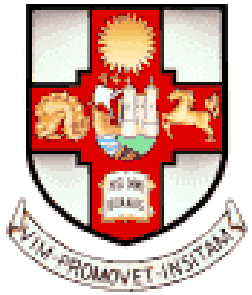
Developments in EMT Simulation

Nick Barlow
University of Bristol



EMT software workshop 11/19/01

Outline

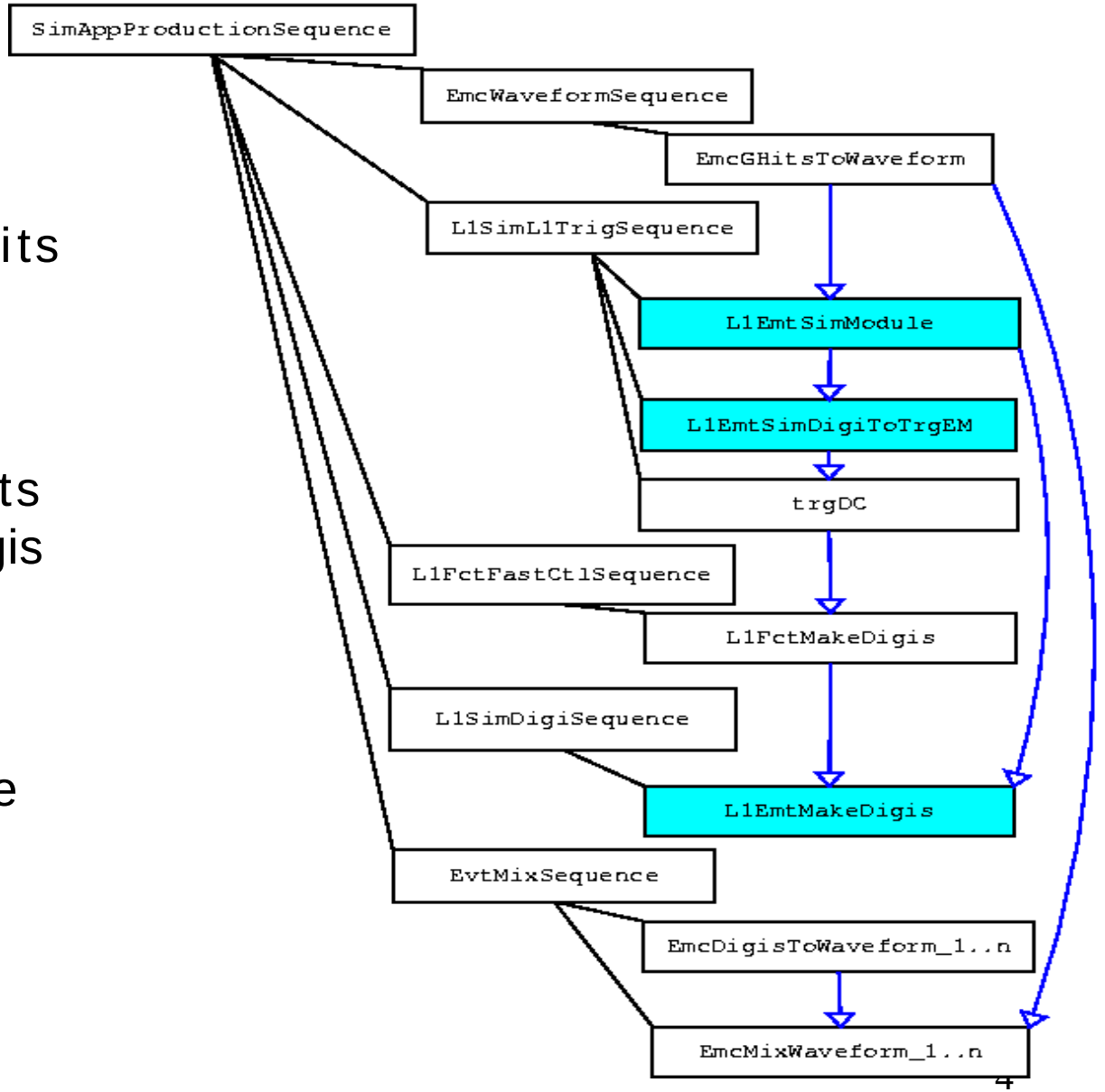
- Database config. objects
- Background mixing
- Double peak in L1Accept time
- The future.....

Getting Ax parameters out of database

- AX parameters include tower mask, FIR constants, M,G,E,X,Y thresholds, time alignment
- In <= 10 series releases, the AX parms used are default values specified in L1EmtSim/L1EmtAxParms.cc
  - Can also be overwritten via tcl (tcl parameters belong to L1EmtSimModule)
- Can now use AxRecord out of database
  - L1EmtBuildEnv called from L1TOepSimEnvSequence, puts proxy for L1EmtAxRecord into the event
  - L1EmtSimModule takes this out of event, puts into an L1EmtAx
  - Which L1EmtAxRecord to be used is controlled by tcl parameters aliasList and configAlias – can either use monthly config alias from "top" alias list or e.g. PHYSICS alias from "orc" alias list.
  - Can have phi-dependent AX parms – as in real EMT

