Study of $D_S^+ \to \tau^+ \nu_\tau$

$$\tau^+ \to e^+ \nu_e \bar{\nu}_\tau$$

$$\tau^+ \to \mu^+ \nu_\mu \bar{\nu}_\tau$$

$$\tau^+ \to \pi^+ \bar{\nu}_\tau$$

$$\tau^+ \to \rho^+_{\pi^+ \pi^0} \bar{\nu}_\tau$$

Henan normal University

Junfeng Sun
Huijing Li
Jiahui Qiao

Outline

- Measure the BF of this decay more accurately.
- Test the SM and search for new physics.

PDG: (5.32±0.11)%

Experiment	Mode	$\mathcal{B}$ (%)
CLEO-c [4]	$D_s^+ \to \tau^+(e^+\nu_e\bar{\nu}_\tau)\nu$	$5.30 \pm 0.47 \pm 0.22$
CLEO-c [5]	$D_s^+ \to \tau^+(\pi^+\bar{\nu})\nu$	$6.42 \pm 0.81 \pm 0.18$
CLEO-c [6]	$D_s^+ \to \tau^+(\rho^+\bar{\nu})\nu$	$5.52 \pm 0.57 \pm 0.21$
Belle [7]	$D_s^+ \to \tau^+\nu$	$5.70 \pm 0.21^{+0.31}_{-0.30}$
Babar [8]	$D_s^+ \to \tau^+\nu$	$5.00 \pm 0.35 \pm 0.49$
BESIII [9]	$D_s^+ \to \tau^+(\pi^+\pi^0\bar{\nu})\nu$	$5.29 \pm 0.25 \pm 0.20$
BESIII [10]	$D_s^+ \to \tau^+(e^+\nu_e\bar{\nu}_\tau)\nu$	$5.27 \pm 0.10 \pm 0.12$
BESIII [11]	$D_s^+ \to \tau^+(\pi^+\bar{\nu})\nu$	$5.21 \pm 0.25 \pm 0.17$
BESIII [12]	$D_s^+ \to \tau^+(\pi^+\bar{\nu})\nu$	$4.83 \pm 0.65 \pm 0.26$

[4] P. U. E. Onyisi et al., CLEO Collaboration, Phys. Rev. D **79** (2009) 052002.

[5] J. P. Alexander et al., CLEO Collaboration, Phys. Rev. D **79** (2009) 052001.

[6] P. Naik et al., CLEO Collaboration, Phys. Rev. D **80** (2009) 112004.

[7] A. Zupanc et al., Belle Collaboration, Journal of High Energy Physics **09** (2013) 139.

[8] P. del Amo Sanchez et al., Babar Collaboration, Phys. Rev. D **82** (2010) 091103.

[9] M. Ablikim et al., BESIII Collaboration, Phys. Rev. D **104** (2021) 032001.

[10] M. Ablikim et al., BESIII Collaboration, Phys. Rev. Lett. **127** (2021) 171801.

[11] M. Ablikim et al., BESIII Collaboration, Phys. Rev. D **104** (2021) 052009.

[12] M. Ablikim et al., BESIII Collaboration, Phys. Rev. D **94** (2016) 072004.

BOSS version : 7.0.3

Data set.

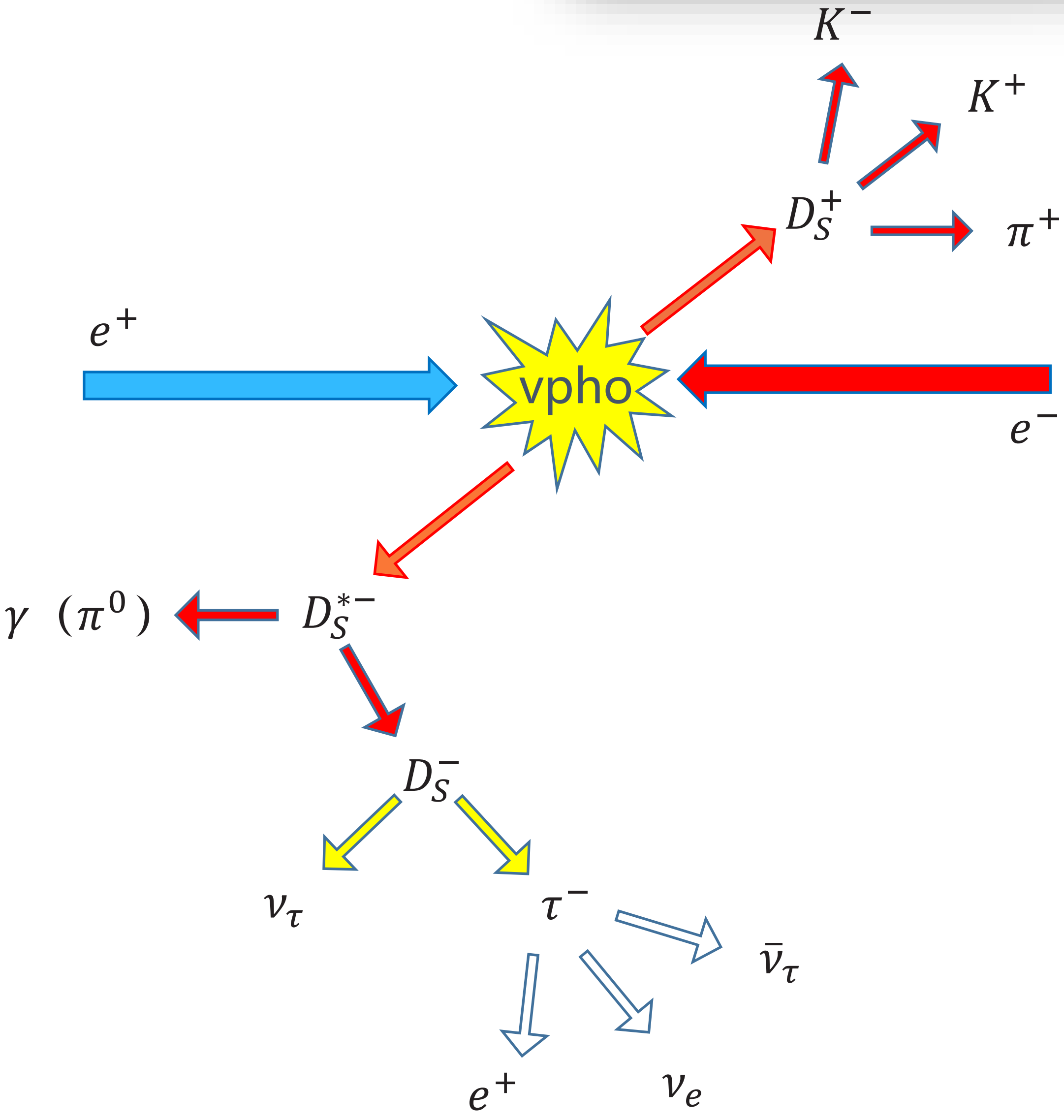
Sample	Year	Run range	Luminosity (pb^{-1})	E_{cm} (MeV)
4180	2016	43716 – 45105		
4180	2016	45418 – 47066	$3189.0 \pm 0.2 \pm 31.9$[1]	4.178 on average[2]
4190	2017	47543 – 48170	$526.7 \pm 0.1 \pm 2.2$[3]	$4188.99 \pm 0.06 \pm 0.41$[3]
4200	2017	48172 – 48713	$526.0 \pm 0.1 \pm 2.1$[3]	$4199.03 \pm 0.05 \pm 0.41$[3]
4210	2017	48714 – 49239	$517.1 \pm 0.1 \pm 1.8$[3]	$4209.25 \pm 0.06 \pm 0.42$[3]
4220	2017	49270 – 49787	$514.6 \pm 0.1 \pm 1.8$[3]	$4218.84 \pm 0.05 \pm 0.40$[3]
4230	2013	32239 – 32849		$4320.34 - 2.87 \times 10^{-3} \times N_{run} \pm 0.05 \pm 0.60$[4]
4230	2013	32850 – 33484	$1047.34 \pm 0.14 \pm 10.16$[5]	$4225.54 \pm 0.05 \pm 0.65$[4]

MC samples.

