FORWARD PHYSICS AT THE LHC

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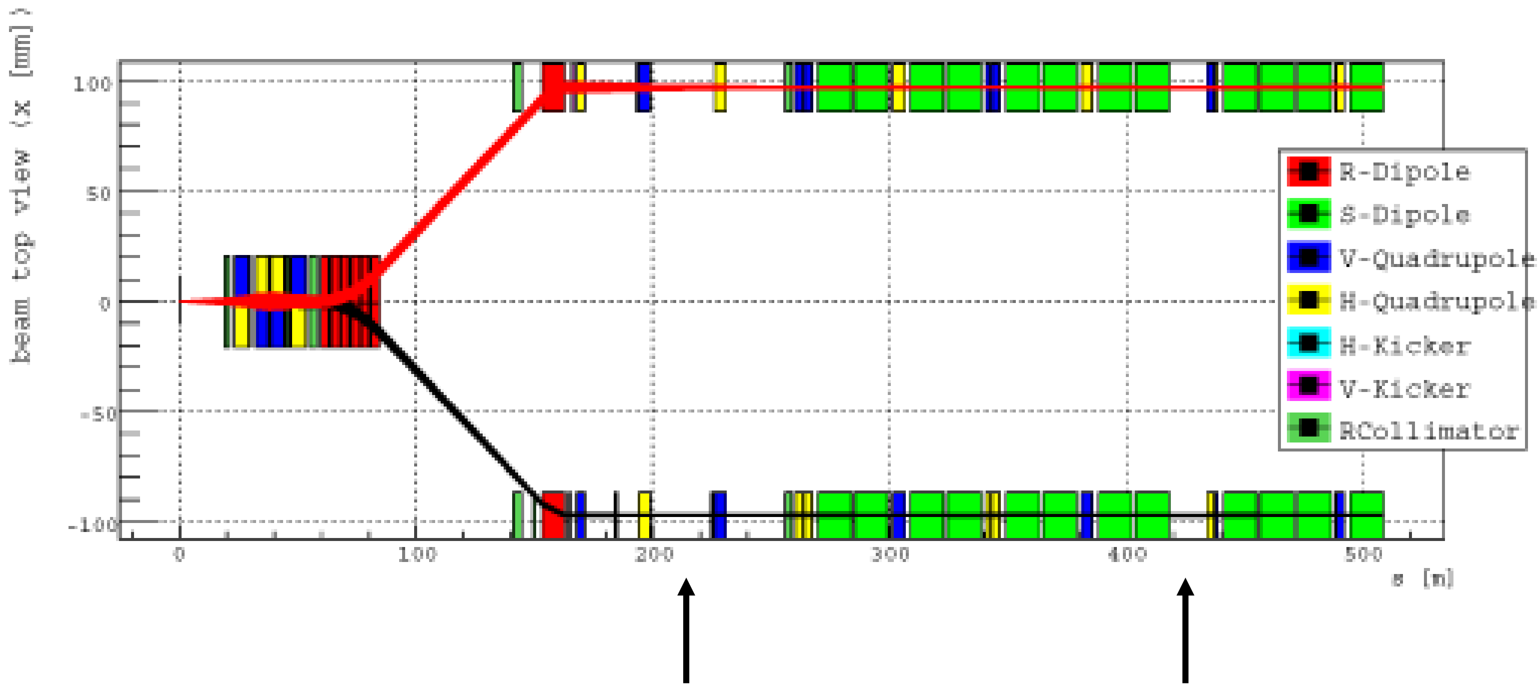
HERA-LHC WORKSHOP
CERN MAY 2008

WHAT WE ARE PLANNING TO DO



Install detectors at 220 m and at 420 m from the interaction points either side of ATLAS and CMS to tag protons that are forward scattered in diffractive and photon-exchange processes.

WHAT HERA HAS DONE SO FAR

(Among many other things) an extensive programme of photoproduction and diffractive physics.

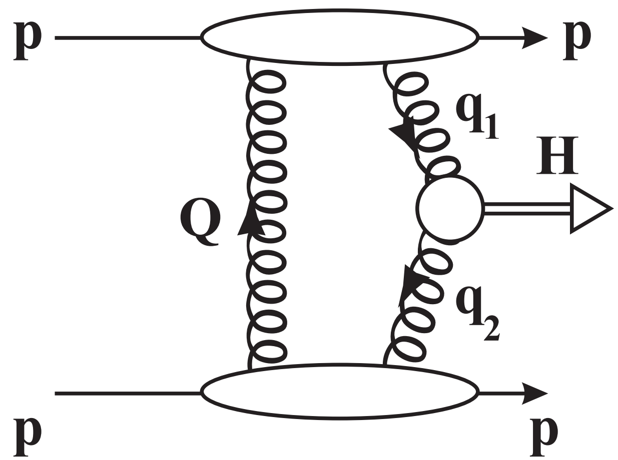
LEP has explored high energy photon-photon physics.

Our proposed LHC programme builds on both of these.

Much higher energies available than at HERA and LEP.
Hard processes are of particular interest at LHC
(Soft processes probably not easily triggerable.)

At LHC we can study double diffractive processes.
(A taste of this already at the **Tevatron**.)

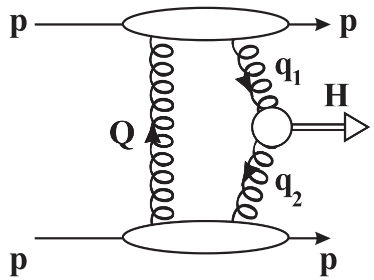
EXCLUSIVE CENTRAL PRODUCTION

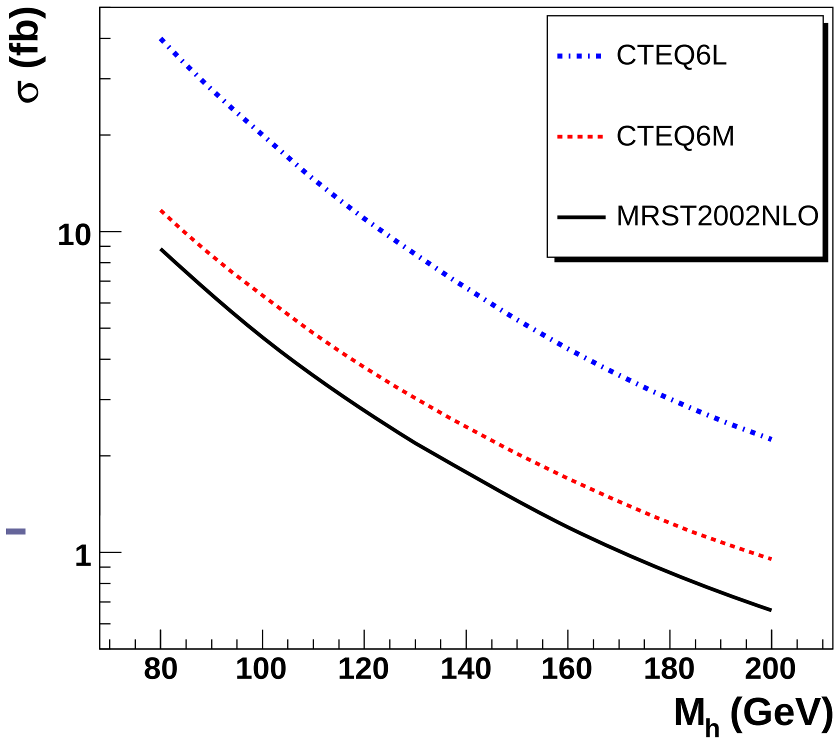


The standard example is illustrated. The missing mass of the two protons gives a precision measurement of the mass of the centrally produced state.

Usually much more precise than from reconstruction in the central detector.

EXCLUSIVE CENTRAL PRODUCTION





Note that in these models there is considerable sensitivity to the proton gluon PDFs.

Unfortunately the SM Higgs near 120 GeV has a rather low accepted and triggered cross section.

SUSY HIGGS

SUSY Higgs offers more chances!

