Level-1 Calorimeter Jet and Missing E_T Simulation

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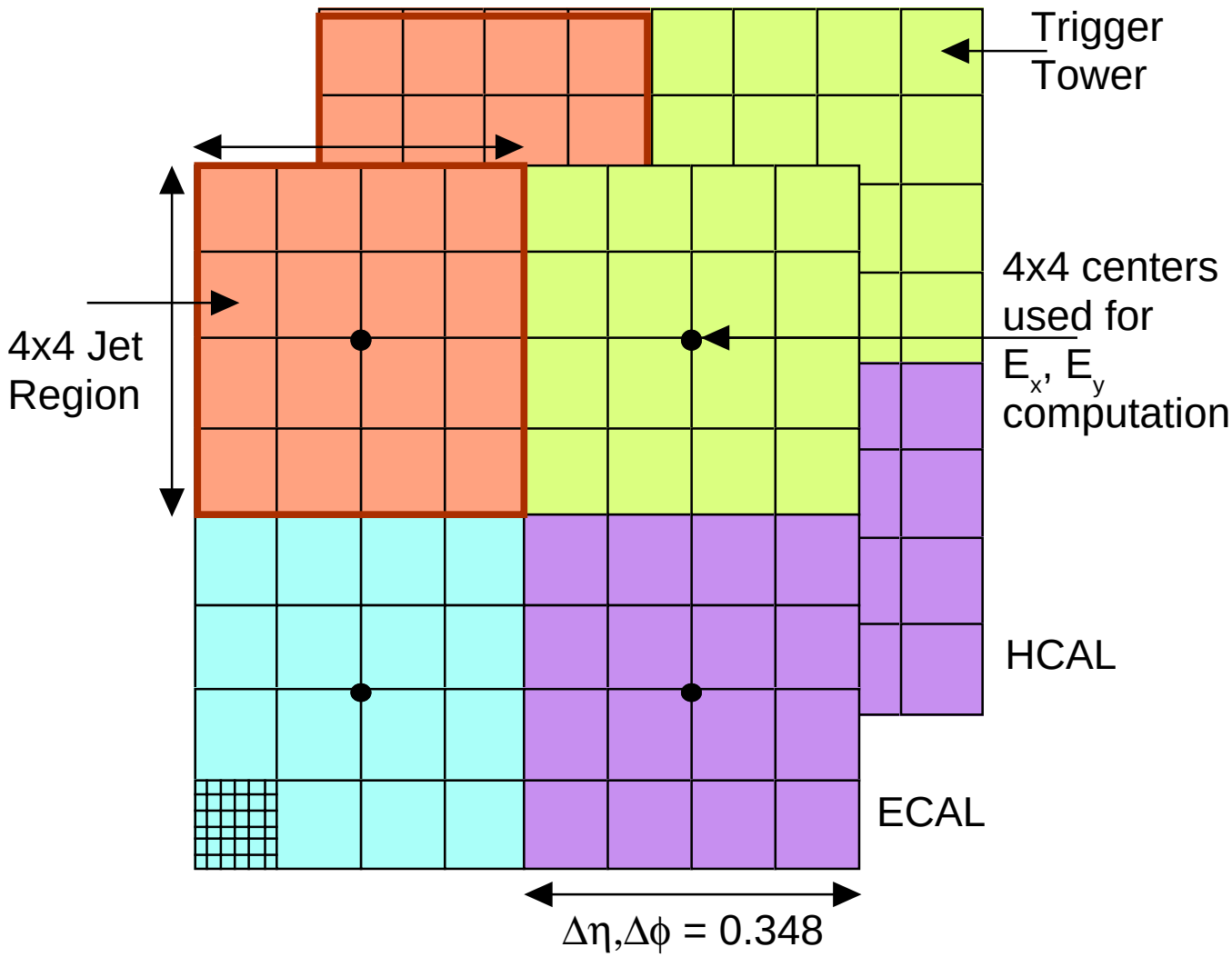
Algorithms
- Jet regions
- Sums and sorts

Simulation tools
- CMSIM 114 & 111
- FASTSIM
- TRGSIM

Simulation results
- Efficiency and rates
- Comparisons

New tools
- ORCA - OO Level-1 simulation
- Plans

Jet, Missing E_T algorithms



Jet E_T is given by the sum of ECAL and HCAL trigger tower E_T in a non-overlapping 4x4 region

Jet candidates are sorted to find highest energy jets

Jet trigger is caused by core of the physical jet. This allows for jet counting without the problems of dealing with multiple jets overlapping in large (0.7hx0.7f) regions

E_X and E_Y are obtained by a memory lookup using 4x4 E_T

Signed E_X and E_Y sums over the entire calorimeter are made to calculate missing E_T

Tools: Generators, Detector & Trigger Simulation

Generators
- PYTHIA
  - QCD jet events with various ranges of P_T
  - Minbias events
  - Some Higgs/top signal events for electron/photon trigger
- ISAJET
  - ISASUSY events with technical proposal (A) settings

Detector simulation
- CMSIM
  - GEANT based
  - Used essentially as a black box
  - Cuts tuned to be somewhat larger 10 MeV
    - > Speeds up execution
  - Tracker used only as dead material
  - Tracked only within the 4T solenoid
- FASTSIM
  - Home brewed
  - Simplified geometry
    - > Tracker is uniform w/ appropriate r.l.
    - > No holes in calorimeter
      - Except between EB/EE
    - > Gap between calorimeters empty
    - > Pre-TDR geometry (matches CMSIM 111)
  - Parameterized showers
    - > Transverse and longitudinal shapes parameterized using GEANT simulation in bulk PbWO4 and Cu-Scin.
    - > Checked to match published data

Trigger simulation
- Trigger primitives are simply sum of hits
  - No attempt at electronics pulse shaping and filtering effects
- Details of cutoffs and limited resolution scales
- Integer arithmetic matching trigger hardware

