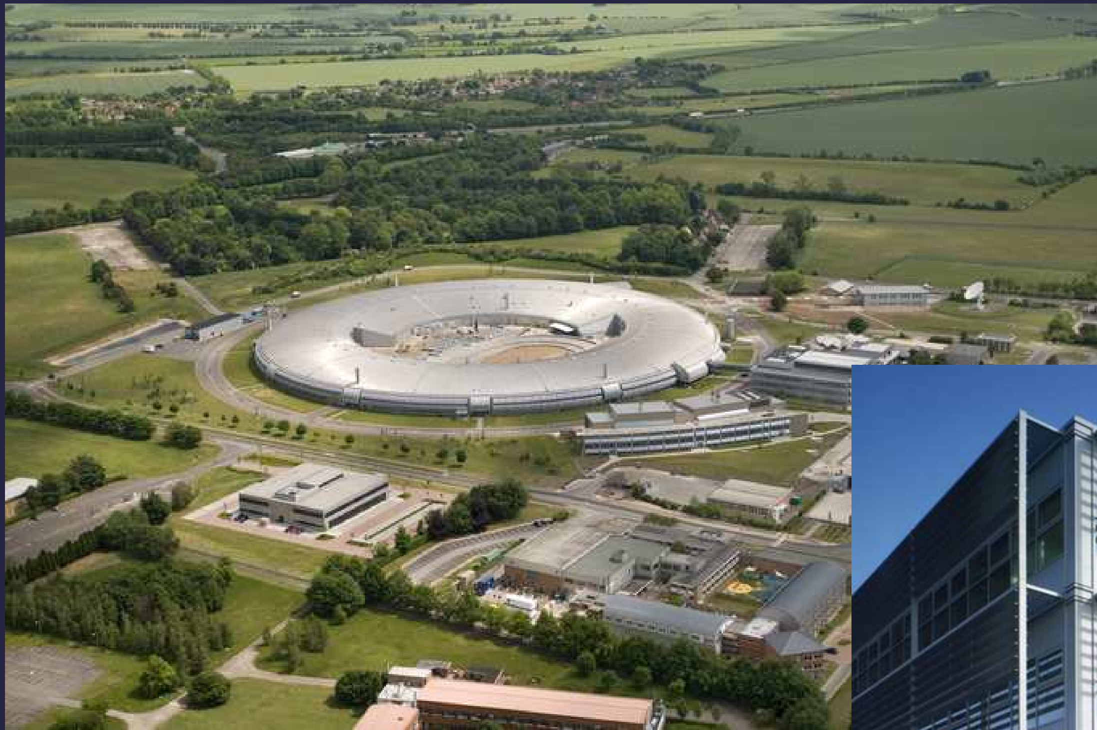
Status of the Diamond SR RF Systems



Morten Jensen
on behalf of SR RF Group

Agenda

- Statistics and reliability
- IOT update
- Cavity update
- FPGA phase measurement
- Arc detection
- RF load simulations

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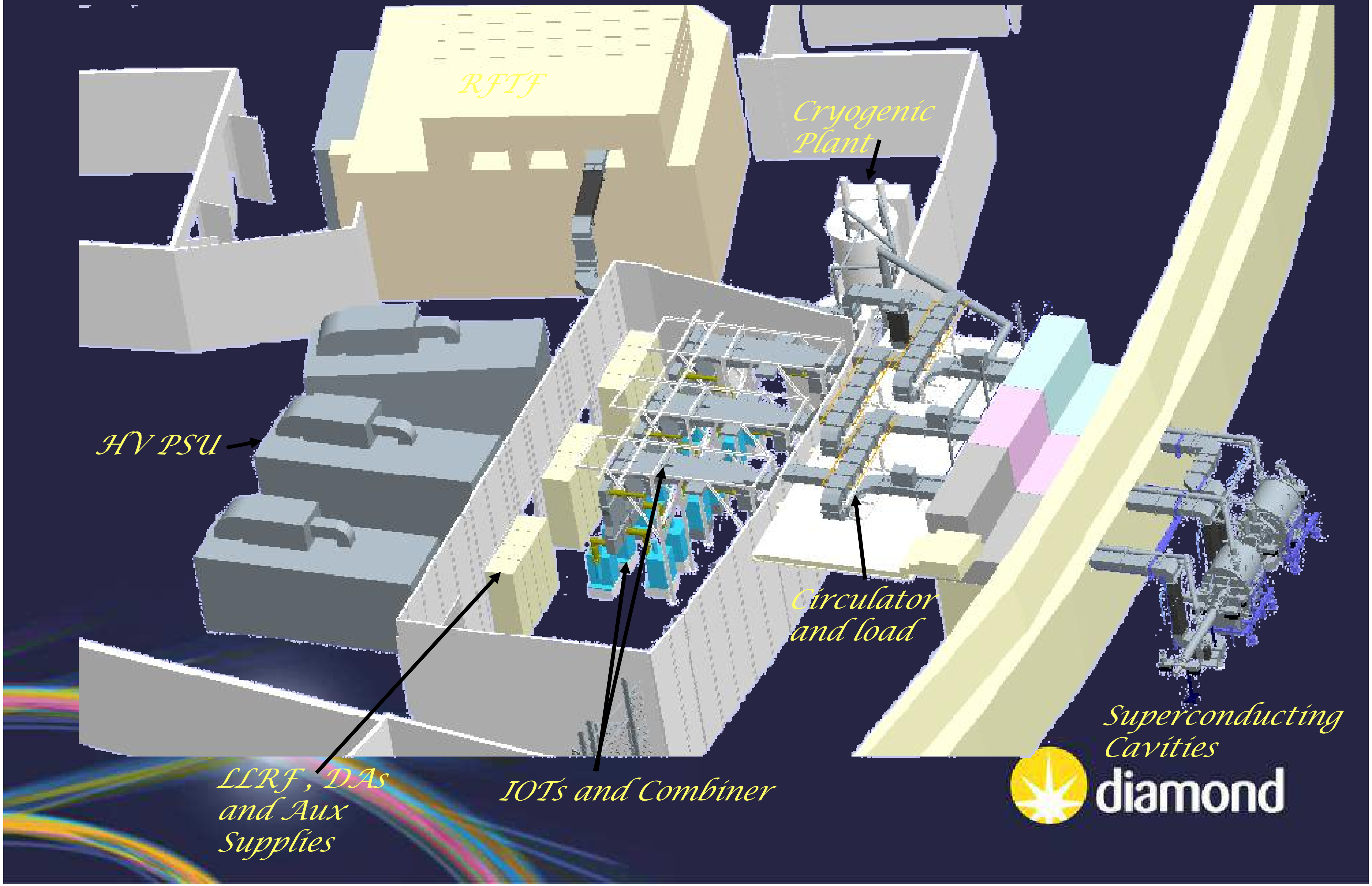
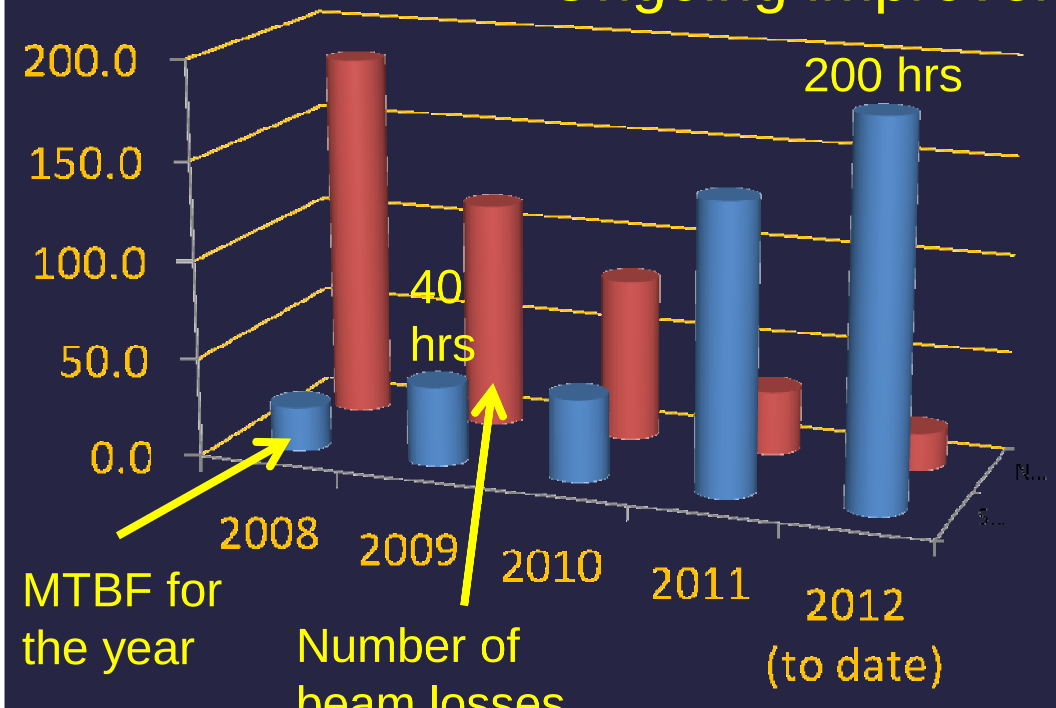
SR RF Systems

