# Physics Needs for the Forward Region

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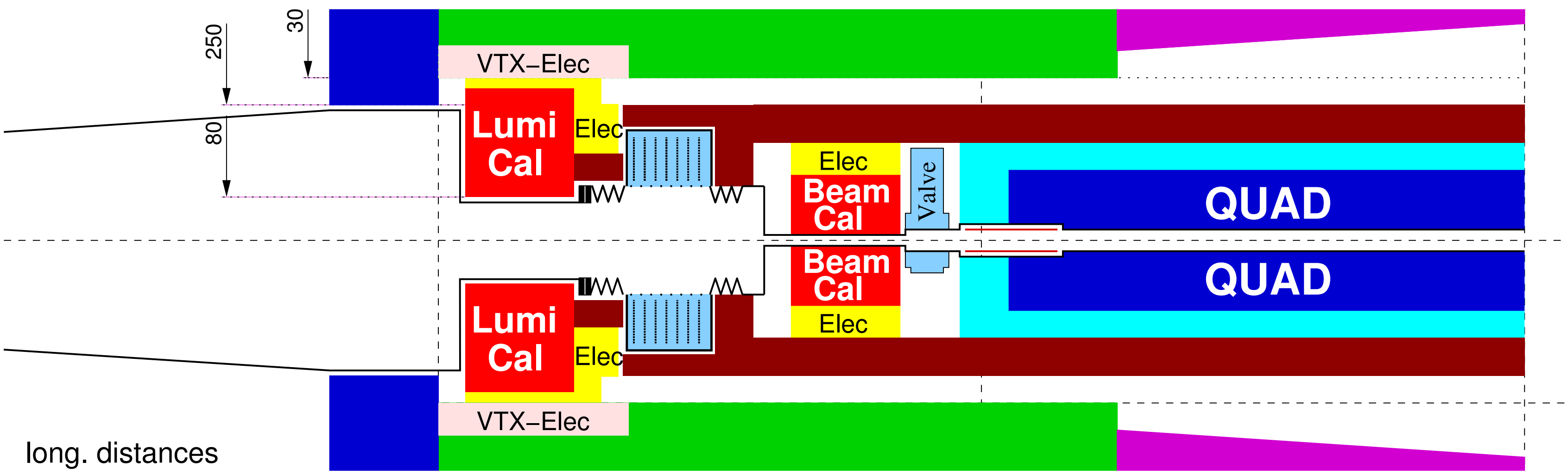
# Introduction

Forward region detectors serve two purposes:

- Hermeticity: Increase acceptance down to lowest possible angles. Mainly relevant for vetoing $\gamma\gamma$ induced $e^+e^- \rightarrow e^+e^- X$ events.
  Beamcal and Lumical are important
- Precision luminosity measurement: Bhabha scattering in the forward region. Extremely good control of systematics required.
  Only Lumical is relevant.



