

MUTAC Review

MTA

Instrumentation

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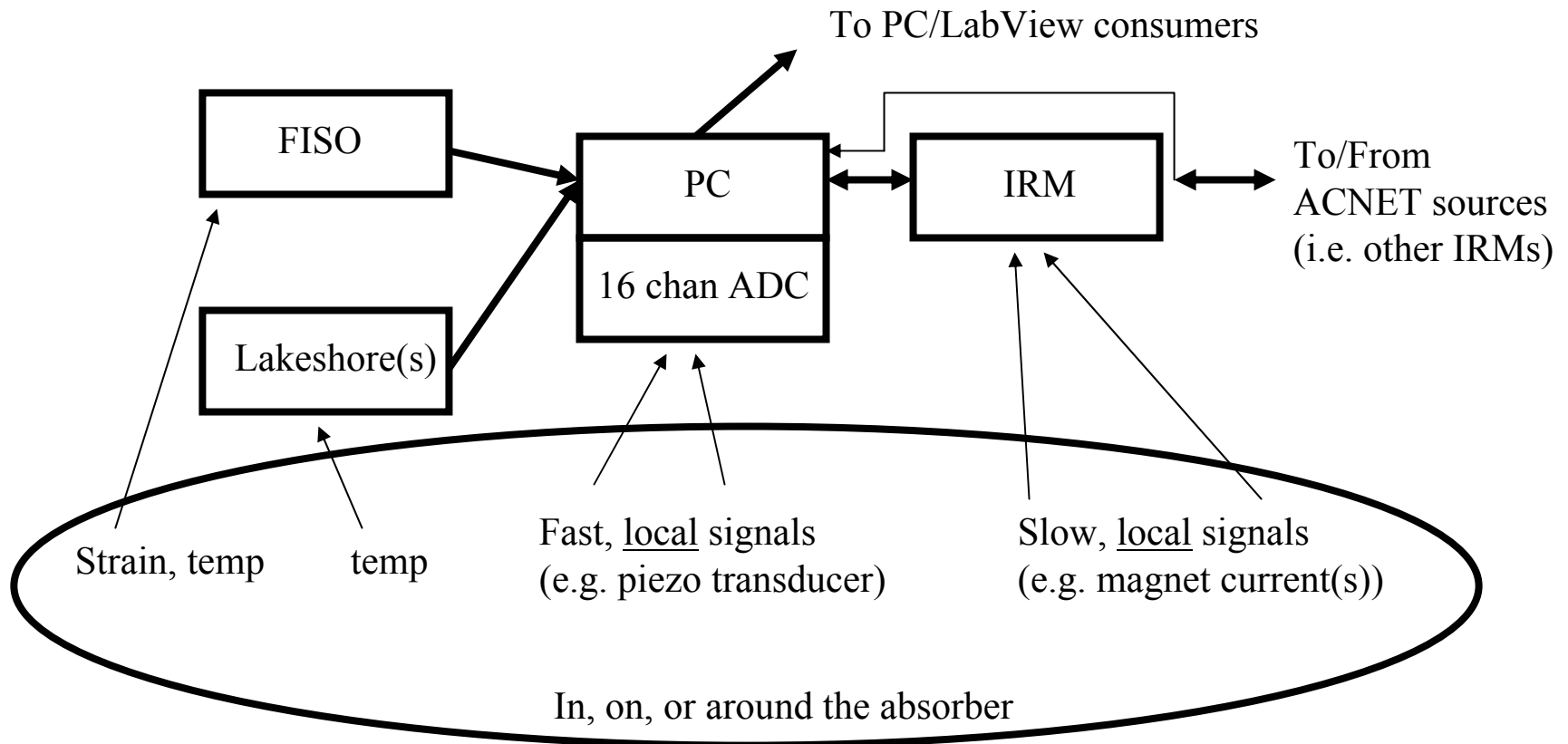
MTA
Instrumentation

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25 February 2004

MTA Instrumentation Data Paths



Signals inside (the cryostat)

- 32 (cryo) temperatures
 - 16 sensors inside absorber, 16 outside
 - Front and back faces
 - readout via Lakeshore 218S(s), GPIB + LabView (PC)
- Multiple fibers
 - FISO fiber optic channels (4 fibers)
 - strain, temperature
 - Laser occlusion (2 fibers)
 - Edgar Black looking at a scheme using standard data fibers...

