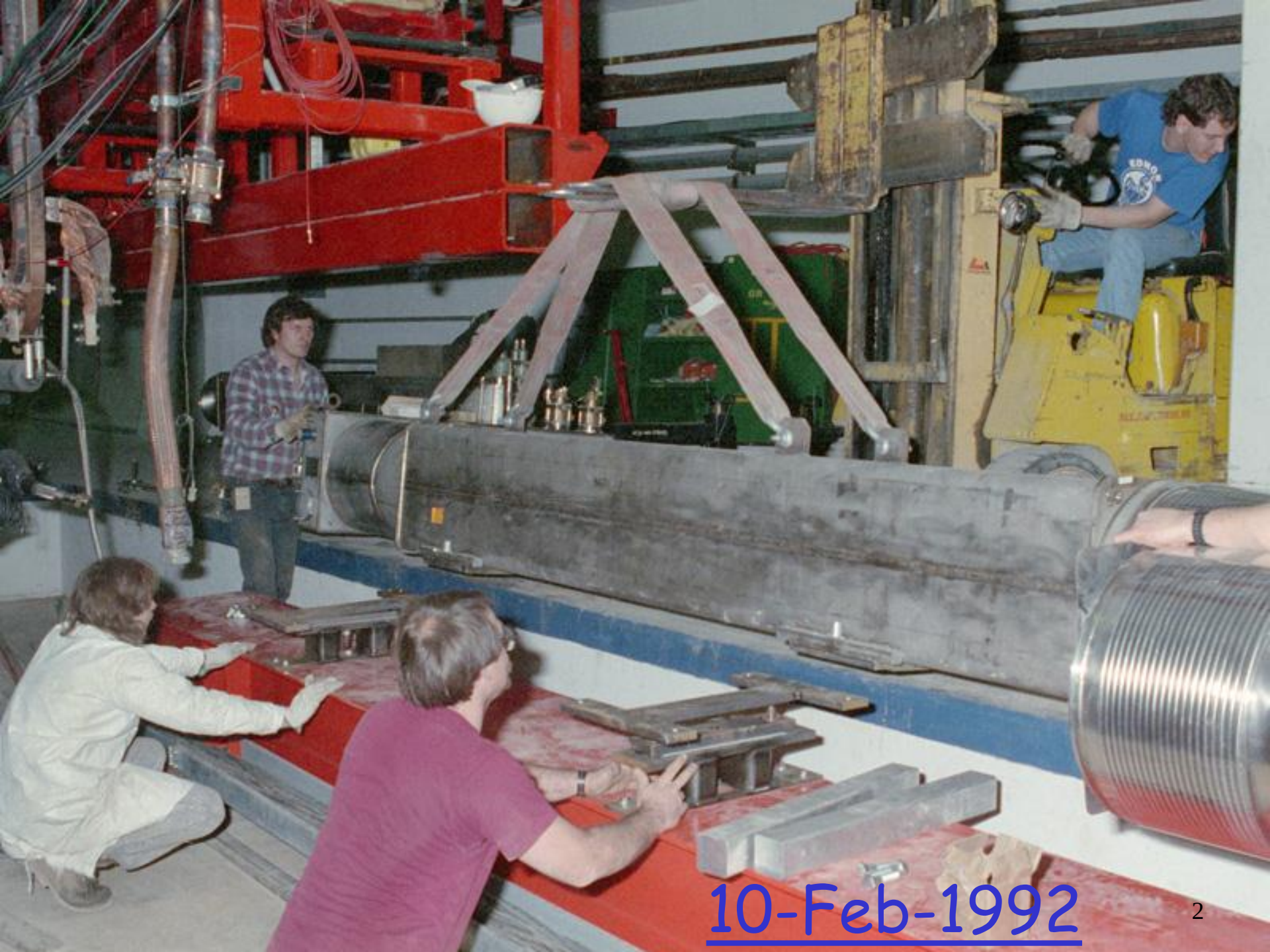
Maintaining and Operating the DØ Detector

George Ginther
Fermilab and University of Rochester
10 June 2014



10-Feb-1992

Selected Highlights of DZero Run I Detector Operations

M. Tartaglia

Some recollections strongly influenced by my logbook and operations notes

(and "Top DOG" cartoons – see "Top Turns 10")

Run I Overview

- DZero Test Beam (NWA) [Dan Owen, Paul Draper]
  - Loads 1,2 Calorimeter Calibration, Muon, FDC Trigger/DAQ/Host System Integration, Offline Reco
  - End Calorimeter Assembly in IB4, in parallel

1989-92

- Detector Commissioning [Jim Christenson, Ian Manning]
  - Roll-in ("sung to the tune of Rawhide") Feb Cosmic Rays
    - Intense efforts on L1,L1.5,L2 Triggers, Host/Logging, Control/Alarms
    - Intense wave of Acronyms: SAMUS, WAMUS, GURU*, GEEK**
    - CALIB, CAHITS, L2EM, FATMEN, COOR, COMM_TKR, EXAMINE
    - Tiger Teams Visit Fermilab (May '92)
  - Run 1a Colliding Beams
    - Collider studies May 12, Collab Mtg in June, Run 1 begins August 31
    - Trigger menu Evolution [Trigger Panel, TriggerMeister established]
    - Rates to match steady increase of luminosity
    - Continuous hardware, online and offline software improvements
    - SSC De-Funded (June-Sept '92)
    - Ian Manning moves on, John Butler steps up (Oct '92)

1992-93

*Grand Universal Repository of Understanding;

**Global Expert of Expanding Knowledge

Run 1a first collisions

124

Preparing for Collisions

June 16, 1992

At Onset of Shot Setup
- Reduce high voltage on CD, Muon chambers
- Ensure that magnets are on at full current, correct polarity

During Shot Setup
- Stop individual takers
- Cleanup LBUF disks
- Check raw data tape supply
- Review/reset all alarms
- Check Main Ring signals
  - (MR_CYCLE,MRBS_LOSS,MICRO_BLANK)
- Do global test run with Step_A triggers
  - test readout of all crates
- Setup and define triggers for data taking

Once Shot is Setup (and scraping complete)
- Set all high voltages to nominal
- Set clock to normal mode, clear errors
- Start run, no recording
  - set prescales, verify trigger rates
  - document trigger
- Check cogging
  - measure BPM relative timing
    - print screen
    - extract crossing position
  - measure L0 qvt relative timing
    - extract mean collision position
  - verify that COGSUM is correct
  - verify that cogging is correct
- Measure beam losses
  - (E:D0MRT/B,E:D0TVP/PB)
  - plot, record losses through scraping
  - compare with previous stores
  - feedback to MCR if warranted
- Record luminosity
  - six bunch intensities similar?
  - satellite bunches small?

Commence Run
- (turn on recording)

Shifts organized into stations staffed by experts:
muon & calor, vtx & trd, daq/controls, fast offline analysis, cryo ops, captain to coordinate w/accelerator

Luminosity rises to
1 10^{30} end September
3 10^{30} mid October
7 10^{30} mid December ‘92
“shit has hit the fan”
“Expect 10 10^{30} by Xmas”

Focus on finding Ws&Zs measuring electron and muon trigger efficiencies

Run 1b

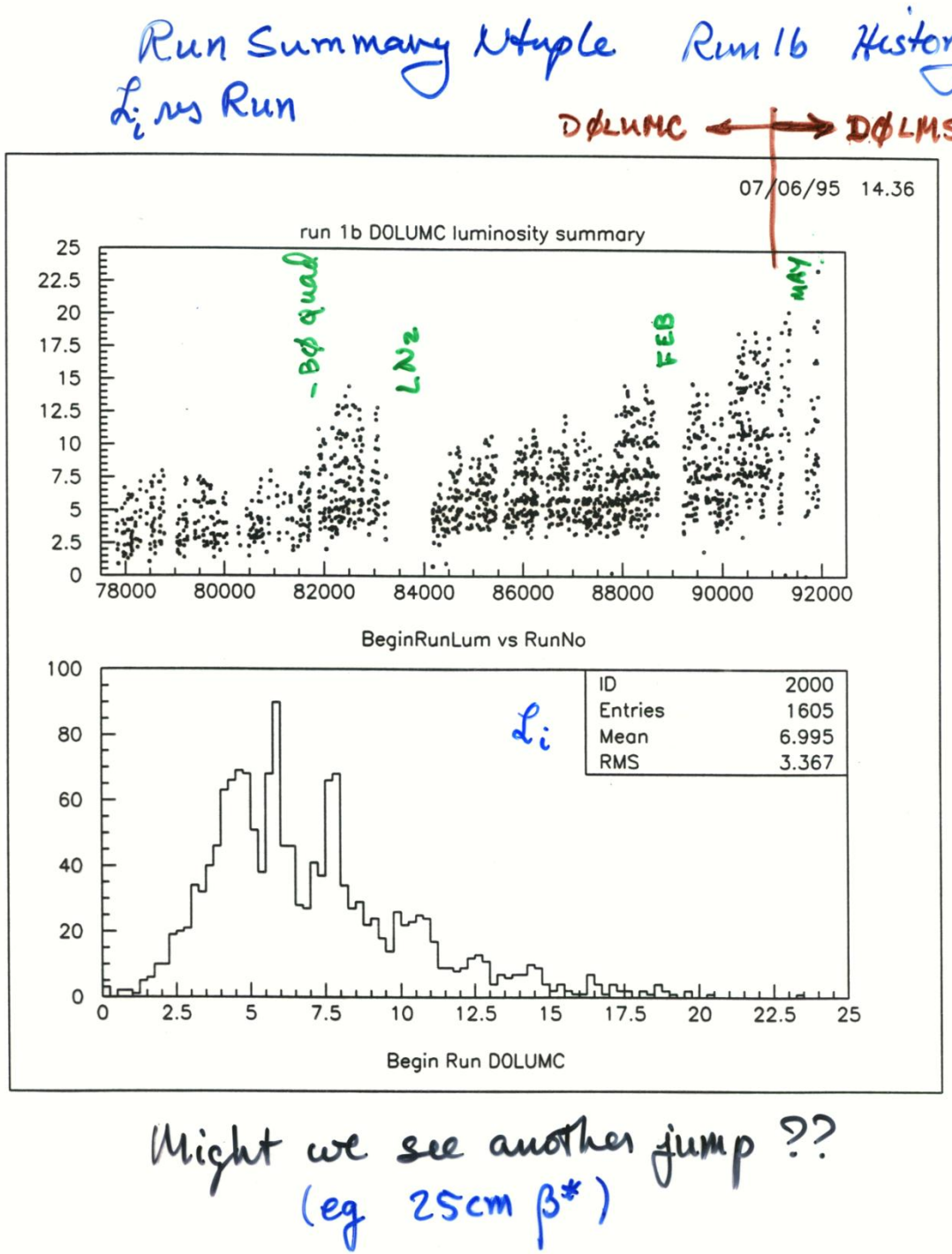
Late ’93Early ‘94 Shutdown for accelerator, detector improvements
[J. Butler heads operations]
Run 1b collider operation begins in February 1994

- Luminosity is low for months, Tev experts struggling to understand
  Online CDF Lum is 25% below D0, with asymmetric Z-distribution
- Finally (late June ’94) survey of B0 low beta quads:
  discovery of 25 mrad rolled quad!
- Tev Experts report immediate improvement in machine behavior and performance

❖ Now DZero online Luminosity is 10% below CDF (is it real??)

- MT becomes operations coordinator in ~July ‘94
- Focus on luminosity, a complicated subject, is *constant*
  - Lack of accelerator diagnostic instrumentation
    - What is actual Beta*? (start developing “synch light mon”)
  - DZero convinces AD to perform some separated beam studies
    ~beam-beam tomography to measure σ^2 vs Z (fn of β,ε)
  - CDF tries to measure σ of vertices with SVX – difficult in run 1

Run 1b Luminosity



1994
Rolled CDF Low Beta Quad

Tevatron shuts down due to shortage of LN2

1995
February, May shutdowns

Top Quark Discovery
Announced March 3, 1995

Online Luminosity monitor improvements, low beta study (35 → 25 cm)

Sep.Beam store each case:
β^* $(V, H)_{35}$ ~ (35, 45) cm
β^* $(V, H)_{25}$ ~ (25, 35) cm
At DZero

Run 1b, continued

Operations teams were constantly focused on maintaining efficiency of the detectors, tracking problems and losses of efficiency, keeping repair accesses short and effective; Trigger Control Board, continuous evolution

Muon Detector: Efficiencies and Live time

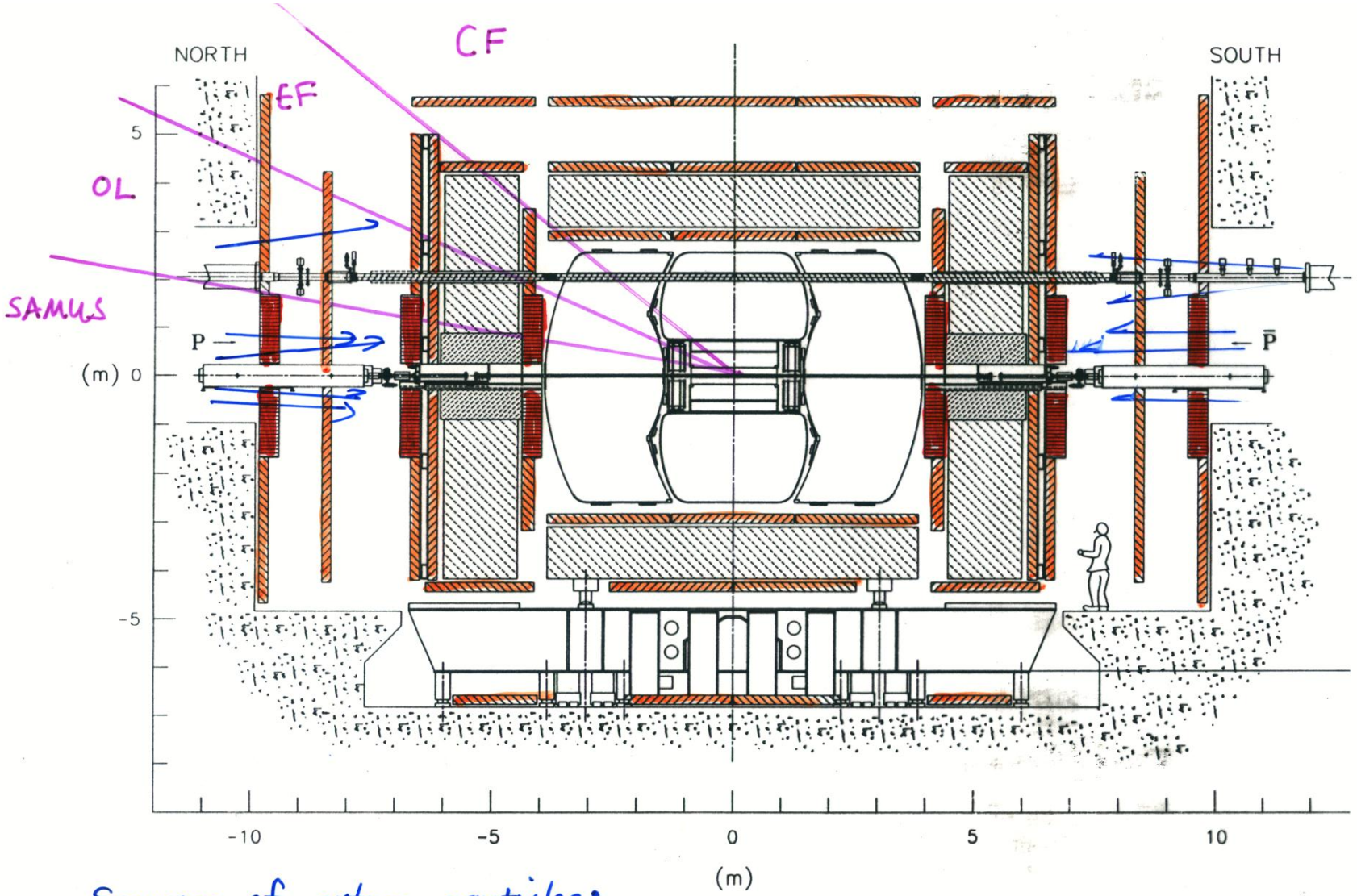
- A continuous campaign since early in the collider run
  - Gating of Main Ring (pbar production "29 cycles")
  - Understand effects, develop solutions ("zapping" to remove buildup of radiation-induced polymerization of anode wires)
  - Electronics Improvements
  - Study Shielding around Low Beta Quads
    (CDF has this, DZero does not)
- Difficult Negotiations with AD, CDF
  - for access, shutdown time to effect improvements at DZero
    Versus running to accumulate luminosity and data
  - Strong Physics Case was pitched to laboratory management
  - (excerpts follow)

An Integrated Approach to Improving Non-Central Muon Physics at DØ

- Improve efficiencies of non-CF chambers
  - electronics fixes
  - shielding effects

- Improve livetime
  - HV trips
  - shielding effects

All Expts Mtg.
11-July-1994
D. Wood



Sources of extra particles:

- TeV halo
- Main Ring
- Radioactivation
- $\bar{p}p \rightarrow$ high η scatters

Problems related to beam backgrounds

- degradation of muon chamber efficiency
- spurious hits in muon chambers
  (combinatoric background)
- increase in muon trigger rates
  (single muon trigger is presently
  prescaled for $\mathcal{L} \gtrsim 8 \epsilon 30$)
- HV trips
  (largest single source of DØ downtime)
- ageing of chambers & muon scintillator
  PMT's.

