Beamstrahlung parameterization and measurement

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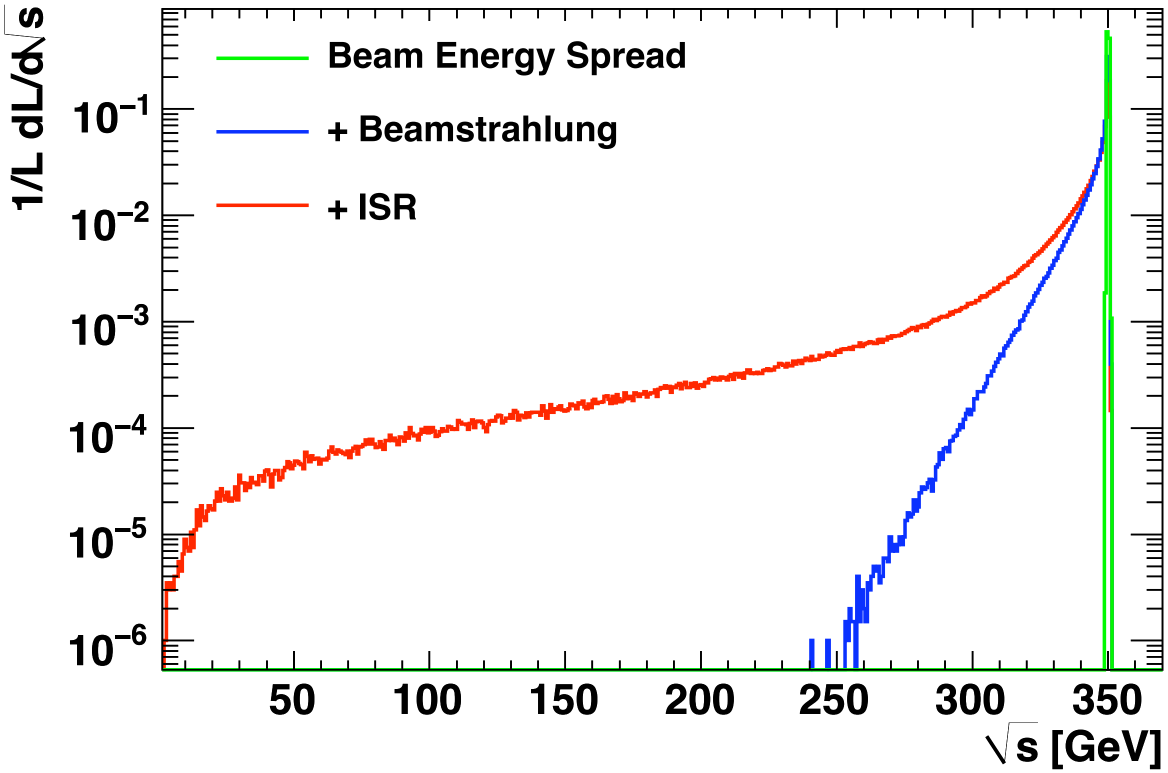
Overview

- Machine parameter sets give significantly different beamstrahlung spectra
- Parametrize spectra (including beam spread effects)
  - Top threshold energies
- Simulate samples of Bhabha events and use acolinearity to extract parameters
  - Investigate the measurement of different parameter sets
- Studied effect of
  - Deflections due to strong fields (GP++)
  - Asymmetry of two colliding beams

