GP Q&A

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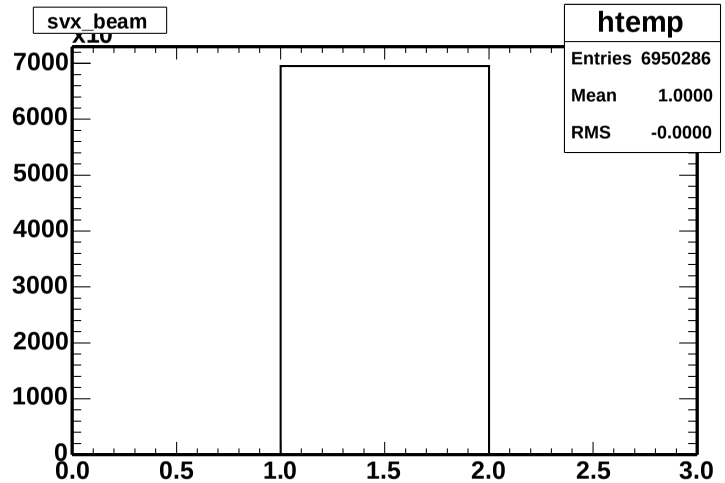
GP meeting

Q1

Q **"The corresponding integrated luminosity is about $220\ pb^{-1}$, no run quality selection has been applied."**
How about valid beamlines

A **$\Xi\pi^+$ and Ξ ntuples contain only valid SVX beamlines**



$$\mathscr{L} = \sum_{i=1}^{N} \mathscr{L}_i = 220.\ \mathrm{pb}^{-1}$$

where $\mathscr{L}_i$ is the integrated luminosity of i-th run in the Ξ ntuple

Q2

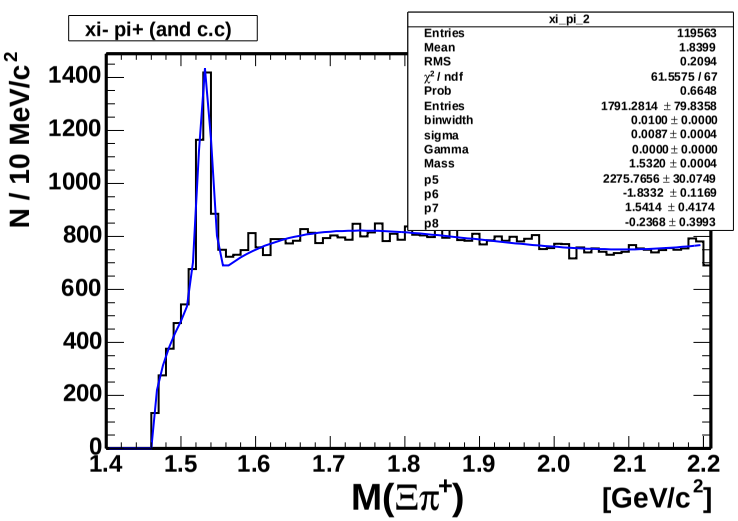
Q You use $\chi^2_{r-\phi}$. For displaced Λs and Ξ it may make sense to use full 3-D χ^2.

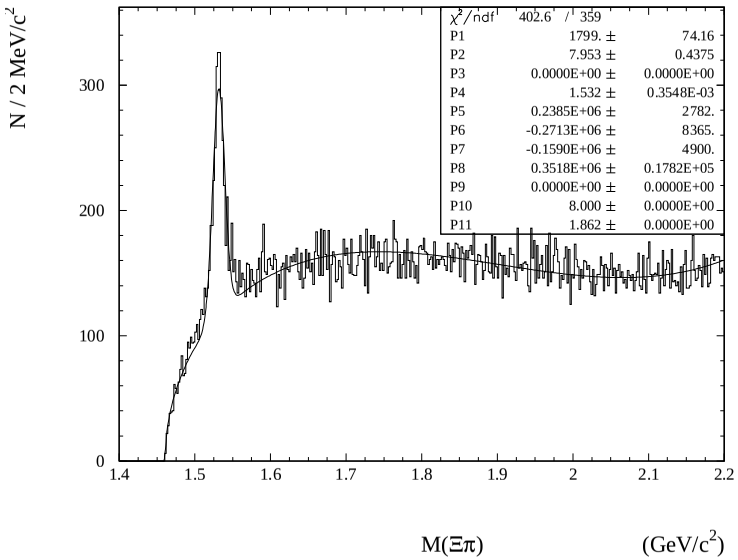
A We use loose $\chi^2_{r-\phi}$ on Λ and no $\chi^2_{r-\phi}$ cut on Ξ to retain as much signal as possible, especially as these would be the cuts applied at the initial sample selection stage, and apply only final $\chi^2_{r-\phi}$ on $\Xi\pi$ fit

Q3

Q You claim $\sigma = (5.8 \pm 0.5)\ \mathrm{MeV/c^2}$. Why do you use $10\ \mathrm{MeV/c^2}$ bin histogram? What happens if you re-bin the histogram to be

A Natural width of $\Gamma(\Xi(1530)) = 9.1\ \mathrm{MeV/c^2}$, so seemed reasonable. Fits With simple Gaussians:





Q4

Q **Upper Limit determination taking into account errors on mass and width**

A We re-did upper limit determination using unbinned likelihood fit. We minimized:

$$F = -2\ln\mathscr{L} = \mathscr{F}(\vec{\alpha}) - \sum_i^N \ln f(x_i,\vec{\alpha}) + \\ + GC(m) + GC(\sigma)$$

where $\mathscr{F}(\vec{\alpha}) = \int_a^b f(x,\vec{\alpha})dx$**,** a **and** b **are integration limits (1.4 and 2.2) and**

$$f(x_i,\vec{\alpha}) = G \otimes BW(x_i,\sigma_1,\Gamma,M_1) + \\ + G(x_i,\sigma_2,M_2) + \sqrt{(x_i-(M_\Xi+M_\pi))} \cdot \sum_{j=0}^{3}(x_i-(M_\Xi+M_\pi))^j$$

and

$$GC(M) = 0.5 \cdot \left(\frac{M_2 - 1.862}{0.002}\right)^2$$

$$GC(\sigma) = 0.5 \cdot \left(\frac{\sigma_2 - 0.008}{0.0012}\right)^2$$

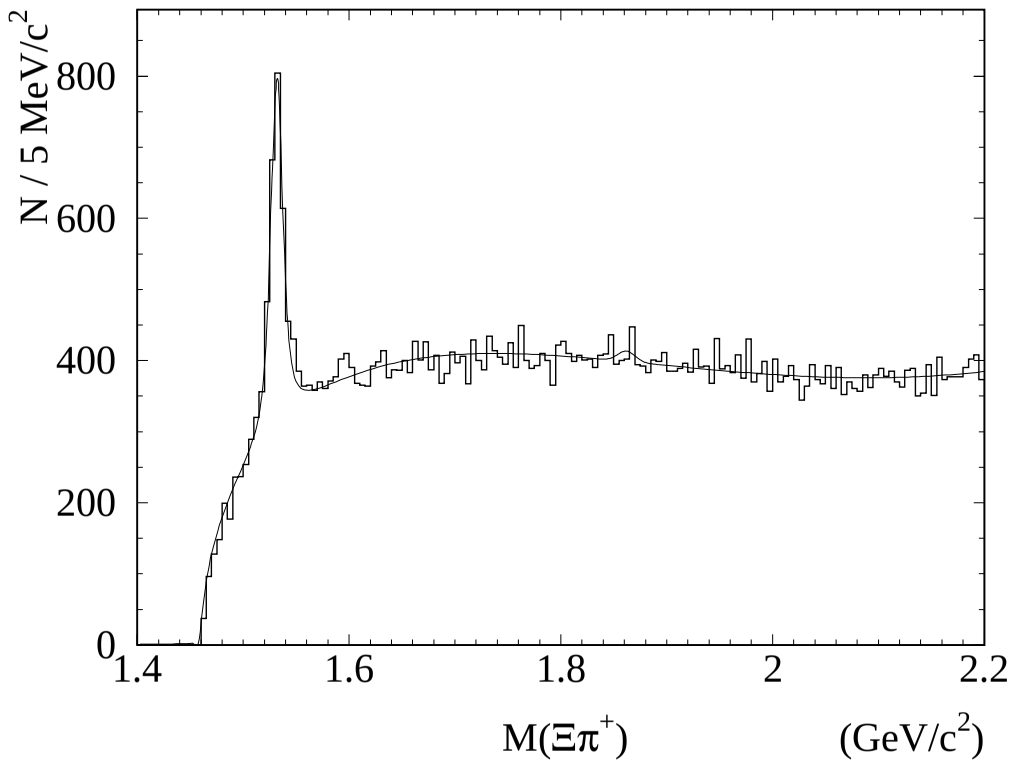
are Gaussian constraints

Q4 (cont)

```
FCN=  -1162269.     FROM MIGRAD    STATUS=CONVERGED    229 CALLS     1491 TOTAL
                    EDM=  0.48E-05    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER NO.	NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	N1	1886.0	76.761	0.56069	0.98624E-07
2	SIG1	0.32726E-02	0.50825E-03	0.19704E-04	0.19453
3	GAMMA	0.91000E-02	constant		
4	M1	1.5317	0.30058E-03	0.63290E-04	-0.82561E-01
5	A0	0.25979E+06	3300.9	22.301	0.24796E-07
6	A1	-0.47752E+06	20827.	41.974	0.24268E-08
7	A2	0.38631E+06	49464.	67.619	0.14031E-07
8	A3	-70483.	40571.	100.11	-0.36921E-08
9	N2	59.112	50.946	2.0333	-0.46272E-04
10	SIG2	0.80406E-02	0.11955E-02	0.62469E-03	1.2600
11	M2	1.8621	0.19703E-02	0.10359E-02	0.78019

Q4 (cont)

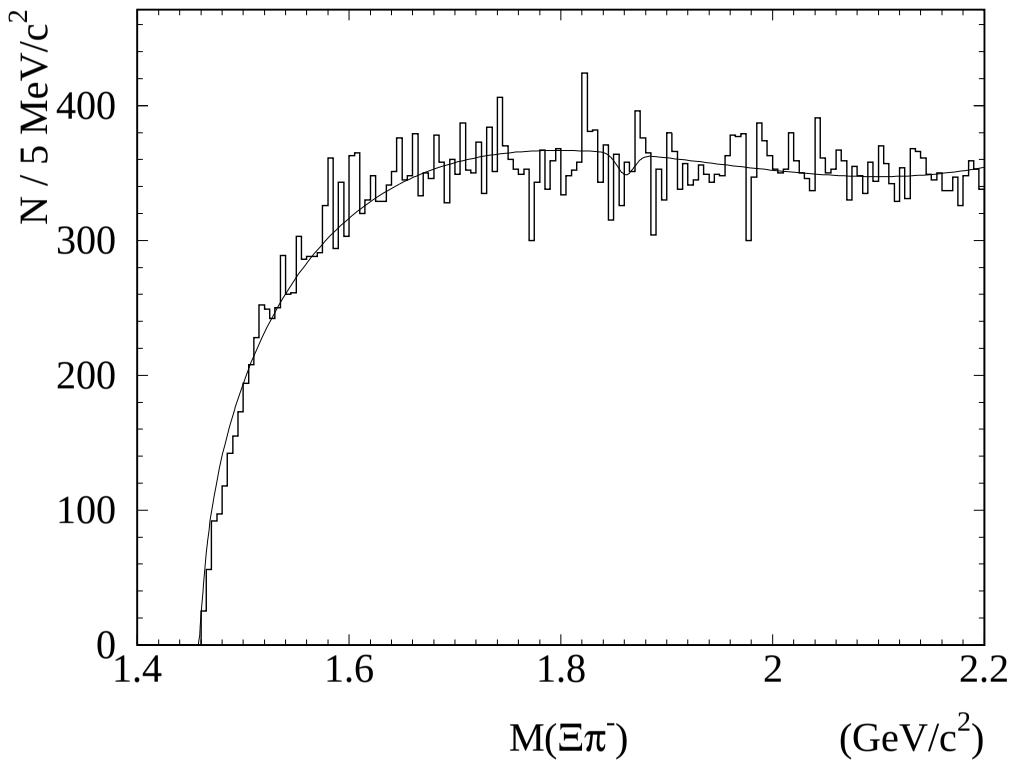


Q4 (cont)

```
FCN=  -988024.5     FROM MIGRAD    STATUS=CONVERGED    165 CALLS     1040 TOTAL
                    EDM=  0.39E-04    STRATEGY= 2      ERROR MATRIX ACCURATE

 EXT PARAMETER                                   STEP         FIRST
 NO.   NAME        VALUE          ERROR          SIZE      DERIVATIVE
  1     N1        -63.244        49.160        21.719       0.14395E-03
  2     SIG1      0.80323E-02   0.12050E-02   0.58222E-03    1.5777
  3     M1         1.8612       0.20556E-02   0.94699E-03    1.4906
  4     A0        0.20637E+06    1886.7        244.23       0.17911E-05
  5     A1       -0.28017E+06    7954.4        464.41       0.11719E-05
  6     A2        0.10579E+06    15060.        750.83       0.83168E-06
  7     A3         62749.        15915.        1116.9       0.51807E-06
```

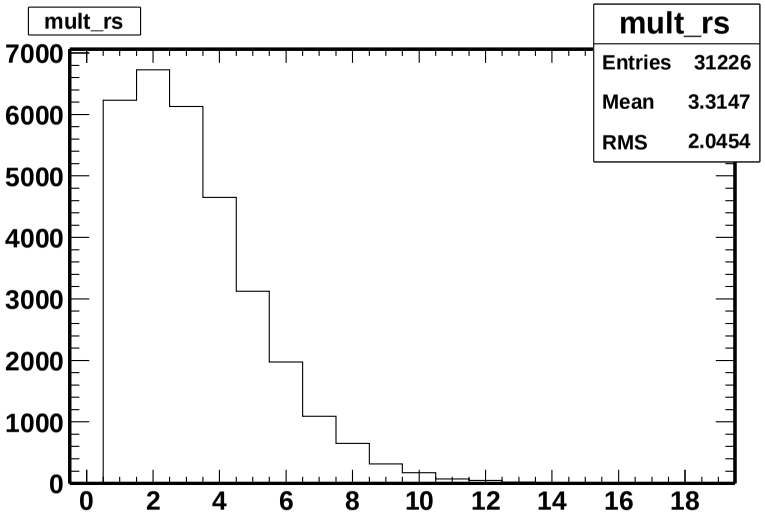
Q4 (cont)

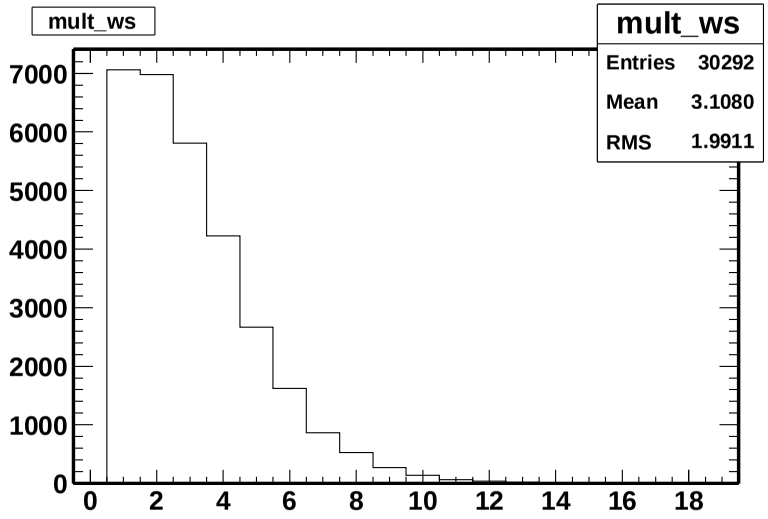


Q5

Q Number of candidates/event and how to handle them

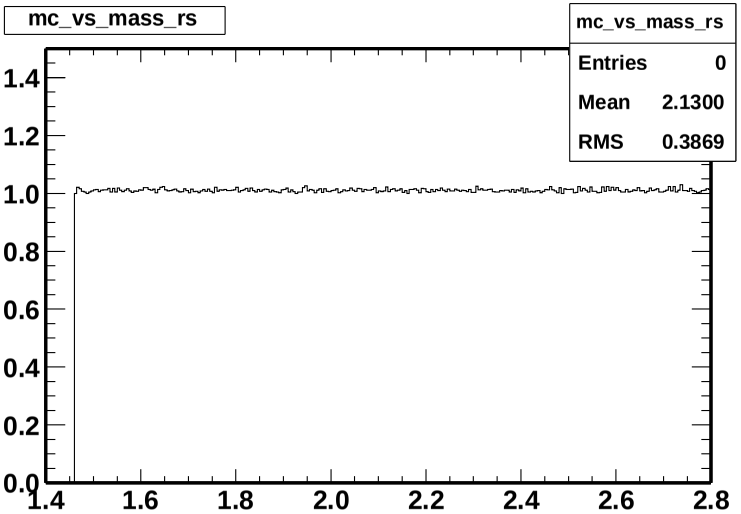
A Number of candidates per event for $1.5 < M(\Xi\pi) < 2.8$

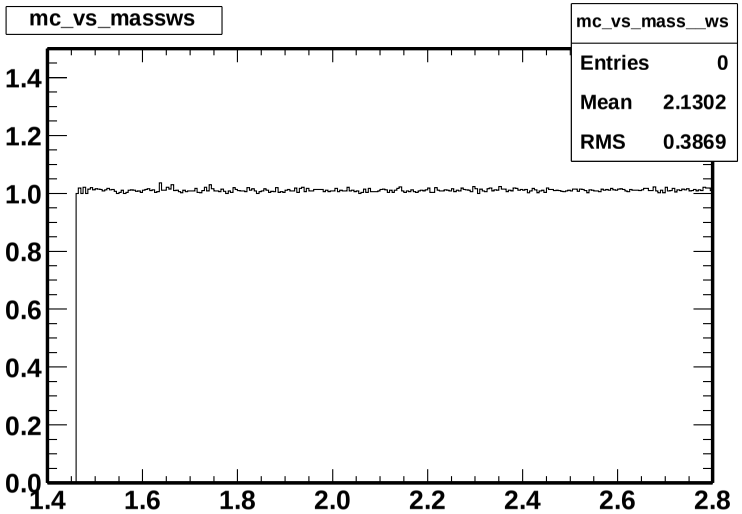




Q5 (cont)

- **Number of candidates/event vs mass, no spikes**





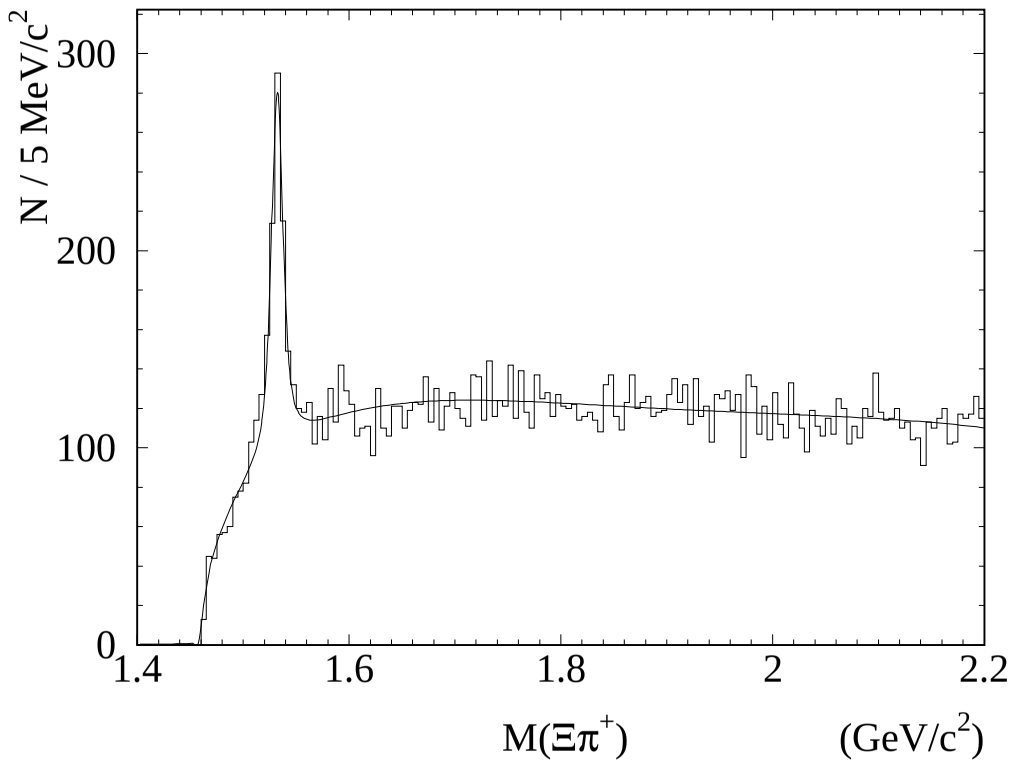
Q5 (cont)

- **Choose randomly one candidate per event, $\Xi\pi^+$**