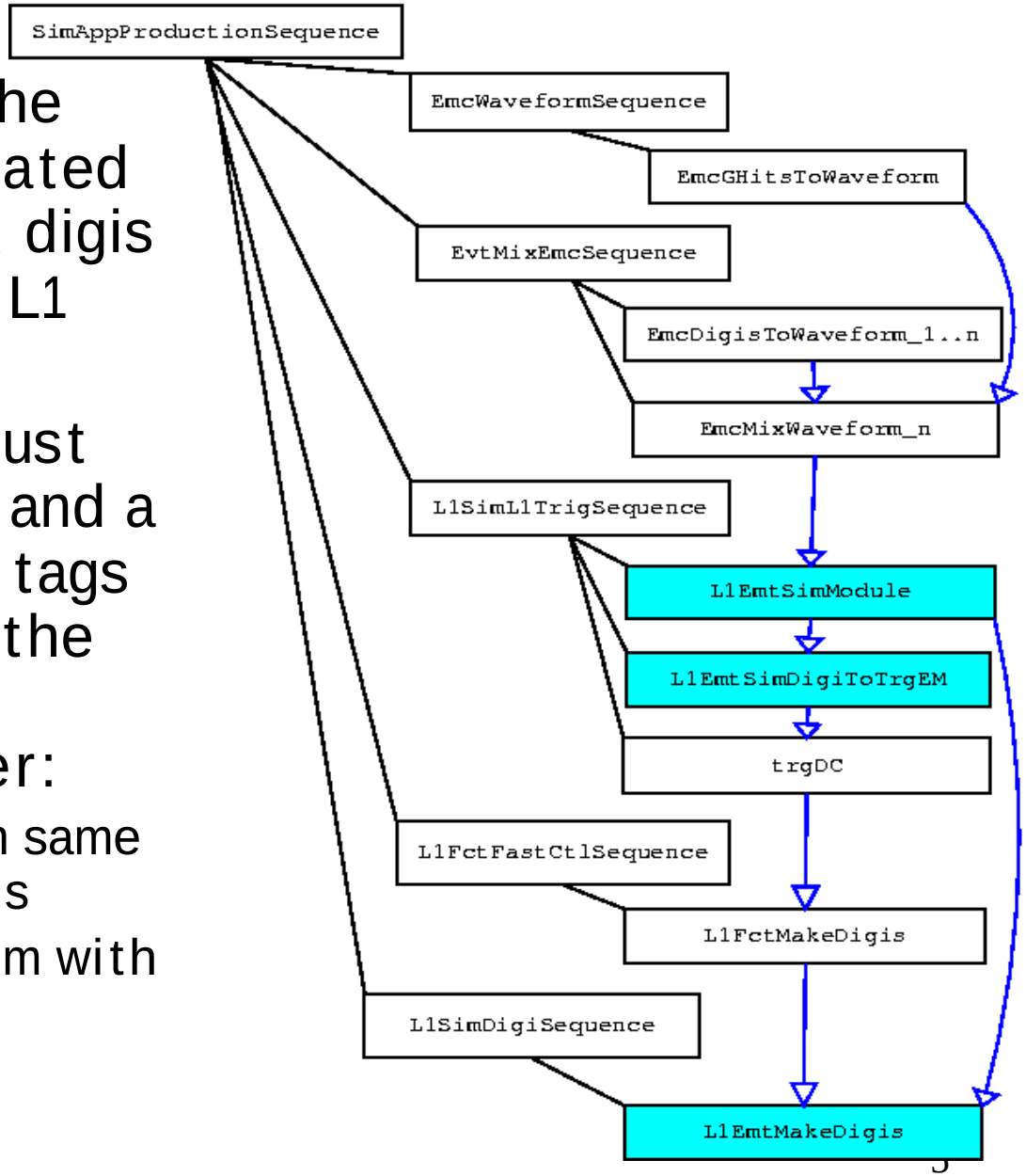
Background mixing

- In releases < 11.6.0, SimAppProduction sequence was →
- EmcSim converts GHits into 64 clk4 tick waveforms used as input to L1EmtSim
- EmcSim later converts cyclic background digis to waveforms and mixes these with existing waveforms
- L1EmtSim doesn't see any background ☹



Background mixing

- In releases >=11.6.0, the waveforms from simulated GHits and background digis are mixed before the L1 trigger stage
- EMC GHits and digis just contain a peak energy and a peak time – different tags of EMC sim deal with the background digis in different ways… either:
  - convert to waveform in same way as is done for Ghits
  - look up stored waveform with same energy and time

