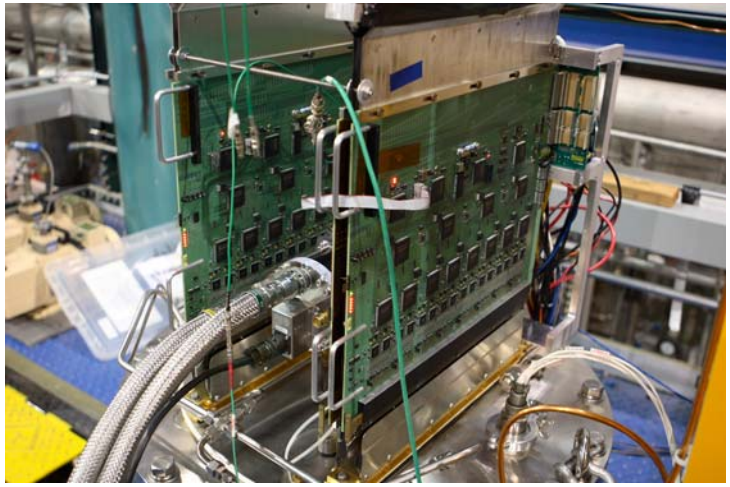
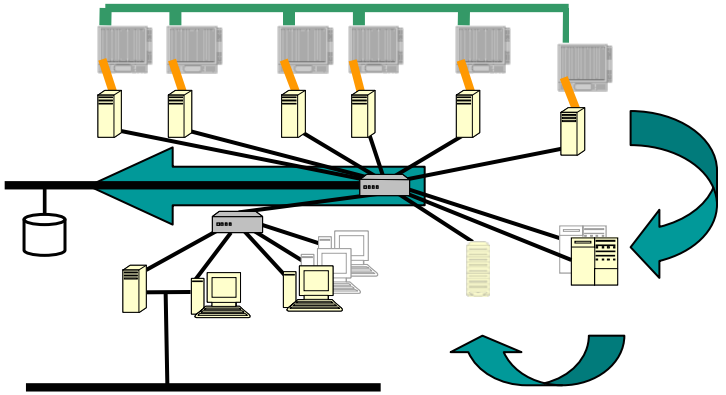
MICE Tracker Readout and Data Acquisition; Solenoid Magnetic Field Measurement





Terry Hart
for the MICE Collaboration,
Illinois Institute of Technology,
NFMCC Meeting,
March 18, 2008

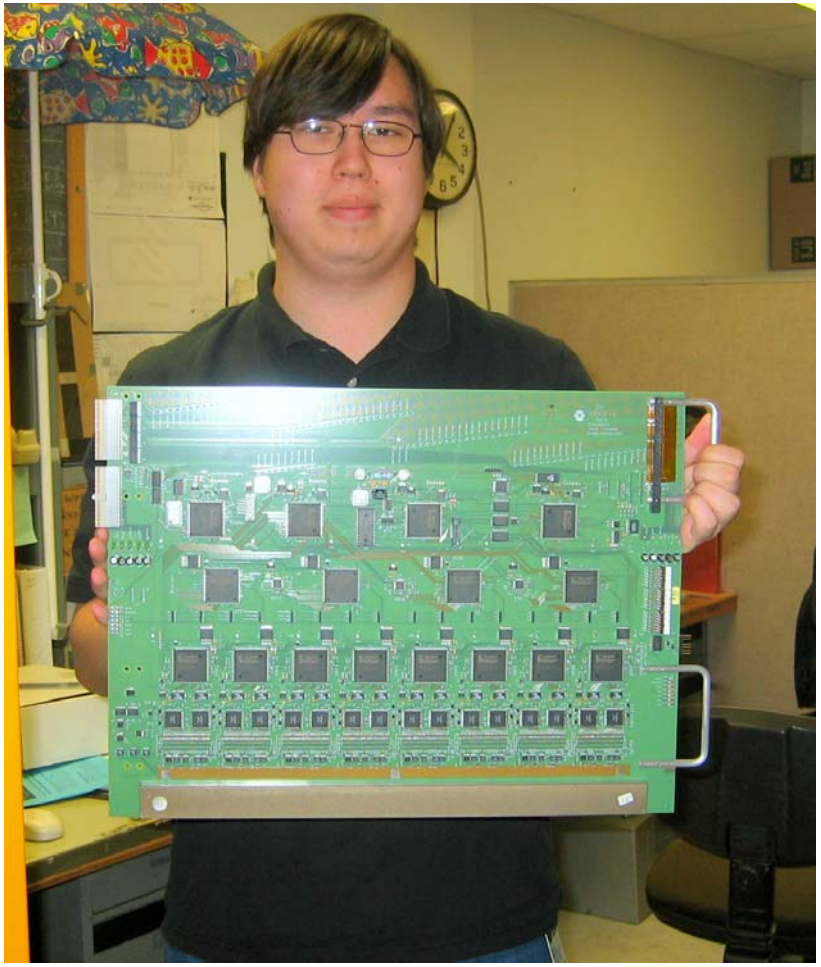
Outline

- Tracker Readout
  - Introduction
  - MICE Modifications
  - Plans
- MICE Data Acquisition (DAQ)
  - DAQ Subsystems and Structure
  - Front End Electronics
- Solenoid Magnetic Field Measurement
  - Initial Progress
  - Issues and Questions
  - Planning for Measurements

MICE Tracker Acronyms

- AFE-IIt – Analog Front End, Version II, with time
- VLSB – VME LVDS Serdes Buffer
  - Versa Module Eurocard
  - Low Voltage Differential Signaling
  - Serialing/Deserializing
- TriP-t – Trigger with Pipeline with time
- VLPC – Visible Light Photon Counter

AFE-IIt Boards

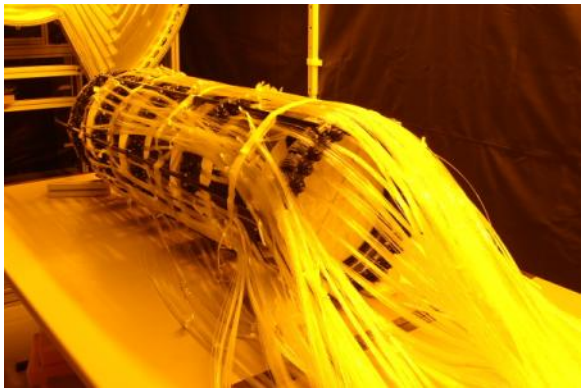


IIT graduate student,
Michael Wojcik,
with a fully tested AFE-IIt board.

