

$$\eta \rightarrow 3 \gamma$$

News

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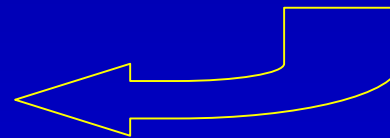
Lu Feng's results

MC $\eta \rightarrow 3 \gamma$ sample	
Cut Type ⁽¹⁾	$\epsilon(\%)$
Pass1	76.3
Pre-selection	61.4
Final selection	32.0
Overall	15.0

Data ₂₀₀₁ (59.933 pb ⁻¹)	
Cut Type	N _{tot} (ϵ)
Pass1	1345779
Pre-selection	4499 (0.3%)
Final Selection	179 (4%)
All.	179 (0.013%)

Estimated background

59



The background problem

Estimated efficiency of the background

Back ground channel	N. MC events	Events (ε%)
$\Phi \rightarrow \rho^0 \pi^0 (\rho^0 \rightarrow \pi^0 \gamma / \eta \gamma) \rightarrow 5\gamma$	120000	327 (0.27)
$\Phi \rightarrow \eta \pi^0 \gamma (\eta \rightarrow \gamma \gamma) \rightarrow 5\gamma$	23598	88 (0.4)
$\Phi \rightarrow \gamma \eta (\eta \rightarrow \pi^0 \gamma \gamma) \rightarrow 5\gamma$	120000	722 (0.6)
$\Phi \rightarrow \gamma \eta (\eta \rightarrow \pi^0 \gamma \gamma) \rightarrow 5\gamma$	100000	9 (0.009)
$\Phi \rightarrow \gamma \pi^0 \rightarrow 3\gamma$	150000	0 (0 ?)
$\Phi \rightarrow \gamma \eta (\eta \rightarrow \gamma \gamma) \rightarrow 3\gamma$	300000	0 (0 ?)
$\Phi \rightarrow \gamma \eta (\eta \rightarrow 3\pi^0) \rightarrow 7\gamma$	285000	3 (0.01 %)
$\Phi \rightarrow K_s K_L \rightarrow 5\pi^0 \rightarrow 10\gamma$	18834	0 (0 ?)
$\Phi \rightarrow K_s K_L \rightarrow 4\pi^0 \rightarrow 8\gamma$	18646	0 (0 ?)
$e^+ e^- \rightarrow \gamma \gamma$	50000	0 (0 ?)
$e^+ e^- \rightarrow \omega \pi^0 (\omega \rightarrow \pi^0 \gamma) \rightarrow 5\gamma$	78571	8 (0.01)

N. of expected events

Back ground channel	σ (nb)	N. ev. expected
$\Phi \rightarrow \rho^0 \pi^0 (\rho^0 \rightarrow \pi^0 \gamma / \eta \gamma) \rightarrow 5\gamma$	0.13	21.7
$\Phi \rightarrow \eta \pi^0 \gamma (\eta \rightarrow \gamma \gamma) \rightarrow 5\gamma$.090	20.3
$\Phi \rightarrow \gamma \eta (\eta \rightarrow \pi^0 \gamma \gamma) \rightarrow 5\gamma$.014	4.9
$\Phi \rightarrow \gamma \eta (\eta \rightarrow 3\pi^0) \rightarrow 7\gamma$	13	8.4
$\Phi \rightarrow \gamma \pi^0 \rightarrow 3\gamma$	0.23	1.3
$e^+ e^- \rightarrow \omega \pi^0 (\omega \rightarrow \pi^0 \gamma) \rightarrow 5\gamma$	0.44	2.7
Total		59

But what about the upper limit on the 0 events samples?

MC statistic too loose!!

Back ground channel	N. MC events	ϵ_{\max} (90% CL)	N^{exp}
$\Phi \rightarrow K_s K_L \rightarrow 5\pi^0 \rightarrow 10\gamma$	18834	1.3×10^{-4}	539
$\Phi \rightarrow K_s K_L \rightarrow 4\pi^0 \rightarrow 8\gamma$	18646	1.3×10^{-4}	2.41
$\Phi \rightarrow \gamma \eta (\eta \rightarrow \gamma \gamma) \rightarrow 3\gamma$	300000	8×10^{-6}	8
$\Phi \rightarrow \gamma \pi^0 \rightarrow 3\gamma$	150000	1.6×10^{-5}	3.9
$e^+ e^- \rightarrow \gamma \gamma$	50000	5×10^{-5}	527

New analysis results

Data normalization: 40 pb^{-1}

N. of events surviving to cuts: 158

Back ground channel	N. MC events	ϵ_{max} (95% CL)	$N_{\text{max}}^{\text{exp}}$
$\Phi \rightarrow K_s K_L \rightarrow 5\pi^0 \rightarrow 10\gamma$	36,000,000	8.7×10^{-8}	0.23
$e^+e^- \rightarrow \gamma\gamma$ Without accidental cluster simulation	5,100,000	6×10^{-7}	8
$e^+e^- \rightarrow \gamma\gamma$ With accidental cluster simulation	5,100,000	6×10^{-7}	8