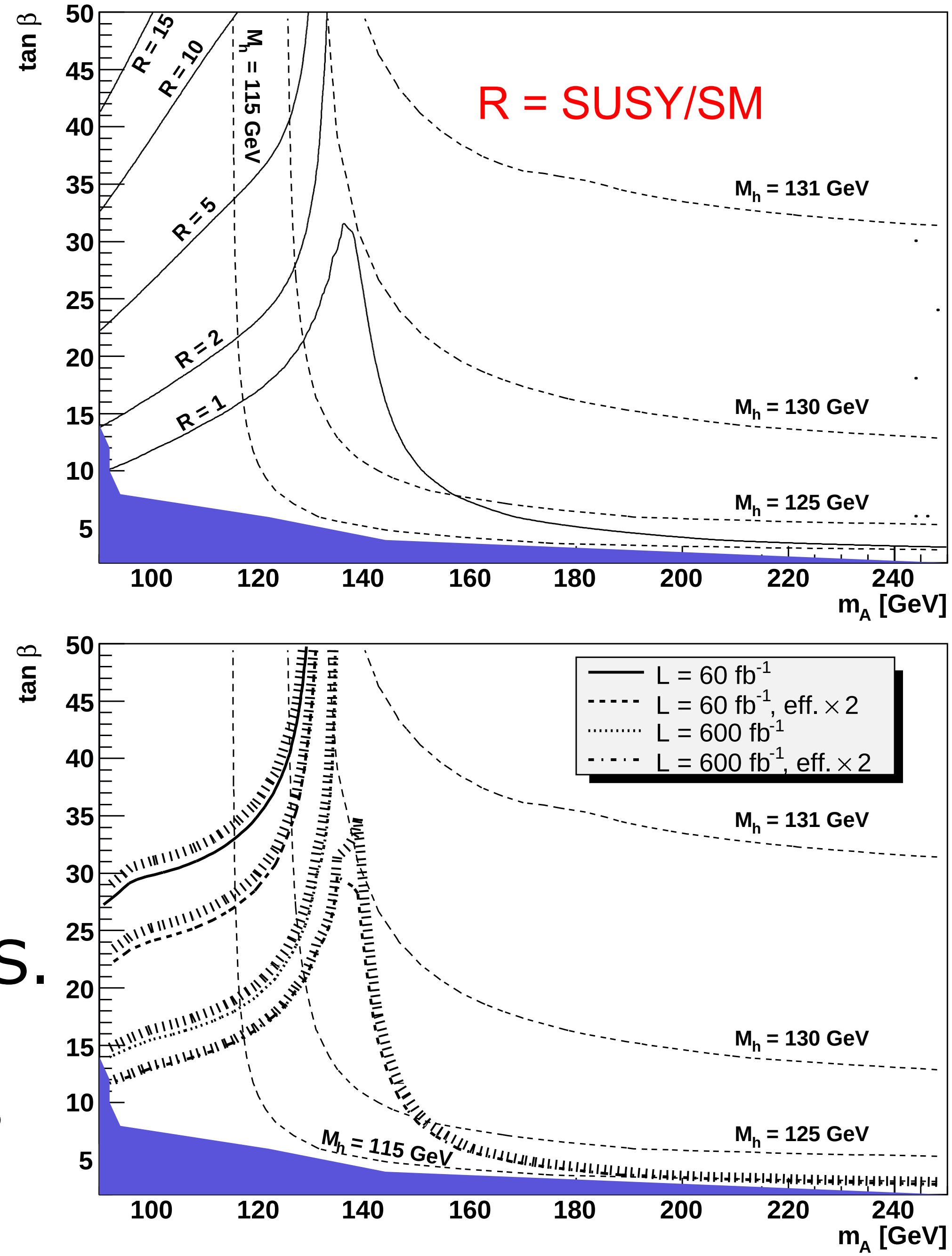
Several MSSM studies (Heinemeyer et al.)

Large tanβ is allowed and can enhance cross sections.

h→bb modelled in CMS.

Blue = LEP-excluded.

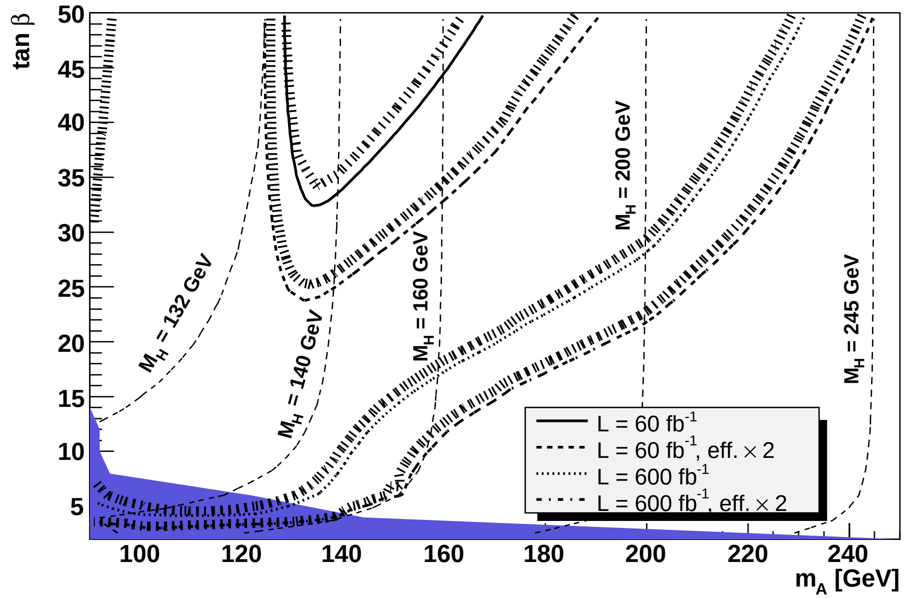
3-σ evidence contours for various scenarios.



SUSY HIGGS

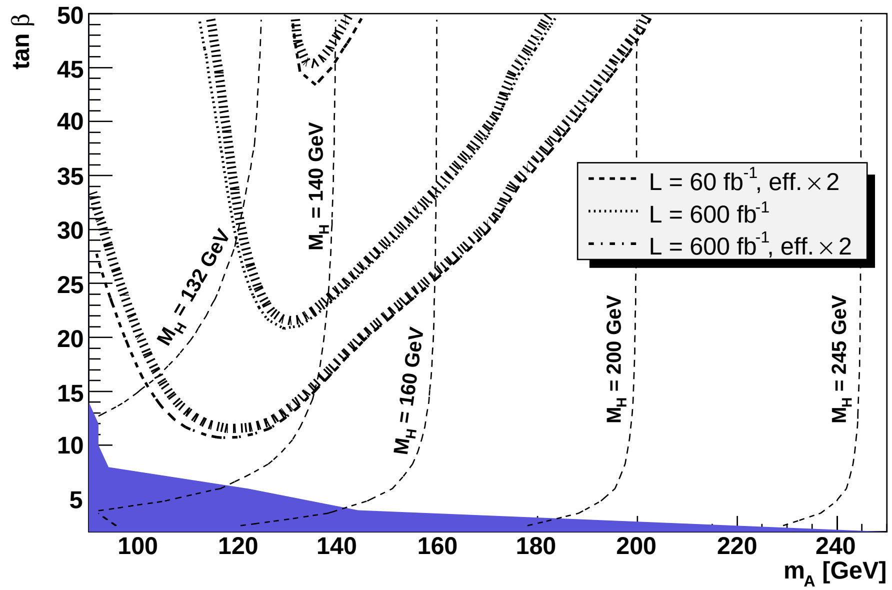
Study of H→bb modelled in CMS

3-σ evidence contours for various luminosity scenarios.



Study of H→ττ modelled in CMS

3-σ evidence contours for various luminosity scenarios.

