Alternating Bi-level Accelerating Gradient Tests at FLASH

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Goal

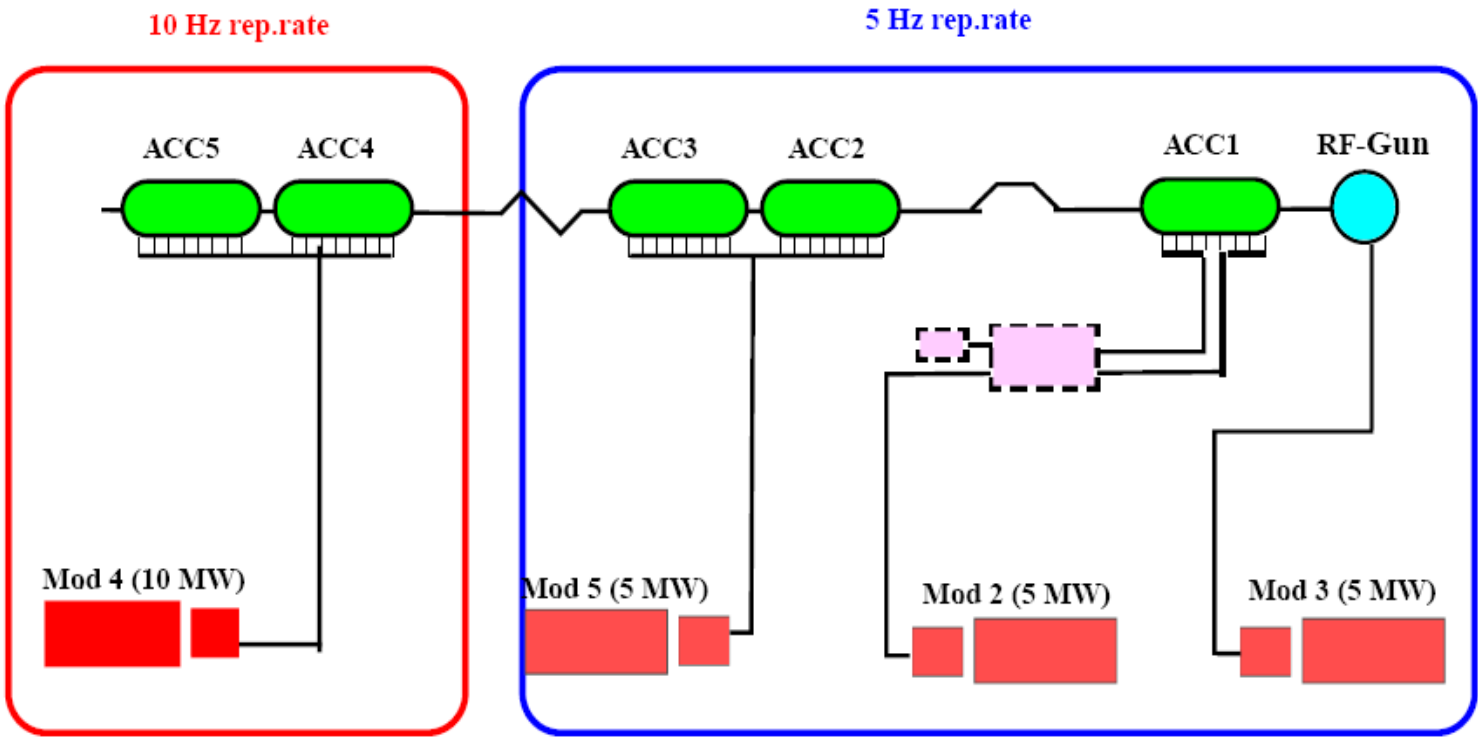
- Establish the possibility of operating the cavities with two gradient levels (pulse to pulse and intra pulse) so that they can be run at high gradient along with (during) SASE operation.

- This will allow for
  - Gaining operating experience at high gradient over long periods of time
  - The possibility of working on the second ramp during FEL runs (needs to be shown that we can do this without disrupting experimental program)

Other Goals

- Establish 10 Hz operation on Klystron 4
- Establish existence proof that SASE is not affected by the second ramp level
- Look at and compare amplitude and phase regulation with standard behavior

FLASH RF System

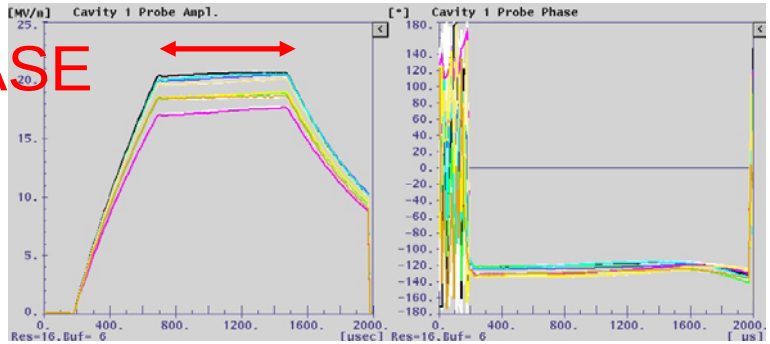


Two Ramp Modes

- Alternate SASE (lower gradient ramp) with a high gradient ramp
- Have a ramp with two levels, 1st for SASE, then going to higher gradient on the same pulse (but usually shorter flat time)
- Possibility of combining both of these (though not clear would want to)

