ATLAS Group at Kobe

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KUBEC International Workshop on Dark Matter Searches
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Members

- Staff
  - Hisaya Kurashige (Prof.)
  - Yuji Yamazaki (Assoc. Prof.)
  - Atsuhiko Ochi, Shima Shimizu, Junpei Maeda (Assis. Prof.)
  - Yuan Li (PD)

- Students
  - Tomoe Kishimoto (PhD course)
  - Ye Chen, Makoto Hasegawa, Ryota Yakabe, Shogo Kido (master)

Contents

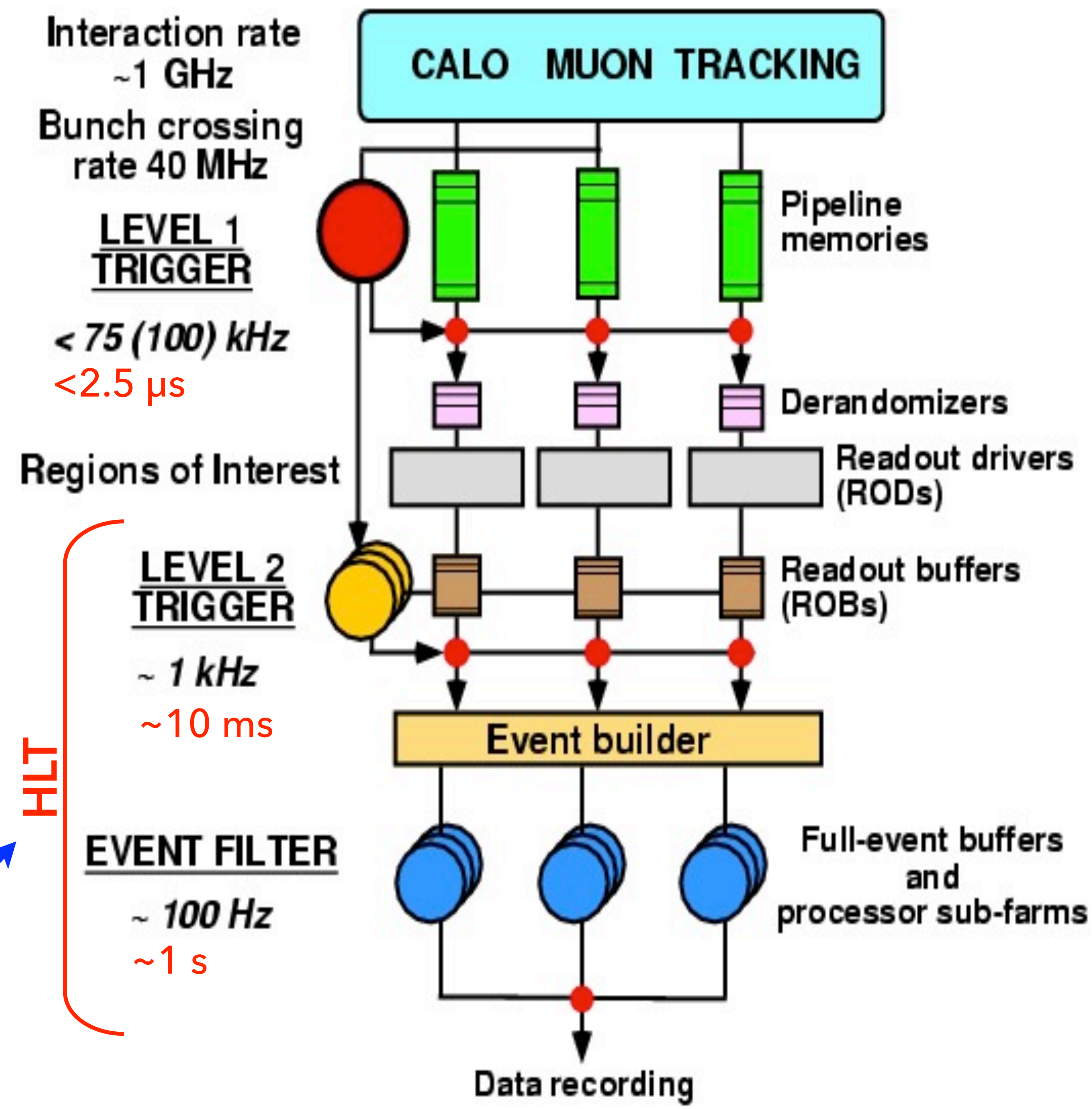
- Muon-trigger
  - Level-1 endcap trigger: hardware-based
  - Level-2 (high-level) muon trigger: software-based
  - Upgrade plan
- Physics
  - Higgs boson decaying to WW
  - QCD - jet physics

ATLAS Muon trigger and Kobe

ATLAS trigger system

- Three-level system
  - L1: pipeline readout
    + hardware trigger
  - L2, L3 (Event Filter): High-Level trigger
- Object-based
  - Object reconstructed only around RoI (Region of Interest)
  - Full reconstruction limited to few events

L2/EF merged from 2015 to reduce readout and event building overhead



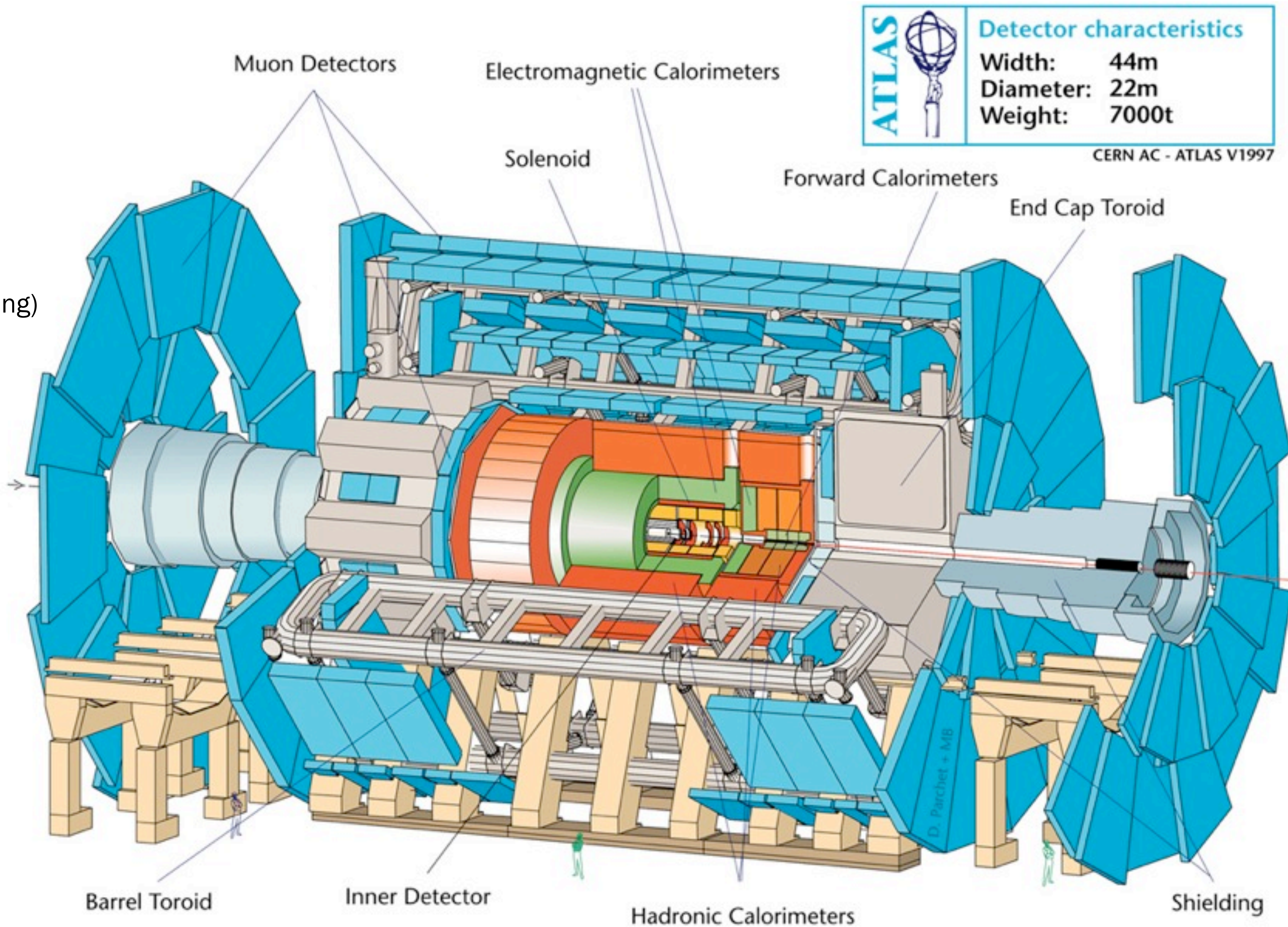
The ATLAS detector

Muon System

Calorimetry

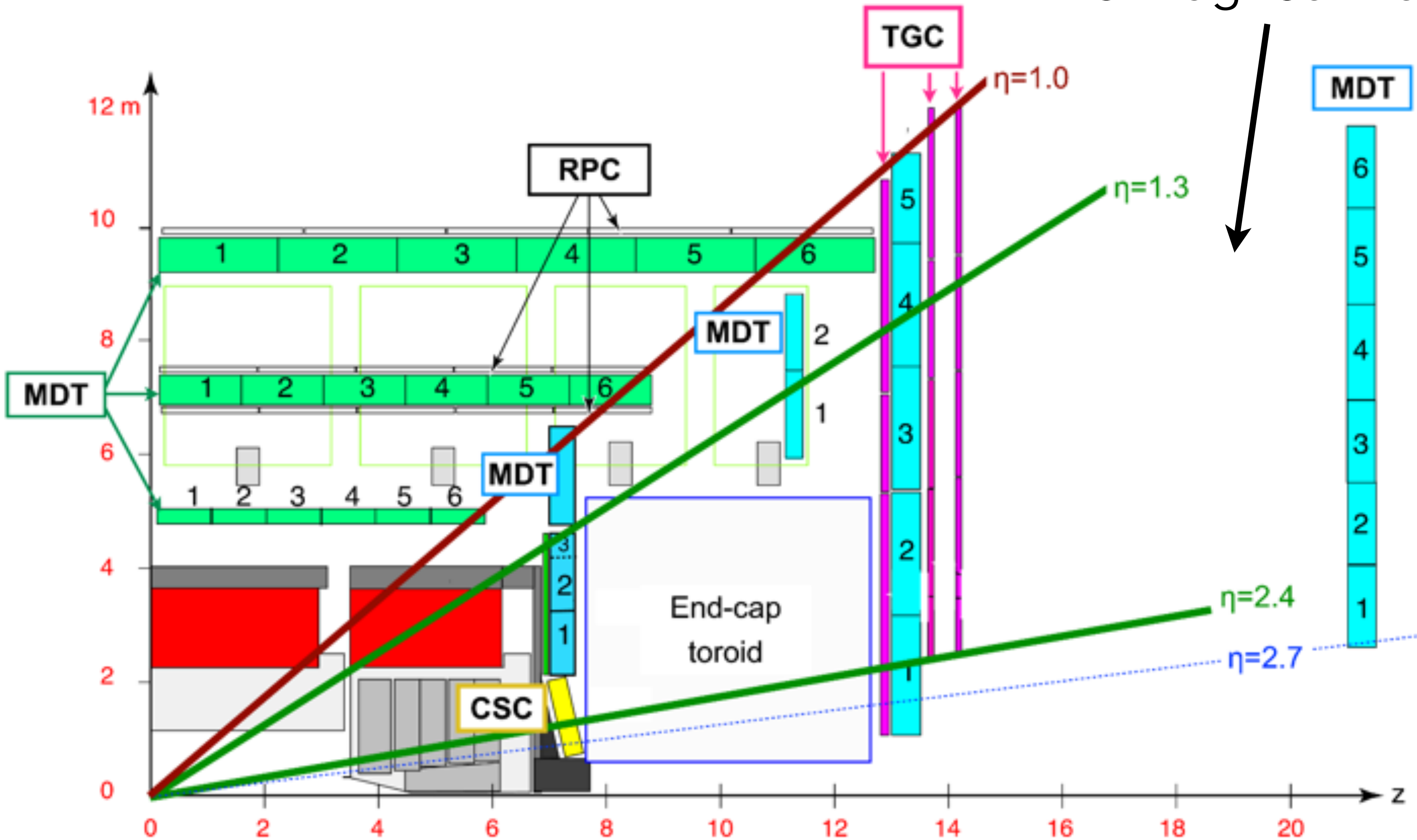
Inner Detector
(tracking and vertexing)