```
FCN=  -316683.2     FROM MINOS     STATUS=SUCCESSFUL  3371 CALLS     4850 TOTAL
                    EDM=  0.15E-05    STRATEGY= 2      ERROR MATRIX ACCURATE

 EXT PARAMETER                   PARABOLIC         MINOS ERRORS
 NO.   NAME        VALUE           ERROR      NEGATIVE      POSITIVE
  1    N1          676.79         43.917       -46.264        47.684
  2    SIG1       0.30437E-02   0.78312E-03  -0.88298E-03   0.86173E-03
  3    GAMMA      0.91000E-02   constant
  4    M1          1.5321       0.47493E-03  -0.48440E-03   0.47420E-03
  5    A0          86439.        1838.2       -3134.8        3152.6
  6    A1        -0.20573E+06    11510.       -26351.        26287.
  7    A2         0.26716E+06    27177.       -66422.        66488.
  8    A3        -0.13549E+06    22216.       -51189.        51197.
  9    N2         0.22414        27.905       -27.565        28.791
 10    SIG2       0.80010E-02   0.12083E-02  -0.12076E-02   0.12079E-02
 11    M2          1.8620       0.20144E-02  -0.20076E-02   0.20182E-02
```

Q5 (cont)



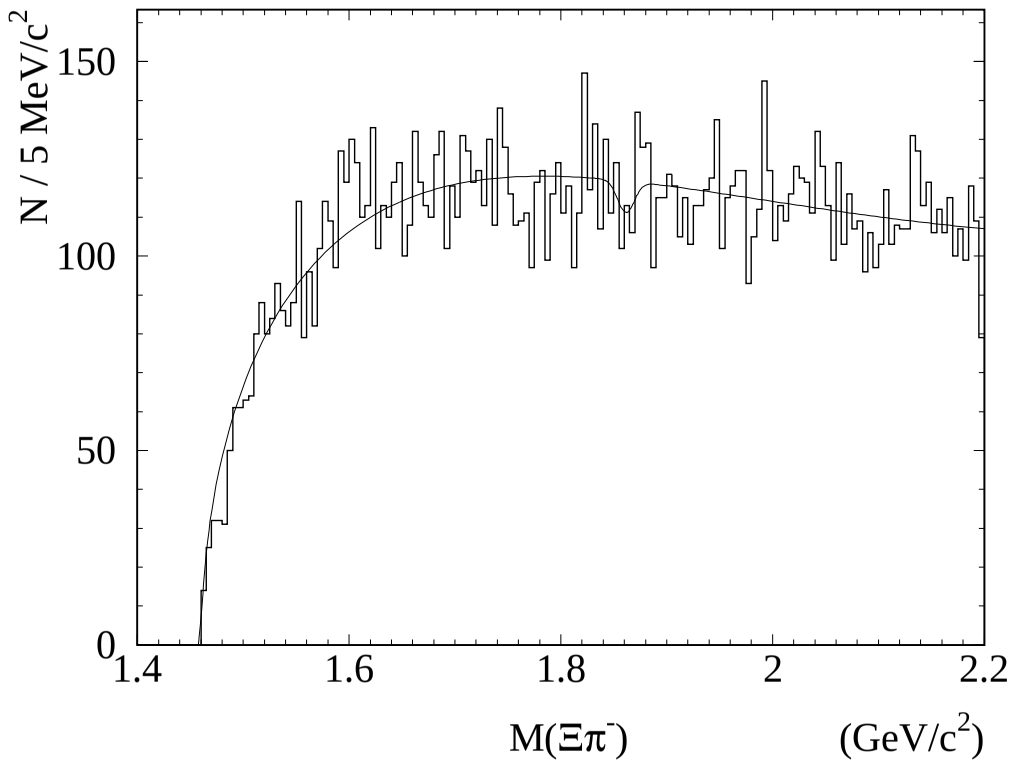
Q5 (cont)

- **Choose randomly one candidate per event, $\Xi\pi^-$**

```
FCN=  -286655.8     FROM MINOS     STATUS=SUCCESSFUL  1842 CALLS     2810 TOTAL
                    EDM=  0.36E-05    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER			PARABOLIC	MINOS ERRORS	
NO.	NAME	VALUE	ERROR	NEGATIVE	POSITIVE
1	N1	-31.743	26.778	-26.592	27.472
2	SIG1	0.78293E-02	0.12081E-02	-0.12007E-02	0.12106E-02
3	M1	1.8616	0.19306E-02	-0.19110E-02	0.19485E-02
4	A0	71486.	1376.3	-2489.7	2503.5
5	A1	-0.11661E+06	8243.9	-22505.	22531.
6	A2	90062.	19788.	-59540.	59265.
7	A3	-23759.	17165.	-46850.	47120.

Q5 (cont)



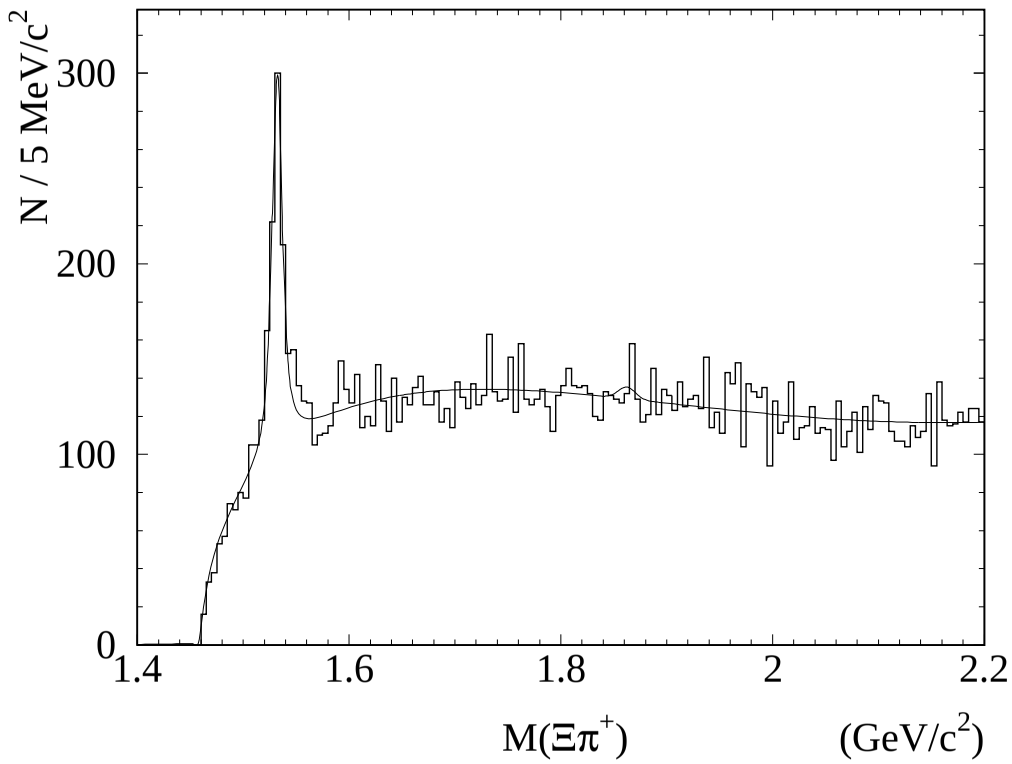
Q5 (cont)

- **Choose candidate with minimum $\chi^2_{r-\phi}$, $\Xi\pi^+$**

```
FCN=  -334971.1     FROM MINOS     STATUS=SUCCESSFUL  5864 CALLS     7651 TOTAL
                    EDM=  0.79E-06    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER			PARABOLIC	MINOS ERRORS	
NO.	NAME	VALUE	ERROR	NEGATIVE	POSITIVE
1	N1	678.04	43.414	-46.511	48.183
2	SIG1	0.23106E-02	0.99153E-03	-0.11375E-02	0.98629E-03
3	GAMMA	0.91000E-02	constant		
4	M1	1.5320	0.43110E-03	-0.43583E-03	0.43153E-03
5	A0	86256.	1233.2	-3199.8	3217.4
6	A1	-0.16267E+06	4823.3	-27031.	26925.
7	A2	0.13595E+06	8575.6	-68123.	68321.
8	A3	-32434.	9161.9	-52626.	52522.
9	N2	24.686	28.900	-29.067	29.723
10	SIG2	0.79507E-02	0.11912E-02	-0.11880E-02	0.11941E-02
11	M2	1.8623	0.19857E-02	-0.20059E-02	0.19735E-02

Q5 (cont)



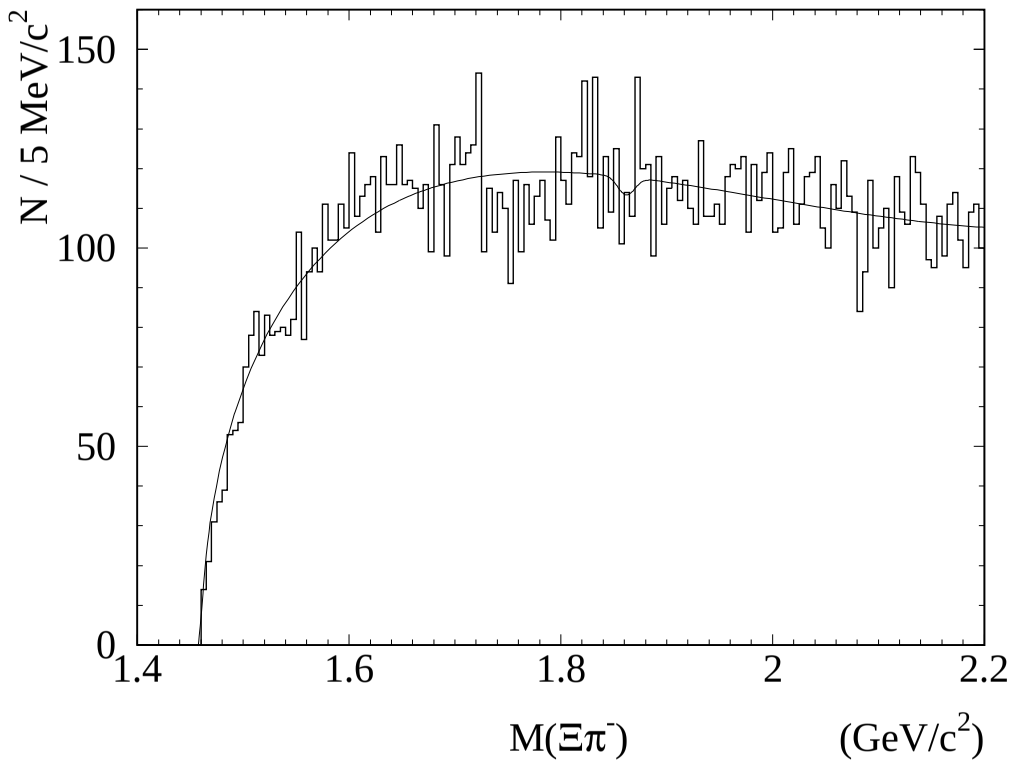
Q5 (cont)

- **Choose candidate with minimum $\chi^2_{r-\phi}$, $\Xi\pi^-$**

```
FCN=  -281640.9     FROM MIGRAD    STATUS=CONVERGED    187 CALLS      930 TOTAL
                    EDM=  0.22E-06    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER NO.	NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	N1	-18.021	27.006	6.5986	0.87540E-05
2	SIG1	0.78919E-02	0.12289E-02	0.31679E-03	-0.35955
3	M1	1.8618	0.19769E-02	0.50468E-03	0.14436
4	A0	69061.	1075.1	73.621	0.23472E-07
5	A1	-0.10434E+06	4483.4	139.82	-0.23807E-07
6	A2	65482.	8358.6	228.57	0.25323E-07
7	A3	-8032.8	8799.0	350.05	-0.86779E-08

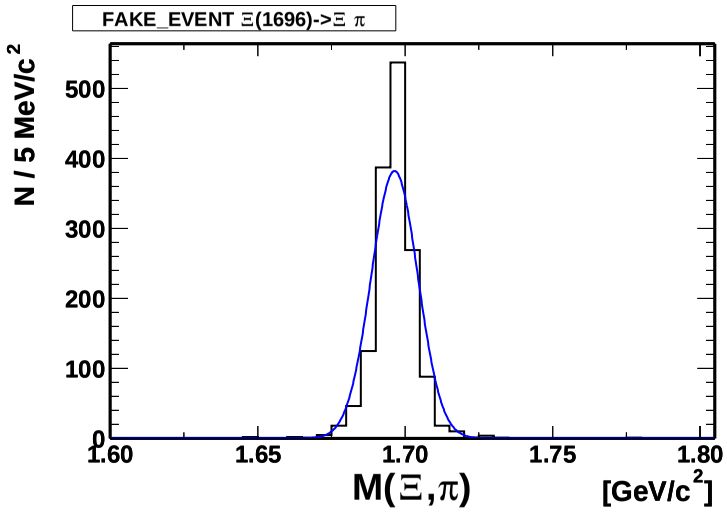
Q5 (cont)



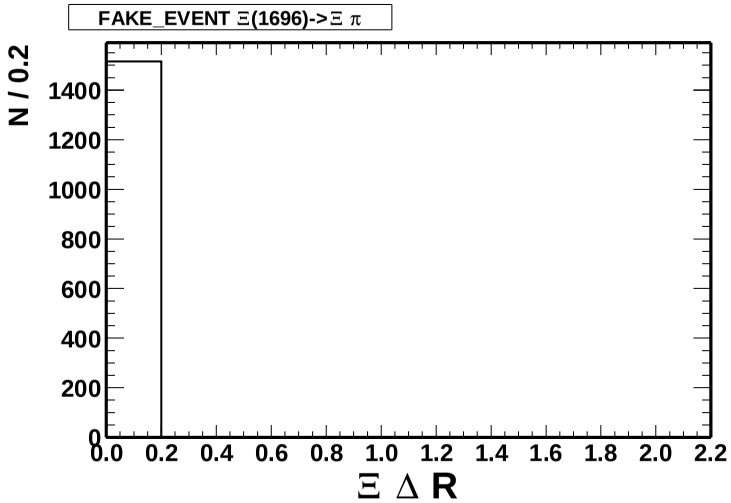
MC Widths & R cuts

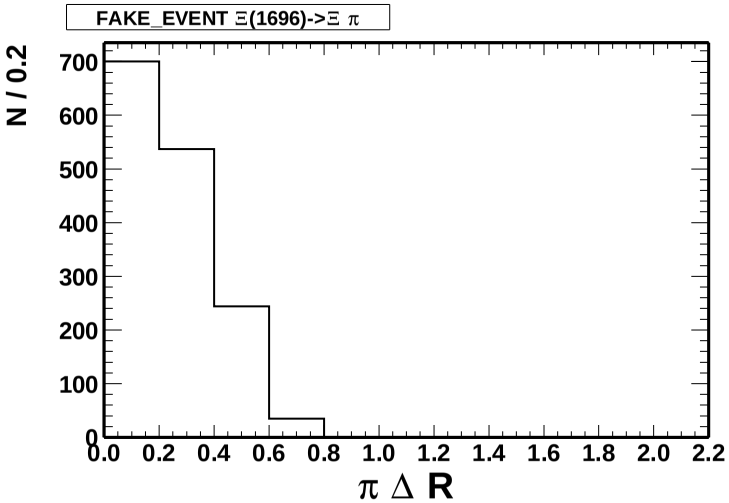
- Generated FAKE_EVENT , flat p_T pentaquarks (Ξ_c) with for masses – 1.532, 1.696, 1.862, 2.027. Full Simulation, cdfsoft2 4.11.2.
- The produced p_T is weighted to match the data

