E835 collaboration meeting *February 5th 1999*

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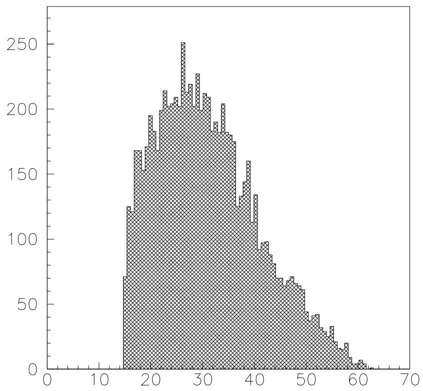
Study of the η_c decay into two ϕ mesons and search for the η_c'

Outline

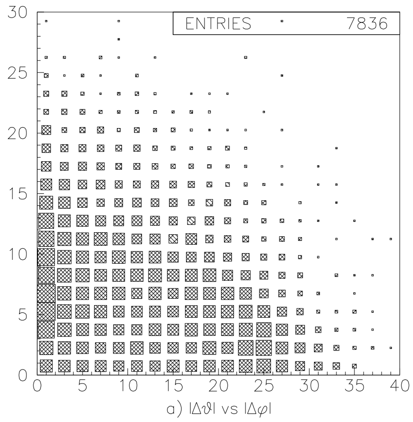
- $\star$ The $\phi\phi$ trigger
- $\star$ *Pre-selection* of the events
- $\star$ The *kinematic fit*
- $\star$ Tests of the fit:
  - with Monte Carlo events
  - with $\overline{\Delta}\Delta$ events
- $\star$ Analysis of the data at the η_c and η'_c energies
- $\star$ Possible improvements at the η'_c

Kinematic features

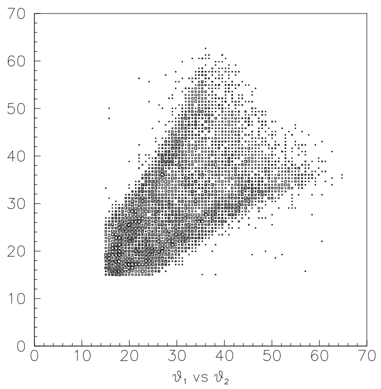
The $K^{\pm}$ have small polar angles

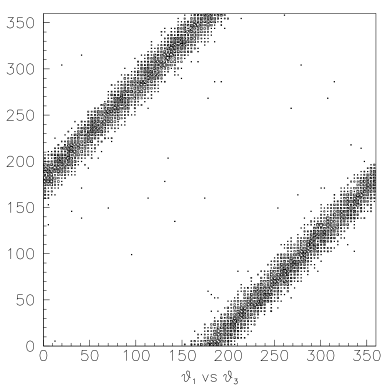


The opening angles of the $K^{\pm}$ coming from the same ϕ are small



The angles of the two couple of $K^{\pm}$ are correlated





The $\phi\phi$ trigger

Thanks to the very peculiar kinematics it has been possible to set up a trigger (the $\phi\phi$ *trigger*) that reduces the rate of a factor $\simeq 1000$ with an efficiency $\varepsilon_{trig} \simeq 65\,\%$.

The logics are based on the kinematic features of the $\phi\phi$ reaction:

1. The $K^{\pm}$ have small polar angles

   $\Longrightarrow$ No tracks with $\vartheta > 50°$

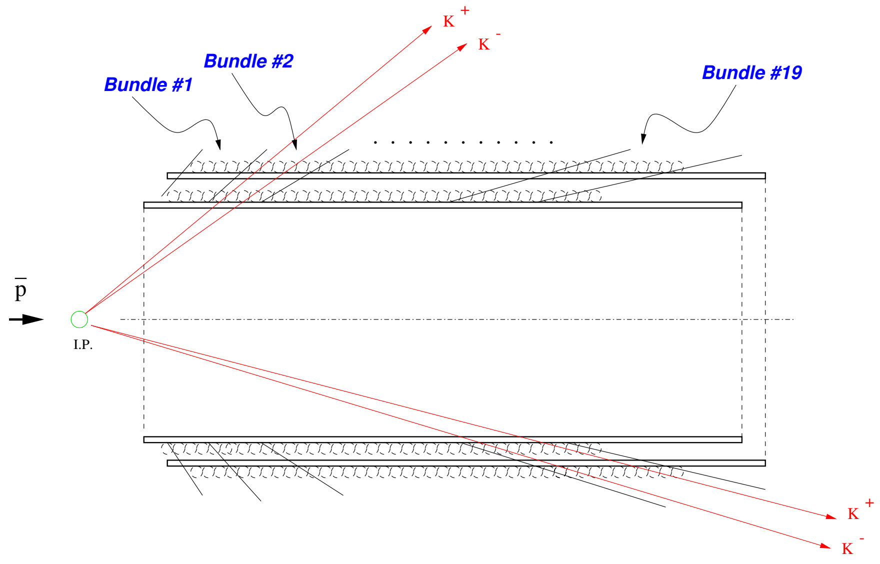
2. The kinematic is similar to the one of a two body reaction

   $\Longrightarrow$ The tracks must be back to back

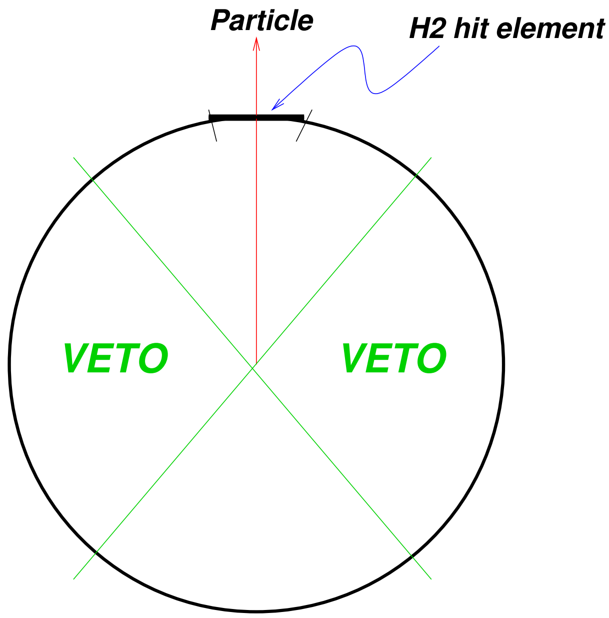
   $\Longrightarrow$ A correlation between the ϑ of the tracks is required

Example of selection logics

Logic based on the SCI-FI detector



Logics based on H2



The pre-selection of the data

On the data taken with the $\phi\phi$ *trigger* a first selection is performed. It requires:

- Exactly 4 charged tracks
- For each track ≤ 4 CCAL blocks
- Cuts on the opening angles of the $K^{\pm}$ coming from the same ϕ:

$$|\Delta\vartheta| < 25^{\circ} \qquad\qquad |\Delta\varphi| < 35^{\circ}$$

- Compatibility with the $4K^{\pm}$ hypothesis
- Calculated* invariant mass of the $K^{\pm}$ within $200\,MeV$ from the ϕ mass:

$$|M_{K1K2} - M_{\phi}| < 200\,MeV$$

$$|M_{K3K3} - M_{\phi}| < 200\,MeV$$

*From the $(E, \vec{p})$ conservation

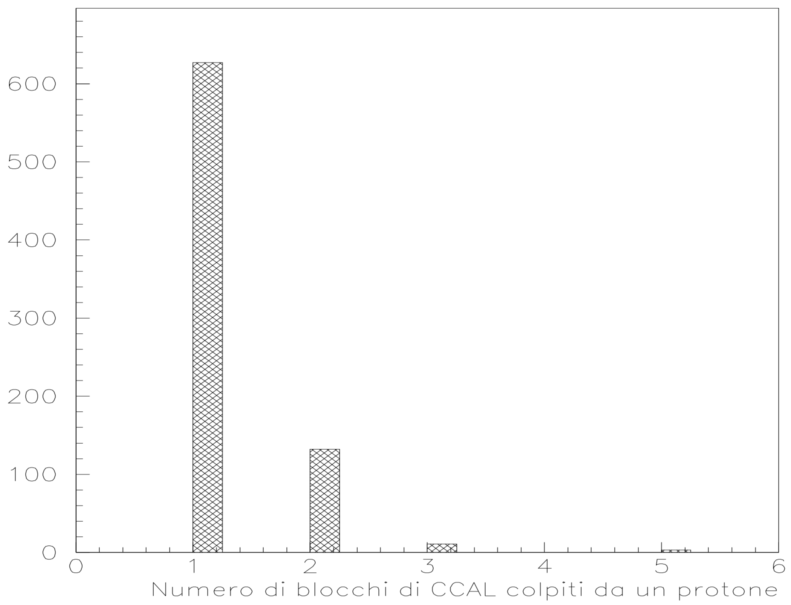
Number of CCAL blocks ≤ 4

The number of CCAL blocks hit by a hadron track has been studied with :

$$\overline{p}p \rightarrow \overline{p}p$$

events

Number of CCAL blocks hit by a proton track:



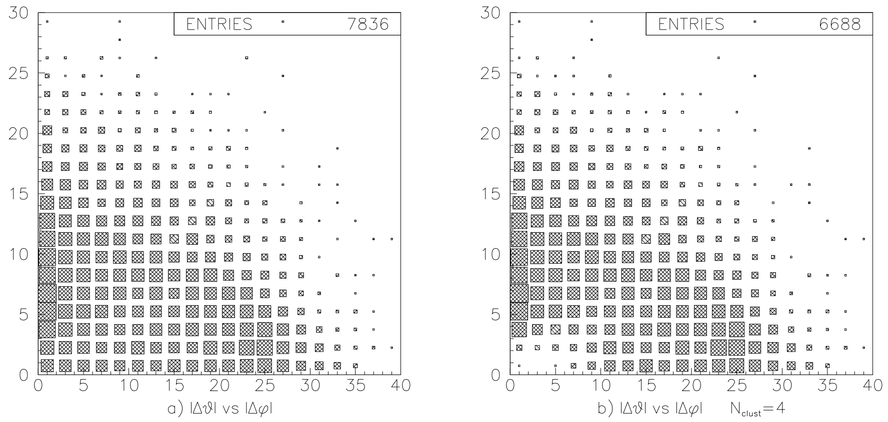
so, preliminarly, we can assume:

$$\varepsilon_{blocks} \;=\; 100\,\%$$

Exactly 4 charged tracks

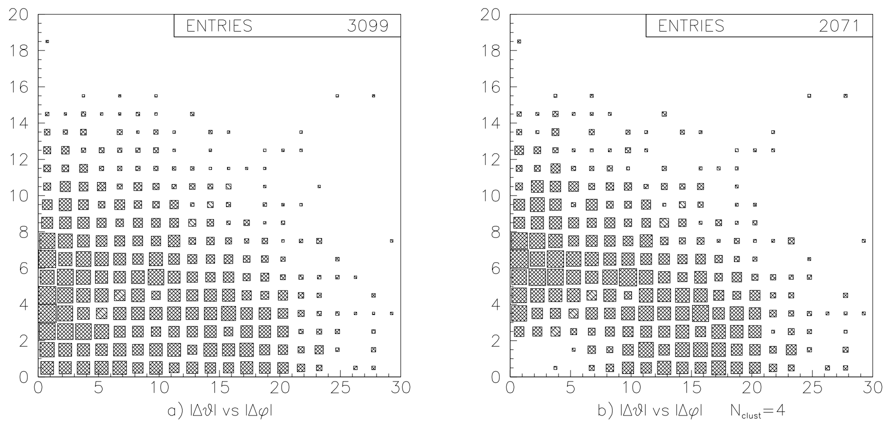
The ϑ and φ lines are associated with CCAL

η_c energy:



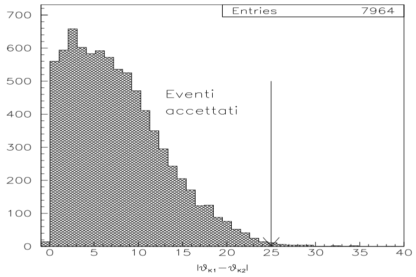
$$\Rightarrow \quad \varepsilon_{4tracks} = 6688/7836 = 85.3\,\%$$

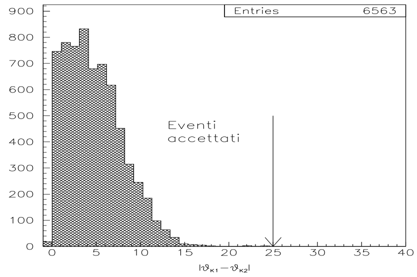
η_c' energy:



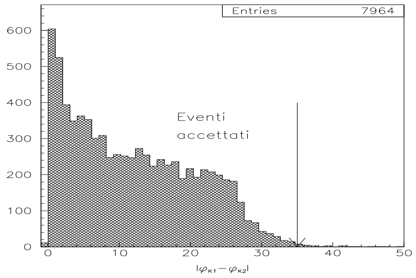
$$\Rightarrow \quad \varepsilon_{4tracks} = 2071/3099 = 66.8\,\%$$

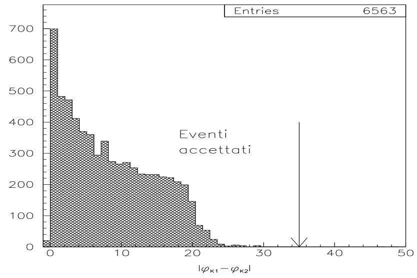
Cuts on the opening angles



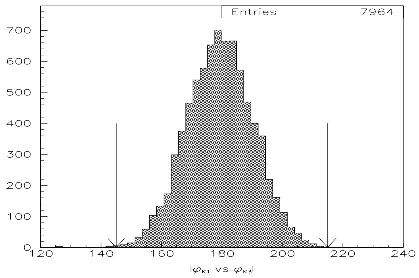


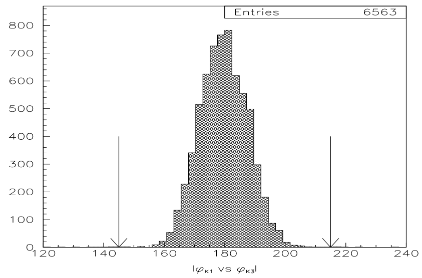
$|\Delta\vartheta| < 25°$





$|\Delta\varphi| < 35°$





$|\,acoplanarity\,| < 35°$

$\varepsilon_{ang} = 98.0\,\%\;\;(\eta_c)$ $\qquad$ $\varepsilon_{ang} = 99.4\,\%\;\;(\eta_c')$

Compatibility with the $4K^{\pm}$ hypothesis

In order to calculate the $K^{\pm}$ energies we solve the system of equations:

$$\begin{cases} \sum_{i=1}^{4} p_i \, sin\vartheta_i \, cos\varphi_i \; = \; 0 \\ \sum_{i=1}^{4} p_i \, sin\vartheta_i \, sin\varphi_i \; = \; 0 \\ \sum_{i=1}^{4} p_i \, cos\vartheta_i \; = \; P_{lab} \\ \sum_{i=1}^{4} \sqrt{p_i^2 + m_K^2} \; = \; E_{lab} + m_p \end{cases}$$

that can have 0, 1, o 2 solutions.

At least 1 solution is required

From Monte Carlo the efficiency is:

