

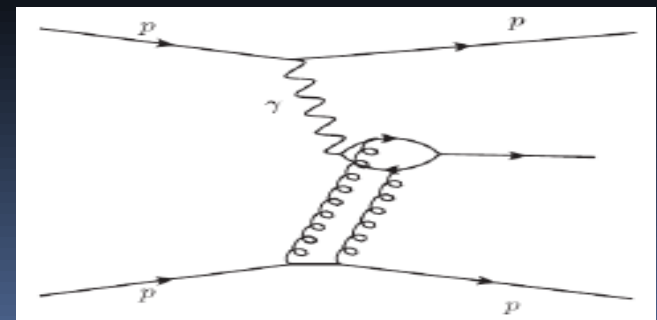
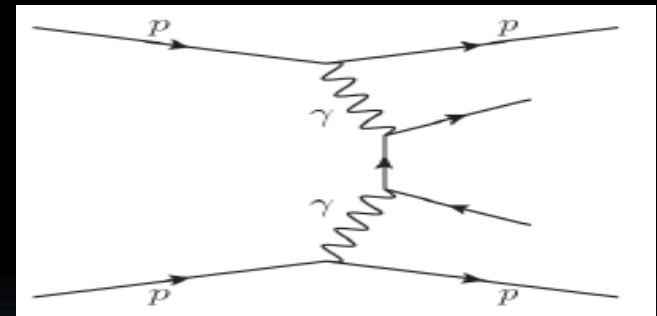
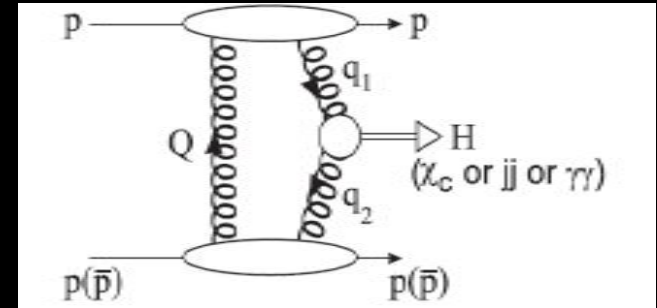
Exclusive Physics at CMS

Jonathan Hollar (UCLouvain)



Exclusive physics

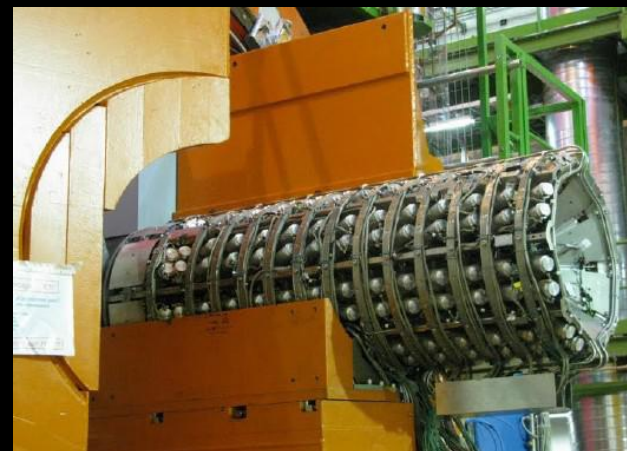
- Both protons remain intact, and escape along the beamline
- Three distinct physics processes involved, covering both **Standard Model** and **New physics** topics
 - Central Exclusive Production
 - **Higgs**, $\gamma\gamma$, **dijets**, $\chi_{b/c}$
 - Low- p_T / hadronic final states: $\pi\pi$, KK
 - $\gamma\gamma$ physics
 - l^+l^- , W^+W^- , $\tilde{l}^+\tilde{l}^-$, $H^{++}H^{--}$, etc.
 - γp physics
 - ρ , J/ψ , Y , Z , etc.
- Follow & extend the Tevatron (+HERA/RHIC/LEP/etc.) program



