Experimental top threshold scan

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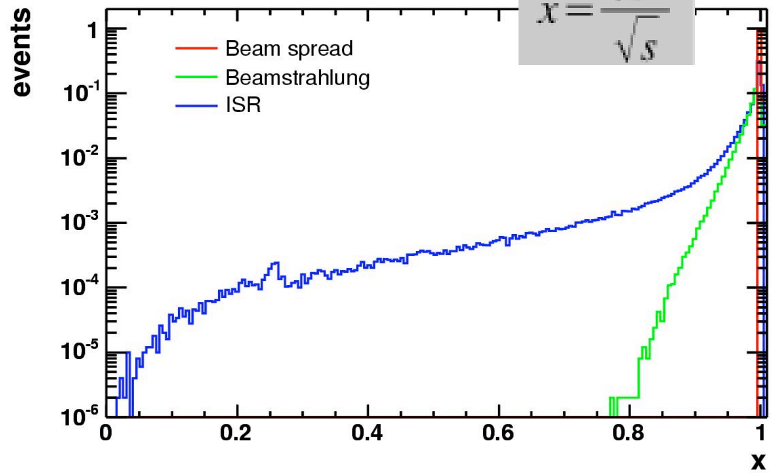
Talk outline

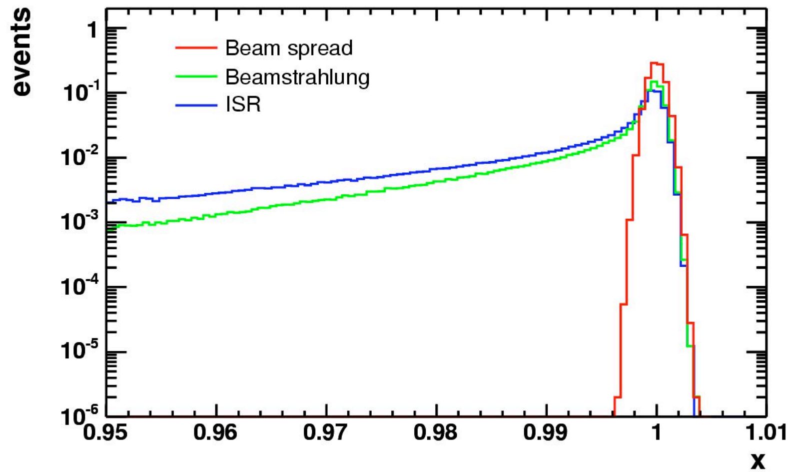
- Introduction
  - Top threshold measurement
    - Beamstrahlung extraction
      - New parameterizations now available
    - Two asymmetric beam extraction just started
    - Various beam parameters possible (P. Bambade's talk in MDI session)
- Top event generator
  - Current status of theoretical calculations
  - Differential distributions (A_{FB} and p_{top})
    - possibly extend sensitivity of top parameter extraction
  - Polarisation?
  - Properly implement beam effects
- Precision top mass essential Standard model measurement
  - Test of QCD and variants at the top threshold
  - Constrain standard model (in conjunction with Higgs measurement)
- Top mass measurement requirement of 50 MeV
  - ~3 parts in 10^4
  - High precision possible due to beam line constraint

