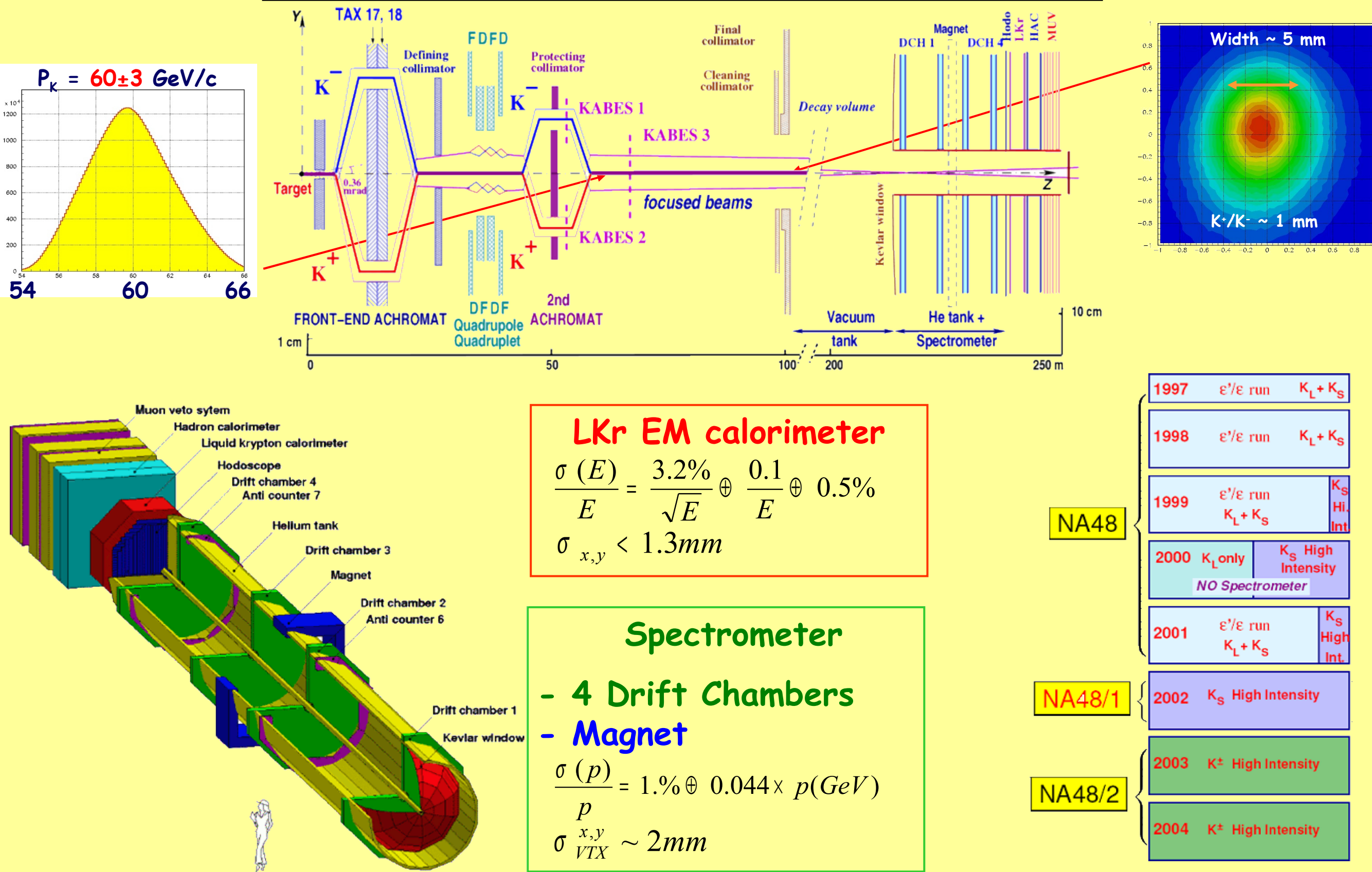


# Precision Measurements of Kaon Radiative Decays at NA48/2

NA48/2

Simultaneous K<sup>+</sup> and K<sup>-</sup> beams:  
Flux ratio: K<sup>+</sup>/K<sup>-</sup> ~ 1.8



**LKr EM calorimeter**  
 $\sigma(E) = 3.2\% \oplus \frac{0.1}{E} \oplus 0.5\%$   
 $\sigma_{x,y} < 1.3\text{mm}$

**Spectrometer**  
 - 4 Drift Chambers  
 - Magnet  
 $\sigma(p) = 1.1\% \oplus 0.044 \times p(\text{GeV})$   
 $\sigma_{x,y} \sim 2\text{mm}$

## K<sup>±</sup> → π<sup>±</sup>γγ

Previous measurement E787:  
BR = (1.1 ± 0.32) · 10<sup>-6</sup>    $\hat{c} = 1.8 \pm 0.6$   
Based on 31 events 5 BG events

