Summary of QCD/Top group

Stewart T. Boogert

University College London

New computation developments in QCD amplitudes

- Stefan Weinzierl : New methods for computing helicity amplitudes
  - hep-ph/0503015
  - Twistor and MHV amplitudes
  - Extension to massive quarks

Top threshold

- Stewart Boogert : Experimental top threshold
- Christoph Reisser : Top Instability and electroweak effects
- Dolores Eiras : $O(\alpha\alpha_s)$ NNNLO matching condition

Squark threshold production

- Pedro Ruiz-Femenia : RG Analysis in NRQCD for Squark Pair production

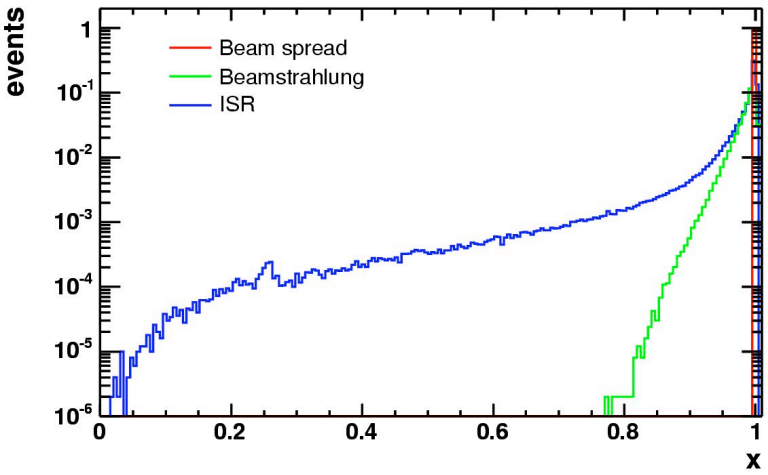
Higgs Yukawa coupling

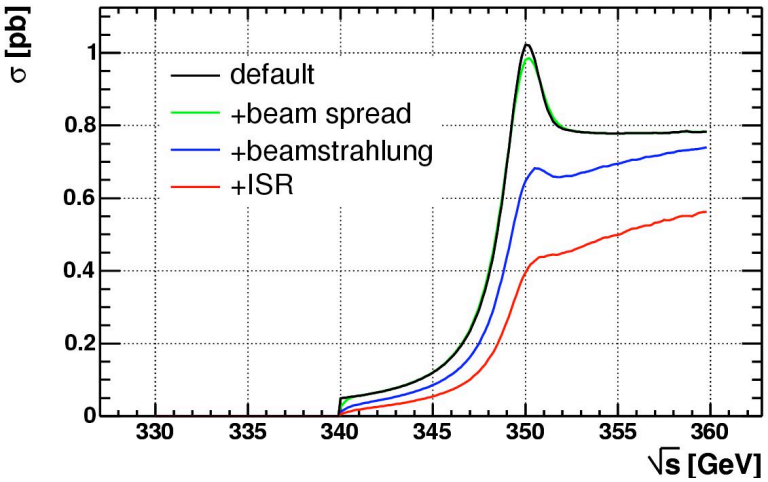
- Cailin Farrel : NLL QCD Corrections to $e^+e^- \to t\bar{t}H$ at 500 GeV

Top pair threshold

Stewart Boogert

- Extraction of top mass, width and
  - Dominated by experimental uncertainties associated with luminosity spectrum
- Work ongoing to extract realistic spectra from machine simulations
  - Bhabha scattering
- QCD effects
  - LL, NLL, NNLL (almost) complete
- Developing event generator for top threshold production
  - NNLL cross section
  - NNLO differential distributions
  - NLO re-scattering corrections

