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High energy photo-photon interaction at the LHC

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(on behalf of the Photon Louvain group)

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Outline :

- Equivalent photon approximation (EPA)
- $\gamma\gamma$ luminosities for the LHC
- Detection and tagging
- Cross section of main interest
  - $\gamma\gamma \to \mu^+\mu^-$ LHC luminosity monitoring
  - $\gamma\gamma \to W^+W^-$ SM
  - new physics
- Conclusion

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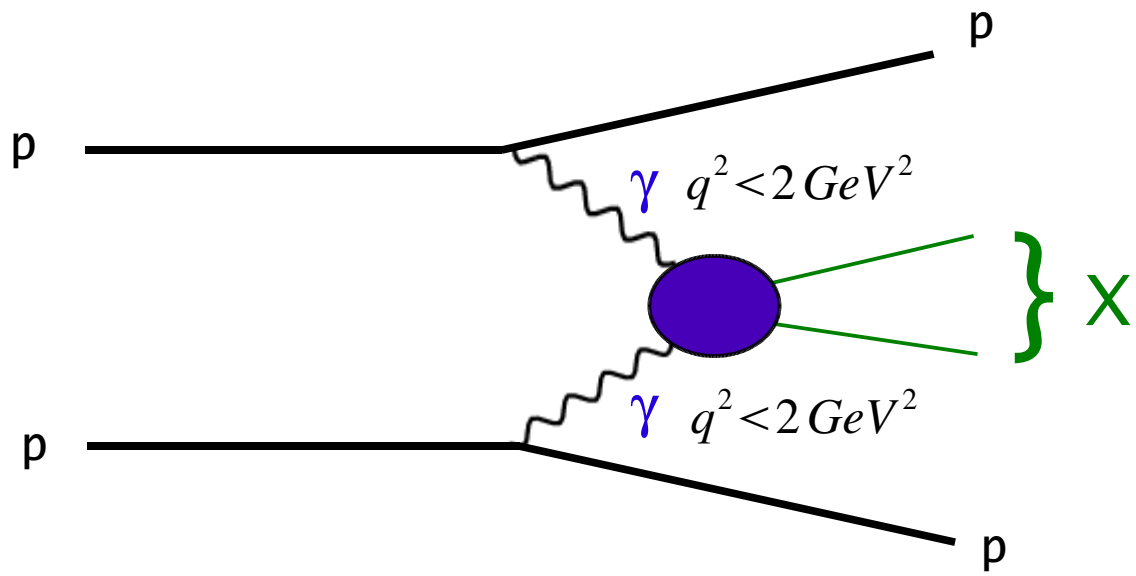
LHC – also a photon-photon collider



$$\sigma(\ pp\to(\gamma\gamma\to X)\,pp\ )$$

low γ virtuality (typical $q^2\sim 0.01\,GeV^2$) $\Rightarrow$

- factorization to
  - long distance photon exchange
  - short distance $\gamma\gamma \to$ X interaction
- zero degree scattered angels

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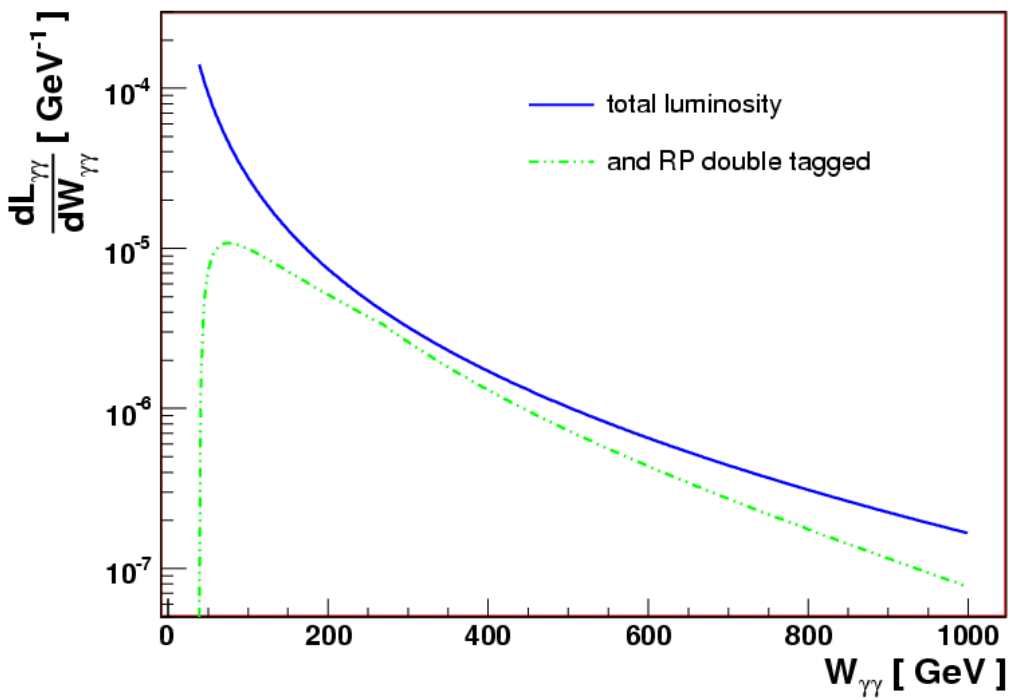
γγ luminosities at the LHC

