Relative phase measurements with e+e- → pipiJ/psi

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BESIII Italia - 5/3/21

On the previous episodes...

What am I missing?

11

Last time I presented at BESIII italia, I had more questions than answers

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Today I show new ideas!

First things first – MC and datasets

2018 psi(2S) scan

Requested Energy (MeV)	Requested Luminosity (nb^{-1})	Run number	Energy (MeV)	Spread (MeV)	Luminosity (nb^{-1})
3580	85	55375-55461	3581.543 ± 0.060	1.493 ± 0.060	85665.6
3670	85	55462-55541	3670.158 ± 0.063	1.410 ± 0.053	84719.7
3681	85	55542-55635	3680.144 ± 0.061	1.517 ± 0.060	84814.5
3683	55	55636-55662	3682.752 ± 0.115	1.710 ± 0.104	28668.3
-	-	55663-55690	3684.224 ± 0.119	1.547 ± 0.122	28651.6
3685.5	25	55691-55716	3685.264 ± 0.105	1.478 ± 0.111	25982.8
3686.6	25	55717-55737	3686.496 ± 0.120	1.594 ± 0.117	25055.1
3690	70	55738-55795	3691.363 ± 0.075	1.541 ± 0.074	69374.6
3710	70	55796-55859	3709.755 ± 0.074	1.460 ± 0.075	70326.7

Additional point at 3.65 GeV - continuum

Boss version 7.0.4 – Using KKMC for each energy
