Trigger menù per il 2012

Workshop ATLAS Italia

Roma2, 17 Aprile 2012

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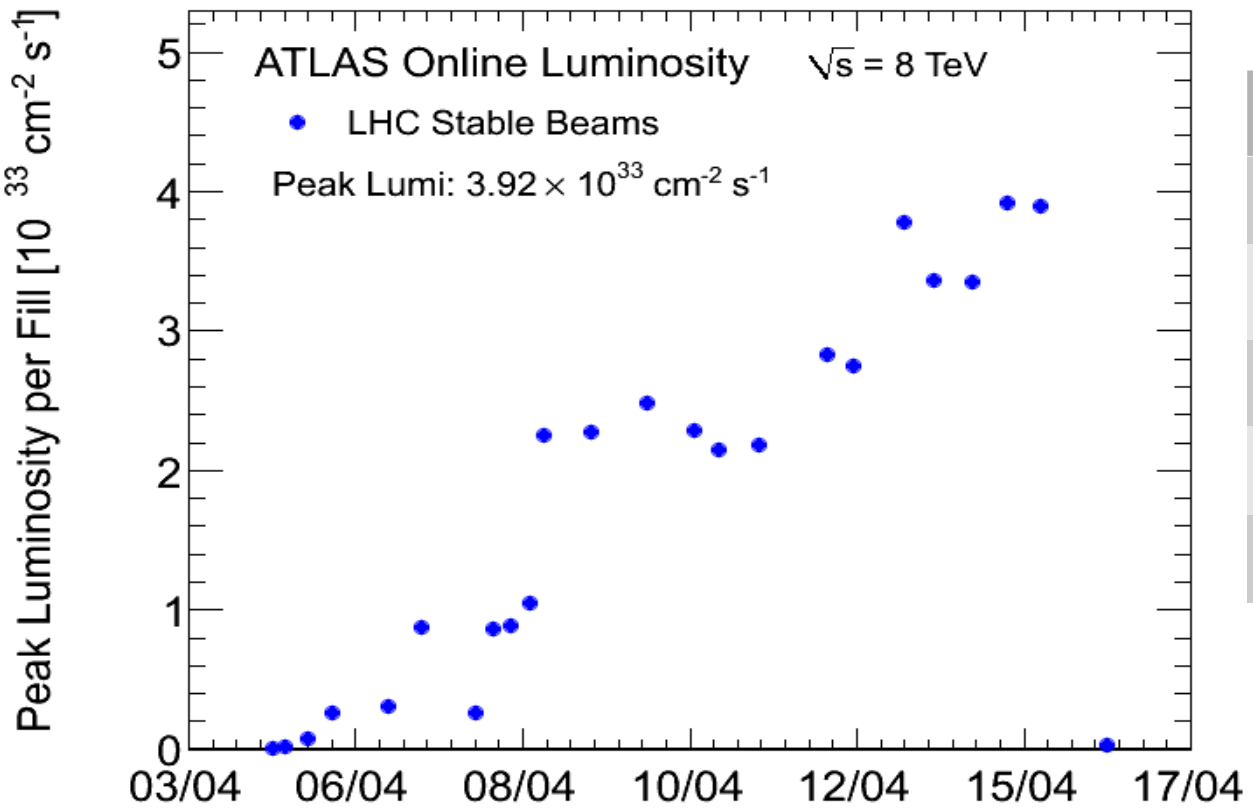
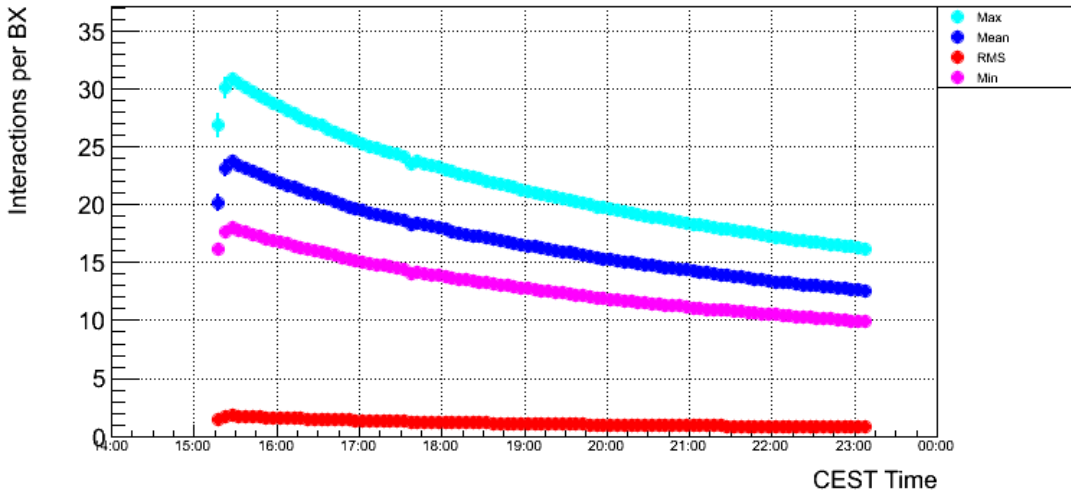
LHC status



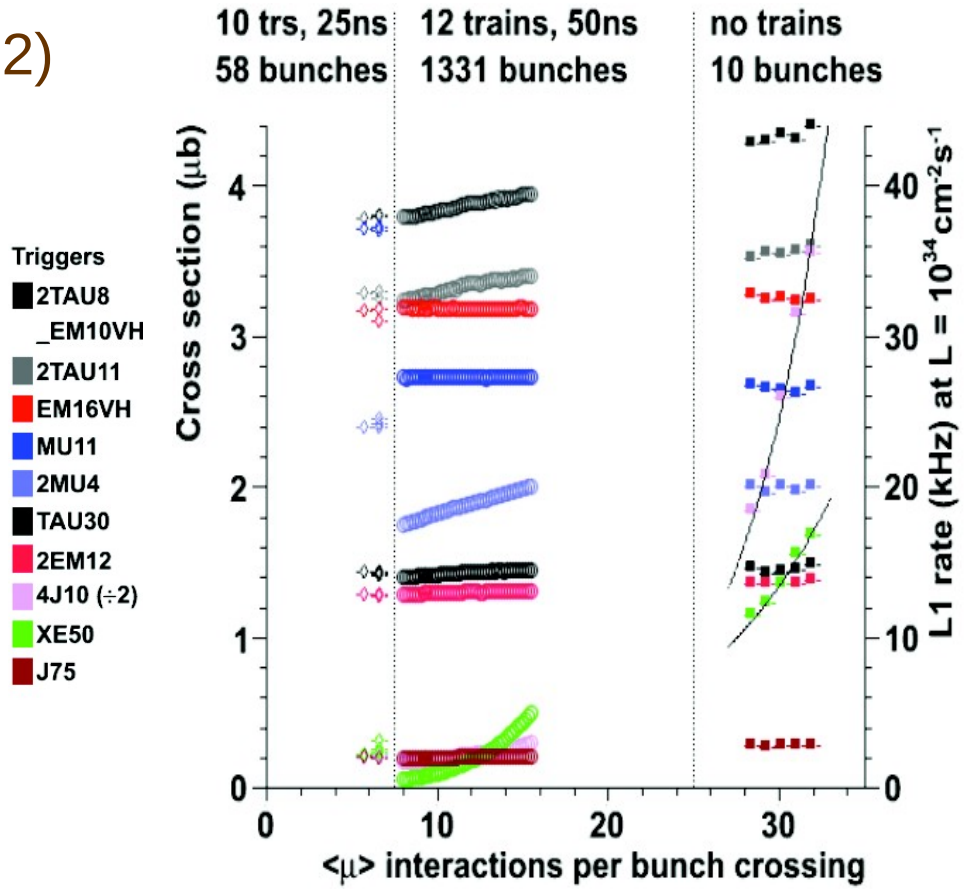
	Now	Max
L [x10^{33} $cm^{-2}s^{-1}$]	3.92	6.68
β* [m]	0.6	0.6
Bunches	1082	1331
p/bunch [x10^{11}]	1.2	1.65
Mu	27	35

Sunday run
Fill 2516



Menu 2012: preparation

- Many discussions among physics and trigger signature groups
  - Ongoing sign off of triggers by signature conveners at: https://twiki.cern.ch/twiki/bin/viewauth/Atlas/TriggerSignOff2012
- Menu 2012
  - Rate predictions using enhanced minimum bias run from 2011 (μ ~ 12)
  - Target: 10^{34}@7TeV
    - 20-30% increase at @8TeV
    - 20% rate contingency left for pileup effects
  - Pileup: expected not linear dependence for jets and MET
- DAQ limitations
  - L1: 65-70 kHz
  - L2/EB: 5 kHz
  - EF: 400 Hz (avg)



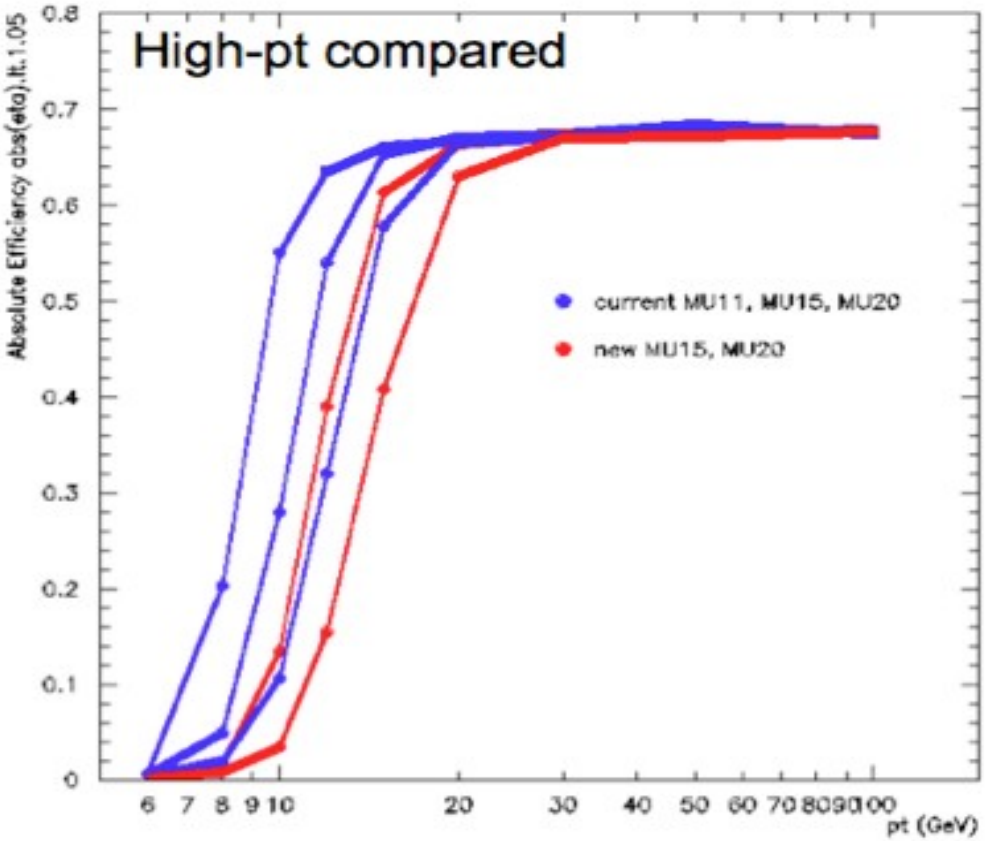
Menu 2012: strategy

- 2012 strategy similar to 2011 one
  - Baseline core triggers, that last the whole run
  - List of prioritized extra triggers to fill up the 400 Hz of EF output
- Single lepton rates at higher luminosity
  - To keep offline threshold low, need to add isolation
  - Apply tracking isolation at EF $p_T\text{cone20}/p_T < 0.1$
  - A relatively loose cut and pile-up robust but only gains ~ factor of 2
- Multi-lepton triggers more important
- Wider use of combined triggers
- Delayed Streams: to be analyzed in 2013
  - ZeroBiasOverlap: 15 Hz of zero bias triggers for MC overlay
  - B-physics (eg: ~70 Hz for muon barrel triggers)

Changes at L1

- Calo
  - More L1 thresholds for e/γ (one less tau)
  - Noise cuts increased in FCAL based on mu = 15
- Muons
  - Tighter barrel road and endcap coincidence window
  - Improvement rate by 25-30%
  - Slight loss in efficiency
  - New shieldings in endcap

TAU8	EM3	MU4
TAU11	EM6	MU6
TAU11I	EM10VH	MU10
TAU15	EM12	MU11
TAU15I	EM14VH	MU15
TAU20	EM16V	MU20
TAU40	EM16VH	
	EM18VH	
	EM30	



Changes at HLT

- 12 new HLT racks (~20k cores)
- ROS rolling refurbishment (Max L2 requests 22 $\rightarrow$ 40 kHz)
- SFO rewritten to support compression
- MET trigger @L2: energy sums from FEB
  - Default for MET chains
- L1.5 jets
  - Default for multi-jet triggers
- Hadronic calibration at L2 and EF for R=0.4 jets/MET
- HLT noise threshold in calorimeter reconstruction raised
  - Use mu = 30 (same as offline)
- L2 tracking algorithm using L2Star (more robust to pile-up)
- Egamma/Tau selections are more pile-up robust
- Muons have merged MuonEF and MuGirl
  - Runs MuGirl only if MuonEF fails

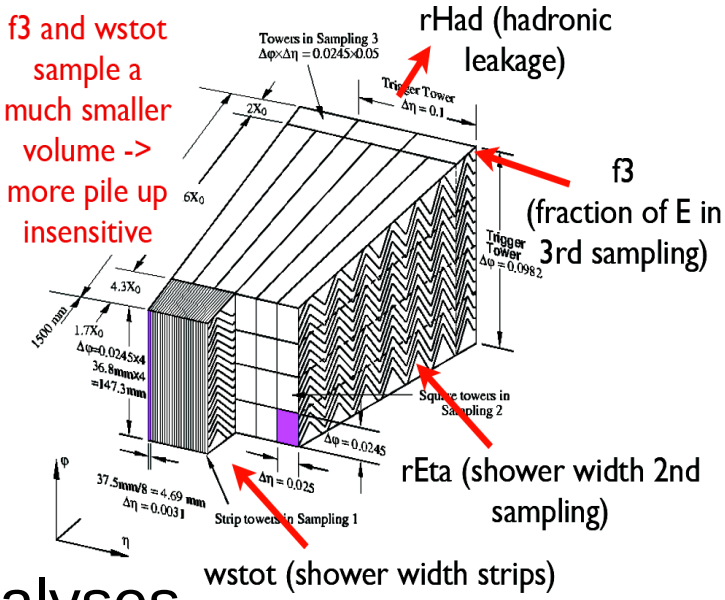
Electron trigger

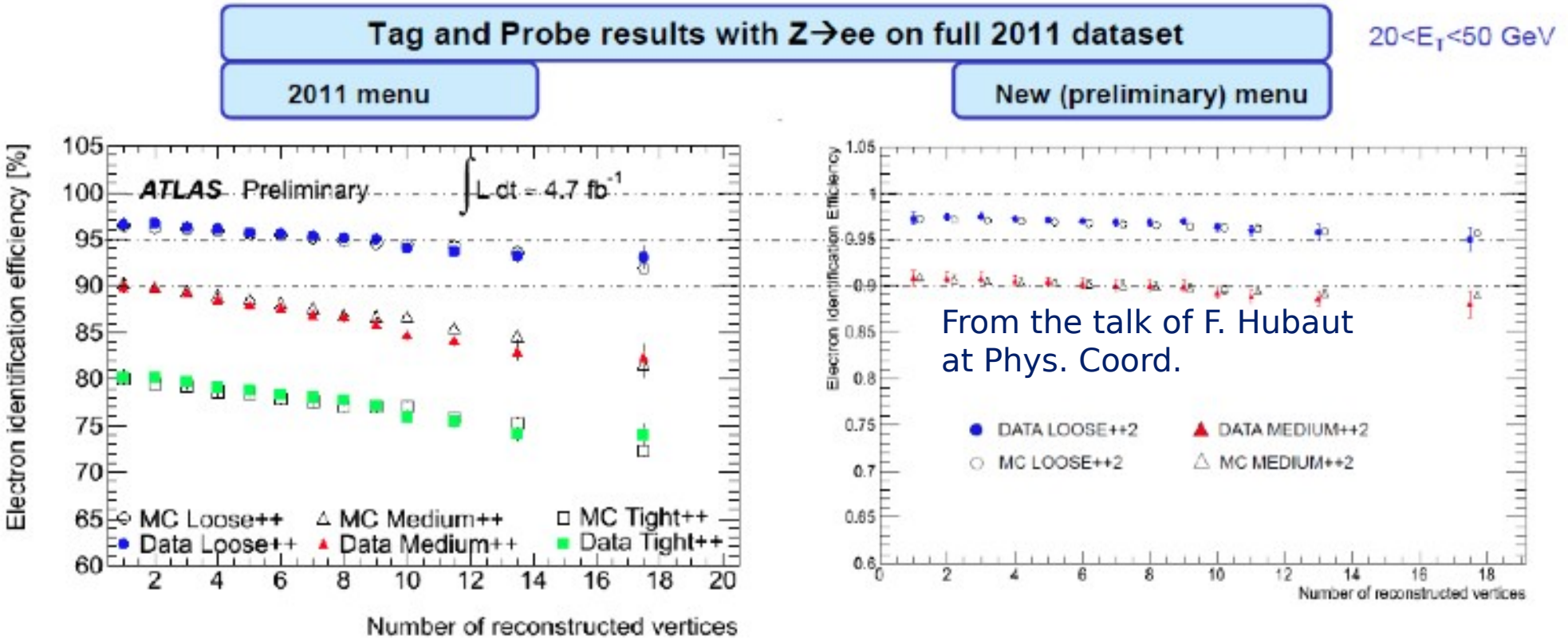
- Lowest unprescaled single-e: e24vhi_medium
  - was e20 or e22 in 2011
  - isolation cut at EF only: ptcone20/pt<0.1
- First non-isolated threshold: e60_medium1
- Multi-e
  - Offline threshold for leading: 15-25 GeV
  - Offline threshold for sub-leading: 10 GeV

