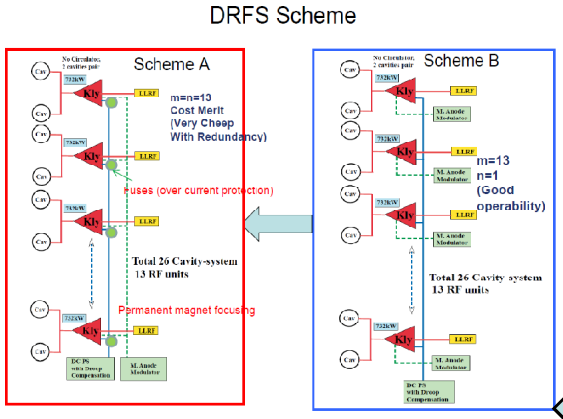
Low Power HLRF System and Impact on Distributed RF System

Shigeki Fukuda and Task Force Team of DRFS in KEK

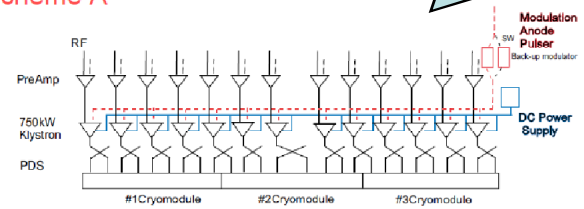
KEK

DRFS with a High Availability

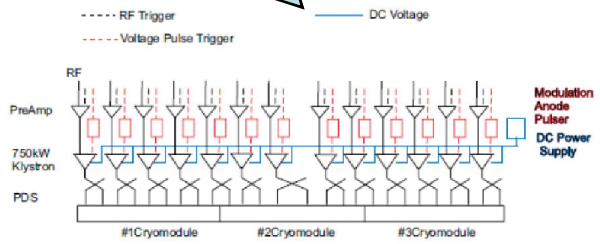
- DRFS with a High Availability was presented in the High Availability Task Force Webex Meeting (Jul.8.09)



Scheme A



Cavity	26	
DC	26	
Magic T	13	
750kW Kly.	13	
PM Focusing	13	
Coil PS	0	PM focusing
Heater PS	2	common
Preamp	13	
MA Pulser	2	one is backup
LLRF&Intlk	13	
DC P/S	1(or2)	



Cavity	26
DC	26
Magic T	13
750kW Kly.	13
Coil	13
Coil PS	13
Heater PS	13
Preamp	13
MA Pulser	13
LLRF&Intlk	13
DC P/S	1

Back-up MA Modulator for Higher Availability
PM Focusing, No IP, Common Heater PS
DC PS back-up is also possible

Needs more revision and R&D

- For Klystron (with the collaboration with Toshiba)
  - Lower the perveance to raise the efficiency aiming for the 60 % efficiency. Then exotic R&D to improve further efficiency.
  - Compact (silicon) oil insulation tank
  - Refined design of permanent focusing, making use of the S-band klystron experience.
- For Power Supply and Modulator
  - Actual circuit design which has the easy power upgradability (from a few MAKs to a large numbers of MAKs)
  - Disconnection device of SW developments
  - Design of reliable and cheap switching device of MA modulator.
- Cooling Issues

