Report from the 2nd meeting of CLIC ACE

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CTF3 Collaboration Board

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Charge and Outline

A short version of the charge:

- Review and assess the R&D program for the RF structures towards demonstration of the full CLIC structures with nominal parameters by 2010 – both CAS and PETS

Outline of report:

- Structure parameters and design
- Testing program
  - Gradient and Damping
  - Materials & Fabrication
- CDR issues and timescales

- CLIC effort has been making great progress

Structure Parameters and Design

- Working with empirical data supported by quasi-theoretical model to design structures
  - Very good approach; we encourage adding new experimental data to directly support these models
  - Concern that re-optimization has led significant changes
    - Need to settle structure design parameters soon to demonstrate for CDR (even at lower specs)
    - May need additional consideration of other LC subsystems
- CLIC accelerator structure design has basis from past experiments and simulations at CERN, KEK, and SLAC
- Concern that PETS is a larger extrapolation; excellent work has been done in design process but need solid experimental confirmation
  - The PETS simulation effort could probably be broadened

CAS Comments

- CLIC Accelerator Structure design is proceeding with large number of test structures
  - Tracking and EDMS is a great addition to CLIC team
- Need experimental results to develop gradient performance and structure geometry
  - Systematically understand the impact of the HOM waveguides on gradient performance
  - May have to separate demonstration structure from understanding geometry & breakdown constraints
  - Schedule for CLIC demonstration structure not clear
- Enjoyed hearing about important materials studies and material breakdown studies
  - Engineering of manufacturing and materials should proceed in parallel but not impact testing program

Structure Fabrication (1)

CLIC accelerating structures (from 2007)

EDMS# 844300
Last update: 16.01.08

Frequency	Structure		Cat.	Status	Supplier
11.424 GHz	C30_vg1.1	old vg1.1	ES	shipped to KEK	
	TD18_vg2.4_quad#1	11WDSQvg1Cu.1	FS	being machined, delivered at CERN in CW04/08	CERN (VDL)
	TD18_vg2.4_quad#2	11WDSQvg1Cu.2	FS	being machined	KEK
	T18_vg2.4_disk#1	11WNSDvg1Cu.1	TU	being assembled at SLAC, ready for test in CW06/08	KEK, tested at KEK
	T18_vg2.4_disk#2	11WNSDvg1Cu.2	TU	being assembled at SLAC, ready for test in CW06/08	KEK, tested at SLAC
	T18_vg2.4_disk#3	11WNSDvg1Cu.3	TU	being machined, ready for test in CW20/08	KEK and SLAC
	T18_vg2.4_disk#4	11WNSDvg1Cu.4	TU	mechanical design approved	CERN
	TD18_vg2.4_disk#1	11WDSDvg1Cu.1	FS	under mechanical design	CERN
	TD18_vg2.4_disk#2	11WDSDvg1Cu.2	FS	RF design finished	KEK
	T28_vg2.9	11T26vg3DCu	TU	being machined	SLAC
	C10_vg2.25_thick#1	11CNSD2.3Cu.1	ES	RF design finished	SLAC
	C10_vg2.25_thick#2	11CNSD2.3Cu.2	ES	RF design finished	SLAC
	C10_vg0.7#1	11CNSD0.7Cu.1	ES	RF design finished	SLAC
	C10_vg0.7#2	11CNSD0.7Cu.2	ES	RF design finished	SLAC
	C10_vg3.3#1	11CNSD3.3Cu.1	ES	RF design finished	SLAC
	C10_vg3.3#2	11CNSD3.3Cu.2	ES	RF design finished	SLAC
	C10_vg1.35#1	11CNSD1.4Cu.1	ES	RF design finished	SLAC
	C10_vg1.35#2	11CNSD1.4Cu.2	ES	RF design finished	SLAC
	HDX11_vg2.x	11HDSQ2.xCu	FS	concept being refined	
	T18_vg2.4_quad	11WUSQ2.4Cu	TU	on hold	
	CLIC_G prototype structure*		FS		CERN
	Total number of structures for x-band tests: 20				
12 GHz	CLIC_G prototype structure* (structure to be defined at the latest in March 2008)		FS		Possible collaboration with CEA-Saclay

LEGEND			
FS:	Full structure, including HDS	ES:	Experimental structure
TU:	Tapered undamped structure	PS:	Prototype structure