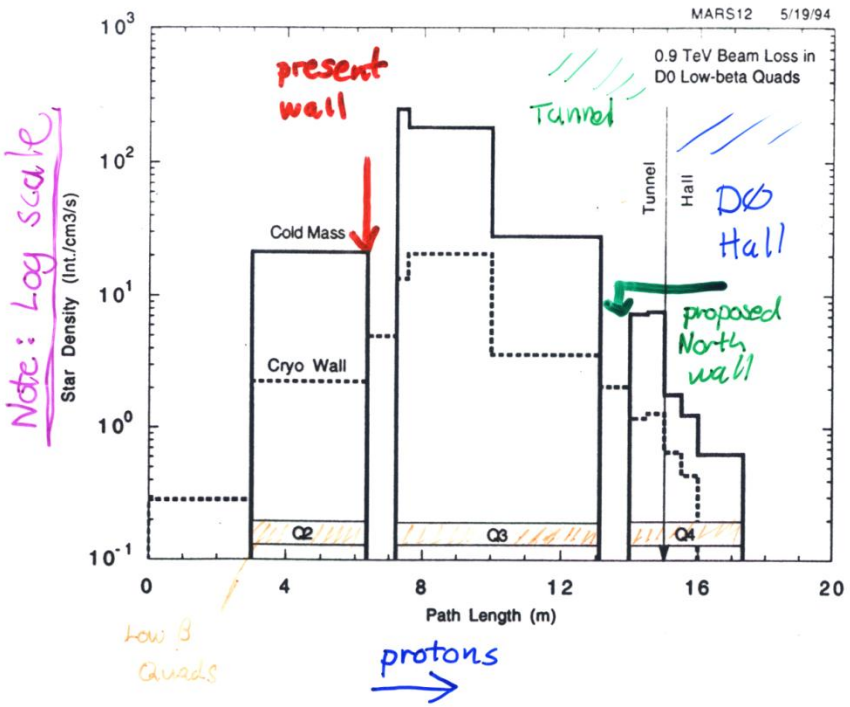
Event Yields

Effect of improving EF efficiency
(to same level as CF efficiency)

Physics signal	Relative increase in acc·eff
$W \to \mu\nu$	~30%
$Z \to \mu\mu$	~25%
$t\bar{t} \to e\mu + X$	~15%
$t\bar{t} \to \mu\nu + \text{jets}$	~30%
$t\bar{t} \to \mu\bar{\mu} + X$	~25%
$t\bar{t} \to X + b \to \mu$	~15%
inclusive $b \to \mu$	~100% in $1 < \lvert\eta\rvert < 1.7$
$b \to \psi X \to \mu\mu$	>100% in $1 < \lvert\eta\rvert < 1.7$

+ improved systematics

Tevatron Beam Loss Simulations
(Nikolai Mokhov - AD)



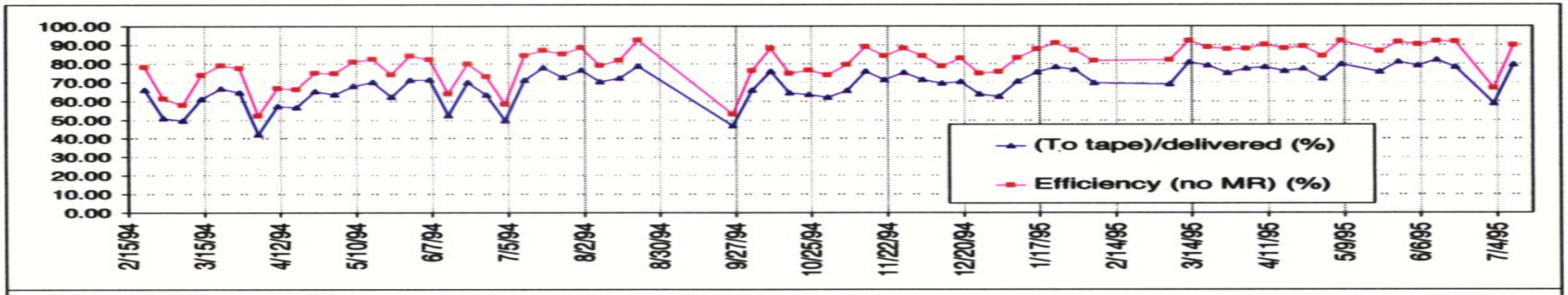
Estimated flux reduction for new 1.5 m wall:

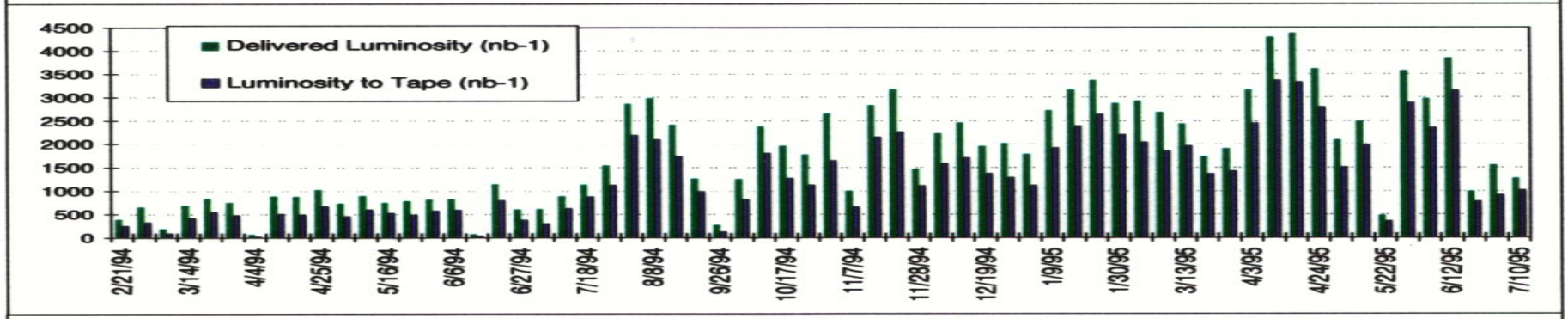
particle type	flux reduction factor
soft neutrons	~6
soft $h^{\pm}$	1.5 - 3
hard $h^{\pm}$	2 - 10
$e^{\pm}$	~10

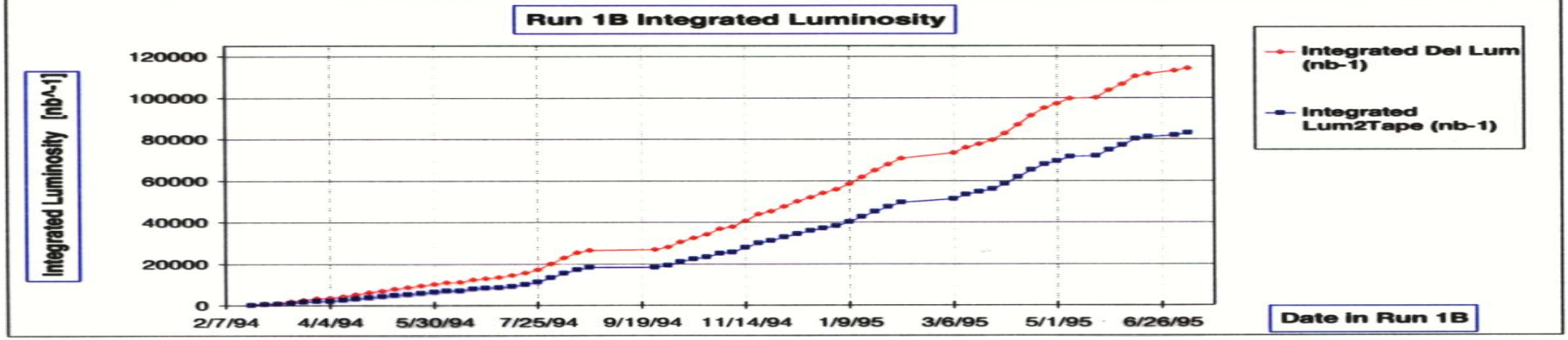
Run 1b Lum, Effic. Monitoring

DO Weekly Statistics			10-Jul-95	to 17-Jul-1995
stores	5599.0	*to*	5610.0	in Run 1b
				DAYS LEFT = 7

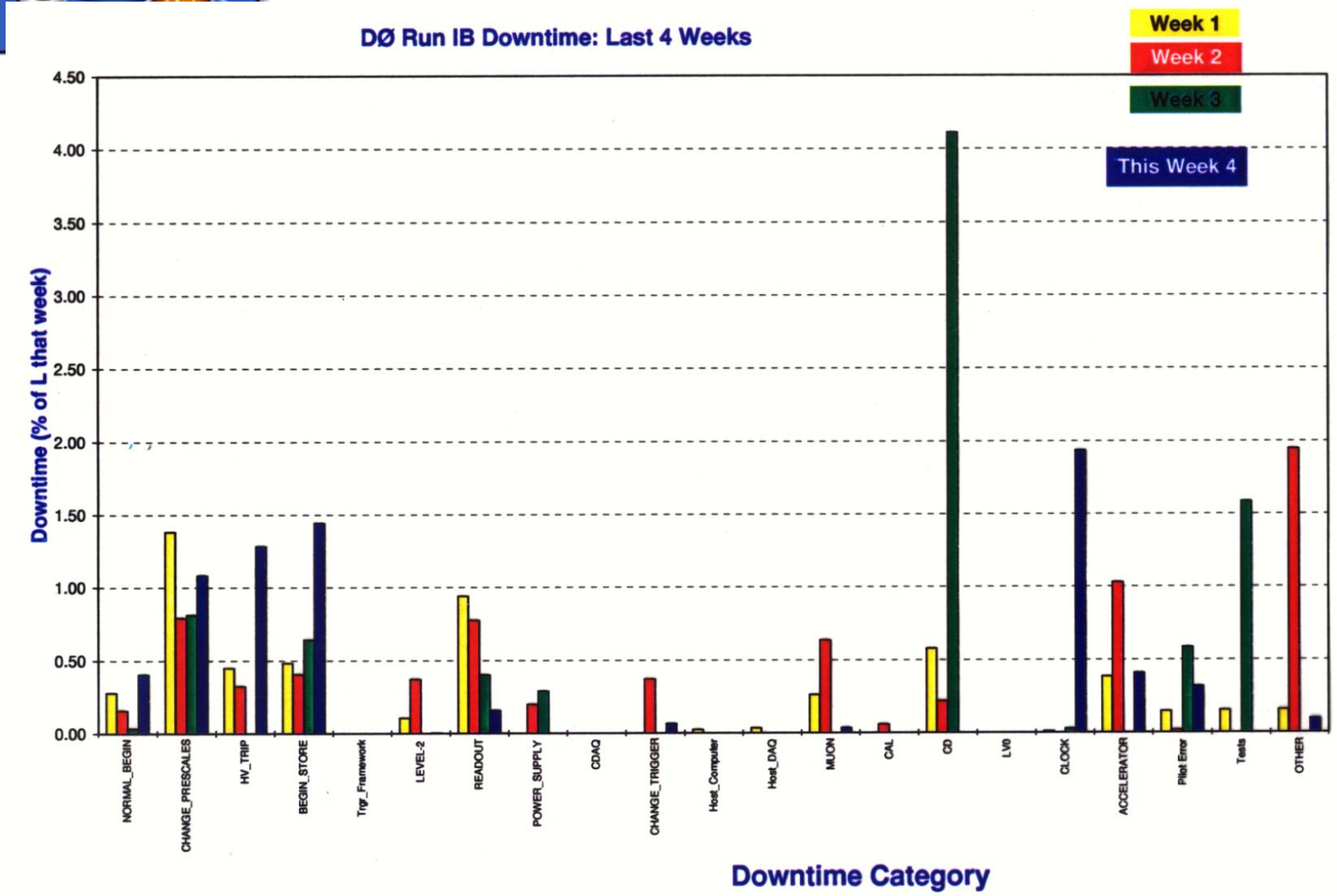
Period	Delivered (pb^{-1})	On Tape (pb^{-1})	Efficiency (%)	Efficiency, No MRBS (%)
Last Week	1.27	1.01	79.6	89.9
Run IB	115.66	83.29	72.0	90.1







Run 1b Lum, Effic. Monitoring



mat - 3:03 PM 4/10/95

End of Run 1b

D-Zero Operations

7/24/95
M. Tartaglia

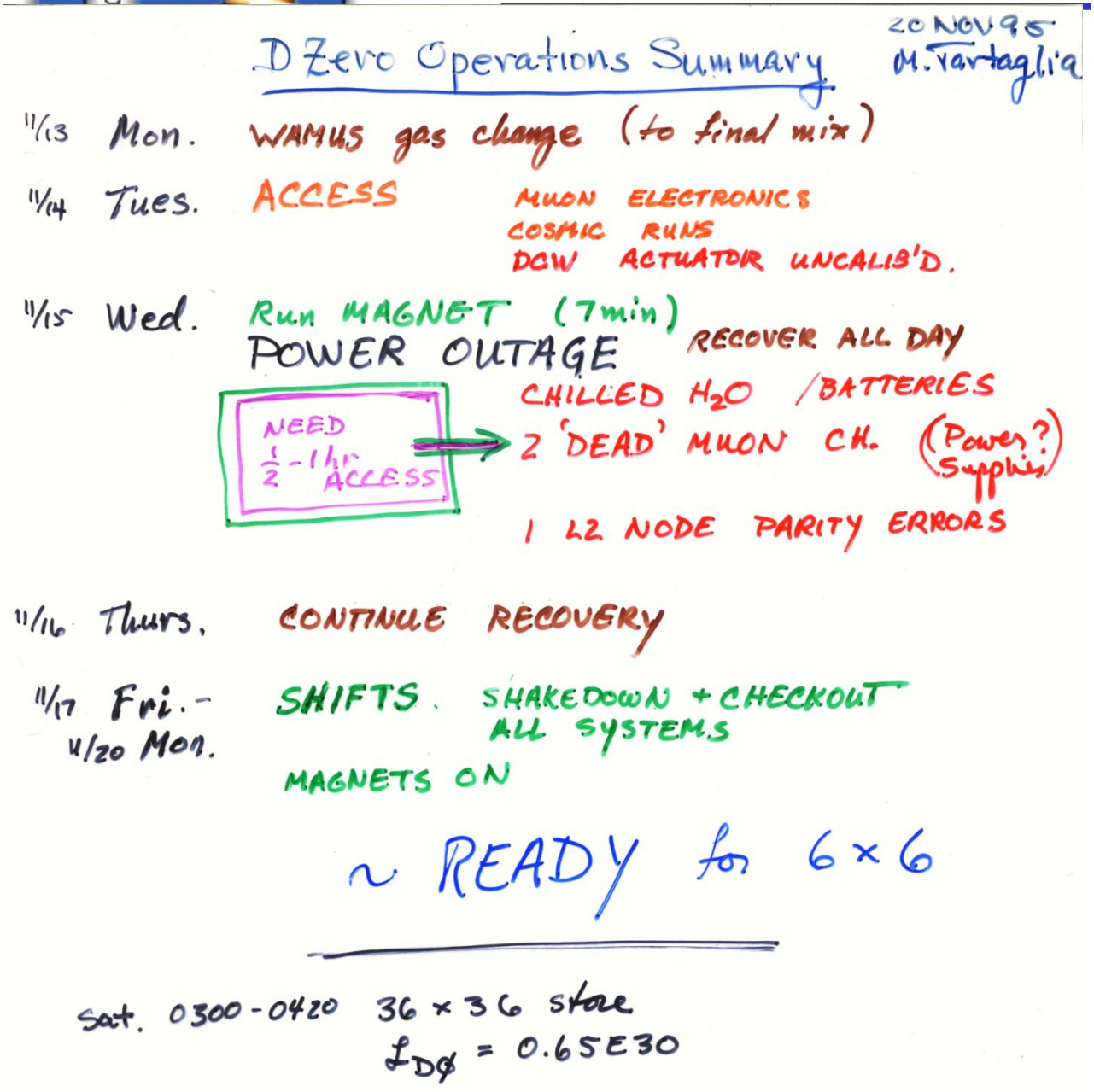
Data Taking For Run 1B is COMPLETED!