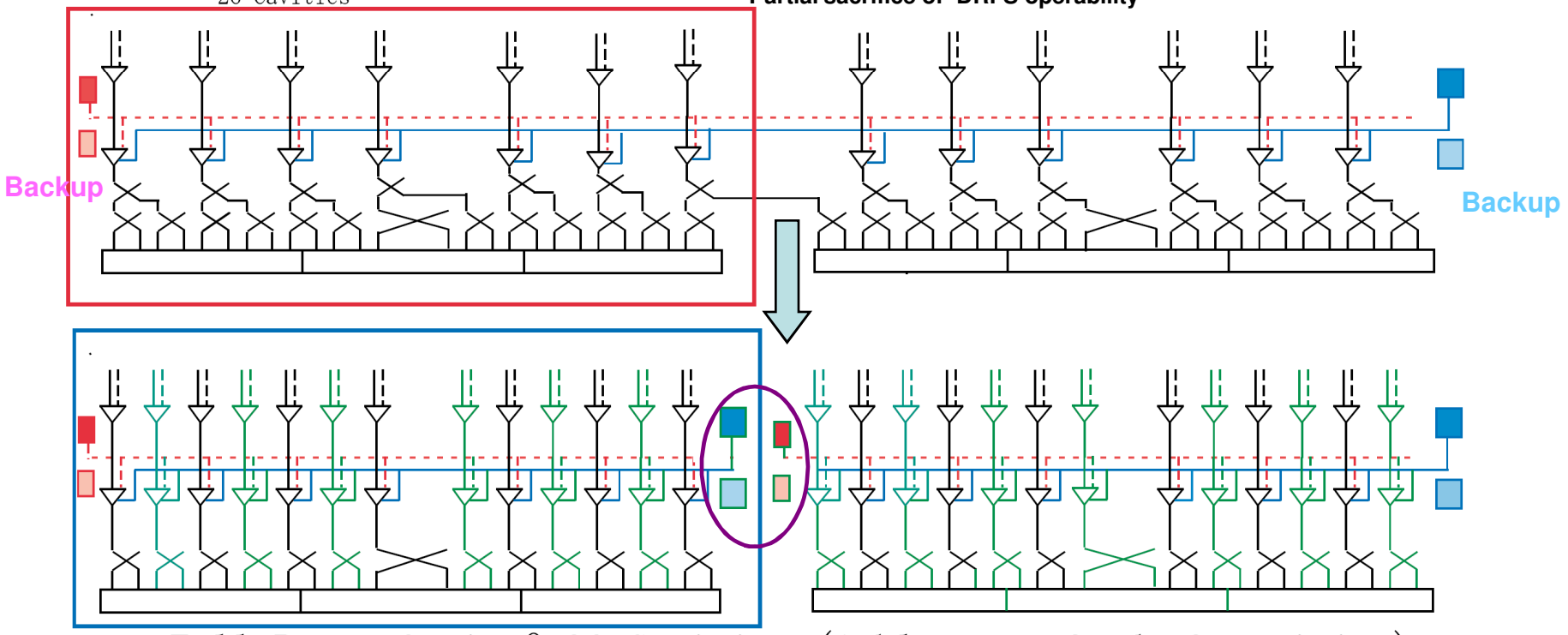
Low Power Option of DRFS and Full Scheme(I)

Low Power Option@ 26-Cavities (1 klystron feeds 4 cavities)

= 0.5 DC P/S 0.5 Back-up
0.5 MA Pulsers 0.5 Back-up
6.5 Klystrons
26 Cavities

19.5 Magic-tee(Hybrid)

Aiming for the easy upgradeability to standard scheme
Partial sacrifice of DRFS operability