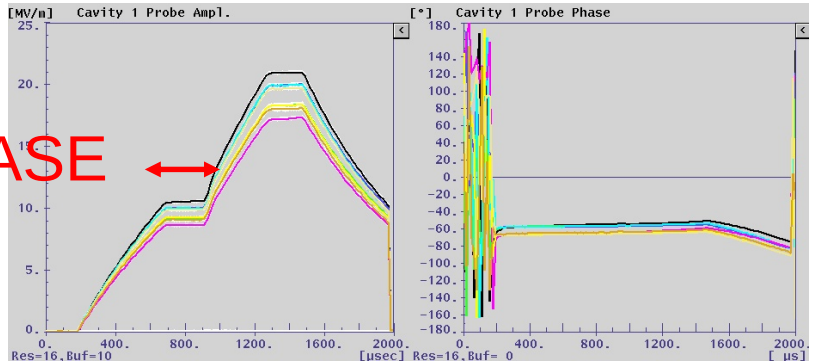
Two Ramp Modes (2)

SASE



Alternate SASE, standard mode of operation

SASE



Ramp with two levels, 1st for SASE
Variable RF pulse length

Requirements

- The second (hi gradient) ramp must be set up so that making an adjustment to the lower (SASE) ramp does not affect the hi gradient ramp.
- This is so that operators can adjust the level with beam without worry of tripping on the high gradient level

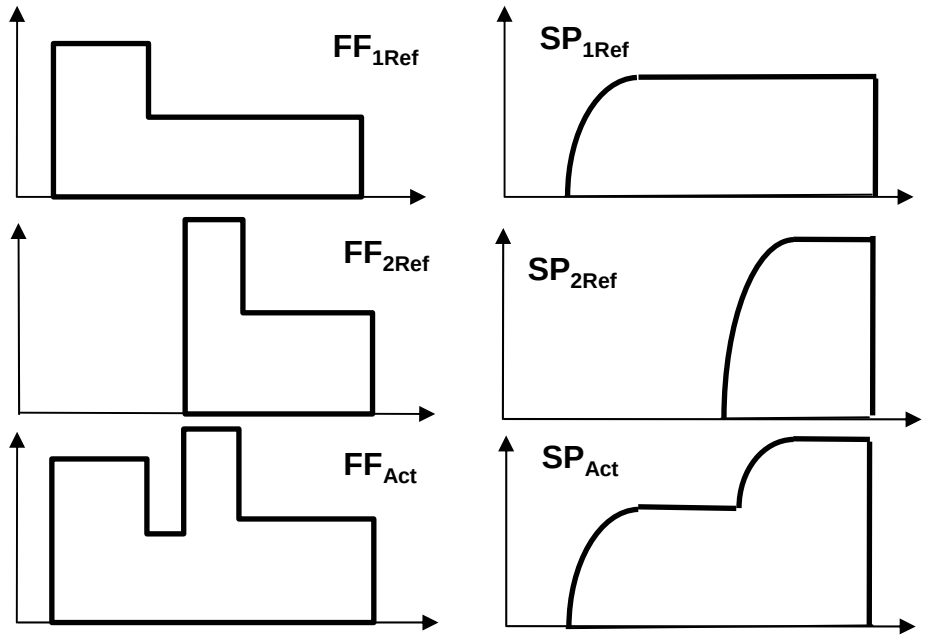
Technical Implementation

DSP server creates two reference SP and FF tables for alternate pulses

Actual tables are superposition of both reference tables

$$SP_{Act} = \max(SP_{1Ref}, SP_{2Ref})$$

$$FF_{Act} = \max(FF_{1Ref}, FF_{2Ref})$$



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Alternating Gradients – shift summary

Implementation and full test with beam bi-modal RF gradient operation at ACC4/5 is successfully completed.

It has bi-modal function with two features in it:

a) Alternate RF pulses have different gradients on ACC4/5, ramps 1 and 2 and beam can be run on ramp 1.

