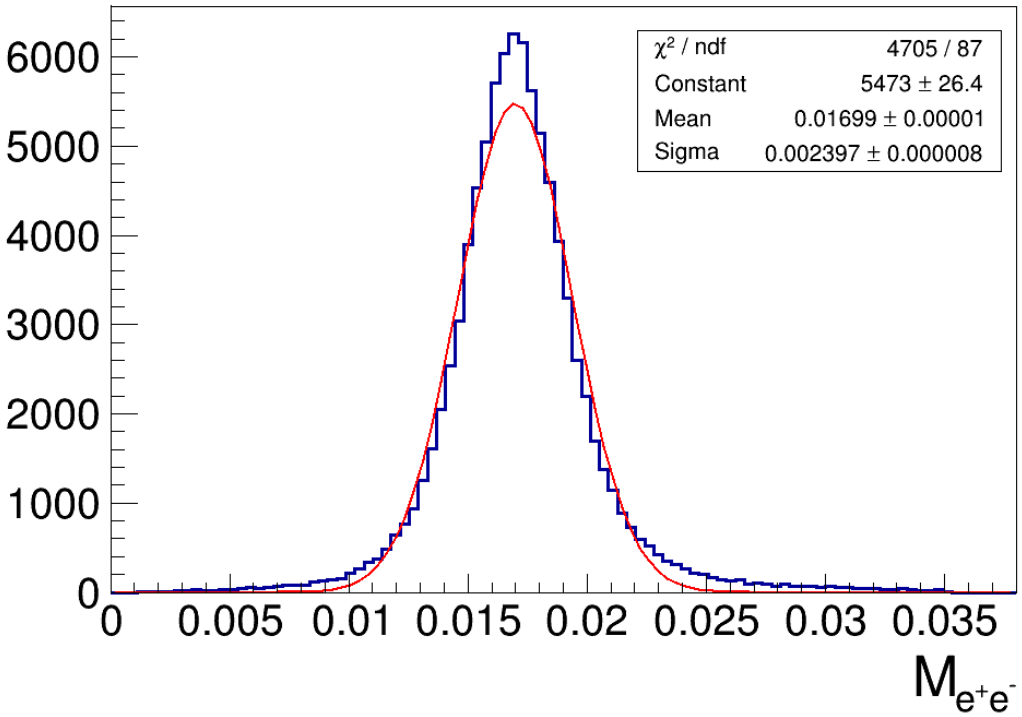
$\eta' \to \pi^+\pi^- e^+e^-$

产生MC样本：$\eta' \to \pi^+\pi^- a, a \to e^+e^-$

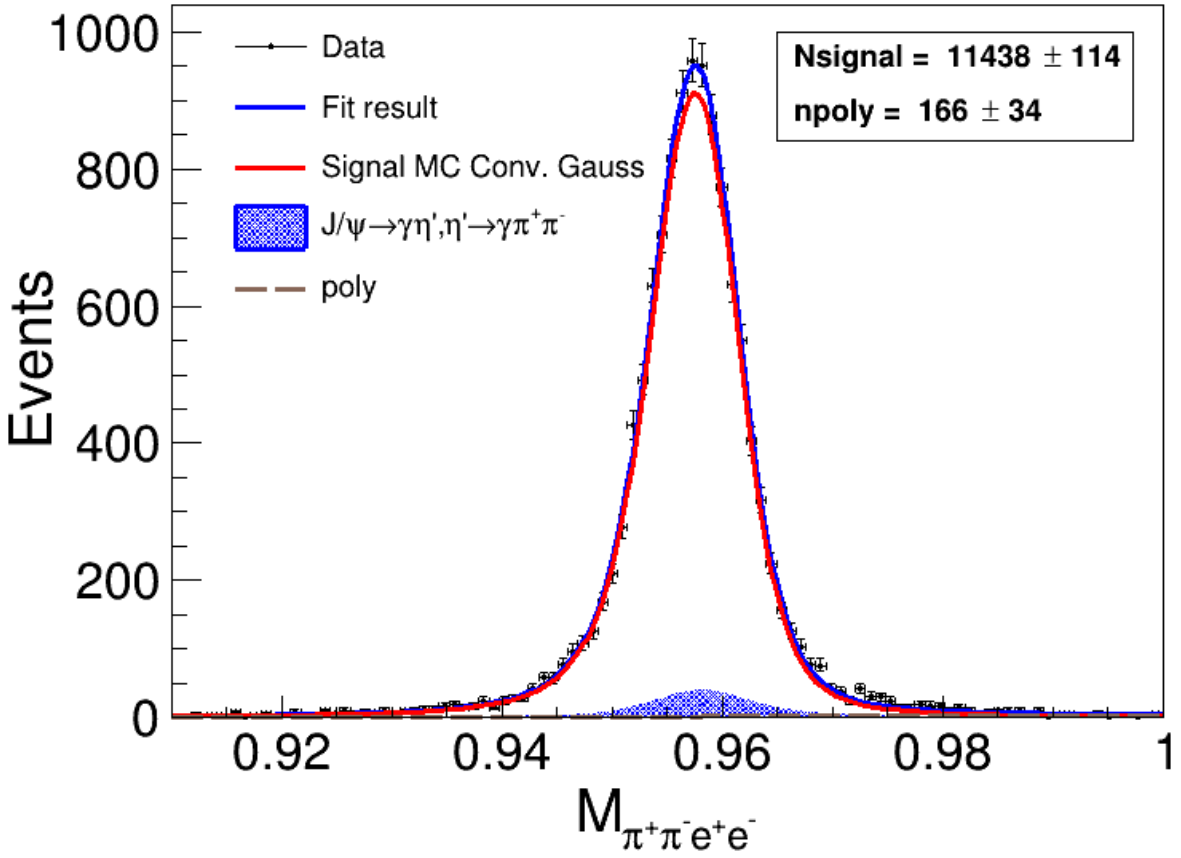
$$\varepsilon = \frac{91078}{500000} = 18.22\%$$



FCN=4705.49 FROM MIGRAD STATUS=CONVERGED 80 CALLS 81 TOTAL
EDM=5.99369e-08 STRATEGY= 1 ERROR MATRIX ACCURATE

EXT PARAMETER NO.	NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	Constant	5.47345e+03	2.63641e+01	6.23288e-01	6.19513e-06
2	Mean	1.69855e-02	8.17014e-06	2.72927e-07	3.22248e+01
3	Sigma	2.39675e-03	8.17628e-06	2.31770e-05	2.95616e-01

