

$$\eta' \rightarrow \gamma \pi^+ \pi^-$$

$$\text{Cut: } \chi^2 < 30;$$

$$|M_{p\pi^-(\bar{p}\pi^+)} - M_{\Lambda(\bar{\Lambda})}| < 6 \text{ MeV}$$

$$M_{\gamma\pi^+\pi^-} \in (0.94, 0.97) \text{ MeV}/c^2$$

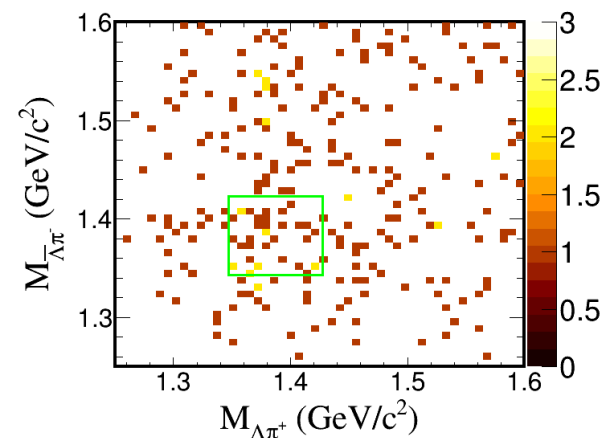
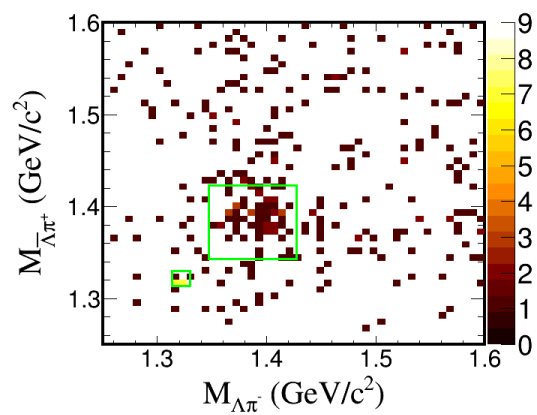
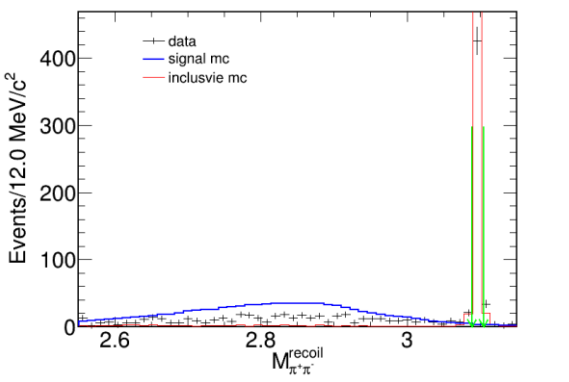
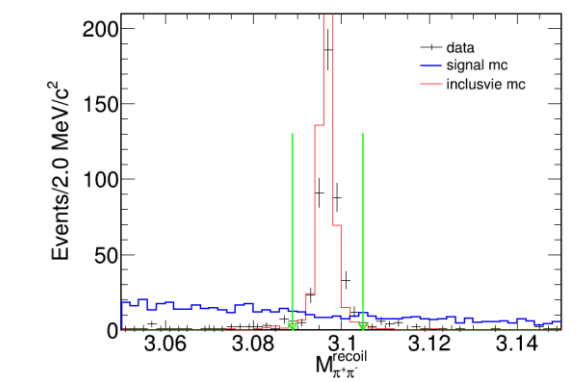
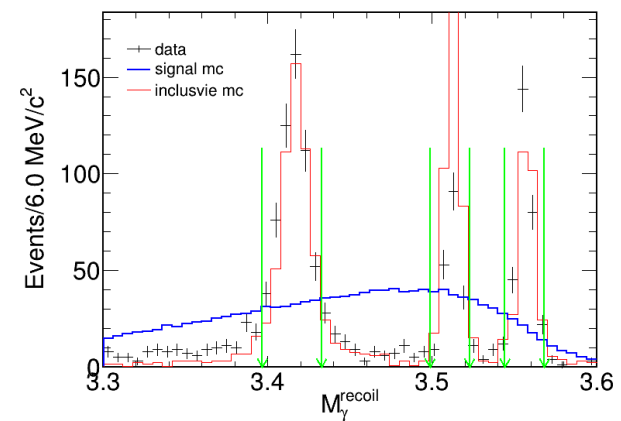
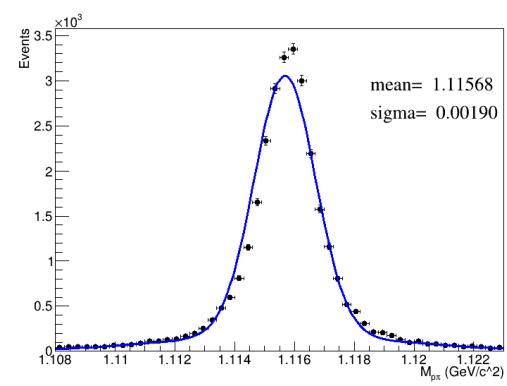
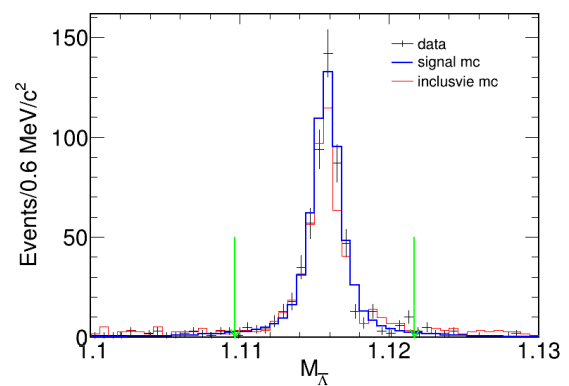
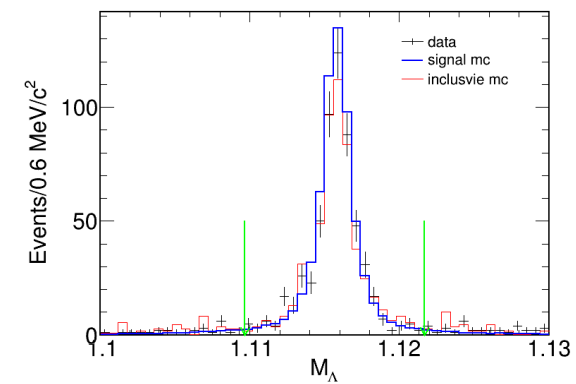
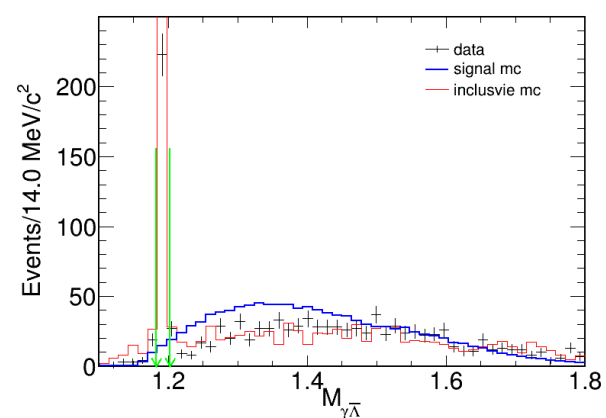
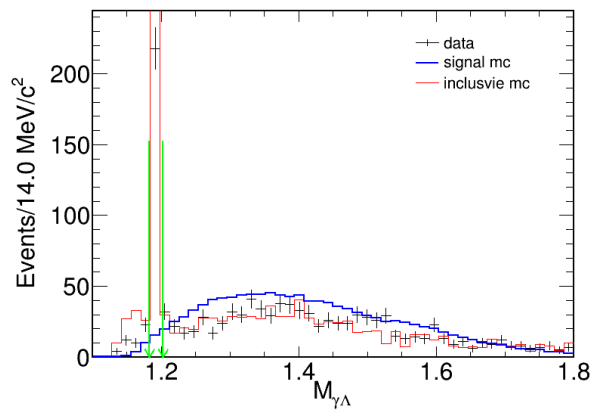
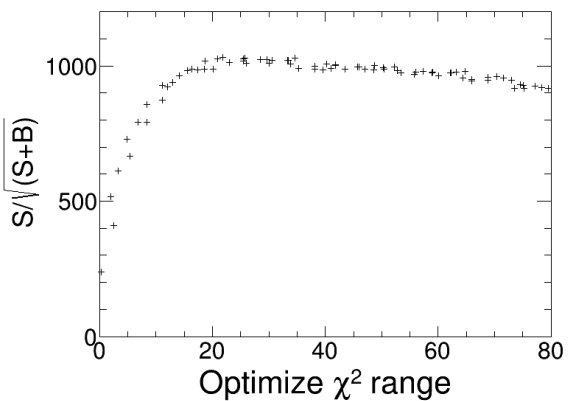
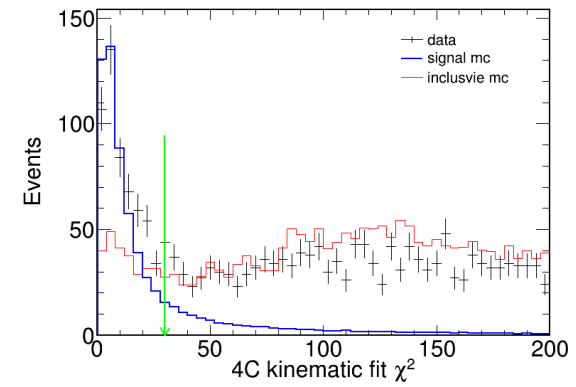
$$|M_{\gamma\Lambda(\bar{\Lambda})} - M_{\Sigma^0}| > 10 \text{ MeV}/c^2$$

$$|M_{2\pi}^{recoil} - 3.097| > 8 \text{ MeV};$$

$$|M_{\gamma}^{recoil} - M_{\chi_{c0}}| > 18 \text{ MeV}/c^2, |M_{\gamma}^{recoil} - M_{\chi_{c1}}| > 12 \text{ MeV}/c^2, |M_{\gamma}^{recoil} - M_{\chi_{c2}}| > 12 \text{ MeV}/c^2$$