Component	directory	4180	4190	4200	4210	4220	4230[1]
D^0D^0	D0D0	179	159	148	139	133	130
D^+D^-	DpDm	197	197	196	195	193	192
$D^{*0}D^0$	DST0D0	1211	1187	1175	1159	1144	1133
$D^{*+}D^-$	DSTpDm	1296	1270	1257	1241	1225	1212
$D^{*0}D^{*0}$	DST0DST0	2173	2112	1855	1491	1096	879
$D^{*+}D^{*-}$	DSTpDSTm	2145	2085	1831	1472	1082	868
$D_s^+D_s^-$	DsDs.newLS[2]	37.7	42.7	38.5	32.3	22.4	18.4
$D_s^{*+}D_s^-$	DsSTDs.newLS[3]	961	925	921	985	750	629
$D_s^{*+}D_s^{*-}$	DsSTDsST						22[4]
$DD^*\pi^+$	DDSTPIp	383	395	406	415	421	427
$DD^*\pi^0$	DDSTPI0	192	198	204	208	211	214
$DD\pi^+$	DDPIp	50	53	55	56	58	57
$DD\pi^0$	DDPI0	25	27	27	28	29	29
$q\bar{q}$	qq	13.8	13.7	13.6	13.6	13.5	13.5
$\gamma J/\psi$	RR1S	0.40	0.39	0.39	0.38	0.37	0.37
$\gamma\psi(2S)$	RR2S	0.42	0.40	0.39	0.38	0.37	0.37
$\gamma\psi(3770)$	RR3770	0.06	0.06	0.06	0.06	0.06	0.06
$\tau\tau$	tt	3.45	3.45	3.46	3.46	3.46	3.47
$\mu\mu$	mm	5.24	5.22	5.16	5.16	5.14	5.13
ee	ee[5]	424.81	422.55	420.47	418.43	416.61	415.20
ee	eeNLO[6]	416.10	414.47	411.87	409.96	408.28	406.87
$\gamma\gamma$	TwoGam	1.7	1.7	1.7	1.7	1.5	1.5
HCT	HCT	0.10178	0.12331	0.14525	0.16555	0.18486	0.19660

Signal MC.

Decay mode	Generator
$D_S^{*+} \to \gamma\ (\pi^0)\ \ D_S^+$	VSP_PWAVE
$D_S^+ \to \tau^+ \nu_\tau$	SLN
$\tau^+ \ \to \ e^+ \nu_e \bar{\nu}_\tau$	PHOTOS TAULNUNU
$\tau^+ \ \to \ \mu^+ \nu_\mu \bar{\nu}_\tau$	PHOTOS TAULNUNU
$\tau^+ \ \to \ \pi^+ \bar{\nu}_\tau$	TAUSCALARNU
$\tau^+ \ \to \ \rho^+_{\pi^+\pi^0} \bar{\nu}_\tau$	TAUHADNU -0.108 0.775 0.149 1.364 0.400



$$\mathcal{B}^{\alpha}_{\rm sig} = \frac{N^{\rm obs,\ \alpha}_{\rm sig_{com}} / \epsilon^{\alpha}_{\rm tag,sig_{com}}}{\mathcal{B}_{\tau^+\to e^+\nu_e\bar{\nu}_\tau} \sum_i N^{\rm obs,\ \alpha,\ i}_{\rm tag} / \epsilon^{\alpha,\ i}_{\rm tag}}.$$

$$N^{\rm obs,\ \alpha,\ i}_{\rm tag} = 2N_{D_s^* D_s} \mathcal{B}^{\alpha,\ i}_{\rm tag} \epsilon^{\alpha,\ i}_{\rm tag};$$

$$N^{\rm obs,\ \alpha,\ i}_{\rm sig} = 2N_{D_s^* D_s} \mathcal{B}^{\alpha,\ i}_{\rm tag} \mathcal{B}^{\alpha,\ i}_{\rm sig} \mathcal{B}_{\tau^+\to e^+\nu_e\bar{\nu}_\tau} \epsilon^{\alpha,\ i}_{\rm tag,\ sig}.$$

$400\ D_S^- \to K_S^0 K^-$
$401\ D_S^- \to K^+ K^- \pi^-$
$404\ D_S^- \to K^+ K^- \pi^- \pi^0$
$405\ D_S^- \to K_S^0 K^- \pi^+ \pi^-$
$406\ D_S^- \to K_S^0 K^+ \pi^+ \pi^-$
$421\ D_S^- \to \pi^- \eta$
$440\ D_S^- \to \pi^+ \pi^- \pi^-$
$441\ D_S^- \to \pi^- \pi^0 \eta$
$460\ D_S^- \to \pi^- \eta'_{\pi^+\pi^-\eta}$
$480\ D_S^- \to \pi^- \eta'_{\gamma\rho^0}$
$502\ D_S^- \to K^- \pi^+ \pi^-$

$\tau^+ \to e^+ \nu_e \bar{\nu}_\tau$

$\tau^+ \to \mu^+ \nu_\mu \bar{\nu}_\tau$

$\tau^+ \to \pi^+ \bar{\nu}_\tau$

$\tau^+ \to \rho^+_{\pi^+\pi^0} \bar{\nu}_\tau$

Good charged tracks

- $|Vz| < 10$ cm
- $Vxy < 1$ cm
- $|\cos\theta| < 0.93$

PID

- K: prob(K) > 0, prob(K) > prob(π)
- π: prob(π) > 0, prob(π) > prob(K)

Good photon

- Barrel E ≥ 25MeV, Endcap E ≥50 MeV
- $\theta_{\gamma-\text{charged}} > 10°$
- 0 ≤ TDC ≤ 14 (x50ns)

K_S^0

- $M_{\pi^+\pi^-} \in (0.487, 0.511)\text{GeV}/c^2$
- $\chi^2_{vtx} < 100$
- $|Vz| < 20$ cm , $|\cos\theta| < 0.93$

π^0/η

- π^0 : $M_{\gamma\gamma} \in (0.115, 0.150)\text{GeV}/c^2$
  $p(\pi^0) > 0.1\ \text{GeV}/c^2$
- η : $M_{\gamma\gamma} \in (0.50, 0.57)\ \text{GeV}/c^2$
- $\chi^2 < 200$

$\rho^{-(0)}$, η'

- $\rho^{-(0)}$: $M(\pi^{0(+)}\pi^{-}) \in (0.57, 0.97)$ GeV/c^2
- η': $M(\gamma\rho^0) \in (0.94, 0.976)$GeV/ c^2

  $M(\pi^+\pi^-\eta) \in (0.946, 0.97)$GeV/ c^2

Further requirements

- $p(\pi^{\pm}) > 0.5$ GeV/c
- $p(\gamma)$ from $\eta' \to \gamma\rho^0$: $p(\gamma) > 0.1$ GeV/c

