

RF POWER SOURCES

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Outline



- **Summary of rf Systems**
- **Progress/accomplishments in past two years.**
- **Plan for next two to three years**
- **The plan for ARRA funds**
- **Collaboration with other national labs and universities**
- **Technical Milestones**
- **Conclusion**

RF Sources Present & Future



- **NML**
 - 5 MWatt rf system for rf gun – Under construction
 - 300KWatt rf system for Capture Cavity I (CCI) – Presently in operation at A0 Photo Injector.
 - 300 KWatt rf system for Capture Cavity II (CCII) - Installed
 - 5 MWatt rf system for Cryomodule # 1 test – Can be upgraded to a 10MW klystron.
 - **10 MWatt rf system (from SLAC in 2010) for Cryomodule string test – for 3 cryomodules.**
 - **80 KWatt 3.9 GHz System**
- **Meson**
 - 300 KWatt rf system for HTS 1 – operational system
 - 80 KWatt 3.9 GHz rf system for HTS 1 – operational system
- **A0**
 - 300 KW rf system for Photo Injector's operational system CCI
 - 5MWatt rf system for Photo Injector's operational system Gun

RF Sources Present & Future



- **New Cryo-building at NML (Future)**
 - **5 MWatt rf system for cryomodule test stand**
 - **3 or 5 MWatt rf system for HTS 2 (2 cavity test stand)**
 - **10 Mwatt MBK test stand (ARRA funds for klystron)**
 - **300 Kwatt rf system for HTS 1 (moved from Meson)**

A0 Photo Injector

5MW 1.3GHz Klystron-Gun
300KW Klystron-CCI
80KW 3.9GHz Klystron

Meson

2.5MW 325 MHz Klystron
300KW 1.3GHz Klystron-HTS
80KW 3.9GHz Klystron-HTS

NML

5MW 1.3GHz Klystron-CM#1
300KW 1.3GHz Klystron-CC2
300KW 1.3GHz Klystron-CC1
80KW 3.9GHz Klystron
10MW 1.3GHz MBK-CM1,2,3
5MW 1.3GHz Klystron-Gun

New Cryo Building @ NML

5MW 1.3GHz Klystron-CM Test
3MW 1.3GHz Klystron-HTS2
300KW 1.3GHz Klystron-HTS1
10MW 1.3GHz MBK

Blue – RF Systems installed and operational

Magenta – RF system installed – Commissioning into dummy load – for CC2

Green – RF system installation nearing completion – for Cryomodule #1

RCyan – RF System under construction

Red – Future

1.3GHz Klystron Tube Count



- **3 – 300 KWatt klystrons (YK1240) in operation today and for the future.**
 - Only 4 tubes available; 2 rebuilds (A0 CCI & Meson HTS), 1 rebuild in progress, and one used (weak) tube (NML CCII).
 - These tubes can only be rebuilt a limited number of times
 - Need to consider future needs for additional power sources in the 300 to 650 KWatt range.
- **2 – 5 MWatt klystrons will be required**
 - RF Gun @ NML
 - Cryo module test stand in new cryo building
- **2 – 3 to 5 MWatt klystrons will be required**
 - HTS 2
 - RF system for Cryomodule # 1 test
- **2 – 10 MWatt MBK**
 - NML String test and operations (from SLAC)
 - 10 MWatt Development system at new cryo building (ARRA funds)

Accomplishments



- **300KWatt rf system for HTS 1**
 - Complete operational system for Horizontal testing of 1.3 GHz cavities at Meson Detector Building.
- **3.9GHz 80 KWatt rf system for HTS 1**
 - Complete operational system for Horizontal testing of 3.9 GHz cavities and coupler conditioning.
- **1.3 GHz and 3.9 GHz operational systems at A0**
 - 5 MWatt 1.3 GHz – RF Gun
 - 300 KWatt 1.3 GHz – CCI (Capture Cavity I)
 - 80 KWatt 3.9 GHz – Coupler conditioning and 80K cavity operation.

