tau reconstruction with ECALs

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CALICE-meeting @ DESY/Hamburg

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Motivation & My goal

- at high energy, tau leptons are highly boosted, thus decay daughters are concentrated in a very narrow angle. and reconstruction of π0 from two gamma is challenging for the ILC detectors.

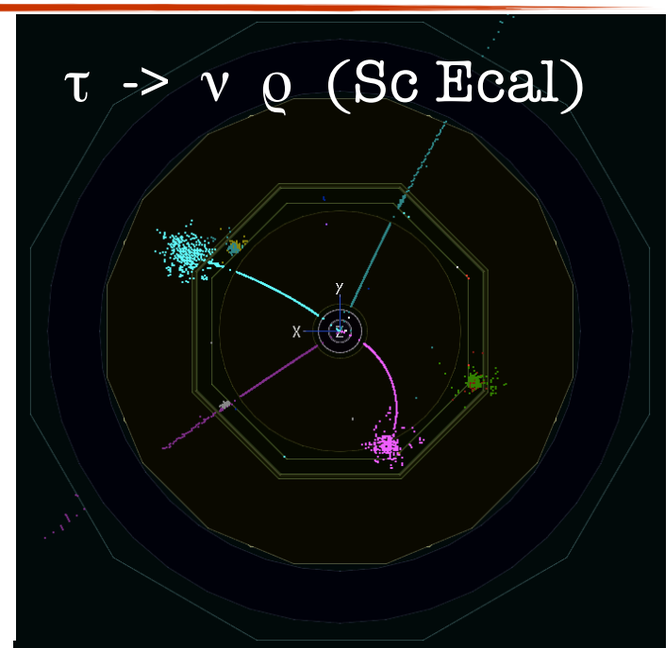
  - to compare the γ separation performance for each ECAL, because, for PFA, high granularity ECAL is demanded.

  - to know how efficiently π0 reconstruction for γs on each ECAL.

- my goal is to evaluate the performance of ECALs using τ-pair process. (try to follow LoI analysis relating τ-pair with different ECALs)

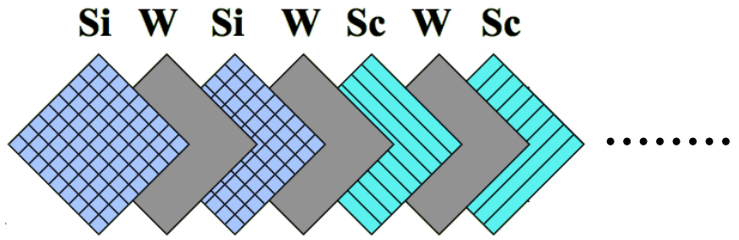
Event simulation

- restricted to only hadronic τ decay with a single charged hadron (1-prong), which γs are included.



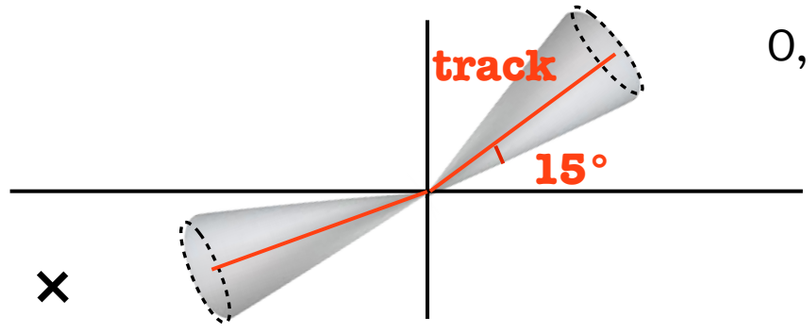
- √s = 250 Gev :
- Production : e+ e- -> Z H -> μ μ τ τ
- τ branching :
  1, τ -> ν π / ϱ / a1 (mixed event)
  2, τ -> ν π
  3, τ -> ν ϱ (-> π π0)
  4, τ -> ν a1 (-> π π0 π0)
- Comparison Ecal :
  1, Sc Ecal (scintillator Ecal w/o SSA)
  2, Sc SSA (scintillator Ecal w/ SSA)
  3, Hybrid
  4, Si Ecal (Silicon Ecal)

Hybrid Ecal :



τ reconstruction with default Pandre PFA (using mixed event)

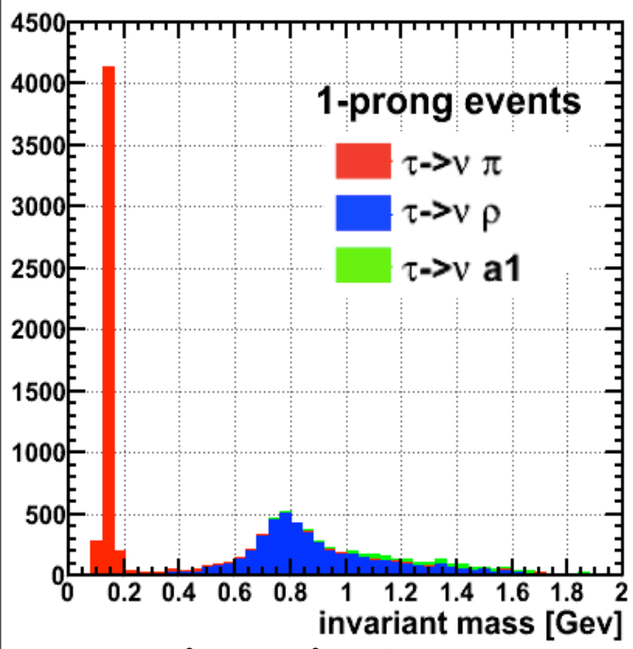
- this reconstruction, for a τ, extracted events found only 0γ (π mode), only 2 γ (ϱ mode) or only 4 γ (a1 mode) and reconstruct τ.
  - I determined cone angle to be 15 degree.



0, 2 or 4 γ -> reconstruction π, ϱ or a1

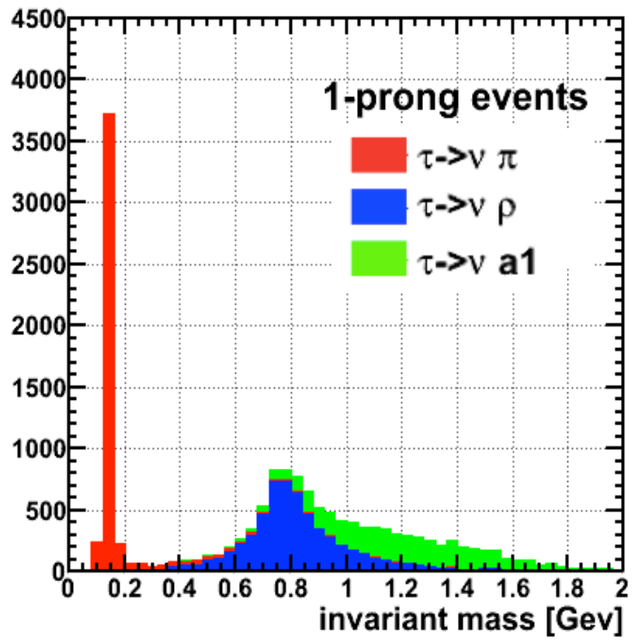
1, 3 or .. γ -> ×

Sc Ecal



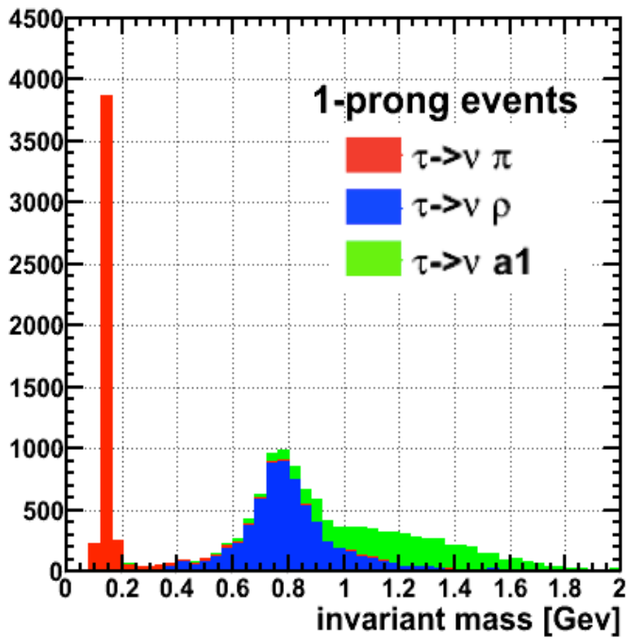
invariant mass

Sc SSA



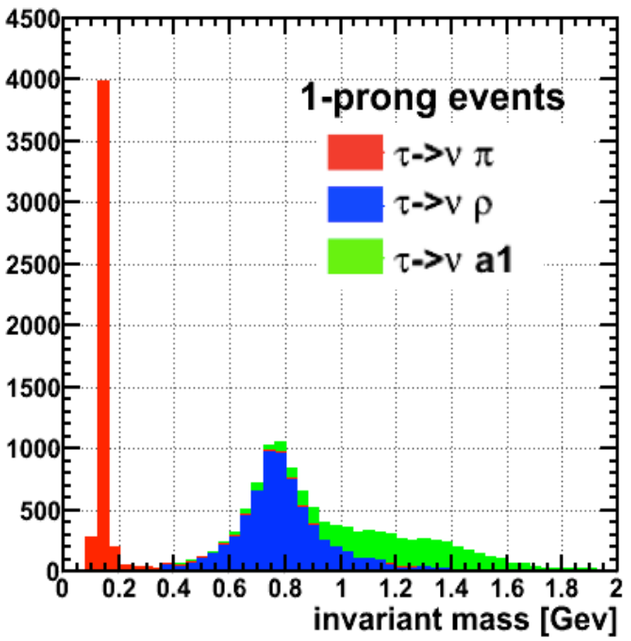
invariant mass

Hybrid



invariant mass

Si Ecal



invariant mass

My analysis

to find a gamma cluster

- search an angular area of 15 degree from track (not include lepton ID)
- reject a gamma which energy of cluster is < 0.08 Gev .
- don't count as a gamma which energy of cluster is < 0.8 Gev,
  but 4momentum is added when reconstructed.
  - these gammas are regarded as fragments from large energy gammas.