MC Widths & R cuts

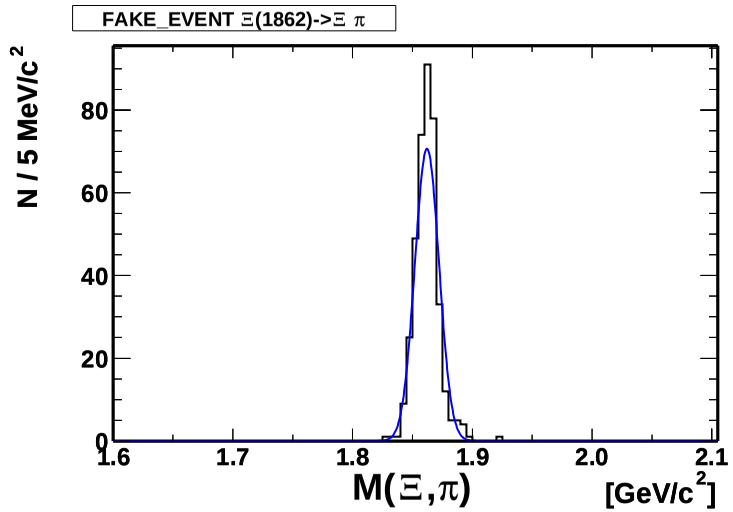


$$\sigma = 7.9 \pm 0.1\ \mathrm{MeV}/c^2$$

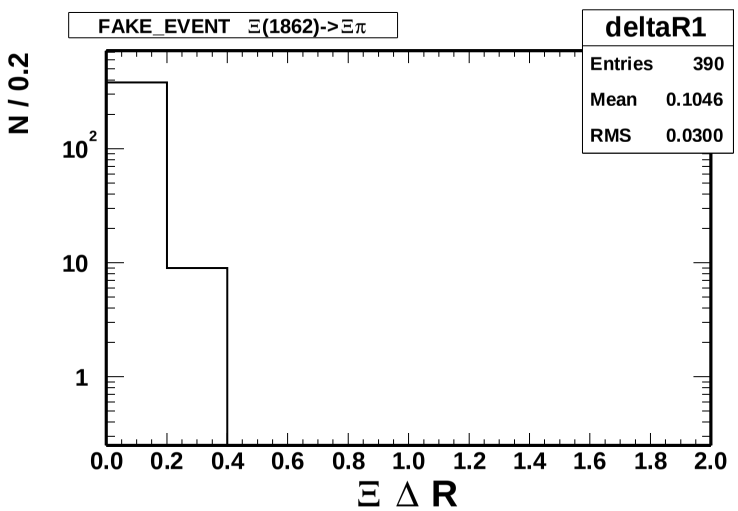


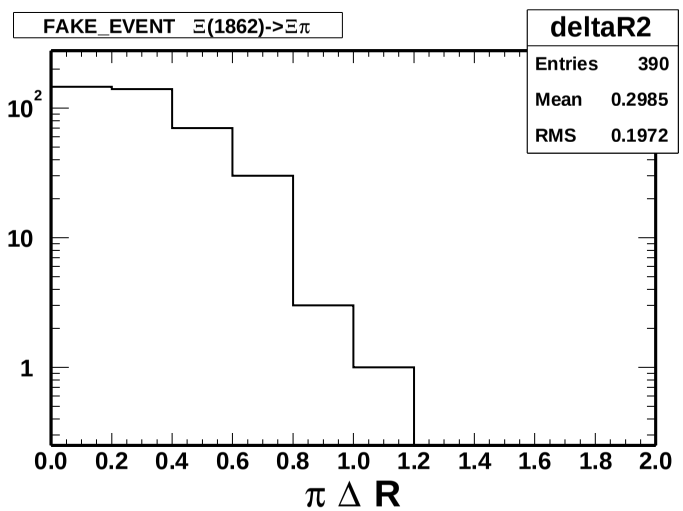


MC Widths & R cuts

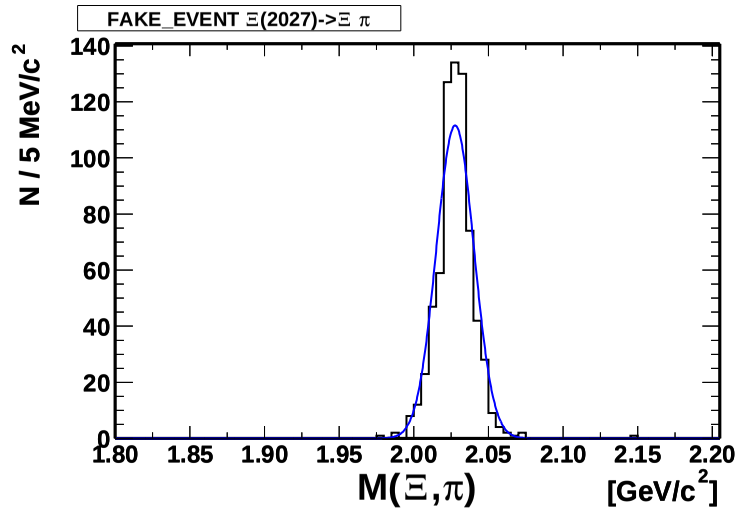


$$\sigma = 10.1 \pm 0.4\ \mathrm{MeV/c^2}$$

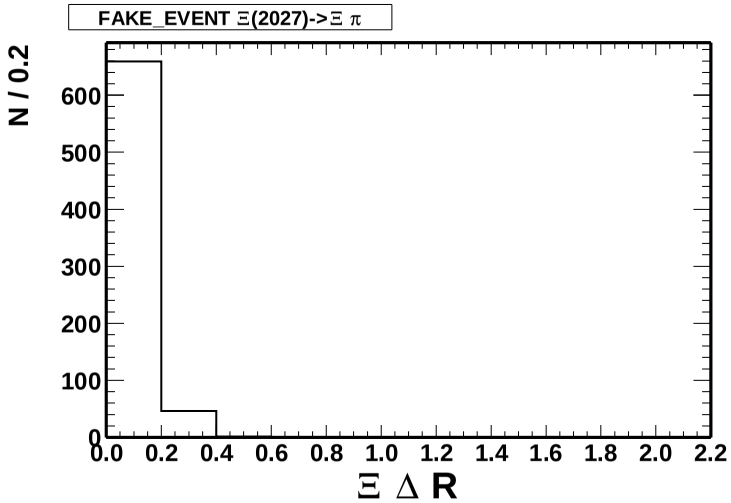


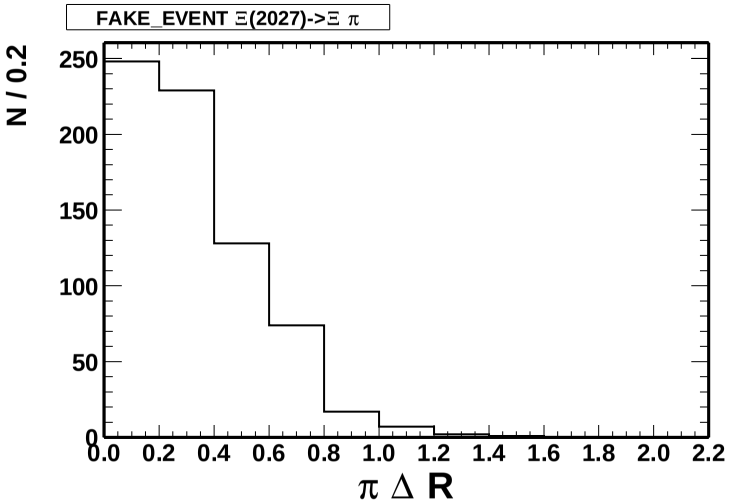


MC Widths & R cuts



$$\sigma = 12.6 \pm 0.3\ \mathrm{MeV}/c^2$$





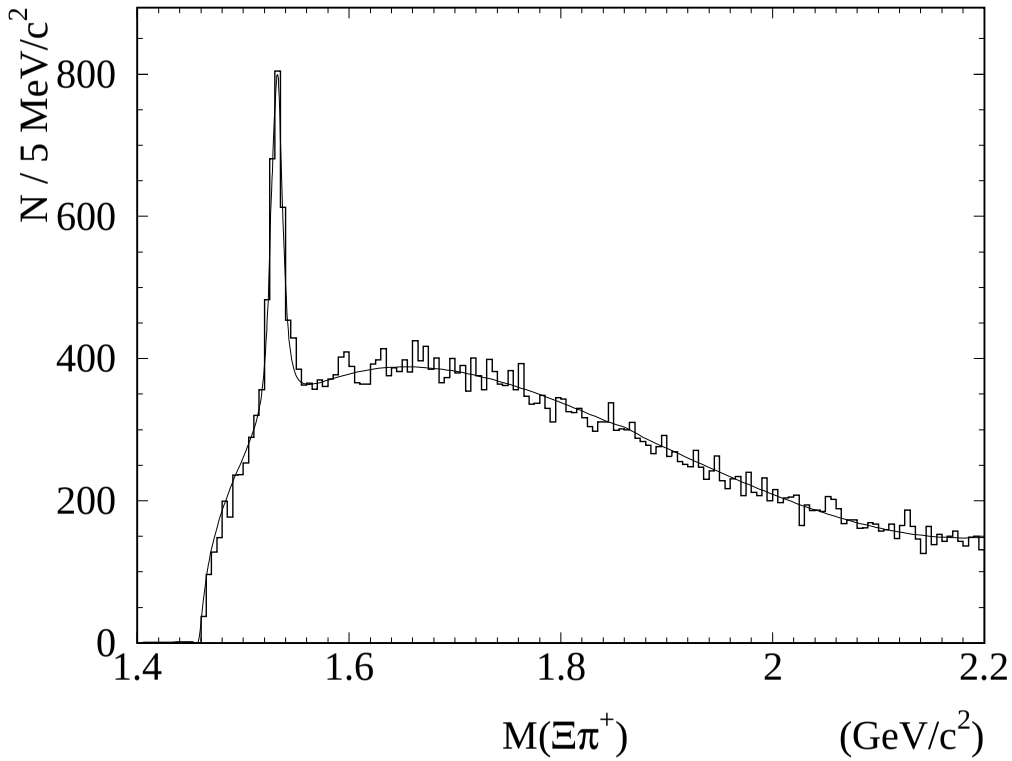
$R < 0.7$

- $\Delta R_1 < 0.7$ **and** $\Delta R_2 < 0.7$ $\Xi\pi^+$

```
FCN=  -848593.5     FROM MINOS     STATUS=SUCCESSFUL  3514 CALLS     4993 TOTAL
                    EDM=  0.12E-04    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER			PARABOLIC	MINOS ERRORS	
NO.	NAME	VALUE	ERROR	NEGATIVE	POSITIVE
1	N1	1801.7	74.044	-78.585	80.047
2	SIG1	0.29628E-02	0.50818E-03	-0.52665E-03	0.51799E-03
3	GAMMA	0.91000E-02	constant		
4	M1	1.5317	0.29899E-03	-0.29934E-03	0.29962E-03
5	A0	0.27001E+06	2787.6	-5396.1	5414.4
6	A1	-0.51178E+06	16215.	-43344.	43291.
7	A2	94753.	38398.	-0.10500E+06	0.10503E+06
8	A3	0.22550E+06	31599.	-78153.	78196.
9	N2	12.157	43.099	-43.473	44.220
10	SIG2	0.79927E-02	0.12018E-02	-0.12029E-02	0.12009E-02
11	M2	1.8620	0.19997E-02	-0.19992E-02	0.20006E-02

$R < 0.7$



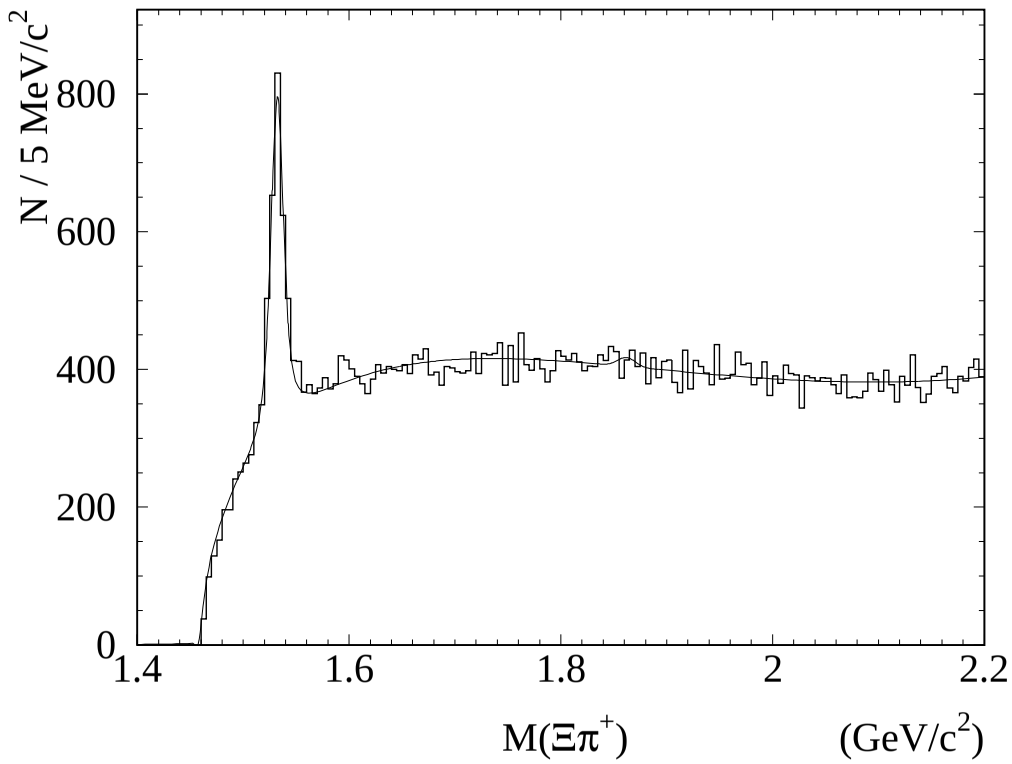
Q7 track refit

Q re-fit decay pion according to standard procedures

```
FCN=  -1182447.     FROM MINOS     STATUS=SUCCESSFUL  3283 CALLS     4891 TOTAL
                    EDM=  0.54E-05    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER			PARABOLIC	MINOS ERRORS	
NO.	NAME	VALUE	ERROR	NEGATIVE	POSITIVE
1	N1	1924.3	77.457	-82.443	83.613
2	SIG1	0.36550E-02	0.49192E-03	-0.50610E-03	0.50262E-03
3	GAMMA	0.91000E-02	constant		
4	M1	1.5321	0.31514E-03	-0.31413E-03	0.31598E-03
5	A0	0.26628E+06	2994.9	-5672.8	5722.4
6	A1	-0.50488E+06	16379.	-48176.	47761.
7	A2	0.43982E+06	36742.	-0.12102E+06	0.12192E+06
8	A3	-0.10647E+06	31592.	-94076.	93485.
9	N2	53.101	52.593	-51.891	54.347
10	SIG2	0.81633E-02	0.11924E-02	-0.11946E-02	0.11885E-02
11	M2	1.8620	0.20211E-02	-0.20243E-02	0.20172E-02

Q7 (cont)



Q7, $R < 0.7$

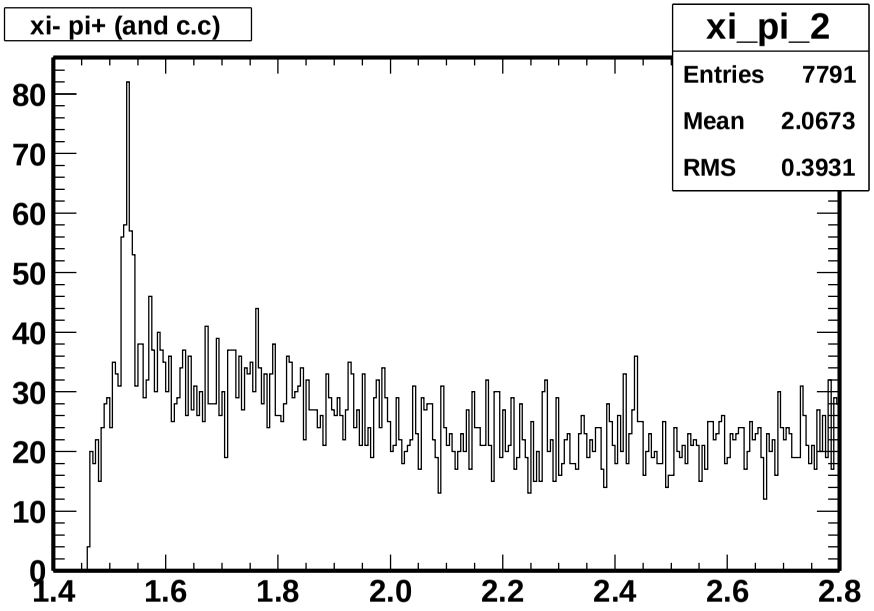
- $\Delta R_1 < 0.7$ **and** $\Delta R_2 < 0.7$ $\Xi\pi^+$

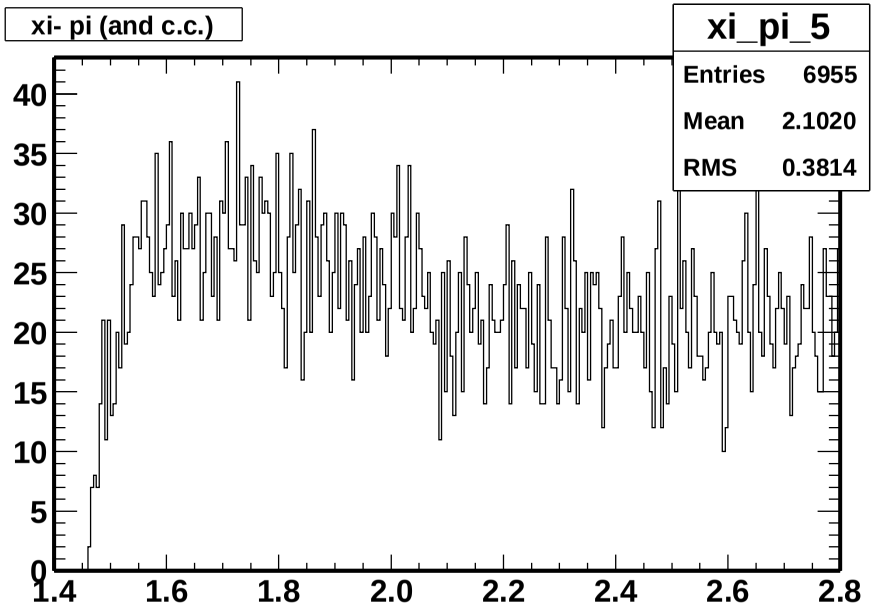
EXT NO.	PARAMETER NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	N1	1837.5	75.649	2.4275	-0.92916E-07
2	SIG1	0.33458E-02	0.49608E-03	0.16694E-04	1.4583
3	GAMMA	0.91000E-02	constant		
4	M1	1.5321	0.31026E-03	0.22713E-05	-11.869
5	A0	0.27675E+06	2869.8	2.8868	0.71077E-07
6	A1	-0.53472E+06	17014.	25.205	-0.20322E-07
7	A2	0.12246E+06	40556.	7.9477	0.20507E-08
8	A3	0.21362E+06	33188.	11.883	0.95275E-08
9	N2	9.7013	43.344	1.5098	0.72289E-07
10	SIG2	0.80008E-02	0.11983E-02	0.24000E-03	-0.43049E-03
11	M2	1.8620	0.19987E-02	0.40000E-03	0.72396E-03

Q8 SVT proton

Q sample composition by TTT track configuration (one, two ...)