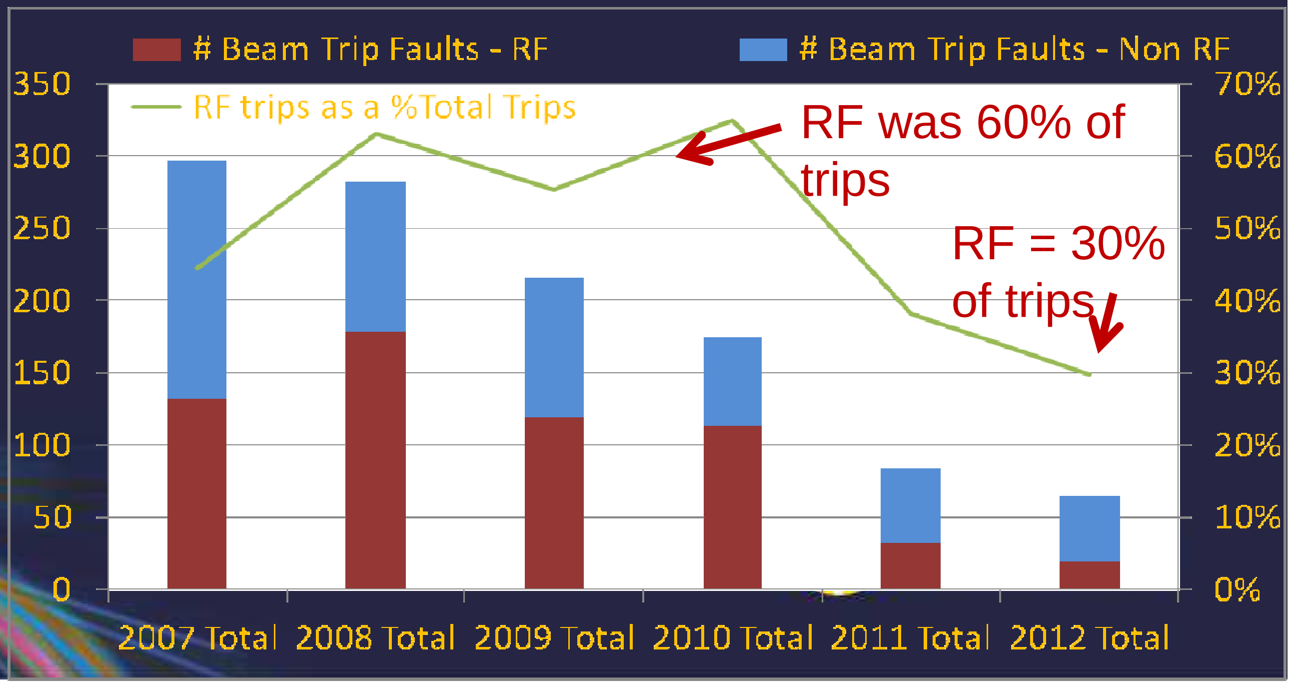


Ongoing improvement in MTBF



Huge improvement in RF MTBF
MTBF still improving

RF improvement faster than the other systems



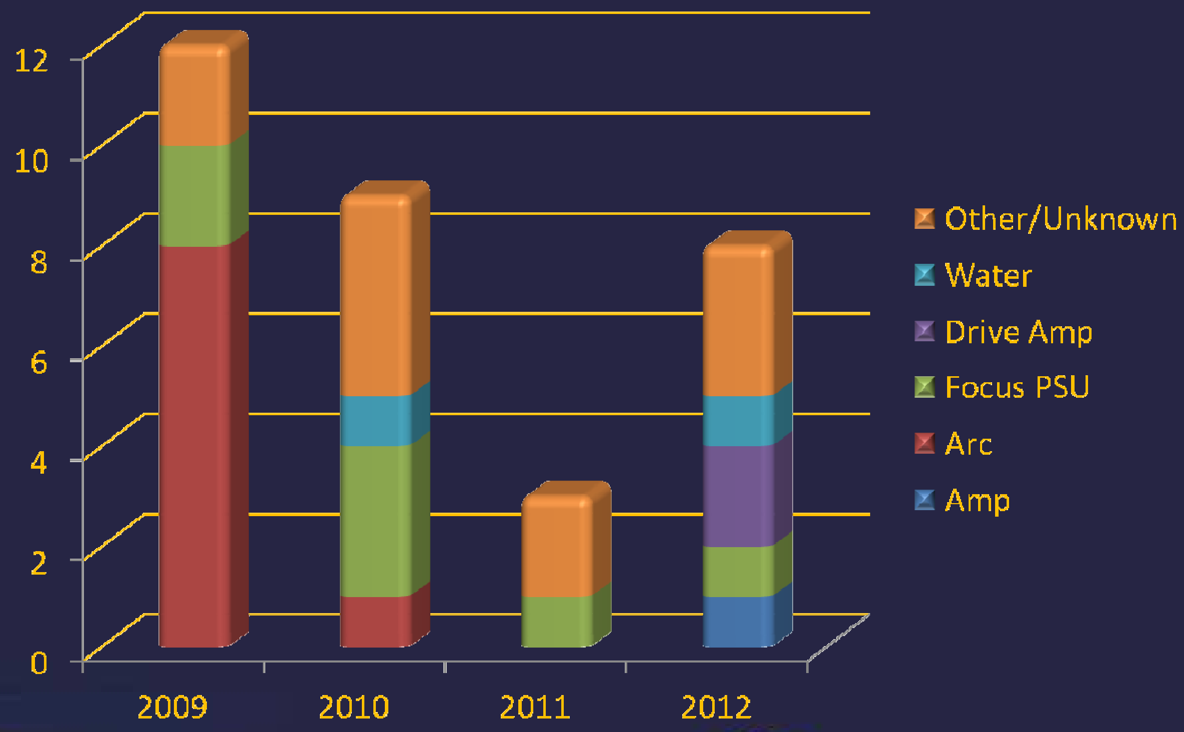
RF Includes:
2 Systems
HV PSU
Auxillary systems
LLRF
IOTs
Cryo
Cavities
Etc etc

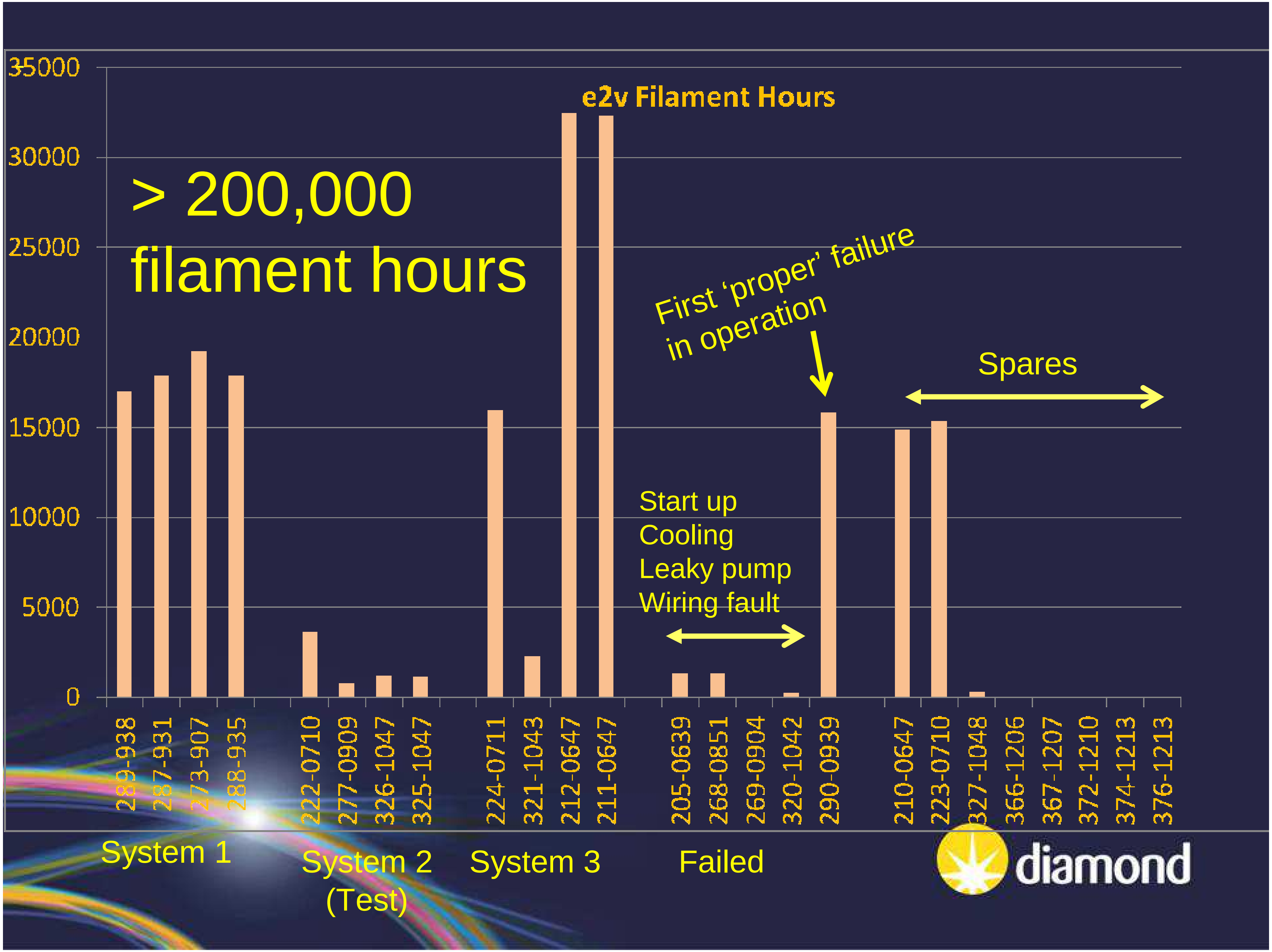
2012 – the story so far – 19 trips (~3600 hrs)