$D_s^{\pm}$

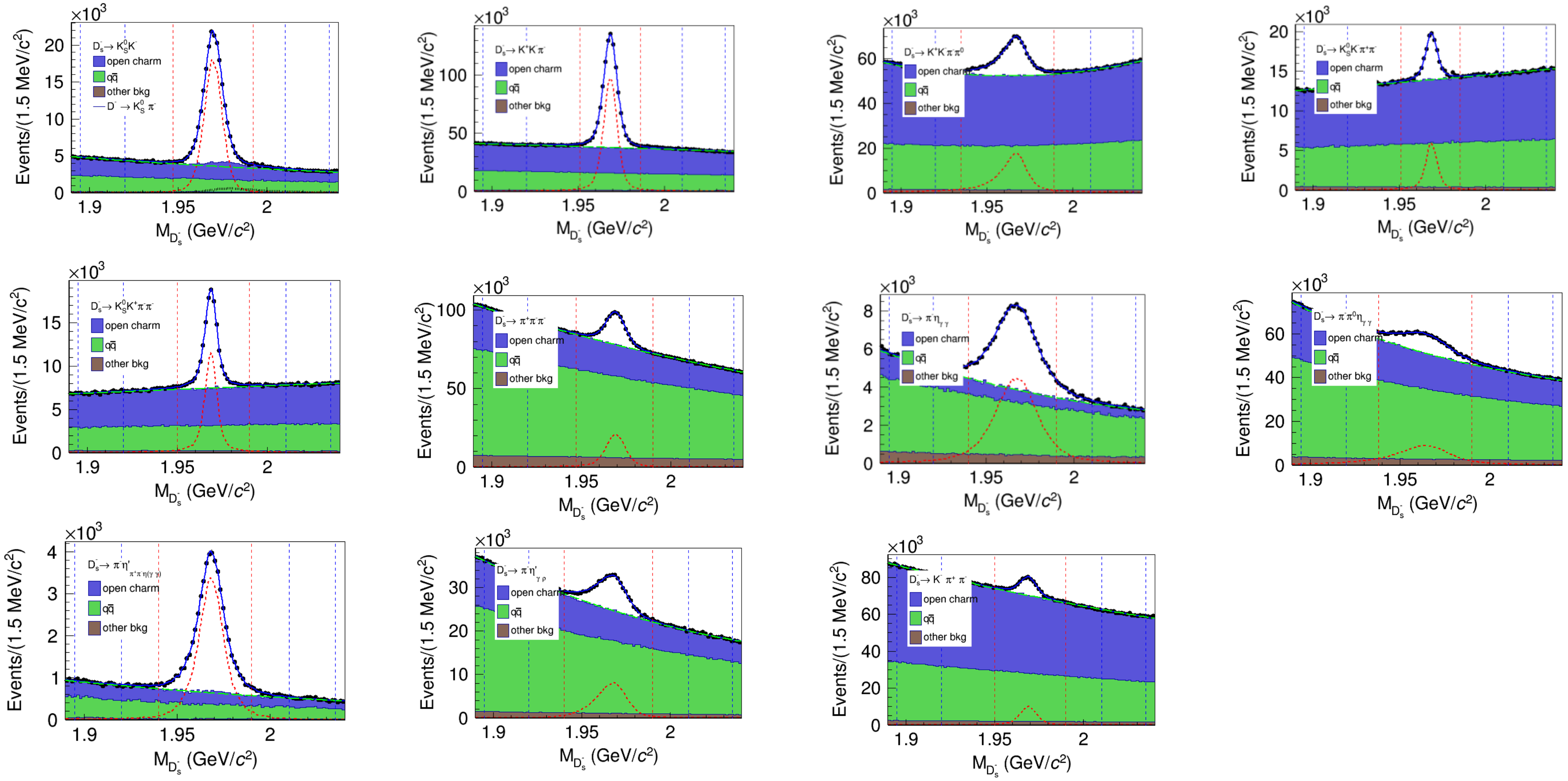
$$M_{\rm rec}^2 c^4 = (E_{\rm cms} - \sqrt{|\vec{p}_{D_s^-}|^2 c^2 + m_{D_s^-}^2 c^4})^2 - |-\vec{p}_{D_s^-}|^2 c^2$$

- minimum $|M_{\rm rec} - m(D_s^*)|$
- $M_{\rm rec} \in (2.05, 2.195)$ GeV/c^2

γ / π^0 from D_s^{*-}

$$\Delta E = E_{\rm cm} - E_{\rm tag} - E_{\rm miss} - E_{\gamma/\pi^0},$$
$$E_{\rm tag} = \sqrt{|\vec{p}_{\rm tag}|^2 + M_{D_s^-}^2},$$
$$E_{\rm miss} = \sqrt{|\vec{p}_{\rm miss}|^2 + M_{D_s^+}^2},$$
$$\vec{p}_{\rm miss} = -\vec{p}_{\rm tag} - \vec{p}_{\gamma(\pi^0)}$$

Event Selection



- Bkg:1st to 3rdChebychev function
- Sig:signal shape extractedfrom MC truth matched sample

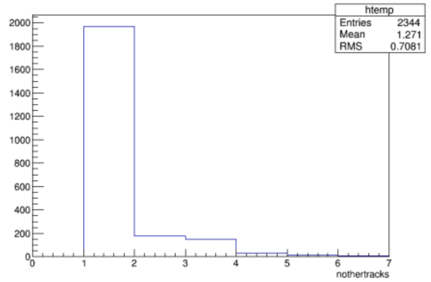
$$\epsilon_{tag}^{\alpha} = N_{ST}^{obs} / N_{ST}^{gen}$$

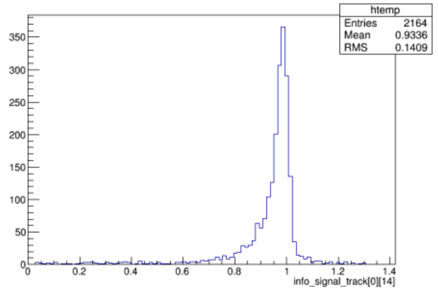
Mode	$M_{D_s^-}$ Signal region	$M_{D_s^-}$ Sideband region
$D_s^- \to K_S^0 K^-$	[1.947,1.992]	
$D_s^- \to K^+ K^- \pi^-$	[1.951,1.986]	
$D_s^- \to K^+ K^- \pi^- \pi^0$	[1.935,1.989]	
$D_s^- \to K_S^0 K^- \pi^+ \pi^-$	[1.951,1.985]	
$D_s^- \to K_S^0 K^+ \pi^- \pi^-$	[1.950,1.990]	
$D_s^- \to \pi^+ \pi^- \pi^-$	[1.947,1.990]	[1.895, 1.92] || [2.01, 2.035]
$D_s^- \to \pi^- \eta_{\gamma\gamma}$	[1.940,1.990]	
$D_s^- \to \pi^- \pi^0 \eta_{\gamma\gamma}$	[1.938,1.990]	
$D_s^- \to \pi^- \eta'_{\pi^+\pi^-\eta(\gamma\gamma)}$	[1.940,1.990]	
$D_s^- \to \pi^- \eta'_{\gamma\rho^0}$	[1.940,1.990]	
$D_s^- \to K^- \pi^+ \pi^-$	[1.950,1.990]	

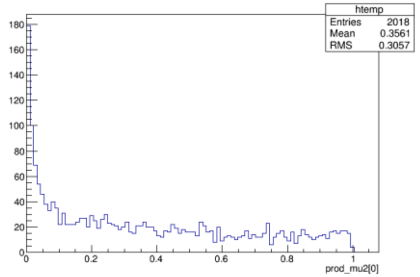
Mode	ϵ_{tag}^{4180}
$D_S^- \to K_S^0 K^-$	34.27±0.12
$D_S^- \to K^+ K^- \pi^-$	41.65±0.07
$D_S^- \to K^+ K^- \pi^- \pi^0$	13.37±0.09
$D_S^- \to K_S^0 K^- \pi^+ \pi^-$	12.92±0.17
$D_S^- \to K_S^0 K^+ \pi^+ \pi^-$	14.37±0.08
$D_S^- \to \pi^- \eta$	55.61±0.39
$D_S^- \to \pi^+ \pi^- \pi^-$	17.16±0.13
$D_S^- \to \pi^- \pi^0 \eta$	7.13±0.05
$D_S^- \to \pi^- \eta'_{\pi^+\pi^-\eta}$	3.40±0.02
$D_S^- \to \pi^- \eta'_{\gamma\rho^0}$	9.91±0.09
$D_S^- \to K^- \pi^+ \pi^-$	48.77±0.69

