CMS detector performance

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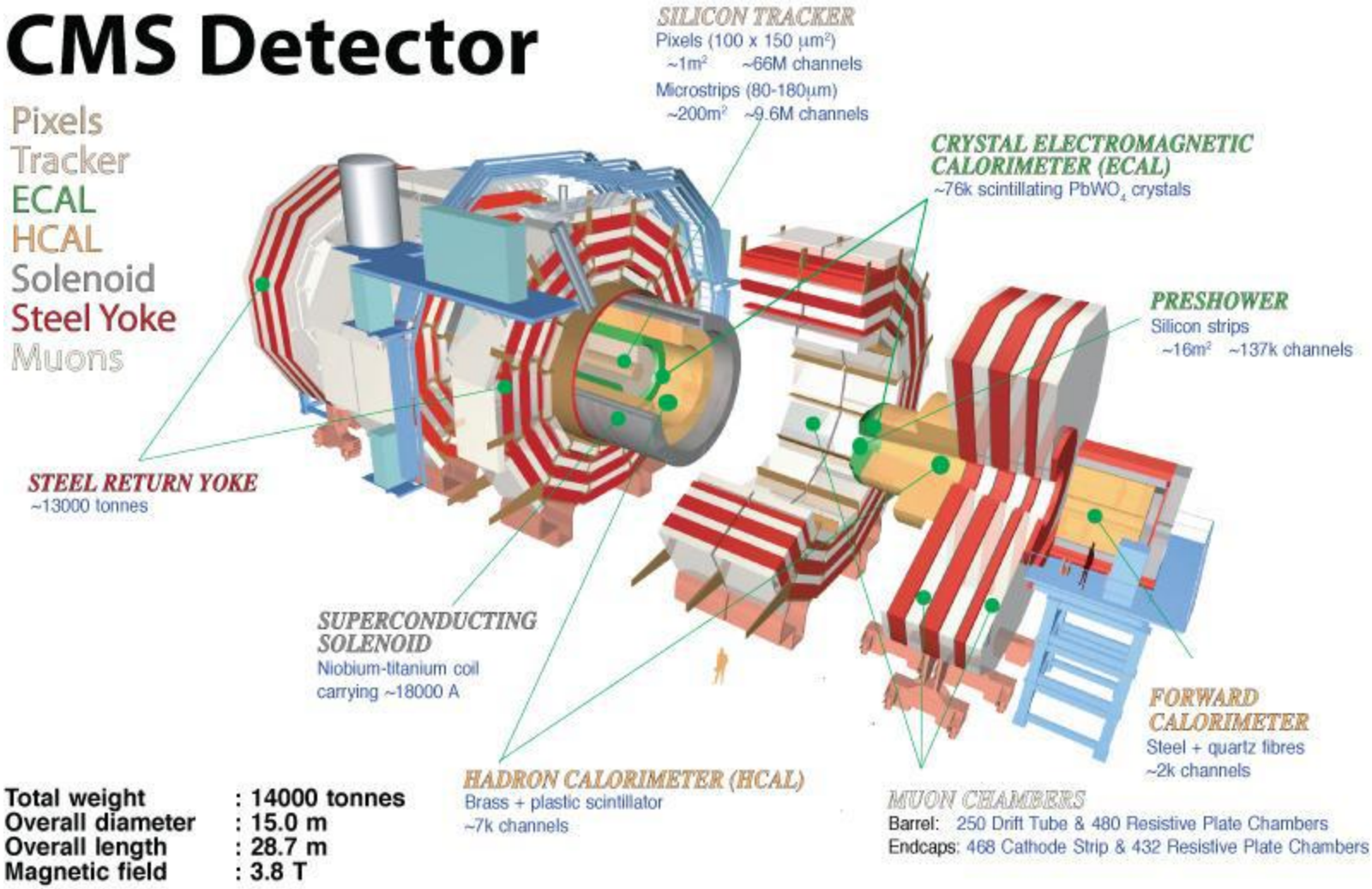
für Bildung
und Forschung

Outline :

- the tool : the Compact Muon Solenoid
- the data taking
- performance of the different sub-systems
- object identification
- outlook

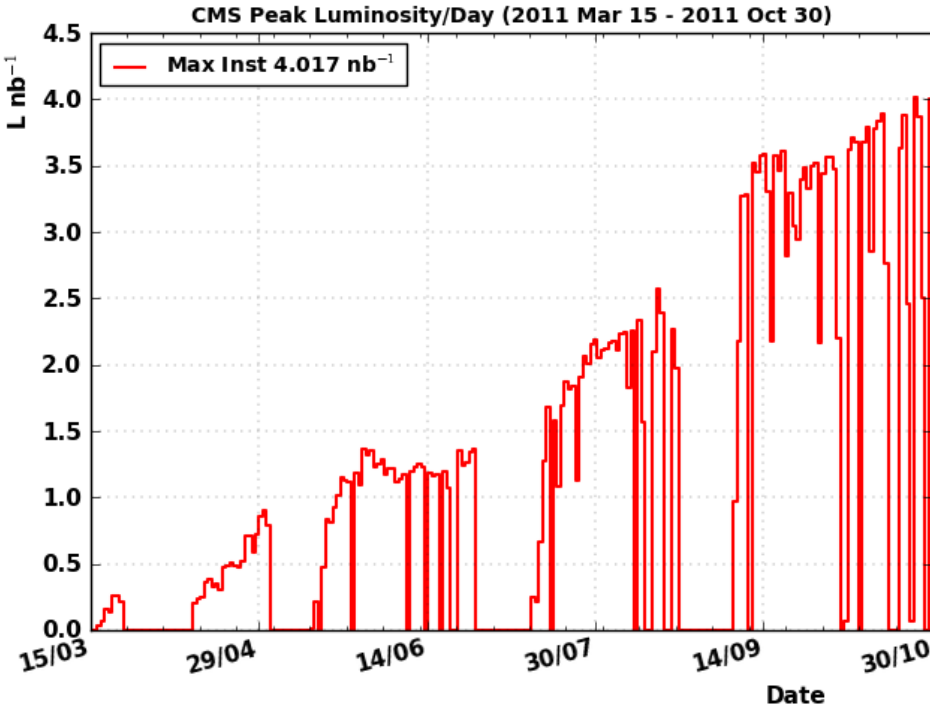
A Compact Muon Solenoid

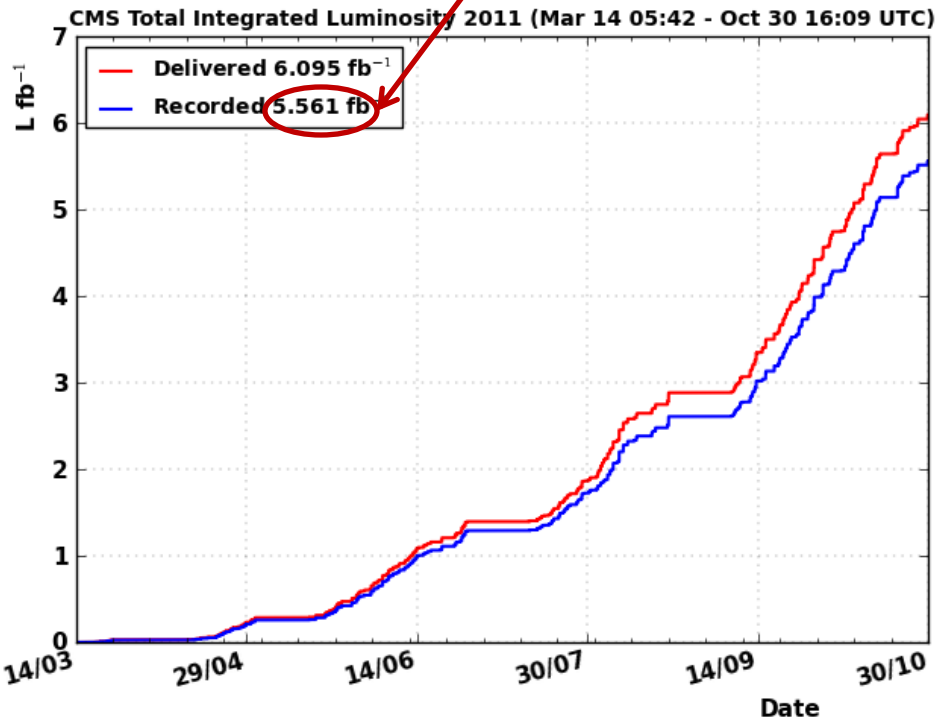


Data taking

- Data taking 2011 :
  - $\sqrt{s}$=7 TeV
  - Pile-up up to 20
  - Max. luminosity 3.5 10^{33} $cm^{-2}s^{-1}$

