TTF/FLASH 9mA Program: January 2009 studies

John Carwardine

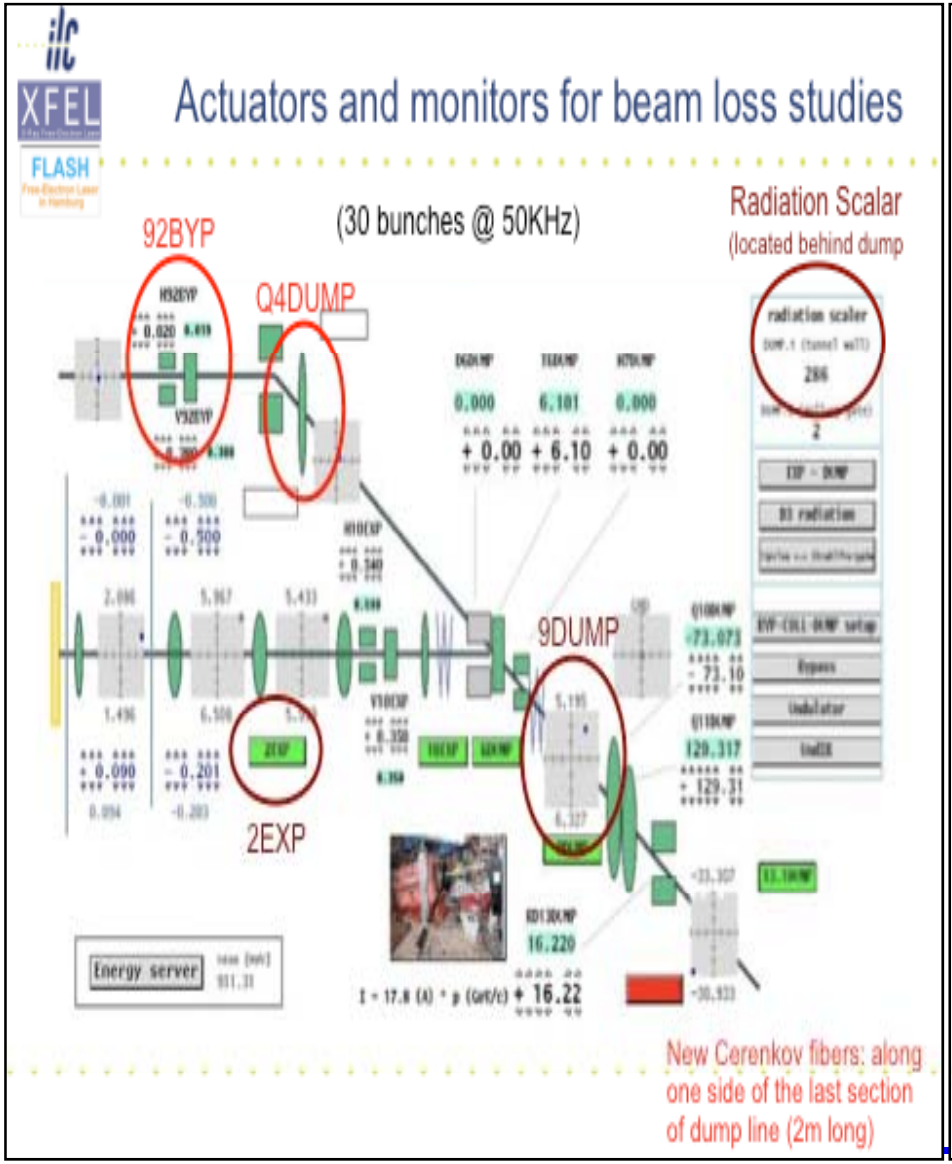
January 28, 2009

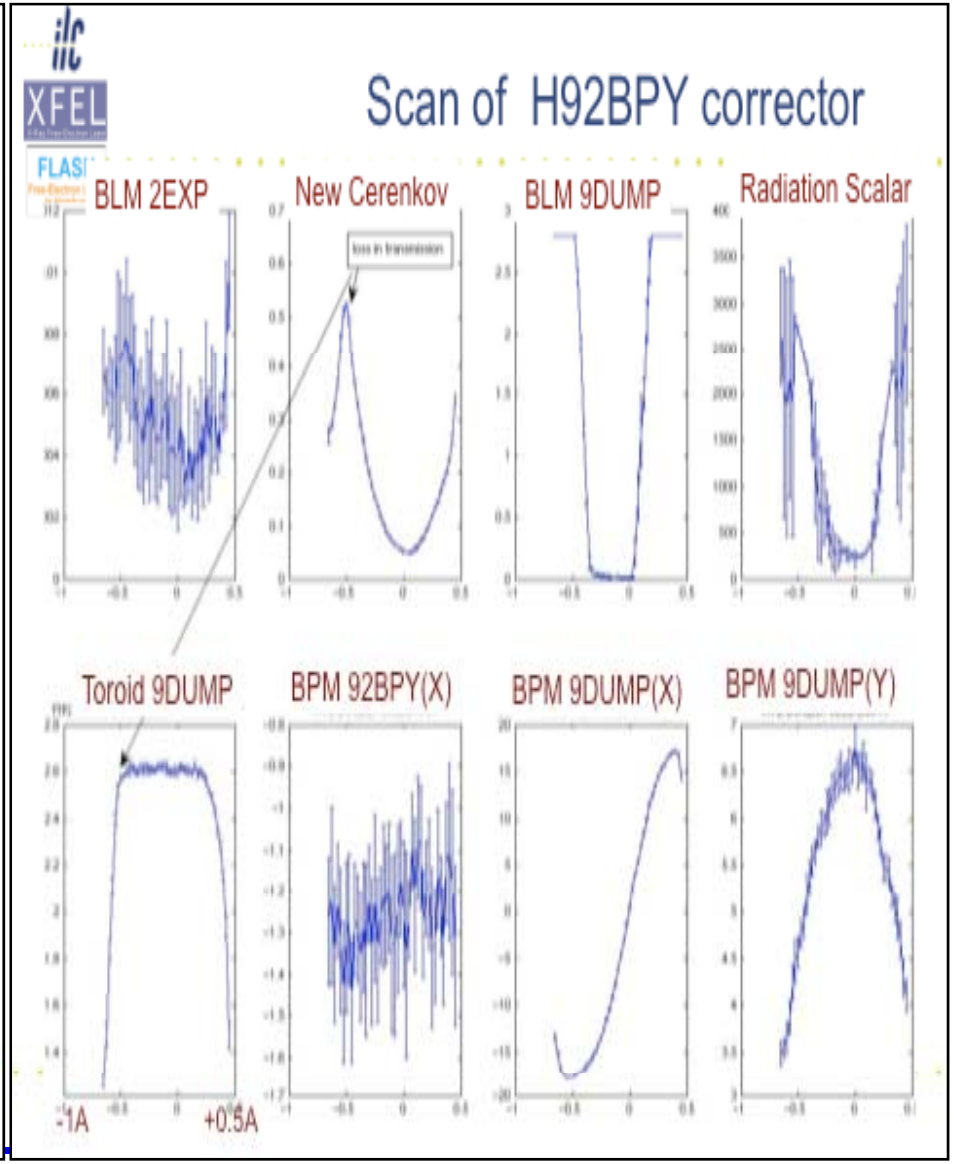
January 9mA studies plans

- Main goals
  - What can we learn about beam losses in the dump line?
  - LLRF studies: feed-forward, feedback gain studies
  - RF studies: cavity field stability for long pulses
