The ILC Crab Cavity System

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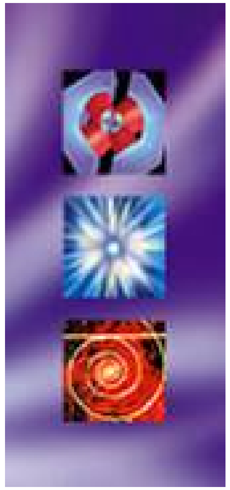
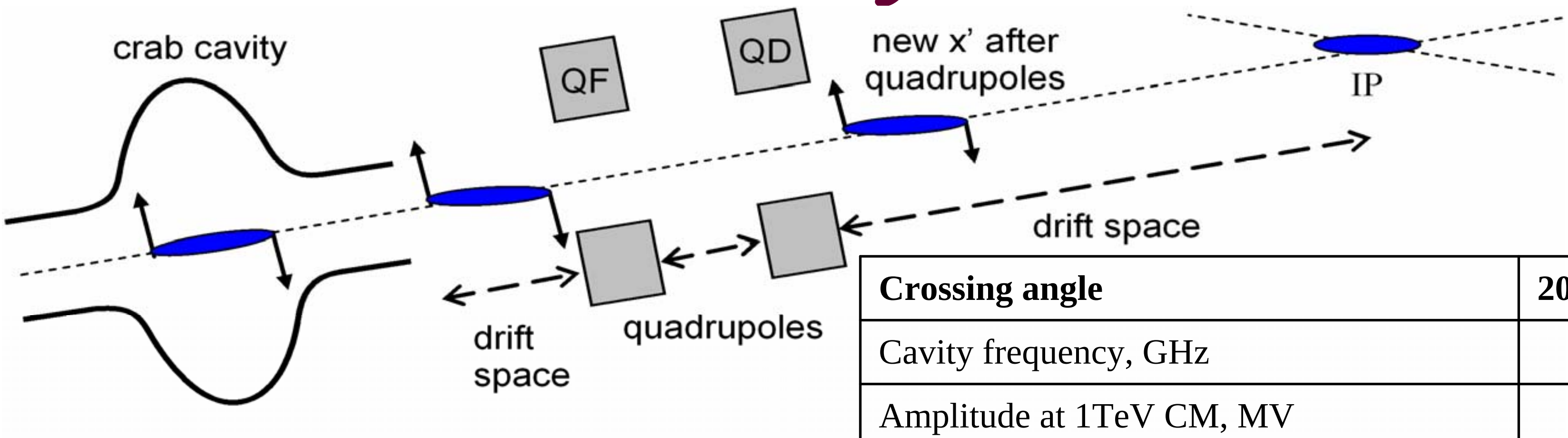


international linear collider

The ILC Crab Cavity Team

- **Cockcroft Institute – Daresbury Laboratory:**
  - Graeme Burt (Lancaster University)
  - Richard Carter (Lancaster University)
  - Amos Dexter (Lancaster University)
  - Philippe Goudket (ASTeC)
  - Roger Jones (Manchester University)
  - Alex Kalinin (ASTeC)
  - Lili Ma (ASTeC)
  - Peter McIntosh (ASTeC)
  - Imran Tahir (Lancaster University)
- **FNAL**
  - Leo Bellantoni
  - Mike Church
  - Tim Koeth
  - Timergali Khabiboulline
  - Nikolay Solyak
- **SLAC**
  - Chris Adolphson
  - Kwok Ko
  - Zenghai Li
  - Cho Ng

Crab Cavity Parameters



- TM_{110} mode dipole cavity.
- Beams receive transverse momentum kick:
  - Each bunch rotated to maximise Luminosity at the IP.
- Crab cavities positioned close to IP @ ~ 12 m.

Crossing angle	**20 mrad**	**2 mrad**
Cavity frequency, GHz	3.9	3.9
Amplitude at 1TeV CM, MV	3.76	0.175
Max amplitude with operational margin, MV	6.5	0.4
RMS relative phase stability for 2% rms Luminosity drop	0.07°	0.7°
RMS amplitude stability for 2% rms Luminosity drop	1.2%	12%
Desired cavity aperture radius, mm	15	15
Minimal cavity aperture radius, mm	10	10
Allowable X beam jitter at crab cavity, μm	500	500
Allowable Y beam jitter at crab cavity, μm	35	35

