

# Linac RF Commissioning with the SNS HPRF Systems

4<sup>th</sup> CWHAP Workshop

**May 3, 2006**

M. McCarthy, R. Fuja, P. Gurd,  
T. Hardek, Y. Kang

SNS RF Group

OAK RIDGE NATIONAL LABORATORY  
U. S. DEPARTMENT OF ENERGY

# The SNS RF Group

- **The mission of the RF Group is to ensure high power rf, precisely controlled in phase and amplitude, is provided to the linac beam in a safe, highly reliable and cost effective manner.**
- **RF Engineers - 8**
- **RF Technicians – 9**
- **Klystron based RF Systems – 92**
- **Gridded tube RF Systems – 8**
- **Total peak pulsed RF power available – 84.13 MW**

# Operators Linac RF Status Screen

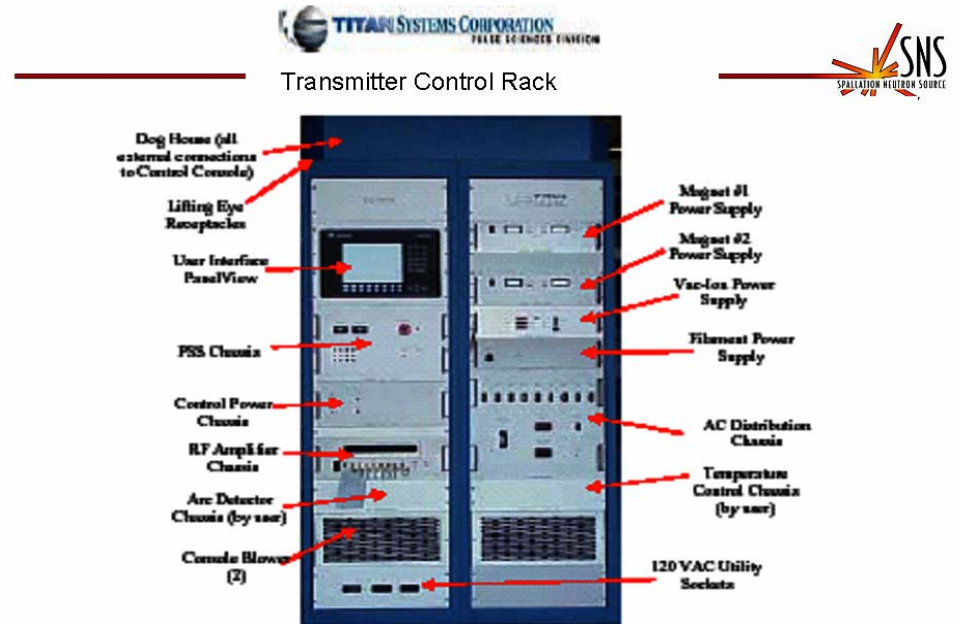
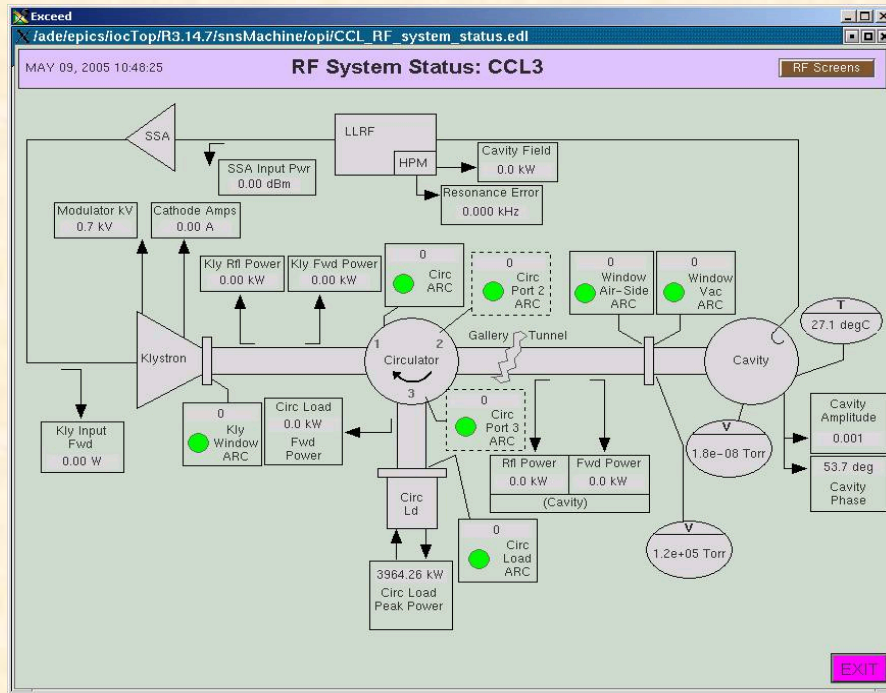
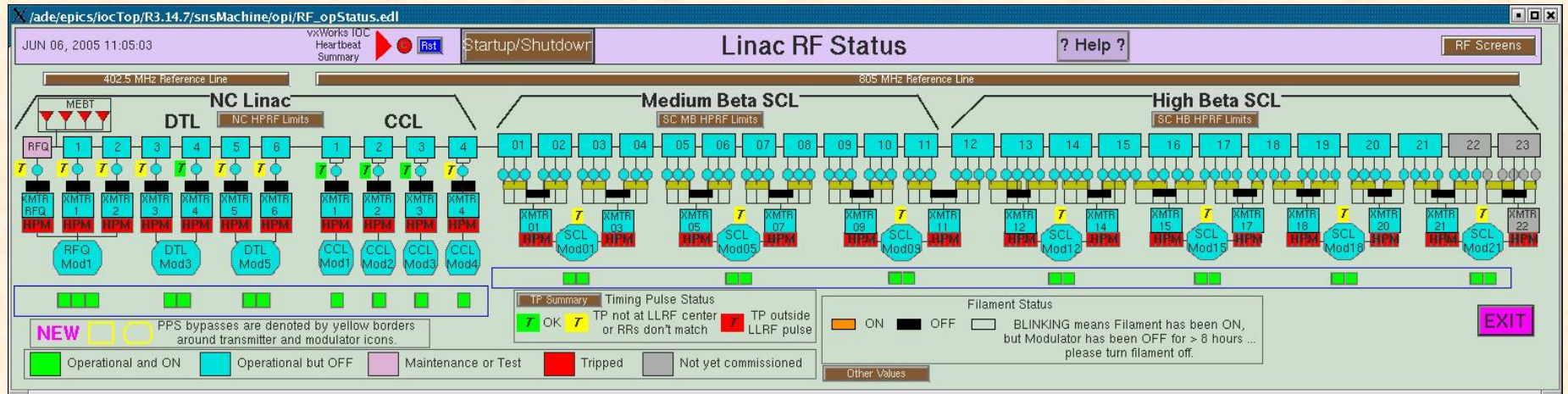


Figure 2-4. Control Console, Front.



# Waveguide Installation into Empty Gallery



Tanks and Tubes Readied at  
Test Facility



# 550 kW Klystrons Transported to Gallery

CPI

THALES





# Weather Not Always Cooperative



# HARDEK'S HELPING HANDS





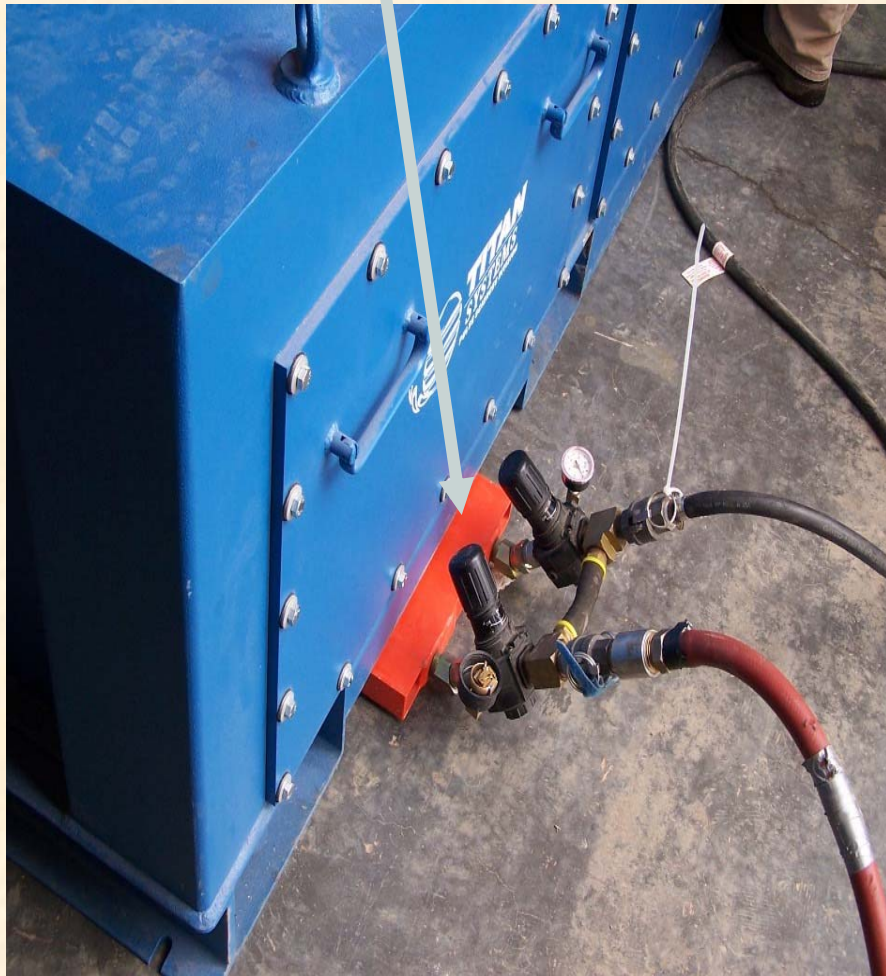
# Source of Low Power Output Discovered in TH-2177 (805 MHz, 550kW klystron)

magnet water leak filled up the magnet cylinder with water.





