An update on systematics at higher ILC energies

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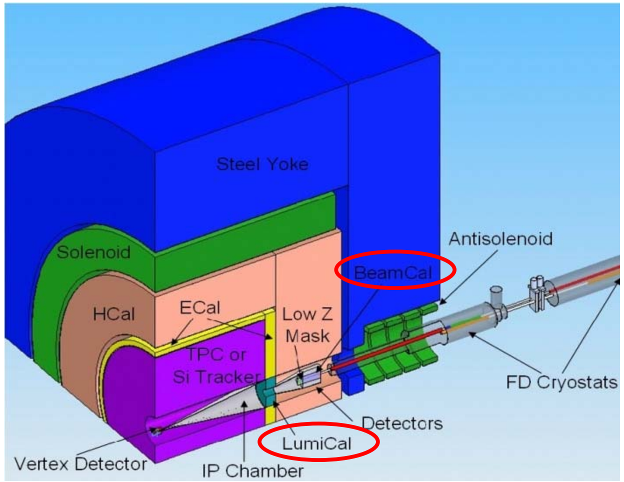
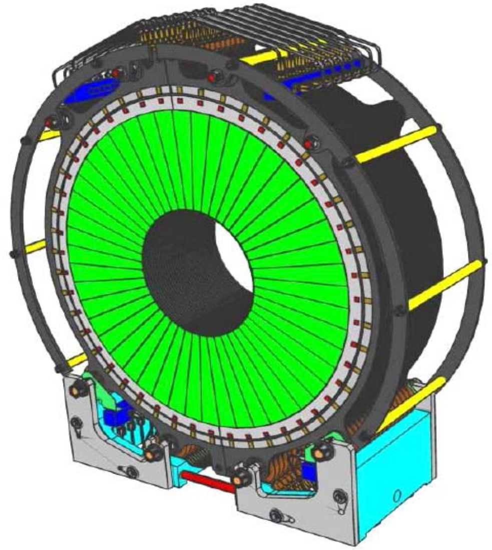
Overview

- Forward region of the ILC, Luminosity Calorimeter
- Luminosity measurement
- Systematics: energy resolution; 2-γ background; space charge effects
- Total systematics
- Summary

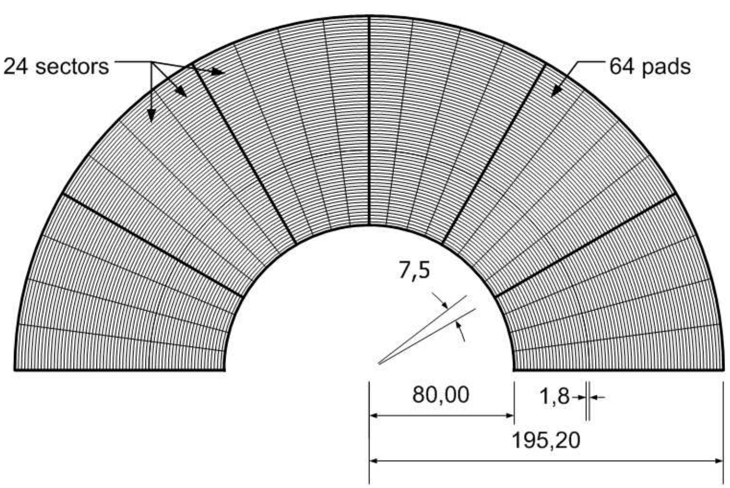
Luminometer at ILC





Distance from IP [m]	**2.5**
Geometrical aperture [mrad]	**[31-78]**
Fiducial volume [mrad]	**[38-69]**
Number of layers	**30 W/Si**
Moliere radus [cm]	**1.5**
Sensor azimuthal/radial divisions	**48/64**
Resolution in polar angle [mrad]	**(2.2±0.02) 10^{-2}**
Energy resolution [$GeV^{1/2}$]	**0.21**

Silicon sensor half plane



Luminosity measurement

Integrated luminosity can be determined from the total number of Bhabha events produced in the acceptance region/fiducial volume of the luminosity calorimeter and the corresponding theoretical cross-section

IT IS COUNTING EXPERIMENT, BUT...

real experiment

$$L_{\text{int}} = \frac{N_{th}}{\sigma_B} \Rightarrow L_{\text{int}} = \frac{N_{\text{exp}} - \sum_i N_i^{cor}}{\varepsilon \cdot \sigma_B} \Rightarrow$$

