



Trigger Upgrade Status - 10/Feb/2006

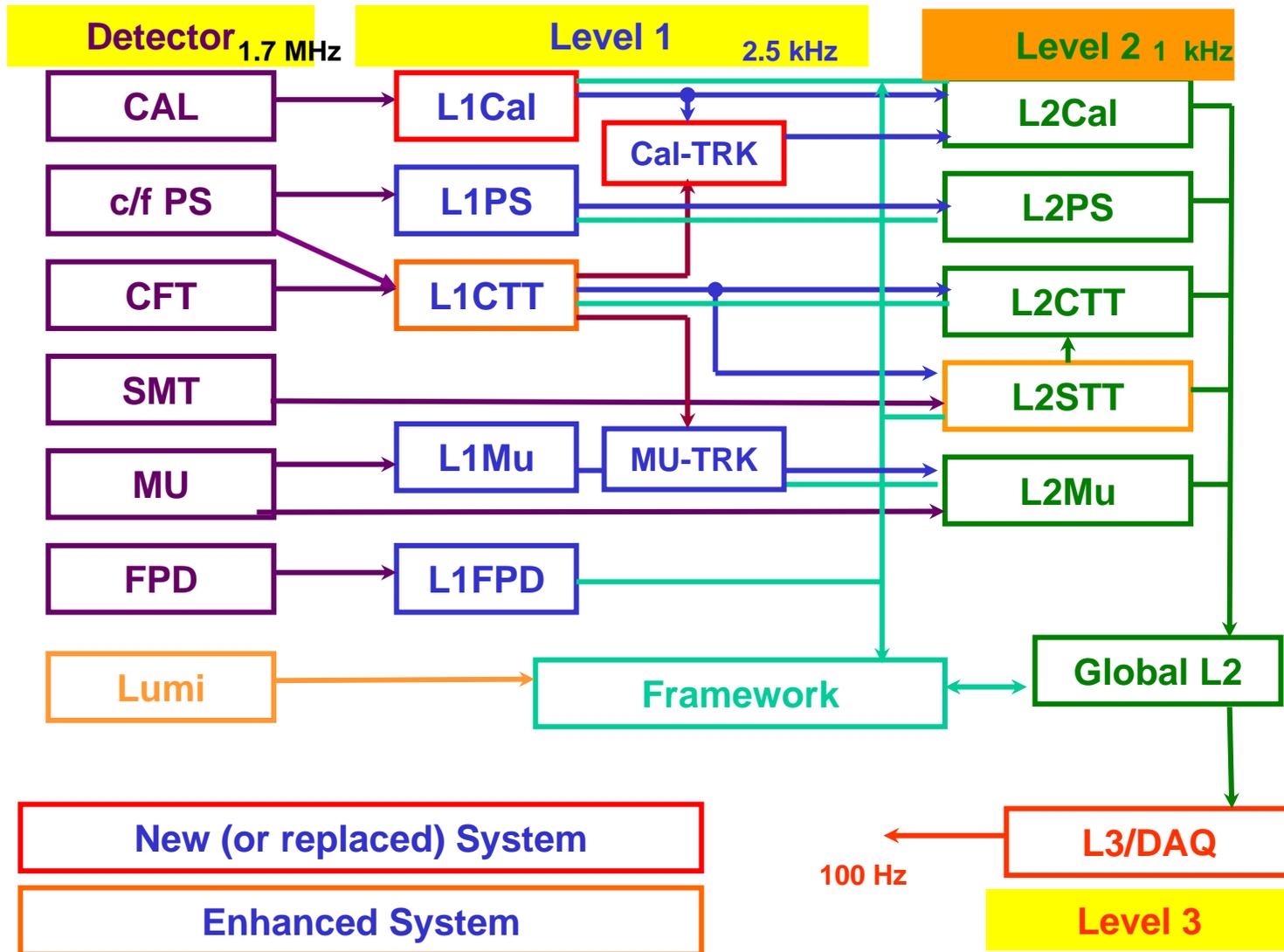
- Review of trigger upgrade basics
- General status
- Progress and installation plans
 - ◆ by subsystem
- Trigger list development
- Follow-up from October Director's Review

Darien Wood, Northeastern University

For the DØ Trigger Upgrade



The Run II b Trigger System





Trigger Upgrade Overview

- The DØ Trigger Upgrade consists of
 - ◆ Complete replacement of Level 1 calorimeter trigger (legacy system from Run 1)
 - ◆ Replacement of the DFEA's (track finding modules) in the Level 1 Central Track Trigger
 - ◆ A new Level 1 system to match calorimeter objects and tracks (L1caltrack)
 - ◆ Upgraded/additional processors for the Level 2 trigger (L2beta)
 - ◆ Incorporation of Layer 0 into the Level 2 Silicon Track Trigger (L2STT)



General Status/Strategy for Fall/Winter 05-06

- Complete/extend/repeat testing of individual hardware components
 - ◆ only new hardware since Oct
 - ▲ remaining parts of L1cal BLS-ADF transition system
 - ▲ final power supply for L1cal TAB/GAB crate
 - ▲ L1cal communications crate
- Run partial systems in as realistic conditions as possible
- Refine and test firmware
 - ◆ new equations for L1CTT
- Plan for installation
- Develop post-shutdown trigger list ("V15")
- Update collaboration on status at All DØ Meetings
 - ◆ Feb 8: L1cal (Hal Evans), L1CTT (Don Lincoln), L1caltrack (Stefan Anderson)
 - ◆ Feb 10: v15 trigger list (Marco Verzocchi)
 - ◆ much of material in this talk is taken from these presentations



