Luminosity spectrum impact on the top mass

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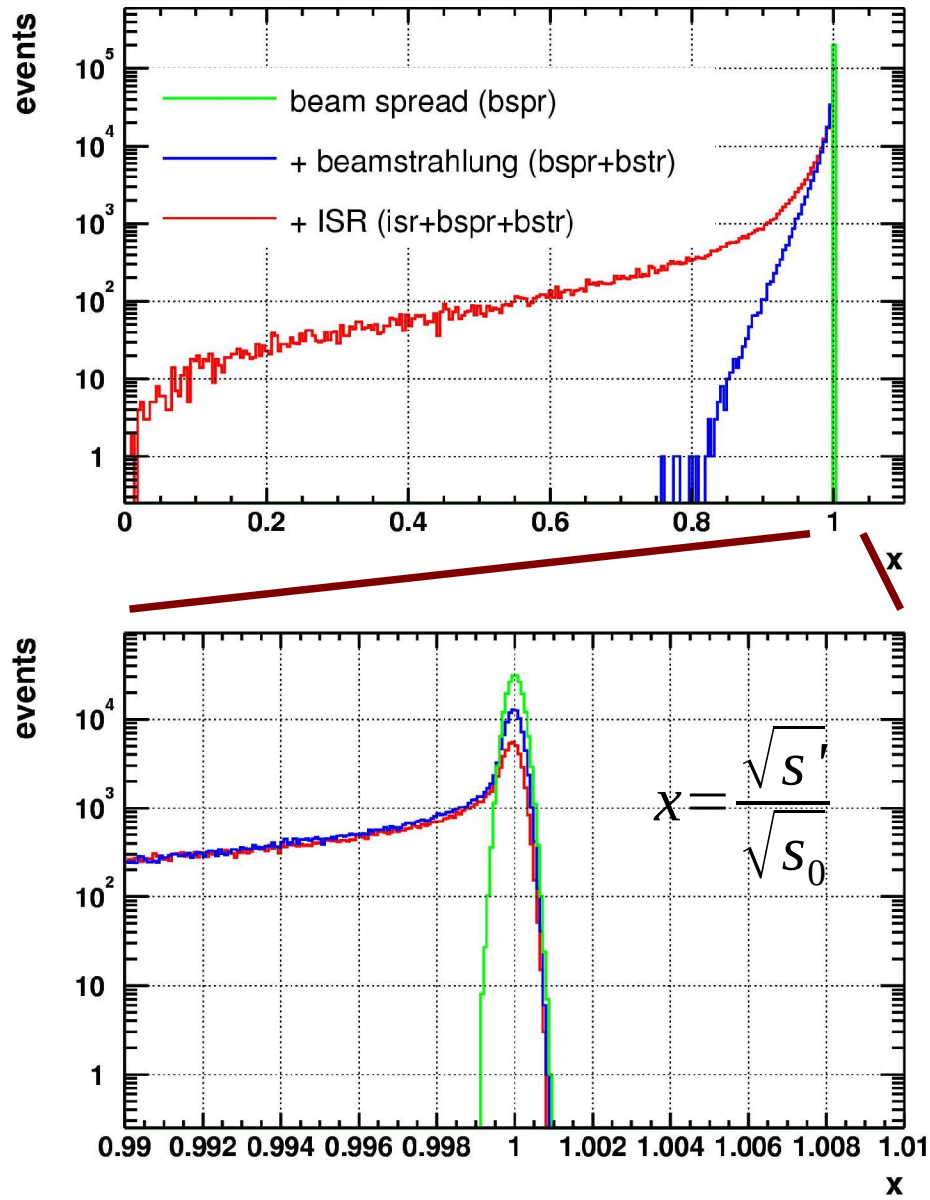
Next 15 mins

- This presentation is already out of date
  - Contains NLC/TESLA comparisons
  - But it is still instructive to look at effect of linac energy spread
- Ongoing analysis/previous presentations
  - Uses Guinea-Pig beam-beam interaction MC and attempts to extract the systematic shift due to the mis-reconstruction of luminosity spectrum
  - Does not include linac/beam spread
- Talk outline
  - New aim:
    - Take simplest luminosity spectrum and evaluate what causes significant shifts of the top mass
  - Introduction
    - Luminosity spectrum
    - Top threshold
    - Simulations/fitting
  - Energy spread
    - Size and shape
    - Add beamstrahlung and ISR
  - Beamstrahlung parameters (CIRCE)

