

PPS at the HL-LHC

EF06: Low x , BFKL

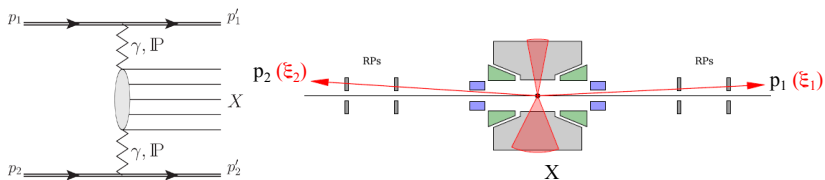


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Motivation



Study processes with exchange of colorless objects:

- Displacement of the protons from the beam determines the protons' momentum loss $\xi = \frac{\Delta p}{p}$
- Potential to reconstruct all final state particles
- Conservation of momentum

CMS Precision Proton Spectrometer

PPS offers the ability to measure proton kinematics in space and time

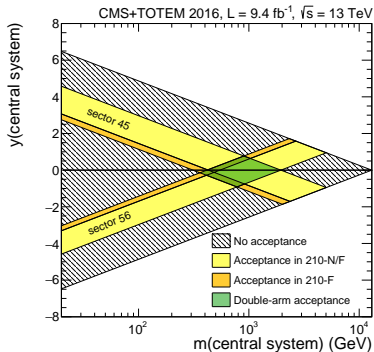
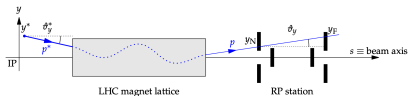
Detectors located at 210m and 220m on both sides of CMS

By measuring kinematics in PPS, IP kinematics can be reconstructed

Time of flight measurement allows vertex position to be reconstructed

$$M = \sqrt{s\xi_1\xi_2}$$

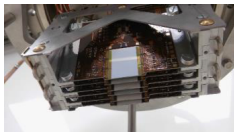
$$Y = \frac{1}{2} \log \left(\frac{\xi_1}{\xi_2} \right)$$



Detectors

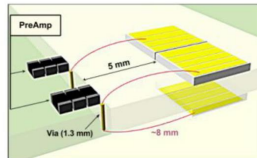
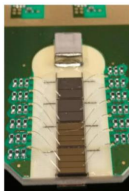
PPS is comprised of near-beam, moveable machinery called Roman Pots (RPs). RPs are the housing for tracking and timing detectors.

3D Pixel detectors



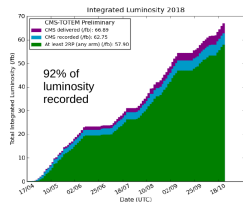
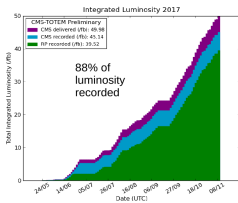
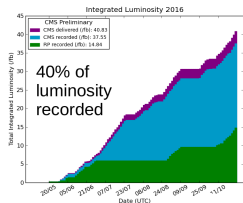
- Sufficient resolution $\sim 25 \mu\text{m}$
- Radiation hard

Diamond timing detectors

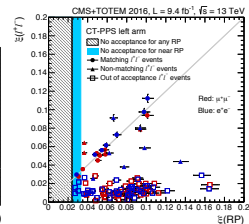
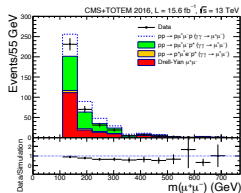


- Time resolution ~ 50 ps for ideal conditions
- Radiation hard

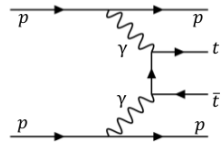
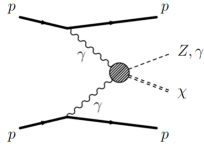
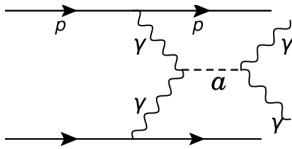
PPS Run II performance