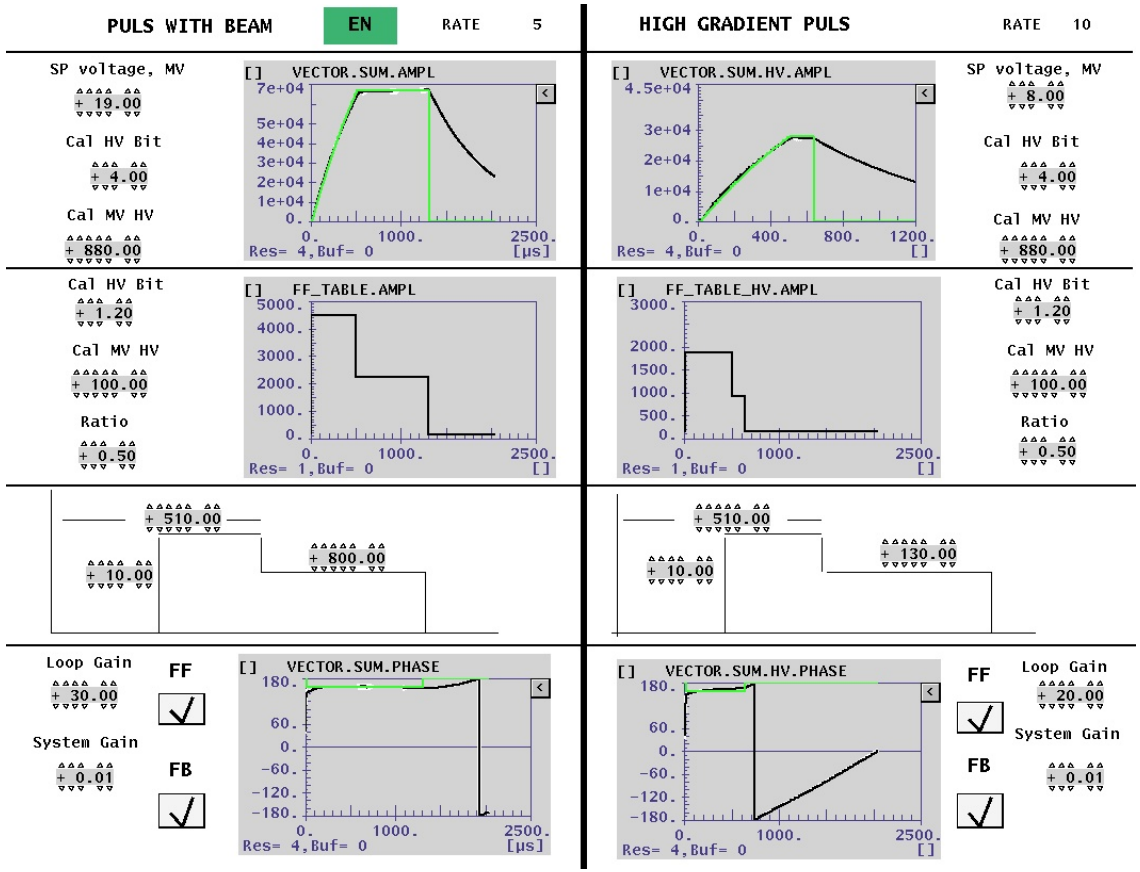
b) Ramp 2 has two gradient levels within the same pulse.

ACC4_5 runs at 10Hz rep. rate stable with average gradient close to 20MV/m. Rest of RF and beam runs at 5Hz rep. rate.

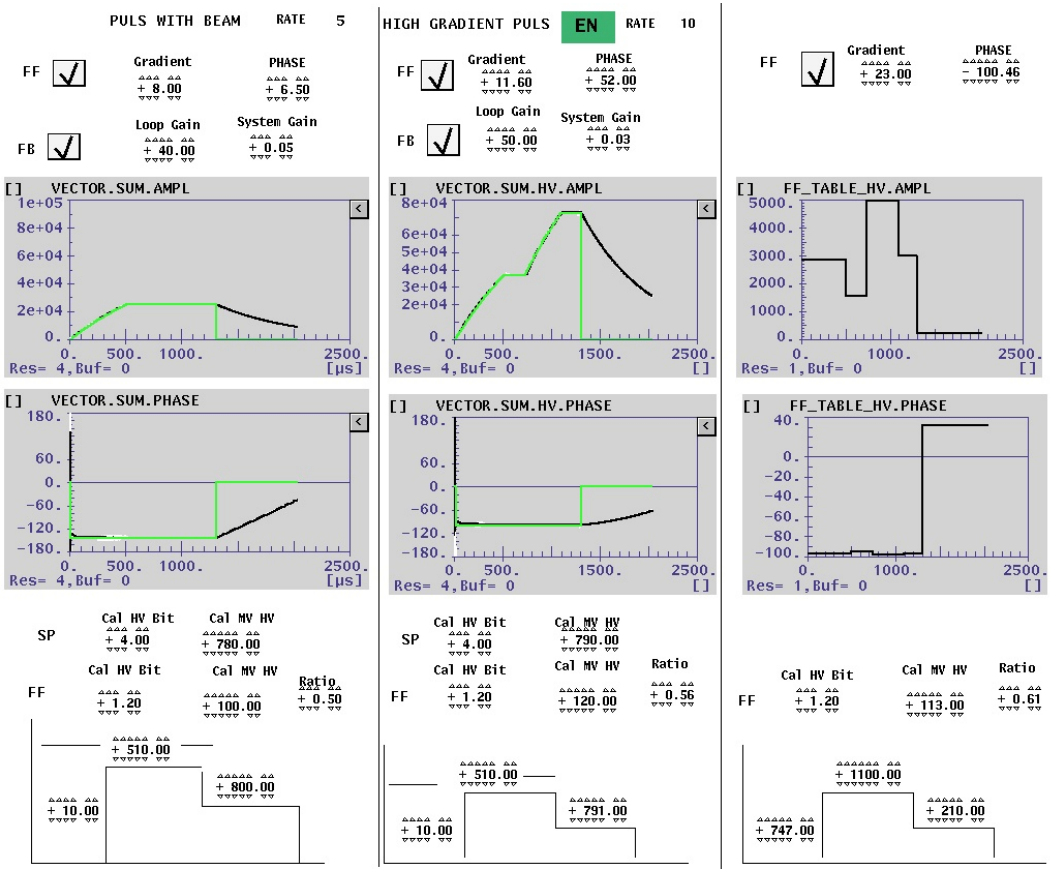
We got full transmission in both cases:on Ramp 1 and Ramp2 on low part of gradients.

