三组：$\tau^- \to \Lambda^0\pi$

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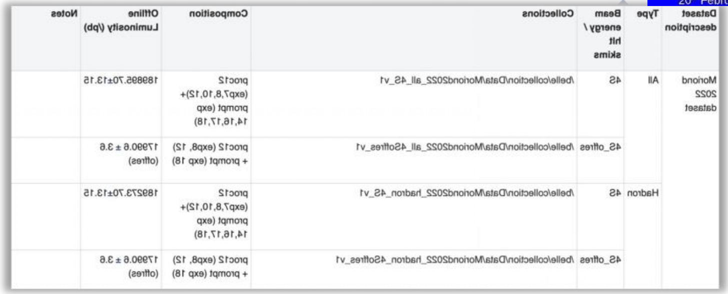
目录

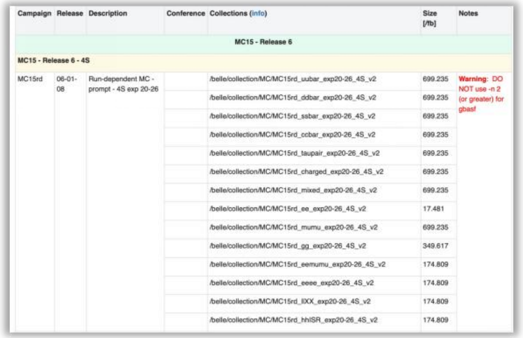
- Belle II 分析大体流程
- 事例初步挑选
- 本底分析
- 上限估计
- 总结

How to anaylysis on Belle II



Dataset description	Type	Beam energy / hlt skims	Collections	Composition	Offline Luminosity (/pb)	Notes
Moriond 2022 dataset	All	4S	/belle/collection/Data/Moriond2022_all_4S_v1	proc12 (exp7,8,10,12)+ prompt (exp 14,16,17,18)	189895.70±13.15	
		4S_offres	/belle/collection/Data/Moriond2022_all_4Soffres_v1	proc12 (exp8, 12) + prompt (exp 18)	17990.6 ± 3.6 (offres)	
	Hadron	4S	/belle/collection/Data/Moriond2022_hadron_4S_v1	proc12 (exp7,8,10,12)+ prompt (exp 14,16,17,18)	189273.70±13.15	
		4S_offres	/belle/collection/Data/Moriond2022_hadron_4Soffres_v1	proc12 (exp8, 12) + prompt (exp 18)	17990.6 ± 3.6 (offres)	

- **Data**
  - Step1:Get the mdst (On the grid point)
  - Step2:Analysis script
  - Step3:Get the root-->gbasf2 <filename> -i <dataset> -p <project name> -s <release>
  - -->gb2_ds_get



Campaign	Release	Description	Conference	Collections (info)	Size [/fb]	Notes
MC15 - Release 6						
MC15 - Release 6 - 4S						
MC15rd	06-01-08	Run-dependent MC - prompt - 4S exp 20-26		/belle/collection/MC/MC15rd_uubar_exp20-26_4S_v2	699.235	Warning: DO NOT use -n 2 (or greater) for gbasf
				/belle/collection/MC/MC15rd_ddbar_exp20-26_4S_v2	699.235	
				/belle/collection/MC/MC15rd_ssbar_exp20-26_4S_v2	699.235	
				/belle/collection/MC/MC15rd_ccbar_exp20-26_4S_v2	699.235	
				/belle/collection/MC/MC15rd_taupair_exp20-26_4S_v2	699.235	
				/belle/collection/MC/MC15rd_charged_exp20-26_4S_v2	699.235	
				/belle/collection/MC/MC15rd_mixed_exp20-26_4S_v2	699.235	
				/belle/collection/MC/MC15rd_ee_exp20-26_4S_v2	17.481	
				/belle/collection/MC/MC15rd_mumu_exp20-26_4S_v2	699.235	
				/belle/collection/MC/MC15rd_gg_exp20-26_4S_v2	349.617	
				/belle/collection/MC/MC15rd_eemumu_exp20-26_4S_v2	174.809	
				/belle/collection/MC/MC15rd_eeee_exp20-26_4S_v2	174.809	
				/belle/collection/MC/MC15rd_llXX_exp20-26_4S_v2	174.809	
				/belle/collection/MC/MC15rd_hhISR_exp20-26_4S_v2	174.809	

- **Generic MC**
  - Step1:Get the mdst(On the grid point)
  - Step2:Analysis script
  - Step3:Get the root-->gbasf2 <filename> -i <dataset> -p <project name> -s <release>
  - -->gb2_ds_get
  - Step4:Analysis background

```
[shaolq@cw01 mdst_root]$ ls
mdst_mbelle2.root     mdst_mbelle2_6.root    mdst_pbelle2_1.root  mdst_pbelle2_7.root
mdst_mbelle2_1.root   mdst_mbelle2_7.root    mdst_pbelle2_2.root  mdst_pbelle2_8.root
mdst_mbelle2_2.root   mdst_mbelle2_8.root    mdst_pbelle2_3.root  mdst_pbelle2_9.root
mdst_mbelle2_3.root   mdst_mbelle2_9.root    mdst_pbelle2_4.root  mdst_pbelle2_10.root
mdst_mbelle2_4.root   mdst_mbelle2_10.root   mdst_pbelle2_5.root
mdst_mbelle2_5.root   mdst_pbelle2.root      mdst_pbelle2_6.root
```