We appreciate EVERYONE'S HELP making this a VERY SUCCESSFUL RUN!

Highlights of the last week:

- LITTLE DOWNTIME
- PHYSICS DATA
- LOW-IMPACT TESTS
  - L2 FDC+CDC+VTX HITFINDING
  - $\mathcal{L}$ STUDIES

Start of Run 1c



Typical Startup…

Run November ’95
To Feb ‘96

Physics groups focus on getting data samples needed for calibration or systematics studies

900 x 900 and
315 x 315 running

More investigation of D0/CDF luminosities (D0 down 10% more at 630 GeV; AD fixed it!)

Internet, WWW take off!

End of Run 1

Joan Guida
2/19/96

DØ WEEKLY STATUS REPORT
Feb 12-19, 1996

Problems:

DØHSC crashed - memory failure.
Lost 1 disk used for staging events before writing to tape.
Many problems with tape drives/controllers.

THANKS to everyone for the productive run.

Roll out, to begin DZero Upgrade

DZero Rollout 26 Feb 96 mt

DAY 1 Tue

FINAL DAQ CALIBRATIONS W/ Beam OFF
Collision Hall Rad Survey
Muon Alignment
μ shield disassy.
Muon gas OFF, CD gas flush
LAR Xfer: Preparations
Disconnections Begin
EMC, MR veto, Accel T,Θ, ...

Day 2 wed

CC Liq Argon Purity (Noise/Measmt)

Day 3 Thu

Platform, MCH Power OFF
chilled H_2O OFF

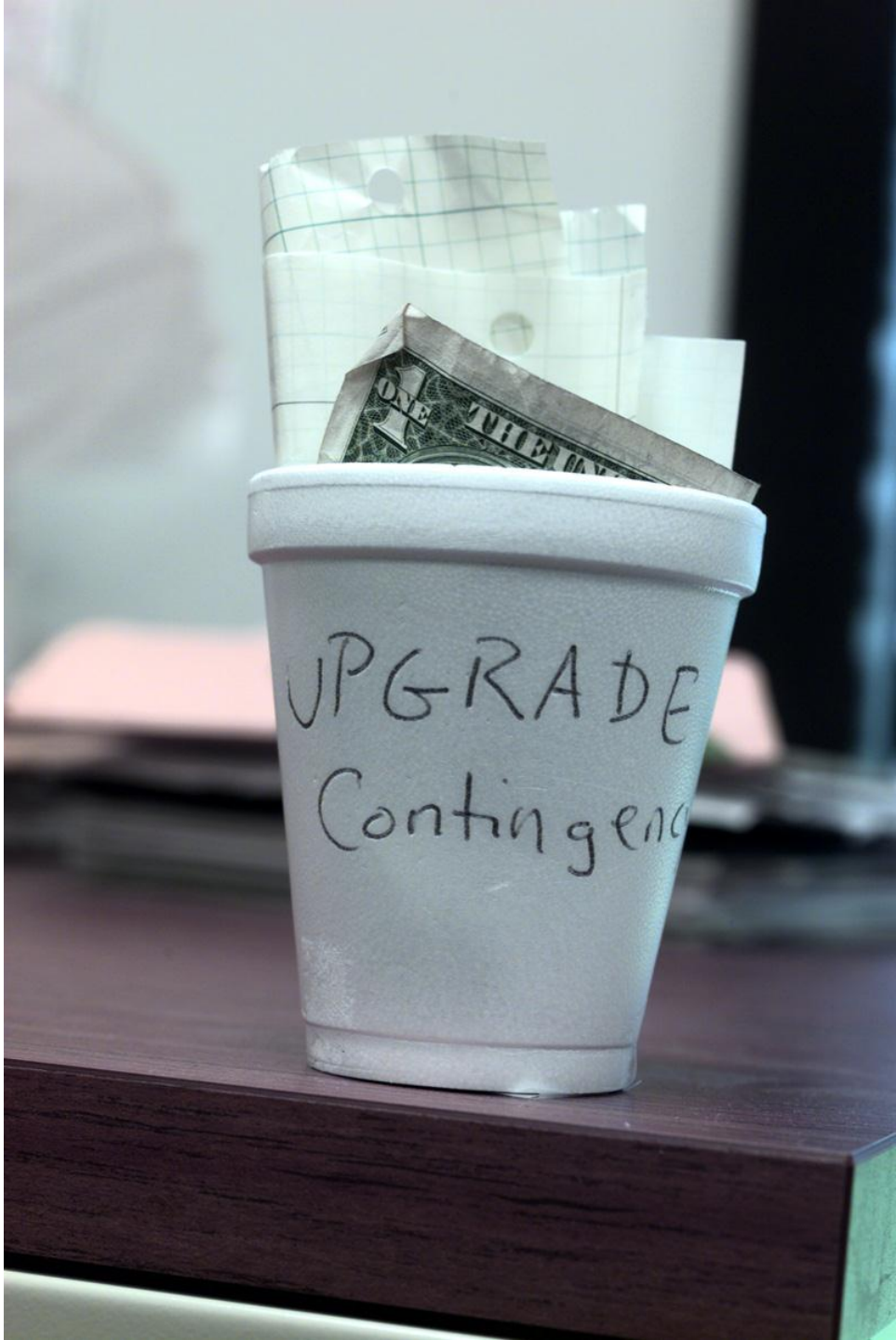
Begin LAR transfer to dewar (2days)

Begin Shield Wall Conduit Removal.

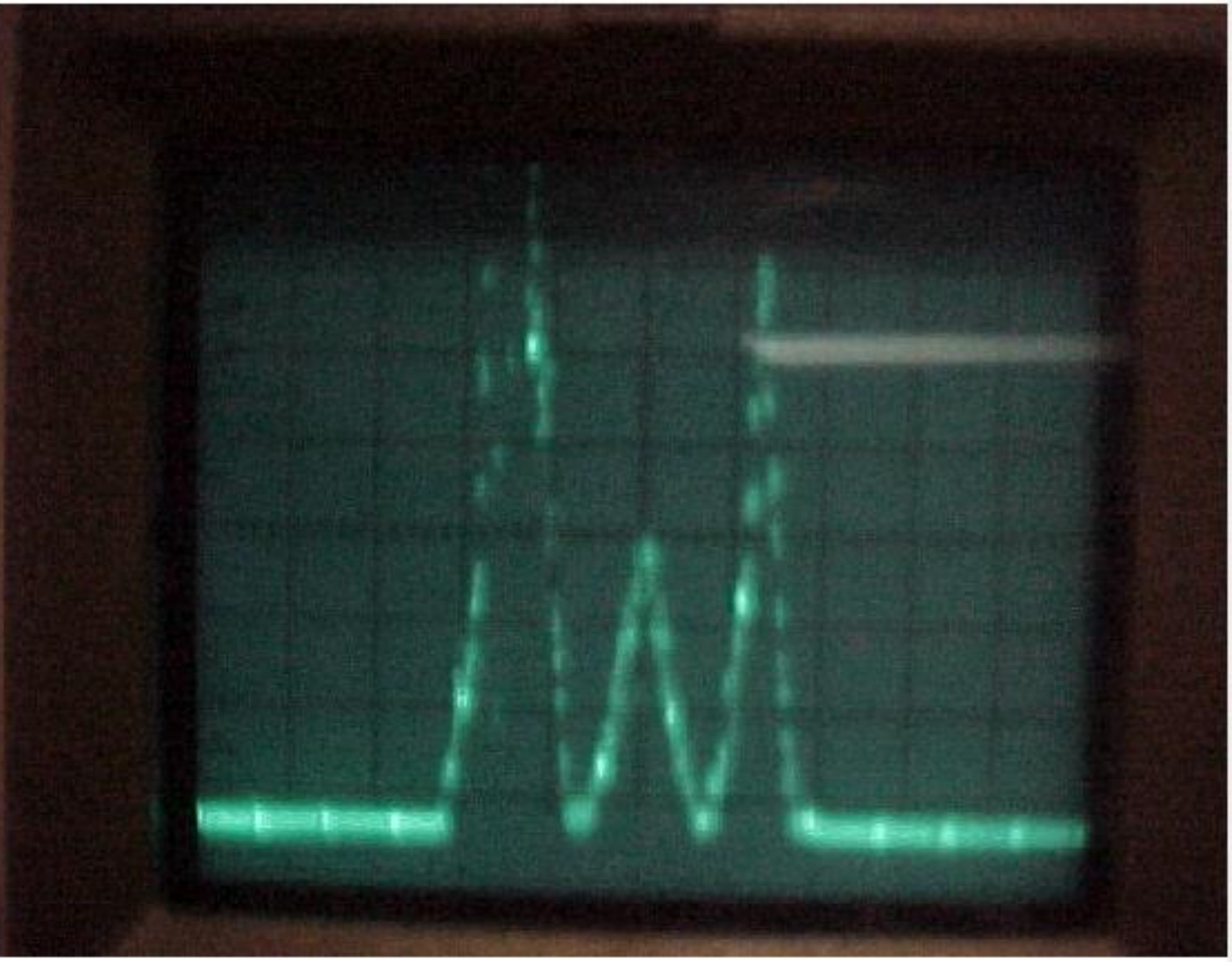
Run II

36 x 36

1.96 TeV



First pbarp interactions at 1.96 TeV
8 October 2000
(photo by Michael Begel)



80 nb^{-1} integrated lumi during the 2000 engineering run

DØ Detector consisted of Run 1 luminosity counters and a few instrumented Roman pots

DØ Status

Timing

- We timed in the Luminosity Monitor using coalesced single proton bunches.
- The rest of the detectors will be timed in with the 1×8 stores.

SMT

- $\approx$ 40% low mass cables hooked up
- Full readout chain:
  - 25% barrels
  - 17% F disks
  - 12% H disks
- Just starting to read out multiple ladders and wedges.

Calorimeter

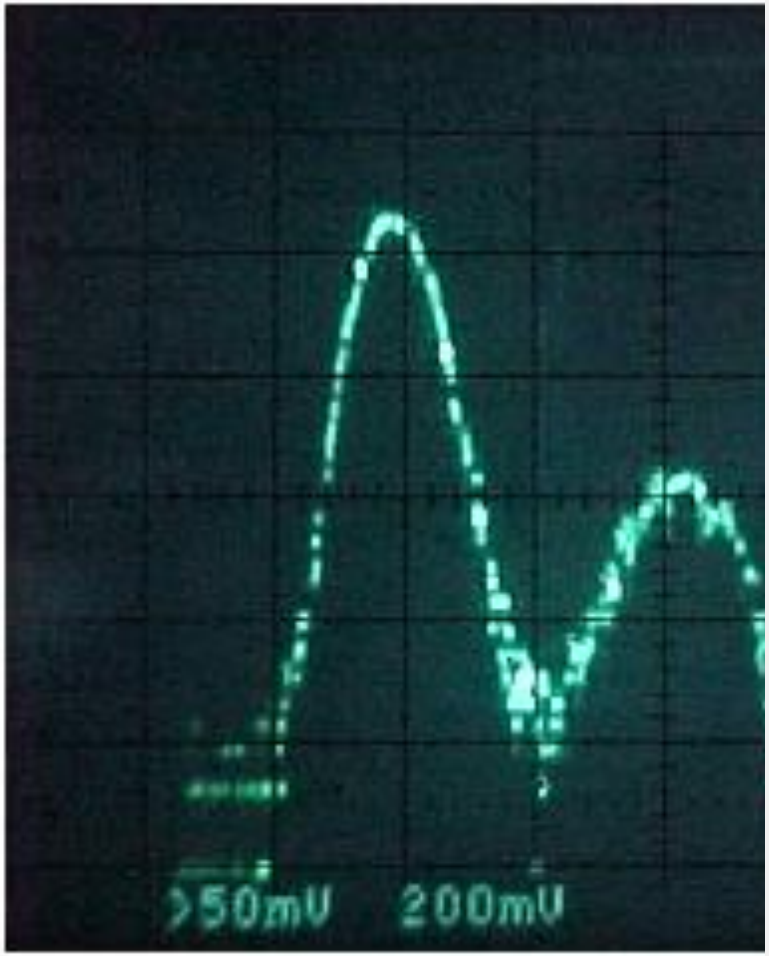
- All preamps, ADCs, and T&C in and powered
- CC fully commissioned
- 3/4 EC BLS electronics installed
- 1/8 instrumented with trigger summers

Muon

- Mostly Complete (gas & HV)

CFT

- 5% instrumented with stereo boards



First collisions in the Run II DØ detector

April 3, 2001

SMT chillers

AFE Test Stand

VRB in the Moveable Counting House

Maintaining the A-phi counters

A Challenge We Wanted

- Increasing instantaneous luminosity required ongoing trigger development
  - The trigger crew regularly updated the trigger to facilitate efficient selection of the events of interest in the changing environment
  - And resulted in unfortunate consequences
    - Radiation damage
      - SMT (HV adjustments)
      - Fiber Tracker (Electronics Improvements)
      - Increasing bias current in the calorimeter
      - Lumi monitor (Electronics adjustments and scintillator replacements as necessary0

A Few of the Unrequested Challenges and Scares

- Noise
  - Major efforts to hunt the sources of noise
  - Toroid, Ring of Fire, Purple Haze , Spanish Fan
- Liquid argon level alarm
- AFE heater incident endangers VLPC cassettes
- VLPC lid heater incident
- Solenoid quench coming out of 2004 shutdown
  - Intensive investigation leads to conclusion that coil had a joint which had gotten progressively worse with each thermal cycle above liquid nitrogen temperature
  - Reduced nominal operating current from 4750 to 4550 Amps
  - Monitor resistance during solenoid ramps
  - Minimize power cycles by arranging for powered access
  - Avoided raising coil temperature above 80K
  - Prepared for possibility of increased liquid helium cooling capacity

