Long-lived Stau

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Intention

· When stau is lighter than lightest neutralino and it is long lived,

-its lifetime is long enough to escape the detector. Stau interacts with detector and can be discovered with a good accuracy.

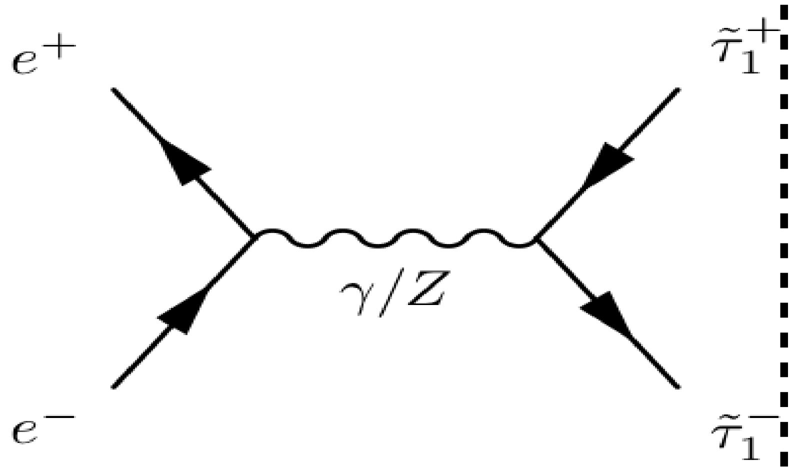
-it should be important to measure its properties.

· Long-lived stau is important not only to determine its properties but also quantum numbers of neutralino.

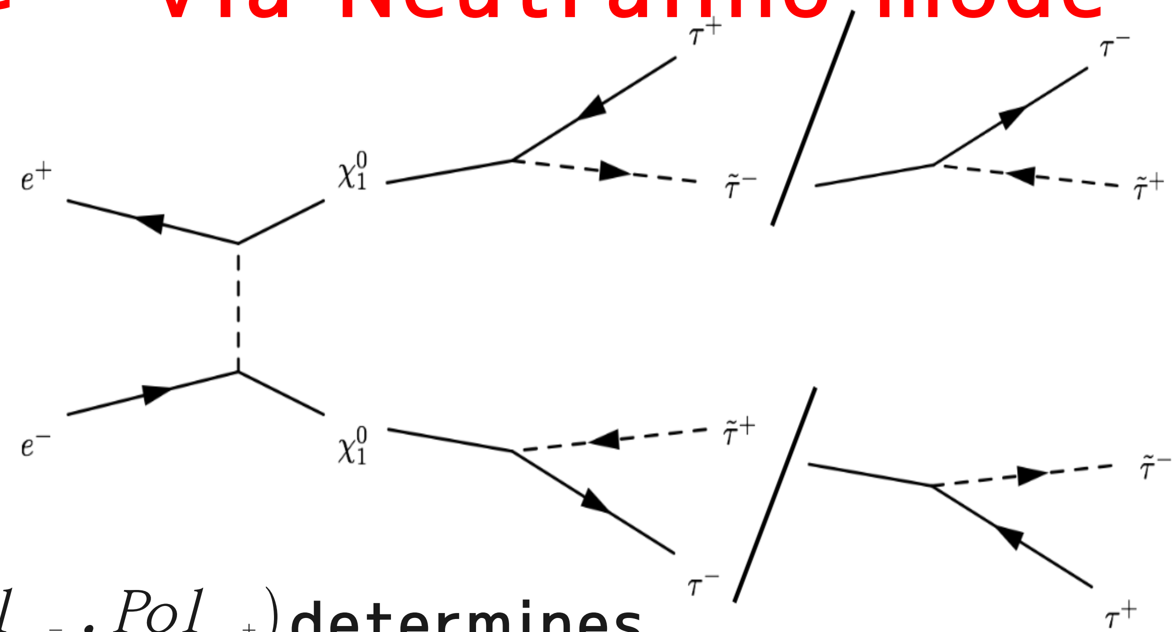
– I study supersymmetric scenario with a long lived stau at ILC by using MC simulation.

Mode

- Stau pair mode



- Via Neutralino mode

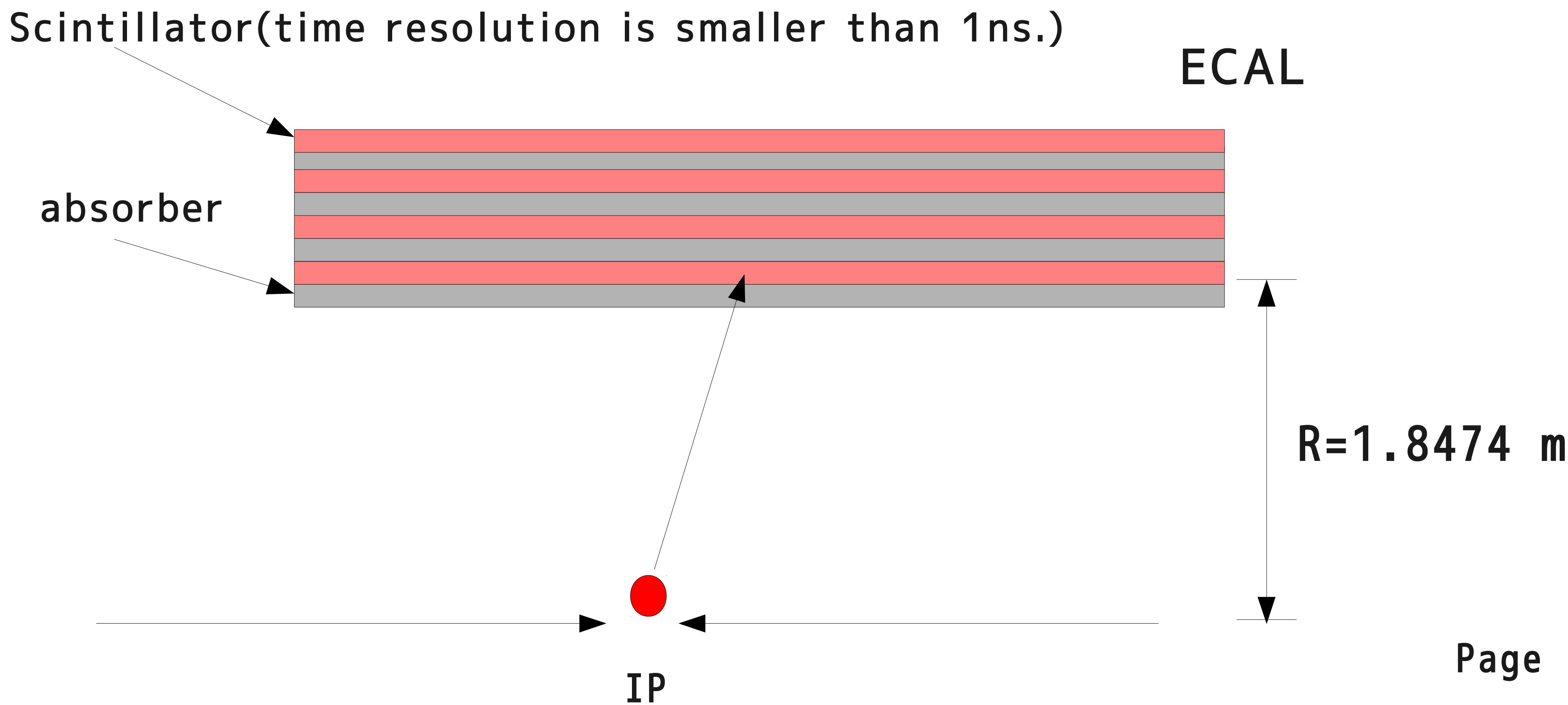


- Stau pair mode $\frac{d\sigma}{d\Omega}(\sqrt{s}, Pol_{e^-}, Pol_{e^+})$ determines quantum numbers of stau($m_{\tilde{\tau}_1}, S, I_3, Y$).
- $m_{\tilde{\tau}_1}$ is determined from dE/dx and TOF at TPC.
- Life time of stau is measured at HCAL.

