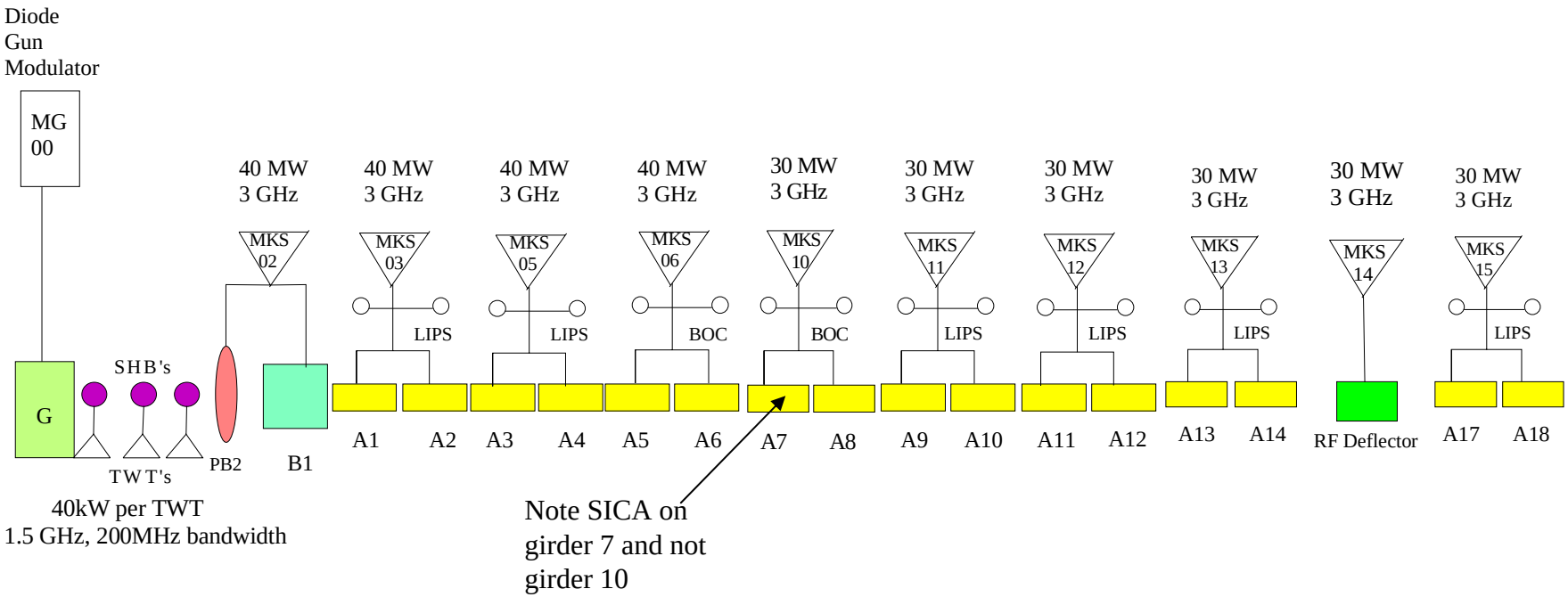
RF Power Systems for CTF3 from 2005 to …..

S-Band 3 GHz systems
Sub Harmonic Buncher
L-Band RF Deflector
Klystron/Thyratron spares vs running time
2004 Operation

G.McMonagle, 25th November 2004

S-Band 3 GHz systems

- Summary of existing installation
- 2005 Installation
- Pulse compressors and water cooling
- Future S band Requirements –Upgrades e.g. EOL Diode stacks, increased repetition rate of switch mode chargers, high power RF components


Diode
Gun
Modulator
MG
00
G
SHB's
TW T's
PB2
B1
40 MW
3 GHz
MKS
02
MKS
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LIPS
BOC
A1
A2
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A4
A5
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A7
A8
A9
A10
A11
A12
A13
A14
RF Deflector
A17
A18
40kW per TWT
1.5 GHz, 200MHz bandwidth
Note SICA on
girder 7 and not
girder 10