AFE-IIt/D0/MICE Background

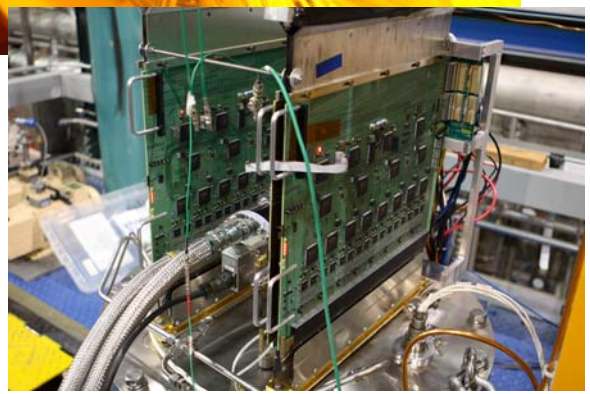
- AFE-IIt boards are latest D0 tracker readout boards.
- D0 and IIT arrangement
  - IIT students test boards for D0
  - MICE received 22 boards
- D0 firmware not fast enough for MICE muon rate
- Substantial efforts from FNAL, IIT, and RAL to modify firmware for MICE

Tracker Readout “Big Picture”



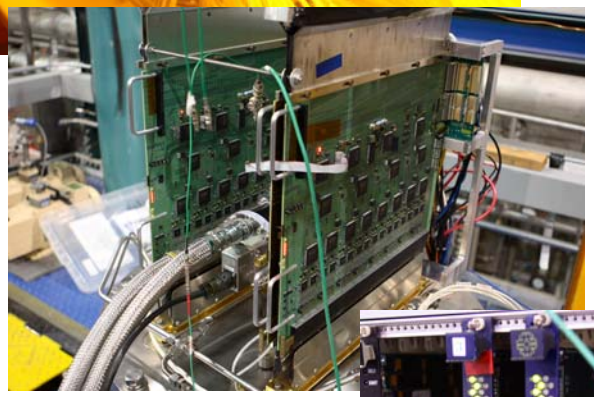
- Scintillating Fiber Tracker (1 of 2)
  - Measures track trajectory and momentum
  - Placed in solenoid

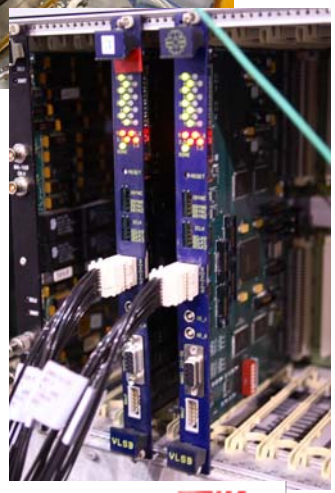
Tracker Readout “Big Picture”



- Scintillating Fiber Tracker (1 of 2)
  - Measures track trajectory and momentum
  - Placed in solenoid
- AFE-IIt boards (4 of 16)
  - Mounted on 4 VLPC cryostats
  - Record, format data from tracker
    - Hit fibers
    - Charge
    - Time

Tracker Readout “Big Picture”





- Scintillating Fiber Tracker (1 of 2)
  - Measures track trajectory and momentum
  - Placed in solenoid
- AFE-IIt boards (4 of 16)
  - Mounted on 4 VLPC cryostats
  - Record, format data from tracker
    - Hit fibers
    - Charge
    - Time
- VLSB boards (2 of 16)
  - Store formatted tracker data
  - Send data to MICE data acquisition (DAQ)

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MICE Time Scales, TriP-t

- Average time between MICE triggers ~ 1700 ns, as short as 628 ns

- TriP-t chips (16 on AFE-IIt board, 32 channels/chip)
  - Pipeline: stores analog charge and time data.
    (Event trigger formation takes ~ 1000 ns)