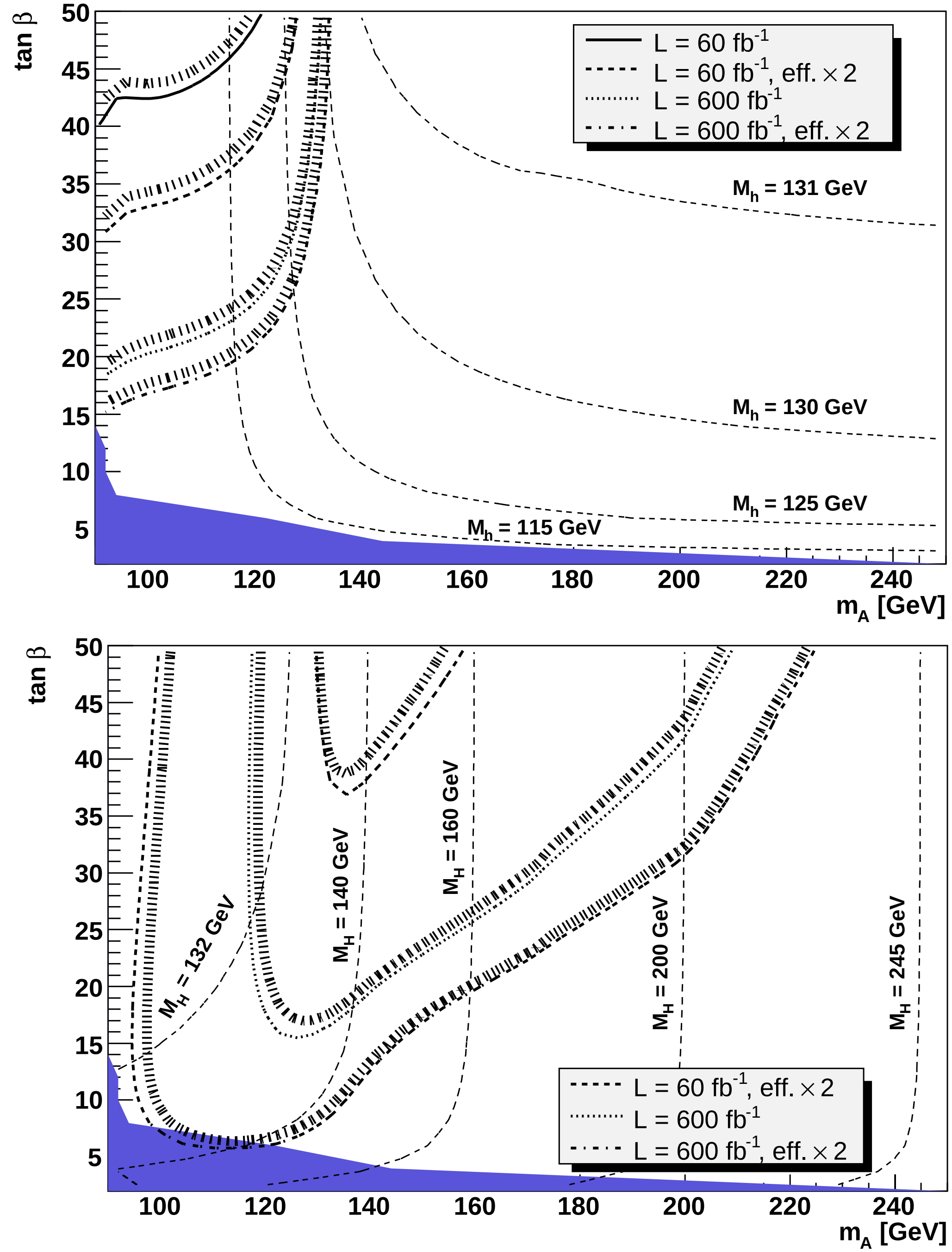


SUSY HIGGS

5-σ discovery contours for the bb channels,

h (top) and
H (bottom),

with the μ parameter set at 200 GeV.



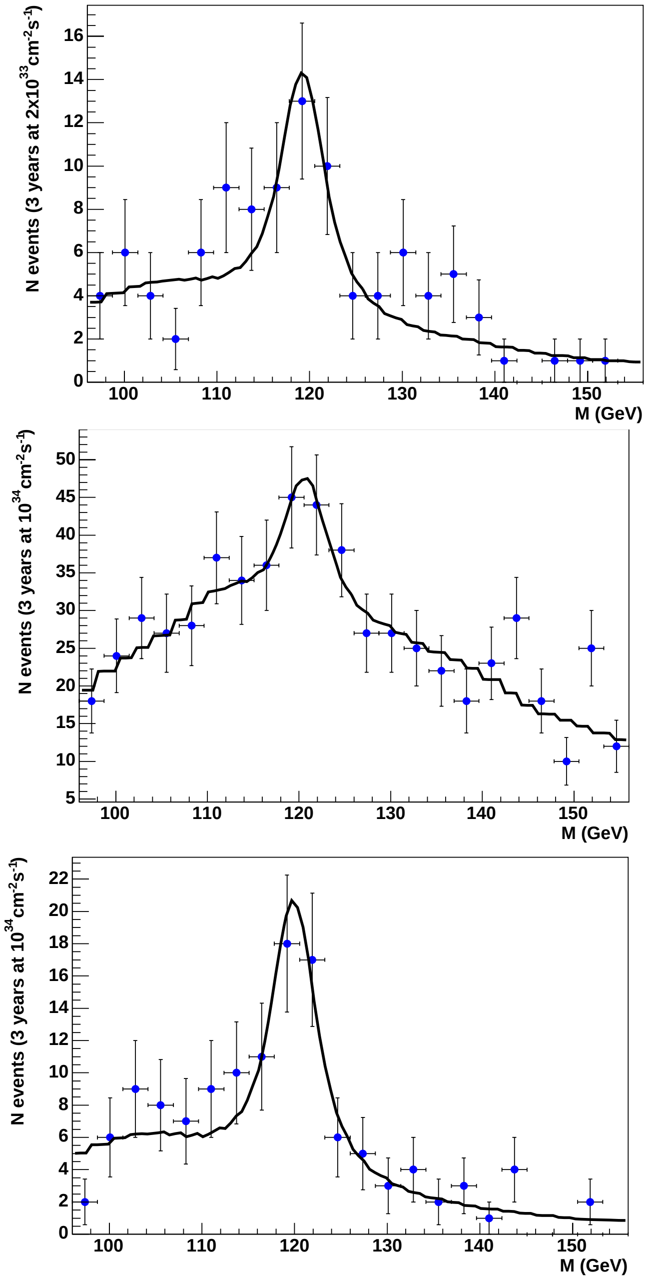
SUSY SIMULATION
(A. Pilkington)

Simulate MSSM   h→bb
at 120 GeV (ATLAS),
+ suitable analysis cuts.

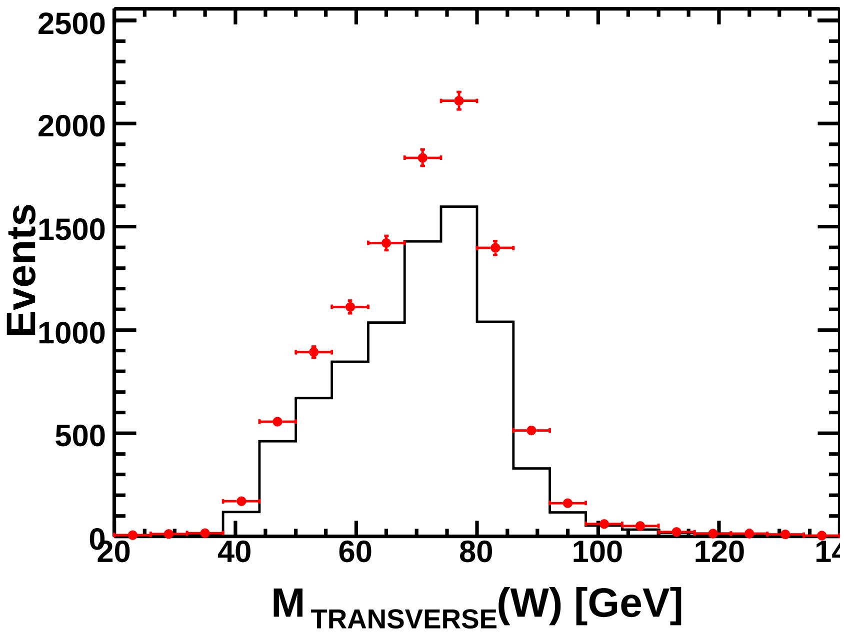
$\int\mathcal{L} = 60$ fb^{-1} (top)

