Study of high energy photon interactions in the CMS experiment

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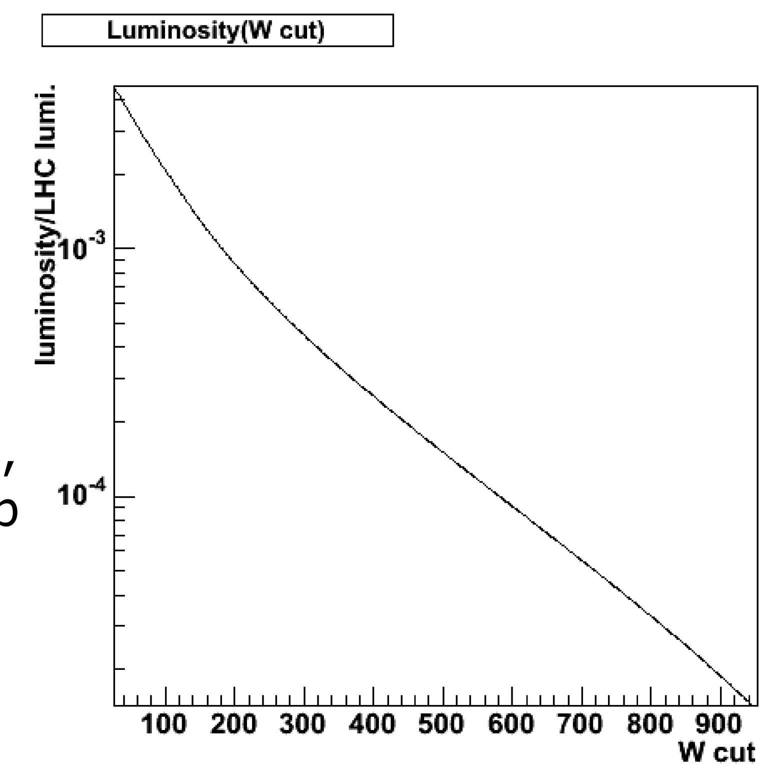
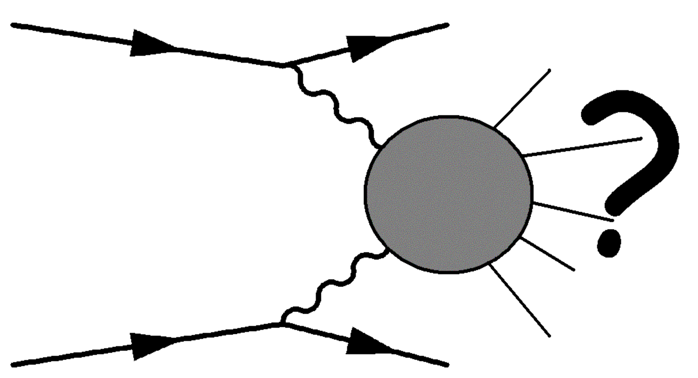


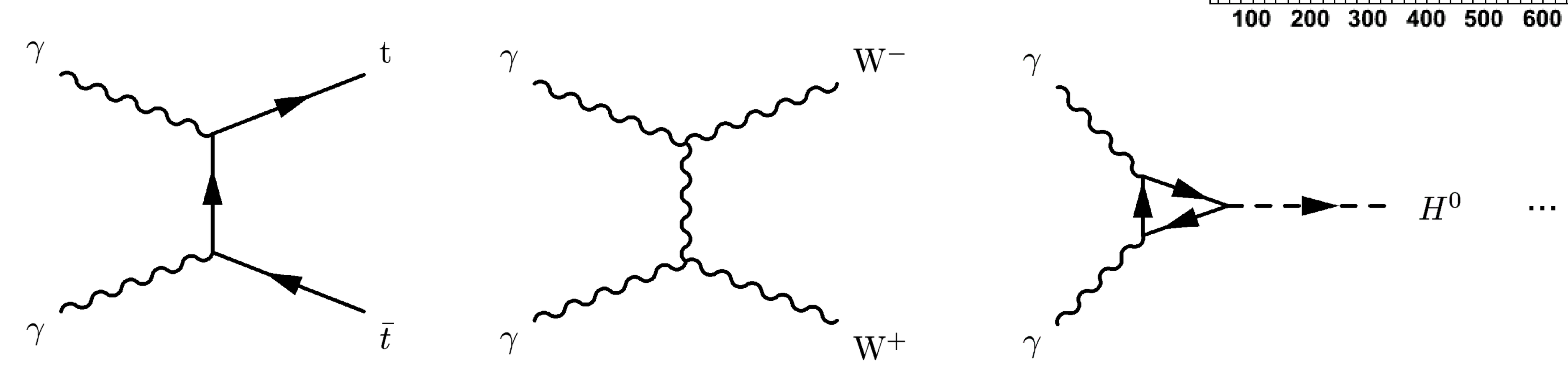
Motivation

Physics studies :

