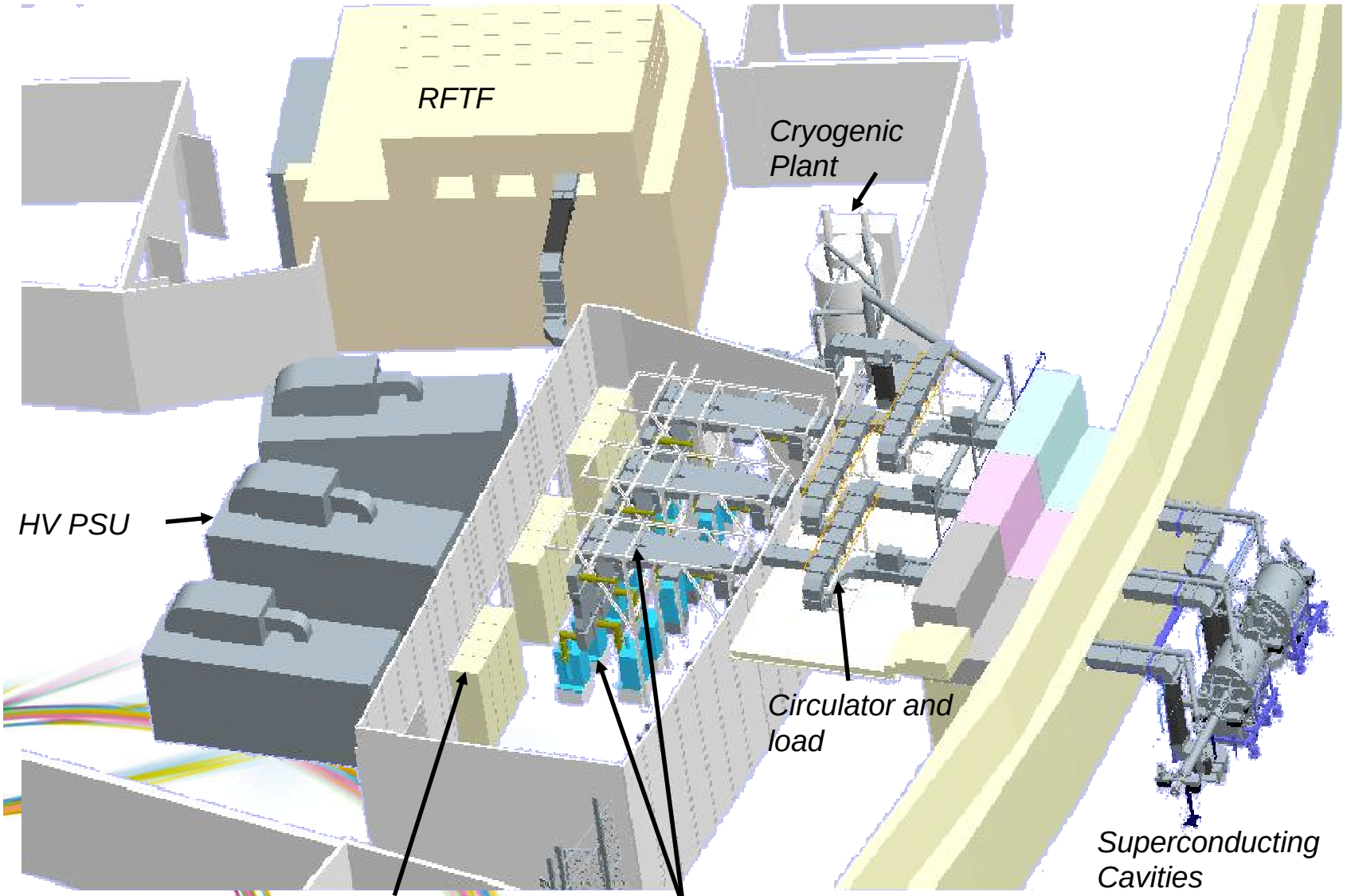
Status of the Diamond Storage Ring RF Systems

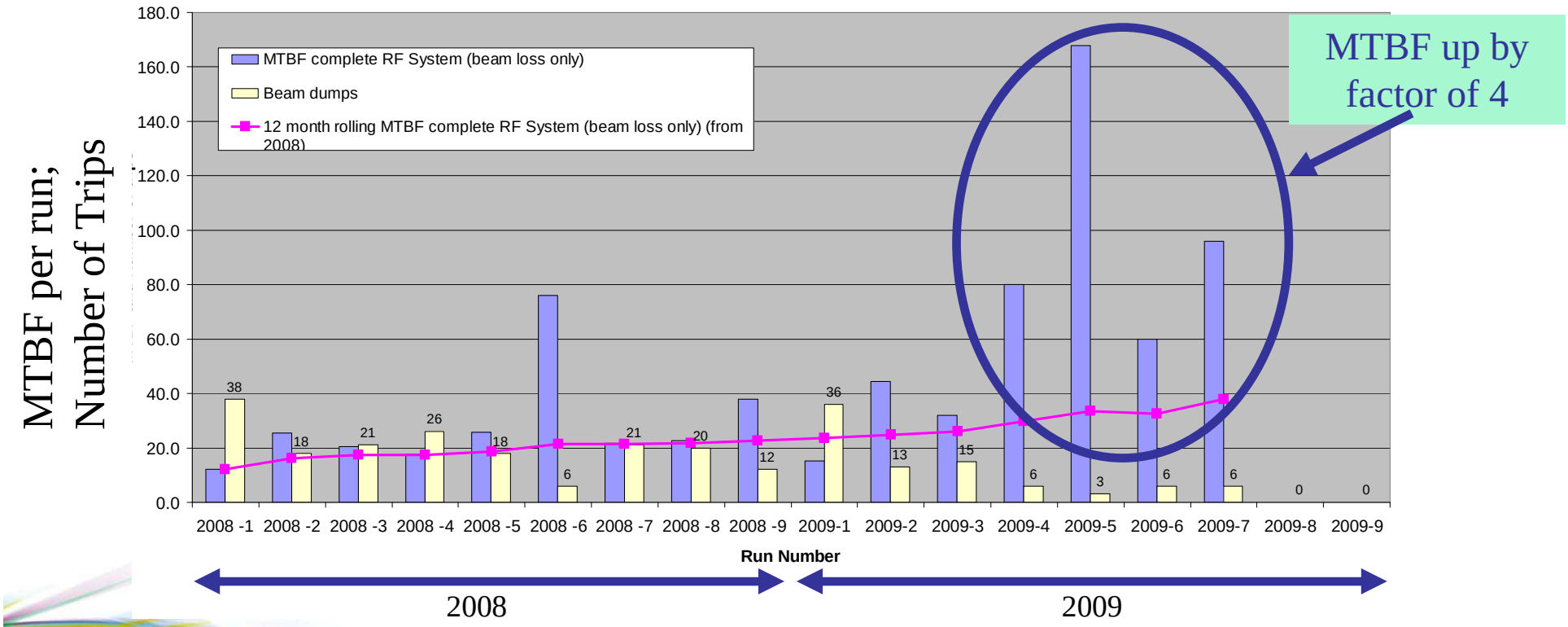
Morten Jensen
on behalf of
Diamond Storage Ring RF Group