Far fewer cavity trips – three
IOT trips – four
User error – three

- Spurious arcs have been eliminated
- Ongoing question regarding focus supplies
- Still suffer from occasional unexplained interlocks

Split of Amplifier faults over the years





e2v Filament Hours
> 200,000
filament hours
First 'proper' failure
in operation
Spares
Start up
Cooling
Leaky pump
Wiring fault
35000
30000
25000
20000
15000
10000
5000
0
289-938
287-931
273-907
288-935
222-0710
277-0909
326-1047
325-1047
224-0711
321-1043
212-0647
211-0647
205-0639
268-0851
269-0904
320-1042
290-0939
210-0647
223-0710
327-1048
366-1206
367-1207
372-1210
374-1213
376-1213
System 1
System 2
(Test)
System 3
Failed
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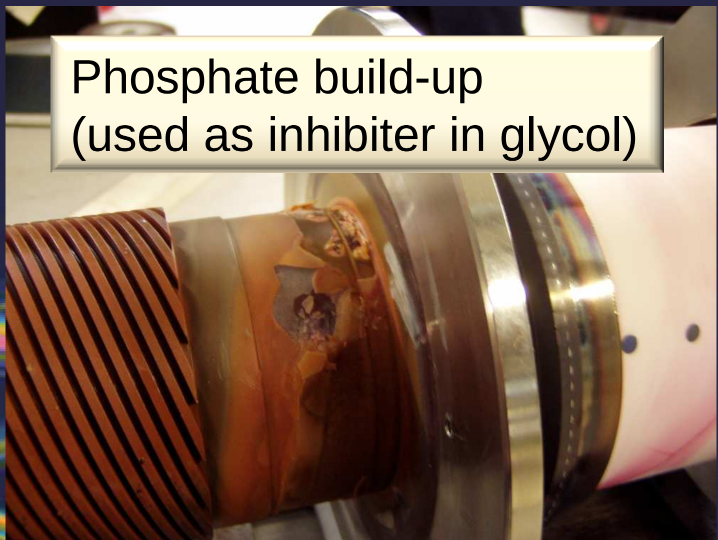
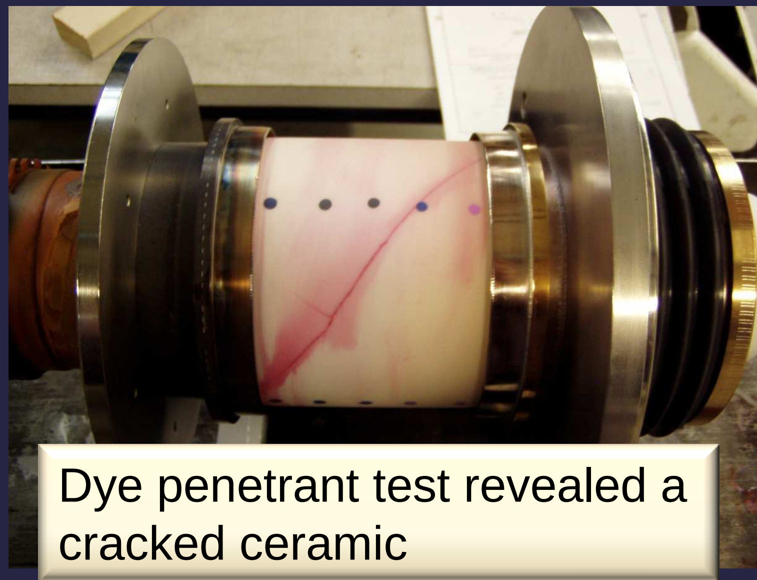
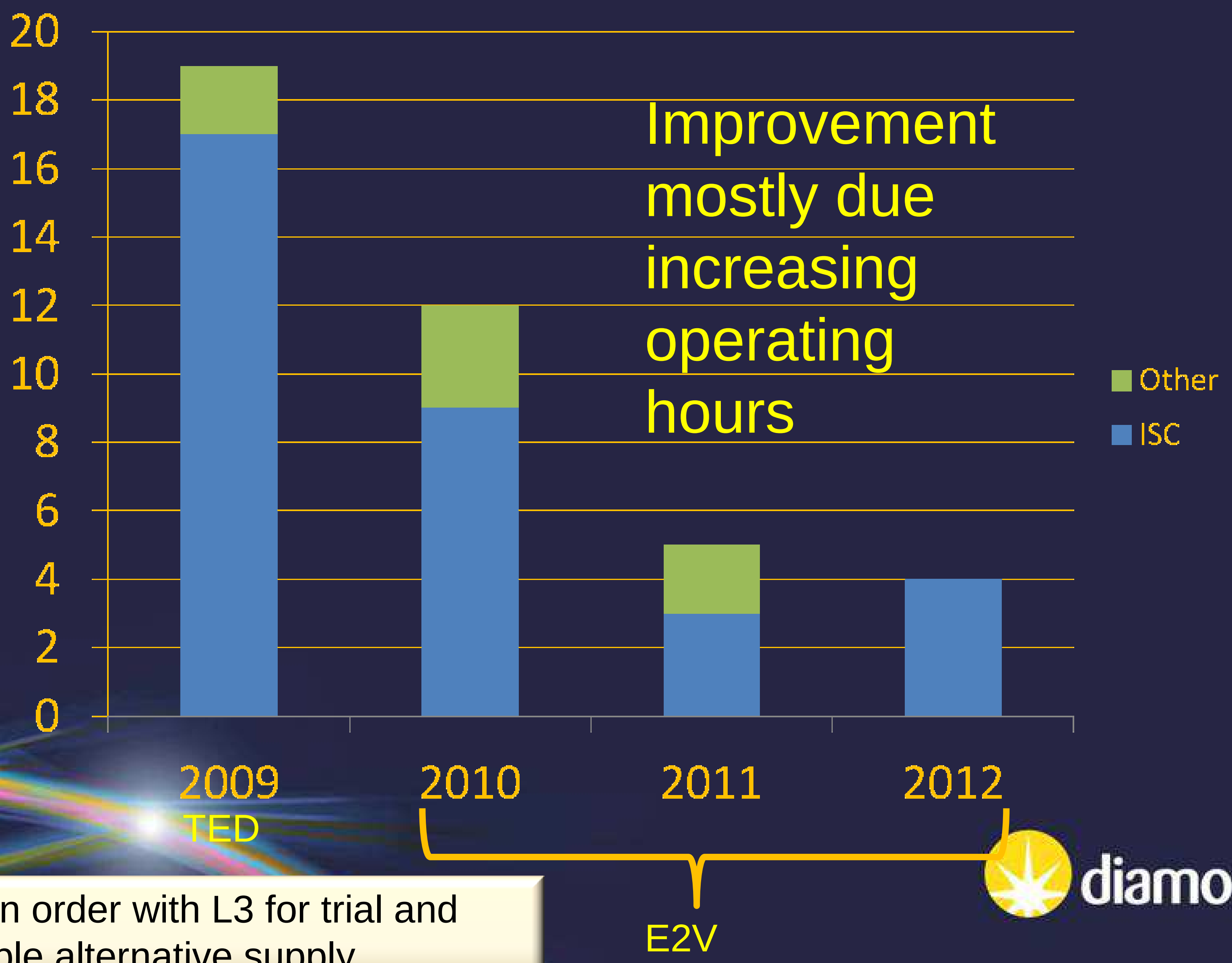
Failed IOT due to focus supply

- IOT failure caused by wiring fault
- Focus supply cables had been swapped
- Interlocks fine when operated in pairs





Number of IOT (ISC) and IOT related trips



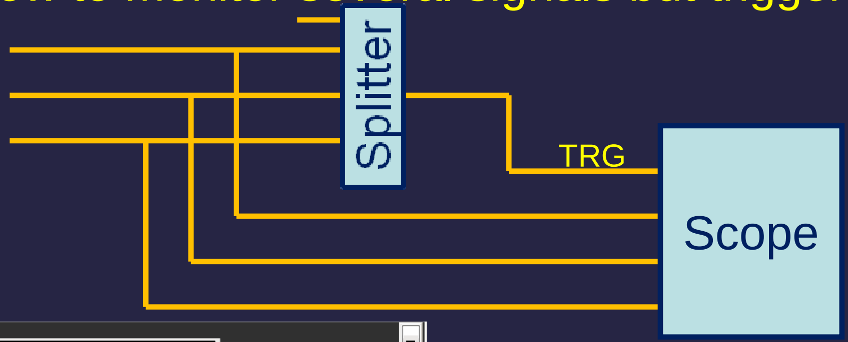
IOT on order with L3 for trial and possible alternative supply

