Odderon and Pomeron Physics in Multi-Photon Final States at HERA

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on behalf of the H1 Collaboration

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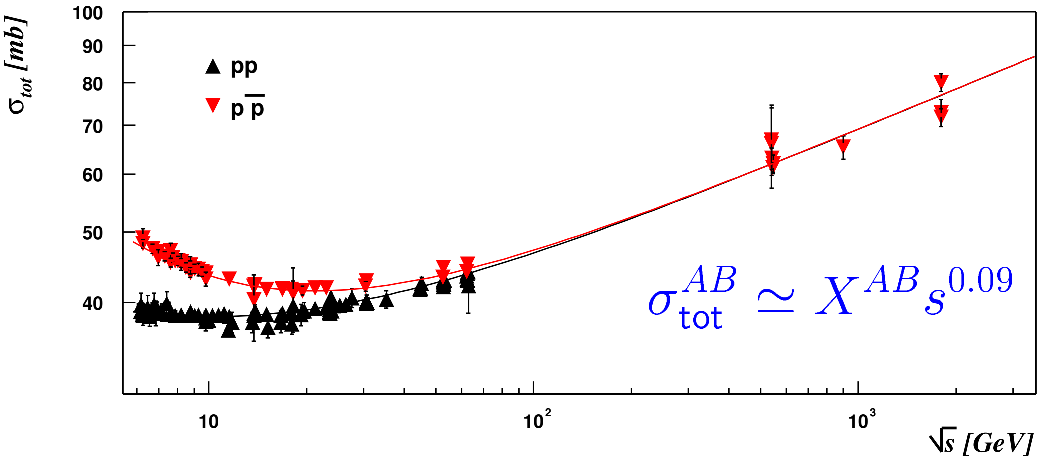
What is the Odderon?

- The
$$C = P = -1$$
partner of the Pomeron!

- But what is the Pomeron?
It is thought to be responsible for the rise of hadronic total cross sections at high energies.



- In pQCD:
$$\mathbb{O} \leftrightarrow 3 \text{ gluons}$$
$$\mathbb{P} \leftrightarrow 2 \text{ gluons}$$

- The Odderon was introduced on amplitude level (for large s) by Łukaszuk and Nicolescu,
$$pp \;:\quad T = T_+ + T_- \overset{\text{crossing}}{\longleftrightarrow} T = T_+ - T_- \quad :\; p\bar{p}$$
as an **odd** *under crossing* piece in the scattering amplitude.

- If $T_- \neq 0 \;\Rightarrow$
$$\Delta\sigma = \sigma_{\text{tot}}^{pp} - \sigma_{\text{tot}}^{p\bar{p}} \not\to 0 \quad \text{for } s \to \infty$$

- But so far there is no evidence for the presence of the Odderon in hadron hadron scattering!

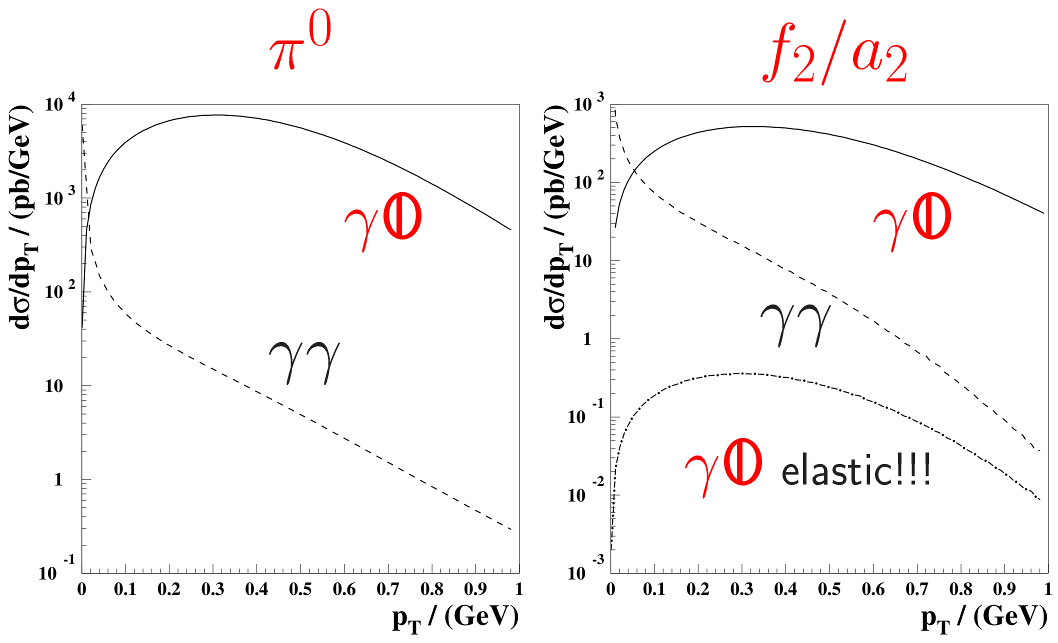
The Odderon at HERA

- HERA is currently the only place to look for Odderon contributions
- There is a non-perturbative QCD model for the Odderon:

  "Stochastic Vacuum Model" (SVM)