Luminosity spectrum

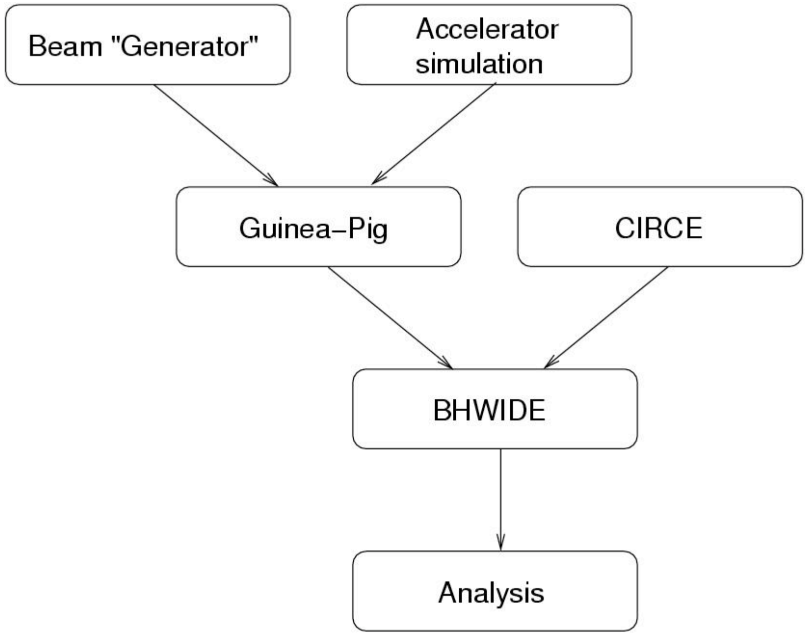
- Centre of mass energy variation, three main sources
  - Accelerator energy spread
    - Typically ~0.1%
  - Beamstrahlung
    - Typically between 0.5% and possibly even 6%
  - Initial state radiation (ISR)
    - Calculable to high precision in QED
    - Complicates measurement of Beamstrahlung and accelerator energy spread
    - Process dependence?

$$x = \frac{\sqrt{s'}}{\sqrt{s}}$$





Luminosity spectrum simulation



- Simulation
  - Accelerator simulation to define beam before collision
    - Distribution of particles in 6 dimensional phase space (position, angles & energy
  - Beamstrahlung input from
    - Guinea-Pig (collision dynamics simulation)
    - CIRCE (parameterization based on Guinea-Pig output)
  - Bhabha scattering based on BHWIDE, wide angle Bhabha scattering Monte Carlo
  - Lumi spectrum format
    - Histogram (distribution)
    - Discrete events (macro particles)
- Problems
  - Interface between Guinea-Pig and Monte Carlo generators

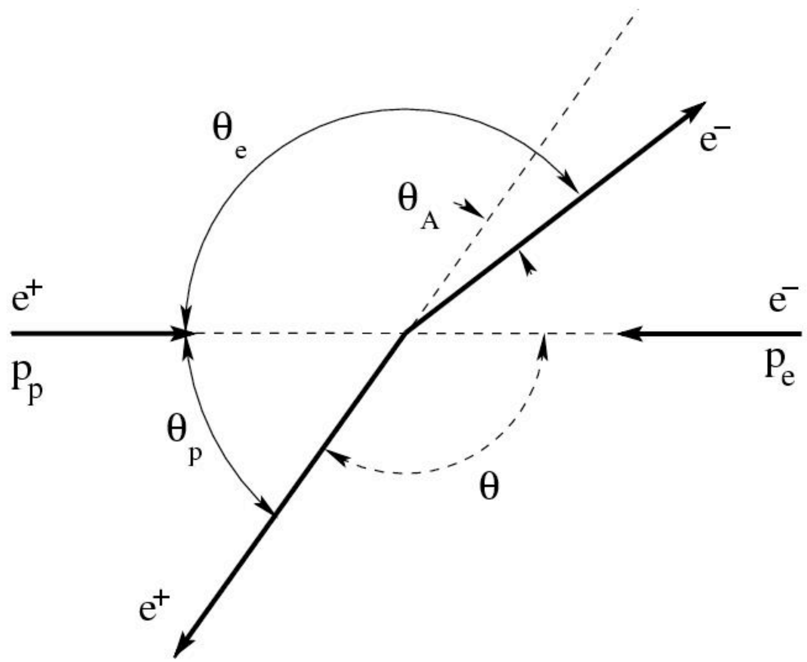
Bhabha acolinearity

- Bhabha scattering to monitor dL/dE
  - $e^+e^- \rightarrow e^+e^- n(\gamma)$
  - High rate compared with top threshold rate
- Two approximate reconstruction methods
  - Only use angles of scattered electron and positron
  - Both based on single photon beamstrahlung
  - Frary-Miller