1. To build a device capable of precise reconstruction of E, θ

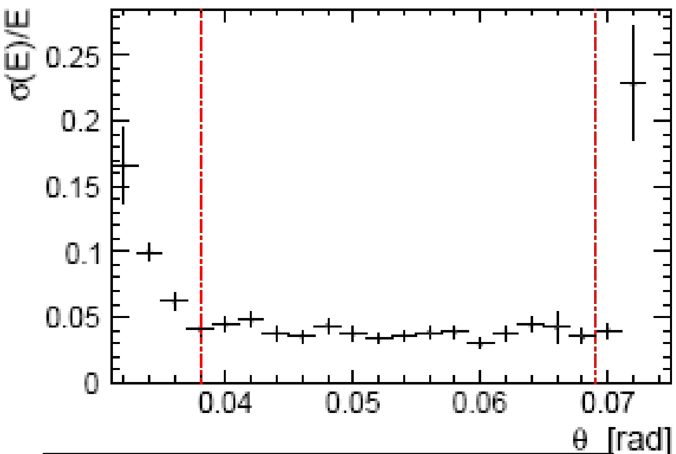
2. To control (other) systematics

When taken as correction, an effect ♋ gives contribution to 👎L/L of ♋♎♋ where ♎♋ is relative (experimental) uncertainty of ♋

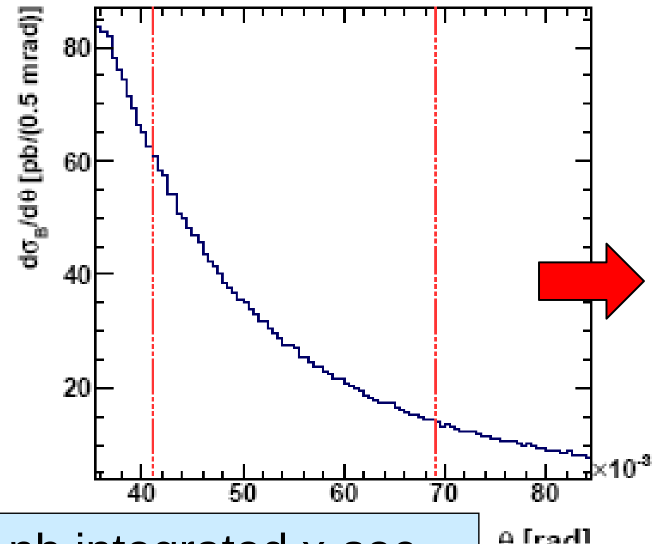
Event selection

- the polar angle of the reconstructed shower must be within the detector fiducial volume at one side and within $\left[\theta_{\min}^{f} + 4mrad, \theta_{\max}^{f} - 7mrad\right]$ at the other.
- total energy deposited in the LumiCal must be more than 80% of the center-of-mass energy

Should we worry about efficiency?

