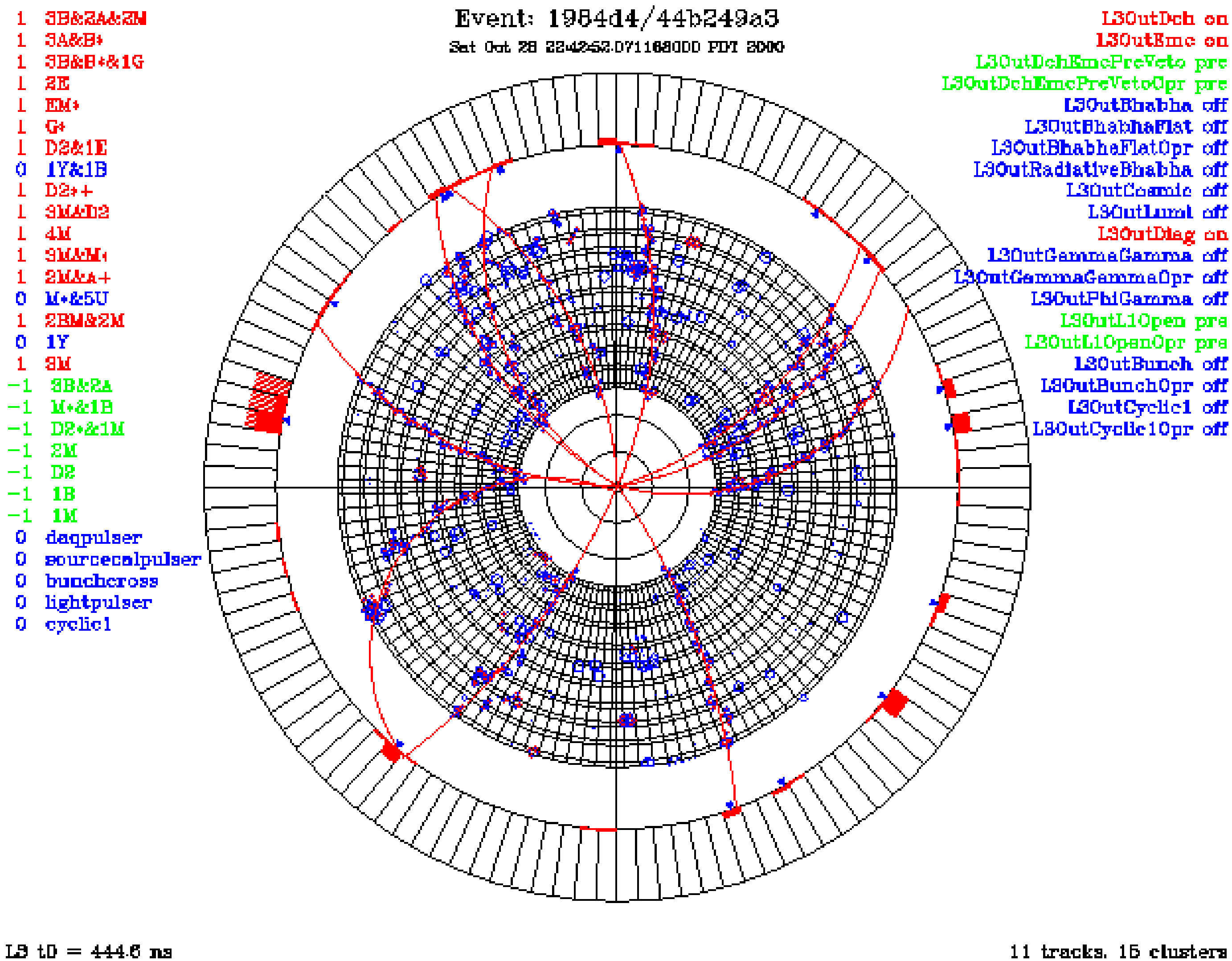
BaBar Trigger

Su Dong Feb/15/02



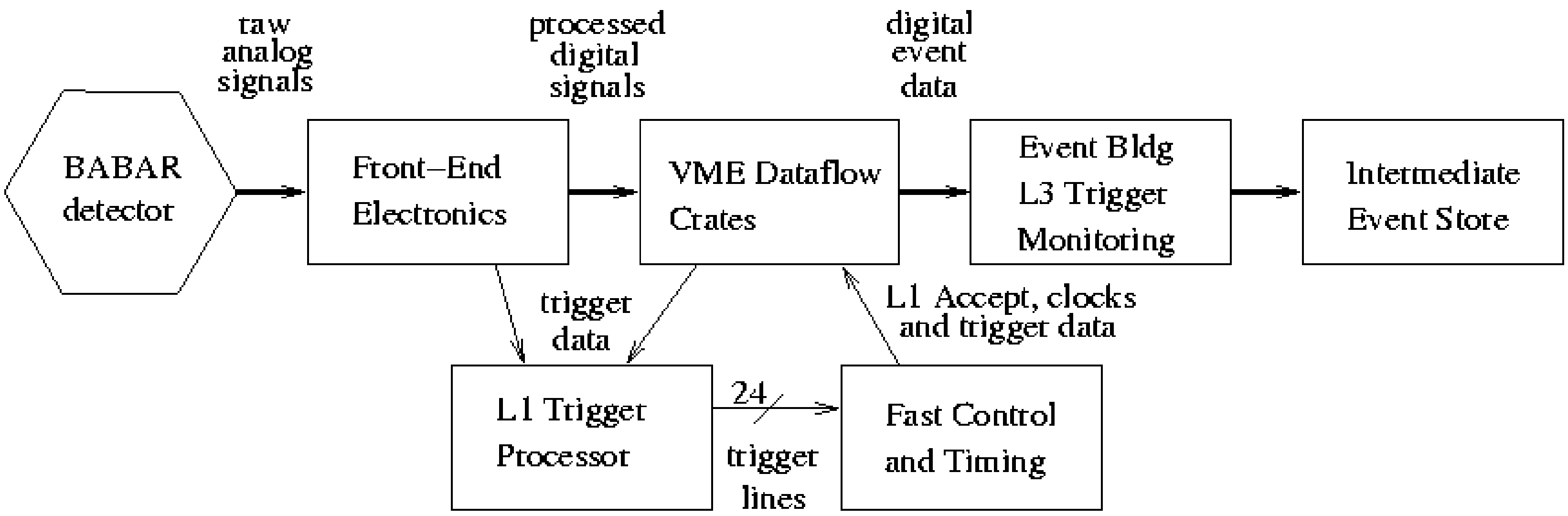
Trigger Requirements and General Strategy

The basic requirement of the trigger system is to select interesting physics events with *high, stable and well understood* efficiency.