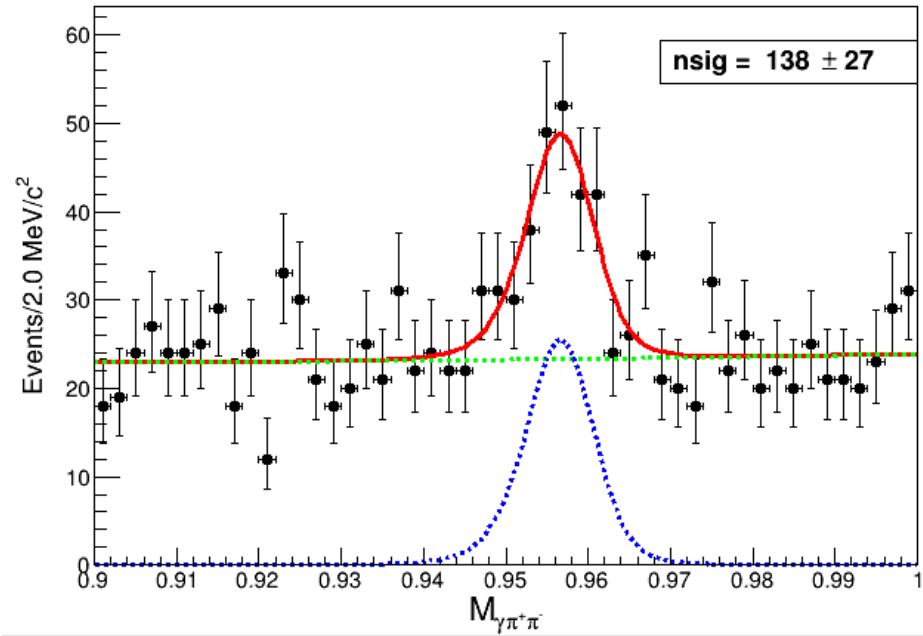
$$|M_{\Lambda\pi^-(\bar{\Lambda}\pi^+)} - M_{\Xi^-(\bar{\Xi}^+)}| > 8 \text{ MeV}$$

$$\text{Veto } \Sigma(1385) \text{ region } |M_{\Lambda\pi} - M_{\Sigma^*}| > 40 \text{ MeV};$$



# Cut flow ( $\eta' \rightarrow \gamma\pi^+\pi^-$ )

Criteria	Efficiency(%)
Ncharge>6	42.59
PID	30.01
$\Lambda/\bar{\Lambda}$ reconstrain	29.06
$\pi^+\pi^-$ vertex fit	23.57
$N_\gamma > 1$	23.44
Pass 4c	15.14
$\chi^2 < 30$	10.35
$ M_{p\pi} - M_{\Lambda(\bar{\Lambda})}  < 5\text{MeV}$	9.23
$M_{\gamma\pi^+\pi^-} \in (0.9, 1.0)$	9.20
$ M_{\gamma\Lambda(\bar{\Lambda})} - M_{\Sigma^0}  > 10\text{MeV}$	8.81
$ M_{\pi^+\pi^-}^{\text{recoil}} - M_{\text{Jpsi}}  > 8\text{MeV}$	8.77
cut $M_\gamma^{\text{recoil}}$	6.51
Cut $\Sigma(1385)\&\Xi^-$	6.23



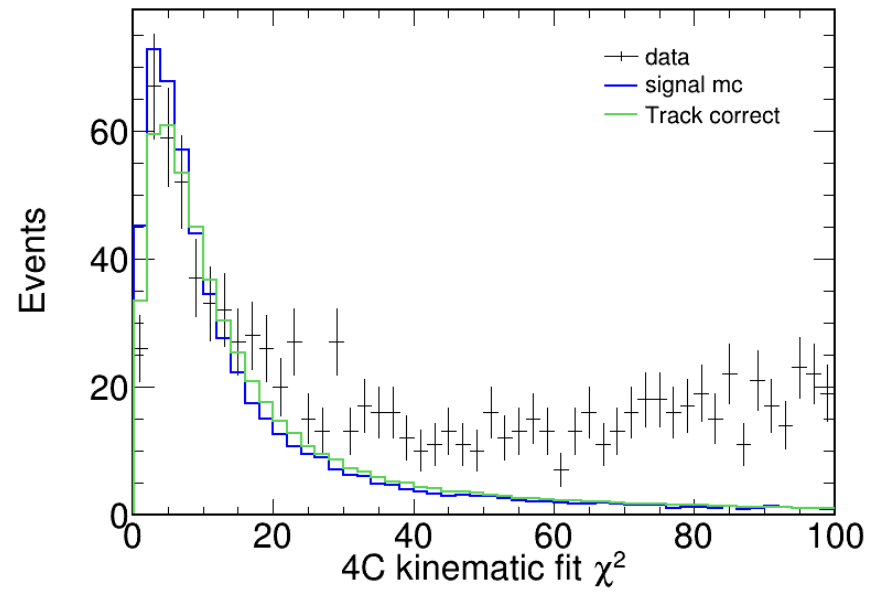
```

FCN=-11085 FROM HESSE      STATUS=OK          40 CALLS      212 TOTAL
                        EDM=6.38832e-06    STRATEGY= 1    ERROR MATRIX ACCURATE
EXT  PARAMETER          VALUE          ERROR          INTERNAL      INTERNAL
NO.  NAME              VALUE          ERROR          STEP SIZE     VALUE
  1  a1                 1.97675e-02   5.16471e-02   7.39789e-06   1.97675e-04
  2  b1                 4.53093e-03   6.00147e-02   1.47680e-06   4.53093e-05
  3  mean_gauss         1.31873e-03   7.50931e-04   1.09806e-03   1.32258e-01
  4  nbkg               1.16604e+03   4.18574e+01   2.56862e-04   9.08200e-01
  5  nsig               1.37970e+02   2.70095e+01   6.74986e-04   -9.08186e-01
  6  sigma_gauss        1.53643e-03   2.20244e-03   5.18405e-04   1.54254e-01
ERR_DEF= 0.5

```

$$\text{BR} = 6.81 \pm 1.33 \times 10^{-6}$$

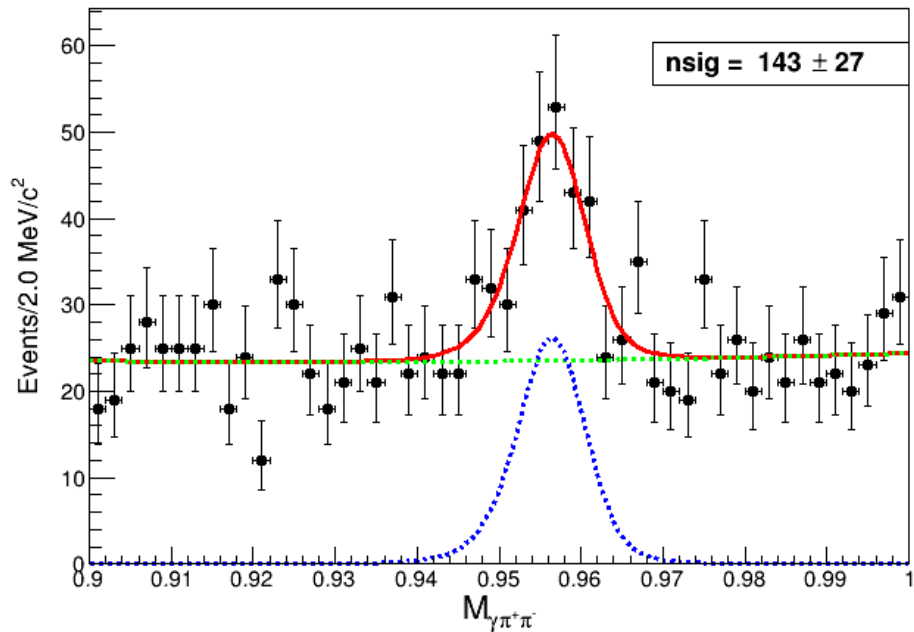
# Track correction



Efficiency:  
Signal : 7.26%  
Trk correct:7.34%  
Uncertainty:1.1%

Mass window

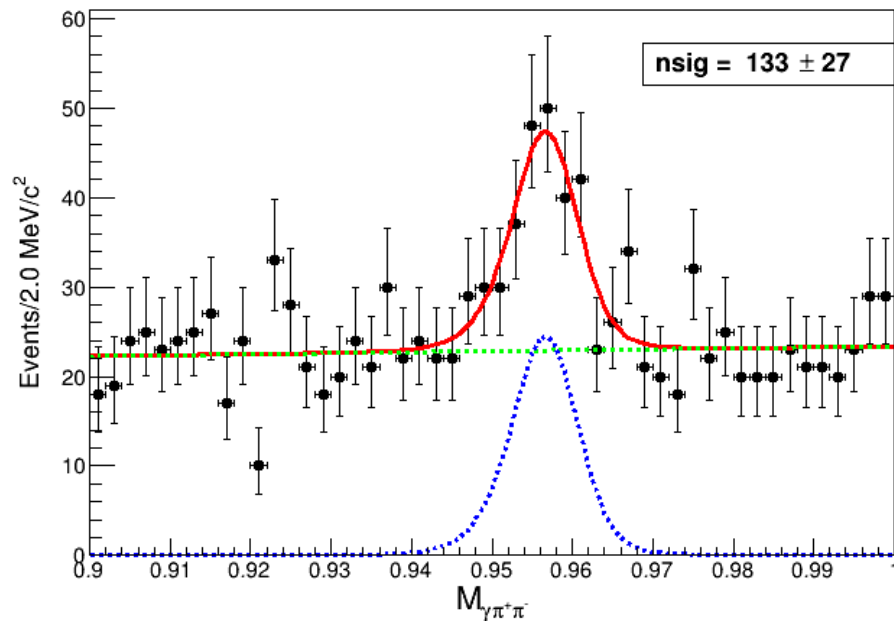
$$|M_{p\pi} - M_{\Lambda}| < 7\text{MeV}/c^2; \epsilon = 6.30\%$$