  - Gradient studies: increase ACC456 to quench (or other limits)

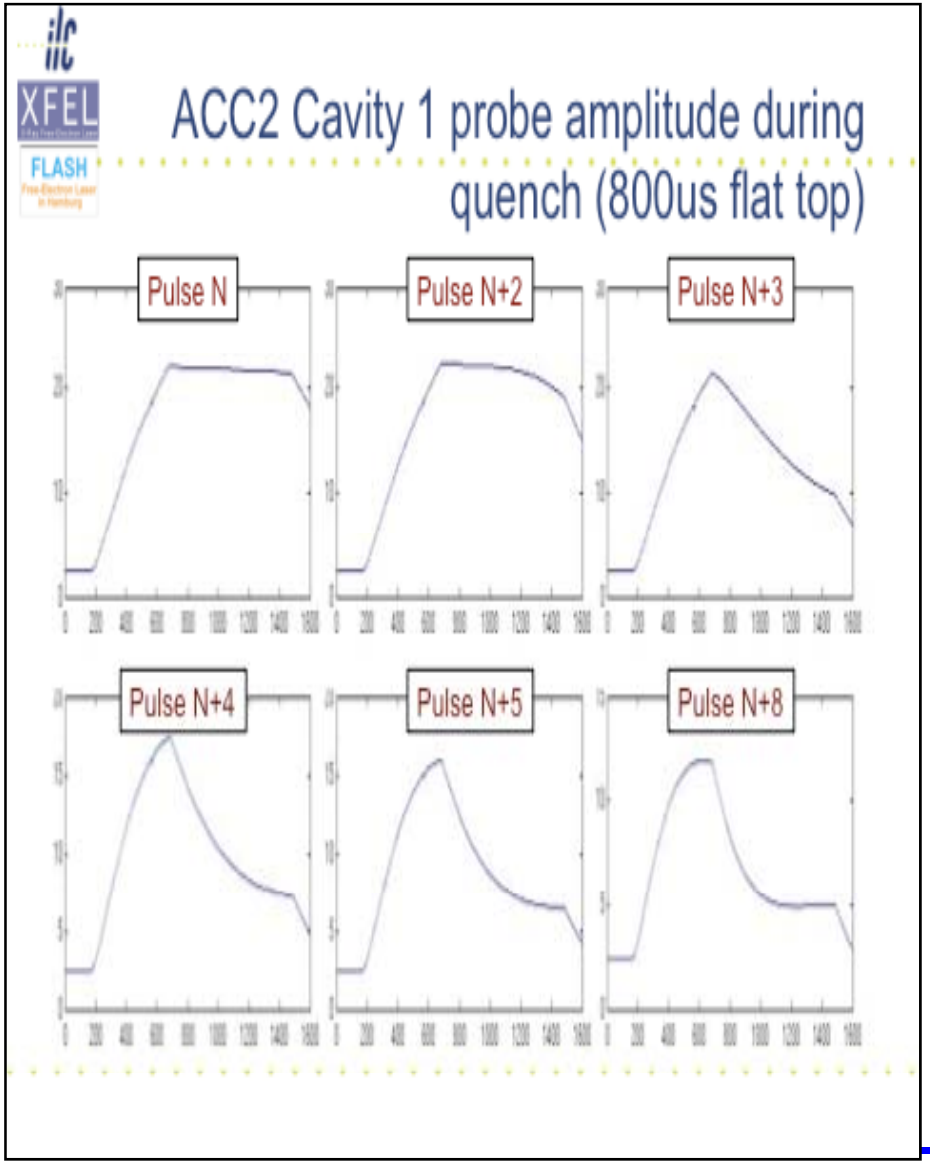
- Operating conditions
  - Maximum charge per pulse: 30nC (nominal)
  - Try to get 3nC operation with 10 bunches, else 1nC with 30 bunches. Low rep rate (40kHz)
  - Long RF flat top (800us)
  - 700MeV in 1st shift, increase ACC456 during 2nd shift