… characterised by large air-core toroidal magnets for muons



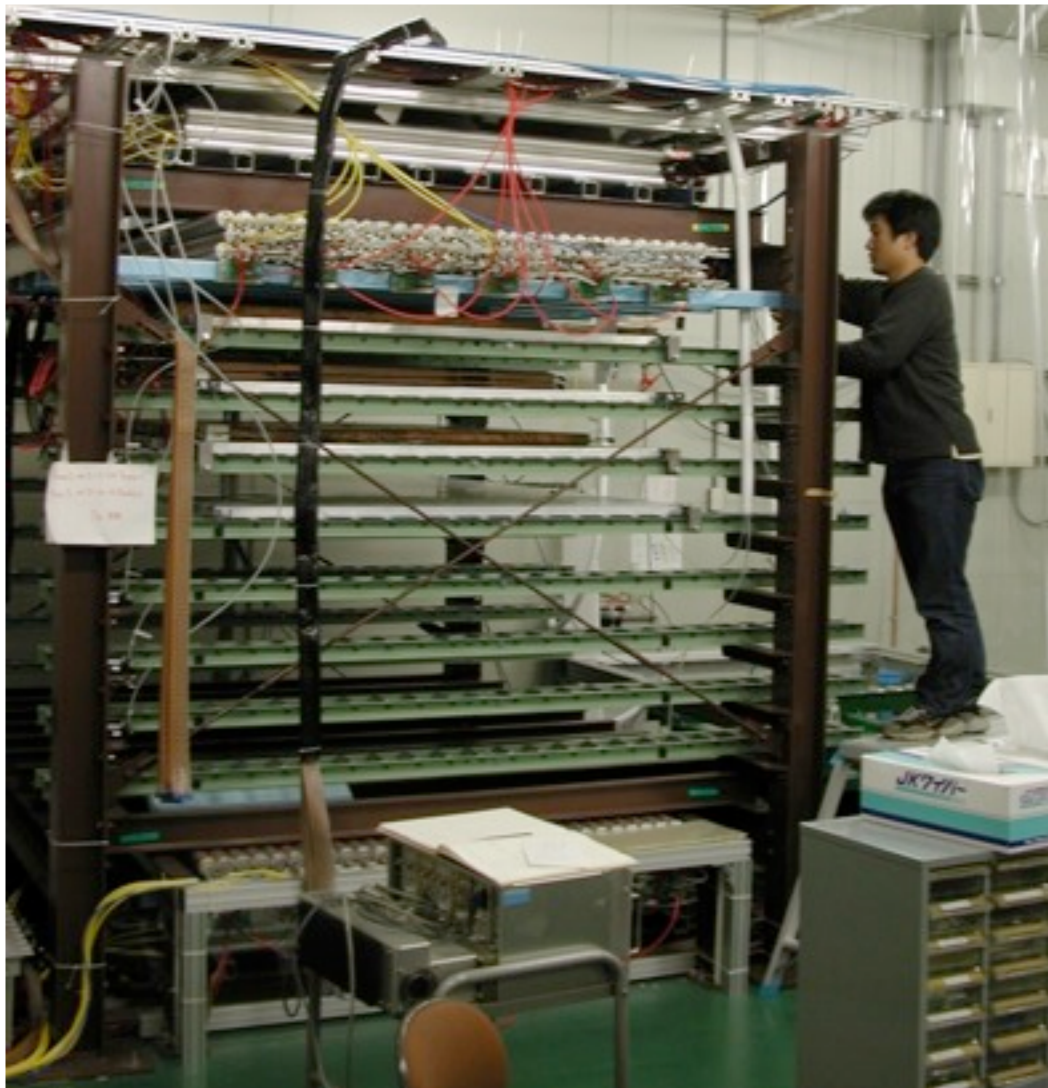
ATLAS muon system

No magnet: muon goes straight



- Precision chamber: MDT (Monitored Drift Tube)
- Fast trigger chamber: RPC and TGC (Thin-Gap Chamber)
- Barrel and Endcap systems
  - Three "stations" to measure bending

Kobe contribution to Endcap trigger chambers



Checking if all the channels are alive using cosmic, in Kobe

CERN

Manufactured at KEK: ~1000 wires being soldered

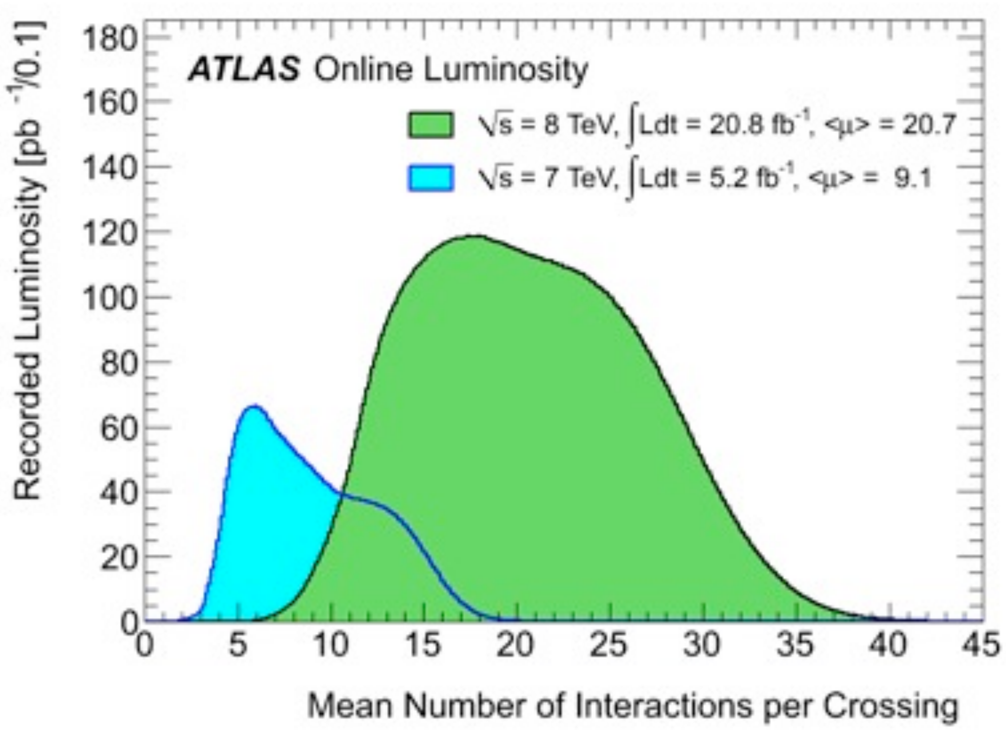
Assembling @ CERN

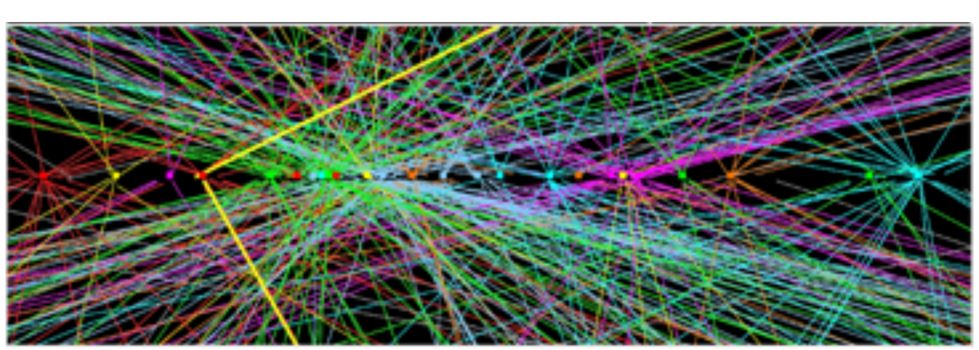
- Checking again
- Mounting to frames
- Integration with electronics

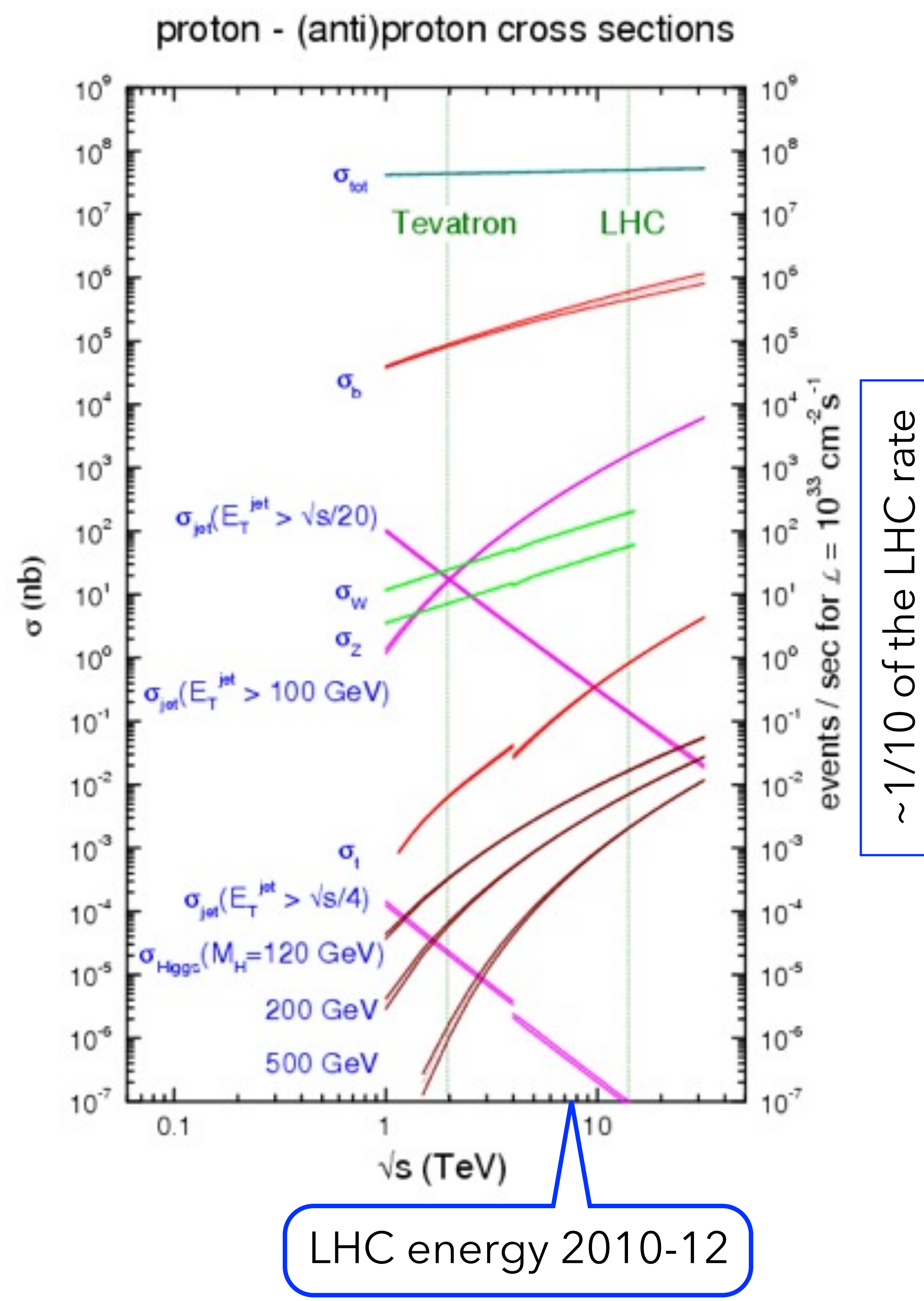
Endcap Sector Logic board

ATLAS trigger - performance requirements

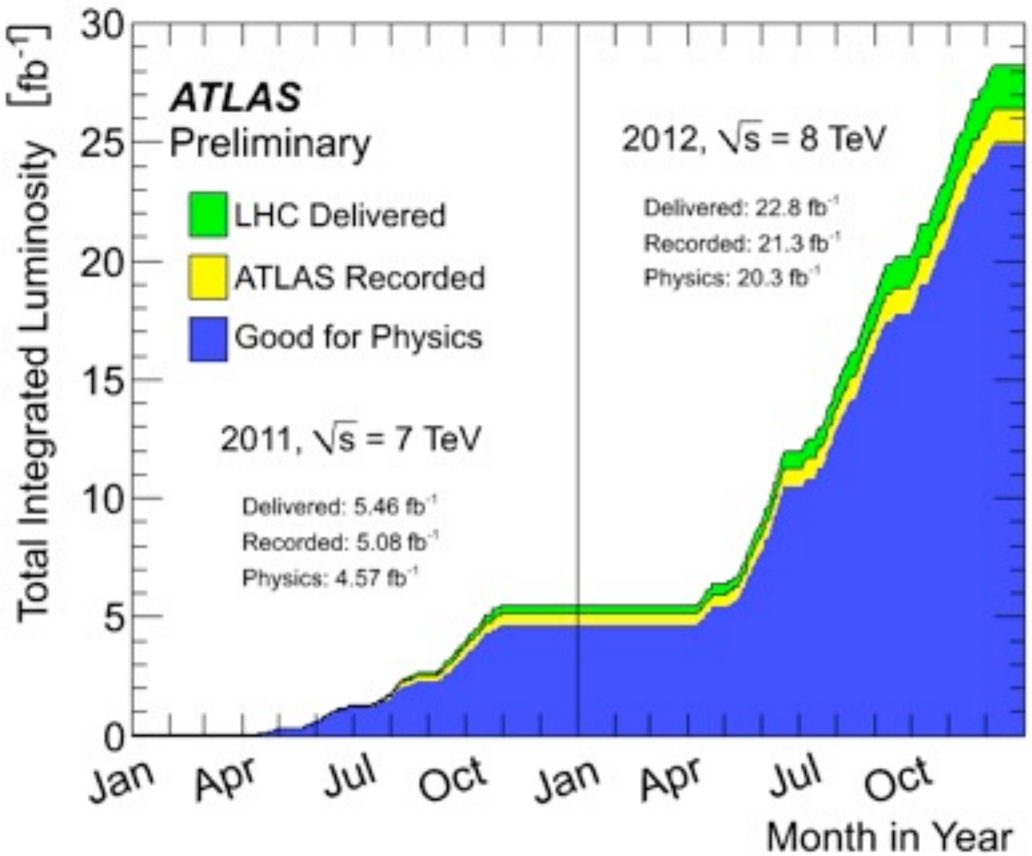
- Small S/N
  - Interesting events: $1/10^n$ where n > 5~15
- High rate and pile-up
  - 1 GHz collisions → <500 Hz for tape