- **Signal MC**
  - Step1:Get the mdst (sim,rec)
  - Step2:Analysis script
  - Step3:Get the root
  - Step4:Calculate a preliminary efficiency

```
[shaolq@cw01 recLambdaPi]$ ls
rec_mdst.root              rec_mdst_mbelle2_7.root    rec_mdst_pbelle2_4.root
rec_mdst_mbelle2_1.root    rec_mdst_mbelle2_8.root    rec_mdst_pbelle2_5.root
rec_mdst_mbelle2_2.root    rec_mdst_mbelle2_9.root    rec_mdst_pbelle2_6.root
rec_mdst_mbelle2_3.root    rec_mdst_mbelle2_10.root   rec_mdst_pbelle2_7.root
rec_mdst_mbelle2_4.root    rec_mdst_pbelle2_1.root    rec_mdst_pbelle2_8.root
rec_mdst_mbelle2_5.root    rec_mdst_pbelle2_2.root    rec_mdst_pbelle2_9.root
rec_mdst_mbelle2_6.root    rec_mdst_pbelle2_3.root    rec_mdst_pbelle2_10.root
```

事例初选条件：$\tau^- \to \Lambda^0\pi$

好带电径迹

```
# track and additional good photon cuts
trackCuts = '-0.866 < cosTheta < 0.956 and pt > 0.1'
ma.cutAndCopyLists('pi+:ps', 'pi+:all', trackCuts, path=main)

ma.cutAndCopyList('pi-:tracks', 'pi-:all', trackCuts, path=main)
ma.cutAndCopyList('mu-:tracks', 'mu-:all', trackCuts, path=main)
ma.cutAndCopyList('e-:tracks', 'e-:all', trackCuts, path=main)
```

好光子

```
gammaCuts = 'E > 0.1'
gammaCuts += ' and -0.8660 < cosTheta < 0.9563'
gammaCuts += ' and clusterNHits > 1.5'
gammaCuts += ' and abs(clusterTiming) < 200'
ma.cutAndCopyLists('gamma:event', 'gamma:all', gammaCuts, path=main)

va.addAlias('nGoodTracks', 'countInList(pi+:ps)')
ma.applyEventCuts('nGoodTracks == 4', path=main)
```

PID

```
ma.applyChargedPidMVA(particleLists=['e-:tracks', 'mu-:tracks', 'pi+:tracks'], trainingMode=Belle2.ChargedPidMVAWeights.ChargedPidMVATrainingMode.c_Multiclass, path=main)

va.addAlias('pre_pid_BDT_e','pidChargedBDTScore(11, ALL)')
va.addAlias('pre_pid_BDT_mu','pidChargedBDTScore(13, ALL)')
va.addAlias("pid_BDT_e", 'formula( ifNANgiveX( pre_pid_BDT_e, -1 ) )')
va.addAlias("pid_BDT_mu", 'formula( ifNANgiveX( pre_pid_BDT_mu, -1 ) )')

va.addAlias('PID_proton_pi', 'ifNANgiveX( binaryPID(2212, 211), 0.5)')
va.addAlias('PID_kaon_pi',   'ifNANgiveX( binaryPID(321, 211), 0.5)')
va.addAlias('PID_kaon_p',    'ifNANgiveX( binaryPID(321, 2212), 0.5)')
va.addAlias('PID_pion_k',    'ifNANgiveX( binaryPID(211, 321), 0.5)')
va.addAlias('PID_pion_p',    'ifNANgiveX( binaryPID(211, 2212), 0.5)')
va.addAlias('PID_proton_k',  'ifNANgiveX( binaryPID(2212, 321), 0.5)')

HadronIDCuts = 'and nCDCHits > 0'
Prcuts = trackCuts + HadronIDCuts +' and electronID < 0.5 and protonID > 0.5 '
Pisig1cuts = trackCuts + HadronIDCuts + ' and electronID < 0.5 and PID_proton_pi < 0.6 and PID_kaon_pi < 0.4'
Pisig2cuts = trackCuts + HadronIDCuts + ' and electronID < 0.5'
Ecuts = trackCuts + 'and pid_BDT_e > 0.9 and  muonID_noSVD <= 0.9'
Mucuts = trackCuts + 'and muonID_noSVD > 0.9 and pid_BDT_e <= 0.9'
Pitagcuts = trackCuts + HadronIDCuts +' and pid_BDT_e <= 0.9 and muonID <= 0.9 and PID_pion_p > 0.6 and PID_pion_k > 0.4'
```

重建 Λ

```
#
ma.reconstructDecay('Lambda0:sig -> p+:sig pi-:sig2', '0.9 < M < 1.30', path=main)

va.addAlias('nElectrons', 'countInList(e-:tag)')
va.addAlias('nMuons', 'countInList(mu-:tag)')
va.addAlias('nPions_tag', 'countInList(pi-:tag)')
va.addAlias('n1Pions', 'countInList(pi+:sig1)')
va.addAlias('n2Pions', 'countInList(pi+:sig2)')
va.addAlias('nProtons', 'countInList(p+:sig)')
va.addAlias('nGoodPhotons', 'countInList(gamma:event)')
```