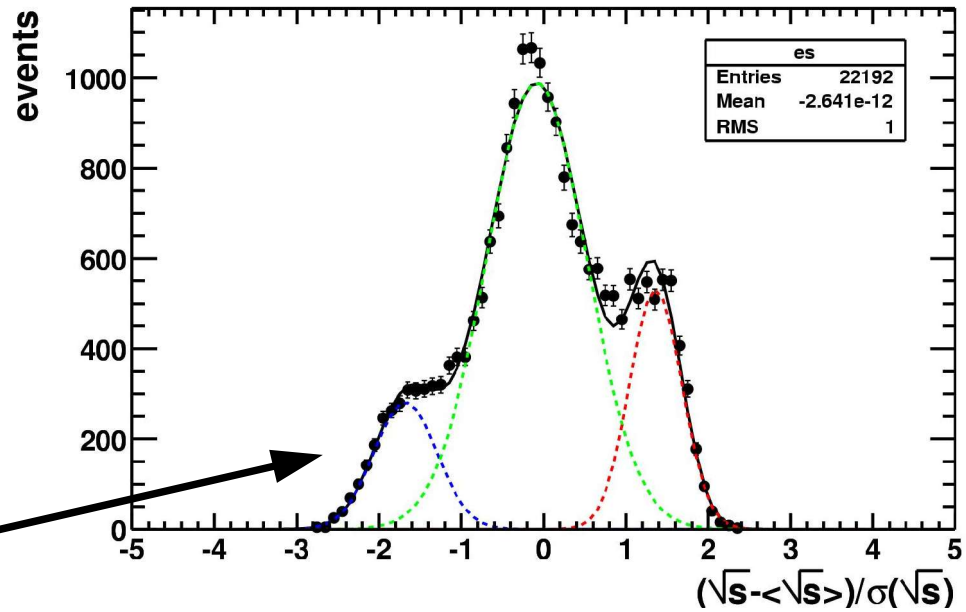
Luminosity spectrum

- Three basic components
  - ISR (Calculable to high precision)
  - Beamstrahlung (CIRCE)
    - Simplest parametrisation available
    - $f(x)=a_0\delta(1-x)+a_1 x^{a_2}(1-x)^{a_3}$
    - a_1 normalisation condition
    - a_0=0.5461, a_2=20.297, a_3=-0.62747
  - Energy spread (Gaussian or parametrisation to NLC shape)
    - Single parameter (σ~0.1%)
  - Beamstrahlung and energy spread determined from accelerator and/or physics event measurements (Bhabhas)



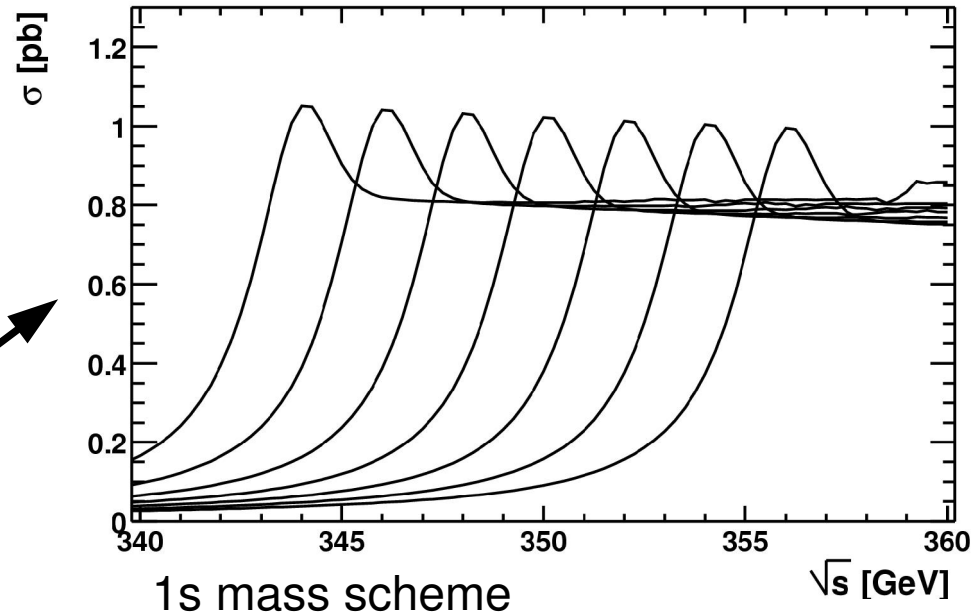
“Warm” energy spread shape

- TESLA energy spread is Gaussian
  - Not always the case, NLC has multiple peaked structure
  - Right: NLC energy distribution
    - Simulation of NLC energy spread from linac and beam delivery simulation.
    - Scaled (such that mean=0 and rms=1)
    - Fitted with 3 independent gassians
    - Use fit result to generate similar shaped distributions with alternative widths