Diamond Storage Ring RF Plant



Operating Statistics

MTBF of RF systems and number of trips



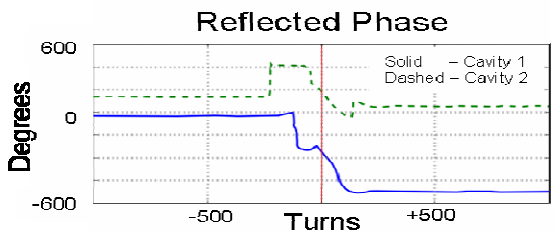
Typical MTBF as ~20 hrs dominated by cavity 2 trips

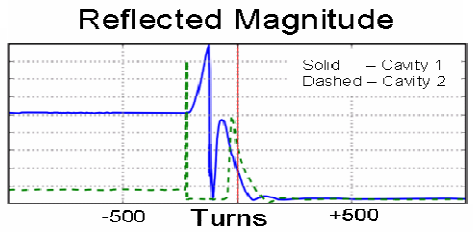
From Run 2 2009, MTBF increased, cavity 2 trips ~ ½ of all trips

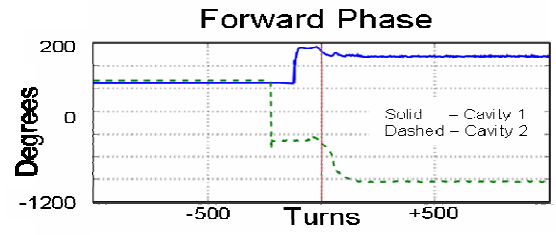
MTBF of last 4 runs (since ~ May '09) = 80 hrs for all SR RF systems incl cryo

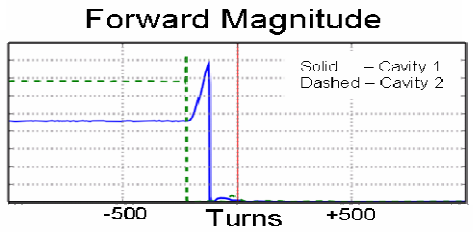
Repeat faults include: cavity, arc detection and IOTs.

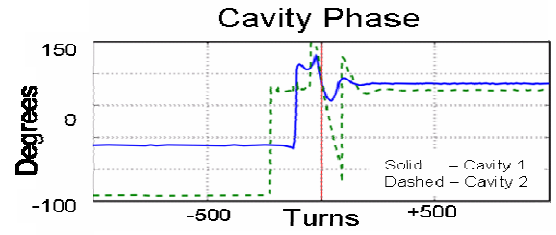
Cavity coupler still suffer from occasional trips