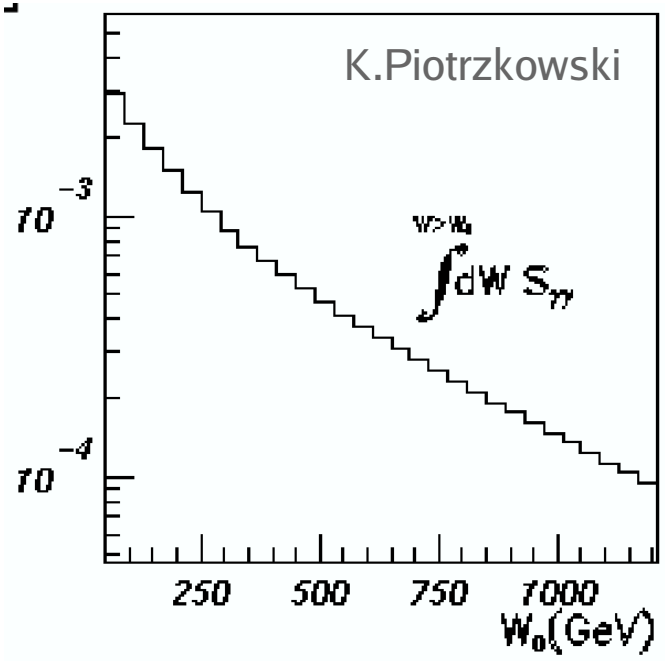
luminosity peaked at low $W_{\gamma\gamma}$

sizable charged pair production up to $W_{\gamma\gamma} \approx 500$GeV

$$\sigma_{pp} = \int \sigma(W_{\gamma\gamma}) \frac{d\,L_{\gamma\gamma}}{dW_{\gamma\gamma}} dW_{\gamma\gamma}$$

