Pulses inside the pulse mode of operation at RF Gun

V. Vogel, V. Ayvazyan, K. Floettmann, D. Lipka, P. Morozov, H. Schlarb, S. Schreiber

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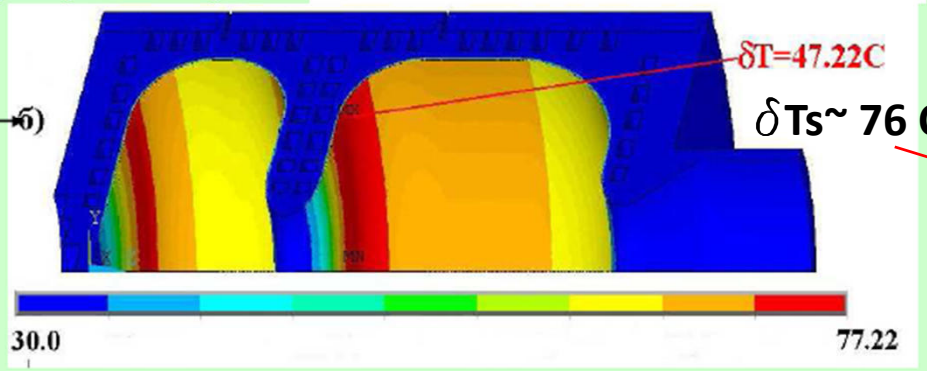
Why we need a PiP mode at RF GUN

Development of RF Gun cavity with improved parameters.

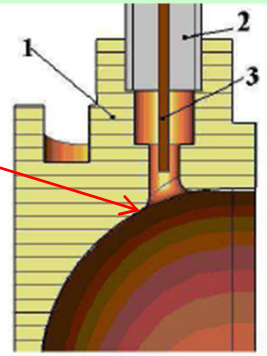
K. Floettmann, Yu. Kalinin**, M. Krasilnikov*, V. Paramonov**, A. Skasyrskaya**, F. Stephan**

Pi=6.18 MW
Q=25750

Gun 5



δTs~ 76 C

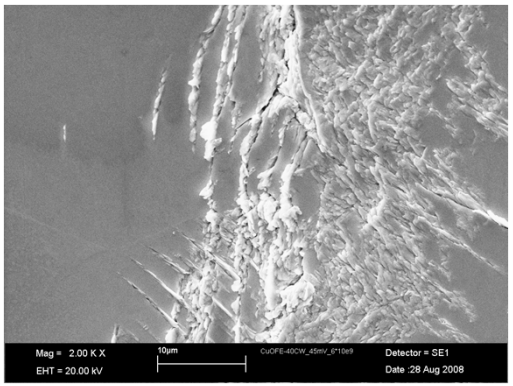


The surface temperature rise after RF pulse τ=1 ms, Ec=60 MV/m.

For PRR=10Hz, Ploss=61.8 kW
T iris ~ 72° C > Ts = 119°C (T pickup ~ 148° C)

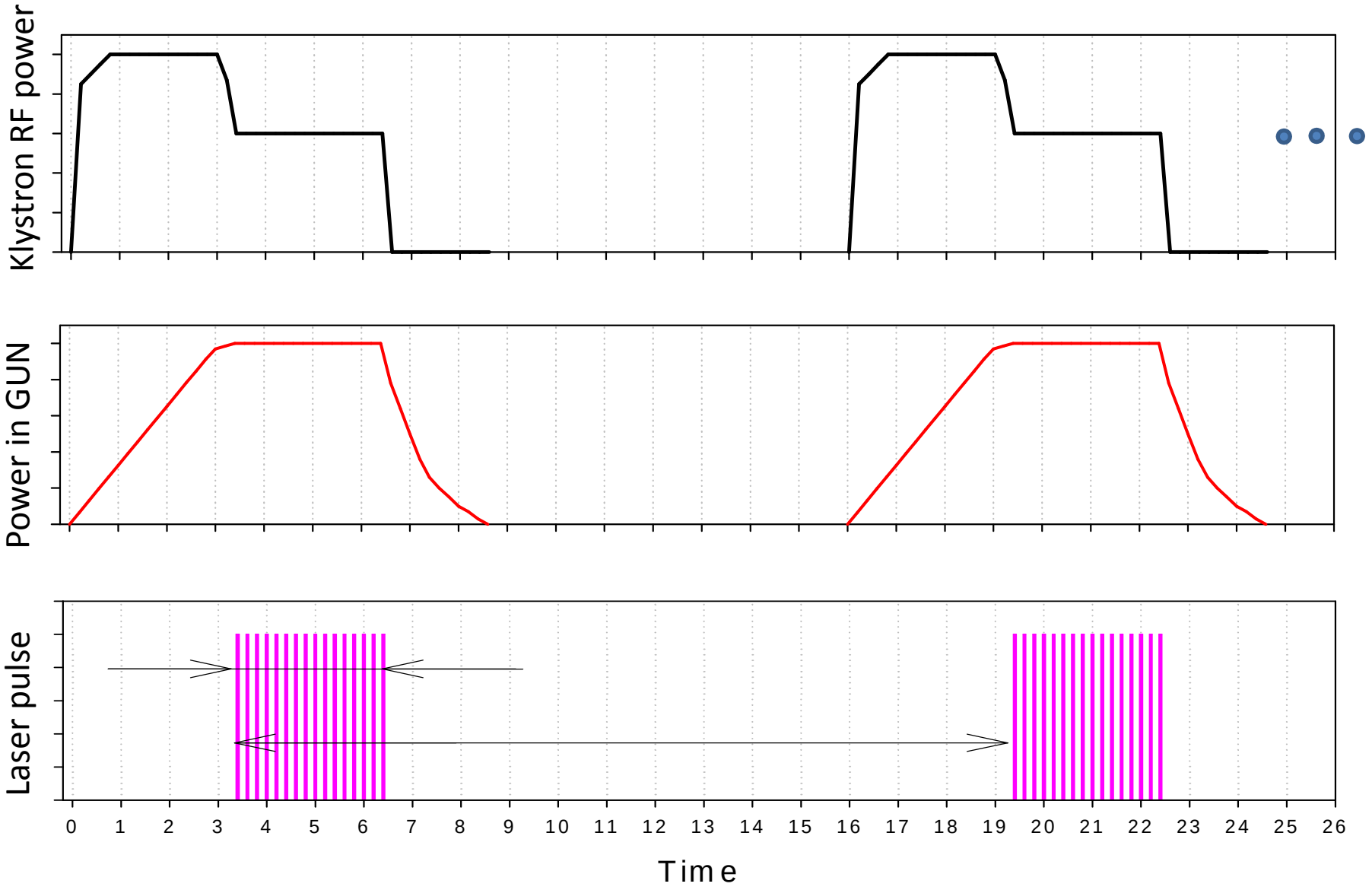
No way to increase pulse length, no way for quasi CW operation

