

STCF上C破坏过程($J/\psi \rightarrow \gamma\phi$) 的灵敏度研究

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一

研究背景

二

数据选择和事例选择

三

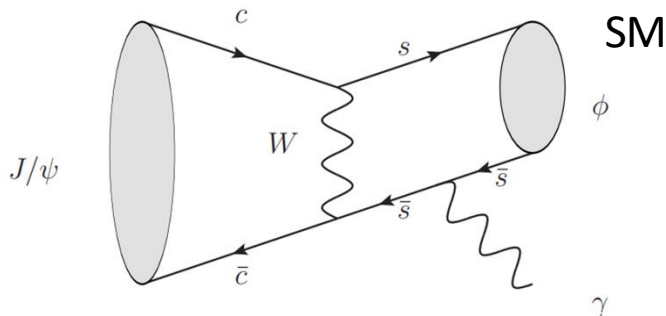
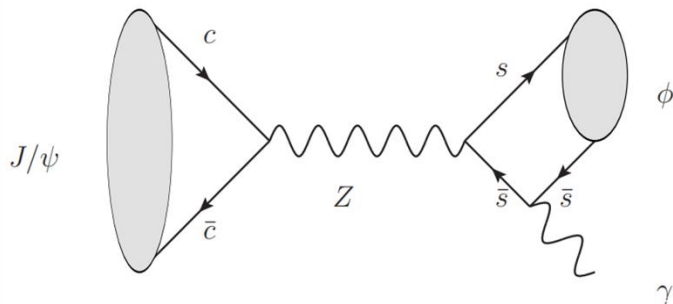
结果分析

四

结论展望

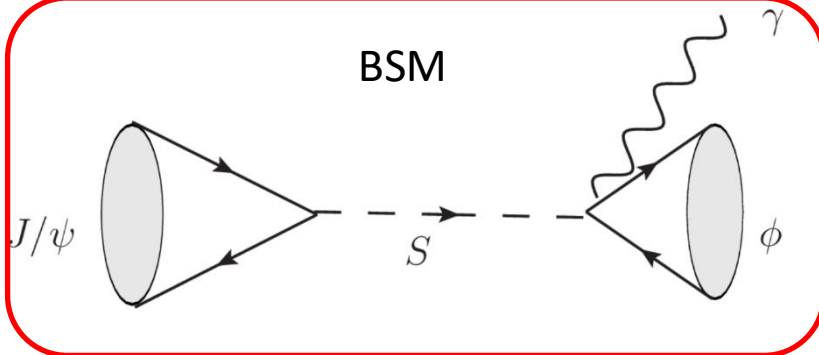
- 标准模型：C宇称不守恒过程
- J/ψ 弱衰变： 10^{-9} [1]
- $J/\psi \rightarrow \gamma\phi(\psi(2S) \rightarrow \pi^+\pi^-J/\psi)$: 1.4×10^{-6} @ 90% C.L.[2]
- 高精度(光子分辨等)、大统计量 $\psi(2S)$ 为了解 J/ψ 弱衰变、寻找新物理提供了绝佳窗口

- [1] T. Wang, Y. Jiang, H. Yuan, K. Chai, and G.-L. Wang, J. Phys. G 44, 045004 (2017);
S. J. Chen, S. L. Olsen, National Science Review 8: nwab189 (2021).
[2] M. Ablikim, et al. (BESIII), Phys. Rev. D 90, 092002 (2014).



$$\Gamma = \frac{1}{3} \frac{|\vec{P}_\phi|}{8\pi M_\psi^2} \left(\frac{G_F}{\sqrt{2}} \right)^2 |V_{cs}|^4 f_\psi^2 m_\psi f_\phi^2 m_\phi (4\pi\alpha) Q_q^2$$

- 预估衰变分支比在 $10^{-11} \sim 10^{-12}$ 量级
- 新物理模型可以提高3~4个数量级左右



➤ 数据选择

OSCAR version: 2.6.2

- Signal $\psi(2S) \rightarrow \pi^+ \pi^- J/\psi ; J/\psi \rightarrow \gamma \phi$ 300万

没有足够的inclusive MC

- Background
 - 1 : $\psi(2S) \rightarrow \pi^+ \pi^- J/\psi ; J/\psi \rightarrow \gamma K^+ K^-$ 3000万
 - 2 : $\psi(2S) \rightarrow \pi^+ \pi^- J/\psi ; J/\psi \rightarrow \pi^0 K^+ K^-$ 3000万