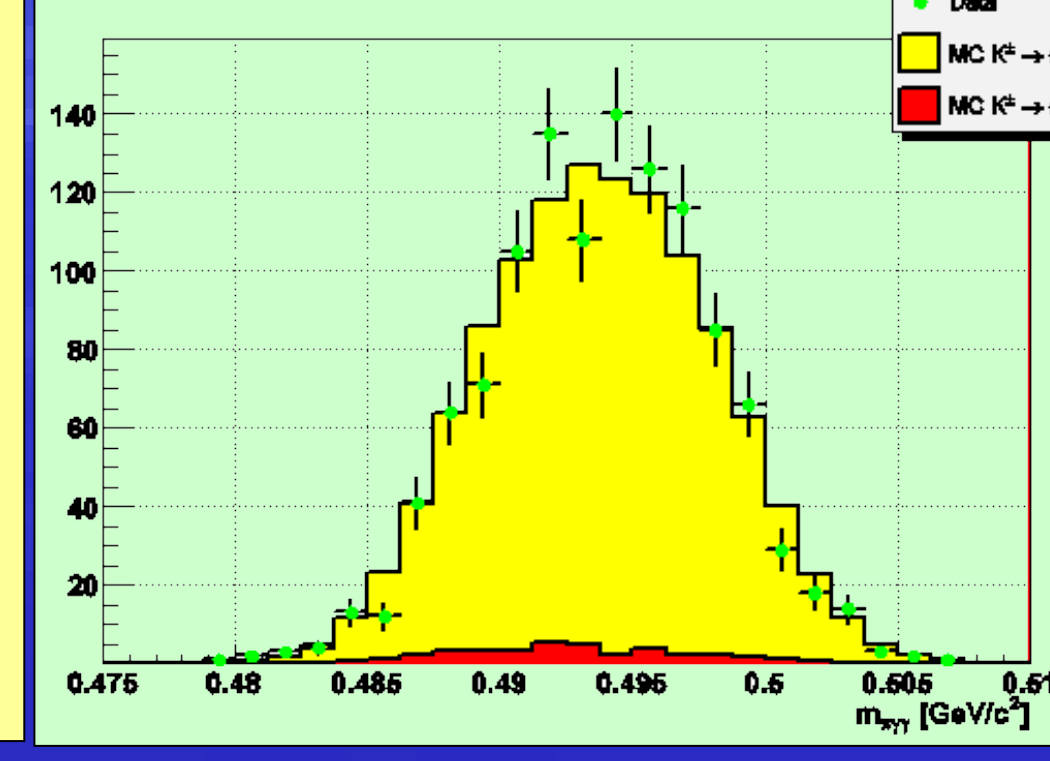
$$z = \frac{(q_1 + q_2)^2}{m_{K^\pm}^2} = \frac{m_\pi^2}{m_{K^\pm}^2} \quad y = \frac{p \cdot (q_1 - q_2)}{m_{K^\pm}^2}$$

$$\frac{\partial^2 \Gamma}{\partial y \partial z} = \frac{m_{K^\pm}}{(8\pi)^3} \left[ z^2 (|A|^2 + |B|^2 + |C|^2) + \left( y^2 - \frac{1}{4} \lambda(1, r_\pi^2, z) \right)^2 (|B|^2 + |D|^2) \right]$$