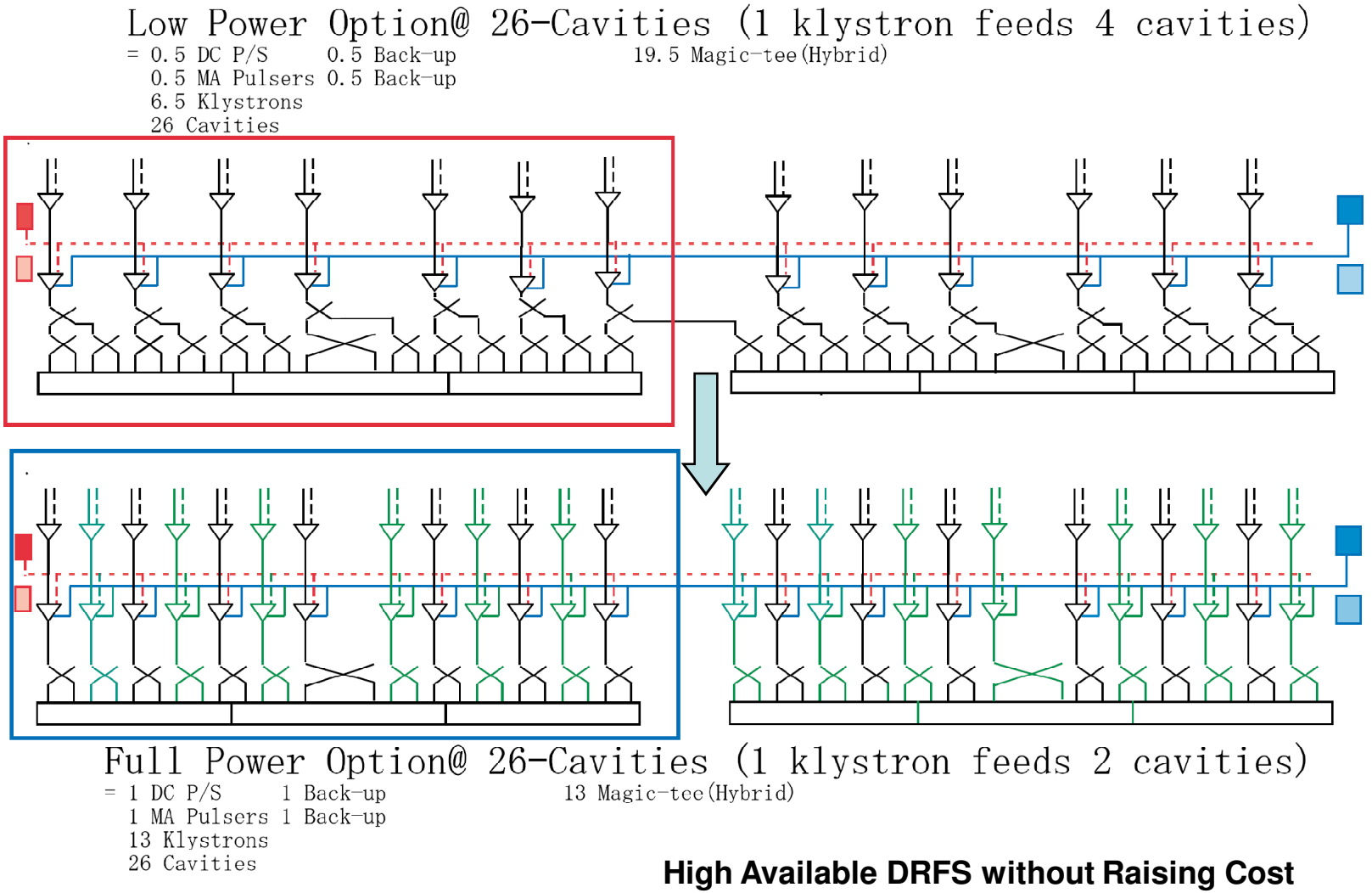


Full Power Option@ 26-Cavities (1 klystron feeds 2 cavities)

= 1 DC P/S 1 Back-up
1 MA Pulsers 1 Back-up
13 Klystrons
26 Cavities

13 Magic-tee(Hybrid)

Low Power Option of DRFS and Full Scheme(II)



High Available DRFS without Raising Cost

Numbers of Components in DRFS

Item	Low P DRFS	Back-up	Full P DRFS	Back-up	BCD
Cavity	26		26		26
Directional Coupler	26		26		26
Magic Tee (Hybrid)	19.5		13		32
Load	39		13		24
700 k W Klystron	6.5		13		
MBK					1
Focusing PM (EM)	6.5		13		1
Coil P/S	0	0	0		1
Heater P/S	1	1	1	1	1
Pre Amp	6.5		13		1
LLRF	6.5		13		1
Interlock module	6.5		13		1-26
Trigger Module/depend on fanout					1
MA Modulator	0.5	0.5	0.5	0.5	
DC P/S	0.5	0.5	0.5	0.5	
Modulator					1
Pulse Transformer					1

Cost Evaluation for the Low Power DRFS

- Re-evaluation from the “High Availability” webex meeting was performed as shown below.
- We made a cost evaluation of Low Power Scheme of DRFS as follows;

  DRFS “Standard” is based on the configuration of slide 4 lower figure, not the one of slide 3 lower figure.

  So “Standard” includes the DC PS backup and DC PS feeds the power to 26 MKAs.

  So both configurations has a high availability.
- Cost evaluation for DC PS was estimated as follows;

  We assume that the cost of the thyristor, capacitor and bouncer are proportional to the power increase, and transformer is proportional to the square root of the power increase.
- For BCD, I showed that the cost of the modulator is proportional to the square root of the power increase, and this may be a bit underestimated cost.