Accomplishments



- **300KWatt rf system for Capture Cavity 2 (CCII) NML**
 - **All high power rf equipment installed at NML and tested into dummy load**
 - Includes Charging supply, Capacitor bank, Modulator, Klystron, Waveguide, Circulator, Directional couplers, signal cabling, and dummy load.
 - 100% of WR650 waveguide installed to CCII.
 - Fast rf protection system installed and tested with klystron running into dummy load.
 - **Low level rf system**
 - All components fabricated and bench tested
 - Presently installing modules and signal cabling.
 - **Start warm coupler conditioning of CCII by May 2009**

Capture Cavity II @ NML

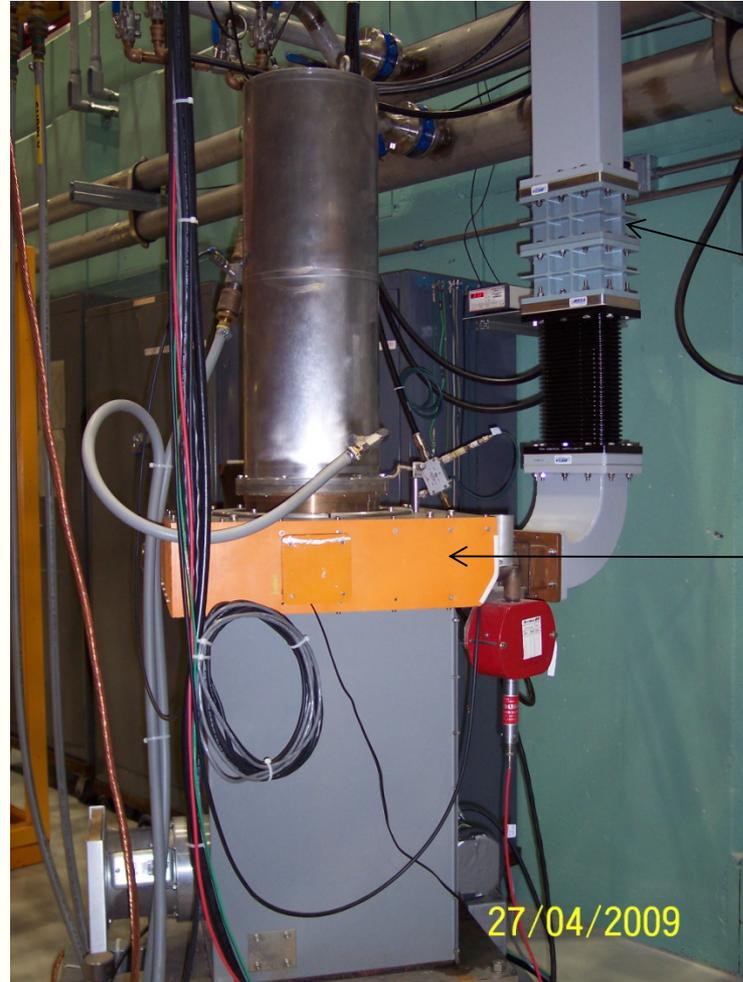
WR650 WG

Bellows

Dual
Directional
Coupler



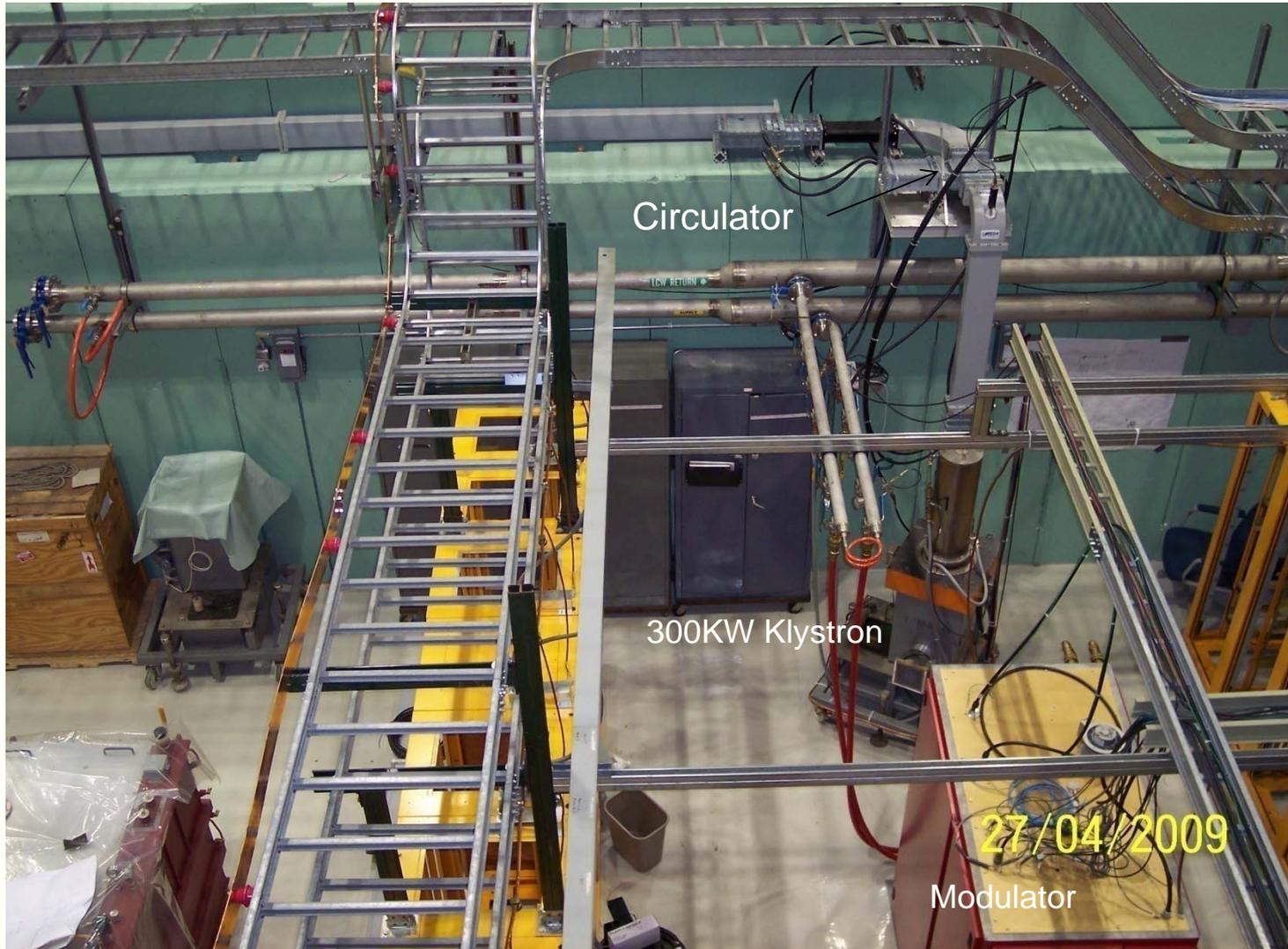
300KWatt Klystron @ NML



Dual
Directional
Coupler

Valvo-Philips
YK1240
Klystron with
Solenoid

300KW RF System - NML



Accomplishments



Fermilab

- **5 MWatt rf system for cryo-module #1 test**
 - **All high power rf equipment installed at NML**
 - Includes Charging supply, Bouncer modulator, HV Pulse transformer, Klystron, Waveguide, Isolator, Directional couplers, High power waveguide switch and dummy load.
 - Waveguide guide distribution system (from SLAC) for cryo-module #1 is ready to be installed. Waiting on cryo-module to be installed in cave.
 - LCW is 50% connected to high power equipment
 - AC power is 100% connected to equipment
 - **Low level rf system**
 - All components fabricated and bench tested
 - Presently getting ready to install modules and signal cabling.
 - **Start warm coupler conditioning – July 2009**