➤ 事例选择

■ 初步选择

➤ 带电径迹

选择 $|d_0| \leq 0.1\text{cm}, |d_z| \leq 0.5\text{cm}, |\cos\theta| < 0.94$

➤ 光子挑选

桶部: $E_{\text{ecal}} \geq 30\text{MeV}, |\cos\theta| \leq 0.8325$

端盖: $E_{\text{ecal}} \geq 50\text{MeV}, 0.85 \leq |\cos\theta| \leq 0.9445$

➤ 顶点拟合

对所有选出的 $K^+K^-\pi^+\pi^-$ 径迹应用共同顶点拟合

➤ 4C运动学拟合

满足事例的总能量与动量守恒

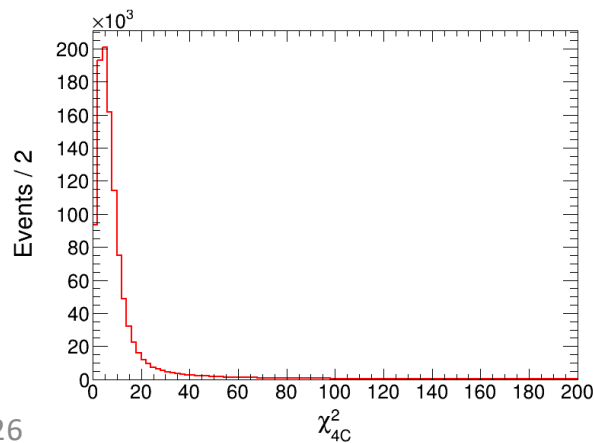
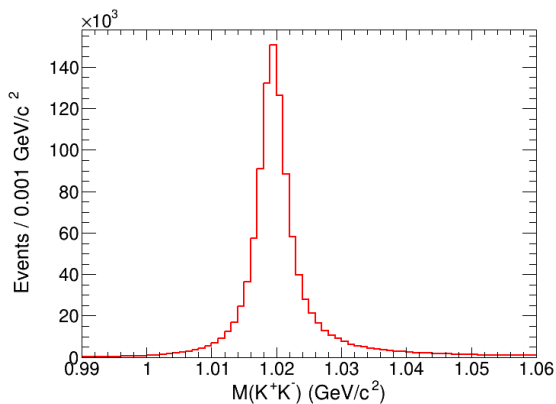
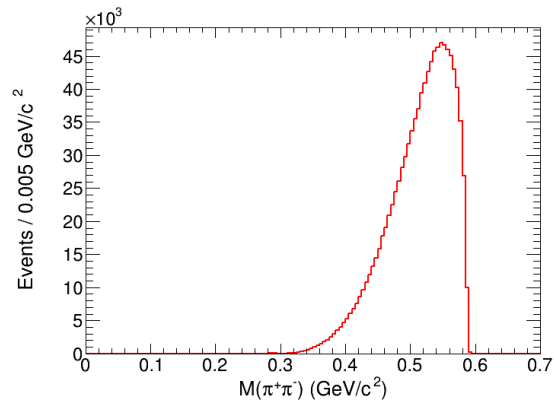
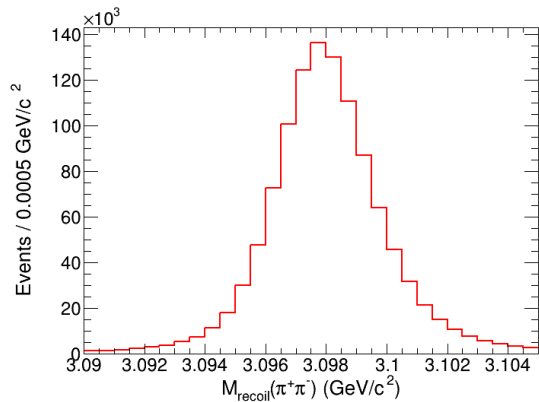
■ 进一步选择

