The DØ Run IIb Trigger Upgrade
(in all its approved glory)

Hal Evans
Columbia University
(for the Run IIb Trigger Group)

Burning Questions:
1. Why?
2. How?
   - Physicist World
   - Real World

Reviewer Questions:
- Who?
- When?
- How Much?
Seizing the Moment

The Higgs is w/in our grasp! If...
- enough luminosity (~15 fb⁻¹)
- performant detector (b-tag)
- strong trigger
  - leptons, b-jets, taus, Et-miss
  - Trig eff assumed for Higgs
    Lepton 100%
    Jet+Met 100%

And don’t forget other physics

Tevatron plans

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Lumi (x10^{32} cm⁻²s⁻¹)</th>
<th>BC [ns]</th>
<th>&lt;N_{int}&gt;</th>
<th>L Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
<td>2</td>
<td>396</td>
<td>5.5</td>
<td>yes</td>
</tr>
<tr>
<td>no L level</td>
<td>4</td>
<td>396</td>
<td>11.1</td>
<td>no</td>
</tr>
<tr>
<td>still alive</td>
<td>5</td>
<td>132</td>
<td>4.1</td>
<td>no</td>
</tr>
</tbody>
</table>

DØ Changes
- Integ Lumi ⇒ New Si
- Inst Lumi ⇒ Upgr Trigger

Focus on High Pt Phys
- frees trig bandwidth
- but not enough...
The Run IIa Trigger System

Level-1
- Mainly detector-based
- Correlations
  - Cal-Trk: quadrant level
  - Mu-Trk: L1trk info → L1Mu
- Not deadtimeless
  - Out rate ~5 kHz (r’dout time)

Level-2
- Calibrated data
- Extensive correlations
- Physic objects out (e,μ,τ,j…)
- Out rate ~1kHz (cal r’dout)

Accept Rate Limits
- L1 = 5 kHz     L2 = 1 kHz
- Cannot change
- Improve triggering by increasing bgrd rej. at same eff.

Detector: 7 MHz → Level 1 5 kHz → Level 2 1 kHz

- CAL → L1Cal → L2Cal
- c/f PS → L1PS → L2PS
- CFT → L1CTT → L2CTT
- SMT → L1Mu → L2Mu
- MU → L1FPD
- FPD

Lumi → Framework → Global L2

L3/DAQ 50 Hz

Level 3
# Growing Pains for the Trigger

## System Problems

<table>
<thead>
<tr>
<th>System</th>
<th>Problems</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1Cal</td>
<td>1) Slow signal rise ⇒ trig on wrong X’ing</td>
<td>• Digital Filter</td>
</tr>
<tr>
<td></td>
<td>2) Trig on $\Delta\eta \times \Delta\phi = 0.2 \times 0.2$ TTs</td>
<td>• Clustering</td>
</tr>
<tr>
<td></td>
<td>⇒ slow turn-on curve, high rates</td>
<td></td>
</tr>
<tr>
<td>L1Track</td>
<td>1) Rates sensitive to occupancy ⇒ $\times 1000$ increase 2a→2b</td>
<td>• Narrower Track Roads</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Improve Cal-Track Match</td>
</tr>
<tr>
<td>L1Muon</td>
<td>No Additional Changes Needed!</td>
<td>• Requires Track Trig</td>
</tr>
<tr>
<td>L2</td>
<td>1) Some L2 func. moved to L1</td>
<td>• Upgrade Beta processors</td>
</tr>
<tr>
<td>L2 STT</td>
<td>1) Silicon is changing ⇒ more data, different geometry</td>
<td>• Produce more boards</td>
</tr>
<tr>
<td>L3</td>
<td>1) Some L3 func. moved to L2</td>
<td>• Buy 96 more L3 Nodes</td>
</tr>
<tr>
<td></td>
<td>2) Want more rate capability ⇒ up to 100 Hz</td>
<td>• More processing power</td>
</tr>
</tbody>
</table>

Note: will concentrate mainly on L1/L2 in this talk
Why Upgrade? (hardware)

L1Cal Signals

Signal rise time > 132 ns
  - Can cross threshold before peak
    ⇒ trig on wrong crossing