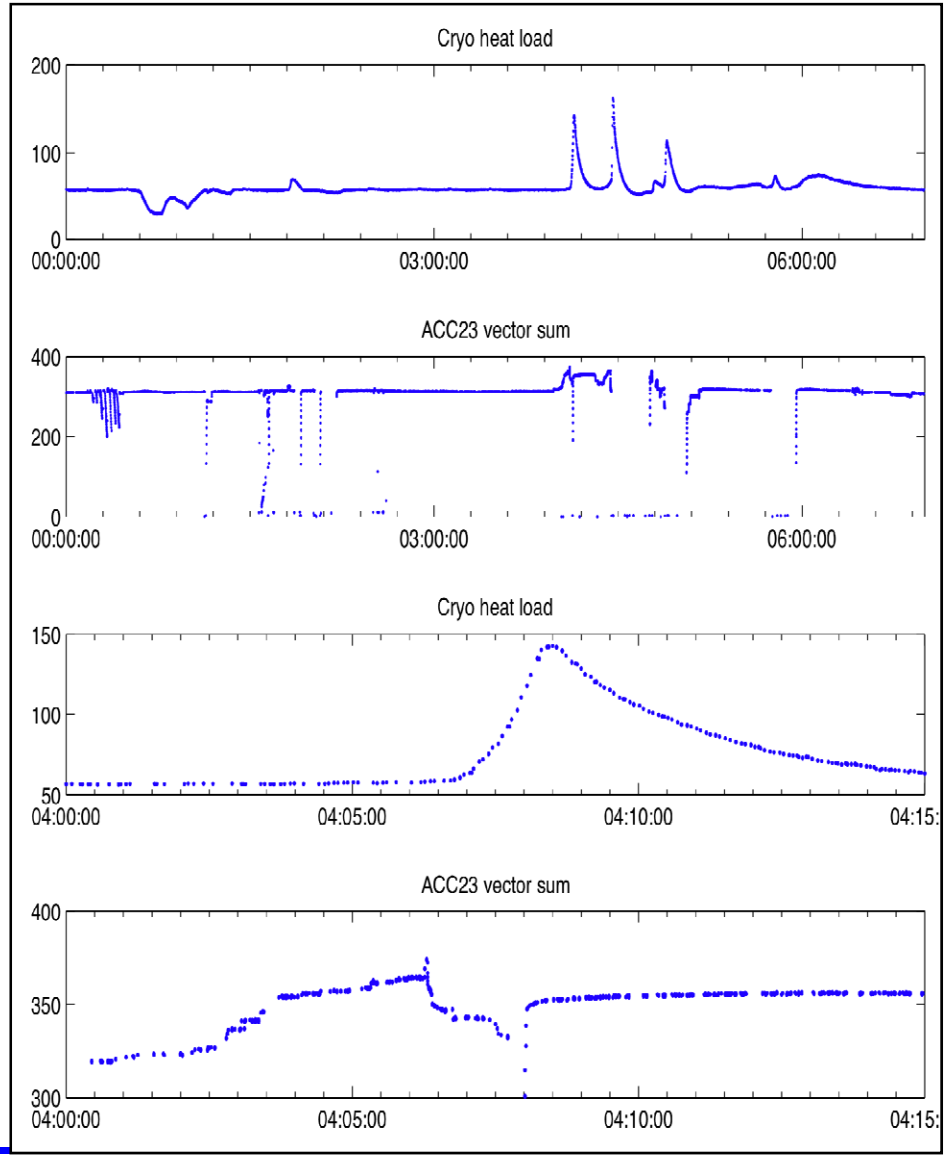
January studies: beam loss studies





Cavity quench studies





Summary of the TTF/FLASH 9mA Mini-workshop on January 16, 2009

John Carwardine

January 28th, 2009

Workshop purpose and goals

This Meeting and Beyond

- **Primary goal: planning for the main experiment**
  - Detailed list of experiments, goals, schedule etc.
  - What must we learn for ILC (S2) and XFEL
  - Discussions on detail planning → this afternoon
- **How well do we understand the challenges?**
  - Based on TTF/FLASH operations experience as well as results from dedicated shifts
- **What can we do from now until September**
  - Data analysis
  - Modelling
  - Hardware preparation (e.g. SIMCON DSP system commissioning, 3MHz pockels cell installation,…)

Workshop agenda

09:00->*10:15* **Introduction, goals, context**
Description:

09:00	Introduction, 9mA program goals, schedule, constraints (30') (Slides)	Nicholas Walker (*DESY*)
09:30	XFEL context of the 9mA program (20') (Slides)	Hans Weise (*DESY*)
09:50	Results and accomplishments to date (30') (Slides)	John Carwardine (*Argonne*)

10:30->*12:30* **Technical System reports**
Description:
Reports on each technical system readiness for a full 9mA demonstration, prior work needed, issues and concerns.

10:45	Diagnostics (15') (Slides)	Kay Wittenburg (*DESY*)
11:00	Diamond beam halo monitor (15') (Slides)	Alexandr Ignatenko
11:15	Machine Protection (MPS, BIS) (15') (Slides)	Lars Froelich (*DESY*) , Martin Staack (*DESY*)
11:30	Beam dump line (15') (Slides)	Michael Schmitz (*DESY*)
11:45	High Power RF (10') (Slides)	Stefan Choroba (*DESY*)
11:55	Cavities, modules (10') (Slides)	Denis Kostin (*DESY*)
12:05	Controls, DAQ (15') (Slides)	Kay Rehlich (*DESY*)

13:45->*18:00* **Planning for a 1-2 week studies run**
Description:
Working session to develop an outline plan for the beam studies period.

