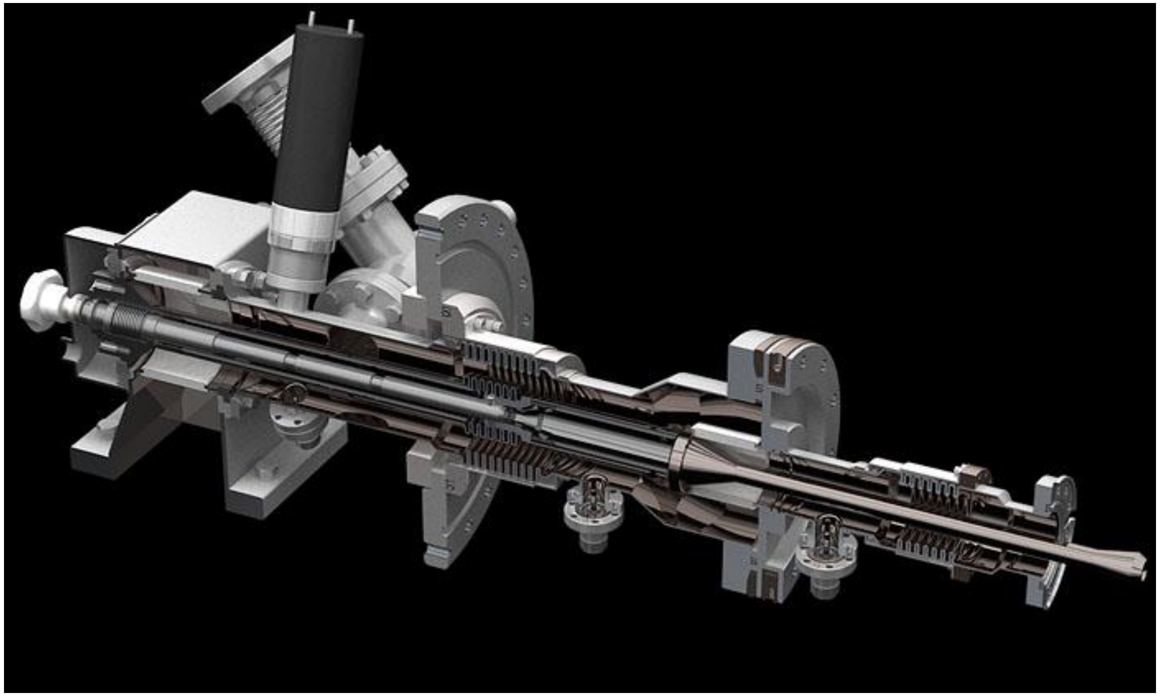
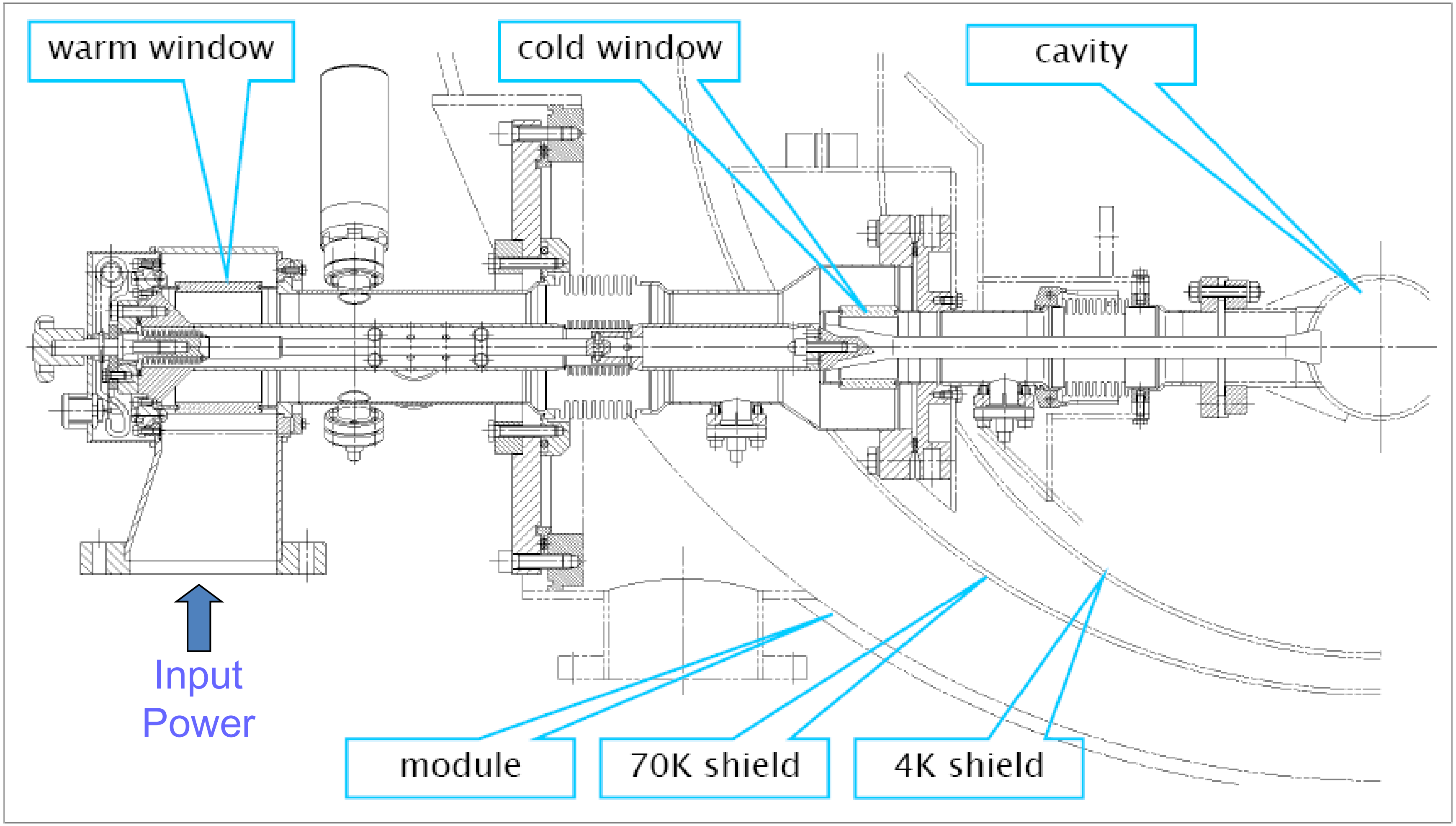
ILC Coupler Power and QL Requirements and Limits