Electron trigger chain	L1 Item	L1 (Hz)	EF rate (avg)	EF unique
e24vhi_medium1	EM18VH	21000	80	55
e60_medium1	EM30	7700	8	4
2e12Tvh_loose1	2EM10VH	6800	9	7
e24vh_medium1_e7T_medium1	EM18VH	21000	3	0
e24vh_medium1_EFxe30	EM18VH	21000	25	2
e12Tvh_medium1_mu8	EM10VH_MU6	2000	5	4
e12Tvh_medium1_mu6_topo_medium	EM10VH_MU6	2000	0.7	0
e24vhi_loose1_mu8	EM18VH	21000	1	1
2e7T_medium1_mu6	2EM6_MU6	1650	1	1
e7T_medium1_2mu6	EM6_2MU6	320	1	1

Electron trigger

- Pileup-sensitive variables (Reta, Rhad) loosened
  - Impact off Had Leakage < 1 GeV cut at L1 still small (0.5%)
- Tightened wstot cut, added f3
- Impact of isolation cuts negligible for all analyses

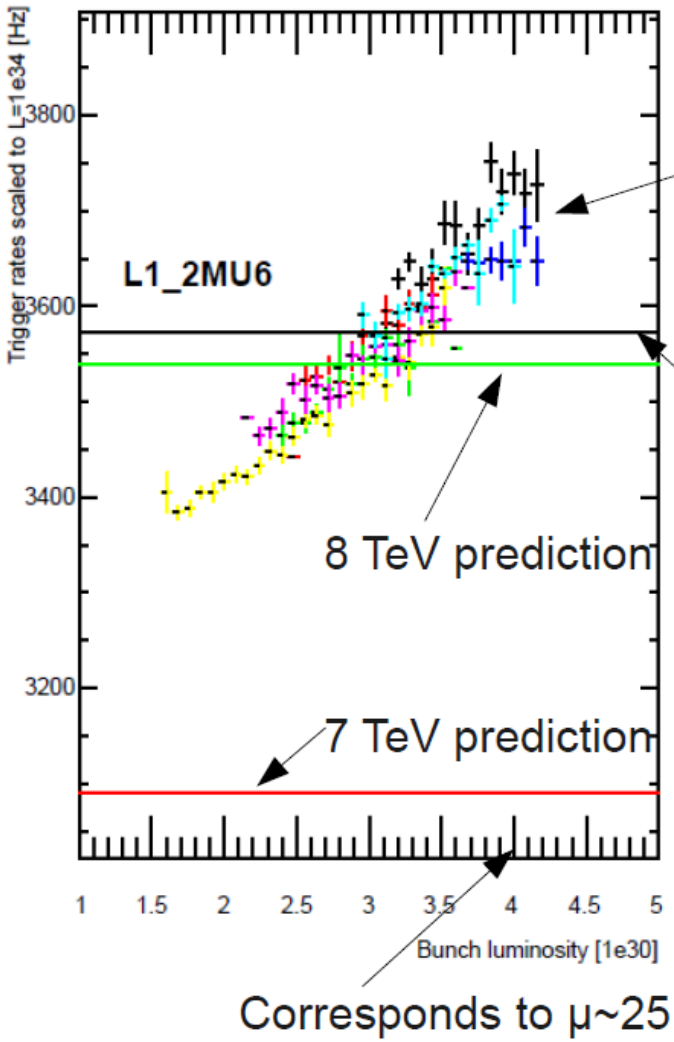




Trigger Rate Plots Explained

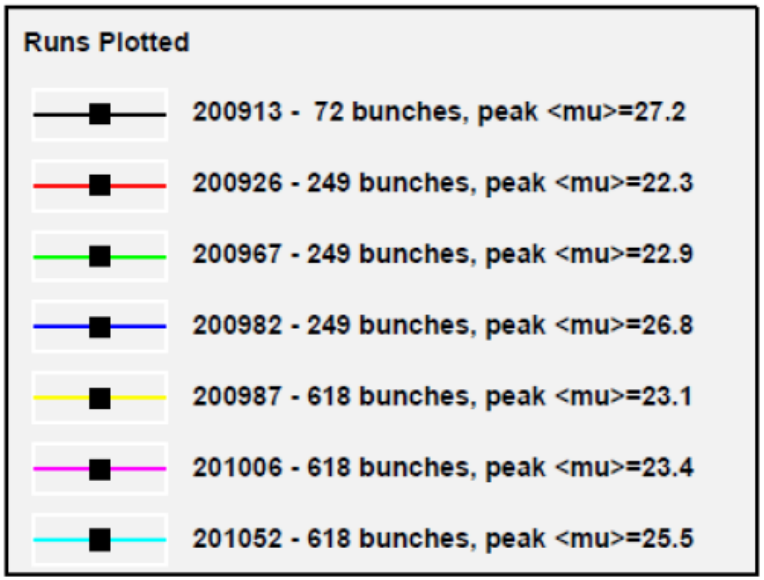
Online rates scaled linearly to an instantaneous luminosity of 10^{34}
- Plotted vs bunch luminosity (=pileup) should be flat except for pileup effects
- equivalent to trigger cross section except for the unit (Hz vs mb)

Example:



Multiple runs plotted to see stability

Average of rates



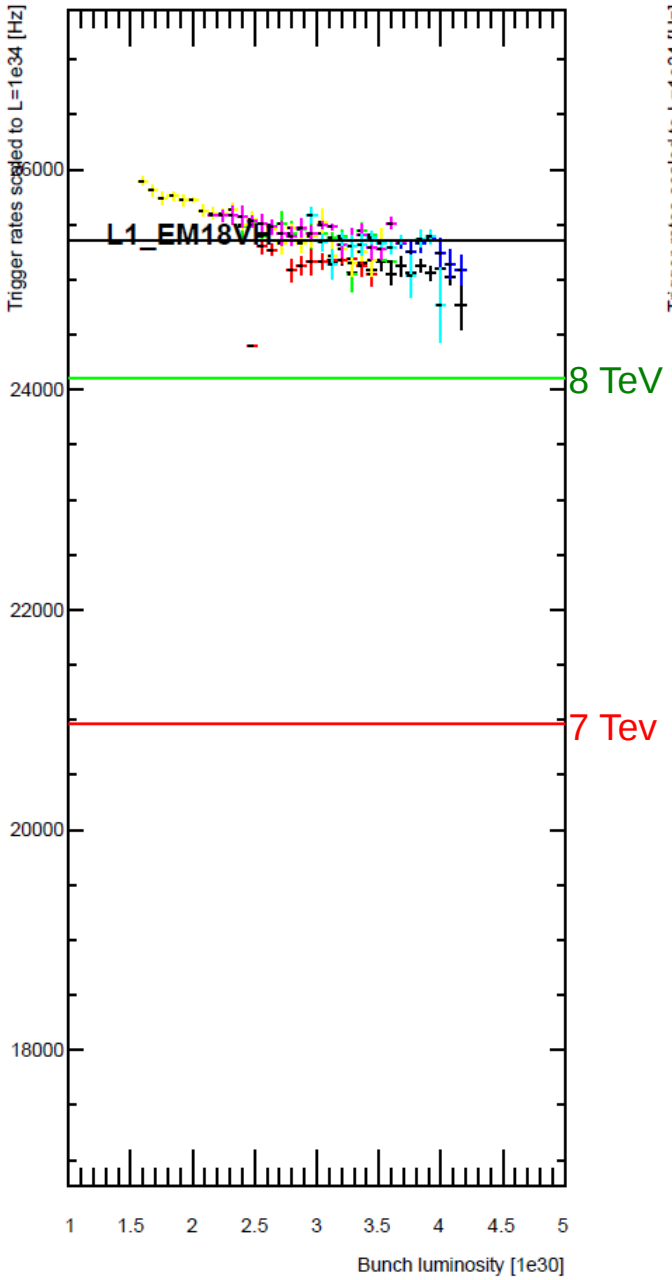
Note: L=10^{34} with 1330 bunches would require bunch luminosity of 7.5x10^{30}

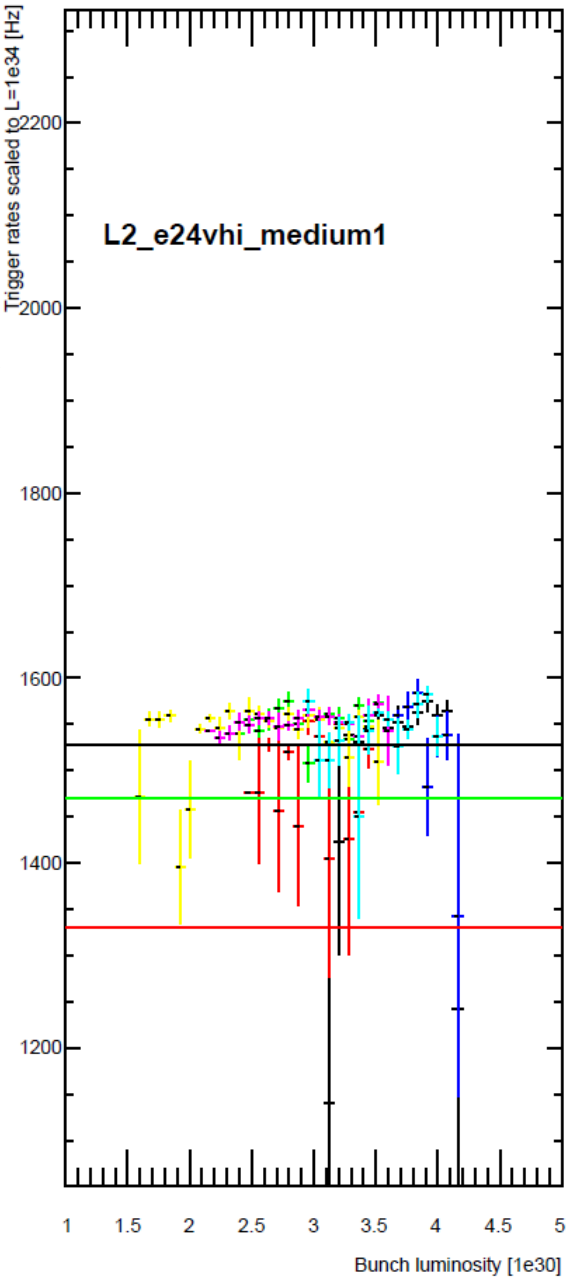
Short term we expect to stay at bunch luminosity ~4x10^{30}, corresponding to a peak luminosity of ~5.5x10^{33}
LHC target for 2012 is bunch luminosity ~5x10^{30}, corresponding to L=6.8x10^{33}

