Trigger Status & Upgrade

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Technical Review of BaBar Improvement Plans

Oct/11/00

Trigger requirements & Design Implementations

- **Requirements (L=3x10^{33}):**

  Accepting physics with high, stable, and well understood efficiencies, while providing background rejection to limit output rate at

  <2 KHz for Level-1

  <120Hz for Level-3 (inc. 30Hz Bhabha).

  For specific efficiencies:

BB	**>99%**
udsc hadrons	**>95%**
fiducial ττ	**>95%**

- **Design Implementations:**

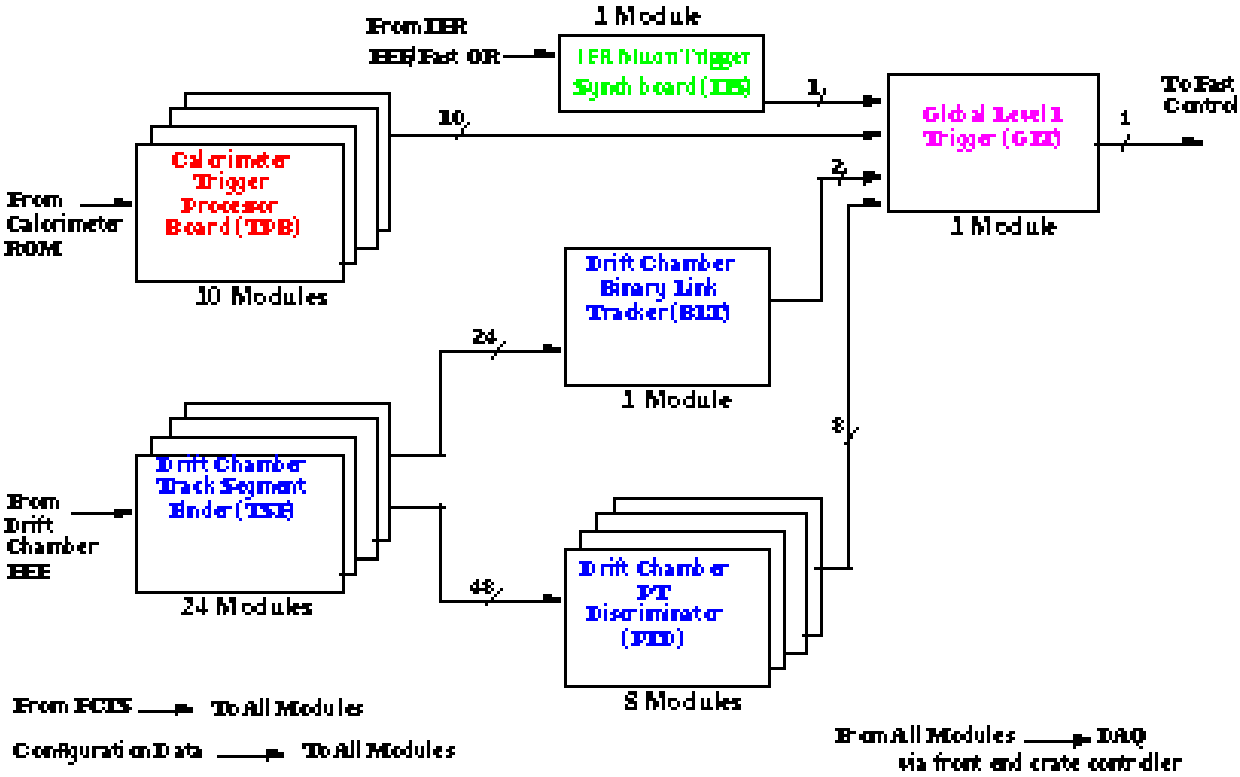
  ⇒ ***Orthogonal triggers from DCH & EMC to accept physics independently at high efficiency. (Already seen its benefits in operation stability and trigger efficiency determination)***

  ⇒ ***Generic event topology triggers accepting all physics to minimize bias from physics assumptions.***

  ⇒ ***Prescaled triggers & pass throughs for efficiency measurements.***

  ⇒ ***Extensive trigger DAQ data for diagnostics.***

L1 Trigger System



Trigger objects: ***(All rϕ projection observables)***

A: long track (>150MeV/c) **M:** EMC MIP (>100MeV)

B: short track (>120 MeV/c) **G:** EMC γ (>300 MeV)

A': high P_t track (>800 MeV/c) **E:** EMC e/γ (>700MeV)

U: IFR muon hit pattern **Y:** EMC backw. e^+ (1GeV)

