RF distribution with semi-fixed Pks

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- Simulation configuration –rectangular distribution
- Solution (1); Matched Qls with various beam loading
- Solution (2); Ql optimization with 20% gradient distribution
- Solution (3); Ql optimization with 10% gradient distribution

Study Schedule on Feb., 2012

- PkQl study
- Quench limit study
- ***RF overhead study***

PROPOSED SHIFT-BY-SHIFT studies plan

Shift Ref.			Operator	9mA Study Leader	Primary goals
1	Tuesday (21 Feb)	07:00-15:00	Avazyan		1. Switch laser to 3MHz 2. Switch machine rate to 5Hz
2		15:00-23:00	Eislage		1. Laser setup/optimization for 3MHz / long bunch trains 2. Machine startup, preparation for 9mA shifts 3. LLRF commissioning for 9mA studies (need list of items)
3		23:00-07:00	Klose		1. Machine tuning, aim for ≥3mA, max. bunches
4	Wednesday	07:00-15:00	Schmidt		1. Beam loading compensation setup 2. Piezo tuner setup 3. Complete measurements of ACC67 quench limits
5		15:00-23:00	Ayvazyan		1. Pk/Ql studies at ≥3mA
6		23:00-07:00	Eislage		Machine tuning, aim for >4mAmA, max. bunches
7	Thursday	07:00-15:00	Schmidt		1. High gradient studies with light beam loading
8		15:00-23:00	Ayvazyan		1. Pk/QL studies at >4mA 2. Preparation for Klystron saturation / RF power overhead studies
9		23:00-07:00	Eislage		1. Machine tuning, aim for ≥6mA, max. bunches
10	Friday	07:00-15:00	Delfs		1. Test procedures for performing gradient scans (+/- few %) with 6+ mA and long bunch trains
11		15:00-23:00	Schmidt		1. High gradient studies with light beam loading
12		23:00-07:00	Ayvazyan		1.Pk/Ql studies at 6mA and long bunch trains 2. Set up for 8hr stable run with gradients close to quench and moderate beam loading
13	Saturday	07:00-15:00	Delfs		8hr stable run with gradients close to quench with moderate beam loading
14		15:00-23:00	Schmidt		1. High gradient studies 2. Set up for RF power overhead studies
15		23:00-07:00	Ayvazyan		RF power overhead studies
16	Sunday	07:00-15:00	Delfs		Set up high gradient studies with heavy beam loading High gradient studies with heavy beam loading
17		15:00-23:00	Schmidt		High gradient studies with heavy beam loading
18		23:00-07:00	Ayvazyan		High gradient studies with heavy beam loading
19	Monday (27 Feb)	07:00-15:00			RESTORE MACHINE TO 1MHz/10Hz

Llrf tuning overhead

- As in RDR, llrf tuning overhead is 16% in power.
- Further suppression of rf overhead is requested.
- LLRF overhead covers such as
  (dynamic) microphonics, fluctuation of HV (klystron), beam current, …
  (static) Pk and Ql tolerance, HV ripple, …