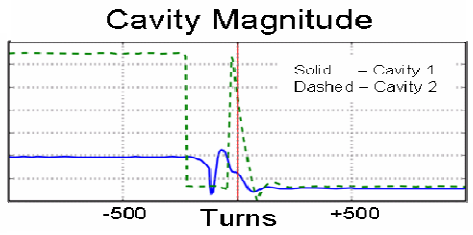




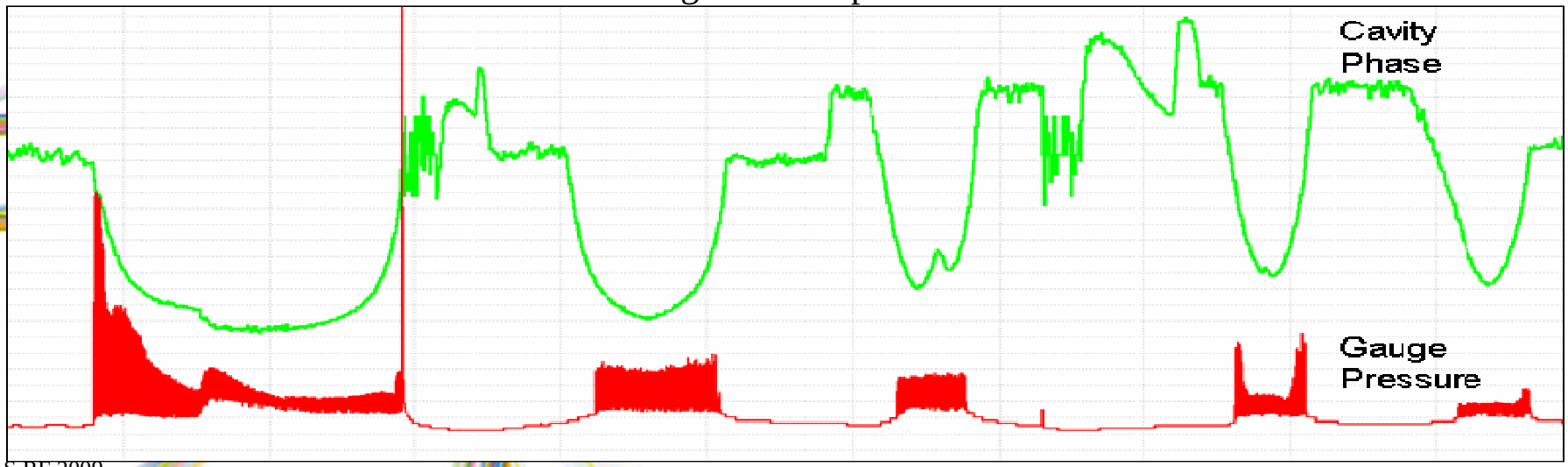






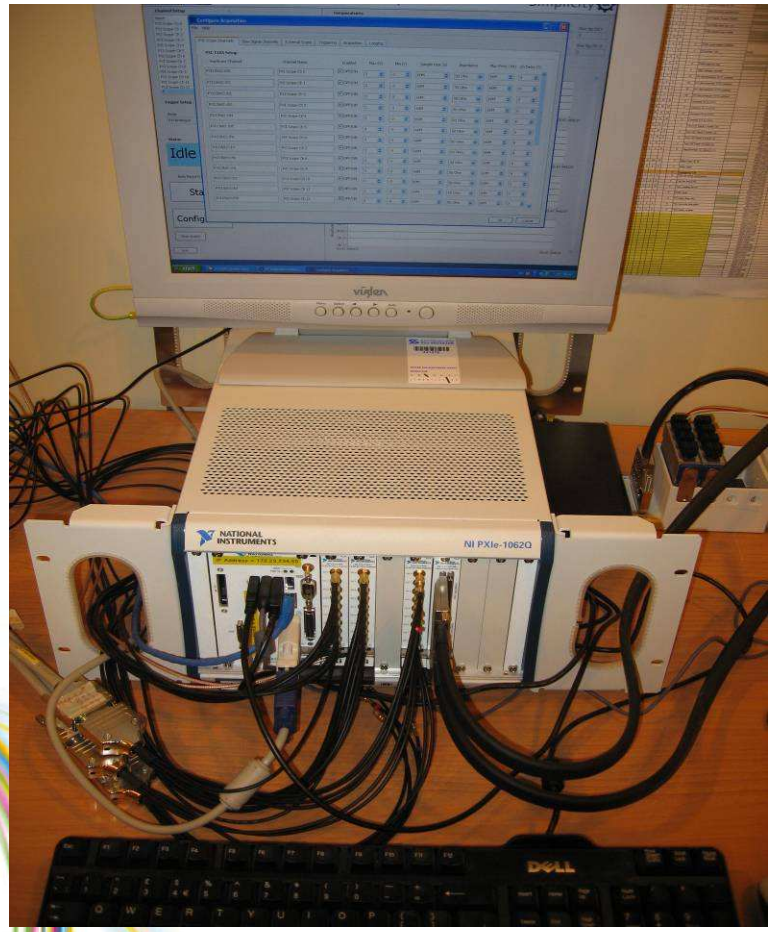


Pulse conditioning indicates presence of MP band

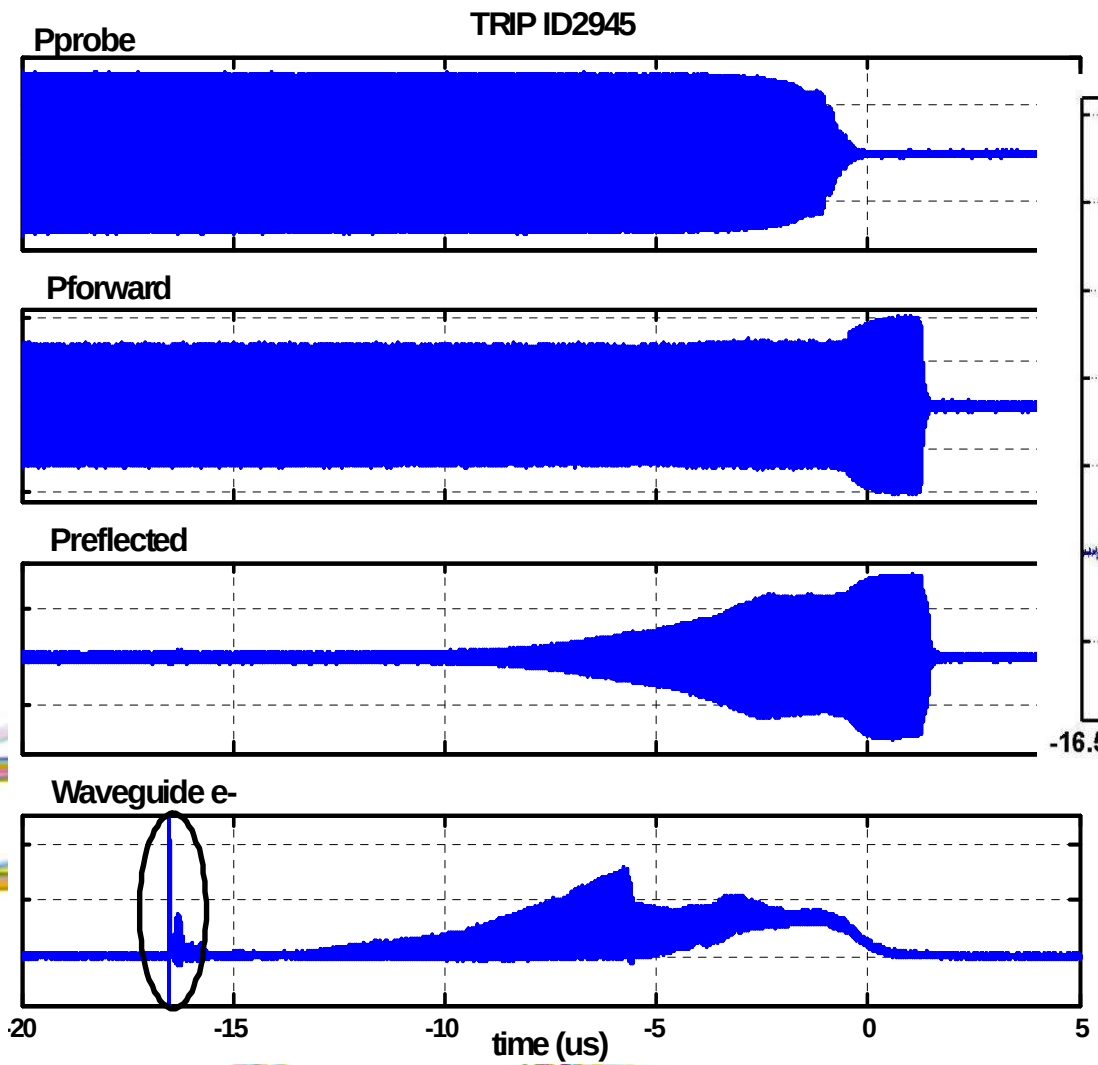


Installation of fast Data Acquisition

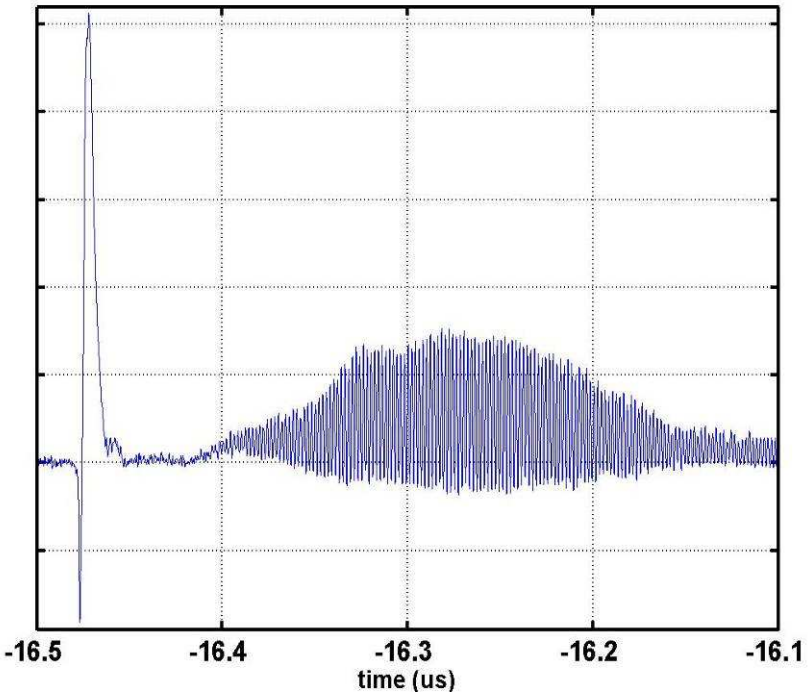
- Fast data acquisition system based on National Instruments PXI platform
- Use of three 60 MHz, 8 channel oscilloscope cards.
- Control of external oscilloscope
- Control of ‘slow’ acquisition of temperatures and pressures
- Simultaneous data acquisition with all channels synchronised.



Installation of fast Data Acquisition



Close up of fast signal on e- pickup



MP signal is typically observed 10-20 μs before complete loss of field.

Is it possible to detect the onset of multipactor, drop the RF to break the MP condition, re-apply RF hard to re-establish cavity field amplitude and phase without loosing the electron beam?

Interruption of RF signal for 10 μs is possible without loss of beam.

- Design underway of fast trigger circuit to detect MP pulse
- RF drive to the cavity will be interrupted for a defined duration.
  Reflected power signal will be gated for this period.
  Trial hardware for operations.

300 kW Amplifier

Four 80 kW IOTs per system

Two systems in operation with users

Third system available for RFTF, conditioning and testing.

Thales Electron Devices

S/N	Hrs (Currently in user operation)	Hrs (Spares)	Hrs (Failed)	Status	Notes