5 /fb were certified as 'golden' data usable by all analysis

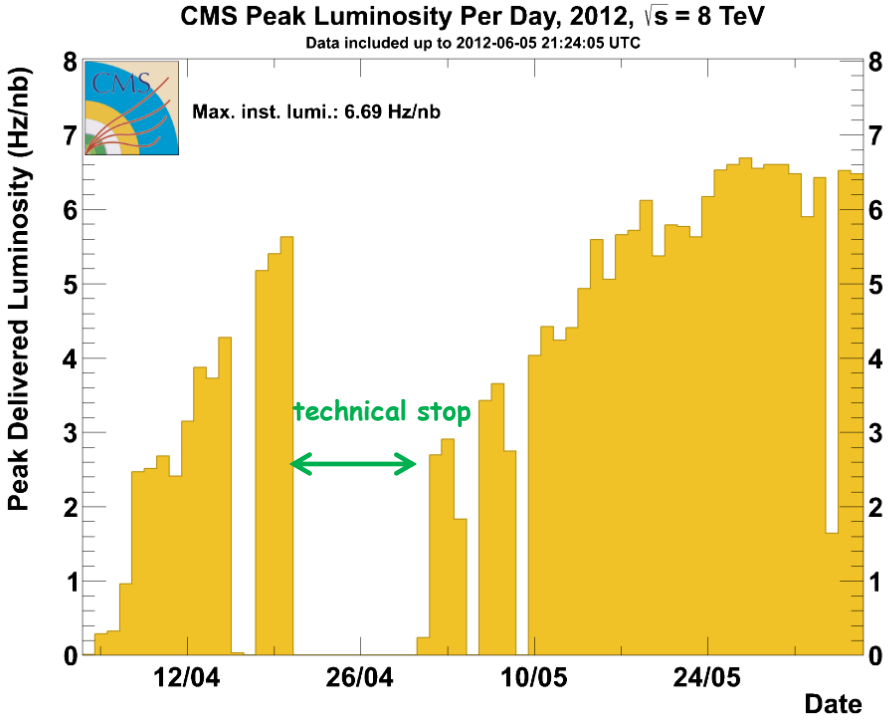


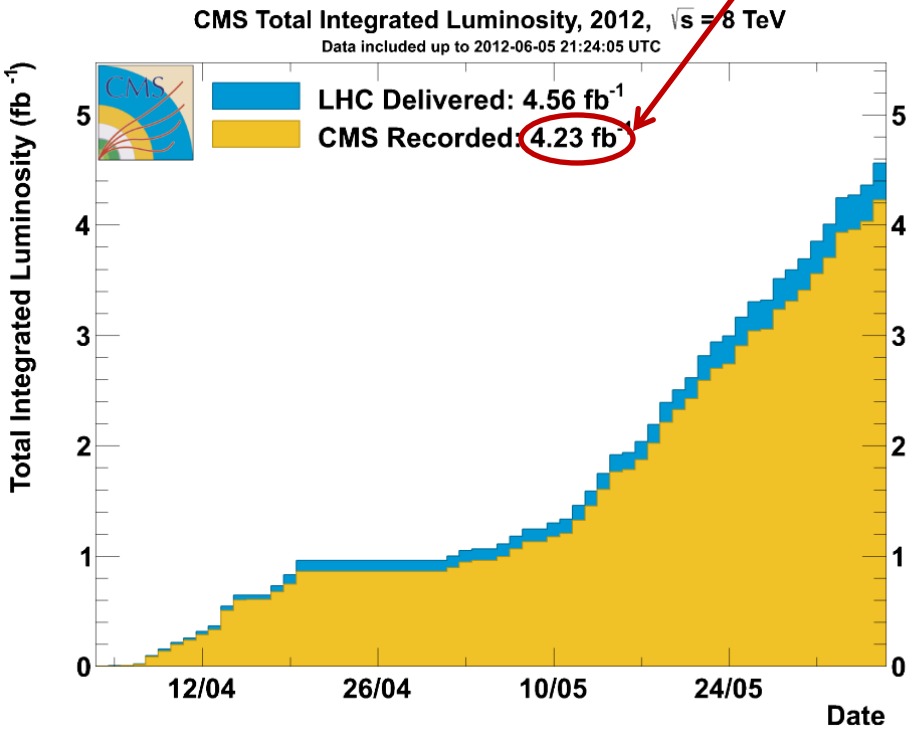


Data taking

- Data taking 2012 :
  - $\sqrt{s}$=8 TeV
  - Pile-up up to 35 @ 7.10^{33} $cm^{-2}s^{-1}$

Already about the same amount of data as in 2011 after only ~2 months !



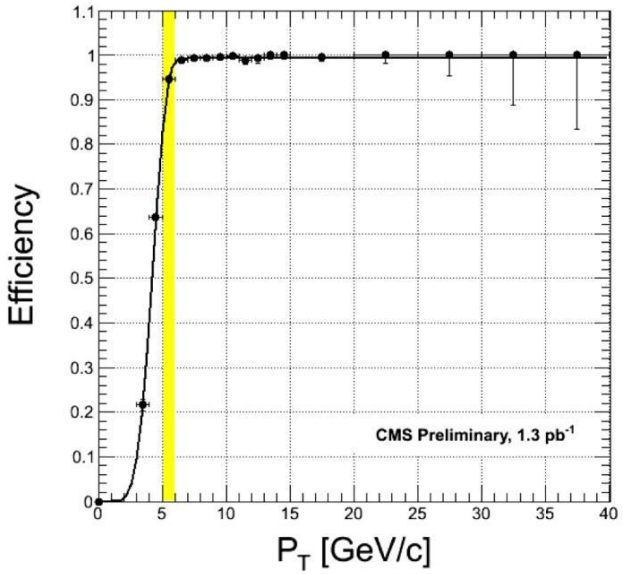


Sub-systems

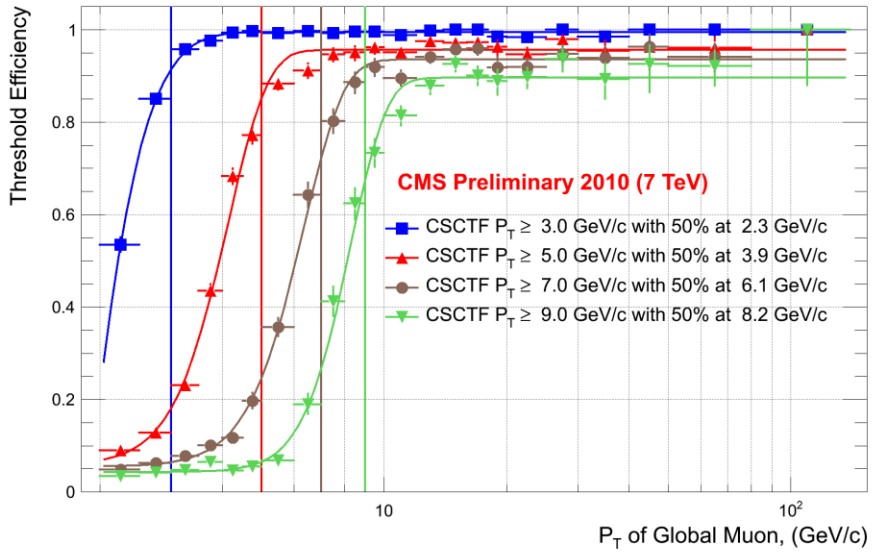
- Trigger L1/HLT :

Design : L1 output 100 kHz
HLT output ~300 Hz

Example : L1 muons, DTTF (track finder) and CSCTF turn-on curves



DTTF Pt turn-on for 5 GeV nominal Pt cut (J/psi events)

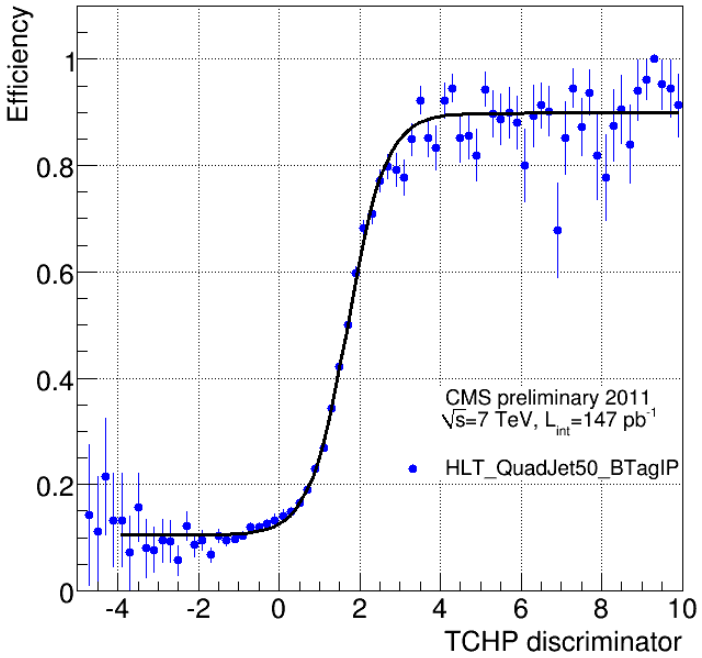


CSCTF Pt turn-on for several nominal Pt cuts

Sub-systems

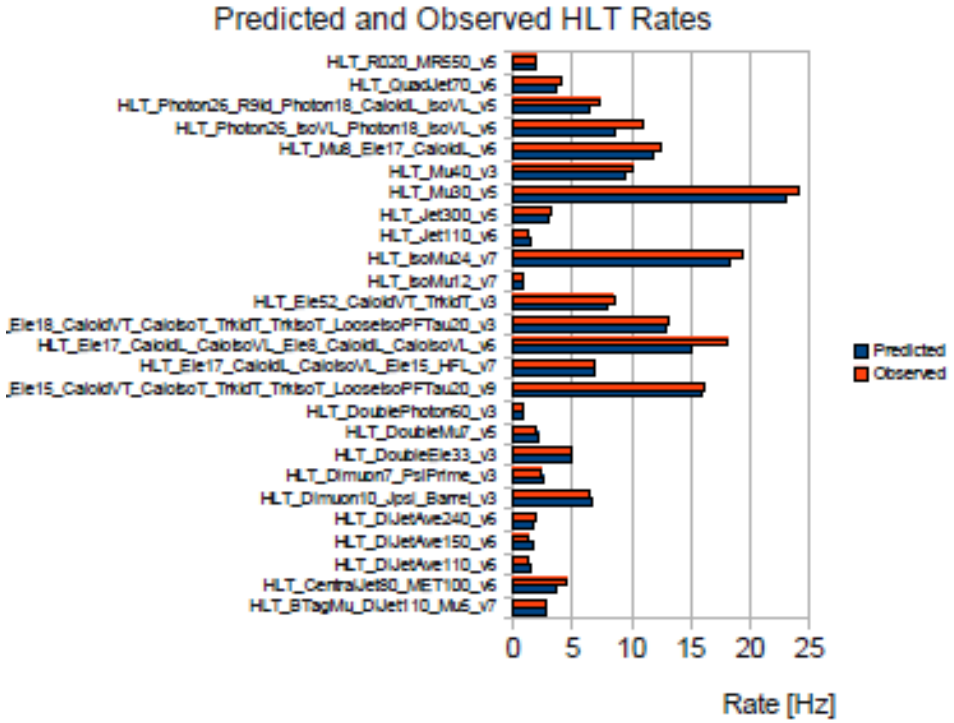
- Trigger L1/HLT :