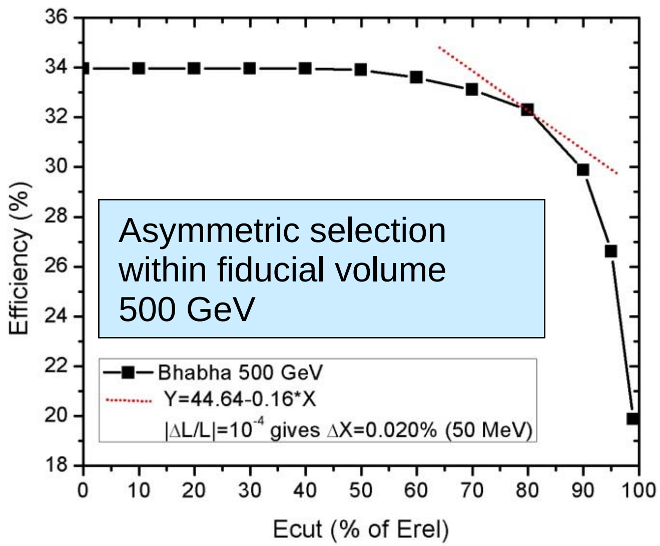


LumiCal fiducial volume

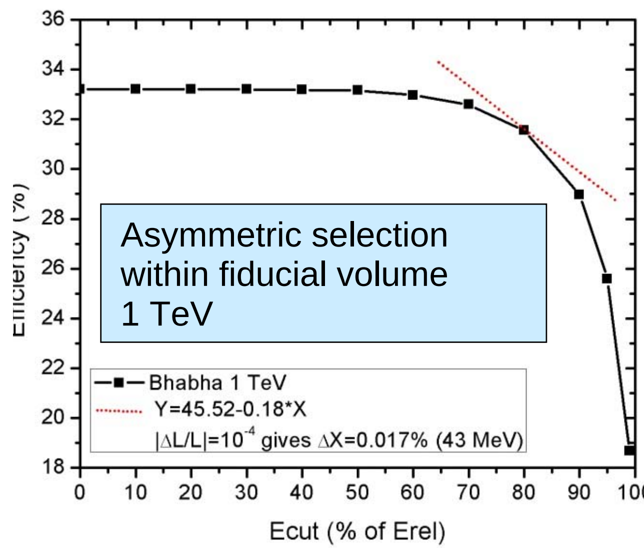


2.1 nb integrated x-sec.

$$\left(\frac{\Delta L}{L}\right)_{stat}^{annual} < 10^{-4}$$



Asymmetric selection
within fiducial volume
500 GeV

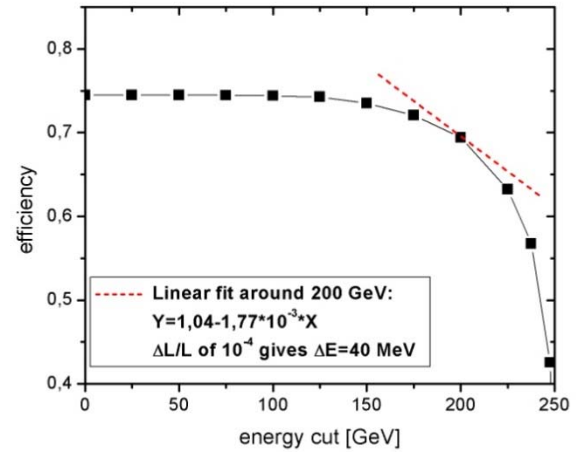


Asymmetric selection
within fiducial volume
1 TeV

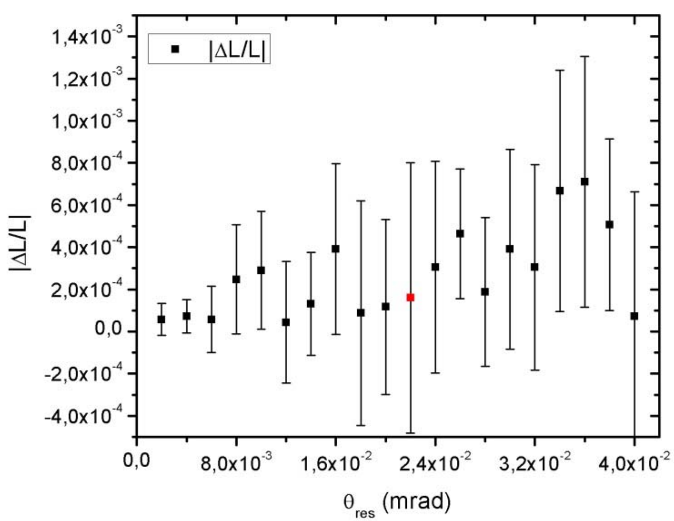
According to the designed luminosity of $2x10^{34}$ cm^2s^{-1}, there should be about10^9 Bhabha events per year (with the proposed selection).

Should we worry about efficiency?

old geometry, physical volume (25-87 mrad)
- Bogdan's comment on efficiency drop with asymmetric selection within fiducial volume.