Consistency
- Same events simulated using all programs

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CMSIM Configuration Differences

CMSIM 111 configuration

- Calorimeter extends to $|\eta| = 2.6$
- Barrel ECAL: 6x6 crystals per trigger tower
- Endcap ECAL: Variable size/count crystals grouped in $0.087\eta \times 0.087\phi$ towers
- HCAL: $0.087\eta \times 0.087\phi$ towers, except last tower which is doubled in η.
- Preshower not used
- ECAL crystal groups line up with HCAL
- Trigger towers match HCAL towers

CMSIM 114/115 configuration

- Calorimeter extends to $|\eta|=3$.
- Barrel ECAL: 5x5 crystals per trigger tower
- Endcap ECAL: 5 sq. cm face crystals in super modules
- HCAL: $0.087\eta \times 0.087\phi$ towers, except the last few larger towers extending coverage to $|\eta|=3$.
- No preshower in barrel but included in endcap
- Trigger towers match HCAL towers
- ECAL crystals "contained" in the HCAL tower used

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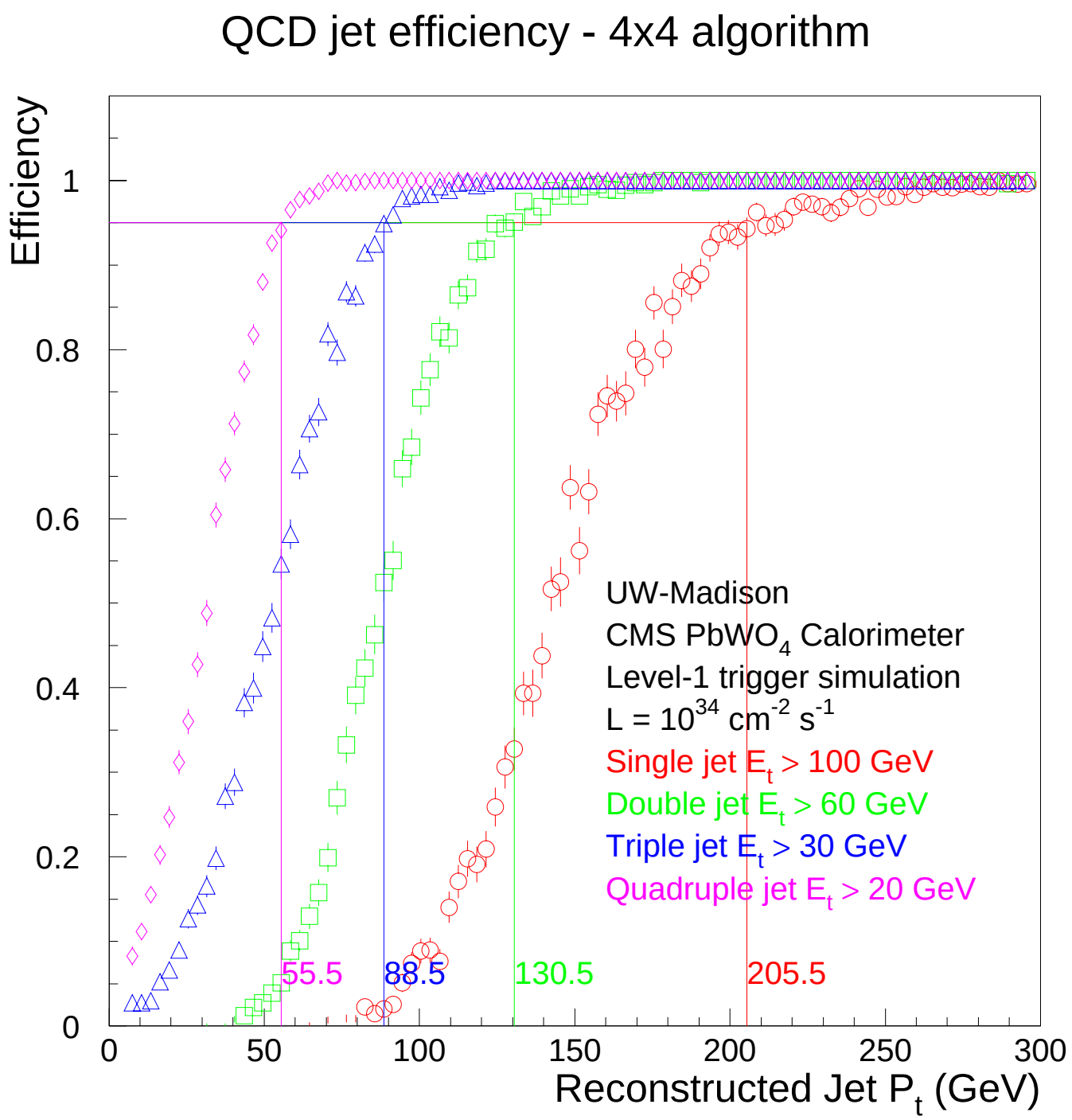
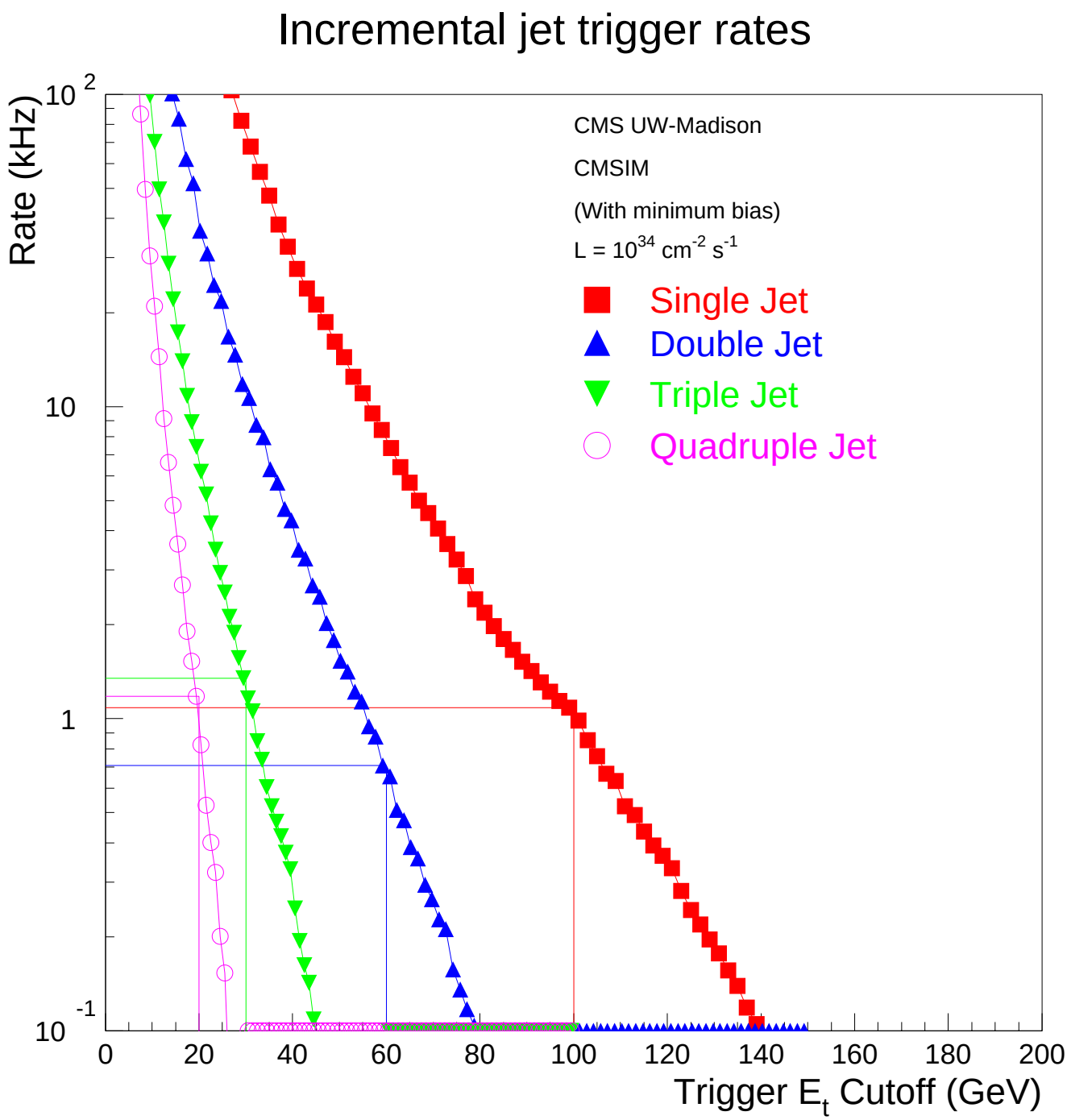
Jet trigger efficiency