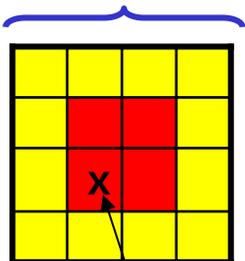
L1cal Physics Algorithms

Clustering

Topological

Jet Algo

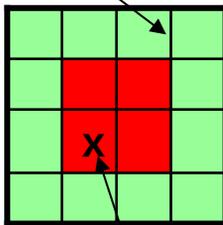
Jet Cluster



ROI

Tau Algo

EM+H Isolation

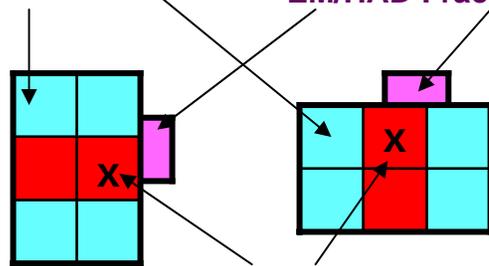


ROI / Tau Cluster

EM Algo

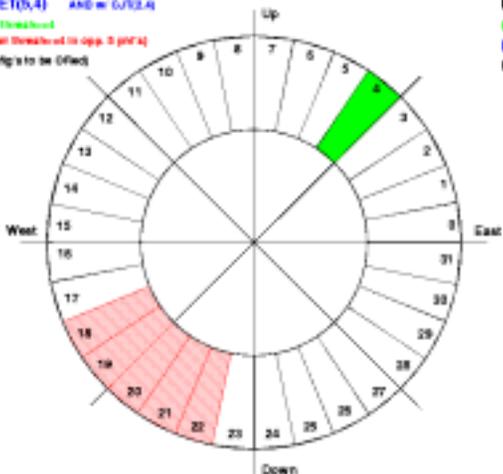
EM Isolation

EM/HAD Fraction



ROI / EM Cluster

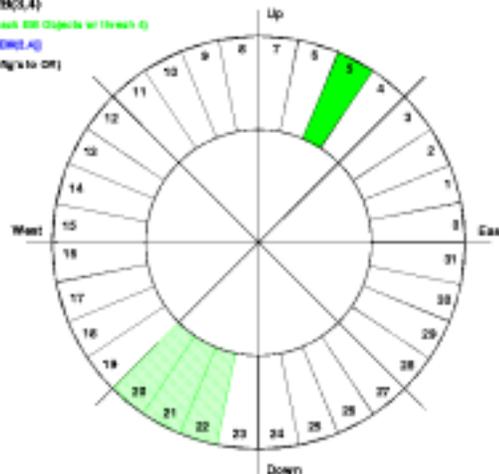
ACOP_JET(5,4) AND w/ C/3/4
(conf. Jet w/ threshold)
+ no Jet w/ threshold in opp. 3 prts)
(1 of 32 configs to be Off)



CSWAKL

coplanar jet veto

DEM_B2B(3,4)
(Back-to-Back EM Clusters w/ threshold)
(Offset = DEM(2,4))
(1 of 32 configs to Off)



CSWBEM

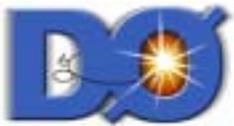
back-to-back EM

Et(miss) and ΣEt

- similar to Run IIa

Inter-Cryostat Reg.

- can be added (or not) to Et(miss) & Jets



L1Cal Hardware

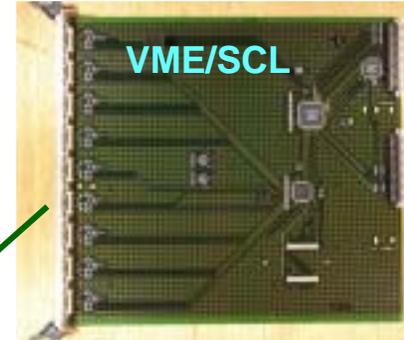


Patch Panels

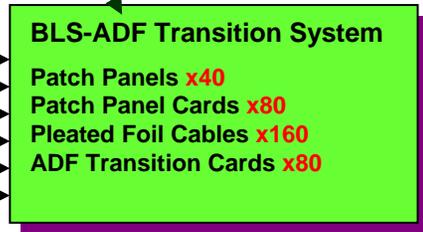
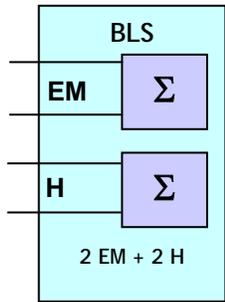
1280 Existing BLS Trigger Cables



