Tau-pair and SUSY analysis for ILD optimization in Jupiter/Marlin framework

Taikan Suehara

ICEPP, The Univ. of Tokyo

Topics

- Overview
  - Physics processes for detector optimization
  - Analysis framework (Jupiter/Marlin)
- Tau-pair analysis
  - Analysis overview and flow
  - A_{FB} analysis
  - A_{pol} analysis including ρ and π_0 reconstruction
- SUSY analysis
  - Smuon/neutralino mass determination
- Plans & Summary

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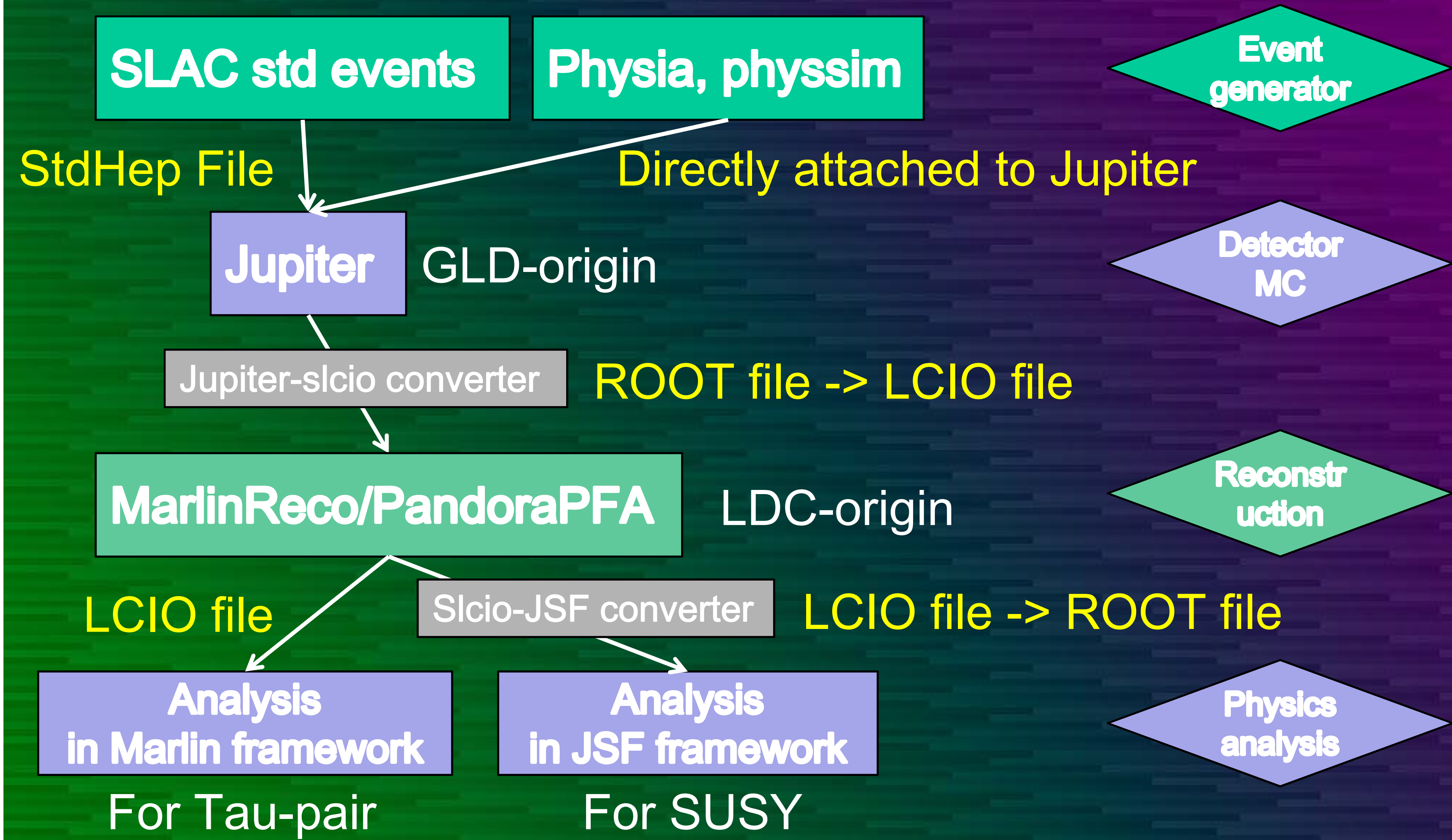
Physics process for optimization

