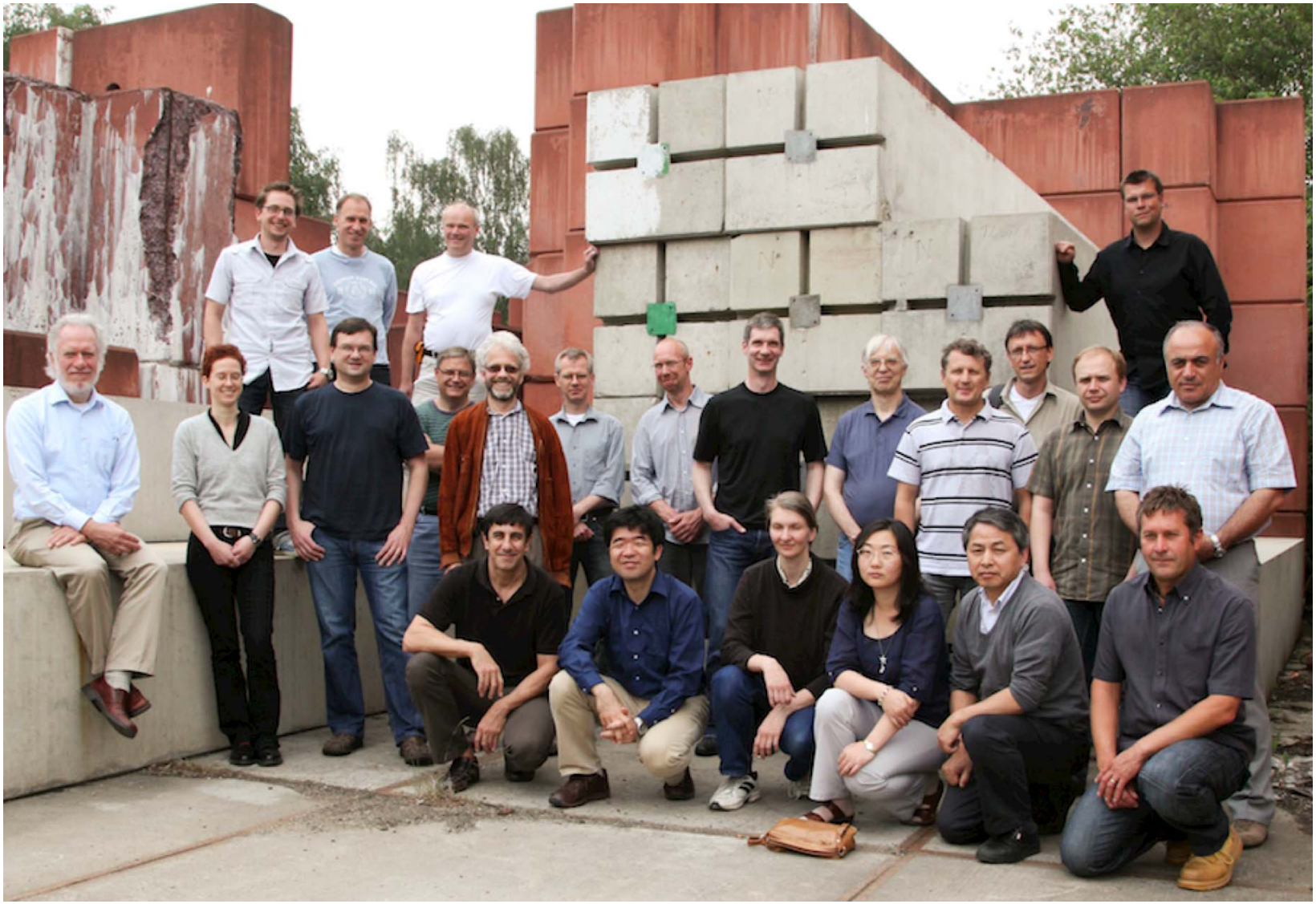
9mA program update

John Carwardine

Global Systems Webex meeting, 31st August 2011

- LBT Workshop
- FLASH Beam Allocation Committee (9th Sept)
- Extrapolating to 9mA high gradient…?
- NML studies on CM1 in support of 9mA program