HLT example : multiple jets and btag trigger



TCHP stands for the Track Counting High Purity b-tagging algorithm

HLT rates overview

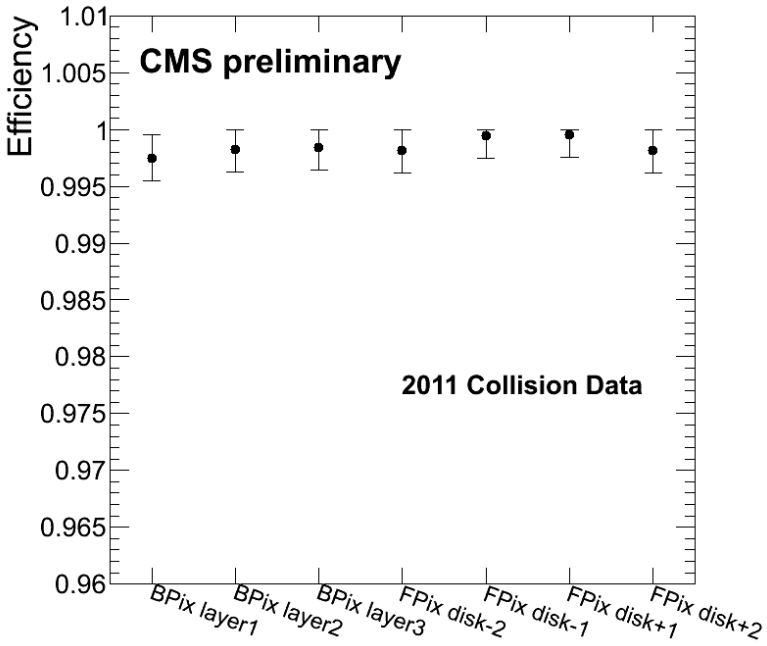


The triggers with highest rates are predicted with precision of ~5%

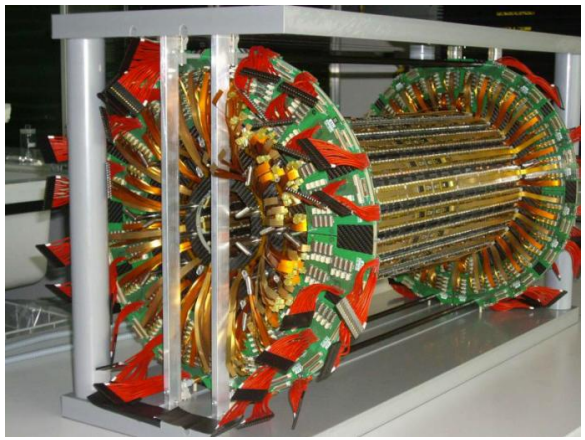
Sub-systems

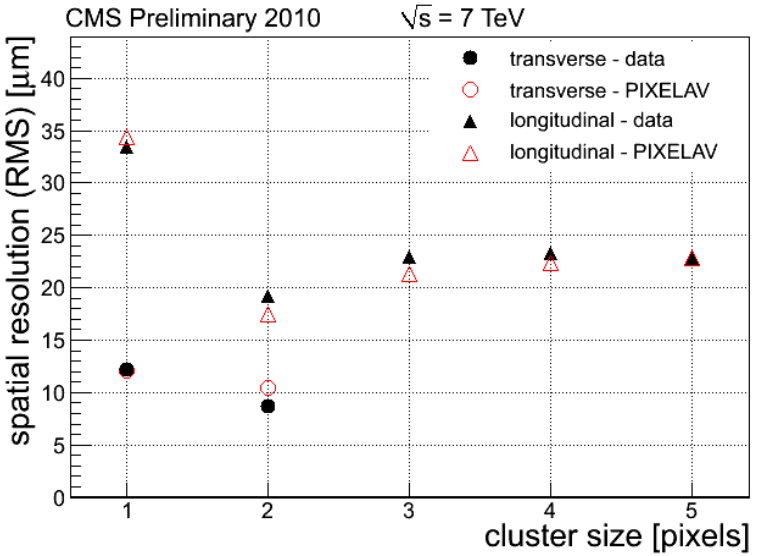
- Tracker (pixels) :

Resolution (pixels + strips) :
$\sigma p_T/p_T \approx 1.5 \cdot 10^{-4}\, p_T(GeV) + 0.5\%$



Efficiency for layers and disks
(systematic uncert.: 0.002, statistical uncert.: ~10^{-5})



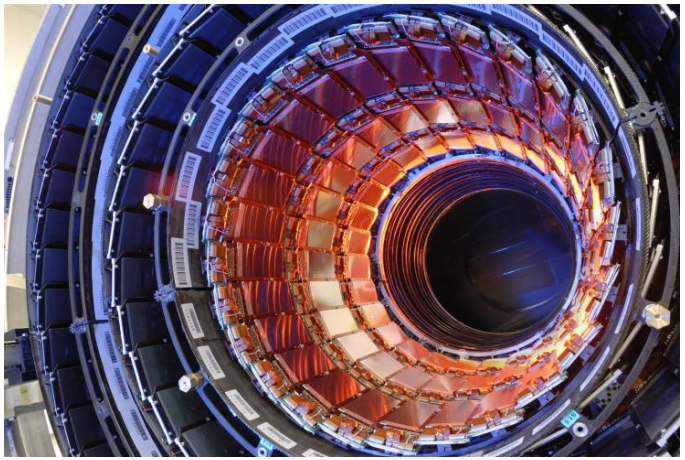


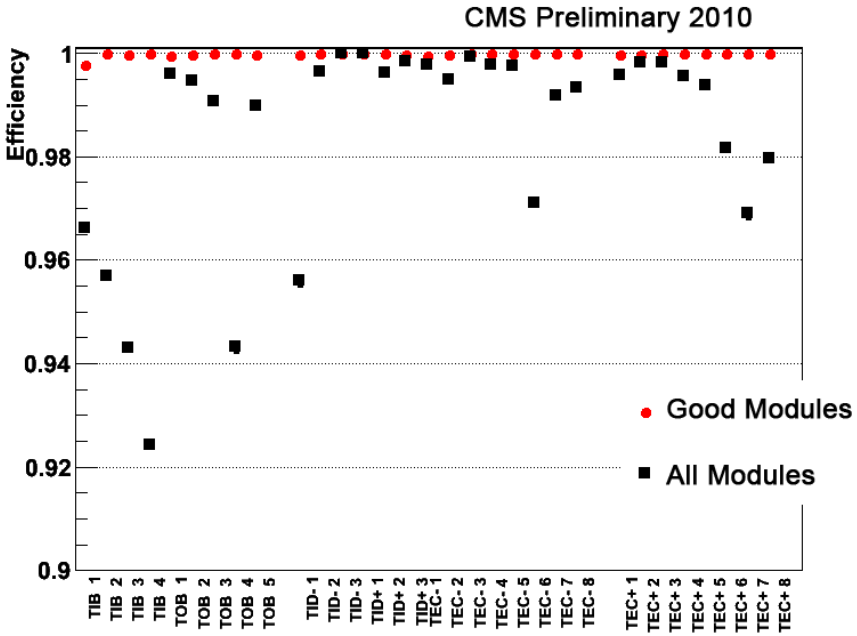
Transverse and longitudinal hit resolution as a function of the cluster length

Sub-systems

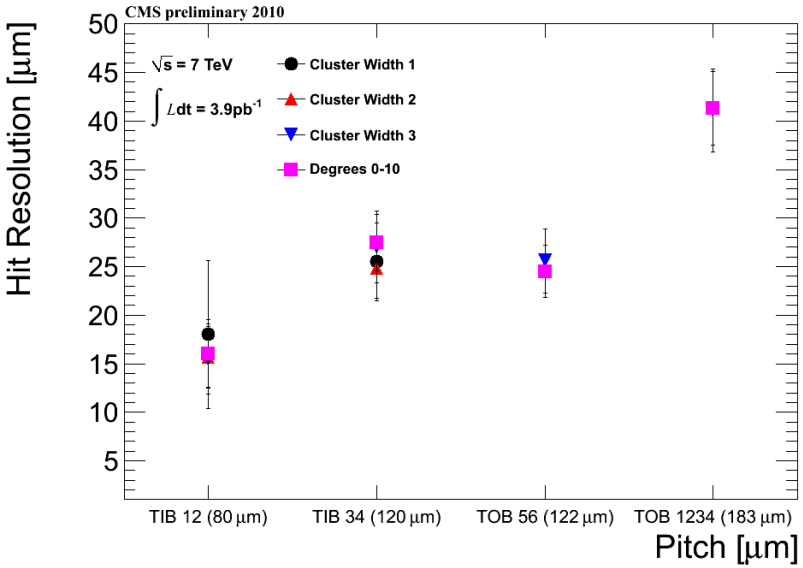
- Tracker (strips) :

Resolution (pixels + strips) :
$\sigma p_T/p_T \approx 1.5 \cdot 10^{-4}\, p_T(GeV) + 0.5\%$





