Report from the 4th meeting of CLIC ACE

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Charge and Outline

The charge asked us to please comment on:

- A prioritized list of the most relevant CLIC technical issues and their classification by feasibility, performance and cost impact.
- The R&D status and plans to address the critical issues
- The R&D program and the schedule to complete a CLIC Feasibility Demonstration and a Conceptual Design Report
- A first proposal of technical objectives and planning for the Technical Design Phase in the years 2011 - 2015

Outline of report:

- Overall comments
- Comments on CDR / feasibility demonstrations
- Comments on TDR phase

Overall Comments

- Lots of progress since last ACE meeting
  - CTF3 operation
  - PETS testing
  - CDR organization
- Strong laboratory support was good to hear
  - Timescales for possible project are being clarified
- Would advise being very careful with costs!
  - Developing a cost 'aware' design is important
    - Doubt that there will be time for the iterations necessary to optimize the design → develop cost 'scale'
  - Laboratory guidance on cost treatment is important (Excel pie charts have data underneath them)

Overall Comments (2)

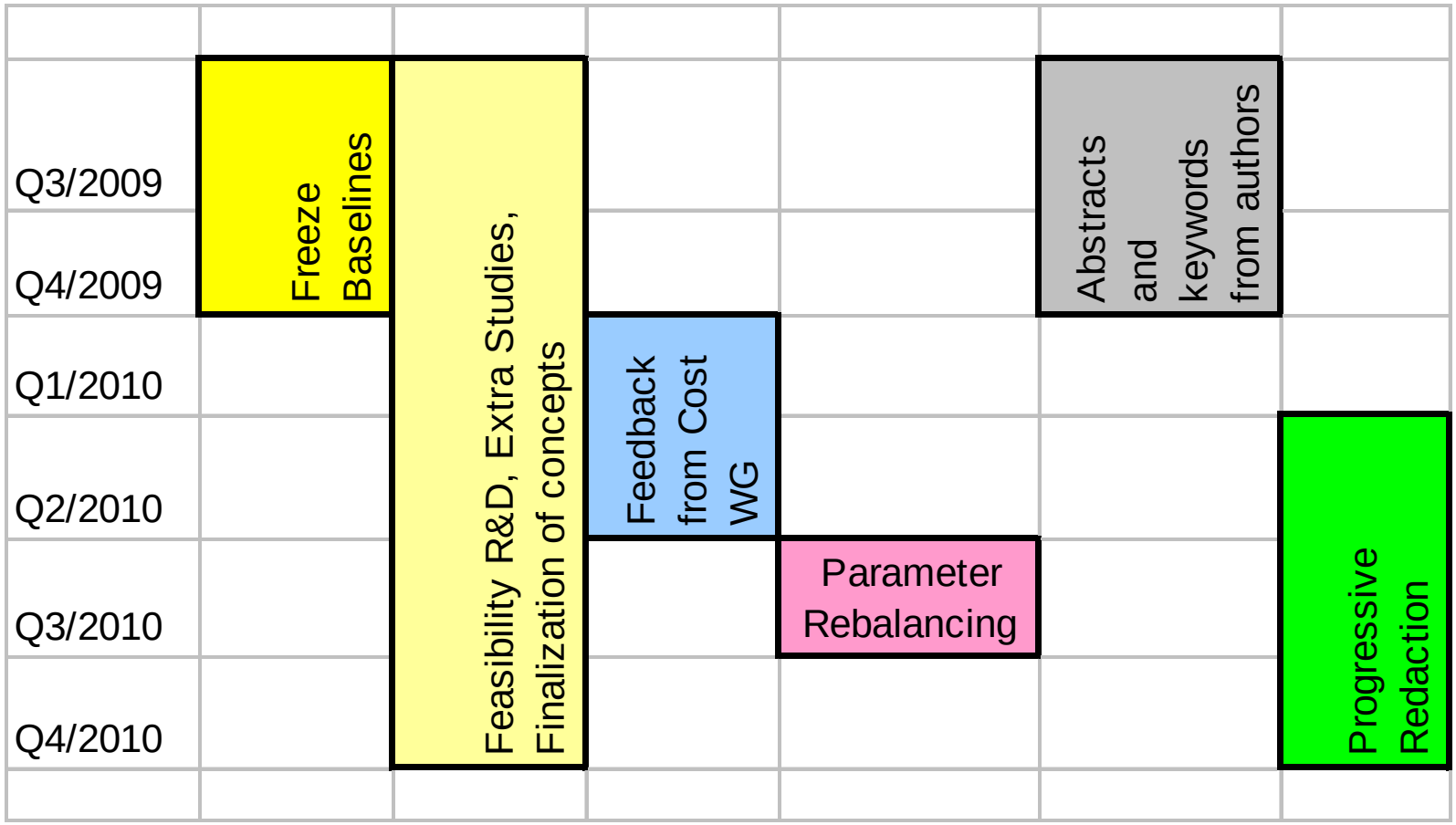
- Should understand audience for CDR
  - Need to define what is meant by ‘feasibility’
  - Sufficiently demonstrated for next level of support
  - Does community need convincing or just Council?
- Feasibility demonstrations can be divided into:
  - Technology, performance, and cost
- Technical feasibility (hardware demonstrations) appear to be on track
  - Need to clarify resource requirements
  - Many efforts at collaborating institutions
  - Concerned that both CERN and collaborators are stretched
  - Benefit from previous or parallel R&D programs