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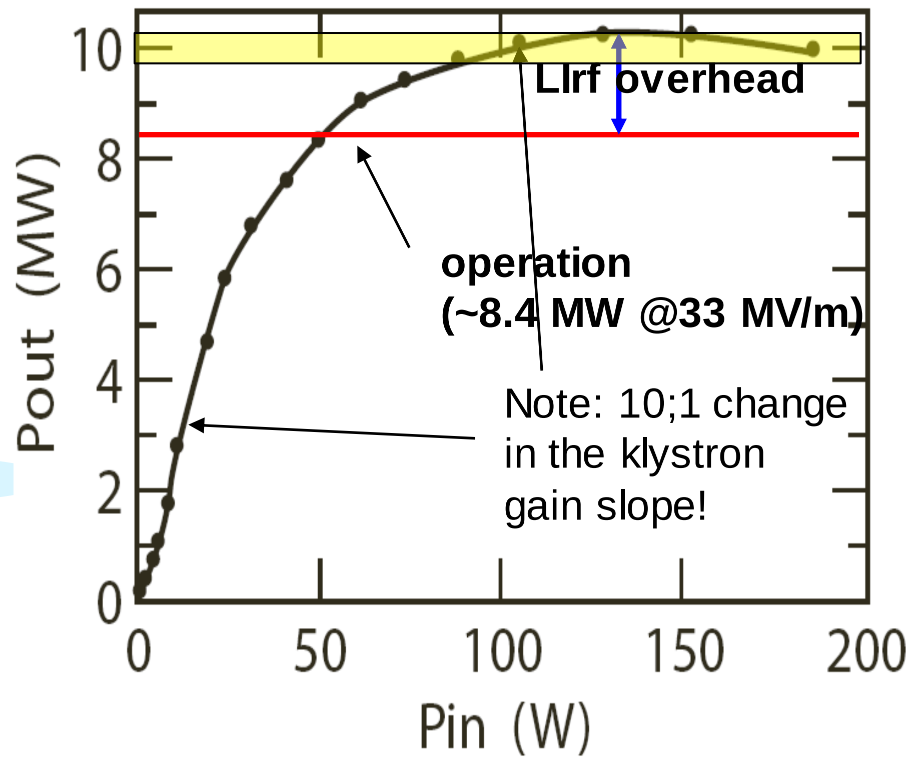
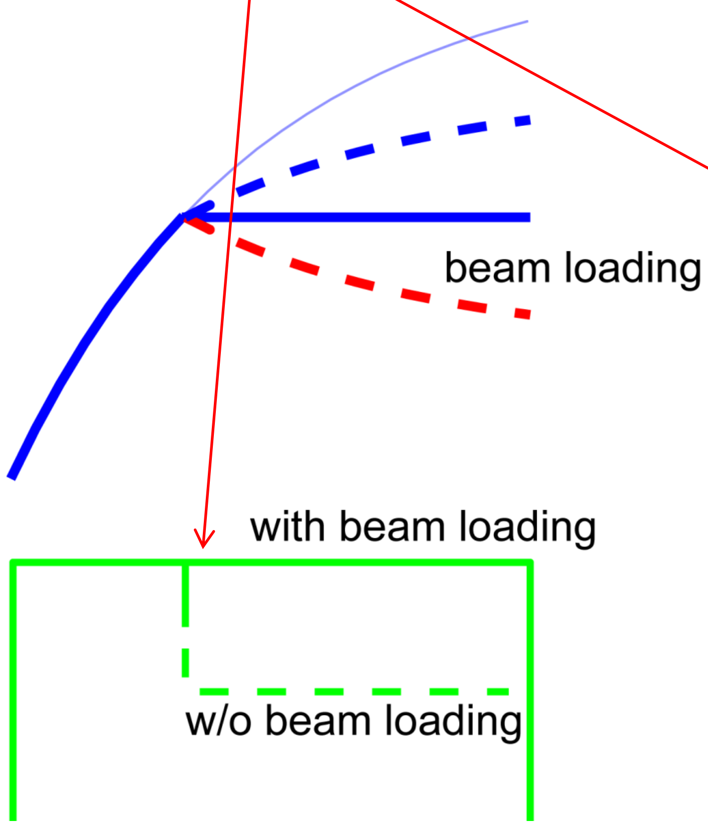
nit parameters.

Parameter	Value	Units
Modulator overall efficiency	82.8	%
Maximum klyston output power	10	MW
Klystron efficiency	65	%
RF distribution system power loss	7	%
Number of cavities	26	
Effective cavity length	1.038	m
Nominal gradient with 22% tuning overhead	31.5	MV/m
Power limited gradient with 16% tuning overhead	33.0	MV/m
RF pulse power per cavity	293.7	kW
RF pulse length	1.565	ms
Average RF power to 26 cavities	59.8	kW
Average power transferred to beam	36.9	kW