Jet trigger efficiency plotted versus particle level reconstructed jet P_T

Cumulative efficiency for multi-jet triggers plotted versus smallest of the reconstructed jet P_T

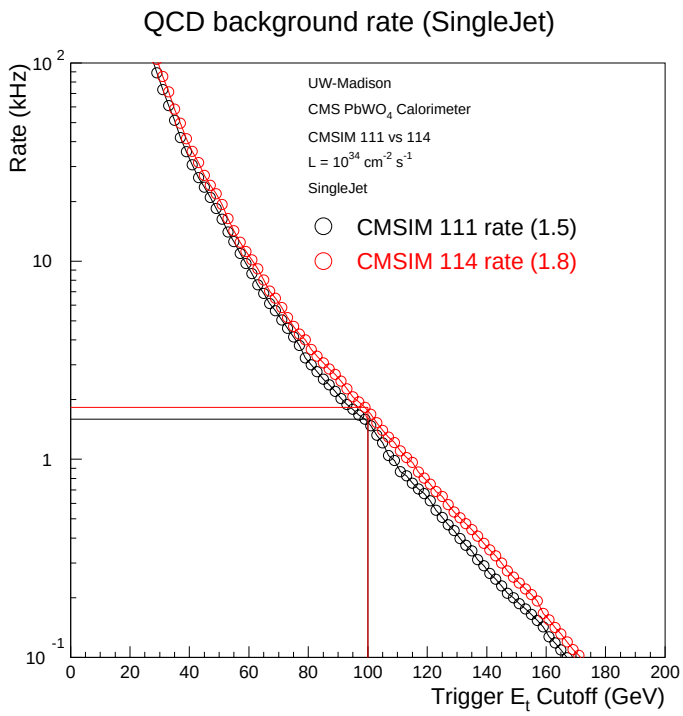
Jet trigger rates

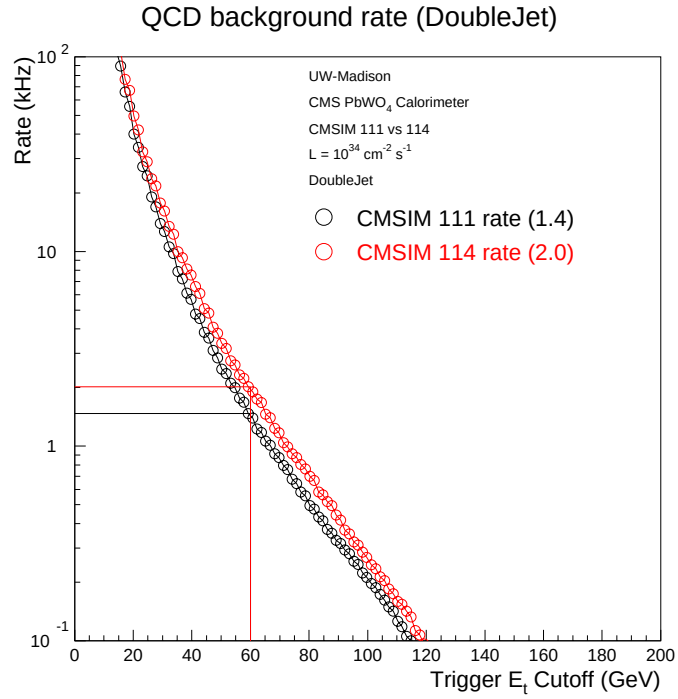


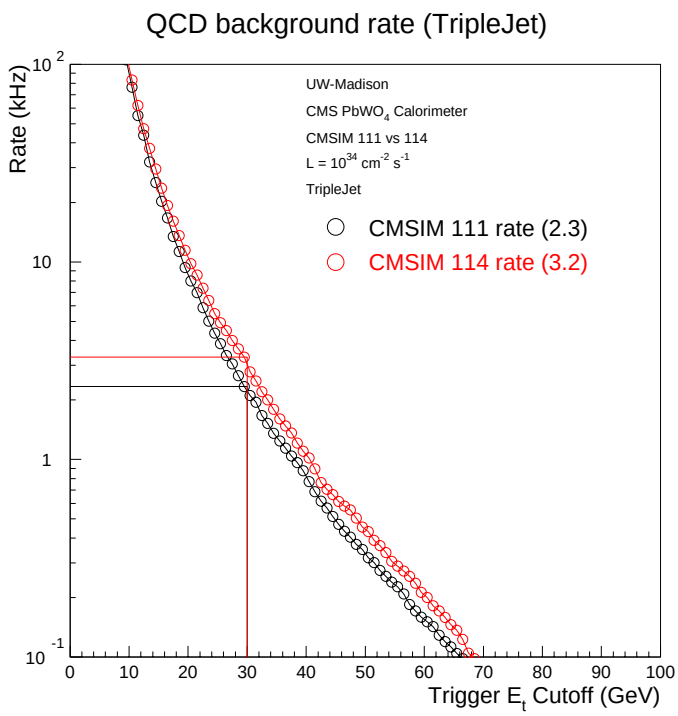
Integrated trigger rate above the trigger E_T cutoff is plotted versus the E_T cutoff.

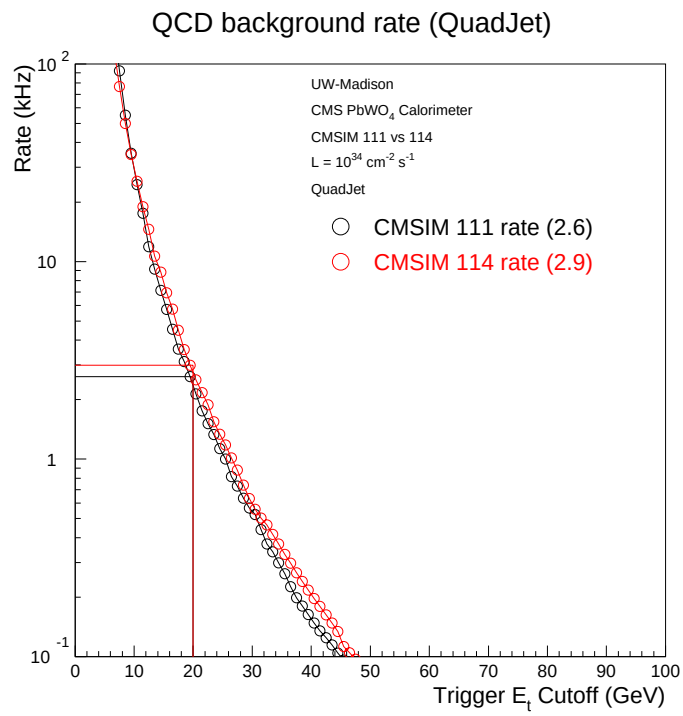
Multijet rates are incrementally over lower multiplicity triggers.

