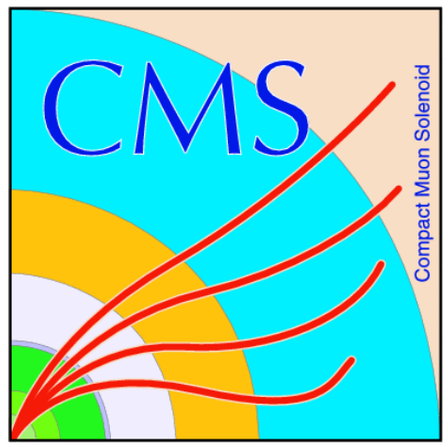
CMS electron and photon performance at $\sqrt{s}$ = 13 TeV

Francesco Micheli on behalf of CMS Collaboration



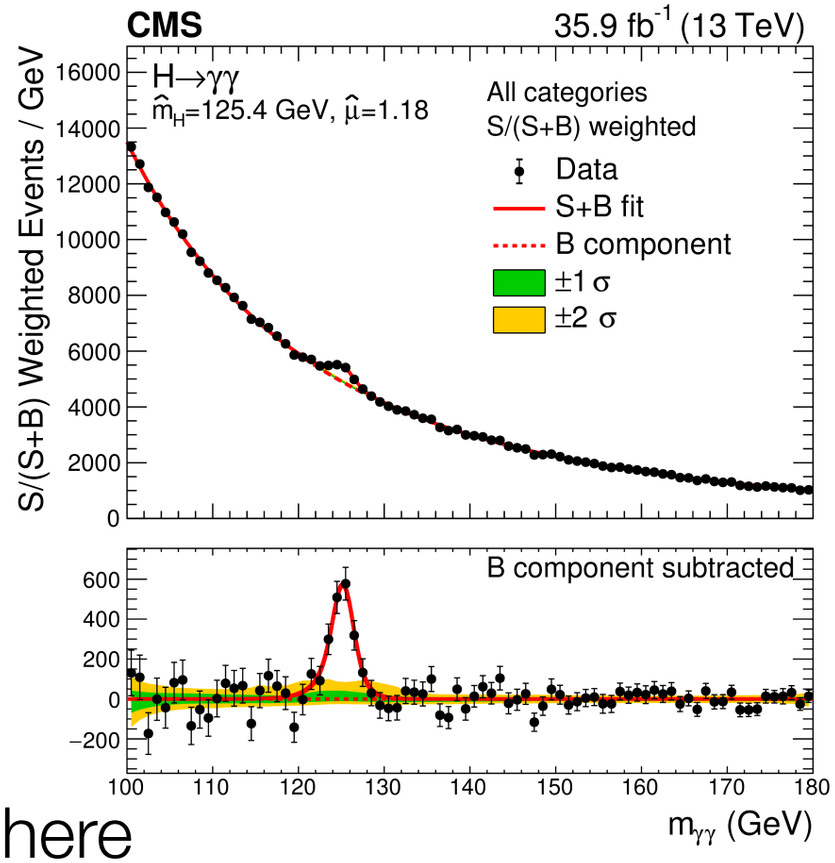
Electrons and Photons @ CMS

- **Electrons** and **photons** are crucial for CMS physics program:
  - SM precision physics, Higgs coupling measurements, BSM searches…

- **Selection** of CMS results in this talk:
  - Updated results for **2016 data (36.3 fb^{-1})**:
    - New data processing, with improved low-level calibration (**legacy** re-reco)
  - New results for **2017 data (42.6 fb^{-1})**:
    - Interesting results @ICHEP using tools shown here

2016

2017



- Talk covers most important **updated results**, stressing improvements due to **new detector conditions** for the different years

Improvements for e/γ reconstruction

- **Photon** (**Electron**) in CMS:
  - Cluster of energy deposits in **ECAL** crystals (matched to a track in the **silicon tracker**), see here for details about detector [CMS overview @ ICHEP]
  - Big effort to maintain good efficiency in **evolving** data taking/detector conditions

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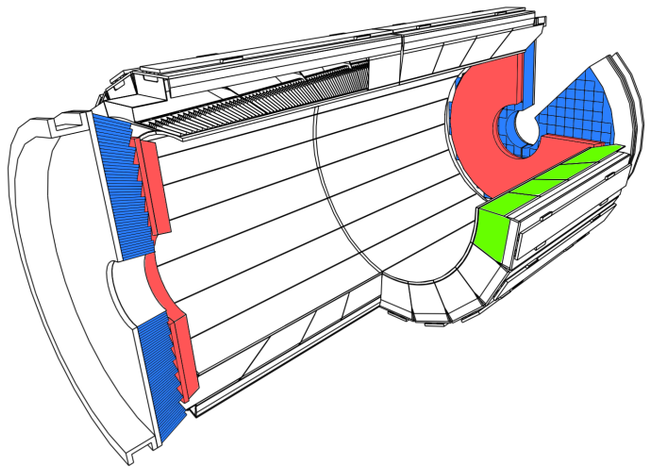
Electromagnetic calorimeter (ECAL)



75848 Lead tungstate crystals ($PbWO_4$)

Cylindrical structure: **Barrel (EB)** + **Endcaps (EE)** + **Preshower (Lead/Silicon Strips)**

2016

- **Legacy reReco of 2016 data** is expected to improve significantly ECAL reconstruction
- Data reprocessed with **improved low-level calibration**
  - Improved **ECAL pedestals and calibrations**

Improvements for e/γ reconstruction

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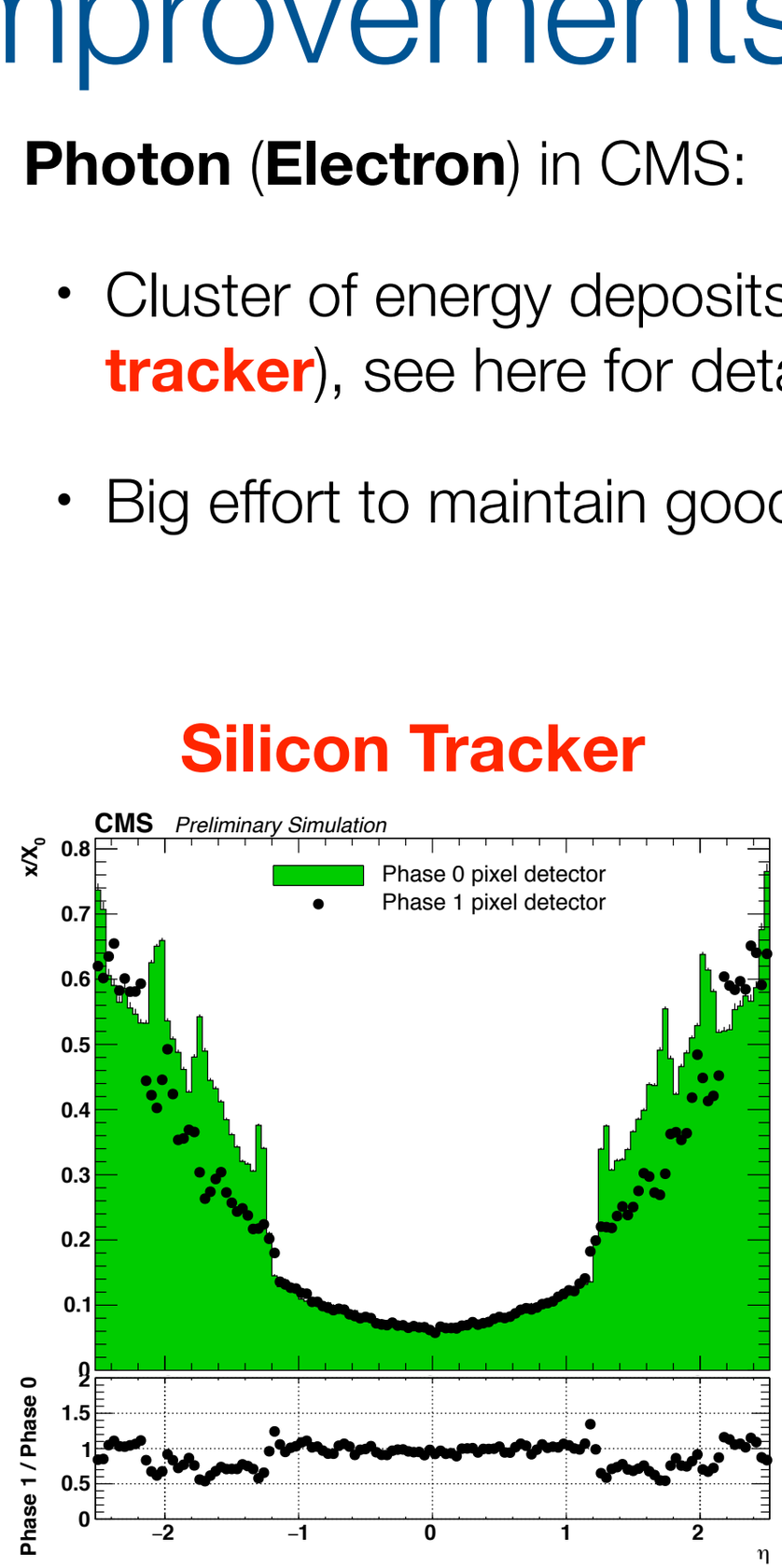
Silicon Tracker