Cross sections of production of a pair of charged particles in **photon-photon** ($\gamma\gamma$) interactions are large at high energies. In addition, a significant luminosity of the $\gamma\gamma$ interactions in proton-proton collisions is expected at the LHC (>1/1000 of the pp one). This will help probing many types of processes such as the production of W bosons, top quarks, etc …, and also possible supersymmetric charged particles. Some more exotic topics, like large extra-dimensions or magnetic monopoles, could also be studied in this scheme.



Where the blob could be



Detection technique:

The main issue is obviously the **tagging** of such interactions – because of the trigger and background constraints. This is most of the time impossible with the main CMS detector only, as the protons usually either continue in the beam pipe (for emission of a low virtuality (Q^2) photon resulting in a small scattering angle, ~100 µrad), or does not survive the interaction (for a high Q^2 photon). However, for low Q^2 photons, the protons can be detected with dedicated detectors, called **roman pots** (RP), far away from the CMS interaction point (IP), thus enabling the tagging.

Three cases can therefore be considered :

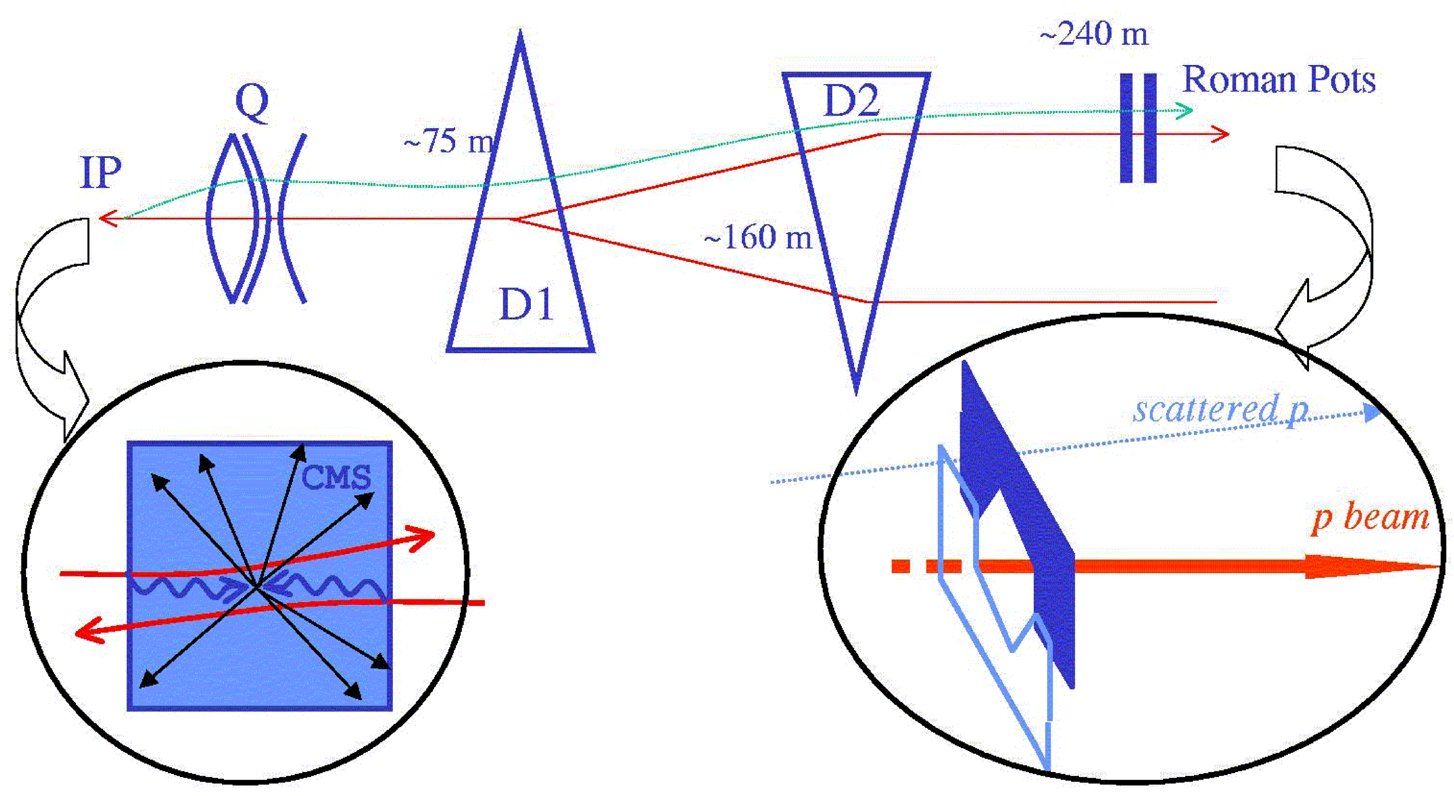
1) both protons emit a low Q^2 photon and are detected.