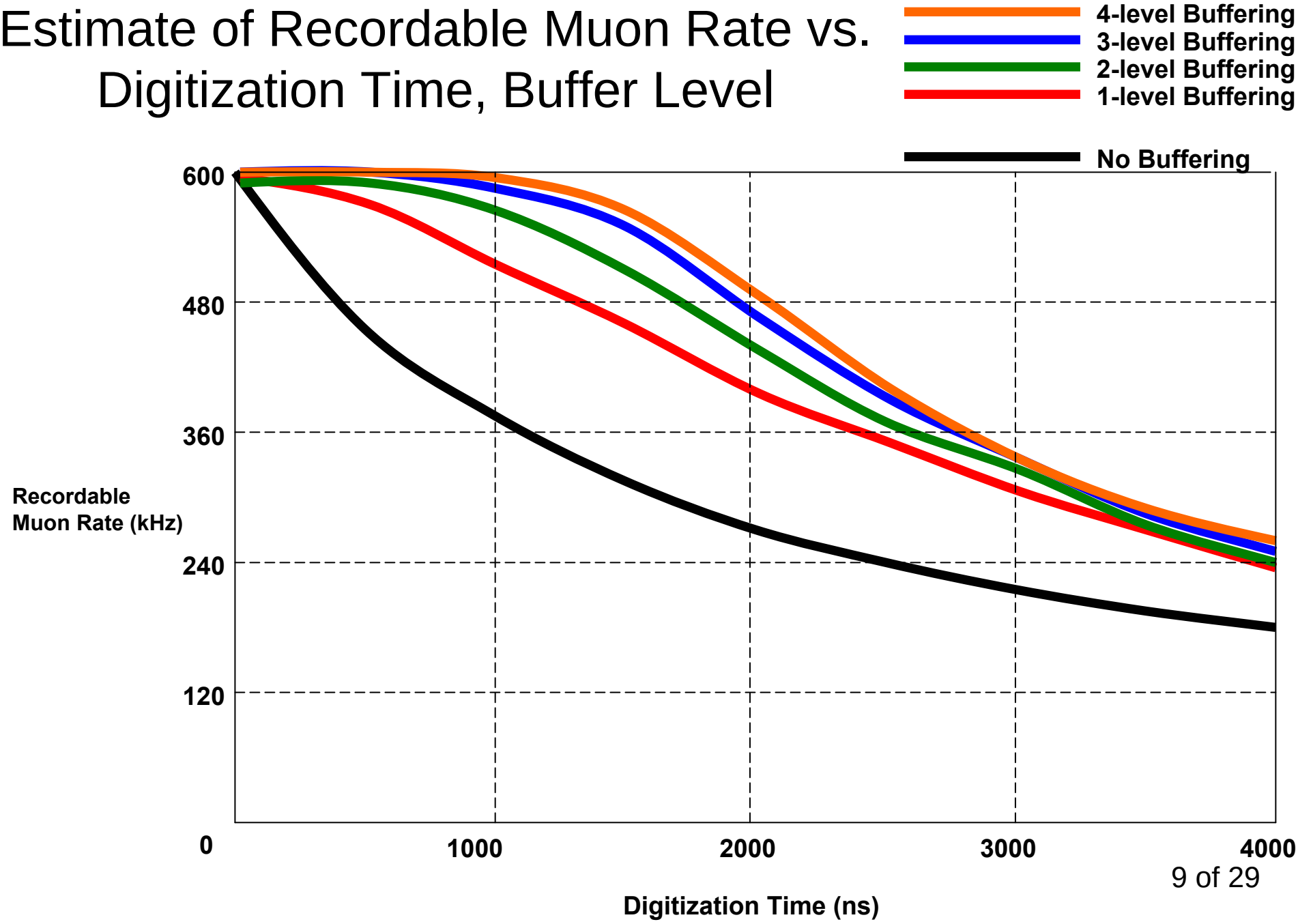
  - Analog buffer: upon trigger, data from pipeline and either
    - Digitized if 4-level buffer empty or
    - Placed in 4-level buffer if digitization of previous event not yet done

TriP-t pipeline and buffer tested and working

MICE AFE-IIt Firmware Modifications

- Reduce time to digitize events
  - Enable TriP-t pipeline to collect data during digitization of event
  - Cycle through non-hit channels as quickly as possible
  - Digitization time will be reduced from 5700 ns to 1600 ns.
- Implement TriP-t 4-level buffer
  - Board can accept, hold data in buffer while previous data digitizing
  - Increases recordable event rate for high input rate, short digitization time
- Enable AFE-IIt clock to lock onto variable signal
  - ISIS clock frequency varies from 52.2 – 55.6 MHz each trigger

Estimate of Recordable Muon Rate vs. Digitization Time, Buffer Level

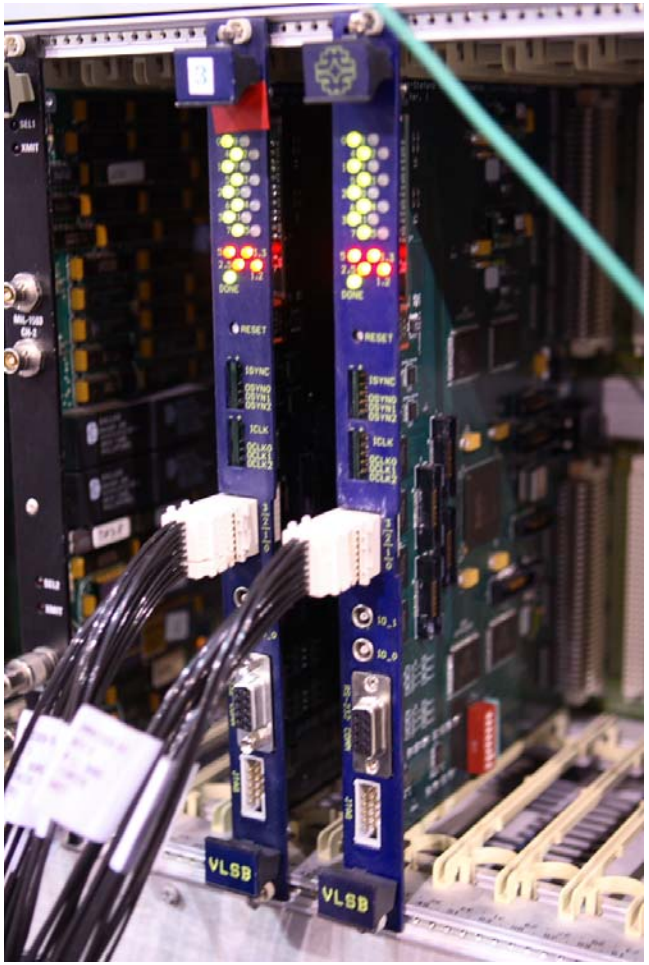


MICE Tracker Readout Plans

- Near term: Cosmic ray tests at RAL
  - Putting together simplified firmware at FNAL
  - Perform full test at FNAL before shipment to RAL
  - About a few week time scale

- Longer term: High rate MICE running
  - Sequentially add functionality
    - Zero suppression
    - 4-level buffer
    - Variable clock

VLSB Boards



2 VLSB boards in VME crate

VLSB Firmware

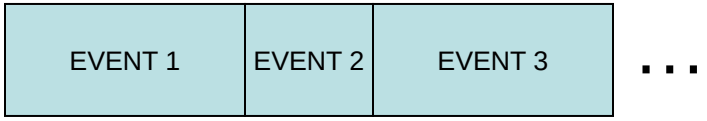
VLSB = VME LVDS Serdes Buffer

- Tracker data storage modules
- Used for KEK test beam
- Used by D0 for diagnostics

