Crab cavity tests at ATF2?

for discussion

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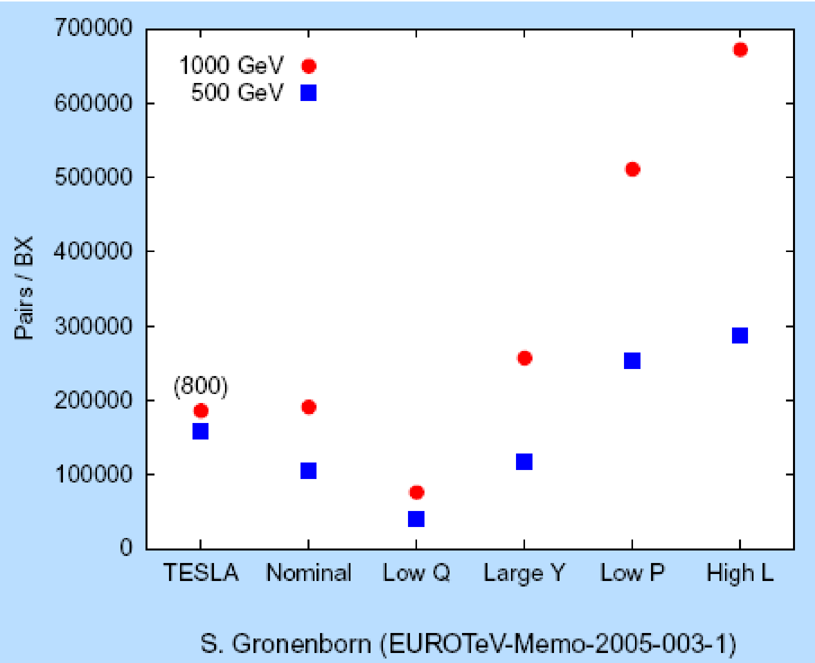
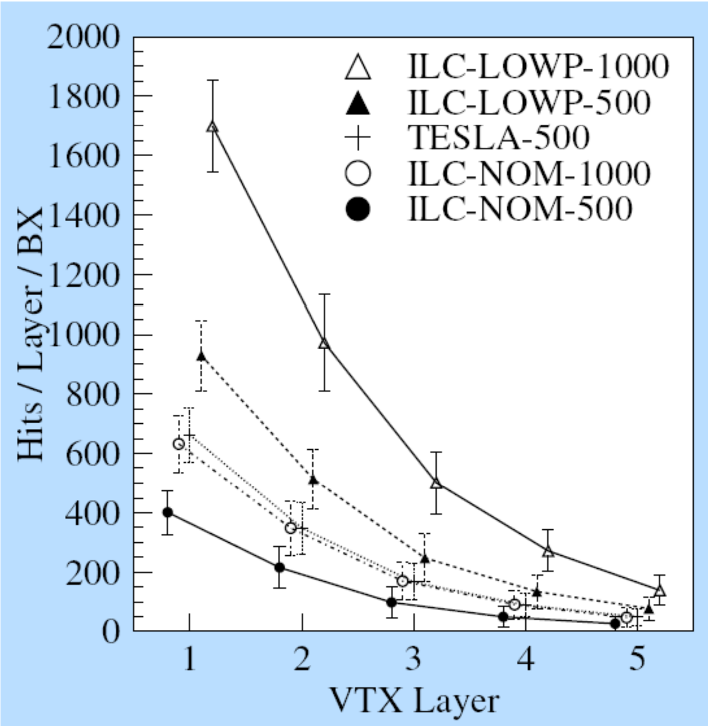
7th ATF2 Project meeting

December 15-18, 2008

Low Power parameter set

- The “low power” option may be a **machine** “cost saving” set
- The RDR “Low P” is not a favorite set for detectors:

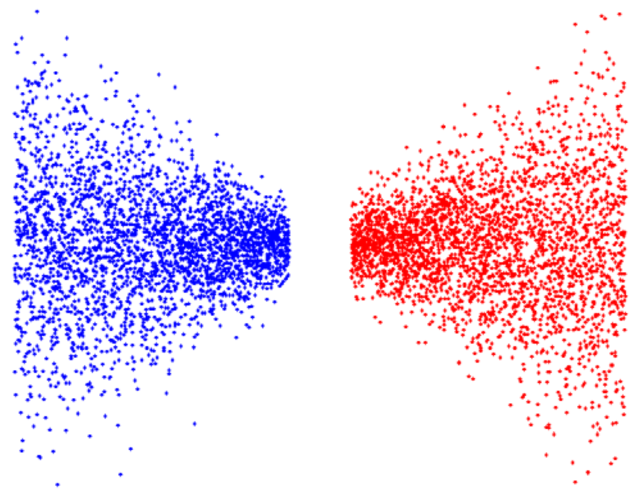


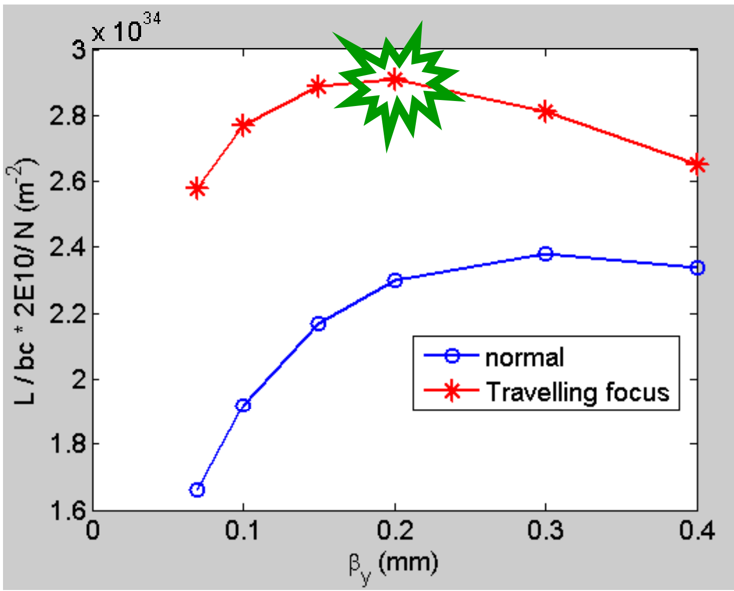


- Improved version of Low Power may require tighter IP focusing, and use of “travelling focus” [V.Balakin, 1990]

New low P parameters

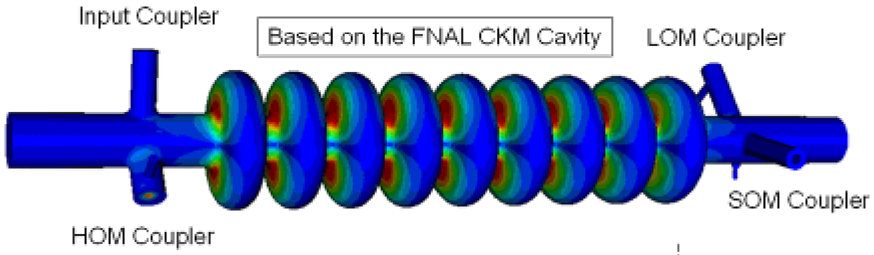
	Nom. RDR	Low P RDR	new Low P
E CM (GeV)	500	500	500
N	2.0E+10	2.0E+10	2.0E+10
n_b	2625	1320	1320
F (Hz)	5	5	5
P_b (MW)	**10.5**	**5.3**	**5.3**
$\gamma\varepsilon_X$ (m)	1.0E-05	1.0E-05	1.0E-05
$\gamma\varepsilon_Y$ (m)	4.0E-08	3.6E-08	3.6E-08
βx (m)	2.0E-02	1.1E-02	1.1E-02
βy (m)	4.0E-04	2.0E-04	2.0E-04
Travelling focus	No	No	**Yes**
Z-distribution *	Gauss	Gauss	Gauss
σ_x (m)	6.39E-07	4.74E-07	4.74E-07
σ_y (m)	5.7E-09	3.8E-09	3.8E-09
σ_z (m)	3.0E-04	2.0E-04	**3.0E-04**
Guinea-Pig $\delta E/E$	**0.023**	**0.045**	**0.036**
Guinea-Pig L ($cm^{-2}s^{-1}$)	**2.02E+34**	**1.86E+34**	**1.92E+34**
Guinea-Pig Lumi in 1%	1.50E+34	1.09E+34	1.18E+34



