Three-boson signals in a three-brane world

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In collaboration with
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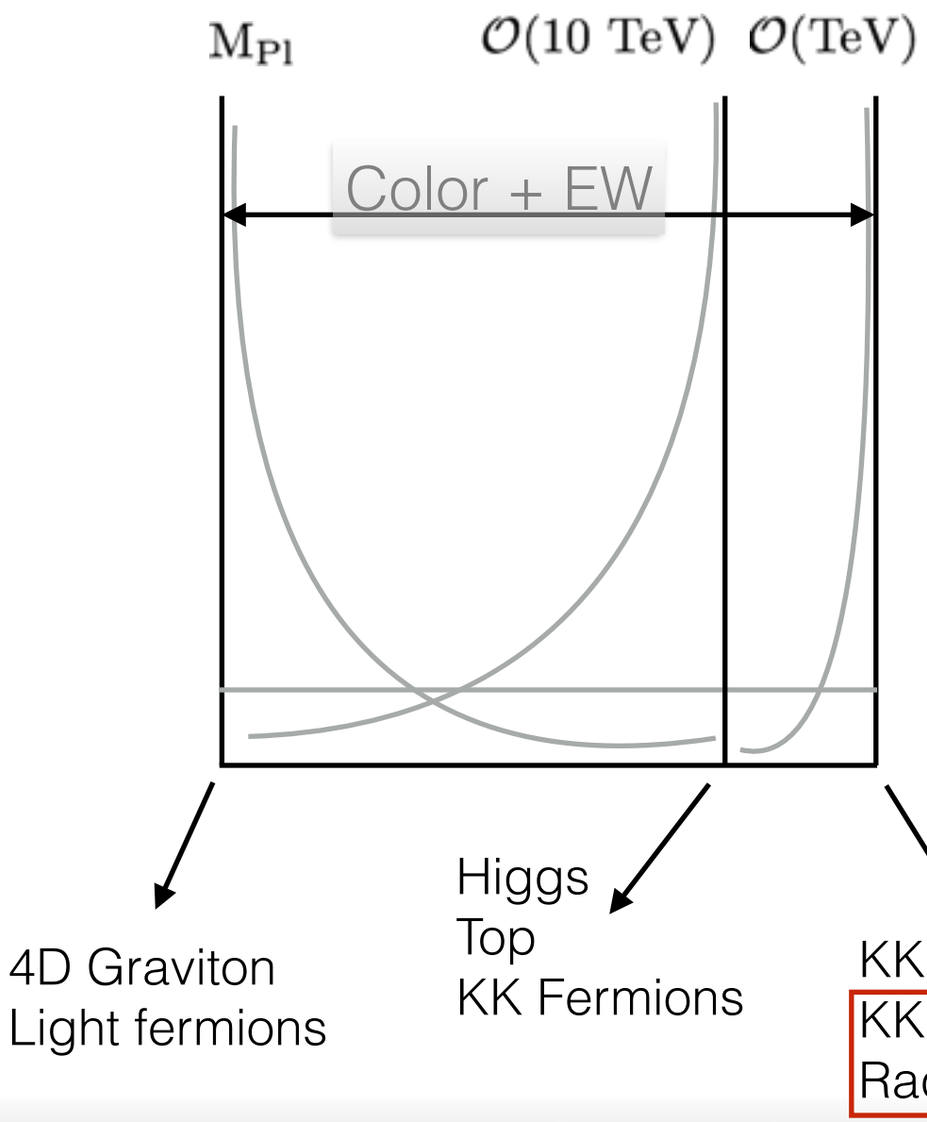
Away from the minimal scenario