The ingredients

Forward calorimeters

- Hadronic Forward Calorimeter (HF)
 - Covers $|\eta| < 5$
- CASTOR
 - $5.2 < \eta < 6.6$ (one side only)
- Zero Degree Calorimeter (ZDC)
 - 140 m from IP5, neutron and γ detection for $|\eta| > 8.4$
- **All fully installed and taking data throughout the 2010 run**
 - HF used extensively for first CMS results on diffraction, energy flow, & jets (talks by D. Volyansky, I. Katkov)

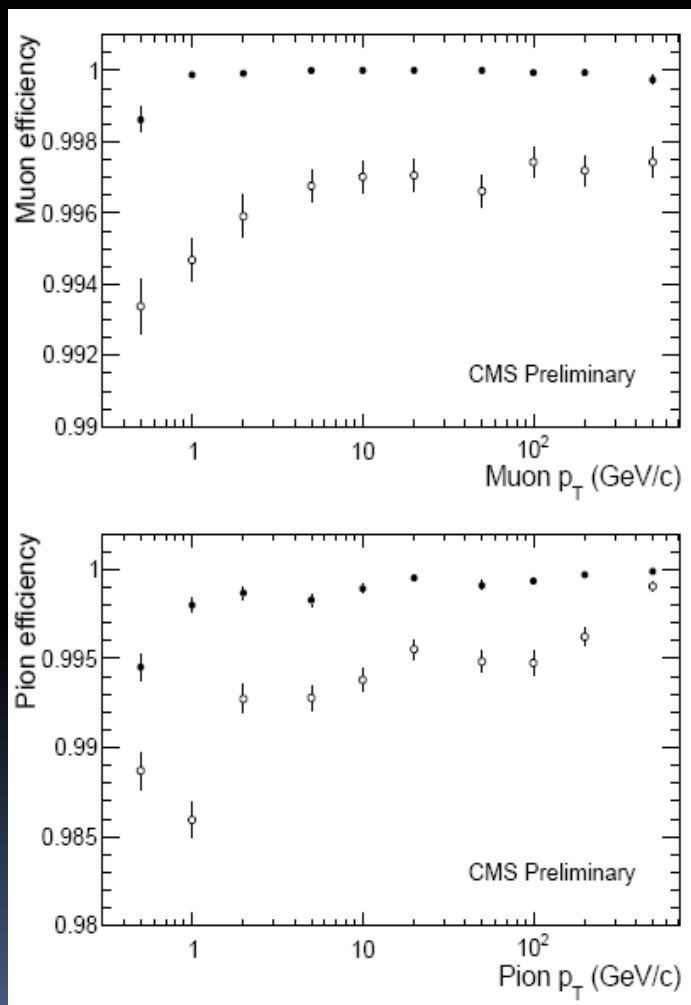


CASTOR



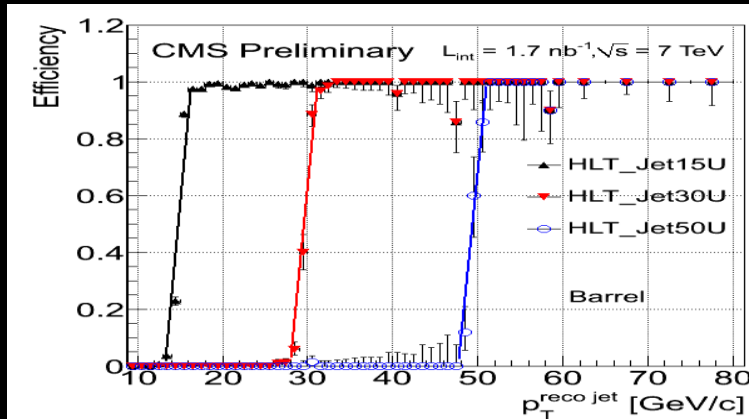
ZDC

Tracking



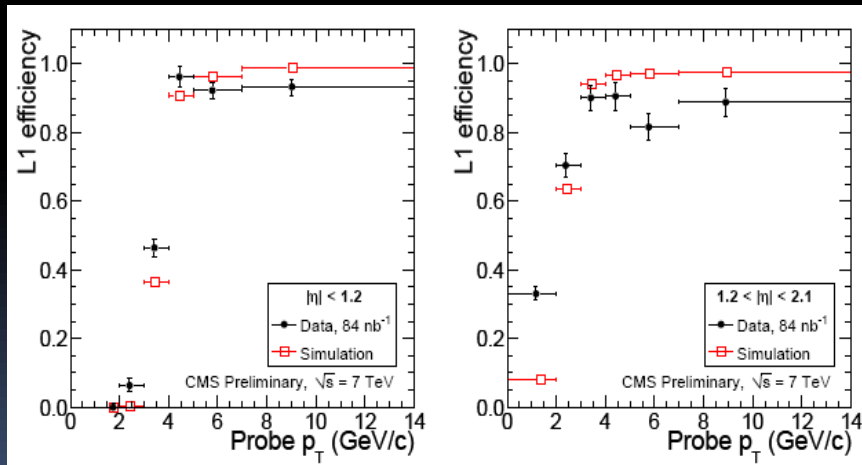
- CMS tracker coverage extends to $|\eta| < 2.4$