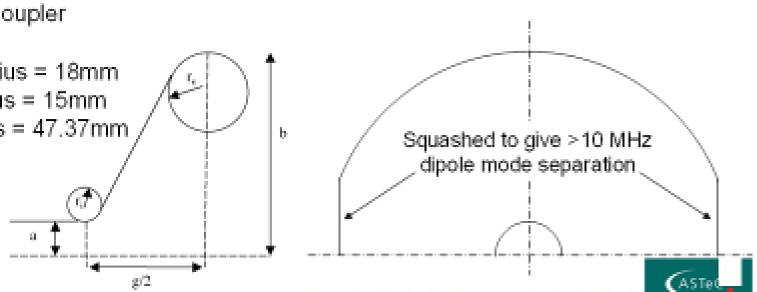


P.McIntosh, A.Seryi, December 15-18, 2008

ILC-CC Design

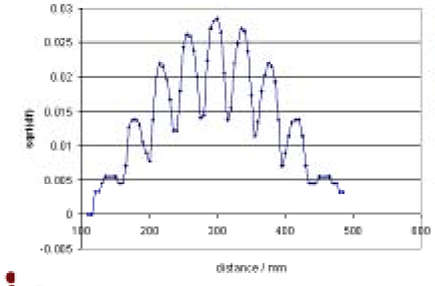


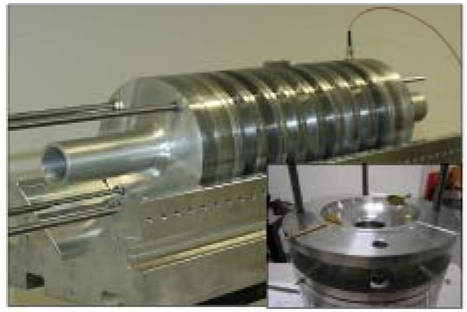
Beam-pipe radius = 18mm
Cavity iris radius = 15mm
Equator Radius = 47.37mm



Structure Characterisation

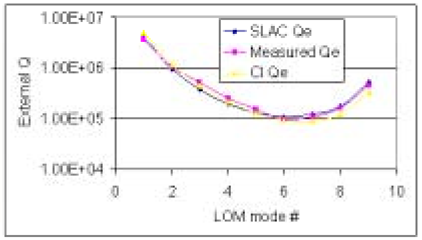
- Model fabricated at DL and used to evaluate:
  - **Mode frequencies**
  - **Cavity coupling**
  - **HOM, LOM and SOM Qe and R/Q**

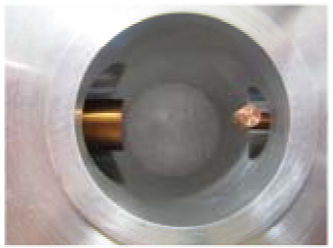




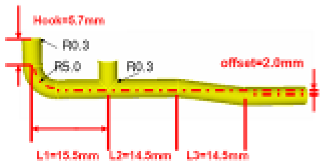
- Modular design allows evaluation of:
  - **Up to 13 cells.**
  - **Including all mode couplers.**

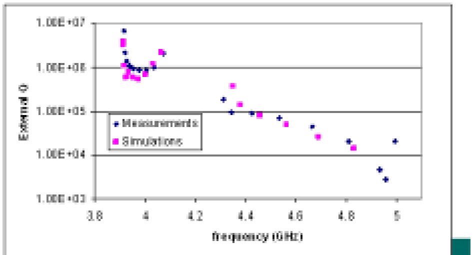
Prototype LOM Qe Measurements





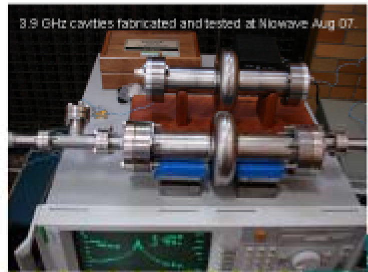
The LOM coupler was found to give good agreement with both MWS and Omega3P simulations.



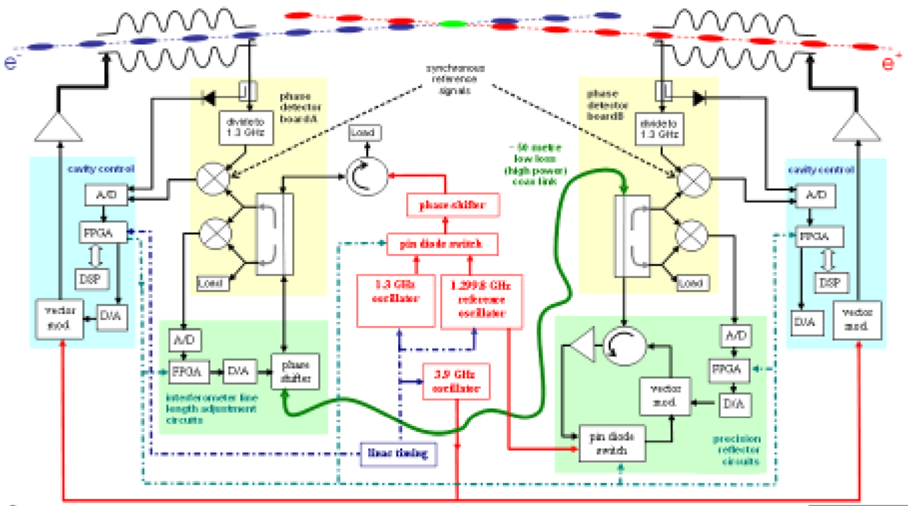


ILC-CC System Verification

- The phase of the field in each cavity is sampled, compared to the timing reference and the error sent to a digital signal processor (DSP) to determine how the input signal must be varied to eliminate the error.
- Provide an RF interferometer between each crab cavity so that the same cavity clock signal is available at both systems.
- 16-bit DAC/ADC architecture (high resolution)