重建 τ

```
# Signal sides
ma.reconstructDecay('tau+:sig -> anti-Lambda0:sig pi+:sig1', '', path=main)
vx.treeFit('tau+:sig', conf_level=0, updateAllDaughters=True, path=main)

# Tag sides
ma.reconstructDecay('tau-:e -> e-:tag', '', path=main, dmID=1)
ma.reconstructDecay('tau-:mu -> mu-:tag', '', path=main, dmID=2)
ma.reconstructDecay('tau-:pi -> pi-:tag', '', path=main, dmID=3)
tau_tagLists = ['tau-:e', 'tau-:mu', 'tau-:pi']
ma.copyLists('tau-:tag', tau_tagLists, path=main)

ma.reconstructDecay('vpho -> tau+:sig tau-:tag', '', path=main)
```

对 τ 做顶点拟合

- Signal Side: $\tau \to \Lambda\pi^+$
- Tag Sides: $\tau^- \to e^-, \tau^- \to \mu^-, \tau^- \to \pi^-$

构建Event变量

```
#                      s modules
particleList = ['pi+:ps', 'gamma:event']
ma.buildEventShape(particleList,
                   foxWolfram=False,
                   cleoCones=False,
                   jets=False,
                   harmonicMoments=False,
                   allMoments=False,
                   collisionAxis=False,
                   sphericity=False,
                   thrust=True,
                   path=main
                   )
ma.buildEventKinematics(particleList, path=main)
```

