Luminosity spectrum impact on the top mass

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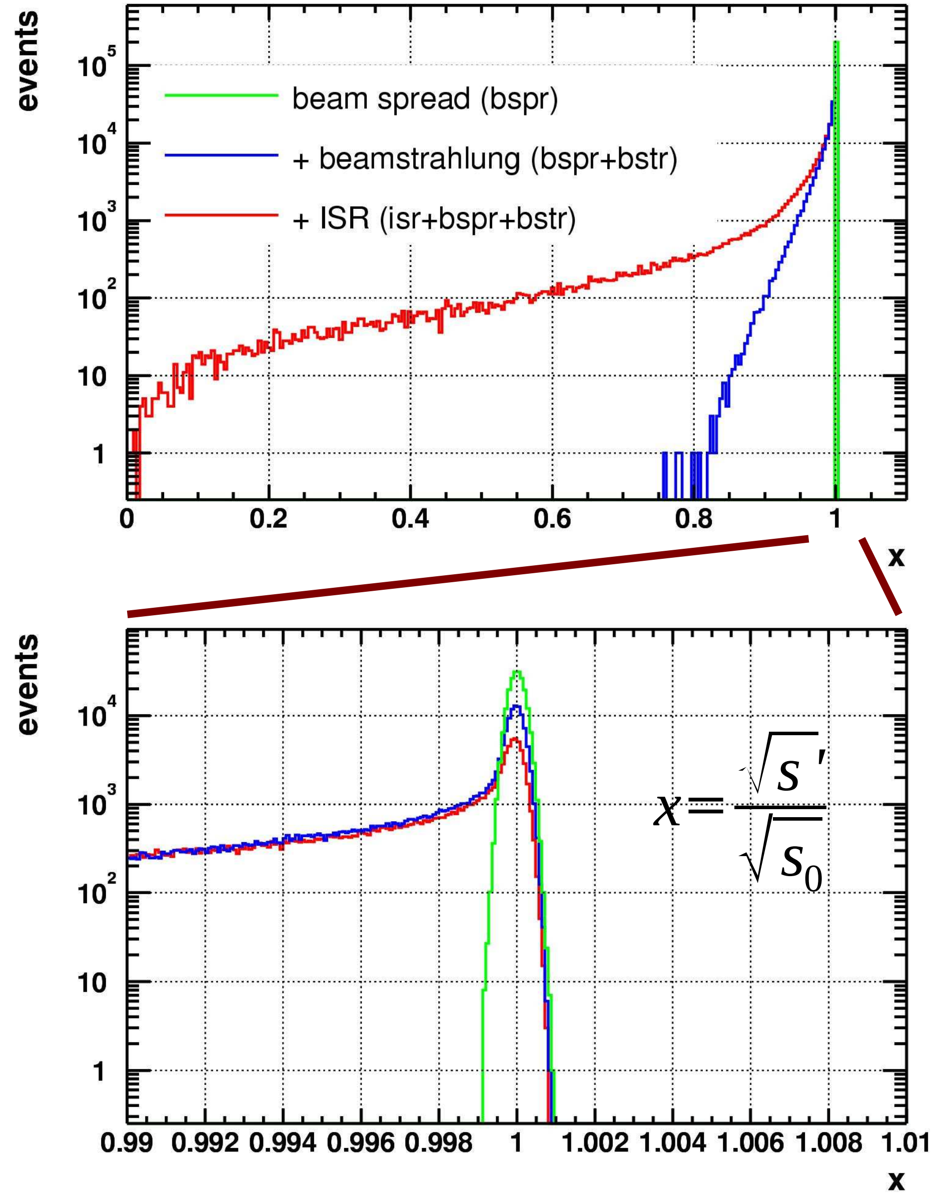
Next 15 mins

- Talk outline
  - Take simplest luminosity spectrum and evaluate what causes significant shifts of the top mass
  - Introduction
    - Luminosity spectrum
    - Top threshold
    - Simulations/fitting
  - Energy spread
    - Beamstrahlung and ISR
  - Beamstrahlung parameters(CIRCE)
- 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