VLSB Firmware Modifications

- Data storage in memory banks
  - Before modifications

  - After modifications

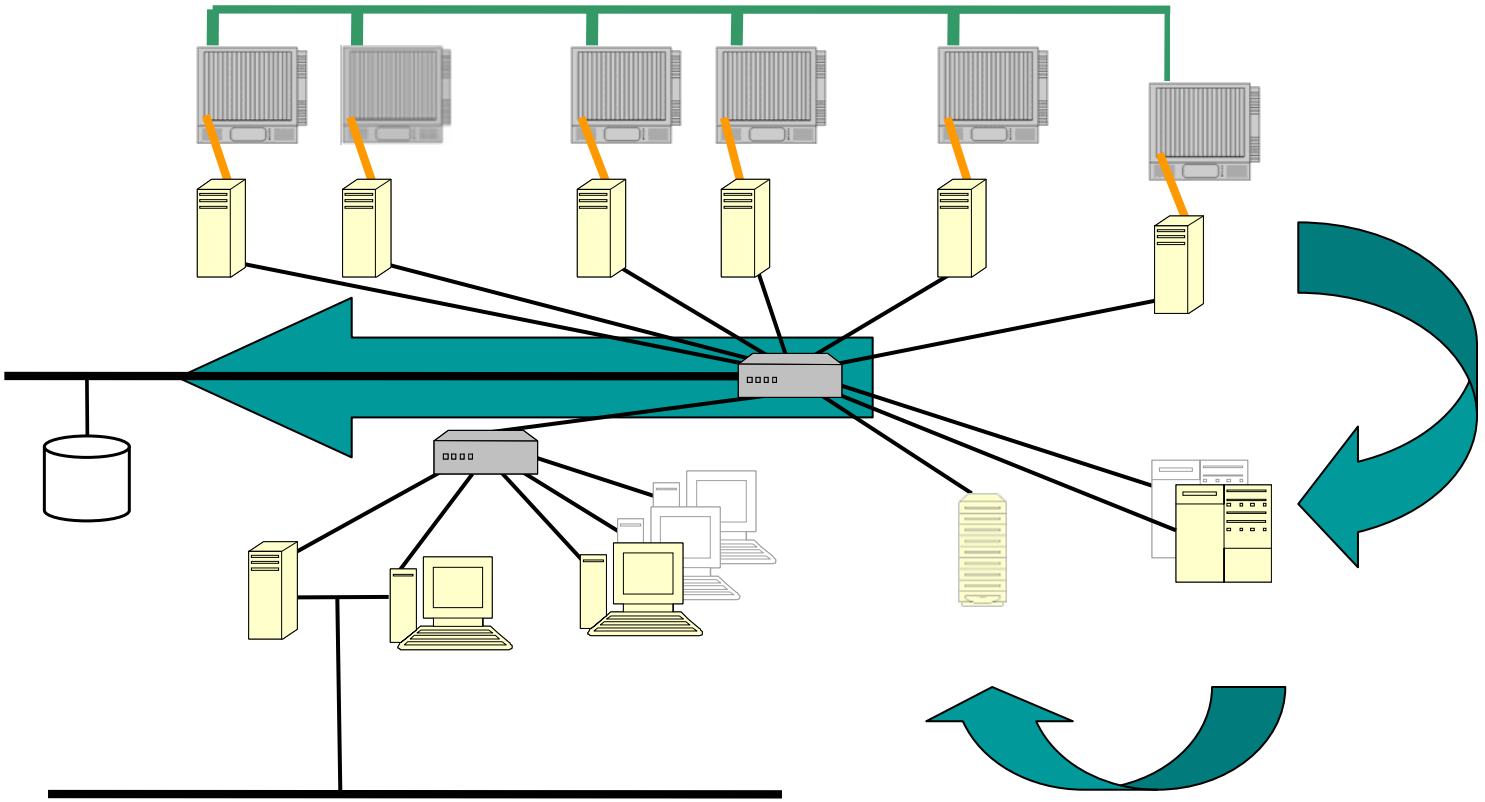


- Newly utilized registers for MICE DAQ
  - 4 registers, each one for each memory bank address of last data word
  - 1 register for number of events in spill
  - 1 register to initiate fast clear of memory banks after each spill

Tracker Readout Status/Summary

- AFE-IIt, VLSB firmware used for cryostat cassette characterization
- AFE-IIt firmware development
  - Package for low rate cosmic ray testing being assembled
  - Firmware for high rate running in advanced development
- VLSB firmware development done

MICE DAQ

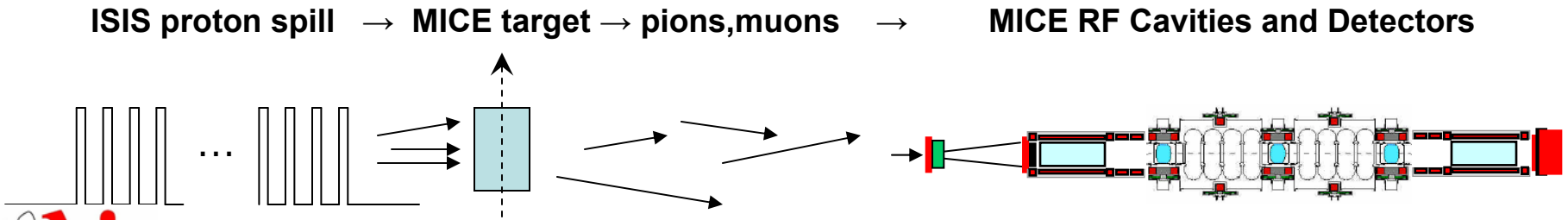


MICE DAQ

- MICE and ISIS Introduction
- MICE Detector Front End Electronics
- Software and MICE DAQ Architecture

Systems for MICE DAQ

- *Target System*: Titanium target inserted into ISIS proton beam produces pions decaying to muons.
- *RF Cavities*: Eight 201 MHz cavities accelerate muons along MICE.
- *DAQ*: Data from MICE trackers, calorimeter, Cherenkov detectors, and time-of-flight counters combined to form MICE events.