LLRF/Synchronisation Scheme (Final)



RF Interferometer Controls

Precision reflector

Interferometer termination

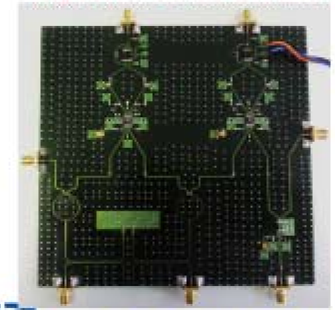
Aluminium cavity

15m medium loss cable

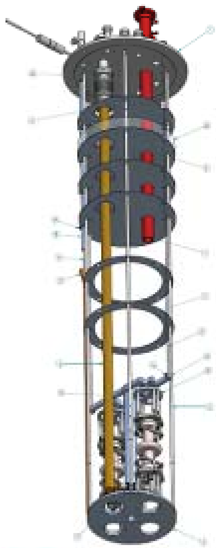
Manual phase shifter

3.9 GHz source

Integrated interferometer termination



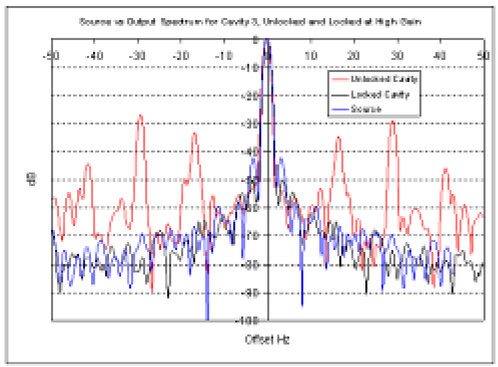
ILC-CC Testing Hardware



Cavities limited in gradient to 1 MV/m (~40kV/cell) – shielding implications.

Preliminary Measurement Results

- Independent phase lock achieved for both cavities:
  - **Unlocked ⇒ 10° r.m.s.**
  - **Locked ⇒ 0.135° r.m.s.**
- Performance limited by:
  - **Source noise (dominant)**
  - **ADC noise**
  - **Measurement noise**
  - **Cavity frequency drift**
  - **Microphonics**
- Improvements being made.
- Next tests scheduled for December 08.



Creating travelling focus, 2 ways

- Small (~%) uncompensated chromaticity and E-z correlation
  - Need σ_z=k L* δ_E
    - where k is relative amount of uncompensated chromaticity
    - and δ_E is 2-3 times > incoherent spread in the bunch
  - E.g. δ_E = 0.3%, k=1.5%, L^*_{eff}=6m for 0.3mm bunch
- Transverse deflecting cavity giving z-x correlation in one of FF sextupoles
  - That gives z-correlated focusing
- Can we test one or both these methods at ATF2?

Crab-cavity induced trav.foc at ATF2

- Can existing single cell cavity be dressed in a cryostat and tested at ATF2 to create x-z correlated offset, via sextupoles, to check shift of the focus?
- Estimation of kicks and focus shift:
  - two 9 cell cavities for ILC at 500GeV/beam, for the particle at $z=\sigma_z$ give kick equal to $x'=\theta_c * \sigma_z / (2*R_{12})$ ~ 1E-7 rad
  - Then for 1.3GeV/beam, single cell, for particle at z, the kick = z[mm]* 1e-5 rad
  - For ATF2, if only SDO considered and R_{12}=10m, then shift of focus Δz_{foc}[mm] ~ 0.3*z[mm] -- to be verified

Comments on existing cells

- Peter's comments:
  - Single cell structures we have made, do not have end groups on them
    - no mechanism for mode damping or input coupler
    - for the beam tests we would either have to fabricate end groups and add them to our existing single cell cavities or otherwise build a new structure
  - costs should not be significant to come up with a simple cryostat and cavity tuner design, which could be Dewar fed at 4K
  - we do have a 600W amplifier which could be used for such tests, providing the input Qe is appropriately set
  - all coupler designs are complete and so these would need engineering for fabrication
  - if it's only a single cavity test, then that removes the interferometer synchronizer which also simplifies the LLRF control needed