Power Couples vs Power Couplers: One ‘r’ Makes A Lot of Difference

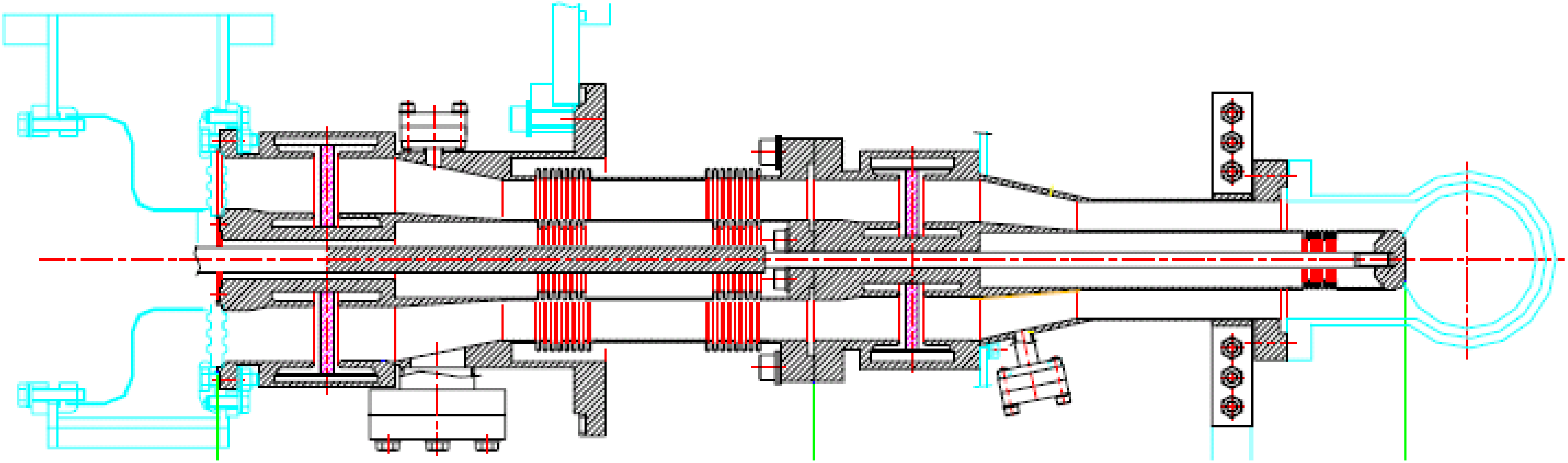


Chris Adolphsen, LCWS13, Tokyo, 11/12/13

TTF3 Power Coupler Design

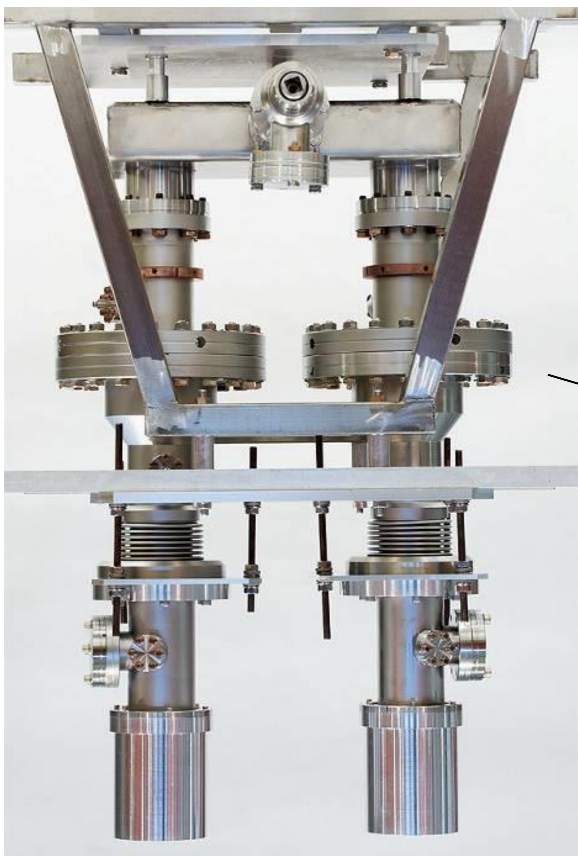


STF-2 Coupler Design



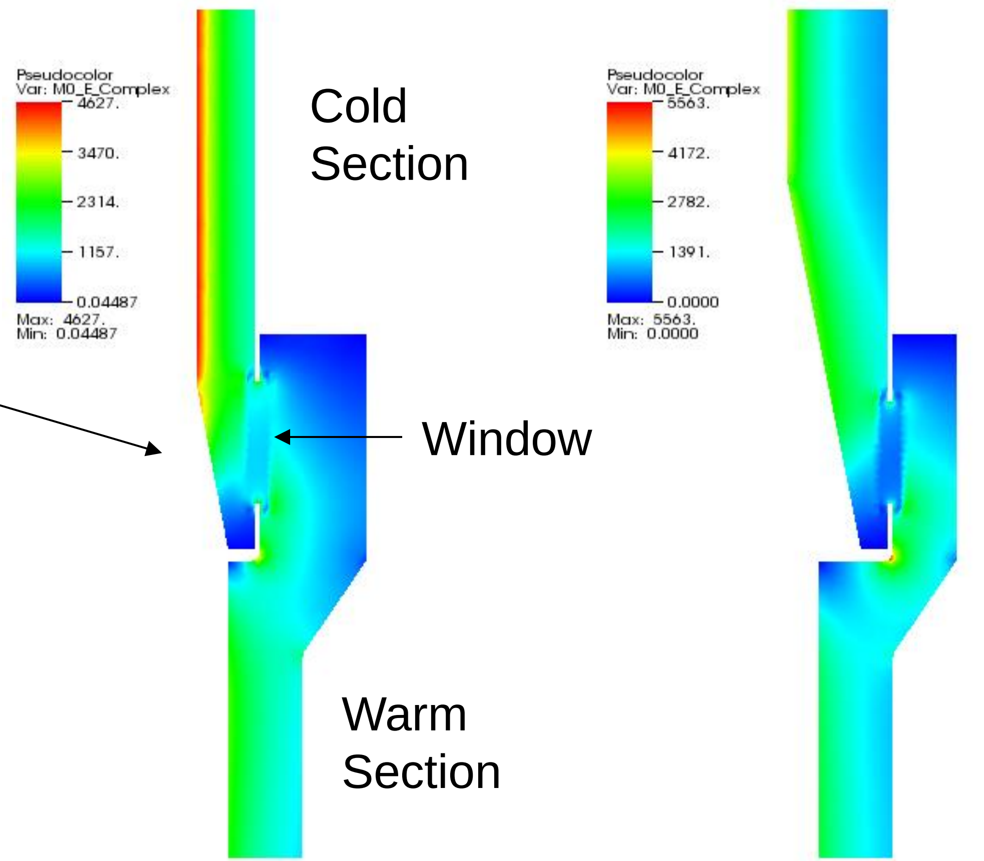
~ 5 Years Ago, Designed a 60 mm Diameter Plug Compatible Coupler Cold Section