20k e+e- → pi+ pi- J/psi → pi+ pi- e+ e-
20k e+e- → pi+ pi- J/psi → pi+ pi- mu+ mu-

Event selection

- Event selection follows similar criteria of other pipiJ/psi final state analyses (PRL 118, 092001 (2017))
- Event Selections:
  - 4 charged tracks with 0 net charge
  - $|\cos\theta| < 0.93$
  - $|V_{z,poca}| < 10$ cm
  - $|V_{xy,poca}| < 1$ cm
  - **p** > 1.06 – track is a lepton
  - **p** < 0.45 – track is a pion
  - 4C kinematic fit is applied

- Radiative Bhabha and radiative dimuons background are suppressed by a cut on the opening angle between the two pions ($\cos|\theta_{pipi}| < 0.98$) and non-radiative Bhabha events are further suppressed with a cut on the opening angle between the two lepton ($\cos|\theta_{ee}| < 0.98$).

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Found first problem!
There was a bug into the 4C fitting procedure.
Gained ~5% efficiency

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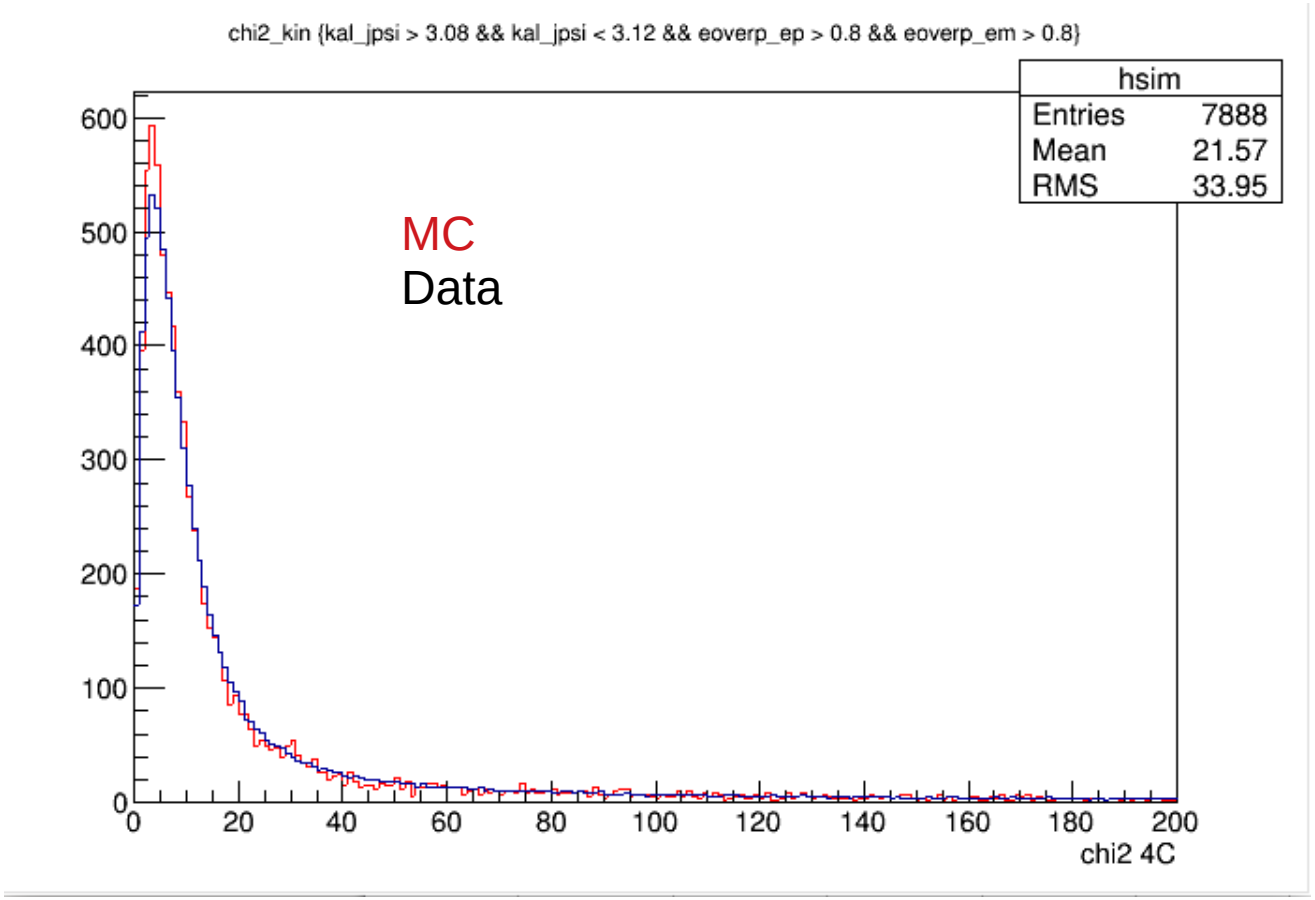
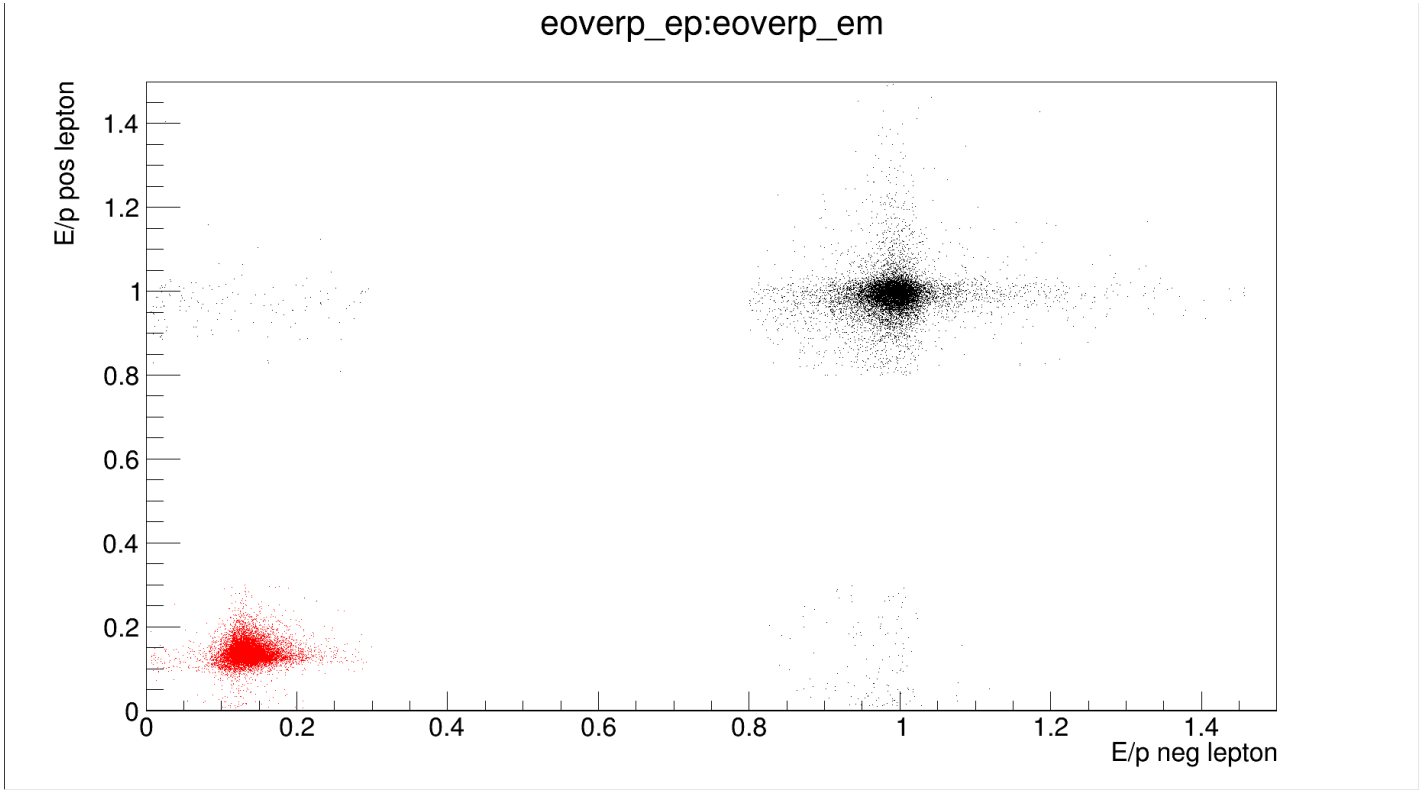
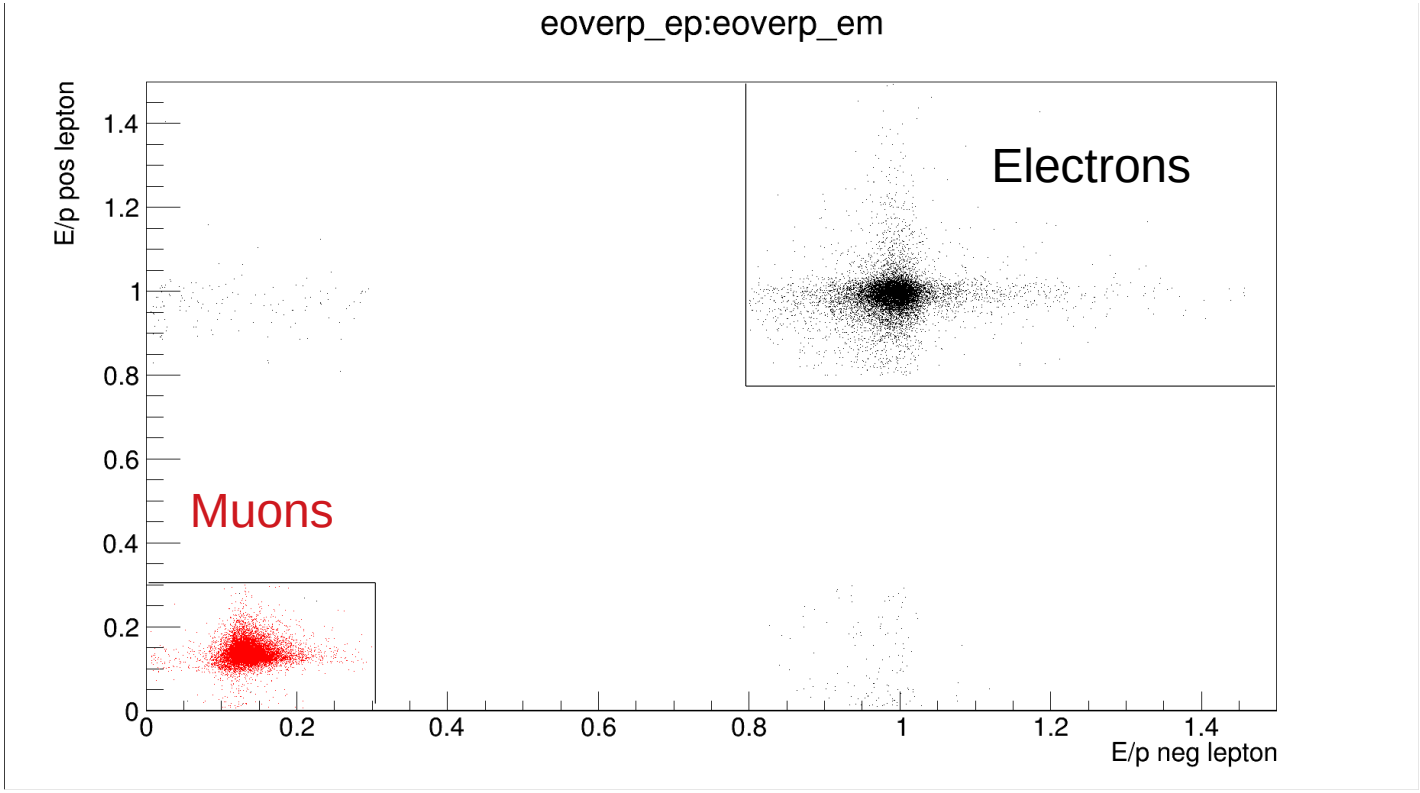
Example plot – chi2 kin



