question

from Giessen group

about the fit

$$
\begin{aligned}
A_K =& c_\phi BW_\phi + c_{\phi'} BW_{\phi'} + c_{R1} BW_{R1} \\
&+ c_\rho BW_\rho + c_{\rho'} BW_{\rho'} + c_{\rho''} BW_{\rho''} + c_{R2} BW_{R2} \\
&+ c_\omega BW_\omega + c_{\omega'} BW_{\omega'} + c_{\omega''} BW_{\omega''} + c_{R3} BW_{R3} \\
&+ c_{con} \cdot s^{-\alpha} \cdot e^{i \cdot \theta},
\end{aligned}
$$

You introduce two Breit-Wigner resonances for the amplitude in order to compensate for unknown effects?

Does that mean you discovered two additional new resonances?

What are the parameters of these resonances R2 and R3?

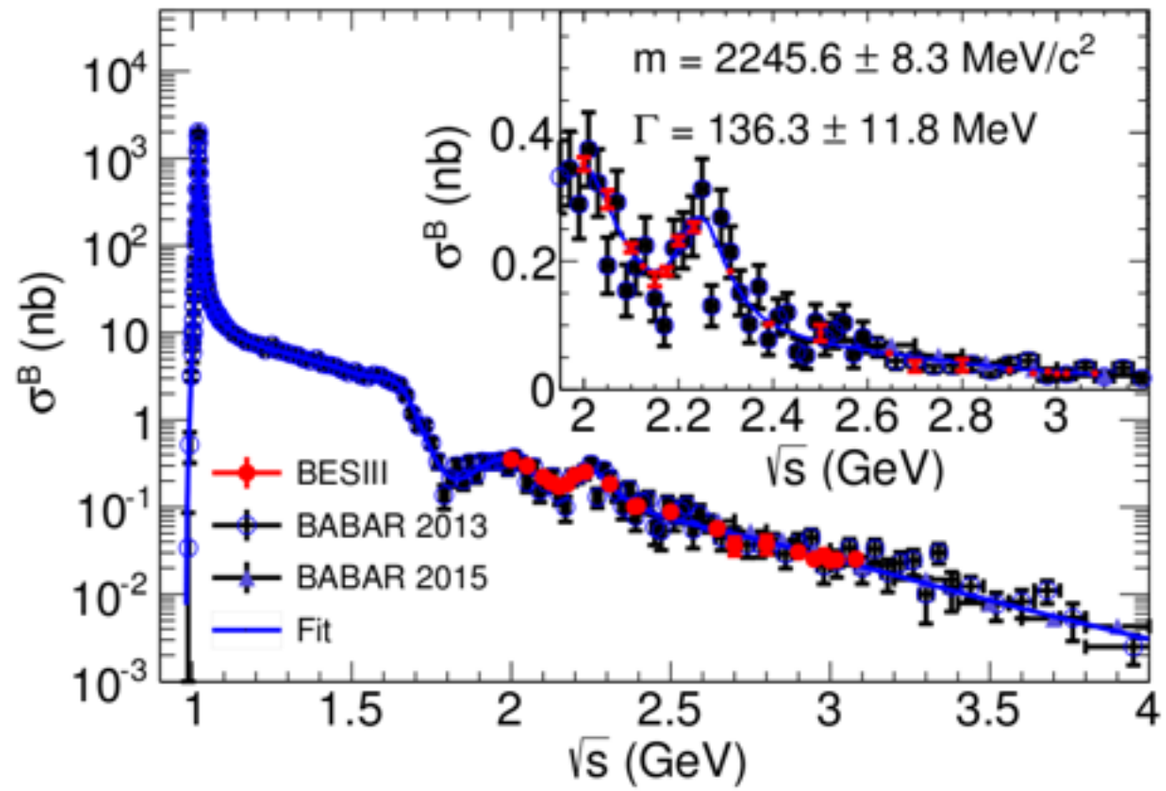
How significant are they?

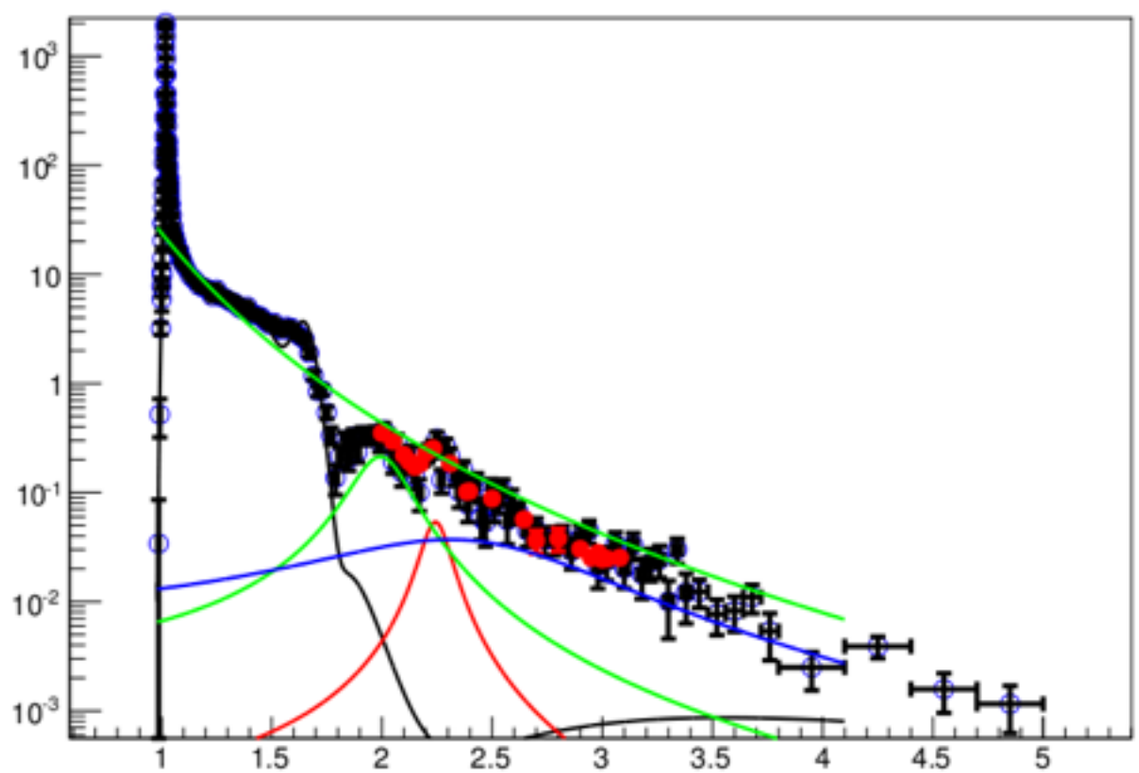
Please also show the significance of the resonance at 2.2456 GeV.

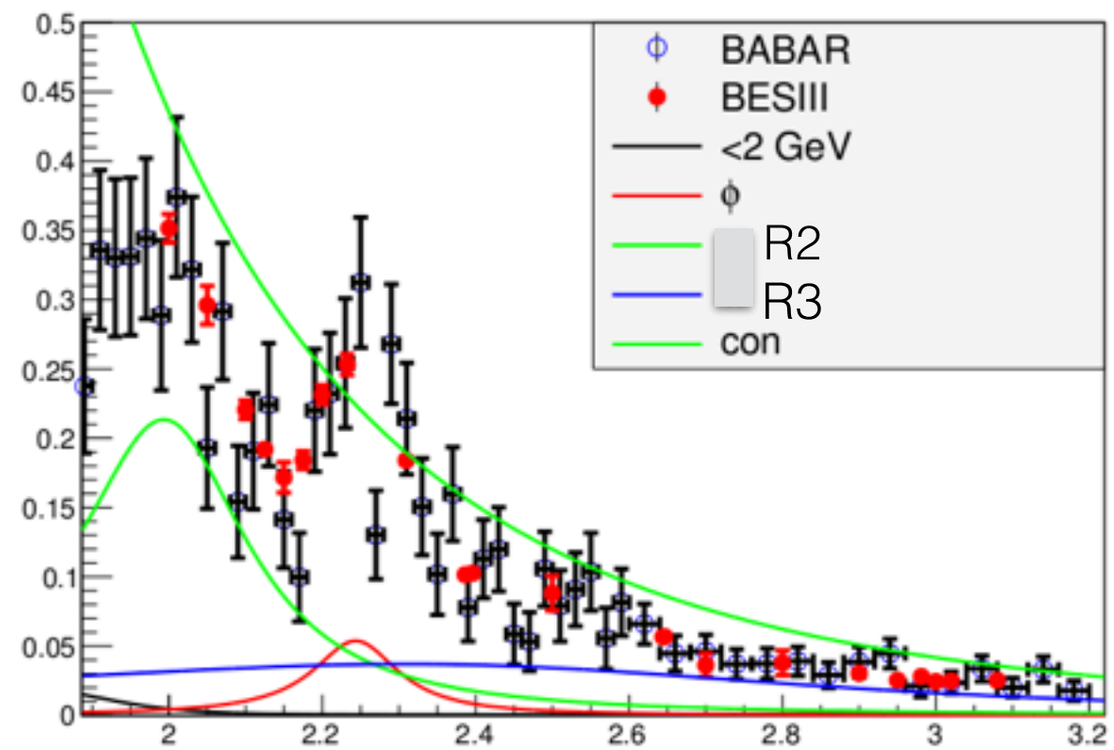
idea

- replace R2 R3 with other shape
- a. with gaussian function
- b. with polynomial (fail)
- c. gaussian plus polynomial

R2+R3

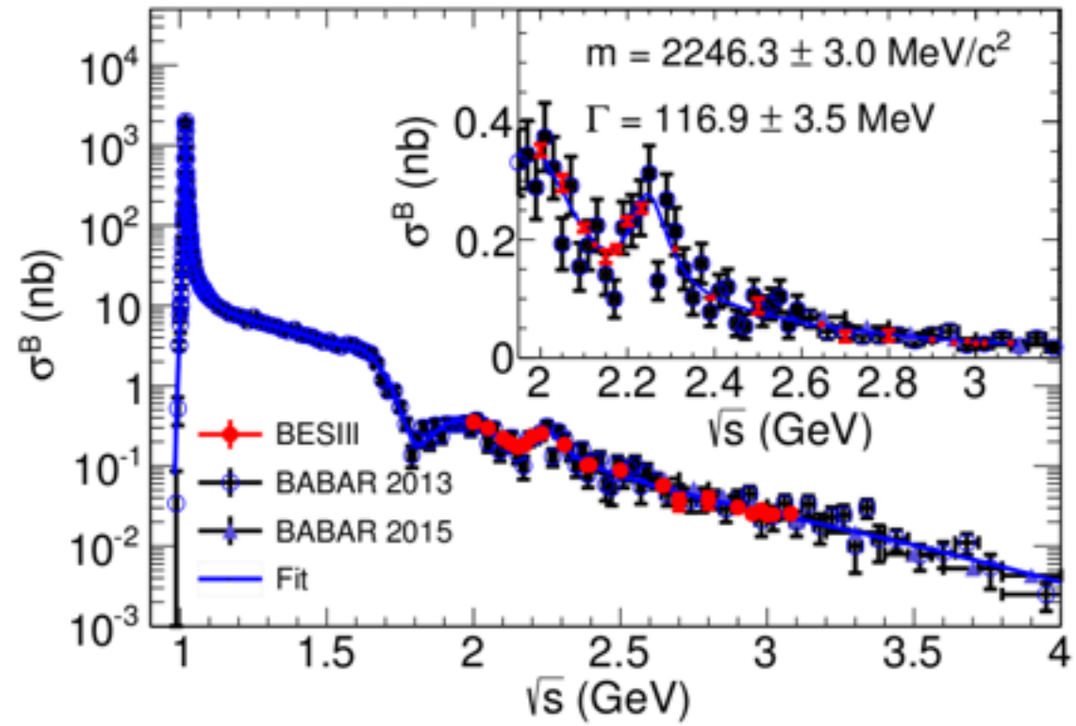

m = 2245.6 ± 8.3 MeV/c²
Γ = 136.3 ± 11.8 MeV
σ^B (nb)
√s (GeV)
BESIII
BABAR 2013
BABAR 2015
Fit

