Gluon Radiation in Top Quark Production and Decay

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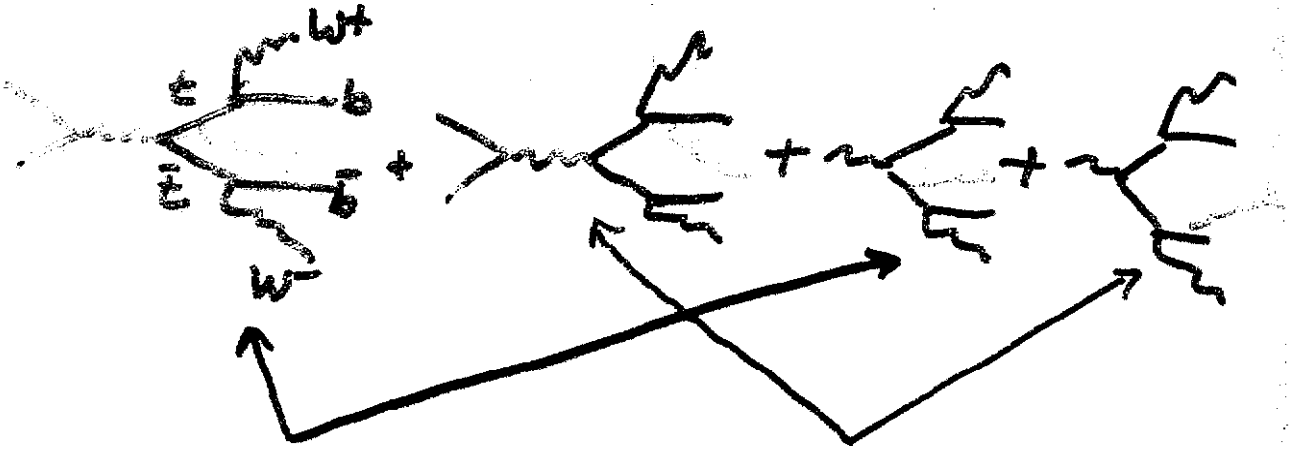
Gluons and top at lepton colliders

- Future e+e- or μ+μ- colliders will provide a relatively clean environment in which to study top physics.

- **Why study gluons?**
  - ▷ top event identification
  - ▷ mass reconstruction from jets
  - ▷ 'fuzziness'
    = systematic effects in anything to do with top

- **Where do gluons** come **from?**
  No gluons from initial state; **but final** state radiation from both top production, **and** decay:



Production & decay Decay **only**

Preliminary results: e+e- → bWbWg

- Monte Carlo calculation includes exact ME for real gluon emission in top production and decay with:
  - ail spin correlations
  - finite width in t propagator
  - b mass
  - all interferences
  - exact kinematics

- Product&on-decay decomposition
  - Is mt equal to

    p_{bW}^2 or p_{bWg}^2 ??

    … what about interference?
  - How we distinguish:

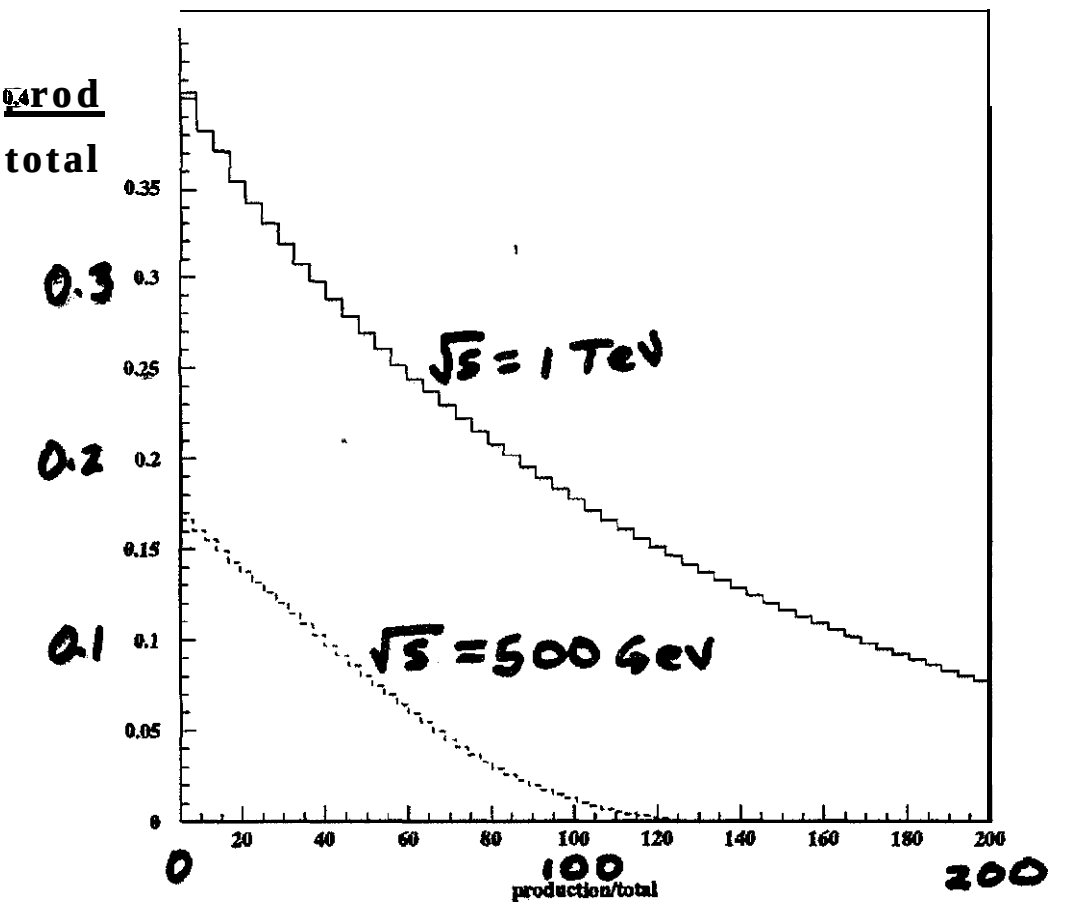
$$ME \sim \left(\frac{1}{p_{bW}^2 - m^2 + im\Gamma}\right)\left(\frac{1}{p_{bWg}^2 - m^2 + im\Gamma}\right)$$

$$= \frac{1}{2 p_{bW} \cdot p_{bWg}}\left(\frac{1}{p_{bW}^2 - m^2 + im\Gamma} - \frac{1}{p_{bWg}^2 - m^2 + im\Gamma}\right)$$