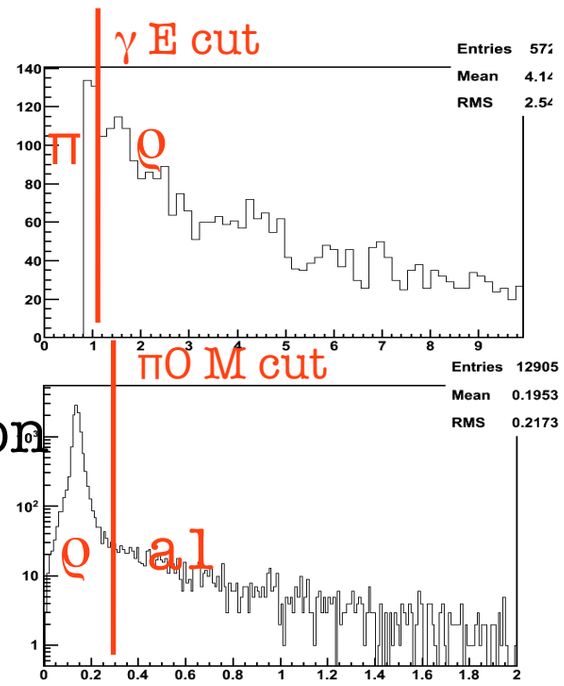
for a τ

0 gamma -> π reconstruction

1 gamma -> γ energy -> π or ϱ reconstruction
γ E cut E < 1.0 1.0 < E

2 or 3 gamma -> π0 reconstruction -> ϱ or a1 reconstruction
π0 M cut M < 0.27 0.27 < M

over 4 gamma -> a1 reconstruction

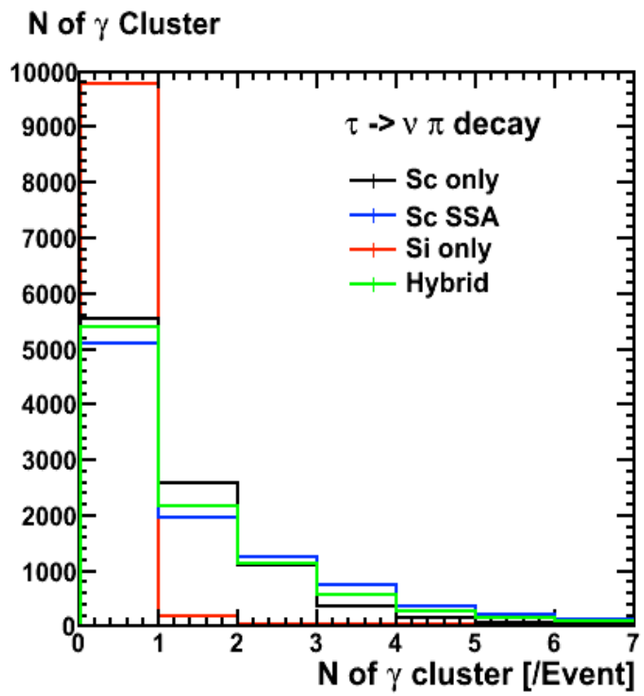


N of γ clusters at τ's each mode

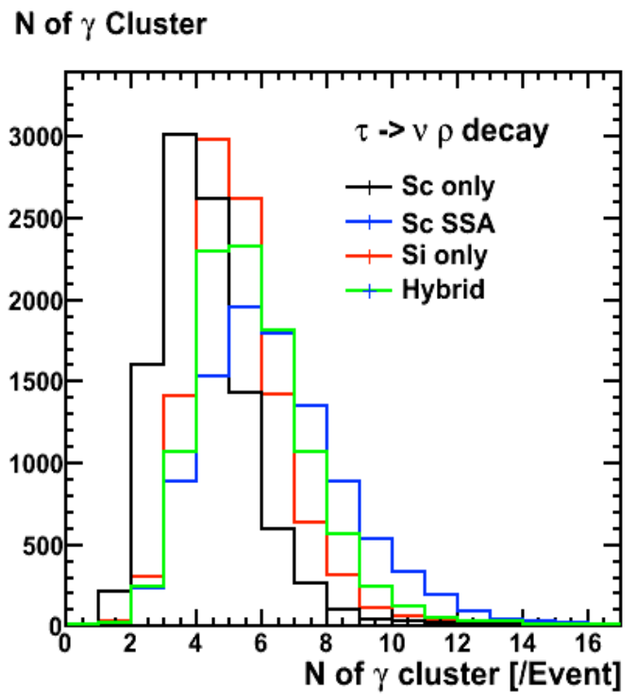
※ applied my analysis, Egamma > 0.8GeV

H -> τ τ

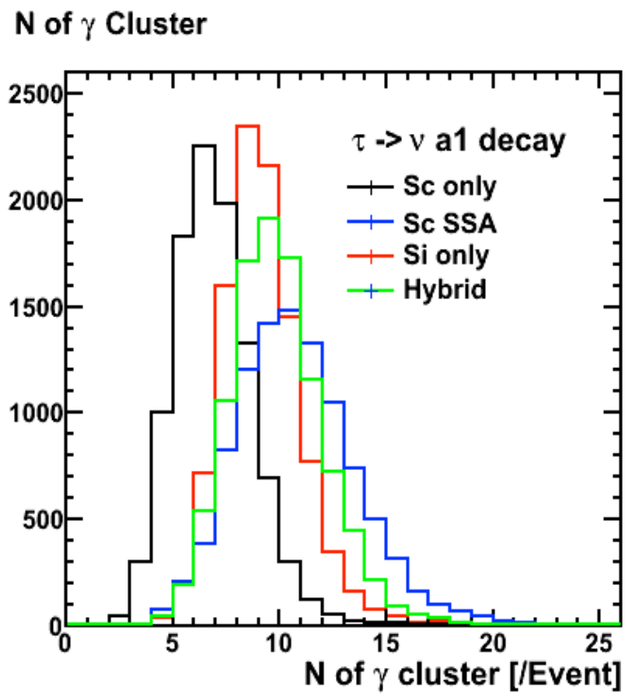
τ τ -> ν π ν π mode



τ τ -> ν ϱ ν ϱ mode



τ τ -> ν a1 ν a1 mode

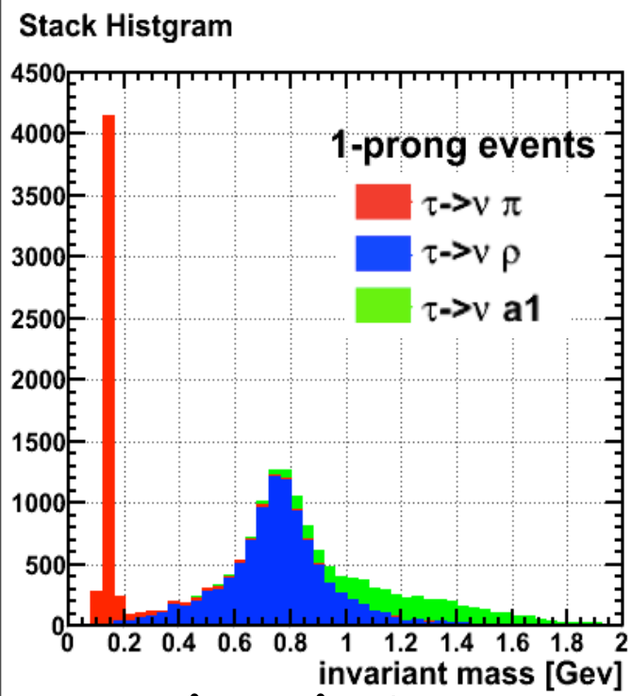


- in Sc SSA and Hybrid, fragmented γ clusters are created by SSA algorithm.