5 MWatt Klystron



Thales TH2104
Klystron

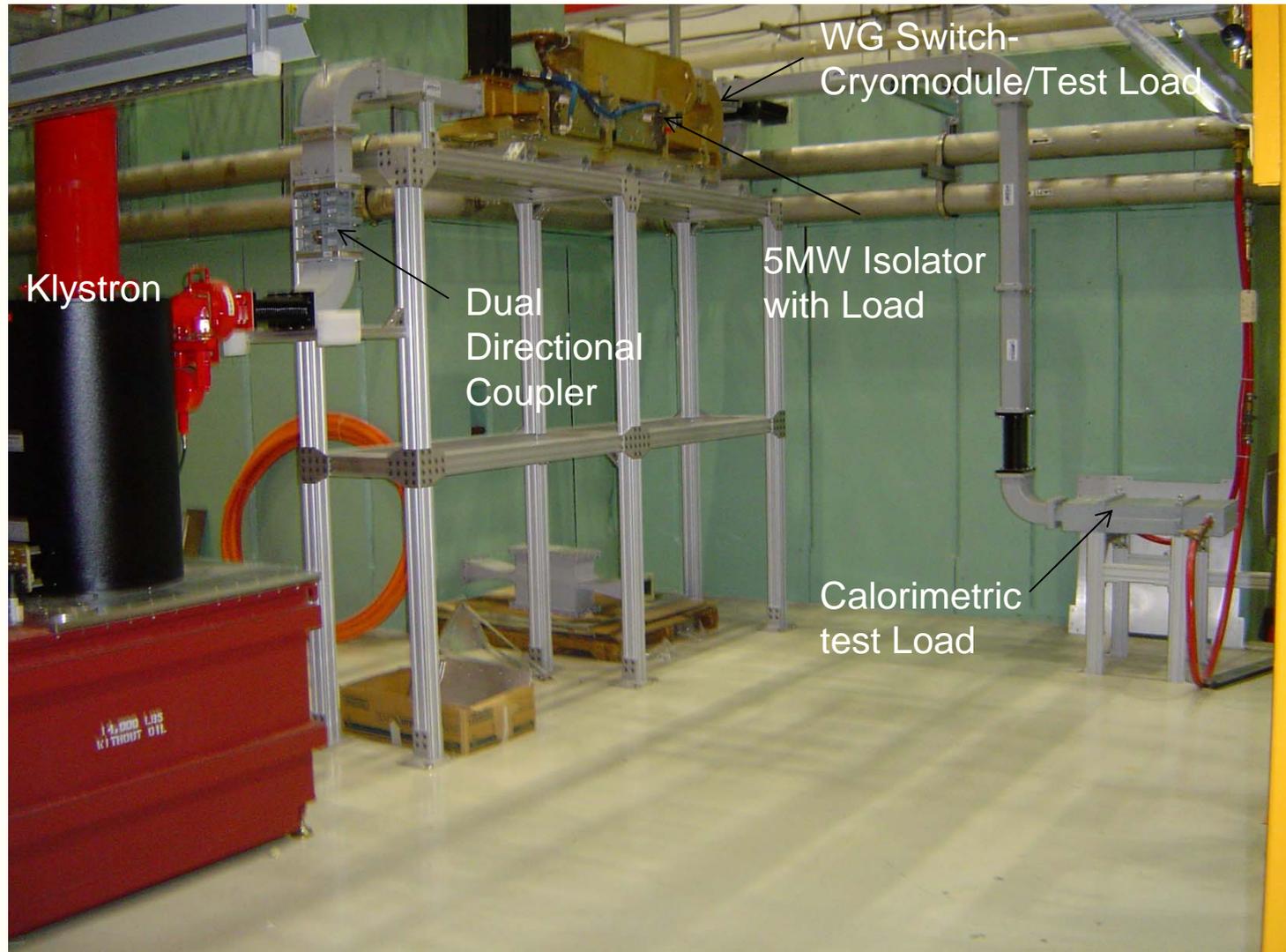
Solenoid

HV Pulse
Transformer

5MW Klystron Modulator & PS



5MW RF System



ARRA Funds



- **10 Mwatt Klystron**
 - Purchase one 1.3 GHz, 10MWatt MBK klystron
- **Fabricate two (2) Bouncer Modulators & Charging supplies**
 - One for 10 MW MBK above
 - One for 3 to 5 MW HTS-2
- **Purchase two (2) HV Pulse transformers**
 - One for 10 MW MBK above
 - One for HTS-2

- **SLAC**

- Fermilab will continue our collaboration with SLAC on the waveguide distribution systems for cryomodules 2 and 3.
- SLAC has delivered waveguide distribution for cryomodule 1.
- SLAC will deliver completed waveguide distributions systems for cryomodules 2 and 3.