Alternative:
SC GUN
DC GUN
Cold GUN in PiP mode
Cold Traveling wave GUN



Breakdown & Pulsed Surface Heating Studies: Thermal Fatigue behavior versus Grain Orientation
by Markus AICHELER (Ruhr-Universitaet Bochum)

"Pulses inside the Pulse" mode



What we need, to operate GUN in the PiP mode

Design of new SW RF Gun

Goal : Keep all of advantages of GUN5 design, but in short pulse

Klystron

~10 MW pulse power, ~ 150 KW average power, bandwidth about 3 MHz

Modulator

Pulse repetition rate ~ few kHz

Modification of software and electronics

Design of new RF Gun

For acceleration of one electron bunch in the GUN,
we need 60 M/m only for time at most of 1 nS.

GUN 5

Qo = 25000, Ql = ~ 12000, > τ = 3 μS. For 60 MV/m - 6.2 MW RF

PiP GUN

1. *Qo = 25000, Ql = ~ 12000, > τ = 3 μS. For 60 MV/m (~20 MW RF during fill time)*
   combine power from two klystrons or power multiplier:
   SLED 2
   delay line
   open cavity

2. *Qo = 25000, Ql = ~ 4000, > τ = 1 μS. For 60 MV/m – 18.6 MW RF*
   For 40 MV/m – 8.2 MW RF

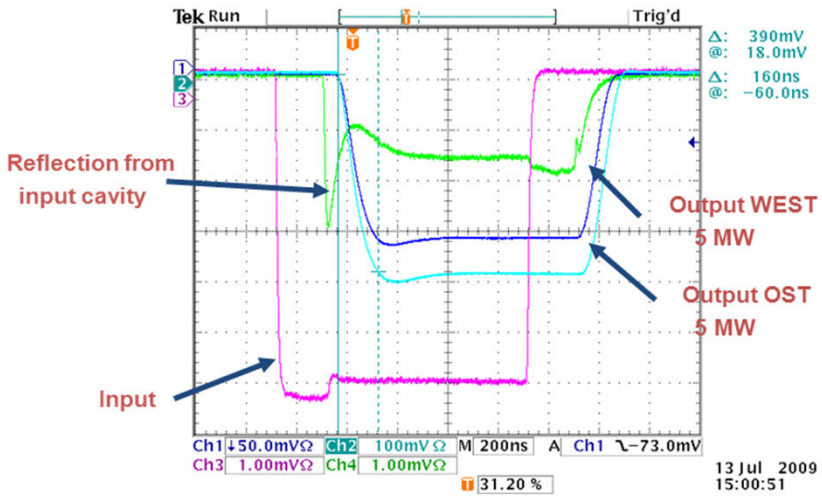
RF power sources

We have three types of MBK

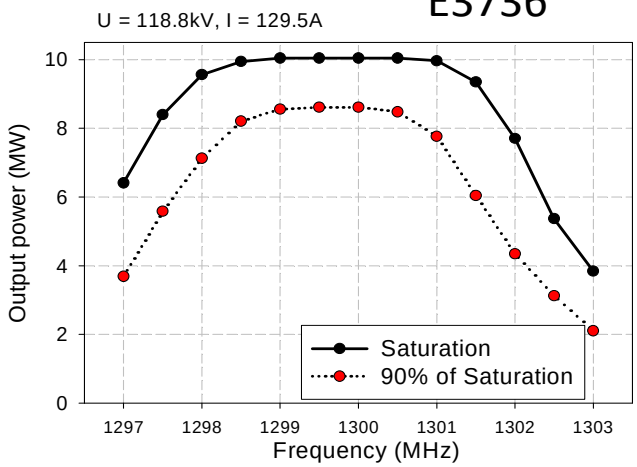
117kV, 140 A, efficiency > 60%

P impulse max	10.5 MW
P rf average	150 kW
P collector average	300 kW
P* body with RF	(2.8 - 4.5) kW
Bandwidth	> 3 MHz