How to leptify?

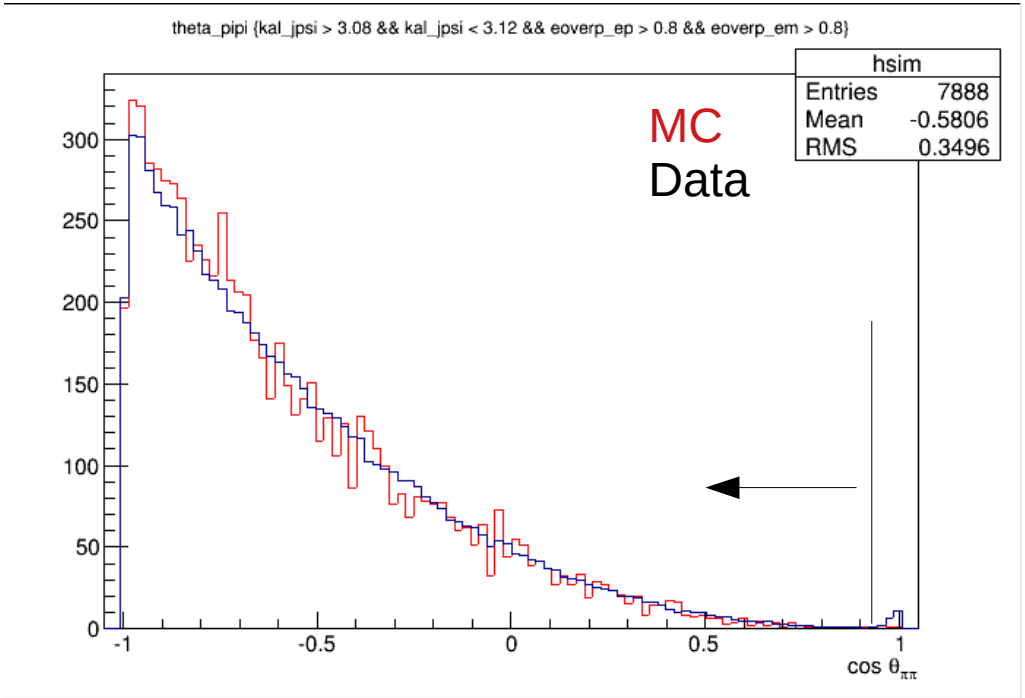


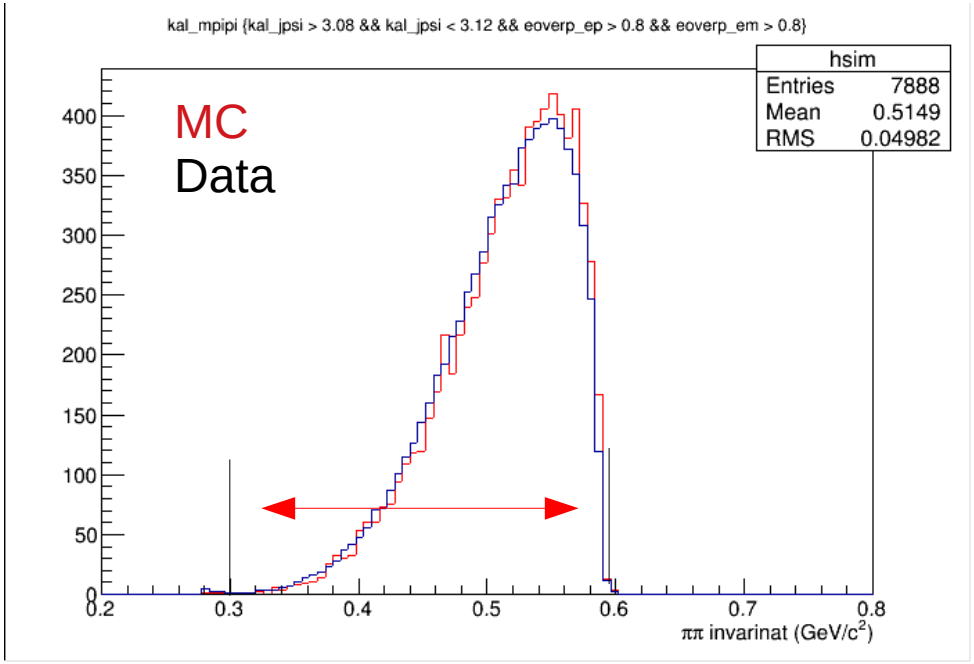
How to leptify?



Difference of the response in the EMC allows to separate electrons and muons

“Typical plots” comparison - @ 3.6866 GeV

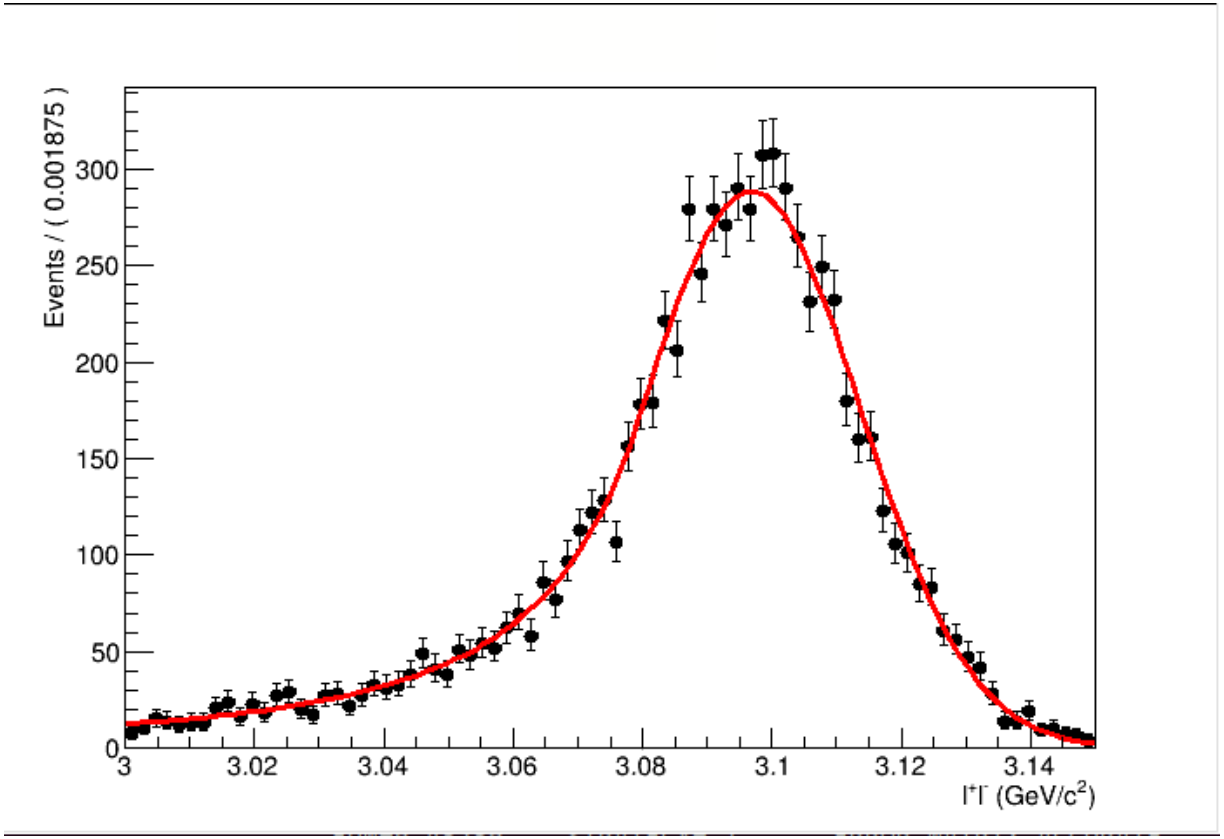




Fitting the electronic final states

Fit to MC – 3.6866 GeV

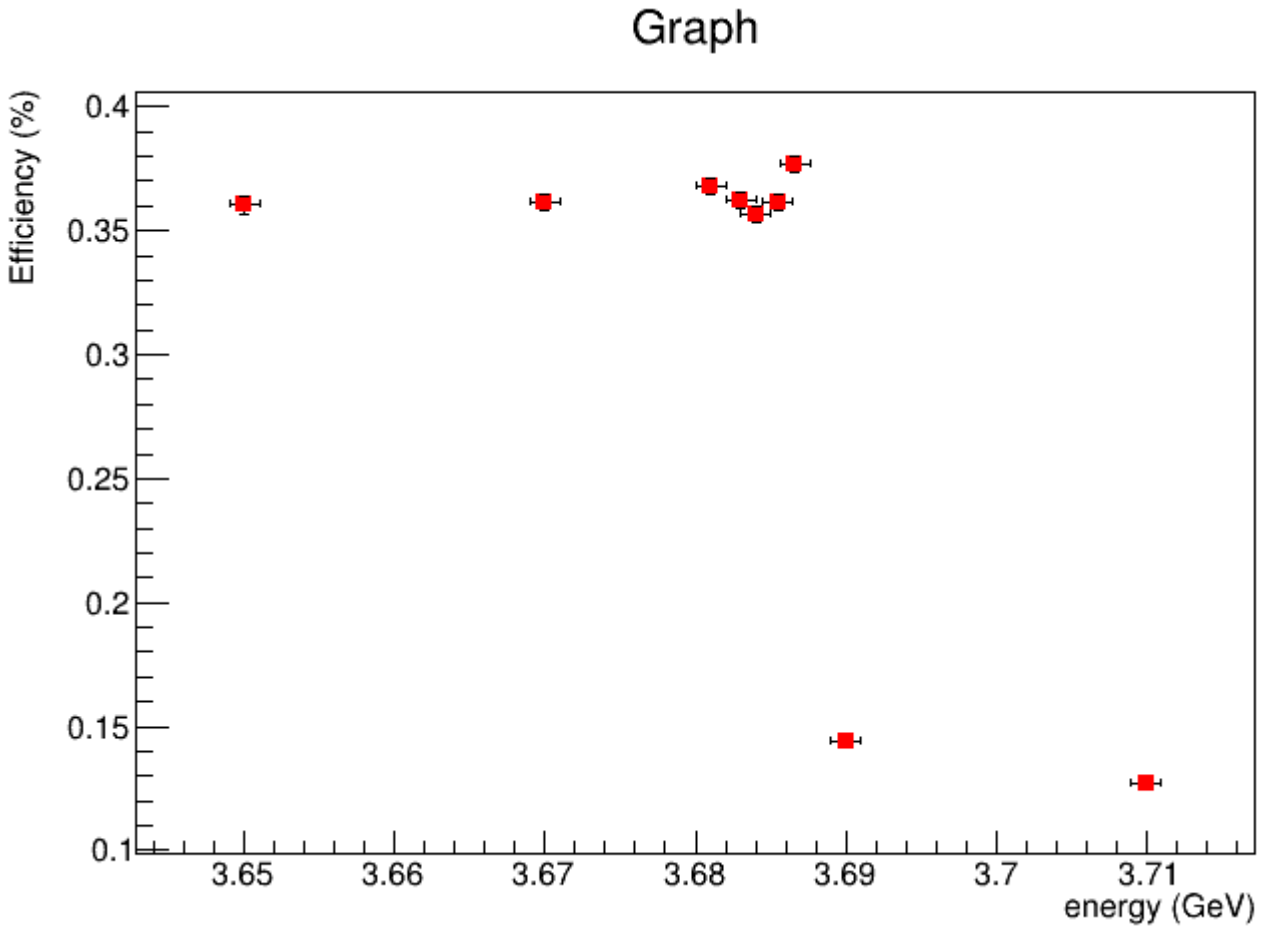
Unbinned Fit to invariant mass events that pass kinematic fits