- Schedules to deliver 10 MWatt rf system components
 - Toshiba Vertical 10 MWatt klystron
 - Marx Modulator

- **KEK**

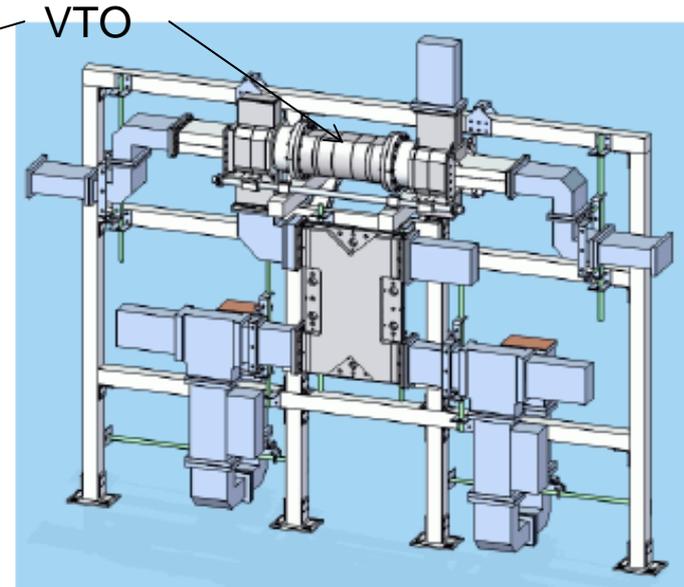
- 1.3GHz RF Gun with coupler

Technical Milestones

- **May 09** Start warm coupler conditioning of CCII @NML.
- **June 09** Cold testing of CCII with high power rf.
- **July 09** Commissioning of 3 MWatt rf power unit for cryomodule #1 (into dummy load) @ NML.
- **July 09** Warm coupler conditioning of cryomodule #1.
- **Fall 09** Cold testing of cryomodule #1 with high power rf.
- **2010** 5 MW rf system commissioning for rf gun @ NML

SLAC WG Distribution

RF PDS Unit



One of 4 two cavity units for Cryomodule #1's RF power distribution. SLAC has delivered all 4 two cavity units to Fermilab.