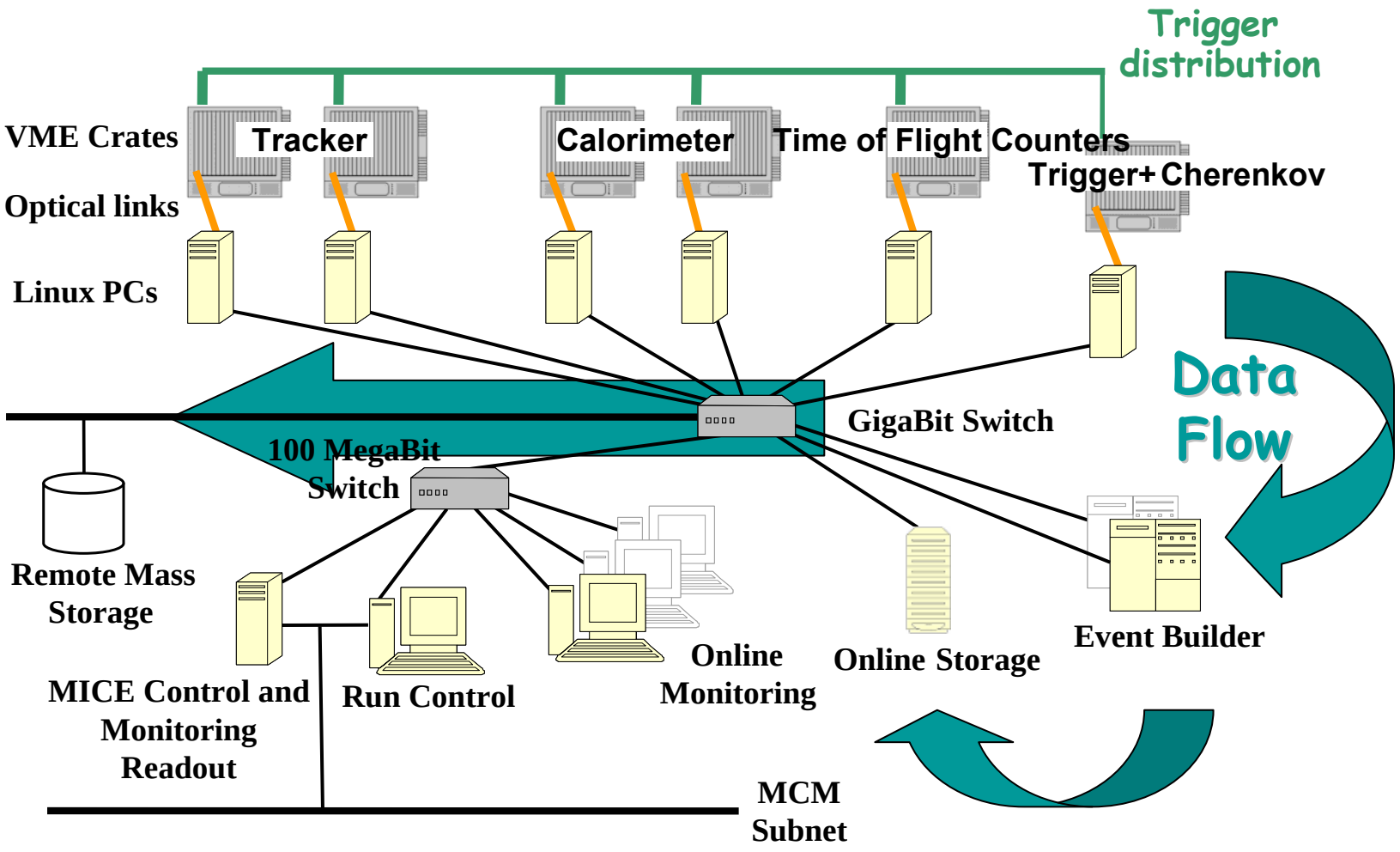
Detector Front End Electronics

- Tracker
  - D0 AFE-IIt boards with firmware modificatons
- Time-of-Flight
  - CAEN V1290 TDC with constant fraction discriminators
- Calorimeter, Cherenkov
  - CAEN V1724 coupled with RC shapers

MICE DAQ Hardware and Software

- MICE DAQ software from DATE framework used by CERN experiment ALICE
  - ALICE = A Large Ion Collider Experiment
  - DATE = Data Acquisition and Test Environment
- MICE detectors read out over VME.
- Online data stream includes variables from MICE Control and Monitoring (MCM).
- Data runs stopped for subsystem fault status or connection problem.