  E. R. Berger et al., Euro. Phys. J **C9**(1999) ibid **C14**(2000) with predictions for HERA of

- *large* cross sections if the proton is excited into N^*s

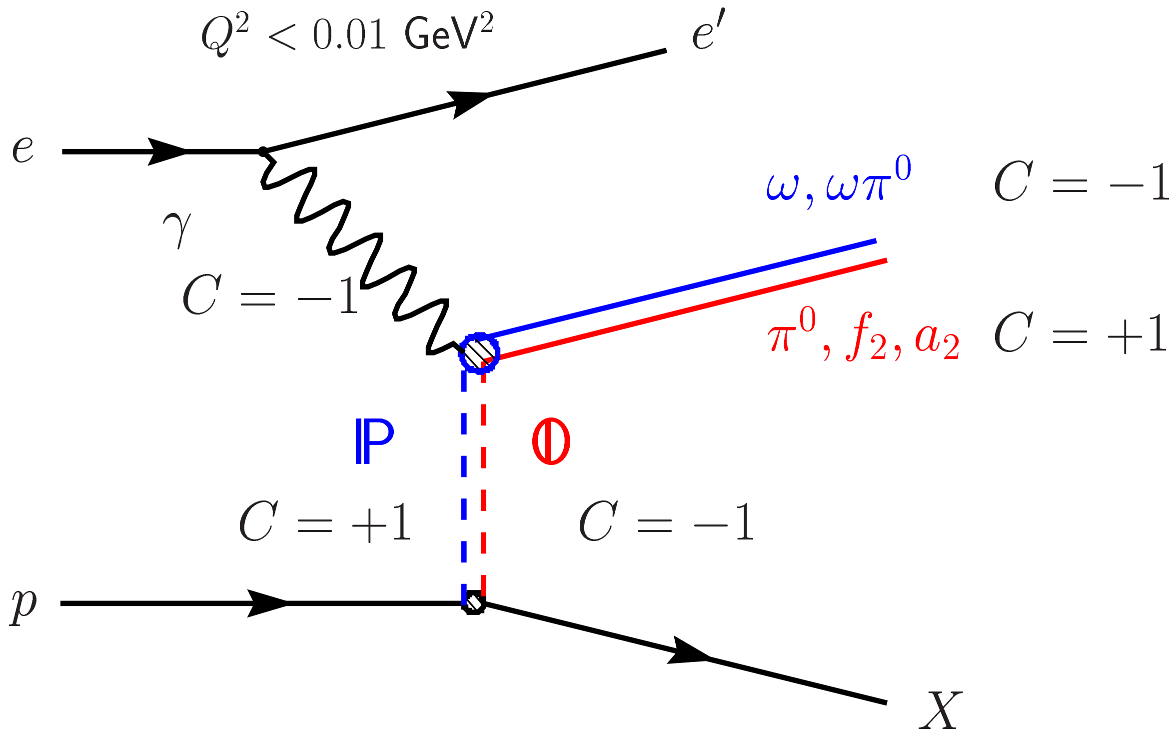


with

$$t = -p_T^2$$

- These distributions were implemented into an event generator

How Do the Pomeron and the Odderon Show up?



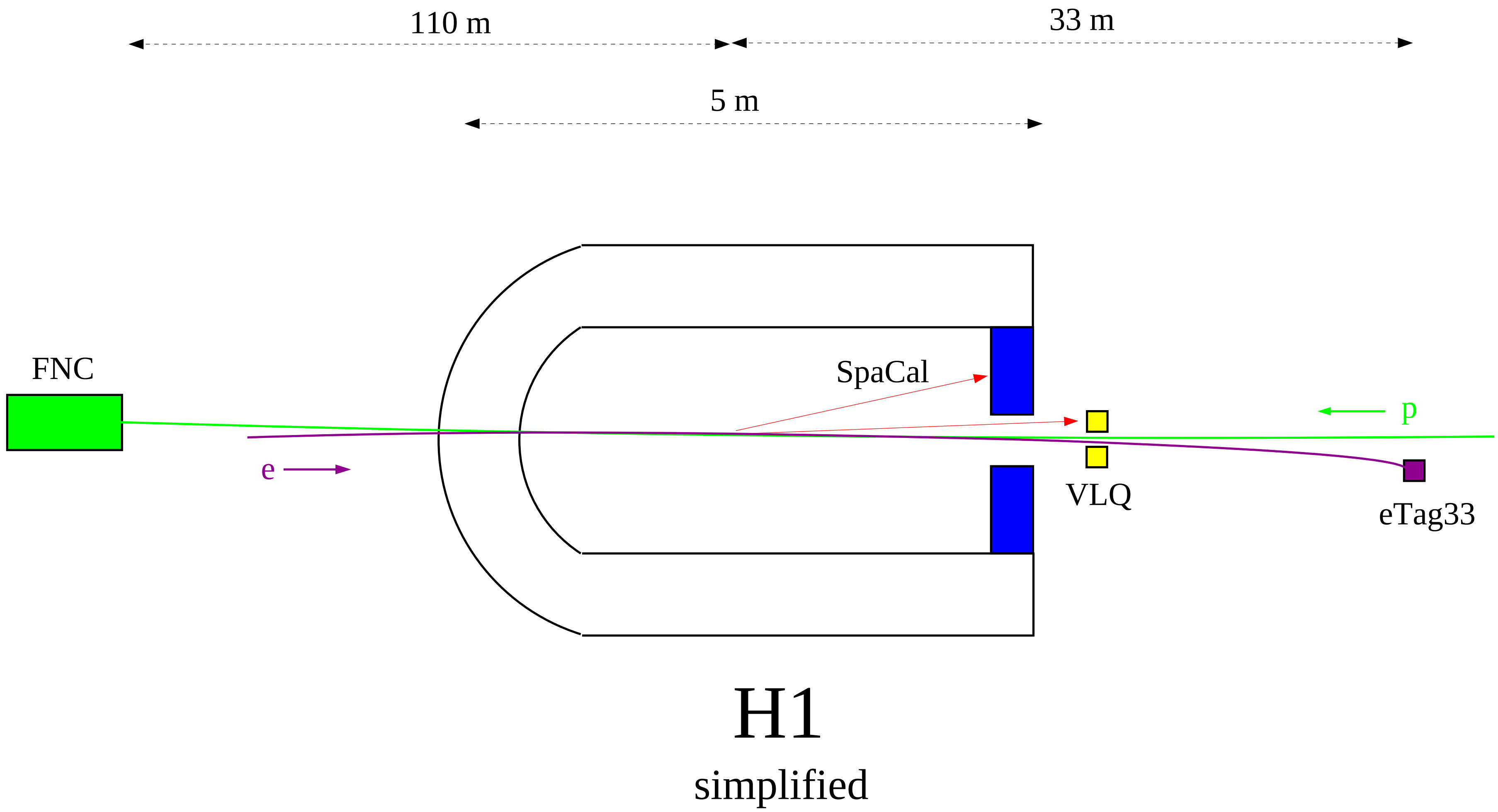
M	$\rightarrow$	decay	$\rightarrow$	$n\gamma$
π^0				2γ
ω	$\rightarrow$	$\pi^0\gamma$	$\rightarrow$	3γ
$f_2(1270)$	$\rightarrow$	$\pi^0\pi^0$	$\rightarrow$	4γ
$a_2(1312)$	$\rightarrow$	$\pi^0\eta$	$\rightarrow$	4γ
$\omega\pi^0$	$\rightarrow$	$\pi^0\gamma\ \gamma\gamma$	$\rightarrow$	5γ

… And Experimentally?