FNAL CKM Test Results

<u>CKM Cavity design parameters</u>

3.9 GHz

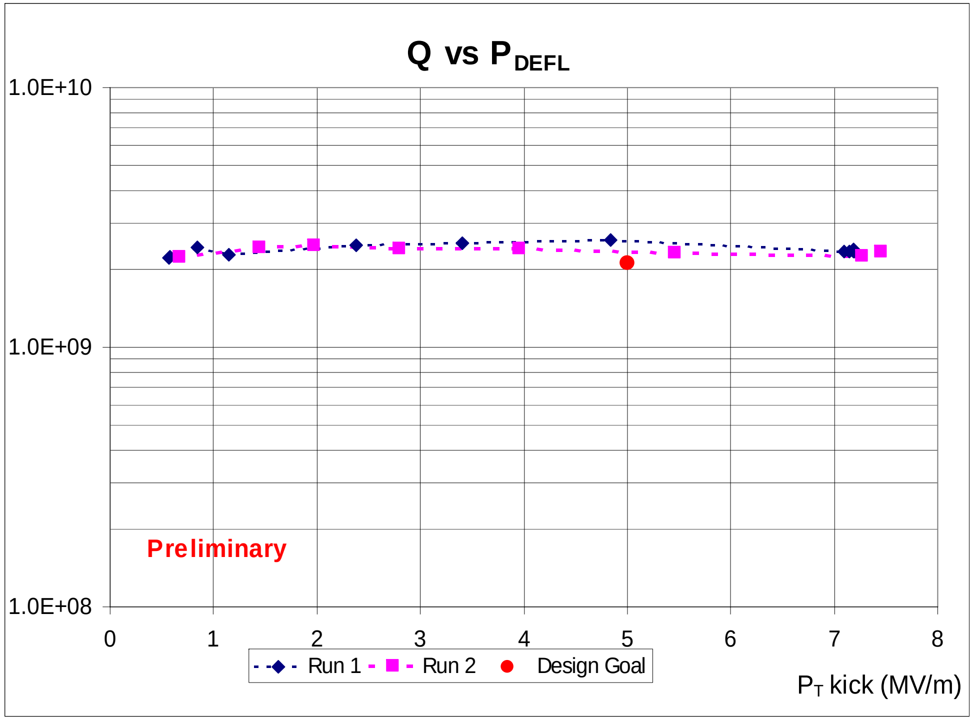
13 cells

B_{max} = 80 mT

E_{max} = 18.6 MV/m

L_{eff} = 0.5 m

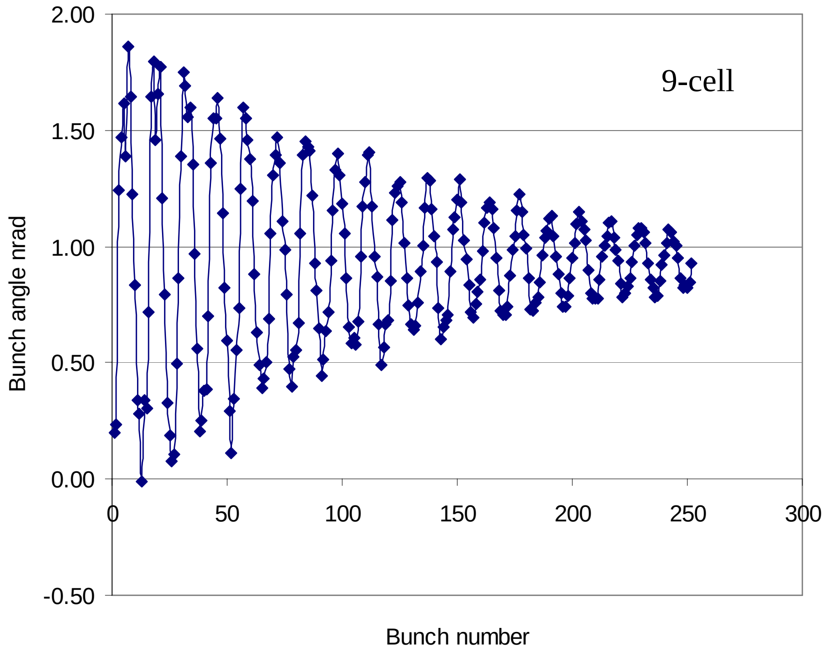
$P_{\perp}$ = 5 M V/m



Courtesy: FNAL

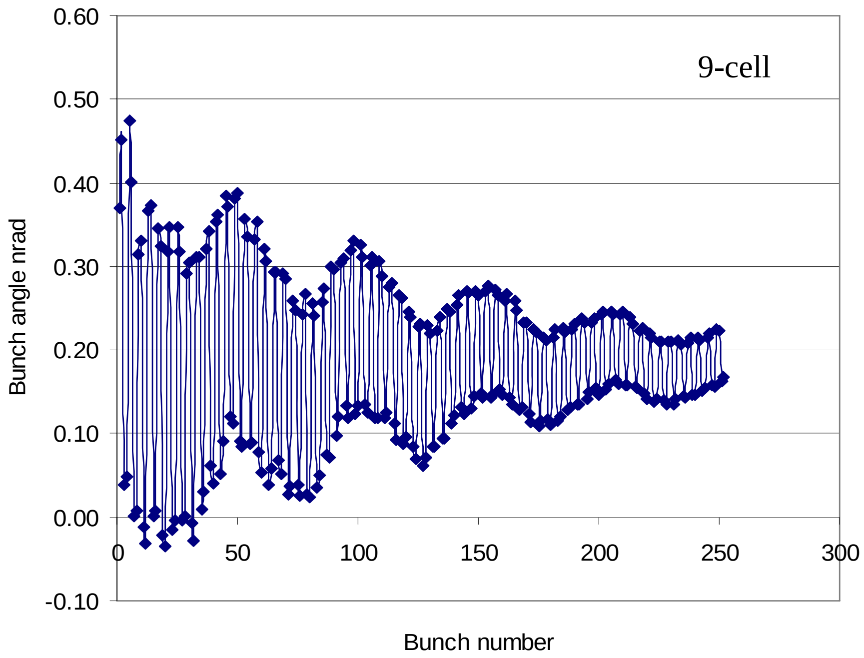
Long Range Wakes (Transverse)

Horizontal kick for 4σ offset.