➤ $0 < \chi_{4C}^2 < 20$

➤ $3.092 < \text{RM } \pi^+\pi^- < 3.102 \text{ GeV}/c^2$

➤ $0.99 < K^+K^- < 1.09 \text{ GeV}/c^2$

➤ Signal



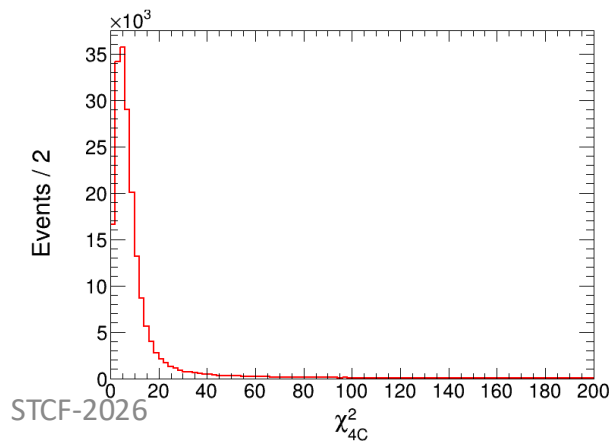
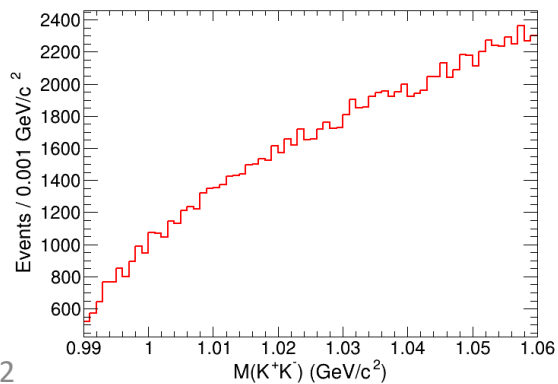
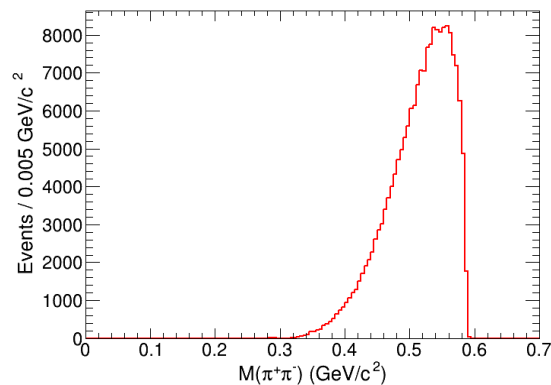
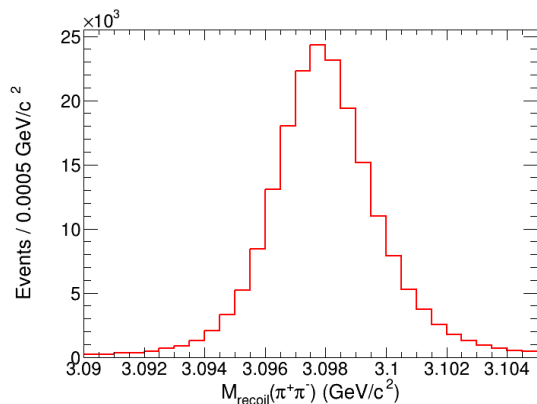
Tab. IV. The topology of backgrounds for $\psi(3686) \rightarrow J/\psi \pi^+ \pi^-$, $J/\psi \rightarrow \gamma \phi$, $\phi \rightarrow K^+ K^-$.