Some implementation features:

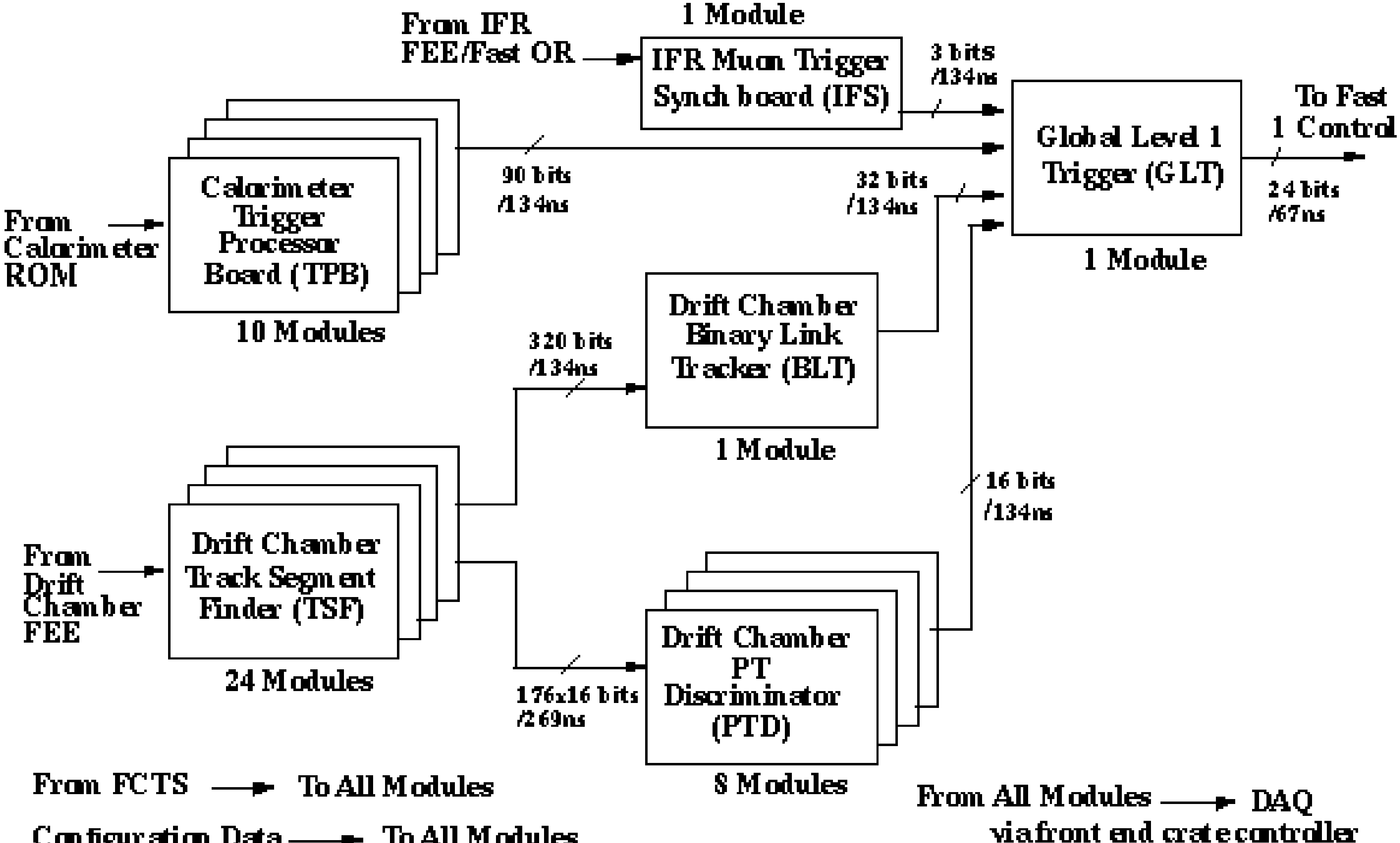
- **Trigger lines mostly defined by generic topology (2,3,4 particles etc.), not by specific physics source.**
- **Deploy orthogonal triggers using pure DCH or pure EMC triggers with high efficiency for affordable topologies.**
  - ***stability and efficiency measurability.***
- **Built in tolerance for detector inefficiencies:**
  - **Accept 3 out of 4 hits for track segment finding in a superlayer**
  - **Allow missing segments in L1 and L3 track triggers**
  - **Include trigger lines where at least one signal particle is allowed to miss DCH or EMC trigger, whenever possible.**

BaBar Trigger/Data Acquisition



- **Detector frontend electronics have 12.9μs pipeline buffers for L1 trigger latency.**
- **4 parallel DAQ event buffers to allow L1 triggers to be taken while other events are being readout. The only steady state dead time is 2.6μs L1Accept broadcast time for each L1 trigger (2.6μs $*$ 1KHz $\sim$ 0.3%)**