$$\varepsilon_{4K} \; = \; 82.2\% \quad (\eta_c)$$

$$\varepsilon_{4K} \; = \; 77.1\% \quad (\eta_c')$$

The inefficiency is due to the errors on the angles

Cut on the calculated invariant mass

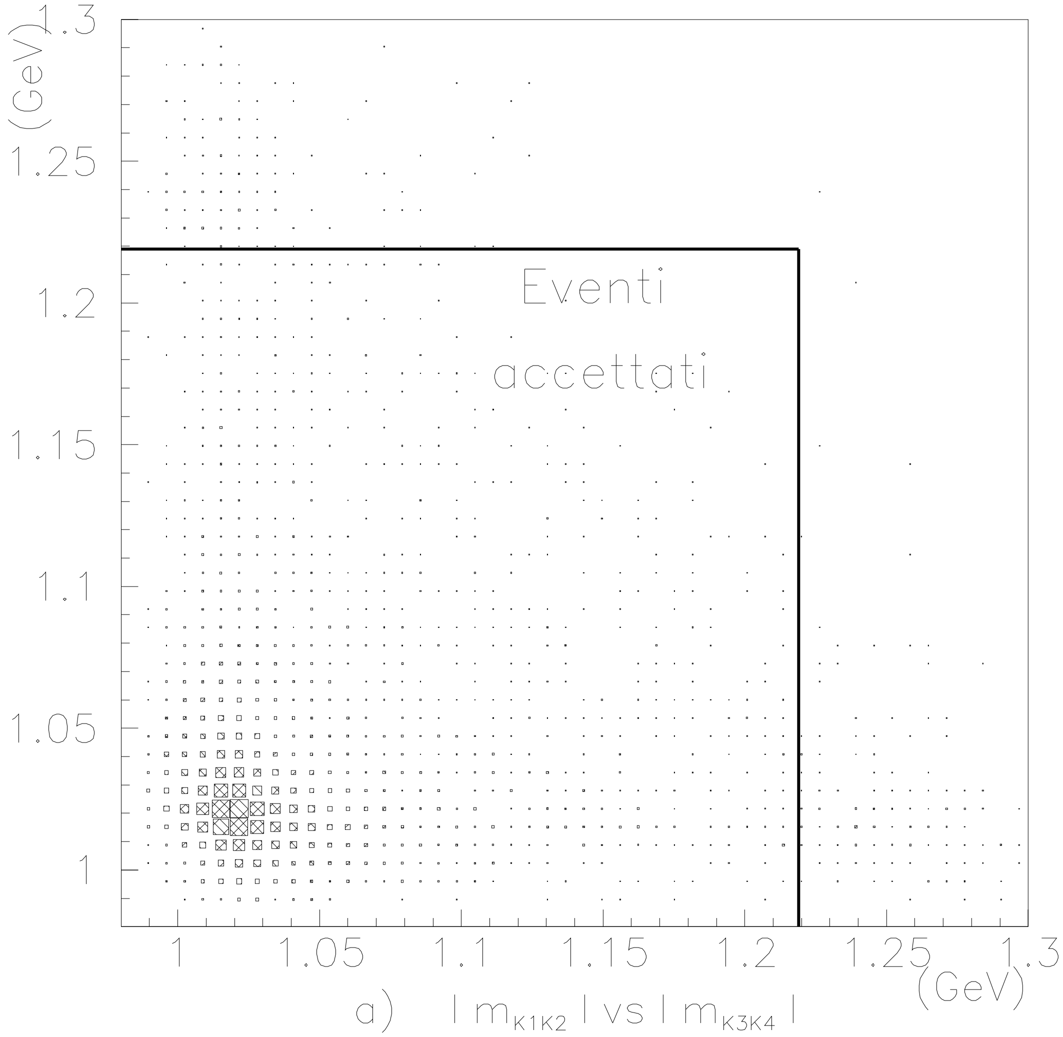
We calculate the invariant masses M_{K1K2} M_{K3K4} from the solutions found

The efficiencies of the cuts:

$\mid M_{K1K2} - M_{\phi} \mid < 200\, MeV$ $\mid M_{K3K4} - M_{\phi} \mid < 200\, MeV$

are:

$\varepsilon_{inv-mass} = 99.9\,\%$ (η_c) $\varepsilon_{inv-mass} = 99.8\,\%$ (η'_c)



a) $|m_{K1K2}|$ vs $|m_{K3K4}|$

Pre-selection efficiency and reduction factor

The total efficiency of the pre-selection is:

$$\varepsilon_{pres} = \varepsilon_{4tracks} * \varepsilon_{blocks} * \varepsilon_{ang} * \varepsilon_{inv-mass} * \varepsilon_{4K}$$

$\Longrightarrow$ 0.85 $*$ 1.0 $*$ 0.98 $*$ 1.0 $*$ 0.82 $=$ 0.69 (η_c)

$\Longrightarrow$ 0.67 $*$ 1.0 $*$ 0.99 $*$ 1.0 $*$ 0.71 $=$ 0.51 (η_c')

The reduction factor, defined as:

$$R = \frac{processed\ \ events}{events\ that\ passed\ the\ cuts}$$

is:

$\Longrightarrow$ $R = (1570 \pm 200)$ (η_c)

$\Longrightarrow$ $R = (3860 \pm 340)$ (η_c')

On the events that pass all of the above cuts we apply the kinematic fit

The method of the variation of M_ϕ

Is applied to distinguish the background reactions:

$$\overline{p}p \to 4\pi^{\pm}$$

$$\overline{p}p \to \overline{\Delta}\Delta \to \overline{p}\pi^{-}\, p\pi^{+}$$

$$\overline{p}p \to \overline{p}\pi^{-}\, p\pi^{+}$$

$$\overline{p}p \to 2\pi^{\pm}2K^{\pm}$$

from the signal:

$$\overline{p}p \to \eta_c \to \phi\phi \to 4K^{\pm}$$

The method used is the following:

- We varies (in the fit) the value of M_ϕ in the two constraints equations:

$$M_{K1K2} - M_\phi = 0 \ \ , \ \ M_{K3K4} - M_\phi = 0$$

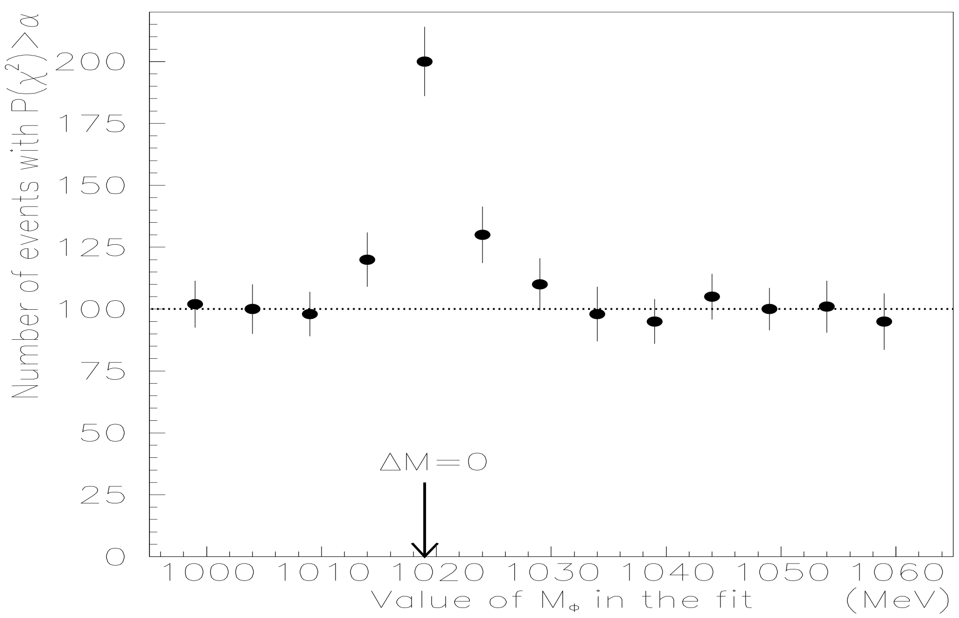
with 5 MeV steps, from 999.0 MeV to 1059.0 MeV)

- for each value of M_ϕ the fit is applied to the data sample, we obtain $P(\chi^2, M_\phi)$.

- for a fixed α we count how many events have $P(\chi^2) > \alpha$, as a function of M_ϕ

- The real $\phi\phi \rightarrow 4K^\pm$ events must satisfy the cut on $P(\chi^2)$ for $\Delta_{M_\phi} = 0$ but not for $\Delta_{M_\phi} \neq 0$

For a fixed $P(\chi^2)$ cut we expect to obtain a plot like this :



The kinematic fit

The 6 constraints are the following:

$$\begin{cases} (E,\vec{p}) \quad conservation \\ M_{K1K2} - M_{\phi} = 0 \\ M_{K3K4} - M_{\phi} = 0 \end{cases}$$

The measured variables are: $(\vartheta_1, \ldots, \vartheta_4, \varphi_1, \ldots, \varphi_4)$

The unknown variables are: $(E_1, \ldots, E_4)$

$\Longrightarrow$ It's a 2c fit: (6 constraints - 4 unknown)

It uses the *Lagrange Multipliers method* to minimize the χ^2

Tests for the kinematic fit

The correct behavior of the kinematic fit has been checked in two ways :