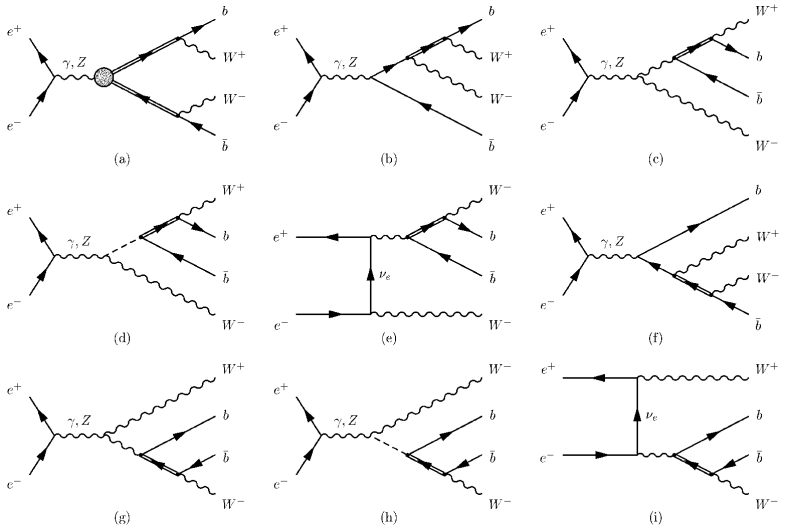




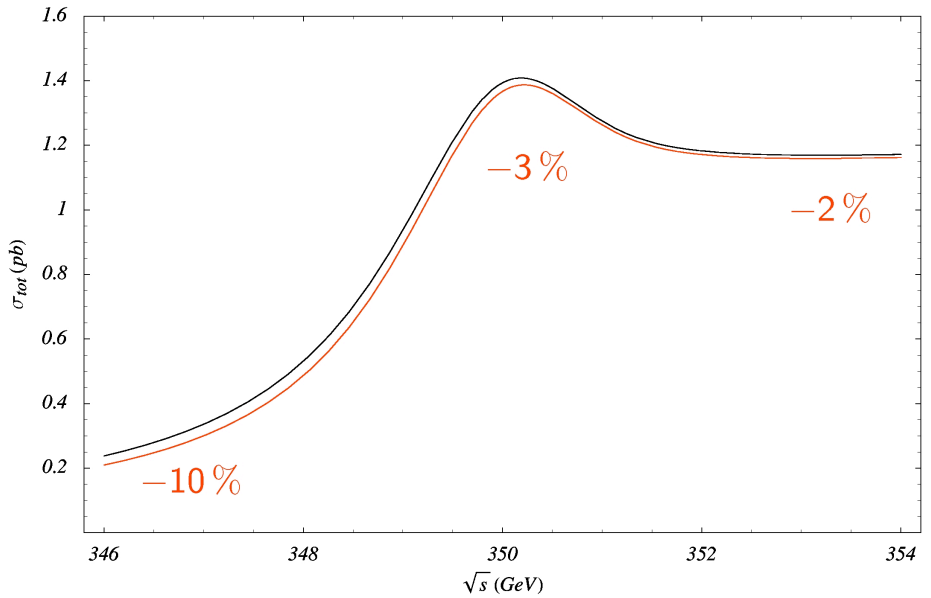
Weak corrections to top pair threshold

Christoph Reisser (Phys. Rev. D 71, 074022)

- Electroweak effects
  - LL
  - NLL (New parametric NNL corrections)
  - NNLL (Top decay corrections)
  - Time dilation
  - Interference
  - Sum $\Gamma_t \left[\alpha_s \log\left(\frac{m_t}{\Gamma_t} \right) \right]^n$