No.	decay chain	final states	iTopo	nEvt	nTot
0	$\psi' \rightarrow \pi^+ \pi^- J/\psi$, $J/\psi \rightarrow f_2(1270) \gamma$, $f_2(1270) \rightarrow K^- K^+$	$\pi^- K^- \pi^+ \gamma K^+$	0	23	23
1	$\psi' \rightarrow \pi^- \pi^+ J/\psi$, $J/\psi \rightarrow \pi^0 K^+ K^-$	$\pi^- K^- \pi^0 \pi^+ K^+$	1	10	33
2	$\psi' \rightarrow \pi^+ J/\psi \pi^-$, $J/\psi \rightarrow \pi^0 a_2^0$, $a_2^0 \rightarrow K^+ K^-$	$\pi^- K^- \pi^0 \pi^+ K^+$	8	4	37
3	$\psi' \rightarrow J/\psi \pi^- \pi^+$, $J/\psi \rightarrow \gamma \eta$, $\eta \rightarrow \pi^- \gamma \pi^+$	$\pi^- \pi^- \pi^+ \pi^+ \gamma \gamma$	3	1	38
4	$\psi' \rightarrow \bar{K}^* \gamma K^*$, $\bar{K}^* \rightarrow K^- \pi^+$, $K^* \rightarrow K^+ \pi^-$	$\pi^- K^- \pi^+ \gamma K^+$	4	1	39
5	$\psi' \rightarrow J/\psi \pi^- \pi^+$, $J/\psi \rightarrow K^+ \pi^- \bar{K}^0$	$\pi^- \pi^- K_L \pi^+ K^+$	5	1	40
6	$\psi' \rightarrow J/\psi \pi^- \pi^+$, $J/\psi \rightarrow \gamma_{FSR} e^- \gamma_{FSR} e^+$	$e^- \pi^- e^+ \pi^+$	6	1	41
7	$\psi' \rightarrow \pi^0 K_1^- K^+$, $K_1^- \rightarrow \pi^- \bar{K}^*$, $\bar{K}^* \rightarrow \pi^+ K^-$	$\pi^- K^- \pi^0 \pi^+ K^+$	7	1	42
8	$\psi' \rightarrow \gamma K_1^+ K^-$, $K_1^+ \rightarrow K^* \pi^+$, $K^* \rightarrow \pi^- K^+$	$\pi^- K^- \pi^+ \gamma K^+$	2	1	43
9	$\psi' \rightarrow K^+ \gamma K_1^-$, $K_1^- \rightarrow K^- \pi^- \pi^+$	$\pi^- K^- \pi^+ \gamma K^+$	9	1	44

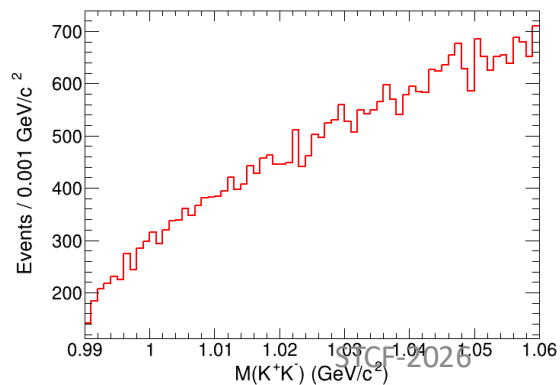
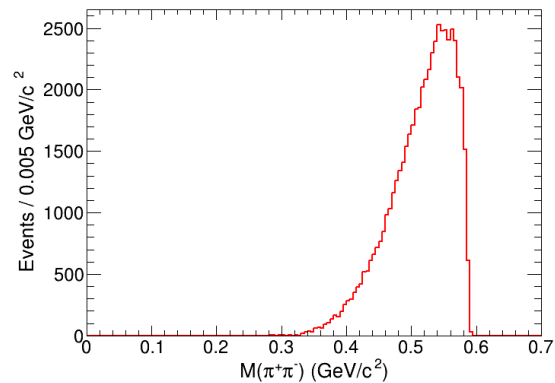
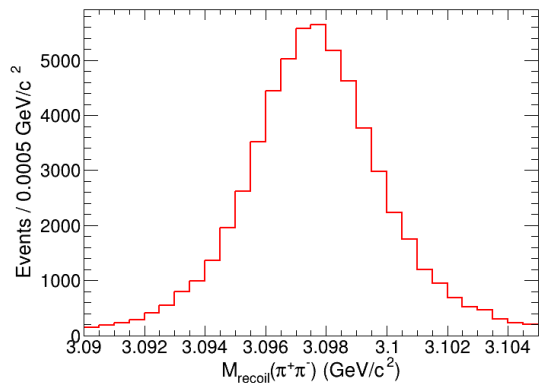
M. Ablikim, et al. (BESIII), Phys. Rev. D 90, 092002 (2014).