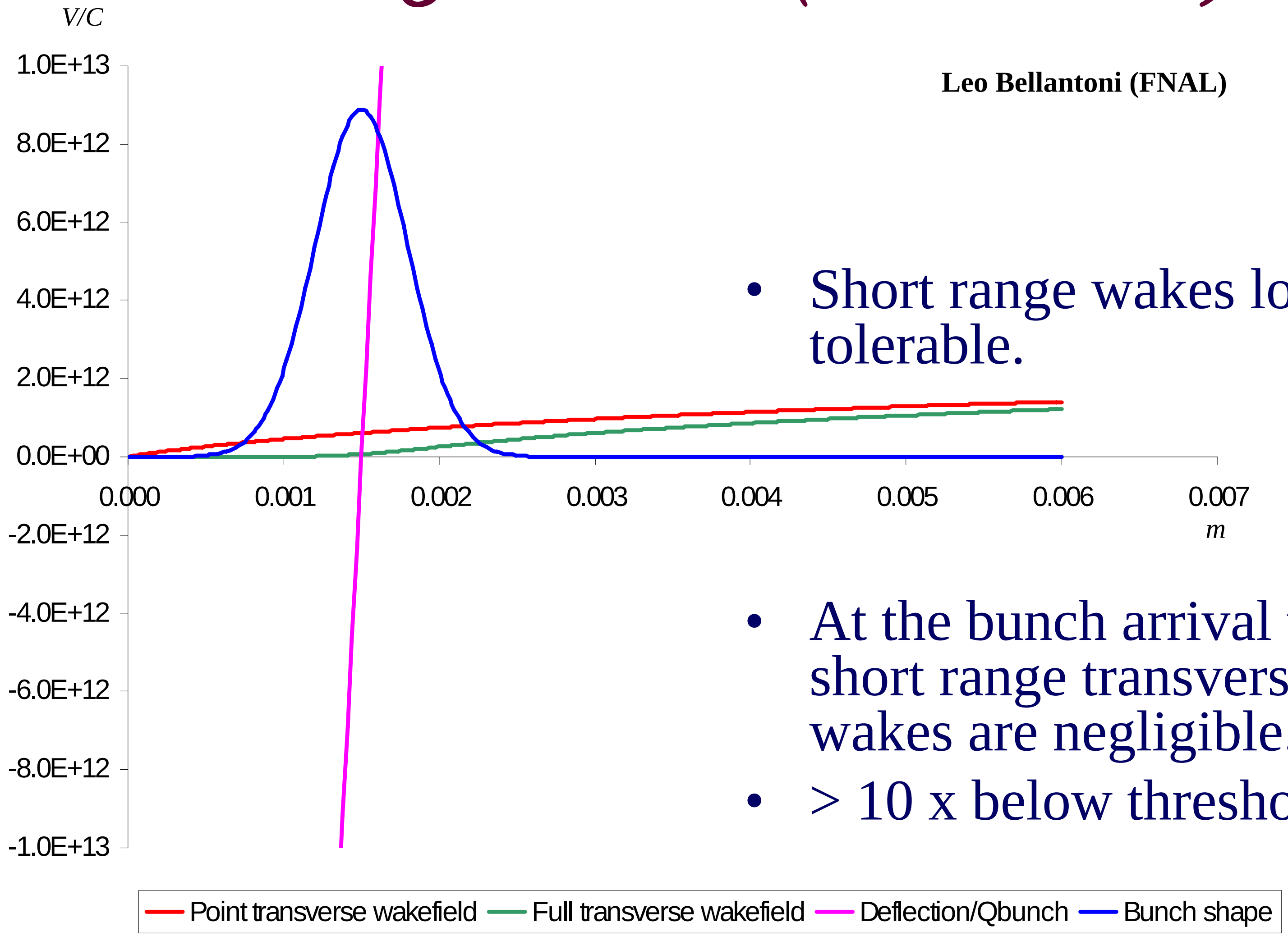
- Horz. wakes lower than ILC threshold (10 nrad).
- Deflecting mode not included.
- External Q's are estimated.

Vertical kick for 4σ offset.



- Vert. wake limited by unwanted polarisation of dipole mode, ILC threshold 0.7 nrad.
- Highly dependent on frequency separation.

Short Range Wakes (Transverse)

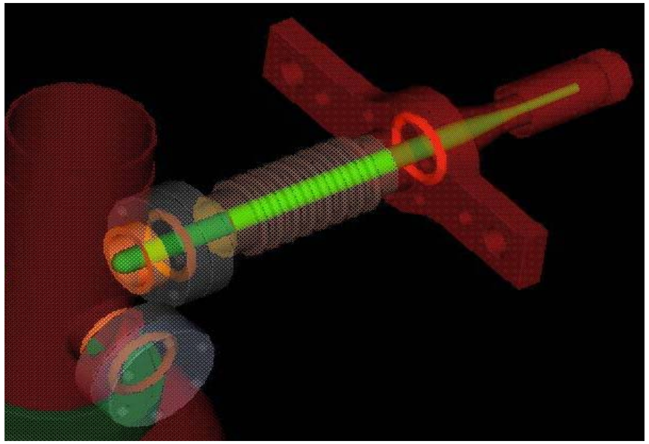


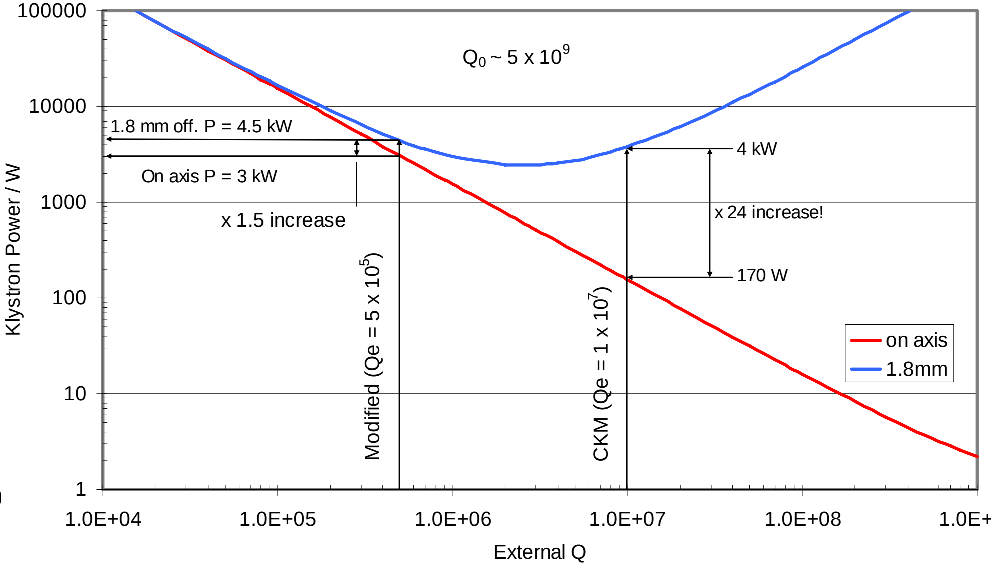
Leo Bellantoni (FNAL)

- Short range wakes look tolerable.
- At the bunch arrival time, short range transverse wakes are negligible.
- > 10 x below threshold.

Input Coupler

- CKM input coupler has Qe ~ 10^7 and 500 W CW power handling capability.
- Predicted that crab cavity has to cope with up to ± 1.8 mm transverse offset.
- Beam loading is linearly proportional with bunch offset and is zero when the beam is on axis.
- Qe must be reduced to ~ 5 x 10^5 and power delivery increased to ~ 4.5 kW CW.
- New input coupler needed for ILC!