LHC running plan and luminosity



- Rapid increase in accelerator performance
- L1 upgrade (1)
- HLT algorithm improvement
- New Small Wheel (L1 and HLT)
- L1 upgrade (2)

2009	Startup		
2010 2011 2012	Run1	$\sqrt{s}$=7-8 TeV, L=7x10^{33} cm^{-2}s^{-1}	25 fb^{-1}
2013 2014	Phase-0 upgrade	Muon: TGC inner stations	
2015 2016 2017	Run2	$\sqrt{s}$=13-14 TeV, L=1~2x10^{34} cm^{-2}s^{-1}	100 fb^{-1}
2018	Phase-1 upgrade	Muon: New Small Wheel	
2019 2020 2021	Run3	$\sqrt{s}$=14 TeV, L ≧ 2x10^{34} cm^{-2}s^{-1}	300 fb^{-1}
2022	Phase-2 upgrade		
2023 -203x	Run4	$\sqrt{s}$=14 TeV, L ≧ 5x10^{34} cm^{-2}s^{-1}	3000 fb^{-1}

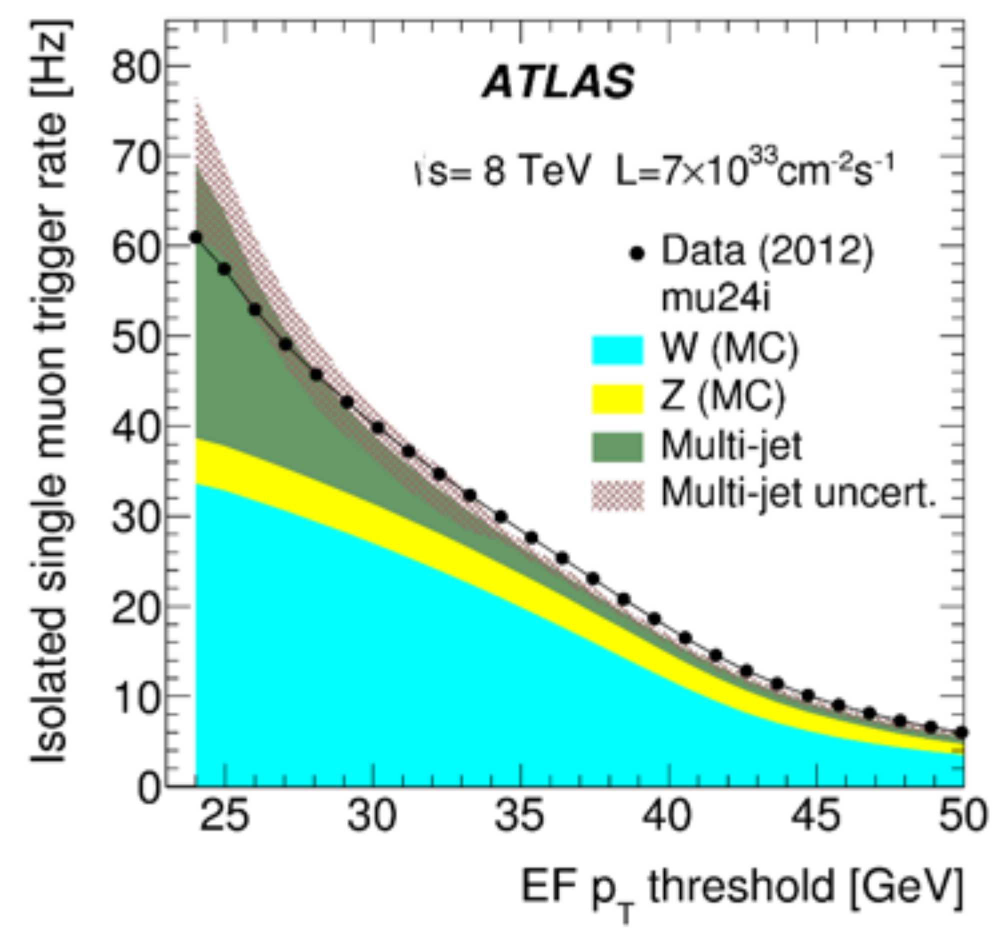
Muon trigger acceptance

Trigger “menu” plan:

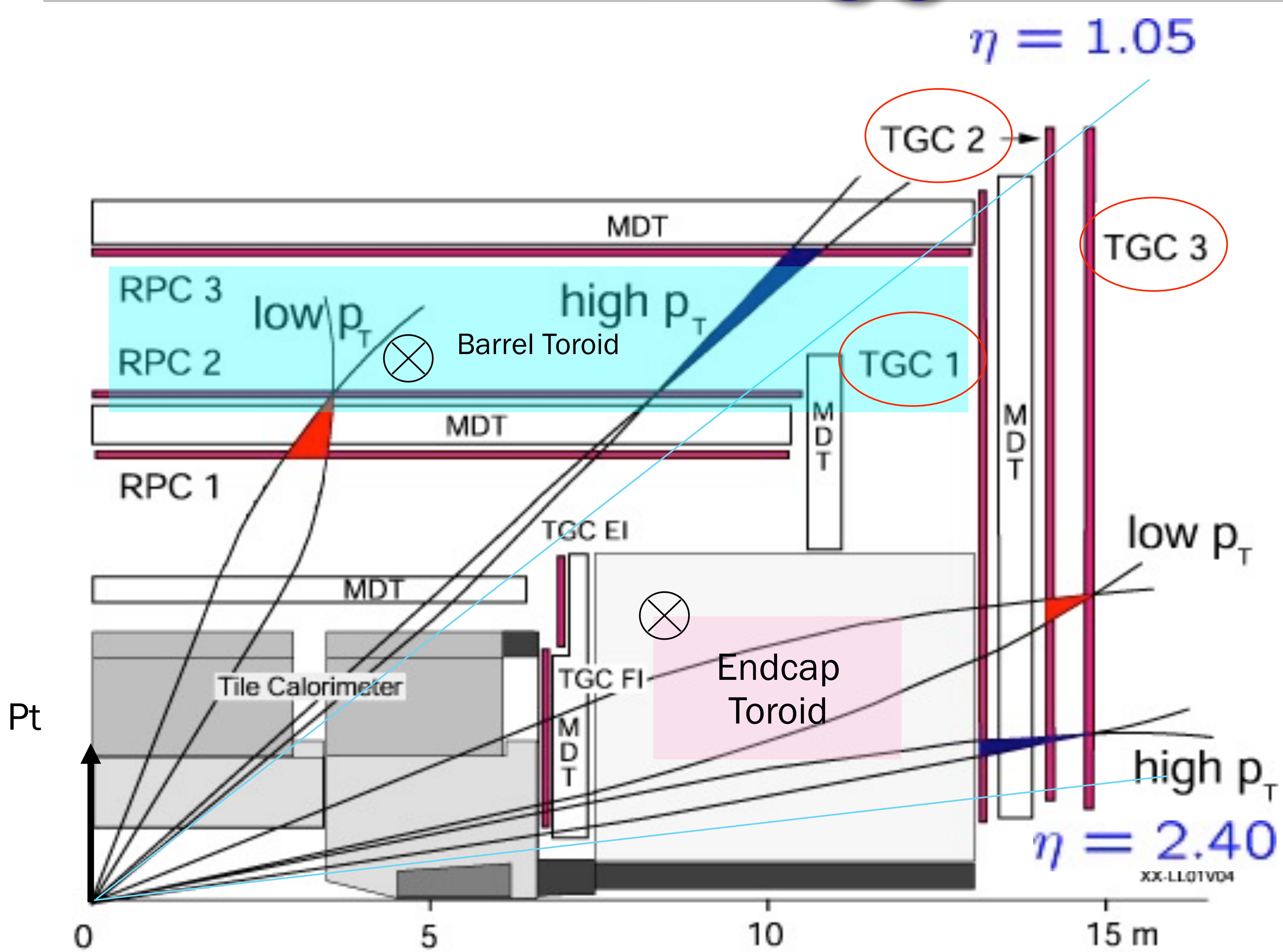
unit in GeV	Single muon	Isolated muon	Dimuon(1) symmetric	Dimuon(2) asymmetric
Thresholds in 2012	40	24	13/13	18/8
Thresholds in 2015	50	none(*)	14/14	24/8

(*) in combination to other trigger signal, or pre-scaled

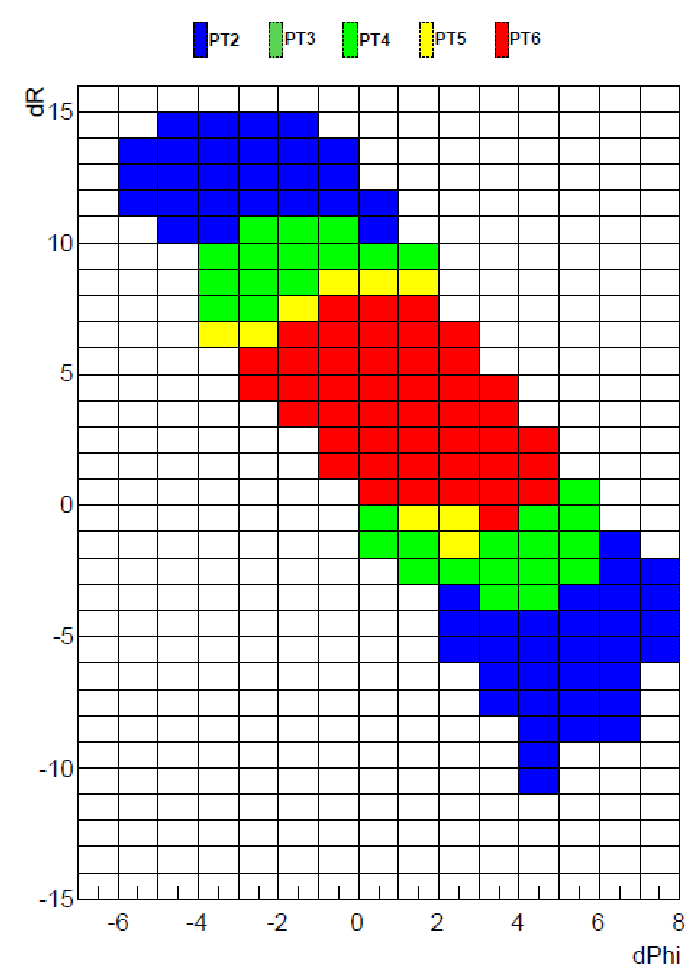
- Run1:
  - Isolated muon trigger for inclusive W/Z
  - Dimuon trigger for Z boson, H→4 lep. etc.
- Run2:
  - About x3 higher rate (lumi, energy)
  - No trigger to take W/Z inclusively need to use “special trigger” e.g. di-muon, μ+jet, μ+e