Overall Comments (3)

- Performance feasibility (especially luminosity) are more challenging
  - Large performance extrapolations will be required
  - Start developing arguments for feasibility of issues that cannot be directly measured on CDR timescale, e.g. DR performance … HOM in structures … positron source
  - Develop fallback options and understand parameter sensitivities
  - Engage larger community: ILC, LHC, SRS, …
- Consider CDR / feasibility schedule carefully
  - Not driven by external factors – important to have solid case
- Plan to engage international community in extended workshop post-CDR
  - Educate community and engage in planning for TDR

CDR Timescale

- CLIC Technical Committee putting together CDR plan



CDR Timescale

- The CLIC Technical Committee is developing plans and schedule for the CDR
  - Developing milestones and list of responsibilities
  - Has a list of critical demonstrations to be completed by end of 2010 and a set of ongoing tasks
- Committee agrees that most feasibility issues are addressed
- Concerned that a large task to complete by 2010
  - Requires combination of technical feasibility demonstrations, accelerator design, engineering studies
- Focus on CLIC-specific items as much as possible
  - CDR based on 3 TeV CLIC design
  - Provide a consistent ‘story’ for a 500 GeV initial phase

Feasibility Issues

SYSTEMS		Critical parameters
Structures	Main Beam Acceleration Structures: Demonstrate nominal CLIC structures with damping features at the design gradient, with design pulse length and breakdown rate .	100 MV/m 240 ns < 3·10-7 BR/(pulse*m) RF to Beam efficiency > 30%?
	RF Power production structures: Demonstrate nominal PETS with damping features at the design power, with design pulse length, breakdown rate and on/off capability	136 MW, 240 ns < 10-7 BR/(pulse*m)? Beam to RF efficiency >? On/Off < 20 ms
Two Beam	Two Beam Acceleration (TBA): Demonstrate RF power production and Beam acceleration with both beams in at least one Two Beam Module equipped with all equipments	Two Beam Acceleration with simultaneous & nominal parameters as quoted above for individual components
	Drive Beam Production	100 Amp peak current

Committee felt that this is an excellent list

Extensive detail behind each topics providing greater detail of feasibility demonstration for 2010 and future studies in early TDR period (2010-2012)

CTC list did not prioritize between programs

- Believe that this may be necessary

Accelerator Structure: Comments & Rec.