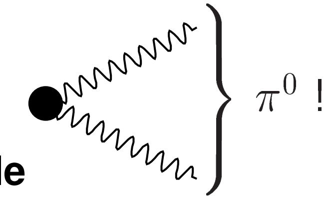
photoproduction ($Q^2 < 0.01$ GeV^2) of the processes

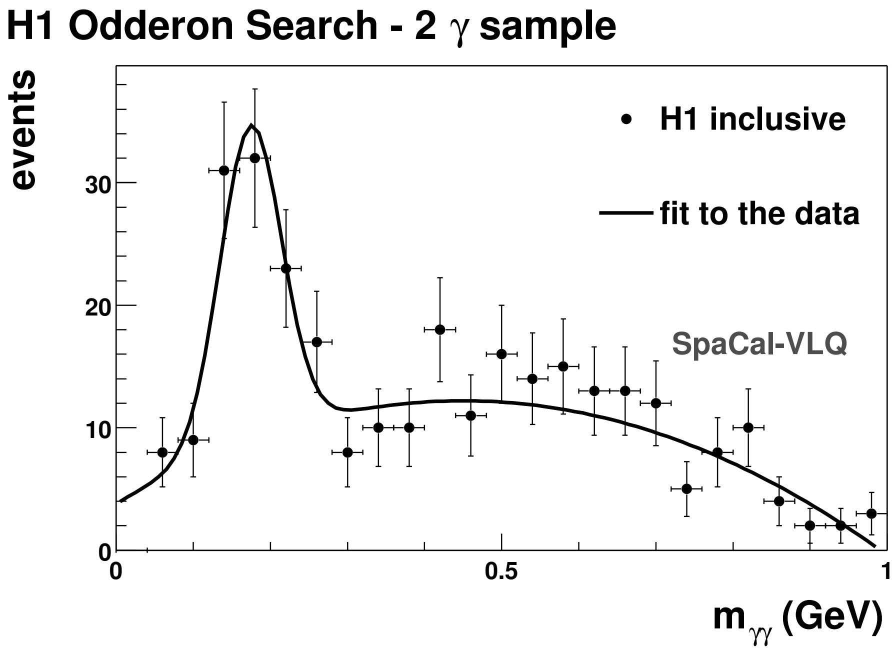
$$ep \rightarrow e'MX$$

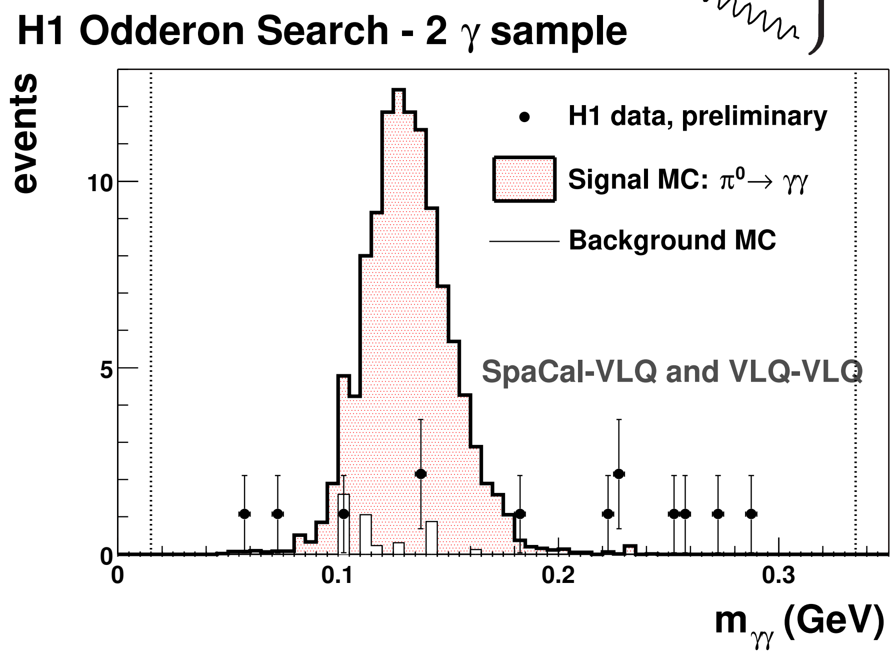
$\hookrightarrow$ photons



There Are Inclusive Pions But No Exclusive Pions







H1 Limit (preliminary) @ 95 % CL

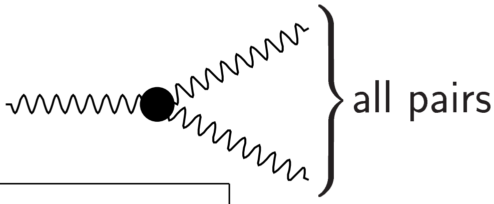
in the visible t-range $0.02 < |t| < 0.3$ GeV^2

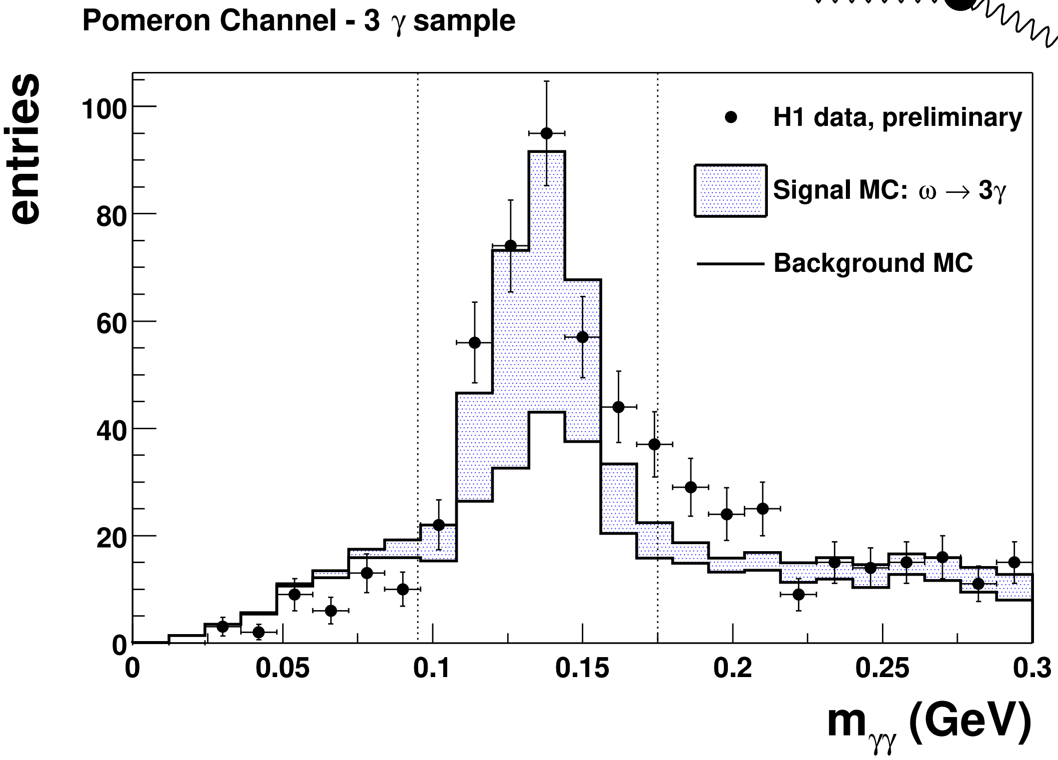
$$\sigma(\gamma p \rightarrow \pi^0 N^*) < 39 \text{ nb}$$