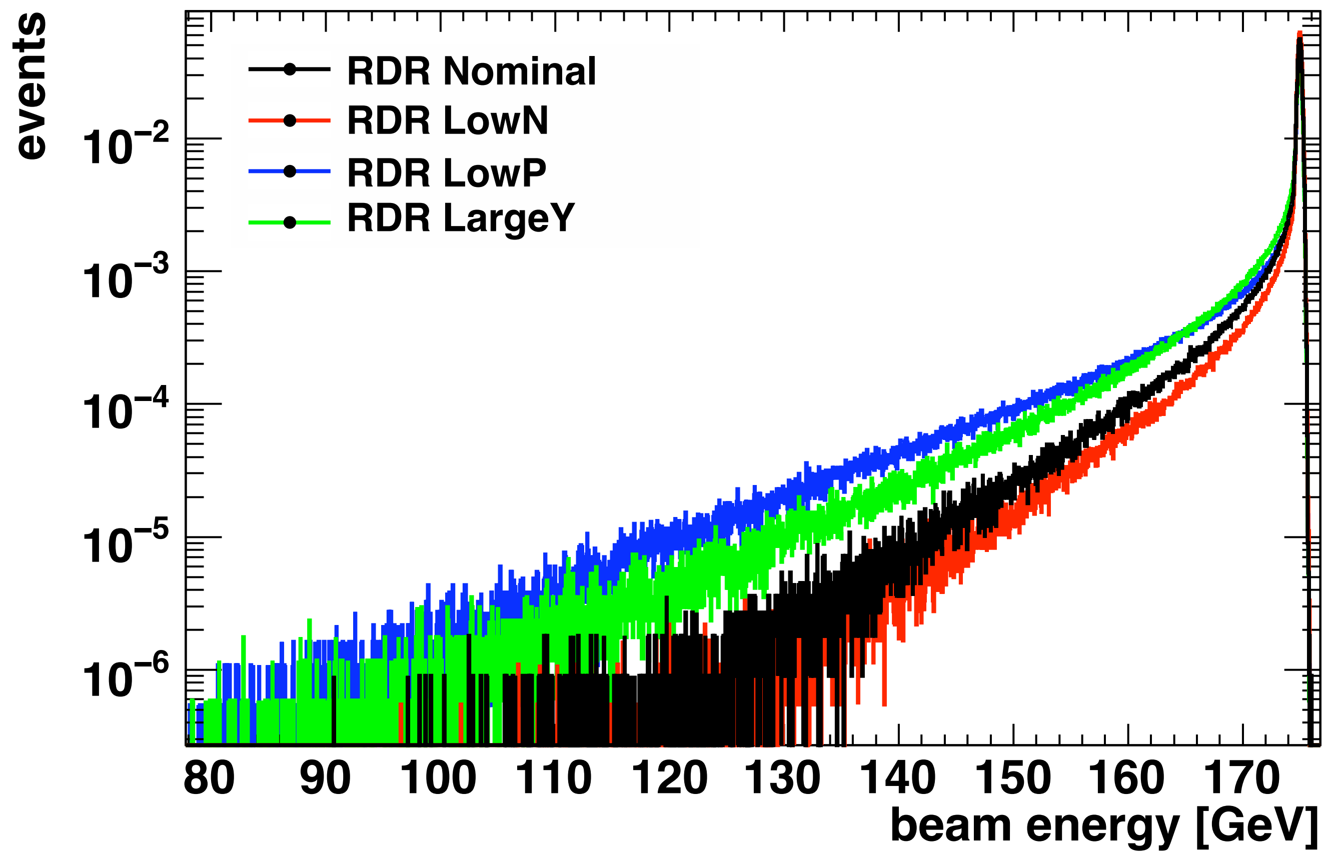
Luminosity spectrum



- Major components
  - Beam energy spread (BES)
  - Beamstrahlung
    - Most machine input
  - Initial state radiation
- RDR parameters sets large space for physics

RDR beam spectra

- Generated using GP++
- Top threshold centre of mass energy
- Most concern is LowP and LargeY option
- Clear luminosity loss for threshold scans