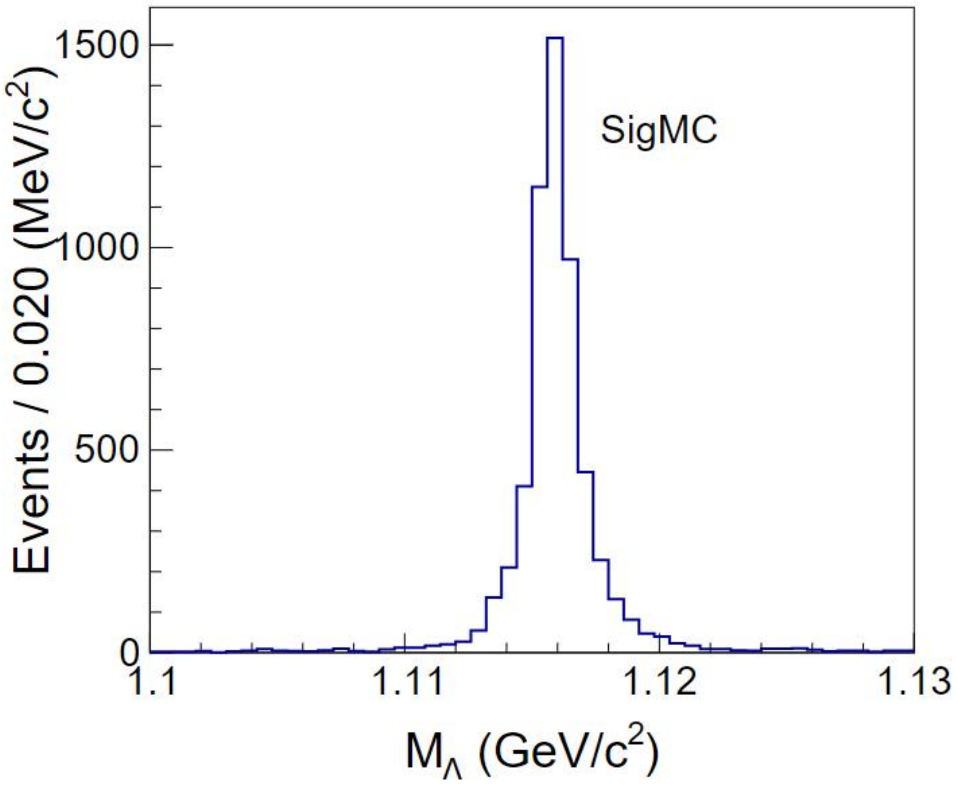
And some event based variables … …

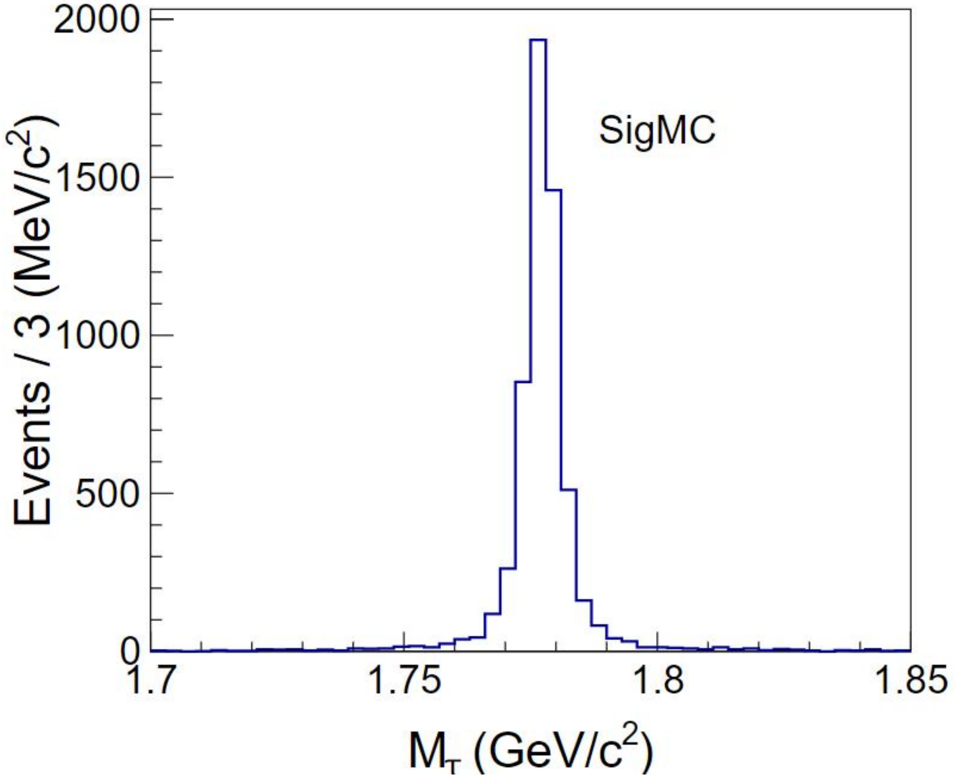
```
eventVariables = ['dmID_tag','nGoodTracks',
            'nElectrons', 'nMuons', 'nPions_tag', 'n1Pions', 'n2Pions', 'nProtons',
                  'nGoodPhotons', 'nPhotons_sig', 'nPhotons_tag'
                  ]

eventVariables += ['EPhotons_tag', 'EPhotons_sig',
           'Lbdpi1Ag', 'ppi1Ag', 'ppi2Ag', 'pi2pi1Ag'
         ]
```

事例初选条件：$\tau^- \to \Lambda^0\pi^-$

- **挑选好带电径迹**
  - $-0.866 < \cos\theta < 0.956$
  - $p_t > 0.1$ GeV/c
  - $N_{good} = 4$
- **挑选好光子**
  - $E > 0.1$ GeV
  - $-0.8660 < \cos\theta < 0.9563$
  - $N_{cluster}^{hits} > 1.5$
  - $|T_{cluster}| < 200$ ns
- **PID**
  - Signal side
    - 鉴别 π : $\mathcal{R}(p|\pi) < 0.6$ & $\mathcal{R}(K|\pi) < 0.4$
    - 鉴别 p : $\mathcal{R}_p > 0.5$
  - Tag side
    - 鉴别 e : $\mathcal{P}_{BDT}^{e} > 0.9$.
    - 鉴别 μ : $\mathcal{P}_{BDT}^{\mu} > 0.9$ and $\mathcal{P}_{BDT}^{e} < 0.9$
    - 鉴别 π : $\mathcal{R}(p|\pi) < 0.6$ and $\mathcal{R}(K|\pi) < 0.4$
- **顶点拟合**
  - 对 $\Lambda^0\pi^-$ 做顶点拟合