τ reconstruction with my analysis (using mixed event)

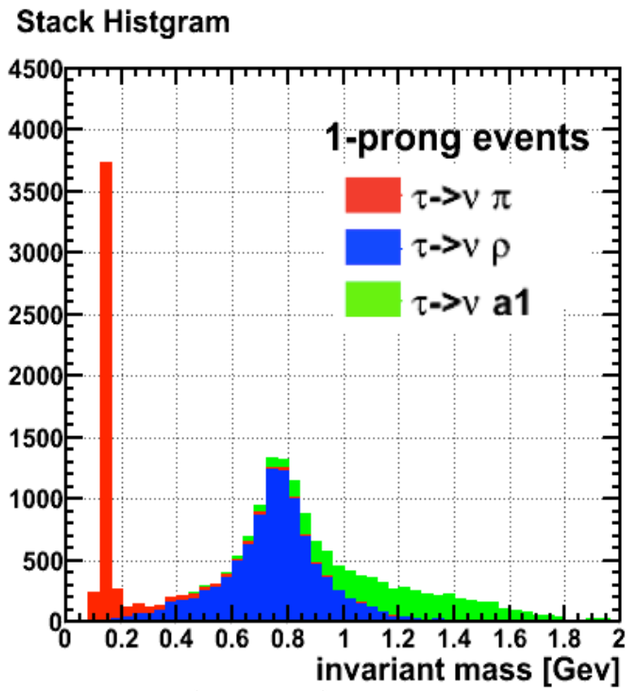
※ applied my analysis, Egamma > 0.8GeV

Sc Ecal



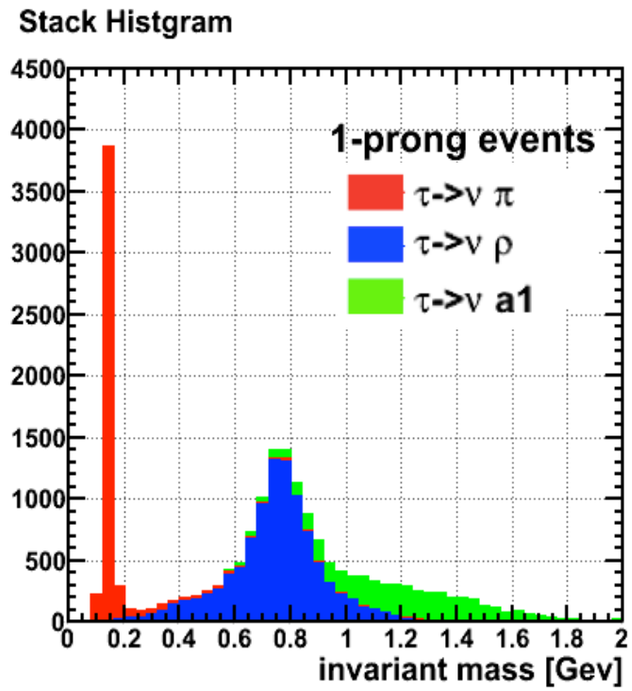
invariant mass

Sc SSA



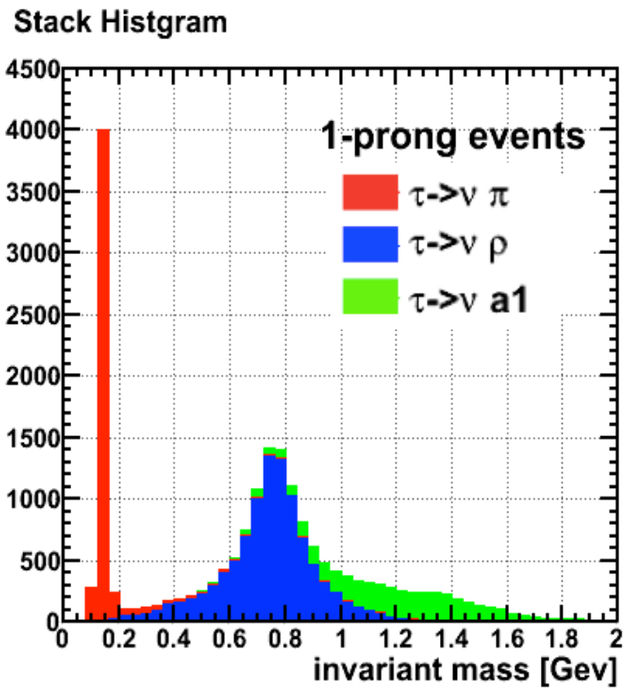
invariant mass

Hybrid



invariant mass

Si Ecal

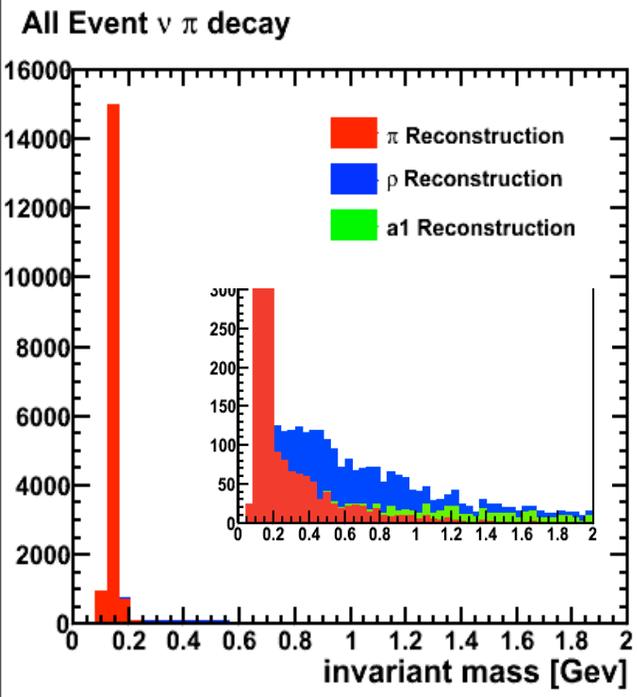


invariant mass

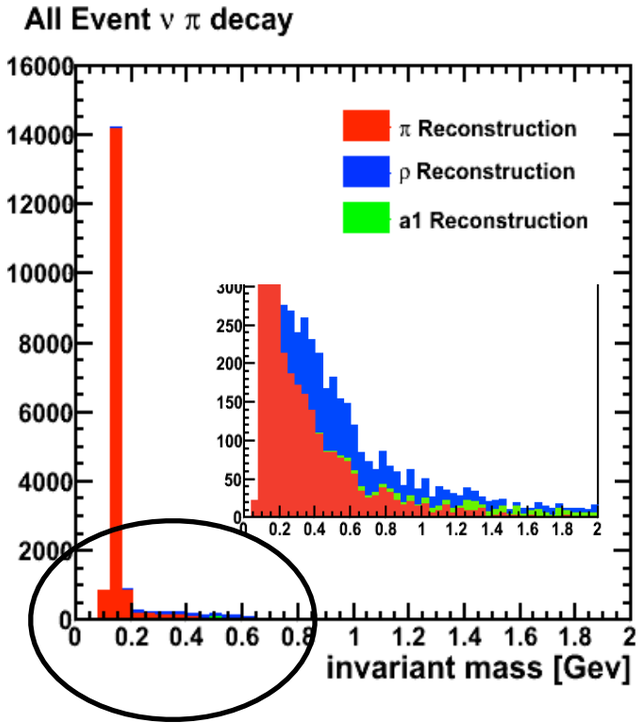
- by my analysis, can make ECALs improve at a level of Si Ecal (particularly Sc) .
- seem to be same at each ECAL, need to study at each mode

