∫ Main Linac

Chris Adolphsen

KOM/GDE Topics

- RDR Lessons
- What we will (or will not) learn by 2011 from
  - ILC facilities
  - XFEL
- ACD Down-Select Criteria and Time Scales
- Beam Related Issues
- Integration Issues
- Cost and Design Optimization
- Work Packages

Nick Walker: Recurring Critical Themes

- Interfaces and requirements for CFS were badly specified during the RDR phase
  - Communication was poor
  - Accelerator Designers (physicists) were not clear how the technical / global groups wanted their information presented
  - Technical / Global groups received information from Accelerator Designers in rather ad hoc fashion
  - NO POSSIBILITY/TIME for design iteration or cross-checking (closing the loop)

- RDR baseline is poorly documented!
  - The RDR is thin (by design!) and rather conceptual
    - There is much more detailed information out there!
  - A critical item to resolve early in the EDR phase

- (“Draconian”) Cost Disclosure Policy often quoted as a “hindrance”
  - Some truth in this, but to often used as an excuse (my opinion)
  - Better access to RDR “Budget book” will be supplied
    - Updated CDP

Sergei Nagaitsev: What we will NOT learn from the ILC SRF Facilities by 2011

- It is likely that by end of 2010 neither facility [NML or STF] will have an rf unit with Type 4 CM's
- NML will not operate at 5 Hz rep rate.
- We (NML or STF) may have at least one CM operating at 31.5 MV/m
  - Need to verify gradient with beam – proof of ILC CM existence!
- Neither lab will have a separate CM test stand
  - Thus no rapid CM tests with pulsed rf power
- NML and STF will not validate system optimization for the best "value engineering", such as
  - Beam dynamics and quadrupoles system design
  - Cryomodule design with cryogenics system design

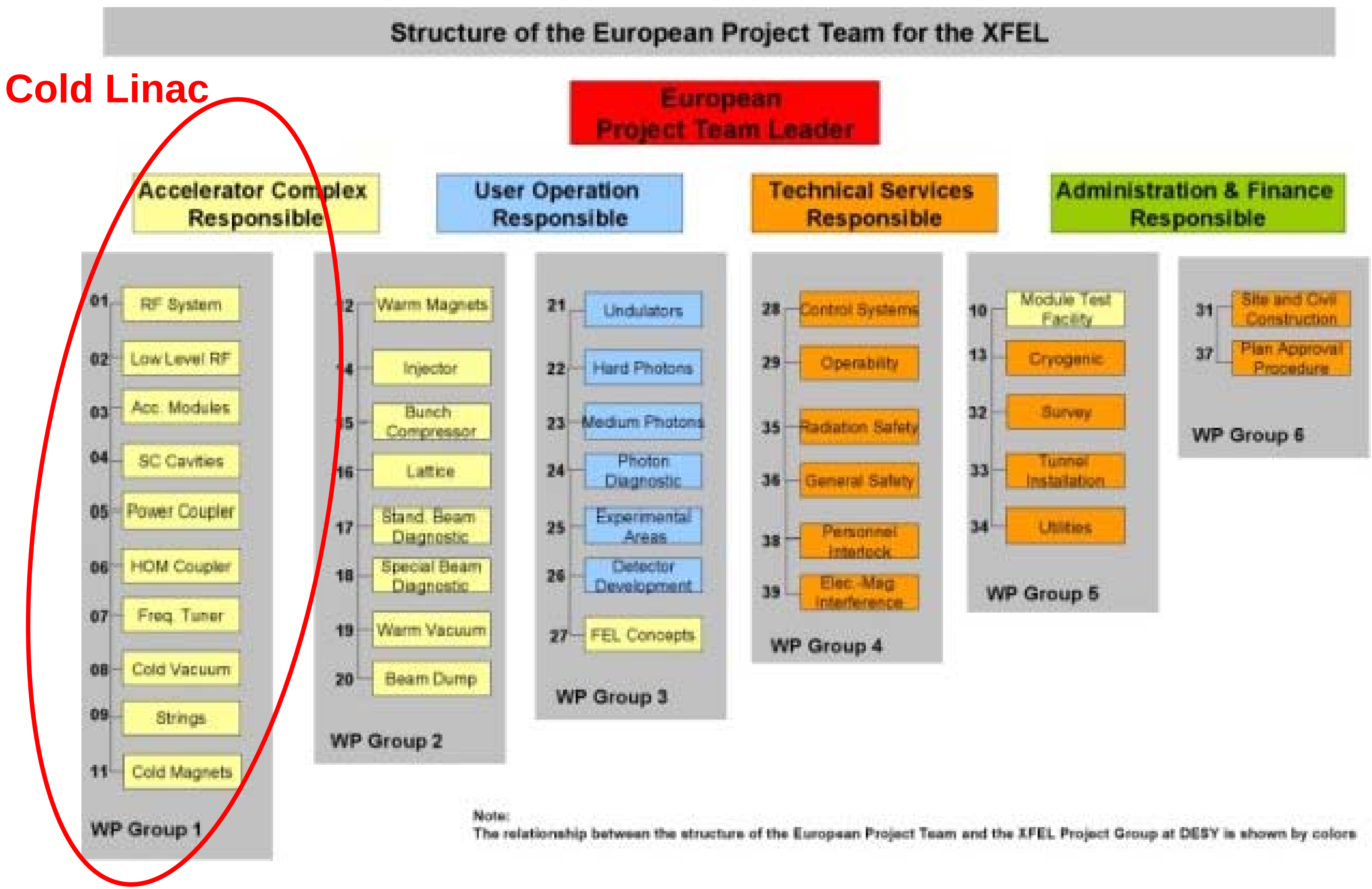
What we will NOT learn … (continued)

- Will not validate some interface parameters:
  - Plug compatibility
- We will have difficulties with:
  - Long-term reliability tests of CM components, such as tuners, piezos, couplers
  - Evaluating HOM absorption and propagation
    - Need to do it with an ILC CM's
  - Static and dynamic heat loads
    - NML temporary cryo system is not properly instrumented; wrong temperatures

XFEL Info Useful for ILC

- Rates at which vendors can build and process cavities, cryomodules and HLRF components
- Cost of these items (although this may not be sharable)
- Feasibility of a single tunnel design including the support of the cryomodules from the ceiling
- Lifetime data for the klystron and modulators from tests at Zeuthen
- Failure mechanisms (such as leaks) for the cavities and cryomodules from the testing program
- Model for lab-industry interactions (if the LHC experience is any indicator, there will likely be a very close lab-industry working relation for XFEL and the ILC)

Hans Weise: XFEL Project Organization



Sharing the XFEL WPs

Summary

		Laboratory	Country	Invest / M€	FTE	FTE / M€
Accelerator Modules	WP – 3	CEA Saclay	France	60%		43%
		INFN	Italy	19%		29%
		DESY	Germany	21%		29%
	sum			*100%*		*100%*
Superconducting Cavities	WP – 4	INFN	Italy	50%		34%
		DESY	Germany	50%		66%
	sum			*100%*		*100%*
		Received from WP-9				
Power Couplers	WP – 5	LAL Orsay	France	73%		52%
		DESY	Germany	27%		48%
		or				
		LAL Orsay	France	99%		100%
		DESY	Germany	1%		0%
	sum			*100%*		*100%*
HOM Coupler / Pick-up	WP – 6	IPJ Swierk	Poland	100%		100%
	sum			*100%*		*100%*
Frequency Tuners	WP – 7	DESY	Germany	100%		100%
	sum			*100%*		*100%*
Cold Vacuum	WP – 8	DESY	Germany	100%		100%
	sum			*100%*		*100%*
Cavity String Assembly / Clean Room Quality Assurance	WP – 9	CEA Saclay	France	90%		51%
		DESY	Germany	10%		49%
		Transferred to WP-4				
	sum			*100%*		*100%*
Cold magnets	WP - 11	CIEMAT	Spain	56%		10%
		DESY	Germany	44%		90%
	sum			*100%*		*100%*

XFEL Components

- XFEL needs
  808 cavities for
  101 accelerator modules, i.e.
  808 frequency tuners,
  808 RF main input couplers,
  1616 HOM pick-ups,
  101 HOM absorbers
  etc.

First 5-10% of modules in 2010, majority in 2011 / 2012

Tunnel installation finished spring 2013

- Overall rate: 1 module per week for 2 years
- Orders will be placed not later than 2009, so the prices are known on the basis of 5% ILC
- Component tests start in Q3/2010

End of 2010 approx.	5 modules, 40+40 cavities, coupler, …
Mid of 2011 approx.	30 modules, 300 cavities, coupler …

XFEL Tunnel

- Feasibility of a single tunnel design including the support of the cryomodules from the ceiling

End of 2010 we have no further ‘experimental data’;

Pre-installation starts in 2011

BUT:

- **FLASH is lasing with the pulse cables going all along the linac…**

- **Installation procedures will be trained at the mock-up**

Fukuda: HLRF ACD Down Select

- Marx Modulator
  - 2009 after few thousands hours of full power operation
- SBK Klystron
  - 2010 after several thousand hours of full power operation
- RF Distribution with adjustable tap-offs and w/o circulators
  - 2009 -10 after beam operation

Note: other ACD components are being developed on a later time scale

Lutz: Cavity ACD Down select

- Cavity design
  - HOM damping concepts need verification
    - Could discuss whether a completely new shape and rotation of HOMs (for wakefield reduction) have identical requirements
  - Beam test seems indispensable
- Cavity material
  - seems to be straight-forward
  - A certain amount (~30 cavities) should have been high-power tested
- Cavity preparation
  - This was not discussed at the KOM in detail
    - Is not really an ACD topic, rather an addition to the baseline
    - Look at S0 planning

Translate the Testing Requirement to a Timescale

- Neglect financial constraints for one slide
- 30 Cavities
  - Production: 0.5 years minimum if material available
  - Preparation and horizontal test: 1 year minimum
  - Installation in modules and string setup: 1 year minimum
- Large-grain material
  - ~2 years to arrive at the proposed tests
- Alternative shapes
  - At least 2-3 years
- Financial constraints mode switched on again

Cavity Preparation Down-select

- Main issue is reproducibility for the baseline
  - Candidate processes developed until today are very promising
    - Fresh EP, Degrease, Alcohol rinse
  - Test requirement (see S0)
    - Confirm results in more than one lab (tight-loop or variant thereof could be used)
      - Time-scale: 1 year
    - Need to vertically test 30 cavities in a production-like mode with sufficient yield in ultimate experiment
      - Time-scale. 1 year minimum if cavities available, if production needed add 1 year
- Total time-scale is roughly 2 years minimum
  - Just in time for EDR (getting tighter daily)
    - Set as a timescale by GDE EC...