HV Oil Tank is Moved into Location using Air Pads



HV Tank Final Prep before Oil Filling





# Installation and Power Testing Complete - 5-5-05



## Component

## Problem

## Solution

2.5 MW Klystron  
(DTL1)

Water leak into HV oil tank

Replace section of body water circuit  
in-situ

2.5 MW Klystron  
(DTL1 - DTL6)

Arcing at klystron output coax when  
 $P_{out} > 350$  kW

Factory design error. Installed  
spacer disk to equalize length of  
inner and outer coax  
conductors.

2.5 MW Klystron  
(DTL3)

Burned through input cavity when HV  
was inadvertently applied with no  
magnet power.

Plated input cavity externally to seal  
leak. Reprogrammed PLC to  
apply mag power with filament  
power.

DTL5 Circulator

Slow accumulative internal water leak

Replaced circulator (factory  
warranty), installed water drains  
in connecting waveguides.

5 MW CCL klystrons

Arcing at output.

Added SF6 to output and circulator.  
Air-cooled waveguide.

5MW waveguide

Arcing in waveguide

Removed waveguide runs, cleaned  
flanges of all silicone,  
reinstalled.

5 MW Loads

Arcing at window

Replaced seals with different  
material.

SCL 550kW klystron

One internal body water leak, one  
internal magnet water leak.

Returned to the factory for repair.

SCRF Xmtr 9  
Circulator

External water leak.

Replaced with spare. Repaired on  
site with brazed part.

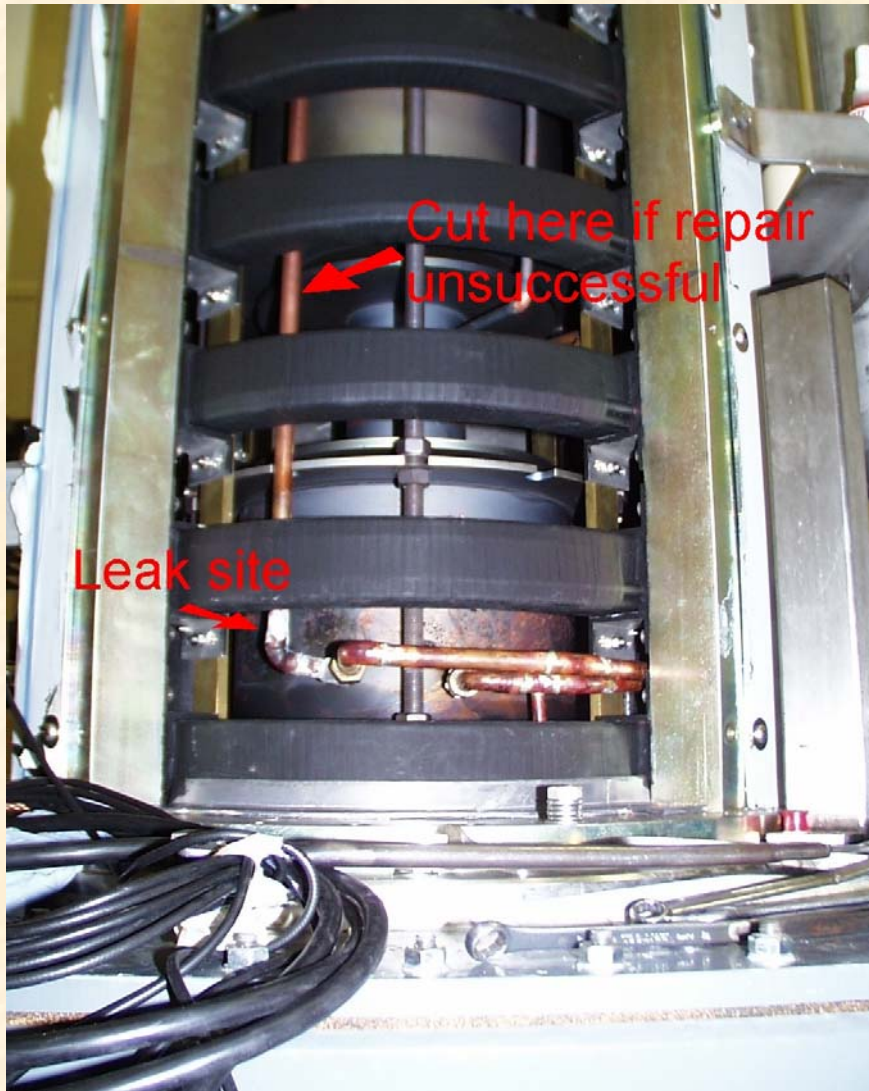


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## Klystron Internal Water Leak (into HV Tank)



Early production units had QA problem with water fittings.

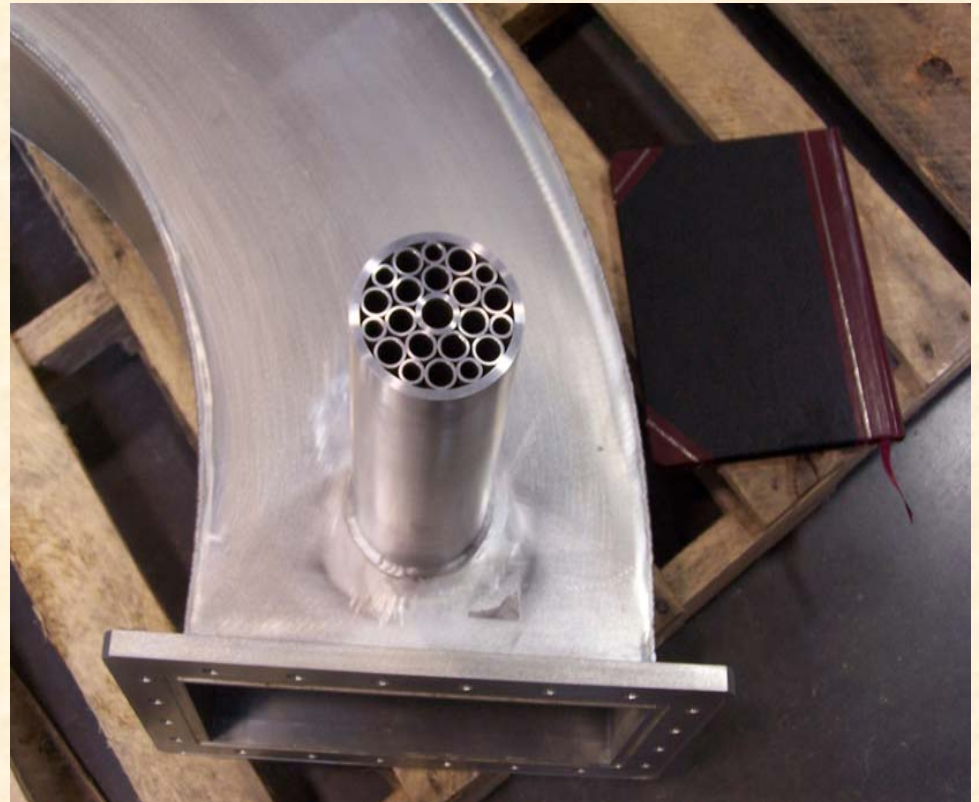
High temperature brazing is potentially damaging to solenoid coils.