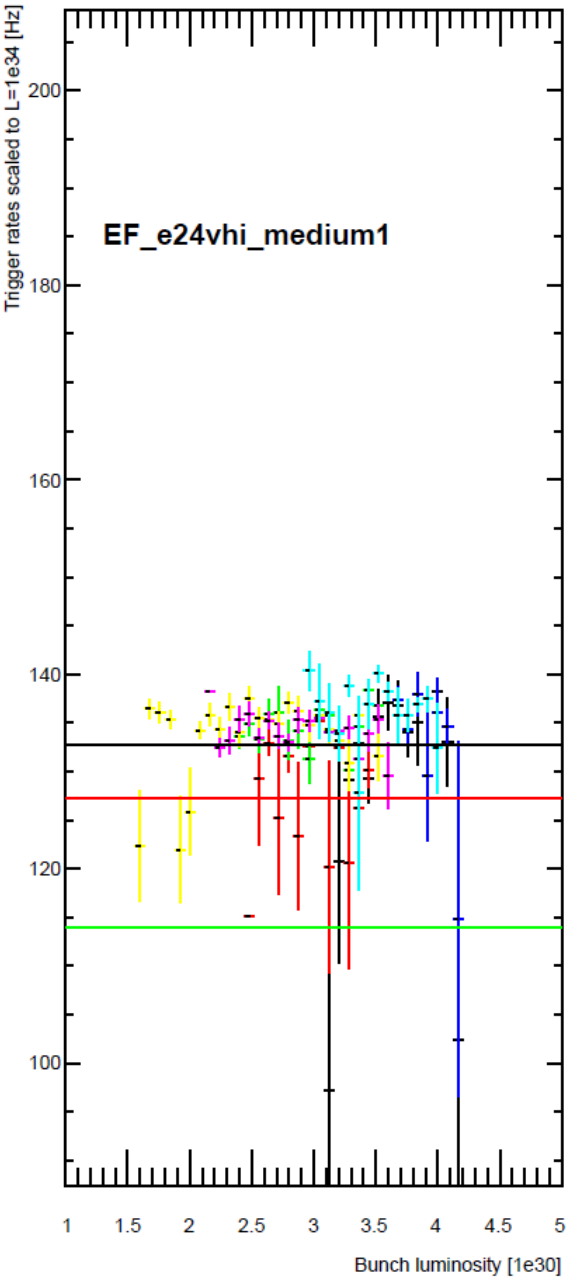
All data from xmon tools

EF_e24vhi_medium1

Data 2012







Photon trigger

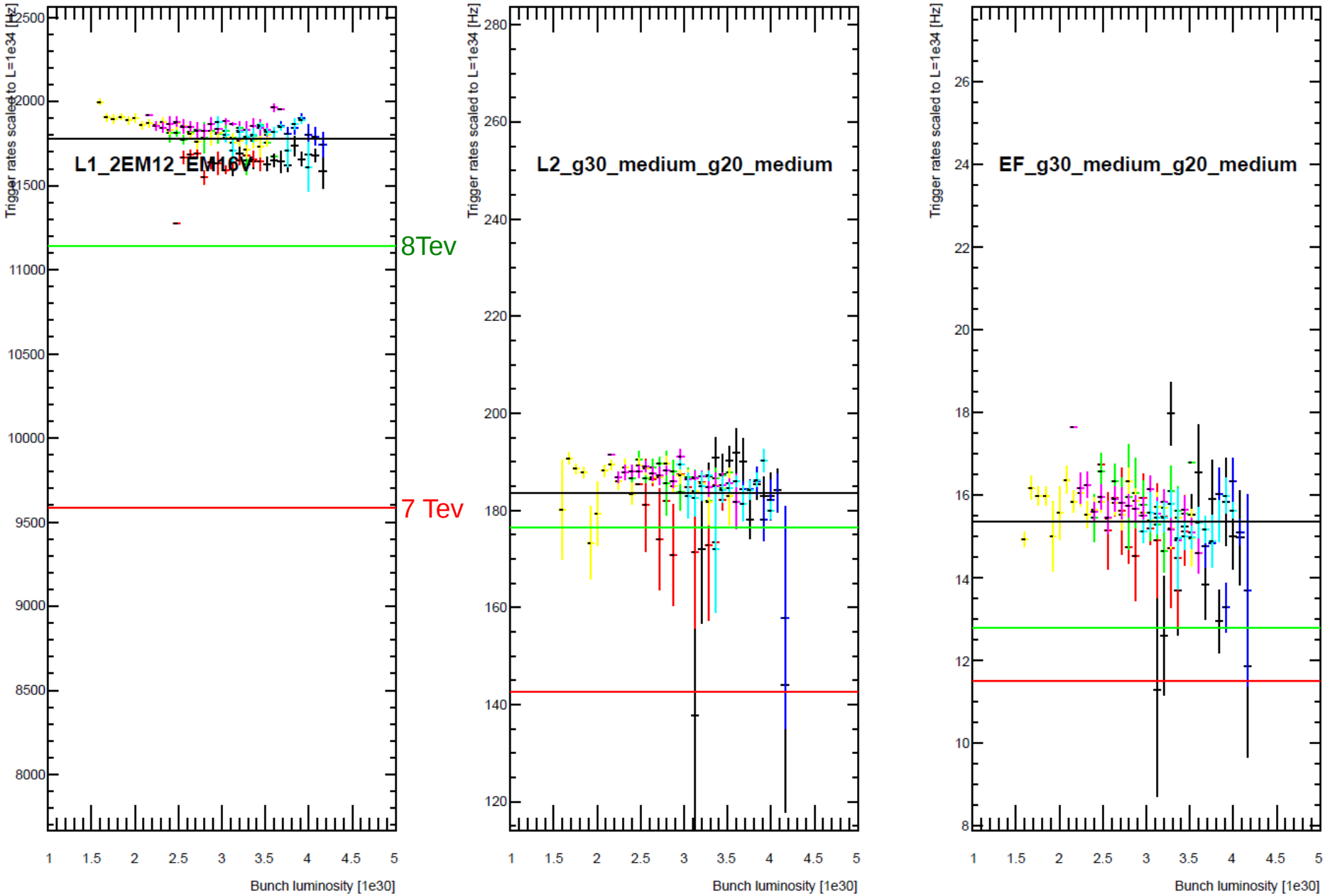
- g30_loose_g20_loose rate not sustainable at high luminosity
- Main interest is for $H \rightarrow \gamma\gamma$
  - analysis requiring two tight, isolated γs with E_T>40, 25 GeV
- 2012 options are
  - g30_medium_g20_medium
  - g35_loose_g25_loose
- First option OK for signal efficiency
  - need to check if ABCD method for background still OK (based on inverting ID and isolation criteria)
- Second option OK for background from data
  - need to raise cut on the sub-leading photon
- Both options will be active for a while

Photon trigger chain	L1 Item	EF rate (avg)
g30_loose_g20_loose	2EM12_EM16V	25
2g30_loose	2EM12_EM16V	10
g35_loose_g25_loose	2EM12_EM16V	13
g35_loose_g30_loose	2EM12_EM16V	9
g40_loose_g25_loose	2EM12_EM16V	9
g40_loose_g30_loose	2EM12_EM16V	8
g30_medium_g20_medium	2EM12_EM16V	8
2g20vh_medium	2EM10VH	11

Trigger	W.R.T.	Efficiency
g30_medium_g20_medium	25 GeV/40 GeV	$99.6^{+0.09}_{-0.1}$
g35_loose_g25_loose	30 GeV/40 GeV	$99.8^{+0.06}_{-0.08}$

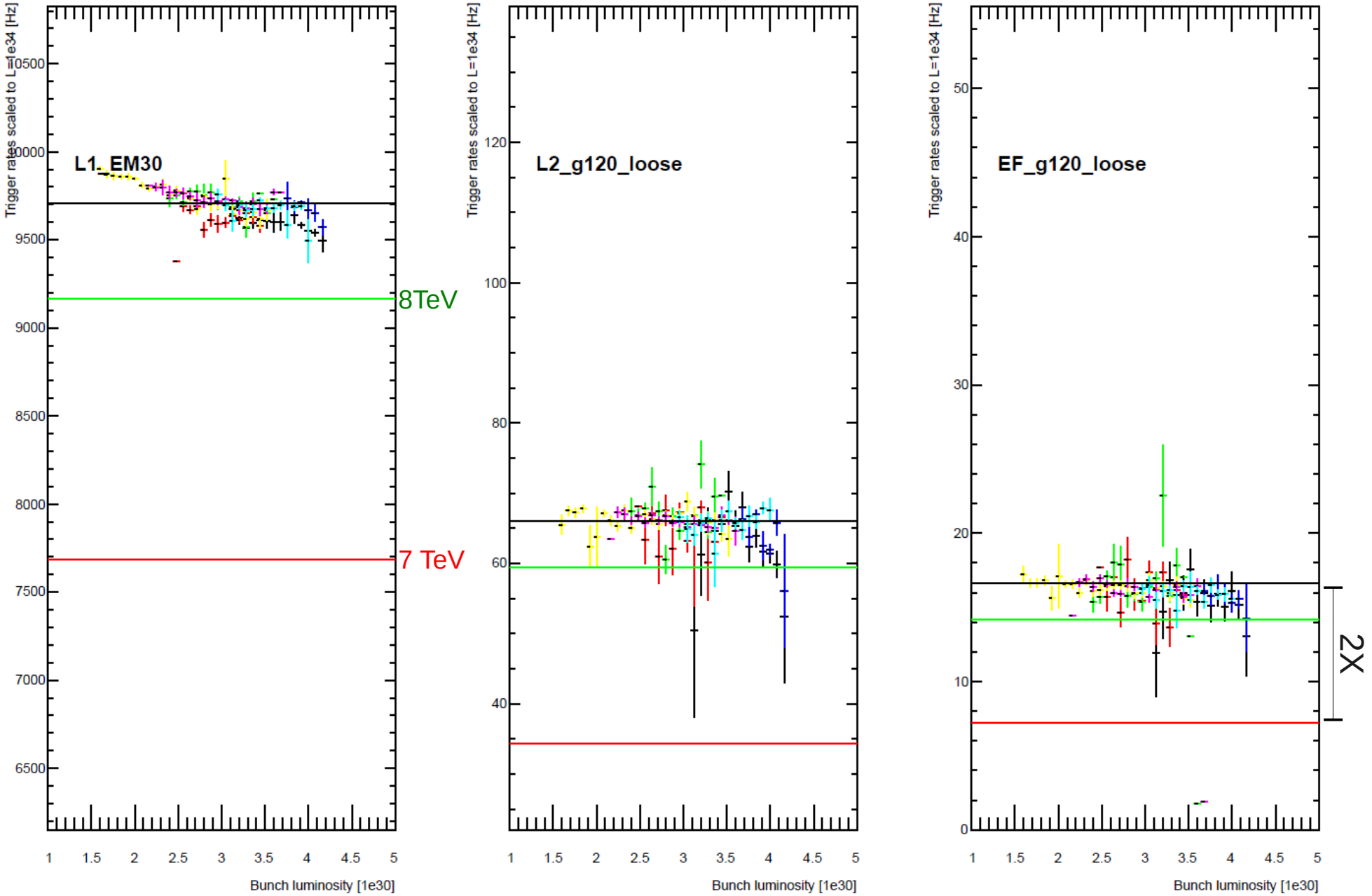
EF_g30_medium_g20_medium

Data 2012



EF_g120_loose

Data 2012



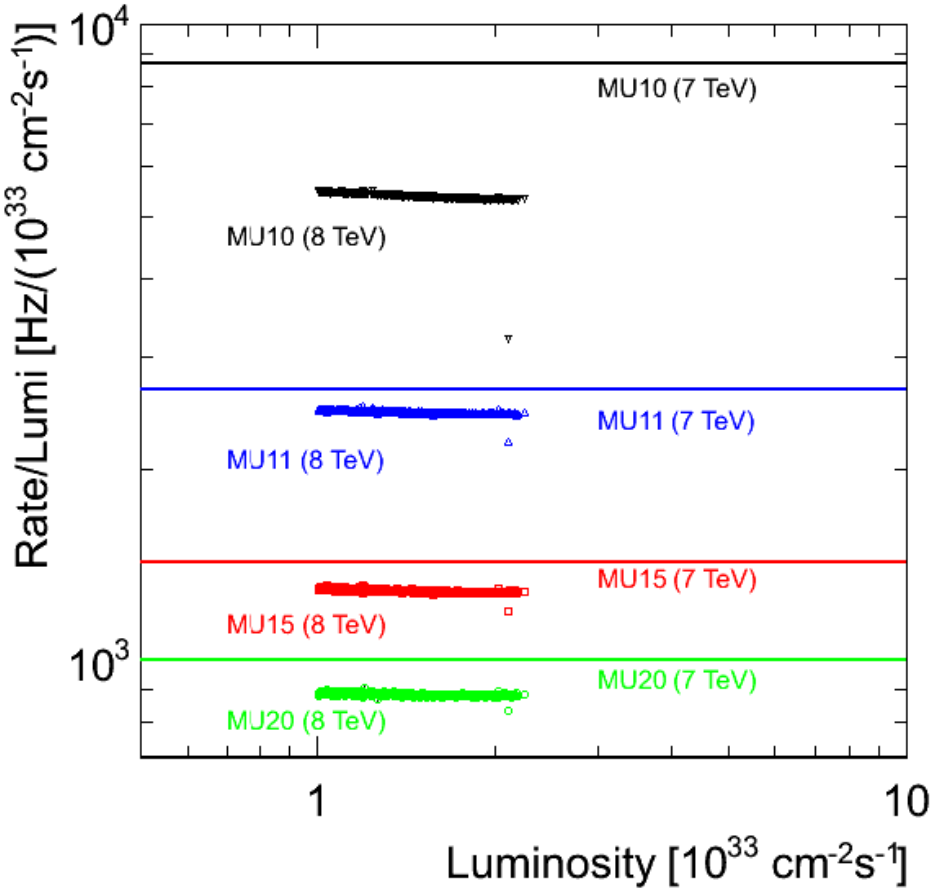
Muon trigger

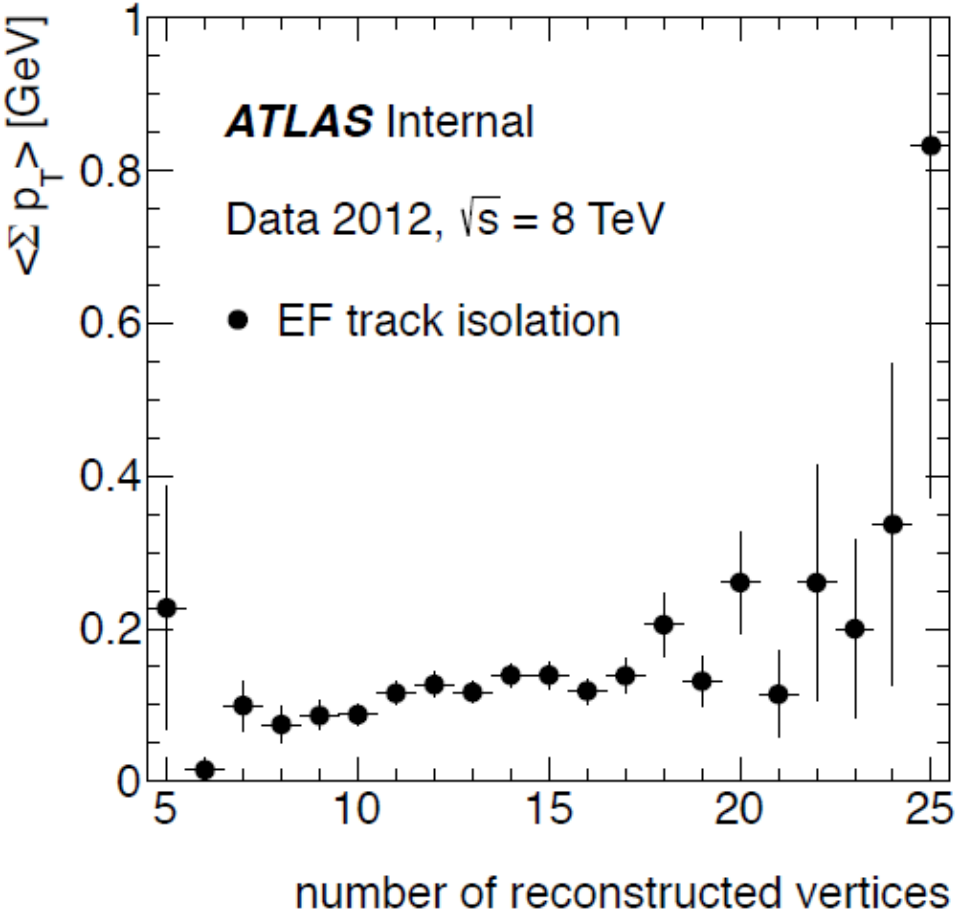
- Lowest unprescaled single-μ: mu24i_tight
  - was mu18_medium in 2011
  - isolation cut at EF only: ptcone20/pt<0.1
- First non-isolated threshold: mu36_tight
- Di-muon
  - 2mu13 di-muon trigger (was 2mu10 in 2011)
  - mu18_tight_mu8_EFFS

Muon trigger chain:	L1 Item	L1 (Hz)	EF rate (avg)	EF unique
mu24i_tight	MU15	10650	56	29
mu36_tight	MU15	10650	28	2
mu50_MSonly_barrel_tight	MU15	10650	3	1
mu60_slow_tight1	MU20	7500	2	0
2mu13	2MU10	1060	8	2
mu18_tight_mu8_EFFS	MU15	10650	10	2
3mu6_MSOnly	3MU6	75	2	1
3mu6	3MU6	75	1	0

Muon trigger

- As a first look, L1 Muon rate even got lower due to new shielding and roads
- At EF, good sign for isolation robustness up to nVtx ~20

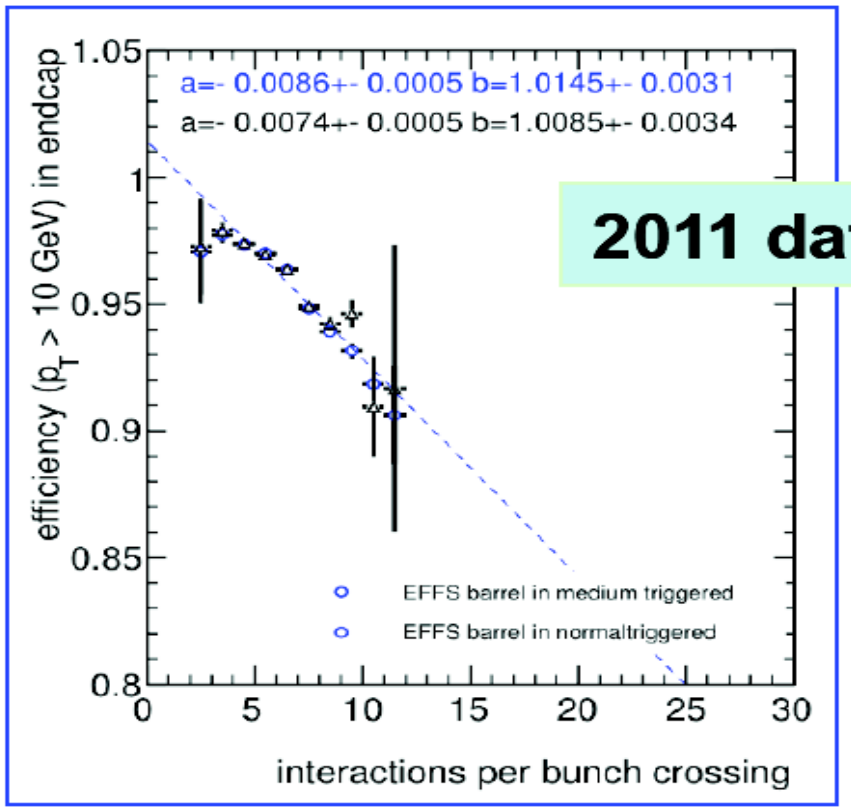




Muon trigger

- mu18_tight_mu8_EFFS
  - important to keep high efficiency for the higgs to 4-muons channel in low-mass region (at 125 GeV)
  - otherwise 4.5% loss