Benchmark processes:

Processes ($e^+e^- \rightarrow$)	$\sqrt{S}$ (GeV)	Observables	Comments
ZH, ZH→e^+e^-X,	250	σ, m_H	m_H=120GeV, test materials and γ_{ID}
→$\mu^-\mu^+X$	250	σ, m_H	m_H=120GeV, test $\Delta P/P$
ZH, H→cc, Z→$\nu\nu$	250	Br(H→cc)	Test heavy flavour tagging and anti-tagging of light quarks and gluon
, Z→qq	250	Br(H→qq)	Same as above in multi-jet env.
$Z^* \rightarrow \tau^+\tau^-$	500	σ, A_{FB}, Pol(τ)	Test π^0 reconstruction and τ rec. aspects of PFA
tt, t→bW, W→qq'	500	σ, A_{FB}, m_{top}	Test b-tagging and PFA in multi-jet events. m_{top}=175GeV
$\chi^+\chi^-$, $\chi_2^0\chi_2^0$	500	σ, $m\chi$	Point 5 of Table 1 of BP report. W/Z separation by PFA

Analysis framework



Compared geometries

Geometry	Gldapr08 (large,low B)	Gldprim_v04 (medium)	J4ldc_v04 (small high B)
Magnetic field	3 Tesla	3.5 Tesla	4 Tesla
TPC drift region Rmin	43.7 cm	43.5 cm	34 cm
ECAL Rmin	210 cm	185 cm	160 cm
ECAL total thickness	19.8 cm	19.8 cm	19.8 cm
HCAL total thickness	120 cm	109 cm	96 cm
TPC Z half length	250 cm	225 cm	206 cm
CAL Z half length	270 cm	235 cm	210 cm

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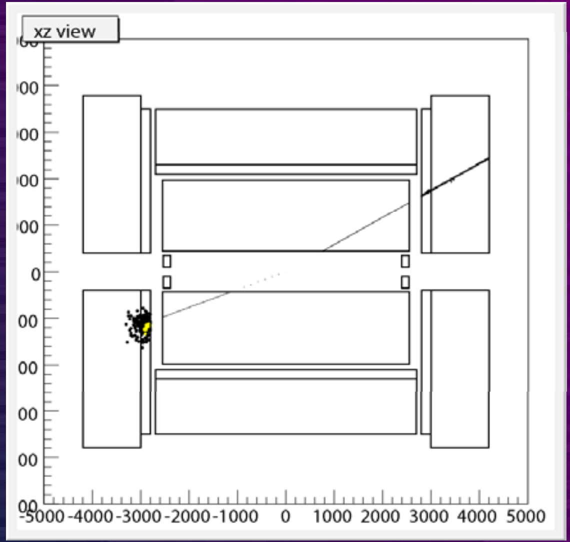
Tau-pair events



