

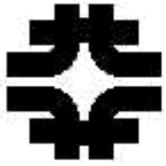
**US-LHC ACCELERATOR COLLABORATION**

*brookhaven - **fermilab** - berkeley*

## IR Quadrupole Measurements: Status and Plans

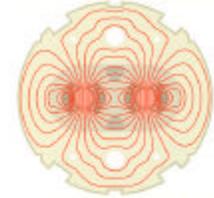
P. Schlabach

2 June, 1998



the Magnet Test Facility

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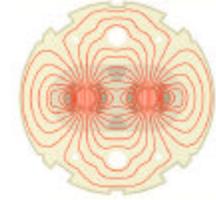
## IR Quadrupole Measurements: Status and Plans

- Scope of Work
- Schedule
- Status/R&D/Development
- Typical Short Magnet Tests



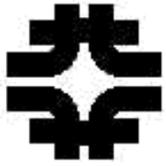
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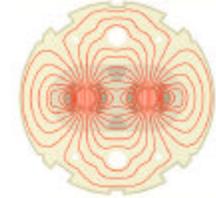
## Scope of Work

- **Magnet Tests**
  - **Fabrication measurements**
  - **Model Magnets**
  - **Prototype Quad Tests**
  - **FNAL Production Quad Tests**
  - **KEK Production Quad Tests**
- **Facilities**
  - **VMTF** (Vertical Magnet Test Facility)
  - **LHC Test Stand**
- **Measurement Equipment**
  - **Harmonics**
  - **Alignment**
  - **Other**



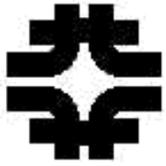
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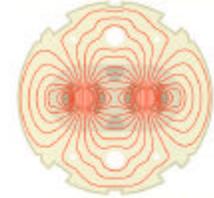
## Schedule

IR Quadrupole Project Schedule (v.1.1)																																
1.1 Interaction Regions				FY1998				FY1999				FY2000				FY2001				FY2002				FY2003				FY2004				
1.1.1		IR Quadrupoles	FNAL	Zlobin	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4																				
1.1.1.4	<i>Test</i>			Schlabach																												
1.1.1.4.1		<i>Infrastructure</i>																														
1.1.1.4.2		<i>Test R&amp;D models</i>																														
1.1.1.4.3		<i>Test Prototype</i>																														
1.1.1.4.4		<i>Test FNAL quads</i>																														
1.1.1.4.5		<i>Test KEK quads</i>																														



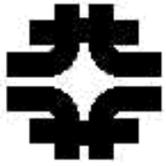
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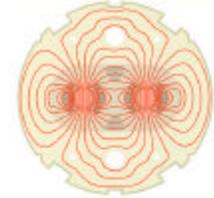
## Schedule

<u>significant dates</u>	
1st 2m model HGQ	now
long prototype test	FY2000, Q4
1st HGQ test	FY2001, Q3



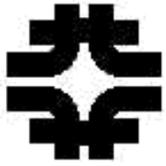
## the Magnet Test Facility

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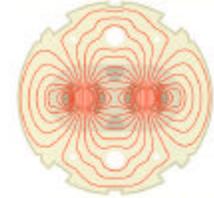
- **Magnet Tests**

- **Fabrication measurements (warm)**
  - QA, harmonics tuning
- **Model Magnets (~6)**
  - R&D tests of short model magnets
- **Prototype Quad Tests (1)**
  - R&D tests of full length cold mass in cryostat
- **FNAL Production Quad Tests (20)**
  - Minimum set of tests verify quench behavior, field quality, alignment
- **KEK Production Quad Tests (20)**
  - Cold tests on only two quadrupoles
  - Alignment needed for all



# the Magnet Test Facility

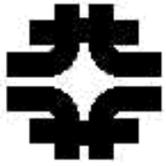
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## Facilities

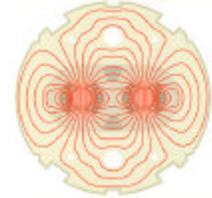
- **VMTF (Vertical Magnet Test Facility)**
  - up to ~4m cold mass
  - temperatures down to 1.9K
  - operational
- 2m HGQ model magnets to be tested in VMTF