(more) Signals inside

- Piezo vibration sensor
 - Available channel, but no sensor yet
 - Readout via (16 chan/12 bit) ADC and LabView (PC)
- Local (64 chan/16 bit) IRM channels
 - Readout via LabView

Signals outside

- Many voltages, currents, temperatures, pressures
 - magnets, beam position monitors, etc.
 - Most available from local IRM or ACNET (other IRMs)
 - via LabView
 - or Quadlog-PLC
 - Dedicated controller(s) used by Cryo system

Instrumentation (1)

- Lakeshore 218S
 - 8 channel cryo temperature monitor
 - 20mV (diodes) or 50 m Ω (RTD) resolution
 - 10's of mK at 20K
 - 16 readings/s (/channel)
 - GPIB interface (to PC)
 - 4 units in-hand (and a spare)
 - Will need to consider (re)calibration protocols



Instrumentation (2)

- CX-1030-SD Cernox RTD sensors (12)
 - $-6.7 \Omega/\text{K}$ at 20K (e.g. calibrated device X28829)
 - Better suited for lower temperatures
 - Recommended for use in magnetic fields ($B < 19\text{T}$)
 - Rad hard
- CX-1050-SD Cernox RTD sensors (24)
 - $-25 \Omega/\text{K}$ at 20K (e.g. calibrated device X27990)
 - Fermi “favorite”
- Also
 - TG-120PL GaAlAs diodes (4)
 - $-180\text{mV}/\text{K}$ at 4.2 K
 - for $B < 5 \text{ T}$, but no longer claimed to be rad hard...



Instrumentation (3)

- FISO Fiber-optic strain and temperature
 - BUS chassis, with 4 (up to 8) modules
 - 1000 readings/s
 - RS-232 interface (to PC)
- FOS-N strain sensors
 - +/- 5000 $\mu\epsilon$; 0.01% full scale; 0.2mm O.D.
- FOT-L temp sensors
 - 0.1 K resolution; 1.5mm x 32mm (10mm active)
 - Slow: 1.5 second response...



