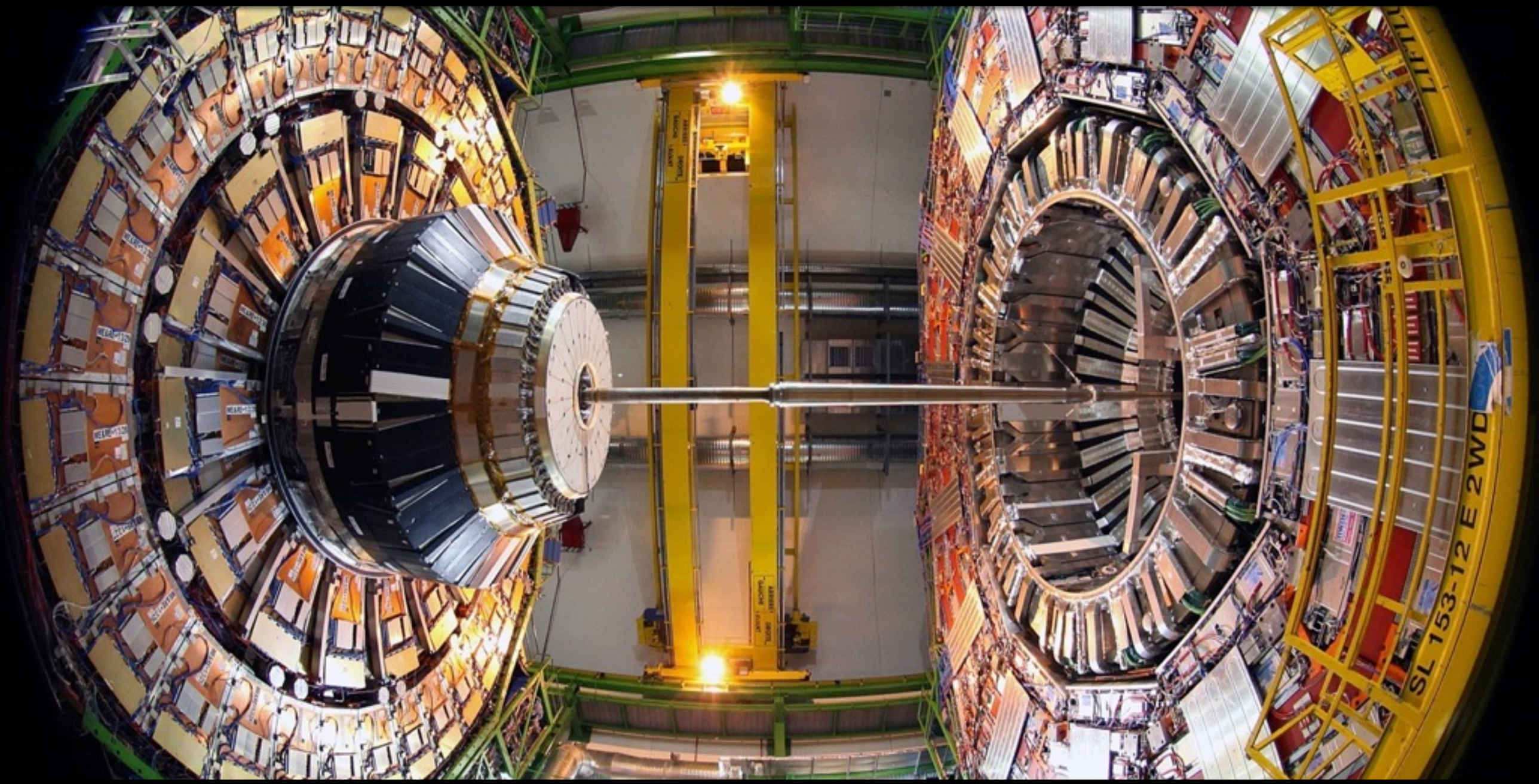
Experimental guidelines for reliable parameterization of detector performance in HL-LHC phenomenological studies



Markus Klute (MIT) for the CMS Collaboration

HL-LHC workshop - CERN - May 12th, 2015

CMS Phase-II Detector

Muon System
- new DT FE electronics, CSC FEBs in inner rings
- extended η region (GEM & iRPC)
- investigate Muon-tagging up to η ~ 3

