

Preliminary Study of Exclusive R Value at 2.0 GeV

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July 6, 2022

Outline

Methodology: recoil mass

Methodology

- To improve the statistics and extract signal of pure charged channel, part reconstruction is applied with one π not reconstructed
- Take $2\pi^+2\pi^-$ as example:
 - If charged tracks satisfy $N_{\pi^+} = 2 \& \& N_{\pi^-} = 1$ or $N_{\pi^+} = 1 \& \& N_{\pi^-} = 2$, the missing $\pi^\pm$ is reconstructed by recoil mass
 - If charged tracks satisfy $N_{\pi^+} = N_{\pi^-} = 2$, drop the π that has least momentum, and reconstructed by recoil mass
 - In the published work of $2K^+2K^-$, the combination of 3K that has least χ^2 of vertex fit is kept and the remain K is dropped
- Take $2\pi^+2\pi^-\pi^0$ as example:
 - Charged tracks must satisfy $N_{\pi^+} = N_{\pi^-} = 2$, no requirement on the neutral tracks, the π^0 is reconstructed by recoil mass
- Only cover
 - $2\pi^+2\pi^-$, $3\pi^+3\pi^-$
 - $2\pi^+2\pi^-\pi^0$, $3\pi^+3\pi^-\pi^0$

$2\pi^+2\pi^-$: momentum

■ momentum of π tracks from the mc truth

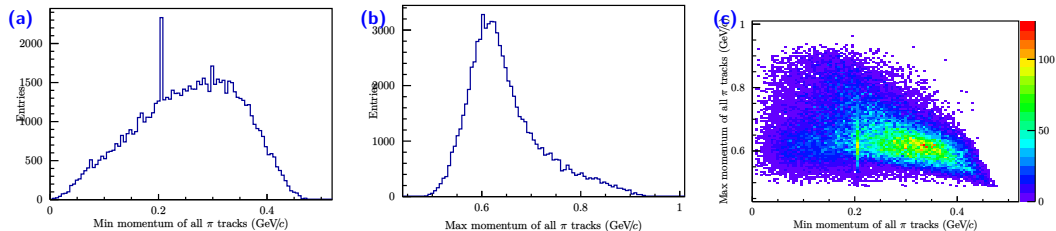
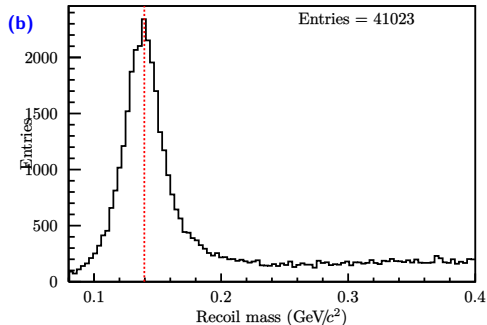
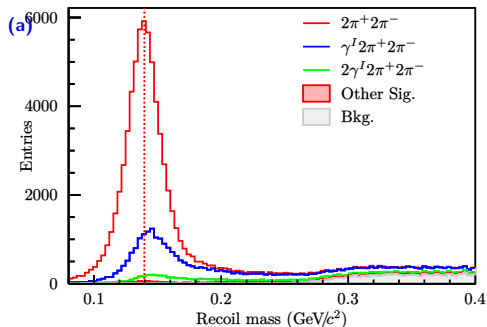


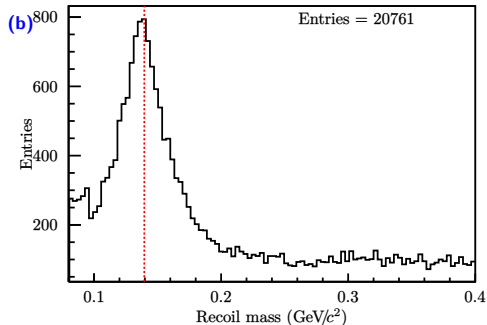
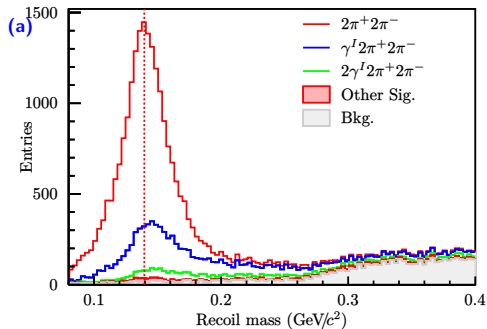
Figure: (a) the minimum of π momentum from mctruth; (b) the maximum of π momentum from mctruth; (c) 2d plot of the minimum and the maximum of π momentum from mctruth;