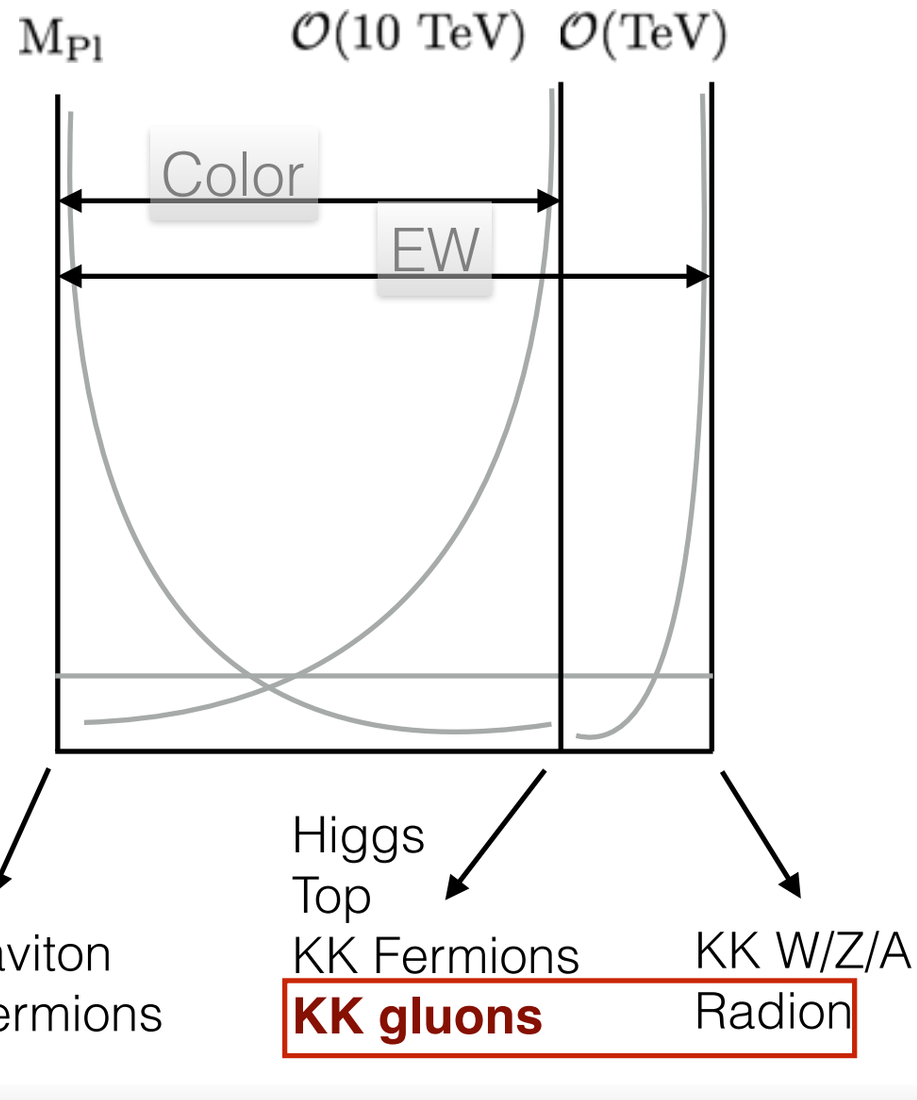
RS_3^{all}



Agashe, Du, Hong, Sundrum (1608.00526)
Agashe, Collins, Du, Hong, Kim, **RKM** (1612.00047)

RS_3^{EW}

Only EW gauge bosons in entire bulk.

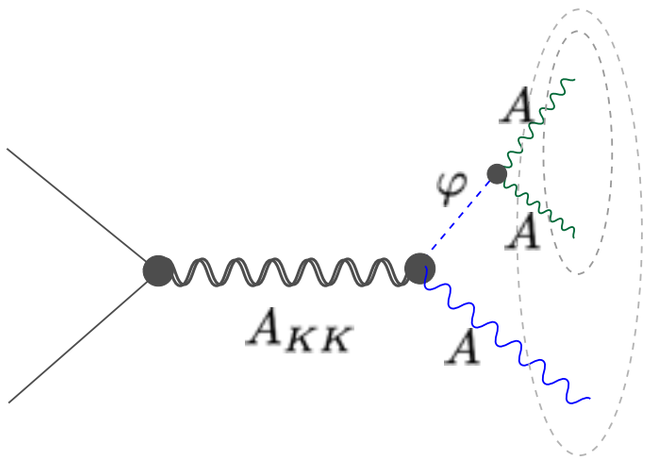


Agashe, Collins, Du, Hong, Kim, **RKM**
(in prep.)

Focus of this talk

What's kept and what's lost/gained?

	RS_3^{all}	RS_3^{EW}
• Planck/EW hierarchy • Fermion mass hierarchy • Flavor constraints	✓	✓
$Q_A \frac{g_A^2}{g_{A_{KK}}} A^\mu_{KK} \bar{\psi} \gamma_\mu \psi$ $\epsilon g_{grav} \frac{g_A}{g_{A_{KK}}} \frac{\varphi}{M_{KK}} A_{\mu\nu} A^{\mu\nu}_{KK}$ $-\frac{1}{4} \left(\frac{g_A}{g_{A_{KK}}} \right)^2 \frac{g_{grav}}{M_{KK}} \varphi A_{\mu\nu} A^{\mu\nu}$	✓ for $A = \{g, W/Z, \gamma\}$	✓ for $A = \{W/Z, \gamma\}$



- **KK gauge boson decay with 2 inv. mass peaks structure remains!**
- **Radion production cross-section reduced: first discovery!**
- **Main signal: Tri-bosons (WWW, W + di-photon)**

Experimental Signals: Tri-Bosons

Focus on hadronic W channels in this talk

- **W + di-photon**
- **Three W**

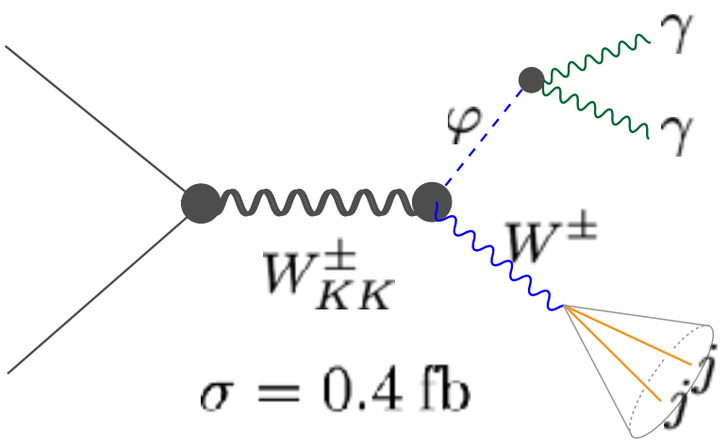
Benchmark point in a simplified model (2 masses and 3 couplings).