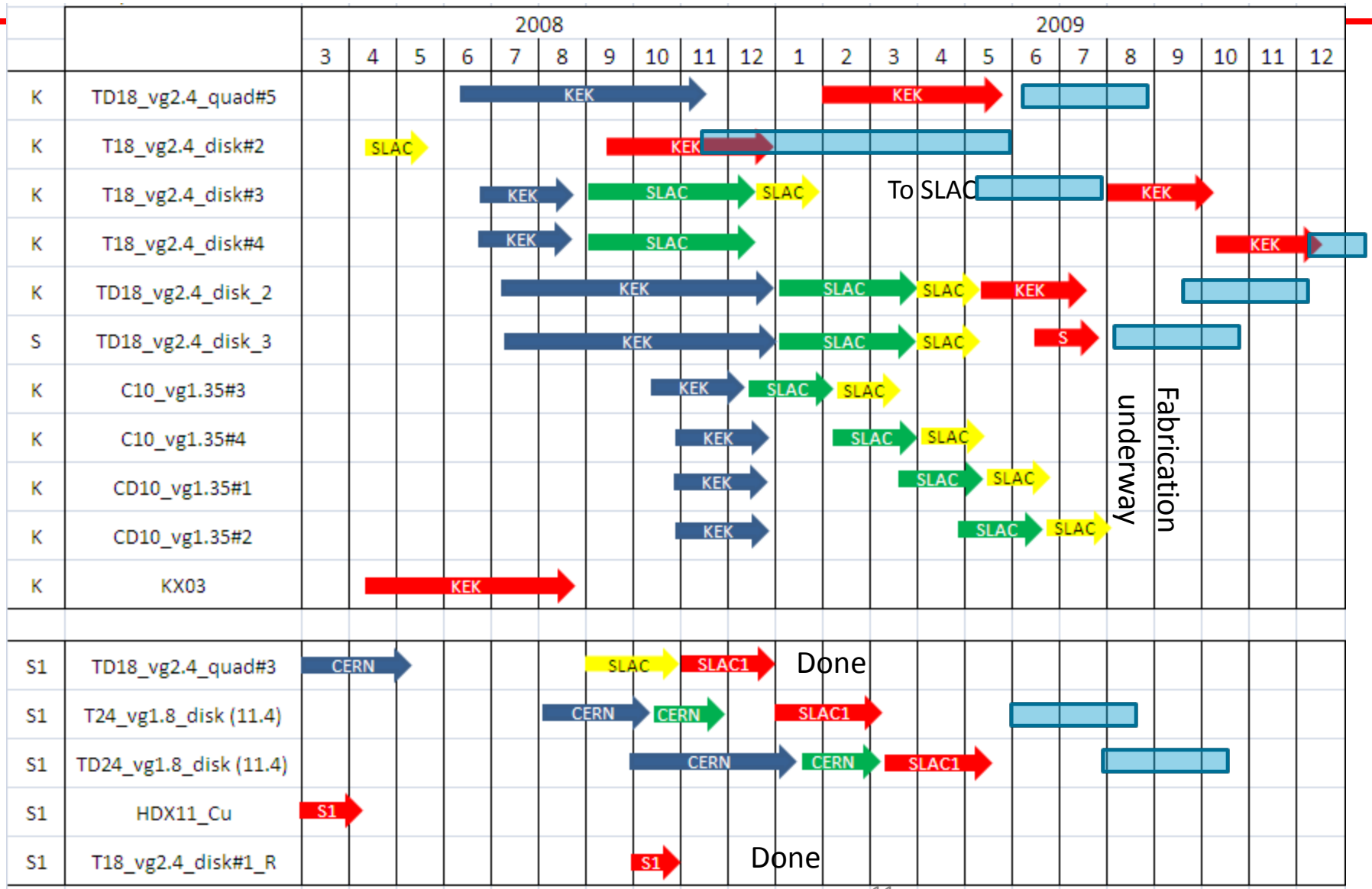
- Great demonstrations with T18 structures!
  - Would like to understand performance details further
  - Concerned that program is moving slower than planned
- Continued baseline using CLIC-G is correct for CDR
  - Post-CDR structure optimization will be possible after important benchmarking of scaling laws with C-10 structures
- Feasibility demonstration of TD structures reasonable
  - Relying on TD18 or TD24 waveguide damped structures
  - Agree that need at least a pair demonstrated for CDR
  - Are there contingency plans?

Accelerator Structures (2)

