# LBNL Magnet Test Facility Capabilities

LARP Collaboration Meeting

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# Test Facility Sub-Systems

- Cryostat
- Power supply
- Magnet protection
- DAQ
- Refrigerator
- Operating costs
- Strengths

# Cryostat Capabilities

Cryostats (vertical, except 36H):

| Name | ID (m) | L (m) | Tmin (K) | Status |
|---|---|---|---|---|
| **32”** | **0.81** | **1.8** | **~3K** | **In use** |
| **15”** | **0.38** | **1.5** | **~3K** | **In use** |
| 25” | 0.65 | 3.0 | 1.8K | Limited diag. |
| 36” | 0.90 | 3.2 | ~3K | Header adapt. |
| 36”H | 0.90 | 1.8 | 1.7K | Storage |

# 32” Cryostat

- Cryostat loading.

# Cryostat-Related Capabilities

- Cryo-pit:
  - 13.5’ deep, 53” ID (4.1 x 1.3 m)
- Crane:
  - Weight: 10 ton
  - Hook height : 13.5’ (4.1 m)
- VC-leads:
  - Imax: 11.5 kA

# Power Supply Capabilities

| Parameter | Value (Sep'04) | Remarks |
|---|---|---|
| $I_{max}$ | 21 kA (3x7, 50V)<br>18 kA (8+10) | Connected<br>Back-up/storage |
| Control | Piece-wise linear | Recallable programs |
| Regulation | I or V | Temp. regulated I. |
| Ripple @ 10 kA | 40 mVpp (60Hz) | ~7 mVpp (Jul'05) |
| SCR-spikes @10 kA | 2 mVpp (500 V/s) | 0.3mV (May'05) |

# Magnet Protection Capabilities

- Energy Extraction:

| Parameter | Value | Status |
|---|---|---|
| Imax | 12 kA<br>14 kA<br>16 kA | Sep'04<br>May'05<br>July'05 |
| Vmax | 500 V | |

- Protection Heaters

| Parameter | Value | Status |
|---|---|---|
| Imax | 200 A | Two, independent |
| Vmax | 450 V | 100 ms |

# Data Access Capabilities

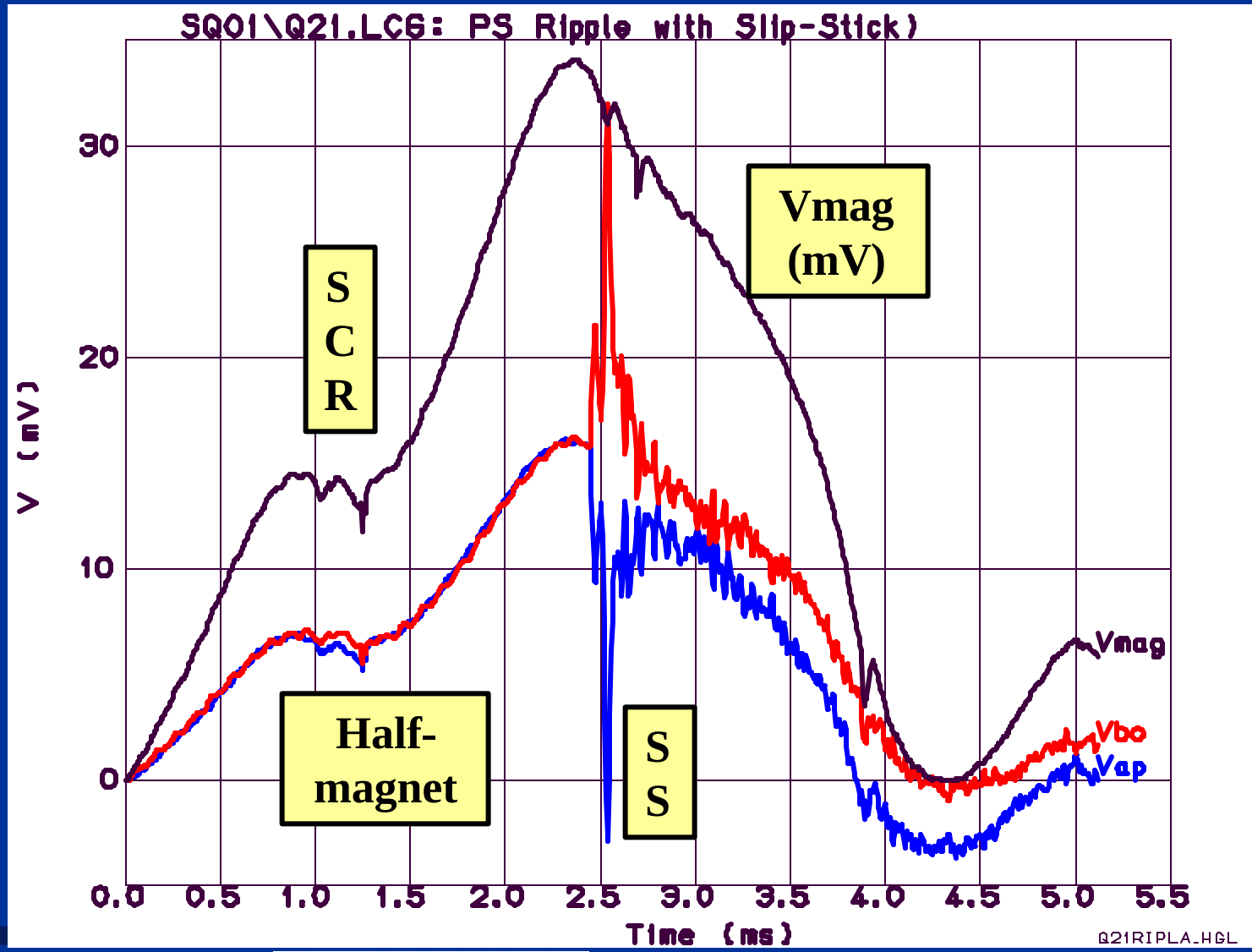
- 32” header access:
  - V-tap: 120 wires
  - Heater-I: 24 wires
  - Heater-V: 40 wires
  - Low-voltage: 192 wires
- Scaling amplifiers:
  - V-only: 30
  - V or dV/dt: 84