Affects interesting high-E events

<table>
<thead>
<tr>
<th>Layers</th>
<th>Axial Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run IIA</td>
<td>4</td>
</tr>
<tr>
<td>Run IIB</td>
<td>6</td>
</tr>
<tr>
<td>Run IIB</td>
<td>5/6</td>
</tr>
</tbody>
</table>
### Why Upgrade? (rates)

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Run Ila Definition</th>
<th>Example Channel</th>
<th>L1 Rate [kHz] (no upgrade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM</td>
<td>1 EM TT &gt; 10 GeV</td>
<td>W→ev WH→evjj</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>2 EM TT &gt; 5 GeV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DiEM</td>
<td>1 EM TT &gt; 7 GeV</td>
<td>Z→ee ZH→eejj</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>2 EM TT &gt; 5 GeV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muon</td>
<td>1 Mu Pt &gt; 11 GeV</td>
<td>W→μν WH→μνjj</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>CFT Track</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Di-Mu</td>
<td>2 Mu Pt &gt; 3 GeV</td>
<td>Z/ψ→μμ ZH→μμjj</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>CFT Tracks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e + Jets</td>
<td>1 EM TT &gt; 7 GeV</td>
<td>WH→evjj tt→ev+jets</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>2 Had TT &gt; 5 GeV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mu + Jet</td>
<td>1 Mu Pt &gt; 3 GeV</td>
<td>WH→μνjj tt→μν+jets</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td></td>
<td>1 Had TT &gt; 5 GeV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jet+MEt</td>
<td>2 TT &gt; 5 GeV</td>
<td>ZH→ννbb</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>MEt &gt; 10 GeV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mu+EM</td>
<td>1 Mu Pt &gt; 3 GeV + Trk</td>
<td>H→WW,ZZ</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td></td>
<td>1 EM TT &gt; 5 GeV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iso Trk</td>
<td>1 Iso Trk Pt &gt; 10 GeV</td>
<td>H→ττ , W→μν</td>
<td>17</td>
</tr>
<tr>
<td>Di-Trk</td>
<td>1 Iso Trk Pt &gt; 10 GeV</td>
<td>H→ττ</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>2 Trk Pt &gt; 5 GeV</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Trk matched w/ EM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Core Trigger Menu**
- \( L = 2 \times 10^{32} \, \text{cm}^{-2}\text{s}^{-1} \)
- \( BC = 396 \, \text{ns} \)

**Total L1 Bandwidth**
- \( = 5 \, \text{kHz} \)
Can You Believe Us?

- Background Rate Simulation
  - PYTHIA QCD Monte Carlo
  - + Poisson Distrib. of PYTHIA min-bias events
- Agreement is pretty good!

CFT Occupancy vs Layer data vs sim min-bias

Jet & EM Trigger Rates data vs sim qcd bgrd
## Algorithm Changes: Summary

<table>
<thead>
<tr>
<th>System</th>
<th>Run IIa</th>
<th>Run IIb</th>
<th>sample extra rej</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1Cal</td>
<td>0.2x0.2 TT based</td>
<td>Jet, EM, Tau Clusters use ICR energies</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1-jet</td>
</tr>
<tr>
<td>L1Cal-Trk</td>
<td>quadrant based</td>
<td>clust-based ⇒ ~x8</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>iso-track</td>
</tr>
<tr>
<td>L1Track</td>
<td>roads based on doublet fibers</td>
<td>roads based on singlet fibers</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>iso-track</td>
</tr>
<tr>
<td>L2STT</td>
<td>4 SMT Layers</td>
<td>5 SMT Layers</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>µvbb</td>
</tr>
<tr>
<td>L2Beta</td>
<td>Alpha CPUs⇒Betas 15 specint95</td>
<td>New Betas 1 GHz PIII: 48 s’int95</td>
<td>2-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>processing</td>
</tr>
</tbody>
</table>
L1Cal Algorithms

Based on Atlas Sliding Windows
- see Atlas L1 Trigger TDR
- Local Max finding on a grid

Additional Benefits
- EM shape & Isolation cuts
- Topological Triggers
- Include ICR in Triggers
- Include output for Track Matching

Turn-on Curves from data

Et(trig) / Et(reco) w/ Run IIa Data!