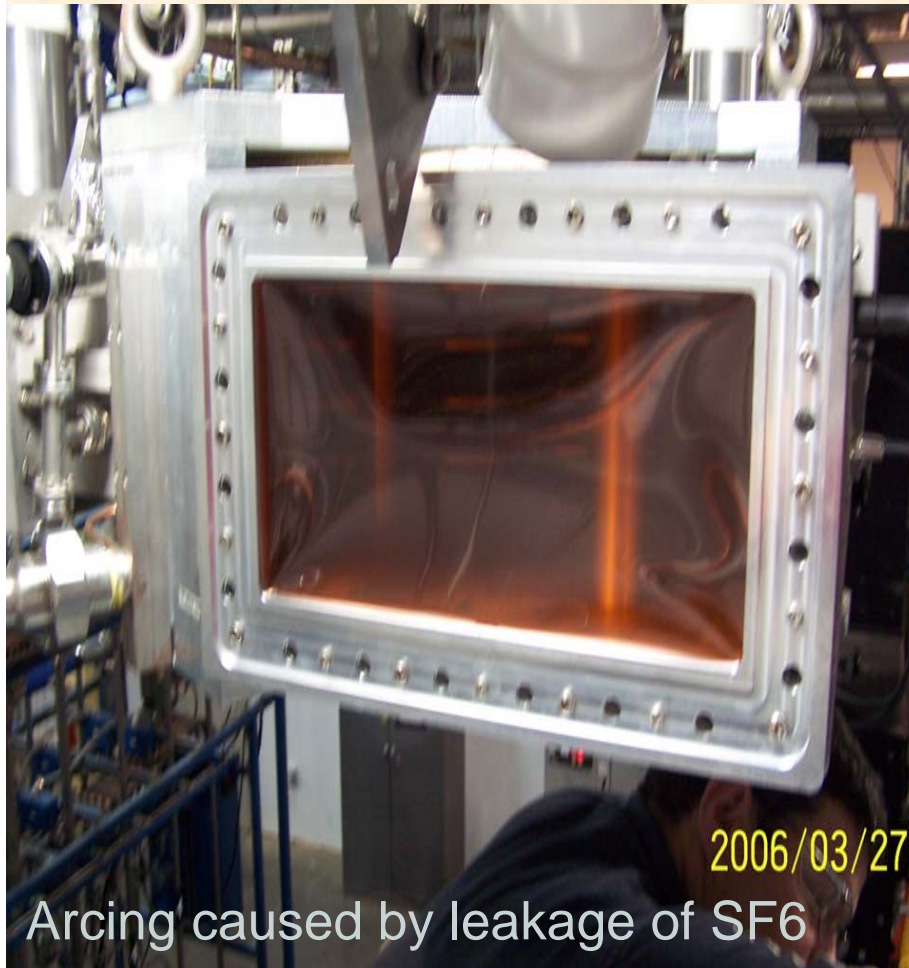
# Modification to Air Cool CCLWaveguides

5 MW klystron will heat the waveguide and increase the chance of arcing. The un-used blower from the 2.5 MW tubes was put to use here.





# 5 MW Circulator Window: Before / After

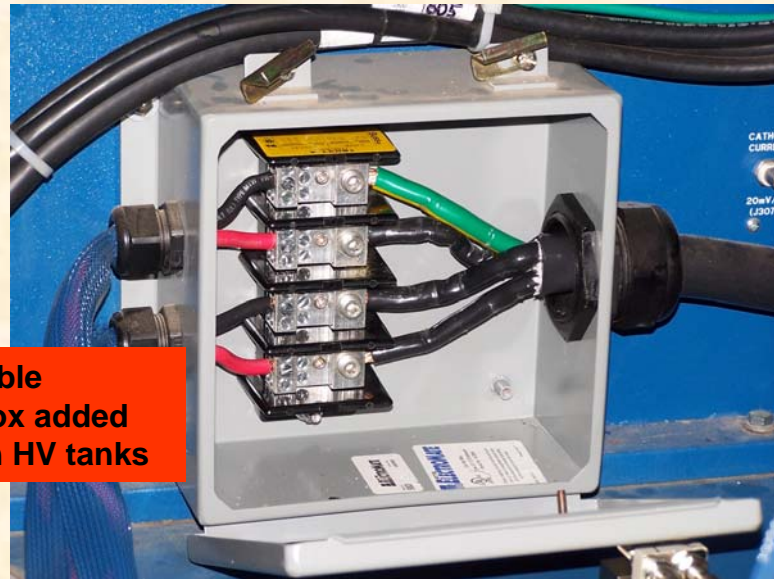




- 5MW water load
- Seal replacement to prevent arcing



- Magnet Cable junction box added to Klystron HV tanks









08/31/2004

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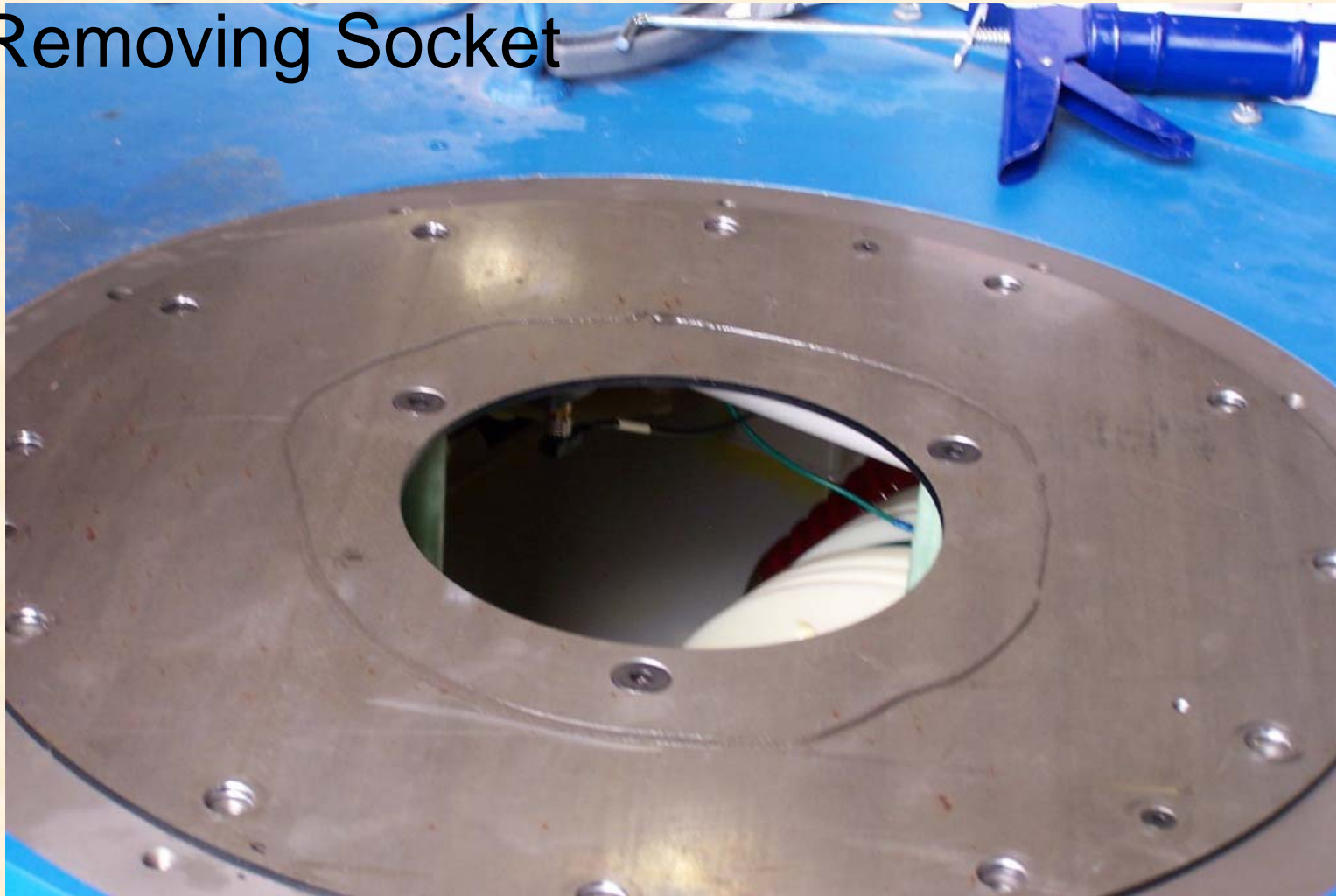