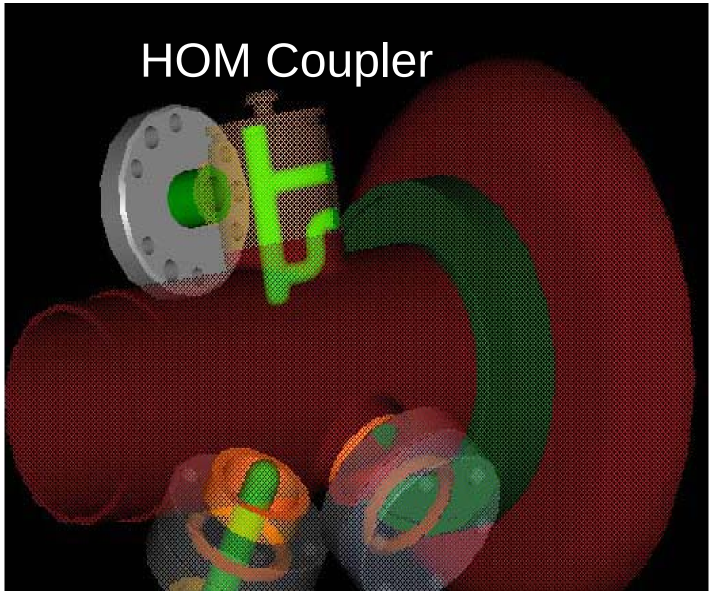


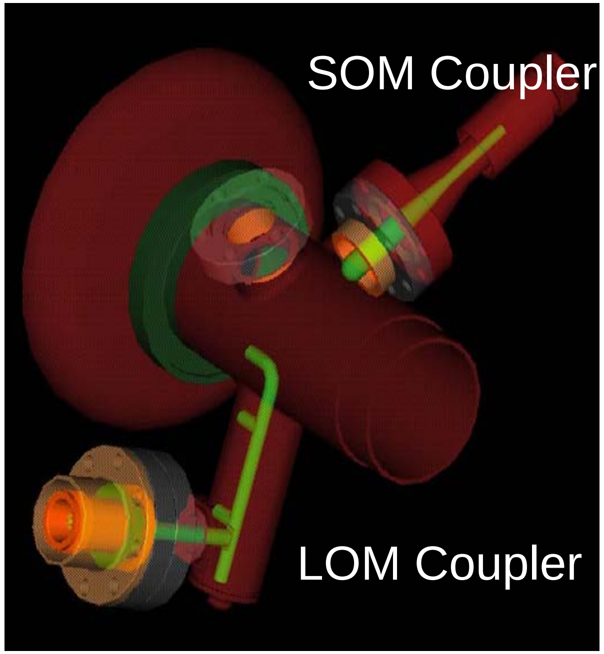


Graeme Burt (Cockcroft)

Crab Cavity Mode Couplers

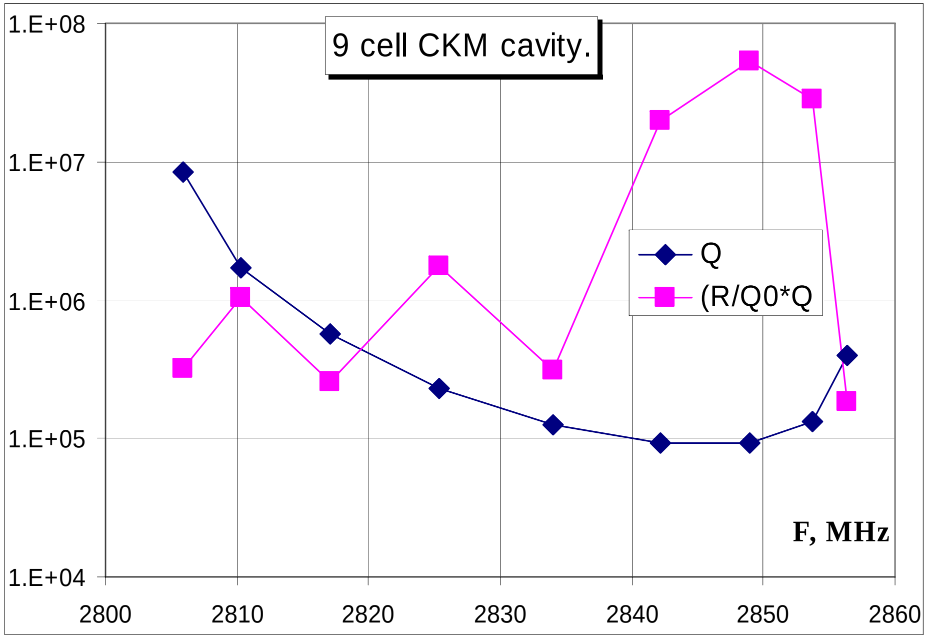
- 3 different couplers for mode extraction required:
  - Higher Order Mode (HOM)
  - Lower Order Mode (LOM)
  - Same Order Mode (SOM)

