TDR Writing:
FLASH 9mA Experiment

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Outline

Outline (2)

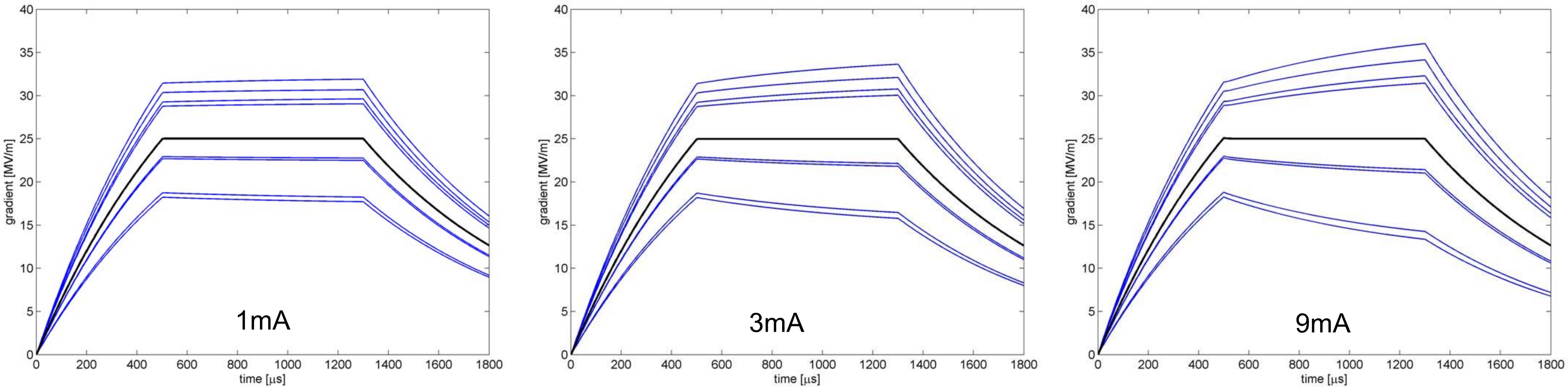
New since Interim Report

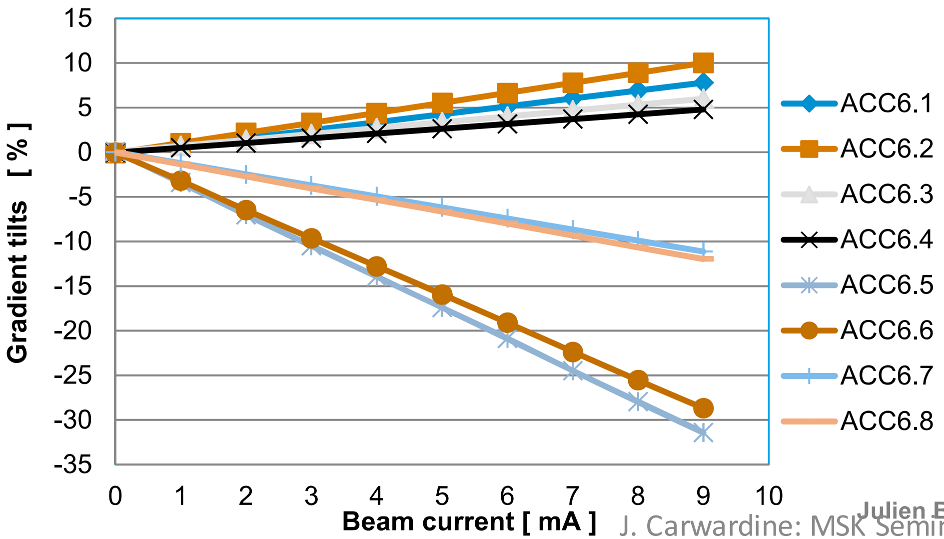
- Pseudo-Pk / Ql studies for flat gradients
- Operation close to quench with beam loading
- Klystron saturation studies with beam loading

- Include background for rf power overhead and gradient margins (cost drivers)?
- Need to explain principles of Pk/Ql control