Control performance for high alternating gradient is as good as for single pulse mode. Additional shift are required to test with SASE.

Tow Ramps (each one level)



Two Ramps, 2nd with 2 levels



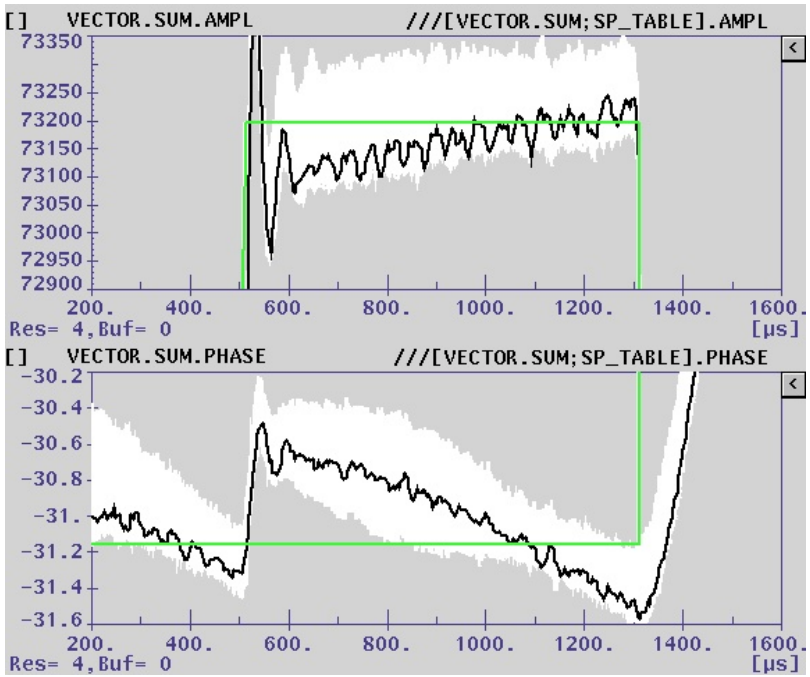
Regulation

Gradients are close to 20Mv/m. Feedback gain is 50.

Control performance for high gradient part is the same as one pulse mode operation, except pulse length is shorter.