$$BR = 6.97 \pm 1.31 \times 10^{-6}$$

Uncertainty = 2.3%

$$|M_{p\pi} - M_{\Lambda}| < 5\text{MeV}/c^2; \epsilon = 6.14\%$$

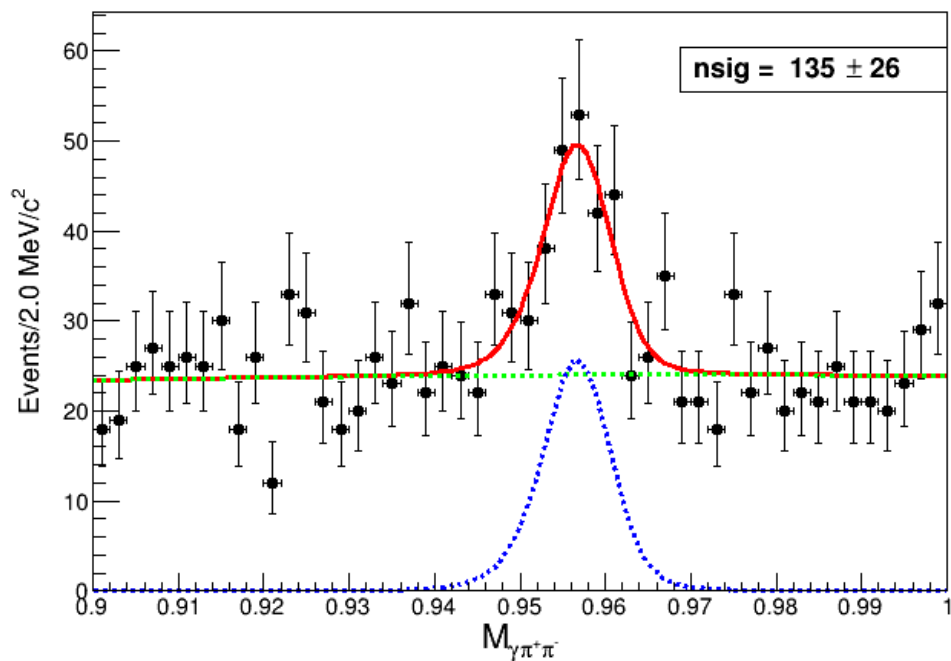


$$BR = 6.66 \pm 1.35 \times 10^{-6}$$

Uncertainty = 2.2%

# Mass window

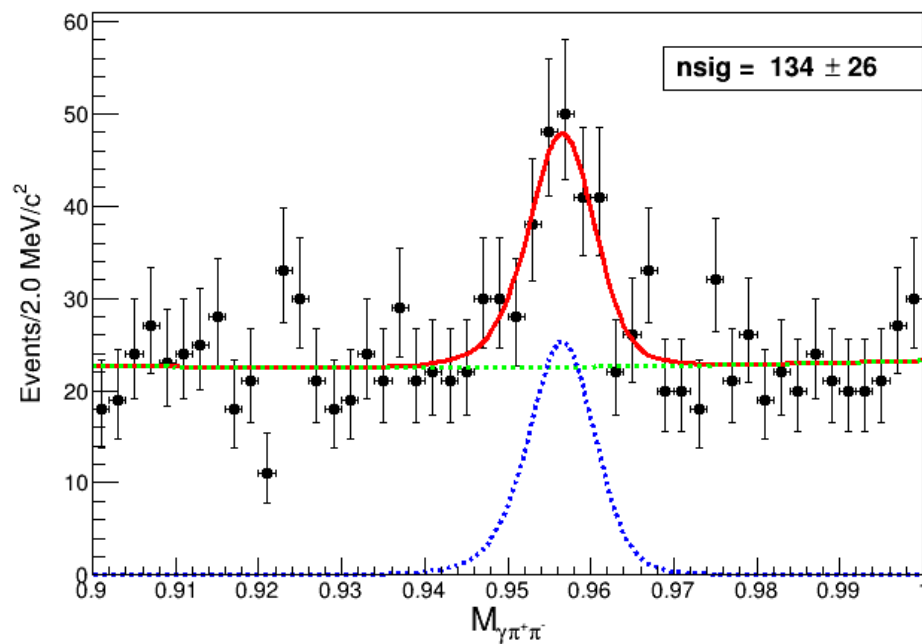
$$|M_{p\pi} - M_{\bar{\Lambda}}| < 7 \text{ MeV}/c^2; \epsilon = 6.30\%$$



$$BR = 6.59 \pm 1.27 \times 10^{-6}$$

Uncertainty = 3.2%

$$|M_{p\pi} - M_{\bar{\Lambda}}| < 5 \text{ MeV}/c^2; \epsilon = 6.14\%$$

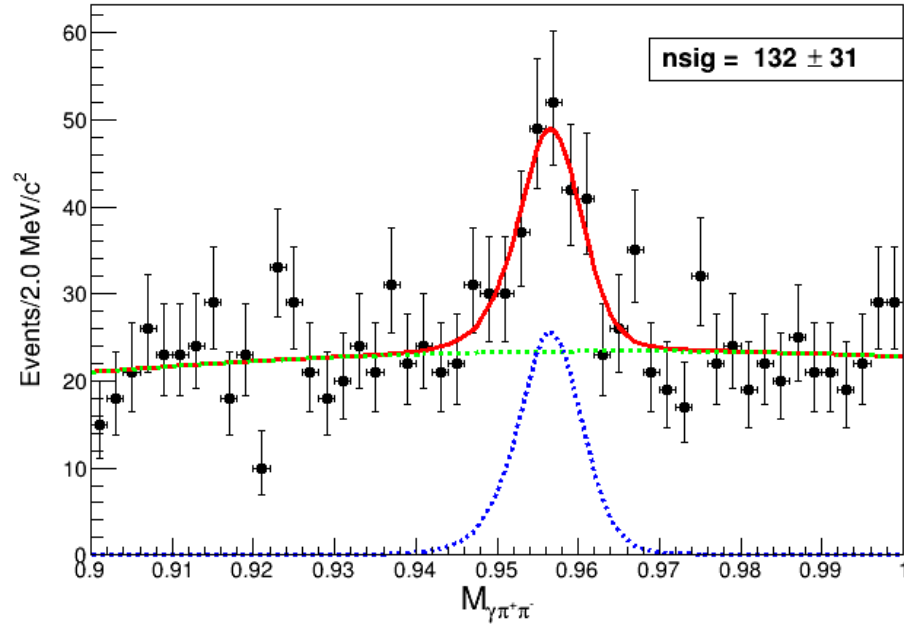


$$BR = 6.66 \pm 1.35 \times 10^{-6}$$

Uncertainty = 2.2%

$$\left| M_{\gamma\Lambda(\gamma\bar{\Lambda})} - M_{\Sigma^0(\bar{\Sigma}^0)} \right| > 12 \text{ MeV}/c^2$$

$$\epsilon = 6.18\%$$

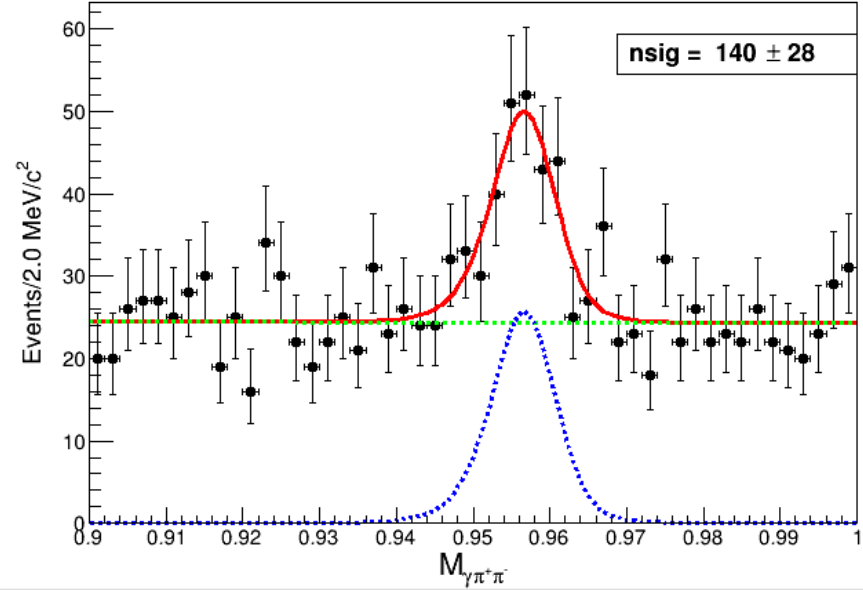


$$BR = 6.57 \pm 1.54 \times 10^{-6}$$

$$\text{Uncertainty} = 3.5\%$$

$$\left| M_{\gamma\Lambda(\gamma\bar{\Lambda})} - M_{\Sigma^0(\bar{\Sigma}^0)} \right| > 8 \text{ MeV}/c^2$$

