Cryomodule String Test: TTF/FLASH 9mA Experiment

Nick Walker (DESY)
John Carwardine (ANL)

GDE ILC10 Beijing March 2010

Primary objectives of 9mA program

- Long-pulse high beam-loading (9mA) demonstration
  - **800μs pulse with 2400 bunches (3MHz)**
  - **3nC per bunch**
  - **Beam energy 700 MeV ≤ E_{beam} ≤ 1 GeV**
- Primary goals
  - **Demonstration of beam energy stability**
    - Over extended period
  - **Characterisation of energy stability limitations**
    - Operations close to gradient limits
  - **Quantification of control overhead**
    - Minimum required klystron overhead for LLRF control
  - **HOM absorber studies (cryo-load)**
  - **…**
- Major operational challenge for FLASH !
  - **Pushes many current operational limits**

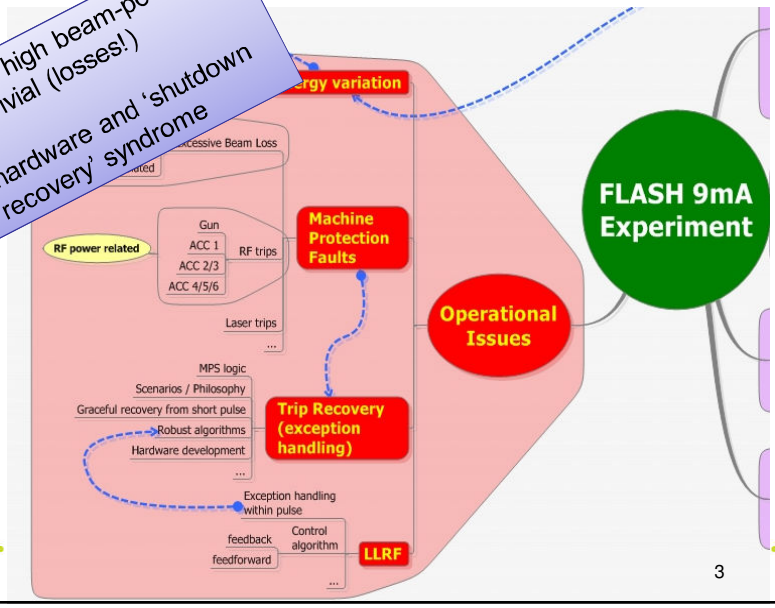
Primarily a LLRF experiment

Goals partially achieved in September 09 run

Achieving the goals…

Dealing with high beam-power not trivial (losses!)

'New' hardware and 'shutdown recovery' syndrome

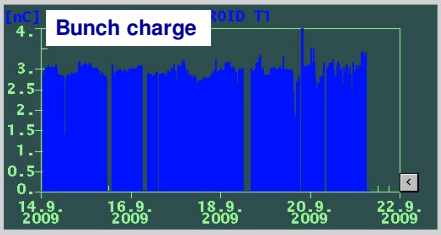


3

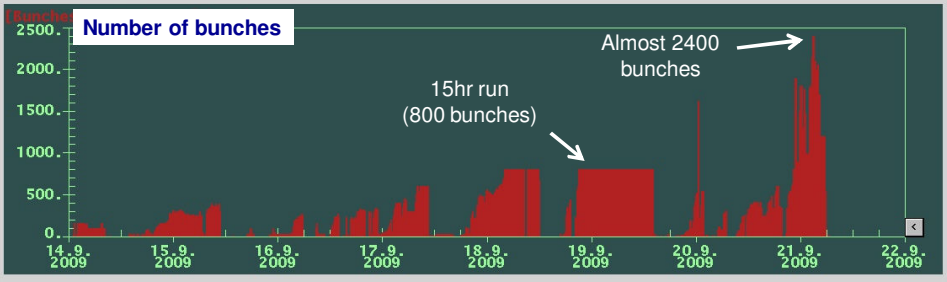
Last week of studies (not *quite* how we'd planned!)