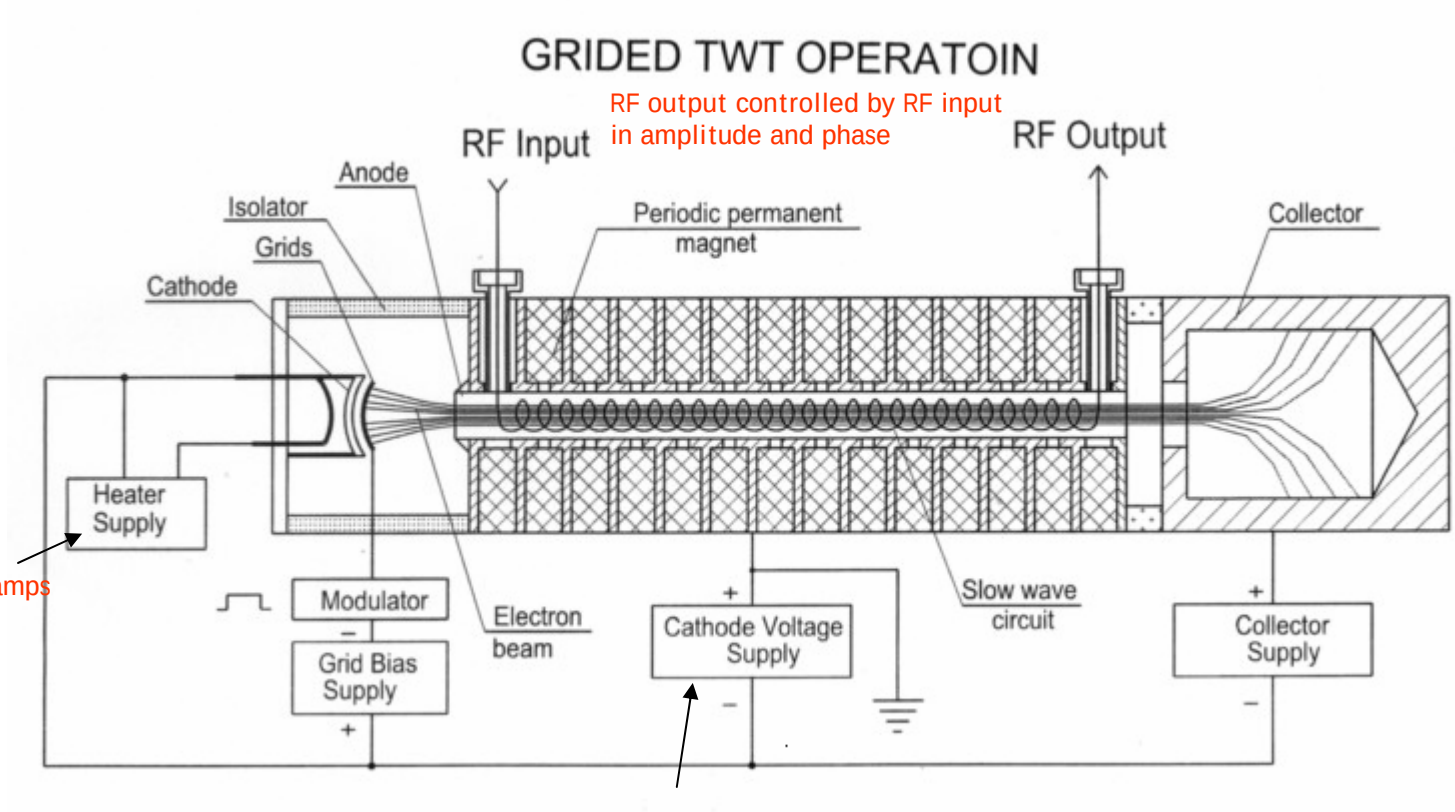
Sub Harmonic Bunching System

- TWT specification
- TWT Power Supply and Amplifier
- Installation
- Commissioning

TWT specification

- Frequency 1500 MHz
- Bandwidth >150 MHz
- Peak Power 40 kW
- Modulated Grid for Pulse Application
- Manufacturers guarantee 1000 hours, increased to 2000 hours for 3uS pulse width and 50 Hz rep rate MAX!!!