Background problem still present

We need to analyze black channel

Decay channel	$\sigma(\text{nb})$	60 pb^{-1}		200 pb^{-1}	
		N_{exp}	N_{needed}	$N_{\text{ev.}}$	N_{needed}
$\Phi \rightarrow \rho^0 \pi^0 (\rho^0 \rightarrow \pi^0 \gamma / \eta \gamma) \rightarrow 5 \gamma$	0.1328	7959	19520	26560	64806
$\Phi \rightarrow \eta \pi^0 \gamma (\eta \rightarrow \gamma \gamma) \rightarrow 5 \gamma$	0.0906	5430	13249	18120	44213
$\Phi \rightarrow \gamma \eta (\eta \rightarrow \pi^0 \gamma \gamma) \rightarrow 5 \gamma$	0.01354	811	1980	2708	6608
$\Phi \rightarrow \pi^0 \omega (\omega \rightarrow \gamma \pi^0) \rightarrow 5 \gamma$	0.4393	26329	64242	87860	214378
$\Phi \rightarrow \gamma^0 (f^0 \rightarrow \pi^0 \pi^0) \rightarrow 5 \gamma$	0.2343	14042	34263	46860	114338
$\Phi \rightarrow \gamma \pi^0 \rightarrow 3 \gamma$	4.043	242309	591234	808600	1972984
$\Phi \rightarrow \gamma \eta (\eta \rightarrow \gamma \gamma) \rightarrow 3 \gamma$	16.85	1009871	2464085	3370000	8222800
$\Phi \rightarrow K_s K_L \rightarrow 5 \pi^0 \rightarrow 10 \gamma$	69.24	4149761	10125417	13848000	33789120
$\Phi \rightarrow K_s K_L \rightarrow 4 \pi^0 \rightarrow 8 \gamma$	0.3074	18423	44953	61480	150011
$e^+ e^- \rightarrow \gamma \gamma$	180	10787940	26322574	36000000	87840000
$e^+ e^- \rightarrow \omega \gamma (\omega \rightarrow \pi^0 \gamma) \rightarrow 4 \gamma$	1.068	64008	156181	213600	521184
$e^+ e^- \rightarrow \omega \pi^0 (\omega \rightarrow \pi^0 \gamma) \rightarrow 5 \gamma$	0.00437	262	639	874	2133
$e^+ e^- \rightarrow \omega \gamma (\omega \rightarrow \eta \gamma) \rightarrow 4 \gamma$	0.00227	136	332	454	1108
$e^+ e^- \rightarrow \rho^0 \gamma (\rho^0 \rightarrow \eta \gamma) \rightarrow 4 \gamma$	0.00087	52	127	174	425

We have them

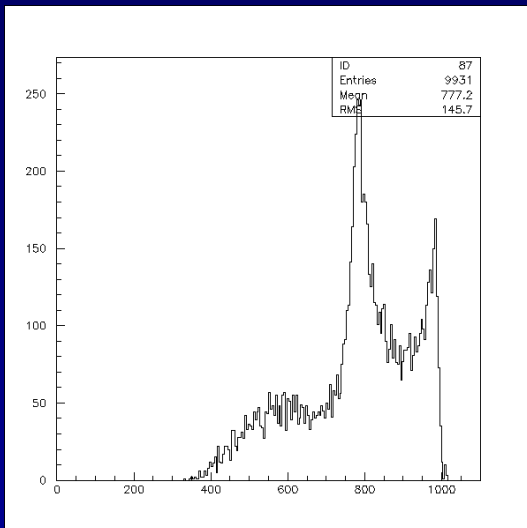
We don't have them but we can start generation now

We don't have them and they are too many for a simple generation (we must include selection cuts in the generator itself)

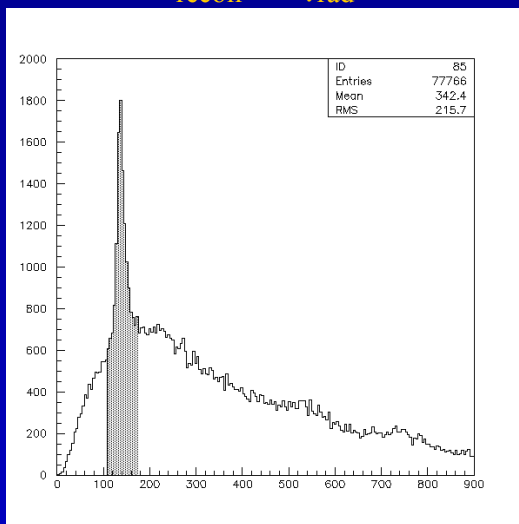
Channels not studied by Lu Feng (we don't have the generator)