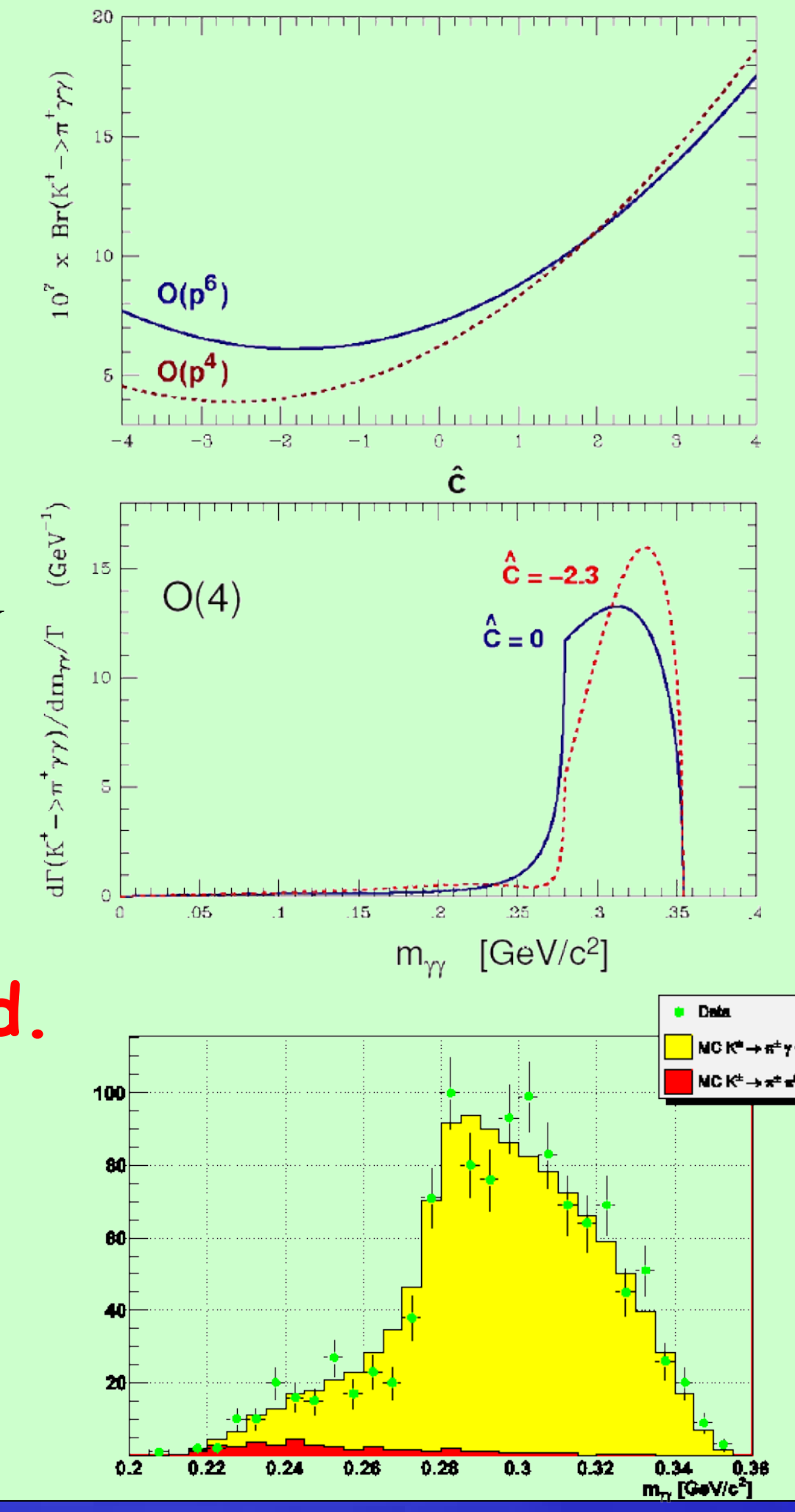
Relevant only @ low m<sub>γγ</sub>

**O(p<sup>4</sup>) in χPT: B=D=0; A: loop diagrams contribution, C: WZW anomaly (10%)**  
 $\Gamma(K^\pm \rightarrow \pi^\pm \gamma\gamma) = \Gamma_{loop} + \Gamma_{WZW}$   
 $\Gamma_{loop} = (2.80 + 0.87 \cdot \hat{c} + 0.17 \cdot \hat{c}^2) \cdot 10^{-23} \text{ GeV}$   
 $\Gamma_{WZW} = 0.26 \cdot 10^{-23} \text{ GeV}$