FLASH Program: 9 mA Studies

ACC studies KW37

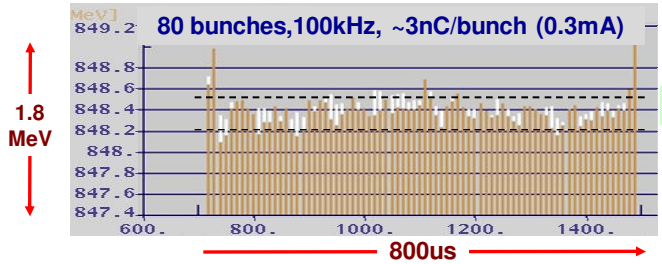


- Bunch charge was consistently between ~2.7nC and ~3nC
- Rapid progress increasing number of bunches during the last 3 days (*but very unstable*)

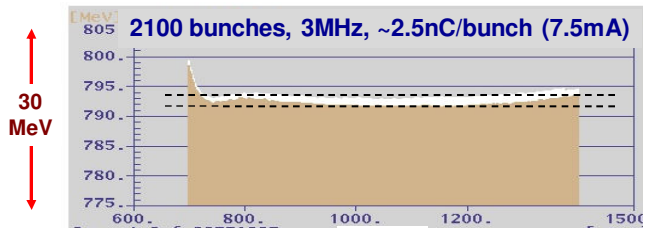


N. Walker - Long Bunch Train Workshop

Energy deviation along bunch train (examples)



Along pulse: 0.035% p-p

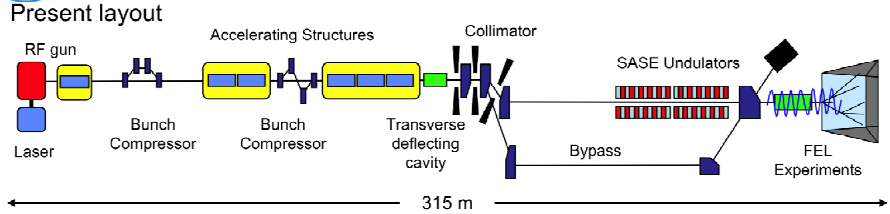


Along pulse: 0.5% p-p
Pulse-pulse: 0.13% RMS

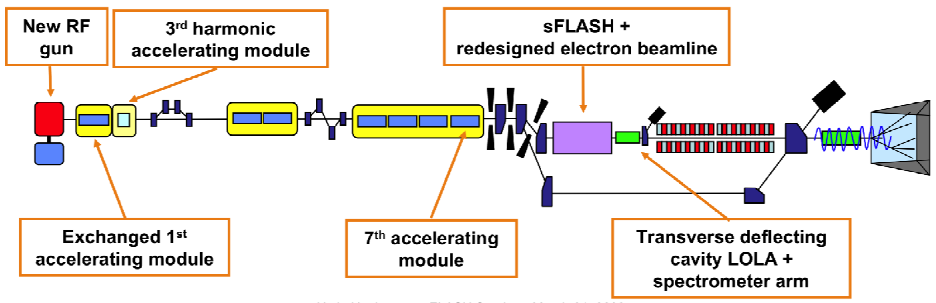
FLASH Upgrade 2009/10

FLASH
Free-Electron Laser in Hamburg

Present layout

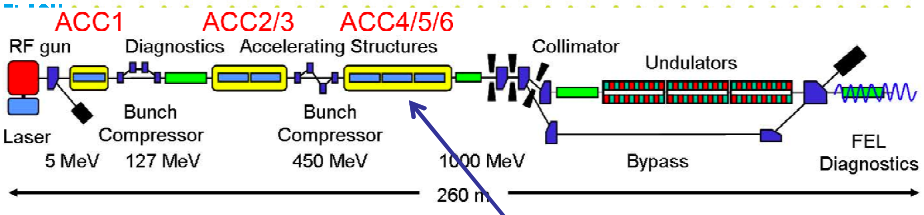


New layout



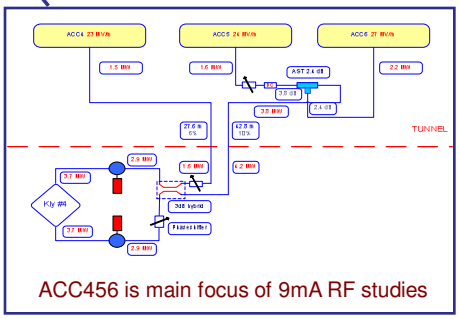
Katja Honkavaara, FLASH Seminar, March-31, 2009

FLASH accelerator layout (then)