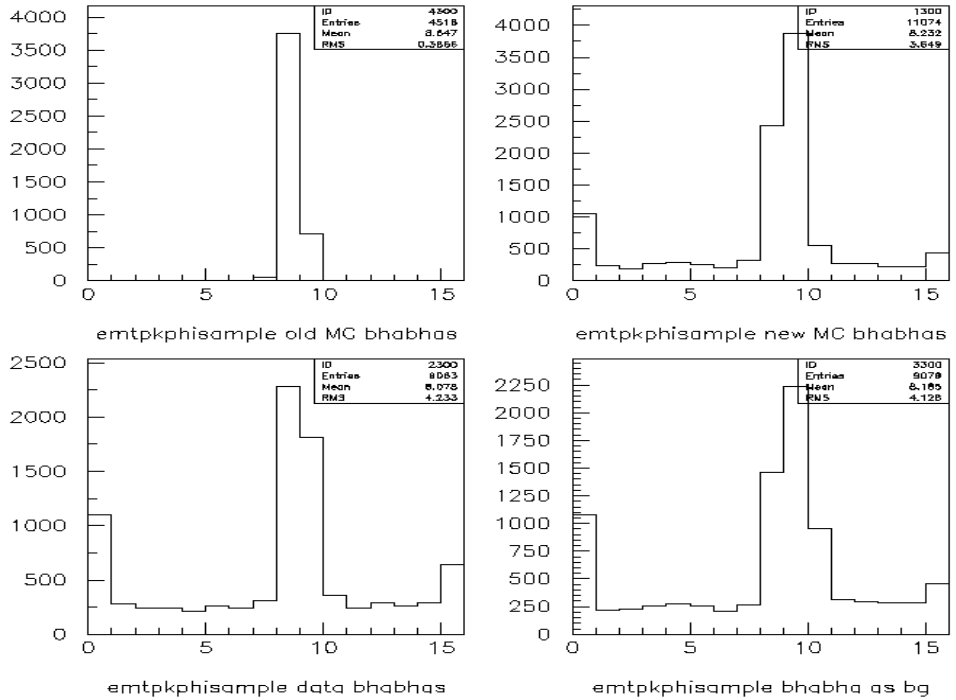


Background mixing

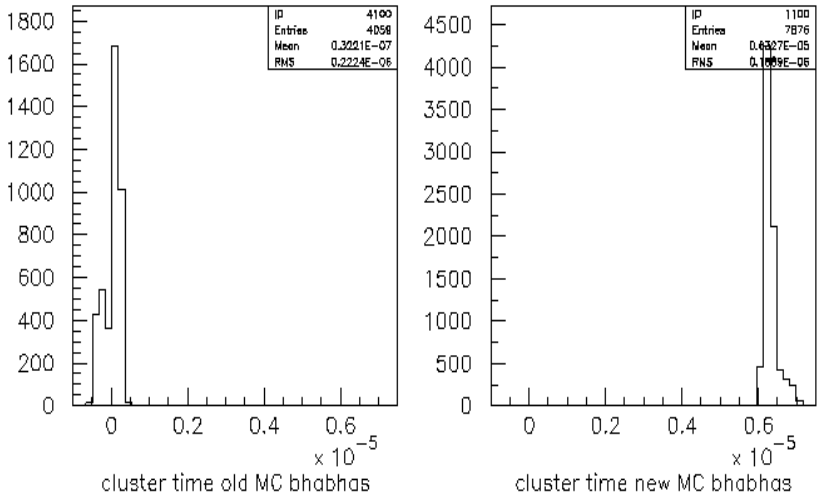
- If both DCT and EMT simulations are to see background, we want to get timing right so real background tracks are treated realistically
- Use empty Bogus collection ($\Upsilon \rightarrow \nu\nu$) as SimAppInputCollection
- Use data bhabha collection as SimAppBkndInputCollection

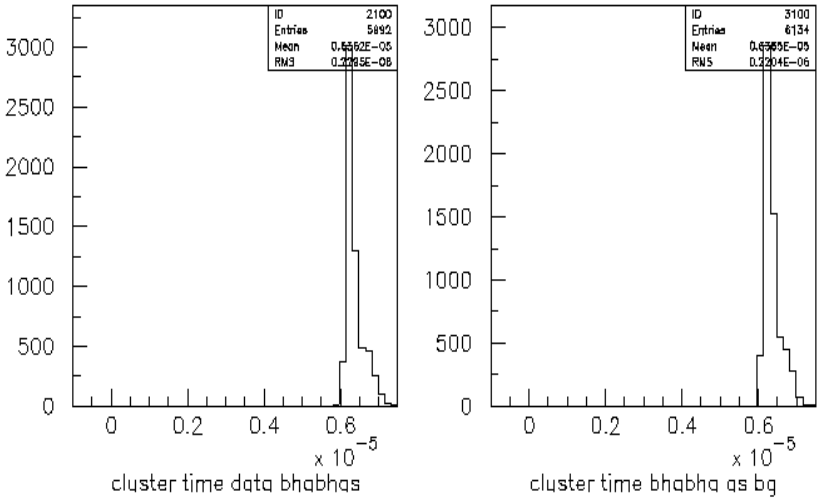
•Want peak to be in same place as when the bhabha collection is reconstructed normally

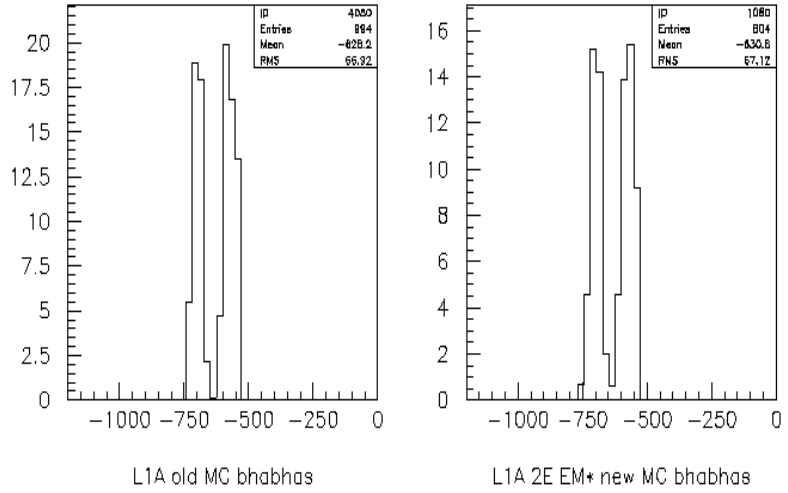
•Can move by adjusting tcl parameters in EmcDigisToWaveform

