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Zero Bias and HF-based Minimum Bias Triggering for pp Collisions at 14TeV in CMS

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CMS collaboration

The Large Hadron Collider

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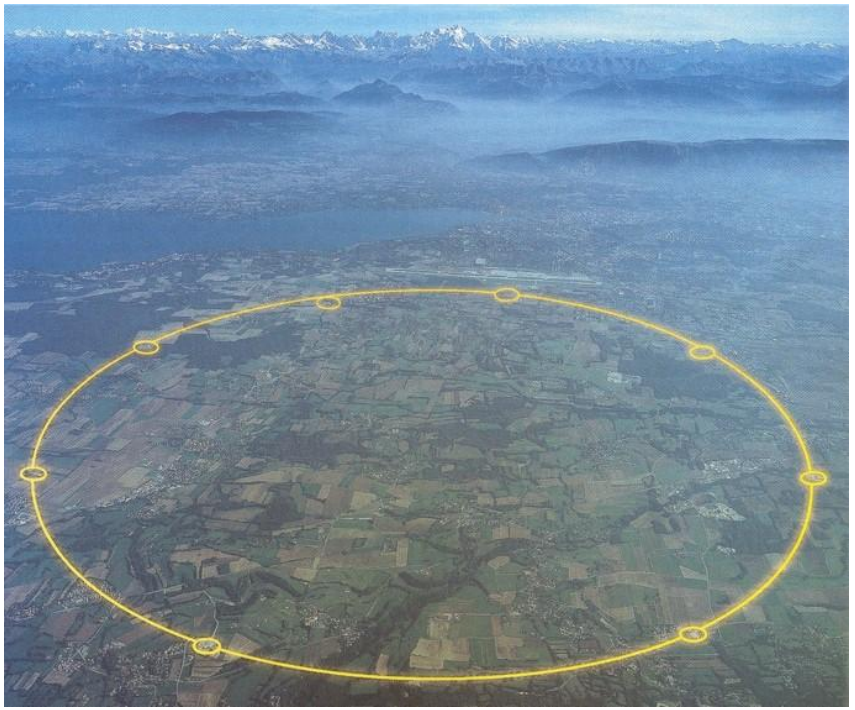
- Located at CERN at the French/Swiss border
- 27km circumference
- Proton collisions first at 0.9TeV, then at 10TeV
- Full energy will be 14TeV
- Startup in Spring 09



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Zero Bias Triggering

- Events triggered by timing of bunch crossing
- Underlying event and other analyses require data as free from triggering bias as possible
- Low luminosities during ramp-up provide opportunity to obtain zero bias data

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Bunch Patterns and Luminosity Ranges

- The LHC has 3564 buckets that can be filled
- Consider 4 different bunch patterns that will be run

Bunch Pattern	Luminosity [cm^{-2} s^{-1}]
43 x 43	$3.8 \times 10^{29} - 1.7 \times 10^{30}$
156 x 156	$1.1 \times 10^{31} - 1.7 \times 10^{32}$
936 x 936	$2.3 \times 10^{31} - 5.0 \times 10^{32}$
2808 x 2808	$1.7 \times 10^{32} - 1.0 \times 10^{34}$

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Ideal Min-Bias Data

- At each bunch crossing, any number of proton collisions can occur
- Data containing events with EXACTLY one collision will be called *ideal data*
- Are there regions of luminosity where one collision per bunch crossing is likely?