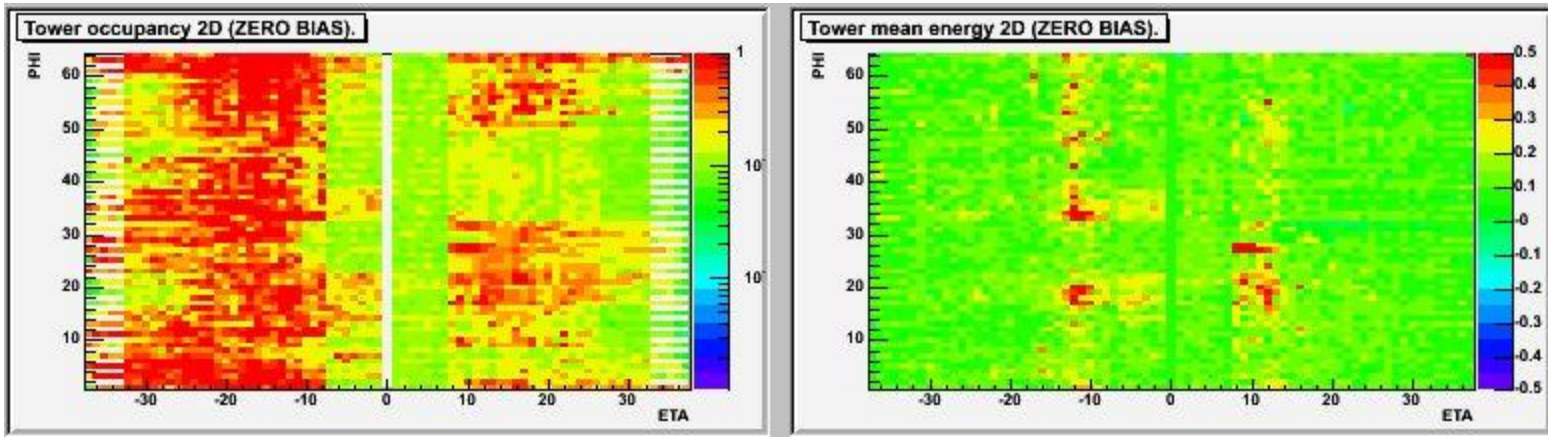
Environmental Related Challenges

- Controlling environmental conditions in the collision hall, moveable counting house and control room was a regular seasonal challenge
  - Humidity
    - Muon PDTs HV distribution was particularly sensitive to humidity
    - Ongoing battle to reduce sensitivity
      - Cleaning HV distribution
      - Dry gas purges
      - Stabilizing humidity control in the hall
    - Eventually discovered that PDT HV trips could trip off SMT
  - Floods/water leaks
    - Leak detectors
      - One leak over SCL hub resulted in subtle damage to the busy signals
  - Smoke (from prairie burns or electronics failures or microwave mistakes among others)

Run IIb Upgrade and the 2006 Shutdown

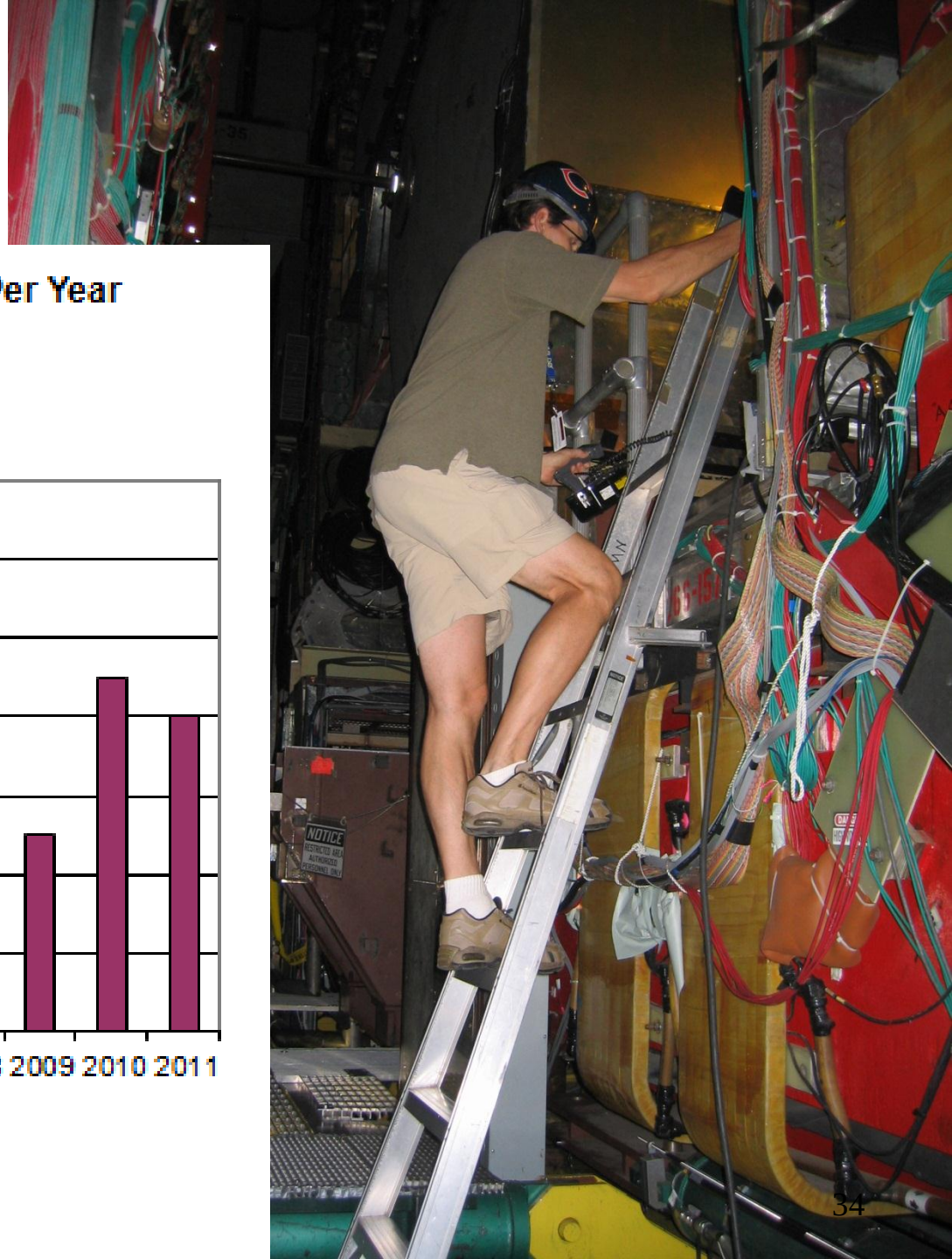
- Layer 0 provides additional layer at small radius
  - Improving impact parameter resolution
  - Based upon R&D for the cancelled Run IIb SMT
- Level 1 CTT and Cal Track Match upgrades improve fake rejection capabilities
  - Note that implementing Cal Track Match would require increased trigger latency
  - This had unfortunate and unanticipated consequences
- Level 1 Cal provides enhanced object ID and sharper turn-on curves
  - Just in time pre-commissioning provides excitement
- AFE II to improve fiber tracker and preshower readout (including improved stability and TDC capability)

Calorimeter noise coming out of the Run IIb 2006 shutdown

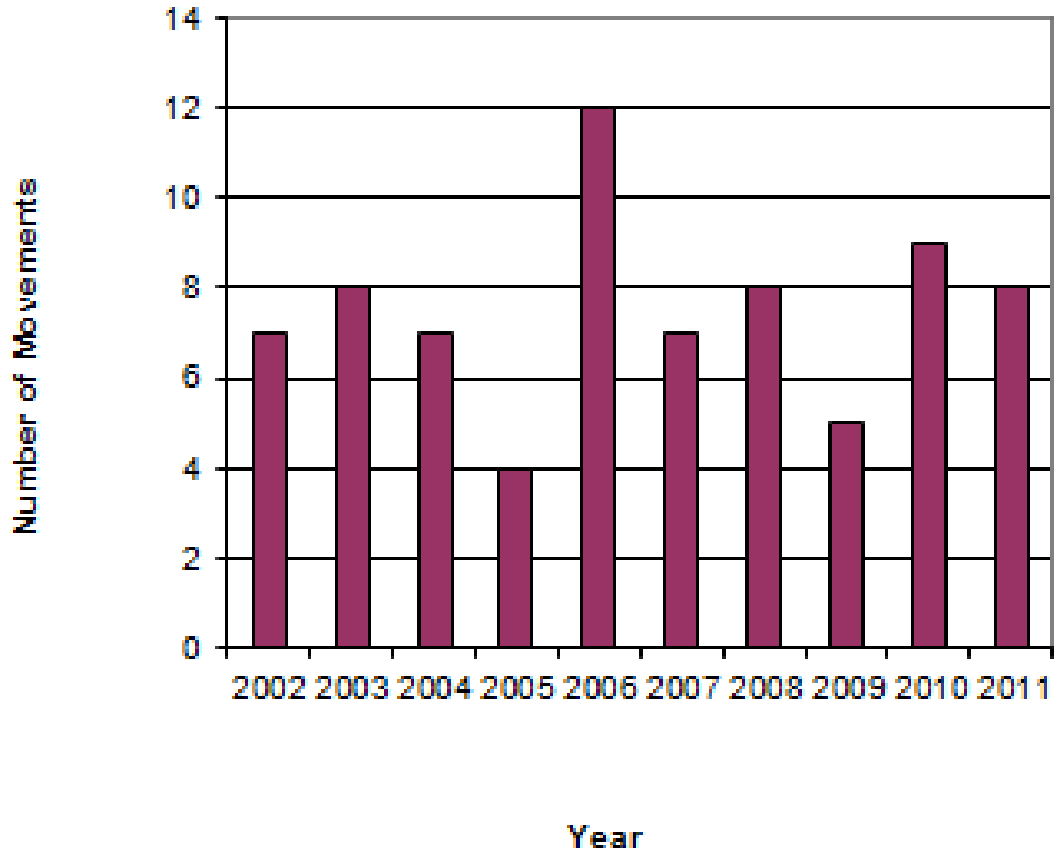


- After significant investigations (including opening and closing various parts of the detector), eventually determined that the cause was the reprogramming of the PDT clock from 53MHz to 45 MHz clock to generate the additional latency required for the Run IIb Level 1 Cal Track Trigger upgrade
  - Firmware changes required access to the COBOs on the A Layer
- Switched PDT readout clock to 4/7*53 MHz
  - With remotely controlled readout frequency implemented

Preparing to Open the Detector Again



Openings of DZero Detector Steel Per Year



Operations coming out of the 2006 shutdown

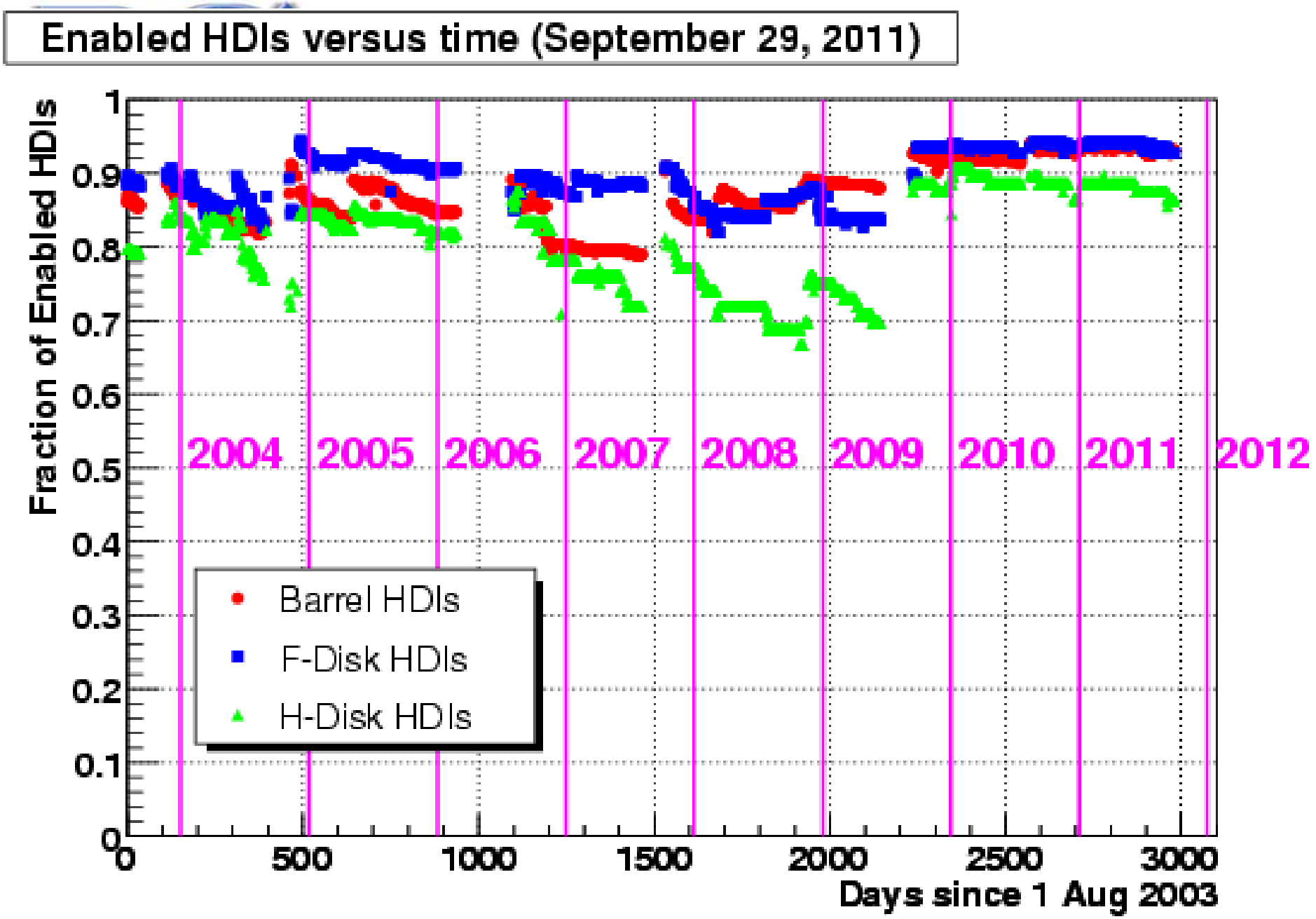
- ICD stabilization and improvements during 2006 shutdown and Oct 2006 mini-shutdowns
  - ICD had been in danger of being discredited prior to this effort

- Updated luminosity constant
- AFEII installation in CFT and CPS (and reduction of the offline threshold boost)

- Latency Shift (to facilitate Level 1 Cal Track implementation) 14-Dec-2006
- Level 1 Cal Track online 3-Feb-2007
- Level 3 farm node upgrade May-2007
- Level 3 tracking algorithm improvements 5-Apr-2007
- Addressed Level 1 busy issue
- Power off PDTs during shot setup in effort to reduce losses
- CFT/CTT and SMT/STT shifts merged into tracking shift 1-Jun-2007
- Enhanced dynamic range for CPS 20-Jul-2007
- Testing TDC implementation in fiber tracker readout

Additional Unsolicited Challenges in 2006

- High DVDD current incident damages SMT
  - Safety investigation in preparation for updated smoke protection in MCH1 resulted in an inadvertent trip of trigger distribution
  - Many HDIs needed to be disabled after this incident
  - Long process of study, protection and recovery
  - Discovered that SVX2 required a regular trigger or wirebonds could be damaged
    - Introduced heartbeat trigger
    - Watchdog timer in sequencer
    - More vigilant shift personnel
    - Devised and implemented a clever technique to recover access to most chips in a daisy chain which had lost a power bond
- Data from SMT only available for last 11 crossings due to challenges of getting SVX2 and SVX4 to cooperate together 54pb^{-1} compromised
  - Layer 0 hits for last crossing only available as of 5-Jan-2007


Enabled HDIs versus time (September 29, 2011)
Fraction of Enabled HDIs
Days since 1 Aug 2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Barrel HDIs
F-Disk HDIs
H-Disk HDIs

2007 Shutdown

- Ten week shutdown provides opportunity to maintain and improve accelerator complex, and infrastructure and detector
  - Power supply repair and maintenance
  - Single channel recoveries in most subsystems
  - SMT HDI recovery effort well underway
  - AFEII TDC and FPS implementation completed
  - Lumi monitor counters replaced
  - Toroid LCW leak repaired
  - Decommissioned FPD
  - Additional ICD improvements

Luminosity Monitor

2009 Shutdown Activities

- Luminosity monitors
  - Scintillators replaced
  - Luminosity monitors remounted
  - Verification underway
- Silicon Microstrip Tracker
  - Efforts to recover individual channels nearing completion
  - High voltage testing underway
- Central Fiber Tracker
  - Reduce readout deadtime via firmware enhancement
- Inner Cryostat Detector
  - Recovery of individual channels complete
  - Monitoring stability
  - High voltage trimming in the near future
- Liquid Nitrogen Dewar #39
  - Repairs of internal leak complete