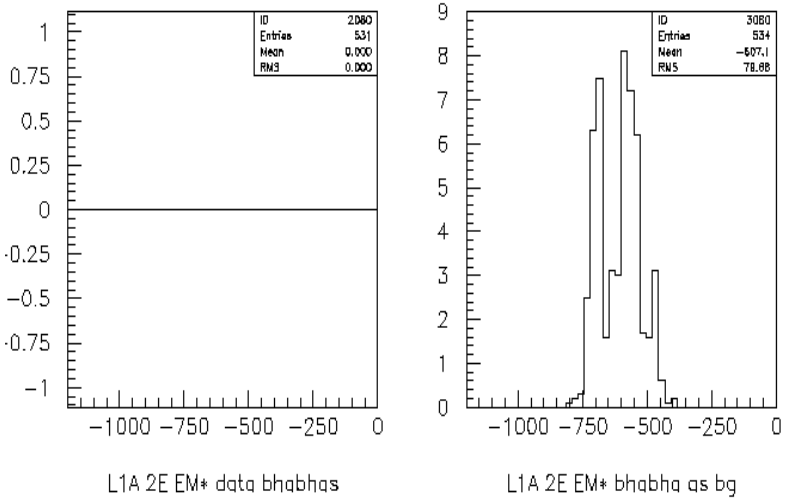


Background mixing







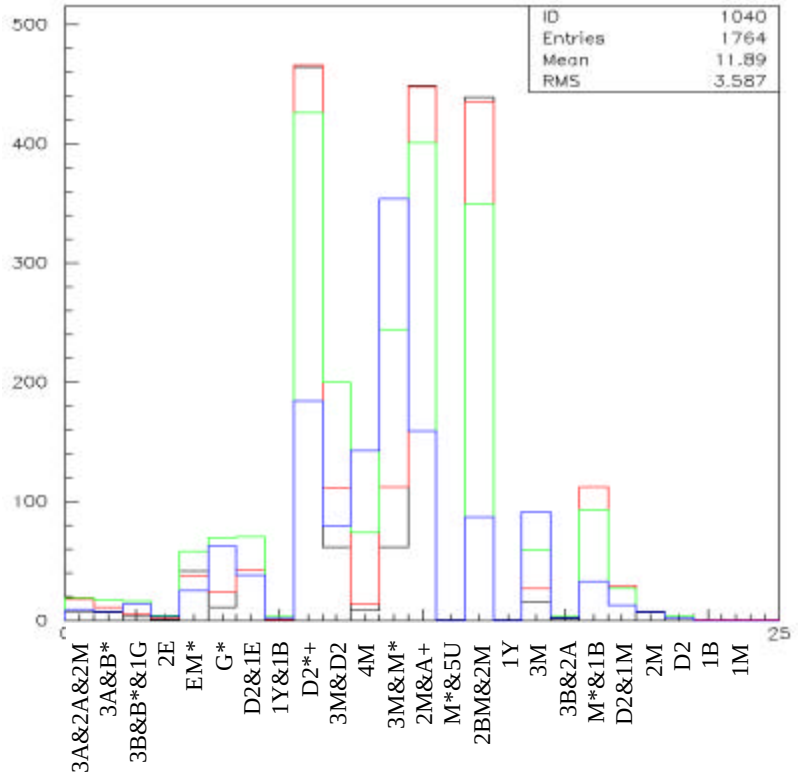


Multiple layers of background

- It is possible to mix more than one cyclic background event per generated MC event
- For the EMC this was done in EvtMixEmcSequence by calling EmcDigisToWaveform and EmcMixWaveform N times

Plotting Fct trigger lines for MC dimuon events with 1, 2, 3, and 4 layers of cyclic background:

Black = 1*bg
Red = 2*bg
Green = 3*bg
Blue = 4*bg



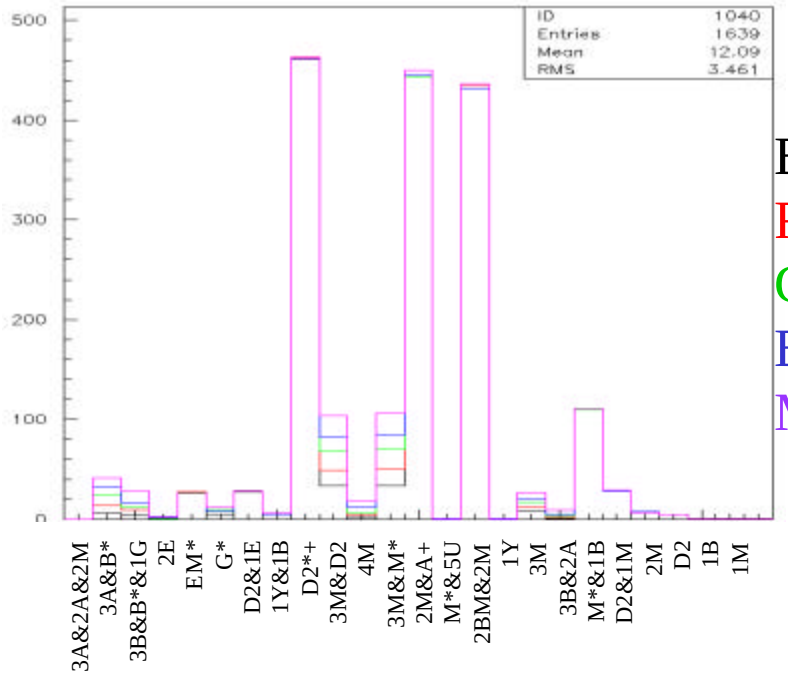
Problem – D2*+ and other lines go down significantly.