τ -> ν π mode

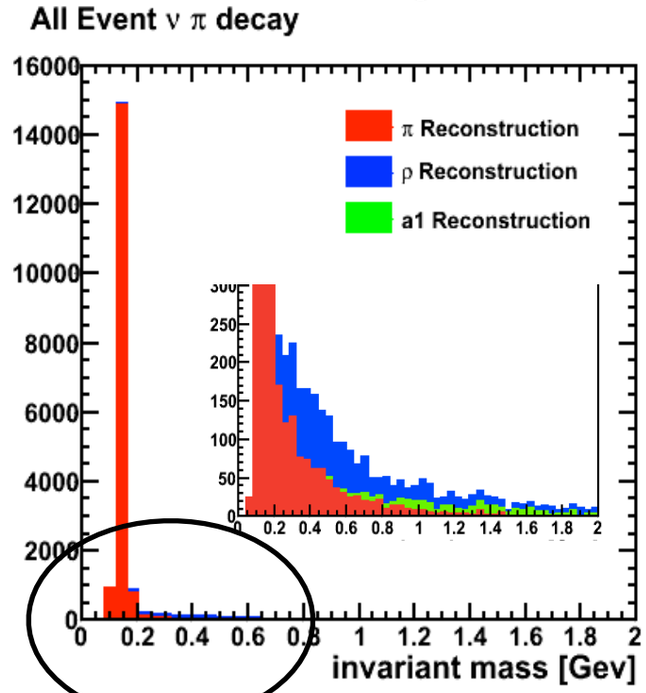
Sc Ecal



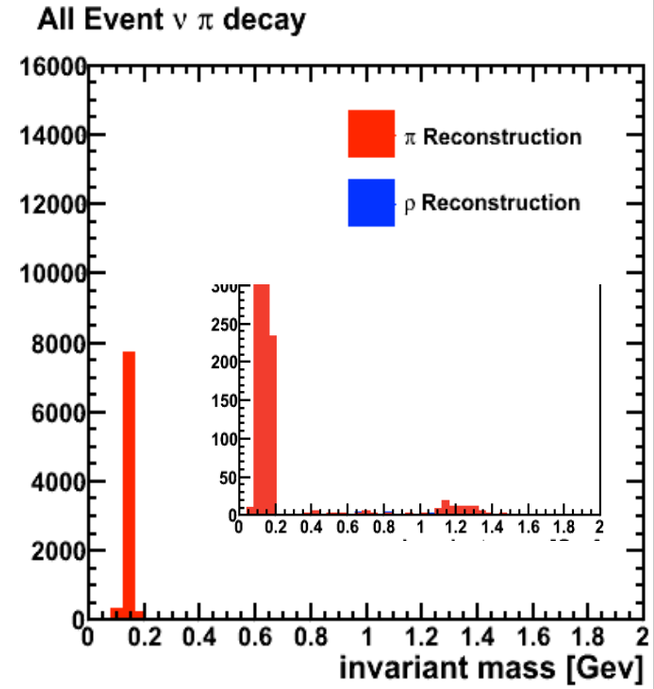
Sc SSA



Hybrid



Si Ecal

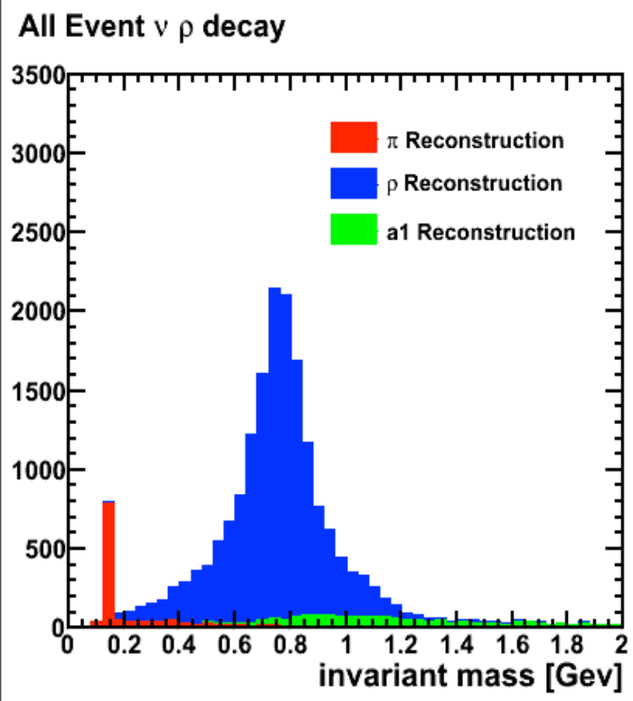


- in Sc SSA and Hybrid, because of a lot of small fragments, π reconstruction has a tail
- reconstruct a1 except SiEcal, because there are γ clusters which have large energy

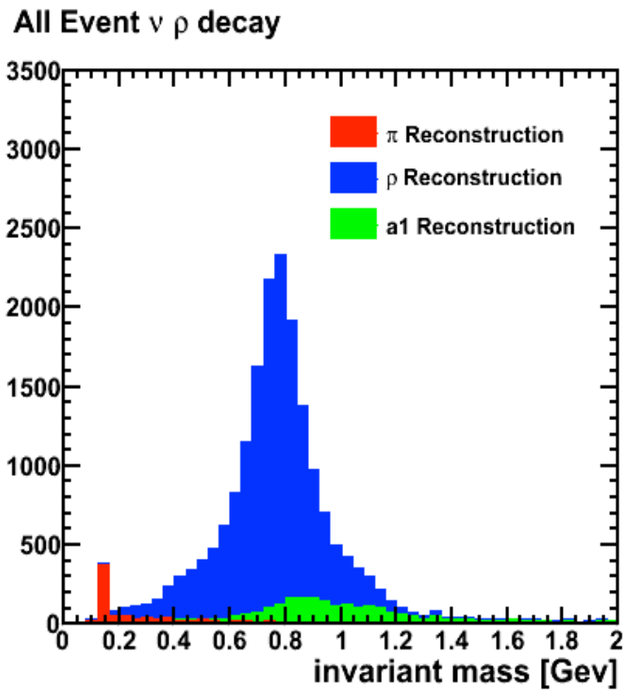
(- in case of SiEcal, PandraPFA judge pion as neutron. bug?)

τ -> ν ϱ mode

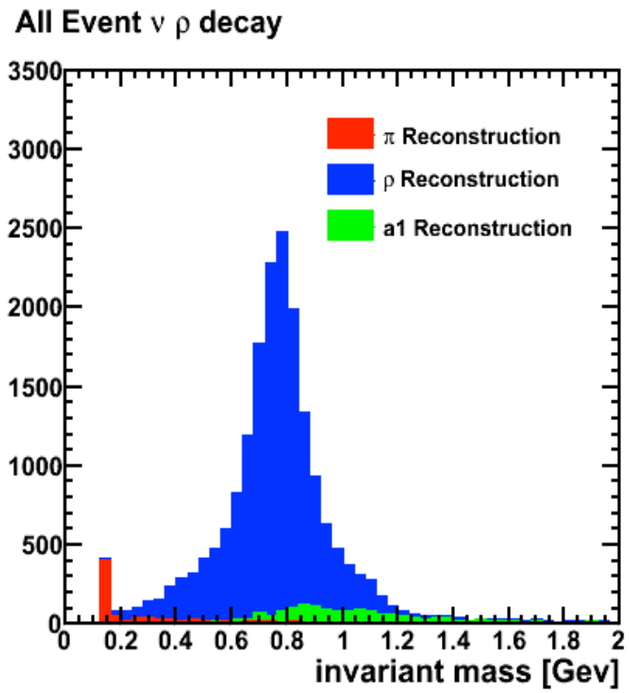
Sc Ecal



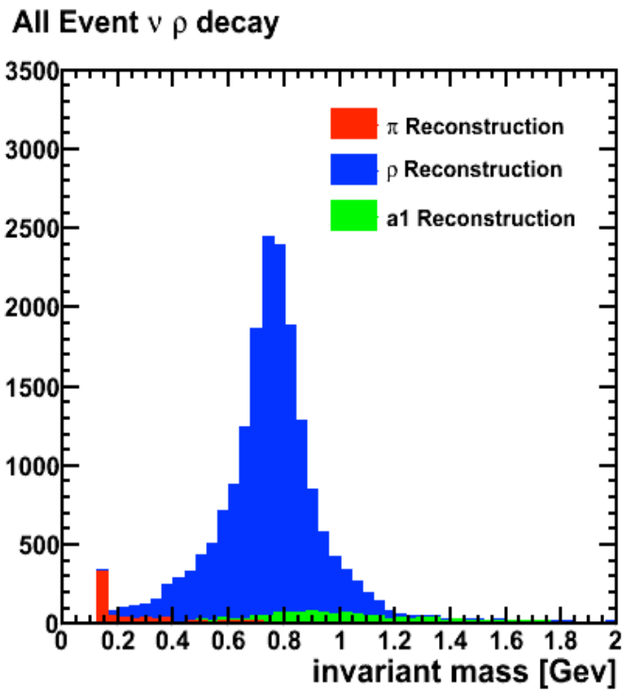
Sc SSA



Hybrid



Si Ecal

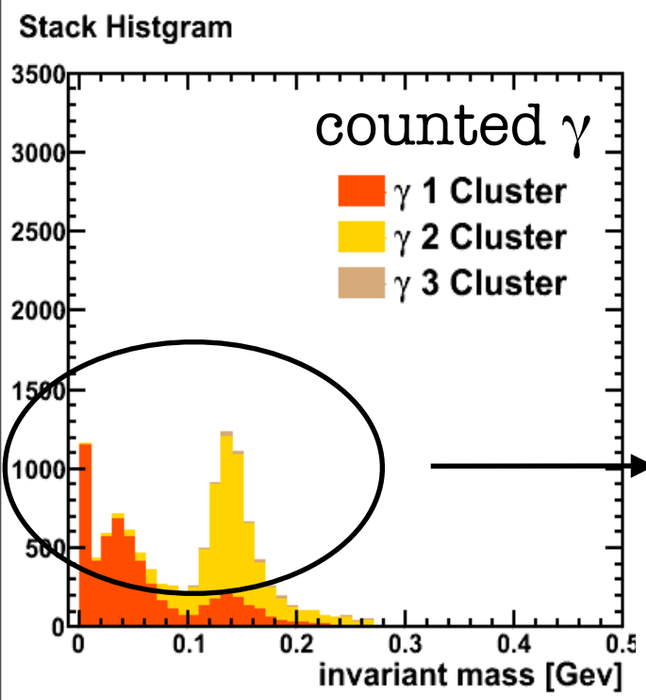


- looks similar for all ECALs.