Usually deal with fractional energy, compared with nomial beam energy

$$x = \frac{E_b}{E_n}$$

Beamstrahlung parametrisation

- Beta function parameterization chosen

$$f(x) = a_0 \delta(0) + a_1 x^{a_2} (1-x)^{a_3}$$

- Problems with logarithmic transforms easier fitting
  - Due to energy spread

$$x' = log(x-1)$$

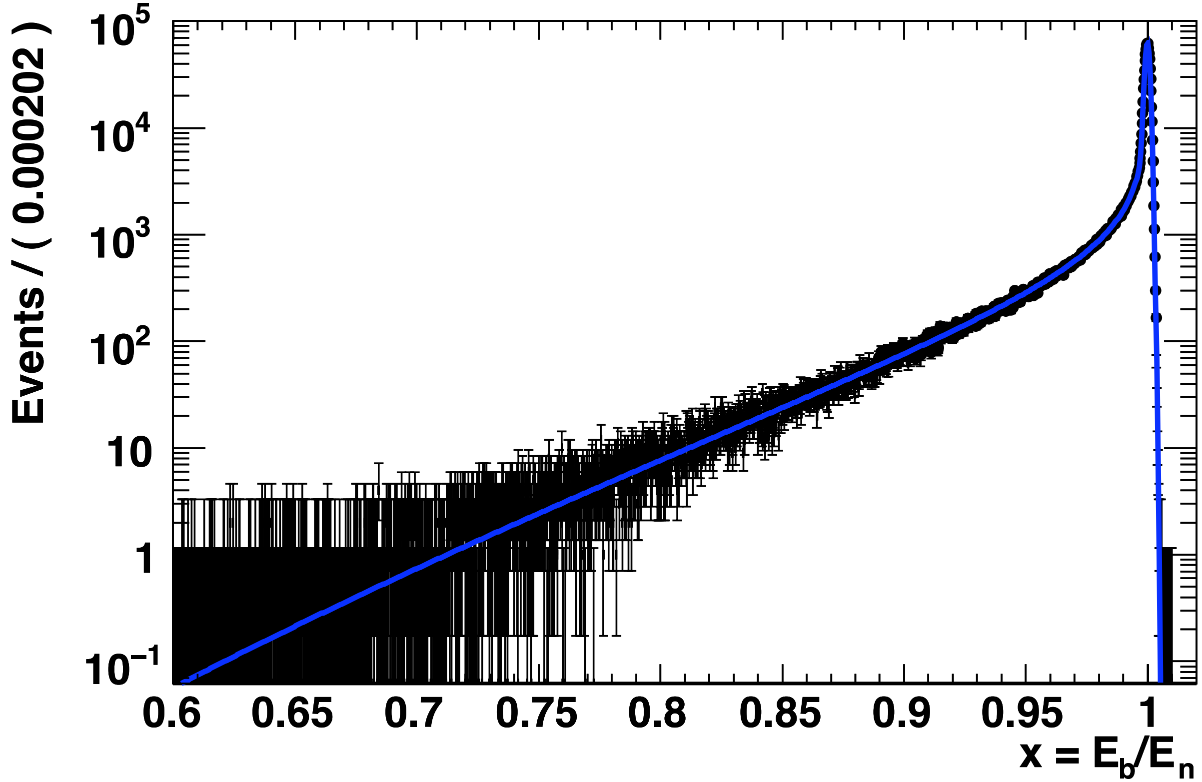
- Convolute with beam energy spread

$$D^*_{e^\pm}(x) = a_0 BES(1,\sigma) + a_1 \int_0^{x_{max}} BES(x,\sigma) \cdot x^{a_2} (1-x)^{a_3} \, dx$$

- Numerically calculate integral

Beamstrahlung fits

- Fit parameterisations
  - Blue curve fit
  - Histogram with errors GP++ simulation
  - Performed for all parameter sets



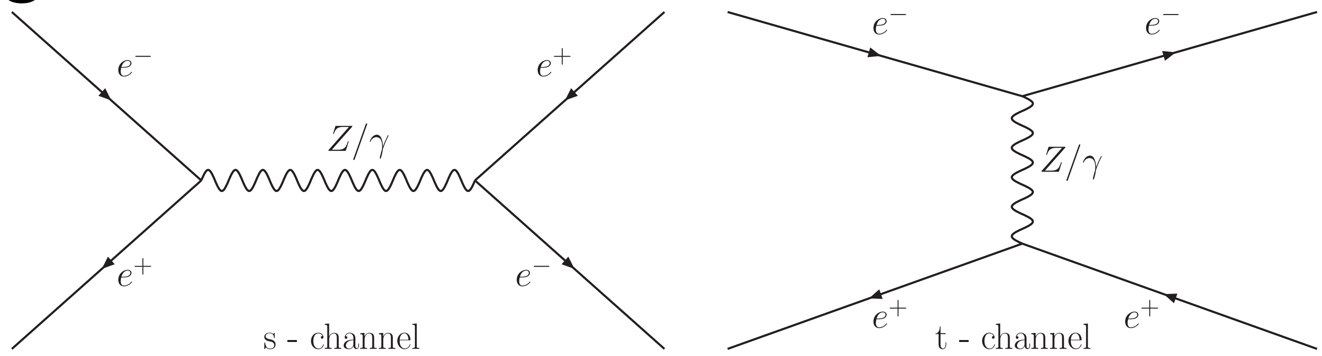
Beamstrahlung parameters and energy spread fitted to GP++ simulations