# Luminosity determination

Luminosity precision is determined by statistics of interesting processes

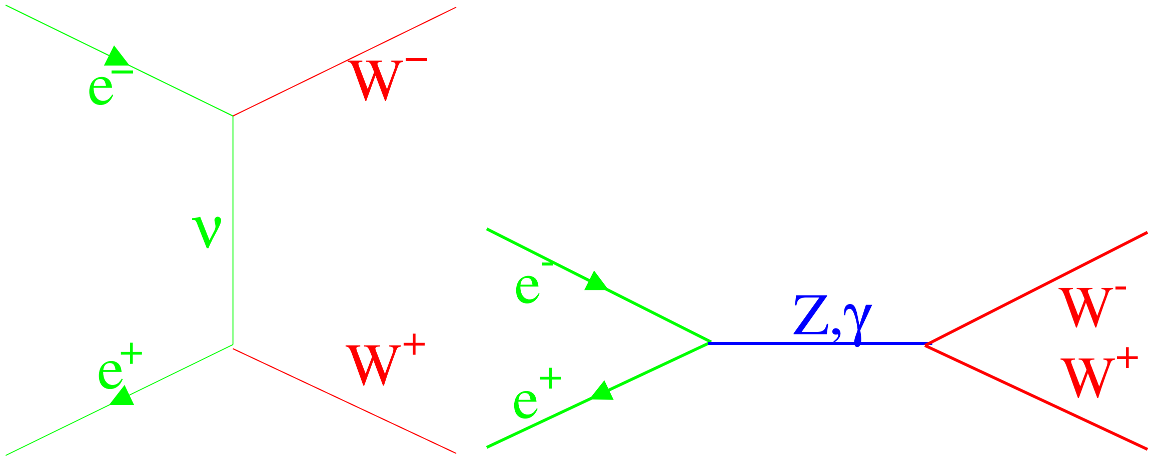
- $e^+e^- \to W^+W^-$: $\sim 10\,$pb at $\sqrt{s} = 340\,$GeV scaling with $1/s$
  ➟ $\mathcal{O}(10^6)$ events ➟need $10^{-3}$ precision
- $e^+e^- \to f\bar{f}$: $\sim 5\,$pb at $\sqrt{s} = 340\,$GeV scaling with $1/s$
  ➟ $\mathcal{O}(10^6)$ events ➟need $10^{-3}$ precision
- GigaZ: aim for $10^9$ hadronic Z decays. Relevant physics quantities (except $N_\nu$) need also leptonic decays (10% of hadronic decays)
  ➟ need $10^{-4}$ precision

Reached at LEP:

- cross section of lumi-monitor $> 60\,$nb
  ($25\text{mrad} < \theta < 60\text{mrad}$)
- experimental error on $\mathcal{L}$: $\Delta\mathcal{L} = 0.03\%$
- theoretical error on $\mathcal{L}$: $\Delta\mathcal{L} = 0.05\%$