2010 Shutdown Activities

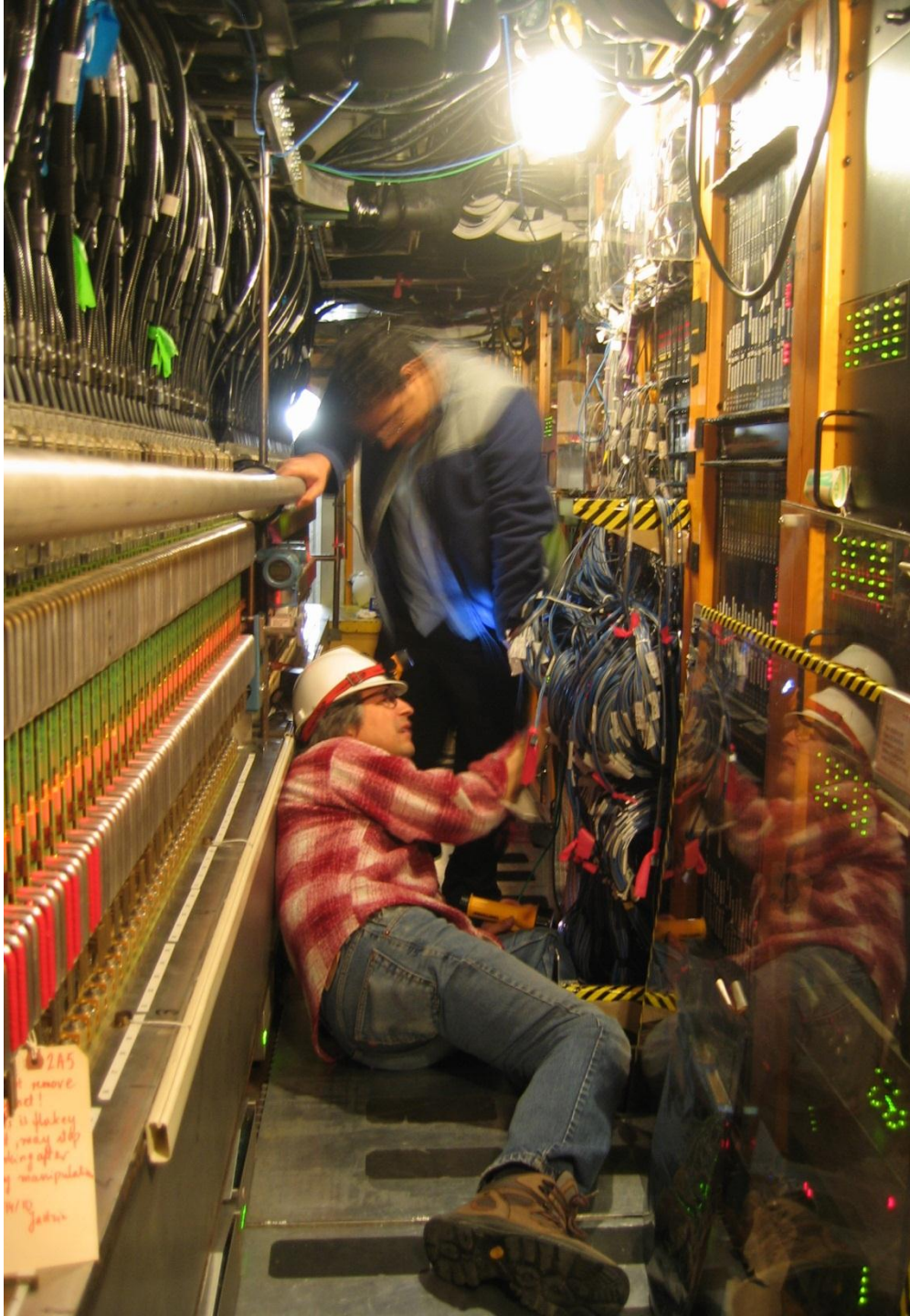
- Recover from five power outages
- Individual channel recovery efforts
- Routine maintenance
  - Calorimeter preamp fans
- Safety system tests
- Replace scintillator for luminosity counters
- Replace 14 of 48 PMTs for luminosity counters
- Silicon Microstrip Tracker HDI recovery efforts
  - 2% additional HDIs returned to service
- Calibrations
- Improved insulation around low beta quadrupoles
- Replaced solenoid power supply due to failure during startup after shutdown

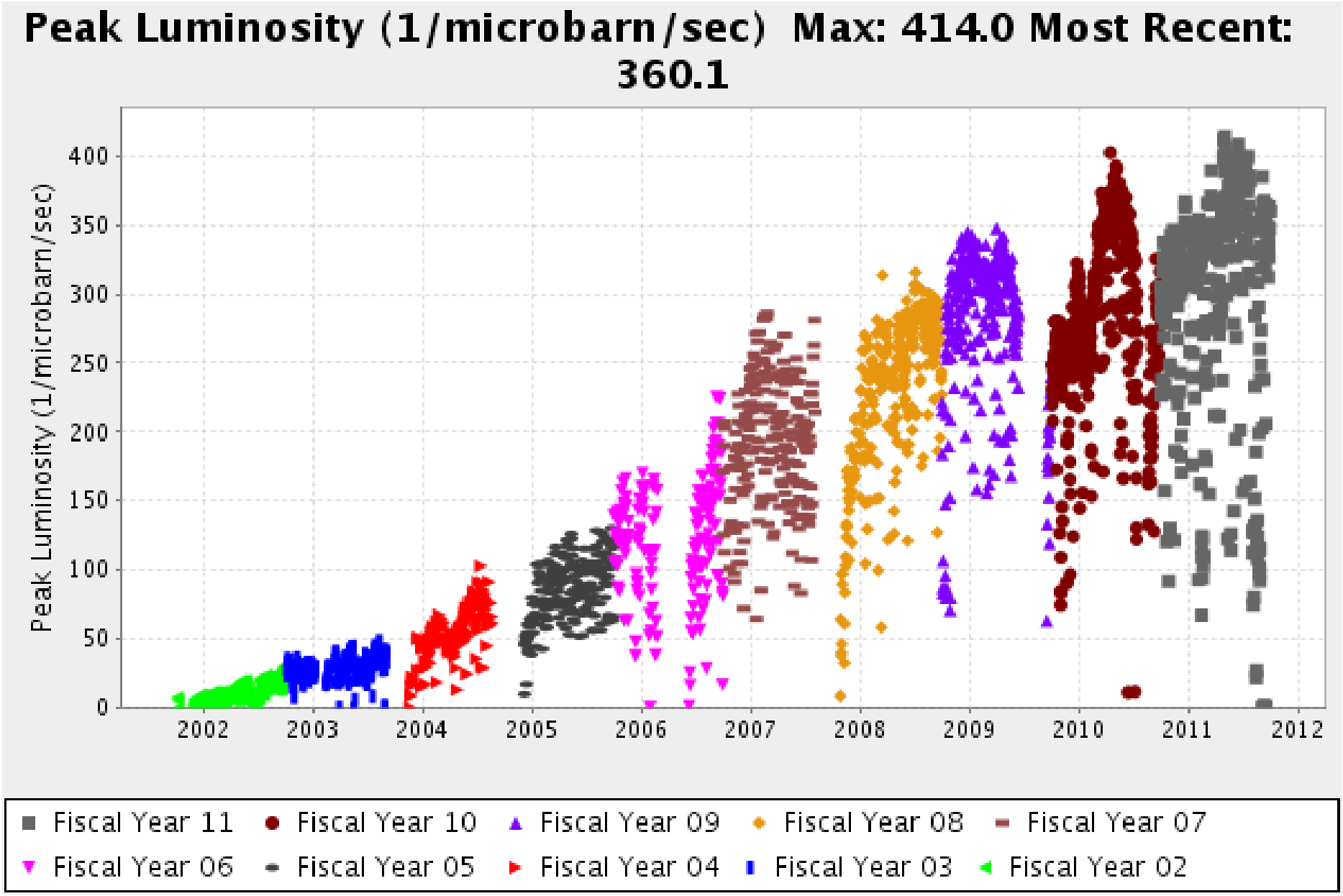

Standard Model of
FUNDAMENTAL PARTICLES AND INTERACTIONS
SAFETY

Just in Time Delivery of Muon Gas

Com Ed Power Glitch


USA
Argentina
Brazil
Russia
Dubna
Moscow
Protvino
St. Petersburg
India
Chandigarh
Delhi
Mumbai
Vietnam
Hochiminh City
China
Beijing
South Korea
Seoul
AREA IN FRONT OF THIS ELECTRICAL PANEL MUST BE KEPT CLEAR FOR 36 INCHES
PP-DO-7
208/120 VOLT
Kimwipes
Run II Special Runs Vol 3




Peak Luminosity (1/microbarn/sec) Max: 414.0 Most Recent: 360.1
Peak Luminosity (1/microbarn/sec)
0
50
100
150
200
250
300
350
400
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Fiscal Year 11
Fiscal Year 10
Fiscal Year 09
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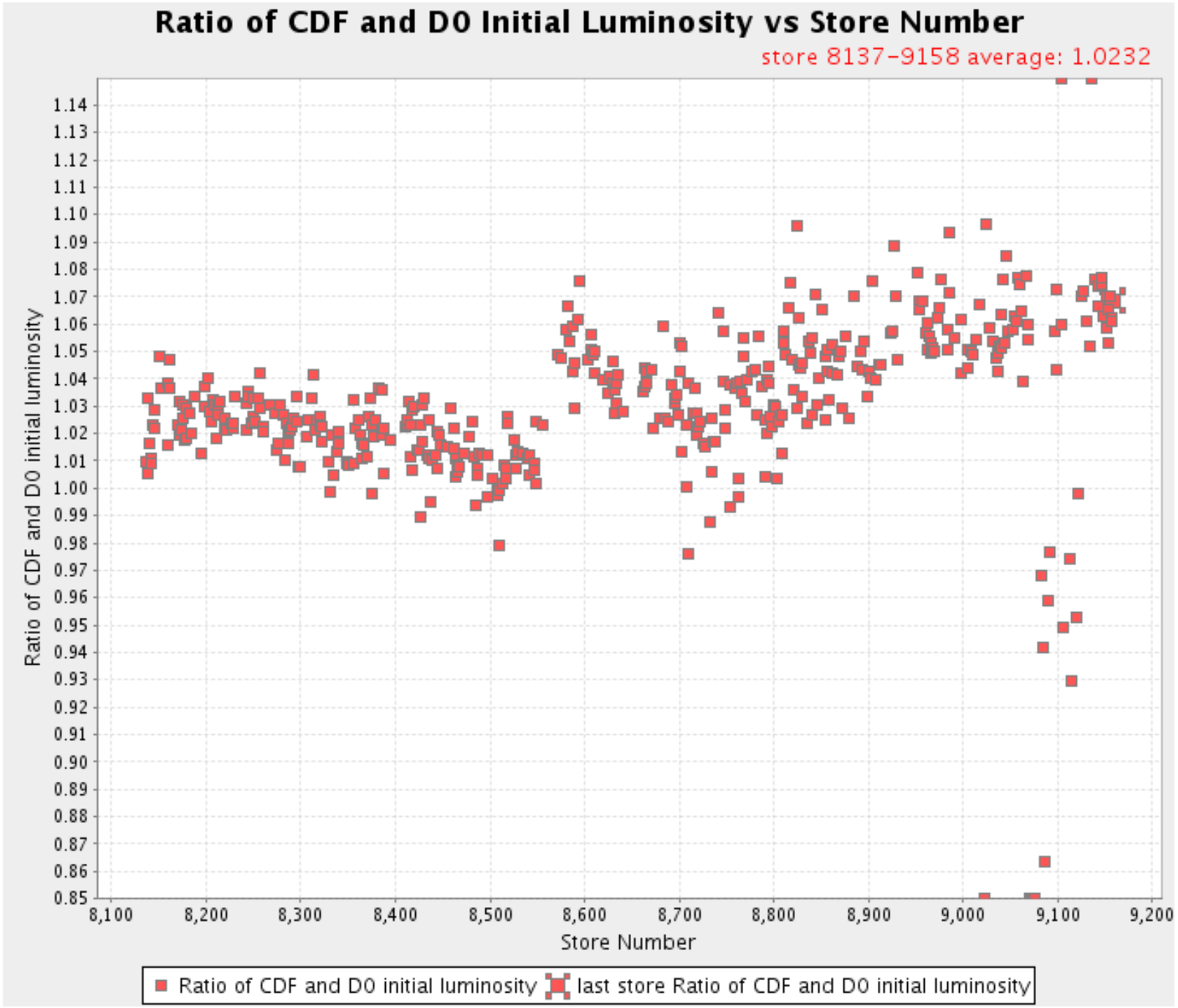
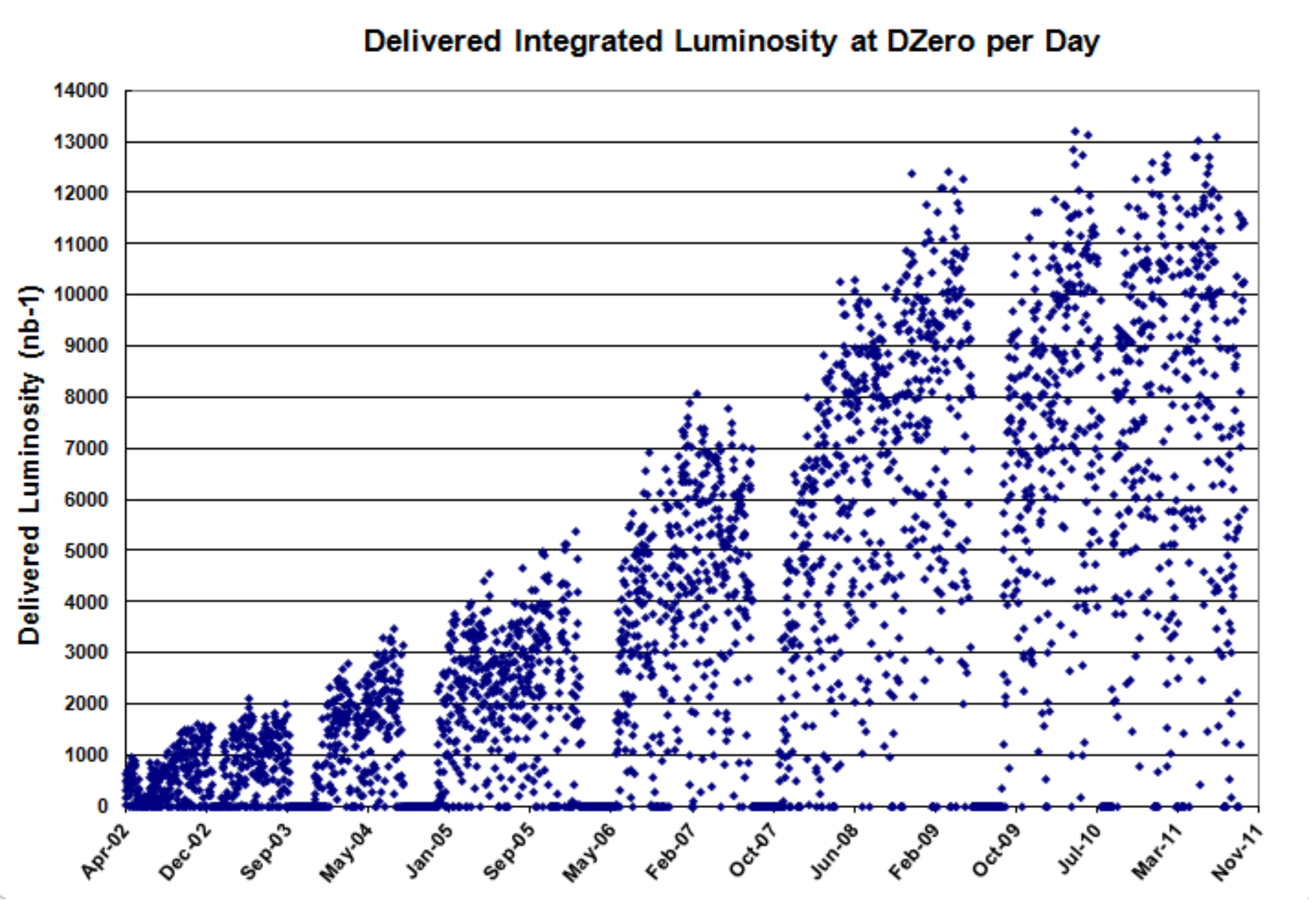
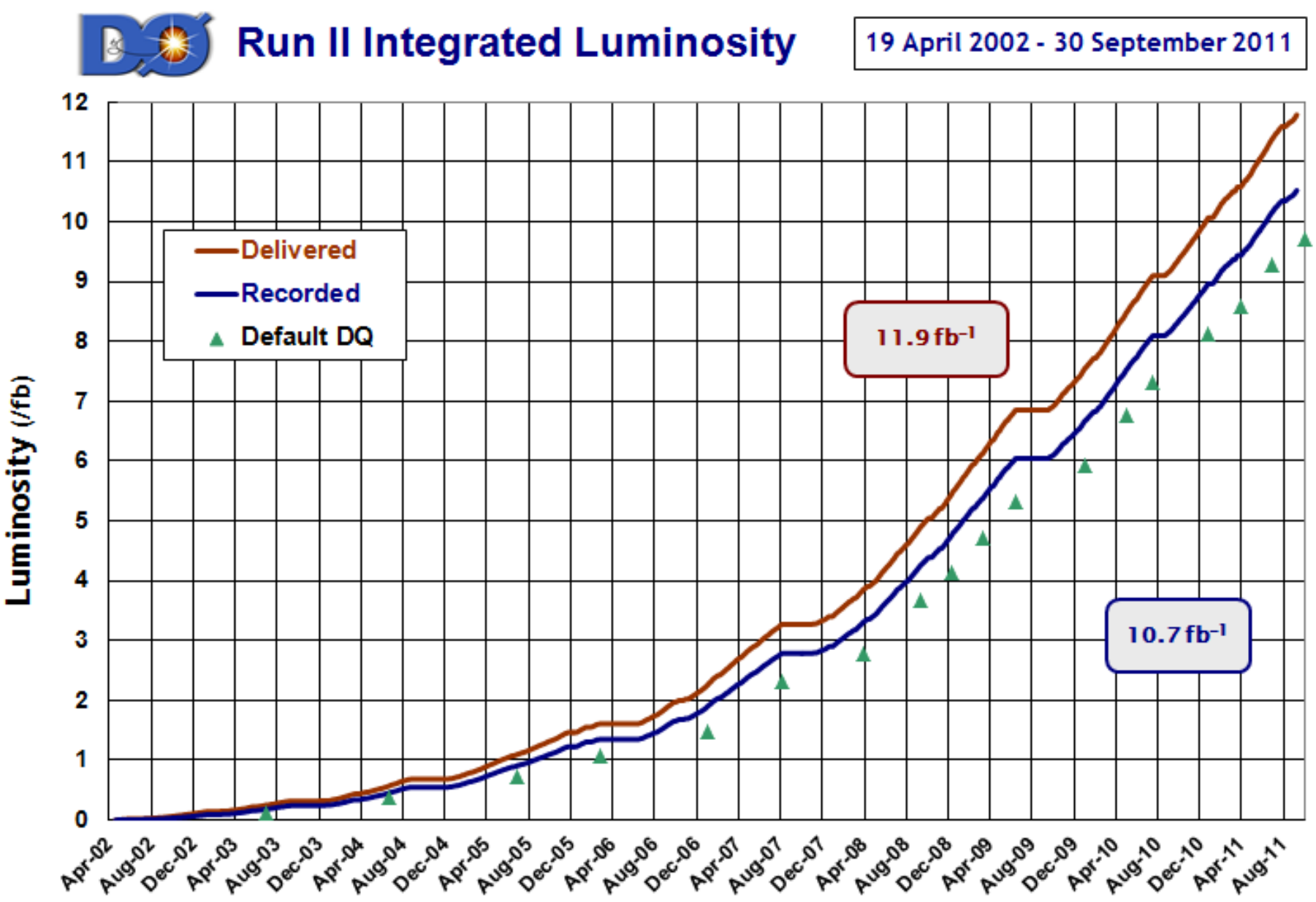
Fiscal Year 05
Fiscal Year 04
Fiscal Year 03
Fiscal Year 02