Cavities continue to suffer from probe blips

- Initially thought to be charging up followed by breakdown

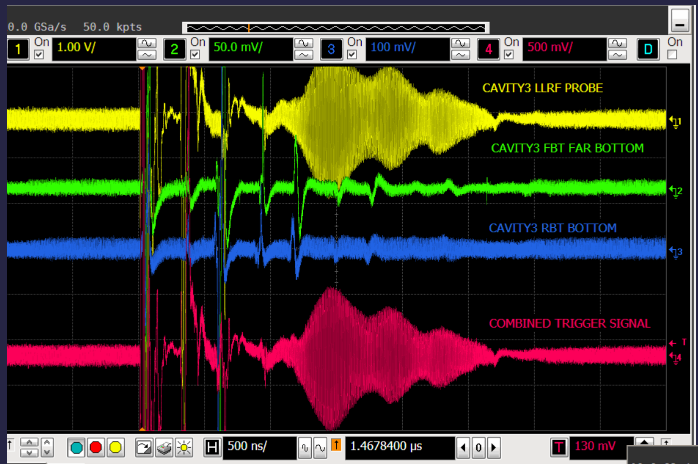
Problem: How to monitor several signals but trigger on any one

Probes 1-3



Ability to monitor and trigger on 3-4 signals simultaneously.

36 events recorded in 12 hours on Cavity 3.

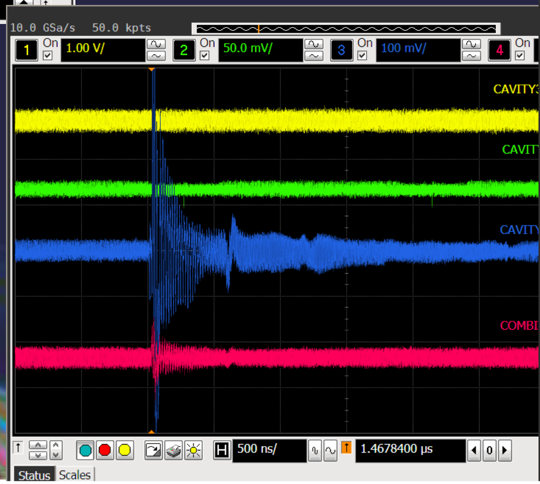


Three different probes

Combined signal (for trigger)

Or only on one probe .

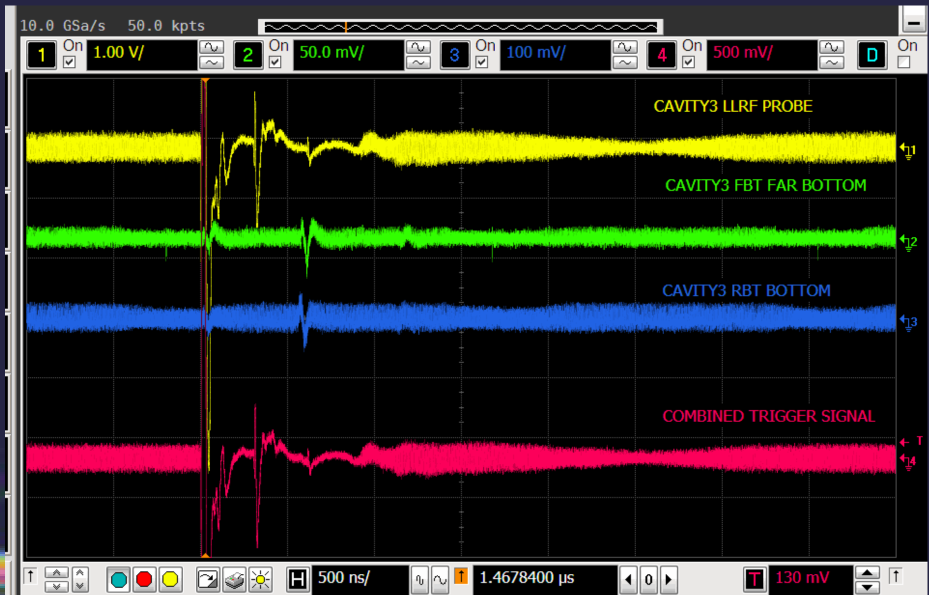
Blips can be observed on all 3 probes at the same time.



Open Questions

A blip on LLRF probe also produces smaller signal on the other probes. Unlikely to be coupling between channels; possibly moving charges

Simultaneous signals on probes on opposite sides of cavity cell
- but not in the middle!



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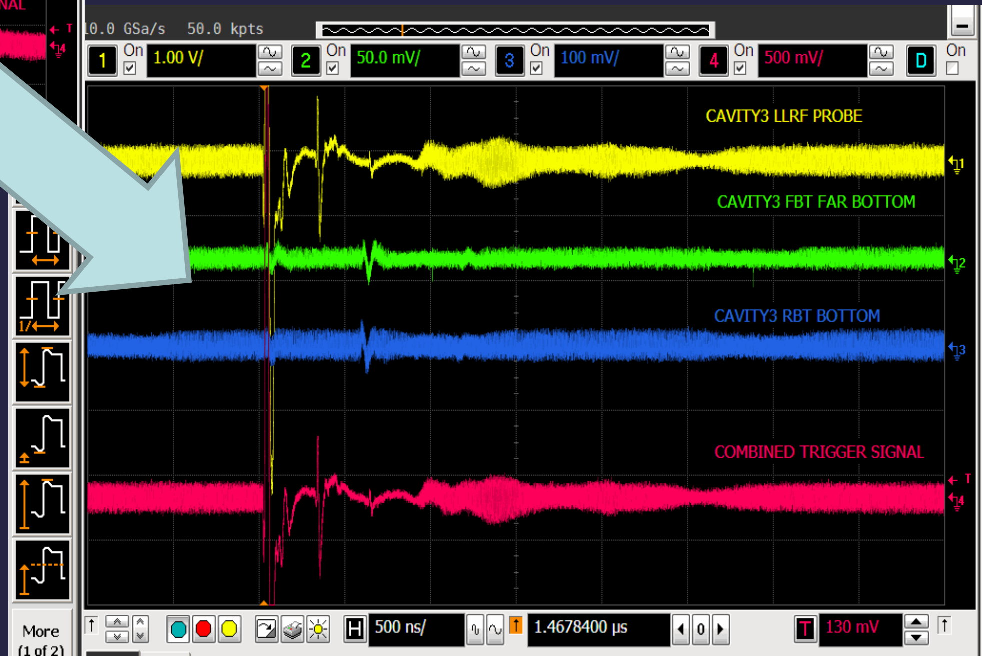
Open Questions

First activity on FBR Far Bottom probe
Then < 1 minute later a new spike but on a different probe

Observed three times in a row



Stop Press!

No blips observed during low alpha
- 10 mA instead of 300 mA!

Phase Measurement and FPGA Development

One unit finished and installed in RF hall.