Back-back objects: e.g. **B*** = 2 B tracks $|\Delta\phi| > \sim 120^o$

EM* = E vs M $|\Delta\phi| > \sim 120^o$

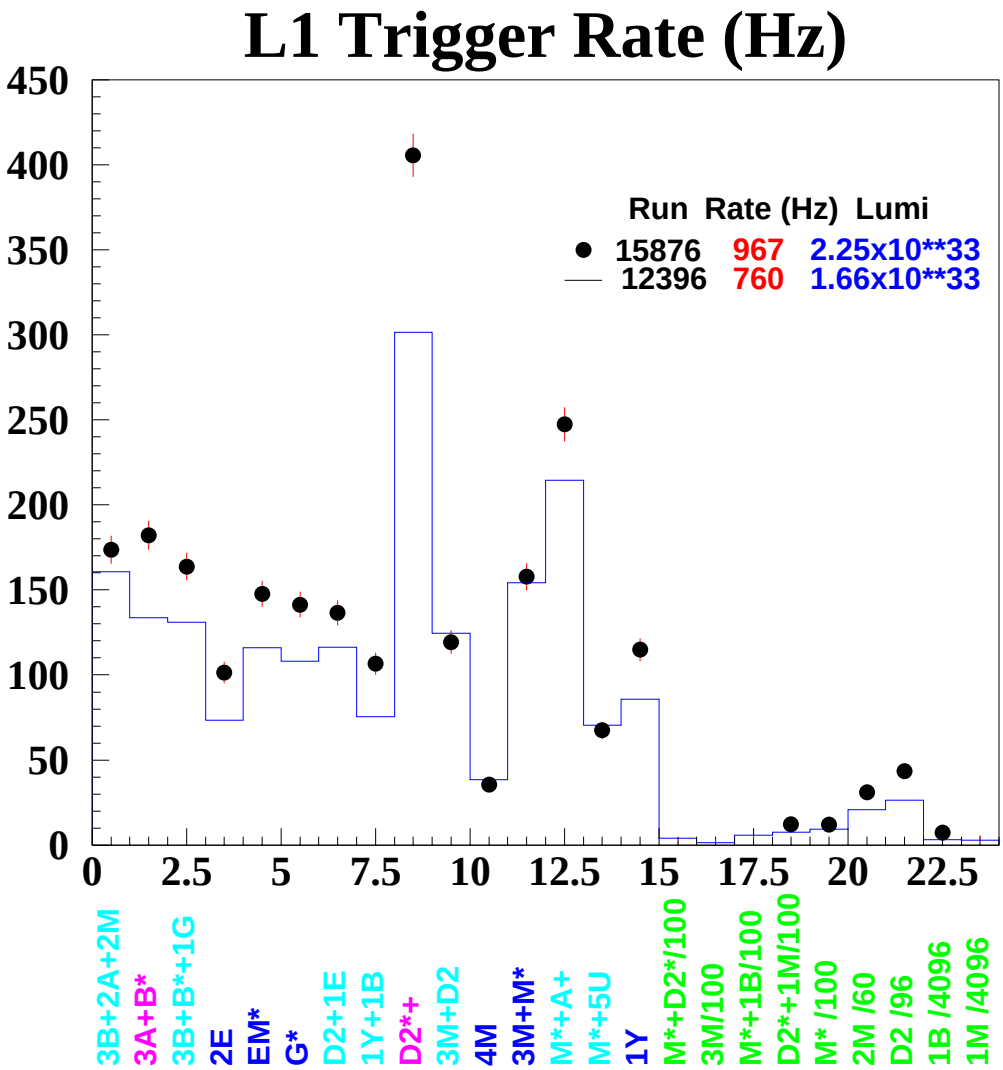
Compound triggers: A^+ = A & A' coincidence count

D2 = B≥ 2 & A ≥ 1

$D2^{*+}$ = B≥ 2 & A^+≥ 1 & B* ≥ 1

⇒ **Total of 24 trigger lines output from Global Trigger**

L1 Trigger Rate



Near term prospect:

a) Tighter XY DOCA on A' and coarse Z cut on A,B tracks ⇒ - (10-15)% L1 rate

b) Improved 2-prong configuration & resurrect prescaled triggers ⇒ +20% L1 rate

Should be well below 2 KHz at $3x10^{33}$ in any case.