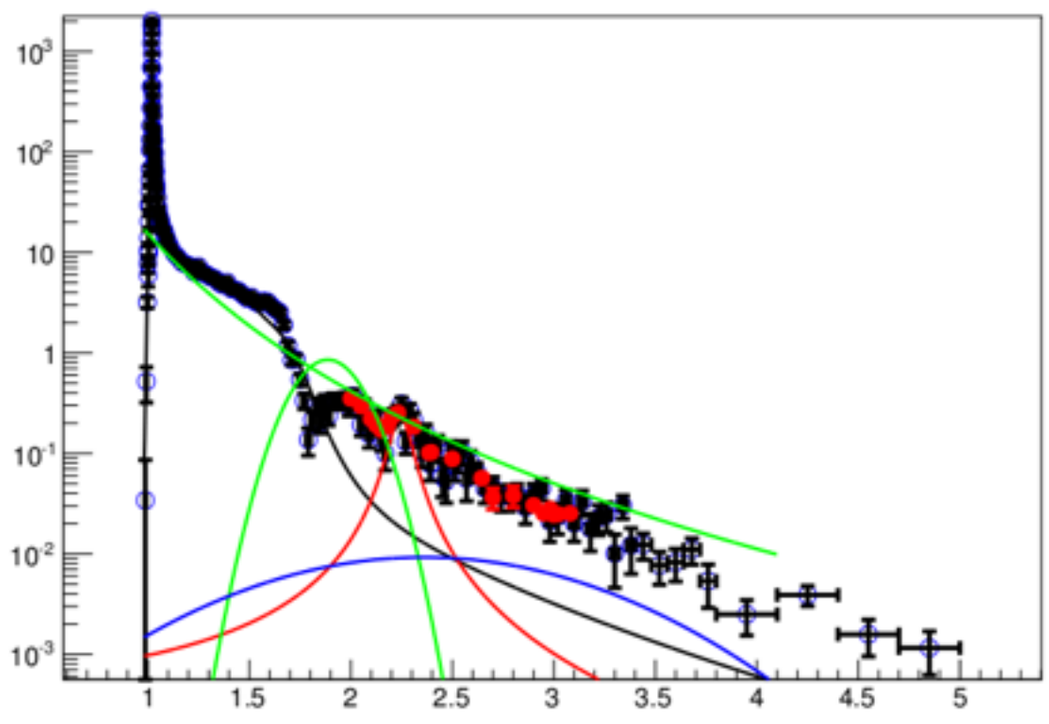


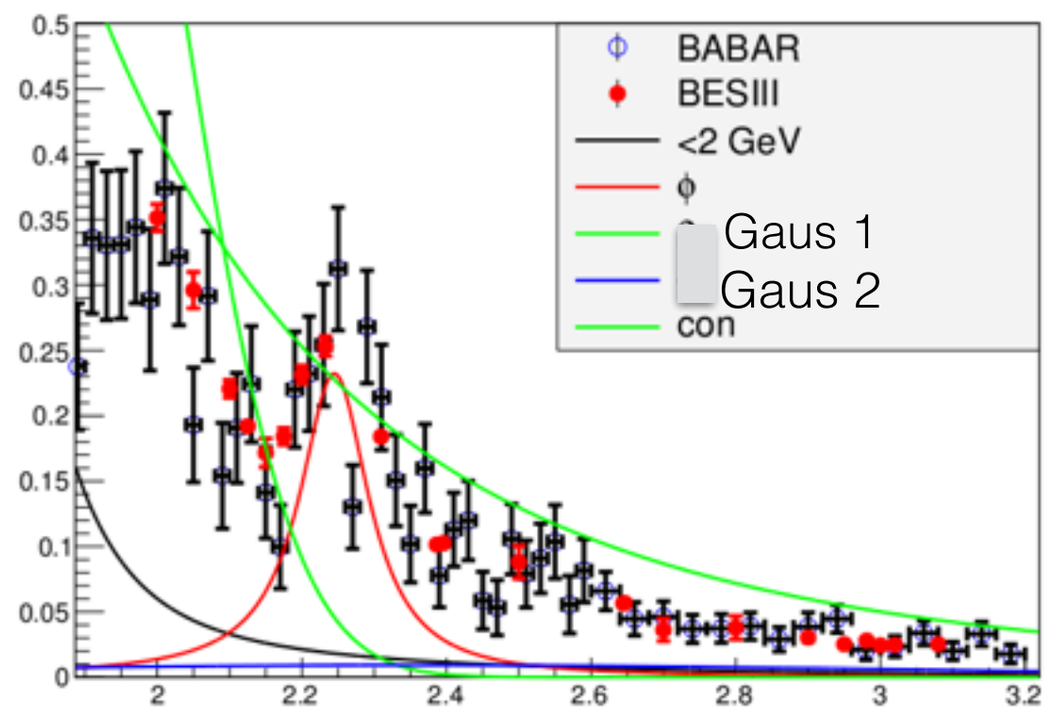

BABAR
BESIII
<2 GeV
ϕ
R2
R3
con

Gaus1+Gaus2

- Replace R2 R3 with two gaussian function

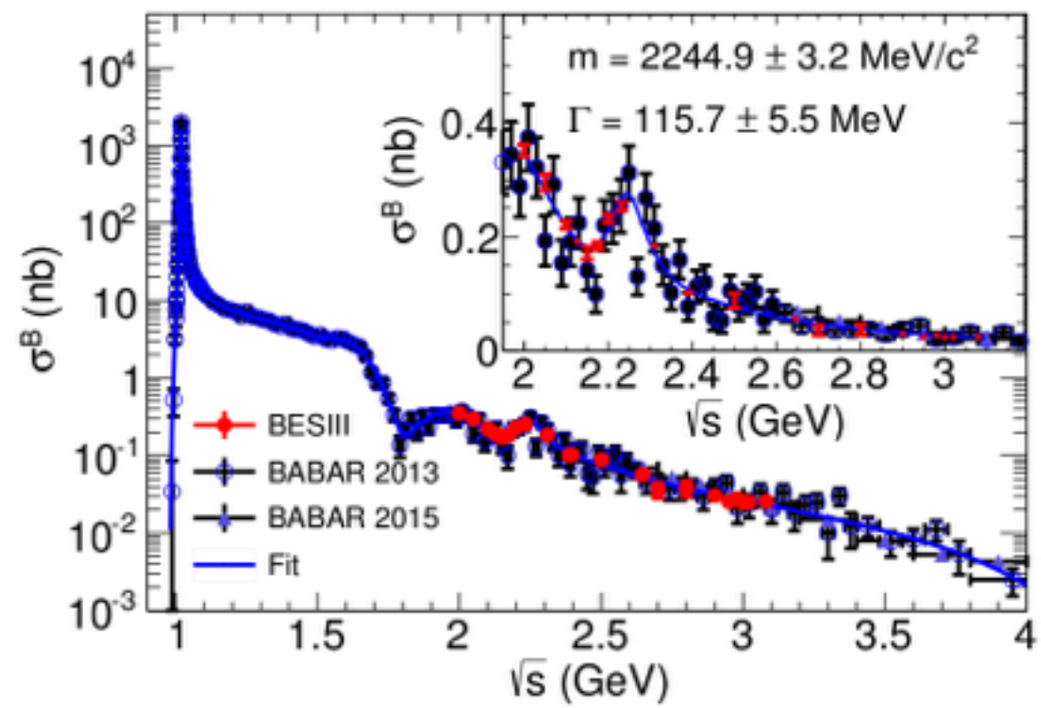


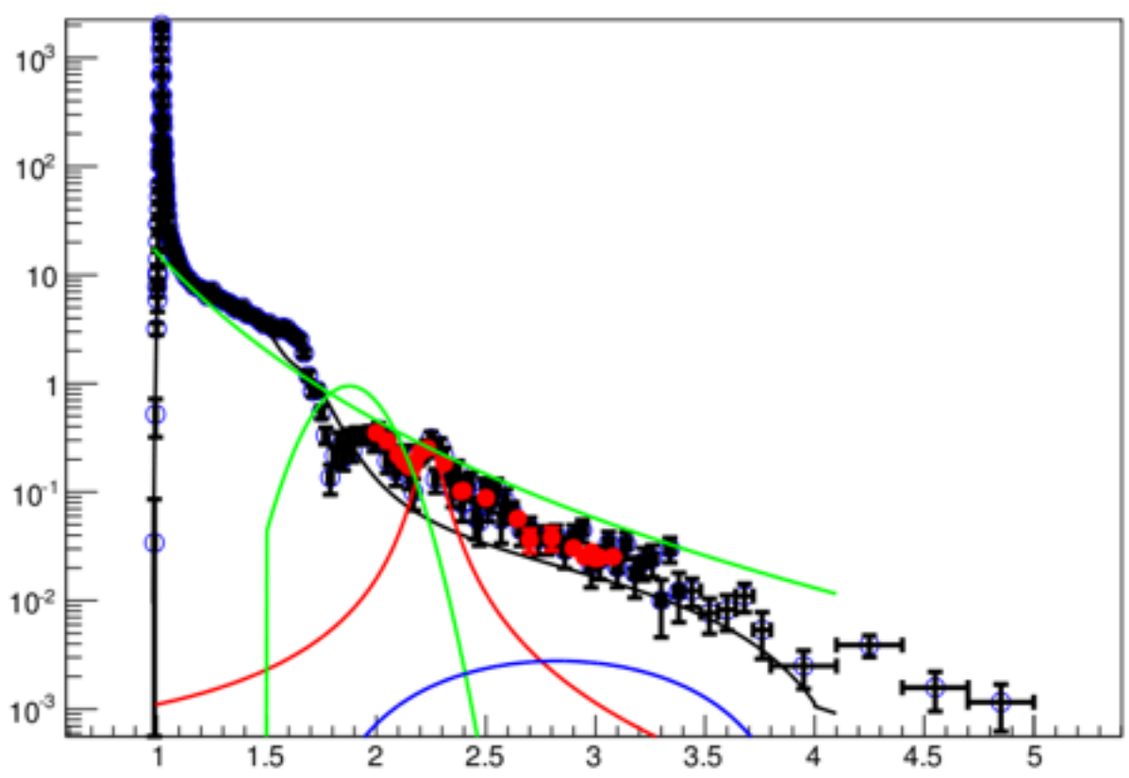


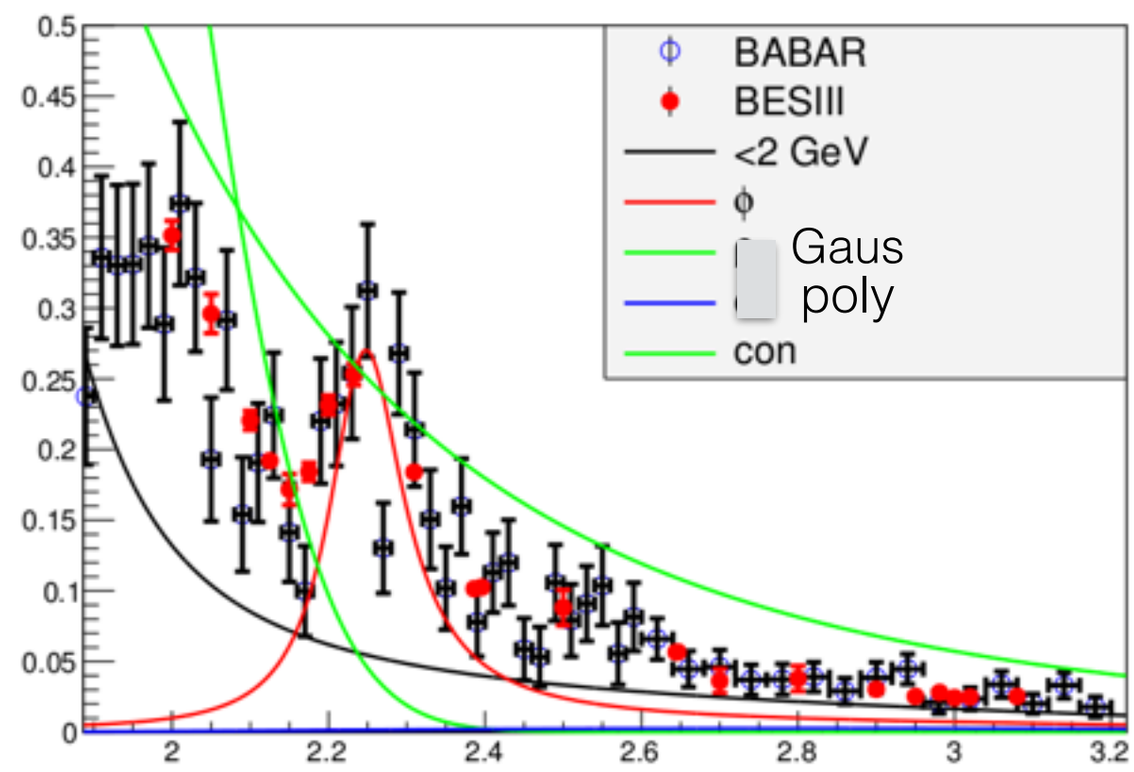


Gaus + poly

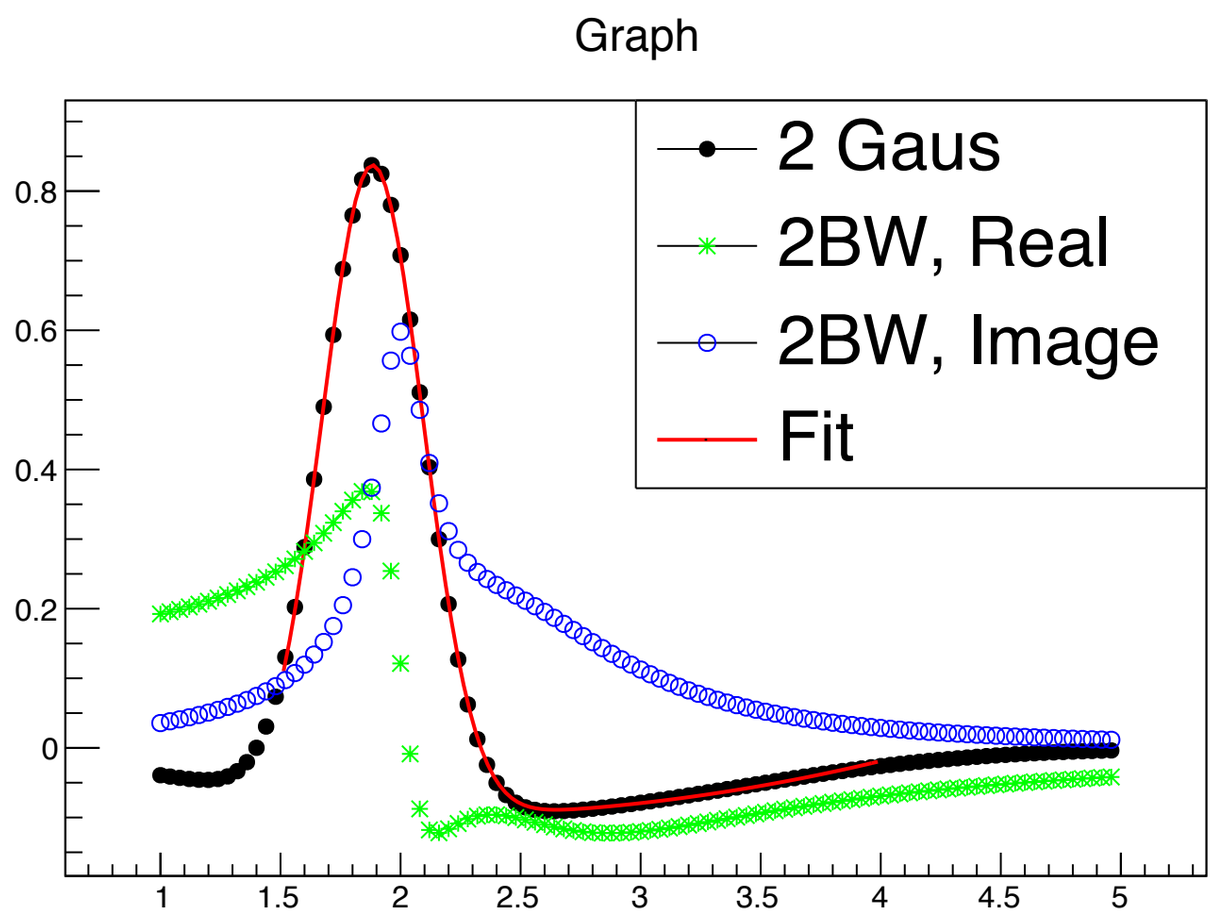
```
 1  c_phi0        1.89024e-01   1.96363e-03
 2  c_phi1       -2.15234e-02   4.43341e-02
 3  c_phi2        2.66776e-02   1.22649e-03
 4  c_rho0       -1.41015e+00   4.36774e-01
 5  c_rho1       -1.03287e+00   1.31440e-02
 6  c_rho2       -3.75553e-01   8.29365e-02
 7  c1            9.74251e-01   2.45249e-02
 8  c_omega0     -3.17495e-01   1.23852e-01
 9  c_omega1      5.85564e-02   1.92229e-02
10  c_omega2      9.53498e-01   1.67843e-01
11  c2            1.87650e+00   6.35450e-03
12  mass1         2.24487e+00   3.23533e-03
13  width1        1.15679e-01   5.47005e-03
14  c3            2.14225e-01   7.04634e-03
15  c4            2.66699e-01   9.97765e-02
16  c5           -2.12587e-01   5.17893e-02
17  c6            1.87913e-02   4.15704e-03
18  c_con         4.00075e+00   4.51210e-02
19  order        -2.56401e+00   3.48350e-02
20  phase        -3.46048e+00   5.39746e-02
Fit  499th. Time seed is 11600026
chi2 is 173.671
bes chi2 is 38.4263
bar13 chi2 is 119.791
bar15 chi2 is 30.9072
```







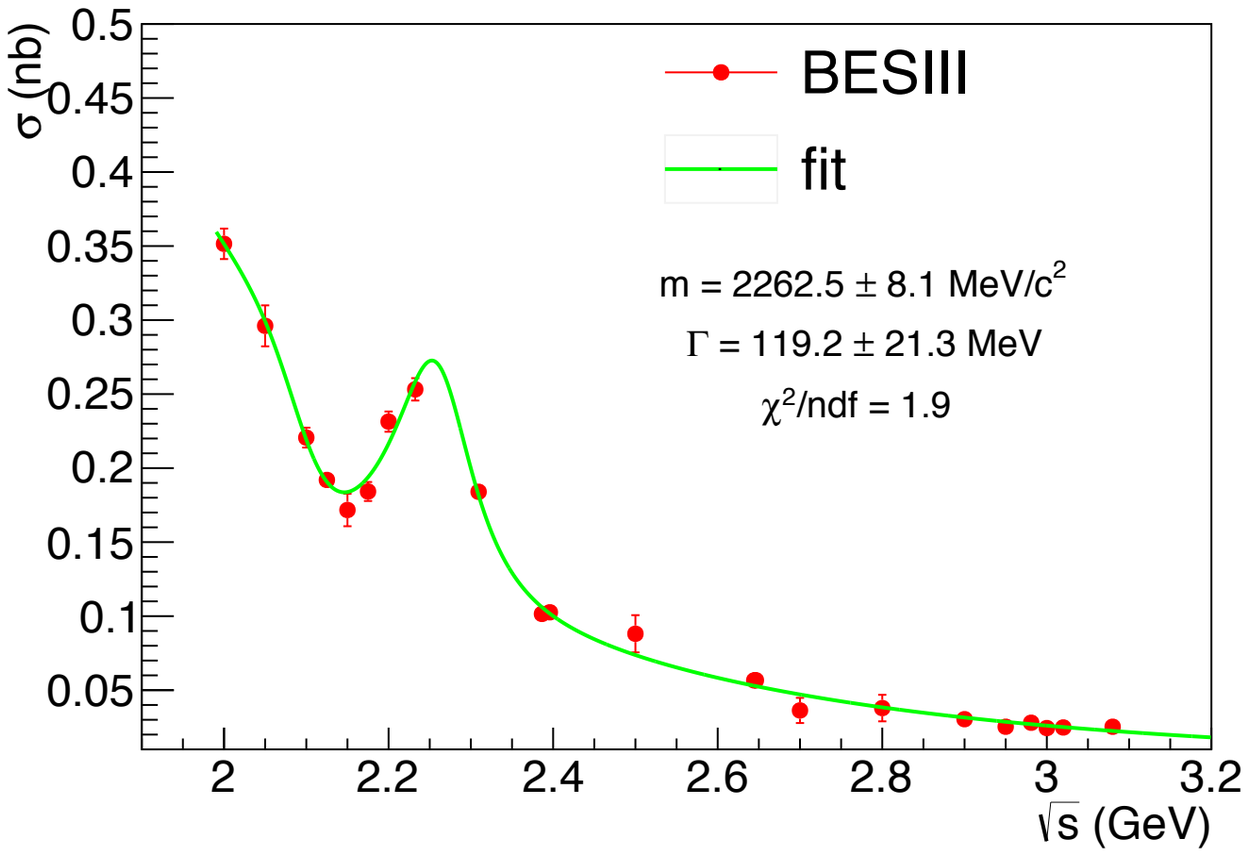
compare different shape



Gaus+polynomial is used to fit 2 Gaus case, and the fit result is used as initial value in data fit.

fit only BESIII data

```
c_phi2    =    -0.00968566 +/- 0.00220265
mass1  =    2.26251 +/- 0.00812298
width1    =    0.119248 +/- 0.0213275
c_con  =    -0.00757724 +/- 0.00326329
phase  =    1.71989 +/- 0.153611
m    =    2.1 +/- 0.00692925
w    =    0.153384 +/- 0.0395609
c1   =    3.90152 +/- 0.490273
alpha  =    -2.85192 +/- 0.130448
phase2    =    -1.82445 +/- 0.114342
```

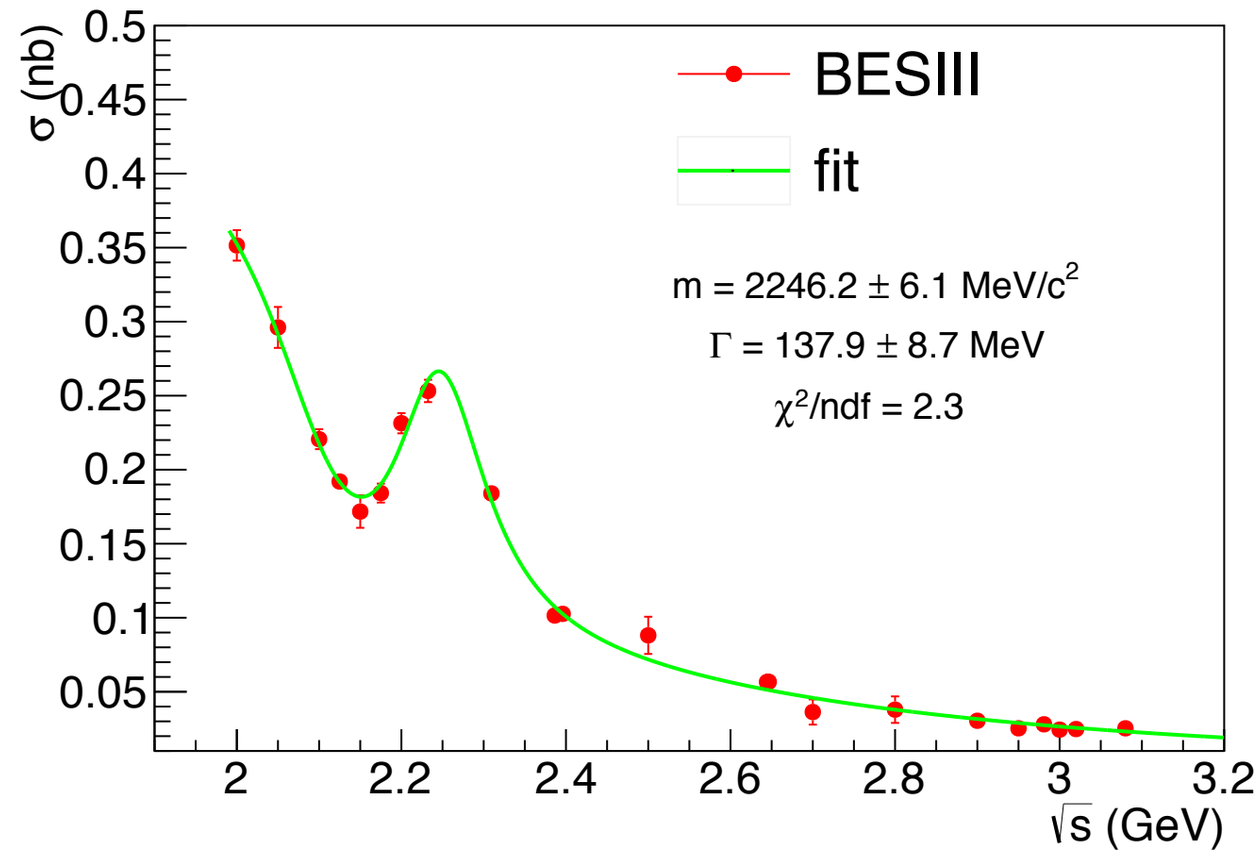


signal: BW

other: BW+ e^alpha

fit only BESIII data

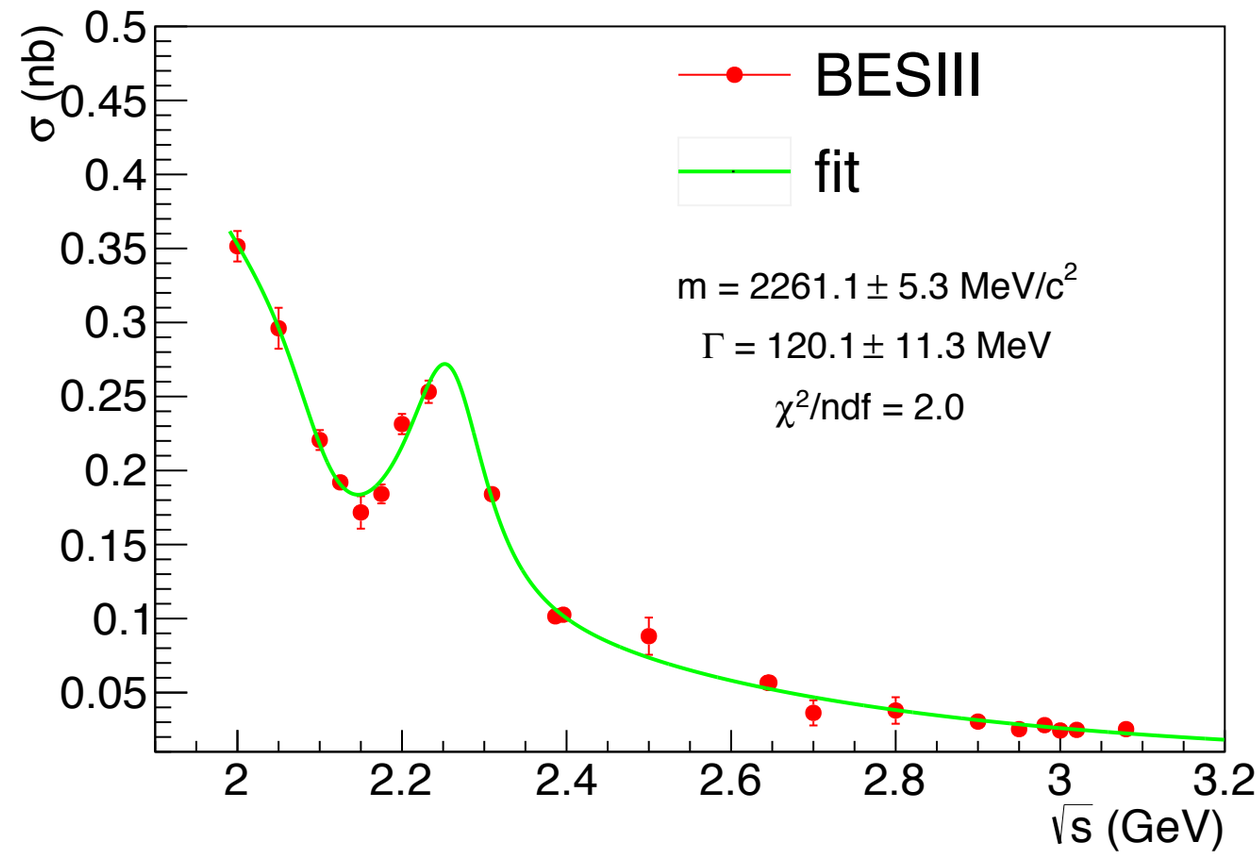
```
c_phi2    =    0.029981 +/- 0.00230337
mass1  =    2.24625 +/- 0.00612214
width1    =    0.137875 +/- 0.00866332
c_con  =    0.0598909 +/- 0.00224348
phase  =    1.82922 +/- 0.0100041
m   =    2.08705 +/- 0.0040113
w   =    0.245349 +/- 0.00186528
c1  =    -3.07388 +/- 0.0804413
alpha  =    -2.62394 +/- 0.03564
phase2    =    3.04051 +/- 0.016965
```



signal: pwave BW

other: pwave BW + e^alpha

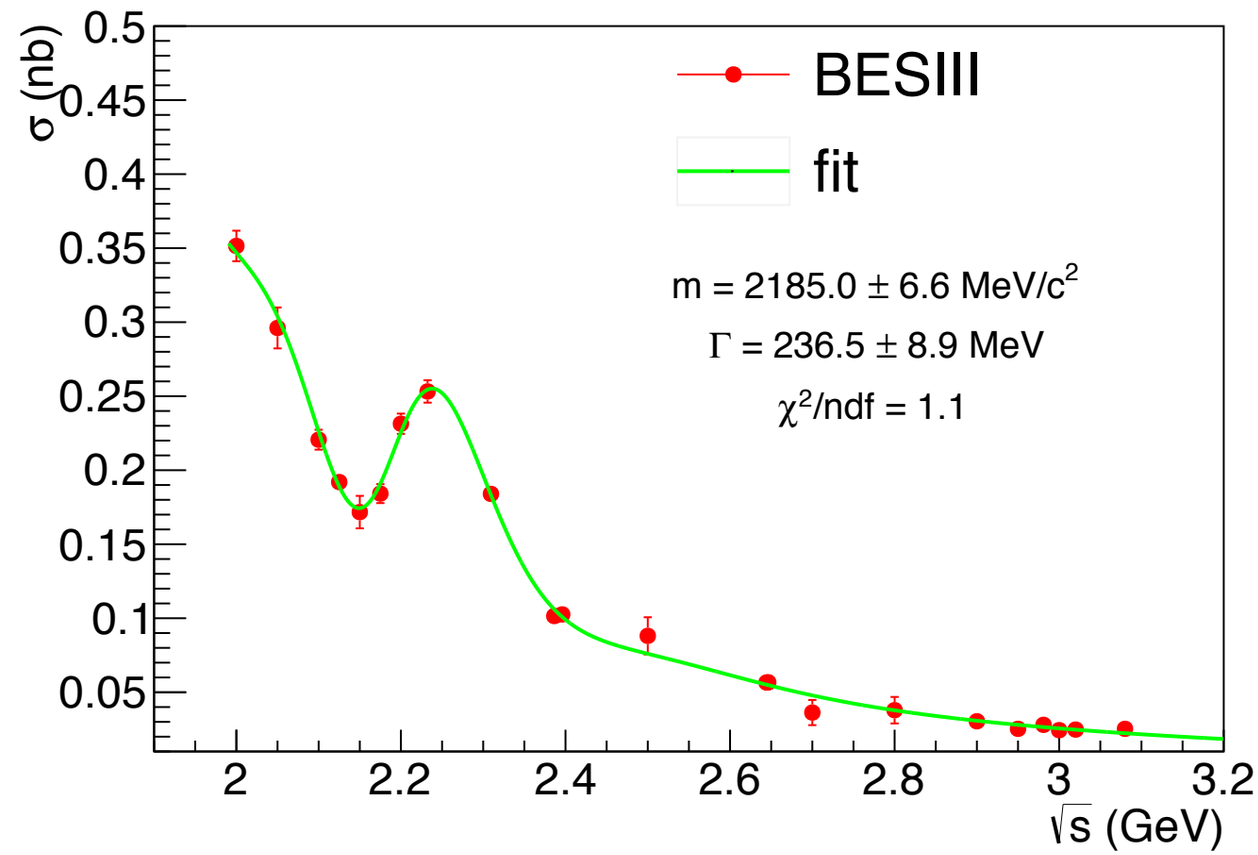
fit only BESIII data




```
c_phi2    =    0.0211283 +/- 0.00239124
mass1  =    2.26114 +/- 0.00526974
width1    =    0.120084 +/- 0.0112611
c_con  =    -0.100543 +/- 0.00268844
phase  =    -1.58953 +/- 0.0240659
m    =    2.09985 +/- 0.00186506
w    =    0.163617 +/- 0.00670549
c1  =    4.16515 +/- 0.193258
alpha  =    -3.02509 +/- 0.0437206
phase2    =    -0.393932 +/- 0.0410847
```