Direct RF sampling

$$Mf_{RF} = Nf_{SF}$$

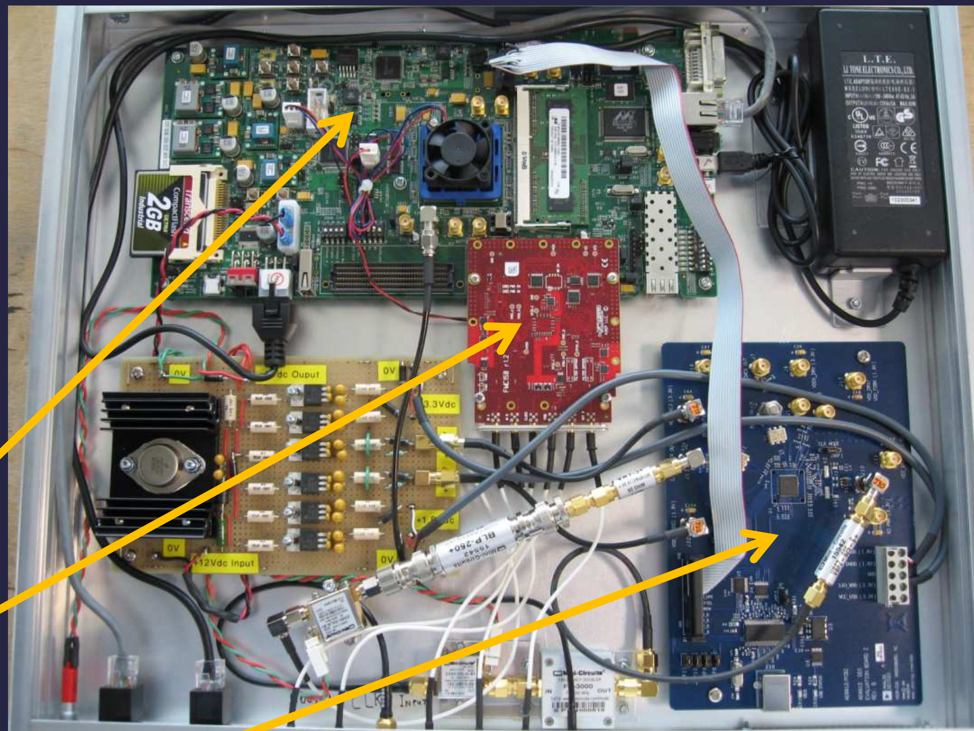
Phase advance between two samples

$$\Delta\varphi = 2\pi \frac{N}{M}$$

Then calculate I and Q

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

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



Xilinx ML605 Development Board

FMC150 module uses Texas Instruments ADS62P49 dual 14-bit, 250 MSPS ADC

ADC clock generation constructed using ADS9912 DDS

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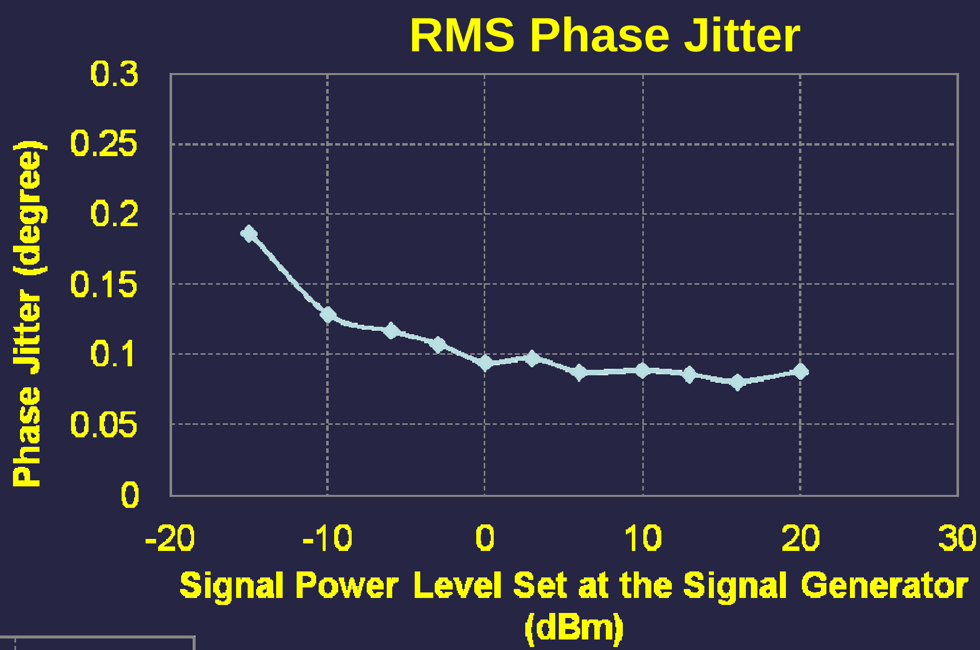
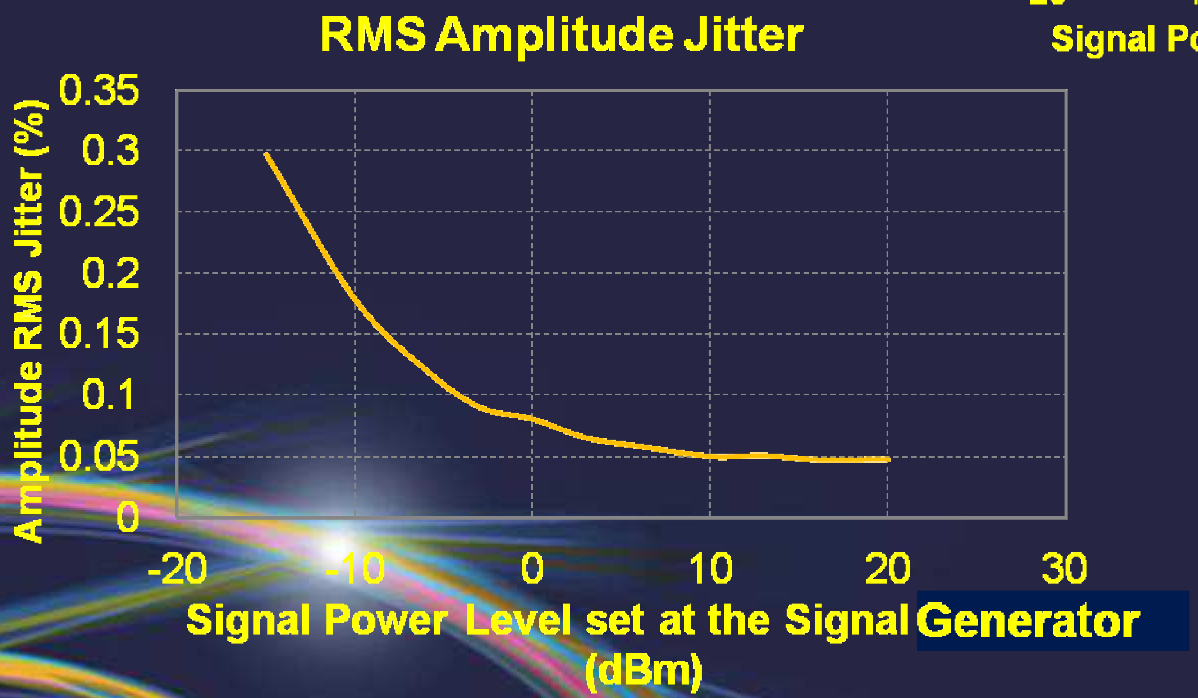
Low Jitter over large dynamic range

The measurements were taken across 35dB range using a signal generator at 500 MHz.





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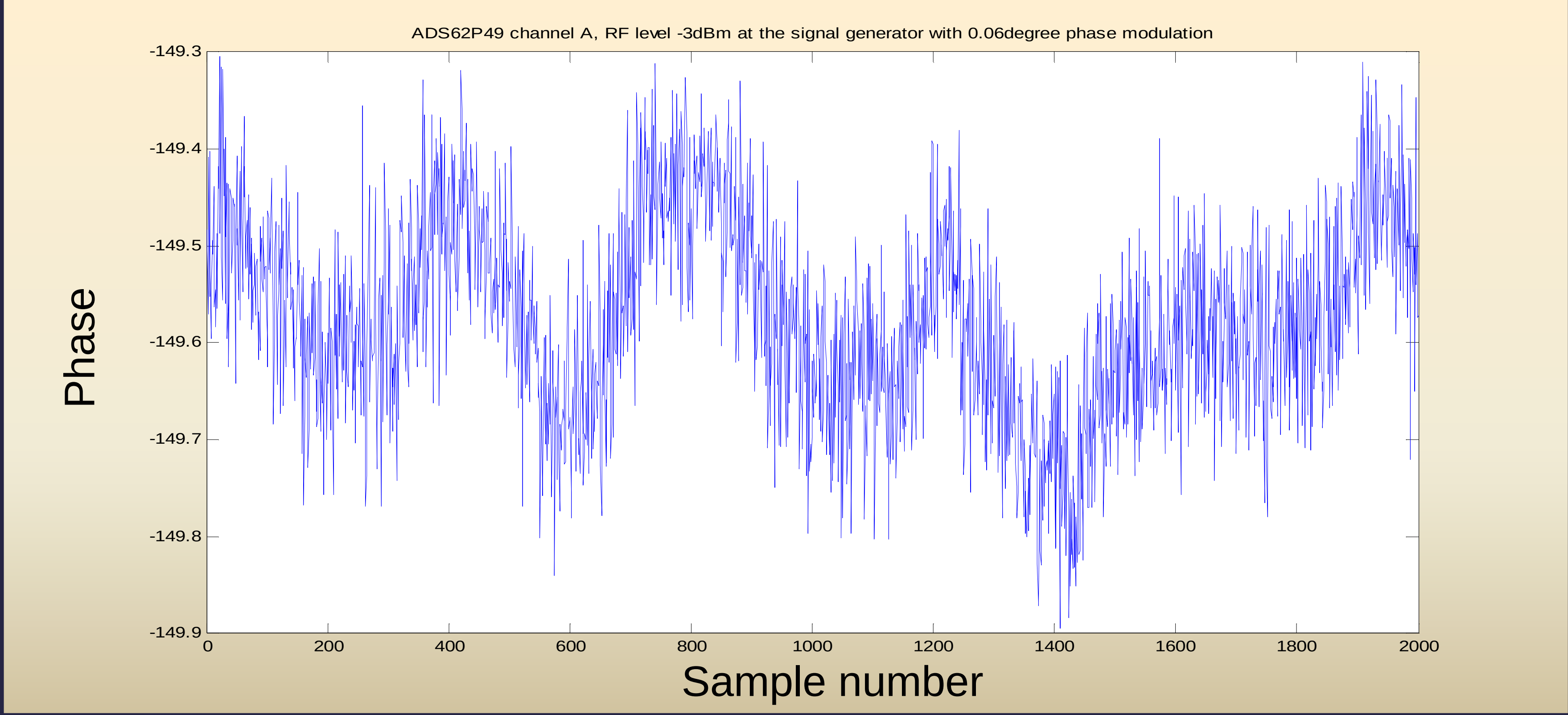
A deliberate 0.06 deg phase modulation is clearly seen from -3dBm.