New fitting function:
Crystal Ball +
0^{th} Chebychev

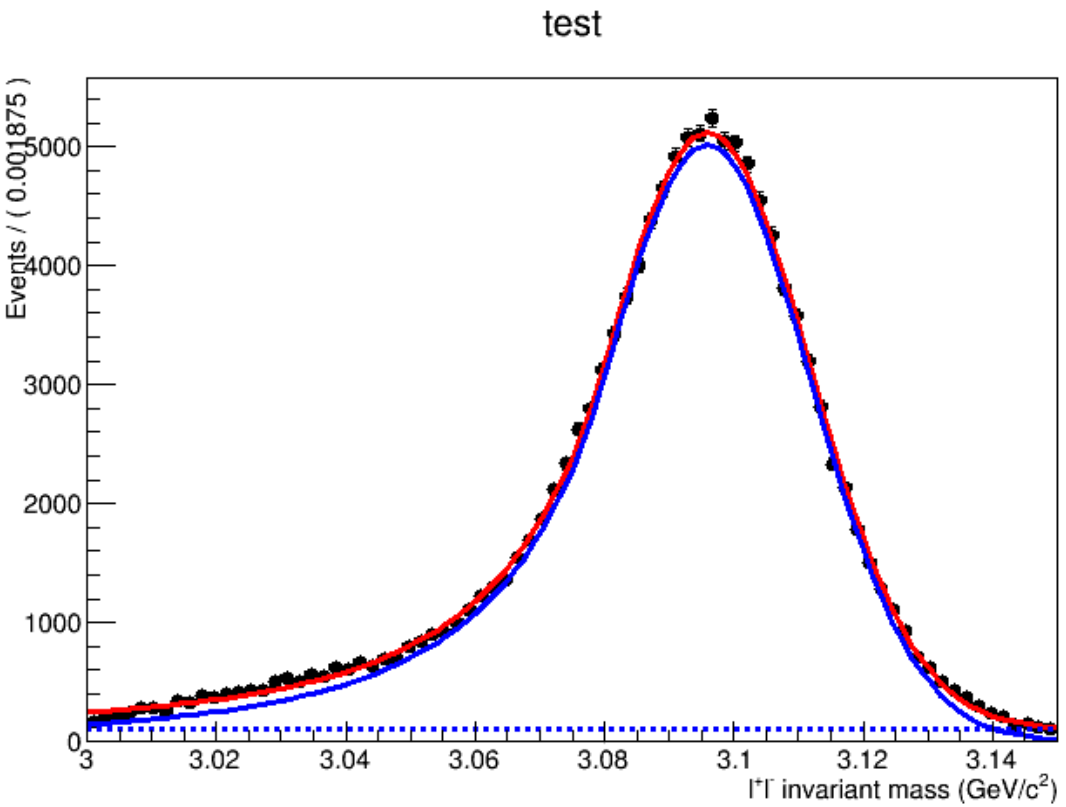
alpha1	1.05503e+00 ± 5.90487e-02
mean	3.09681e+00 ± 3.22573e-04
n1	2.26127e+00 ± 3.70681e-01
nbkg	2.14006e+01 ± 1.57284e+02
nsig	7.53783e+03 ± 9.91426e+01
sigma1	1.69784e-02 ± 2.82328e-04

Efficiency


Graph
Efficiency (%)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
3.65
3.66
3.67
3.68
3.69
3.7
3.71
energy (GeV)

Real data – 3.6866 GeV

Unbinned Fit to invariant mass events that pass kinematic fit

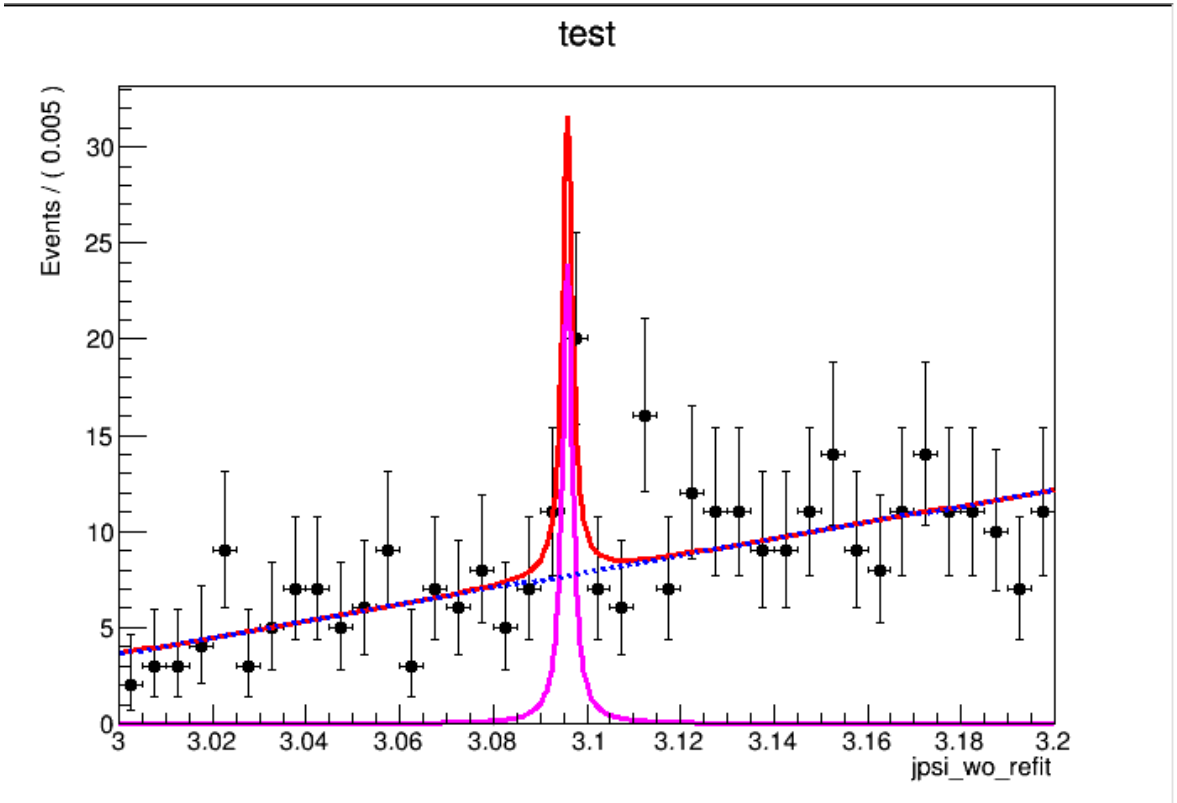


Same function as in the MC

alpha1	9.74508e-01 ± 1.87461e-02
mean	3.09588e+00 ± 8.80194e-05
n1	3.56526e+00 ± 2.66951e-01
nbkg	8.27942e+03 ± 4.84592e+02
nsig	1.23186e+05 ± 5.91305e+02
sigma1	1.59832e-02 ± 9.20850e-05

