MULTI PHOTON SIGNALS AT LHC

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Work done in collaboration with Ayres Freitas, Daniel Wyler

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WHY PHOTONS?

- Low standard model backgrounds
- Clean collider signature
- May be signals of extended Higgs sectors or of new strong dynamics

SOURCES FOR MULTI PHOTON SIGNALS

- Light fermiophobic Higgs bosons — *Akeroyd et. al. 2004, 2006*
- New scalars in Little Higgs models — *Freitas, PS, Wyler 2009*
- Composite scalars (Pions) in strongly coupled BSM scenarios — *Kilic & Okui 2010, Bai & Martin 2010*
- Gravitons in RS/ADD models

VECTORLIKE CONFINEMENT

Kilic, Okui, Sundrum 2009

- Fermions ψ with vectorlike $\mathrm{SU}(2)_w$ couplings

- Confined by new $\mathrm{SU(N)_{hc}}$

  → Composite "hyperpions"

- Triplets π_T with $300 - 600\ \mathrm{GeV}$ masses

- Pair produced, decay to SM gauge bosons

- Also appear in other models, e.g. Bai & Martin 2010

LITTLE HIGGS WITH X-PARITY

Freitas, PS, Wyler 2009

- Four copies of QCD like nonlinear sigma model

- Fields decompose as:

Arkani-Hamed et. al. 2002

$$\begin{pmatrix} \phi_i + \frac{\eta_i}{2} & h_i \\ h_i^\dagger & -\eta_i \end{pmatrix}$$

triplet

complex doublet

singlet

- Effective two Higgs doublet model with little Higgs protection, stable dark matter

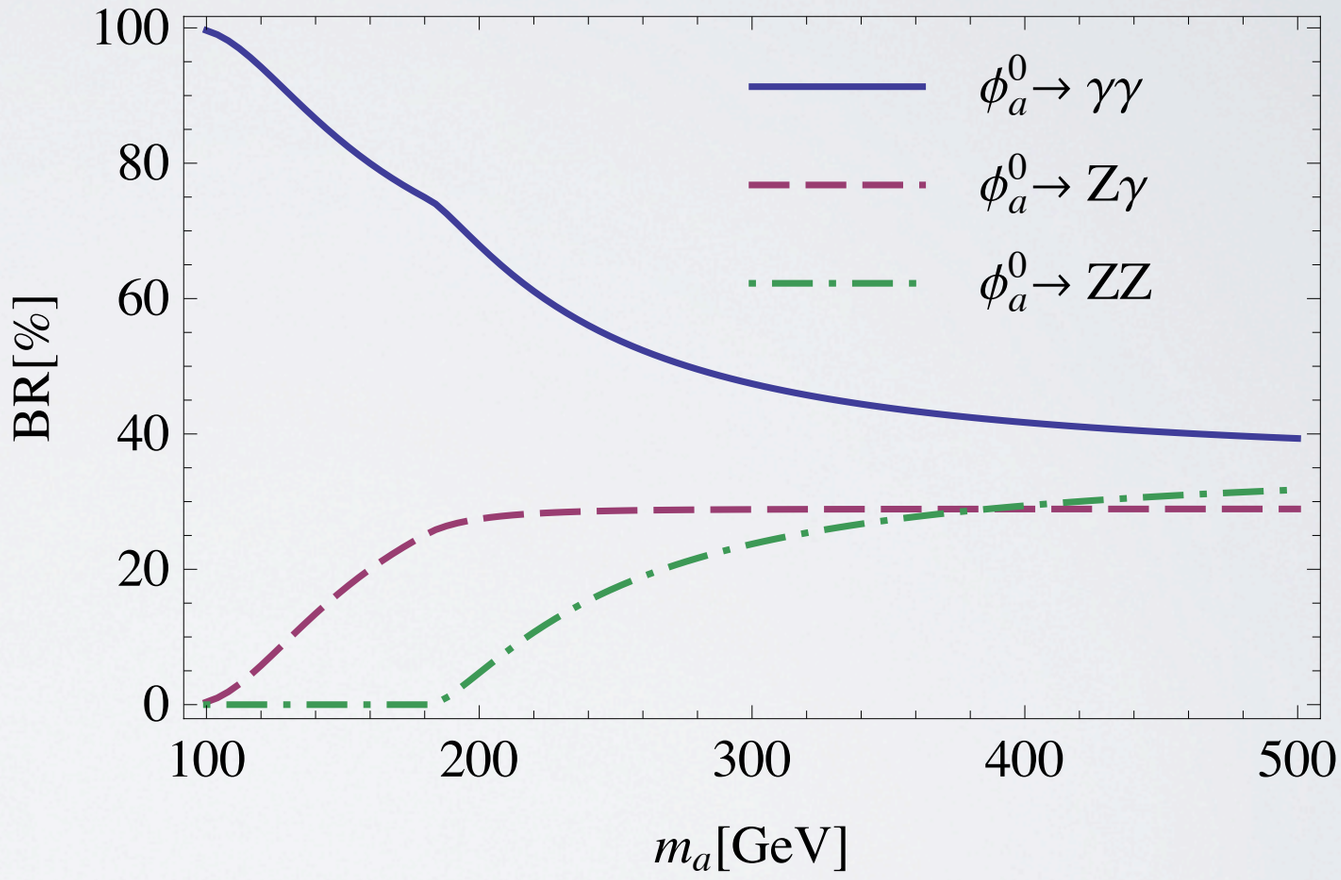
- Triplet $\phi_a = \phi_1 + \phi_2$ with $\mathcal{O}(v)$ mass, decay into SM gauge bosons