- 拟合$M_{\pi\pi ee}$

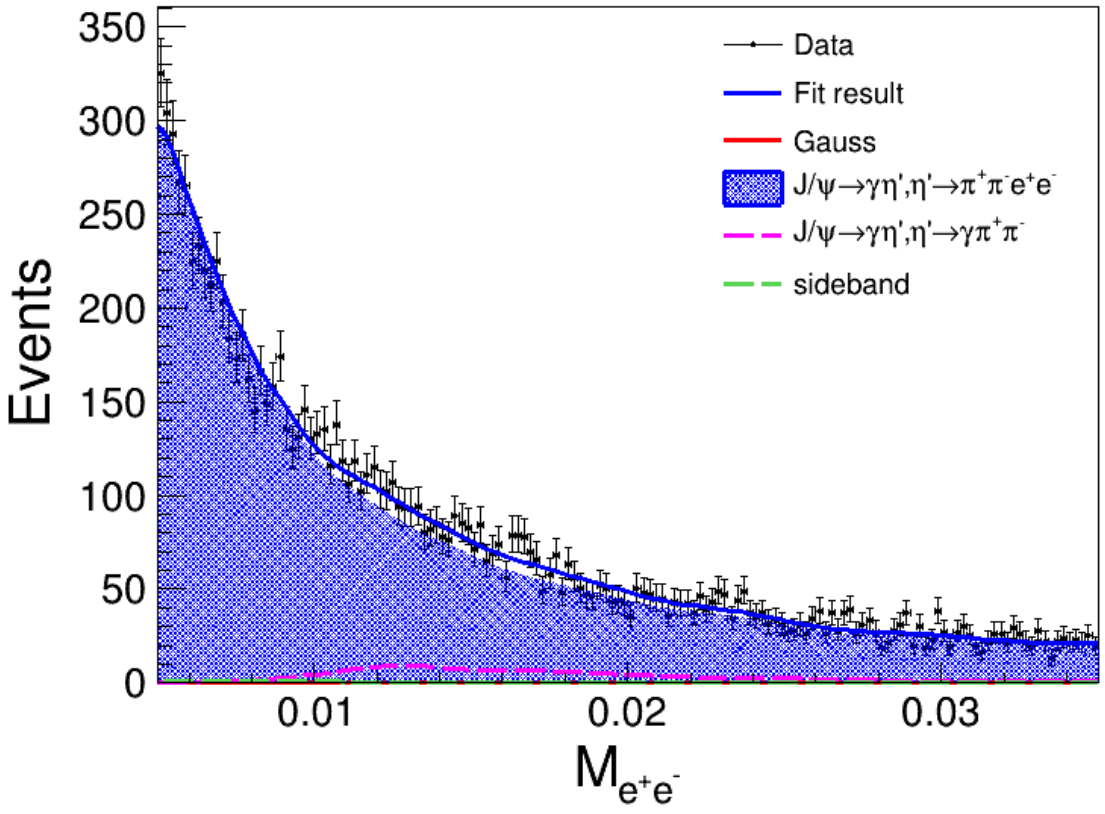


- $M_{\pi\pi ee} \in (0.945, 0.97)$
- $M_{ee} \in (0.005, 0.035)$

$\mathrm{N}(\pi\pi ee) = 10784.9$