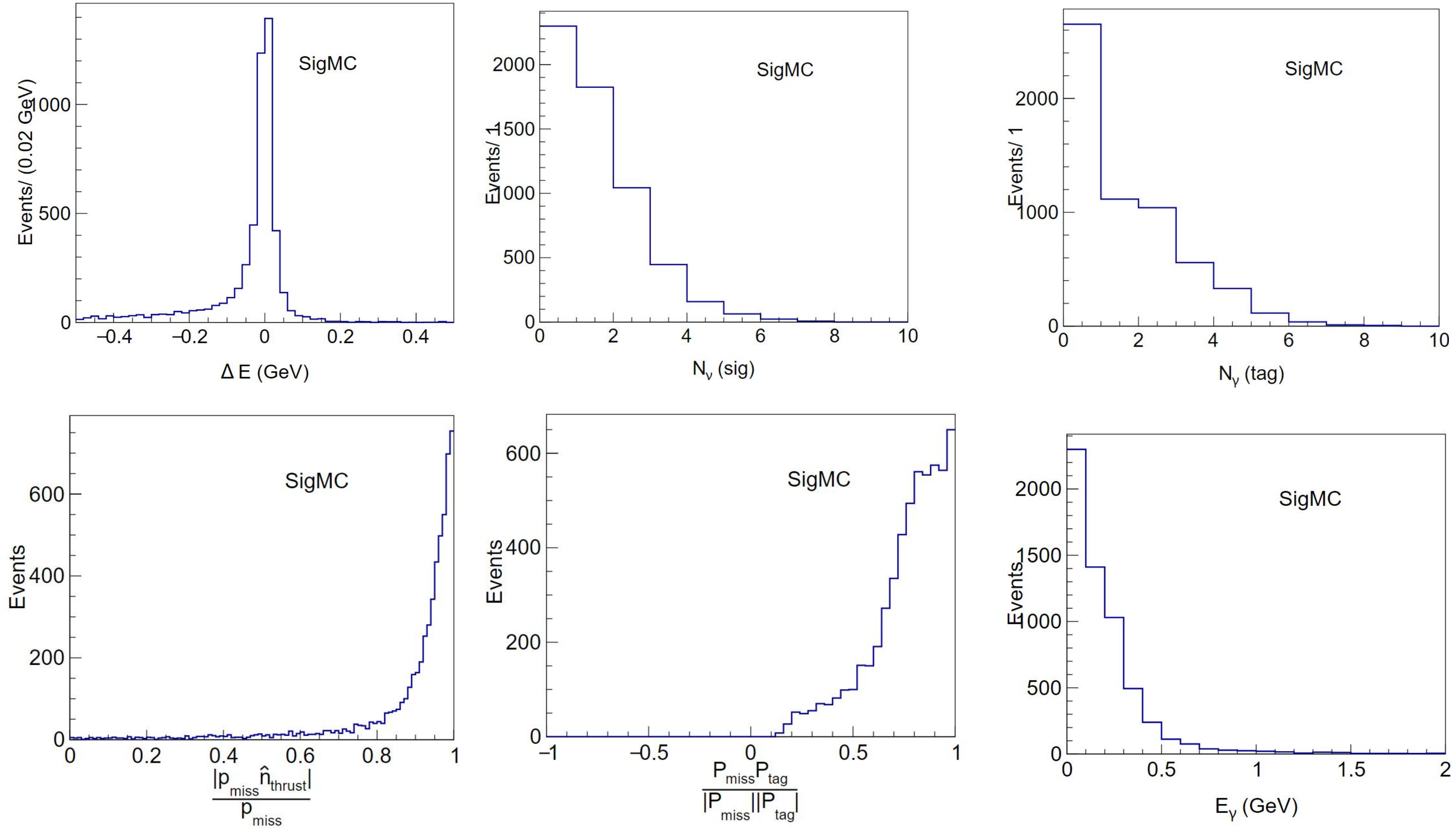
Distribution of invariant mass of Λ and τ for signal MC



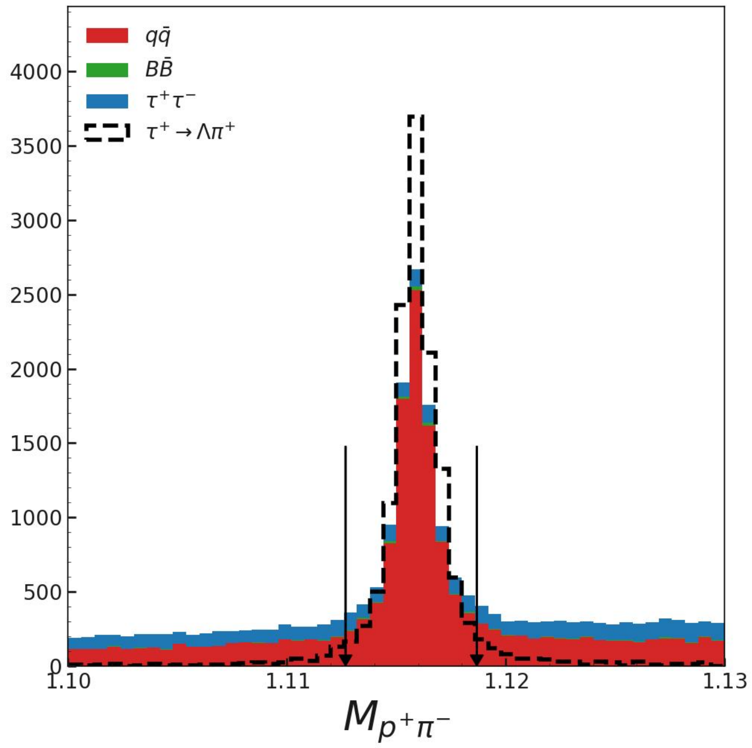


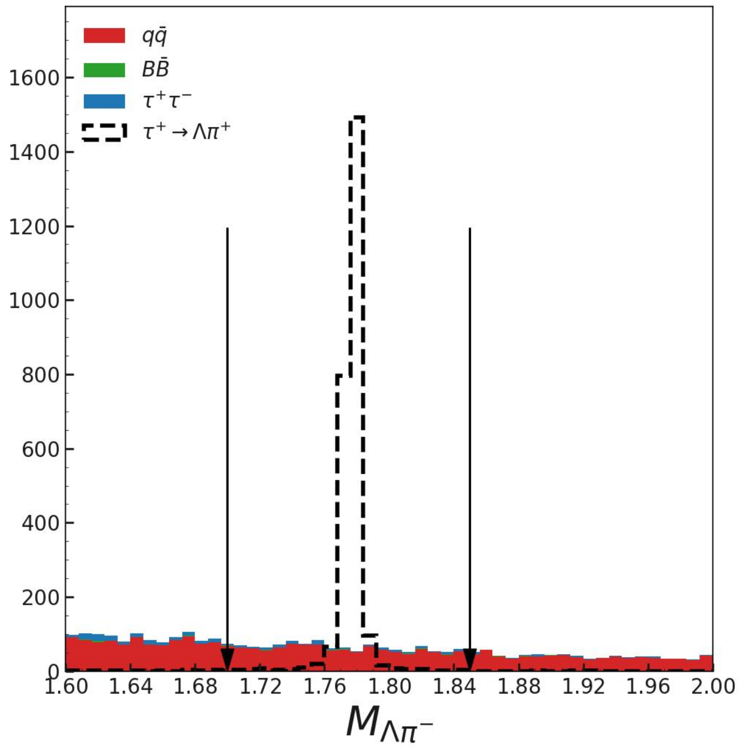
- **Invariant mass of $p\pi$ for Λ**
- **Invariant mass of $\Lambda\pi$ for τ**