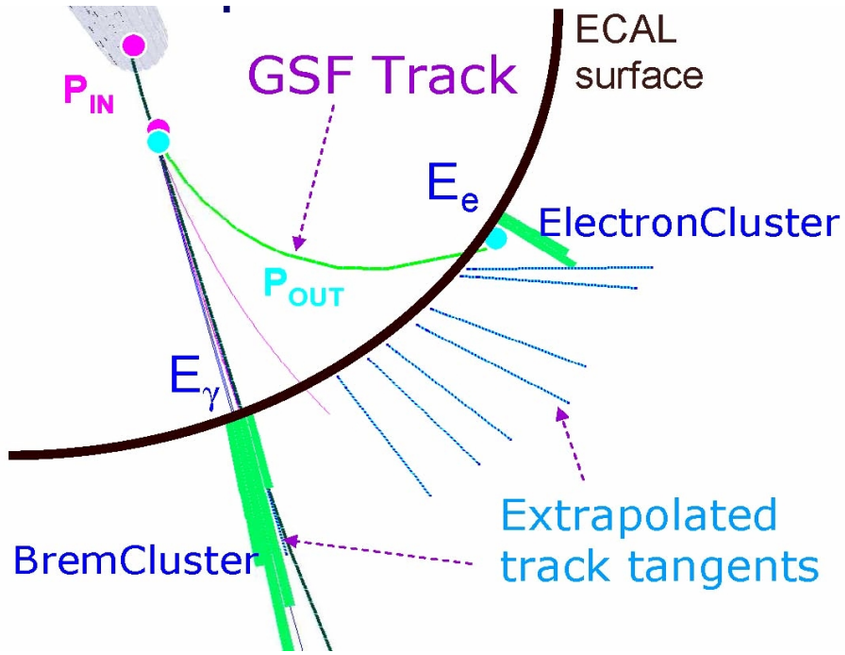
2017

- **New pixel detector in 2017** with added **4th layer** and **reduced material** budget in the endcaps:
  - Pixel **4th layer/quadruplet seeding** reduces number of fake tracks
  - More external layer closer to strip detector → better extrapolation of tracks

Reconstruction

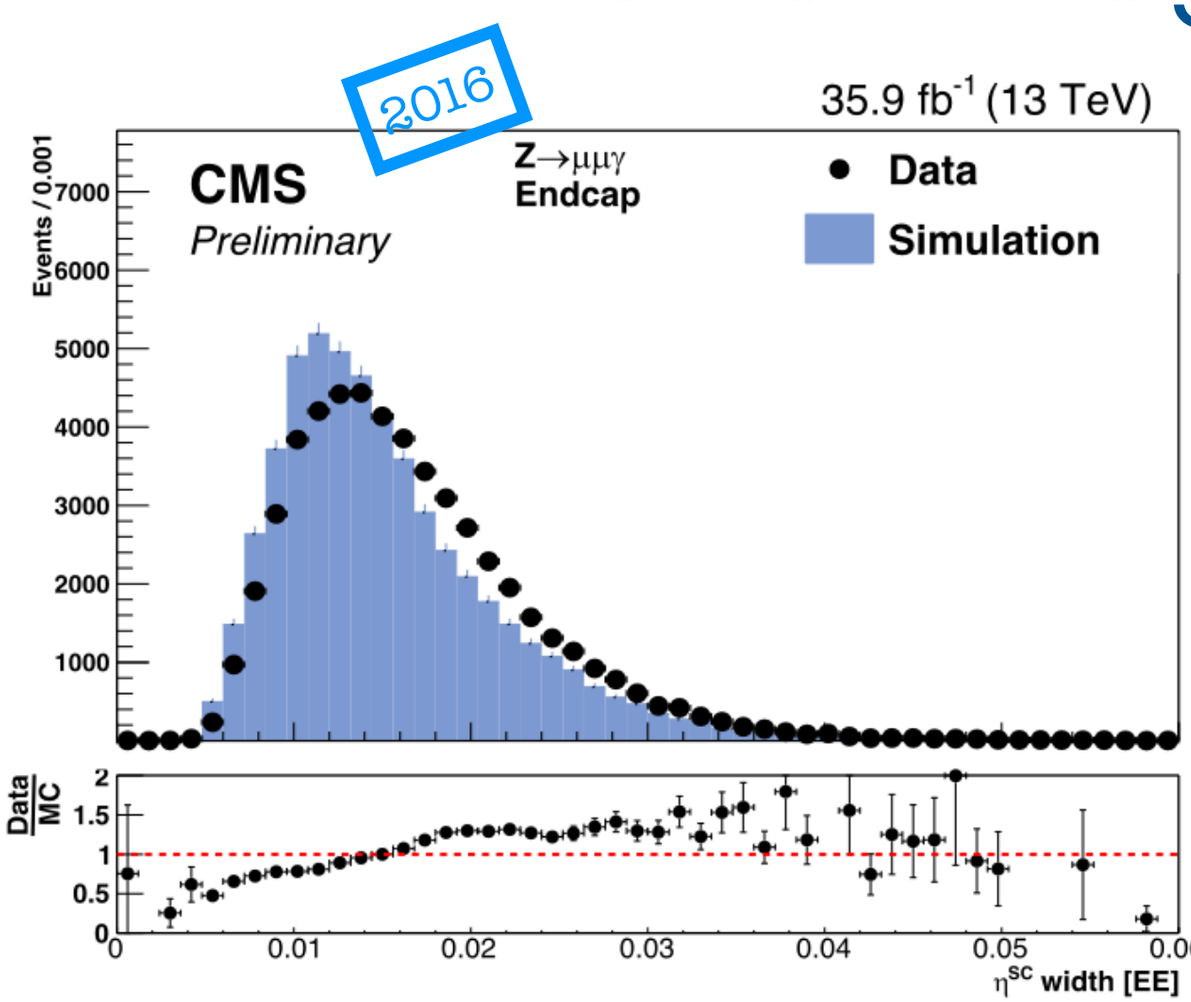
- **Reconstruction** algorithms exploiting interplay between **clustering** and **tracking** to achieve best resolution

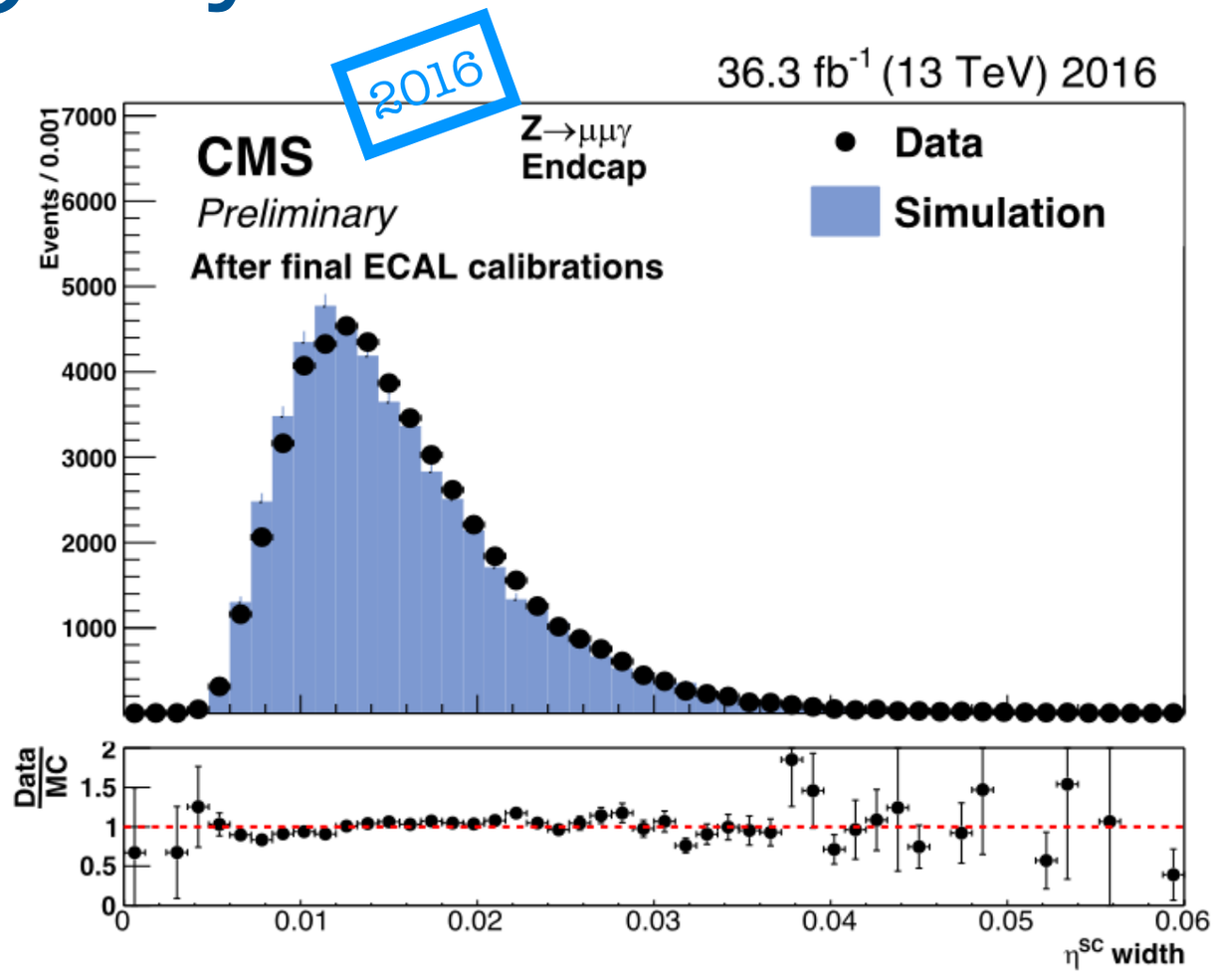
- **High Level Trigger (HLT)** and **reconstruction** following similar path:
  - Requiring **isolation**, **Et** cuts and compatibility ECAL/tracker for electrons + additional corrections (gaps, energy loss…)
  - Seeding from **ECAL hits** (**Tracker hits** seeding important for low pt electrons)
  - **Brem** and **photon conversion recovery** are of paramount importance