$2\pi^+2\pi^-$ (with one $\pi^\pm$ dropped): recoil mass



decay tree	nEtr	eff(%)
$e^+e^- \rightarrow \pi^+\pi^+\pi^-\pi^-$	51251/76841	66.70
$e^+e^- \rightarrow \gamma^I \pi^+\pi^+\pi^-\pi^-$	21217/41466	51.17
$e^+e^- \rightarrow \gamma^I \gamma^I \pi^+\pi^+\pi^-\pi^-$	5621/14644	38.38
$e^+e^- \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0$	2173/13138	16.54
$e^+e^- \rightarrow \gamma^I \eta \pi^+\pi^-$ $\eta \rightarrow \pi^+\pi^-\pi^0$	911/2654	34.33
$e^+e^- \rightarrow \gamma^I \gamma^\nu$ $\gamma^\nu \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0$	880/7839	11.23
$e^+e^- \rightarrow \eta \pi^+\pi^-$ $\eta \rightarrow \pi^+\pi^-\pi^0$	722/1571	45.96
$e^+e^- \rightarrow \omega \pi^+\pi^-$ $\omega \rightarrow \pi^+\pi^-\pi^0$	384/2210	17.38

$2\pi^+2\pi^-$ (with one $\pi^\pm$ missing): recoil mass



decay tree	nEtr	eff(%)
$e^+e^- \rightarrow \pi^+\pi^+\pi^-\pi^-$	16261/76841	21.16
$e^+e^- \rightarrow \gamma^I \pi^+\pi^+\pi^-\pi^-$	6702/41466	16.16
$e^+e^- \rightarrow \gamma^I \gamma^I \pi^+\pi^+\pi^-\pi^-$	1922/14644	13.12
$e^+e^- \rightarrow \gamma^I \pi^+\pi^-\pi^0\pi^0$	1099/179335	0.61
$e^+e^- \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0$	976/13138	7.43
$e^+e^- \rightarrow \gamma^I \pi^+\pi^-\pi^0\pi^0$	553/4389	12.60
$\pi^0 \rightarrow \gamma e^- e^+$		
$e^+e^- \rightarrow \gamma^I \eta \pi^+\pi^-$	498/2654	18.76
$\eta \rightarrow \pi^+\pi^-\pi^0$		
$e^+e^- \rightarrow \eta \pi^+\pi^-$	397/1571	25.27
$\eta \rightarrow \pi^+\pi^-\pi^0$		

$3\pi^+3\pi^-$: momentum

- momentum of π tracks from the mc truth

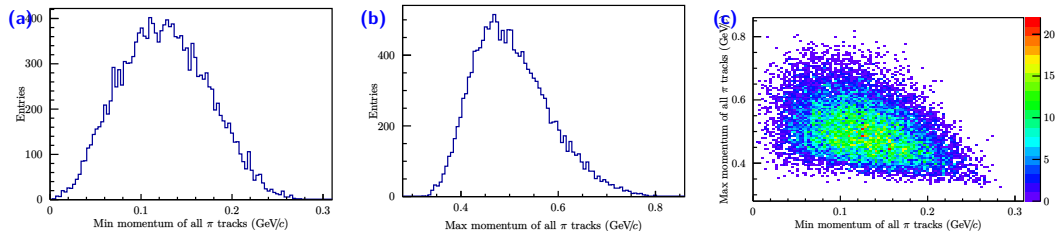
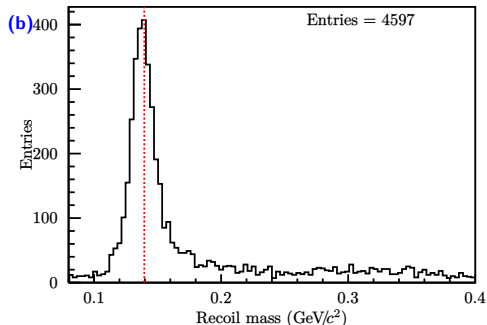
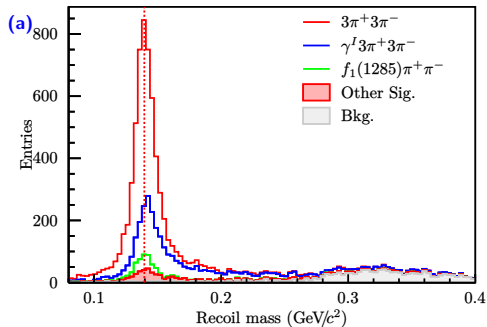