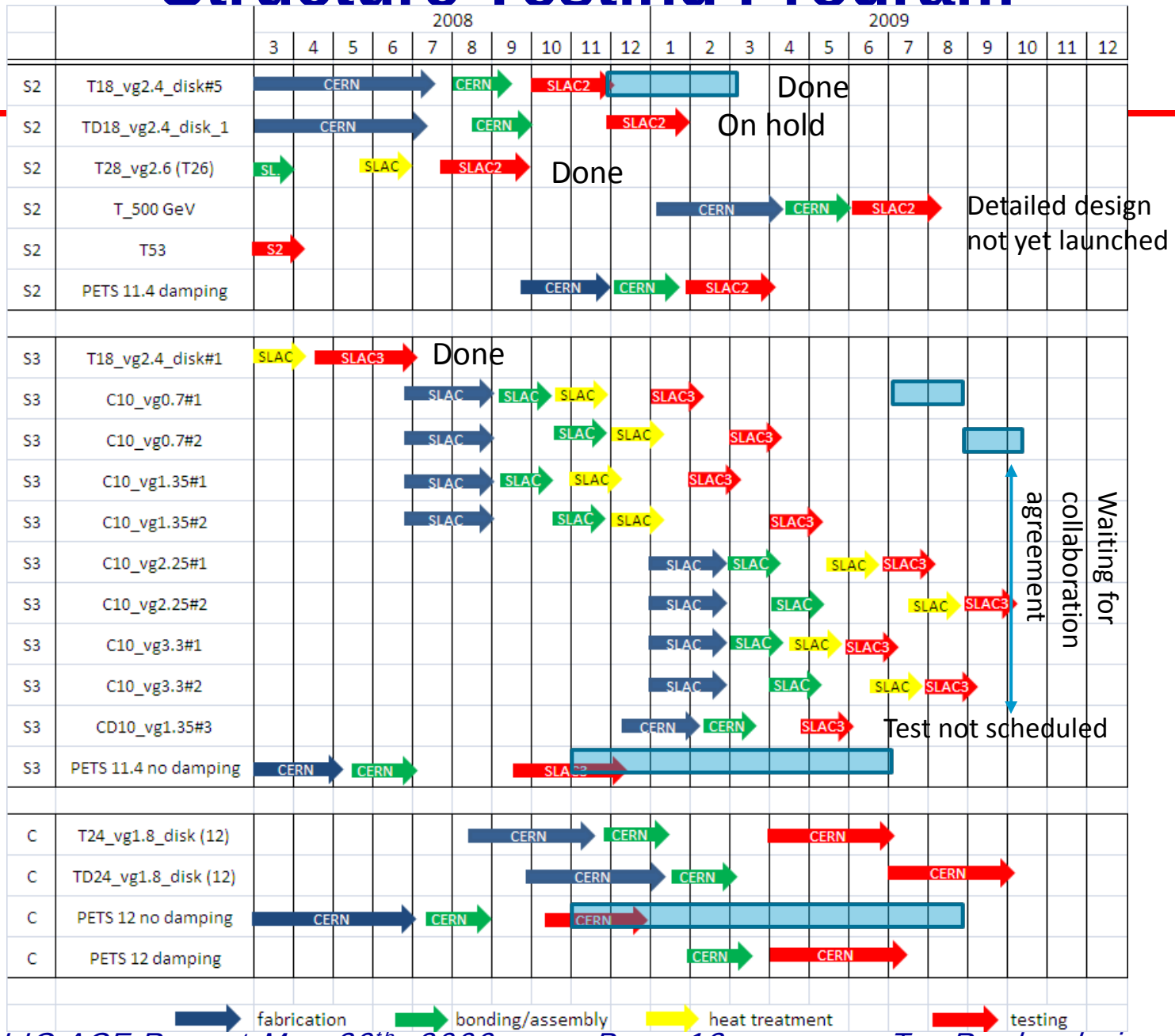
- Structure testing program is very aggressive
  - Relies heavily on external collaborators
  - Need coordination with collaborators to ensure timely testing
  - Parallel paths of ‘full’ structure demonstrations, C-10 studies, materials & breakdown studies and fabrication studies is good but may need to prioritize for CDR
- Should consider future beam HOM measurements
  - Wakefields related to both rf design and fabrication
  - Structure alignment measurements should be performed
  - Wakefield BPM is critical for luminosity
    - Have a plan development and testing
- Should establish CERN manufacturing capability by early TDR-timescale