mu18_tight_mu8_EFFS
efficiency (EC) vs n of vertices



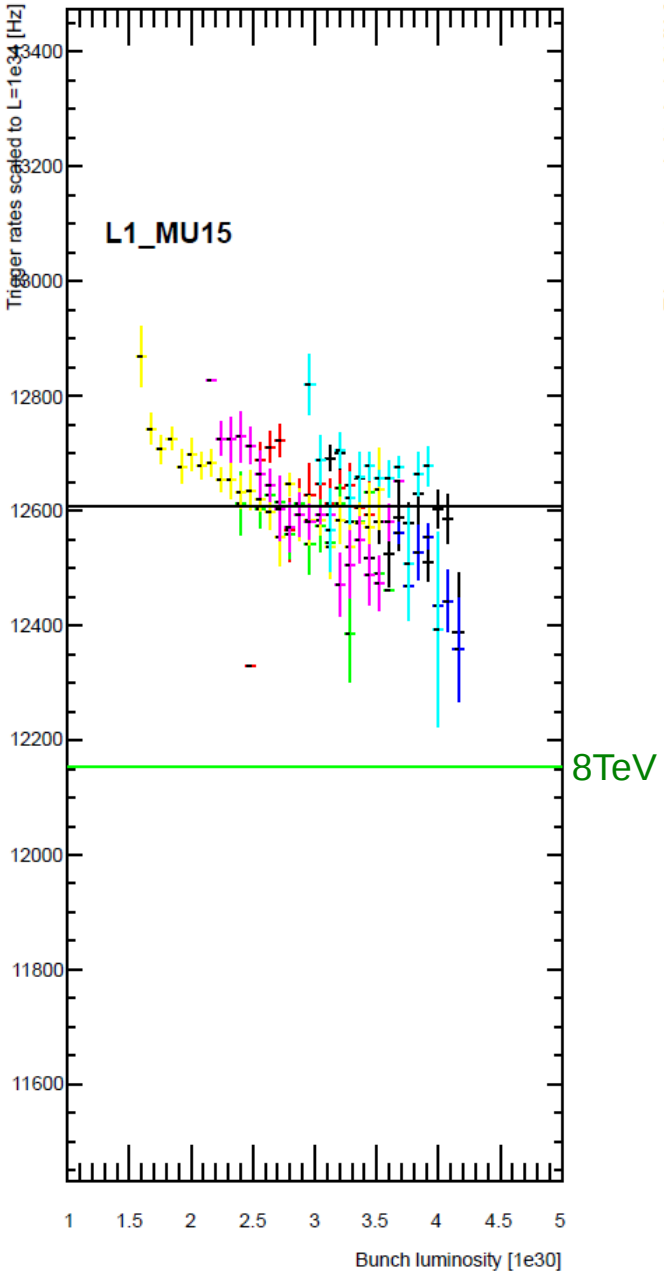
Some bugs in rel16:
pattern recognition
failing in high
multiplicity conditions

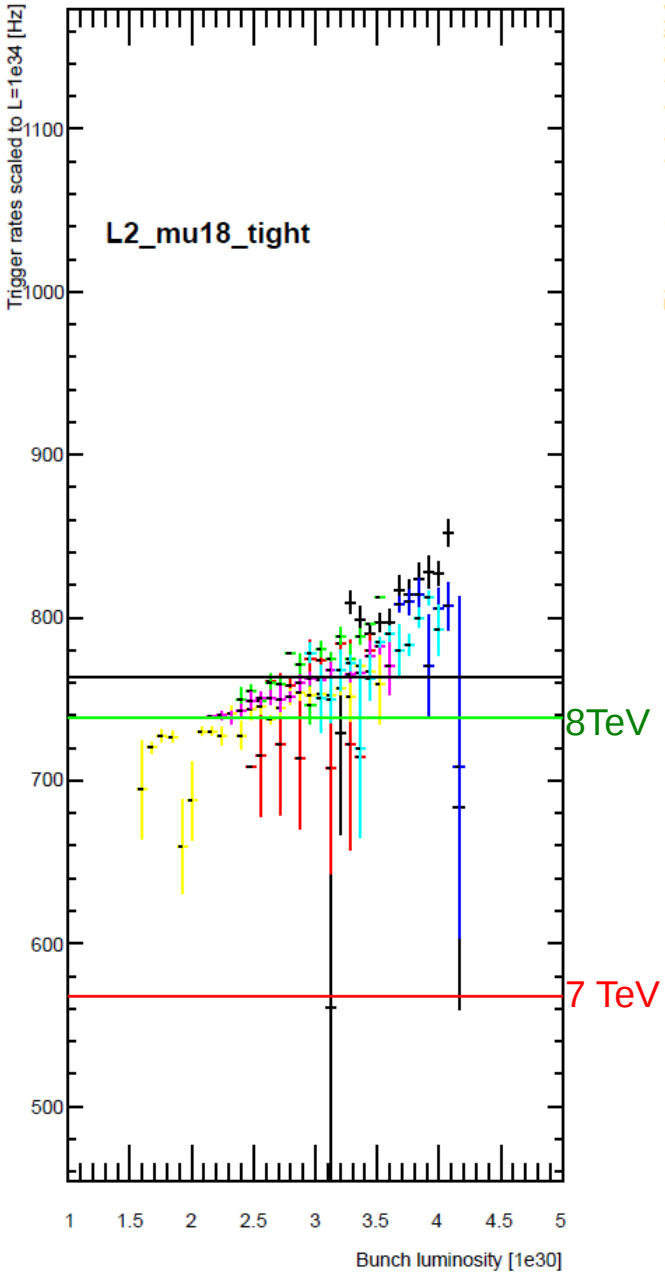
Seems solved now
(most recent 2012 data, rel17)

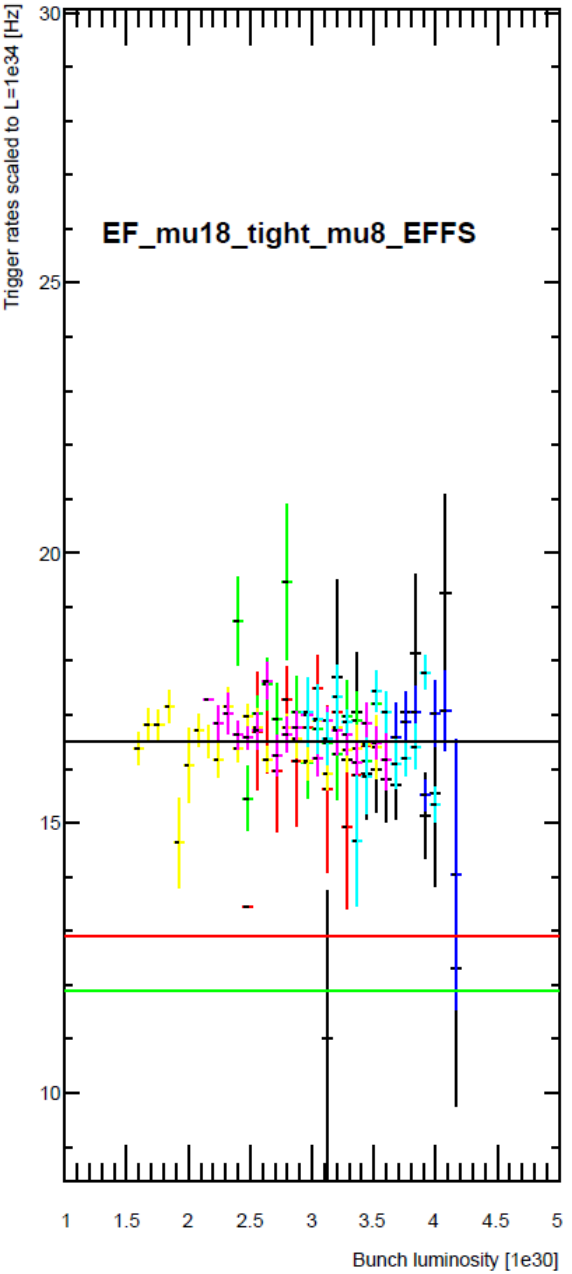
K. Nagano

EF_mu18_tight_mu8_EFFS

Data 2012







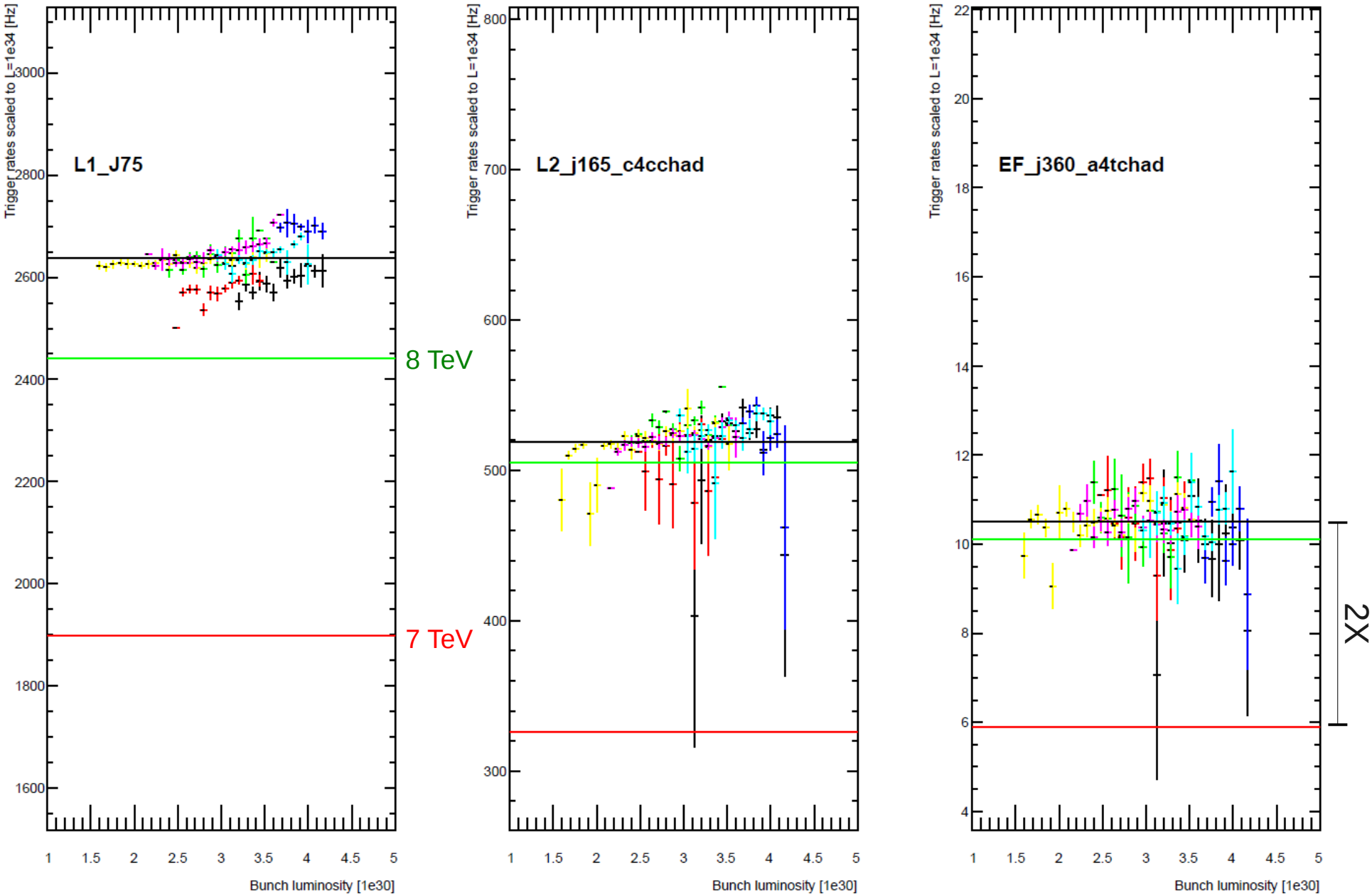
Jets

- Lowest unprescaled jet: 360 GeV
- Unprescaled Multi-jets: 4j80, 5j55
- Use hadronic calibration at L2 and EF
- New default for multi-jets
  - Full-scan jet reconstruction using L1Calo towers

Jet trigger chain	L1 Item	L1 (Hz)	EF rate (avg)	EF unique
j360_a4tchad	J75	1900	4	1
j360_a10tcem	J75	1900	1.7	0
L1J350_NoAlg	J350	2	2	1?
fj145_a4tchad	FJ75	40	0.5	0.5
3j170_a4tchad	J75	1900	2	0.5
4j80_a4tchad_L2FS	4J15	1000	8	4
5j55_a4tchad_L2FS_4L1J15	4J15	1000	6	3
6j45_a4tchad_5L2j15_4L1J15	4J15	1000	2.5	0.5
7j35_a4tchad_5L2j15_4L1J15	4J15	1000	2.5	1
j170_a4tchad_ht700	J75	1900	8	2

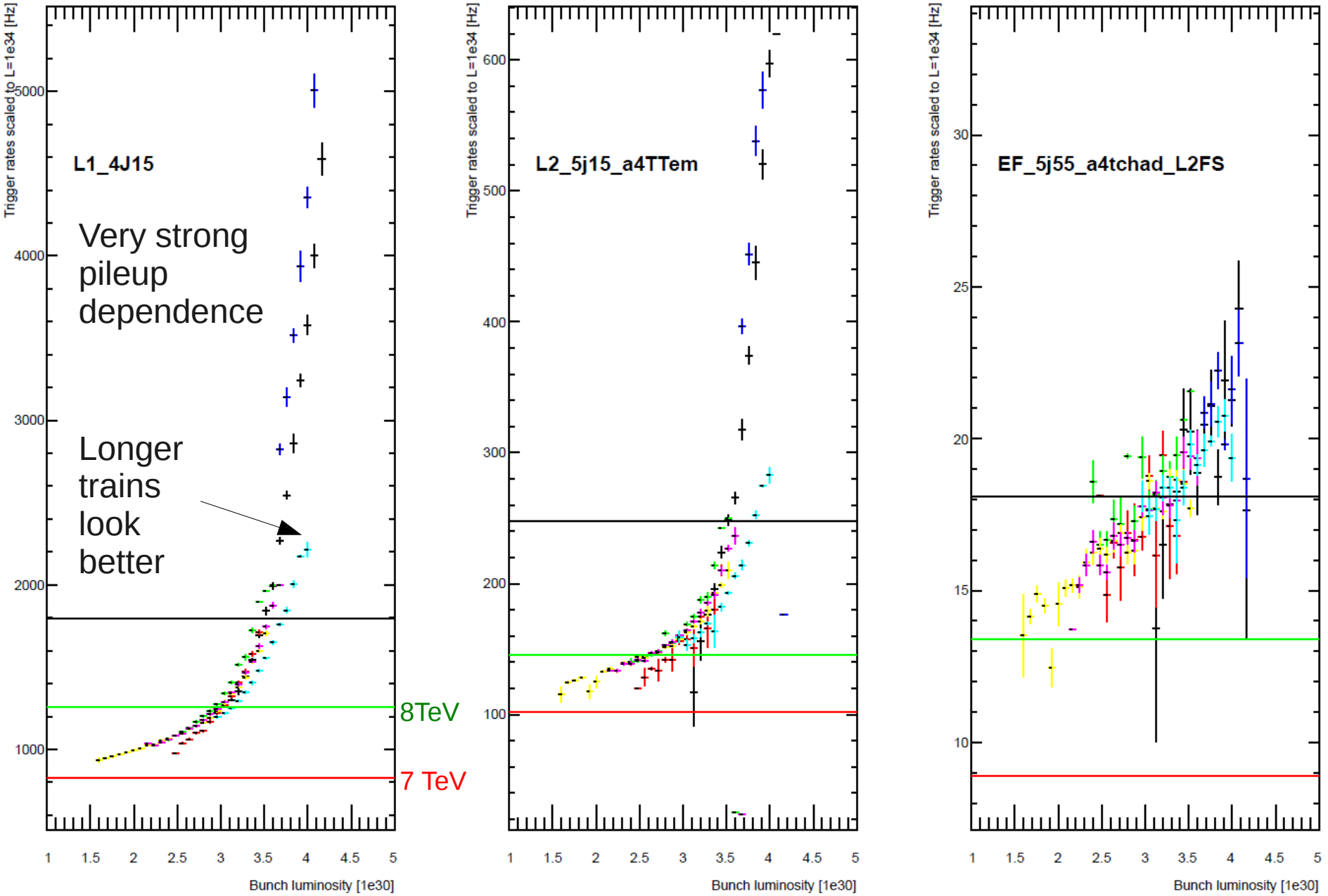
EF_j360_a4tchad

Data 2012



EF_5j55_a4tchad_L2FS

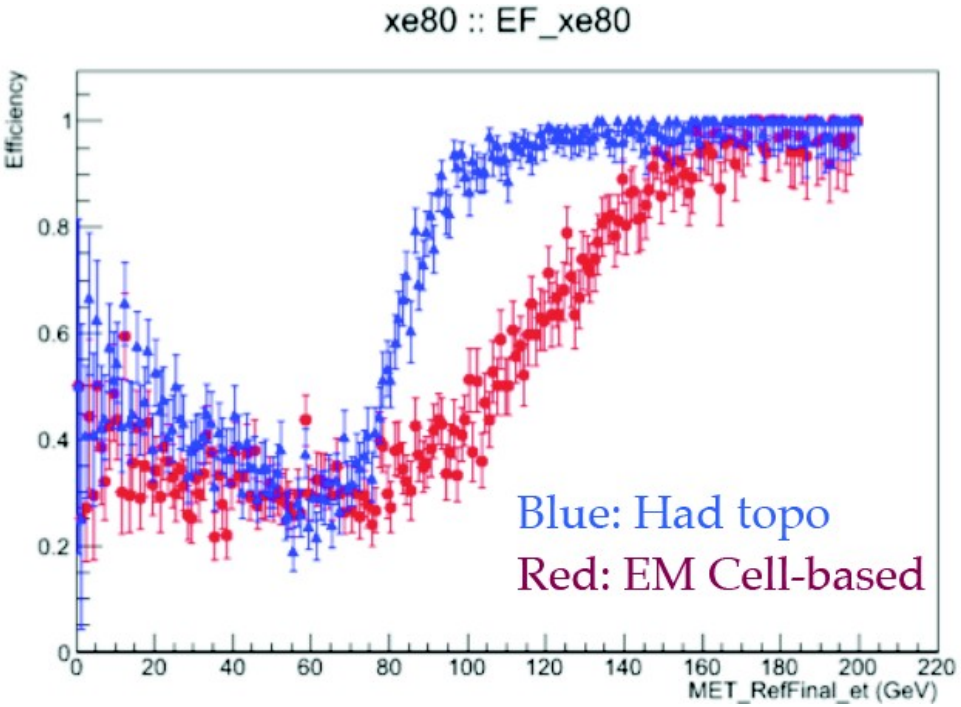
Data 2012



Missing E_T trigger

Data 2012

- In 2011: xe_70
  - seed L1_XE50
- In 2012: xe_80
  - seed L1_XE60
- MET@L2
- Events with jets use LC calibrated topo-clusters

