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10Hz Operation in DRFS HLRF System

KEK S. Fukuda

Low-energy running 10Hz Scenario

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Plan	Energy(CM)	Current	Rep.	Rel. Power
RDR	500 GeV	9mA	5Hz	1
SB2009	500 GeV	4.5mA	5Hz	0.5
Low E	250 GeV	4.5mA	5Hz	0.25
Low E*10Hz	250 GeV	4.5mA	10Hz	0.5

HLRF Consideration for Low-energy running with 10Hz operation (KCS)

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- KCS (Chris Adolphson)

  MBK: Toshiba NBK Klystron Data

  – **125GeV case**

  - NBK

    P0=10MW -> 5MW

    V=117kV -> 94kV

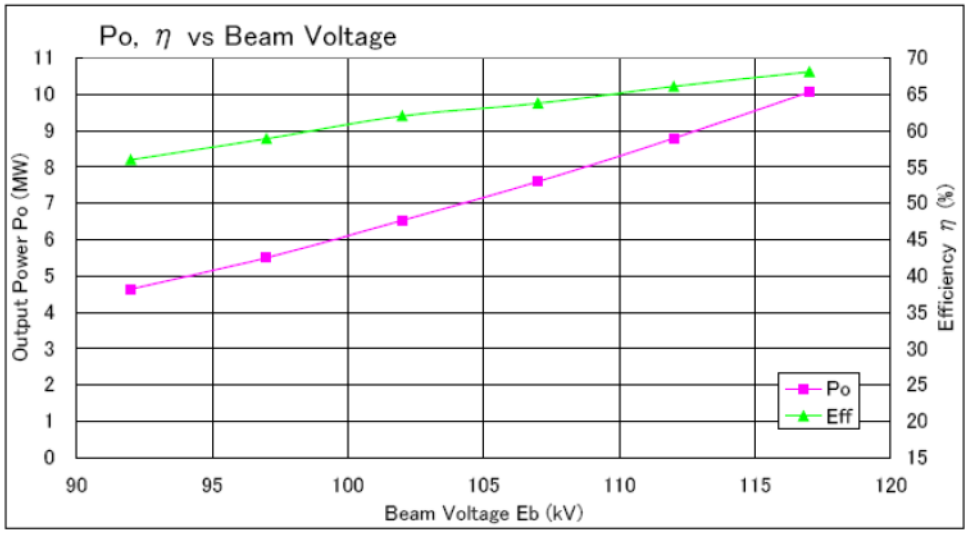
    Eff. 67% - > 59-60%

  - Modulator

    Power=100% -> 58%

    Pulse Width = 100% -> 47%

    Near to the 50%



MBK Data

HLRF Consideration for Low-energy running with 10Hz operation (DRFS)-1

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- General Consideration of DRFS Klystron

Comparing with 10MW MBK, operating voltage for nominal power (750kW) of DRFS is lower than 10MW MBK. Generally saying, *if DRFS klystron is diode type klystron*, efficiency drop for the lower voltage corresponding to the half power may be larger than the case of 10 MW MBK.

Since DRFS Klystron is a modulating-anode type, namely, triode type, it is possible to change the beam perveance.

This possibly enables us to keep the high efficiency in the lower applied voltage operation.

(By the Toshiba engineer).