The **measurement** of the **proton position and momentum direction** at the RP allows for the **reconstruction** of the photon **energy** and **virtuality** (Q^2). One then knows accurately the initial state of the interaction.

2) only one proton emits a low Q^2 photon, which interacts directly with another proton (γ p interactions).

3) one proton emits a high Q^2 photon and is destroyed, while the other photon is soft and recoils against its "parent" proton.

In these latter two cases, only one proton is detected with the RP. This still allows an efficient tagging for the emission of a low-energy photon.



Finally, $\gamma\gamma$ and γ p events are in general far **cleaner** than pp ones. This will also improve the reconstruction of the event.

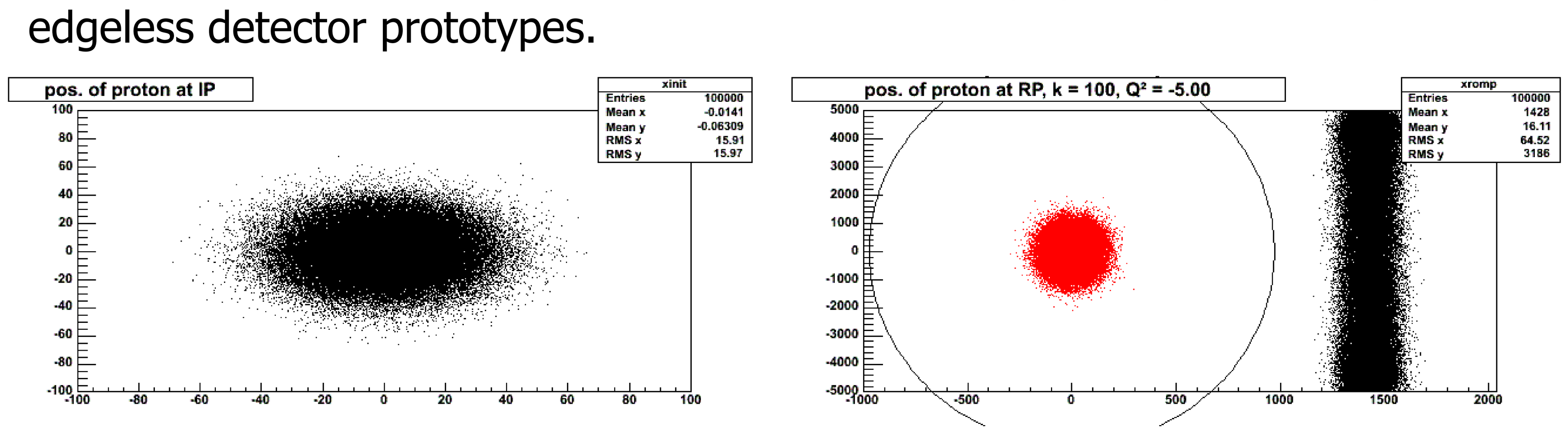
Tagging

Roman pots :