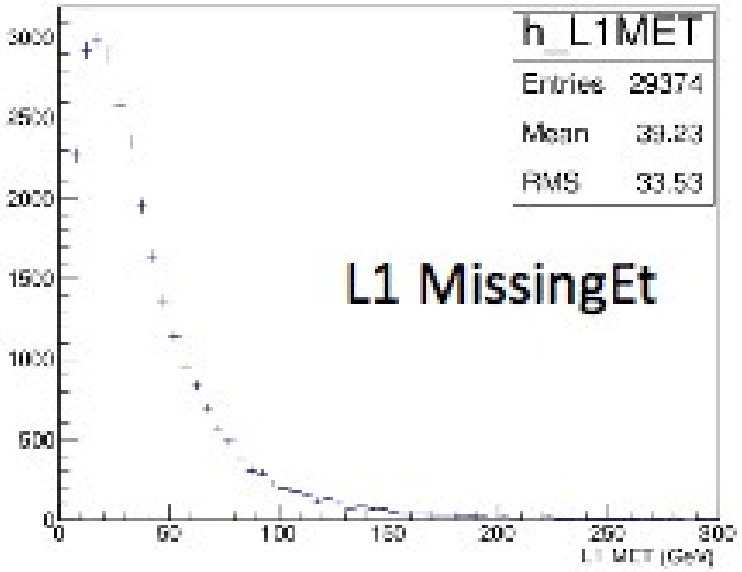


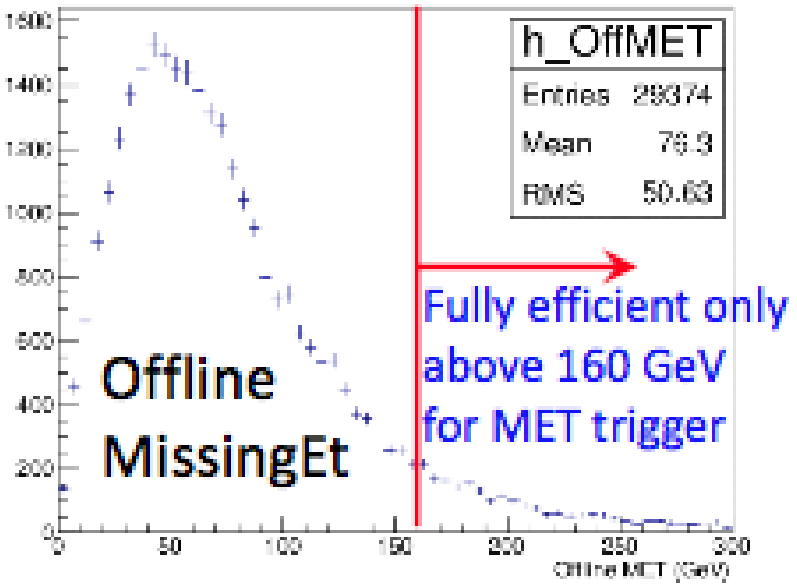
Jet + MET chain	L1 Item	L1 (Hz)	EF rate (avg)	EF unique
xe80	XE60	1000	7	2
xe80T	XE50_BGRP7		?	?
j110_a4tchad_xe100_tclcw_veryloose	J50_XE40	1100	6	3
j145_a4tchad_L2EFxe90_tclcw	J75	1900	8	?
j170_a4tchad_EFxe80_tclcw	J75	1900	5	3
j80_a4tchad_xe100_tclcw_loose	J30_XE50	2000	6	4
j80_a4tchad_xe85_tclcw_dphi2j45xe10	J30_XE50	2000	7	3

Missing E_T trigger

Data 2012

- xe_80 (seed L1_XE60) can penalize some channels
  - e.g. ZH→ννbb, among the most important channels for H→bb
  - >80% of signal killed by MET trigger (Y. Nagai)



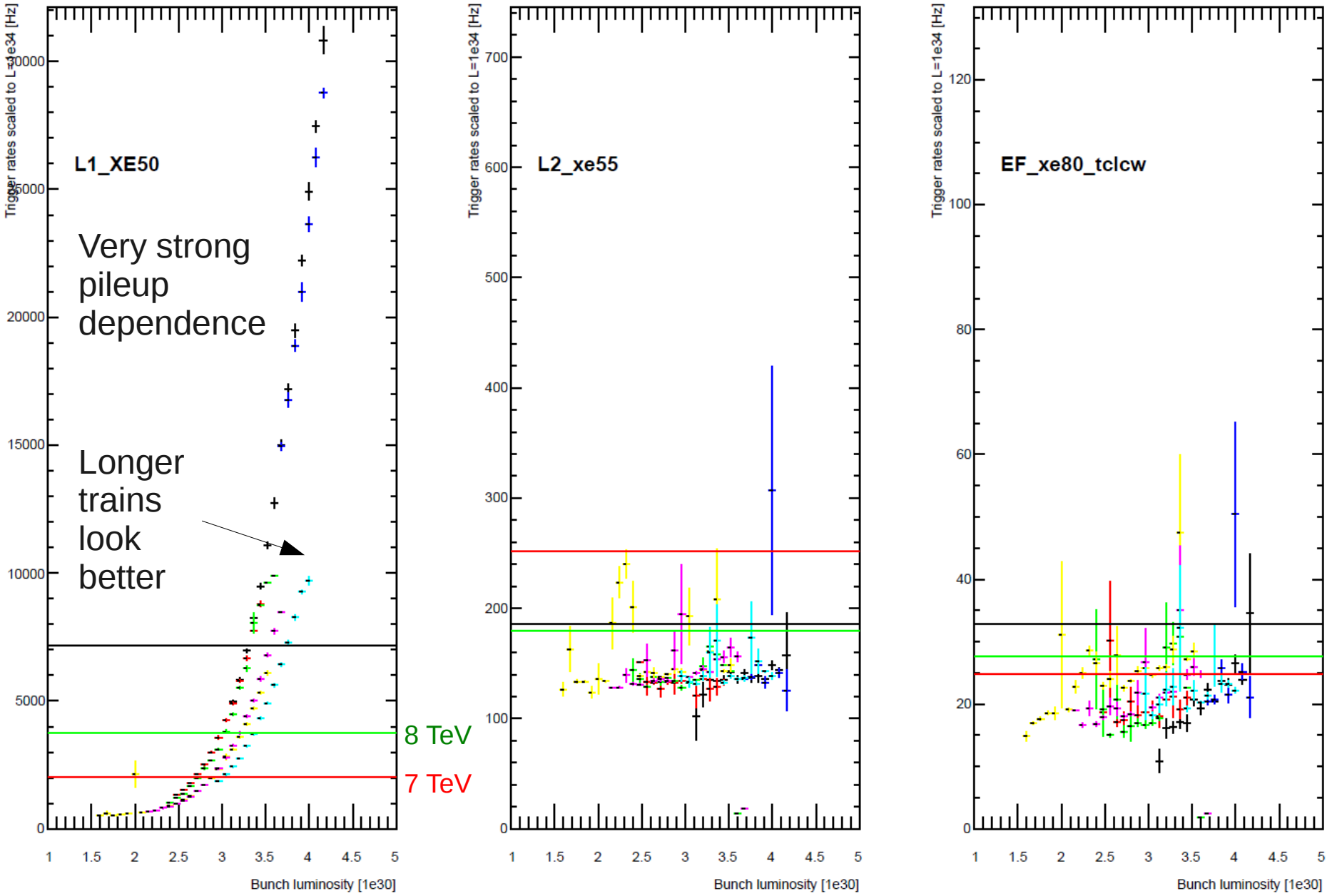


- Example of MET-JET dφ cut in ZH→ννbb

Trigger	dϕ > 0.75	dϕ > 1.0	dϕ > 1.5	dϕ > 2.0
Signal efficiency	0.902	0.854	0.752	0.563
Data efficiency (rejection)	0.406 (2.46)	0.282 (3.55)	0.101 (8.01)	0.061 (19.8)

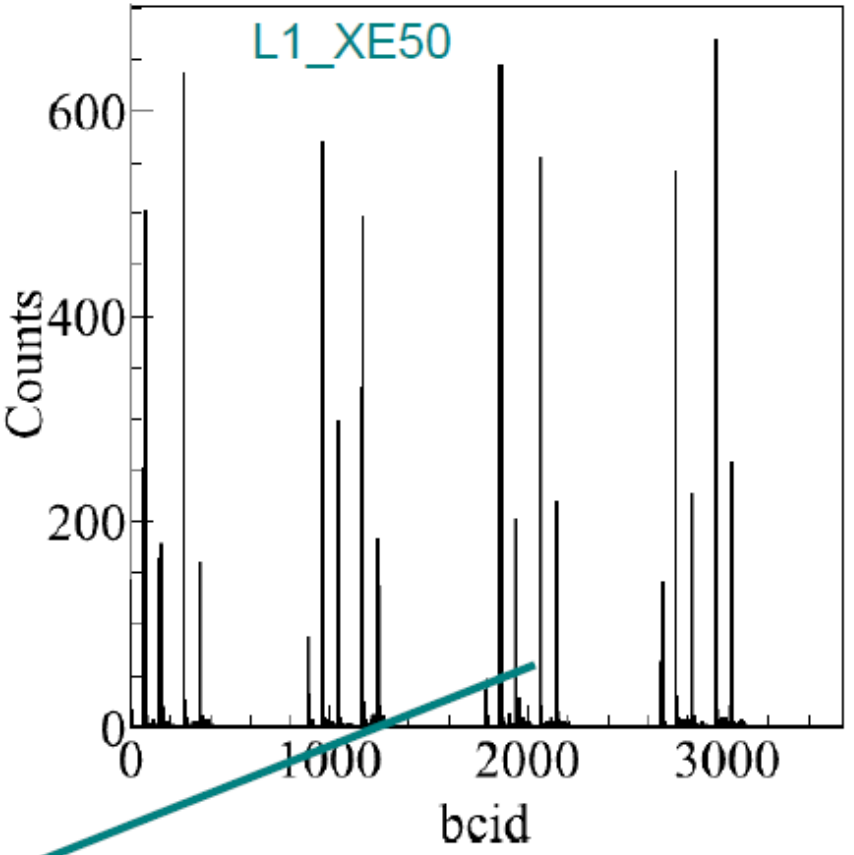
EF_xe80_tclcw

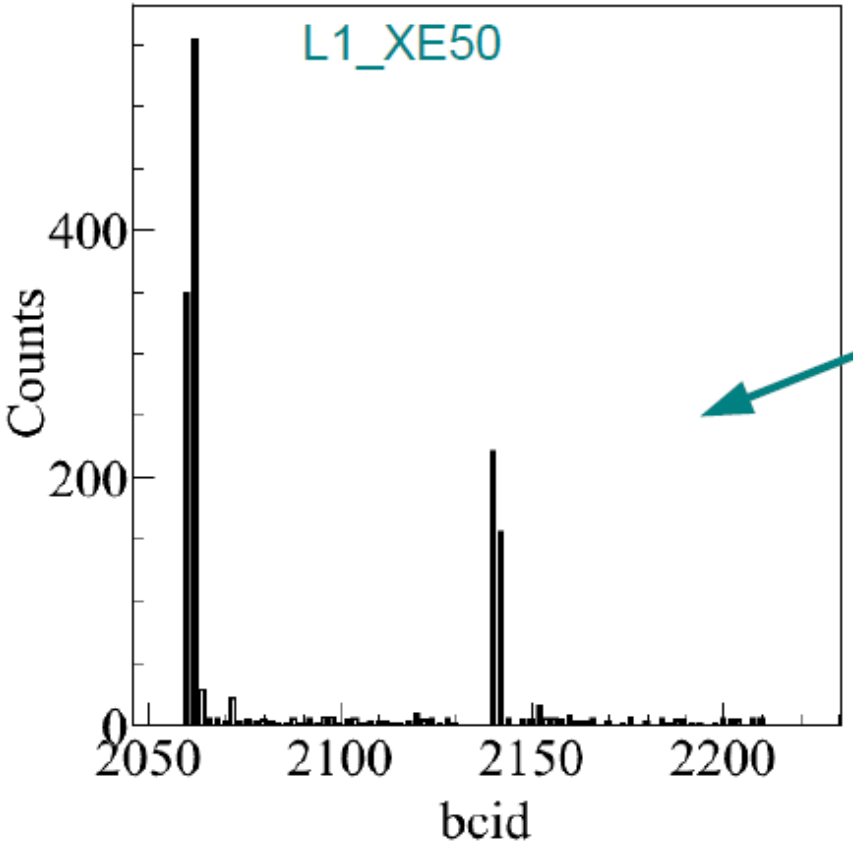
Data 2012



Bunch Crossing Dependence

Pileup dependence, particularly at L1, is mostly seen in first 1-3 bunches of an LHC bunch train
For these bunches the L1Calo pedestal shifts high due to LAr pulse shape
LHC also appears to often give higher luminosity in those bunches