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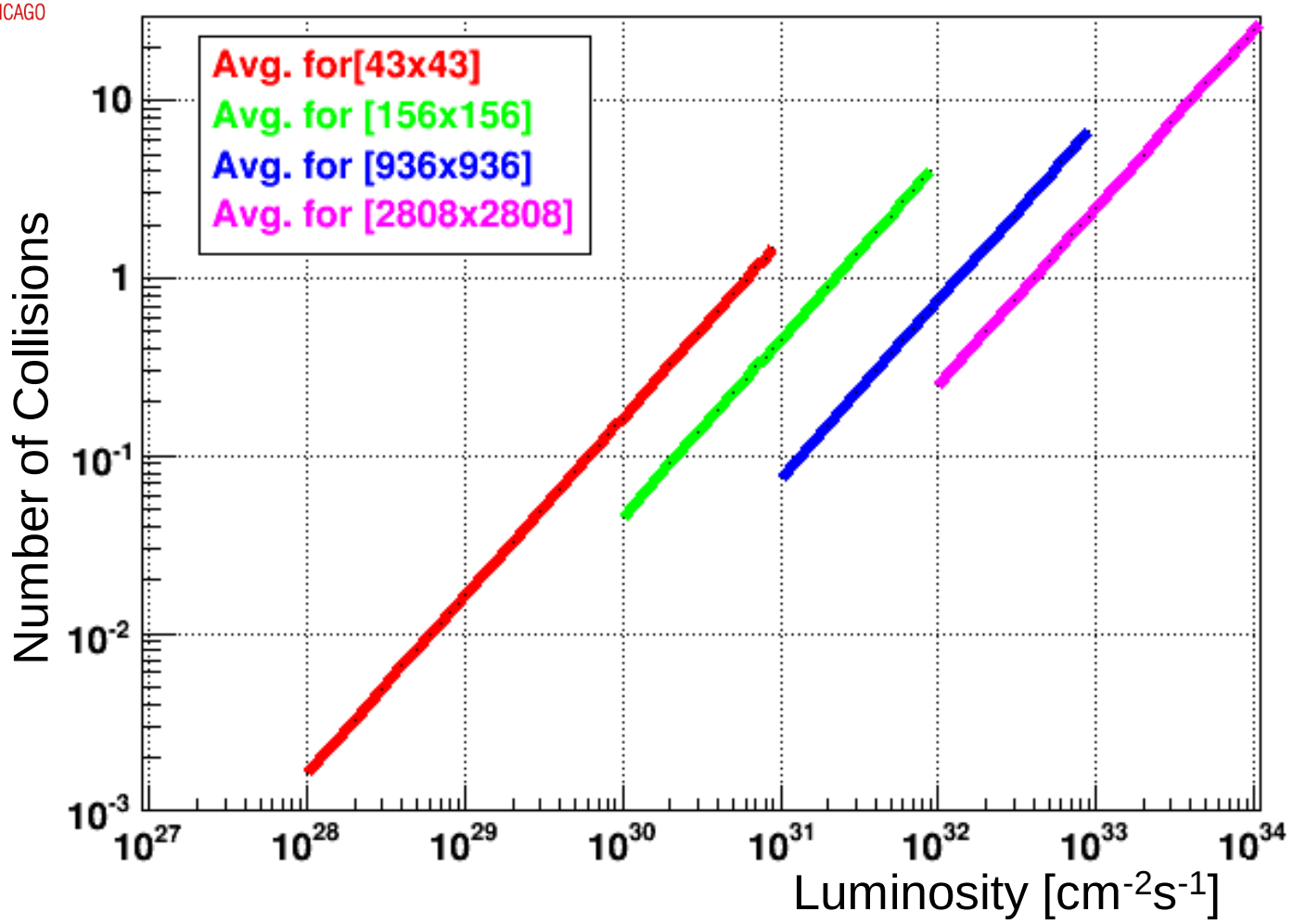
Avg. # Coll. Per Bunch Crossing (BC)



Obtaining Ideal Min Bias Data

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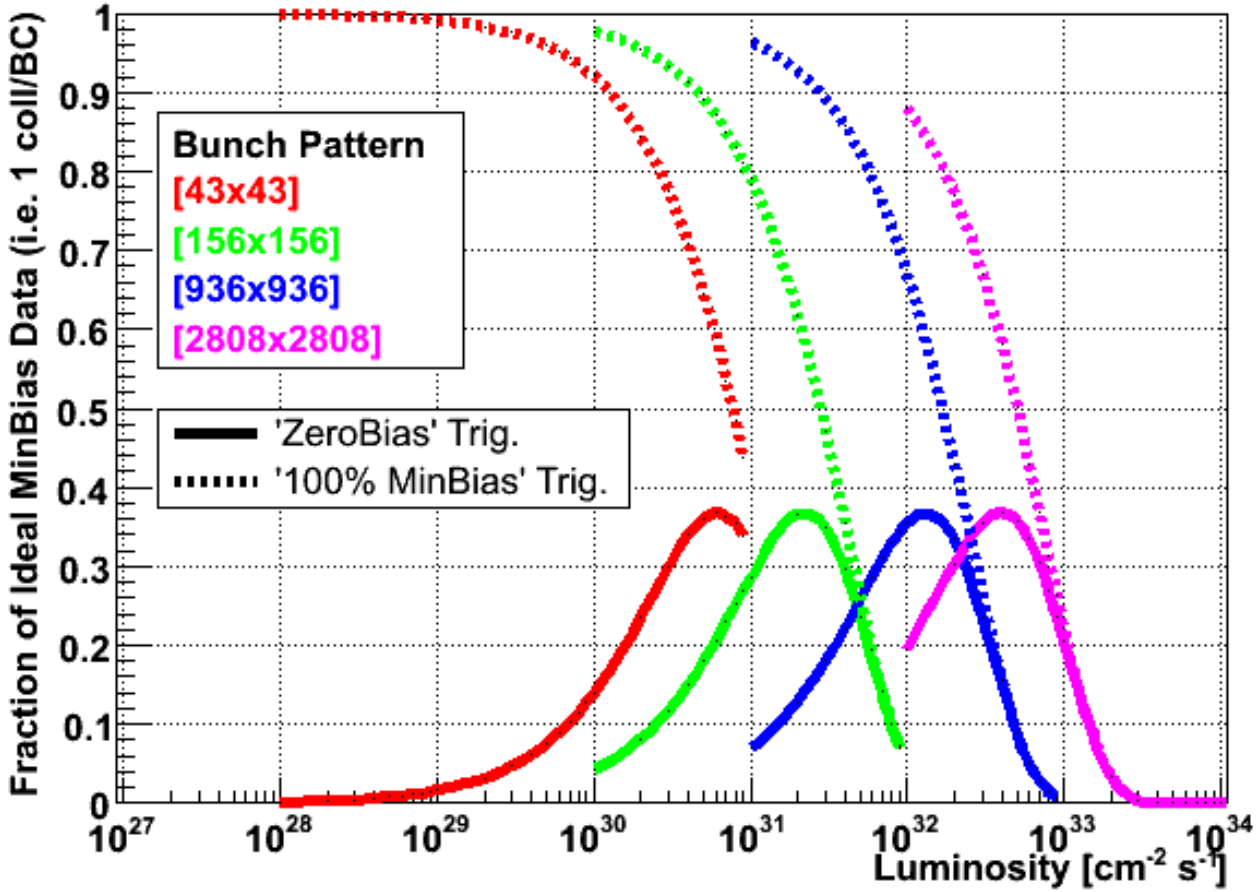
- Consider two triggering schemes:
  - Zero Bias Trigger:
    - We record every bunch crossing, and we ask what fraction of the data is *ideal*
  - 100% Efficient Min-Bias Trigger:
    - We consider a hypothetical perfect detector, that records every bunch crossing with AT LEAST one collision, and we ask what fraction of the data is *ideal*