Structure Testing Program

Currently active or scheduled testing time

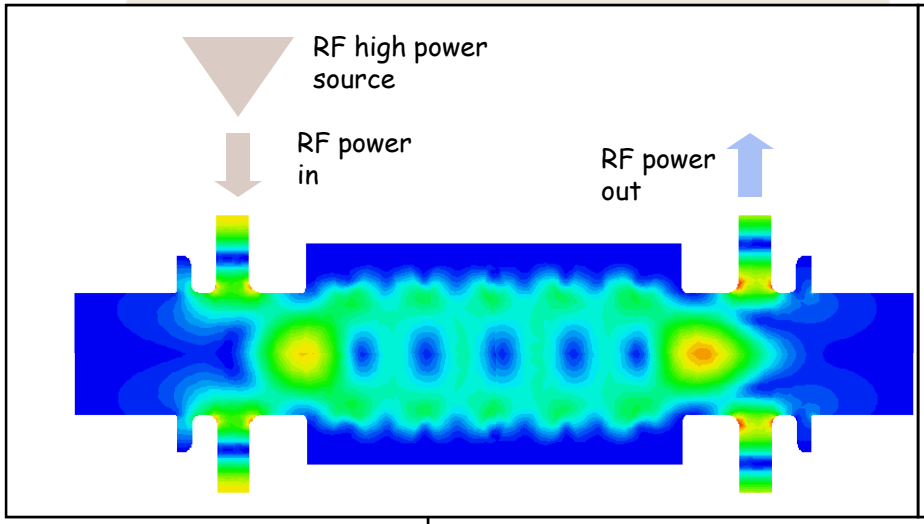


Structure Testing Program

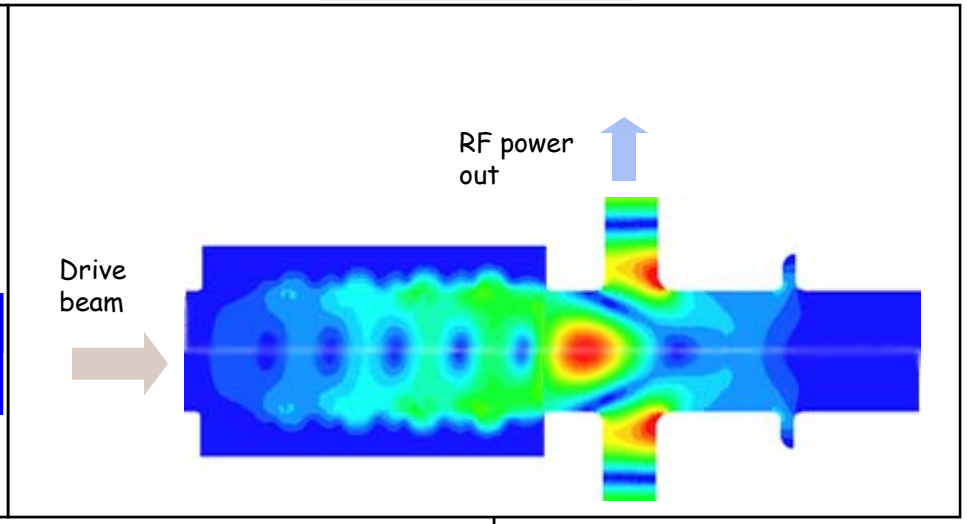


PETS Testing Plan
(Parallel paths)

External RF power source



Drive beam



ASTA (SLAC)

Objective: to understand the limiting factors for the PETS ultimate performance.

- Access to the very high power levels (300 MW) and nominal CLIC pulse length.
- High repetition rate – 60 Hz.

CTF3 (CERN + Collaborations)

Two beam test stand (CERN + Collab)