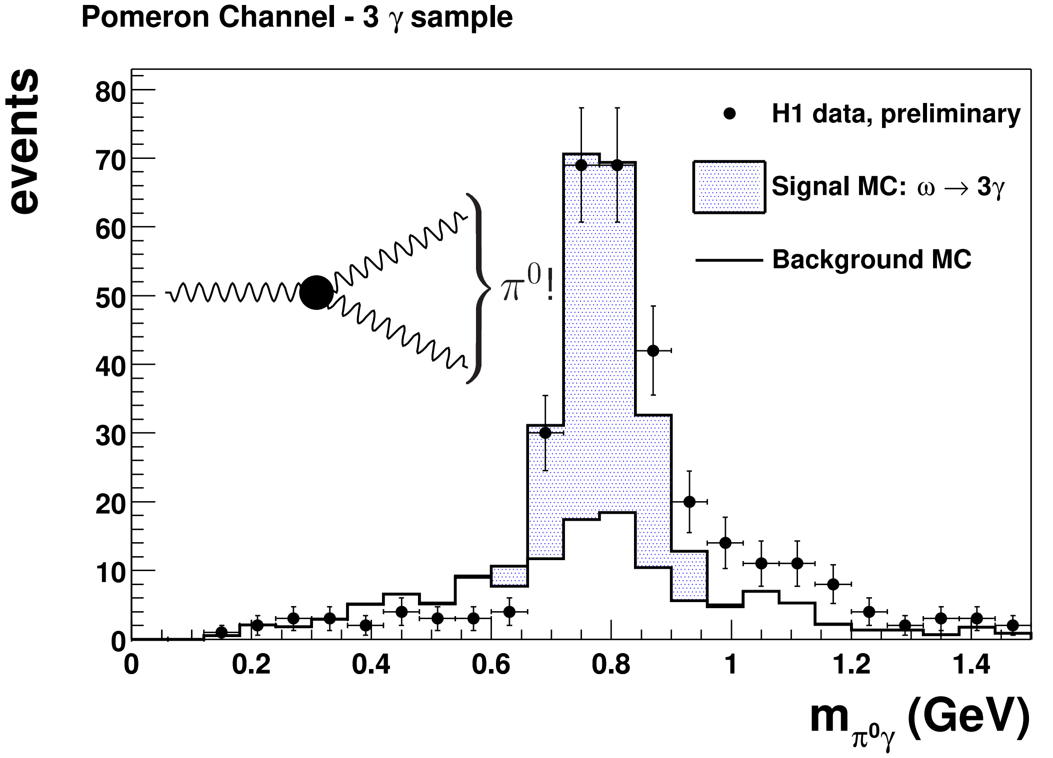
at $\langle W \rangle = 210$ GeV
compared to the SVM prediction of E. R. Berger et al.

200 nb

$3\ \gamma$-Sample — ω





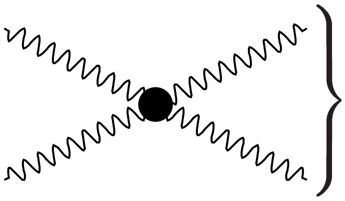


$$\sigma(\gamma p \rightarrow \omega p) = (1.25 \pm 0.18 \pm 0.22)\ \mu\text{b}$$

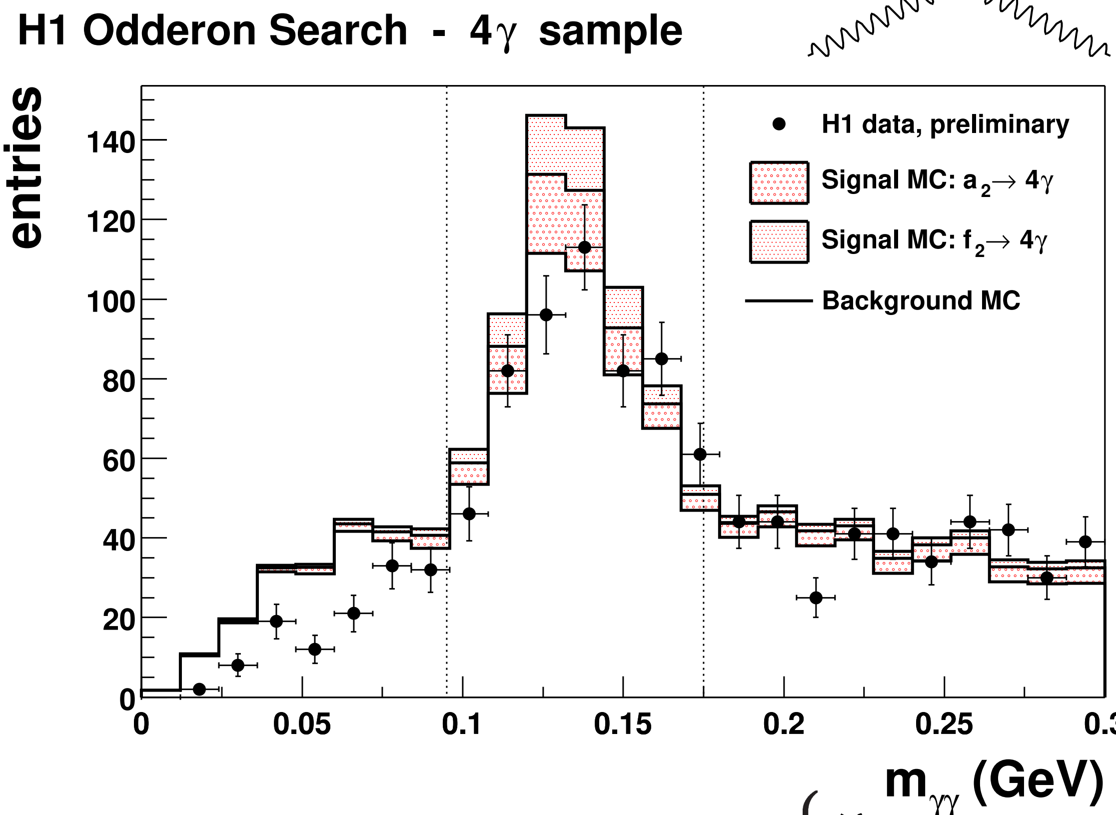
at $\langle W \rangle = 200$ GeV

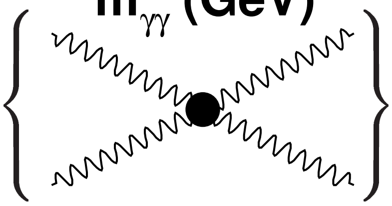
as expected!