signal: pwave BW
other: BW + e^alpha

fit only BESIII data



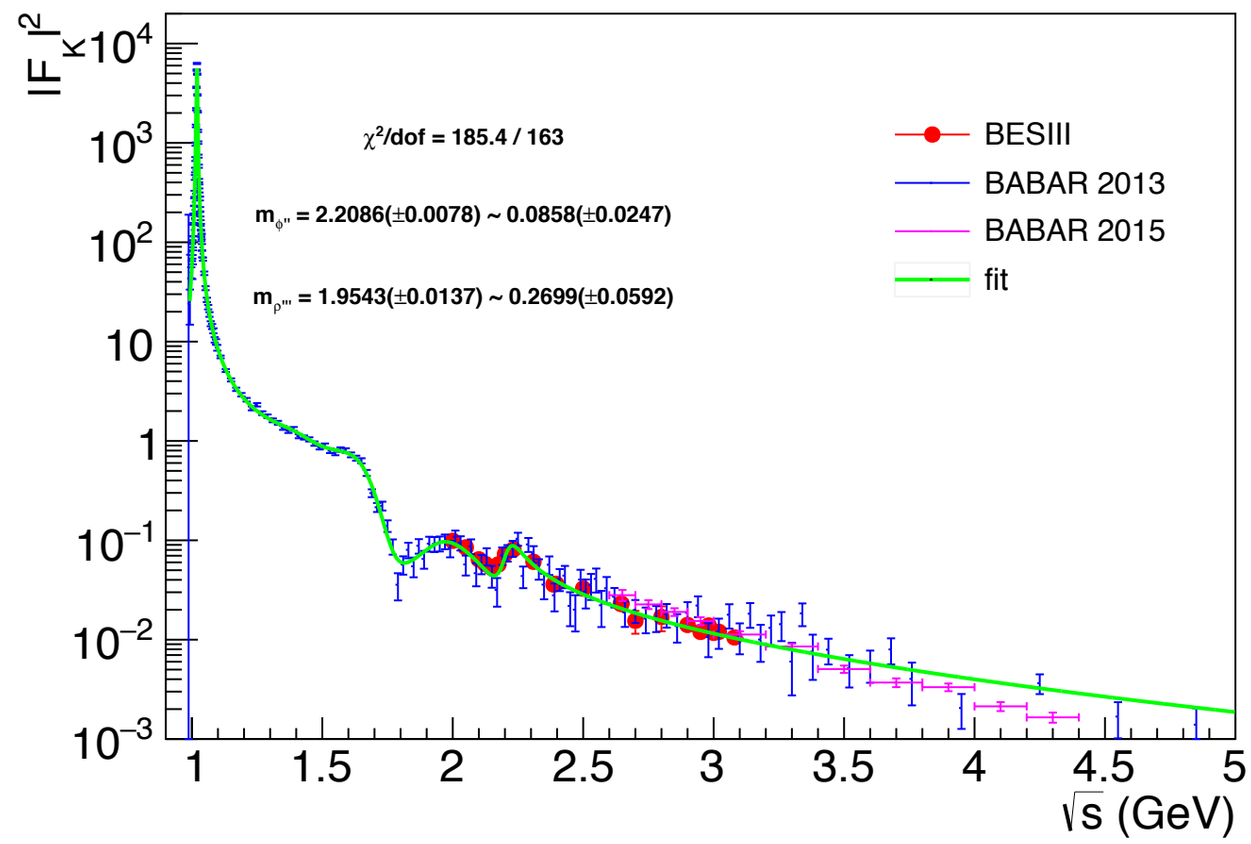

```
c_phi2    =    0.0278707 +/- 0.00151713
mass1  =    2.18495 +/- 0.00658233
width1    =    0.236474 +/- 0.00892345
c_con  =    -1.00353 +/- 0.0241503
phase  =    1.20003 +/- 0.0445706
m   =    2.09986 +/- 0.00354159
w   =    0.167732 +/- 0.00741438
c1  =    3.1839 +/- 0.386115
alpha  =    -2.55065 +/- 0.113821
phase2    =    0.793284 +/- 0.0751686
```

signal: pwave BW
other: gaus+ e^alpha

fit BABAR FF

BABAR 13

$$
\begin{aligned}
A =& c_\phi BW_\phi + c_{\phi'} BW_{\phi'} + c_{\phi''} BW_{\phi''} \\
&+ c_\rho BW_\rho + c_{\rho'} BW_{\rho'} + c_{\rho''} BW_{\rho''} + c_{\rho'''} BW_{\rho'''} \\
&+ c_\omega BW_\omega + c_{\omega'} BW_{\omega'} + c_{\omega''} BW_{\omega''} \\
&+ c_{con} s^{-\alpha}
\end{aligned}
$$



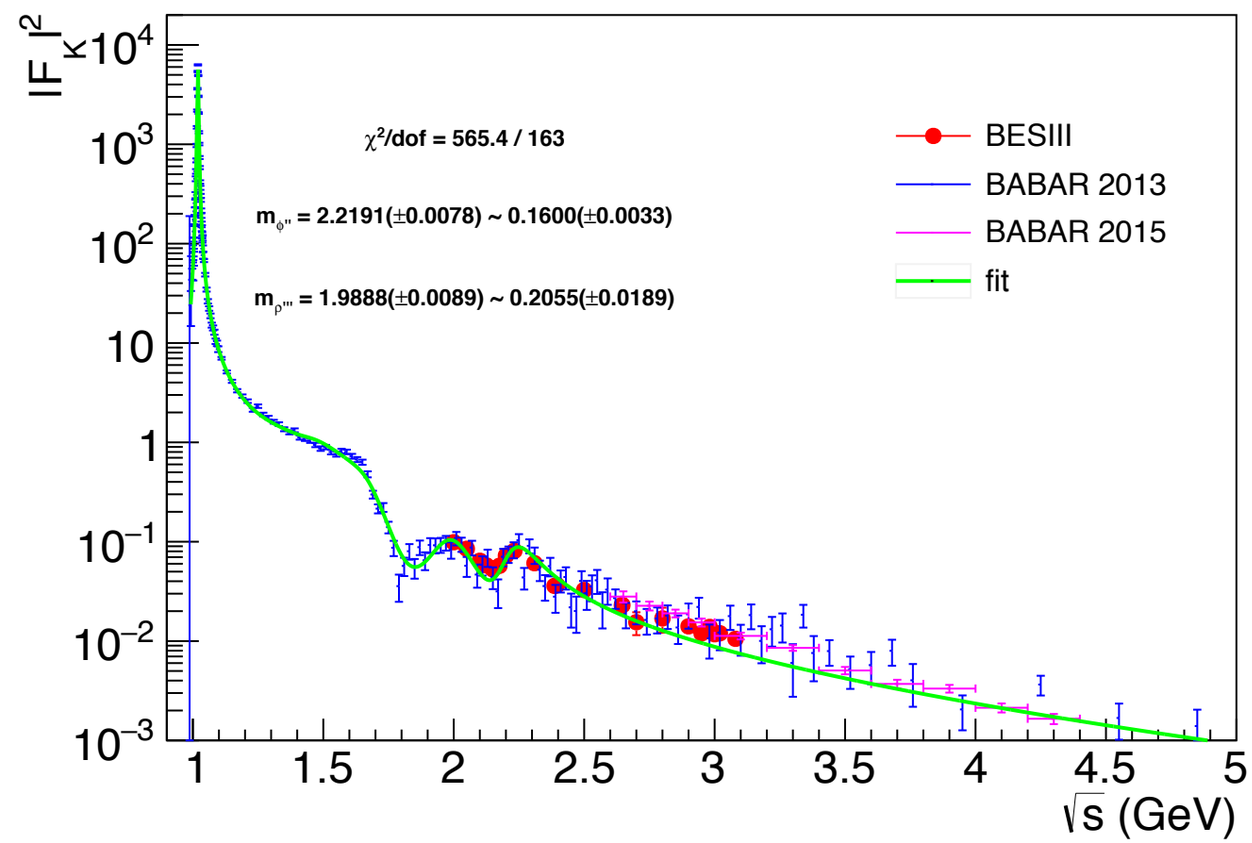

```
Print results from minuit
c_phi0|     = |       0.998127 +/- 0.00261576
c_phi1|     = |       0.0167067 +/- 0.00487479
c_rho0|     = |       1.00311 +/- 0.0636329
c_rho1|     = |       -0.236801 +/- 0.0592086
c_rho2|     = |       0.282195 +/- 0.0172087
c_omega0|   = |       2.68588 +/- 0.136948
c_omega1|   = |       -0.0794571 +/- 0.0520035
m_phi2|     = |       2.20863 +/- 0.00784626
w_phi2|     = |       0.0857645 +/- 0.0246844
m_rho3|     = |       1.95429 +/- 0.0136585
w_rho3|     = |       0.269882 +/- 0.0591601
c_con|      = |       0.498316 +/- 0.0369944
alpha|      = |       -1.73445 +/- 0.0833558
```

no R3

BABAR 13+15

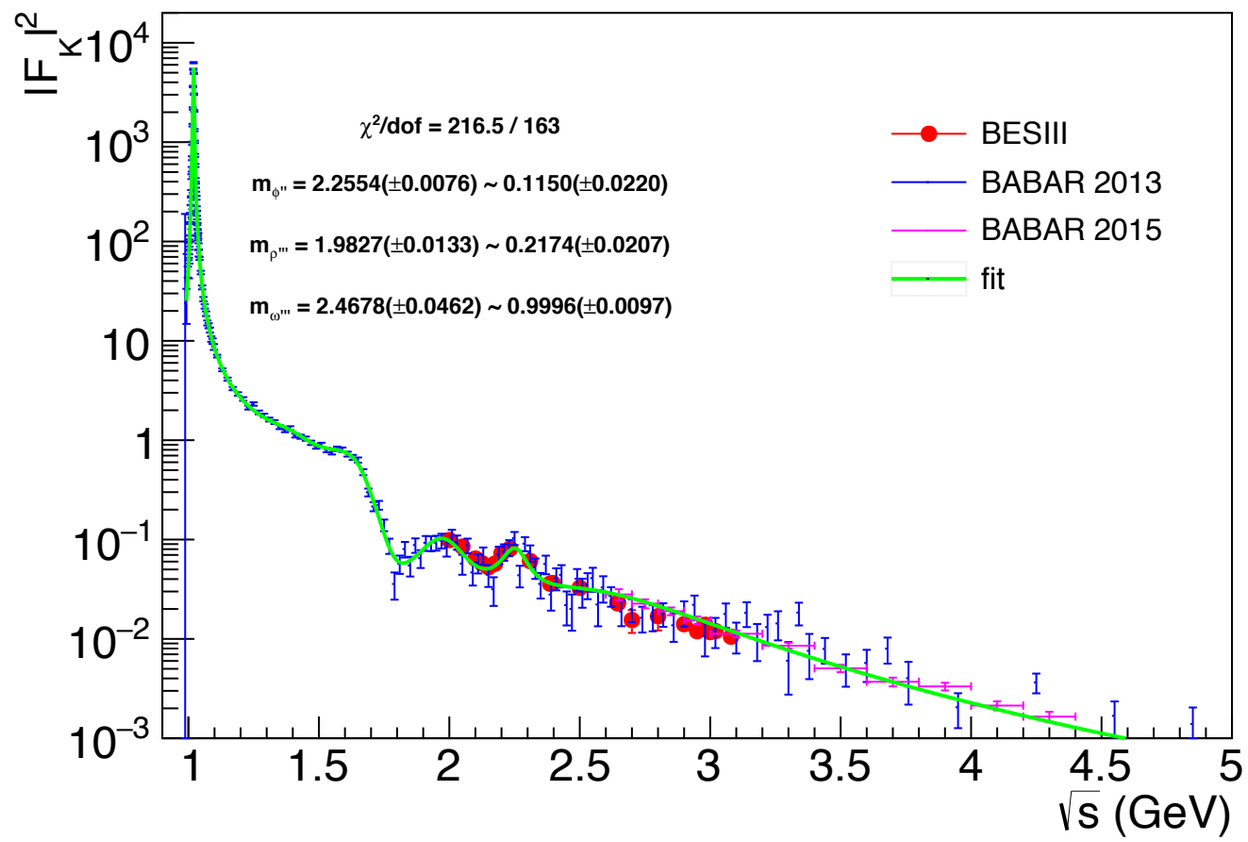
no R3

```
c_phi0|     = |      0.994047 +/- 0.00266652
c_phi1|     = |      0.0490051 +/- 0.00470653
c_rho0|     = |      1.73185 +/- 0.0175977
c_rho1|     = |      -0.861958 +/- 0.0195342
c_rho2|     = |      0.206198 +/- 0.00631633
c_omega0|   = |      5 +/- 0.0287848
c_omega1|   = |      0.171726 +/- 0.0368529
c_omega2|   = |      0 +/- 0
m_phi2      = |      2.2191 +/- 0.00780726
w_phi2|     = |      0.16 +/- 0.00332804
m_rho3|     = |      1.98877 +/- 0.00891759
w_rho3|     = |      0.205479 +/- 0.0188672
m_omega3|   = |      0 +/- 0
w_omega3|   = |      0 +/- 0
c_con|      = |      1.50248 +/- 0.0132092
alpha|      = |      -2.5 +/- 0.00245886
```



BABAR 13+15

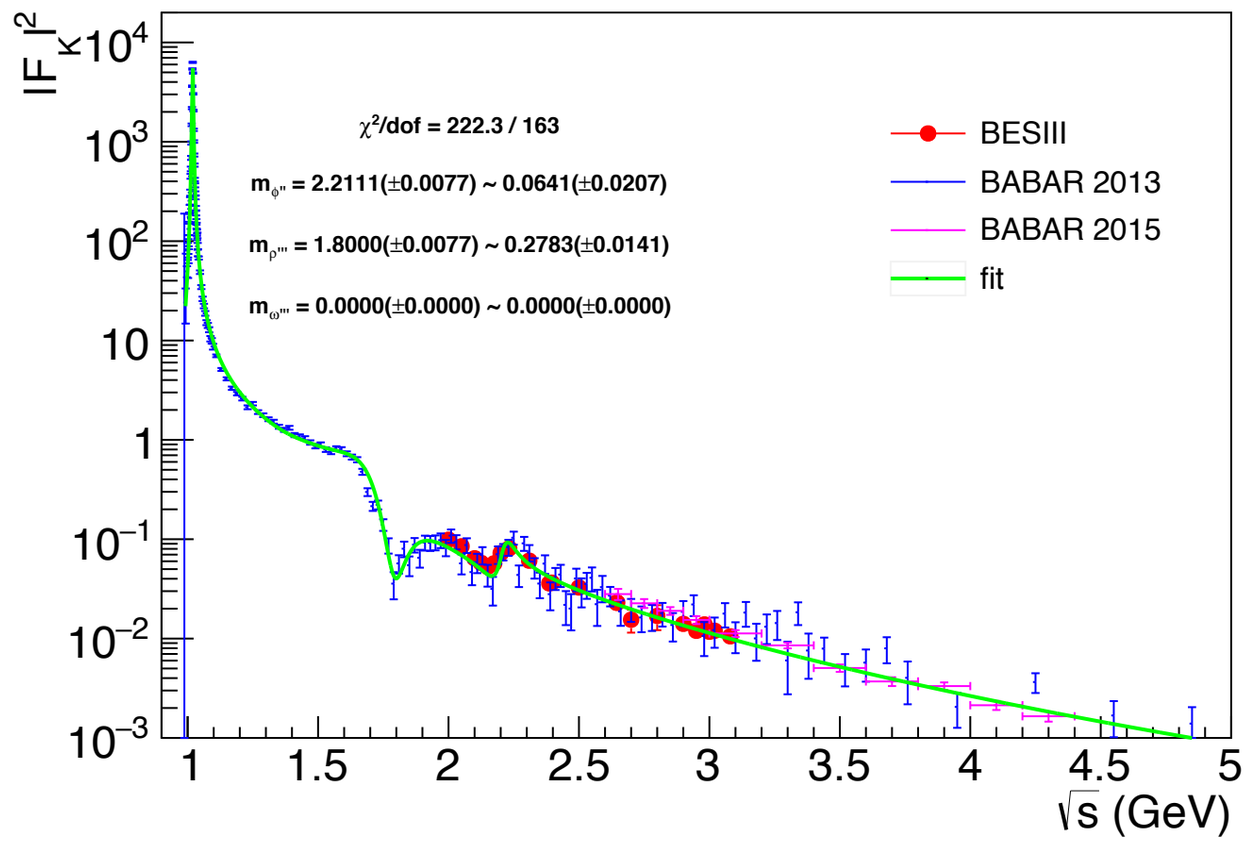
```
c_phi0|     = |      1.00268 +/- 0.00256618
c_phi1|     = |      0.0696272 +/- 0.0119572
c_rho0|     = |      0.709571 +/- 0.0204605
c_rho1|     = |      -0.148308 +/- 0.0375866
c_rho2|     = |      0.360507 +/- 0.0146098
c_omega0|   = |      2.51727 +/- 0.0440861
c_omega1|   = |      -0.116557 +/- 0.0333738
c_omega2|   = |      -1.9795 +/- 0.0328915
m_phi2|     = |      2.25545 +/- 0.00760027
w_phi2|     = |      0.115037 +/- 0.021951
m_rho3|     = |      1.98271 +/- 0.0132918
w_rho3|     = |      0.217427 +/- 0.0206618
m_omega3|   = |      2.4678 +/- 0.0462054
w_omega3|   = |      0.999627 +/- 0.00967137
c_con|      = |      0.372973 +/- 0.0301169
alpha|      = |      -1.98735 +/- 0.0908574
phase|      = |      -1.49793 +/- 0.0445538
```



