UNIVERSITY
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Dilepton-Diphoton CSC results and activities

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Introduction

- Reorganisation of the ATLAS working groups:
  - 5 working groups in Exotics: KDF proposal (performance driven)
    - Lepton + X,
    - VBS
    - Black Holes
    - Jets
    - Long Lived Particles
  - Our suggestion: Lepton + X split into 2 independent teams:
    - Dileptons
    - Dileptons + jets teams
    - Alternate with Common Lepton Performance meetings
- CSC note: Inside the Exotic chapter
- Meeting yesterday → Post CSC activities:
  - Many updates and new topics investigated
- In this talk:
  - Only final results inside the CSC (no updates)
    - Z'→ee,mumu,tautau. G*→ee and Technicolor in mumu
  - No performance and trigger work presented

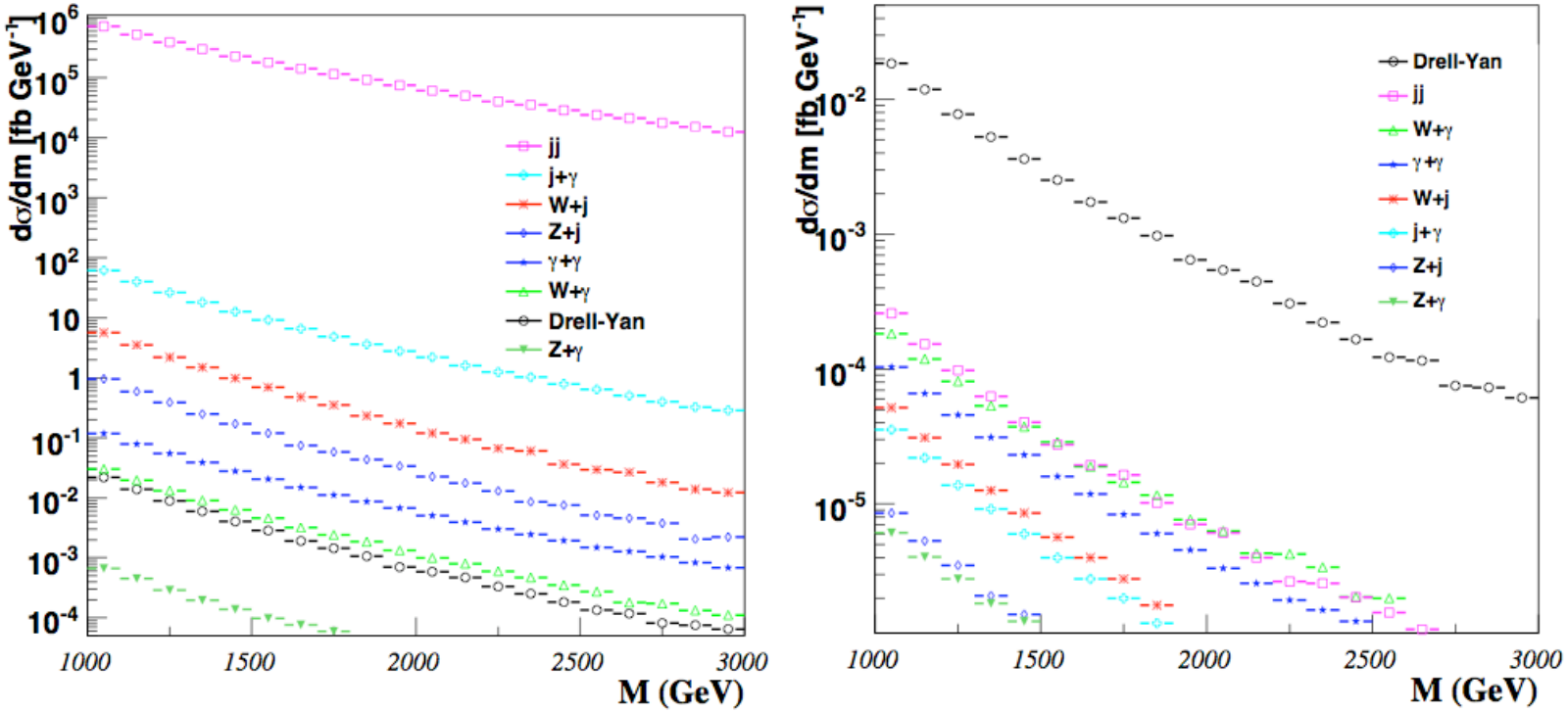
CSC note contents

Understanding the detector performance and trigger

Understanding the Standard Model Predictions

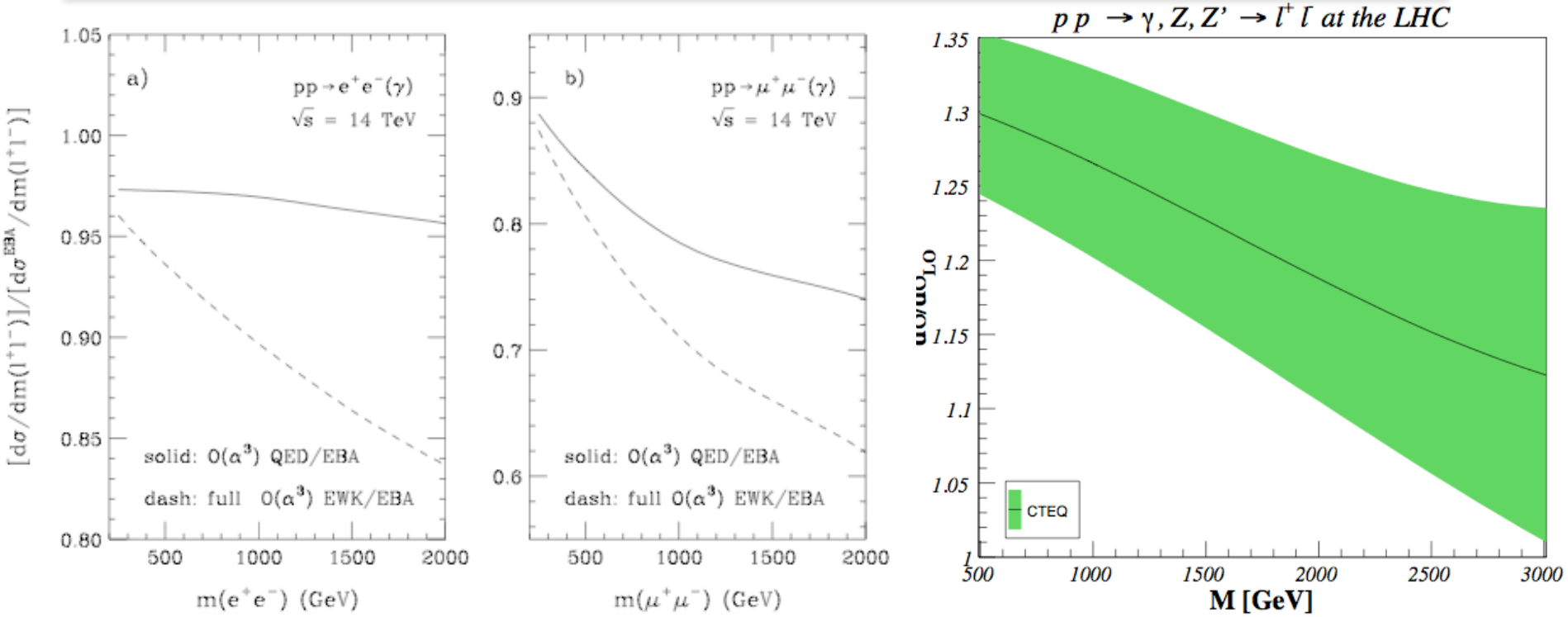
Searching for new Physics: Z' , G* and Technicolor

Standard Model: backgrounds



- Source of (ir) reducible background: (non tautau)
  - Drell-Yan
  - Jet→e, gamma→e contamination
  - e and mu production from Z and W decay
- Cuts:
  - $R_{e\text{-}jet}=10^4$, $R_{e\text{-}gamma}=10$, Pt and pseudorapidity ($R_{e\text{-}jet}$ & $R_{e\text{-}gamma}$ varied by a factor 2)
  - The Drell-Yan is the dominant background
- Muons are cleaner & taus studied separately (see below)