- Via neutralino mode determines quantum number of neutralino.

Precision of measurement of stau mass by TOF

ECAL is superior to TPC or SET in the point of the time resolution,so we measure stau mass by time of flight at ECAL.



Precision of measurement of stau mass by TOF

Function

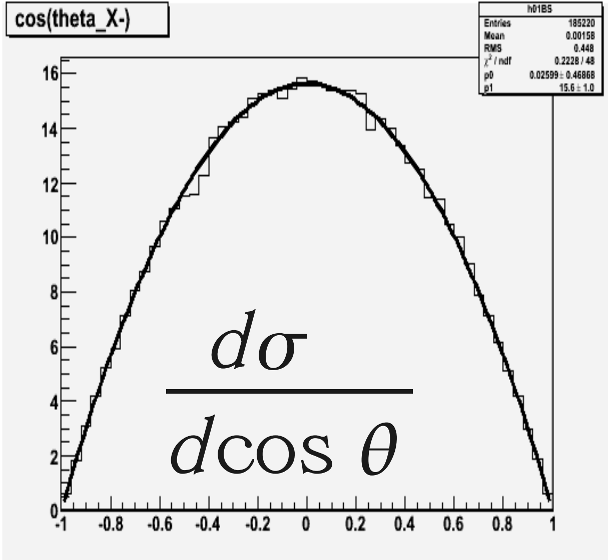
$$\left(\frac{\sigma_M}{M}\right)^2 = \frac{P^2 + M^2}{M^4 R^2} \sigma_T^2 P^2 \sin^2\theta$$

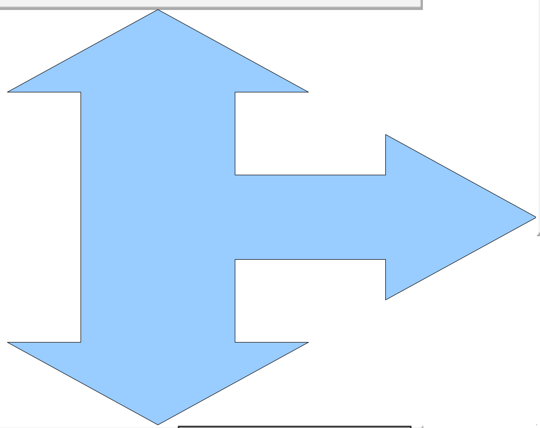
Time resolution of ECAL

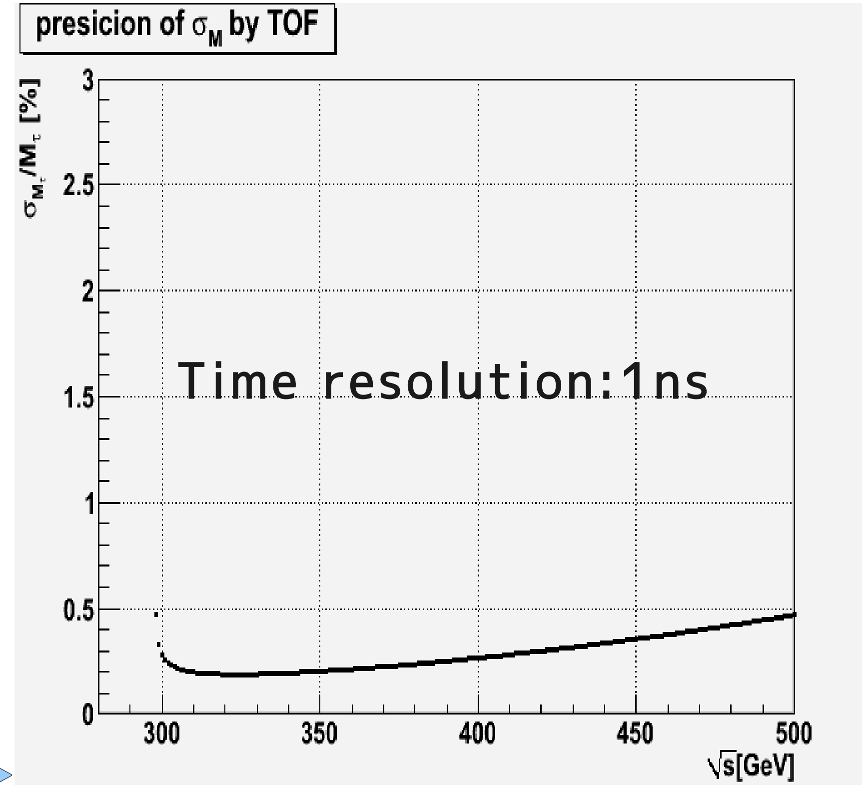
Mass of stau
M=148.83GeV

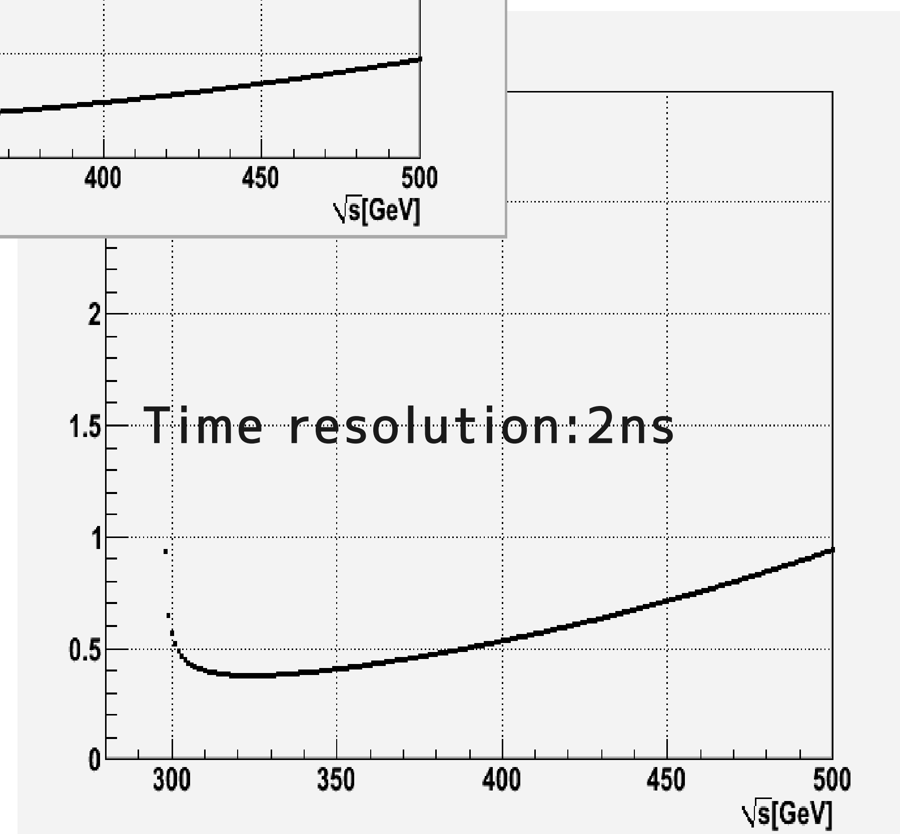
Consider cross section and angular distribution