Strip efficiency summary

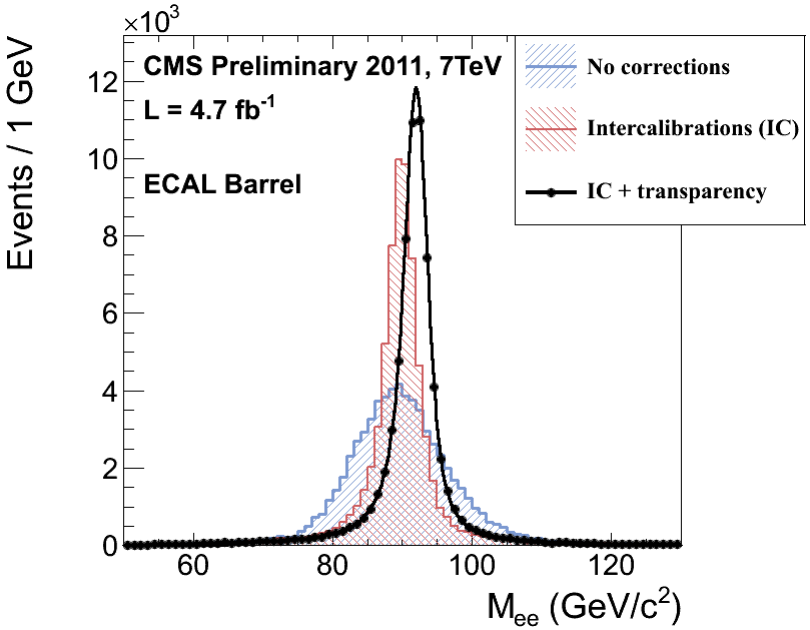


Resolution as a function of the strip pitch

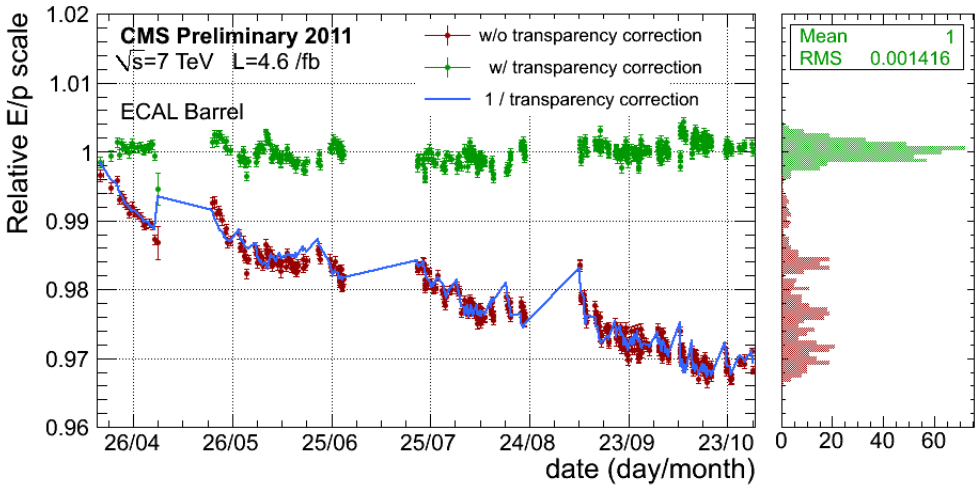
Sub-systems

- ECAL :

Resolution (barrel) :
$\sigma E/E \approx 2.9\%/\sqrt{E(GeV)} + 0.5\%$



Overall effect of single channel intercalibration and transparency correction on the Z→ee invariant mass in the ECAL barrel : instrumental resolution of 1.0 GeV in ECAL Barrel



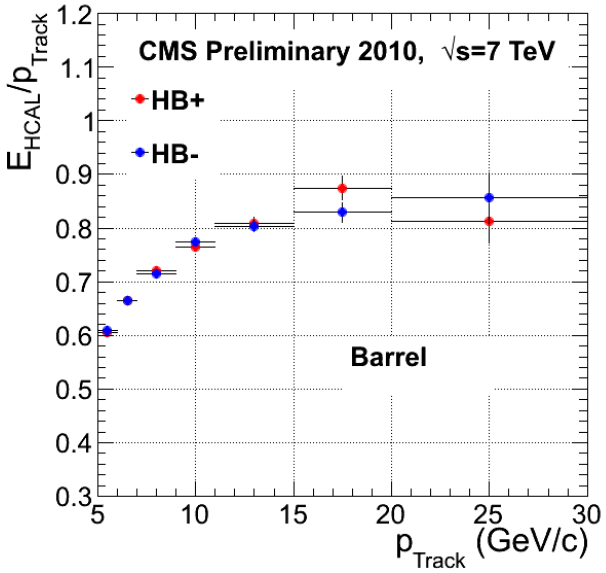
Single electron energy scale (E/p) stability in the ECAL barrel for 2011 CMS data measured using W→ev events: in the barrel (endcap), average signal loss ~2.5% (~10%)

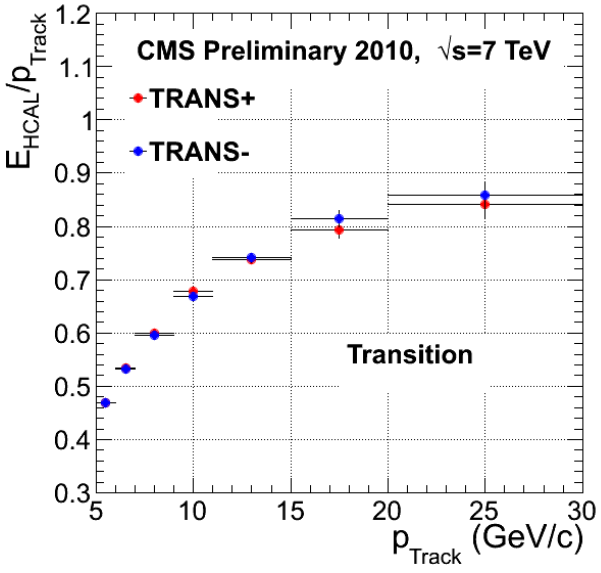
Sub-systems

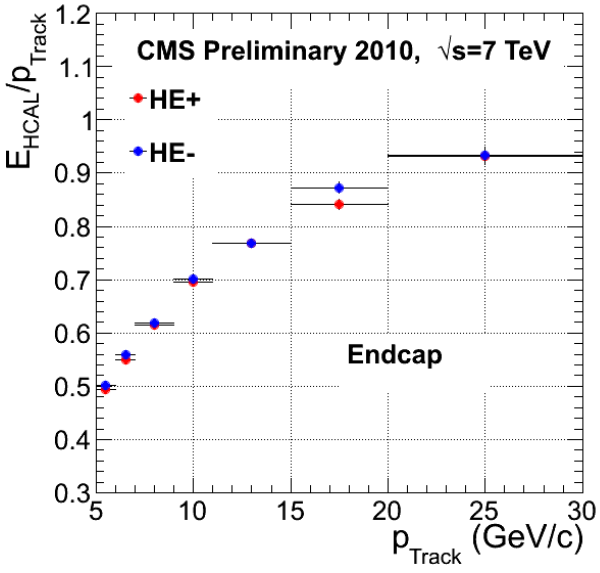
- HCAL :

Resolution (barrel) :
$\sigma E/E \approx 120\%/\sqrt{E(GeV)} + 6.9\%$

HCAL mean response :







HCAL mean response for $|\eta| < 1.1$ using isolated tracks with $p_T > 5$ GeV

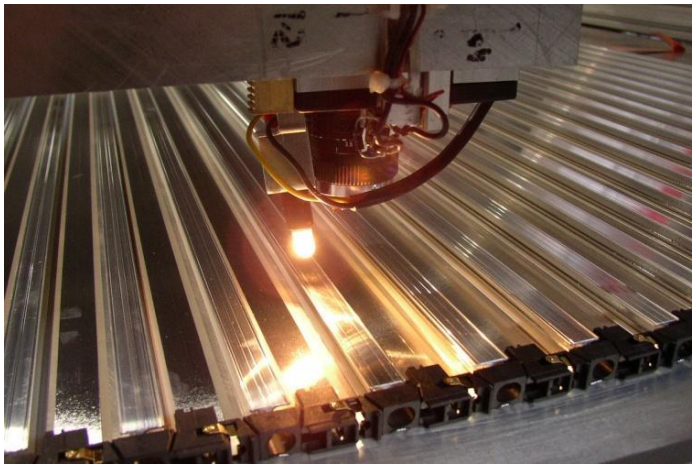
$1.1 < |\eta| < 1.7$

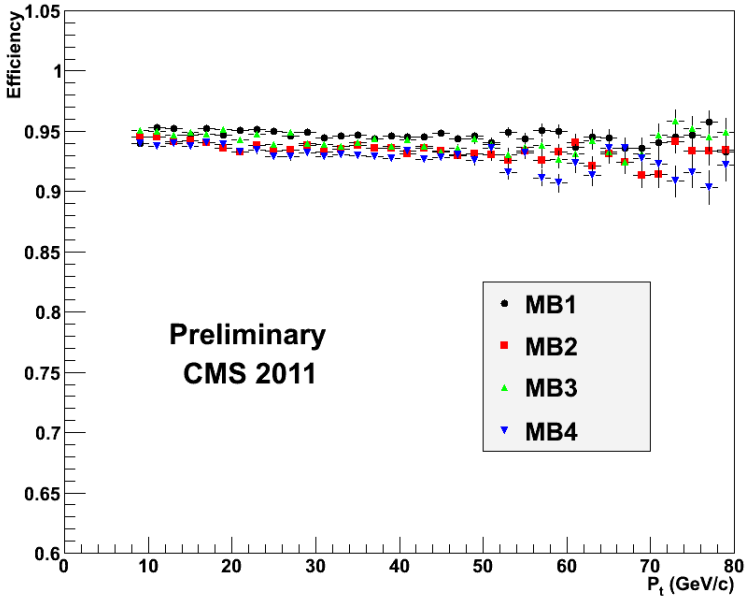
$1.7 < |\eta| < 2.2$

Sub-systems

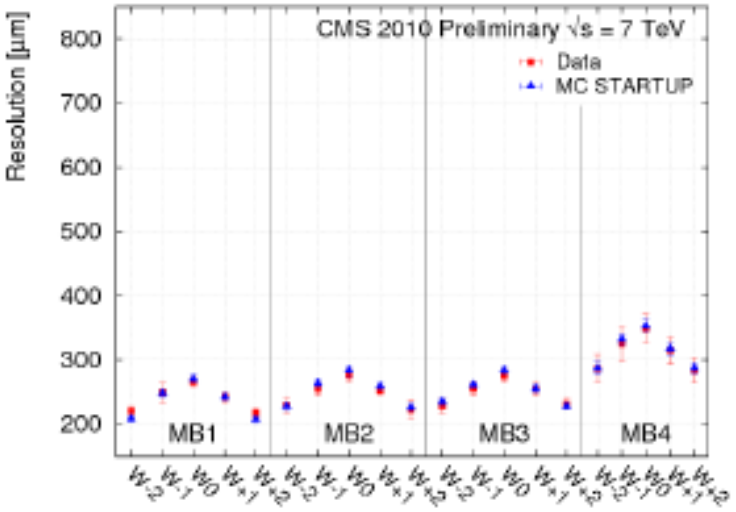
- Muon system : DT

Resolution (muon system + tracker) :
$\sigma p_T/p_T \approx 1\%$ for low p_T muons
$\sigma p_T/p_T \approx 5\%$ for 1 TeV muons