- **Identification** selection based on high level variables to remove fakes

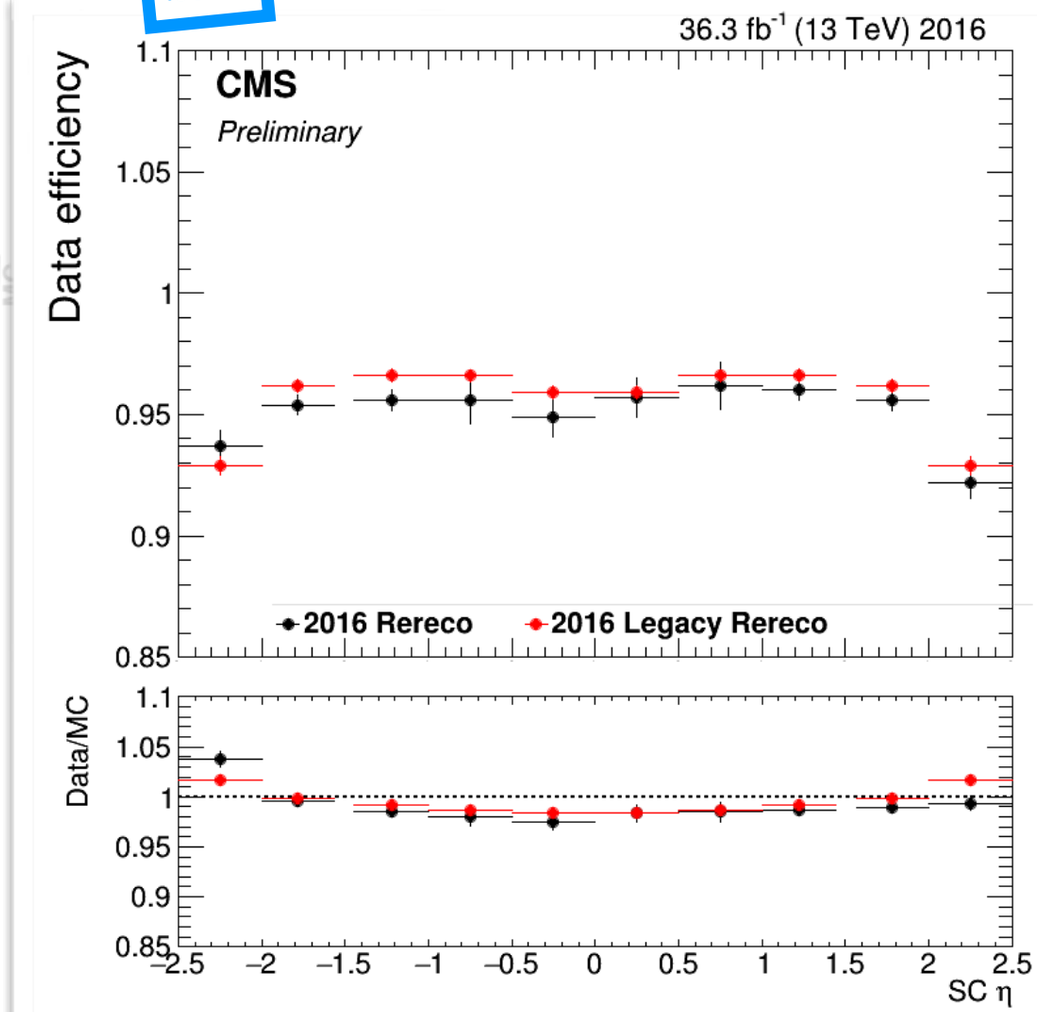
2016 - Legacy reReco

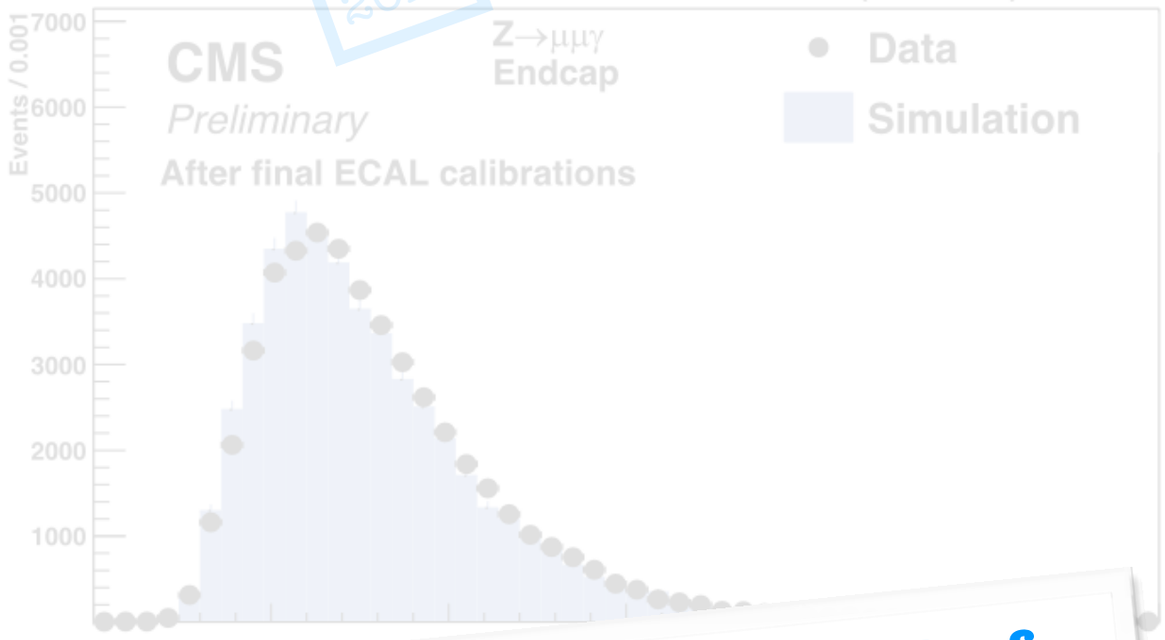




- ECAL improved reconstruction for 2016 has visible good effects
- Main effect is **better data/MC agreement** → better performance, lower SF
  - Example of **pseudorapidity width of the supercluster** for photons (EE)