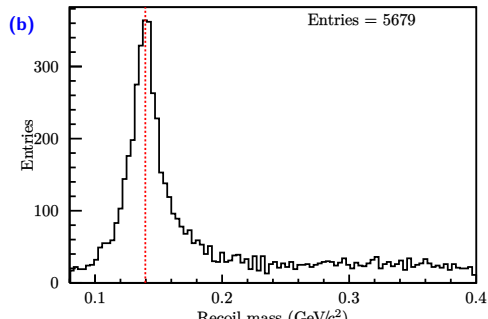
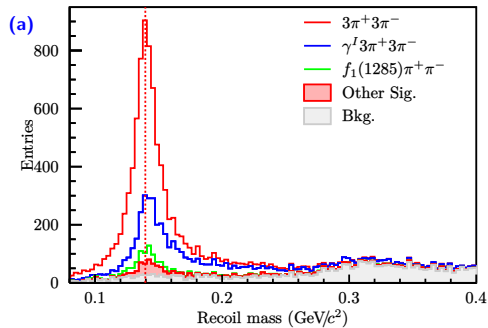
Figure: (a) the minimum of π momentum from mctruth; (b) the maximum of π momentum from mctruth; (c) 2d plot of the minimum and the maximum of π momentum from mctruth;

$3\pi^+3\pi^-$ (with one $\pi^\pm$ dropped): recoil mass



decay tree	nEtr	eff(%)
$e^+e^- \rightarrow \pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$	4005/14461	27.70
$e^+e^- \rightarrow \gamma^I \gamma^\nu$ $\gamma^\nu \rightarrow \pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$	2416/8926	27.07
$e^+e^- \rightarrow f_1(1285)\pi^+\pi^-$ $f_1(1285) \rightarrow \pi^+\pi^-\rho^0$ $\rho^0 \rightarrow \pi^+\pi^-$	303/1075	28.19
$e^+e^- \rightarrow \eta\pi^+\pi^+\pi^-\pi^-$ $\eta \rightarrow \pi^+\pi^-\pi^0$	273/1247	21.89
$e^+e^- \rightarrow \gamma^I \gamma^\nu$ $\gamma^\nu \rightarrow f_1(1285)\pi^+\pi^-$ $f_1(1285) \rightarrow \pi^+\pi^-\rho^0$ $\rho^0 \rightarrow \pi^+\pi^-$	166/580	28.62
$e^+e^- \rightarrow \gamma^I \gamma^\nu$ $\gamma^\nu \rightarrow \eta\pi^+\pi^+\pi^-\pi^-$ $\eta \rightarrow \pi^+\pi^-\pi^0$	103/693	14.86
$e^+e^- \rightarrow f_1(1285)\pi^+\pi^-\pi^0$ $f_1(1285) \rightarrow \pi^+\pi^-\rho^0$ $\rho^0 \rightarrow \pi^+\pi^-$	80/422	18.96