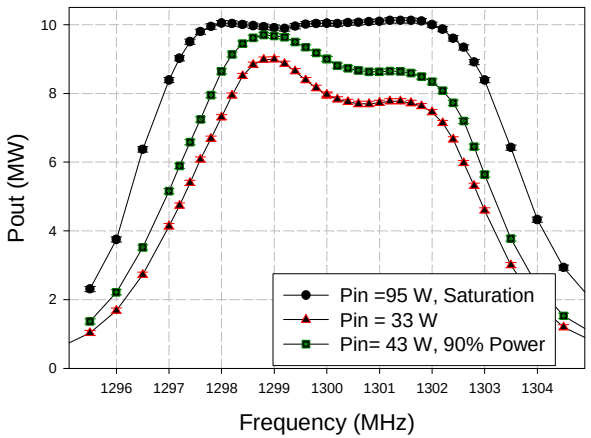
Toshiba MBK, short RF pulse



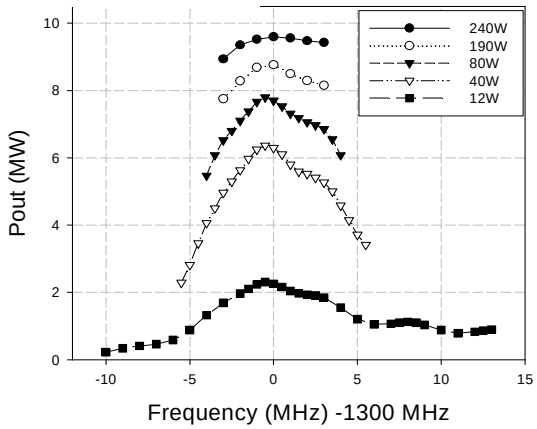
E3736



VKL 8301

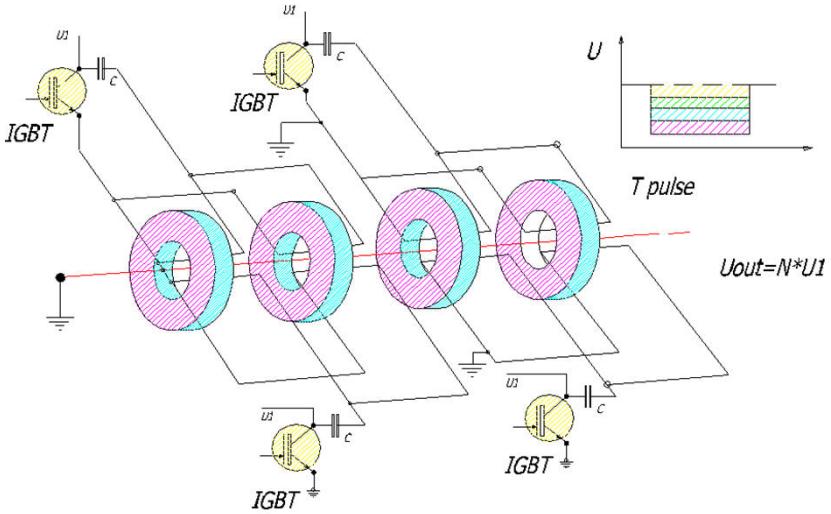


TH1802



Modulator

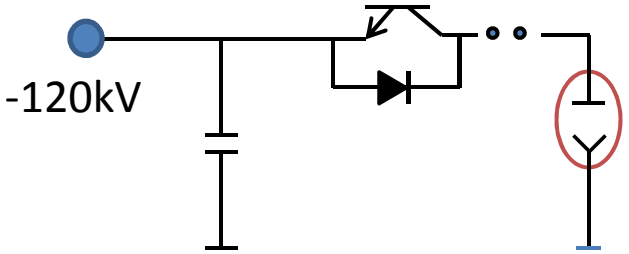
Linear type modulator



SLAC, KEK,..

Trise ~ 0.4 μS
T hv 1.6 – 4 μS
Imax ~ kA
PRR ~ kHz
Low voltage P/S

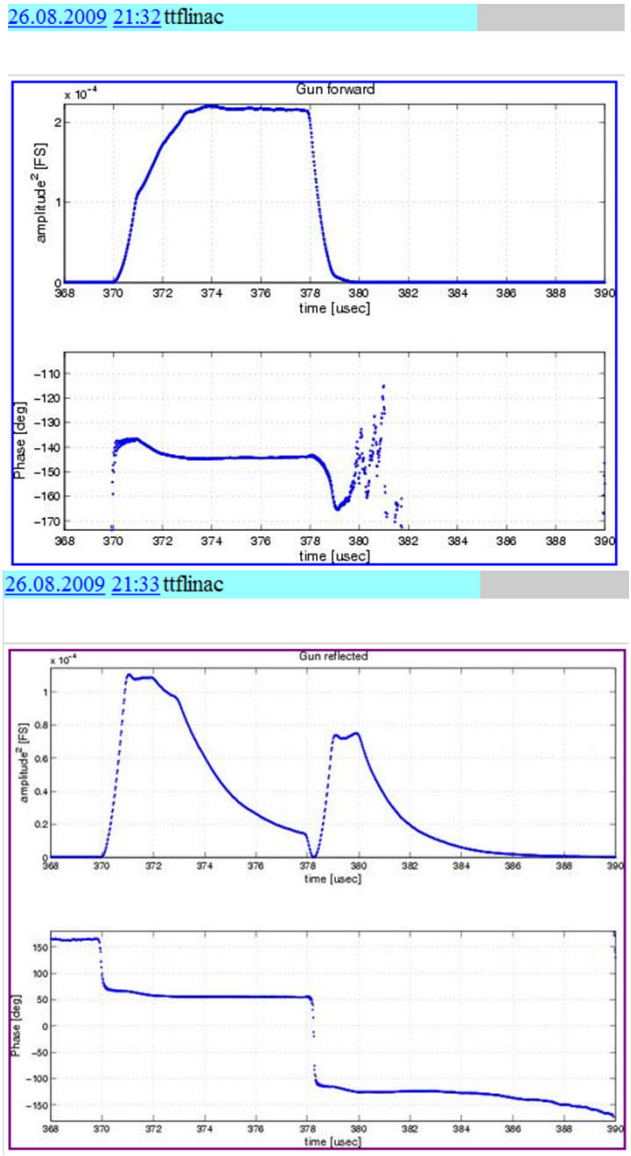
Direct hard-switch modulator



DESY,
Diversified Technologies, Inc.,
Toshiba factory test stand,..

Trise ~ 0.6 μS
Thv 2.5 - 10000 μS
Imax ~ 200-300A
PRR ~ kHz
High voltage P/S

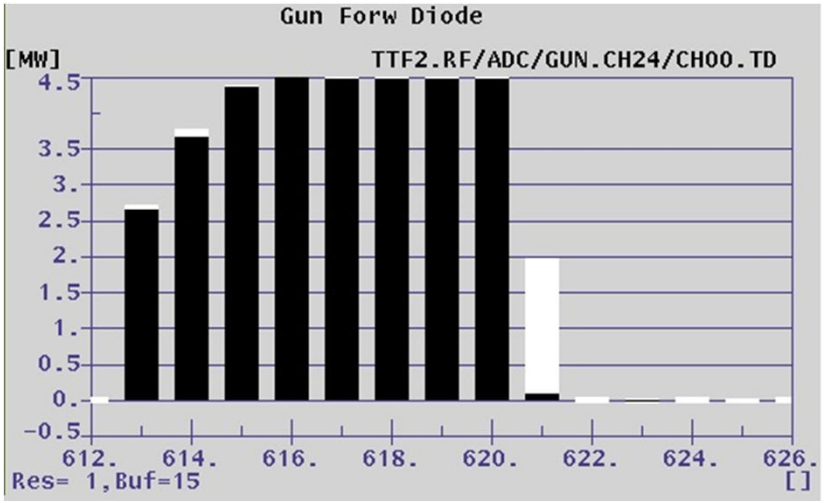
PiP mode study at FLASH with existing components