Like Orsay's TTF5 60 mm coupler shown on left, but warm section unchanged

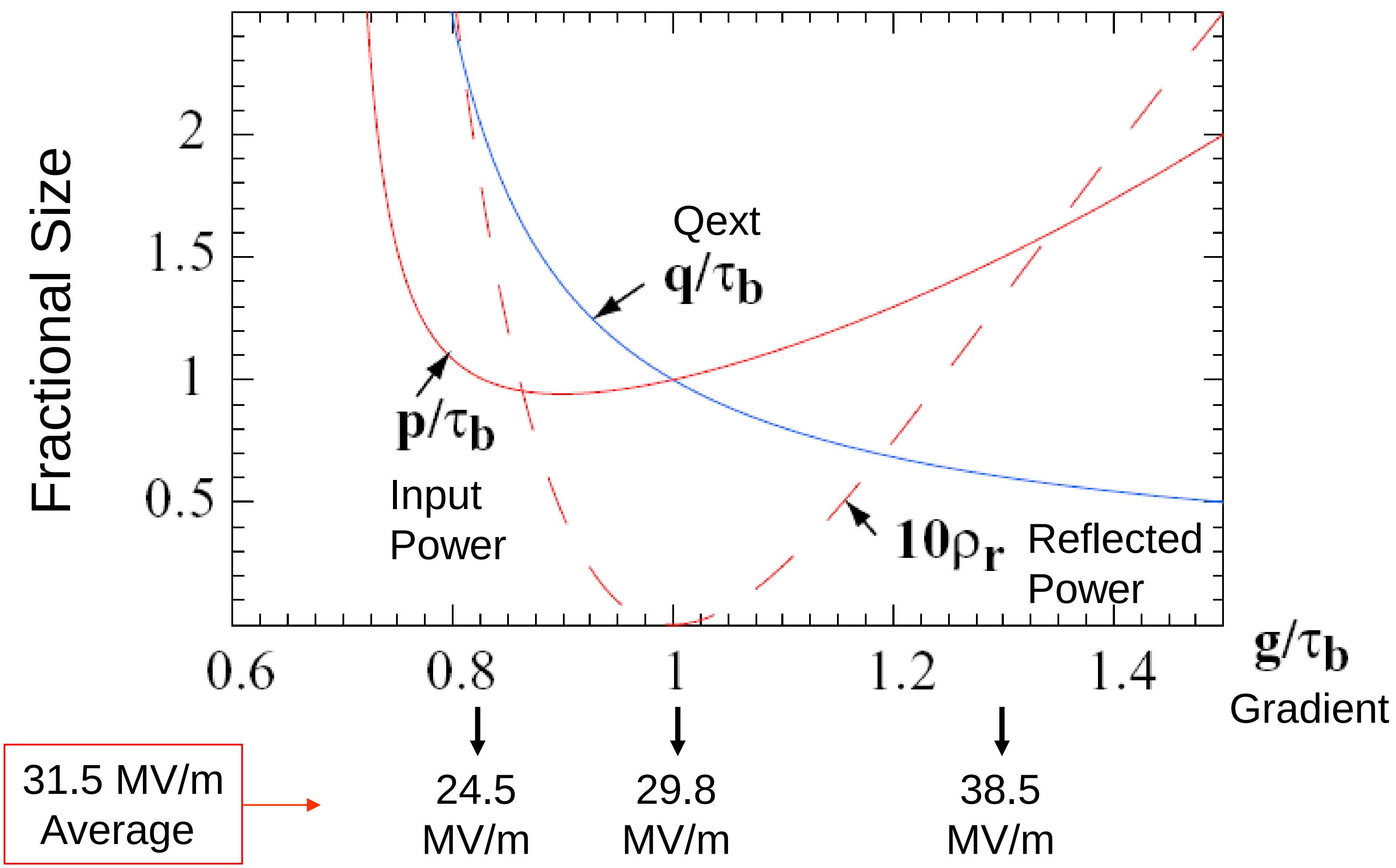


TTF3 40 mm

60 mm Design

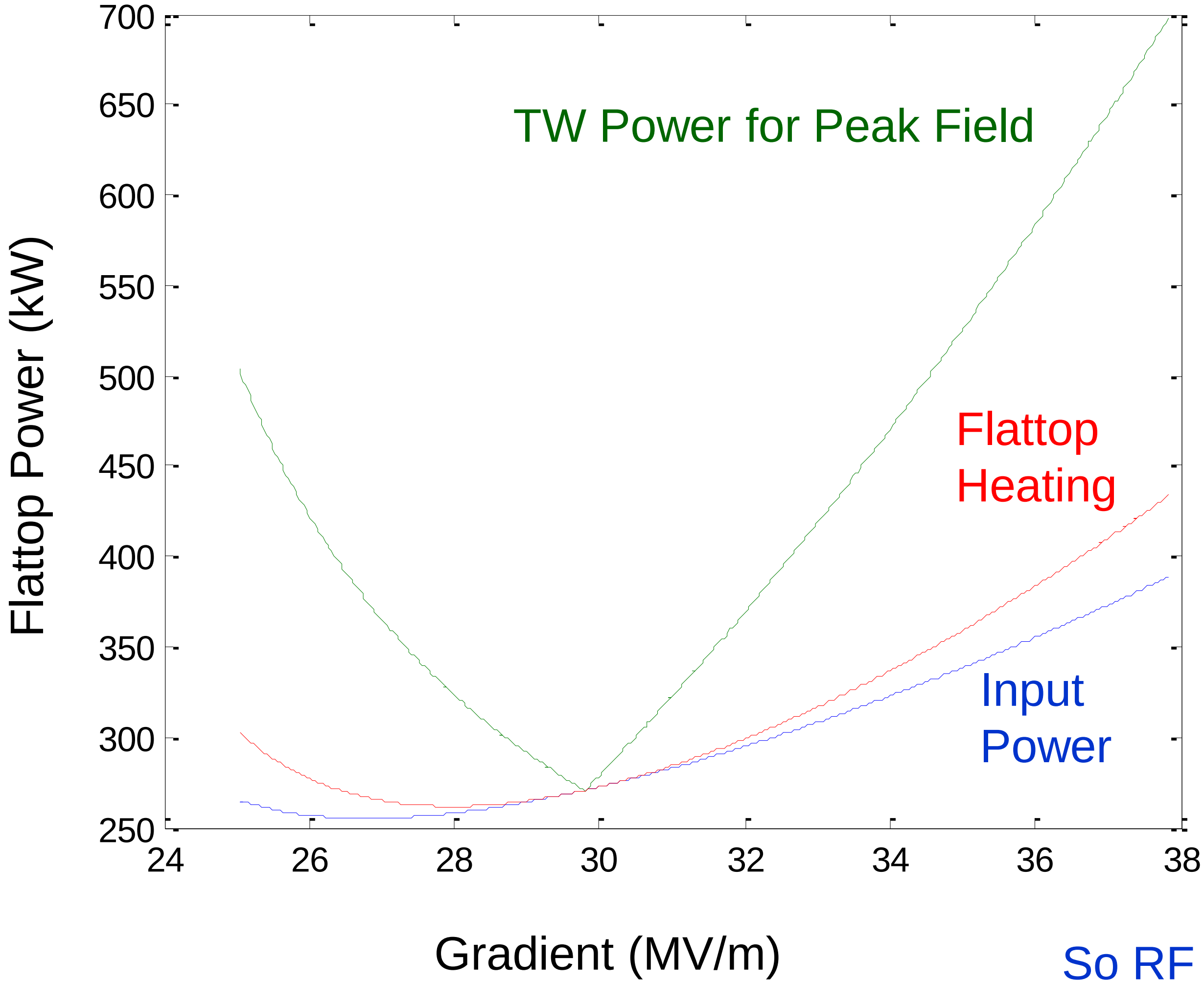


Flattop Operation with a Spread of Cavity Gradients



31.5 MV/m
Average

Coupler Power



Worse Case:

Ave Grad = 31.5 MV/m

Upgrade Current = 8.75 mA

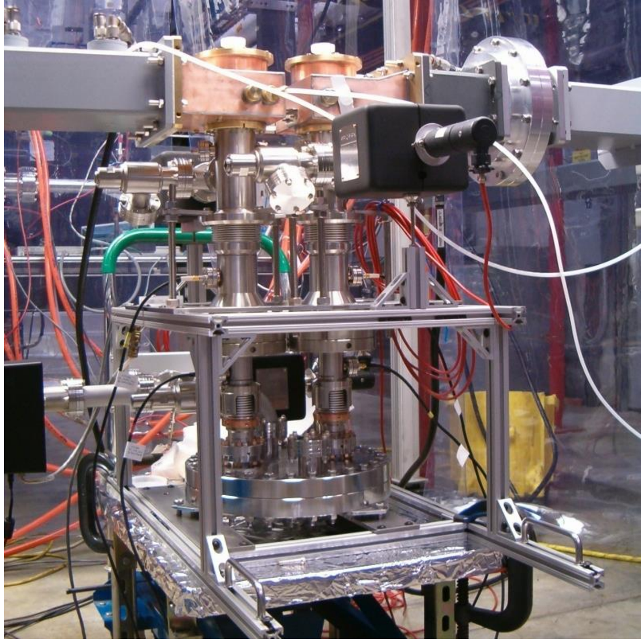
Matched Grad = 29.8 MV/m

Matched QL = 3.4e6

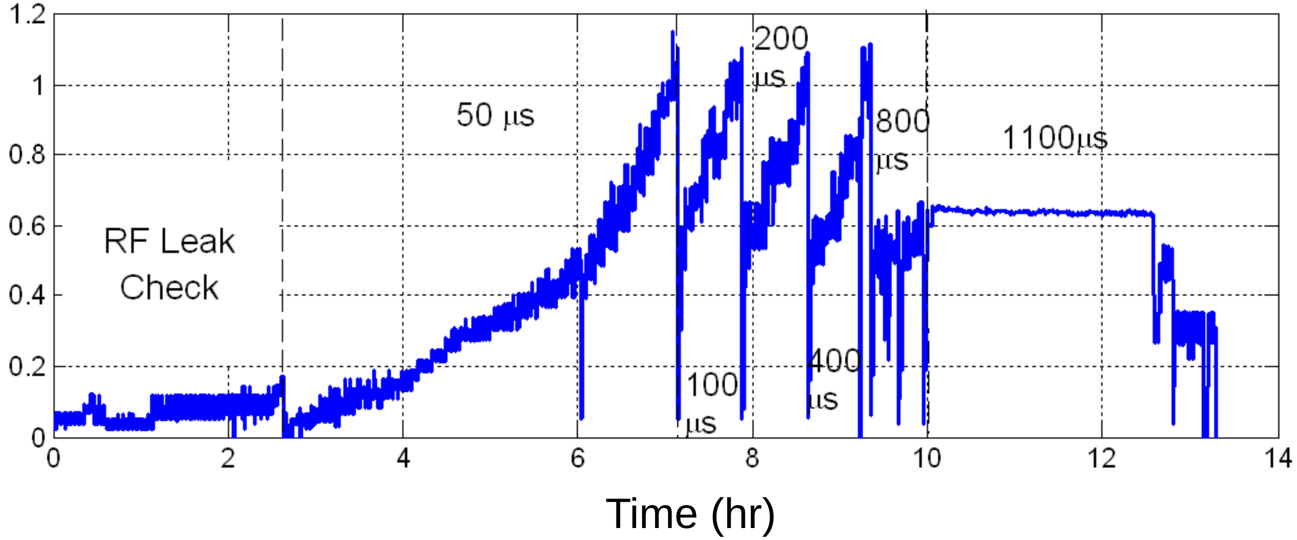
Matched Power = 271 kW

So RF Process to at Least Four Times Max Input Power ~ 1.6 MW

RF Processing of Coupler Pairs at SLAC

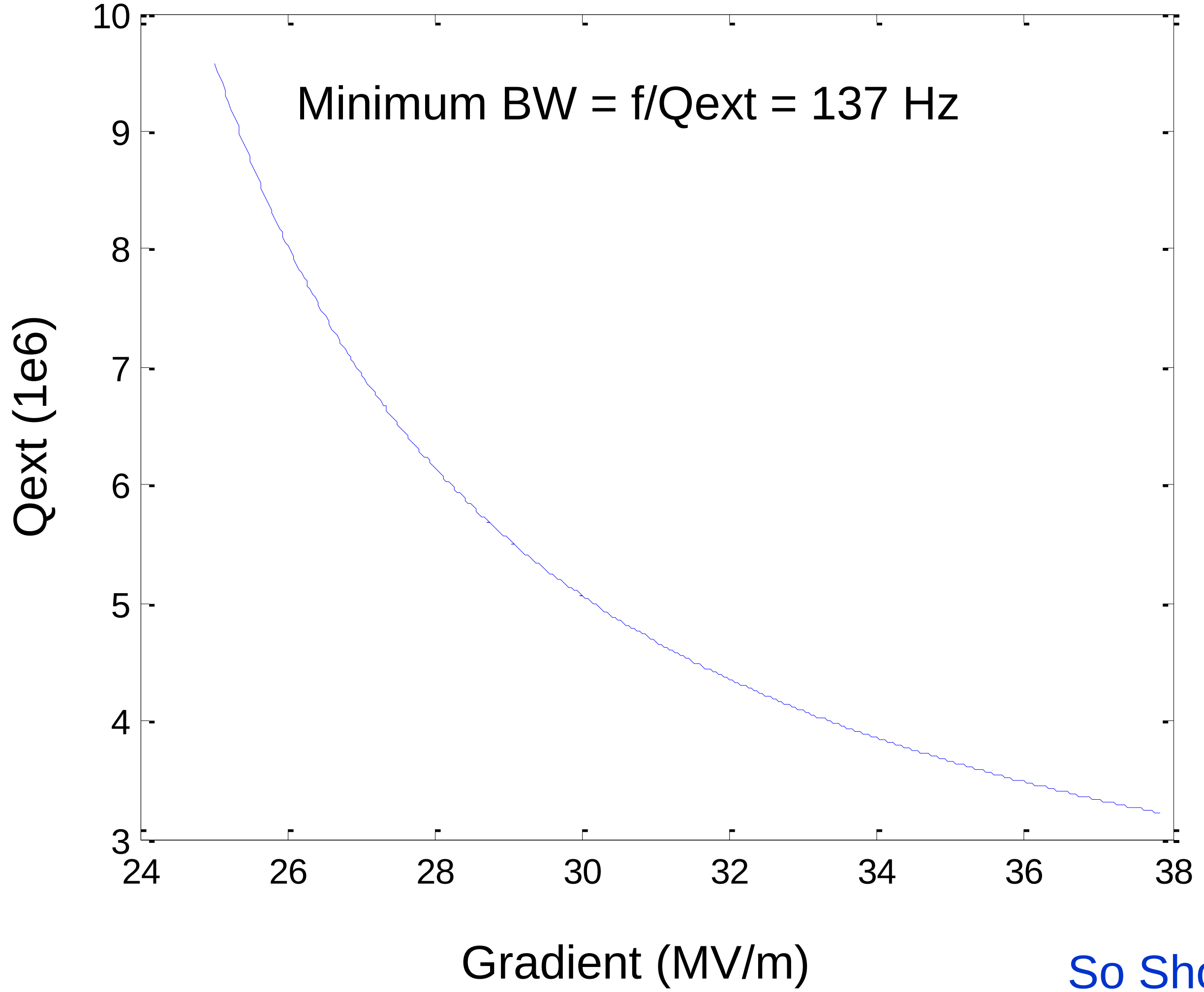


Power (MW) -vs- Time for Pulse Widths of 50,100, 200, 400, 800, 1100 μs