NEUTRAL SCALAR DECAYS

- Decay through WZW term

$$\Gamma = \frac{N}{48\pi^2 f} \mathrm{tr}(\phi F \tilde{F})$$

- No free parameter in branching fractions



Freitas, PS, Wyler

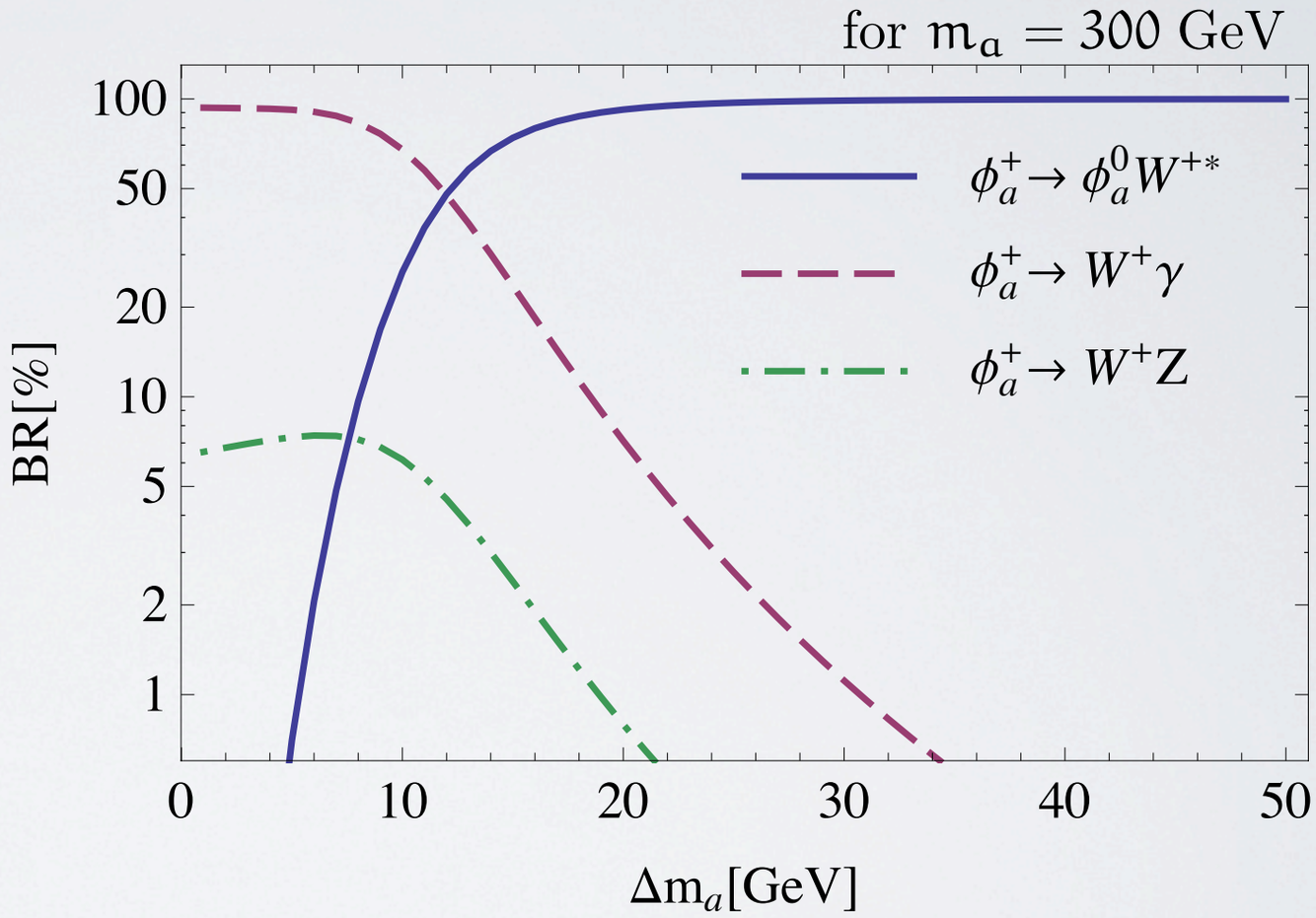
CHARGED SCALAR DECAYS

- Depend on mass splitting $m_a^+ - m_a^0$

- Purely radiative splitting: (Kilic & Okui)