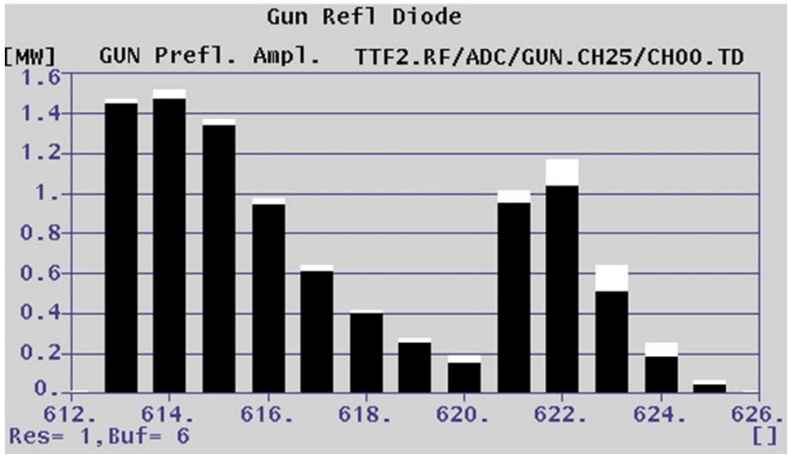


GOAL of first run:

Examination of the hardware and software.

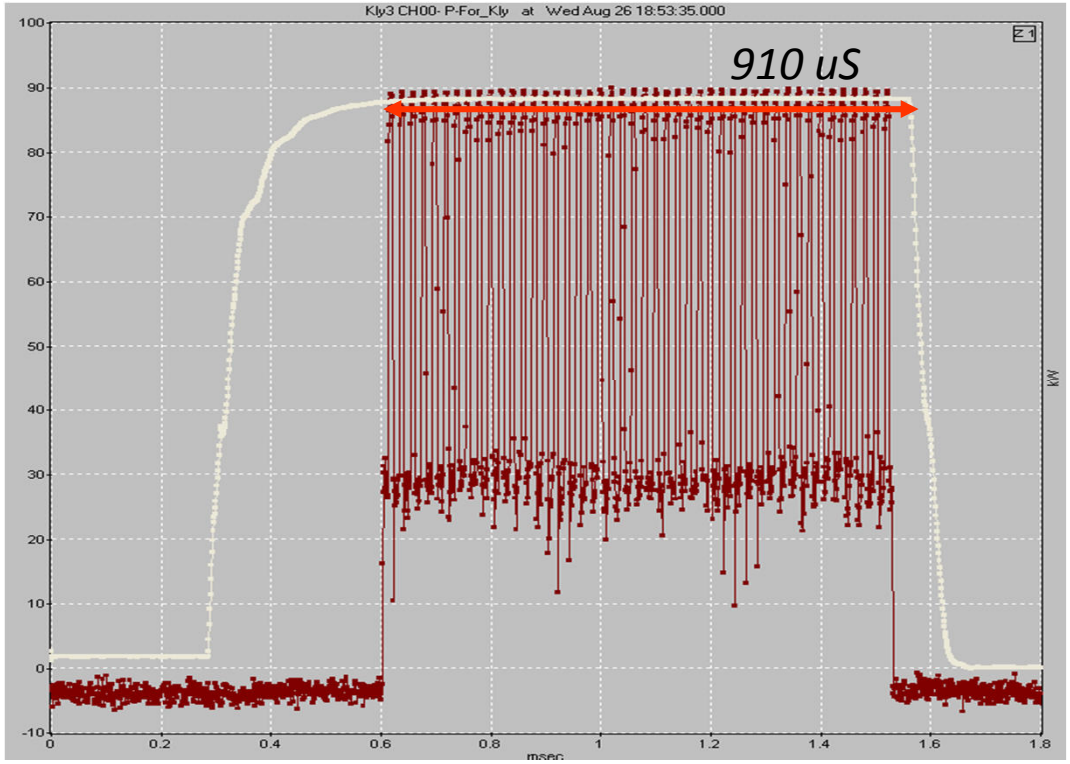
Optimization of the RF pulse shape.



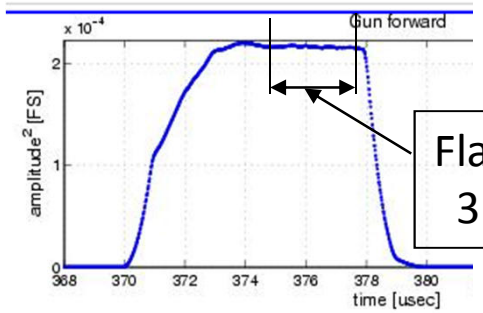


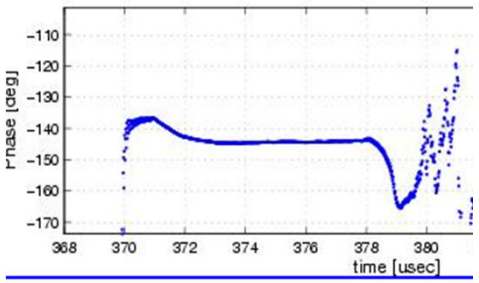
For pulse shape generation an user tables was used
In feed-forward mode of operation

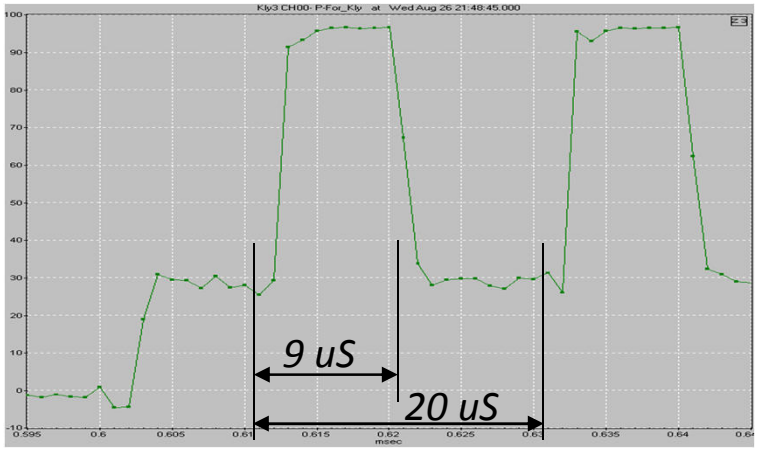
"pulses inside the pulse" mode first test at FLASH 27.08.2009