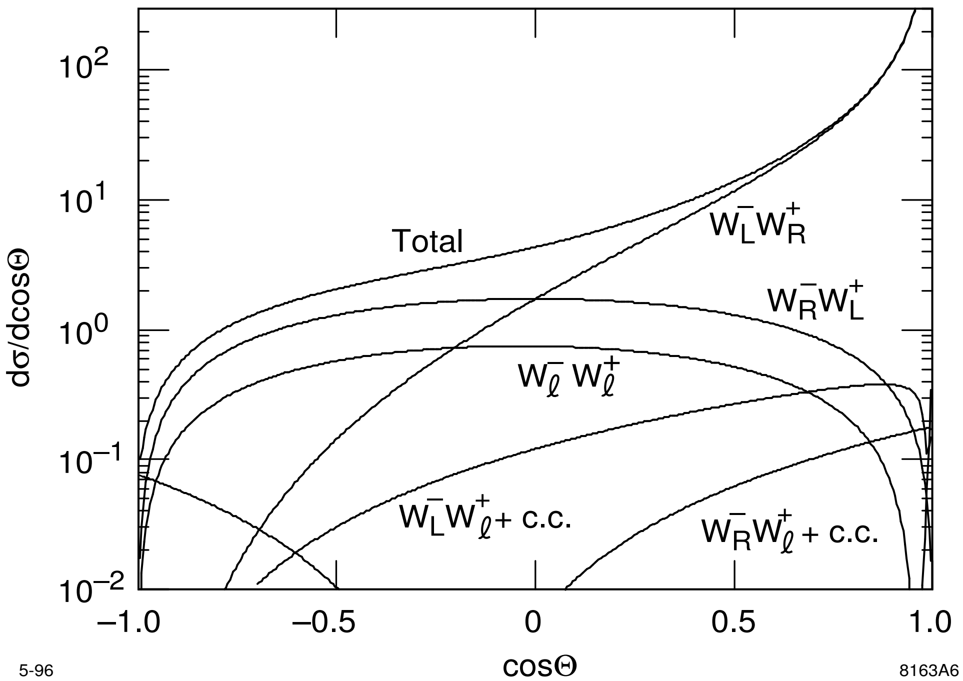
# $e^+e^- \rightarrow W^+W^-$

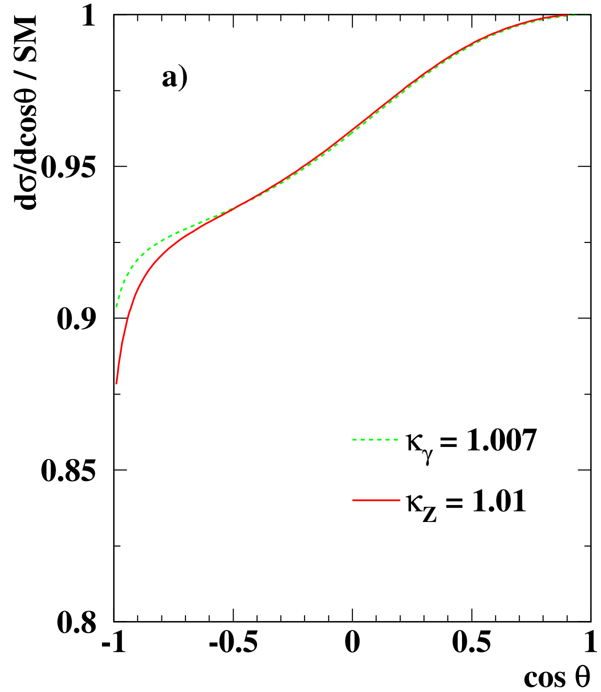
W-pair production from $\nu$ t-channel and Z,$\gamma$ s-channel exchange