No averaging, smoothing etc
Sampling at ~ 241 MHz
Phase measurement ~ 16 MHz

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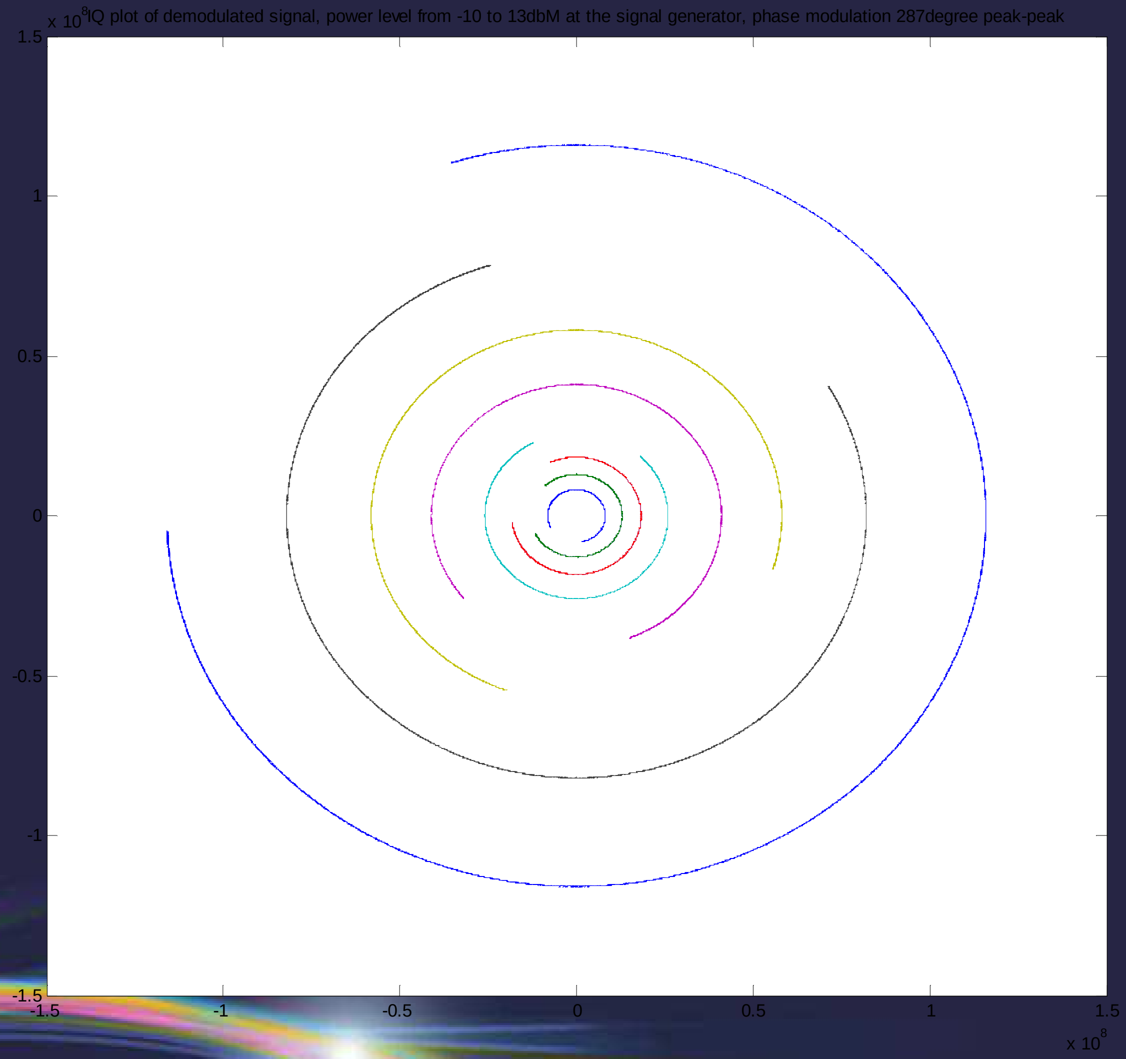
IQ Plot of Demodulated Signal from -10 to 13dBm with 287degree Phase Modulation



Phase measurement at discrete power levels.

Minimal distortion over dynamic range

Advantages of this method:

- No imbalance between I and Q channels often observed using IQ demodulators
- No DC offset errors

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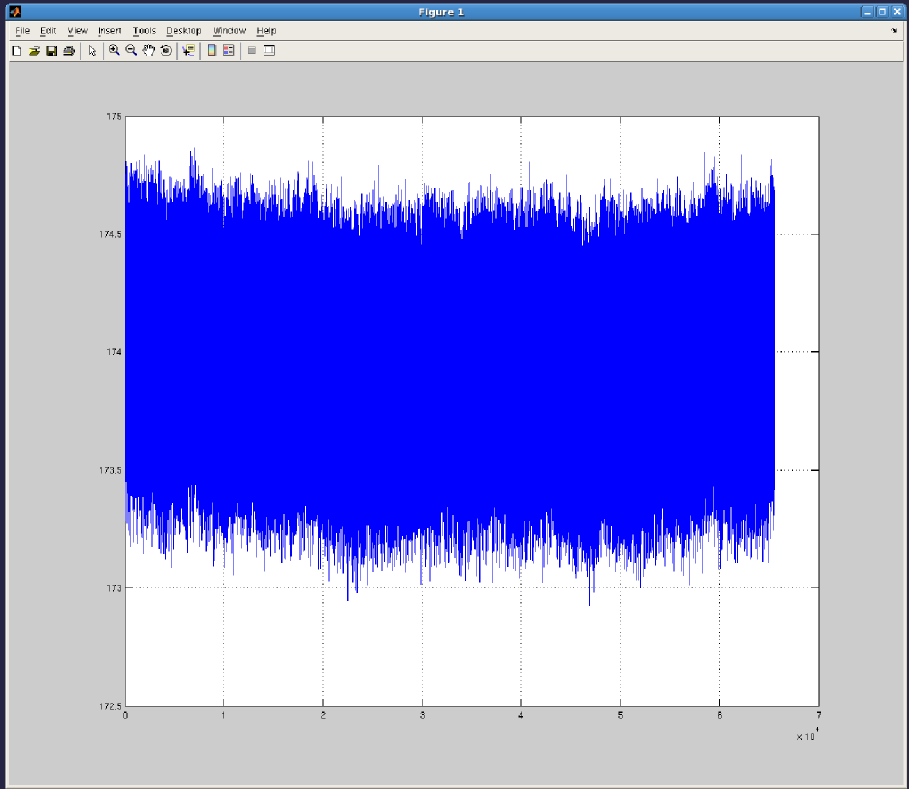
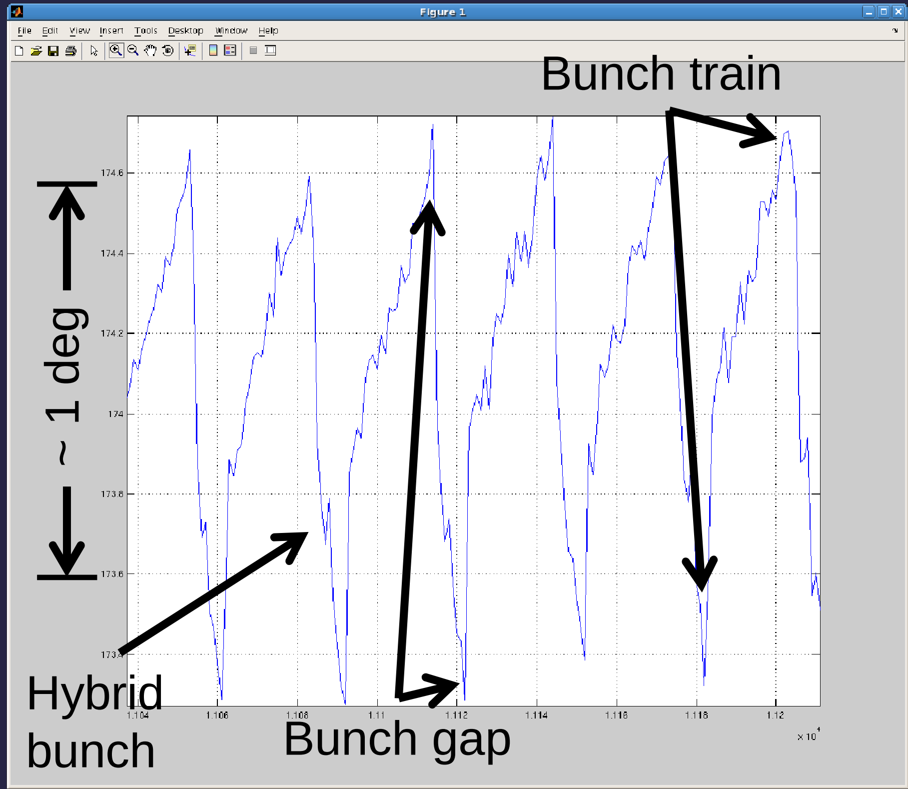
First results from cavity 3 probe signal
Phase variation and the single bunch can be clearly recognized.