ATLAS muon trigger - Level 1



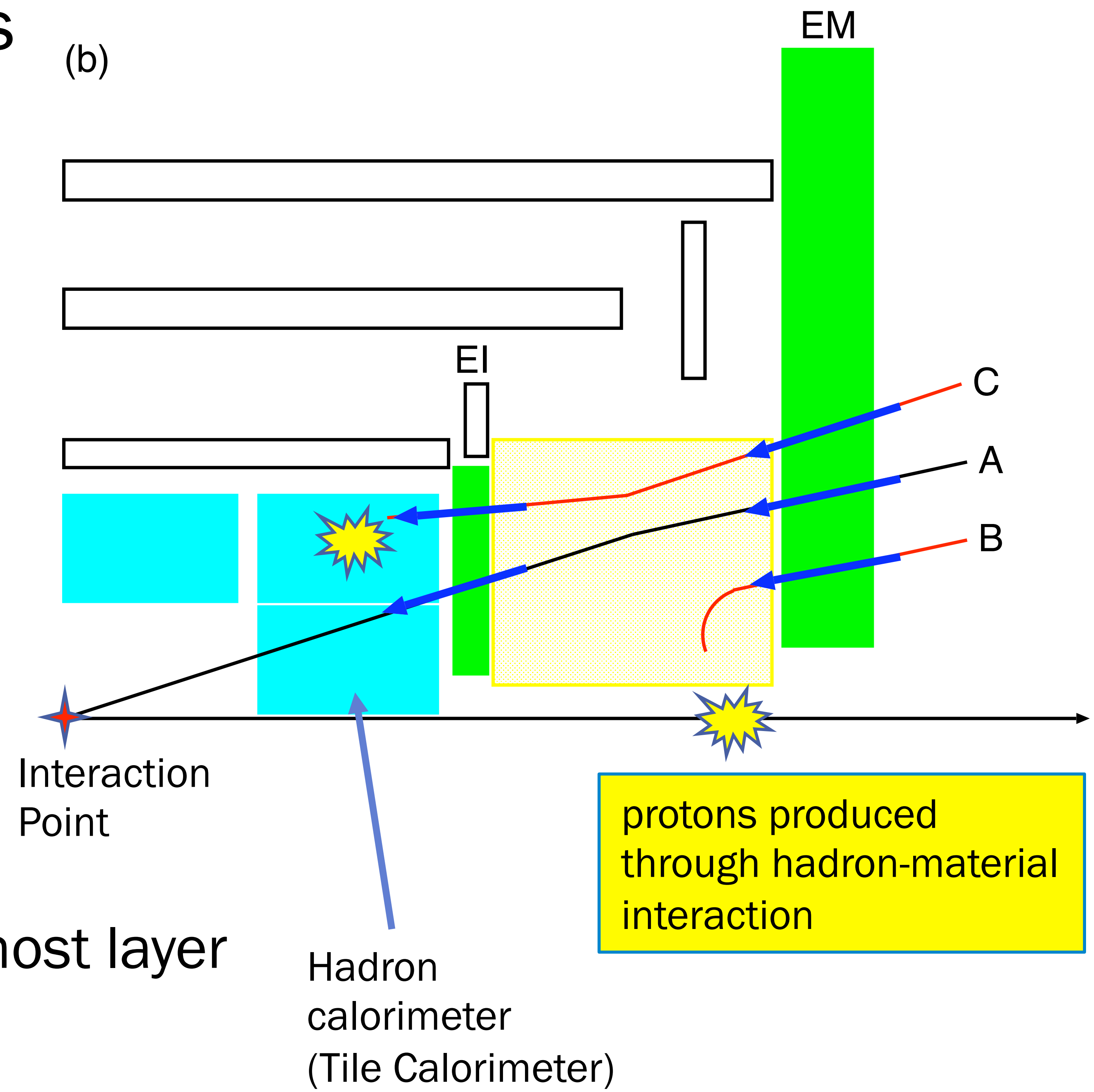
- Kobe effort: endcap trigger
  - Measuring p_T from the track angle measured by 3 layers of TGCs in the middle station
  - Using hardware look-up table (LUT)



- Improvement in Run-1
  - LUT optimisation: loose during commissioning tighter when operation is stable

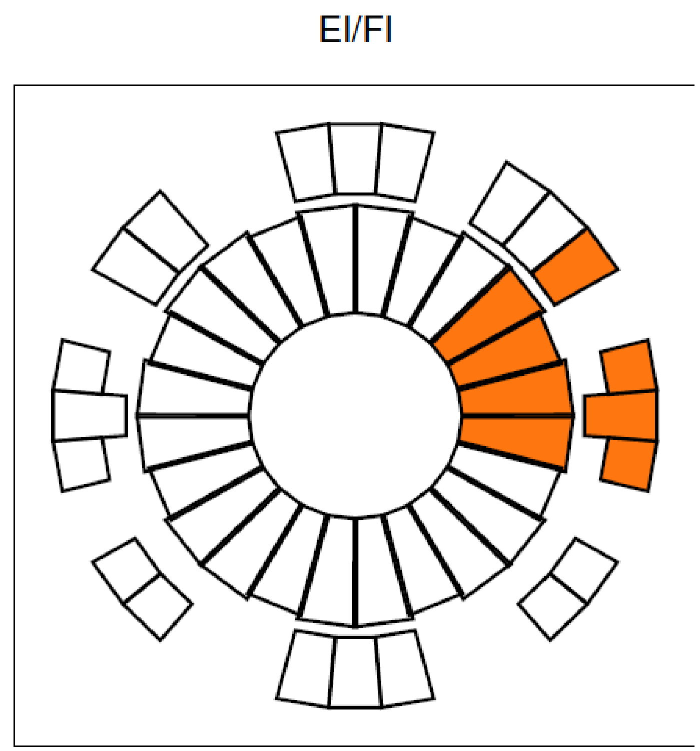
ATLAS L1 muon: background

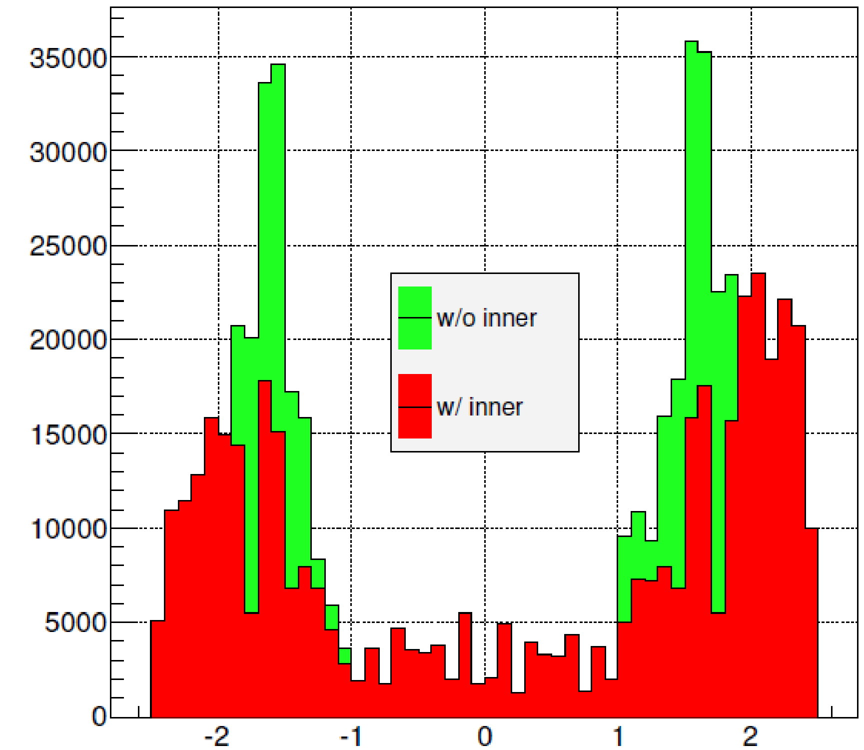
- Main background: protons
  - produced by interaction of hadrons from pp interaction and material
    - of beam element (B) or
    - in the detector (C)
- Reduction expected by
  - requiring a TGC hit in the inner station (EI) consistent with that comes from the interaction point
  - requiring energy at the rear-most layer of the hadron calorimeter



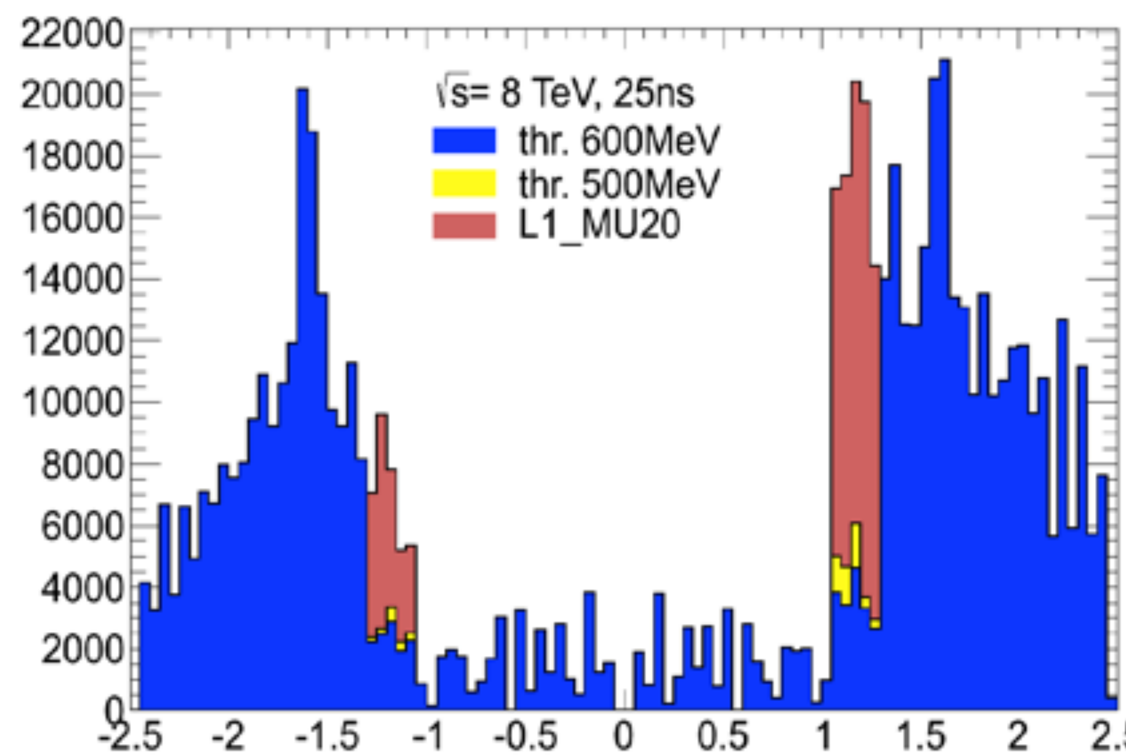
Performance with new coincidences

- Inner station
  - coincidence limited by chamber coverage
  - ~30% reduction
- Calorimeter
  - very effective reduction for 1.0<η<1.3
- Hardware being prepared
  - LUT implementation
  - Communication test with new Calorimeter trigger board developed by Brazil