# Data Acquisition & Analysis

- A/D conversion
  - 96 chn: 5 kHz, 12-bit, +/-5V
  - 40 chn: 1 Hz, 18-bit, auto-scale.
  - 40 chn: 1 Hz, 24-bit, auto-scale.
  - 4 chn: 1 MHz, 12-bit, manually adjustable.
- Data-viewing, analysis, publishing
  - DataView.exe (quench & FFC binaries)
  - SGView.exe (ramp history, *.tsv)
  - CryoView.exe (cryo history, *.csv)
  - EXCEL (*.tsv, *.csv, *.txt files).

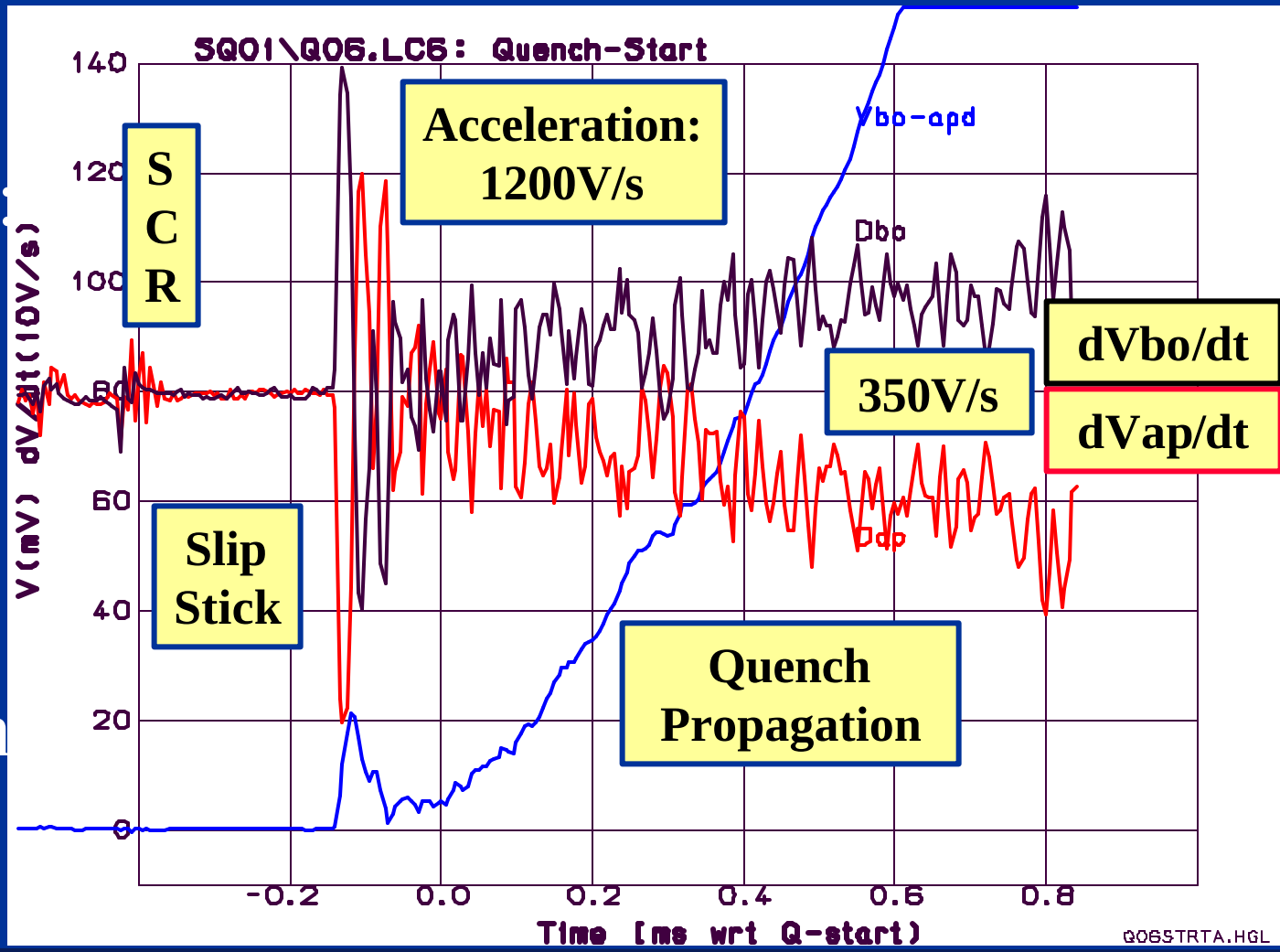
# PS Noise @ 10 kA (SQ01, Sep'04)