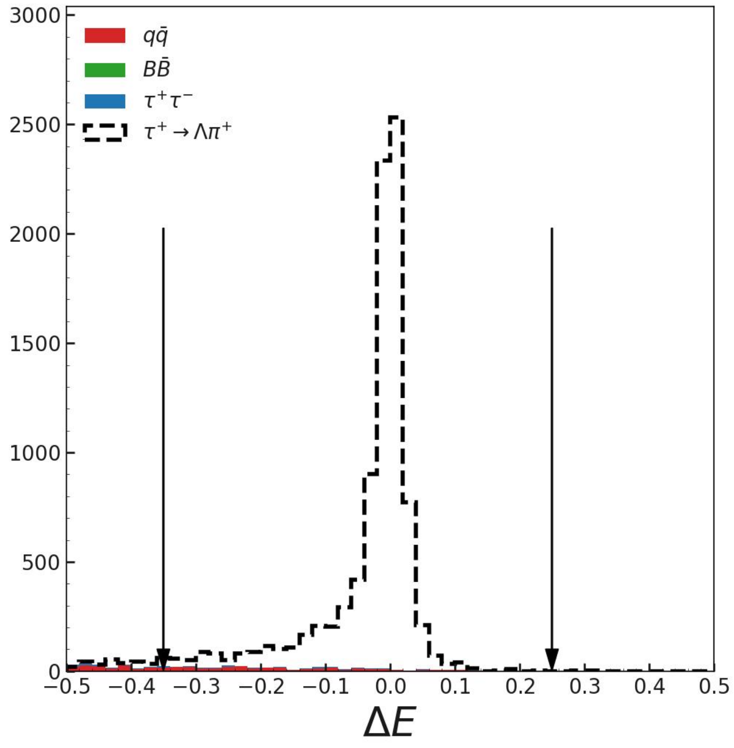
Distribution of ΔE, N_{γ}, $E_{\gamma}(tag)$, cosθ of $p_{miss}\, p_{tag}$ and cosθ of $p_{miss}\, \hat{n}_{thrust}$ for signal MC



Distribution of invariant mass of Λ, τ, and ΔE: $\Longrightarrow$apply mass window and ΔE window