Hayano: BCD/ACD/Tech Choice for Cavity Package

Item	BCD	RDR	ACD / technology choice
Tuner	not selected	not selected	Saclay tuner, Brade tuner, Slide-jack tuner, Ball-screw tuner
Motor position	not specified	not specified	motor inside, motor outside
Piezo maintenability	not specified	not specified	piezo inside(double?), accessible
Coupler	TTF-III(variable β),	TTF-III(variable β)	Two-disk Window type(fixed β), Capacitive coupling type(fixed β), TW60(fixed β), SLAC coupler?,…
Coupler peripheral	not specified	not specified	tmp/arc sensors, pumping,…
Magnetic shield	not specified	not specified	He vessel outside, inside
Vessel material	Titanium	Titanium	SUS
HOM probe,etc	not specified	not specified	feed-through,….
Alignment method	not specified	not specified	endplate+jig, machined endplate Invar fixing, slider hang,….

Technology Down-Selection, Decision and Timeline Proposal

2007.10 - 2008. 3 : Make specification/parameter range table.
Identify the down-selection item, decision item.
Identify the proponent of the technology.
Make comparison tables of merits and points by each proponent.

2008. 4 - 2008. 5 : PM/TA Make fair-minded comparison table to be filled in by each proponent.

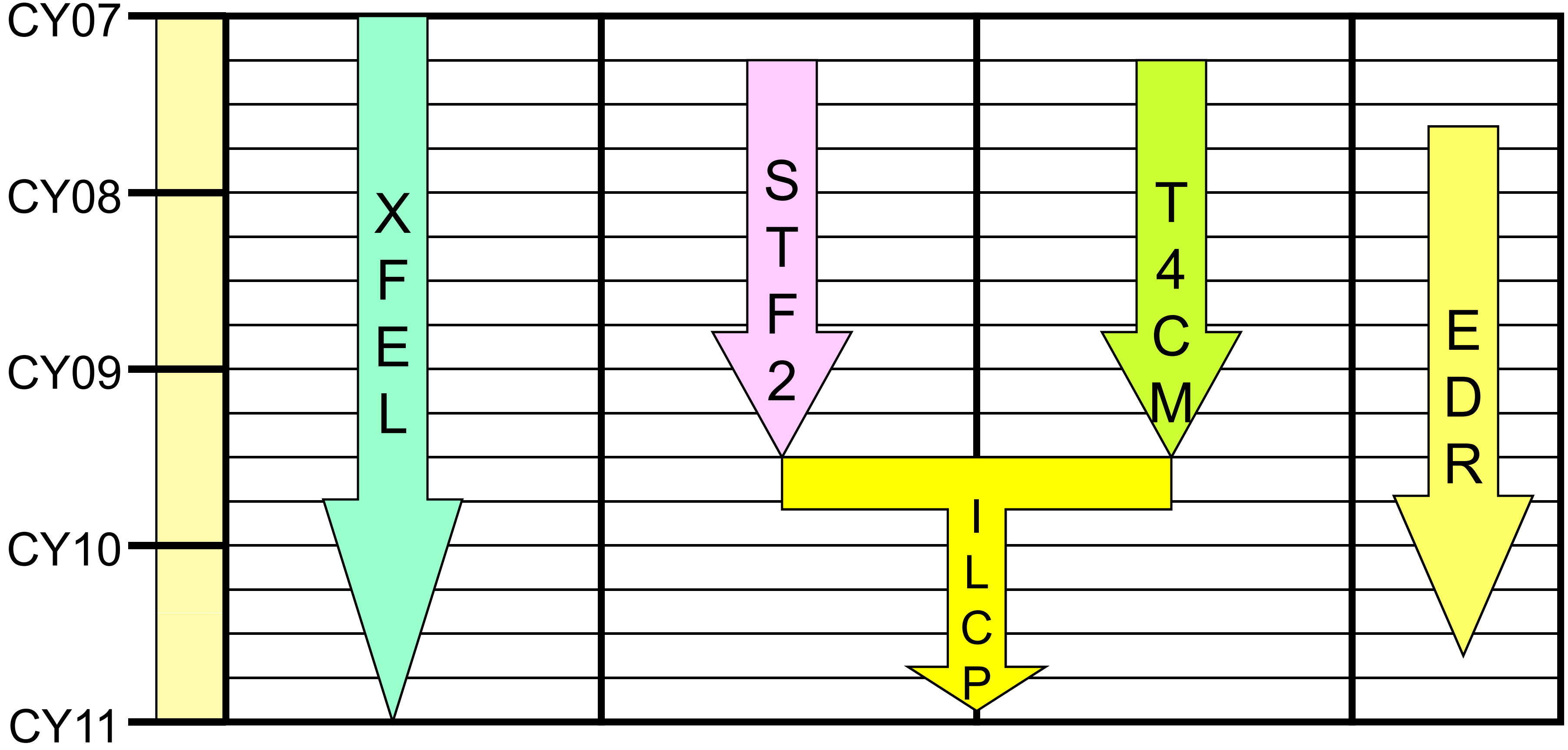
2008. 5 - 2008. 7 : Fill in the comparison table, and be documented.

2008. 8 PM/TA decide the technology according to the table.

2008. 9 - 2008. 12 : Identify plug-compatible proposals

2008. 9 - 2010. 8 : Start detail Engineering Design according to the decision (2 years)

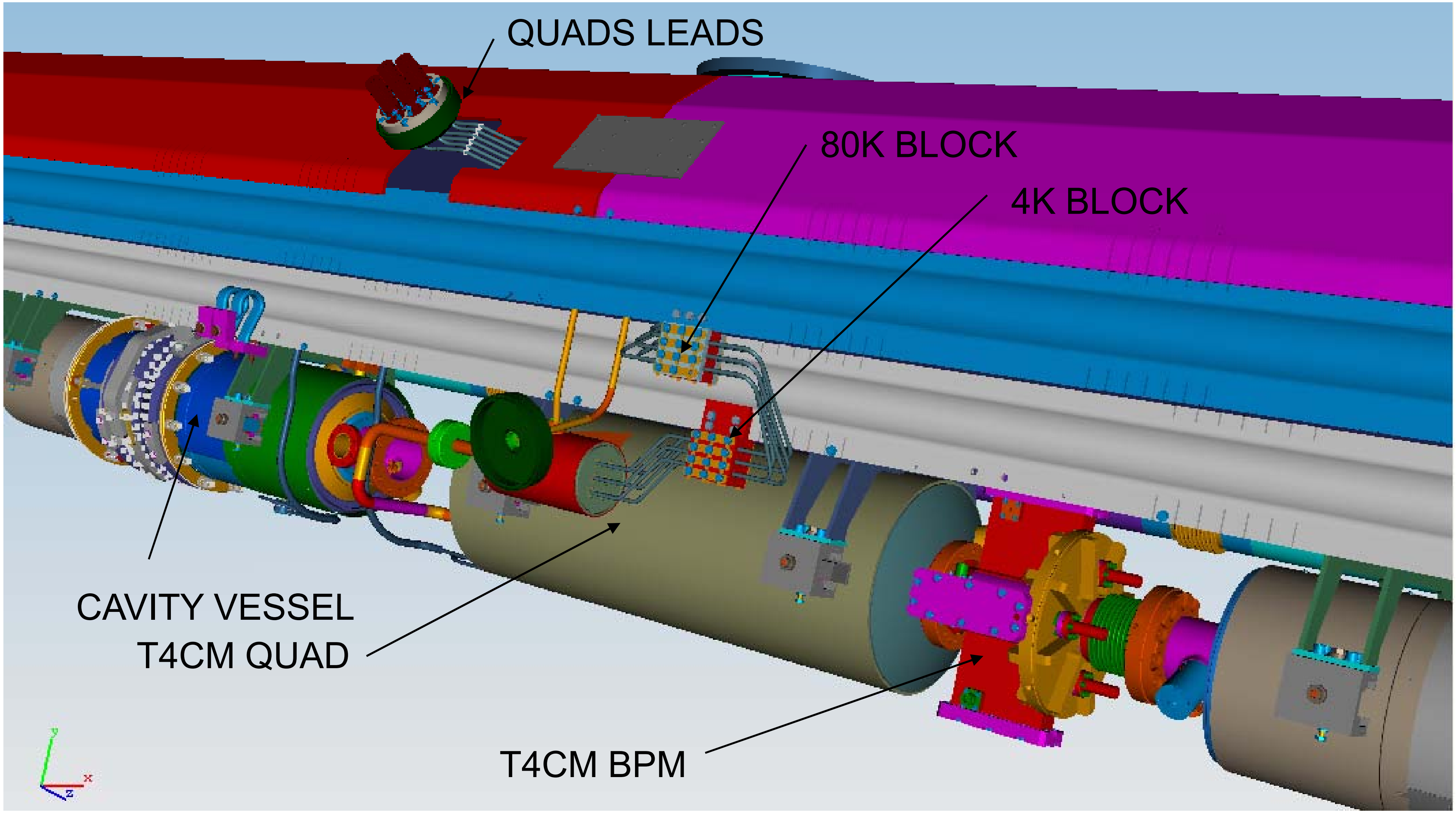
Harry Carter: CM Down-Select Timeline



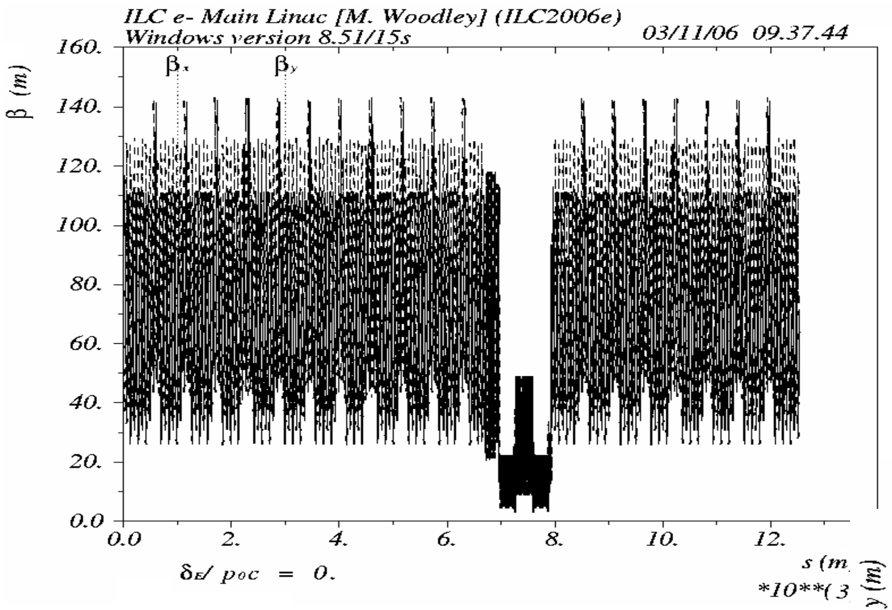
Cryomodule design is relatively simple once you remove the “high tech” components (dressed cavities)