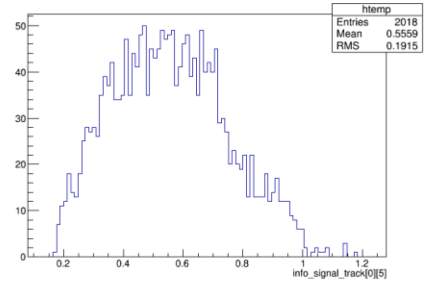
Selection criteria for $D_S^+ \to \tau^+ \nu_\tau$, $\tau^+ \to e^+ \nu_e \bar{\nu}_\tau$

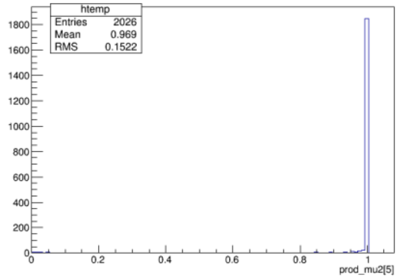
- Only one charged track
- $P(e) > 0.001$;
- $\mathrm{R}(e^+) = \frac{P(e)}{P(e)+P(\pi)+P(K)}$ >0.8;
- the deposited energy in EMC over the momentum for positron: $\frac{E}{p}(e^+) > 0.8$.
- the momentum of positron: $p(e^+) > 0.2$ GeV/c.

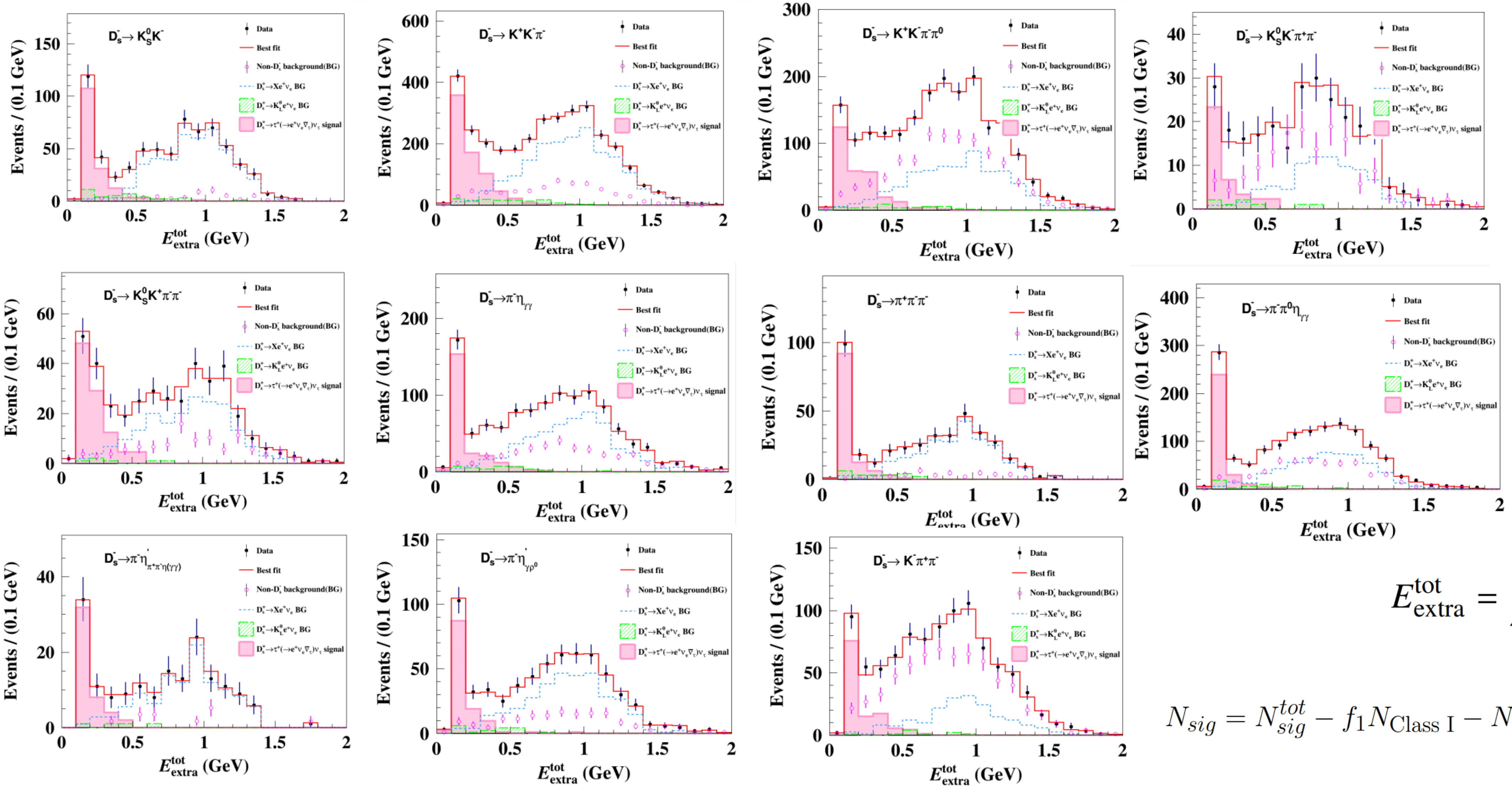












$$E_{\rm extra}^{\rm tot} = \sum_i E_i$$

$$N_{sig} = N_{sig}^{tot} - f_1 N_{\text{Class I}} - N_{\text{Class II}} - f_2 N_{\text{Class III}}$$

$$E_{\rm extra}^{\rm tot} = \sum_i E_i$$

- Class I: non-D_s^+ backgrounds, which are described by the events from $M_{D_s^-}$ sideband region. For different tag modes, we also checked the components of the events in the $M_{D_s^-}$ sideband region using cocktail MC sample, and found the signal contributions can be negligible, except for the tag modes including the neutral particles, where the signals in the $M_{D_s^-}$ sideband region are subsequently removed according to $D_s^{\pm}D_s^{(*)\mp}$ inclusive MC sample.

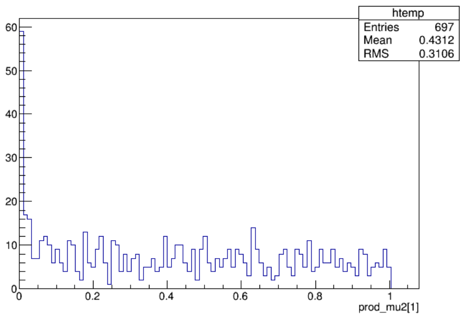
- Class II: D_s^+ peaking background, $D_s^+ \to K_L^0 e^+ \nu_e$ decay. For the tag mode $D_s^- \to K_S^0 K^-$, there is another peaking background from $D^- \to K_S^0 \pi^-$.