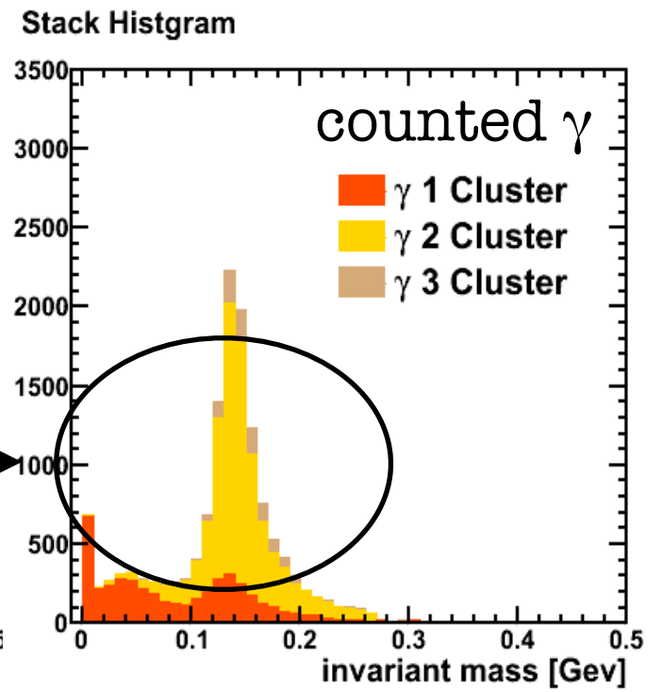
π0 reconstruction, reconstructed ρ at τ -> ν ρ mode