499175				Damaged	
539481	17305			In Use	
539652	13452			In Use	
539653			12133	Failed	
541272		9860		Spare	Taken offline due to trips
541273			2666	Failed	
541276			8252	Failed	
542301			1597	Failed	
542789			2890	Failed	
576282			3982	Failed	
595367			2461	Failed	
600663			2969	Failed	
600664			4314	Failed	
602801	4905			In Use	
606648			2146	Failed	
608801	1461			In Use	
615402			4052	Failed	TH793-1
628638		241		In Use	TH793-1
		Average life on failure	**4314.727273**		

E2V

S/N	Hrs (Currently in user operation)	Hrs (Spares)	Hrs (Failed)	Status	Notes
205-0639			1219	Failed	During initial commissioning
273-0907	89			In Use	
210-0647		14828		Suspect	Under investigation for tripping
211-0647	14793			In Use	
212-0647	14927			In Use	
223-0710	13630			In Use	

Spares which have not been installed are not included above

IOT Upgrade Project

System 1: TED IOTs

IOT type TH793 and one TH793-1 have been used.

- Average IOT life on failure 4300 hrs; 11 failures to date
- 1 IOT > 17000 hrs
- IOT trips are typical prior to failure.

System 2: E2V IOTs

IOT type IOTD2130

- First IOT removed from operation at 14800 hrs.
  IOT tripped twice and was replaced.
  Initial indication suggest that IOT will condition back up

Conclusion:

System 1 upgrade required. Options were:

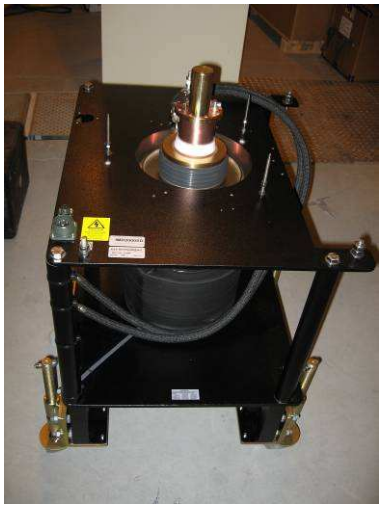
Upgrade to TED TH793-1 including full circuit

or

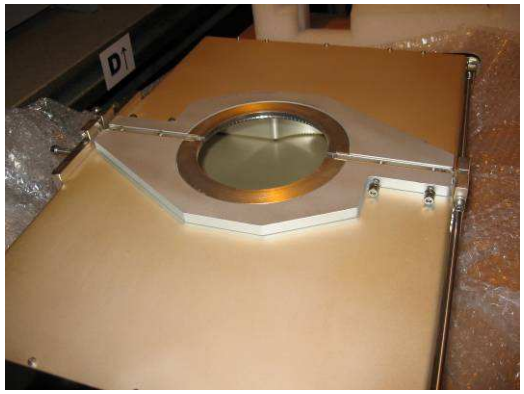
Upgrade to E2V IOTD2130 including full circuit