2nd Workshop on Linac Operations with Long bunch-trains



2nd Workshop on Linac Operations with Long bunch-trains

https://indico.desy.de/conferenceOtherViews.py?view=standard&confId=3007

- 6-8 June at DESY
- 40 participants (incl. 10 from ILC/GDE, 2 from STFC)
- 38 presentations (available from the workshop website)

- Five main themes:
  - **Results and analysis from the 9mA studies**
  - **Toward future 9mA studies**
  - **Operations modes for FLASH2**
  - **Feedback and control of longitudinal phase space**
  - **Machine protection for long bunch-train operation**

Long bunch-trains workshop report

- We distributed a ‘final draft’ of the report to the workshop participants this week for their comment
  - **~30 pages with figures**
  - **Includes a list of 21 specific follow-up items**

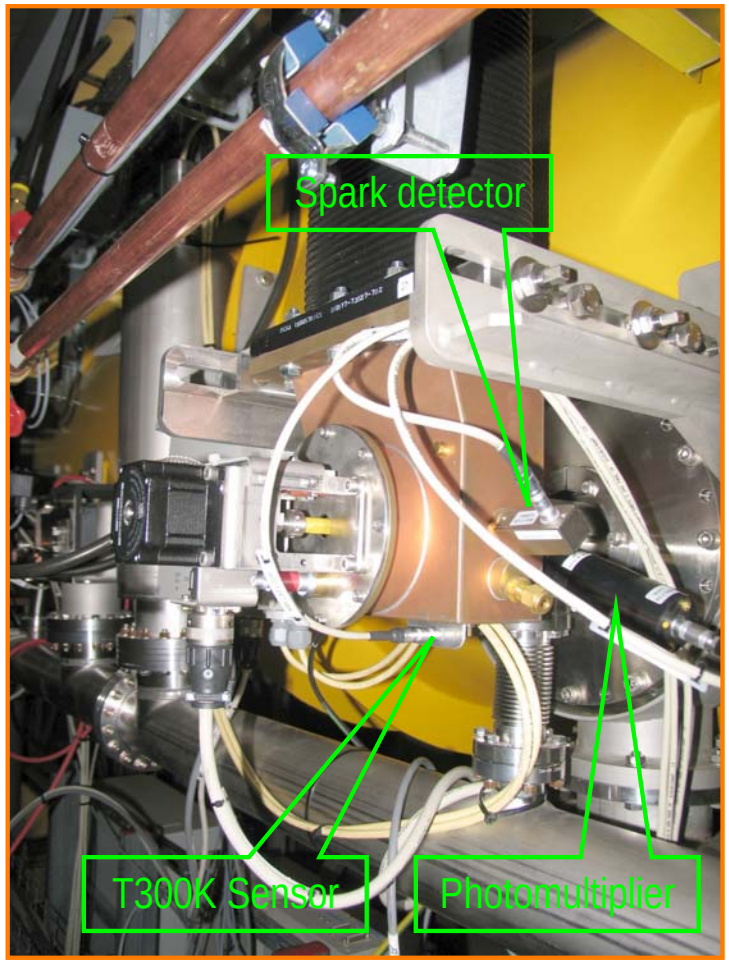
- Report draft is available from the LBT workshop website:
  https://indico.desy.de/conferenceOtherViews.py?view=standard&confId=3007
  - **Comments are being accepted until 6th Sept**
  - **Final report will be released as a DESY ‘M-Division’ report and as an ILC report**

