Trigger For SUSY in ATLAS and CMS

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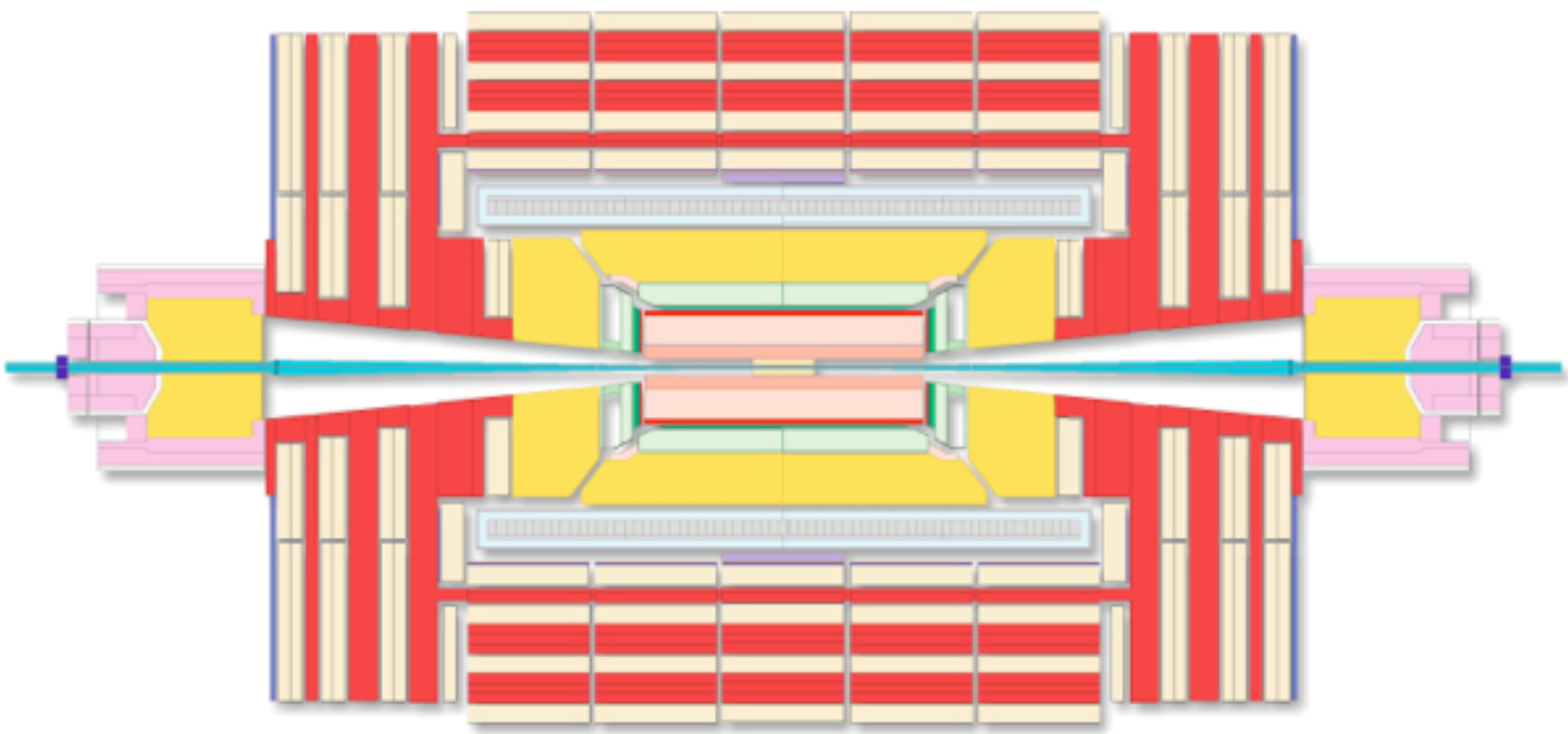
What is a Trigger ?

The Trigger is a Function of

T() = Accept / Reject

Event data and Apparatus
Physics channel and Parameters

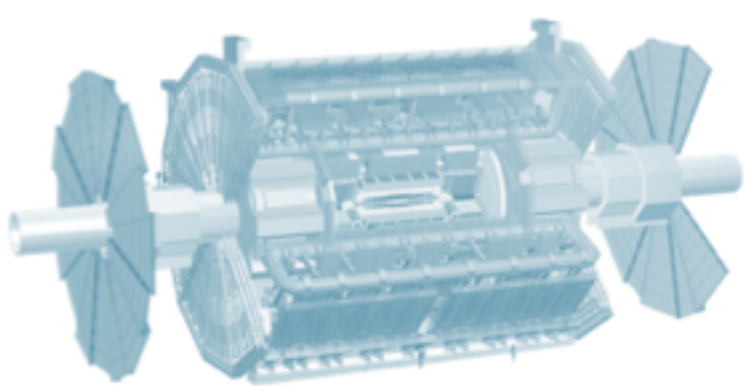
Look at (almost) all bunch crossings, select most interesting one, collect all detector information and store it for offline analysis (do this for a reasonable amount of money)

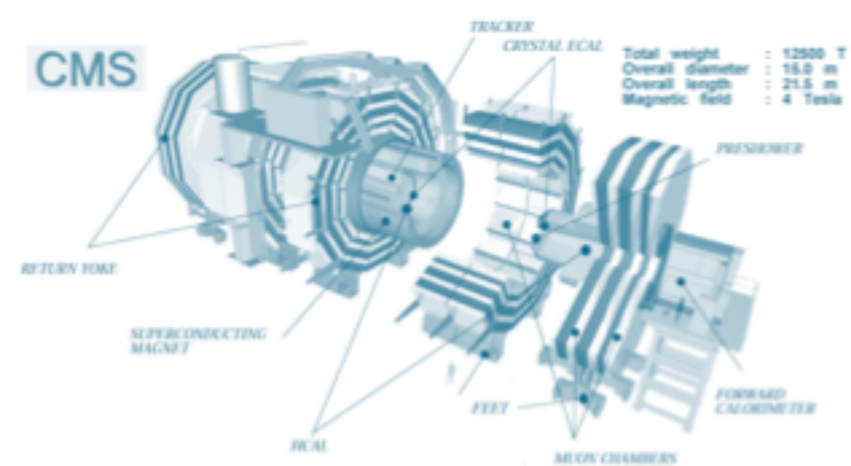
ATLAS and CMS Trigger Constraints

Online rate reduction to manageable level for data recording & offline analysis

- $L = 10^{34}\ cm^{-2}s^{-1}$ has 1 GHz interaction rate ("interesting" rate O(300 Hz))
- The size of the RAW events is very large, O(1 MB)
- Huge number of detector channels, high multiplicity of events
- Recording and processing offline, O(400) Hz event rate with 10 s reconstruction time per event → 3000 CPUs to keep up
- Hence, only a tiny fraction $O(10^{-7})$ of proton-proton collisions can be selected

Must balance needs of maximizing coverage for a very diverse physics programme and reaching acceptable (i.e. affordable) recording rates

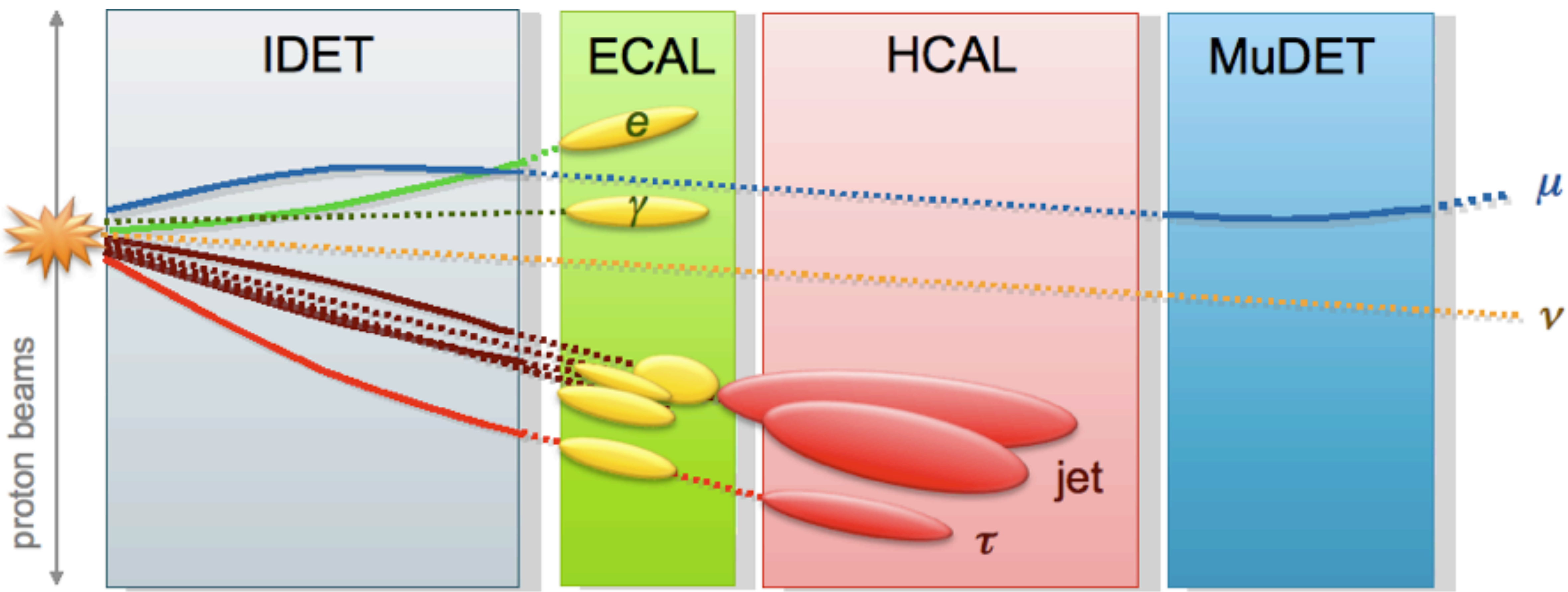




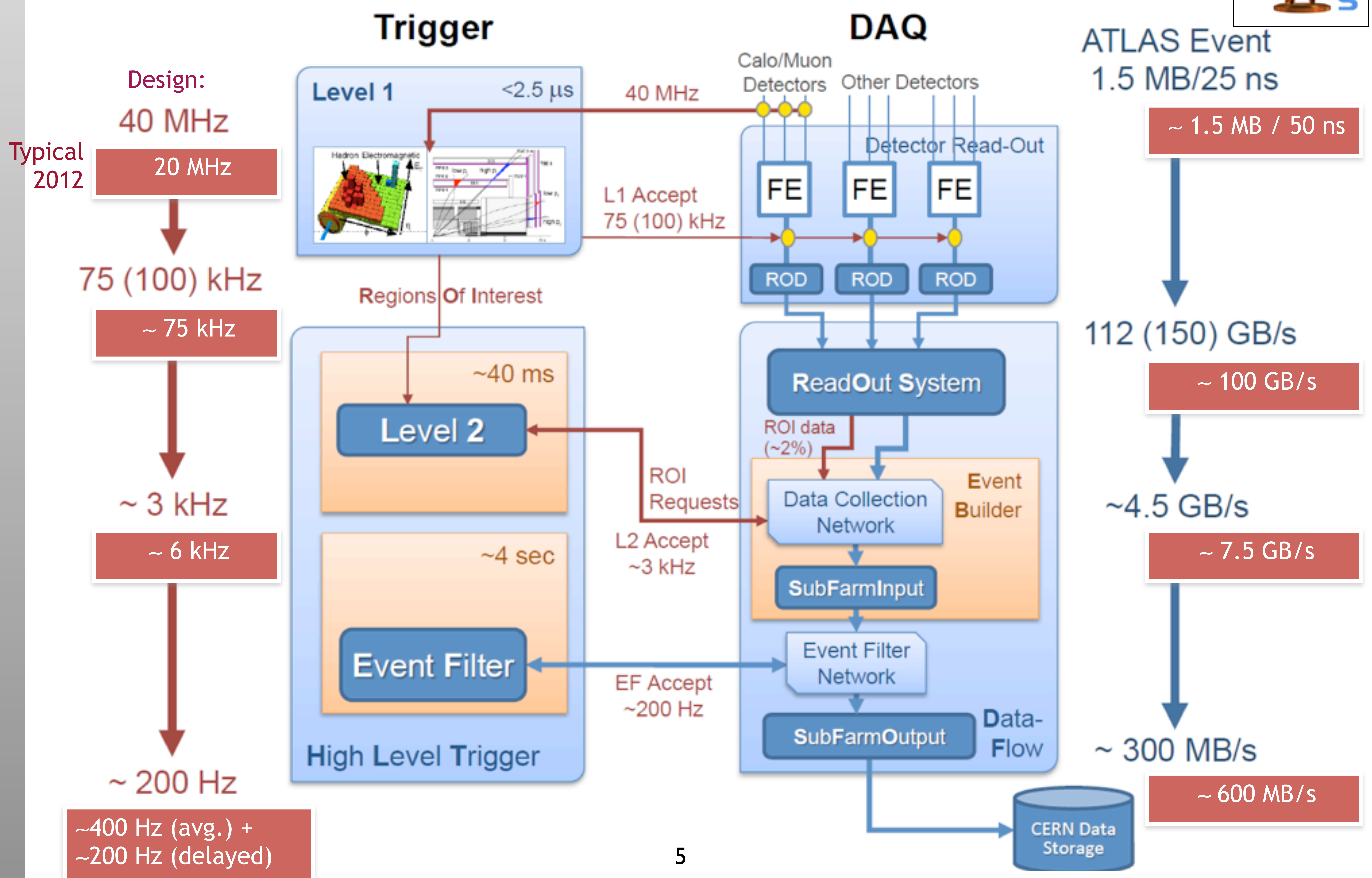
Trigger Signatures

Features distinguishing new physics from the bulk of the SM cross-section

- Presence of high-p_T objects from decays of heavy particles (min. bias $\langle p_T \rangle$ ~ 0.6 GeV)
- More specifically, the presence of isolated high-p_T leptons or photons
- The presence of known heavy particles (W, Z)
- Missing transverse energy (either from high-p_T neutrinos, or from new invisible particles)