12.5 nS ADC

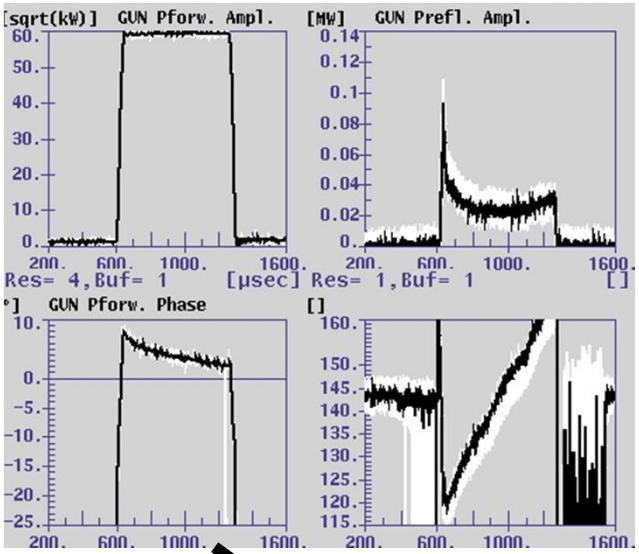


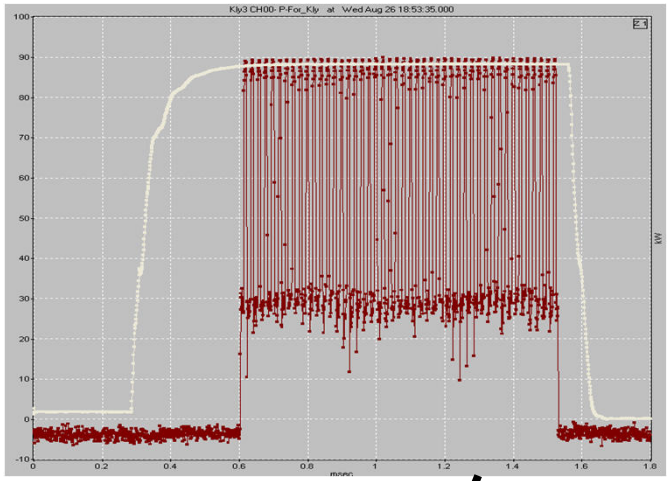




46 bunches,(50kHz), P forward = 4.0MW
about 1 hour of operation without any interlock!