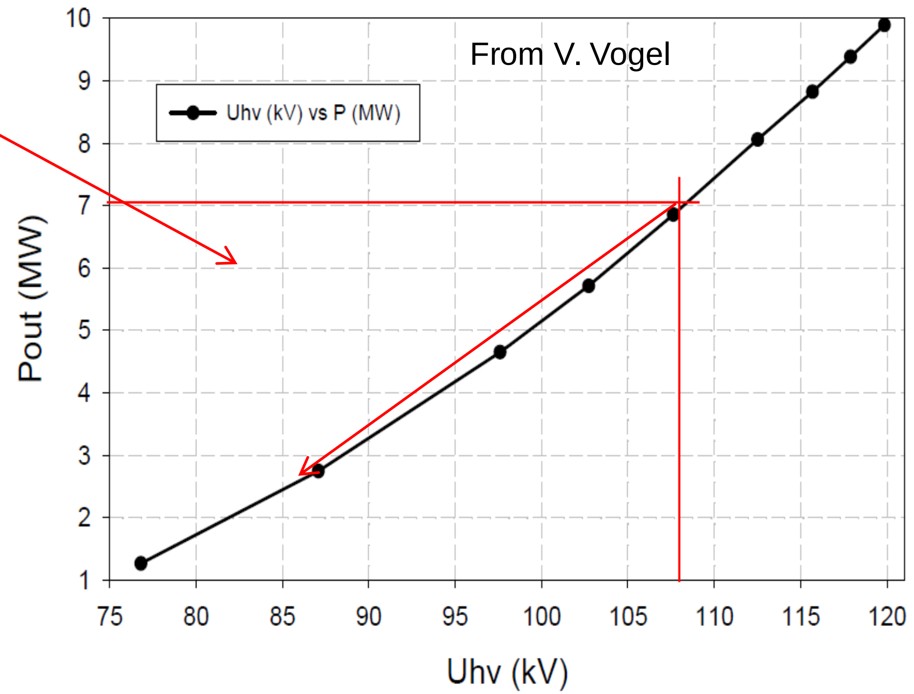


Preparation for RF overhead study

• Rectangular rf output (not "Step-like") is required because the rf overhead should be examined at flat-top.
 -> high current beam is desired.
-> filling time should be optimized.
• Near saturation operation is required.
-> Lower voltage operation of the klystron