- STCF没有产生足够的inclusive MC
- 产生exclusive MC 描述: $J/\psi \rightarrow \gamma K^+ K^-$, $\pi^0 K^+ K^-$

➤ 本底1 : $\psi(2S) \rightarrow \pi^+ \pi^- |/\psi ; |/\psi \rightarrow \gamma K^+ K^-$



➤ 本底2 : $\psi(2S) \rightarrow \pi^+ \pi^- J/\psi ; J/\psi \rightarrow \pi^0 K^+ K^-$



► 本底统计量估计

$$N_{survive} = N_{\psi(3686)} \times \epsilon \times \mathcal{B}(\psi' \rightarrow \pi^+ \pi^- J/\psi) \times \mathcal{B}(J/\psi \rightarrow \gamma K K)$$

$$\begin{aligned} N_{survive} \\ = N_{\psi(3686)} \times \epsilon \times \mathcal{B}(\psi' \rightarrow \pi^+ \pi^- J/\psi) \times \mathcal{B}(J/\psi \rightarrow \pi^0 K K) \times \mathcal{B}(\pi^0 \rightarrow \gamma \gamma) \end{aligned}$$

$$N_{\psi(3686)} = 2747 \times 10^6$$

信号: $\epsilon = 31.91\%$

$$\mathcal{B}(\psi' \rightarrow \pi^+ \pi^- J/\psi) = (34.68 \pm 0.3)\%$$

本底1: $\epsilon = 0.57\%$

$$\mathcal{B}(\phi \rightarrow K^+ K^-) = (50.1 \pm 0.6)\%$$

本底2: $\epsilon = 0.027\%$

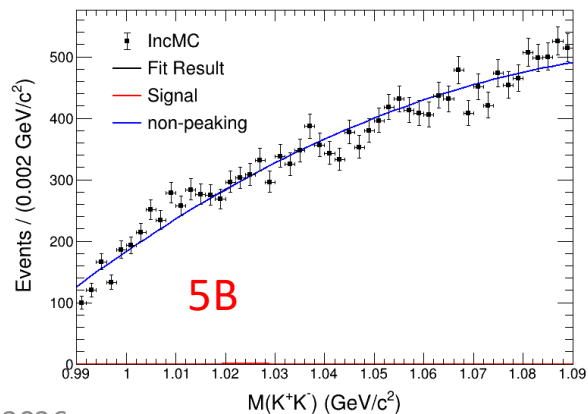
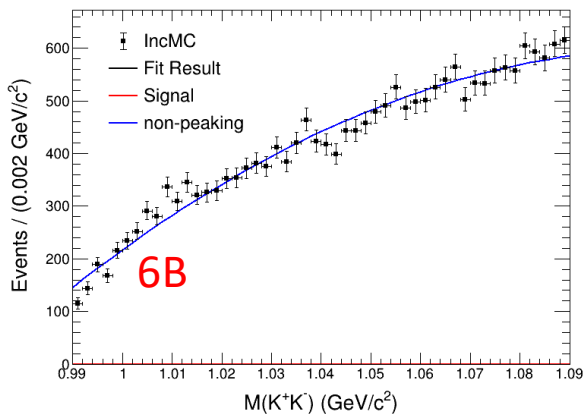
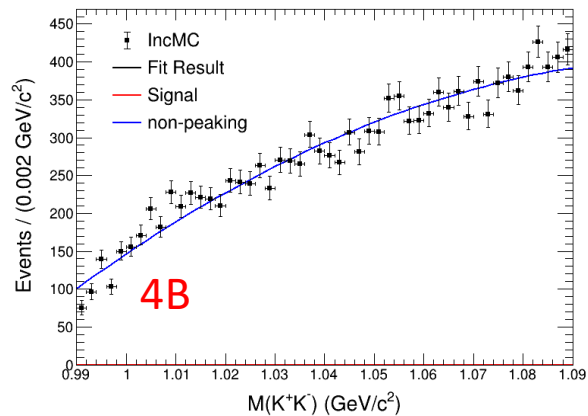
$$\mathcal{B}(J/\psi \rightarrow \gamma \phi)^{up} < \frac{N^{up}}{N_{\psi(3686)} \times \epsilon \times \mathcal{B}(\psi' \rightarrow \pi^+ \pi^- J/\psi) \times \mathcal{B}(\phi \rightarrow K^+ K^-)}$$