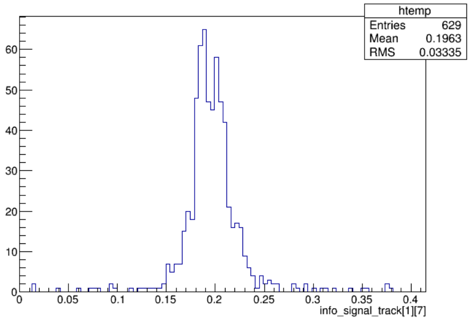
- Class III: D_s^+ non-peaking background, which are dominated by other six main semileptonic D_s^+ decays, $D_s^+ \to \eta e^+ \nu_e$, $D_s^+ \to \eta' e^+ \nu_e$, $D_s^+ \to \phi e^+ \nu_e$, $D_s^+ \to f_0(980) e^+ \nu_e$, $D_s^+ \to K^*(892)^0 e^+ \nu_e$ and $D_s^+ \to K_S^0 e^+ \nu_e$,

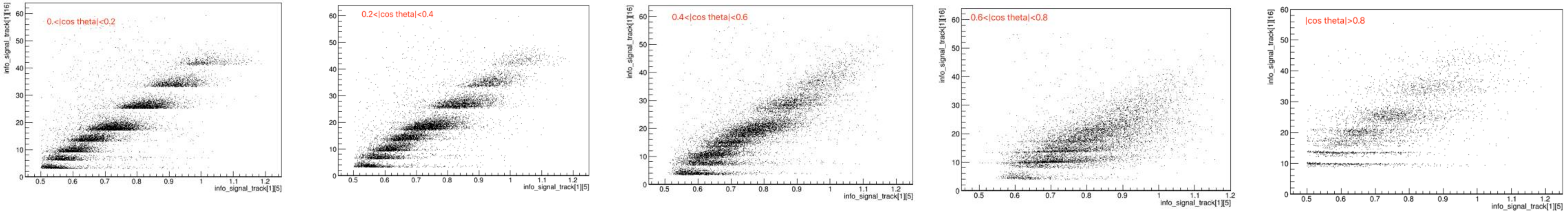
Selection criteria for $D_S^+ \to \tau^+ \nu_\tau$, $\tau^+ \to \mu^+ \nu_\mu \bar{\nu}_\tau$

- Only one charged track
- P(μ) > 0.001 , P(μ) > P(K) , P(μ) > P(e)
- The deposited energy in EMC ∈ (0.1, 0.3)GeV
- cosθ , momentum , depth

$\lvert\cos\theta\rvert$	momentum (GeV/c)	depth (cm)
(0.0,0.2)	$0.50 < p < 0.61$	> 3.0
	$0.61 < p < 0.75$	$> 100.0 \times p - 58.0$
	$0.75 < p < 0.88$	> 17.0
	$0.88 < p < 1.04$	$> 100.0 \times p - 71.0$
	$1.04 < p < 1.20$	> 33.0
(0.2,0.4)	$0.50 < p < 0.64$	> 3.0
	$0.64 < p < 0.78$	$> 100.0 \times p - 61.0$
	$0.78 < p < 0.91$	> 17.0
	$0.91 < p < 1.07$	$> 100.0 \times p - 74.0$
	$1.07 < p < 1.20$	> 33.0
(0.4,0.6)	$0.50 < p < 0.67$	> 3.0
	$0.67 < p < 0.81$	$> 100.0 \times p - 64.0$
	$0.81 < p < 0.94$	> 17.0
	$0.94 < p < 1.10$	$> 100.0 \times p - 77.0$
	$1.10 < p < 1.20$	> 33.0
(0.6,0.8)		> 9.0
(0.8,0.93)		> 9.0

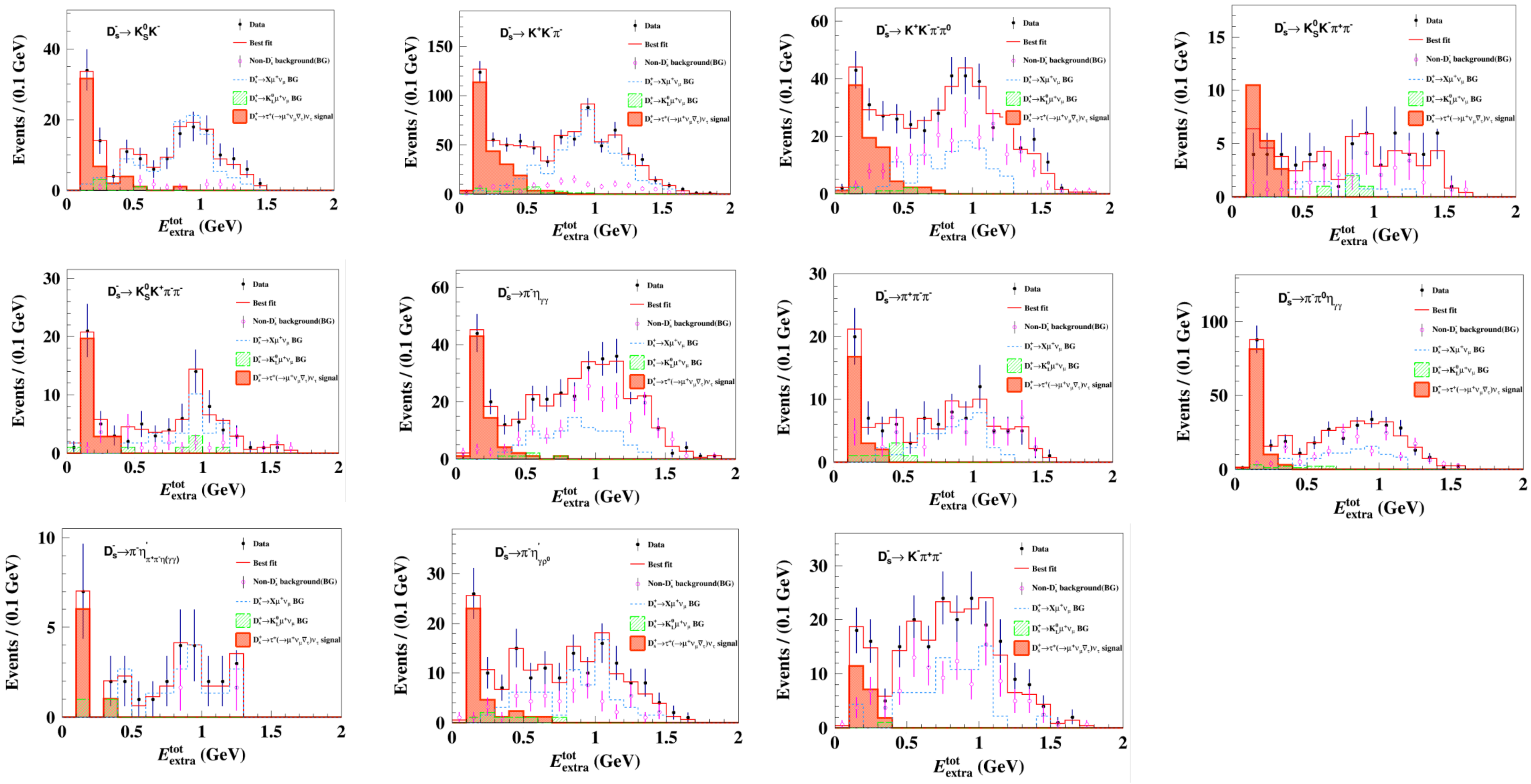






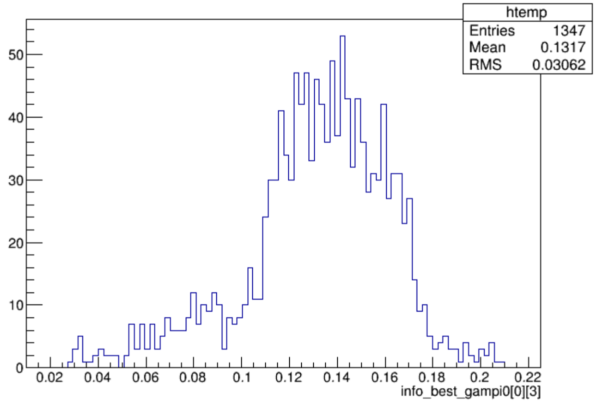
DT Analysis

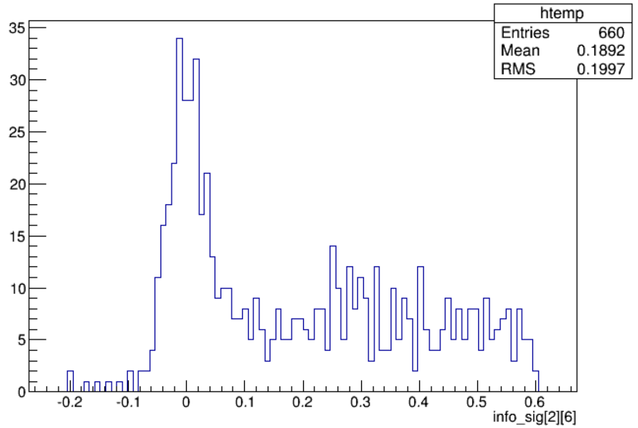
Henan normal University



Selection criteria for $D_S^+ \to \tau^+\nu_\tau$, $\tau^+ \to \pi^+\bar{\nu}_\tau$