TTs
Ave $= 0.4$
RMS/Ave $= 0.5$

Sliding Windows
Ave $= 0.8$
RMS/Ave $= 0.2$
Jet Algorithm Parameters
- RoI Size
- Declustering Region
  RoI’s comp to find local max
- Et cluster region

EM Algorithm
- sliding windows local max
- EM isolation
- Had Veto

Tau Algorithm
- ~jet algo with
  \( Et(2x2)/Et(4x4) > \text{cut} \)
**L1 Track Algorithm**

- **H**: (51.4 cm) $2 \times 44$ fibers
- **G**: (49.4 cm) $2 \times 40$ fibers
- **F**: (44.5 cm) $2 \times 36$ fibers
- **E**: (39.6 cm) $2 \times 32$ fibers
- **D**: (34.7 cm) $2 \times 28$ fibers
- **C**: (29.8 cm) $2 \times 24$ fibers
- **B**: (24.9 cm) $2 \times 20$ fibers
- **A**: (20.0 cm) $2 \times 16$ fibers

**Fake Rates**

- **Run IIa**: doublets define roads
- **Run IIb**: singlets define roads

**Nominal 2E32 @ 396 ns**

- (1 high pT track)
  - Run IIa
  - Run IIb

**4E32 @ 396 ns**

- (1 high+1 medium pT)
L1 Track Results

<table>
<thead>
<tr>
<th>Pt Range</th>
<th>Scheme</th>
<th>Tracking Eff (%)</th>
<th>Rate of Fake Tracks (% of evts)</th>
<th>Resources (# eqns x # terms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt &gt; 10 GeV (IIa)</td>
<td>ABCDEFGH</td>
<td>96.9</td>
<td>1.02 ± 0.10</td>
<td>11k x 7</td>
</tr>
<tr>
<td>Pt &gt; 10 GeV</td>
<td>abcdefgh</td>
<td>98.03 ± 0.22</td>
<td>0.056 ± 0.009</td>
<td>9.4k x 16</td>
</tr>
<tr>
<td>5 &lt; Pt &lt; 10 GeV</td>
<td>abcdEFGH</td>
<td>99.02 ± 0.14</td>
<td>0.89 ± 0.11</td>
<td>8.9k x 12</td>
</tr>
<tr>
<td>3 &lt; Pt &lt; 5 GeV</td>
<td>abcdEFGH</td>
<td>98.40 ± 0.20</td>
<td>4.5 ± 1.2</td>
<td>11.3k x 12</td>
</tr>
<tr>
<td>1.5 &lt; Pt &lt; 3 GeV</td>
<td>abcdEFGH</td>
<td>95.15 ± 0.32</td>
<td>25.4 ± 0.2</td>
<td>15.5k x 12</td>
</tr>
</tbody>
</table>

**Scheme**

- A(a) = inner superlayer; H(h) = outer superlayer
- Uppercase (A) = use doublet
- Lowercase (a) = use singlet

**Hot News!**

- managed to prune equations for 5-10 GeV bin such that abcdefgh (all singlet) scheme can be used
Run IIb Simulation

- rejection using 1 track w/ impact param signif > cut
- bgrd $\rightarrow$ qq
- signal $\rightarrow$ $\mu$bb

- Results at L=4e32 and 396ns
  - large eff/rejection decline
  - probably need new hit selection algorithm

- Results at $\mathcal{L}$=4e32 and 396ns
  - large efficiency/rejection decline
  - probably need new hit selection algorithm
## Trigger Design Work

<table>
<thead>
<tr>
<th>Subproject</th>
<th>Groups Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Cal: Dig. Filter</td>
<td>Saclay, MSU</td>
</tr>
<tr>
<td>L1 Cal: Algorithms</td>
<td>Columbia</td>
</tr>
<tr>
<td>L1 Cal-Track</td>
<td>Arizona</td>
</tr>
<tr>
<td>L1 Track</td>
<td>Boston, Fermilab</td>
</tr>
<tr>
<td>L2 Beta</td>
<td>Maryland, Orsay, Virginia</td>
</tr>
<tr>
<td>L2 STT</td>
<td>Boston, Columbia, FSU, Stony Brook</td>
</tr>
<tr>
<td>Online &amp; Integration</td>
<td>FSU, MSU, Northeastern, Langston</td>
</tr>
<tr>
<td>Simulation</td>
<td>Brown, Kansas, Manchester, Notre Dame, Saclay</td>
</tr>
<tr>
<td>Level 3</td>
<td>Brown, Washington</td>
</tr>
</tbody>
</table>
# L1 Cal Design