## Congestion Between Tunnel Wall and Cryomodule

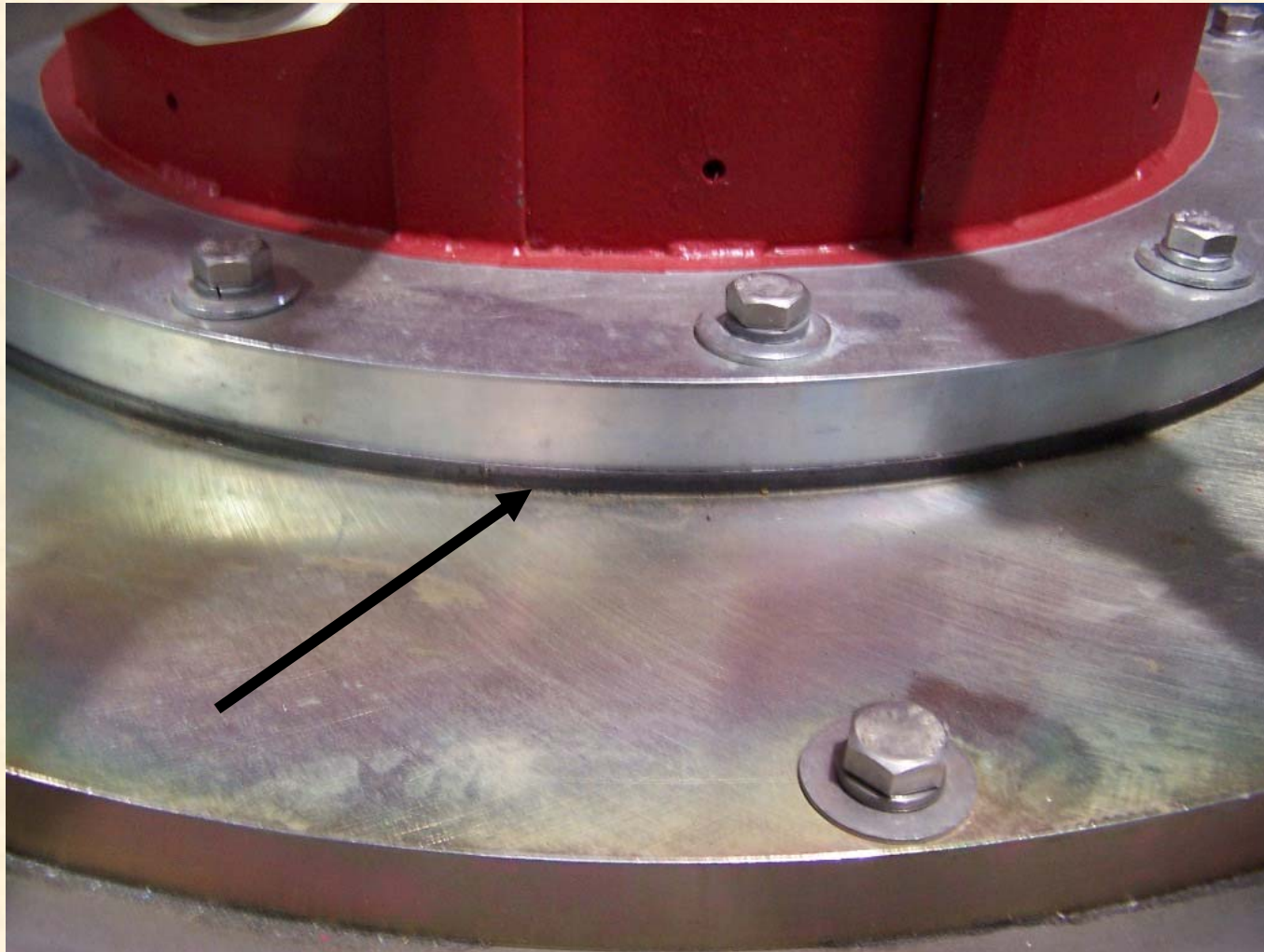


# Plate Added to Klystron Base to Allow Separation of Tube From Tank Without Removing Socket





# Socket Holding Plate Under 550 kW Tube

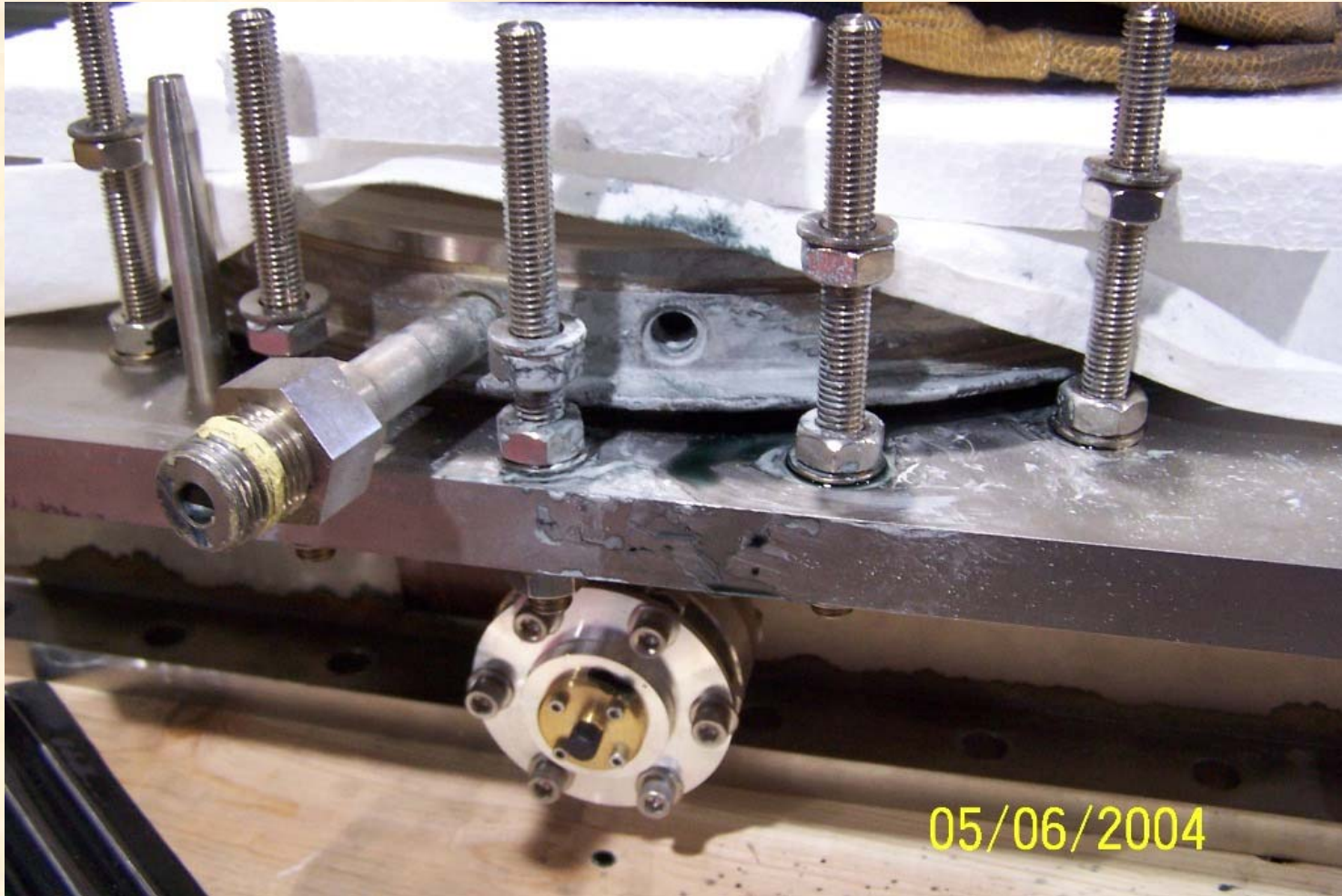


# 402 MHz DTL Window With Low Water Flow





# Water Passage Connections



## Some Debris Found in the Water Passage





# Source of Low Power Output Discovered in TH-2177 (805 MHz, 550kW klystron)

magnet water leak filled up the magnet cylinder with water.





# Leaky Circulator - DTL5



Water leak at internal joint

Replacement coming in.