$$x = 1 - \frac{\theta_A}{2\sin\bar{\theta}}$$

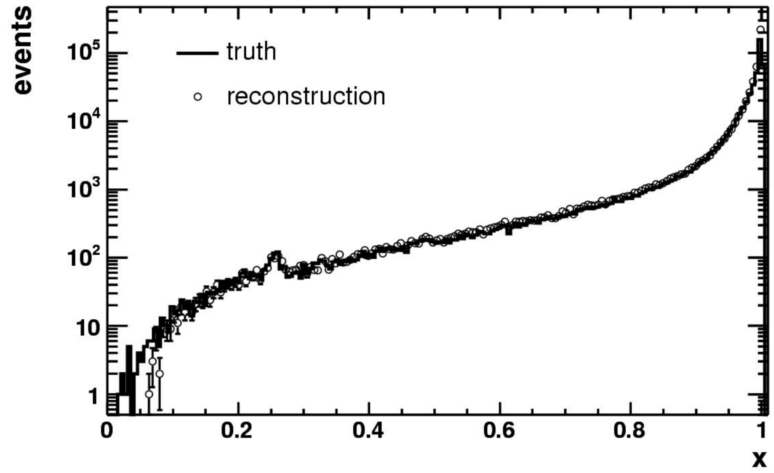
  - K. Moenig

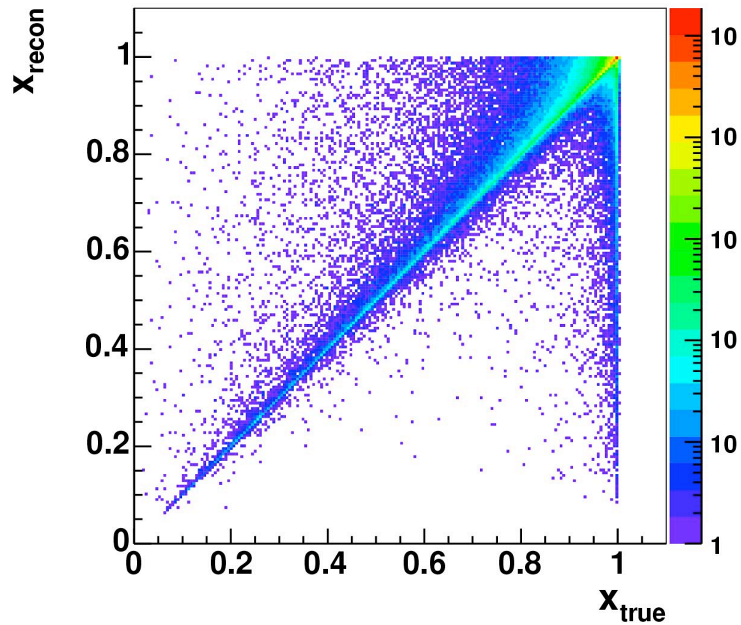
$$x = \sqrt{\cot\frac{\theta_p}{2}\cot\frac{\theta_e}{2}}$$