A require proton SVT match

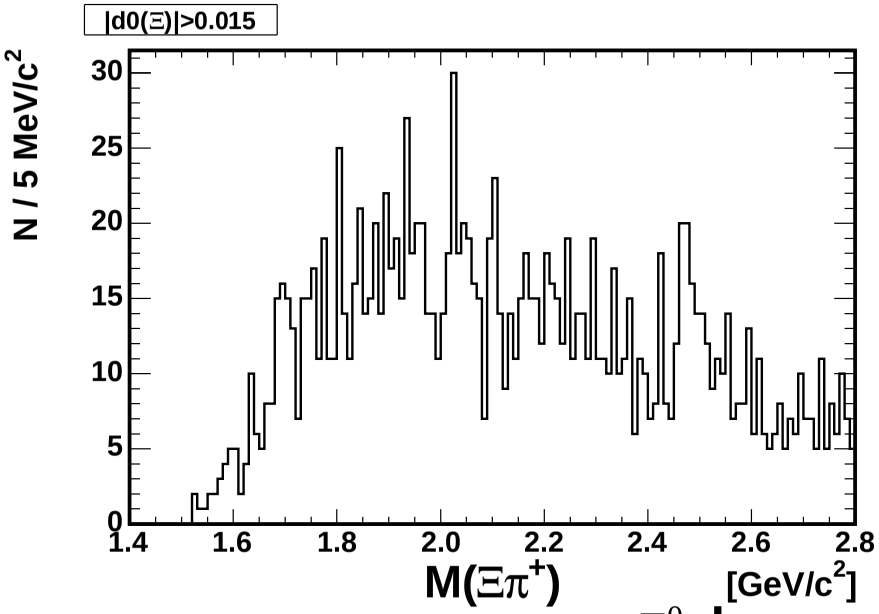


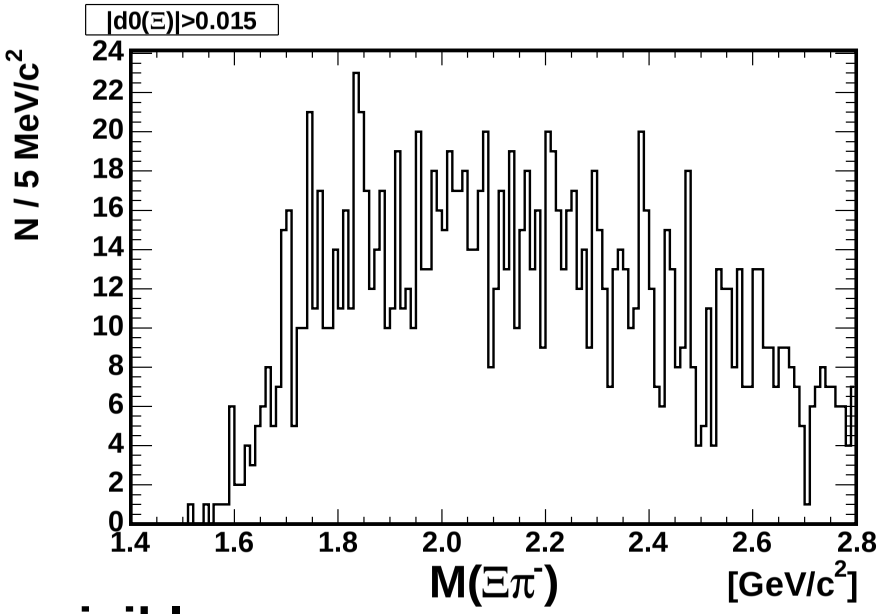


Q9 SVT proton

Q How the spectra look like with $|d_0(\Xi)| > 0.015$

A :





Ξ_c^0 **becomes visible...**

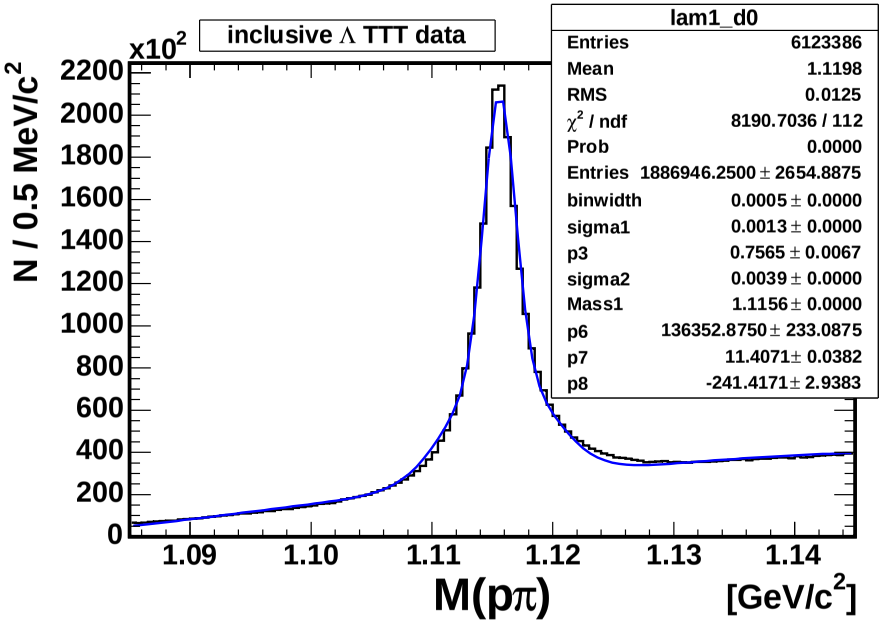
MC Studies

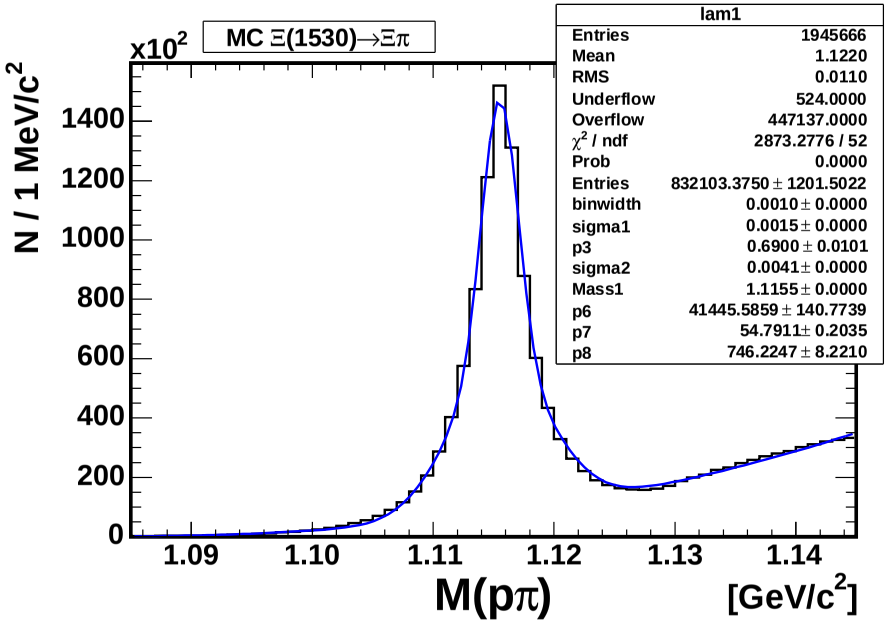
MC samples

- we have 4 samples generated with `FAKE_EVENT` for different masses 1530, 1696, 1862, 2027MeV/c^2
- using correct alignment table all the widths went down and look good now
- present comprison of MC/dat to show that we can trust MC
- mass plots fit with the function:

$$F = N \cdot \left(\frac{1}{1+r} \cdot Gauss(m, M_0, \sigma_1) + \frac{r}{1+r} \cdot Gauss(m, M_0, \sigma_2) \right)$$

Λ resolution





TTT data,

$\sigma_1 = 1.3\ \mathrm{MeV/c^2}$,

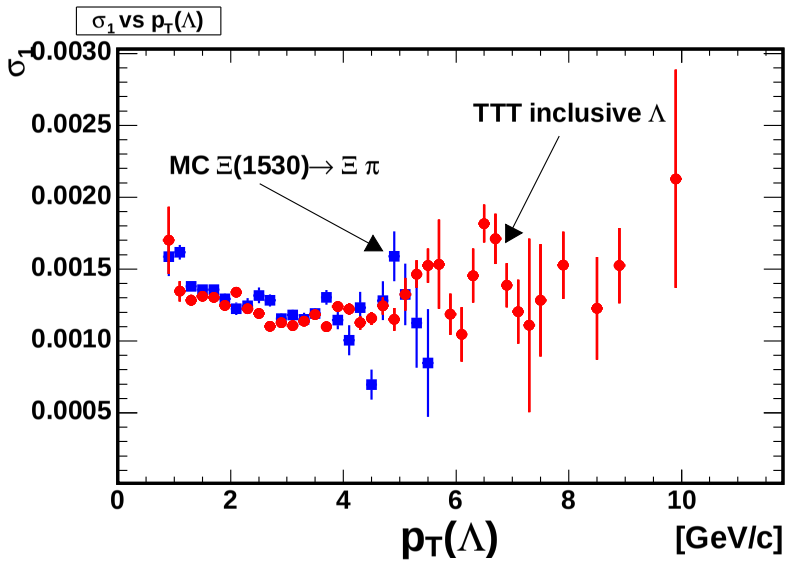
$\sigma_2 = 3.9\ \mathrm{MeV/c^2}$

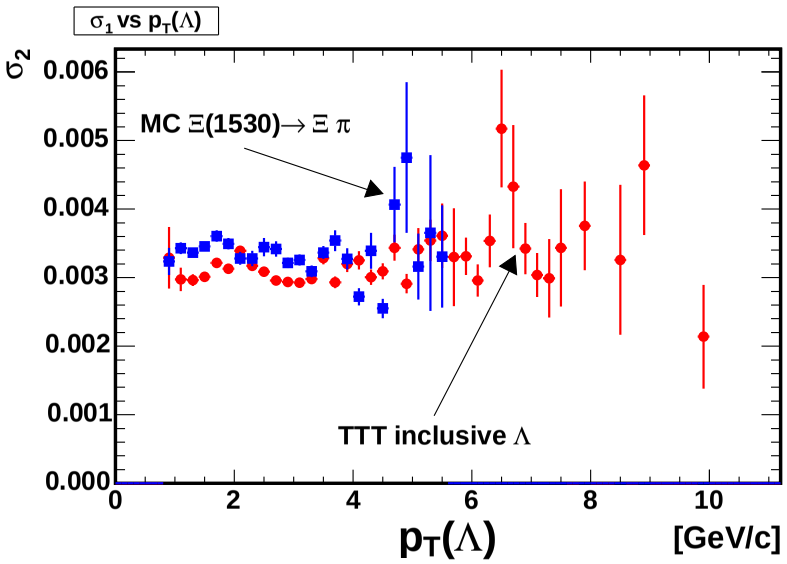
FAKE_EVENT

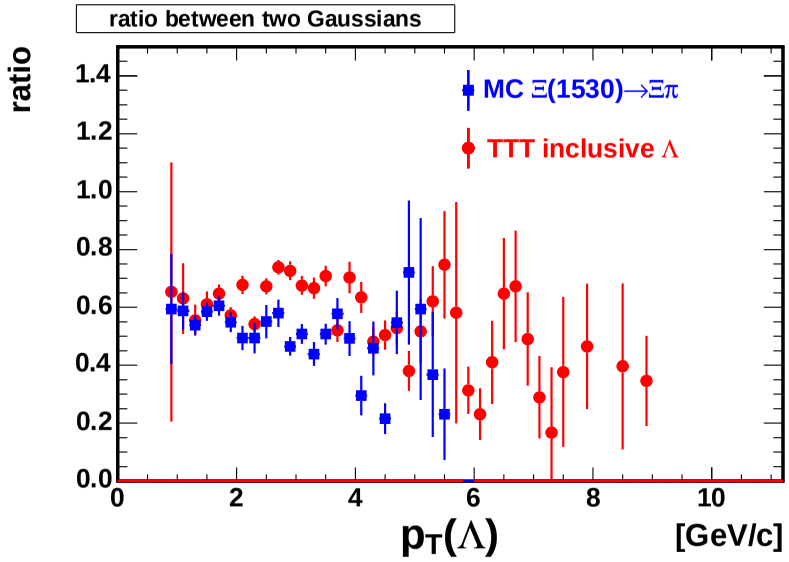
$\sigma_1 = 1.5\ \mathrm{MeV/c^2}$,

$\sigma_2 = 4.1\ \mathrm{MeV/c^2}$

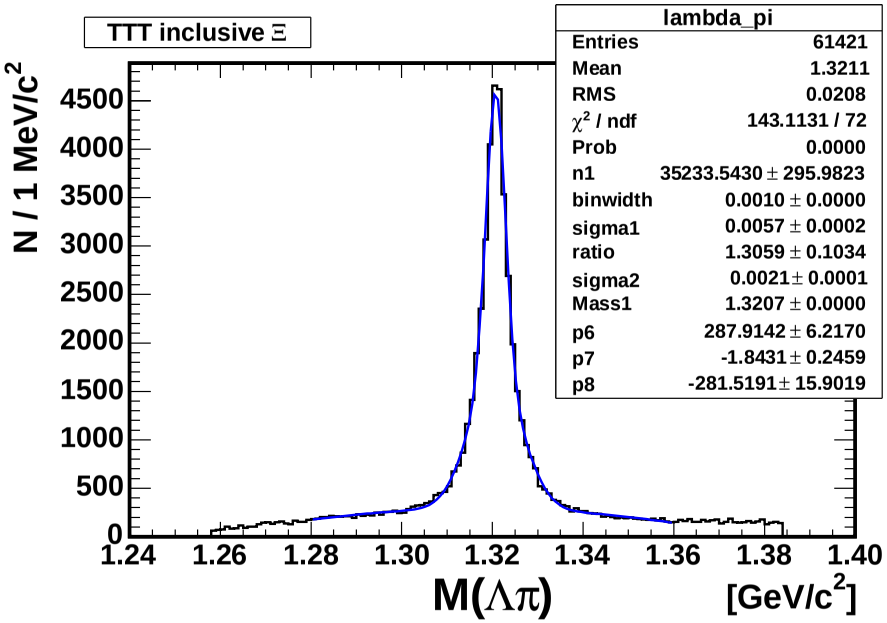
Λ resolution (Cont)

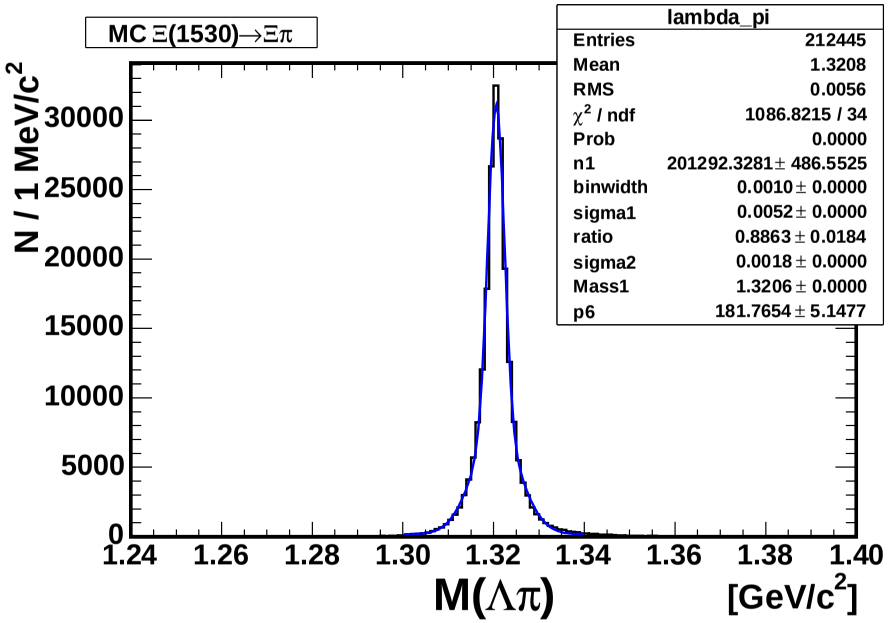






Ξ resolution





TTT data,

$\sigma_1 = (5.7 \pm 0.2)\ \mathrm{MeV/c^2}$,

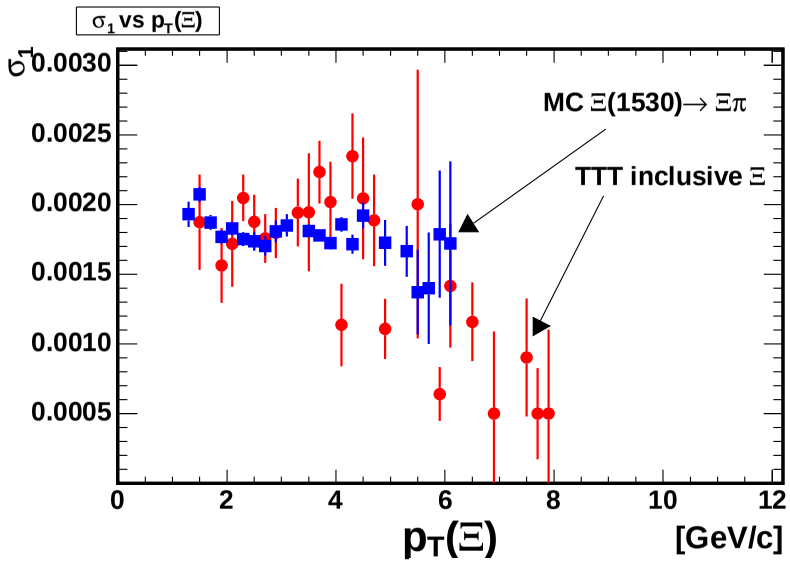
$\sigma_2 = (2.1 \pm 0.1)\ \mathrm{MeV/c^2}$