► 本底统计量估计

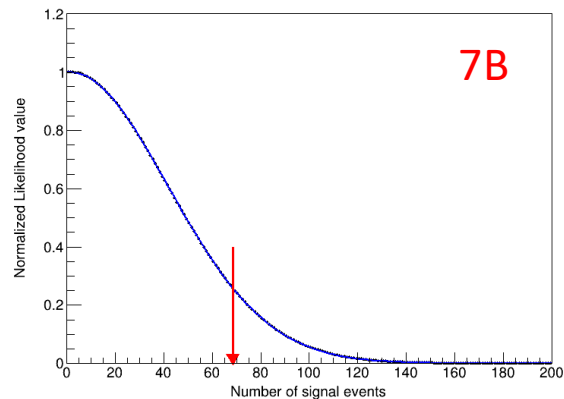
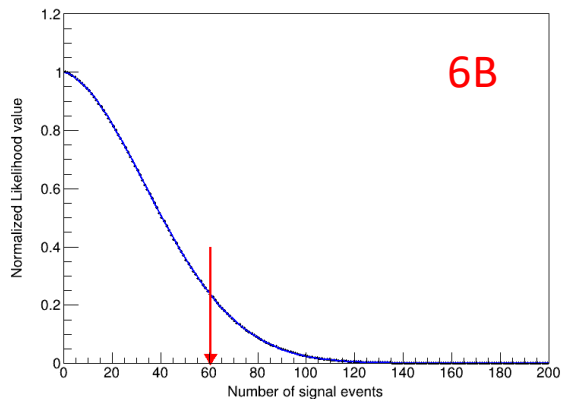
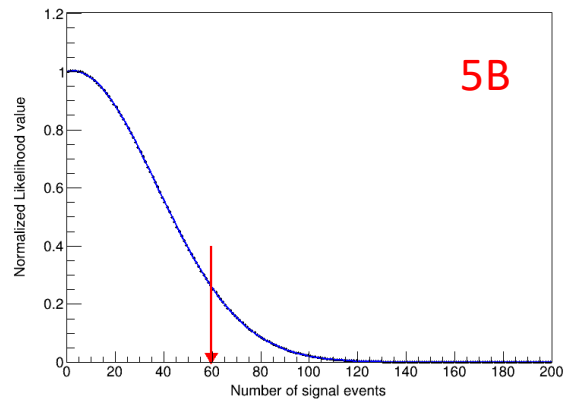
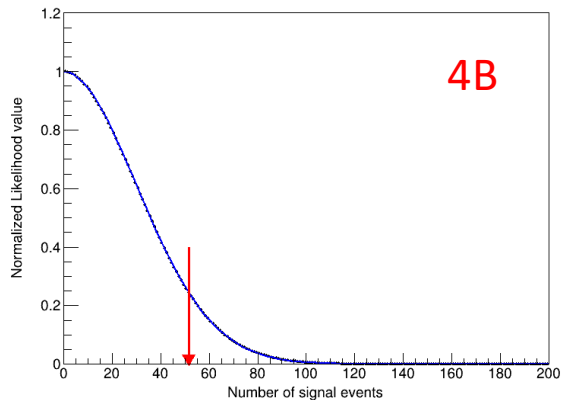
$N_{\psi(3686)}$	γkk	$\pi^0 kk$	$\gamma kk + \pi^0 kk$
4×10^9	12809	1066	13875
5×10^9	16012	1332	17344
6×10^9	19214	1599	20813
7×10^9	22416	1865	24281
8×10^9	25619	2132	27751
9×10^9	28821	2398	31219
10×10^9	32024	2665	34689