4 γ-Sample

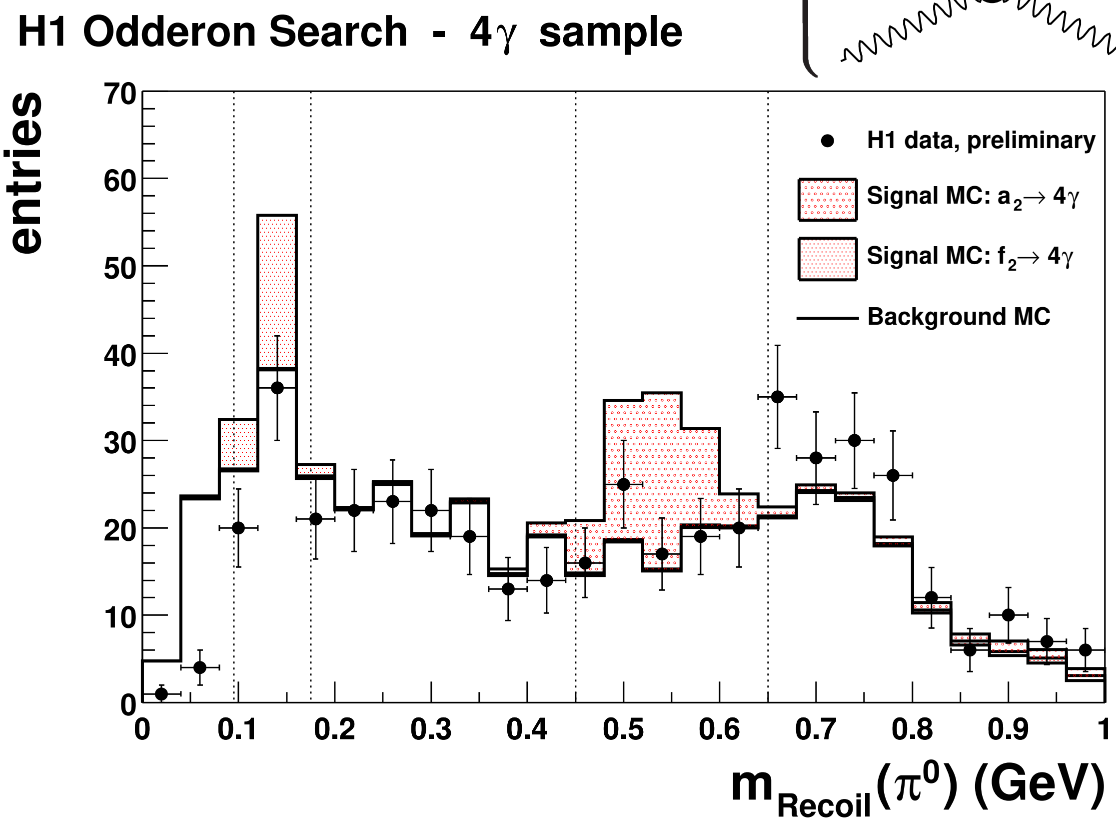


all pairs

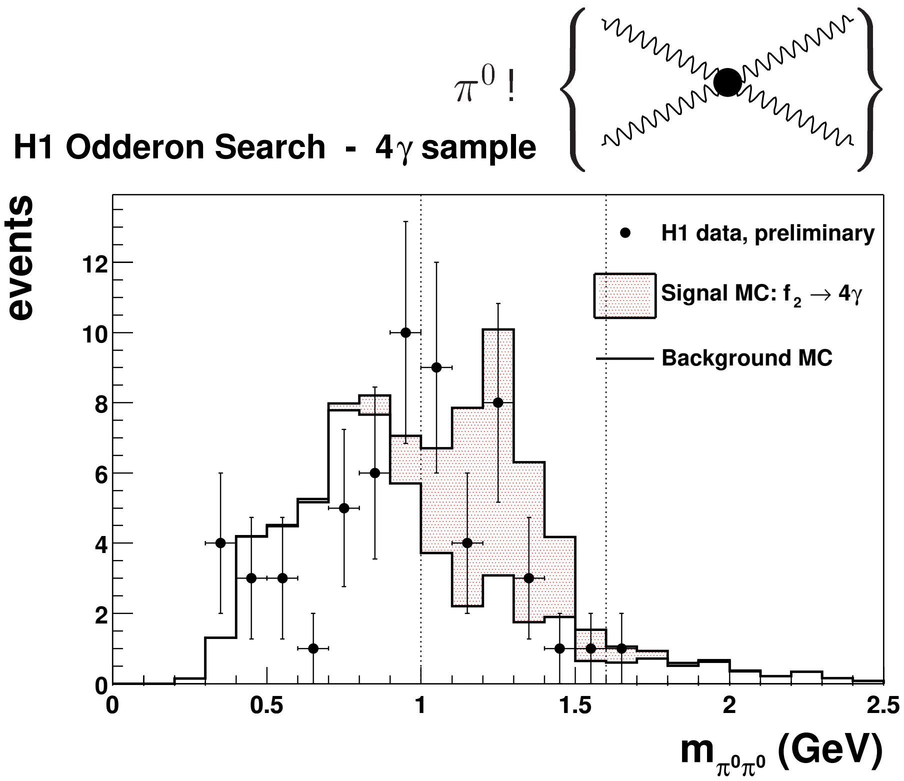




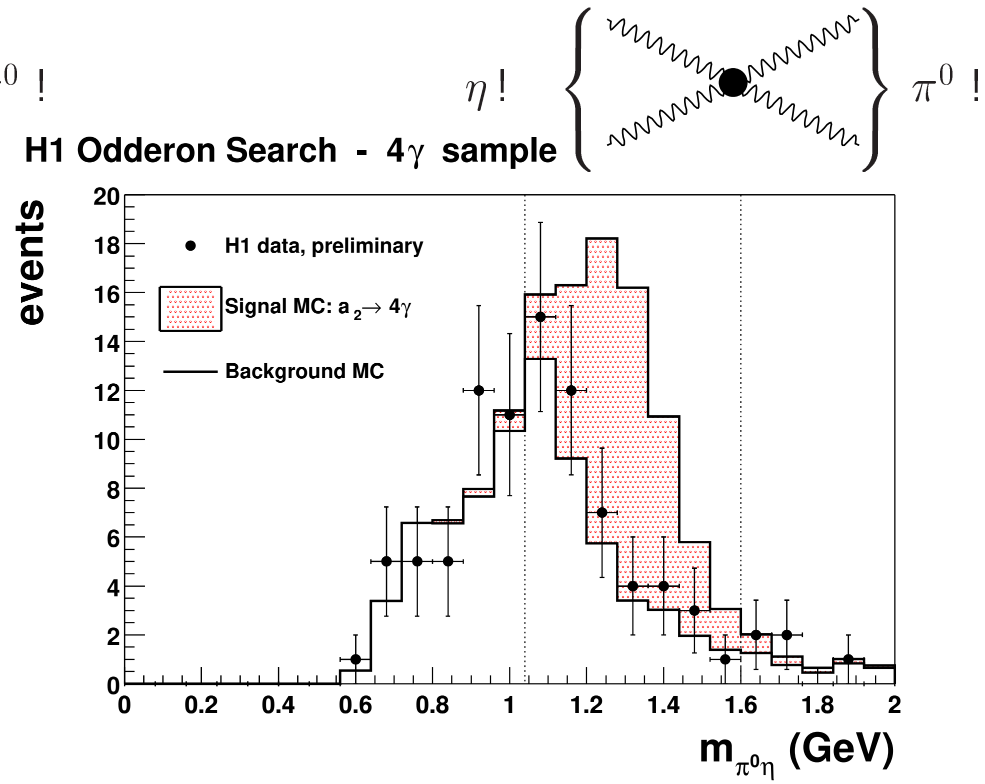
π^0 !