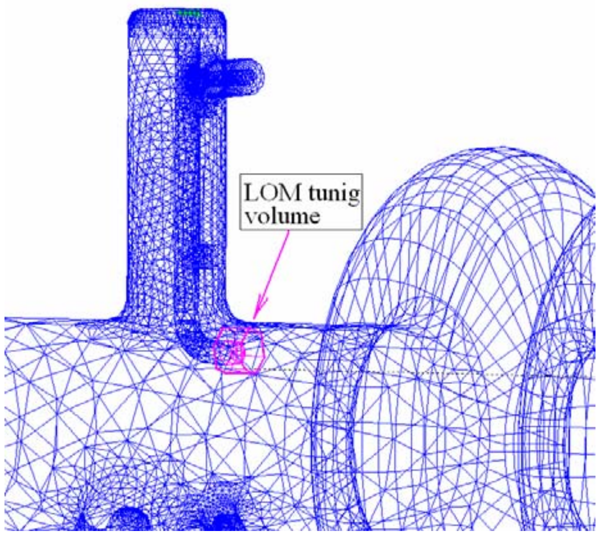




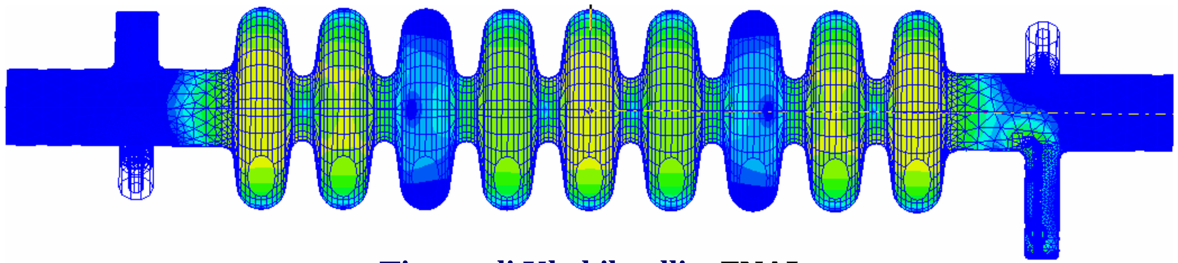
- These couplers are difficult to fabricate at 3.9GHz.
- CKM cavity HOM couplers have shown problems in tests:
  - high tuning sensitivity (~ 1.6 MHz/μm)
  - multipacting.
- New HOM coupler needed for ILC!

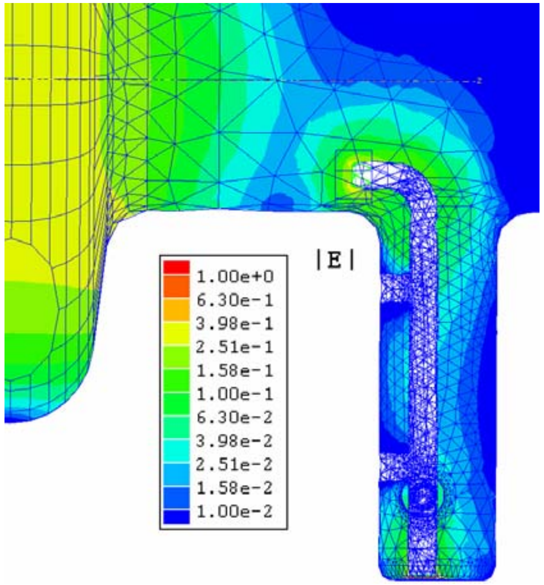
LOM Coupler Tuning





|E|, 7π/9 mode, F=2848.95MHz, ε=1.15 tip_LOM.