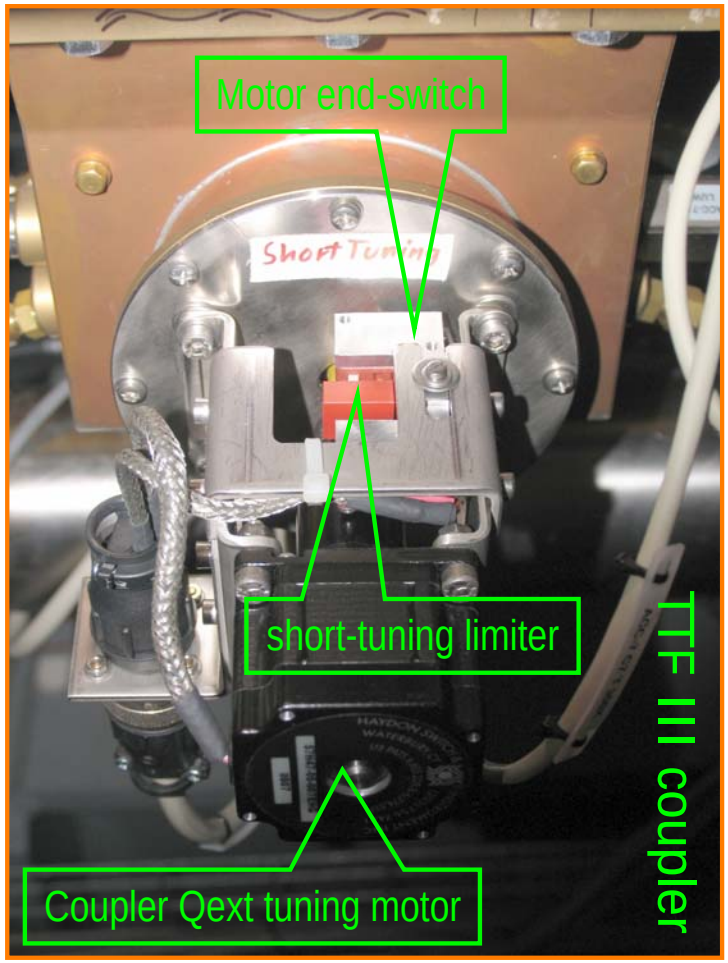
Some identified issues and follow-up items

- Thermally related changes in Loaded-Q
- Widen the Loaded-Q adjustment range
- Quantify cavity misalignments by correlating beam trajectory with changes in cavity detuning
- Issues with online measurement of cavity detuning
- Methodology for reaching full current / full pulse length
- Criteria for measuring cavity operational gradient limits

Restricted adjustment range of Loaded-Qs... solved?

