Emancipation Oak

RS gravitons in an ATLAS full simulation

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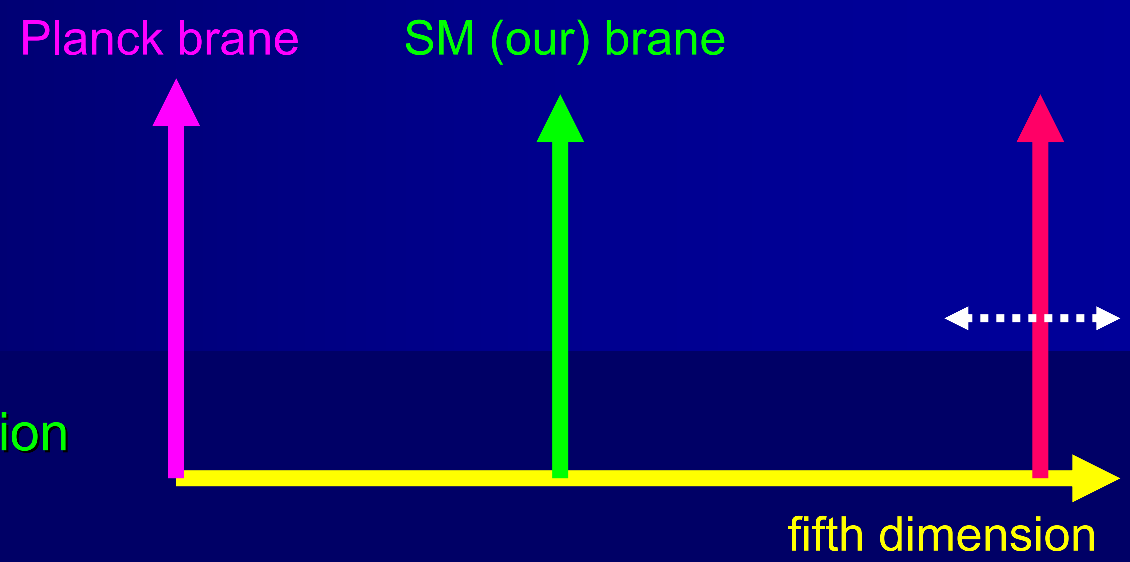
Summary

- Randall-Sundrum graviton production and decay (to e^+e^- and 4e) has been simulated for the ATLAS detector within the full Athena framework, release 10.0.1
- The emphasis has been on discovery potential in initial running
- Further work is underway.

Randall-Sundrum gravitons

- warped extra dimensions (Randall-Sundrum model PRL 83, 3370 (1999))
- narrow graviton resonances; isolated (?)
- decay to SM particles

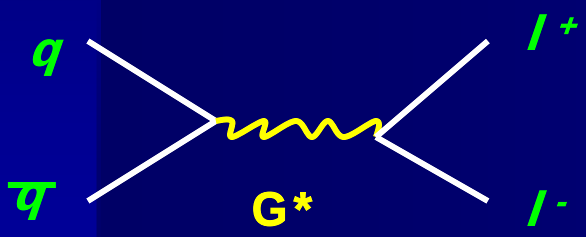
J. Lyyken and L. Randall

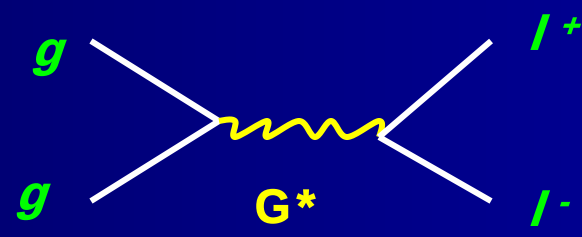


- predictions for . . .
  - dark energy
  - Higgless mass generation
  - dark matter
  - hierarchy problem
  - . . .

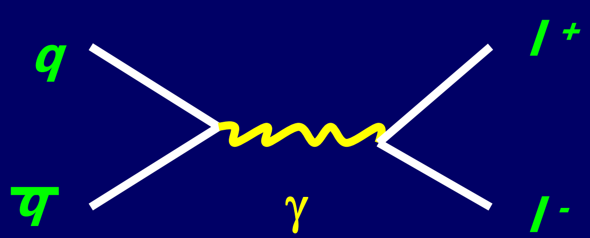
Parameters, processes . . .

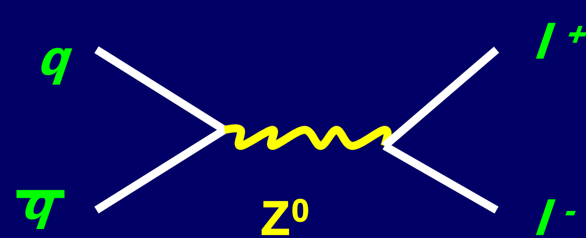
- $\Lambda \sim k \cdot \exp(-k r_c \phi_0) \sim \mathrm{TeV}$ exponential is 'warp factor'
- k is the curvature scale ($kr_c \sim 12$)
- $m_n = x_n \cdot \Lambda$ mass of *n*th KK graviton, where x_n are the zeros of the first order Bessel function.