Jeff Tice, Faya Wang

Coupler Qext



Worse Case:

Ave Grad = 31.5 MV/m

Baseline Current = 5.8 mA

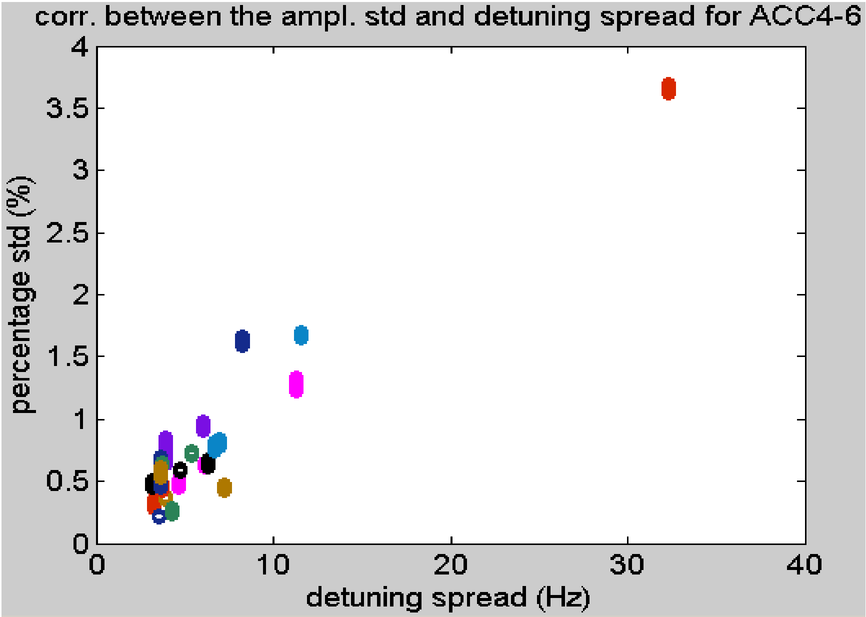
Matched Grad = 29.8 MV/m

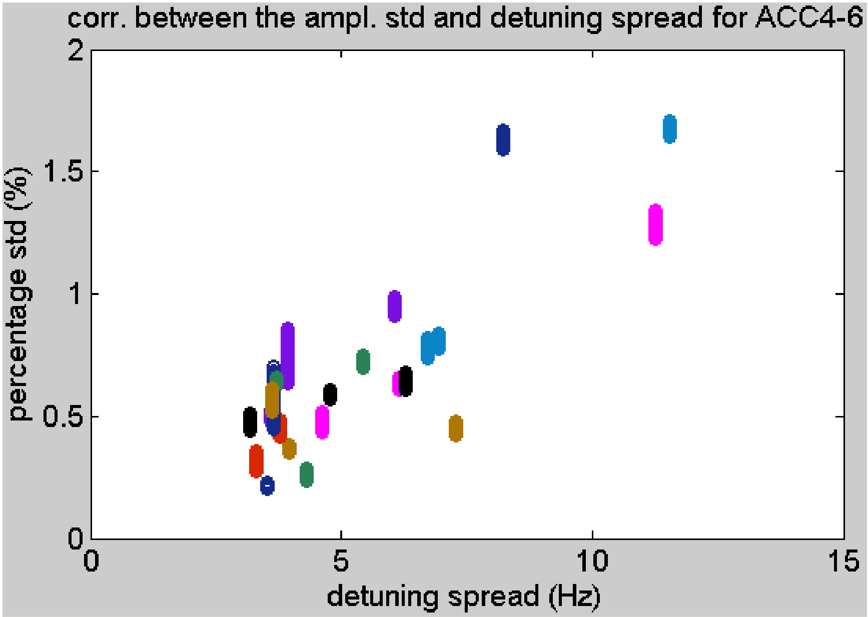
Matched QL = 5.1e6

Matched Power = 271 kW

So Should Check Flattop Regulation
At 25 MV/m and Qext ~ 1e7

FLASH Microphonics: RMS Gradient Jitter Amplitude -vs- RMS Detuning for the 24 Cavities in ACC 4-6 when Run Off Tune