Ratio of CDF and D0 Initial Luminosity vs Store Number
store 8137-9158 average: 1.0232
Ratio of CDF and D0 initial luminosity
1.14
1.13
1.12
1.11
1.10
1.09
1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.90
0.89
0.88
0.87
0.86
0.85
8,100
8,200
8,300
8,400
8,500
8,600
8,700
8,800
8,900
9,000
9,100
9,200
Store Number
Ratio of CDF and D0 initial luminosity
last store Ratio of CDF and D0 initial luminosity


Delivered Integrated Luminosity at DZero per Day
Delivered Luminosity (nb-1)
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Apr-02
Dec-02
Sep-03
May-04
Jan-05
Sep-05
May-06
Feb-07
Oct-07
Jun-08
Feb-09
Oct-09
Jul-10
Mar-11
Nov-11


Run II Integrated Luminosity
19 April 2002 - 30 September 2011
Luminosity (/fb)
Delivered
Recorded
Default DQ
11.9 fb-1
10.7 fb-1
0
1
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8
9
10
11
12
Apr-02
Aug-02
Dec-02
Apr-03
Aug-03
Dec-03
Apr-04
Aug-04
Dec-04
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Apr-10
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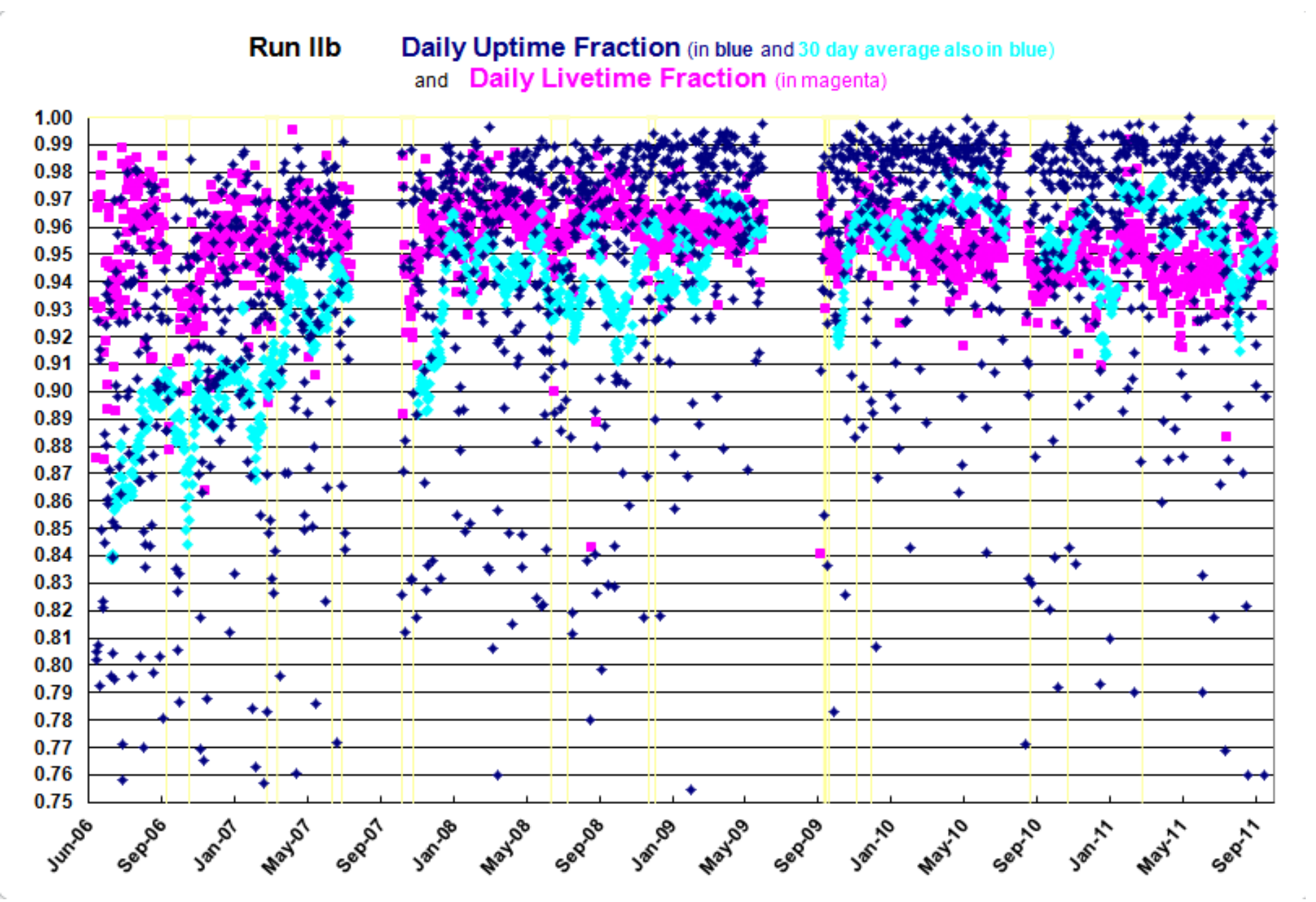
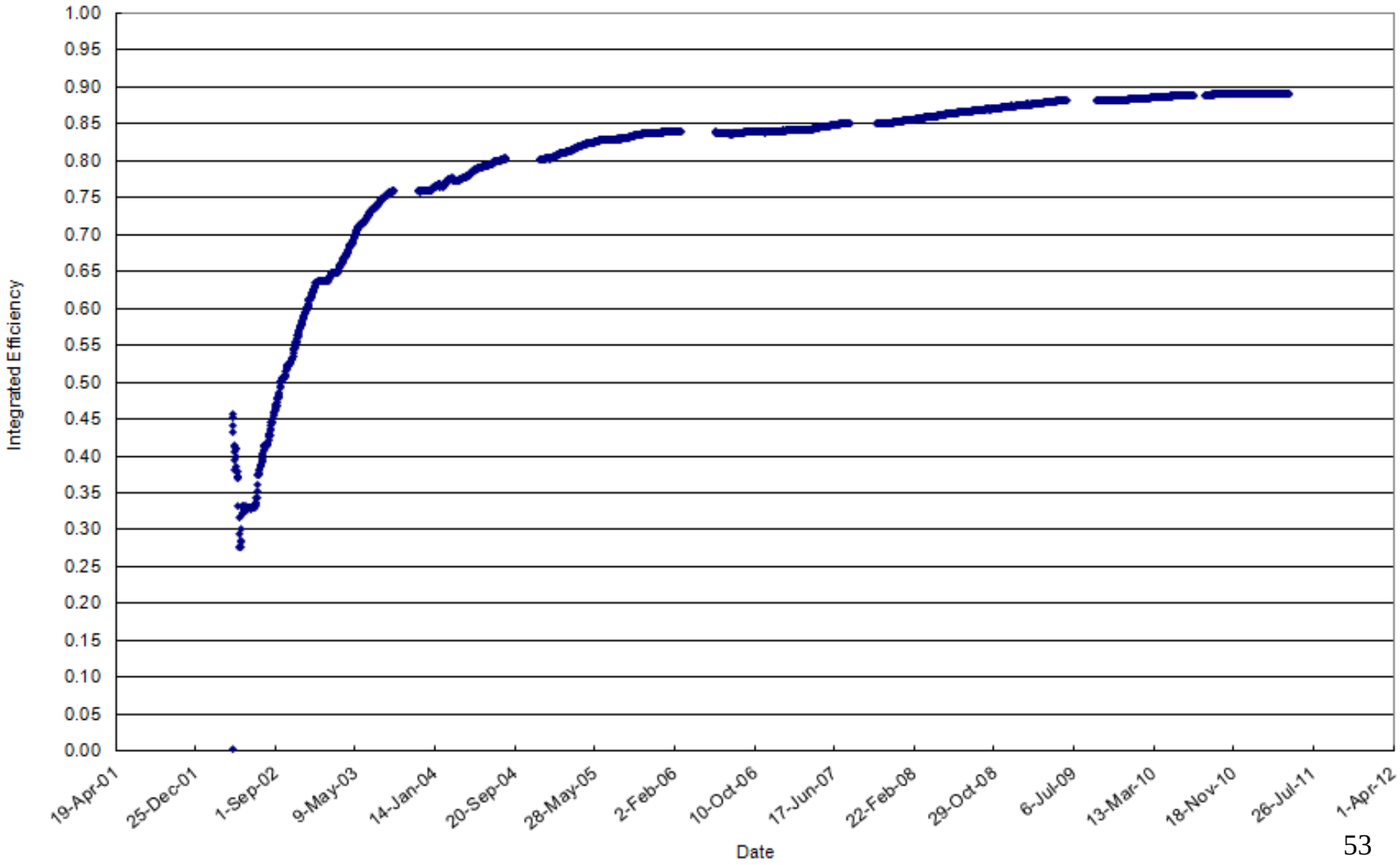
Dec-10
Apr-11
Aug-11


Run IIb
Daily Uptime Fraction (in blue and 30 day average also in blue)
and Daily Livetime Fraction (in magenta)
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.90
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0.82
0.81
0.80
0.79
0.78
0.77
0.76
0.75
Jun-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Jan-10
May-10
Sep-10
Jan-11
May-11
Sep-11

Run II Integrated Efficiency

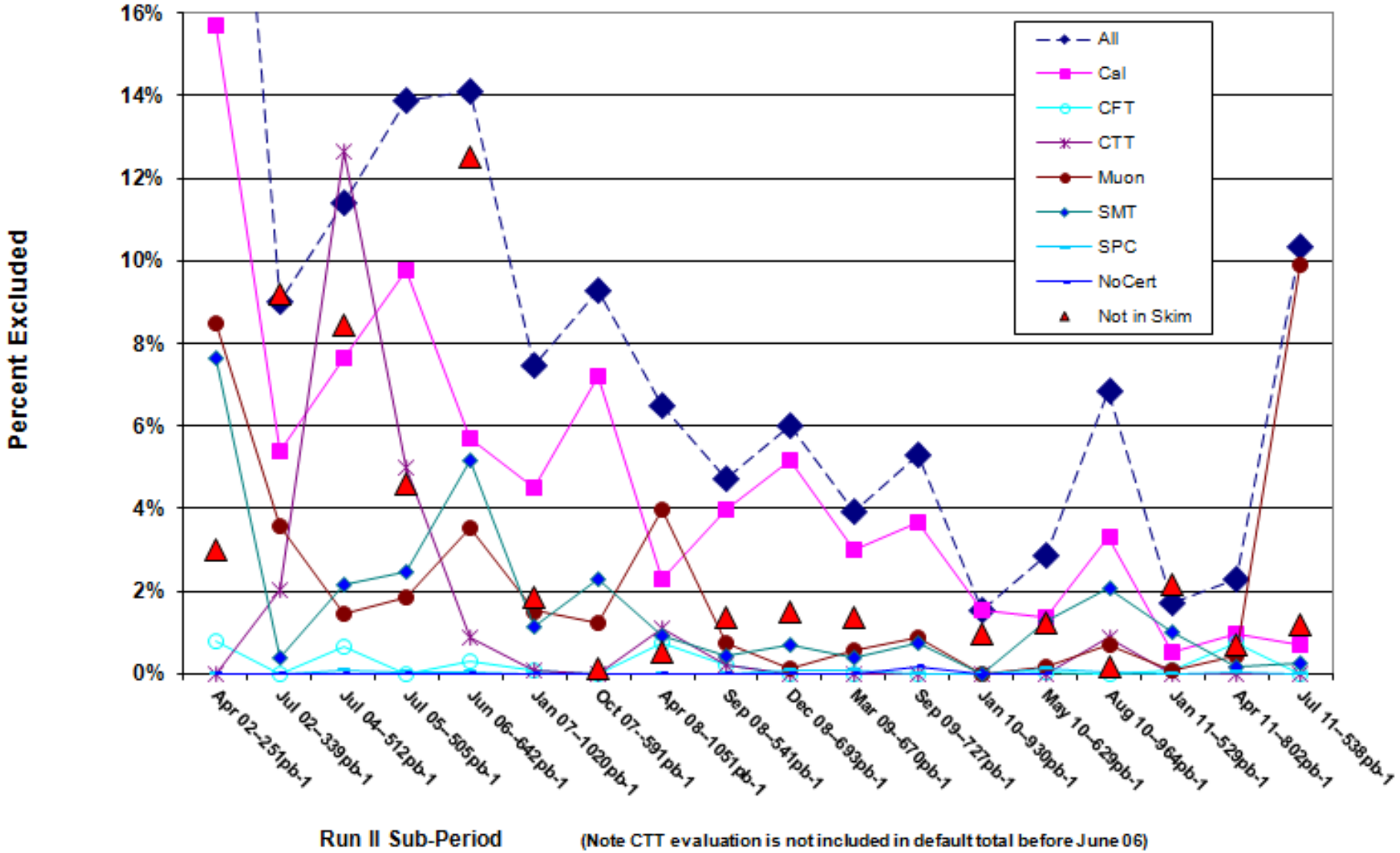


- Vigilance and persistence by the shift crew and expert support team resulted in continuing improvements in detector performance in spite of the aging detector