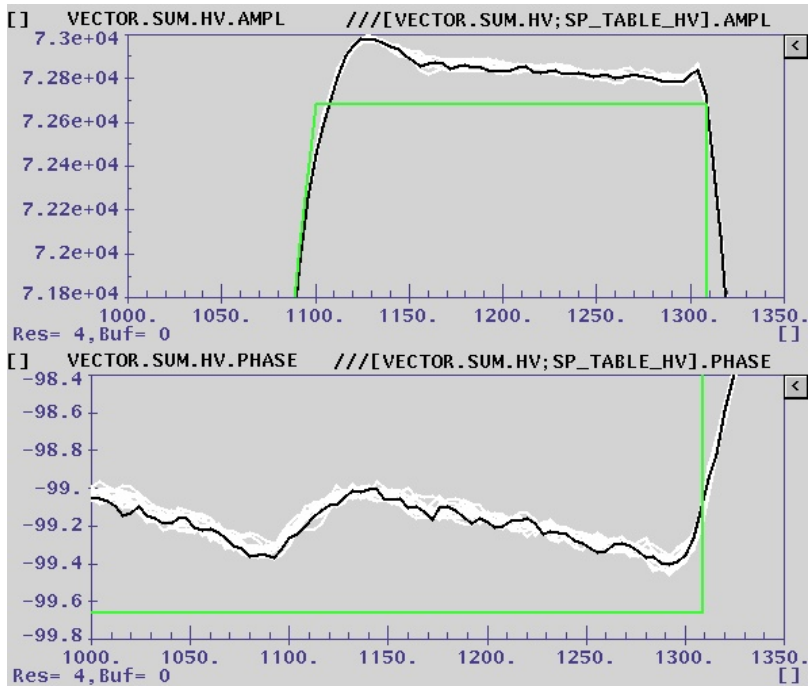
One pulse mode

~1/1000 Amp, 0.9 deg per 700 micsec



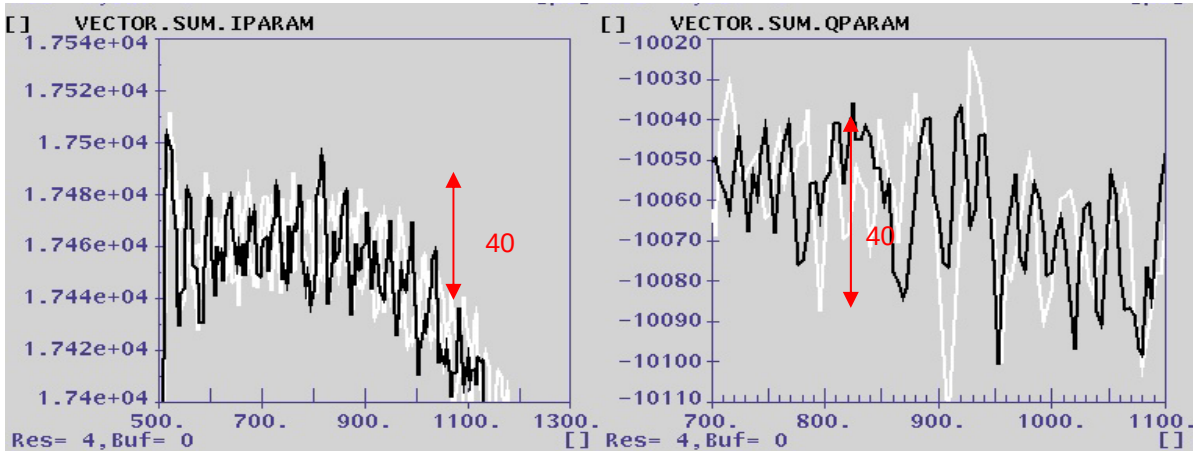
Alternating gradient mode

~1/1000 Amp, 0.3 deg per 150 micsec

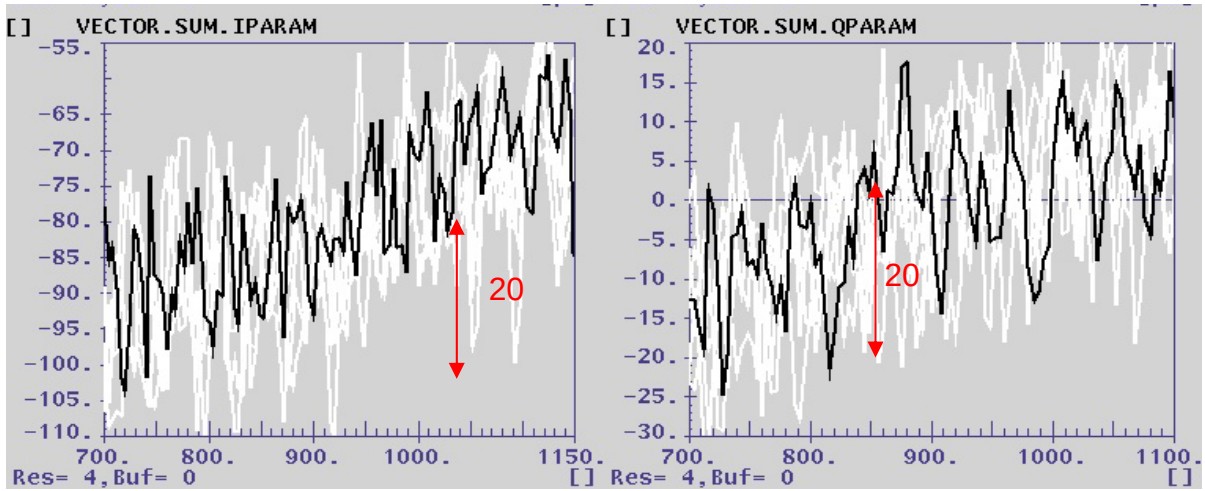


Noise investigation

Measured the ripple on the power supplies for the down-converters for ACC4/5
Cry modules. Discovered short noise spikes with an amplitude of several hundred mV from +-15V.
The repetition rate of the noise spikes was of the order of 50 kHz.
Recommend an experiment where switched power supplies are replaced with linear power supplies.