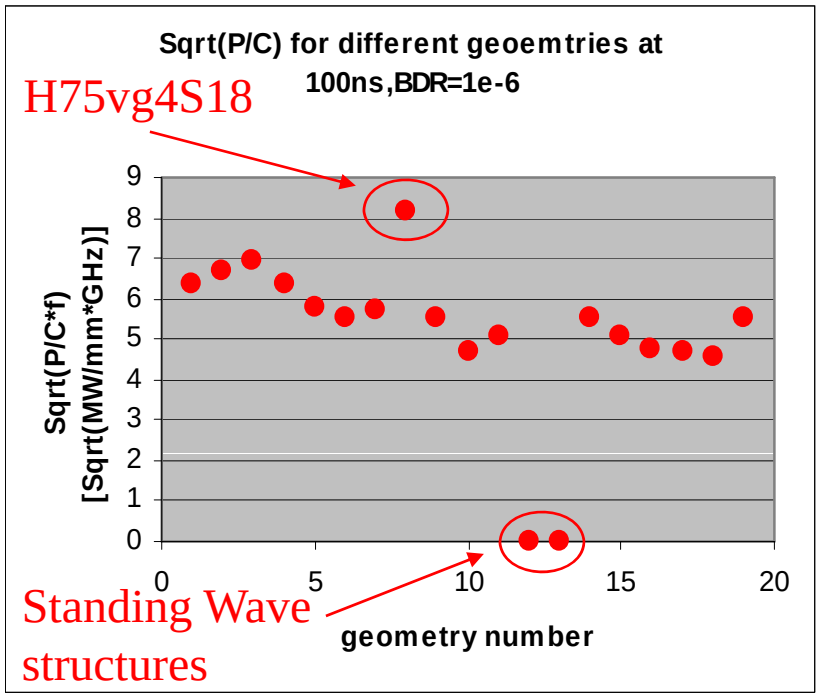
Structure Fabrication (2)

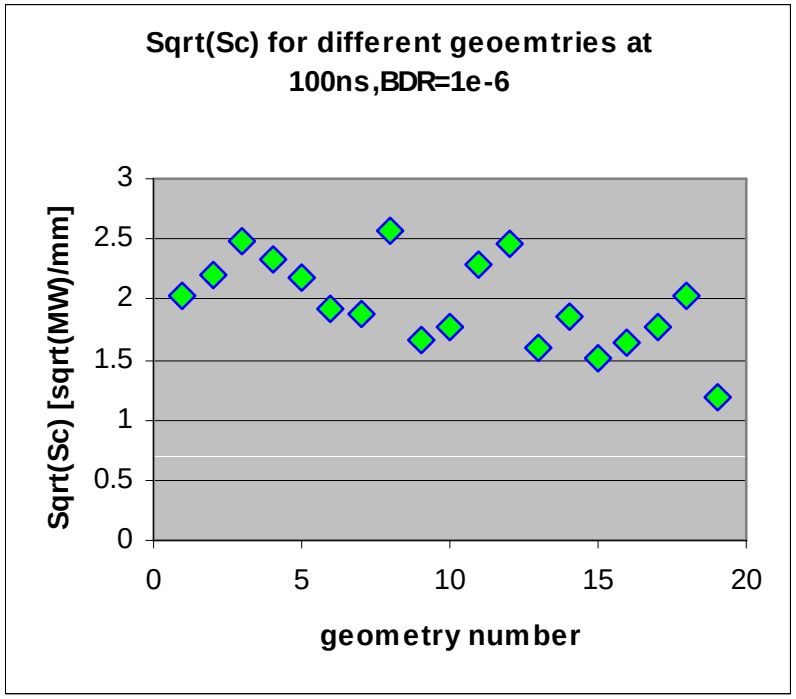
CLIC accelerating structures (from 2007)					EDMS# 844300 Last update: 08.01.08
Frequency	**Structure**		**Cat.**	**Status**	**Supplier**
30 GHz	C40_vg4.x_π/2	30CNSD1p2Cu	FS	tested in 2007	
	C30_vg4.7_W	W 2π/3 clamped	FS	available at CERN	
	Pulse heating cavity		ES	available at CERN	
	HDS11_vgx_Mo	30HDS11S_Mo	FS	available at CERN	CERN (IMTEC)
	HDS11_vgx_Ti	30HDS11S_Ti	FS	available at CERN	CERN (IMTEC)
	HDS4_vg2.6_thick#2	30HDS__TkCu.2	FS	tested in 2007	CERN (GREENFOX)
	HDS4_vg2.6_thick#1	30HDS__TkCu.1	FS	*available at CERN (HPR at Saclay done)*	CERN (GREENFOX)
	NDS4_vg2.5_thick#1	30CNSQ_TkCu.1	TU	available at CERN (damage on mid cell iris)	CERN (VDL)
	NDS4_vg2.5_thick#2	30CNSQ_TkCu.2	TU	tested in 2007	CERN (VDL)
	HDS11_vgx_Cu	30HDS11S_Cu	FS	available at CERN	CERN (IMTEC)
	NDS4_vg3.6_thin	30CNSQ_ThCu	TU	available at CERN	CERN (Megic)
	HDS11_vg2#1	30HDSR12_Cu.1	FS	being machined, delivered at CERN in CW09/08	CERN (VDL)
	HDS11_vg2#2	30HDSR12_Cu.2	FS	being machined, delivered at CERN in CW05/08	CERN (Unitek)
	C30_vg4.7_quad	30CNSQ2p3Cu	TU	available at CERN	CERN (Micron-Cluny)
	C30_vg4.7_sb	30CNSD4.7Cu	ES	mechanical design approved	Under bidding
	C30_vg2.6	30CNSD2.6Cu	ES	mechanical design approved	
	C30_vg8.2	30CNSD8.2Cu	ES	under RF design	
	C30_vg2_TM02	30CNSD2.0Cu	ES	mechanical design approved	
	HDS4_vg2.6_thick_Mo	30HDS__TkMo	FS	on hold	CERN (GREENFOX)
	NDS4_vg2.5_thick	30CNSQ_TkMo	TU	on hold	
	Bi-metal structure		FS	on hold	
	Total number of structures for 30 GHz tests: 18+3				
	Total number of structures: 38+3				
** proposal to be approved by the CLIC structure WG*					