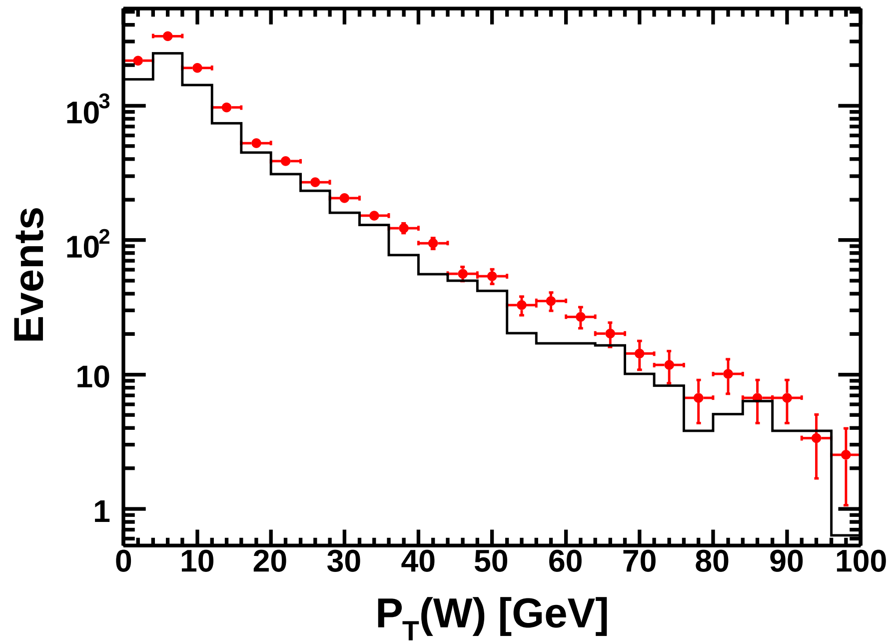
$\int\mathcal{L} = 300$ fb-1 (middle)
+ effect of overlap bgd.

Use fast timing detectors
to remove overlap bgd.
$\int\mathcal{L} = 100$ fb-1 (bottom)
now giving 5-σ discovery.



W in DOUBLE DIFFRACTION



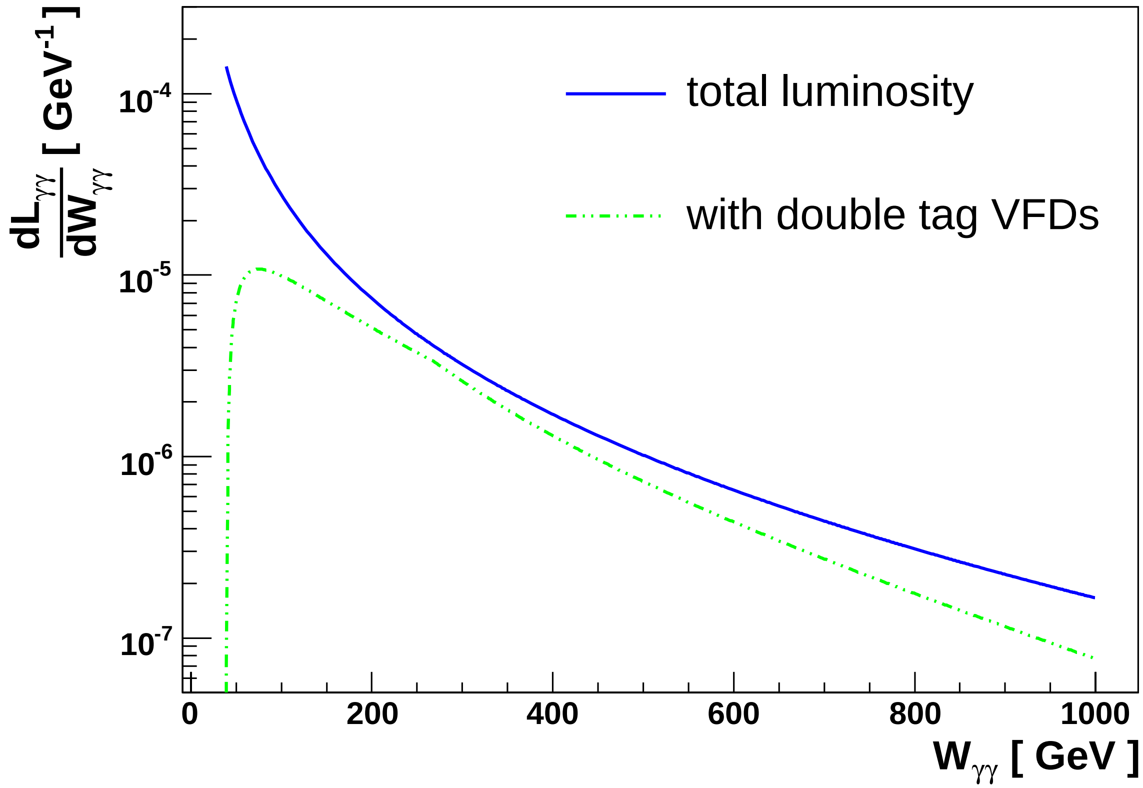


Simulate in CMS system pp→ppXW. Select leptonic W decay channels.

For 1 fb^{-1} several thousand events are expected.

γγ PHOTO-PRODUCTION

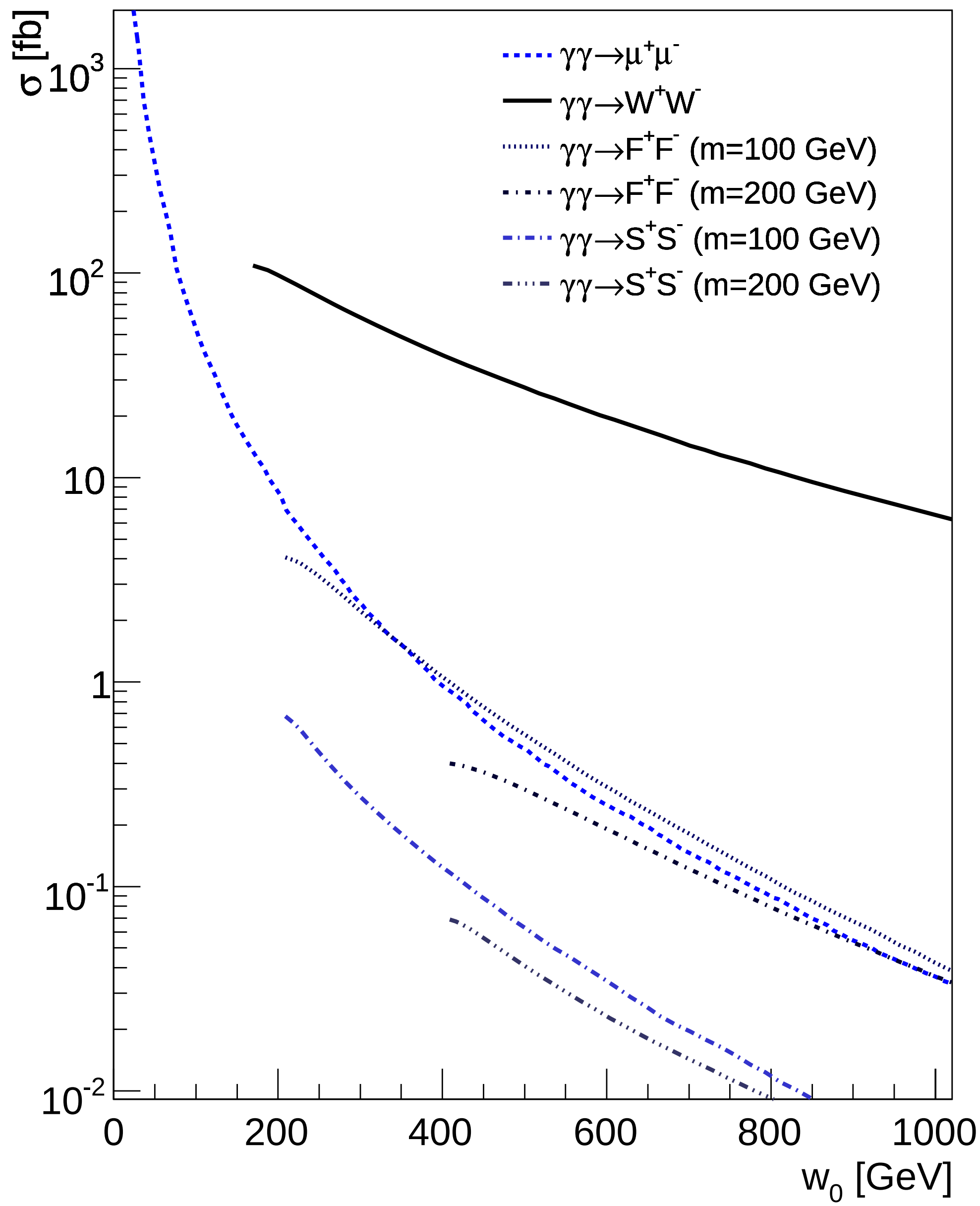
Luminosity vs. $W_{\gamma\gamma}$



High energy protons are quite efficient at radiating photons. Kinematically resembles diffractive scattering but with smaller p_T transfer to the proton. Overtakes double diffraction at W ≈ 1 TeV.