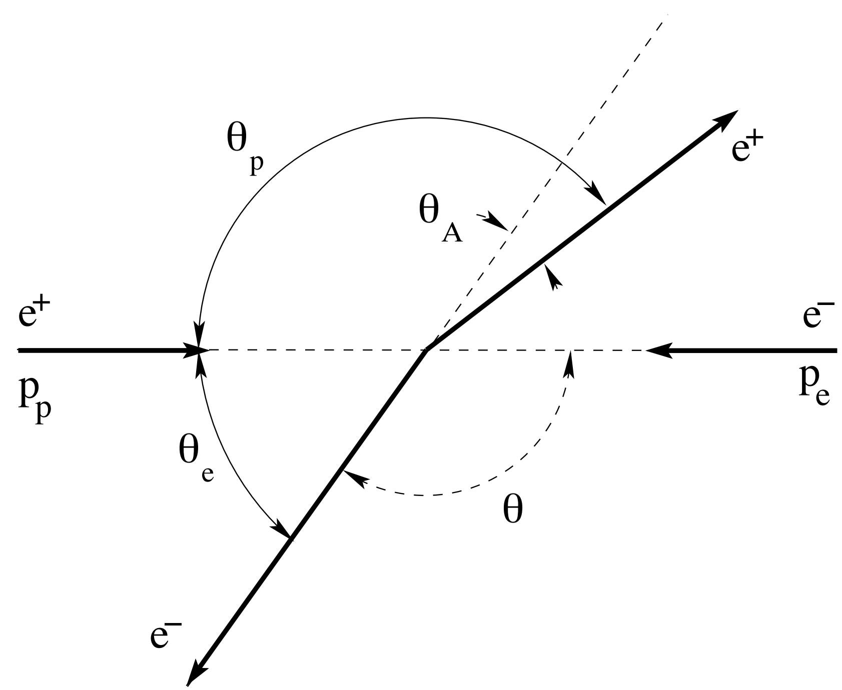
	Nominal	Low-N	Large-Y	Low-P
a_0	0.606	0.705	0.445	0.531
a_2	15.340	15.869	11.192	8.026
a_3	-0.708	-0.744	-0.690	-0.642
σ_E [GeV]	0.175	0.175	0.174	0.176
$\langle E \rangle$ [GeV]	173.58	174.05	172.26	171.62

Bhabha acolinearity

- Monitor low angle Bhabha events
    - >7degrees
- Simulation
    - Generated using BHWIDE
    - Fold in luminosity spectrum for a given centre of mass energy
- Measure final state angles and compute

