Trigger

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HLT Online Demonstrated Capability

HLT executed in validation Filter Farm

- Operates as if data were provided by DAQ system
- 1 rack (20 PC's) of the DAQ at P5

Online conditions

- XDAQ environment, asynchronous event loop, DB conditions from local frontier squid

Test Events:

- 20 Million un-weighted MinBias events in raw data format
- Skimmed on the basis of the L1 results (menu from CMSSW174)
- ~100k event available for feeding the HLT
- 10k events only taken as initial statistics
  - Each FF node can deal only with ~1k events in replay mode

Scale by performance to FF Nodes: HLT code: 43 ms/ev

- Assumes 3 GHz nodes used for Filter Farm
- Confirms HLT exercise result from Summer '07
- Use 100 ms/event/core in subsequent calculations for safety

DAQ Capability

100 kHz EVB (readout) installed

Use of EVB Farm as 25 kHz EVB + limited Filter Farm

- With 100 ms/core (@2 GHz on EVB nodes): 14 kHz
- Could be factor of 2 off, but present HLT measured 43 ms on 3 GHz
- Operational Now
  - Drop to 7 kHz during May (recable) & August (integration of new PCs)

Dedicated Nodes for Filter Farm

- Purchase of 400 PCs (two quad-core @ 3GHz)
- Capacity 36 kHz
- Operational: expect end of summer

Storage: (i.e. HLT accept rate)

- Expect about 0.7 kHz peak, assuming 1.5 MB evt size (1 GB/s)
- Local Storage: Now: 22 TB, Mar: 50 TB, ~June: 100 TB
  - 100 TB = 28 hours at 1 GB/s
- Link to Tier-0 (1×10 Gb/s & one spare -- needs sustained throughput)

Summary of DAQ Capability vs. Time

(tentative)

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50% EVB	Daq test	Daq test	Daq test	-	-	-	-	-	-	-	-
50% EVB	GR	GR	GR	GR	GR	GR	GR	GR	GR	GR	GR
HLT @EVB kHz				~7	~14	~14	~7	~14	-	-	-
HLT @FF kHz								~36 +	~36 +	~36 +	~36 +
				Cable 50%			Integr.				
CMS		GR	CR B=0T		CR B=4T						
LHC beam					ready	→	→	→	→	→	→

(+) depending whether contingency needed can add more nodes

Trigger & DAQ Commissioning, Testing & Operating Plans

Now:

- Testing Storage Manager
- First transfers to T0 over CDR links (120 MB/s so far)

Mar:

- Technical run: EVB farm (640 PCs) in SCX configured as EVB + limited HLT & transfer to CDR T0 link

April:

- Cosmic Run at B=0
- Cosmic Ray Triggers, noise rate measurements

June:

- Cosmic Run at B=4T (CRAFT)
- Ready for Beam if available
- Full L1 & HLT Startup menu (modulo timing change for beam)

Startup Luminosities

Approx 30 days of beam time to establish first collisions

1 to N to 43 to 156 bunches per beam

Bunches	β*	I_b	Luminosity	Pileup	Minbias rate
1 x 1	18	10^{10}	10^{27}	Low	55 Hz
43 x 43	18	3 x 10^{10}	3.8 x 10^{29}	0.06	20 kHz
43 x 43	4	3 x 10^{10}	1.7 x 10^{30}	0.28	60 kHz
43 x 43	2	4 x 10^{10}	6.1 x 10^{30}	0.99	200 kHz
156 x 156	4	4 x 10^{10}	1.1 x 10^{31}	0.50	400 kHz
156 x 156	4	9 x 10^{10}	5.6 x10^{31}	2.3	2 MHz
156 x 156	2	9 x 10^{10}	1.1 x10^{32}	5.0	4 MHz

Calculation relating pileup, luminosity & bunch structure corrected (+20%)

Trigger Algorithm Status

Our highest priority is initial L1 & HLT menus for startup

- **Includes emulation, DQM, performance tools, & clear strategy for validation of triggers with first data (see later slides)**
- **We are able to do this because:**

Have set of L1 & HLT algorithms & thresholds for 10^{32}

- **L1A = 50 kHz/3 = 17 kHz**
- **HLT out to SM: 150 Hz of 1.5 MB events (230 MB/s)**
  - 230 MB/s "physics" + 100 MB/s Al/Ca = 330 MB/s = 1 GB/s/3 "safety"
  - Using the retuned standard L1 trigger menu in 16X
  - Provides for "ECAL coincidence" for jet triggers, etc. (remove HCAL noise trigs.)
  - Candidate triggers w/adjusted prescales add ~ 10 Hz & small processing time
  - Will add candidate triggers to standard trigger menu in 18x/200
- **Both L1 & HLT include prescaled "relaxed" triggers**
  - Single detector (e.g. RPC or DT or CSC only)
  - Reduced conditions: no isolation, lowered thresholds
  - Used for efficiency & acceptance studies