Constraints from

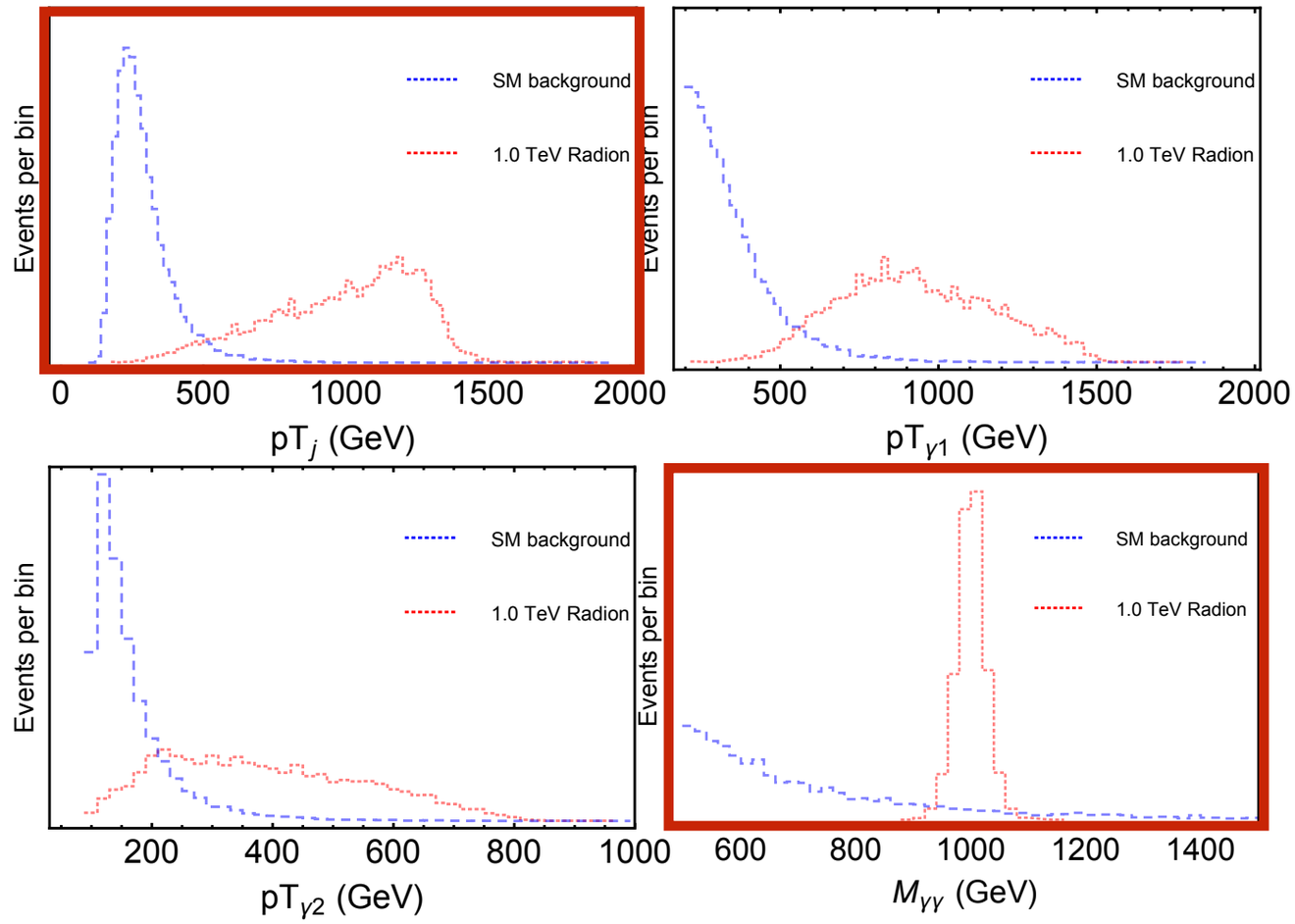
- radion to di-photon
- KK W to lepton and neutrino

M_{KK}	M_{φ}	$g_{W_{KK}}$	$g_{Z_{KK}}$	ϵg_{grav}	
3 TeV	1 TeV	3.0	4.24	3.0	W-diphoton channel
3 TeV	1 TeV	3.0	6.71	3.0	WWW channel

