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LHC black holes and the end of high-p_T physics

- How could this be possible?
- Why is it the end of high-p_T physics?
- Simulations
- Results
- Uncertainties
- Conclusion

Work done with Leif Lönnblad and Torsten Åkesson

Lund
2005.05.13
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- This could be solved if gravity was allowed to propagate in a lager space than the other forces

- Imagine for example that we have n extra dimensions with radius R reserved for gravity, then

$$V(r) \propto \frac{1}{M_{PF}^{n+2}} \frac{m}{r^{n+1}} \qquad r << R$$

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- This is the Arkani-Hamed Dimopoulos Dvali (ADD) model
- Modified version by Randall and Sundrum (RS) with curved space and only one extra dimension

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- If gravity is strong at 1 TeV, black holes can form at LHC
- This means that energetic partons which otherwise would have undergone a QCD scattering may be trapped behind the event horizon
- But the partons need to be well localized also in transverse direction
- Hence the end of high p_T-physics!

Simulations:

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- PYTHIA - favorite event generator

  Creates QCD events, but we cut some away according to

$$\frac{d\sigma_{\mathrm{QCD}}(Q^2)}{dQ^2 d\hat{s}} = \int dx_1 dx_2 \sum_{i,j} f_i(x_1, Q^2) f_j(x_2, Q^2) \frac{\hat{\sigma}_{ij}^{\mathrm{QCD}}(\hat{s}, Q^2)}{dQ^2} \times$$
$$\delta(\hat{s} - x_1 x_2 s) \left[1 - \Theta(\sqrt{\hat{s}} - M_{\min}) \Theta(Q^2 - \frac{const}{r_{Sch}^2(\hat{s})}) \right]$$

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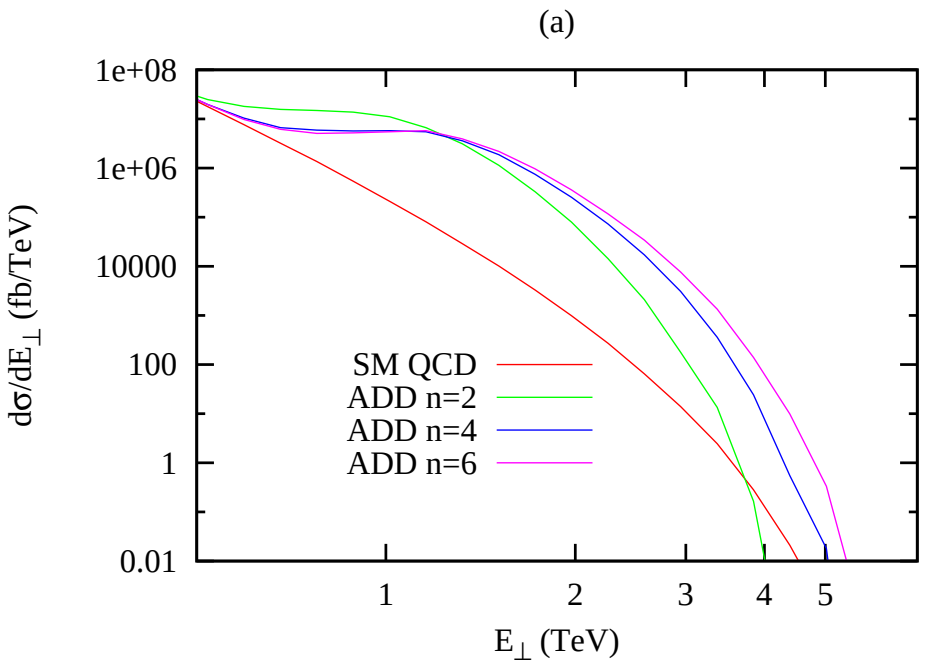
  Adjusts temperature according to mass, $T \propto 1/r(m)$