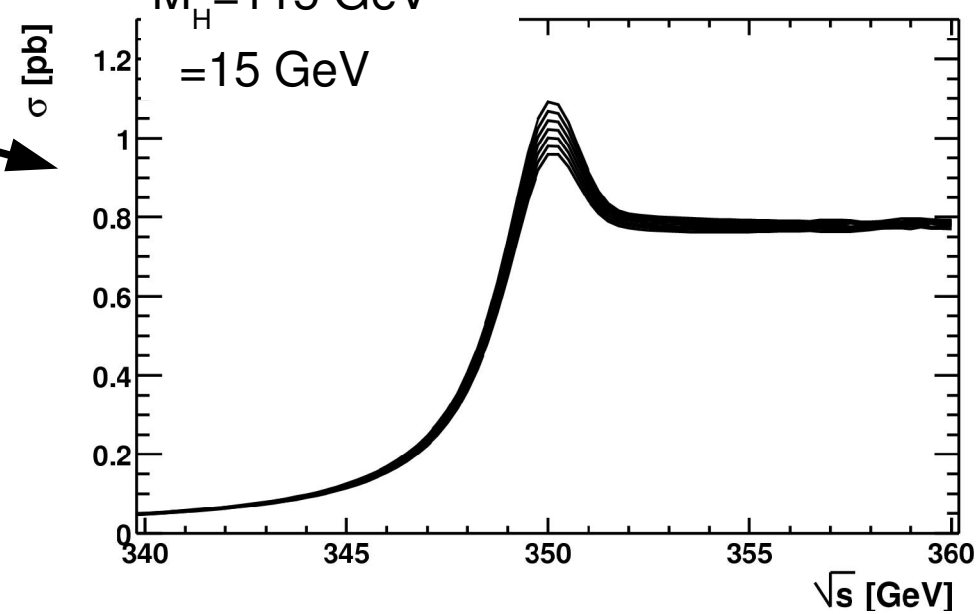


Top threshold simulation

- Threshold simulated using TOPPIK
  - Hoang and Teubner
  - Generate grid of cross section values
    - m_t= 172→178 GeV
    - Γ_t= 1.40→1.46 GeV
    - α_s= 0.115→0.121
  - Default threshold grid centre
    - (m_t,Γ_t,α_s)=(175,1.44,0.118)
  - Interpolate cross section in above parameter space, so can obtain
    - $\sigma(m_t,\Gamma_t,\alpha_s,\sqrt{s})$