Hadronic W + di-Photon

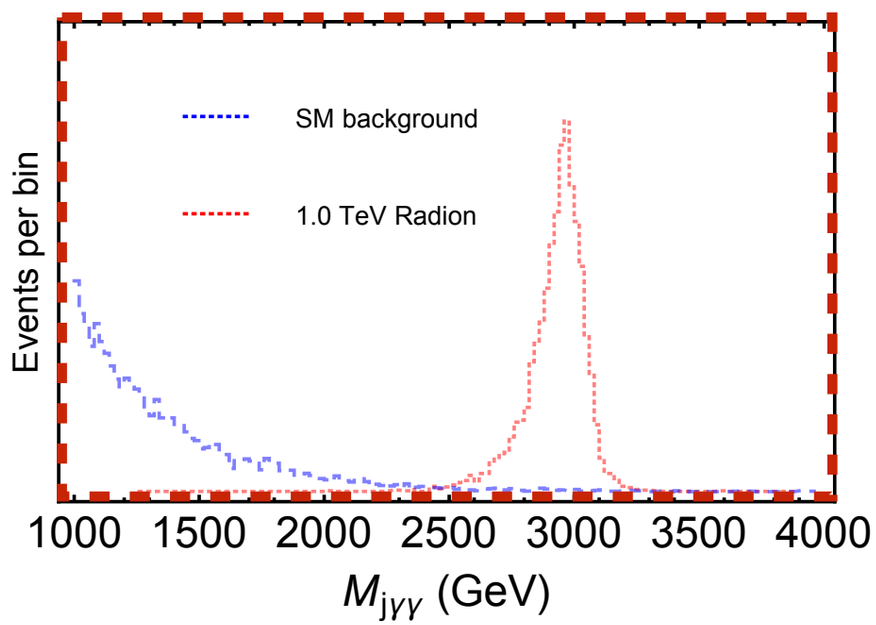


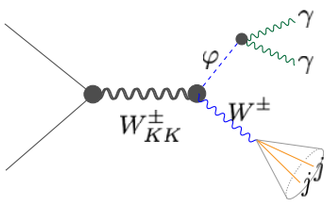
Boosted W: two jets merge into a fat jet



Discovery channel for Radion

- W tagging: $65 < M_J < 105\,\mathrm{GeV}, \tau_{21} < 0.75$ with **60**% efficiency.
- Primary background: $j\gamma\gamma$, $jj\gamma$ (jet faking photon)
- Signal discriminants: high pT jet/photons, clean 2 body inv. mass in photons
- Additionally: Three body inv. mass peak - crucial for KK gauge boson discovery
- **Achieved significance** $\sim 5\sigma$ @ $300/fb, \mathrm{LHC14}$

