CLEO-c Sensitivity to Radiative Decay of Scalar Mesons

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Discussion Points

- Scalar mesons $f_0(1370)$, $f_0(1500)$, and $f_0(1710)$
- What we know about $J/\psi \to \gamma f_0$
- What can CLEO-c add about $J/\psi \to \gamma f_0$
- Unravelling glue and $q\bar{q}$ with $f_0 \to \gamma V$

Specific example: $f_0(1710) \to \gamma\rho$ in CLEO-c

The $f_0(1370)$, $f_0(1500)$, and $f_0(1710)$

- Well established "light" scalar mesons
- All are seen in some experiments, but none of them are seen in all experiments.
- Current best guess: These are mixtures of isoscalar quarkonia and the lightest glueball
- The mixing remains an unknown matrix, both experimentally and theoretically

What we know about $J/\psi \to \gamma f_0$

For $f_0(1710)$:

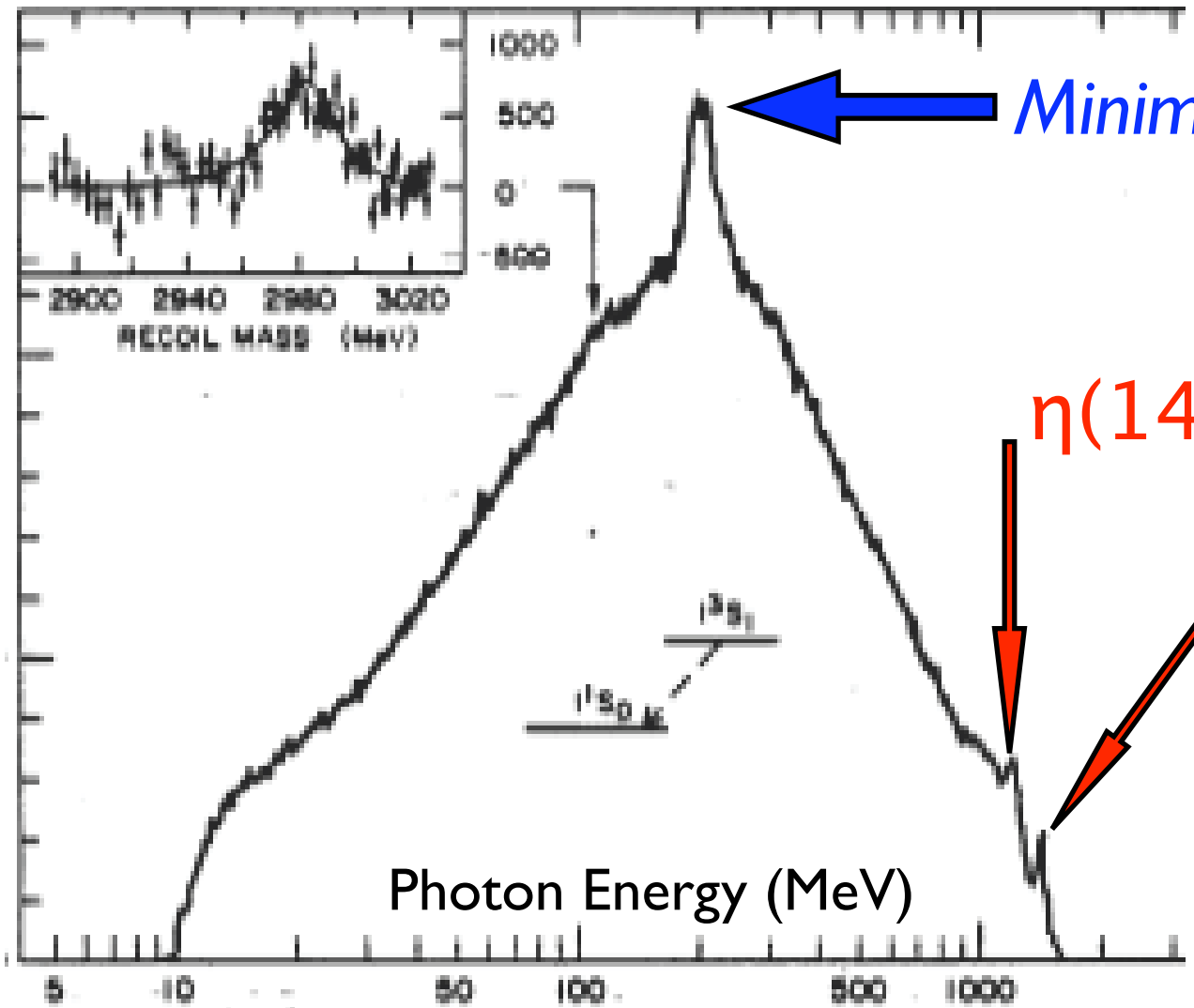
- Clear peak in $J/\psi \to \gamma f_0 \to \gamma K^+K^-$,etc...
- Branching ratio 10^{-3}
- Spin well established in partial wave analysis

The $f_0(1370)$ is a broad S-wave peak in the PWA.

The $f_0(1500)$ is not (obviously) observed.