Cross section strongly forward peaked

However forward peak independent on anomalous couplings




Normalisation in TGC fits can be obtained internally

Luminosity measurement only interesting for anomalous $e\nu W$ couplings

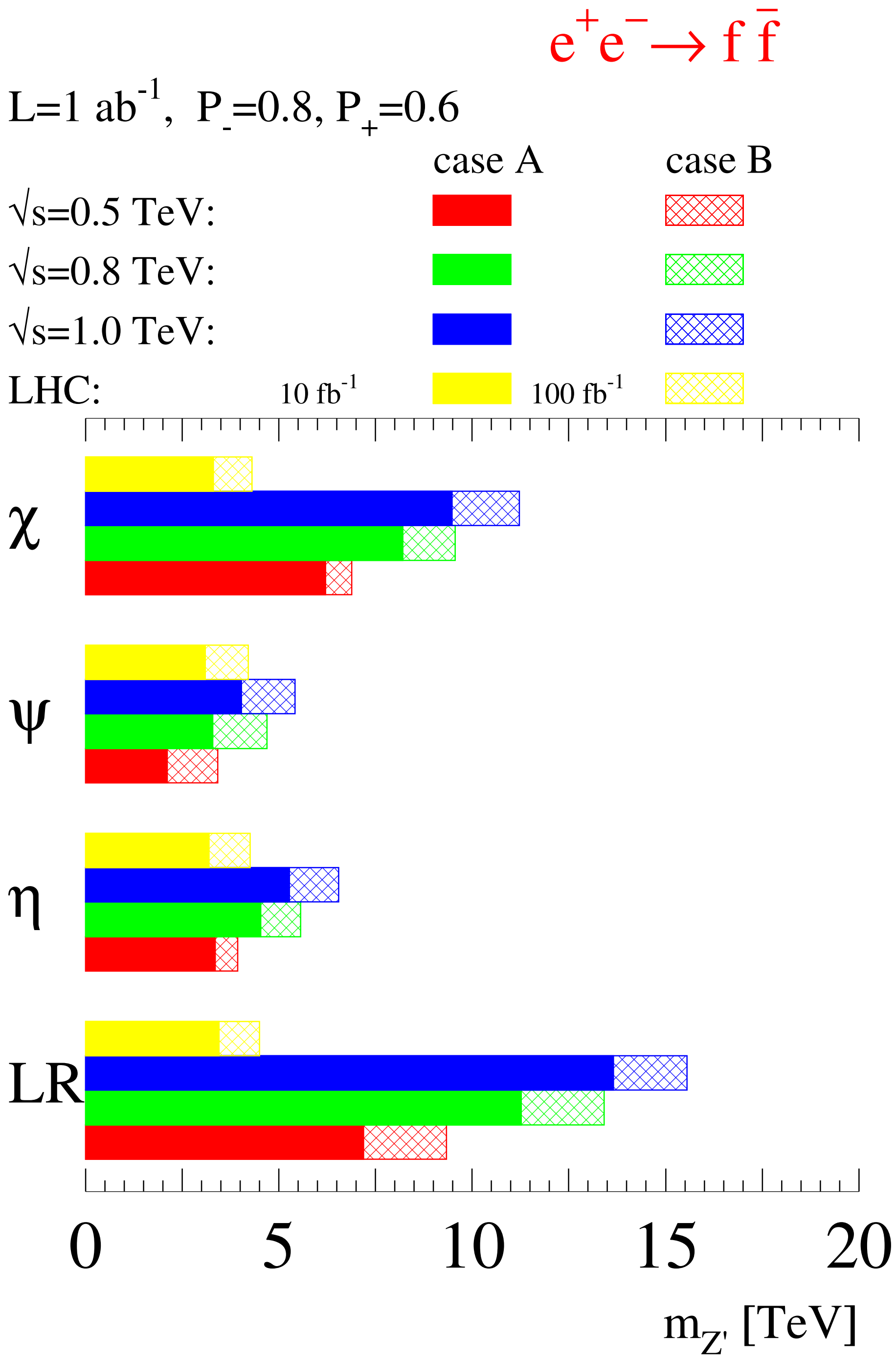
# $e^+e^- \to f\bar{f}$

$e^+e^- \to f\bar{f}$ is sensitive to physics at very high scales (compositness, Z', extra space dimensions)

Sensitivity is mainly via interference with Standard Model amplitude
➠ $\propto 1/M^2$

All observables (cross section, left-right asymmetry, forward-backward asymmetry) are important

Systematic errors (e.g. luminosity) effect results significantly




## Case A:

$$\Delta\mathcal{P} = 1\%$$
$$\Delta\mathcal{L} = 0.5\%$$
$$\Delta\varepsilon_l = 0.5\%$$
$$\Delta\varepsilon_{had} = 0.5\%$$

## Case B:

$$\Delta\mathcal{P} = 0.5\%$$
$$\Delta\mathcal{L} = 0.2\%$$
$$\Delta\varepsilon_l = 0.1\%$$
$$\Delta\varepsilon_{had} = 0.1\%$$

# GigaZ

GigaZ = $10^9$ Z at $\sqrt{s} \approx m_Z$

Main aim: $\sin^2\theta^l_{eff}$ determination ➡ no $\mathcal{L}$ dependence

Important additional information from "lineshape" parameters $\Gamma_Z$, $\sigma_0^{had}$, $R_l$

Interesting information is obtained from combination of these parameters:

$$\sigma_0^{had} = \frac{12\pi}{m_Z}\frac{\Gamma_e\Gamma_{had}}{\Gamma_Z^2}$$

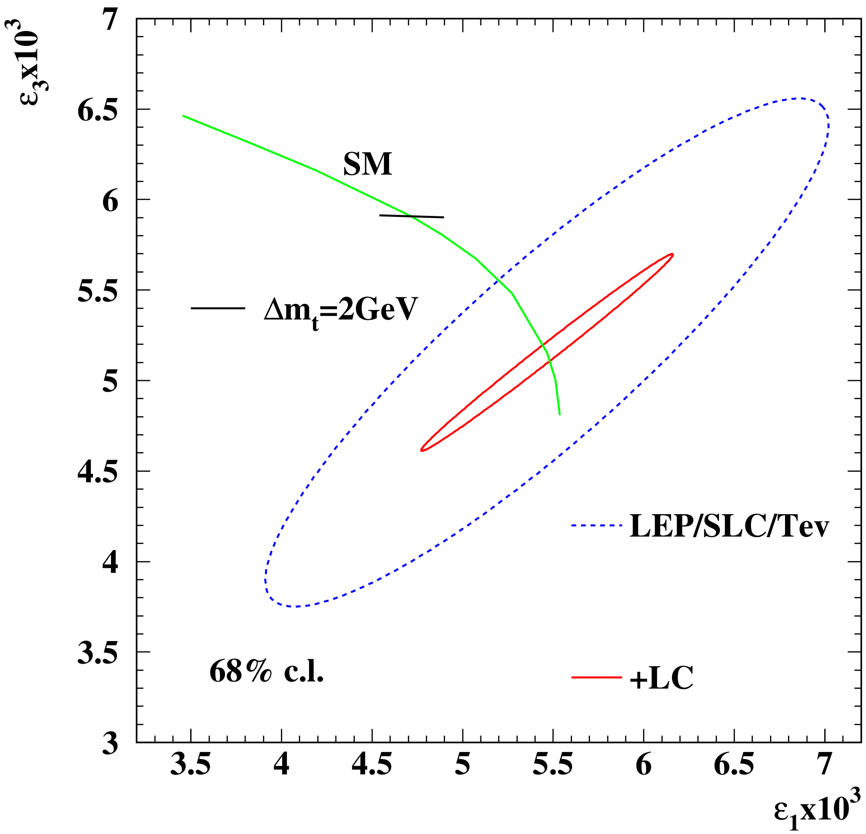
$$R_l = \frac{\Gamma_{had}}{\Gamma_l}$$

$\Rightarrow$ need all parameters with about the same accuracy

- $\Gamma_Z$: difficult to estimate (beam energy, beamstrahlung, beamspread) but $\Delta\Gamma_Z = 1\,\mathrm{MeV}$ ($\Delta\Gamma_Z/\Gamma_Z = 4 \cdot 10^{-4}$) seems realistic
- $R_l$: $\Delta R_l/R_l = 10^{-4}$ from lepton statistics

➡ need lumi error (exp+theo) $\Delta\mathcal{L}/\mathcal{L} \sim 2 \cdot 10^{-4}$

Gain of GigaZ:



# Hermeticity

Signal: $e^+e^- \rightarrow X + p_{inv}$ with $p(X)$ small and $p_{inv}$ = momentum of invisible particles (e.g. LSP)

Background: $e^+e^- \rightarrow e^+e^- Y$ with electrons lost in forward region

Maximum transverse momentum of $Y$: $p_t(Y) < \sqrt{s}\theta_{veto}$

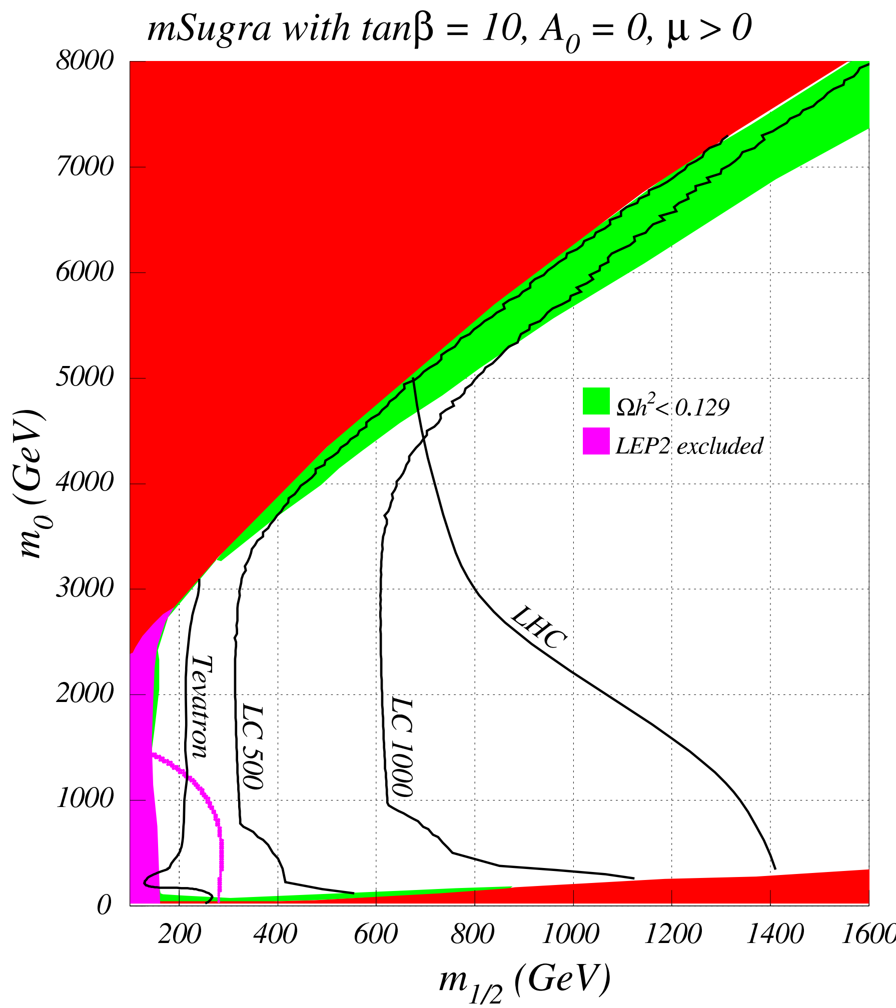
$\Rightarrow$ signal-background separation depends on $\theta_{veto}$