Typical event

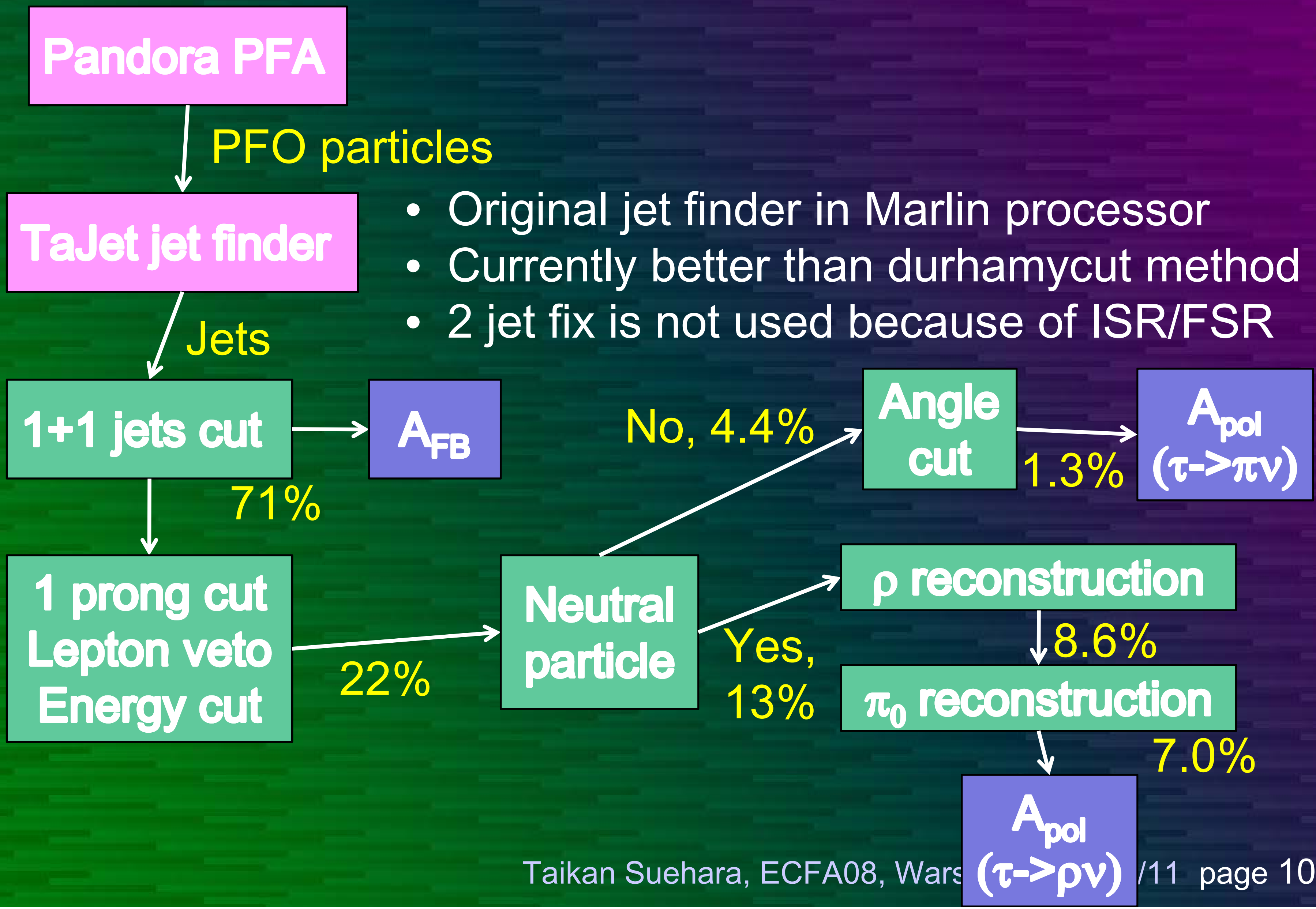
- Event characteristics
  - 2 jets (+ ISR/FSR photons)
  - 1 or 3 prongs/jet, very condensing (taus in 500 GeV beam are highly boosted)
  - Cross section is large, ~2 pb^{-1}
- Event samples
  - 57000 events (25 fb^{-1}) in each GLD, GLD', LDC geometries using SLAC stdhep files Left and right initial beam polarization are supplied separately.
  - 25000 events in GLD (slightly old configuration) using physia (polarization effects are not included)
- Observables
  - σ, total and differential cross section
  - A_{FB}, forward-backword asymmetry
  - A_{pol}, polarization asymmetry (paticularly in polarized beams)

Decay modes in A_{pol} analysis

$\tau \to e\nu\nu$	• Branching ratio: 17.8% • 3 body decay; pol. info is smeared
$\tau \to \mu\nu\nu$	• Branching ratio: 17.4% • 3 body decay; same as $e\nu\nu$ mode
$\tau \to \pi\nu$	• Branching ratio: 10.9% • Pol. can be directly observed by π distribution (Back to back τs are required because of missing neutrino)
$\tau \to \rho\nu$, $\rho \to \pi\pi$	• Branching ratio: 25.2% • Pol. of ρ can be obtained by π distribution in ρ-rest frame (pol. of ρ is connected to pol. of τ) Back to back is not required
$\tau \to a_1\nu$, $a_1 \to \pi\pi\pi$	• Branching ratio: 9.3% • Currently not used because statistics is low