※ γ fragments are included

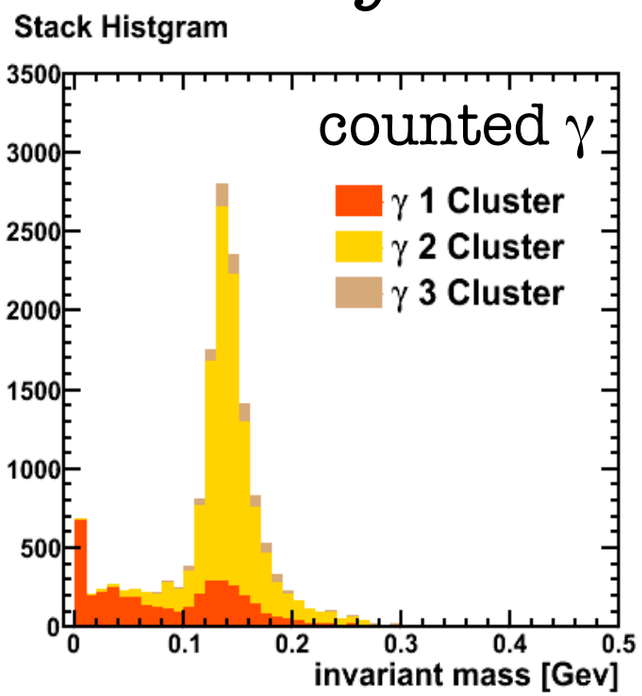
Sc Ecal



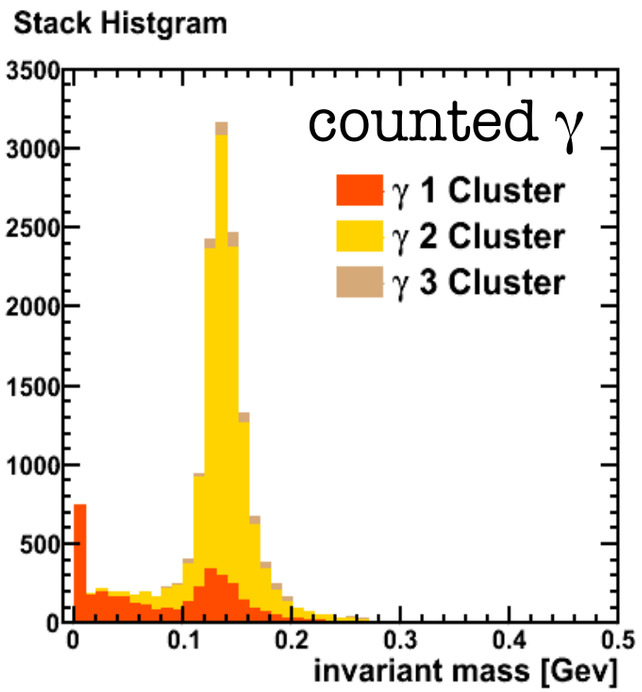
Sc SSA



Hybrid

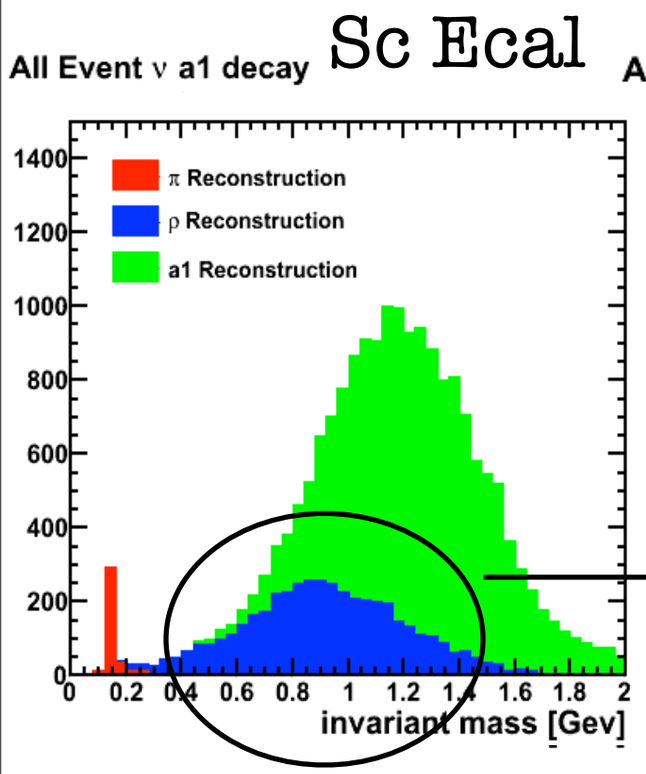


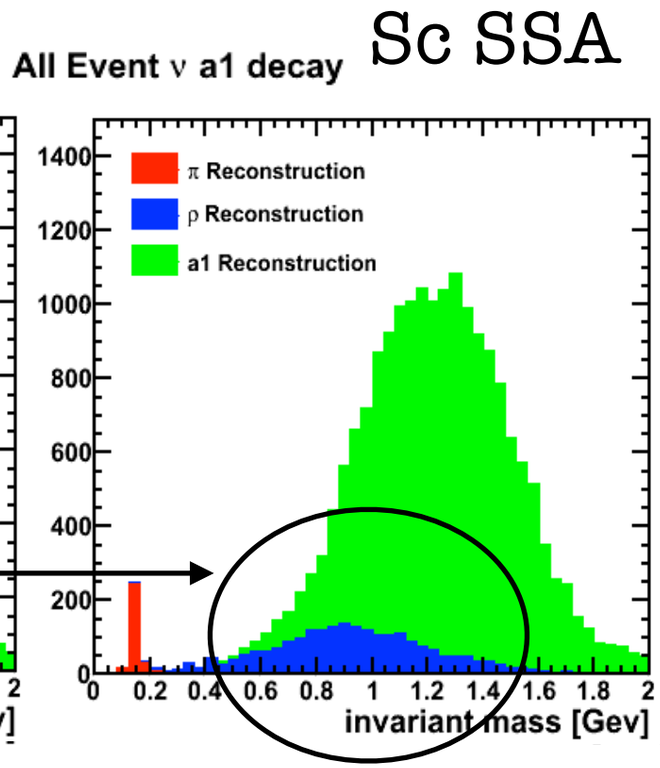
Si Ecal

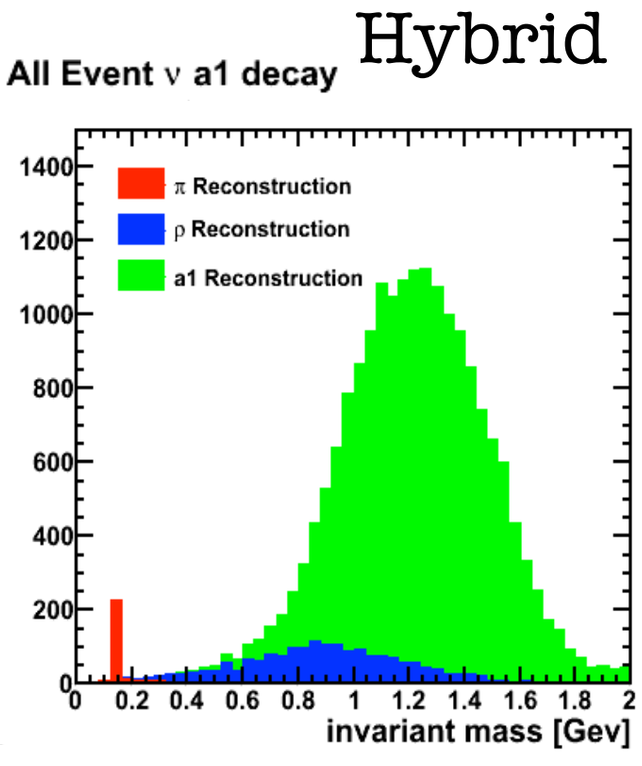


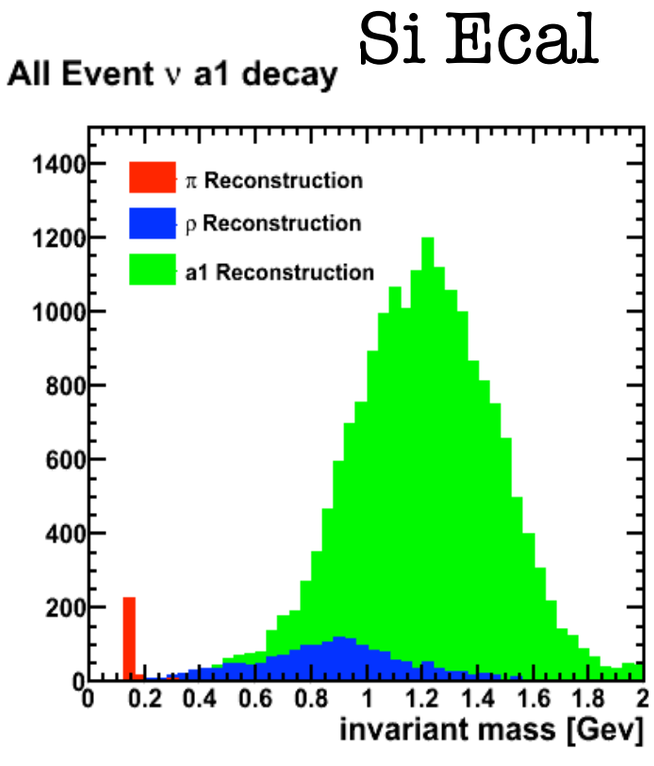
- SSA algorithm can make π0 reconstruction included 2γ improve.
- in Hybrid and Si Ecal, there are slightly difference at N of counted γ clusters.

τ -> ν a1 mode









- Sc Ecal can not separate γs (more than 4) which are generated at narrow area, and many ϱs are reconstructed.

- SSA algorithm can make Sc Ecal improve about a1 reconstruction at same level with Si Ecal.

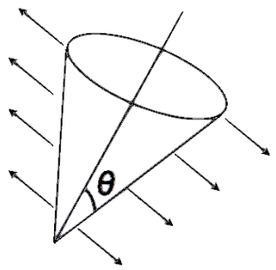
Summary & Plan

- to estimate the γ separation performance of Ecals,
  I simulated τ decay restricted only 1-prong modes.

- by my analysis, reconstruction ratio at mixed events seem to be the same at all ECALs, but reconstruction of each mode is a bit different.
  and also, find out that reconstruction with Sc Ecal can be improved by SSA

- in case of Sc SSA, many γ fragments or ghost γ clusters are reconstructed by SSA algorithm, even Hybrid, also, are created at a certain level.

- to reduce γ fragments created by SSA, need tuning a cone following hits.



- advance my simulation about more detailed analysis relating τ-pair process with some ECALs, following LoI's result with different ECALs.

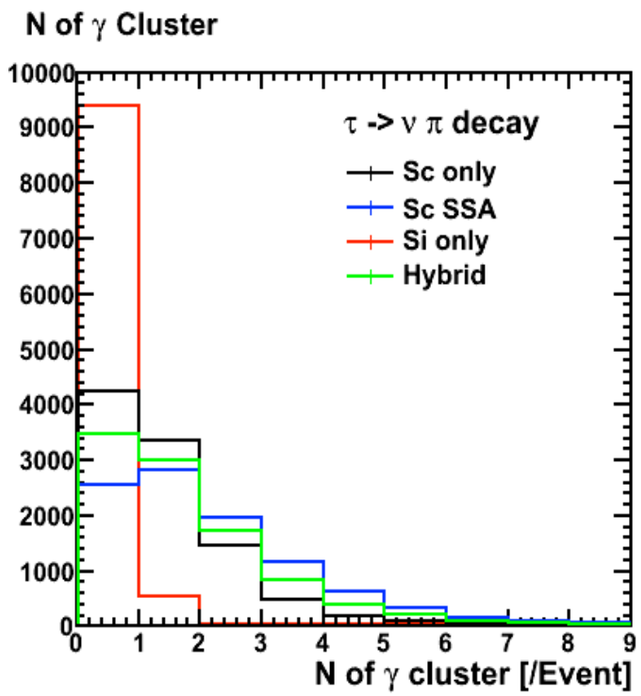
back up

※ actually i would have liked to compare with the conclusion of LoI Ecal simulation
relating τ reconstruction, but could not get information about that. So, this is estimation of my own.

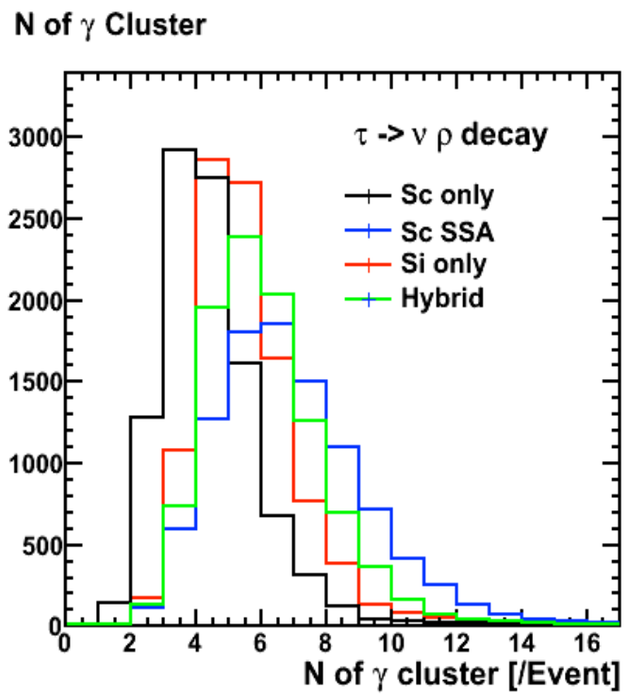
Channel	Dominant Decay Mode	BR [%]
$e^-\bar{\nu}\nu$	$e^-\bar{\nu}_e\nu_\tau$	$17.82 \pm .04$
$\mu^-\bar{\nu}\nu$	$\mu^-\bar{\nu}_\mu\nu_\tau$	$17.39 \pm .04$
$h^-\nu$	$\pi^-\nu_\tau$	$11.61 \pm .06$
$h^-\pi^0\nu$	$\rho^-\nu_\tau \to \pi^-\pi^0\nu_\tau$	$25.94 \pm .09$
$h^-\pi^0\pi^0(\pi^0)\nu$	$a_1^-\nu_\tau \to \pi^-\pi^0\pi^0\nu_\tau$	$10.85 \pm .11$
$h^-h^-h^+(\pi^0)\nu$	$a_1^-\nu_\tau \to \pi^-\pi^-\pi^+\nu_\tau$	$14.56 \pm .07$