$L_{\gamma\gamma}$ / L_{pp} at LHC





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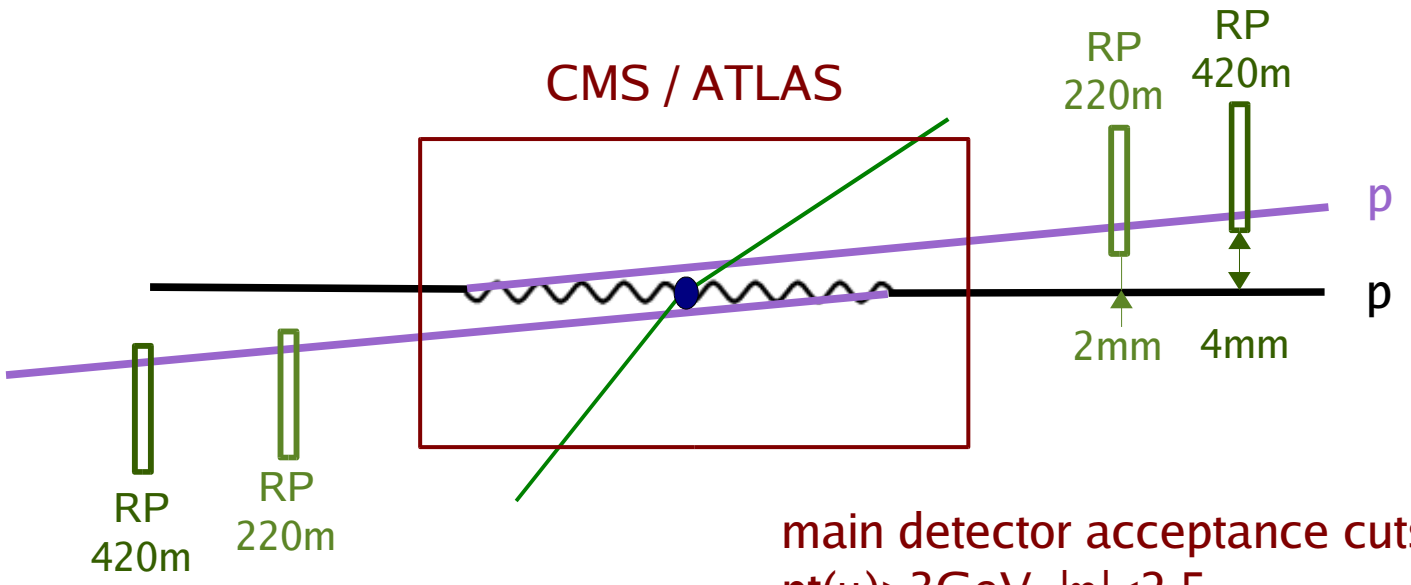
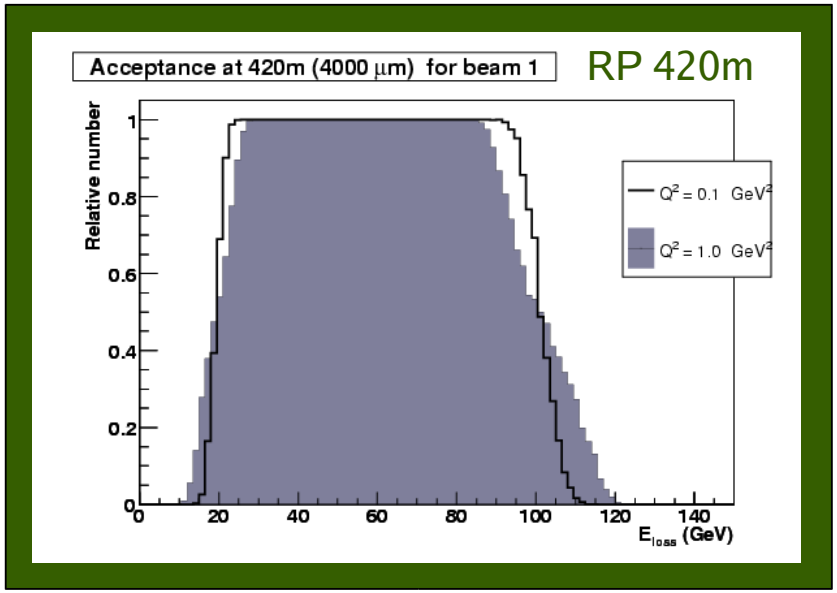


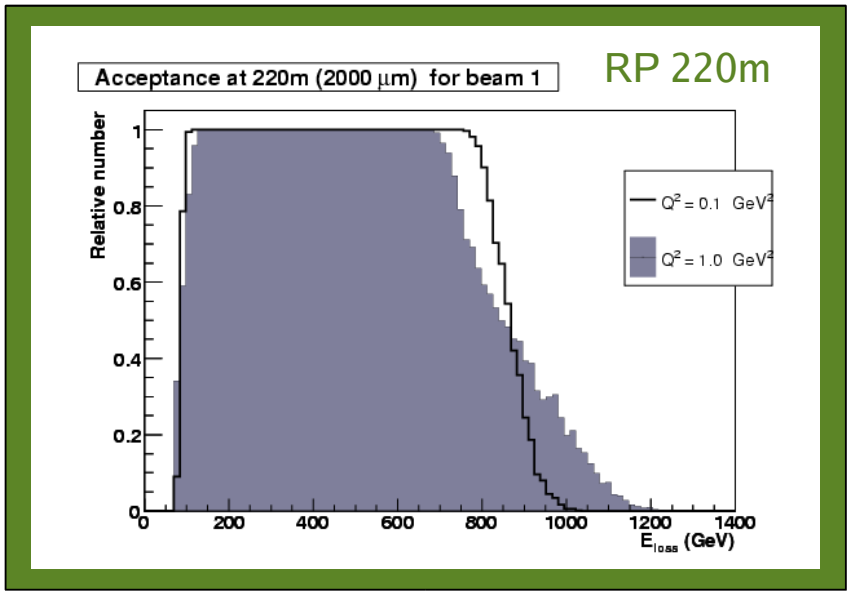
main detector acceptance cuts
pt(μ)>3GeV, |η|<2.5