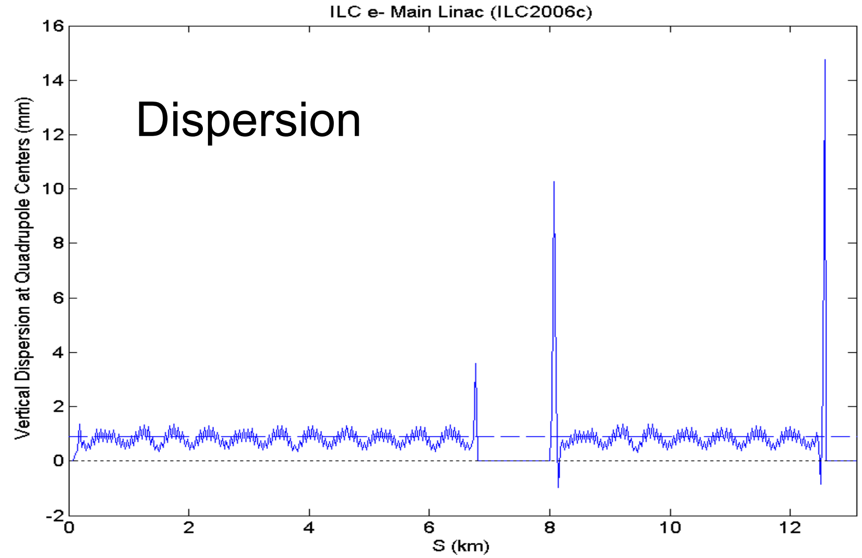
- We will choose the best features from the different regional designs to incorporate in the ILC Prototype
- A parametric model can be used to explore the “ripple effect” associated with the incorporation of these “best features”. The T4CM is such a model.

Quad Package and Beam Dynamics

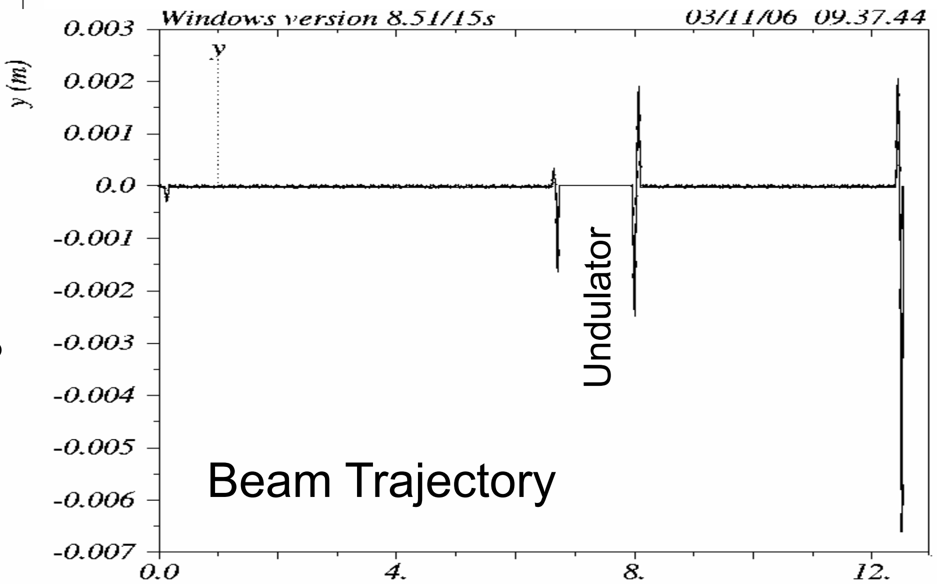


Solyak: ILC Lattice for Curved Linac





- 1 Quad/3CM (9-8-9) Lattice
- Spacing ~38m
- x/y phase advance = 75°/60°
- ~10% strength variation in matching sections



Quad Specs

- *Dimensions:*
  - Beam pipe diameter = 78 mm
  - Quad total length (z- slot) ~ 0.66m (TESLA - 0.666 m)
- *Maximum Integrated gradient:* (if L=0.66 m)
  - (B'*L) = 37 T (B' = 60 T/m) - at 250 GeV
- *Max current:* (at 250 GeV) = 100A
- *Stability*:
  - faster than orbit correction (< 1 ms) < 2.e-5
  - slower than orbit correction (>0.2 s) < 1.e-3
- *Higher harmonic tolerance*: not studied yet
  - Skew quad < 3.e-4 (at r = 5mm)
  - High harmonics < 1.e-3 (at r = 5mm)
  - Field in cavity region <10 μT (at r = 35mm, z ~ 650 mm from quad center).

Quad Specs (cont.)

Alignement tolerances (installation) :

- *X/Y Position* < 0.3 mm *(rms)*
- Pitch, yaw, roll : < 0.3 mrad
  - Reference: TDR alignment (angle) < 0.1 mrad (~5um @ 50mm)
- Roll tolerance are tight, needs built-in skew corrector (?)

Field changes:

- 20% of nominal for quad shunting (finding BPM-Quad offset),
- 100% for ballistic alignment
- Within a few seconds
- Center motion: below 2 um for 20% quad strength changes

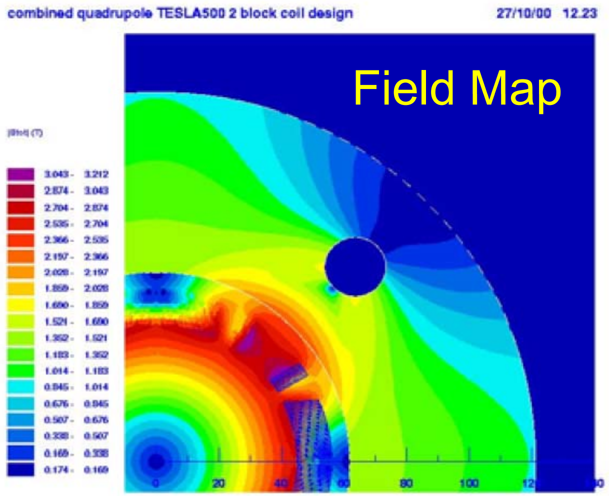
Upgrade Path (500 GeV/linac):

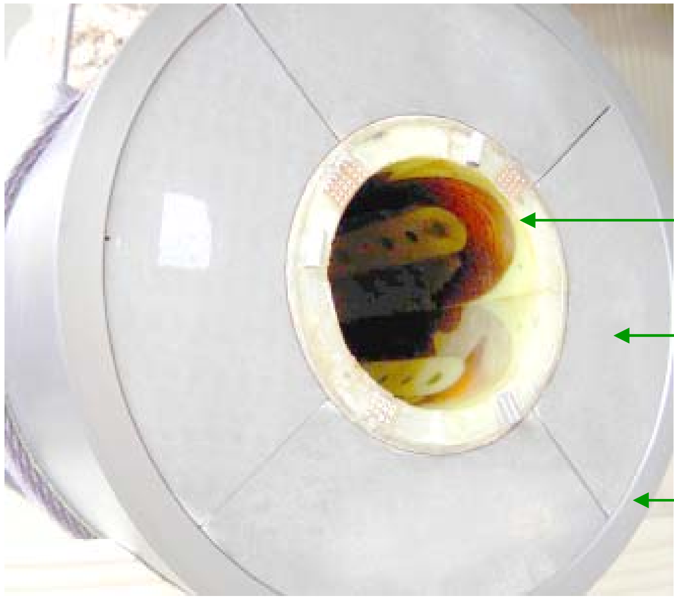
- Twice weaker lattice at high energy (>250GeV)

SLAC Will Evaluate DESY/CIEMAT SC Quad for Magnetic Center Stability

Cos(2Φ) SC Quad

(~ 0.7 m long)