Limit on the f_2



Limit on the a_2



H1 Limit (preliminary) @ 95 % CL

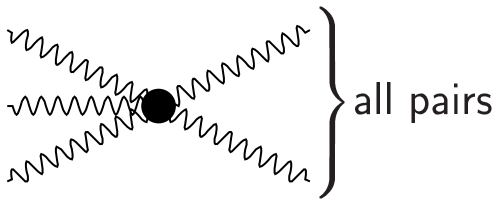
$\sigma(\gamma p \to f_2 X) < 16$ nb $\qquad$ $\sigma(\gamma p \to a_2 X) < 96$ nb

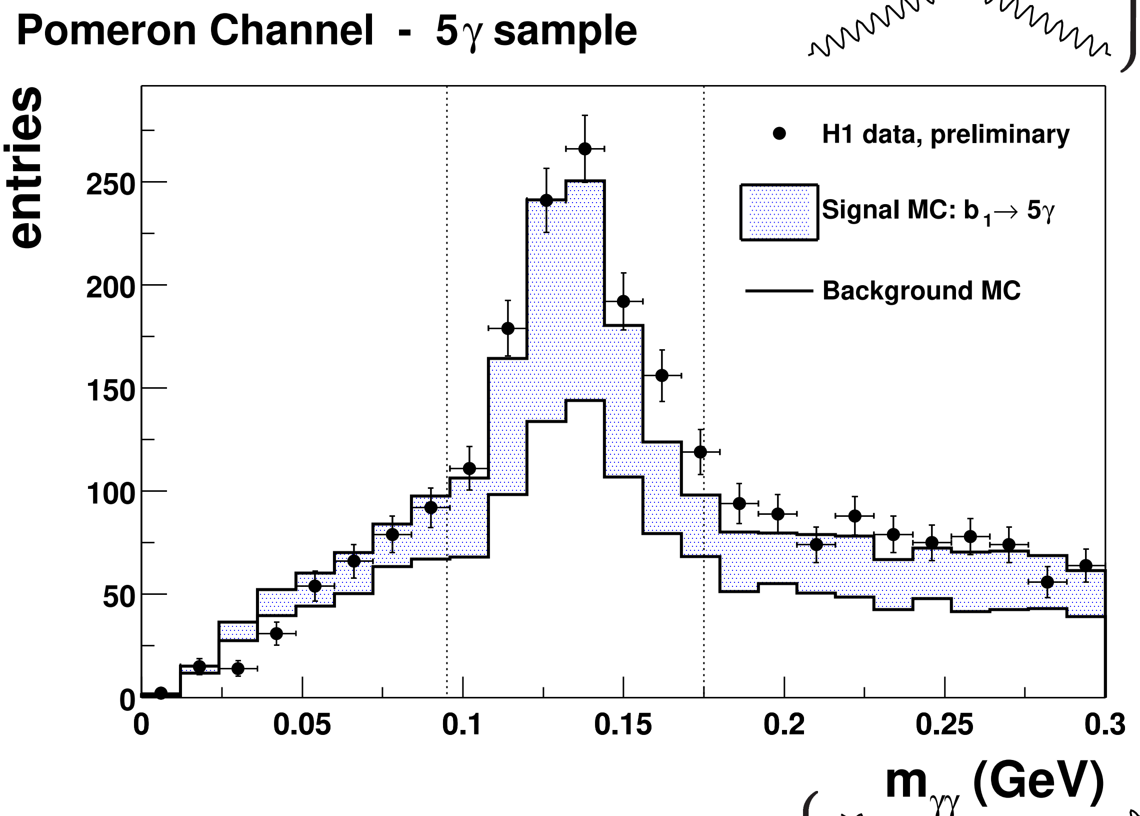
at $\langle W \rangle = 200$ GeV

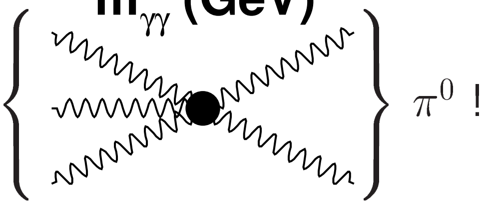
compared to the SVM prediction of E. R. Berger et al.