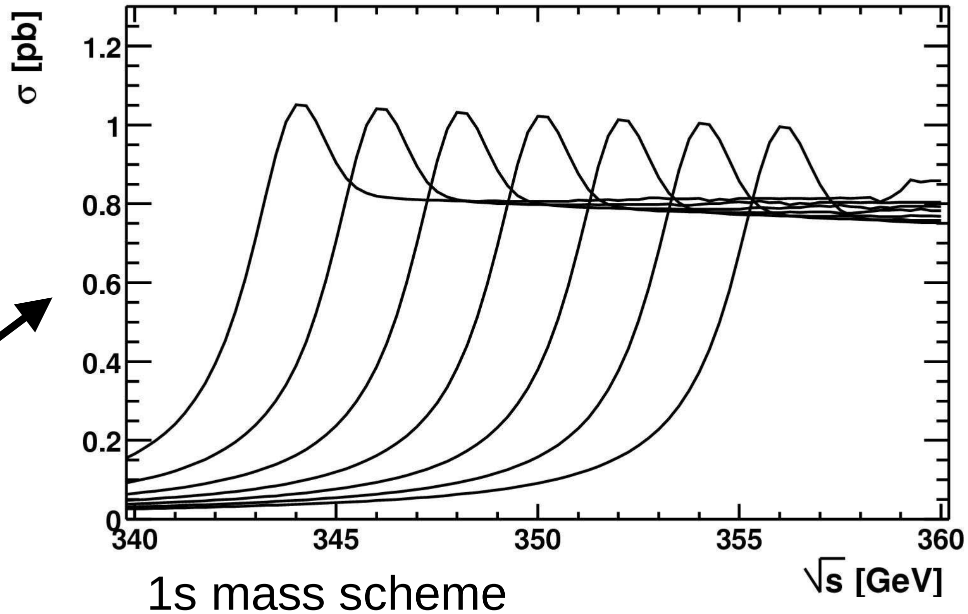
Luminosity spectrum

- 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 (□~0.1%)
  - Beamstrahlung and energy spread determined from accelerator and/or physics event measurements (Bhabhas)

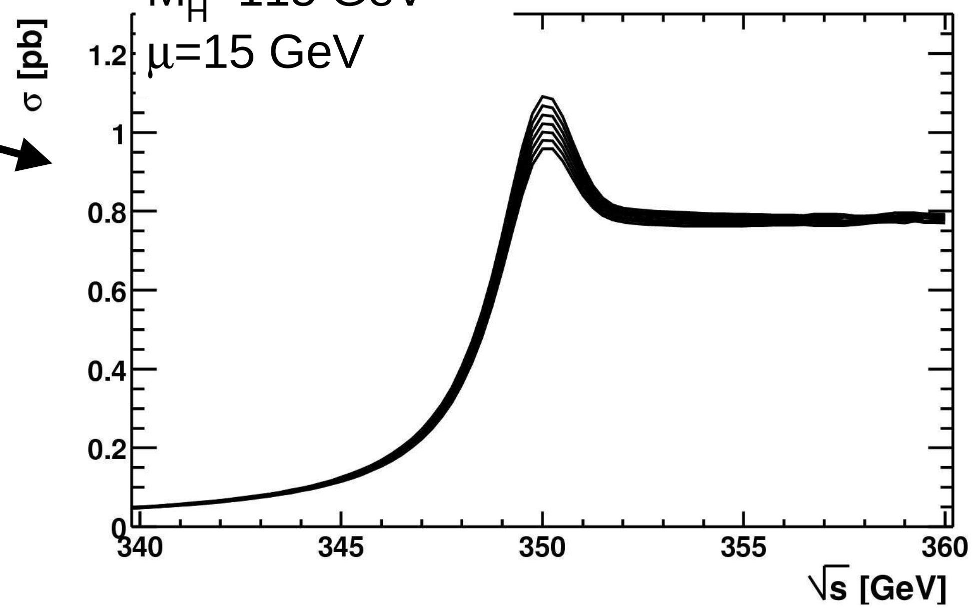


Top threshold simulation

- Threshold simulated using TOPPIK
  - Hoang and Teubner
  - Generate grid of cross section values
    - $m_t = 172 \rightarrow 178$ GeV
    - $\Gamma_t = 1.40 \rightarrow 1.46$ GeV
    - $\alpha_s = 0.115 \rightarrow 0.121$
  - Default threshold grid centre
    - $(m_t, \Gamma_t, \alpha_s) = (175, 1.44, 0.118)$
  - 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
μ=15 GeV