Fractions of Ideal MinBias Data:

Triggered on 'ZeroBias' (Bunch Crossing) and '100% MinBias' (Detector)



Fractions of Ideal MinBias Data:

Triggered on 'ZeroBias' (Bunch Crossing) and '100% MinBias' (Detector)

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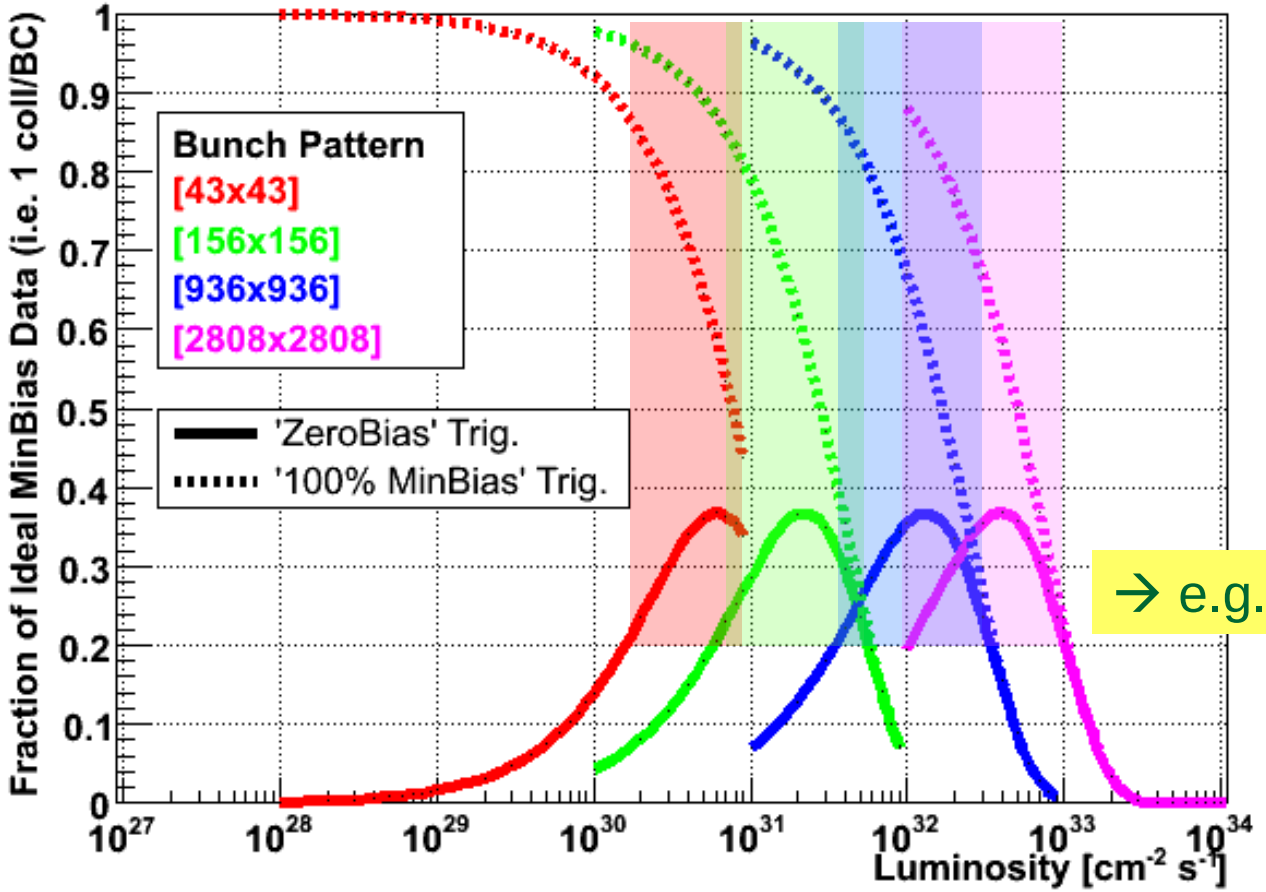
Regions where one could (& should!) include Zero Bias trigger



→ e.g. Frac > 0.2

The CMS Detector (Compact Muon Solenoid)