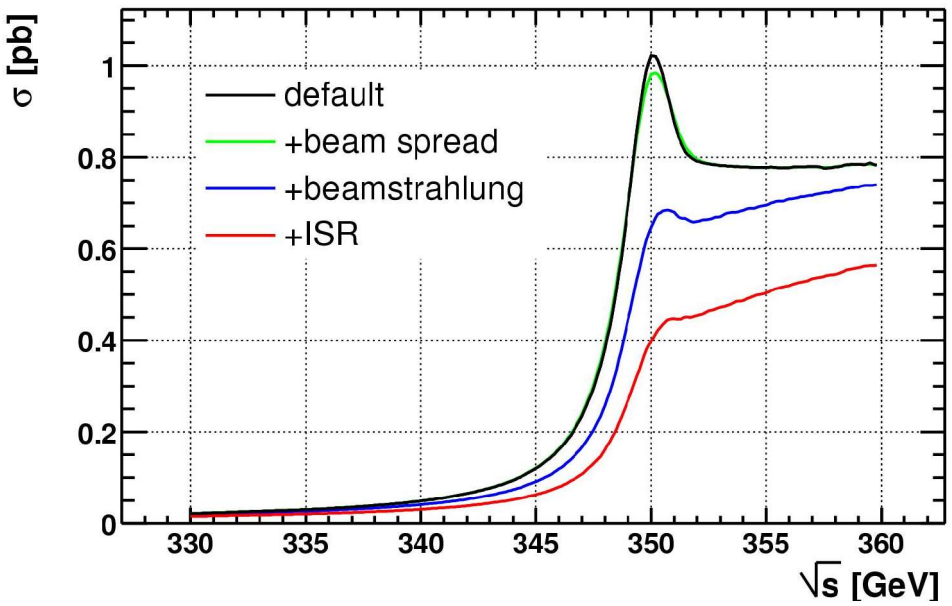


1s mass scheme
M_H=115 GeV
=15 GeV

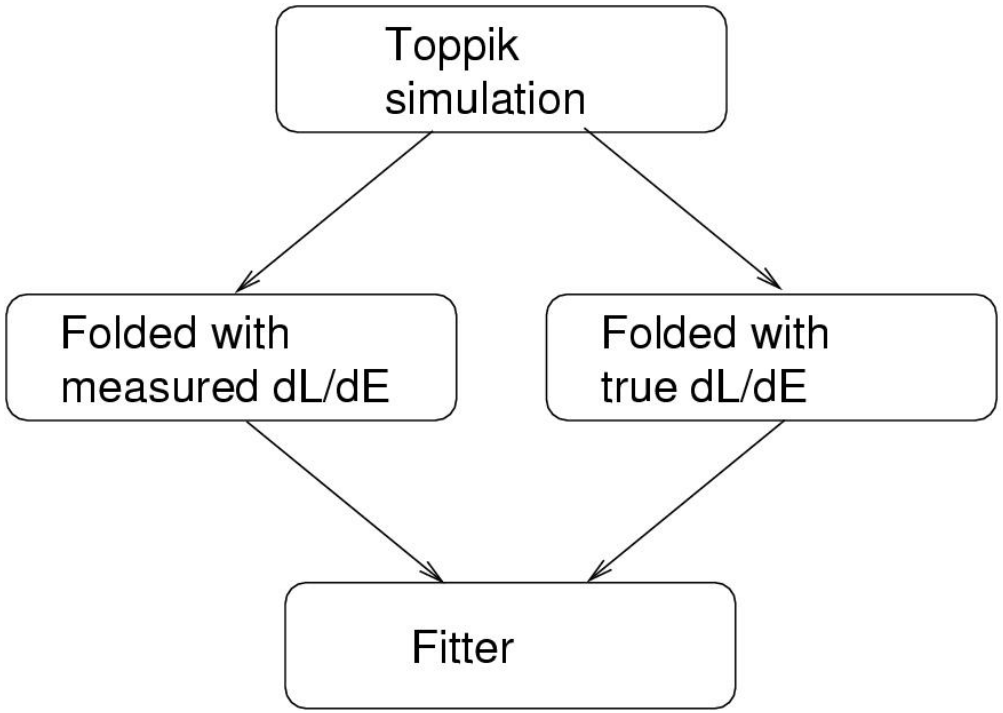


Smearing the threshold

- Two alternative methods are used to smear the threshold curve
  - Histogram (binned)
    - $\sigma(\sqrt{s}) = \int_0^1 f(x)\sigma(x\sqrt{s})\,dx$
    - 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)
    - $\sigma(\sqrt{s}) = 1/N \sum_{samples}^{N} \sigma(x_i\sqrt{s})$
    - Large number of samples (N) of x distributed in a luminosity spectrum

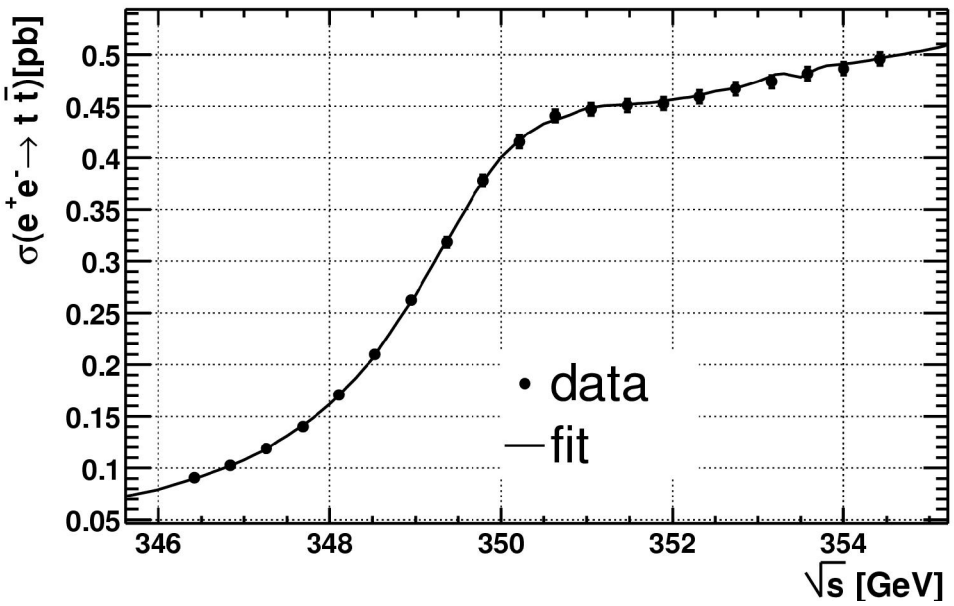


Fitting introduction



- Definitions
  - Data
    - Theoretical cross section smeared with the TRUE luminosity spectrum
  - Fit
    - Theoretical cross section smeared with the MEASURED luminosity spectrum
  - In this way biases introduced to the top cross section by the luminosity spectrum can be studied by comparing the top folded/smeared cross sections