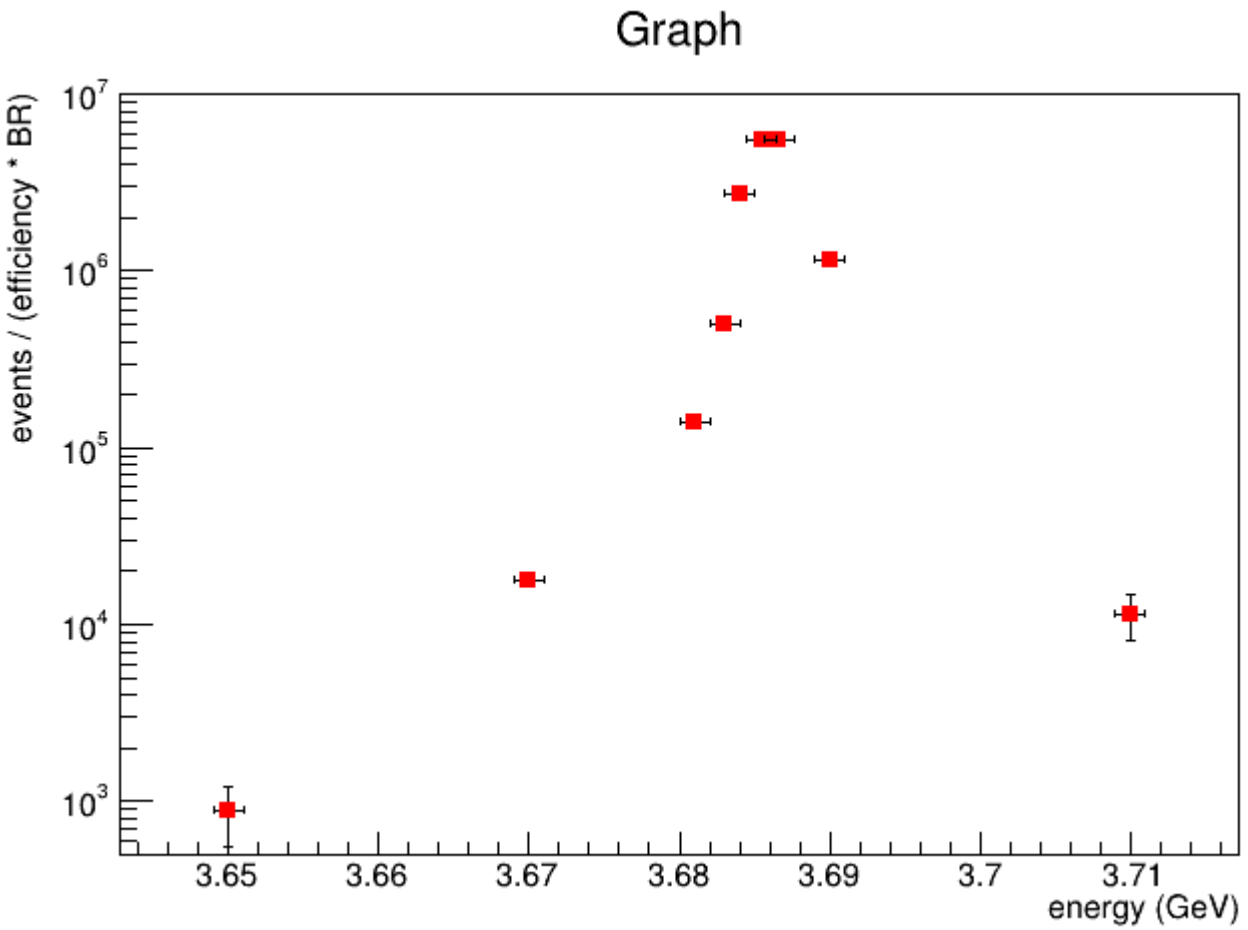
Real data – 3.650 GeV

Optimized fit to extract signal – fixed mass Breit-Wigner + 1th Chebychev



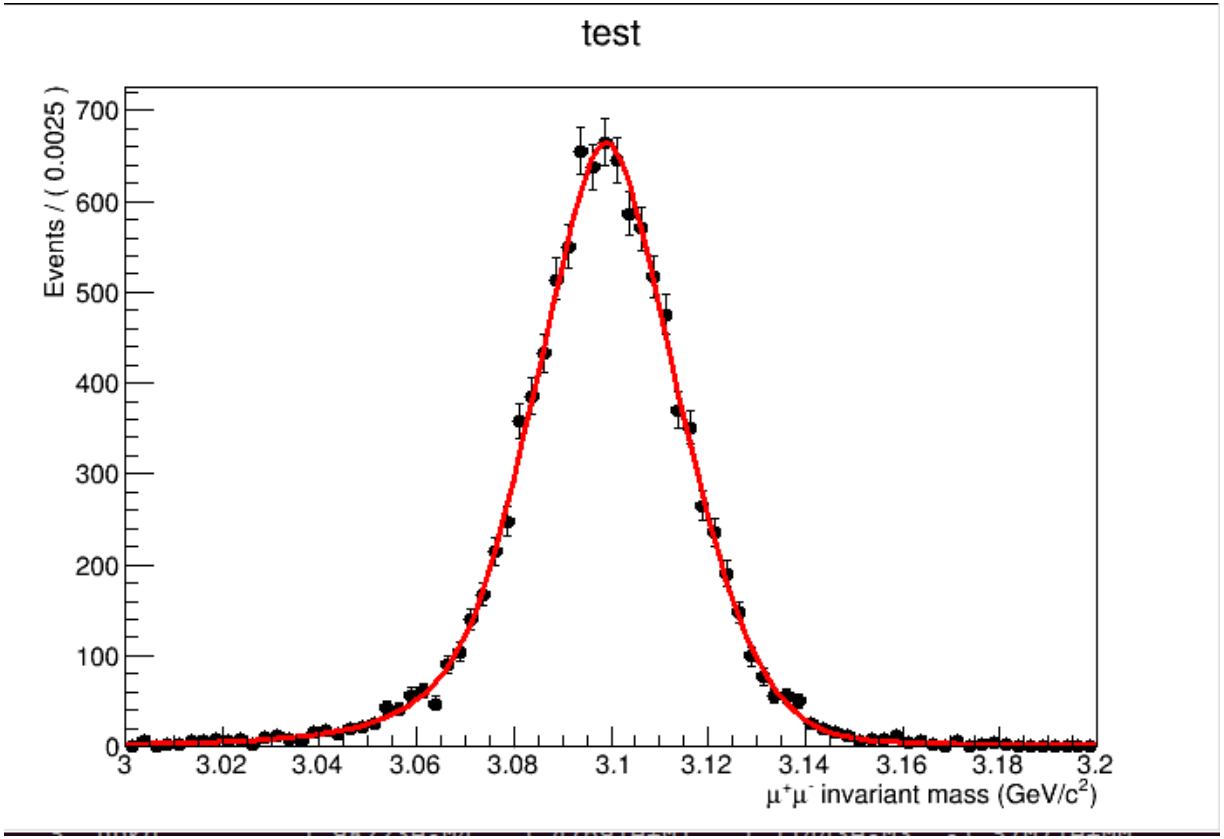
a0	5.39714e-01 ± 9.09439e-02
gamma	2.48143e-03 ± 1.38787e-03
nbkg	3.16410e+02 ± 1.86233e+01
nsig	1.85960e+01 ± 7.00263e+00