BABAR 13+15

uncertainty from Ecm, no R3

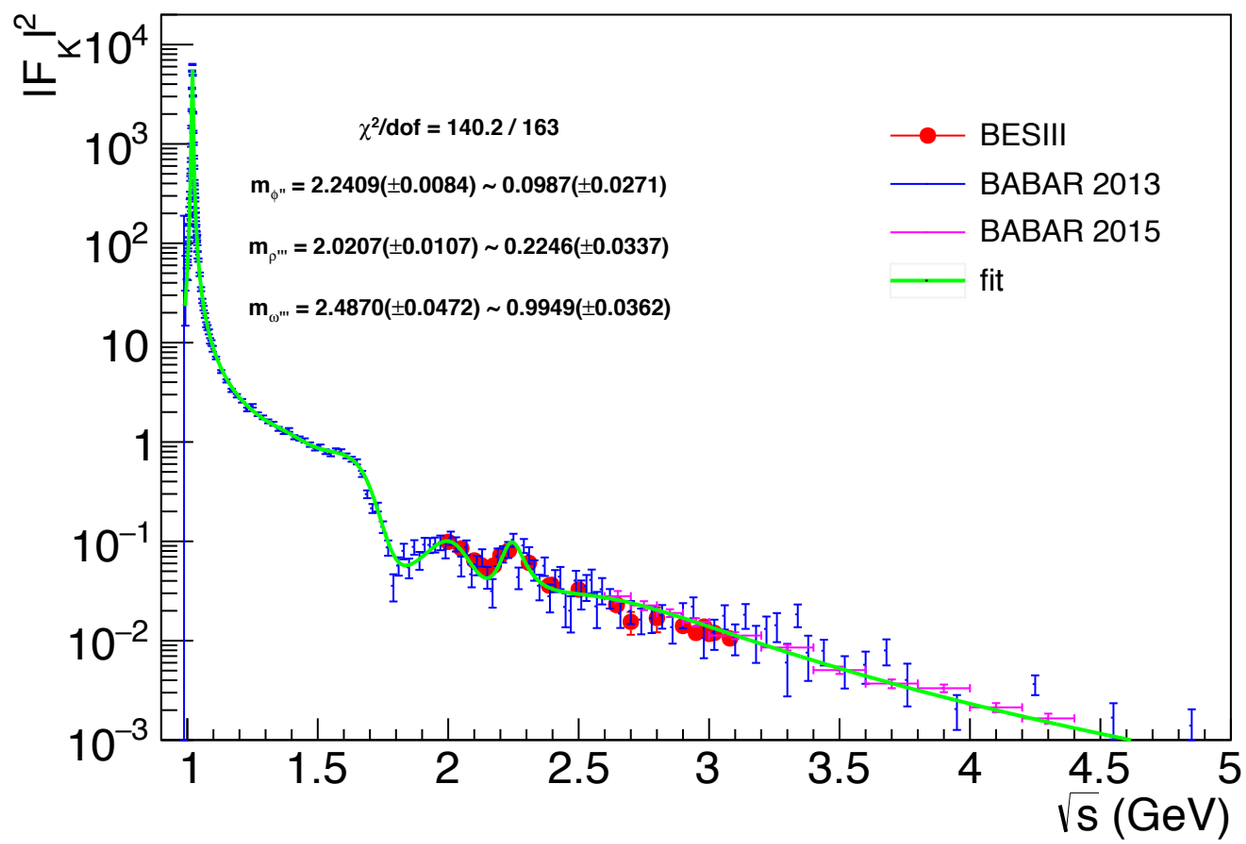
```
c_phi0|     = |      0.984304 +/- 0.0085807
c_phi1|     = |      0.00536344 +/- 0.00877322
c_rho0|     = |      1.12315 +/- 0.0233498
c_rho1|     = |      -0.0200086 +/- 0.033124
c_rho2|     = |      -0.396508 +/- 0.0158255
c_omega0|   = |      0.8 +/- 0.0940237
c_omega1|   = |      0.0254361 +/- 0.0448899
c_omega2|   = |      0 +/- 0
m_phi2|     = |      2.2111 +/- 0.00768893
w_phi2|     = |      0.0640635 +/- 0.020702
m_rho3|     = |      1.8 +/- 0.00774426
w_rho3|     = |      0.278288 +/- 0.0140913
m_omega3|   = |      0 +/- 0
w_omega3|   = |      0 +/- 0
c_con|      = |      0.576513 +/- 0.0457859
alpha|      = |      -2.1 +/- 0.00807963
phase|      = |      -2.96452 +/- 0.190634
```



BABAR 13+15

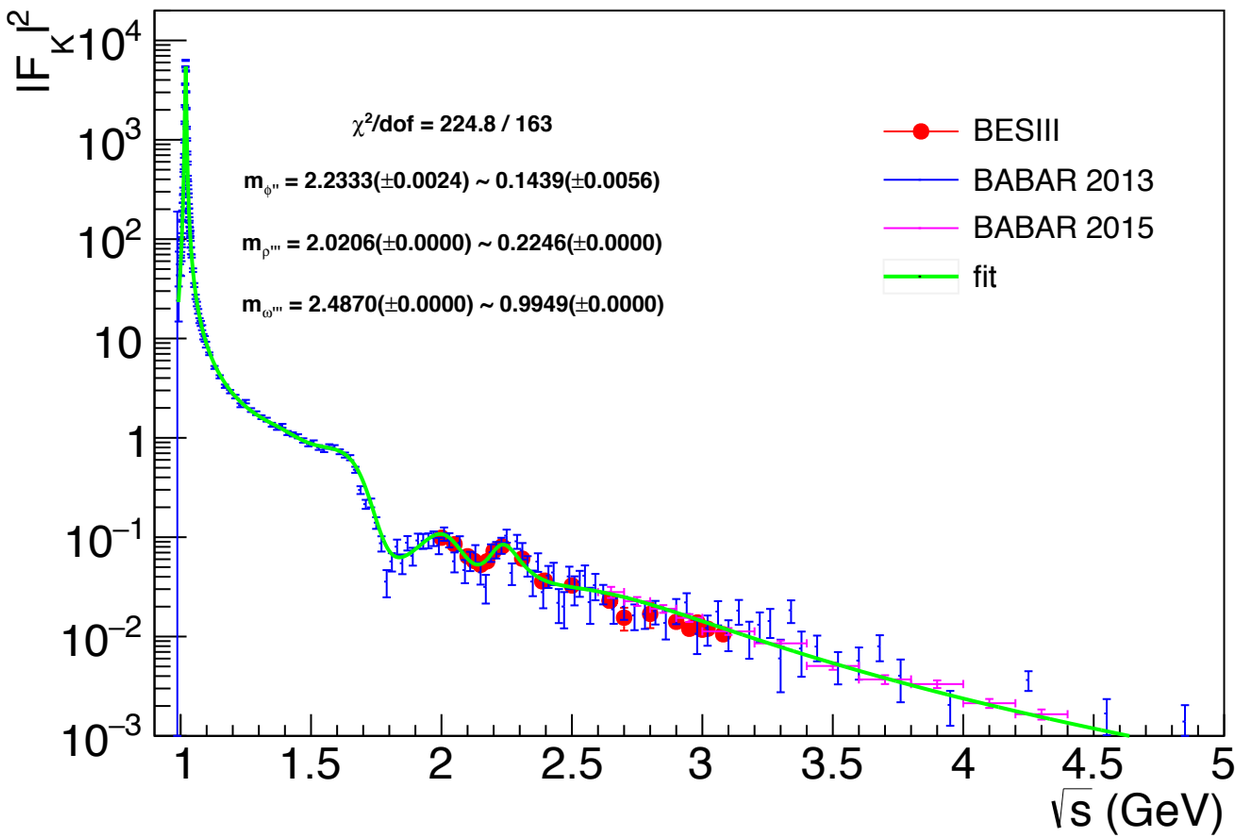
uncertainty from Ecm

```
c_phi0|     = |      0.98941 +/- 0.00810945
c_phi1|     = |      -0.0121633 +/- 0.00991889
c_rho0|     = |      0.714988 +/- 0.0467975
c_rho1|     = |      -0.134851 +/- 0.0333409
c_rho2|     = |      0.355537 +/- 0.0275832
c_omega0|   = |      2.54978 +/- 0.112916
c_omega1|   = |      -0.0554647 +/- 0.04037
c_omega2|   = |      -1.8343 +/- 0.0820294
m_phi2|     = |      2.24092 +/- 0.00836582
w_phi2|     = |      0.0986994 +/- 0.0270501
m_rho3|     = |      2.02065 +/- 0.0107125
w_rho3|     = |      0.224572 +/- 0.0337497
m_omega3|   = |      2.48703 +/- 0.047232
w_omega3|   = |      0.994878 +/- 0.0362471
c_con|      = |      0.246496 +/- 0.0261262
alpha|      = |      -2.09887 +/- 0.0812294
phase|      = |      -1.86841 +/- 0.116722
```



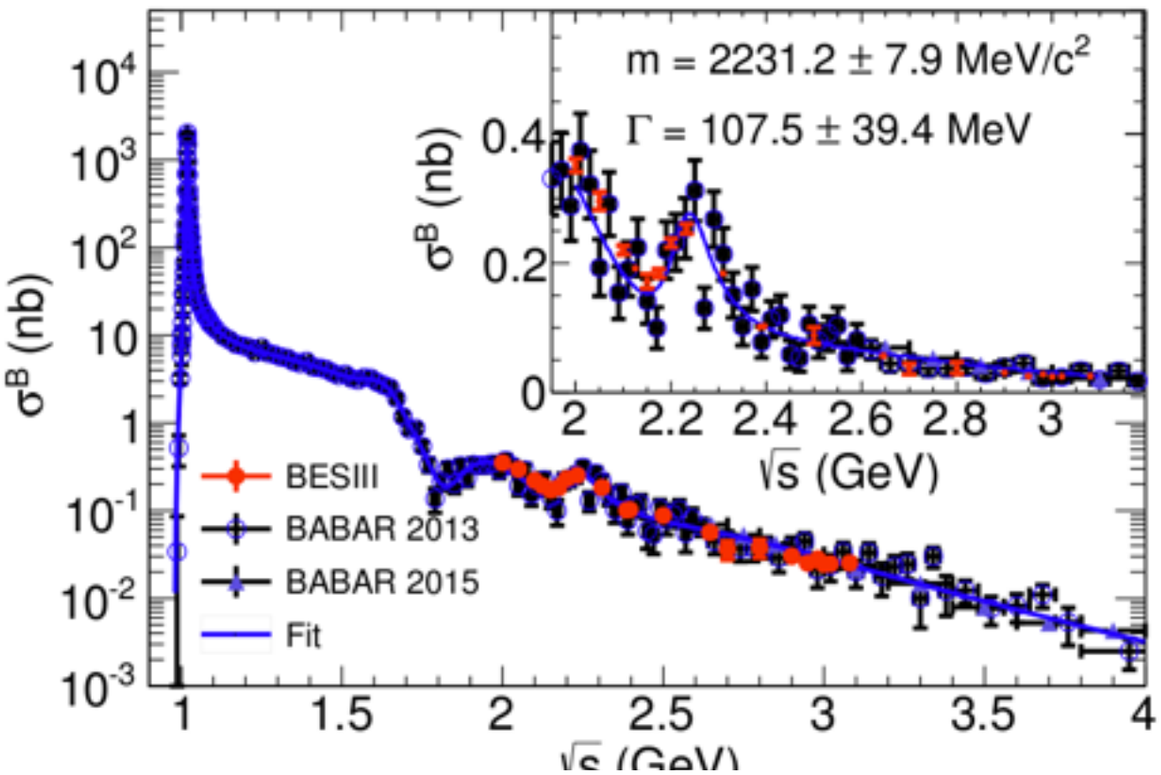
fix babar, add bes

```
c_phi0|     = |       0.986834 +/- 0.00287903
c_phi1|     = |       -0.0156014 +/- 0.00289905
m_phi2|     = |       2.23325 +/- 0.00242215
w_phi2|     = |       0.143858 +/- 0.00559564
```



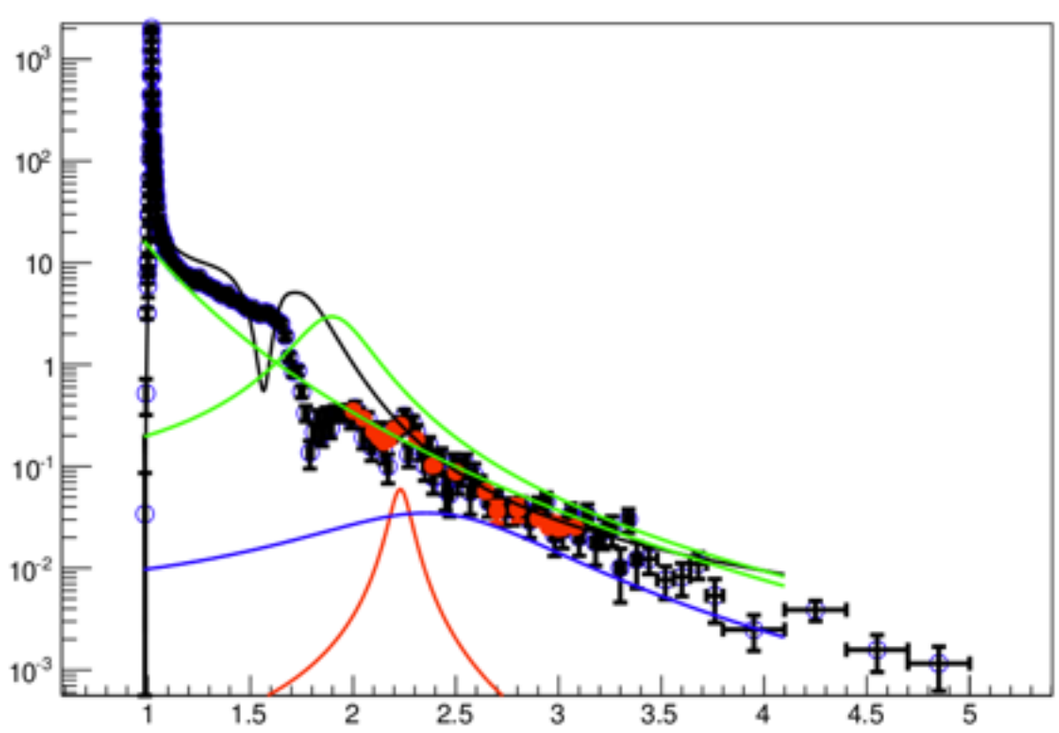
fit BABAR XS

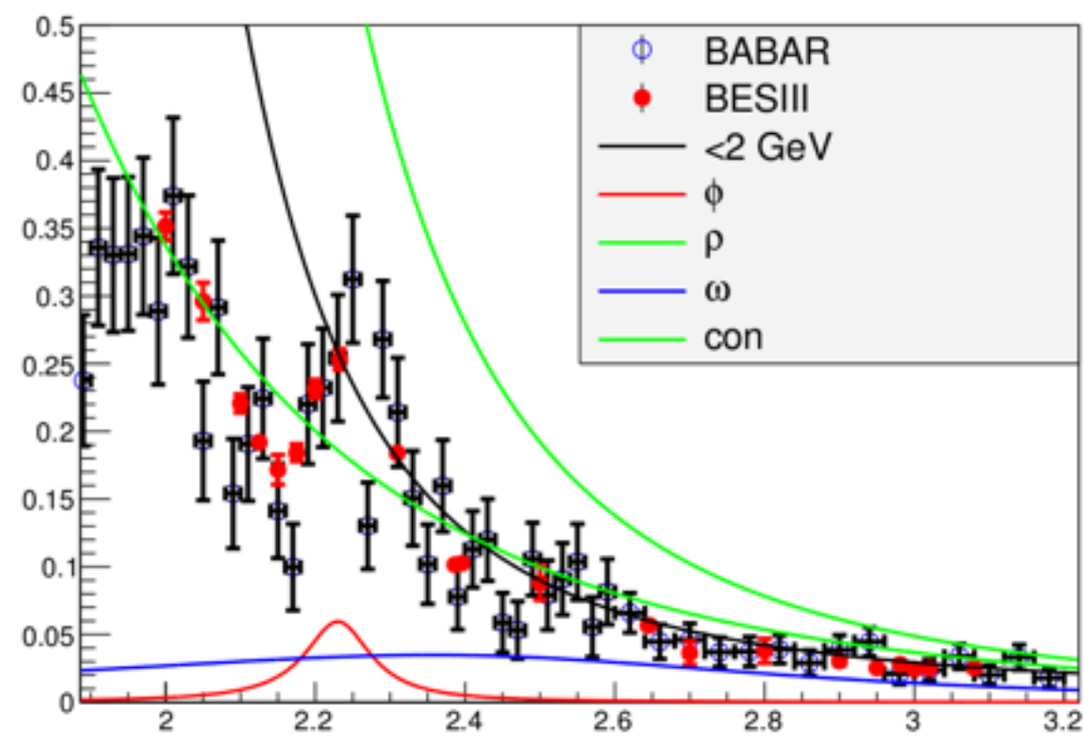
BABAR 13+15



1	c_phi0	1.88765e-01	1.85952e-03
2	c_phi1	-2.98134e-01	9.31256e-03
3	c_phi2	1.17549e-02	1.57412e-03
4	c_rho0	6.73290e-01	3.43518e+00
5	c_rho1	-1.25153e+00	1.65534e-02
6	c_rho2	-2.07843e+00	1.32479e-02
7	c_rho3	3.28976e-01	9.94307e-03
8	c_omega0	-1.65794e+00	1.08964e-01
9	c_omega1	3.30719e-02	8.89236e-03
10	c_omega2	2.86687e+00	1.55298e-02
11	c_omega3	8.51953e-02	8.36248e-03
12	mass1	2.23120e+00	7.92350e-03
13	width1	1.07524e-01	3.93964e-02
14	mass2	1.91330e+00	2.73124e-02
15	width2	3.67550e-01	1.21355e-02
16	mass3	2.49689e+00	4.34164e-02
17	width3	1.17246e+00	6.95306e-02
18	c_con	3.86024e+00	1.46995e-01
19	order	-2.73269e+00	3.60012e-02
20	phase	-3.12014e+00	4.63410e-02

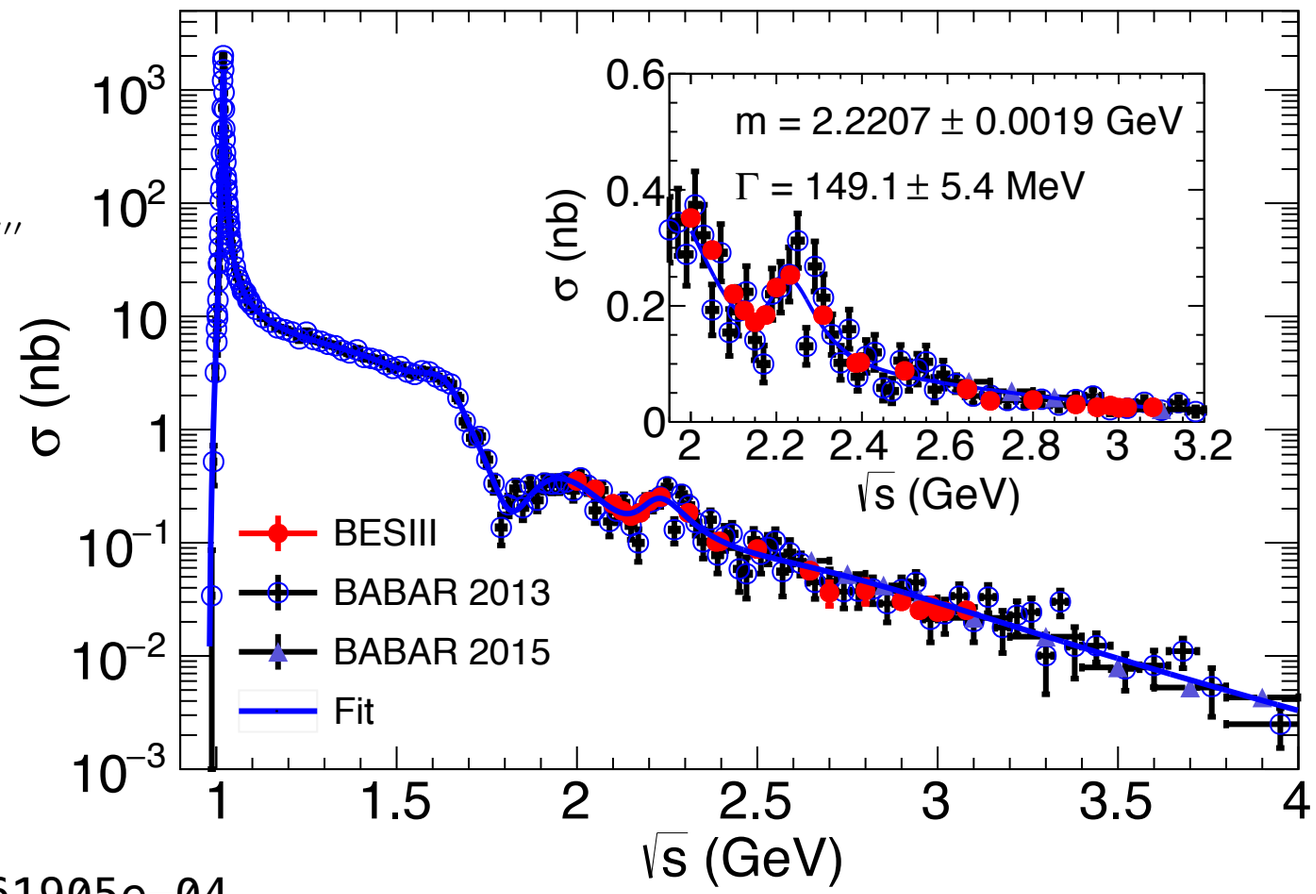
```
Fit  1999th. Time seed is 1680309
chi2 is 121.321
bes chi2 is 0
bar13 chi2 is 113.879
bar15 chi2 is 7.4423
```