Results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1e+06
10000
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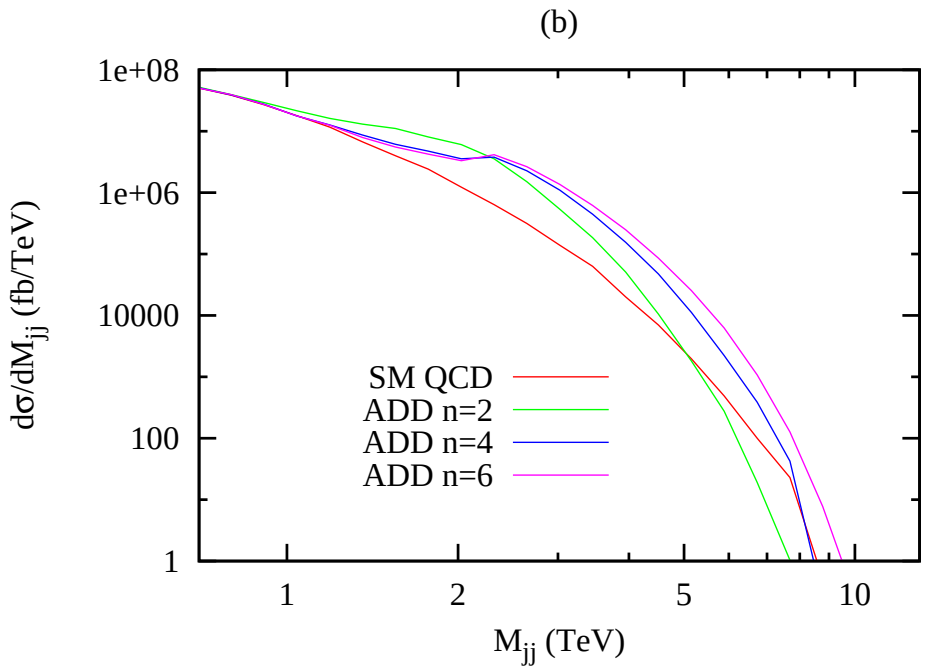
0.01
dσ/dE⊥ (fb/TeV)
SM QCD
ADD n=2
ADD n=4
ADD n=6
1
2
3
4
5
E⊥ (TeV)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1e+06
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100
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dσ/dMjj (fb/TeV)
SM QCD
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ADD n=4
ADD n=6
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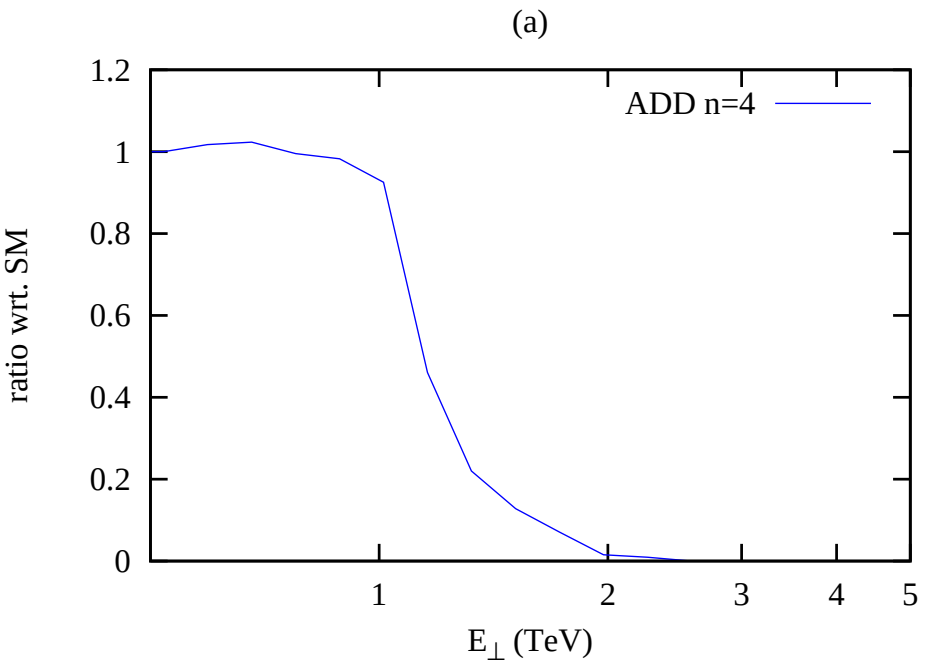
2
5
10
Mjj (TeV)