Extraction of luminosity spectrum

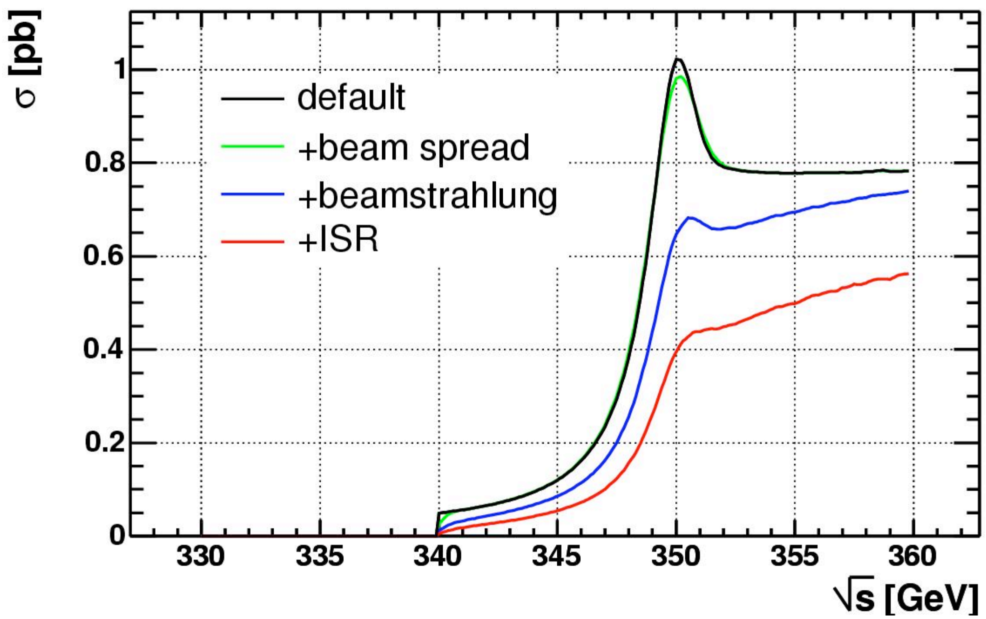
- Bhabha lumi-spectrum reconstruction performance
  - Reasonable given assumptions in x reconstruction
  - Definition of true luminosity spectrum problematic due to overlap of ISR and FSR in Bhabha scattering
  - Main differences between measured and true x at x~1
- Scatter plot of x_{recon} and x_{true}
  - Mainly diagonal contribution, good!
  - Degeneracy at large x
    - Mainly due to the single photon approximation
- Problem now
  - How to extract beamstrahlung and beam spread from the observable x
  - Two different methods being investigated
    - Unfolding (F. Poirer)
    - Fitting (SB, K. Moenig, E. Torrence)





Top threshold simulation

- Top threshold simulated using Toppik
  - Hoang and Teubner
  - NNLO pNRQCD



- Two alternative methods are used to smear the threshold curve
  - Histogram (binned)

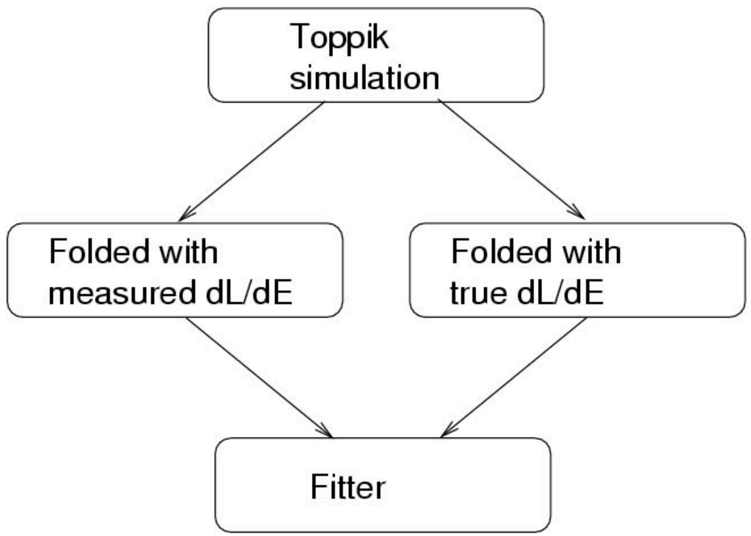
$$\sigma'(\sqrt{s}) = \int_0^1 p(x)\,\sigma(x\sqrt{s})\,dx$$