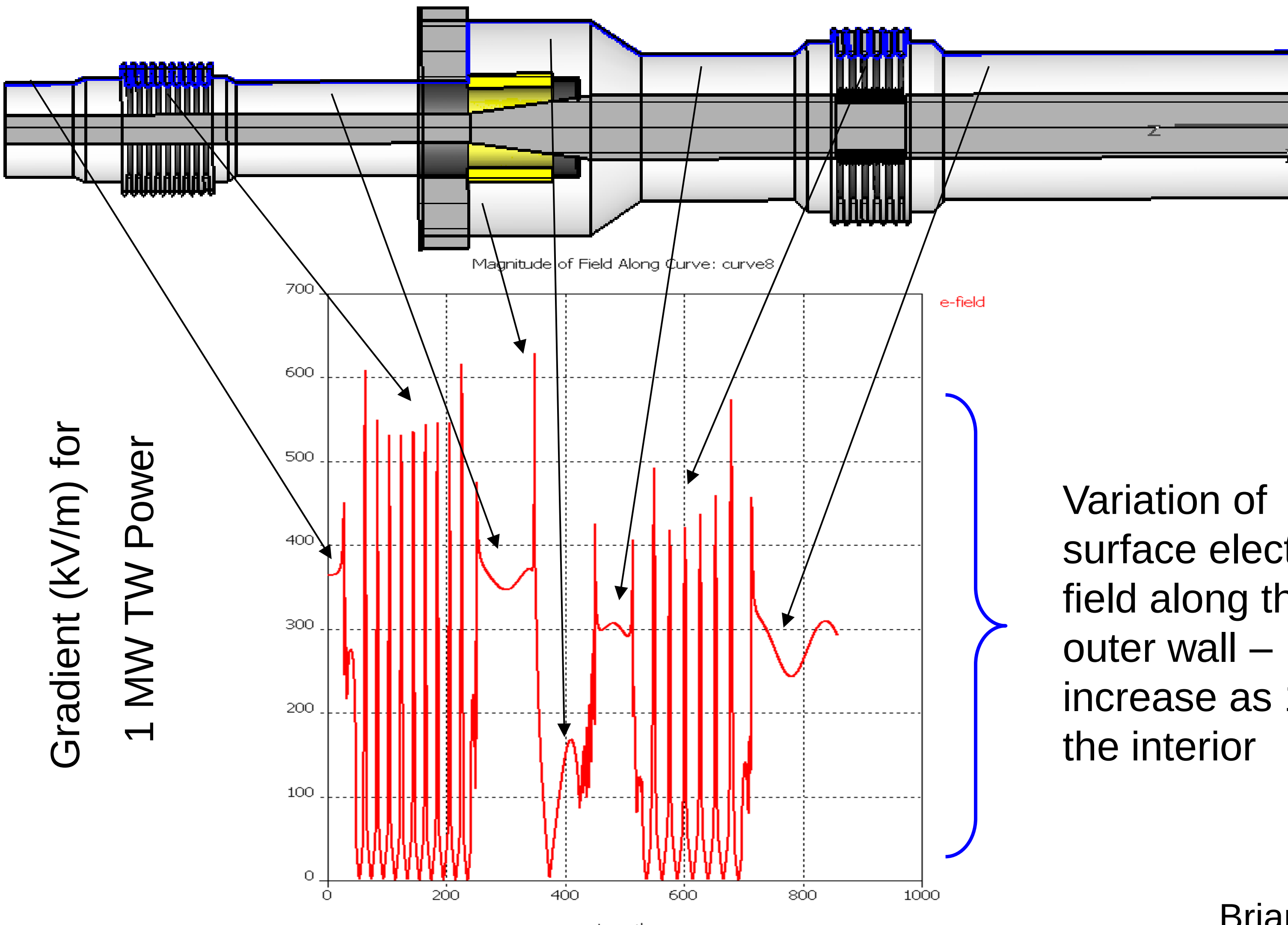
Lorentz Force Detuning vs BW w/o Gradient Spread

- Stronger Lorentz Force Detuning (LFD) to Cavity Bandwidth (BW) Ratio: For TESLA cavities:

Gradient (MV/m)	Current (mA)	Qext (10^6)	BW (Hz)	LFD (Hz)	LFD/BW
31.5	9.0	3.5	370	990	2.7
31.5	4.5	7.0	185	990	5.4
40	4.5	8.9	146	1600	11
50	4.5	11.1	117	2500	21

  - BW > 1e7 required for CW electron and proton linacs, but LFD is constant after slow ramp-up
  - Could stiffen cavity but constrained by thermal runaway if make the walls thicker