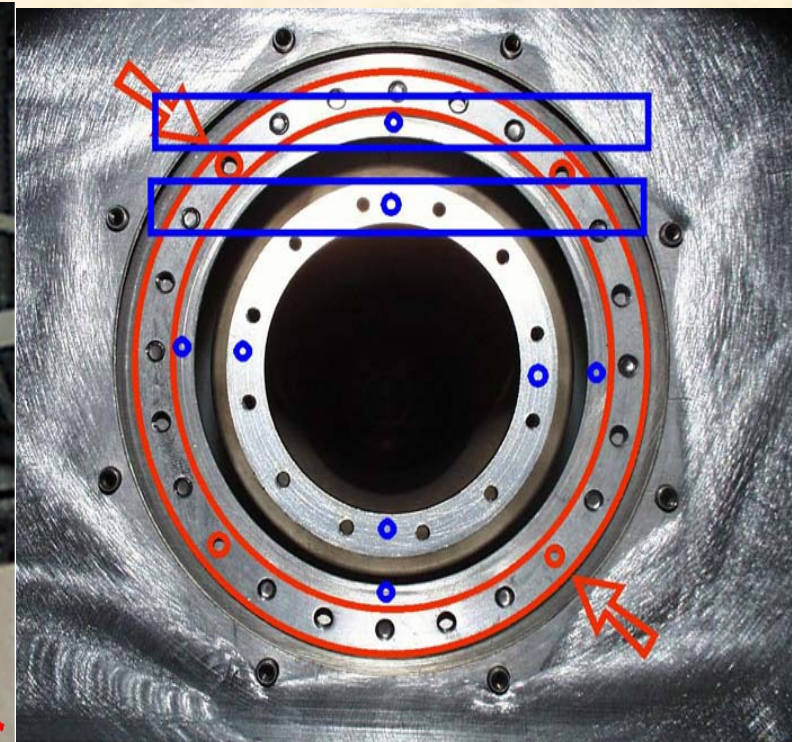
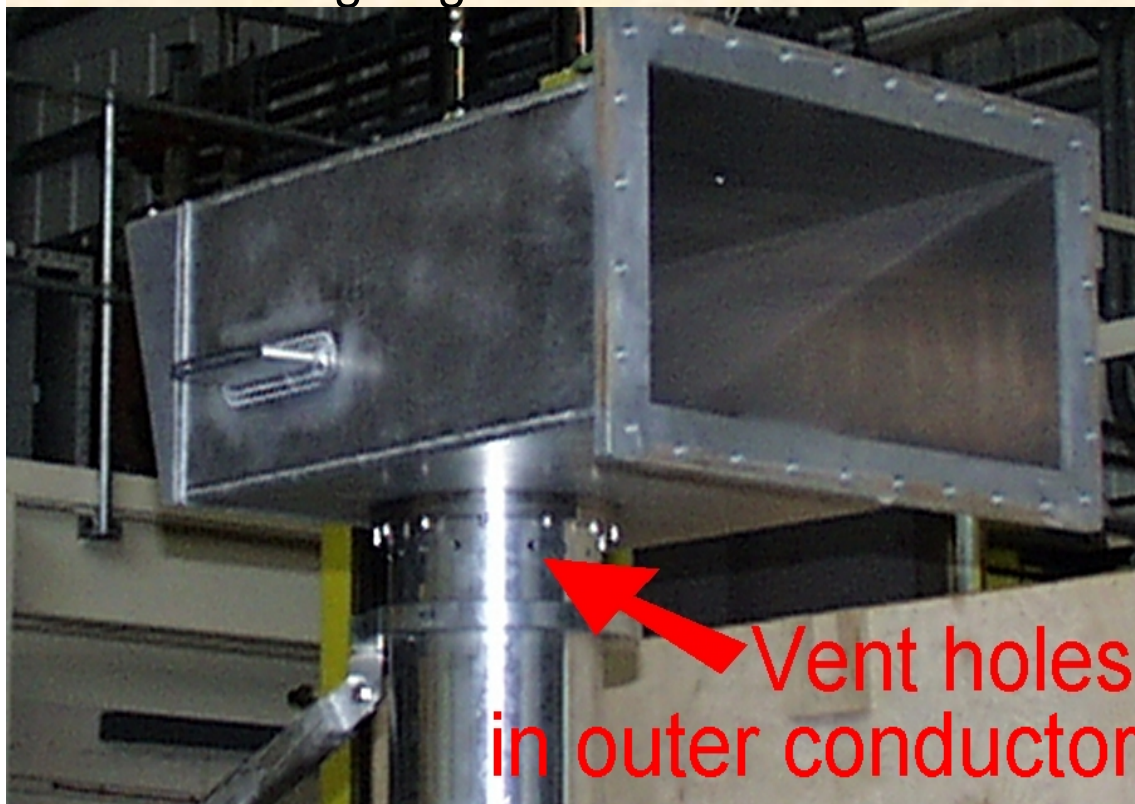
## Leaking Magnet Filled Cylinder Up to Here



# Broken 2.5 MW Klystron Output Coax-to-WG Connection

Symptoms: Arcing seen in air vents at coax to waveguide interface when power exceeded 350 kW peak.

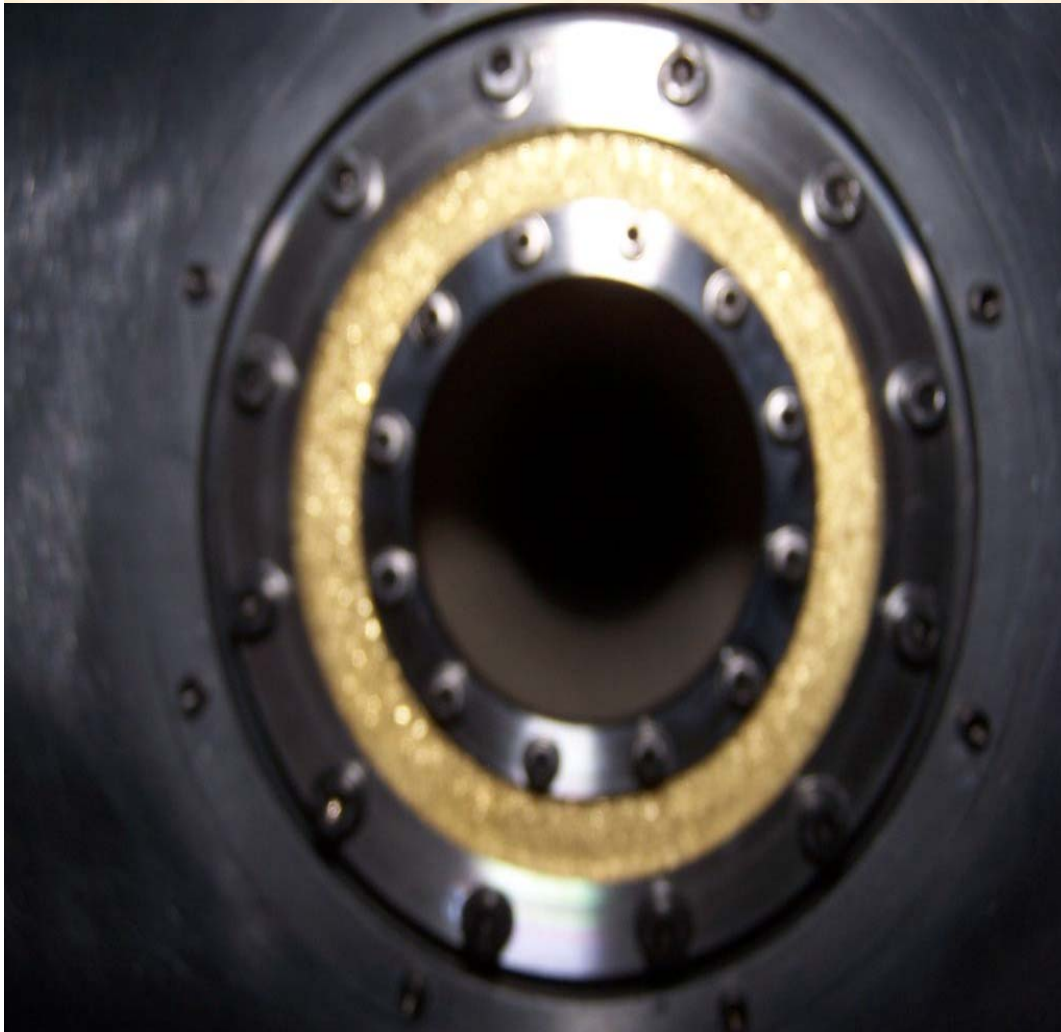
Problem: Inner and outer coax unequal in length causing stress on connecting ring.





2.5 MW Klystron Output Coax to Waveguide Connection. Gold Ring Connects Inner to Outer Conductor.

Inner Conductor 1-2 mm longer than Outer Conductor. Resulting Stress Fracture.