ACC7 / Module PXFEL1 coupler



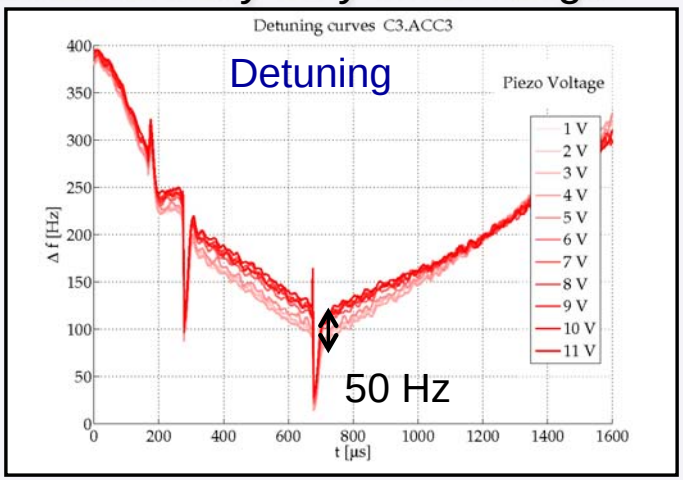


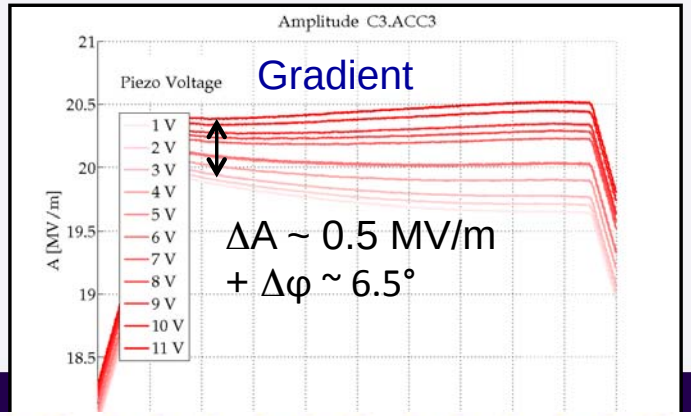
D. Kostin

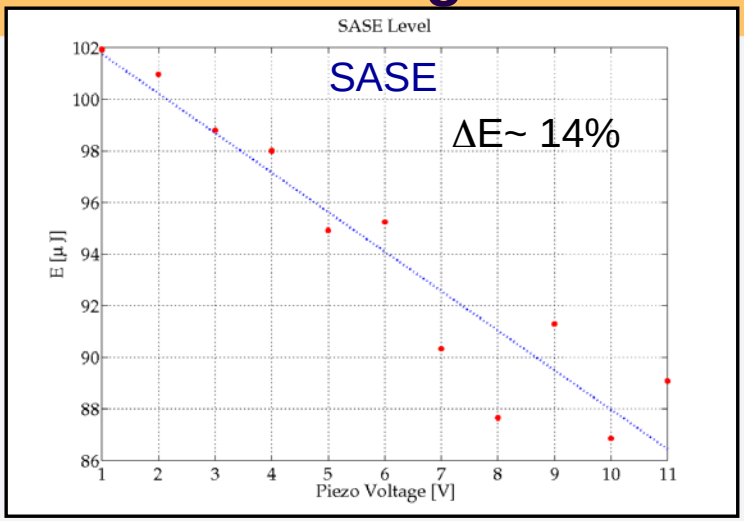
Orbit changes due to misaligned cavities and changes in detuning

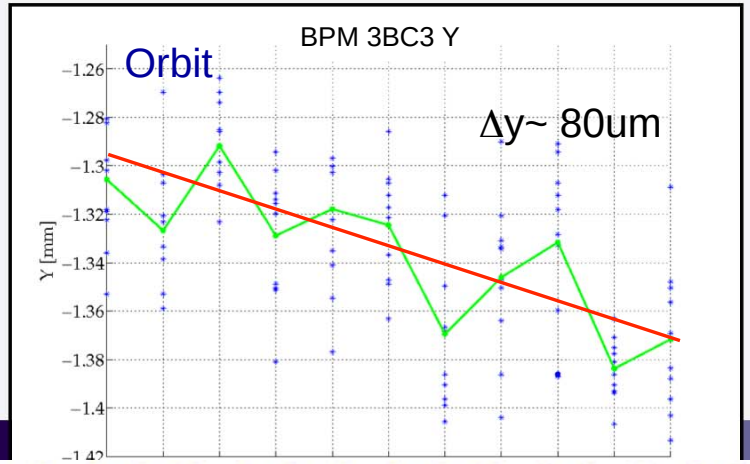
Motivation: flat gradients => orbit changes

Unfortunately very small range:

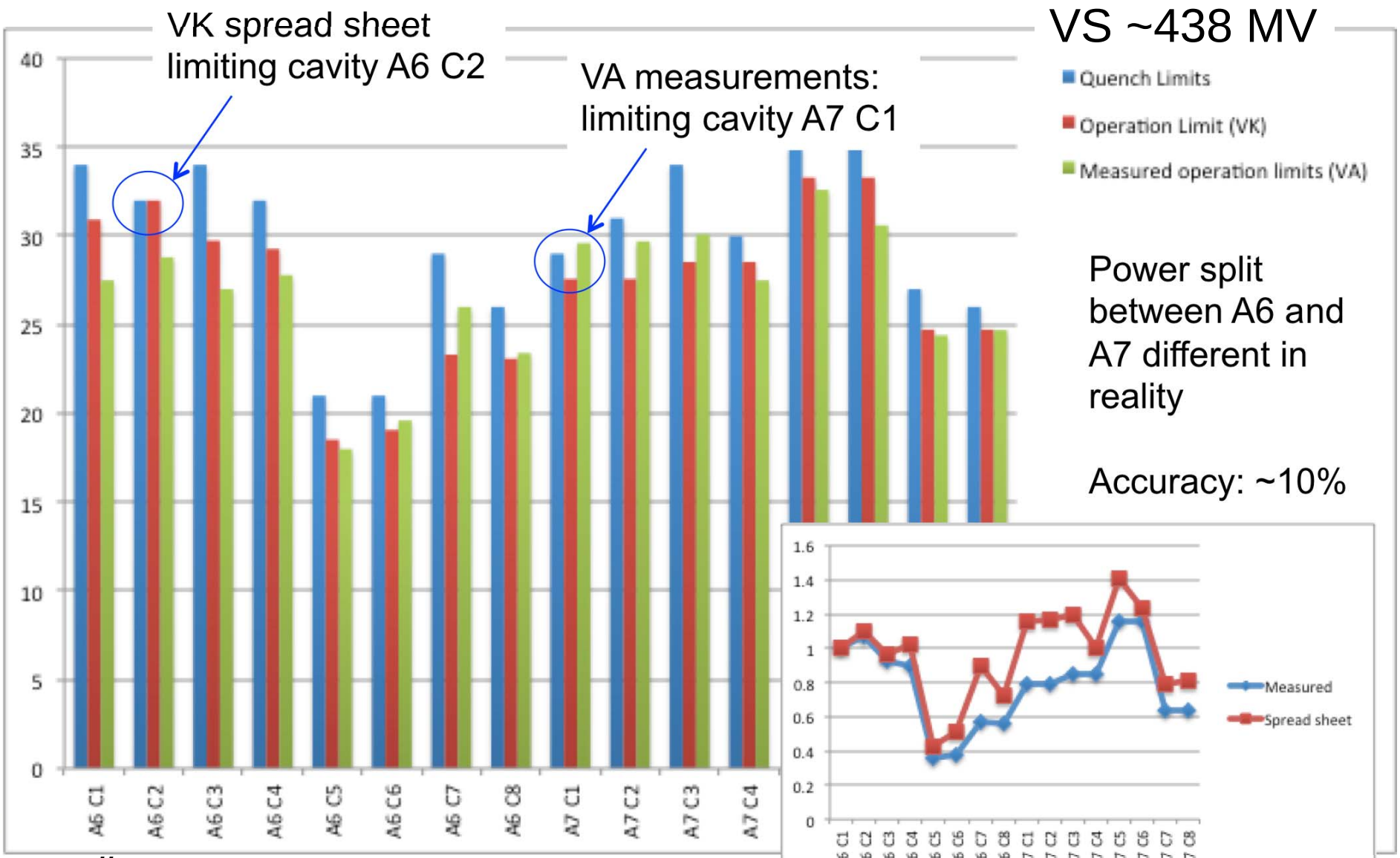








Experimentally determined operational limits



N. Walker

What do we mean by operational gradient limits…?