Orientation: Inclusive J/ψ→γX

Bloom & Peck (Crystal Ball) Ann.Rev.Nuc.Part.Sci. 33(1983)143



Minimum Ionizing

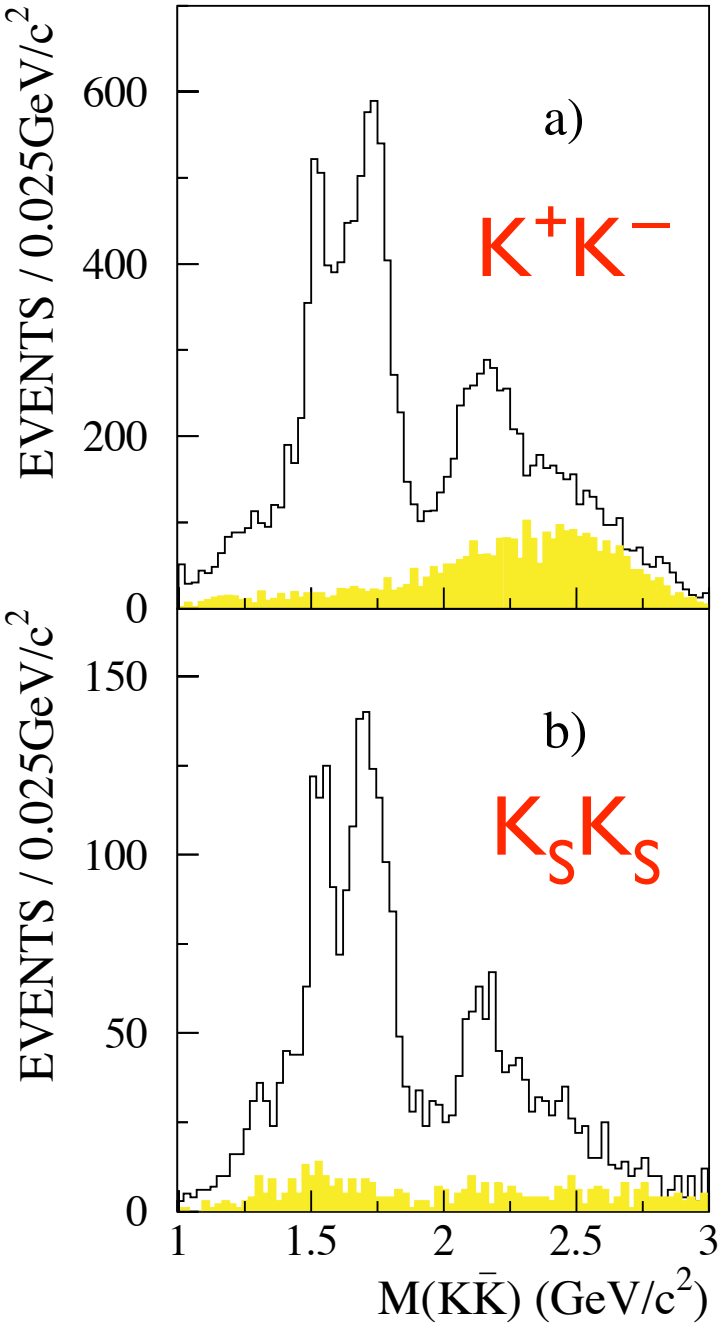
η(1440)

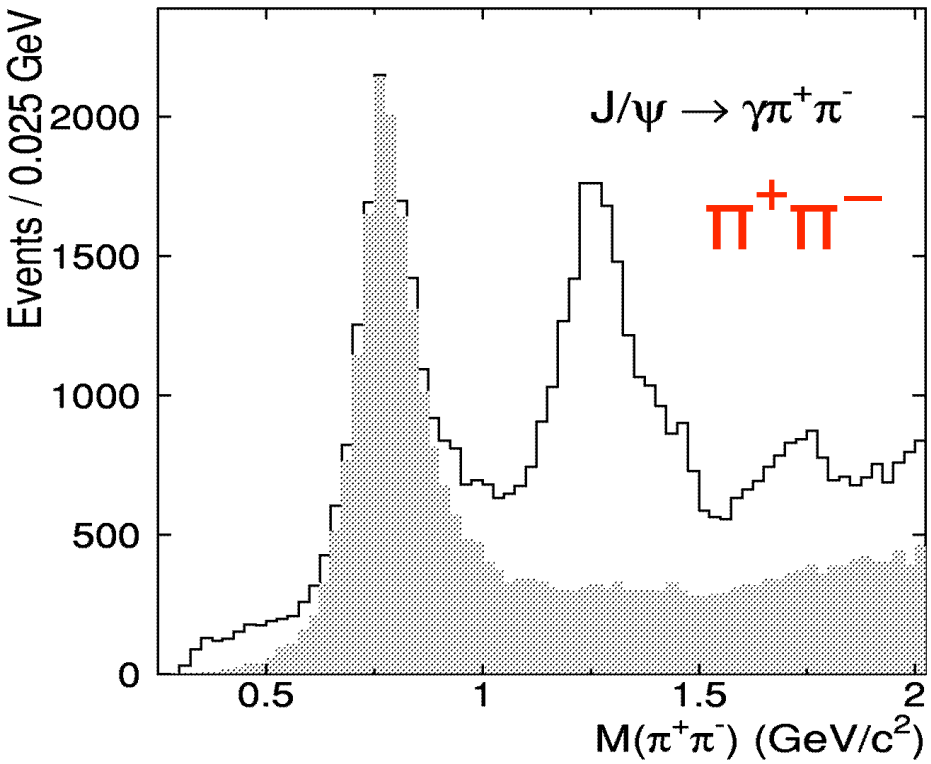
η′

No other prominent peaks in the inclusive spectrum.

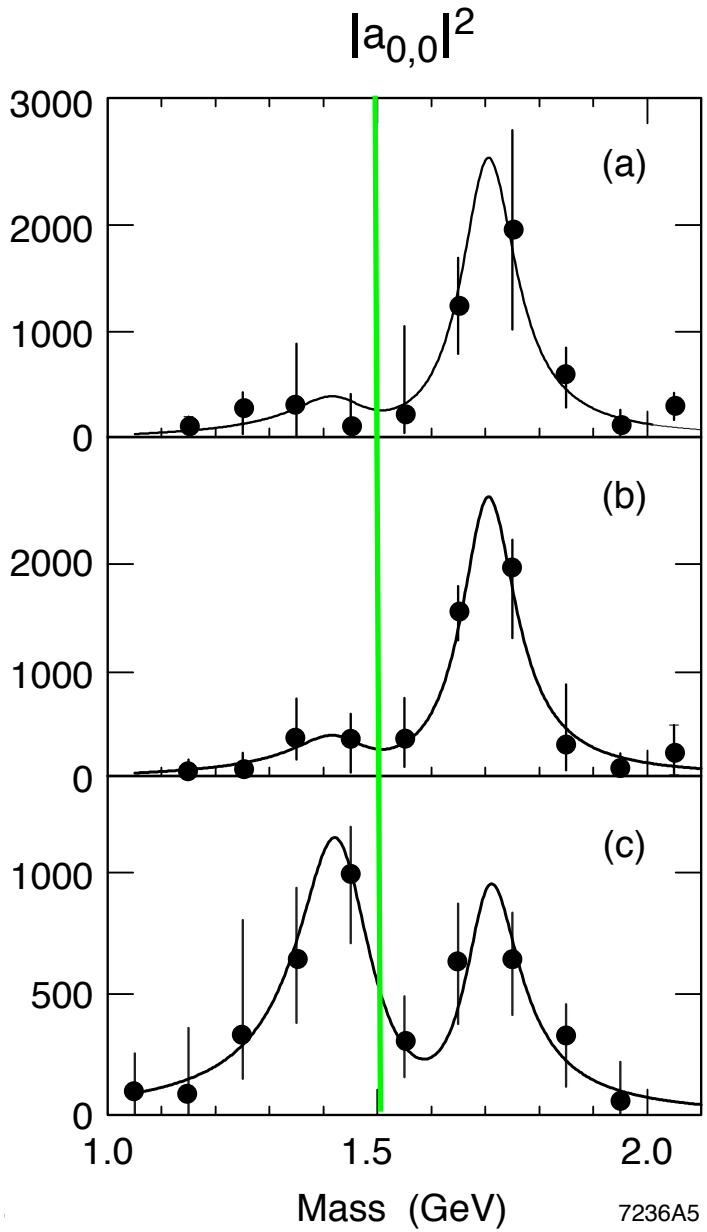
Exclusive final state shows lots of peaks.