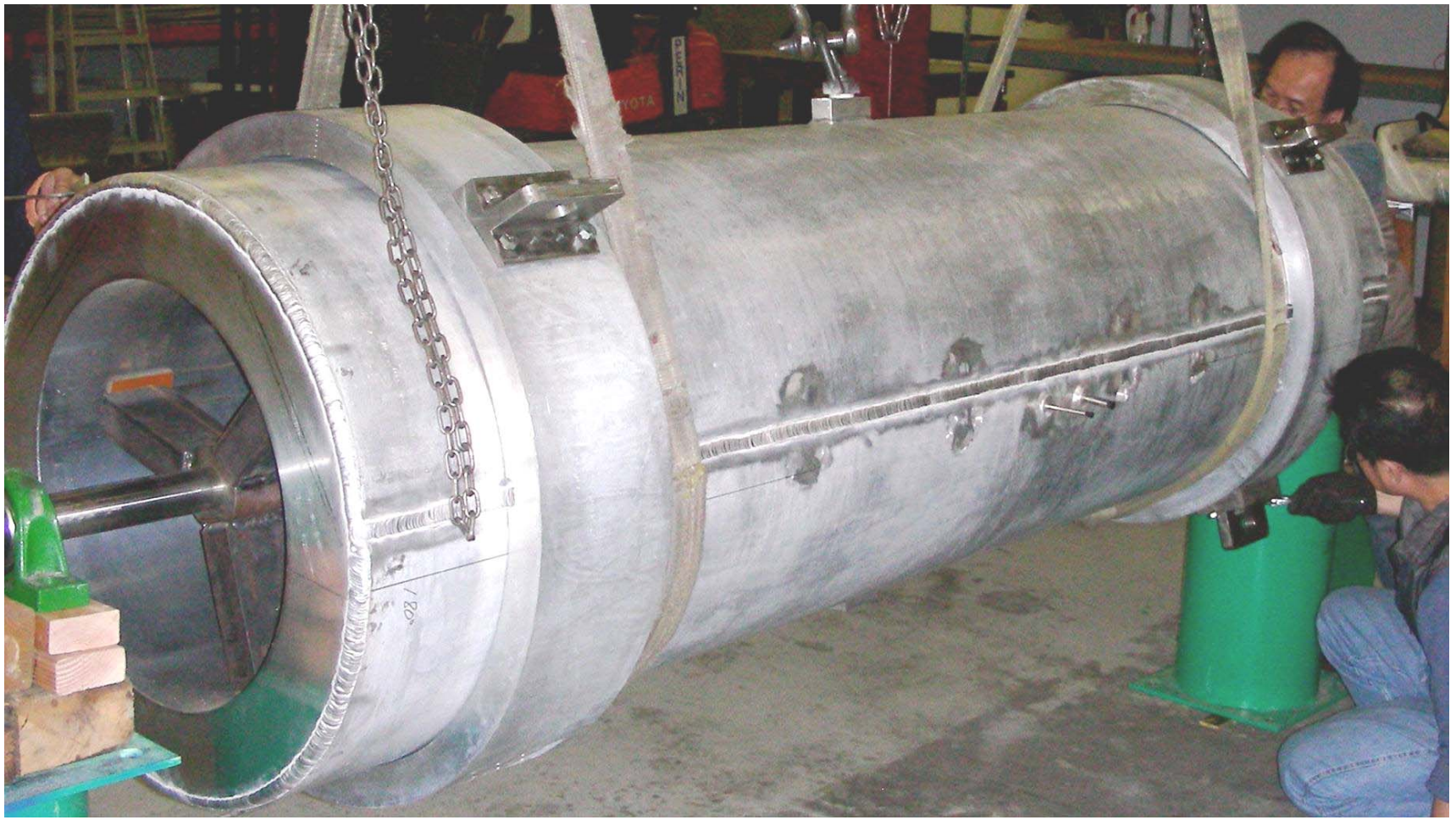
MICE DAQ Architecture



MICE DAQ Summary

- DAQ architecture determined
  - DATE framework
  - Detector FEEs read out by VME
  - Control and monitoring established
- Detector FEEs under development
  - Tracker FEE software modified from D0
  - FEE hardware for calorimeter, time-of-flight counters, and Cherenkov detectors set
- Trigger signals and run modes established
- MICE DAQ ready for initial beam.

Solenoid Magnetic Field Measurement



Solenoid Magnetic Field Measurement

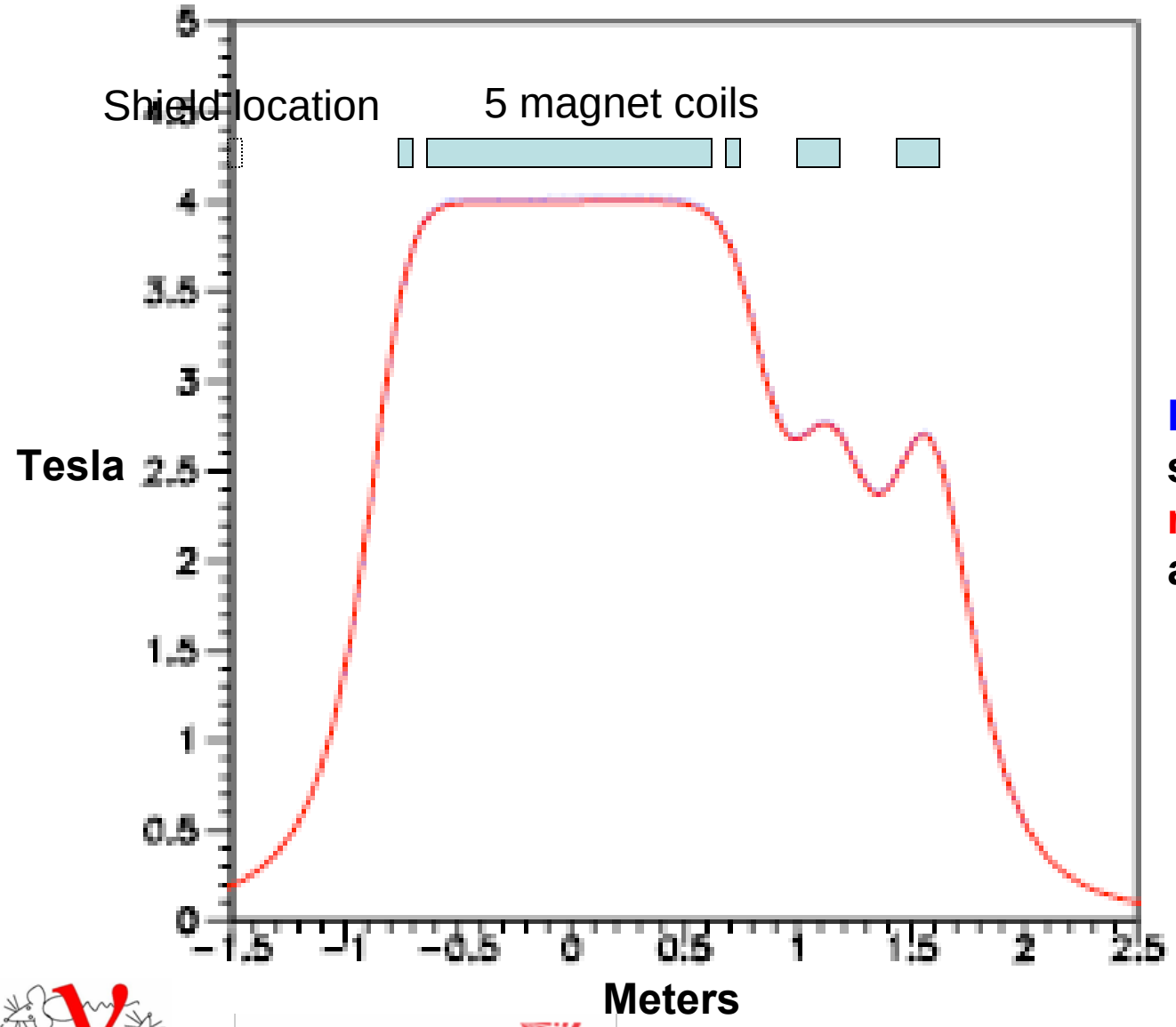
- MICE solenoid consists of 5 coils and iron shield
- First solenoid expected at FNAL for magnetic field measurements in April
- Measurements to be done with ZipTrack system.