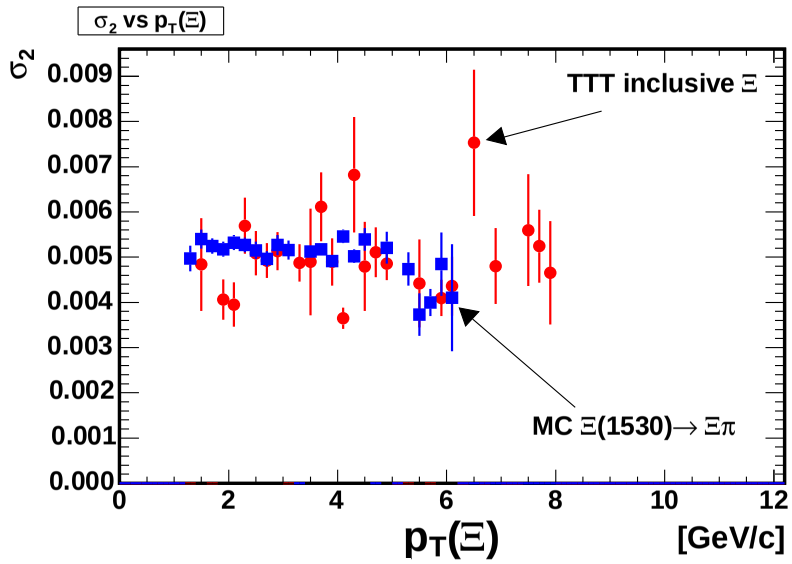
FAKE_EVENT

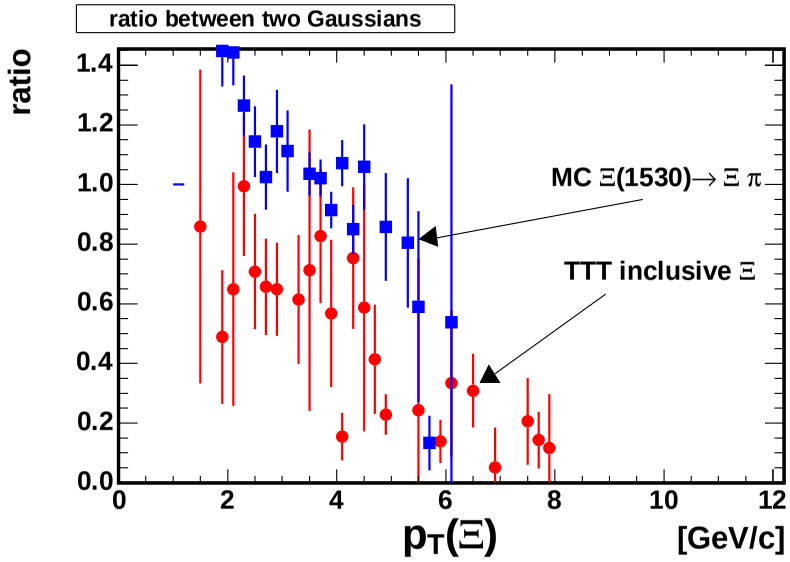
$\sigma_1 = 5.2\ \mathrm{MeV/c^2}$,

$\sigma_2 = 1.8\ \mathrm{MeV/c^2}$

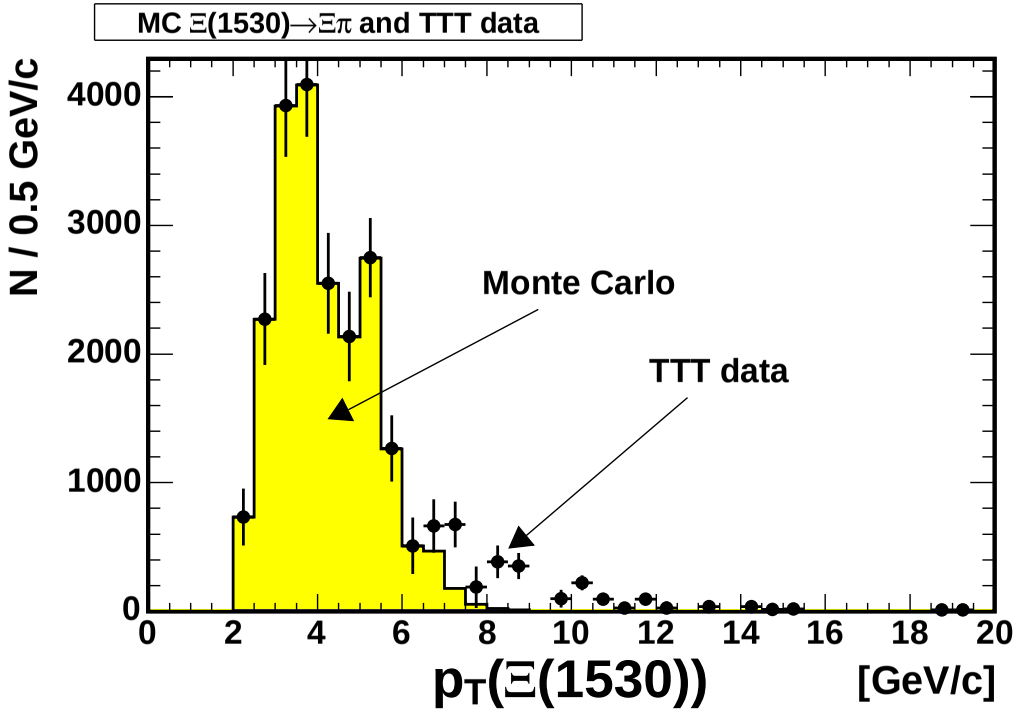
Ξ resolution (Cont)



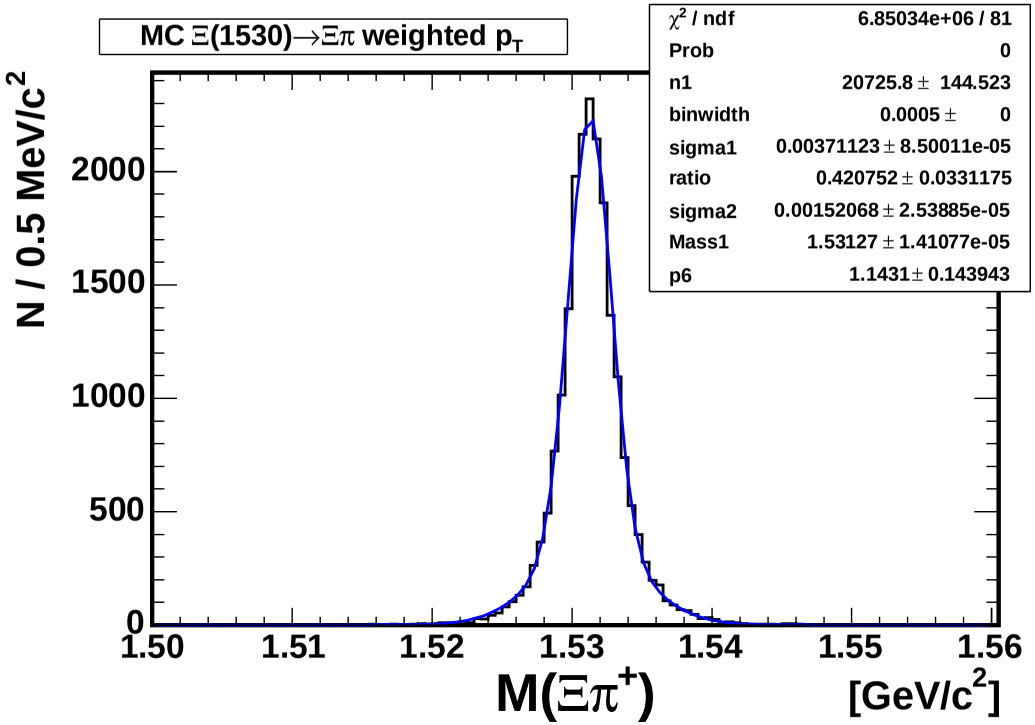




$\Xi(1530)$ resolution

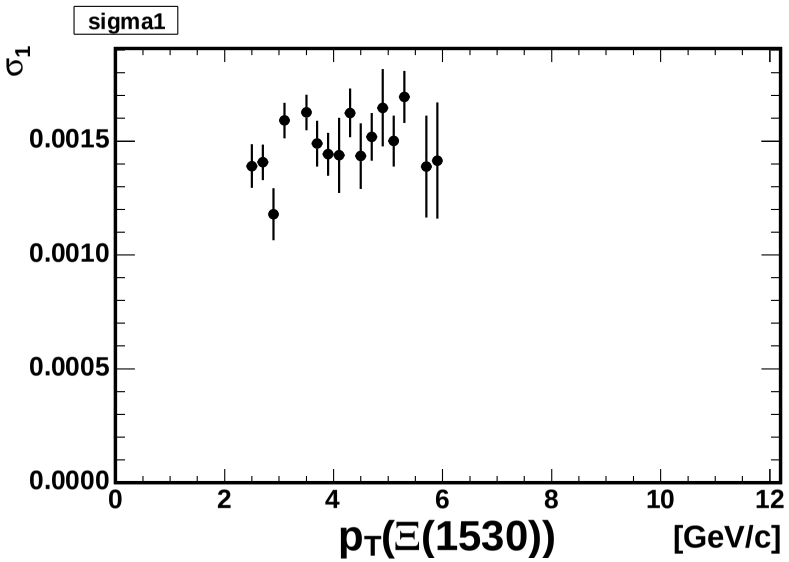


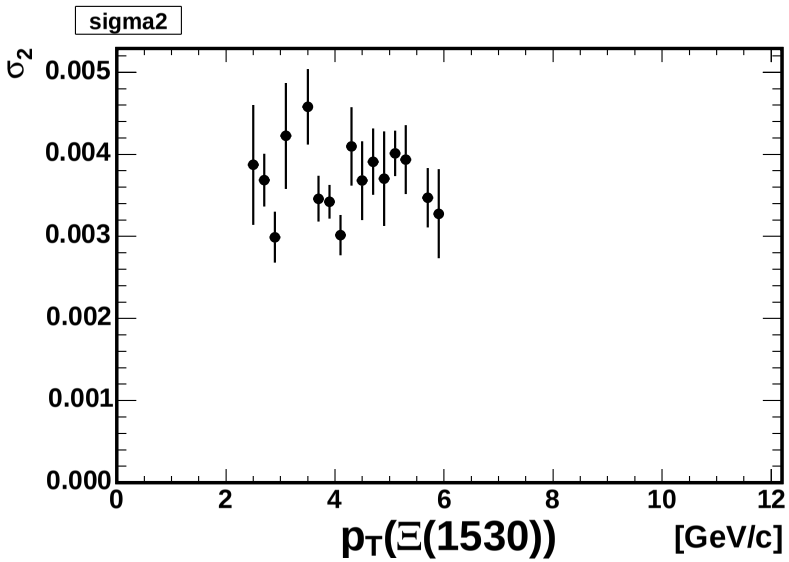
$\Xi(1530)$ resolution

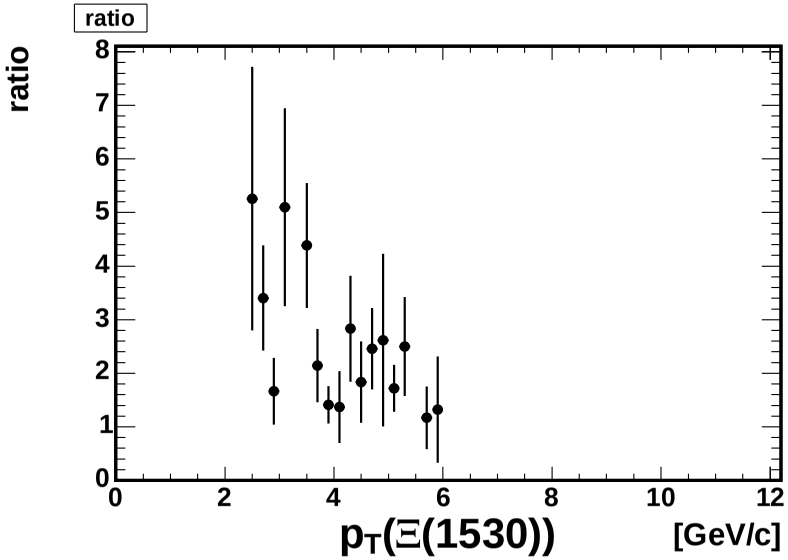


FAKE_EVENT $\sigma_1 = 1.5\ \mathrm{MeV/c^2}$, $\sigma_2 = 3.7\ \mathrm{MeV/c^2}$

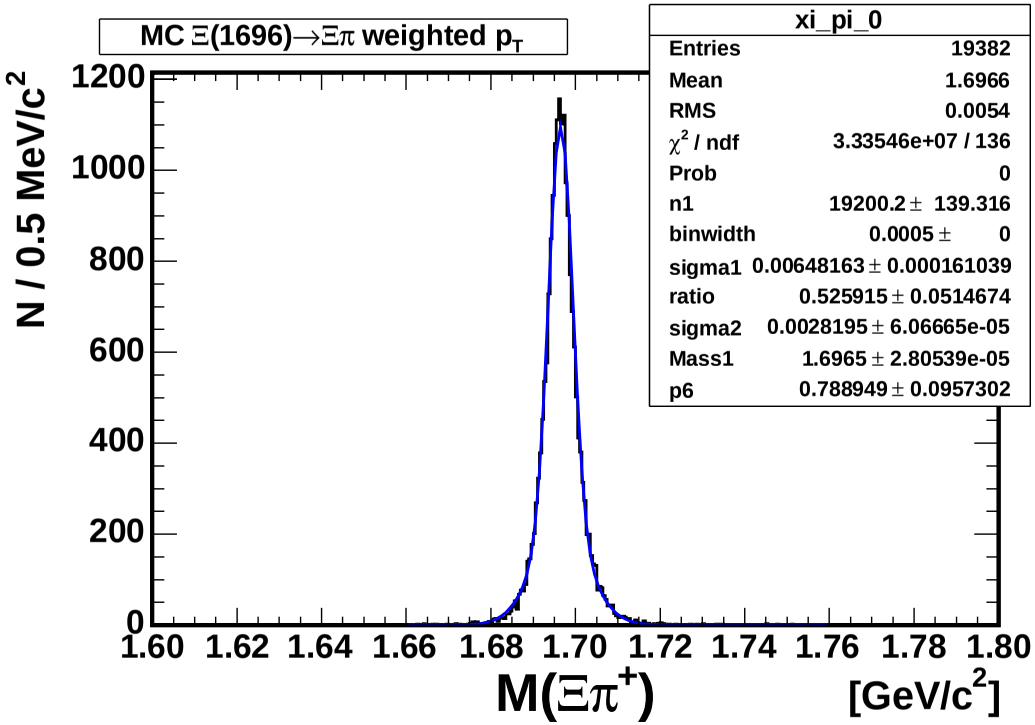
$\Xi(1530)$ resolution





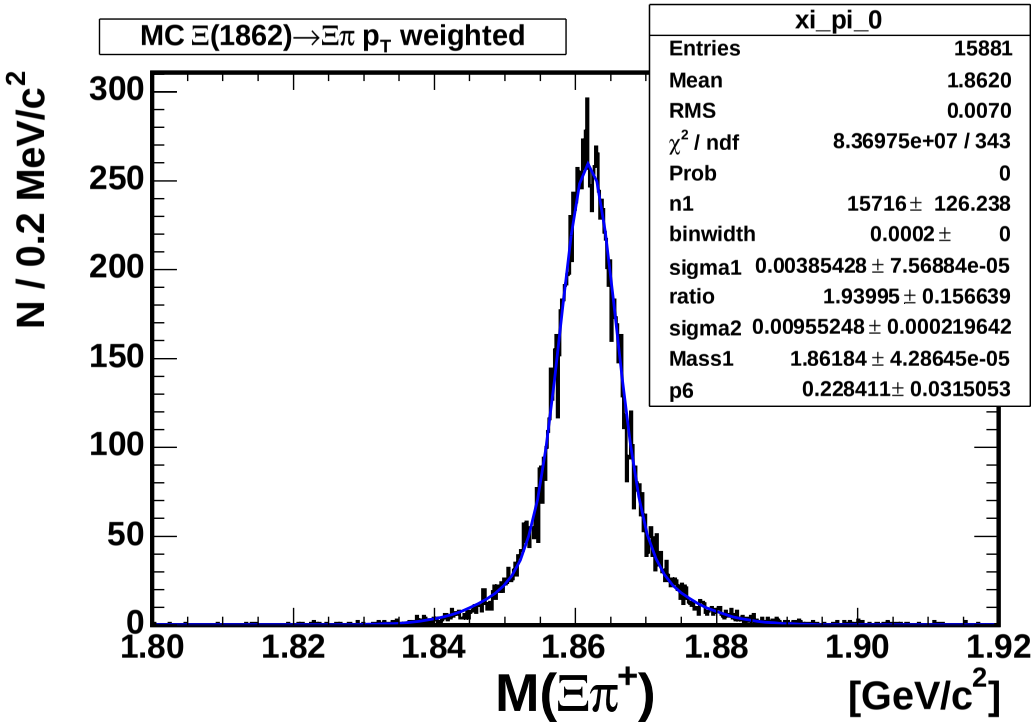


$\Xi(1696)$ resolution



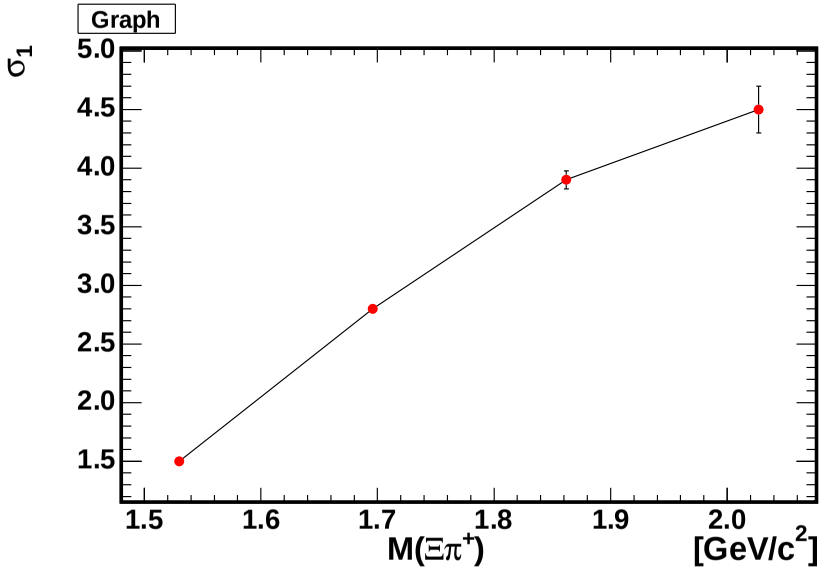
FAKE_EVENT $\sigma_1 = 2.8\ \mathrm{MeV/c^2}$, $\sigma_2 = 6.4\ \mathrm{MeV/c^2}$

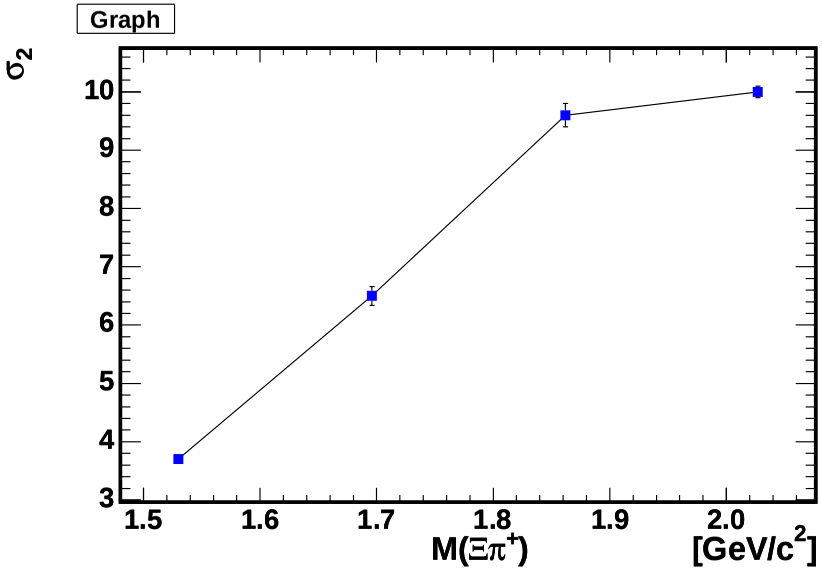
$\Xi(1862)$ resolution



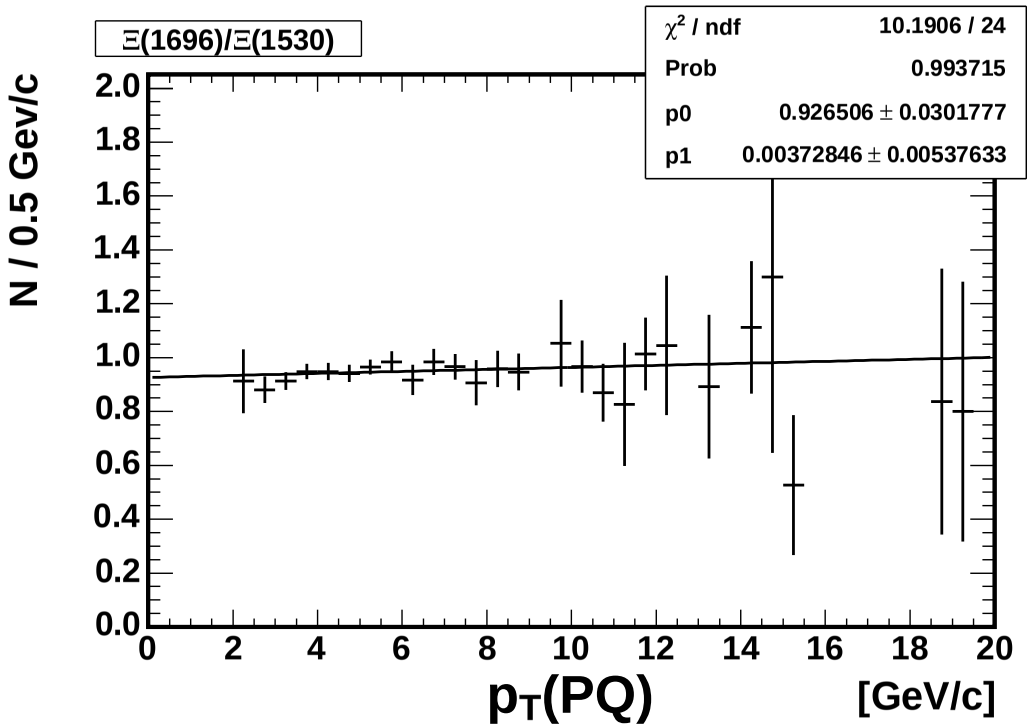
FAKE_EVENT $\sigma_1 = 3.8\ \mathrm{MeV/c^2}$, $\sigma_2 = 9.6\ \mathrm{MeV/c^2}$