$\Delta m_a \sim 170$ MeV

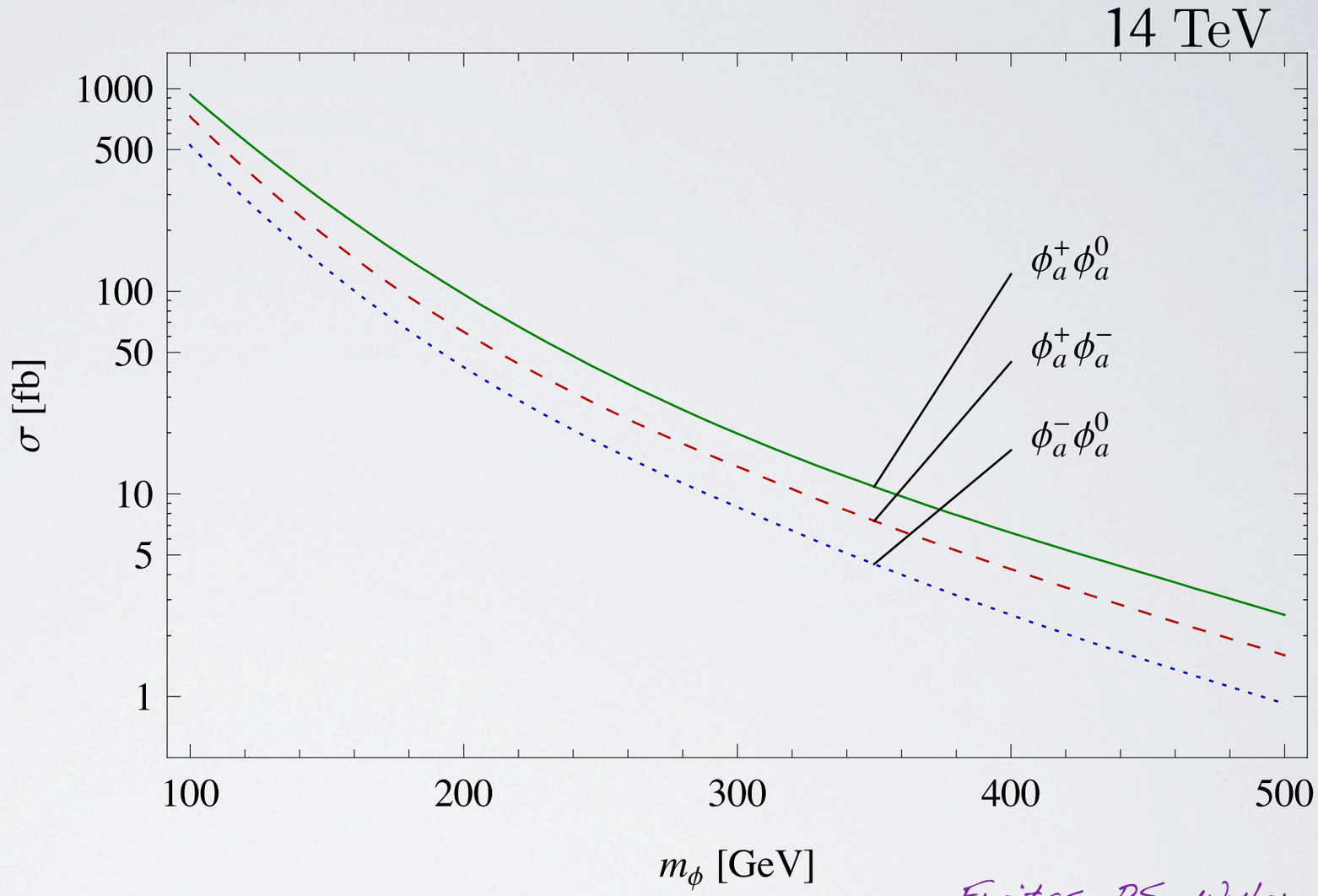
- Larger splittings possible



Freitas, PS, Wyler

PRODUCTION AT LHC

- No neutral pair production
- Three photon signal from $\phi_a^{\pm}\phi_a^0$ pair production