Cost Impact for LowP DRFS

DRFS	Standard		Low P		Cost Impact
	No@26 Cav	Cost	No@26 Cav	Cost	%
DC PS w Backup	1	269	1	186	
MA Modulator	1	100	1	50	
MA Klystron	13	845	6.5	423	
Magic Tee	13	91	20	137	
		1305		795	60.9
BCD	Standard		Low P		Cost Impact
	No@26 Cav	Cost	No@26 Cav	Cost	%
Mod	1	515	0.5	297	
Kly	1	300	0.5	150	
PDS	1	345	0.5	173	
		1160		620	53.4

For red character, see the comments of slide 7 in this presentation.
For green character, this may be underestimated. Ray in SLAC may present new Estimation.

Water Cooling Comparison

Oct 31 2007

WATER AND AIR HEAT LOAD (all LCW) and 9-8-9 ML

Components	Quantity Per 36m	Location	Total Heat Load (KW)		
MAIN LINAC - ELECTRON & POSITRON					
Non-RF Components					
LCW Skid Pump 1 per 4 rf - Motor/Feeder Loss	0.25	Service Tunnel	0.60	0.60	0.60
I^2R Loss and Motor Loss (misc)	1	Service Tunnel	10.92	10.81	10.31
Fancoils (5 ton Chilled Water) 1.5 Hp	2	Service Tunnel	2.91	2.91	2.91
Rack Water Skid	0.25	Service Tunnel	0.20	0.20	0.20
Lighting Heat Dissipation ~1.3W/sf		Service Tunnel	1.65	1.65	1.65
AC Pwr Transformer 34.5-.48 kV	0.25	Service Tunnel	2.00	2.00	2.00
Emerg. AC Pwr Transformer 34.5-.48 kV		Service Tunnel	1.00	1.00	1.00
RF Components					
RF Charging Supply 34.5 Kv AC-8KV DC	1/36 m	Service Tunnel	4.0	4.00	14.0
Switching power supply 4kV 50kW	1/36 m	Service Tunnel	7.5	7.50	
Modulator	1/36 m	Service Tunnel	7.5	7.50	
Pulse Transformer	1/36 m	Service Tunnel	1.0	0.00	0.0
Klystron Socket Tank / Gun	1/36 m	Service Tunnel	1.0	6.50	6.5
Klystron Focusing Coil (Solenoid)	1/36 m	Service Tunnel	5.5	20.00	0.0
Klystron Collector	1/36 m	Service Tunnel	59.8	59.80	59.8
Klystron Body & Windows	1/36 m	Service Tunnel			
Relay Racks (Instrument Racks)	1/36 m	Service Tunnel	10.0	10.00	10.0
Attenuators	2/36 m	Service Tunnel	1.0	0.00	0.0
Waveguide (in service tunnel)	1/36 m	Service Tunnel			
Waveguide (in penetration)	1/36 m	Penetration	0.6	0.00	0.0
Waveguide (in beam tunnel)	1/36 m	Beam Tunnel	4.0		
Circulators With loads (isolator)	26/36 m	Beam Tunnel		0.00	0.0
Loads	24/36 m	Beam Tunnel	22.8	22.80	22.8
Subtotal RF unit Only			109	108	103
Total RF			144	157	132