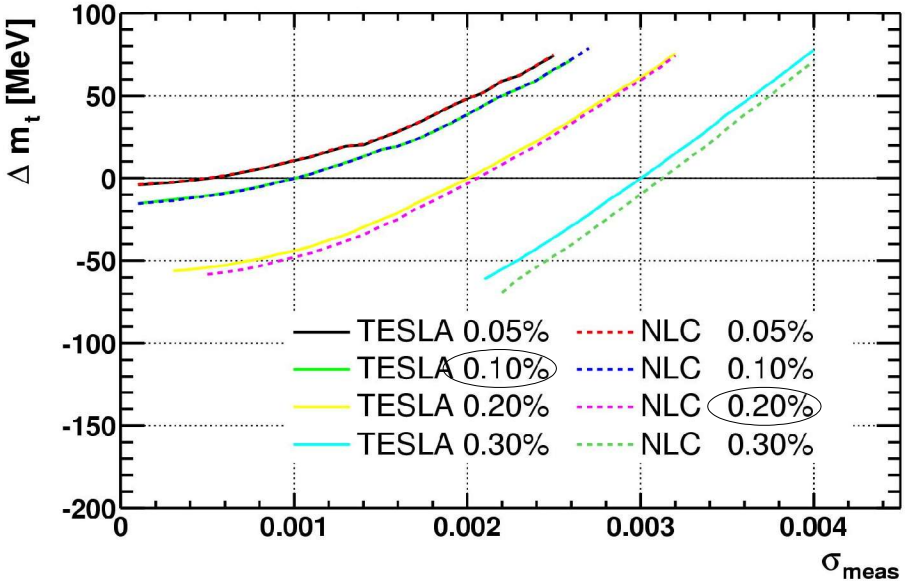
Fitting the top threshold

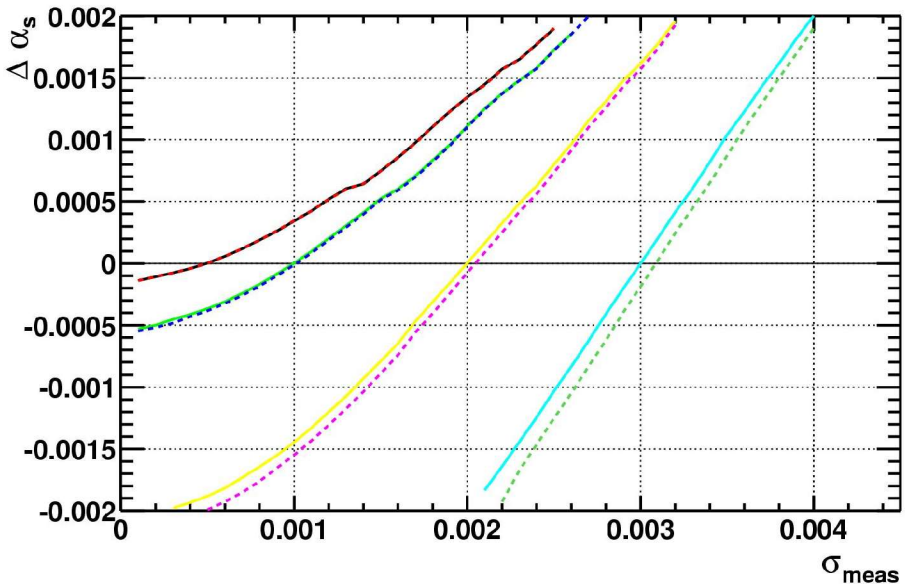


- Generate data with
  - 20 equidistant scan points
  - Range 346→354 GeV
  - High luminosity, 30nb per point
  - Nominal luminosity spectrum
    - Linac energy spread 0.1%
    - CIRCE parameters on slide 3
- Fit cross section
  - Smeared with different luminosity spectra, so different CIRCE and beam spread parameters
  - Form usual χ^2 between “data” and “theory” cross section
  - Γ_t fixed, extract m_t and α_s

Effect of beam spread

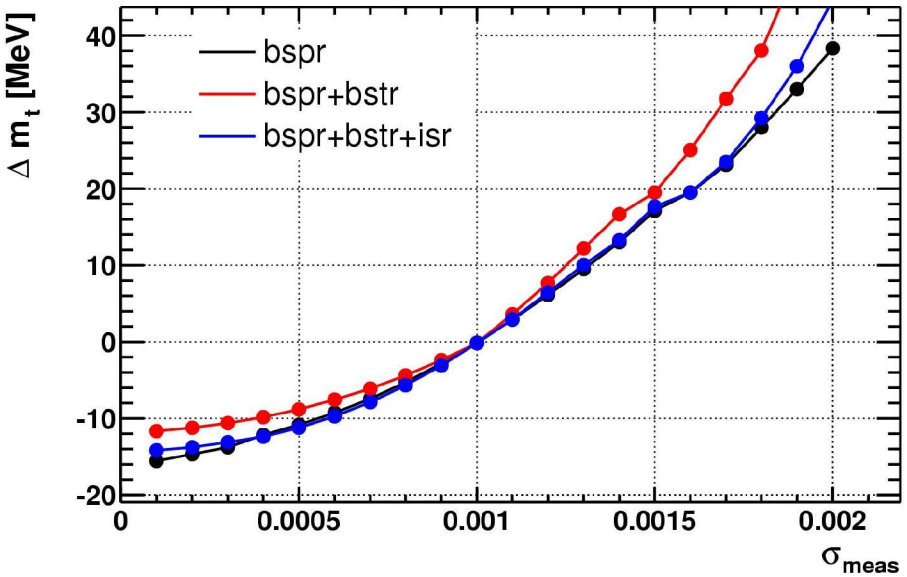
- Results sent to the ITRP
  - Effect of just beam spread without ISR or Beamstrahlung
  - Data and theory generated with histogram smearing method
- Conclusion
  - Beam spread effect more pronounced at larger values
    - "low" values <0.05% can almost neglect the energy spread in the fit ...
    - Effect of NLC/Warm/Multi-peaked energy spread only has effect at large energy spreads