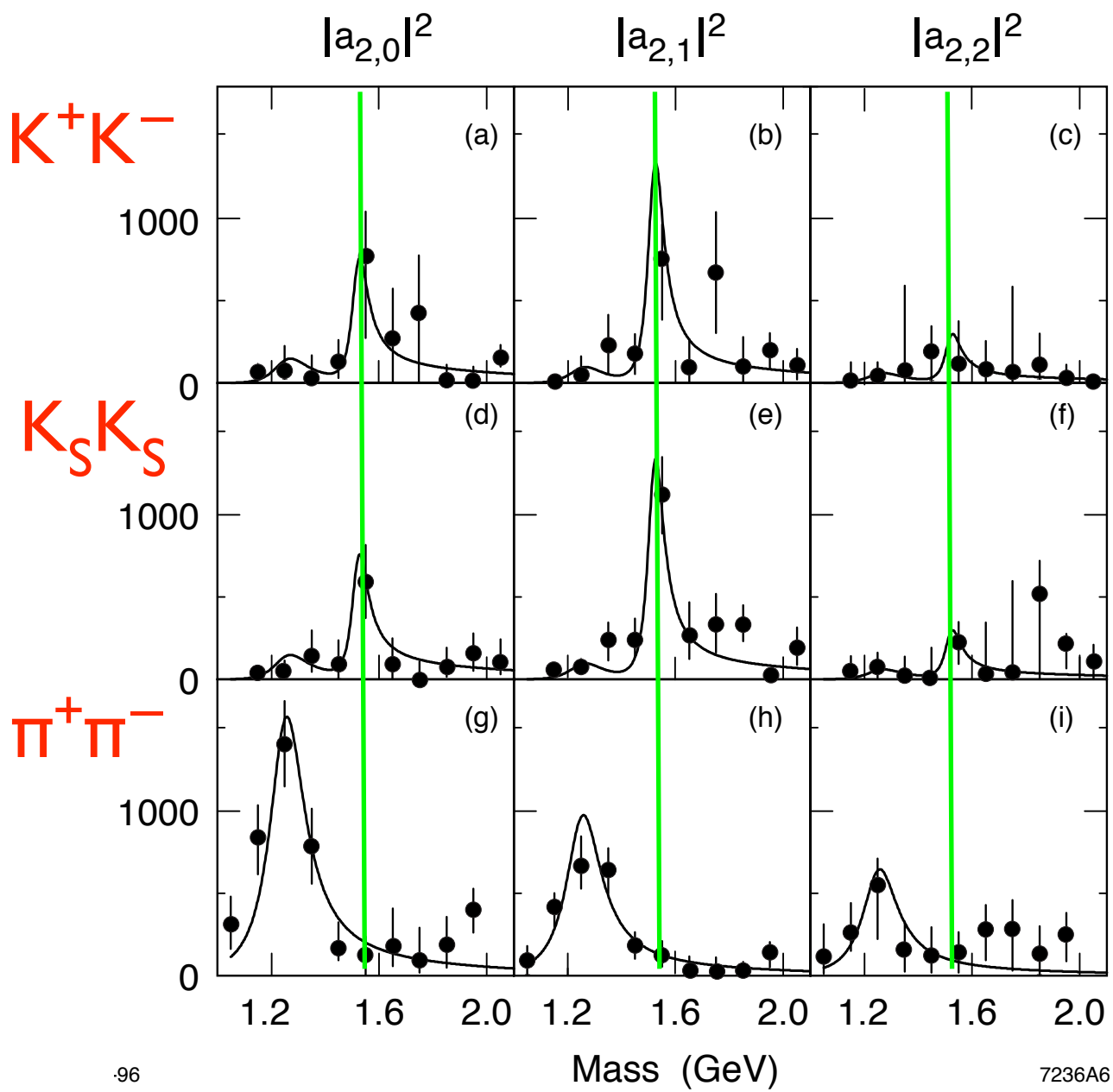
Recent results from BES





"Partial Wave Analysis" *SLAC Mark-III (Dunwoodie, et al.)*





What can CLEO-c add?

- Up to 10^9 J/ψ (≈20× BES)
- High resolution photon detection
- Excellent particle identification

Obviously, CLEO-c will look for narrow structures ala $f_J(2230)$ with high sensitivity.

What other specific measurements can CLEO-c make that bear on the issue of gluonic excitations?

Unravelling glue and $q\bar{q}$ with $f_0 \rightarrow \gamma V$

<u>Basic idea</u>: Glue component doesn't couple to photons, and flavor component sensitive to $V=\{\rho,\omega,\varphi\}$.

Radiative decays: A New flavor filter.
By Close, Donnachie, and Kalashnikova.
Phys.Rev.D67:074031,2003

Radiative scalar decays in the light front quark model.
By DeWitt, Choi, and Ji.
Phys.Rev.D68:054026,2003

Decay width calculations are basically consistent, especially in the ratios to different vector mesons.