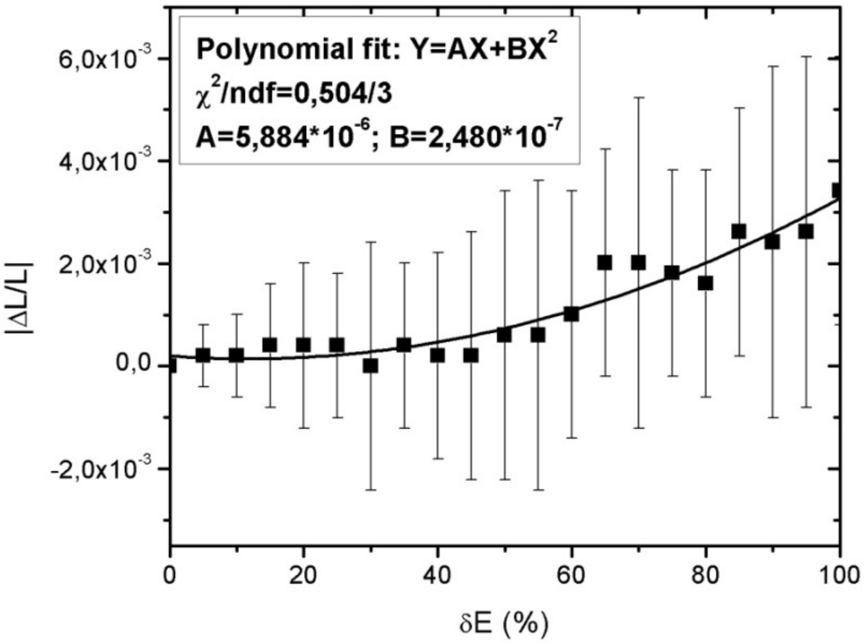
However, $|\Delta L/L|_{stat}$ stays OK.



Other systematics

The polar resolution of LumiCal is $\sigma_\theta = (2.2 \pm 0.01)\mathrm{x}10^{-2}$ mrad (θ_{res} on the plot). For this value of polar resolution, $|\Delta L/L|=1.6*10^{-4}$. Smearing the value of polar angle around that value shows that $|\Delta L/L|$ stays at the 10^{-4} level even if we have a 100% uncertainty of σ_θ.

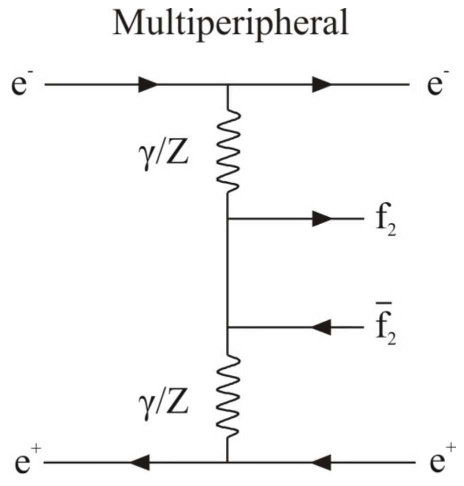
Other systematics - Energy resolution



old geometry, physical volume (25-87 mrad): for declared energy resolution of ♋$_{res}$ (♎E) =21%, |👎L/L| =2.32*10^{-4}.

new geometry, fiducial volume (38-69 mrad): for declared energy resolution of ♋$_{res}$=21%, |👎L/L| =2.18*10^{-4} for 500 GeV and |👎L/L| =2.92*10^{-4} for 1 TeV, so NO SIGNIFICANT CHANGES