DT local trigger efficiency

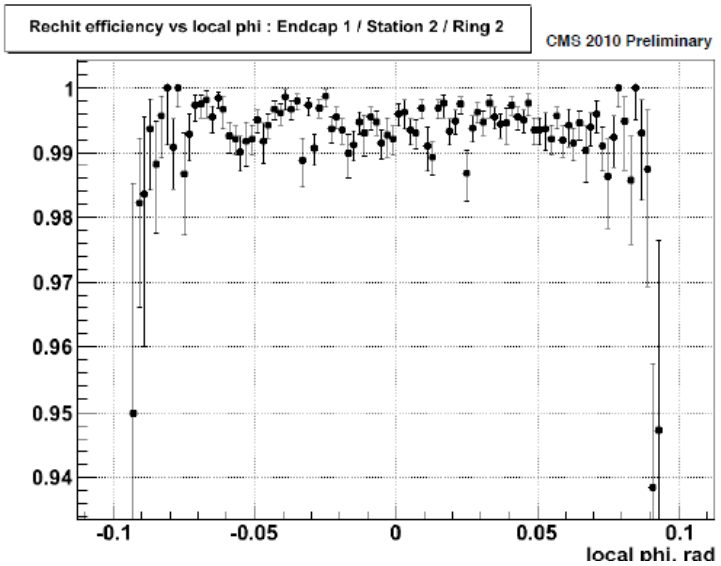


Hit resolution in the rφ view

Sub-systems

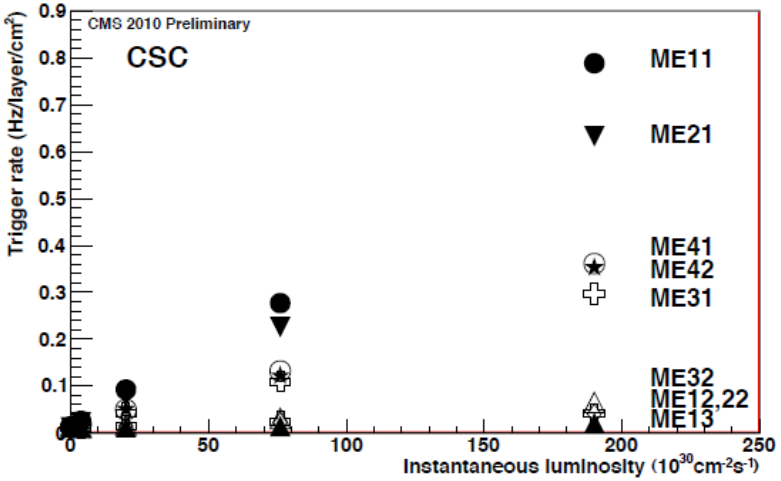
- Muon system : CSC

Resolution (muon system + tracker) :
$\sigma p_T/p_T \approx 5\%$ for 1 TeV muons



Efficiency as a function of local φ of strip

The CSC hit resolution varies from 56 to 140 μm

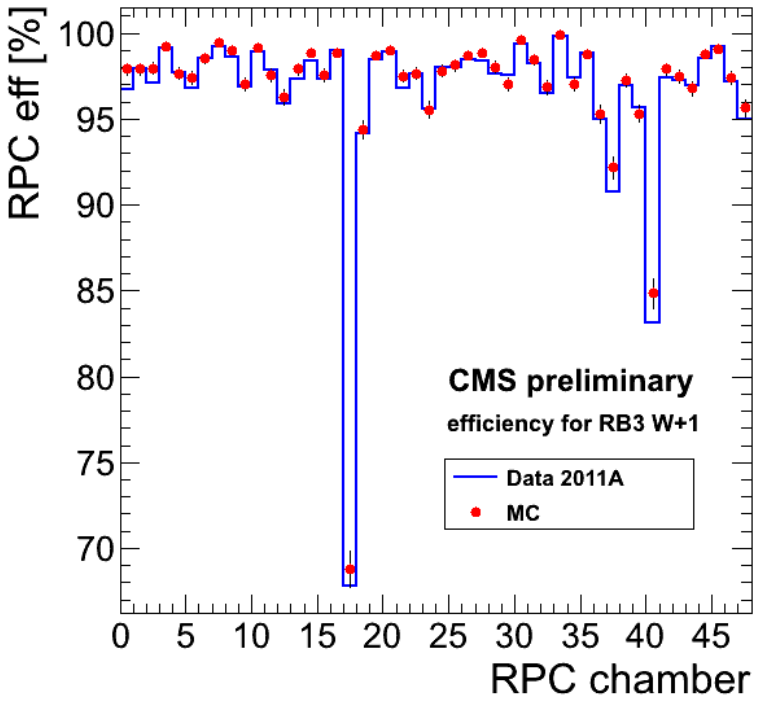


The CSC background trigger rate as a function of the luminosity

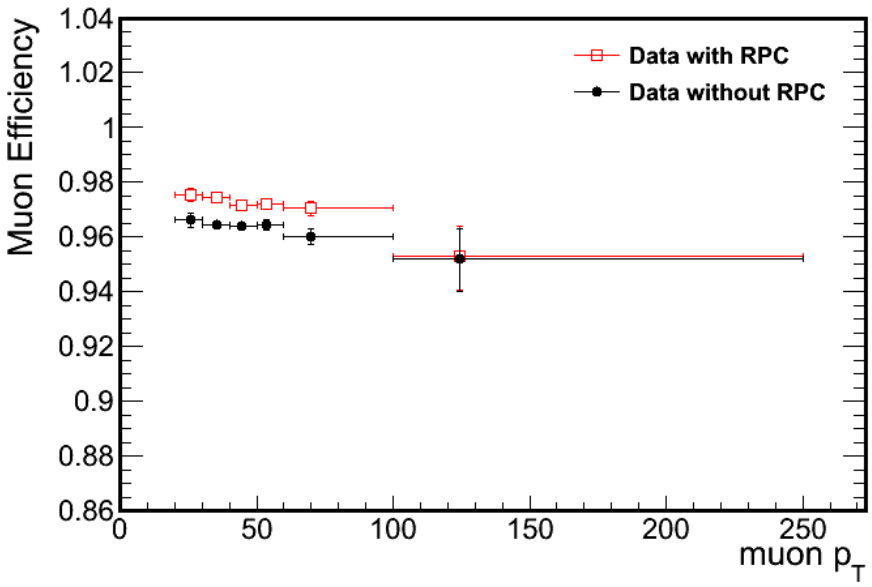
Sub-systems

- Muon system : RPC

Time resolution < 3 ns



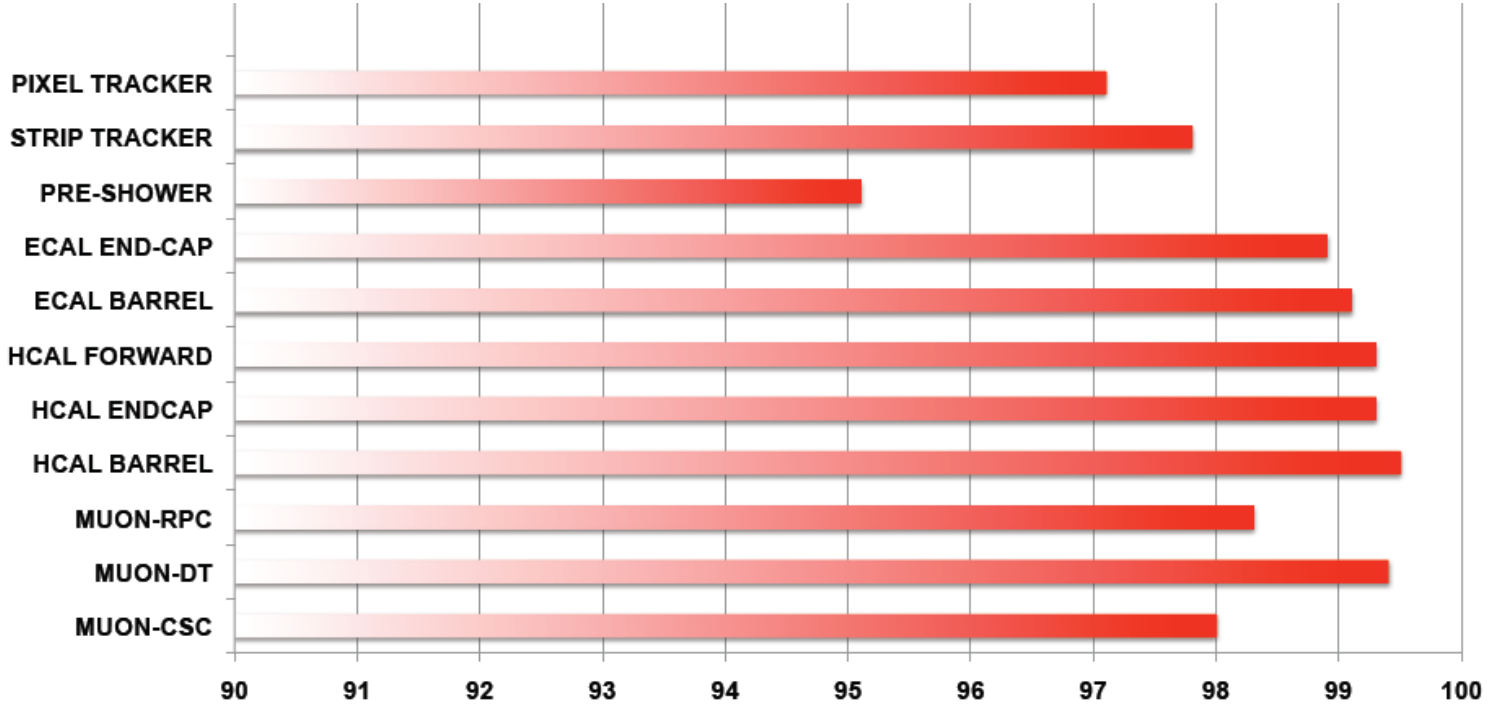
Example of the efficiency for all the RB3 chambers of the Barrel Wheel+1