Tender exercise started → Upgrade of System 1 to IOTD2130 IOTs

IOT Upgrade Project
Build and Assembly of new IOT circuits



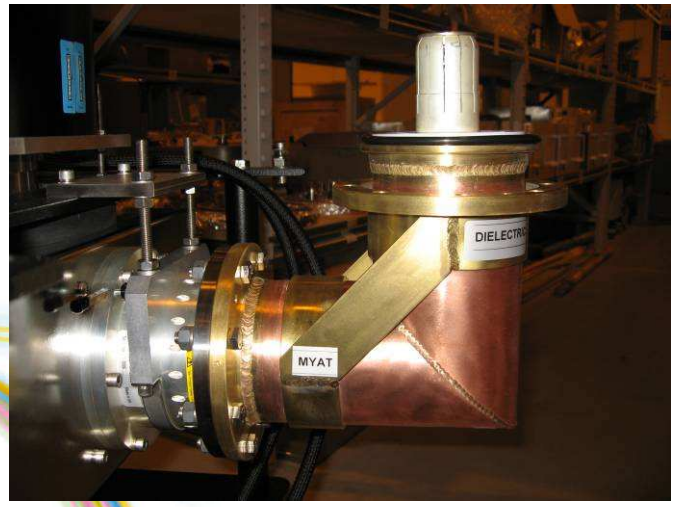
Before installation of output cavity



Split output cavity

Single output cavity tuner

Coaxial output

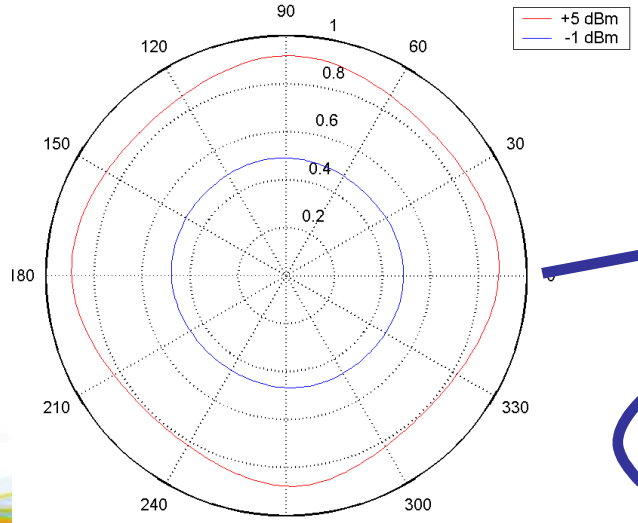


First new circuit in user operation

LLRF Progress

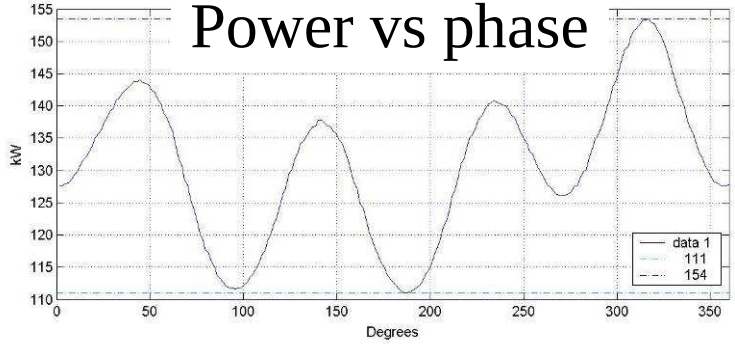
Problem with beam loss during system set up by 360 deg phase rotation

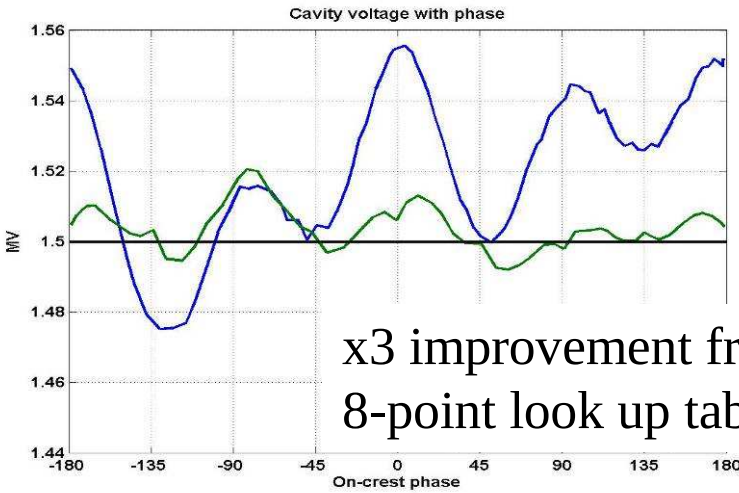
- Variation with phase of LLRF readings of Pfwd, Probe confirmed
  - Variation due to distortion in IQ demodulator chain
  - 8 phase lookup tables produced
  - Instability at certain phases → faulty module
  - Variation of suppression at different phases studied



Polar plot of IQ demodulated forward power signal.
Distortion clearly visible at the higher input level.

Power vs phase

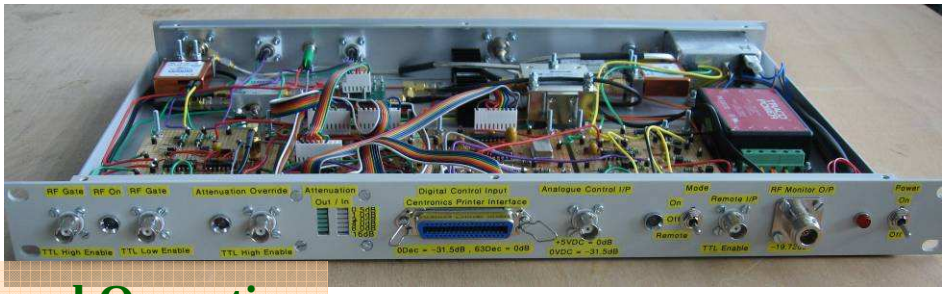




x3 improvement from 8-point look up table

Selection of other work

Pulse conditioning box designed, built and installed



RF Bypass for normal Operation

LLRF Output

Local Display

PSU drives relay circuits

Additional interlock

Pulse generator input

Programmable parallel port

diamond

Selection of other work

Drive amplifier Power monitoring:

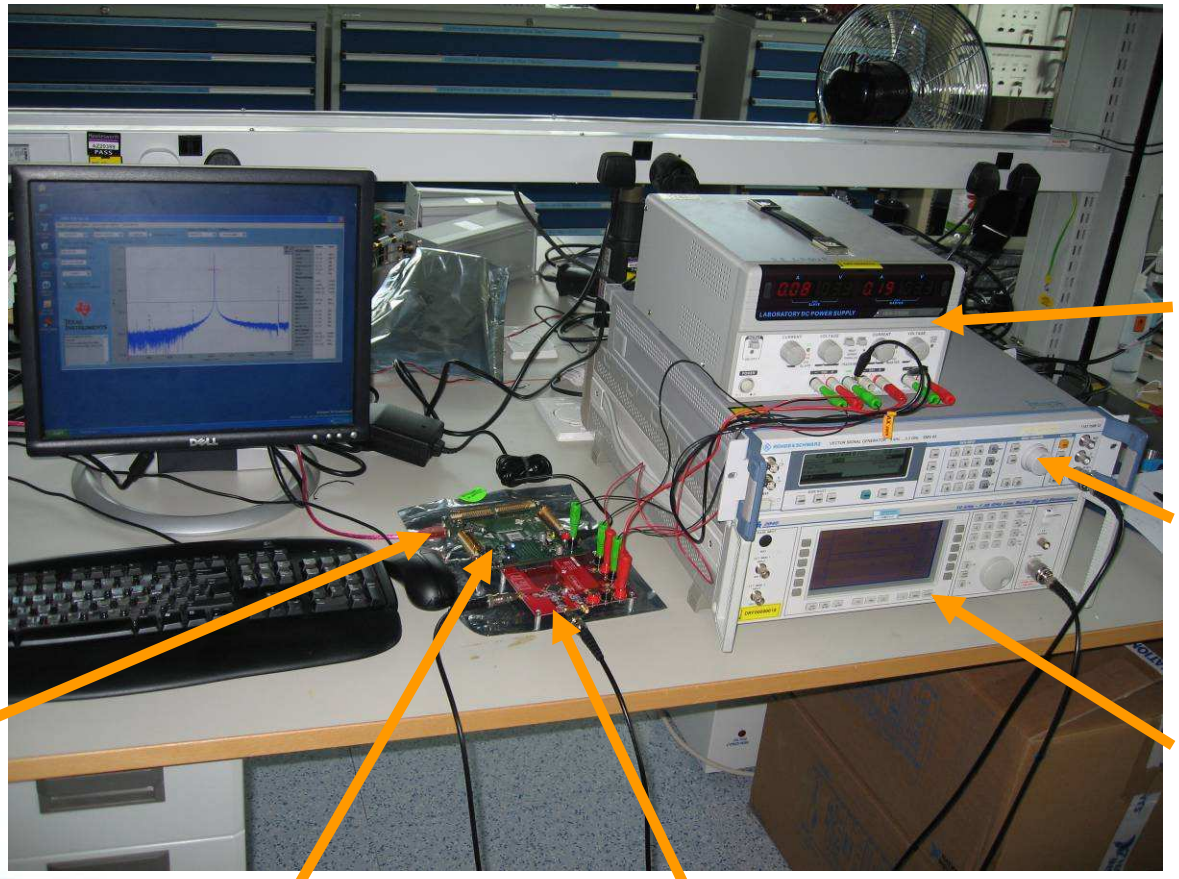
- local read out
- data archiving

Design and build of IQ phase modulation to enhance synchrotron oscillation for accelerator physics studies such as low alpha optics

FPGA development – phase measurement

FPGA development

Initial test set-up



PSU

Signal generator with phase modulation

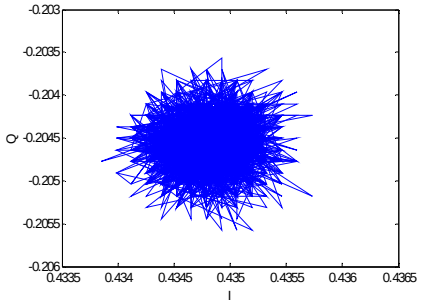
MO to generate clock signal

USB connection to PC

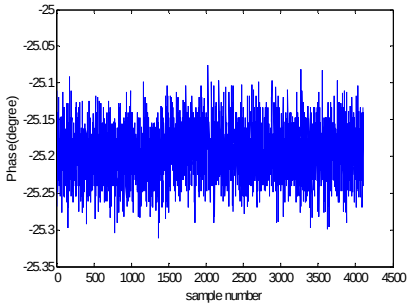
FPGA Data capture: TSW1200 by TI

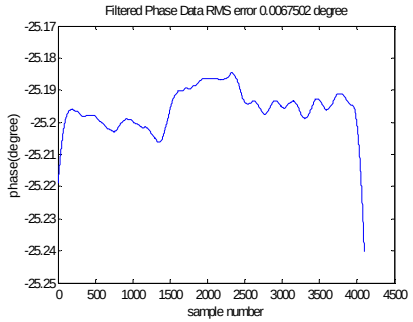
ADC converter: ADS 5474 evaluation board

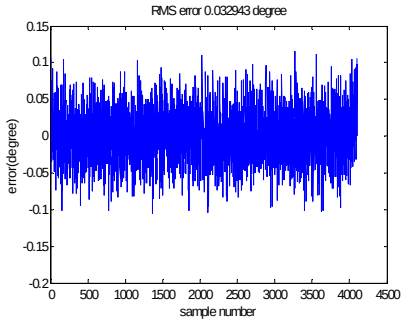
Raw I Q data



Calculated phase







Measurement of RF signal with no deliberate modulation showing drift of the signal generator

Measurement of RF signal with 0.001 rad phase modulation

Initial phase resolution obtained is better than 0.02 deg RMS before filtering or with 0.007 deg RMS with filtering applied