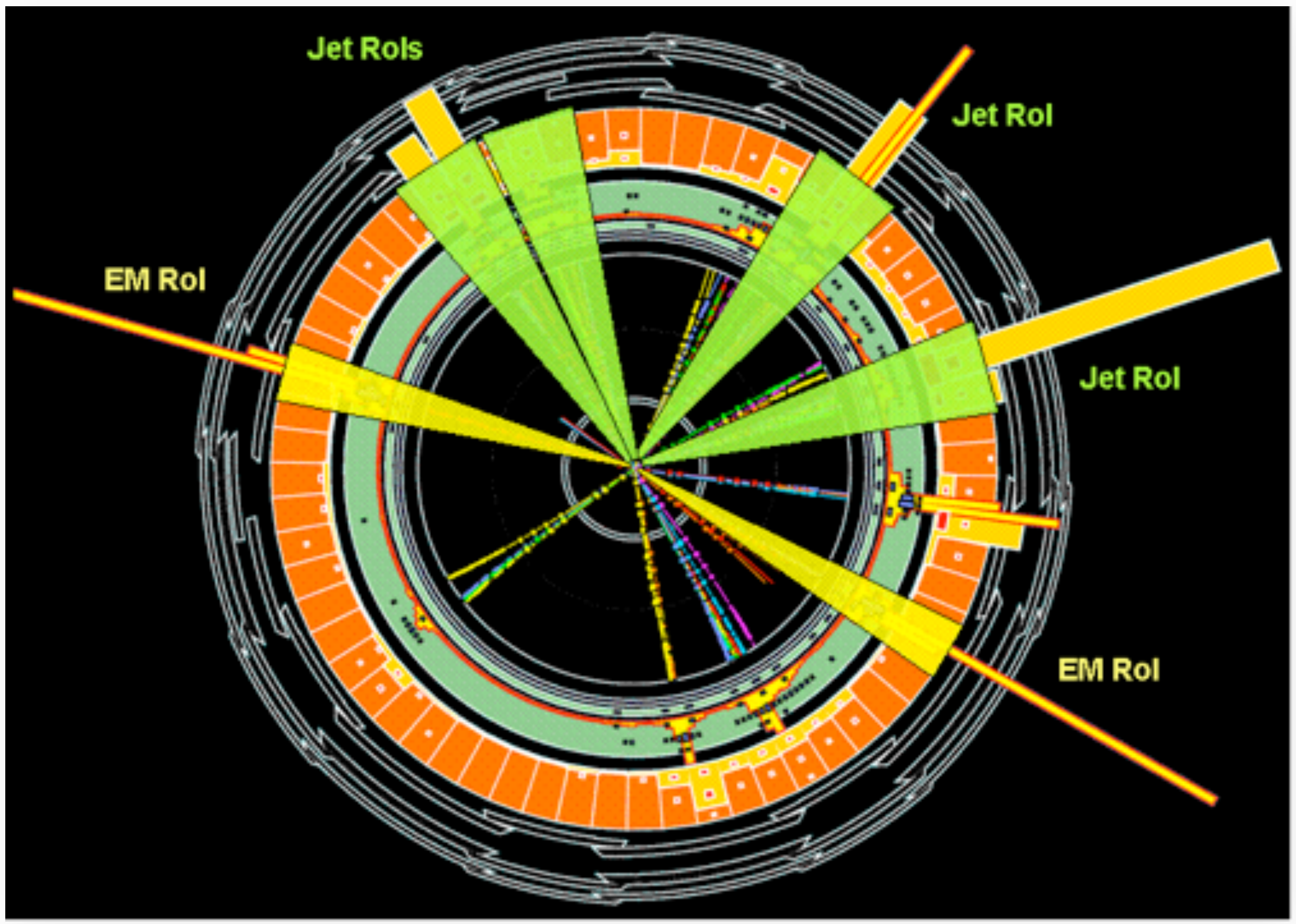


ATLAS Trigger and DAQ System



ATLAS Trigger and DAQ System

Three level trigger system mostly based on Region-of-Interest (RoI) concept



Nomenclature:

Chain: one full L1 ® EF selection sequence

Menu: full set of chains and prescale factors

→ Typical menu has ~500 chains

Level-1 [20 MHz ® ~75 kHz_{peak}]

- Fast, custom-build electronics finds and defines RoIs
- Muon and Calorimeters only
- Coarse resolution
- Triggers readout from FE electronics

Level-2 [65 kHz ® ~6 kHz_{peak}]

- Dedicated, fast software algorithms
- Works on full-granularity RoI data (for leptons), enlarged RoI for jets, cell-based MET sum

Event Filter

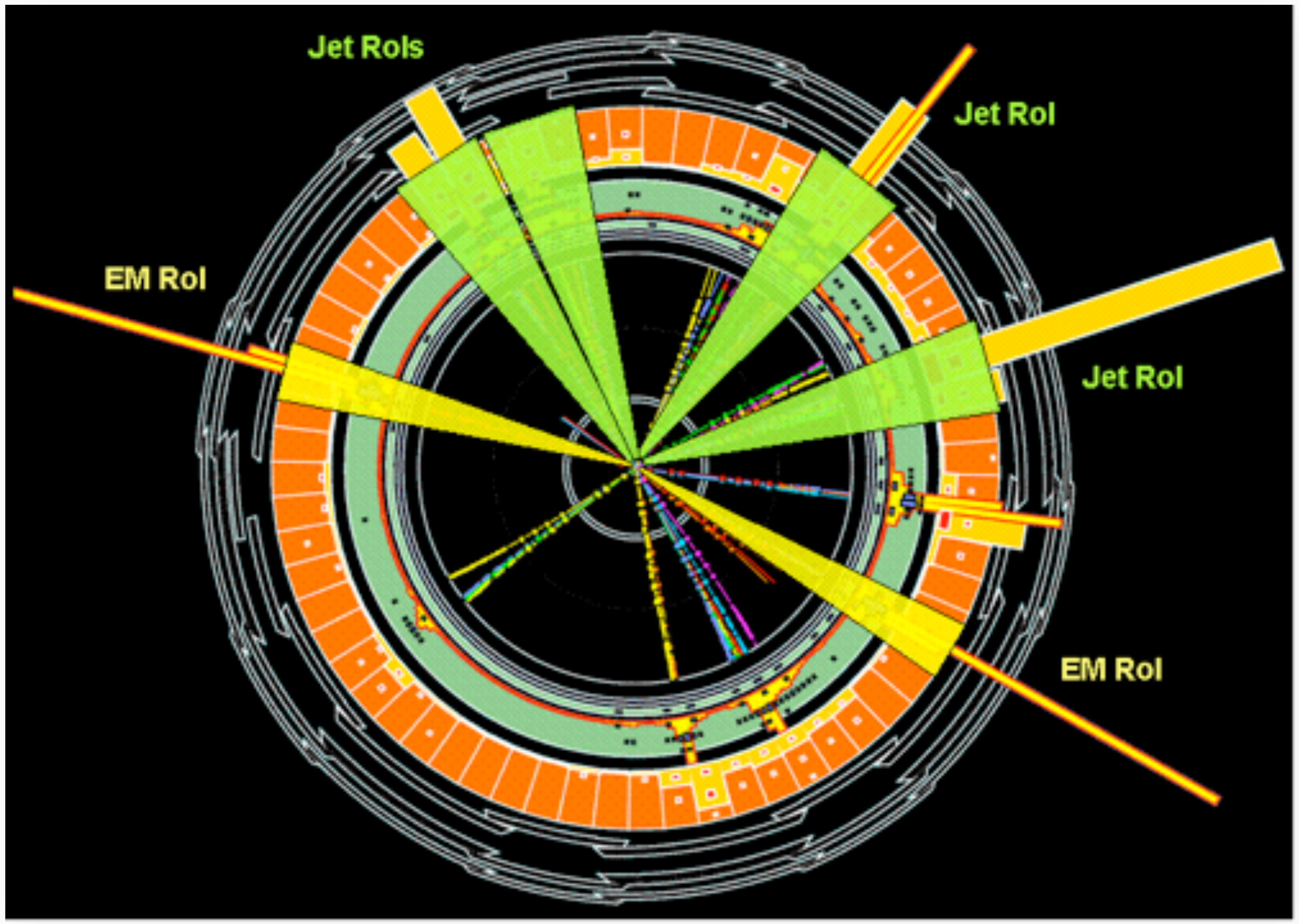
[5.5 kHz ® ~1 kHz_{peak}, 400 Hz_{ave}, 200 Hz_{delay}]

- Software reused from offline
- Full event information available, but partly still RoI based

Events written out in streams based on trigger decision, followed by express stream reconstruction, calibration, offline reconstruction, and data distribution

ATLAS Level-1 Signatures

Short 2.5μs latency of L1 does not allow track reconstruction



High-p_T muons

- Identified beyond calorimeters; need p_T cut to control rate from $\pi^+/K^+ \rightarrow \mu\nu$ and b/c $\rightarrow \mu\nu$

High-p_T photons & electrons

- Identified as narrow EM calorimeter clusters; need cut on ET; cuts on isolation and hadronic-energy veto reduce rates from high-p_T jets

High-p_T taus (decaying to hadrons)

- Identified as narrow cluster in EM+hadronic calorimeters

High-p_T jets

- Identified as local cluster in EM & hadronic calorimeter — need to cut at very high p_T to control rate (jets are dominant high-pT process)

Large missing E_T or E_T sum

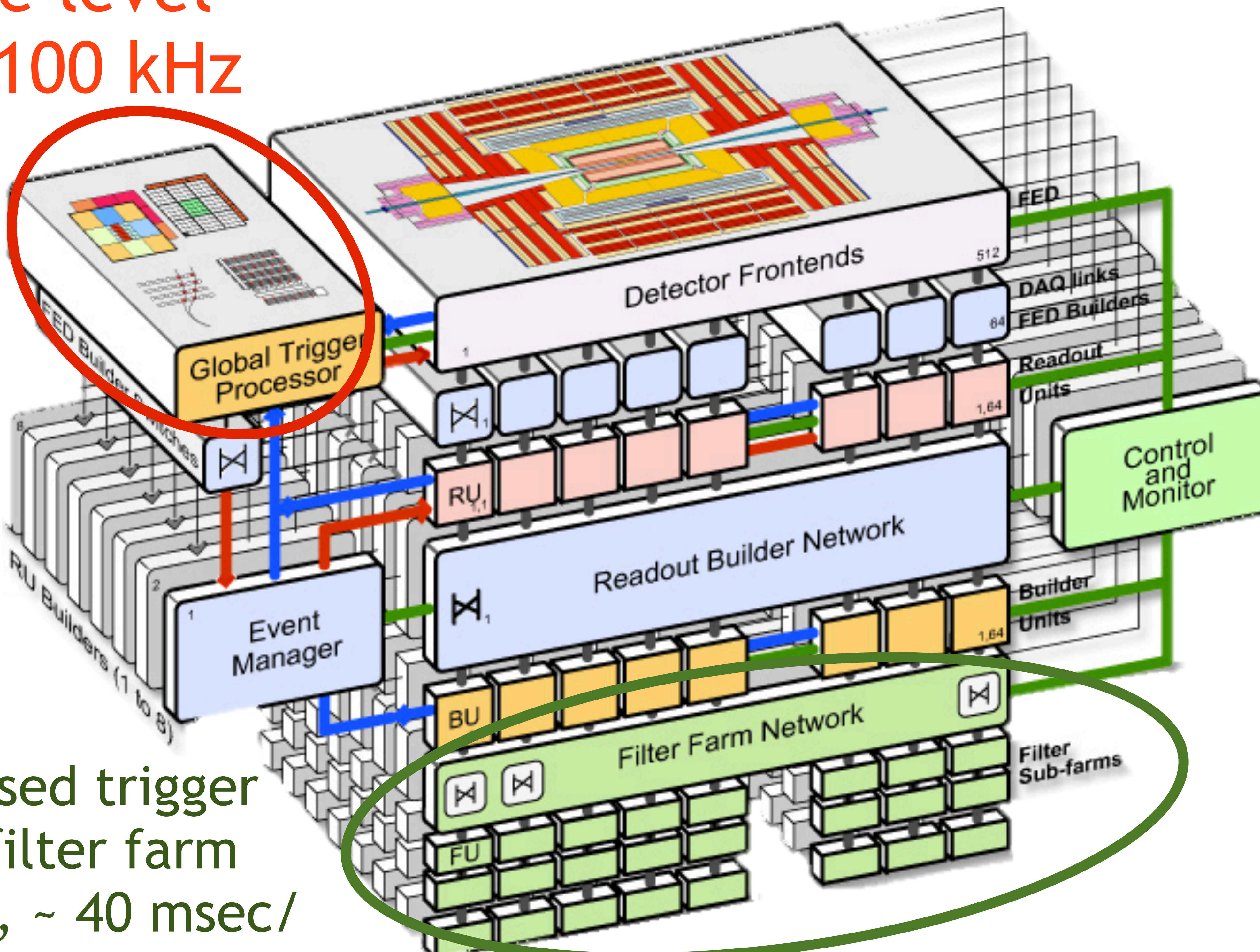
- Identified beyond calorimeters; need p_T cut to control rate from π^+/K^+ ® $\mu\nu$ and b/c ® $\mu\nu$

ATLAS main triggers in 2012 — rates

Signature	Offline selection	Trigger selection L1	Trigger selection EF	L1 Peak (kHz) L_{peak}= 7x10^{33}	EF Ave (Hz) L_{ave}= 5x10^{33}
Single leptons	Single muon p_T > 25 GeV	15 GeV	24 GeV	8	45
	Single electron p_T > 25 GeV	18 GeV	24 GeV	17	70
Two leptons	2 muons p_T >15	2x10 GeV	2 x 13 GeV	1	5
	2 muons p_T > 20,10 GeV	15 GeV	18,8 GeV	8	8
	2 electrons, each p_T > 15 GeV	2x10 GeV	2x12 GeV	6	8
	2 taus p_T > 45, 30GeV	15,11 GeV	29,20 GeV	12	12
Two photons	2 photons, each p_T > 25 GeV	2 x10 GeV	2 x 20 GeV	6	10
	2 loose photons, p_T > 40,30 GeV	12,16 GeV	35, 25 GeV	6	7
Single jet	Jet p_T > 360 GeV	75 GeV	360 GeV	2	5
MET	MET > 120 GeV	40 GeV	80 GeV	2	17
Multi-jets	4 jets, each p_T > 85 GeV 5 jets, each p_T > 60 GeV	4x15 GeV	4x80 GeV 5x55 GeV	1	8
b-jets	*b* + 3 other jets p_T > 50 GeV	4x15 GeV	4x45 GeV+btag	1	4
TOTAL				**< 75**	**~ 400 (ave)**