- Developments by the controls group were essential in improving the performance

- Feedback from the data quality team and from offline analysis were other key components in detecting features, as well as maintaining and boosting the performance of the DØ Detector

Default Data Quality Assessments

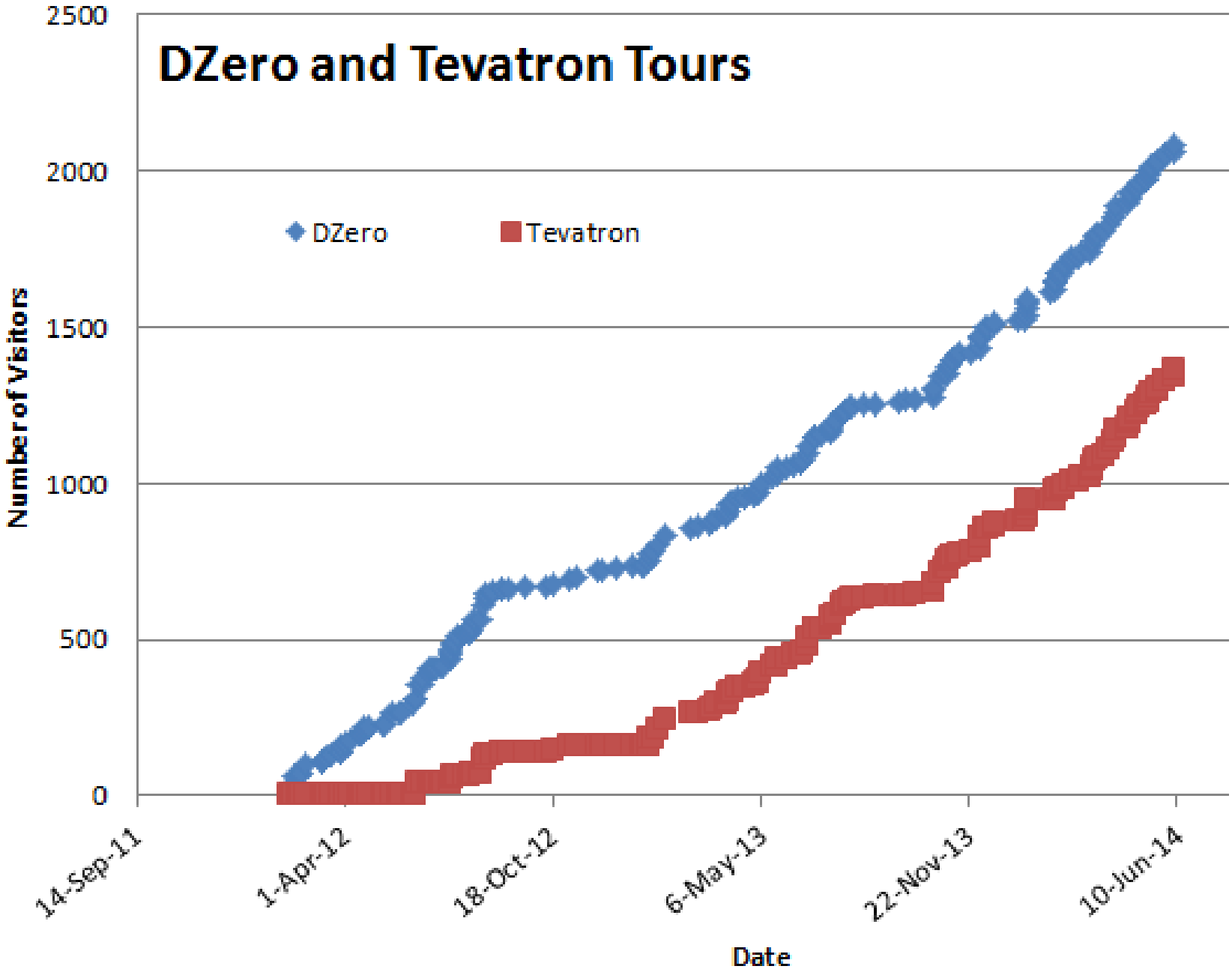


30 September 2011

Summary

- The outstanding performance of the Fermilab accelerator complex coupled with our excellent use of the resulting data made the significant effort of maintaining and operating the DØ Detector well worthwhile
- The Tevatron and the DØ Detector presented us with many and varied challenges and opportunities over the decades
- The collaboration and the supporting technical staff did a remarkable job of addressing (and/or circumventing) the challenges and taking full advantage of the opportunities
- Significant efforts by this dedicated, diverse and highly skilled team has been and continues to be critical to the DØ successes


Energized
Energized


DZero and Tevatron Tours
DZero
Tevatron
Number of Visitors
2500
2000
1500
1000
500
0
14-Sep-11
1-Apr-12
18-Oct-12
6-May-13
22-Nov-13
10-Jun-14
Date

- DØ detector is in exhibit mode
- Stefan Gruenendahl is serving as DØ tour coordinator
- Please send email to d0rc@fnal.gov for tour related inquiries **or to volunteer for service as a tour guide**

- Apologies to those whose contributions or most memorable DØ detector related operating experiences were not explicitly cited

- Special thanks to
  - Mike Tartaglia for compiling the selected highlights of DØ Run I Detector Operations
  - Dean Schamberger for sharing his Run 1 recollections
  - Michael Begel for providing information on early Run II activities

Coyote Inspecting Tevatron

Turtle (but not the kind used to detect water leaks)

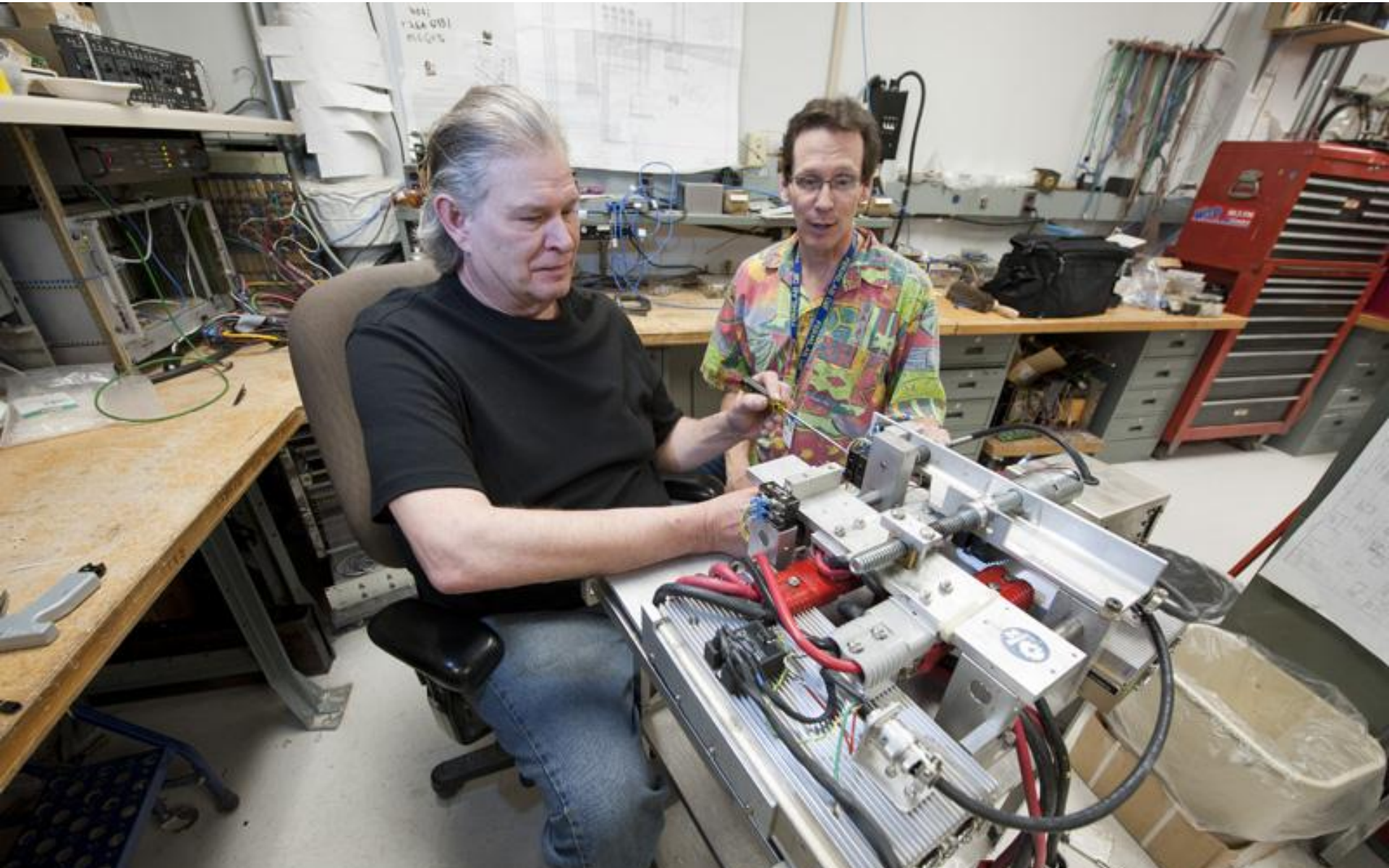
The Blizzard of 1 and 2 Feb 2011

The Blizzard of 1 and 2 Feb 2011

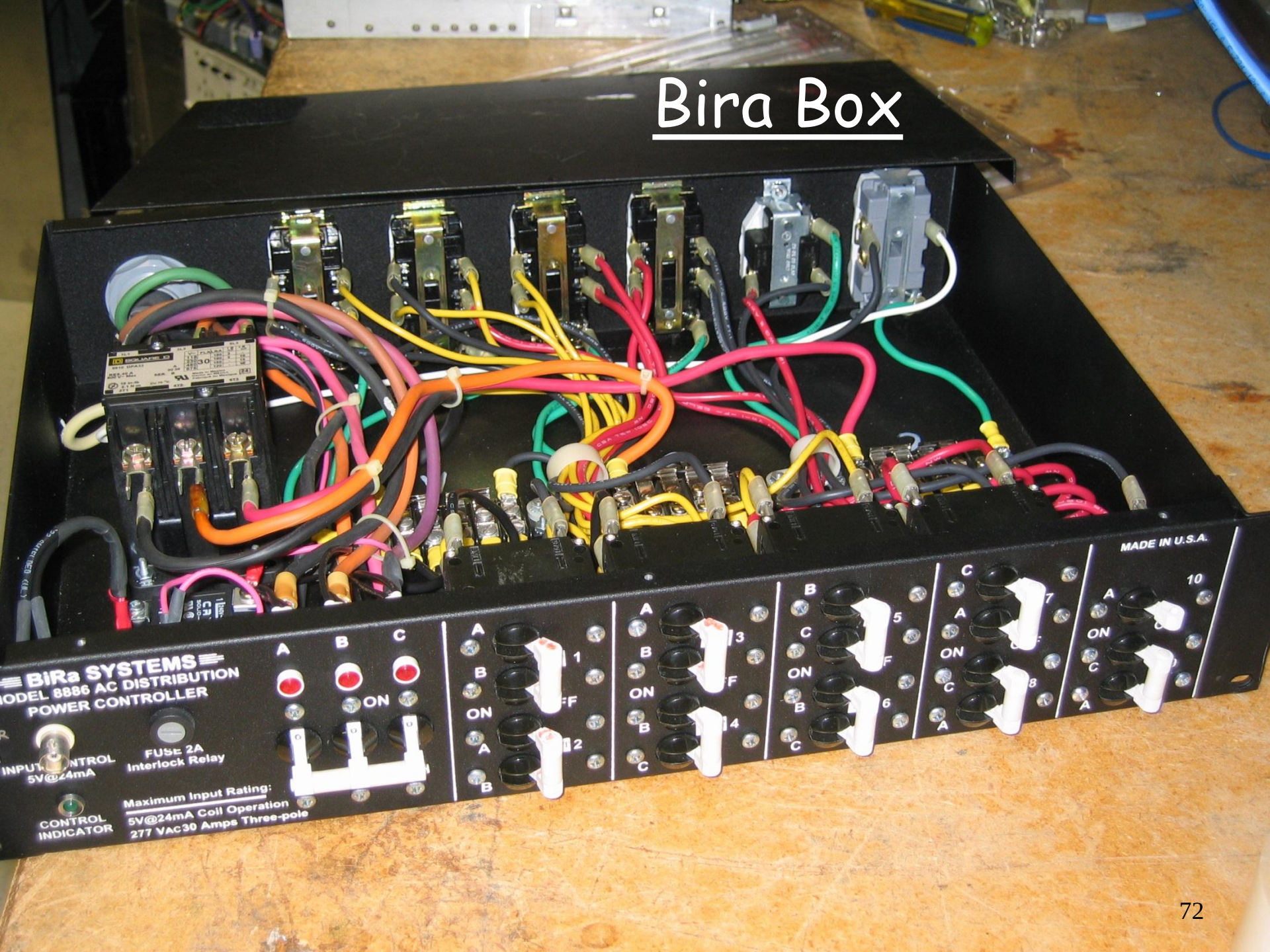
Preparing for another Flood?
26 Aug 2011

Getting Ready to Open the Detector 16 Feb 2011

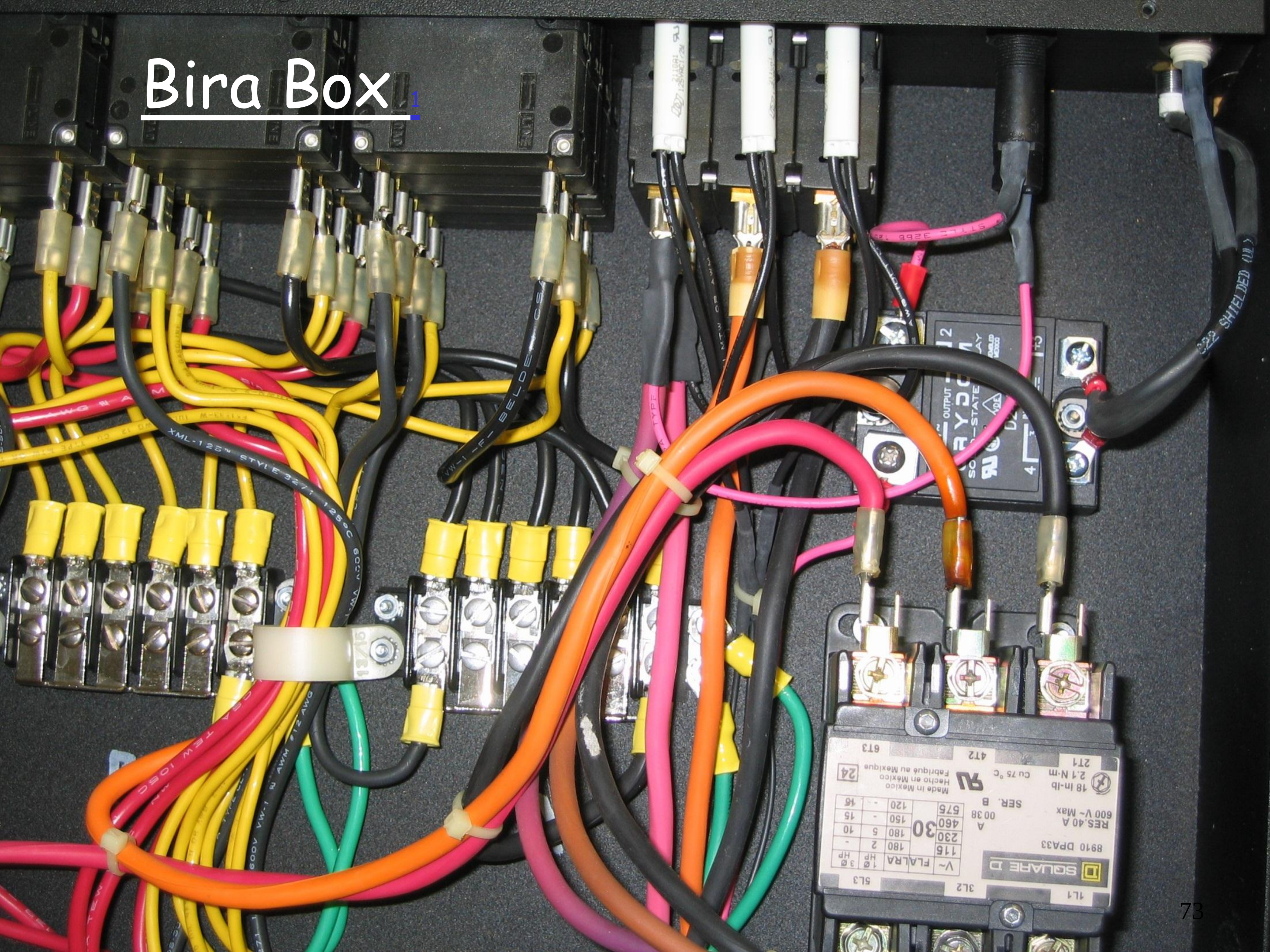
R2DØ Remote controlled power supply switching device