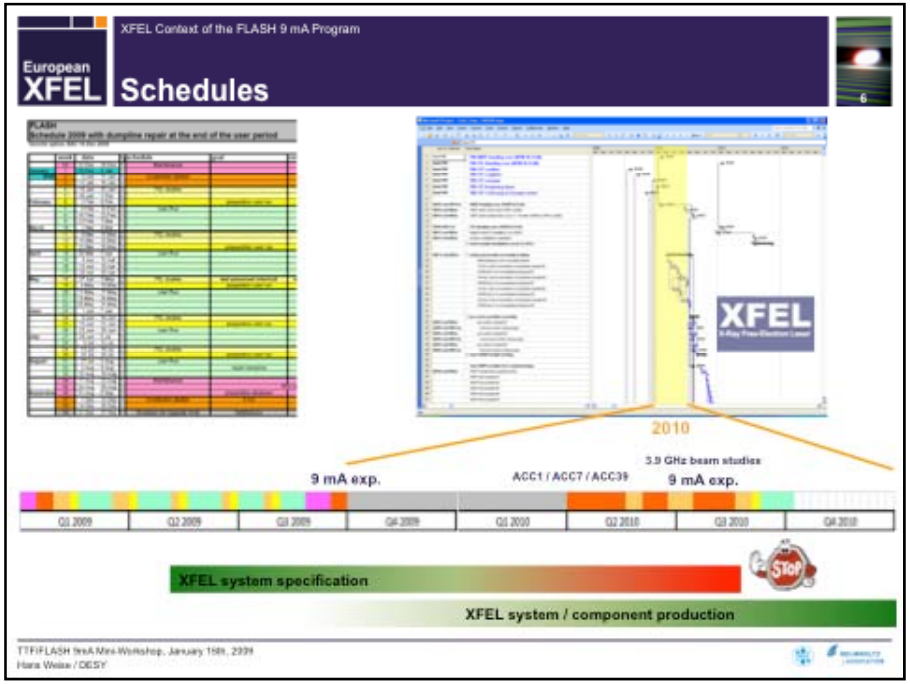
13:45	Beam Line Absorber / HOM Heatload Studies (15') (Slides)	Jacek Sekutowicz (*DESY*)
14:00	Low Level RF Technical Systems (35') (Slides)	Mariusz Grecki (*DESY*)
14:35	RF Gun, Laser (25')	Siegfried Schreiber (*DESY*)
15:00	Framework for the September studies plan (25') (Slides)	Nicholas Walker (*DESY*)
15:25	Discussion on studies planning (1h00') (Extra slides)	
	• Proposed RF/LLRF performance measurements (15') (Slides)	Shinichiro Michizono (*KEK*)
	• A list of LLRF items for the 9mA test (15') (Slides)	Gustavo Cancelo (*Fermilab*)

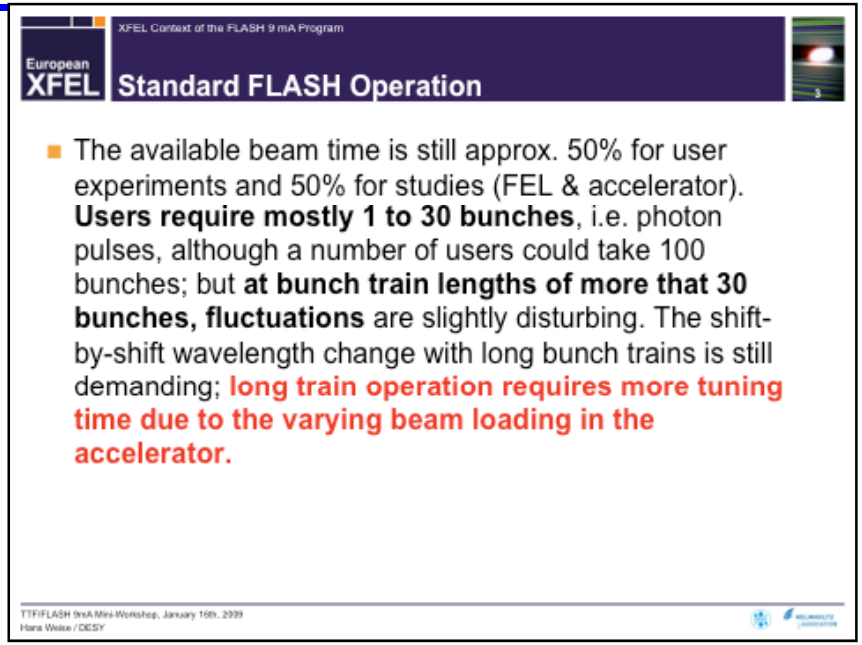
http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=3234

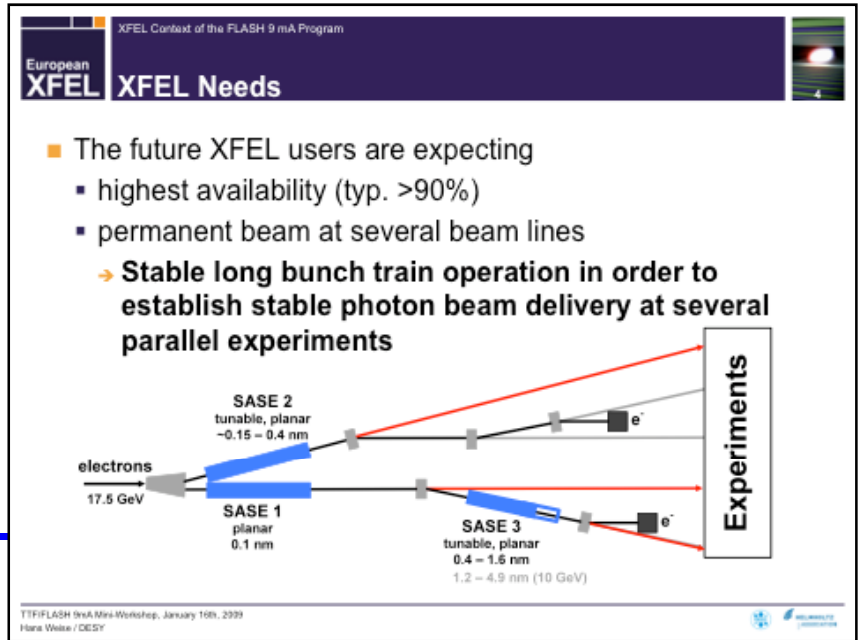
Attendance

- John Carwardine Argonne
- Nick Walker DESY
- Alexandr Ignatenko Zeuthen
- Gustavo Cancelo Fermilab
- Katja Honkovaara DESY
- Stefan Choroba DESY
- Nicoleta BaboiDESY
- Raimund Kammering DESY
- Tim Wilksen DESY
- Michael Davidsaver Fermilab
- Toshihiro Matsumoto KEK
- Elmar Vogel DESY
- Jacek Sekutomcz DESY
- Martin Staack DESY
- Lars Frölich DESY
- Michael Schultz DESY
- Shin Michozono KEK
- Kay Rehlich DESY
- Alexander Gamp DESY
- Vladimir Balandin DESY
- Valeri Ayvazyan DESY
- Mariusz Grecki DESY