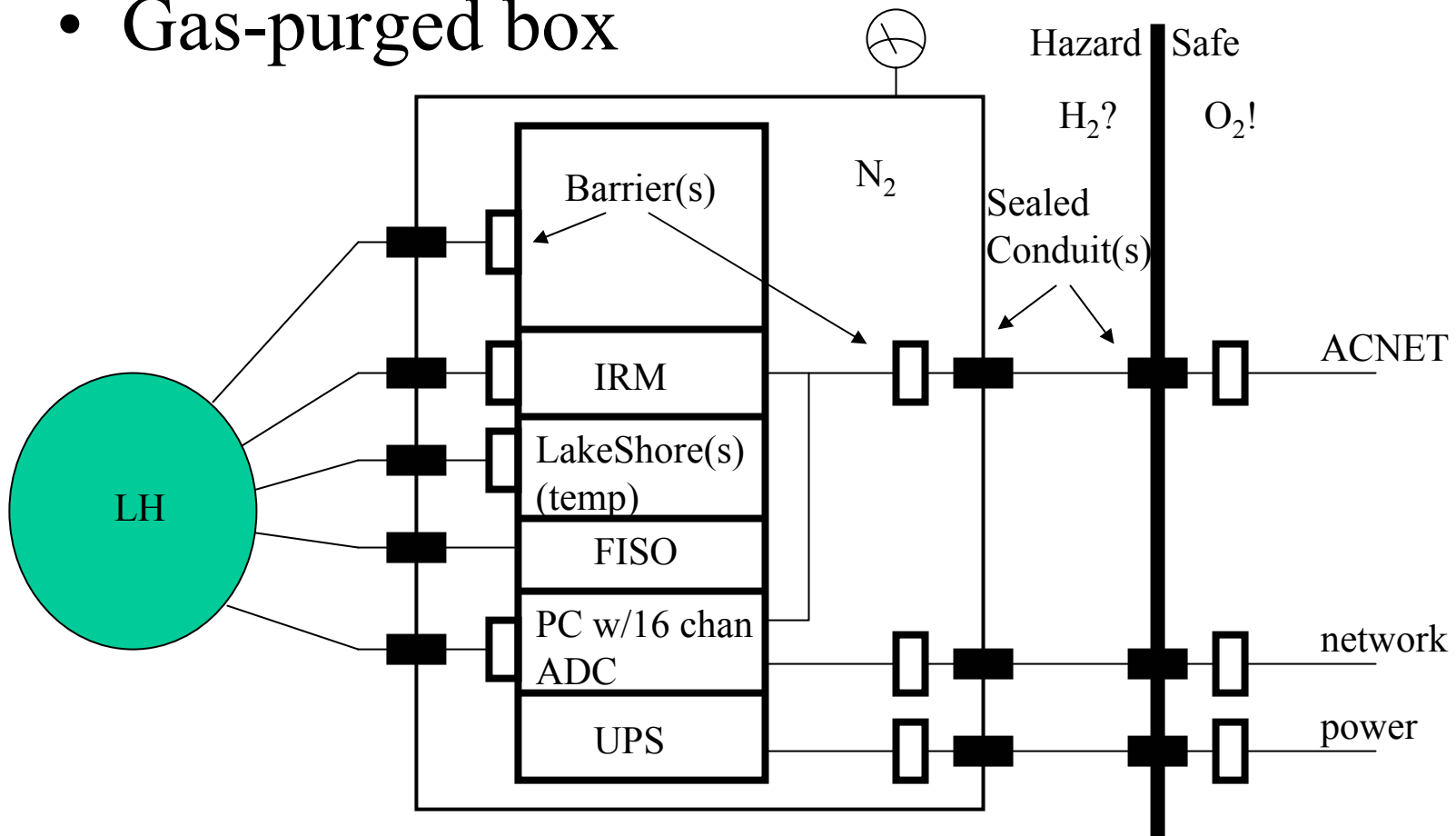
Instrumentation (4)

- Gateway E-4000 PC
 - 1.8 GHz, 1Gbyte RAM, 0.5Gbyte cache
 - 120Gbyte disk, Windows 2000
 - 15” LCD flat panel display
 - 640x480 CCD camera, microphone
- PCI-MIO-16E-1
 - 16 channel ADC, 1.25 Msample/s, 12 bits, +/-10 V
- Tripplite Internet Office UPS
 - 500 VA
 - 30 minutes (nominal) power for PC
 - But mostly intended as power filter for Lakeshore 218's