production decay

Fraction of emissions radiated in production stage

e+e- collisions



E_{cm} = 1 TeV

E_{cm} = 500 GeV

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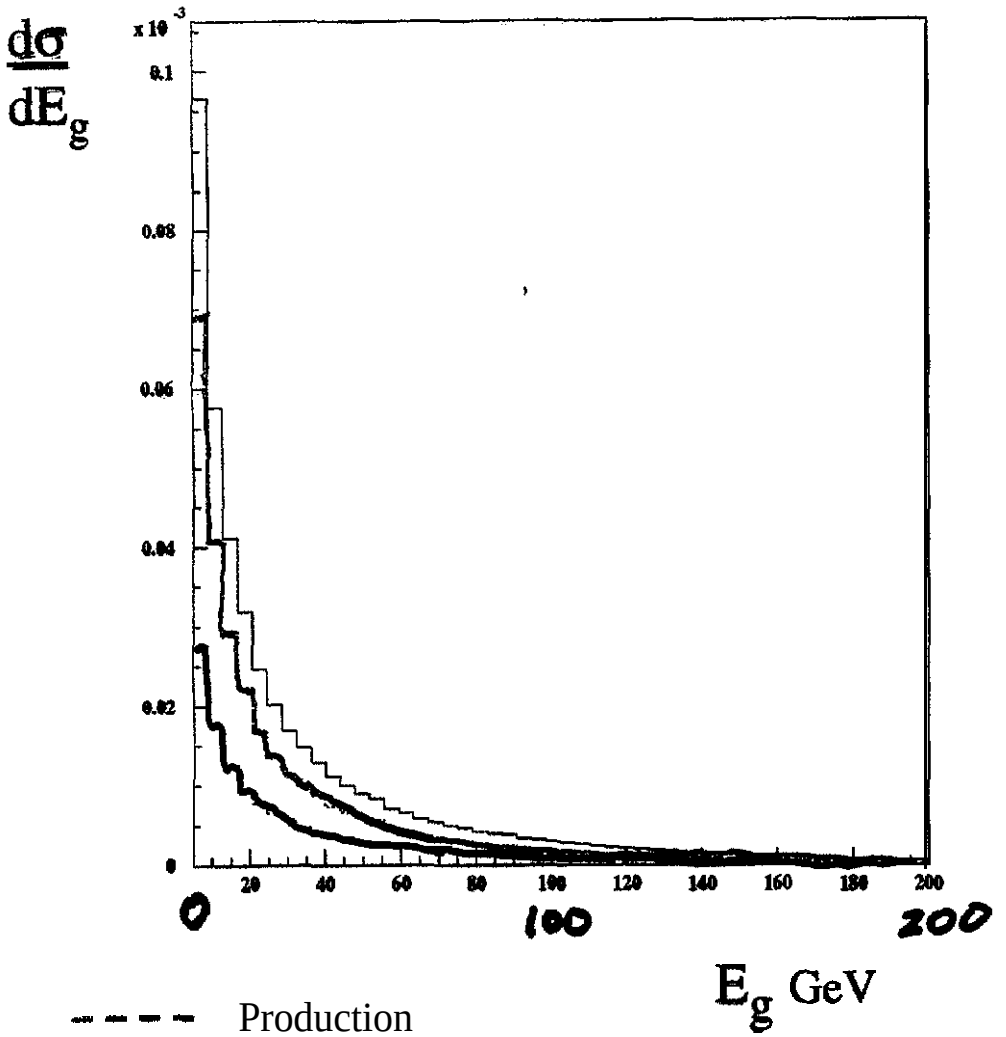
Gluon energy spectrum

e+e- collisions: E_{cm} = 750 GeV



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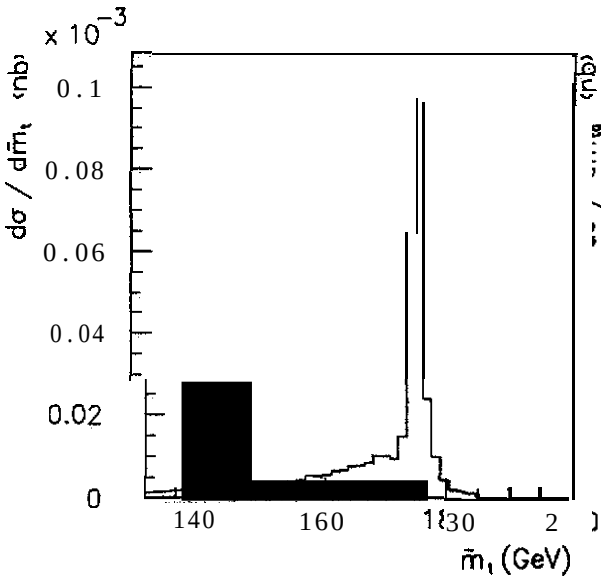
Top mass reconstruction