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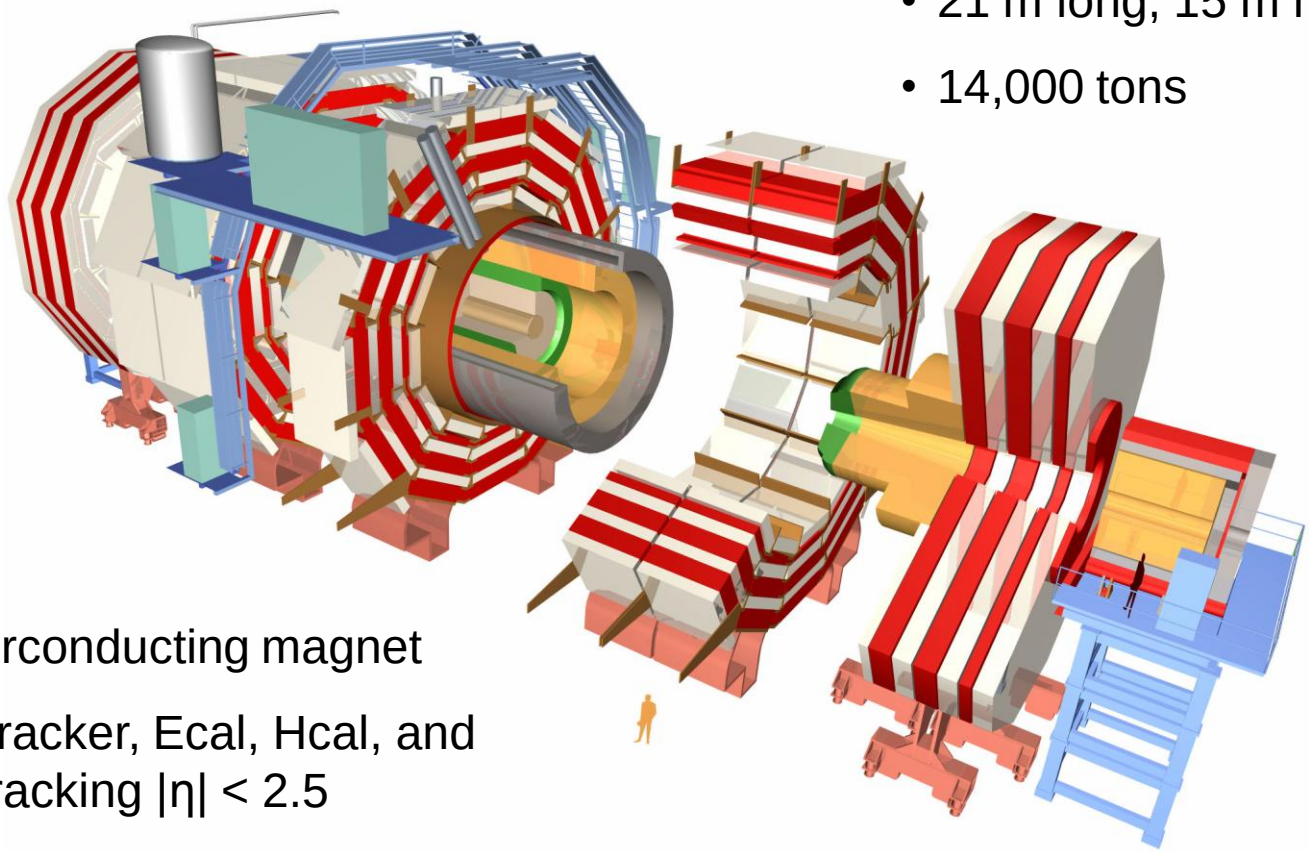

- 21 m long, 15 m high
- 14,000 tons

- 4T superconducting magnet
- Silicon tracker, Ecal, Hcal, and Muon Tracking $|\eta| < 2.5$
- Forward Detectors out to higher η

The Forward Hadronic Calorimeter (HF)