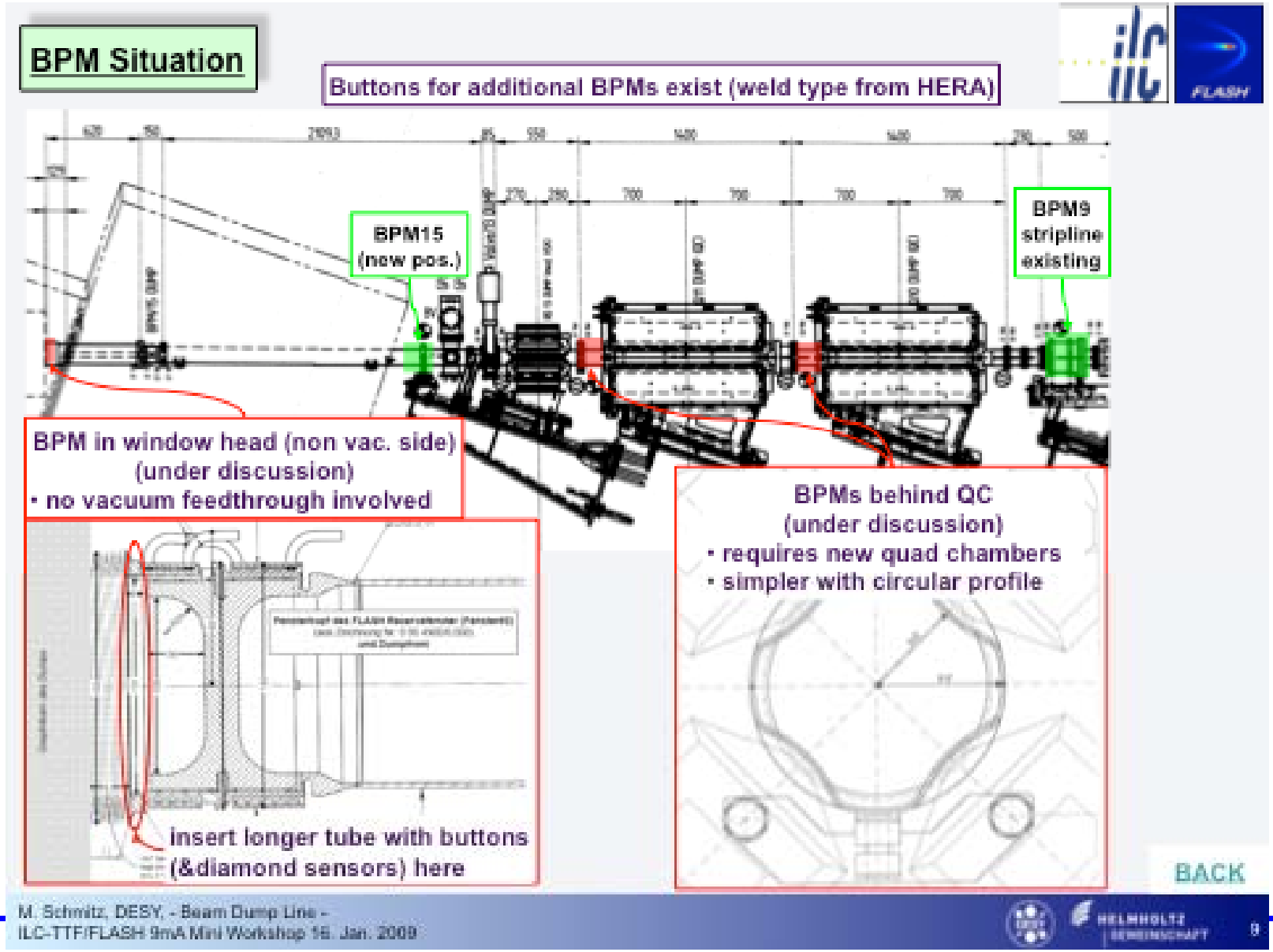
XFEL Context: the need for operational experience (H. Weise)





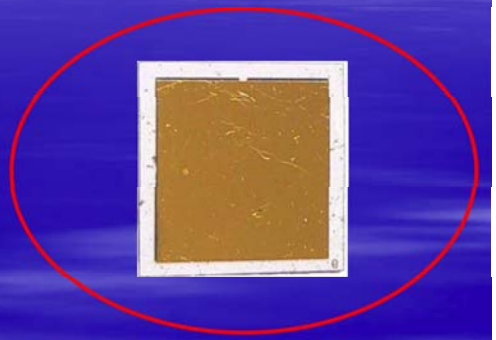


Dump line (M. Schmitz)



Beam halo monitor

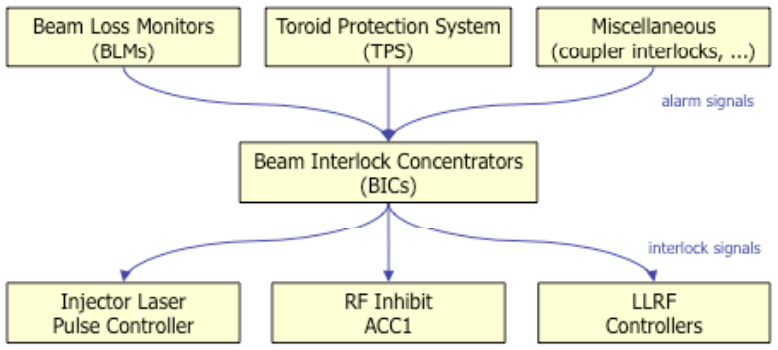
Plans for beam halo monitor at FLASH



Element 6
pCVD diamond
400 – 500 µm
2(3)-layer metallization

MPS (L. Fröhlich, M. Staack)