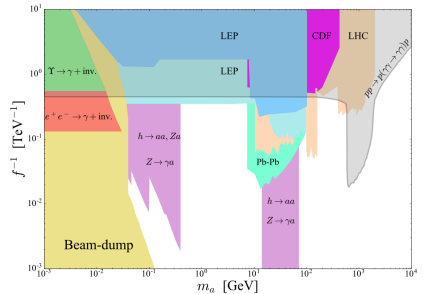
- PPS recorded over 110 fb^{-1} of data in Run II.
- 2016 dilepton analysis published in [JHEP](#)
- "Standard candle"
 $\gamma\gamma \rightarrow \ell^+\ell^-$ observed at 5.1σ



Ongoing studies in CMS



- Anomalous Couplings
(see Cristian's talk)
- Axion-Like Particle searches
- Missing mass searches
- Exclusive top pair production



Detector locations at the HL-LHC

196m Station

- Interesting for high masses

220m Station

- Similar to the Run II setup

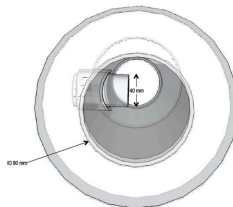
234m Station

- Requires slight rearranging of DQR

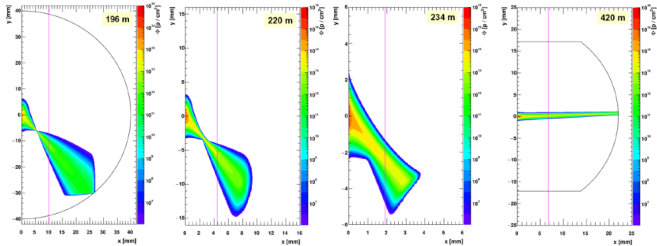
420m Station

- Cold region of LHC
- Not suitable for RPs, needs new technology
- Needed for Higgs physics

Station	M_{min} (GeV)	M_{max} (GeV)
196m	1100 - 1200	2750
220m	520 - 533	960
234m	262 - 265	370
420m	43 - 47	163



Conditions at the HL-LHC



Challenging conditions to overcome at the HL-LHC:

- Increased pileup (~ 200)
- Detector radiation
- Vertical/horizontal crossing angles (CMS prefers vertical)
- Impedance for certain LHC locations

Mass and rapidity acceptance

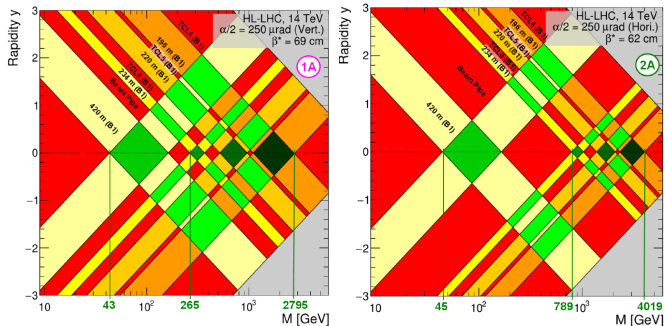
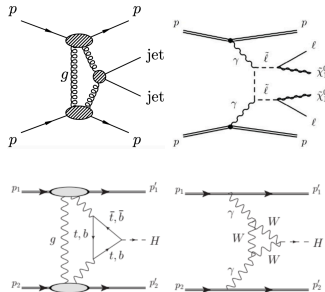


Figure 1: Mass and rapidity acceptance for PPS detectors at various locations for vertical beam crossing (left) and horizontal beam crossing (right).

Physics Program

A rich physics program is available with these detectors.

- Discussed in the **PPS TDR**
- Exclusive $b\bar{b}$ production (main background for Higgs searches)
- Search for exclusive SUSY particle production
- Central exclusive Higgs production



Conclusion

- PPS in Run II covered mass ranges between 350 GeV - 2 TeV
- Potential to cover masses between 43 GeV - 2.8 TeV with all 4 proposed stations
- New technology required for 420m station
- Proton simulations for HL-LHC conditions are being prepared

Done 😊