- Ripple:
  - 34 mVpp
- HF SCR-spikes:
  - 2 mV
- Large slip-stick:
  - 38 mV



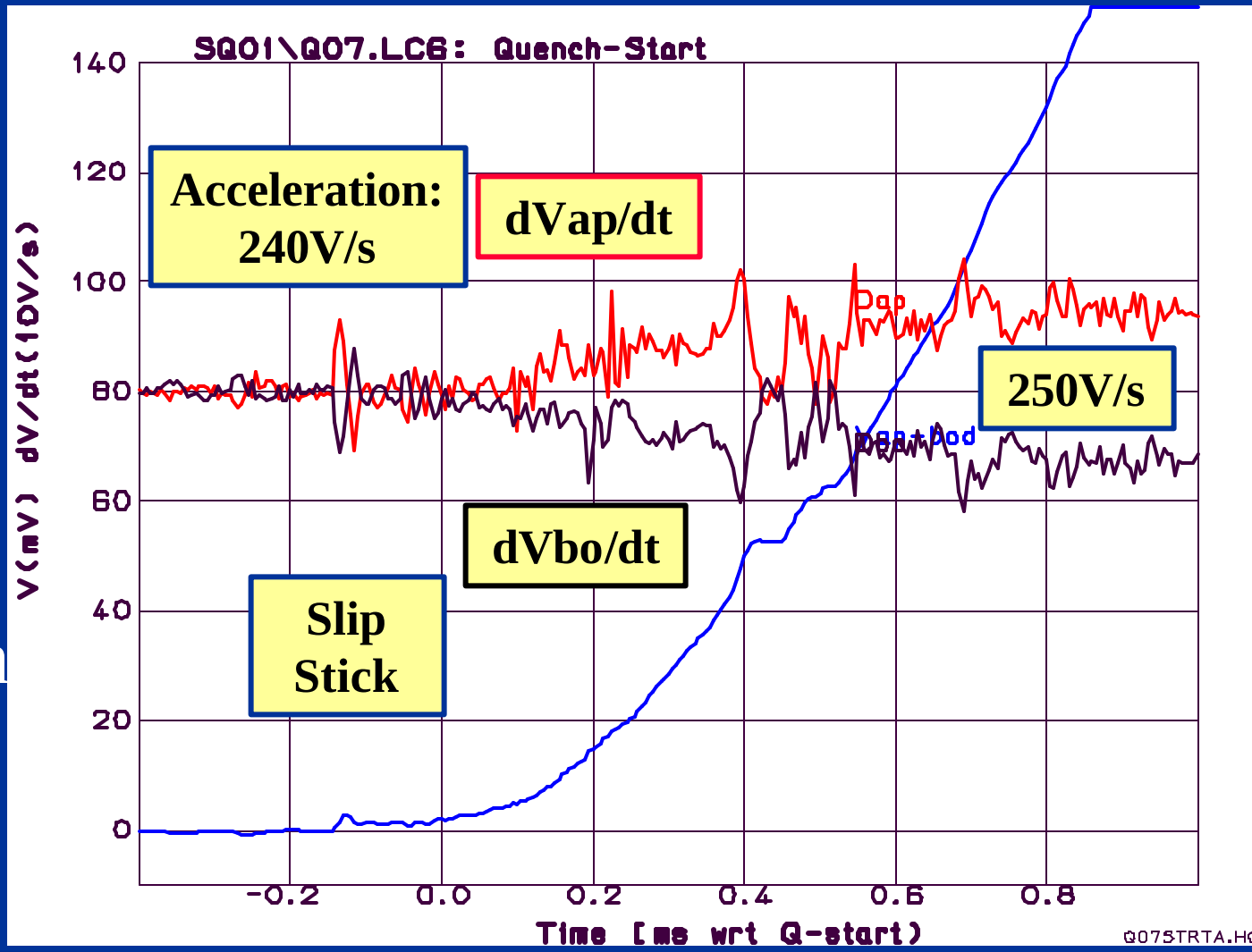
# dV/dt View: 2nd T-Quench (SQ01)

- Trigger recognition:
  - Large Motion
- Size:
  - 1200 V/s
  - 20 mV
- Propagation speed:
  - 350 V/s