Summary

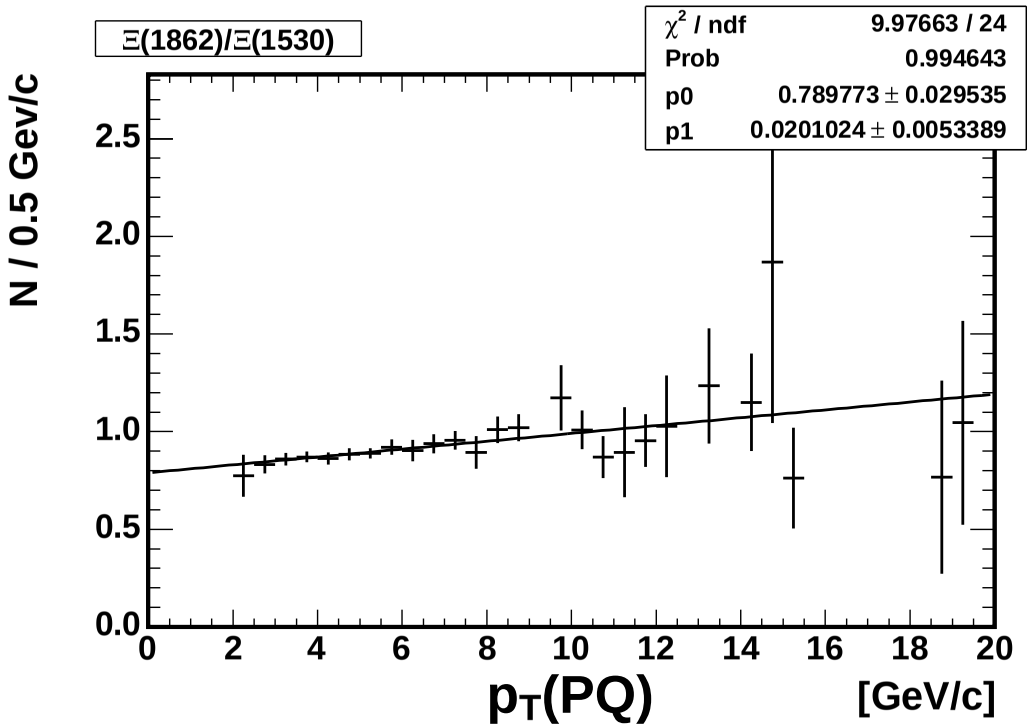

Graph
σ1
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.5
1.6
1.7
1.8
1.9
2.0
M(Ξπ+)
[GeV/c2]


Graph
σ2
10
9
8
7
6
5
4
3
1.5
1.6
1.7
1.8
1.9
2.0
M(Ξπ+)
[GeV/c2]