$3\pi^+3\pi^-$ (with one $\pi^\pm$ missing): recoil mass



decay tree	nEtr	eff(%)
$e^+e^- \rightarrow \pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$	5175/14461	35.79
$e^+e^- \rightarrow \gamma'\gamma^\nu$ $\gamma^\nu \rightarrow \pi^+\pi^+\pi^+\pi^-\pi^-\pi^-$	3050/8926	34.17
$e^+e^- \rightarrow f_1(1285)\pi^+\pi^-$ $f_1(1285) \rightarrow \pi^+\pi^-\rho^0$ $\rho^0 \rightarrow \pi^+\pi^-$	372/1075	34.60
$e^+e^- \rightarrow \eta\pi^+\pi^+\pi^-\pi^-$ $\eta \rightarrow \pi^+\pi^-\pi^0$	355/1247	28.47
$e^+e^- \rightarrow \omega\pi^+\pi^-\pi^0$ $\omega \rightarrow \pi^+\pi^-\pi^0$	261/33254	0.78
$e^+e^- \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0\pi^0$	233/28232	0.83
$e^+e^- \rightarrow \gamma'\gamma^\nu$ $\gamma^\nu \rightarrow f_1(1285)\pi^+\pi^-$ $f_1(1285) \rightarrow \pi^+\pi^-\rho^0$ $\rho^0 \rightarrow \pi^+\pi^-$	204/580	35.17
$e^+e^- \rightarrow \gamma'\gamma^\nu$ $\gamma^\nu \rightarrow \eta\pi^+\pi^+\pi^-\pi^-$ $\eta \rightarrow \pi^+\pi^-\pi^0$	165/693	23.81

$4\pi^+4\pi^-$: momentum

- Since the inclusive MC samples contain very low $4\pi^+4\pi^-$ events, a 1000K $e^+e^- \rightarrow 4\pi^+4\pi^-$, non-ISR MC samples is generated and analysed
- momentum of π tracks from the mc truth

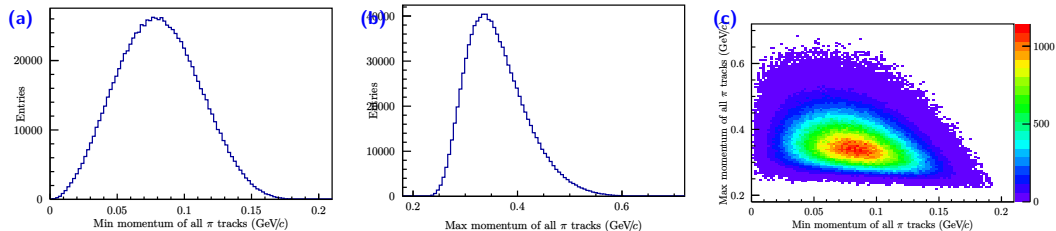


Figure: (a) the minimum of π momentum from mctruth; (b) the maximum of π momentum from mctruth; (c) 2d plot of the minimum and the maximum of π momentum from mctruth;

$4\pi^+4\pi^-$: recoil mass

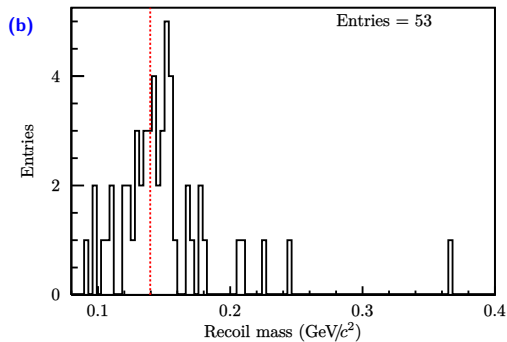
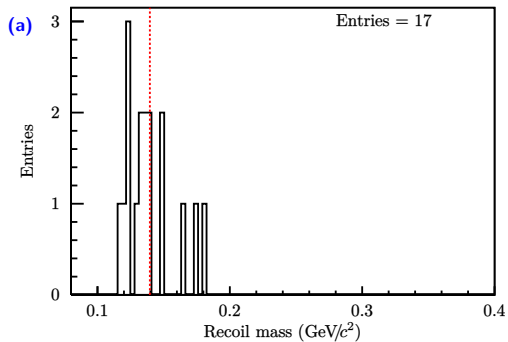
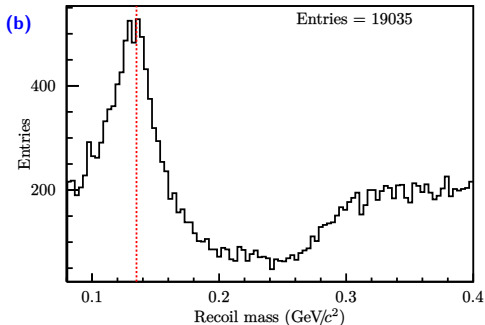
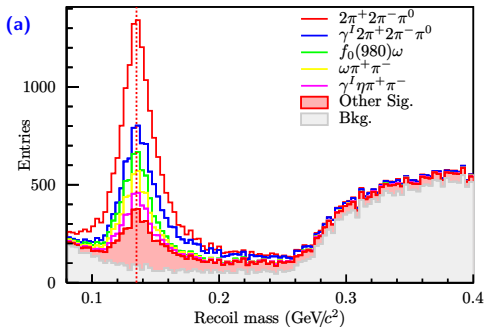