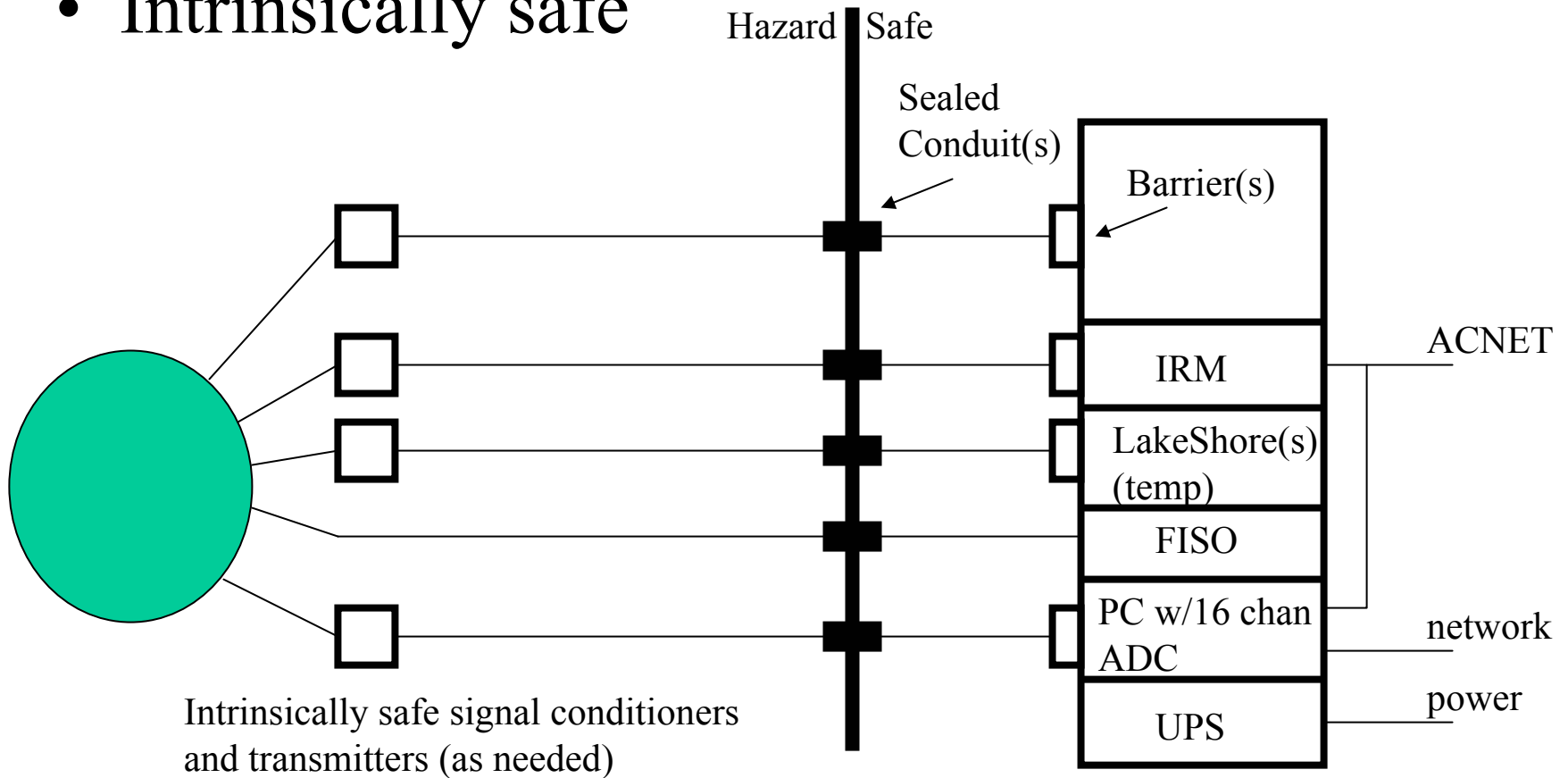
Two Safety Possibilities (1)