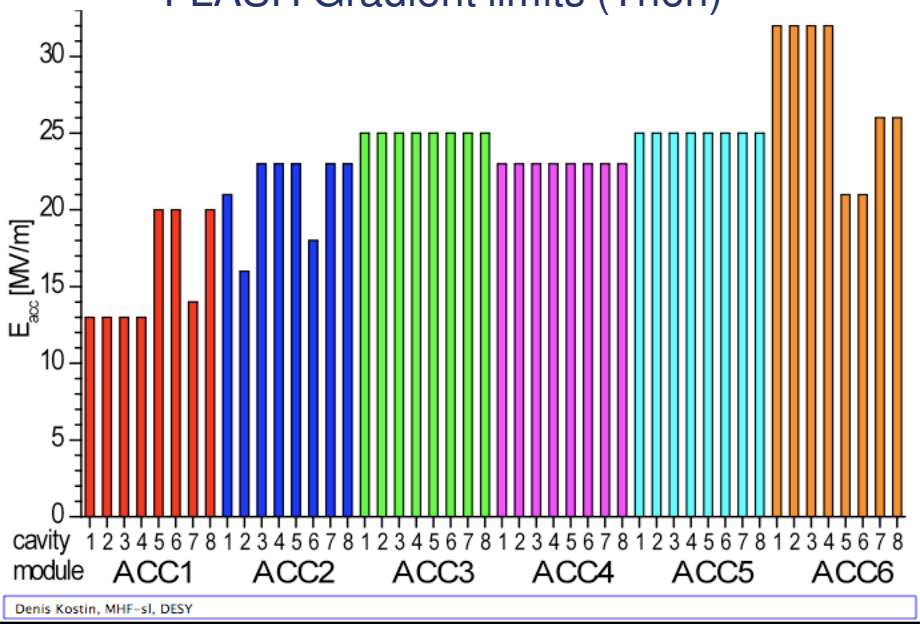
Comparison of machine parameters

		XFEL	ILC	FLASH design	9mA studies
Bunch charge	nC	1	3.2	1	3
# bunches		3250	2625	7200*	2400
Pulse length	μs	650	970	800	800
Current	mA	5	9	9	9



ACC456 is main focus of 9mA RF studies

FLASH Gradient limits (Then)



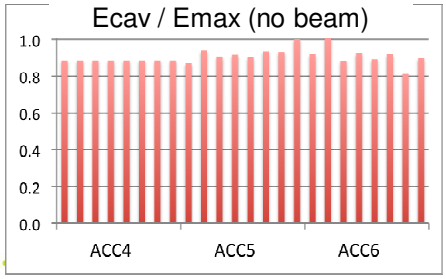
Denis Kostin, MHF-sl, DESY

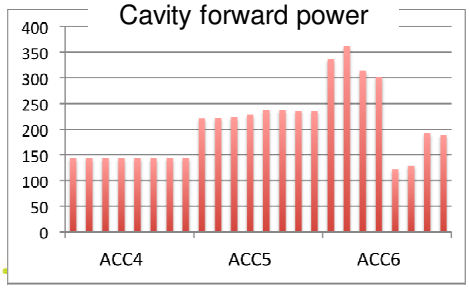
Ecav / Emax (then)

(All Qexts set equal, nominal power ratios)

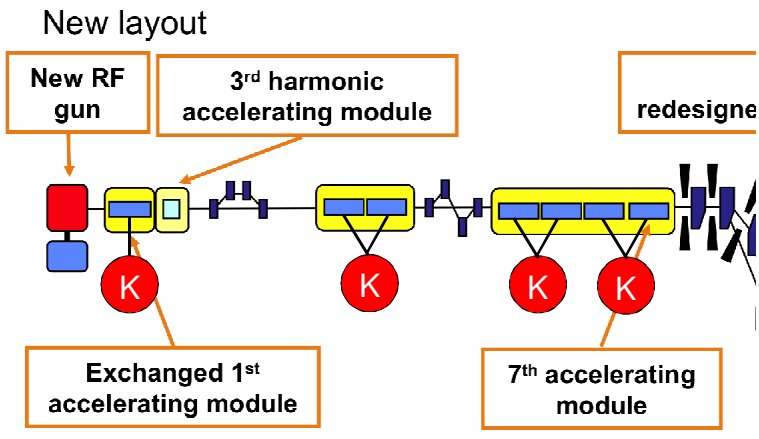
- If cavities are filled to point where first cavity quenches,
  - **Average gradient ACC4/5/6 ~24MV/m**
  - **Average gradient ACC6 C1-C4 ~30.8MV/m**
  - **Klystron power 6.4MW**
  - **ACC6 C2 forward power 360kW**

Limit: 5-7MW
Limit: 390kW

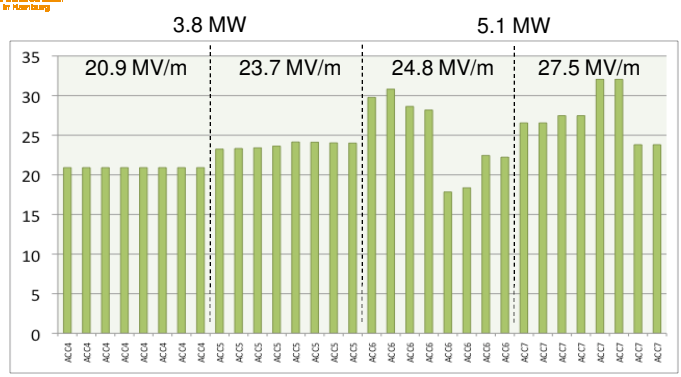




FLASH layout (now)