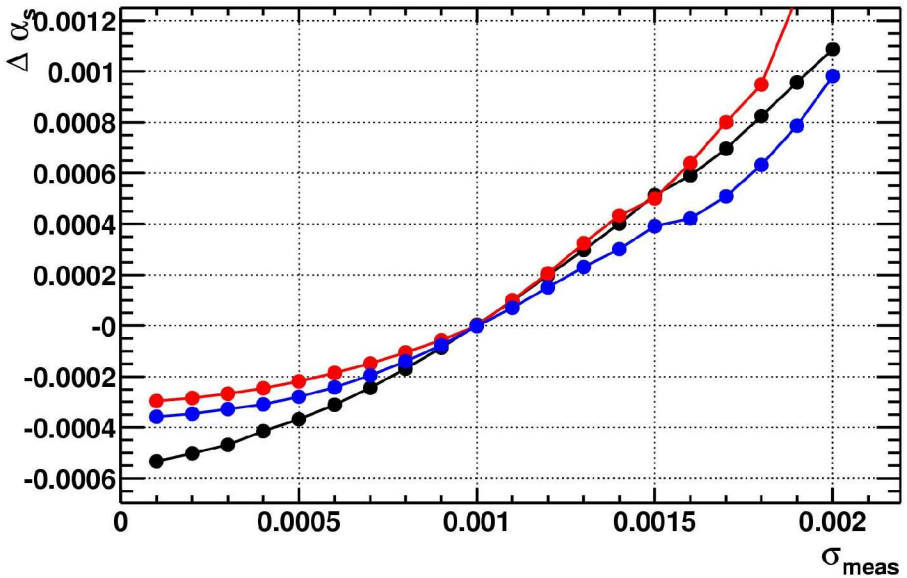




Effect of beam spread (with Beamstrahlung and ISR)

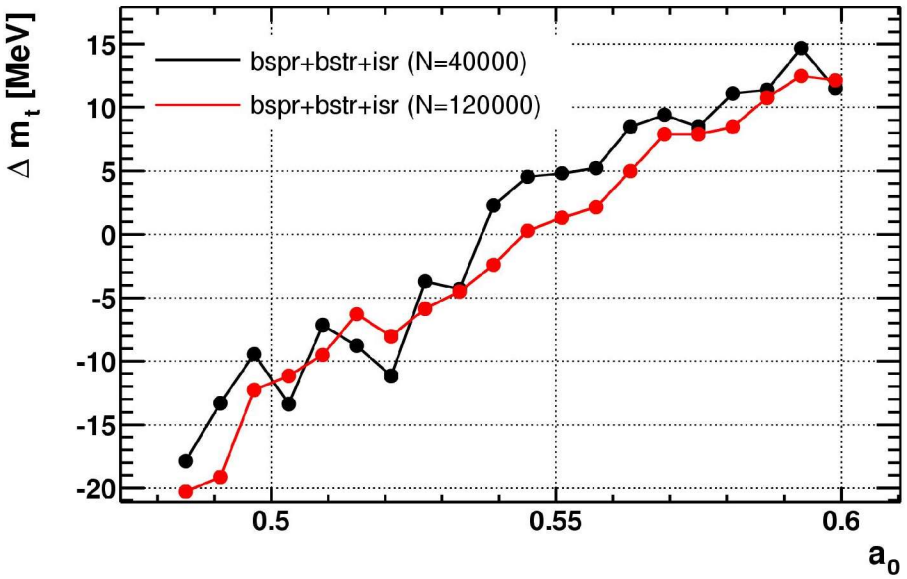
- Again look at the effect of linac energy spread
  - It has been proposed the effect of energy spread on previous slide is reduced due to beamstrahlung and ISR
  - Take the Gaussian and σ=0.1% width case
  - Now including
    - Beamstrahlung
    - Beamstrahlung and ISR
    - Generated with unbinned method
- Effect of beam spread unchanged

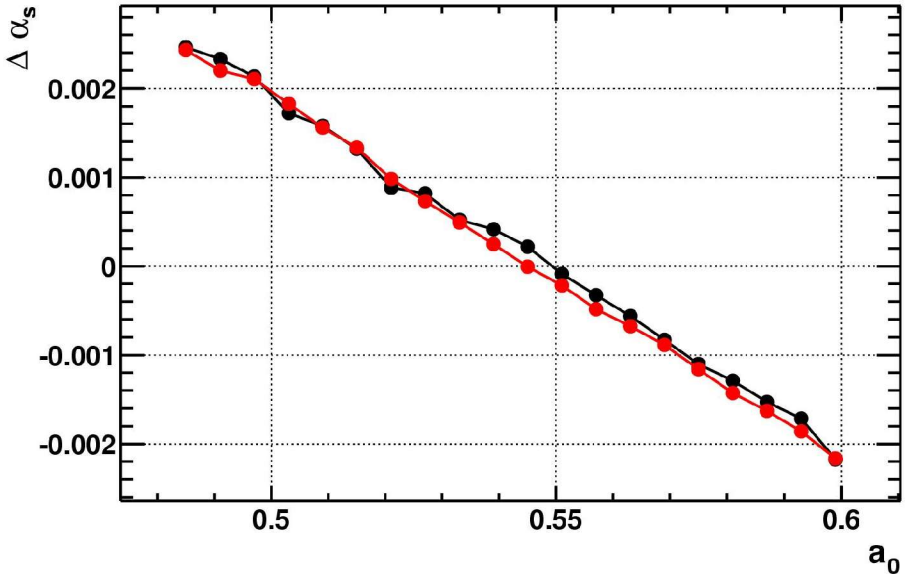




Effect of CIRCE parameters (a_0)