L1 Trigger System



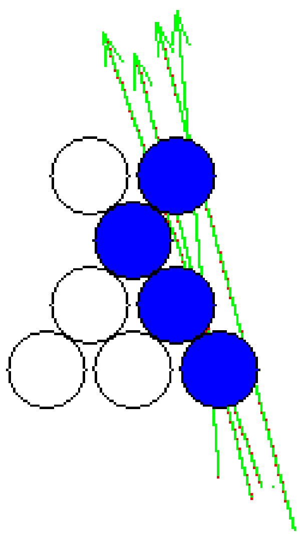
L1 Trigger Features

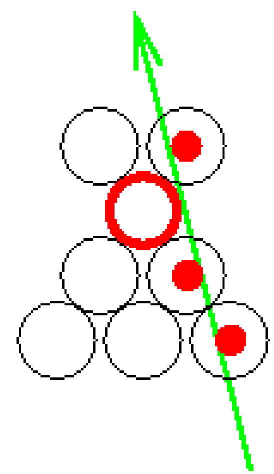
- **PEP-II beam essentially continuous so that L1 trigger also operates in `DC' mode.**
- **Input information to L1:**
  - **DCH wire hits at 267ns intervals. 7104 DCH cells transmitted to TSF via 24 fibers from DCH frontend.**
  - **EMC energy sums for 280 towers (θxϕ=7x40) of 24 crystal each are transmitted to EMT at 267ns intervals from EMC ROMs.**
  - **IFR ϕ strip ORs for 6 barrel sextants & 4 endcap sectors.**
- **There is no fast trigger detector element such as TOF but still a reasonable L1 time resolution of ~50ns.**
- **Existing system essentially pure rϕ triggers only.**
- **Intermediate trigger DAQ data logged each event and elaborate diagnostic memories system for testing.**

Track Segment Finder Conc

use drift time information to better determine track position and even

One - shot *versus* ***Counter - Based***





Event ti

(9

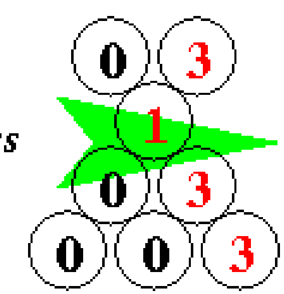
180

Position

0.0

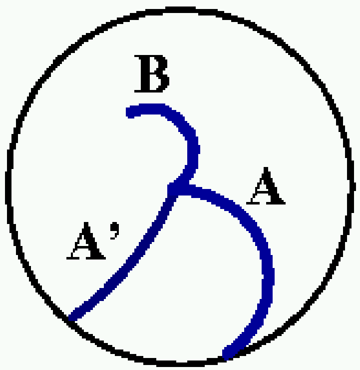
—

Look-Up-Table address



positi

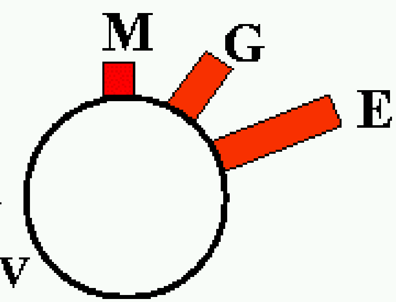
Level 1 trigger objects



B: short track reaching SL5, $p_t \sim 120$ MeV

A: long track reaching SL10, $p_t \sim 180$ MeV

A': long track reaching SL10, pt > 800 MeV

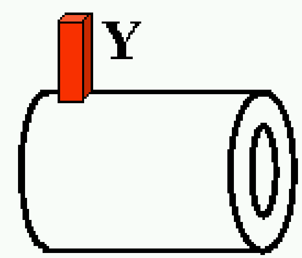


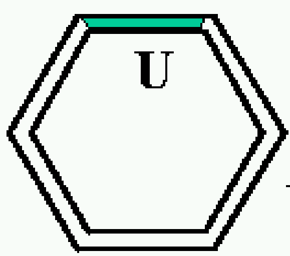
M: minimum ionizing cluster, E > 120 MeV

G: intermediate energy cluster, E > 300 MeV

E: high energy cluster, E > 700 MeV

Y: backward barrel cluster, E > 1 GeV





U: muon in IFT

L1 Trigger Line Naming Conventions

EMT signals M,G,E are 20 bit ϕ maps (Y is 10 bits)