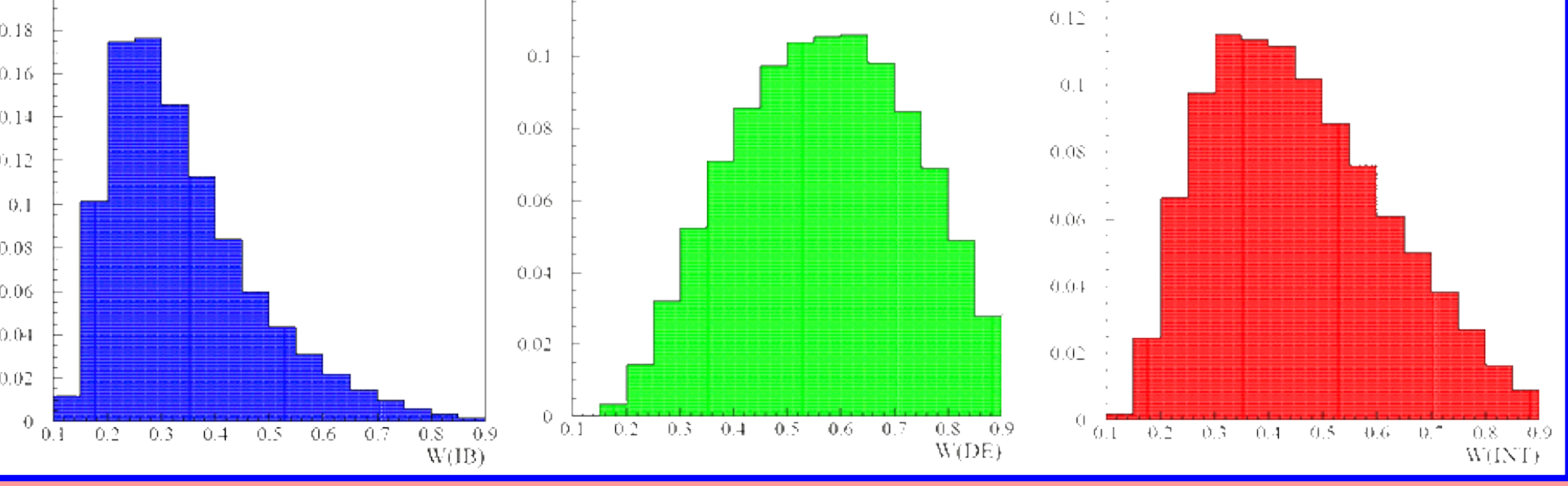
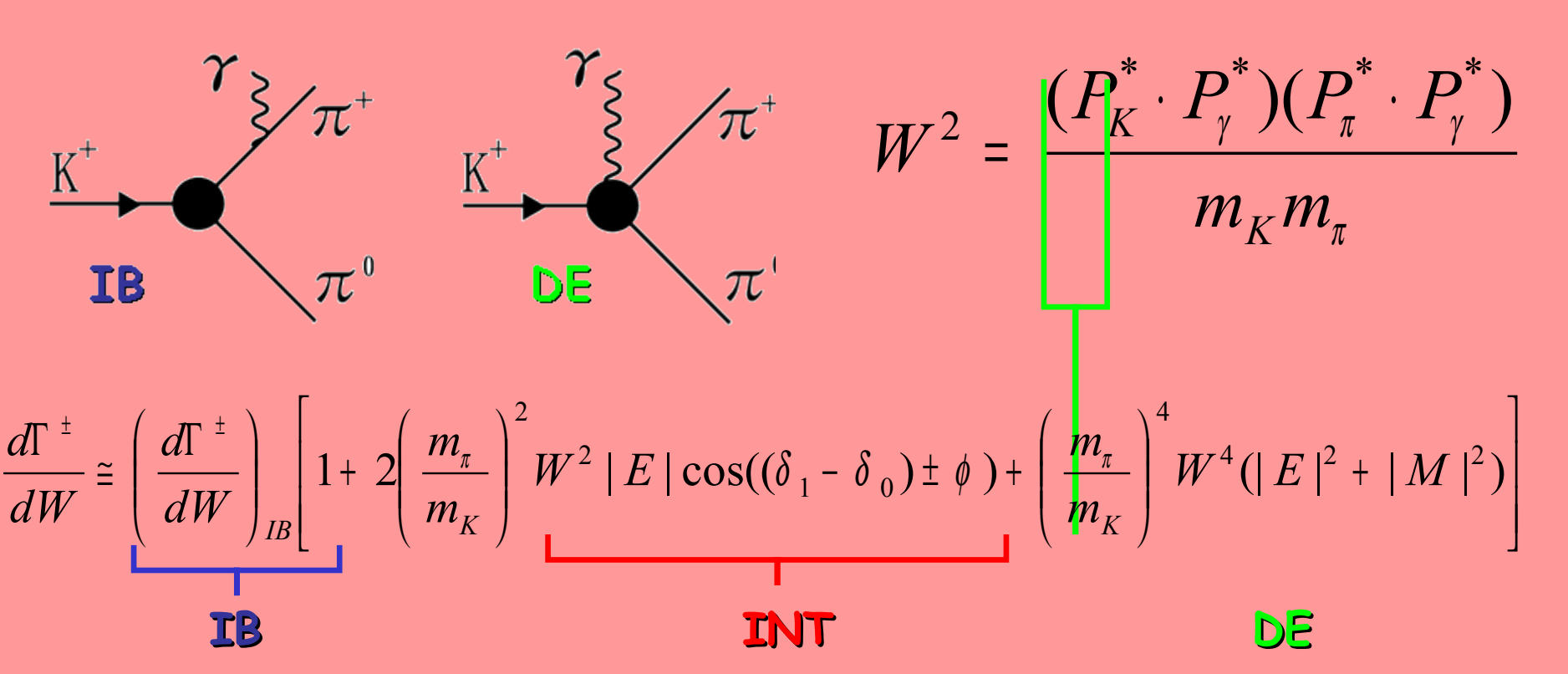
**O(p<sup>6</sup>) χPT: unitarity corrections can increase BR by 30-40 %**  
 [G. D'Ambrosio and J. Portoles, Nucl. Phys. B386 (1996), 403]



**2003+2004 data: 4155 cand.**  
**Preliminary:**  
 $\hat{c} = 1.67 \pm 0.07_{\text{stat}} \pm 0.34_{\text{sys}}$   
 $BR_{(O(p^6), z > 0.24)} = (0.963 \pm 0.019_{\text{stat}} \pm 0.052_{\text{sys}}) \cdot 10^{-6}$