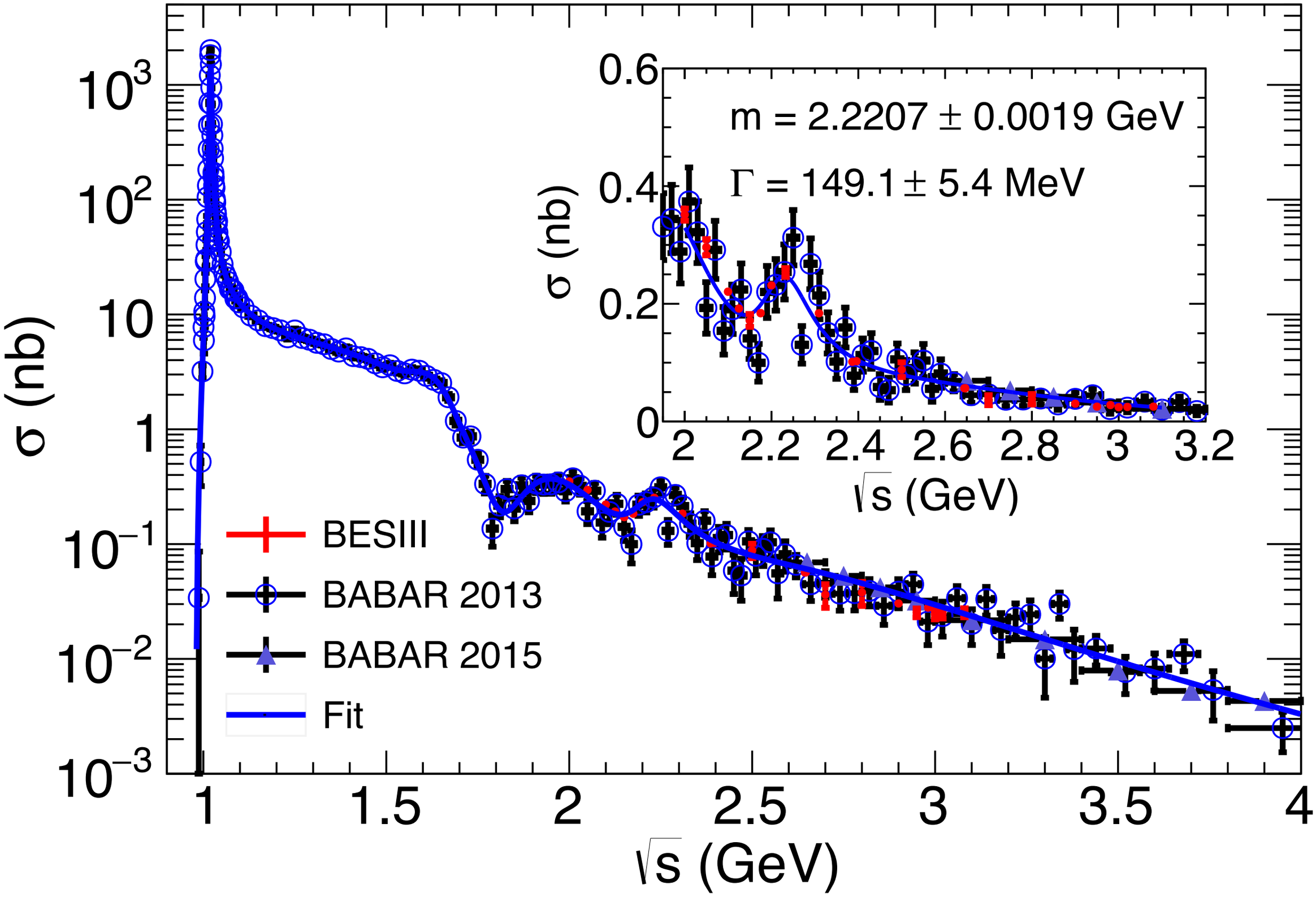


fix babar, fit babar and bes

$$
\begin{aligned}
A =& c_\phi BW_\phi + c_{\phi'} BW_{\phi'} + c_{\phi''} BW_{\phi''} \\
&+ c_\rho BW_\rho + c_{\rho'} BW_{\rho'} + c_{\rho''} BW_{\rho''} + c_{\rho'''} BW_{\rho'''} \\
&+ c_\omega BW_\omega + c_{\omega'} BW_{\omega'} + c_{\omega''} BW_{\omega''} \\
&+ c_{con} s^{-\alpha}
\end{aligned}
$$

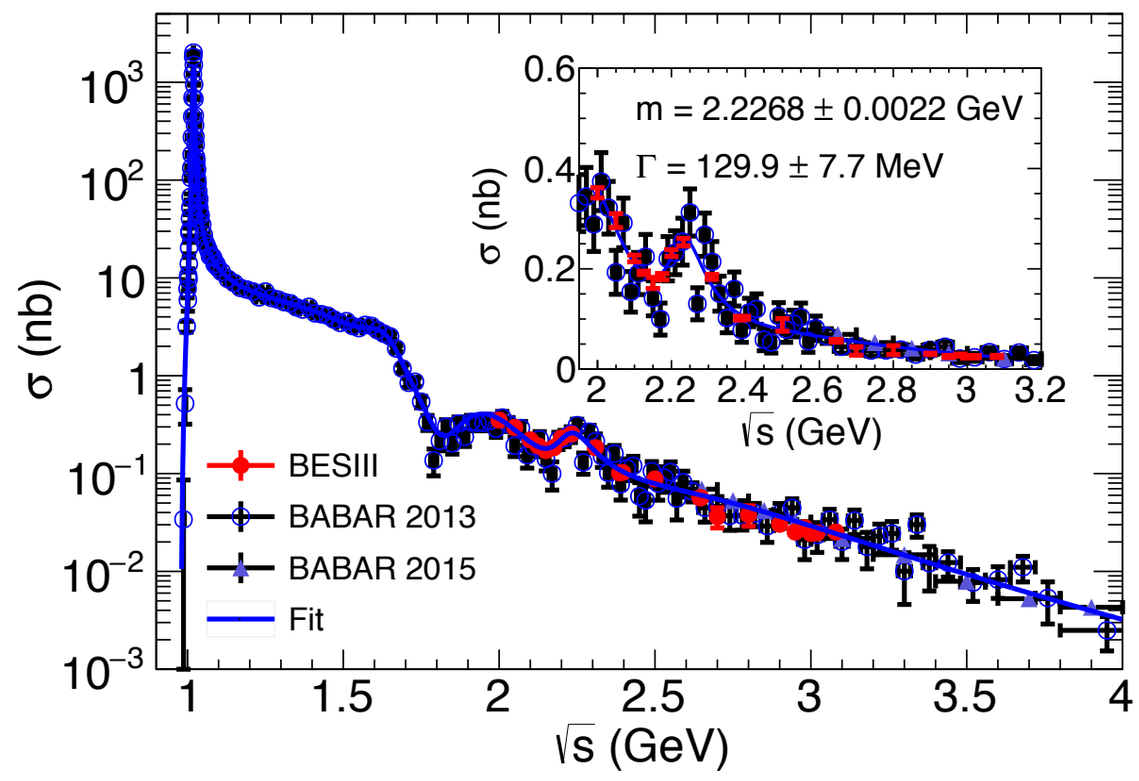



```
   3  c_phi2        1.40083e-02   4.61905e-04
  12  mass1         2.22066e+00   1.88539e-03
  13  width1        1.49144e-01   5.39604e-03
Fit  499th. Time seed is 1513326451
chi2 is 237.303
bes chi2 is 113.147
bar13 chi2 is 120.299
bar15 chi2 is 7.71473
```


m = 2.2207 ± 0.0019 GeV
Γ = 149.1 ± 5.4 MeV
σ (nb)
√s (GeV)
BESIII
BABAR 2013
BABAR 2015
Fit

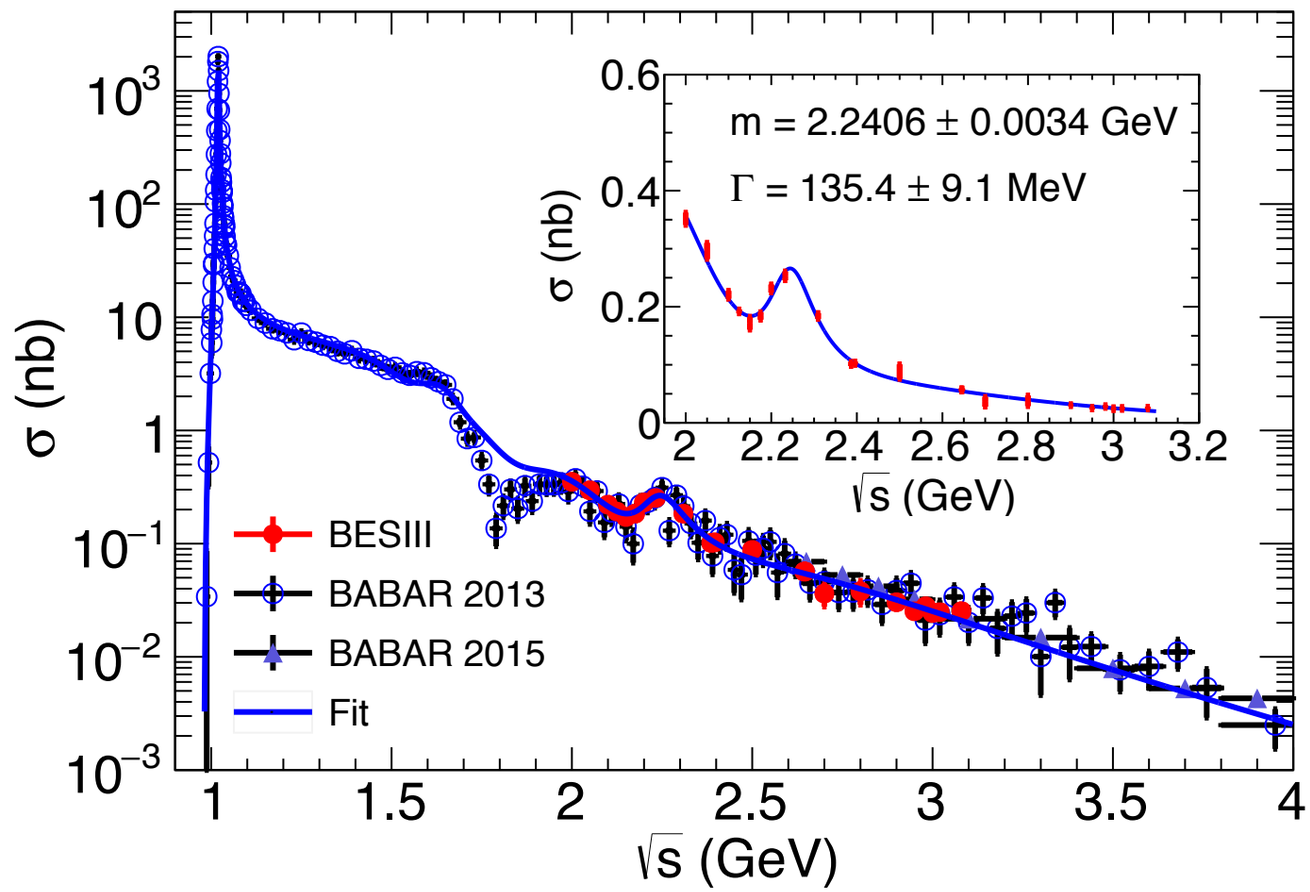
float 2 resonances

```
  3  c_phi2        1.25105e-02   8.25984e-04
  7  c_rho3        3.25423e-01   2.76739e-03
 12  mass1         2.22677e+00   2.24075e-03
 13  width1        1.29857e-01   7.66664e-03
 14  mass2         1.92037e+00   1.98283e-03
 15  width2        3.67629e-01   4.91793e-03

Fit  499th. Time seed is 1513567837
chi2 is 203.561
bes chi2 is 68.0748
bar13 chi2 is 131.953
bar15 chi2 is 7.06597
```

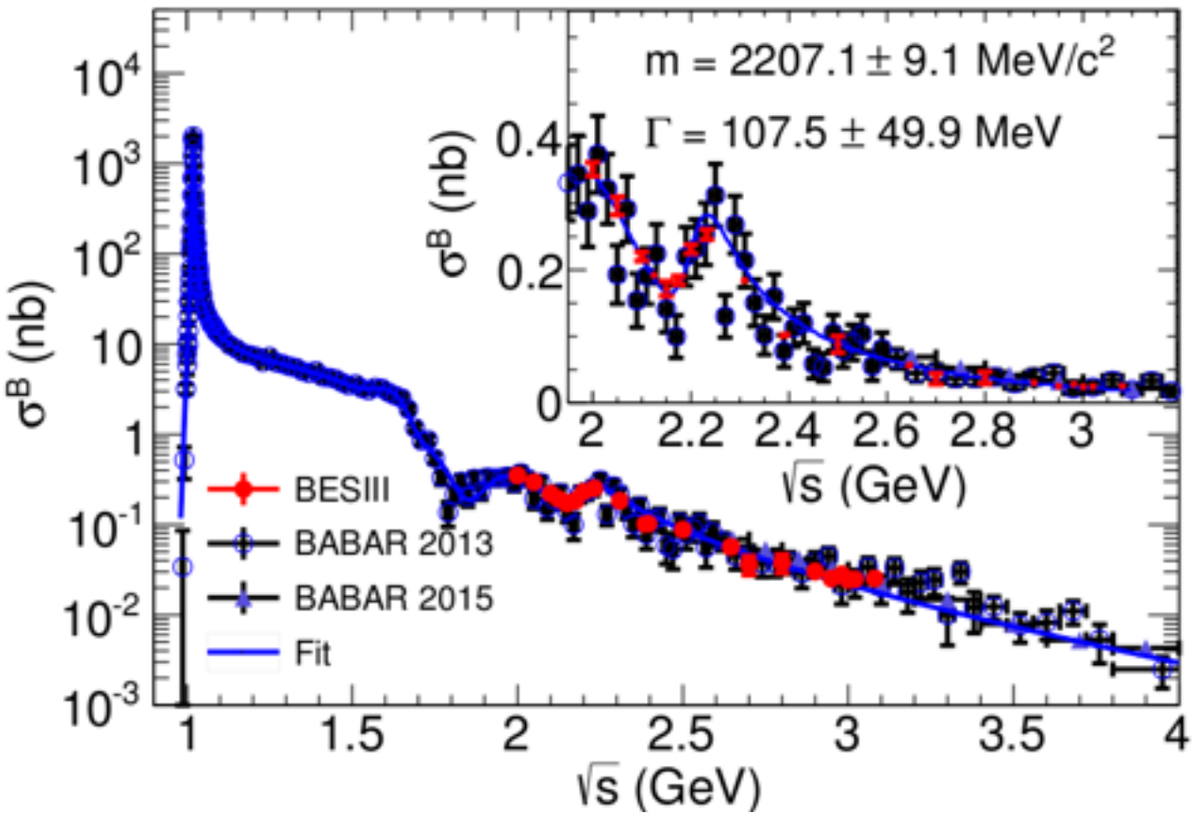


fix babar, fit only bes

```
 3   c_phi2        1.42500e-02   1.07932e-03
 7   c_rho3        2.85851e-01   6.53002e-03
12   mass1         2.24059e+00   3.43528e-03
13   width1        1.35438e-01   9.07370e-03
14   mass2         1.94963e+00   5.29032e-03
15   width2        3.86397e-01   1.03204e-02

Fit  499th. Time seed is 1513583119
chi2 is 29.158
bes chi2 is 29.158
bar13 chi2 is 0
bar15 chi2 is 0
```

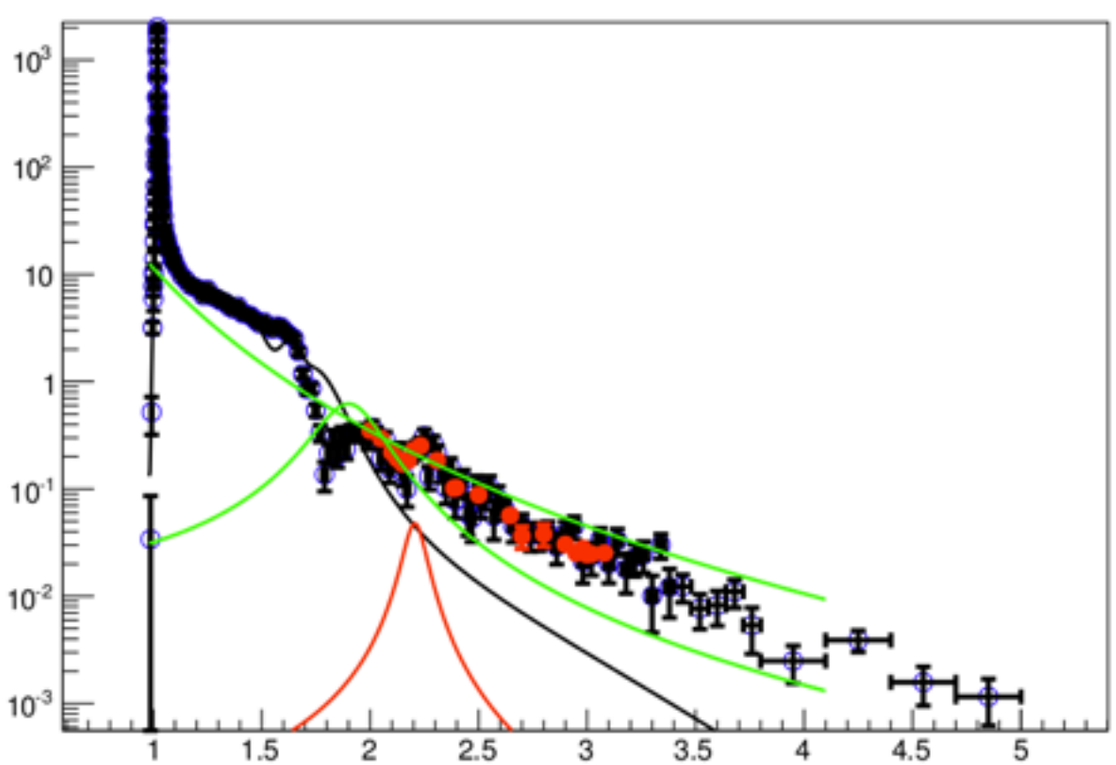


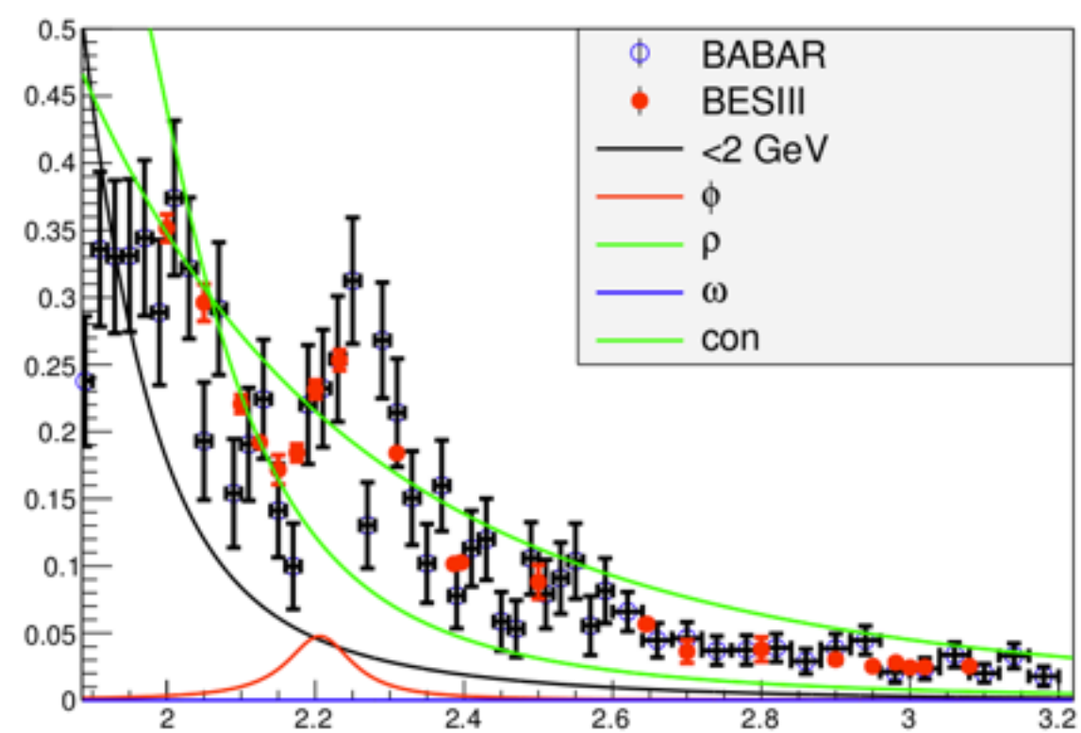
BABAR 13+15



1	c_phi0	1.90246e-01	1.88552e-03
2	c_phi1	-3.81227e-01	3.43222e-02
3	c_phi2	1.06333e-02	1.60265e-03
4	c_rho0	6.75164e-01	1.29398e-01
5	c_rho1	-1.30106e+00	7.44543e-02
6	c_rho2	-1.33927e+00	4.85570e-02
7	c_rho3	1.30748e-01	1.64802e-02
8	c_omega0	-1.29255e+00	1.72009e-01
9	c_omega1	5.34184e-02	3.20259e-02
10	c_omega2	2.55607e+00	1.07614e-01
11	c_omega3	0.00000e+00	fixed
12	mass1	2.20709e+00	9.12214e-03
13	width1	1.07524e-01	4.98714e-02
14	mass2	1.91330e+00	1.69755e-03
15	width2	3.18171e-01	2.97521e-02
16	mass3	2.00000e+00	fixed
17	width3	1.00000e-01	fixed
18	c_con	3.38120e+00	1.82748e-01
19	order	-2.51934e+00	3.78817e-02
20	phase	-2.99505e+00	6.05385e-02