Diffraction mainly produces gluon jets, photoproduction mainly quark jets.
Little interference between the two processes (V. Khoze, priv. comm.)

γγ PHOTOPRODUCTION



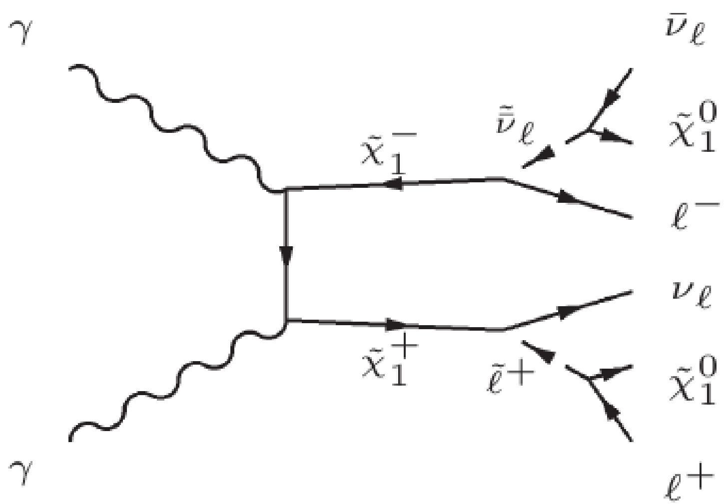
Cross sections for various γγ processes.

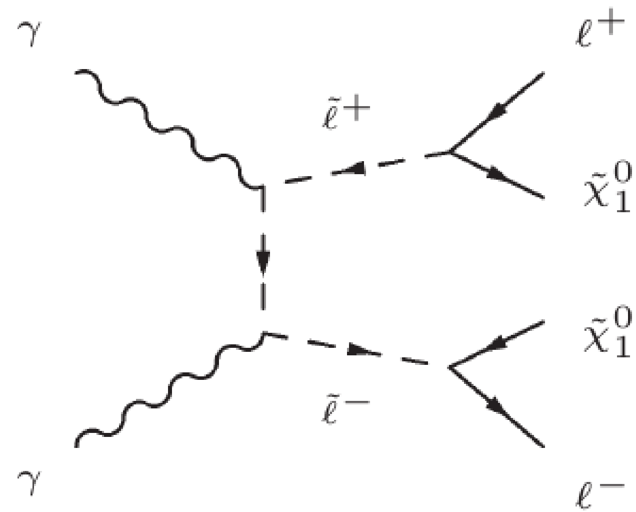
The dimuon process may be good for LHC luminosity monitoring.

W^+W^- has a large cross section of 100 fb.

ZZ only by anomalous couplings. But if heavy H→ZZ, γγ → is a small background.

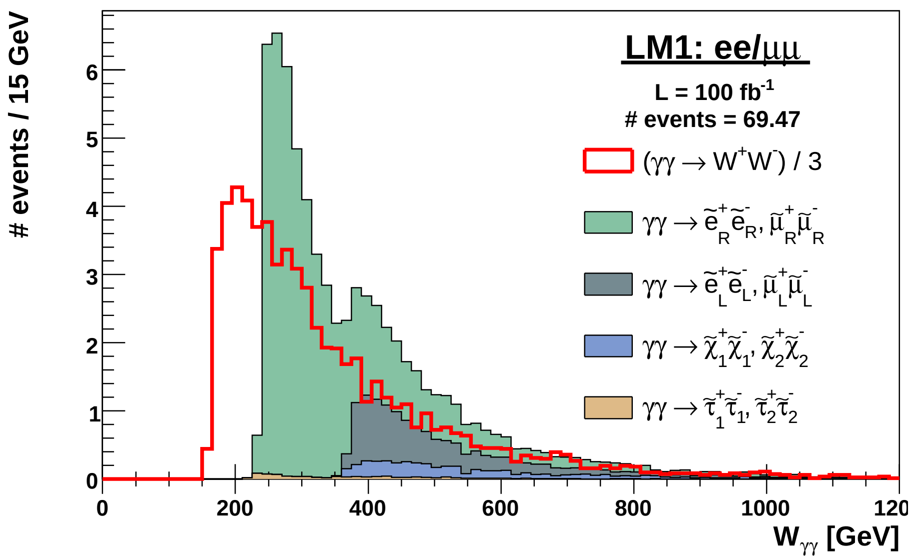
γγ PHOTOPRODUCTION

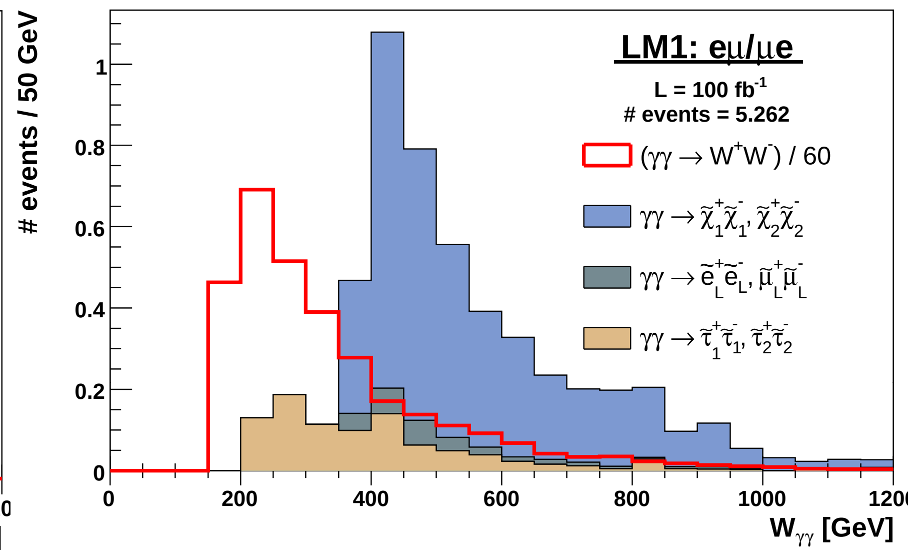




Examples of SUSY processes in photon photon interactions.