Calculations from Close, et al:

State	Radiative Decay Widths (keV)						Total width (MeV)
	$f_0 \to \gamma\rho(770)$			$f_0 \to \gamma\varphi(1020)$			
	L	M	H	L	M	H	
$f_0(1370)$	443	1121	1540	8	9	32	300
$f_0(1500)$	2519	1458	476	9	60	454	109
$f_0(1710)$	42	94	705	800	718	78	125

For example, for the three different mixing scenarios, we have

$$B[f_0(1710) \to \gamma\rho] = (42\ to\ 705)/(125 \times 10^3) = (0.3\ to\ 5) \times 10^{-3}$$

$$B[f_0(1710) \to \gamma\phi] = (800\ to\ 78)/(125 \times 10^3) = (6.4\ to\ 0.6) \times 10^{-3}$$

$$B[f_0(1710) \to \gamma\rho]/B[f_0(1710) \to \gamma\phi] = 42/800\ to\ 705/78 = 1/19\ to\ 9$$

Specific example: $f_0(1710) \rightarrow \gamma\rho$ in CLEO-c

The Challenge: Need to extract a signal with BR$\approx 10^{-6}$

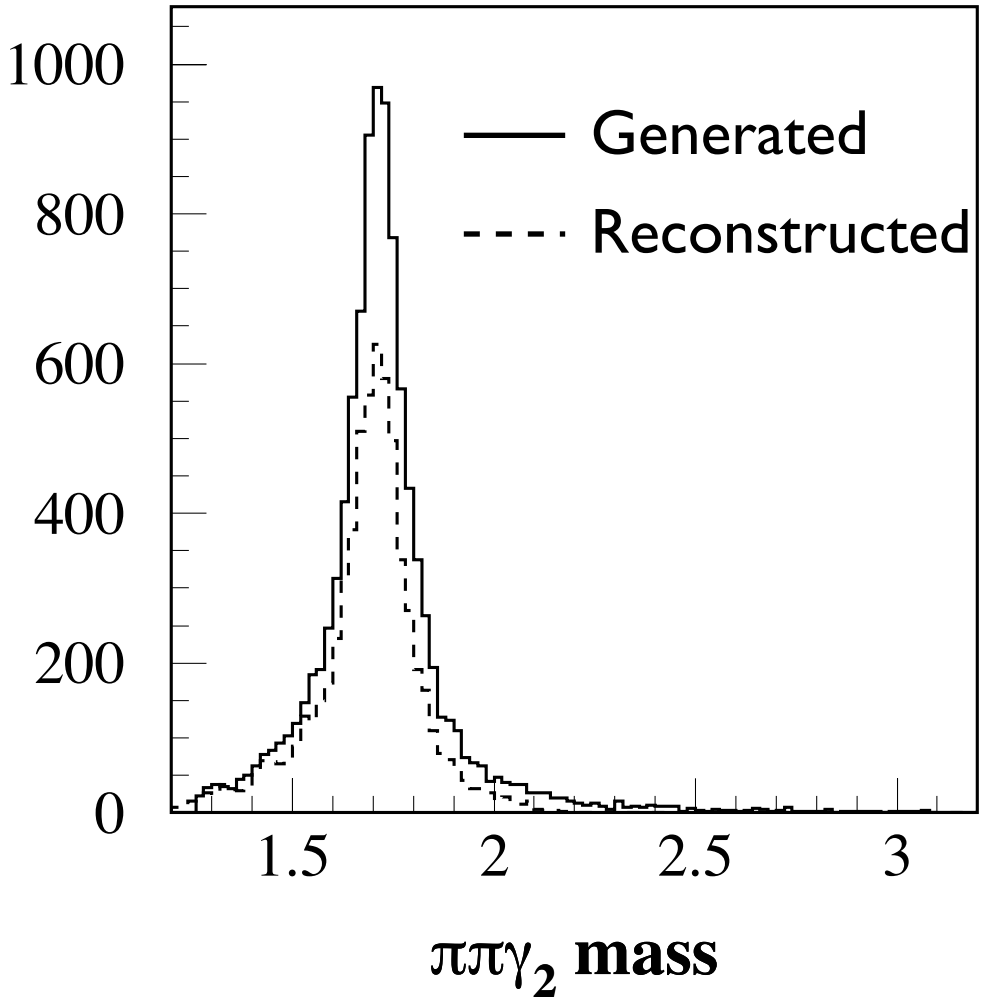
Monte Carlo study:

- Signal: Generate $J/\psi \rightarrow \gamma f_0(1710) \rightarrow \gamma\gamma\rho \rightarrow \gamma\gamma\pi^+\pi^-$ and attempt to extract events with high efficiency
- Background: Generate "generic" J/ψ events using best available information and apply same cuts as those used to extract the signal

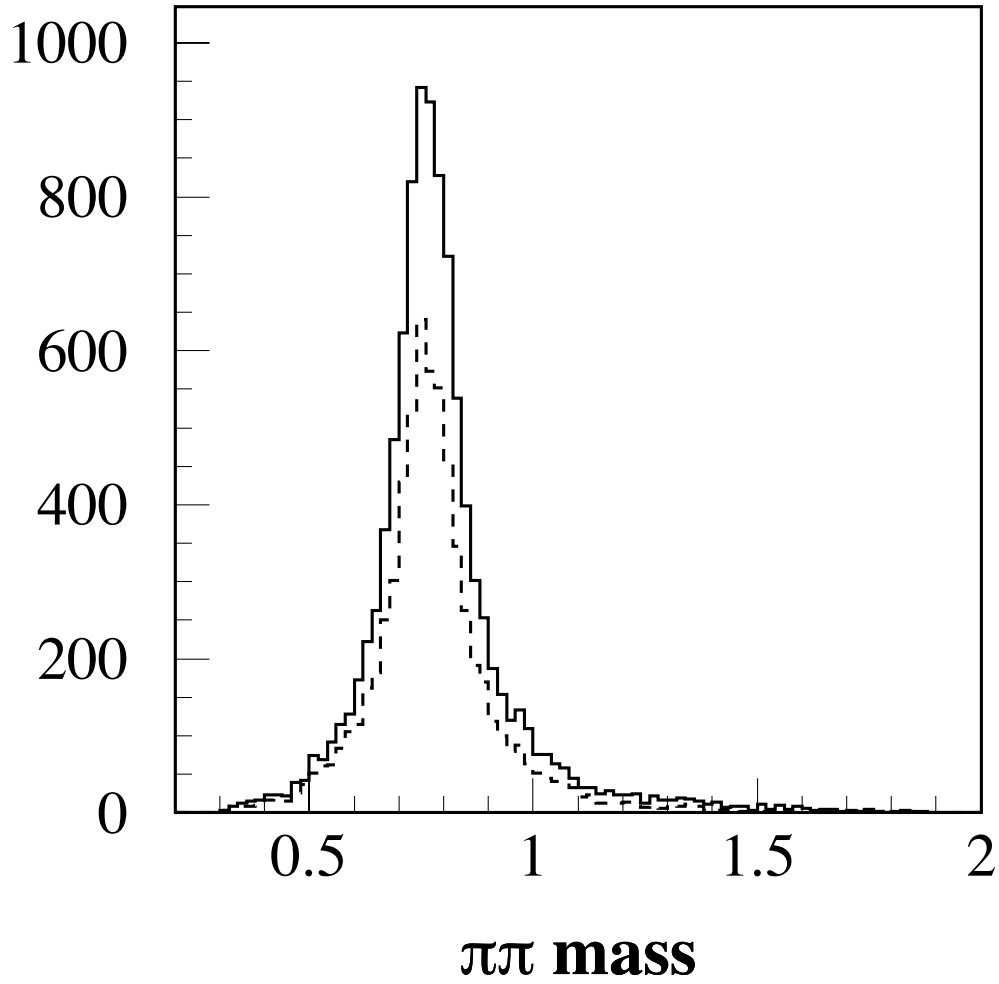
Work done by Istvan Danko (RPI)