**L1 Cal System**
- Replace old L1Cal
  - partial upgrade not feasible

**Main Design Challenge**
- data distribution w/in system
- use commercial LVDS

**Groups Involved**
- Columbia, MSU, Saclay

## Board Specifications

<table>
<thead>
<tr>
<th>Board</th>
<th>No</th>
<th>Input $(\eta \times \phi)$</th>
<th>Output $(\eta \times \phi)$</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACD/Dig. Filt.</td>
<td>80</td>
<td>4x4</td>
<td>4x4</td>
<td>digitize, filter, E-Et</td>
</tr>
<tr>
<td>ADF Timing F’out</td>
<td>1</td>
<td>all</td>
<td>all</td>
<td>control of ADF</td>
</tr>
<tr>
<td>Trig Algo Brd</td>
<td>8</td>
<td>40x9</td>
<td>31x4</td>
<td>algo’s, Cal-Trk, sums</td>
</tr>
<tr>
<td>Global Algo Brd</td>
<td>1</td>
<td>all</td>
<td>all</td>
<td>TAB ctrl, sums, trig’s</td>
</tr>
</tbody>
</table>
# L1 Cal Status

<table>
<thead>
<tr>
<th>Component</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Splitter</td>
<td>• used to split signals from BLS cards</td>
</tr>
<tr>
<td></td>
<td>• board produced – in test</td>
</tr>
<tr>
<td>ADF</td>
<td>• digital filter algorithm (matched filter + peak det)</td>
</tr>
<tr>
<td></td>
<td>• coded and simulated in Xilinx XC2V500 (-4)</td>
</tr>
<tr>
<td></td>
<td>• vme interface also coded and simulated</td>
</tr>
<tr>
<td>ADF-to-TAB xfer</td>
<td>• proposed Xmit-Cable-Rcvr Test System built</td>
</tr>
<tr>
<td></td>
<td>• first tests ok – more complete test in progress</td>
</tr>
<tr>
<td>TAB</td>
<td>• EM, Jet and Tau algos coded and sim in Altera Stratix</td>
</tr>
<tr>
<td></td>
<td>• Preliminary layout of input section finished</td>
</tr>
</tbody>
</table>
Layout of TAB Input Section

Inputs from 3 ADFs

Sliding Windows Chips: Stratix

Channel Link Receivers
L1 Cal-Track Match Design

Uses same hardware as existing L1mu
  - modest cost and effort required

Design Progress:
  - detailed latency calculation for all system ⇒ OK
  - DØ pipeline depth to be increased for extra headroom

Groups Involved:
  • Arizona
L1 Track Design

L1CTT System
- replace 80 Digital Front End Axial daughterboards
  - new FPGAs ⇒ remake card
- rest of L1CTT remains the same

Main Challenge
- fitting increased number of eqn’s into reasonable FPGA
  - requires intelligent “pruning” of eqn’s

Groups involved
- H’ware: Boston, Fermilab
- Sim: Brown, Kansas, Manchester, Notre Dame
L1 Track Status

Compared several diff. algo’s
  - baseline algorithm chosen
    - similar in spirit to Run IIa
    - but prunes low eff eqn’s

Singlet Algo coded & sim
  - Xilinx Virtex II XC2V6000
    - currently available
  - Resource Usage
    - Pt > 10 bin ~35%
    - 1.5 < Pt < 3 bin ~30%

DFEA w/ new FPGA footprint
Run IIb STT Design

Upgrade
- make more of same cards

Challenge
- new algo at highest lumi?

Groups Involved
- Boston, Columbia, FSU, Stony Brook

Run IIb STT Crate (1 of 6)

Previous crate

CPU

SBC

Terminator

to L2CTT

TFC

STC

FRC

TFC

Next crate

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

CPU

SBC

Terminator

to L2CTT

TFC

STC

FRC

TFC

Comp | Purpose | Run IIa (per crate) | Run IIb (5 Layer) | Run IIb (6 layer)
--- | --- | --- | --- | ---
FRC | L1CTT roads distrib + Syst control | 1 | 1 | 1
STC | SMT hits + assoc to roads | 9 | 10 | 12
TFC | Track fits | 2 | 4 | 4

H. Evans
D0 Collab Meeting: 11-Oct-02
L2 Beta’s for Run llb

Run llb
- 24 β’s replace α’s
- PCBs just released for production!