TWT Power Supply and Amplifier



11 volts 8 amps

-20kV max
Once set at factory remains constant

TWT Power Supply and Amplifier

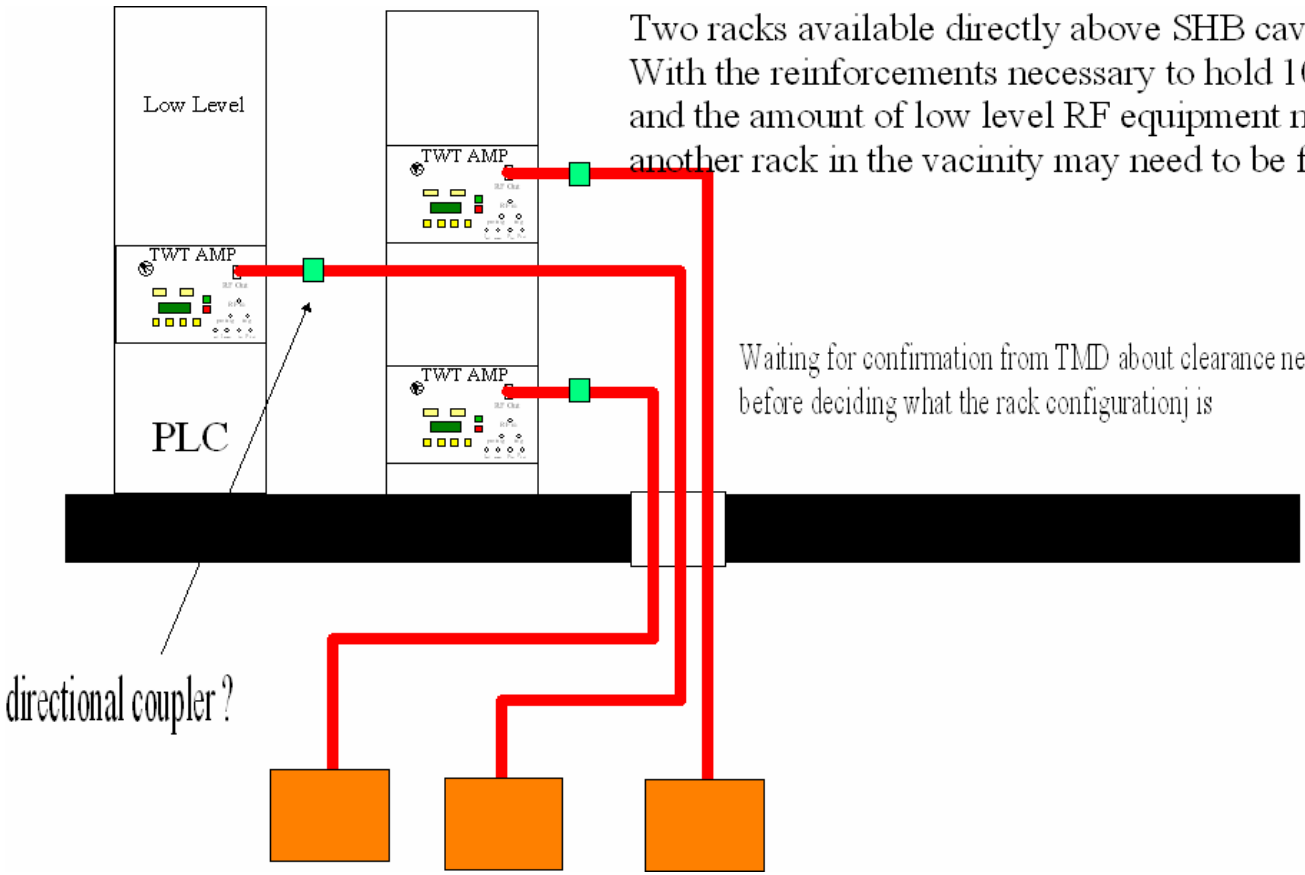
- The amplifier requires a pretrigger of at least -10μs to allow the turn of the charging supply and heater supply
- Necessary to guarantee the 1 volt droop during the pulse (this relates to a phase sensitivity of 0.3 deg)
- RF input is CW , it is the grid pulse modulator that determines output pulse width. Maximum pulse width 3μs and maximum repetition rate 50 Hz
- Interlock on reflected power, internal power supply interlocks , plus an external interlock contact (will incorporate acces control)
- There is a forward power indicator on each unit but not calibrated, will need a directional coupler in circuit.

TWT Power Supply and Amplifier

- Dimensions
- 19 inch standard rack width
- 9 Units High
- 1.20 metres depth
- 100 kg
- Initial installation will be stand alone for commissioning and testing (no remote)
- Remote control will be done via PLC.The PLC exists (old modulator project) needs to be modified once requirements are defined, will be done once more manpower is available