N of γ cluster at τ's each decay

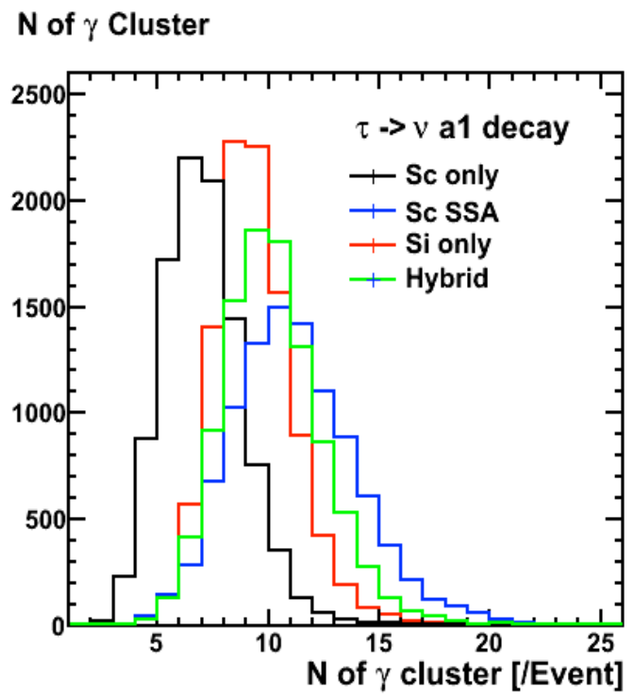
τ -> ν π decay



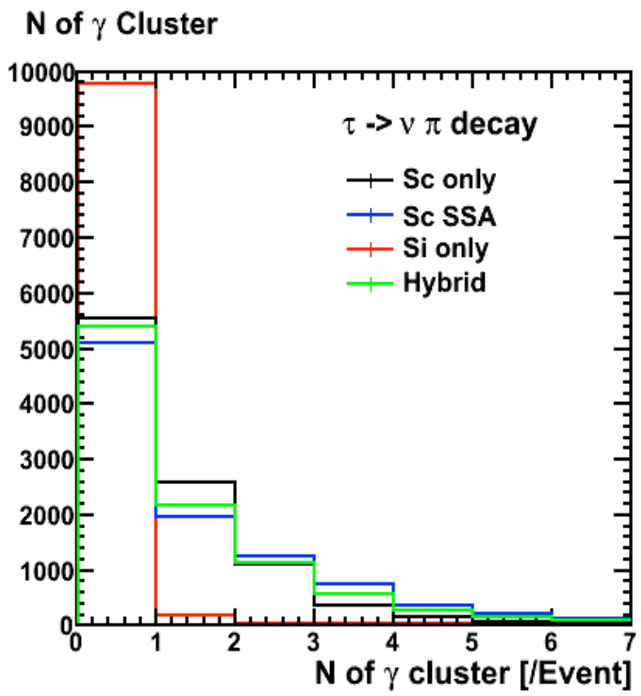
τ -> ν ϱ decay

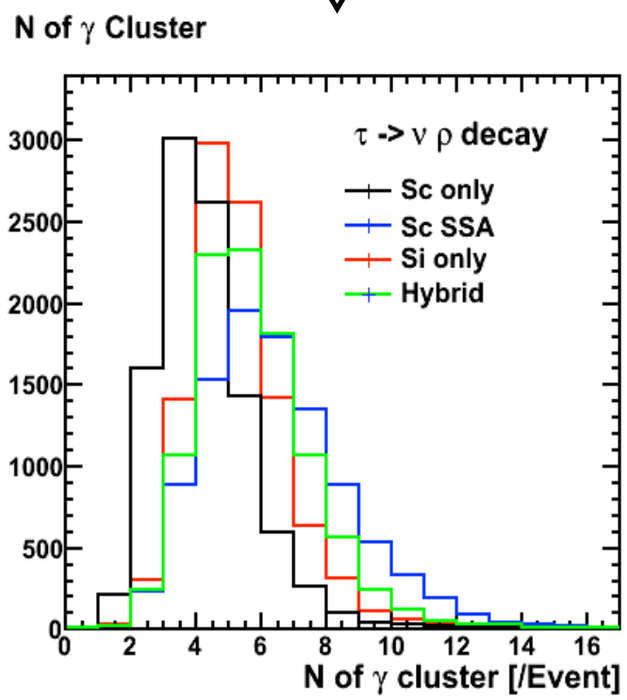


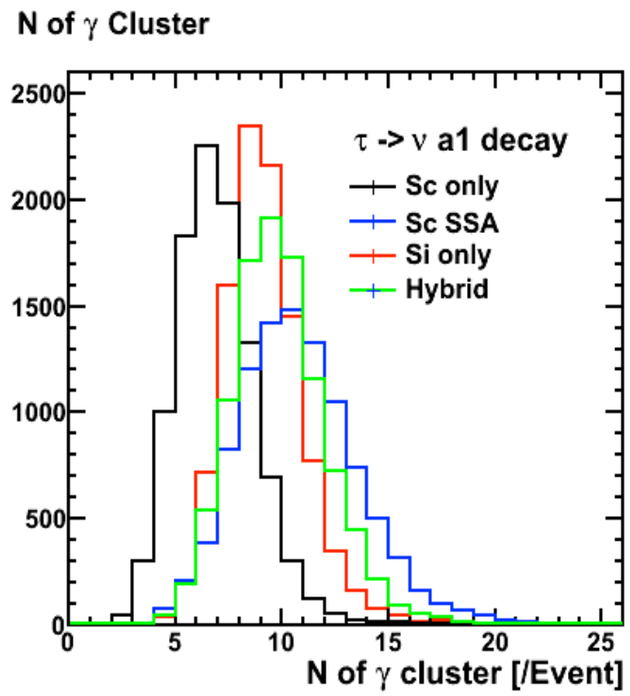
τ -> ν a1 decay



don't count fragments



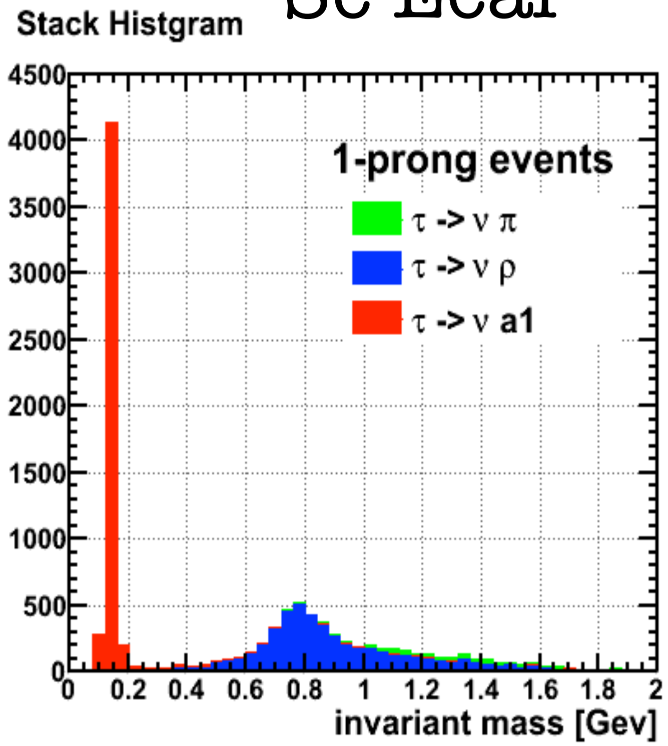




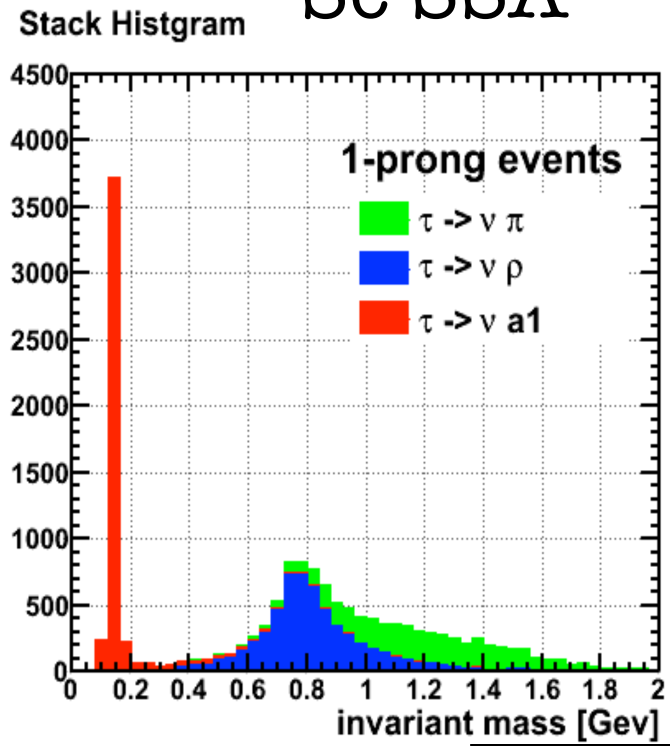
τ -> only 1-prong decay

only 0 or 2 or 4 γ events (only pure events)