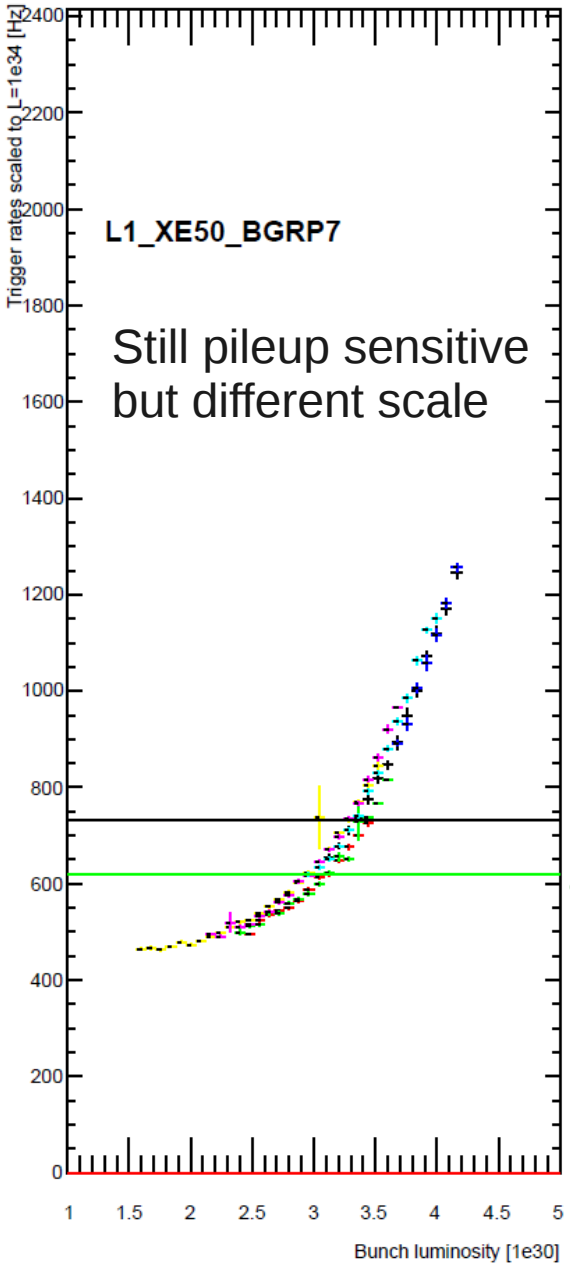


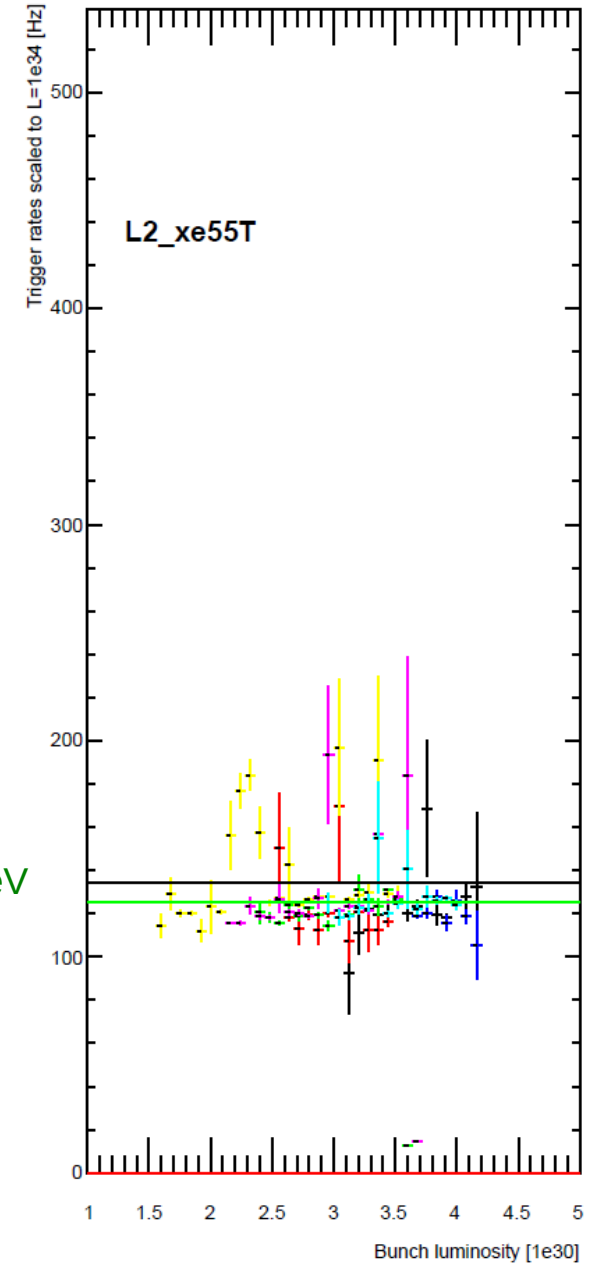
For missing ET, we redefined BGRP7 to excluded first 3 bunches in train and have special XE triggers for these

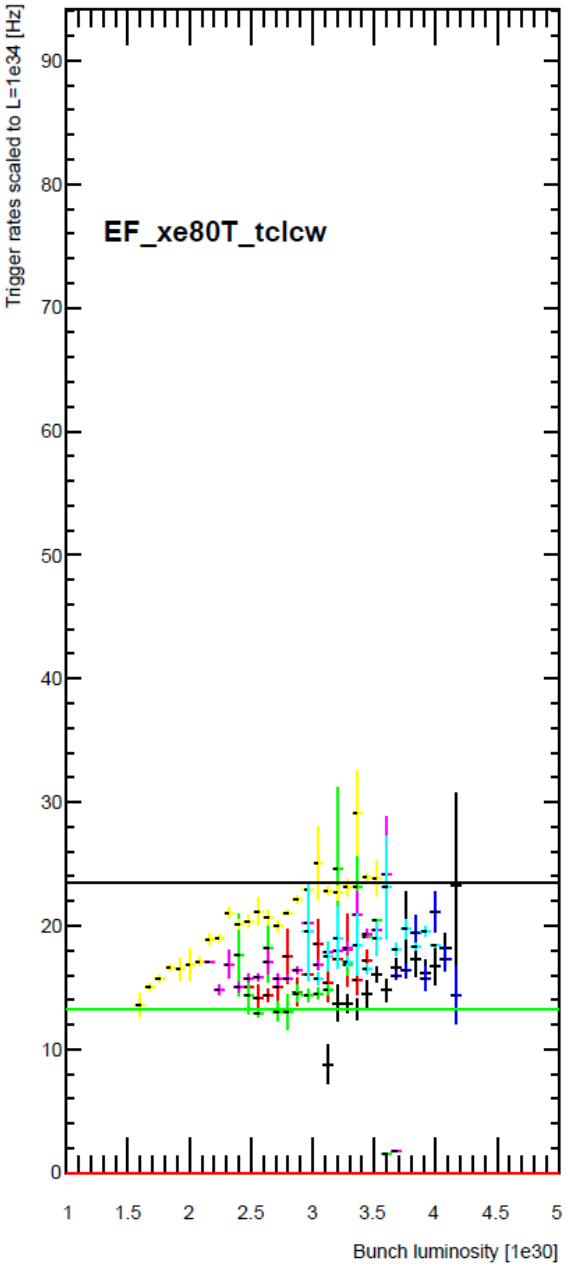
Most trains are 36 bunches long, so loose about 8% of integrated luminosity, but rates are much better behaved (next slides)

EF_xe80T_tclcw

Data 2012

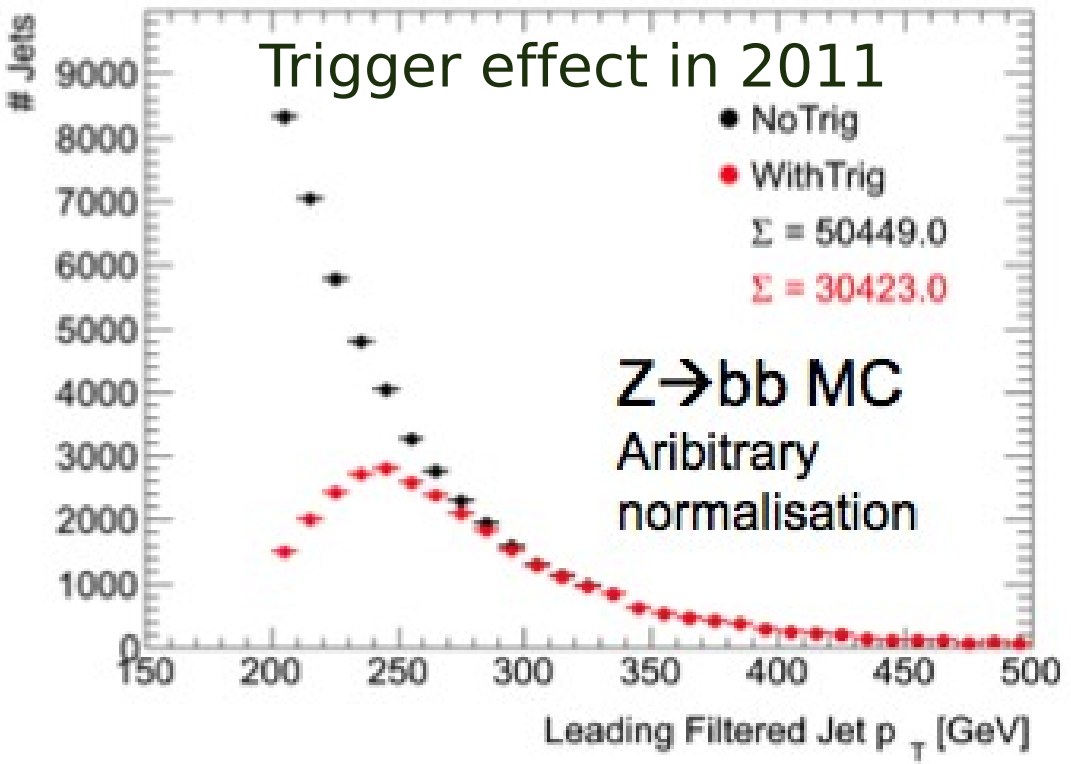






b-jet trigger

- b-jet trigger of central importance for many signals in 2012
  - Higgs, Susy, Top (higher untagged jet thresholds due to pileup)
- E.g. boosted Z→bb, benchmark analysis for H→bb signal, quite difficult but promising analysis
  - useful to study efficiencies and systematics of subject analysis
  - was using EF_j100_a4tc_EFFS_ht350 disabled after period J 2011
- After various studies, shown (A. Coccaro) that triggers
  - 2 tagged loose b-jets with threshold 35, 45, 55 GeV
  - 3-4 jets at L1
- … give efficiency for Z→bb ranging from 56% to 45%



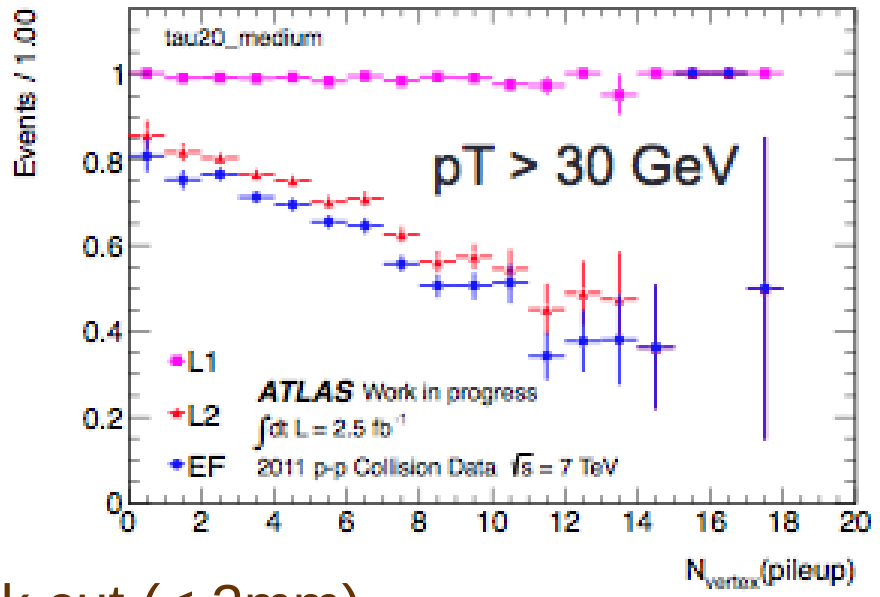
Tau trigger

- Strong pileup depend. in 2011 (L2)
  - mainly due to the cone size (0.4) and the cut on EMradius

$$r_{EM} = \frac{\sum_i \Delta R_i^2 E_i}{\sum_i E_i}$$

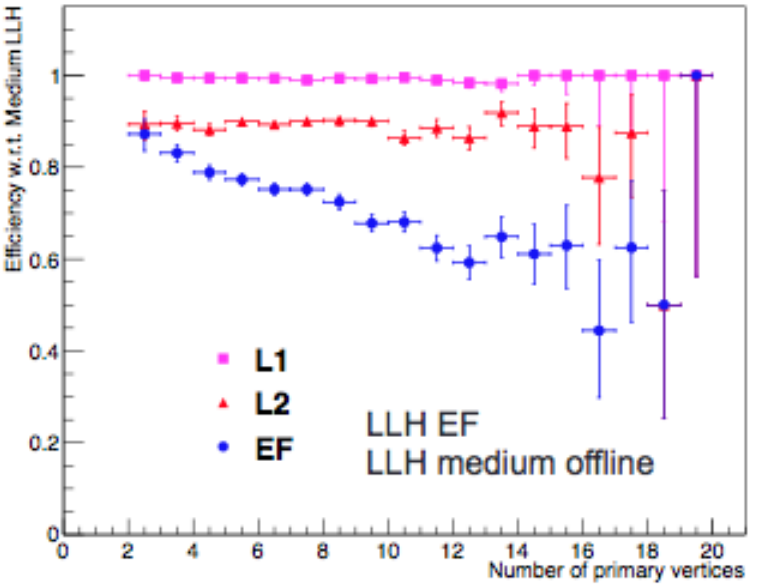
- Changes in L2 for 2012
  - Cone size 0.2 and EMradius not used anymore
  - Reduce dependency of track-based variables with a |ΔZ| w.r.t. leading track cut (< 2mm)

Data 2011



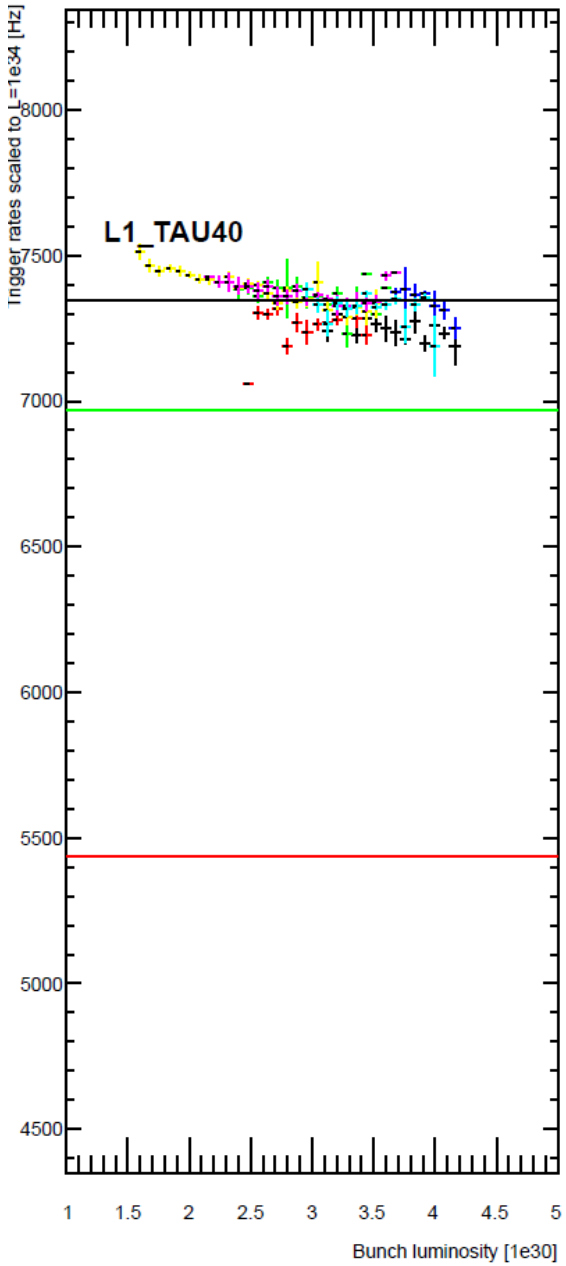
MC

- Changes in EF in 2012:
  - Two options: LLH and BDT
    - to be decided looking at physics signals (not done yet)
  - Same input variables as in offline ID
  - Still some efficiency decrease vs pileup → need to implement |ΔZ| cut at EF too