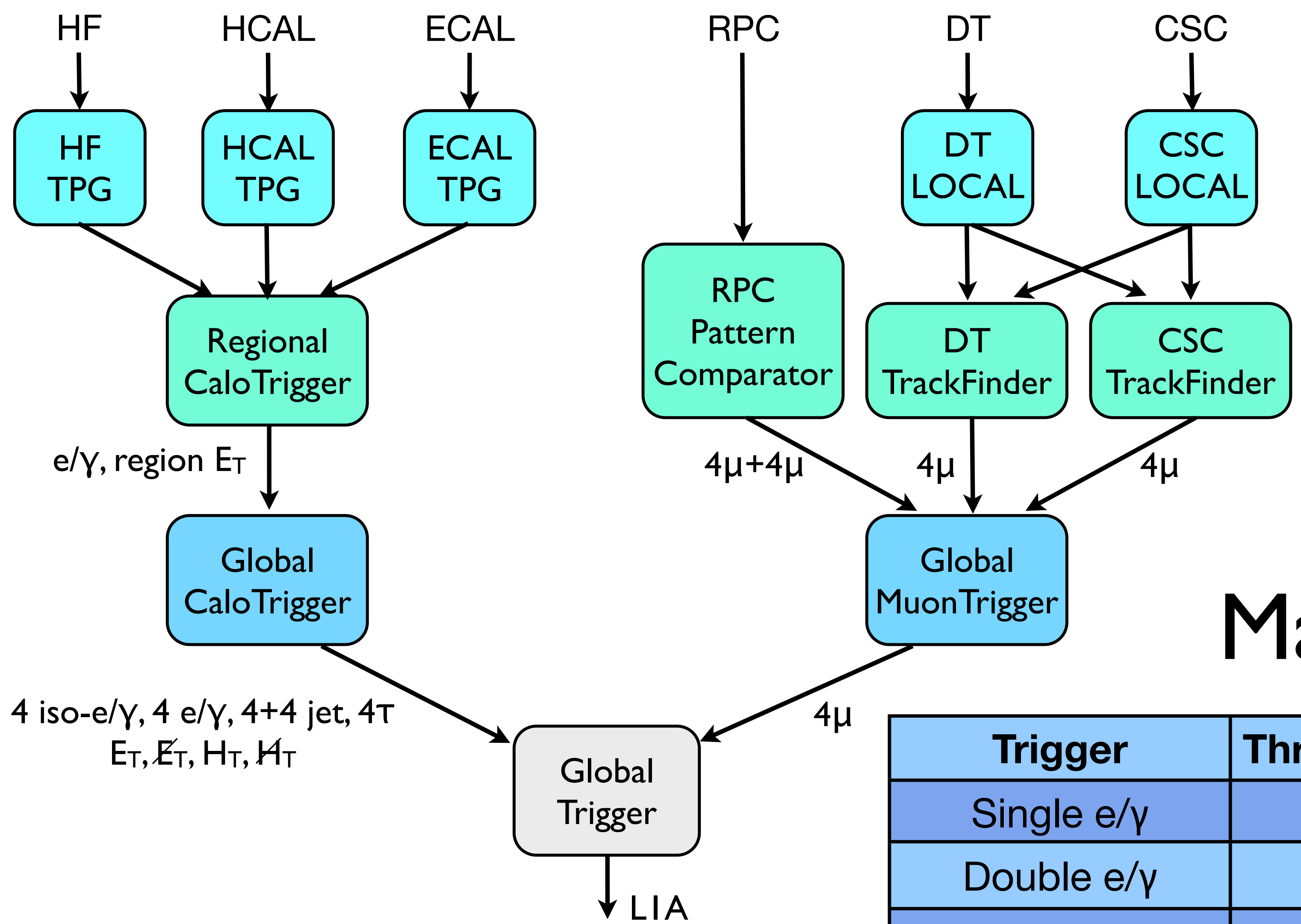
CMS Trigger & DAQ System

L1: hardware level triggering @ 100 kHz



HLT: software-based trigger integrated in a filter farm
Take data at 1k Hz, ~ 40 msec/ event

CMS L1 Trigger



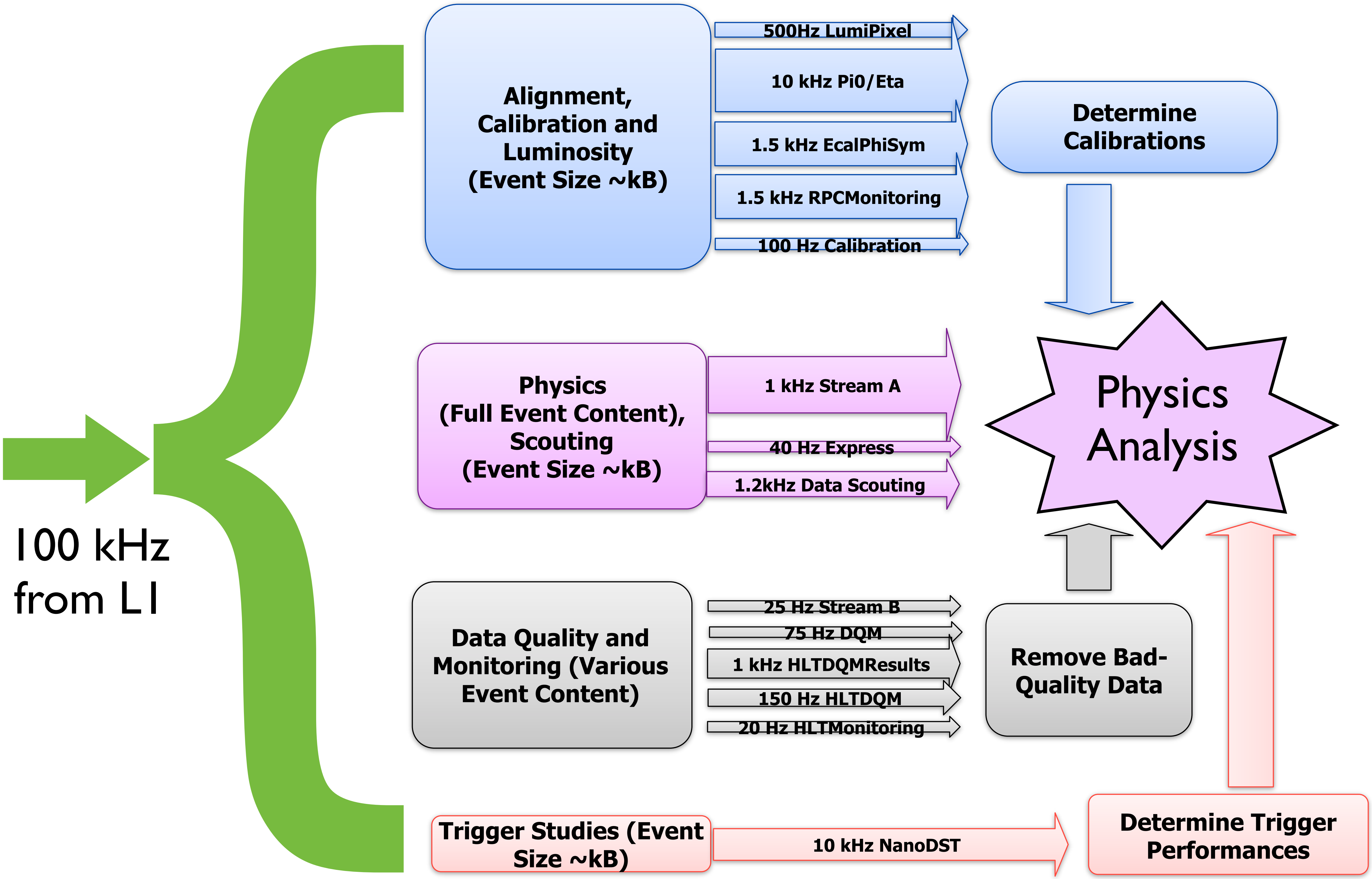
Main Triggers for 2012

Trigger	Threshold (GeV)	Rate (kHz)	Physics
Single e/γ	20	13	Higgs, SM, EXO
Double e/γ	13,7	8	Higgs, SM, SUSY, EXO
Single μ	14 ($\lvert\eta\rvert<2.1$)	7	Higgs, SM, SUSY, EXO
Double μ	10, 0	6	Higgs, SM, EXO
e/γ + μ	12, 3.5	3	SM, SUSY, EXO
μ + e/γ	12, 7	1.5	SM, SUSY, EXO
Single Jet	128	1.5	SM, EXO
Quad Jet	36	3.5	SM, SUSY, EXO
H_T	150	5	SUSY, EXO
E_T^{miss}	36	8	SUSY, EXO

CMS Main Triggers

(Unprescaled) Object	Trigger Threshold (GeV)	Rate (Hz)	Physics
Single Muon	40	21	Searches
Single Isolated muon	24	43	Standard Model
Double muon	(17, 8) [13, 8 for parked data]	20 [30]	Standard Model / Higgs
Single Electron	80	8	Searches
Single Isolated Electron	27	59	Standard Model
Double Electron	(17, 8)	8	Standard Model / Higgs
Single Photon	150	5	Searches
Double Photon	(36, 22)	7	Higgs
Muon + Ele x-trigger	(17, 8), (5, 5, 8), (8, 8, 8)	3	Standard Model / Higgs
Single PFJet	320	9	Standard Model
QuadJet	80 [50 for parked data]	8[100]	Standard Model /Searches
Six Jet	(6 x 45), (4 x 60, 2 x 20)	3	Searches
MET	120	4	Searches
HT	750	6	Searches

CMS HLT


100 kHz from L1
Alignment, Calibration and Luminosity (Event Size ~kB)
500Hz LumiPixel
10 kHz Pi0/Eta
1.5 kHz EcalPhiSym
1.5 kHz RPCMonitoring
100 Hz Calibration
Determine Calibrations
Physics (Full Event Content), Scouting (Event Size ~kB)
1 kHz Stream A
40 Hz Express
1.2kHz Data Scouting
Physics Analysis
Data Quality and Monitoring (Various Event Content)
25 Hz Stream B
75 Hz DQM
1 kHz HLTDQMResults
150 Hz HLTDQM
20 Hz HLTMonitoring
Remove Bad-Quality Data
Trigger Studies (Event Size ~kB)
10 kHz NanoDST
Determine Trigger Performances

Resources Allocation

Resource Allocation

Optimal distribution of available bandwidth is critical: driven by physics requirements and priorities; most bandwidth given to most generic triggers

Group	Peak L1 rate [kHz]	Peak L2 rate [kHz]	Average EF rate [Hz]
B-jets	5	0.9	45
B-physics	7	0.05	20
E/gamma	30	2	140
Jets	3	1	35
MET	4	0.8	30
Muon	14	1.2	100
Tau	24	0.8	35
Sum	**65**	**5.5**	**400**

(Unprescaled) Object	Rate (Hz)	Physics
Single/Double Muon	**65/25**	**SM/Higgs/SUSY/EXO/Top**
Muon+Had	**15**	**SUSY**
Single/Double Electron	**70/14**	**SM/Higgs/SUSY/EXO/Top**
Electron + Had	**15**	**SUSY**
Single/Double Photon	**15/35**	**SM/Higgs/SUSY**
Photon + Had	**12**	**SUSY**
Double Photon High PT	**10**	**EXO**
Bphysics+Onia	**40**	**Flavor**
Btag	**5**	**Btag POG**
MultiJet	**25**	**Top/SUSY/EXO**
HTMHT	**15**	**SUSY**
MET	**16**	**SUSY/EXO**
JetHT	**15**	**SUSY/EXO**
BJet	**25**	**Top/Exo**
SUM	**500 (1000)**	**600 (1200) Hz @ T0**

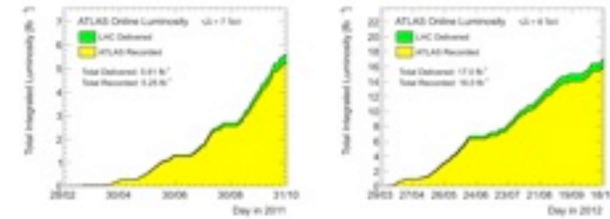
Which Kind Of Triggers

Optimal distribution of available bandwidth is critical: driven by physics requirements and priorities; most bandwidth given to most generic triggers

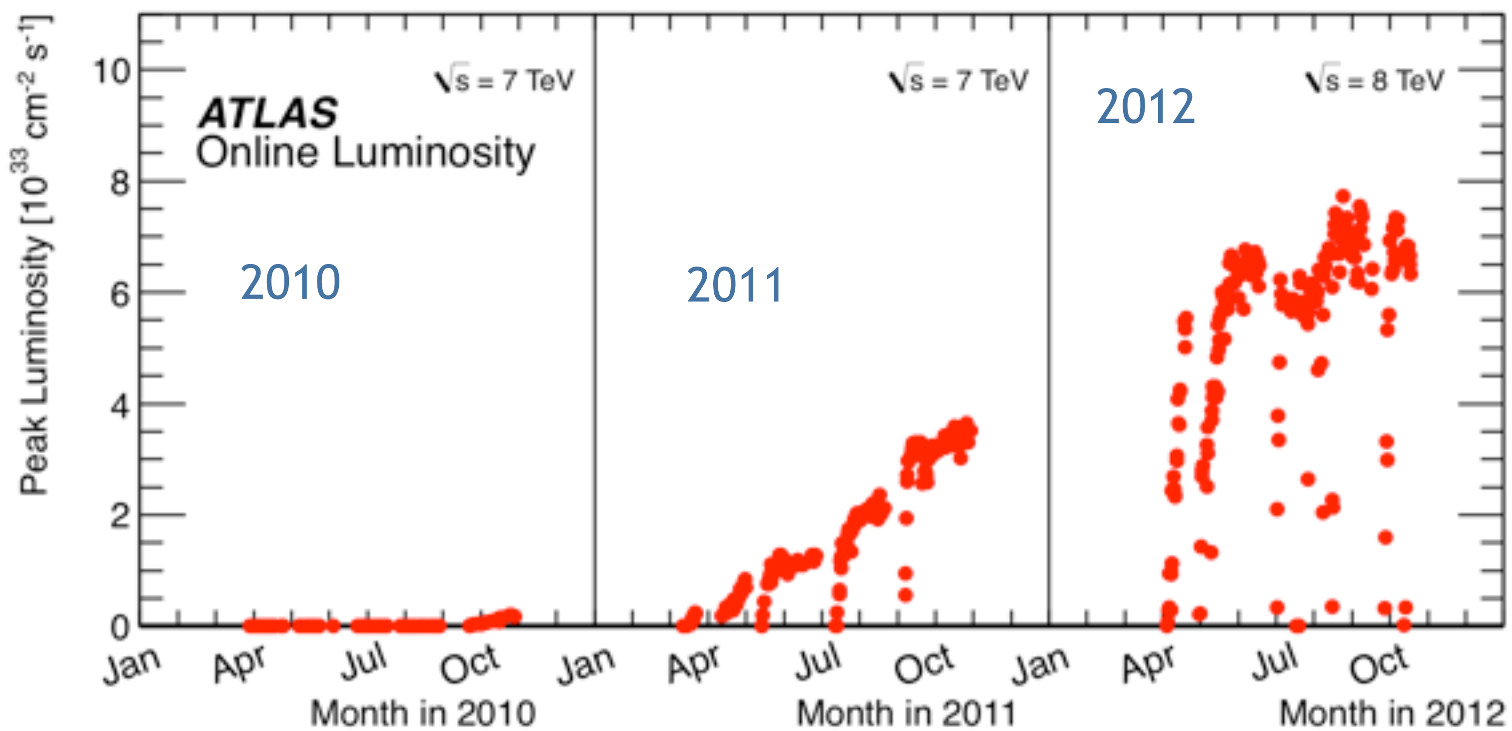
Triggers	Example	ATLAS	CMS
Single Leptons	e, mu	50 Hz each	65 Hz each
Generic Triggers	multijet, dimuon	5-15 Hz	5-25 Hz,
Specialized Triggers	long-lived, analysis specific (Razor, αT)	~1 Hz	1Hz-10Hz
Supporting Triggers	prescaled triggers for efficiency	20%	20-30%