Freitas, PS, Wyler

- Four photon signal possible for large splitting

SM BACKGROUNDS (14 TEV)

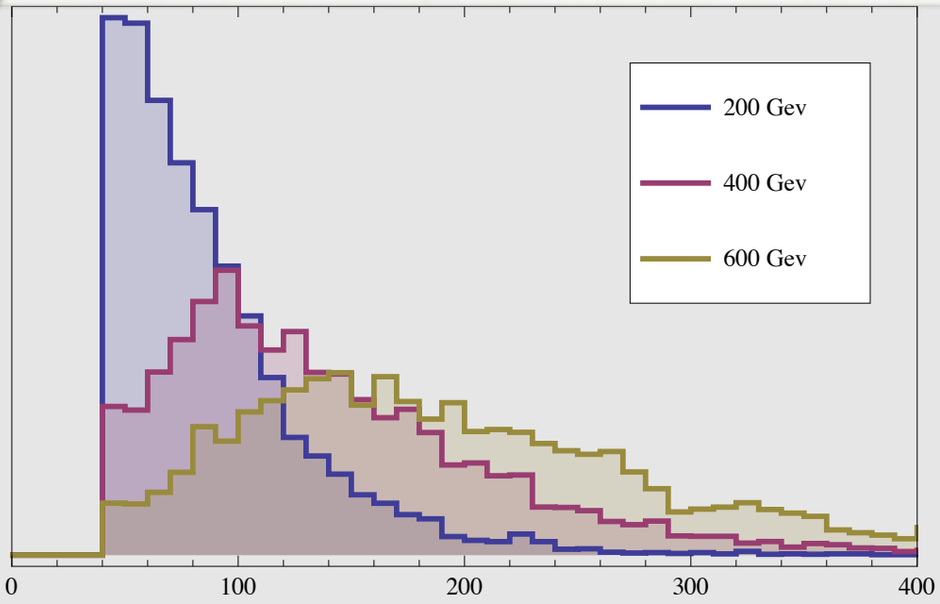
- Real Backgrounds ($p_T > 40\ \mathrm{GeV},\ \Delta R > 0.3,\ |\eta| < 2.5$)