Jet rate: CMSIM 111 vs 114





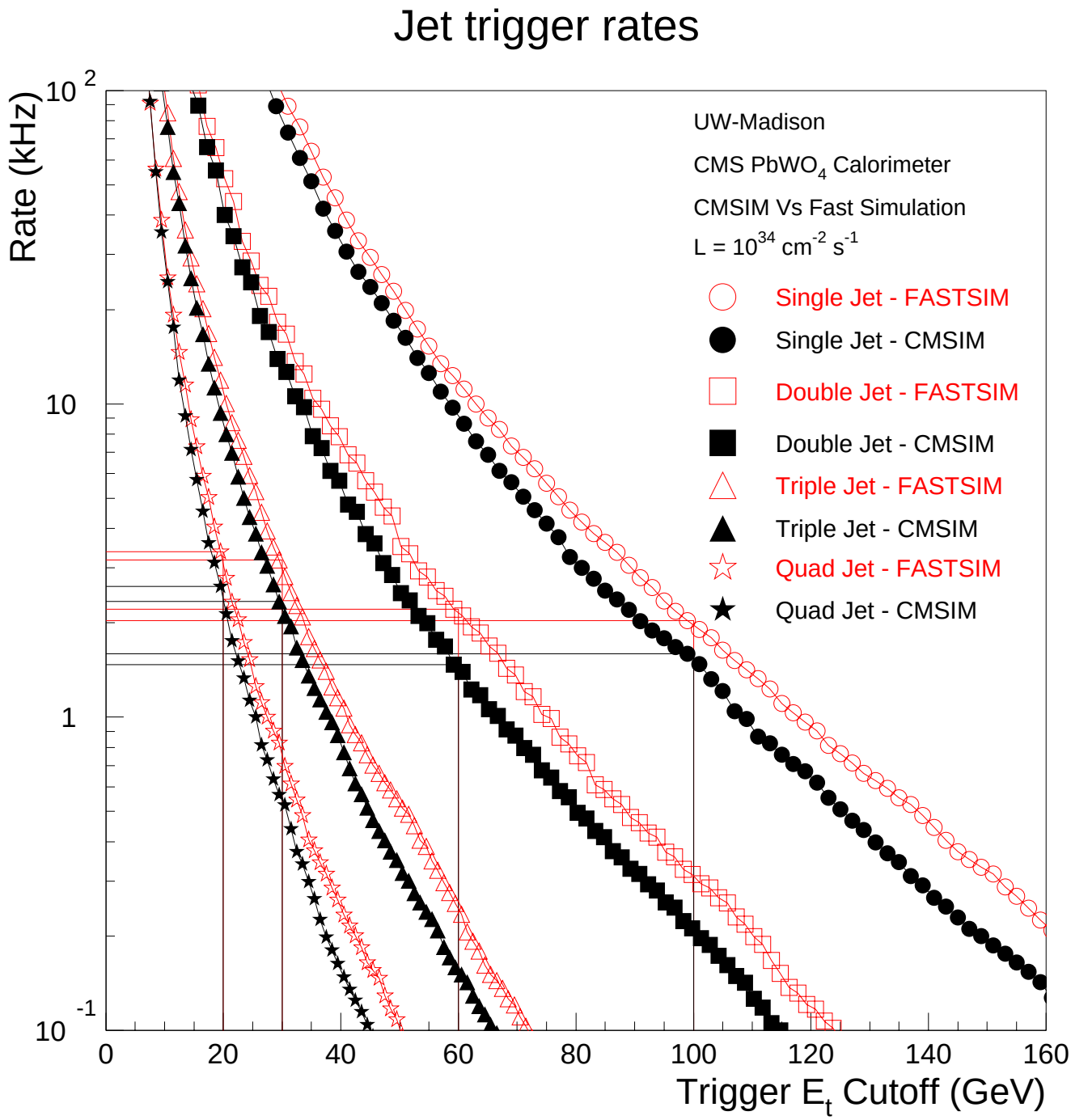




Integrated jet trigger rates plotted as a function of trigger E_T cutoff comparing CMSIM 111 versus 114.

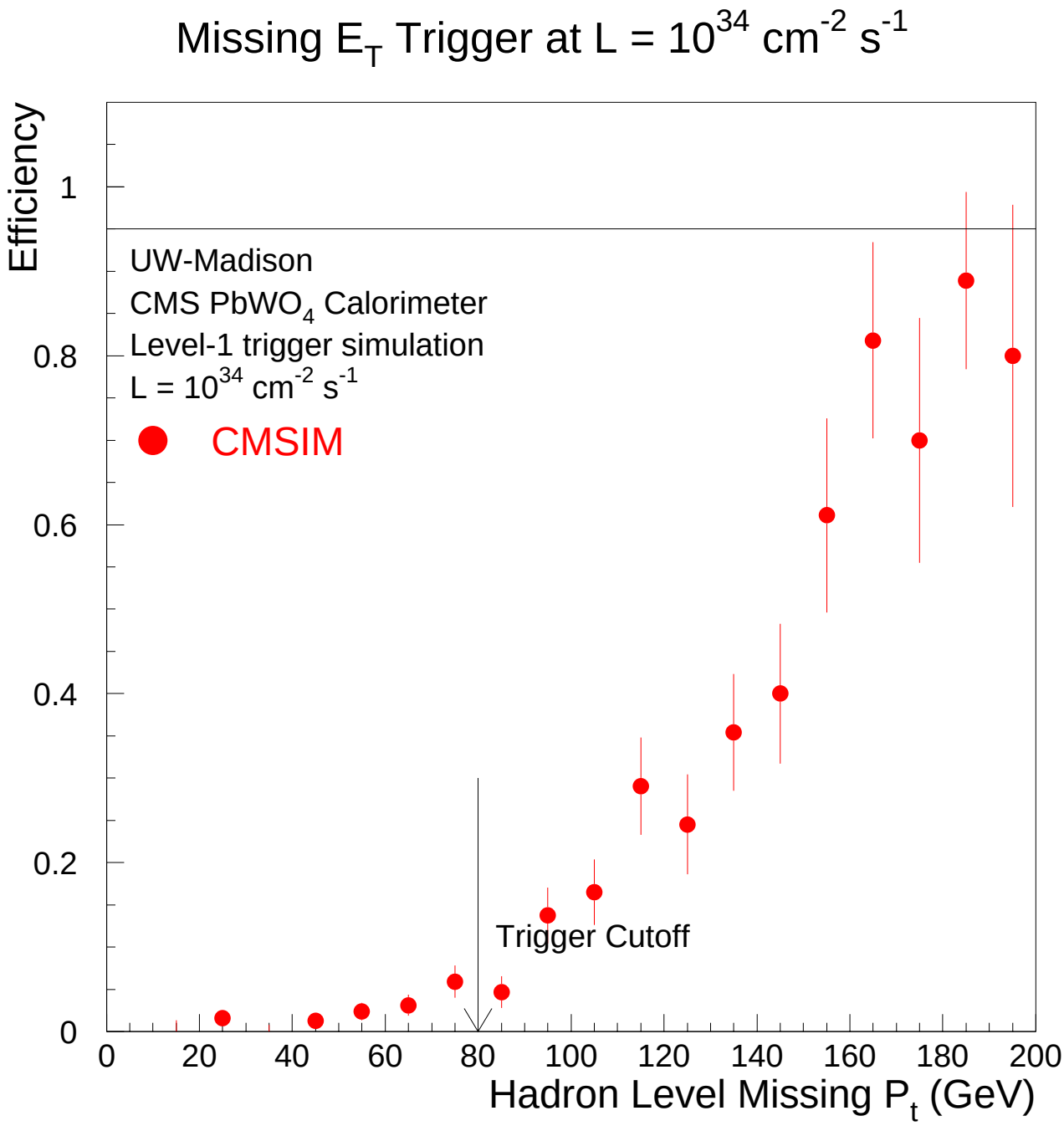
The rates are only marginally higher.