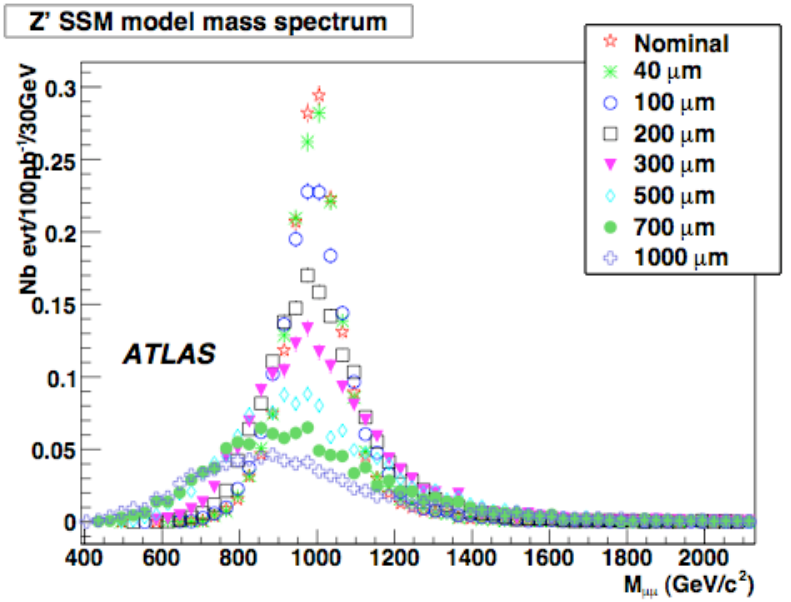
Standard Model: NLO corrections



- 2 independent studies: gamma,Z,Z' and gamma,Z
- ee and mumu studied separately
- EW corrections -12to-18% for ee, -4to-16% for mumu
- QCD corrections using MC@NLO
- Combination QCD/QED resummation
- Combination Full QCD Full EW for Drell-Yan

Systematic uncertainties

- Alignment for Z'→mumu
  - Most important systematic.
  - Affects the reconstruction efficiencies and sensitivities
  - 8 configurations are investigated. 40,100,…,1000μ
- Systematic uncertainties:
  - Renormalisation/factorisation energy
  - PDFs: 5% @ 1TeV, 11% @ 3TeV
  - Efficiencies: 1%(e), 5% (mu,tau)
  - Energy scale: 1%(e), 5% (mu,tau)
  - Resolution: 20% e, 45% taus
  - Luminosity: 20% @100 pb^{-1}, 3% @ $10fb^{-1}$