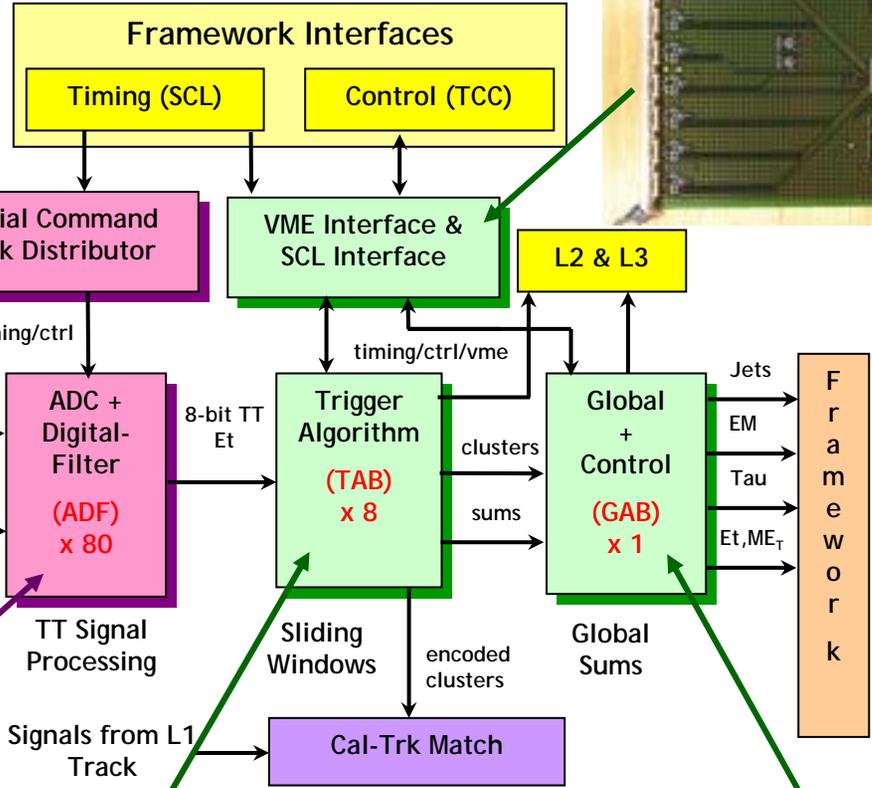
SCLD



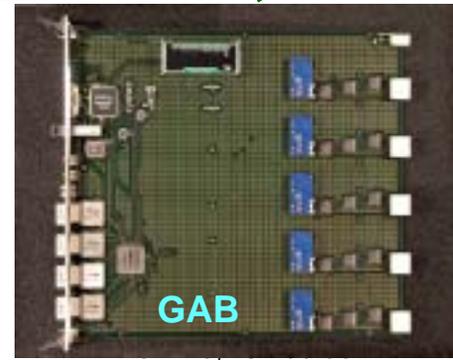
VME/SCL



ADfv2



TAB

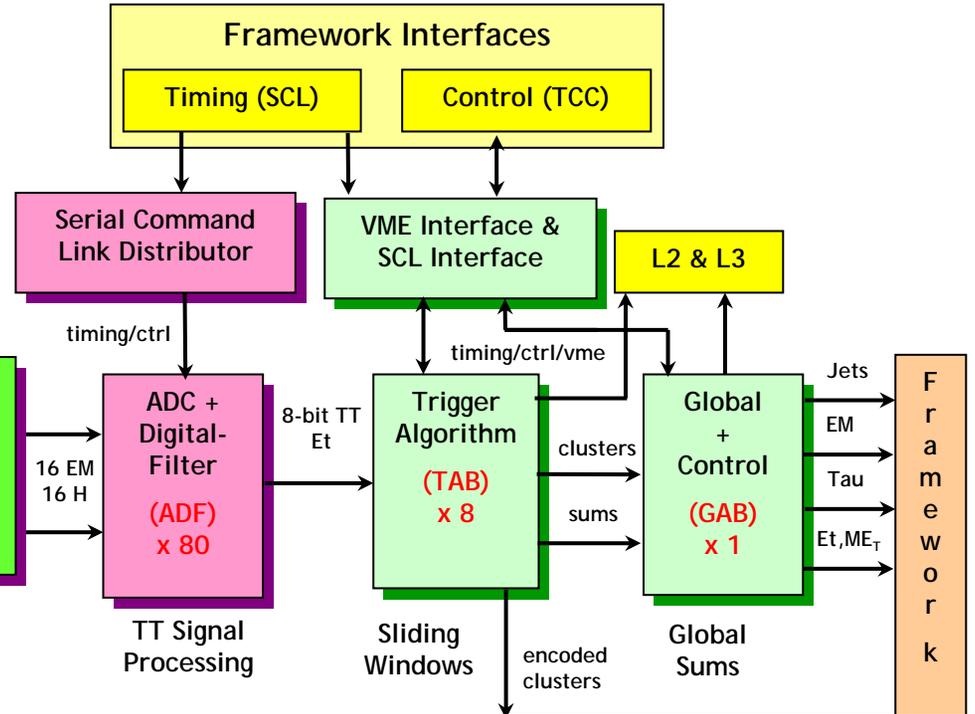
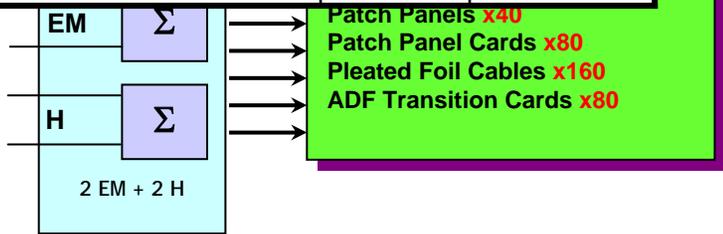


GAB



L1cal Component Counts

Board	Syst	Spare
Patch Panel	40	4
PP Cards	80	20
Pl. Foil Cables	160	32
ATCs	80	22
LVDS cables	240	~30



Crate	Syst	Spare
ADF	4	1
TAB	1	2
Online	1	

Board	Syst	Spare
SCLD	1	1
ADF	80	20

Board	Syst	Spare
VME/S CL	1	3
TAB	8	4
GAB	1	3



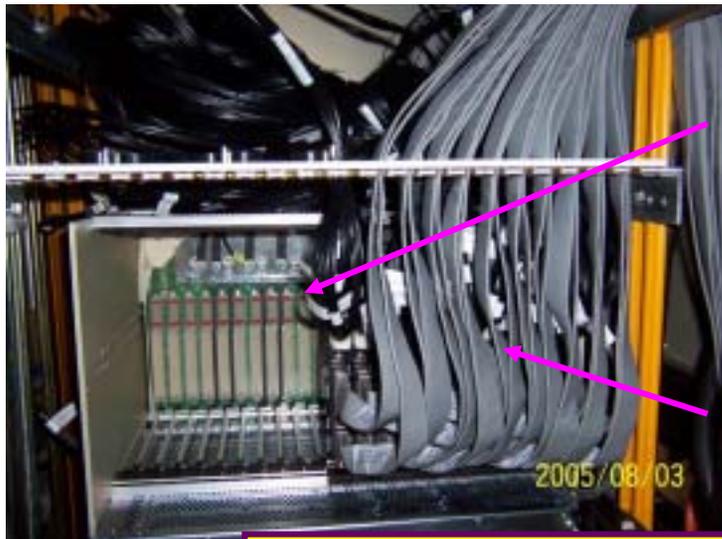
L1cal hardware: recent progress (since October)

- **BLS Transition system**
 - ◆ All parts in hand and tested
 - ◆ Installed on sidewalk:
 - ▲ ADF transition cards (ATC's)
 - ▲ LVDS cables (from ATC's to TAB/GAB backplane)
 - ◆ Tested, but not part of sidewalk (will be installed in move to MCH1)
 - ▲ BLS patch panels
 - ▲ Pleated foil cables (patch panel to ATC)
- **All Components Tested as Part of the Full System**
 - ◆ includes: crates, power, boards, cables, I/O paths...
 - ◆ some details to work out on GAB → L2/L3 headers/trailers
 - ◆ some ADF-to-TAB transmissions to adjust
- **Weiner power supply for TAB/GAB crate installed**
- **Safety systems (fuse panels, etc.) required for ORC installed**



L1cal Hardware Status

- Recent Exercise in Full ADF-to-TAB Cabling
 - ◆ 240 LVDS cables between 4 ADF crates & 1 TAB/GAB crate
- Valuable Lessons Learned
 - ◆ quantify cable and backplane fragility
 - ◆ Will attempt to leave cables connected to TAB/GAB crate for installation
 - ◆ Data Transmission Problems in ~10% of channels when fully cabled
 - ◆ tuning of LVDS transmission/reception parameters ongoing



ADF-to-TAB

pleated foil cables
(BLS signals)

1/2 of ADF Crate Cabled



TAB/GAB Backplane



L1cal Firmware Status

Feature	Firmware	Physics Studies	in v15 studies
ADF	done	yes	yes
Jet	done	yes	yes
EM	new ver. in test	yes	yes
EM Isolation	new ver. in test	yes	yes
Tau	non-optimal ver.	ongoing	no
MEt	done	no ICR study	yes
Topological	new ver.'s in test	no	yes
Cal-Track	yes	some	yes