Klystron for DRFS

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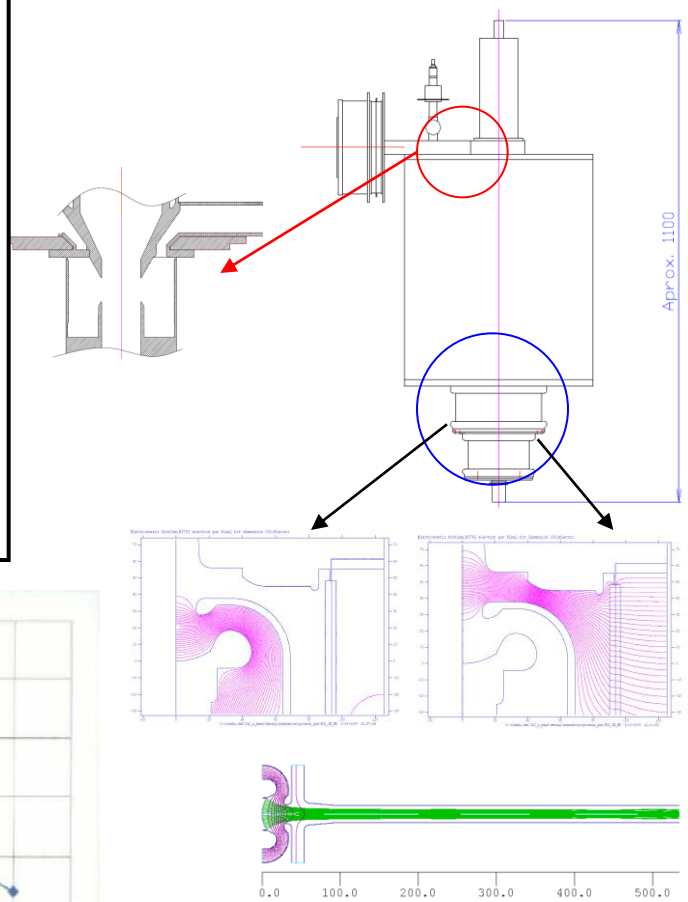
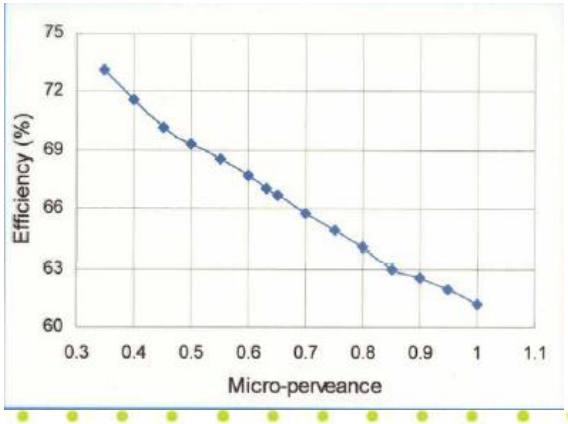
DRFS Klystron is a Modulated-anode type klystron or triode type klystron,

By changing the voltage of modulated anode electrode relative to cathode, it is possible to change the beam perveance.

Beam perveance is strongly related to the RF efficiency. Lower the beam perveance, higher the efficiency is.



Relation between the Efficiency and perveance



HLRF Consideration for Low-energy running with 10Hz operation (DRFS)-2

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- General Consideration of DRFS Klystron (2)

Even diode klystron can keep the high efficiency by choosing the focusing solenoid field profile properly.

(XK-5 in SLAC by R. L. Sringall, PV3030 in KEK by S. Fukuda)

MA Klystron with proper solenoid field profile keeps the high efficiency, however, DRFS will employ permanent magnet focusing, which is a fixed magnetic field profile.

Slight reduction of efficiency may be expected even though operation with lower perveance increase efficiency.

More exact data will be obtained by detailed computer simulation and proto-type tube performance (by end of 2010). We will present it in next WS.

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Rough estimation of the efficiency for DRFS Klystron

	Po=375kW					750kW
Microperveance=1.2						
Efficiency	60%	55%	**50%**	**45%**	40%	60%
kV	48.6	50.3	**52.3**	**54.5**	57.2	64.1
A	12.9	13.5	**14.3**	**15.3**	16.4	19.5
kW	375.0	375.0	**375.0**	**375.0**	375.0	750.0
Rel.P(kW)	625.0	681.8	**750.0**	**833.3**	937.5	1250.0
pps	10.0	9.2	**8.3**	**7.5**	6.7	
Microperveance=1.1						
Efficiency	62%	**57%**	**52%**	47%	42%	
kV	49.7	**51.4**	**53.3**	55.5	58.0	
A	12.2	**12.8**	**13.5**	14.4	15.4	
kW	375.0	**375.0**	**375.0**	375.0	375.0	
Rel.P(kW)	604.8	**657.9**	**721.2**	797.9	892.9	
pps	10.3	**9.5**	**8.7**	7.8	7.0	
Microperveance=1.0						
Efficiency	63%	**58%**	**53%**	48%	43%	
kV	51.3	**53.0**	**54.9**	57.2	59.7	
A	11.6	**12.2**	**12.9**	13.7	14.6	
kW	375.0	**375.0**	**375.0**	375.0	375.0	
Rel.P(kW)	595.2	**646.6**	**707.5**	781.2	872.1	
pps	10.5	**9.7**	**8.8**	8.0	7.2	

Cont.