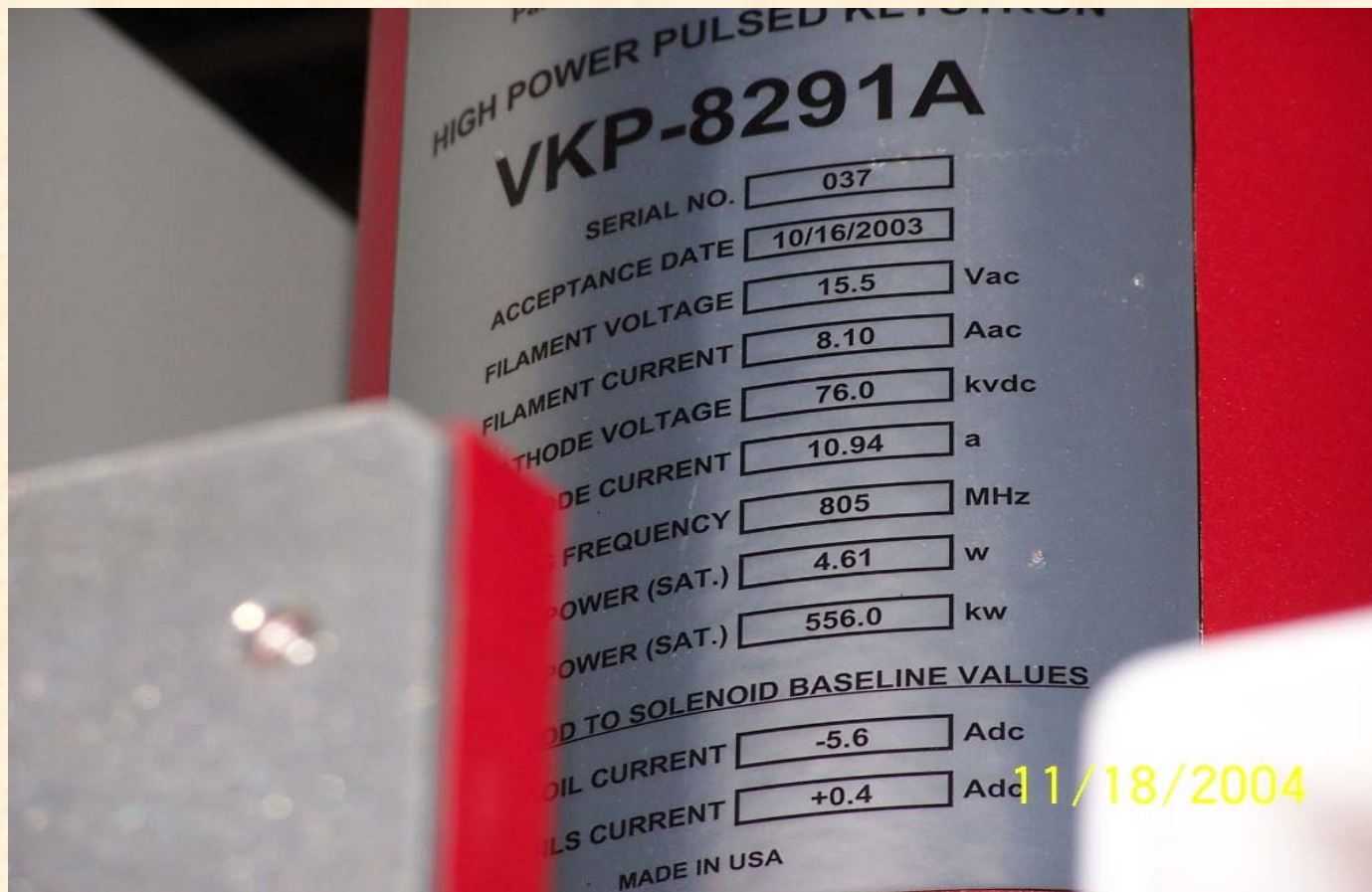
2005/10/11

# Loose Water Guide Pipe Inside 550 kW Water Load





# Klystron Operating Parameters Nicely Labeled on Name Plate.



# Technique for Pre-Bending Flexible Waveguide





# Dedicated Fill Spout Hastens Oil Fill Operations and Eliminates Static Electricity



HVCM Interlocks

Junction box facilitates quick disconnect to klystron and allows measurement of magnet current and voltage.