- $>99\%$ efficient for 0.5 GeV tracks, with efficiency down to ~ 0.1 GeV
- Important for
 - Vetoing on additional tracks in the event
 - Reconstructing low- p_T tracks in leptonic or hadronic final states
- Association of tracks to a vertex becomes more important with pileup (multiple interactions in 1 bunch crossing)
 - Already in 2010, majority of the data collected by CMS has >1 interaction

Trigger



- Flexible trigger system, allowing topological and cross-triggers

- Both at Level 1 (hardware) and High-Level Trigger (software)

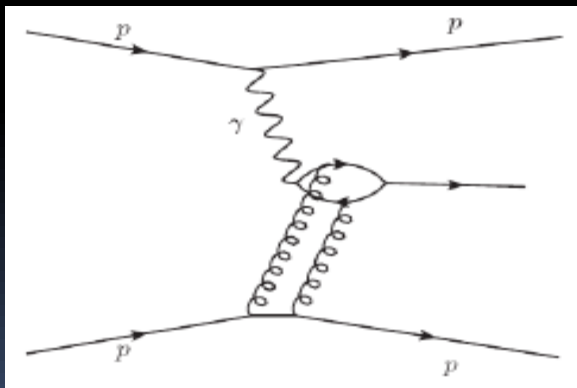
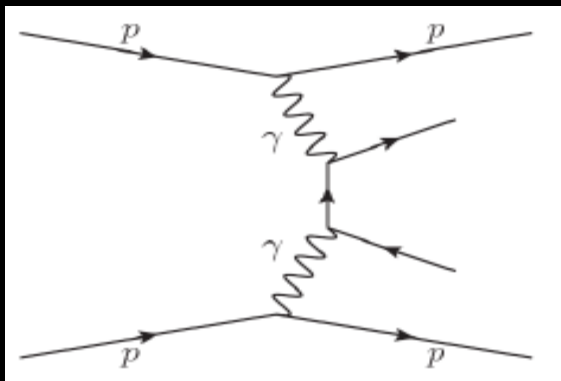