Signal



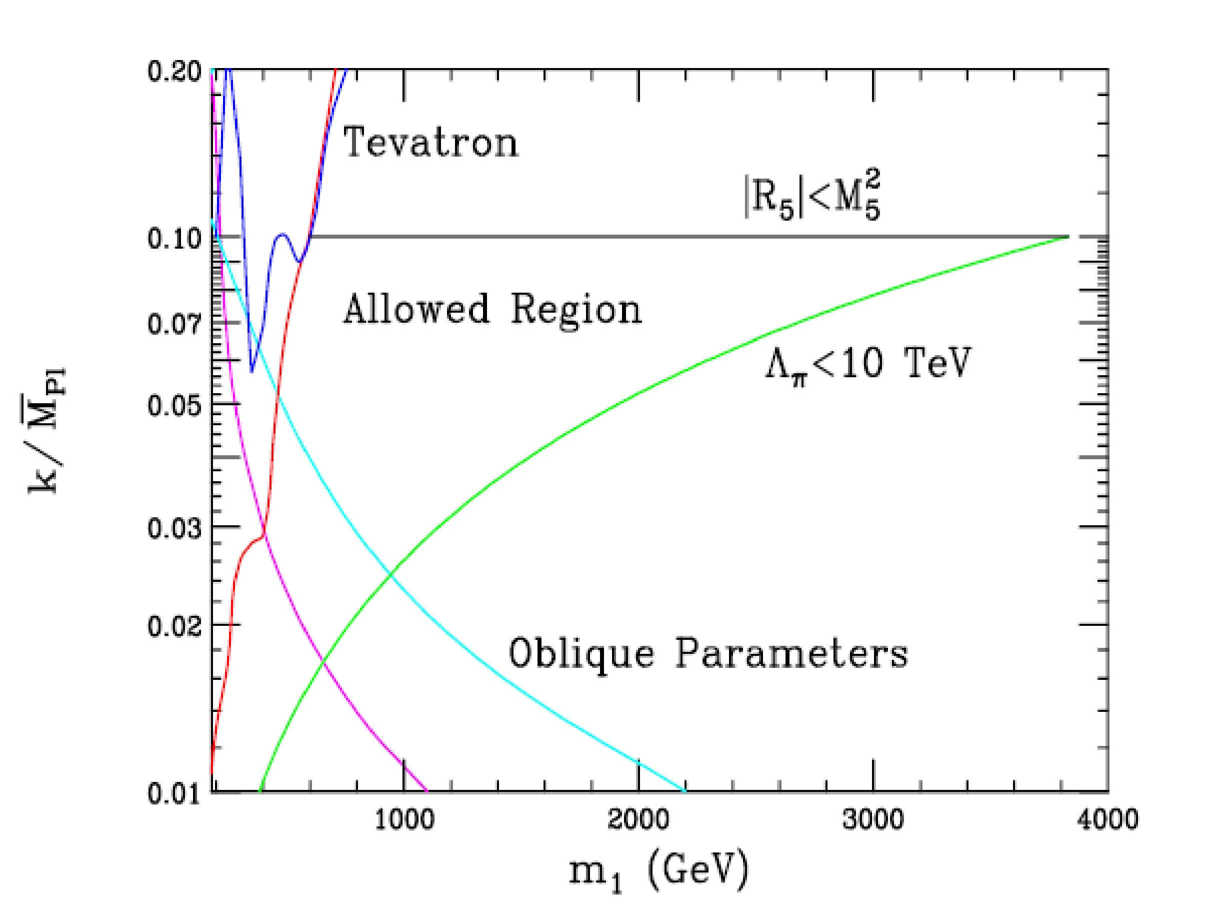


Main background is DY

Please note: elsewhere in the talk, qq means q-qbar.

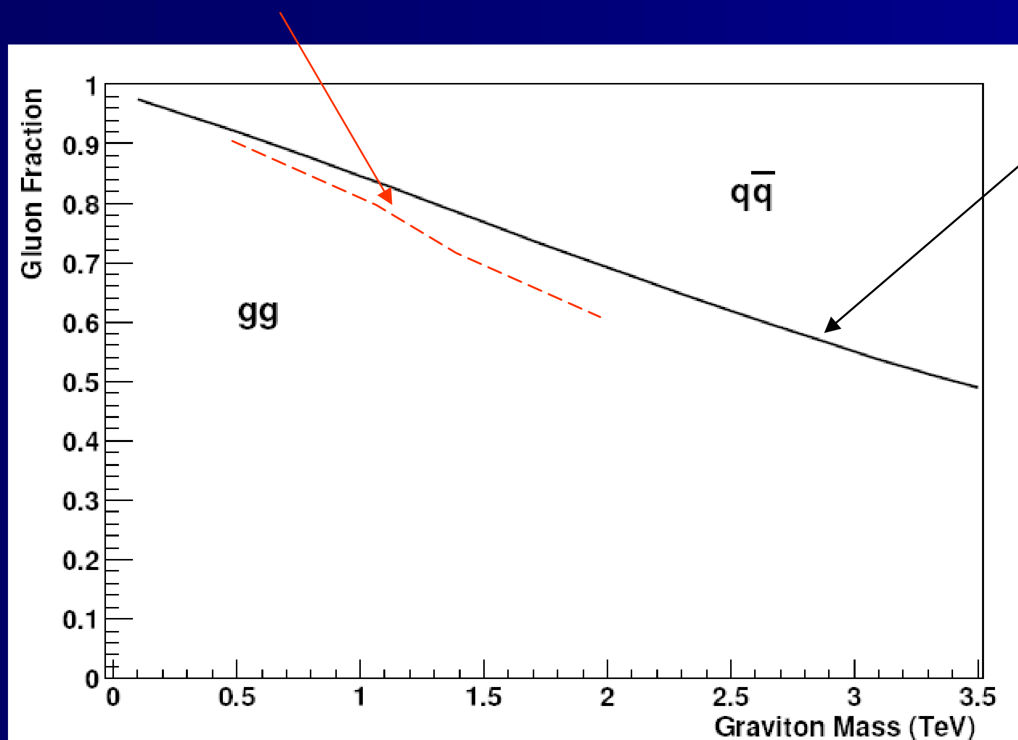
Allowed region

- From Davoudiasl *et al*., SLAC-PUB-8436, 2000



Ratio of *qq*bar/gg production vs. mass

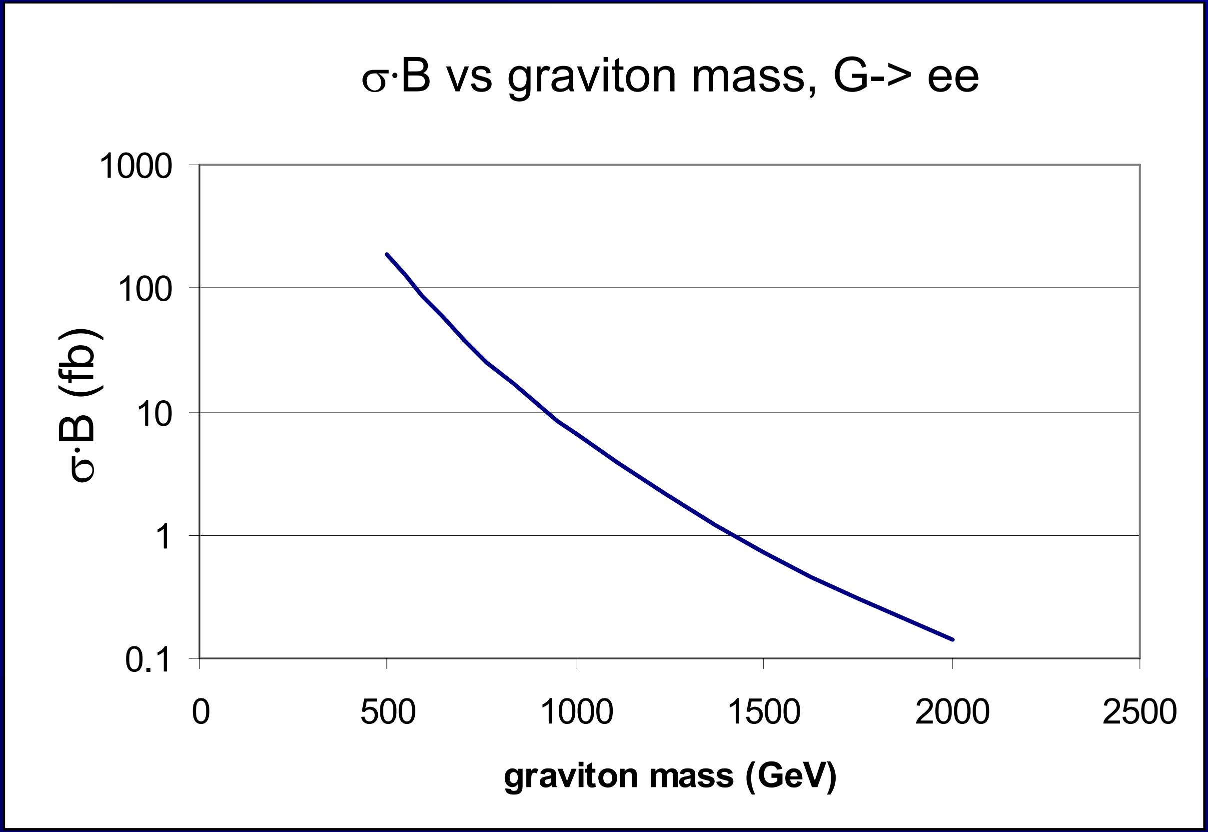
This study:



Allanach et al. ATL-COM-PHYS-2002-043

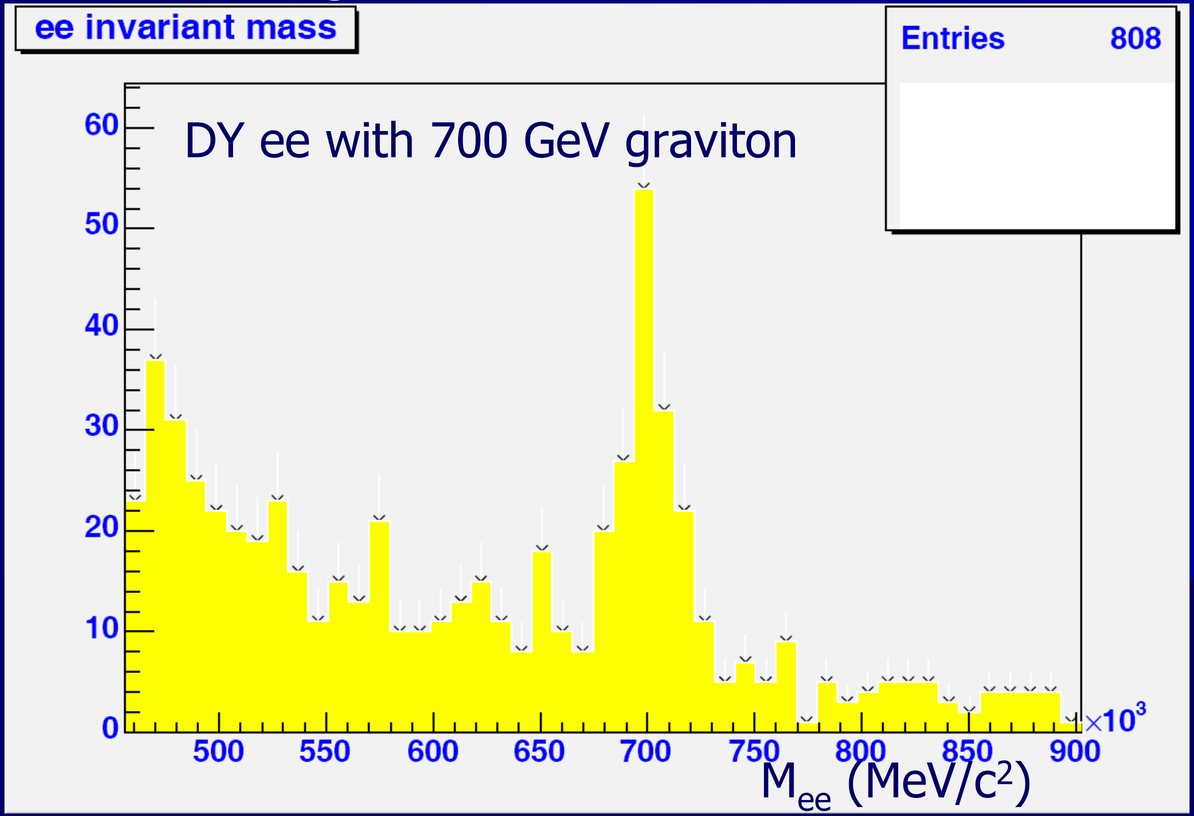
Cross-section and B.R. for *G→ee*

B.R.:
500 GeV, 0.0209
2000 GeV, 0.0204



Sample full simulation plot

700 GeV graviton -> *ee* combined with DY background. Separately simulated with matching statistics

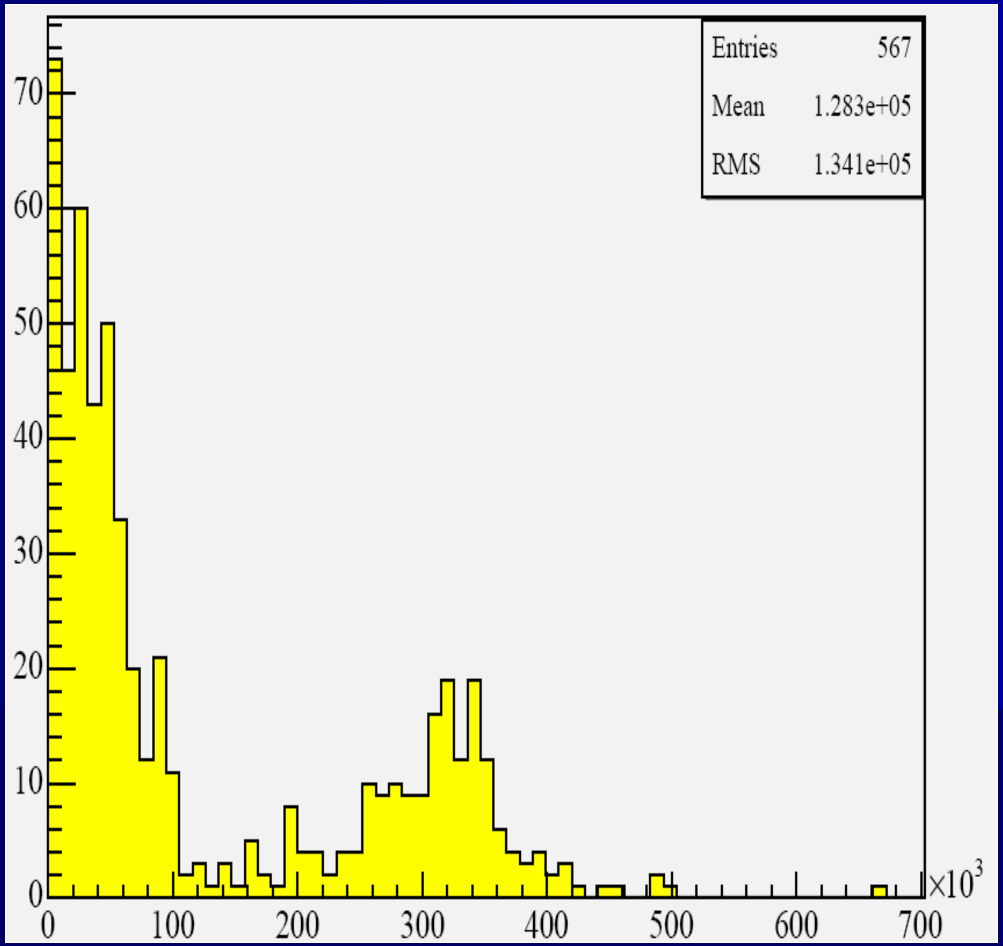


Backgrounds simulated

- Top production, *t* and *t*-*t*bar $\rightarrow$ *ee*
- *Z* production, *Z* $\rightarrow$ *ee* and jets
- Drell-Yan $\rightarrow$ *ee*

Top production background (1)

p_T distribution of electrons from *G* and *t* decays.
A p_T cut will reduce this.