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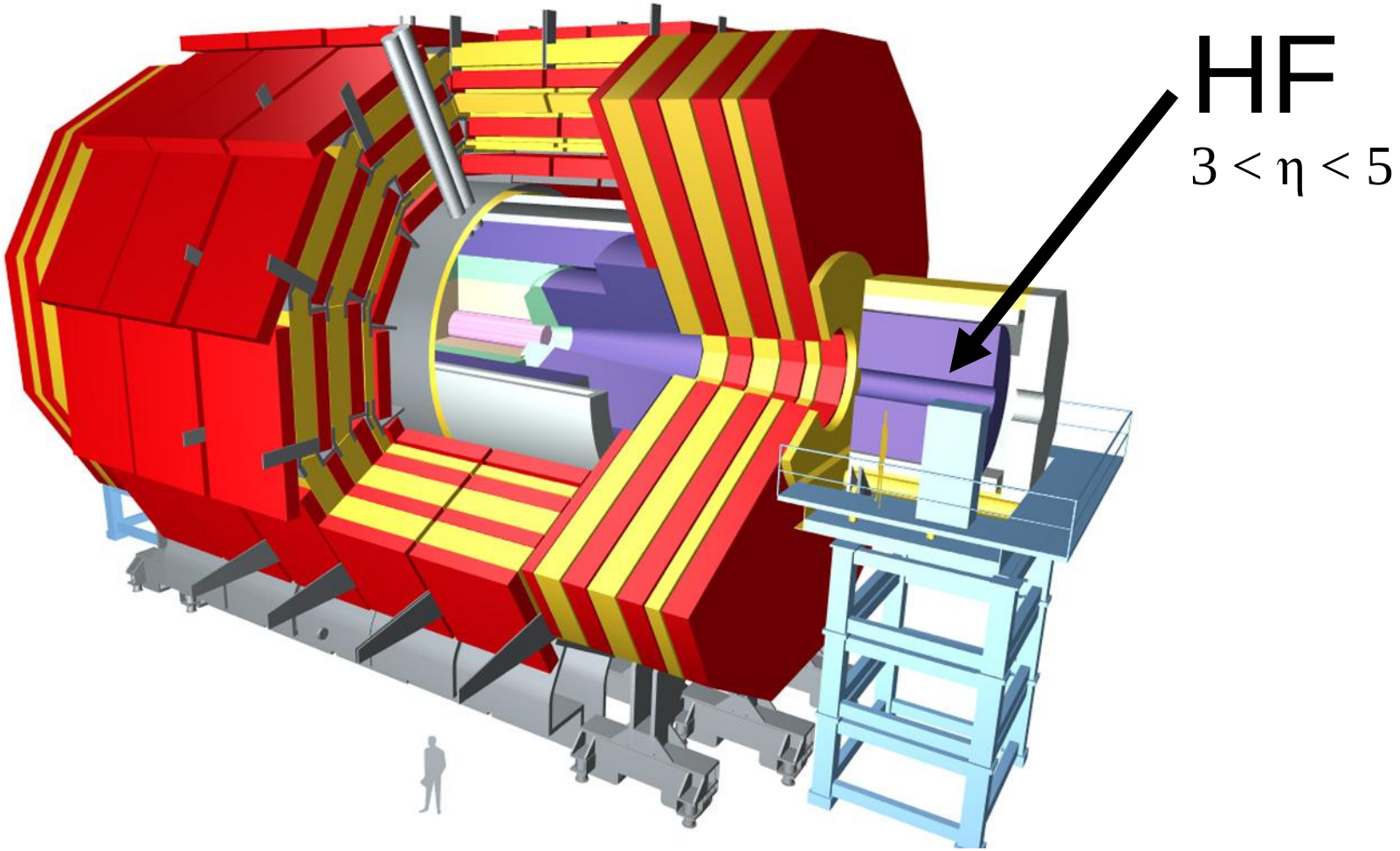

HF Triggering

- There are 144 trigger towers designed for fast readout available at level 1 in each HF detector

- Two min-bias triggers should be employed:
  - **OR** Trigger: Trigger on at least one HF trigger tower on ***either*** side (positive or negative η)
  - **AND** Trigger: Trigger on at least one HF trigger tower on ***both*** sides (positive and negative η)

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Beam Gas/Halo

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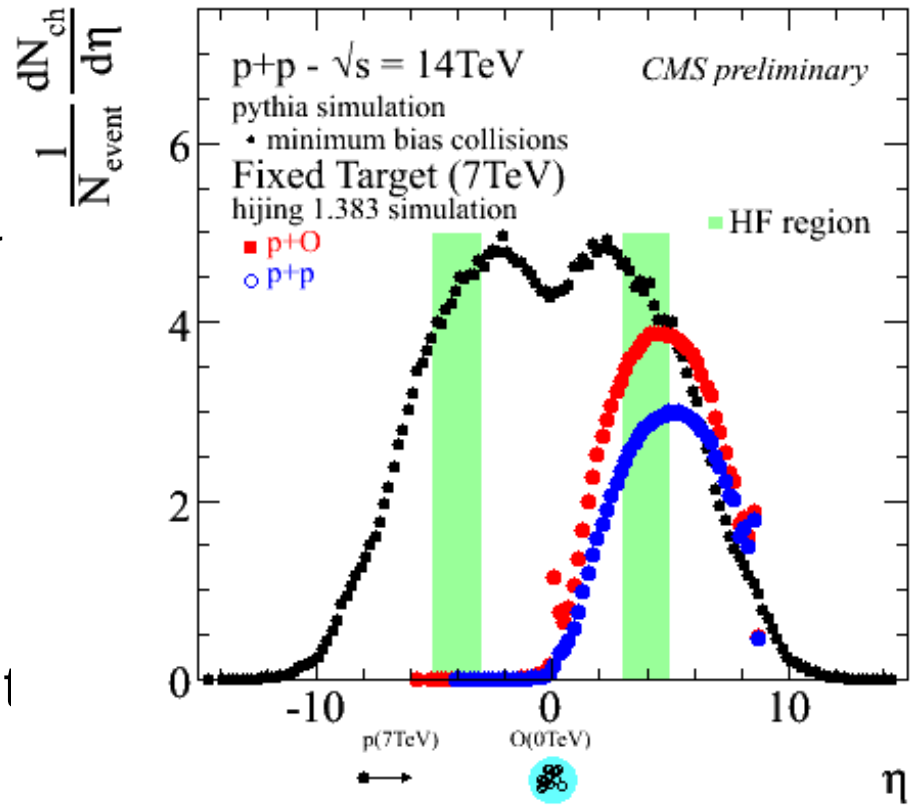
- Beam gas/halo collisions could contaminate the data sample
  - Need to reject such collisions
  - This can be done by requiring hits on *both* sides of HF, i.e. using t **AND** trigger