$$x_{acol} = \sqrt{\cot\frac{\theta_e}{2}\cot\frac{\theta_p}{2}}$$

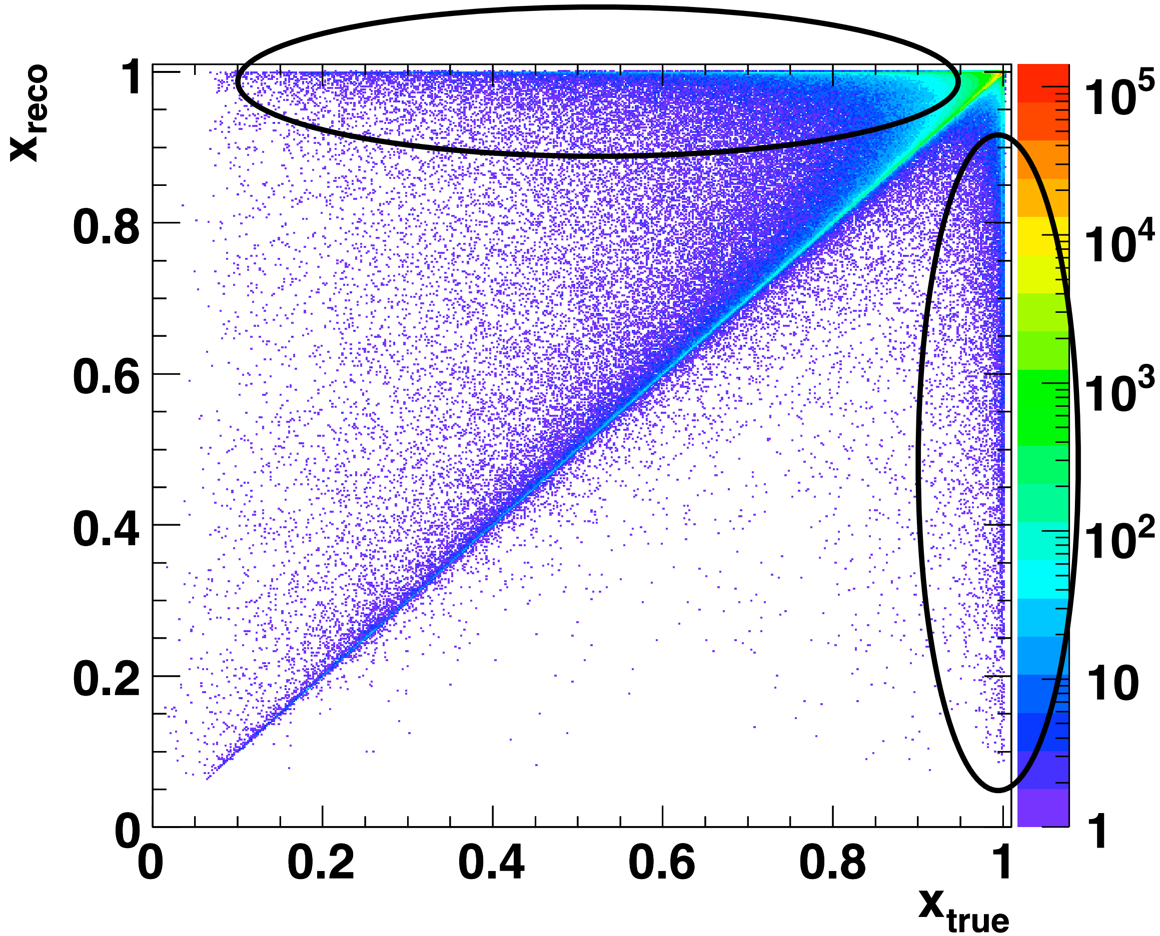




Assuming single photon radiation

Reconstructed energy loss

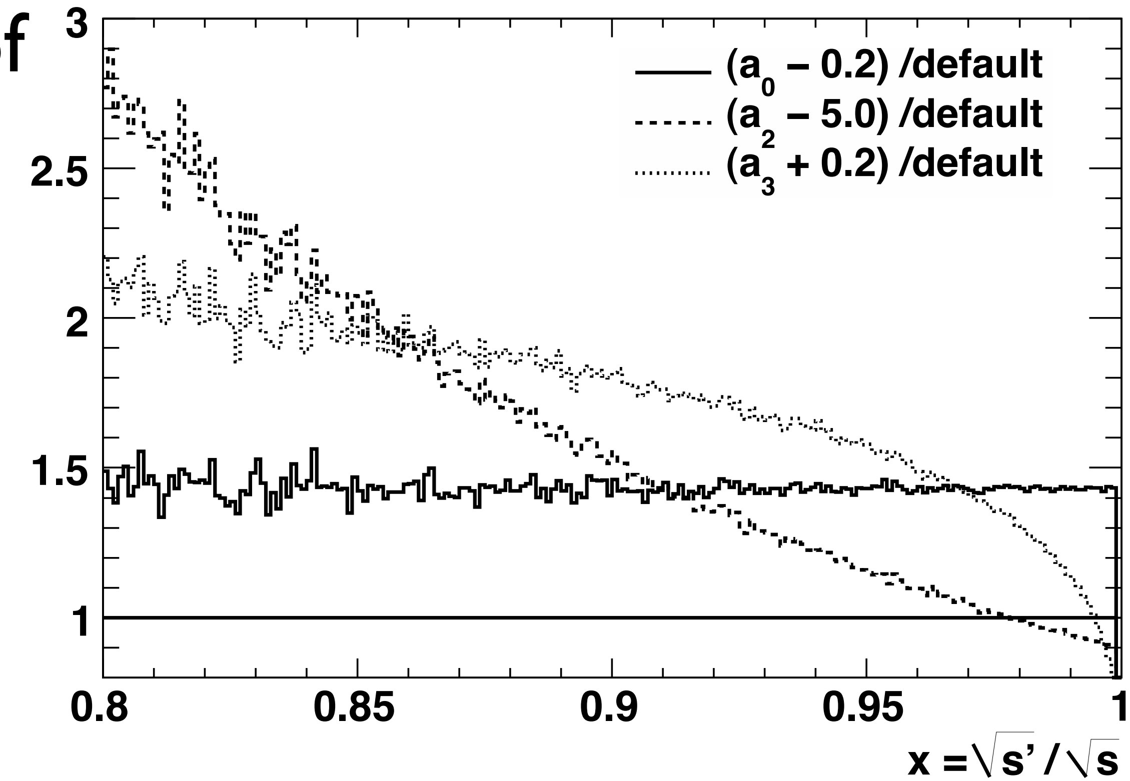
- Compare reconstructed x and true x
- Nominal parameter set
- Large deviations from main diagonal
  - Multiple photon radiation
  - Final state radiation