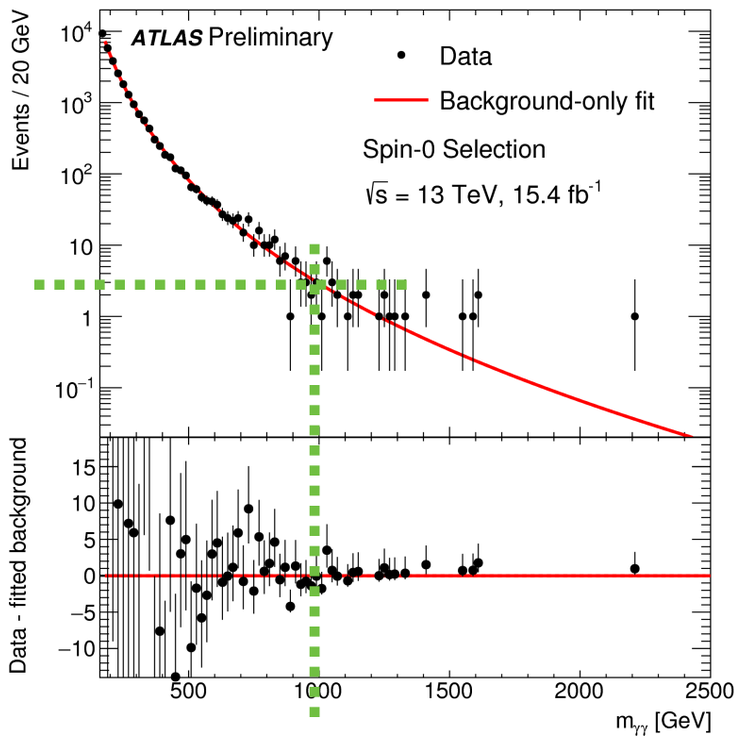




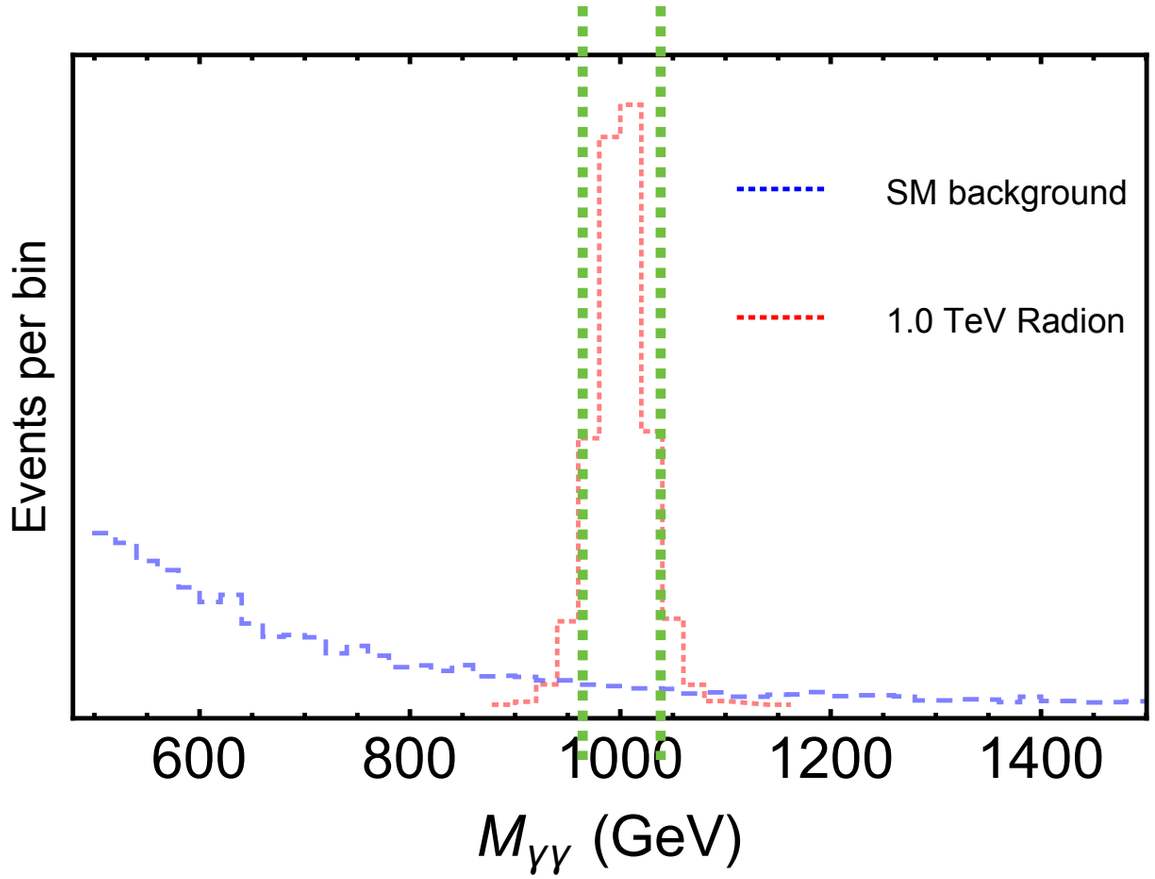
Hadronic W + di-Photon (cont.)

Significance with **existing** di-photon searches

2016 di-photon data



di-photon Inv mass in signal



Ignoring W-tagging and Jet pT/ M_jaa, we can do a crude significance estimate (for 300/fb data)

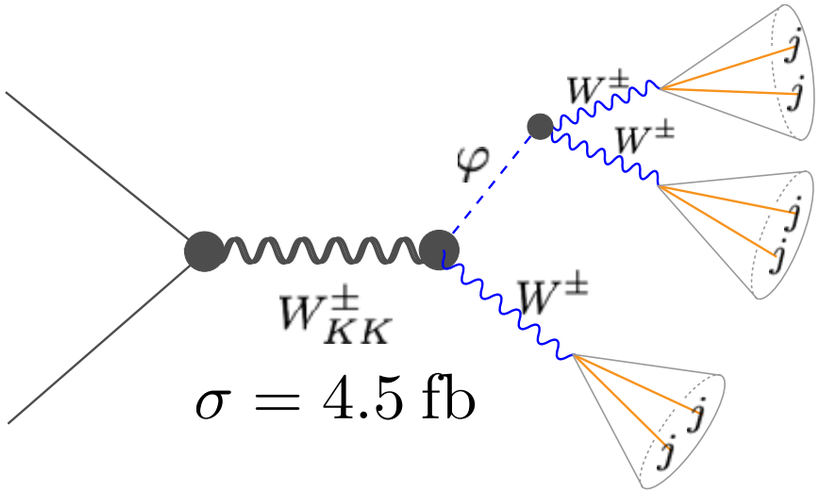
$$S \sim 0.4 \times 2/3 \times 3/5 \times 300 \times 4/5 \sim 40$$

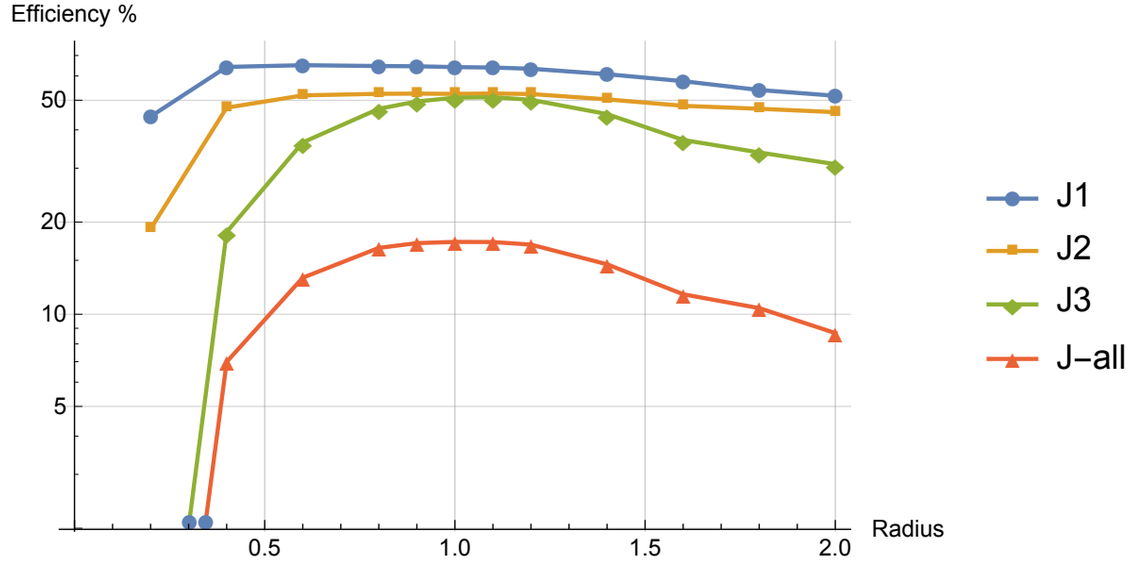
$$B \sim 3 \times 6 \times 300/15 = 360$$