RDR

DRFS Scheme B

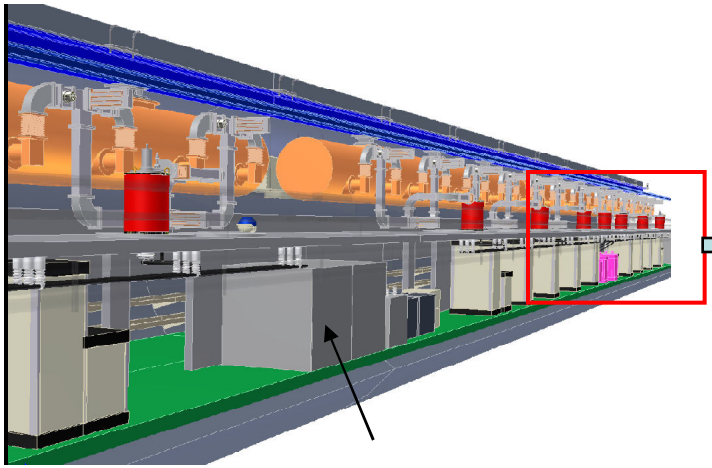
DRFS Scheme A

Assume the same efficiency with J-Parc DC PS

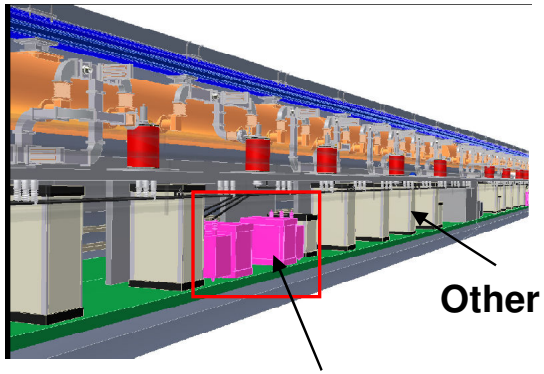
Slight increase including the 2 MA modulators

Some amount of increases including the13 MA modulators

Layout for Revised DRFS Scheme



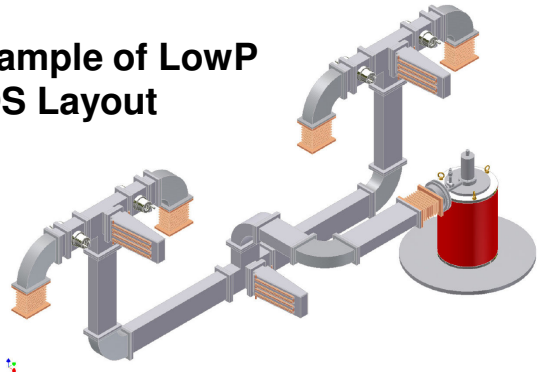
DC Power Supply Space



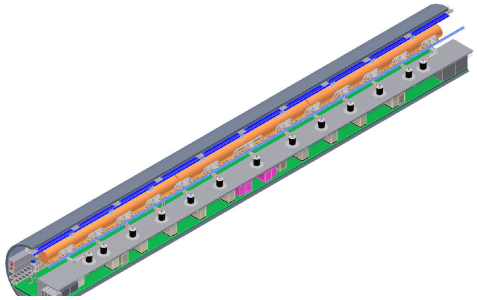
Other Racks

MA Modulator
& HLRF(+LLRF) Rack

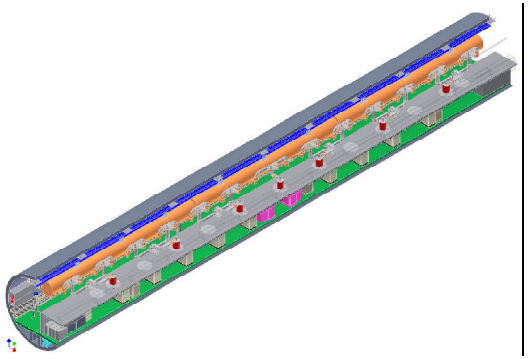
Example of LowP
PDS Layout



Add klystron in future



DRFS Full Scheme



DRFS Low Power Option

Maintenance of Main Linac in Scheduled Shut down in LowP

- Here let's consider the repairing work of main components (Only for the Main Linac) of DRFS in scheduled Shut Down for the LowP Option.
- DC PS and MA Modulator of 280 in Main Linac, MA Klystron of 3640

  Operation hr of a year; 5,000hrs. Scheduled shut down of 3 months
- No. of Failure components in a year
  - DC PS : 28 if MTBF of 50,000 hr (assume)
  - MA Modulator: 20 if MTBF of 70,000hr (assume)
  - MA Klystron: 165 if MTBF of 110,000hr (assume)

Resources required for fixing main components of DRFS in Main Linac (Low Power Option)

- Resources Per 1 shaft
  - Klystron replacement of 165= 2.5 weeks*person=100 hrs*person
  - MA modulator replacing of 20=0.35 weeks*person=14 hrs*person
  - DC power supply repairing of 28=2.1 weeks*person=83 hrs*person

    (including engineer work of 1.4 weeks*person(55 hrs*person)

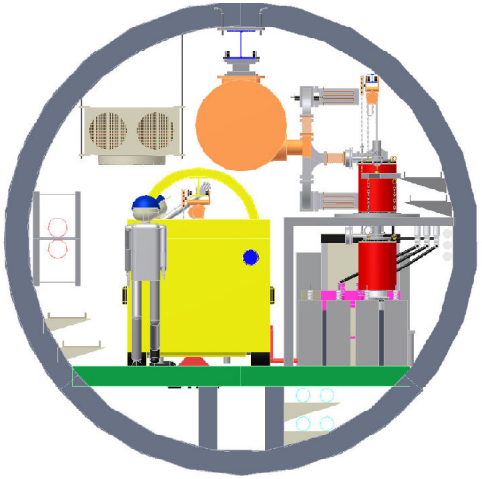
    Is this overestimate???)