1) selecting events:

$$\bar{p}p \to \eta_c \to \phi\phi \to 4K^{\pm}$$

generated with a Monte Carlo

2) and selecting events similar to the $\phi\phi$ but with a much higher cross section (2.3 mb at the η_c):

$$\bar{p}p \to \overline{\Delta}\Delta \to \bar{p}\,\pi^{-}\,p\,\pi^{+}$$

Test of the fit with Monte Carlo events

We generate events with two $G(M_\phi)$ distributions:

1) $$G(M_\phi) = \delta(M_\phi - 1019)$$

(all the events have exactly the mass of the ϕ meson)

2) $$G(M_\phi) = \frac{\Gamma^2}{(M_\phi - M_0)^2 + \Gamma^2/4}$$

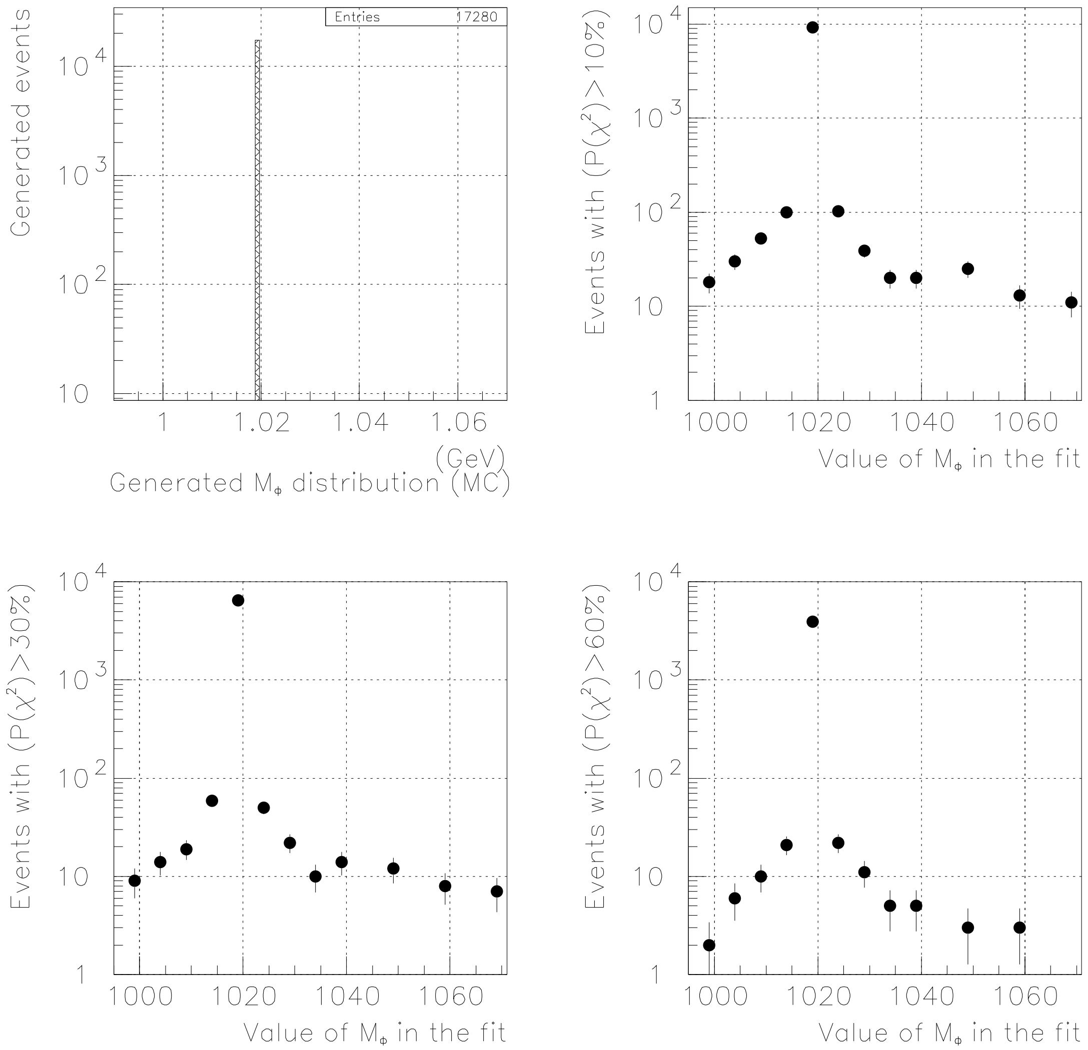
(*Breit-Wigner*), where:

$$\begin{cases} M_0 = 1019.0\,MeV \\ \Gamma = \Gamma_\phi = 4.4\,MeV \end{cases}$$

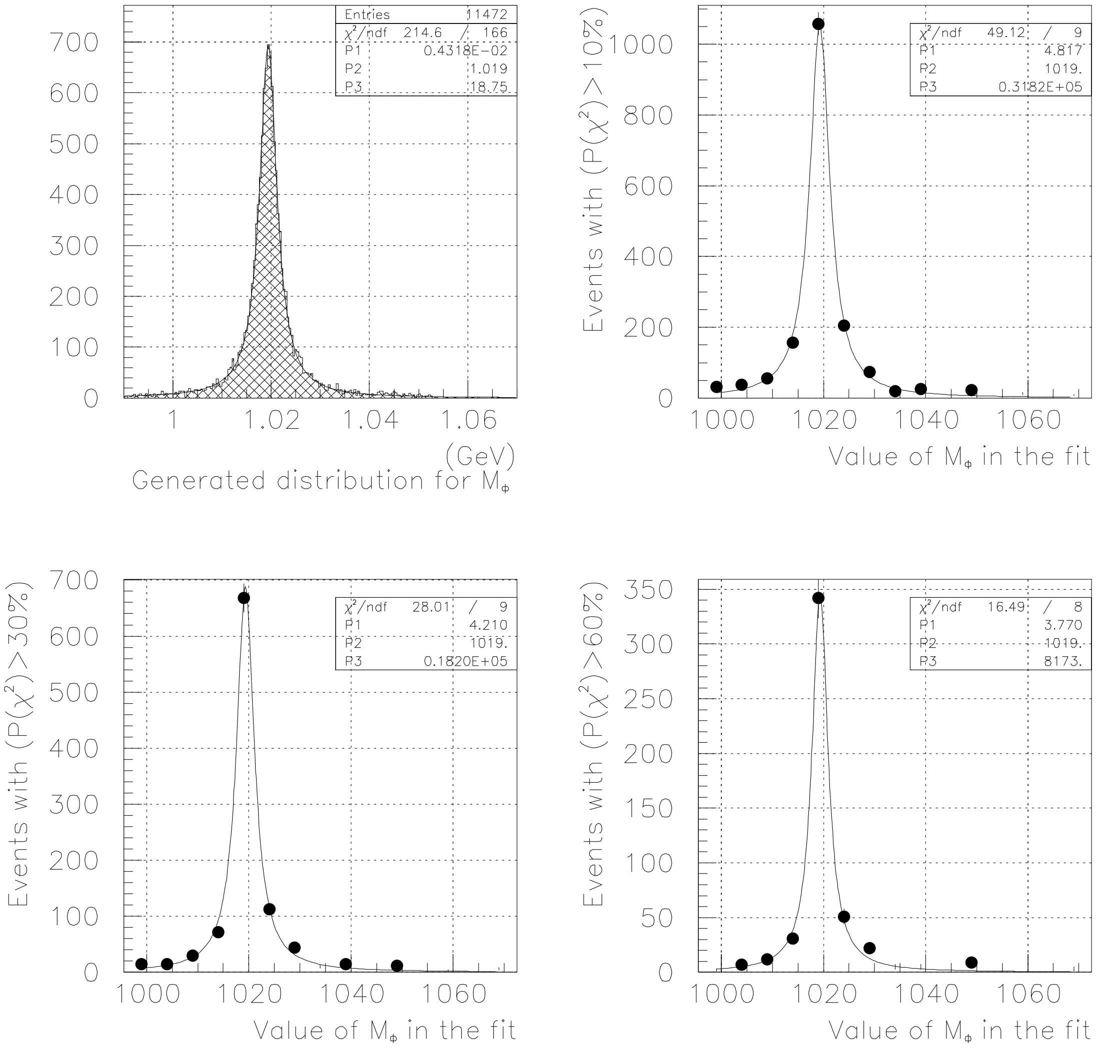
We then apply the M_ϕ variation method to the MC events