- Good algorithmic efficiency (L1xHLT) for low- p_T jet, e/γ , μ triggers

- Mainly limited by trigger rates/CPU timing

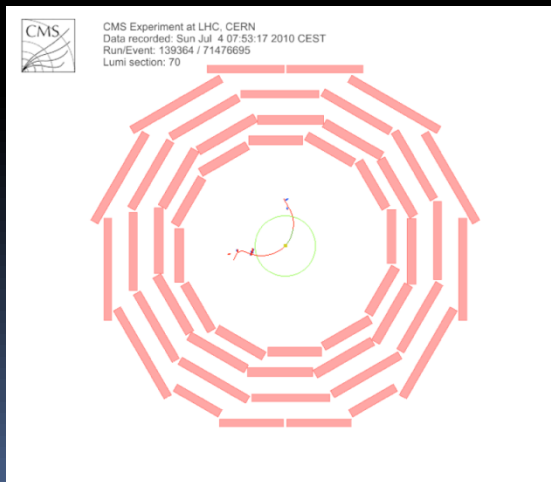
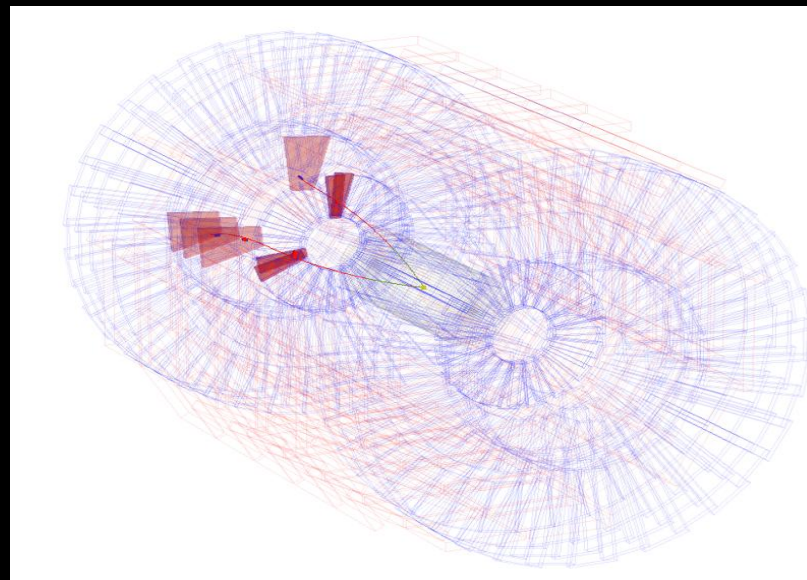
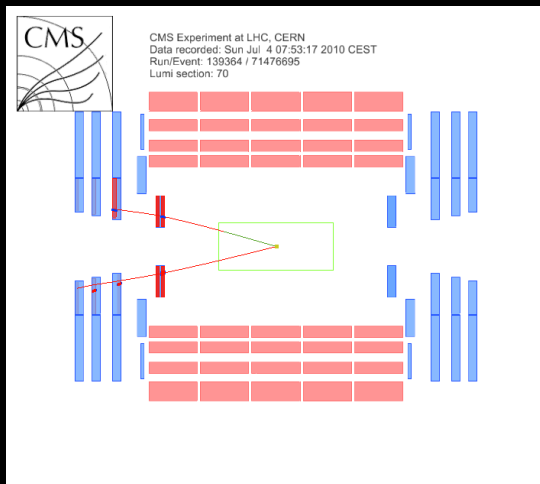
Current analyses