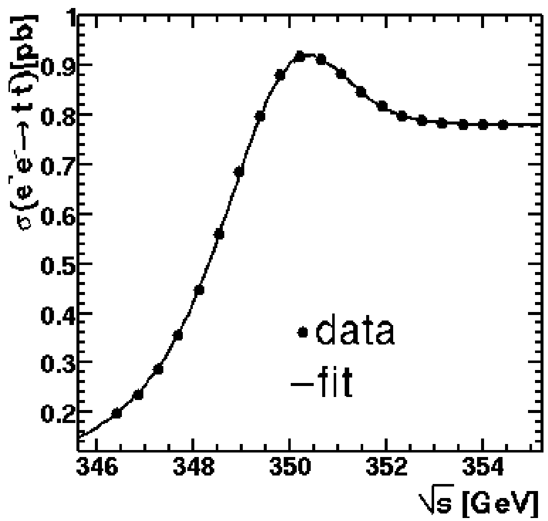
    - Large number of bins required when including all effects
      - ISR : 0<x<1
      - Beamstrahlung : 0.75<x<1
      - Energy spread : 0.99<x<1.01
  - Event sample (unbinned)
    - Large number of samples (N) of x distributed in a luminosity spectrum

$$\sigma'(\sqrt{s}) = \frac{1}{N}\sum_{i=1}^{N} \sigma(x_i\sqrt{s})$$

Extraction of top parameters

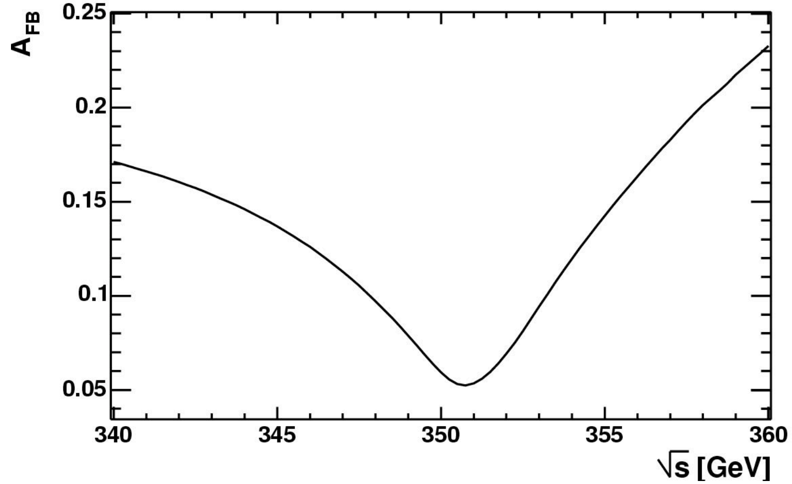
- Generate data with
  - 20 equidistant scan points
  - Range 346→354 GeV
  - High luminosity, 30nb per point
  - Nominal luminosity spectrum
    - Linac energy spread 0.1%
    - CIRCE parameters on slide 3
- Fit cross section
  - Smeared with different luminosity spectra
    - Measured from Bhabha analysis
    - True luminosity spectrum from accelerator simulation or parameterization
  - Form usual χ^2 between "data" and "theory" cross section