Trigger Performance Status

Trigger PAG validation status (10^{32} menu)

- Top efficiencies look good
- SUSY & Exotica: investigating changes in jet paths
- Higgs & Tau: Underway
- Jet/MET: Single jet efficiencies measured, others being done
- B-Jet: B-jet(s), B-HT measured, B-jet + mu next
- eγ: W, Z, High-E_T γ OK, High-E_T e HLT OK w/ecal iso. retune, H→γγ next

Monitoring

- Paths being developed for monitoring & validation
- Data rates, Hardware status & errors, rates of physics signal flow
- Separate use for online DQM, Offline DQM, L1/HLT validation
- Streams for rejected events, buggy events, unbiased signal candidates
- Proposal: rejection path defined for each factor of 10 reduction at HLT
  - Properly load balanced with .3% of each trigger devoted to rejection paths
- Proposal: signal paths treated as physics triggers specified by PAG,POGs
  - Use tag & probe to study, also add dedicated paths for certain backgrounds

Early Trigger Pile Up Simulation

preliminary first look -- ongoing study

Most extreme case: In-time PU = 5 at 1.1 × 10^{32} (156 × 156)

- **FAMOS: overlay minbias on signal directly at generation**
  - reading from files of minbias pre-generated events
  - μ, γ, e POG validation, jet reco in good agreement to ~120 GeV
  - L1, HLT rates within stat. errors of about 20%

Total L1 rate (old menu) increase × 2 (needs further checks)

- **Max change: L1 HT(300), Tau(30) & MET(30), Iso EG(10) & Jet(30)…**
- **Largest effects in low threshold 2-object triggers**
- **Total rate within L1 safety margin -- will adjust L1 to account for PU**

HLT rate increase of 25%

- **Also largest effects in low-threshold 2-object triggers**
- **Max change: MET&HT, 2-e, eμ, e-jet, μ-jet…**
- **Relaxed electron paths more affected than unrelaxed**
- **HLT thresholds & algorithms will be adjusted when studies done**

As expected, source of increase is from QCD 20-30,30-50

Trigger Strategy Phases w/Beam

Phase 0:

- **Run complete "Phase 1" program in CCAFT**
- **"Seamless" transition from Cosmics to Beam**
  - Modulo adjustment for timing

Phase 1:

- **Accept all filled crossings (zero-bias) at L1**
- **Run L1 Emulator at HLT to validate (only) L1 HW**
- **Send all "non-empty" events to T0**
  - Use "relaxed" HLT (anything > noise) without L1 seeds

Phase 2:

- **After validation of L1 HW bits, allow L1 HW to reject events**
- **Start prescaling zero-bias events**
- **After validation of HLT bits, allow HLT to reject events on those bits**
- **Keep prescaled HLT rejected L1 accept. & zero-bias prescaled**
- **In parallel, operate all triggers planned for Luminosity up to 10^{32}**

Triggers with first data

We will start with 3 categories of triggers:

Zero-Bias

- Zero-bias uses either the BPTX to detect crossings with beam and/or we program to select the collisions between known full bunches
- These are prescaled.

Min-Bias

- Next Slides

Alignment & Calibration

- Much of min-bias sample used for these also
- See following slides

"Min-Bias"

HF Single particle

- Any fiber pair over threshold (HF sums are over 6 pairs).
- Should be a good trigger for studying min-bias, but many triggers may not have tracks in the central region → less useful for DPGs

HF E_T rings around beampipe

- Potentially a good minbias trigger but integrates over noise & beam backgrounds

EB/EE Tower-pair over Threshold

- Gives sharp turn-on with tower energy sharing, equals electron L1 w/o any isolation
- Useful even without the APD gain change (x4).
- Should catch 33% of particle production w/γ from π^0 decays
- Set trigger tower thresh. ~ 150 MeV. Many events have multiple particles.
- Especially useful for ECAL calibration.

HB/HE Tower over Threshold

- Noise is a concern.

"Open Muon"

- Not really "min-bias": CSC LCT, DT Segment, RPC open road, RBC

Beam Scintillator Counter Coincidence

- This has a poor acceptance but adequately illuminates the tracker.