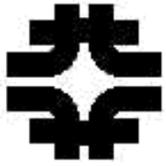
## the Magnet Test Facility

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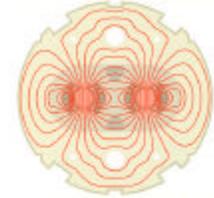
### Facilities

- LHC test stand
  - LHC-specific
  - 1.9K operation
  - cryostated Q1 and Q3 ~7m
  - Q2a,Q2b in one cryostat ~13.5m
- power supplies shared with VMTF
- some instrumentation may be “shared” with other horizontal test stands



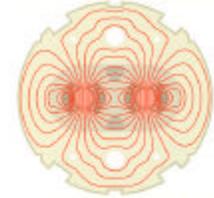
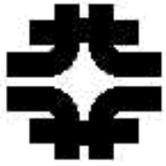
## the Magnet Test Facility

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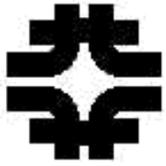
### Measurement Equipment

- Harmonics measurement
  - probes
    - tangential main coils, 2 dipole, 2 quad bucking coils
    - 1-2m long for VMTF and warm measurement systems
    - 6m probes will be used for production measurements
  - positioning and drive systems
    - similar concept for 3 measurement systems (VMTF, warm, LHC test stand)
      - angular encoder on drive gives z position relative to drive
    - probes interchangeable on drive system
    - calibration magnet on drive system to establish angle in an absolute sense
    - angular encoder gives probe azimuthal angle
    - Not yet decided: **alignment of magnet relative to drive system**



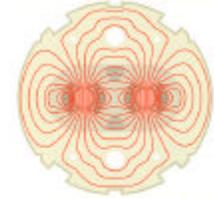
## Measurement Equipment

- Alignment
  - single stretched wire (SSW) system
  - determines the quadrupole magnetic center and angle
    - integrated with the LHC test stand
    - uses cold measurement DAQ with additions specific to the SSW
    - alignment of SSW stages to cryostat with laser system
  - based on SSW systems used for Main Injector magnets
    - significantly longer length of wire needed
    - >16m required
    - FMI SSW 4m long
  - R&D required



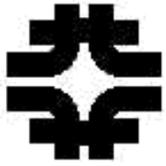
## the Magnet Test Facility

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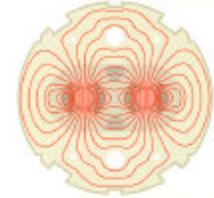
### Measurement Equipment

- Other Equipment
  - quench antenna array
    - similar to measurement probe coils
    - quench origin localization for production magnets without voltage taps



## the Magnet Test Facility

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### Measurement Equipment

#### DAQ/control

Integrate voltage from windings

1 Metrolab PDI/winding

analog + digital bucking (?)

HP 3458 for magnet current measurement

Trigger PDIs, DVM simultaneously using probe angular encoder signal

Continuous measurement (slip rings)

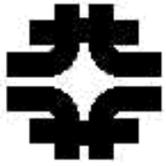
start acquiring data, then execute script to control magnet current

no synchronization required (field, current measurements synched)

SSW also uses PDI

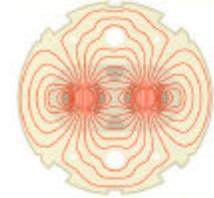
control more complicated

2 degrees of freedom at each end



## the Magnet Test Facility

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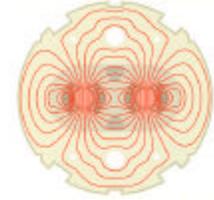
### Status

- Using Vintage SSC measurement system(s)
  - FE1 mole for warm measurement
    - probe pulled through magnet aperture
    - no angular information
  - B&W system for VMTF measurement
    - velocity feedback to stabilize rotation
    - probe driven into warm bore for measurement
    - z position control not integrated into measurement system
- winding VOLTAGE recorded
  - continuous measurement but 50% duty cycle (dead during read of HP 3458 DVM)
- similar probe geometry
  - tangential main coil, 2 dipole, 2 quad bucking coils