$$\epsilon = 6.28\%$$



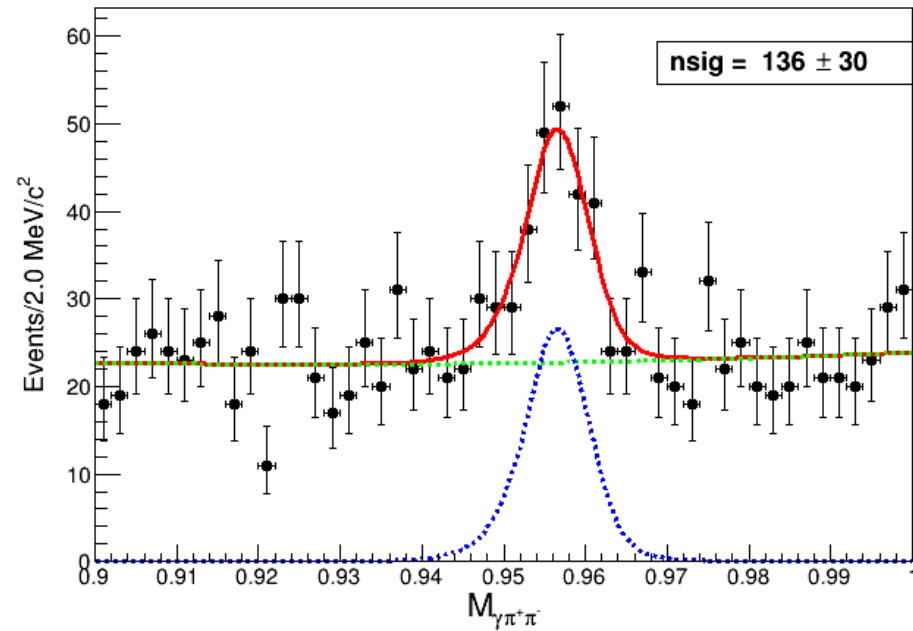
$$BR = 6.85 \pm 1.37 \times 10^{-6}$$

$$\text{Uncertainty} = 0.6\%$$



$$\left| M_{\pi^+\pi^-}^{recoil} - M_{J/\psi} \right| > 12 \text{ MeV}/c^2$$

$$\epsilon = 6.22\%$$

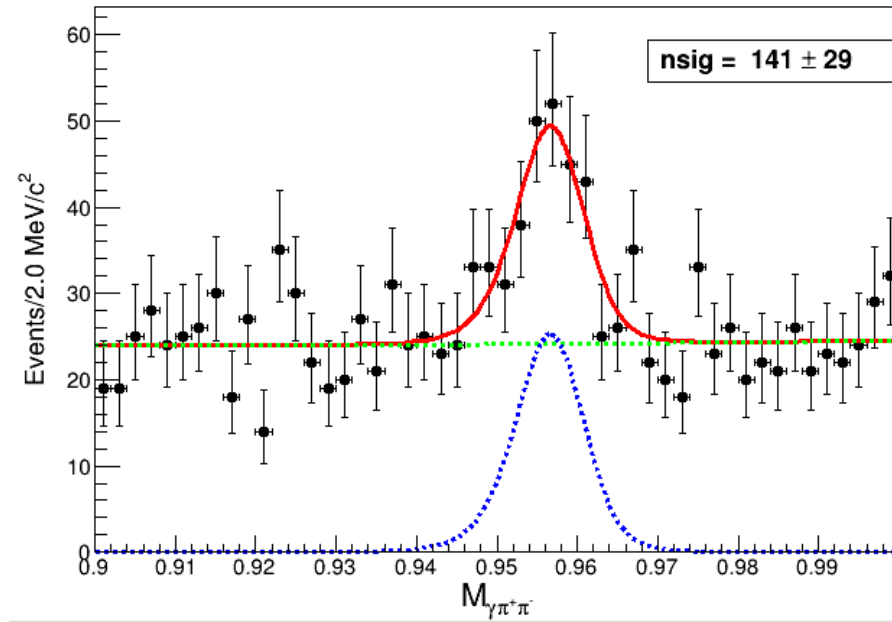


$$BR = 6.72 \pm 1.48 \times 10^{-6}$$

$$\text{Uncertainty} = 1.3\%$$

$$\left| M_{\pi^+\pi^-}^{recoil} - M_{J/\psi} \right| > 6 \text{ MeV}/c^2$$

$$\epsilon = 6.24\%$$

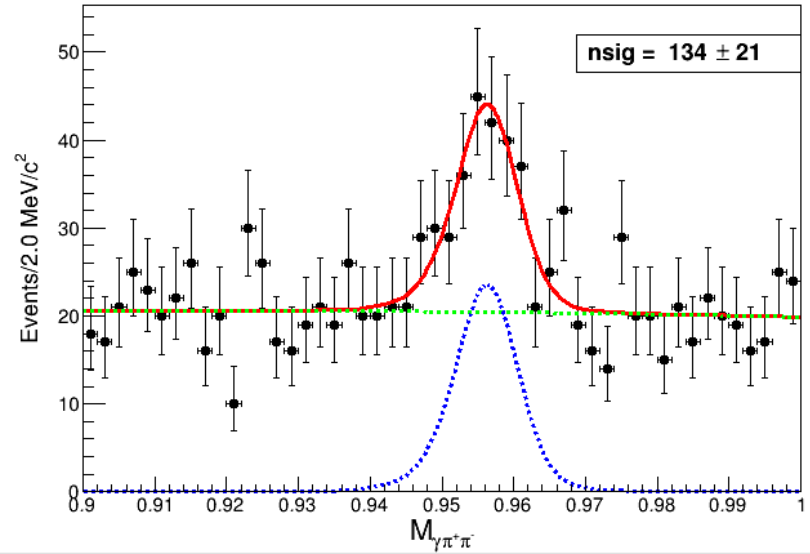


$$BR = 6.95 \pm 1.43 \times 10^{-6}$$

$$\text{Uncertainty} = 2.0\%$$

$$|M_{\gamma}^{recoil} - M_{\chi_{co}}| > 24 \text{ MeV}/c^2$$

$$\epsilon = 5.89\%$$

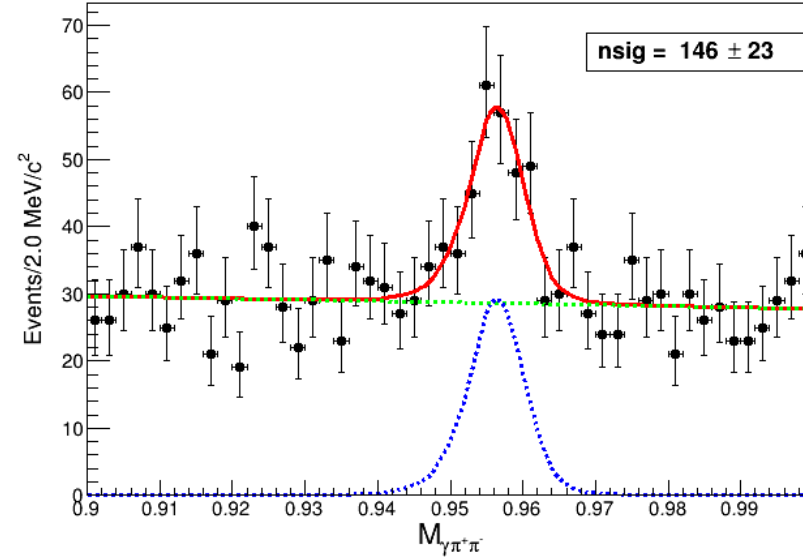


$$BR = 7.00 \pm 1.10 \times 10^{-6}$$

$$\text{Uncertainty} = 2.8\%$$

$$|M_{\gamma}^{recoil} - M_{\chi_{co}}| > 12 \text{ MeV}/c^2$$

$$\epsilon = 6.57\%$$



$$BR = 6.83 \pm 1.07 \times 10^{-6}$$

$$\text{Uncertainty} = 0.3\%$$

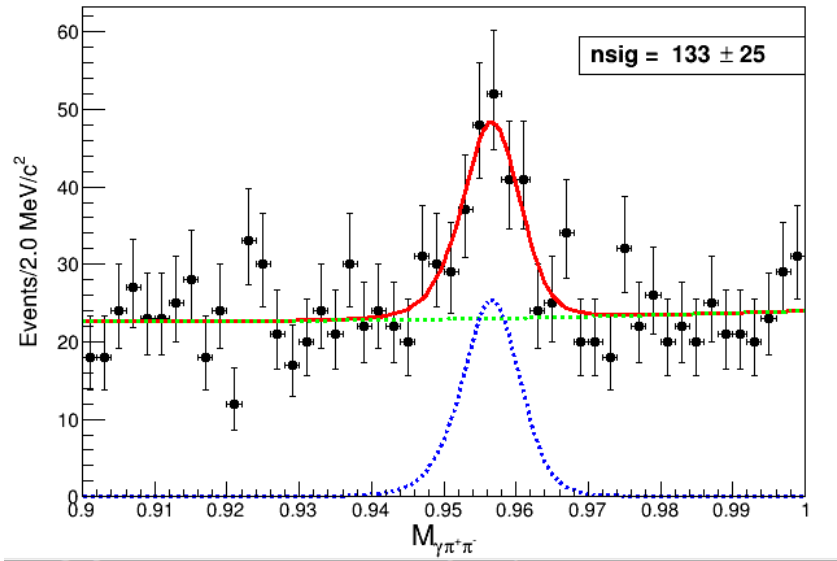
```

FCN=-9672.57 FROM HESSE      STATUS=OK          40 CALLS      201 TOTAL
                        EDM=7.91295e-07    STRATEGY= 1    ERROR MATRIX ACCURATE
EXT  PARAMETER
NO.  NAME      VALUE      ERROR      INTERNAL  INTERNAL
1    a1        -1.65768e-02  5.49566e-02  7.39314e-06 -1.65768e-04
2    b1        -6.52215e-03  6.04143e-02  1.48444e-06 -6.52215e-05
3    mean_gauss  4.62722e-04  8.24654e-04  1.11650e-03  4.62887e-02
4    nbkg      1.02013e+03  3.65617e+01  2.44263e-04  8.75700e-01
5    nsig      1.33893e+02  2.13153e+01  1.33134e-04  -8.75633e-01
6    sigma_gauss 2.00000e-03  1.31220e-03  9.13643e-03  1.57084e+00
WARNING - - ABOVE PARAMETER IS AT LIMIT.