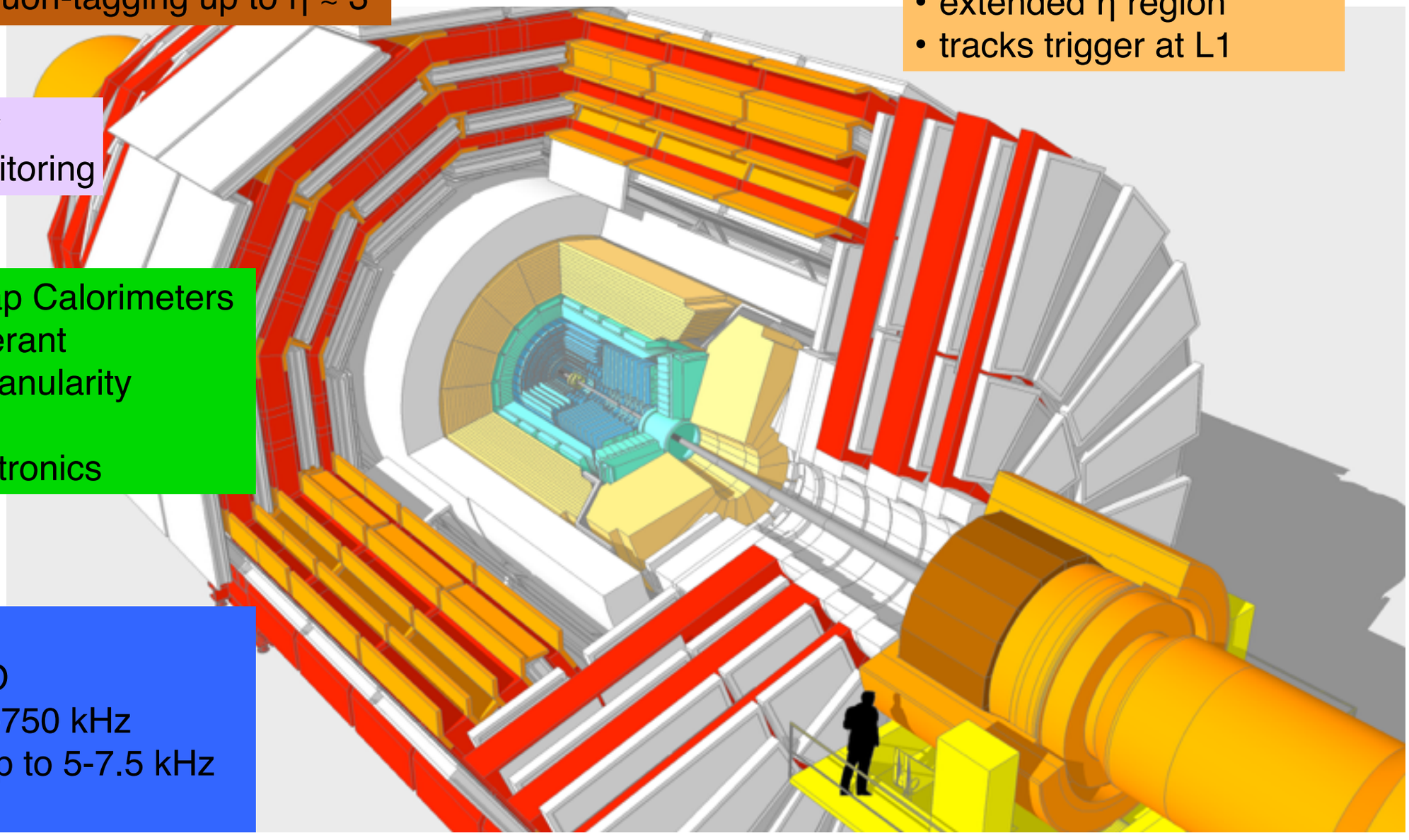
Tracker
- higher granularity
- less material
- better p_T resolution
- extended η region
- tracks trigger at L1