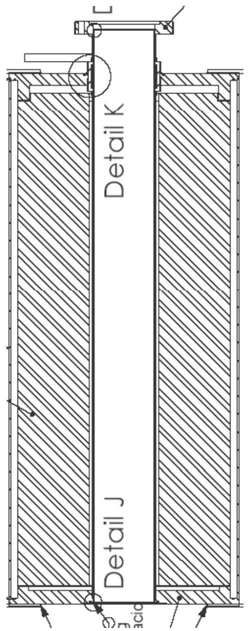


He Vessel

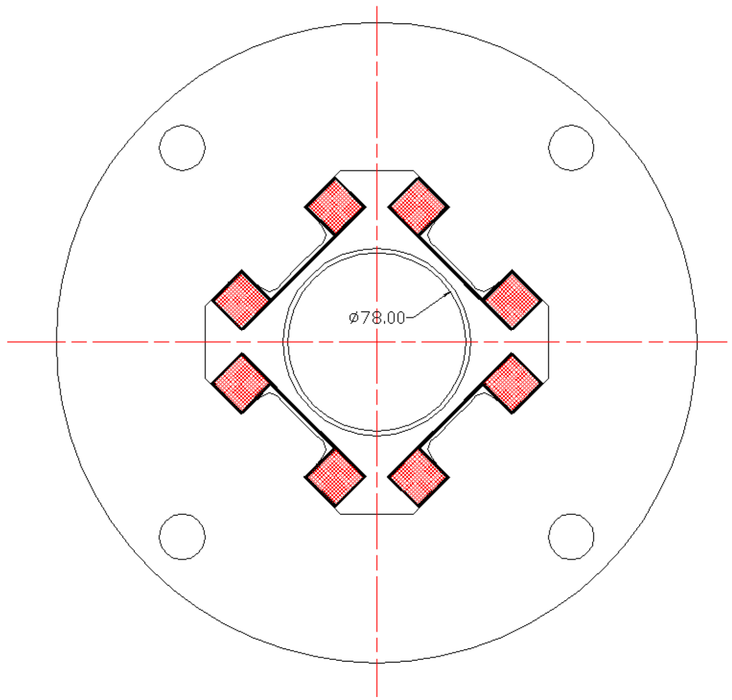
SC Coils

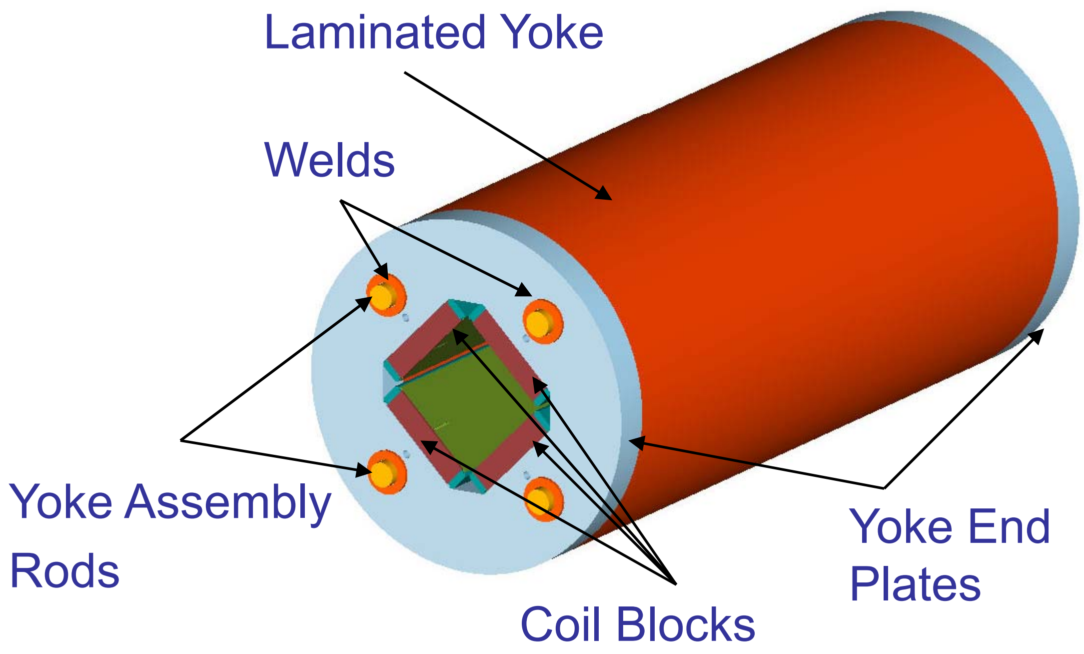
Iron Yoke Block

Al Cylinder



Kashikhin: Building Linac Quad and Corrector Prototypes at FNAL

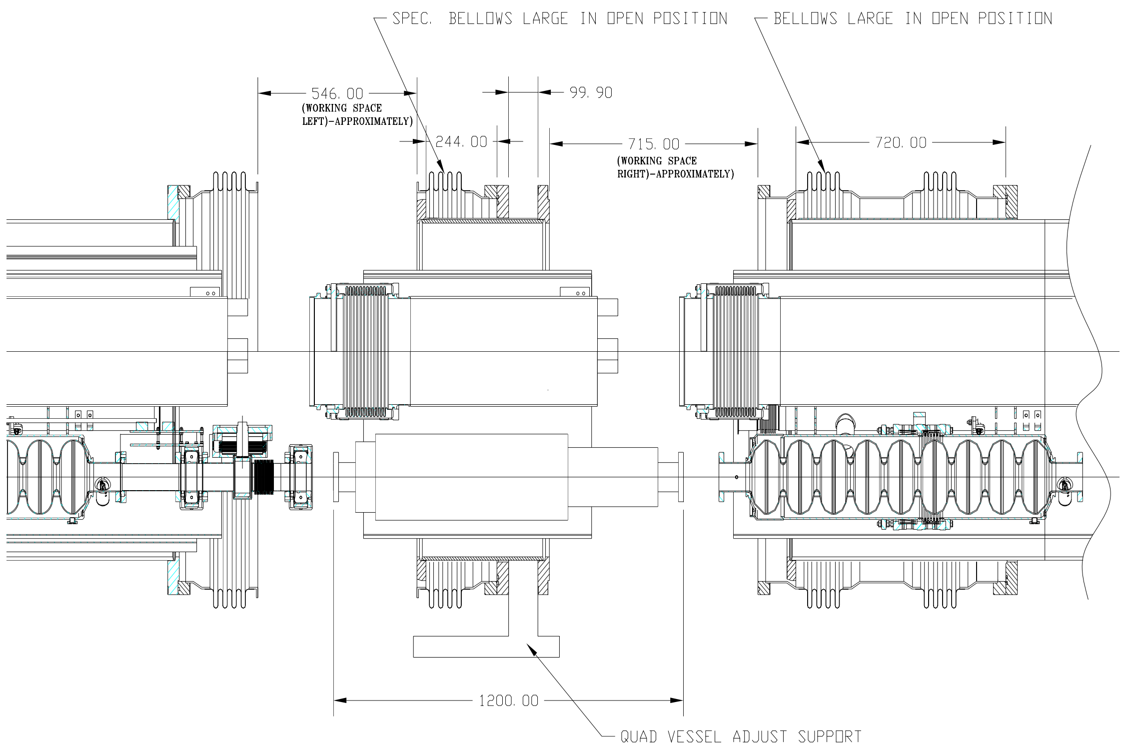




Cold mass: Length 680 mm

Outer Diameter 280 mm

Kashikhin: Pro/Con of Having Quadrupole Package Between Cryomodules



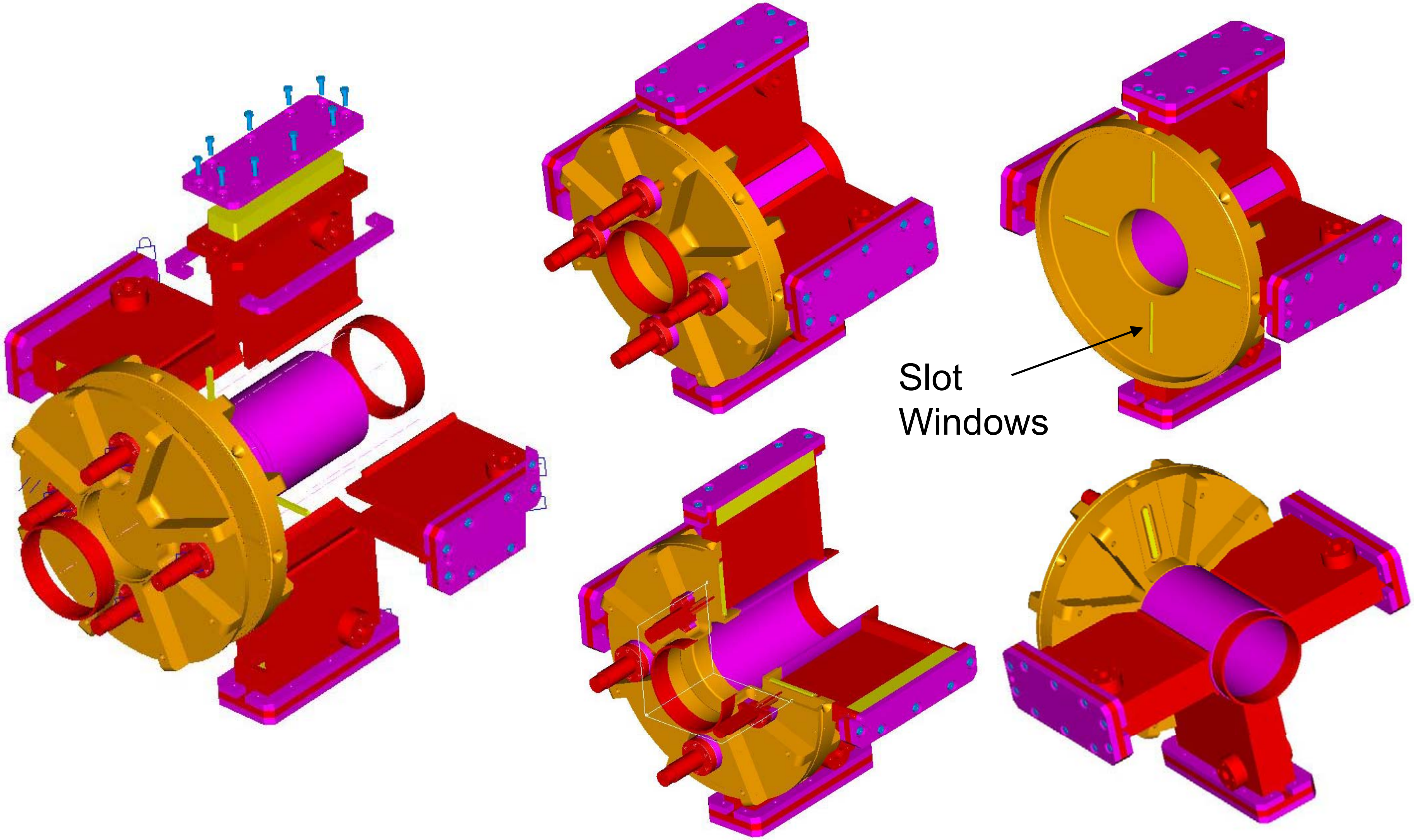
Pros:

- Cryomodules and Quadrupoles having different specs and performance are decoupled
- Cryomodules could be identical
- Manufacturing, assembly and test lines are independent
- Independent design, prototyping and tests
- Could be different (higher) temperature and lower corresponding cryoload
- Lower influence of fringing fields from magnets and current leads
- Feed boxes decoupled from Cryomodule
- Lower quadrupole vibrations
- Higher accuracy of quadrupole positioning
- Easy mechanical position adjustment and long term space stability
- Easy replacement
- Lower fabrication and assembly cost

Cons:

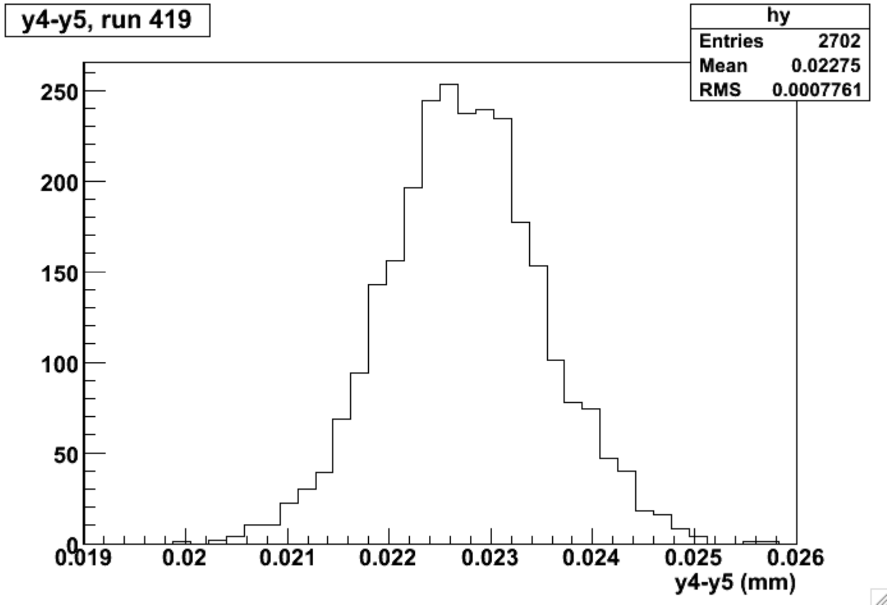
- More connections and higher tunnel installation cost