Smearing the threshold

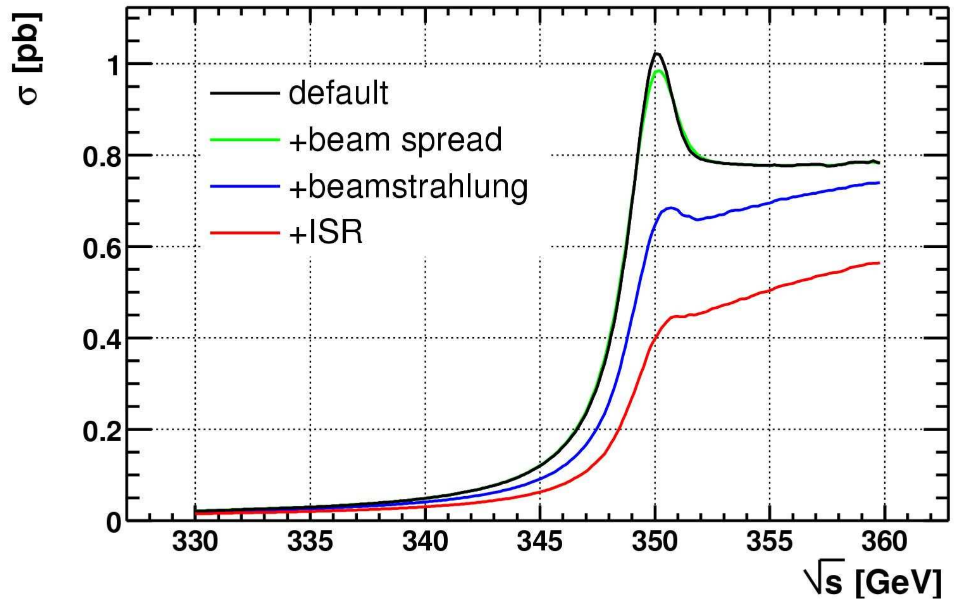
- Two alternative methods are used to smear the threshold curve
  - Histogram (binned)

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

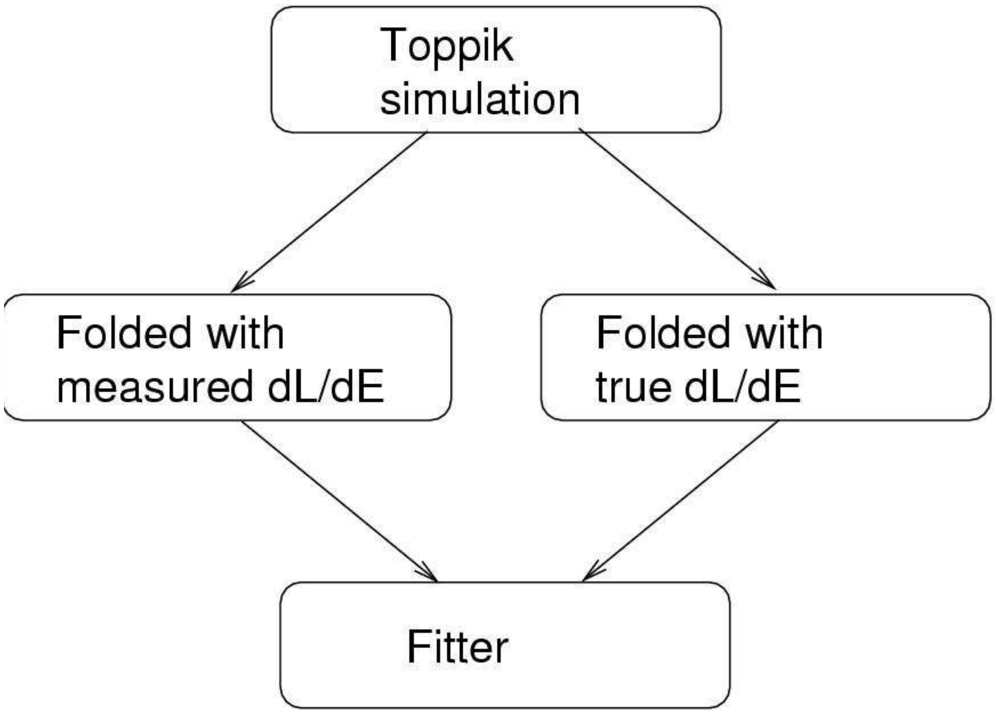
    - Large number of bins required when including all effects
      - ISR : 0<x<1
      - Beamstrahlung : 0.75<x<1
      - Energy spread : 0.99<x<1.01
  - Event sample (unbinned)