Impact of beam loading

> Beam loading tilts scale linearly with beam current





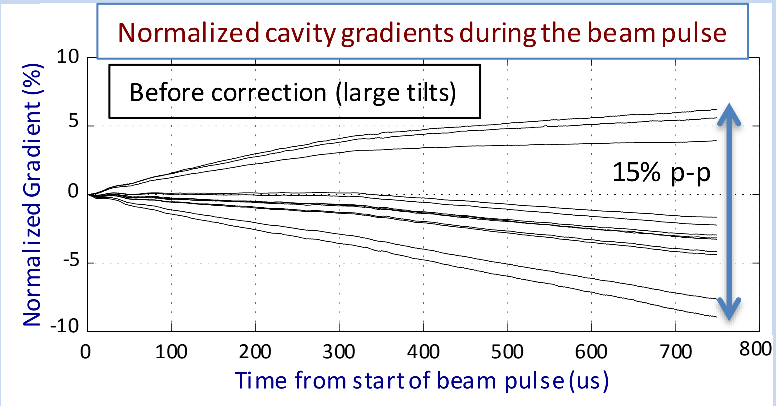
Simulated gradient tilts in ACC6,

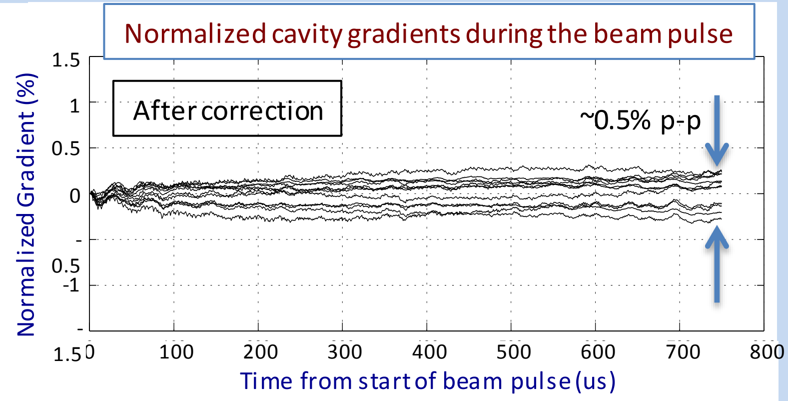
for a 800 usec flat top

with current FLASH Q_L setup

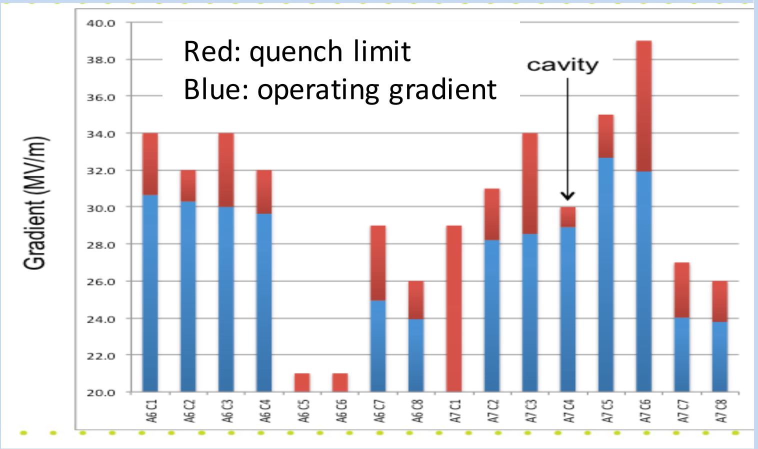
9mA Studies: beam operation close to cavity gradient limits (4.5mA/800us bunch trains)

Tailored cavity Loaded-Qs to cancel beam-loading induced gradient tilts





Operation at 380MeV on ACC67 (13 cavities)