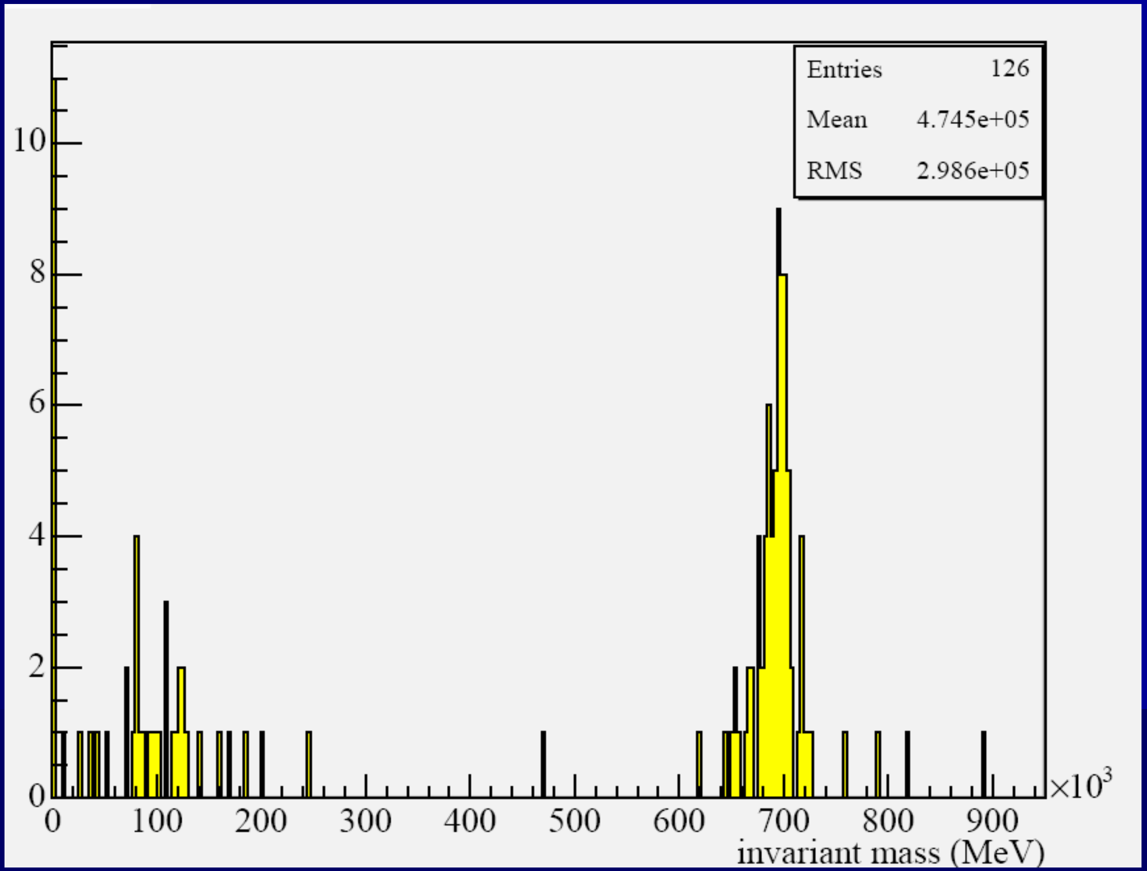


p_T (Mev/c)

Top background

Reconstructed *ee* mass from *t*-*t*bar and 700 GeV graviton.

With p_T cut, the background at the graviton mass is negligible.

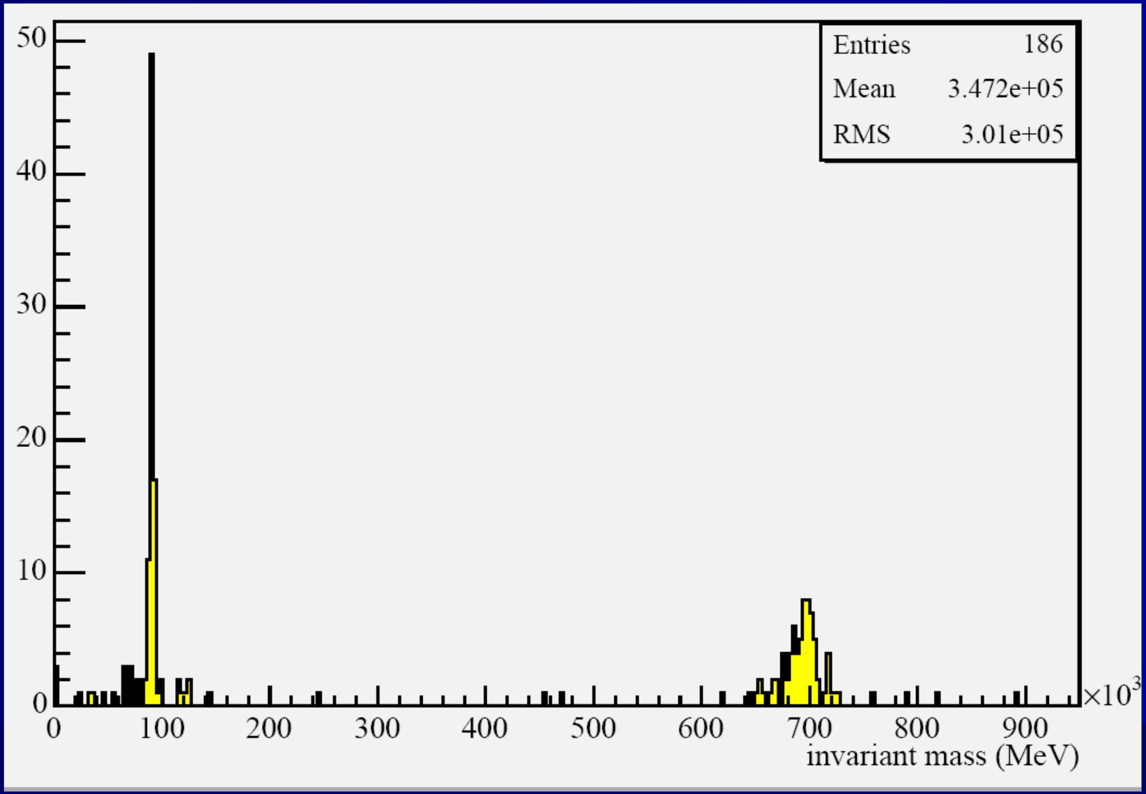


M_{ee} (MeV/c^2)

Z production background

Reconstructed mass from $Z \rightarrow ee$ and jets, and 700 GeV graviton.