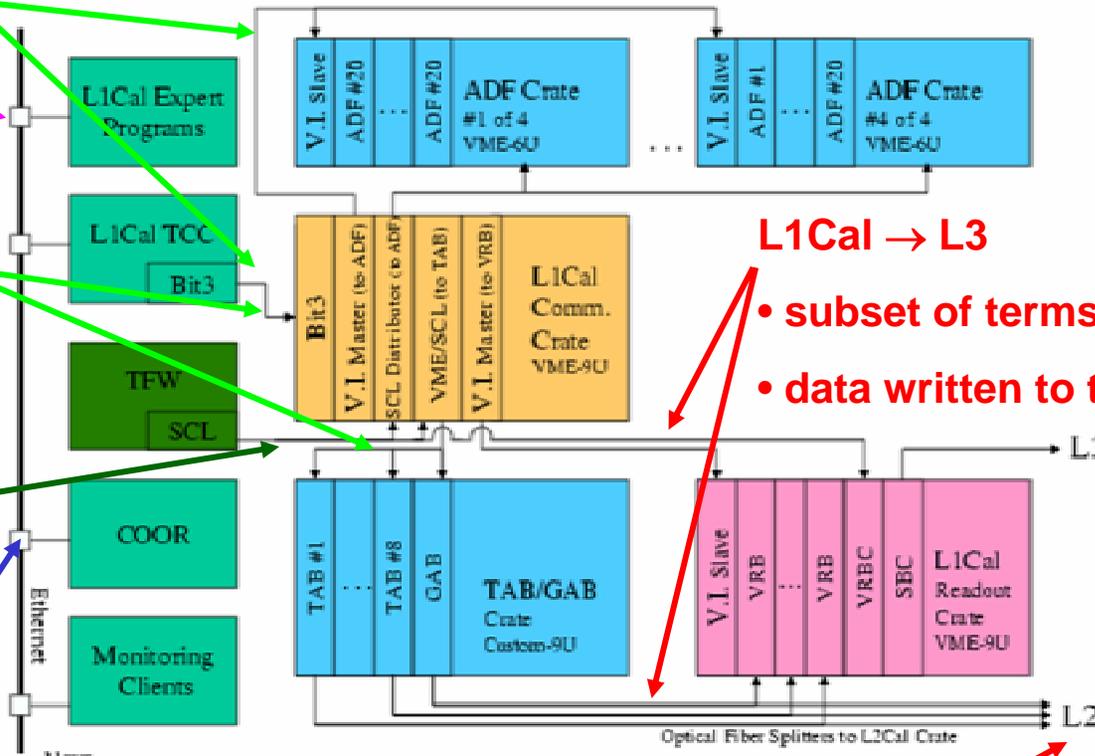
Toolkit for Firmware Verification

- ◆ bit-by-bit compare of hardware output w/ simulation for test data
 - ▲ at various stages of the algorithm
- ◆ online L3 data dump
- ◆ Trigger Rate Tool



L1cal Online System Tests

Run Iib L1 Calorimeter Trigger Control Path



L1CalTCC ↔ ADF: done

Expert Programs
• in use, being refined

L1CalTCC ↔ TAB/GAB
• all designed, subset tested

TFW/SCL → L1Cal
• used by default

COOR – L1Cal protocol
• designed & tested

Final Tests: next few weeks

• TriggerDB → Taker → COOR → L1CalTCC → Hardware → Tape
• Program full set of system resources

L1Cal → L3
• subset of terms used
• data written to tape

L1Cal → L2
• data read by L2 worker

Trigger Terms → Framework

• sample terms tested



L1cal Monitoring

1. Online Monitoring GUIs

- ◆ power, TT monitoring (ADF), TAB/GAB Algo monitoring

2. Examines

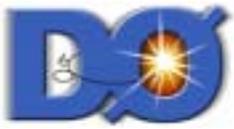
- ◆ run on TAB data
- ◆ GAB Examine in progress

3. Pulser

- ◆ tool has been updated, improved & tested
- ◆ Run IIb unpacker incorporated

4. Calibration

- ◆ Examine-based TT vs. Precision comparison
⇒ Digital Filter Coeff's
 - ▲ good first estimate already made using existing data
- ◆ Final Run IIa Calibration planned for shortly before shutdown



L1cal remaining work

- Highest priority is getting full system (80 ADF's, 8 TAB's, 1 GAB) working smoothly on sidewalk
 - ◆ difficult debugging problem
 - ◆ getting valuable help from Ted Zmuda (FNAL engineer recently assigned to TAB/GAB system)
- Review of installation plans in L1cal group
 - ◆ much of cable plant planning was done by Alan Stone (UIC), who recently took a position with the lab
 - ▲ Selcuk Cihangir (FNAL appl. phys.) has agreed to take over Alan's responsibility for physical installation & cabling issues
 - ◆ Lyn Bagby (FNAL), Dan Edmunds (MSU) in charge in installation



The (recent) L1cal Group

<u>Columbia</u>	J.Ban, C.Johnson, S.Lammers, M.Mulhearn, J.Parsons, B.Sippach, L.Zhang
<u>Fermilab</u>	J.Anderson, L.Bagby, M.Cherry, S.Cihangir, J.Fogelsong, J.Green, T.Martin, V.Martinez, J.Moua, T.Zmuda
<u>FSU</u>	T.Adams
<u>Indiana</u>	H.Evans
<u>MSU</u>	M.Abolins, J.Benitez, J.Biel, C.Brock, D.Edmunds, P.Laurens, R.Unalan, H.Weerts
<u>NEU</u>	E.Barberis, C.Fantasia, A.Roe, D.Wood
<u>SMU</u>	B.Kehoe, P.Renkel
<u>UIC</u>	M.Adams, A.Stone, N.Varelas
<u>York</u>	E.Aguilo, S.Beale, W.Taylor
<u>Others</u>	Md.Naimuddin (U.Delhi), M.Cwiok (UC Dublin)
<u>KEY</u>	Faculty, Postdocs, Students, Engineers/Techs



L1 Cal Installation Tasks

ID	WBS	TASK NAME	START-DATE	FINISH-DATE	DURATION
2	1.5.1	Beginning of Run IIb Tevatron Shutdown	2/27/06	2/27/06	0 w
148	1.5.3.2.1.2	Final Cal Noise Studies	3/3/06	3/6/06	0.2 w
153	1.5.3.2.1.7	Decable BLS cables from Trigger Crates	3/7/06	3/14/06	1 w
161	1.5.3.2.1.15	Depopulate & Remove Run I Trigger Crates	3/23/06	3/29/06	2 w
165	1.5.3.2.1.19	Install New Heat Exchangers in Racks	4/3/06	4/5/06	3 w
167	1.5.3.2.1.21	Install Smoke Detectors, Test Safety Sysems	4/11/06	4/13/06	2 w
168	1.5.3.2.1.22	Install Crates from Sidewalk Test Stand	4/14/06	4/18/06	1 w
171	1.5.3.2.1.25	Connect LVDS Cables	4/24/06	4/26/06	1 w
170	1.5.3.2.1.24	Connect Pleated Foil Cables	4/27/06	5/01/056	1 w
173	1.5.3.2.1.27	Connect BLS Cables	5/4/06	5/10/06	0.4 w
174	1.5.7.2.1.28	L1 Cal Ready for Technical Commissioning	5/10/06	5/10/06	0 w

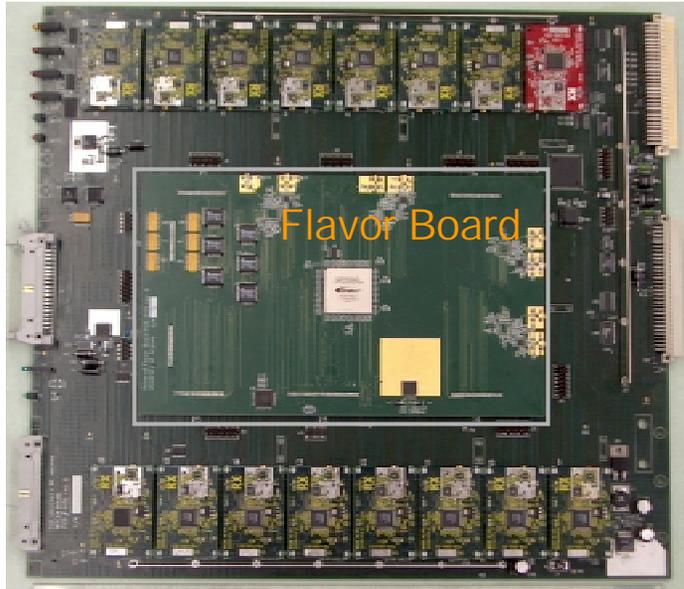
L1 Cal Ready for Technical Commissioning