- Gas-purged box

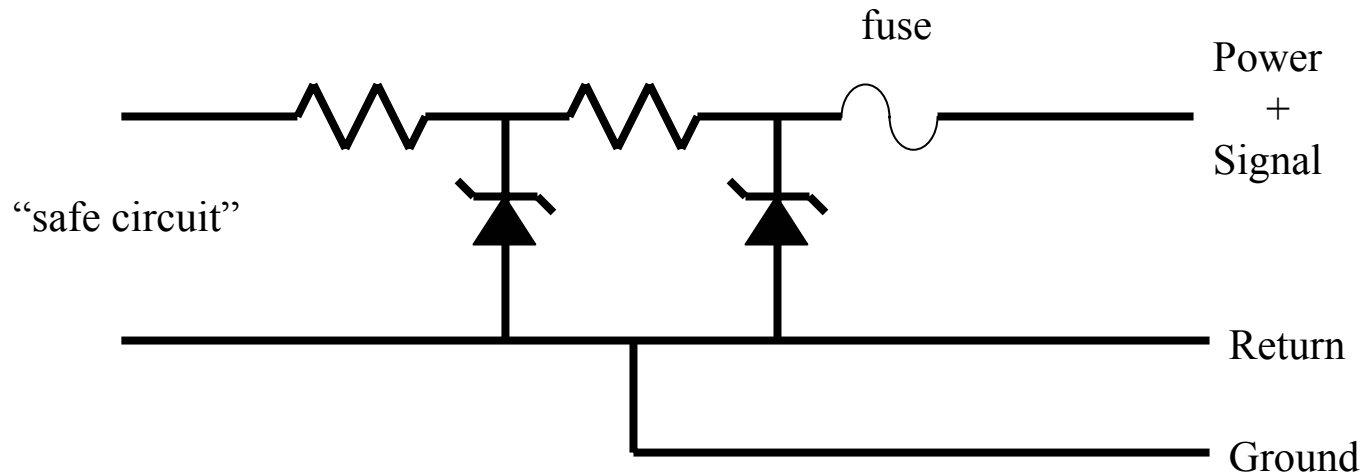


Two Safety Possibilities (2)

- Intrinsically safe



(basic) Barrier

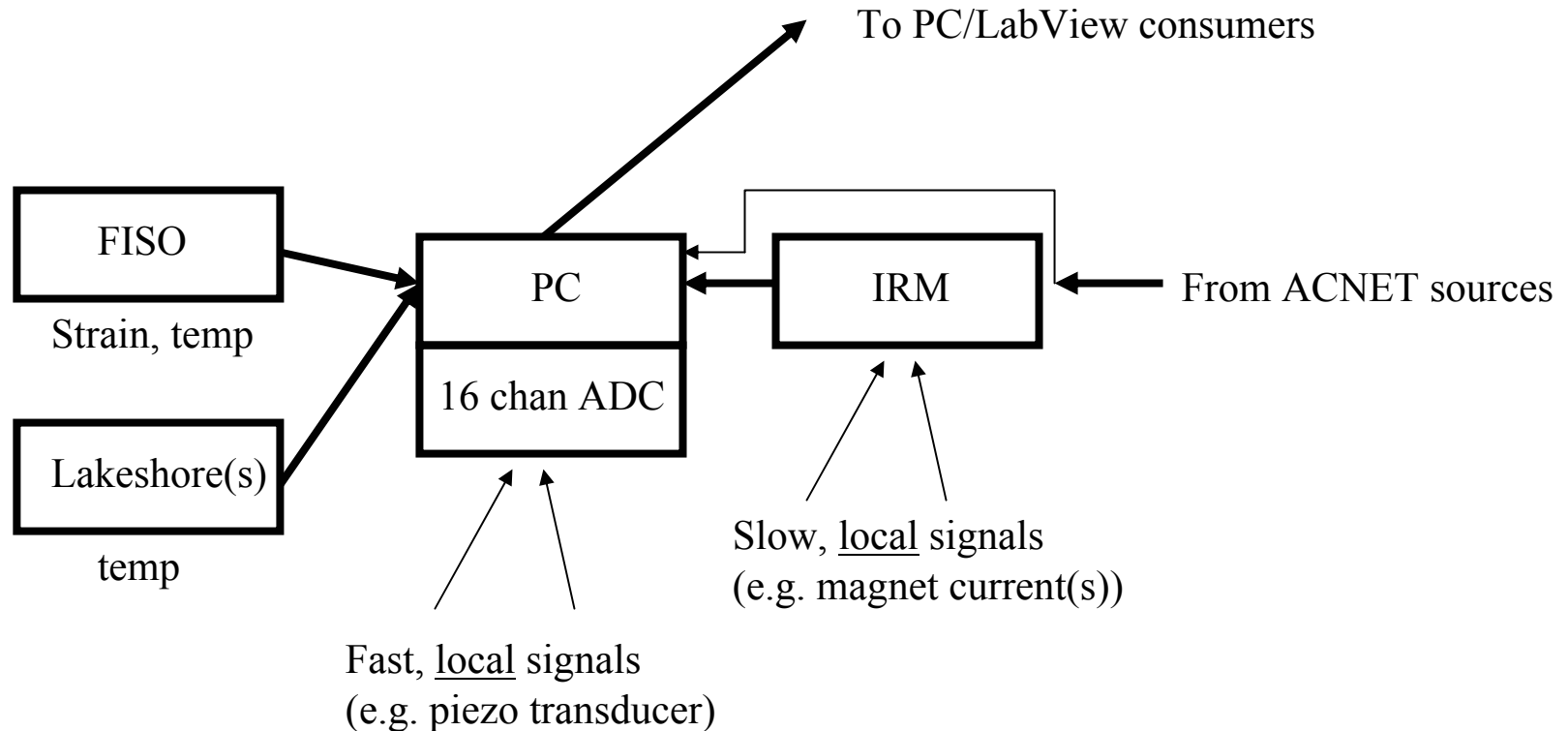


Instrumentation (5)