Work to Date

- Simulations of field done with
  - Superfish (with and without iron shield)
  - FORTRAN numerical simulation
  - Analytic on-axis solution

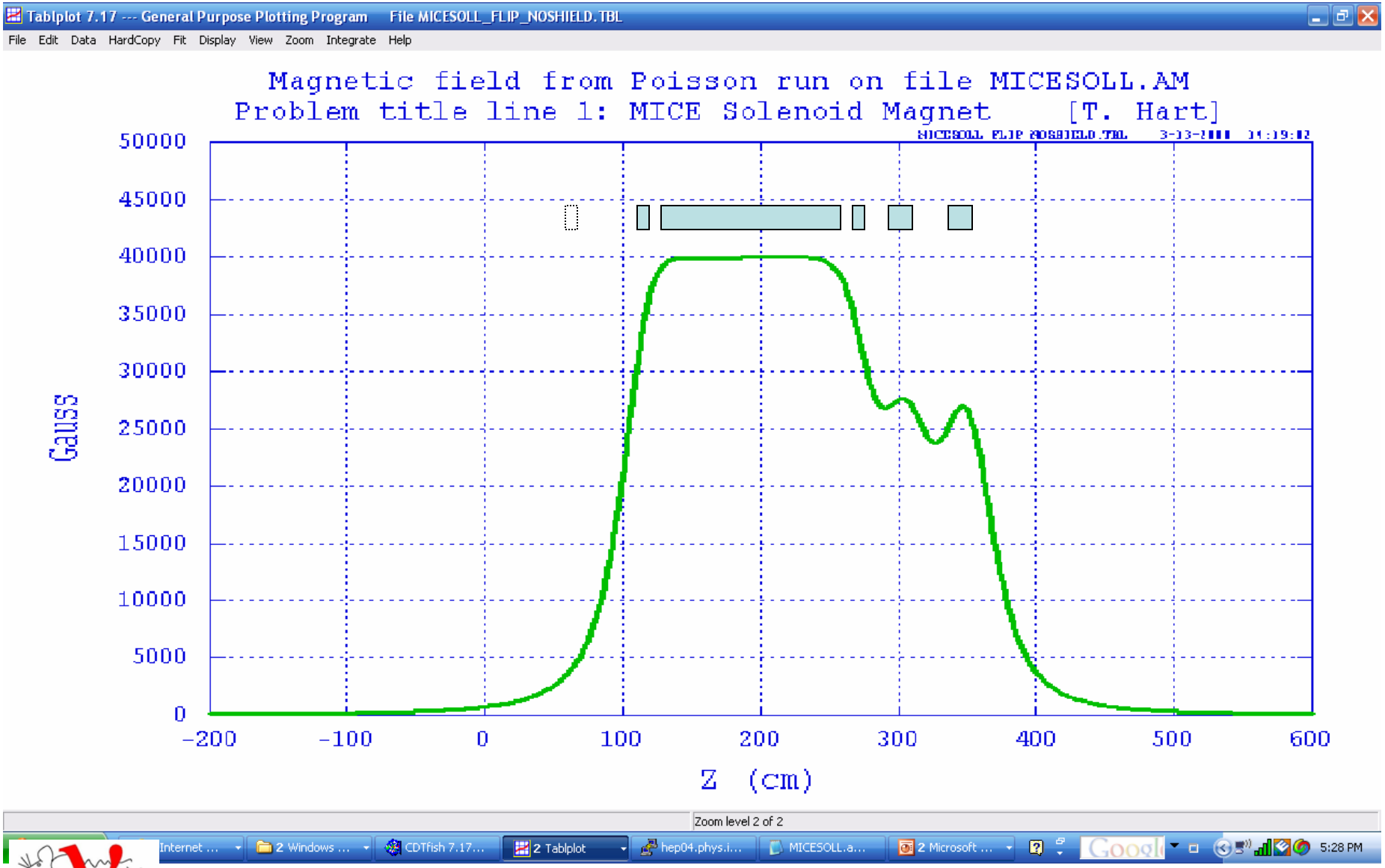
- Meetings with FNAL Alignment Group who will survey magnet and measure field