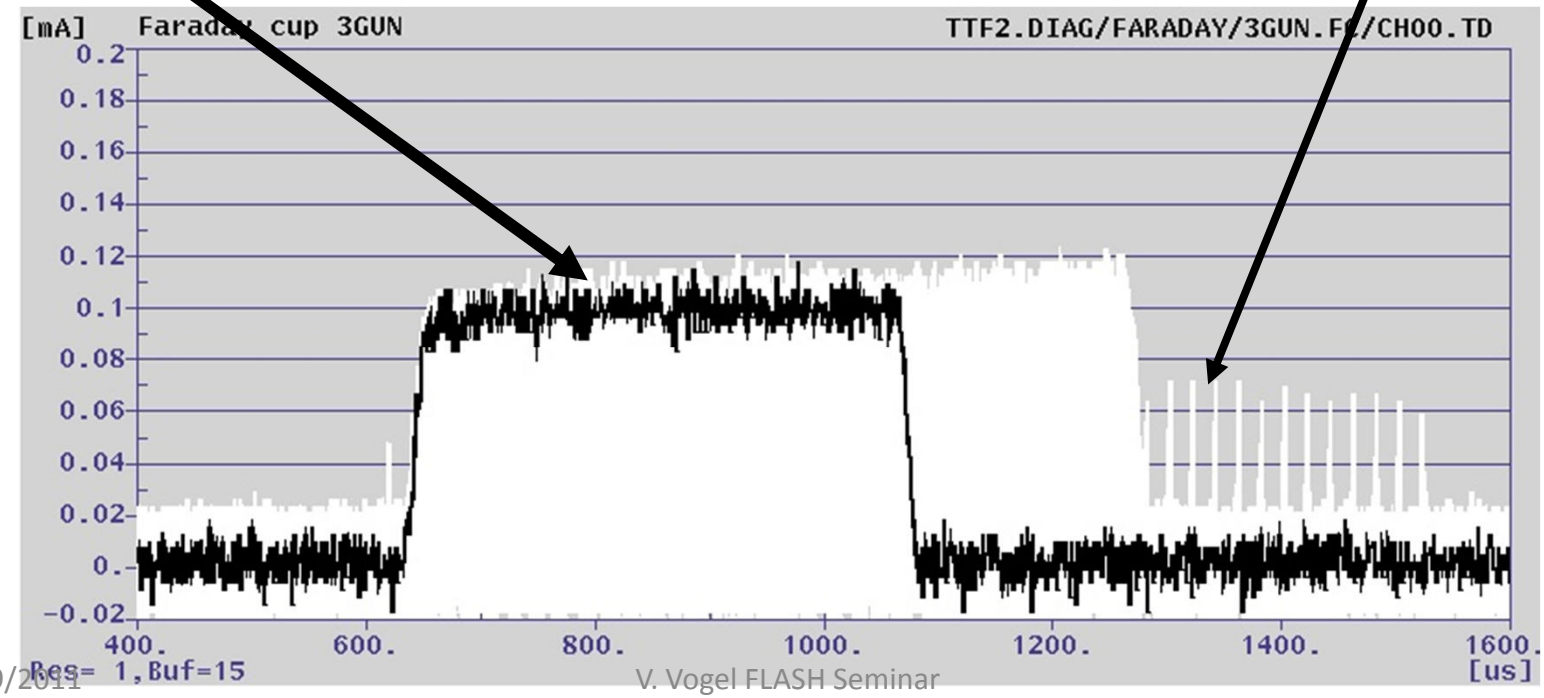
Dark current study





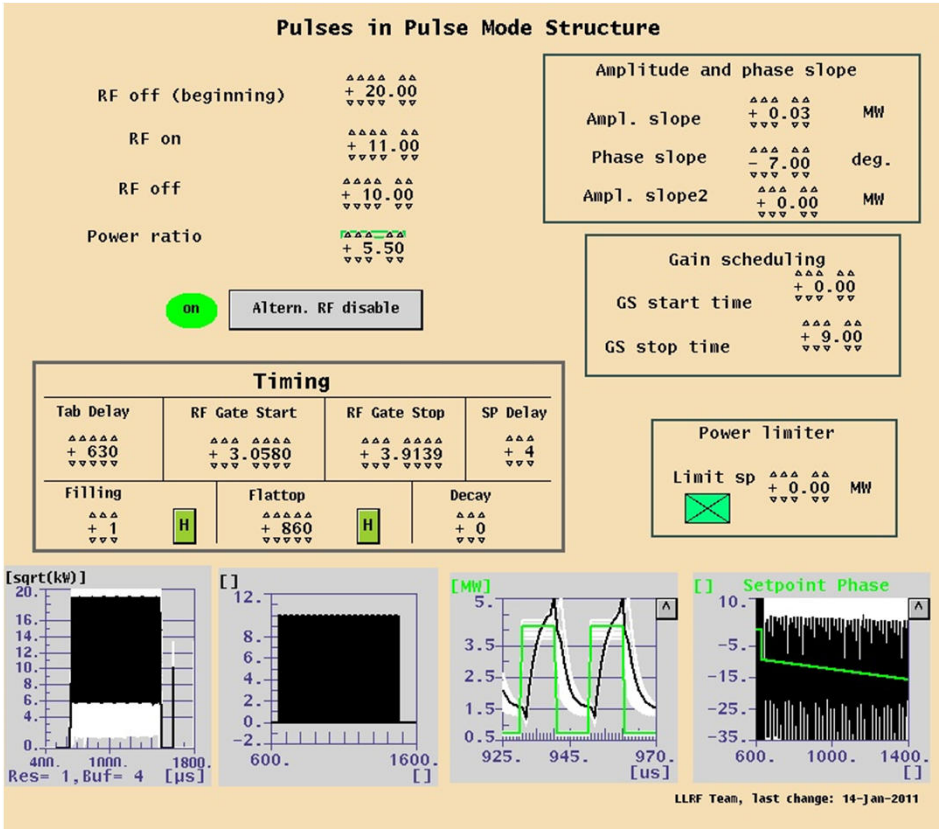
P klystron 3.7 MW

P klystron 4.0 MW



Second run 16/01/2011

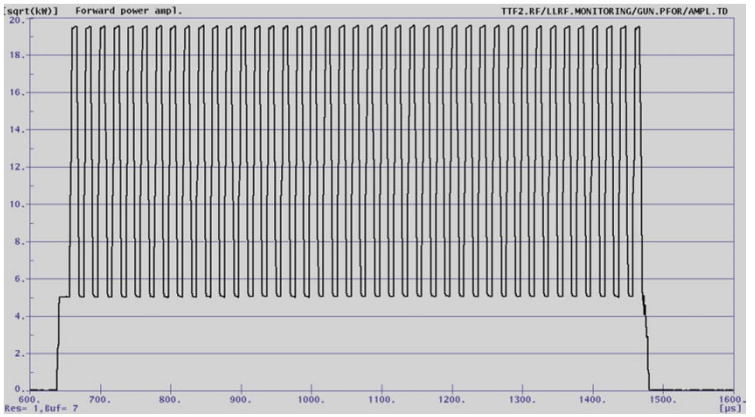
Normal mode, gun set points:
Pf = 3.70, Flattop = 350uS, T window = 43°C