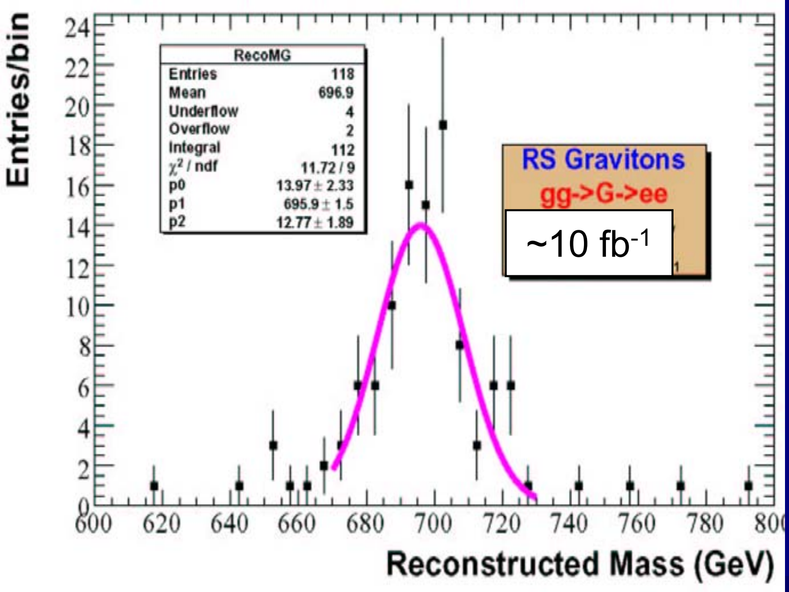
Background at the graviton mass is negligible.



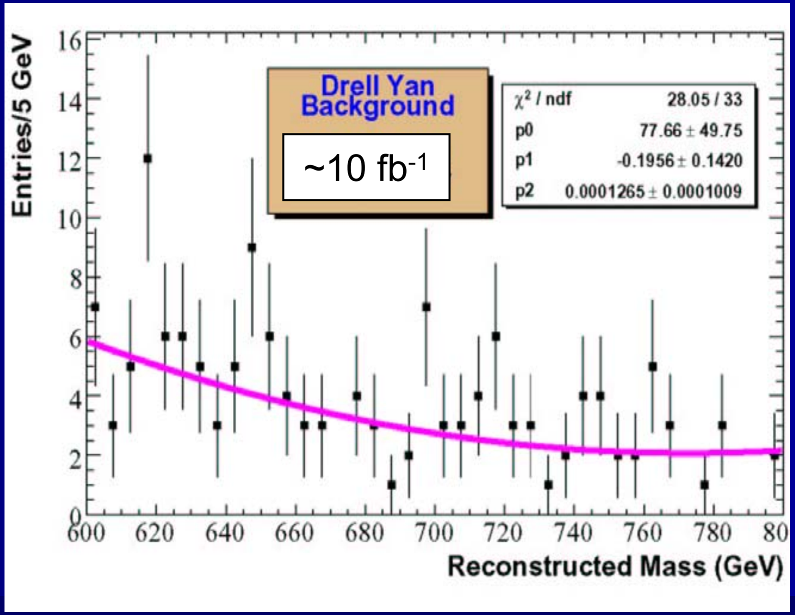
M_{ee} (MeV/c^2)

Drell-Yan background

Graviton only



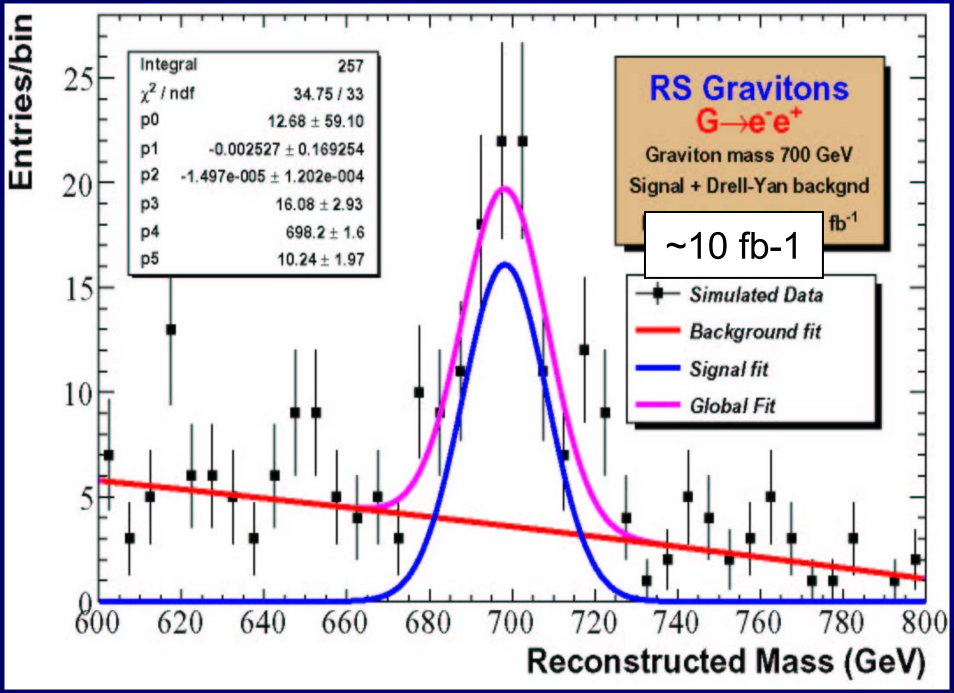
Drell-Yan *ee* (background)



The Drell-Yan background is significant; it is the only one considered in what follows.