RP acceptance :

20GeV < tagged photon E < 120GeV



120GeV < tagged photon E < 900GeV



Hector : J. de Favereau, X. Rouby and K. Piotrzkowski

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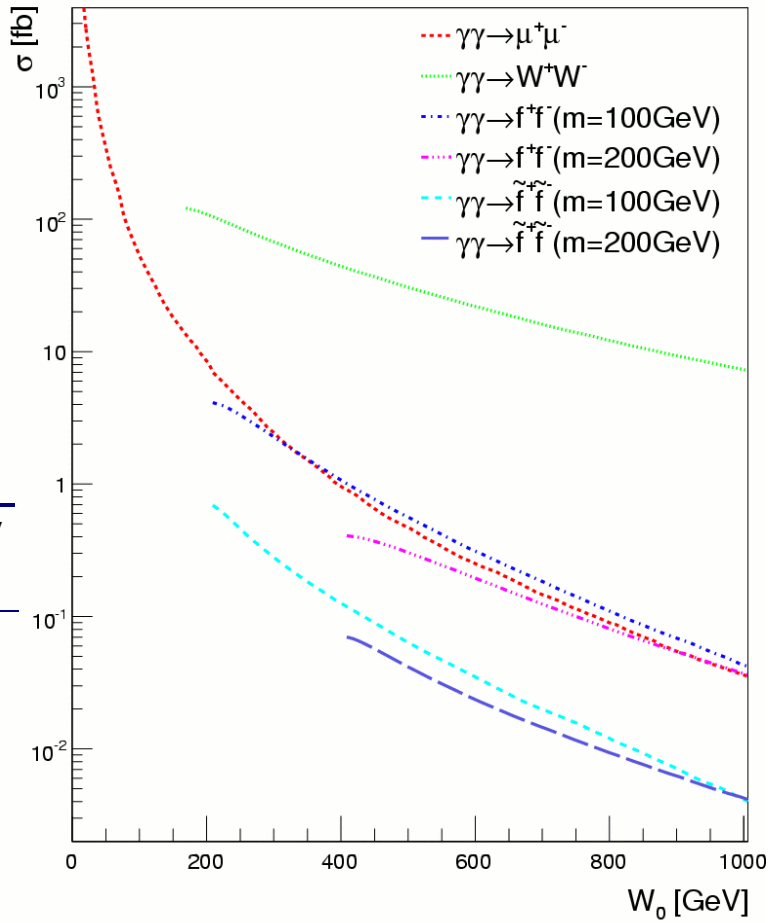
- $\gamma\gamma \to \mu\mu$ first γγ process to be seen
- $\gamma\gamma \to W^+W^-$ very interesting SM process 103fb
- New physics !

Processes	[fb]	Generator
$\gamma\gamma \to \mu\mu$	72 500	LPAIR pt > 2 GeV $\lvert\eta\rvert$ < 3.1
W^+W^-	103	
f^+f^- (m=100GeV)	4.1	MadGraph
f^+f^- (m=200GeV)	0.41	/
$\tilde{f}^+\tilde{f}^-$ (m=100GeV)	0.69	MadEvent
$\tilde{f}^+\tilde{f}^-$ (m=200GeV)	0.07	



Cross sections for γγ processes as a function of the minimal γγ cms energy W_0

moreover :
lepton final states
clear signature – background suppression

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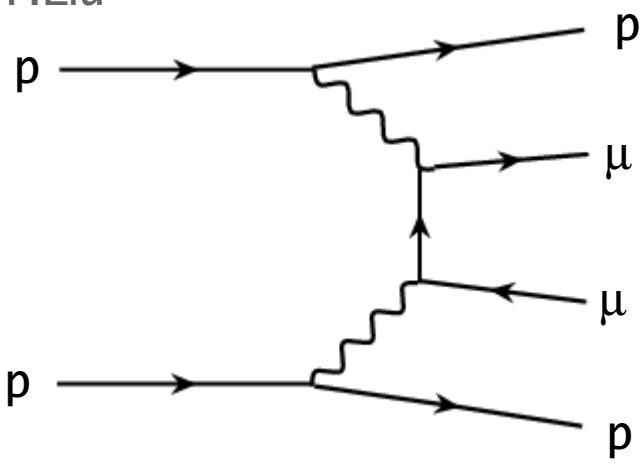
γγ → μμ X.Rouby, Y.Liu