$\mathrm{N}(\gamma\pi\pi) = 526.647$
$\mathrm{Npoly} = 48.4651$

- 拟合M_{ee}：MC + bkg PDF

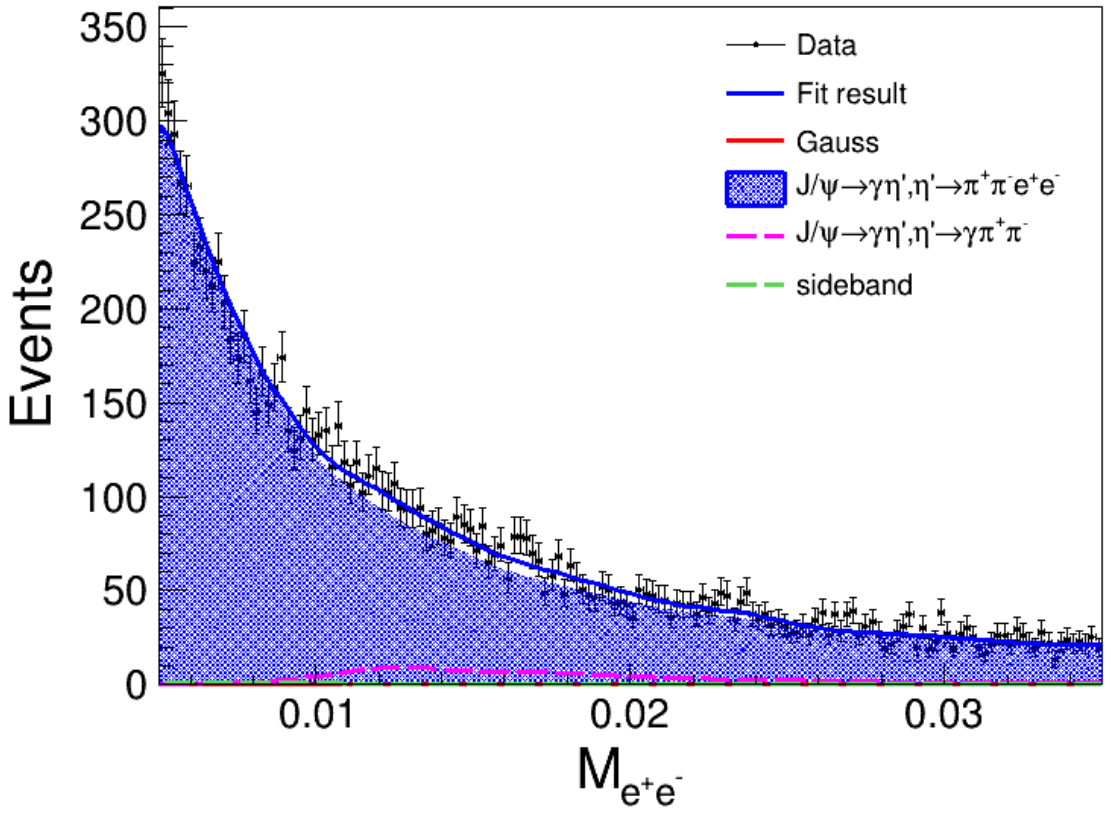
N($\pi\pi ee$) = 10784.9
N($\gamma\pi\pi$) = 526.647
poly = 48.4651