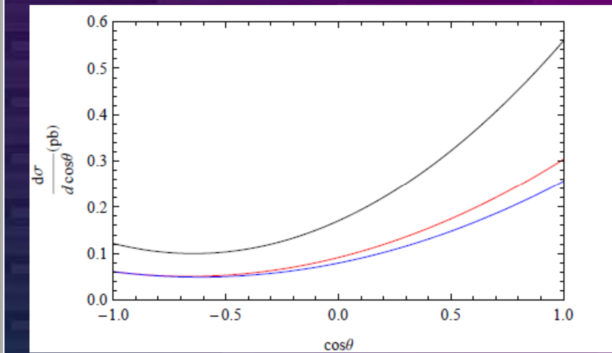
Analysis flow

- Original jet finder in Marlin processor
- Currently better than durhamycut method
- 2 jet fix is not used because of ISR/FSR



Tau A_{FB} result

$$A_{FB} = \frac{N_F - N_B}{N_F + N_B}$$



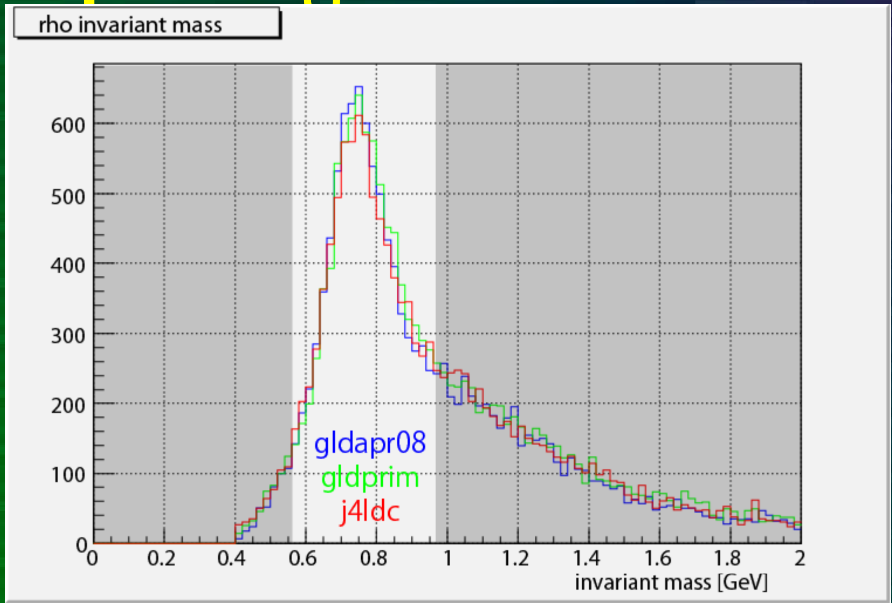
SM calculation
(Red: left, Blue: right)

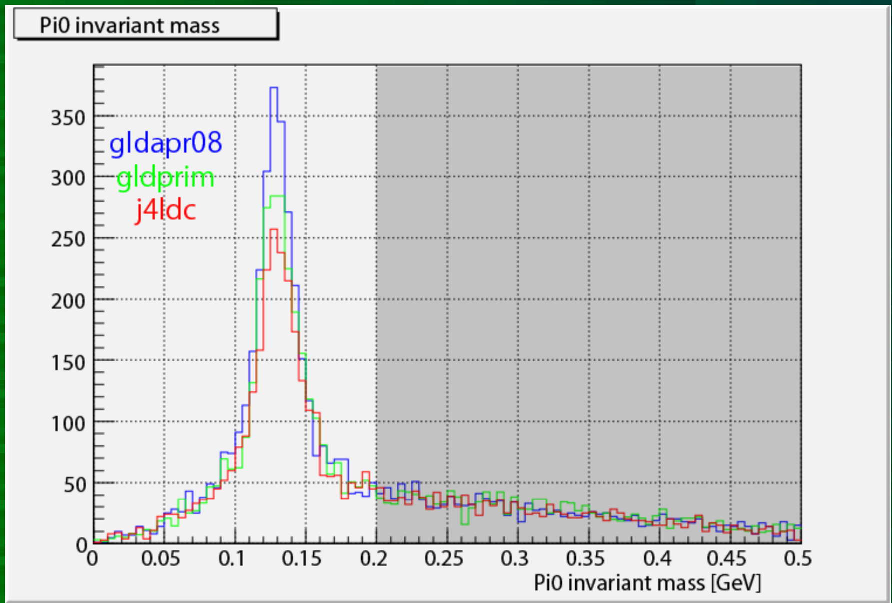
Geometry	A_{FB}(edge only)	A_{FB}(full range)
Gldapr08:	65.71 ± 0.26%,	49.76 ± 0.17%
Gldprim:	64.99 ± 0.27%,	49.73 ± 0.17%
J4ldc:	65.30 ± 0.26%,	49.44 ± 0.17%