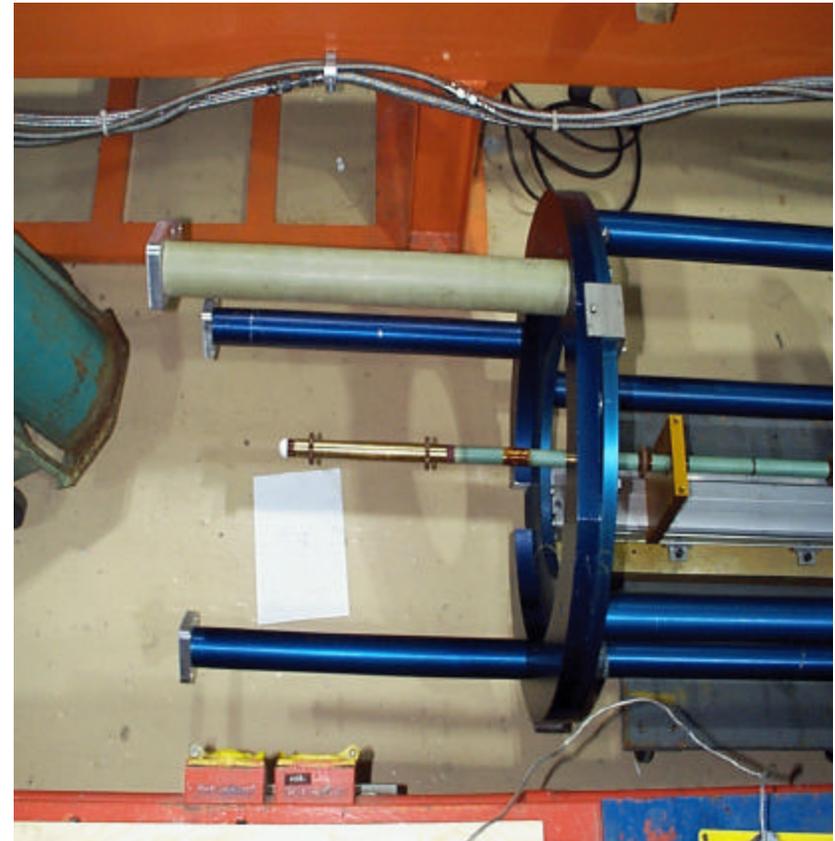
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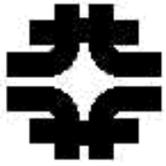
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## Measurement Probe(s)

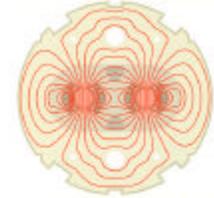
- length
  - B&W probe 25 cm
  - FE1 1 m
- 1 inch nominal diameter
- 5 windings
  - tangential main coil, sensitive to all harmonics
  - 2 dipole “bucking” coils
    - off-center probe causes “feed-down” of quad to dipole; dipole assumed nill, feed-down used to center magnet in x-y plane
  - 2 quadrupole bucking coils measure fundamental





# the Magnet Test Facility

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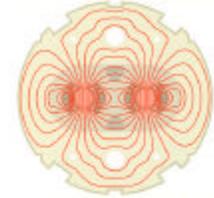
## View of VMTF Measurement System





