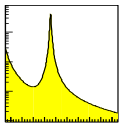

Sensitivity to Contact Interactions and Extra Dimensions in Di-lepton and Di-photon Channels at Future Colliders

Study of Parton Density Function Uncertainties with LHAPDF and PYTHIA at LHC

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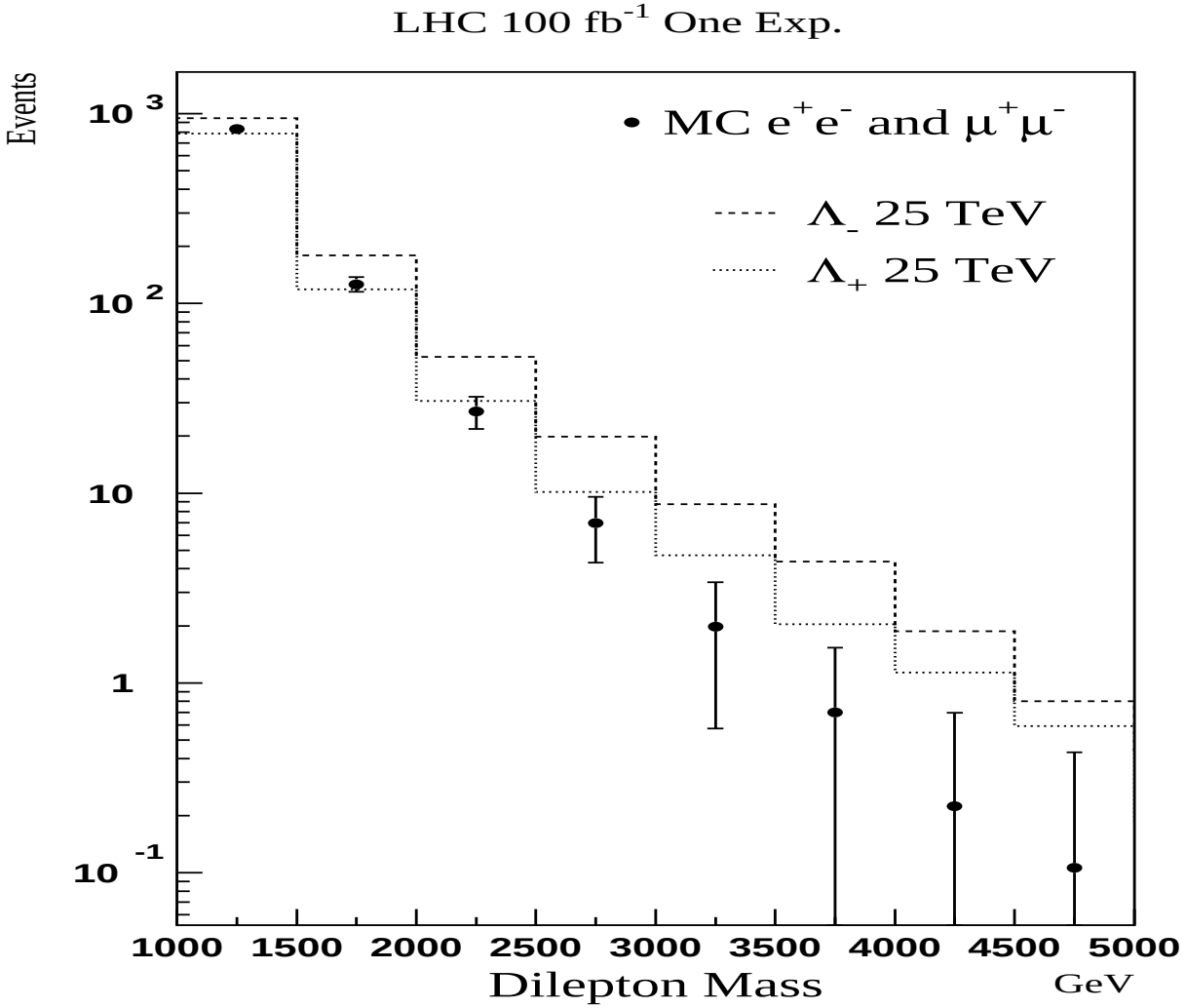
http://cern.ch/bourilkov/lhc-lc-ff3.ps.gz

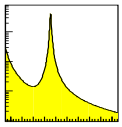
general framework for a new interaction with coupling g and typical energy scale $\Lambda \gg \sqrt{s}$

Model	LL	RR	LR	RL	VV	AA	LL+RR	LR+RL
	Non-parity conserving				Parity conserving			
η_{LL}	±1	0	0	0	±1	±1	±1	0
η_{RR}	0	±1	0	0	±1	±1	±1	0
η_{LR}	0	0	±1	0	±1	∓1	0	±1
η_{RL}	0	0	0	±1	±1	∓1	0	±1

Drell-Yan pairs at high mass > 0.5 TeV
200 PYTHIA simulations (100k events each)
LHC: for both leptons $|\eta| < 2.5$, $p_T > 20$ GeV