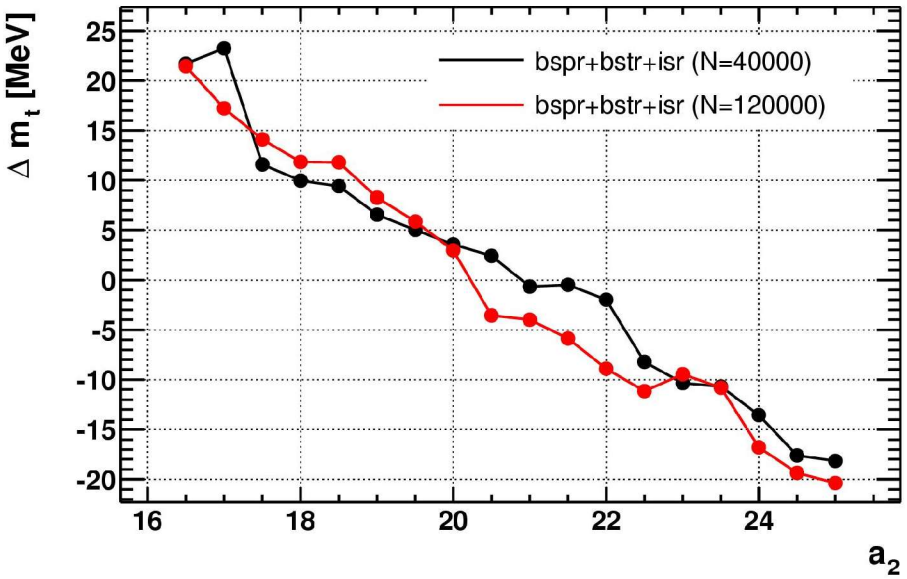
- Determines the fraction of particles at full beam energy
  - No beamstrahlung
  - Events at full beam energy ~a^2_0
  - Dependence on a_0
    - Simple and linear
    - m_t : larger $a_0 \Rightarrow$ less radiation losses $\Rightarrow$ fit cross section biased to higher energies
    - $_s$: larger $a_0 \Rightarrow$ smaller loss of full beam energy luminosity $\Rightarrow$ overall increase in fit cross section

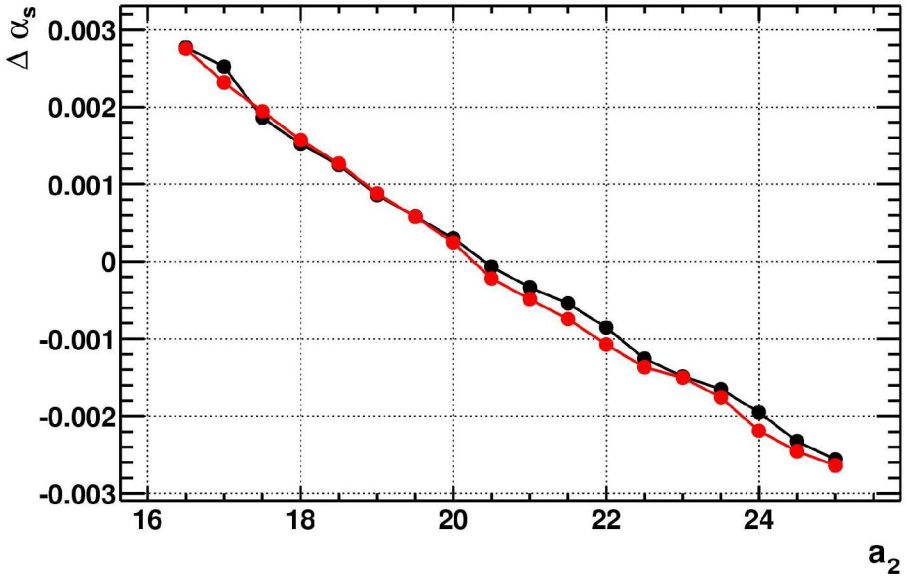




Effect of CIRCE parameters (a_2)

