

# RF Specification discussion

MICE CM32 RAL

February 2012

# Amplifier system

- High voltage power supplies for these amplifiers have been designed that will allow operation at 1 Hz and 1 ms RF pulse length. The amplifier system will be able to produce a maximum of 2 MW of RF power. This will be split between two cavities; however losses in the coax transmission system are expected to reduce the available power by up to 10 % into each cavity coupler.
- The amplifier tubes will typically have a lifetime of at least 15000 hours, performance will degrade within that period which means power levels will decline. The MICE experiment is expected to run for approximately 3 years at a low duty cycle; therefore we expect that one set of tubes will be enough for the experiment. The minimum gradient useful for physics operation is 50% of the initial gradient.
- An accelerating gradient of up to 8 MV/m is possible across the cooling channel, this equates to 21.4MV on crest acceleration, with each cavity powered by 1 MW of RF power.
- 6 1/8 inch and 4 1/16 inch transmission lines will be used. The safe RF working level for these coax systems is 1550 kW and 700 kW respectively (in air). RF pulse shaping will be used to reduce reflected power during cavity filling so that the peak break down voltage level is not exceeded. The coax system will be pressurised with 1.5 Bar of nitrogen to provide an additional voltage breakdown overhead of 10%

# Cavity control

- A cavity phase angle of  $124^\circ$  will be fixed between cavities driven by a single amplifier system. This will allow muon acceleration to take place between 140 to 240 MeV/c with 98 % efficiency
- The field in the MICE cavities will be controlled to  $\sim 0.5$  Degrees and 1 %.
- In order for the gradient loop to function the peak RF power delivered to the cavities will have to be 15-20% lower than the maximum available from the amplifier chain. This will reduce the cavity gradient.
- The control of absolute phase with respect to external time is not needed, since the experiment will measure time events during the each cycle.
- The cavities will be deformed to have a centre frequency of 201 MHz and have a tuning range of 230 kHz by using mechanical actuators on the cavity body. This tuning system will be active to remove temperature drifts caused by ambient and RF heating changes
- Experiment timing with RF is a issue which is only starting to receive some effort, currently there is no real understanding of what is needed here, need to agree the issues and put some effort on to it

# RF specification summery

Amplifier system		
Parameter	Value	Unit
Frequency	201	MHz
Peak Power Level	2	MW
Repetition Rate	1	Hz
RF Pulse Length	1	mSec
Average RF Power Level	2	kW
Electrical to RF Conversion Efficiency	50	%
RF cavity		
Quality Factor, $Q_o$	44000	
Cavity R/Q	26750	Ohm
3dB Bandwidth	7.5	kHz
Tuning Range	230	kHz
Nominal Accelerating Gradient	8	MV/m
Minimum Accelerating Gradient	4	MV/m
On crest acceleration (total for 8 cavities)	21.4	MV
Phase Regulation	0.5	%
Gradient Regulation	1	%

# Questions and recommendations from the review panel

- The MICE RF system does not have a formal specification detailing what is expected and can be delivered by the system.
- Before procurement of the coax distribution scheme is done, a test of the example coax layout into a cavity should be performed.
- The Daresbury test system was developed to test the amplifiers and power supply systems as there were repaired and built. There has been no plan to test more components of the distribution system and cavity on the Daresbury site. – there is no bunker to operate a cavity in.
- Ideally this work should be done at the MTA where the test cavity is installed. However there are no RF couplers on this cavity at present.
- As a matter of urgency we would ask that the MTA system be equipped with N<sub>2</sub> gas in the 4 inch coax system , couplers installed and the cavity system operated at 1MW (with slow cavity filling) to simulate the MICE operational parameters . This will provide significant confidence that the 4 inch coax design is an acceptable solution and will allow procurement to take place