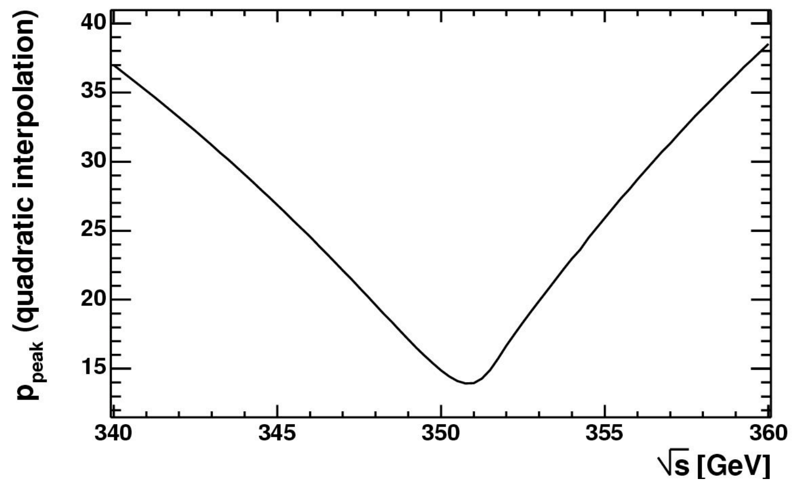




Differential measurements

- Only discuss the effect of beam energy on total cross section
- A_{FB} and p_{peak} have still not been included
  - Still require precision on the beam energy measurement
- How to best include the effects of beam energy variation?
  - Averaging over luminosity spectrum possible but what about possibly asymmetric boost due to beamstrahlung?
  - Top Monte Carlo generator required
  - Plan to extent analysis to use event style generator, possibly reweighing events to match Toppik predictions





Accelerator simulation

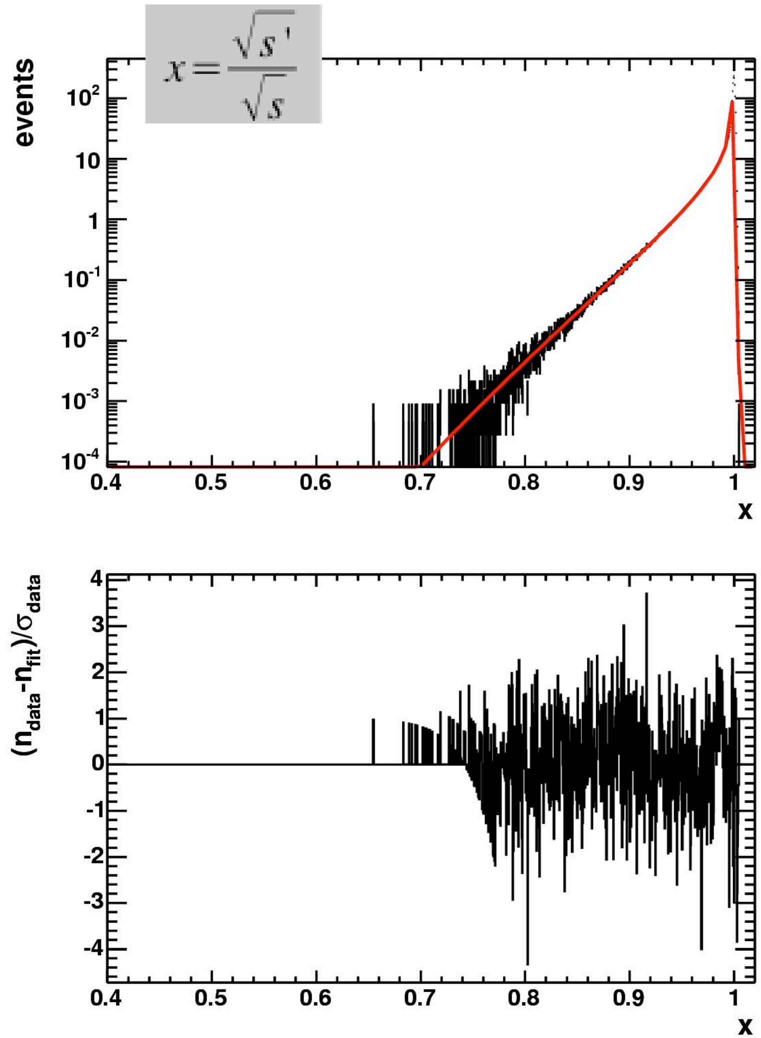
- Integrated simulations of whole accelerator available
  - Linac (beam spread)
  - Beam delivery system (associated diagnostics, including beam energy spectrometer)
  - Guinea-pig collision simulation
  - Designed for fast beam feedback and general accelerator design simulation and optimisation
    - Simulation of first 600 bunches in the train
- Currently available
  - 500 GeV and 1 TeV samples available
  - 350 GeV (top threshold) sample just generated (G. White)
    - Switch off some of the Linac + re-optimize beam delivery
- See G. White's webpage http://hepwww.ph.qmul.ac.uk/lcdata/ for more details

350 GeV accelerator simulations

- 350 GeV ILC simulations now available
  - Requires re-optimization of the linac and beam delivery system
  - Thanks to G. White for producing data files!