L1 Trigger Efficiency

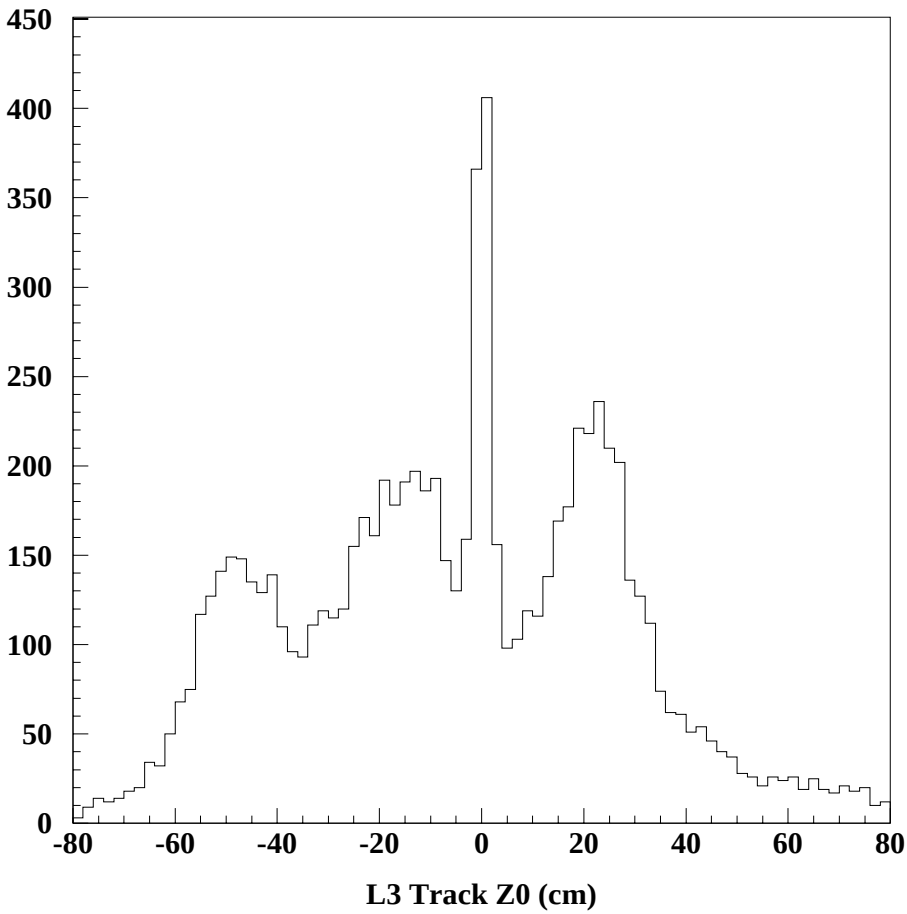
	uds	*c*	*b*
Pure DCT	90.6	95.3	99.1
Pure EMT	95.6	98.8	99.8
All triggers	98.2	99.9	>99.9

	2-prong Bhabha	Fiducial ττ
Pure DCT	98.6	81.0
Pure EMT	97.8	65.2
All triggers	>99.9	95.8

(*Efficiency values mostly from MC except Bhabha results are from data*)

Efficiency has met design requirement, but 2-prong ττ,γγ, orthogonality and measurability marginal with present configuration.

Where do the background triggers come from ?



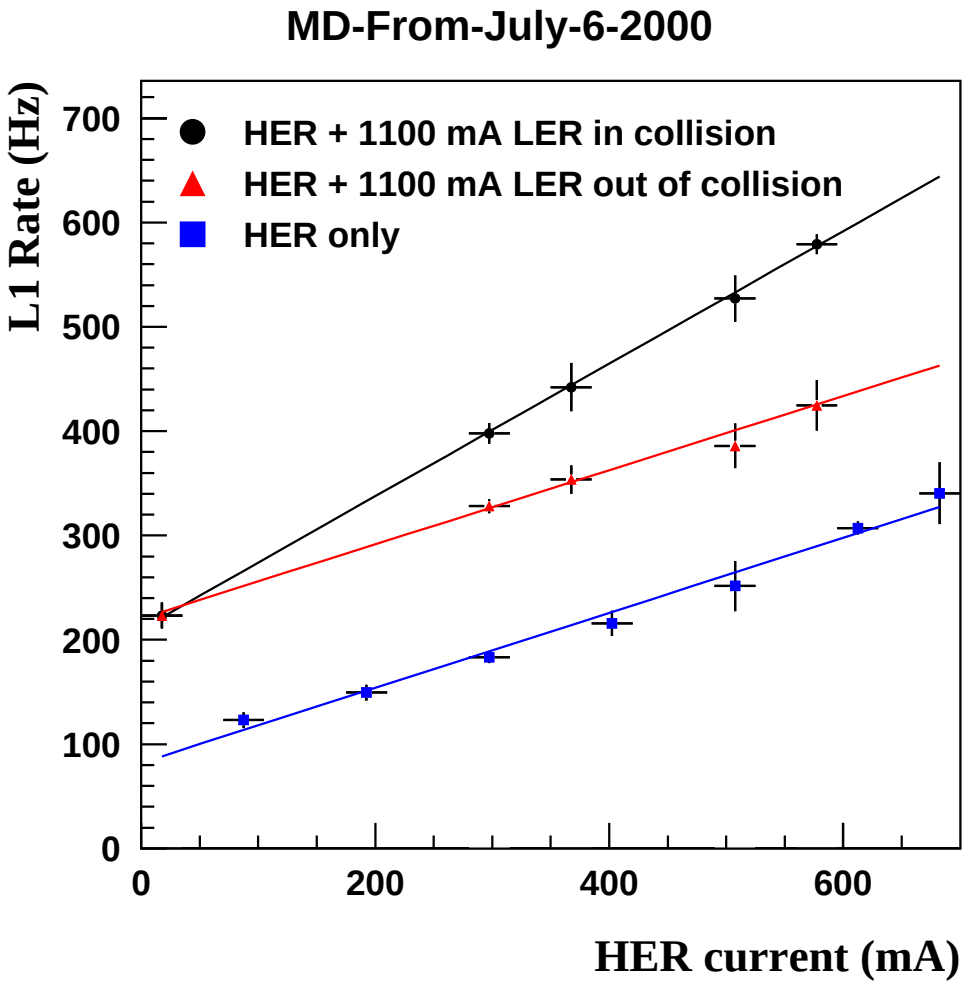
Mainly lost beam particles interacting at:

Z= ±20cm (*beampipe end flange*)

Z= -50cm (*synchrotron mask - the rate here has more fluctuation depending on beam quality*)

The interaction vertex typically at beampipe radius in the XY view.