Analytic and Numerical Simulations of B_z Along Solenoid Axis

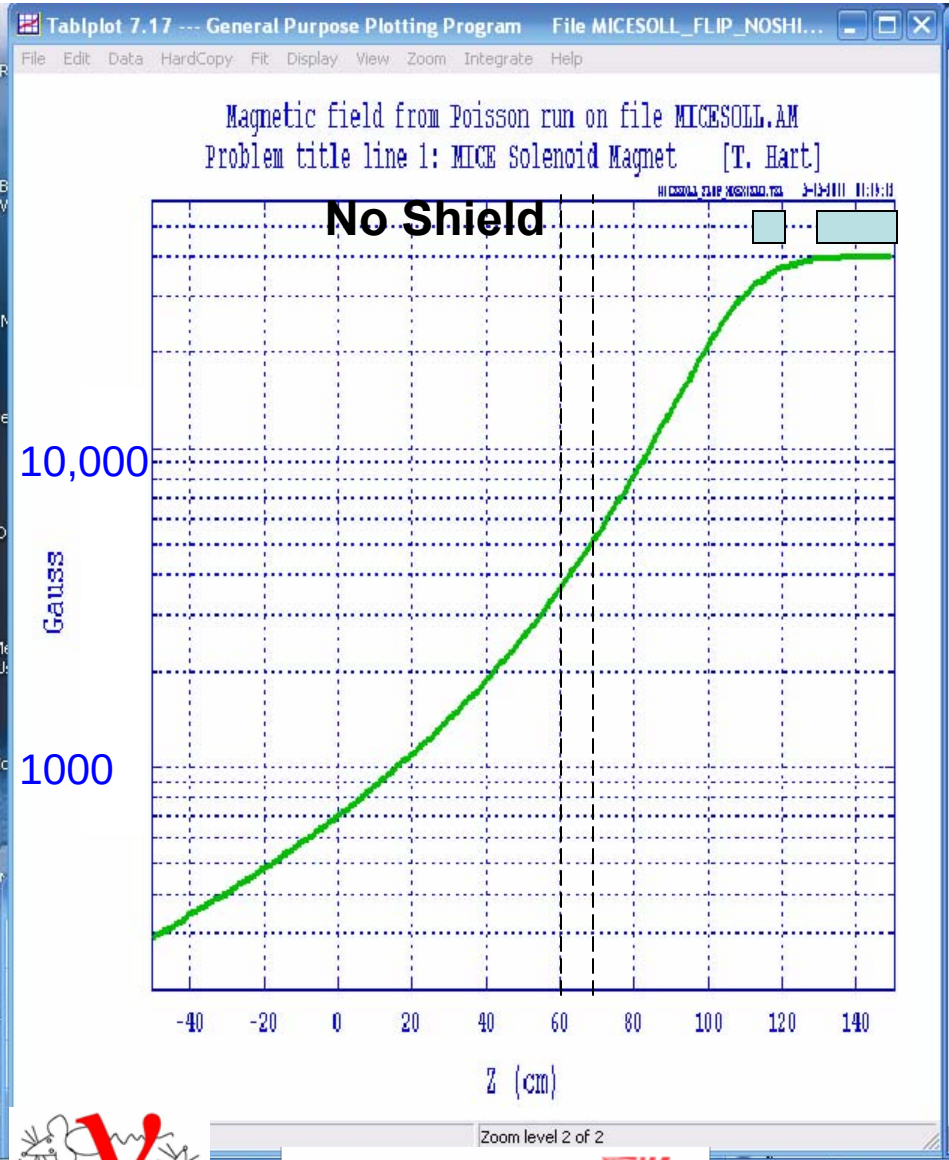


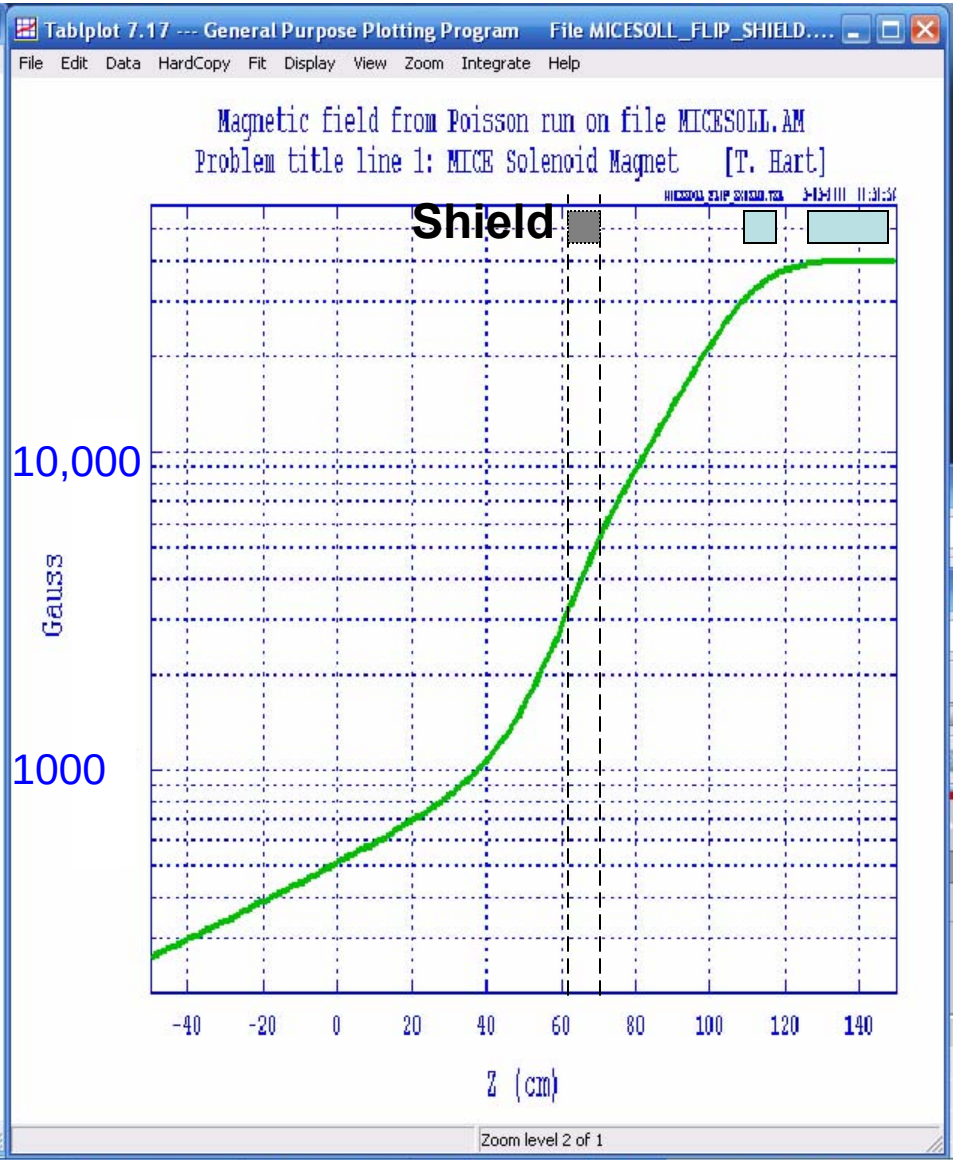
Blue points of numerical simulation hidden by red line on-axis analytic solution.

Superfish Simulation of B_z Along Solenoid Axis



Effects of Iron Shield in Superfish Simulation





Questions/Measurement Plan

- Iron shield affecting magnetic field?
- Measure field beyond ends of solenoid? (where time of flight counters will be)
- Measurement precision sufficient for MICE tracking and emittance measurement?
- Measure field in possible different modes? (different current densities in coils)

Summary

- Tracker firmware for cosmic ray tests at RAL being put together
- Firmware for high rate MICE running well underway.
- MICE DAQ is ready for initial MICE beam
- Spectrometer field measurement and simulation program getting started