Fast Protection: Overview

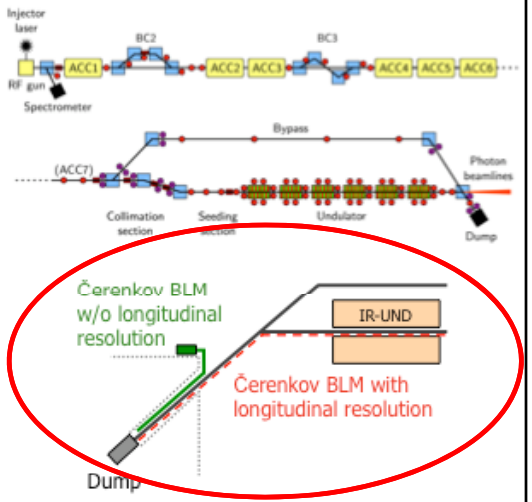


Beam Loss Monitors

- Sufficient instrumentation up to dump entrance
- New Čerenkov BLMs added (1 installed, 1 in next weeks)

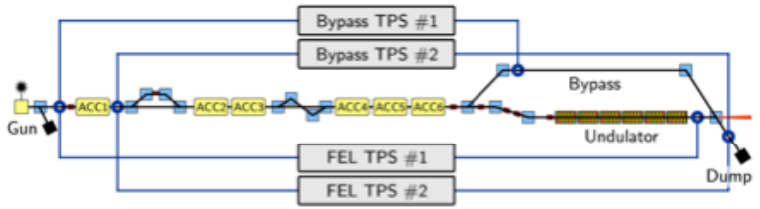
Shutdown:

- Long ionization chambers (K. Wittenburg): integration to MPS prepared
- Čerenkov BLM with longitudinal resolution (M. Körfer): no integration to MPS



Toroid Protection System

- Bypass TPS #1 and #2 operational, but...
- Re-calibration required because of major changes to toroid signal levels (time needed: ~2 h at low losses)
- Designed for up to 9 MHz, but never tested



Connections to LLRF Controllers

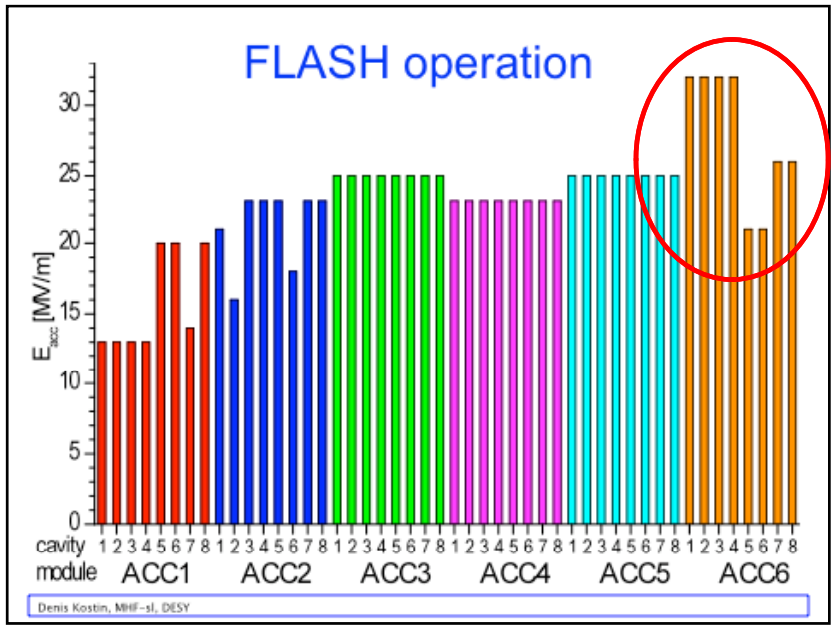
- Connection MPS → ACC1 available
- ACC1 LLRF is aware of MPS alarms: output is zeroed for remaining pulse
- Past coupler interlock problems solved

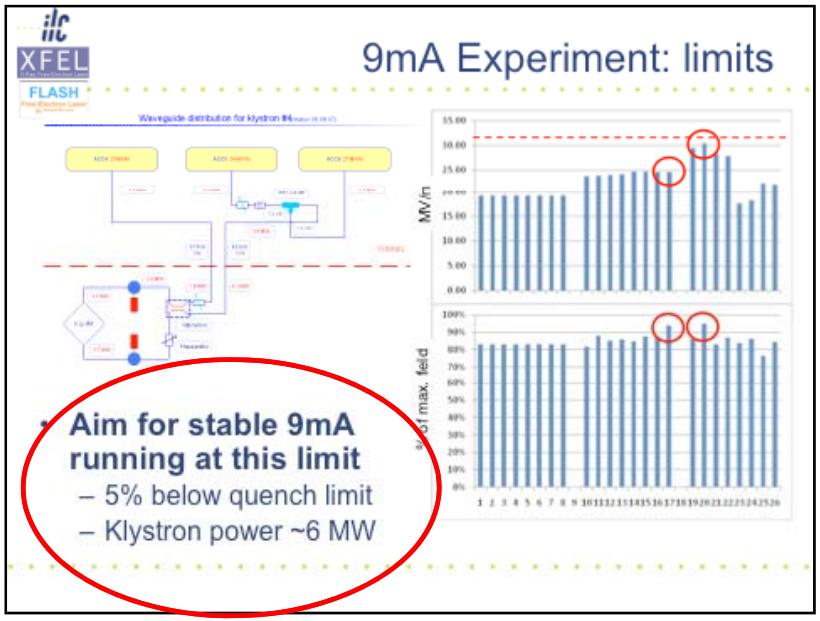
- New problem with adaptive feedforward: irritated by shortened RF pulse → instability

shortening of ACC1 RF pulses disabled until there is a solution

- Do we need connections to the LLRF of the other modules, e.g. for beam loading compensation?