Exclusive dileptons



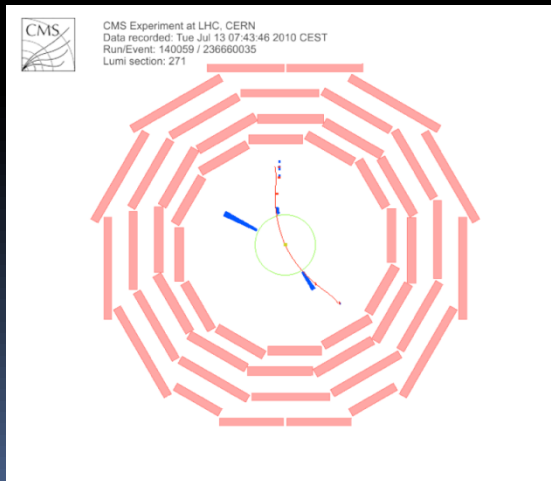
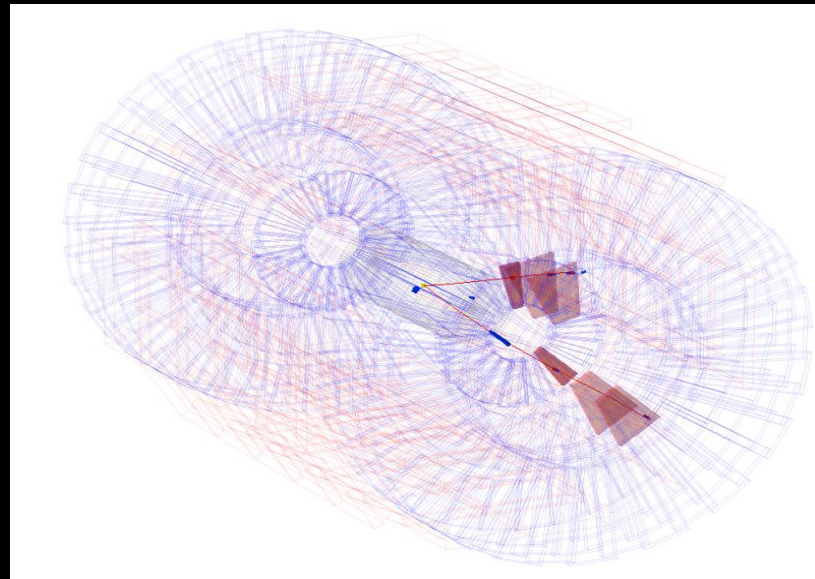
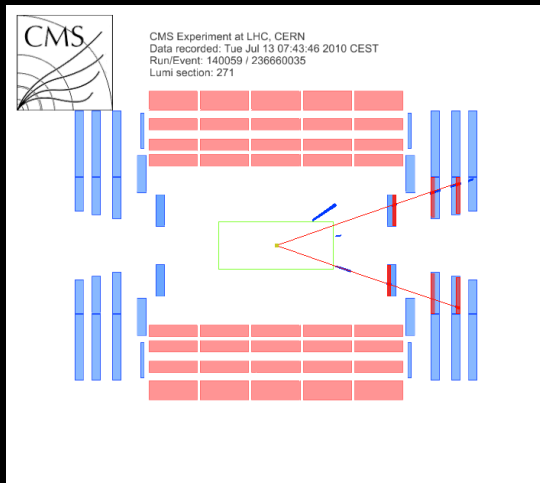
- QED $\gamma\gamma \rightarrow \mu\mu$
 - “Standard candle” process, proposed for luminosity normalization, forward detector alignment, etc.
- $\gamma p \rightarrow Y p \rightarrow \mu\mu p, \gamma p \rightarrow J/\psi p \rightarrow \mu\mu p$
 - Elastic diffractive photoproduction
- Event selection
 - $\mu\mu$ events with 0 extra tracks
 - < 5 calorimeter towers above threshold
 - No activity above threshold in ZDC
 - $|\Delta\phi| > 0.9, \Delta p_T < 1.5$ GeV
- A few “interesting” events displayed...