Analysis (700 GeV graviton)

Graviton + Drell-Yan *ee*

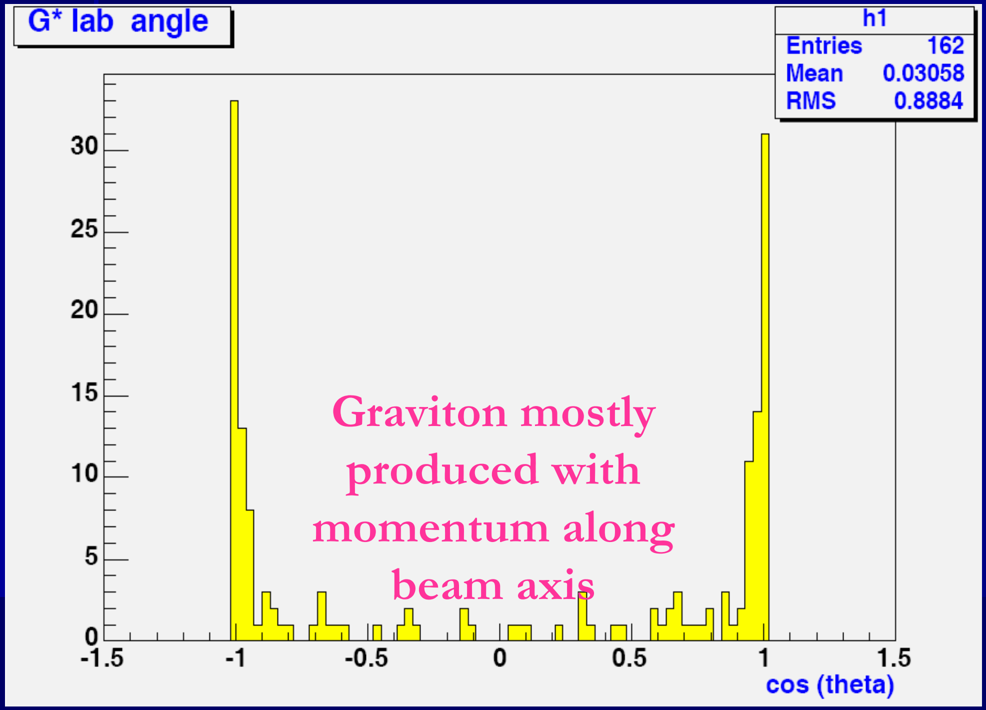


Fit to graviton only: M_G = 695.9 ± 1.5 GeV (previous slide)

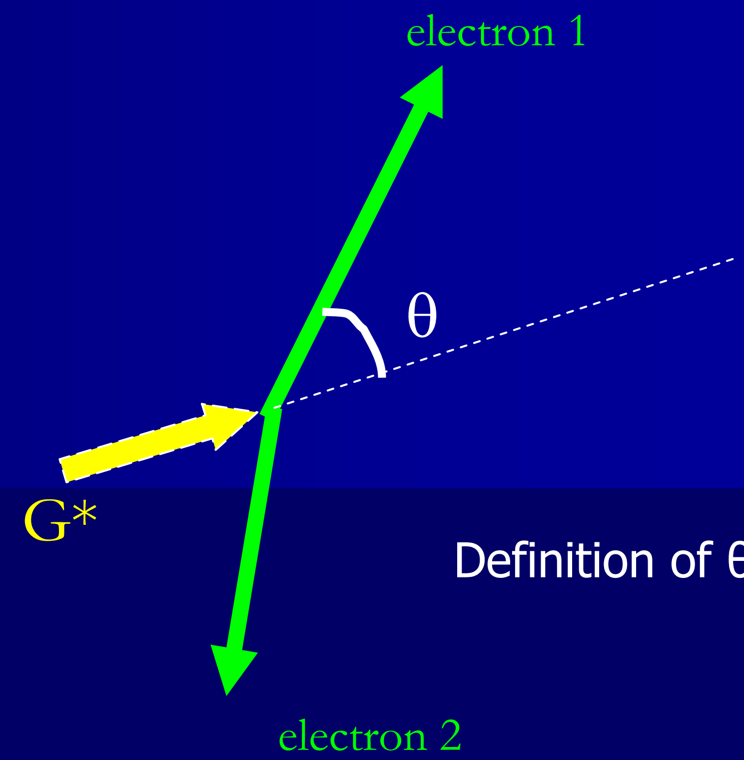
Fit to G+DY background: M_G = 698.2 ± 1.6 GeV