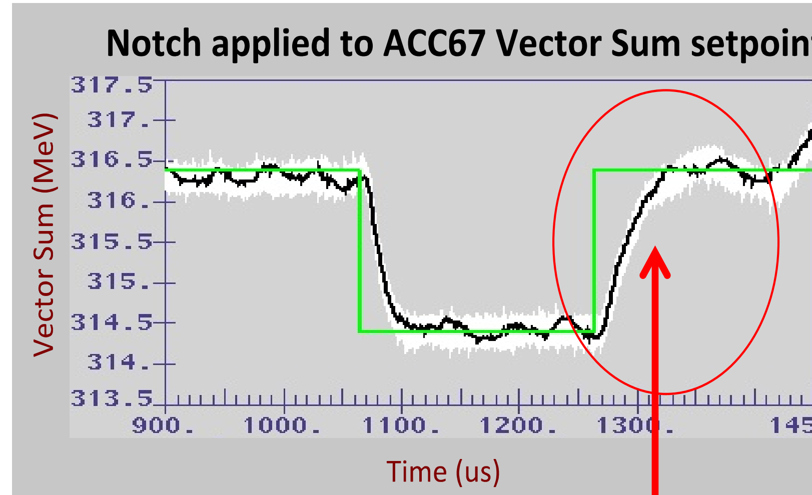


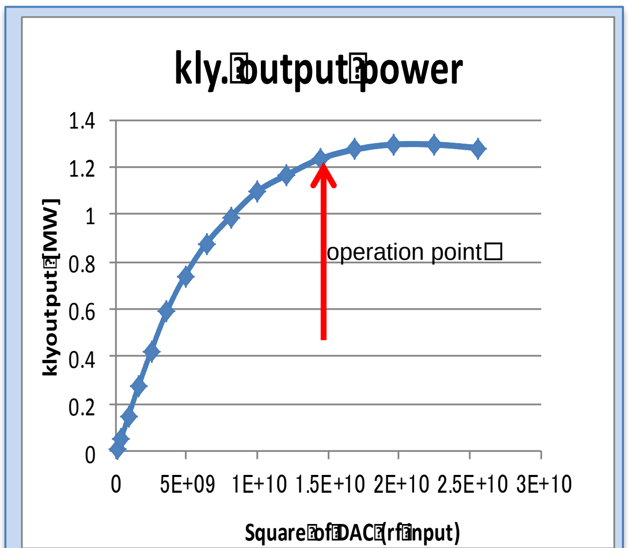
The limiting cavity is within 5% of quench

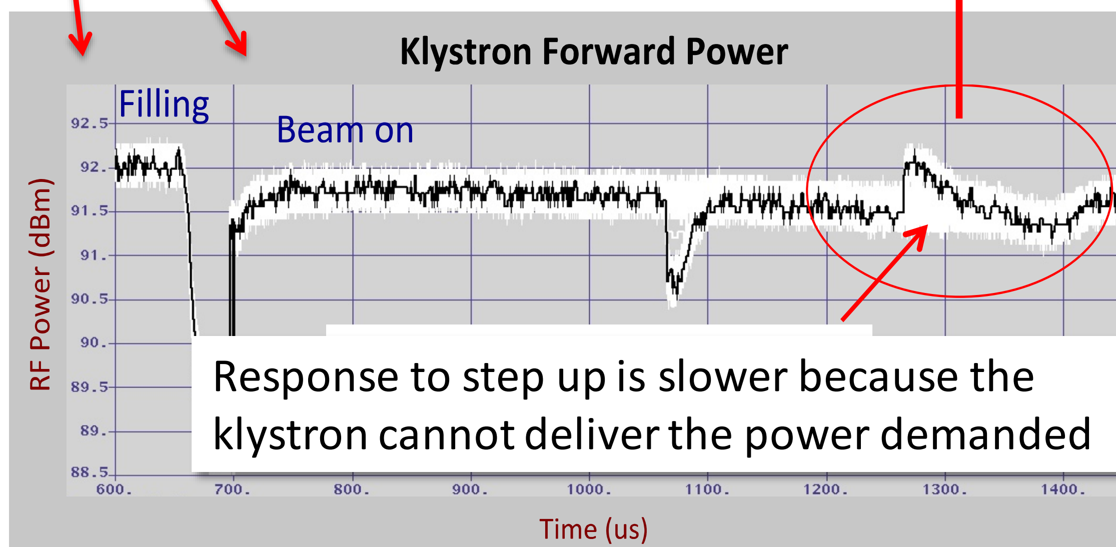
- Flattened individual gradients to <<1% p-p
- Several cavities within 10% of quench
- 'Crash test': very rapid recovery of 800us / 4.5mA after beam trip
- Ramped up current from ~zero to 4.5mA with ACC67 gradients approaching quench
- 'Cavity gradient limiter' to dynamically prevent quenching without turning off the rf

9mA Studies: evaluating rf power overhead requirements
(4.5mA/800us bunch trains)

- Klystron high voltage was reduced from 108KV to 86.5KV so that the rf output just saturated during the fill
- The required beam-on power ended up being ~7% below saturation