$$\sigma(\sqrt{s}) = 1/N \sum_{samples}^{N} \sigma(x_i\sqrt{s})$$

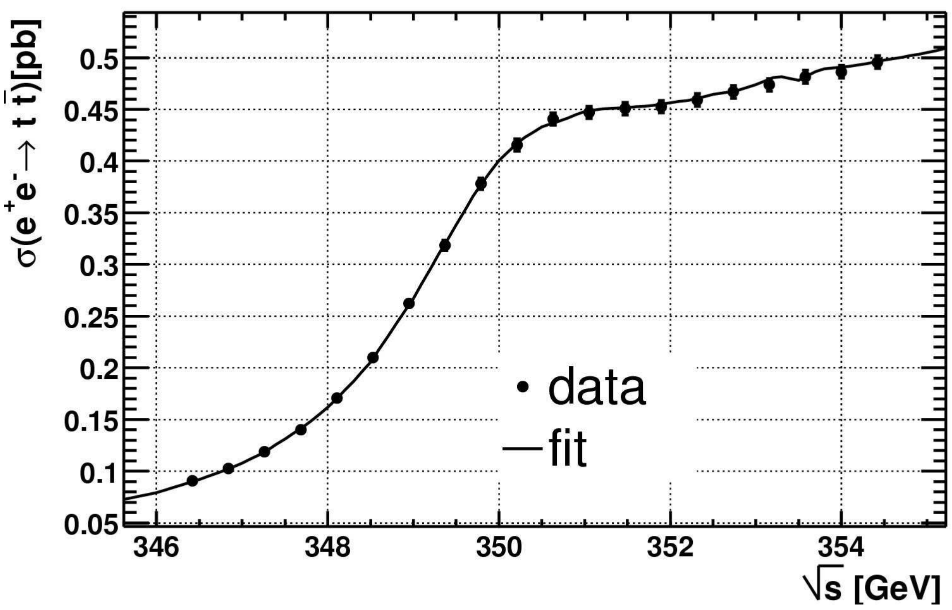
    - Large number of samples (N) of x distributed in a luminosity spectrum