Montecarlo statistic needed to obtain $N_{\text{max}} < 1$

$e^+e^- \rightarrow \omega\gamma_1$ events



$M_{\text{recoil of } \gamma_{\text{rad}}}$



$M_{\gamma\gamma}$ MeV/c²

Decay chain

$$e^+e^- \rightarrow \omega\gamma_1$$



γ_1 is the least not π^0 energetic one

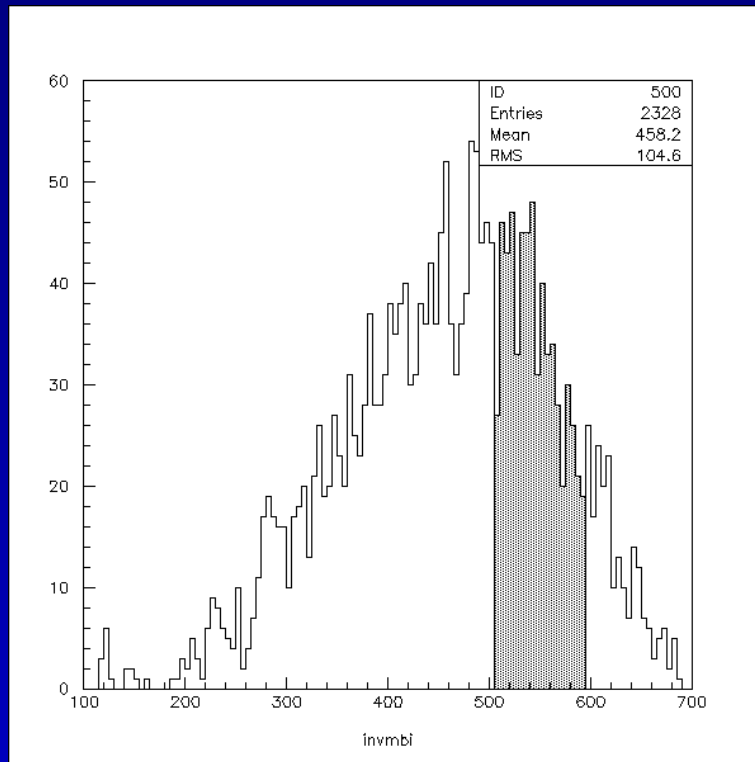
Cutted with π^0 invariant mass.
But how many of them survives to cuts? We cannot know it without a generator.

Distribution of M_{η} on 142 pb⁻¹ (2001 data)

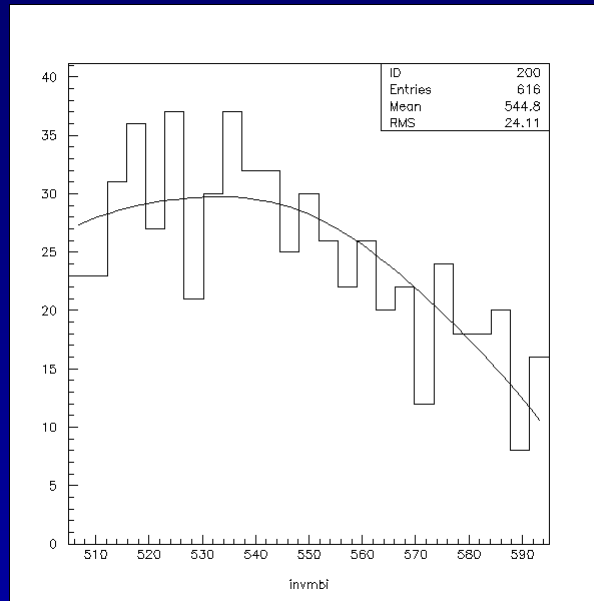
Analysis done on all 2001 dst (rad sream).

Many dst data still missing.

Production asked to Bloise and Moulson



Very preliminary and raw upper limit evaluation



Distribution fitted with paw ($a+bx+cx^2+N_{\text{sign}} \times \text{gauss}$)

It is found: $N_{\text{sign}} = 8 \pm 23$

N_U (90 %C.L.) = $N_{\text{sign}} + 1.28 * \sigma_{N_{\text{sign}}} = 38$

$\text{Br}(\eta \rightarrow \gamma\gamma) < N_U / (\text{Lum} \times \sigma_\phi \times \text{Br}(\phi \rightarrow \eta\gamma) \times \epsilon) = 3.17 \times 10^{-5}$

$\epsilon = 20\%$

Next steps

- Generator for $e^+e^- \rightarrow \omega\gamma_1$ to try to solve the background problem
- Extend the analysis to all available data (500 pb⁻¹, but waiting for DST production)
- Improve the analysis after having known the main source of background