L1 Rate Extrapolation



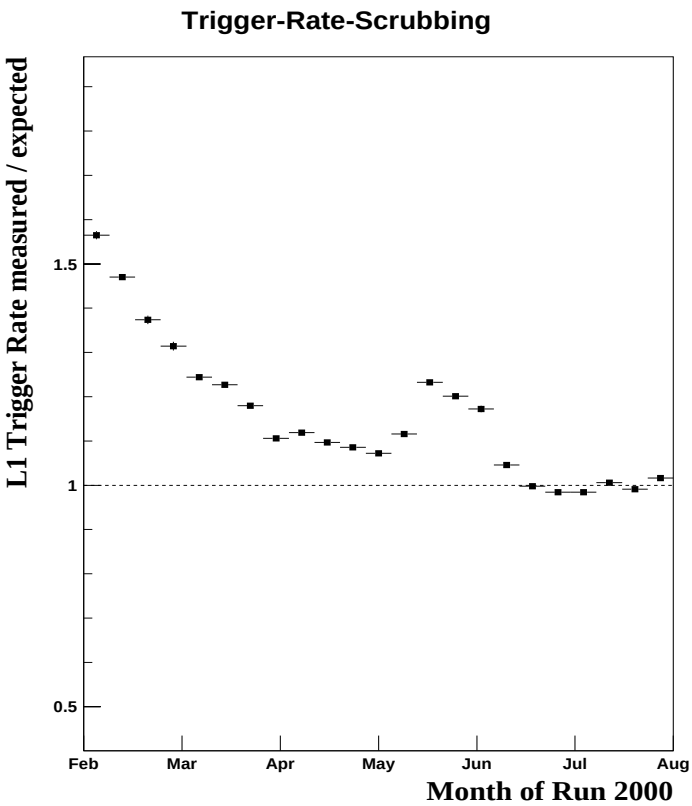
If we assume no L1 upgrade & extrapolate linearly:

(Note: background runs are taken at best beam conditions)

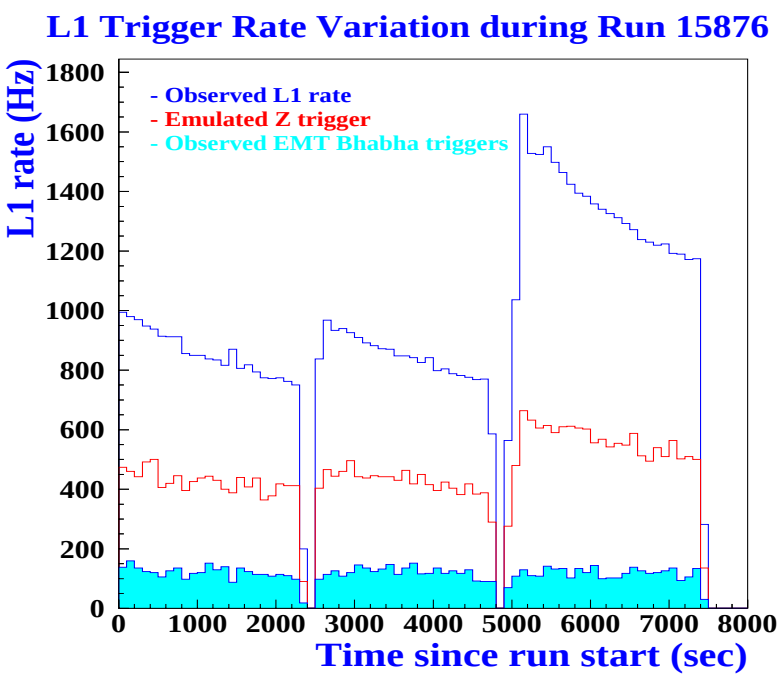
	Current(A) HER/LER	Lumi L(10^{33})	L1 rate (Hz) HER/LER	Lumi	Total	Rate Limit
Best 2000	0.8/1.1	2.5	290/140	180	740	
Dec/2002	1.1/2.8	9.3	400/360	650	1540	2300
Dec/2003	1.3/3.7	14.8	470/480	1040	2120	3070

Dataflow+L3 need to be able to cope with at least the "rate limit" (2x background) case with minimal dead time.

The reasons for L1 rate headroom



Start run vacuum are generally worse and takes a long time to scrub down.



Background can fluctuate during running.