Fitting introduction



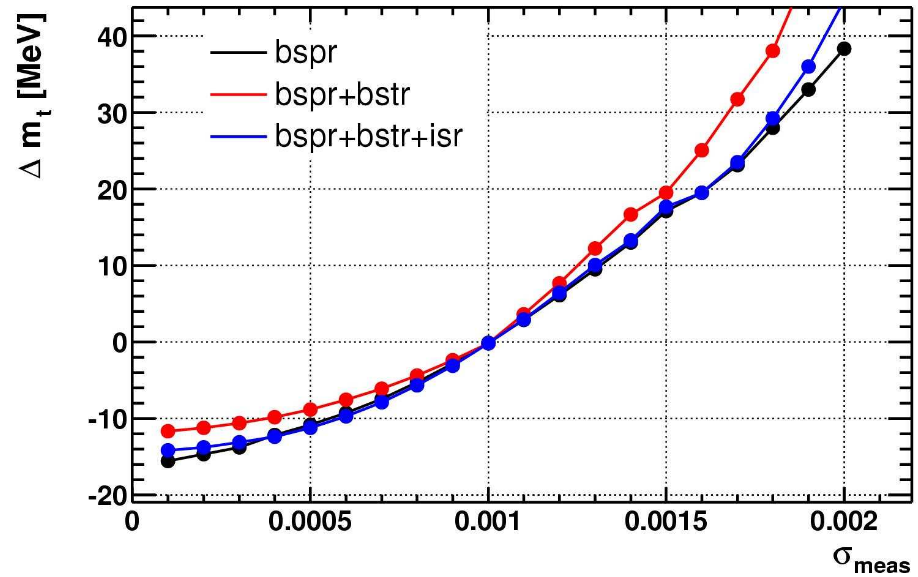
Fitting the top threshold

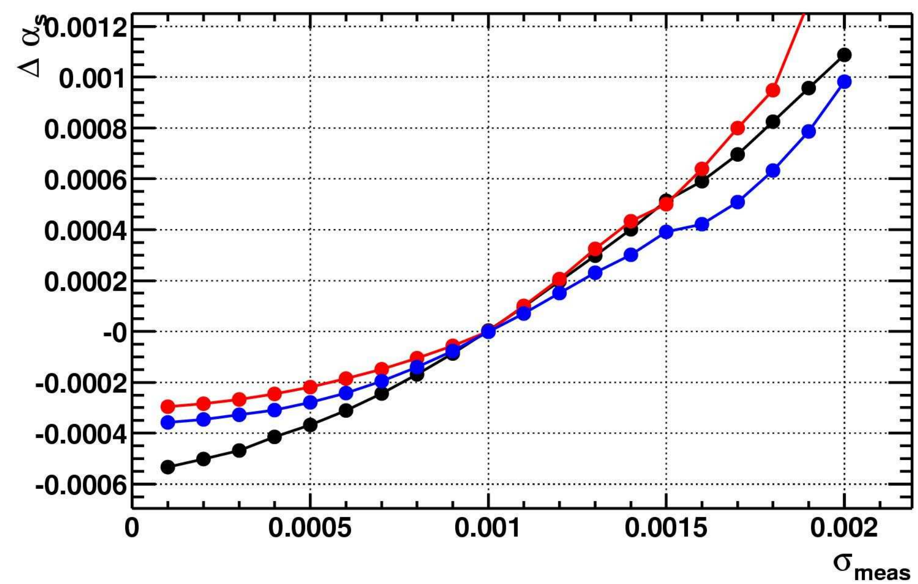


- Generate data with
  - 20 equidistant scan points
  - Range 346$\rightarrow$354 GeV
  - High luminosity, 30nb per point
  - Nominal luminosity spectrum
    - Linac energy spread 0.1%
    - CIRCE parameters on slide 3
- Fit cross section
  - Smeared with different luminosity spectra, so different CIRCE 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 (with Beamstrahlung and ISR)

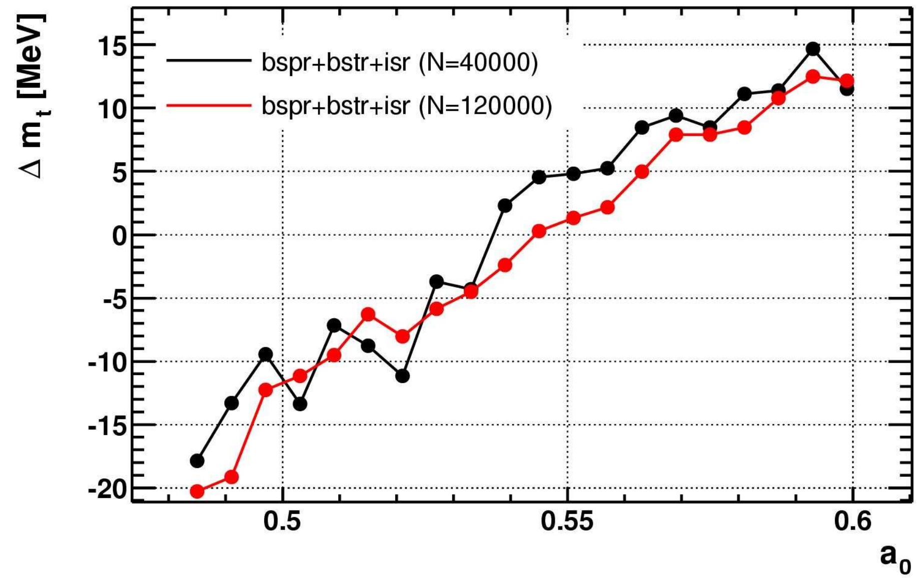
- Again look at the effect of linac energy spread
  - It has been proposed the effect of energy spread on previous slide is reduced due to beamstrahlung and ISR
  - Take the Gaussian and σ=0.1% width case
  - Now including
    - Beamstrahlung
    - Beamstrahlung and ISR
    - Generated with unbinned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