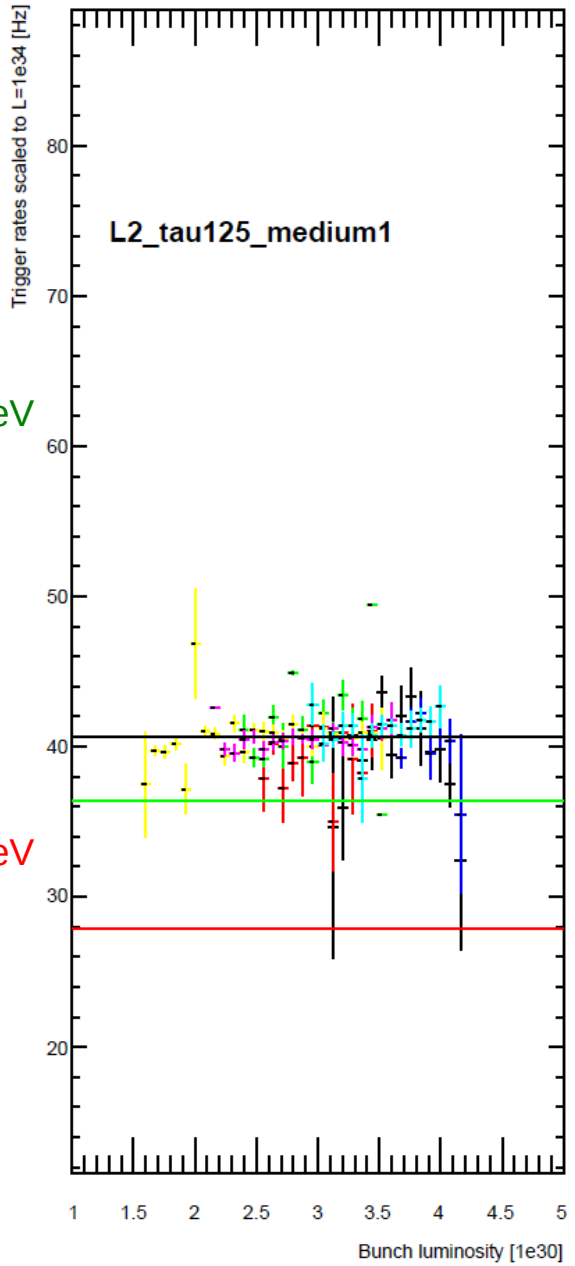
EF_tau125_medium1

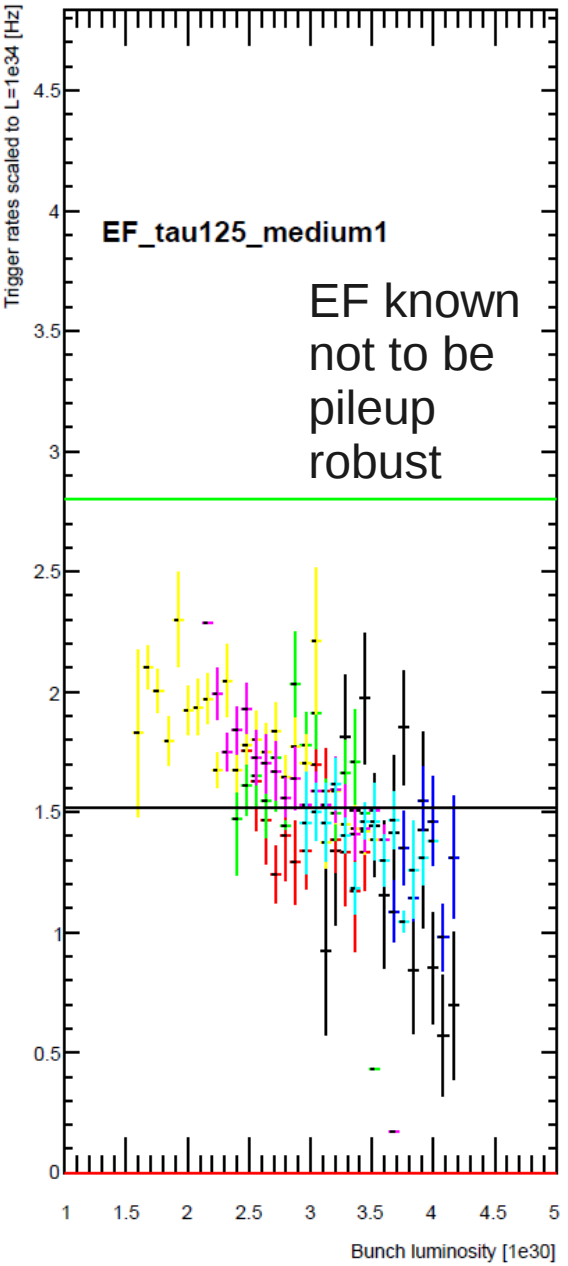
Data 2012



8 TeV

7 TeV





B-physics trigger

- 2011: 2mu4
- 2012: main triggers are based on 2mu6
- Expect to run with a new “barrel only” 2mu4 trigger for Bs→μμ
  - Gains back > 50% of 2MU4 efficiency
  - A large J/Psi sample will be sent to the delayed stream

Estimated yields from data periods K-M for J/psi, Upsilon and Bmumu mass regions

Trigger scenario	Yield relative to 2mu4	
2mu6	25%	27%
mu4mu6_muB	37%	38%
2mu4_notendcap	44%	47%
2mu4B	55%	52%
mu4mu6	69%	71%
2mu4	100%	100%

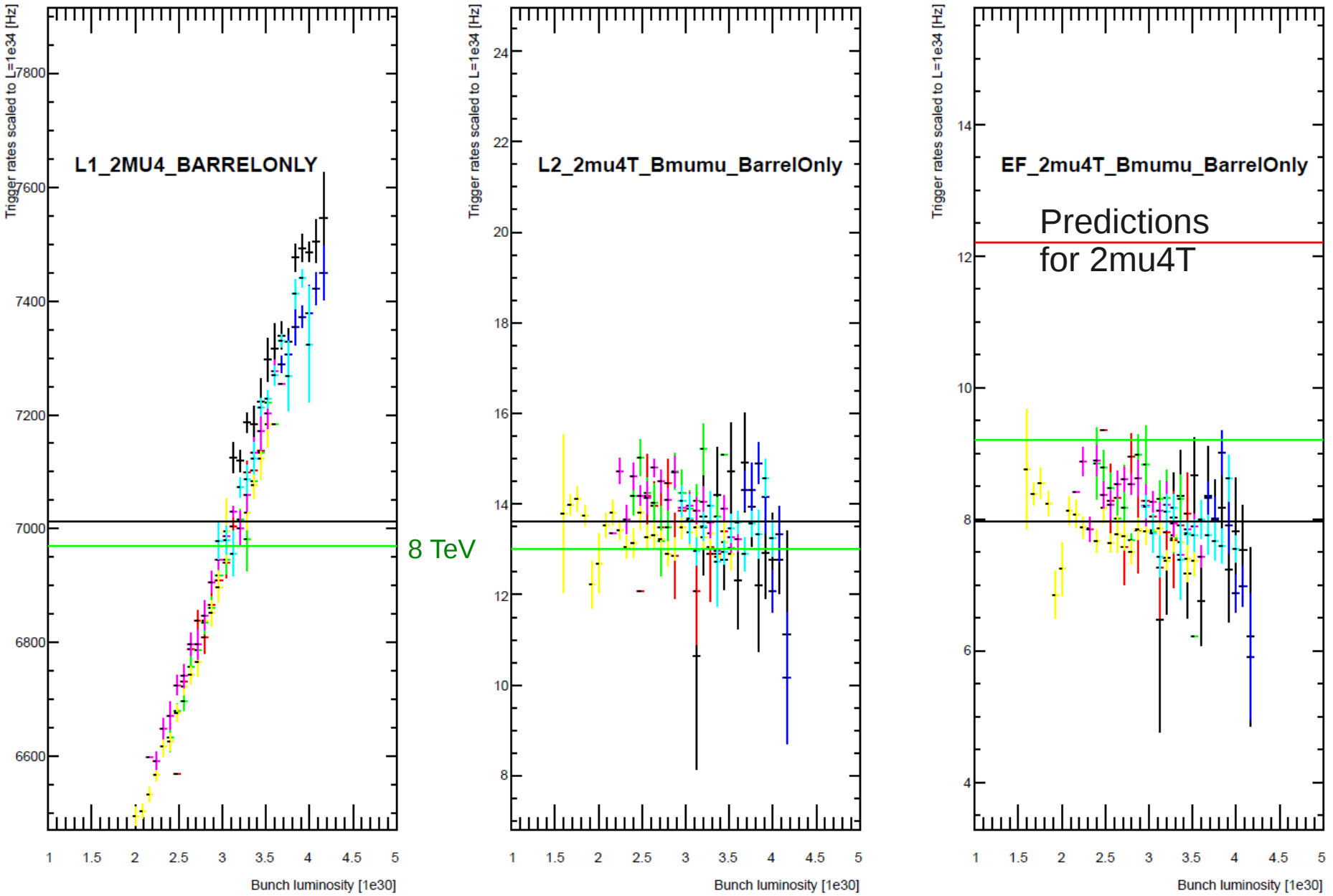
Trigger scenario	Yield relative to 2mu4	
2mu6	12%	14%
mu4mu6_muB	34%	31%
2mu4_notendcap	41%	38%
2mu4B	71%	65%
mu4mu6	51%	50%
2mu4	100%	100%

Trigger scenario	Yield relative to 2mu4	
2mu6	17%	17%
mu4mu6_muB	35%	39%
2mu4_notendcap	43%	44%
2mu4B	67%	64%
mu4mu6	56%	58%
2mu4	100%	100%

Yields seen in data: ↑↑ ↑↑ ↑↑
(very preliminary, run 200926, LB 401-408)

EF_2mu4T_Bmumu_BarrelOnly

Data 2012



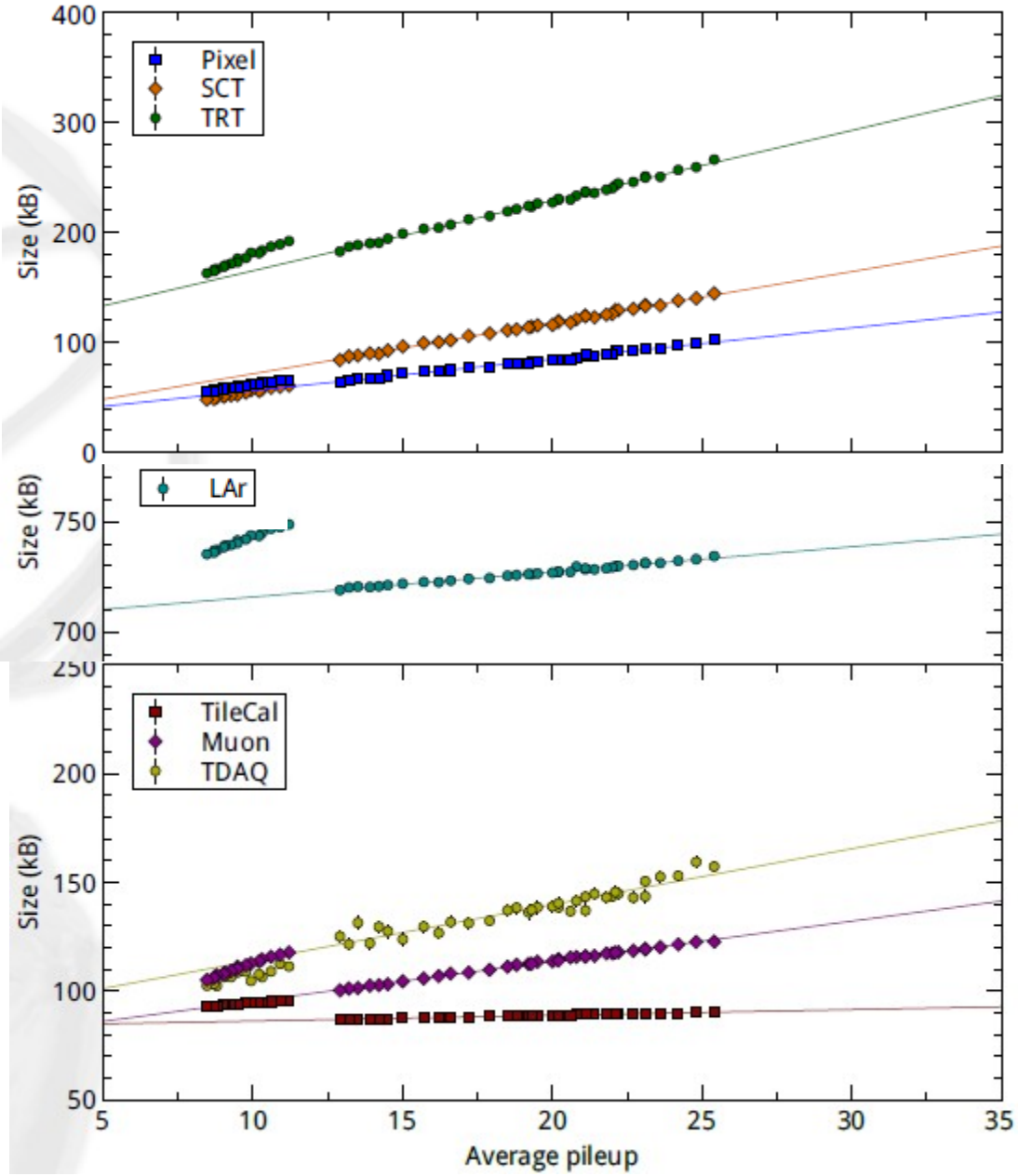
Conclusions

- All trigger signatures went through various optimizations to deal with pileup, driven by rates and physics needs
- Many improvements for 2012:
  - HLT Bjets, hadr. jet calib., L2 MET, improved egamma/tau IDs, ...
- Trigger is now running at 8 TeV and at pileup up to ~27
- Change to 8 TeV mostly affected high-p_T triggers and rate increases from this overall are within the 20% safety
- Multi-jet and missing ET triggers strongly affected by pile-up
  - For missing ET, dropping first bunches seem to be solution
    - Have to look at combined triggers as well
  - L1_4J15 maybe ok, but could use EMEC noise cuts in L1Calo
- Most signatures signed-off by signature coordinators
  - Tau and jets sign-off still ongoing
- Expect to remove commissioning items for steps up to $5x10^{33}$

Spares

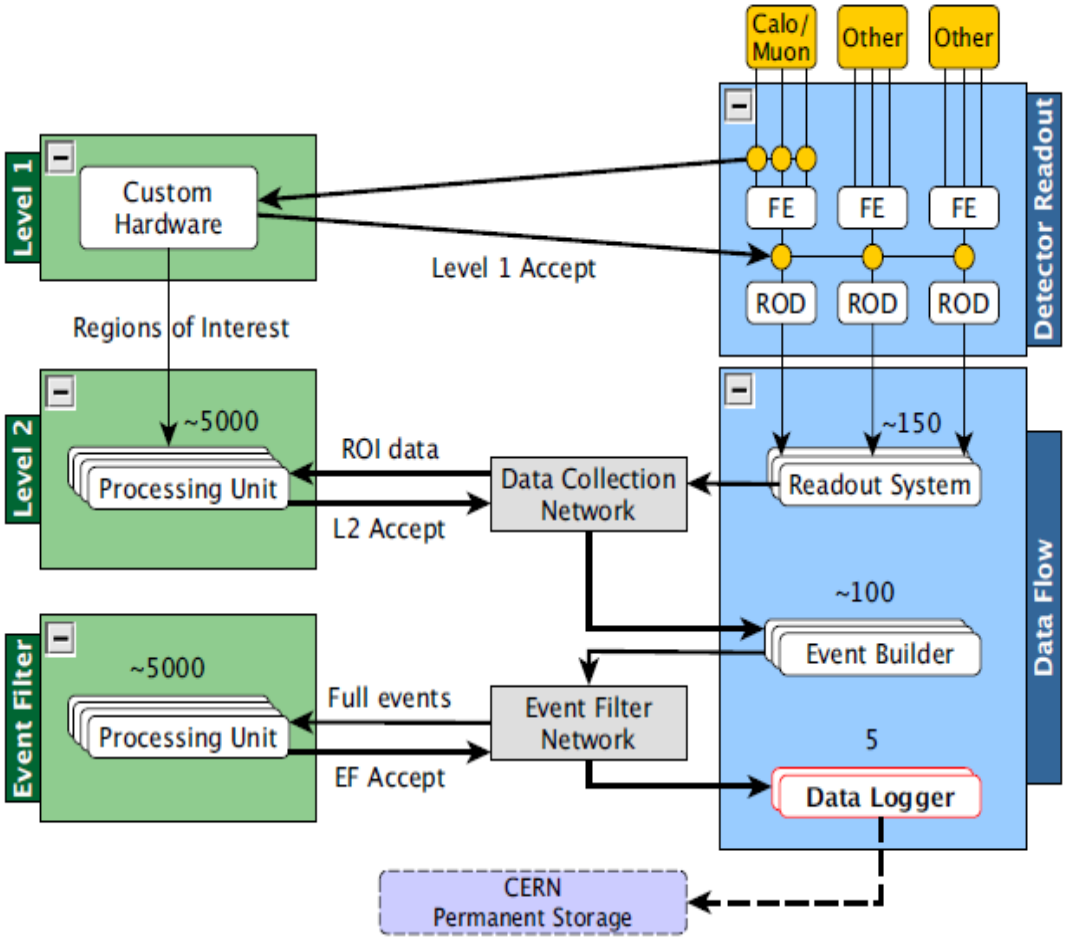
Sub-detector fragment size

- Data:
  - 2011: run 191715
  - 2012: runs 201052, 201113
  - JetTauEtmiss stream ("fattest" stream)
- All sub-detectors have reduced their fragment sizes wrt. 2011 except SCT
- But pile-up increases the sizes significantly
  - At mu~35, event size = 1.8 MB (JetTauEtmiss stream)