2016 - Legacy reReco



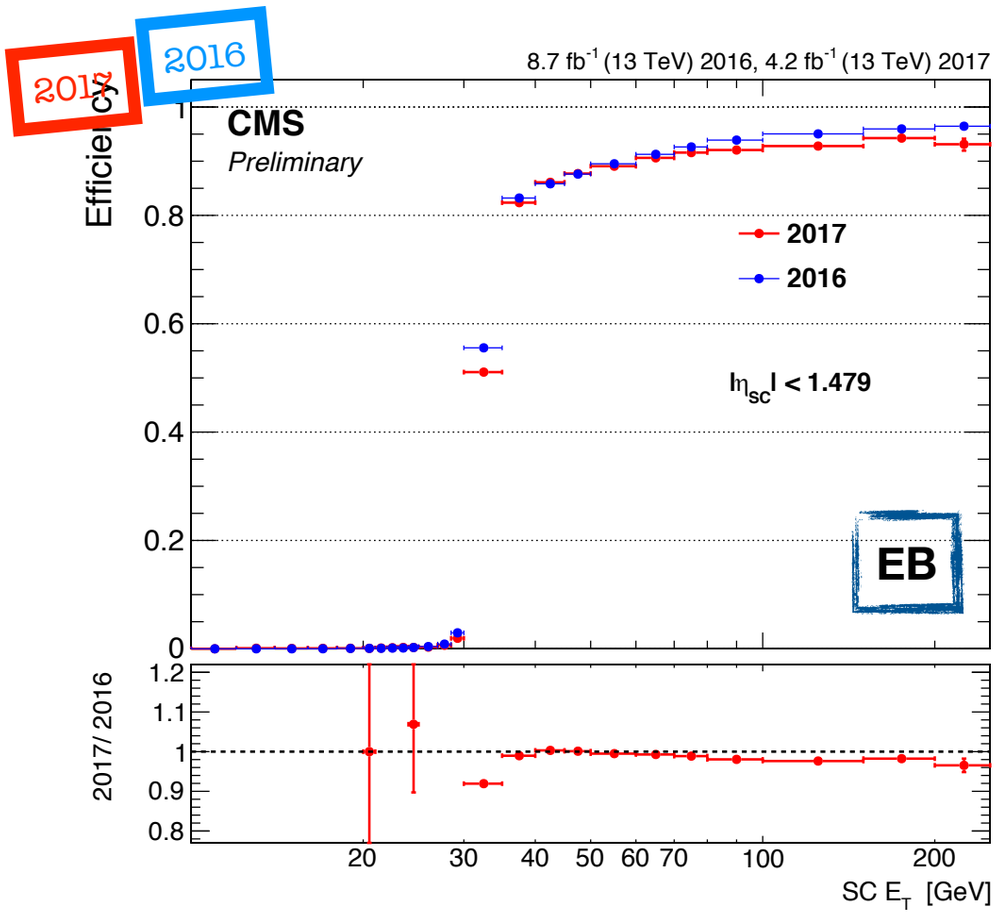


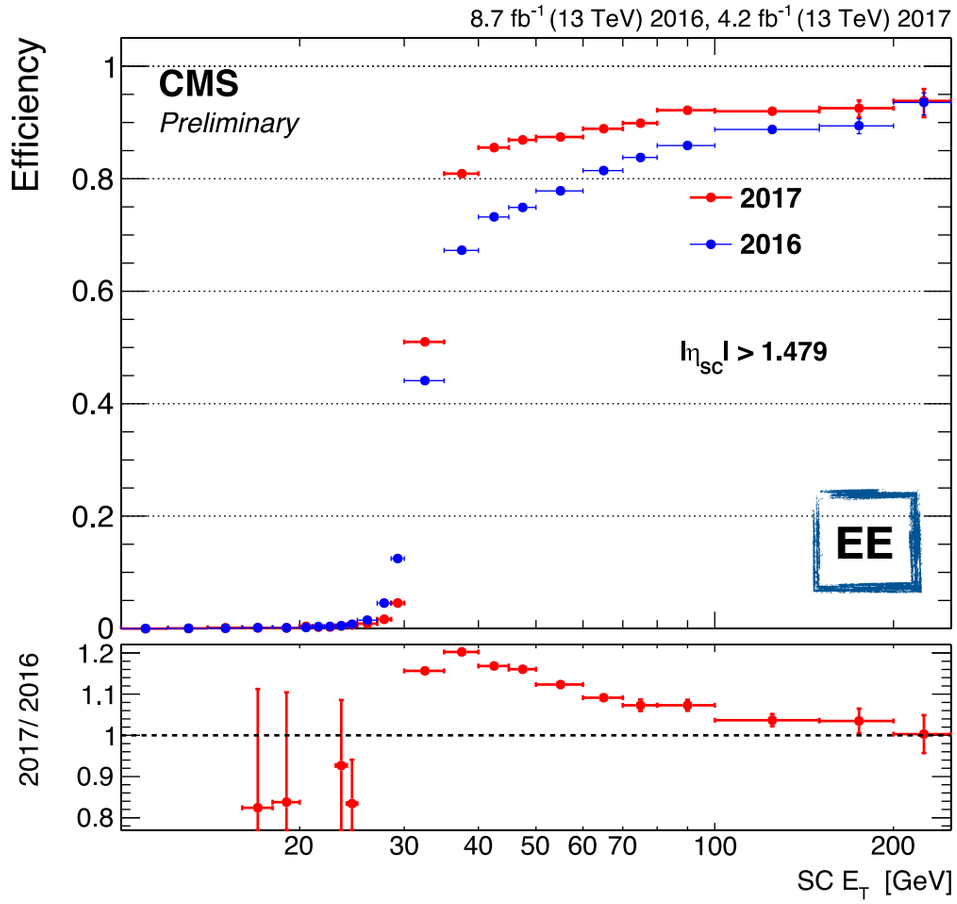
Significant **improvement of reconstruction efficiency** on the whole eta/pt range for 2016

This improvements will be used for final **Run II CMS results**

2017 - High level trigger (HLT)

- **HLT** measured with **TnP method on Z→ee,** visible effects due to new pixel:
  - **Reduced rate** (despite higher pileup), especially at low p_T:
    - Rate reduction up to 70% for low p_T double electron triggers
  - **Improved efficiency in the endcap** for single electron paths

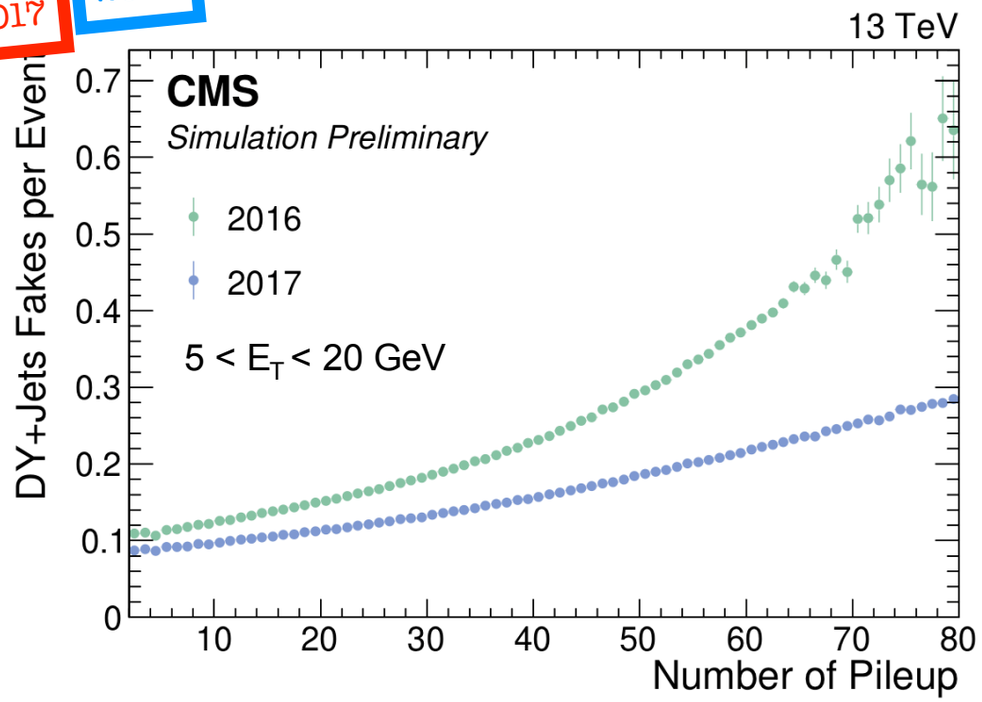




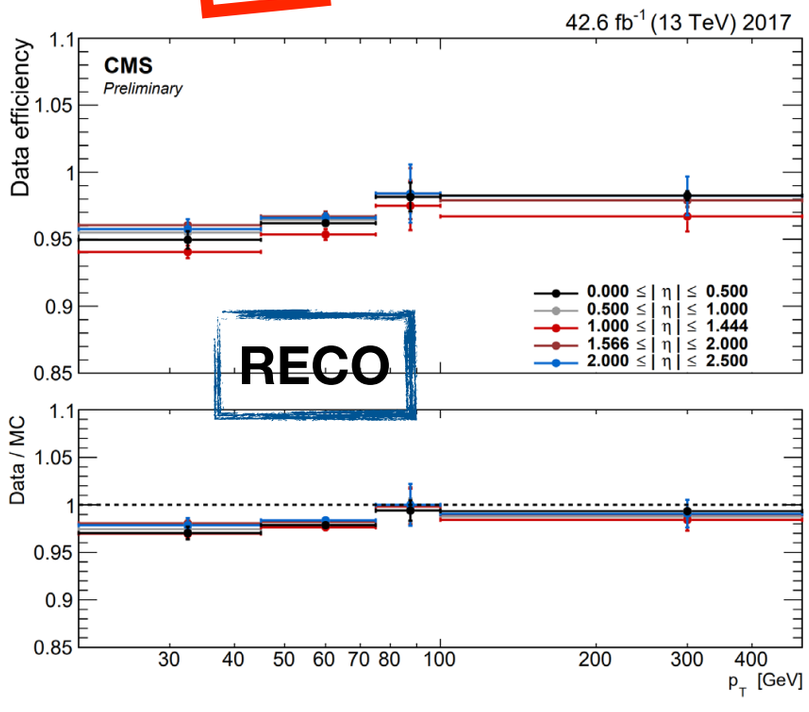
Single isolated Electron p_T>32, tight ID and isolation requirements