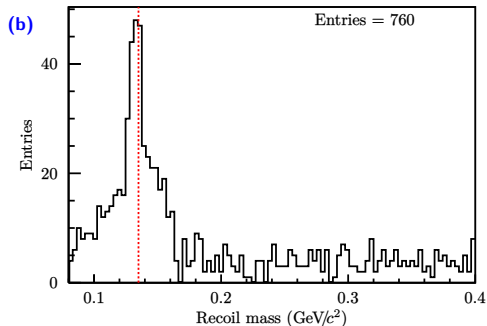
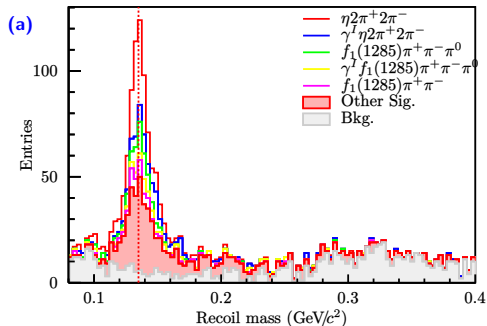
Figure: (a) with one $\pi^\pm$ dropped; (b) with one $\pi^\pm$ missed

$2\pi^+2\pi^-\pi^0$: recoil mass



decay tree	nEtr	eff(%)
$e^+e^- \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0$	6298/13138	47.94
$e^+e^- \rightarrow \omega\pi^+\pi^-\pi^0$ $\omega \rightarrow \pi^+\pi^-\pi^0$	4428/33254	13.32
$e^+e^- \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0\pi^0$	3844/28232	13.62
$e^+e^- \rightarrow \gamma^I\gamma^v$ $\gamma^v \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0$	3514/7839	44.83
$e^+e^- \rightarrow \gamma^I\gamma^I\pi^+\pi^+\pi^-\pi^-$	2078/14644	14.19
$e^+e^- \rightarrow \gamma^I\gamma^v$ $\gamma^v \rightarrow \omega\pi^+\pi^-\pi^0$ $\omega \rightarrow \pi^+\pi^-\pi^0$	1921/21805	8.81
$e^+e^- \rightarrow \gamma^I\gamma^v$ $\gamma^v \rightarrow \pi^+\pi^+\pi^-\pi^-\pi^0\pi^0$	1527/16434	9.29
$e^+e^- \rightarrow \gamma^I\pi^+\pi^+\pi^-\pi^-$	1468/41466	3.54

$3\pi^+3\pi^-\pi^0$: recoil mass



decay tree	nEtr	eff(%)
$e^+ e^- \rightarrow \eta \pi^+ \pi^+ \pi^- \pi^-$ $\eta \rightarrow \pi^+ \pi^- \pi^0$	272/1247	21.81
$e^+ e^- \rightarrow \gamma' \gamma^\nu$ $\gamma^\nu \rightarrow \eta \pi^+ \pi^+ \pi^- \pi^-$ $\eta \rightarrow \pi^+ \pi^- \pi^0$	128/693	18.47
$e^+ e^- \rightarrow f_1(1285) \pi^+ \pi^- \pi^0$ $f_1(1285) \rightarrow \pi^+ \pi^- \rho^0$ $\rho^0 \rightarrow \pi^+ \pi^-$	91/422	21.56
$e^+ e^- \rightarrow \gamma' f_1(1285) \pi^+ \pi^- \pi^0$ $f_1(1285) \rightarrow \pi^+ \pi^- \rho^0$ $\rho^0 \rightarrow \pi^+ \pi^-$	68/385	17.66
$e^+ e^- \rightarrow \gamma' \gamma^\nu$ $\gamma^\nu \rightarrow \pi^+ \pi^+ \pi^+ \pi^- \pi^- \pi^-$	67/8926	0.75
$e^+ e^- \rightarrow f_1(1285) \pi^+ \pi^-$ $f_1(1285) \rightarrow \eta \pi^+ \pi^-$ $\eta \rightarrow \pi^+ \pi^- \pi^0$	60/227	26.43