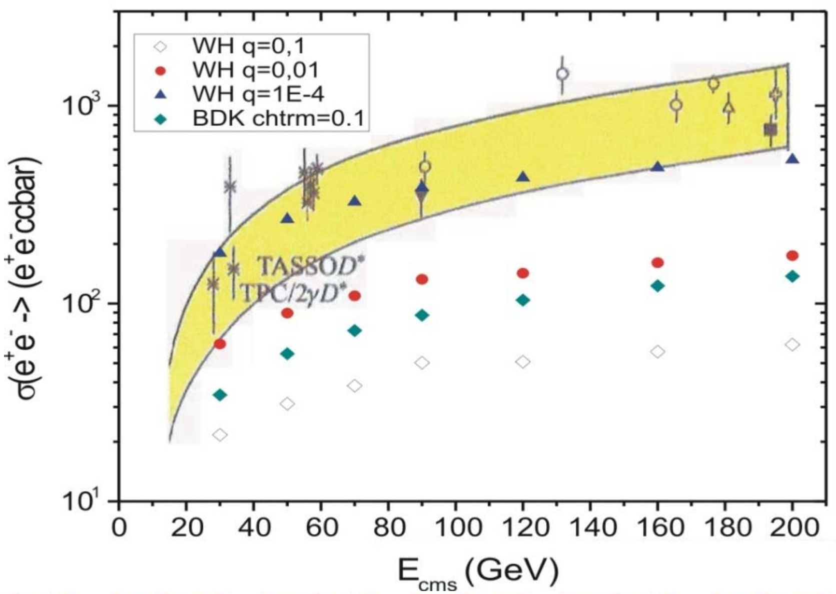
Other systematics – 2-γ background

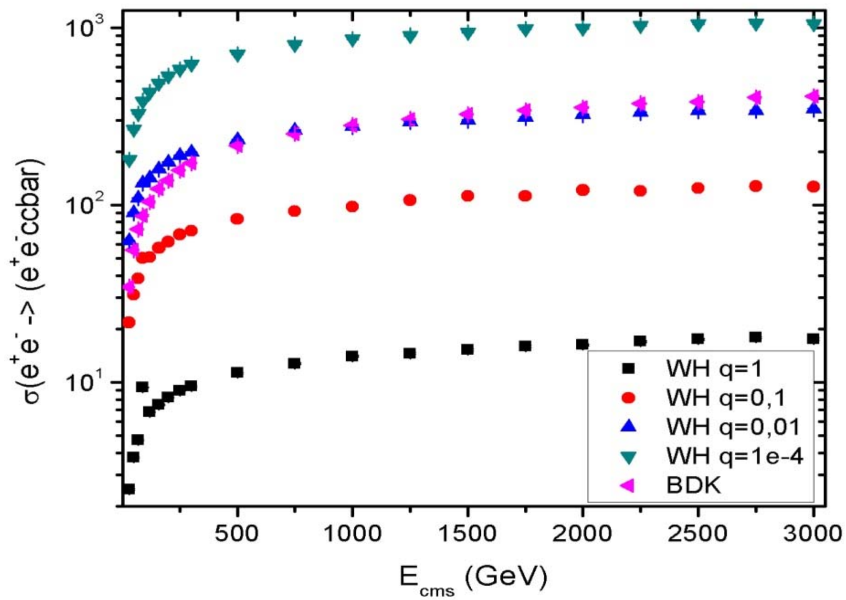


High x-sec ~10s nb, spectators close to the beam pipe – less than 1% of spectators in the LumiCal

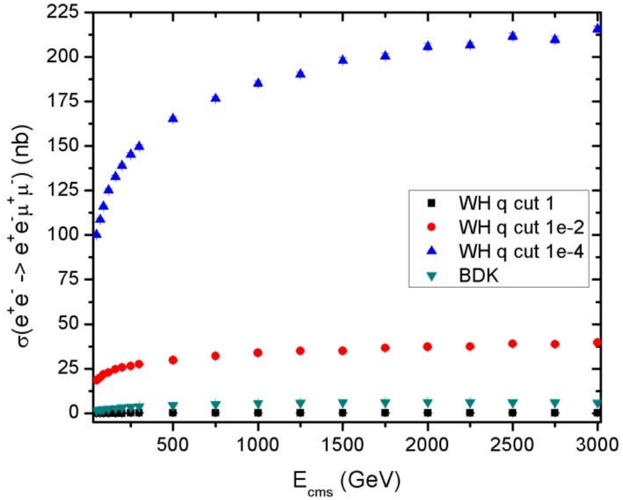
Problem with difference between BDK and WHIZARD is solved – it is possible to tune WHIZARD to reproduce LEP experimental results for eecc cross-section.

B/S ratio saturates within the same order of magnitude (10^{-3}) at ILC energies - B/S=2.3 10^{-3} at 500 GeV and B/S = 5.2 10^{-3} at 1 TeV