Signal Monte Carlo: Reconstruction efficiency

$f_0(1710) \rightarrow \gamma\pi^+\pi^-$



$\rho \rightarrow \pi^+\pi^-$

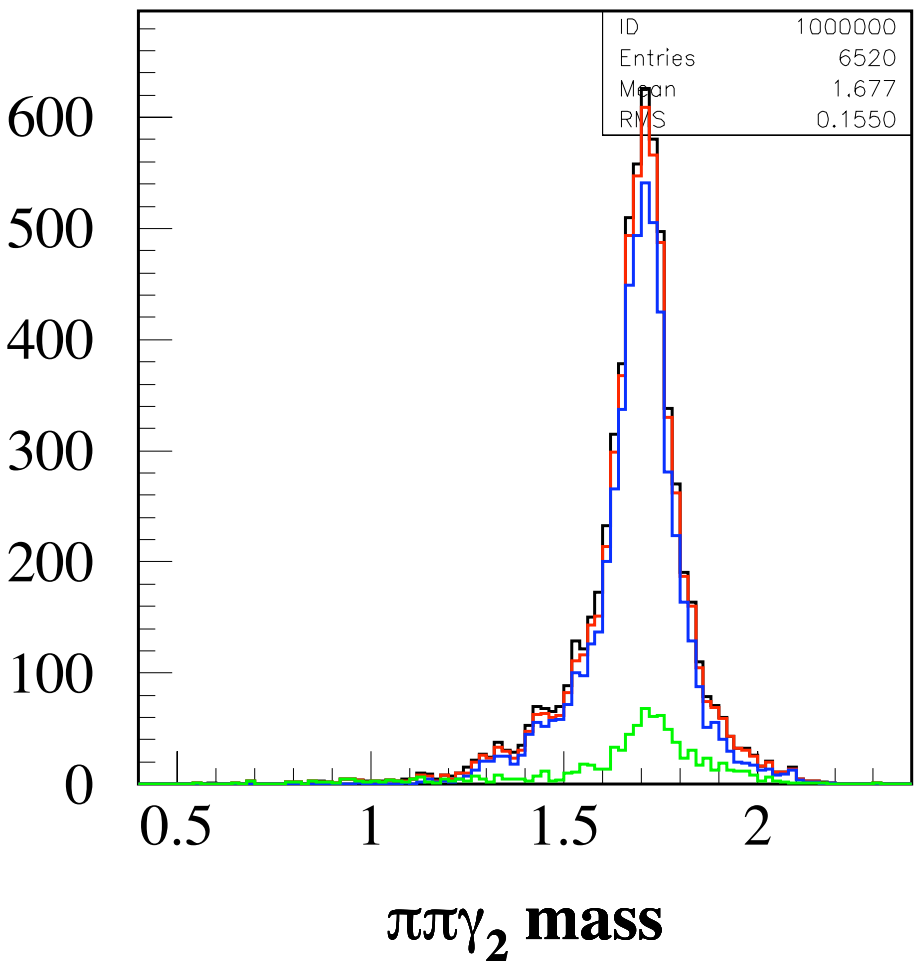


Efficiency=65.2%

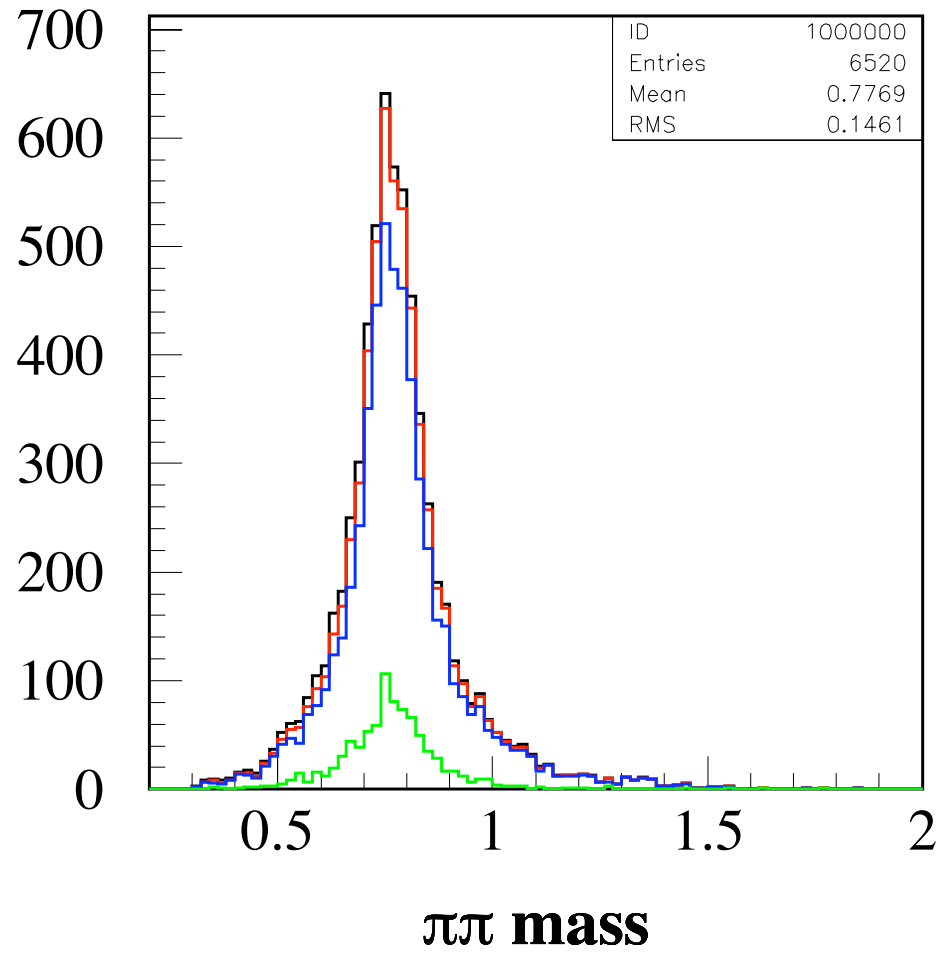
Signal Monte Carlo: Truth matching

$\pi^+\pi^-$ correct
All correct
$\pi^+\pi^-$ correct, γ's wrong

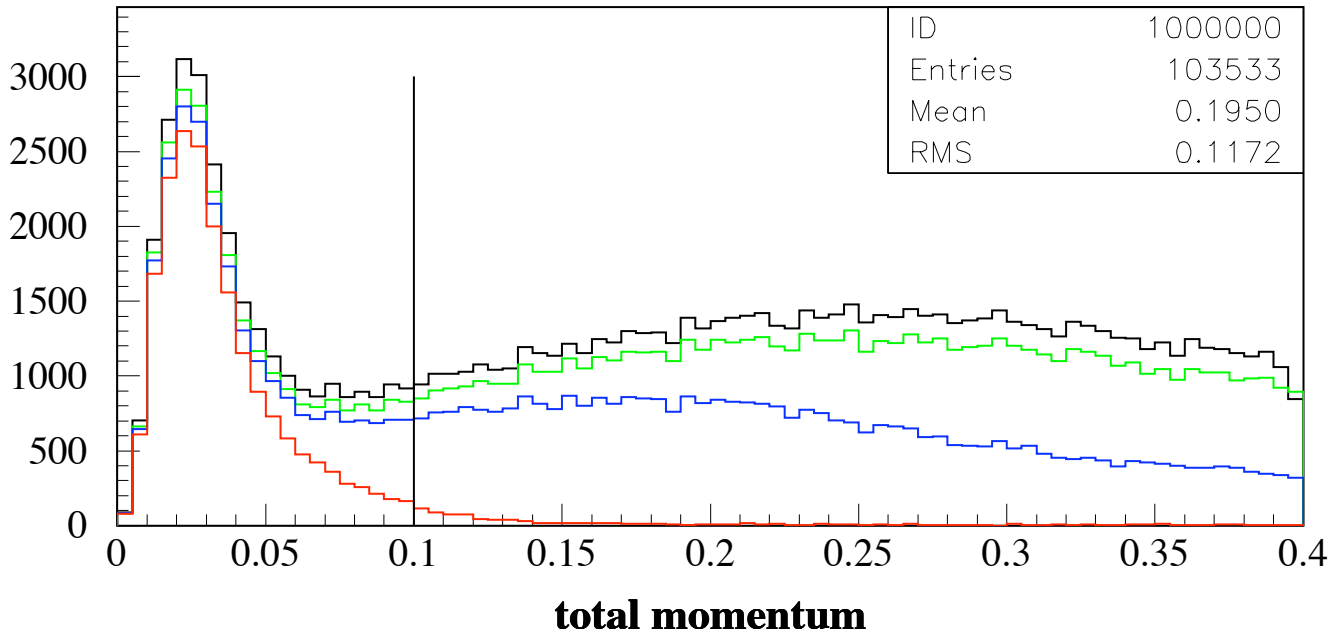
$f_0(1710) \rightarrow \gamma\pi^+\pi^-$