High background in the EMT causes early triggers – tracks fall outside DCT window

Multiple layers of background

- The cause of the excessive background in EMT is a problem first identified by David Stoker in April
- For each layer *n* (= 1 .. *Nmixers*) of background:
  - EmcDigisToWaveform_n takes cyclic background digis, converts them to waveforms, and appends them to noiseWaveformList
  - EmcMixWaveforms_n mixes noiseWaveformList with the waveform list from GHits to produce output waveform list
  - Therefore, *n*th layer of background is added *Nmixers* – *n* +1 times

•This bug has been fixed in the latest tags of EvtMix, by only calling EmcMixWaveforms once per MC event, after all the calls to EmcDigisToWaveforms

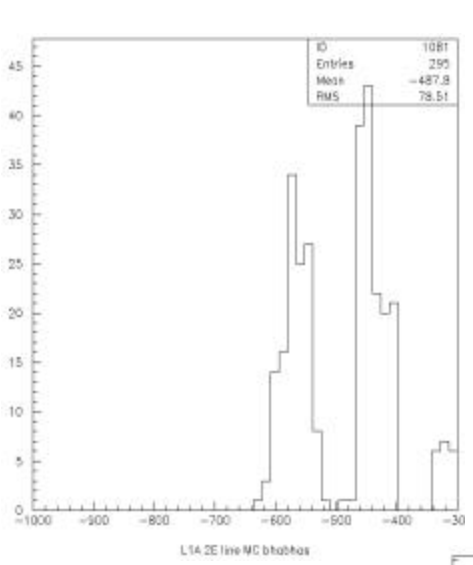


Black = 1*bg
Red = 2*bg
Green = 3*bg
Blue = 4*bg
Magenta=5*bg

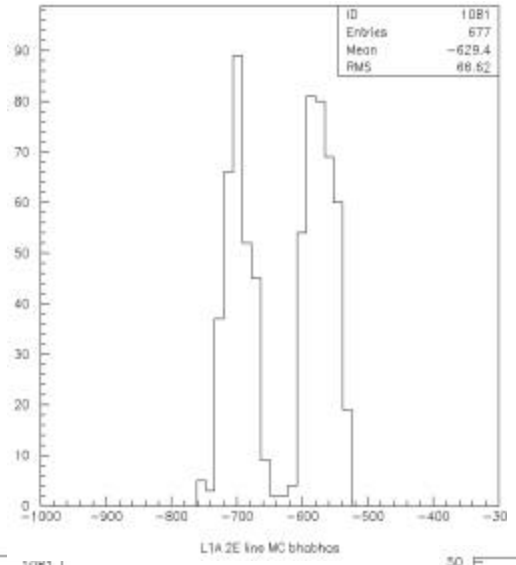
Double peak in L1Accept time

- For a long time, a double peak structure has been seen in BunchT0 for MC bhabha events
- This is not seen in data
- This is seen to a lesser extent in MC dimuon events and is hardly visible in multihadron events
  - Bhabha triggers are dominated by EMT-only lines (2E and EM*)
  - Dimuon and multihadron events have more DCT-only and mixed lines; L1A time comes mainly from DCT
- Points to a problem with EMT simulation ☹ ☹

Double peak in L1Accept time

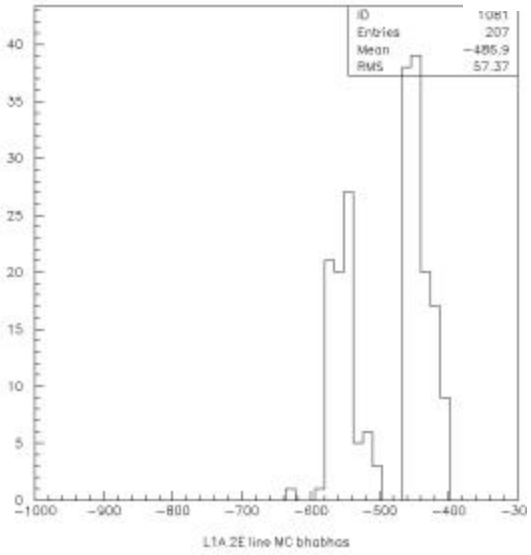


analysis-8
(=10.0.1)

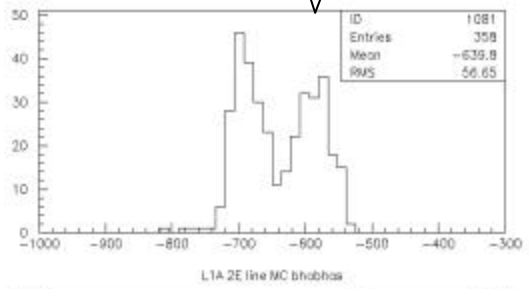


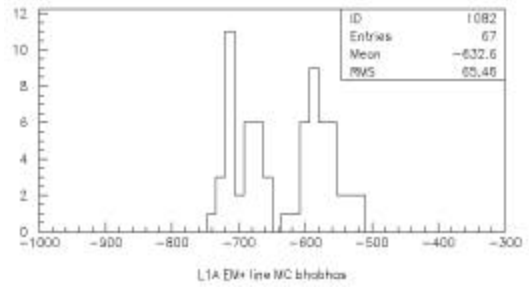
10.2.3+tags

8.8.1b
(Geant3)