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Expected $dN_{ch}/d\eta$

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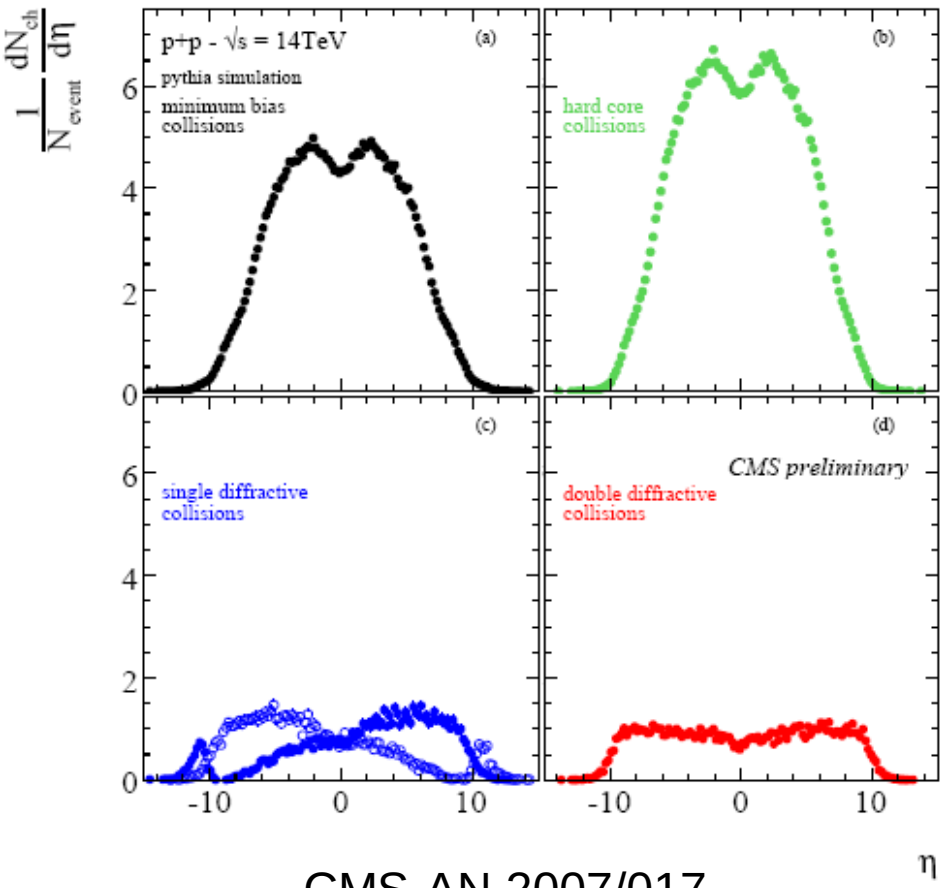
- Three main collision types
  - **Hard core**
  - **Single diffractive**
  - **Double diffractive**
- Averaged to
  - Minimum Bias
- Diffractive events require **OR** trigger



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HF Triggering Efficiency

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Triggering Efficiency for both triggers

	OR	AND
Minimum Bias	91.9%	71.5%
Hard Core	98.9%	88.7%
Single Diff	74.9%	31.3%
Double Diff	76.8%	30.9%

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Triggering Bias

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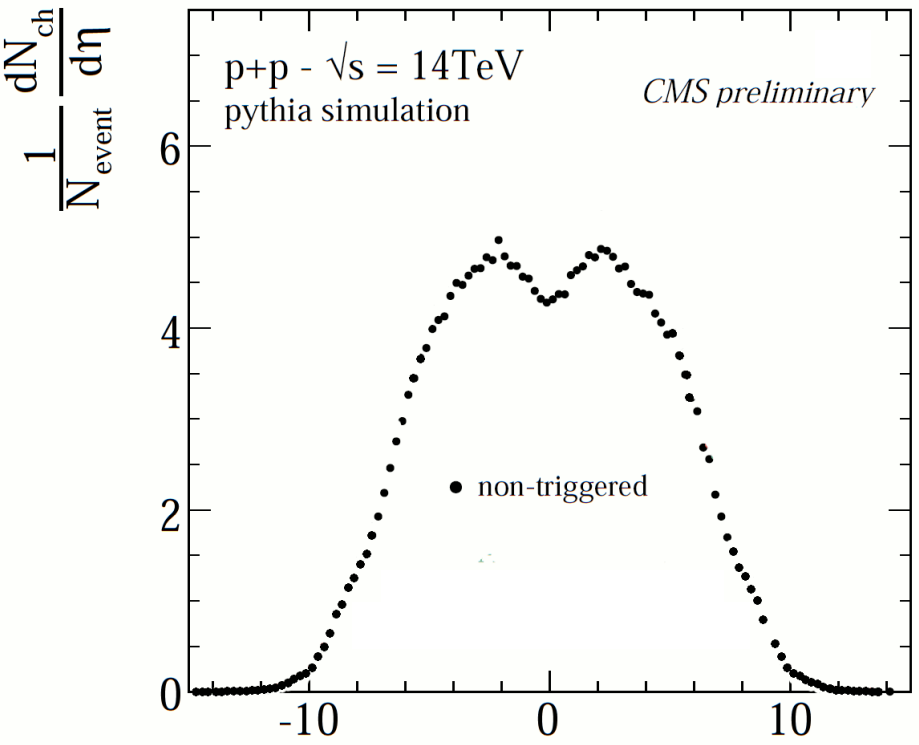
- Let's use this trigger to make a measurement of dN/dη