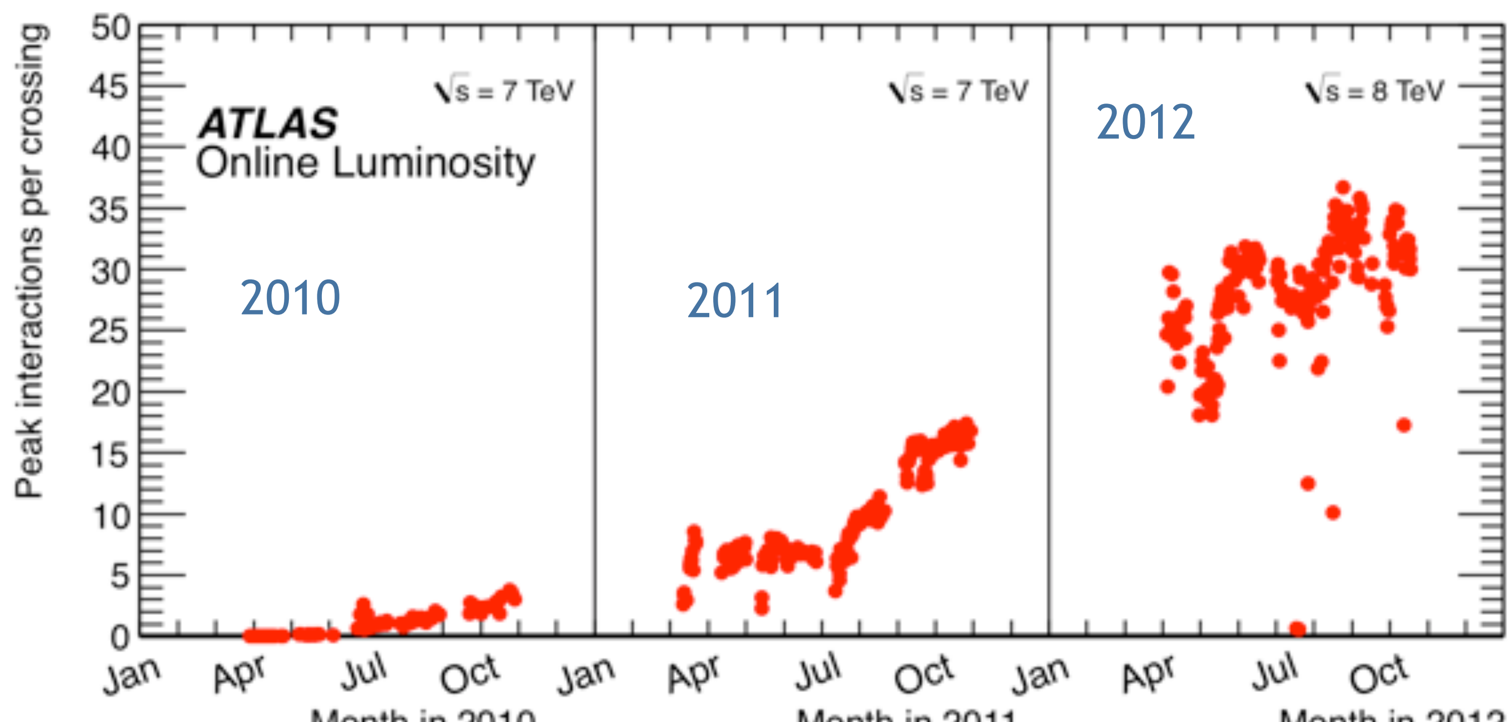
- Both the experiments use an inclusive approach for leptonic triggers
- ATLAS triggers more on generic single-object triggers (one trigger, many analyses)
- CMS gives more resources to analyses-dedicated triggers
- PROS & CONS: CMS can customize the trigger to the analyses, but this implies a big duplication of work (trigger design, efficiency measurements, etc) and sometimes conflicting requests

Luminosity Challenge



LHC had extremely successful luminosity ramp up



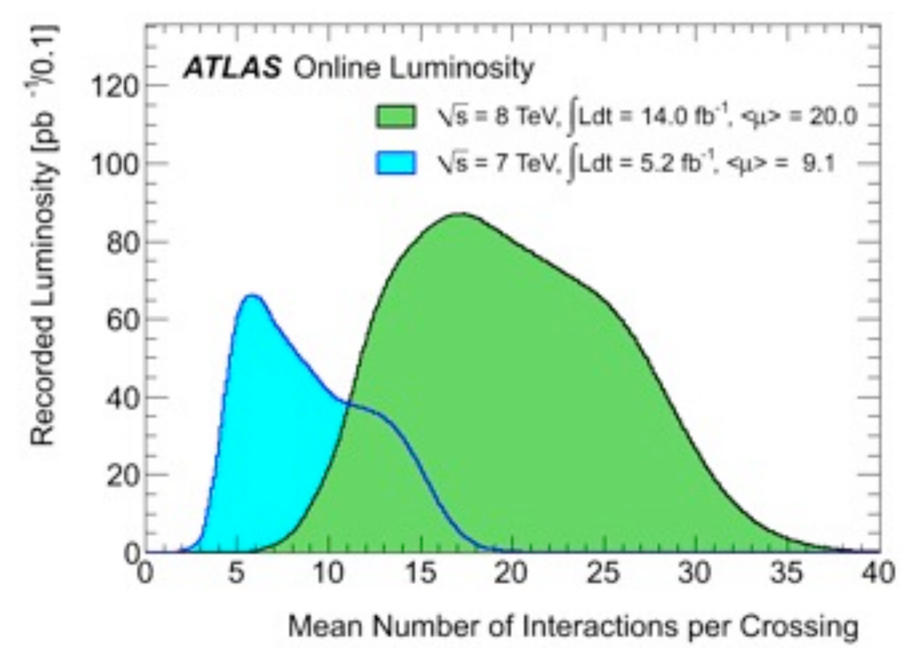


Rapid changes in trigger to follow six orders of magnitude changes in luminosity during first years

In 2012 luminosity increased mostly from more bunch luminosity

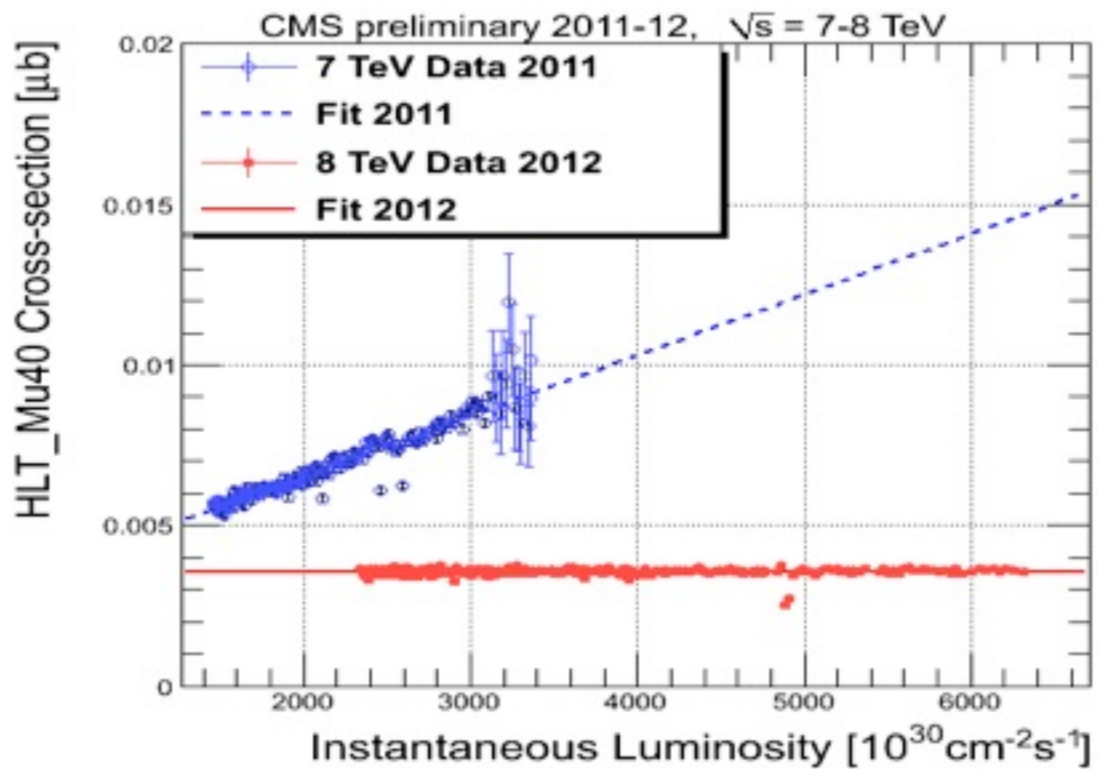
Challenge for trigger to keep efficiency and rejection stable in high pileup conditions

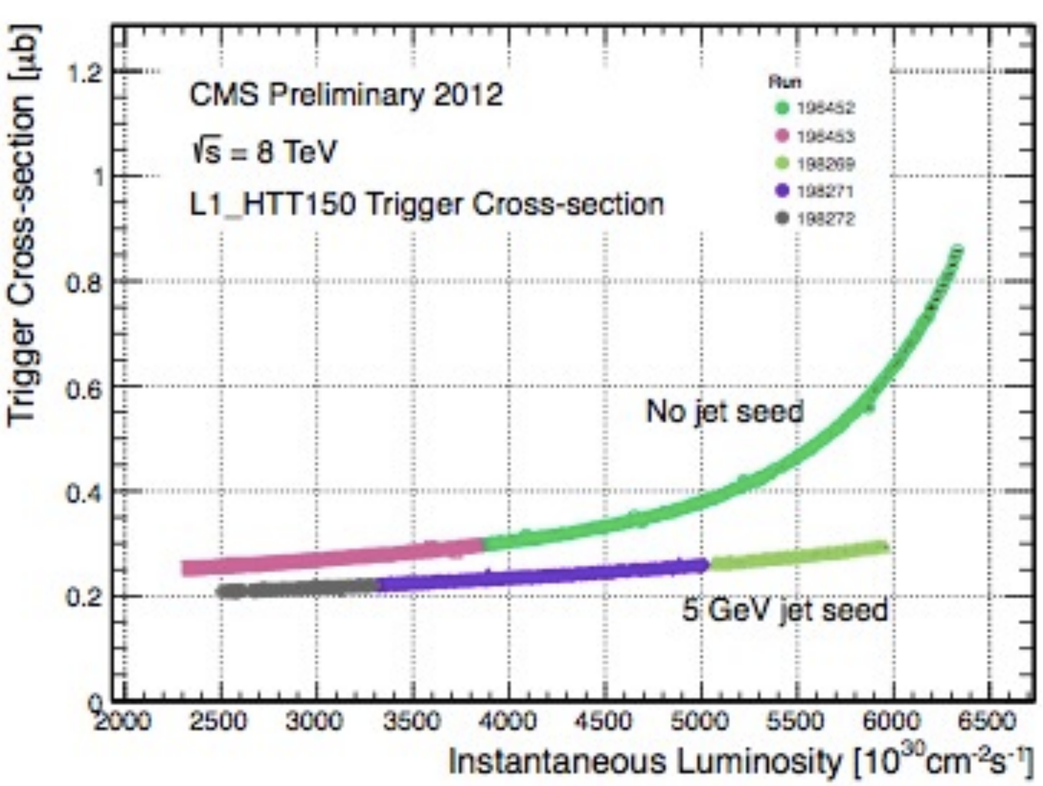
Frequent menu changes complicate physics analysis. For 2011-2012 ran with just 3 base menus for *pp* coll.