$\sqrt{p^2_{bW}}$ $\sqrt{p^2_{bWg}}$

$E_{cm} = 600\ \text{GeV}$

$E_g > 10\ \text{GeV}$

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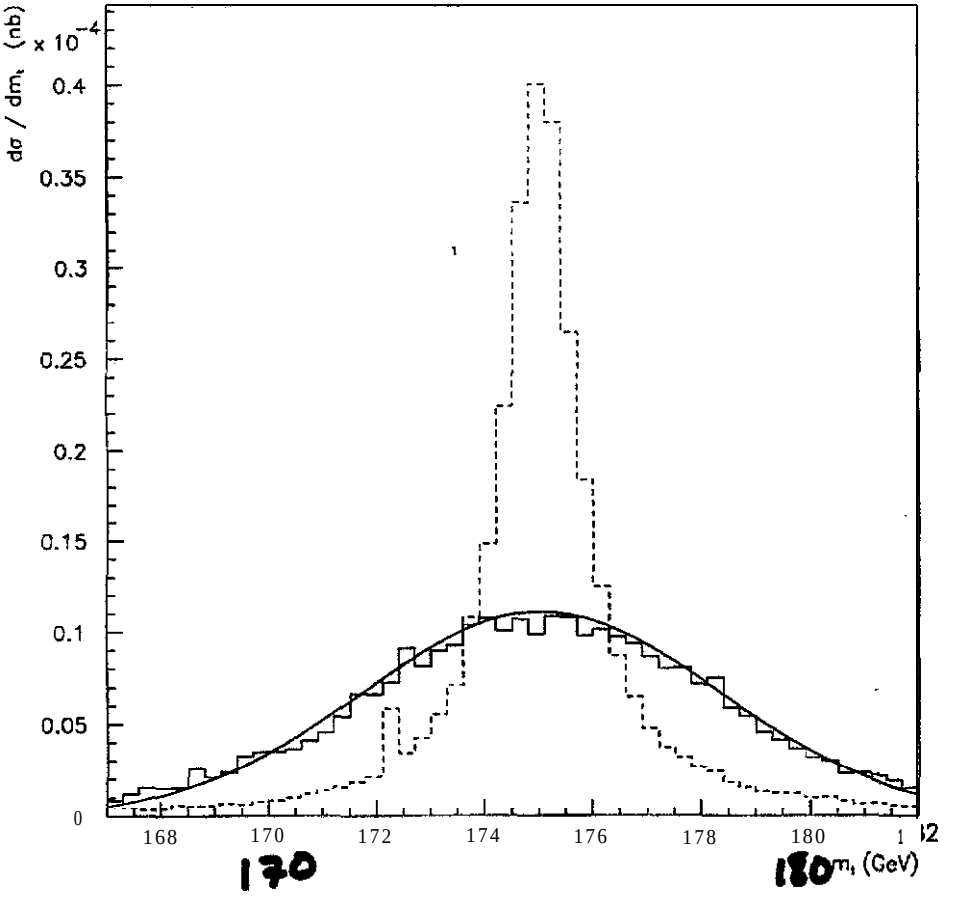
Top mass reconstruction

$E_{cm} = 600$ GeV

$E_g > 10$ GeV



Exact momenta

With E smearing

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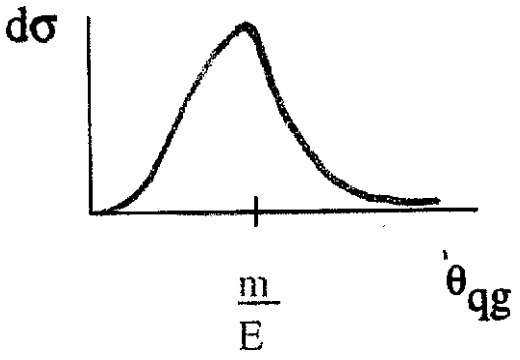
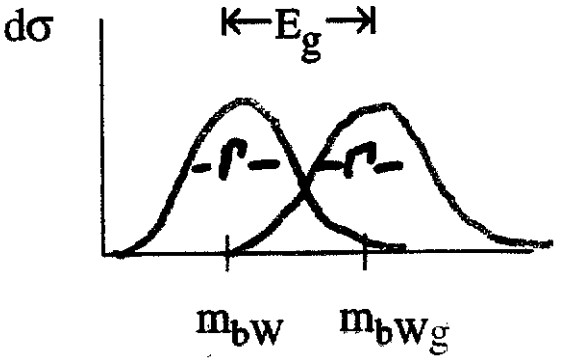
Gluons and top at lepton colliders