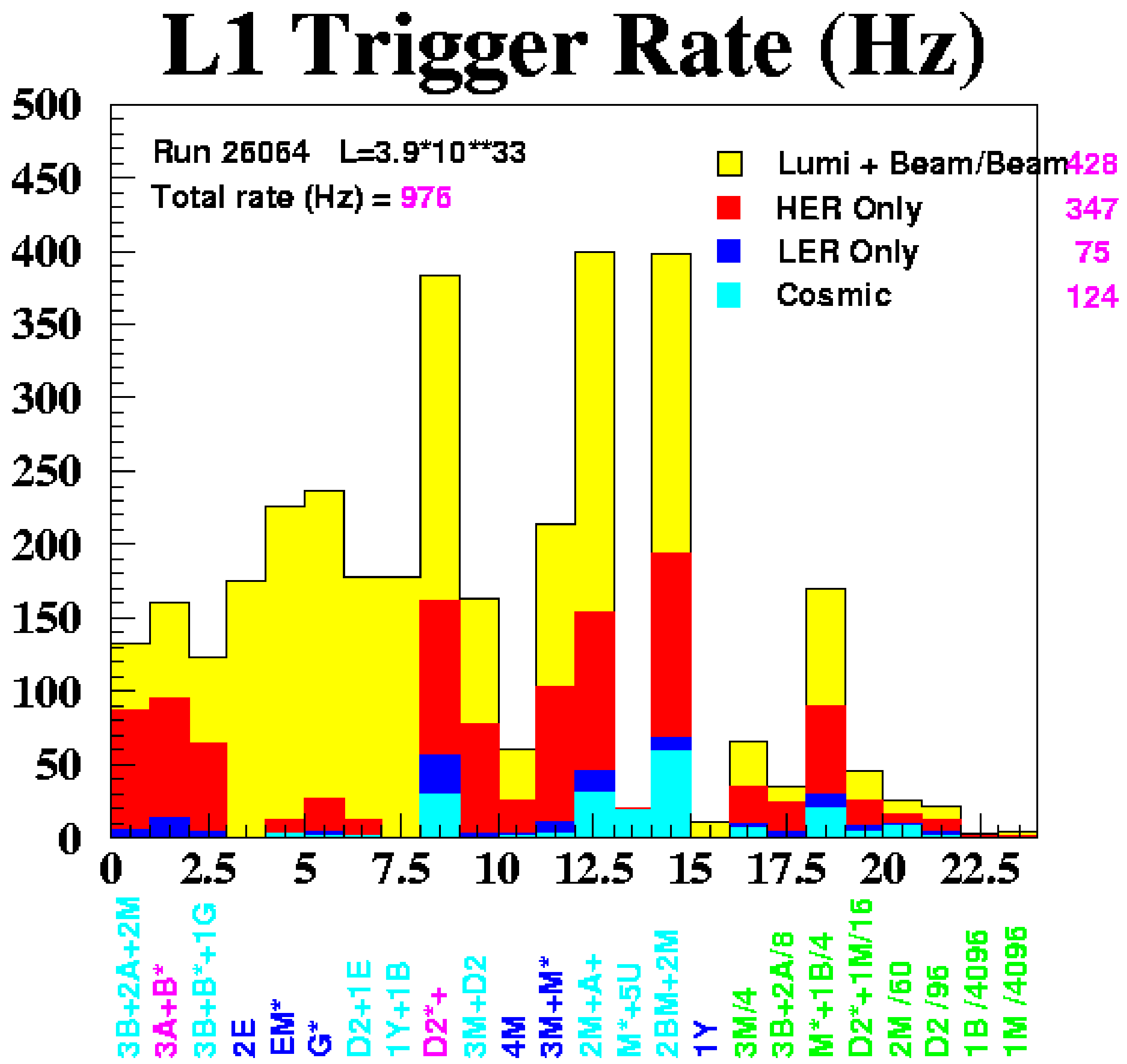
DCT signals A,B,A' are 16 bit ϕ maps

- **3B&2A** means **$B \geq 3$ and $A \geq 2$**
- **M*** means **2 M hits back to back**
- **EM*** means **M and E hits back to back**
- **A+** means **$A \geq 1$ & $A' \geq 1$**
- **D2** means **$B \geq 2$ & $A \geq 1$ (short hand 2 track trg)**
- **BM** means **B matched by M in same ϕ location**

For counting distinct objects from the ϕ maps:

- **Normal objects (B,A,M,E etc.) are separated by more than 1 ϕ bin: 22.5^o for DCT tracks, 18^o for EMT hits.**
- **Back to back angles cuts for B*,M*,EM* ~120^o.**
- **DCT/EMT match objects BM ~90^o apart.**

Feb/02



(Current Feb/02 rate improved significantly from last year mainly in lowering of LER background)