Logarithmic z scale

Beamstrahlung measurement

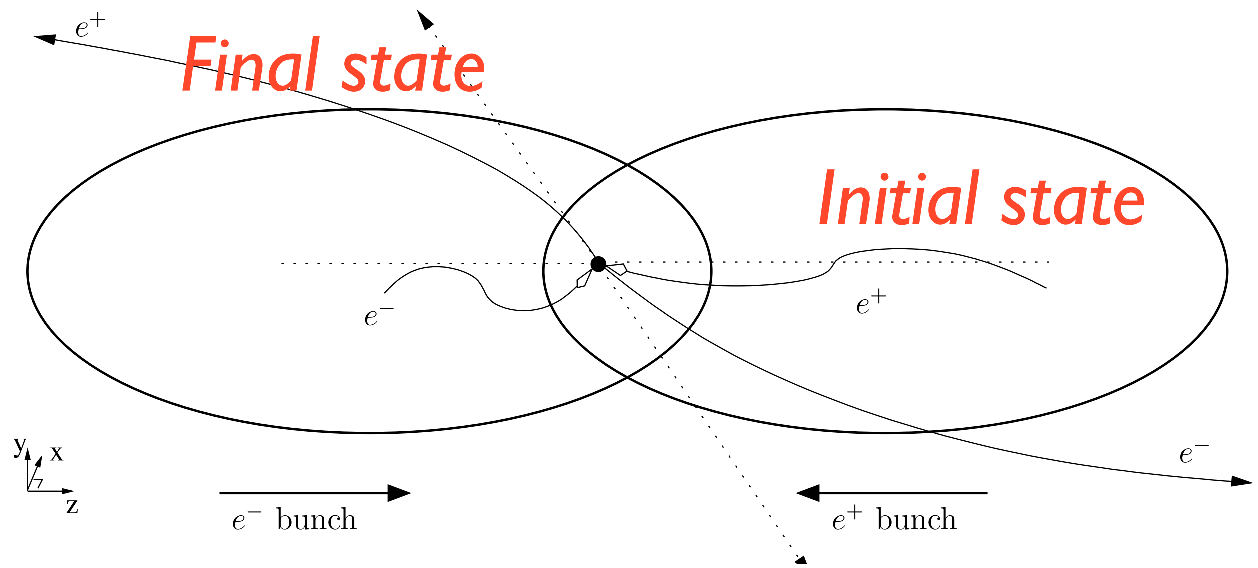
- Simulate various sets of Bhabha events with different a parameters
- Create histograms of x_{acol}
- Minimize to determine beamstrahlung parameters which best describe sample