- 'Dead cone' for massive quarks



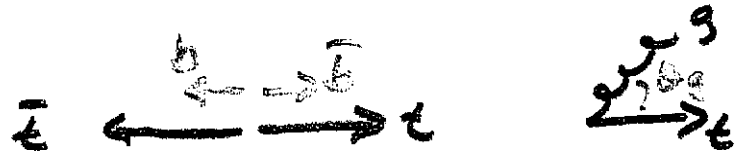
➡ radiation suppressed along quark direction

- Interference between production and decay radiation for $E_g \sim \Gamma_t$ (≈1.5 GeV). Imagine overlapping [illegible]:

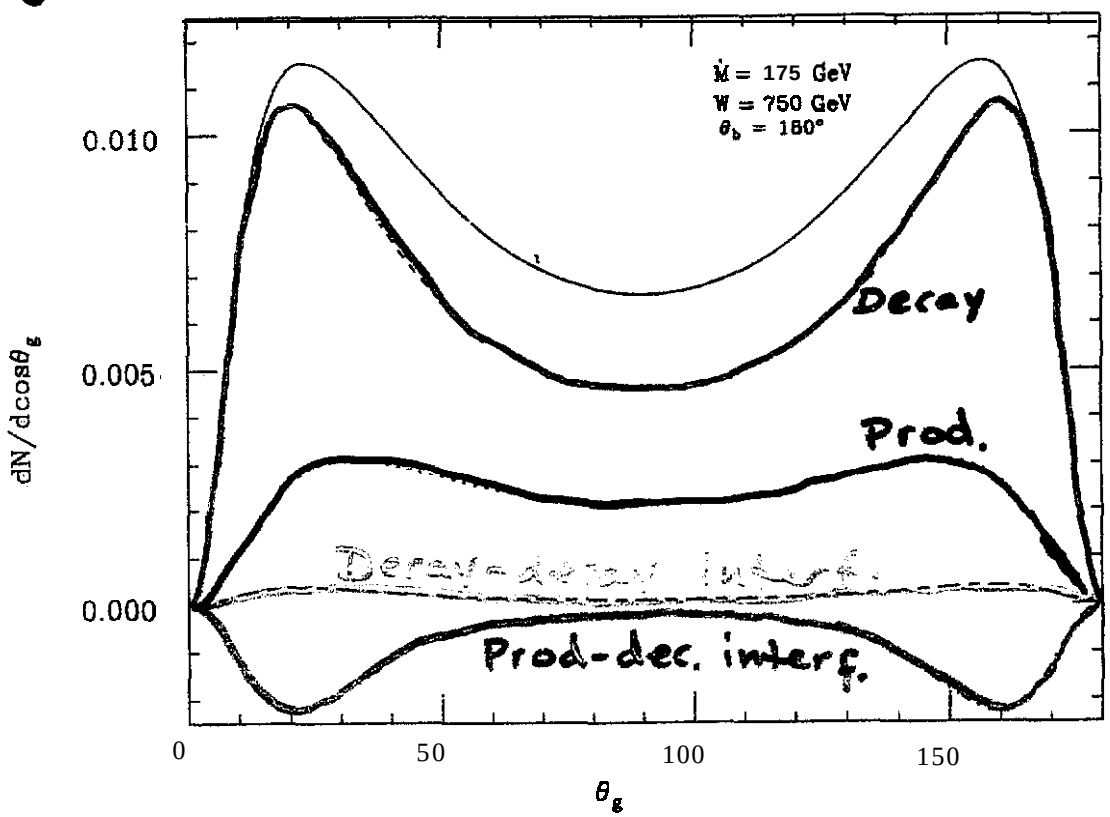


➡ [illegible] sensitive to Γ_t

Soft Gluon Radiation in $e^+e^- \to t\bar{t}$



Khoze