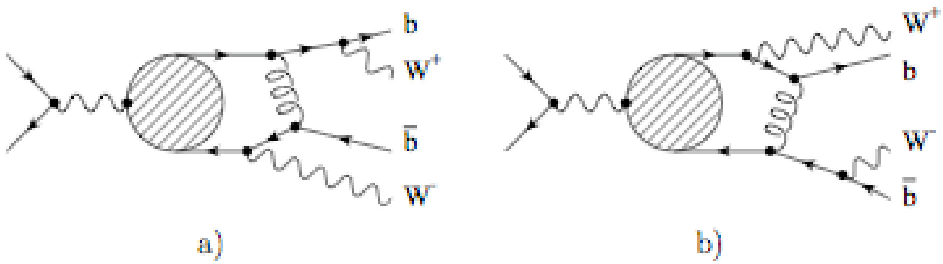
	CME (500)	CME (350)
a0	0.337	0.307
a2	18.576	28.739
a3	0.419	0.319
bs (%)	0.089	0.096

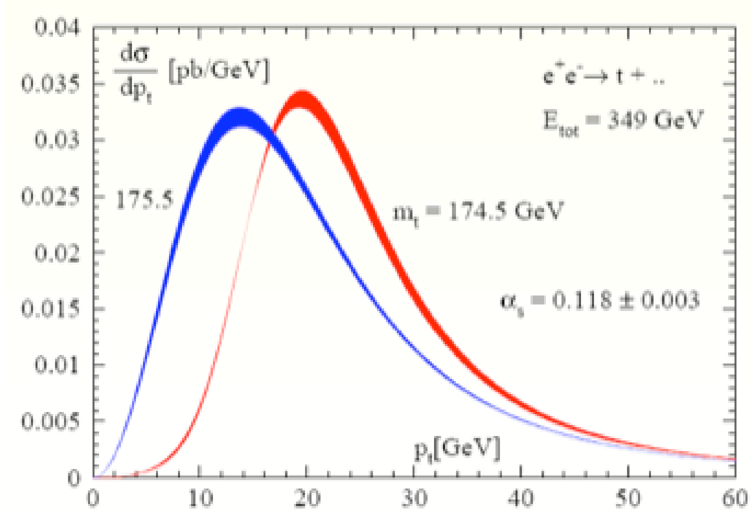
  - Check for other differences between 350 and 500 GeV simulations
- Use this parameterization to apply to Bhabha and top samples
- Working now to extract Beamstrahlung parameters from this "realistic" data



Top threshold enerator

- Event generator required
  - Essential for determining detector effects, reconstruction efficiency etc
  - Proper implementation of beam effects on differential quantities
- Theoretical input
  - NNLO program for total cross section
  - NNLL, renormalization group improved total cross section
  - NLO re-scattering corrections
- Implementation
  - Fast Greens function interpolation based on NNLO Green's functions
  - Naïve decay of top quarks





Summary

- Progress since Snowmass limited
  - Precision analysis must track developments in beam parameter sets
  - Working on extraction of beamstrahlung parameters from Bhabha acolinearity problematic
    - Parameterization of Beamstrahlung difficult
    - Fitting of acolinearity distribution more complicated
      - Electron beam $\neq$ positron beam
  - See talk by P. Bambade in Monday’s MDI session

- Collaboration started for Top threshold generator
  - Teubner, Gournarnis & Boogert
  - Fast interpolation of s and p wave top threshold Green’s functions