The L1 Upgrade Considerations

Our trigger background study indicate that the most profitable L1 improvement can come from a Z-trigger to remove the dominant source of beam-wall background at Z ~ ±20cm.

The option of an additional mini-tracking detector is not attractive:

a) **Mechanical issues, operational complications…**
b) **More material to degrade resolution.**
c) **Still not clear how to restrict background as close in as Z=20cm.**

No obvious upgrade to EMT can help.

No simple way to use SVT either…

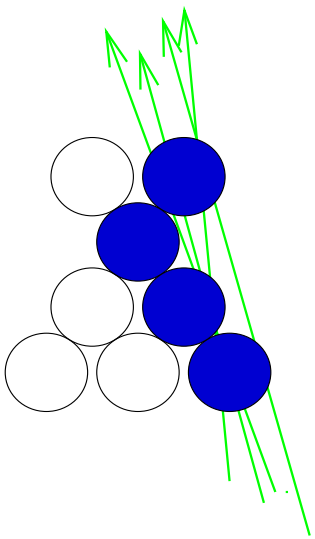
The most elegant solution would be if the TSF fine-ϕ information can be utilized to make a Z-trigger from the DCH stereo layer hits. The 1-2mm ϕ resolution is just about in the right range.

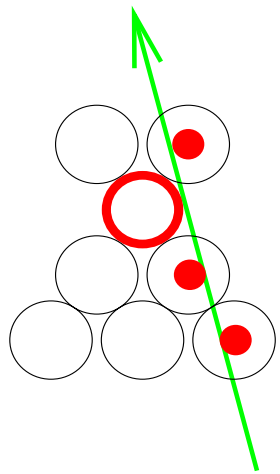
Including a trigger requirement of one track from IP in Z is sufficiently unbiased kinematically, so that it can also be used to back the EMT triggers for an overall L1 rate reduction.

Track Segment Finder Concept

use drift time information to better determine track position and event time

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





Event time jitter window:

(99% C.L.)

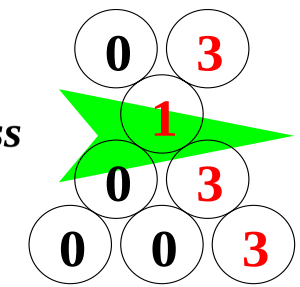
180 ns @ L 1

Position Resolution:

0.05 cell width

→ 1 mm

Look-Up-Table address



position and time

How to get TSF stereo data ?

- **Current TSF:**

  All superlayer coarse ϕ data-> BLT
  Only axial layer fine ϕ data -> PTD

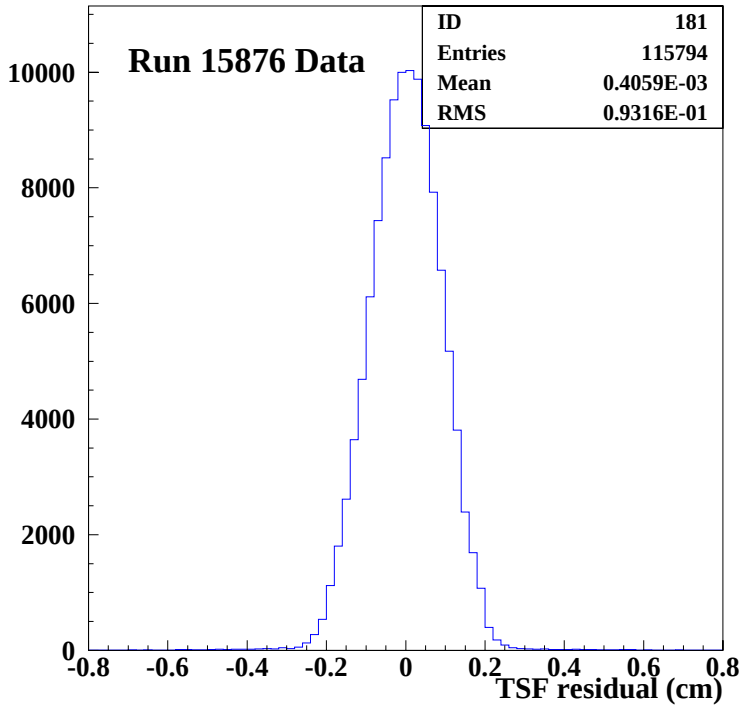
  Not enough traces on TSF to pipe all stereo layer fine ϕ info to the output end.