```

$$|M_{\gamma}^{recoil} - M_{\chi_{c1}}| > 15 \text{ MeV}/c^2$$

$$\epsilon = 6.04\%$$

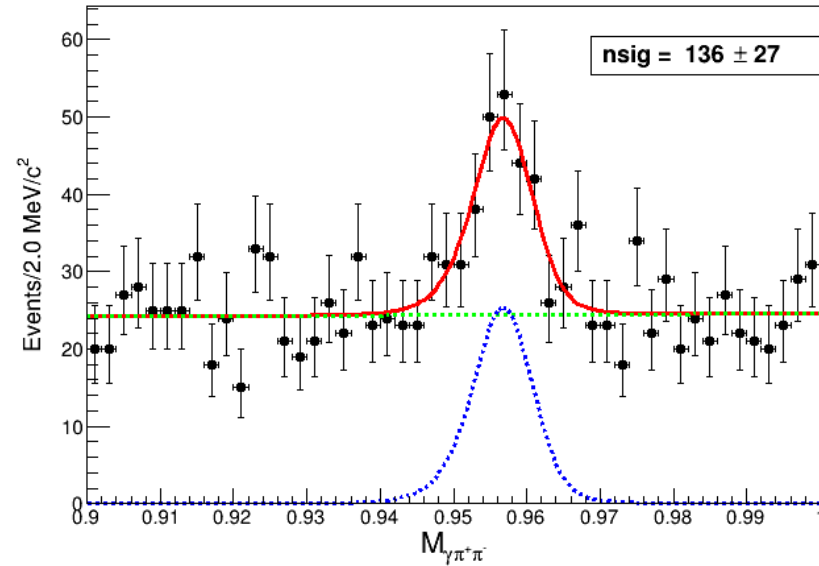


$$BR = 6.77 \pm 1.27 \times 10^{-6}$$

$$\text{Uncertainty} = 0.6\%$$

$$|M_{\gamma}^{recoil} - M_{\chi_{c1}}| > 9 \text{ MeV}/c^2$$

$$\epsilon = 6.42\%$$

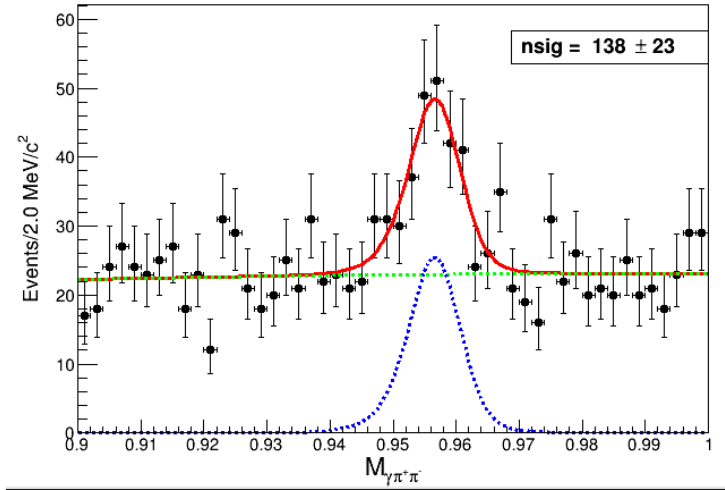


$$BR = 6.51 \pm 1.29 \times 10^{-6}$$

$$\text{Uncertainty} = 4.4\%$$

$$|M_{\gamma}^{recoil} - M_{\chi_{c2}}| > 15 \text{ MeV}/c^2$$

$$\epsilon = 6.13\%$$

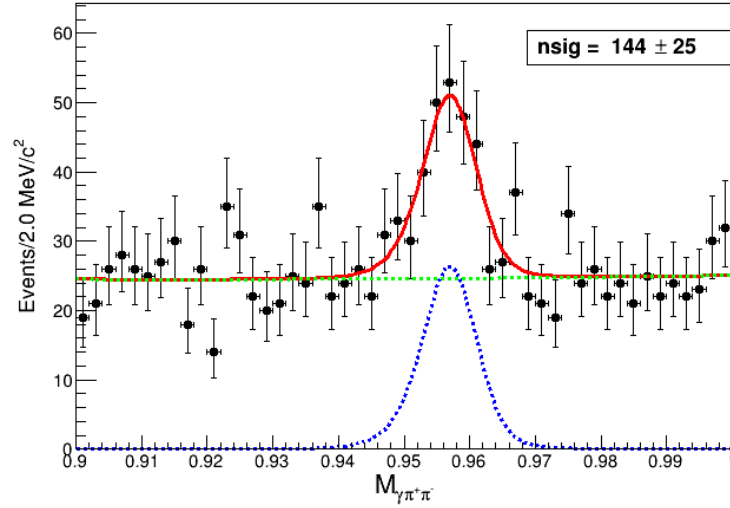


$$BR = 6.92 \pm 1.15 \times 10^{-6}$$

$$\text{Uncertainty} = 1.6\%$$

$$|M_{\gamma}^{recoil} - M_{\chi_{c2}}| > 9 \text{ MeV}/c^2$$

$$\epsilon = 6.33\%$$

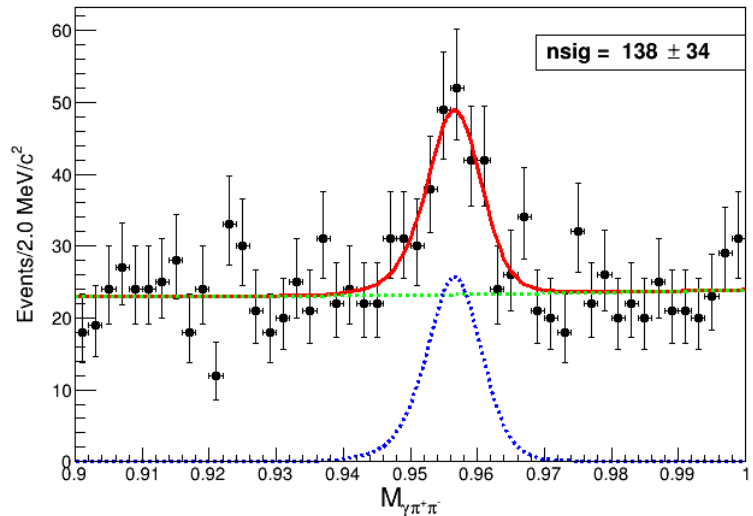


$$BR = 6.99 \pm 1.21 \times 10^{-6}$$

$$\text{Uncertainty} = 2.6\%$$

$$|M_{\Lambda\pi^-(\bar{\Lambda}\pi^+)} - M_{\Xi^-(\bar{\Xi}^+)}| > 10\text{MeV}$$

$$\epsilon = 6.23\%$$

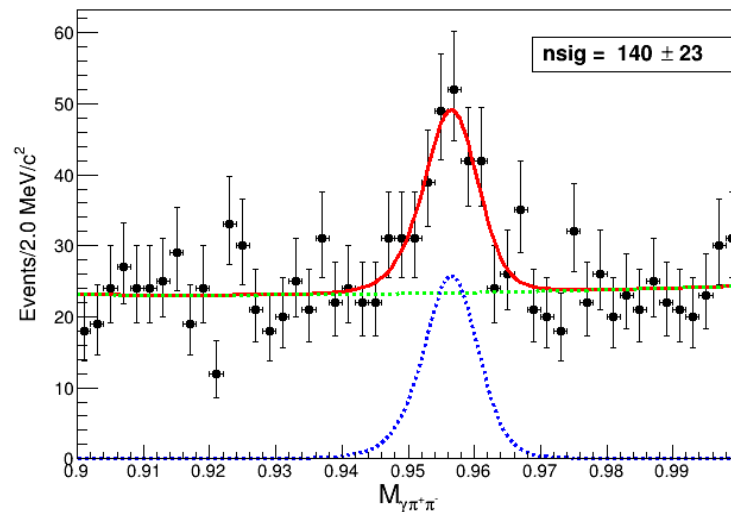


$$BR = 6.81 \pm 1.66 \times 10^{-6}$$

Uncertainty=0.0%

$$|M_{\Lambda\pi^-(\bar{\Lambda}\pi^+)} - M_{\Xi^-(\bar{\Xi}^+)}| > 6\text{MeV}$$