Efficiency for muon identification with and without RPC

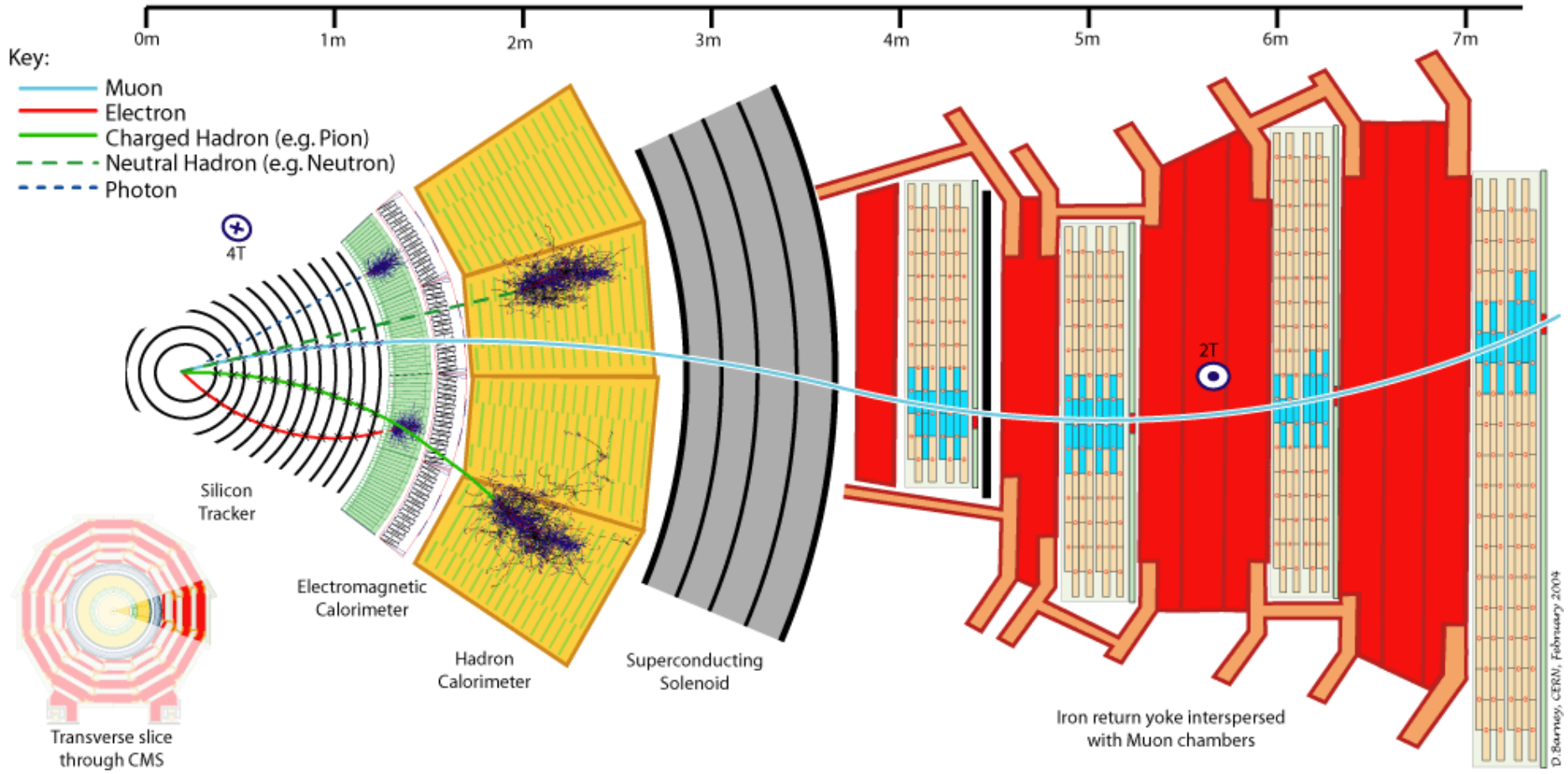
Sub-systems

- Overview : live channels fraction per sub-system



	MUON-CSC	MUON-DT	MUON-RPC	HCAL BARREL	HCAL ENDCAP	HCAL FORWARD	ECAL BARREL	ECAL END-CAP	PRE-SHOWER	STRIP TRACKER	PIXEL TRACKER
Series1	98	99.4	98.3	99.5	99.3	99.3	99.1	98.9	95.1	97.8	97.1

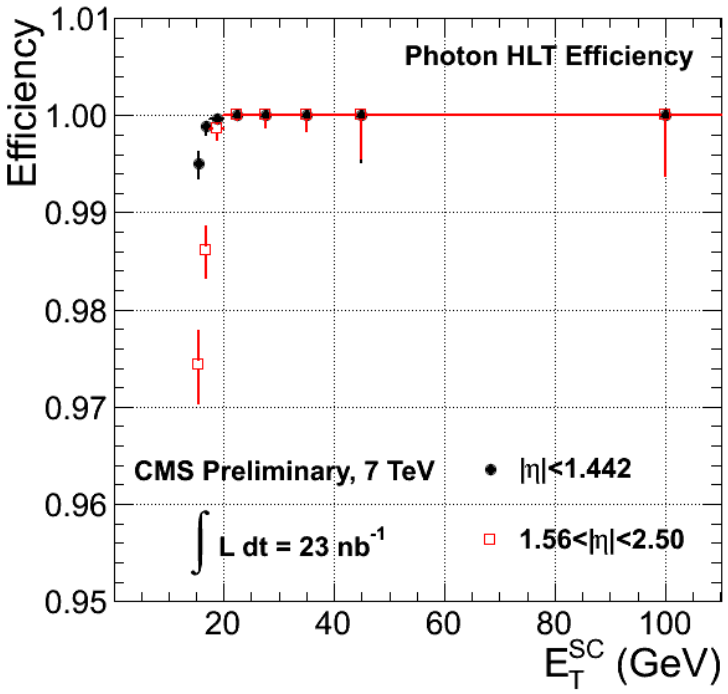
Object identification

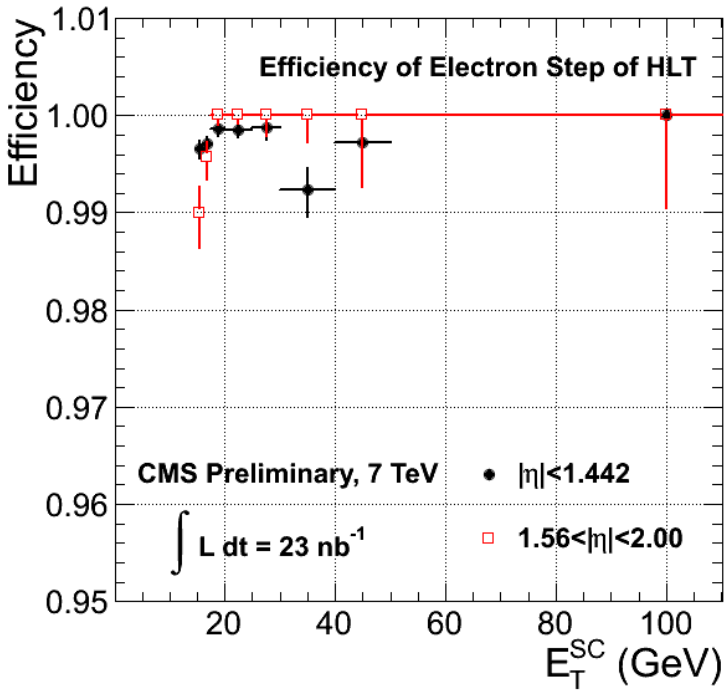


Object identification

- E/γ :

HLT e/γ efficiency for an offline object matching with an L1 object :





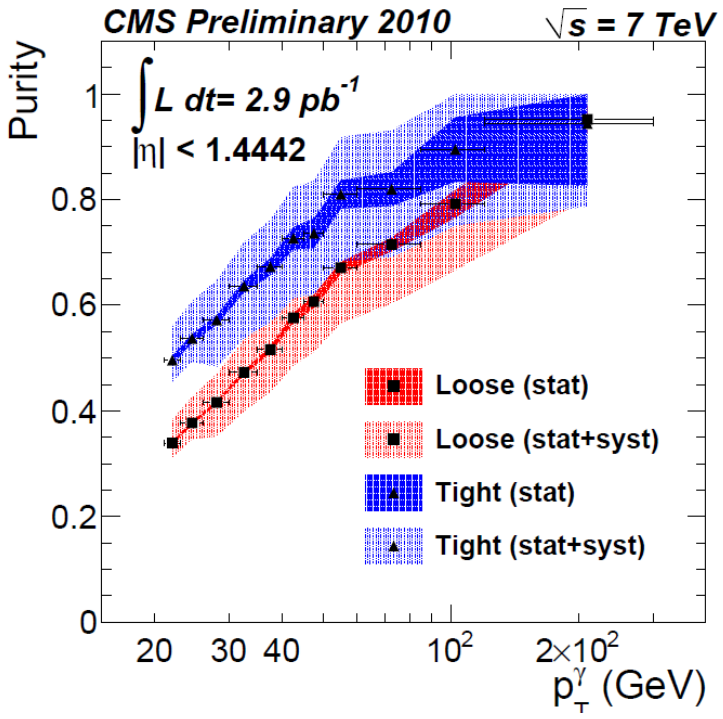
Electron reconstruction efficiency :

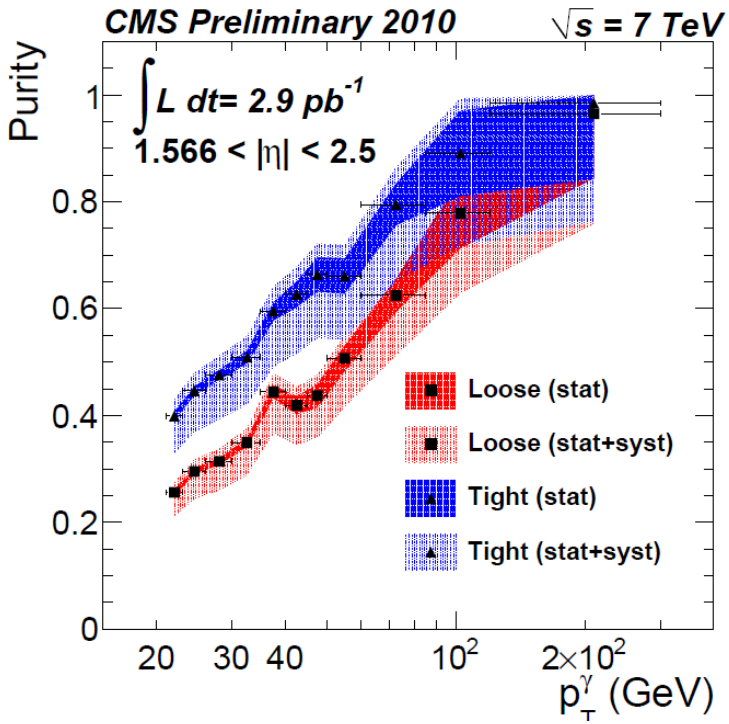
Z Tag & Probe	Measured efficiency	Error (stat. + syst)	MC efficiency
Reco Eff Barrel	99.3%	1.4%	98.5%
Reco Eff Endcap	96.8%	3.4%	96.1%