⇒ **We envisage that the replacement production with relatively minor modifications for the TSFs (30 boards) may be necessary to bring the full fine ϕ info out from all layers.**

- ***We considered a kluge firmware fix to get fineϕ data out with faster transfer, which may be able to save up to $100K, but has high risk of not being a workable solution in the end, which can be a detour costing extra $ and schedule.***

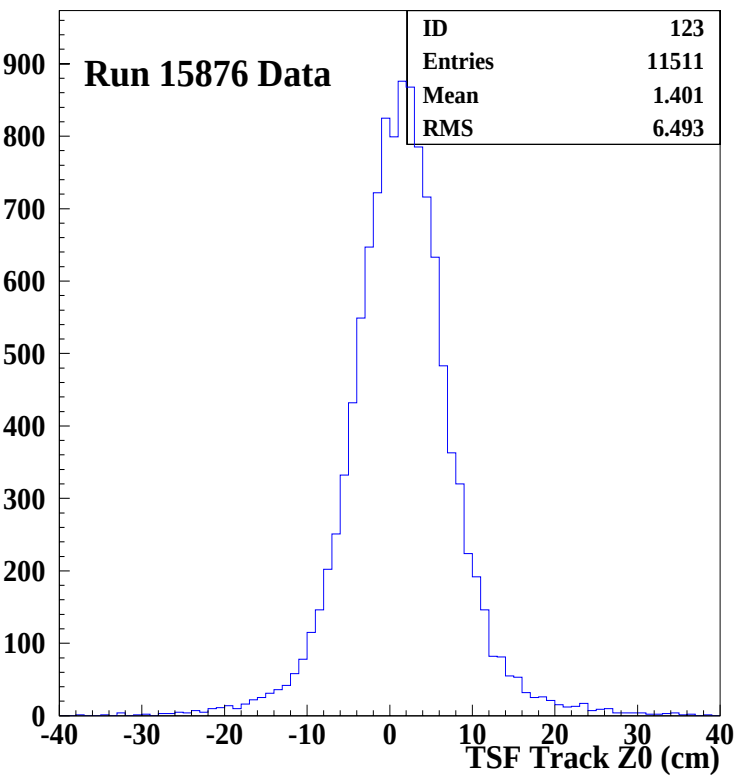
Z-trigger resolution test

TSF-track r-phi residual



Test TSF hit r-phi residual in data against reco tracks

TSF SL-pair Linear Fit



Toy model TSF track using only TSF hit superlayer A+U/V pairs to obtain hit RZ coordinates. A simple linear regression fit for track Z0.

7cm Z0 resolution may be possible.

DCT Z-Trigger Design Study

Initial thoughts on a simpler upgrade with minimal TSF mod. to send subset of stereo info looks to be insufficient resolution-wise.

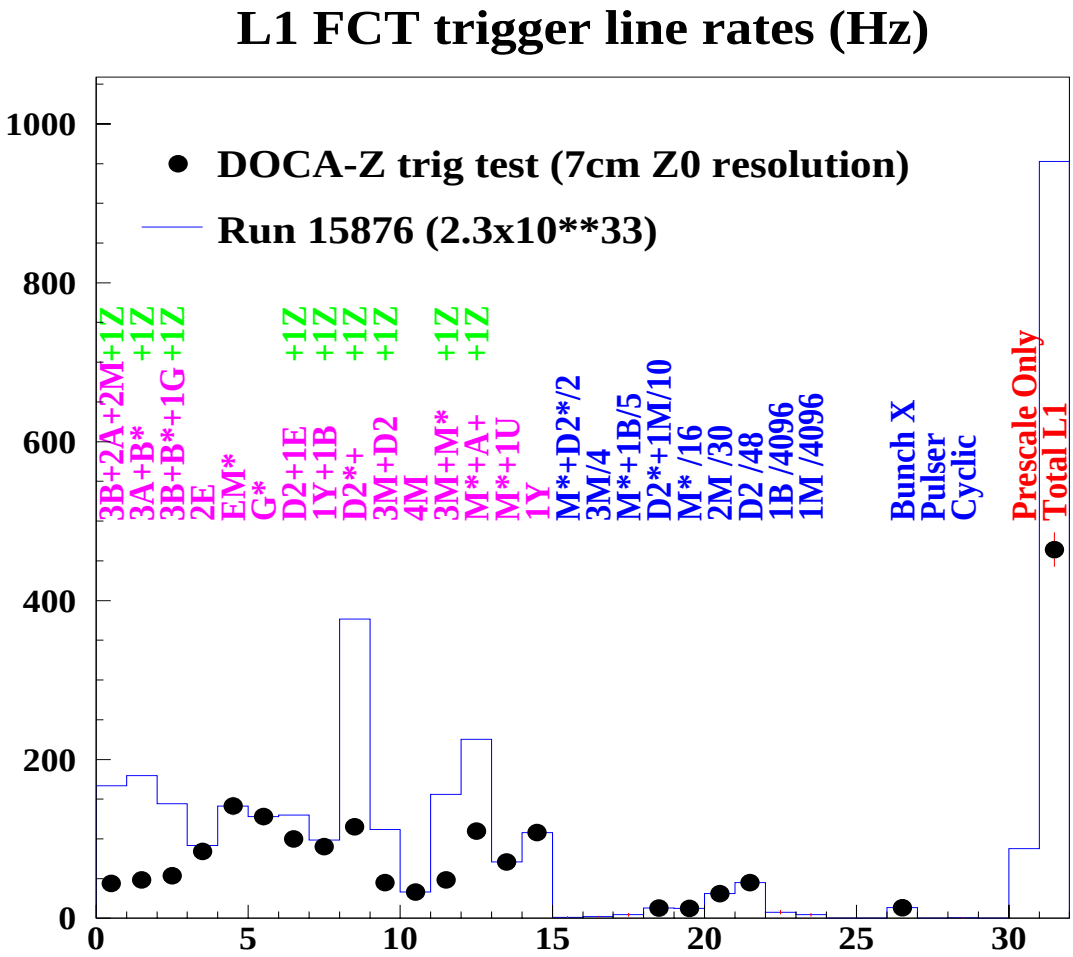
⇒ ***A new set of full DOCA+P_t+Z trigger boards to replace current PTDs.***
+ Replacement production of TSFs.