# Much Support Came From LANL

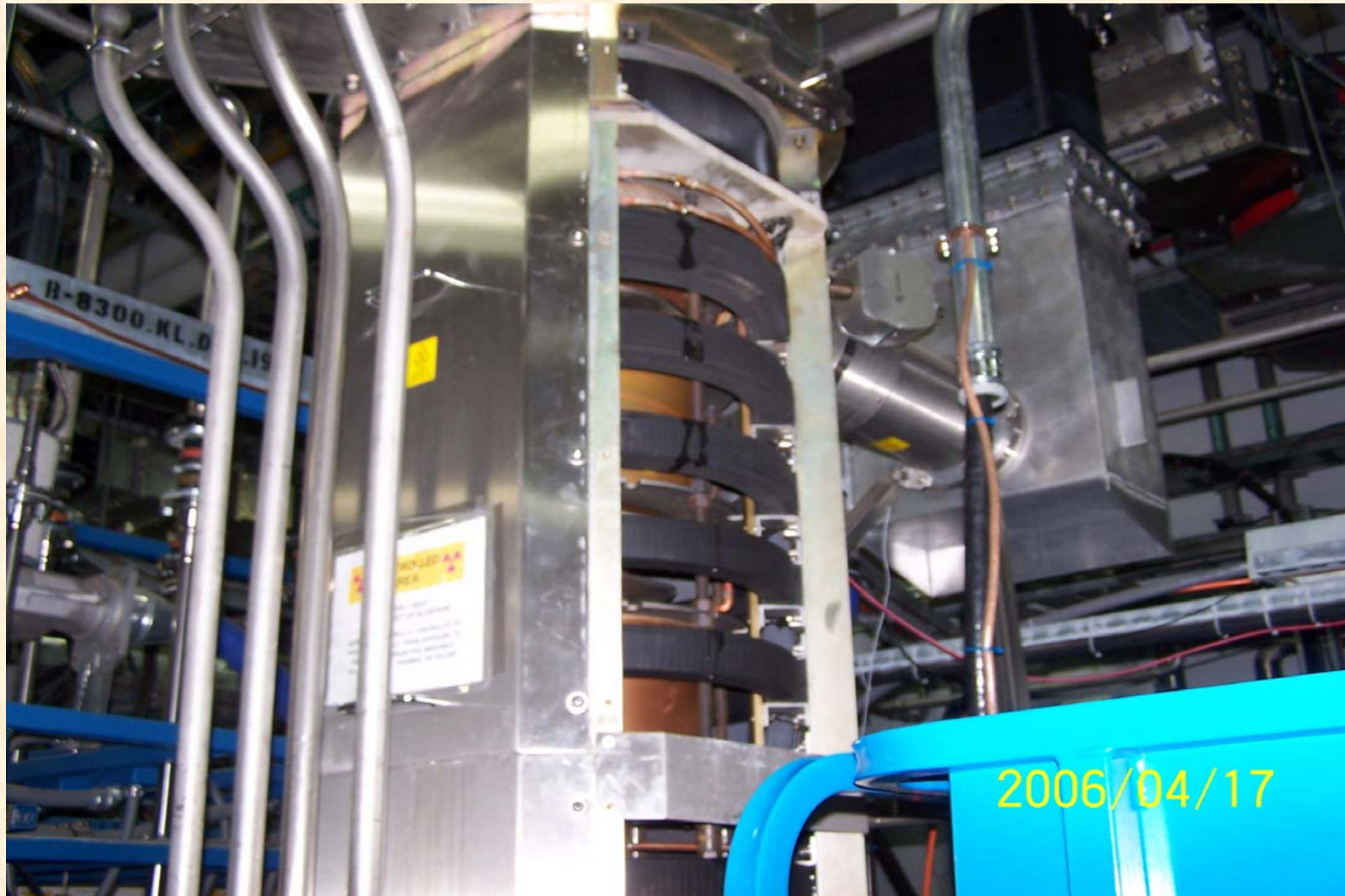




# RFQ/DTL 2.5 MW Klystrons

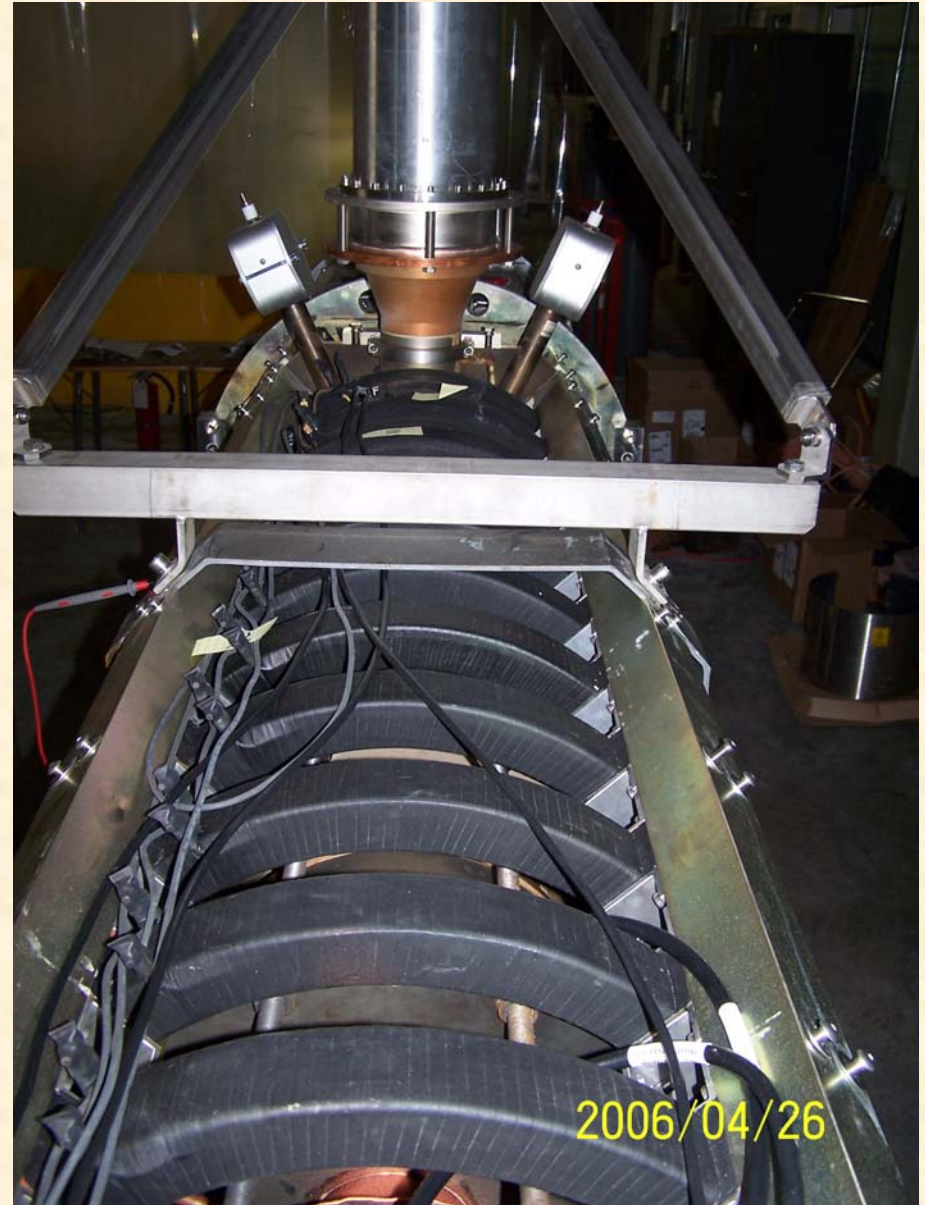


# Most Recent DTL-3 Klystron Failure





DTL-3 2.5 MW Klystron with shorted magnet cables. Cables were likely shorted by water leaking into barrel connector.