2017 - Reconstruction

2017 2016



2017



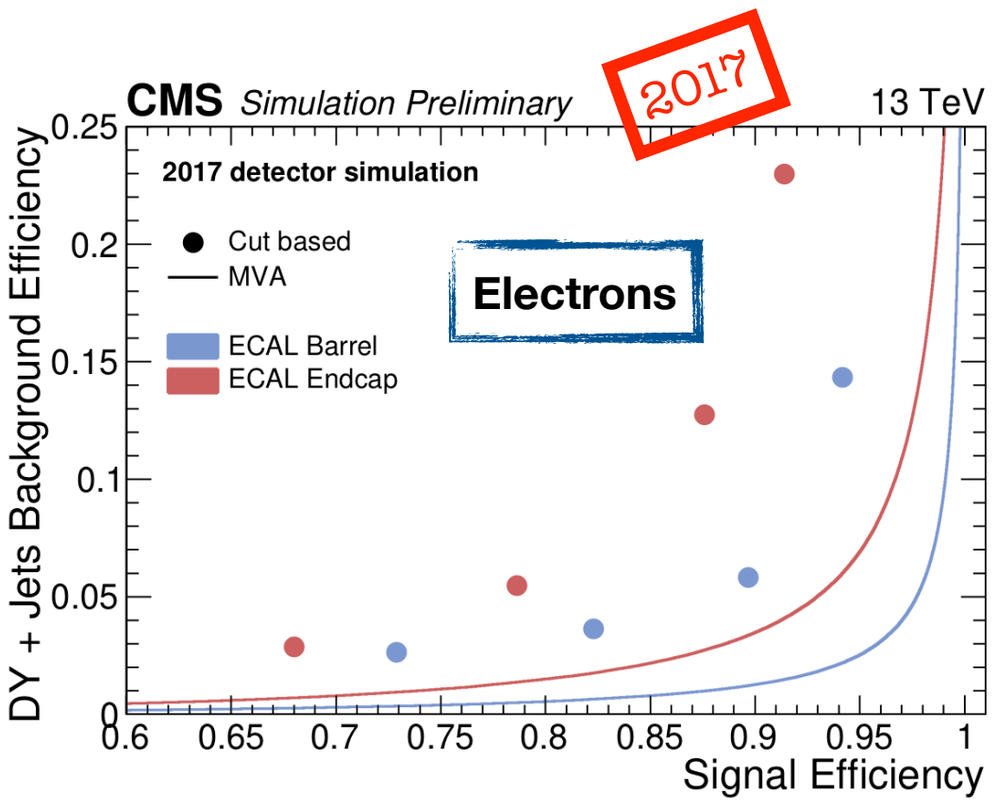
- **Fake rate and reconstruction efficiency** measured on **on Z→ee** (TnP method)
- In 2017, the **fake rate is lowered** due to the **new pixel detector**, by 30%:
  - Additional reduction of fake rate after the Identification step
- **2017** reconstruction efficiency **~96%** over the full **E_t/η spectrum**:
  - **Similar efficiency wrt 2016**, Increase of efficiency in some regions (low pt, high eta)

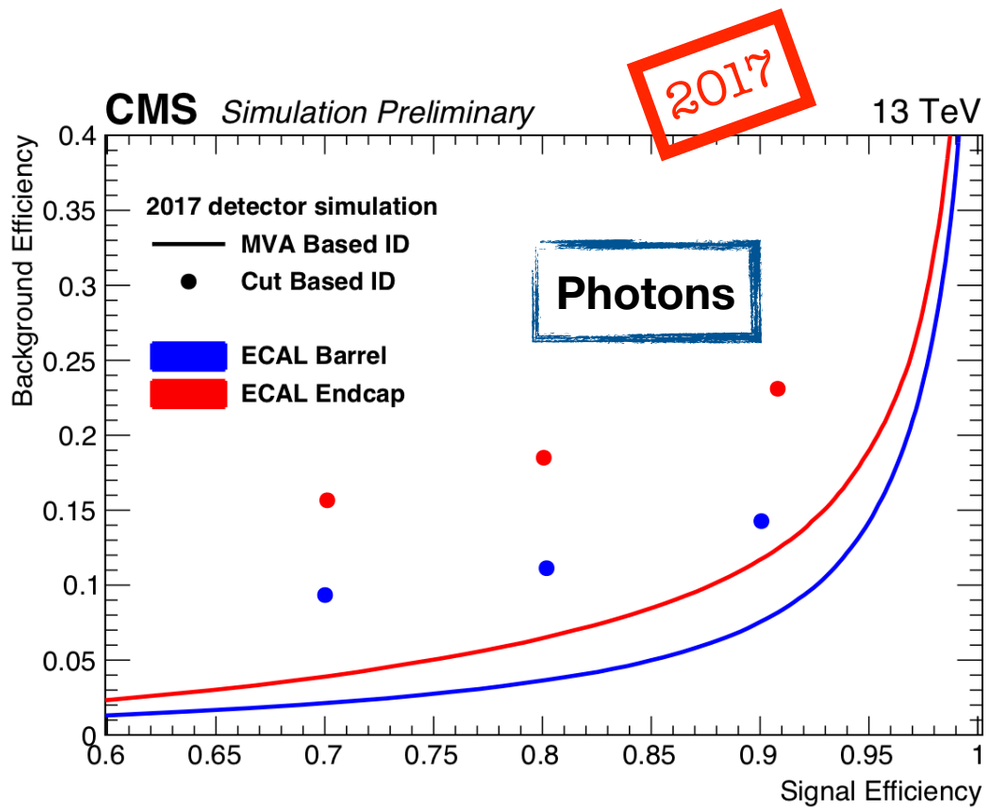
Identification

- Ele/γ **identification variables** to separate from backgrounds (jets, conversion, non-prompt particles):
  - **Calorimetric shower shape** observables
  - **Isolation**
  - **Tracking** observables (+matching with clusters)

- **Several selections** are derived depending on the analysis, based on this variables (**MVA** and **cut-based** approach):
  - Several **working points** (WP)
  - Different selections **EB/EE**
  - **Data/MC scale factors** derived for each selection