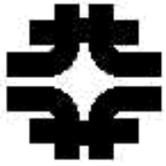
## the Magnet Test Facility

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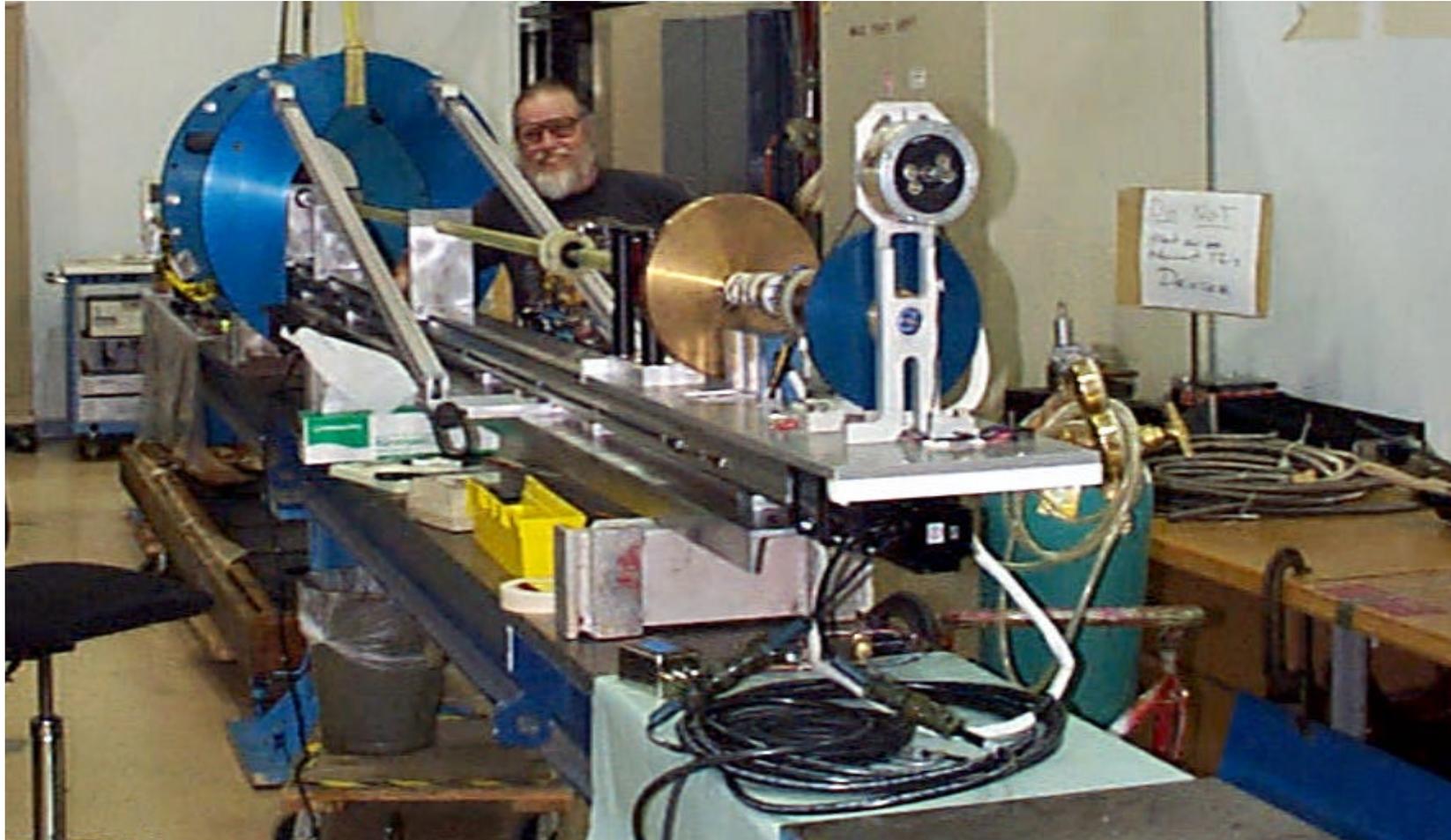
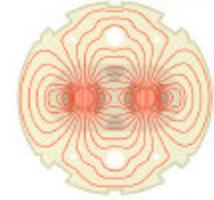
### R&D/Development Activities

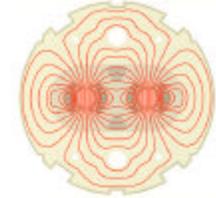
- VMTF
  - Upgrade/replacement of B&W drive system
  - Upgrade of DAQ
    - prototype of 5 PDI system under test
  - Replacement of measurement software
    - similar look and feel to existing system, but supportable and **upgradeable**
      - rotation-based summary of signals: raw + analyzed
      - add accumulating display of analyzed values
  - Integrated measurement/control system
    - z position controlled by measurement system
    - position automatically recorded in measurement data