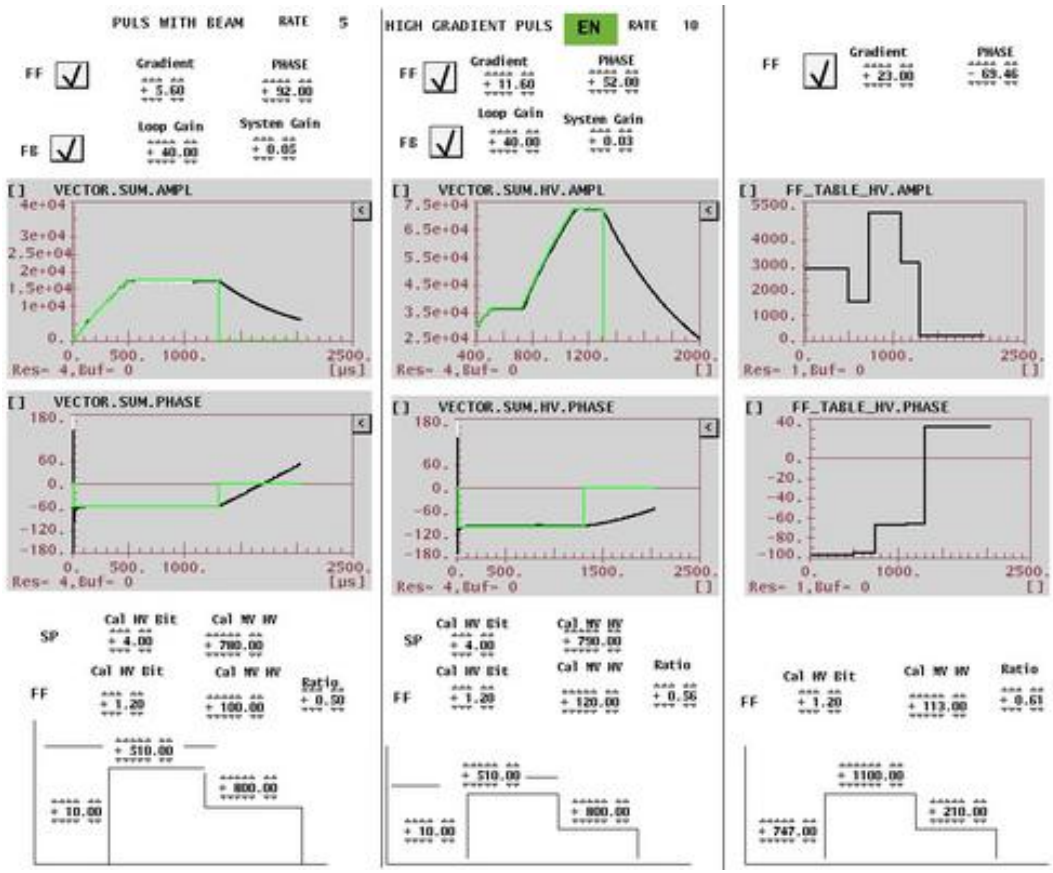


ACC4/5 with close to 20MV/m gradient.



ACC4/5 with 0 gradient (no rf).

11.08.2006 12:58 Ayvazyan,Petrosyan,Yurkov ACC45 is running at 10Hz rep. rate with alternating gradients and SASE conditions.