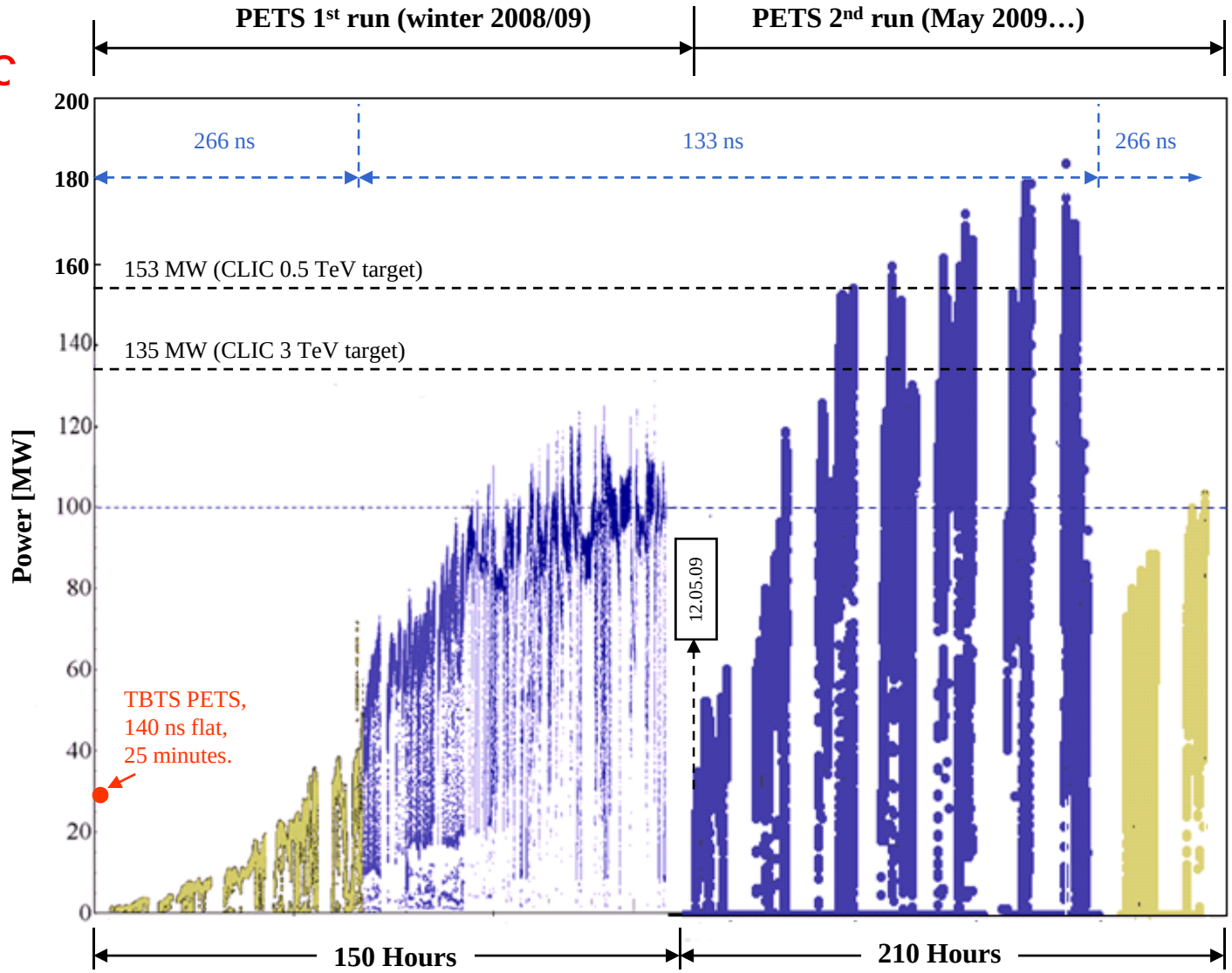
Objective: to demonstrate the reliable production of the nominal CLIC RF power level throughout the deceleration of the drive beam.

Test beam line (CERN + Collaborations)

Objective: to demonstrate the stable, without losses, beam transportation in a presence of the strong (.50%) deceleration.

Power Extraction Structures (PETS)

- Fantastic results!
- Previously considered PETS a significant risk



PETS Comments

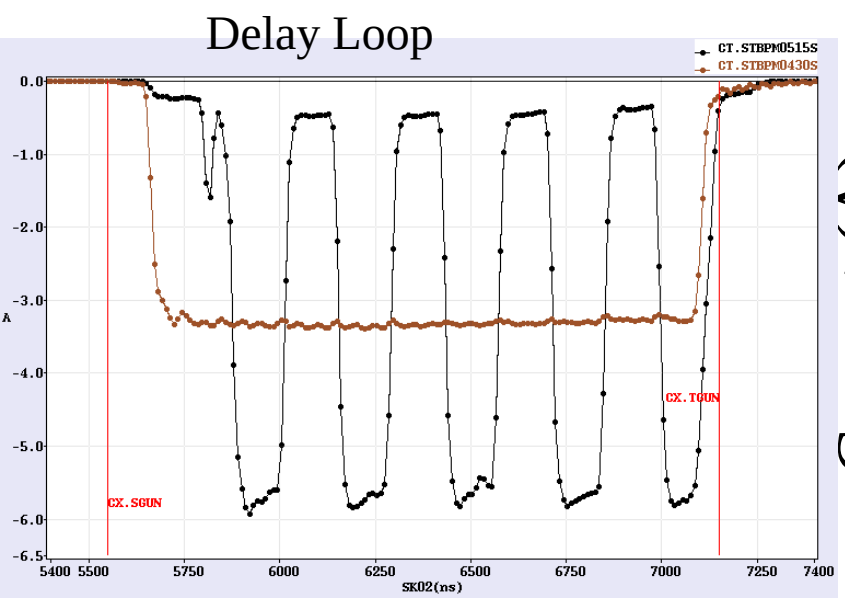
- Support combined approach to PETS demonstration
  - Both RF and beam testing programs
- Two efforts depend on CTF3: high and low current
  - Prioritize CTF3 program – CTF3 required for many studies
- New PETS on/off concept seems very attractive
  - Would like to see early demonstration
- Compare rf measurements with tolerance studies
- Would like to see HOM benchmarking studies
  - Beam tests using rf probes (installed in TBTS PETS) which are compare against simulations
  - Direct beam verification on longer TDR-timescale