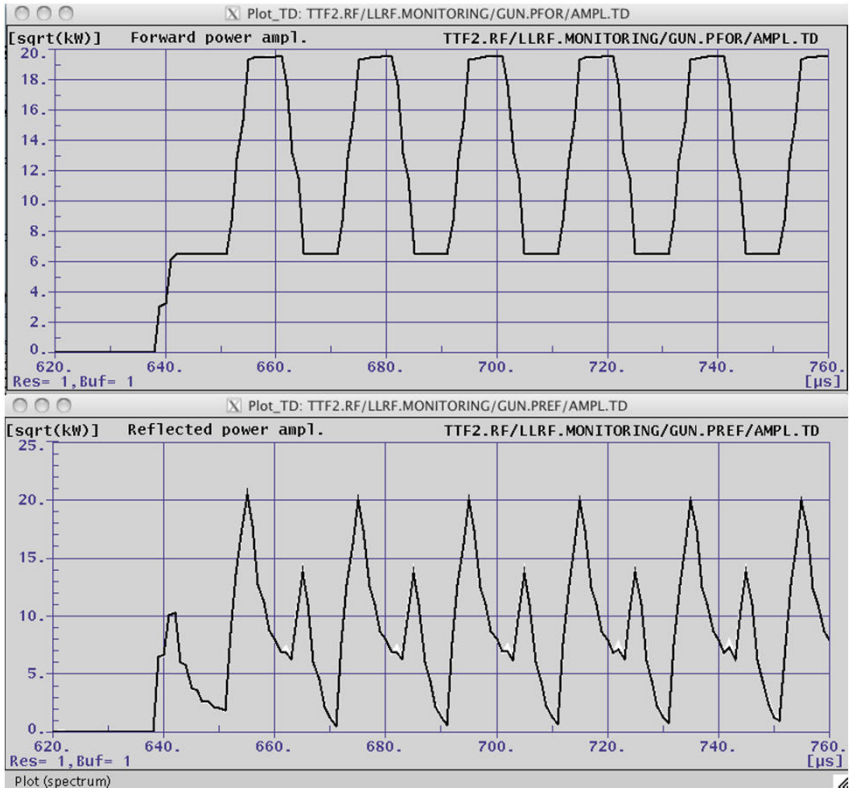
New DOOCS panel for PiP mode

Table generation (FF,SP, GT) was extended
Feedback loop can be closed

GUN mode

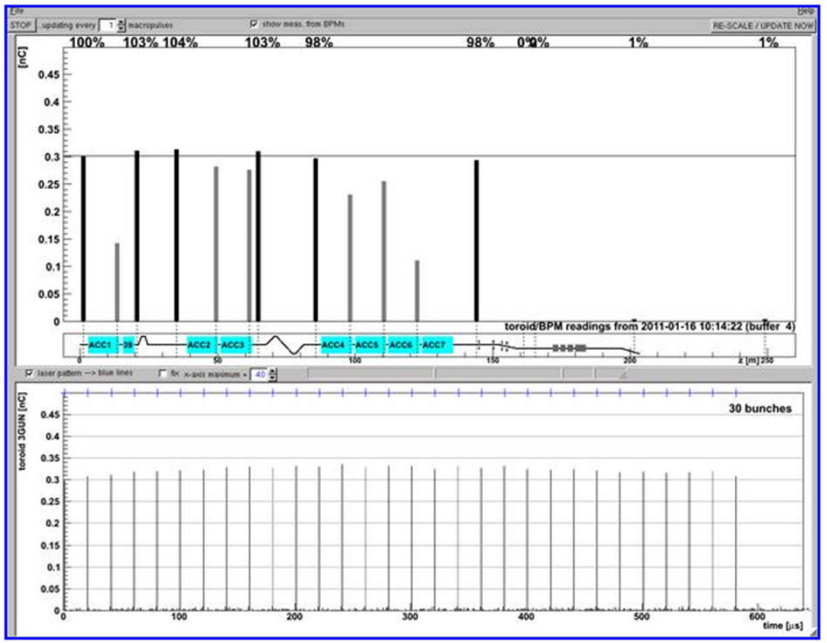


41 pulse, each 10μS, in total RF 800μS

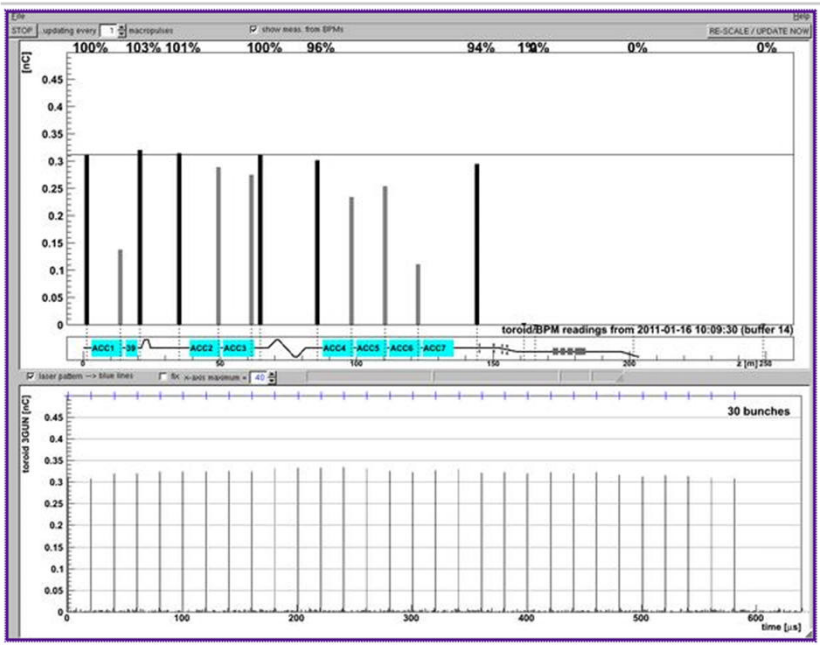


Bypass mode

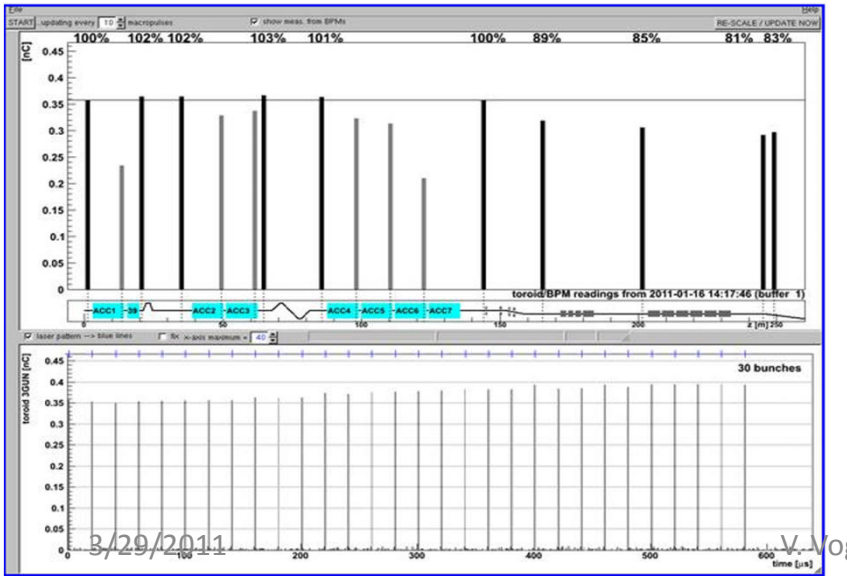
rf gun feedback on



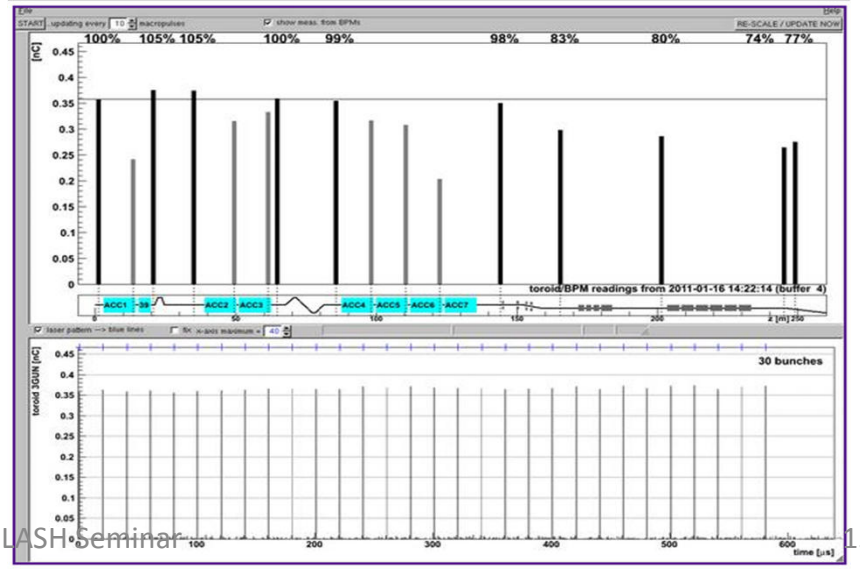
30 bunches 50 kHz, gun in PiP mode
feedback off