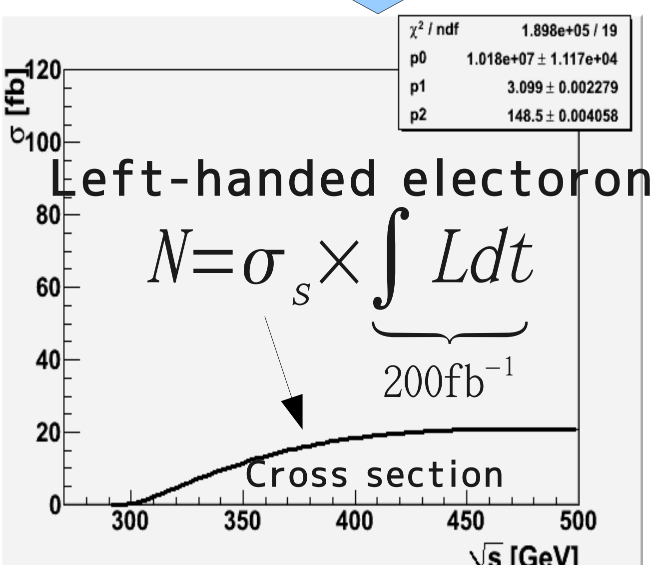
$$\sigma_{M_{\tilde{\tau}}}^2 = \frac{1}{N \int \frac{1}{\sigma_M^2} \cdot \frac{d\sigma}{\sigma\, d\cos\theta} d\cos\theta}$$





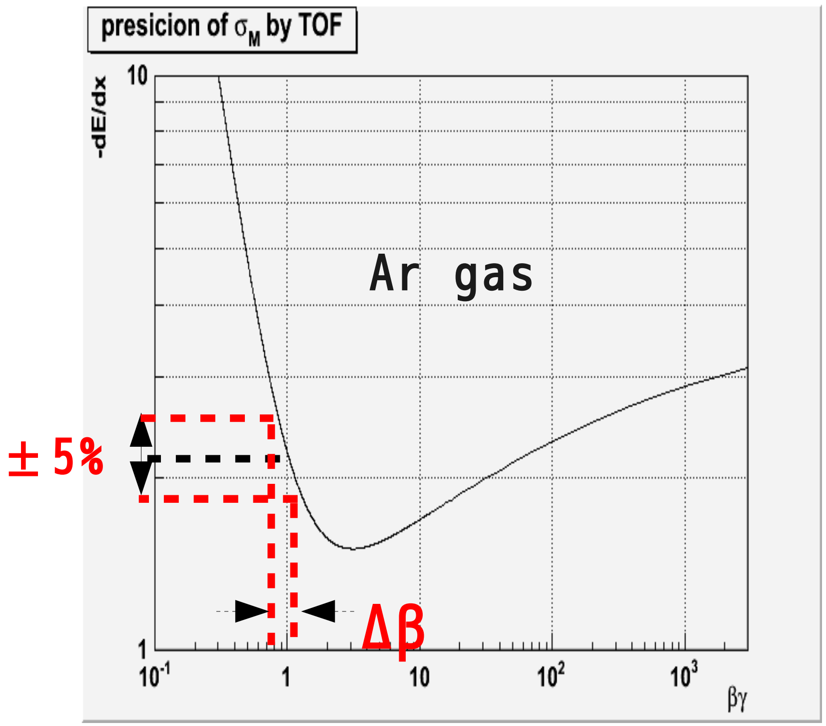






About 320-330 GeV,sigma M value is minimum.

Precision of measurement of stau mass by dE/dx



Stopping power

Mass of stau is 148.83 GeV

Measure precision of mass by dE/dx at TPC.dE/dx resolution is ～5%.

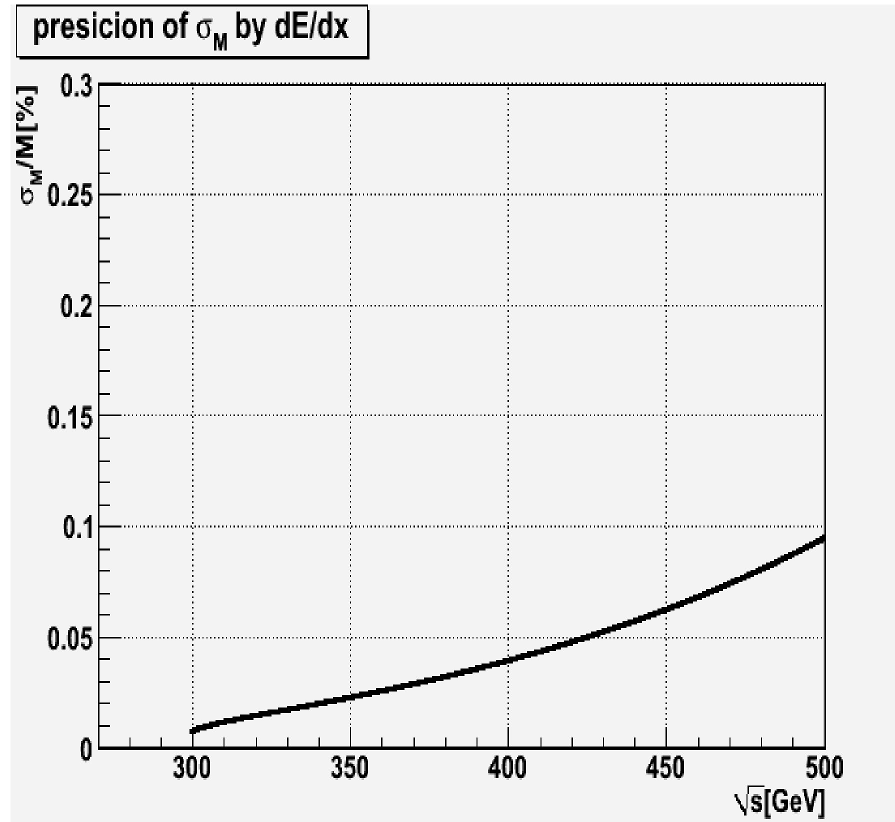
$$M = \frac{\sqrt{s}}{2} \cdot \sqrt{1-\beta^2}$$

$$\sigma_{M_{dE/dx}} = \frac{\sqrt{s}}{2} \cdot \sqrt{\frac{\beta^2}{1-\beta^2}} \cdot (\Delta\beta)$$

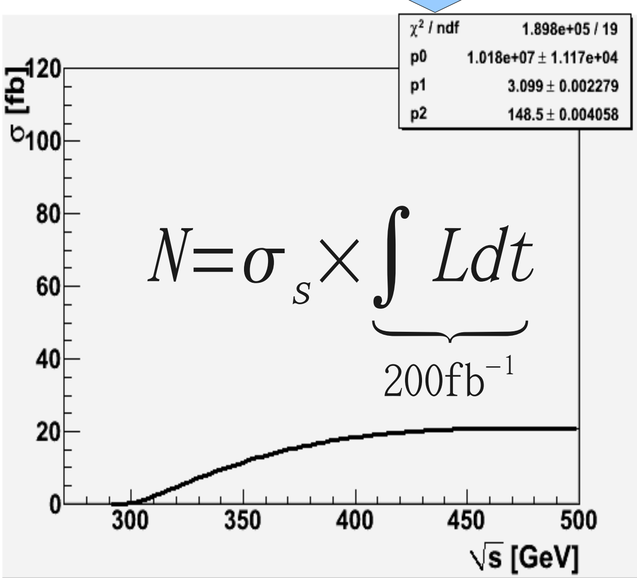
$$\sigma_M = \frac{\sigma_{M_{dE/dx}}}{\sqrt{N}}$$