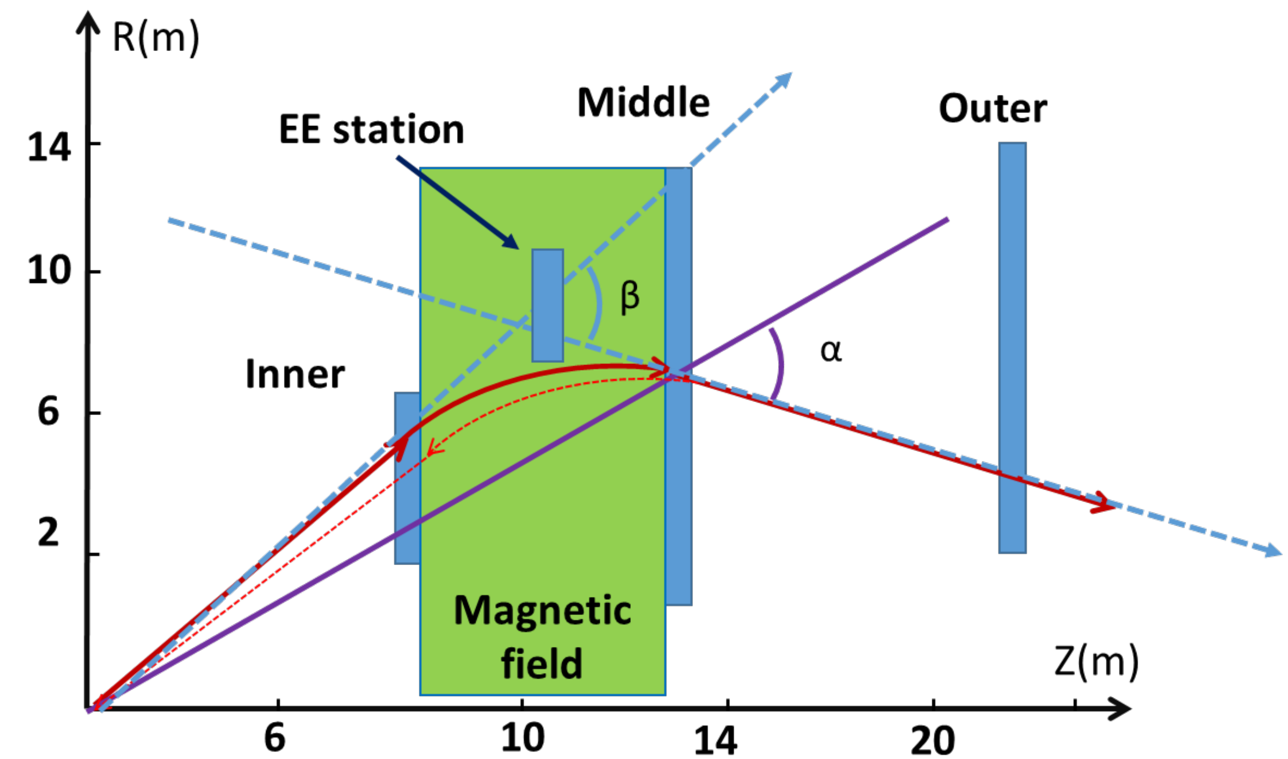
Pseudorapidity η



Pseudorapidity η

HLT muon trigger

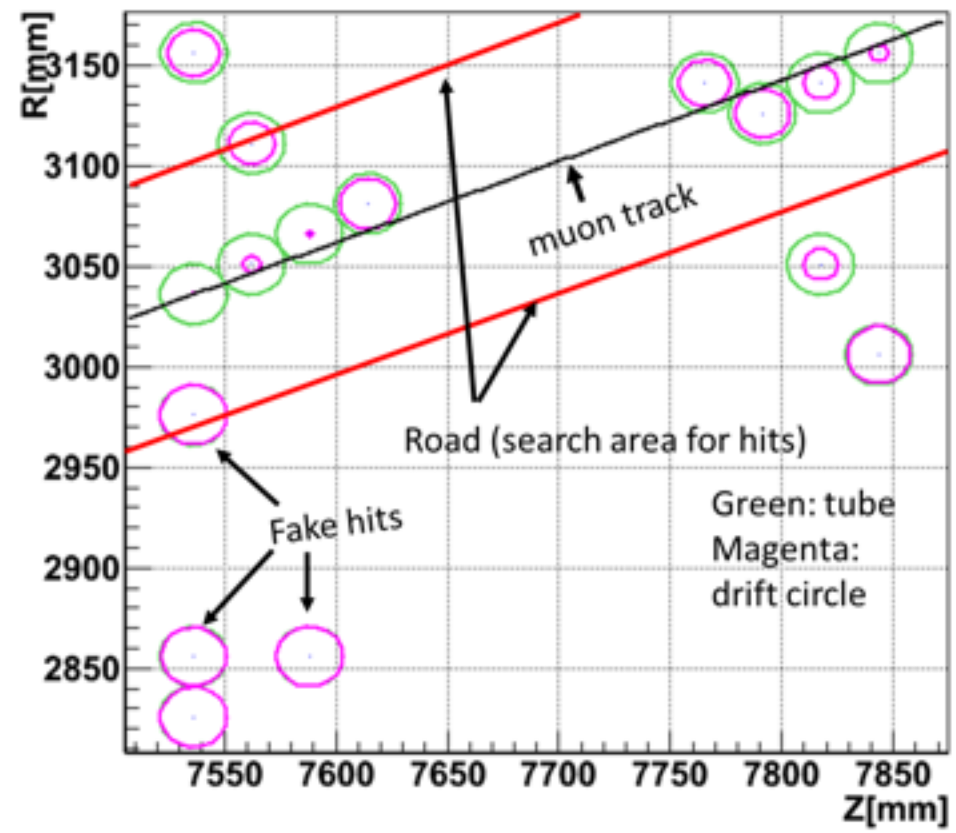
- L2 muon: outside-in strategy
  - Standalone: muon system only
    - low rate, but coarse resolution
  - Combined: require a track in the inner detector
    - precise determination of momentum
  - Endcap: bending angle

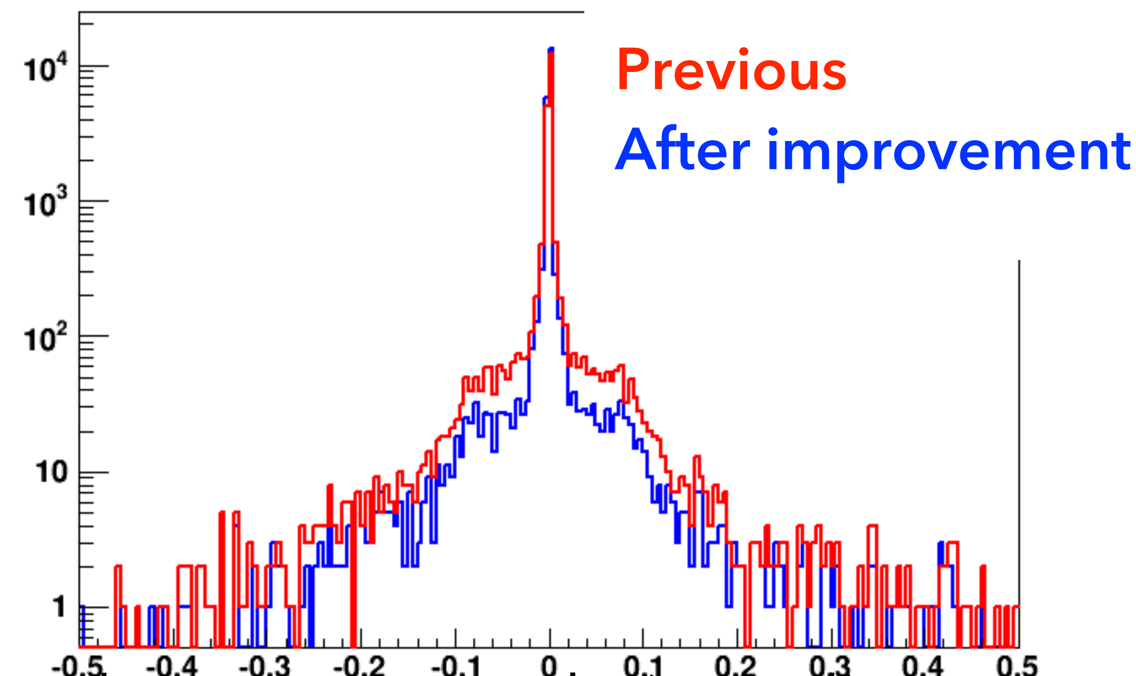


- EF muon
  - Combined muons mainly used for physics analysis
  - Optional isolation requirement using tracks/calorimetry

HLT (L2) muon: problem

- Many fake hits in MDT
  - in Inner Station
  - failure in pattern recognition
- Removing the outliers by
  - narrower searching “road”
  - removing hits with big contribution to χ^2 etc.
- Utilising EE chamber
  - One more layer in B field
    - fully installed in this shutdown
  - determining bending radius with 3 stations a la Barrel

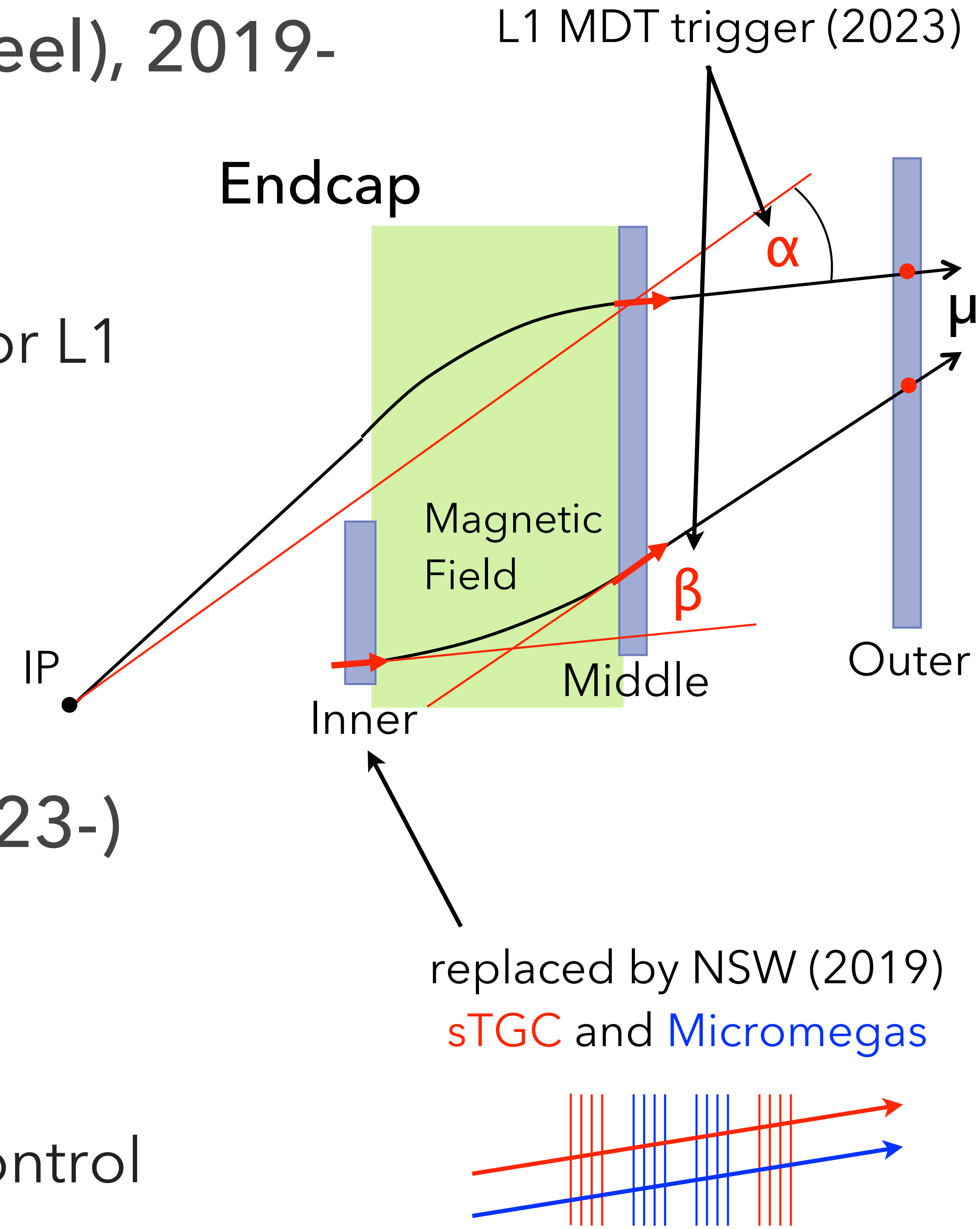




track segment angle (in rad)
deviation from that reconstructed offline

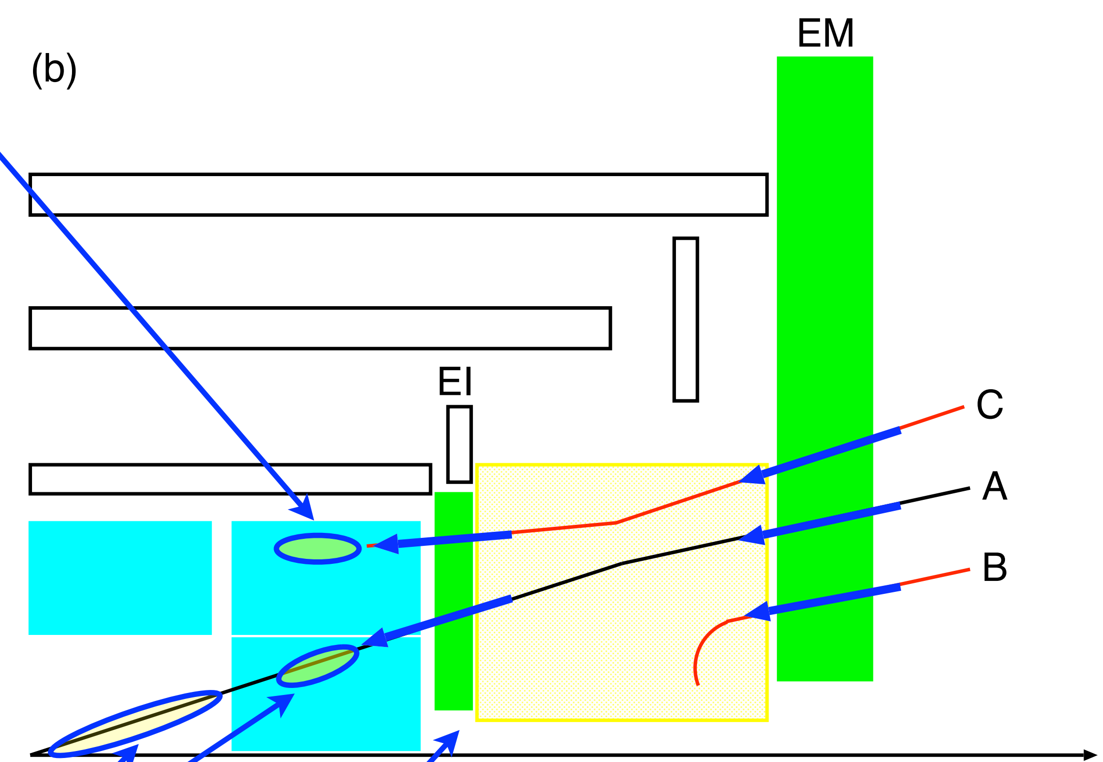
L1 upgrade: future plan

- Mid. term: NSW (New Small Wheel), 2019-
  - upgrading the inner station
  - Narrow strip: stronger for pileup
  - Providing both fast signal (sTGC) for L1 and precision measurement (Micromegas) for HLT/analysis
    - ~130 μm position resolution
  - see next talk by A. Ochi
- Long Term: fast MDT trigger (2023-)
  - The β parameter also for L1
- Kobe contribution
  - Micromegas production, quality control
  - electronics, LUT optimisation