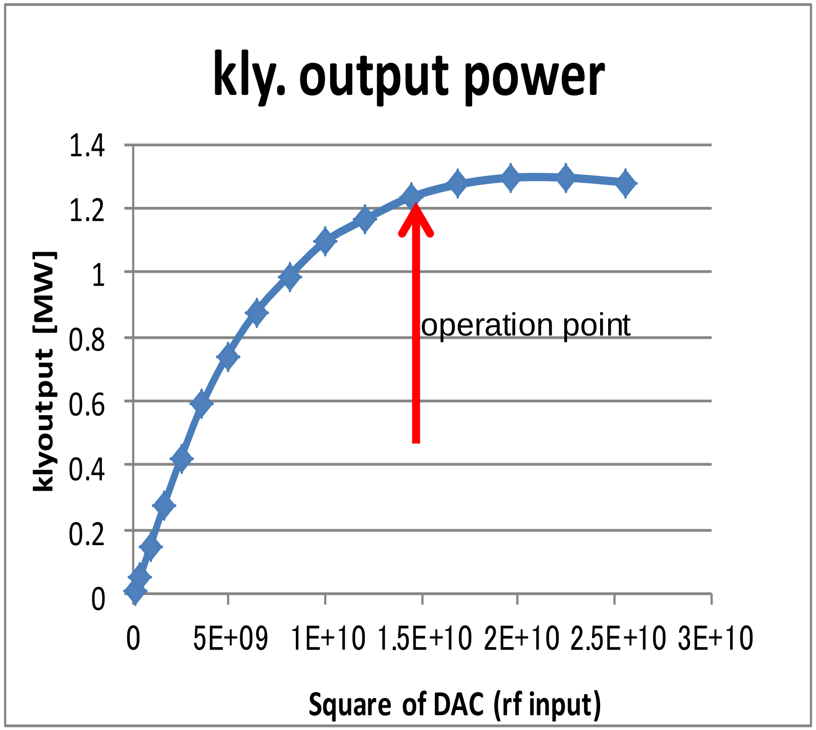
Klystron voltage v.s. rf output

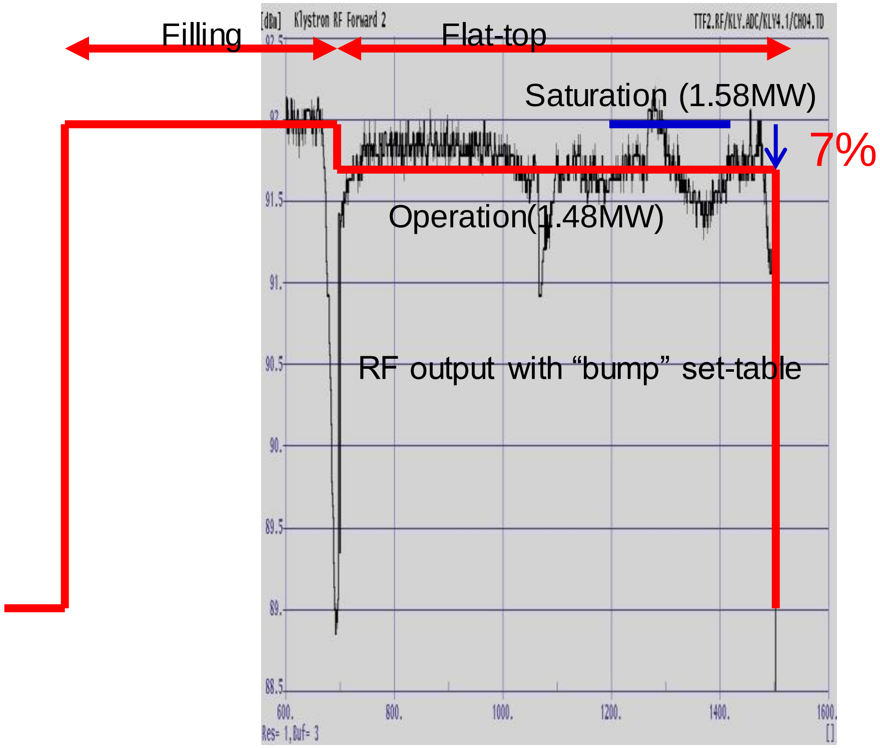


KILC12 (Apr.23, 2012)