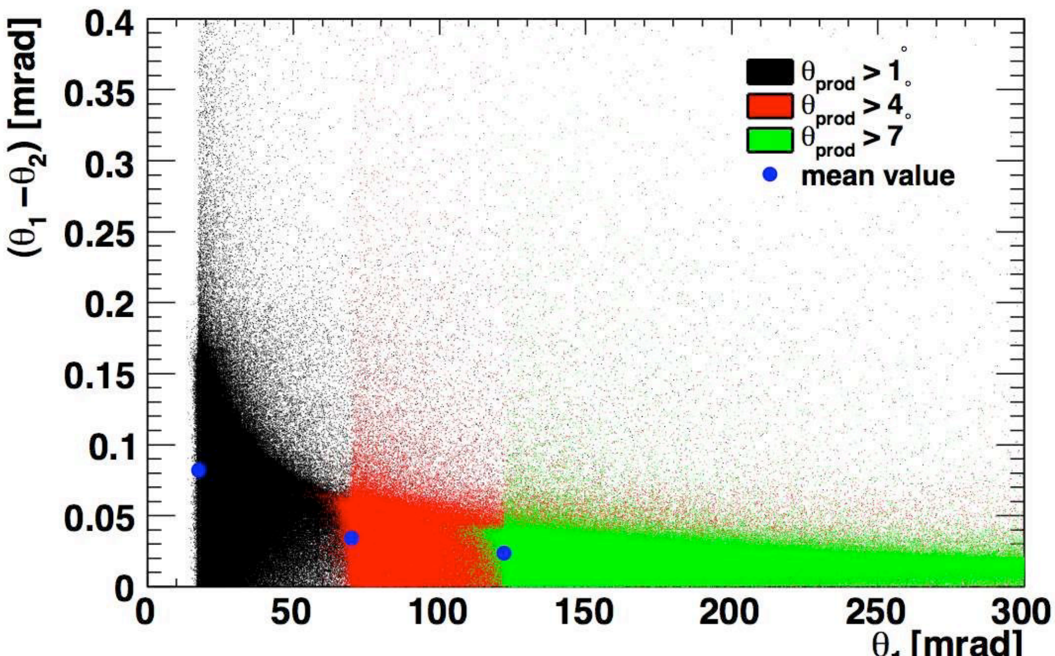


$$x_j^{fit}(\mathbf{a}) = x_j^0 + \sum_i \frac{a_i - a_i^0}{\delta a_i}(x_j^i - x_j^0)$$

Effect of bunch fields

- Look at effect of
  - initial and final state perturbation of Bhabha scattered particles
- Final state is not a problem
  - <5 micro-rad
- Initial state
  - 150 micro-rad





Summary of extracted spectra

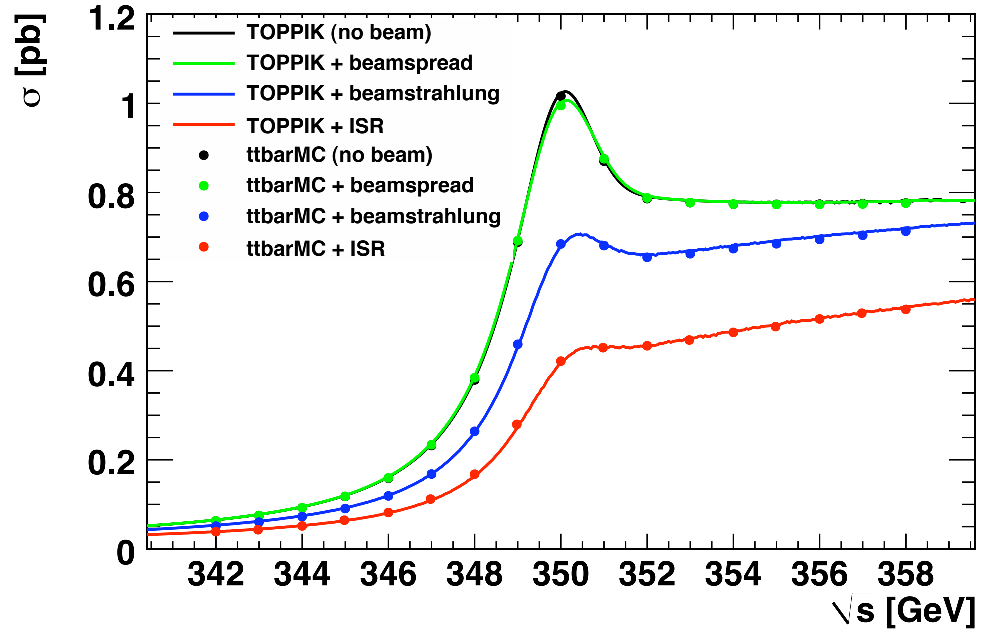
- Extract beamstrahlung parameters for each set
  - Largest effect for LowP
  - Problem exasperated due to initial state momentum
- Nominal and LowN fine, LargeY a problem