Precision of measurement of stau mass by dE/dx

$$\sigma_M = \frac{\sigma_{M_{dE/dx}}}{\sqrt{N}}$$

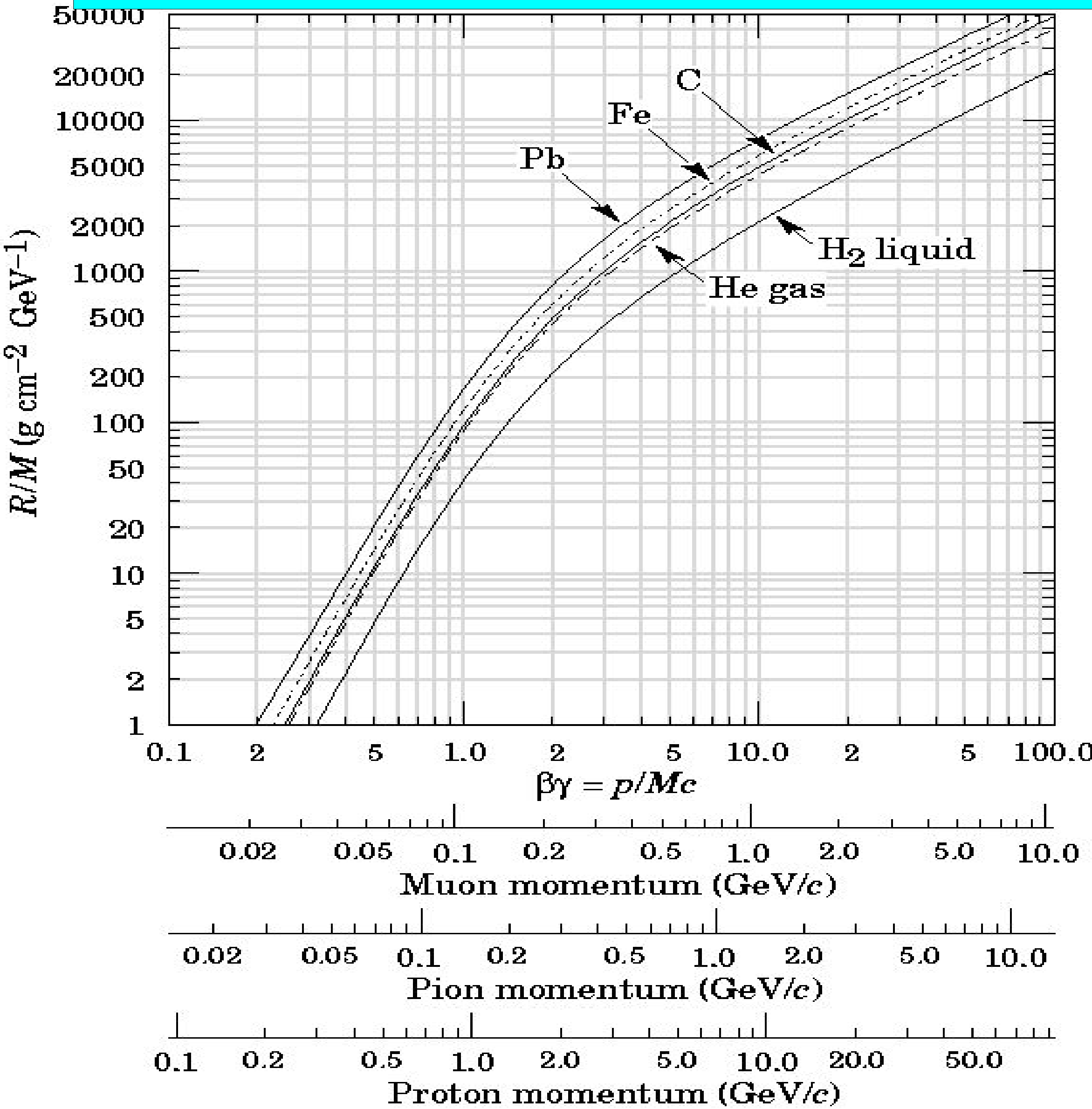


At Threshold,
precision of measurement is the best.



Left-handed electoron

Life time



Life time is measured at HCAL.

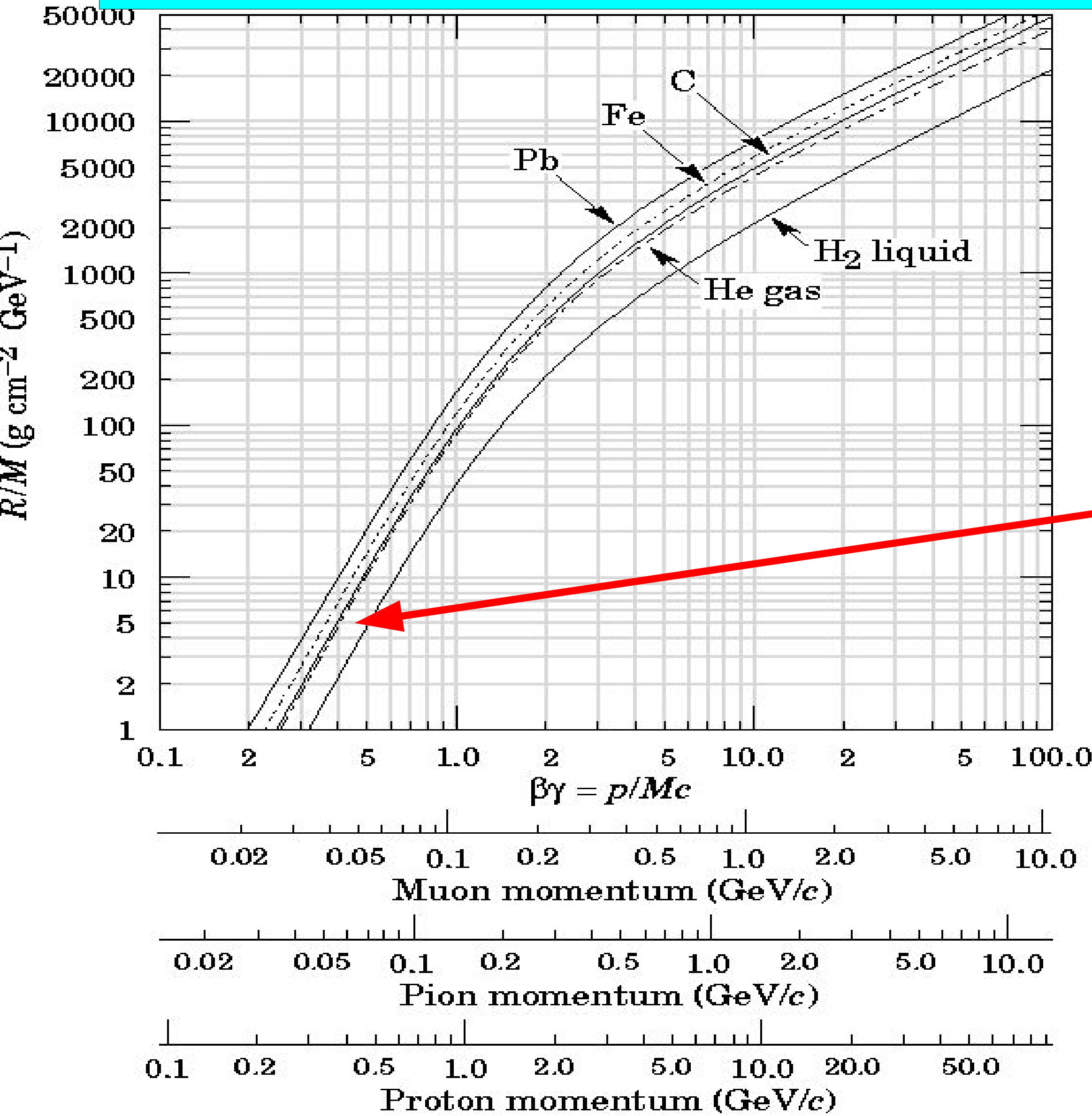
Calculate beam energy when particle stops in HCAL and precision of life time measurement by luminosity and cross section.