New luminosity and beam monitoring

Replace Endcap Calorimeters
- radiation tolerant
- increased granularity

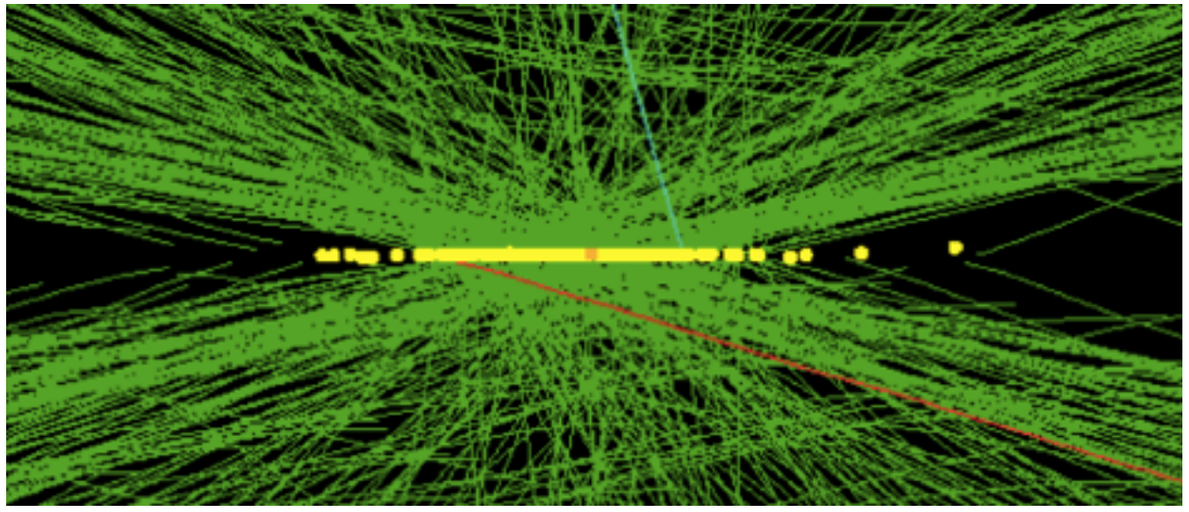
Barrel ECAL
- new FE electronics

Trigger/DAQ
- new FE & RO
- L1 up to 500-750 kHz
- HLT output up to 5-7.5 kHz
- tracking @L1

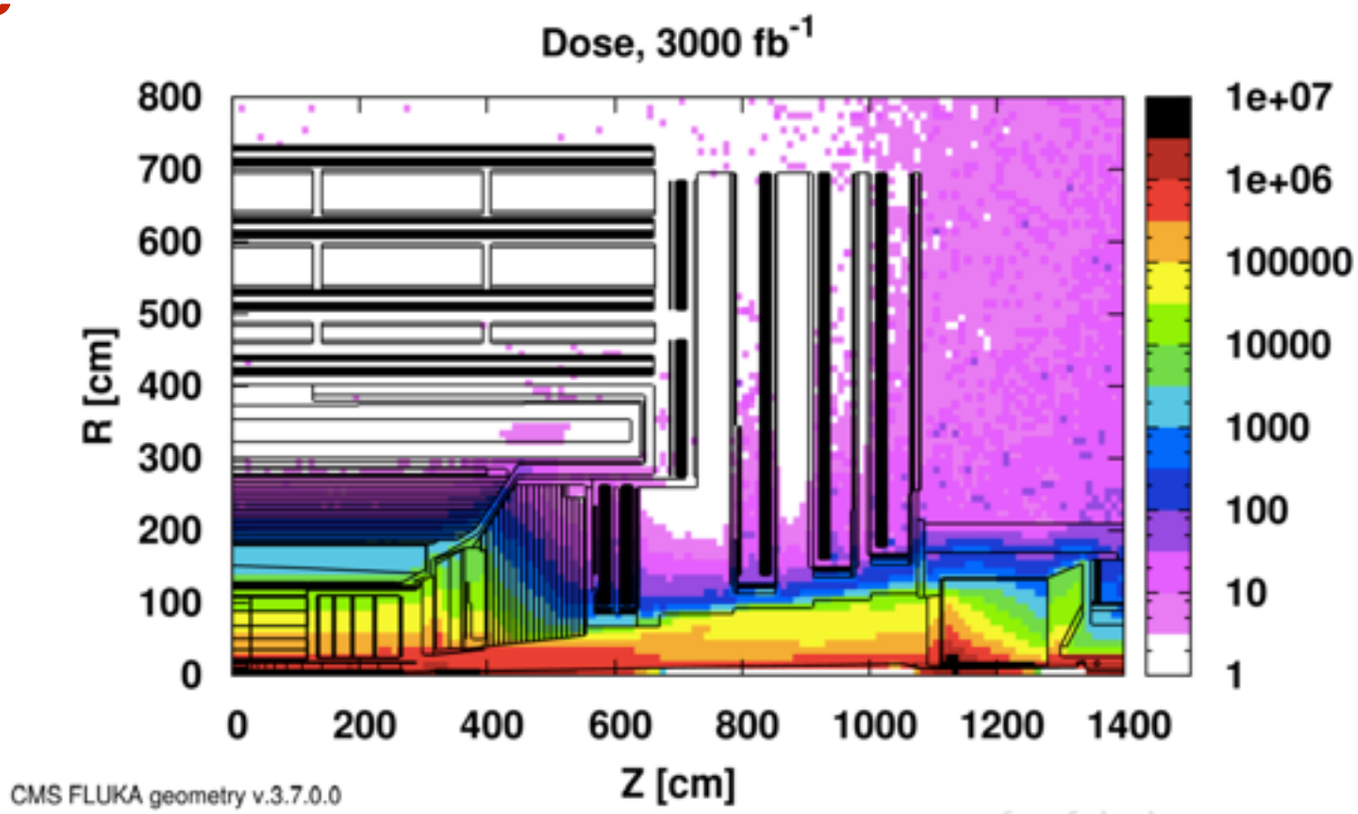


CMS Phase-II Detector Performance

- ➡ **CMS performance is well documented**
- ➡ **Preliminary Phase-II performance results discussed in the context of ECFA workshops**