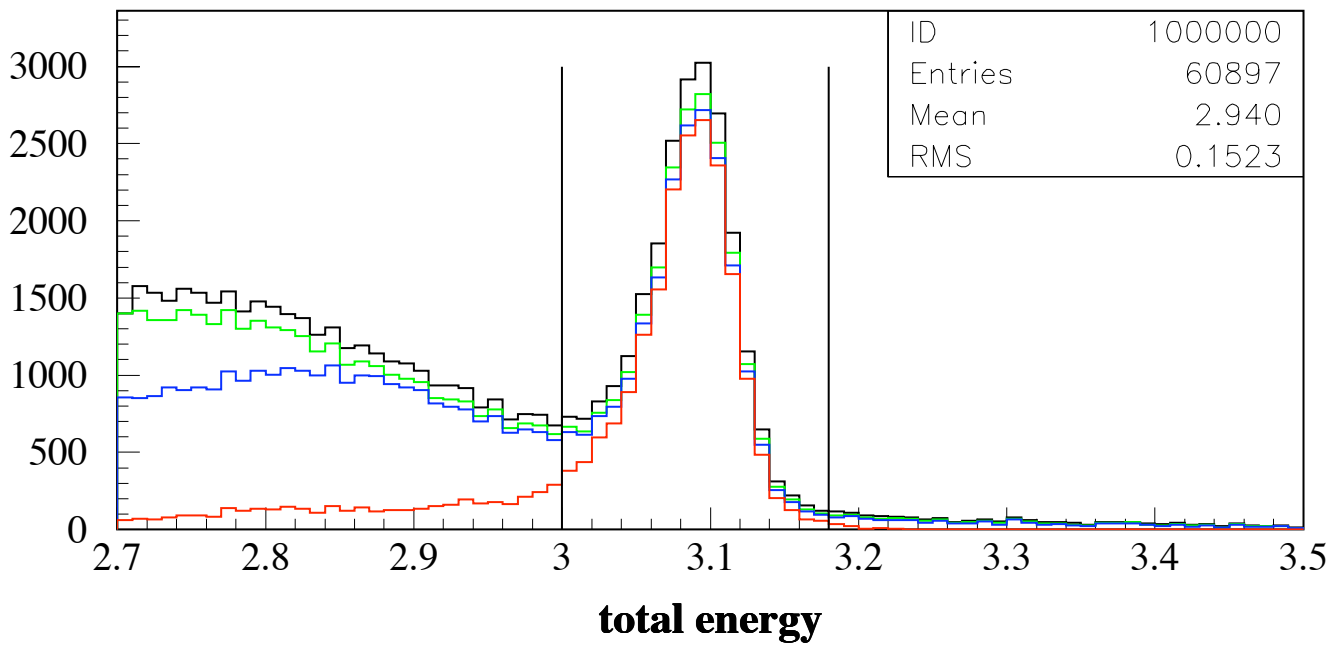


$\rho \rightarrow \pi^+\pi^-$



Generic Monte Carlo: Generated 7×10^6 events





All events

Exactly two tracks w/opposite charge

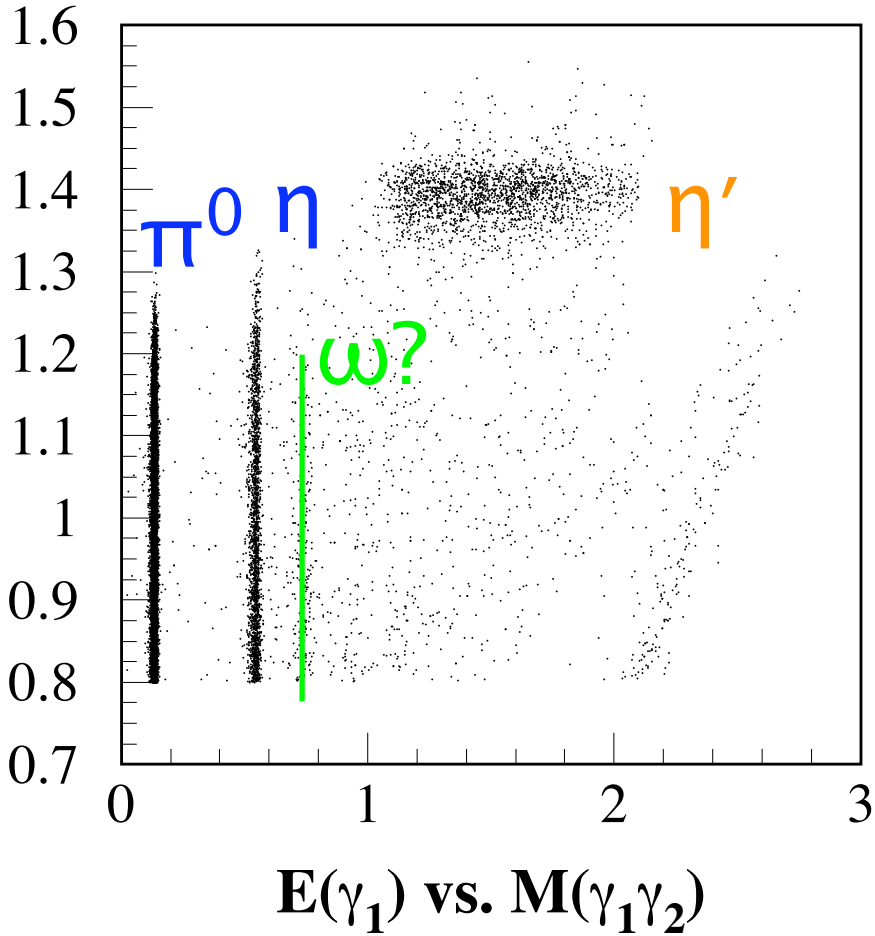
Exactly two, high energy, unmatched showers in CsI