Bira Box

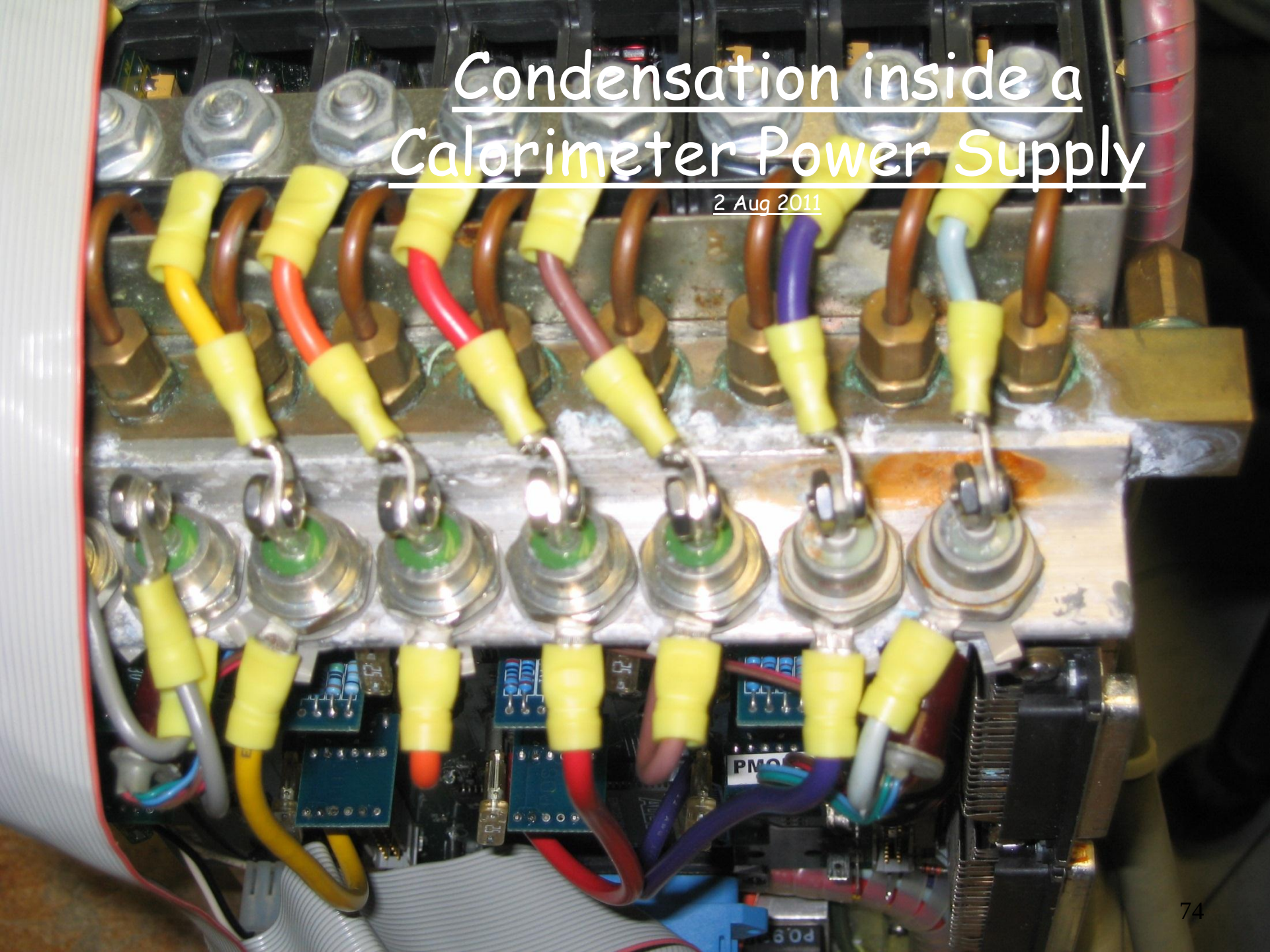

BiRa SYSTEMS
MODEL 8886 AC DISTRIBUTION
POWER CONTROLLER
A
B
C
ON
FUSE 2A
Interlock Relay
CONTROL
INDICATOR
Maximum Input Rating:
5V@24mA Coil Operation
277 VAC 30 Amps Three-pole
MADE IN U.S.A.

Bira Box[1]



Condensation inside a Calorimeter Power Supply

2 Aug 2011



LCW Chillers

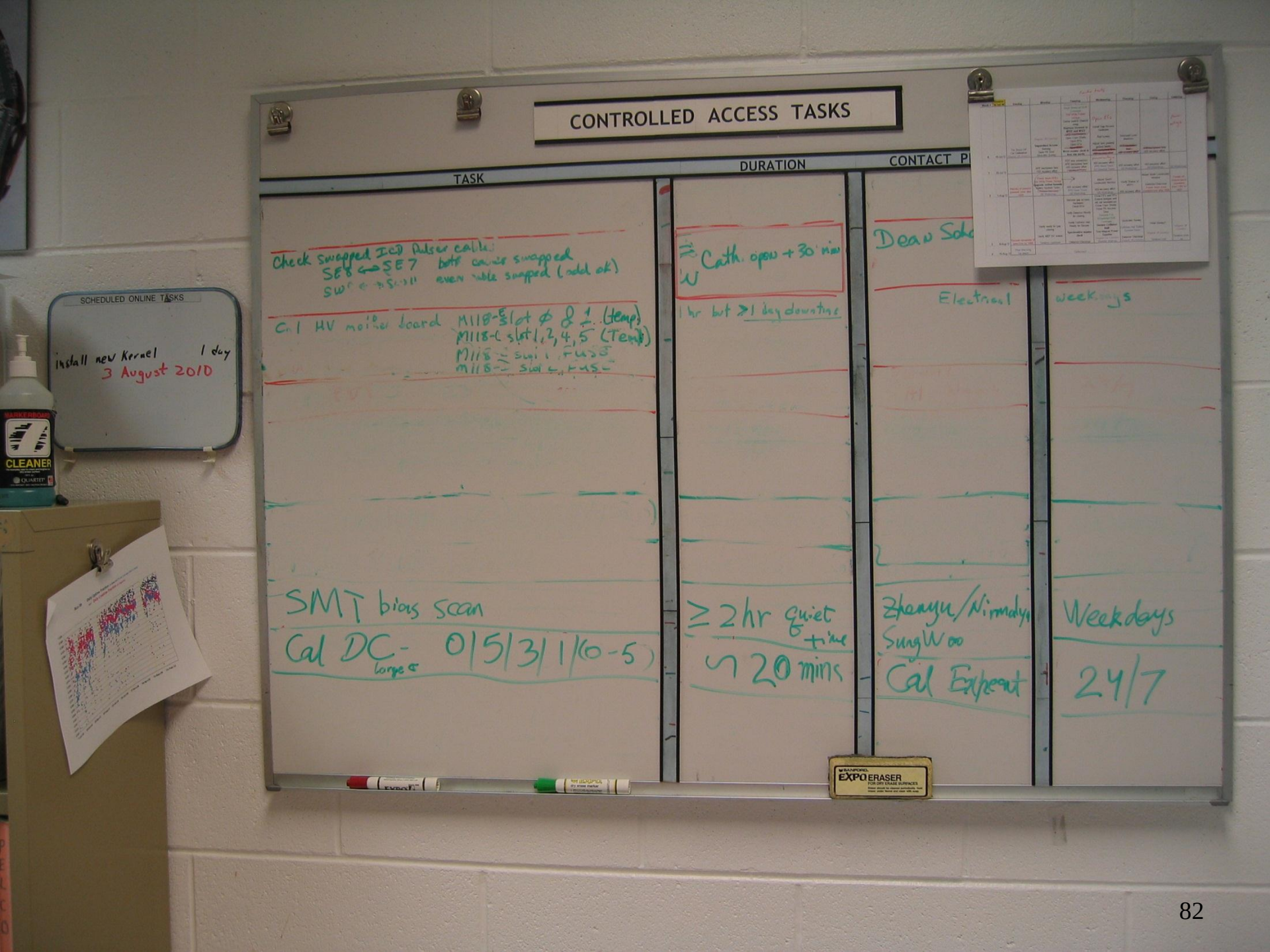
- As of fall 2009 had two Tranes (each with two compressors) and a York available at ~200 tons each
  - One Trane failed last fall
- Could not get a permanent replacement in place prior to return of warm weather
  - Rented spare capacity
  - Revived the 30 ton clean room chiller
  - Procured a "new" York
- Installed and commissioned "new" York during shutdown
- 30 ton clean room chiller recently failed
  - Fault localized to crankcase heater circuit
- One half of remaining Trane failed during shutdown
- Any two of the three larger chillers should provide sufficient chiller capacity for most situations
  - Not much margin until the Trane is repaired


Trane
Wreck

Renting Chiller Capacity

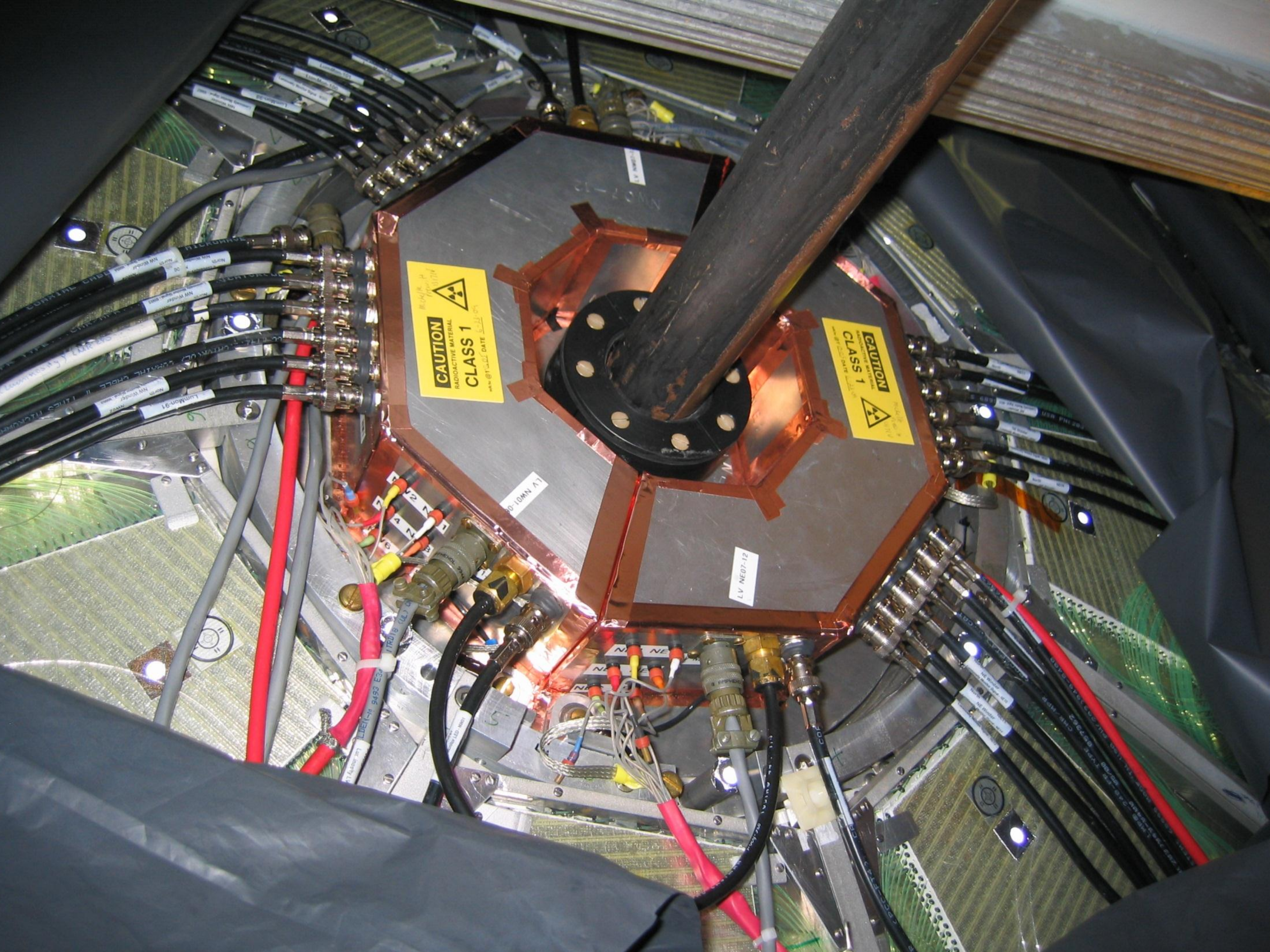

Thu 12/Oct/95 10:20
GAS ON
FIRUS NORMAL
LASER SECURED
POWER SUPPLY READY
LASER OFF


Tue 04/Aug/09 9:52
SMT HV Off !
Area Not Secured
Solenoid OFF
Toroid OFF


CONTROLLED ACCESS TASKS
TASK
DURATION
CONTACT P
Check swapped ICD Pulser cable:
SE8 ↔ SE7 both cables swapped
SW ↔ SW11 even cable swapped (odd ok)
≥ Cath. open + 30 min
Dean Sch
Electrical
weekdays
C-1 HV motherboard M118-E slot 0 & 1 (Temp)
M118-C slot 1, 2, 4, 5 (Temp)
M118-
M118-
1 hr but ≥ 1 day downtime
SMT bias scan
Cal DC- 0/5/3/1/(0-5)
≥ 2hr quiet time
~ 20 mins
Zhenyu/Nimdy
SungWoo
Cal Expert
Weekdays
24/7
SCHEDULED ONLINE TASKS
install new Kernel 1 day
3 August 2010
CLEANER
EXPO ERASER

Some of the infrastructure to facilitate operation of the detector


Level 3 Farm


CAUTION
RADIOACTIVE MATERIAL
CLASS 1
CAUTION
RADIOACTIVE MATERIAL
CLASS 1
LV NE07-12

SMT Commissioning

L1 Cal Trigger Upgrade

Toroid Power Supply

Dry Air to Actuate and Protect Equipment


DHP-DO-2
480Y/277V. A.C.
C1
C2
C3
C4
C5
C6
C7
C8
C9
MCH
MCH
TRANSREX SUPPLY
MAIN MAGNET
P.E.I. SUPPLY
SOLENOID MAGNET

Power Distribution and Emergency Generator

C4 Pump House (usually) Delivers Pond Water for the Chiller Heat Exchangers

Heat Exchanger

Air Handling Units on the sixth floor

Regular (nearly daily) Liquid Nitrogen Deliveries

Backup Air Supply
(and a test cryostat in the background)

Muon Chamber Gas Supply

View from inside the Tevatron Ring
Note the DA Compressor Room