LHO
Stirling

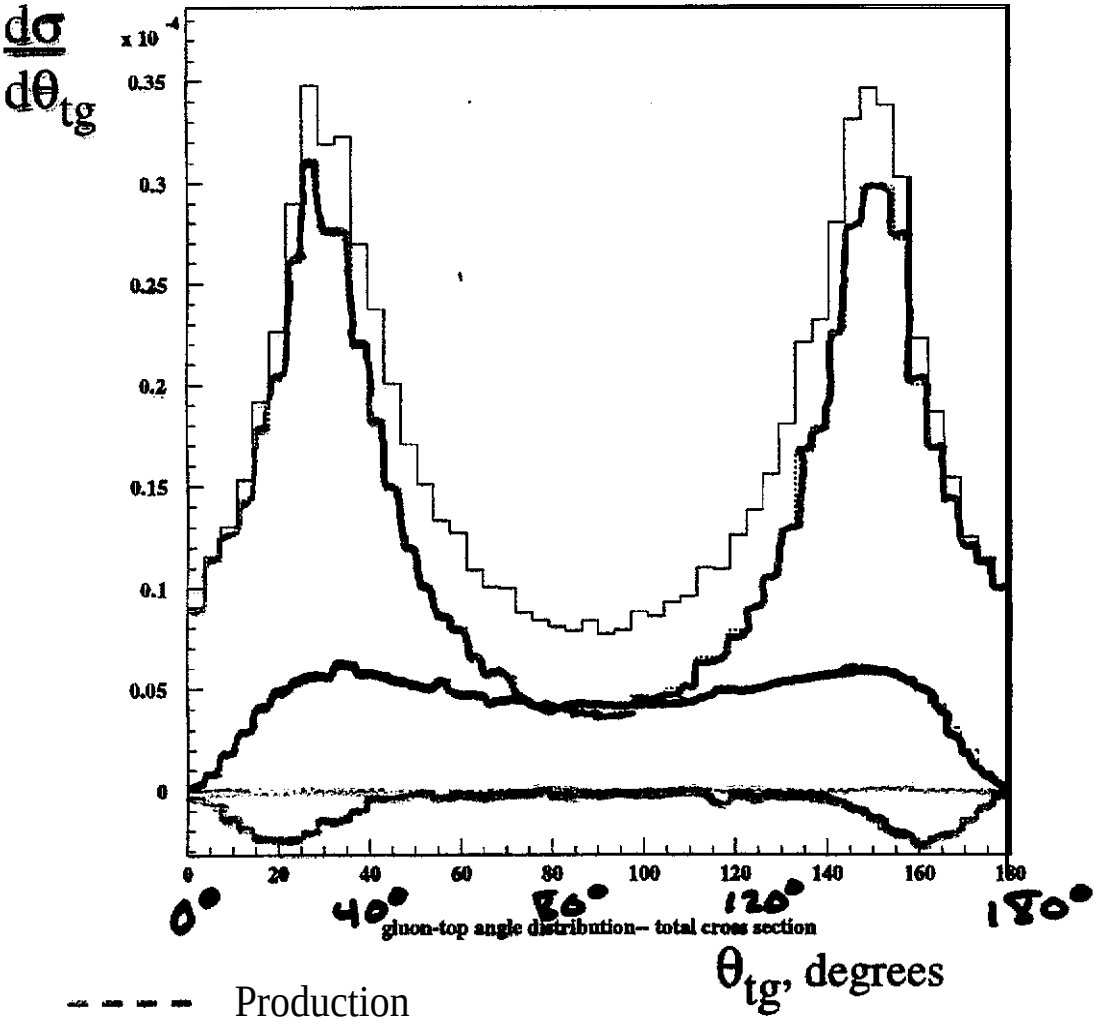


Top-gluon angle

e+e- collisions, $E_{cm} = 750$ GeV

$\cos\theta_{tb} < 0.9$

$5 < E_g < 10$ GeV



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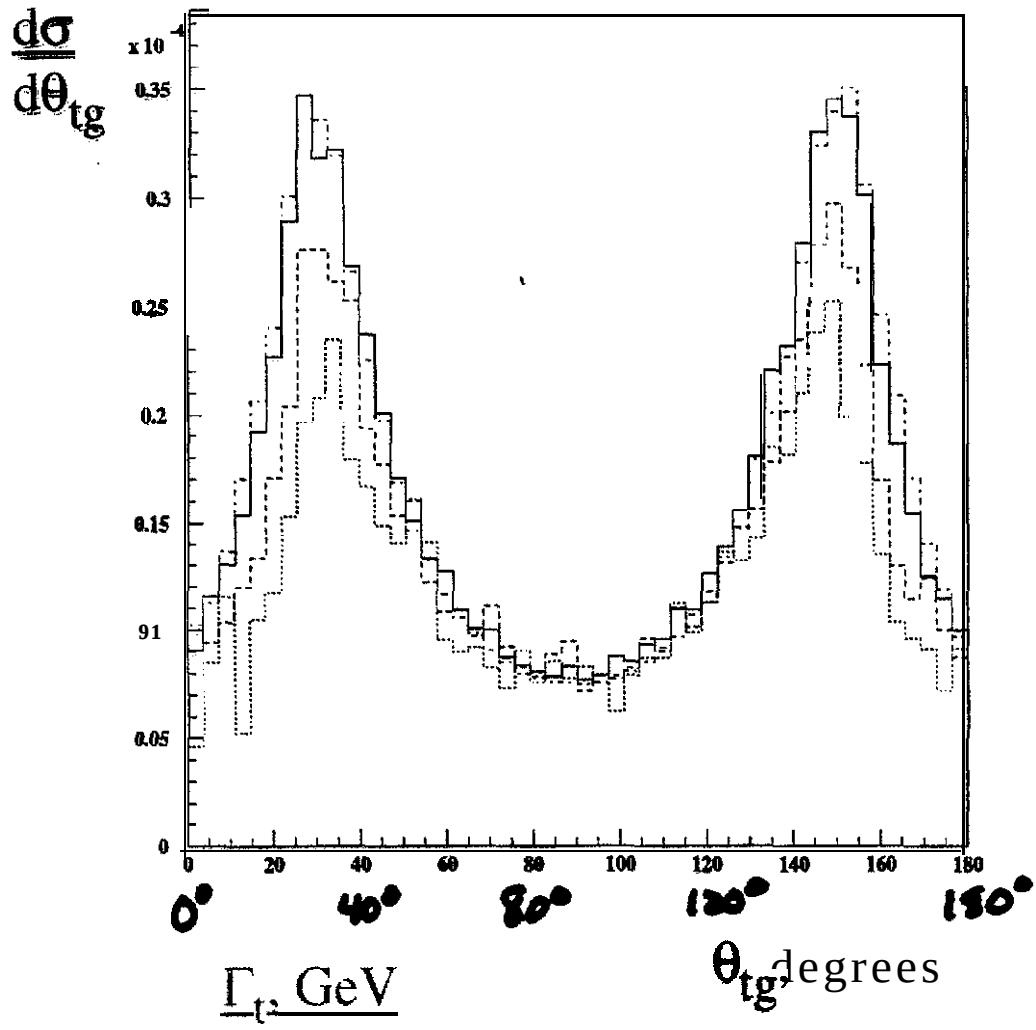
Top-gluon angle: effect of top width

e^+e^- collisions, $E_{cm} = 750$ GeV

$\cos\theta_{tb} < 0.9$

$5 < E_g < 10$ GeV



Γ_t, GeV

- 0.1
- 1.5 (SM)
- 5.
- 20.

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Summary

- Gluon radiation in top production and decay: exact ME calculation for real gluons
- Radiation in both production and decay stages; relative amounts depend on
  - ▷ total collision energy
  - ▷ minimum gluon energy
- Top mass reconstruction
- Interference effects

... more to come