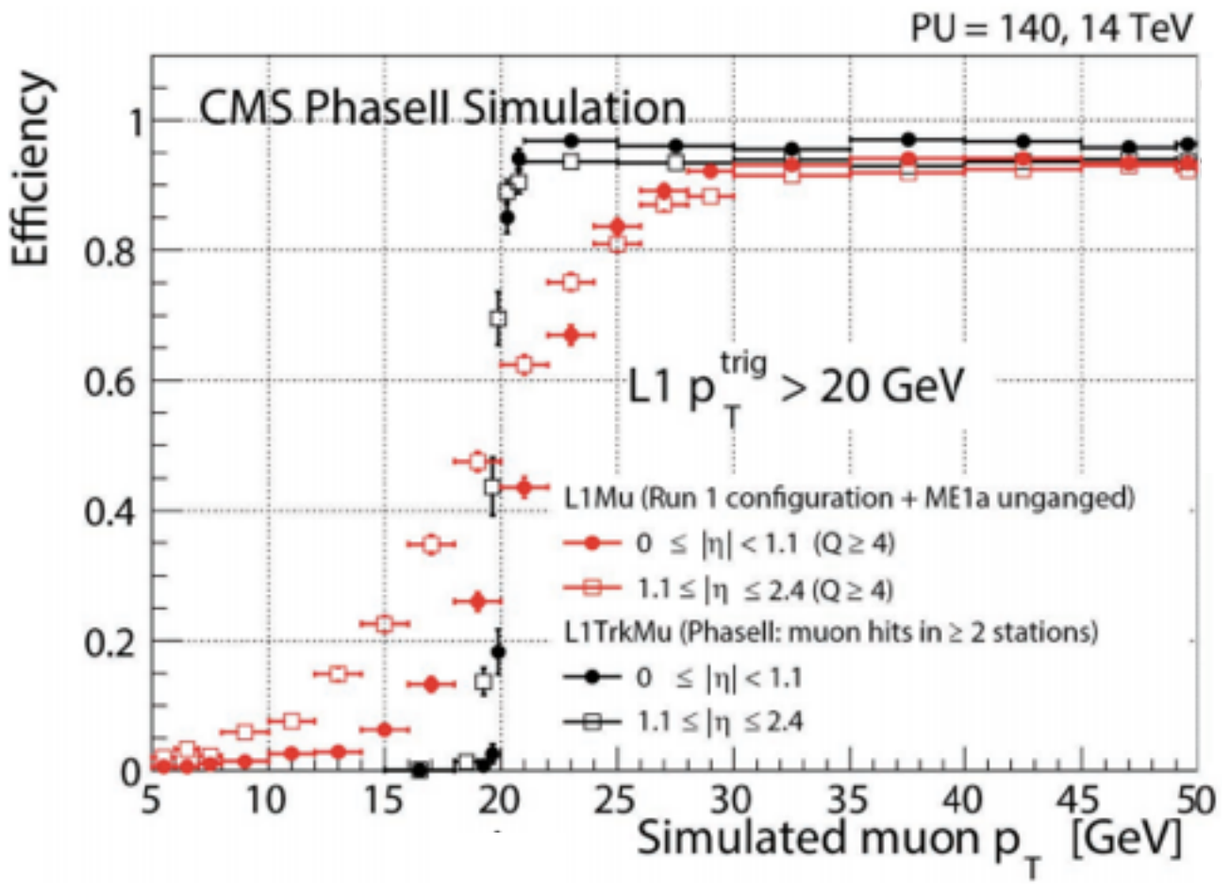


- ➡ **HL-LHC CMS performance will be described in the CMS Phase-II Technical Proposal**
- ➡ **Performance evaluated using full simulation including pileup and longevity consideration (aging)**
- ➡ **Delphes used to parametrize detector performance**



CMS Phase-II Trigger

- ➡ **Proposed L1 trigger using particle tracking and increased bandwidth**
- ➡ **Developed example L1 trigger menu to evaluate the rates**
- ➡ **Thresholds and efficiency close or better than for Run I**



$L = 5.6 \times 10^{34}$ cm^{-2}s^{-1} $\langle PU \rangle = 140$	Level-1 Trigger with L1 Tracks	
Trigger Algorithm	Rate [kHz]	Offline Threshold(s) [GeV]
Single Mu (tk)	14	18
Double Mu (tk)	1.1	14 10
ele (iso tk) + Mu (tk)	0.7	19 10.5
Single Ele (tk)	16	31
Single iso Ele (tk)	13	27
Single γ (tk-veto)	31	31
ele (iso tk) + e/γ	11	22 16
Double γ (tk-veto)	17	22 16
Single Tau (tk)	13	88
Tau (tk) + Tau	32	56 56
ele (iso tk) + Tau	7.4	19 50
Tau (tk) + Mu (tk)	5.4	45 14
Single Jet	42	173
Double Jet (tk)	26	2@125
Quad Jet (tk)	12	4@72
Single ele (tk) + Jet	15	23 66
Single Mu (tk) + Jet	8.8	16 66
Single ele (tk) + H_T^{miss} (tk)	10	23 95
Single Mu (tk) + H_T^{miss} (tk)	2.7	16 95
H_T (tk)	13	350
Rate for above Triggers	180	
Est. Total Level-1 Menu Rate	**260**	