Summary of ee



Fitting the muonic final states

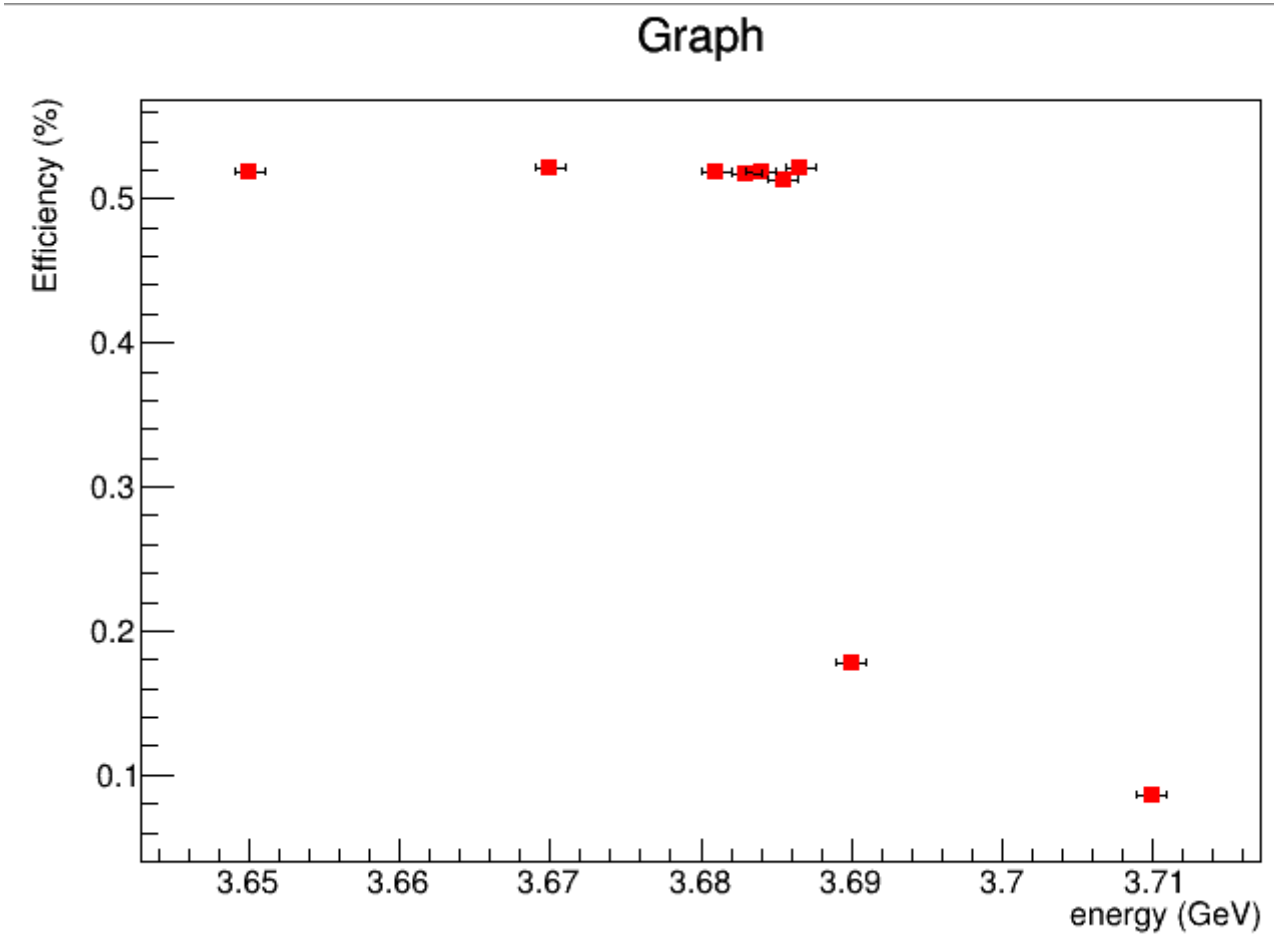
Fitting to MC – 3.6866 GeV



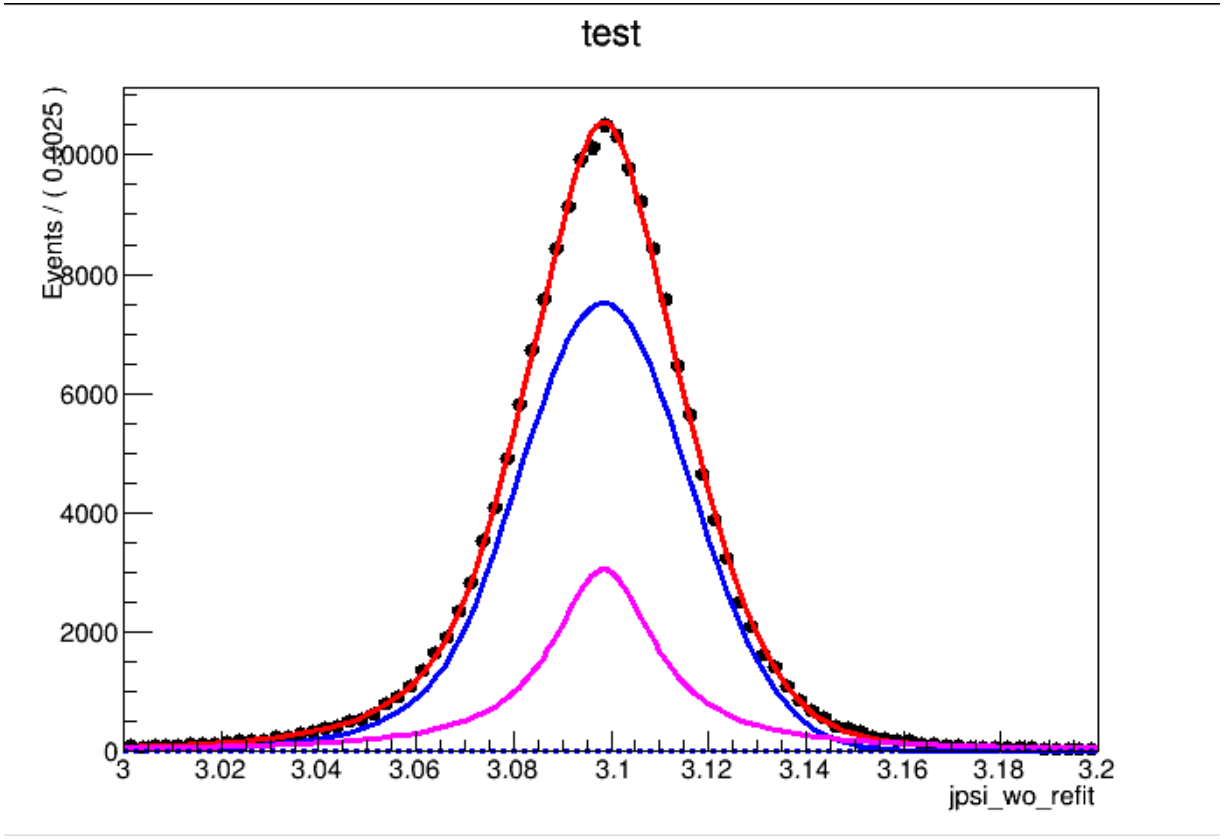
Fitting function:
Crystal Ball + BW +
0^{th} Chebychev

alpha1	1.66566e+00 ± 1.15748e-01
gamma	2.14475e-02 ± 2.50036e-03
mean	3.09900e+00 ± 1.84948e-04
n1	5.94048e+00 ± 2.44408e+00
nbkg	1.98223e-04 ± 1.47691e+01
nsig	1.04192e+04 ± 1.02078e+02
sigfrac	8.33683e-01 ± 2.09238e-02
sigma1	1.60936e-02 ± 2.71149e-04