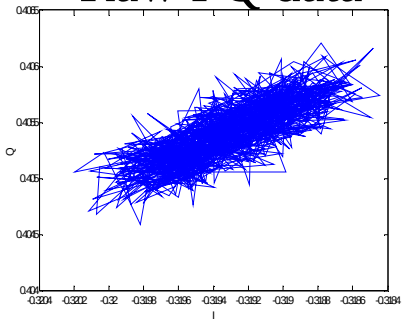
Phase calculated from

$$Mf_{IF} = Nf_{SF} \qquad \Delta\varphi = 2\pi\frac{N}{M}$$

$$I = \frac{2}{M}\sum_{i=0}^{M-1} y_i \sin(i\cdot\Delta\varphi)$$

$$Q = \frac{2}{M}\sum_{i=0}^{M-1} y_i \cos(i\cdot\Delta\varphi)$$

Raw I Q data



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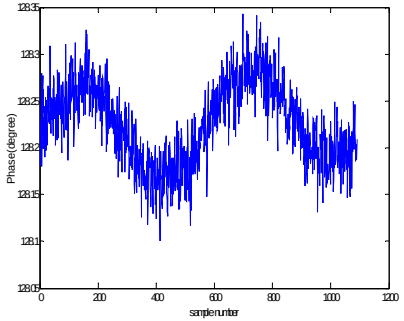
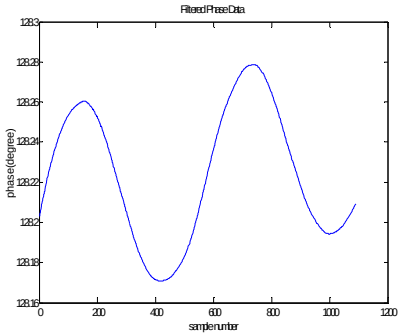
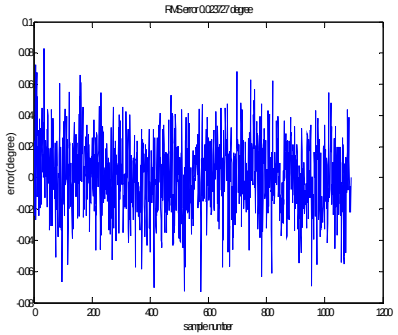
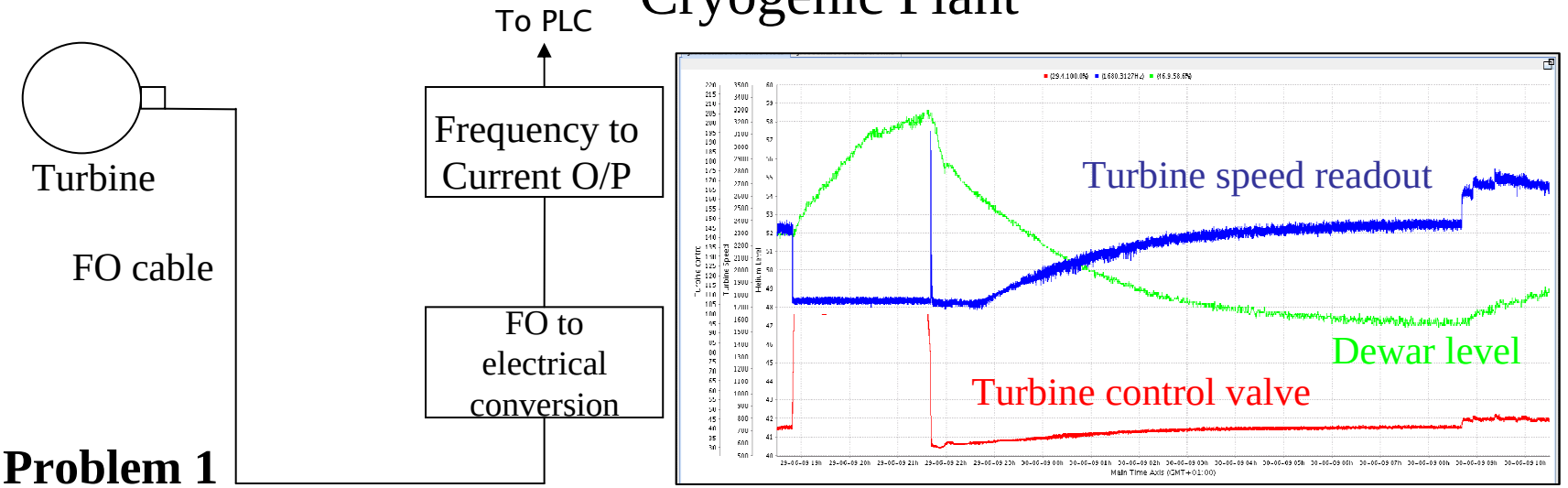






Cryogenic Plant



Problem 1

Intermittent turbine speed sensor miss-reading → Sudden drop in ‘speed’
Gas inlet to turbines opens to 100% under PID control.
Dewar level rises indicating increased performance despite ‘low’ speed
Danger of running out of gas or overfilling of dewar

Changed speed transducer, no more faults to date (fingers crossed).

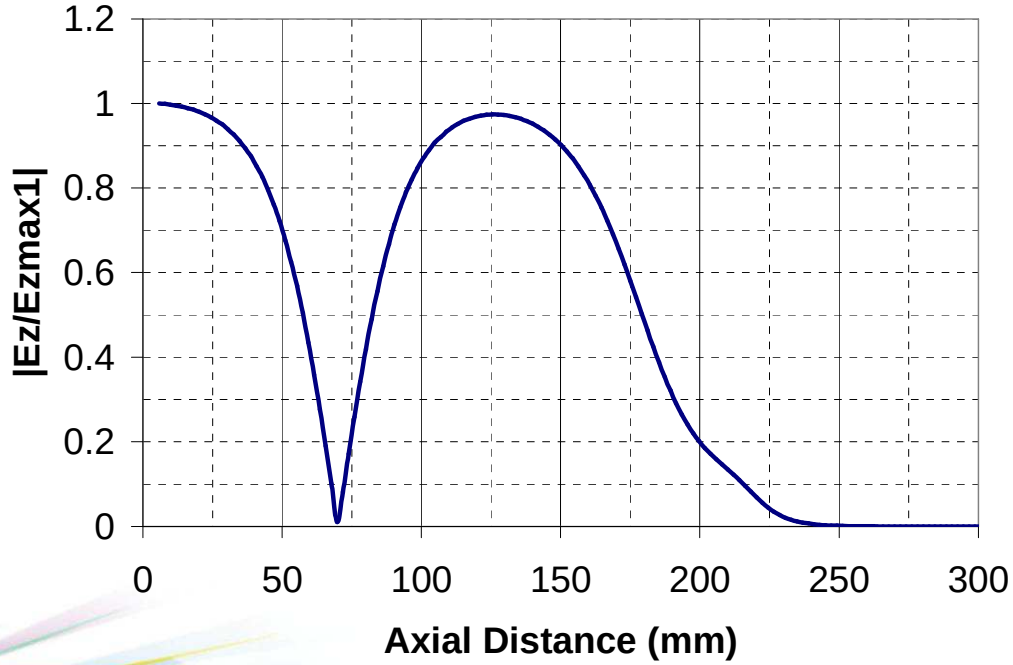
Problem 2

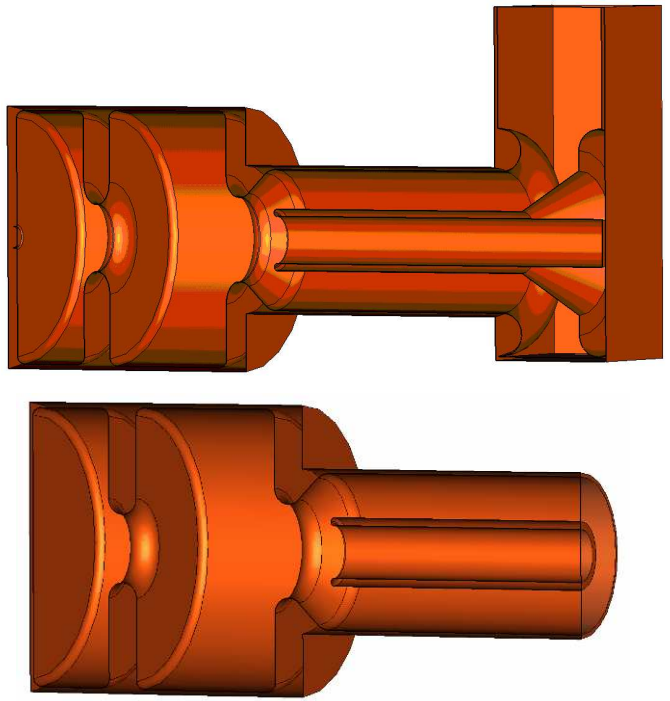
No loss of beam or beam time

Reduced refrigeration performance
Top Heat Exchanger running warm
Temporary fix by additional heating on thermal LN2 interlock
Suspect contamination of the LN2 heat exchanger