$$\epsilon = 6.23\%$$

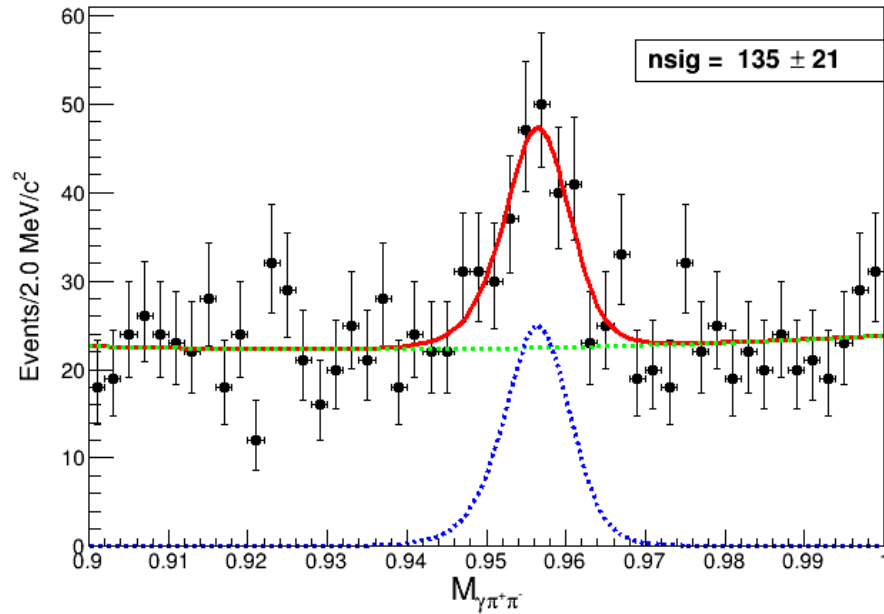


$$BR = 6.91 \pm 1.13 \times 10^{-6}$$

Uncertainty=1.4%

$$|M_{\Lambda\pi^-(\bar{\Lambda}\pi^+)} - M_{\Sigma^*}| > 50 \text{ MeV}$$

$$\epsilon = 6.15\%$$

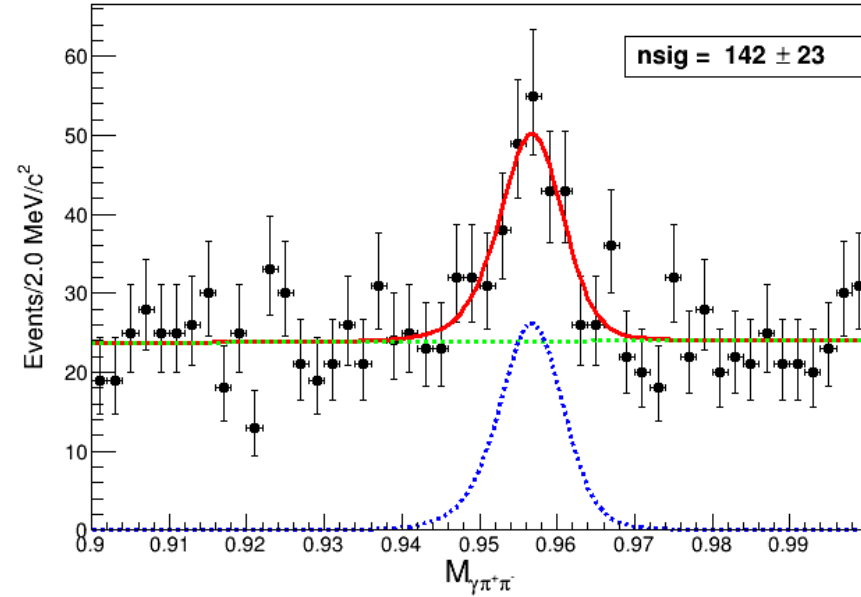


$$BR = 6.75 \pm 1.05 \times 10^{-6}$$

$$\text{Uncertainty} = 0.9\%$$

$$|M_{\Lambda\pi^-(\bar{\Lambda}\pi^+)} - M_{\Sigma^*}| > 30 \text{ MeV}$$

$$\epsilon = 6.29\%$$

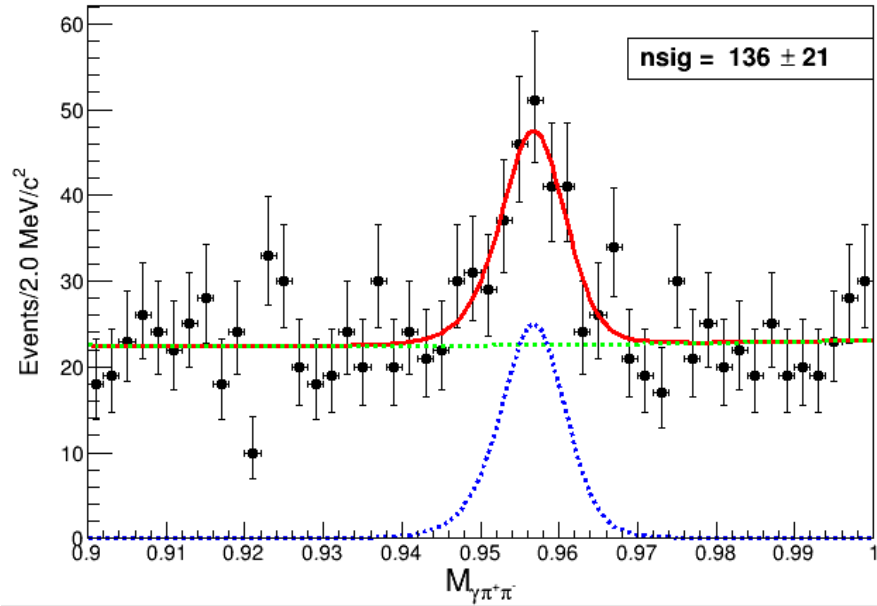


$$BR = 6.94 \pm 1.12 \times 10^{-6}$$

$$\text{Uncertainty} = 1.9\%$$

$$|M_{\Lambda\pi^-(\Lambda\pi^+)} - M_{\Sigma^*}| > 50 \text{ MeV}$$

$$\epsilon = 6.16\%$$

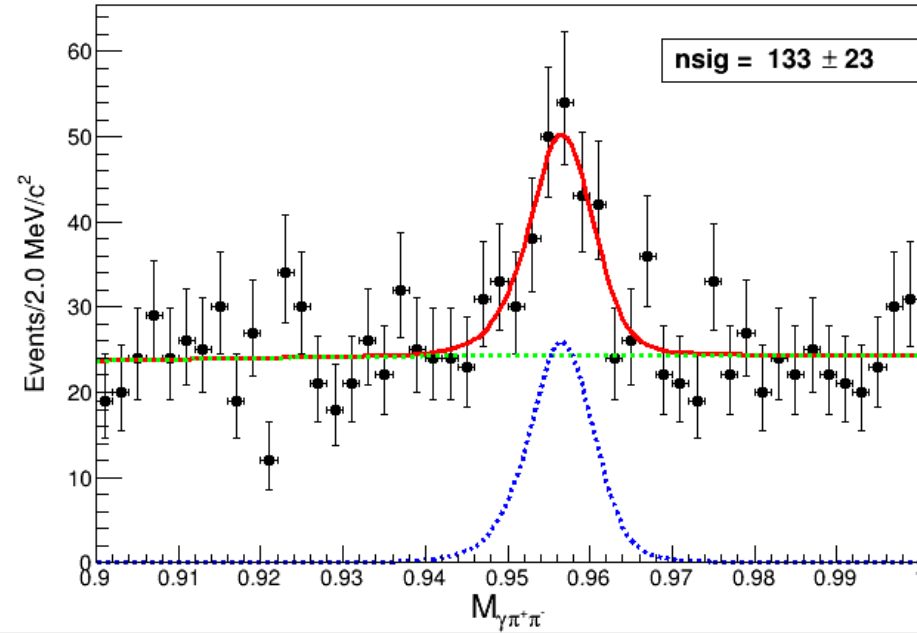


$$BR = 6.79 \pm 1.05 \times 10^{-6}$$

$$\text{Uncertainty} = 0.3\%$$

$$|M_{\Lambda\pi^-(\Lambda\pi^+)} - M_{\Sigma^*}| > 30 \text{ MeV}$$

$$\epsilon = 6.29\%$$



$$BR = 6.50 \pm 1.12 \times 10^{-6}$$

$$\text{Uncertainty} = 4.5\%$$

$$\eta' \rightarrow \gamma\pi^+\pi^-$$

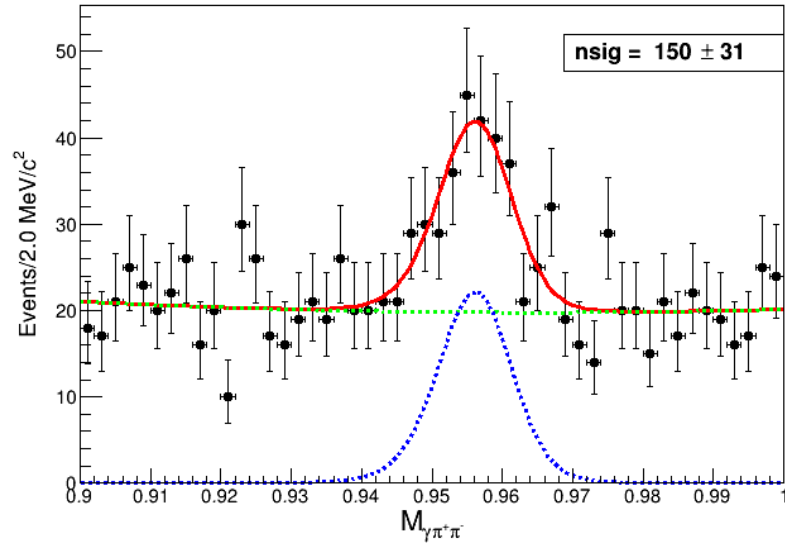
System uncertainty

source		Uncertainties(%)
$\psi(3686)$ events		
MDC tracking		6.0
PID efficiency		6.0
Photon detection efficiency		1.0
$\Lambda$ and $\Lambda^-$ reconstruction efficiency		2.0
Kinematic Fit		1.1
Intermediate decay	$\Lambda \rightarrow p\pi^-$	0.5
	$\bar{\Lambda} \rightarrow \bar{p}\pi^+$	0.5
	$\eta' \rightarrow \gamma\pi^+\pi^-$	0.4
Mass window	$\Lambda$	2.3
	$\bar{\Lambda}$	3.2
	$J/\psi$	2.0
	$\Sigma^0/\bar{\Sigma}^0$	3.5
	$\chi_{c0}$	2.8
	$\chi_{c1}$	4.4