Object identification

- E/γ :

Isolated photon purity :



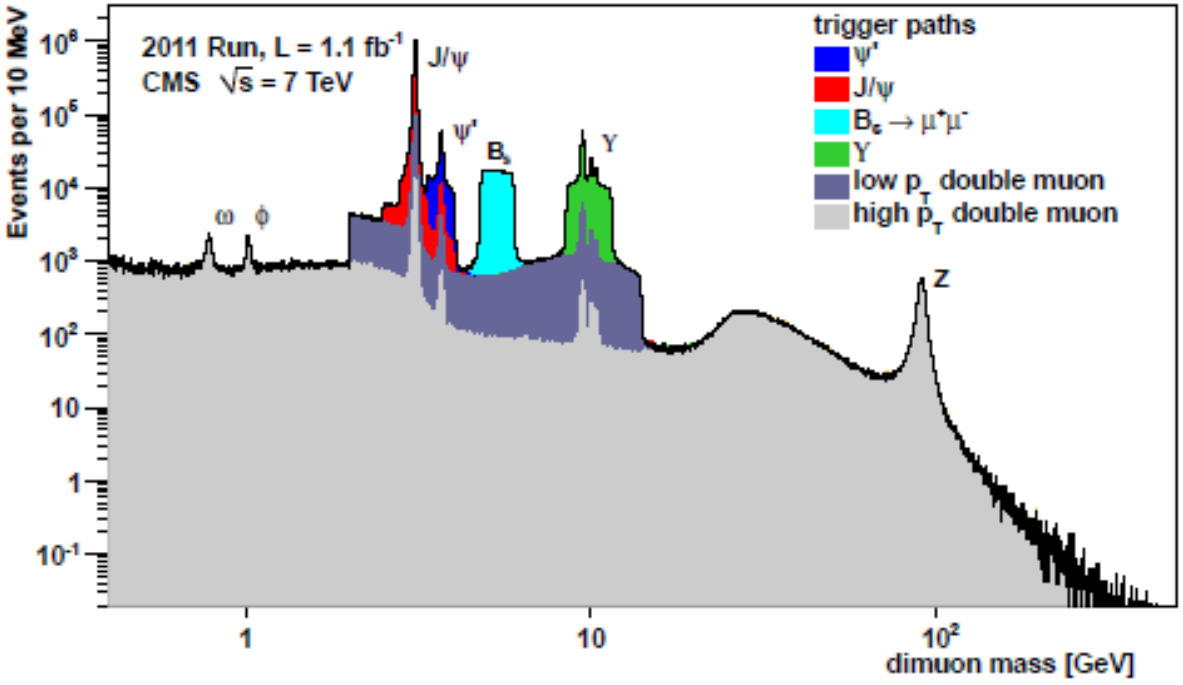


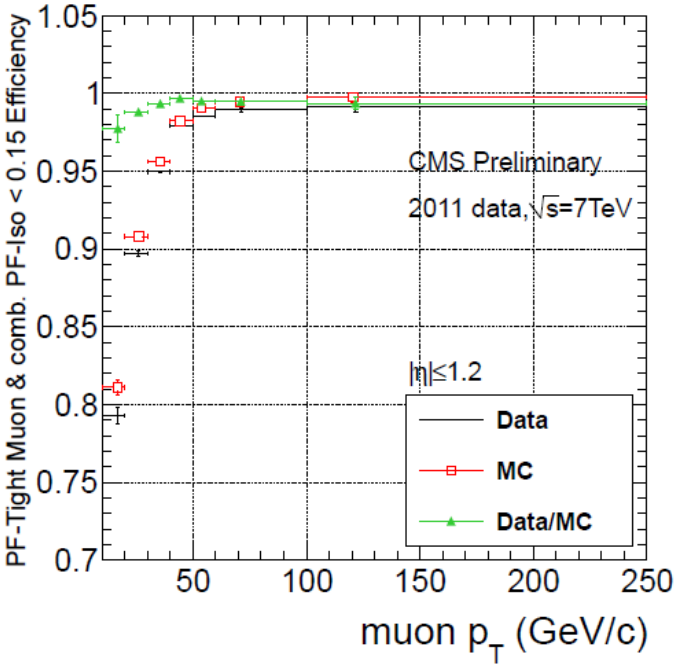
Measured purity (ie. fraction of prompt photons) for both barrel (left) and endcap (right) regions requiring isolation criteria The tighter selection got higher purity but lowers the detection efficiency by bout 20%

Object identification

- Muons :

Dimuon mass spectrum: superposition of various dimuon trigger paths



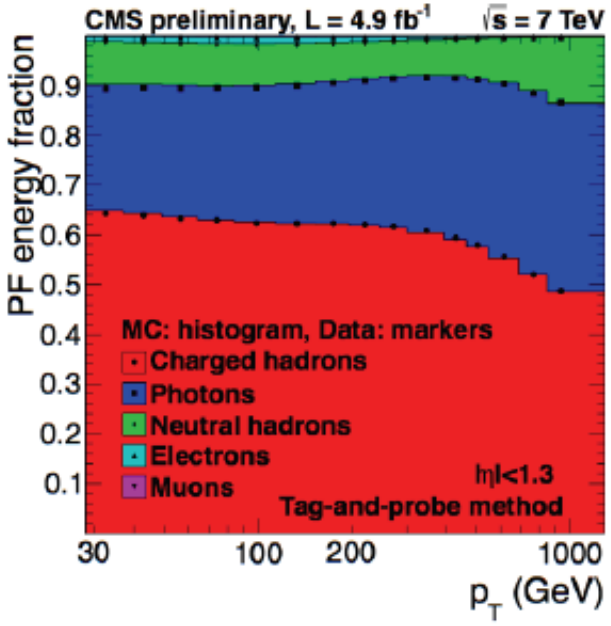


Isolation efficiency

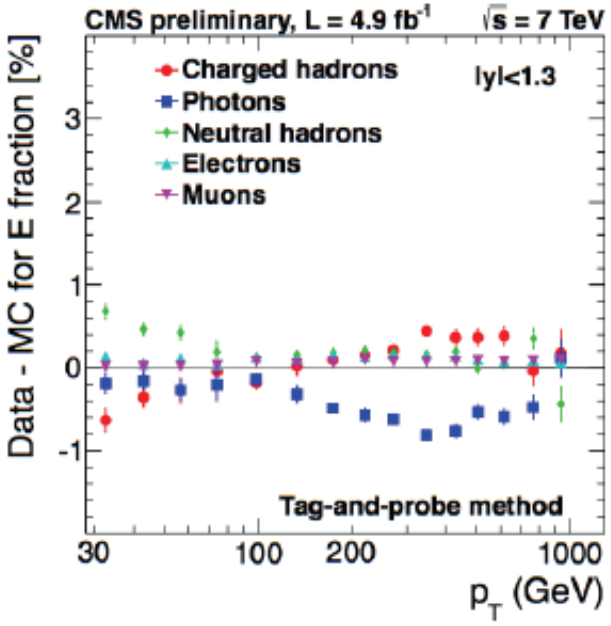
Object identification

- Jets :

Jet composition :



Comparison data/MC :