(stat. error only)

Error value is extrapolated to 500 fb^{-1} (for 25 fb^{-1}, ~1.2% & 0.7%)

ρ / π_0 invariant mass distribution





ρ invariant mass:
invmass between the prong and all neutrals combined.

Geometry	width(σ,MeV)	# accept
Gldapr08	95.4	7987
Gldprim	99.6	8099
J4ldc	99.8	7812

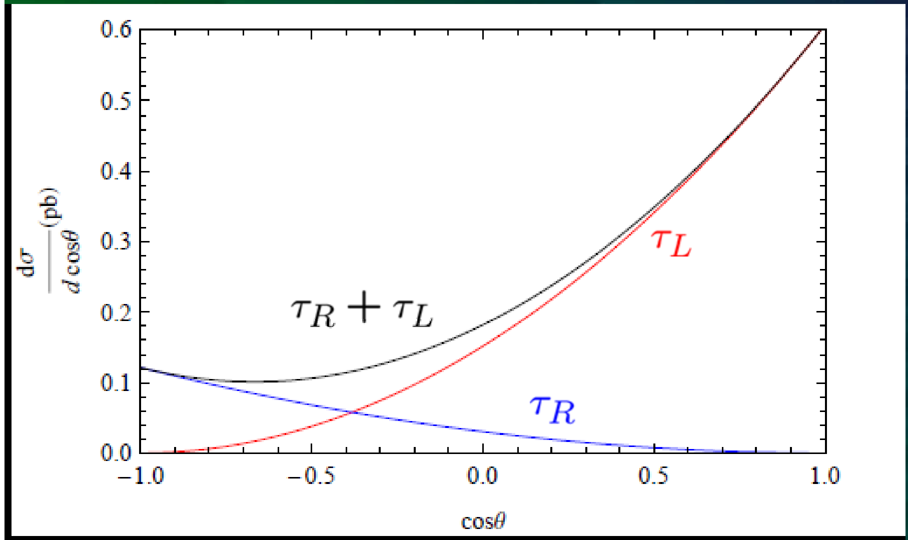
No significant difference.

π_0 invariant mass:
event with >=2 neutrals
(if >2 neutrals, nearest neutrals are combined till 2 neutrals rest.)

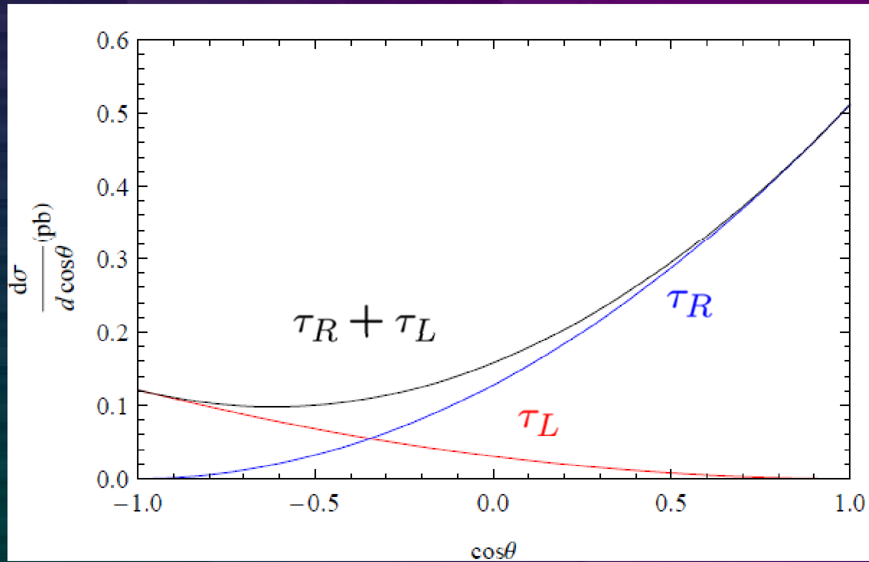
Geometry	width(s,MeV)	# accept
Gldapr08	14.7	2662
Gldprim	15.0	2410
J4ldc	16.5	2219

Better performance in gldapr08!