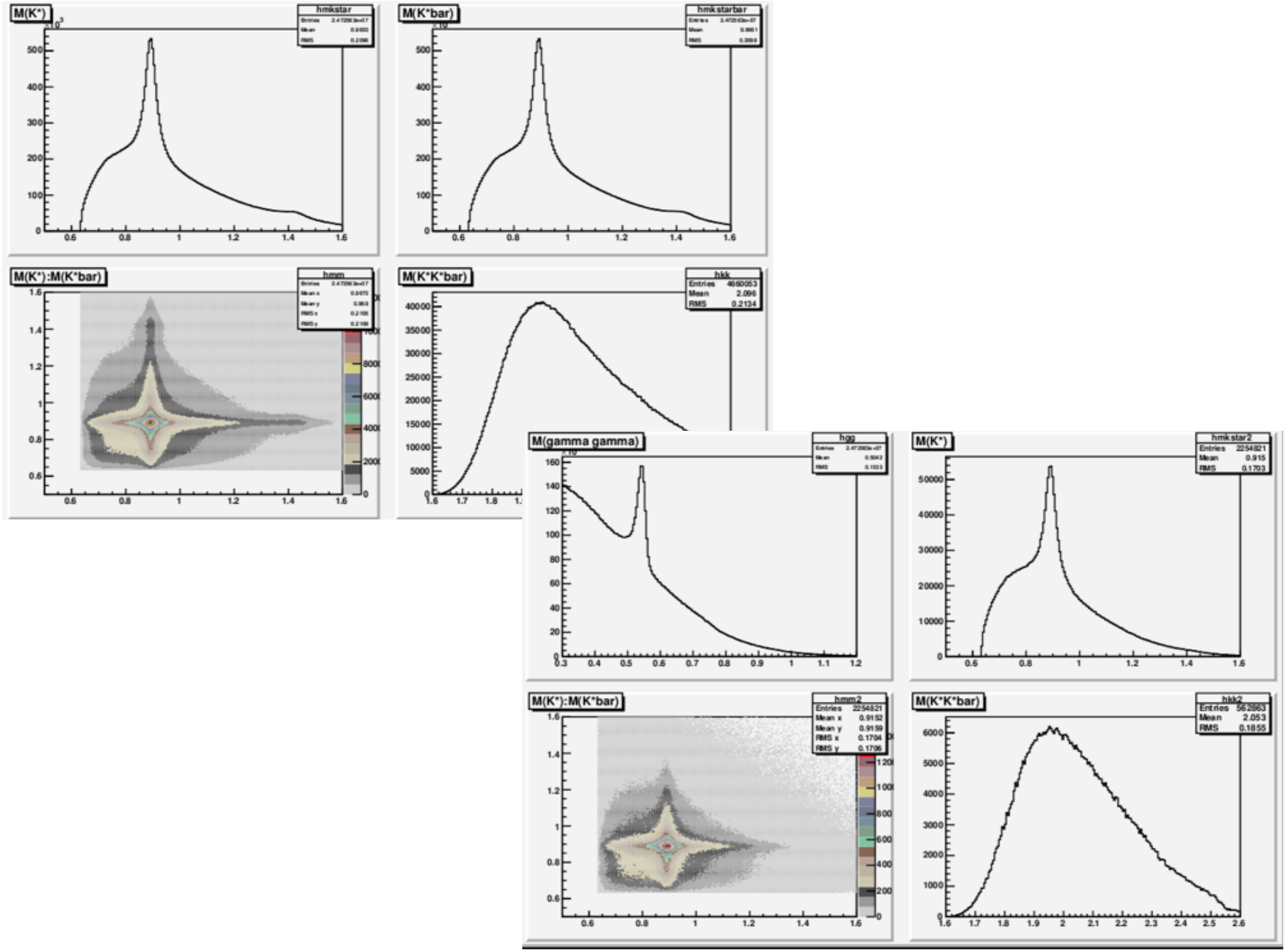
```
Fit  1999th. Time seed is 1101497
chi2 is 176.867
bes chi2 is 0
bar13 chi2 is 150.22
bar15 chi2 is 26.6472
```

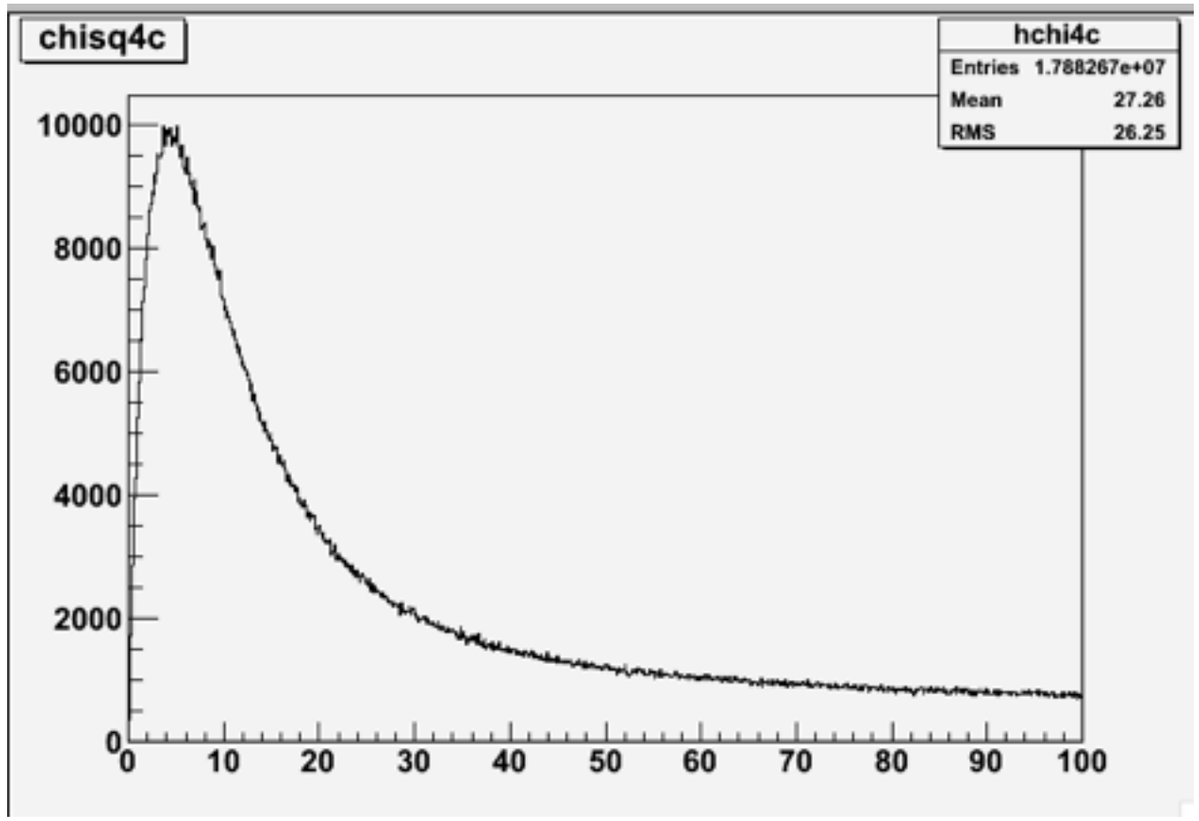


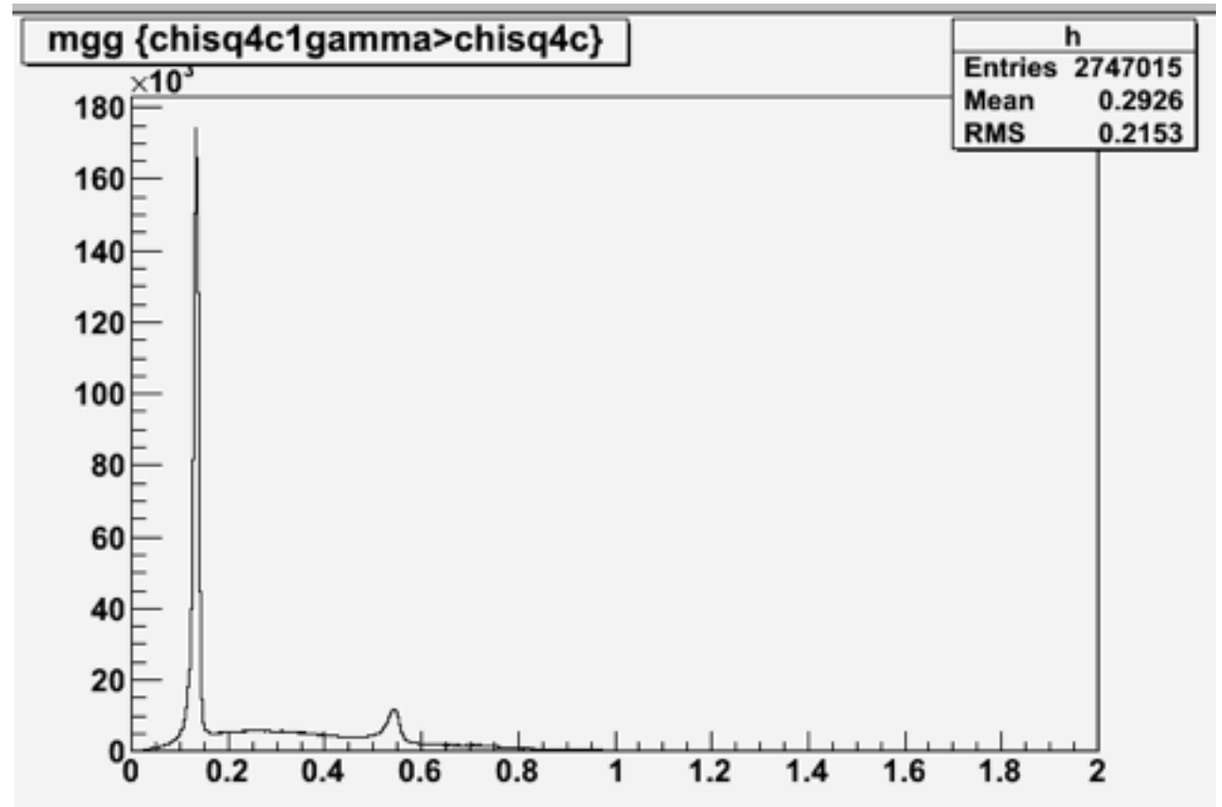


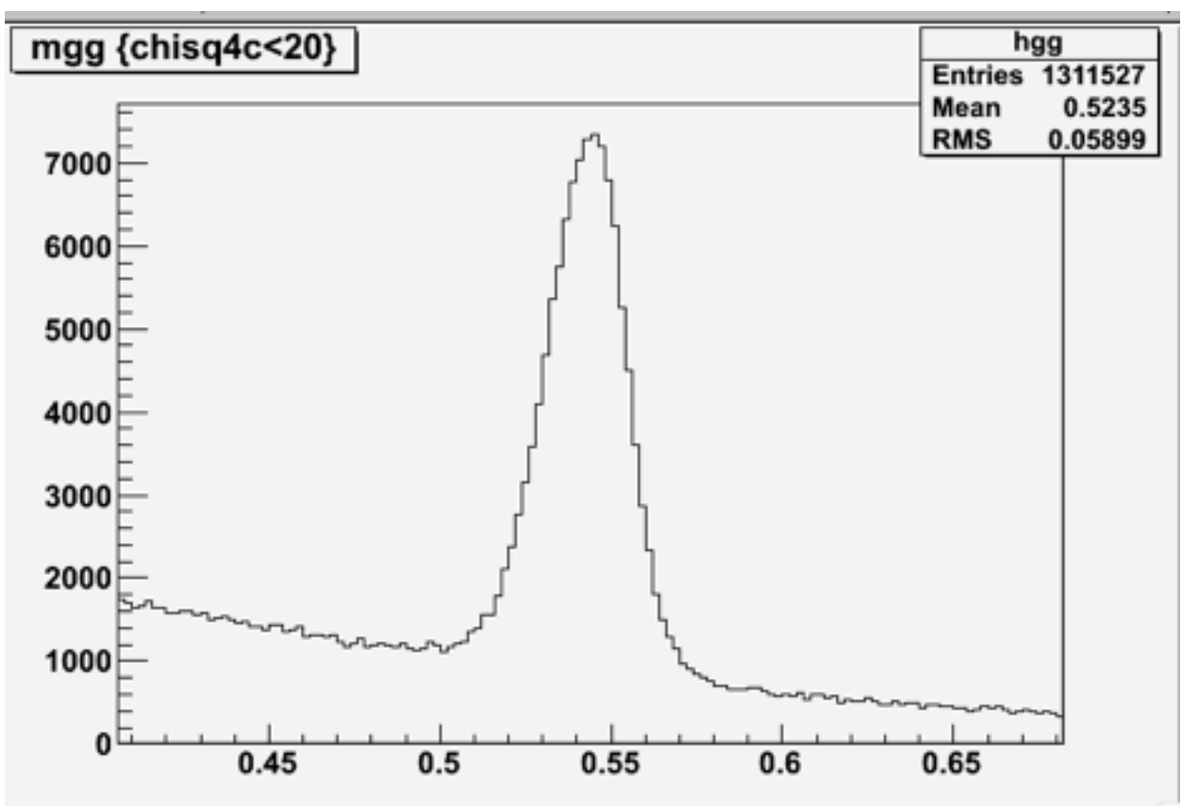
Jpsi ->eta K* K*bar

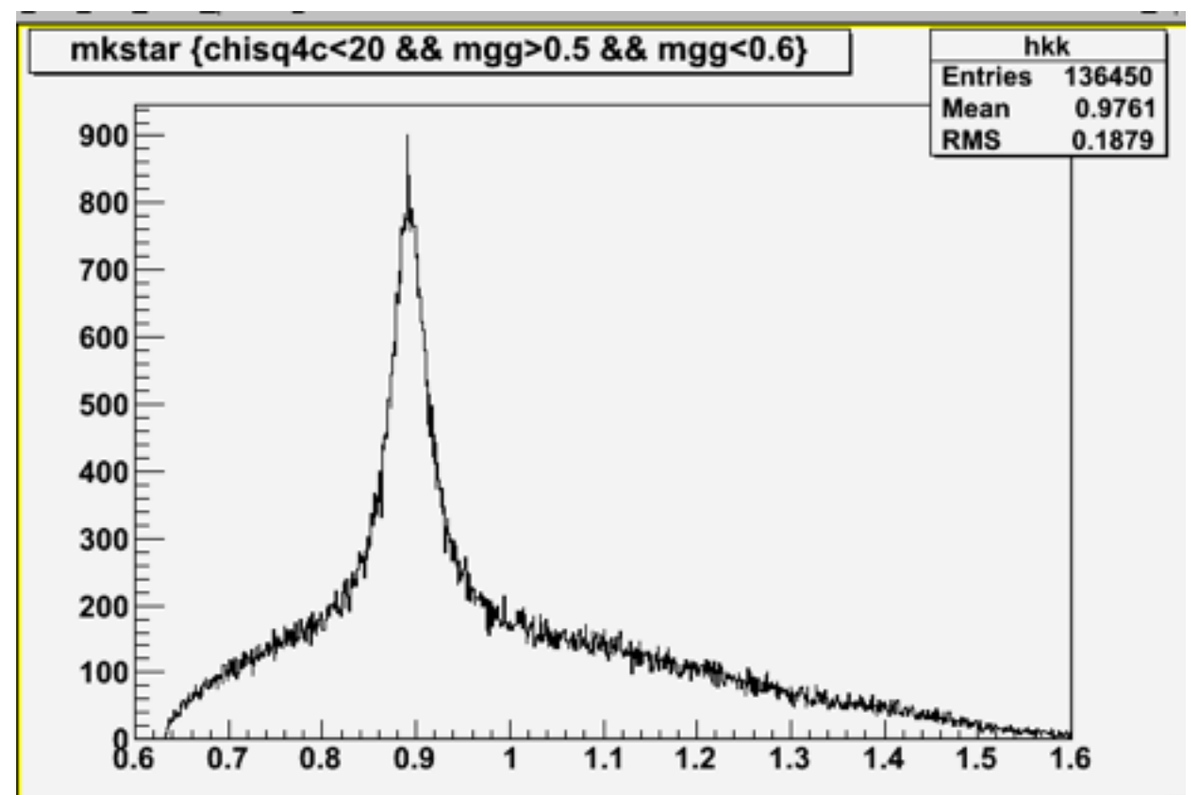
jpsi->eta Kstar Kstarbar

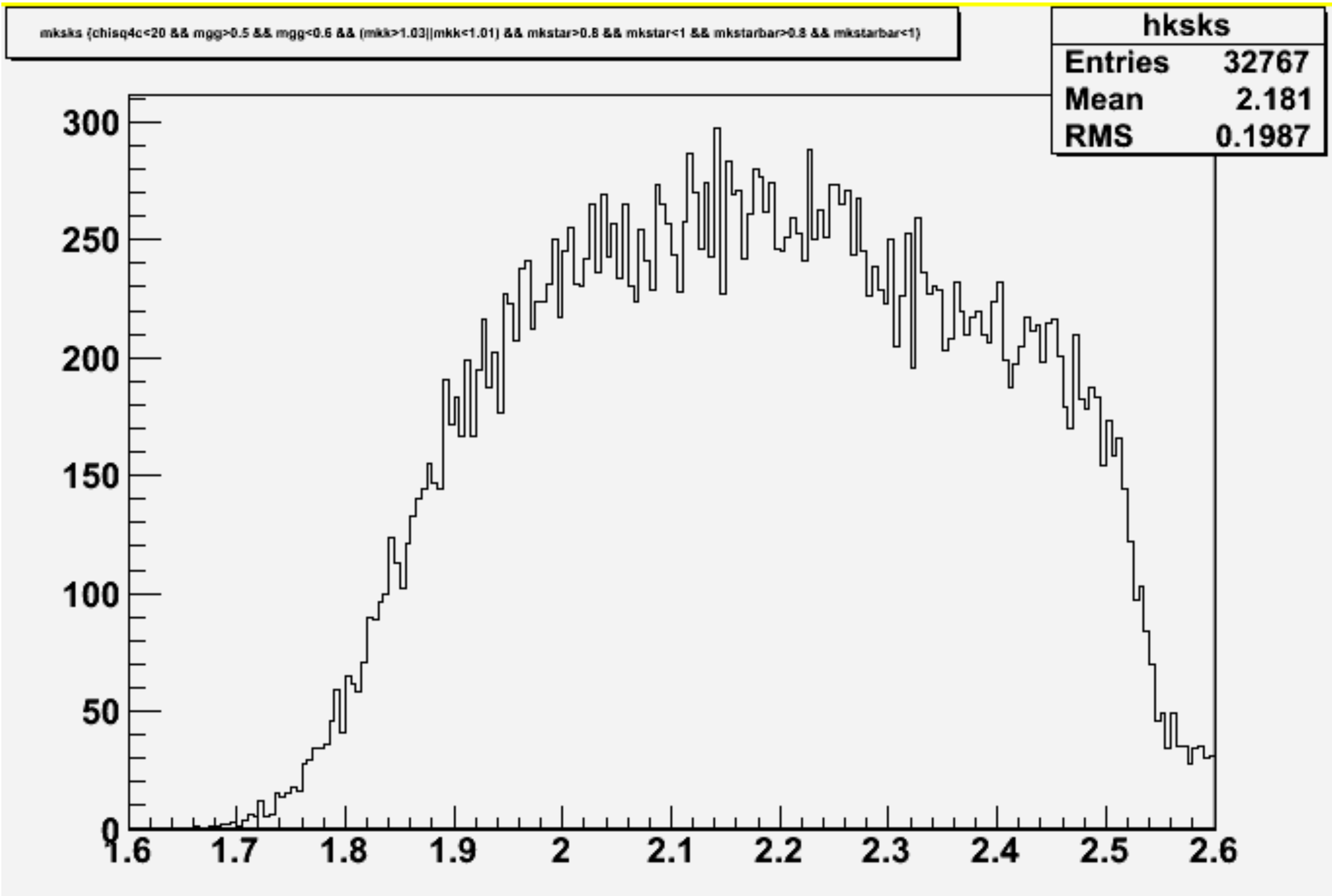

M(K*)
hmkstar
M(K*bar)
hmkstarbar
M(K*):M(K*bar)
hmm
M(K*K*bar)
hkk
Entries 4660053
Mean 2.096
RMS 0.2134
M(gamma gamma)
hgg
M(K*)
hmkstar2
Entries 2254821
Mean 0.915
RMS 0.1703
M(K*):M(K*bar)
hmm2
Entries 2254821
Mean x 0.9152
Mean y 0.9159
RMS x 0.1704
RMS y 0.1706
M(K*K*bar)
hkk2
Entries 562863
Mean 2.053
RMS 0.1855


chisq4c
hchi4c
Entries 1.788267e+07
Mean 27.26
RMS 26.25


mgg {chisq4c1gamma>chisq4c}
h
Entries 2747015
Mean 0.2926
RMS 0.2153


mgg {chisq4c<20}
hgg
Entries 1311527
Mean 0.5235
RMS 0.05899


mkstar {chisq4c<20 && mgg>0.5 && mgg<0.6}
hkk
Entries 136450
Mean 0.9761
RMS 0.1879

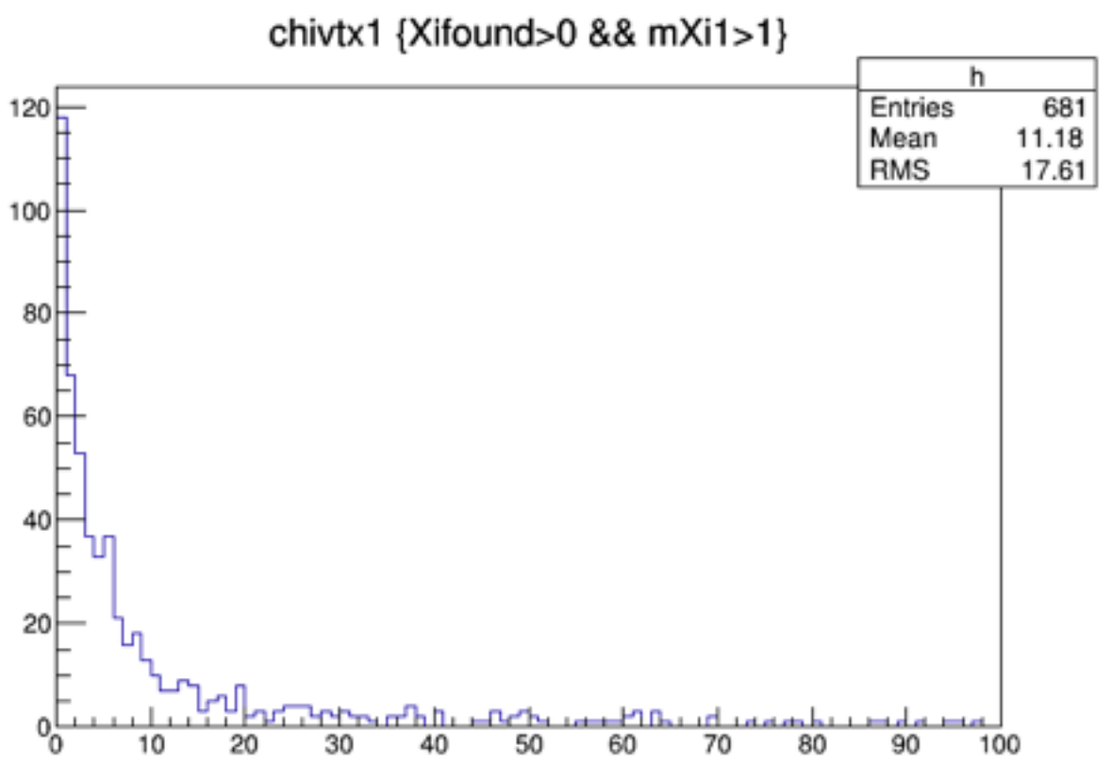

mksks (chisq4c<20 && mgg>0.5 && mgg<0.6 && (mkk>1.03||mkk<1.01) && mkstar>0.8 && mkstar<1 && mkstarbar>0.8 && mkstarbar<1)
hksks
Entries 32767
Mean 2.181
RMS 0.1987
300
250
200
150
100
50
0
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6