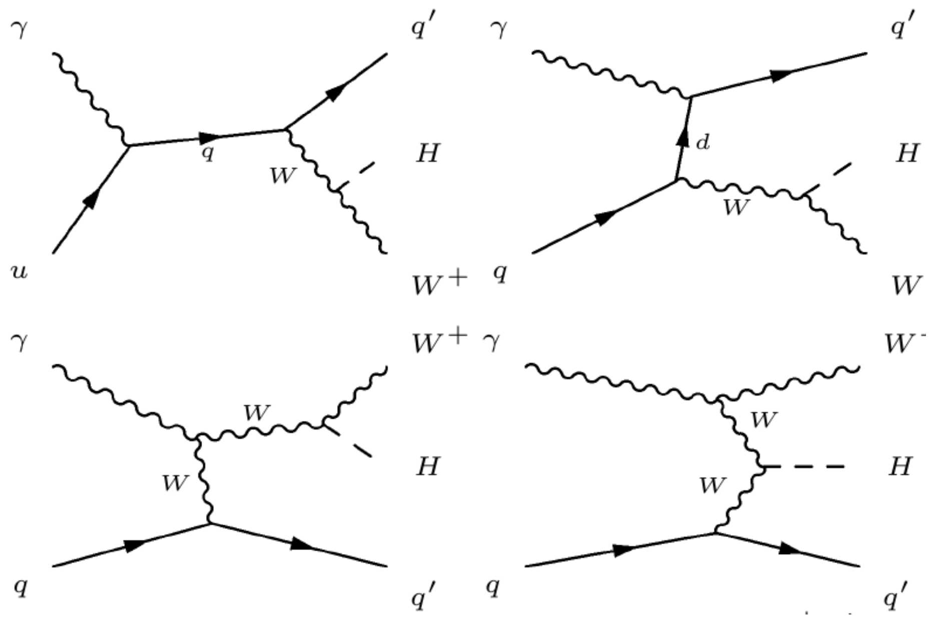
γγ PHOTOPRODUCTION

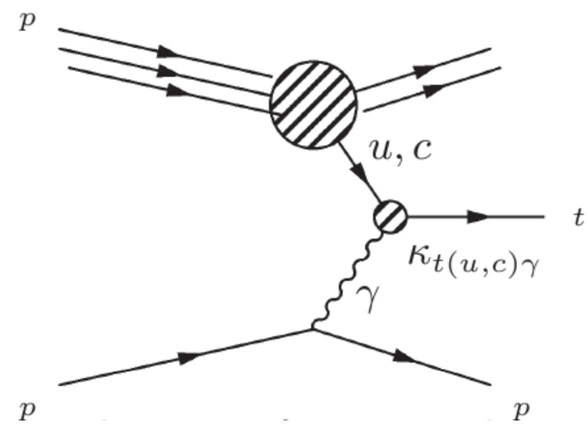




Simulation of chargino and slepton channels.
[chargino, slepton(L), slepton(R), stau]
same lepton flavour (l), different flavour (r).
SUSY scenario: LM1 = very light LSP, light slepton and chargino.
Background from WW will be challenging.

γp PHOTOPRODUCTION

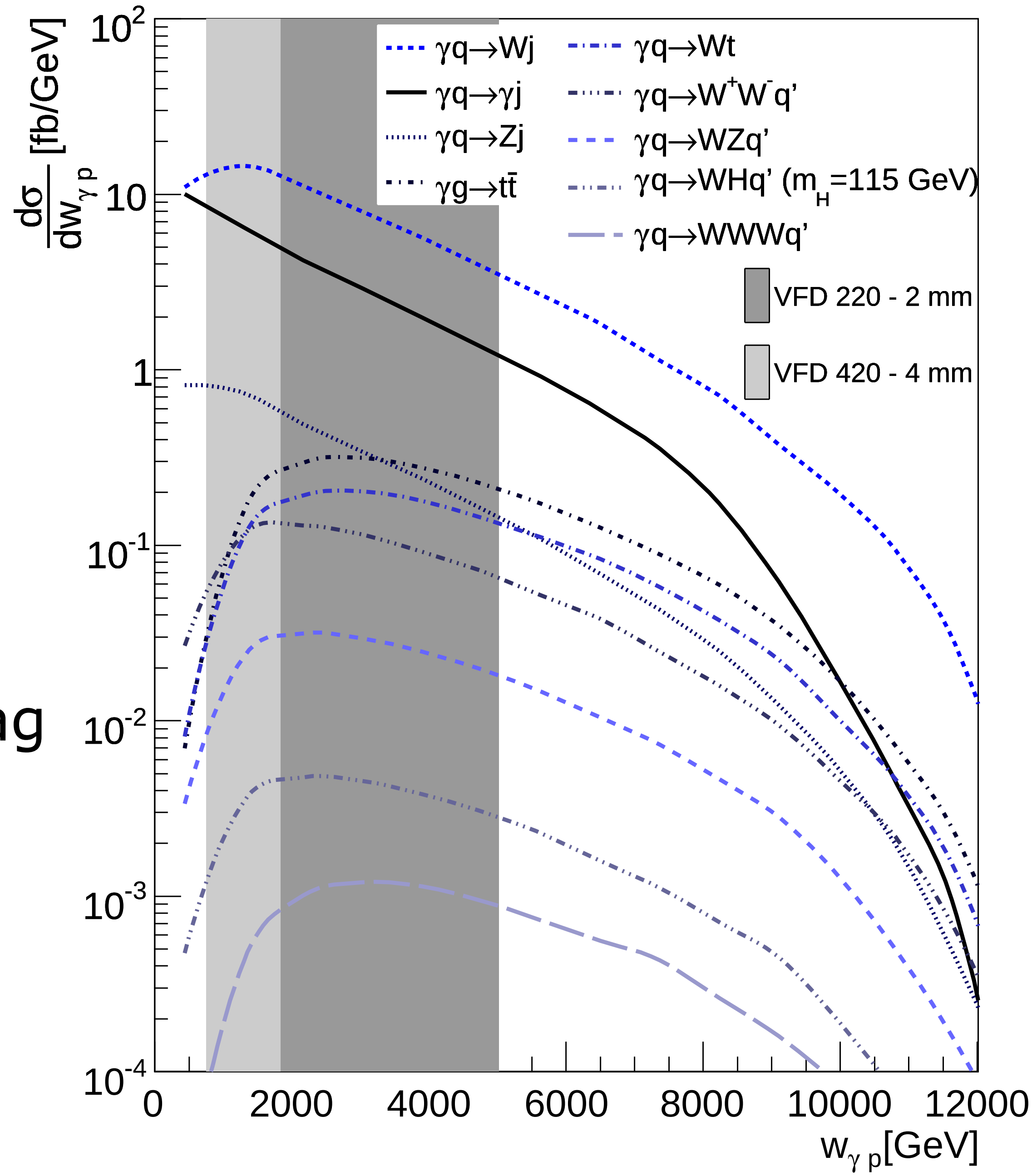




WH mechanism in SM can be enhanced in some models – probably not a discovery channel.

Look for anomalous single top via FCNC.

γp PHOTOPRO-DUCTION SUMMARY.



Various processes can be studied or sought for.

These are single-tag studies – the relevant tagger is indicated.

OTHER PHYSICS CHANNELS

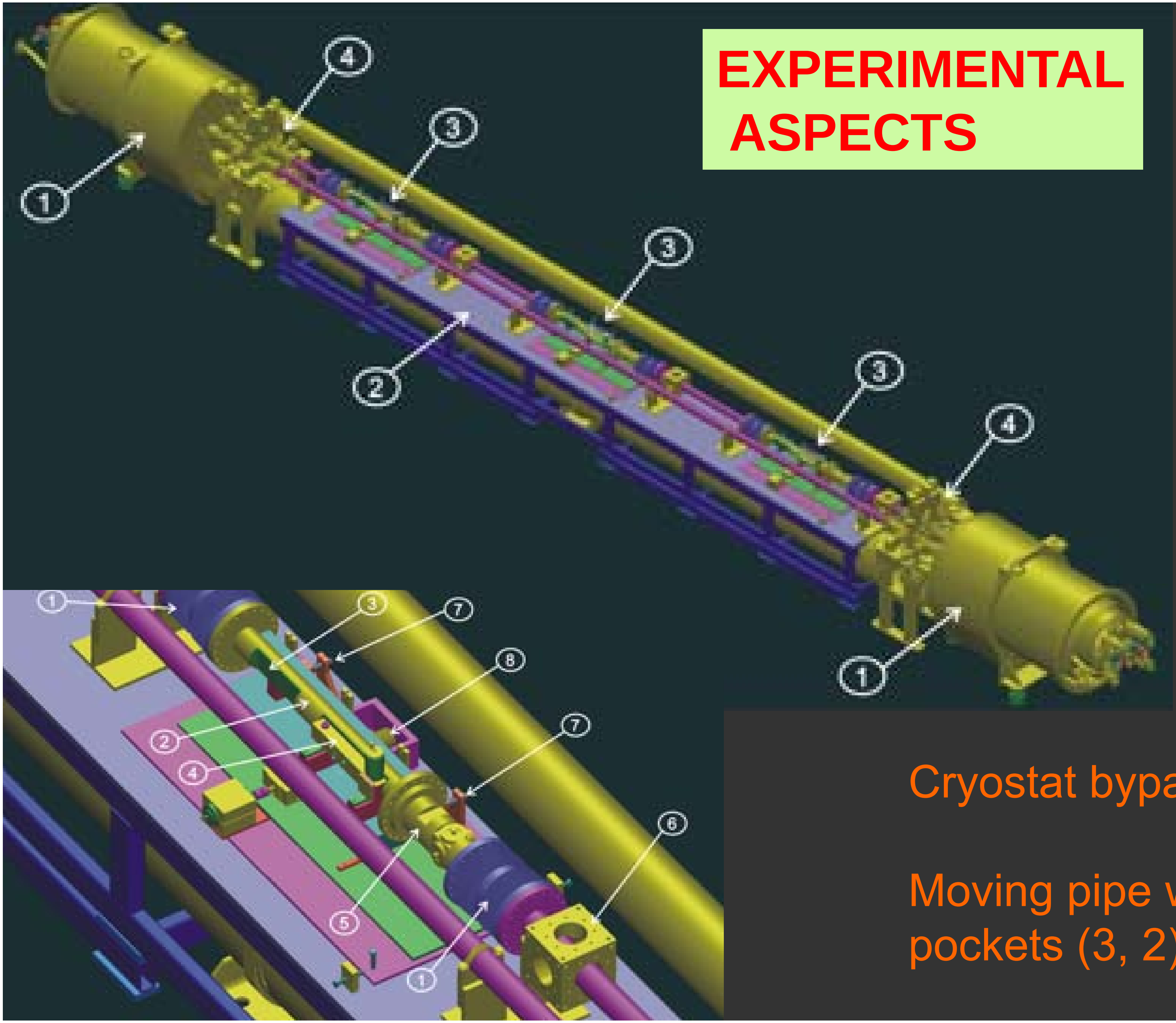
– High P_T jet production – QCD tests – hard pomeron-pomeron scattering. Note that the q-q final state is suppressed at low quark masses.