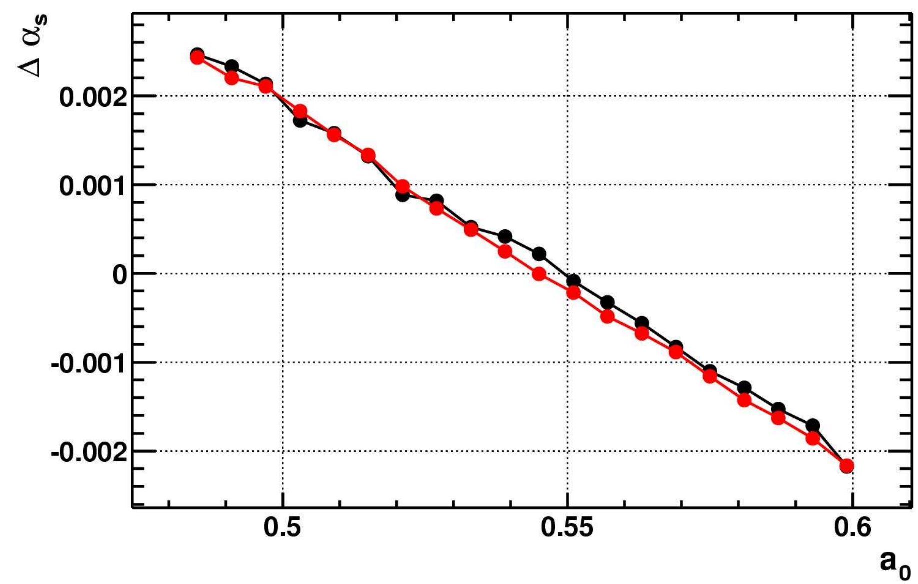




Effect of CIRCE parameters (a_0)

- 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
    - α_s : larger a_0 $\Rightarrow$ smaller loss of full beam energy luminosity $\Rightarrow$ overall increase in fit cross section



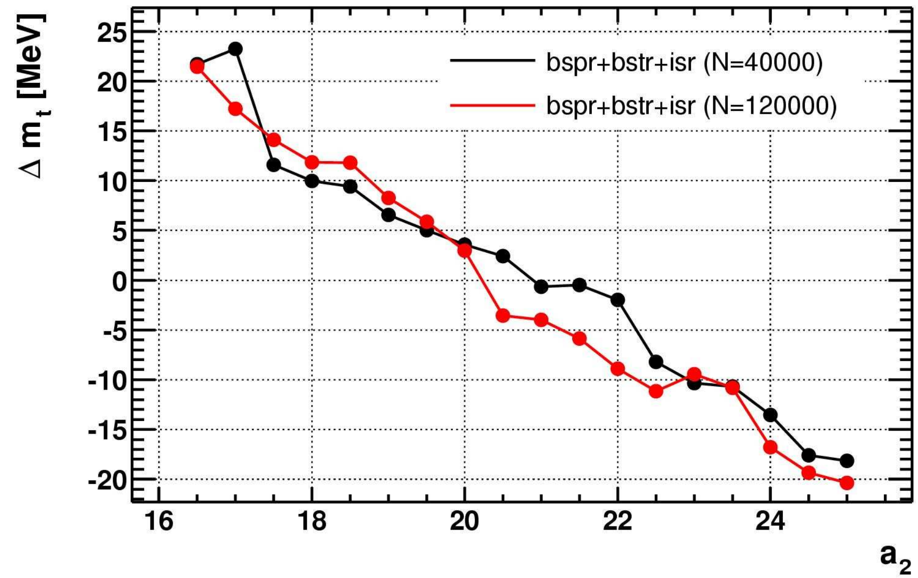


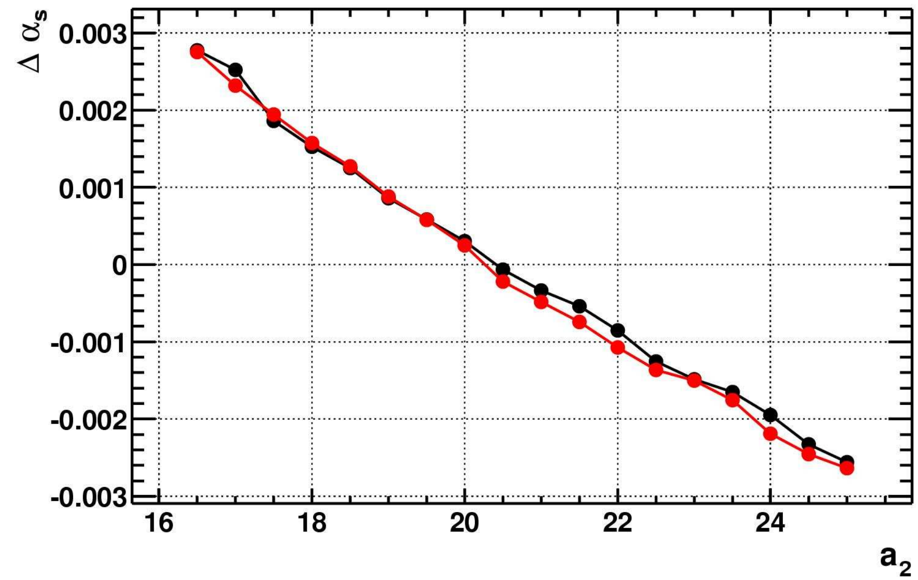
Effect of CIRCE parameters (a_2)