Angular distributions

Graviton production angle relative to beam

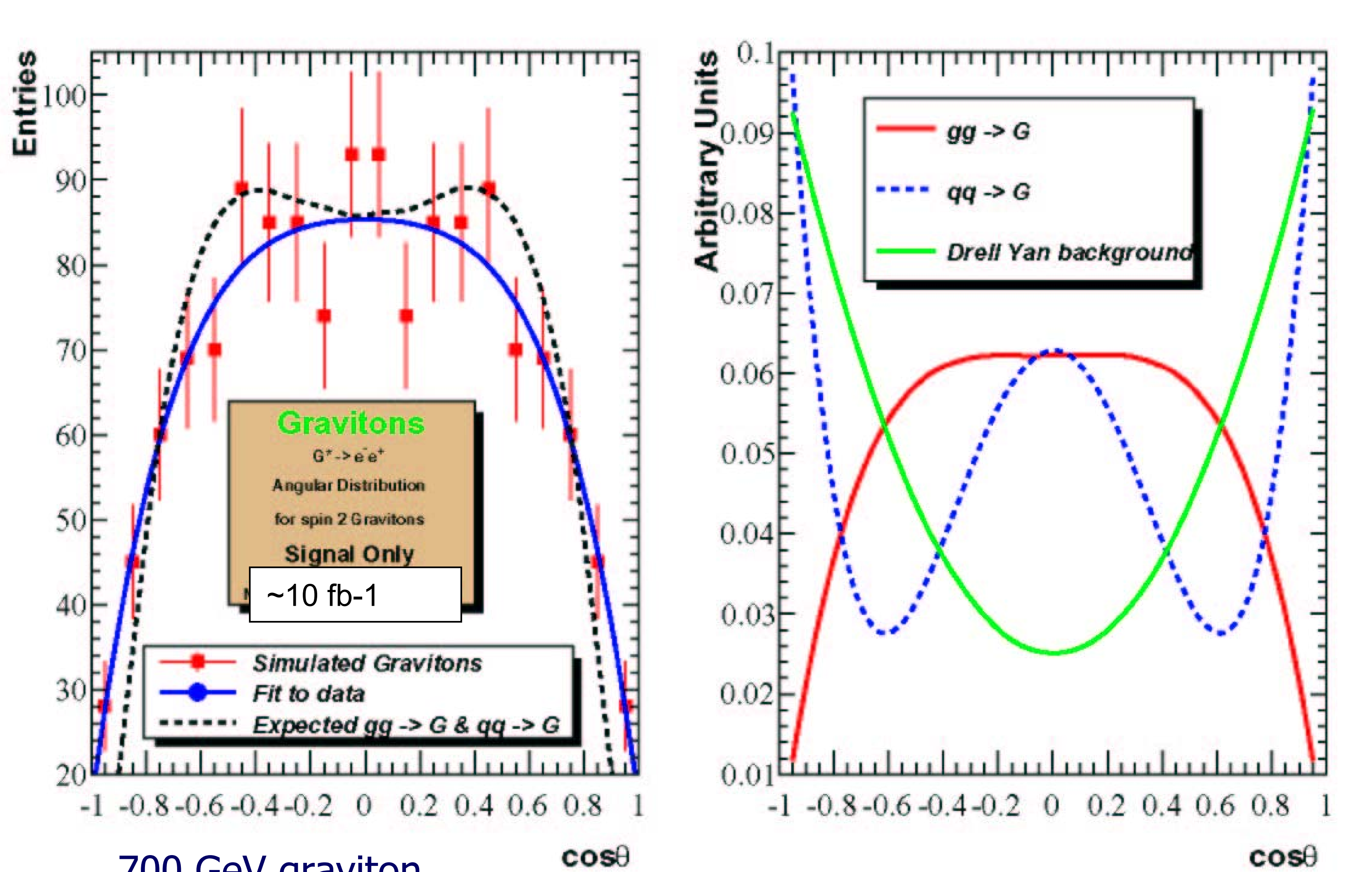


Angular distribution of electrons will differentiate spin 2 from spin 1



Definition of θ

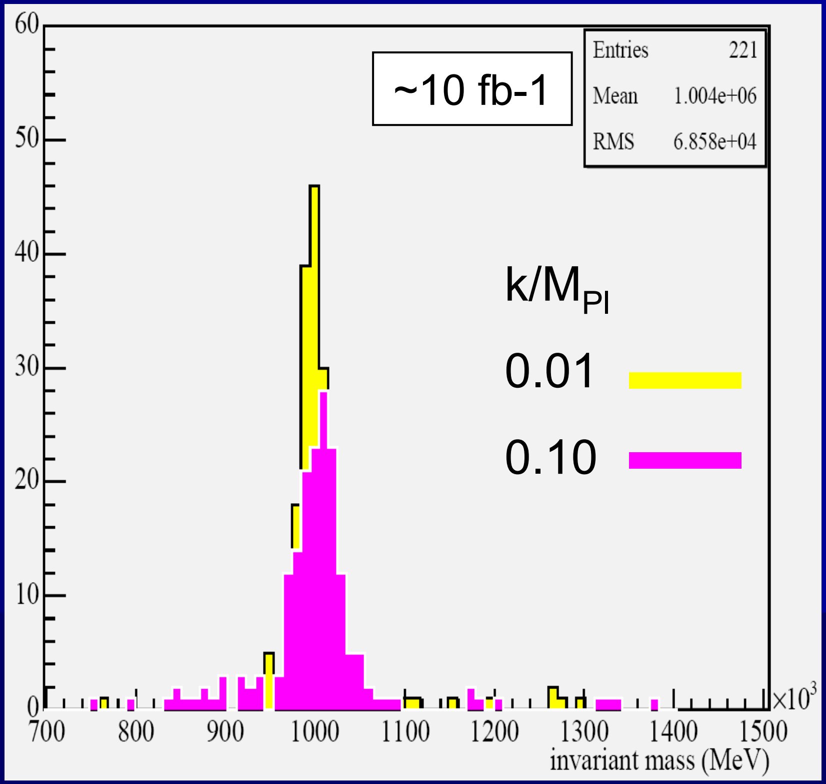
Graviton decay angular distribution



700 GeV graviton

Effect of varying k/M_{Pl}

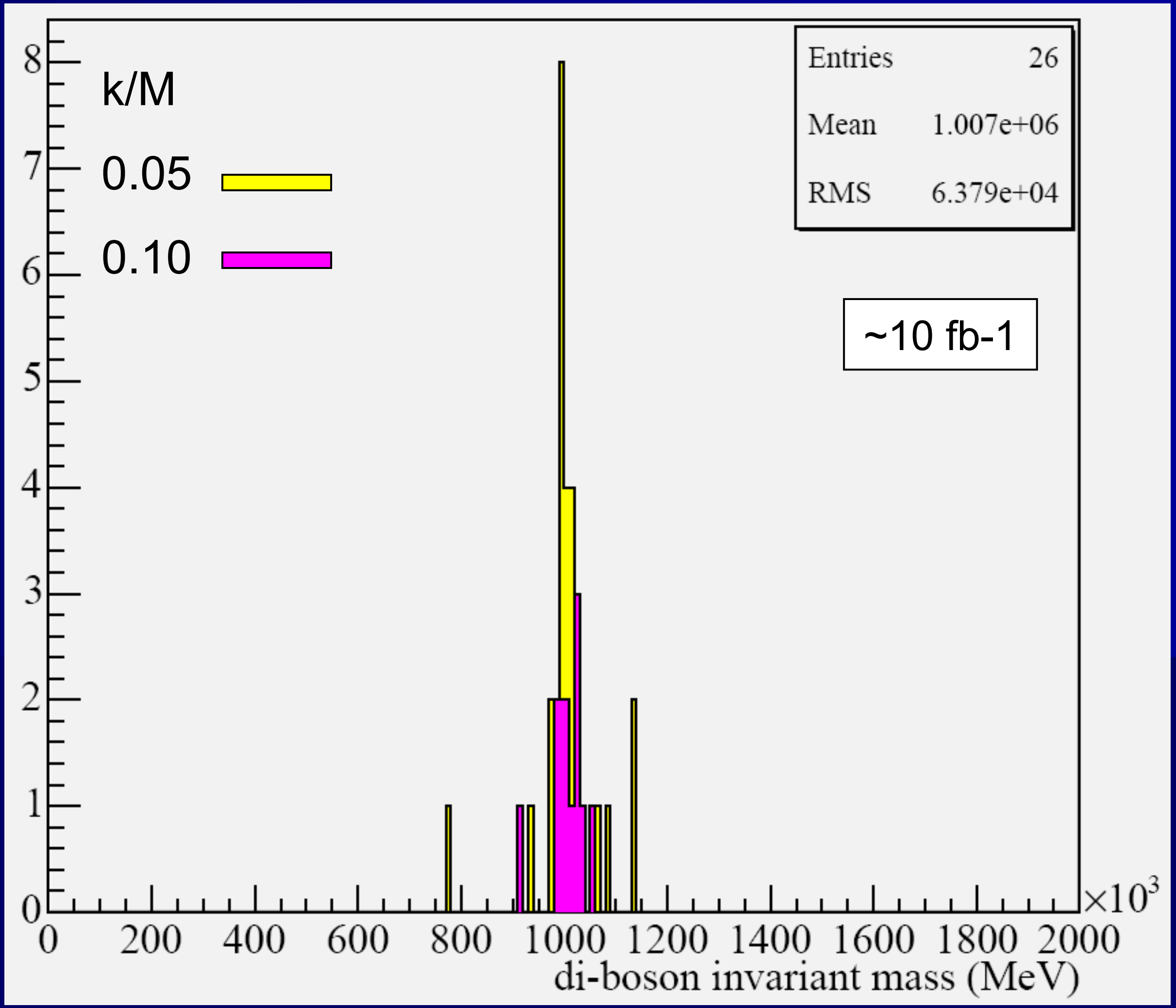
G → *ee* at 1 TeV. The histograms show the the distributions at *k/M* = 0.01 and 0.10. The widths differ slightly. The same number of input events are used in both cases.