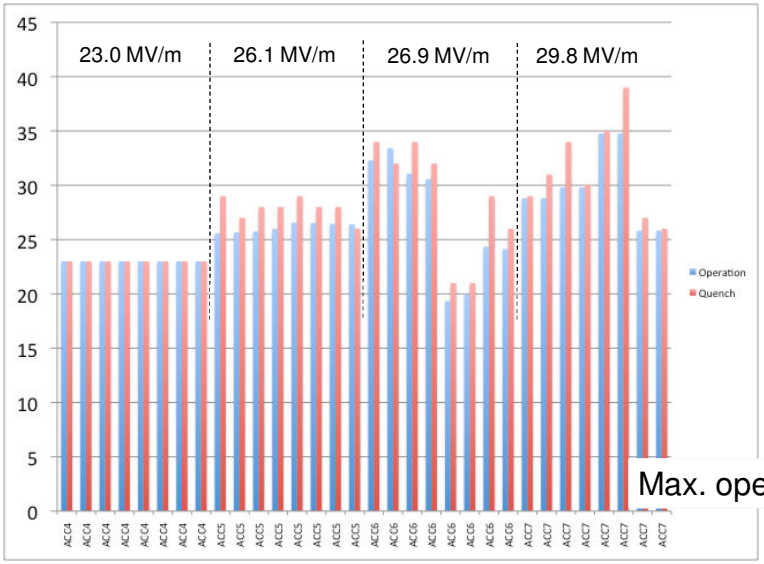


FLASH layout (now)



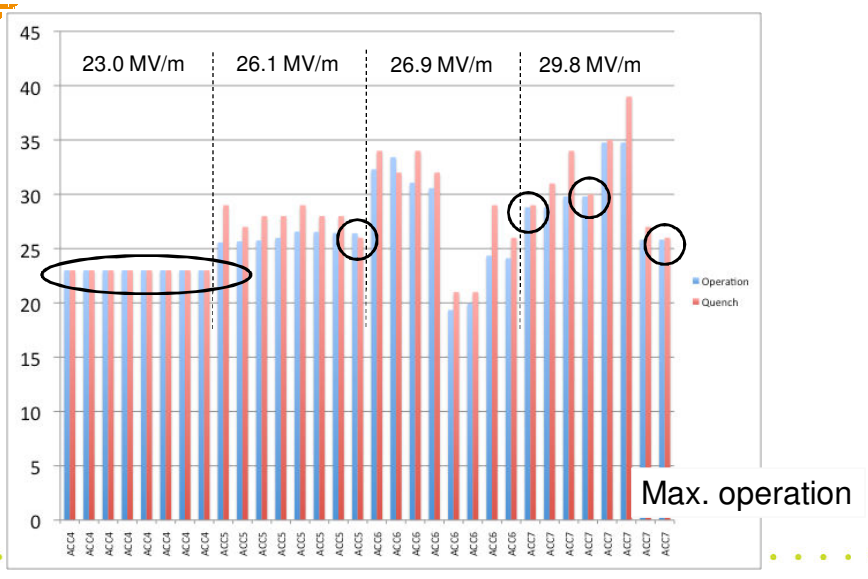
Nominal foreseen for 1.3 GeV beam energy

FLASH layout (now)



Max. operation

FLASH layout (now)



Other considerations

- LLRF systems updated and standardised
  - **All will use 'standard' Simcon-DSP system**
  - **Bunch patter feed-forward**
  - **Better exception handling (toroid based)**
  - **....**
- New 3.9 GHz system 'unknown territory'
  - **Special considerations for 9mA operation**
- General very new machine
  - **Will take time to re-commission**

Future for long-bunch train ops

- Commissioning now ~ 19 July
- 6 months of alternating
  - **FEL studies**
  - **Photon user runs**
- Next Accelerator Physics period early January
  - **Expect to have dedicated 9mA experimental time**

- Concept to use some of the FEL/user blocks to develop long bunch trains for SASE
  - **Typically 1 mA 800 bunches**
  - **Many (LLRF) issues are identical**
  - **Stable systems available before dedicated 9mA experiments**