Signal : MC shape

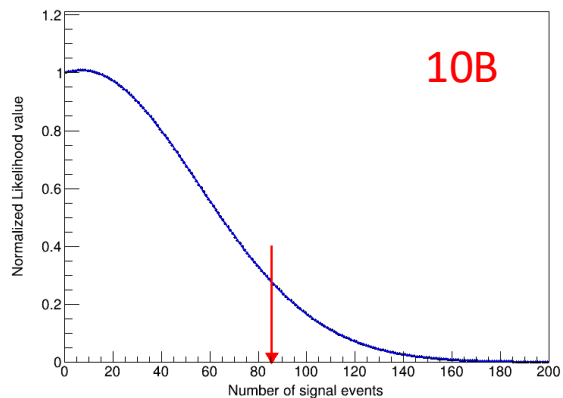
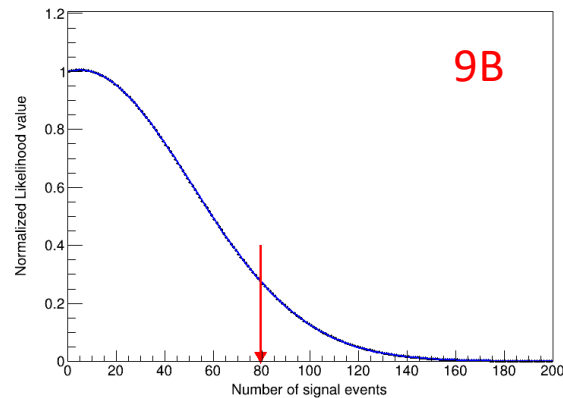
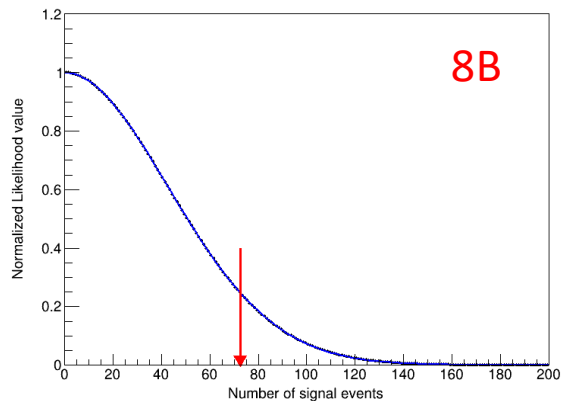
BG: 2nd Chebyshev



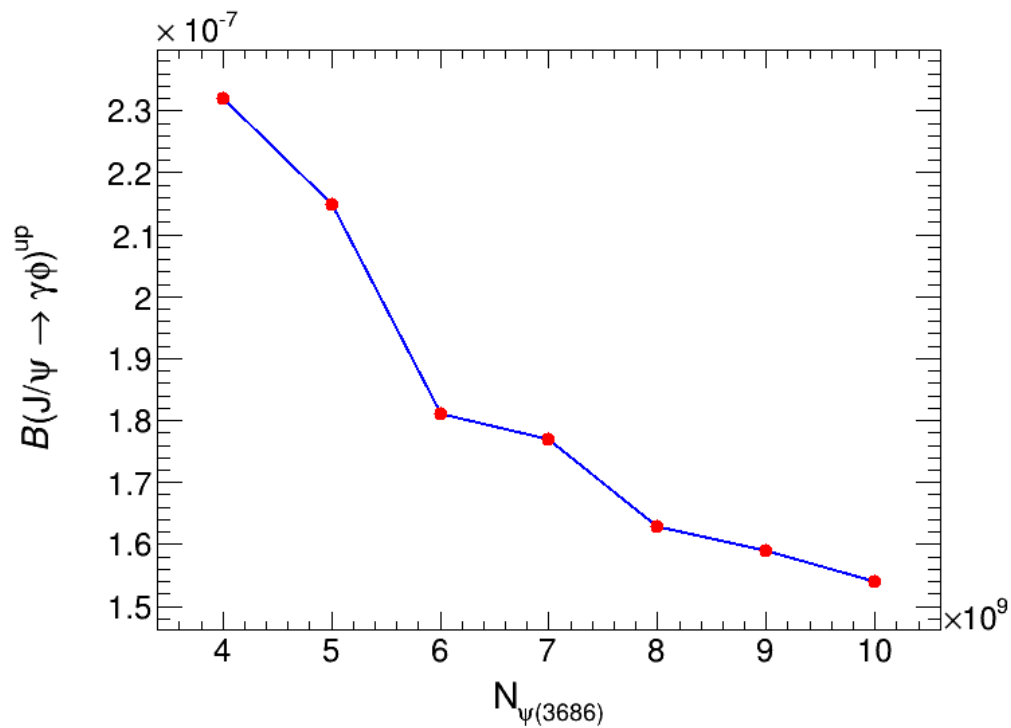
➤ 90% Upper Limit (N^{up})



➤ 90% Upper Limit (N^{up})



➤ $\mathcal{B}(J/\psi \rightarrow \gamma \phi)^{\text{up}}$



➤ 结论:

- 测量无误差的敏感度
- 10B→接近新物理预测范围
- 更大统计量

➤ 展望:

- 进一步完善筛选条件
- 讨论电磁量能器对测量的影响
- 预期统计量?
- $J/\psi \rightarrow \gamma\gamma$ 、 γV 、 VV

➤ **建议:** 产生大统计量 $\psi(2S)$ 样本!!!

谢谢!