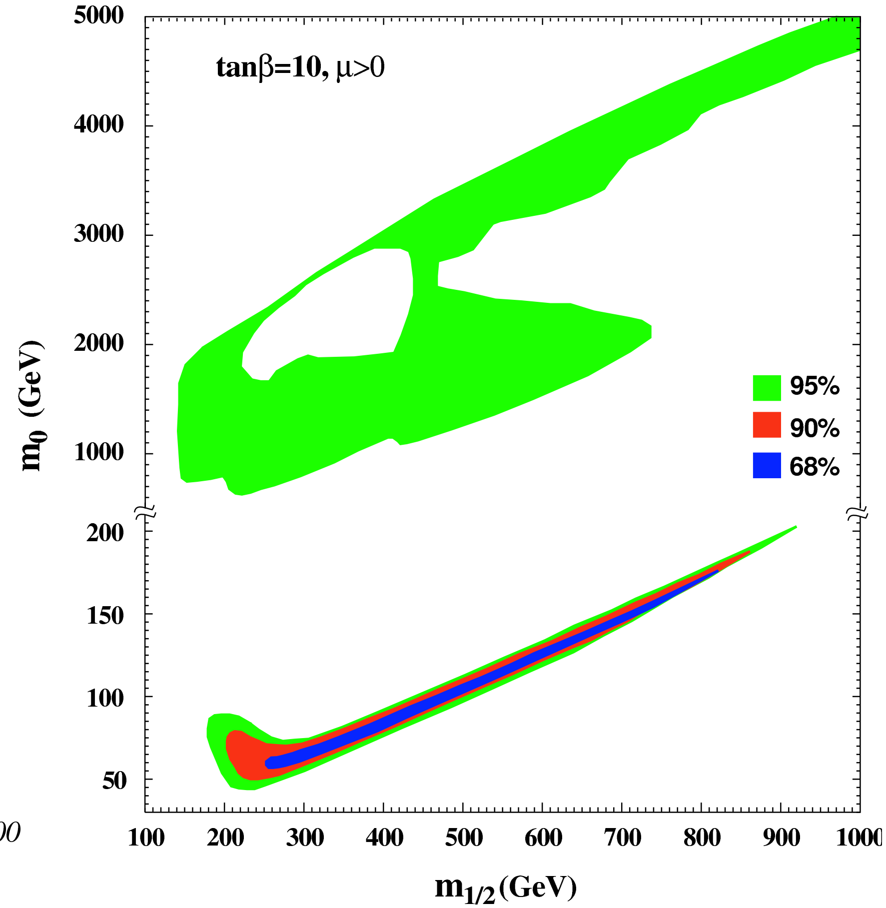
Example with $\sqrt{s} = 500\,\mathrm{GeV}$:

- no Beamcal: $p_t(veto) = 10\,\mathrm{GeV}$
- full Beamcal: $p_t(veto) = 1.4\,\mathrm{GeV}$

Cosmology favours regions with small mass difference (e.g. $m_{\tilde{\tau}} - m_{\chi_1^0}$):

