

Photon structure

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Why and how?

- total cross section dominated by low- Q^2 region
- this is where in good old language “photo-production” sits
- photon-proton interactions given by

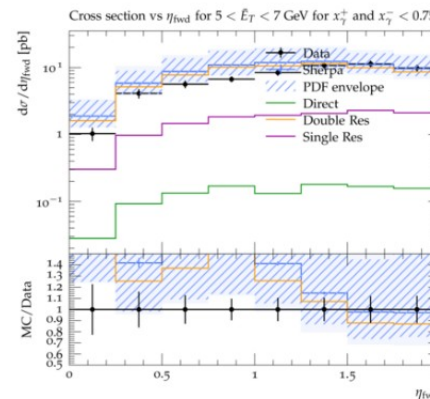
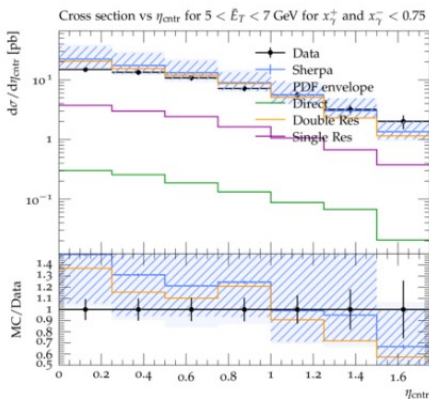
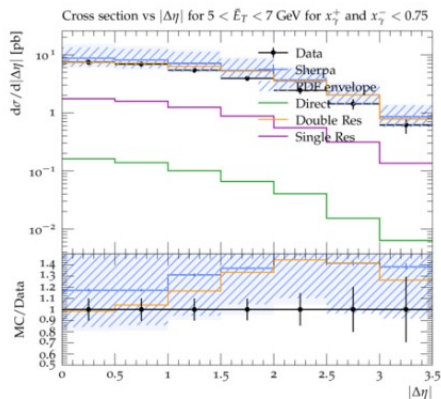
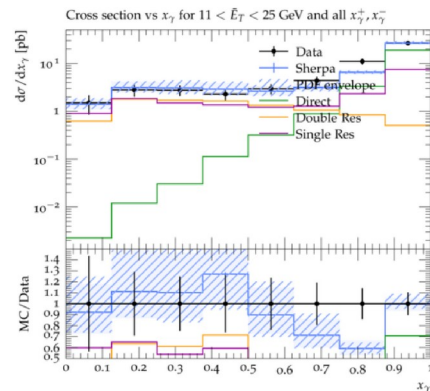
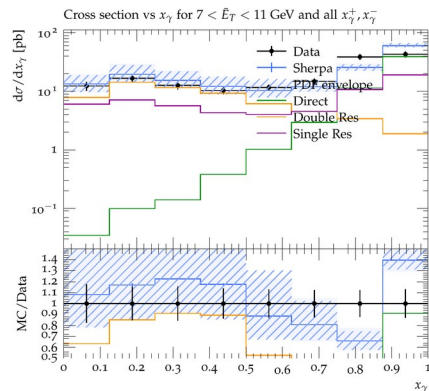
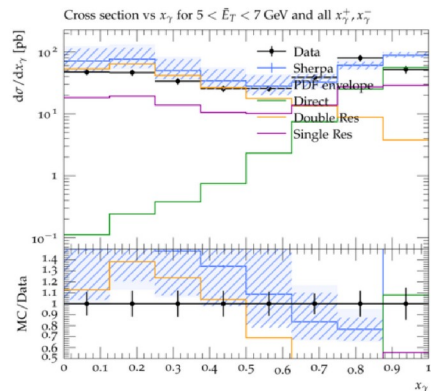
$$\sigma_{\gamma p} = \sigma_{\text{dir}} + \sigma_{\text{VMD}} + \sigma_{\text{anom}}$$

- VMD is sensitive to the PDF's of vector mesons with $m^2 \sim Q^2$
- anom is the qq-driven PDF
- **need to measure and fit!**

Photon structure at lepton colliders

Process	$\sigma(E_{\text{cms}} = 250 \text{ GeV}) / \text{pb}$				$\sigma(E_{\text{cms}} = 500 \text{ GeV}) / \text{pb}$			
$e^+e^- \rightarrow jj$	29.1	± 0.2	± 1.8		7.3	± 0.4	± 0.4	
$\gamma\gamma \rightarrow jj$	68.78	± 0.03			108.89	± 0.05		
$\gamma j \rightarrow jj$	73	± 0	$^{+26}_{-16}$	± 10	(0.16	± 0.00	$^{+0.06}_{-0.04}$	$\pm 0.03) \cdot 10^3$
$jj \rightarrow jj$	(0.2	± 0.0	$^{+0.2}_{-0.1}$	$\pm 0.1) \cdot 10^3$	(0.8	± 0.0	$^{+0.7}_{-0.3}$	$\pm 0.3) \cdot 10^3$
$jj \rightarrow b\bar{b}$	0.029	± 0.000	$^{+0.014}_{-0.008}$	± 0.007	0.12	± 0.00	$^{+0.06}_{-0.04}$	± 0.04
$\gamma j \rightarrow b\bar{b}$	0.29	± 0.00	$^{+0.07}_{-0.05}$	± 0.06	1.0	± 0.0	± 0.2	± 0.2
$jj \rightarrow cc$	0.08	± 0.00	$^{+0.05}_{-0.02}$	± 0.02	0.33	± 0.01	$^{+0.19}_{-0.10}$	± 0.12
$\gamma j \rightarrow cc$	3.1	± 0.1	$^{+0.8}_{-0.6}$	± 0.7	10	± 0	$^{+3}_{-2}$	± 2
$\gamma\gamma \rightarrow e^+e^-$	1.090	± 0.001			2.241	± 0.001		
$\gamma\gamma \rightarrow b\bar{b}$	0.237	± 0.001			0.423	± 0.001		
$\gamma\gamma \rightarrow cc$	7.459	± 0.011			12.721	± 0.017		
$\gamma\gamma \rightarrow \mu^+\mu^-$	1.092	± 0.001			2.243	± 0.003		