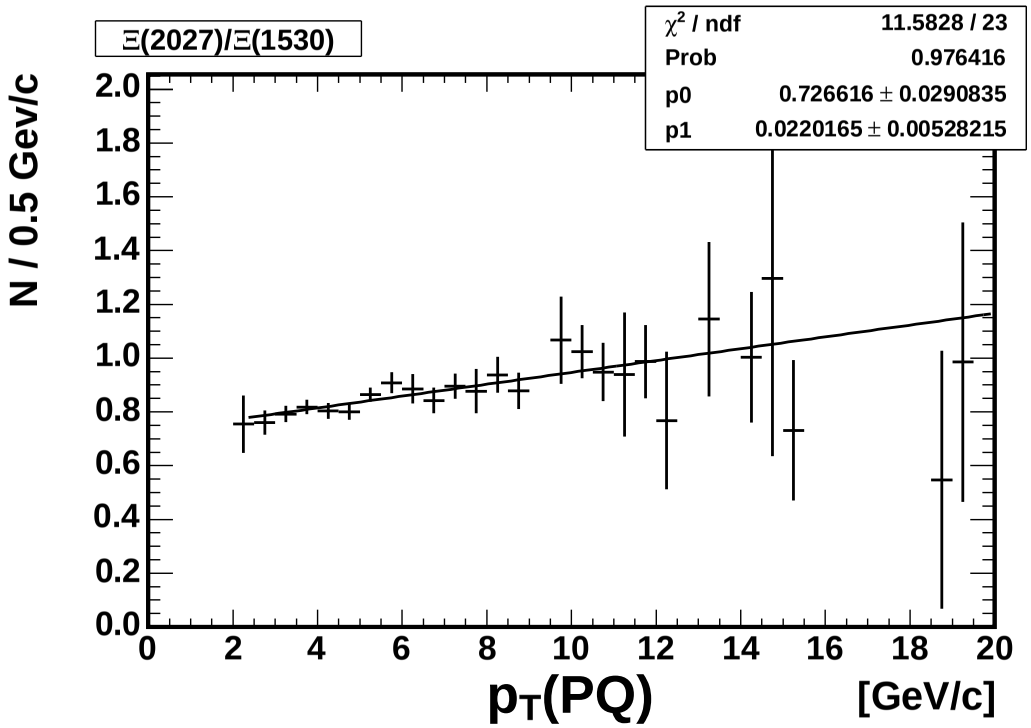
Relative Efficiency



Relative Efficiency



Relative Efficiency



Long Hiatus

Finalizing Numbers

Reminder

- **Width**
- **Fit procedure**
- **Relative Efficiencies**

Width

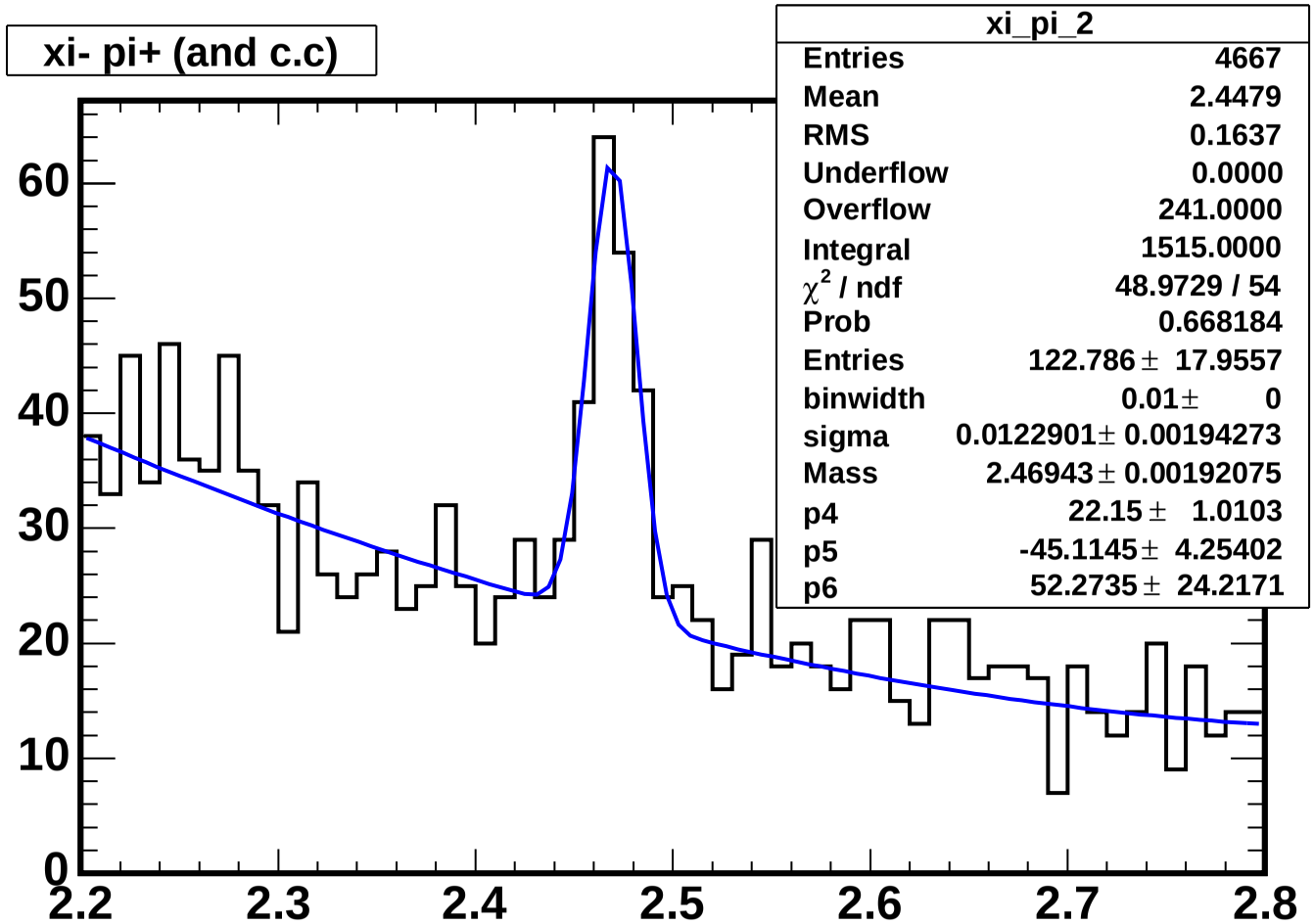
Reminder

```
FCN=  -1162269.     FROM MIGRAD    STATUS=CONVERGED    229 CALLS     1491 TOTAL
                    EDM=  0.48E-05    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER NO.	NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	N1	1886.0	76.761	0.56069	0.98624E-07
2	SIG1	0.32726E-02	0.50825E-03	0.19704E-04	0.19453
3	GAMMA	0.91000E-02	constant		
4	M1	1.5317	0.30058E-03	0.63290E-04	-0.82561E-01
5	A0	0.25979E+06	3300.9	22.301	0.24796E-07
6	A1	-0.47752E+06	20827.	41.974	0.24268E-08
7	A2	0.38631E+06	49464.	67.619	0.14031E-07
8	A3	-70483.	40571.	100.11	-0.36921E-08
9	N2	59.112	50.946	2.0333	-0.46272E-04
10	SIG2	0.80406E-02	0.11955E-02	0.62469E-03	1.2600
11	M2	1.8621	0.19703E-02	0.10359E-02	0.78019

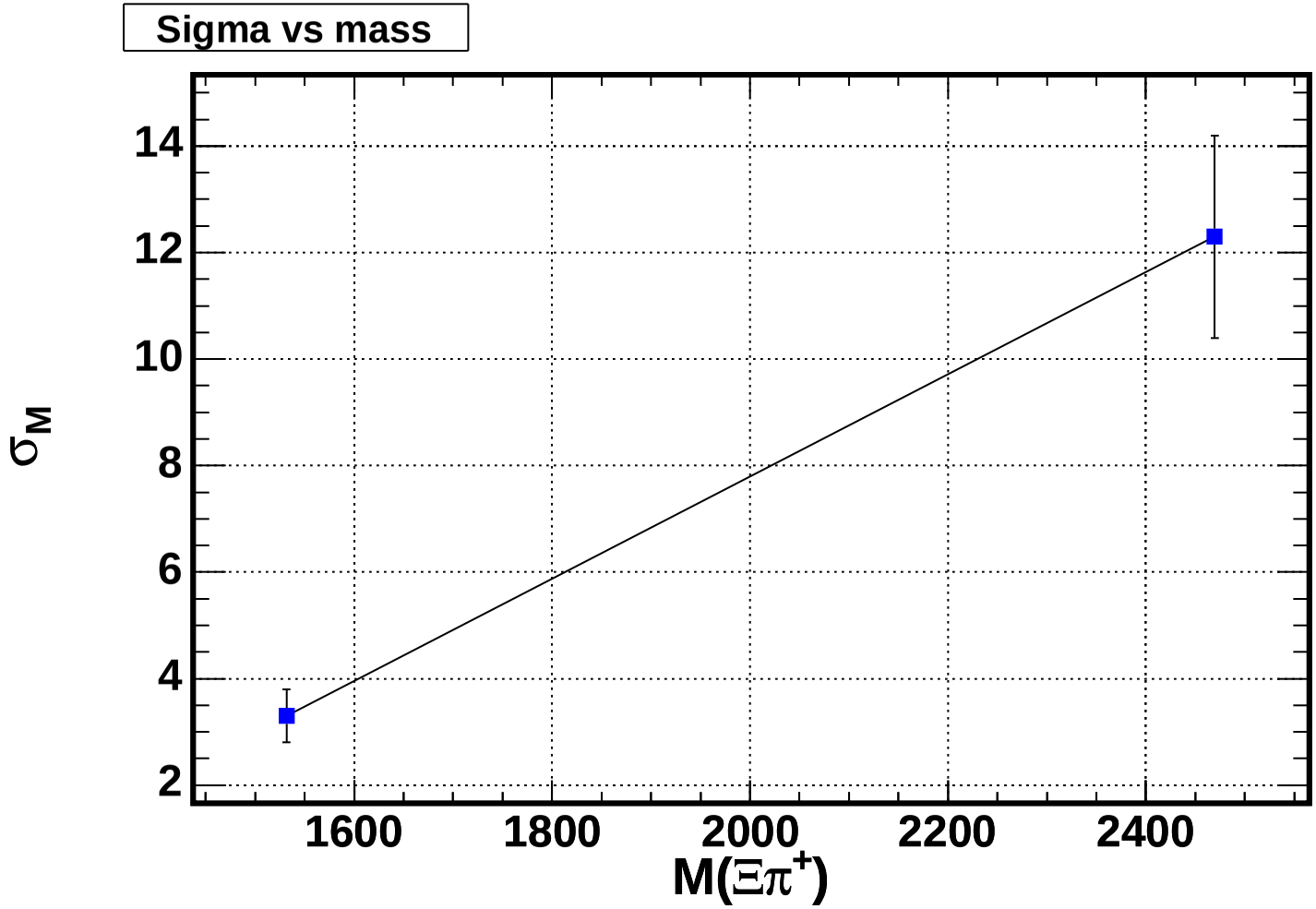
with fixed Γ the $\sigma = (3.3 \pm 0.5)\ \mathrm{MeV/c^2}$

Higher mass state



Ξ_c^0 **resolution is** $(12.3 \pm 1.9)\ \mathrm{MeV}/c^2$

Widths

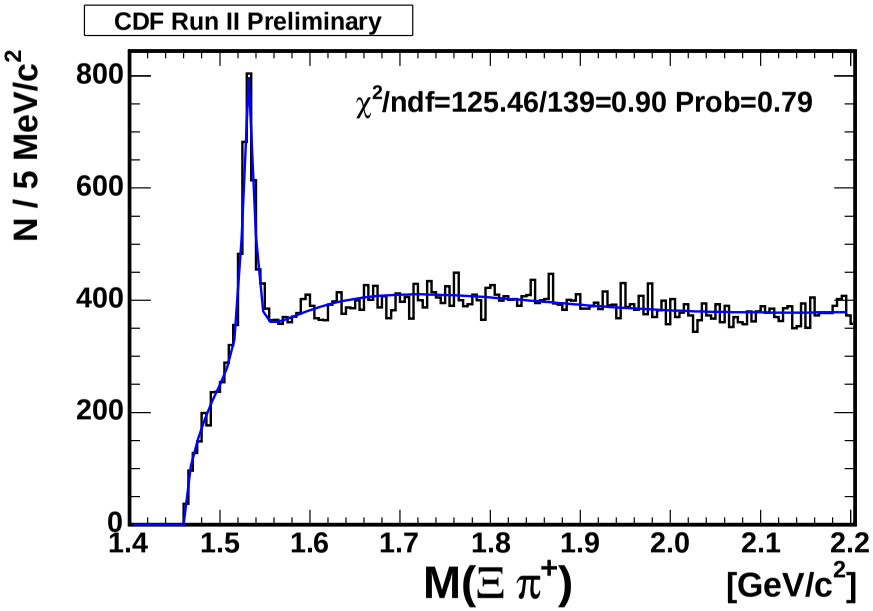

Sigma vs mass
14
12
10
8
6
4
2
σ_M
1600
1800
2000
2200
2400
$M(\Xi\pi^+)$

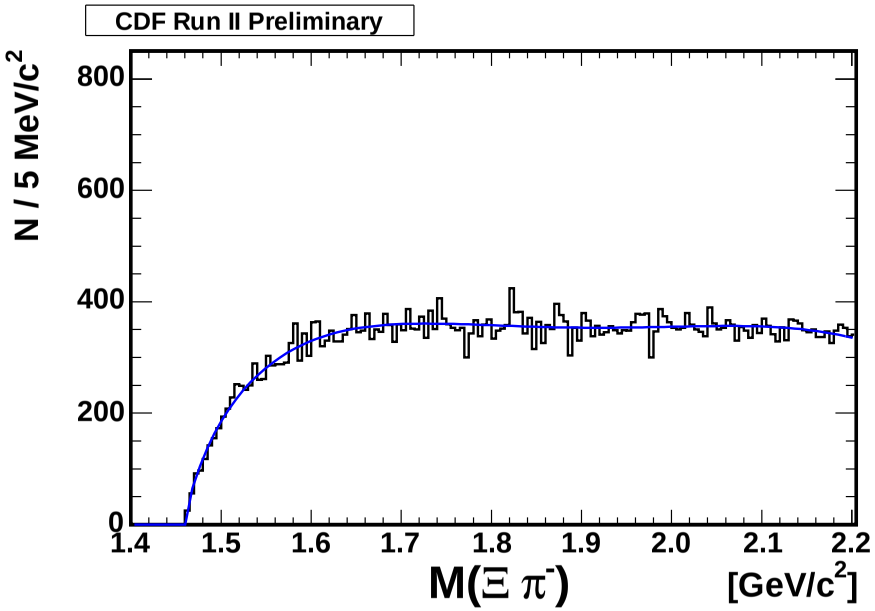
$\Xi(1530)$ fits

Comment	Mass MeV/c^2	number of events
Γ constrained (sqrt thr)	1531.7 ± 0.3	1857.3 ± 74.6
Γ constrained (exp thr)	1531.7 ± 0.3	1843.8 ± 79.3
Γ fixed,	1531.7 ± 0.3	1876.3 ± 79.3
Γ constrated (CTVMFT err)	1531.5 ± 0.3	1830.3 ± 9.5

$$N(\Xi(1530)) = 1843.9 \pm 79.3 \pm 30$$

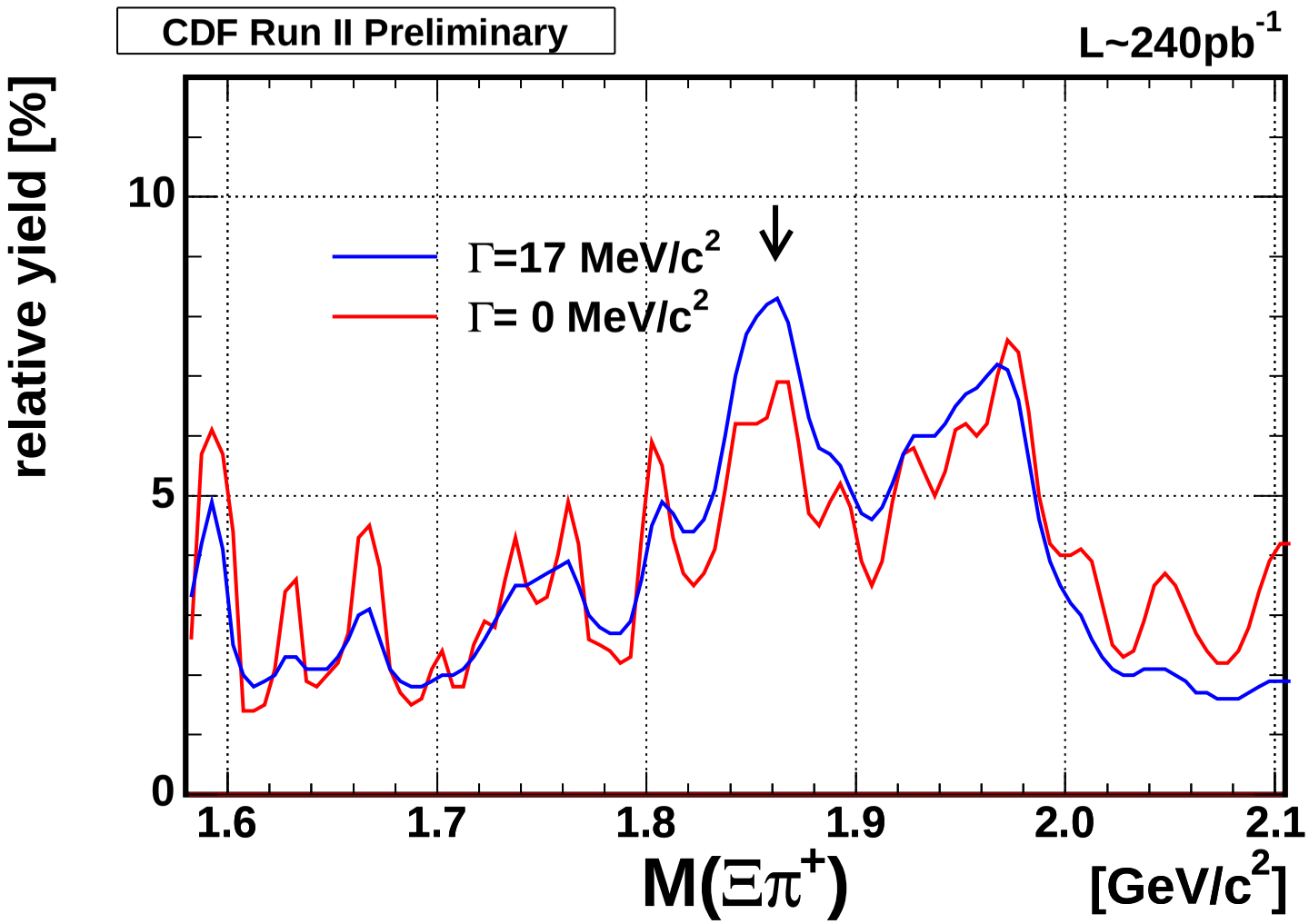
Final Plots





Projection of maximum likelihood fit

Uncorrected(yet) Relative Yeilds



Uncorrected(yet) Relative Yeilds

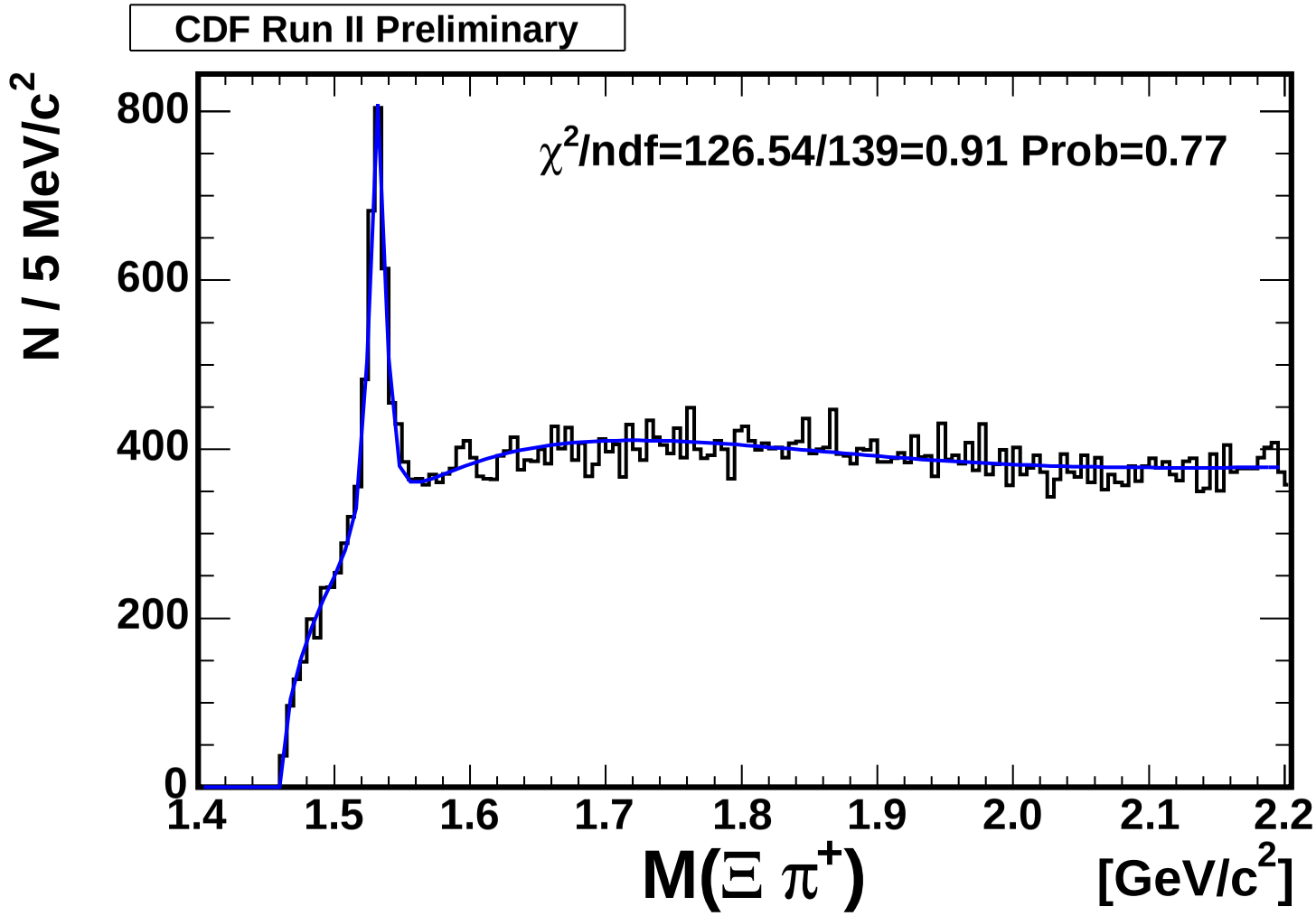
$\Gamma = 0$

$$\frac{\sigma(\Xi(1860)) \cdot \mathrm{BR}(\Xi(1860) \to \Xi\pi^+)}{\sigma(\Xi(1530))} = 2/3 \cdot 6.9\% = 4.6\%$$

$\Gamma = 17$

$$\frac{\sigma(\Xi(1860)) \cdot \mathrm{BR}(\Xi(1860) \to \Xi\pi^+)}{\sigma(\Xi(1530))} = 2/3 \cdot 8.3\% = 5.5\%$$

2 Gaussians


CDF Run II Preliminary
χ^2/ndf=126.54/139=0.91 Prob=0.77
N / 5 MeV/c^2
800
600
400
200
0
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
M($\Xi\ \pi^+$)
[GeV/c^2]

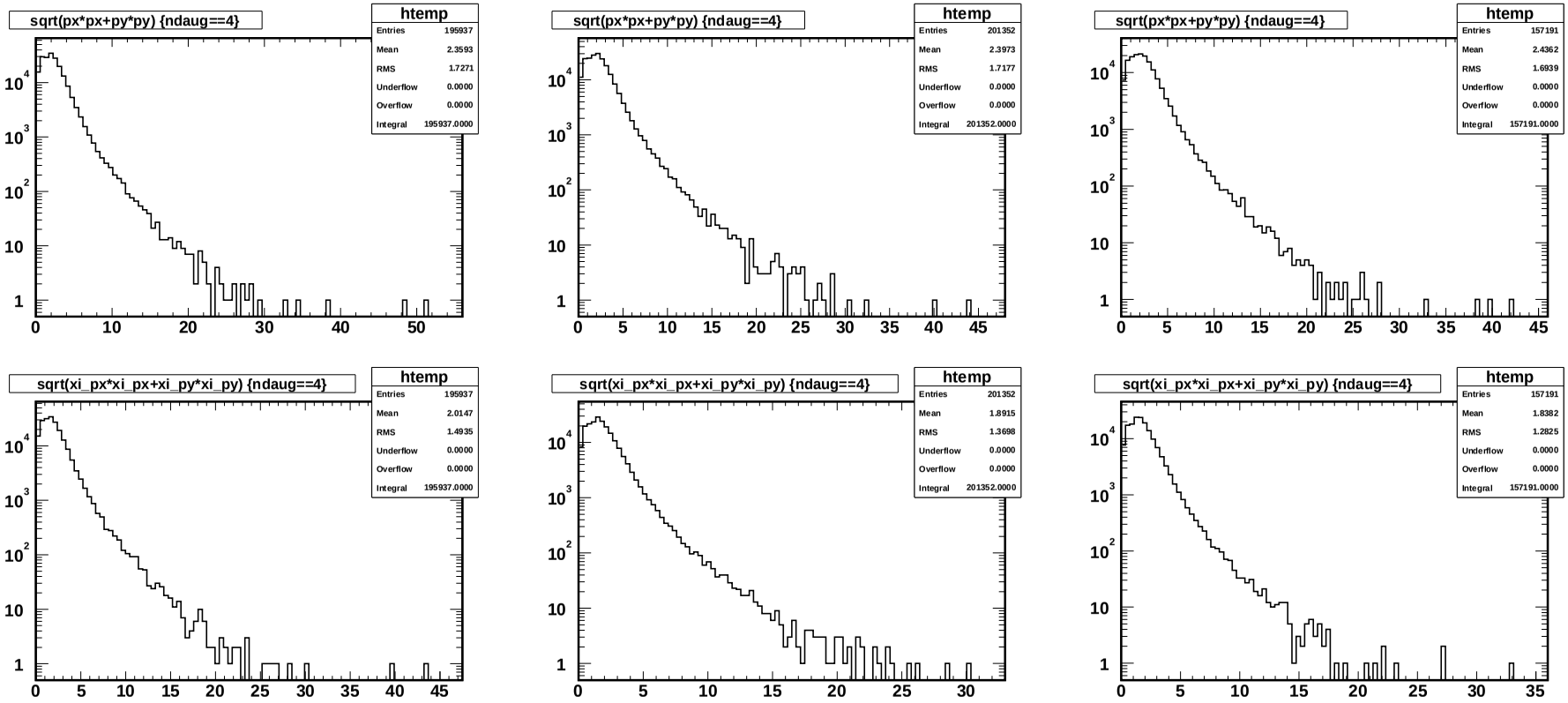
2 Gaussians

```
FCN=  -1162279.     FROM MIGRAD    STATUS=CONVERGED    540 CALLS     1522 TOTAL
                    EDM=  0.52E-04    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER NO.	NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	N1	1836.2	76.670	34.396	-0.42666E-04
2	SIG1	0.17000E-02	fixed		
3	GAMMA	0.81015E-02	0.44874E-03	0.20642E-03	13.585
4	M1	1.5317	0.29863E-03	0.15702E-03	6.5553
5	PWR	0.55667	0.73022E-02	0.16580E-02	-0.23128
6	A0	0.31606E+06	3922.0	291.37	-0.10967E-06
7	A1	-0.75033E+06	10154.	540.63	0.48676E-06
8	A2	0.87586E+06	15901.	865.85	-0.11318E-06
9	A3	-0.37241E+06	17496.	1275.6	0.44616E-07
10	SIG2	0.38000E-02	fixed		
11	RATIO	0.11436	0.25173	0.11928	0.64439E-02

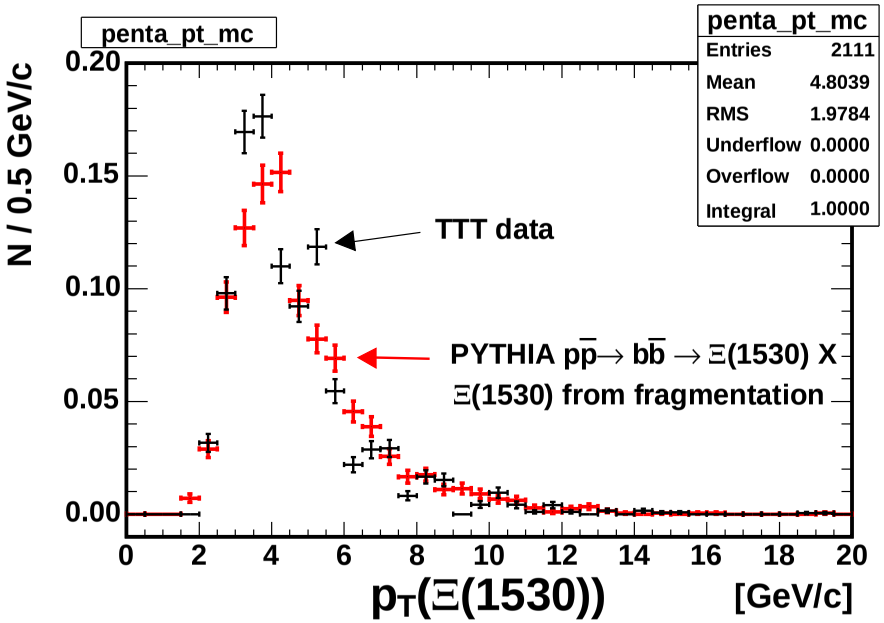
PYTHIA spectra

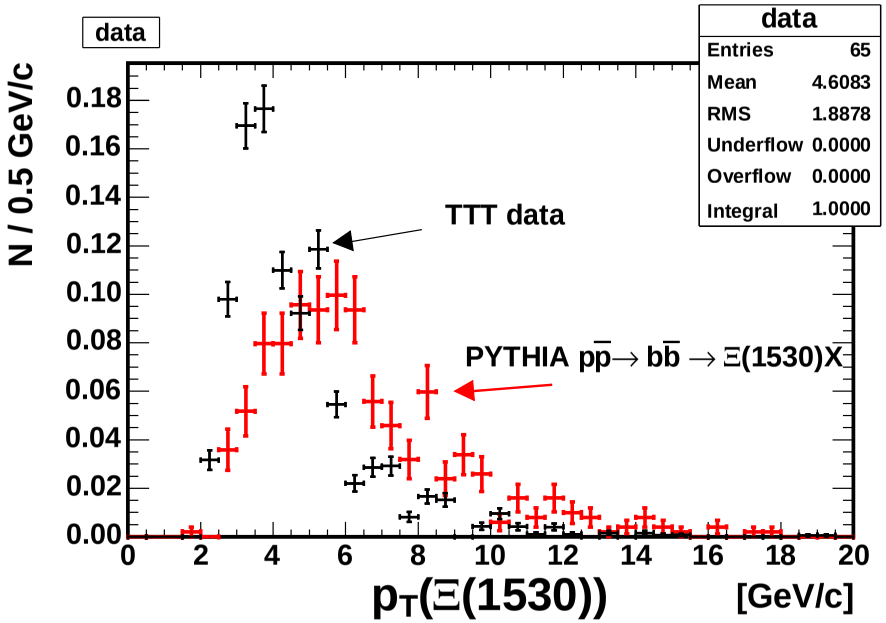
- **old homework PYTHIA** $p\bar{p} \to b\bar{b} \to$ "PQ″X **1530,1696,1862**