Overall CMS Phase-II Detector Performance

➡ **Object characterized in the Technical Proposal**

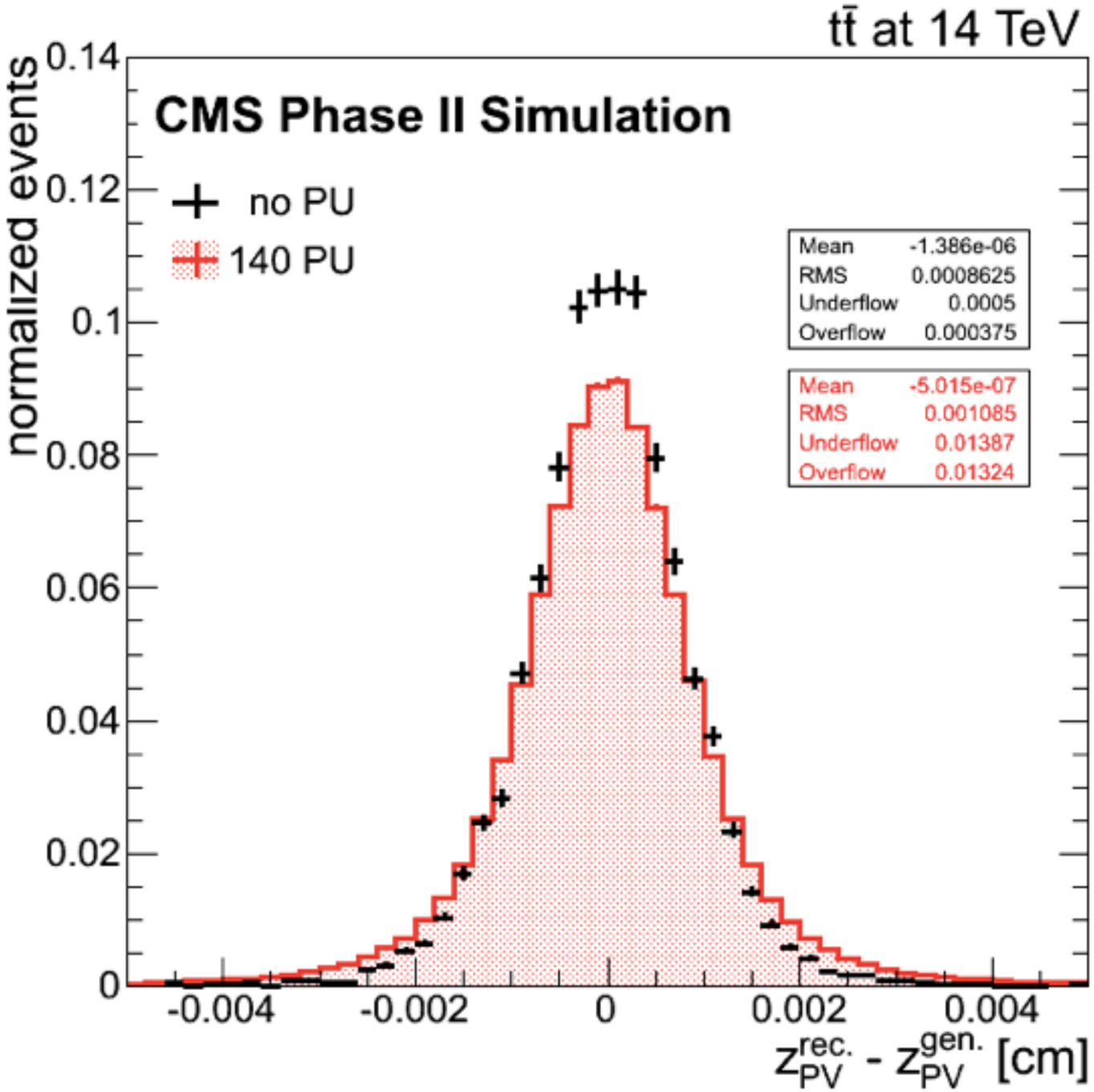
- Particle flow candidates
- Primary vertex
- Jet and missing transverse energy
- B-tagging performance
- Electrons and photons
- Muons
- Hadronic taus

➡ **Main characteristics**

- Efficiency and fake rate (working point or ROC curves)
- Resolutions
- Performance given as function of p_T and η