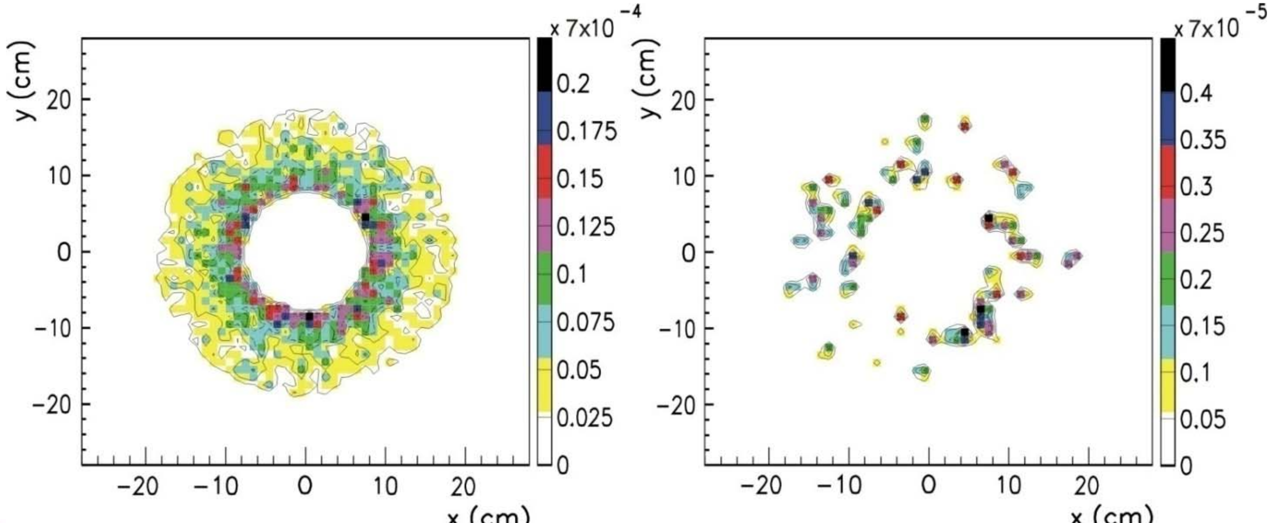


Other systematics – 2-γ background



4-l cross-sections

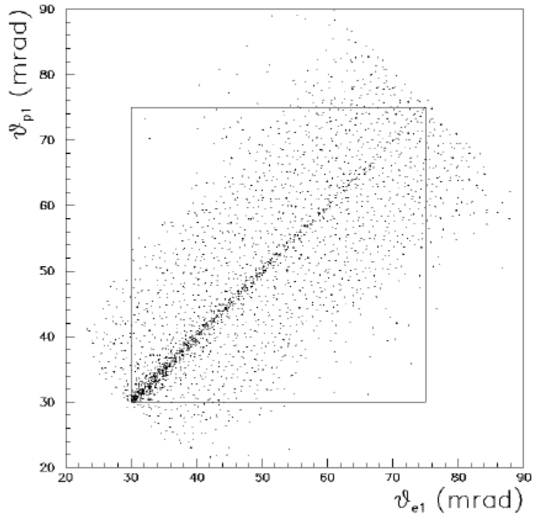
Background hits on the front plane before and after selection applied



Beam-beam interactions

- Modification of initial state**: Beamstrahlung**
  $\Rightarrow$ $\sqrt{s'} \leq \sqrt{s}$, 👎❑$_{ini}$≠ 0, $E_{elec} \neq E_{posit}$
- Modification of final state: **Electromagnetic deflection** $\Rightarrow$ Bhabha angle reduction (~10^{-2} mrad) + small energy losses

  Total BHabha Suppression Effect (BHSE) ~1.5%



On experimental determination on BHSE uncertainty see Ivanka's talk at LCWS10 and also 'Impact of beam-beam effects on precision luminosity measurements at the ILC, C. Rimbault et al., JINST 2:P09001,2007'

Total systematics

TOTAL SYSTEMATICS at 500 GeV

	Value	Uncertainty of the value	$\Delta L/L$
x-sec$_{Bhabha}$ [nb]	2.1	$5.4\ 10^{-4}$ **	$5.4\ 10^{-4}$
σ_θ [mrad]	$2.2\ 10^{-2}$	100%*	$1.6\ 10^{-4}$
$\Delta\theta$ [mrad]	$3.2\ 10^{-3}$	100%*	$1.6\ 10^{-4}$
α_{res} [GeV$^{-1/2}$]	0.21	1.5%	$1.0\ 10^{-4}$
E$_{Bhabha}$ [GeV]	≥ 200	$2.0\ 10^{-4}$	$1.0\ 10^{-4}$
B/S	$2.3\ 10^{-3}$	100%*	$2.3\ 10^{-3}$
BHSE	1.51%	9.9%***	$1.5\ 10^{-3}$
Σ			**$2.8\ 10^{-3}$**

* marks upper limits.

** Uncertainty of the theoretical cross-section for Bhabha at LEP energies [OPAL, G. Abiendi et al., Eur. Phys. J C14(2000)373].