$$\frac{\sigma_\tau}{\bar{\tau}} = \frac{1}{\sqrt{L \cdot \sigma_s}}$$

Life time

Cross section

Life time



$$\frac{\sigma_\tau}{\bar{\tau}} = \frac{1}{\sqrt{L \cdot \sigma_s}}$$

L: $200 fb^{-1}$

HCAL :48 steel plates
thickness 20mm

R/M=5.079

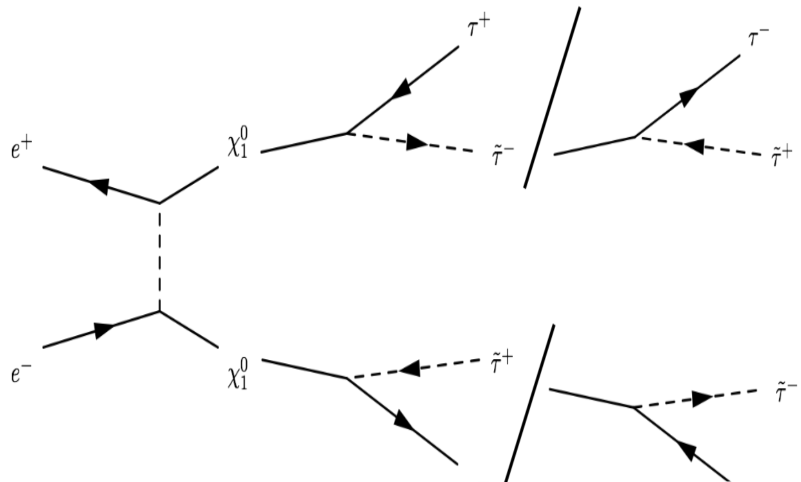
βγ=0.35±0.01

√s=315.4±1.0[GeV]

Cross section: σ=3.7±0.3[fb]

$$\frac{\sigma_\tau}{\bar{\tau}} = \frac{1}{\sqrt{L \cdot \sigma_s}} = 3.7 \pm 0.1\%$$

Via neutralino mode

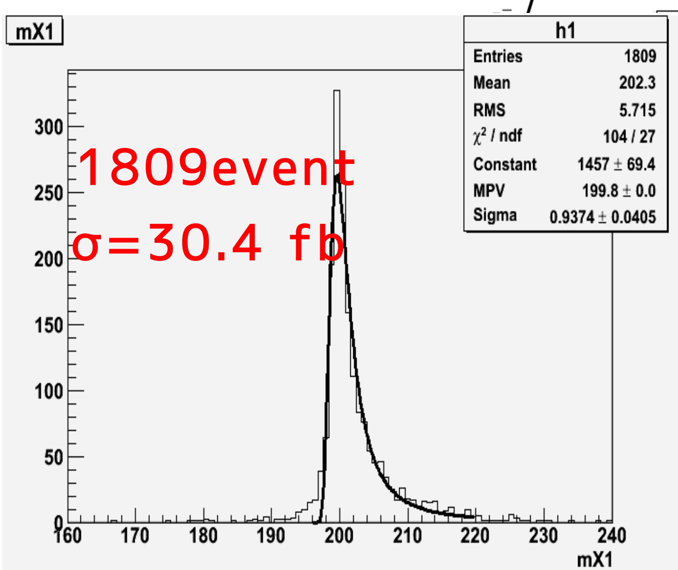


MC simulation with Via neutralino mode

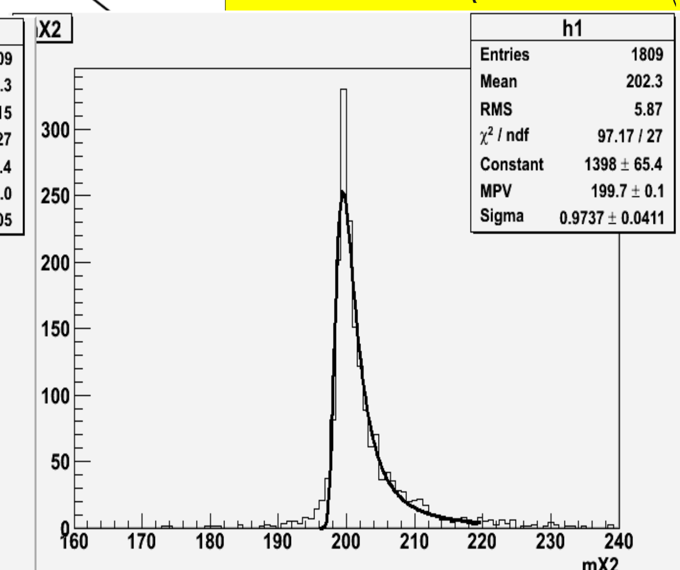
Calculate neutralino invariant mass by 4 momenta of tau jet and stau.

$$M_{j_\tau \tilde{\tau}} \equiv \sqrt{\left(p_{j_\tau} + p_{\tilde{\tau}}\right)^2} = m_{\chi_1^0}$$

Landau fit



1809event
σ=30.4 fb



Input value of $m_{\chi_1^0}$ is 200.0 GeV

$m_{\chi_1^0} = 199.81 \pm 0.05$ GeV

Deviation from input value: 0.10%

$m_{\chi_1^0} = 199.72 \pm 0.05$ GeV

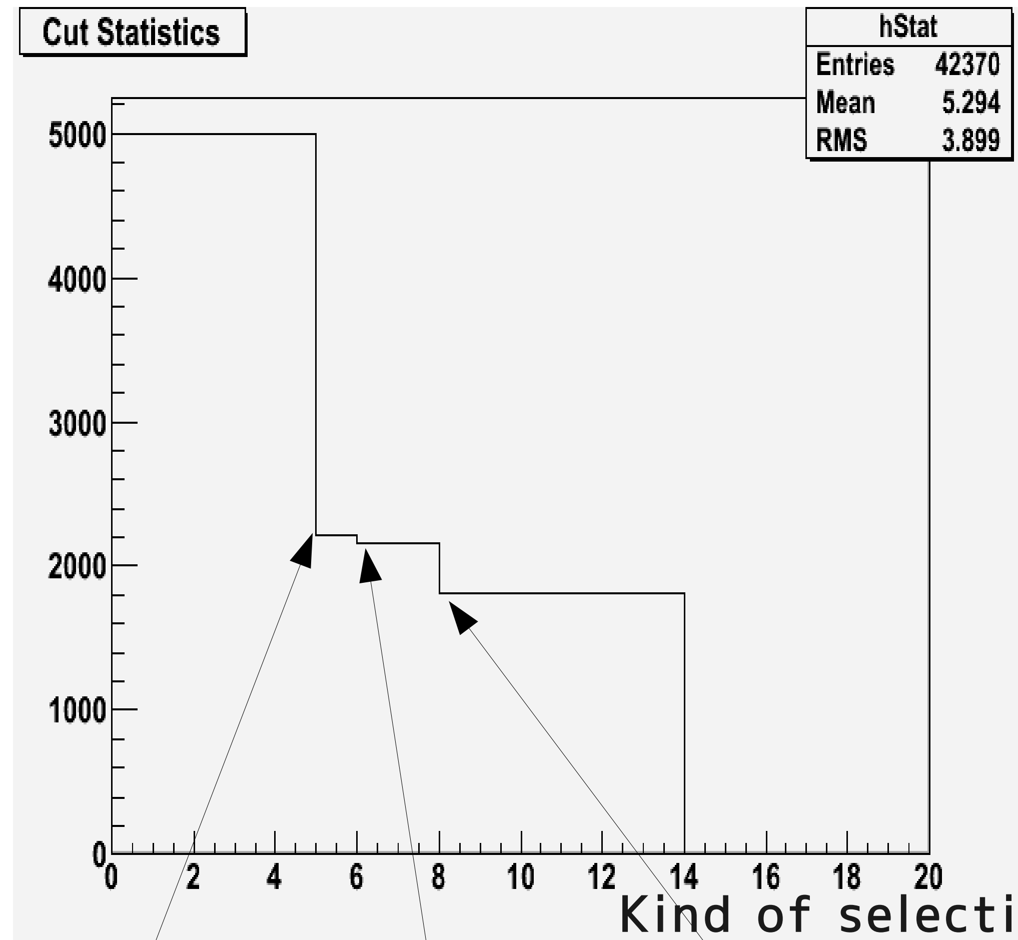
Deviation from input value: 0.14%

→ Good accuracy

Event selection

Main selection

Number of slepton == 2
Number of jets == 2
for Y < 0.004
E jet >= 5 GeV



N slepton (2219event)