Phase data



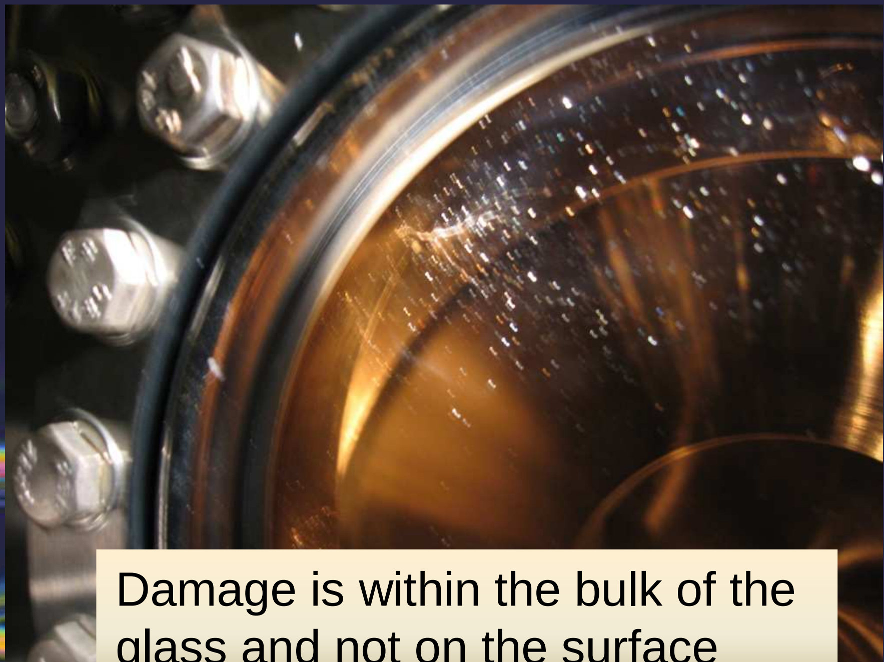
Close up shows clear phase shift across bunch train

Cavity 2 Update

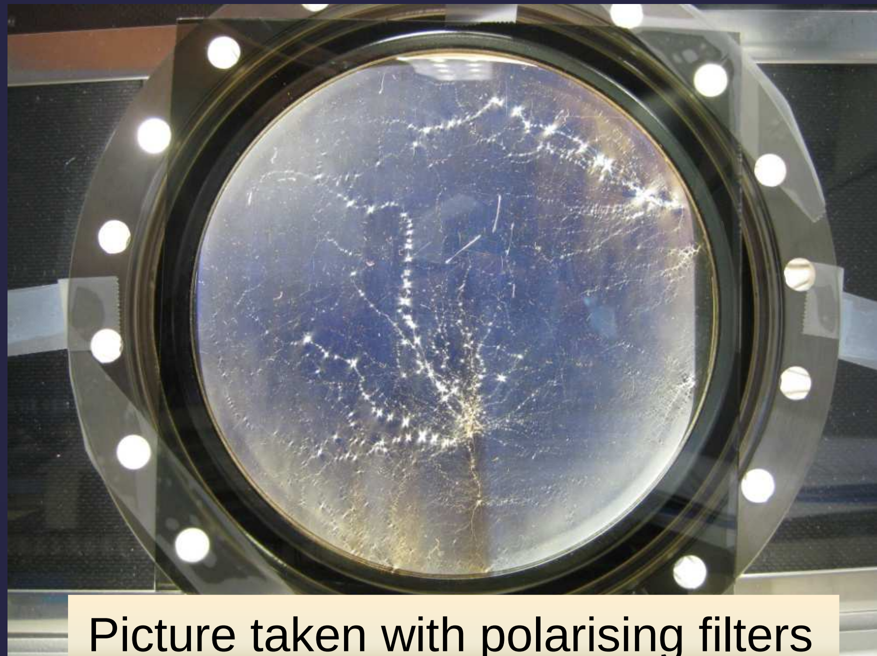
Delivered to DLS in March 2012
Conditioning and RF work have been ongoing
Cavity Q similar to the original
2 MV performance appears to be more reliable than the original
Cavity to be installed in November 2012 when cavity 1 will come out
A glass window was installed on the gate valve to allow us to observe the inside of the cell with RF on

Cavity 4 has been ordered
Delivery expected end of 2013

X-ray intensity caused the glass to turn brown and caused internal tracking/breakdown. The valve was quickly closed and the glass removed for fear of failure



Damage is within the bulk of the glass and not on the surface



Picture taken with polarising filters

ARC Detection

Original system based on AFT arc detection.
•High intensity x-rays cause the fibre optic cables to turn opaque
•Frequent false triggers even with no fibres connected

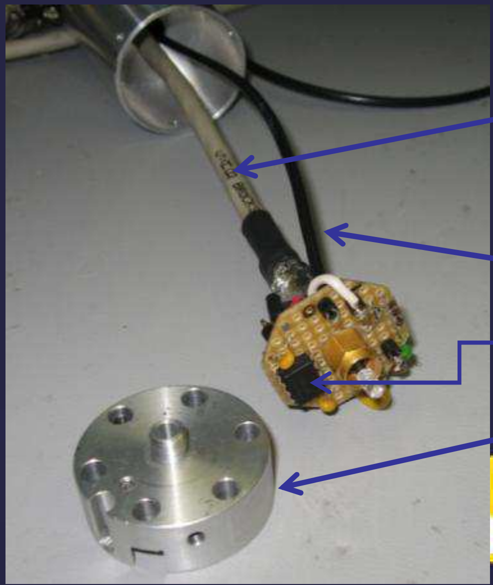
Two approaches being tried:
• Photodiode
• Photomultiplier Tube (PMT)

Detector head will be on the cavity (waveguide and RF window ports)
Minimal or no electronics at cavity end to provide radiation tolerance.

Photodiode prototype:

Long term test in tunnel is being carried out to determine long term reliability

Disadvantage that some electronics is needed at the detector end to drive the long cable length



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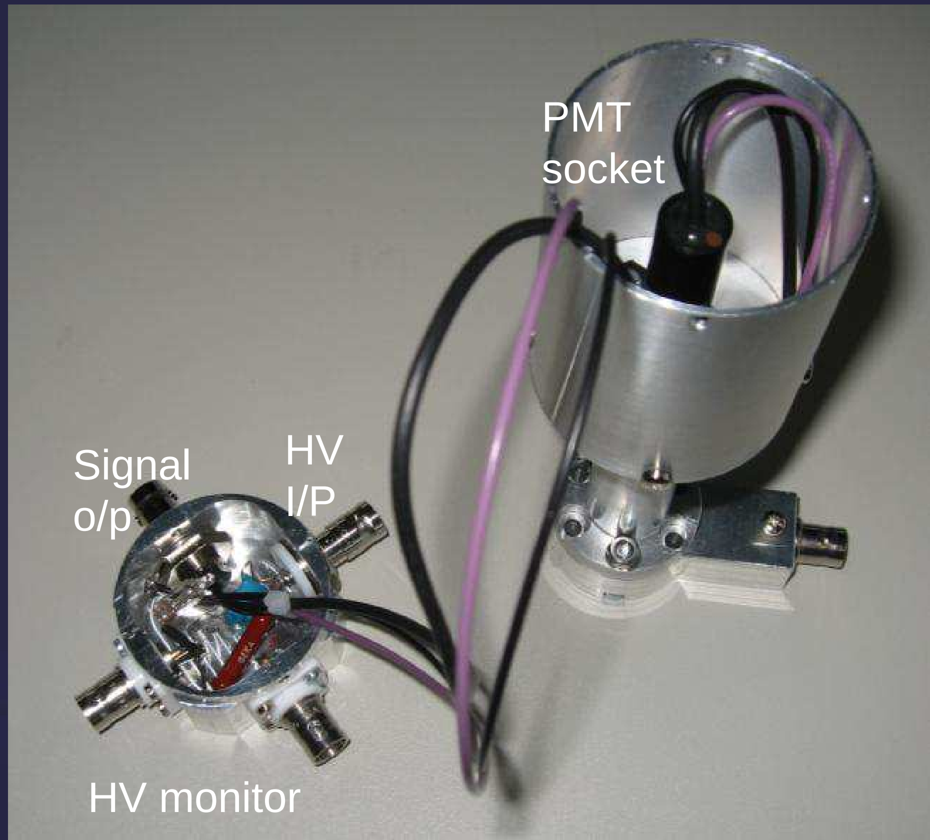
PMT prototype detector head

Detector housing made by Diamond workshop based on Cornell CESR drawings



First PMT assembly:
• Hamamatsu R647-01 tube

The assembly fouls with the waveguide bellows!
A shorter form factor (and maybe PMT) is needed

Water Load

- Glycol used to improve RF match in reject loads
- Wish to eliminate use of glycol

- Co-axial 6-1/8" line size
- Well matched to the input transmission line

  (Absorb all the input power)
- Able to handle 80 kW

- Heat removal by water recirculation
- Bandwidth – our application is 'narrow band'