TWT Power Supply and Amplifier

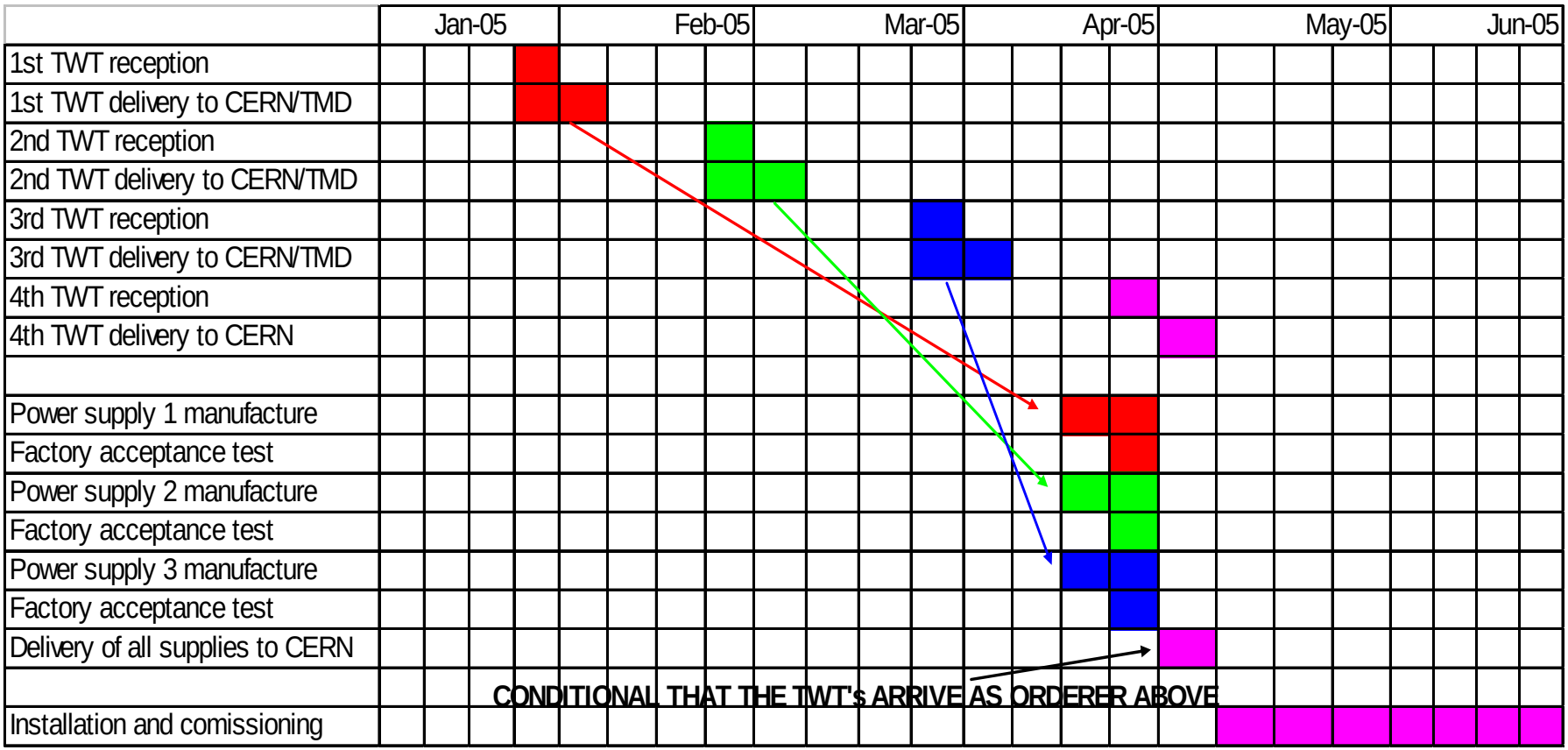
Installation

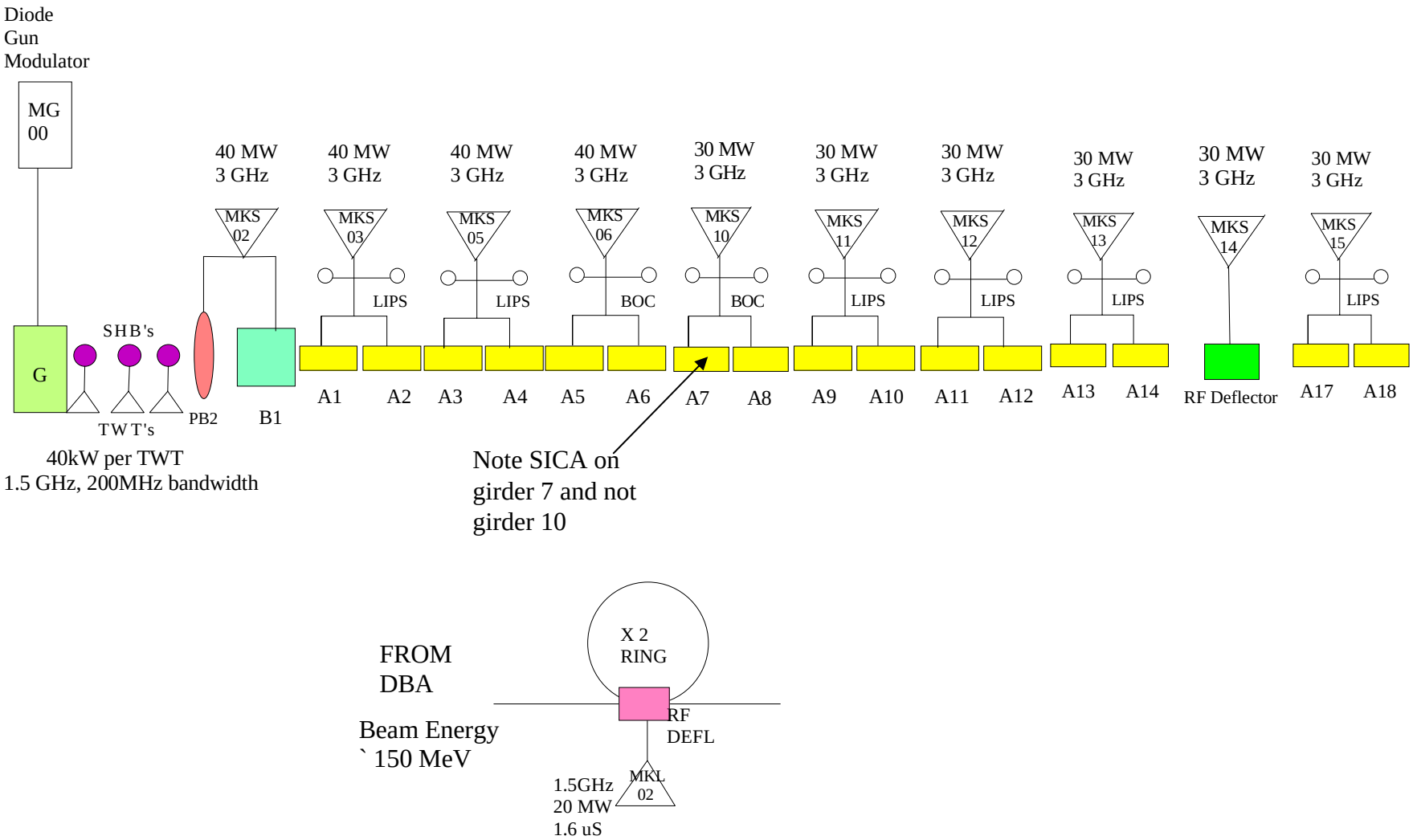


Two racks available directly above SHB cavities
With the reinforcements necessary to hold 100kg chassis and the amount of low level RF equipment necessary another rack in the vacinity may need to be found

Waiting for confirmation from TMD about clearance needed for cooloing purposes before deciding what the rack configurationj is

Commissioning

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40kW per TWT
1.5 GHz, 200MHz bandwidth
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FROM
DBA
Beam Energy
` 150 MeV
X 2
RING
RF
DEFL
MKL
02
1.5GHz
20 MW
1.6 uS