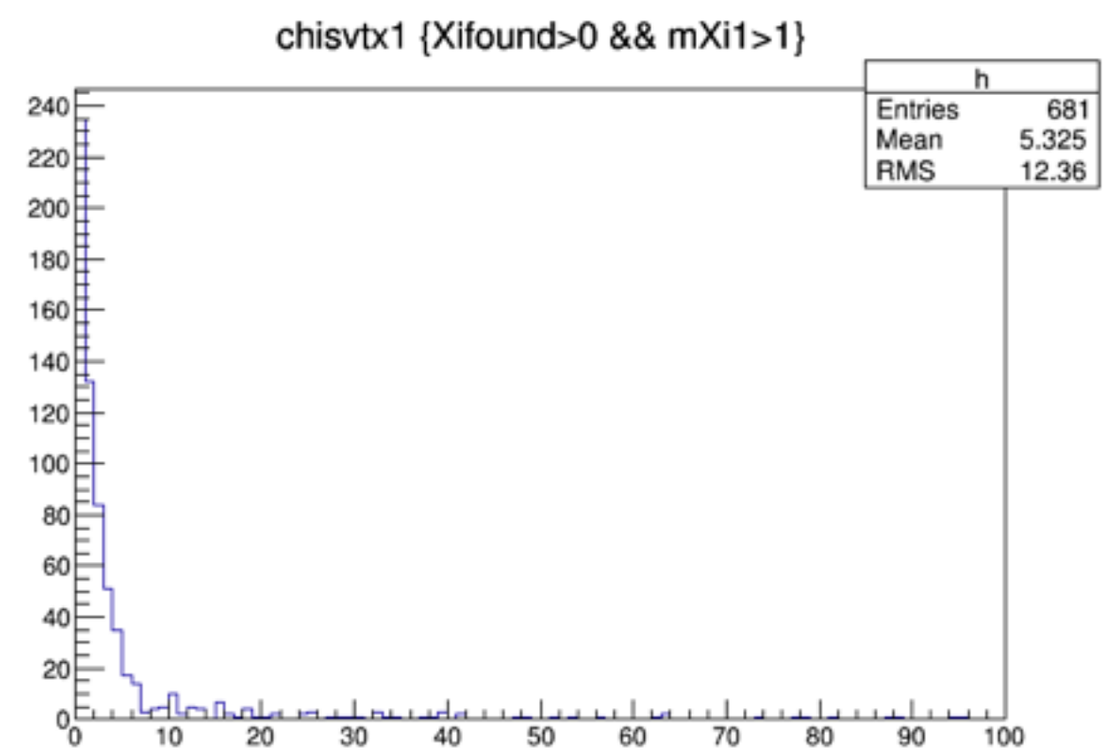
ee -> Xi- antiXi+

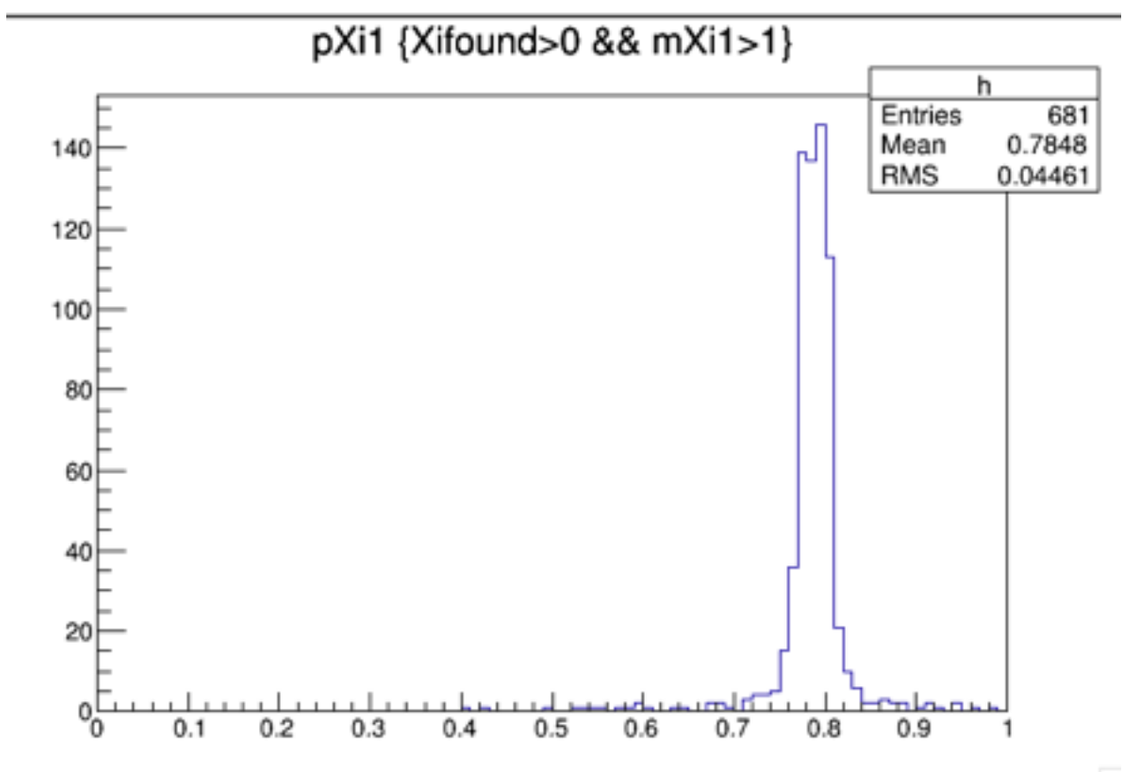
event selection

1. Good track and PID:
   npi- =2, np =1 | npi+=2, npbar=1
2. Vertex fit:
   Xi- ->Lamdba pi-, Lambda -> p pi-
3. Second vertex fit:
   Xi- -> Lambda pi-