LEGEND			
FS:	Full structure, including HDS	ES:	Experimental structure
TU:	Tapered undamped structure	PS:	Prototype structure

Models for Breakdown Limitations

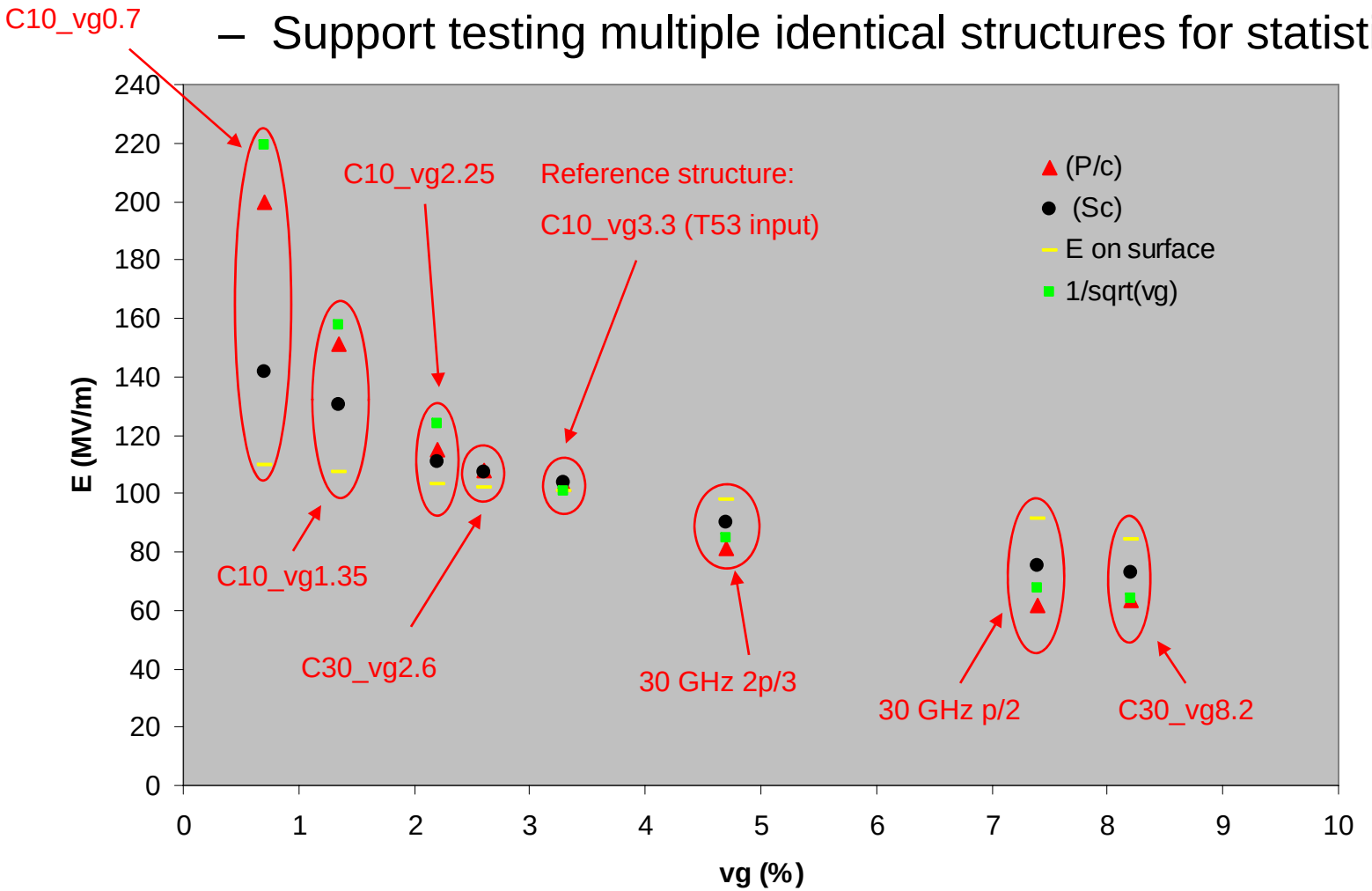
- Very good work on quasi-empirical breakdown models
  - Important to test this scaling to enable structure design optimization → ultimately will point to optimal NC structures
  - Good to understand differences between models experimentally





Test Structures for Breakdown Studies

- Important to study full range of C10 test structures
  - Support testing multiple identical structures for statistics