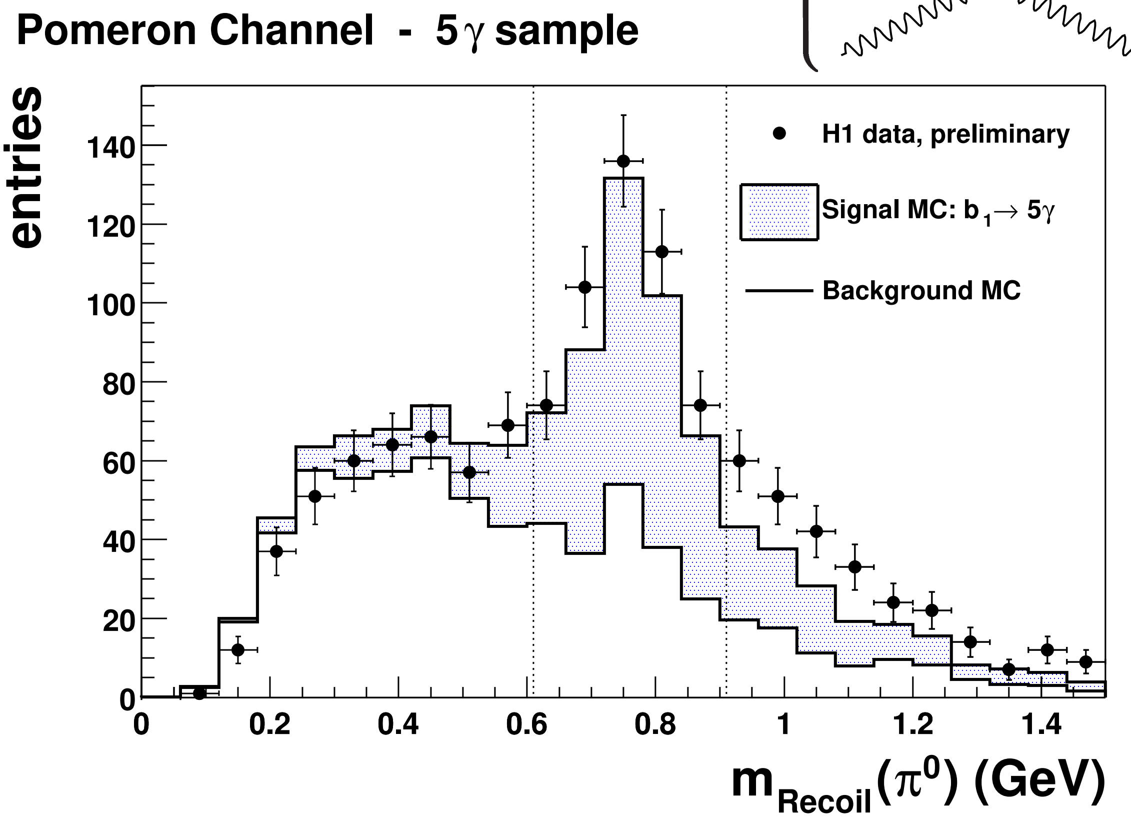
21 nb $\qquad$ 190 nb

5 γ-Sample — $\omega\pi^0$

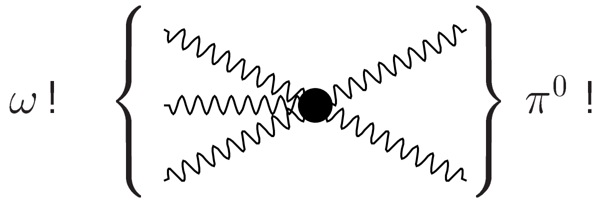


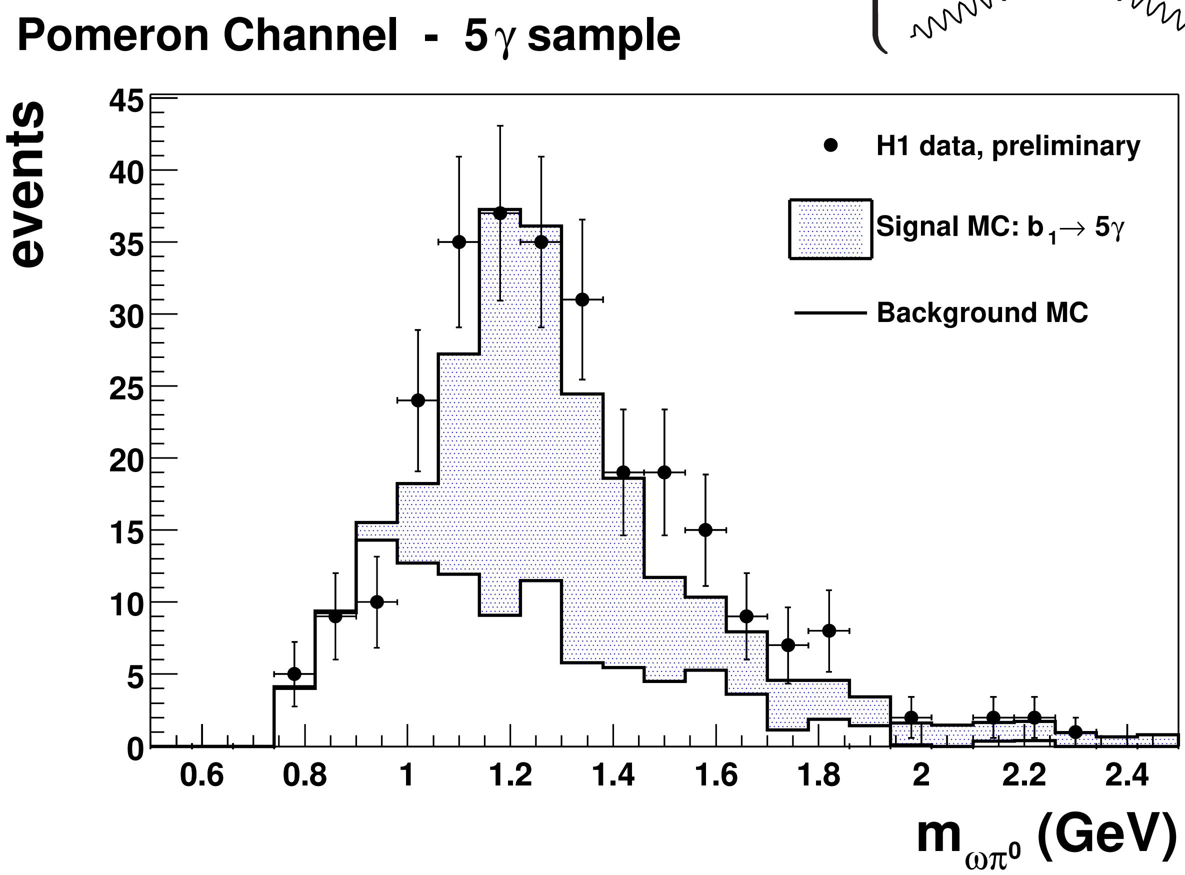






$\omega\pi^0$ — Cross Section





First measurement at HERA!!!

