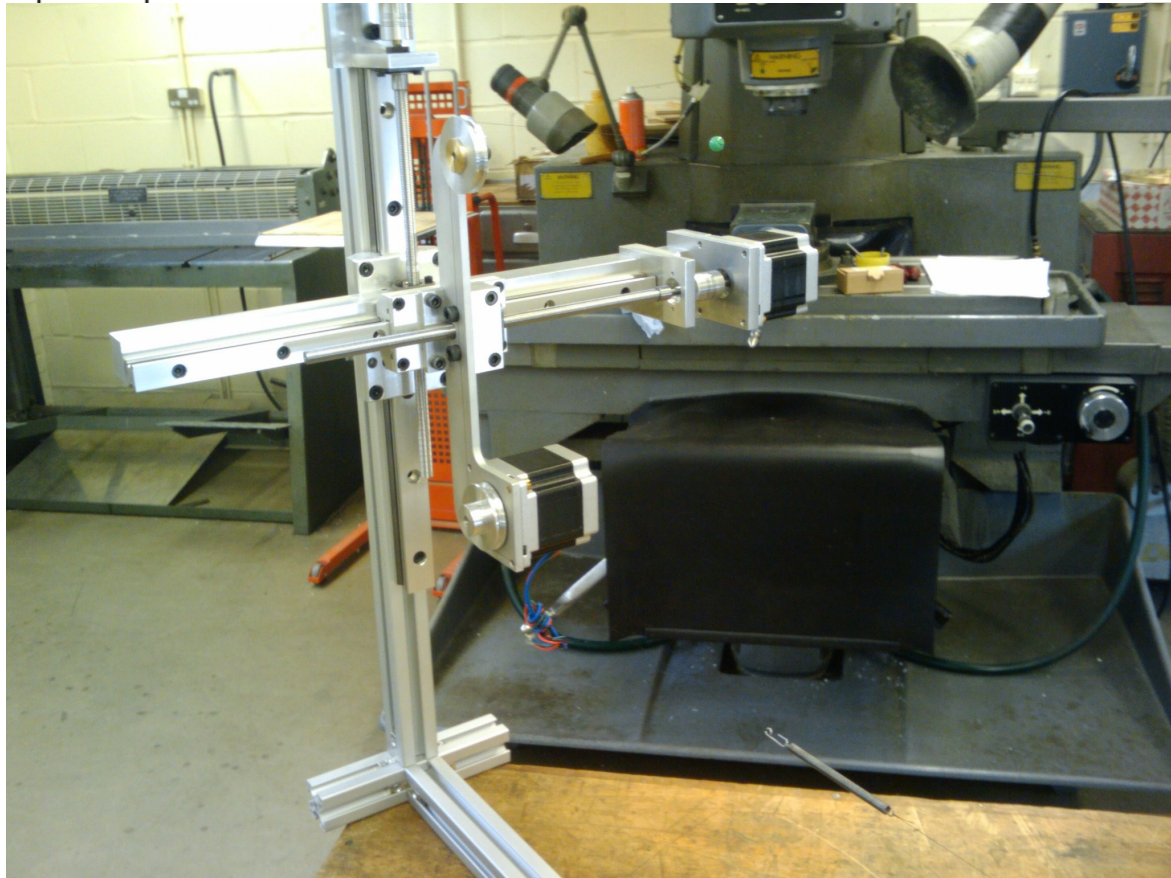
- Funded by college grant
- Construction ~75% complete
  - Summer student to build & test control system
- Initial tests on prototype BPMs
  - Cavity loans:
    - Beta=1 SPL cavity
    - FETS RFQ prototype

# RHUL Bead Pull Facility



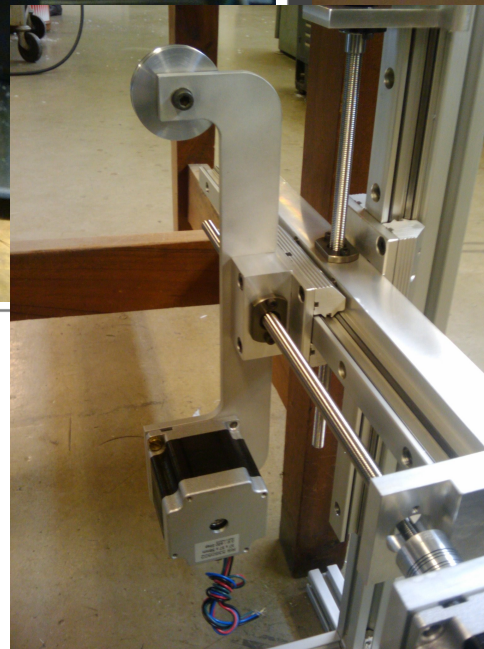
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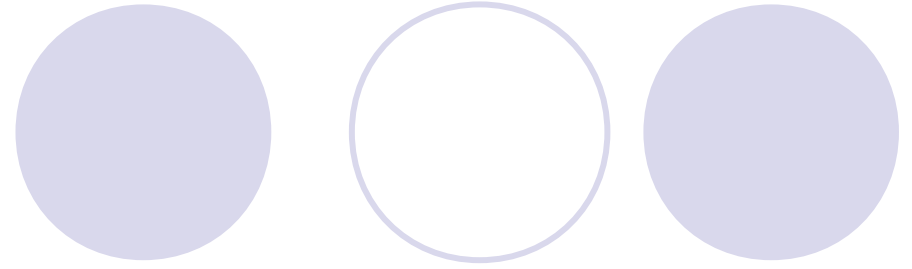
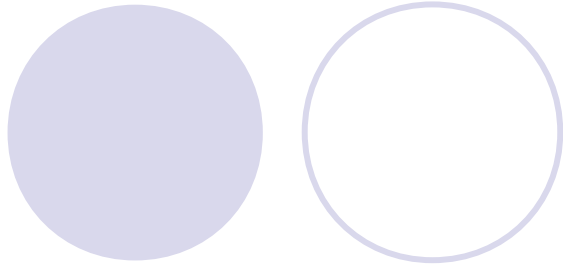


- FETS RFQ prototype

# RHUL Bead Pull Facility



- FETS RFQ prototype



Thank you for listening!