"Min-Bias" Status

HF Single particle & HF E_T rings around beampipe

- Code Implemented in GCT Emulator (HCAL TPG Emulator being updated)
- Will be included in 2.0.0 and should be compatible with releases since 170
- Calculation of the 2 inner rings now in GCT Leaf Card Firmware
  - Path through GCT wheel & concentrator being defined.
- HF single particle being prepared in GCT Firmware
  - Plan for availability when Jet Trigger Commissioned (end March)

EB/EE & HB/HE Tower over Threshold

- Can be enabled in emulator with simple configuration change
- Operating in Global Runs using Electron path through GCT

"Open Muon"

- Emulation & FW exists, but is a matter of configuration.

BSC Coincidence

- Hardware ready for installation -- planned for May
- HF-front-face BSCs (not the 2x2 small paddles on the back of HF yet) are in CMS GEANT & CMSSW up to the sim hits.
  - Note: BSC hits are not recorded in the readout
- Exact trigger logic is under discussion

Next Steps for "Min-Bias" Triggers

Measure the thresholds and the noise rates

- Do this first in Global Runs, then Cosmic Run at 0T, CRAFT

Thresholds set at 5 - 7 sigma above noise.

- From measured rates

Test the HLT algorithms run on these samples

- Start with HLT menu for 4×10^{29} (next slide)
- Get Feedback from DPGs & PAGs

First Look at HLT for 4×10^{29}

Trigger object	*L1 Seed*	*HLT thresh [GeV]*	*Prescale*	*HLT Rate [Hz]*
Jet(MET)	L1_SingleJet15	30	10	15
	L1_SingleJet30	60	1	55
	L1_ETM30	30	1	15
Electron	L1_SingleEG5	5	1	5
Photon	L1_SingleEG5	10	1	33
Muon	OR of All MuSeeds	none	1	34
ALL				140

Preliminary -- ongoing study

Alignment & Calibration Triggers

Calibration

- **phi-symmetry trigger: needed by ECAL and HCAL.**
  - Will use min.bias & output RecHits only
  - Requesting 1 kHz of min.bias and 1 kHz of dijets at L1.
  - Single path for ECAL and HCAL
  - Plan is to continue testing and integrate for 2_0_0/CSA08.
- **π^0 ECAL trigger:**
  - regional unpacking around L1 EM candidates.
  - 1 kHz of π^0 for 1% calibration.
  - Output size: 2 kB/evt.
  - Plan is to continue testing & integrate for 2_0_0/CSA08.

Alignment

- **Cosmics for tracker/muon barrel alignment**
  - Hope to collect 25k muons with p > 50 GeV in 2 weeks (RBC trigger)
- **Beam Halo**
  - BSC for tracker & CSC beam-halo for muon endcaps -- working on HLT path
- **"wide open" single muon for startup -- working on HLT path**
- **single- and di-muon triggers from physics stream (express).**

Trigger Menus for CSA08

Considering two scenarios (straw-man examples)

- 2×10^{30} & 2×10^{31}
- Integrated luminosity: 1 pb^{-1} & 10 pb^{-1} after 1 month of running
  - Assuming initial 20% duty cycle

Emphasis on triggers for

- Alignment and calibration
- Detector/physics commissioning
- Trigger monitoring and validation

Differences in menus between 2×10^{30} & 2×10^{31}

- Give more bandwidth to "physics" at 2×10^{31}

HLT Data Model, Config DB

Old data model (1_7_x and earlier):

- **Save all intermediate HLT byproducts for all events**
- **Increases event size, inefficient memory usage, many small data structures**
- **Large number of ROOT branches and "splitting"**
  - Reduction crucial: large # of root branches → streaming at T0 very demanding.

New data model (as of 1_8_x):

- **Save all intermediate HLT byproducts for small fraction of events**
  - HLT commissioning phase
- **Save high-level trigger objects only for analyses/AOD**
- **HLT book-keeping: saves info in same format for all HLT paths**
- **Pack all information up in single compact efficient data structure**
- **Reduction in # of branches (preliminary):** -50% in AOD, -15% in FEVT
- **Reduction in event size (preliminary):** -20 to 25% in AOD, -15% in FEVT