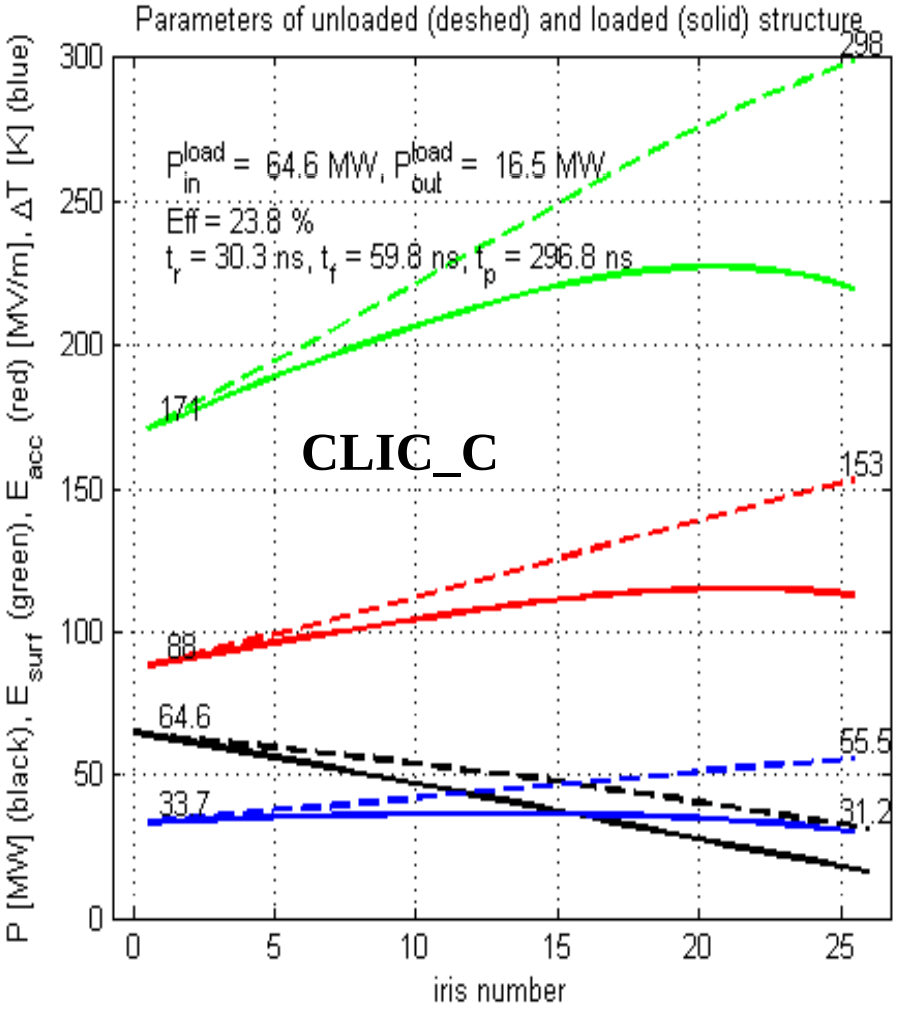


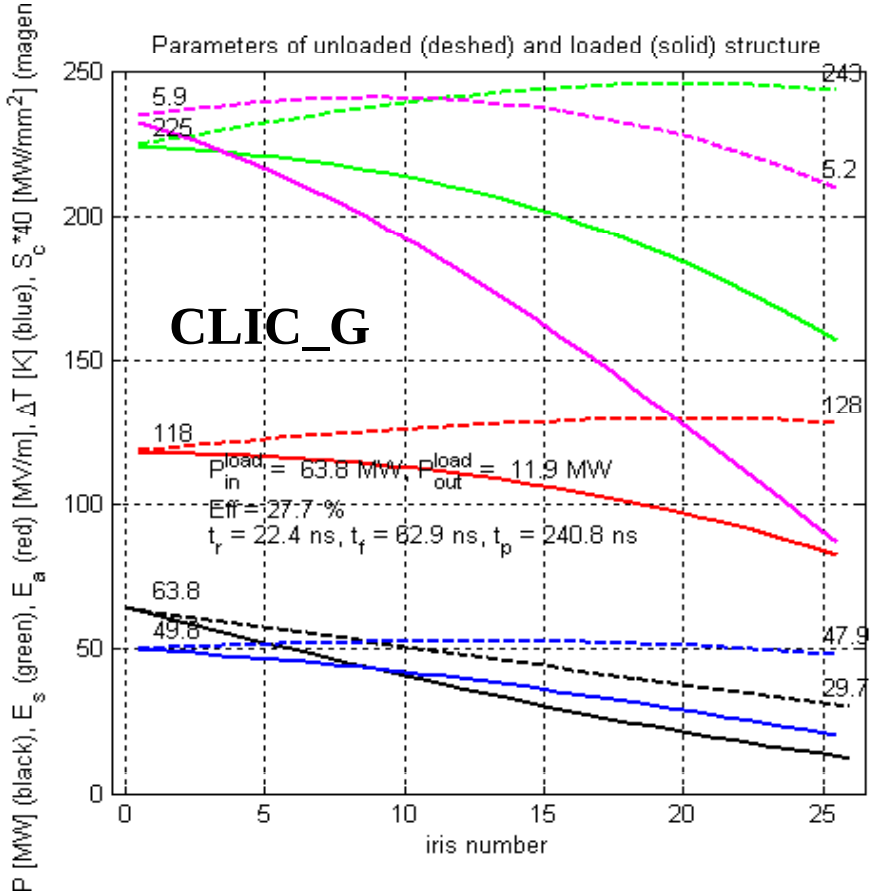
CLIC Demonstration Structure

- Concern that small changes in optimization led to significant changes in structure design
  - Need to work backwards from 2010 date and determine date to finalize ‘CLIC’ structure design – is 2010 a ‘hard’ date?
  - Demonstration does not need to be ‘final’ structure but want to demonstrate near CLIC parameters (difference between 90 MV/m and 100 MV/m would not seem too important)
- Main goals:
  - Loaded gradient ~100 MV/m
  - HOM damping at required level
- Work on setting appropriate expectations
- Worry about optimization convergence
  - Large differences between CLIC_C and CLIC_G
  - Need to consider all LC systems
    - Particular concern about 6 bunch spacing for CLIC_G