Run llb Upgrade
- upgrade 12 CPUs
  - only CPUs – use Run llA adapter boards
- put in crates w/ highest load

Main Challenge (llb)
- design better algo’s

Groups Involved
- Maryland, Orsay, Virginia

---

64 bit 33 MHz PCI

9U board

64 bit <2MHz VME

32 bits 66 MHz (max) Local bus

128 bits ~20 MHz MBus

PLX 9656

FPGA

UII

Drivers

ECL Drivers
## What Do We Get?

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Run Ila Definition</th>
<th>Example Channel</th>
<th>L1 Rate [kHz] (no upgrade)</th>
<th>L1 Rate [kHz] (w/ upgrade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM</td>
<td>1 EM TT &gt; 10 GeV</td>
<td>W→eν</td>
<td>1.3</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WH→eνjj</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DiEM</td>
<td>1 EM TT &gt; 7 GeV, 2 EM TT &gt; 5 GeV</td>
<td>Z→ee</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ZH→eejj</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muon</td>
<td>1 Mu Pt &gt; 11 GeV, CFT Track</td>
<td>W→μν</td>
<td>6</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WH→μνjj</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Di-Mu</td>
<td>2 Mu Pt &gt; 3 GeV, CFT Tracks</td>
<td>Z/ψ→μμ</td>
<td>0.4</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ZH→μμjj</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e + Jets</td>
<td>1 EM TT &gt; 7 GeV, 2 Had TT &gt; 5 GeV</td>
<td>WH→eνjj</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tt→eν+jets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mu + Jet</td>
<td>1 Mu Pt &gt; 3 GeV, 1 Had TT &gt; 5 GeV</td>
<td>WH→μνjj</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tt→μν+jets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jet+MEt</td>
<td>2 TT &gt; 5 GeV, MEt &gt; 10 GeV</td>
<td>ZH→ννbb</td>
<td>2.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Mu+EM</td>
<td>1 Mu Pt &gt; 3 GeV + Trk, 1 EM TT &gt; 5 GeV</td>
<td>H→WW,ZZ</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Iso Trk</td>
<td>1 Iso Trk Pt &gt; 10 GeV</td>
<td>H→ττ, W→μν</td>
<td>17</td>
<td>1.0</td>
</tr>
<tr>
<td>Di-Trk</td>
<td>1 Iso Trk Pt &gt; 10 GeV, 2 Trk Pt &gt; 5 GeV, 1 Trk matched w/ EM</td>
<td>H→ττ</td>
<td>0.6</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Total Rate</td>
<td>~30</td>
<td>3.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Core Trig Menu
- \( L = 2 \times 10^{32} \)
- \( BC = 396 \) ns

### More Headroom
- L1Cal Topo cuts
- MEt w/ ICR
- L1Cal Taus

### Total L1 Bandwidth
= 5 kHz
The Long & Winding Road

Task Force Study:
- Summer 2001, DØ Trigger Task force studies upgrade options for trigger

Technical Design:
- first draft TDR – Apr 2002
- substantially revised – Aug 2002 (reflects detailed design)

Defining the Trigger Upgrade Project:
- responsible institutions identified by Jan 2002
- all WBS Level 3 managers in place by Mar 2002
- Biweekly full group meetings, plus subproject meetings
- Planning with fully resource-loaded schedule (341 tasks)

NSF MRI award:
- $456k + $113k matching for L1 tracking subproject
- Complements ~$400k Saclay in-kind contribution for L1cal

Reviews:
- PAC (Oct 01, Apr 02), Technical Review Committee (Dec 01), Director’s Review Committee (Apr 02), DRC/TRC (Aug 02), DOE/Lehman (Sep 02)
- Jun 02 – PAC recommends stage 1 approval
- Aug 02 – DRC/TRC recommends all D0 Trig upgrades ready for baselining.
- Sep 02 – DOE review recommends baselining (!!!)
Trigger Management

WBS 1.2: Trigger Upgrade
H. Evans (Columbia), D. Wood (Northeastern)

- WBS 1.2.1: Level 1 Calorimeter
  M. Abolins (MSU), H. Evans (Columbia), P. LeDu (Saclay)

- WBS 1.2.2: Level 1 Cal-track match
  K. Johns (Arizona)

- WBS 1.2.3: Level 1 Tracking
  M. Narain (Boston)

- WBS 1.2.4: Level 2 Beta upgrade
  R. Hirosky (Virginia)