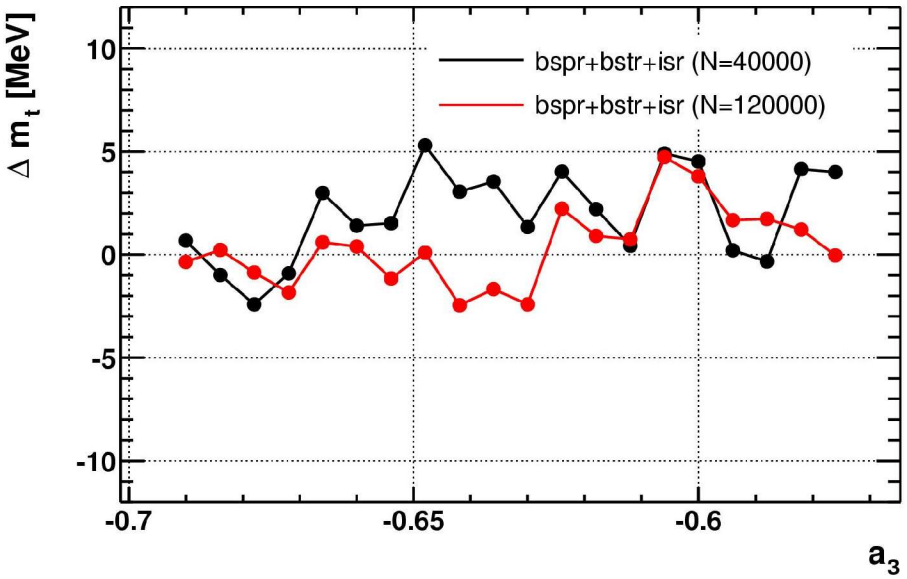
- Power law term
  - x^{a_2}
  - a_2 dependence
    - Again linear
    - m_t : larger $a_2 \Rightarrow$ less radiation losses $\Rightarrow$ fit cross section biased to higher energies
    - $_s$: larger $a_2 \Rightarrow$ smaller loss of full beam energy luminosity $\Rightarrow$ overall increase in fit cross section

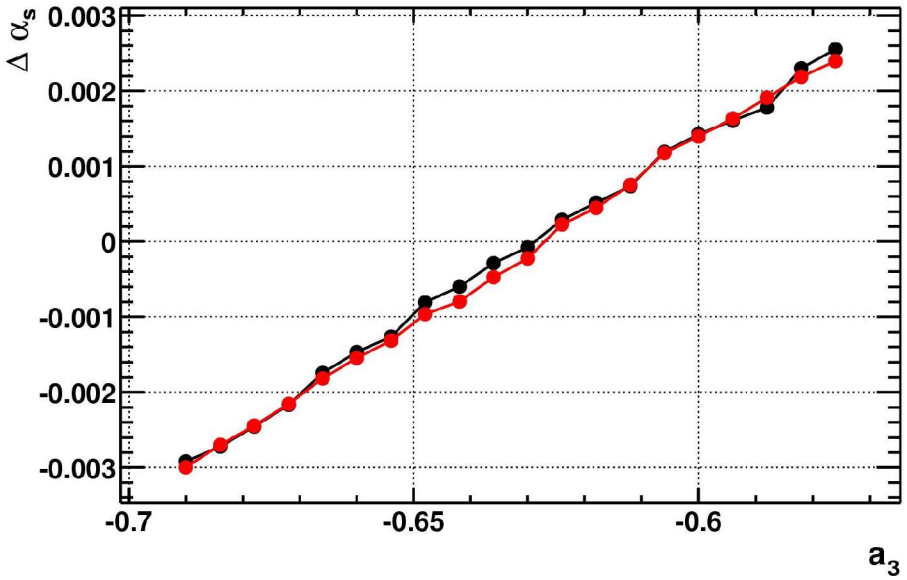




Effect of CIRCE parameters (a_3)

- Divergent term in Beta function
  - $(1-x)^{a_3}$
  - a_3 dependence
    - m_t : little dependence
    - $_s$: same argument as before but just enters function as negative power
- Satistics
  - N=40,000 or 120,000 lumi spectrum samples
  - Trends consistent





Words of caution

- Luminosity spectrum parametrisation
  - Might be wrong, CIRCE function is only one choice
  - Not flexible enough
  - Must include effects of
    - correlation between colliding beams
    - Long time average of many accelerator effects
      - Ground motion
      - Accelerator configuration/performance
    - Subject of on going work on the luminosity spectrum
- Not yet optimised scan range
  - Essentially random choice for analysis presented here,
    - 20 scan points
    - $\sqrt{s}$: 346→354 GeV
  - Simple study can check this
    - Number of scan points
    - Start and end
    - Luminosity per point
- Only looked at systematic error on top mass
  - what about statistical error dependence, assumed it is small
  - Might depend on scan parameters

Summary and outlook

- Detour from previous presentations
  - Investigated the effect of linac energy spread
    - Larger energy spread has larger effect
      - “Set it small or measure it well”
    - Shape not important for cold energy spreads
    - Effect still present with beamstrahlung and ISR
  - Study of beamstrahlung shape effect on top mass reconstruction
    - Threshold top mass seems most sensitive to parameters a_0 and a_2.
  - Future work
    - Perform fit with luminosity spectrum parameters extracted from Bhabha events generated with realistic accelerator and bunch-bunch interaction codes. Use the true luminosity spectrum to smear top threshold and create data
      - Provides “independent” cross check of previous analysis, where **only** Bhabha events were used for the luminosity spectrum
    - Merge two analyses, extract luminosity spectrum parametrisation from Bhabha events and apply to top threshold