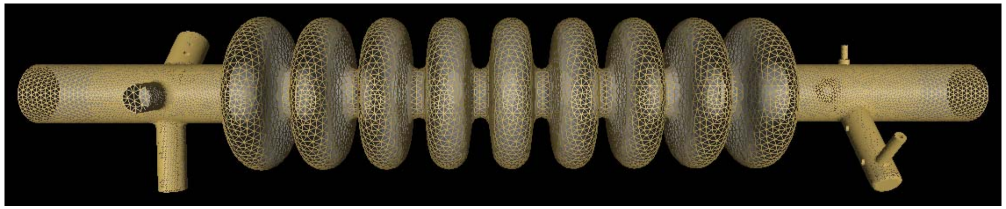




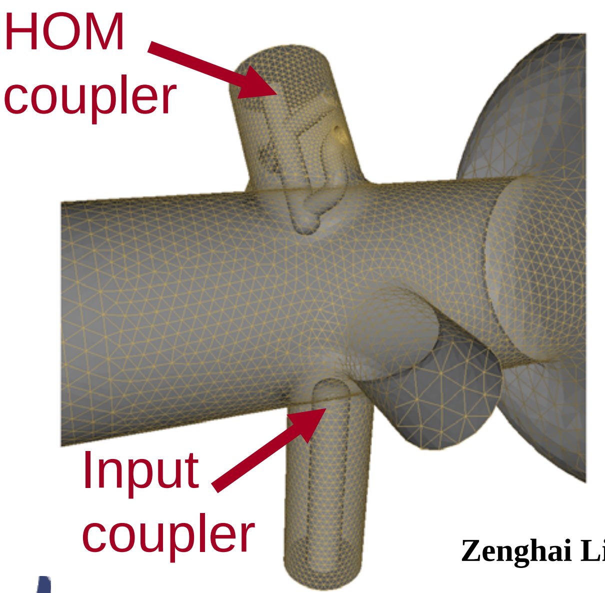
Timergali Khabiboullin, FNAL

Full Coupler Optimisation

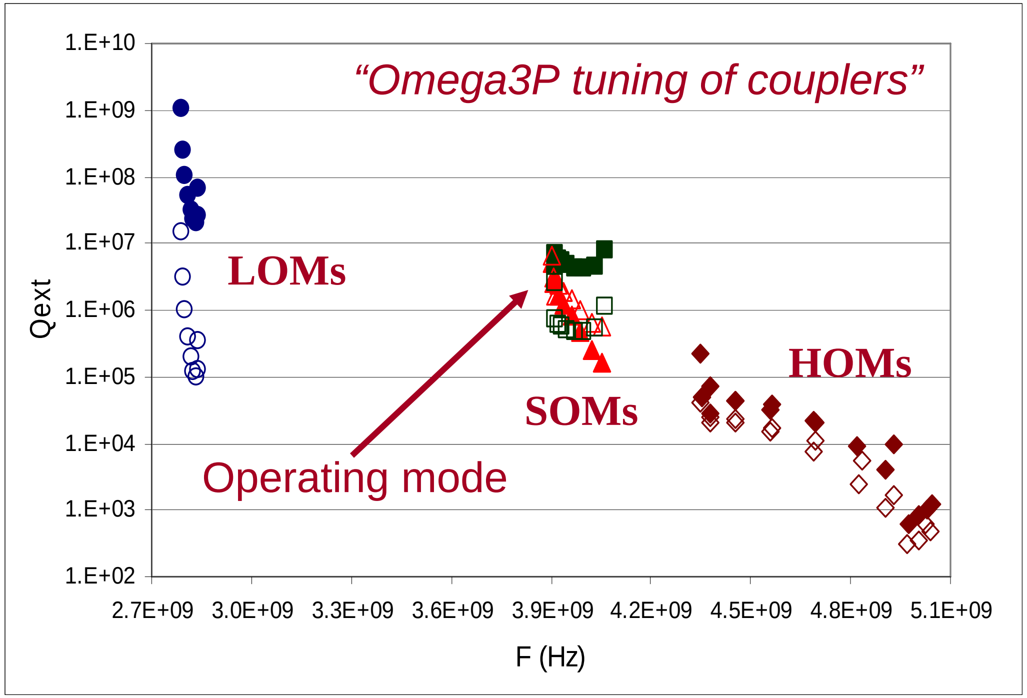
Omega3P Mesh



- Extensive CPU resources used at SLAC to verify parametric coupler tuning and HOM Qe evaluations.

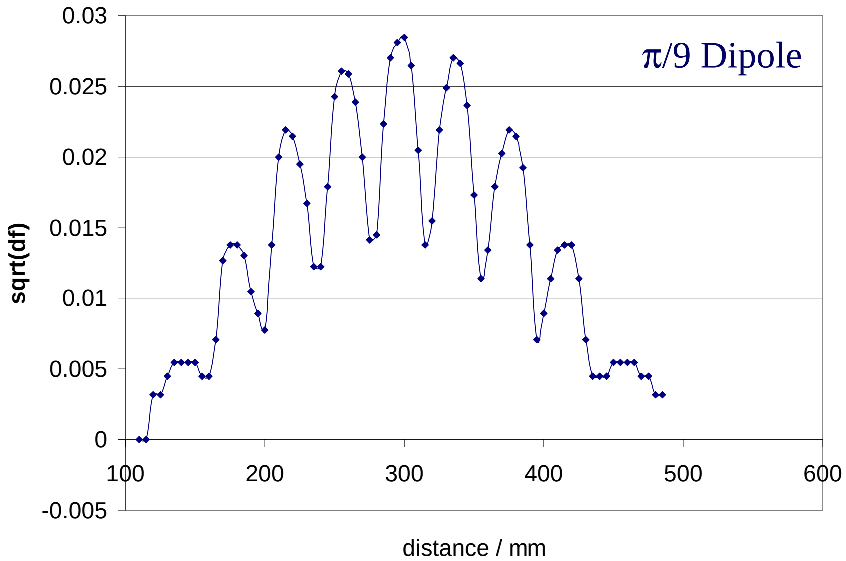


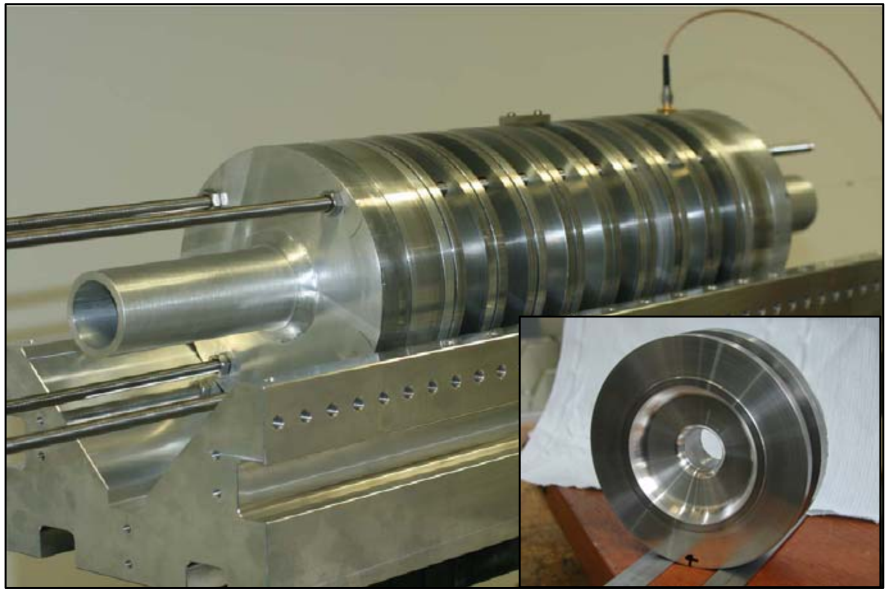
Zenghai Li (SLAC)



Test Model Cavity Verifications

- Model will be used to evaluate:
  - Mode frequencies
  - Cavity coupling
  - HOM, LOM and SOM Qe and R/Q

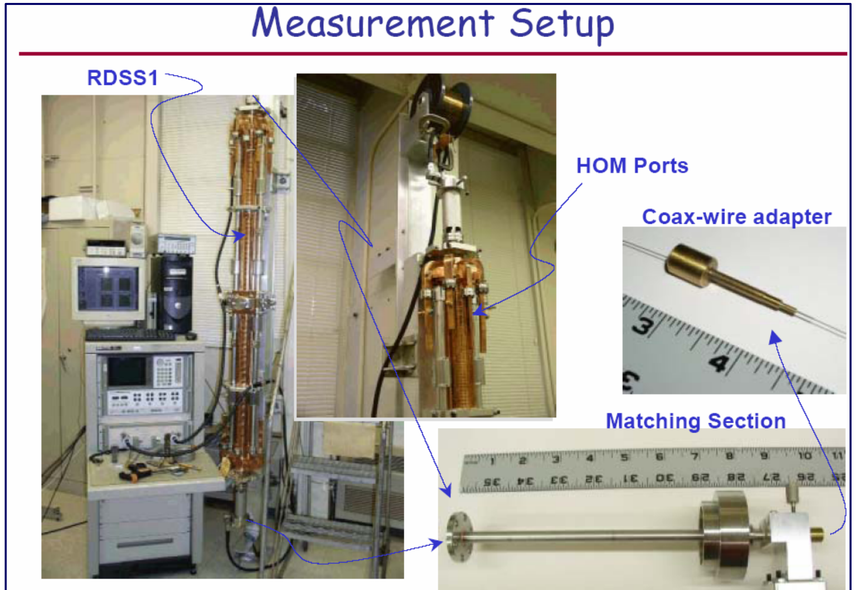




- Modular design allows evaluation of:
  - Up to 13 cells.
  - Including all mode couplers.