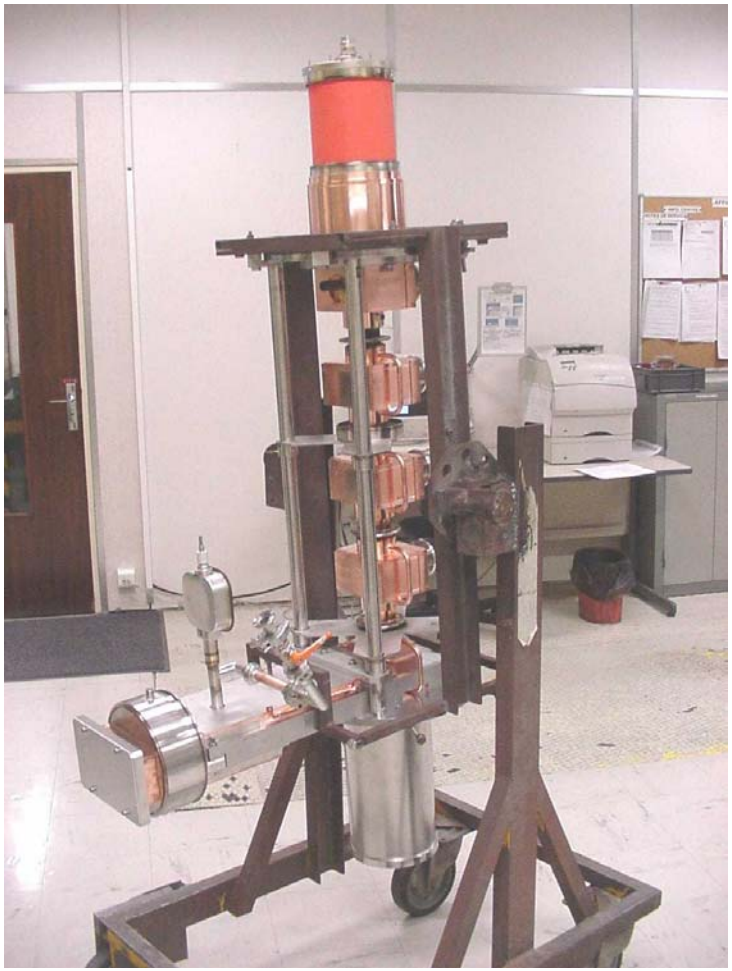
L Band Klystron

- Frequency 1500 MHz
- Bandwidth 8 MHz *
- Peak RF power 20 MW
- Pulse width 5.5 μs
- Micro perveance (1.9-2.1) $\mu A/V^{3/2}$ This allows us to use same modulator electrical circuit as the S-Band Klystron
- Modification to HT tank adaptation plate, lead shielding, focus power supply necessary (all this should be ready for March 2005)
- Commissioning diode mode as soon as possible after start up of LINAC
- RF tests into water load immediately after diode test

L Band Klystron

- New klystron positioning support needed to allow flexibility in connecting to RF network
- RF Network being ordered by INFN delivery early 2005
- Gallery installation after RF tests on klystron
- Installation in machine when RF deflector is ready
- Note waveguide system is pressurised with SF6 gas

L Band Klystron



Klystron lifetimes and failures

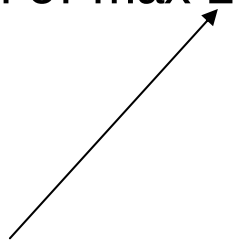
- Failure mechanisms
- Progressive wear of Cathode emitter (gradual exhaustion and metal fatigue due to thermal cycling)

  For Thales tubes anything from 20000 hours to 25000 hours

  For Valvo tubes 25000 hours up to the exceptional case 43000 hours
- Vacuum ion pumps connected to the klystron
- Klystron RF windows
- Heater resistance, or even contamination of gun from impregnations in cathode e.g. Barium if klystron is left on heaters for a long time without HT

Klystron Overview Last Year

- Klystron situation good for moment to be reviewed each year (no orders needed at moment based on estimation of max 2500 hours per year operation)



This is no longer the case

From LPI to CTF3
tube running costs are they the same?

	LPI	CTF2	CTF3 PETS	CTF3 LINAC	CTF3	CTF3	CTF3 PETS	CTF3 LINAC	CTF3	CTF3
year			**2005**	**2005**	**2005**	**2005**	**2006**	**2006**	**2006**	**2006**
running time hours	6000	1000	4500 (6000)	2000	2000	2000	6000	3000	3000	3000
no. of s-band klystrons	4	4	5	4			5	5		
no. of L-Band Klystrons					1				1	
no. of TWT's						3				3
average operational time per klystron per year	3500		3100 (4200)				4500			
average klystron replacement rate per year	2									
estimation of klystron replacement rate per year			2 (2.5)				2.6			
operating point of klystrons from nominal and rep rate	70% 100Hz		99% 50Hz							
Thyratrons	4	4	5	4	1		5	5	1	
average operational time per thyratron per year	3500		3250(4000)				4400			
average thyratron replacement rate per year	4		4(4.5)				5			

TWT's ?