- Test stand single-cavity gradient (breakdown) limits are defined to be the gradients at which (first of these):
  - **Onset of cryo instability (LHe pressure/level)**
  - **Loaded Q drop by some 10% (flat-top breaking)**
  - **Sharp increase of cryo-losses to >5W per cavity.**
  - **High field emission (gamma radiation increase)**

- Operationally, three additional issues to take into account:
  - **CALIBRATION!!!**
  - **Time-dependence of the onset of a quench: if a quench occurs 500us into a pulse, can we run at higher gradients with 400us pulses…?**
  - **Effect of Vector Sum control: total voltage from module can be stabilized even during the onset of a quench**
- *How do these factors impact operational gradients…?*

FLASH schedule

- The present FEL studies campaign ends mid Sept 2011
- FLASH shutdown: mid Sept to ~January
  - **Primary driver: preparatory civil work for FLASH-II beamline installation**
  - **Secondary items include installation of new uTCA-based LLRF control systems (XFEL prototypes)**
- Accelerator studies will begin immediately after shutdown and will continue to ~March/April (date TBD)
- Next FEL studies campaign starts in ~March/April

- FLASH Beam Allocation Committee meets on 9 Sept
  - **Develop top-level schedule for FEL campaign (2012-2013)**
  - **Schedule for next 9mA studies will be discussed**

Proposal to BAC for next 9mA studies

- Up to now, we had assumed we would only get one more block of 9mA studies shifts before the end of 2012
  - **During accelerator studies period in first quarter of 2012**
- But we don't want our studies to be immediately after a major shutdown when new hardware is being debugged

- An alternative proposal for **two** one-week blocks has been discussed and will be presented to the BAC on 9th Sept:
  - **First block: end of Q1 just before start of FEL User op.**
    - This would be with 800us ≤6mA as previously discussed
  - **Second block: probably in Sept/Oct timeframe**
    - Maybe revisit the feasibility of operating at ≤9mA *(at higher rep rates, lower charge??)*
  - **If approved, would be very positive for the 9mA program**

Preparing next studies… Achievements to date

High beam power and long bunch-trains *(Sept 2009)*

Metric	ILC Goal	Achieved
• **Macro-pulse current**	6mA 9mA	9mA
• **Bunches per pulse**	2400 x 3nC (3MHz)	1800 x 3nC 2400 x 2nC
• **Cavities operating at high gradients, close to quench**	31.5MV/m +/-20%	4 cavities > 30MV/m

Gradient operating margins *(Feb 2011)*

Metric	ILC Goal	Achieved
• **Cavity gradient flatness (all cavities in vector sum)**	2% $\Delta V/V$ (800μs, 9mA)	2.5% $\Delta V/V$ (400μs, 4.5mA) *"Methodology established"*
• **Gradient operating margin**	All cavities operating within 3% of quench limits	*(Focus of early 2012 run)*
• **Energy Stability**	0.1% at 250GeV	<0.15% p-p (0.4ms) <0.02% rms (5Hz)

Achievements relative to top-level goals: what's left?

- Demonstrate principles of tailoring Pks/Qls to flatten cavity gradients with beam loading

Done!