Luminosity Challenge

Sophisticated methods employed for software-based triggers (e.g. PF@HLT, FASTJET PU subtraction)
More problematic for hardware-based triggers (were one had to act on the thresholds and the seeds)
Whenever the L1 rate was kept under control, creative solutions allowed to stay as loose as for 2011, and sometimes to get looser by being smarter



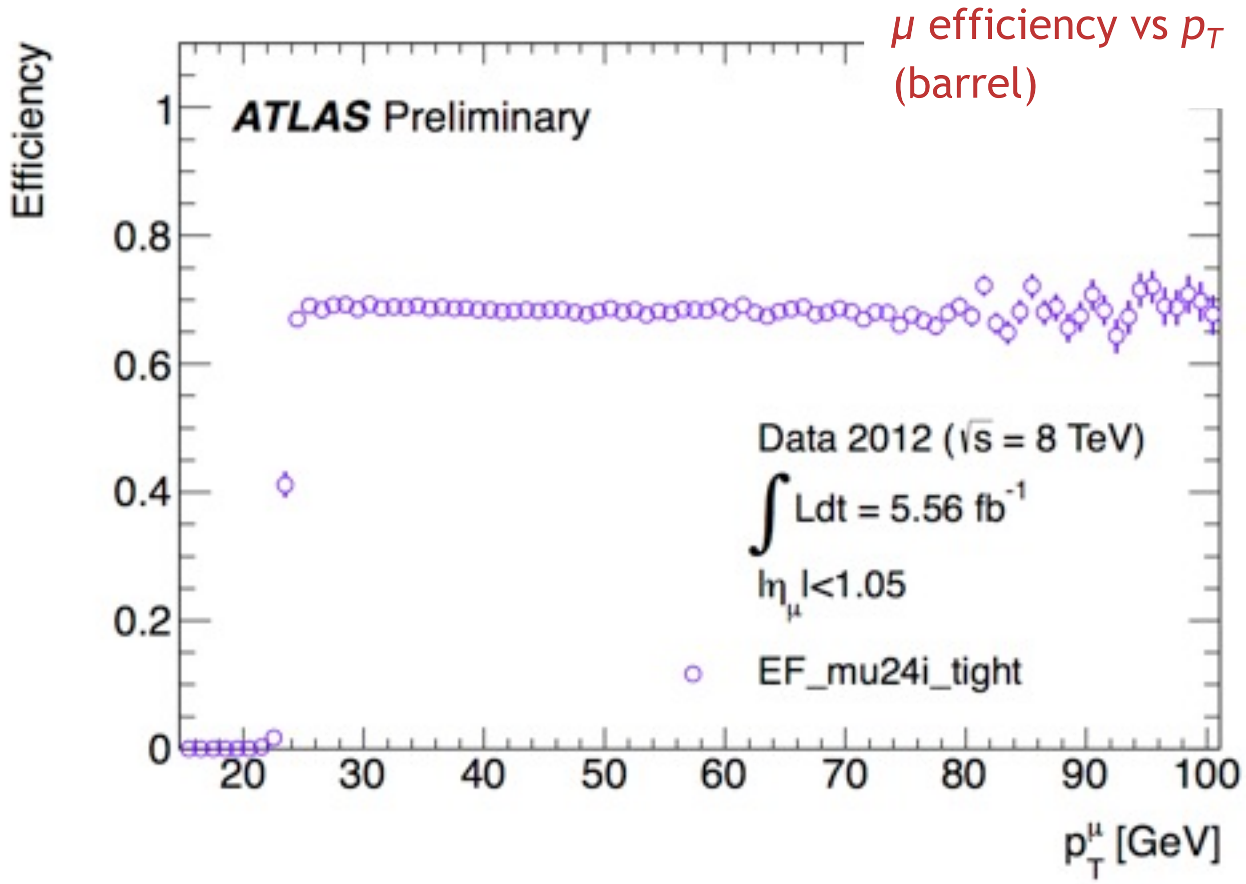


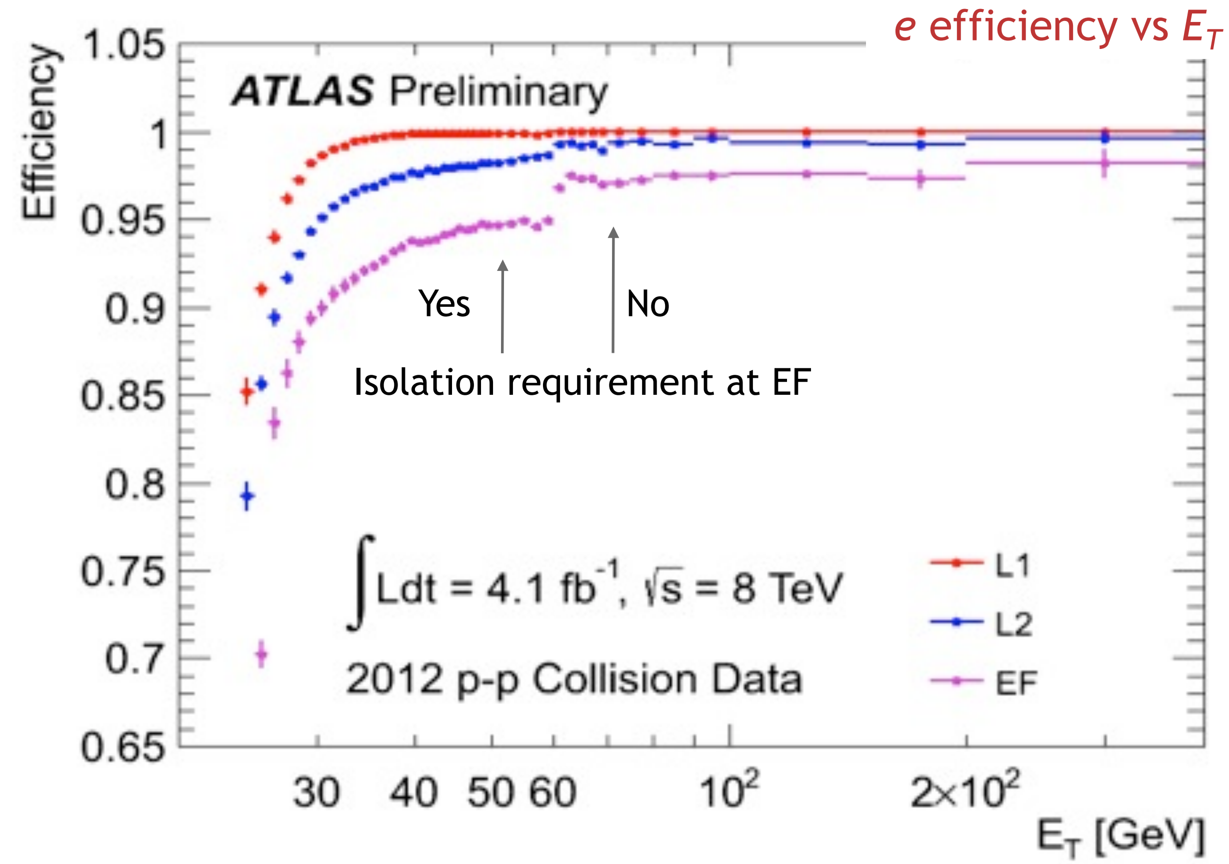
EXAMPLE: HT L1 trigger (seed to many SUSY HLT paths)

- Trigger cross section diverges with number of vertices
- Effects visible at large luminosity (raised by increasing pileup)
- Situation kept under control redefining the ingredients to the trigger (e.g. jet seeds to 5 GeV)

Trigger For SUSY

ATLAS Muon and EM triggers — efficiency and turn-on





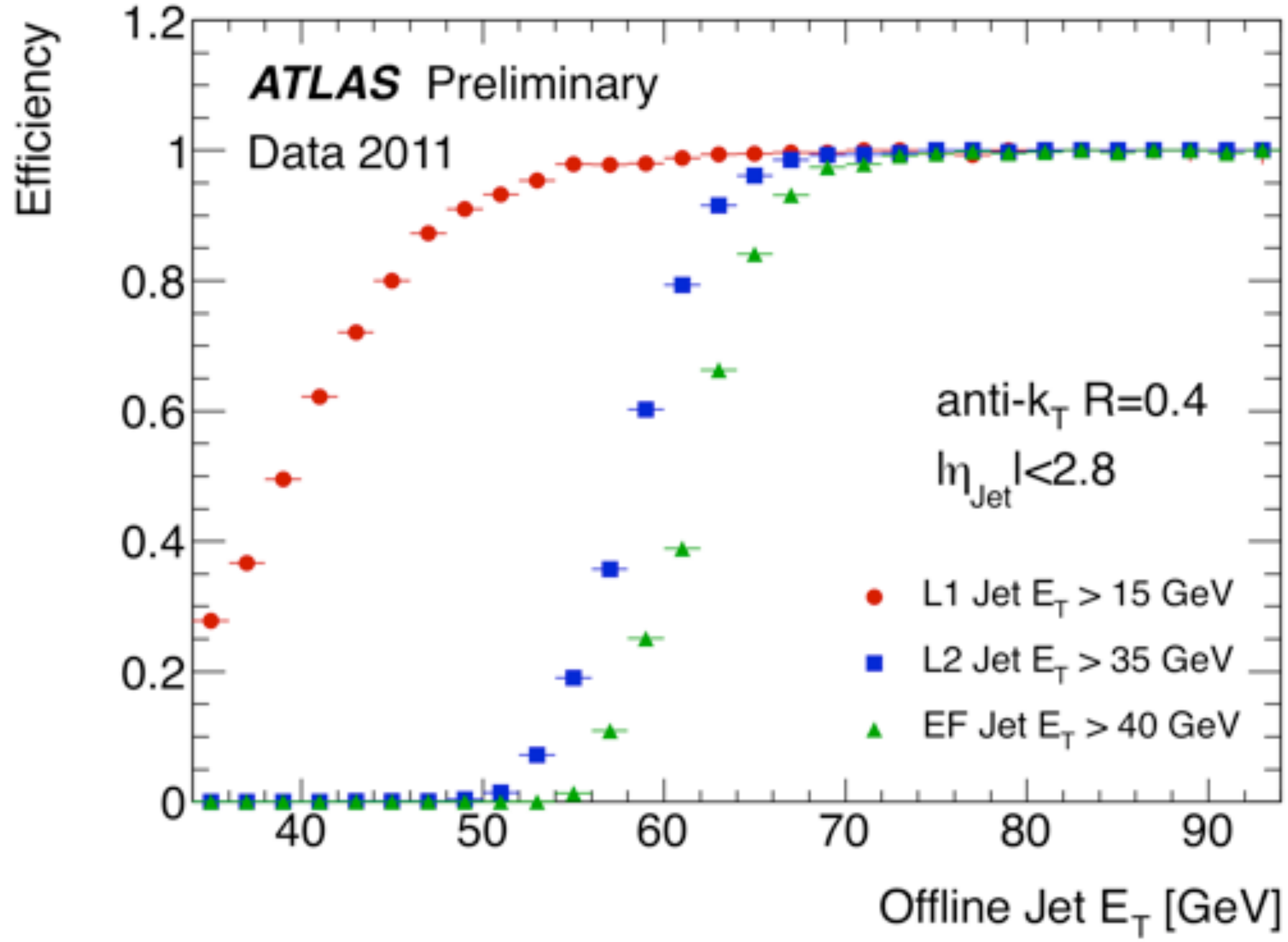
Lepton and photon triggers crucial for many SUSY analyses

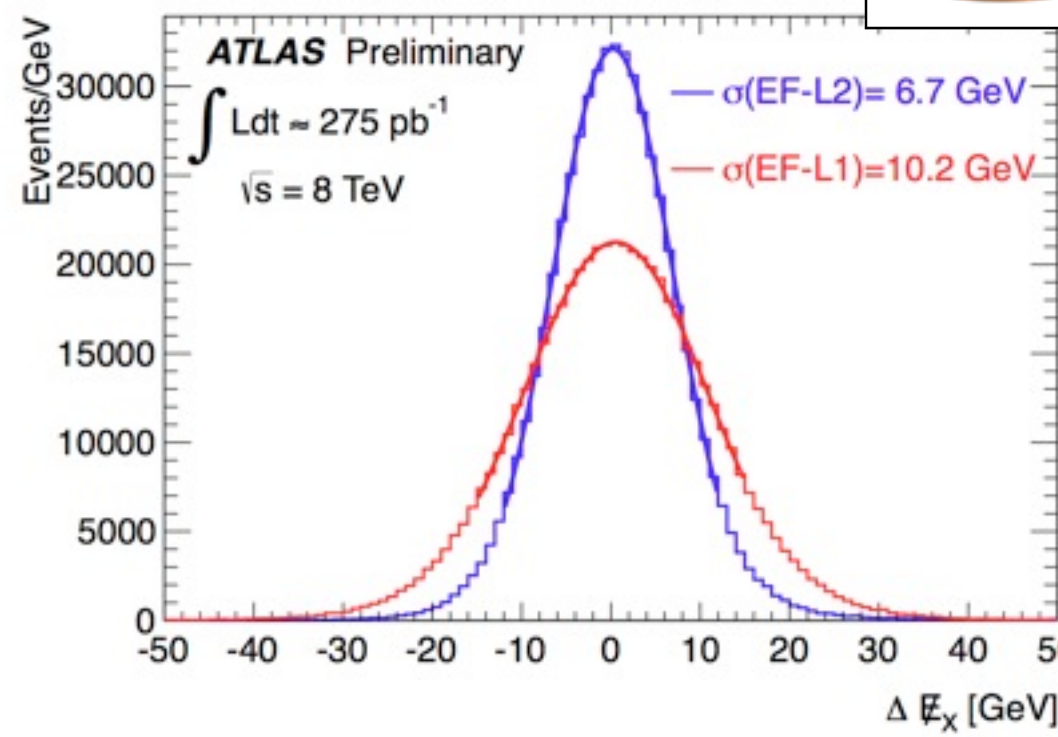
•Muon efficiency in barrel ~70% due to acceptance (additional detector shielding installed for 2012)

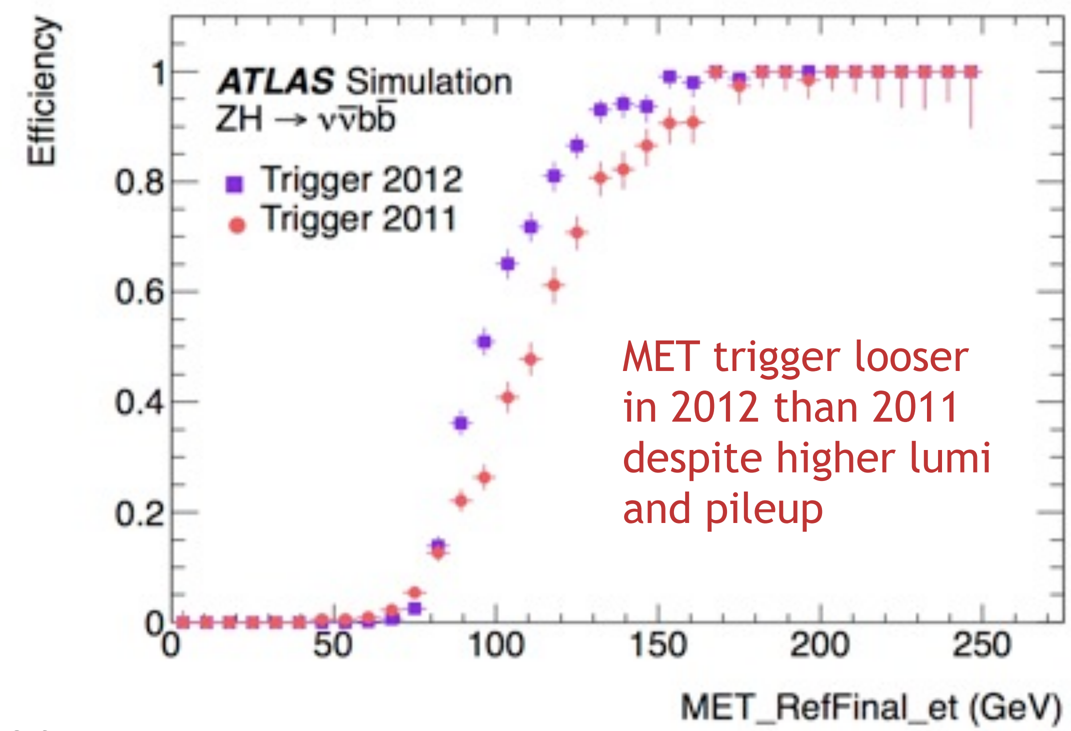
•Electron and muon triggers require track isolation (electron only for E_T < 60 GeV)