Example: Primary Vertex

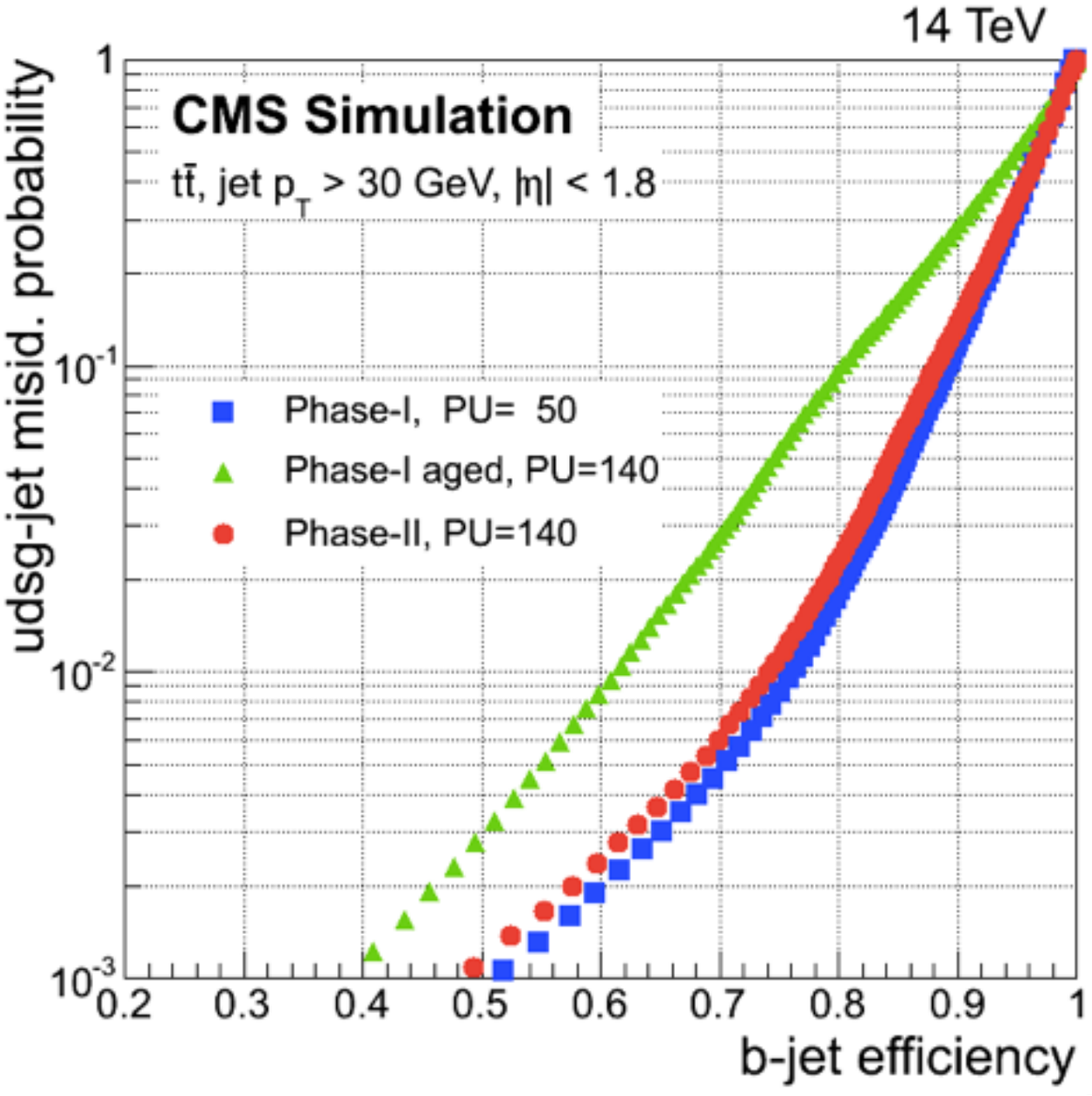
➡ **Correct vertex found with 97% efficiency**