$\Longrightarrow$ We expect to get a distribution of M_ϕ equal to the generated one

$$G(M_\phi) \;=\; \delta(M_\phi - 1019)$$



$$G(M_\phi) = \frac{\Gamma^2}{(M_\phi - M_0)^2 + \Gamma^2/4}$$



Test of the kinematic fit with events $\Delta\bar{\Delta}$

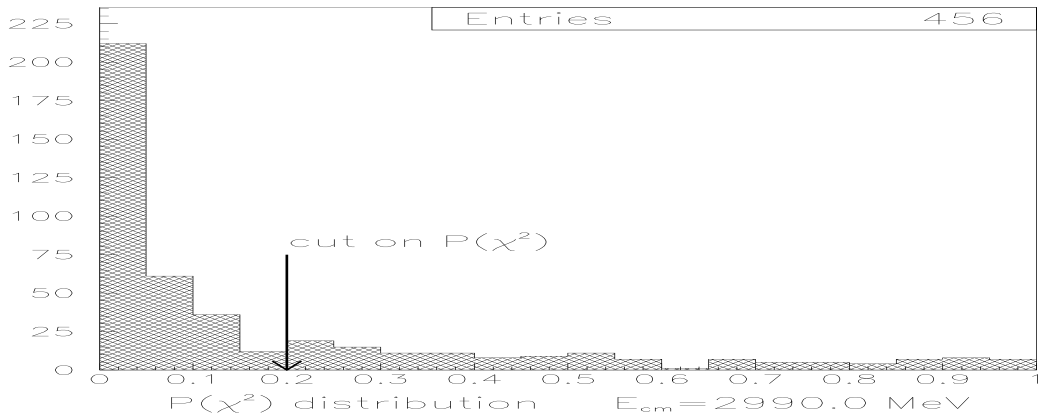
The selection of the events requires:

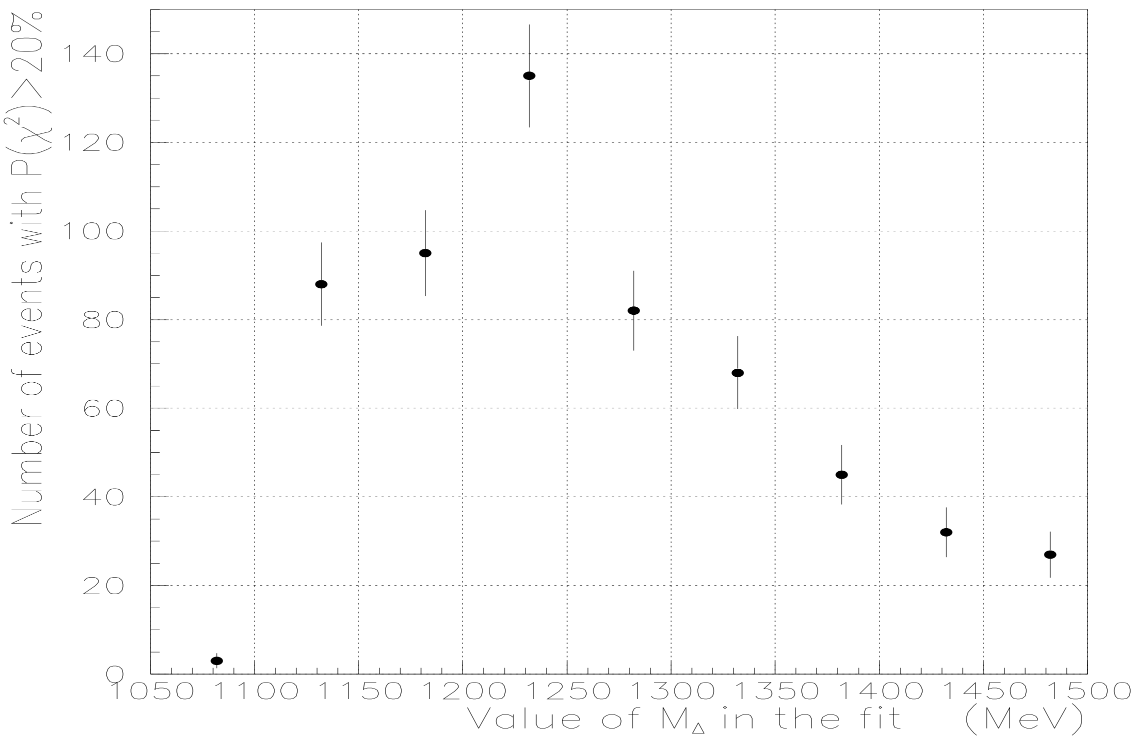
- exactly 4 charged tracks
- at least three tracks with ≤ 3 CCAL blocks
- reconstructed invariant mass within 400 MeV from M_{Δ} (1232 MeV)
- $P(\chi^2) > 0.2$ in the fit

two sets of data have been analyzed:

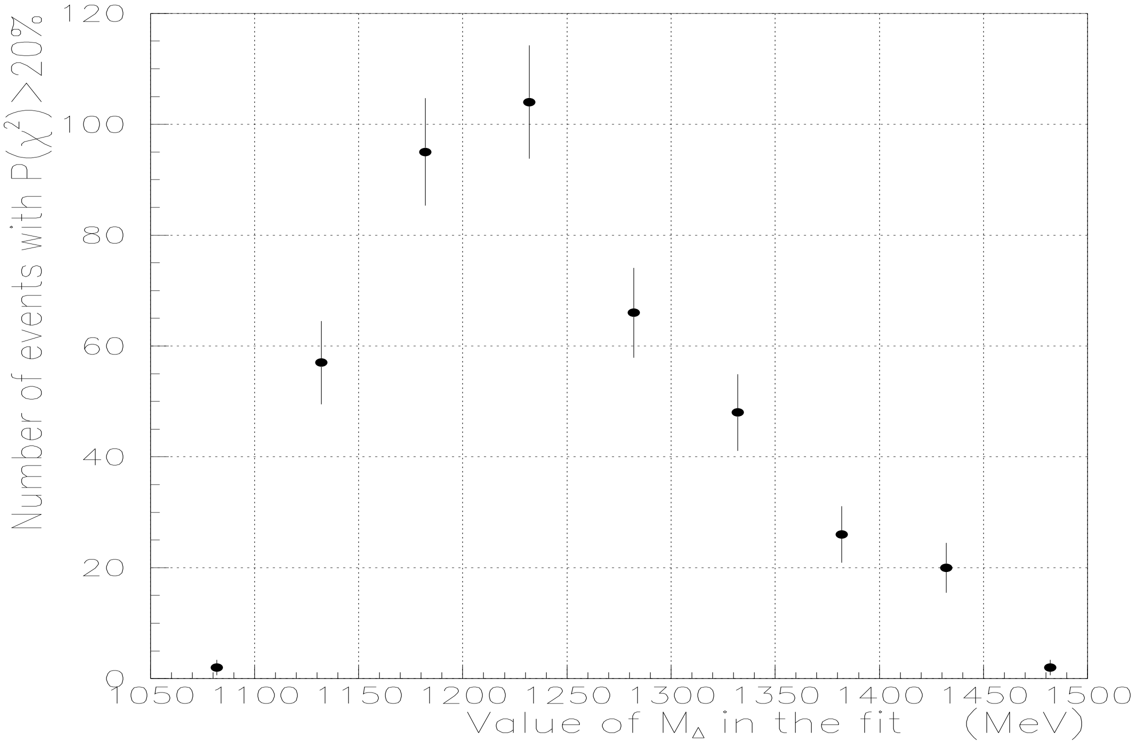
1. $E_{cm} = 2990.0\,MeV$ (η_c peak)
2. $E_{cm} = 2950.0\,MeV$ (off-resonance)

Selection of $\overline{\Delta}\Delta$ events at $E_{cm} = 2990.0\,MeV$





Selection of $\overline{\Delta}\Delta$ events at $E_{cm} = 2950.0\, MeV$



Efficiency of the cut on $P(\chi^2)$

We generate a sample of Monte Carlo events with M_ϕ distributed like a Breit-Wigner

We count how many events pass the cut:

$$P(\chi^2) > \alpha \qquad \alpha = 0.1, 0.2, \ldots$$

with $M_\phi = 1019\, MeV$ in the fit

The efficiency is then: $\varepsilon_\alpha = N_{(P(\chi^2)>\alpha)}/N_{generated}$

the values of the efficiency are the following:

α	N_α	$\varepsilon(\alpha) = N_\alpha/N_{tot}$
0.1	9131	0.702
0.2	7610	0.585
0.3	6370	0.490
0.4	5273	0.405
0.5	4263	0.328
0.6	3319	0.255
0.7	2472	0.190
0.8	1623	0.125
0.9	808	0.062

Decay probability of the $K^{\pm}$

The probability that a $K^{\pm}$ does *not* decay before CCAL is:

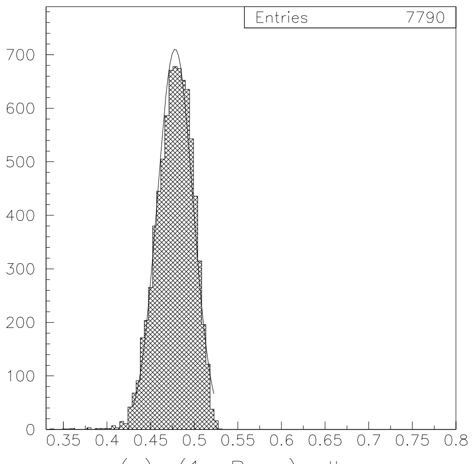
$$P_K = e^{-(x/x_0)}$$

where:
x_0 = mean decay distance of a K

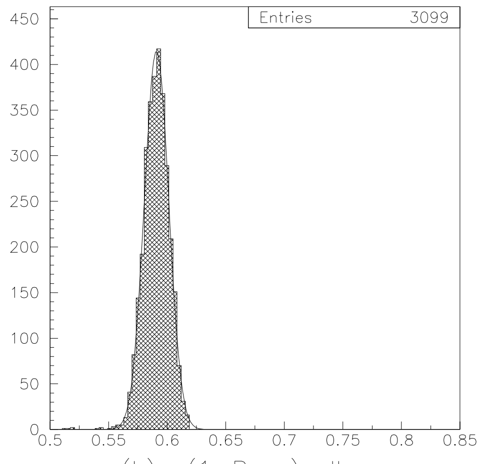
the probability that all the $K^{\pm}$ reach the calorimeter is:

$$[1 - P_{decay}] = \sum_{i=1}^{4} P_{K_i}$$

from the Monte Carlo we have:



(a) $(1 - P_{Kdecay})$, alla η_c



(b) $(1 - P_{Kdecay})$, alla η'_c

$[1 - P_{decay}] = 48\%$ (η_c) $[1 - P_{decay}] = 59\%$ (η'_c)

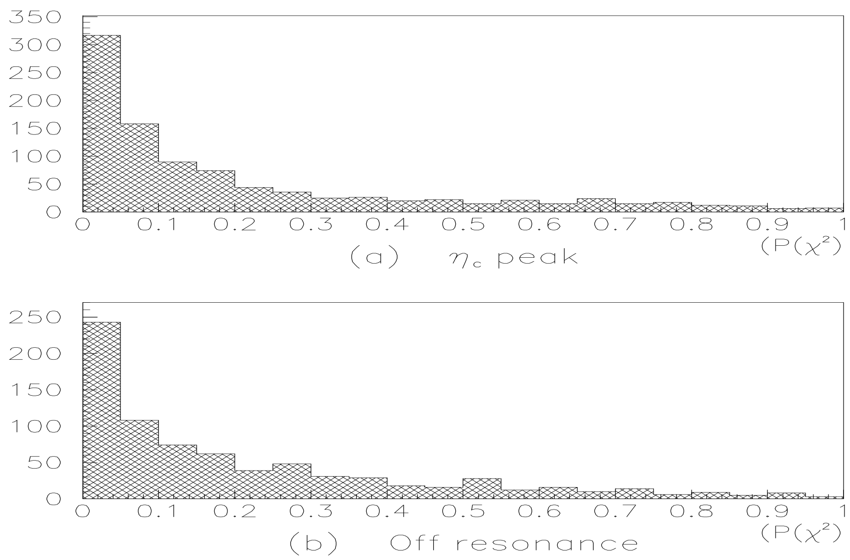
Analysis of the η_c data

Luminosity collected:

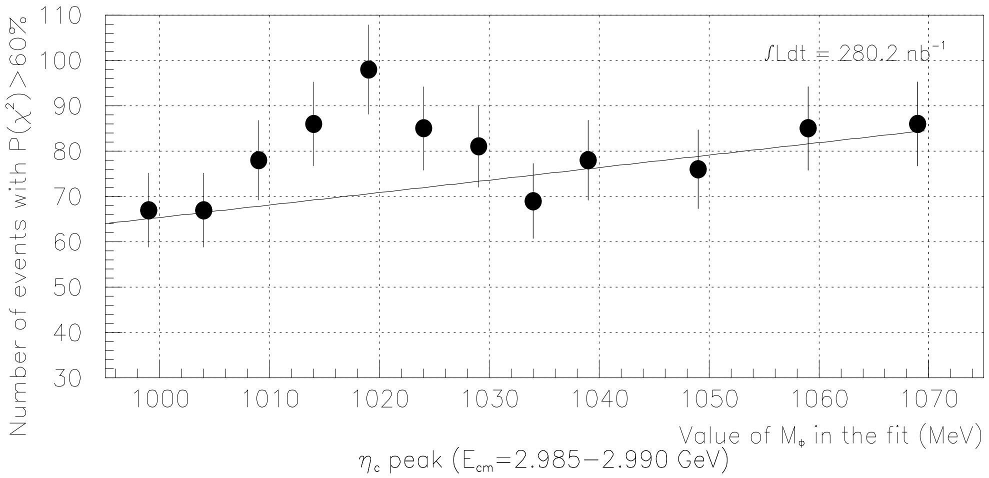
- on the peak $(2985 \div 2990)\, MeV$: $280.2\, nb^{-1}$
- above the resonance $(3004 \div 3009)\, MeV$: $145.5\, nb^{-1}$
- below the resonance $(2950 \div 2956)\, MeV$: $139.6\, nb^{-1}$

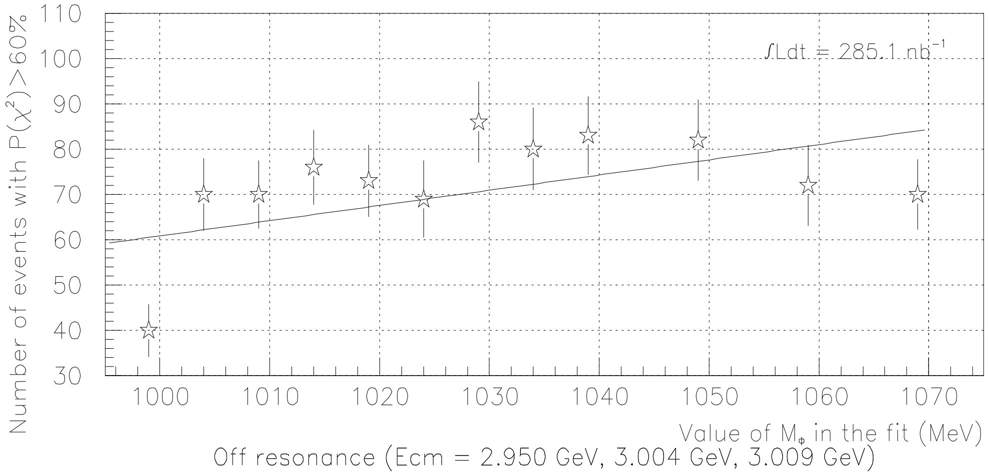
The number of events that passed the preliminary selection is $\simeq 34000$