# the Magnet Test Facility

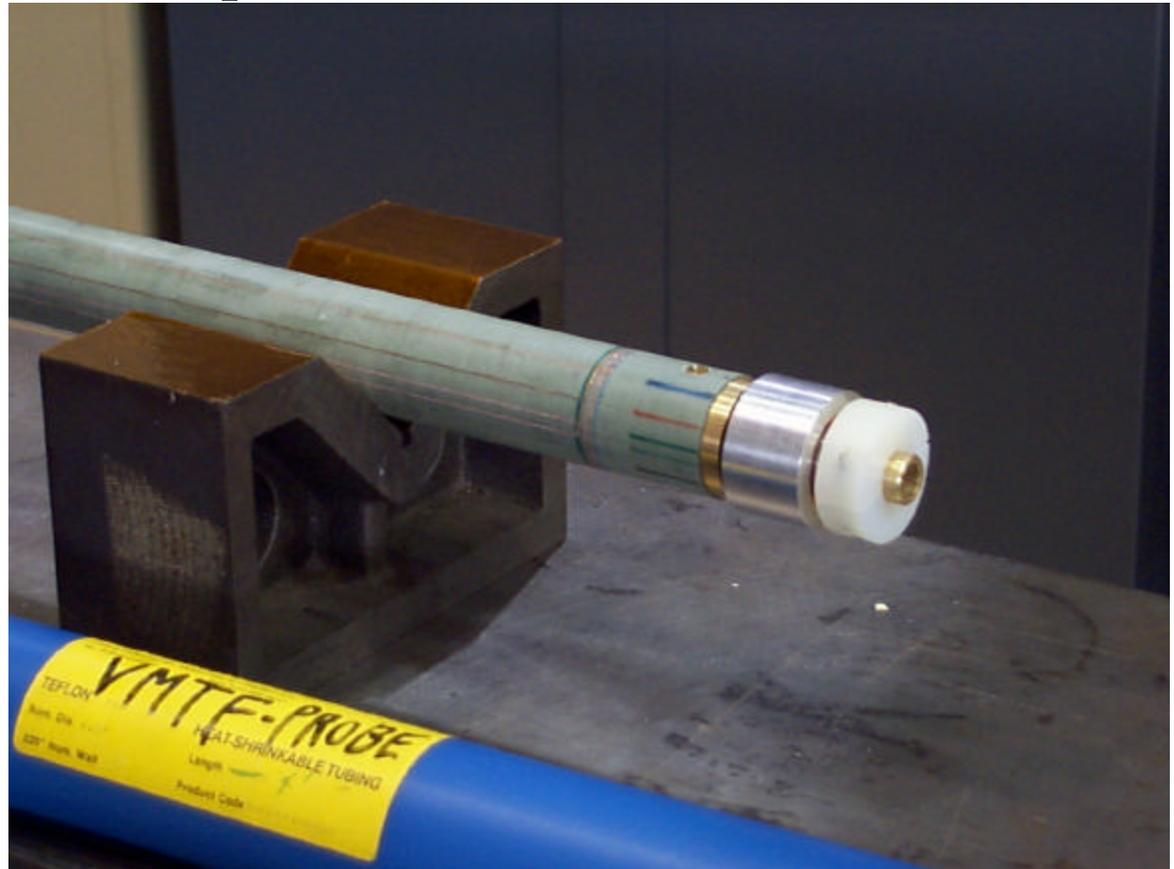
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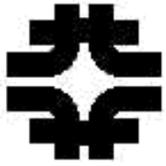




## R&D/Development Activities

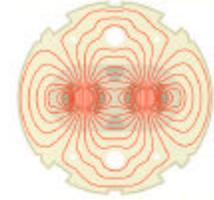
- Probe development
  - New probe optimized for HGQ bore
  - 1.6 inch nominal diameter, ~3 feet long
  - wound on G10 shaft
  - “thermometer” integrated into probe





## the Magnet Test Facility

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### Typical Tests of Short Models

- warm measurements of
  - collared coil assembly
  - final assembly
    - in IB3
    - in vertical dewar
- types of measurements
  - loop from  $I_{min}$ - $I_{max}$  several times
  - “stairstep” measurements
  - z (axial) scans
    - coarse scan of entire magnet
    - scan of lead end
  - pseudo-accelerator cycles