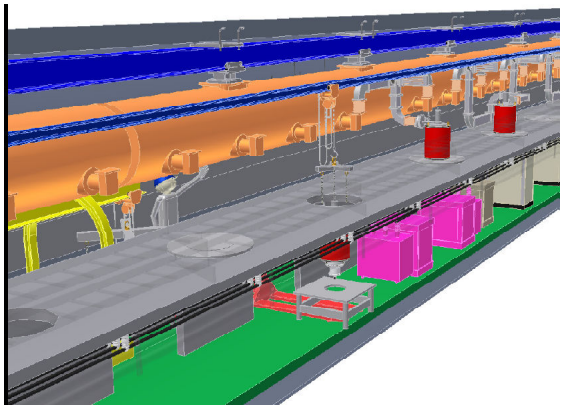
    =4.95 weeks*person(198 hrs*person) per shaft
- Resources of whole LC

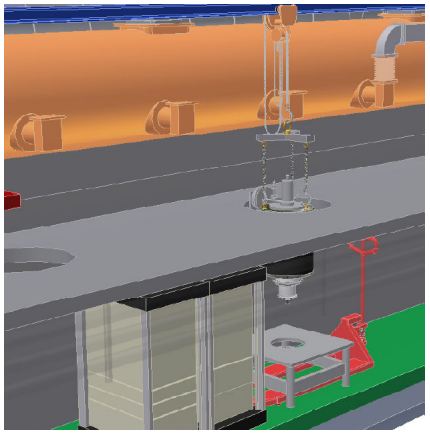
  =39.6 weeks*person=1584 hrs*person

We needs to count another labor relating with the failure except for above causes.

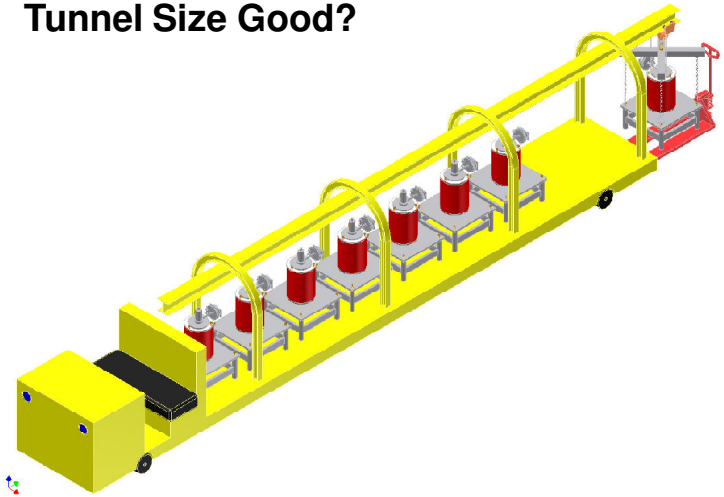
Tentative Concept for Klystron Replacement in Scheduled Shut Down







Tunnel Size Good?



Total 46 MA modulators, 8 Shafts, --5.75 MA modulators @shaft,
1 carrier with 2 MA modulators →3 go and come
then MA modulators delivering takes 2.6 hrs with 2 person
One MA modulators disassemble and install
Exchange whole Rack of MA Modulator
Disconnecting the cable and remove failure set
Install new MA modulator
Cabling Work
(1 MA Modulator Exchange takes 2 hrs with 2 person)

Summary

- This presentation showed the Low Power Option of ILC in the case of DRFS Scheme.
- A high available full DRFS, in which DC PS and MA modulator with backup unit respectively connect to 26 MA klystrons which feed powers to two SC cavities.
- Low power option of DRFS are proposed in this presentation and it has an easy pass to full DRFS.
- Cost comparison is shown on this presentation.
- Study of cooling issues has just started and rough trend is shown.
- Maintenance scheme and improved layout drawing of DRFS is also shown in this presentation.