11.3.0a

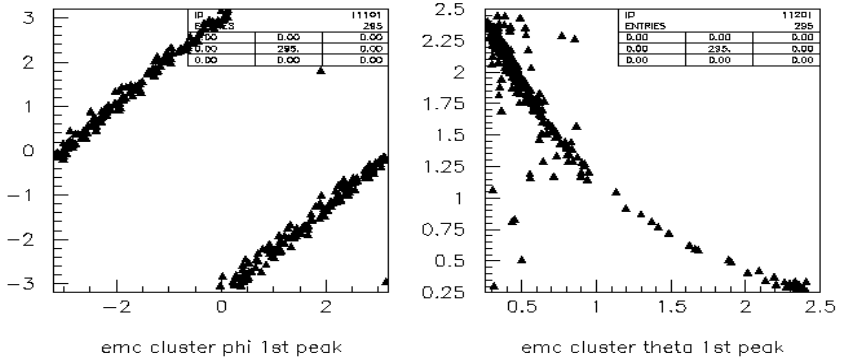


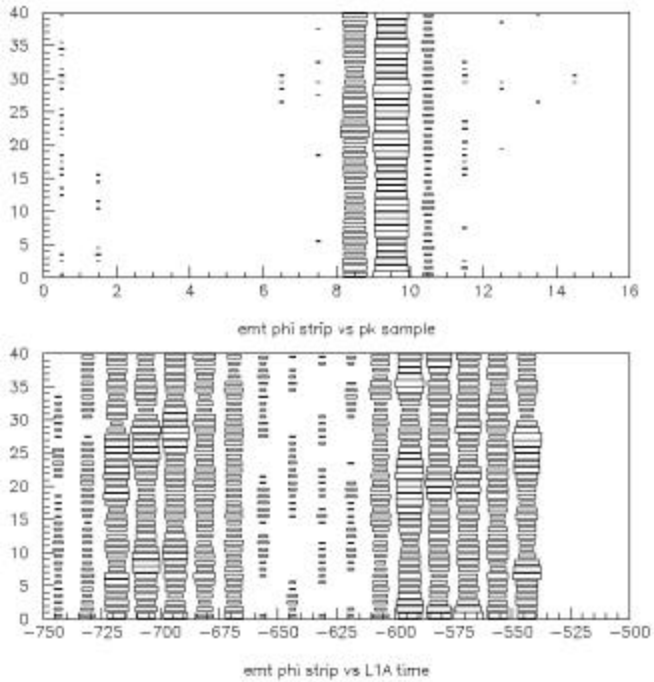


2 peaks seem to be ~1 clk 8 tick apart

Double peak in L1Accept time

- Look for any theta or phi dependence
  - Phi sectors 13-21 have different FIR constants to compensate for different shaping times in EMC pre-amps – (probably not simulated) – could that cause this?
    - Seems very unlikely – problem has been there since before phi-dependent AX parameters were put into EMT simulation…





Double peak in L1Accept time

- Could L1EmtSim/L1EmtSpy be performing the EMT algorithm incorrectly?
  - In particular the clk4 to clk 8 transition
    - FIR constants are applied in clk4, zero cross is in clk 8
- Check output of sim at various stages against output of L1EmtSpy/L1EmtSpyModel – independent model of EMT algorithm
  - Make L1EmtSpyModel object from L1EmtSpy/L1EmtSpySector, with the L1EmtHistory<d_Ushort> containing phi sum after NN and the L1EmtAx being used in the simulation
  - Can compare outputs at each stage of algorithm – e.g. FIR output, zero cross position, output map
  - Checked ~10 events*40 sectors*64 ticks in this way, and about 30 other events checking just the output maps

Double peak in L1Accept time

- Found NO discrepancies between output of simulation and L1EmtSpyModel !!!

MixedEvtCounter: processing event # 1

Doing AXsim for sector 9
L1EmtSpyModel: zx at: 82
L1EmtSpyModel: M at 77
L1EmtSpyModel: G at 77
L1EmtSpyModel: E at 77
L1EmtSpyModel: M at 78
L1EmtSpyModel: G at 78
L1EmtSpyModel: E at 78
L1EmtSpyModel: M at 79
L1EmtSpyModel: G at 79
L1EmtSpyModel: E at 79

L1EmtAxSim sector 9:-

zeroCrossing[22-133] at bin 82

outputSectorMap[38-133]= M:77-79 G:77-79 E:77-79 Y:77-79

Doing AXsim for sector 10
L1EmtSpyModel: zx at: 82
L1EmtSpyModel: M at 77
L1EmtSpyModel: G at 77
L1EmtSpyModel: E at 77
L1EmtSpyModel: M at 78
L1EmtSpyModel: G at 78
L1EmtSpyModel: E at 78
L1EmtSpyModel: M at 79
L1EmtSpyModel: G at 79
L1EmtSpyModel: E at 79

L1EmtAxSim sector 10:-

zeroCrossing[22-133] at bin 82

outputSectorMap[38-133]= M:77-79 G:77-79 E:77-79 Y:77-79

MixedEvtCounter: processing event # 2

Doing AXsim for sector 22
L1EmtSpyModel: zx at: 80
L1EmtSpyModel: M at 75
L1EmtSpyModel: M at 76
L1EmtSpyModel: M at 77
L1EmtSpyModel: M at 78

L1EmtAxSim sector 22:-

zeroCrossing[22-133] at bin 80

outputSectorMap[38-133]= M:75-78

Doing AXsim for sector 23
L1EmtSpyModel: zx at: 81
L1EmtSpyModel: M at 75
L1EmtSpyModel: G at 75
L1EmtSpyModel: M at 76
L1EmtSpyModel: G at 76
L1EmtSpyModel: M at 77
L1EmtSpyModel: G at 77
L1EmtSpyModel: M at 78