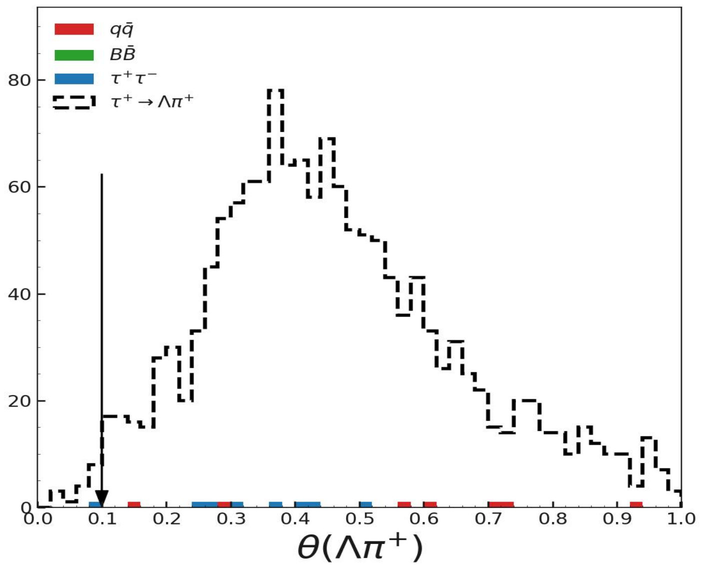




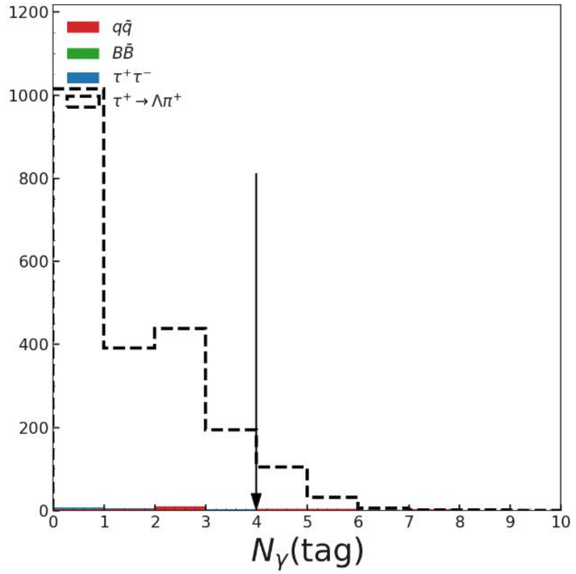


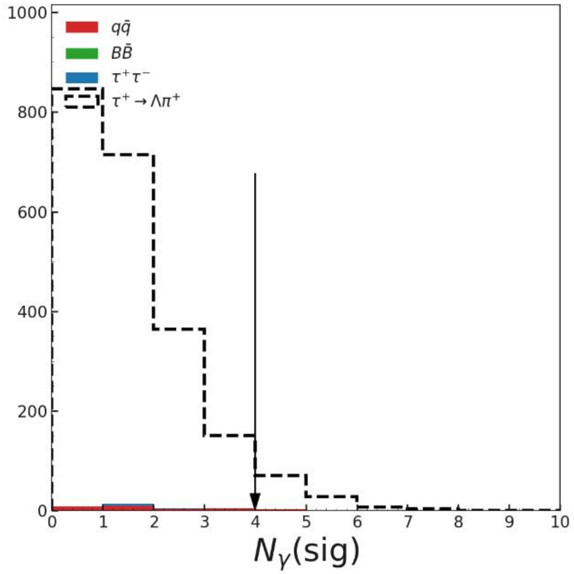
- **Require $|M_{p\pi}$ -1.115683| < 0.003 GeV/c^2**
- **Require 1.7 <M_τ < 1.85 GeV/c^2**
- **Require -0.35 < ΔE < 0.25 GeV**

- **For the open angle between $\Lambda\pi$, require $\theta_{\Lambda\pi} > 0.1$**

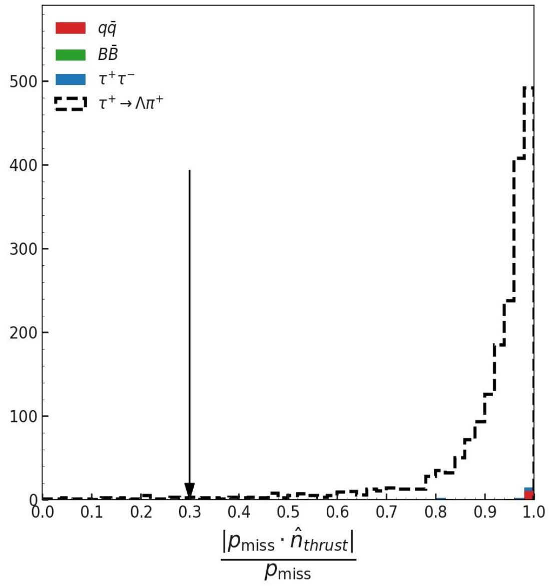


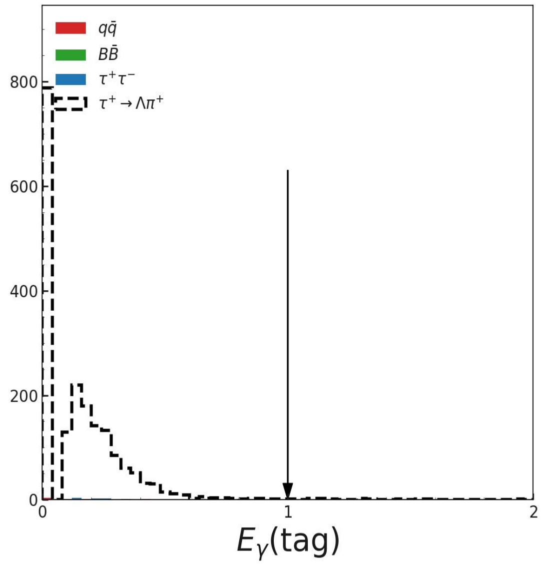
- **For photons, require number of photons<=3 in both sides**