- For the power Supply, situation is almost the same as the KCS.
- In order to change the perveance, modulated anode modulator must have a mechanism to change the modulated anode voltage. Cheap solution is introducing manual tap-off of resistor array.
- Therefore from the energy consideration, DRFS system may be OK for the low-energy running for 10 Hz operation.
- Configuration layout should be developed for this scenario.

PS system for DRFS (one unit)

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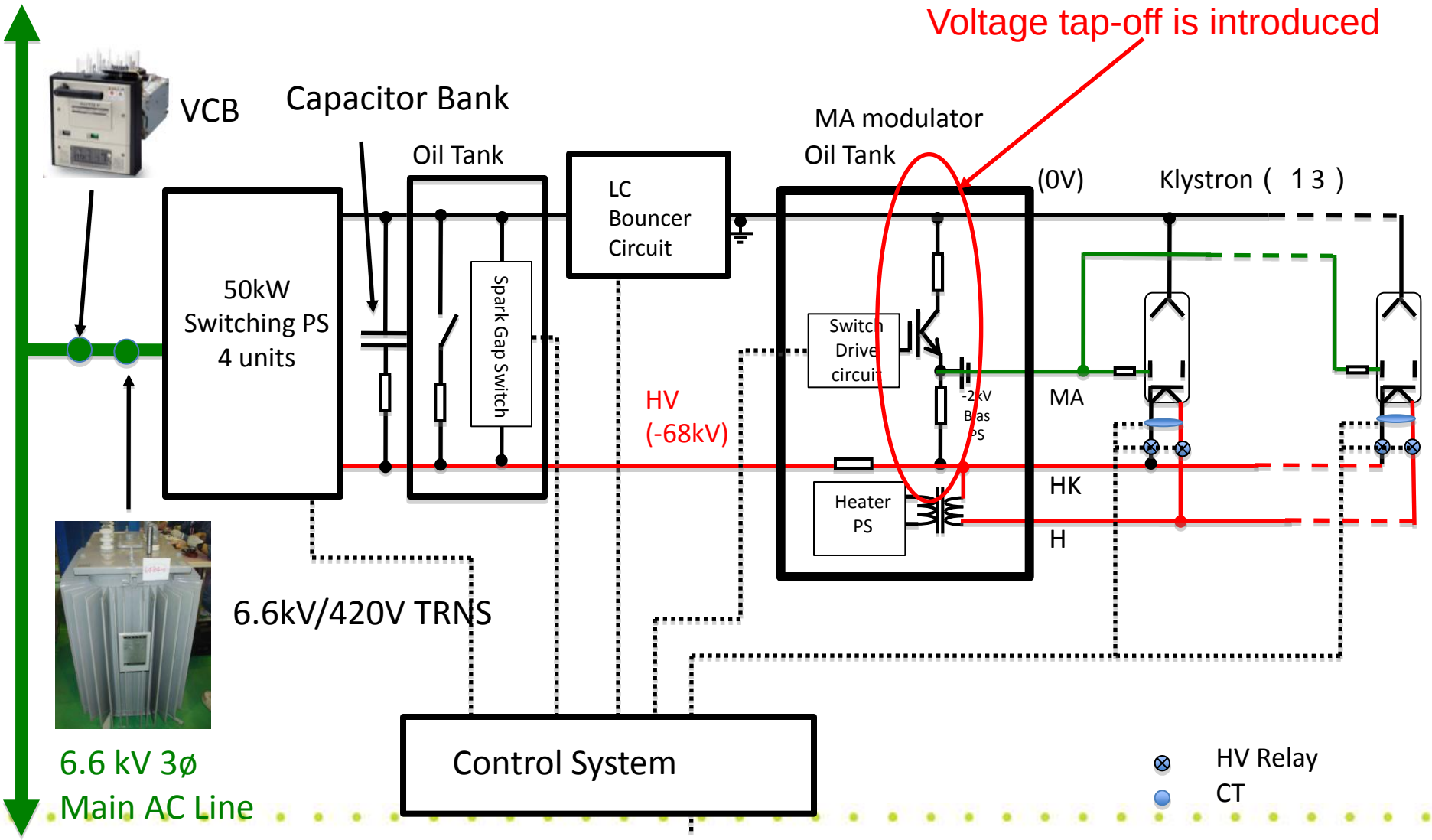
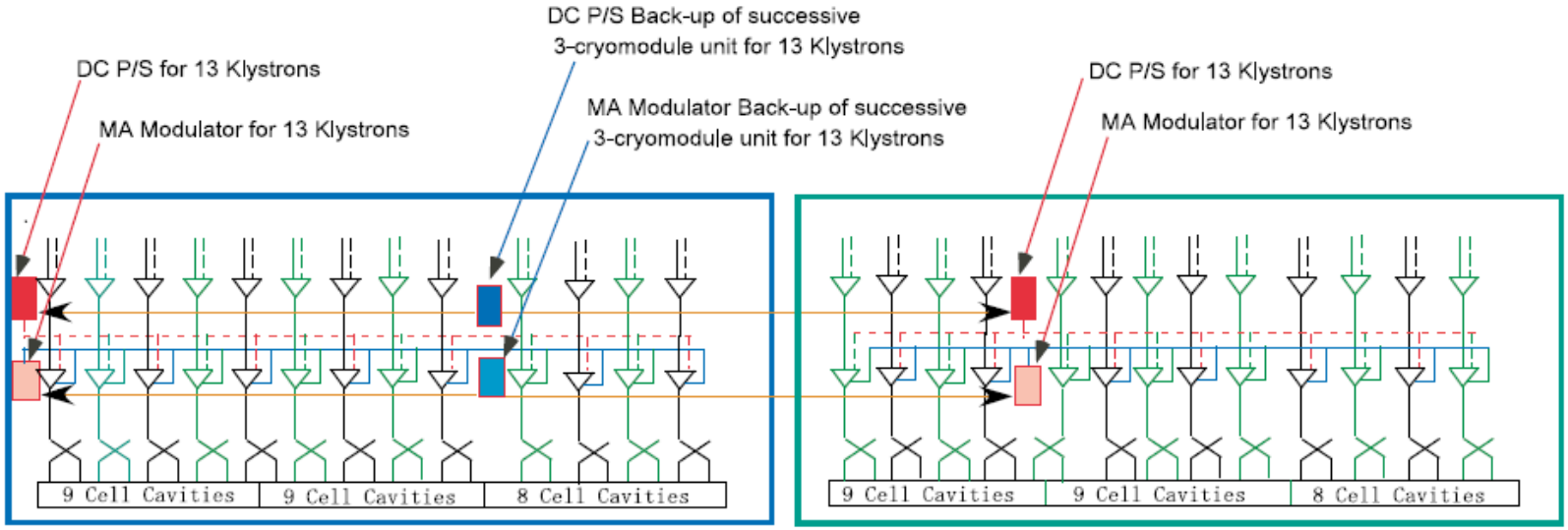