→ Further study of nature of the pomeron

– White pomeron tests (A. R. White): a new symmetry group QCD_S is asserted which implies more quarks, strong pomeron-W,Z coupling and no Higgs (there is an alternative mechanism).

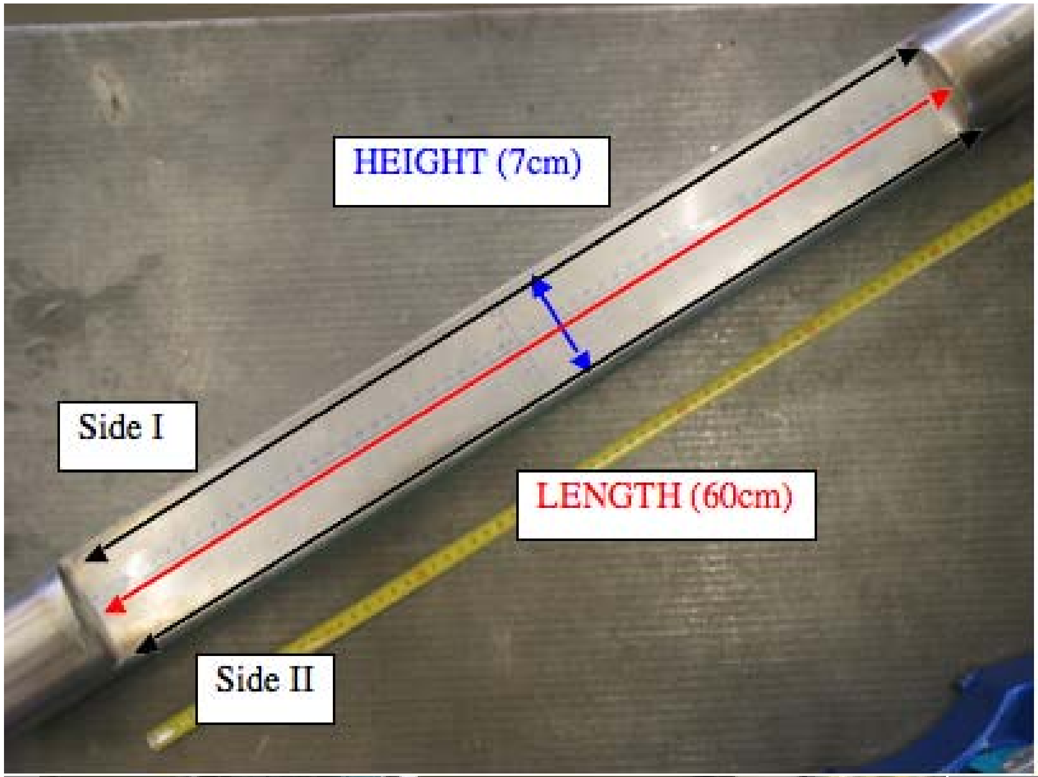
→ LHC should see proliferation of W, Z production and the forward programme is essential to test this coupling.

EXPERIMENTAL ASPECTS



Cryostat bypass.

Moving pipe with pockets (3, 2).