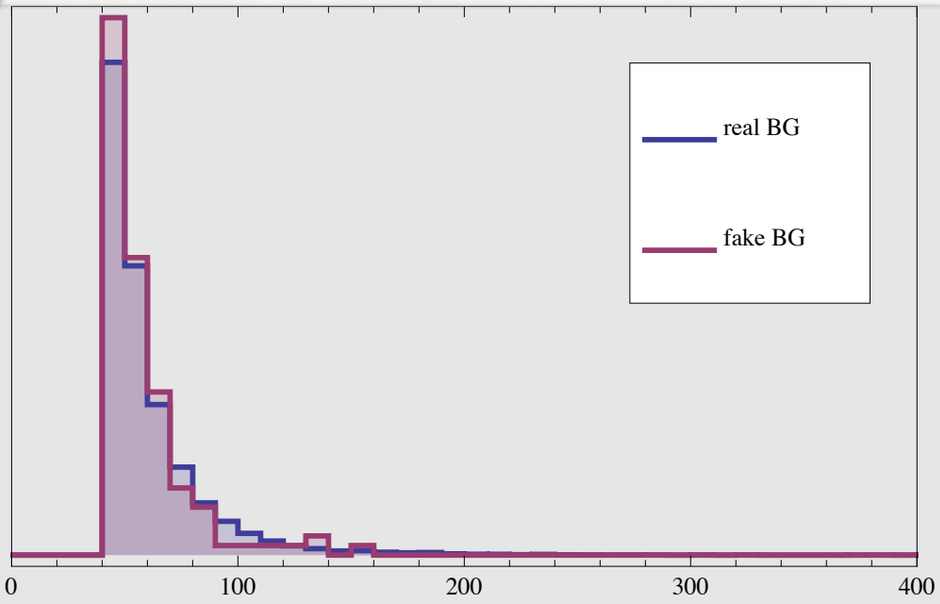
process	parton level $[fb]$	PGS $[fb]$	sub $[fb]$
3γ	2.72	2.26	2.04
$3\gamma + j$	2.80	2.04	-
$3\gamma + W^+$	$7.07 \cdot 10^{-3}$	$4.37 \cdot 10^{-3}$	

- Fake Backgrounds ($j \to \gamma$ conversion)

process	parton level $[fb]$	sub $[fb]$	PGS fake $[fb]$	est. fake $[fb]$
$2\gamma + j$	2874	2325	5.35	0.465
$2\gamma + jj$	2019	1409	3.95	0.56
$2\gamma + jjj$	651	-	2.44	0.39

S/B ANALYSIS, P_T





- p_T of 3rd hardest photon
- higher cuts will efficiently remove background, lose some sensitivity for low masses

S/B CONTINUED

	$p_T > 60$ GeV	$p_T > 80$ GeV	$\sigma[fb]$
real BG	34%	14%	0.57
fake BG	29%	10%	1.17
Sig 200 GeV	70%	46%	19.0
Sig 400 GeV	92%	81%	2.1
Sig 600 GeV	97%	92%	0.1