N jets (2155event)

E jets (1817event)

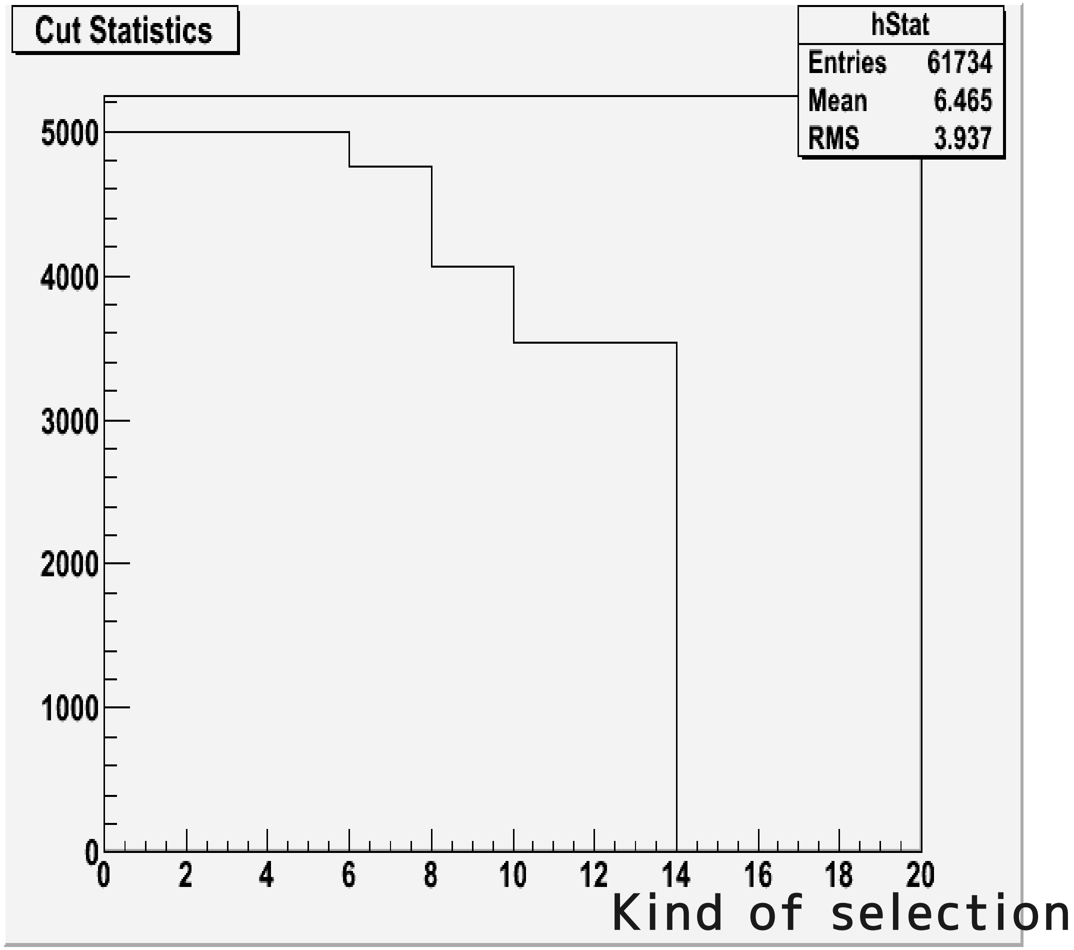
result

5000 → 1809event

Event selection

Main selection

Number of slepton == 2
Number of jets == 2
for Y < 0.004
E jet >= 5 GeV



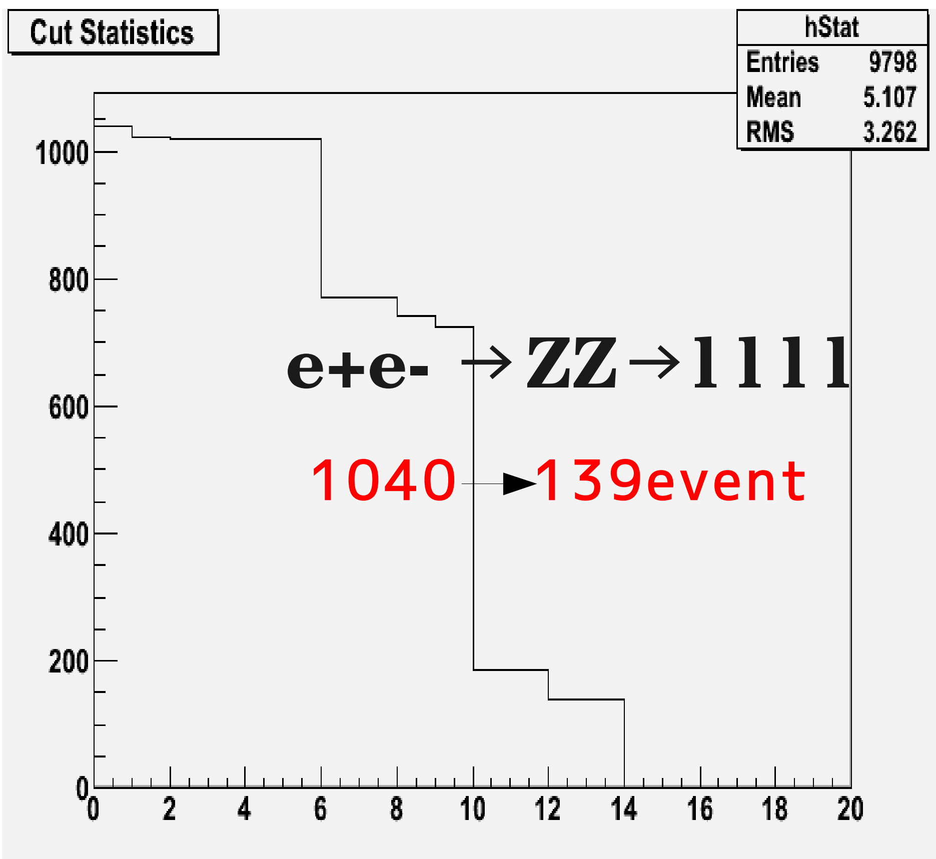
result

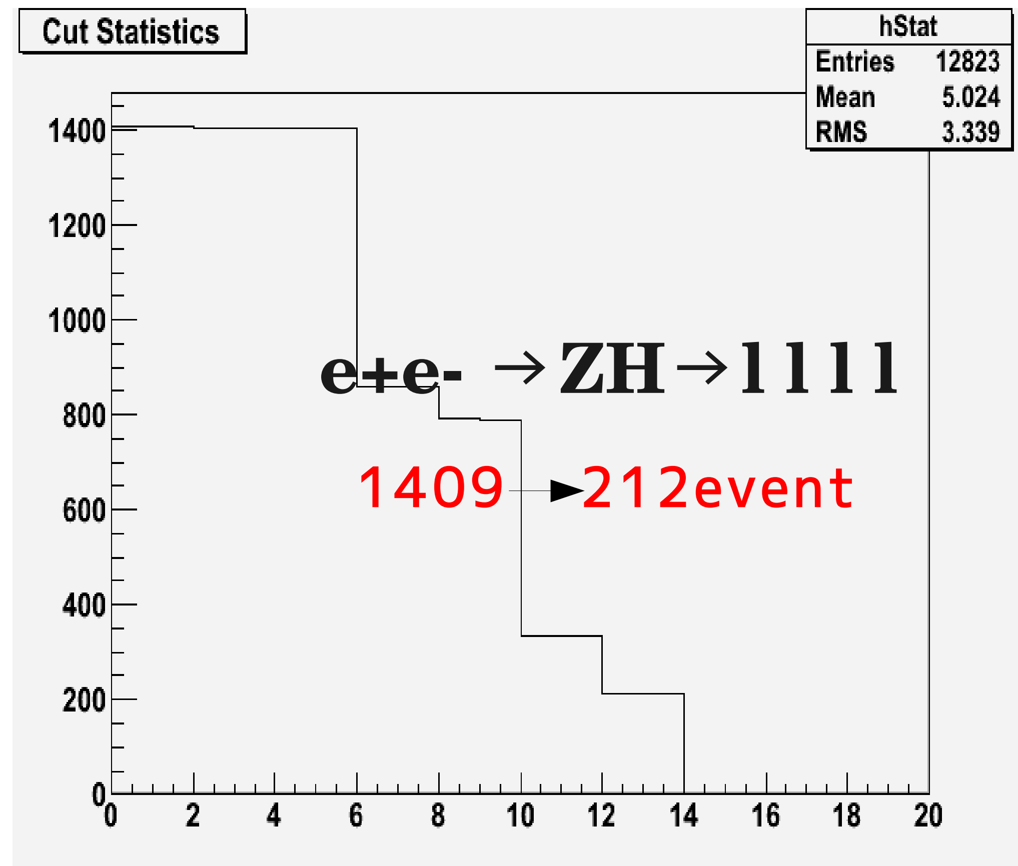
5000 → 3529event

Background

e+e- → ZZ → l l l l (5.197 fb)
e+e- → ZH → l l l l (7.046 fb)

No polarization





Background

Regarded background

e+e- → ZZ
e+e- → ZH

→ 4 lepton

etc…

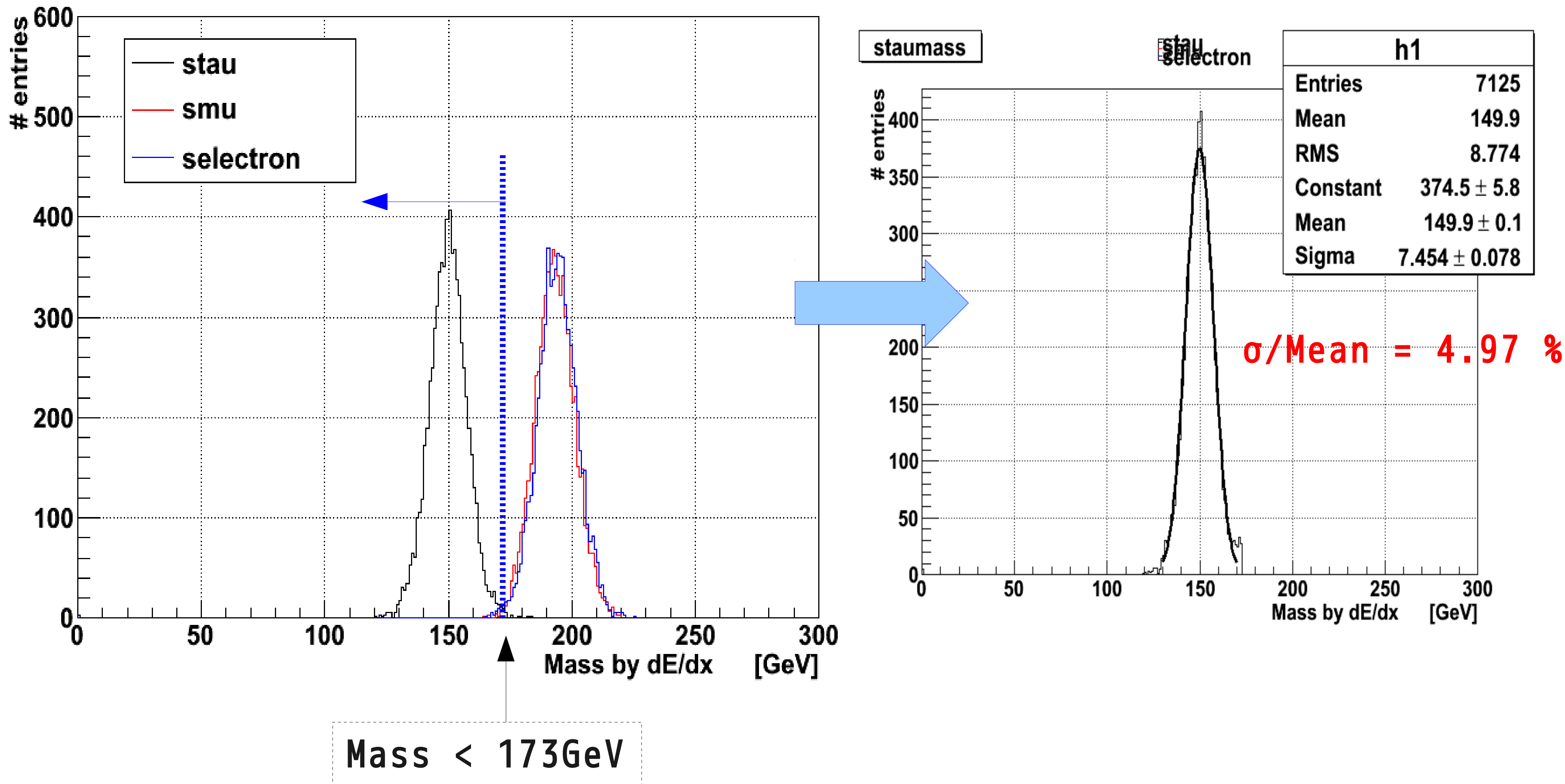
If ZZ or ZH cross section is smaller,BG is ignored

Calculate for ZZ mode and ZH mode with MC simulation.

		Generated numbers at 200 fb^{-1}
e+e- → ZZ → l l l l	(5.197 fb)	→ 1040 event
e+e- → ZH → l l l l	(7.046 fb)	→ 1409 event
Neutralino mode	30.4 fb	→ 6080 event

No polarization

measurement of stau mass by dE/dx



measurement of stau mass by dE/dx

	No Cut	< 173GeV	acceptance
Stau	7058	7038	99.87%
Smu	7058	41	0.58%
selectron	7058	46	0.65%

Almost events of smu and Selectron are cut.