	$\chi_{c2}$	1.6
	$\Xi^-, \bar{\Xi}^+$	1.4
	$\Sigma(1385)$	6.4
Fitting	Signal shape	
	Background shape	
	Fitting range	
Total		



$$|M_{\gamma}^{recoil} - M_{\chi_{co}}| > 24 \text{ MeV}/c^2$$

$$\epsilon = 5.89\%$$

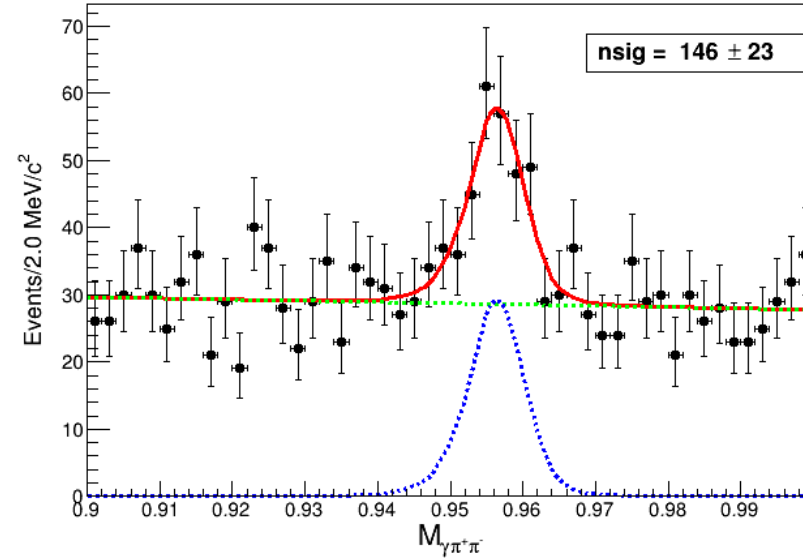


$$BR = 7.83 \pm 1.62 \times 10^{-6}$$

$$\text{Uncertainty} = 15.0\%$$

$$|M_{\gamma}^{recoil} - M_{\chi_{co}}| > 12 \text{ MeV}/c^2$$

$$\epsilon = 6.57\%$$



$$BR = 6.83 \pm 1.07 \times 10^{-6}$$

$$\text{Uncertainty} = 0.3\%$$

```

FCN=-9672.87 FROM HESSE      STATUS=OK          40 CALLS      190 TOTAL
                        EDM=3.80245e-05    STRATEGY= 1    ERROR MATRIX ACCURATE
EXT  PARAMETER
NO.  NAME      VALUE      ERROR      INTERNAL  INTERNAL
STEP SIZE  VALUE
  1  a1        -2.24908e-02  5.61198e-02  7.45006e-06 -2.24908e-04
  2  b1         1.87819e-02  7.03347e-02  7.47790e-06  1.87819e-04
  3  mean_gauss  8.92566e-04  8.97930e-04  1.21555e-03  8.93755e-02
  4  nbkg       1.00413e+03  4.25685e+01  2.31571e-04  8.33462e-01
  5  nsig       1.49879e+02  3.10353e+01  1.33807e-04 -8.33433e-01
  6  sigma_gauss 3.42716e-03  1.59955e-03  7.20692e-04  9.11279e-01

```



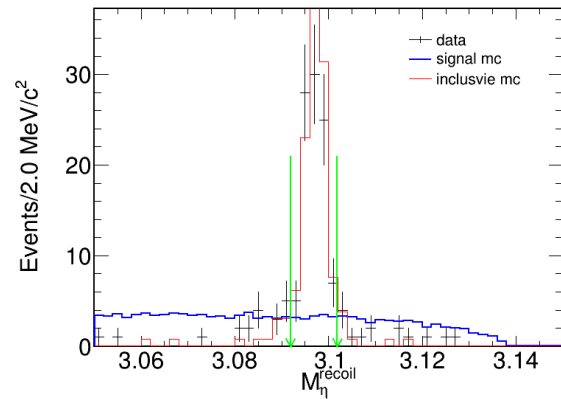
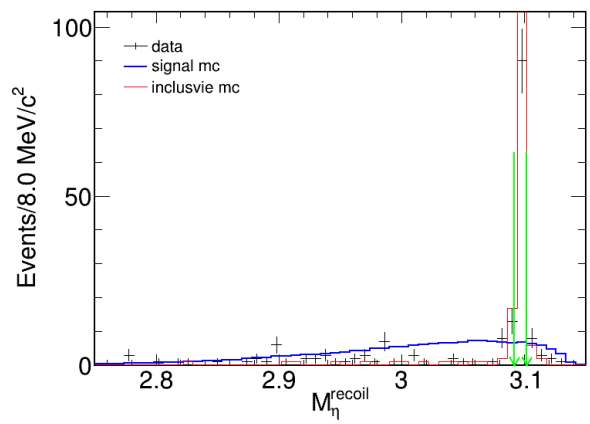
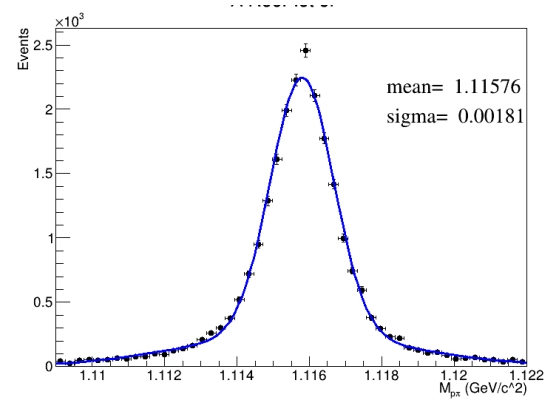
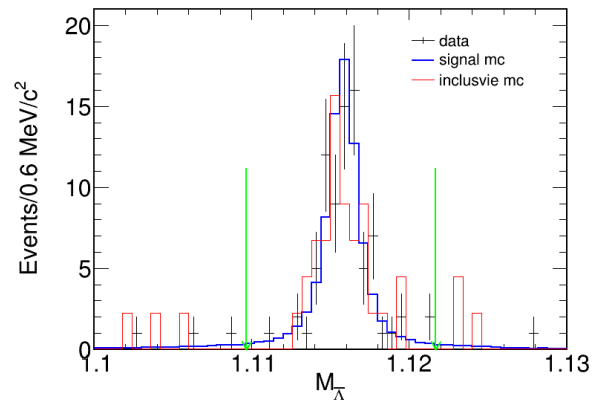
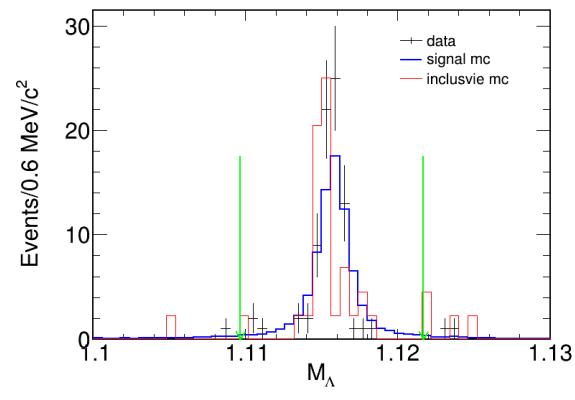
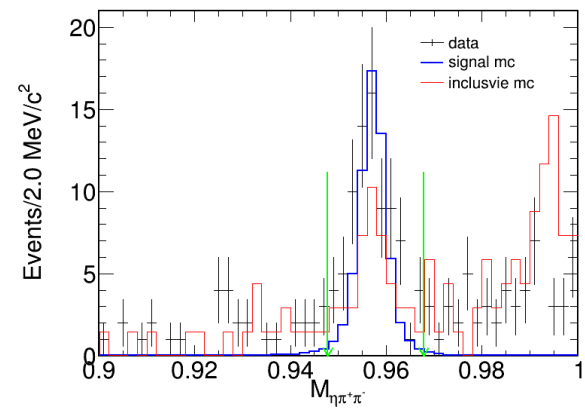
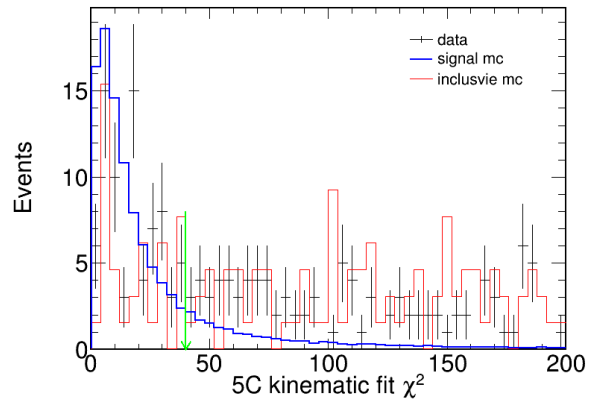
$$\eta' \rightarrow \eta\pi^+\pi^-$$