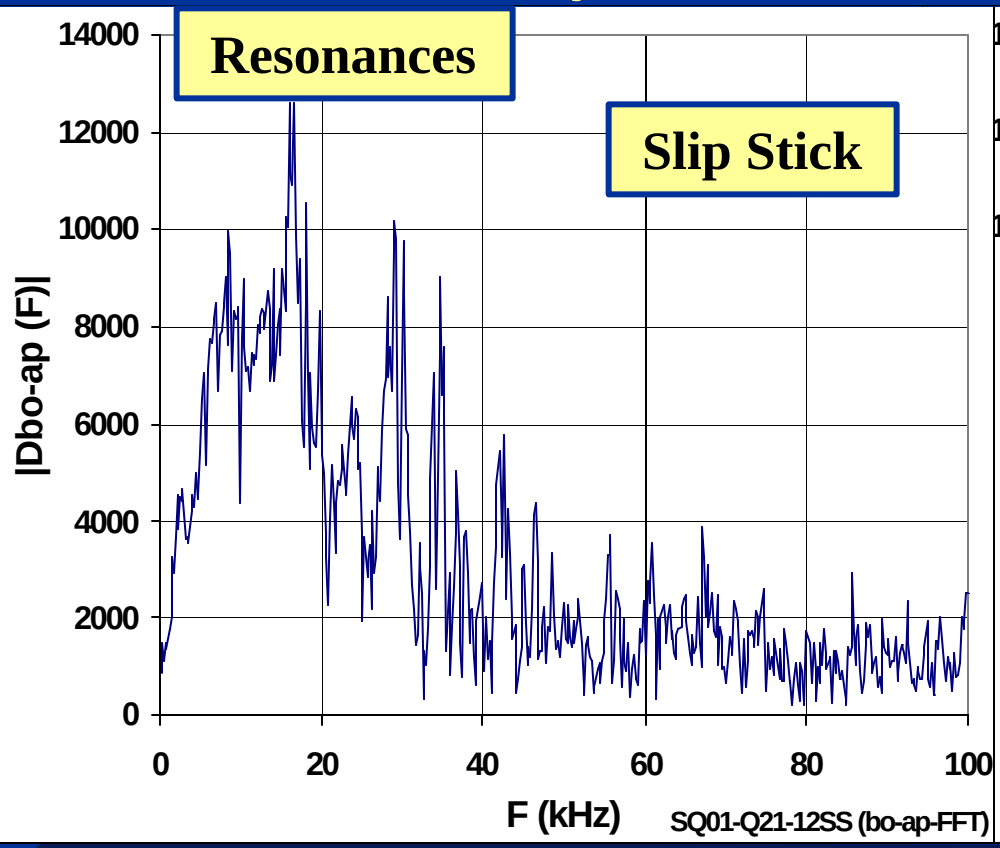
# 3rd Training Quench (SQ01)

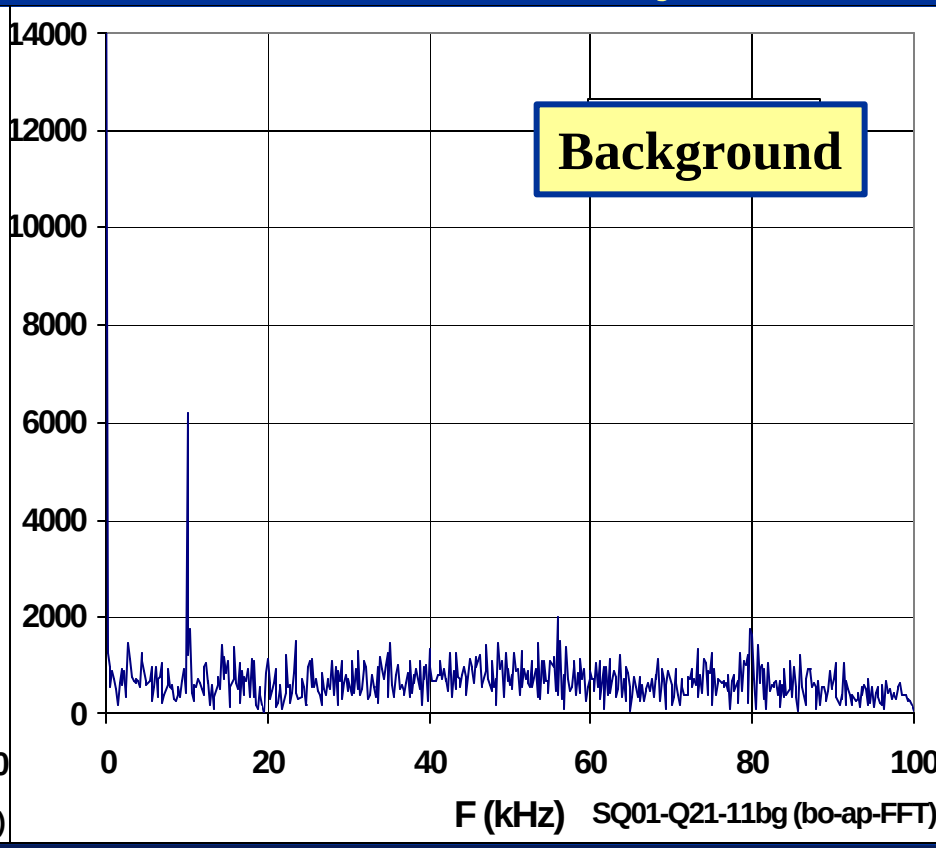
- Trigger:
  - Small motion
- Size
  - 240V/s
  - ~2mV
- Propagation
  - Delay
  - 250V/s