$$S/\sqrt{B} \sim 2.1$$

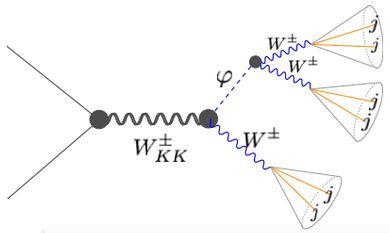
Requiring a high pT merged W jet can reduce background sufficiently.

Hadronic 3 W (Preliminary)





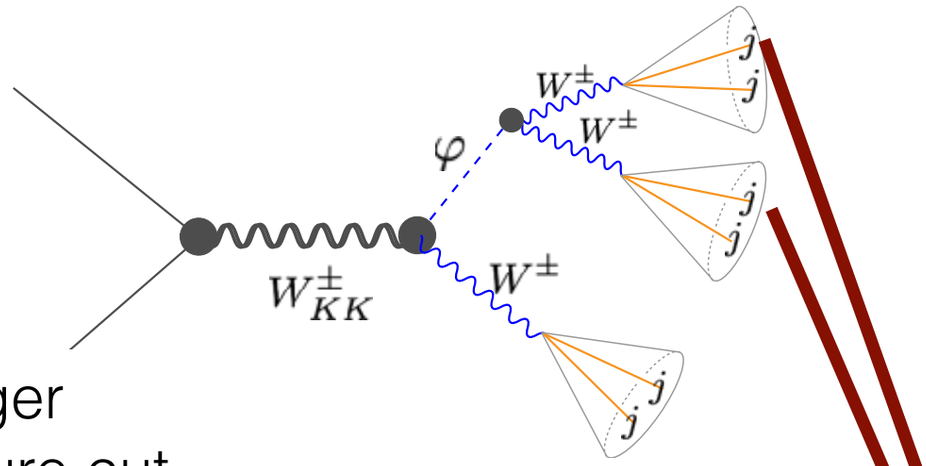
- 3 boosted Ws now. Optimal jet Radius needed. Competition between large R (capture fat jet) and small R (contamination from adjacent W in radion decay). This is a feature of the signal.
- Optimal R = 1 gives ~ 18% overall tagging efficiency.
- Signal discriminants: 2 body (M_{23}) and 3 body inv. mass. Higher rate but less clean discriminants due to combinatorics.
- Get around $\sim 2\sigma$ @ $300/fb, \mathrm{LHC14}$, but **improvement** possible.



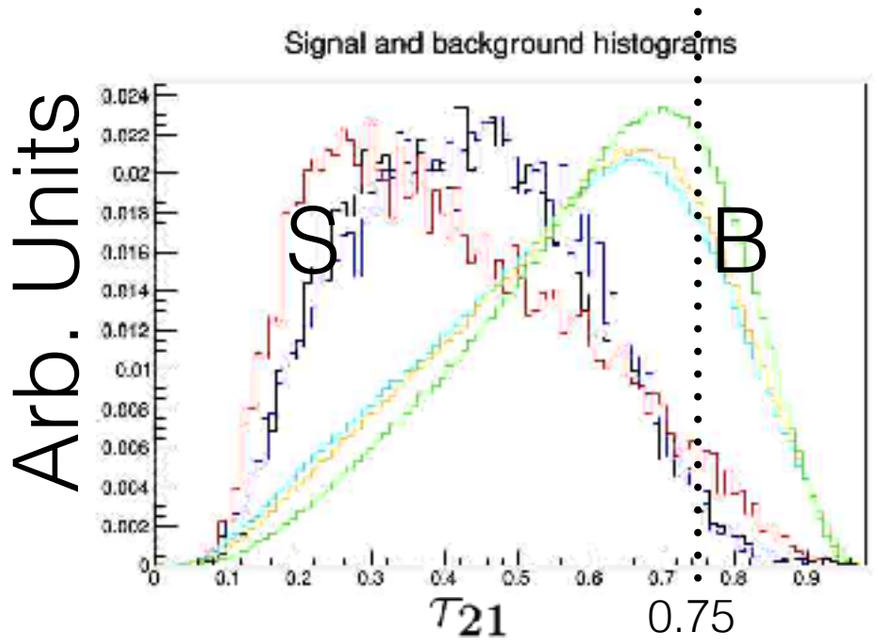
Hadronic 3 W (cont.) (Preliminary)

Improvements for higher significance

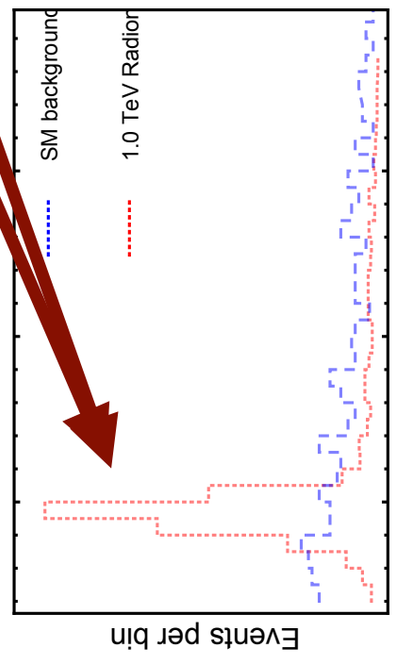
- Substructure information: harder cuts on 2-subjettiness variable τ_{21}
- Kinematic information: “+” cuts on combination of inv. masses.