Efficiency

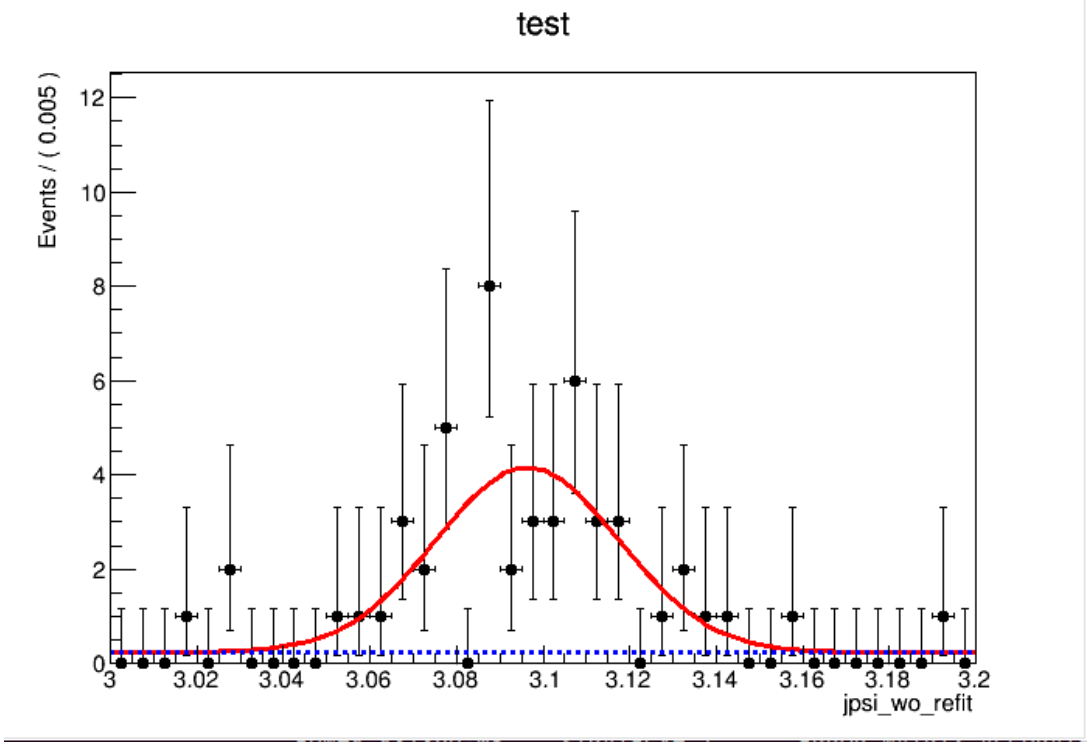

Graph
Efficiency (%)
0.5
0.4
0.3
0.2
0.1
3.65
3.66
3.67
3.68
3.69
3.7
3.71
energy (GeV)

Fit to Real Data – 3.6866 GeV



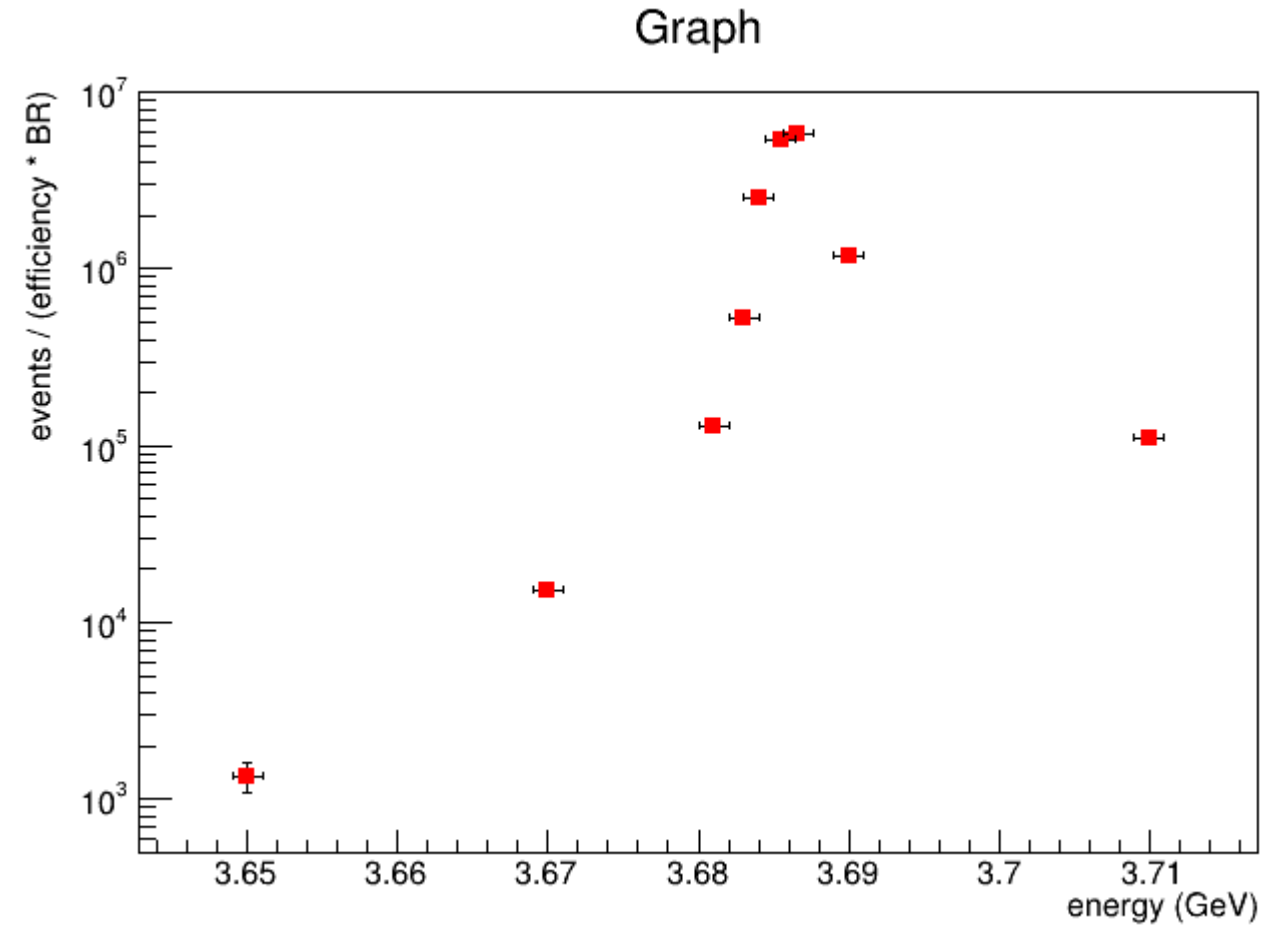
alpha1	1.57547e+00	3.36875e-02
gamma	2.56587e-02	5.69988e-04
mean	3.09845e+00	5.04345e-05
n1	8.13535e+00	1.31221e+00
nbkg	1.29140e-04	2.29854e+01
nsig	1.81377e+05	4.25886e+02
sigfrac	7.51178e-01	5.79167e-03
sigma1	1.76689e-02	9.20908e-05

Fit to Real Data – 3.650 GeV



gamma	1.01445e-03 ± 1.96171e-01
nbkg	9.06233e+00 ± 4.98768e+00
nsig	4.19076e+01 ± 7.59716e+00
sigma	2.09922e-02 ± 3.50514e-03

Summary of mumu



Towards the phase extraction

Luminosity

Luminosity determination

B.X. Zhang

Ecm(GeV)	σ (nb)	ε	Nsig/Nsid	$\mathcal{L}$ (pb^{-1})
3.5815	27.45	0.4607	1083759/13731	84.604±0.082
3.6702	26.07	0.4585	1011812/12722	83.582±0.084
3.6801	25.95	0.4599	1004371/12847	83.060±0.083
3.6828	25.92	0.4597	340128/4437	28.175±0.049
3.6842	25.92	0.4598	336256/4534	27.840±0.048
3.6853	25.96	0.4575	305462/4496	25.342±0.046
3.6865	25.85	0.4610	296299/4484	24.481±0.045
3.6914	25.84	0.4602	826832/10539	68.647±0.076
3.7098	25.56	0.4590	823445/10384	69.326±0.077