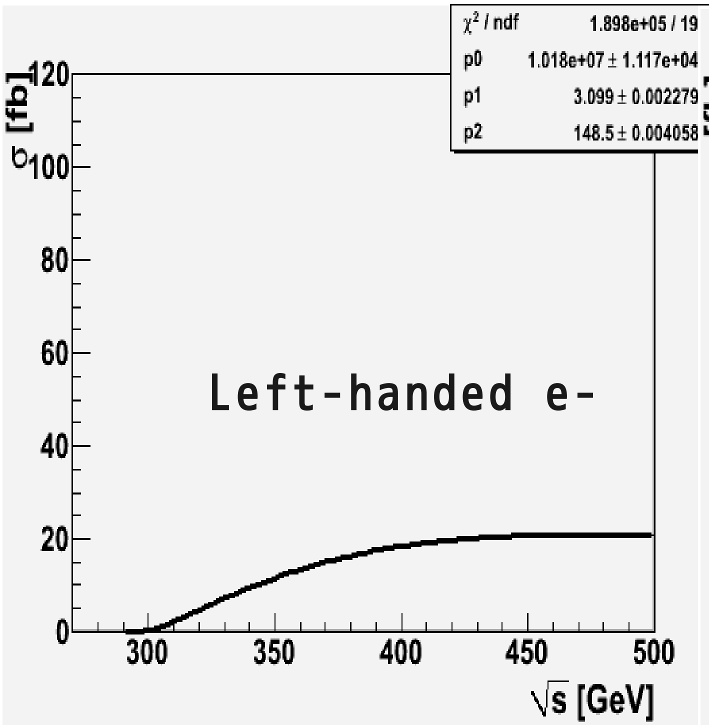
Summary & Plan

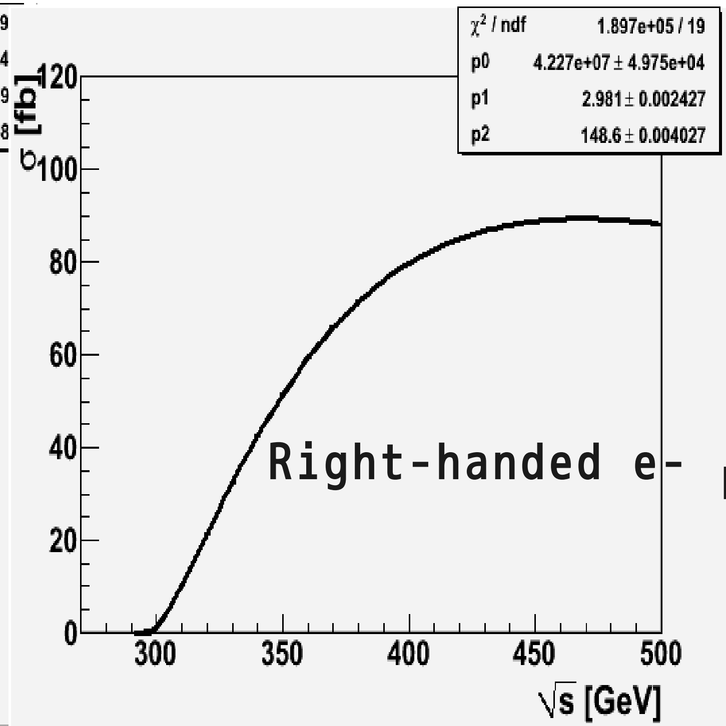
- Mesurement of stau mass by TOF
- Efficiency
- Background

Try to fix an event selection

Backup

Stau pair mode cross section





Input value of stau mass is 148.8 GeV

M=148.5±0.1 GeV

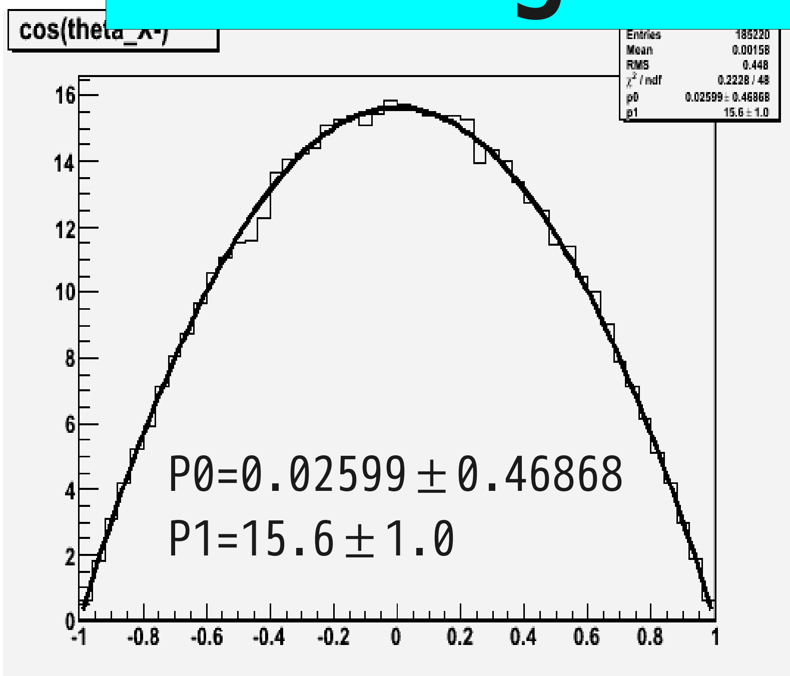
M=148.6±0.1 GeV

Fitting: $P0 \times \left(\sqrt{\frac{(\sqrt{s}/2)^2 - P2^2}{(\sqrt{s}/2)^2}} \right)^{P1} \times \frac{1}{s}$

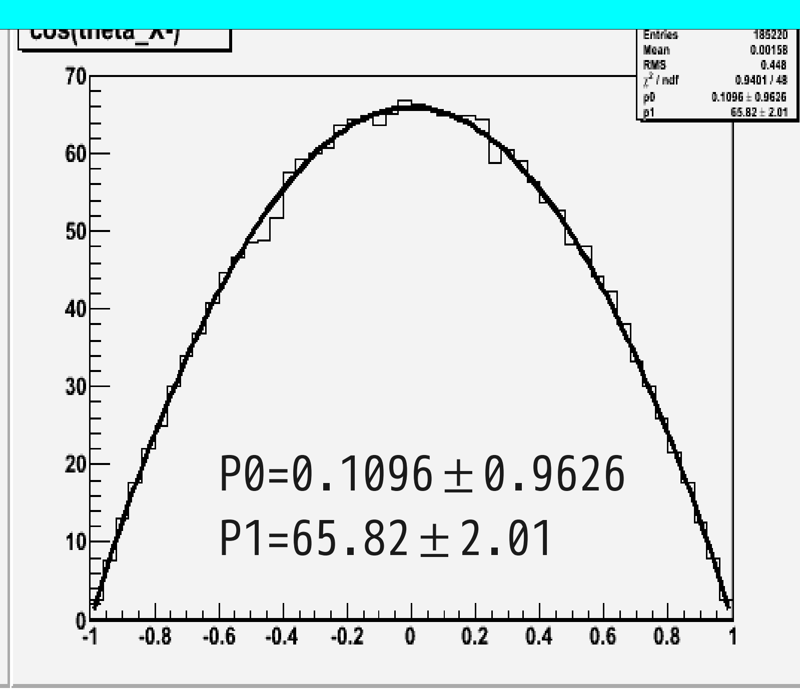
$P0 = |T|^2$: Amplitude

$P2 = m_{\tilde{\tau}}$: Stau mass

Stau pair mode angular distribution

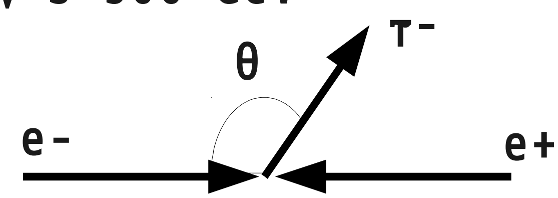


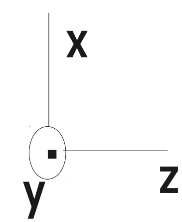
Left-handed e- √s=500 GeV



Right-handed e- √s=500 GeV

Fitting: $P0 + P1 \times \sin^2\theta$





From law of conservation of angular momentum,these figures show that this particle is boson.