The $P(\chi^2)$ distribution became almost flat for $P(\chi^2) > 0.3$



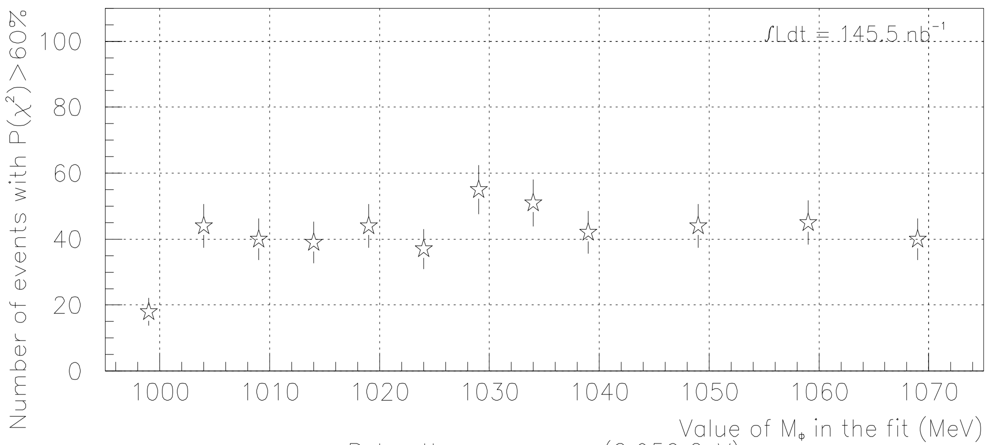
$P(\chi^2) > 0.6$



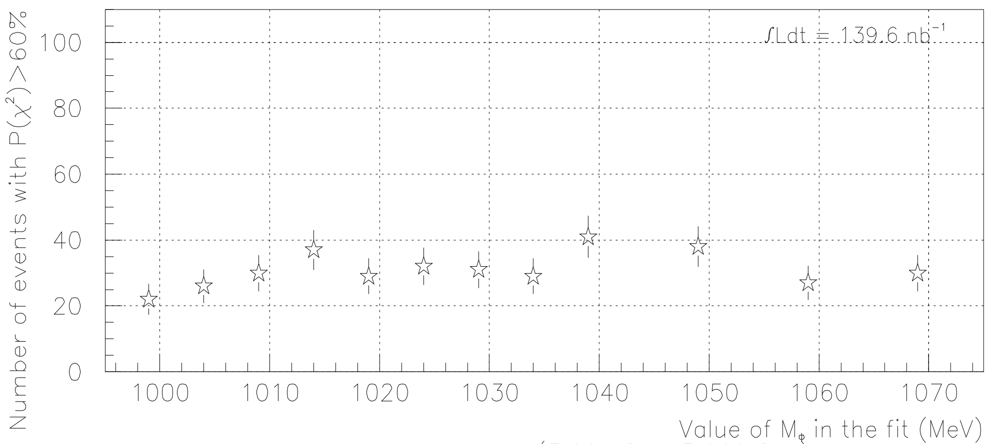


$$N_{\phi\phi} = N_{(M_\phi=1019)} - N_{bkg} = 98 - 71 = 27$$

$P(\chi^2) > 0.6$

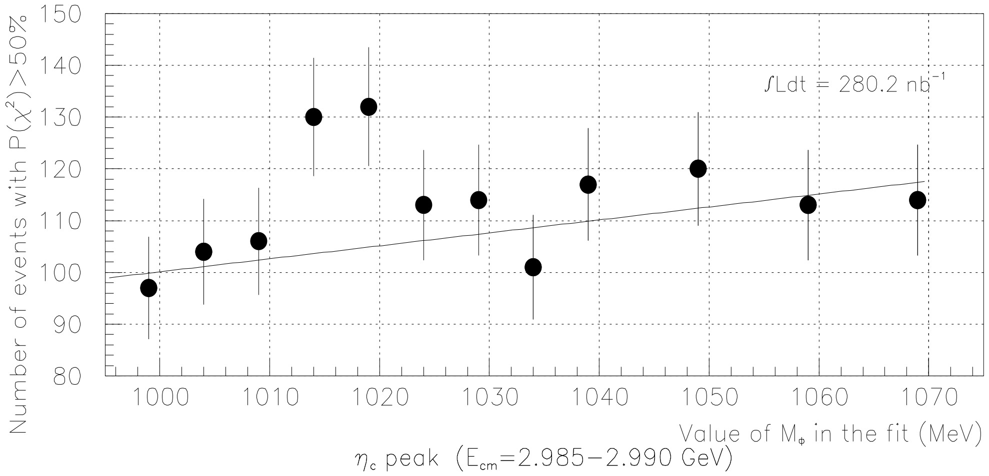


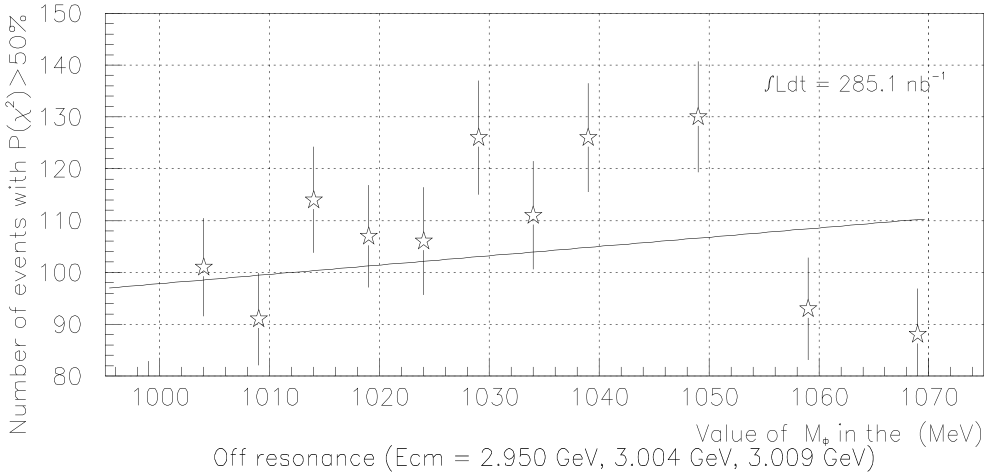
Below the resonance (2.950 GeV)



Above the resonance (3.004 GeV, 3.009 GeV)