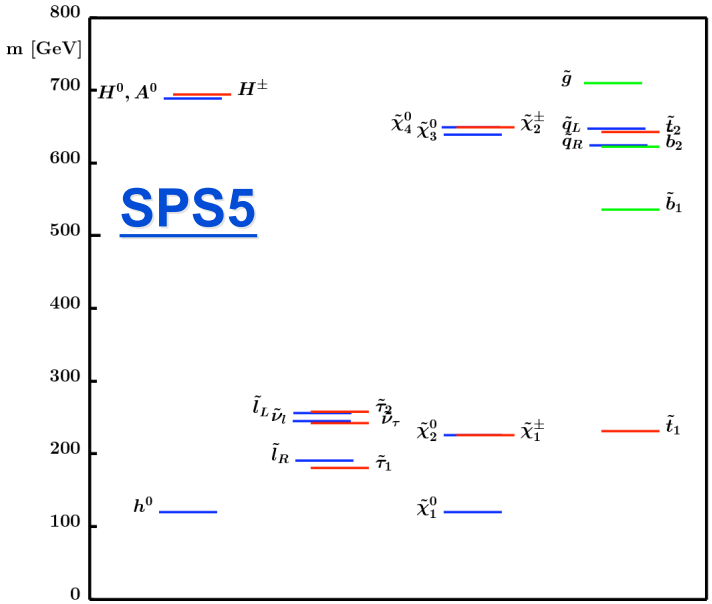
- Electroweak corrections to top pair total threshold cross section
  - Comparable to NNLL QCD corrections
  - LL peak position shifted by 30-50 MeV

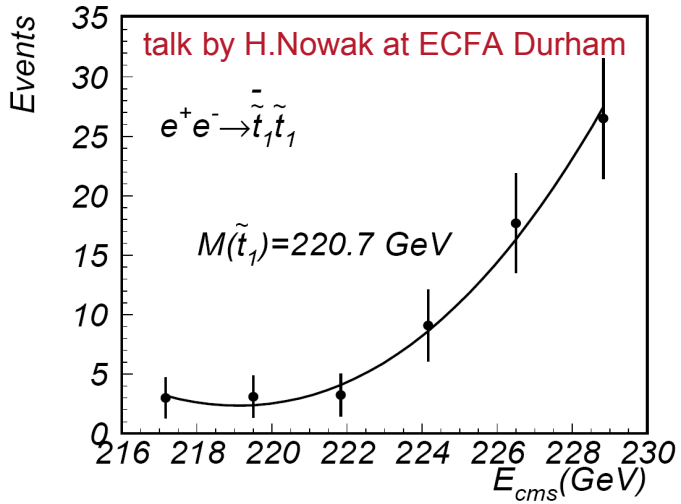


- Experimental uncertainty
  - ~15 MeV statistical
  - ~30-50 MeV systematic (luminosity spectrum)

RG analysis in NRQCD for squark pair production

Pedro Ruiz-Femenia (hep-ph/0511102)





- Goal
  - NNLL description of squark production at threshold
- mSugra scenarios with relatively light scalar top quark

$$m_{\tilde{t}} \sim 250\,\mathrm{GeV} \qquad \Gamma_{\tilde{t}} \sim 40\,\mathrm{MeV}$$

- Experimental analysis

$$\Delta m_{\tilde{t}} \sim 2\,\mathrm{GeV}$$

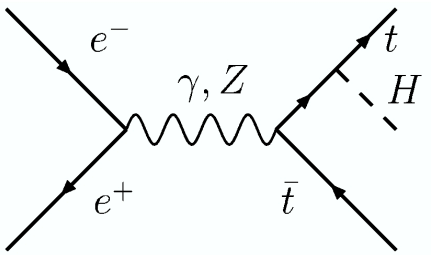
- Computed NLL running of Wilson Coeficients
  - P wave (e^+e^- production)
  - S wave ($\gamma\gamma$ production)