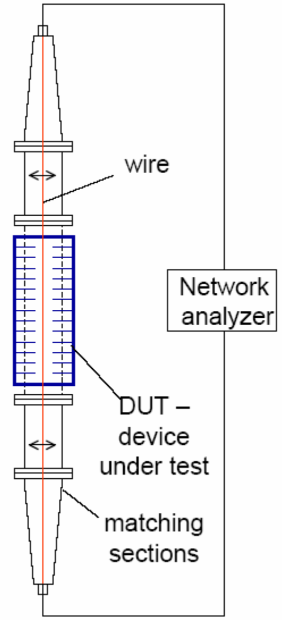
Wire Measurements Technique

- **Technique employed extensively on X-band structures at SLAC.**
- **Bench measurement provides characterisation of:**
  - **mode frequencies**
  - **kick factors**
  - **loss factors**



Measurement Setup

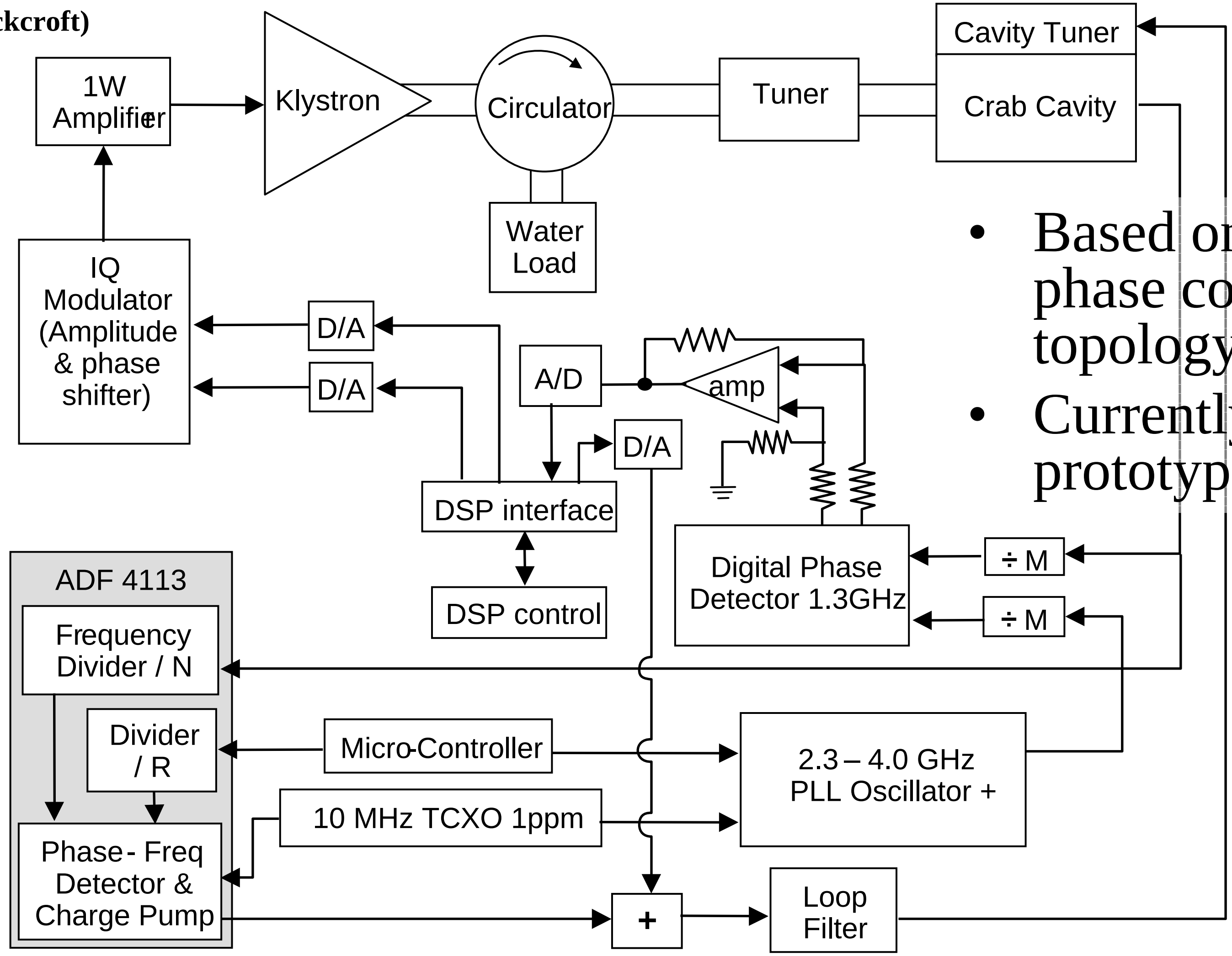
- Principle
  - based on similarity of field in presence of beam and of thin wire
- For dipole modes: 2 options
  - twin-ax
  - single off-axis wire
- Frequency domain method
  - setup for 11-18 GHz (first dipole band for NLC traveling-wave structures)
  - matching sections: S11 < -30dB for most freq.
  - possibility to move wire transversely
- Wire
  - 300μm diameter



Roger Jones (Cockcroft Institute)