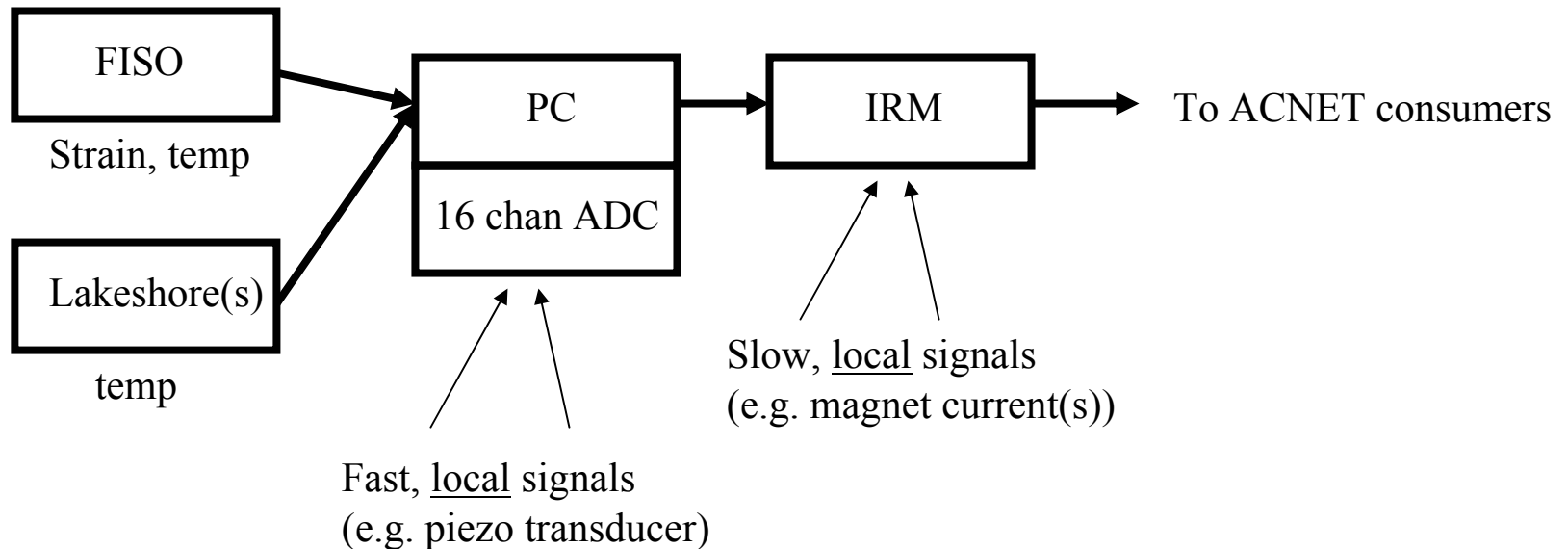
- MTL7055ac barriers
 - Low level AC
 - 24 Ω per line
 - 3 V max
- MTL7060ac barriers
 - Star-connected AC
 - 101 Ω per line
 - 8.5 V max



MTA Instrumentation: Data Paths: LabView Perspective



MTA Instrumentation: Data Paths: ACNET Perspective



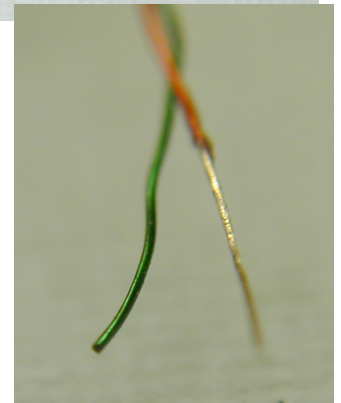
Instrumentation (6)