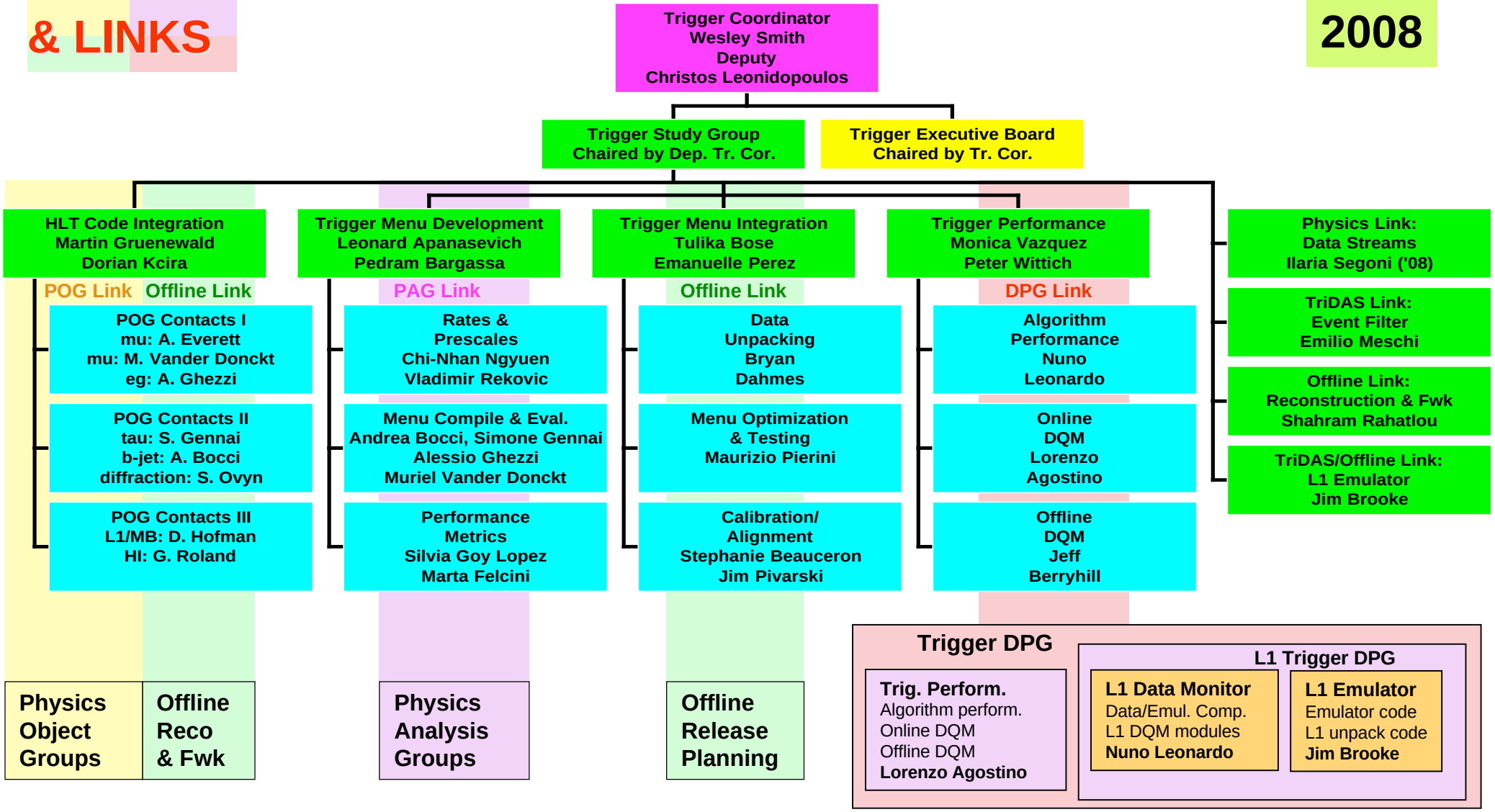
Configuration Data Base

- **Online & offline HLT now work with Configuration Data Base**
- **Integration with FastSim soon**

Trigger Coordination Organization

& LINKS

2008



Trigger Conclusions

- **Well-integrated team is in place**
- **HLT now validated under "real" operational conditions**
- **Readout, Filter Farm, & Storage capability & evolution well matched to expected rates & event sizes**
- **Have a set of L1 & HLT algorithms & thresholds for 10^{32}**
  - Pileup studies are producing first results
- **Good progress on DQM online, offline & algorithm performance**
  - Definition of monitoring streams underway
- **Have a well-defined strategy for testing & implementation of physics, alignment & calibration triggers from startup luminosity on up**
  - Zero-bias & several different min-bias triggers
  - Triggers being readied for testing in CR at 0T, CSA08, CRAFT…
  - Ready for beam from June onwards