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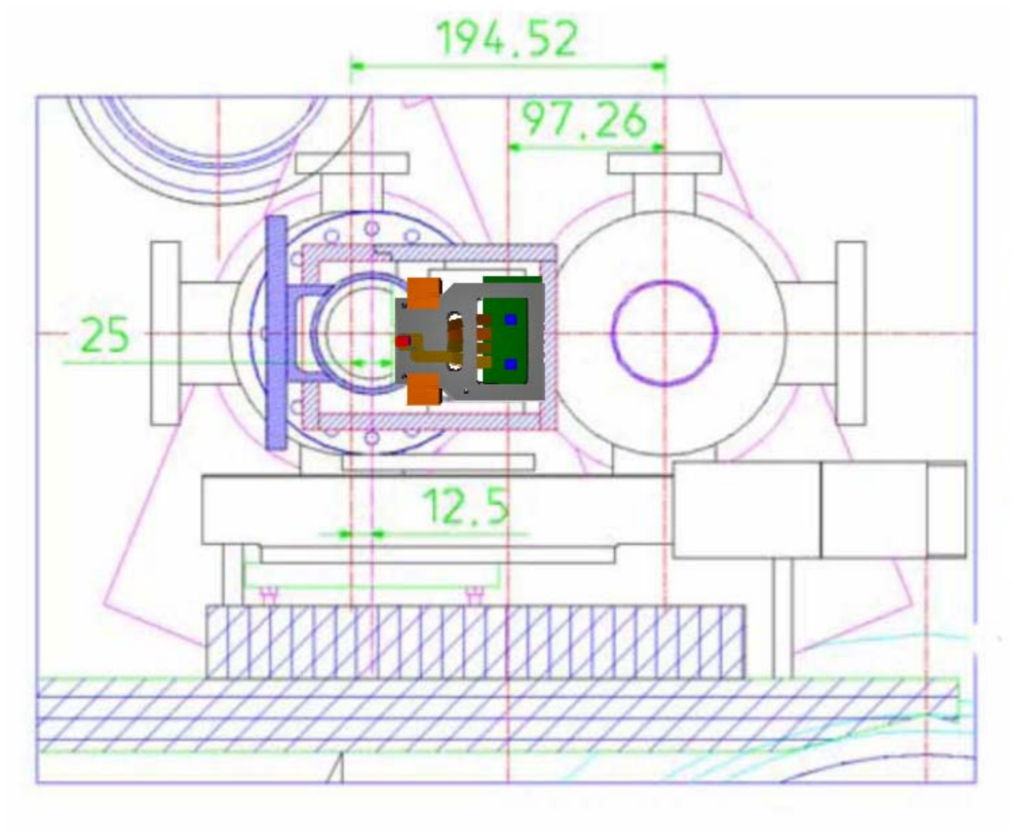
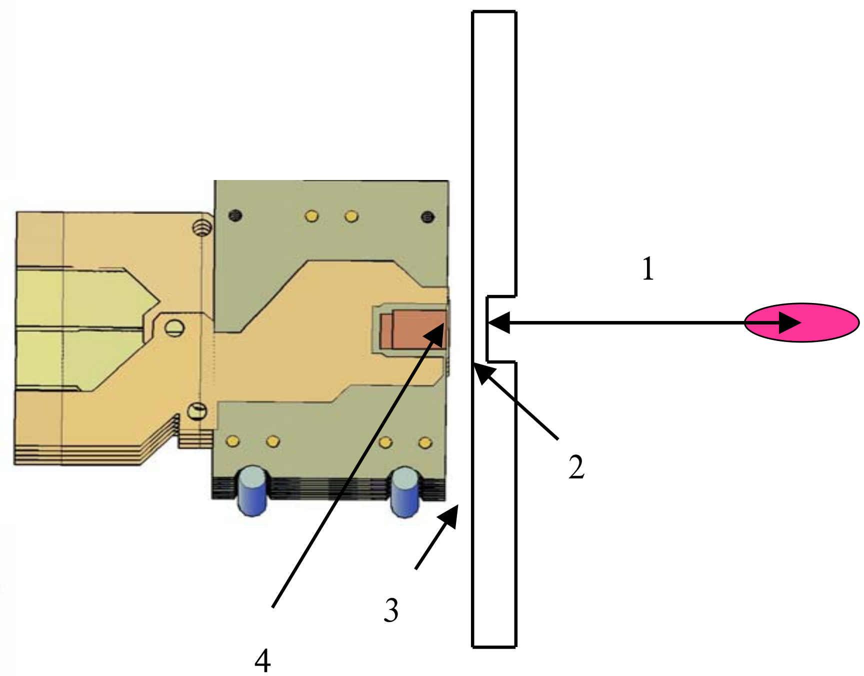
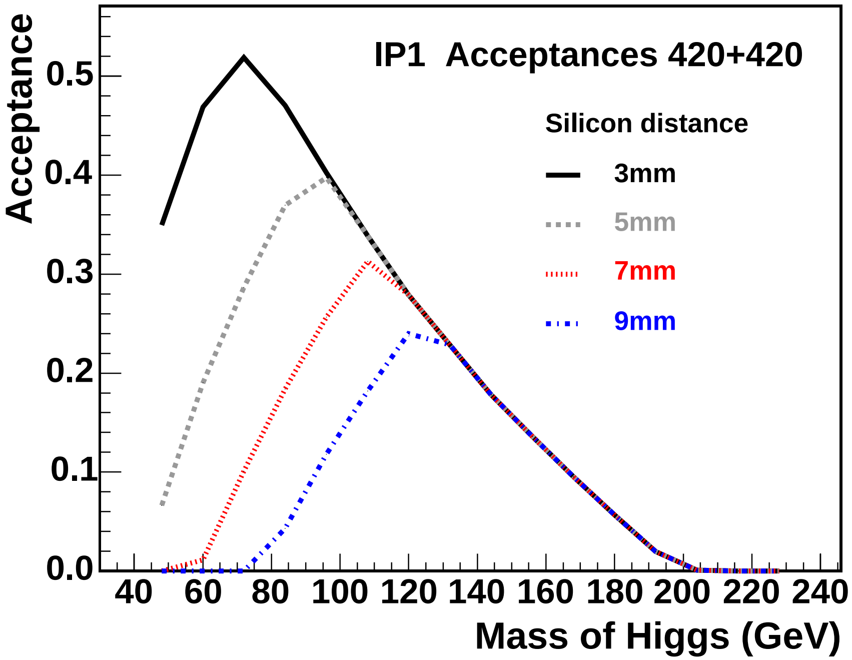
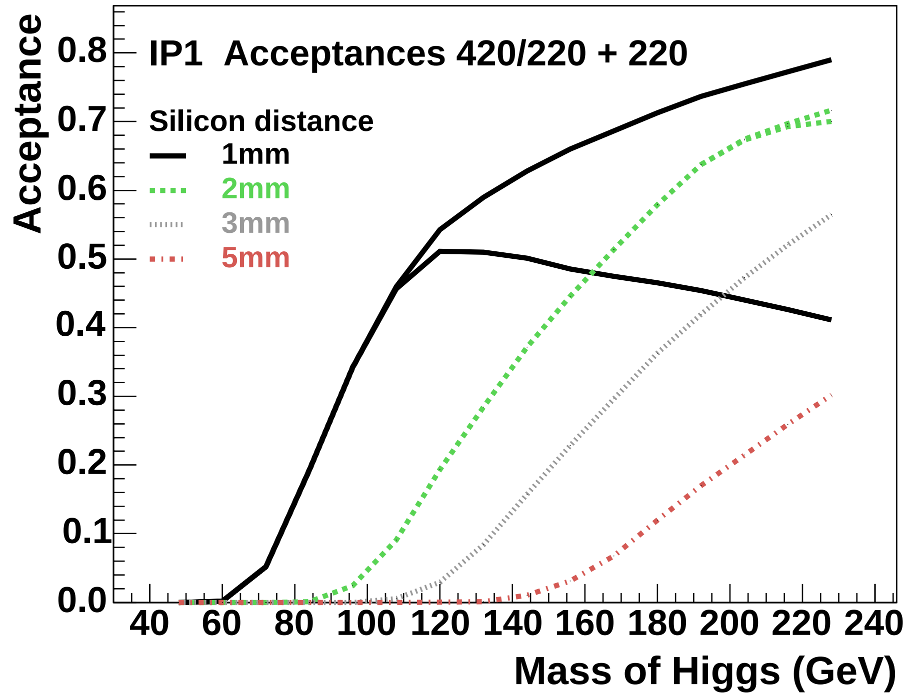




Space is tight around the beam pipe.
Distance of closest silicon approach is crucial.

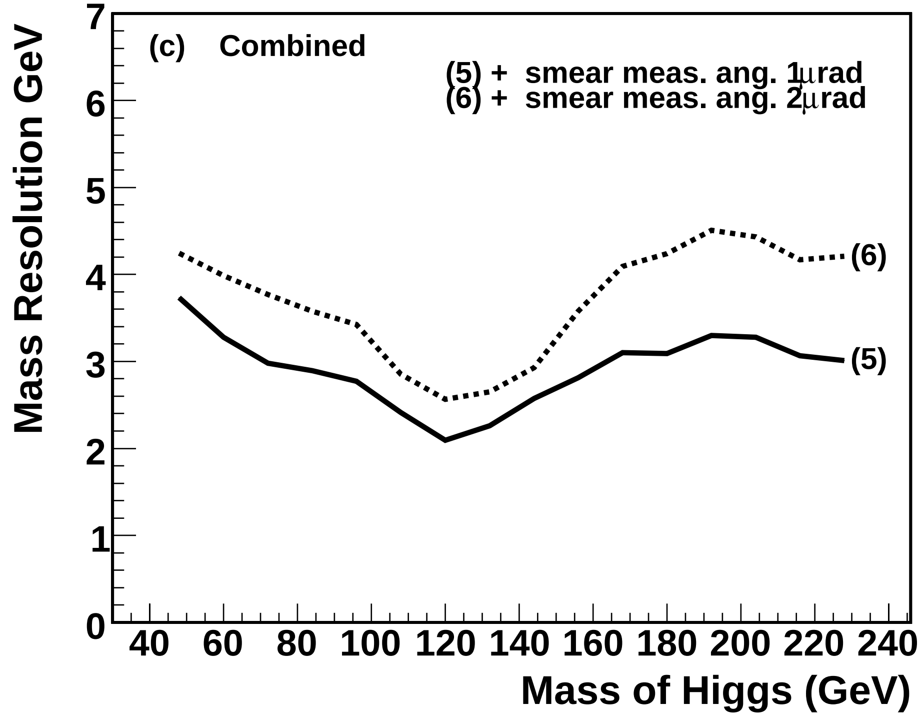
ACCEPTANCES





420 + 420 acceptance falls off at 150 GeV but peaks at 120. For higher central masses we need the 220 m system (distance at 420 fixed at 5mm in right-hand plot.) Good acceptance values!

MASS RESOLUTION



Reconstructing the mass of the centrally produced object from the two tagging photons at 420/220 m.

$$M^2 = 4(p_0 - p_1)(p_0 - p_2)$$

(Calculate from measured proton trajectories, and incorporate experimental uncertainties.)

CONCLUSIONS

Forward tagging opens up a wide range of diffraction and photoproduction processes, following from the HERA experience and extending it to much higher energies.

Discovery potentials and study of known physics processes.

A major new area for the LHC.