Tau A_{pol} expected result



e^-_L beam: τ^+_L is increased

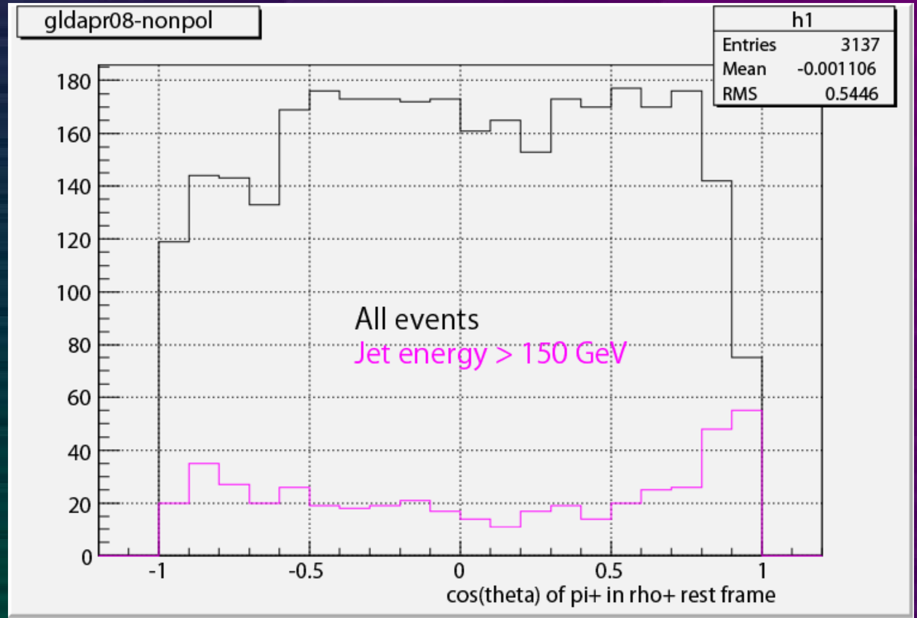


e^-_R beam: τ^+_R is increased

If we choose the beam polarization,
large τ polarization should be observed.

Tau A_{pol} result

π^+ dist. in $\tau^+ \to \pi^+\nu$ decay



π^+ dist. in $\rho^+ \to \pi^+\pi^0$ decay

- Flat π^+ distribution in $\tau^+ \to \pi^+\nu$ decay
  - No τ polarization in generator
- Edge enhancement of π^+ dist. in $\rho^+ \to \pi^+\pi^0$
  - Polarization of ρ is observed