$$\text{Cut: } \chi^2 < 40;$$

$$|M_{p\pi} - M_{\Lambda(\bar{\Lambda})}| < 6\text{MeV}/c^2;$$

$$|M_{\eta\pi^+\pi^-} - M_{\eta'}| < 0.01\text{GeV}/c^2;$$

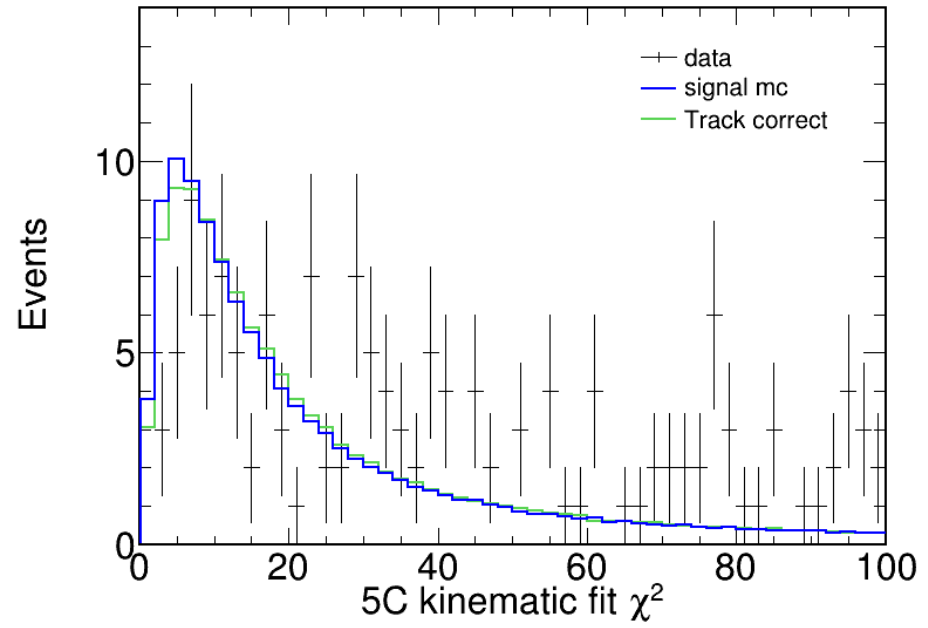
$$|M_{recoil}^{\eta} - M_{J/\psi}| > 5\text{MeV}/c^2;$$



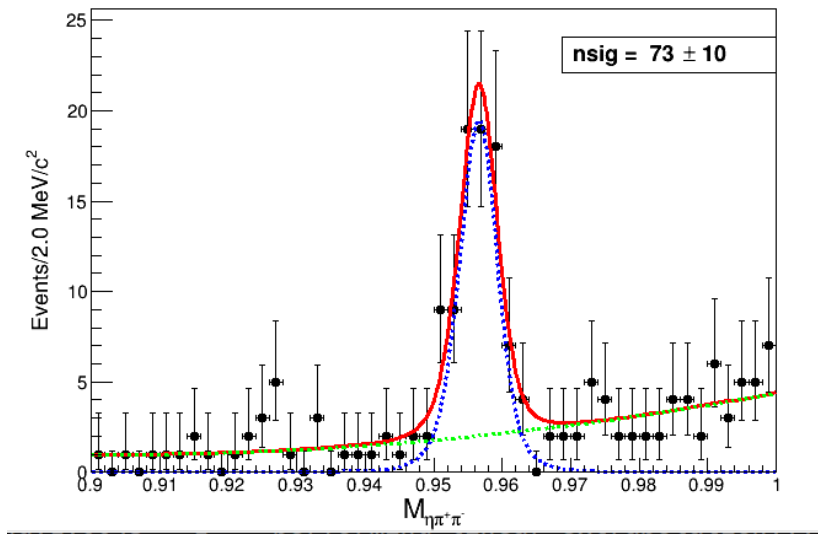
# Cut flow( $\eta' \rightarrow \eta\pi^+\pi^-$ )

Criteria	Efficiency(%)
Ncharge>6	36.05
PID	23.93
$\Lambda/\bar{\Lambda}$ reconstrain	23.11
$\pi^+\pi^-$ vertex fit	15.86
$N_\gamma > 2$	15.41
Pass 5c	8.24
$\chi^2 < 40$	5.56
$ M_{p\pi} - M_{\Lambda(\bar{\Lambda})}  < 5\text{MeV}$	4.93
$M_{\eta\pi^+\pi^-} \in (0.9,1.0)\text{GeV}/c^2$	4.90
$ M_{\text{eta}}^{\text{recoil}} - M_{\text{Jpsi}}  > 5\text{MeV}$	4.66

# Track correction

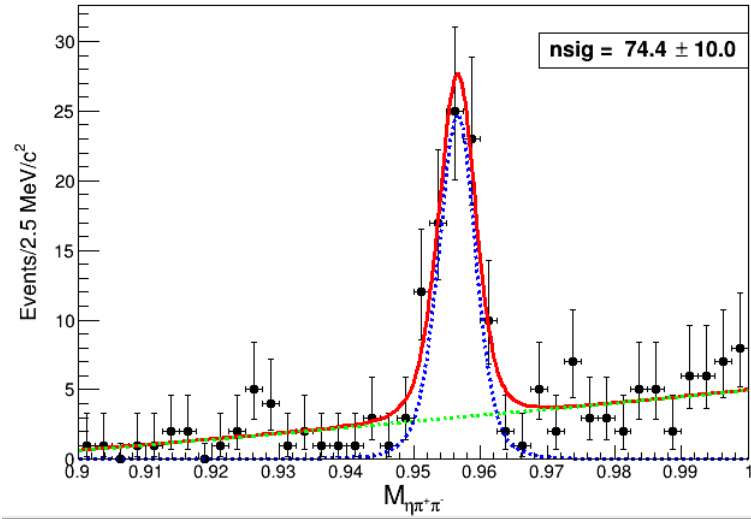


Efficiency:  
Signal : 5.46%  
Trk correct:5.40%  
Uncertainty:1.3%



$$BR = 8.47 \pm 1.16 \times 10^{-6}$$

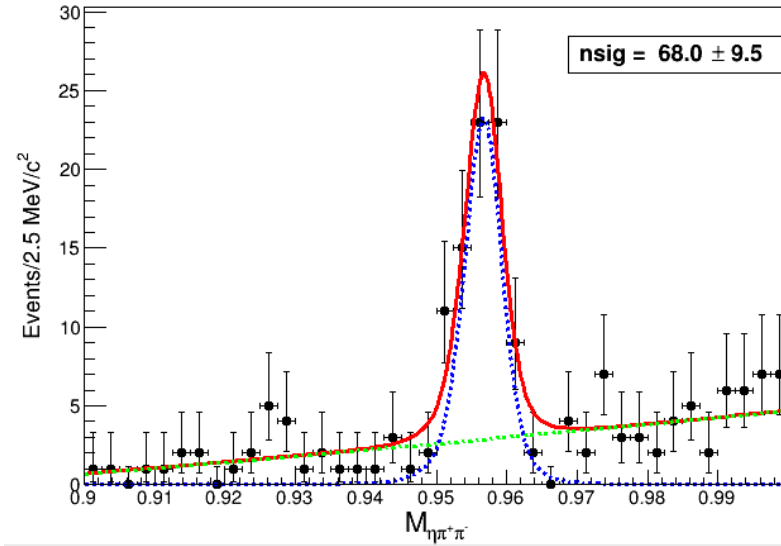
$$|M_{p\pi} - M_{\Lambda}| < 7 \text{ MeV}/c^2; \epsilon = 4.72\%$$



$$BR = 8.53 \pm 1.15 \times 10^{-6}$$

Uncertainty=0.7%

$$|M_{p\pi} - M_{\Lambda}| < 5 \text{ MeV}/c^2; \epsilon = 4.59\%$$



$$BR = 8.01 \pm 1.12 \times 10^{-6}$$

Uncertainty=5.4%



$$\eta' \rightarrow \eta\pi^+\pi^-$$

System uncertainty

source		Uncertainties(%)
$\psi(3686)$ events		
MDC tracking		6.0
PID efficiency		6.0
Photon detection efficiency*		2.0
$\Lambda$ and $\Lambda^-$ reconstruction efficiency**		2.0
Kinematic Fit		2.4
Intermediate decay	$\Lambda \rightarrow p\pi^-$	0.5
	$\bar{\Lambda} \rightarrow \bar{p}\pi^+$	0.5
	$\eta' \rightarrow \eta\pi^+\pi^-$	0.5
	$\eta \rightarrow \gamma\gamma$	0.18
	Mass window	$\Lambda$
	$\bar{\Lambda}$	
	$J/\psi$	
	Fitting	Signal shape
	Background shape	
	Fitting range	
Total		

\*DOI: [10.1103/PhysRevD.99.032006](https://doi.org/10.1103/PhysRevD.99.032006)

\*\* [10.1103/PhysRevD.87.052007](https://doi.org/10.1103/PhysRevD.87.052007)