•Fiducial efficiencies precisely (< 1%) measured with Z decays (tag & probe technique)

ATLAS Jet and MET triggers — resolution and turn-on







Evolution away from RoI based jet triggers in 2012, better calibration and noise suppression:

- Full scan reconstruction of L1 towers for anti-kt jets at L2
- Hadronic scale for HLT jets, calibrated clusters for HLT MET
- Noise thresholds adjusted for high pileup (mainly forward!)
- Factor 10-20 L1 MET trigger rate reduction
- Efficiencies measured with bootstrap method using prescaled lower threshold ("support") triggers

Triggers used for SUSY searches (7 / 8 TeV analyses)

References for analyses: http://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

Inclusive searches for squarks & gluinos use simple one or two-objects triggers

Analysis	CM energy	Min. offline selection	Main EF triggers	Support triggers / comments
0 lepton + 2–6 jets + MET	8 TeV	Jet p_T > 130 GeV MET > 160 GeV	j80_xe100 (Had scale)	g120_loose, 1-lepton, single jets (prescaled – QCD seed events)
0 lepton + 6–9 jets + MET	8 TeV	Jet p_T > 80 GeV Jet p_T > 55 GeV	5j55 6j45	4j45 (prescaled) + others, 1-lepton
1 lepton + jets + MET	8 TeV	Lepton p_T > 130 GeV MET > 100 GeV	e24i mu24i	e24_xe35, e60 mu24_j65_xe40 + prescaled single-lepton triggers for QCD CR
1 soft-lepton + jets + MET	7 TeV	e (mu) p_T > 7 (6) GeV MET > 250 GeV	xe60 (EM scale, no μ)	Tuned for compressed spectrum
2 leptons (SS) + jets + MET	8 TeV	MET > 150 GeV	xe80	2e12, e12_mu8, mu18_mu8
γγ + MET	7 TeV	Photon p_T > 50 GeV	2g20	g80 for γ + X analyses
τ + X + MET	7 TeV	Jet p_T > 130 GeV MET > 130/150 GeV	j75_xe45/55	dilepton triggers

Triggers used for SUSY searches (7 TeV analyses)

References for analyses: http://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

Searches for 3rd generation squarks and EW production of gauginos & sleptons

Analysis	CM energy	Min. offline selection	Main EF triggers	Support triggers (CR, eff) / comments
3 b-jets + 1–3 LF jets + MET	7 TeV	Jet p_T > 130 GeV MET > 160 GeV	j75_xe55	
direct sbottom (0 lepton)	7 TeV	Jet p_T > 60 GeV MET > 150 GeV	xe60	mu18, j75_xe55
direct stop (0 lepton)	7 TeV	Jet p_T > 130 GeV MET > 150 GeV	j75_xe55	
direct stop (1/2 leptons)	7 TeV	e (mu) p_T > 25 (20) GeV	e22 mu18_J10 xe60 (1L)	stop ® top + LSP analyses ('heavy' stop)
EW production (2/3 leptons)	7 TeV	e (2e) p_T > 25 (17) GeV mu (2mu) p_T > 20 (12) GeV e (mu) p_T > 15 (8) GeV	e22, 2e12 mu18, 2mu10 e10_mu6	dilepton triggers

Triggers used for SUSY searches (7 TeV analyses)

References for analyses: http://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

RPV and LLP searches

Analysis	CM energy	Min. offline selection	Main EF triggers	Support triggers (CR, eff) / comments
2x2 jets (scalar gluon)	7 TeV	Jet p_T > 80 GeV	4j45	4j30 (prescaled, low mass), e22 (reference trigger)
2x3 jets (RPV gluino)	7 TeV	Jet p_T > 60 GeV (resolved) Jet p_T > 350 GeV or H_{T4j} > 600 GeV (boosted)	5j30 j100_ht400 or j350	3j30, 4j30
disappearing track (AMSB)	7 TeV	Jet p_T > 90 GeV MET > 90 GeV [below plateau] $\Delta\phi$ > 1 [isolated > 10 GeV track]	j55_xe55_ dphi2j30xe10	EW production with ISR jet, $\Delta\phi$ > 1 cut for back-to-back topology,
R-hadrons	7 TeV	No MET cut [isolated > 10 GeV track, $\beta\gamma$ & β requirements]	xe60 (no muon)	Exploit ISR jet production and below-plateau efficiency

Hadronic SUSY Searches

Analysis	Signature	HLT Requirement	Offline Selection	Target Model
HT/MHT	≥3jets	HT>350 MHT>110	HT>500 MHT>200	gluinos
αT	≥2jets	staircase HT vs αT	αT>0.55	squarks/gluinos
MT2	≥3jets	(PF)HT>650	HT>750 MET>30	gluinos
Razor Inclusive	1μ1e+≥2jets	1μ pT>12 GeV+ OR of staircase Razor cuts	M_R>300 R^2>0.11 1μ pT>20 GeV	generic SUSY colored particles pair-produced (*inclusive analysis*) Also performed with ≥1btag for 3rd generation
	2μ+≥2jets			
	1μ+≥2jets			
	2e+≥2jets	1e pT>12 GeV+ OR of staircase Razor cuts	M_R>300 R^2>0.11 1e pT>20 GeV	
	1e+≥2jets			
	0lep+≥2jets	staircase Razor cuts	M_R>400 R^2>0.18	

Third Generation Squarks

Analysis	Signature	HLT Requirement	Offline Selection	Target Model
HT/MHT	≥3jets+≥1btag	HT>400 MHT>250	staircase HT/MHT	stop or sbottom from gluinos
αT	≥2jets+btag counting	staircase HT vs αT	αT>0.55	stop/sbottom/gluinos
MT2	≥3jets+≥1btag	(PF)HT>650	HT>750 MET>30	stop or sbottom from gluinos
Razor Stop	≥6jets	≥4jets	≥6jets	direct stop or from gluino cascade
SS leptons + jets + MET	dilepton (17,8)	dilepton (17,8)	dilepton (20,20)+ ≥2jets + HT>200	direct stop or from gluinos
One Lepton	≥1 lep + HT + MHT	lepton pT>15 + HT>300 + PFMHT>40	lepton pT>20 + HT>375 + PFMHT>60	CMSSM

Lepton SUSY Searches

Analysis	Signature	HLT Requirement	Offline Selection	Target Model
Charginos	multilepton	dilepton (17,8)	three lepton (20,10,10)	SUSY models with Ws, Zs, sleptons
OS Dilepton	OS leptons + jets + MET	dilepton (17,8)	dilepton (20,20)+HT>125+MET >200	CMSSM,χ^2_0 in gluino cascade
SS Dilepton	SS leptons + jets + MET	dilepton (17,8)	dilepton (20,20)+ ≥2jets + MET>30	CMSSM,leptons in gluino cascade
Multilepton	multilepton	dilepton (17,8)	three lepton (20,10,10)	coNLSP,RPV
JZB and MET template	Z(ll)+ ≥2jets	dilepton (17,8)	dilepton (20,20)+JZB>50 or MET>30	Z from χ^2_0 in gluino cascades
SUSY with tau	≥2 tau + MHT	PFMHT>150	PFMHT>250	tau produced in SUSY cascades
One Lepton	≥1 lep + HT + MHT	HT vs lepton pT staircase	HT vs MHT regions	CMSSM

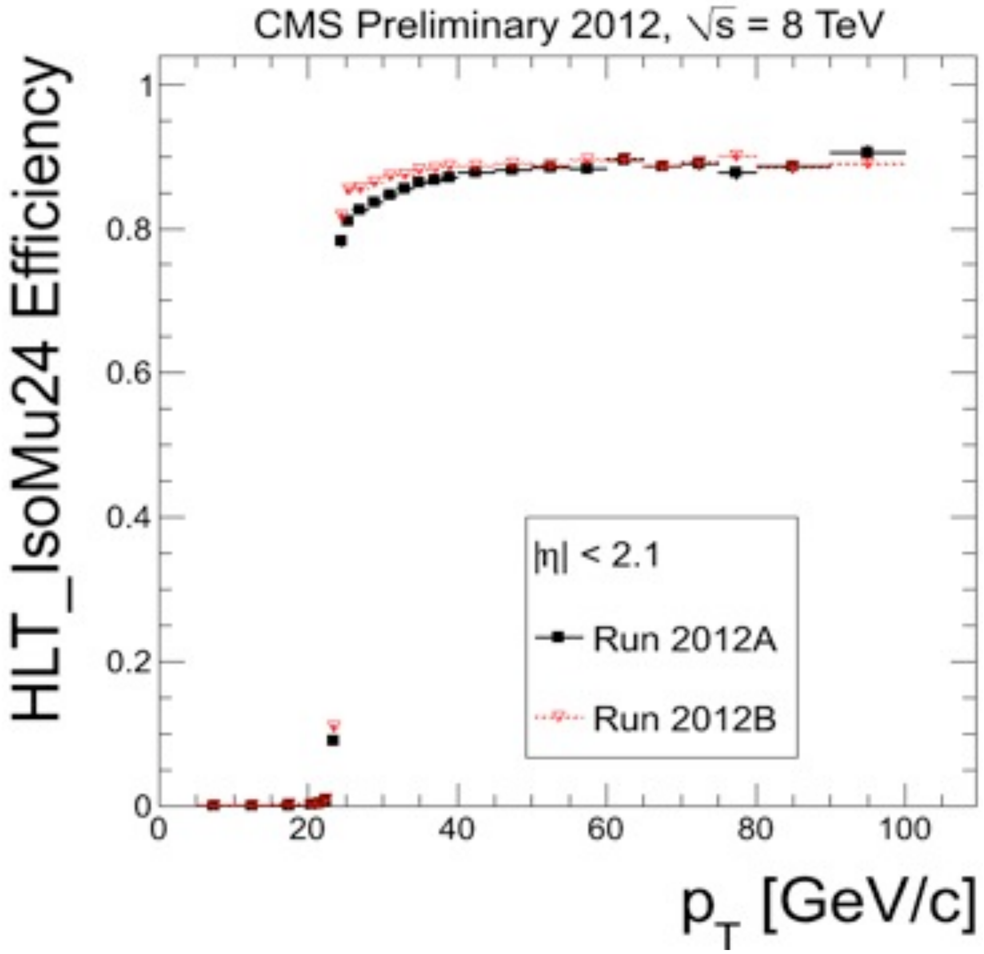
Photon SUSY Searches

Analysis	Signature	HLT Requirement	Offline Selection	Target Model
DiPhoton	$\geq 2\gamma$ + $\geq$2jets	DiPhoton (36,22)+ Photon ID	DiPhoton (40,25)+ Photon ID	Stealth SUSY
DiPhoton+MET	$\geq 2\gamma$ + $\geq$MET	DiPhoton (36,22)+ Photon ID	DiPhoton (40,25)+ Photon ID	GMSB
JGB	$\geq 1\gamma$ + $\geq$2jets+MET	photon pT>70 and HT>400	photon pT>80 and HT>460	GMSB

“Exotic” SUSY Searches

Analysis	Signature	HLT Requirement	Offline Selection	Target Model
LLP	heavy stable charged particle	PHMHT>150 or dedicate trigger (+/ 1 bunch crossing)		compressed spectra,
Stopping Gluinos	out-of-time high-pT jets	one jet pT>50 and no beam	one jet pT>70 and no beam	Split SUSY
Monojet	High-pT jet + MET	jet pT>80 and MET>95	jet pT>110 and MET>200	Direct DM production
RPV trijet	pair-produced X→3j	HT>750	HT>900	PRV gluino decay
Displaced photons	two long-living NLSP decaying to γ+LSP	DiPhoton (40,28)+ Photon ID	DiPhoton (45,30)+ Photon ID	GMSB

HLT vs Offline



Turn-on very sharp for muons (online vs offline objects very similar)

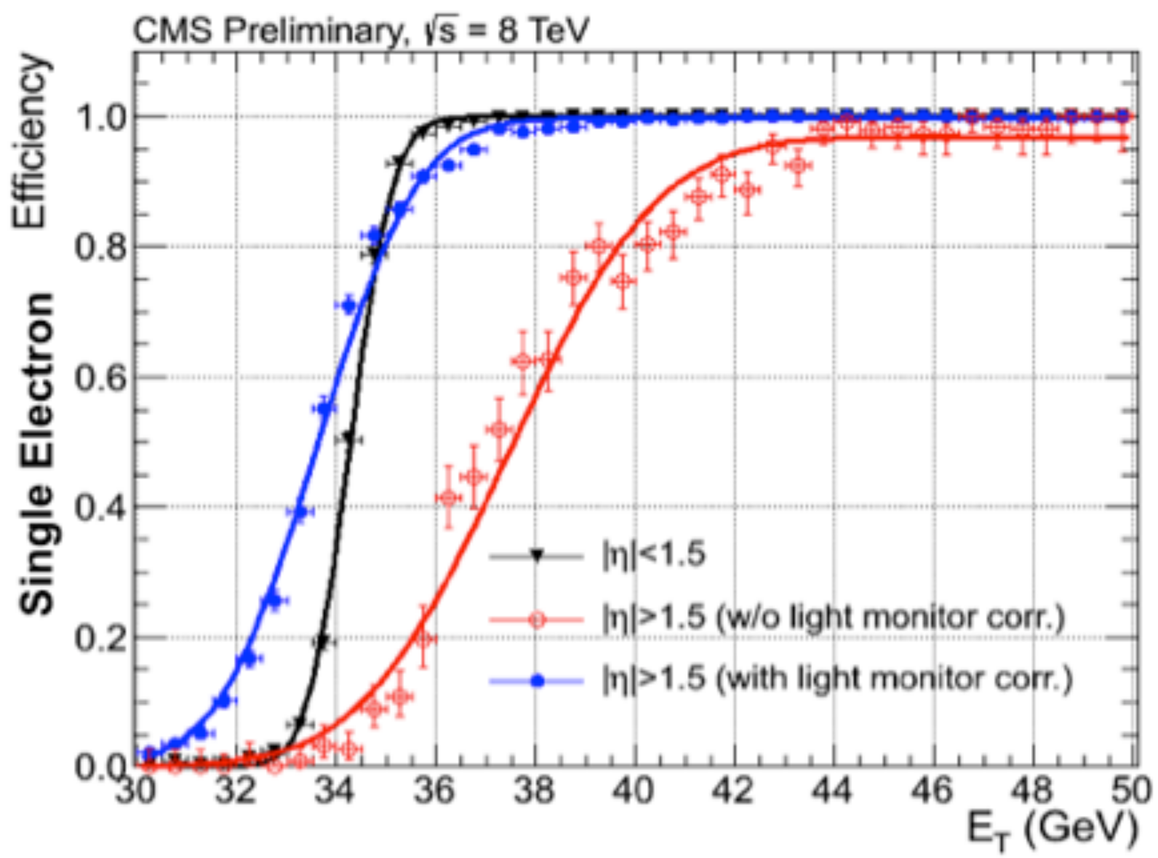
Efficiency plateau ~90%, due to an inefficiency intrinsic to the L1 seed