~ 3 weeks before beam Resumes



L1 Caltrack match: Hardware & Firmware Commissioning

Trigger card



Production & testing of all cards **complete**

- ▲ 16 trigger cards (8+1 needed)
- ▲ 16 flavor boards (8+1 needed)
- ▲ 6 crate managers (2 needed)
- ▲ 10 splitter cards (if needed)

Note: spares function for L1 Muon, too

Control firmware **complete**

Preliminary trigger firmware **in place**

- ◆ Trigger crates **successfully run** in experiment for short periods
 - ▲ Triggers generated and sent to trigger framework
 - ▲ Crates read out to L3
 - ▲ New L1Cal and L1CTT inputs pathways tested
 - ▲ Measurement of latency for BC->L1Cal->L1CalTrack complete
 - Within expected 3 bunch crossings over current latency



L1CTM Infrastructure

• Rack

- ◆ Crates installed in final location in MCH1
 - ▲ Trigger
 - 8 cards form matched triggers in each octant
 - ▲ Manager
 - forms combined counters and sends triggers to framework
- ◆ Rack services in place
 - ▲ Power, cooling, safety, ...
- ◆ ORC coming soon!

• Cables

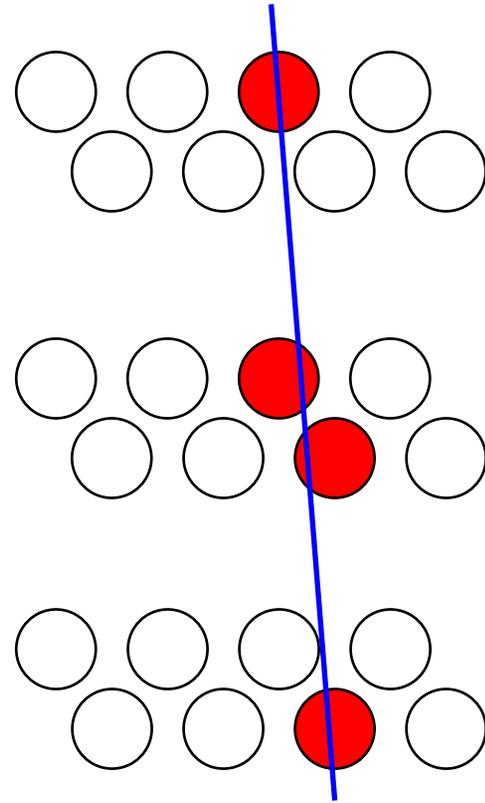
- ◆ Installation and termination complete
 - ▲ Some cables still need more thorough testing
 - ▲ Labels and final placement during shutdown





L1CTT: Physics Motivation

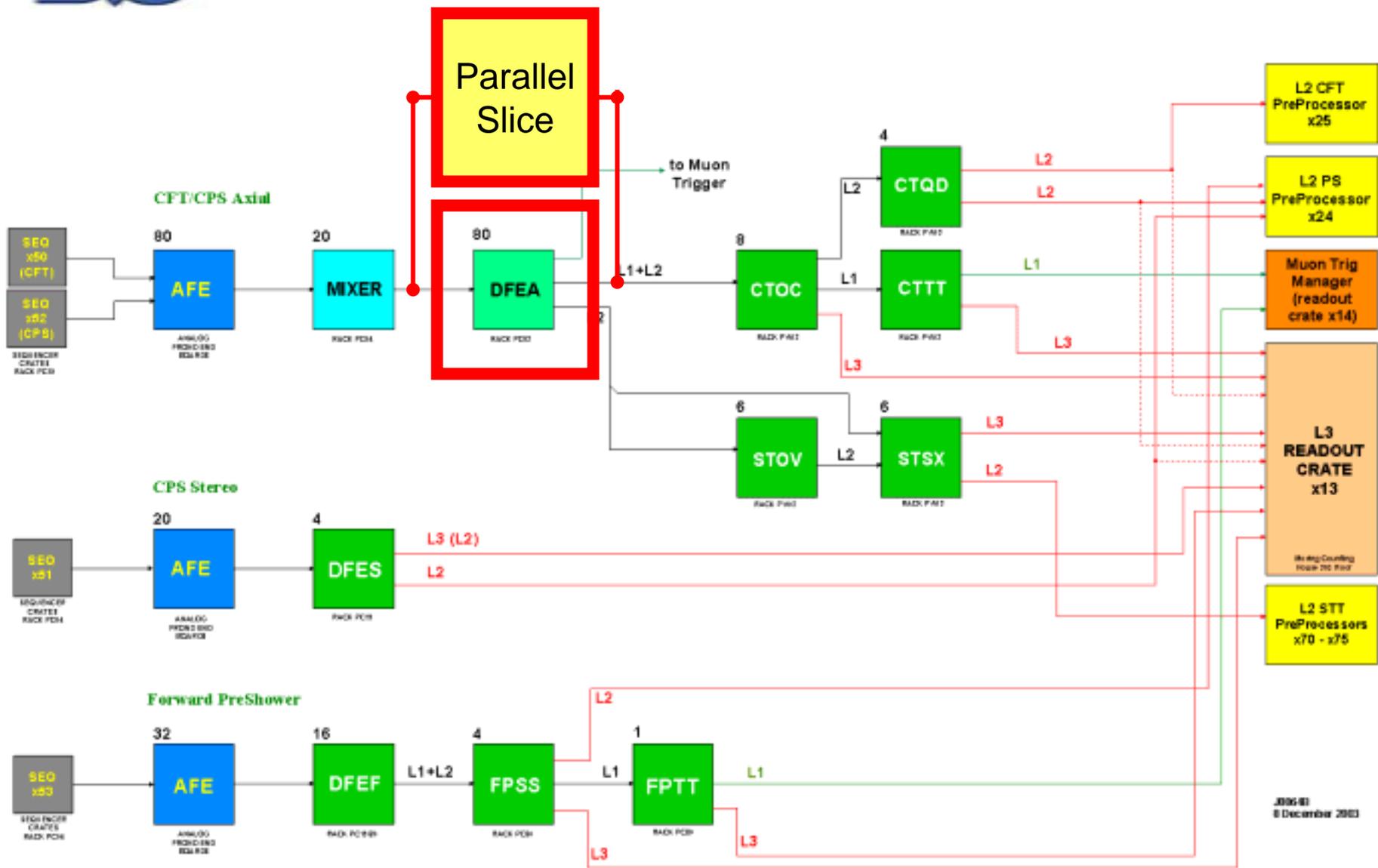
- In Run I Ia and Run I Ib, the L1 Track Trigger Provides:
 - ◆ CFT tracks for L1Muon Seeds
 - ◆ High p_T isolated track trigger capability
 - ◆ CFT tracks + CPS clusters \Rightarrow embryonic electrons
 - ◆ Found tracks for STT
- As $L \rightarrow 10^{32}$, the rejection for L1CTT drop drastically.
- Accomplish high efficiency with low fake rates using the full granularity of the CTT.
- Bottom line:
 - ◆ Singlets reduce rate and increase efficiency