- IRM
 - 64 channel multiplexed ADC
 - 16 bit, 100 Ksamples/s
 - ACNET network connection
 - All PC data will be posted to IRM for ACNET access



Wire Considerations - inside

- QuadTwist
 - 2-pair, 36 AWG phosphor bronze
 - Formvar insulated, color-coded
 - Compared to 32 AWG manganin
 - QT is pre-twisted, color coded pairs, 0.63 smaller, yet 0.6 less DC resistance(!)
 - But, QT has 1.9 greater thermal loss, and end-prep is (somewhat) delicate work
 - If I can do it, it can't be that delicate...



Internal Shielding

- Stainless steel (36 AWG) drain, with foil around pairs
 - See next slide (foil+drain)
- Stainless steel braid around all
 - Easier to handle than stainless conduit



Mr. Gasket Steel Braid Hose Cover Kit (Blue)
Part: Mr. Gasket 8091

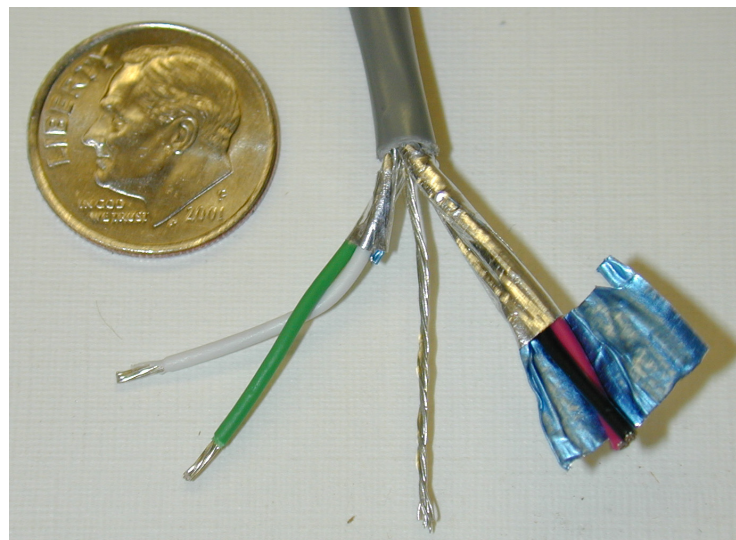
Braided stainless steel look for less. Blue anodized aluminum, Flex-Braid engine kit

This Dress Up Kit combines Flex-Braid stainless steel-style hose sleeving with aluminum Pro-Hex hose clamp covers. This kit includes:

3 ft. of vacuum line sleeving
4 ft. of fuel line sleeving
12 ft. of heater hose sleeving
4 1/2 ft of radiator hose sleeving
4 blue fuel line fittings
4 blue heater hose fittings
2 blue upper radiator hose fittings
Shrink sleeves for vacuum line

Wire Considerations - outside

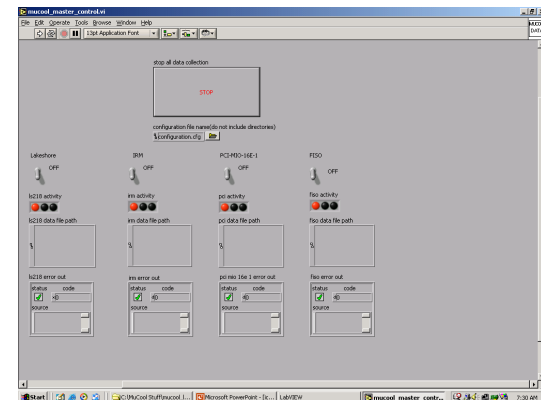
- Shielded twisted pair
 - Using 2-pair here
 - foil-out, common drain
 - Recommend N-pair
 - foil-in, drain-per-pair
 - Consistent with Lakeshore 218 shielding
 - 4-wire measurement, shield-per-pair
 - Belden offers (up to) 32-pair cables
 - DigiKey has (up to) 6-pair