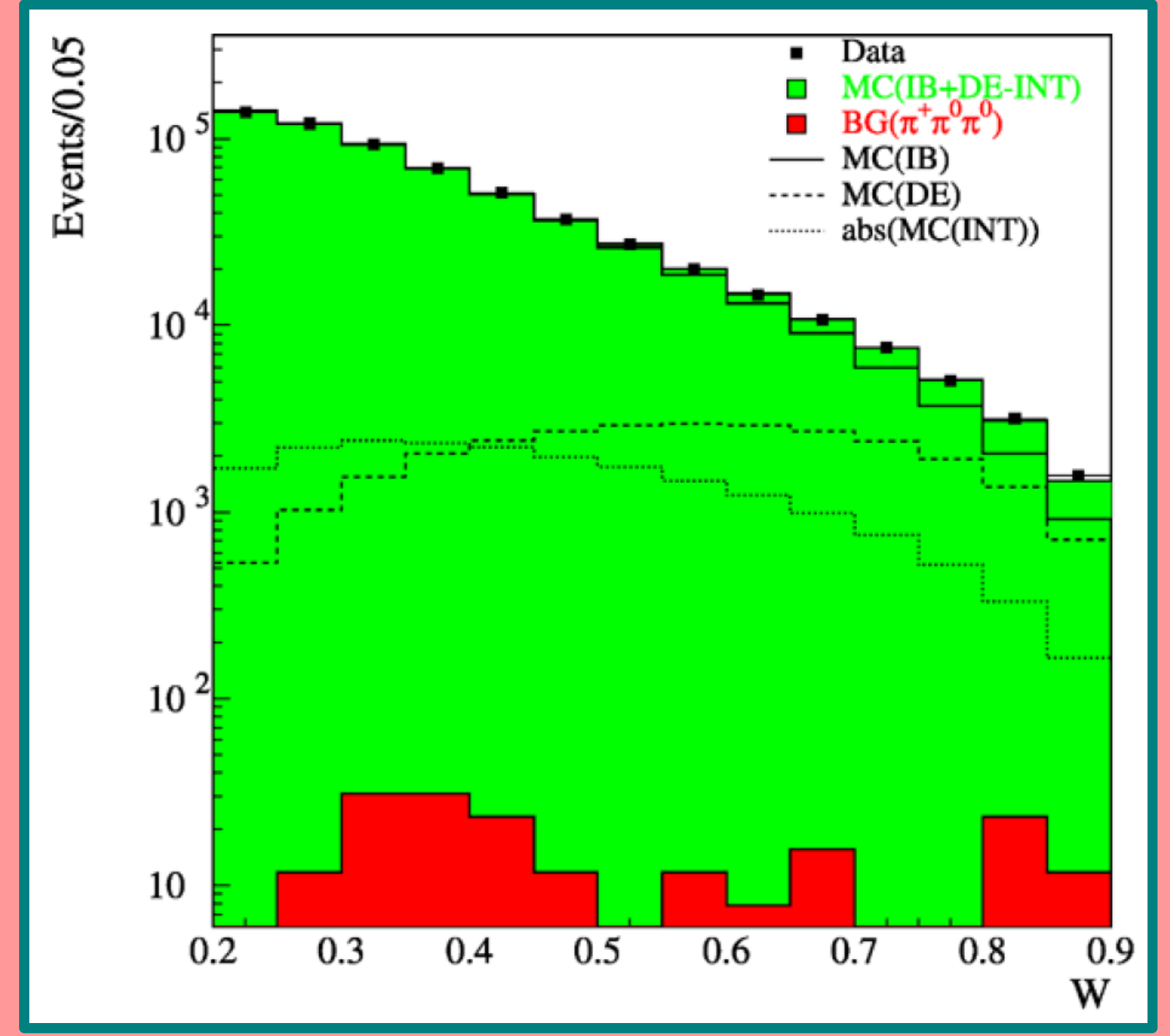
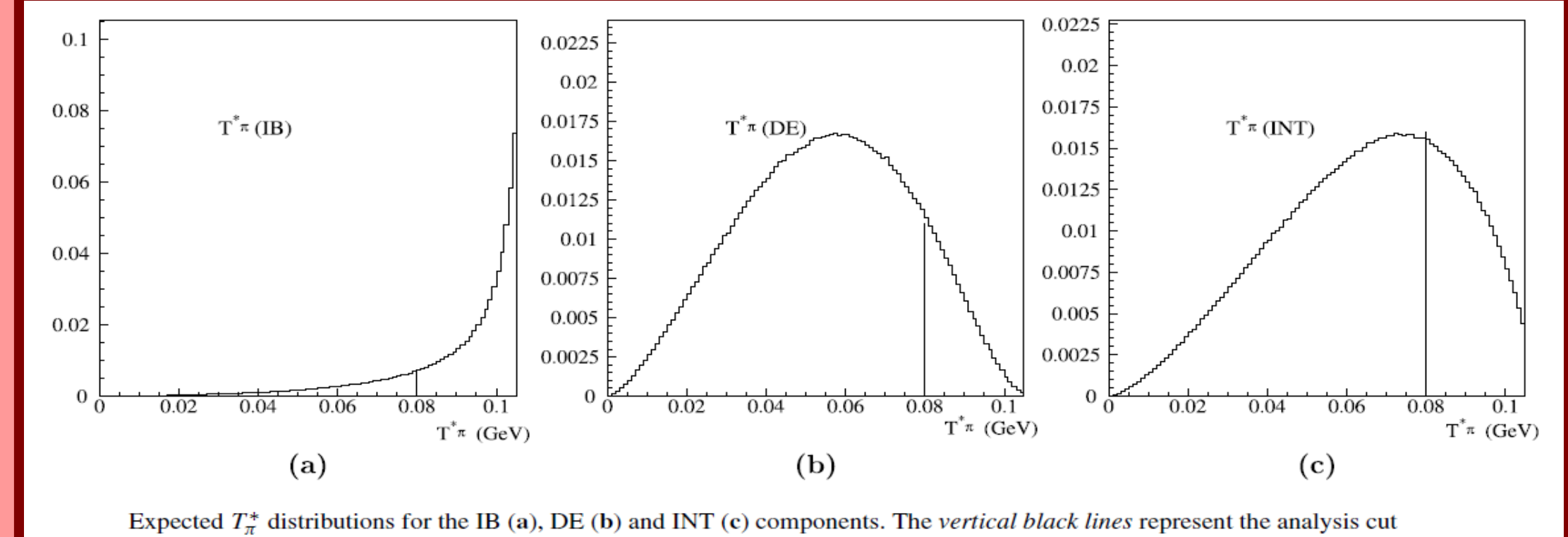