$pp \to e^+e^-X,\ \mu^+\mu^-X$ One Experiment Contact Interactions LL Model				
	6 % syst. err.		3 % syst. err.	
Luminosity $[fb^{-1}]$	Λ^- [TeV]	Λ^+ [TeV]	Λ^- [TeV]	Λ^+ [TeV]
1	22.1	19.0	22.1	19.0
10	31.8	24.3	31.7	24.2
100	56.9	32.0	51.7	31.0





Fast semi-analytic program: improved Born approximation, effective couplings, QED effects in the initial and final states

cut on the "effective" energy: $\sqrt{s'}/\sqrt{s} > 0.85$

Two cases are distinguished:

1. "Realistic"
   xsec error: stat. error and syst. error 0.5 % experiment, 0.2 % luminosity, theor. uncertainty 0.5 %
   A_{FB} error: stat. error and syst. uncertainty of 0.002 (absolute) e^+e^- and 0.001 $\mu^+\mu^-$
2. Optimistic
   xsec error: stat. error and 0.2 % luminosity
   A_{FB} error: stat. error and syst. uncertainty - the *minimum* of the syst. uncertainty for the "Realistic" case and the stat. error; in practice only important for e^+e^-

$e^+e^- \to e^+e^-$ Contact Interactions				
	"Realistic"		Optimistic	
Model	Λ^- [TeV]	Λ^+ [TeV]	Λ^- [TeV]	Λ^+ [TeV]
LL	23.2	23.3	43.5	44.9
RR	22.5	22.5	42.1	43.4
VV	43.9	45.2	83.3	89.1
AA	32.5	35.0	71.9	77.1
LR	25.2	24.4	50.7	52.4
RL	25.2	24.4	50.7	52.4
LL+RR	32.0	32.6	59.9	63.0
LR+RL	35.0	35.2	71.0	75.0

VV Model		
	"Realistic"	Optimistic
Luminosity $[fb^{-1}]$	Λ^+ [TeV]	Λ^+ [TeV]
1	27.3	28.4
10	39.8	49.9
100	44.4	74.8
1000	45.2	89.1

fermion- or boson-pairs in e^+e^- or pp collisions - virtual effects due to graviton exchange: modifies in a unique way the differential cross sections

effective scale (cut-off): M_s Hewett; $\Lambda_T = 1.1195\ M_s$ Giudice

$e^+e^- \rightarrow e^+e^-$ Hewett Scale		
	"Realistic"	Optimistic
Luminosity $[fb^{-1}]$	M_s [TeV]	M_s [TeV]
1	2.6	2.6
10	3.1	3.5
100	3.3	4.2
1000	3.3	4.6

$e^+e^- \rightarrow \mu^+\mu^-$ Hewett Scale		
	"Realistic"	Optimistic
Luminosity $[fb^{-1}]$	M_s [TeV]	M_s [TeV]
1	1.6	1.6
10	2.1	2.1
100	2.8	2.8
1000	3.5	3.5

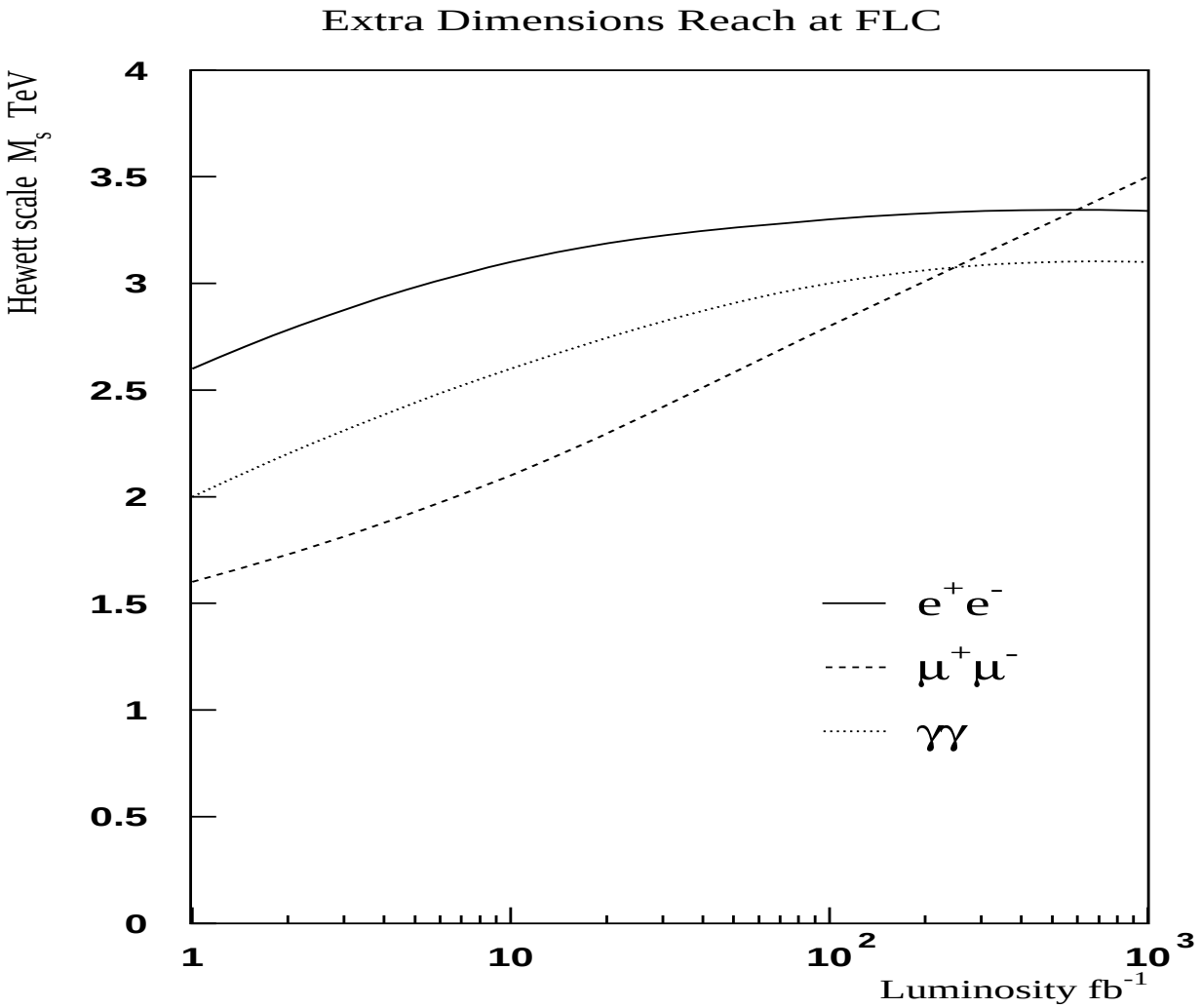
Deviations from QED typically have the form:

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{QED} \cdot \left(1 \pm \frac{1}{(\Lambda_{\pm}^{\mathrm{QED}})^4} \cdot \frac{s^2}{2} \sin^2\theta\right)$$

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{QED} \cdot \left(1 \pm \frac{\lambda}{\pi\alpha(M_s)^4} \cdot \frac{s^2}{2} \sin^2\theta + ...\right)$$

$e^+e^- \rightarrow \gamma\gamma$ Hewett Scale		
	"Realistic"	Optimistic
Luminosity $[fb^{-1}]$	M_s [TeV]	M_s [TeV]
1	2.0	2.0
10	2.6	2.6
100	3.0	3.4
1000	3.1	4.1
Λ^{QED} 1000	1.2	1.6

$e^+e^- \to e^+e^-,\ \mu^+\mu^-,\ \gamma\gamma$ Hewett Scale		
	"Realistic"	Optimistic
Luminosity $[fb^{-1}]$	M_s [TeV]	M_s [TeV]
1	2.6	2.6
10	3.2	3.5
100	3.5	4.3
1000	3.8	4.8



$$\frac{\Delta(A_{FB})}{\Delta(\sin^2\theta^{\rm lept}_{\rm eff}(M_Z^2))} = k$$

if we know the quark direction k $\sim$ 5

LHC and rapidity < 2.4 - much reduced sensitivity

Samples of 110 000 000 events (after cuts) for different values of $\sin^2\theta^{\rm lept}_{\rm eff}(M_Z^2)$

Rapidity	0.0 - 0.8	0.8 - 1.6	1.6 - 2.4
k	-0.021	-0.38	-0.59
$\Delta(A_{FB})$	0.00001	0.00019	0.000295
PDF uncertainty	< 0.00048	< 0.00053	< 0.000820
Events needed	10000 M	27.7 M	11.5 M
Events in one ch/exp 100 fb^{-1}	30.7 M	25.0 M	10.5 M

two indep. measurements: 0.8–1.6 and 1.6–2.4

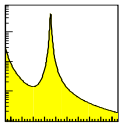
27.7(11.5) x 10^6 events in the two intervals needed

available from one channel/exp for $\sim$ 110 fb^{-1}

big run with CTEQ6 - 40 x 15 x 10^6 events

even with this statistics we can only set upper limit

it is possible that the PDF uncertainty is not a show-stopper, runs with huge samples are needed



- systematic study of the search reach of LHC / LC as a function of luminosity
- the high energy/luminosity of LHC offers a rich search field in the DY channel (contact interactions ...)
- LC: search reach for extra dimensions, compositeness in e^+e^- , $\mu^+\mu^-$, $\gamma\gamma$
- PYTHIA 6.2 interfaced to LHAPDF
- large scale calculations for Drell-Yan, Higgs production; the effects of PDF uncertainties on SM predictions for the investigated channels are small (below 4 %)
- $\sin^2\theta^{lept}_{eff}(M_Z^2)$ - is a competitive "hadron" measurement possible? (TEVATRON ?)
  PDF uncertainty is quite small - need huge data set to estimate it