# Slip-Stick Fourier Analysis:

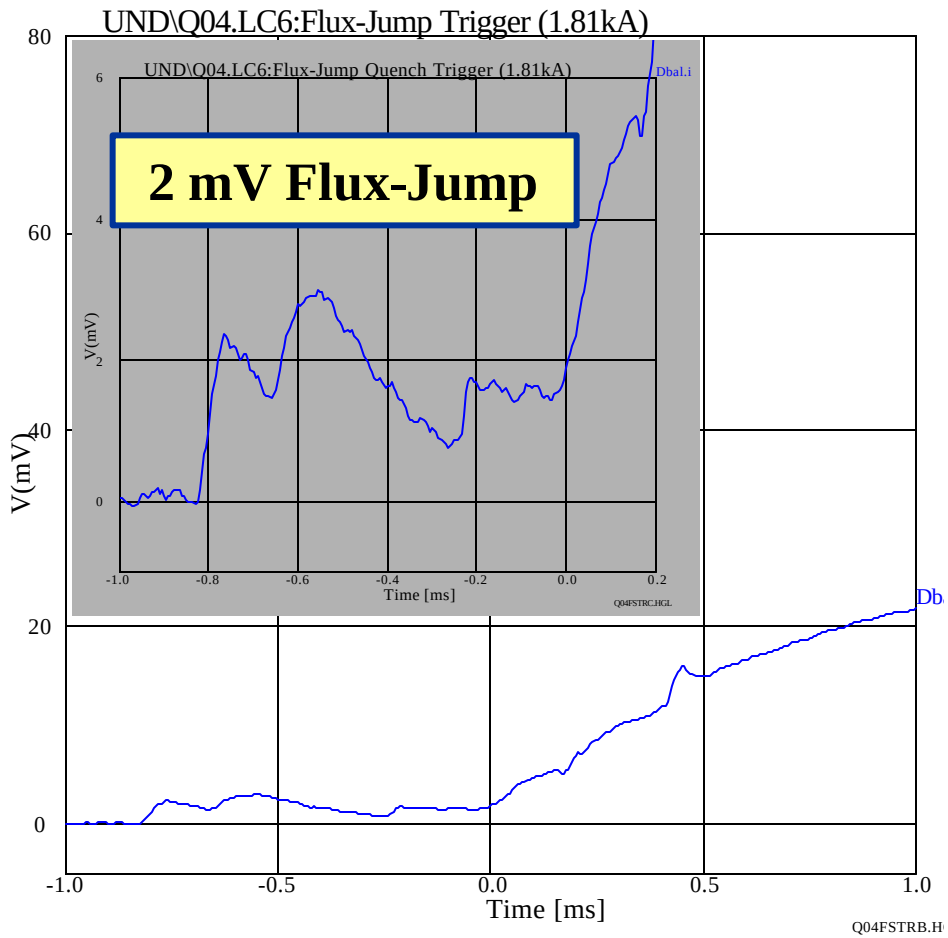
- Slip-stick spectrum:
  - Resonances vary with event.
- Background spectrum
  - Not contaminated by the PS.