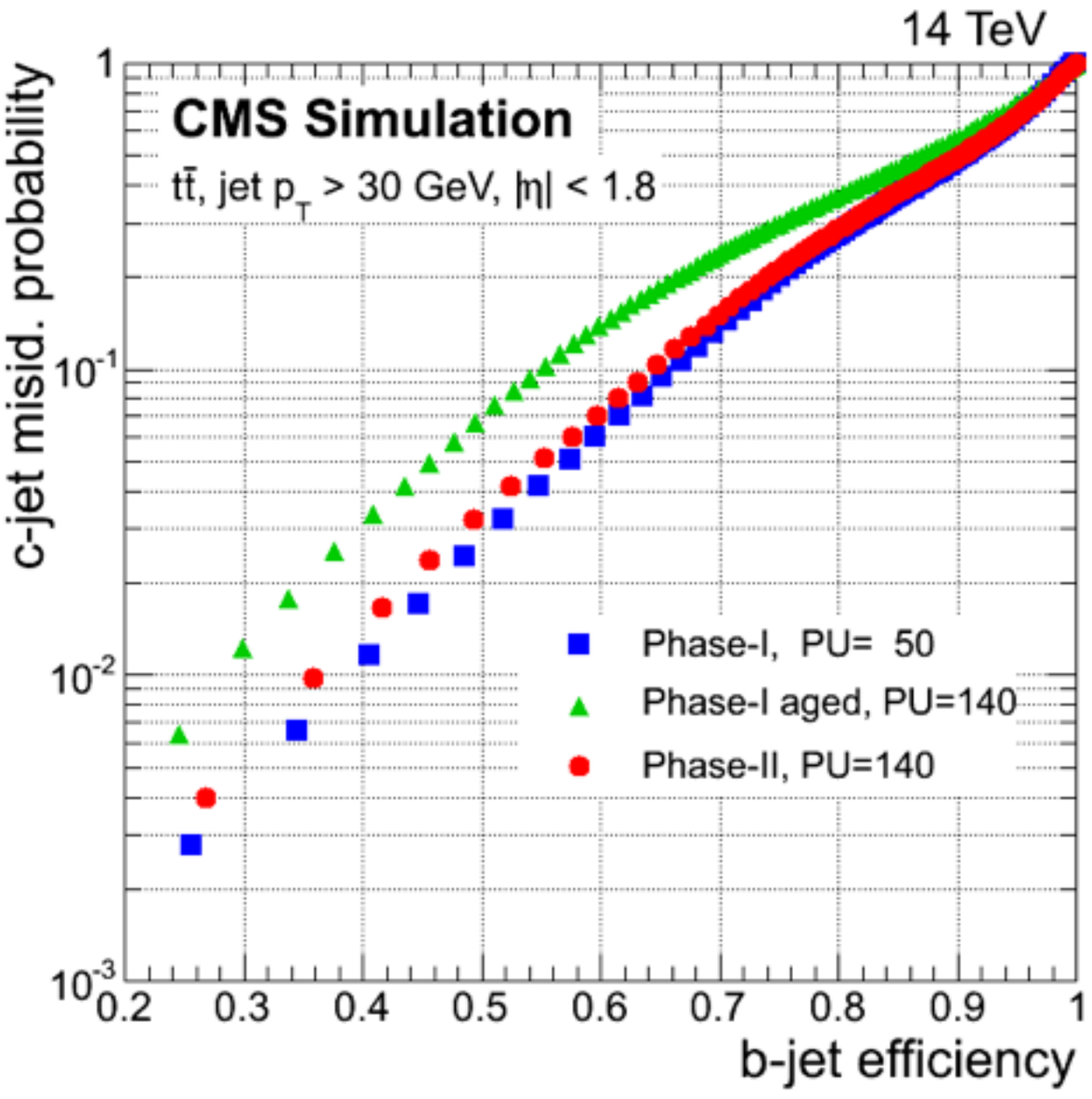


Example: B-tagging

➡ **Phase-II (PU = 140) performance close to Phase-I (PU = 50)**

➡ **Simulated Phase-II Pixel detector a copy of the Phase-I detector plus additional forward disks**