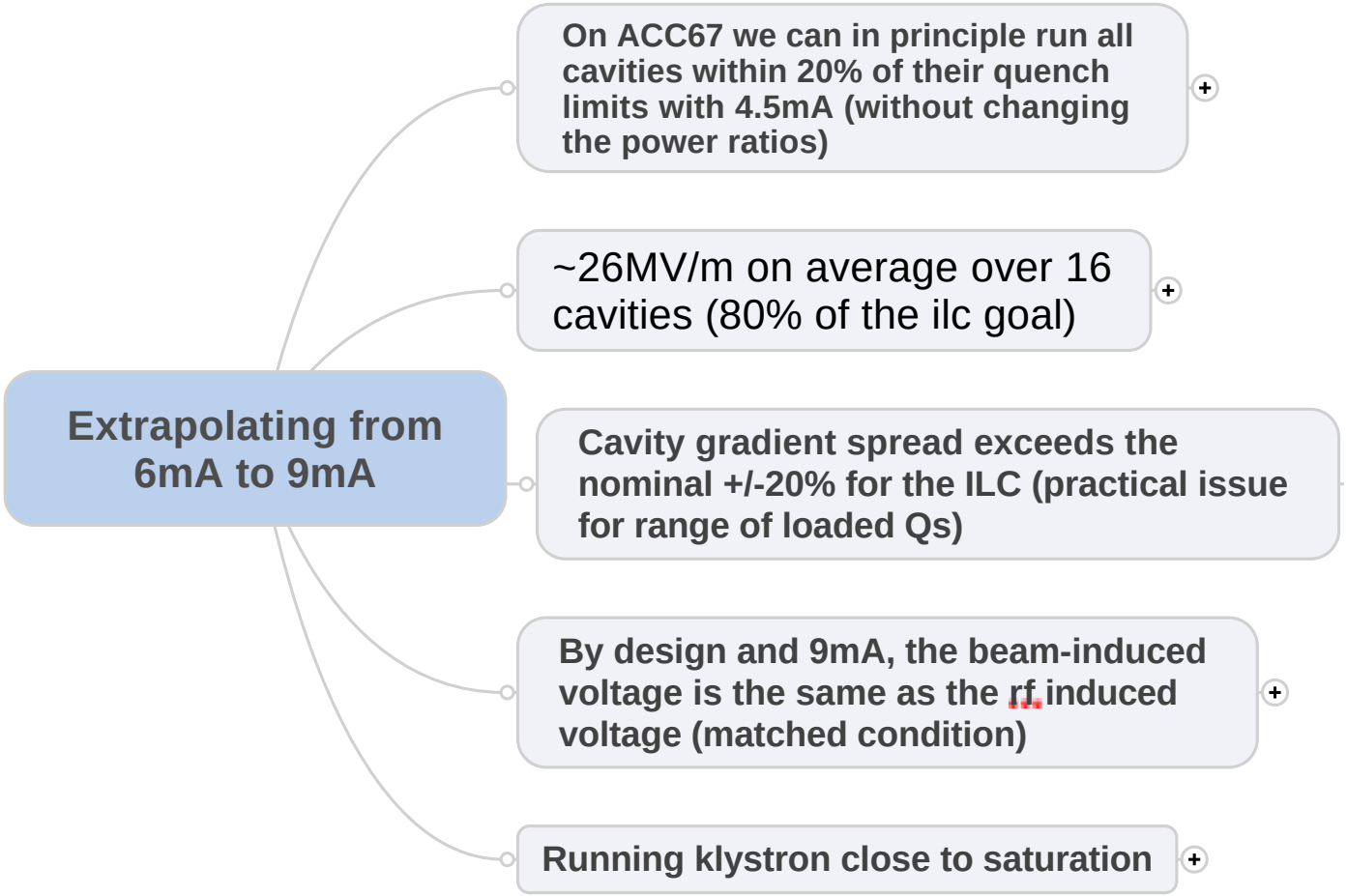
- Module operation close to quench with ILC-like gradients & gradient spread and ILC-like beams

Significant progress

- Next logical steps
  1. **Flatten gradients on all 16 cavities with 6mA / 800us bunch-trains, including**
     - Better control of systematic errors
     - Automated procedures for Pk/Ql optimization
  2. **Operation of all 16 cavities within a few percent of quench with 6mA / 800us bunch-trains**

Preparatory studies at NML...?

TDR topic: extrapolating to 9mA…?



Musings… (to be explored, elaborated,…)

- If we want to emulate 9mA running at 4.5mA, does this mean that running within 3% of quench at 9mA translates to running within 1.5% of quench at 4.5mA?
  - **Or at least that we can control the tilts twice as well)**
- The 'bootstrap' issue of getting from zero beam loading to full beam loading at full gradient without quenching
  - **Will get harder as we go up in gradient and current**
- If we run two cavities within few percent of quench (maximum extent of the gradient spread above and below the vector sum), can we show mathematically that we've effectively demonstrated we can do it for all conditions?

Central themes for future 9mA webex meetings

- Analysis of Feb 2011 studies data
- NML studies in support of 9mA program
- Modeling and simulation work
- Follow-up items from the LBT workshop