Run I Ib



CTT System Overview





Electronics Needed

Electronics	Needed	In Hand
DFEA2	40	58
Crate Controller	2	10
Crates	2	5
Backplane	2	6
Power Supplies	1 [3]	5

Electronics available since May 2005.
Bit error rates better than $1 : 10^{16}$



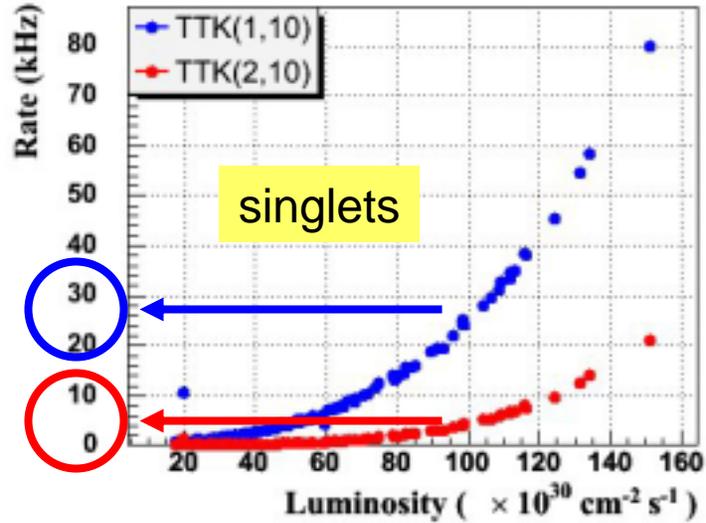
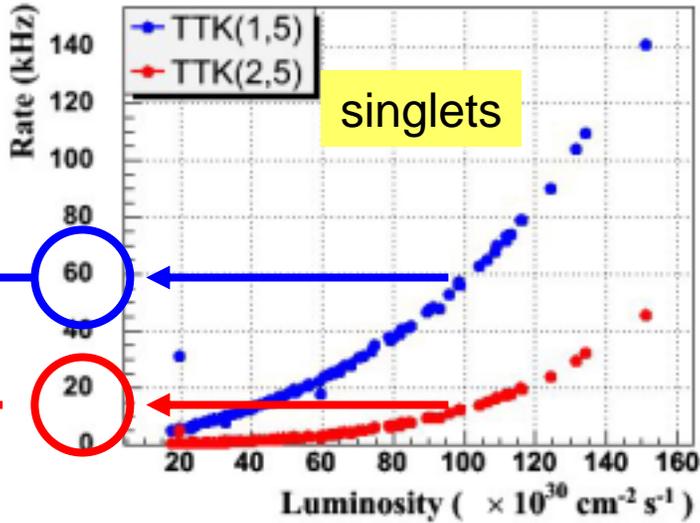
Roadmap and Definitions

- DFEA (Run I I a Hardware)
 - ◆ Doublet firmware [Beginning - December 05]
 - ◆ Mixed doublet/singlet [Dec 05 - Shutdown] (v102)
- DFEA2 (Run I I b Hardware)
 - ◆ Mixed doublet/singlet [Shutdown - briefly]
 - ◆ Singlet firmware [Shutdown + briefly - forever]
- Crosschecks
 - ◆ Doublet/Doublet & Mixed/Mixed [hardware]
 - ◆ Trigsim/hardware comparison
 - ◆ MC/Trigsim rate predictions



L1 Trigger Term Rate Reduction

Measured on existing [Run IIa] hardware.

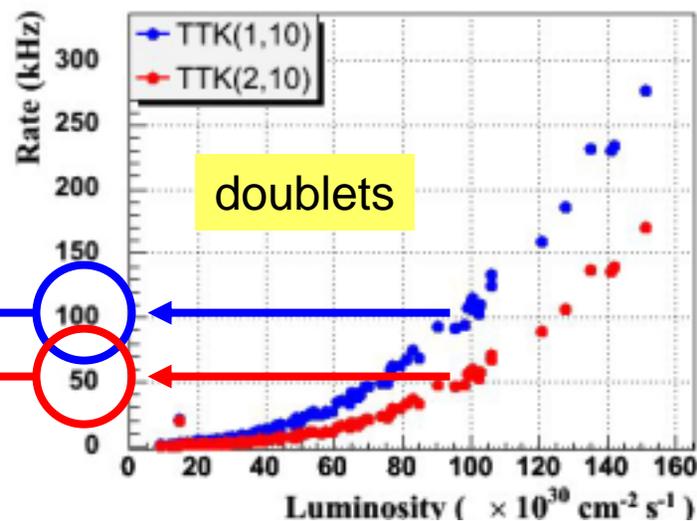
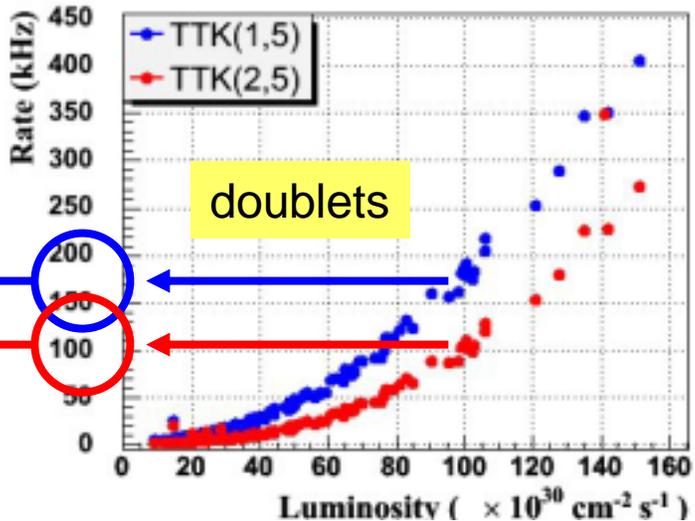