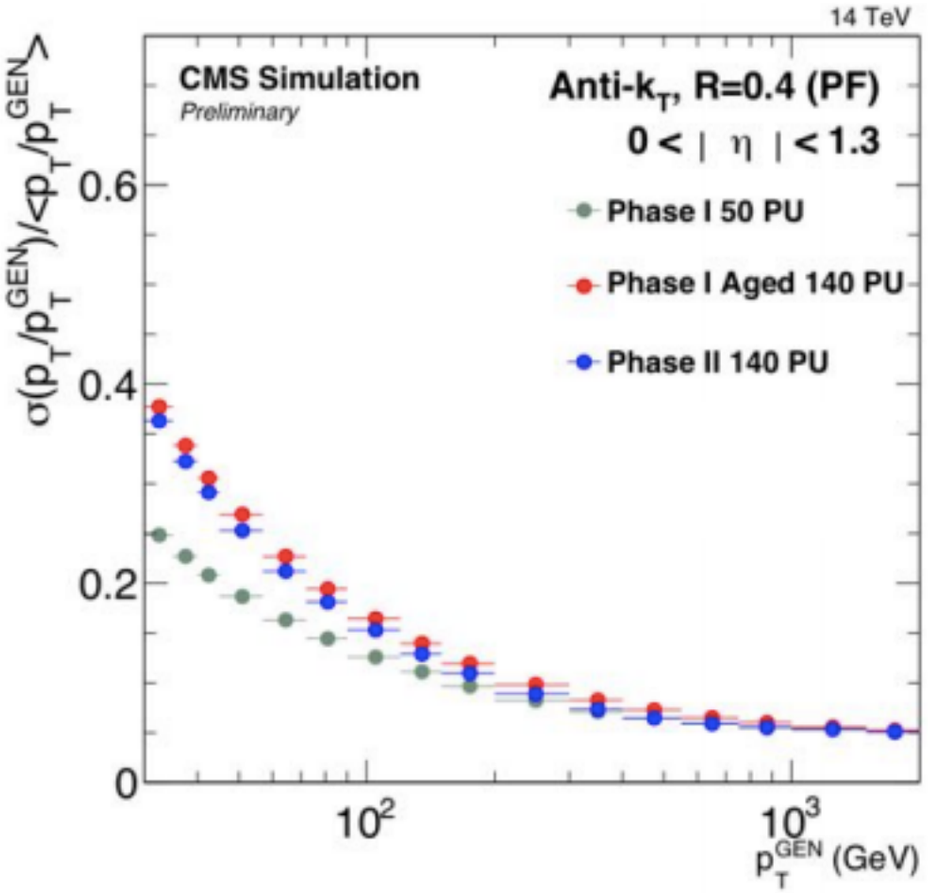


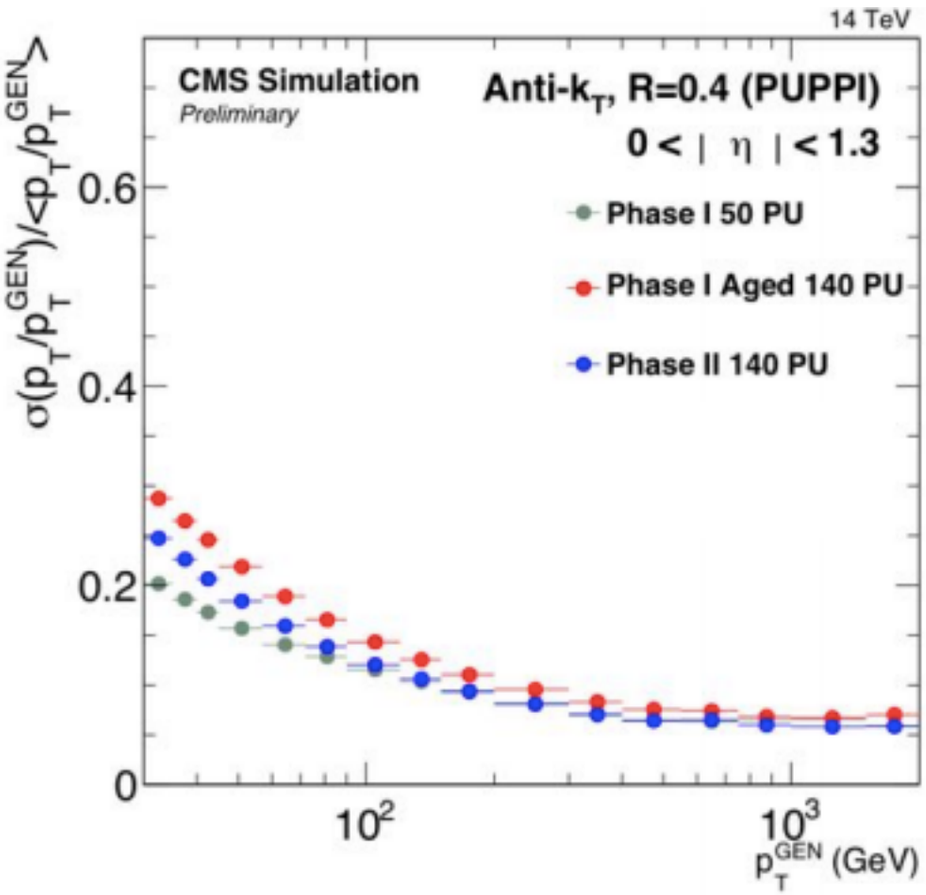
Example: Jet Performance

➡ Phase-II (PU = 140) performance close to Phase-I (PU = 50)

➡ PUPPI shows improved jet resolution

➡ Pileup degrades performance for jet with pT < 100 GeV





Summary and Conclusion

- **CMS studies Phase-II upgrade detector performance in HL-LHC environment**
  - preliminary results presented at ECFA workshop 2014
  - will be documented in Technical Proposal soon

- **Overall, the current CMS performance is a good proxy for the HL-LHC performance**
  - jet resolution at low pT degraded

- **Using Delphes to parametrize detector performance**
  - cards will be made available soon
  - caveat: performance based on todays understanding of the detector and reconstruction performance

- **We are happy to give feedback on specific detector performance questions**
  - not all detector performance features are documented or considered in Delphes