FCN=-137312 FROM HESSE STATUS=OK 7 CALLS 42 TOTAL
EDM=1.15025e-08 STRATEGY= 1 ERROR MATRIX ACCURATE
EXT PARAMETER INTERNAL INTERNAL
NO. NAME VALUE ERROR STEP SIZE VALUE
1 Nsignal 1.10783e+01 3.16902e+01 2.00000e-01 -5.90611e-01
ERR DEF= 0.5
EXTERNAL ERROR MATRIX. NDIM= 25 NPAR= 1 ERR DEF=0.5

- 拟合M_{ee}：MC + bkg PDF

N($\pi\pi ee$) 放开拟合
N($\gamma\pi\pi$) = 526.647
poly = 48.4651



FCN=-137312 FROM HESSE STATUS=OK 14 CALLS 47 TOTAL
EDM=2.33186e-05 STRATEGY= 1 ERROR MATRIX ACCURATE

EXT PARAMETER NO.	NAME	VALUE	ERROR	INTERNAL STEP SIZE	INTERNAL VALUE
1	Nbkg1	1.07286e+04	1.06213e+02	5.48957e-04	-1.36140e-01
2	Nsignal	5.96362e-03	3.05336e+01	5.00000e-01	-1.54895e+00

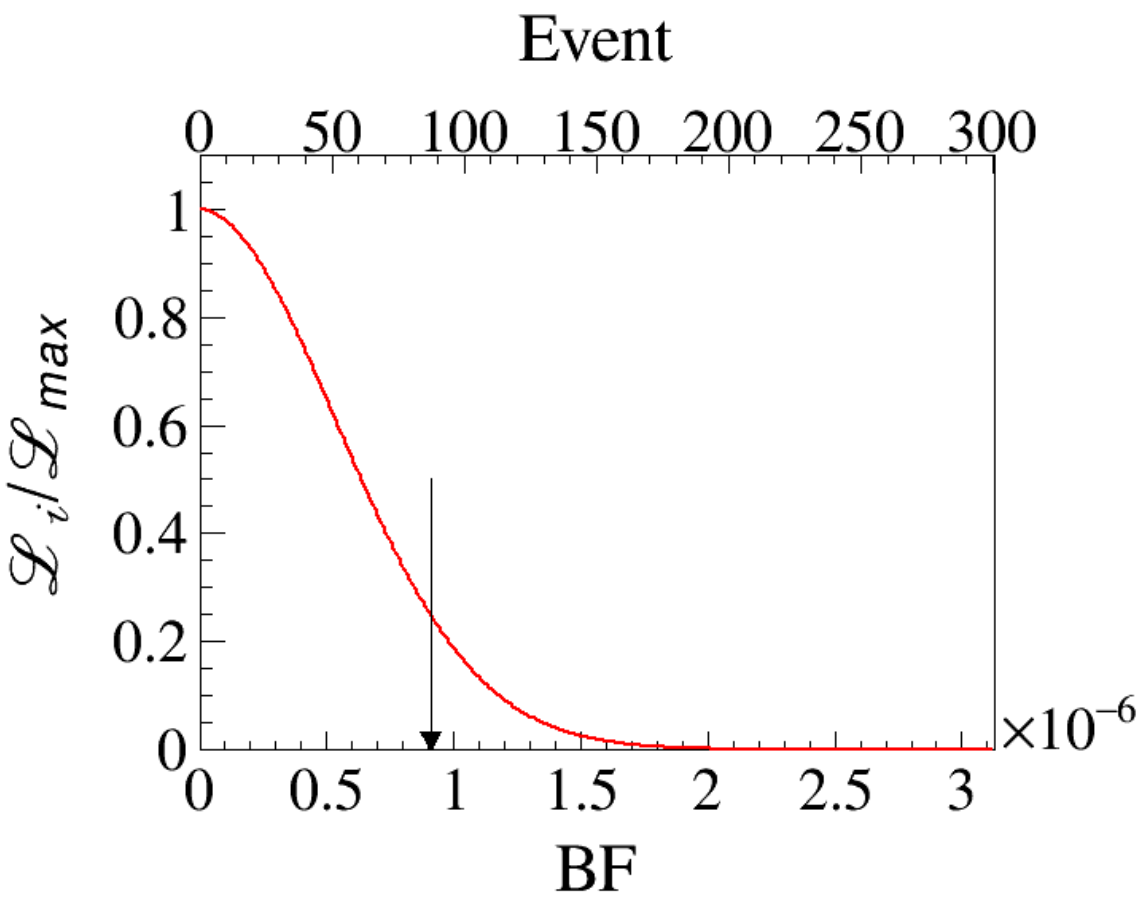
ERR DEF= 0.5