L1EmtAxSim sector 23:-

zeroCrossing[22-133] at bin 81

outputSectorMap[38-133]= M:75-78 G:75-77

Double peak in L1Accept time

- Use L1FctSim/L1FctPrintDigi to see in output of SimApp the L1Accept time and which trigger lines fired…
- Try to look for pattern in which events end up with L1Accept time < -620ns (1st peak) or > -620ns (2nd peak)

```
MixedEvtCounter: processing event # 3 [ 1d:ffffffff:0001e1/d26e433b:X ]

L1EmtGltDigi has 134 samples starting at BX -2089
  E: 4:77-79 5:77-79 14:77-79
  G: 4:77-79 5:77-79 14:77-79
  M: 4:77-79 5:77-79 13:77-80 14:77-79

 trgEMPrintGL; Number of phi towers     20 Cluster types  5 Expected trigger tick  0
  -3 M Phi  0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0
  -3 G Phi  0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0
  -3 E Phi  0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0
  -3 X Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  -3 Y Phi  0 0 0 0 0 0 0 0 0 0 0
  -2 M Phi  0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0
  -2 G Phi  0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0
  -2 E Phi  0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0
  -2 X Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  -2 Y Phi  0 0 0 0 0 0 0 0 0 0 0
  -1 M Phi  0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0
  -1 G Phi  0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0
  -1 E Phi  0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0
  -1 X Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  -1 Y Phi  0 0 0 0 0 0 0 0 0 0 0
   0 M Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
   0 G Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 E Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 X Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 Y Phi  0 0 0 0 0 0 0 0 0 0 0

L1FctDigi time= 12/31/97 23:59:59 (local time) 123456789 ns (absolute)
  FctDigi lines=      20856 Trigger 00011110100010100000000000000000
        floatTime= -709.984 ns
```

```
MixedEvtCounter: processing event # 5 [ 1d:ffffffff:0001e1/d26e4a0d:K ]

L1EmtGltDigi has 134 samples starting at BX -2128
  E: 5:79-81 6:78-81 16:79-81
  G: 5:79-81 6:78-81 16:79-81
  M: 3:78-81 4:78-81 5:79-81 6:78-81 15:78-81 16:79-81

 trgEMPrintGL; Number of phi towers     20 Cluster types  5 Expected trigger tick  0
  -3 M Phi  0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0
  -3 G Phi  0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
  -3 E Phi  0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
  -3 X Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  -3 Y Phi  0 0 0 0 0 0 0 0 0 0 0
  -2 M Phi  0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0
  -2 G Phi  0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0
  -2 E Phi  0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0
  -2 X Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  -2 Y Phi  0 0 0 0 0 0 0 0 0 0 0
  -1 M Phi  0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0
  -1 G Phi  0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0
  -1 E Phi  0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0
  -1 X Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  -1 Y Phi  0 0 0 0 0 0 0 0 0 0 0
   0 M Phi  0 0 0 1 1 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0
   0 G Phi  0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0
   0 E Phi  0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 1 0 0 0
   0 X Phi  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 Y Phi  0 0 0 0 0 0 0 0 0 0 0
trgDCDchDigis:number of digis in event=277
NICK1: BX at L1A is: -128

L1FctDigi time= 12/31/97 23:59:59 (local time) 123456789 ns (absolute)
  FctDigi lines=     285560 Trigger 00011110110110100010000000000000
        floatTime= -537.715 ns
```

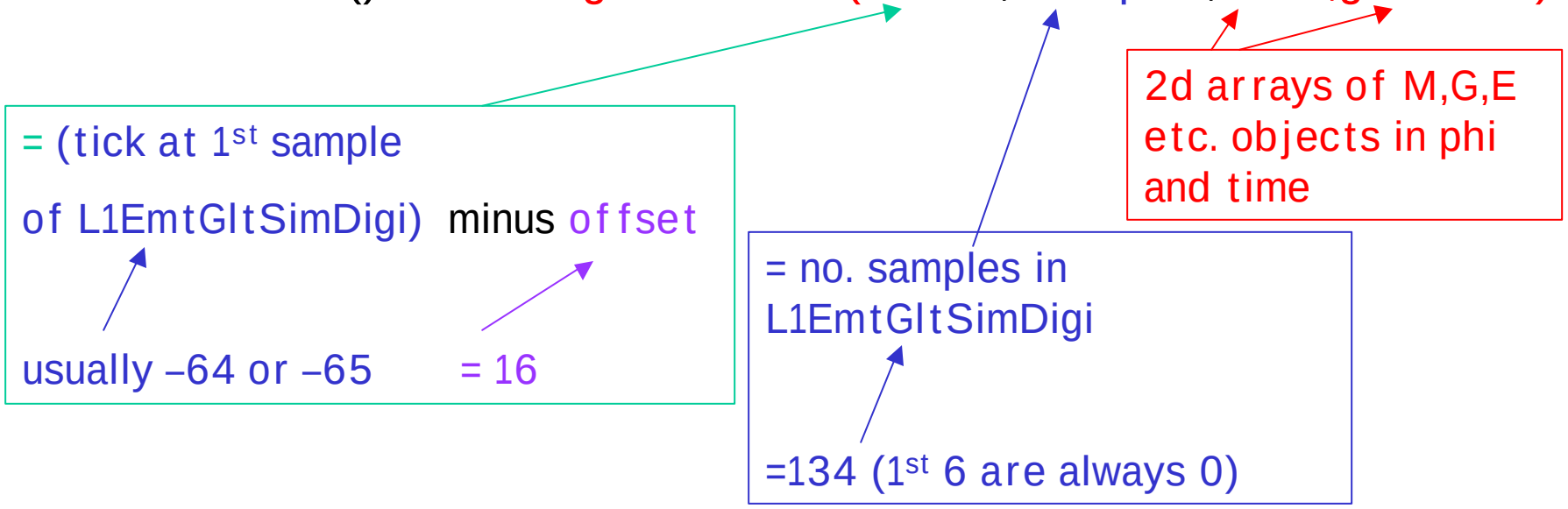
Double peak in L1Accept time

L1A < -620ns				L1A> -620			
event	L1A (ns)	Expected tick	HPL tick	event	L1A (ns)	Expected tick	HPL tick
3	-710	80	79 (2E)	2	-550	82	81 (EM*)
4	-723	81	80 (2E)	5	-538	81	81 (2E)
6	-668	80	80 (2E)	7	-580	81	81 (2E)
11	-718	81	80 (EM*)	8	-555	80	80 (2E)
12	-676	81	80 (2E)	9	-588	81	81 (EM*)
13	-676	81	80 (2E)	10	-542	80	80 (2E)
15	-672	81	80 (1Y&1B)	14	-538	80	80 (2E)
16	-714	80	79 (2E)	17	-554	81	81 (2E)
				18	-538	80	80 (EM*)
				19	-538	81	81 (2E)

- Events seem to fall in left hand peak when 'expected tick' does not match 'actual' tick
- Where does 'expected trigger tick' come from???