RF operation condition

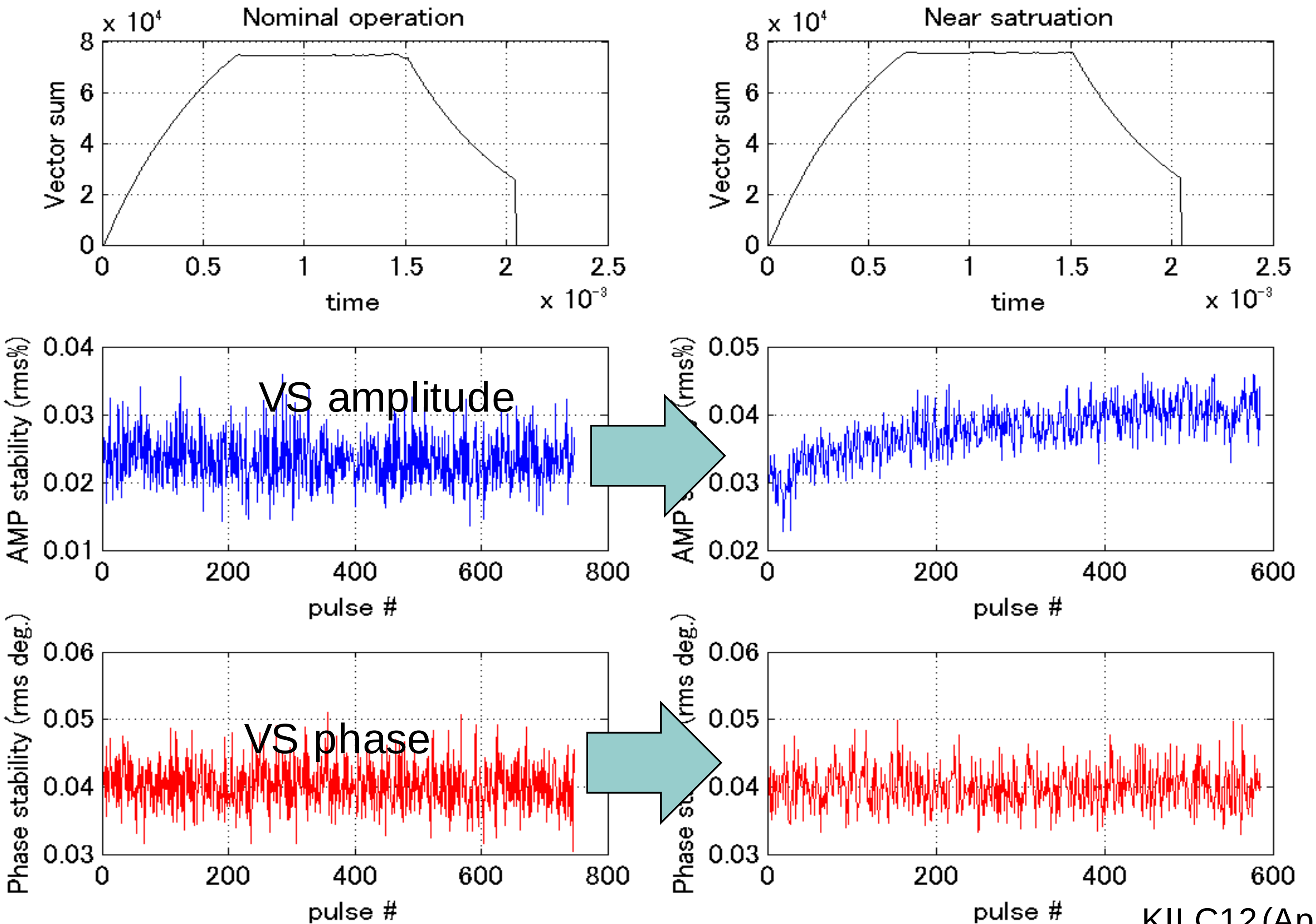
- HV of klystron was decreased from 108 kV to 86.5 kV.
- 4.5 mA beam was used.
- Filling time was adjusted to have ~rectangular output.(500us ->660us)
- Operation point is about -7% (in power) from saturation.





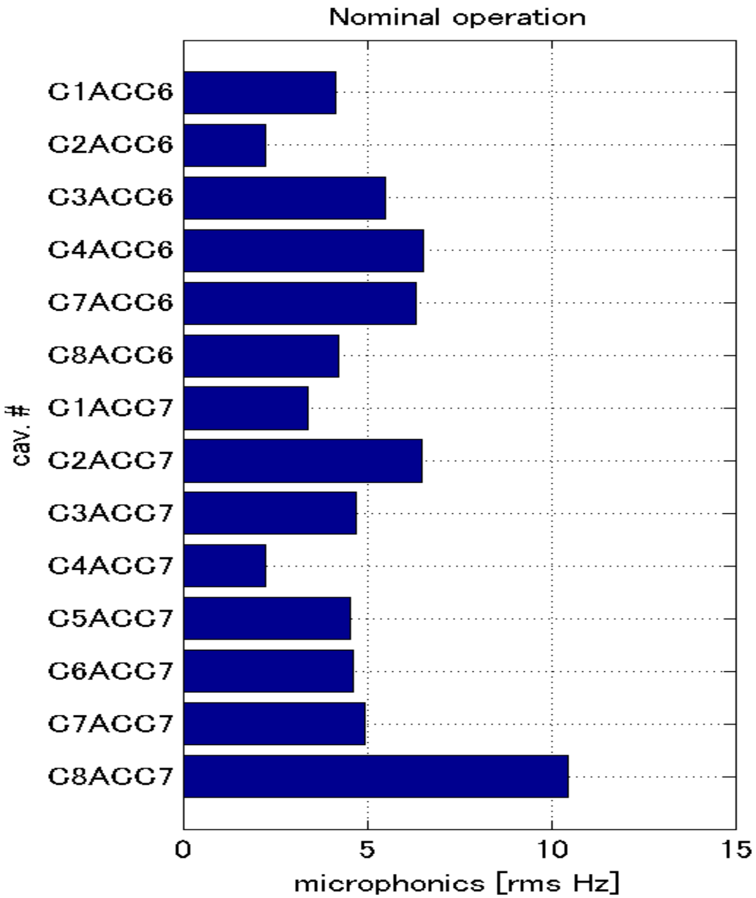
Stabilities at nominal and near sat.