End

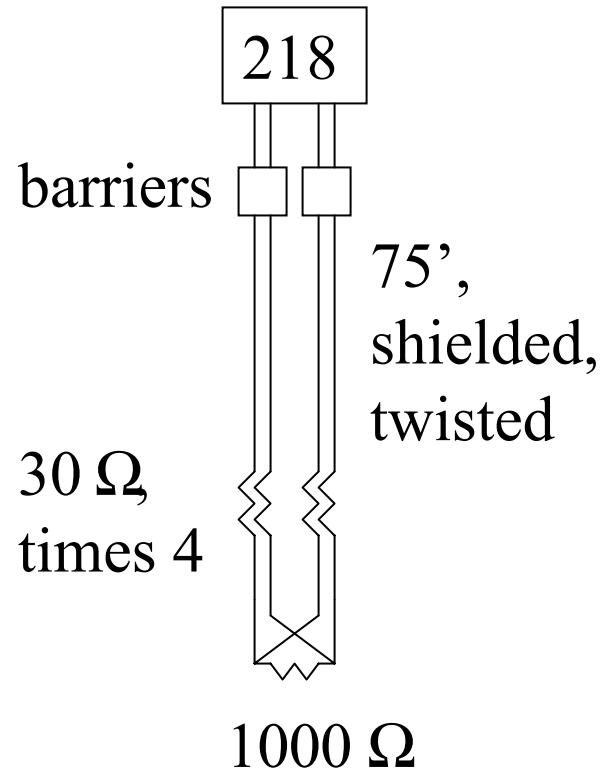
Status

- Hardware acquired
 - PC, FISO, Lakeshore (temp) +sensors, IRM, etc.
 - All major items in-hand
- Software written
 - IRM communications: to, from
 - Lakeshore readout
 - FISO readout
 - All major elements written and integrated
 - For one Lakeshore 218...
- Intrinsically safe solutions (barriers)



Testing

- Lakeshore 218 monitor
- MTL7055ac (low level) and MTL7060ac (star-connected)
 - Intrinsically Safe Barriers
- 23m (75 ft) of shielded twisted pair
 - 2-pair, 22 AWG, belfoil (out), common drain
 - \$76/500ft from Digikey
- 30 Ω on each of the 4 wires,
 - to mimic 2m of 32 AWG manganin wire
 - Lakeshore MW-32
 - 13.5 Ω /m at 4.2K, 14.3 Ω /m at 77K
- 1000 Ω load resistor
 - Compare to CX-1050-SD-4L
 - @14.000K, $R = 819.7521 \Omega$, $dR/dT = -50.16117 \Omega/K$
 - @20.000K, $R = 607.6232 \Omega$, $dR/dT = -25.14299 \Omega/K$



Results

- Cleanliness is paramount!
 - 10 μA excitation, so nanoamps of leakage are significant!
- Worst-case deviation: 0.5 Ω
 - 1000 Ω on back of 218, *vs* full test setup
 - At $dR/dT = -25.14299 \text{ } \Omega/\text{K}$...
 - 0.0199 K (systematic) error

Other/Work in Progress

- Recently acquired
 - Keithley 7001 switch mainframe,
7013s isolated switch module
- Recently borrowed
 - Keithley 2701 6 ½ digit multimeter
- Goals
 - Confirm quantitative cleanliness (little/no leakage)
 - Confirm (non)effect of thermoelectric (junction) voltages

Backup Slides

Open Issues

- Wire+Shielding Concerns
 - Cable plant into solenoid
 - Shielded-twisted pairs (two pairs per Cernox)
 - Shield drains carried from Lakeshore(s) to sensors (not grounded)
 - Grounding
 - Details depend on overall MuCool grounding scheme
 - Common mode (surges) due to magnets
 - Need to protect electronics without burning barriers
 - Noise/sensitivity issues

Open Issues (2)

- FISO temp/strain sensors
 - Qualification at cryogenic temps
- Software Concerns
 - System integration
 - 3 more LakeShore 218's
 - Remote control of PC
 - PCAnywhere vs VNC
 - Fermi network security policies...