Peak Coupler Surface Fields

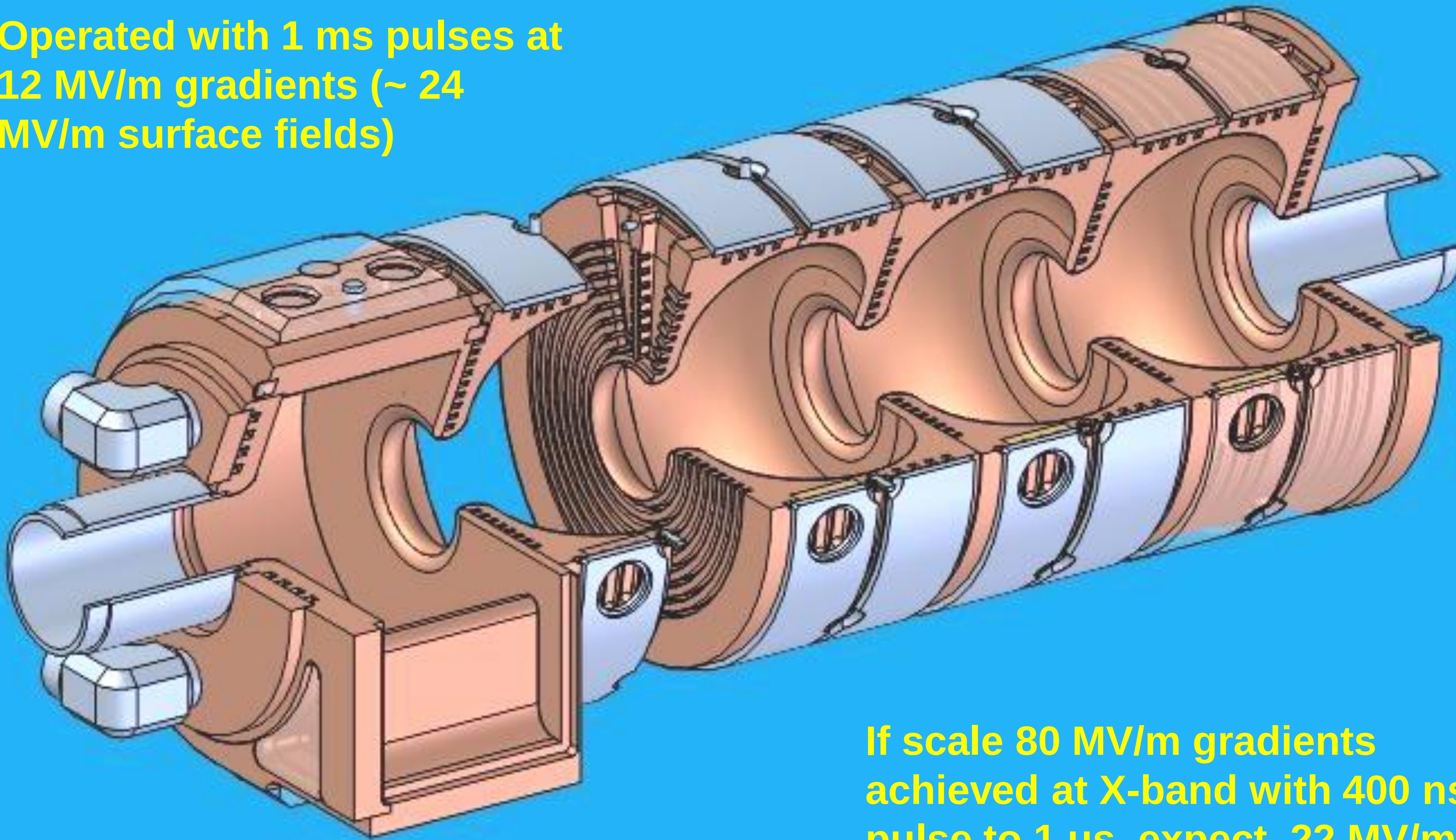


Variation of surface electric field along the outer wall – increase as 1/r in the interior

Brian Rusnak

Surface Field Limits: ILC Capture Cavity

Operated with 1 ms pulses at 12 MV/m gradients (~ 24 MV/m surface fields)



If scale 80 MV/m gradients achieved at X-band with 400 ns pulse to 1 us, expect 22 MV/m

Pill Box Window Fields

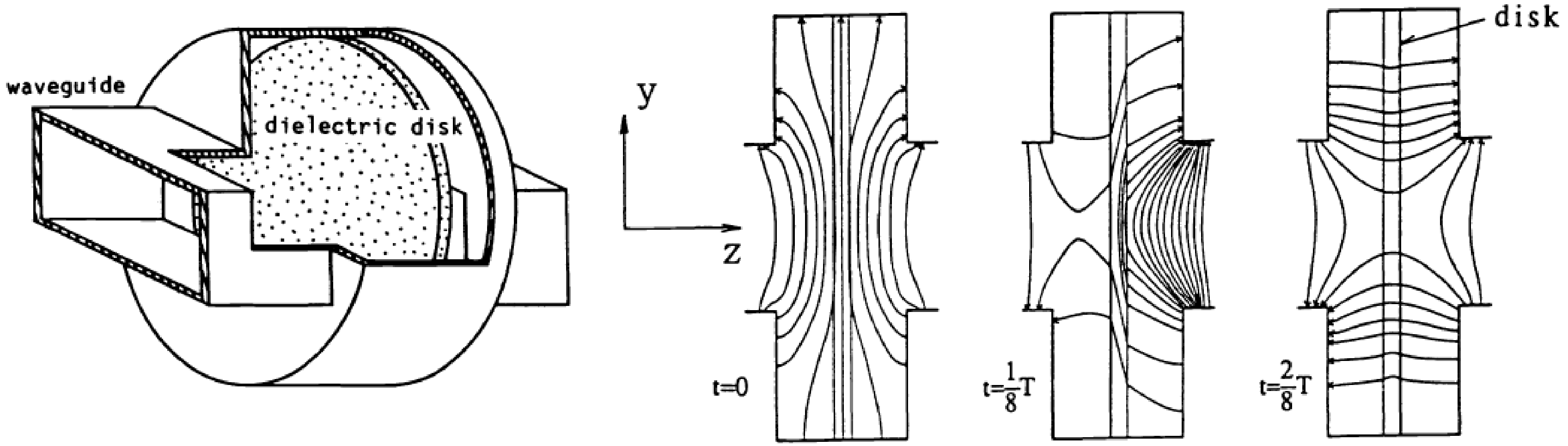
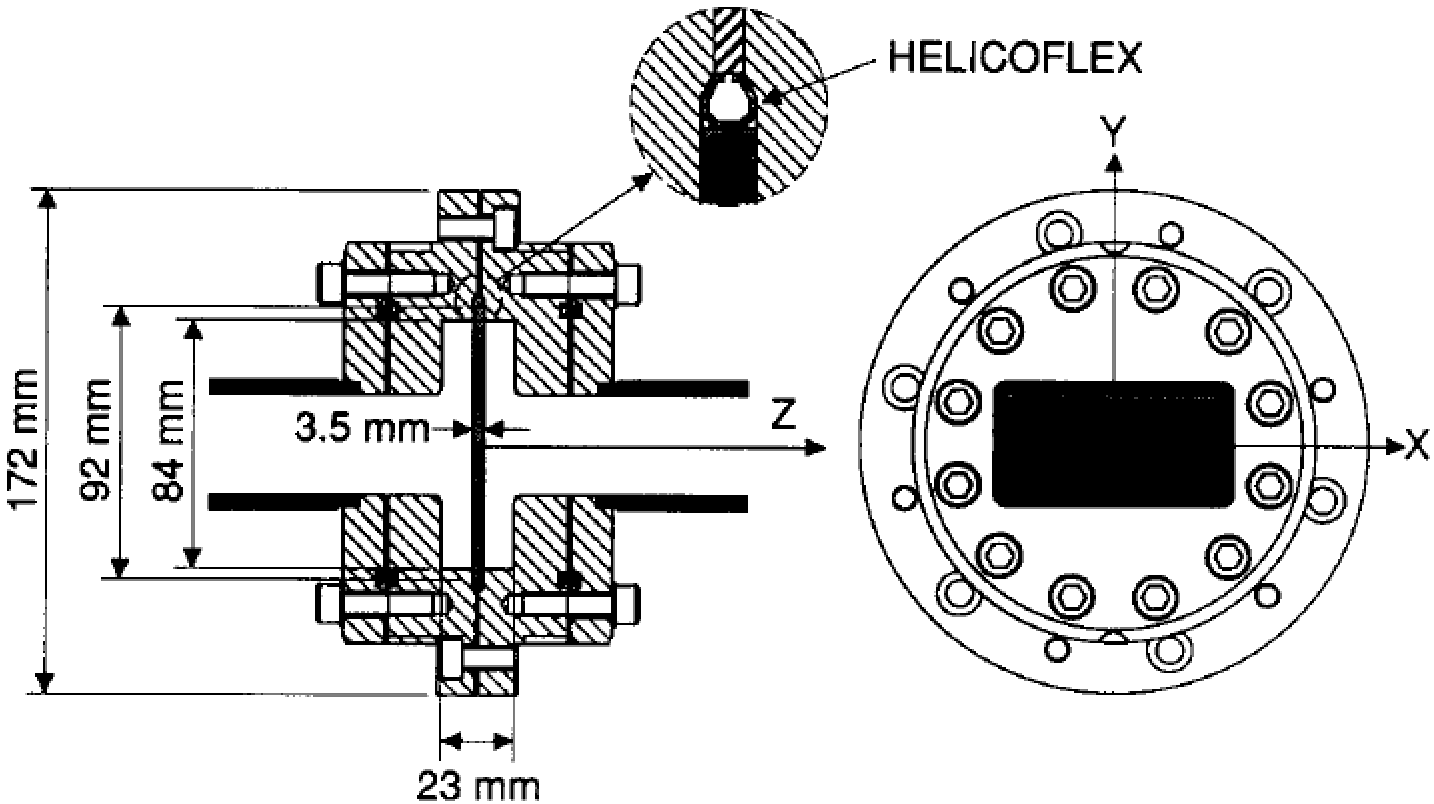