It is important to get a good P_t measurement to preserve resolution in ϕ->z conversion.

Expect the new DCZ to output 2 sets of 16 bit ϕ maps for the GLT with tight/loose P_t,Z, DOCA cuts.

We have the real TSF DAQ data which can answer precisely how well any design works.

What can a Z-trigger Accomplish ?



Toy model to smear DCH reco track Z_0 with 7cm resolution and only accept events with at least one track (1Z): $|z_0|<14$cm; $|d_0|<1.5$cm; $P_t>250$ MeV.

Estimate L1 rate effect:

reduce beamwall background triggers by 50-70%

	Nominal (Hz)	Rate limit (Hz)
Dec/2002	1540 -> 1100	2300-> 1420
Dec/2003	2120 -> 1580	3070-> 1900

DCT Upgrade Cost Estimate

TSF production:

TSF+TSFI parts: $100K

(based on existing TSF with new generation of replacements for FPGAs at lower cost)

EDIA: $60K

Fabrication: $15K

TSF sum: $175K

New DCZ design/production:

Old PTDs ~4K/board. New components are cheaper, but algorithm much more complex -> more advanced parts. Assume 4k/board still for a 16 prod + 4 spare + 2 prototype system.

M&S: 4K$/board x 22 = $90K

EDIA: $160K

Production/Proto: $15K

DCZ sum: $265K

Total DCT upgrade cost: $440K

DCT Upgrade
Manpower/Schedule

People directly involved at present:

Harvard: Masahiro Morii (faculty)
+ recruiting new postdoc

Oregon: Nick Sinev (staff physicist)
+ possibly more physicsts.

SLAC: Su Dong
Valerie Halyo (new postdoc Nov/00)
Leonid Sapozhnikov (Engineer)

Many from existing trigger groups will also help on part time bases. However, still need more manpower for TSF re-production.

Schedule:

Conceptual design until Mar/00.

Mar/01 TSF production decision.
DCZ/TSF interface spec.

Oct/01 Preliminary DCZ design and prototype.

Apr/02 Final design and TSF/DCZ production.

Aug/02 Installation and commissioning.

Level-3 Trigger

Design Requirements:

- **Provide high efficiency for B physics (>99%) and other physics processes.**
- **Reduce output rate from 2 KHz L1 to 120Hz.**
- **Fast algorithms: <10ms/event *(~50% CPU on 32 Sun Ultra-5 online farm nodes*).**
- **Support online calibration and monitoring.**