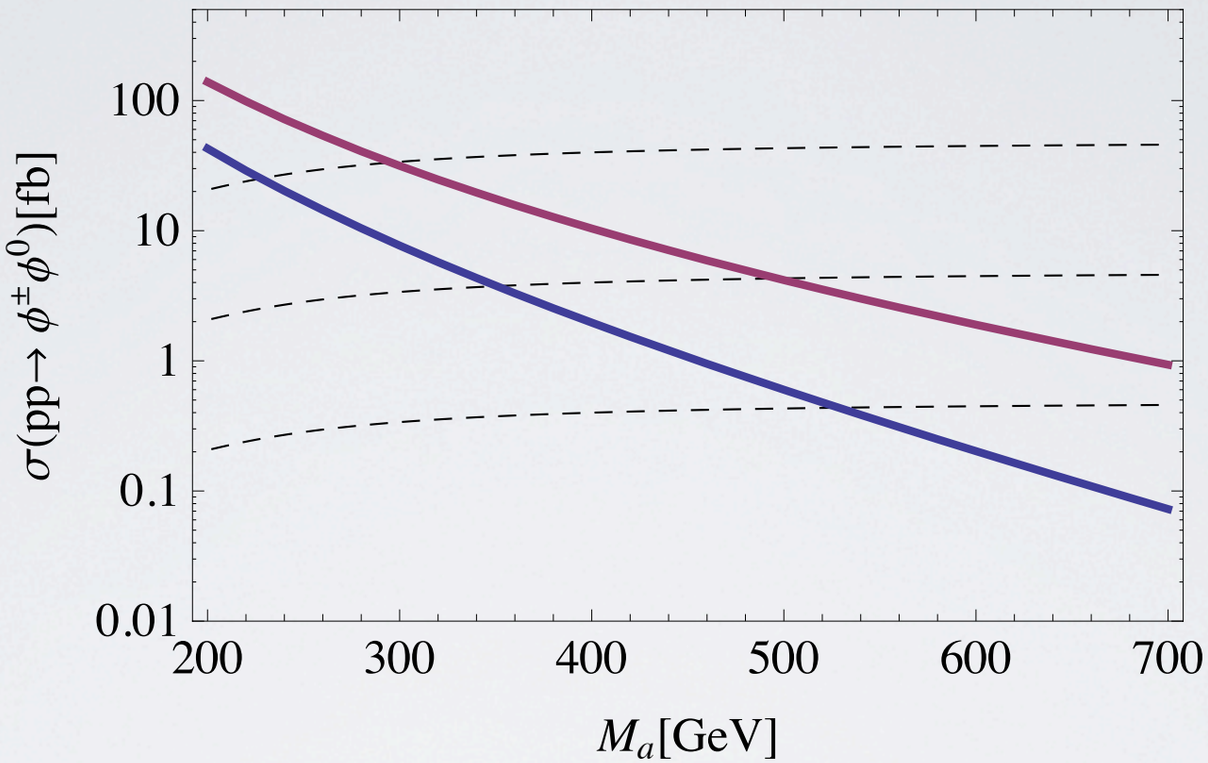
- Good prospects for 14 TeV LHC
- 7 TeV LHC with limited range ($m_a < 250$ GeV)
- Have a second look at Tevatron!

OTHER PROPERTIES / OUTLOOK

- Accurate mass measurement with few events
- Almost free spin determination: Only 0, 2 possible
- ZZ decays $\longrightarrow$ parity
- γZ and ZZ branchings to verify WZW origin

THANKS FOR YOUR ATTENTION!