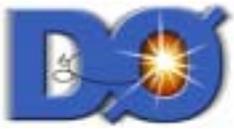
One track

$\times \sim 3$

Two tracks

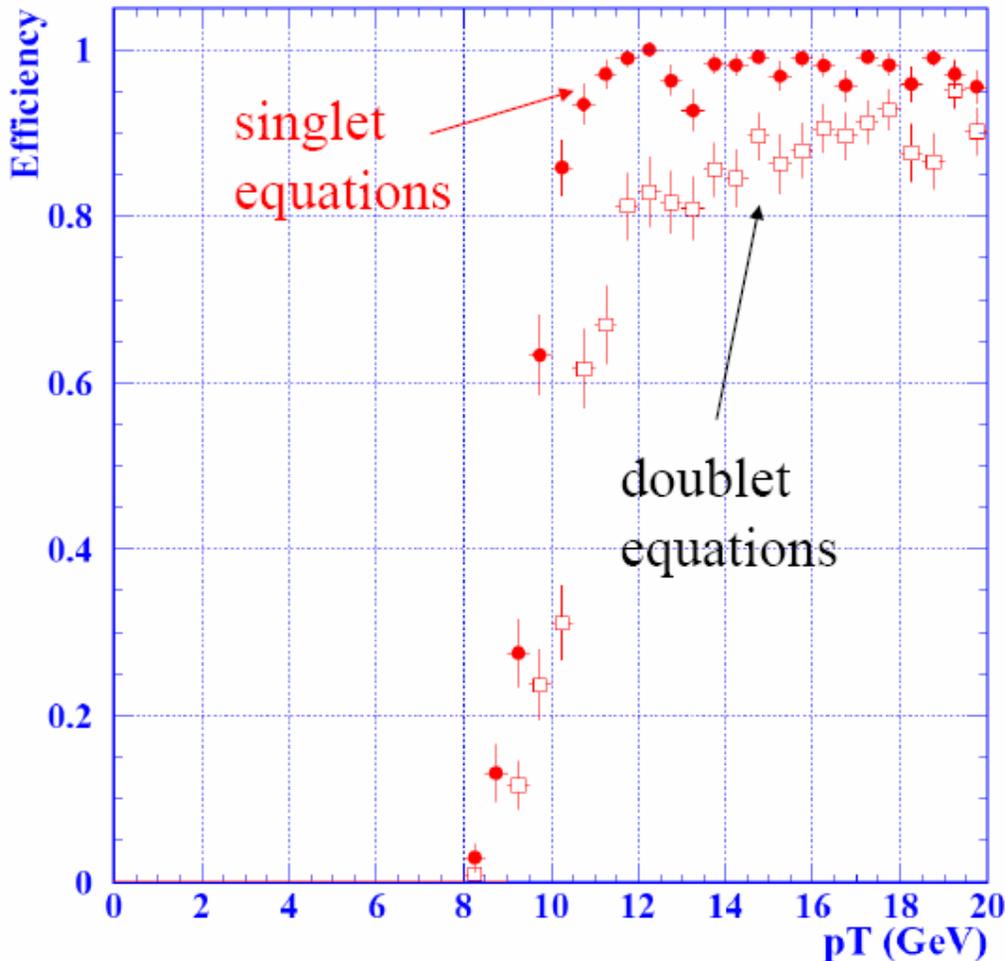
$\times \sim 10$





Singlet/Doublet Efficiency

TTK(1,10) Efficiency



- Turn on
 - ◆ Steeper for singlets
- Plateau
 - ◆ Doublet ~90%
 - ◆ Singlet ~98%



Efficiency Improvements

Sample	DFEA2 singlets (6 nr/GeV)		Doublet/Singlets V102		Doublets	
	efficiency	error	efficiency	error	efficiency	error
50 GeV mu	0.974	± 0.003	0.974	± 0.003	0.888	± 0.005
7.5 GeV mu	0.980	± 0.004	0.973	± 0.005	0.884	± 0.010
4.0 GeV mu	0.968	± 0.006	0.880	± 0.010	0.880	± 0.010
2.2 GeV mu	0.969	± 0.005	0.880	± 0.010	0.880	± 0.010

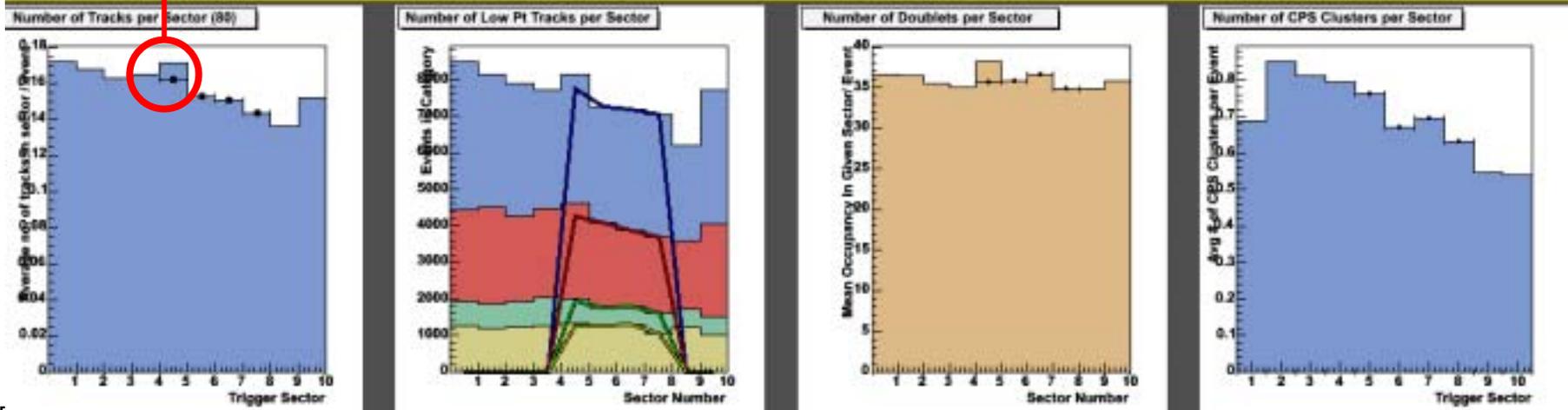
- Single muon efficiency from MC + Trigsim



DFEA/DFEA2 Comparison (v102) (Primum non nocere)

- Current DFEA [Run II a] firmware (v102) uses mixed doublet/singlet architecture
- DFEA2 electronics (with appropriate firmware) reproduces exactly Run II a performance

Known problem in Run IIa electronics





Shutdown and Ongoing Support

- Fermilab (Grünendahl, Tomoto, Olsen, Rapisarda)
- University of Kansas (Wilson, Hensel)
- University of Manchester (Mommson)
- University of Virginia (Buehler)
- Rice University (Mackin, Corcoran)
- Boston University (Narain, Wu, Hazen, Jabeen, Khalatyan, Khalatian, 1-2 students)

Engineering



CTT Shutdown Tasks w/o Beam

Personnel:

CTT physicists:

Norik Khalatyan,
 Samvel Khalatian,
 Monica Pangilinan,
 Marc Buehler,
 Stefan Grünendahl,
 Remi Mommsen

CTT engineers:

Jamieson Olsen,
 Shouxiang Wu

Mixer engineer:

Stefano Rapisarda

L1Muon-L1Caltrack group:

Ken Johns,
 Susan Burke, Jeff Temple et al.