## K<sup>±</sup> → π<sup>±</sup>π<sup>0</sup>γ

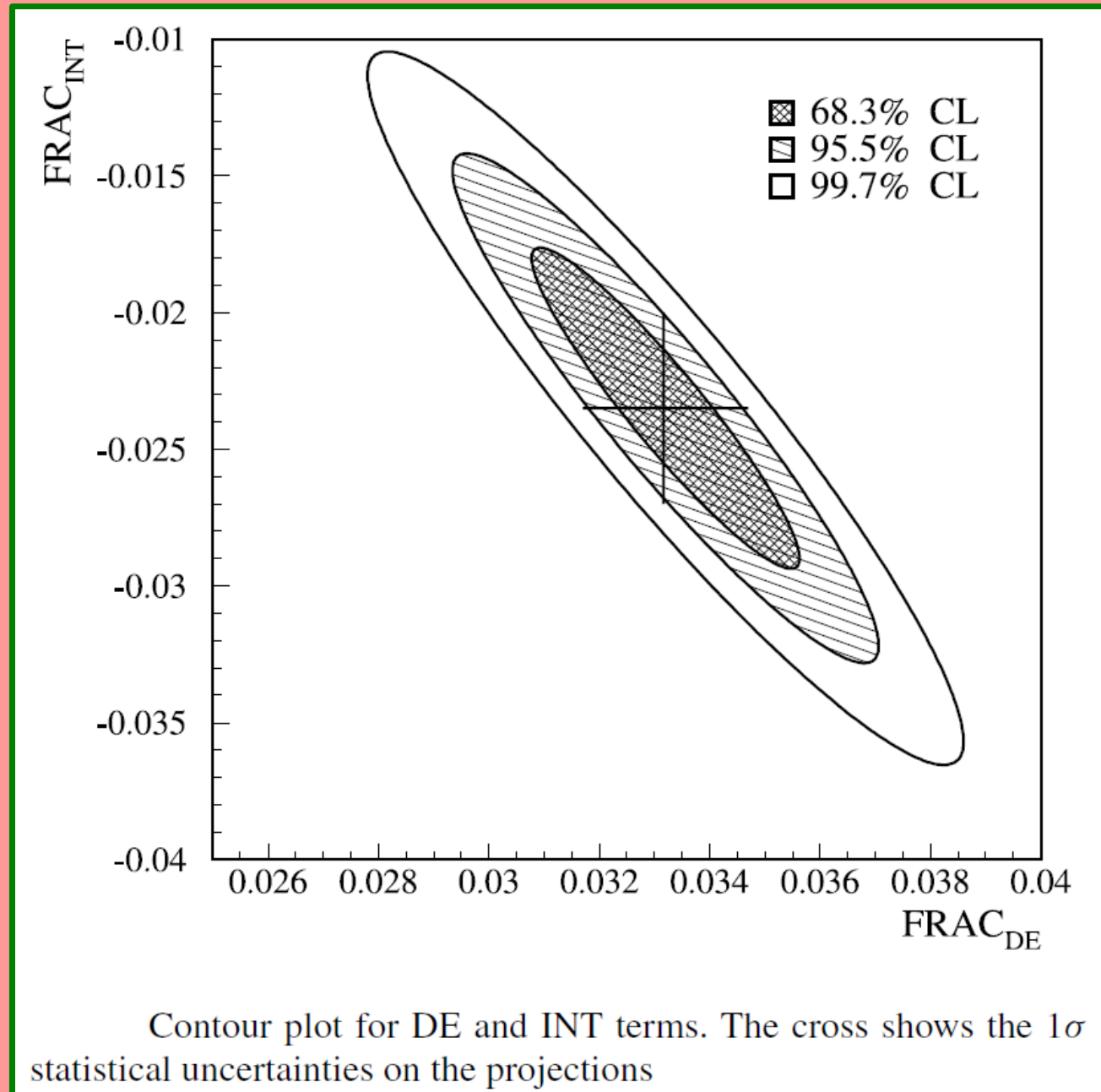


### Events selection

- 1 track with P > 10 GeV/c, E/p < 0.85, in time
- 3 LKr clusters with E > 3 GeV, in time
- Distance between track and cluster at Lkr > 35 cm
- Distance between clusters > 10 cm
- Zch: from CDA between the track and beam axis
- π<sup>0</sup> pair: closest to PDG π<sup>0</sup> mass from Zch
- (Zπ<sup>0</sup> - Zch) < 400 cm
- No MUV hits
- 54 < Ekaon < 66 GeV



