

Report on the 9mA program

John Carwardine
13th April, 2011

- **Parallel session on 9mA studies at ALCPG, four presentations:**
 - Carwardine: Results of the 9mA studies in Feb 2011
 - Grecki: Detuning compensation during the 9mA studies
 - Branlard: Results from 9mA studies on achieving flat gradients with beam
 - Chase: preparing for future 9mA studies
- **Data Acquisition System access / analysis**
 - Enhanced data browsing tool: beta version was released to a small group for testing
 - Working on setting up a mirror for the 9mA studies data at either Fermilab or Argonne to give more convenient access for data analysis
- **Long Bunch-trains Workshop has been announced (at DESY, 6-8th June)**
- **Only two additional 9mA studies periods are likely before the end of 2012 (Spring and Autumn 2012)**
 - Assessing progress towards the TDP R&D Goals for 9mA studies...

Long bunch-trains workshop: June 6-8th at DESY

- **The '9mA' programme remains a central theme of the workshop, but in keeping with the broader issues of the challenges of operations with long bunch-trains and the spirit of the first meeting, this workshop will also focus on specific issues relevant to FLASH VUV-FEL and future European XFEL operations**
- **Unlike the first workshop, this meeting will be entirely plenary with no parallel working groups**
- **The time will be divided into sessions dedicated to the following themes:**
 1. Results from 9mA studies on controlling cavity gradient slopes
 2. Preparing for future 9mA studies
 3. Feedback control of longitudinal phase space
 4. Concurrent operation modes for FLASH and FLASH2
 5. Machine protection for long bunch-train operation
 6. Beam-based feedback and rf field-control

Tentative timetable for Long Bunch-trains workshop: (at DESY, June 6-8, 2011)

	Monday	Tuesday	Wednesday
09:00 – 10:30	<i>DAQ tools tutorials?</i>	Feedback control of longitudinal phase space	Machine protection
11:00 – 12:30	<i>DAQ tools tutorials?</i>	Feedback control of longitudinal phase space	Concurrent modes for FLASH and FLASH2
14:00 – 15:30	Opening Session (13:30 – 15:30) <ul style="list-style-type: none"> •Welcome (10min) •Long bunch train operations at FLASH (40min) •Photon science operations with long bunch trains (20min) •Scope/Goals for WS (20min) 	9mA studies analysis and results	9mA future studies
16:00 – 17:30	9mA studies analysis and results	9mA future studies	Closing session
		Workshop Dinner	

Webex will be available

- **Feedback control of longitudinal phase space**
 - TBA
- **Operations modes for FLASH2**
 - TBA
- **Machine protection for long bunch-train operation**
 - S. Schreiber + N. Walker
- **Results and analysis from 9mA studies in February 2011**
 - M. Ross + M. Grecki
- **Looking toward future 9mA studies**
 - J. Carwardine + TBA

TDP Phase 9mA R&D program

- **Modeling of the cavity / HLRF/ power distribution / LLRF control system, including**
 - *‘Lorentz Force detuning’ and microphonics*
 - *Development of LLRF controls*
 - *Integration of high-power linac machine protection systems*
 - *Studies of needed RF power and cavity gradient overhead*
 - *Studies of long-term RF stability*
 - *Studies and demonstrations of ILC bunch compressor RF stability*

How well are we doing with the TDP R&D 9mA goals?

- **Demonstrate principles of tailoring Pks/QIs to flatten cavity gradients with beam loading**
- **Module operation close to quench with ILC-like gradients & gradient spread and ILC-like beams**