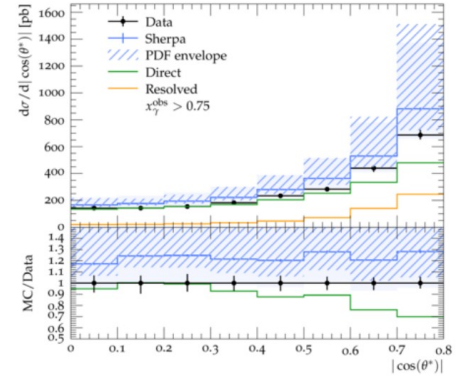
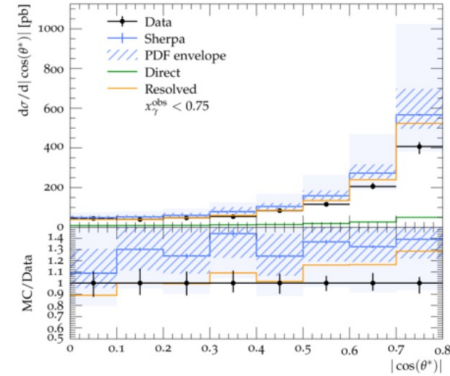
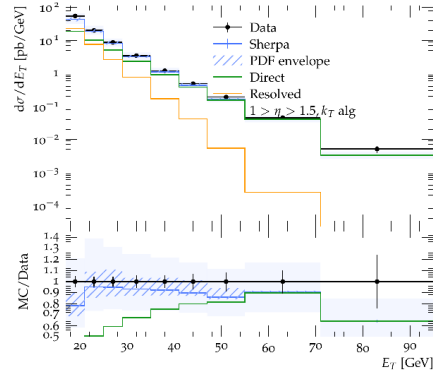
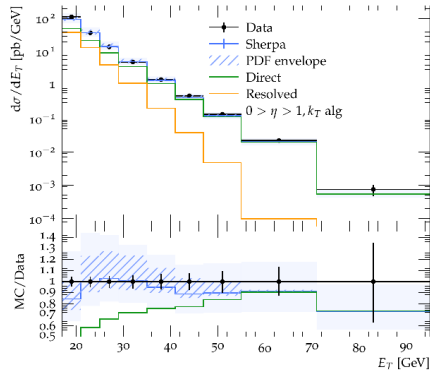
Photon structure at LEP



Photon structure at ep colliders

Process	$\sigma(E_{\text{cms}} = 100 \text{ GeV}) / \text{nb}$			$\sigma(E_{\text{cms}} = 500 \text{ GeV}) / \text{nb}$					
$ep \rightarrow ej$	0.43	± 0.14	$^{+0.01}_{-0.01}$	2.6	± 0.7	$^{+0.1}_{-0.1}$			
$\gamma p \rightarrow jj$	40	± 0	$^{+14}_{-8}$	$(21 \pm 0 \quad ^{+7}_{-6}) \cdot 10$					
$jp \rightarrow jj$	62	± 1	$^{+54}_{-22}$	± 11	$(1.4 \pm 0 \quad ^{+1.2}_{-0.6}) \cdot 10^3$				
$jp \rightarrow b\bar{b}$	(3.0	± 0.0	$^{+1.5}_{-0.8}$	$\pm 0.4)$	$\cdot 10^{-3}$	0.21	± 0.00	$^{+0.10}_{-0.06}$	± 0.04
$\gamma p \rightarrow b\bar{b}$	0.12	± 0.00	$^{+0.04}_{-0.03}$	2.3	± 0.0	$^{+0.5}_{-0.3}$			
$jp \rightarrow cc$	(13	± 0	$^{+7}_{-4}$	$\pm 2)$	$\cdot 10^{-3}$	0.6	± 0	$^{+0.4}_{-0.2}$	± 0.1
$\gamma p \rightarrow cc$	1.7	± 0.0	$^{+0.5}_{-0.3}$	20	± 0	$^{+5}_{-4}$			

Photon structure at HERA



- there are more HERA analyses, but they are not (yet) in Rivet
- can bias towards resolved photons by selecting x_γ^{obs}
- this is an **activity with potential UK leadership**
(HERA legacy data + MC + PDF fitters)