Improved the performances with R&D during run (Run2012A vs Run2012B)

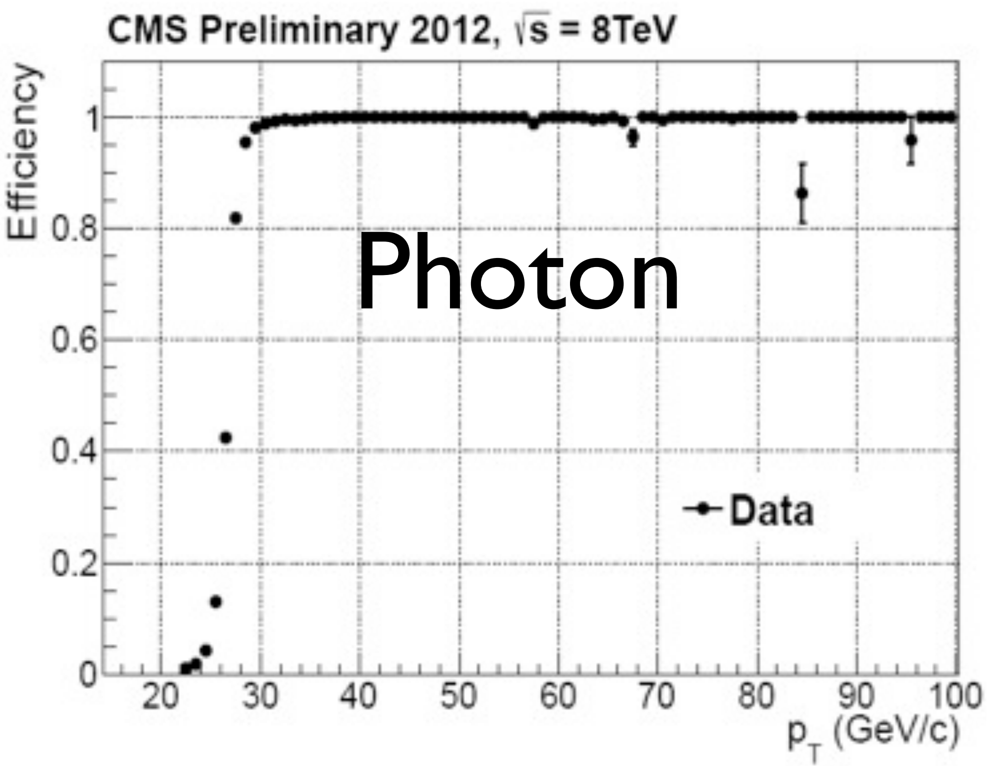
The energy resolution changes across the run, due to the change of the ECAL transparency while taking data

This effect is measured offline and the calibration is regularly updated, offline and online

This improves the efficiency in the endcap region (blue vs red)



HLT vs Offline



Turn-on very sharp for photon, due to the very small differences between online and offline

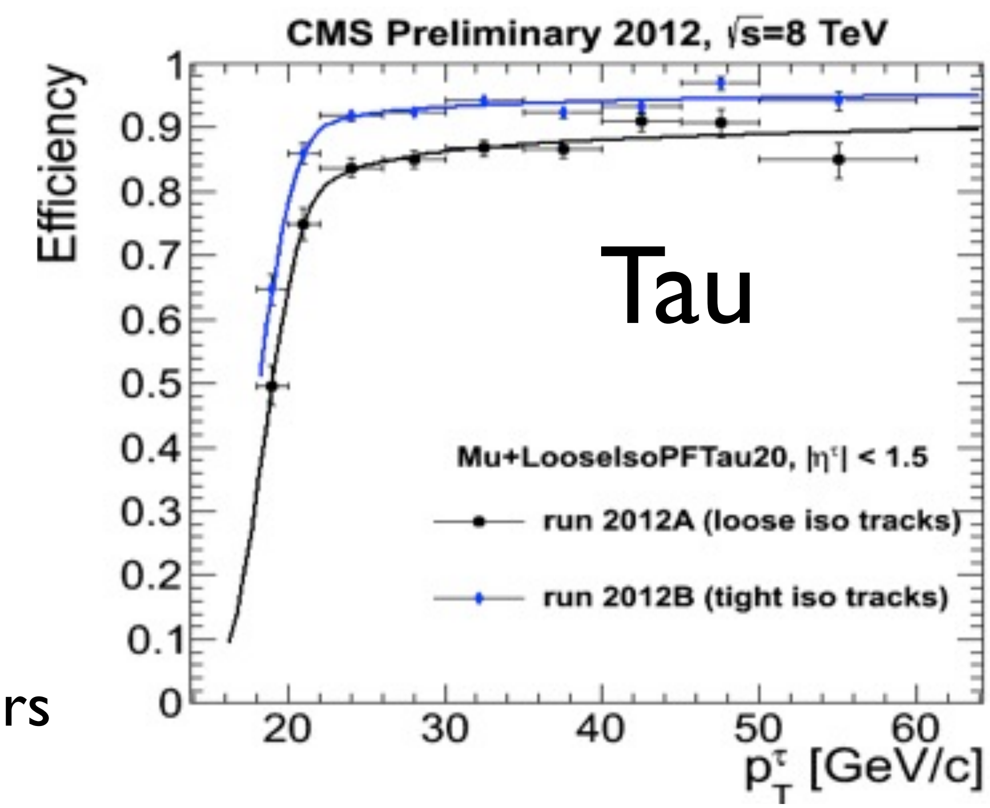
This is not the case of electrons, for which the tracking introduces a difference in the reconstruction algorithm (e.g. matching of the cluster to the track)

Tau are triggered with a set of dedicated paths, mostly designed for Higgs analyses. HT+tau cross triggers developed for SUSY

Trigger efficiency is measured with dedicated prescaled triggers

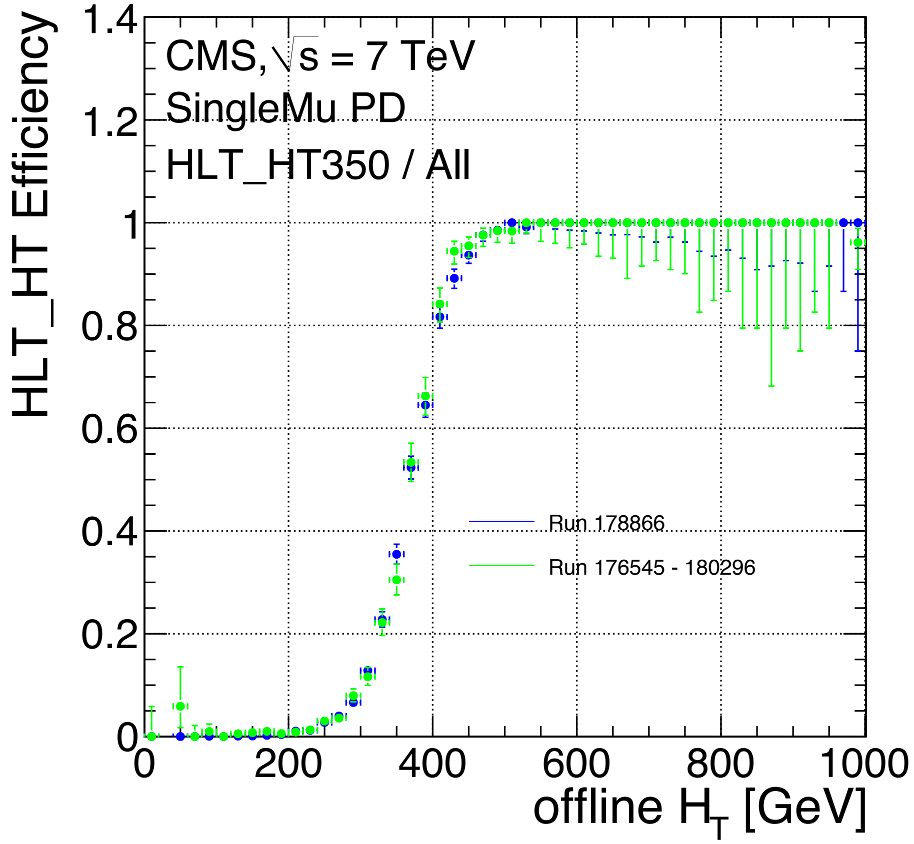
Excellent efficiency turn-on, due to the use of PF@HLT

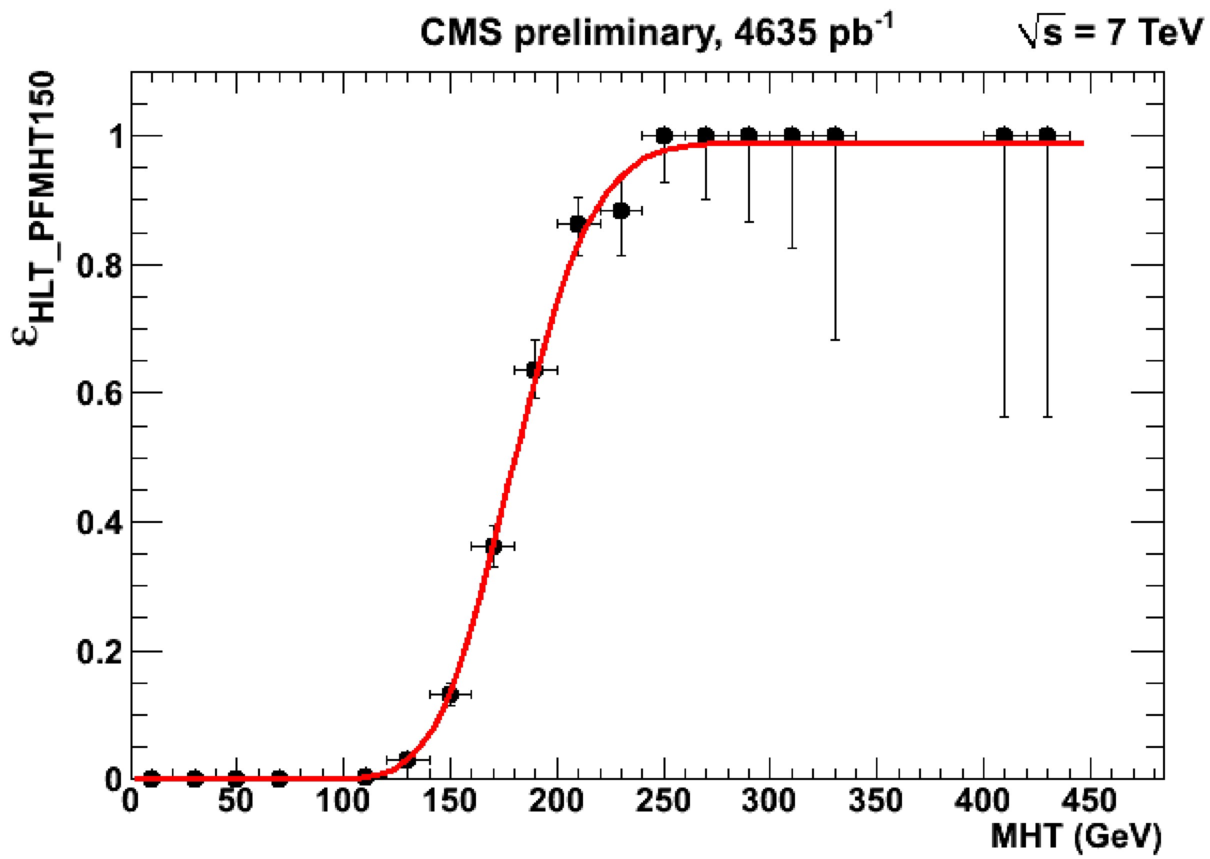
Tau HLT R&D became beneficial for the hadronic triggers too (PF@HLT also used for HT and MET)



HLT vs Offline

In general, HT and MHT triggers in CMS were expected to suffer for the jet resolution, mainly limited by the HCAL resolution





The possibility of running the PF reconstruction online limited this effect, substantially improving the performances for both MET and HT

More dedicated analyses have then being implemented already at the HLT level (e.g. the wide-jet reconstruction for the dijet resonance curves)

New Ways of Triggering

Trigger is not the limiting factor in data taking

These days, the limitation comes in CPU resources for offline processing

We can then take more data than what we can look at

This implies new resources allocated, which will be turned into analyses next year

Moreover Triggers new triggers are introduced between 2011 and 2012 (not yet used in analyses)

Other triggers and developments (for 8 TeV data only)

'Hadronic delayed stream' collecting triggers that are not promptly reconstructed

For SUSY searches of interest:

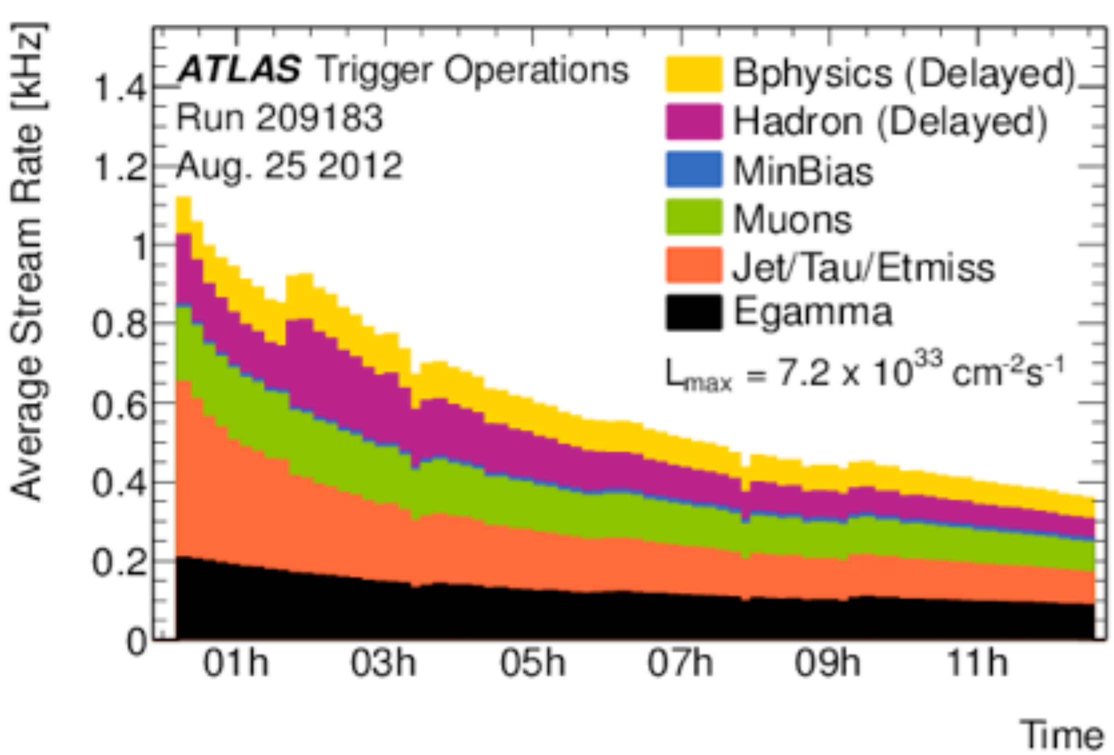
- **multijets:** **4j65, 5j45** [lowest prompt trigger: 4j80, 5j55, 6j45, 7j40]
- H_T: **j145_ht500** [j145_ht700]
- **'Fat' jet:** **j360 (R=1.0)** [j460]
- **Single jet:** **j280** [j360]