- $114 < E_\gamma < 149$ MeV
- No extra charged tracks.
- No extra π^0.
- $-0.2 < M^2_{\rm miss} < 0.6$ GeV$^2/c^4$ $\quad M^2_{\rm miss} = (E_{\rm cm} - E_{\rm tag} - E_{\gamma\pi^0} - E_{D_s^+})^2 - (-\vec{p}_{\rm tag} - \vec{p}_{\gamma\pi^0} - \vec{p}_{D_s^+})^2$
- The ratio of the energy deposited in the EMC over the MDC momentum of the charged track is less than 0.9.
- The absolute value of the cosine of the polar angle of $\vec{p}_{\rm miss}$ in the center-of-mass system of initial e^+e^- is less than 0.9.
- The maximum energy of extra photons is less than 0.3 GeV.


htemp
Entries 1347
Mean 0.1317
RMS 0.03062
info_best_gampi0[0][3]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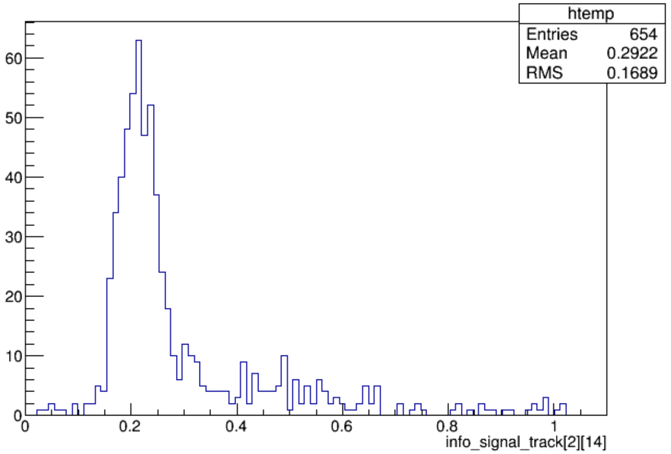
info_sig[2][6]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Entries 654
Mean 0.2922
RMS 0.1689
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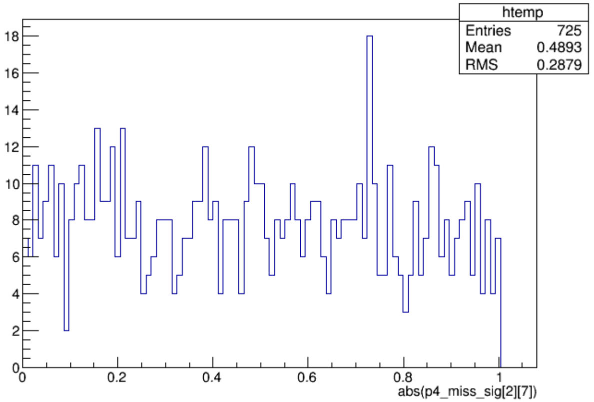
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Entries 725
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RMS 0.2879
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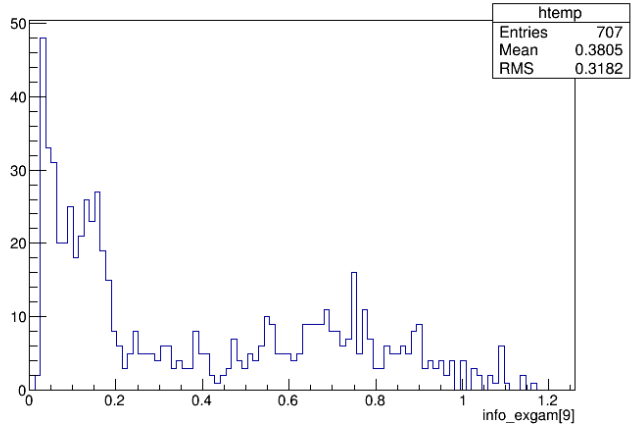
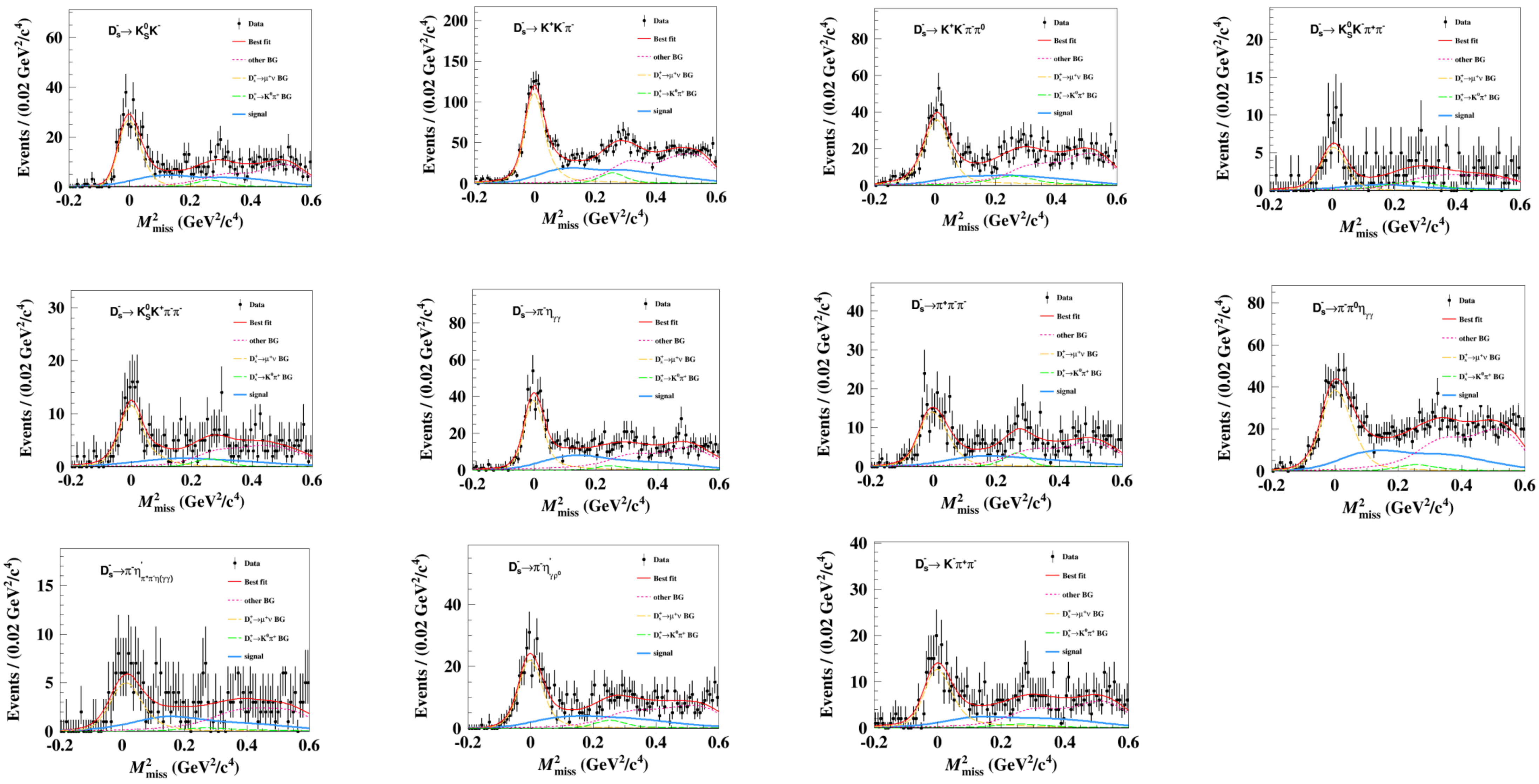

htemp
Entries 707
Mean 0.3805
RMS 0.3182
info_exgam[9]