- 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
    - α_s : larger $a_2 \Rightarrow$ smaller loss of full beam energy luminosity $\Rightarrow$ overall increase in fit cross section



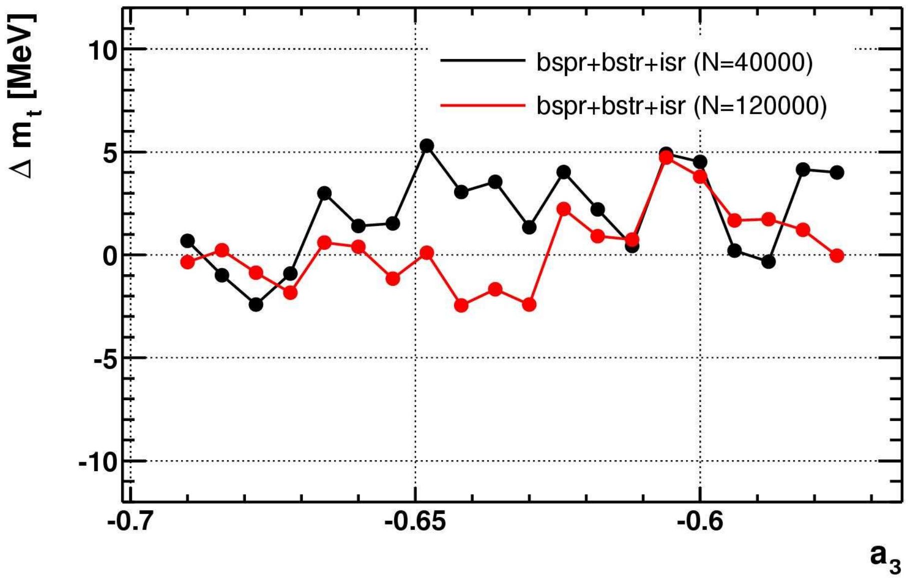


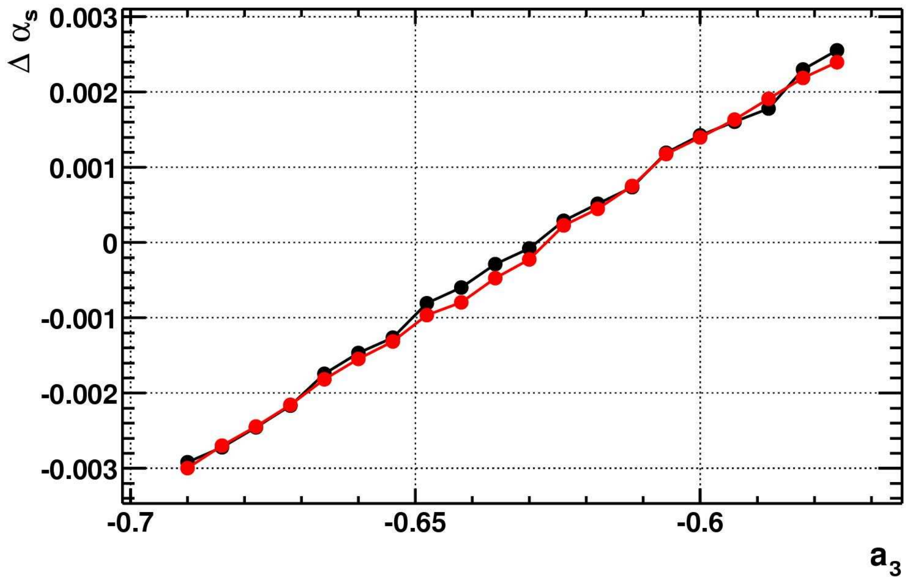
Effect of CIRCE parameters (a_3)