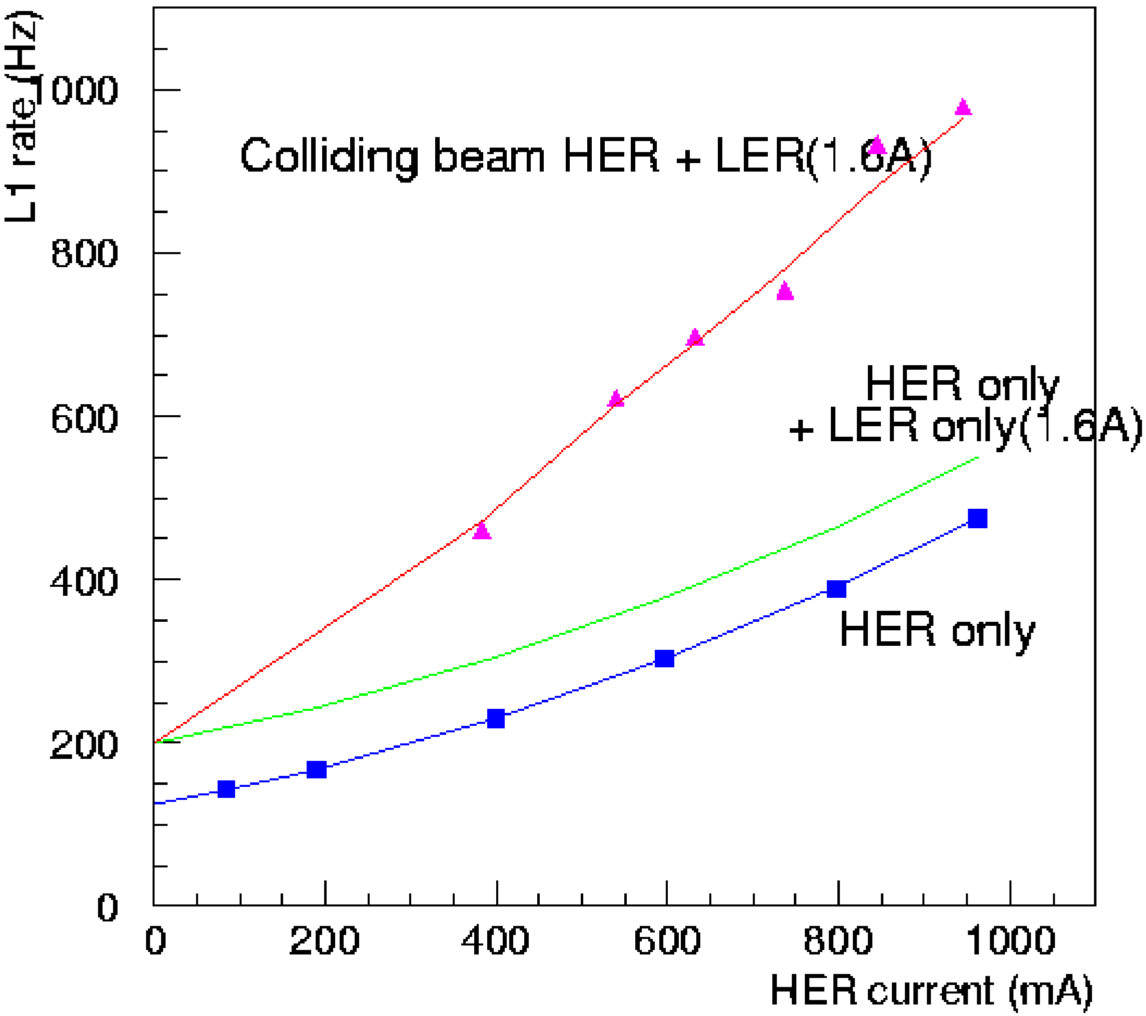
L1 Trigger Efficiency

	Pure DCT	Pure EMT	All L1 lines
BB generic	99.1%	99.8%	>99.9%
B->$\pi^0\pi^0$ + B->X	79.7%	99.2%	99.8%
B->$\tau\nu$ + B->X	92.2%	95.5%	99.7%
cc	95.3%	98.8%	99.9%
uds	90.6%	95.6%	98.2%
Bhabha	98.9%	99.2%	>99.9%
$\mu\mu$	99.1%	-	99.6%
$\tau\tau$	80.6%	77.6%	94.5%

(Hadronic final states: all events

Leptonic final states: fiducial events)

L1 Rate Projection



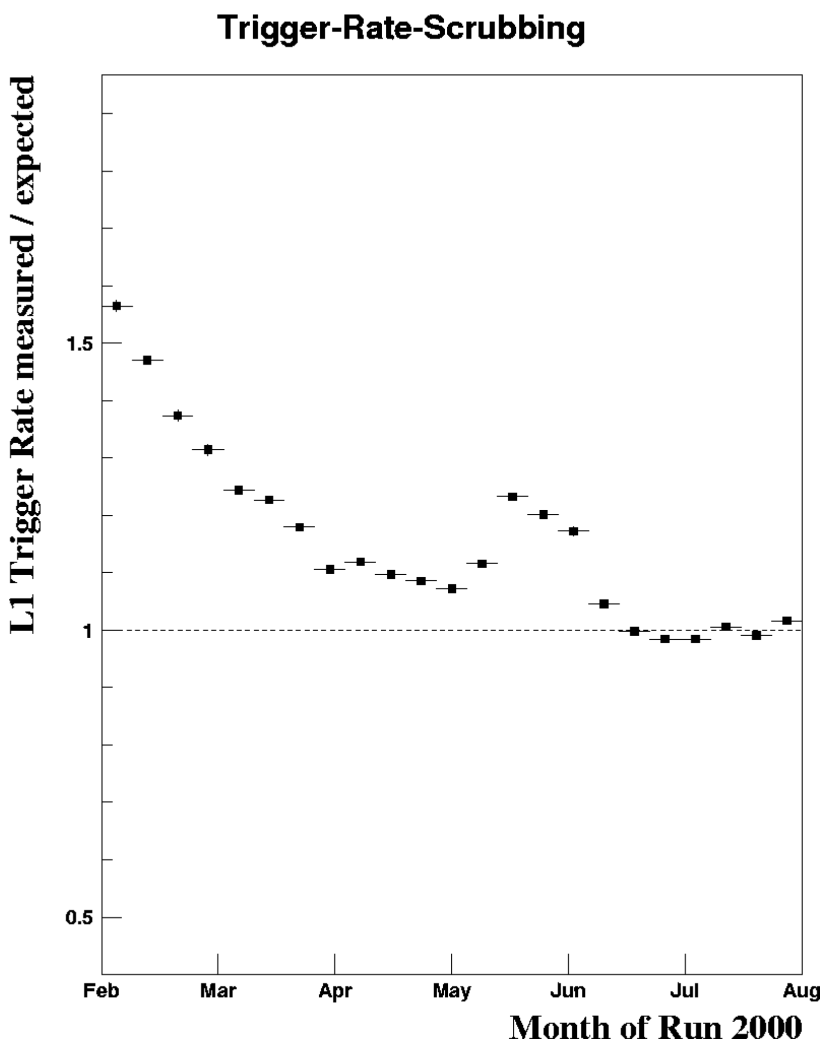
Feb/02 background run result suggest Possible model:

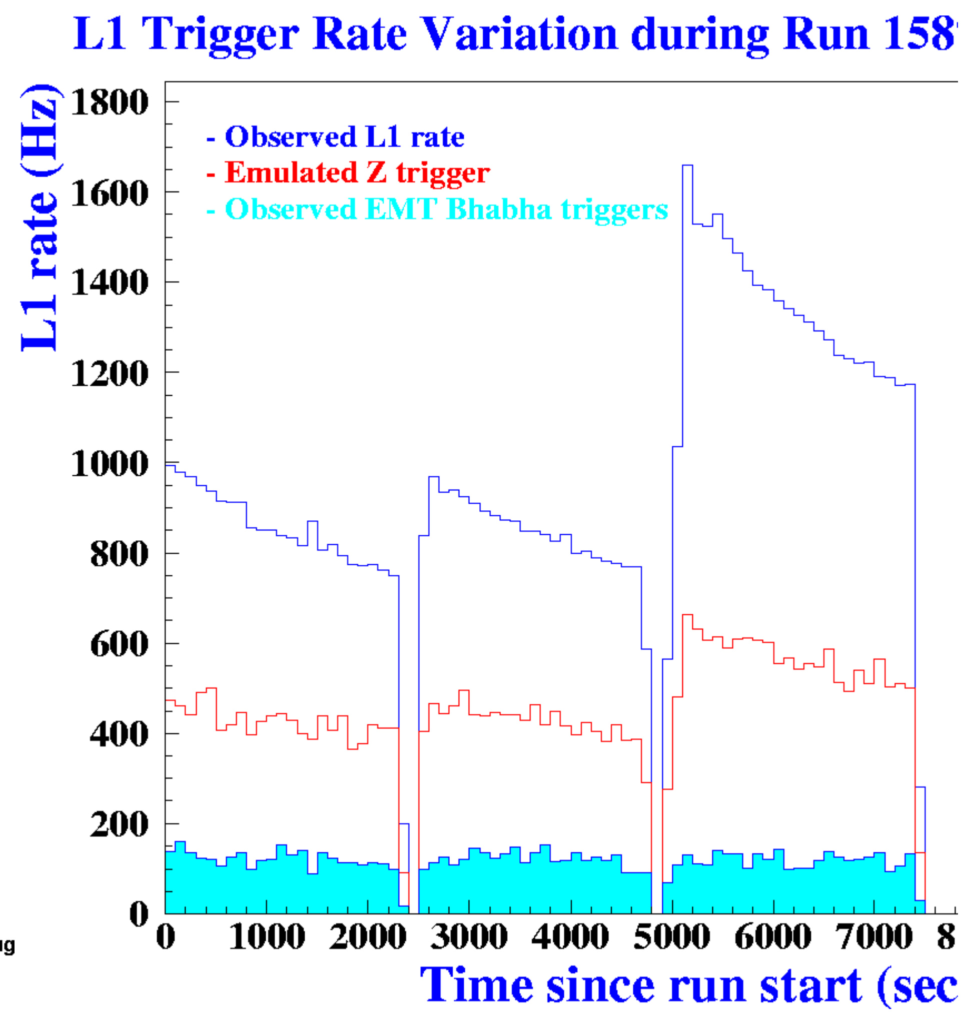
L1 Rate (Hz)

= 125 (cosmic)
+ $50*I_{LER}(A)$
+ $190*I_{HER}(A)$
+ $180*I^2_{HER}(A)$
+ $70*\mathcal{L}/10^{33}$
+ $100*I_{LER}*I_{HER}$

at good conditions

Need head room to absorb fluctuations





L1 Rate and DAQ Bottlenecks

Currently known DAQ rate capability issues:

a) **DCH frontend->ROM GLINK saturation**
   at L1 ~3-4 KHz (*Major modifications to DCH FEE*)

b) **Dataflow rate limitations (at higher background)**
   many items at L1 ~4 KHz (*can improve at some cost*)

c) **L3 processing time**
   can now handle L1 >4 KHz (*easily more with LINUX*)

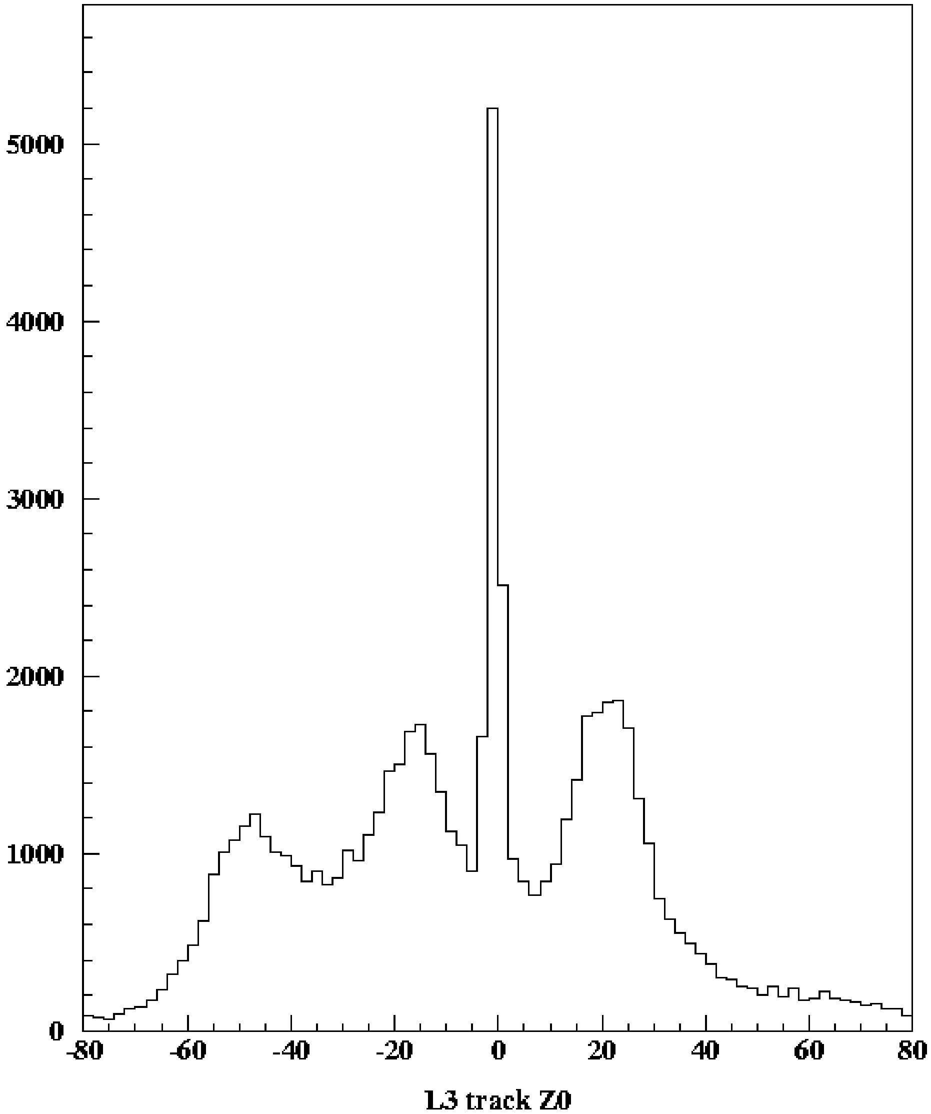
⇒ ***Aim to keep L1 significantly below 4 KHz.***

(need to cope cases of fluctuation of background*2)

L1 rate (Hz) without trigger upgrade

	HER/LER(A)	$L(10^{33})$	Nom All/Lumi	Backgr*2 All
2003	1.25/2.25	7.5	1560 / 530	2460
2005	1.6 /3.0	13	2430 / 910	3830
2007	2.0 /4.0	20	3430 / 1400	5330

Where are the background triggers from?