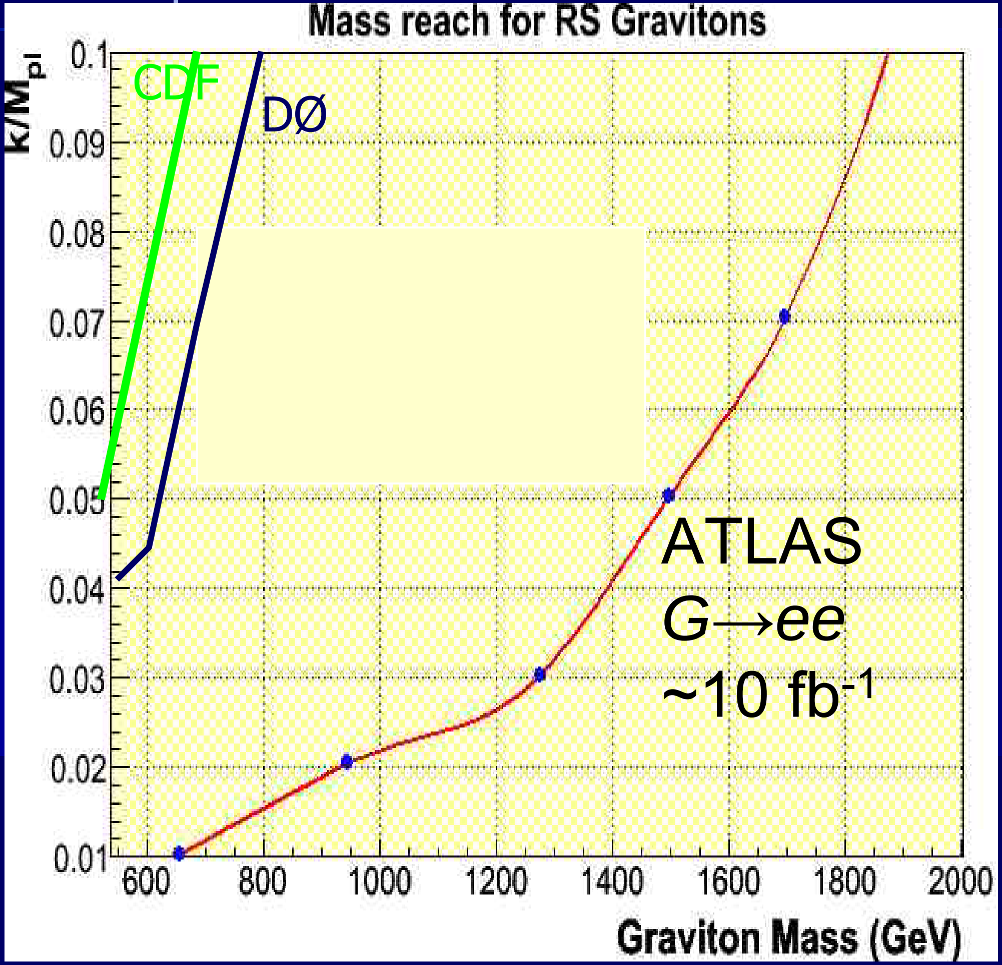
G → ZZ →4e at 1 TeV

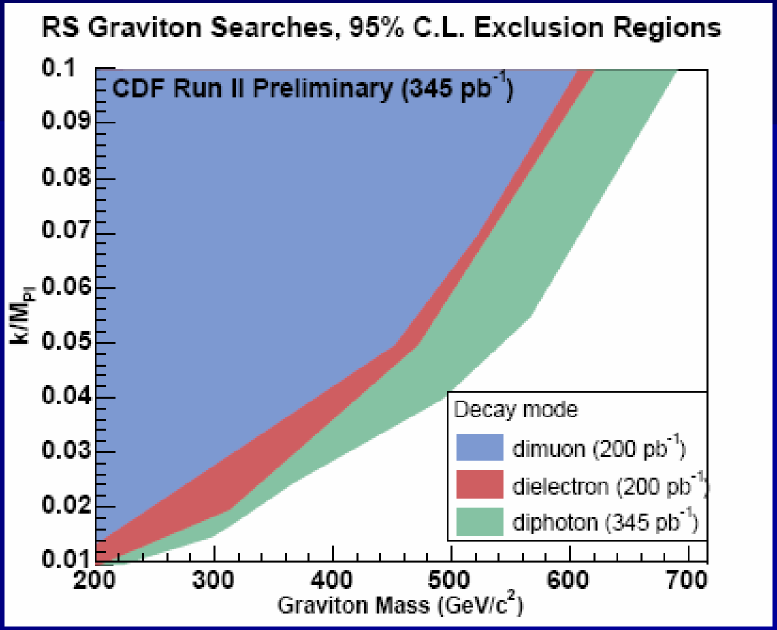
G → *ZZ* →4*e* at 1 TeV for *k/M* = 0.05 (20 events input) and 0.10 (50 events input).

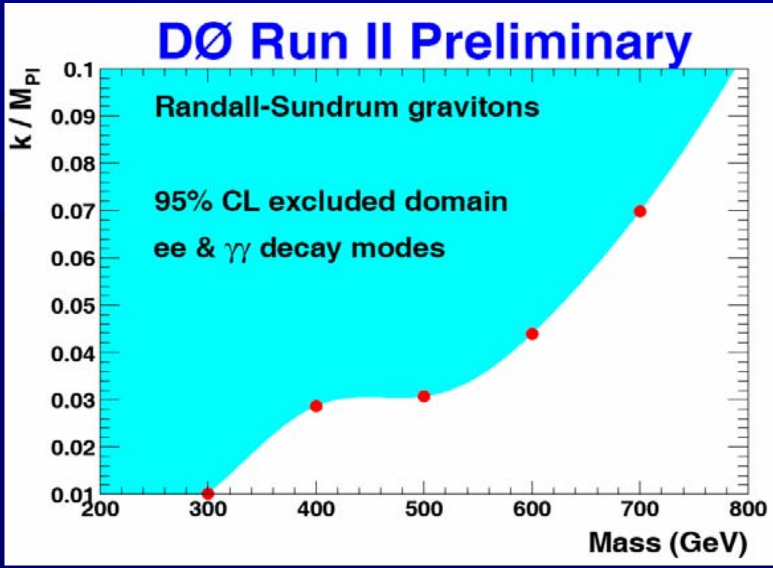
Note low number of events



Comparison to Tevatron data







Conclusions

- The graviton mass is reconstructed close to the generated mass, with a resolution that allows a narrow cut on mass, reducing backgrounds
- Backgrounds are small
- Discovery of a low-mass RS graviton, or exclusion of a large part of the allowed region can be achieved in early running
- Spin-determining angular distributions for a low mass RS graviton can be obtained in early running.

Work to be done

- Generate and analyze samples up to 4 TeV, k=0.16, to define discovery limits, for different luminosities
- Evaluate effect of LVL1, HLT, EF, and analysis cuts on efficiencies
- Evaluate statistics needed to determine spin across range of masses
- Look at n = 2 for lower mass gravitons?
- Etc.