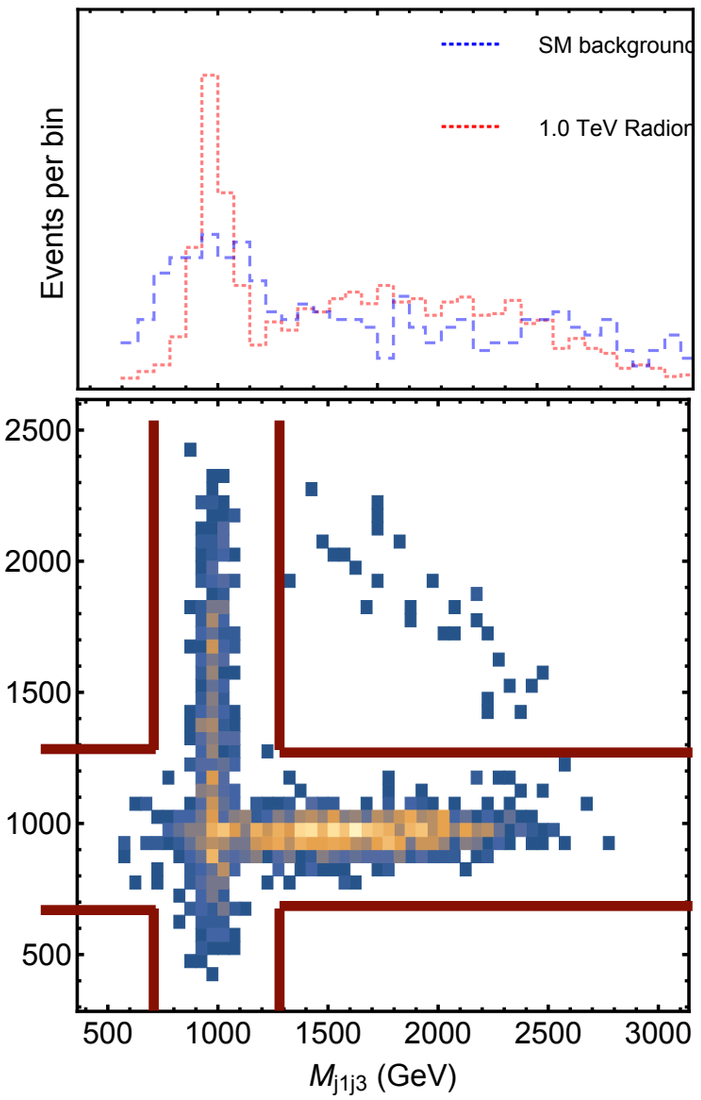


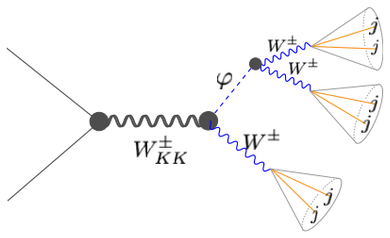
Stronger substructure cut



“+” cut after Mjjj window cut



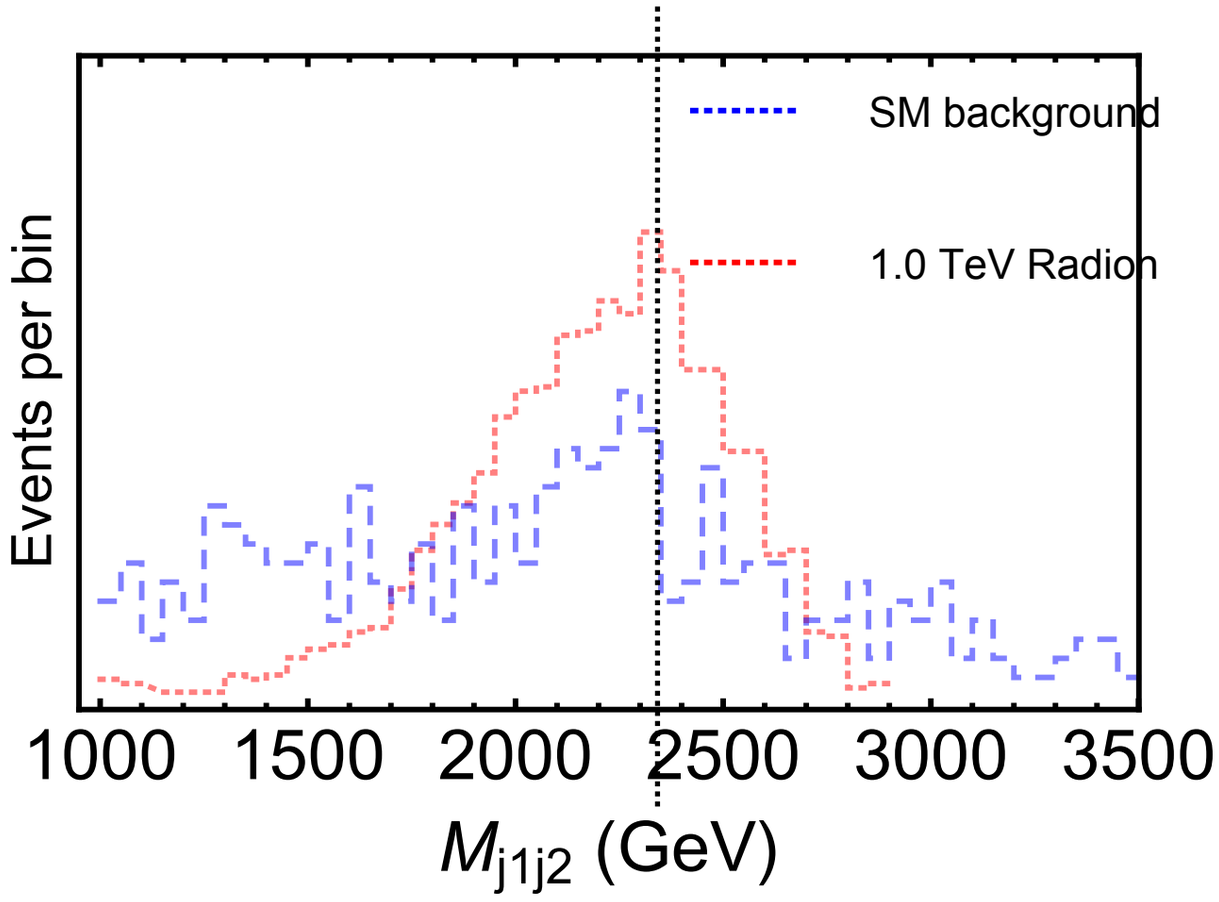


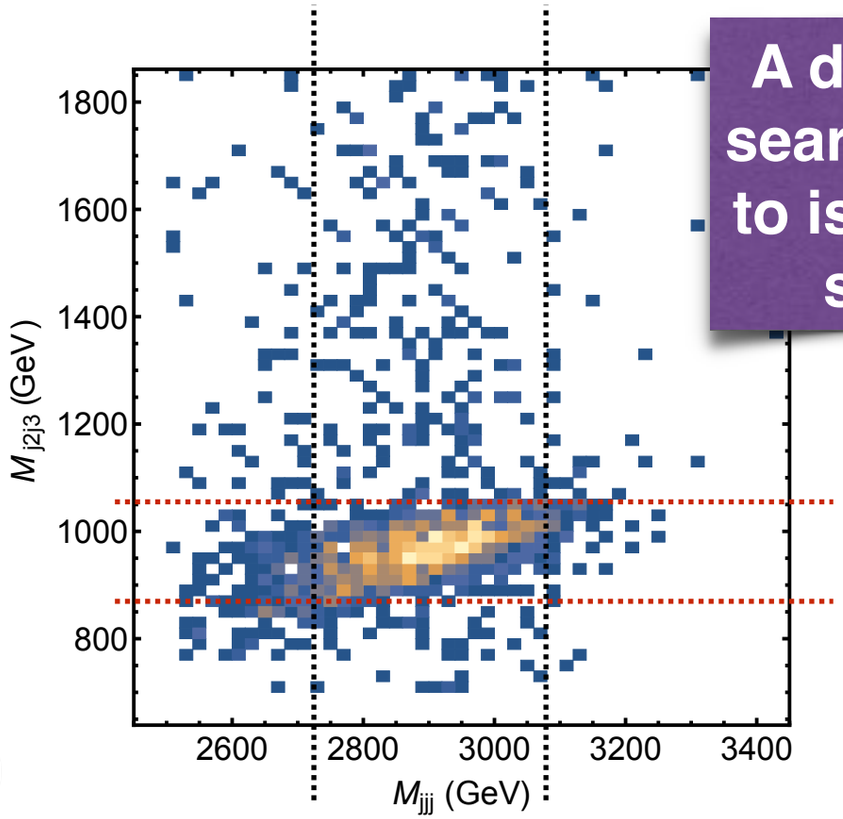


Hadronic 3 W (cont.) (Preliminary)

- In (**existing**) di-boson searches: Combinatorics makes the (2 highest pT) jet Inv. mass M_{12} broad. This is in addition to higher background from inclusive di-boson searches
  - Peak of M_{12} at lower scale
  - No jet tagging and high pT cut for third jet

A more detailed analysis is needed. (J. Collins, in progress)





A dedicated search useful to isolate the signal.

Summary

- Important to explore corners of theory space and confront them with data.
- New model considered: EW gauge boson in entire bulk in 3 brane RS model.
- 3W and W+di-photon signal in hadronic decay mode: possible to get high statistical significance. Signal can hide in data, dedicated search is needed.