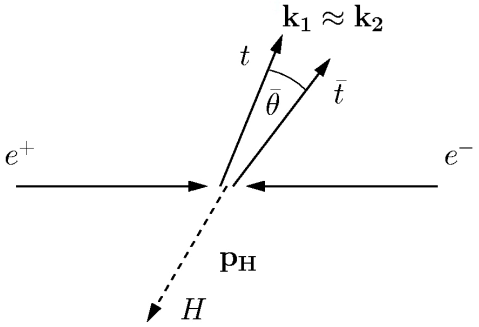
$$\sigma_{\mathrm{tot}} \propto \mathrm{Im}\left[\int d^4x\, e^{-i\hat{q}\cdot x} \left\langle 0 \left| T\, \mathbf{O}_{\mathbf{p}}^{\dagger}(0)\, \mathbf{O}_{\mathbf{p}'}(x) \right| 0 \right\rangle\right]$$

$$\propto \mathrm{Im}\left[C(\mu)^2\, G_{(}0,0,\sqrt{s})\right]$$

Threshold effects in ttH production

Cailin Farrel (Phys. Rev. D71:014007)



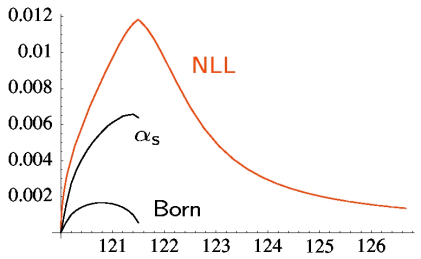


ttH production

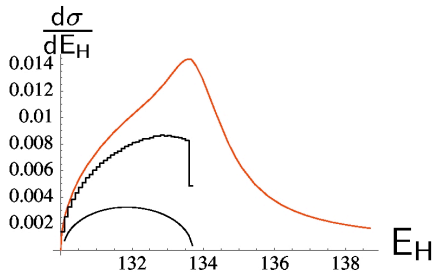
- Top Yukawa coupling
- In region of low Higgs momentum tops become collinear

- Existing fixed order calculations break down in the region of large Higgs energy
  - Again use vNRQCD to calculate cross section
  - Consistent matching onto fixed order calculation
- Enhancement of cross section in threshold region
  - Implications for ttH analysis at low energies