Two Beam Acceleration

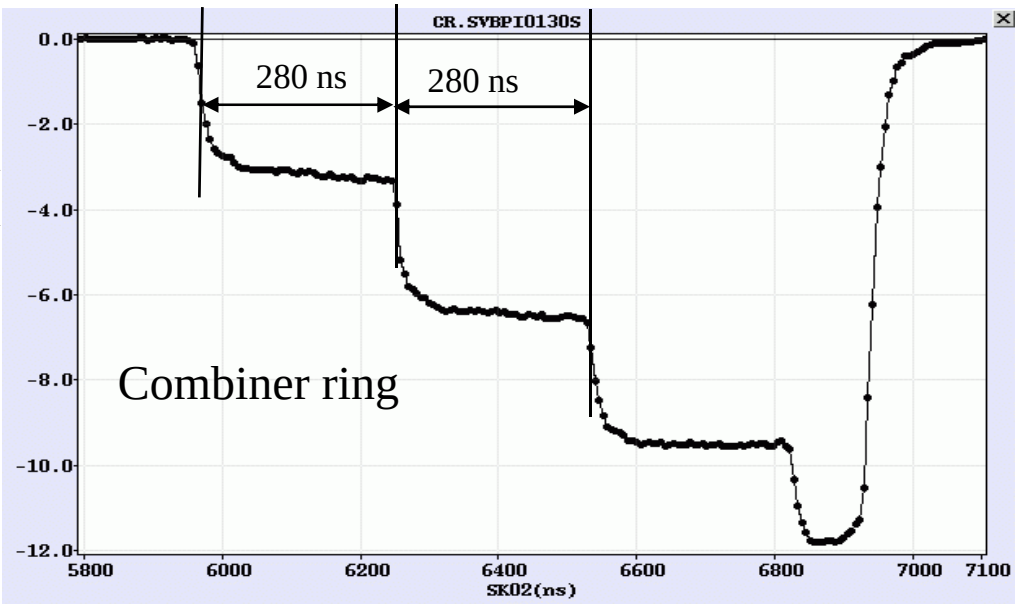
- Feasibility demonstration requested as part of 2003 TRC
- Proposed to use 1 PETS → 1 structure (or 2?) in TBTS
  - CTF3 with 28 Amp, 140 ns → ~240 MW >> 135 MW required
    - Important to study performance at higher power
  - Upper bound on breakdown limits (established with rf testing)
  - Prototype CLIC Two Beam Module with interconnects etc
  - Measure beam loading compensation & breakdown kicks
- Committee has a number of concerns:
  - Requires commissioning all CTF3 systems
  - Significant risks however need to complete the demonstration
  - Would urge leaving sufficient commissioning time for successful demonstration

Drive Beam Generation

- CLIC drive beam is specified ~2 GeV, 100 A & 240 ns
  - CTF3 is designed to deliver 150 MeV, 30 Amps and 140 ns
  - CTF3 will provide a critical feasibility demonstration
- Past demonstration of delay loop and combiner ring illustrate feasibility of achieving CTF3 design parameters
  - However still need to put it all together



Current (A)



Drive Beam Generation (2)

- Injector issues
  - Bunches are phase coded by switching the SHB phase
  - Significant satellite bunches that limit CTF3 operation and would limit CLIC operation
  - Design studies of alternate options such is photo-injector
    - Improved demonstration not necessary for CDR
- Very impressive $\Delta N/N$ and $\Delta E/E$ performance at CTF3
  - Still concerned about the whole system-wide sensitivities
  - Would recommend a comprehensive list of all drive beam tolerances and physics limitations – may just be presentation
- Demonstrate diagnostics and perform measurements at CTF3 where possible
  - Diagnostics and feedback will be critical for CLIC
- TBL demonstration important but TBTS higher priority