Results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0
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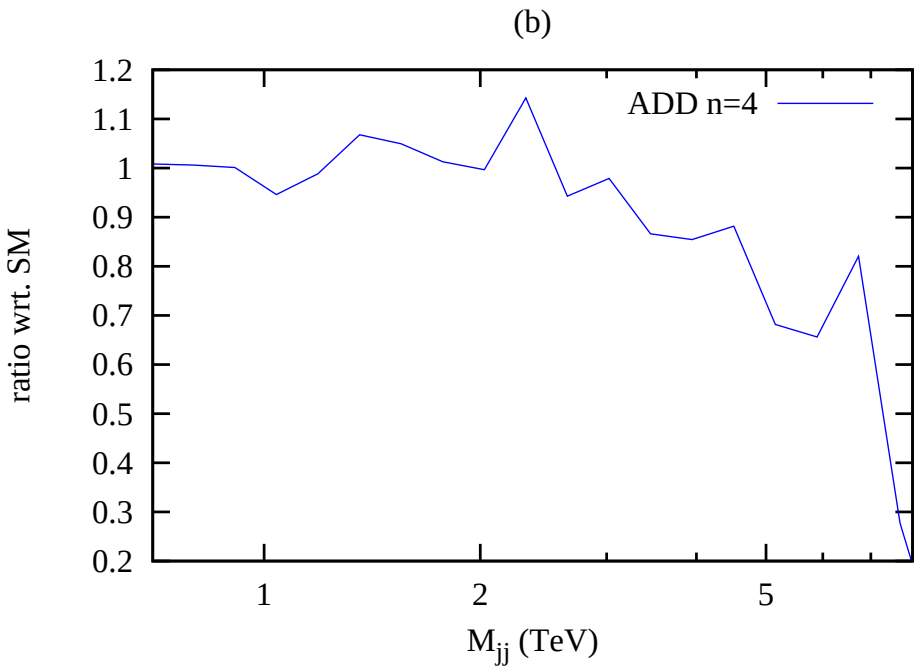
2
3
4
5
E⊥ (TeV)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ADD n=4
ratio wrt. SM
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
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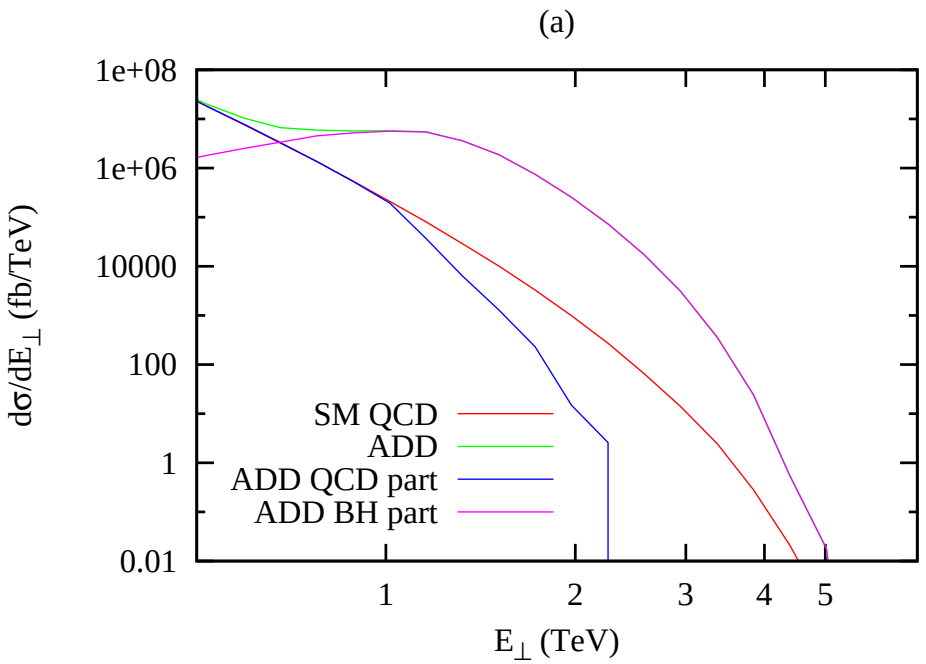
(a)
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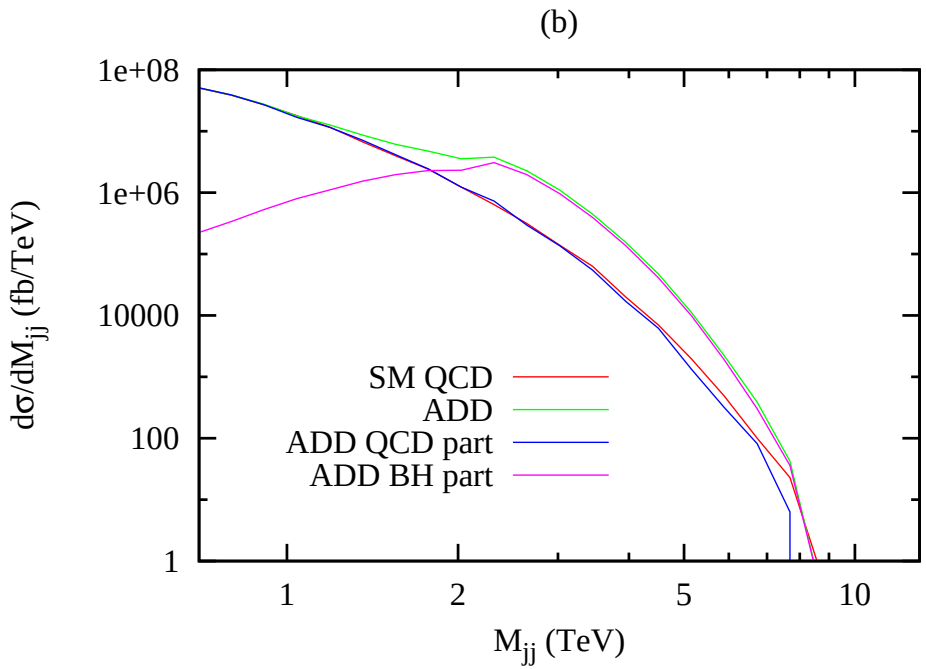
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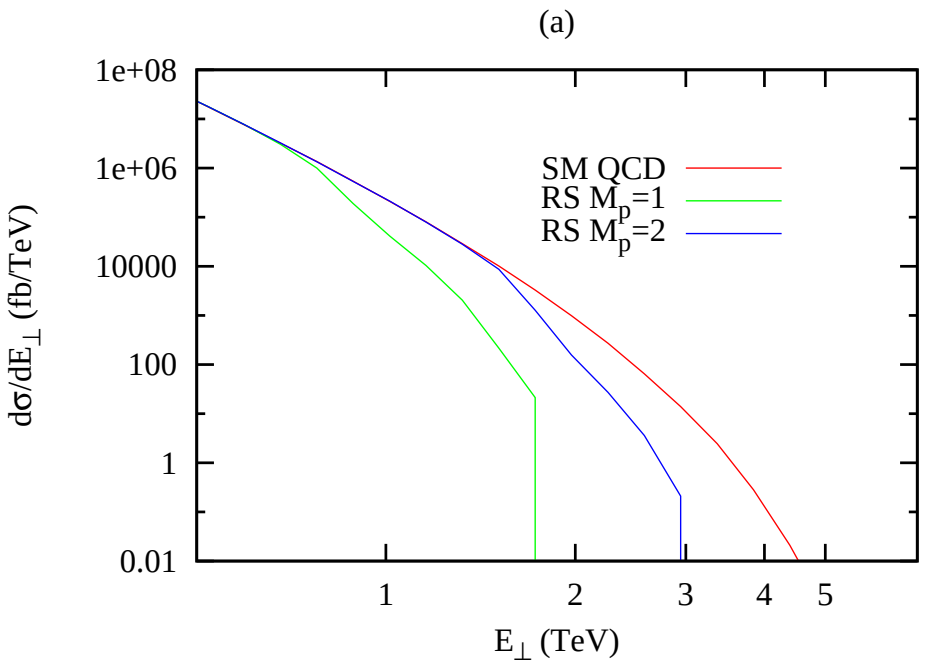
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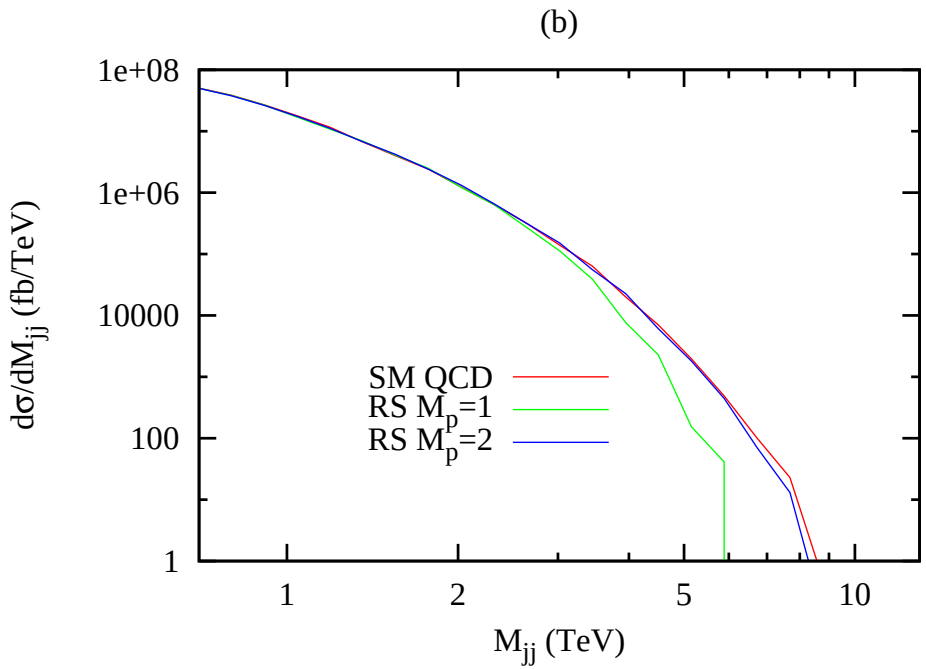
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CAROLINÆ
SIGILLVM
AD VTRVMQVE

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- How do we terminate the decay of the black hole?

  2 particles when we reach M_p

  More particles $\longrightarrow$ Fewer energetic particles

  $\longrightarrow$ Better chance to observe QCD drop

- Gravity important before black hole production?

  Yes, we should have non black hole gravitational events.

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- But this may (naively) be camouflaged by the black hole decay products for rather large transverse energies
- More sophisticated methods are needed to observe QCD drop
- If the black hole is stable on collider timescales (RS) there is no radiation to camouflage the drop