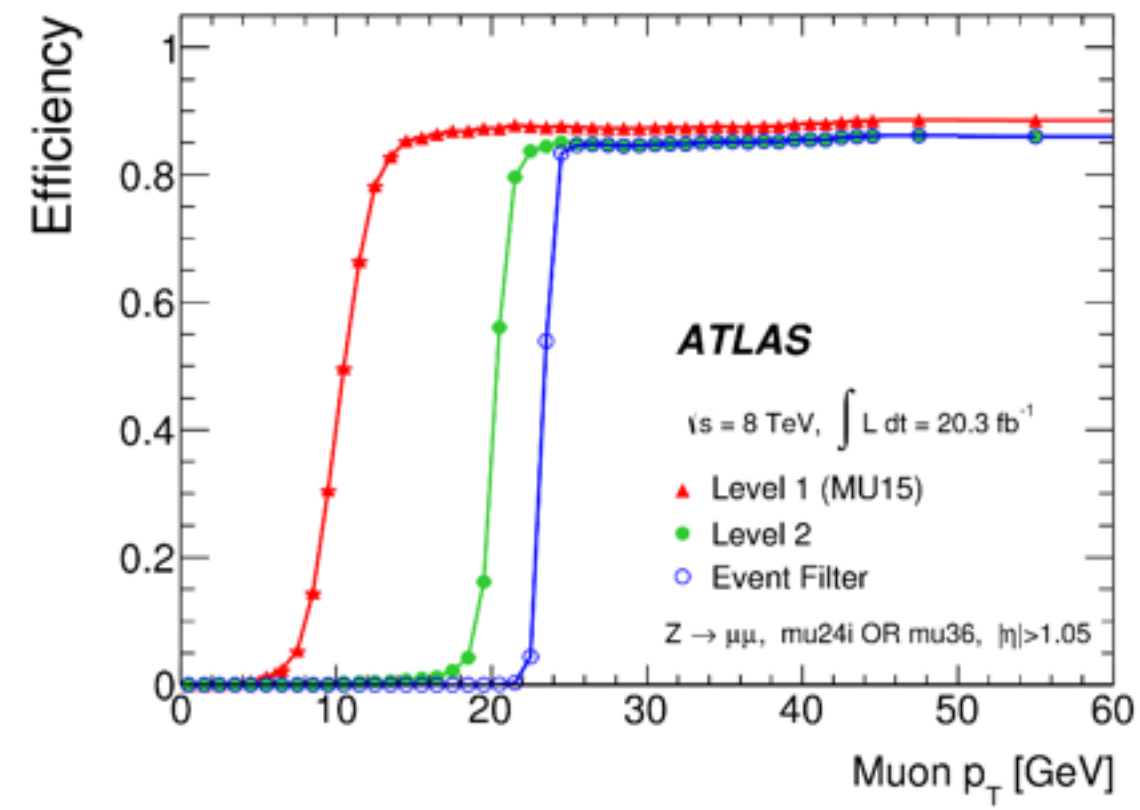
L2 upgrade: future plan

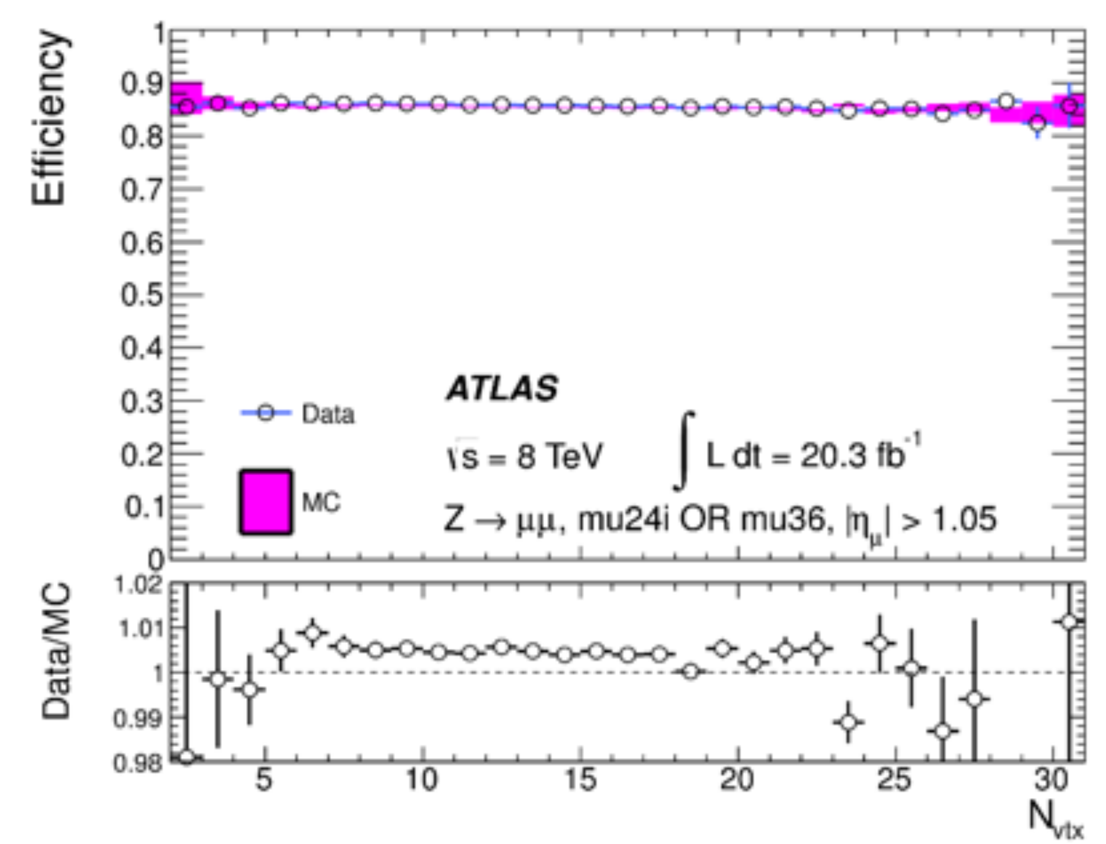
- Coincidence with TileCal
  - like L1, still possible reduction of fakes
- Track-seeded algorithm
  - Hardware-based FTK (fast tracking) available from 2015
    - Signal is ready while L2 starts to process
  - FTK-track + a segment in Inner Station or TileCal may suffice to find a muon track?
- HLT development for NSW for 2019
  - Fast algorithm at the first step of muon HLT algorithm sequence



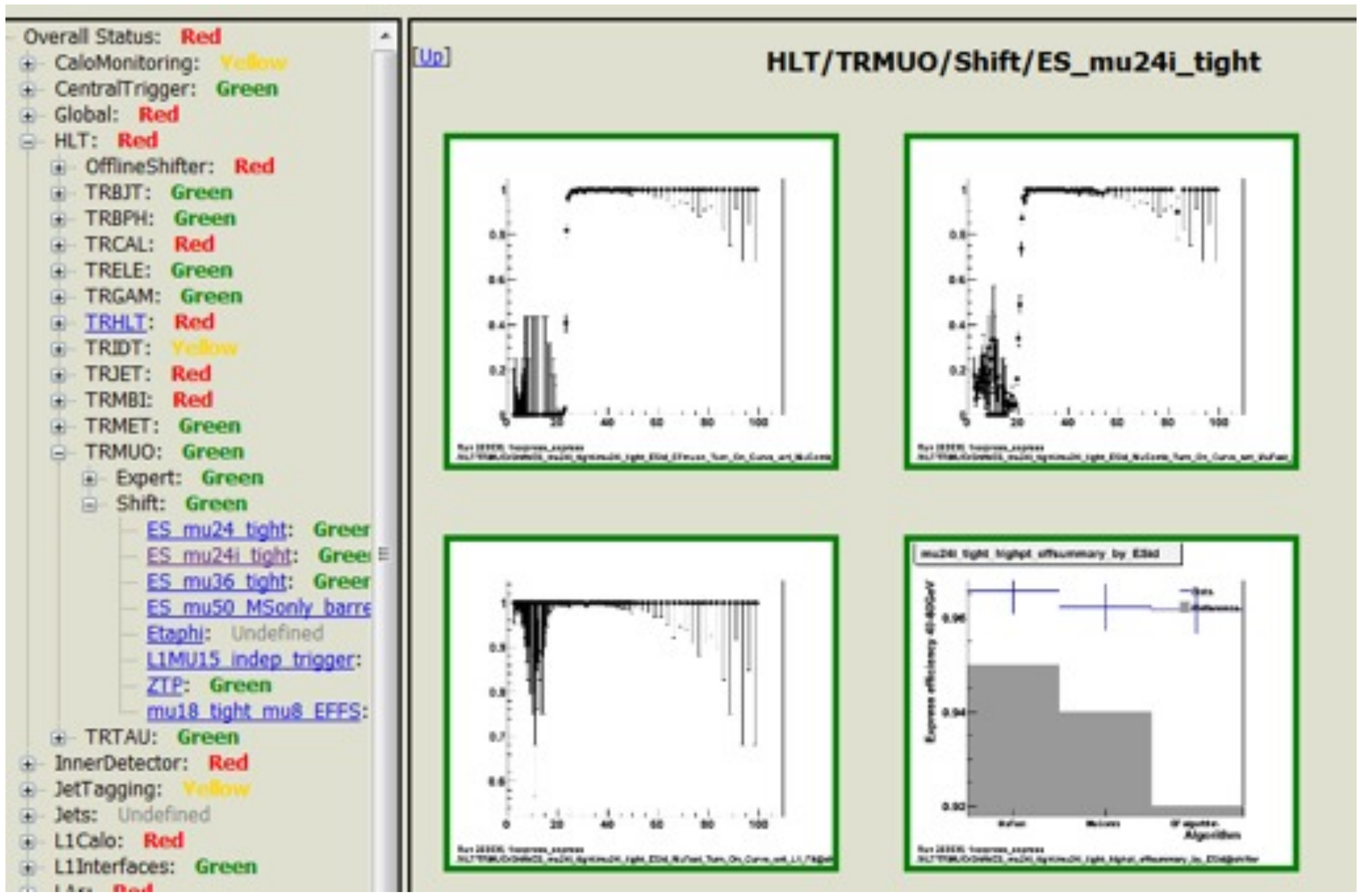
Understanding the trigger

- Precise determination of the trigger efficiency
  - using copious $Z \to \mu\mu$ decays
- The "MC scale factor"
  - precision: typically below 1%
  - also simulation good to <1% level
- Little dependence to the amount of pileup
  - muon trigger is robust for high-luminosity environment