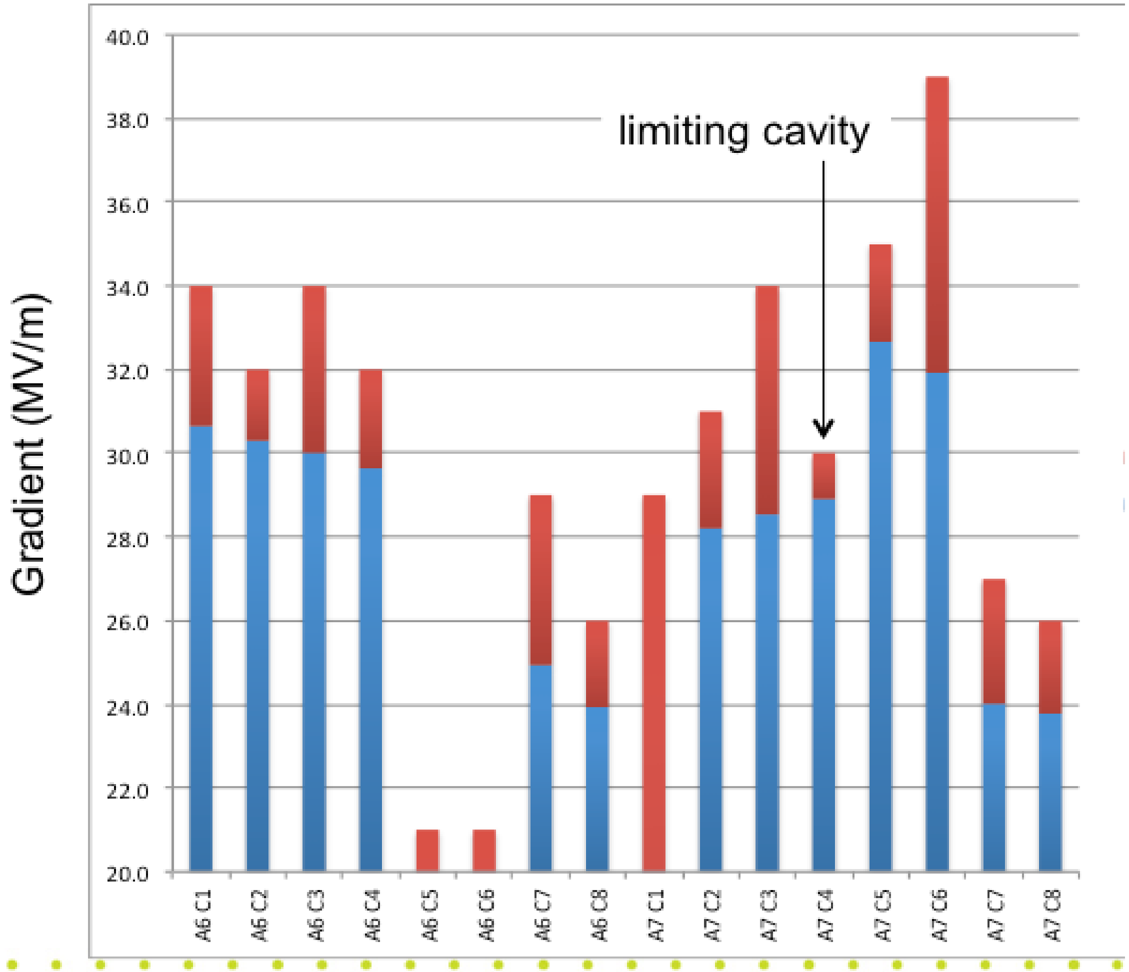




Extrapolation to ILC baseline

- Long bunch trains, heavy beam loading
  - 6mA / 800us demonstrated (baseline)
  - 9mA / 800us marginally achieved (upgrade)
  - Energy stability demonstrated
- Vector Sum control of RF unit
  - Operation of RF unit demonstrated with 24 cavities and 16 caviities
  - Relevance to KCS control…?
- Gradient
  - FLASH: average is ~28MV/m, but cavities go to 35MV/m
  - Gradient spread is comparable
  - Lorentz-force detuning

Limits achieved (380 MV)



Extrapolation to ILC baseline

- Pk/Ql control
  - Demonstrated flat gradient solutions to << 1% pk-pk
  - ILC baseline has more knobs, so easier

- Operation close to quench
  - Several cavities within 10% of quench at 4.5mA, 800us
  - One cavity within 5% of quench

- Klystron overhead
  - Preliminary results: operation within 7% of saturation
  - Need to evaluate effect on energy stability

Extrapolation to ILC baseline

- Operability
  - Ramp-up to 4.5mA, 800us within 10% of quench demonstrated without quenching
  - Rapid recovery after quench
  - Quench detection / prevention with beam loading

- Taking credit for FLASH FEL operations…
  - Many 1000’s hours of routine operation
  - LLRF control and automation
  - Energy and arrival time stability better than RTML requirements