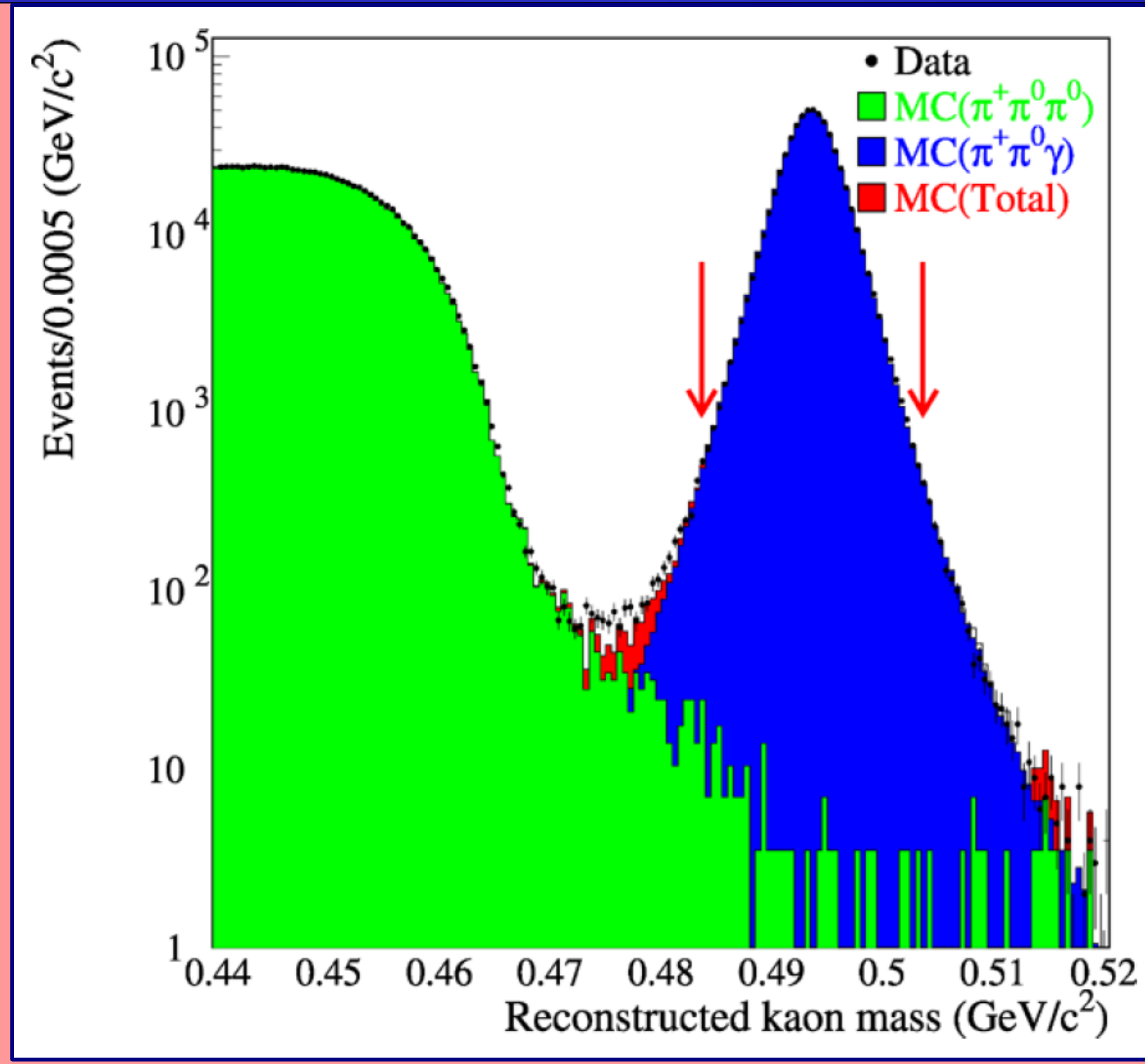
Fit performed with free INT term  
 Use extended ML for 0.2 < W < 0.9 range  
 Fit the W data spectrum using MC shapes:  
 $W_{\text{dat}} = (1 - \alpha - \beta)W_{\text{IB}} + \alpha W_{\text{DE}} + \beta W_{\text{INT}}$   
 First evidence of non zero INT term!  
 Parameters are highly correlated ρ = -0.93