Done, but not yet at maximum gradients and 9mA

- **Next logical steps**

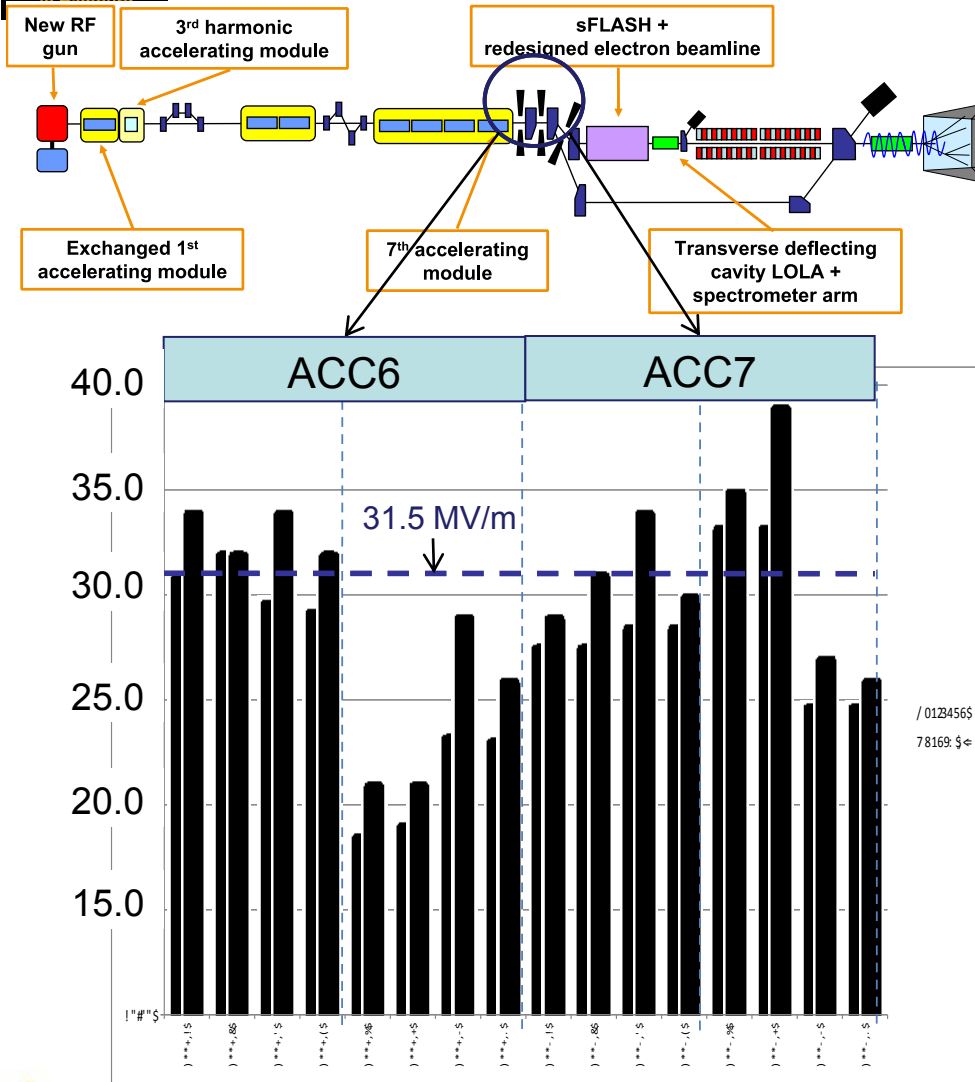
1. Flatten gradients on all 16 cavities with 6mA / 800us bunch-trains, including
 - Better control of systematic errors
 - Automated procedures for Pk/QI optimization
2. Operation of all 16 cavities within a few percent of quench with 6mA / 800us bunch-trains

Preparatory studies at NML...?

A list of questions from Marc...

- **How will we meet 'S2' goals in general, and specifically the TDP RD goals?**
- **In general we won't be able to do it all – what are the problems and limits?:**
 - Cavity detuning measurement
 - **Cavity gradient – what do we miss with only limited high grad cavities?**
 - **Beam current – what do we miss by having ½ nominal 9 mA?**
 - Coupler performance
 - LDF compensation performance
 - Q-loaded adjustment control
 - Integral / proportional feedback; gain
 - What should we plan to do at FLASH, next run?
 - Other test facilities?
 - Dark current interaction with linac operation.
 - Data analysis – what's been done? What is needed? What is basic? (svd?)

What about gradient...?



- **ACC67 modules at FLASH have operating gradient spread around +/-25%**
- **Max. gradient: ~38MV/m**
- **Highest average gradient used during Feb 2011 studies was ~23MV/m**
- **There is good justification for extrapolating to ILC operating gradients**
- **Carefully consider gradient context of the next 9mA studies**
- **We already have experience cavities at the upper end of the TDP gradient range (38MV/m)**

It was a strategic decision not to push for 9mA for the Feb '11 studies

- **Achieving flat gradients with up to 5mA was already expected to be quite difficult**
- **Operations rationale**
 - Achieving stable long bunch-train operation at 3nC could have taken a large fraction of the 15 shifts available
 - Much could still be learnt with beam current less than 9mA
 - We operated in 'FEL Mode' with bunch charge up to ~1.7nC
 - It was a good decision to not push for 9mA for this studies period
- ***An open issue for future studies: when (or whether) to push to get 9mA before the end of 2012 (personal view: stick to ~6mA)***
 - *Will take into account TDP baseline current + FLASH operations*

February 9mA studies were very positive: bodes well for future studies periods

- **Flawless operation of the FLASH accelerator**
- **Good progress towards TDP R&D goals**
 - Achieved flat gradients +/-few % at 1.5mA - 4.5mA
 - Gradient spreads up to 17-25MV/m
 - Lorentz-force detuning compensation with beam loading
- **Significant operational experience, insight into practical issues:**
 - Fine control of and repeatability of setting Loaded-Q
 - Absolute measurements: Loaded Q, Detuning
- **TDP R&D goals for 9mA program are challenging, especially with such limited studies time – but significant additional progress can be made on (all) the key issues**