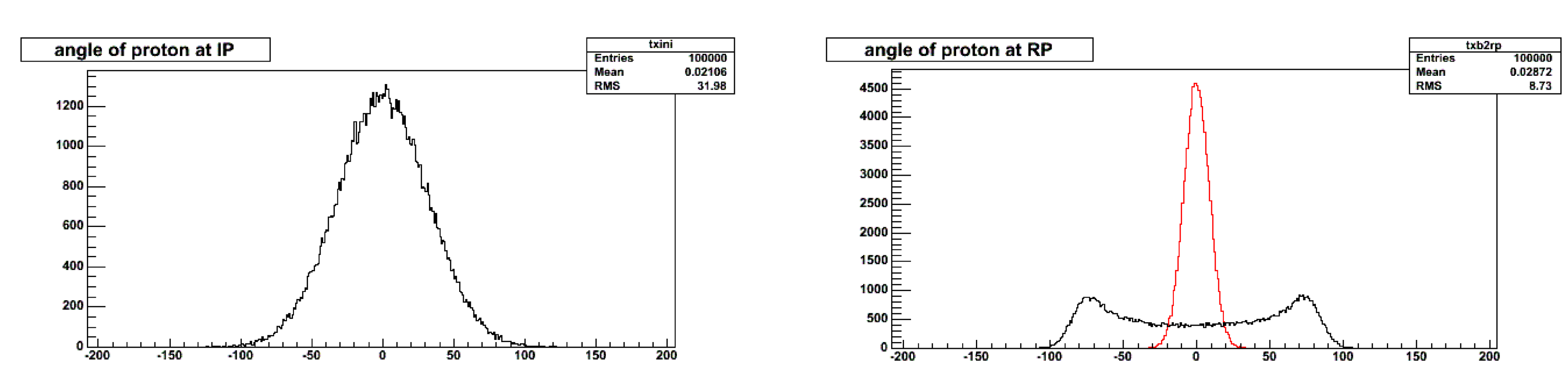
Deflection of proton's trajectories by the beam-line dipoles depends on the proton energy. About **240m away from the CMS IP**, the beam lateral size is small (100–500 µm). Putting a detector as close as **1mm from the beam** would then allow for the detection of protons having emitted a low Q^2 photon (of >100 GeV). Therefore, major requirements for such detectors, namely roman pots, are the radiation hardness and the ability to approach the beam as close as possible.

Dedicated edgeless silicon microstrip sensors are investigated for the detection of these forward scattered protons. Here, edgelessness means the minimization of the detector insensitive border. By combining the position and momentum angle measurements at the RPs, both the photon energy and virtuality can be reconstructed with a precision of about 5 GeV and 1 GeV², respectively.

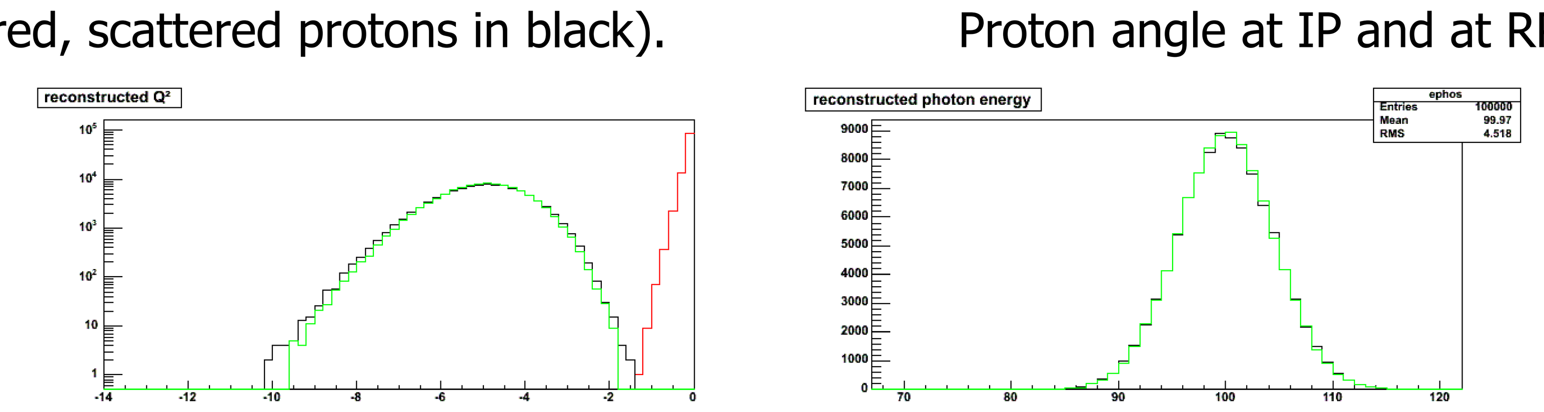
Current work is focussed on the simulations of the physics processes (Monte Carlo), of the beam optics transport of scattered protons and on the building of edgeless detector prototypes.



Proton position at IP and at RP (beam in red, scattered protons in black).



Proton angle at IP and at RP (beam in red, scattered protons in black).



Reconstructed photon virtuality and energy, with smearing due to the detector resolution. (beam in red, scattered protons in green/black).