'End-of-fill' triggers (not available for full luminosity, had. delayed stream is end-of-fill)

For SUSY searches of interest:

- **MET triggers with lower L1 thresholds** (same plateau as primary trigger, but earlier turn on)

Introduced during 2012 running: muon correction In MET triggers at HLT level



2011 / 2012 menus include powerful *b*-jet triggers, but not yet used in SUSY

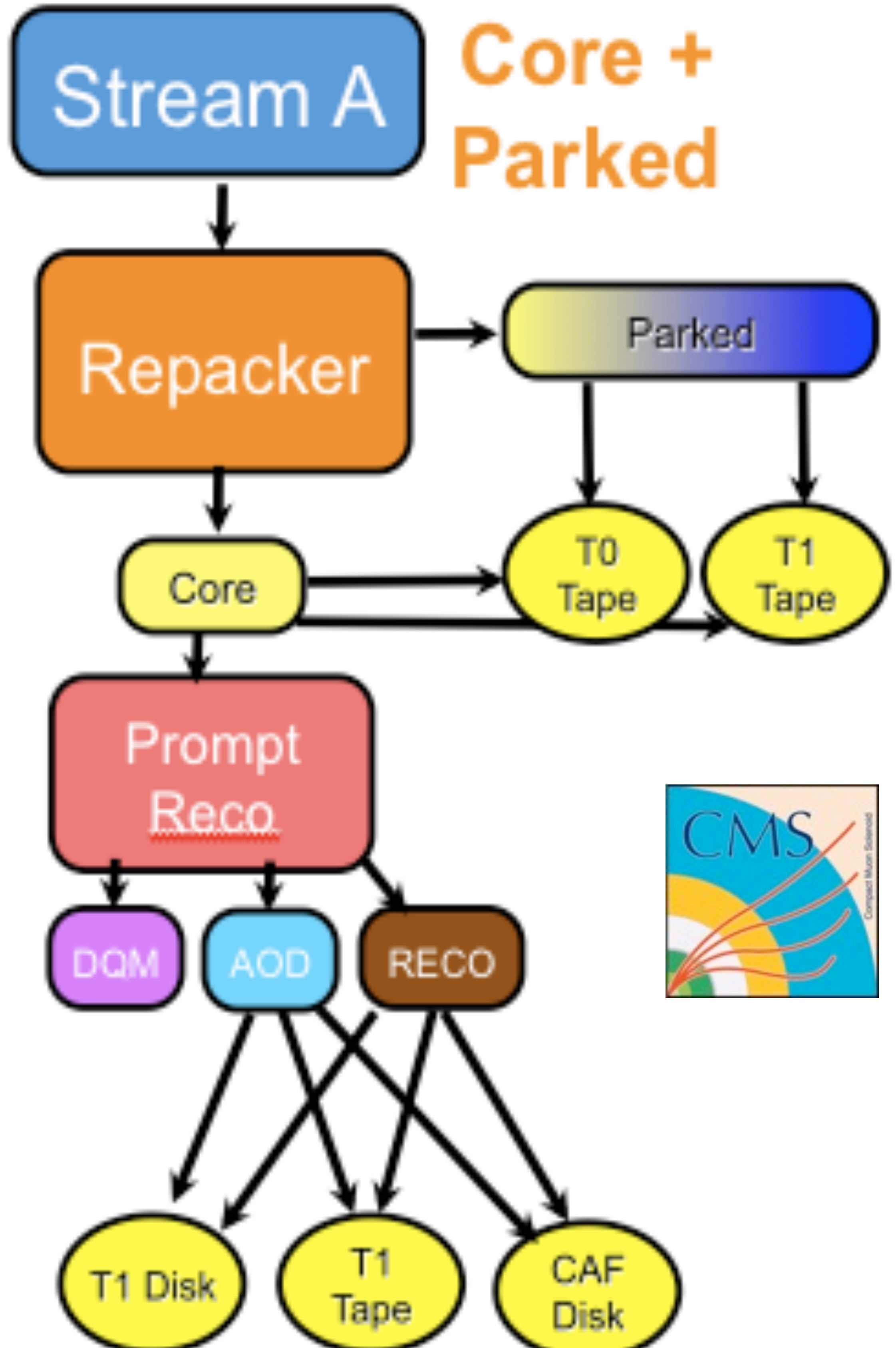
About 150 Hz of 2012 additional *B*-physics and jet triggers recorded for later processing in 2013

Data Parking

LHC will stop in 2013/2014:
Recording additional events to be studied at that time:

Vector Boson Fusion: M_{jj}>650 GeV , $\Delta\eta_{jj}$>3.5
MultiJet: 4 Jet with p_T>50 GeV
HT and MHT: For susy searches
MuOnia: low $M_{\mu\mu}$ (Jpsi, Psi`, ..)
DoubleMu: Mu13_Mu8
TauParked: ττ (with 3prong decays)
5% of parked data are promptly reconstructed for monitoring purpose

On average 350 Hz of "core physics" is promptly reconstructed and 300 Hz of data is parked for future reconstruction



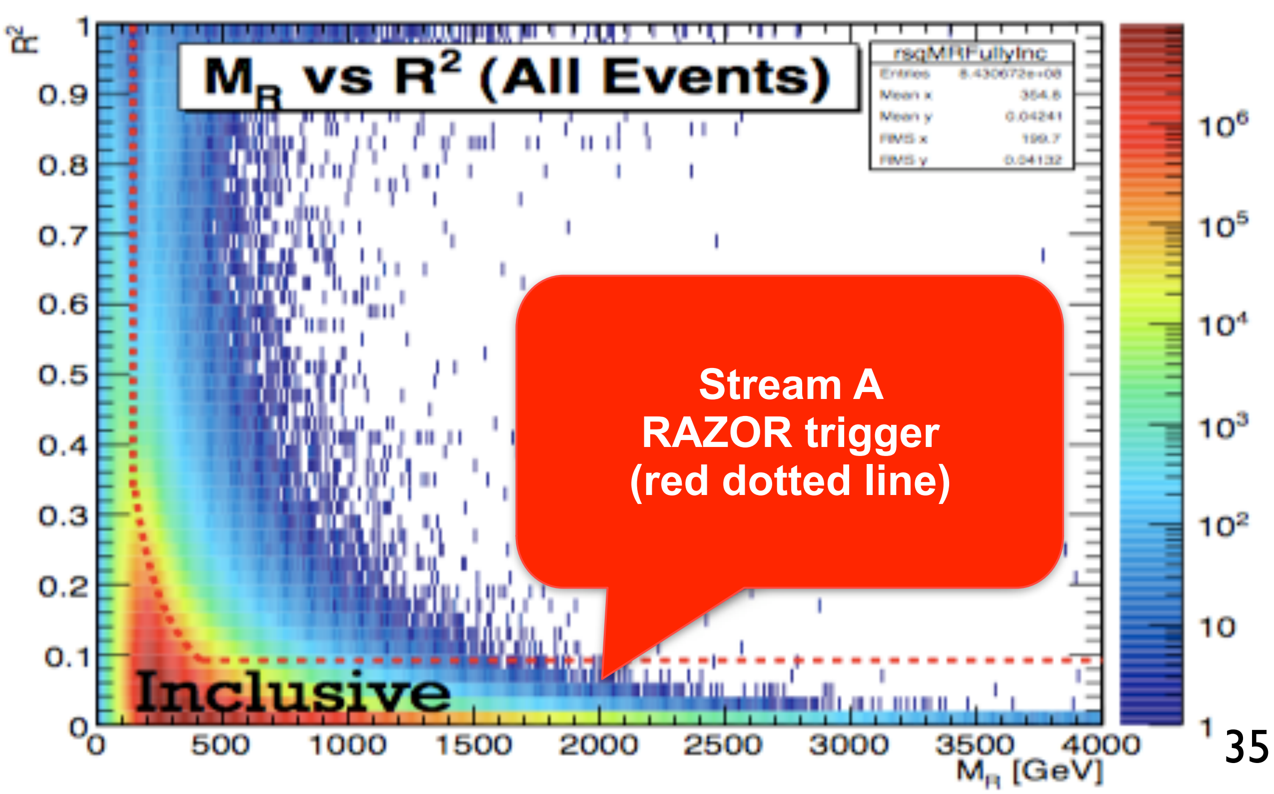
Data Scouting

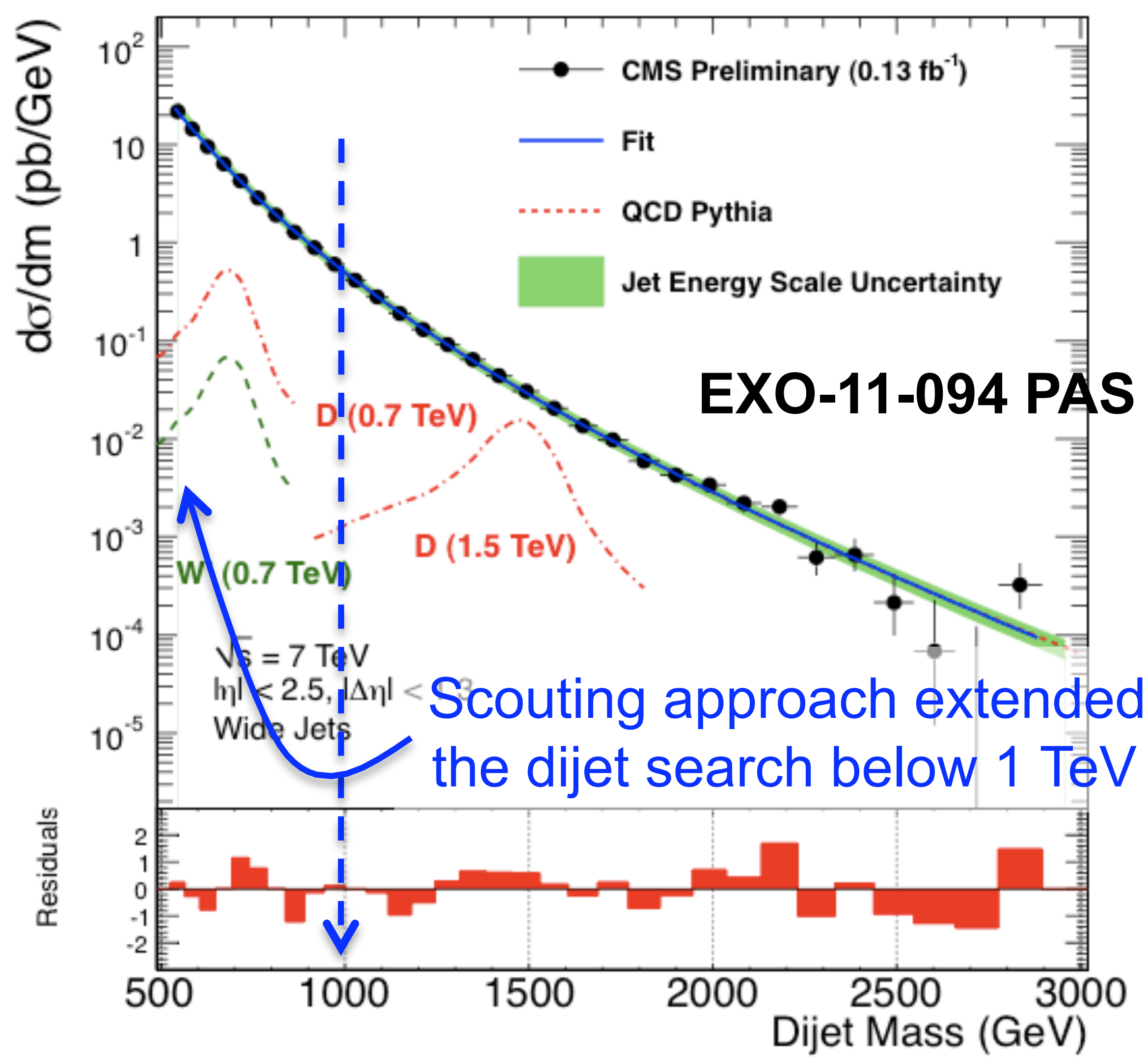
Look at events not collected in main stream due to trigger constraints.
Scouting approach:
Trigger: H_T>250 GeV unprescaled

High rate (~1 kHz) + reduced event content (i.e. store HLT jets, no RAW data)

- Bandwidth (= rate x size) under control [a few MB/s]
- Possibility to change stream A triggers in case something interesting is seen by"scouting"

Analyses in Data Quality Monitoring-like framework for:
Exotica: Dijet search
SUSY: Razor, α_T





In 2012, we can benefit from almost the full integrated luminosity (>15 fb^{-1})

Conclusions

- Despite the worse environment for 2012 run, both ATLAS and CMS managed to keep the trigger performances very high
- Similar strategies (inclusive single-object triggers) are used for the leptons, with similar allocation resources
- Different trigger strategies are used for the rest: ATLAS stays with a few general single-object triggers (one trigger many analyses) while CMS decided to be more diversified (one or more triggers for one analysis)
- Both the experiments are investigating new approaches to data taking, delaying a subset of the events, introducing looser triggers at the end of the fill, taking now data that will be looked in 2013, keeping some information of the events that are rejected at the last stage of the trigger
- With the LHC environment becoming more hostile, creativity is allowing us to survive

Backup

Staircase Triggers

- Based on the 2D kinematic plane used in the analysis (R vs MR, aT vs HT)
- Apply a rectangular cut on the plane for each trigger
- Define a set of triggers tightening the cut on one leg and loosening the other
- Typically ~4 triggers used