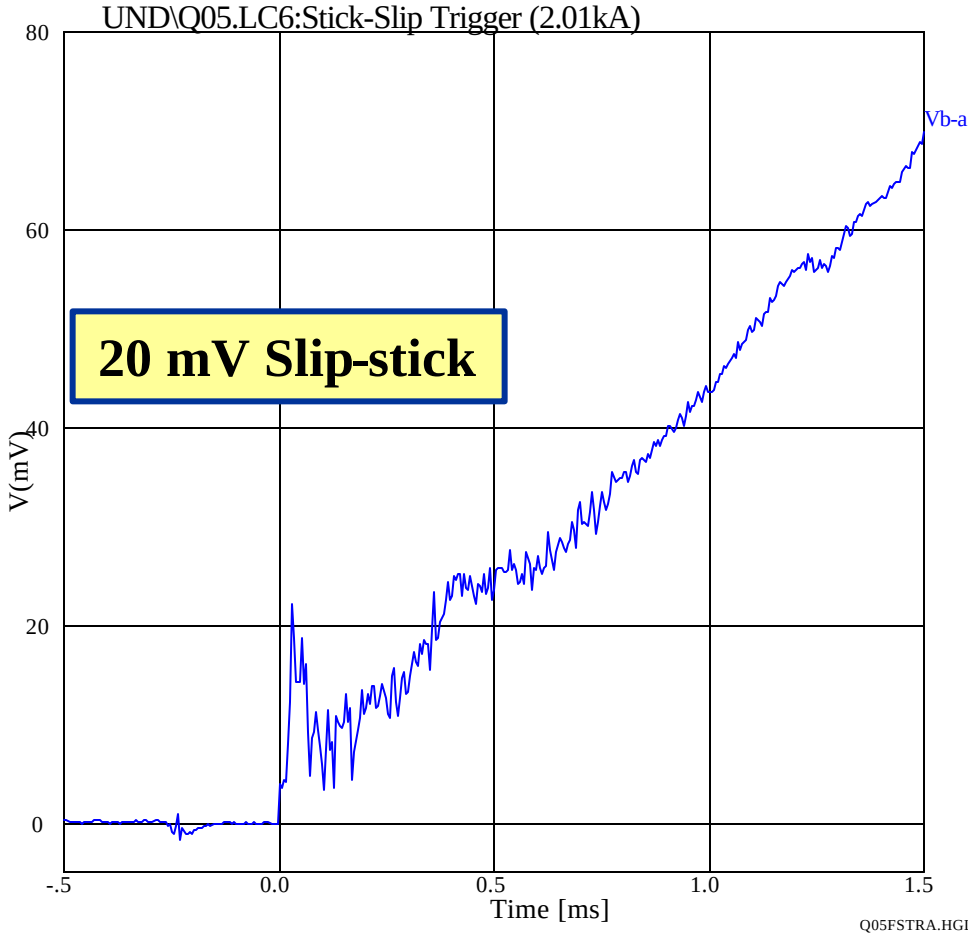


# Quench-Trigger Differentiation

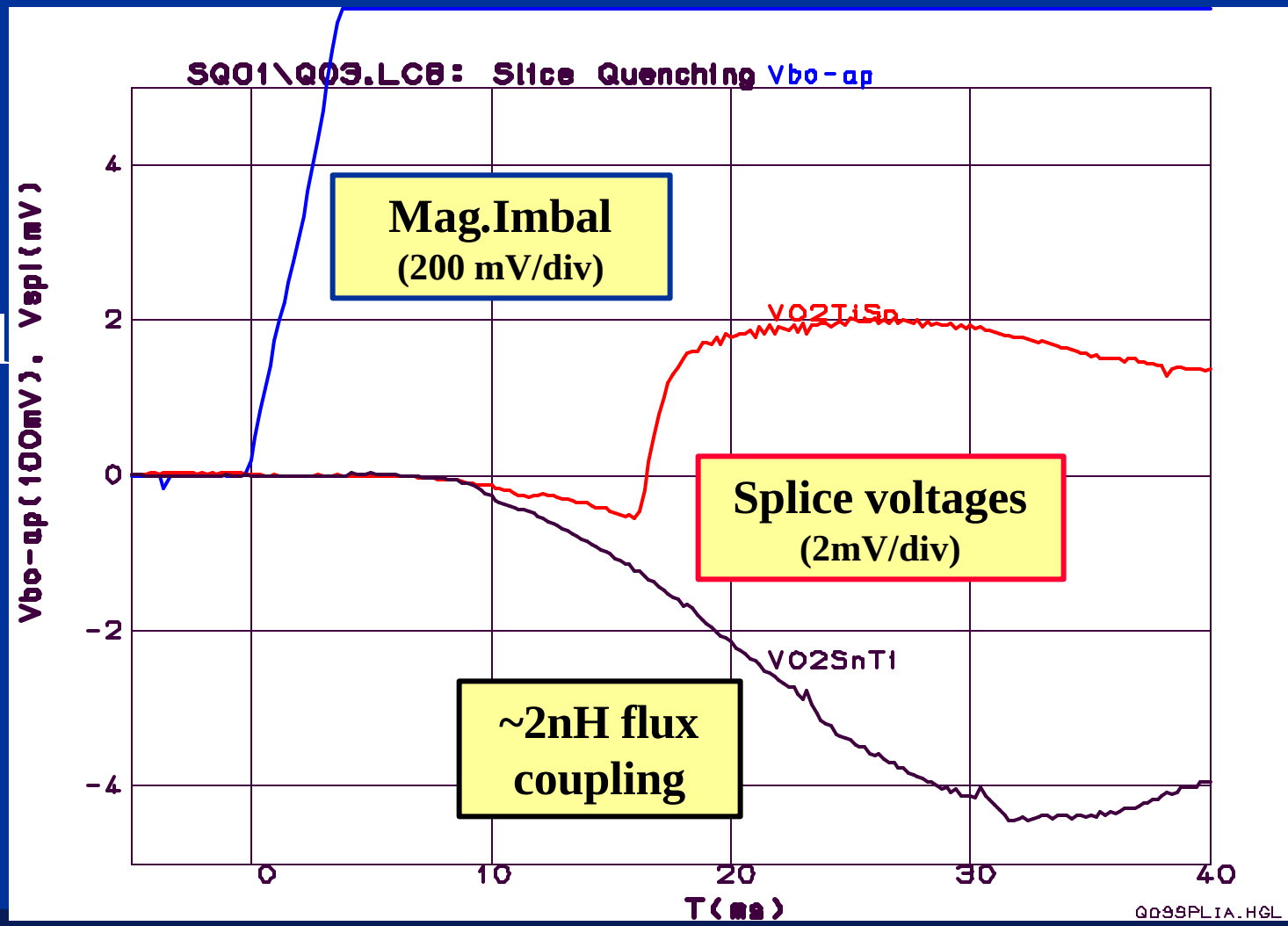
- "Flux-Jump" (Q04)
- "Stick-slip" (Q05)