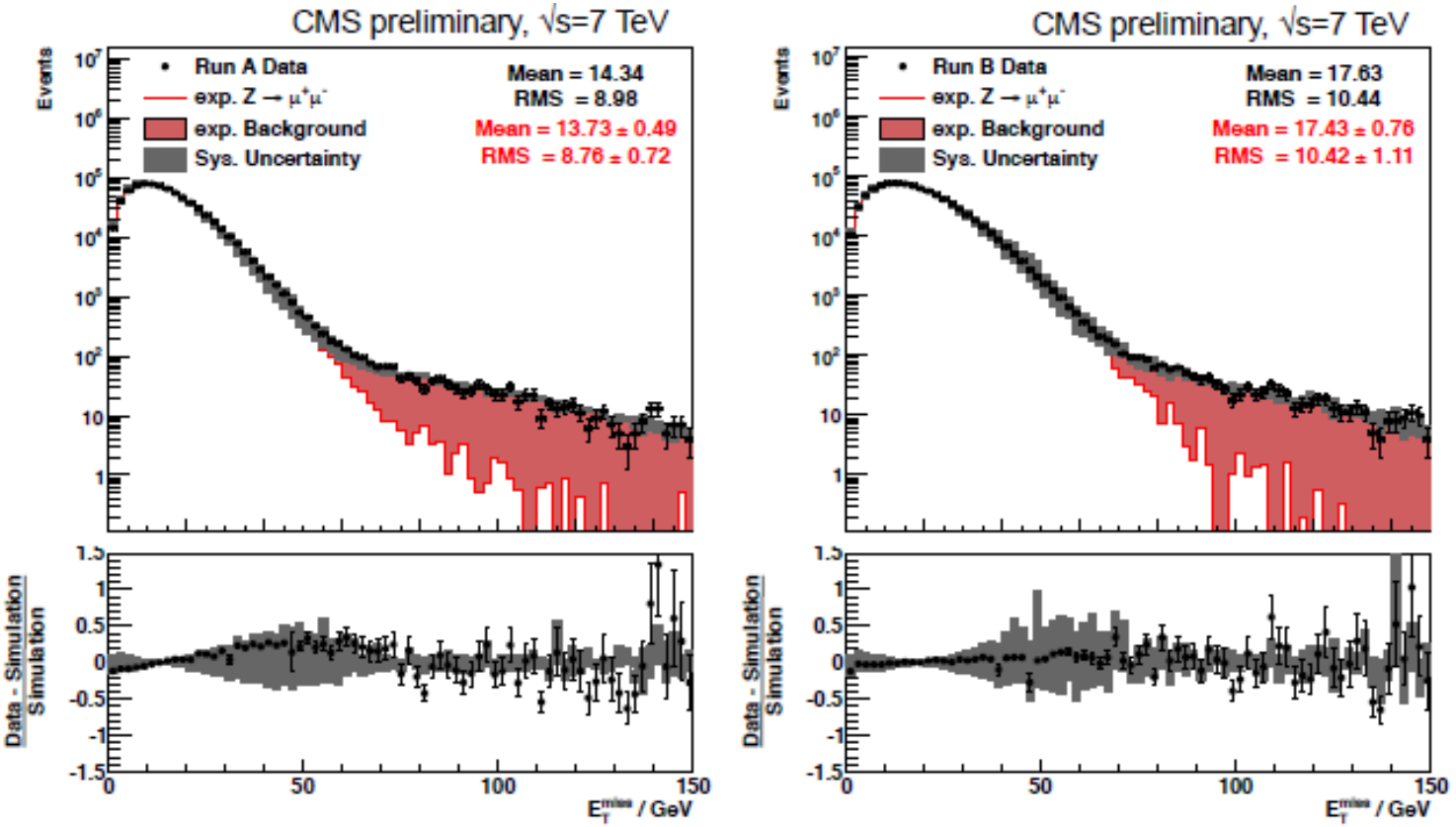


Jet composition in dijet and Zμμ+jet samples shows agreement for track (charged hadrons), ECAL (photons) and HCAL (neutral hadrons) energies to within 1% in barrel

Object identification

- MET :

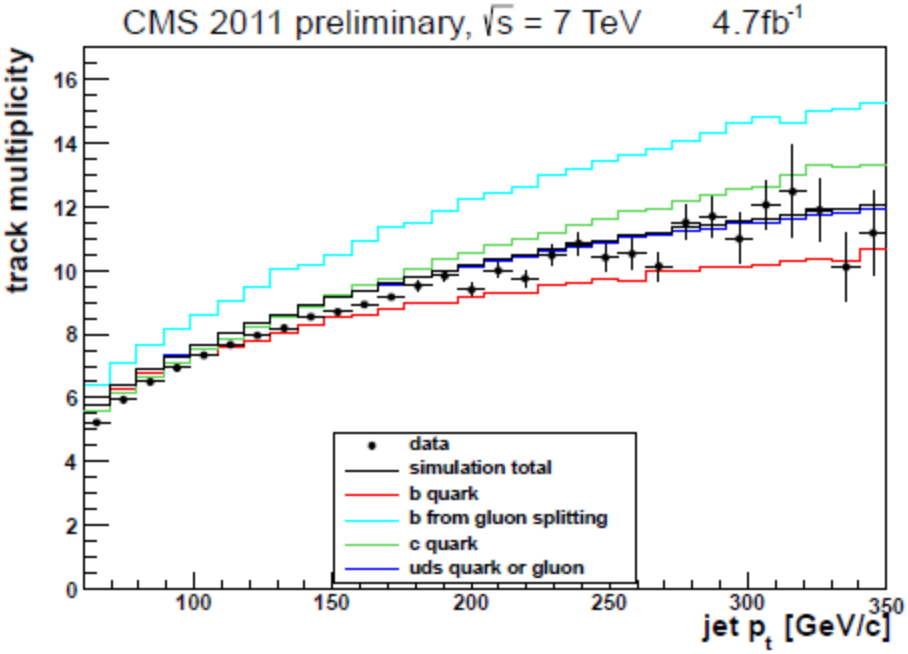
MET in Z→μμ events :



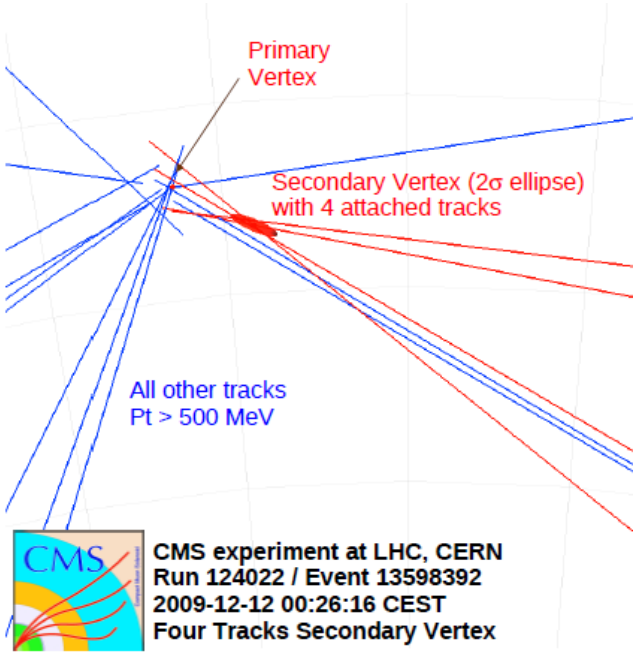
MET distributions agree well between data and MC (simulation was corrected for jet energy scale and the jet energy resolution is smeared to match that observed in data)

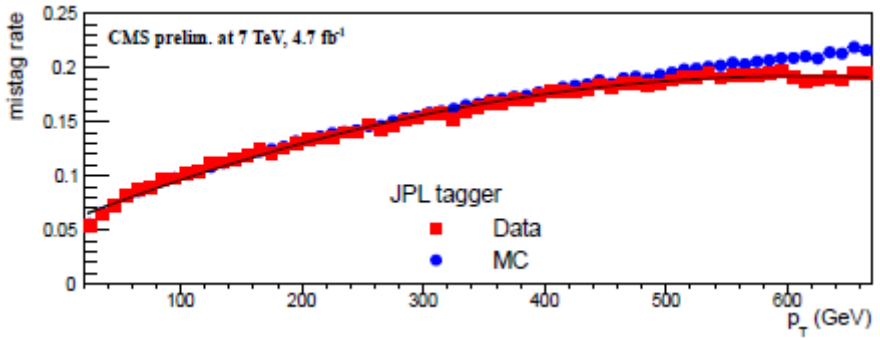
Object identification

- B-tagging :



Average number of selected tracks associated to a jet

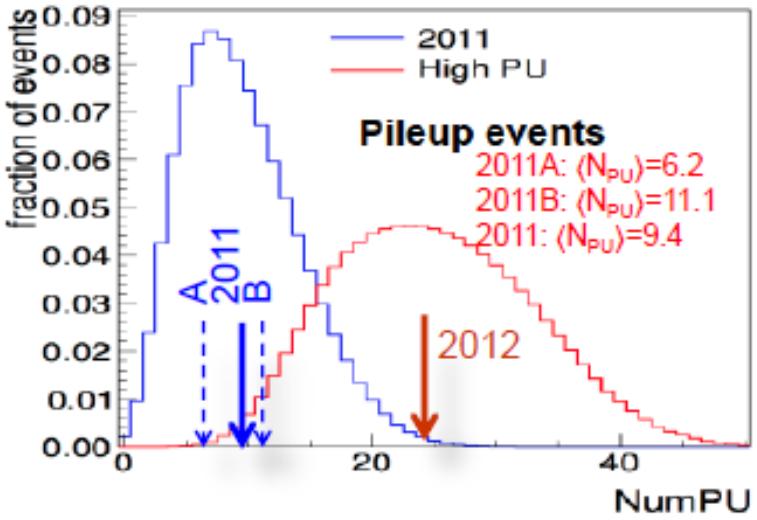


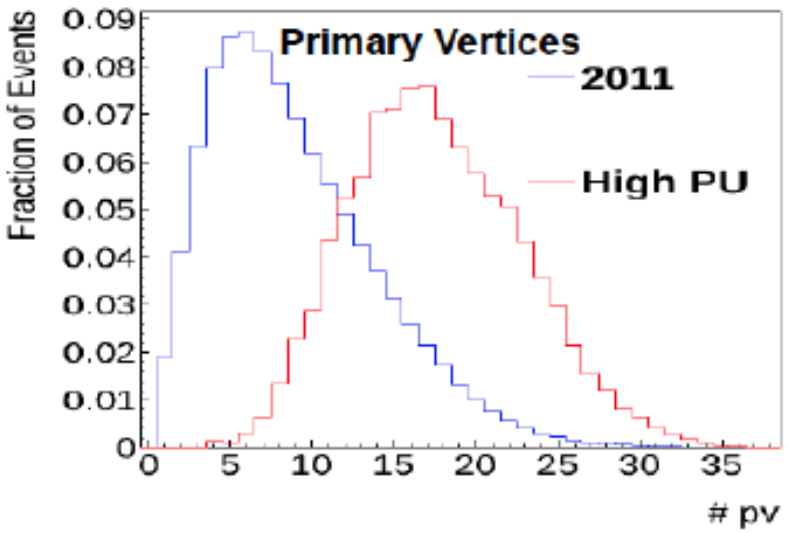


Mistagging rate for both data (red) and MC (blue)

Outlook

- High luminosity counterpart : pile-up





CMS Simulation

- Effect on lepton efficiency (few percent), isolation efficiency, MET and jets resolution …
- Example : the top mass resolution is expected to be worse by 8% (in 2012 against 2011)

Outlook

- Expectation for this year data :
  - 15 /fb of integrated luminosity, needed in particular to close the Higgs question
  - luminosity to be reached : 7.10^{33} $cm^{-2}s^{-1}$ with pile-up up to ~35
  - the pp data taking should be ended by the end of October, then will start a one month heavy ions program
- Long Shutdown 1 (2013- September 2014) :
  - A lot of activities/improvements in the detector
- Longer plans :
  - upgrade (see talk by Aldo Penzo "CMS upgrade")

Conclusion

- The CMS detector performed excellently in all aspects, from the data taking to the various sub-systems
- The live channels fraction is in average higher than 98.5% for all sub-systems and the observed resolutions are within the design resolutions
- The object identification (E/γ, muons, jets, MET, btagging) performed also very well, giving the ingredients for all analysis
- The 2012 pp data taking is on-going, with the target of 15/fb of integrated luminosity
- The CMS detector is ready to cope with higher luminosity and consequently higher pile-up conditions