Fig.1. Schematic of pill-box type rf window, and electric force lines in the window (on the plane x=0) at each 1/8 cycle.

K Saito, Surface breakdown phenomena in alumina rf windows

S-band Pill Box Window
2.5 us Resonate Ring Tests



No Multipacting above 0.45 MV/m – some windows survived up to 1.1 MV/m (300 MW)

H. Matsumoto, Development of an S-band rf window for linear colliders, A334 (1993) 341-352

Planar and Pill Box Windows
S-band 2 us Resonate Ring Tests

3 MV/m

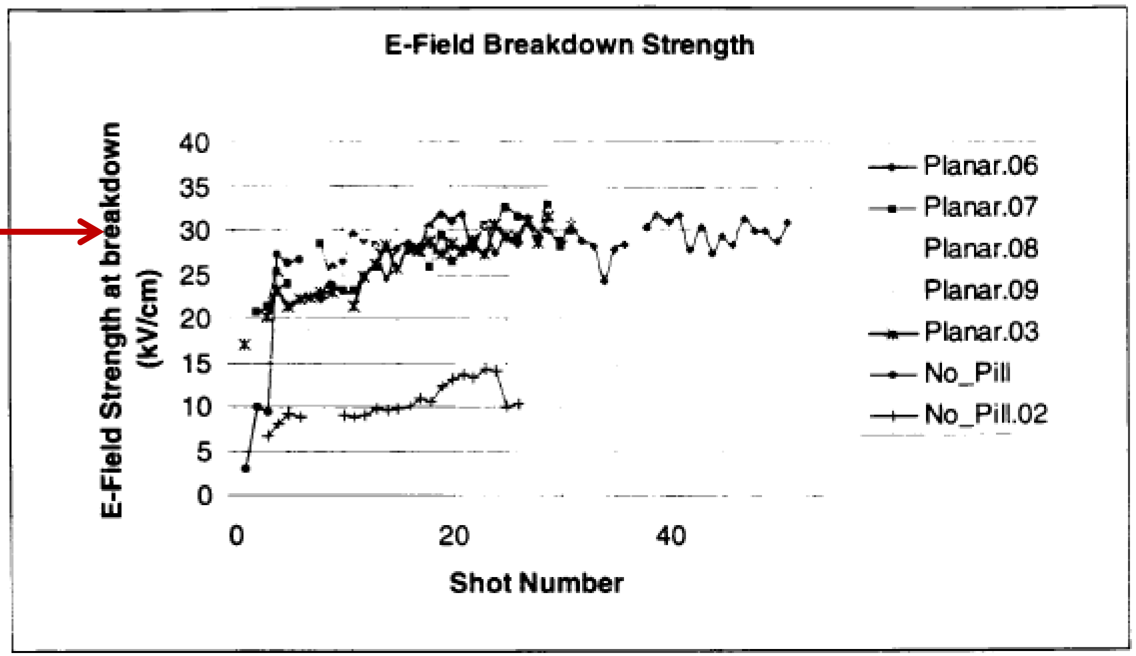


Figure 4.6 Electric Field Breakdown Strength for Different Samples

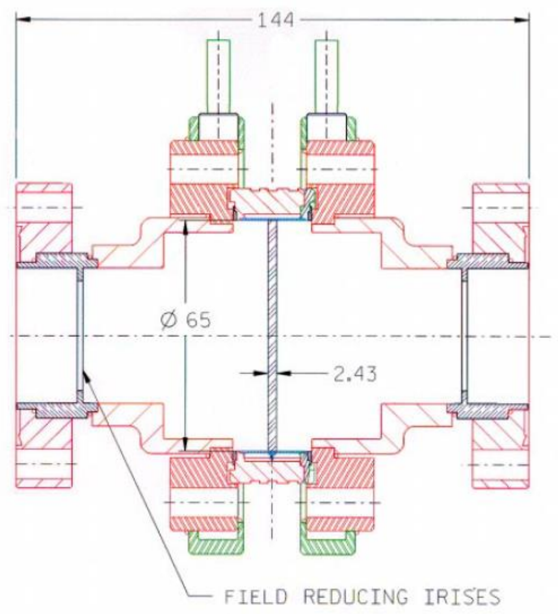
The graph shows the electric field strength at breakdown for each shot in which a true breakdown occurred for different samples.

1998 MS Thesis: DAVID HEMMERT, WINDOW AND CAVITY BREAKDOWN CAUSED BY HIGH POWER MICROWAVES

TE01 Reduced Field XL4 Window X-band, 1.5 us, 50 MW

XL4 Window operates at 3.8 MV/m for 50 MW Output Power

If use -1/6 breakdown scaling, expect one can operate at 1.2 MV/m at 1.6 ms



So from an RF breakdown limit, might expect TTF3 Coupler to work up to ~ 4 MW in TW mode for 1.6 ms pulses

W. R. Fowkes, **LARGE DIAMETER REDUCED FIELD TE01 TRAVELING WAVE WINDOW FOR X-BAND**