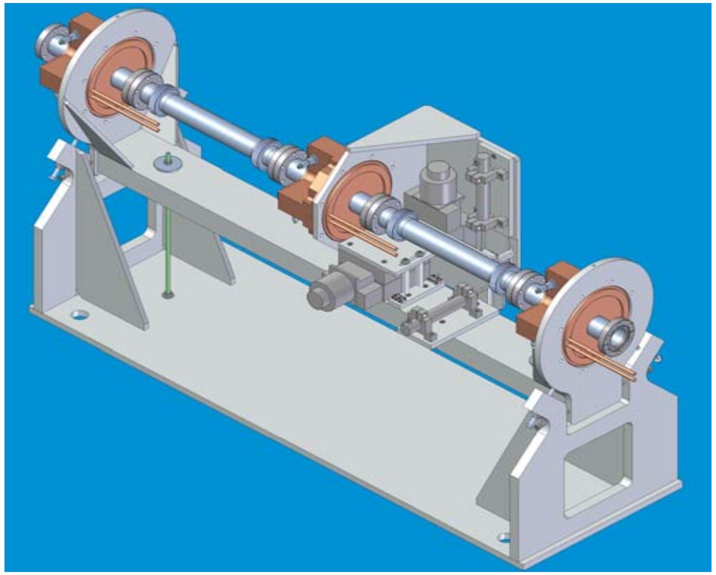
Manfred: Building Prototype μm-Resolution, 1.5 GHz, Cavity BPM in Next Few Months at FNAL

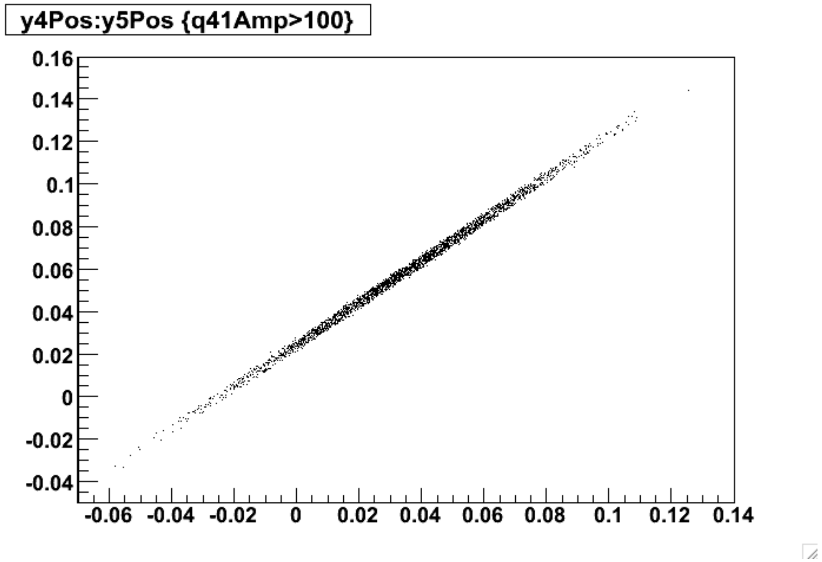


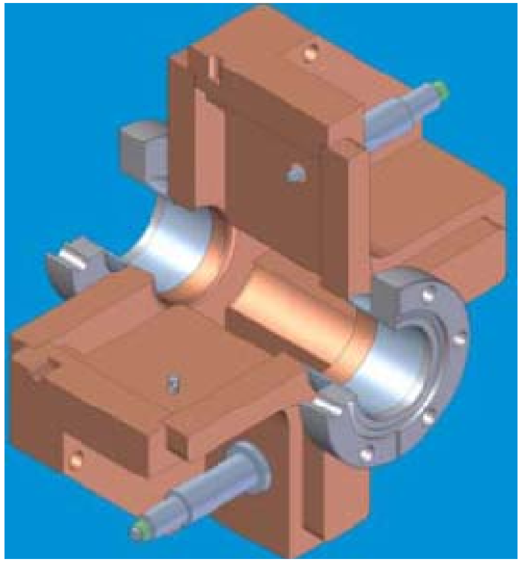
SLAC Half-Aperture BPM Prototype

(0.5 micron resolution, 1.4e10 electrons, Q of 500 for clean bunch separation)









SLAC/FNAL Examining HOM Absorber Efficiency at and Location of Power Loss

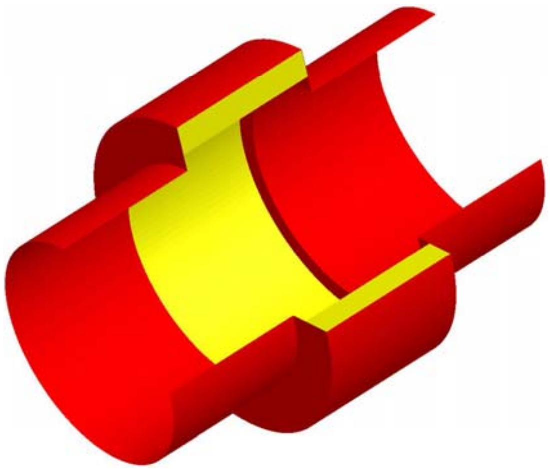
$f_{rep} = 5$ Hz
$T_{HF} = 0.95$ ms

a) Collider (500GeV)

$\sigma_{bunch} = 400$ µm
$N_{bunch} = 2820$
$q_{bunch} = 3.2$ nC (9.5 mA)

losses per module (12x9cells):

$P =$ 23.3 W
$P(f >$ 5 GHz$) =$ 17.4 W
$P'(f >$ 10 GHz$) =$ 12.7 W
$P'(f >$ 20 GHz$) =$ 8.1 W
$P'(f >$ 50 GHz$) =$ 3.0 W
$P'(f >$ 100 GHz$) =$ 0 .7 W



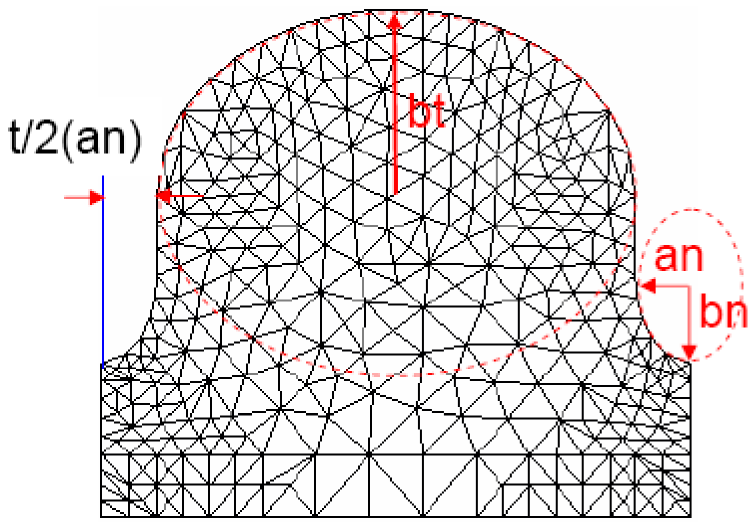
(M. Dohlus, absorber_zeuthen_dohlus.pdf)

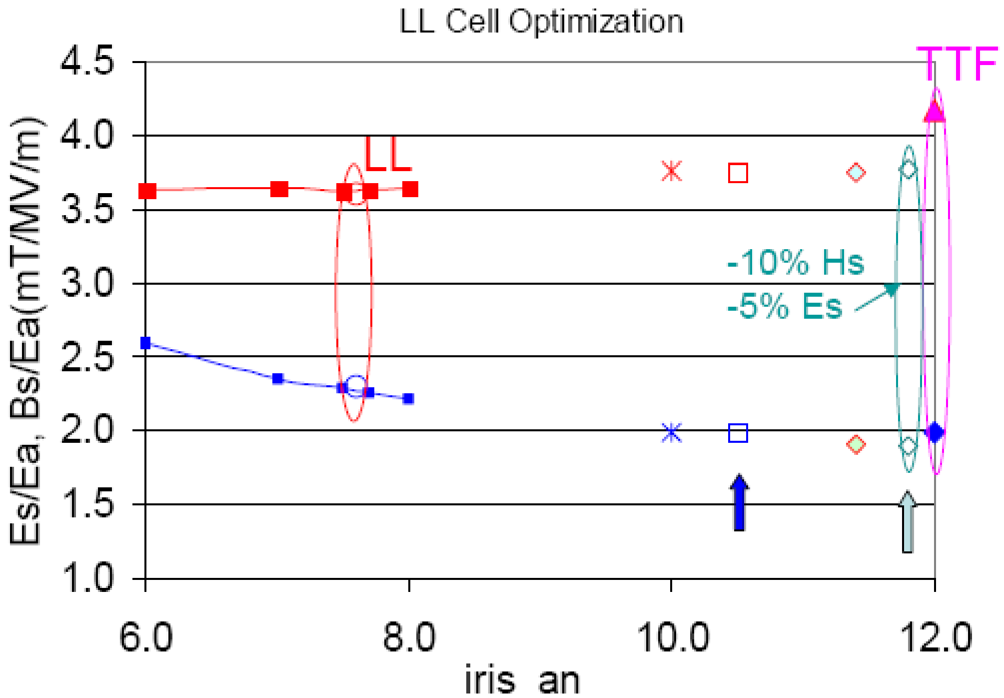
For 300 micron bunch the total losses in CM (8cav x 9cells) are about 16 W. Loss spectrum at low frequencies is about the same.