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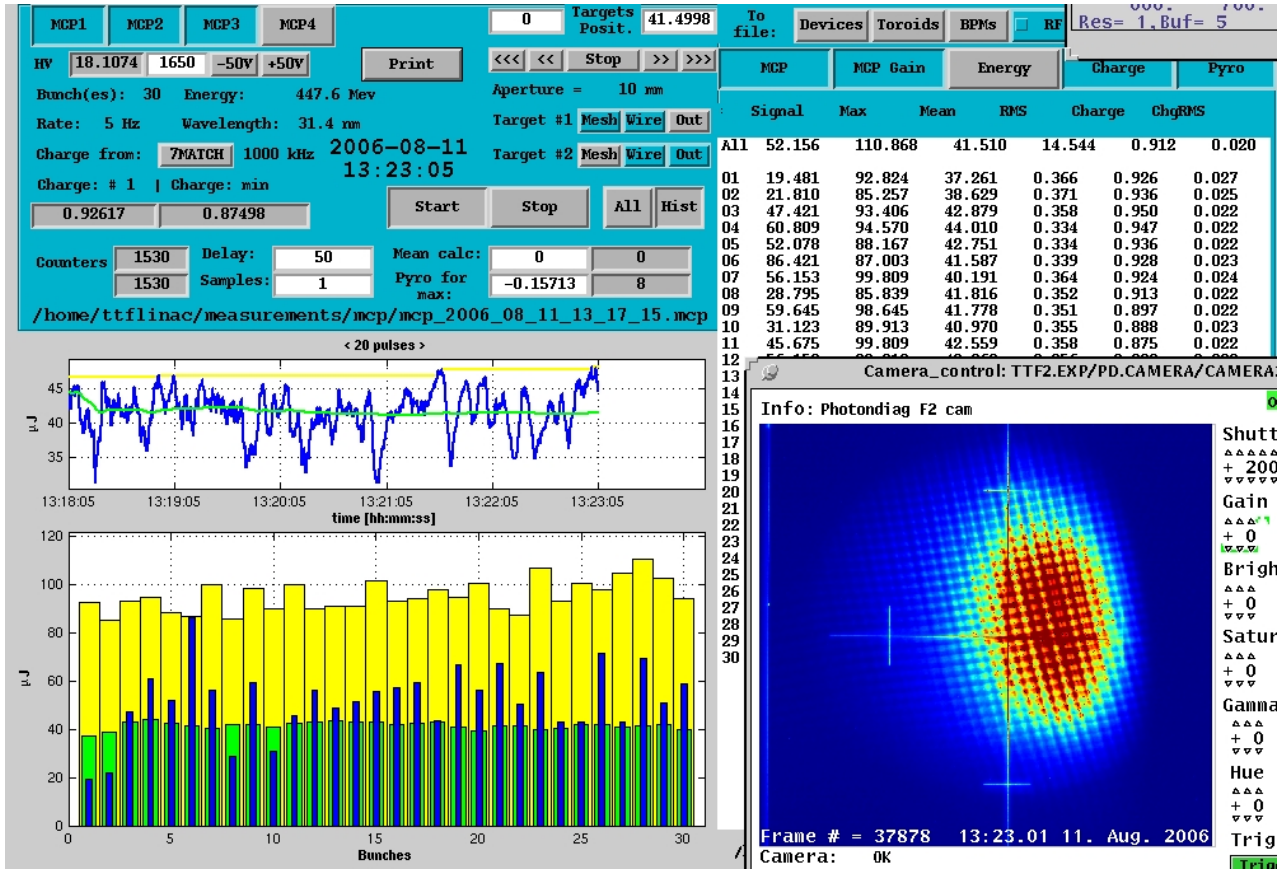
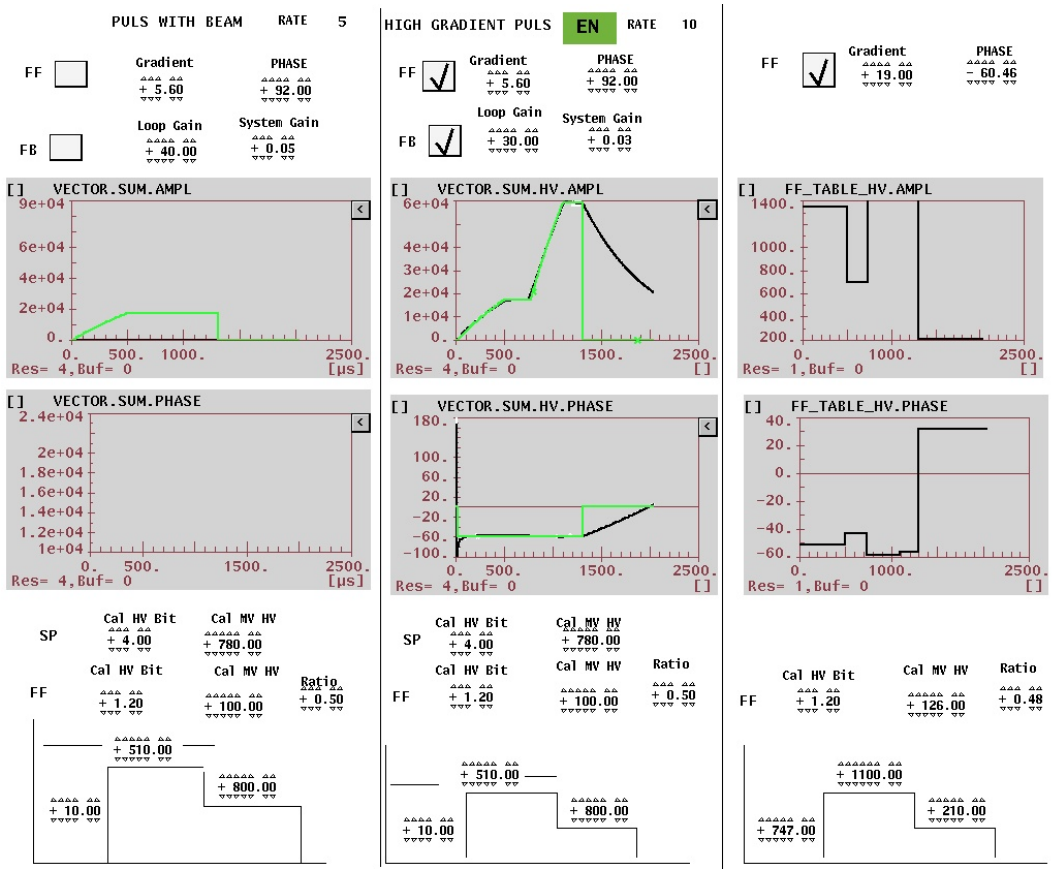
SASE level with alternating pulses. First pulse with beam, second pulse without beam and with 2 level of gradients. The SASE level is the same as with one pulse mode operation (see picture at 12:51).