Double peak in L1Accept time

- Interface between EMT and GLT simulation is through L1EmtSim/L1EmtSimDigiToTrgEM
- Calls several trgEM functions in trgDC
  - In beginJob() – calls trgEMCenterGL with argument 0
    - *This is what translates into 'expected trigger tick 0'*
  - In event() – calls trgEMPointGL(nstart,nsamples,msim,gsim etc.)



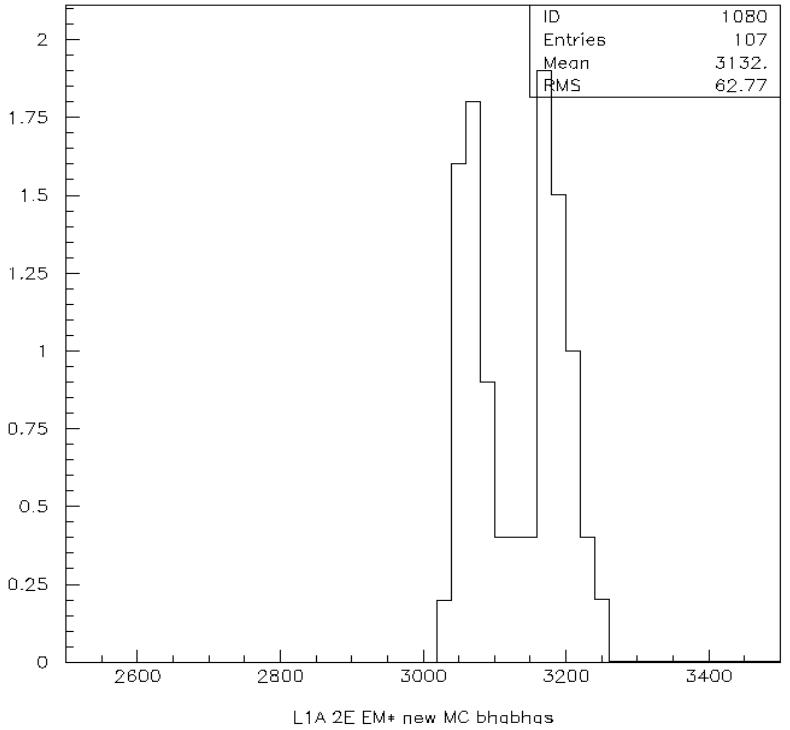
trgEMPointGL fills the trgEM_GL common block in trgDC

Double peak in L1Accept time

- So, arrays in trgEM start counting from ~ -80 or -81, depending on which BX the L1EmtGltSimDigi starts from BUT nTrgCenterEM is always 0.
- Only function which uses both nTrgCenterEM and the trgEM_GL common block is trgGLTickDelay

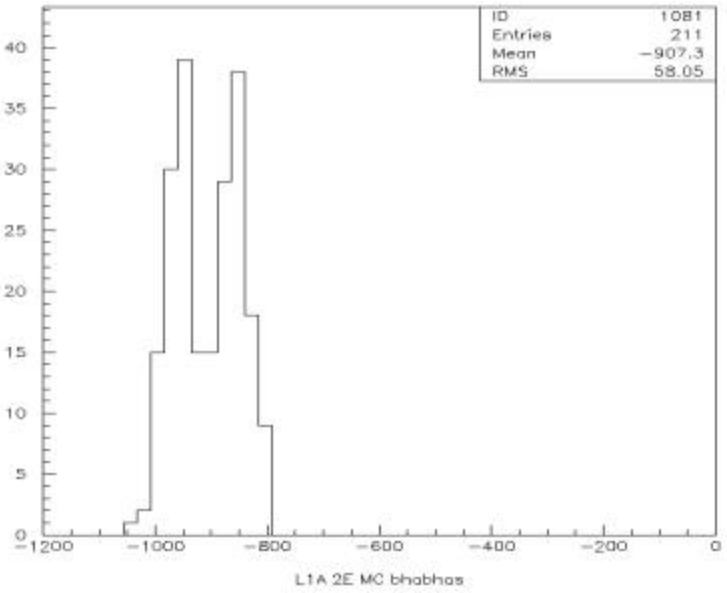
–Thought I had found something funny in there the other day – everywhere else where tickAtBX is used, first argument is 5 (this is 'speed' in FcsClock::tickAtBx; 2^5 bunch crossings per clk8??) but in trgGLTickDelay it calls this function with speed 6

–Tried changing this to 5…



Double peak in L1Accept time

- Try calling trgEMCenterGL with argument 2
  - →nTrgCenterEM→'expected trigger time'



- Moves L1A time by ~2 ticks!
- Why is nTrgCenterEM used at all?

Other (minor) things…

- Fixed memory leak in L1EmtSim/L1EmtAxParms
- Removed all mentions of xdr files and AppFileInputModule as part of Geant 3 deprecation

The future…

- Fix double peak problem
  - Figure out what's going on in trgGLTickDelay…
- Teach Mark everything I know about EMT simulation
- Document everything
- Write thesis…