PYTHIA spectra

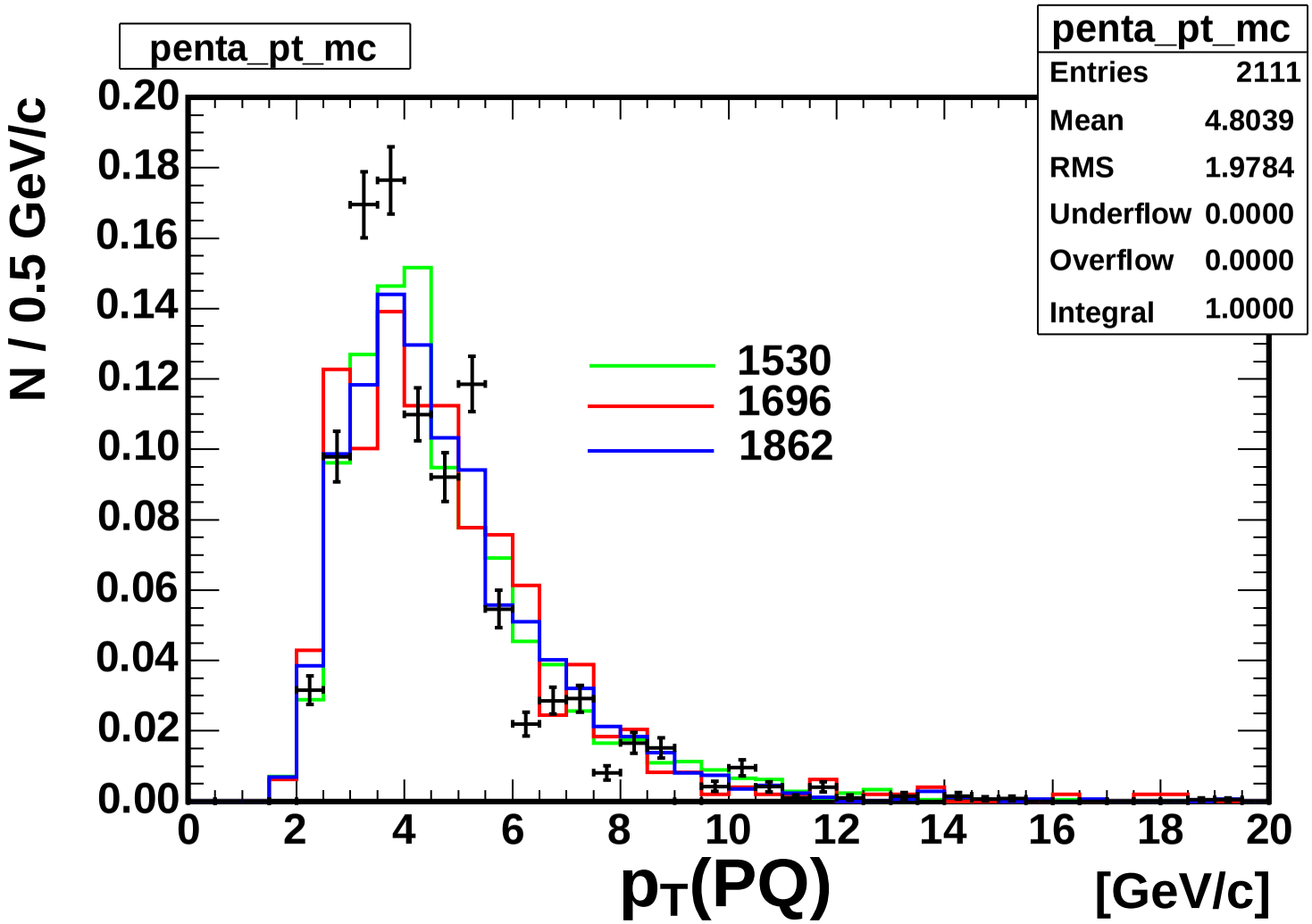
- old homework PYTHIA $p\bar{p} \to b\bar{b} \to$ "PQ"X 1530 reconstructed spectra





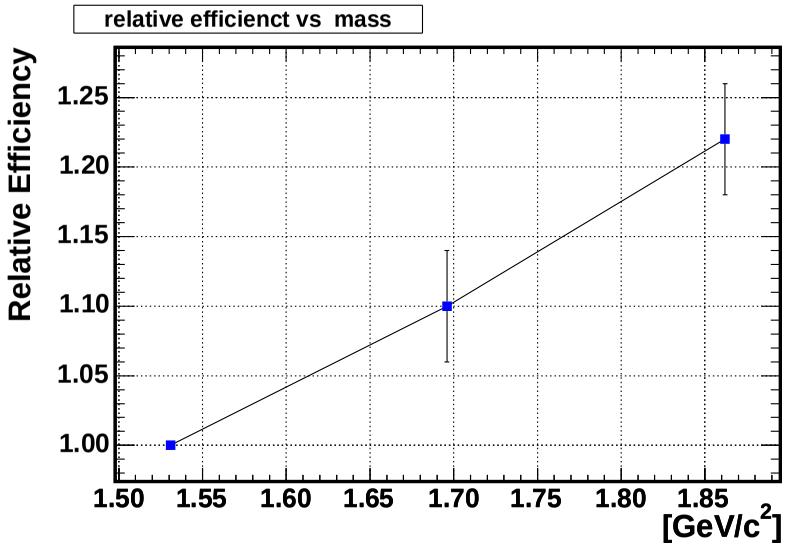
PYTHIA spectra

- reconstructed spectra

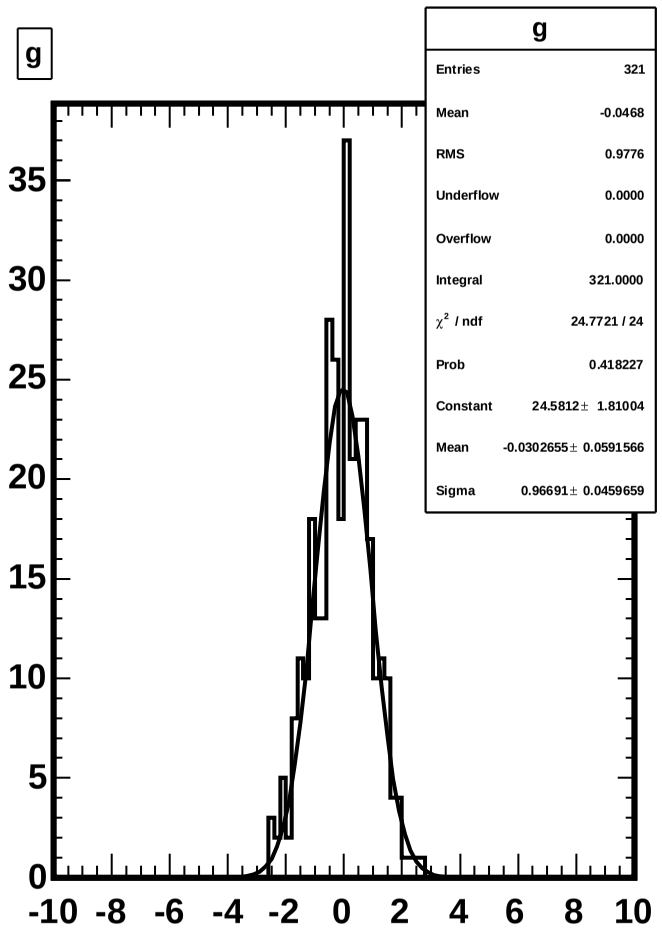


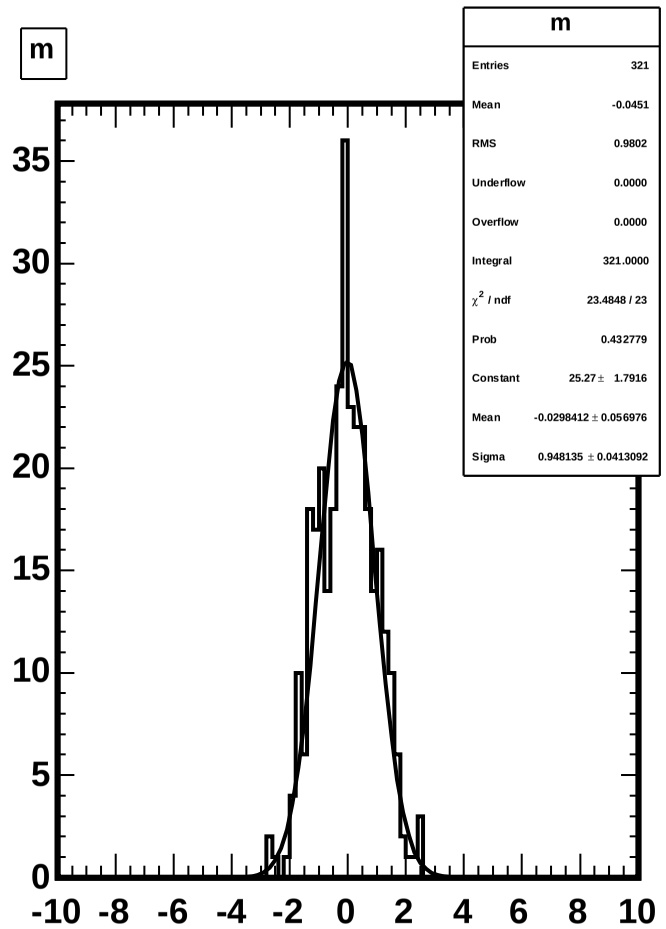
Efficiencies

$\Xi(5130)$	$(0.115 \pm 0.003)\%$	1.
$\Xi(1696)$	$(0.127 \pm 0.003)\%$	1.10 ± 0.04
$\Xi(1862)$	$(0.140 \pm 0.003)\%$	1.22 ± 0.04
$\Xi(2027)$	**missing**	**missing**



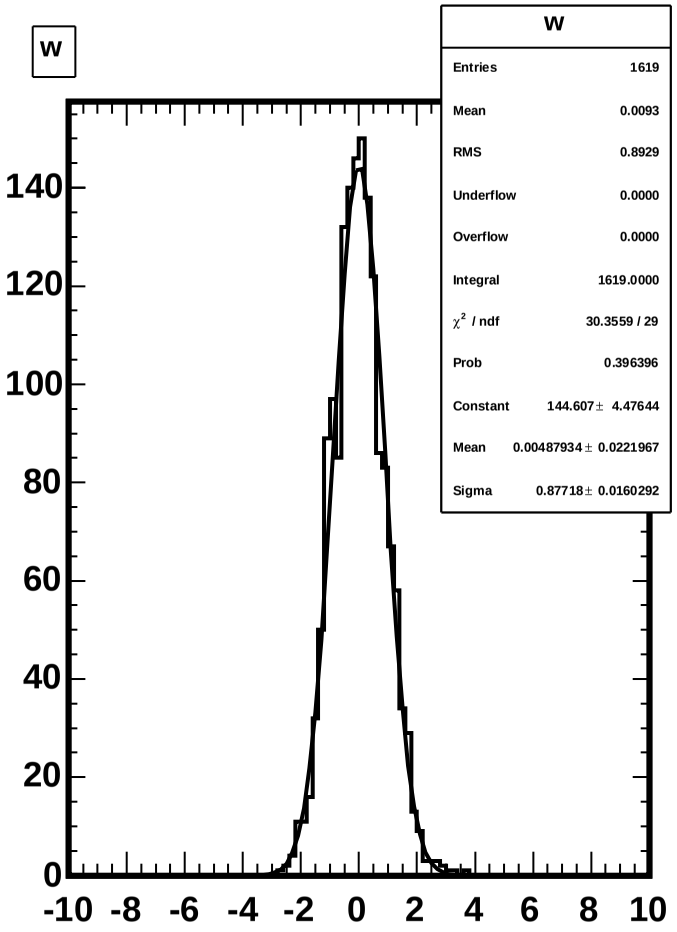
Fit Residuals

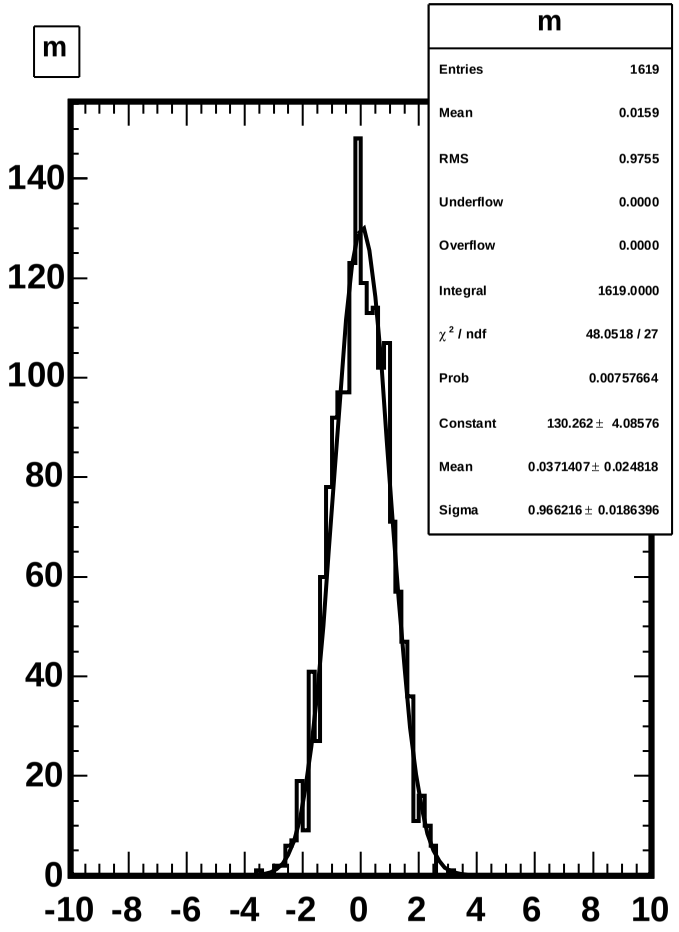




fixed sigma

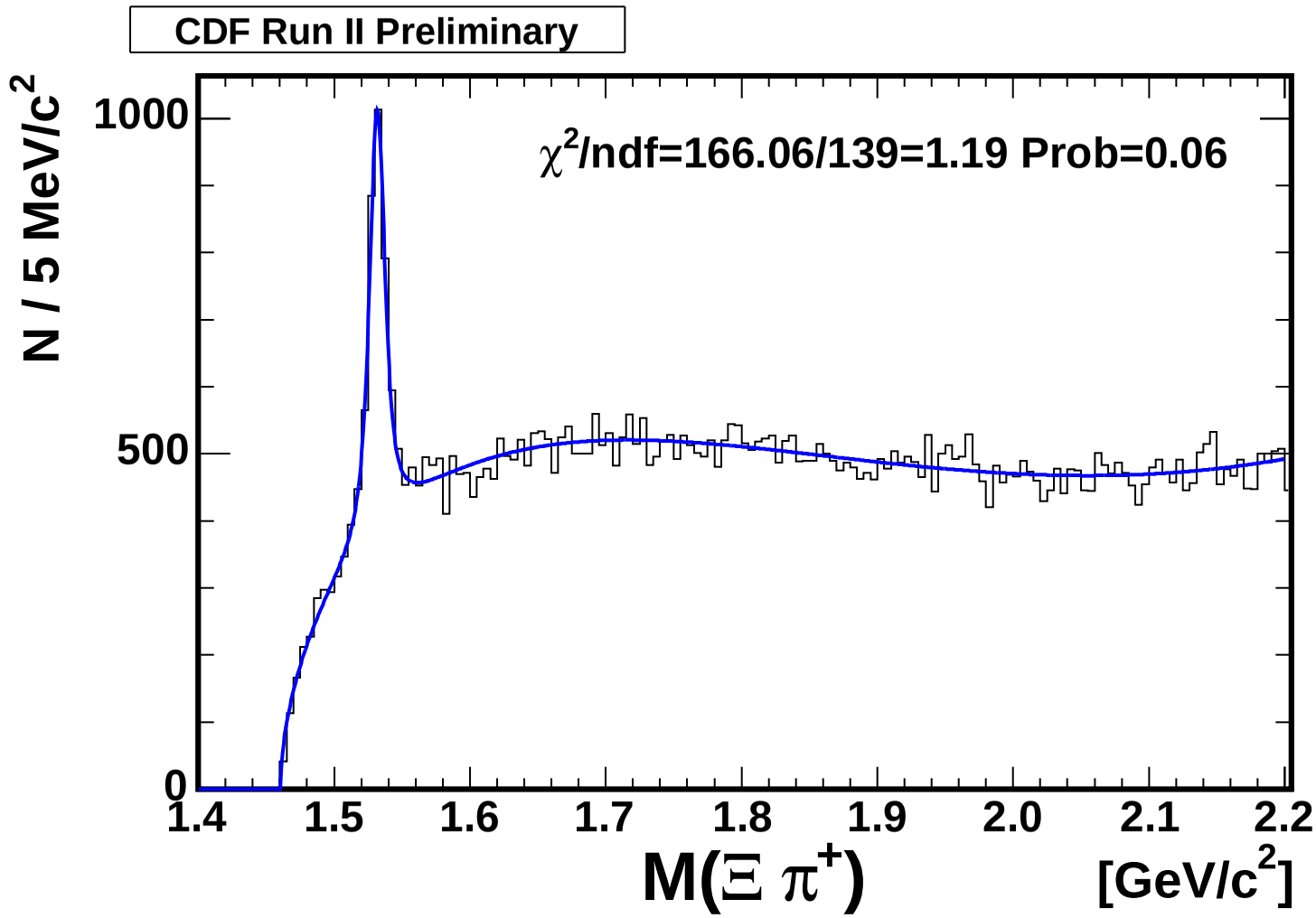
Fit Residuals





constrained gamma

Toy MC example



Sigma of 1530

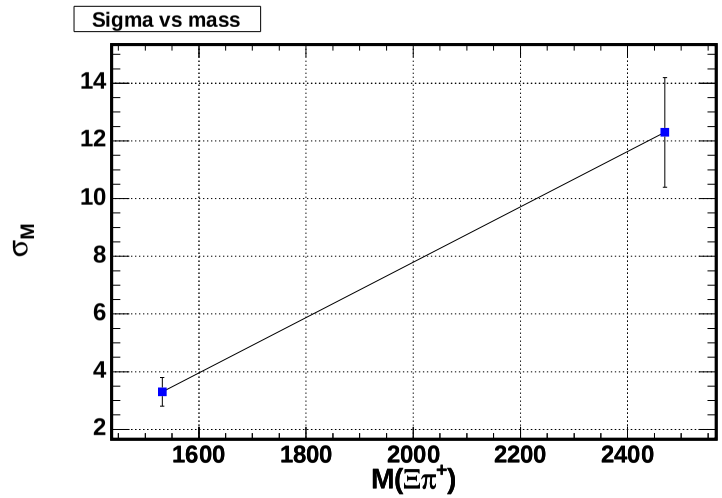
```
FCN=  -1162362.     FROM MIGRAD    STATUS=CONVERGED    379 CALLS      380 TOTAL
                    EDM=  0.19E-04    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER NO.	NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	N1	2019.3	81.627	36.308	0.41677E-04
2	SIG1	0.36194E-02	0.51500E-03	0.24515E-03	3.1891
3	GAMMA	0.91000E-02	constant		
4	M1	1.5316	0.30405E-03	0.15993E-03	-1.2245
5	PWR	0.55102	0.74413E-02	0.16648E-02	0.48180
6	A0	0.30473E+06	3927.0	290.08	0.87913E-06
7	A1	-0.68084E+06	10127.	539.03	0.85562E-06
8	A2	0.73359E+06	15873.	863.83	0.65832E-06
9	A3	-0.27829E+06	17457.	1273.4	0.45319E-06

Sigma of 1530

```
FCN=  -1162362.     FROM MIGRAD    STATUS=CONVERGED    410 CALLS      411 TOTAL
                    EDM=  0.51E-04    STRATEGY= 2      ERROR MATRIX ACCURATE
```

EXT PARAMETER NO.	NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	N1	2030.7	85.120	36.468	-0.82963E-05
2	SIG1	0.35015E-02	0.57248E-03	0.25046E-03	12.458
3	GAMMA	0.93334E-02	0.47927E-03	0.20907E-03	18.413
4	M1	1.5317	0.30349E-03	0.15963E-03	-11.138
5	PWR	0.55099	0.75000E-02	0.16657E-02	0.62083
6	A0	0.30426E+06	3932.7	290.03	-0.67424E-06
7	A1	-0.67754E+06	10128.	538.96	0.30013E-06
8	A2	0.72642E+06	15876.	863.74	0.43674E-06
9	A3	-0.27342E+06	17458.	1273.3	0.39206E-06

Sigma

$\Xi(5130)$	(3.5 ± 0.6) MeV/c^2
$\Xi(1696)$	$(5.0 \pm ?.?)$ MeV/c^2
$\Xi(1862)$	$(6.5 \pm ?.?)$ MeV/c^2
$\Xi(2027)$	$(8.1 \pm ?.?)$ MeV/c^2