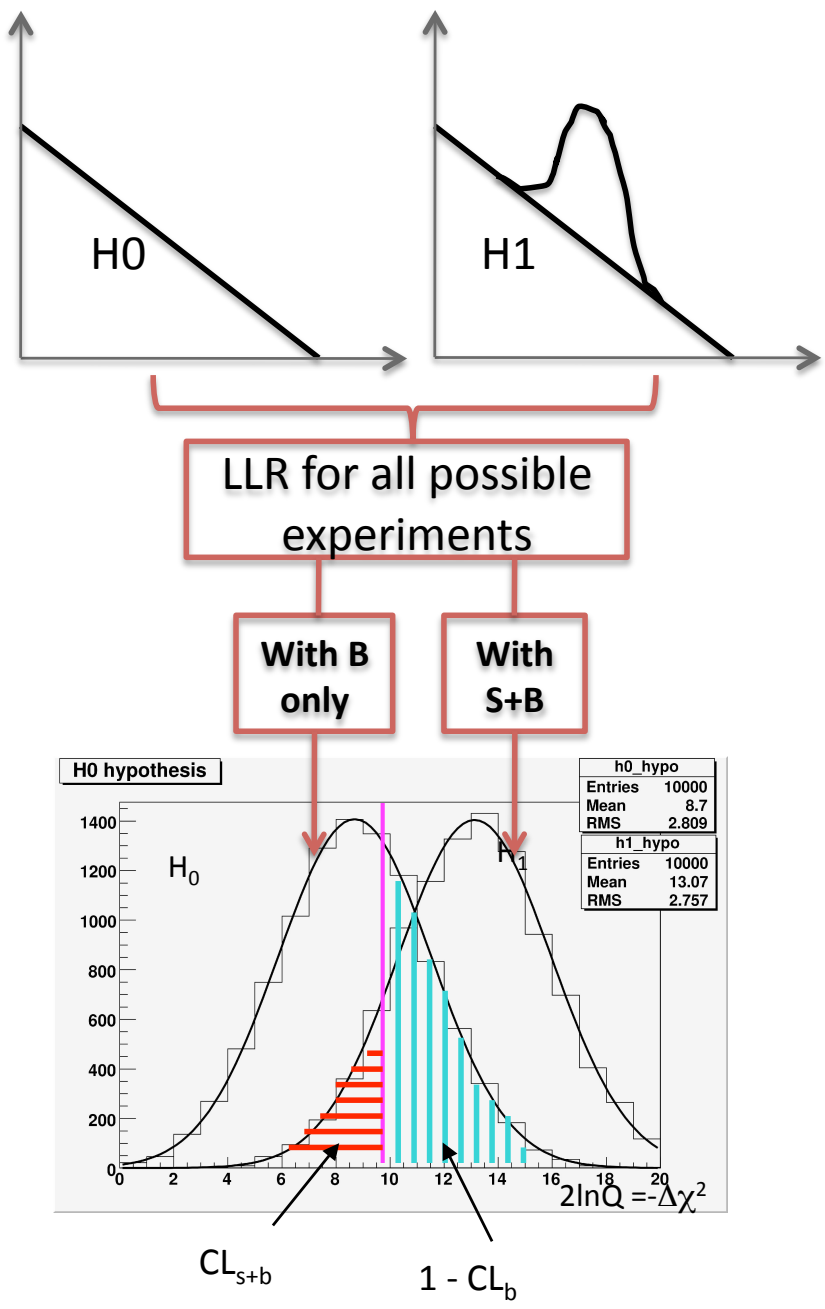


Misalignment (μm)	Nominal	40	100	200	300	500	700	1000
Relative loss	0.984	0.984	0.984	0.98	0.973	0.948	0.918	0.877

Exotic searches

- Investigated physic channels
  - Z'→ee,mumu,tautau.
    G*→ee and TC in mumu
- Methods:
  - Counting
  - Shape analysis
    - Bayesian
    - Parameterized
      - Direct Log Likelihood Ratio

        $5\sigma \Leftrightarrow 1\text{-}CL_b = 2.9\text{x}10^{-7}$ → ***high number of pseudoexperiments***
      - Fast Fourrier Transform
    - Non parameterised
- Backgrounds:
  - Limited statistic in Drell-Yan
  - Parameterized and extrapolated when needed

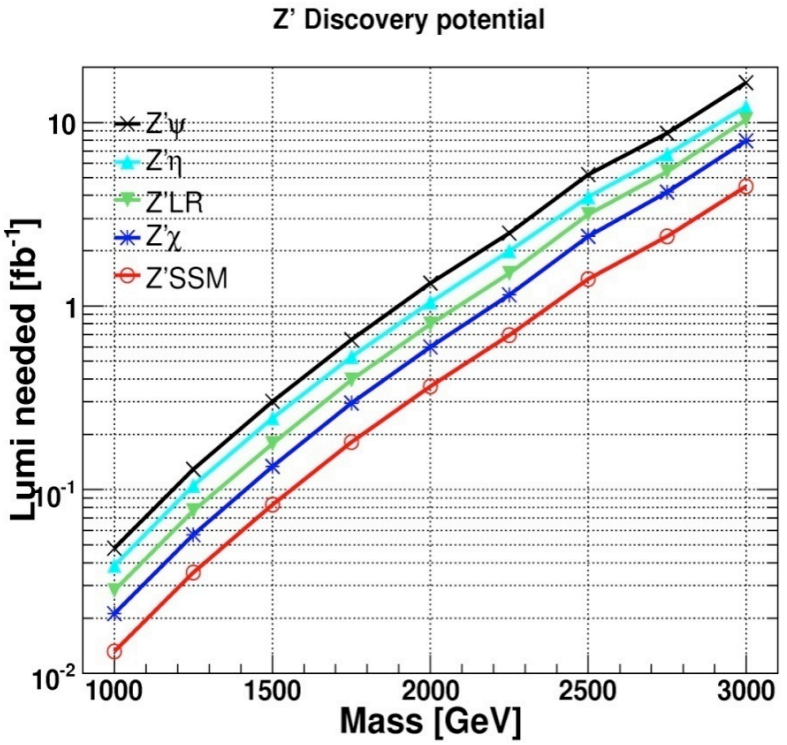


Exotics: Z'→e-e

- Fully simulated Z'$_\chi$ with 1,2 and 3 TeV
- Mass spectrum generation for ψ,η, χ, LR and SSM models:
  - Parameterisation of both Drell-Yan and Z's
  - Width Z' resonances
- FFT methods used: DY<1%
- Uncertainties on the DY have negligible effect
- 100 pb^{-1} are sufficient to discover Z' beyond the Tevatron limits:

  1.2 TeV < $m_{Z'}$ <1.6TeV

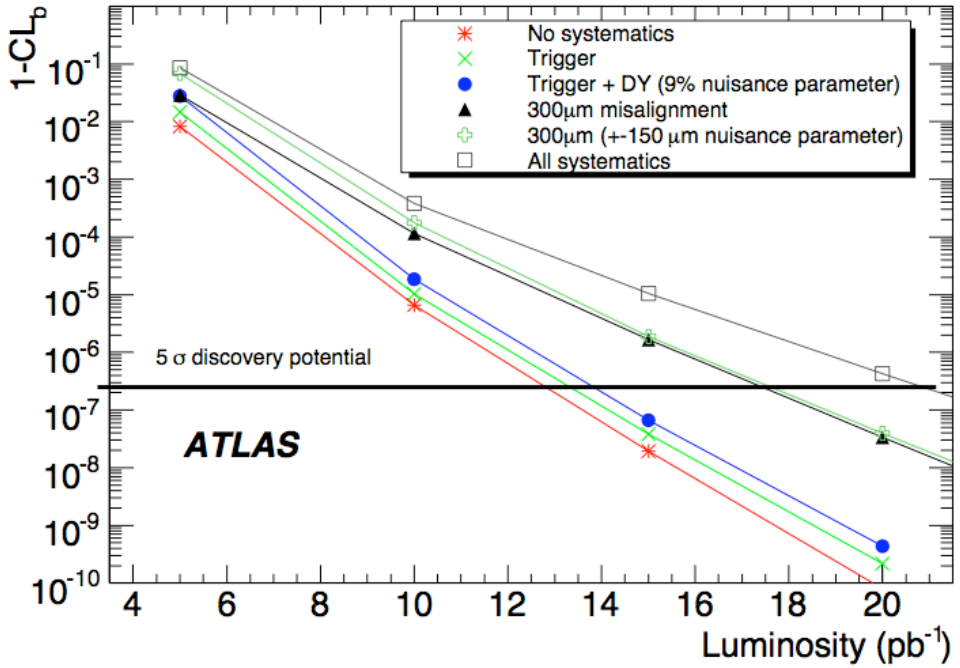
Selection	Signal at 1 TeV	DY at 1 TeV	Signal at 2 TeV	DY at 2 TeV	Signal at 3 TeV	DY at 3 TeV
	347	3.56	14.7	0.16	1.22	0.015
2 generated $e^{\pm}$, $\|\eta\| < 2.5$	299	3.07	13.7	0.15	1.16	0.013
2 clusters with a track	201	2.06	8.0	0.09	0.62	0.009
2 *loose* electrons	190	1.96	7.2	0.08	0.52	0.008
At least one $p_T > 65$ GeV	190	1.96	7.2	0.08	0.47	0.008
Event triggered	173	1.77	6.6	0.07	0.43	0.007
2 opposite charges	166	1.70	6.2	0.07	0.41	0.007