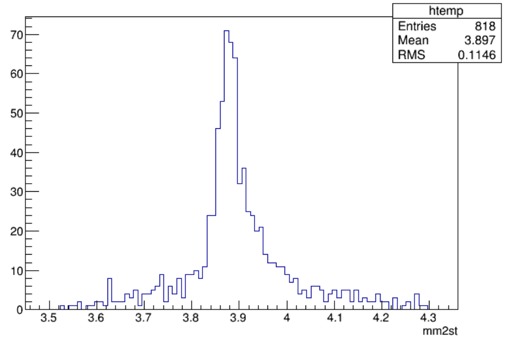
DT Analysis

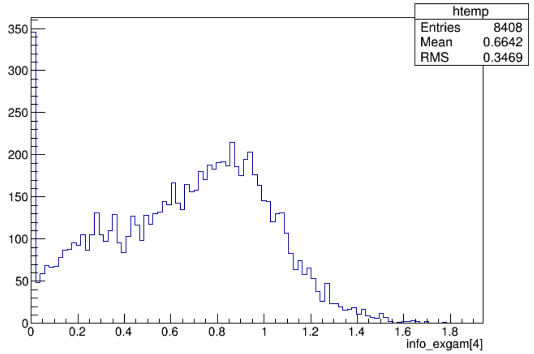
Henan normal University

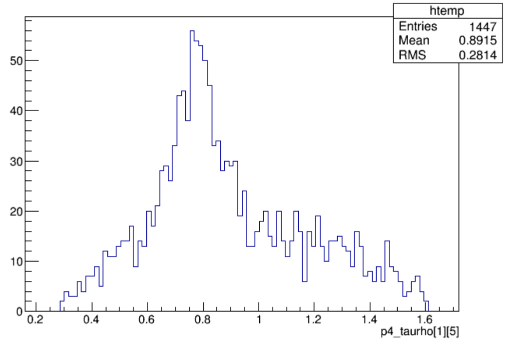


Selection criteria for $D_S^+ \to \tau^+ \nu_\tau$, $\tau^+ \to \rho^+_{\pi^+\pi^0} \bar{\nu}_\tau$

- $MM^{*\,2} \in (3.82, 3.98)\ GeV/c^4$
- Only one good charged track
- At least 2 good photos to form a π^0
- $|M_{\pi^+\pi^0} - M_{\rho^+}| < 0.2\ GeV/c^2$
- E^{sum}_{extra} I < 0.1 GeV

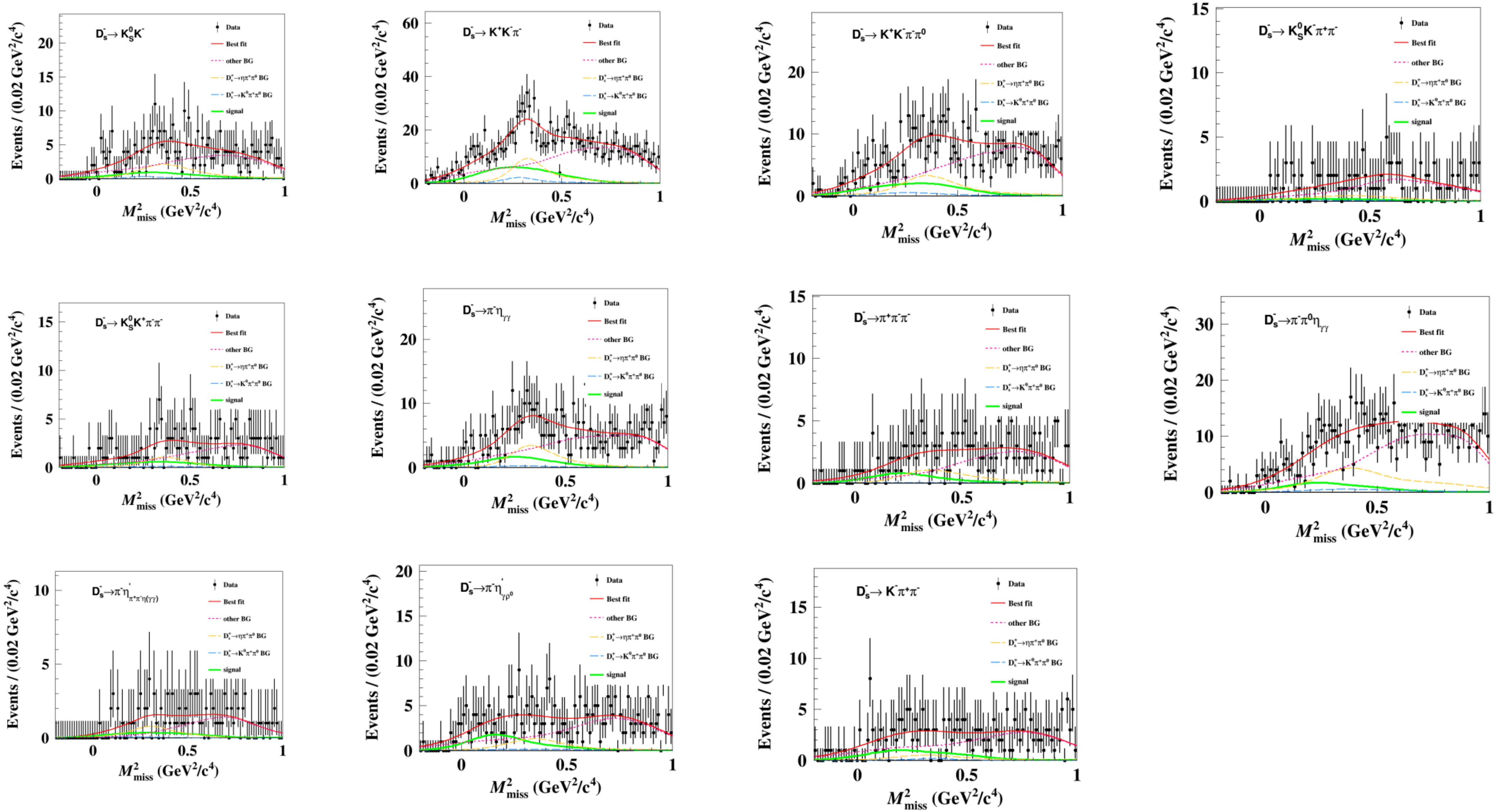






$$MM^{*2} = (E_{cm} - E_{tag} - E_{\gamma/\pi^0})^2 - (P_{cm} - P_{tag} - P_{\gamma/\pi^0})^2$$

$$MM^2 = (E_{cm} - E_{tag} - E_{\gamma(\pi^0)} - E_{\pi^+} - E_{\pi^0})^2 - |-\vec{p}_{tag} - \vec{p}_{\gamma(\pi^0)} - \vec{p}_{\pi^+} - \vec{p}_{\pi^0}|^2$$