- Divergent term in Beta function

  $$(1-x)^{a_3}$$

  - a_3 dependence
    - m_t : little dependence
    - α_s : same argument as before but just enters β–function as negative power
- Satistics
  - N=40,000 or 120,000 lumi spectrum events
  - Trends consistent



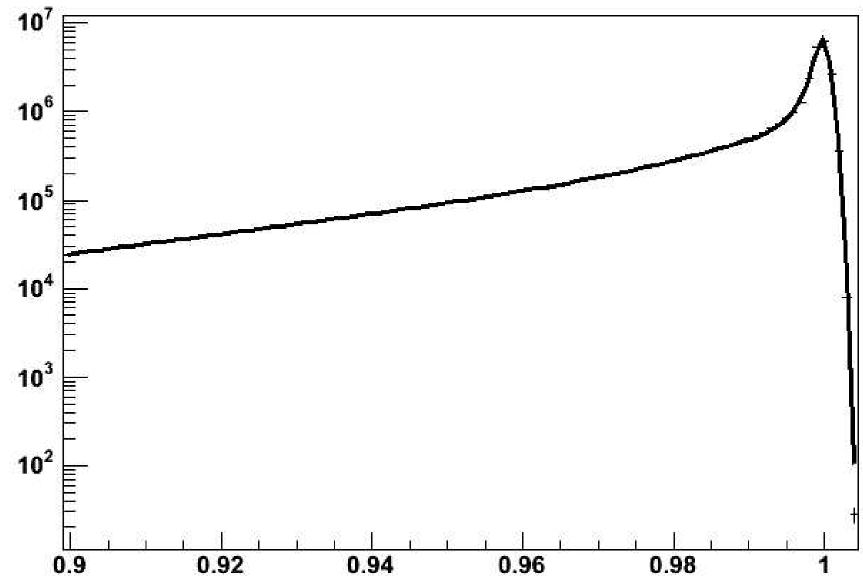


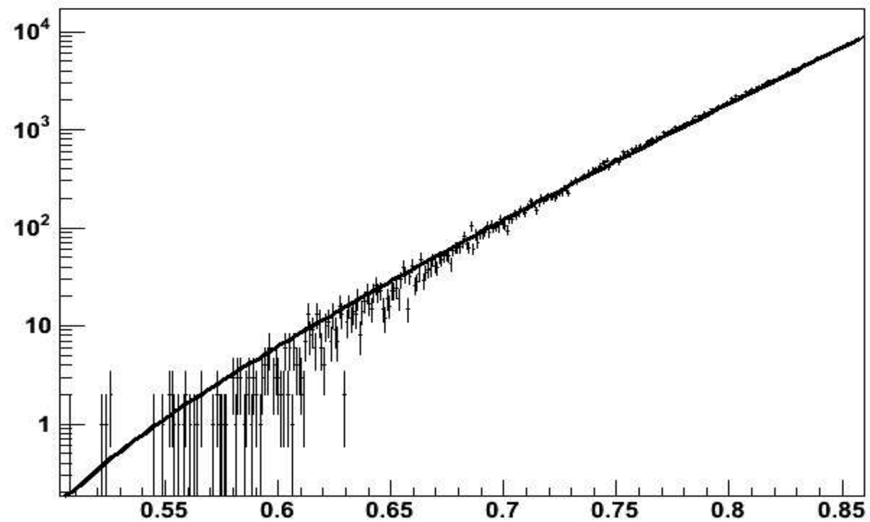
Words of caution

- Luminosity spectrum parametrisation
  - Might be wrong, CIRCE β–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
- Scan range not yet optimised
  - 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

Luminosity spectrum development

- Luminosity spectrum parametrisation
  - Currently developing parameterisation from Glen White's ILC simulation
  - Including linac wakefields, feed back system, ground motion etc.
  - Lumi spectrum parametrisation can be used for luminosity spectrum extraction
    - Fit Bhabha events for parameters of luminosity spectrum
  - Hoped to present new analysis here (top and Bhabha) but still not ready, Parametrisation looks look but not applied to top threshold.
    - Example fit of one "bunch train", 550 bunches, 500 GeV





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”
    - 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