Jet rate: FASTSIM vs CMSIM 111



For what it is worth - a consistency check.

Missing E_T efficiency

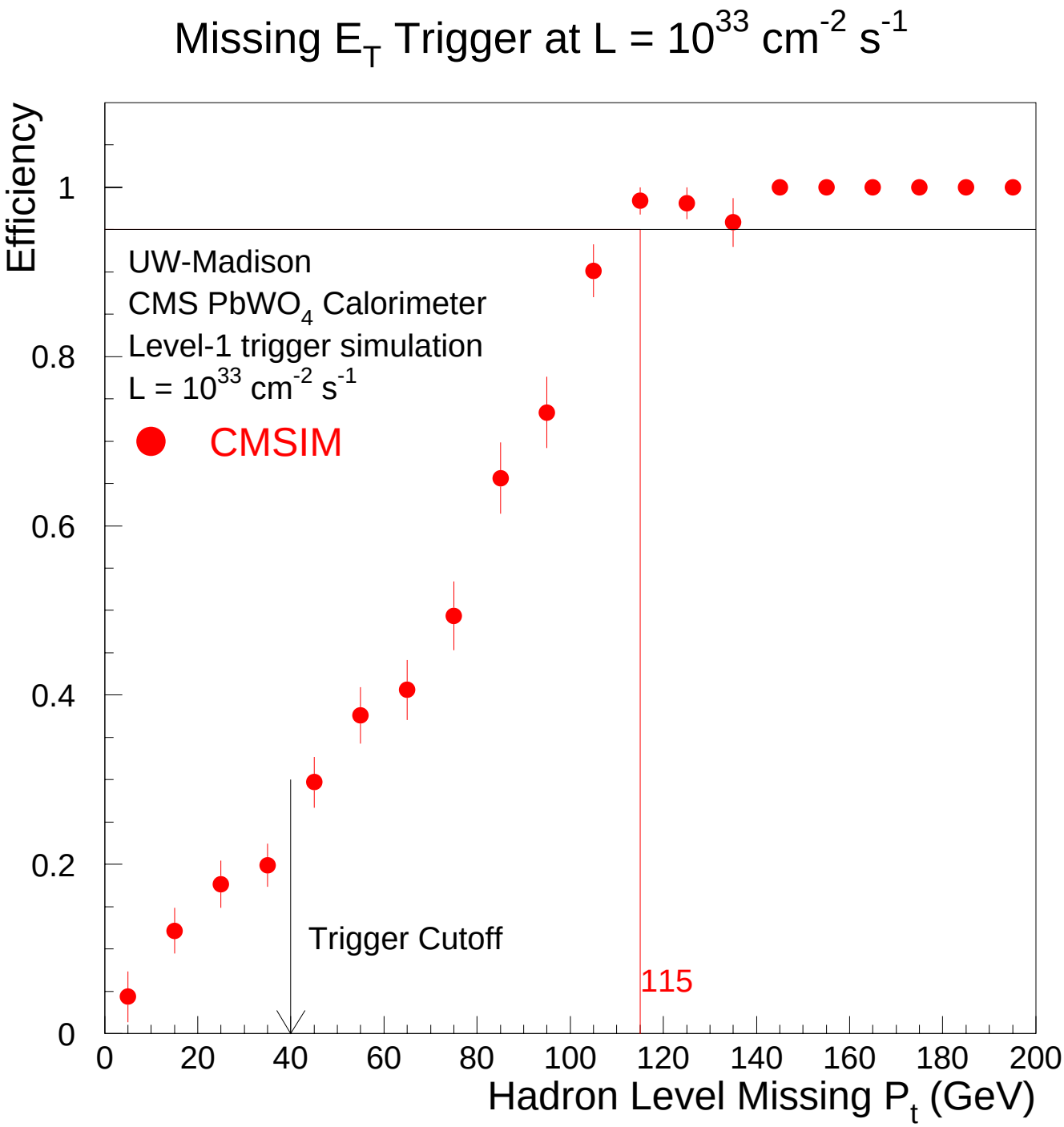


ISASUSY events - plotted versus generated hadron level missing E_T

Rather slow turn-on of efficiency

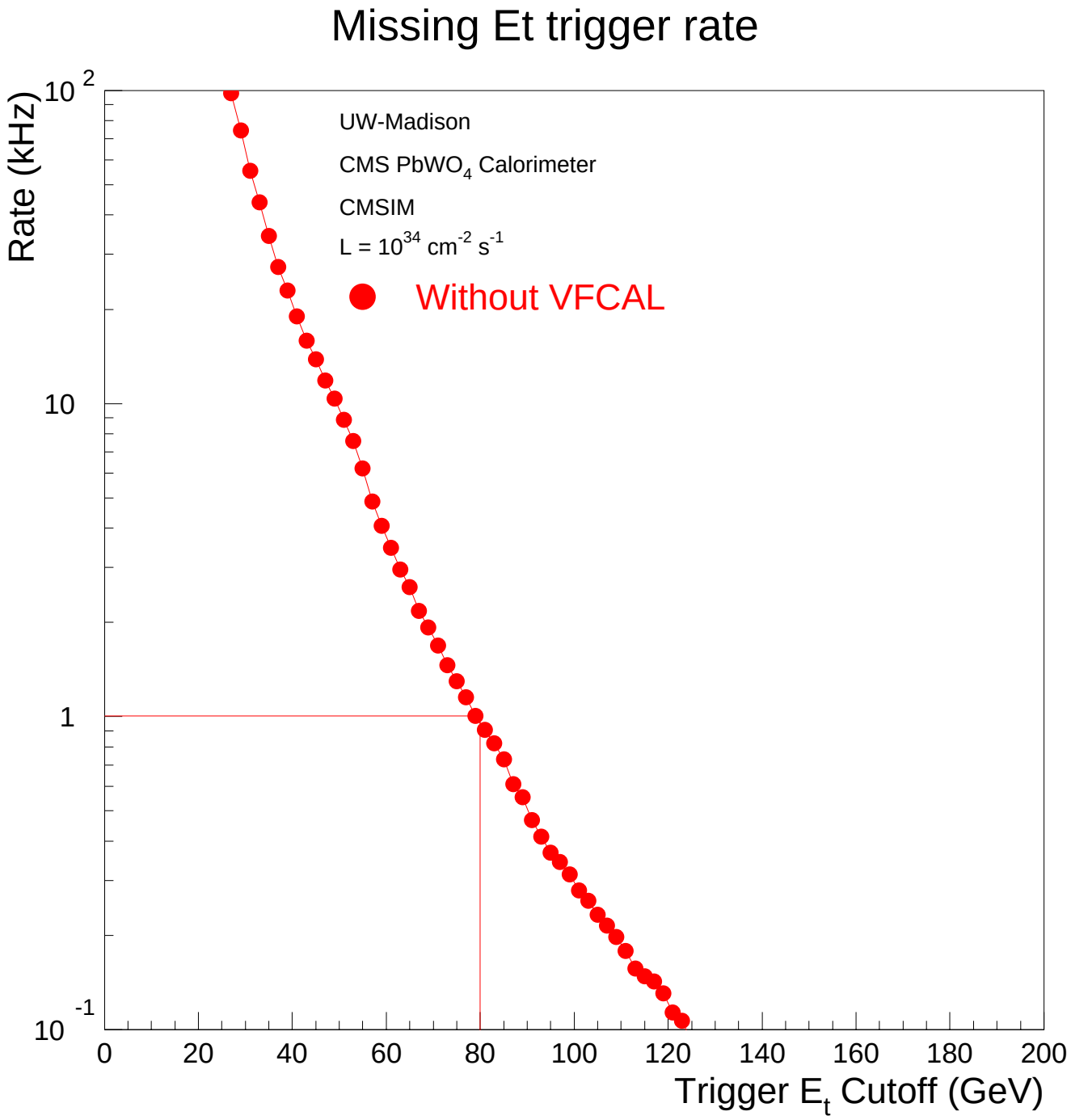
- Resolution worsening due to various components studied in fast simulation earlier - need to repeat this with CMSIM.
- Only a ~25% due to level-1 trigger compromises