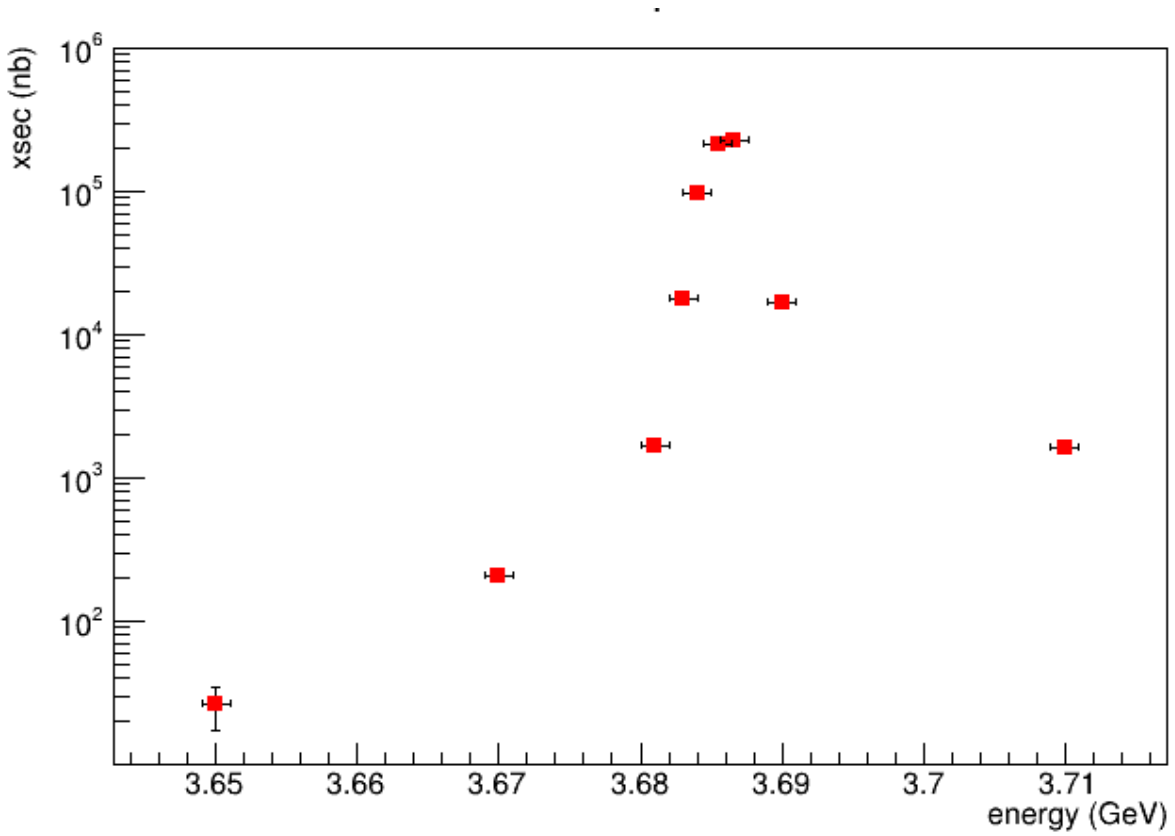
The difference between Bhabha and two gamma method is less than 3%

From

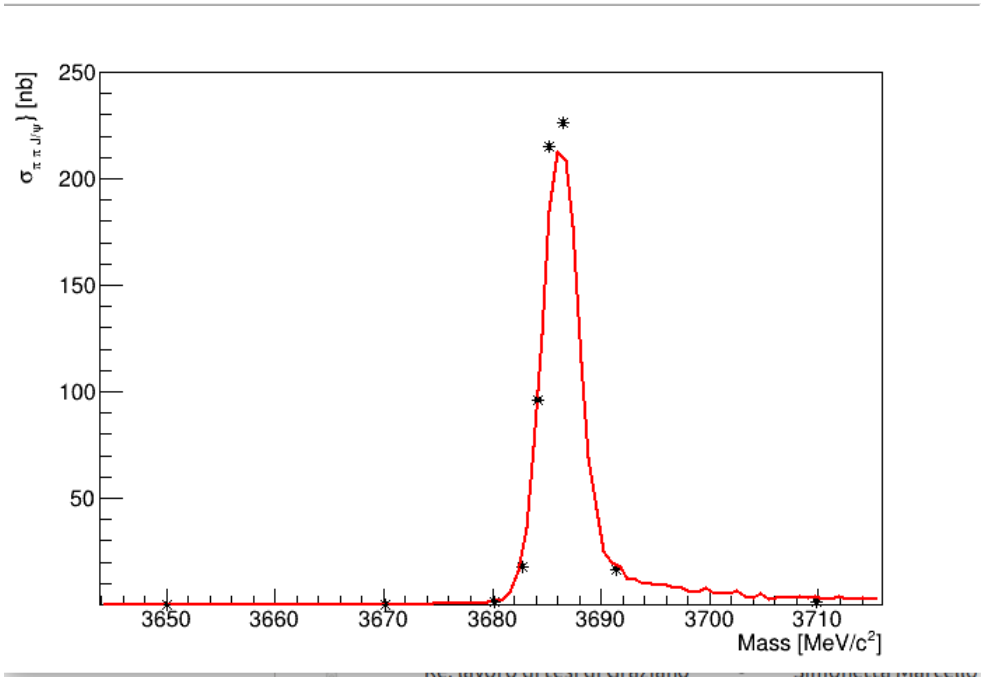
https://indico.ihep.ac.cn/event/13433/contribution/5/material/slides/0.pdf

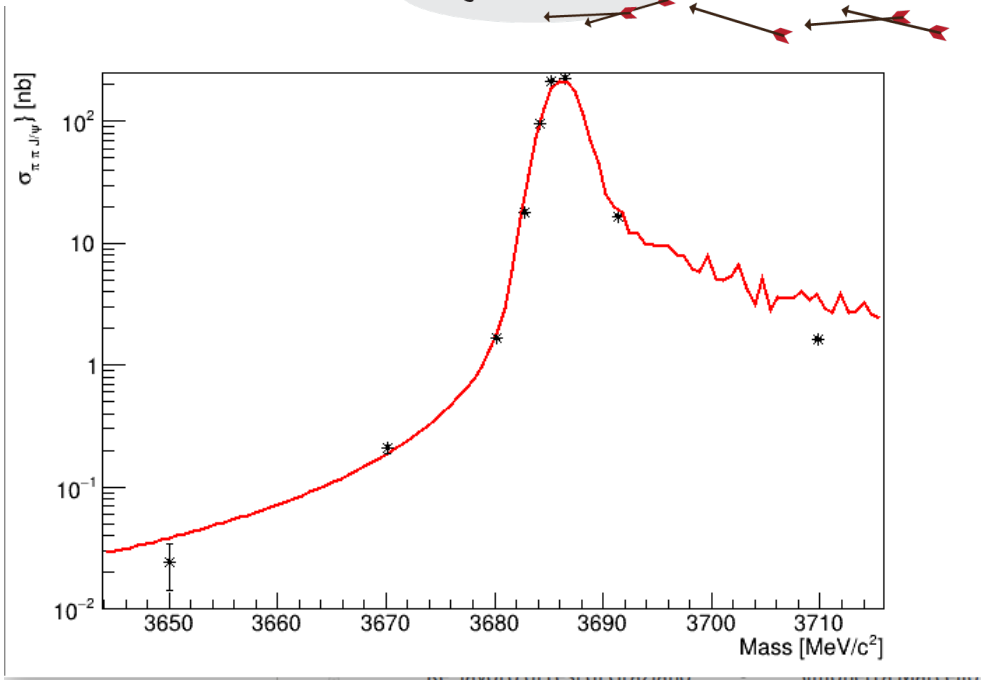
Combined cross sections

Combined two datasets with weighted mean



Fit to the phase

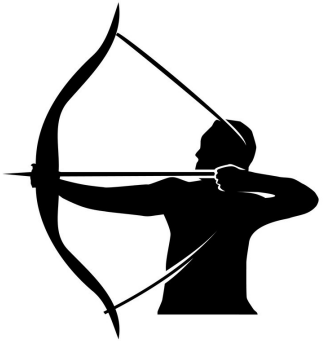




Fase (rad)	1.03639e-05	1.92755e+00
Cont (3 GeV)	9.99995e-08	7.68446e-08
BR	3.30097e-01	4.83255e-03
Width	2.94000e-01	fixed
Mass	3.68607e+03	1.22418e-02

Looking at the future

- Further review @ 3650 and @ 3710 MeV
- Test “chinese” fitting function
- Finalize the systematics



Grazie!