**Final result, 2003+2004 data set:**

$\text{Frac(DE)}_{0 < T^* < 80 \text{ MeV}} = (3.32 \pm 0.15_{\text{stat}} \pm 0.14_{\text{syst}})\%$   
 $\text{Frac(INT)}_{0 < T^* < 80 \text{ MeV}} = (-2.35 \pm 0.35_{\text{stat}} \pm 0.39_{\text{syst}})\%$

where T\* is the kinetic energy of charged pion in the kaon rest frame.  
 Allows the measurement of electric and magnetic amplitudes:  $X_E = -24 \pm 6 \text{ GeV}^{-4}$ ,  $X_M = 254 \pm 9 \text{ GeV}^{-4}$

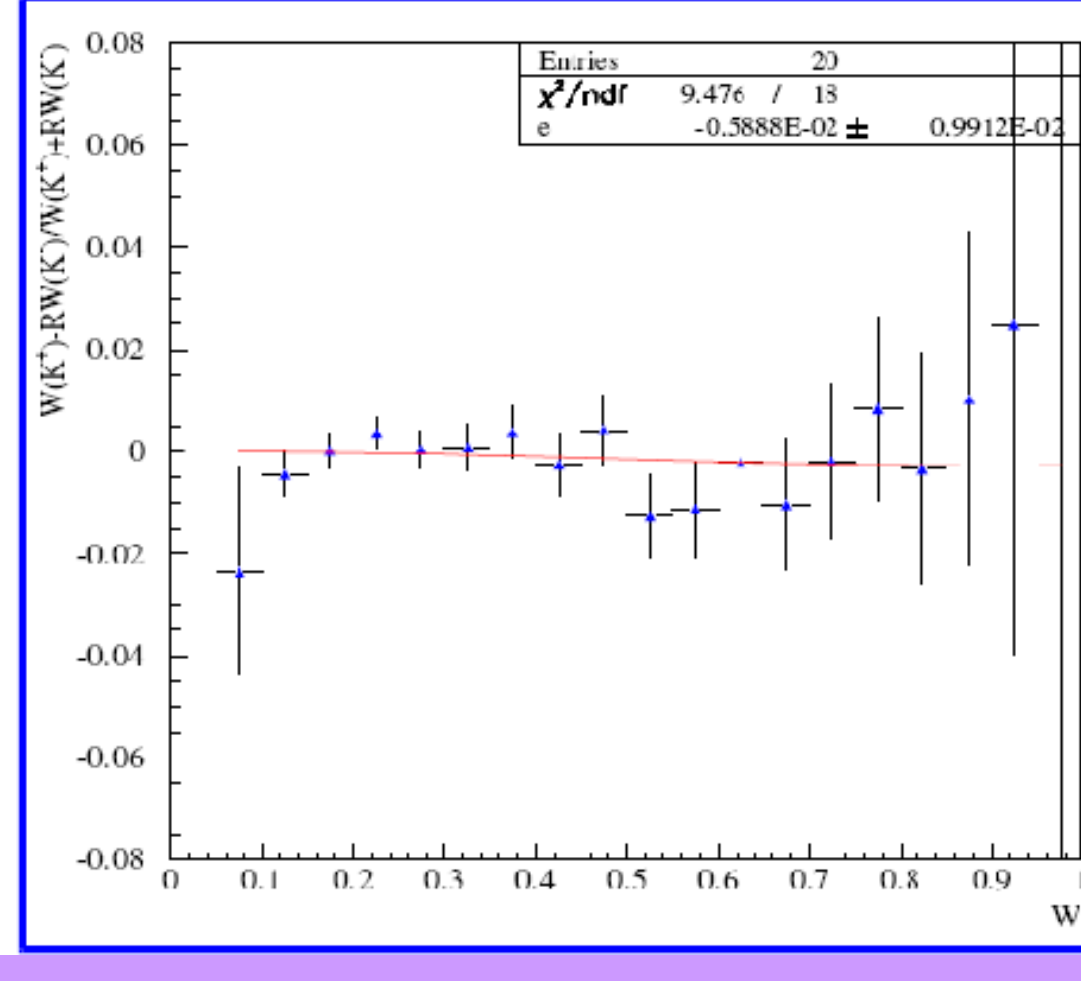


600K ππγ candidates  
 with negligible BG contribution

### CPV TESTS

1) Difference in K<sup>+</sup> and K<sup>-</sup> decay rates:  
 $A_N = (N^+ - RN^-)/(N^+ + RN^-)$ ,  
 where R(K<sup>+</sup>/K<sup>-</sup>) ratio = 1.7998 ± 0.0004 from K<sub>3</sub>π  
 Result (systematics from trigger and kaon momentum distributions):  
 $A_N = -0.0 \pm 0.001_{\text{stat}} \pm 0.0006_{\text{syst}}$     $|A_N| < 1.5 \times 10^{-3}$  at 90% CL

2) Difference in W spectra shapes:  
 $dA_W/dW = (\Gamma^+ - \Gamma^-)/(\Gamma^+ + \Gamma^-) = eW^2(1 + aW^2 + bW^4)$   
 e is a free parameter  
 Result (integrating):  
 $(I_{\text{INT}}/I_{\text{IB}})A_W = -0.0006 \pm 0.001_{\text{stat}}$



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