Redundancy Scheme in Full Energy

Availability Consideration Revised



Full Power Option@ 26-Cavities
(1 klystron feeds 2 cavities)

= 1 DC P/S +0.5 Back-up
1 MA Pulser +0.5 Back-up
13 Klystrons
26 Cavities
13 Magic-tee(Hybrid)

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Configuration for Low-energy with 10 Hz

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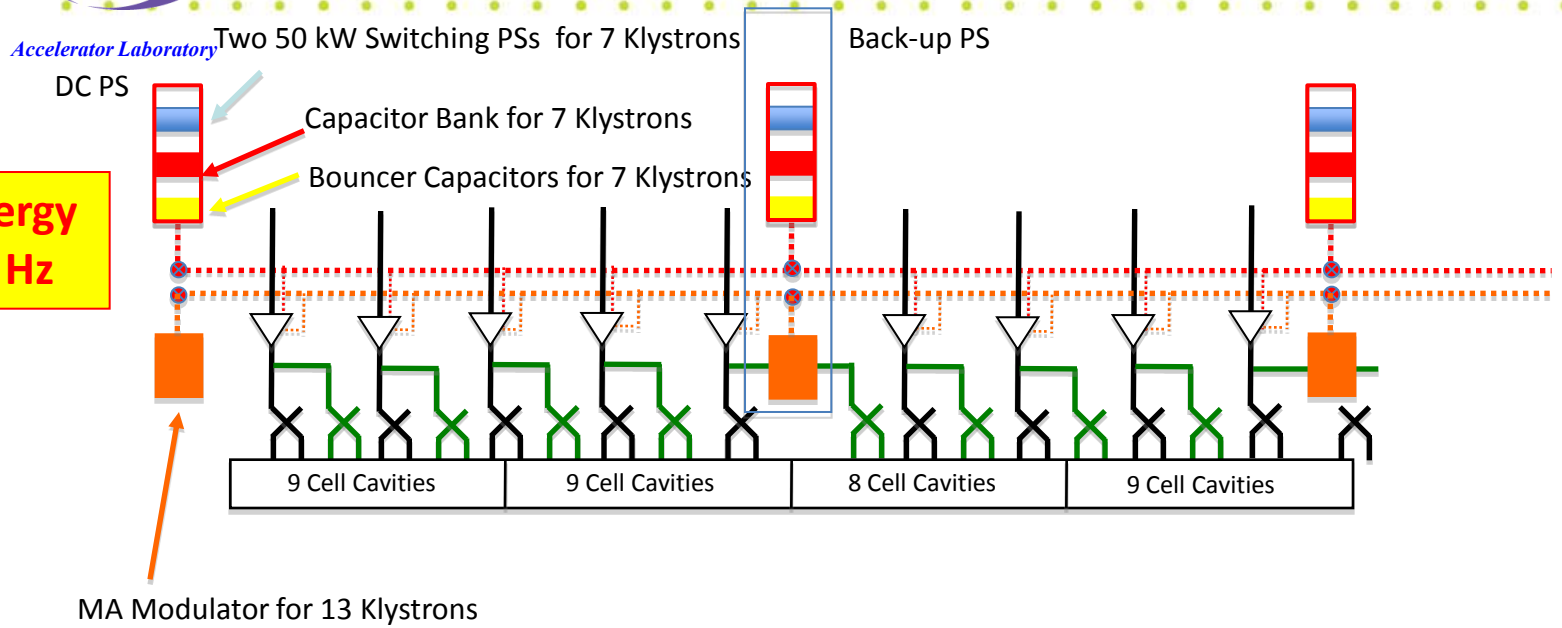
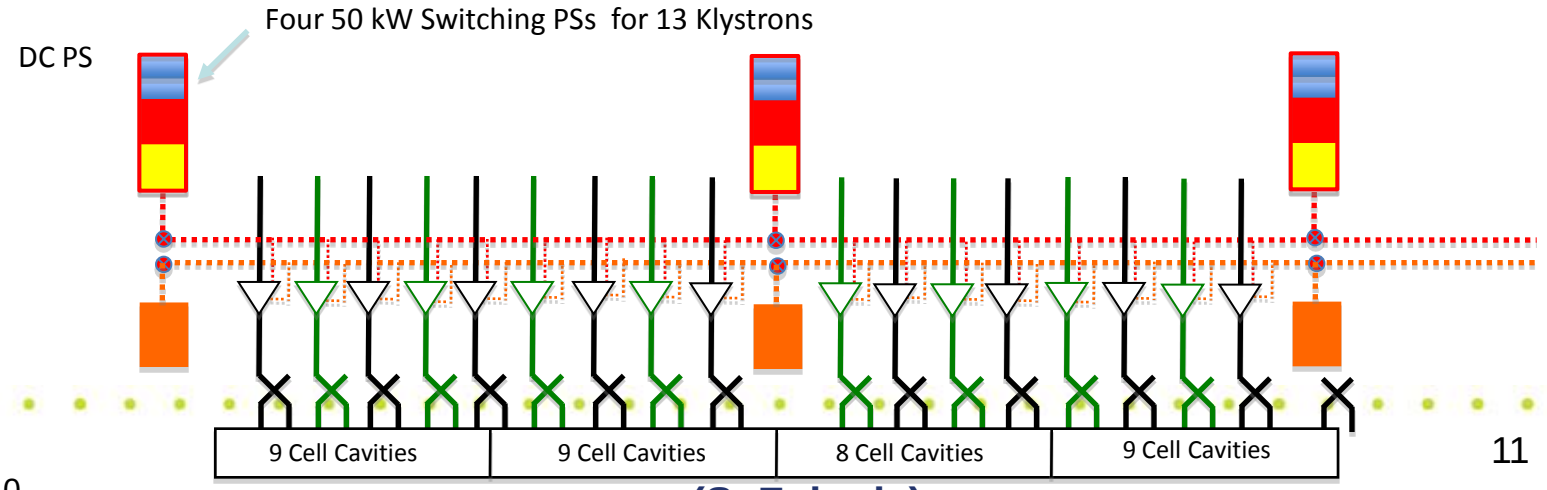
Low-energy with 10 Hz