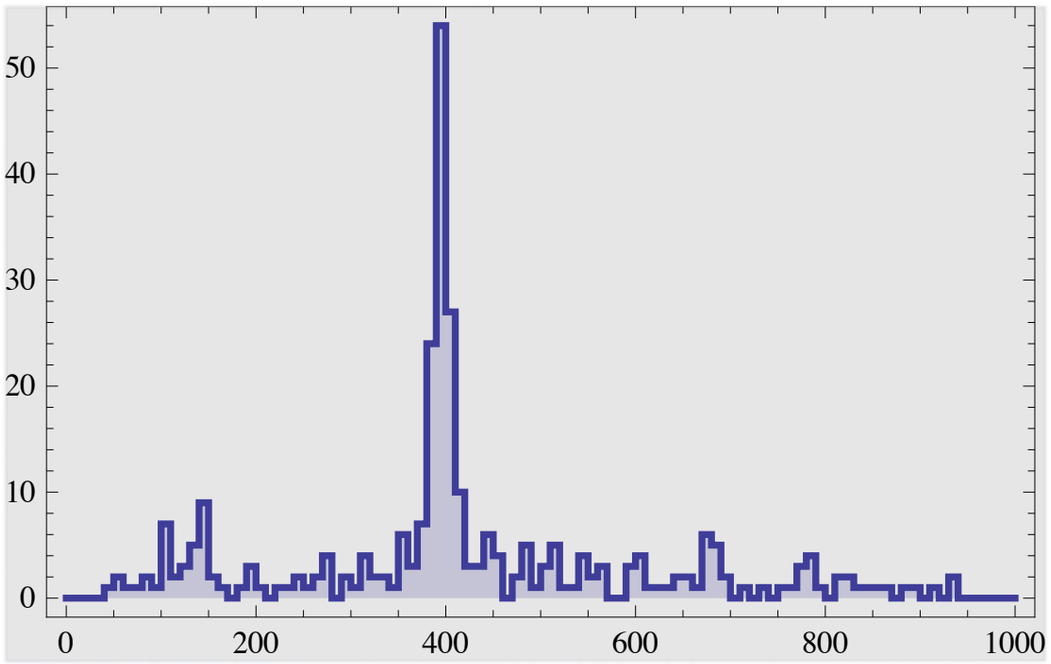
LHC REACH



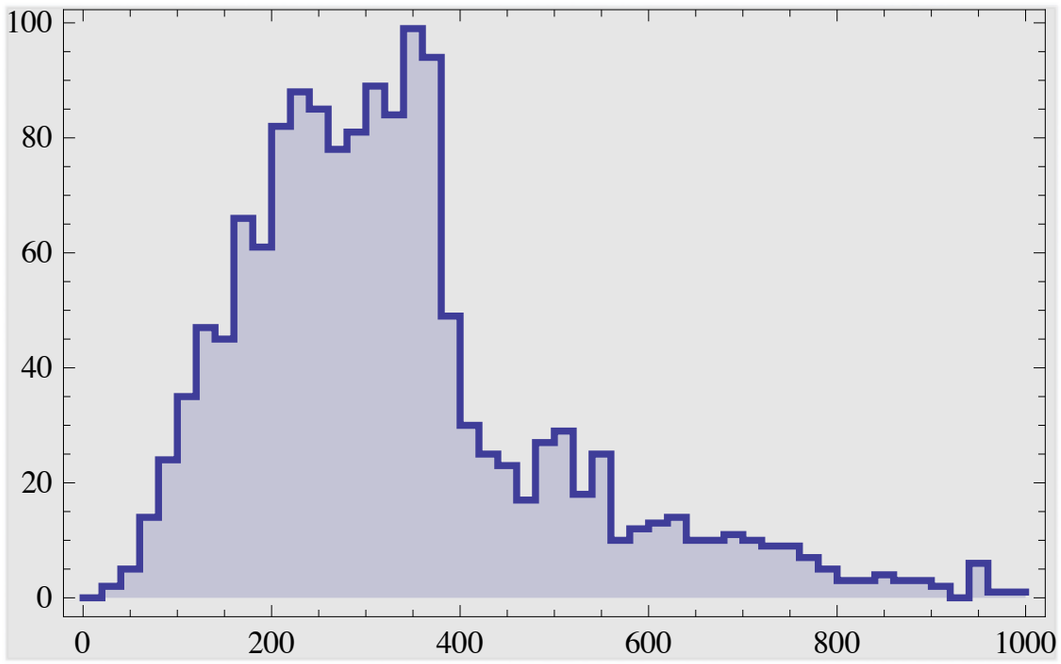
- Assuming zero background and 10 events for discovery

MASS MEASUREMENT

$m_a{}^0$ with 100 events



$m_a{}^+$ with 500 events



- Neutral mass from peak in photon invariant Mass
- Charged mass from cusp in photon-lepton inv. Mass