This does not include probe beam or photo injector

Klystron Position and Hours

MODULATOR	KLYSTRON	Peak Power	No. Of Hours					
MKS02	TH2132 S.No.17	45 MW	18500					
MKS03	TH2132 S.No.21	45 MW	7820					
MKS05	TH2132 S.No.13	45 MW	11195					
MKS06	TH2094 S.No.2R	35 MW	16620					
MKS07	YK1600 S.No.5R	35 MW	16312			**END OF LIFE**		
MKS11	YK1600 S.No.4R	35 MW	42989		**Klystron**	**Peak Power**	**No. Hours**	
MKS12	TH2100 S.No.8	37 MW	2963		TH2100 S.No.23	37 MW	28836	Can be sent back for refit
MKS13	TH2100 S.No.7	37 MW	0					
MKS14	YK1600 S.No.11	35 MW	23036			**Sent Back to Thales**		
MKS15	YK1600 S.No.12	35 MW	19677		TH2100 S.No.11	37 MW	high gain	
MKL02	TH2170	20 MW	0					
	HOT SPARES							
	TH2132 S.No.22	45 MW	0					
	TH2094 S.No.9	35 MW	2843					
	TH2100 S.No.24	37 MW	6900					
						SPARES		
					TH2100 S.No.10	37 MW	0	
					TH2100 S.No.40	42 MW	0	
					YK1600 S.No.6R	35 MW	0	
					YK1600 S.No.8	35 MW	1000	to be cleaned and retested, focal coil problem
					YK1600 S.No.7	35 MW		RF breakdown on window, will try and clean and retest

Modulator Klystron Operational Observations in CTF3 Run this year

- After a lengthy klystron conditioning time to arrive at full voltage on klystron cathode, the klystrons operated reasonably well during the run.
- This is the first time that we have ran the klystrons at nominal power over a prolonged period of time (LEP/CTF2/CTF3 prelim about 70%)
- As with any run we get breakdowns in the klystron gun from time to time which causes a fault current in the end of line diode assembly.
- Until this year we probably lost 1 diode stack on average per year
- This year near the end of the run we lost 4 stacks within a few weeks (ALL 45MW klystrons)
- The temperature control system being used for pulse compression at the moment is not good enough

Pulse Compression Temperature Controllers

- Existing system not sufficient,
- Water station rated at 20 m^3/hour, where only 0.7 m^3/hour is used in the pulse compressor
- Problems with slow regulation to recover from step temperature changes in pulse compressor (up to 3 hours)
- **New solution being studied by TS department**
- **1 Water station for 9 pulse compressors and 3 spares**
- **Each of the 12 circuits has to be regulated independently**
- **Temperature range for each circuit between 20 ºC and 35 ºC**
- **Temperature stability +/- 0.05 ºC (to be discussed 0.1 ºC corresponds to 10kHz)**
- **Temperature stabilisation should be achieved in less than 10 minutes**
- **At 50Hz rep rate the power dissipated by LIPS is approx 500W (BOC to be confirmed), is it possible to have replacement heating system on system activated when no RF?**
- **All pipework and pulse compressors to be thermally insulated**

Diode Stacks

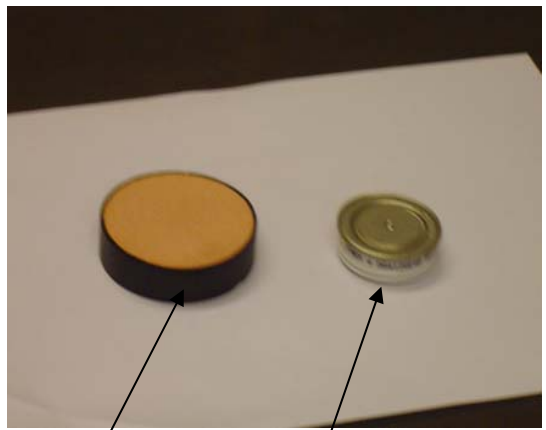
- Diode stack rated for 86kV (60 diodes, 1.6kV per diode)
- Diode peak surge current rating 6000 Amps
- Diode average current rating 240 Amps

- Under normal operating conditions no problem the average current in the diode is in spec
- However when fault occurs in klystron when PFN voltage is above 40kV the peak current can be as high as 7500 Amps !!!

- Capacitors from new batch, same manufacturer same spec (so they say) different casing. These are short circuited when diode fails. What fails 1st diode or capacitor?