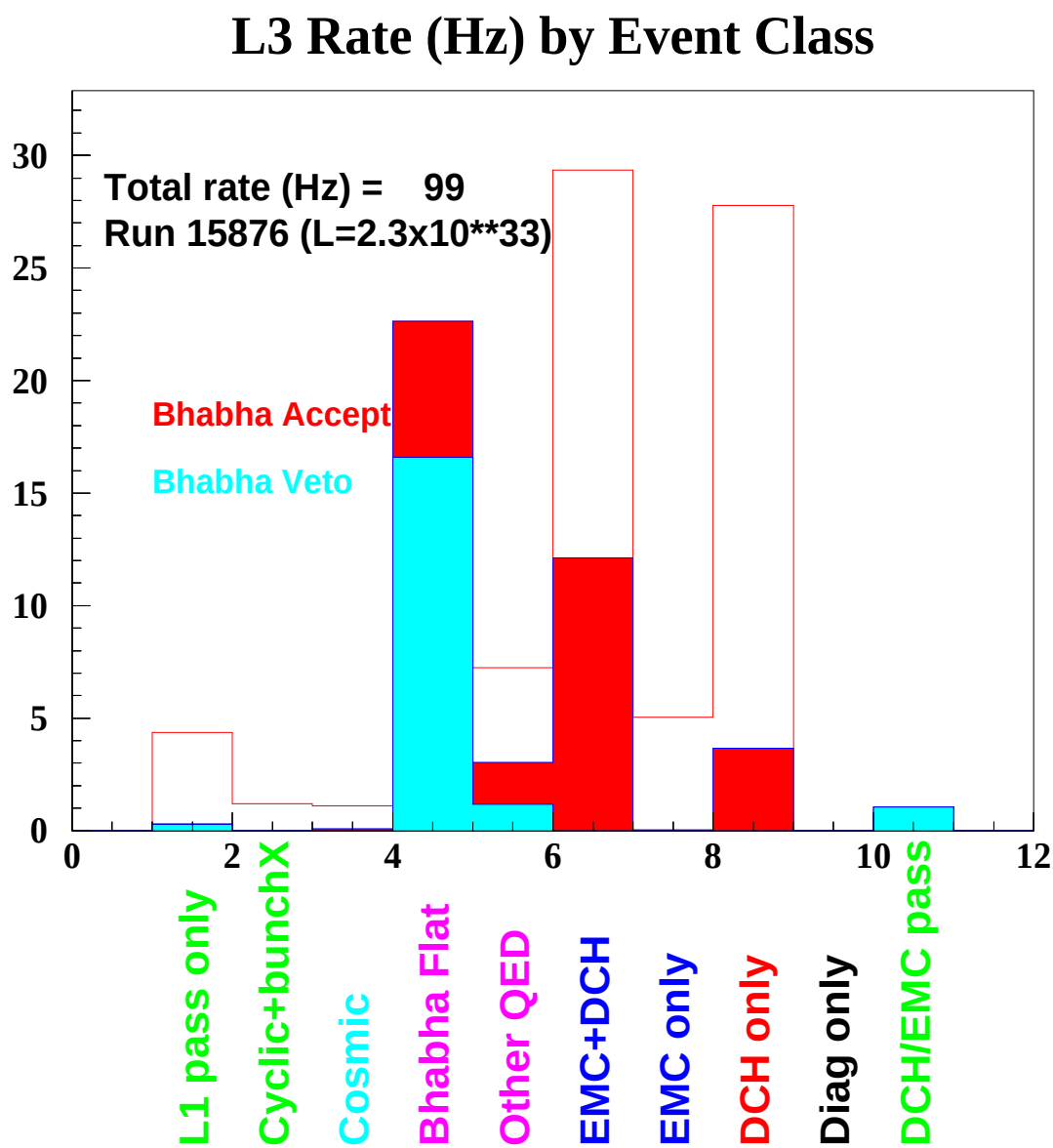
Implementation:

- **L3 DCH tracking for P_t>250 MeV/c**
  Physics filter: 2 IP tracks or 1 high P_t IP track.
- **L3 EMC clusters E>100 MeV**
  Physics filter: 2 high energy clusters, or
  4 MIP clusters, & m_{pseudo}>1.5 GeV
- **Veto well identified Bhabhas from physics lines using combined DCH+EMC info.**
- **Serve cosθ flattened Bhabhas and other calibration samples + many monitoring tasks.**

Currently L3 + dataflow can run at >2KHz L1 rate.

L3 processing ~8.5ms/event.

L3 rate & composition



Some known improvements are coming:

- ***Improved IP track filter: -12 Hz***
- ***Improved Bhabha Veto: -5 Hz***

L3 Rate Extrapolation

Run 15876 (L=2.3x10^{33}) Total=99 Hz

Improved IPtrack filter & Bhabha veto: -17 Hz

Expect => 82 Hz for same conditions with new L3.

Extrapolate assuming no further improvements:

Composition	Output (Hz) Now	3x10^{33}	1.5x10^{34}	OPR CPU sec/ev	sum
Had+μ+τ	13	18	90	3	270
Calib. Bhabhas	23	30	30	3/30	3
γγ & Rad. Bhabha	7	7	7	2.5	18
L1 pass through	4	6	8	.75	6
Cosmic+randoms	3	3	3	3	9
Sum wanted events:	50	64	138		306
Bhabha leakage	12	16	80	1	80
Other QED/2-γ	11	15	75	1	75
Beam wall (HER)	7±3	8	15	.75	9
Beam wall (LER)	2	2	5	.75	4
Total	82	105	313		168

Beam wall background will be much less important. The main tasks will be improving Bhabha veto and rejecting other QED collision backgrounds. The remaining background would contribute to 35% of OPR load at 1.5x10^{34} without L3 improvement.

L3 Summary & Future prospects

- *Level-3 has essentially achieved its design goals for $3x10^{33}$: capable of running at L1 rate of 2 KHz and restrict output <120 Hz.*
- *Physics acceptance efficiency for all L1 events:*

	BB	*cc*	*ττ*
L3 DCH alone:	**99.1%**	**97.1%**	**91.3%**
L3 EMC alone:	**93.9%**	**87.4%**	**43.9%**
Combined	**>99.9%**	**99.0%**	**94.3%**

- *The next steps in L3 will be better distinction of different event topologies (instead of removing beam wall background). BaBar as a whole needs to redefine the requirements for L3 at $>10^{34}$.*
- *To aim for a better topology classification, we most likely need L3 tracking to reach P_t<250MeV which requires an online farm CPU upgrade. A x2 CPU power would suit the short term and long term needs in conjunction with L1 upgrade.*
- *The physics output fraction is already quite high so that we should be able to preserve the clean open physics acceptance philosophy to log all physics to tape with relatively light burden to OPR after some L3 improvements.*