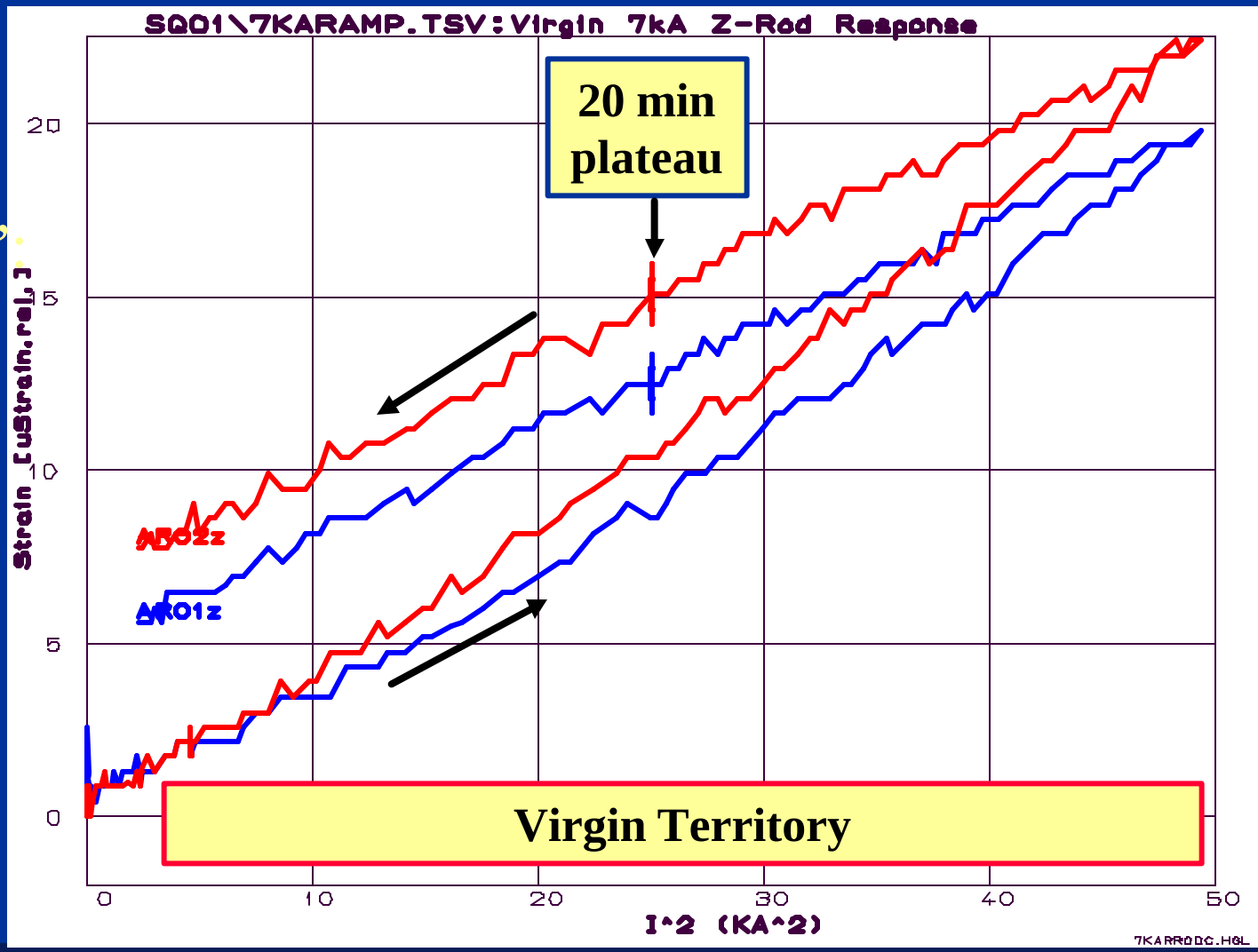
# Splice Quenching (SQ01)

- Precise timing despite small signal.



# SQ01: Strain Gage Signals

- 1 uV strain resolution:
  - "Ratcheting"
  - When?
    - Quenching (thermal shock)?
    - Virgin territory?
    - Creep?



# Magnetic Measurement Hardware

- Anti-cryostats (2):
  - 35 mm (OD)
  - 63 mm (OD)
- Header-plates (2):
  - 15”
  - 32”
- Tangential coils (4):
  - R=1.7, L=10, 43, 100 cm
  - R=2.3, L=80 cm (FNAL)
- Positioning Benchs: (1v, 1h).

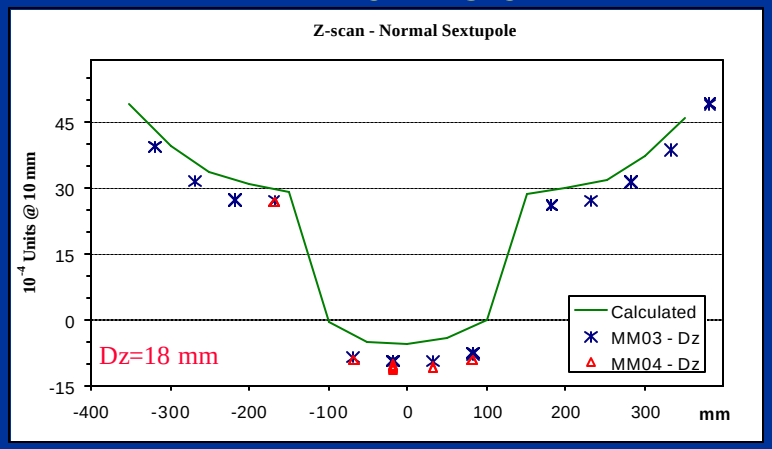
# Magnetic Measurements (RD3c)