Background triggers mainly from Z~±20cm beampipe flange, and some from a step in the mask at Z~ -50cm.

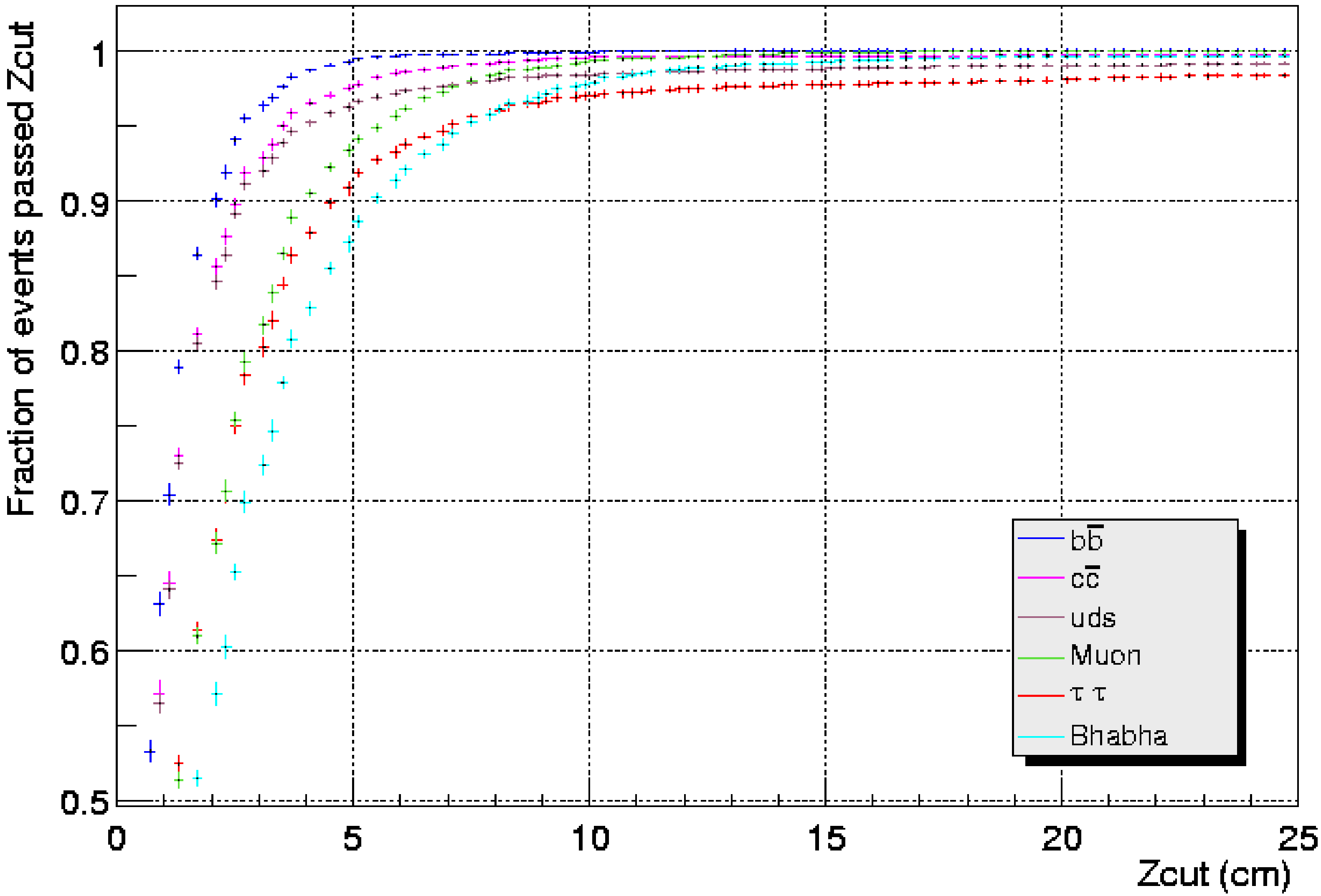
They also mainly occur at around the beampipe radius in the rϕ view, concentrated in the horizontal plane.

One most effective way of reducing L1 background triggers is to demand tracks from IP in Z.

L1 DCT Upgrade

- **Rebuilding 24 TSFs (Stereo superlayer data output). New 8 Z-P_t-Discriminator (ZPD) boards replacing PTDs, using TSF fine ϕ data (1mm rϕ -> 2-3cm in Z) to achieve single track Z_0 resolution ~3-5cm.**
- **Require 1 ZPD track from IP with $|Z_0|$<10-15cm can achieve high physics efficiency and reject 60% DCT background triggers (~40% of all background triggers). The 2*background rate for 2007 2×10^{34} setting 5330 -> 3820Hz.**
- **New board designs well advanced. Full prototypes by Apr/02 and installation in 2003.**