  S11 < -30dB @499.654 ± 2 MHz

	40% Glycol-Water Mixture @25°C	**Pure Water @25°C**
Dielectric Constant (ε′)	**56**	**78**
Loss Tangent (tanδ)	**~0.2**	**~0.024**

Easier for RF matching
Faster power absorption
Shorter interaction length

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Electromagnetic Issues

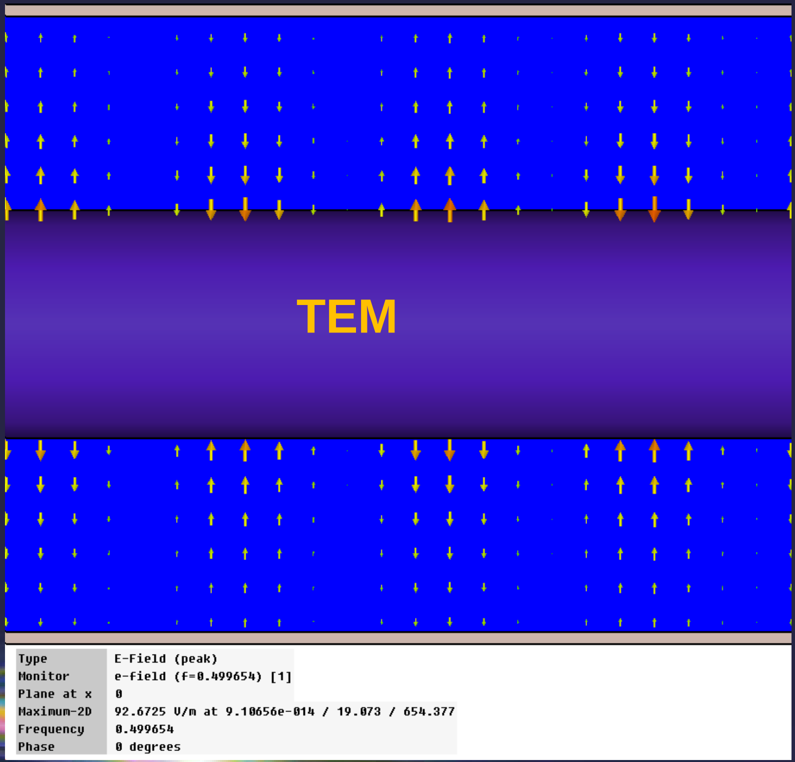
- Very high relative permittivity (ε′) = 78
- Leads to very high ratio of inner (b)/outer (a) conductor radii
- The cut-off frequency of the E01 mode becomes lower than operating frequency

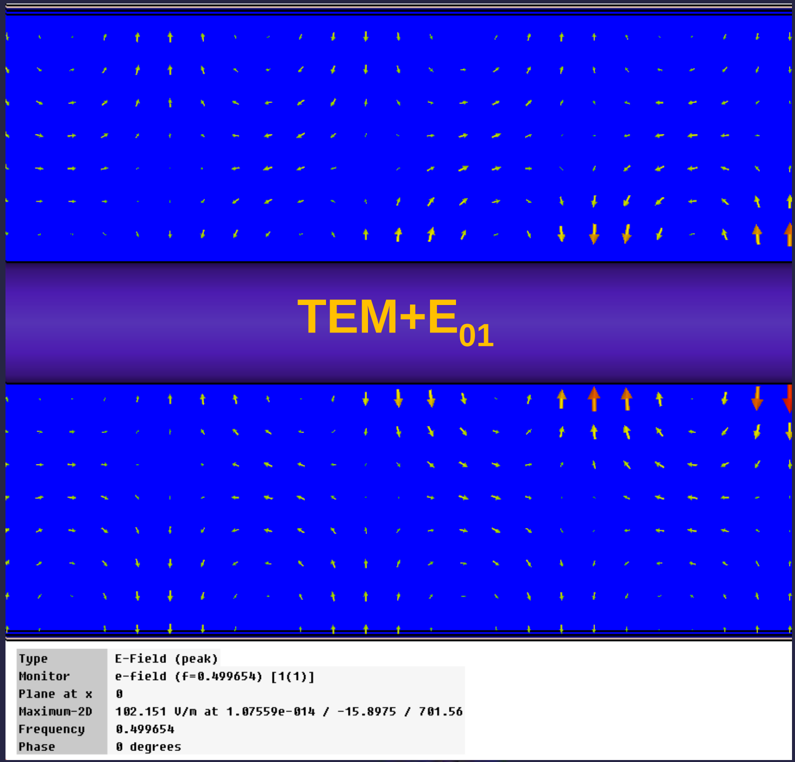
$$\lambda c = \frac{2\pi}{(a/b-1)\chi_{01}}(a-b)$$

Where χ_{01} is the 1st non-zero root of a complex combination of Bessel & Neumann functions

Electromagnetic Issues

Propagation in two modes





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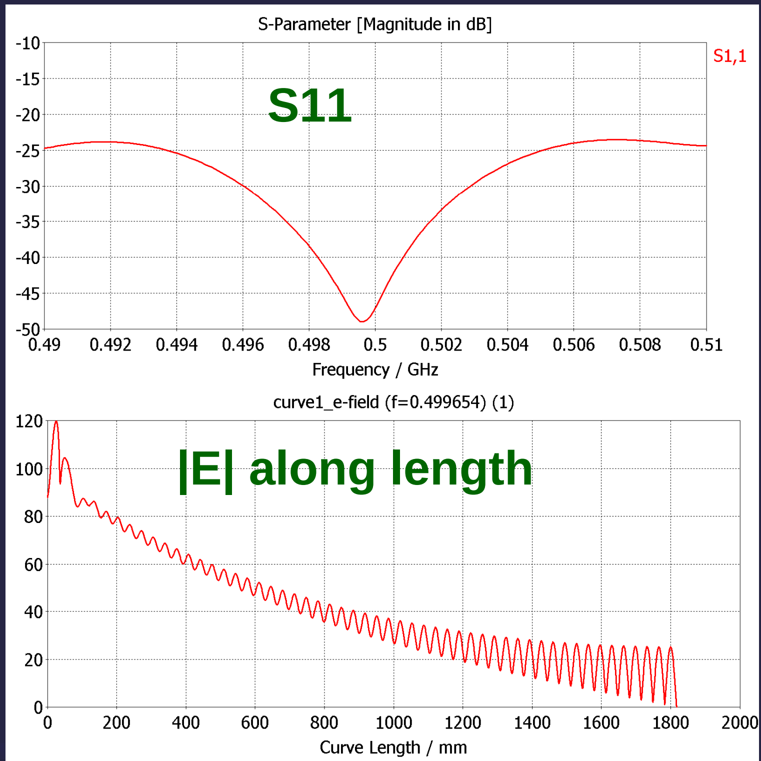
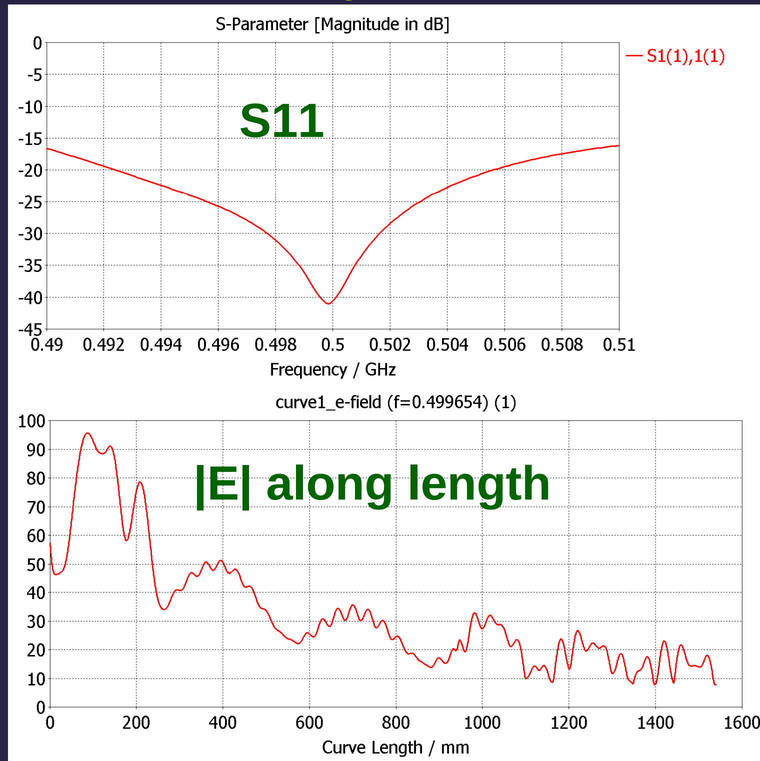
Two Designs

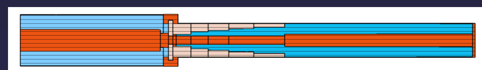
Pure TEM



Power Loss Density

TEM + E_{01}(Hybrid)





Comparative size of original glycol load

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Optimisation is ongoing

On behalf of the RF Group

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Shivaji Pande

Simon Rains

Adam Rankin

David Spink

Alun Watkins

Thank you for your attention!

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