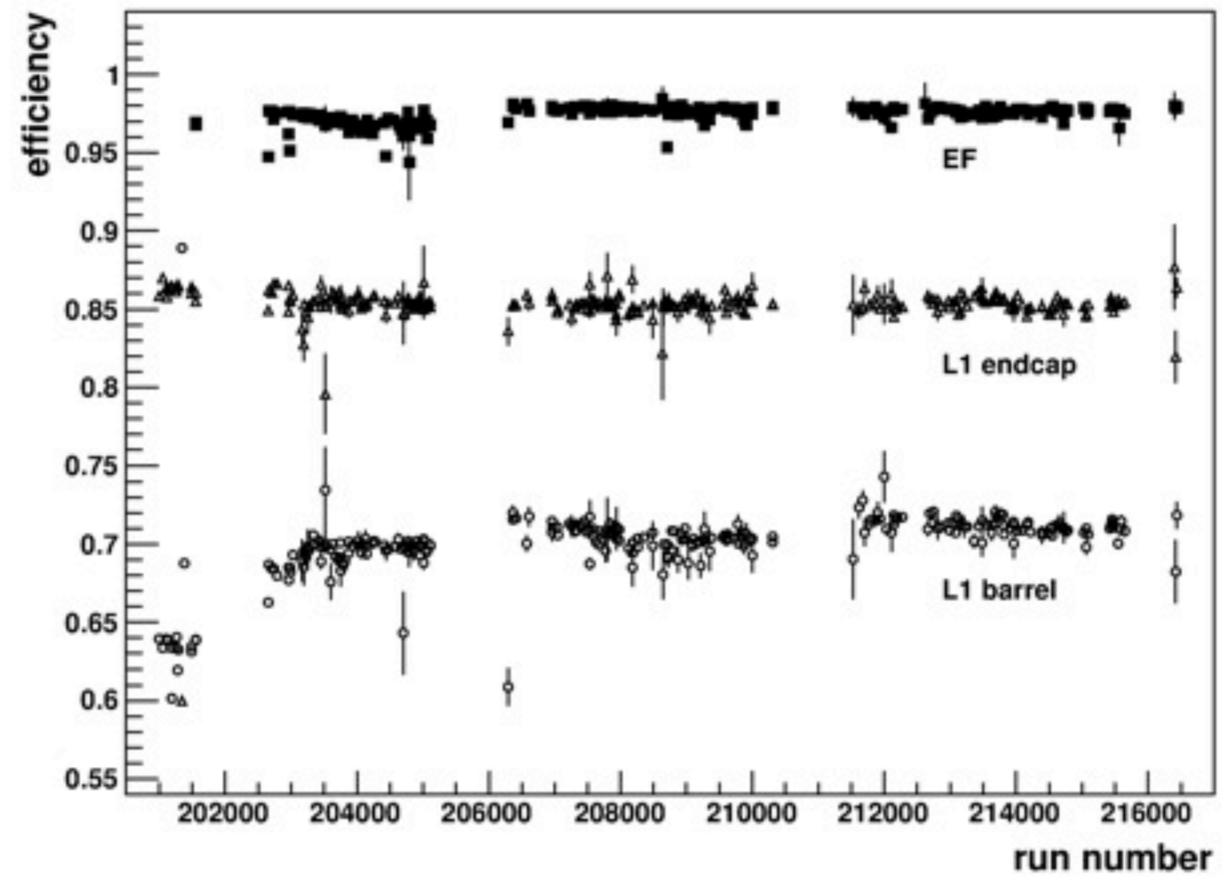




Monitoring the trigger: data quality



Web page display for DQ histograms: example for HLT



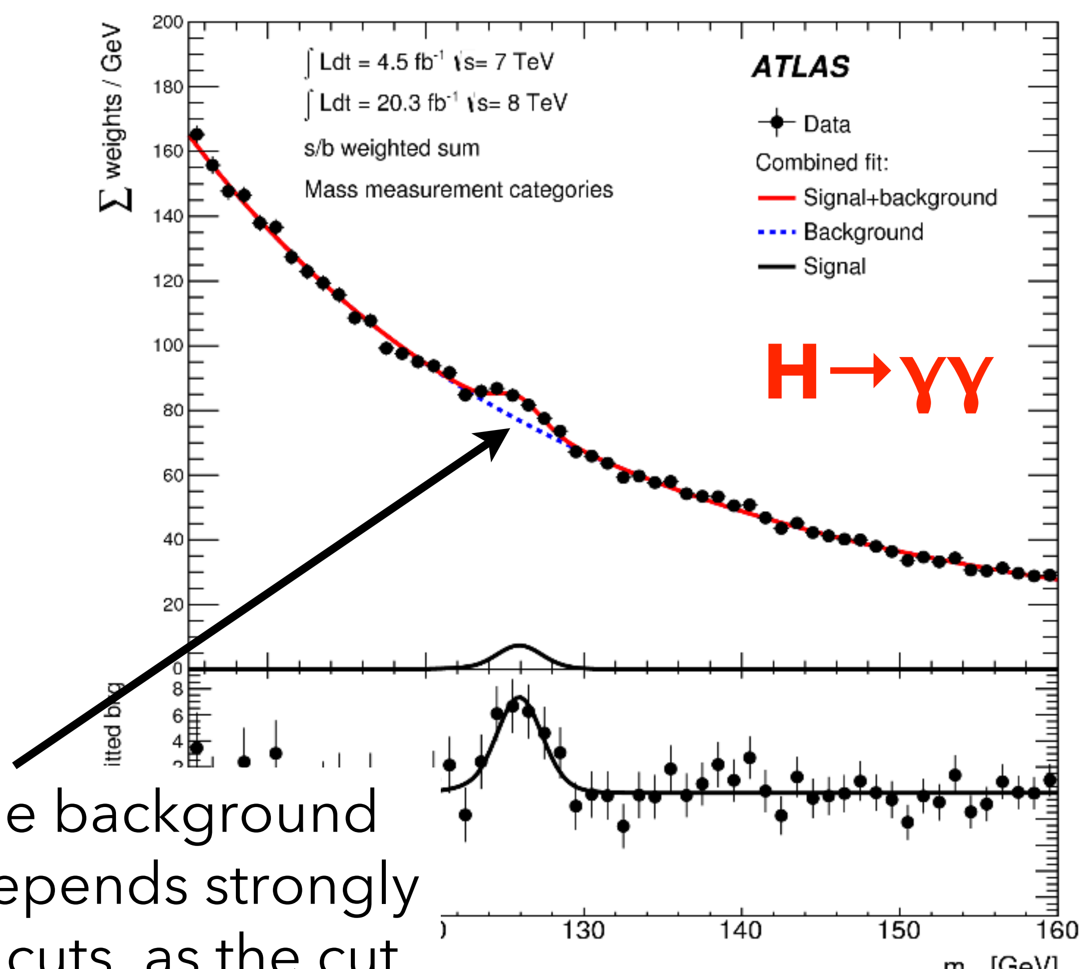
Trigger efficiency vs run number for 2012 operation

- Both L1 and L2 muon trigger monitors developed by Kobe
- Helping stable operation

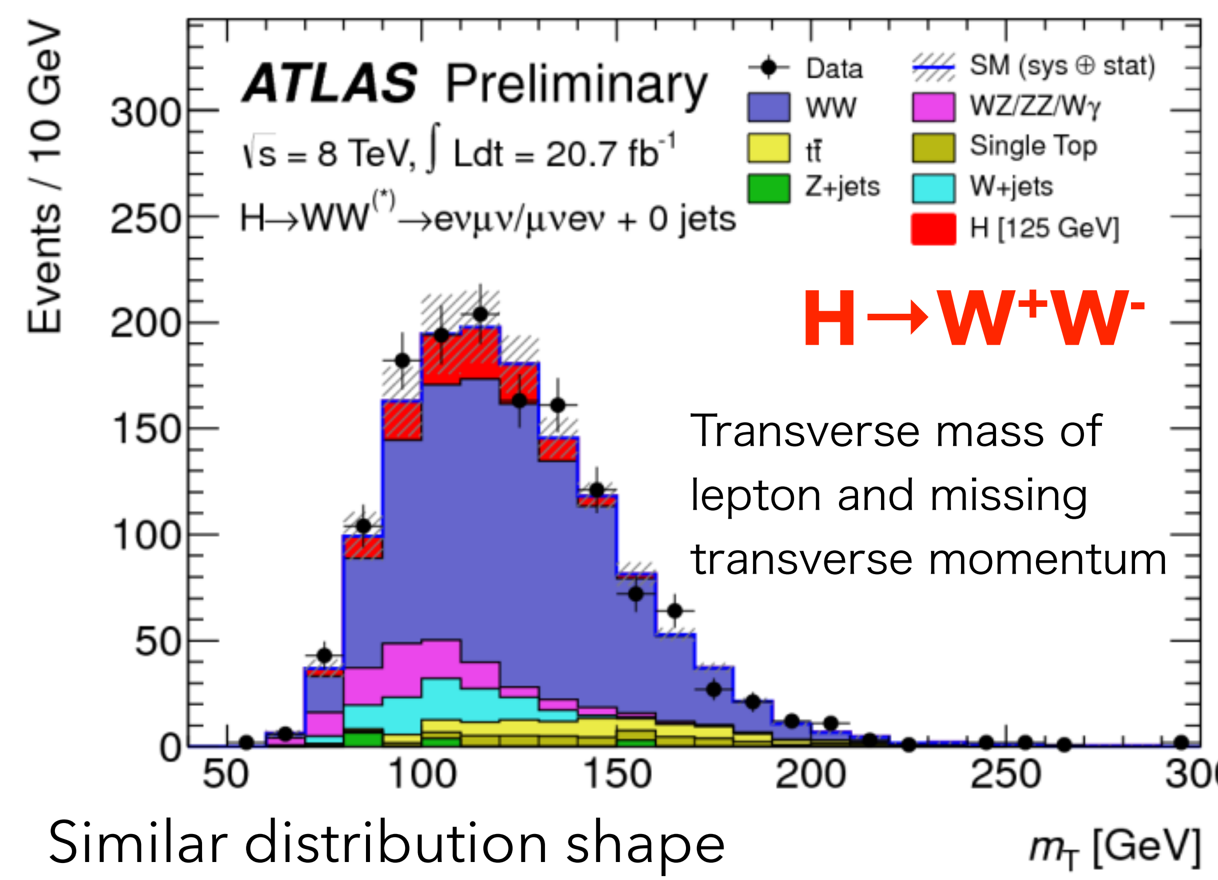
ATLAS Physics from Kobe

Reducing errors in Higgs cross-section measurements through H→llνν

- L. Yuan and T. Kishimoto from Kobe
- Main focus: extending the kinematic range
  - Higgs is lighter than what was assumed when designing analysis
  - But this increasing background, too



Shape of the background does not depends strongly on analysis cuts, as the cut values are low enough.

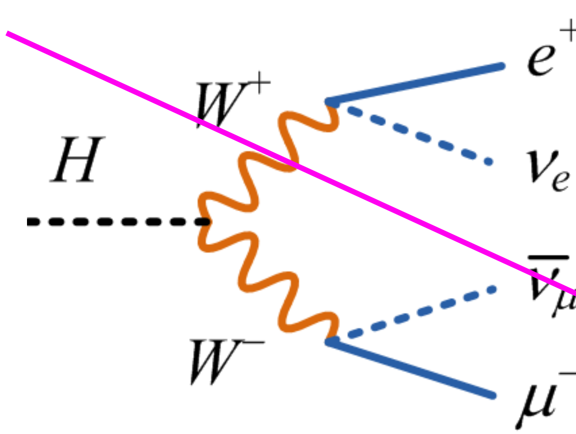


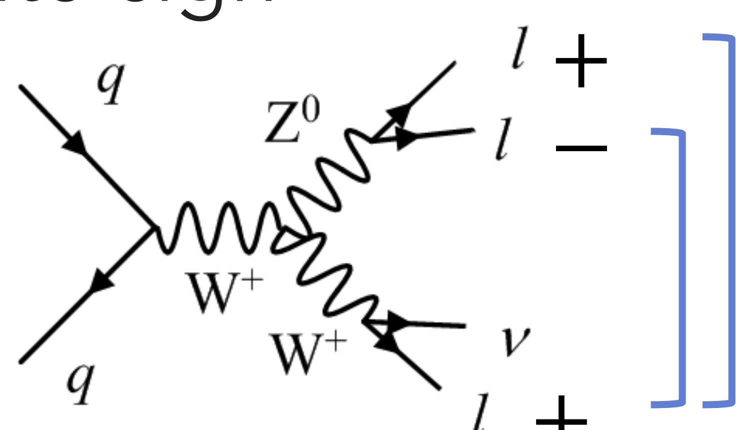
Similar distribution shape between Signal and Background
→ difficult to distinguish