Exotics: Z'→mu-mu

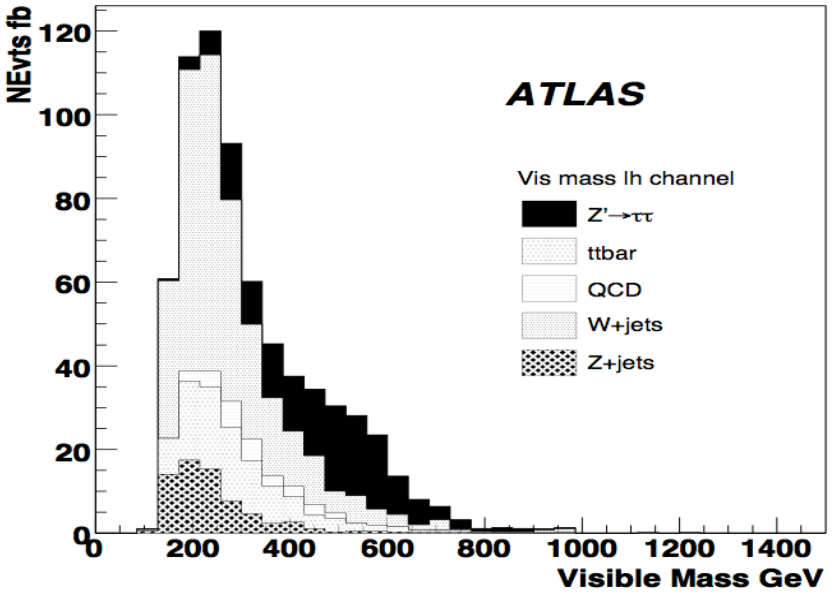
- Complement to Z'→ee, especially when the designed rejections are not reached.
- SSM and Chi models investigated of 1 & 2 TeV
- Sensitivity computed using FFT
- Systematics (5s discovery):
  - Standard uncertainties has modest effect:
    - 14 → 13 pb^{-1} @ $m_{Z'}$=1 TeV
  - Alignment is the main source of degradation:
    - 14→ 20 pb^{-1} @ $m_{Z'}$=1 TeV

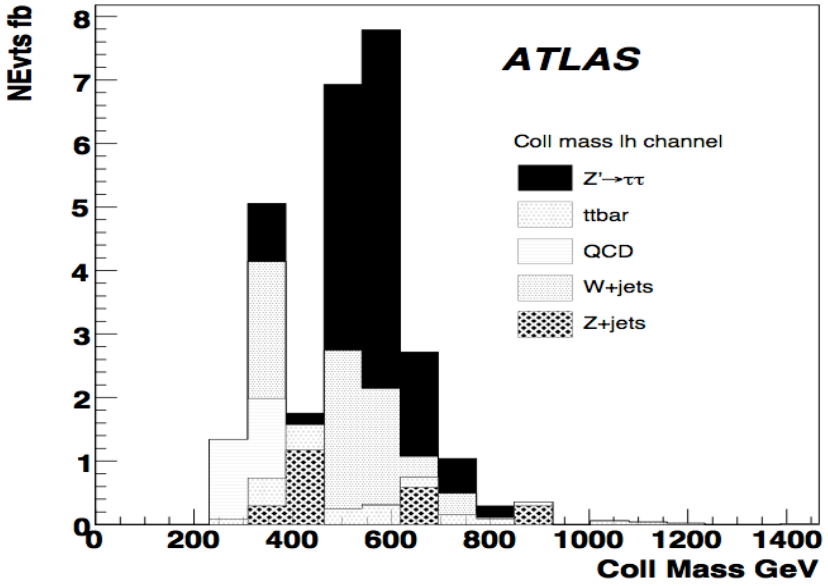
Sample	Z' (1 TeV SSM)	Z' (2 TeV SSM)	Z' (1 TeV χ)	Drell-Yan ($M \geq 800$ GeV)
Generated	508.6	23.8	380.6	13.5
$\|\eta\| \leq 2.5$	366.8	18.1	271.5	10.8
$p_T \geq 30$ GeV	364.0	17.9	270.1	10.7
Muon identification	342.3	17.0	256.0	10.0
Trigger	325.2	16.2	243.2	9.5
Opposite charge	324.8	16.2	243.0	9.5



Exotics: Z'→tau-tau

- Study done for 1 fb-1 in the lepton-hadron channel only
- Collinear approximation for the invariant mass → breaks down at high masses
- Significance for 600 GeV:
  - 9.9 s down to 3.4 s with systematics
- Total systematic uncertainties 22% (lumi, had energy scale..)





Trigger	1355.9	213578	2.3949e+07	4.19221e+06	6.69373e+06
Lepton	905.0	150921	1.25982e+07	1.08225e+06	120411
Tau selection	367.5	7818.0	145680	40080.3	4587.4
Opposite charge	314.8	2497.6	5305.5	23243.1	771.0
MET>30	269.6	2040.3	2562.1	834.7	161.9
$M_{tr} < 35$ GeV	202.5	302.4	388.0	436.4	83.8
$P_T^{tot} < 70$ GeV	155.0	106.7	331.5	221.6	28.4
$M_{vis} > 300$ GeV	132.5	26.2	105.6	33.8	15.0
MColl	13.3	2.1	5.5	2.3	2.7