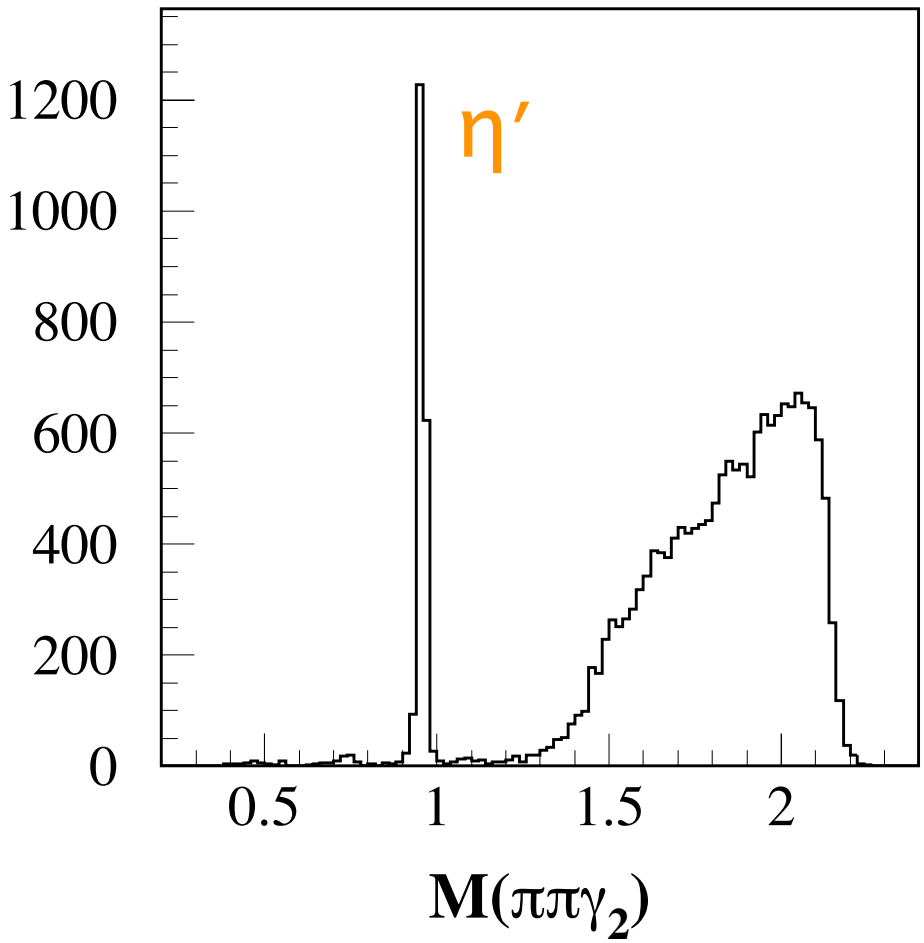
Result of imposing vertical line cut on "other" histogram

Understanding the remaining backgrounds

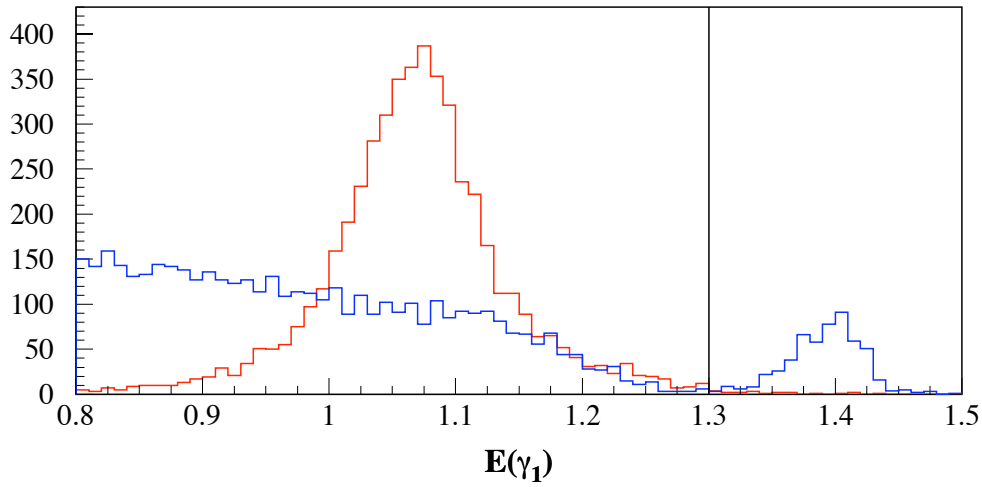
$J/\psi \to \rho\pi \to \pi^0\pi^+\pi^- \to \gamma\gamma\pi^+\pi^-$ (BR=1.27%)