ZPD 1Z track efficiency



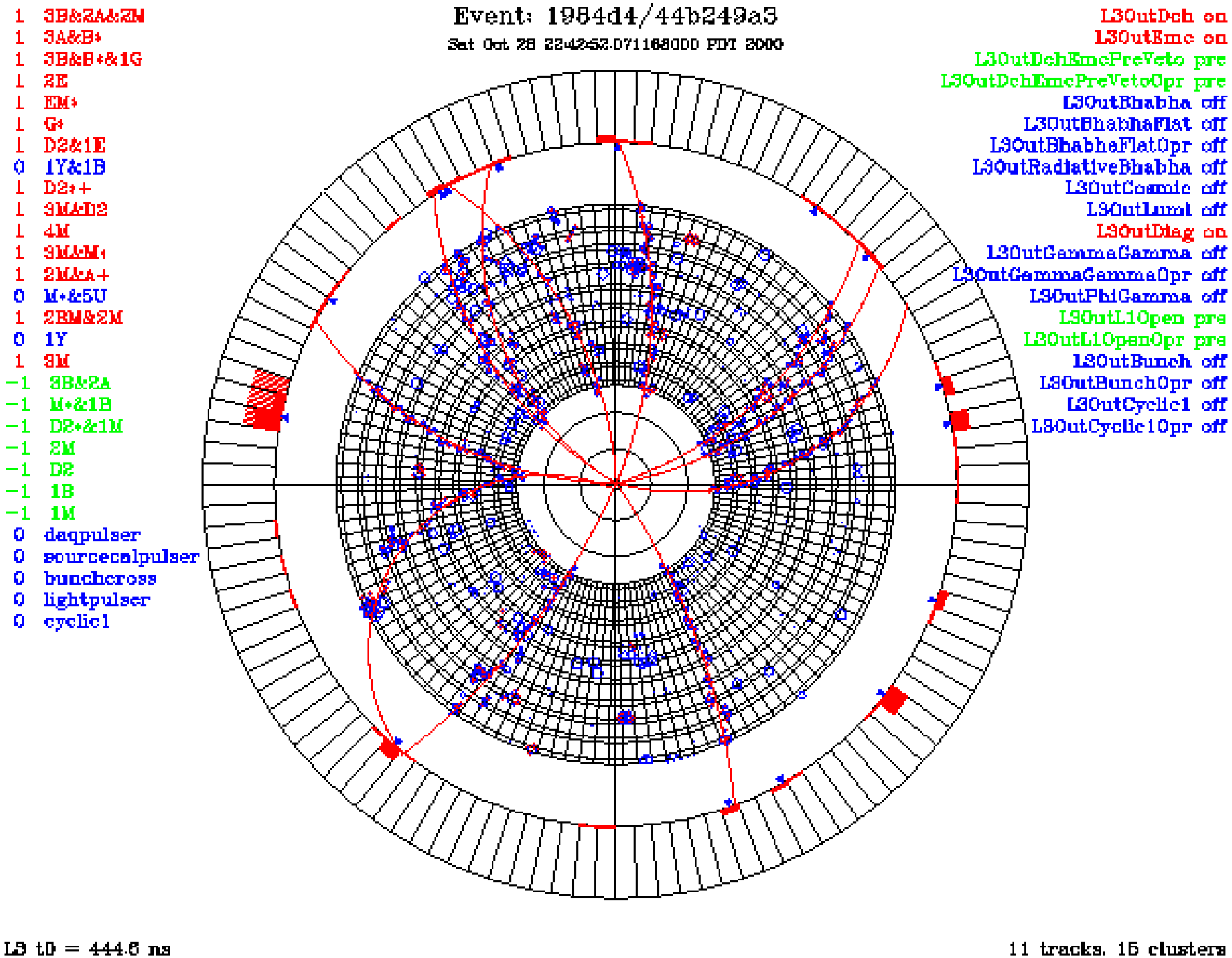
Level-3 Trigger

- Processes all L1 trigger events on a farm of 60 Sun Ultra-5 nodes at ~10ms/event. Can process >4Khz L1 input.
- Separate L3Dch and L3EMC algorithms

	L3DCH	L3EMC	Combined
BB generic	99.4%	93.5%	>99.9%
B->$\pi^0\pi^0$ + B->X	89.1%	95.7%	99.3%
B->$\tau\nu$ + B->X	96.6%	62.3%	98.1%
cc	97.1%	87.4%	98.9%
$\tau\tau$	95.5%	46.3%	97.3%

- Veto Bhabhas and prescaled Bhabha accept.
- Many calibration event selection and monitoring tasks.
- L3 output ~130Hz at $L=4*10^{33}$.

=> *See Rainer's talk for more details.*


Event: 1984d4/44b249a3
Sat Oct 28 22:42:52.071168000 PDT 2000
1 3B&2A&2M
1 3A&B*
1 3B&B*&1G
1 2E
1 EM*
1 G*
1 D2&1E
0 1Y&1B
1 D2*+
1 3MAD2
1 4M
1 3MAM*
1 2MA+
0 M*&5U
1 2BM&2M
0 1Y
1 3M
-1 3B&2A
-1 M*&1B
-1 D2*&1M
-1 2M
-1 D2
-1 1B
-1 1M
0 daqpulser
0 sourcecalpulser
0 bunchcross
0 lightpulser
0 cyclic1
L3OutDch on
L3OutEmc on
L3OutDchEmcPreVeto pre
L3OutDchEmcPreVetoOpr pre
L3OutBhabha off
L3OutBhabhaFlat off
L3OutBhabhaFlatOpr off
L3OutRadiativeBhabha off
L3OutCosmic off
L3OutLumi off
L3OutDiag on
L3OutGammaGamma off
L3OutGammaGammaOpr off
L3OutPhiGamma off
L3OutL1Open pre
L3OutL1OpenOpr pre
L3OutBunch off
L3OutBunchOpr off
L3OutCyclic1 off
L3OutCyclic1Opr off
L3 t0 = 444.6 ns
11 tracks, 15 clusters

Summary

- **Trigger/DAQ operates at ~1Khz L1 rate comfortably.**
- **With L1 DCT upgrade in 2003, can probably run comfortably up to $2*10^{34}$.**
- **For even higher luminosities, the most effective next step would be to veto Bhabhas at L1.**

- **L3 trigger already has >4Khz L1 rate capability. Upgrade to Linux farm can ensure rate capabilities beyond $2*10^{34}$ fairly easily.**