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Triggering Bias

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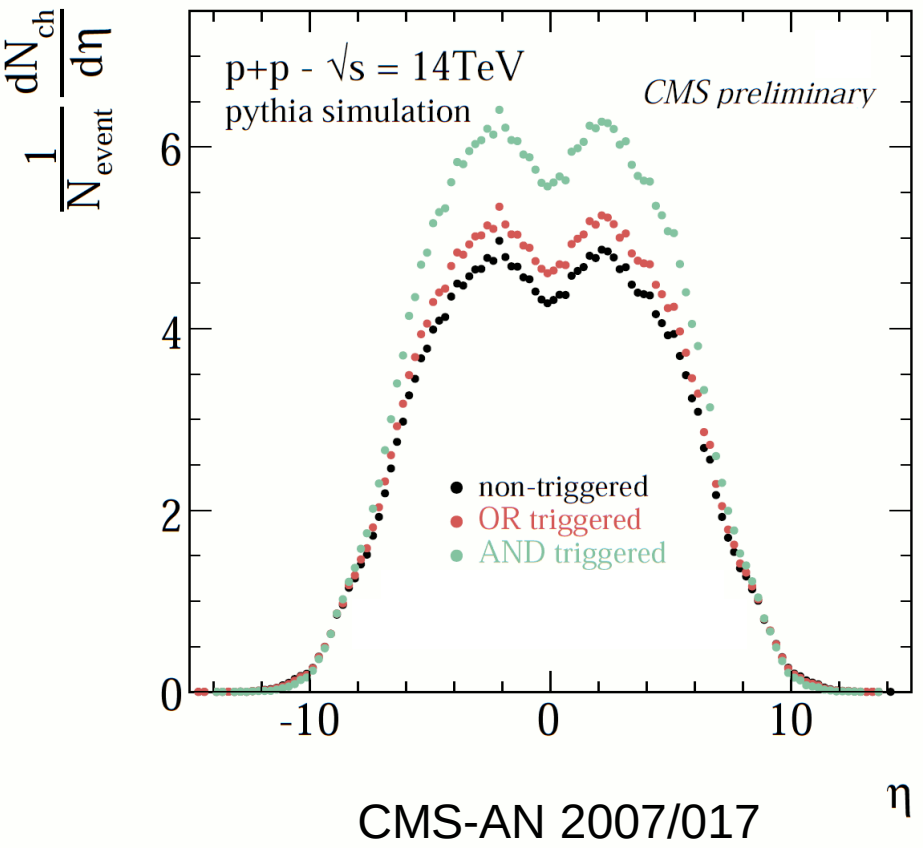
- Let's use this trigger to make a measurement of dN/dη
- Measured dN/dη appears higher due to trigger bias



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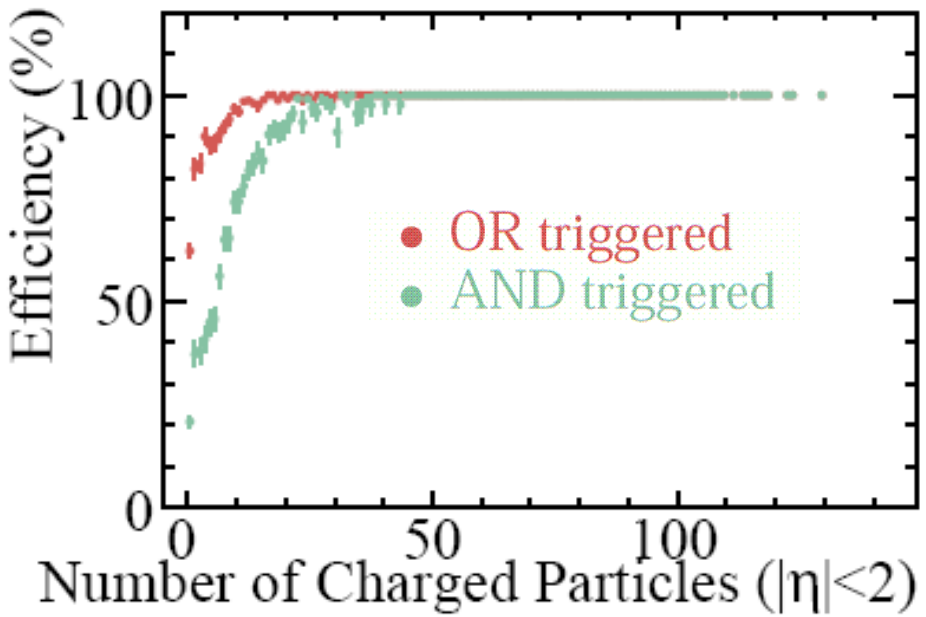
Trigger Bias Correction