Melted Electrical Tape and Corroded Magnet Connections

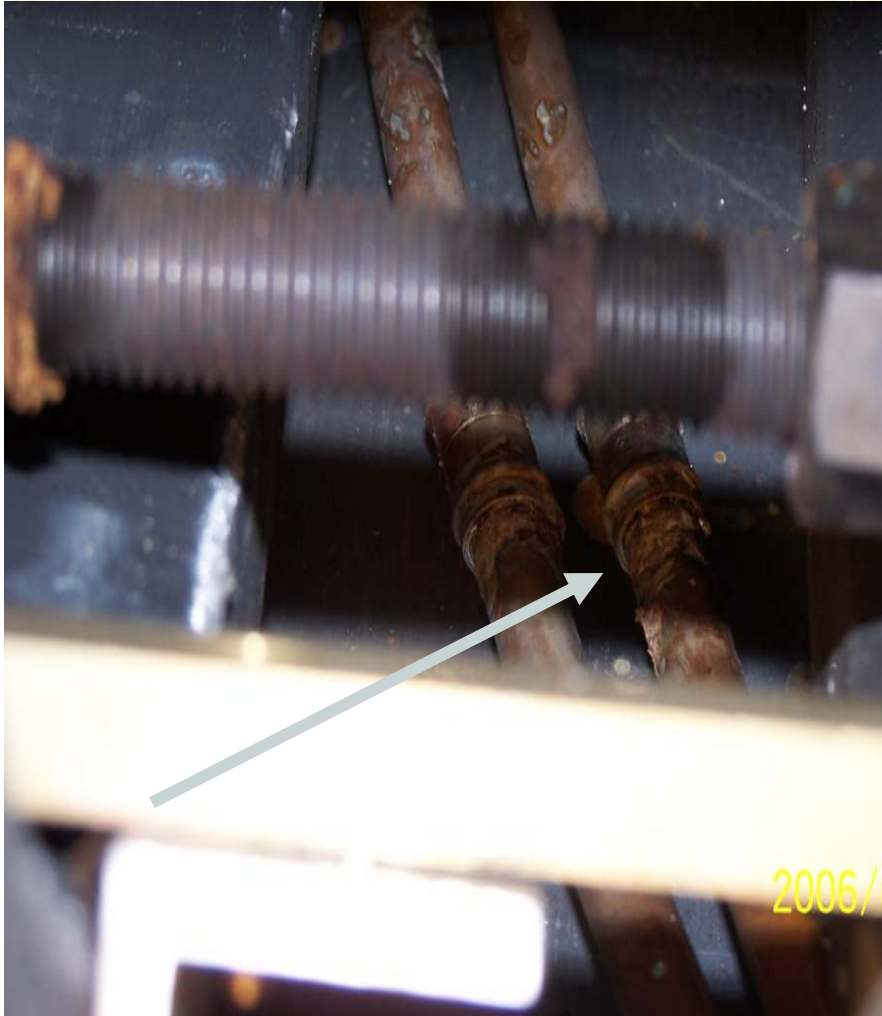


Short May Have Started By Water Leaking into This Connector

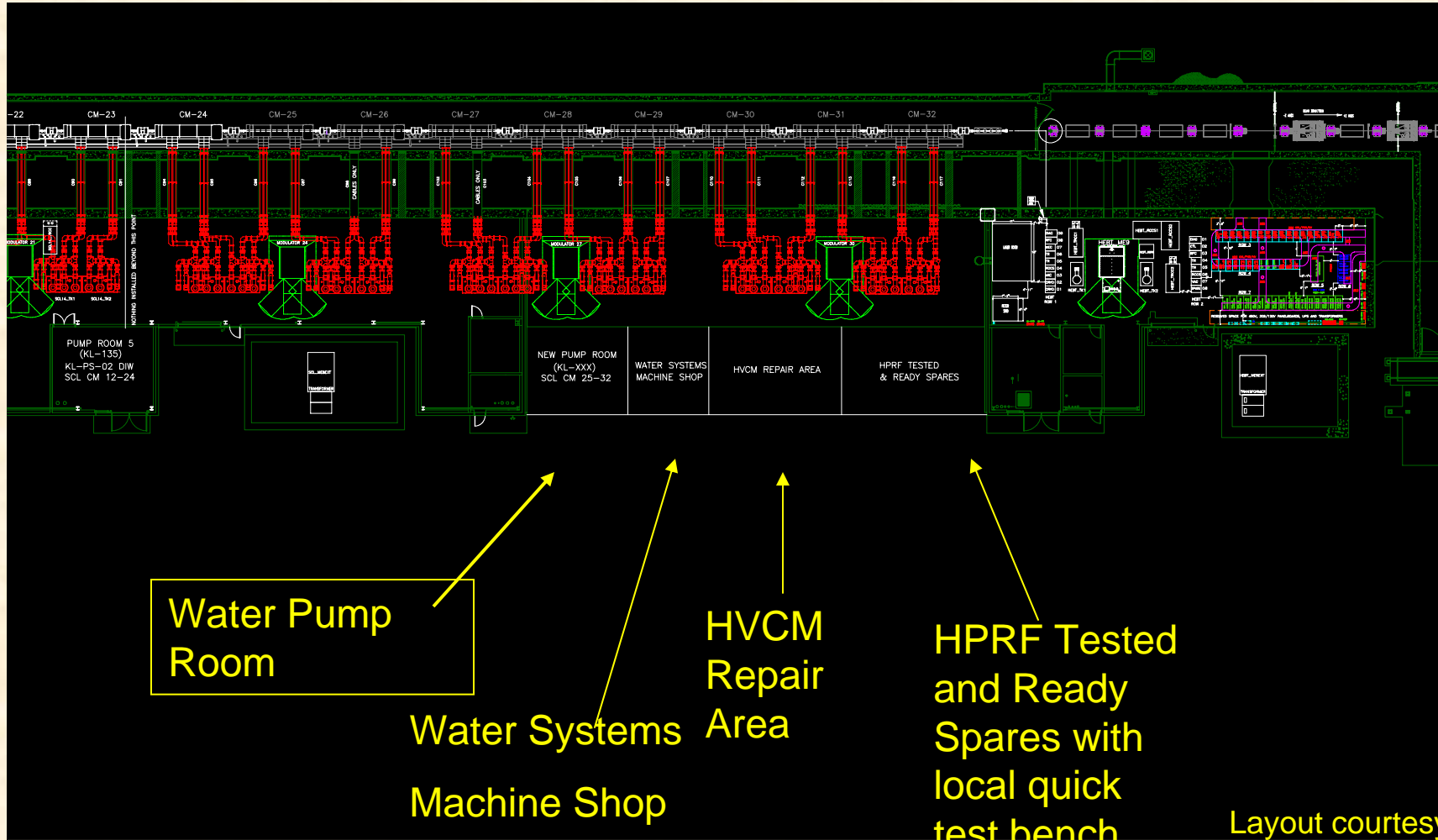




# Klystron Water/Electrical Connections



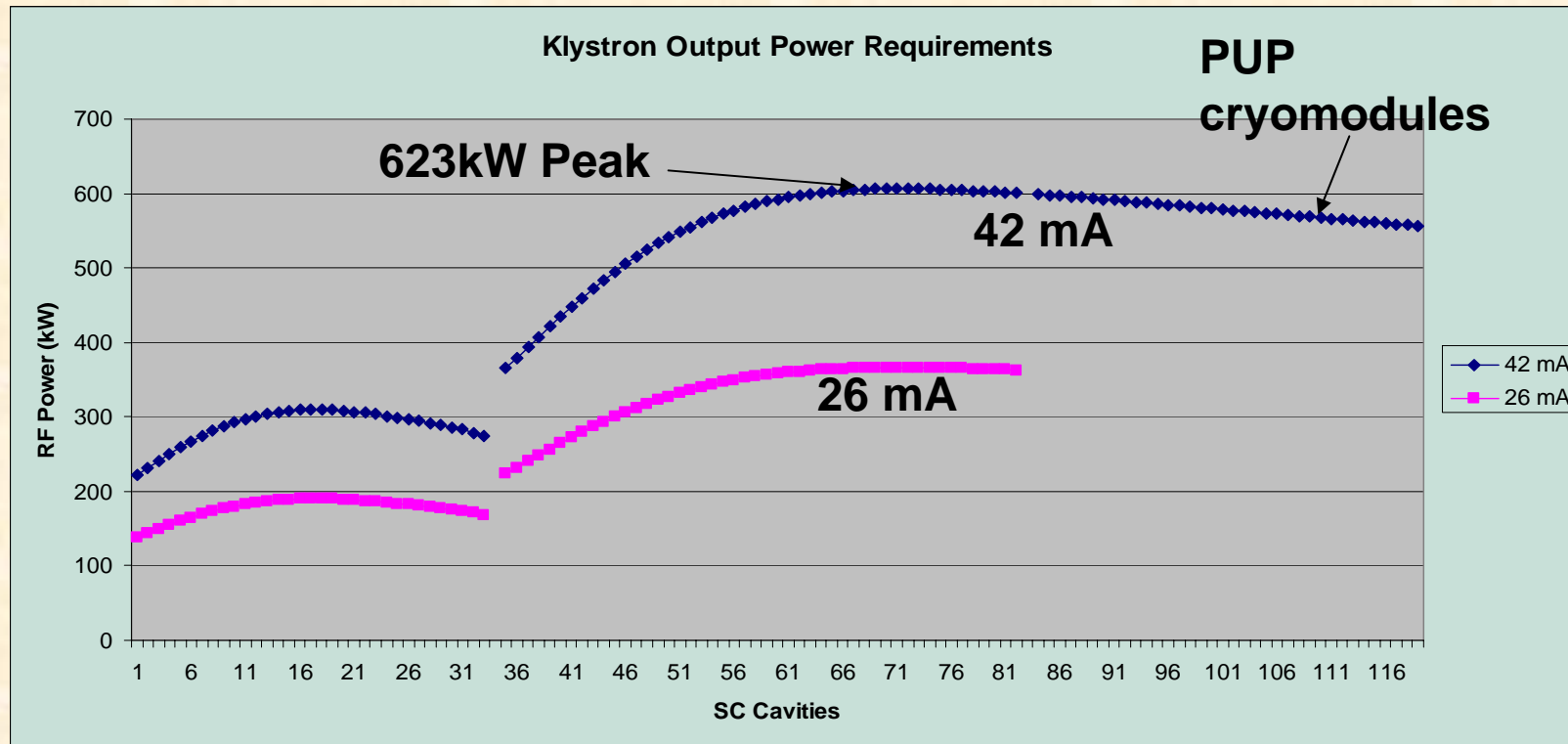
# Power Upgrade Project (PUP) Preliminary Layout – Basic Fit



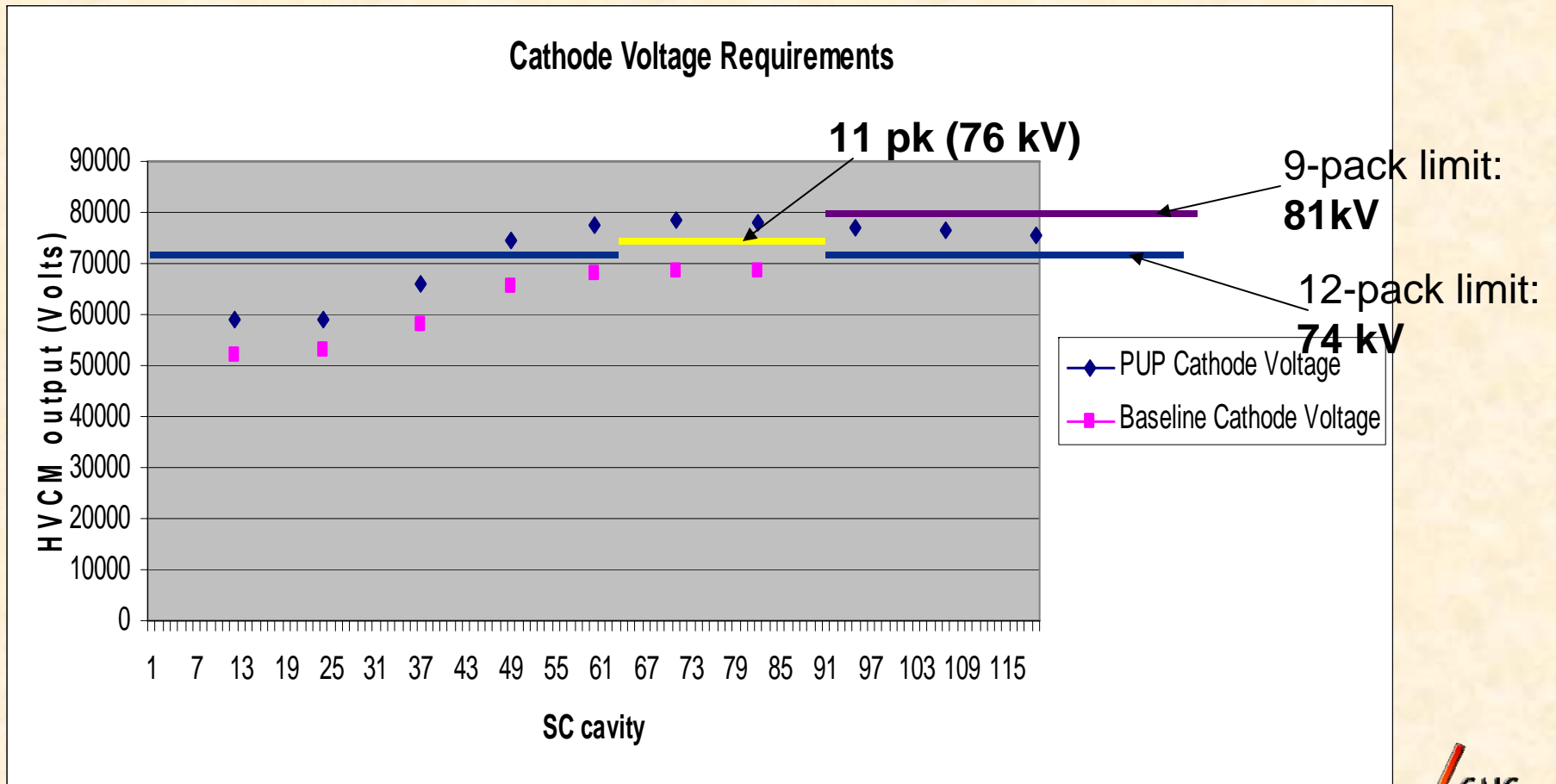
Layout courtesy of  
Marianne Champion



# SCRF Power Requirement Comparison



# SCRF Cathode Voltage Requirements shows HVCM Must be Modified to Drive 12 klystrons with more than 74 kV





# Conclusion

- **RF Equipment problems mostly mechanical (QA and water related).**
- **Beginning of Beam on Target Operations started 4-28-2006**
  - **Change over to operating regime/culture**
  - **Track failure-mode statistics**
  - **Ensure tested spares are ready and accessible**

**Planning for PUP RF Equipment layout and acquisitions starting.**