$\gamma p \rightarrow J/\psi p \rightarrow \mu\mu p$ candidate



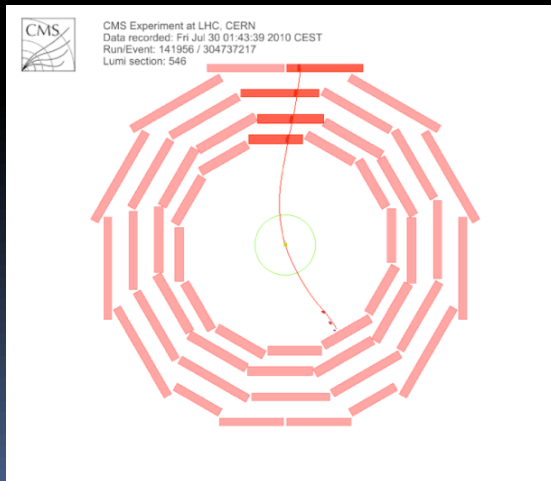
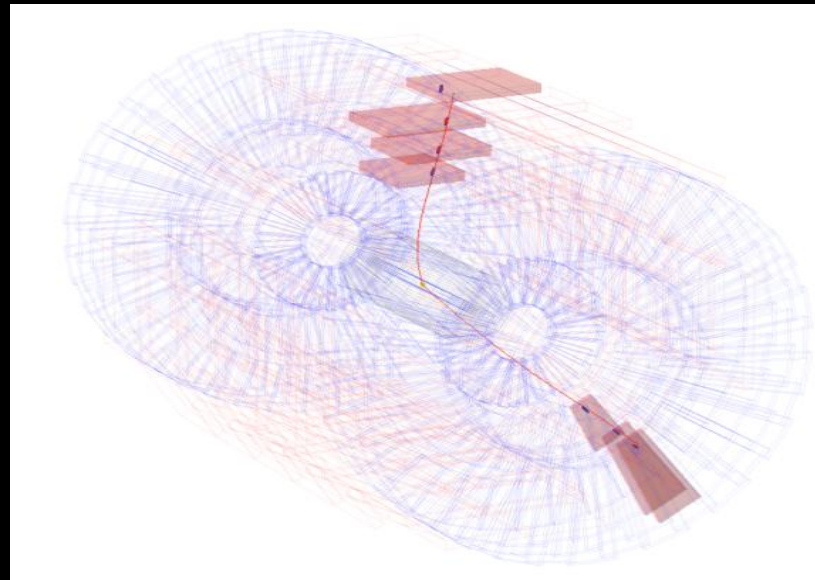
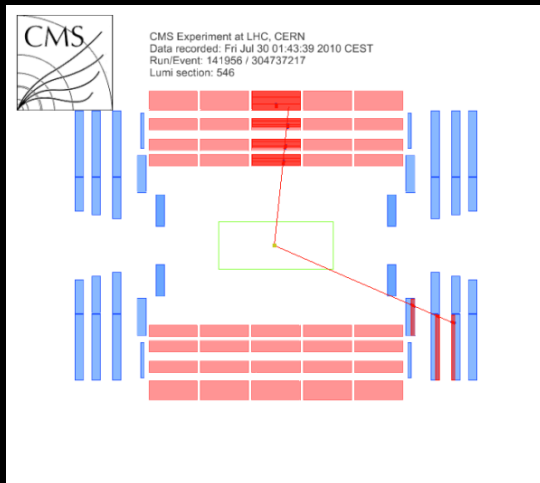
$$\begin{aligned} m &= 3.05 \pm 0.03 \text{ GeV} \\ \frac{\Delta\phi}{\pi} &= 0.98 \\ \Delta p_T &= 0.05 \text{ GeV} \end{aligned}$$

$\gamma p \rightarrow Y p \rightarrow \mu \mu p$ candidate



$$\begin{aligned} m &= 9.44 \pm 0.08 \text{ GeV} \\ \frac{\Delta\phi}{\pi} &= 0.99 \\ \Delta p_T &= 0.20 \text{ GeV} \end{aligned}$$

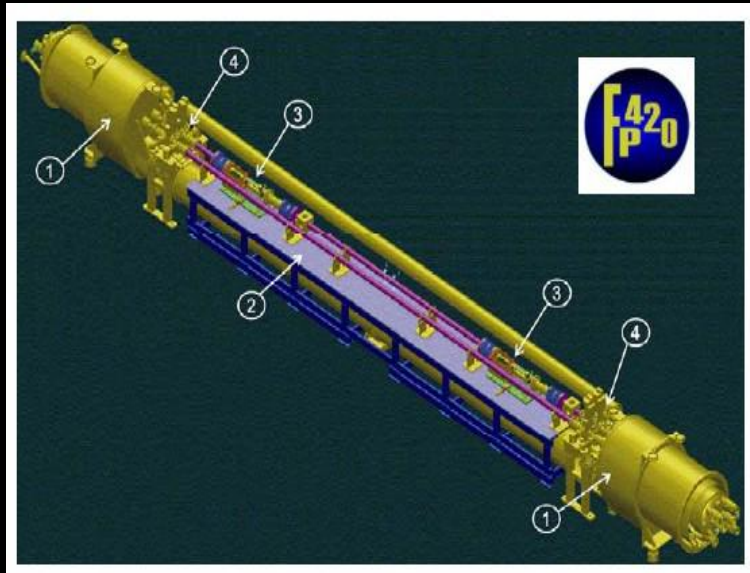
Higher-mass $\gamma\gamma \rightarrow \mu\mu$ candidate