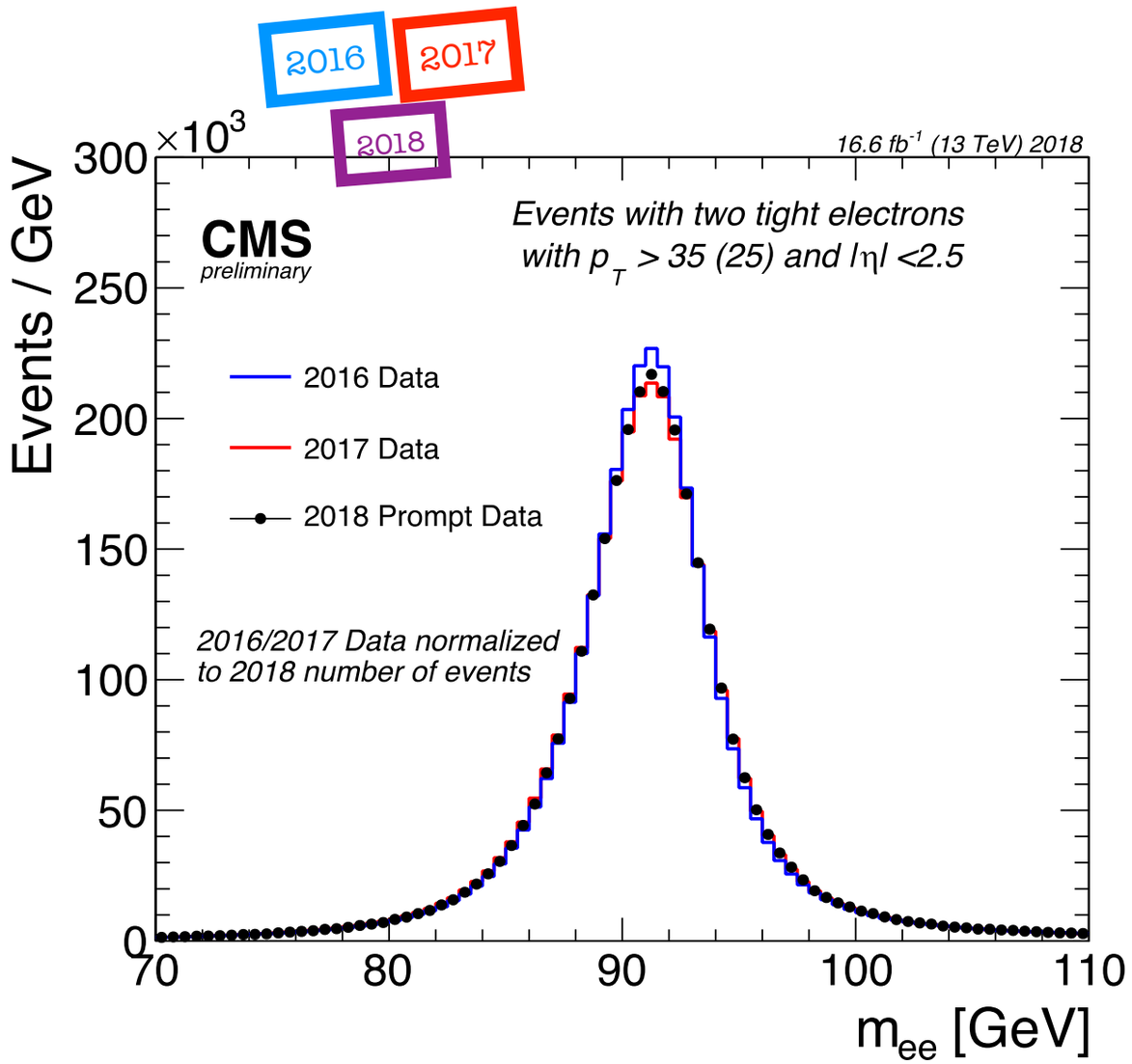
2017- Identification





- **MVA** and **cut-based** approach with several **working points** (separate optimization depending on eta/pt)
- Improved performance for photons and electrons, in both barrel and endcap
- Upgraded pixel: **electron fake rate in endcaps reduced** by 20 % (at 90% efficiency)
- Updates of **Electron MVA ID in 2017**:
  - Uses more advanced machine learning techniques
  - Optionally **includes PF isolation components** (more flexible)

2018 - First look at data



- **Dielectron invariant mass**
- 2018 **'Prompt'** reconstruction:
  - Single electron trigger
  - **Minimal selection** on electron pT and identification, EB and EE together
  - Opposite charge for the two electrons

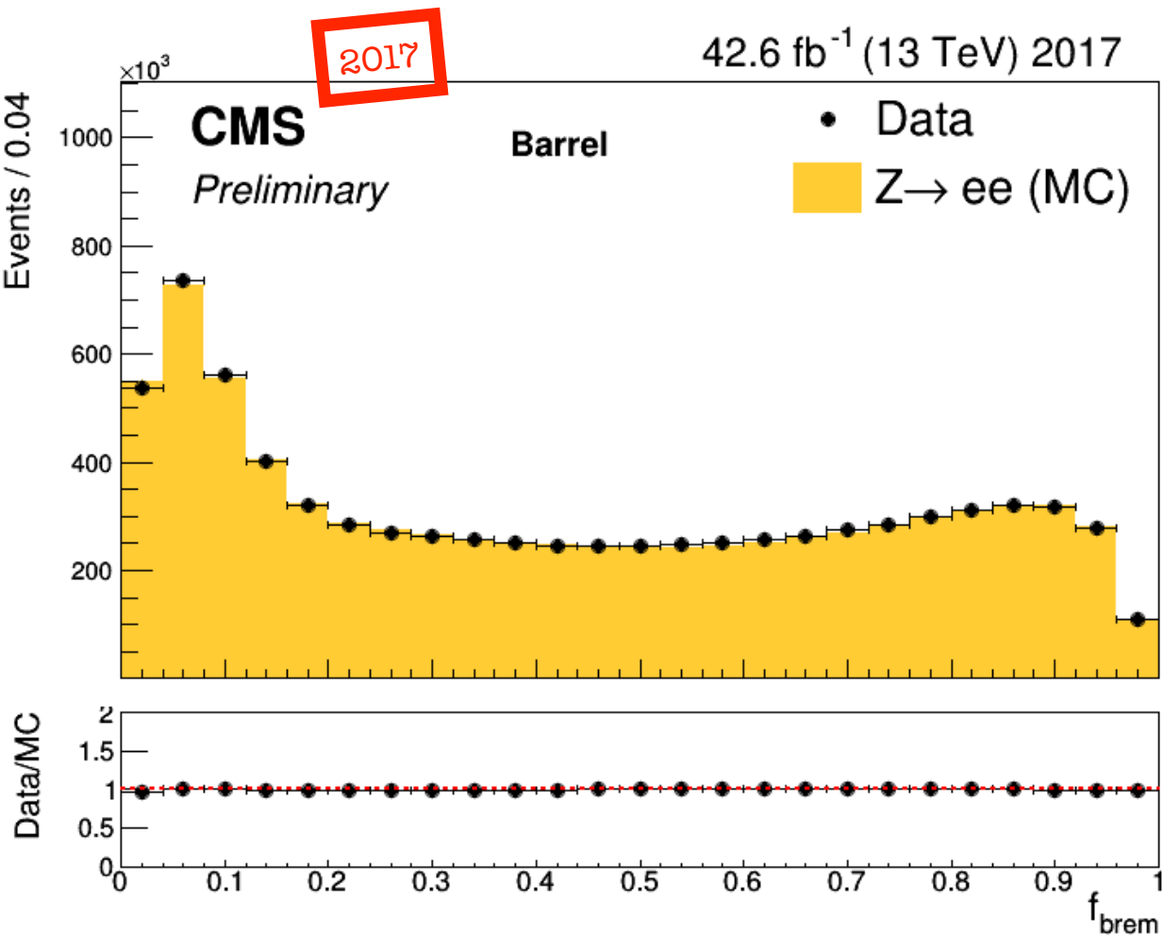
2018 data taking is ongoing.
CMS is performing well, we are already updating
our E/gamma strategy for 2018.
Updated results soon, stay tuned!