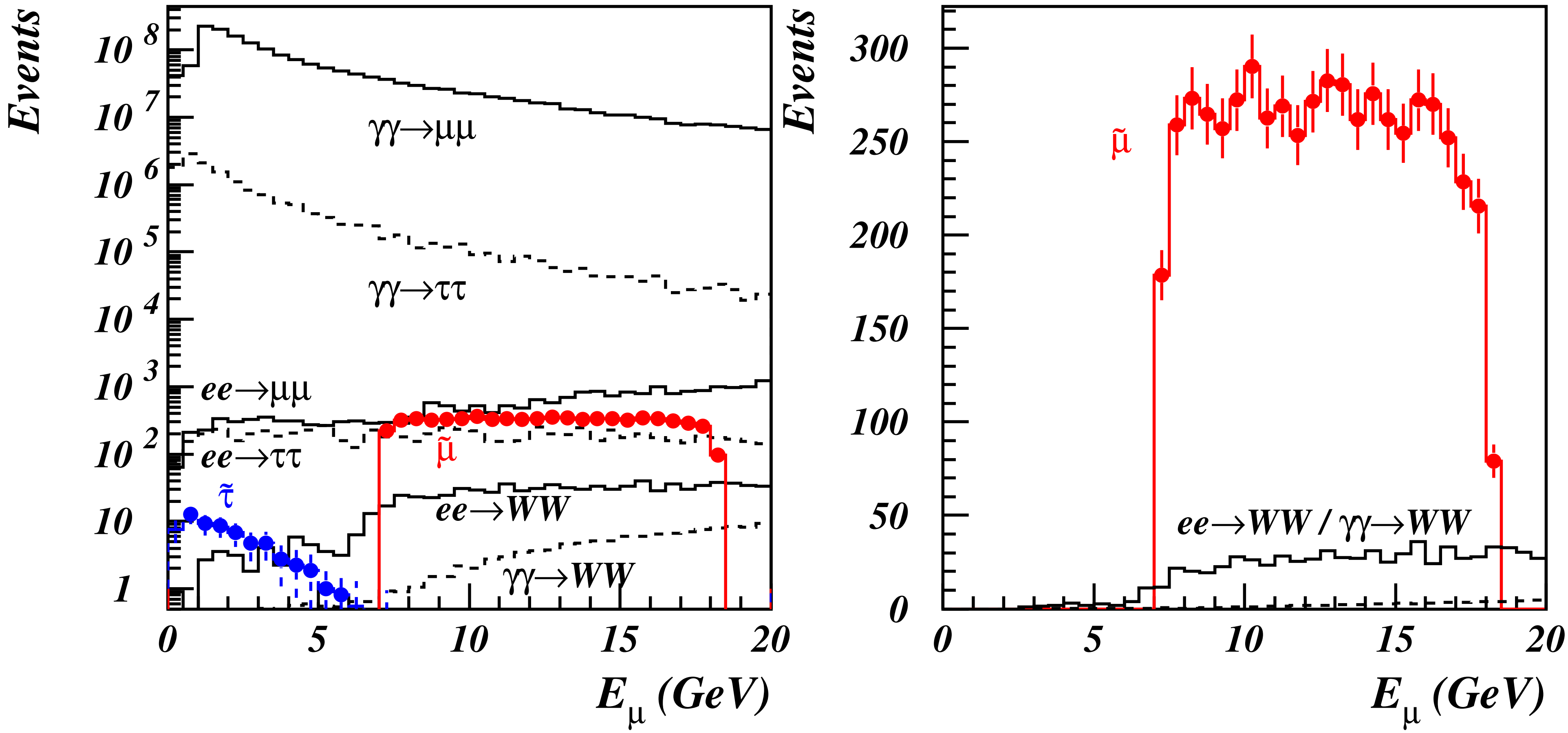
(from Bambade et al., hep-ph/0406010)