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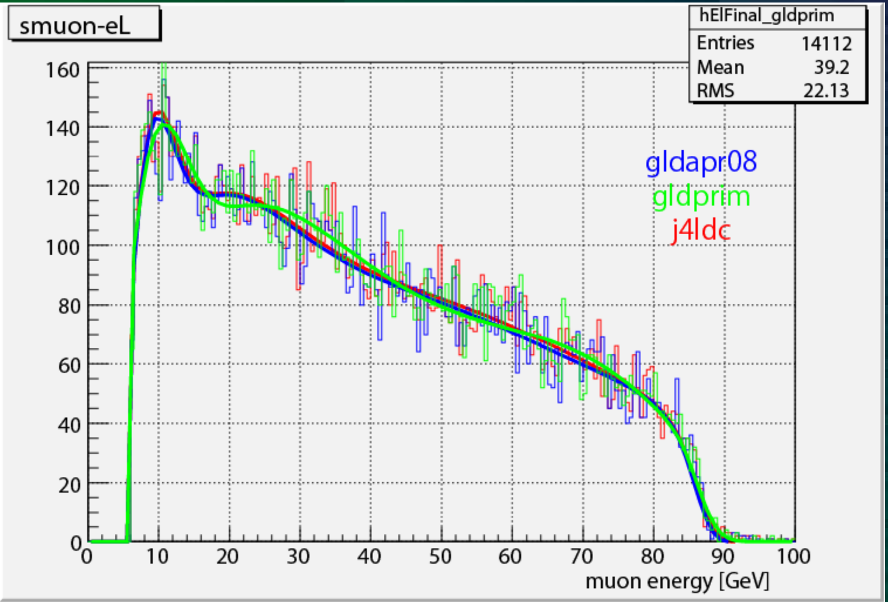
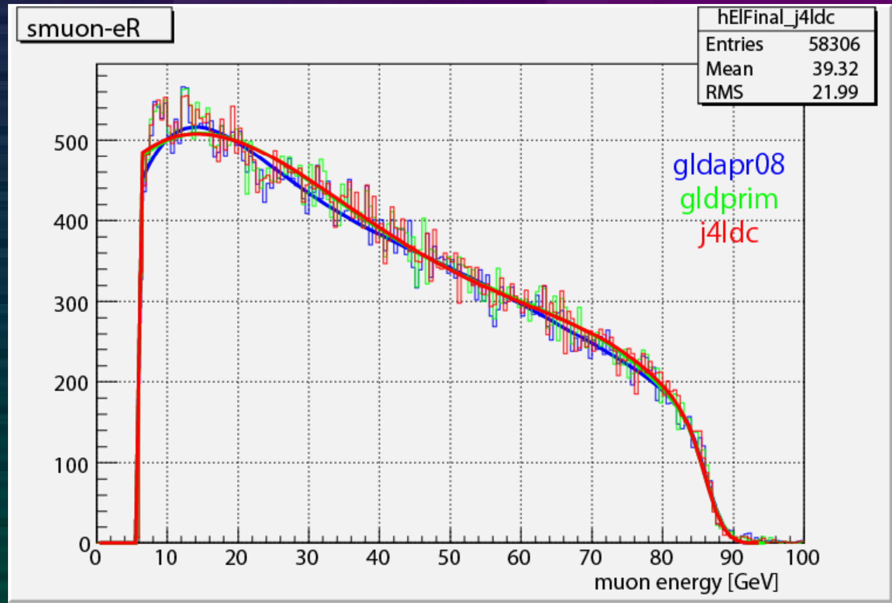
Smuon mass determination

- $500 fb^{-1}$ smuon (point 1), chargino and neutralino (point 5) events are generated for SUSY analysis
- Currently only smuon events are analyzed.
- Generator input (point 1):
  - Smuon mass: 122.98 GeV
  - LSP Neutralino mass: 97.44 GeV
- SUSY masses are determined by fitting of the muon energy distribution
  (error function $\times$ poly (6^{th}) + gaussian)
- Cut is the same as TILC08 (Yoshioka-san)

Smuon/neutralino mass fit





Geometry	pol.	smuon mass[GeV]	neutralino mass[GeV]
Generator		122.98	97.44
Gldapr08	left	123.86 ±0.45	98.21 ±0.37
Gldapr08	right	124.04 ±0.19	98.26 ±0.17
Gldprim	left	124.28 ±0.39	98.48 ±0.33
Gldprim	right	124.24 ±0.19	98.44 ±0.16
J4ldc	left	123.78 ±0.45	98.12 ±0.37
J4ldc	right	124.25 ±0.18	98.45 ±0.15