	$\|\eta\| < 2.5$	
	pt(μ)>3 GeV	pt(μ)>10 GeV
σ_{acc}	21600 fb	1340 fb
σ_{acc} (with RP)	7260 fb	1270 fb

γγ → μμ will be used for:

- pp luminosity monitoring ~ 800events/12h (for L= $10^{33} cm^{-2} s^{-1}$)
- calibration of RP – to set photon energy scale
  and RP acceptance
  including misalignment of beam optic

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γγ → WW probing anomalous couplings γγWW

$$L_6^0 = \frac{-e^2}{8}\frac{a_0^W}{\Lambda^2} F_{\mu\nu}F^{\mu\nu}W^{+\alpha}W^-_{\alpha}$$

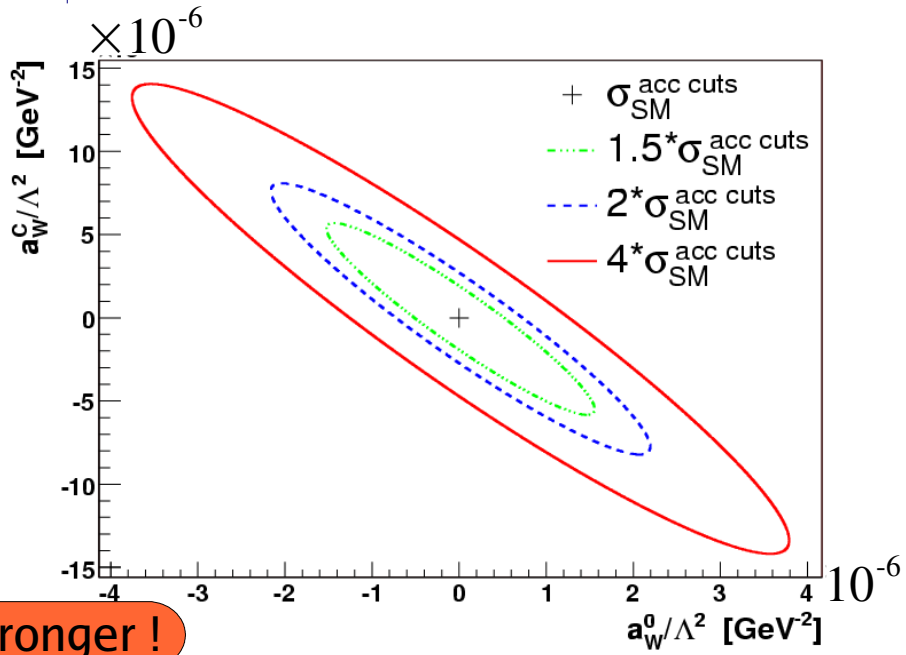
Commonly used Lagrangian
for anomalous quartic vector boson couplings
which conserves C, P as well as local $U(1)_{em}$

$$L_6^C = \frac{-e^2}{16}\frac{a_C^W}{\Lambda^2} F_{\mu\alpha}F^{\mu\beta}(W^{+\alpha}W^-_{\beta} + W^{-\alpha}W^+_{\beta})$$

investigating $\gamma\gamma \to W^+W^- \to \mu^+\mu^-\bar{\nu}_\mu\nu_\mu$ effective cross sections (σ_{acc}) are:

SM here background	pt(μ)>3 GeV	pt(μ)>10 GeV
σ_{acc}	0.76 fb	0.72 fb
σ_{acc} (with RP)	0.66 fb	0.62 fb

no other background than SM γγ→WW
for 30 fb^{-1} expected 22.8 (18.6) events



while current OPAL limits are:

$$-0.020\ \text{GeV} < a_0^W < 0.020\ \text{GeV}$$

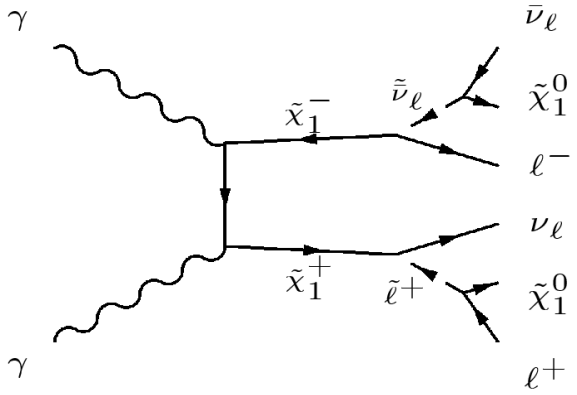
$$-0.052\ \text{GeV} < a_C^W < 0.037\ \text{GeV}$$

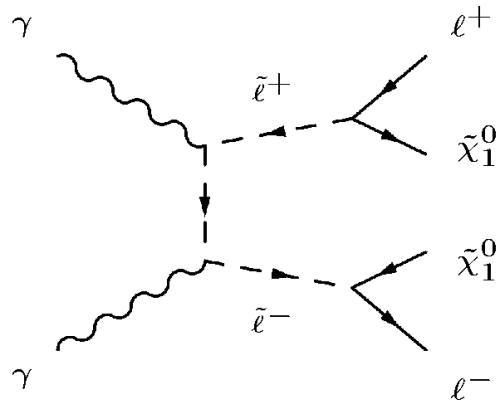
we expect limits to be ~ 10 000 times stronger !

SUSY pairs

N. Schul

massive SUSY pairs have very clean signature
- pair of charged leptons and large missing E_t -





three benchmark points in mSugra parameter space constrained by the post – WMAP research were checked:

- **LM1** – very light LSP, light sleptons and light chargino, tg(β)=10
- **LM2** – medium LSP, heavy sleptons and chargino, tg(β)=30
- **LM6** – heaviest LSP, light right sleptons, heavy left slepton and heavy chargino, tg(β)=10

m [GeV]	LM1	LM2	LM6
$\tilde{\chi}_1^0$	97	141	162
$\tilde{l}_R^+$	118	229	175
$\tilde{l}_L^+$	184	301	283
$\tilde{\tau}_1^+$	109	155	168
$\tilde{\tau}_2^+$	188	313	285
$\tilde{\chi}_1^+$	180	265	303
H^+	386	448	592

SUSY pairs N. Schul

$\gamma\gamma \rightarrow$ SUSY pairs with CalcHEP; decays with Pythia

acceptance cuts pt^{lep} > 3GeV (10GeV), $|\eta|<2.5$

here $\gamma\gamma \rightarrow$ WW as a irreducible background

Benchmark		LM1	LM2	LM6
σ [fb]	$\tilde{l}_R^+ \tilde{l}_R^-$	0.805	0.087	0.220
	$\tilde{l}_R^+ \tilde{l}_R^-$	0.185	0.032	0.040
	$\tilde{\tau}_i^+ \tilde{\tau}_i^-$	0.611	0.180	0.148
	$\tilde{\chi}_1^+ \tilde{\chi}_1^- H^+ H^-$	0.605	0.144	0.087
		0.006	0.003	0.001
	$W^+ W^-$		103	
σ acc	$\tilde{l}_R^+ \tilde{l}_R^-$	0.633(0.479)	0.075(0.074)	0.177(0.087)
	$\tilde{l}_R^+ \tilde{l}_R^-$	0.144(0.135)	0.014(0.012)	0.036(0.035)
	$\tilde{\tau}_i^+ \tilde{\tau}_i^-$	0.023(0.006)	0.008(0.001)	0.003(0.001)
	$\tilde{\chi}_1^+ \tilde{\chi}_1^-$	0.103(0.029)	0.006(0.001)	0.033(0.028)
	$W^+ W^-$		4.057(3.512)	

Possible to observe with high luminosity run – RP needed !

Conclusions

- LHC – a photon-photon collider
- $\gamma\gamma \to \mu\mu$
  - LHC luminosity monitoring
  - RP calibration
- limits for anomalous $\gamma\gamma WW$ could be 10 000 better
- possibility to observe SUSY charged pairs for high luminosity runs

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