CLIC_C versus CLIC_G

- Think CLIC G is a better starting point but …





PETS and Drive Beam Comments (1)

- The PETS is very innovative design which operates in an unusual configuration
  - Some experience with CTF2 and CTF3 at 30 GHz
  - Very important to test fundamental and HOM performance
    - Concern that 'hidden' modes could have impact
- CLIC drive beam is ~100 Amps at 12 GHz with 1 mm bunches
  - No experience with beams like this anywhere in the world
    - Maybe sensitive to transitions, bellows, diagnostics, …
    - Can diagnostics accurately work with such a beam?
- Drive beam increases to fill PETS aperture
  - What is permissible beam loss
  - What is impact of field nonlinearities
  - What is the solution if BD effects are worse than planned

PETS and Drive Beam Comments (2)

- PETS on/off is also an innovative solution for the operational concerns
  - Still concerns about the viability of the approach. Have all other considerations been exhausted?
    - Are there partial solutions?
  - Experimental understanding of breakdown recovery is important to determine need for PETS on/off or other options
  - Glad to see inclusion of overhead in CTF3 testing capability
- Would like to see studies of beam dynamics in CTF3 that could be used to fully confirm HOM performance
  - Assess real sensitivity to PETS errors in CTF3
    - May require extensive high performance diagnostics
  - Are there effects (nonlinearities?) that could impact long CLIC PETS lines but not seen in CTF3?

Testing Program (1)

- Four elements of testing program: 30 GHz at CTF3, 11.424 GHz at KEK and SLAC, 12 GHz at CTF 3 and 12 GHz at new test stand.
  - Need to prioritize 11.424 GHz structure testing at SLAC and KEK due to possible limited availability
    - Balance between testing CLIC-like structures and doing tests to establish breakdown scaling
  - Important to establish 12 GHz test stand as quickly as possible (probably hard to meet 2009 deadline)
    - What about starting with 11.424 GHz klystron?
  - Good to complete the 30 GHz testing but may be less relevant and seems to require significant resources
    - Important to understand recent relatively poor performance of 30 GHz structures

Testing Program (2)

- Urge extended collaboration to complete TBTS laser system/injector to approach CLIC beam parameters
  - Very important to test two-beam system with as many CLIC-like parameters as possible
- Glad to see consideration of extension of TBL functionality
  - Would like to see further plans and how does this play into final demonstrations of two-beam technology?
- Did not hear about resource constraints but worry that there will be limitations
  - Would like to understand priorities and to understand how CLIC ACE might be able to help

Testing Program Beyond CTF3

- Suggest that thought be given to the testing & demonstration facilities beyond CTF3
  - What will be needed to firmly establish two-beam technology before LC construction?
  - Are there straight-forward upgrade paths for CTF3 to approach CLIC parameters
  - What is the correct frequency choice to engage the international community most effectively
- Would like to see timeline & milestones for path between present and a future two-beam linear collider
  - Great progress has been made but need to be realistic about timescales and ‘expectation’ management

Comments on CDR and CLIC Parameters

- New emphasis on project organization is good
  - Engineering support and EDMS are very nice additions
  - Need to bring engineering limitations to the design
  - Would be good to see organization chart with names
- Overall machine parameters and their ranges should be based on full systems consideration as well as rf optimization
- Developing CDR may require adding headroom onto R&D goals for reliability operation (operational ranges)
  - Maybe develop staged parameters for initial lower energy configurations with more aggressive upgrades to meet final specs – we heard about the start of such a study
- Engage international community to help with design to allow focus of main CERN effort on rf R&D goals

Final Comments

- Very impressed with CLIC effort
  - Large amount of progress over the last decade and last 6 months
  - Has the potential to offer a real path to multi-TeV e+/e- LC
  - Enthusiasm of the group is very refreshing!
  - Great to see young people engaged!
- CTF3 will address many of the critical issues
  - Need to understand limitations of CTF3 and what has to happen next in the testing / construction program
- Like to have the next meeting focused on beam dynamics and subsystem designs towards a CDR for 2010
  - Dates TBD but probably early summer
- Thanks to all participants!
  - CLIC team gave excellent presentations