Zenghai Li: Wakefield/Cavity Studies at SLAC

- *Accelerating Cavity (DESY, KEK, JLab)*
  - *Alternative design*
  - *HOM damping*
  - *Coupler asymmetry effects*
- *Cavity imperfection modeling*
  - *Effects On HOM damping*
  - *3D Wakefields and beam dynamics*
- *Cryomodule and RF unit simulation*
  - *Trapped modes*
  - *Wakefidls, x-y coupling effects*
- *Cryomodule HOM heating*
  - *Beamline absorber*
  - *Heat load distribution in low temperature environment*
- *Integrated multi-physics tools for RF/Thermal/Mechanical analysis*
- *Input Coupler study*
- *L-Band Sheet Beam Klystron – Gun and window modeling*
- *BDS Crab Crossing (FNAL/UK) - Deflecting cavity*
- *Damping Ring (LBNL) – Impedance calculations*

More Optimal 30 mm LL Cavity Design



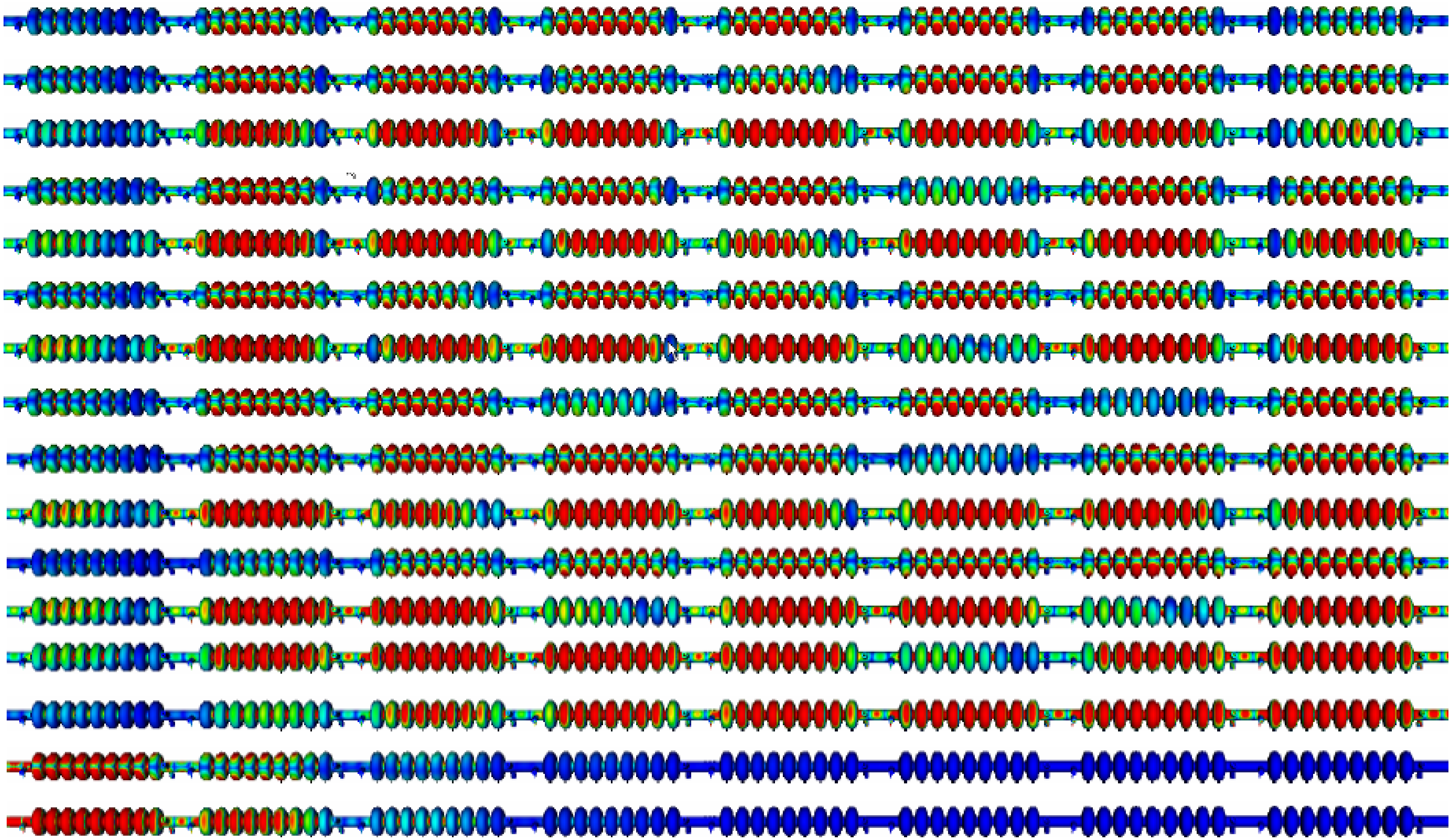


	an	bn	Es/Ea	Hs/Ea	Bs/Ea (mT/(MV/m))	Ea ((MV/m)/180mT)
TTF cell (a=35mm)	12.00	19.00	1.984	0.00332	4.168	43.19
Original LL (a=30mm)	7.60	10.00	2.303	0.00287	3.608	49.88
opt-3 (a=30mm) 0mm slope	10.50	17.10	1.984	0.00295	3.712	48.49
a=30mm 0mm slope	11.80	20.80	1.894	0.00300	3.770	47.75

5% Es reduction
10% Hs reduction

TDR 8-Cavity Module 3rd Band Modes From Omega3P Calculation

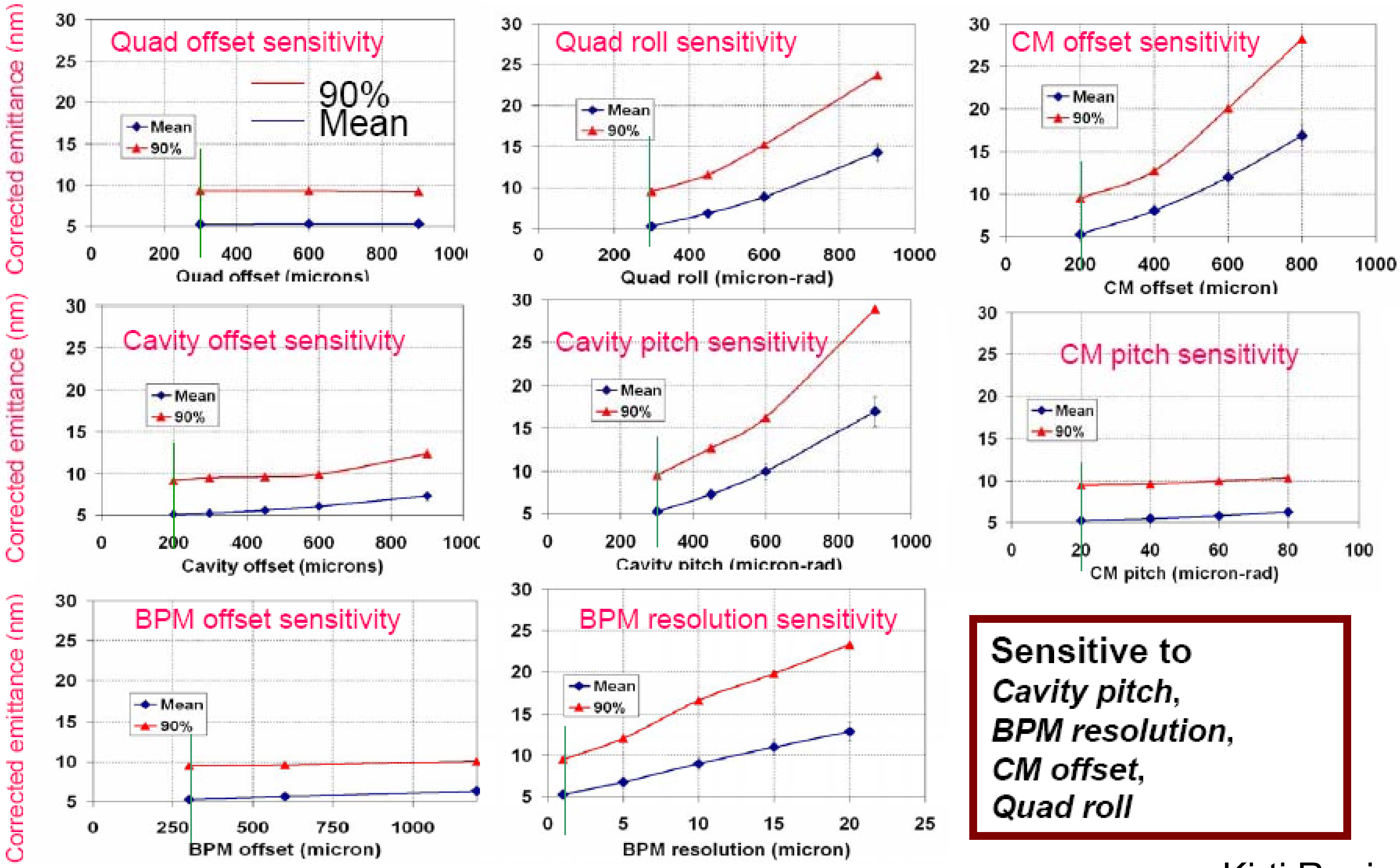
(R. Lee)



Calculated on NERSC Seaborg: 1500 CPUs, over one hour per mode

Kubo: Static and Dynamic Beam Tuning

Vary one misalignment from its nominal value - keeping all other misalignments at their nominal values



Sensitive to
Cavity pitch,
BPM resolution,
CM offset,
Quad roll

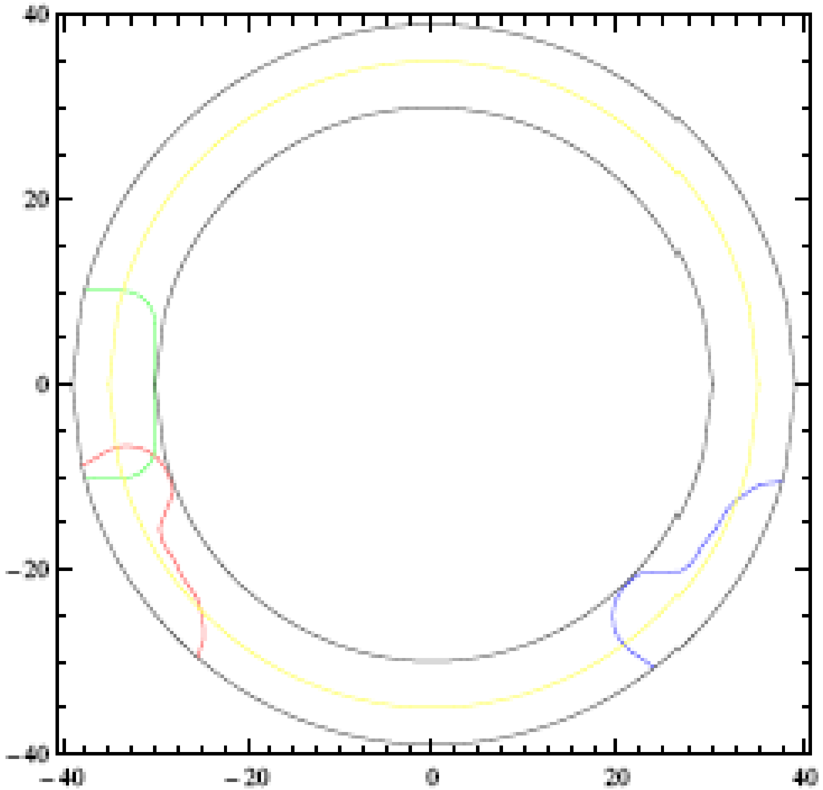
Kirti Ranjan

Integration Issues and Cost Studies

Wake Offsets

Shadow of FPC and HOM antennae cause non-zero wake at cavity centers

fm (green) and hm couplers (red, blue); circles with a= 30 mm, 35 mm, 39 mm



Chris Adolphsen, MLI KOM, 9/28/07

ILC Impact if Not Corrected

Assume

- Wt slope = 0.15 GeV/m^3 with 3 nC bunches
- Wake offset = 2.5 mm
- Sigma z of bunch = 9 mm (RTML) to 300 microns (ML)