TDAQ rate limits

- L1 limited to about 65-70 kHz
- ROS rolling refurbishment
  - Max L2 requests 22 ↔ 40 kHz
- HLT
  - 12 new racks, total ~ 20k cores
  - Max L2 avg: ~ 50 ms
  - Max EF avg: ~ 1 s
  - MET@L2
  - L1.5 jet
- Event Builder
  - EB bandwidth: ~ 5 kHz
- Event logger
  - Limited to 400 Hz (avg) by T0 and offline resources
  - SFO rewritten to support compression

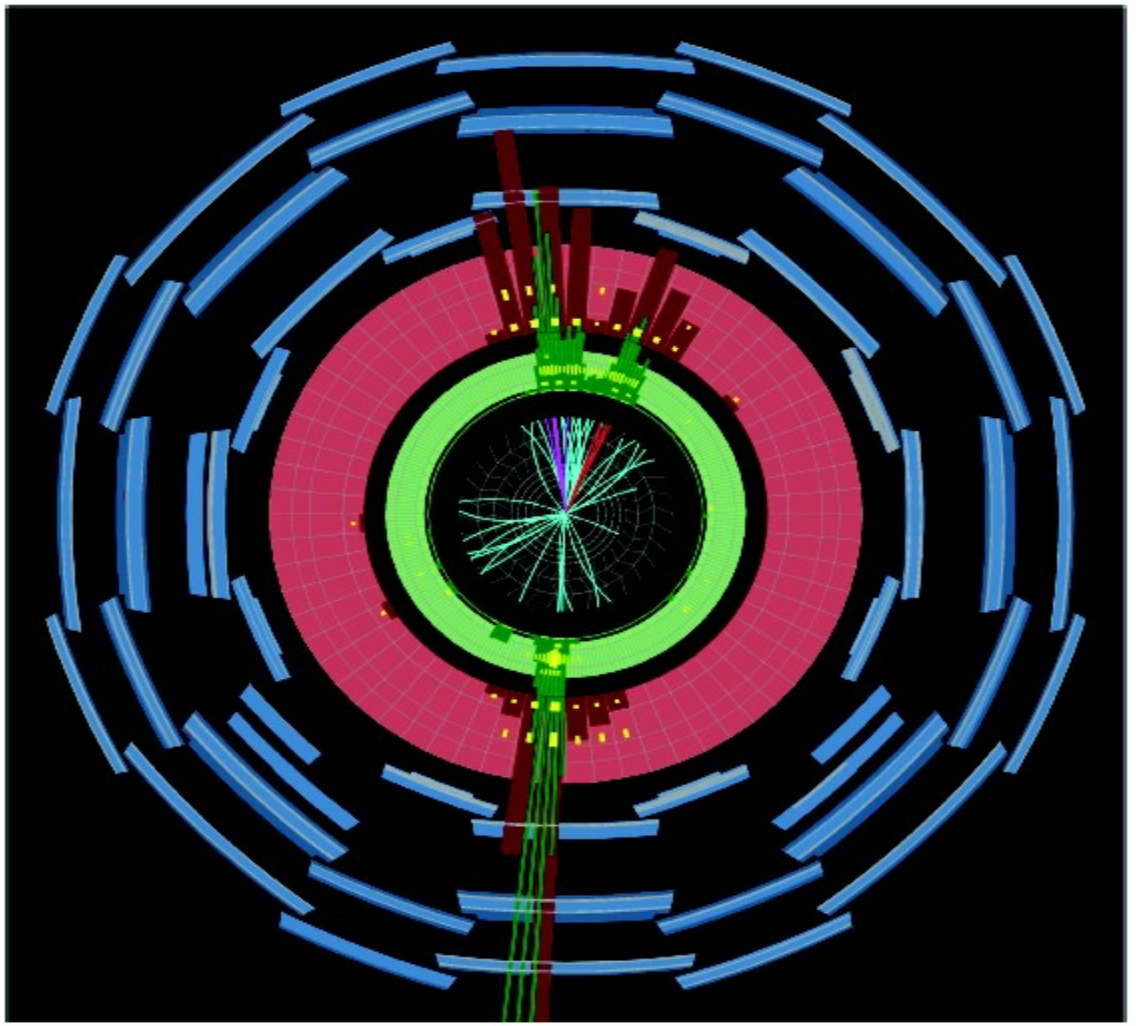


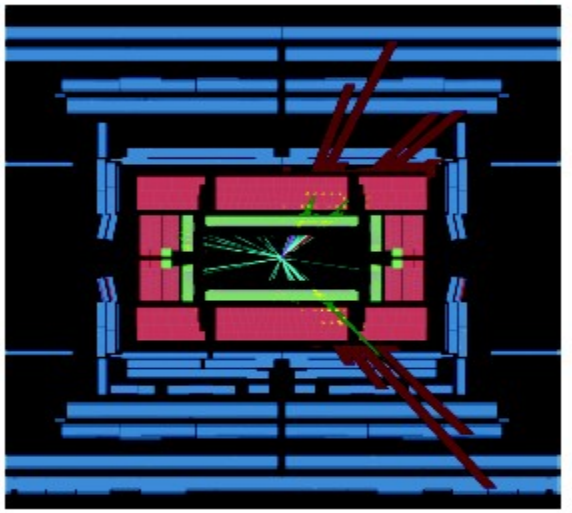
REMINDER OF 2011 PRIMARIES

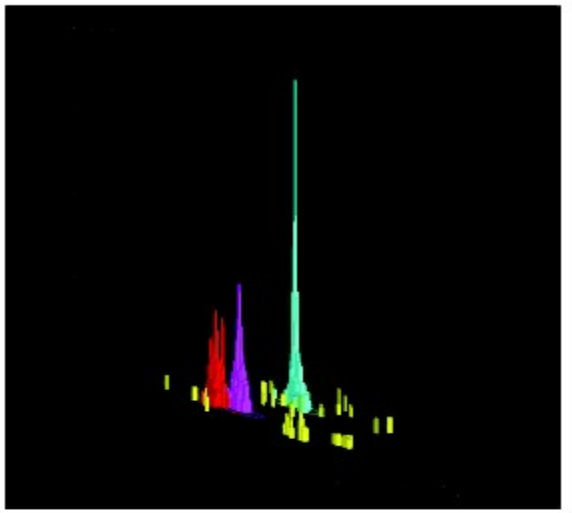
- The 2011 primaries are much too high for 2012
  - In many cases for 2012 must both increase threshold and tighten

Primary	Type	Would be 2012 Rate
e22vh_medium1	Single Electron	200 Hz
2e12Tvh_medium	Di-electron	4 Hz
mu18_medium	Single Muon	400 Hz
2mu10_loose	Di-Muon	25 Hz
2g20_loose	Di-photon	25 Hz
tau125_medium1	Single Tau	10 Hz
j240_a10tc_EFFS	Single Jet	25 Hz
5j30_a4tc_EFFS	MultiJet	35 Hz
mu4Tmu6_DiMu	BPhysics	120 Hz
xe60_verytight_noMu	MET	27 Hz
b10_medium_4j30_a4tc_EFFS	BJet	45 Hz

Boosted Z→bb Candidate Event







- Event topology: 3 high pt jets: 1 that balances the Z and two b-jets from the Z decay
  - Use jet pt thresholds for 3 jets and look for 2 b-tagged jets in event

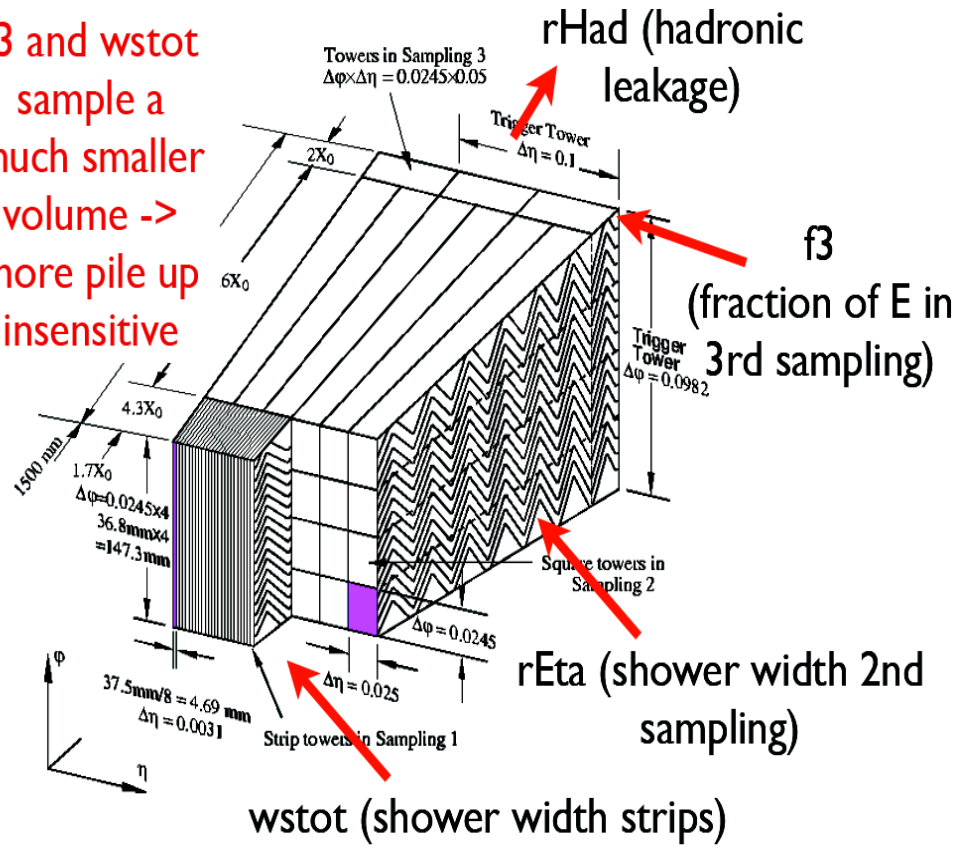
Signature coordinators

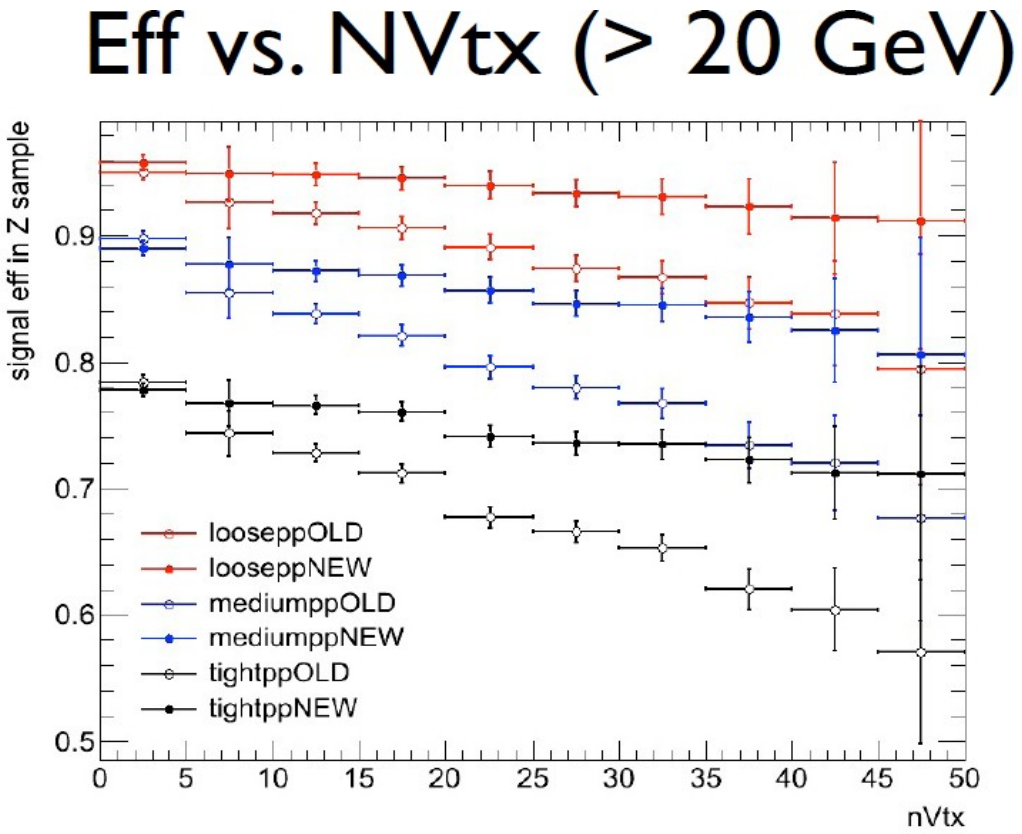
- **egamma** Alessandro Tricoli (CERN), Paul Bell (Geneva)
- **muon** Kunihiro Nagano (KEK), Kevin Black (BU)
- **tau** Soshi Tsuno (KEK), Phillip Urquijo (Bonn)
- **jet** Michael Begel (BNL), Mario Campanelli (UCL)
- **MET** Allen Mincer (NYU), Florian Bernlochner (Victoria)
- **Bphysics** Julie Kirk (RAL), Pavel Reznicek (LMU)
- **b-jets** Lorenzo Feligioni (Marseille), Carlo Schiavi (Genoa)
- **MinBias** Antonio Sidoti (Roma I)

PID for electrons

- re-optimize menu by loosening pile-up sensitive (Reta, Rhad) variables and adding/tightening correlated pile-up robust variables (f3, wstot)
- f3 loses efficiency at higher Et due to leakage
  online solution: e24vhi_medium1 | e45vh_medium1 (no iso, f3)

f3 and wstot sample a much smaller volume -> more pile up insensitive





Tau and b-jets rates

Tau:	L1 Item	L1 (Hz)	L2 (Hz)	EF rate (avg)	EF unique
tau125_medium1	TAU40	5500	30	0.7	1
tau20_medium1_mu15	TAU8_MU10	3500	90	12	10
tau20Ti_medium1_e18vh_medium1	2TAU11I_EM14VH	7000	200	6	5
tau38T_medium1_e18vh_medium1	2TAU11_TAU20_EM14VH	8500	67	2.8	?
tau29Ti_tight_tau20Ti_tight_bdt	2TAU11I_TAU15	14000	450	12	12
2tau38T_medium1	2TAU20	6400	37	3	?
tau29Ti_medium1_xe45_tight	TAU15I_XE40	1000	55	2.5	
tau38T_medium1_xe45_tight (+)	TAU20_XE40	1300	62	2.5	

b-jet chain	L1 Item	L1 (Hz)	L2 (Hz)	EF rate (avg)	EF unique
muon+jets (b-tag calibration)		50	20	7	7
b55_medium_4j55_a4tchad	4J15	1000	15	5	3
2b35_medium_3j35_a4tchad_4L1J15	4J15	1000	5	2	2
2b35_loose_4j35_a4tchad (+)	4J15		5?	2?	0?
2b35_loose_j145_2j35_a4tchad	J75	1900	?	4?	2
2b55_loose_j145_j55_a4tchad	J75	1900	14	2	0
b80_loose_j80_a4tchad_xe75_tclcw	J30_XE50	2000	50	1?	0.5
b110_loose_j110_a4tchad_xe60_tclcw (+)	J50_XE40	1100	40	1	1
b145_mediumEF_j145_a4tchad_L2EFxe60_tclcw(+)	J75	1900	170	1.5	0

Streams

Stream rates	EF rate (target rate) Hz
Egamma stream	150 (135)
Muon stream	125 (125)
JetTauEtmiss stream	120 (120)
Minimum Bias stream	5 (5)
Express stream	10 (10)
Calibration streams	
Total	410 (~400)