- Efficiency is not uniform across NCharge



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Trigger Bias Corrected

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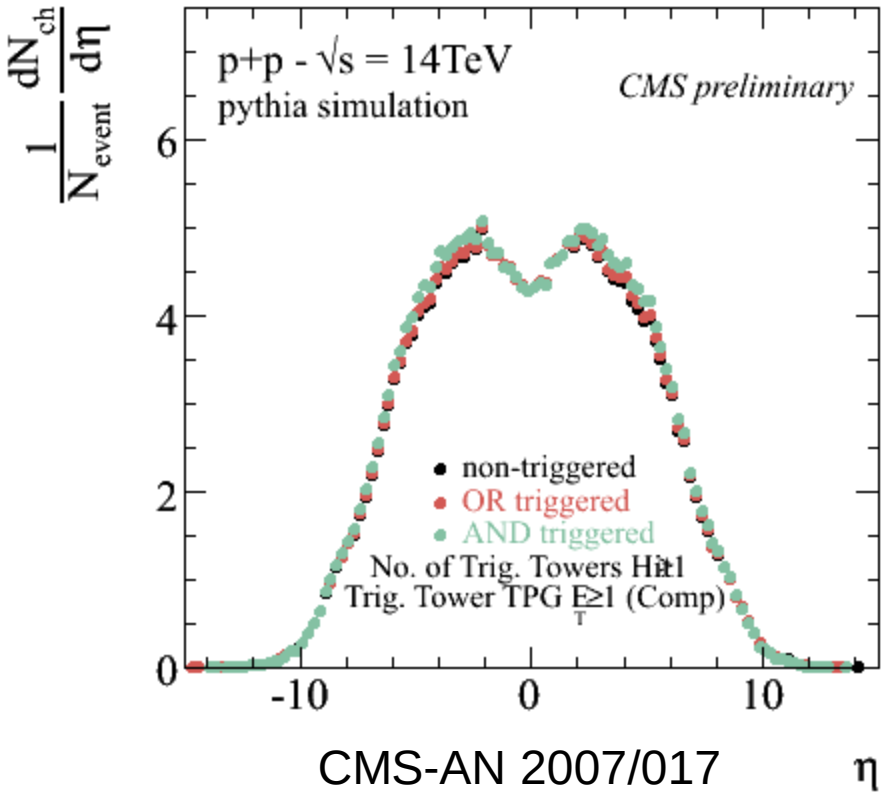
- Data inverse weighted by efficiency curve
- Good agreement with non-triggered data
- Trigger bias can be corrected.



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Summary and Outlook

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- Rare opportunity to collect a significant sample of zero bias data during low luminosity startup of the LHC
- HF provides an effective trigger for min-bias data taking
- Detailed studies of early physics measurements using this trigger data are underway
  - Measurement of the Underlying Event in Jet Topologies using Charged Particle and Momentum Densities CMS-AN 2007/034
  - Measurement of Charged Hadron Spectra in Proton-Proton Collisions at 14 TeV CMS-AN 2007/021

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Backup Slides

HF Triggering

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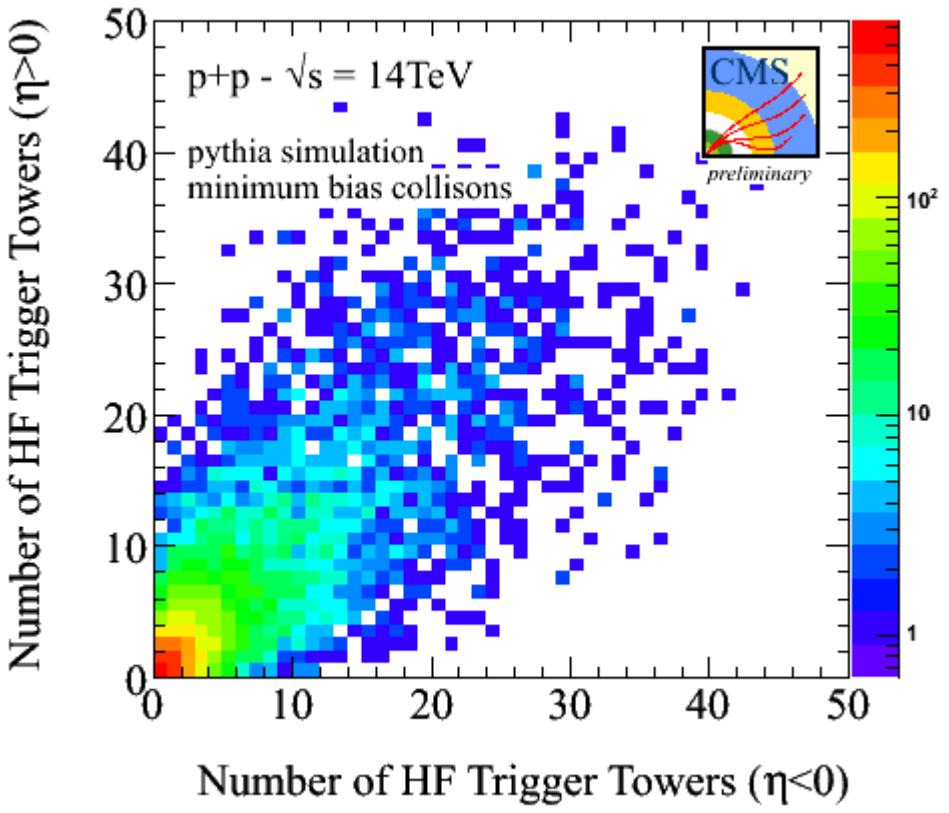
- Correlation of the number of trigger towers hit above threshold
  - Minimum number of hits (1) should be employed



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