$$\sigma(\gamma p \to \omega\pi^0 X) = (980 \pm 200 \pm 200)\ \text{nb}$$

to be compared with

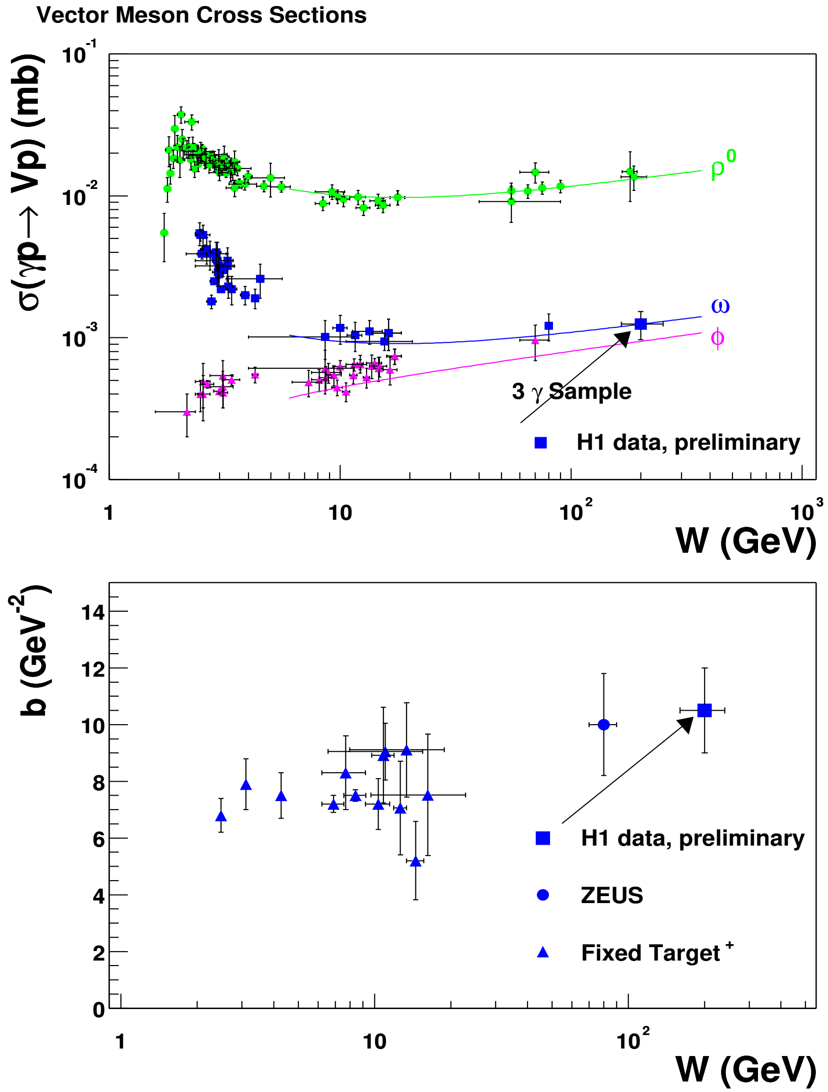
$$\sigma(\gamma p \to \omega\pi^0 (NR) X) = 190\ \text{nb} \quad \text{(from PYTHIA)}$$

$$\sigma(\gamma p \to b_1 X) = 660\ \text{nb} \quad \text{(extrapolated from low } E\text{)}$$

at $\langle W_{\gamma p} \rangle = 200$ GeV

Summary

The Pomeron is there as expected



$\sigma(\gamma p \to \omega\pi^0 X) = (980 \pm 200 \pm 200)$ nb

First search of $\mathbb{O}$-contribution in an $e(\gamma)p$ environment. And

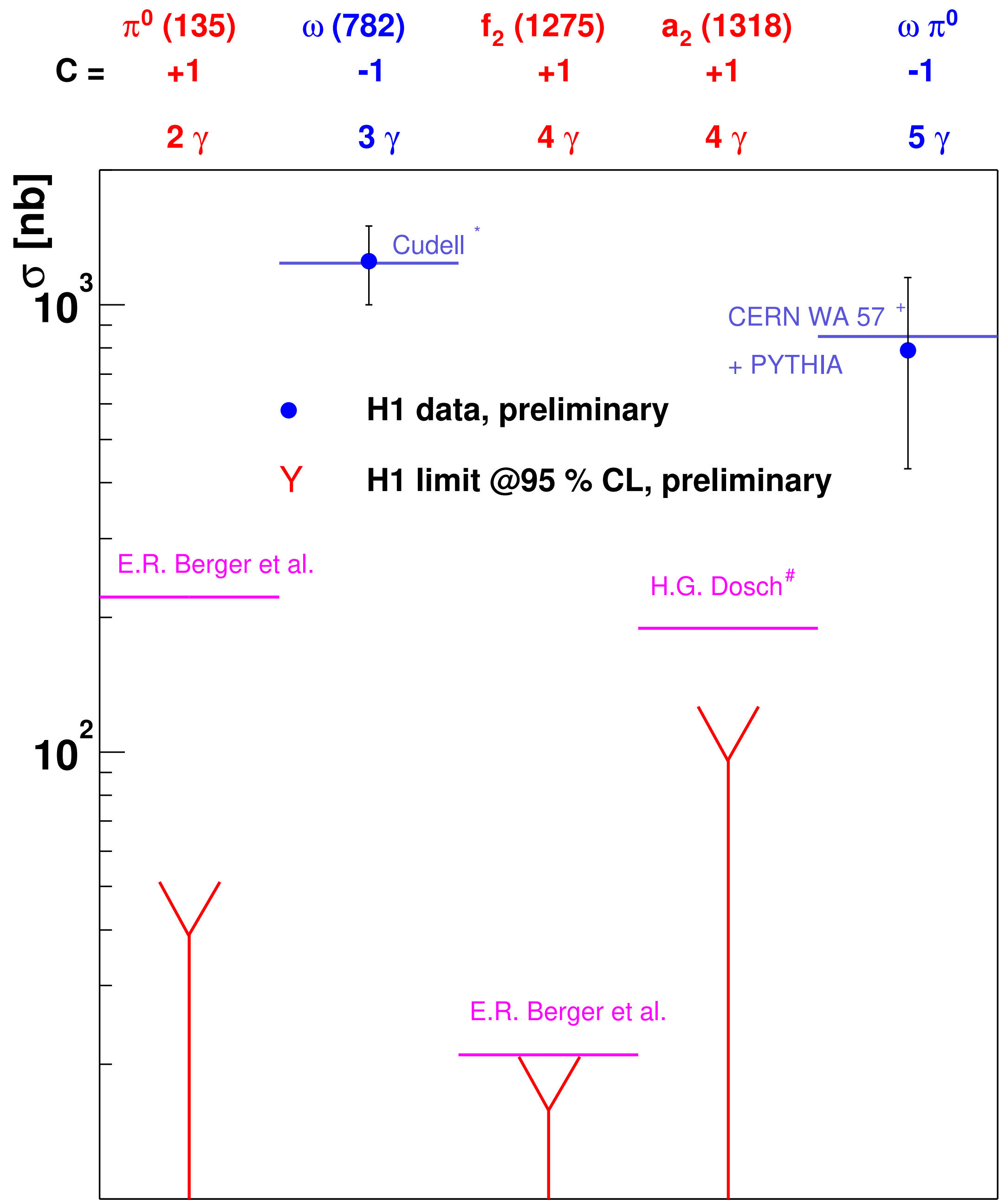
No Odderon-contribution seen!!!

$$\sigma(\gamma p \to MX)$$

	H1 Preliminary	E. R. Berger (SVM)
$\pi^0 N^*$	$<$ 39 nb	200 nb
$a_2 X$	$<$ 96 nb	190 nb
$f_2 X$	$<$ 16 nb	21 nb

N.B.: This is a QCD-test with purely electromagnetic final states

Summary



* Cudell et al.: Phys.Rev. D61 (00), 034019; Schuler, Sjoestrand: Nucl.Phys. B407 (93), 539

\+ CERN WA 57: Nucl.Phys. B243 (84), 1; extrapolated to HERA energies

\# private communication

Outlook

- Increase luminosity to reduce the statistical uncertainties: possible with HERA II