EXTERNAL ERROR MATRIX. NDIM= 25 NPAR= 2 ERR DEF=0.5
1.129e+04 -3.465e+00
-3.465e+00 2.992e-01

PARAMETER CORRELATION COEFFICIENTS

NO.	GLOBAL	1	2
1	0.05962	1.000	-0.060
2	0.05962	-0.060	1.000

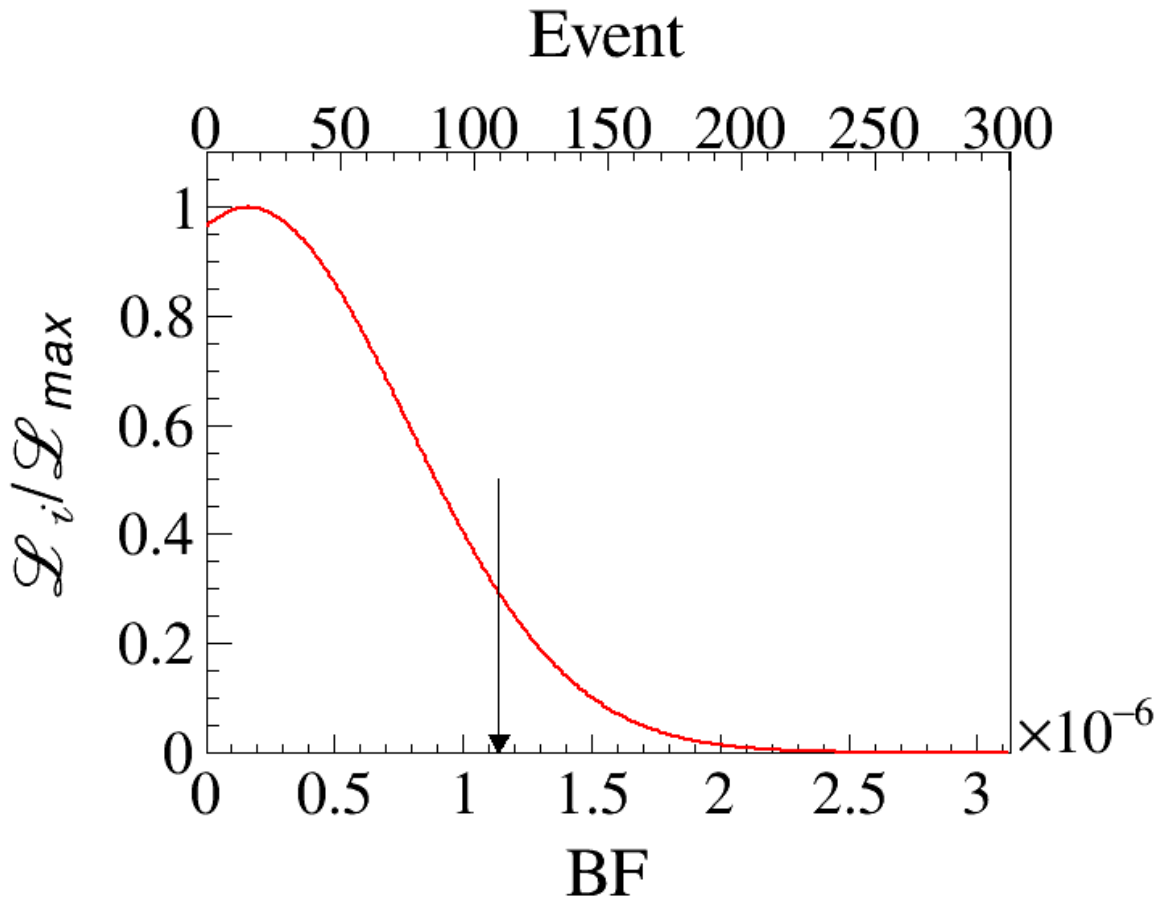
bkg1 = 10784.9, bkg2 = 526.647



$\pi\pi ee$事例数固定

N = 87

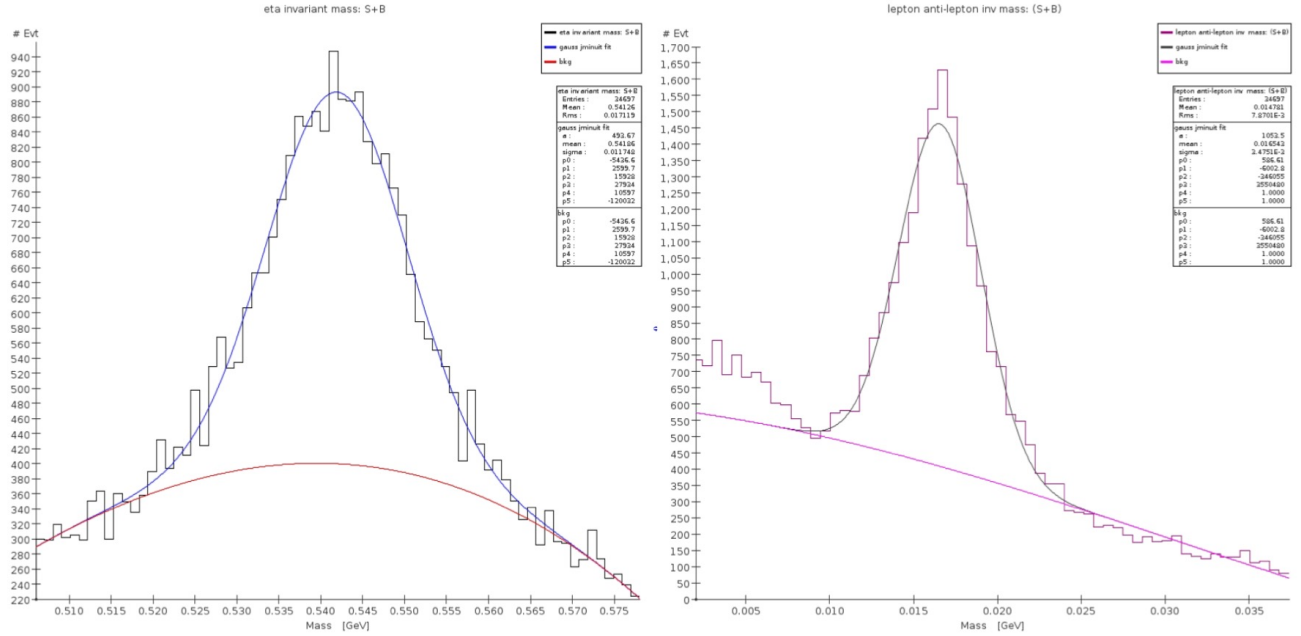
$< 9.085\times10^{-7}$ (90% CL)