D$_s^-$→ K$_S^0$K$^-$
D$_s^-$→ K$^+$K$^-$π$^-$
D$_s^-$→ K$^+$K$^-$π$^-$π^0
D$_s^-$→ K$_S^0$K$^-$π$^+$π$^-$
D$_s^-$→ K$_S^0$K$^+$π$^-$π$^-$
D$_s^-$→π$^-$η$_{γγ}$
D$_s^-$→π$^+$π$^-$π$^-$
D$_s^-$→π$^-$π^{0}η$_{γγ}$
D$_s^-$→π$^-$η$'_{π^+π^-η(γγ)}$
D$_s^-$→π$^-$η$'_{γρ^0}$
D$_s^-$→ K$^-$π$^+$π$^-$
Data
Best fit
other BG
D$_s^+$→ηπ$^+$π^0 BG
D$_s^+$→K^{0}π$^+$π^0 BG
signal
Events / (0.02 GeV^2/c^4)
M^2_{miss} (GeV^2/c^4)

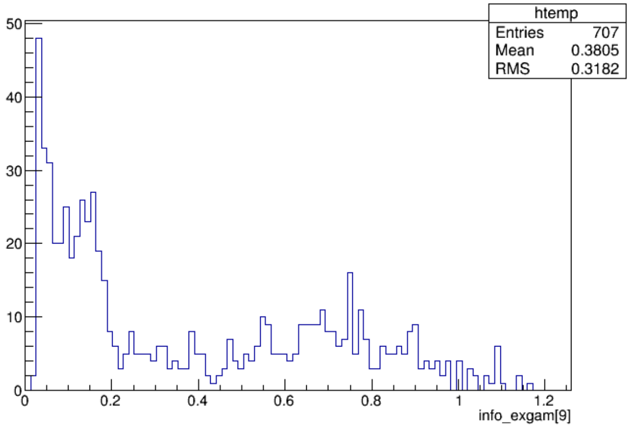
Next to do

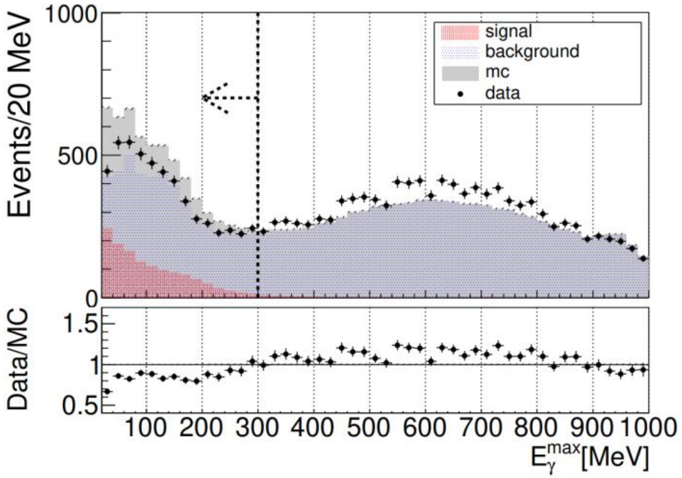
- Solving the problem of the BKG of $\tau^+ \to \rho^+_{\pi^+\pi^0}\bar{\nu}_\tau$
- The signal efficiency of each tag mode
- Try to do combined fit

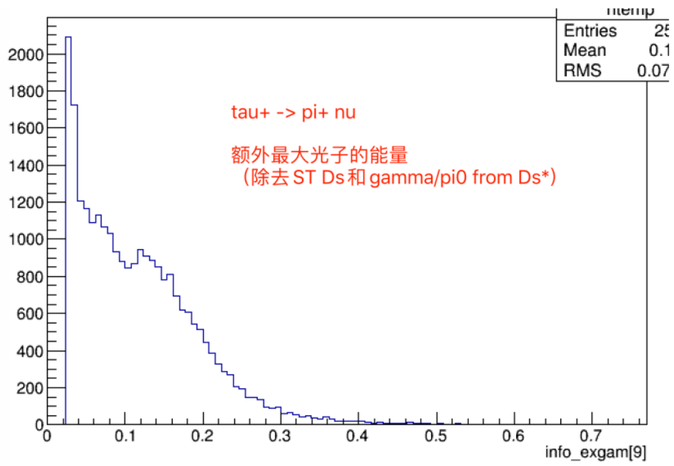
Thank you for your attention!

Back up

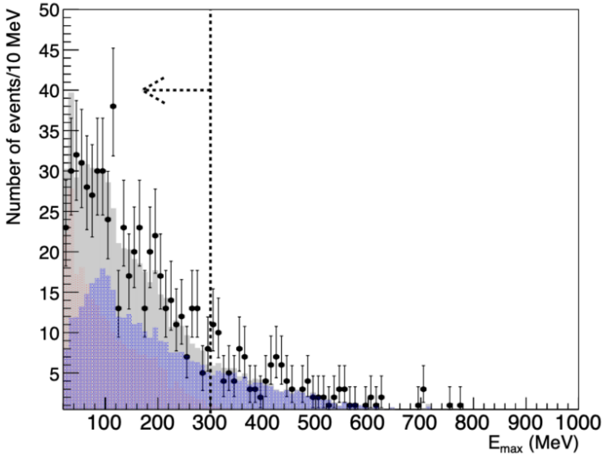
$D_S^+ \to \tau^+\nu_\tau$	$\tau^+ \to e^+\nu_e\bar{\nu}_\tau$	BAM-372(DocDB-623)
	$\tau^+ \to \mu^+\nu_\mu\bar{\nu}_\tau$	BAM-545(DocDB-854)
	$\tau^+ \to \pi^+\bar{\nu}_\tau$	BAM-590(DocDB-1071)
	$\tau^+ \to \rho^+_{\pi^+\pi^0}\bar{\nu}_\tau$	BAM-420(DocDB-841)







Memo of tau -> pi nu



研究目的

$D_S^+ \to \tau^+\nu_\tau$

$e^+e^- \to D_S^{*+}D_S^-$，$D_S^{*+} \to \gamma$（π^0）D_S^+，$D_S^- \to 11$标记道，$D_S^+ \to \tau^+\nu_\tau$。联合拟合$\tau^+ \to e^+\nu_e\bar{\nu}_\tau$，$\mu^+\nu_\mu\bar{\nu}_\tau$，$\pi^+\bar{\nu}_\tau$，$\rho^+_{\pi^+\pi^0}\bar{\nu}_\tau$ 精确测量$D_S^+ \to \tau^+\nu_\tau$分支比。之后，通过带入非微扰量子色动力学理论计算的$f_{D_S^+}$得到$|V_{cs}|$，检验是否与CMK全局拟合的$|V_{cs}|$存在偏差；另一方面通过带入CKM全局拟合得到的$|V_{cs}|$可以得到$f_{D_S^+}$，检验与非微扰理论计算的$f_{D_S^+}$是否一致。此外，结合$D_S^+ \to \mu^+\nu_\mu$的分支比，可以得到这两个纯轻衰变的分支比比值以此检验是否与标准模型预言值存在偏差。

$D_S^+ \to \tau^+\nu_\tau$分支比

$|V_{cs}| \to f_{D_S^+}$，$f_{D_S^+} \to |V_{cs}|$

$D_S^+ \to \tau^+\nu_\tau / D_S^+ \to \mu^+\nu_\mu \to SM$

研究方法

$D_S^+ \to \tau^+ \nu_\tau$

用双标的方法来得到绝对的分支比。双标记方法：先通过11个单标记道完全重建单标记D_S^-候选者，然后重建来自D_S^{*+}直接衰变的γ（π^0），再在它们的反冲侧，通过一条好的带电径迹研究信号过程$D_S^+ \to \tau^+ \nu_\tau$，随后利用共同的$D_S^+ \to \tau^+ \nu_\tau$分支比作为约束条件，对$\tau^+$的四个衰变过程联合拟合，测量得到$\tau^+$的分支比。

$\tau^+ \to e^+ \nu_e \bar{\nu}_\tau$

$\tau^+ \to \pi^+ \bar{\nu}_\tau$

$\tau^+ \to \mu^+ \nu_\mu \bar{\nu}_\tau$

$\tau^+ \to \rho^+_{\pi^+\pi^0} \bar{\nu}_\tau$