## Central harmonics

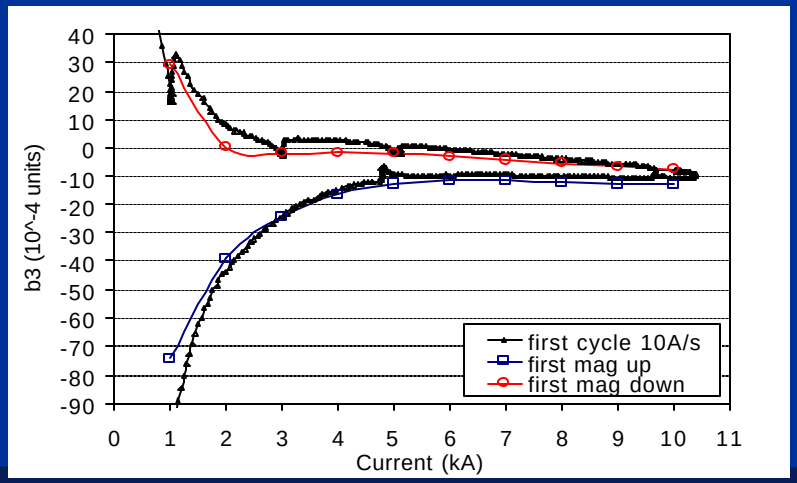
| Normal | calculated | measured |
|---|---|---|
| $b_3$ ($10^{-4}$) | -5.44 | -10.39 |
| $b_5$ ($10^{-4}$) | -0.24 | -0.02 |
| $b_7$ ($10^{-4}$) | 0.58 | 0.61 |
| $b_9$ ($10^{-4}$) | <0.01 | <0.01 |

$I_{op}$=10 kA, $R_{ref}$=10 mm

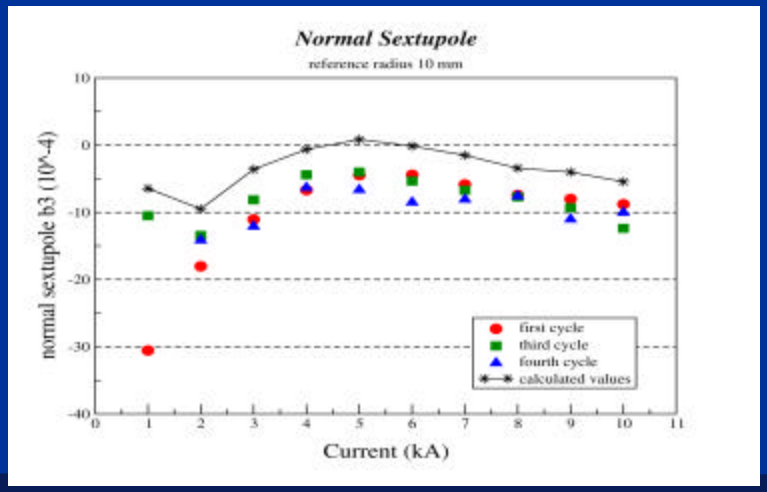
## End-Field




## Magnetization – Eddy Currents




## Iron Saturation



# Refrigeration

- Helium refrigerator:
  - 200W (Wet and dry expansion engines)
- Floor dewars.
- Choice depends upon economics:
  - # of quenches.
  - Energy/quench.
  - Duration of test.

# Magnet Test Costs

- Test preparation (20 V-taps/coil, 4 coils, Quench-protection, 40 SG's, assembled):
  - Documentation: 1 man-wk
  - Wiring:1.2 man-wk
  - Check-out: 1.2 man-wk
- Testing:
  - PS operator: 1 man
  - DAQ operator: 1.5 man
  - Refrig. operator: 0.5-1 man
  - Observers: ??? interest and visibility.
  - Refrigeration costs

# Magnet Test Costs

- Refrigeration:
  - ~$100/hr for compressor.
  - ~15 man-hours for refrigerator-prep.
  - LHe replacement + transfer labor.
  - ~0.5 man while quenching.
  - ~1 man while sub-cooling.
- Post-test:
  - Analysis: 1 man-week (depends on Nquench & data-errors).
  - Initial report preparation: 1 man-week (depends on detail).
  - Publishing: ??? (depends upon requirements).

# Upgrades: Future

| Sub-system | Description | Cost (K$) | Avail. |
|---|---|---|---|
| PS | 17 kA energy-extraction | 10 | Jul'05 |
| | 20kA, 1kV | 50 | ?? |
| Cryostat | 16 kA VC-leads | 30 | ?? |
| | 4.1 meter cryostat | 80 | ?? |
| Refrigeration | Sub-cooling HX (2.2K) | 100 | ?? |
| | Lambda-plate | 100 | ?? |

# Strength: Economical R&D Focus

- A variety of cryostats.
- 10 Ton 13.5’ crane over a 13.5’ deep pit.
- Ample current:
  - 21 kA (w/o energy extraction)
  - 16 kA (energy extraction, Jul’05).
- Low-noise PS & data acquisition systems:
  - Record small magnet adjustments.
  - Determine cause & location of quench-origin.
  - Analyze slip-sticks that don’t cause quenching.

# Strengths: Flexible, Integrated

- Flexible R&D test configuration:
  - Small/large dewar testing.
  - Rapid PS/filter configuration.
  - Rapid DAQ reconfigurations.
  - Rapid quench-location and mystery/trouble diagnosis.
  - Automated ramp/quench/event trend analysis.
- Tight, integrated team:
  - Technician team (winding-to-testing ownership).
  - Design team (design-to-analysis ownership).