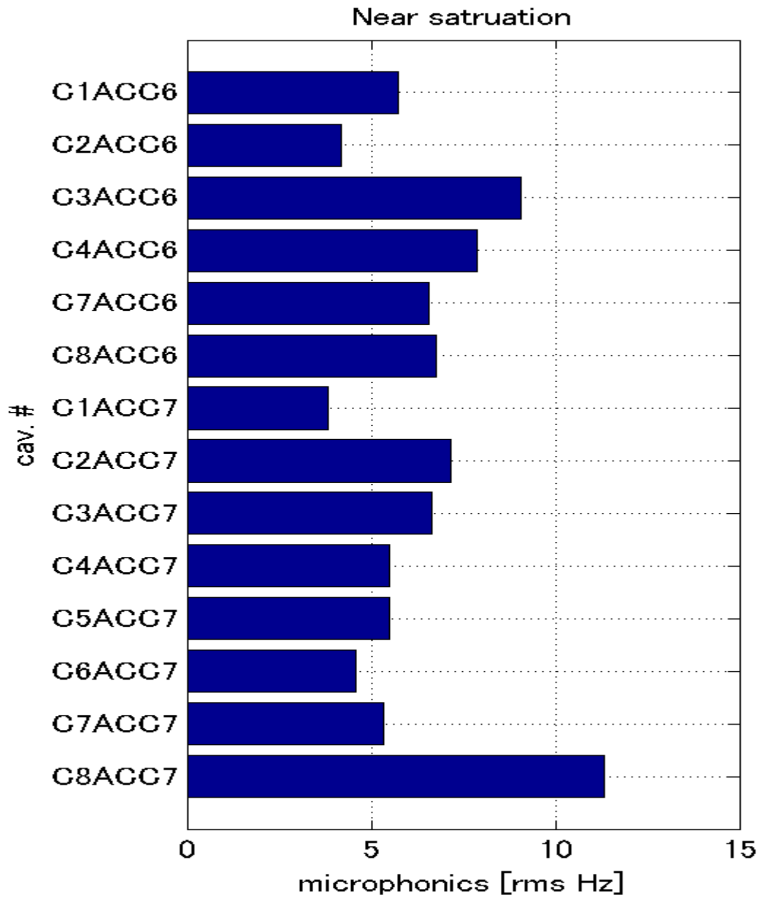
- Amplitude stability was worse twice at near sat. because of the limitation of rf.
- But 0.05%rms in amplitude can satisfy the requirements (~0.1% in amplitude)
- Phase stability was almost same between nominal and near saturation.



Detuning (microphonics)

- Microphonics was measured using the phase slope at the end of the rf pulse.
- ~5Hz rms agrees well with the experience.
- These values are almost same between nominal and near saturation.
- The difference in amplitude performance is not related to the cavity itself but rf.





Summary

- RF overhead was evaluated.
- It is possible to operate near saturation (~7% below saturation).
- The performance (amplitude and phase stabilities) satisfy the requirements.
- Dynamic fluctuations such as
  - Klystron HV fluctuation
  - Beam current fluctuation
  - Dynamic detuning (microphonics+ Lorentz force detuning)

  can be compensated.

Note: Evaluation of static rf losses, which use the rf overhead at all times, should be considered.

- Ql tolerance, Pk distribution tolerance, …