Exotics: G*→e-e

- 2 loose electrons
- DY extrapolated using:

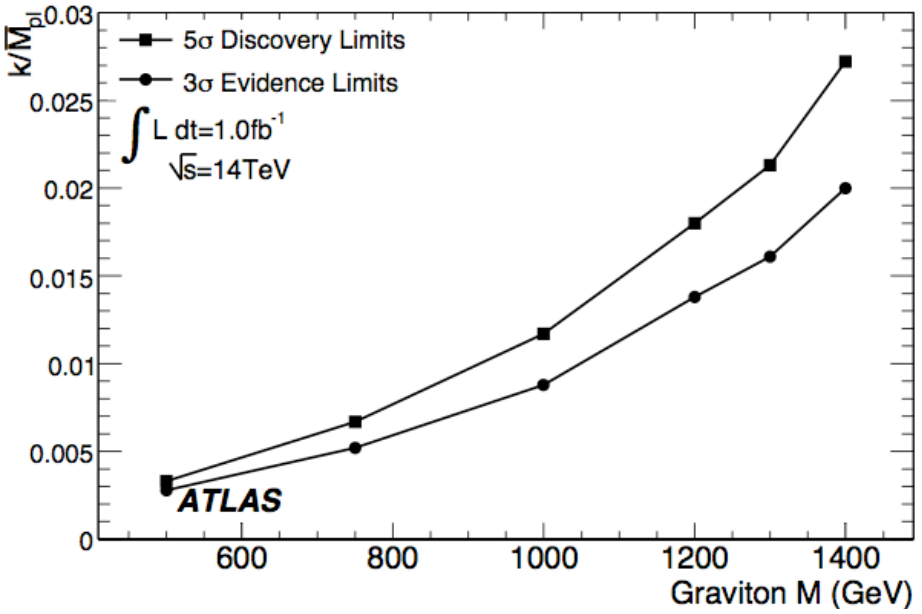
$$exp^{2.2M^{0.3}}$$

- Physics parameter in Rundall-Sundrum:

$$\frac{k}{\overline{M_{pl}}}$$

- Sensitivity for 1fb^{-1} using parameterized CLs method:
  - Up to m_{G^*}=1.5 TeV

Selection	500 GeV	750 GeV	1.0 TeV	1.2 TeV	1.3 TeV	1.4 TeV	Drell-Yan (650 ≤ M (GeV) ≤ 800)
Generated	187.4	27.7	26.0	22.4	25.3	26.8	17.7
Acceptance	172.4	25.9	24.6	21.2	24.0	25.3	16.4
hline Trigger	168.7	24.9	23.9	20.6	23.3	24.5	15.9
Electron ID	128.0	18.1	16.9	13.0	15.9	16.2	14.8
$P_T > 65$ GeV	125.7	17.7	16.3	12.8	15.6	15.9	14.6
$cos\Delta\phi_{ee} < 0$	122.5	17.0	16.0	12.5	15.1	15.3	14.0
Efficiency	65.6 ± 1.1%	64.4 ± 1.0%	61.7 ± 1.1%	56.3 ± 1.1%	56.4 ± 1.1%	53.9 ± 1.1%	60.8 ± 1.0%