$$\begin{aligned} m &= 20.51 \pm 0.2 \text{ GeV} \\ \frac{\Delta\phi}{\pi} &= 0.98 \\ \Delta p_T &= 0.48 \end{aligned}$$

The future

HPS



- High Precision Spectrometer upgrade proposal (based on FP₄₂₀ CMS/Atlas R&D collaboration)
 - Install tracking and precision timing detectors 240m and 420m from CMS to detect scattered protons

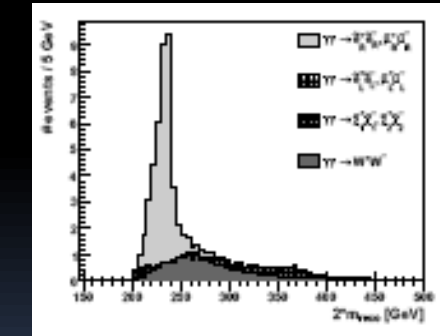
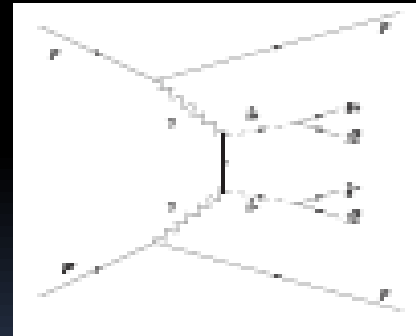
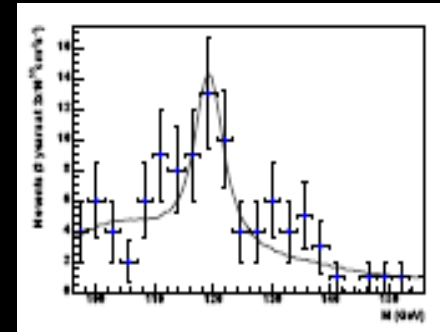
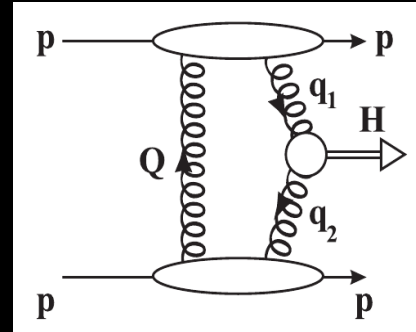
- Currently R&D proposal for “Stage 1” (detectors at 240 m)

See talks by J. Gronberg/M. Albrow (CMS), A. Brandt (ATLAS)

HPS Physics

- Exclusive Higgs $\rightarrow bb$
 - Measurement of H mass independently of final state
 - Constraints on quantum numbers of H candidates

- Exclusive $\gamma\gamma$ interactions
 - Probe of $\gamma\gamma WW$ and $\gamma\gamma ZZ$ anomalous couplings
 - Search for $\gamma\gamma \rightarrow \tilde{l}\tilde{l}$



JHEP 0710:090,2007

AIP Conf.Proc.1200:434-437,2010

JINST 4:T10001,2009

Summary

- CMS has a broad program of exclusive SM and BSM physics
 - Designed to evolve with changing luminosity/pileup conditions
- For 2010
 - Candidates for several exclusive $\mu\mu$ processes with $\sim 35\text{pb}^{-1}$ (= "a few" pb^{-1} of single interactions data)
 - Full analyses in progress
- For 2011
 - Expect significantly more data, but pileup will be a challenge
- For the longer term
 - HPS upgrade project proceeding
- As always – stay tuned for new results!