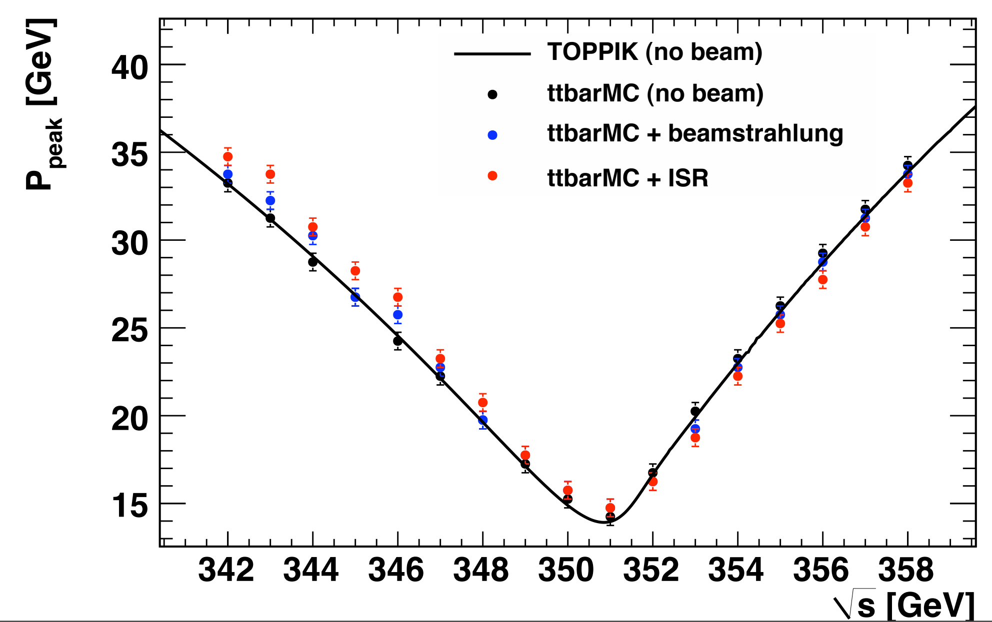
Correlations Effect				
Parameter	Nominal	LowN	LargeY	LowP
a_0	0.623	0.712	0.463	0.597
a_2	15.669	16.347	11.549	8.257
a_3	-0.688	-0.727	-0.684	-0.717
σ_x	$1.0061 \cdot 10^{-3}$	$1.0001 \cdot 10^{-3}$	$1.0069 \cdot 10^{-3}$	$1.0080 \cdot 10^{-3}$
Δa_0	2.78%	2.25%	4.17%	12.40%
Δa_2	2.14%	3.01%	3.12%	2.87%
Δa_3	2.77%	2.18%	0.84%	-11.63%
$\Delta \sigma_x$	0.61%	0.01%	0.69%	0.80%
$\Delta \langle E \rangle$ [MeV]	-5.3	11.2	109.4	1070.0

Initial State Transverse Momentum Effect				
Parameter	Nominal	LowN	LargeY	LowP
a_0	0.623	0.726	0.465	0.657
a_2	15.799	16.335	11.655	8.315
a_3	-0.685	-0.722	-0.683	-0.697
σ_x	$1.2503 \cdot 10^{-3}$	$1.1550 \cdot 10^{-3}$	$1.3400 \cdot 10^{-3}$	$1.3007 \cdot 10^{-3}$
Δa_0	2.71%	2.99%	4.61%	23.62%
Δa_2	2.99%	2.93%	4.14%	3.60%
Δa_3	3.28%	2.90%	1.08%	-8.60%
$\Delta \sigma_x$	25.03%	15.50%	34.00%	30.07%
$\Delta \langle E \rangle$ [MeV]	-7.5	7.8	124.5	1275.8

Propagation to top threshold

- Final test is the effect on top threshold
  - Can consider fraction of luminosity within few %
  - Cumulative distribution
- Fold spectrum with top threshold to
- Study not quite complete ... few weeks





Conclusions

- Simplistic extraction of luminosity spectrum parameters
  - Small shifts for Nominal and LowN parameter sets
  - Shifts significant for LargeY and LowP
  - Problem is exasperated for LowY and LowP when pre-collision disruption is included
  - Will continue looking at LowP
  - Must check with traveling focus solutions for LowP
- Detector effects are not significant compared with deflections due to high bunch fields