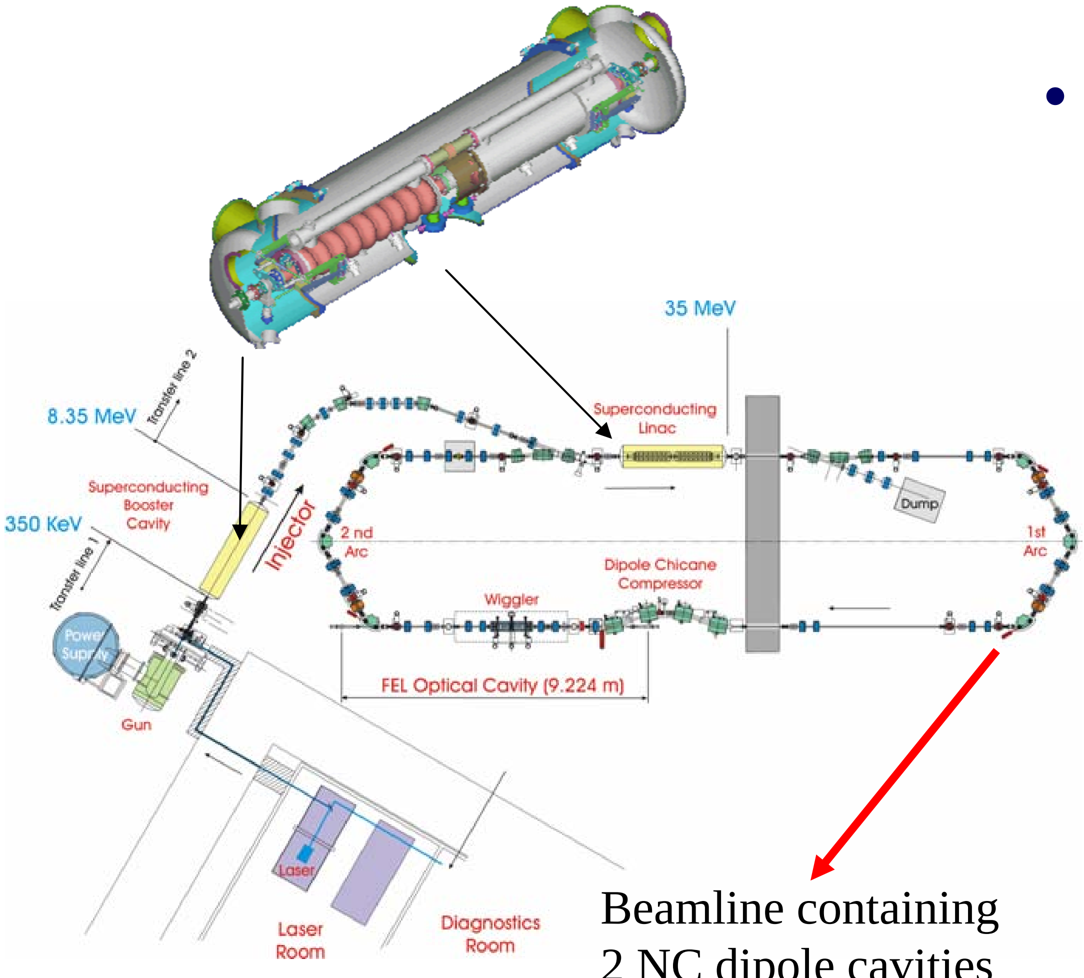
Phase Control Development

Imran Tahir (Cockcroft)



- Based on FLASH phase control topology
- Currently being prototyped

Phase Control Beam Tests



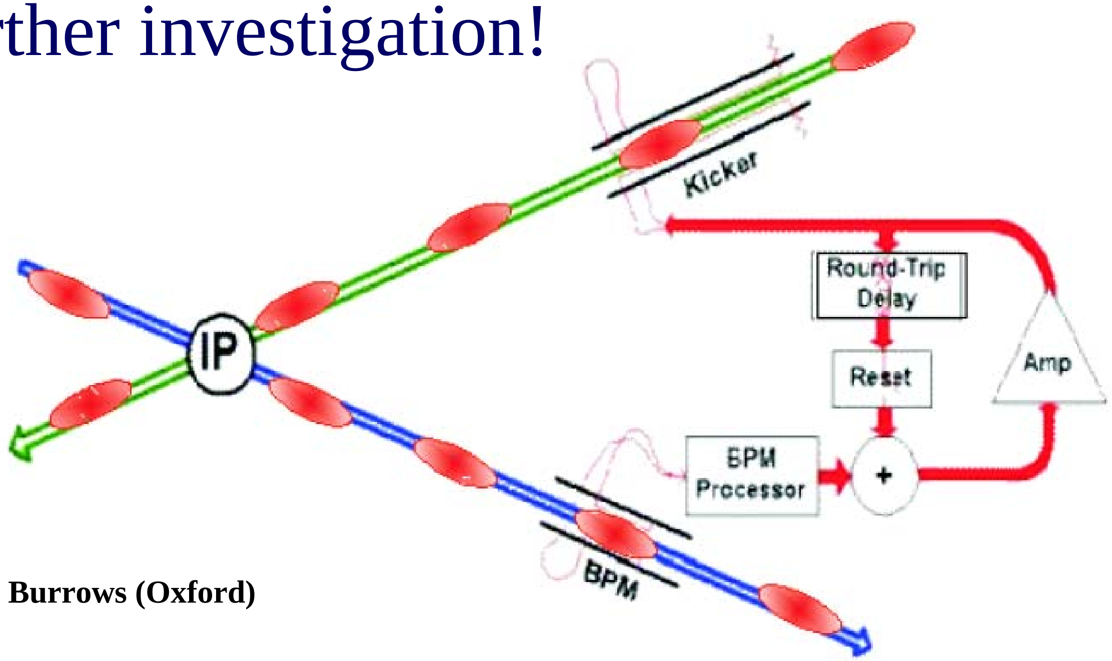
Beamline containing 2 NC dipole cavities plus diagnostics.

- In 2007, the ERLP at Daresbury will allow for crab cavity phase control electronics evaluation using:
  - 2 SRF accelerating cavities at 1.3 GHz.
  - 2 NC dipole cavities at 3.9 GHz.

Philippe Goudket , Alex Kalanin, Lili Ma (ASTeC)

Integration with FONT

- The use of Feedback On Nanosecond Timescale, could significantly reduce the phase stability requirements of the crab cavity.
- Needs further investigation!



Chris Adolphson (SLAC), Phil Burrows (Oxford)