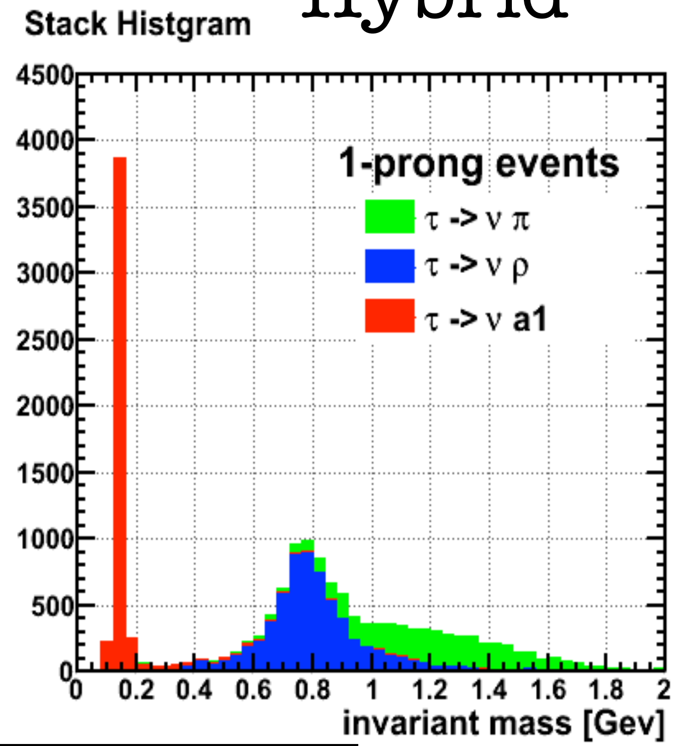
Sc Ecal



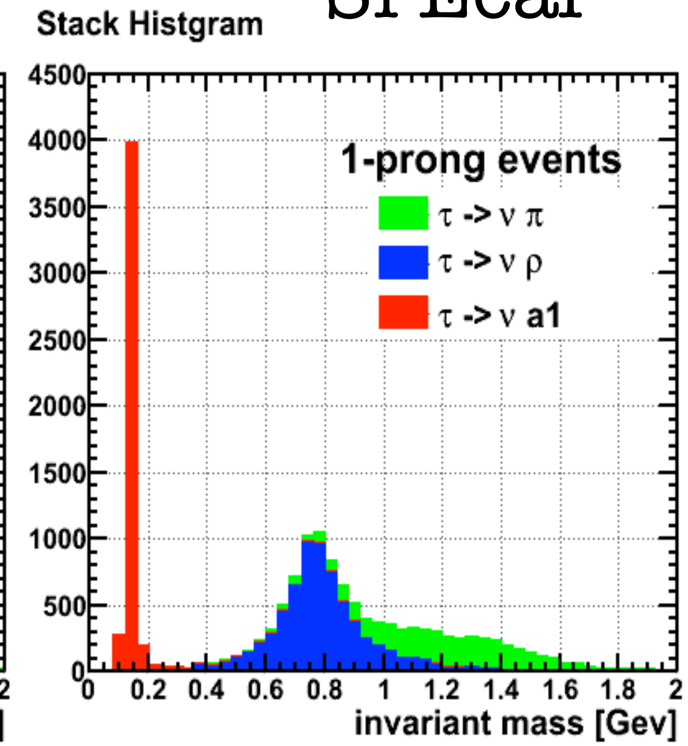
Sc SSA



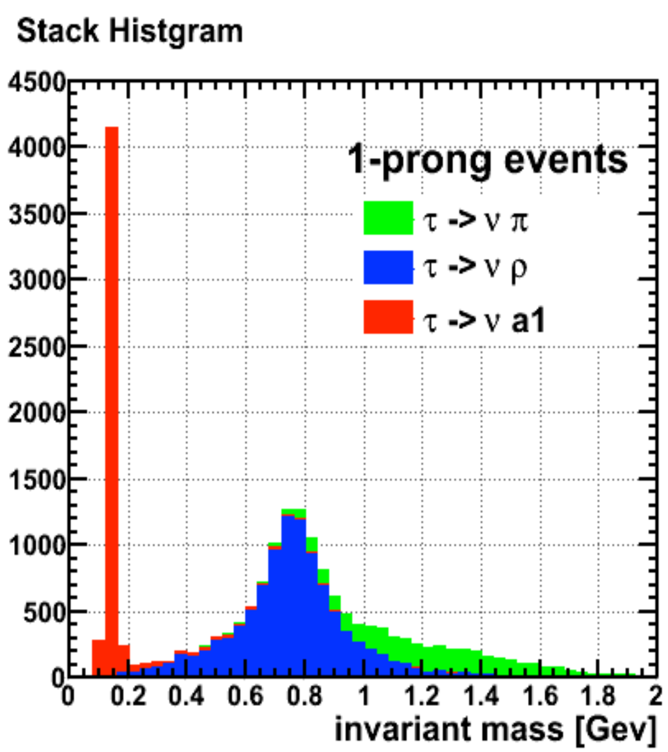
Hybrid

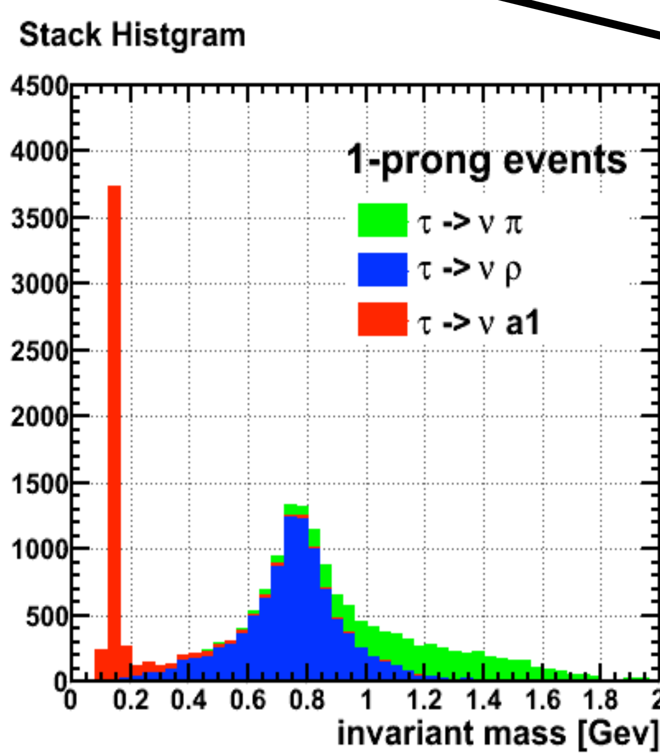


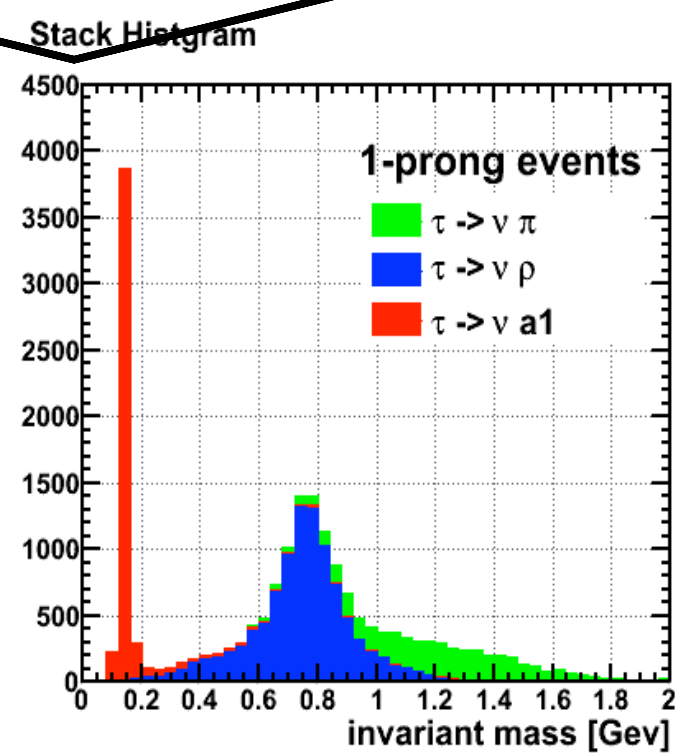
Si Ecal

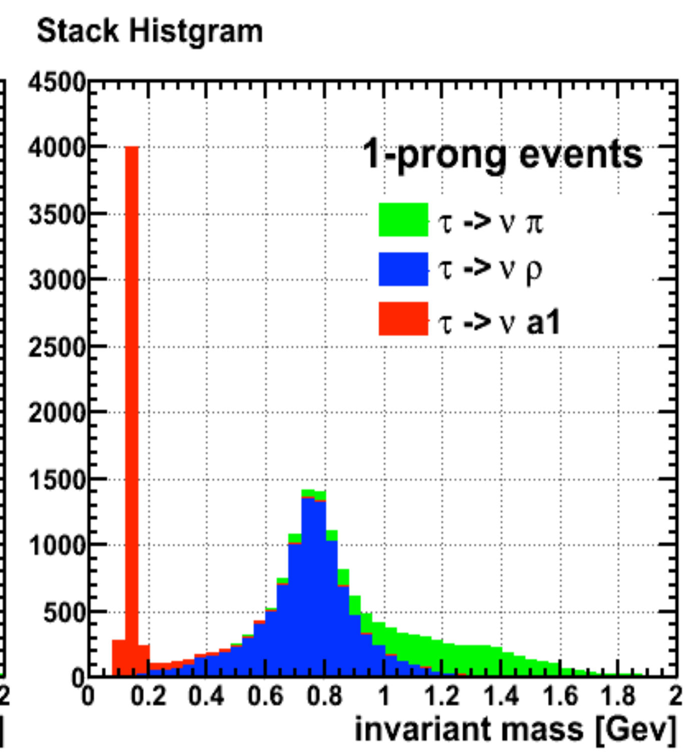


my analysis
for all events









τ -> only 1-prong decay : how improve

- reconstructed N of τ decay

	Sc Ecal			Sc SSA			Hybrid			Si Ecal		
	pure γ event	γ selection	how improve	pure γ event	γ selection	how improve	pure γ event	γ selection	how improve	pure γ event	γ selection	how improve
πreco	5014	5080	-1.4%	4773	4856	+1.7%	4792	4867	+1.5%	4879	4924	+0.8%
ρreco	5128	10325	+47%	6149	9973	+35%	6771	10083	+30%	7060	10144	+28%
a1reco	855	4098	+75%	2083	4975	+22%	2156	4824	+24%	2086	4516	+34%

- BR ratio at each decay

	my Change BR ratio	Sc	Sc ssa	Hyb	Si
πdecay	24.9	26.0	24.5	24.6	25.1
ρdecay	54.8	52.9	50.4	50.9	51.8
a1decay	19.8	21.0	25.1	24.4	23.0

- seem to be same
- need to watch each mode

Table : each reconstruction

※ in reconstruction succeeded

	Sc Ecal			Sc SSA			Hybrid			Si Ecal		
	π mode	ϱ mode	a1 mode	π mode	ϱ mode	a1 mode	π mode	ϱ mode	a1 mode	π mode	ϱ mode	a1 mode
πreco	90.0	7.2	2.1	89.8	4.8	1.8	89.7	4.7	1.5	99.9	4.42	1.5
ϱreco	7.7	82.2	22.5	8.4	81.7	13.1	8.1	84.9	9.4	E-4	87.1	9.0
a1reco	2.2	10.5	75.4	1.7	13.4	86.7	2.1	10.3	88.9	0	8.39	89.5

○ ghost gamma cluster are created

○ there are more ghost gamma cluster than Hybrid

- need to improve SSA algorithm, and do so,
  will also lead to improvement of Hybrid performance.