Now we switch off the first pulse for alternating gradient scheme and put the beam pulse on the first low level flat top of two levels of rf pulse.We see the same level of SASE.



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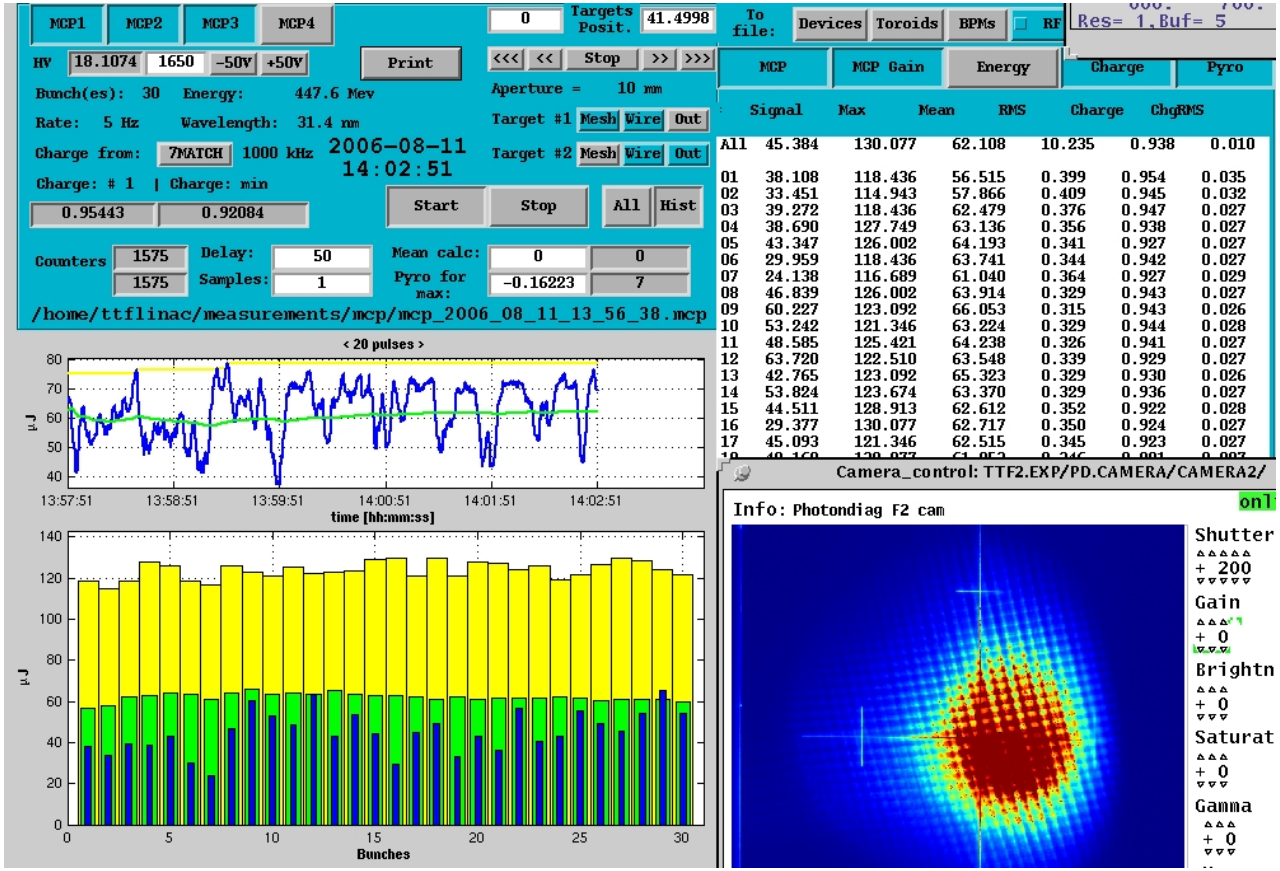
SASE with alternating pulses



Things that could be improved

- Connection between Feed Forward table and Setpoint table
- Regulation
- Adaptive feed forward?

Success – in Use

- Gain experience with high gradient operation, trips and reliability
- Explore gradient level can operate with and without feed back
- Work on regulation, Feedback, Feed Forward, Adaptive FF

Acknowledgements

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