HLRF, Cavities (S. Choroba, D. Kostin)





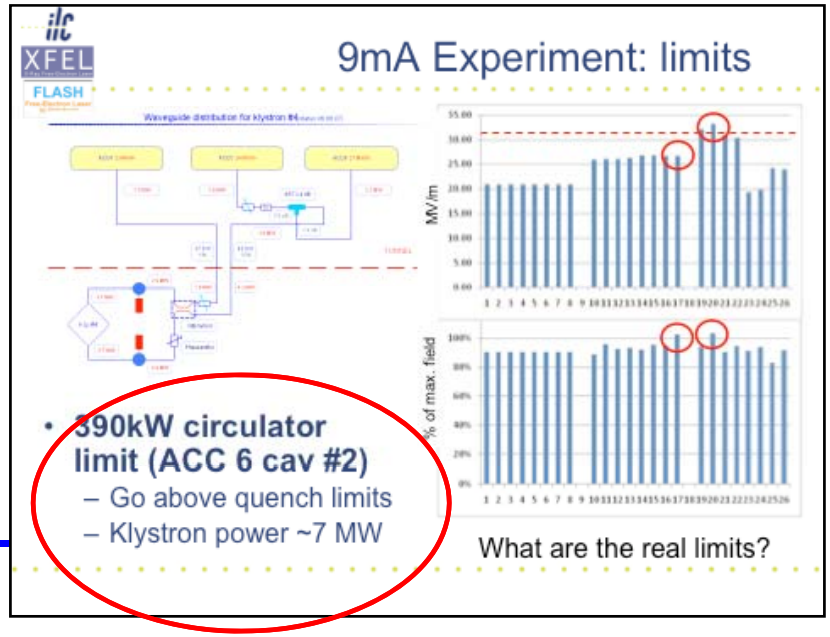
Waveguide Components

Design

- Designed in high power part for 5MW max.
- Designed in low power part for 230kW max.

Limits

- Limit in high power power part: ca. 5-7MW ?
- Limit in low power part ca. 350kW

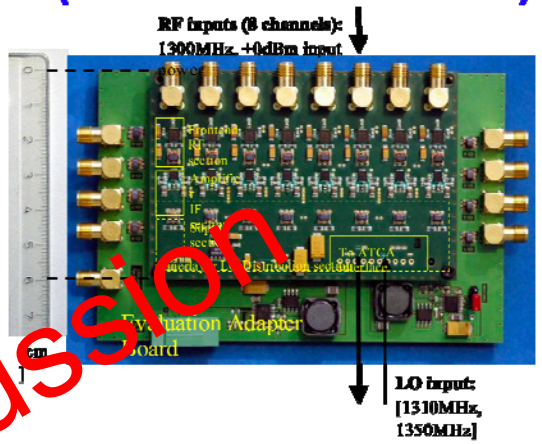


LLRF (M. Grecki)

What has been / must be done? (Hardware)

- Installation of SimconDSP based LLRF system in ACC456 as parallel system
  - Cabling (splitting signals) – done
  - Crate with 9xSimconDSP – smaller system with 3 SimCon boards installed
  - Downconverter – obtained, installed and during tests
  - Communication between 9 SimconDSP boards – it was never tested before
  - Piezo control – temporary installation, permanent installation in progress

New downconverter (obtained on 20.12.2008)



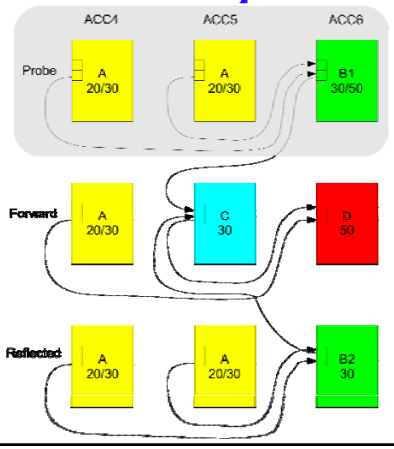
What has been / must be done? (Software)

- SimconDSP firmware – was tested in FLASH, but not with all required features
  - Beam loading compensation – never tested with high beam loading
  - Loaded Q and detuning measurements – Matlab scripts exist, DSP/FPGA implementation is under development
  - Quench detection - Matlab scripts exist, DSP/FPGA implementation is under development
- DOOCS server - version for simpler system ready
- Matlab scripts for HL algorithms (VS calibration, AFF, klystron linearization, etc.) - ready
- Exception handling (quench detection, klystron trips) – must be worked out

Under discussion

ACC456 controller (Simcon DSP based)

- A,Bx,C,D – type of firmware
- 20/30/50 – Virtex2Pro ...
- optolink
- 2 VME crates needed



What I think the LLRF baseline should be for the 9mA expt

- **ACC456**
  - 3x SimconDSP system with new 54MHz IF boards (no forward/reflected power signals into Simcons)
  - Do not attempt to develop a 9x SimconDSP system – instead, put the resources into making a SimconDSP system for ACC23.
- **ACC23**
  - 2x SimconDSP system with new 54MHz IF boards (no forward/reflected power signals into Simcons)
  - Use the 3-week shutdown to temporarily hook up the SimconDSP system to existing RF cabling