Then Estimate (Roughly)

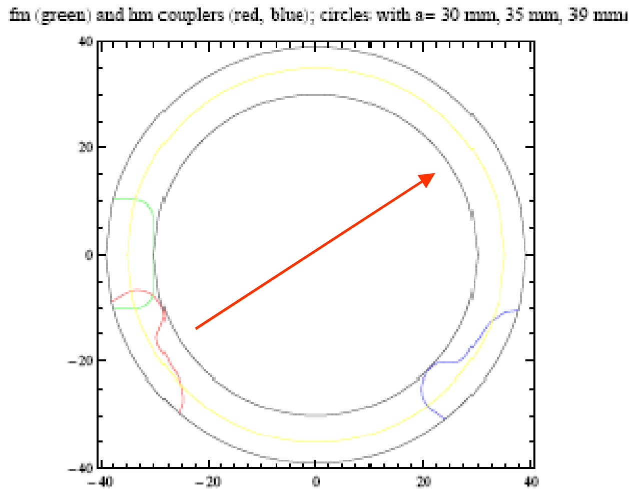
- RMS Head-to-Tail Offset / Vertical Beam Size

  = up to ~ 10 in the 5-15 GeV RTML depending on cancellation

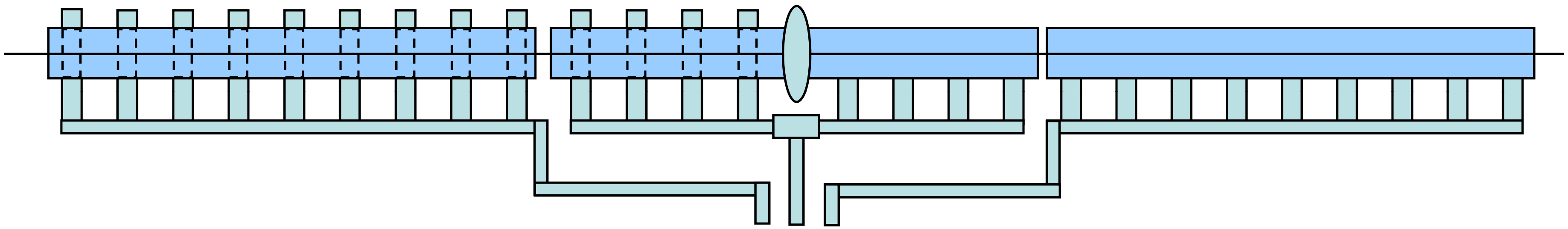
  = ~ 2 in Main Linacs (x4 emittance) if cancelled in RTML and beta is constant: better cancellation if beta ~ sqrt(E)

Solution that does not change design of cavity components and cancels all on-axis angular kicks

First: Rotate downstream HOM by 180 degrees to reduce local effect

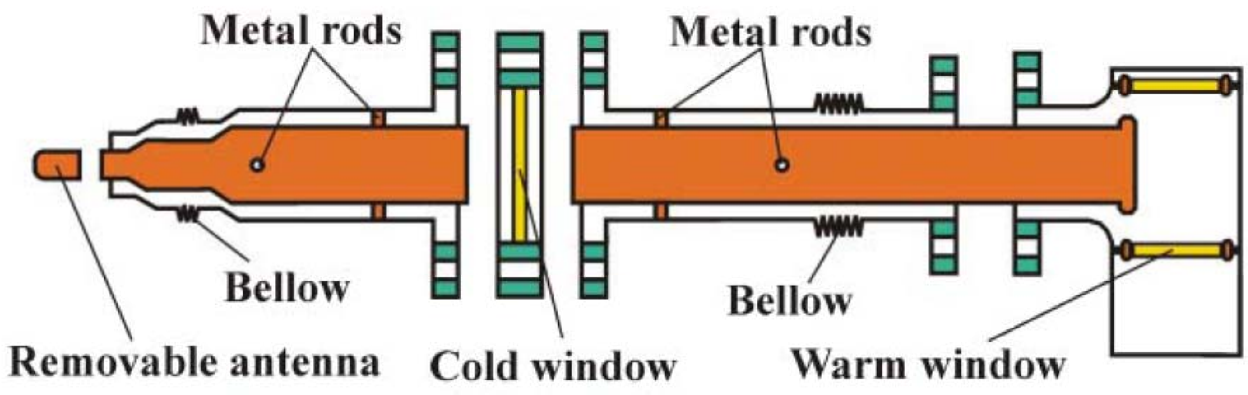


Second: Rotate cavities by 180 degrees in downstream half of rf unit and connect WG to couplers on wall side (although distribution on aisle side)



Coupler Choice: Cost versus Operation Issues

	Cold Window	Bias-able	Variable Qext	Cold Coax Dia.	# Fabricated
TTF-3	Cylindrical	yes	yes	40 mm	62
KEK2	Capacitive Disk	no	no	40 mm	3
KEK1	Tristan Disk	no	no	60 mm	4
LAL TW60	Disk	possible	possible	62 mm	2
LAL TTF5	Cylindrical	possible	possible	62 mm	2



Nantista: Tradeoffs of WG Heat Removal

AIR CONDITIONING

Assume running at an intermediate power level, using some but not all of the overhead, with ~90% efficient water-cooling (maybe we can do better) on the loads/attenuators & circulators.

There might then be ~6.2 kW of air heating.

Removing this would require

6.2 kW × 3,412 BTU/h/kW = 21,154 BTU/h of air conditioning.

One can buy a 10,000 BTU/h portable air conditioner for $380.

→ 21,154BTU/h / 10,000 BTU/h × $380 = ~$804

Assume a typical heat pump efficiency:

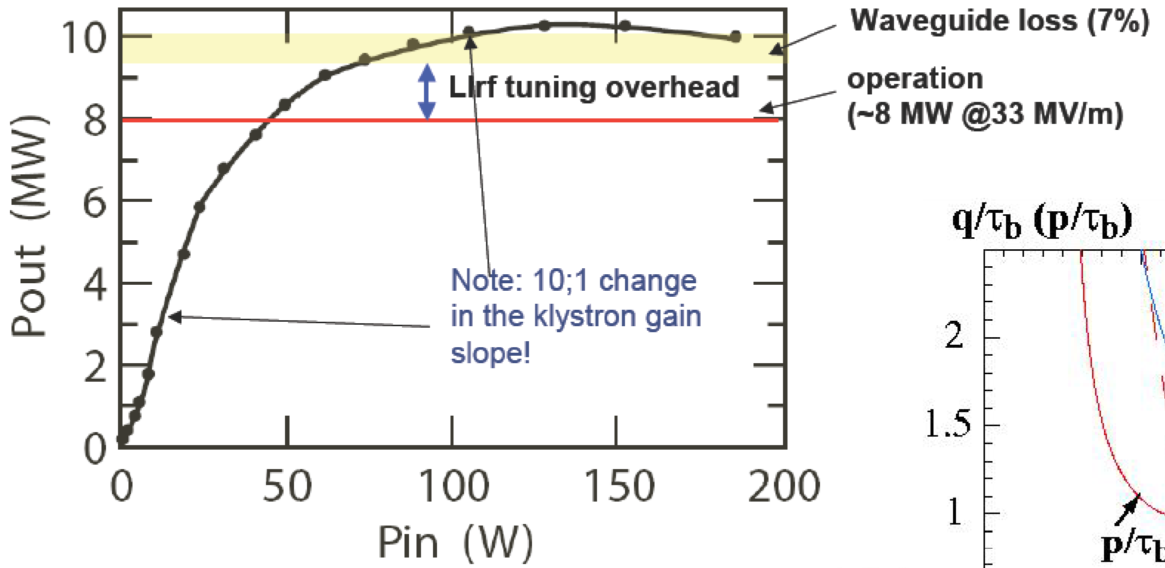
COP* = heat removal rate / AC power used ~= 3

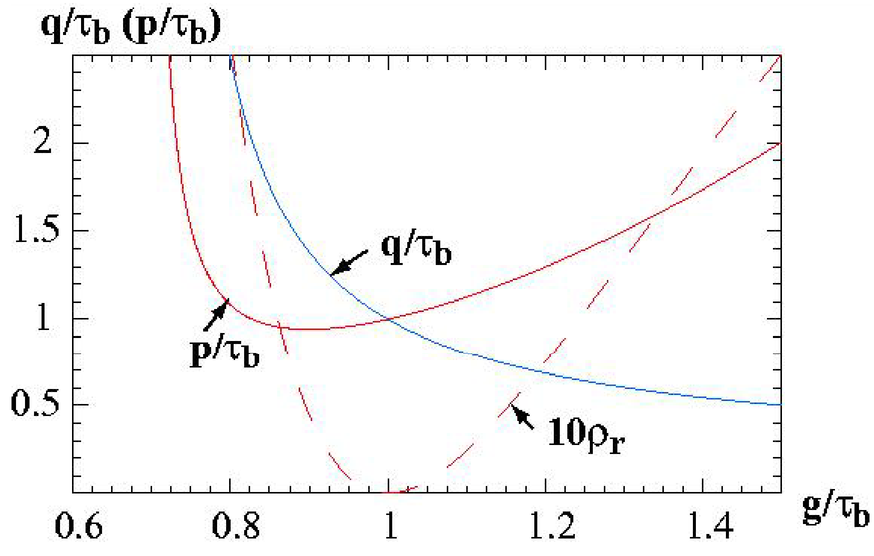
→ 6.2 kW of cooling @ COP of 3 = 2.07 kW AC power

× 8,766 h/yr. × $.087/kW-h = $1,576/yr

Brian Chase: Issues of RF Overhead and Operation with a Gradient Spread

- As in RDR, llrf tuning overhead is only 16% in power. corresponding to 8% in driving amplitude. (too narrow!)