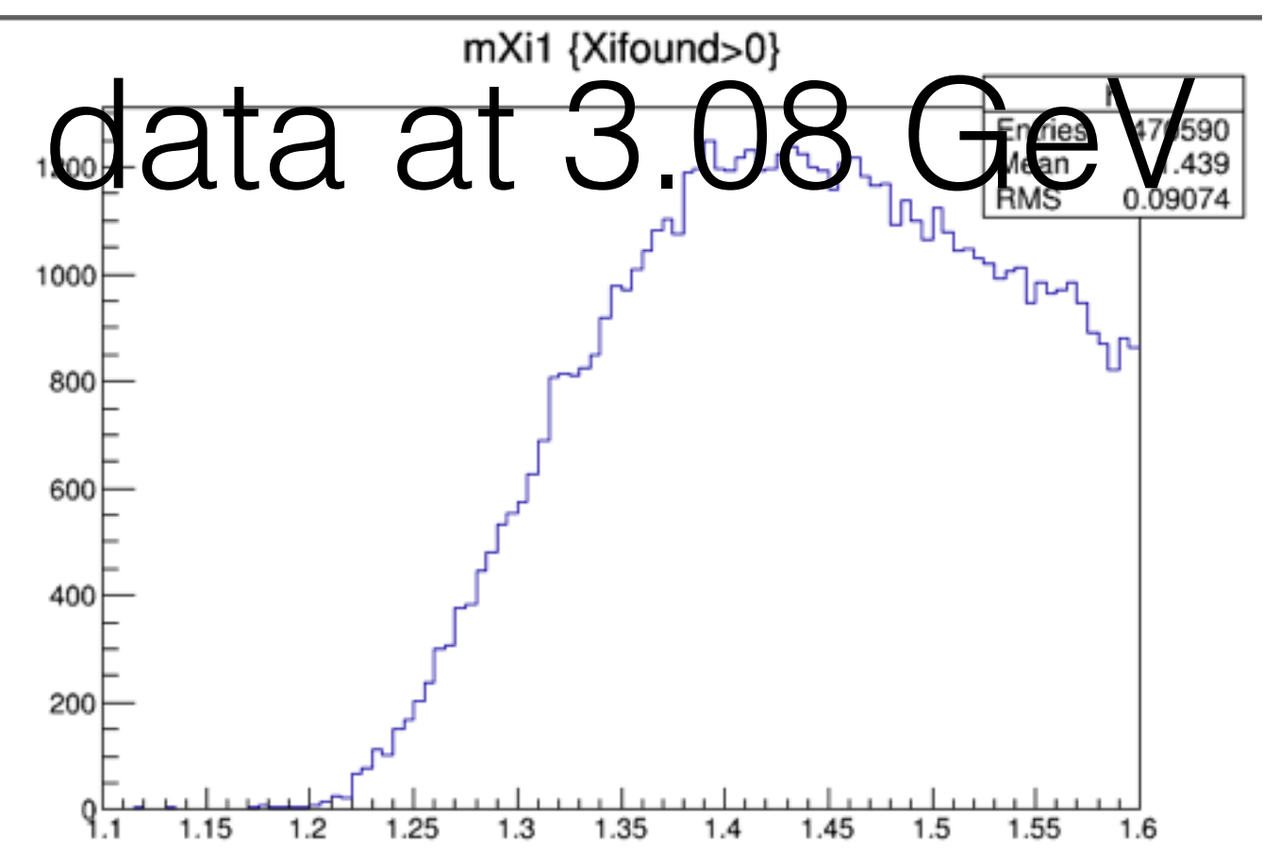
MC at 3.08 GeV

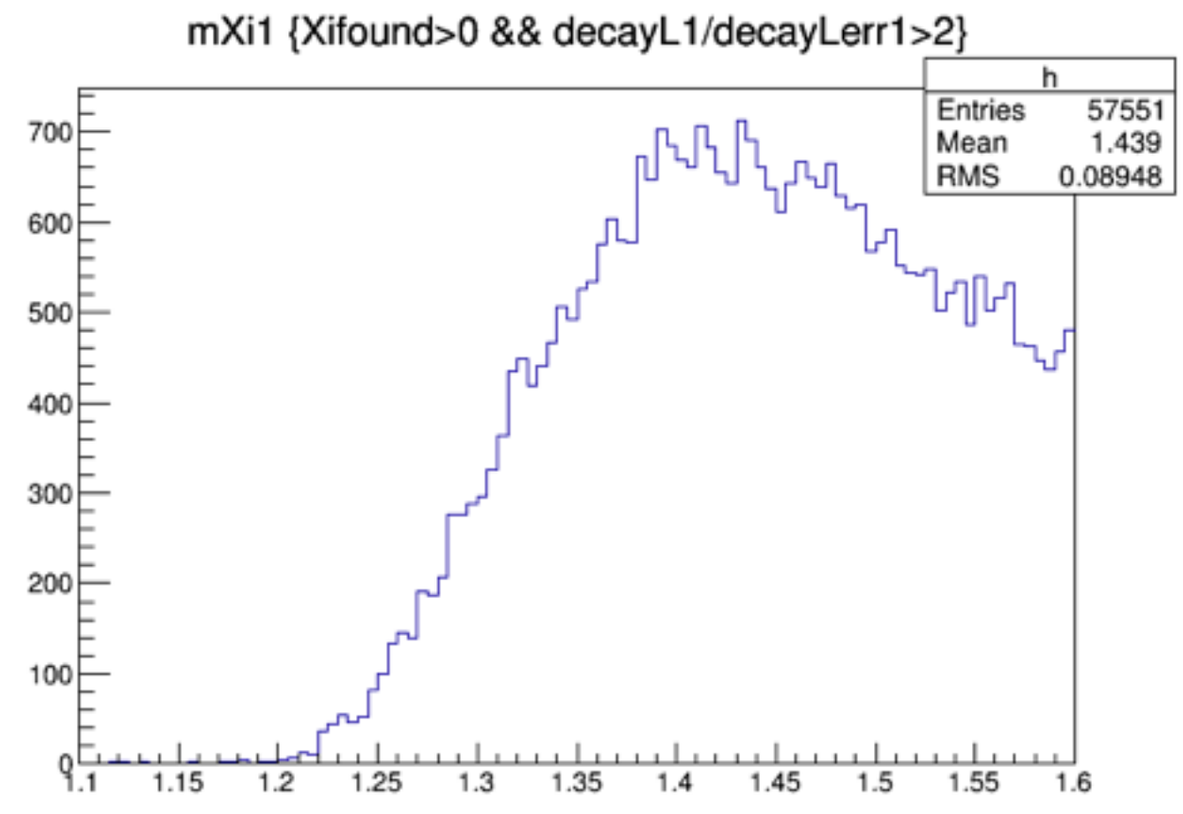

chivtx1 {Xifound>0 && mXi1>1}
h
Entries 681
Mean 11.18
RMS 17.61

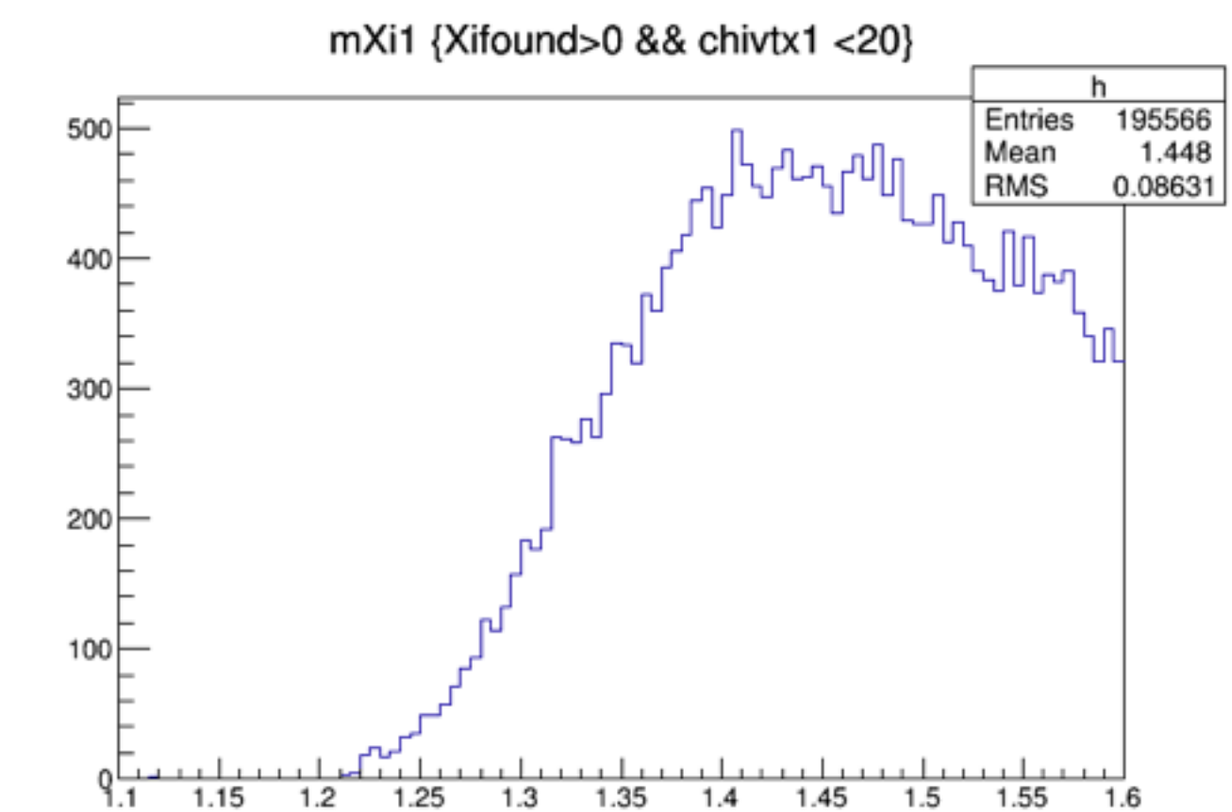

chisvtx1 {Xifound>0 && mXi1>1}
h
Entries 681
Mean 5.325
RMS 12.36

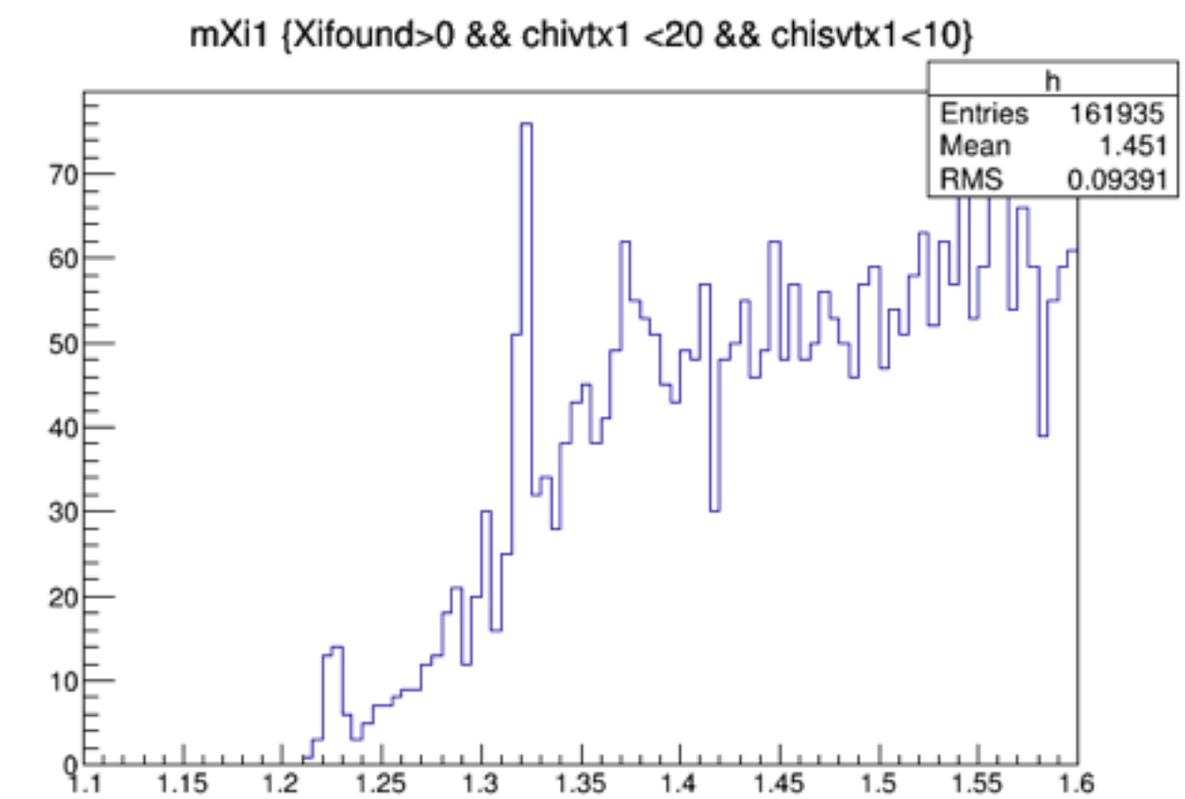

pXi1 {Xifound>0 && mXi1>1}
h
Entries 681
Mean 0.7848
RMS 0.04461

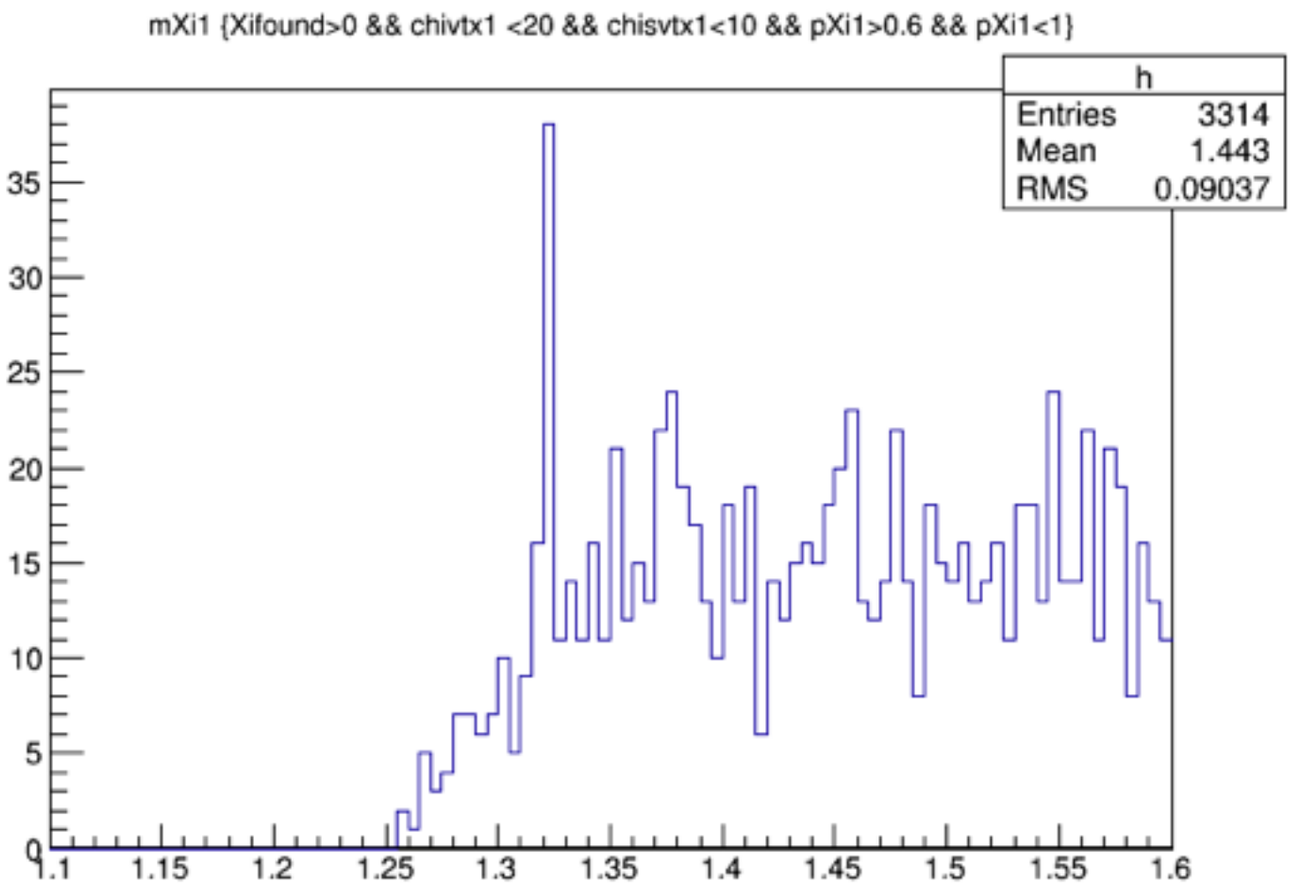
data at 3.08 GeV

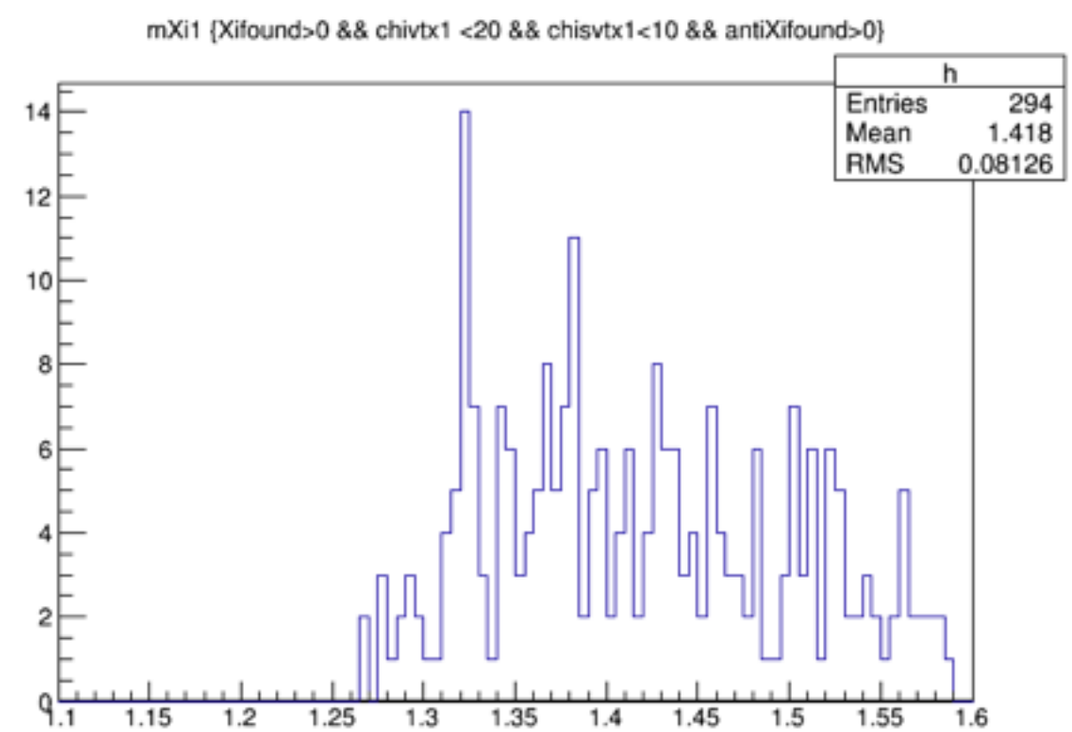




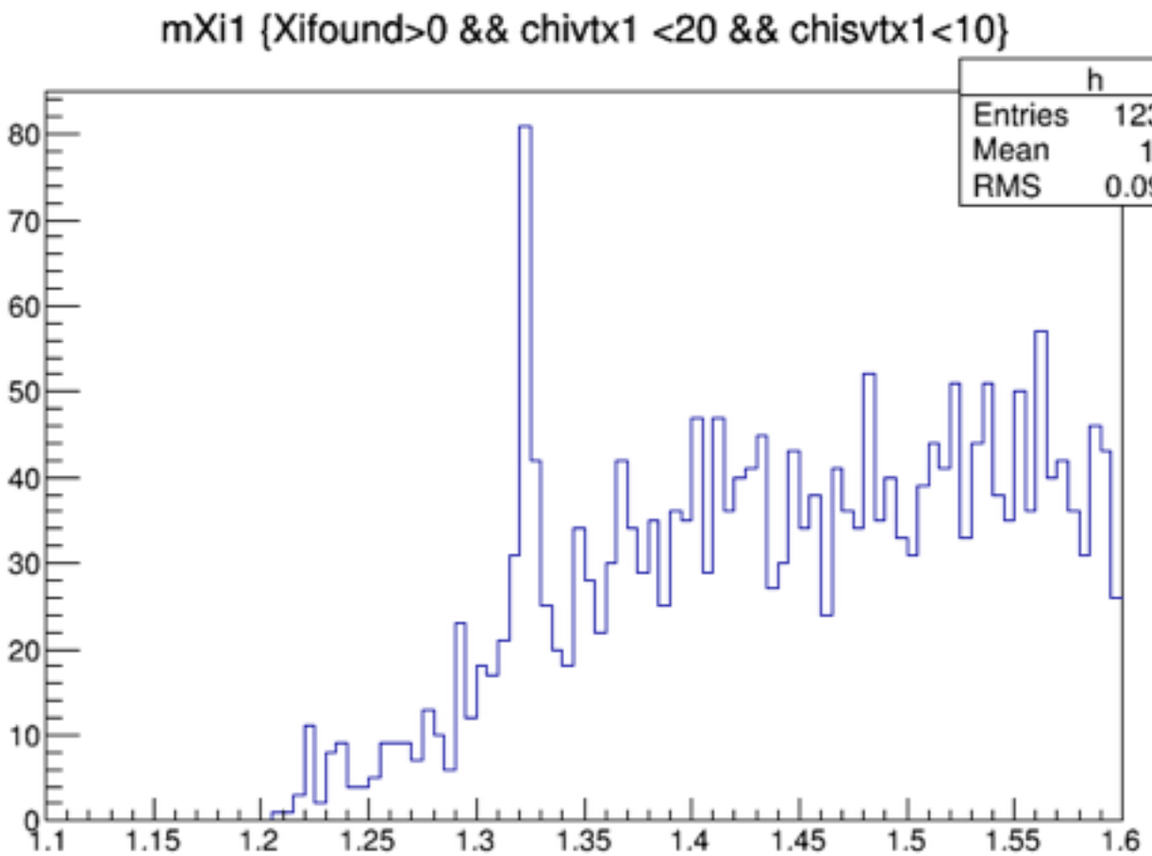


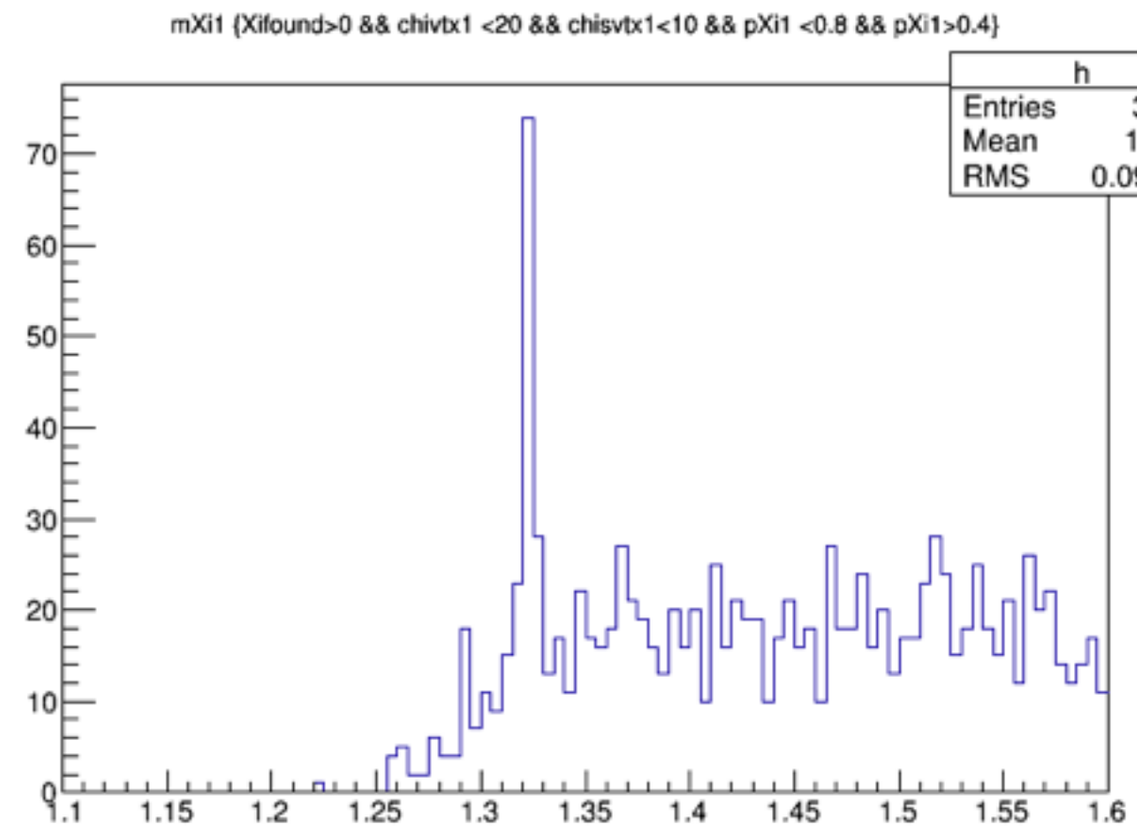



mXi1 {Xifound>0 && chivtx1 <20 && chisvtx1<10 && pXi1>0.6 && pXi1<1}
h
Entries 3314
Mean 1.443
RMS 0.09037
0
5
10
15
20
25
30
35
1.1
1.15
1.2
1.25
1.3
1.35
1.4
1.45
1.5
1.55
1.6

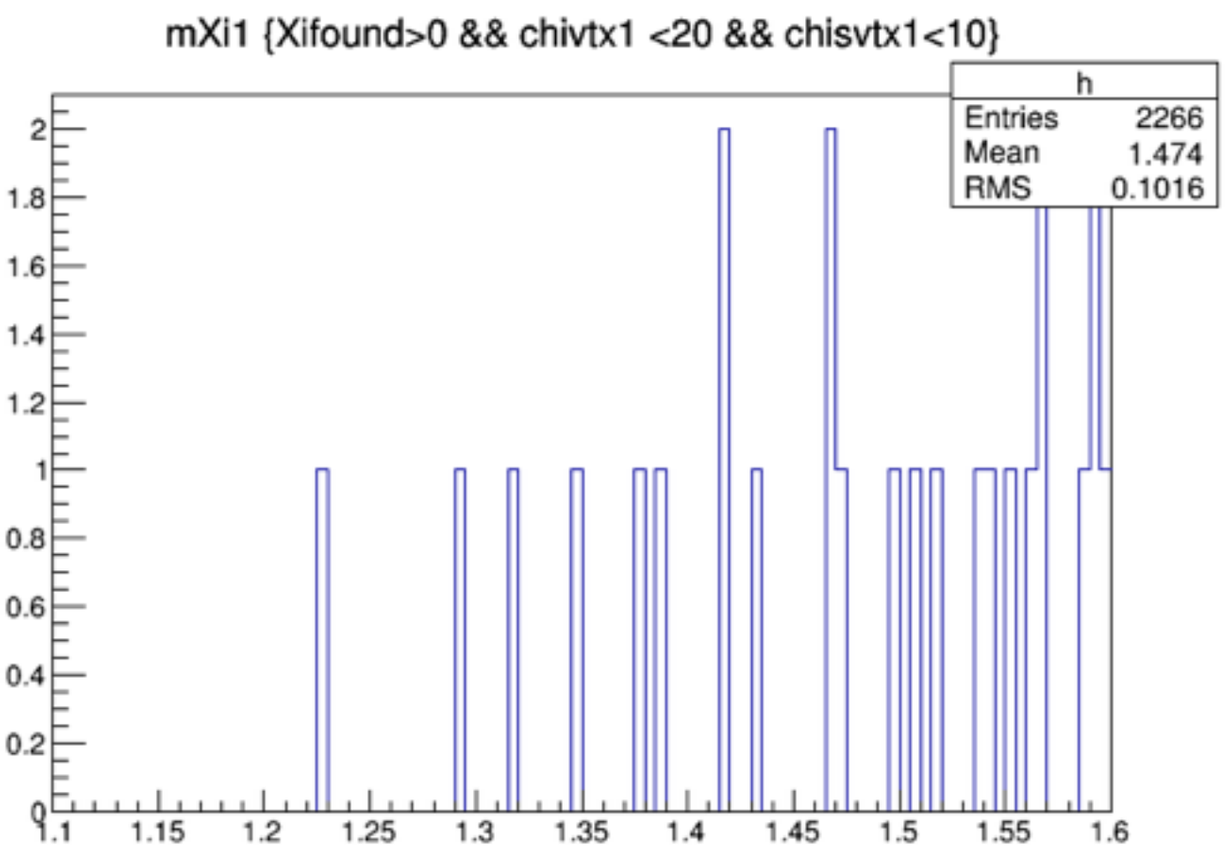

mXi1 {Xifound>0 && chivtx1 <20 && chisvtx1<10 && antiXifound>0}
h
Entries 294
Mean 1.418
RMS 0.08126
0
2
4
6
8
10
12
14
1.1
1.15
1.2
1.25
1.3
1.35
1.4
1.45
1.5
1.55
1.6

data at 2.9 GeV

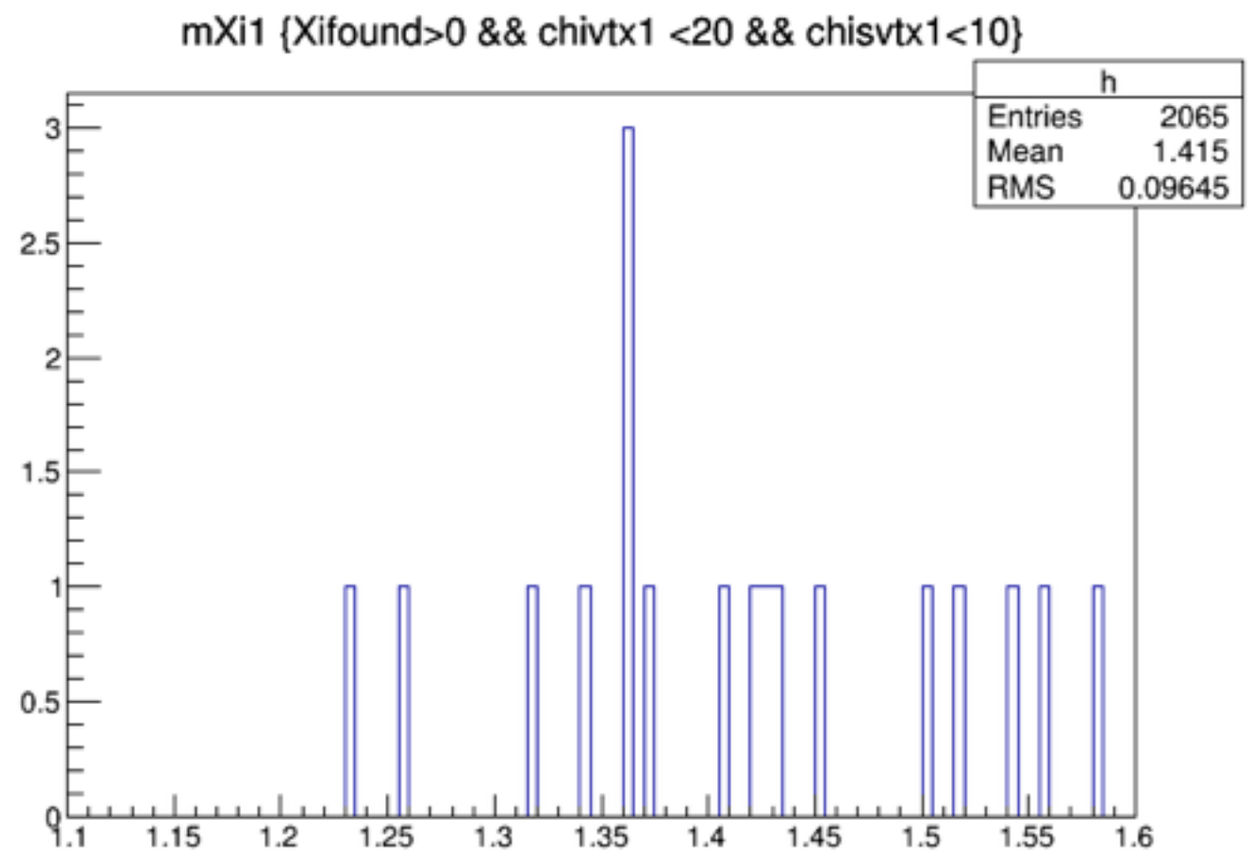


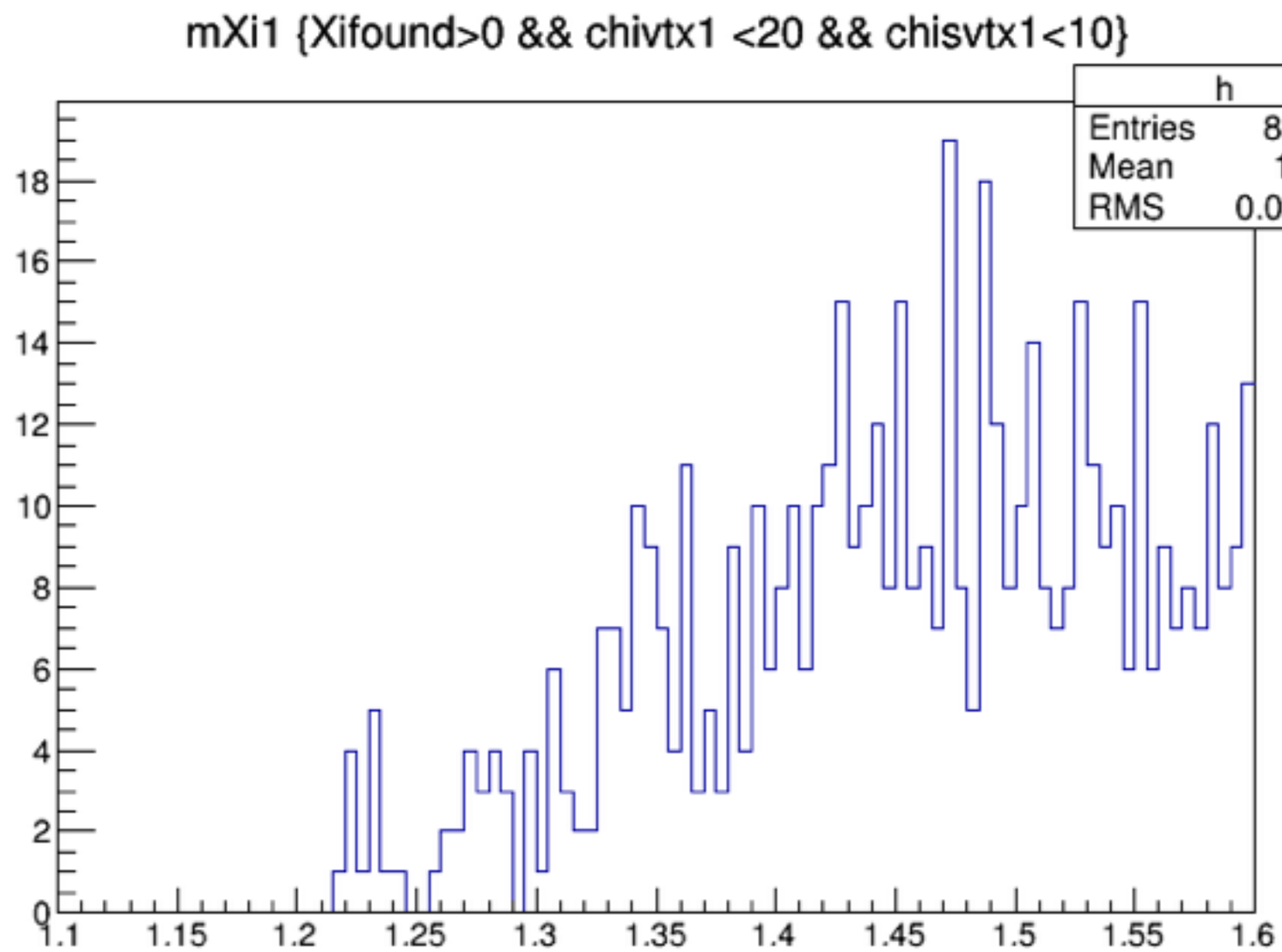


data at 2.8 and 2.7 GeV



2.8 GeV



2.7 GeV

data at 2.6464 GeV