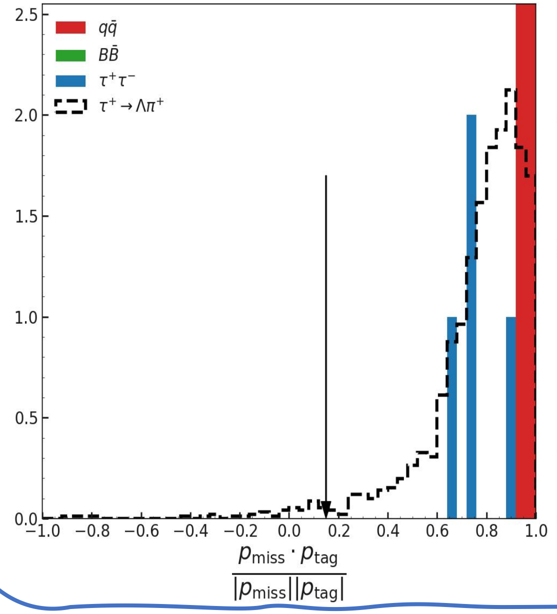


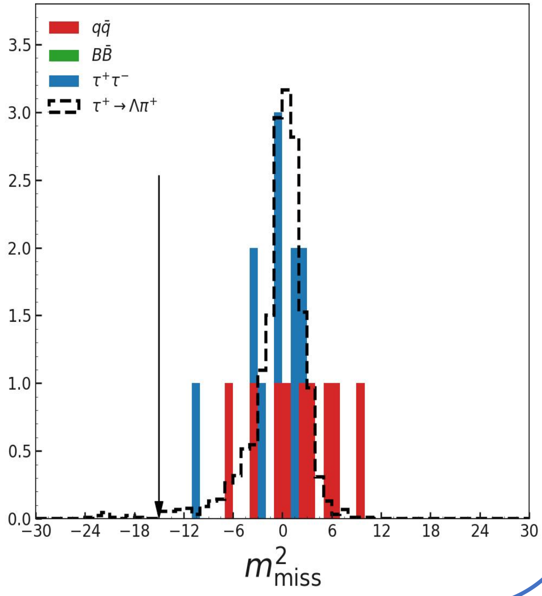


- **Some other selections..**

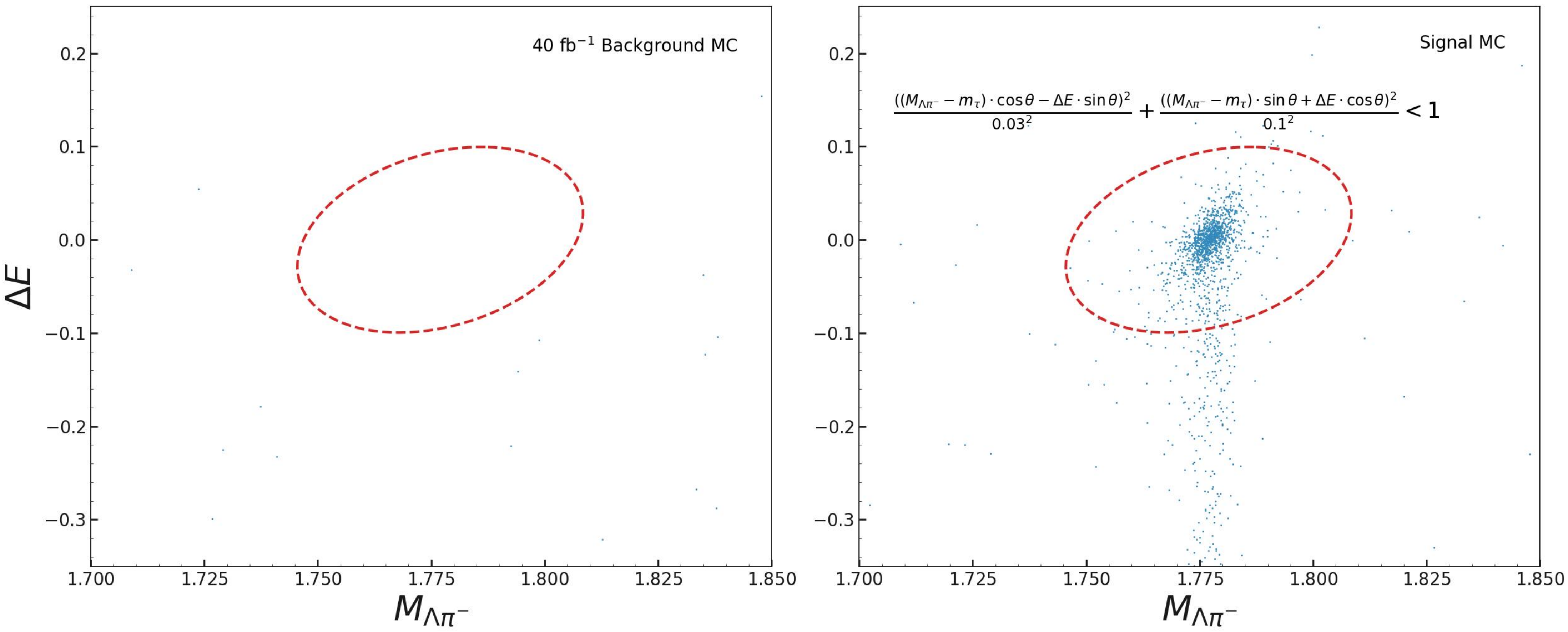








➢ 经过事例选择后的Generic MC与信号MC在信号区的分布，定义椭圆信号区，其他区域为边带区



- **Nbkg in Generic MC in sideband region: 16**
- **Nsig in signal region: 0**
- **Efficiency: 6.2%**
- **90% UL:** $\mathbf{B(\tau^+ \to \Lambda\,\pi^+) < 5.9 \times 10^{-8}}$

Summary

- 通过Generic MC和信号MC对轻子数重子数破坏过程$\tau^+ \to \Lambda\ \pi^+$进行了分析
- 完成了事例选择优化和Generic MC本底分析
- 得到了基于40 fb^{-1} Generic MC的上限估计

- 本次Project，初步熟悉了Belle2分析框架和物理分析的初步流程，充分运用了冬季学校期间所学的理论、实验与代码知识。

分工

- 杨润佳：事例选择
- 刘成：本底分析
- 邵麟筌：课题介绍与总结
- 李启铭：上限估计
- 本组所有人均熟悉了整个Project流程，并合作完成PPT

Thank you for your attention！