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Plans

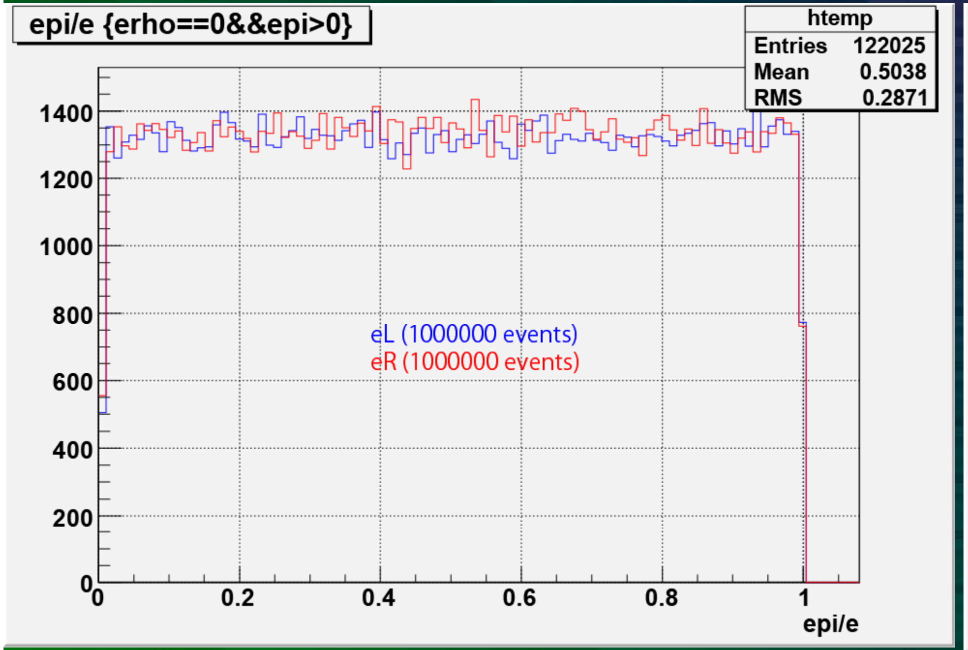
- Tau-pair analysis
  - Angular distribution in polarized tau samples
  - Obtain A_{pol}
  - Compare performance on A_{pol} measurements
  - Quantitatively estimate the relation between performance and detector parameters
- SUSY analysis
  - Better fitting with no deviation to input masses
  - Chargino and neutralino analysis (benchmark process)

Summary

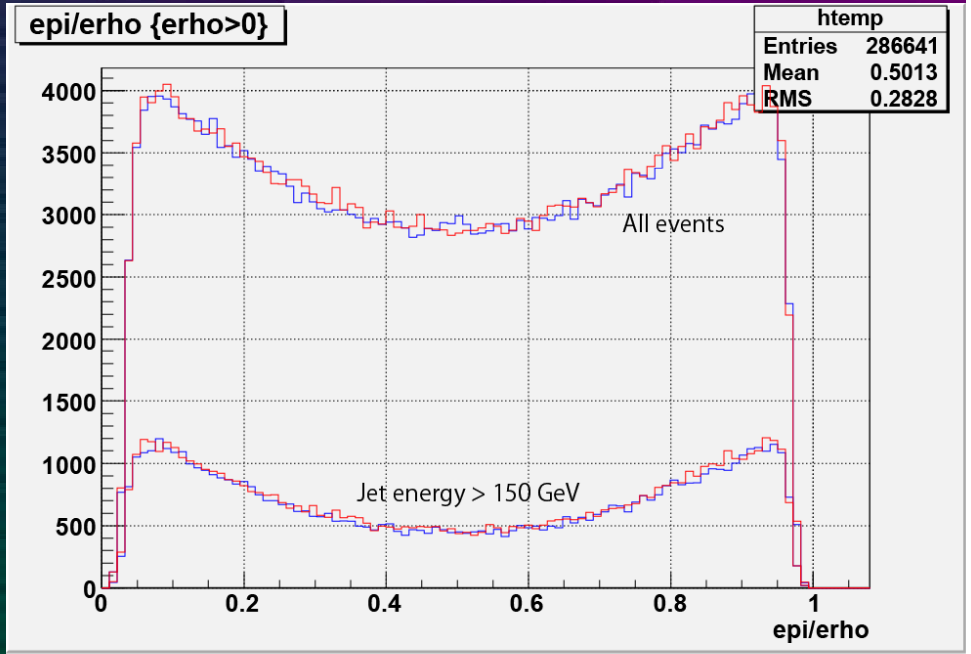
- Physics analyses are important for detector optimization.
- Tau-pair and SUSY analysis are ongoing.
- GLD-like geometry gives better performance in π_0 reconstruction (mainly because of the detector size).
- No tau polarization is included in current data samples, must be implemented.
- Result of sumon mass fit is a little heavier than generator parameter.

Backup

Generator info



π^+ dist. in $\tau^+ \rightarrow \pi^+\nu$ decay



π^+ dist. in $\rho^+ \rightarrow \pi^+\pi^0$ decay