$\pi\pi ee$事例数放开

N = 109

$< 1.1383\times10^{-6}$ (90% CL)



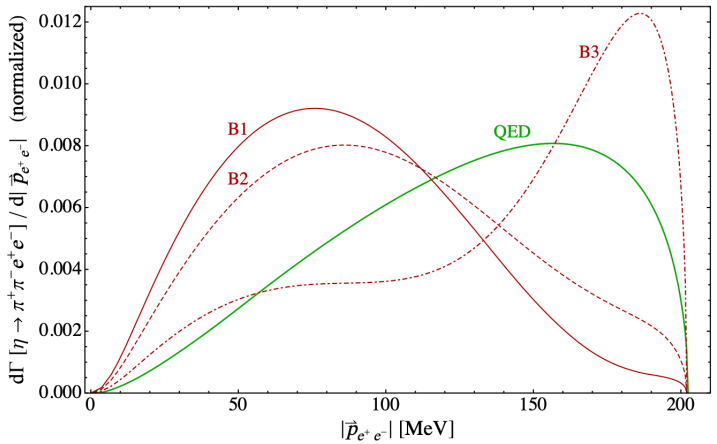


FIG. 4. The differential rate for $\eta \to \pi^+\pi^- a$ as a function of $|\vec{p}_{e^+e^-}| \equiv |\vec{p}_{e^+} + \vec{p}_{e^-}| = \vec{p}_a$, for three benchmark choices of RχT parameters specified in Table I. For comparison, we also show the differential rate of the SM process $\eta \to \pi^+\pi^- e^+ e^-$, labeled "QED."

Process	Benchmark set	*Trigger* L0	*Trigger* L1	*Trigger* L2	*Reconstruction*	Analysis	**Total**	BR sensitivity
$\eta \to \pi^+\pi^- a\ ;\ a \to e^+e^-$	B1	55.28%	21.81%	76.41%	75.12%	42.94%	2.97%	2.07×10^{-8}
$\eta \to \pi^+\pi^- a\ ;\ a \to e^+e^-$	B2	56.15%	22.32%	76.76%	75.12%	42.83%	3.10%	1.98×10^{-8}
$\eta \to \pi^+\pi^- a\ ;\ a \to e^+e^-$	B3	59.67%	23.06%	79.81%	76.14%	44.03%	3.68%	1.67×10^{-8}
Urqmd		21.7%	1.7%	22.2%	0.26%	1.04%	2.31×10^{-6}%	

TABLE XXVI. Reconstruction efficiencies for $\eta \to \pi^+\pi^- a\ ;\ a \to e^+e^-$ for the piophobic axion model [63] and for the Urqmd generated background

TABLE I. Benchmarked RχT parameters for the examples in Fig. 4 and the resulting prediction for the total decay rate of $\eta \to \pi^+\pi^- a$.

	m_{a_0} (MeV)	Γ_{a_0} (MeV)	m_{f_0} (MeV)	Γ_{f_0} (MeV)	$\lvert\widehat{c}_d\rvert = \lvert\widehat{c}_m\rvert$	$\mathrm{Br}(\eta \to \pi^+\pi^- a)$
B1	980	40	980	200	1.125	0.96×10^{-3}
B2	980	50	980	100	1.125	1.1×10^{-3}
B3	1000	50	1000	100	1.125	0.49×10^{-3}