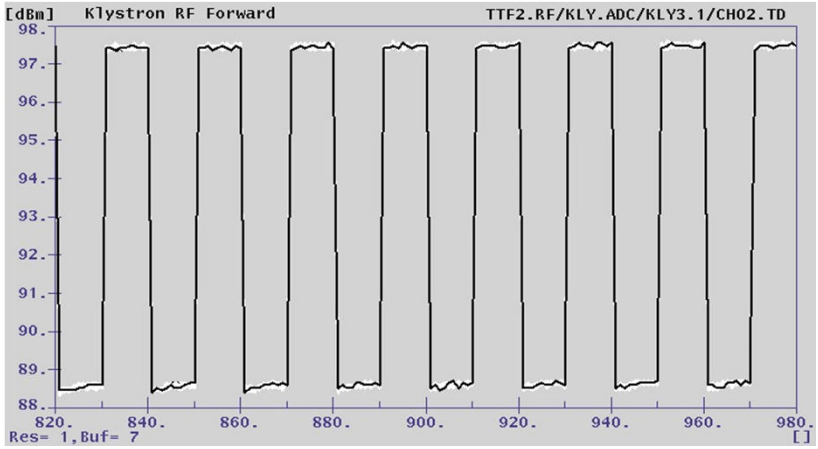


FEL mode

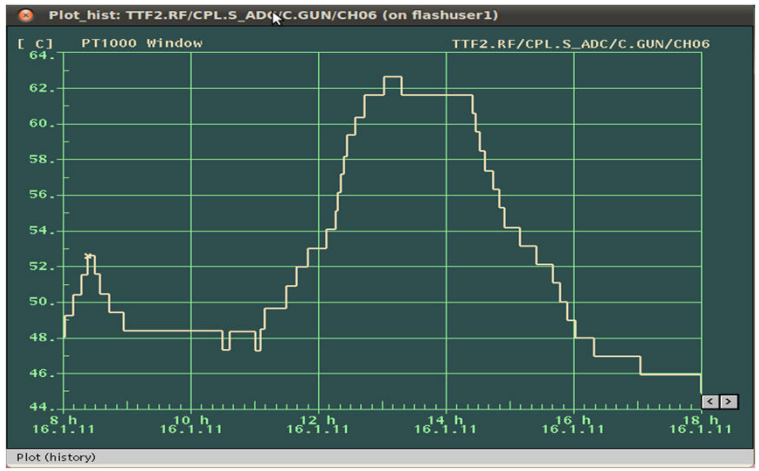


FEL mode, 30 bunches 50 kHz, gun in PiP mode feedback on





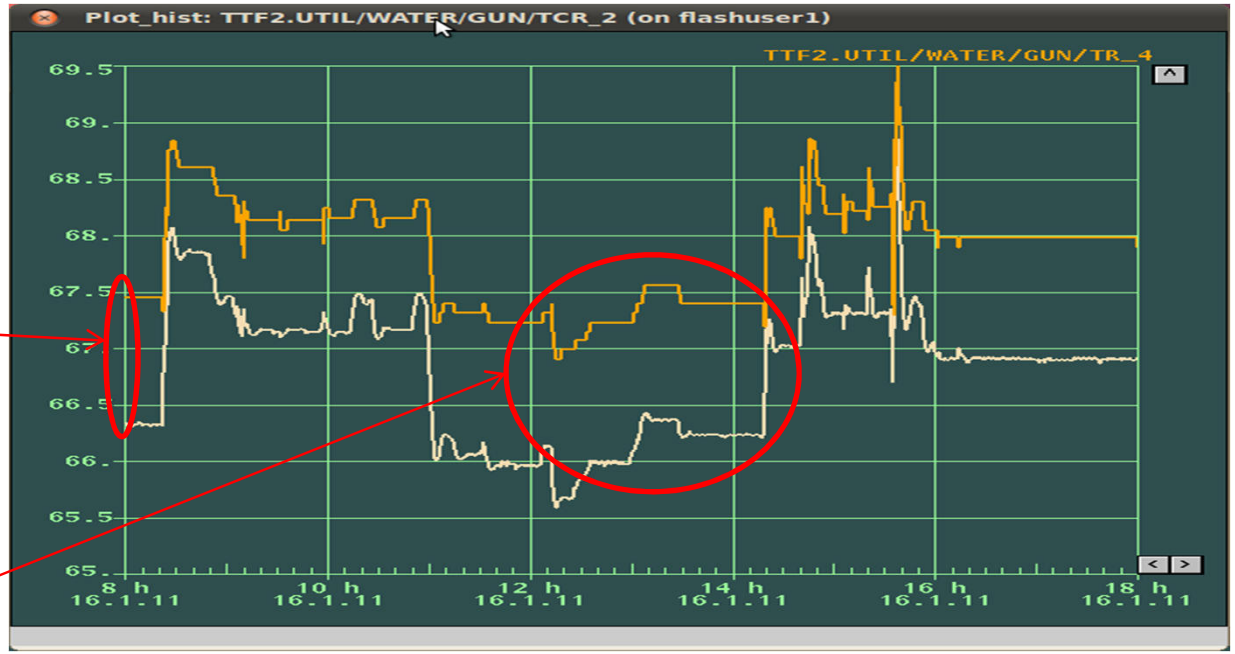
Klystron output power: max 5.6MW, min 0.7 MW



RF window temperature during test

normal mode, 13 kW average power , Pf = 3.7 MW, 370μS

PiP mode, 16 kW average power , Pf = 4.2MW, 10/10μS, 680μS



Temperature of water for GUN cooling

Outlook

With PiP mode in the FLASH on the existing RF GUN we can expect to have:

Single beam pulse
Two beam pulses, separated on 1000 μS
Three beam pulses, separated on 500 μS
…….
Fifty beam pulses, separated on 20 μS

In the next FLASH study run, we will continue the PiP mode study:

-new software for feedback regulation
-optimization of PF pulse shape
-long time test
-lasing in PiP mode
-up to now we don't have a problem with breakdown in the GUN in PiP mode, maybe 10 MW klystron at GUN RF station?

Thank you for attention!

welcome for discussion