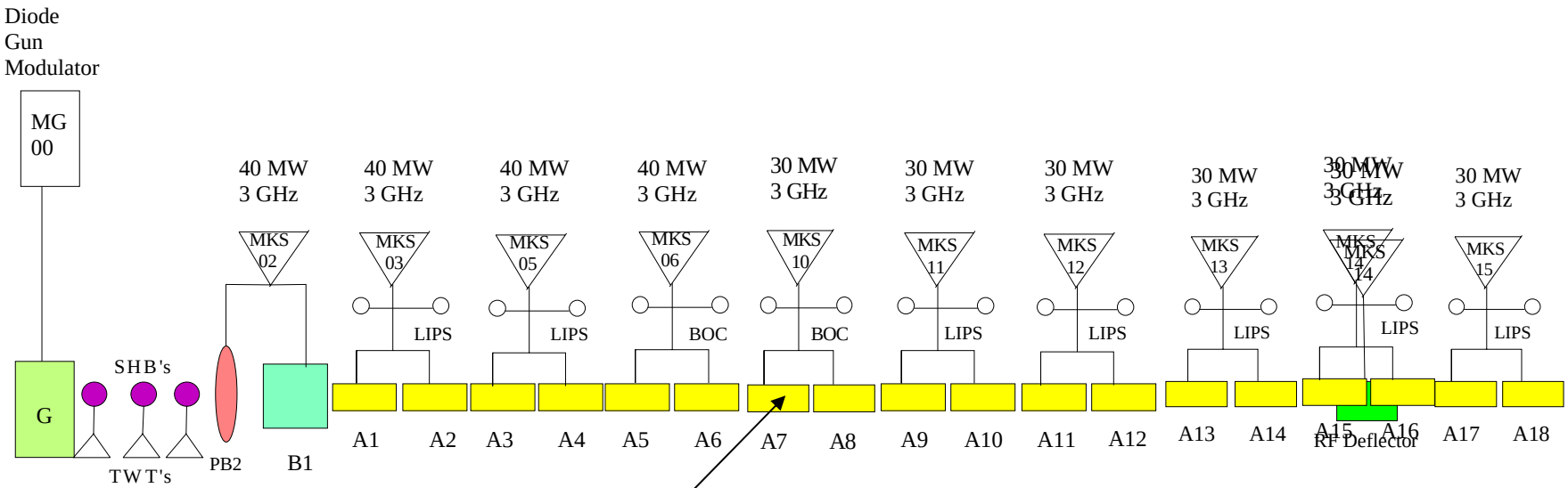
Diode replacement solution?

Diode stack



Varistor

Diode

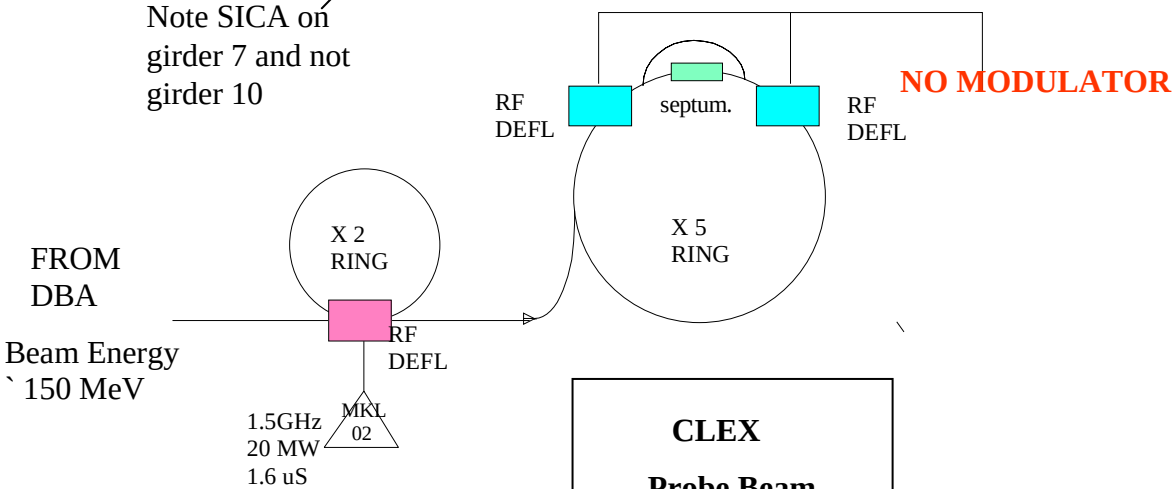


40kW per TWT
1.5 GHz, 200MHz bandwidth

Note SICA on girder 7 and not girder 10

CTF2 Photo Injector 2006, if MKS10 used no parallel running of PETS

NO MODULATOR



NO MODULATOR

CLEX

Probe Beam

NO MODULATOR(S)

Summary

- 2005 Installation on schedule as long as delivery of wavegudes pumping ports etc. arrive as foreseen
- New klystron renewal contract to be negotiated (presentation at Finance 1st session 2005)
- New EOL diode assembly solution for 45 MW klystron operation to be resolved rapidly
- Find solution for missing modulators (collaborations?)
- Recruitment of new technician