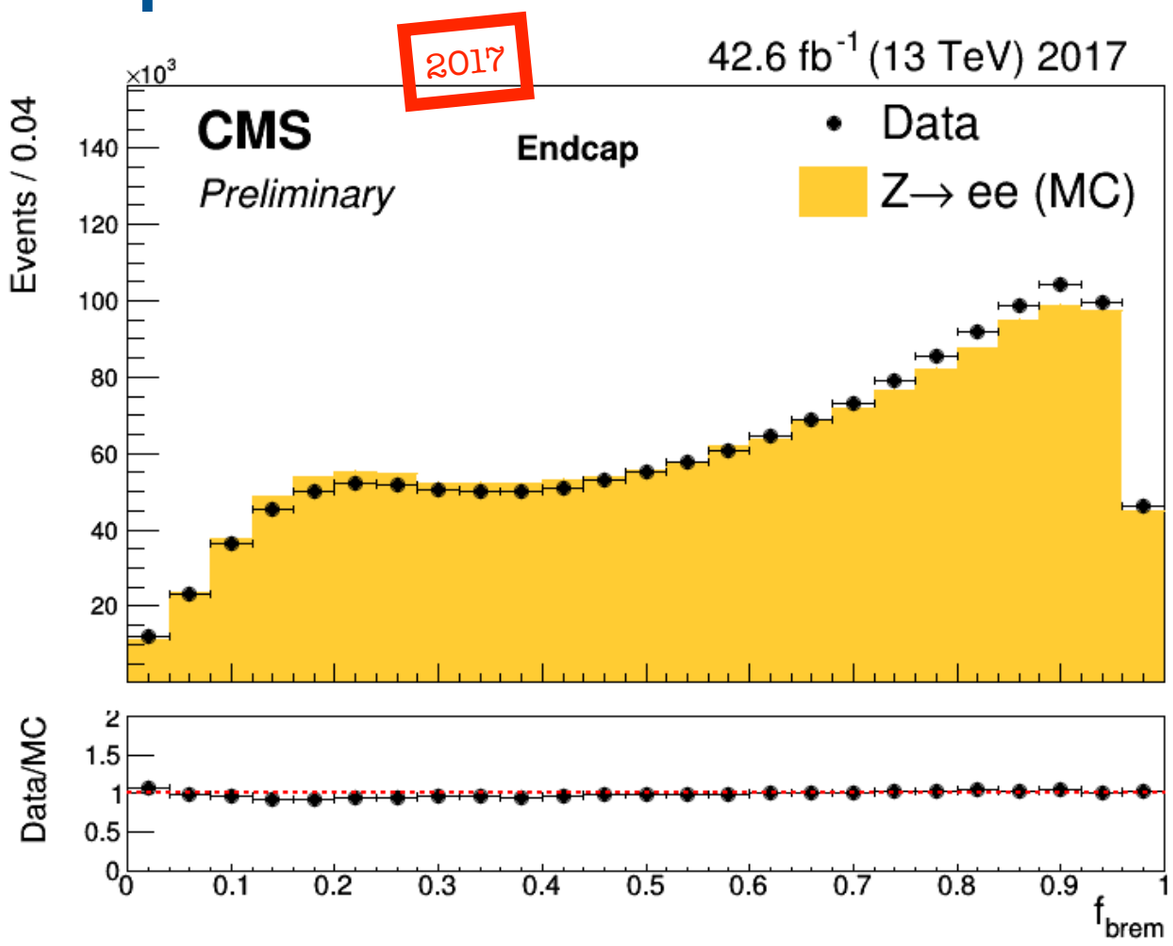
Conclusions

- **First data processing of 2017** for e/gamma shows excellent performance:
  - **Improved HLT/Reconstruction/Identification efficiency**, despite harsh experimental conditions
- **Final 2016 reprocessing** significantly improves data/MC agreeement:
  - Analyses can exploit the **understanding of low-level ECAL calibrations** for final results
- Reconstruction algorithm and sophisticated MVA techniques always **maintained** and **improved:**
  - Good modelling of physics effects and good separation from background ensures good physics performance for CMS physics program
- **2018 Data Taking ongoing:**
  - First look at data shows excellent quality, updated results soon

BACKUP

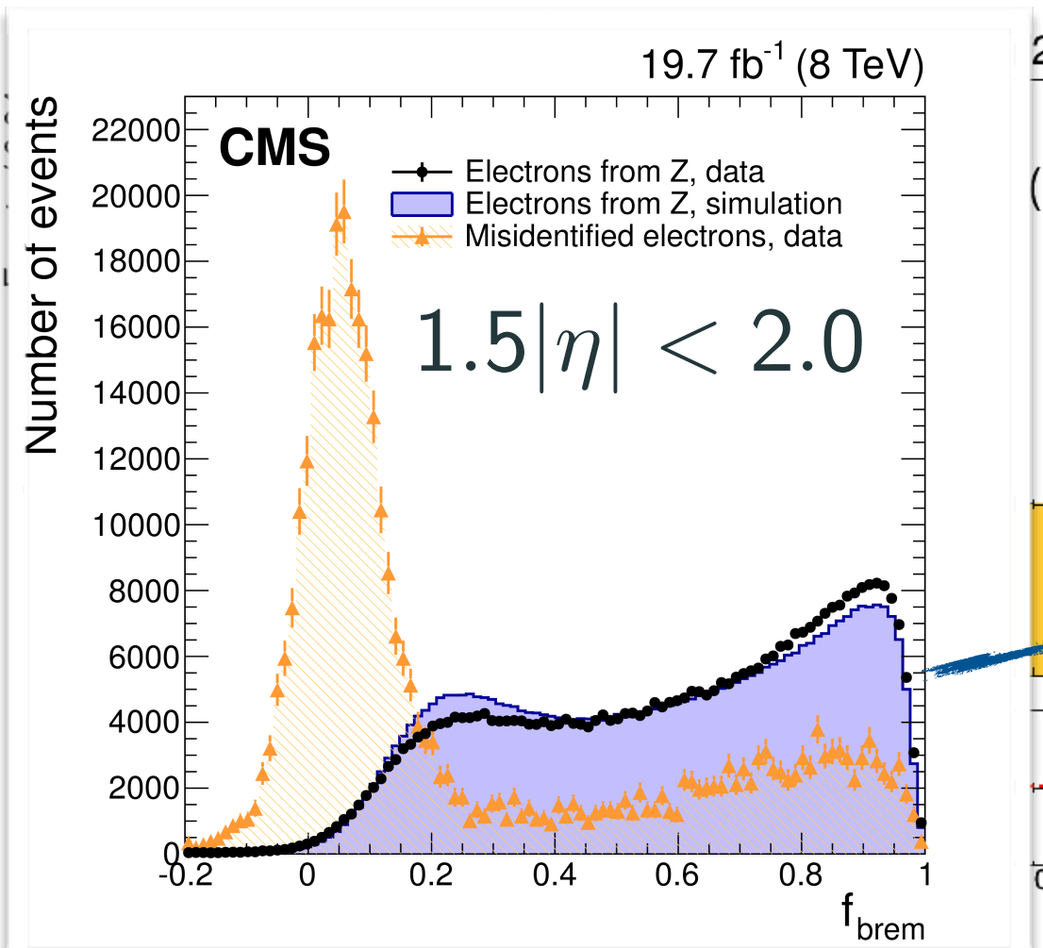
Identification - input variables

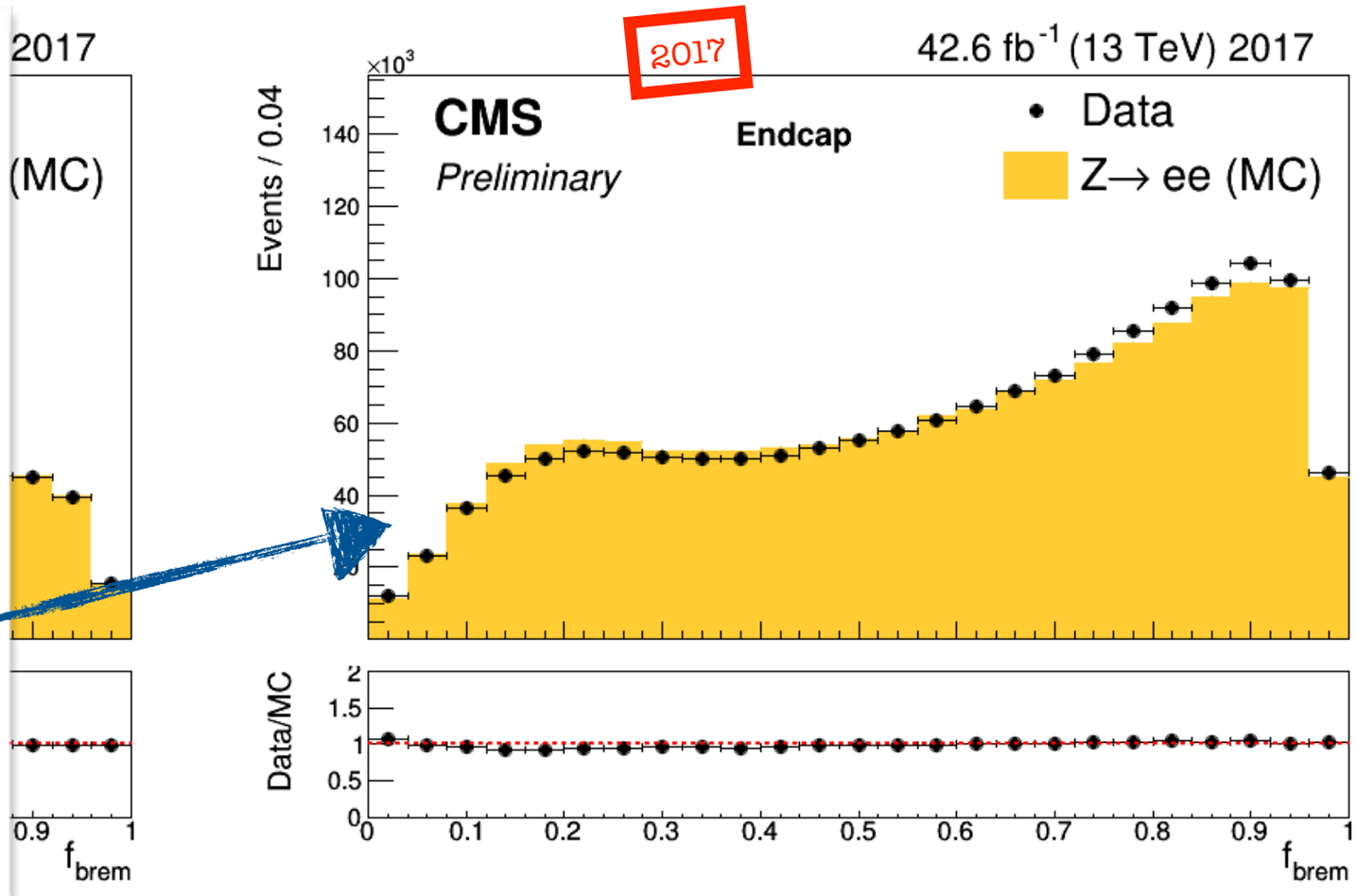




- **f_{brem}** = (p_{in}-p_{out}) /p_{in}, **fraction of the momentum lost to bremsstrahlung** in tracker:
  - Good way to check accuracy of MC simulation