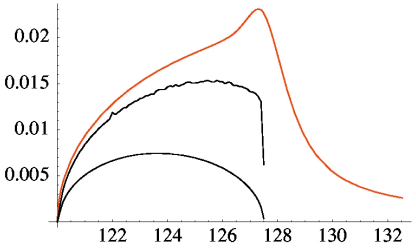
$\sqrt{s} = 482$ GeV, $m_H = 120$ GeV



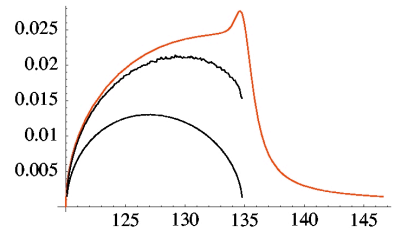
$\sqrt{s} = 500$ GeV, $m_H = 130$ GeV



$\sqrt{s} = 490$ GeV, $m_H = 120$ GeV

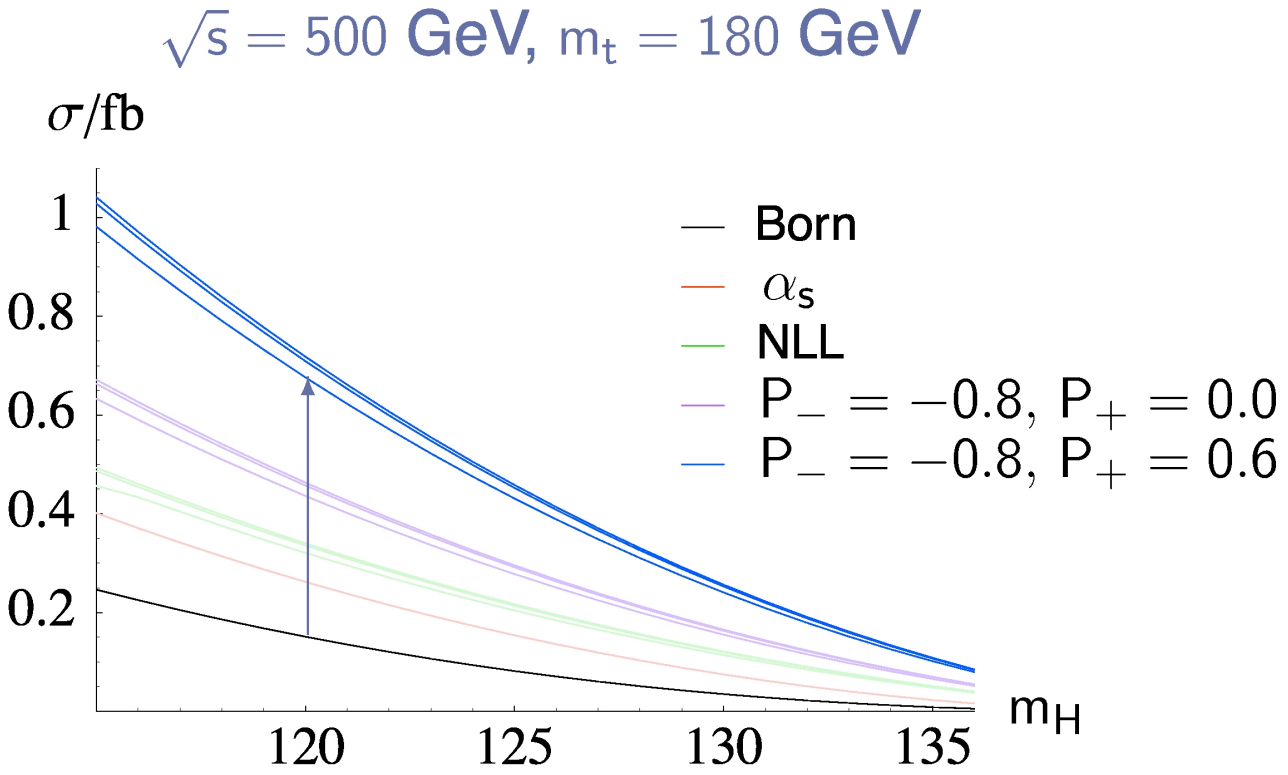


$\sqrt{s} = 500$ GeV, $m_H = 120$ GeV



Increase in ttH cross section at 500 GeV

Cailin Farrel (Phys. Rev. D71:014007)



- Increase in σ_{tot} section by a **factor of 4** vs Born cross section
  - Decrease of statistical error of top Yukawa coupling by **factor 2** for 120 GeV Higgs
  - Sensitivity to top Yukawa coupling up to 135 GeV Higgs mass

NRQCD and threshold physics

Relevant scales

$$m_t \text{ (hard)} \quad \gg \quad \mathbf{p} \sim m_t v \text{ (soft)} \quad \gg \quad E \sim m_t v^2 \text{ (ultrasoft)}$$

Lagrangian (LL)

$$\mathcal{L} = \mathcal{L}_{\text{bilinear}} + \mathcal{L}_{\text{potential}}$$

$$\mathcal{L}_{\text{bilinear}} = \psi^\dagger_{\mathbf{p}}(x) \left\{ iD^0 - \frac{\mathbf{p}^2}{2m_t} - \delta m_t \right\} \psi_{\mathbf{p}}(x) + \dots$$

$$\mathcal{L}_{\text{potential}} = -\frac{\mathcal{V}_c(\mu)}{(\mathbf{p}-\mathbf{p}')^2} \psi^\dagger_{\mathbf{p}'} \psi_{\mathbf{p}} \chi^\dagger_{-\mathbf{p}'} \chi_{-\mathbf{p}} + \dots$$

$\Rightarrow$ Schrödinger equation with Coulomb potential

$$G^{LL}(0,0,\sqrt{s}) = \frac{m_t^2}{4\pi} \left\{ i v - C_F \alpha_s \left[\frac{1}{4\epsilon} + \ln\left(\frac{-i m_t v}{\mu} \right) + \dots \right] \right\}$$