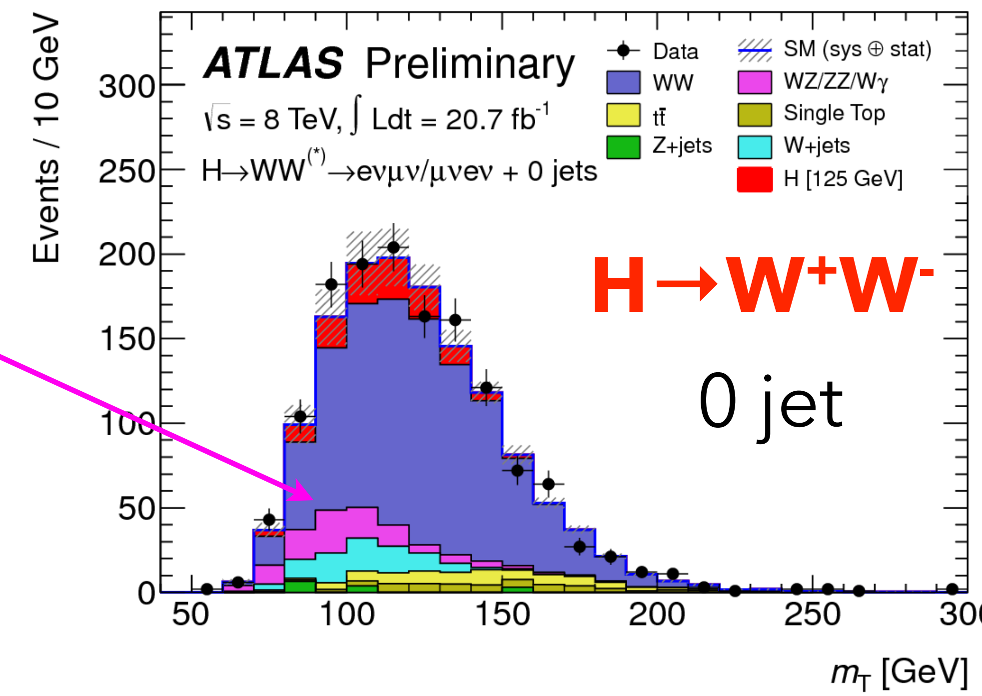
final result in preparation…

Background estimation technique developed by us

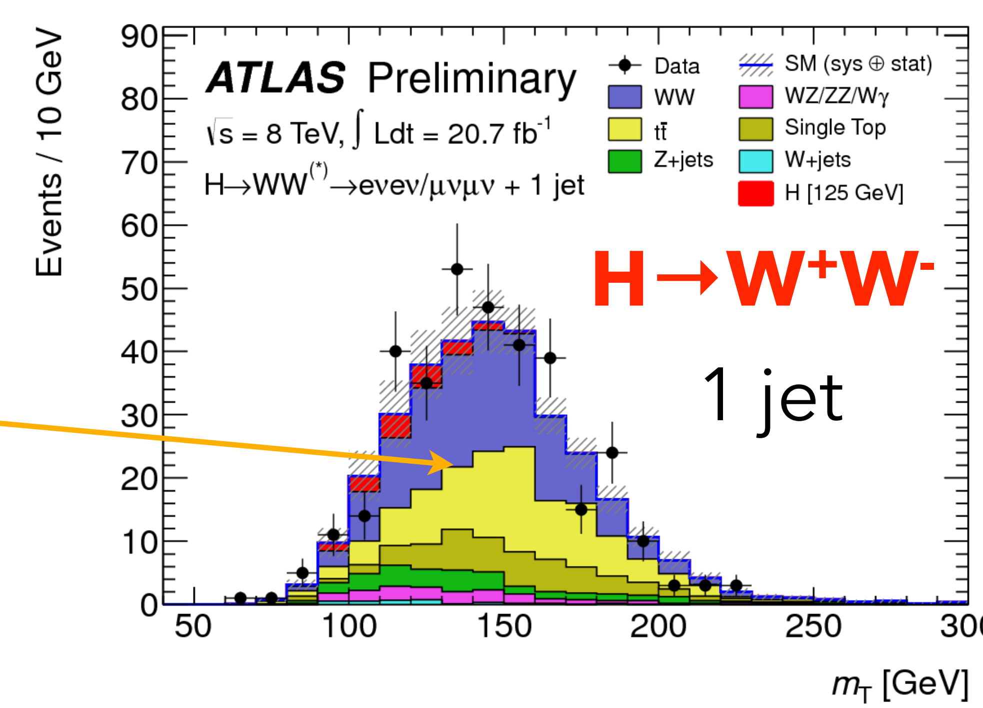
- Diboson (WZ, ZZ, Zγ)
  - looks similar to signal in extended kinematic range
  - use the same-sign contribution to estimate opposite-sign signal





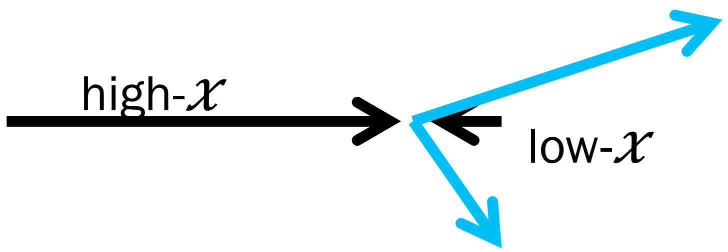


data-driven method to improve precision in estimation

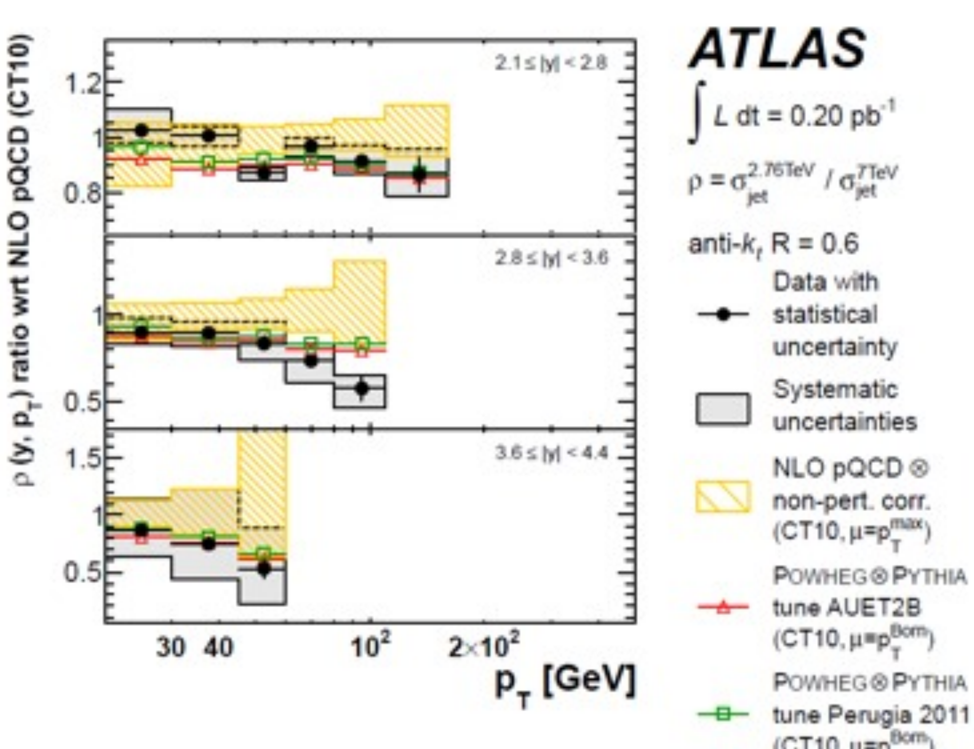


- Top quark
  - Using exactly the same sample to the data analysis to estimate b-quark rejection efficiency

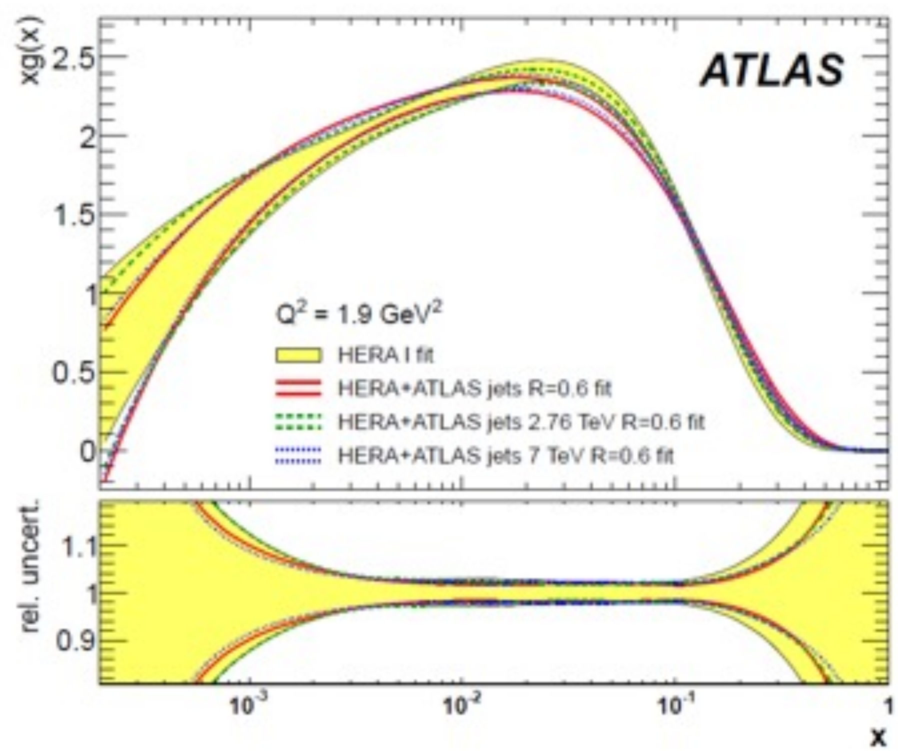
Forward jet in different CMS energies and parton densities in proton



- by S. Shimizu
- asymmetric configuration of jet production
  - sensitive to parton densities in both low-x and high-x regions



vs POWHEG ⊗ PYTHIA
(NLO interfaced to parton shower)



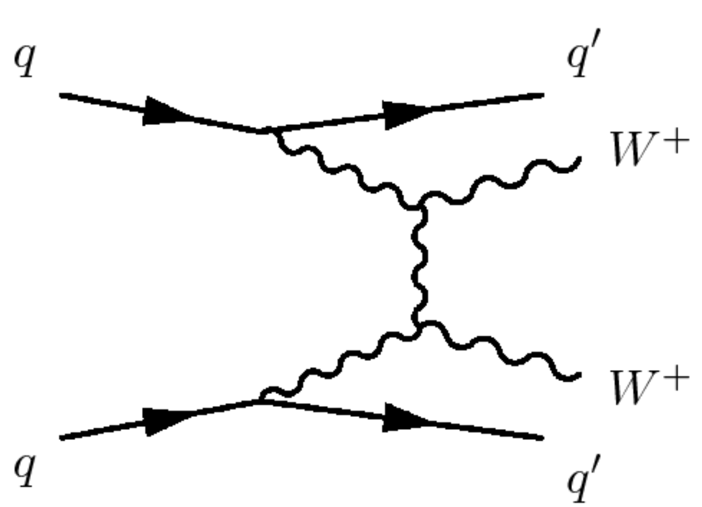
Other contributions in physics analyses

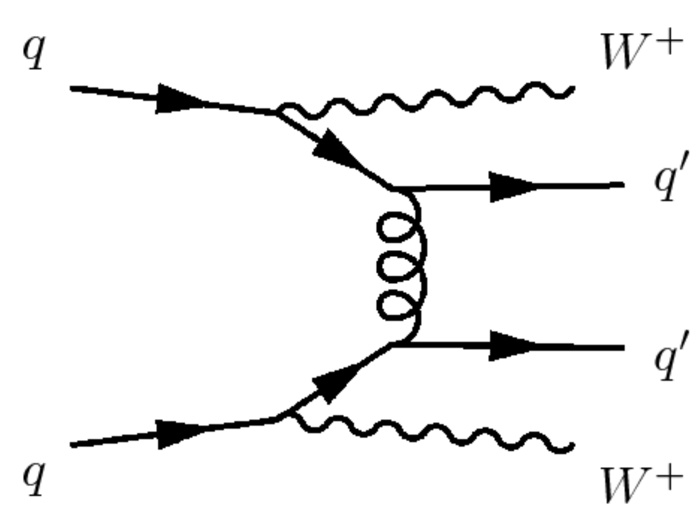
- Standard model jet+photon
  Previous subgroup convener (S. Shimizu)
- Speakers committee member (Y. Yamazaki)
- Editorial board: internal referees (S. Shimizu, Y. Yamazaki)

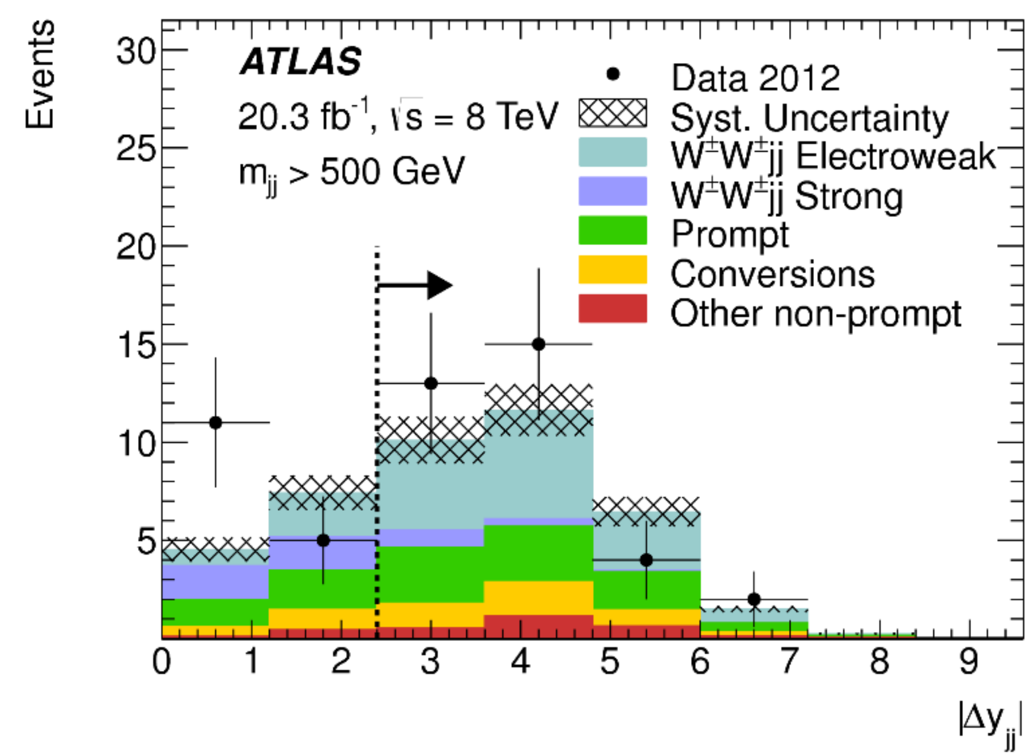
Forward jet: large $|\Delta y_{jj}|$

Central jet: small $|\Delta y_{jj}|$

An example: first evidence of EW diboson scattering







Summary

- Kobe contribution muon trigger on
  - construction
  - future development

- Physics analysis
  - Various contribution, experience gained
  - Jumping into Run-2, wishing for (at least) one more discovery.