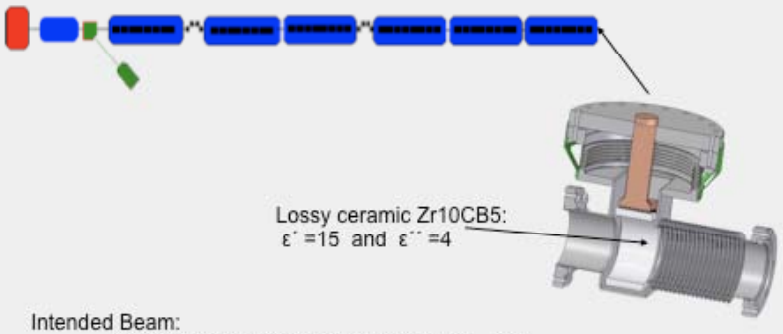
- **Advantages of SimconDSP with high IF for the 9mA Expt.**
  - Lower noise floor due to higher sampling rate
  - Higher IF gives higher open-loop bandwidth
  - There are spare resources on the board to allow implementation of additional key functions

LLRF capabilities needed for 9mA Expt (draft)

Function	ACC456	ACC23
High feedback gain (>>40)	Yes	Yes
Feedback gain is ramped from low to high during fill time	Yes	Yes
Klystron linearization	*?*	*No*
Pre-load beam loading compensation based on nominal bunch pattern and charge provided by DOOCS	Yes	Yes
Smoothing algorithm on feed-forward tables	Yes	Yes
Respond gracefully to MPS trip	Yes	Yes
Simple cavity quench detection - detect at end of the RF pulse, inhibit the next pulse (eg integral of cavity probe, loaded Q at end of pulse)	Yes	No
Respond gracefully to cavity quench	Yes	Yes
Adaptive correction of feed-forward tables ("AFF")	*No*	*No*
Advanced cavity quench detection – detect and act within the RF pulse (eg real-time computation of loaded Q)	*No*	*No*

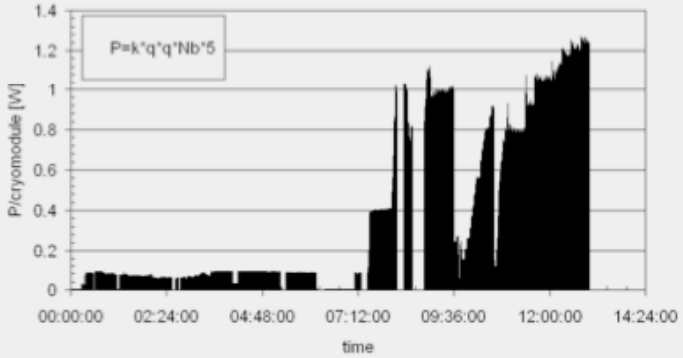
Beam Line Absorber (J. Sekutowicz)

Location of the BLA prototype in the FLASH linac



Intended Beam:
3 nC @ 500 bunches/pulse @ 5 Hz rep. rate
σ = 2 mm

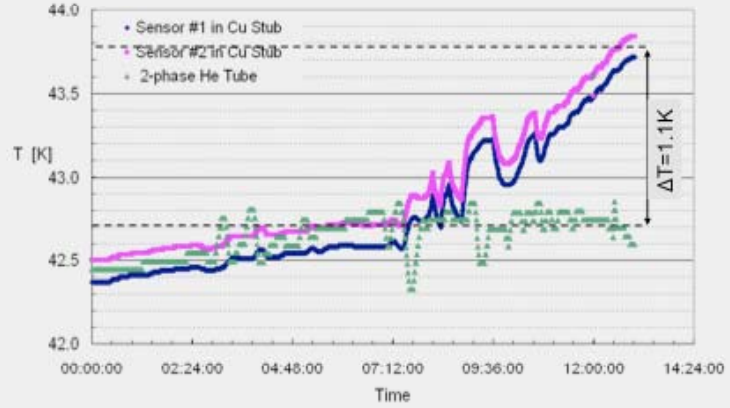
Estimated power induced by the beam in the high current experiment on September 25th



A fraction of this power is absorbed by the BLA and leads to the temperature rise.

M. Dohlus theoretical estimation for the present linac configuration is 15% (180mW)

Measured temperature rise at the braid



(reasonable close to the theoretical value of 180 mW)

Planning the experiment

Planning "The Experiment"

- No more beam-time between now and dedicated run
- Several 'sub-systems' we had originally hoped to test out and have operational will get "first look" during the run
- No "dress rehearsal" as originally planned
  - **September was "it"!**

How long? (Needs Discussion)

	Guess
3nC gun / injector / RF (long pulse) set-up (1MHz) <30 bunches	3 shifts
Dump line instrumentation commissioning / characterisation / thresholds	3 shifts
3MHz beam (<30 bunches)	2 shift
SIMCON DSP work (closed loop, commissioning)	3 shifts
Achieve long pulse operation (3 shift cycles)	15 shifts
Additional experiments (not included in above)	3 shifts
Contingency	5 shifts
Total guesstimate	34 shifts

Issues list (part)

Item #	Issue
1	Should we install new bpms just after Q10 and Q11 in the beam dump line?
2	Should we try to modify Q10 and/or Q10 to add steerers
3	Diamond sensors for the dump window – can they be ready in time?
4	What diagnostics do we really need to run the 9mA experiment?
5	What additional LLRF functions do we need for the 9mA experiment?
6	For what data time ranges do we need to keep DAQ data?
7	Install fluorescent screen or similar into the dump window for imaging upstream
8	Can we modify the D6 dumpline vacuum chamber to give an imaging port for the dump?

Concerns (partial list)

- No resolution on LLRF for ACC456 and ACC23
  - Hardware, software, necessary functions for 9mA run
- Schedule may be too tight for new bpms, halo monitor,..
- We will be relying on several untested/unproven systems
- HLRF limitations may limit high gradient operation
- What to do with the daq data
  - How to archive/catalog/document raw and processed data
  - How to limit the amount of DAQ data (1.1TB/day being collected)
- LLRF signal calibration – vector sum and energy
- Automate cavity tuning
- Lack of operational time on new SimconDSP installations on ACC23 and ACC456 when we begin the Sept studies run