Full Power Option



(S. Fukuda)

Another Attractive Plan for DRFS in Low-energy 10Hz Running

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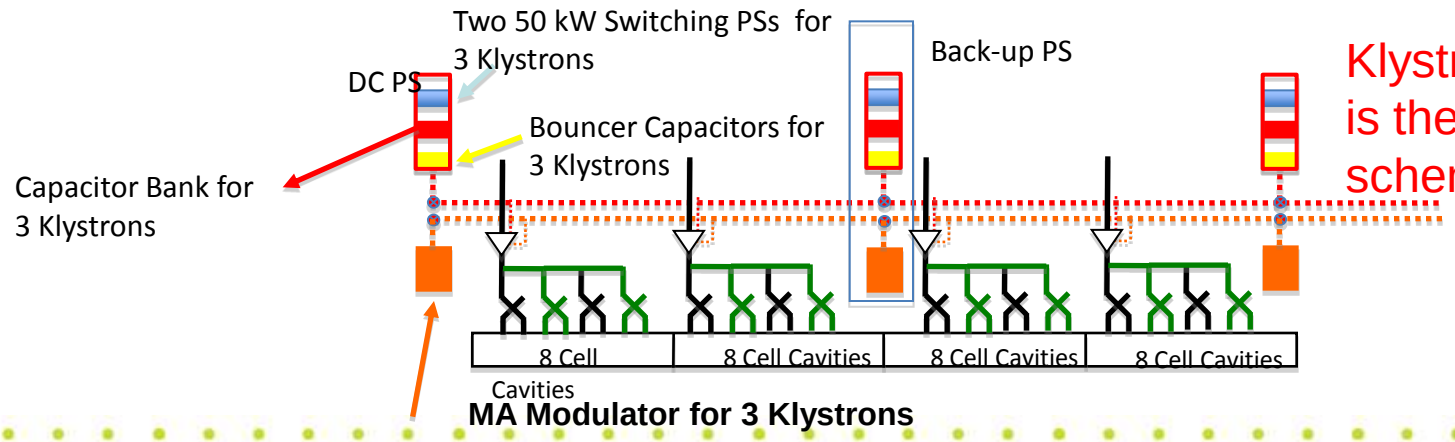
- DRFS is free from the BCD cryomodule configuration such as the cavity number of 9,8 and 9 (or 9,9 and 8).
- If every cryomodule has 8 cavities, RF layout in DRFS becomes very simple for both full scheme and low-energy 10Hz scenario.

	gradient[MV/m]	cavities/rf	current[mA]	rep. [Hz]	Pkly [kW] 38M 15%margin	#of rf /8cav.	Modulator/8cavities (60%eff.,1.5ms) [kW]
RDR	31.5	26	9	5			
DRFS	31.5	2	9	5	750	4	37.5
LowPower	15.75	4	4.5	10	375	2	18.75
LowP'	15.75	8	4.5	10	750	1	18.75



Klystron efficiency is the same as full scheme

Summary

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- HLRF consideration for Low-energy running with 10Hz operation in the DRFS is presented.
- Even though exact data should be shown from the computer simulation or proto-type tube performance, simple estimation shows that slight reduction of efficiency may be expected, because the DRFS klystron is the triode type klystron and its perveance is possible to be changed.
- For layout change from Low-energy to full energy, it is necessary to study more, but basically the same scenario from low-power option to full power option in SB2009.
- More intense study for the DRFS of recent proposal is necessary.
- Another scheme, which a cryomodule having 8cavites, are shown as the simple configuration for this discussion.