Missing E_T efficiency - low luminosity

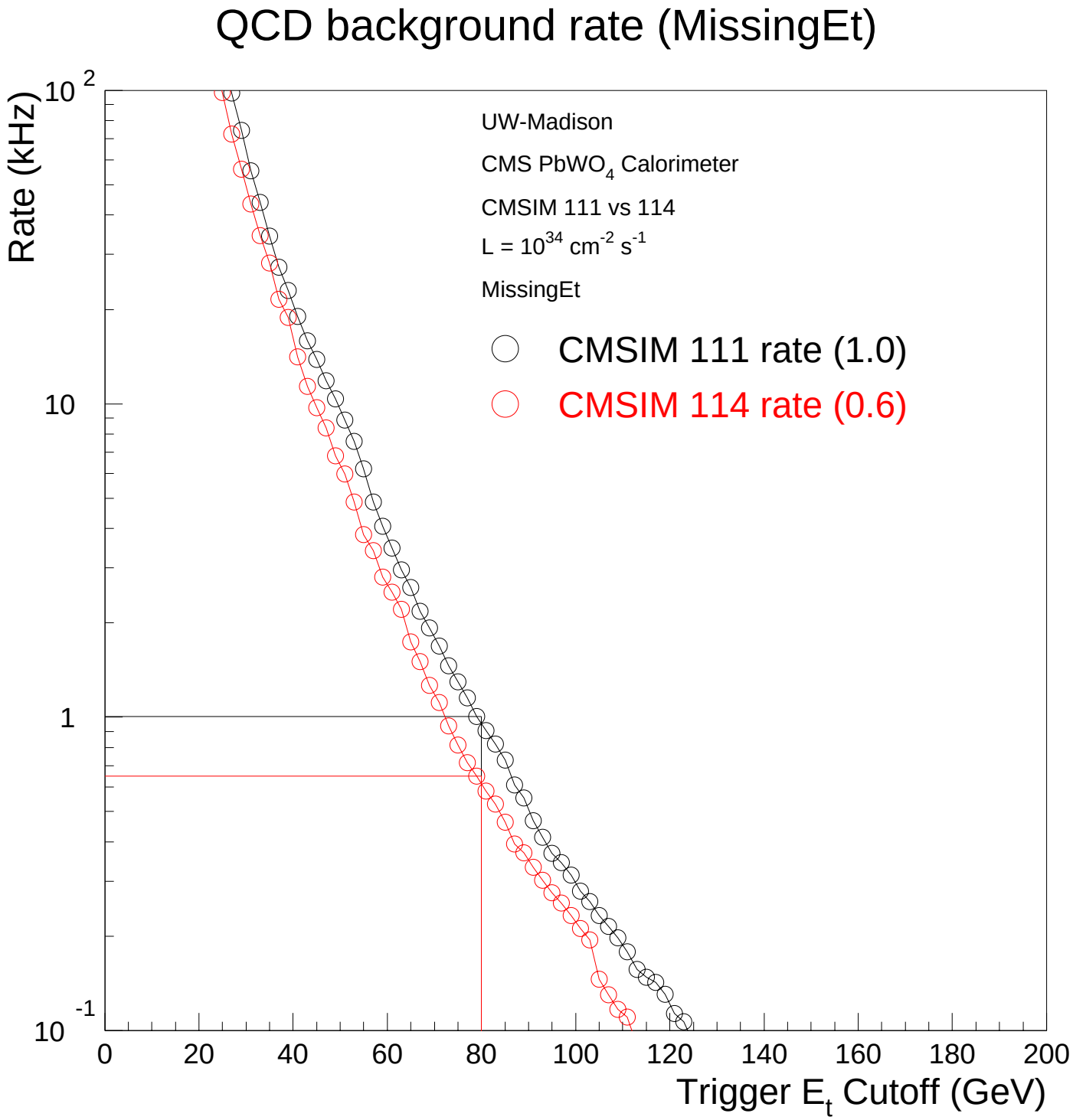


Well, it eventually reaches full efficiency

Missing E_T rate

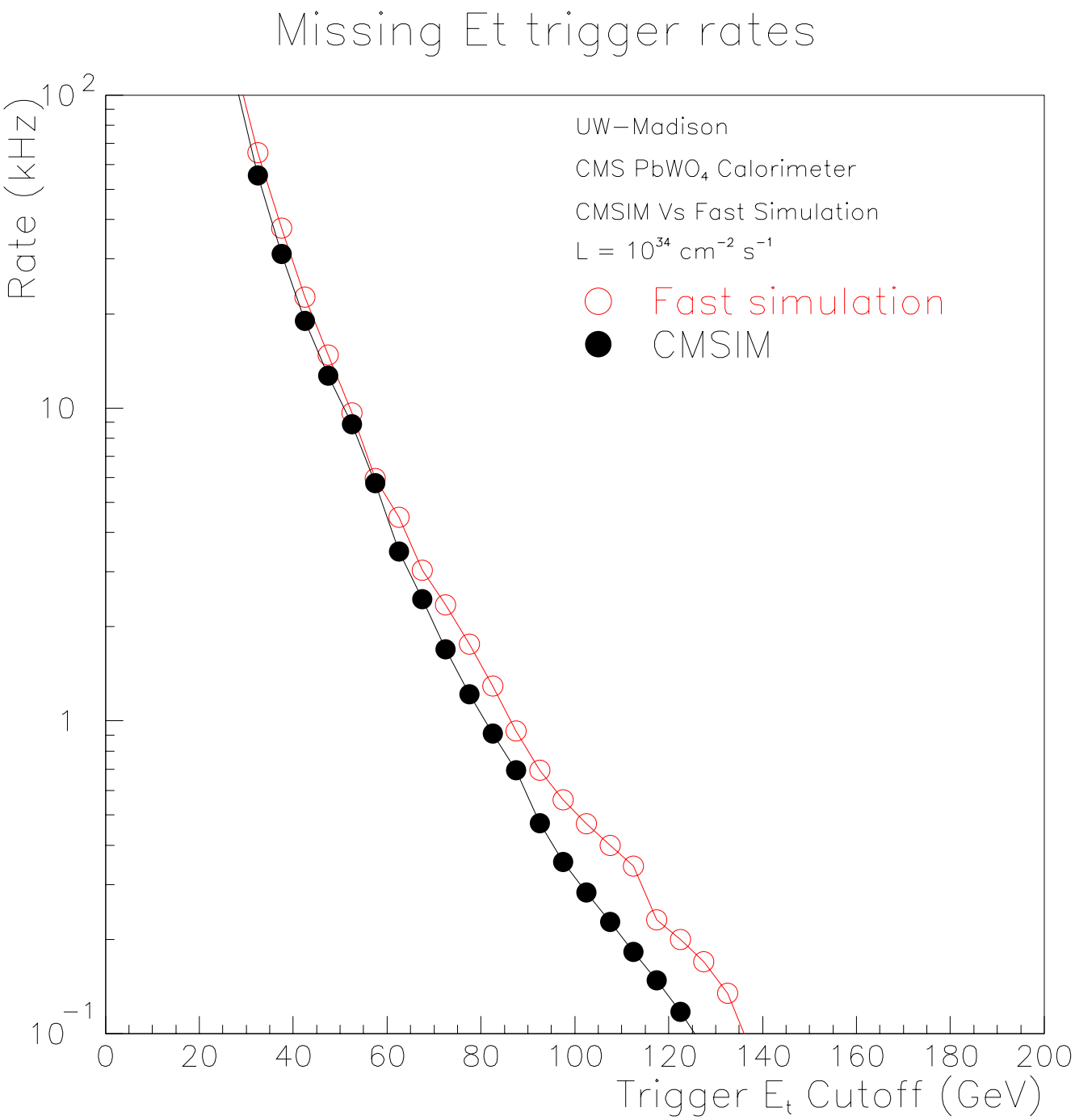


Missing E_T rate: CMSIM 111 vs 114



As expected missing E_T rate reduces with better η coverage.

Missing E_T: FASTSIM vs CMSIM 111



Higher level trigger problems

~5kHz rates need to be brought down to a fraction of 100 Hz output to mass storage

Unlike in the case of electron/photon trigger, the jet candidates found by level-1 are not fakes - there is really energy there!

Further jet energy may at most be underestimated.

Jet counting may not be quite right

- May count large jets as two jets
- How do we deal with "voluteers"?

Event topology may have to be used early in HLT to reduce the rate

There is no separate Tau trigger

- Can create Tau/DiTau + X trigger from jet triggers using calorimeter information only.

Calibration triggers

ORCA plans

Object oriented trigger simulation

Will extend existing ORCA L1CaloTrigger code to cover the entire calorimeter and update algorithms (EM)

Began work on coding the trigger hardware details

- May mean limited use of existing ORCA code

Need to define interfaces with both ECAL and HCAL trigger primitives groups

- Details of trigger primitives may be important for isolation cuts
- Not well simulated in the past
- Example: MinI bit from HCAL
  - How do we use it at level-1?
  - At level 2?
- Will use existing L1CaloTrigger primitives code in the interim

Expect to have first version in mid April

Code validation

- Level-1 data sample reuse?
  - Provide interface to read my custom CMSIM output file format
  - Must match rates and efficiencies with above results
  - Is geometry evolution a problem?
- Regenerate CMSIM data and go through proper channel?
  - Time consuming to get ~100000 events
  - Particularly if we include tracker and muon systems