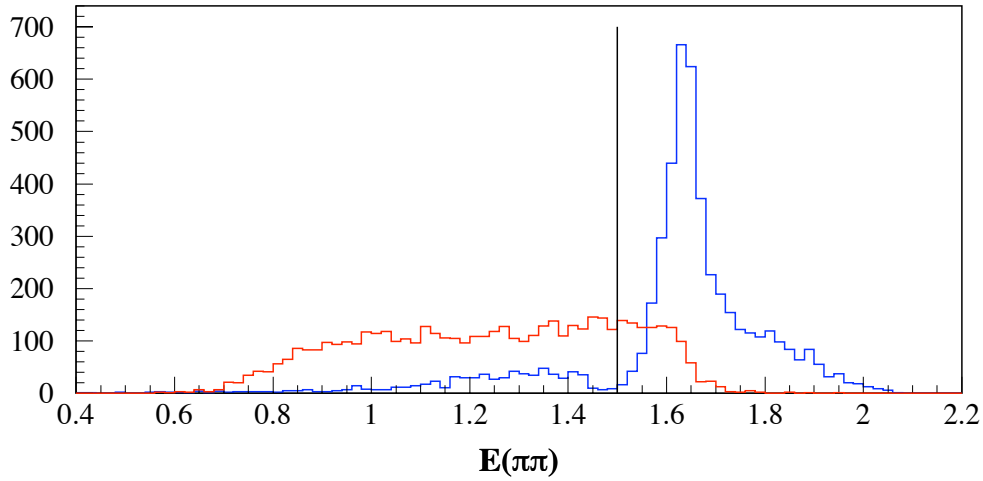
Also $J/\psi \to \{\rho\eta, \gamma\eta', \ldots\} \to \gamma\gamma\pi^+\pi^-$

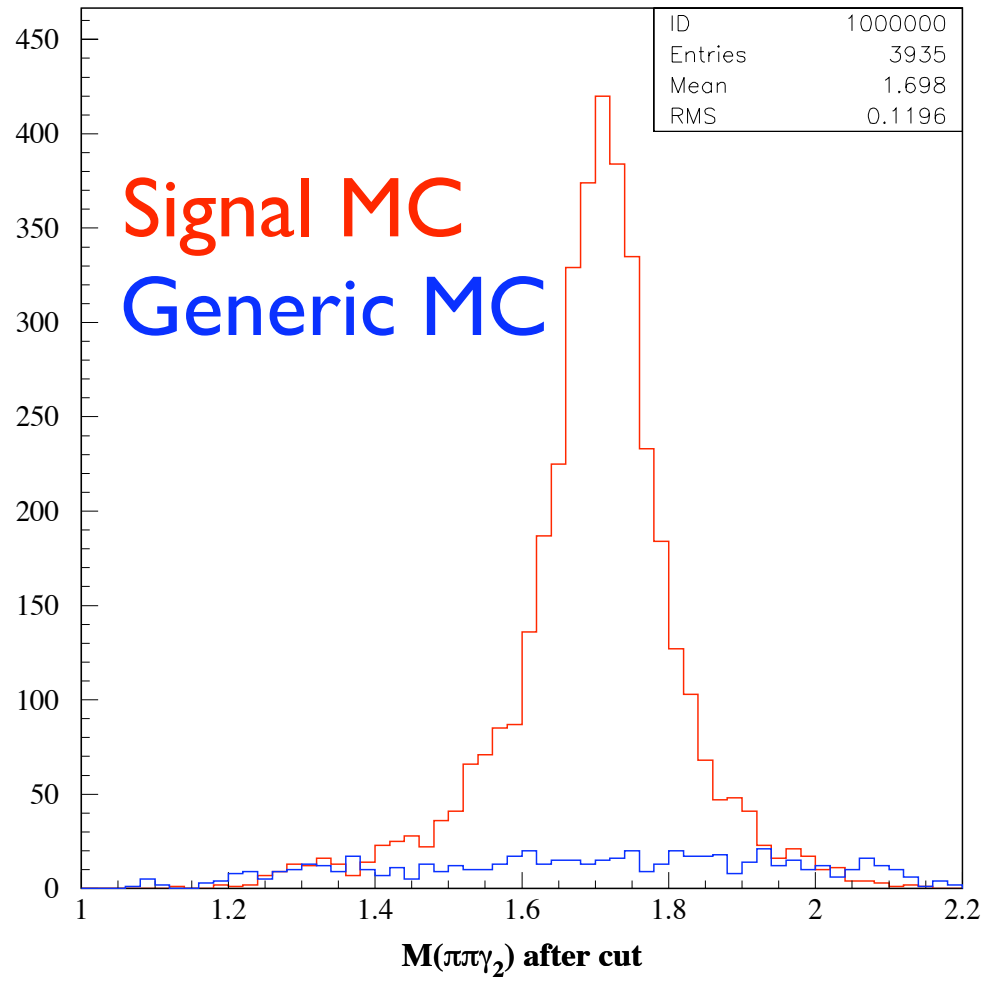




Removing the remaining backgrounds (*work in progress*)







Results so far: 604 events remain (10^{-4} rejection) with signal detection efficiency 39.4%. "*Not bad, but more to go.*"

Where we are going from here...

- Continue to study generic backgrounds and reduce them as far as possible.
- Work on a partial wave analysis technique for verifying the $J/\psi \rightarrow \gamma f_0(1710) \rightarrow \gamma\gamma\rho$ signal
- Study $J/\psi \rightarrow \gamma f_0(1710) \rightarrow \gamma\gamma\varphi$ *(in progress)*
- Study $J/\psi \rightarrow \gamma f_0(1710) \rightarrow \gamma\gamma\omega$

Summary

- The situation of glueball components in the scalar meson sector remains murky
- CLEO-c will contribute high statistics and precision techniques towards the problem
- One key problem we will attack is finding the "mass mixing matrix" elements
- Simulations are underway so that we are ready for the problem when the data arrives