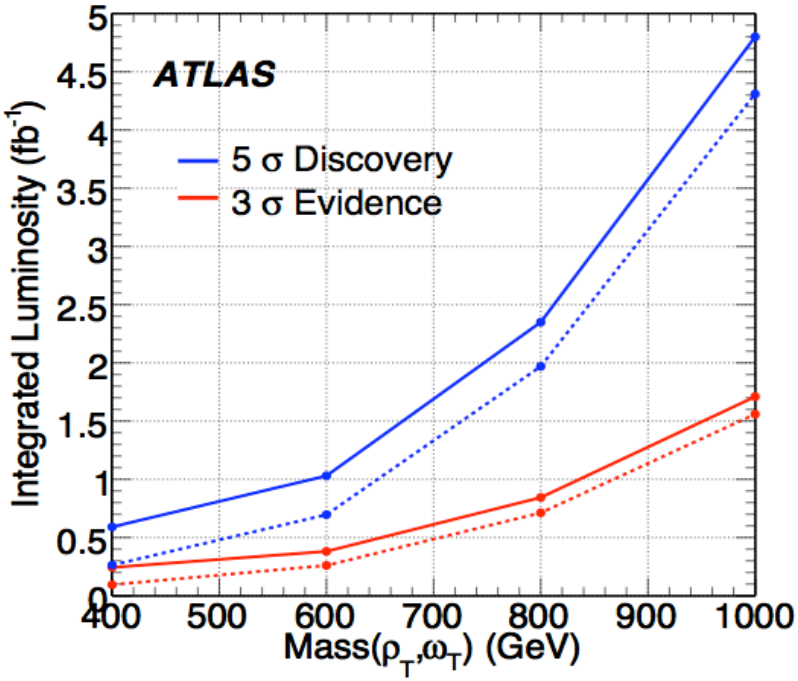
Exotics: Technicolor in mu-mu

- Snow mass technicolor models: ρ_T,ω_T
- Techni-isospin symmetry:

$$m_{\rho T}=m_{\omega T}$$

- Sensitivity computed using:
  - Counting
  - D0 Bayesian method
  - Parameterized CLS method
- $1fb^{-1}$ are enough to discover a 600 GeV technimeson

$M(\rho_T,\omega_T)$ (GeV)	400	600	800	1000
Peak Mass (GeV)	403	603	804	1004
$\sigma(M)$ (GeV)	13	22	34	46
Cut Flow				
Generated	201	60.8	23.0	10.1
$\|\eta\| < 2.5$	116	39.8	15.8	7.3
$p_T > 30$ GeV	114	39.5	15.7	7.2
L1_MU20 || L1_MU40	112	38.7	15.3	7.0
L2_Mu20i	110	38.0	15.1	6.9
EF_Mu20i	109	37.5	14.9	6.8
Match $\chi^2 < 100$	104	35.7	14.0	6.4
Opposite charge	104	35.7	14.0	6.4
Mass Window	78.2	26.3	10.3	4.7
Drell-Yan Background	46.9	14.1	6.1	2.8
Selection Efficiency (%)	38.9 ± 0.5	43.2 ± 0.5	44.8 ± 0.5	46.8 ± 0.5



Future: Post CSC tasks…

- Electrons:
  - Contamination:
    - Jet ➞electron, photon➞electron
  - Lack of efficiencies at high energy
    - Reported in the note and meeting
    - Need to develop the eID at high pt
  - Linearity:
  - Efficiency measurement from data
- Photons:
  - Efficiency measurement from data
    - Electron ➞ Photon contamination
  - Linearity:
- Muons:
  - Efficiency measurement from data
  - Contamination
- Taus:
  - Efficiency measurement from data
- Trigger:
  - Efficiency measurement from data
  - Single high Pt lepton without isolation but Studies are still needed for backup (dielpton without isolation), calibration triggers.

- **Uncertainties**: **first attempt but need more investigations & agreement with others**:
  - Higher order corrections (EW, QCD, N**LL)
  - Linearity
  - Alignment
  - Efficiencies
  - Luminosity
- **Backgrounds:**
  - Top, WW, W+jet, tautau, gamma conversion
  - Fake rate: jet jet, gamma+jet
- **Exotics:**
  - Statistical methods for resonances: S>>B
  - Combination of ee and mumu channels
  - ee:
    - Z', G*, ADD Graviton, Heavy scalars, LQ, LG, Technicolor
  - mumu:
    - Z', G*, heavy scalars, LQ, LG, Technicolor
  - Tautau:
    - Z', G*, heavy scalars, LQ, LG, Technicolor
  - Photon-photon:
    - G*, heavy scalars, Excited quarks.
  - **Disentangling the underlying models**
  - **Non resonant excess: Contact interaction, ADD extra dimensions**

Conclusion

- Sensitivity to exotic dilepton resonances:
  - Z' →ee, 15 to 50pb^{-1} for 5s discovery of $Z'_{Chi,eta,Psi,LR,SSM}$
  - Z' →mumu, 20pb^{-1} for 5s discovery of Z'_{Chi}
  - Z' →tautau, 1fb^{-1} gives 3.4 s for $m_{Z'}$=600GeV
  - G*→ee, 5s dicovery @ 1fb^{-1}: up to m_{G*}=1.5 TeV
  - TC→mumu, 5s discovery @ 1fb^{-1}: up to m_{TC}=600GeV
- 10 to 100 Pb^{-1} are enough to go beyond the Tevatron limits for most of dilepton resonances
- Future…