*** 5% control of buch x and z sizes.

Total systematics

TOTAL SYSTEMATICS
at 1 TeV- very preliminary

	Value	Uncertainty of the value	$\Delta L/L$
x-sec$_{Bhabha}$ [nb]	1.1	$5.4\ 10^{-4}$ **	$5.4\ 10^{-4}$
σ_θ [mrad]	$2.2\ 10^{-2}$	100%	$2.9\ 10^{-4}$
$\Delta\theta$ [mrad]	$3.2\ 10^{-3}$	100%*	$1.6\ 10^{-4}$
α_{res} [GeV$^{-1/2}$]	0.21	6%	$1.0\ 10^{-4}$
E_{Bhabha} [GeV]	≥ 400	$1.7\ 10^{-4}$	$1.0\ 10^{-4}$
B/S	$5.2\ 10^{-3}$	$5.2\ 10^{-3}$	$5.2\ 10^{-3}$
BHSE	6%	9.9%***	$5.9\ 10^{-3}$
Σ			**$7{,}9\ 10^{-3}$**

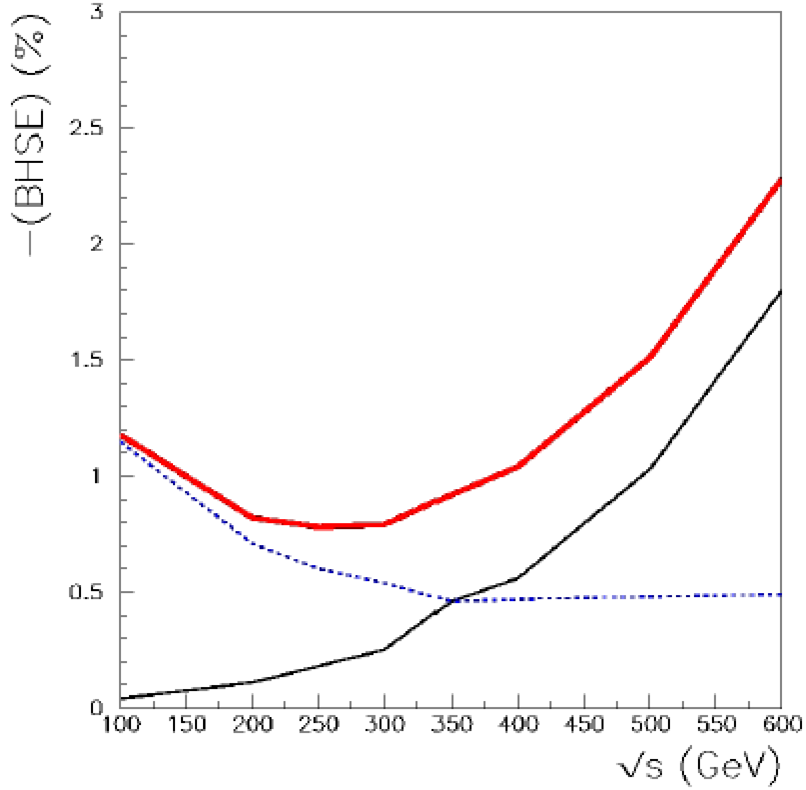
* assuming the same as at 500 GeV
** Uncertainty of the theoretical cross-section for Bhabha at LEP energies [OPAL, G. Abiendi et al., Eur. Phys. J C14(2000)373].
*** 5% control of buch x and z sizes, same error control as at 500 GeV.

Summary

SUMMARY ON SYSTEMATICS

- Test beam studies are needed to determine experimental uncertainties of effects that should be taken as corrections (i.e. bias in polar angle).
- Precision determination of Bhabha energy and understanding of detector energy resolution is necessary due to the applied (energy dependent) selection.
- NLO calculations at ILC energies are needed both for Bhabha and background processes. Could be as large as 40% (at LEP energies).
- Dominant effects come from beam-beam interaction (BHSE) and 2-γ processes. Both can be corrected for. In BHSE case the correction is large and require beam parameter control at 20% level or better (BS component), while uncertainty in physics background comes from the error on x-section.
- Systematic effects amount to 2.8•10-3 systematic uncertainty in luminosity at the upper limit at 500 GeV and ... at 1 TeV (very preliminary),

Backup



Bhabha suppression effect as a function of energy, keeping all optical parameters constant. The contributions due to beamstrahlung (thin line) and electromagnetic deflections (dashed line) are shown as well as the combined effect (top thick line) – taken from 'Impact of beam-beam effects on precision luminosity measurements at the ILC, C. Rimbault et al., JINST 2:P09001,2007'.