CTF3 Test Facility

- CTF3 is the primary demonstration of the Two-Beam Acceleration concept
  - Many achievements thus far:
    - Fully loaded acceleration
    - Frequency multiplication (delay loop and combiner ring)
    - Delivered beam to TBTS
    - Commissioned CALIFES
    - Identified and fixed stability limitations
- Large scale and complex test facility
  - Largest and most complex linear collider test facility
  - Difficult to commission and operate and limited by small group
- The full CTF3 experimental program is very ambitious but important for CDR

CTF3 Recommendations

- Support from control room staff very valuable to maintain operational status
- Would urge increased effort to support experimental program
  - Will need to operate and optimize many separate systems
  - Is there additional support from the CTF3 collaboration?
- Develop schedules and priorities to balance operating R&D and commissioning programs
- Consider real operational performance as compared to demonstrations; set expectations

Beam Physics Comments & Rec.

- Developing fairly complete concept designs for subsystems
  - Very broad set of topics
- Many issues that will require significant extrapolations
  - Committee largely agrees with topics identified by CTC
  - One of the most challenging issues for any future LC
- Important to develop broad arguments supporting extrapolations and get international community feedback
  - Much of the present state-of-the art is at photon sources
  - Would be useful to show luminosity factors versus present state
- Concerned that there is too much to do!
  - Committee would urge focusing on most critical issues and scaling or adopting as much as possible from other designs

Subsystem Comments (1)

- Injectors
  - Beam current and stability challenges
  - Scaling from existing designs may be sufficient
- Damping rings
  - Many challenges: IBS, collective effects, RF, vacuum, …
  - Great progress in developing optics over last year
  - Complete optics and develop concepts for RF and vac.
    - Committee less concerned about kicker requirements
- RTML
  - Good progress putting together system and simulations
  - Concern that complete system becomes large & expensive
    - Iterate with cost/engineering early

Subsystem Comments (2)

- Main Linacs
  - Many studies defining tuning and stabilization requirements
  - Main concern is technical and instrumentation needs
  - However tolerances are tight and will be a visible flag
  - Real beam tests are not possible but consider how to support extrapolations
- Beam Delivery System
  - Good development with strong ILC collaboration
  - ATF2 experience and extensions will be important
- Functional requirements are well established however important to optimize combined LC systems
  - i.e. trade difficulty between damping rings and bunch compressors; length of BDS versus length of linac; …
  - Mechanism for balancing and iteration not transparent

Stabilization Issues

- Beam feedback
  - Large global systems
  - Technical challenge but not feasibility issue
- Mechanical stabilization tolerances are very tight
  - These are critical demonstrations
  - Worried that progress has been slow
  - Gain factors of 100 are quite large for complex fdbk systems
- Complete finite element simulations of CLIC Module
  - May want to consider further refinement to reduce vibration
- Concerned about 2 Angstrom final doublet req.
  - Strongly encourage consideration of multiple approaches including tolerance rebalancing, FFS design, intra-train feedback, and detector modifications

Operation, Availability and MPS

- Important to consider these issues as part of CDR
  - Great to see this effort started
- Reliance on passive systems for fast main beam faults
  - Passive survival for both energy and transverse errors?
  - Similar requirements for drive beam?
- Important to develop catalog of operating and possible failure modes
- Loss simulations are important and should be supported
- Availability studies important to understand cost implications and operational limits

CLIC Collaborations

- Have developed strong collaborations world-wide
  - CTF3 collaboration
  - CERN / KEK / SLAC high gradient collaboration
  - Growing important CLIC - ILC GDE collaboration
  - Other CLIC design collaborations:
    - Darsebury; Jlab, …
- Continue to work with collaborators
  - Overall effort needs to grow and collaborators provide a path
    - Requires careful management to maintain focus
    - Supporting collaborators require effort
  - Mobilize the CTF3 collaboration for increased participation in operating the test facility

Planning for TDR-Phase

- Initial thoughts were presented on post-CDR program
- Possible for a strong CERN program (3 ~ 4x present)
- Consideration of pre-construction demonstrations
  - Very hard to demonstrate CLIC ‘rf unit’
    - ~700 meters of TBA linac
  - Challenging to even demonstrate CLIC drive beam hardware and beam dynamics
    - 100 A and 240 ns drive beam
- Must balance between completing broad design and demonstrating near-final drive beam linac hardware
  - Ongoing discussion that should engage international community pre- and post-CDR

Final Comments

CLIC team should be strongly congratulated for strong effort and great progress!