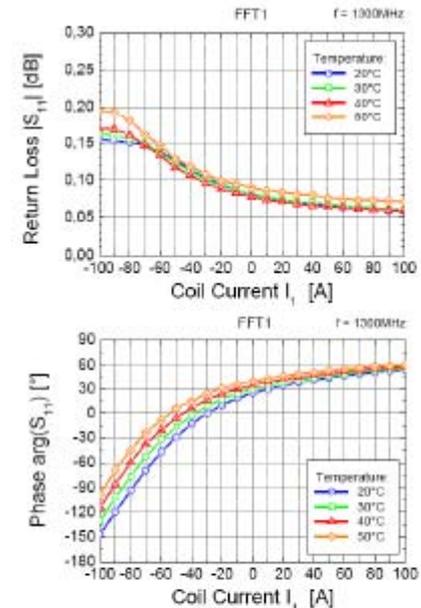
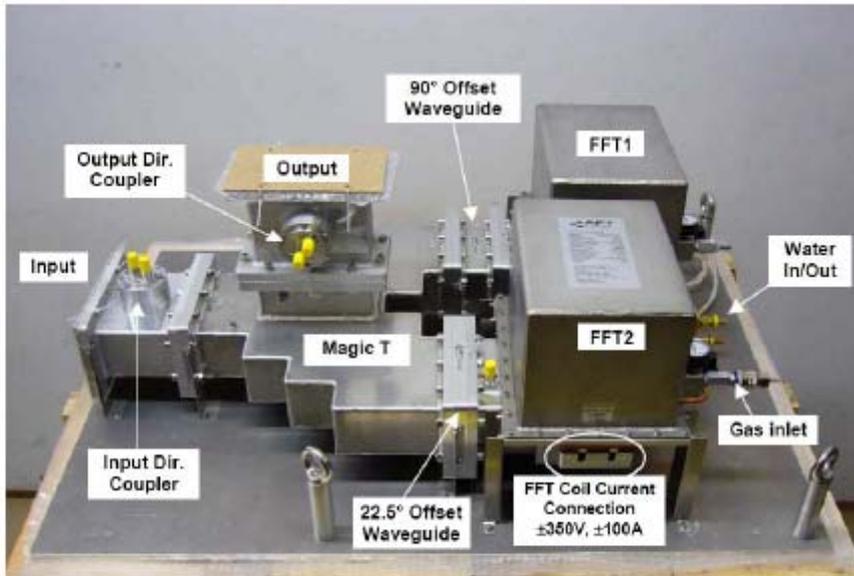
When installed, the front wall of the 80/20® frame will be removed, and the U-bends reversed to go under the remaining wall.

Plan for next 2-3 yrs

- **Finish NML rf systems**
 - 300KW for CCII – Presently operational into dummy load.
 - 3MW system for Cryomodule #1 test
 - 5MW system for RF Gun
- **Order components for rf test stands in new building**
- **RD&D Plan**
 - WR650 Waveguide Vector Modulator development & testing.
- **How do ARRA funds help?**
 - Allows Fermi to procurement of a 10 MWatt klystron, Modulator, Charging supply for Project X and ILC development.
- **Explain why this infrastructure or R&D is needed, relevance to Project X and/or ILC**
 - NML is the test facility for cavity, rf systems, and electron beam.
 - New cryo building allows accelerated cavity, cryo module, and rf station development for ILC or Project X.

Prototype Vector Modulator

Fast Amplitude and Phase Control



Rated for 550 kW at 1.3 GHz and has a 30 μs response time

Plan for next 2-3 yrs

- **What components will be built?**
 - 4 Modulators & Charging supplies for RF Gun, HTS-2 , Cryomodule test stand & MBK
 - Waveguide & WG components for Cryomodules #2 & #3, HTS-2, Cryomodule test stand & 10MWatt MBK
 - 3 HV Pulse transformers for HTS-2, cryomodule test stand & MBK
- **Collaborations in place and planned? Yes**
 - **SLAC & KEK**
- **Industrialization**
 - Most of our major components are purchased from commercial vendors.
 - Klystrons
 - Waveguide and waveguide components
 - HV Pulse Transformers
 - Modulator & power supply components

Conclusions



- **Made good progress in commissioning 300KW system for CCII at NML. RF system running into dummy load and warm coupler conditioning is imminent.**
- **3 to 5 MW rf system for cryomodule #1 test is nearing completion.**
- **5MW rf system for rf Gun is under construction. Klystron, pulse transformer, solenoid, modulator & charging supply cabinets are all in house. Ordering modulator & charging supply components is underway.**
- **Prototype high power WG Vector Modulator (VM) testing has started.**
- **ARRA funds will allow procurement of high power rf system components (10MW MBK, Bouncer modulators, Charging supplies, and HV pulse transformers).**
- **Continue our collaboration with SLAC.**