Technician for rack prep/metal work (Victor?)

STT expert

L2 expert

TASK	WHO	DURATION
Check L1CalTrack cables using old DFEA system	CTT phys, KJ et al.	2 days
remove DFEA crates	JO, 2*CTT phys	1 day
retract Mixer-DFEA cables	2*CTT phys	1 day
Install DFEA2 crates	JO, 2*CTT phys	2 days
connect 48V	JO, CTT phys	2 days
connect L1Muon and L1CalTrack cables to pigtails	2*CTT phys	2 days
connect Mixer-DFEA2 cables at backplane	2*CTT phys, JO,SR	2-5 days
Debug Inputs: check clock/sync/parity status of DFEA2 using DFEA2 status reporting	3*CTT phys, JO	2-20 days
check clock/sync/parity of CTOC/STSX/STOV/L1Muon/L1CalTrack inputs	3*CTT phys, JO	2-20 days
Check trigger functionality using test vectors and DAQmon + CTT_examine	2*CTT phys	2-5 days



Level 2 Beta

- Upgrade consists of more and more powerful processors for the Level 2 trigger
- Last project milestone was completed in August
 - ◆ all hardware built and tests
 - ◆ algorithms documented
- Four upgrade beta processors now running in DØ
 - ◆ I2muf, I2cal, I2ps, I2ctt
 - ◆ installed with no interruption to operations
- More to be installed next week



L2STT Upgrade

- Upgrade consists of addition Silicon Track Trigger modules to include Layer 0 in the STT
- Last project milestone completed in December
 - ◆ all hardware in hand, tested
 - ◆ simulator updated, tested
- Final changes to downloading software will wait until shutdown
 - ◆ avoid interference with Run II a operations



Trigger Simulation

- Last project milestone completed in December
 - ◆ simulation code for all upgrade components written, tested and released
 - ◆ critical tools in place for
 - ▲ trigger list development
 - ▲ physics studies



Trigger list development: v15 Task Force

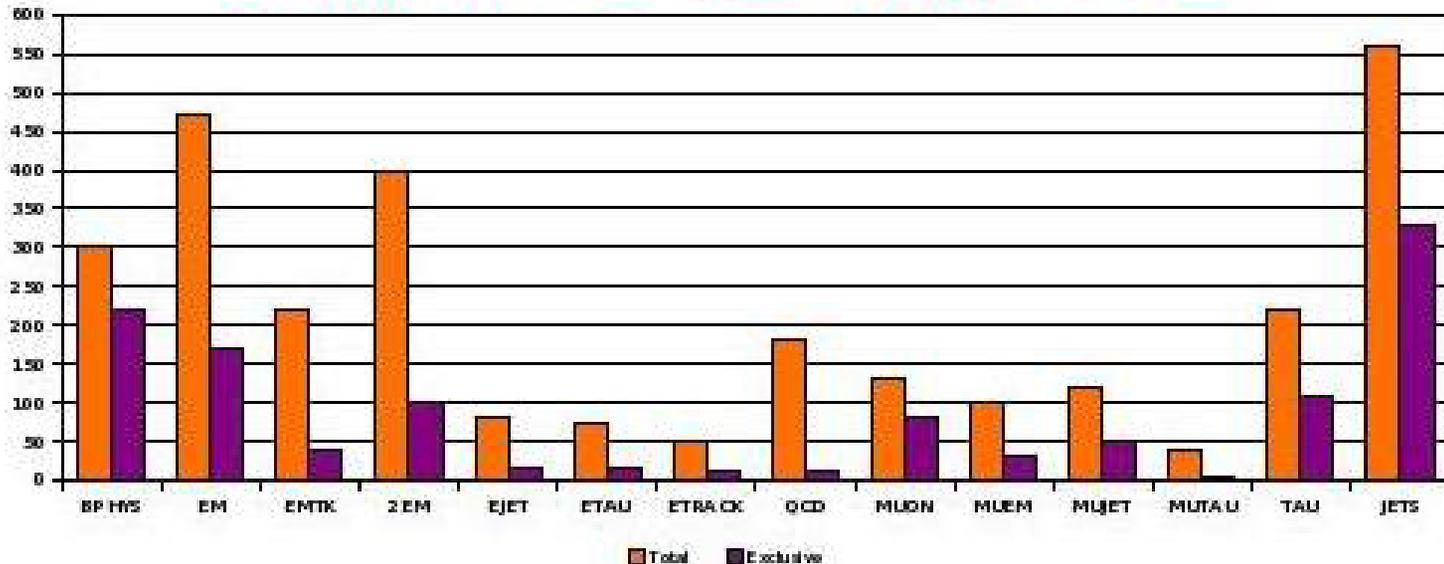
- lead by Marco Verzocchi (Trigger Board Chair) and Miroslav Kopal & Reinhard Schwienhorst (Trigger Studies Group conveners)
- three meetings per week
 - ◆ 2 working meetings, running trigger rate tool in situ
 - ◆ 1 meeting joint with Trigger Board
- first V15 list released in trigger database
- L1 and L2 menus fixed for first pass - special runs will be taken to allow optimization of L3 terms



V15 Trigger list status

- Menu planned for operation at $L=300e30$
 - ◆ draft menu works up to $\sim 220e30$
 - ◆ more (lower E_t) triggers can be added at lower luminosities
 - ◆ try to anticipate non-linearities in trigger rate vs. luminosity

L1Trigger rate at $L=300E30$ (triggerlist V15)





Responses to Oct 05 Director's Review Action Items

- 3.1: The completion of the production of the transition cards should be tracked to ensure it does not become an issue.
 - ◆ complete and tested
- 3.2: Continue system testing and integration as broadly and deeply as possible, continuing to emphasize moving toward physics data.
 - ◆ continuing. Current emphasis on broadening to full system. Progress monitored at weekly meetings (L1cal, CTT), plus daily meetings for L1cal
- 3.3: Complete the L1Cal TRR report recommendation to detail the people assigned to specific tasks in order to do the resource analysis and solve resource problems well before the shutdown. This should address schedule risks for the project
 - ◆ most specific names are assigned. Revisions needed due to recent departure of Alan Stone from the project.



Summary

- All hardware done (for months now)
- L1cal
 - ◆ continuing full-scale system tests
 - ◆ installation planning being reviewed
- L1caltrack
 - ◆ largely installed - some cable testing remaining
- L1CTT
 - ◆ hardware ready
 - ◆ using time to study equations in situ
- L2beta
 - ◆ finished, 4 beta's installed
- L2STT
 - ◆ finished, waiting for shutdown
- Simulation
 - ◆ finished, being used in trigger studies
- Trigger list (v15)
 - ◆ mature and active refinement of L1 L2 trigger list for 300e30