The values q/τ_b, input power p/τ_b, and reflected power ρ_r which yield a flat gradient, as functions of g/τ_b.

Tom Lackowski: CFS Option Studies

- **Near Surface Study**
  - Component Configuration
- **Single Tunnel Study**
  - Life Safety Study
    - **Fire Load**
    - **Hazards**
- **Value Management Workshop (Power/Cooling)**
  - Nov. 27-29 @ Fermilab
    - **Power and Cooling Criteria with Klystrons, Waveguides, Modulators, Racks and Charging Supplies**

Tom Peterson: Cryogenic Layout Issues

- Cryogenic box designs are only conceptual
- Lengths may change
  - Drift space length may change slightly both for string ends and for unit ends
  - For string end box estimate 2.5 meters slot length +1 m / -0.5 m range
  - For cryogenic unit end box or service (feed) box, selected cryomodule slot length = 12.65 m
    - Estimate 7.65 m of this is available warm beam tube length
- Locations of short strings may change
  - Locations with only 116.4 m between string end boxes may change
- Cryogenic box design is a major task for the EDR
  - Will not have detailed drawings in 2010
  - Aim for good 3-D CAD models and better definition of lengths and interfaces

Quad Field and Position Requirements

- Fast Motion (Vibration)
  - Require uncorrelated vertical motion > ~ 1 Hz to be < 100 nm
  - Many measurements being done – data look close to meeting spec.
- Slow Motion (Drift)
  - For dispersion control, want quad to stay stable relative to it neighbors at few micron level, day to day
  - Although slow ground motion is large, it is correlated on over long distance range which makes its net effect small.
  - No data on local day-to-day motion of quad in a cryostat.
- Change of Field Center with Change in Field Strength
  - For quad shunting technique to be effective in finding the alignment between the quad and the attached bpm, quad center must not move by more than a few microns with a 20% change in field strength
  - No data for prototype ILC quads.

Cryomodule and Cryogenic Costs

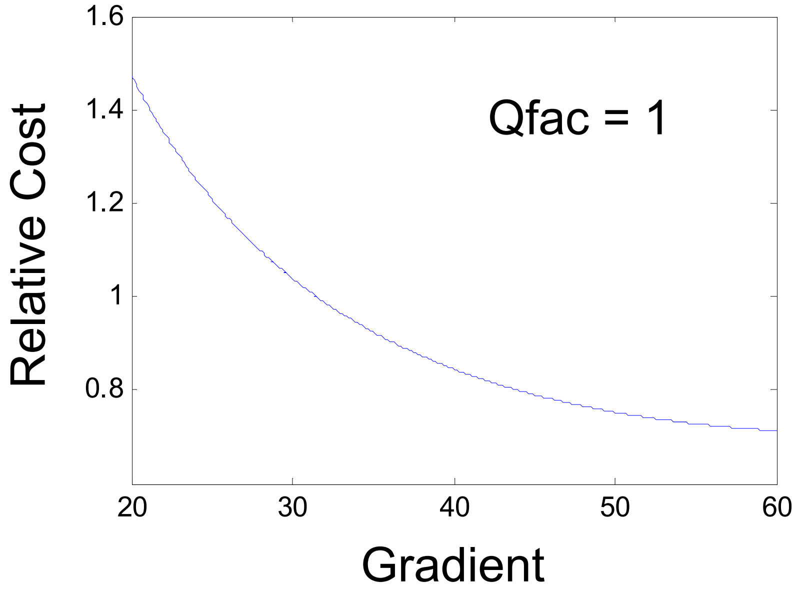
Pulse Length: Tfac = (Tb + Tfo*g/go)./(Tb + Tfo);

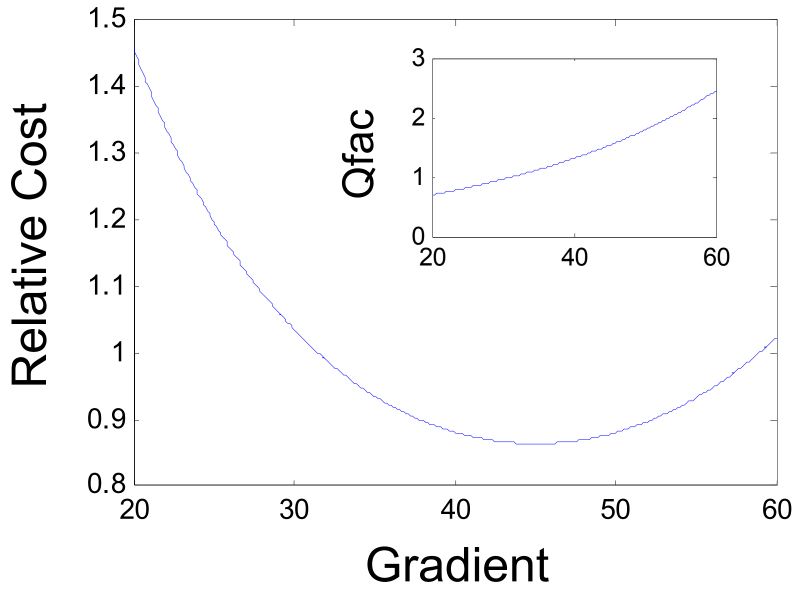
Coupler Cryo Loading Pfac = (g/go).*(Tb + 2*Tfo*g/go)./(Tb + 2*Tfo);

Cavity Cryo Loading: Gfac = (g.^2/go^2).*Qfac.*(Tb + 1.1*Tfo*g/go)./(Tb + 1.1*Tfo);

Cryomodule + Cryogenic Costs = (C_mod + C_inst + C_vac

+ (C_plant + C_dist + C_shaft)*(0.51 + 0.9*Pfac + 0.40*Gfac)) .* (go./g);





Tom Peterson: Cost Tradeoff from 5K Thermal Shield Bridge Removal

- Removal of the 5 K thermal shield bridge from the cryomodule interconnects should provide net gain
  - Length is ~800 mm, and thermal impact scales with shield length removed = 0.8/12.65
  - Impact on cryoplant M&S is no more than 0.063 x $4200 = $270 added cryogenic system M&S per cryomodule
  - Impact on operating costs is 0.063 x $770 = $50 per cryomodule per year
- Shield bridge interferes with pipe interconnect bellows and is labor-intensive to install, so cost is more than the per meter shield cost
  - Cost more than $500 per cryomodule
- Result is net savings for leaving out the 5 K thermal shield bridge at interconnects even after 5 years

Main Linac Integration

Work Packages

WP1.1: Quad Package Design

- Determine the cost/performance optimal quad/bpm aperture considering beam dynamics, cryo heat loads and beam interception issues.
- Describe likely backgrounds (Halo, SR, MP, dark currents) and the means of dealing with them and minimizing beam interception damage.
- Based on the linac optics and magnet field requirements (from other WPs), work with magnet experts to design a set of SC quads and correctors.
- Based on the linac bpm requirements (from other WPs), work with instrumentation experts to design the bpms and signal processing system.
- Based on above results and the HOM absorber requirements (from other WPs), work with cryomodule group to define layout of the quad package that achieves the required performance.

WP1.2: Quad Package Prototypes

- Build prototype quads and correctors (combined and separate) to verify quad center stability and basic field requirements can be met
- Build prototype bpms to verify required resolution and stability in a ‘cleanable’ design
- Using prototype quads and bpms in a beamline, show that quad shunting will provide a stable, micron-level measure of the quad magnetic center
- Build prototype HOM absorbers to verify HOM attenuation in bench tests and in beam operation in one of more the test facilities

WP2: General ML BD

- Do analytical estimates of the various emittance growth mechanisms in the linac to establish the relative sizes and scalings with energy and lattice strength.
- Use this info to optimize the linac lattice and identify the critical alignment, resolution and magnetic field requirements.
- Compare simulations to analytic results - understand any significant deviations and 'cross-term' effects.
- Identify those mechanisms that ultimately limit further emittance reductions and suggest possible mitigations.

WP3: Initial Alignment

- Develop realistic models of both short and long range spatial misalignments for the beamline components based on the likely methods of installation and global alignment.
- Incorporate these models into the beam simulation programs to determine if the misalignments will cause unacceptable emittance growth after beam-based steering
- Work with the installation/alignment groups to establish specs for the initial alignment of the components that can be easily interpreted by those who will do this work.

WP4: Energy Errors

- Develop realistic models of how the bunch energy and energy spread may vary from ideal along the linac and along each bunch train.
- Incorporate these models into the beam simulation programs to determine the allowed energy errors.
- Work with the LLRF group to translate these errors to specs on their system to regulate the rf gradients and phases in each rf unit.

WP5: Static Tuning

- Evaluate the various proposed linac alignment methods, including quad shunting, in terms of performance, impact on operation, sensitivity to lattice errors and requirements on beam position resolution, accuracy and offset stability.
- Briefly describe how the tuning will be done in other parts of the machine
- Describe how various tuning bumps could be used to further reduce the emittance growth

WP6: Dynamic Tuning

- Specify acceptable fast and slow quad motion in terms of amplitudes and correlations. For the latter, determine the implications for the 'static' tuning system.
- Specify a fast FB system to stabilize the beam orbits, including the requirements on the magnet response times.
- Specify methods for measuring the bunch/beam energy profile, matching the quad lattice and regulating the bunch energy at the end of the linacs. Work with Controls and LLRF to have these implemented
- Specify system and procedures to monitor the bunch/beam emittance including the instrumentation requirements. Work with the Instrumentation group to design bunch size monitors.

WP7: Wakefield and Cavity Topics

- Compute wake offsets due to FPC/HOM antennae intrusions and propose methods to reduce it.
- Specify short and long range wakefields and cross (x-y) coupling effects.
- Evaluate the effectiveness of the HOM absorber to remove the wake energy before it is absorbed in the 2K cryo system.
- Simulate multi-cavity trapped modes to look for significant wakefield build up.
- Develop cavity distortion model to match first/second band dipole mode properties.
- Analyze dipole mode signals to provide info on cavity properties.
- Evaluate multipacting in power and HOM couplers.
- Design a lower R, E field and B field cavity with 60 mm irises

Summary

Likely Level of Technical Readiness of the ILC Main Linacs by 2011

- Cavities and Cryomodules – Poor
- HLRF/LLRF – Fair
- Quad/Instrumentation/BD – Good
- Civil - Good