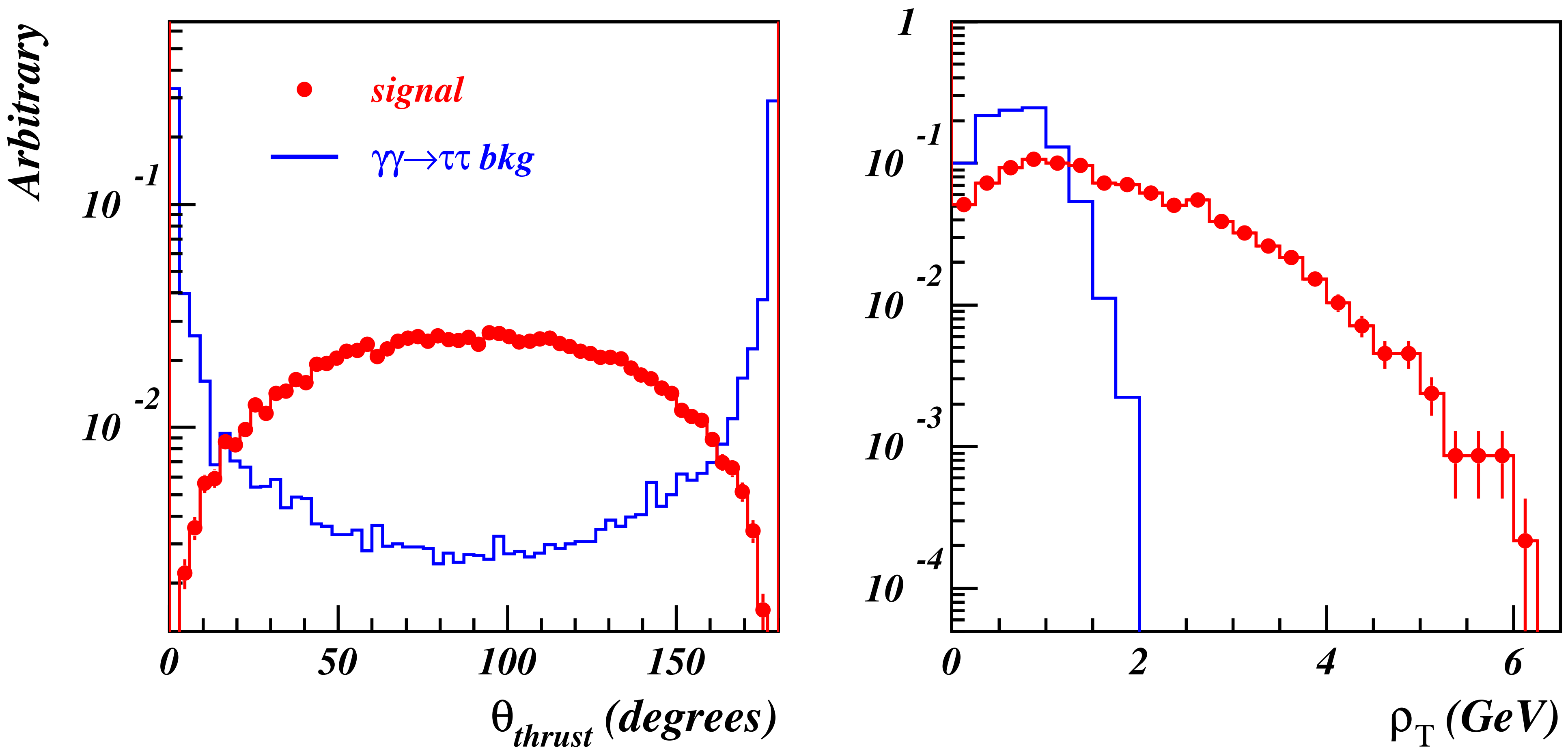




Signal: $e^+e^- \to \tilde{\tau}^+\tilde{\tau}^- \to \tau^+\tau^-\chi_1^0\chi_1^0$ with $\chi_1^0$ invisible and $p(\tau)$ small.

# Situation before cuts:



# Situation after $p_t$ (and some other) cuts:




Excellent hermeticity allows separation of signal and background

# Conclusions

Forward region of TESLA detector is important:

- Luminosity needs to be known on the $10^{-4}$ level

- Excellent hermeticity allows SUSY detection in region favoured by cosmology and invisible for LHC