Identification

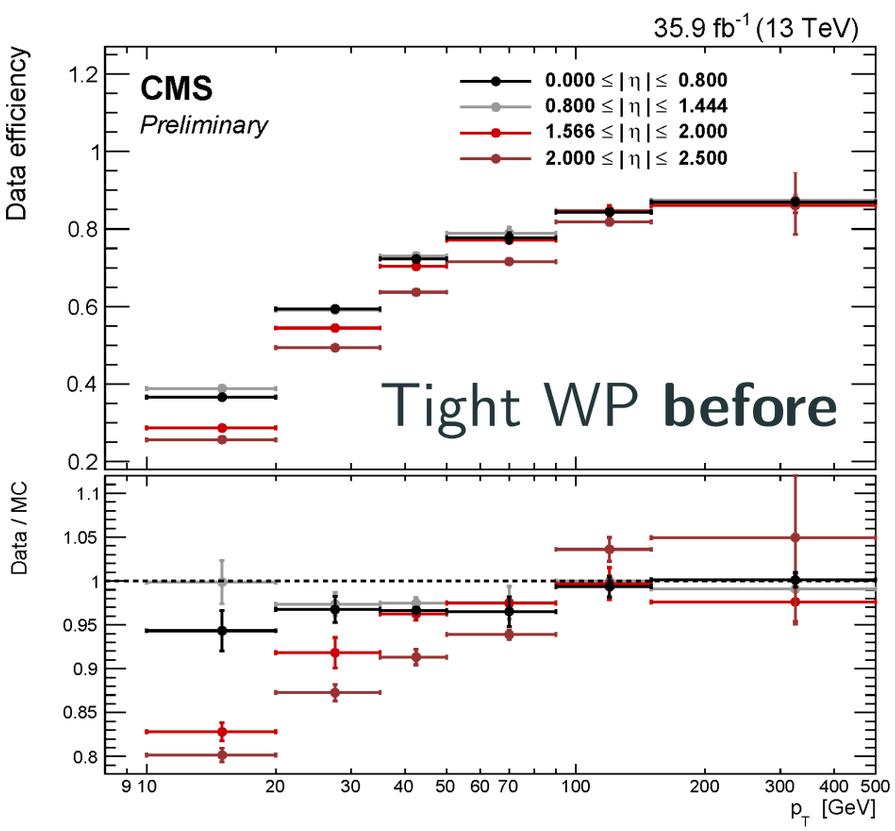


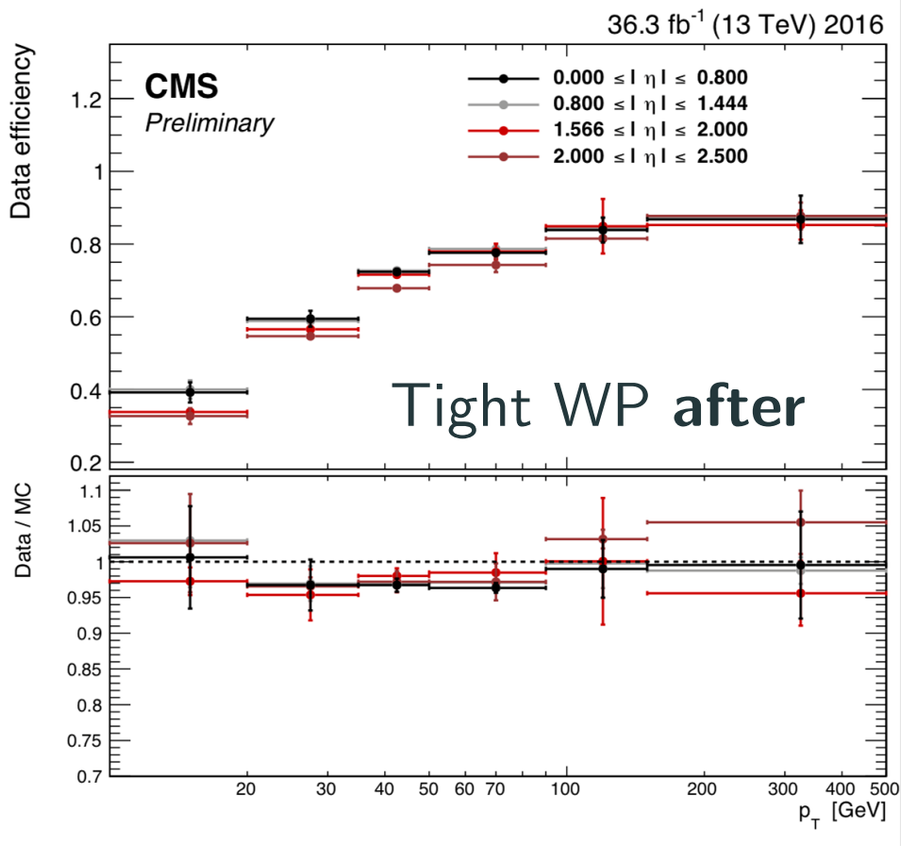


- **f_{brem}** = (p_{in}-p_{out}) /p_{in}, **fraction of the momentum lost to bremsstrahlung** in tracker:
  - Good way to check accuracy of MC simulation
- **Improved agreement wrt Run I** → correction of mismodeling of material budget

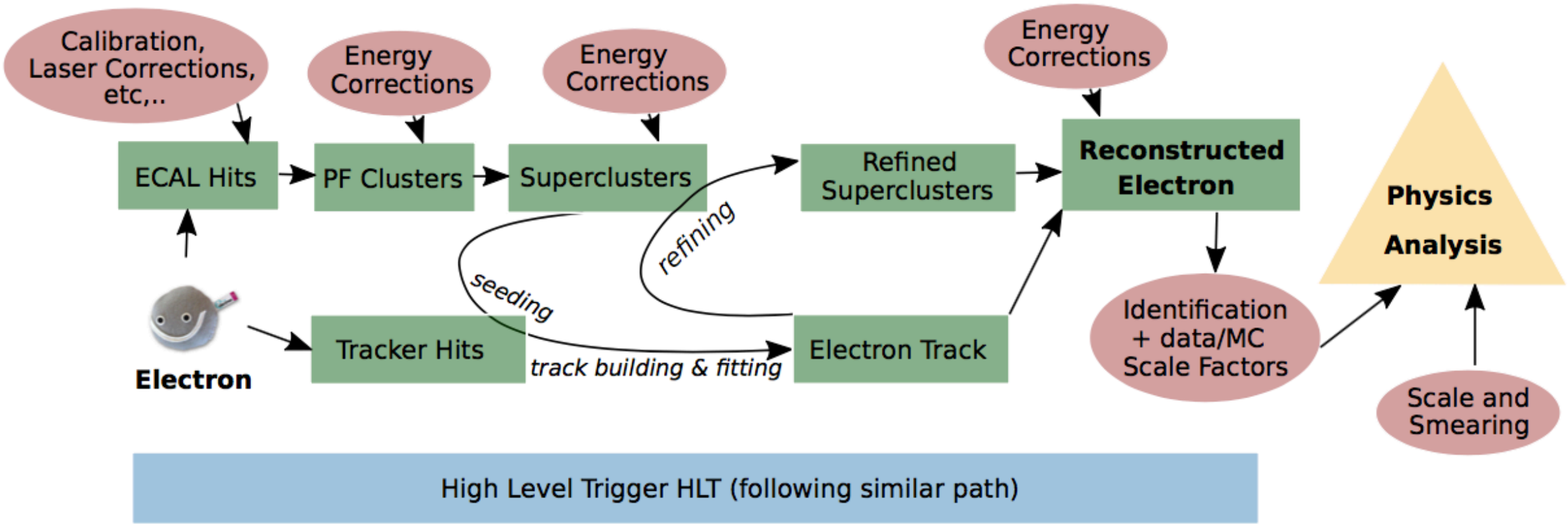
2016 - ID improvement

- **Electron cut based** identification **reReco** vs **Legacy**





Reconstruction algorithm



- Picture is similar for photons.
- Also seeding from Tracker hits matching clusters (complementing at low p_T, called "tracker driven").
- *Refining:* adding clusters matching extrapolated tangents at tracker layers, recovering bremsstrahlung or conversions.