- WBS 1.2.5: Level 2 STT upgrade
  U. Heintz (Boston)

- WBS 1.2.6: Trigger Simulation
  M. Hildreth (ND), E. Perez (Saclay)

WBS 1.3: DAQ/Online
S. Fuess (Fermilab), P. Slattery (Rochester)

- WBS 1.3.1: Level 3 Systems
  G. Watts (Washington)
  D. Chapin (Brown)

- WBS 1.3.2: Network & Host Systs
  J. Fitzmaurice
  S. Krzywdzinski

- WBS 1.3.3: Control
  F. Bartlett, G. Savage
  V. Sirotenko

WBS 1.4: Other

H. Evans
## Schedule & Personnel

<table>
<thead>
<tr>
<th>Project</th>
<th>Milestone</th>
<th>Effort [py]</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Calorimeter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ADF prototype shipped to Fermilab</td>
<td>5/03</td>
<td>Eng 6.4</td>
</tr>
<tr>
<td>• TAB prototype complete</td>
<td>5/03</td>
<td>Phys 5.2</td>
</tr>
<tr>
<td>• Production &amp; Testing complete</td>
<td>2/05</td>
<td></td>
</tr>
<tr>
<td>L1 Cal-Track Match</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Prototype MTFB complete</td>
<td>5/03</td>
<td>Eng 2.3</td>
</tr>
<tr>
<td>• Production &amp; Testing complete</td>
<td>7/04</td>
<td>Phys 0.5</td>
</tr>
<tr>
<td>L1 Tracking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Target FPGA algorithm coded</td>
<td>7/03</td>
<td>Eng 3.2</td>
</tr>
<tr>
<td>• Prototype tested at Fermilab</td>
<td>4/04</td>
<td>Phys 3.5</td>
</tr>
<tr>
<td>• Production &amp; Testing complete</td>
<td>3/05</td>
<td></td>
</tr>
<tr>
<td>L2 Beta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Prototype testing complete</td>
<td>10/04</td>
<td>Eng 0.3</td>
</tr>
<tr>
<td>• Production complete</td>
<td>2/05</td>
<td>Phys 4.8</td>
</tr>
<tr>
<td>L2 STT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Place parts orders</td>
<td>4/03</td>
<td>Eng 1.1</td>
</tr>
<tr>
<td>• Production &amp; Testing complete</td>
<td>2/05</td>
<td>Phys 1.0</td>
</tr>
<tr>
<td>Level 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• L3 Filter Node Commissioning</td>
<td>9/05</td>
<td>Comp 1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phys 0.2</td>
</tr>
</tbody>
</table>

Note: Integration & Commissioning not included in “Effort” numbers

Silicon Ready ~7/05
### The Bill

<table>
<thead>
<tr>
<th>Project Costs [FY02 k$]</th>
<th>M&amp;S equip</th>
<th>Labor</th>
<th>Total</th>
<th>Contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Calorimeter</td>
<td>457</td>
<td>928</td>
<td>1385</td>
<td>45%</td>
</tr>
<tr>
<td>L1 Cal-Track Match</td>
<td>177</td>
<td>71</td>
<td>248</td>
<td>40%</td>
</tr>
<tr>
<td>L1 Tracking</td>
<td>569</td>
<td>301</td>
<td>870</td>
<td>51%</td>
</tr>
<tr>
<td>L2 Beta</td>
<td>49</td>
<td>44</td>
<td>93</td>
<td>80%</td>
</tr>
<tr>
<td>L2 STT</td>
<td>172</td>
<td>63</td>
<td>235</td>
<td>43%</td>
</tr>
<tr>
<td>L3</td>
<td>210</td>
<td>1.1</td>
<td>211</td>
<td>70%</td>
</tr>
</tbody>
</table>

### Notes:

- much of labor covered by in-kind contributions
  - French $587k
  - US Universities $398k
- integration & commissioning costs not included here

### Total Cost (L1 & L2 – FY02 $)

- $2,871k no conting.
- $4,249k 48% conting.
We have a Goal
- before the LHC turns on

We have a Problem
- > x6 too high at required luminosity

We have a Solution
- L1: Cal, Cal-Track, Track
- L2: Beta’s, STT

We have a Team
Strong University Commitments

We have a Mountain of Paper

We have Approval

Let’s Go!