NLS Gun Design using CST Studio

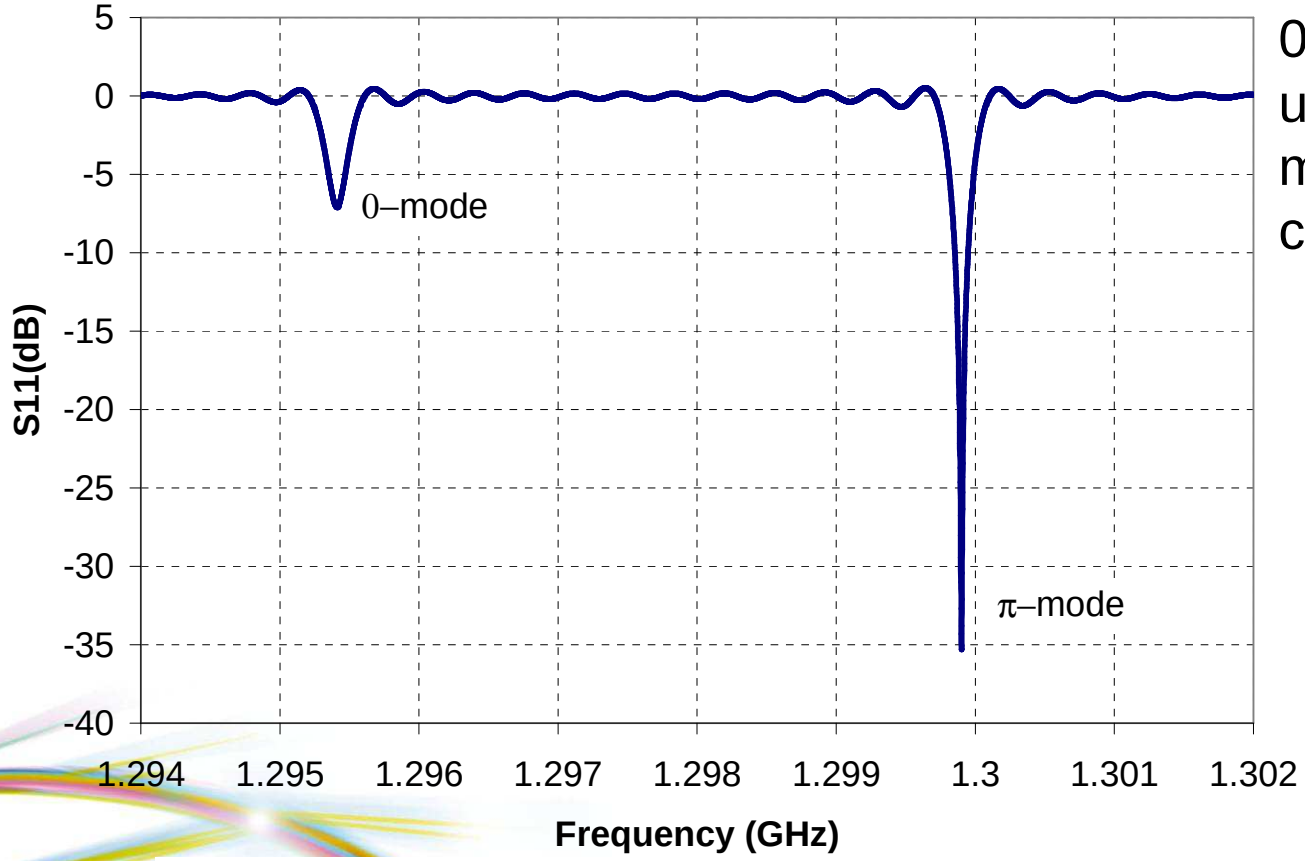
- The cell dimensions and coupling gap are adjusted iteratively for field balance and critical coupling at 1.3 GHz.





Axial E field normalised to the maximum field in the first cell for the π mode

S11 of final design

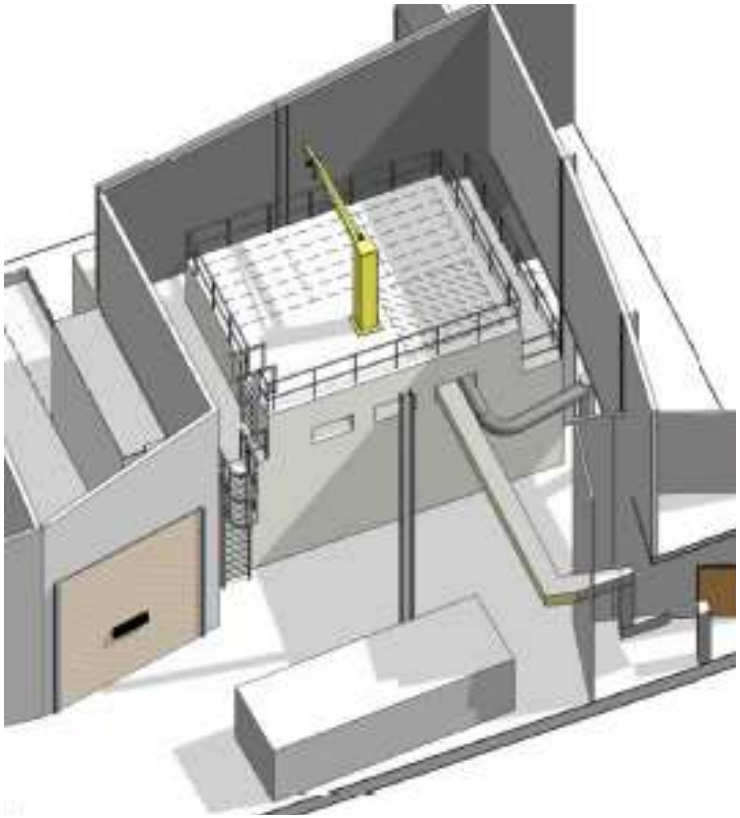


0-mode undercoupled, π-mode critically coupled.

- Aluminium test cavity ordered.
- Funding approved for Cu cavity.
- Bench testing about to start.
- Gun test facility under consideration

RF Test Facility

- Shielded high power cavity conditioning area
- Full PSS control
- 300 kW RF power from any of the 3 amplifiers
- Integration into the Liquid Helium Refrigerator
- Full cavity control system



RF Test Facility

On behalf of the RF Group

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David Spink
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Thank you for your attention!