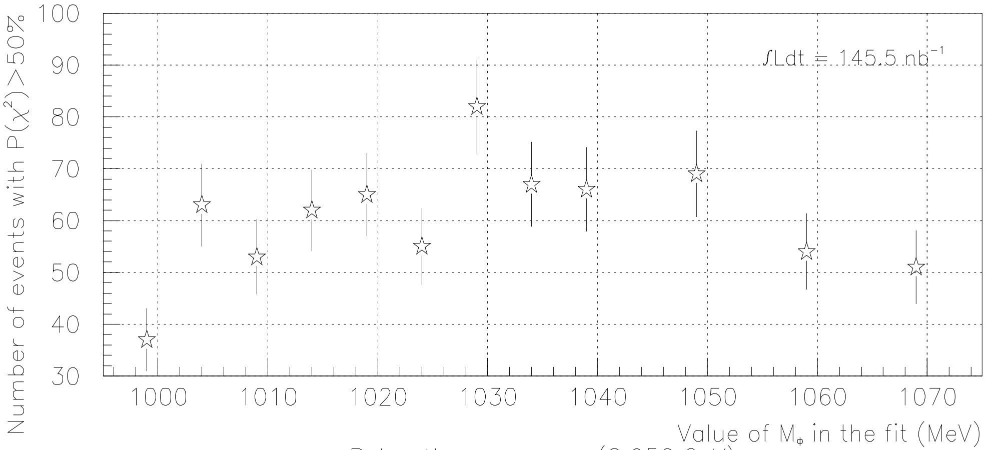
$P(\chi^2) > 0.5$



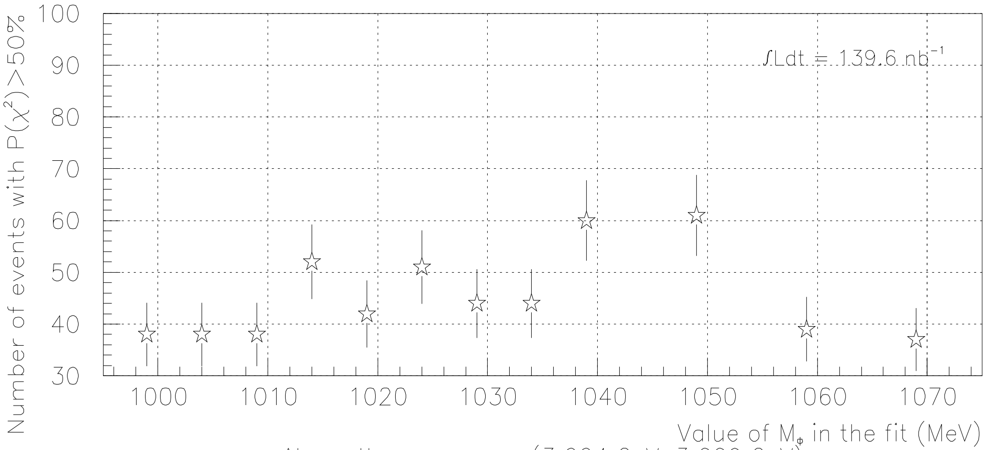


$$N_{\phi\phi} = N_{(M_\phi=1019)} - N_{bkg} = 132 - 105 = 27$$

$P(\chi^2) > 0.5$

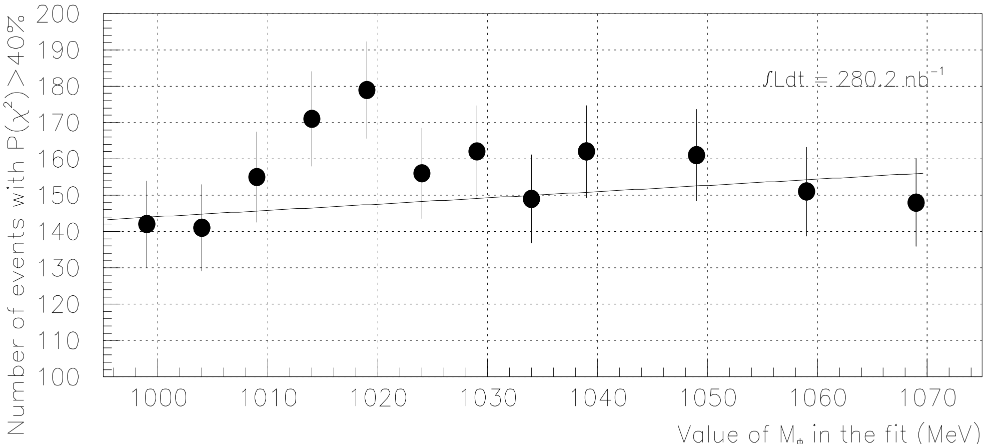


Below the resonance (2.950 GeV)

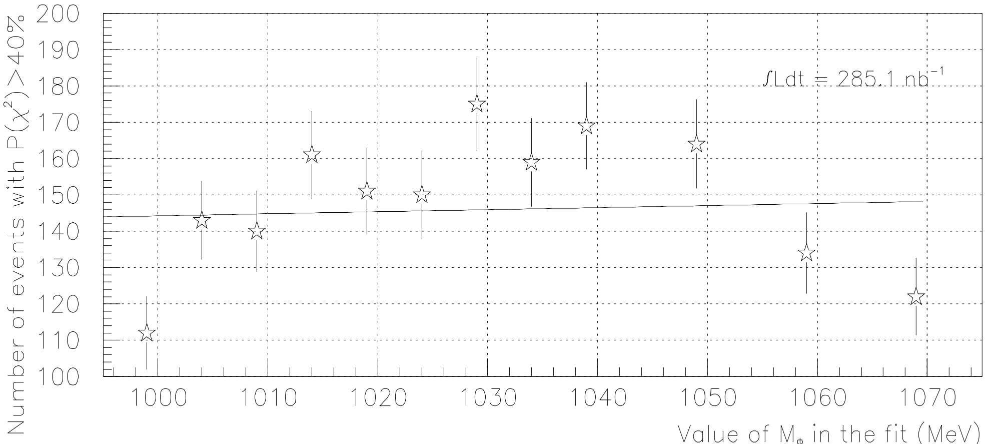


Above the resonance (3.004 GeV, 3.009 GeV)

$P(\chi^2) > 0.4$



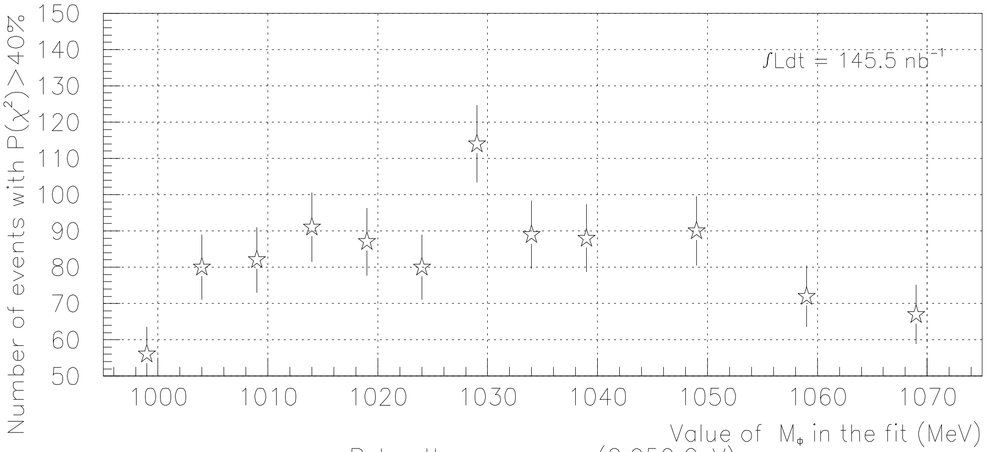
η_c peak (E_{cm}=2.985−2.990 GeV)



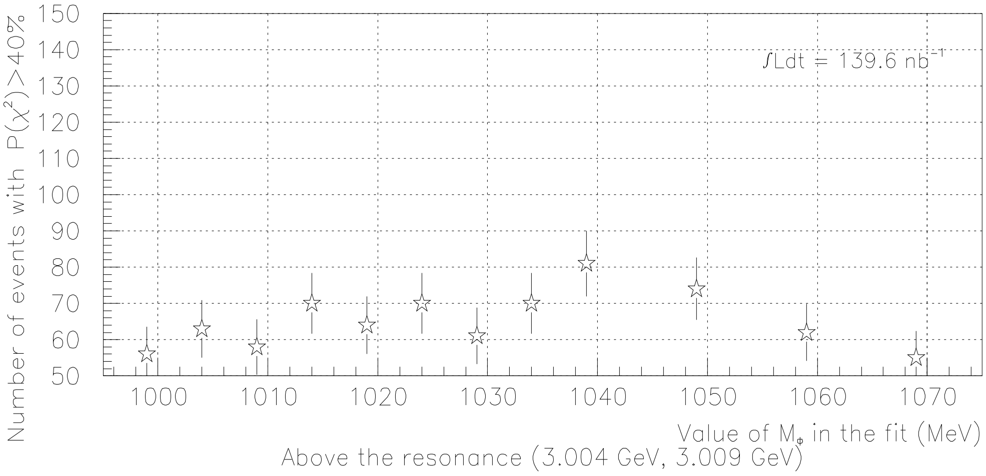
Off resonance (Ecm = 2.950 GeV, 3.004 GeV, 3.009 GeV)

$$N_{\phi\phi} = N_{(M_\phi=1019)} - N_{bkg} = 179 - 1146 = 33$$

$$P(\chi^2) > 0.4$$



Below the resonance (2.950 GeV)



Above the resonance (3.004 GeV, 3.009 GeV)

Number of $\phi\phi$ events

To get the number $N_{\phi\phi}$ of events compatible with the hypothesis: $\phi\phi \rightarrow 4K^{\pm}$ we apply the M_{ϕ} variation method for :

$$P(\chi^2) > 0.4 \qquad P(\chi^2) > 0.5 \qquad P(\chi^2) > 0.6$$

to the data

at the η_c peak we observe the following number of events:

Cut on $P(\chi^2)$	$N_{\Delta M=0}$	N_{bkg}	$N_{\phi\phi}$
$P(\chi^2) > 0.4$	179 ± 13	146 ± 8	33 ± 15
$P(\chi^2) > 0.5$	132 ± 11	105 ± 7	27 ± 13
$P(\chi^2) > 0.6$	98 ± 10	71 ± 4	27 ± 11

There in no evidence of a $\phi\phi$ signal in the off-resonance regions

Efficiency of the analysis

- $\varepsilon_{trig} \ = \ 0.51$
- $\varepsilon_{pres} \ = \ 0.69$
- ε_{fit}:

  $P(\chi^2) > 0.4 \ \Rightarrow \quad = 0.40$

  $P(\chi^2) > 0.5 \ \Rightarrow \quad = 0.33$

  $P(\chi^2) > 0.6 \ \Rightarrow \quad = 0.26$
- $acceptance(\phi\phi) \ = \ 0.58$
- $[1 \ - \ P_{decay}] \ = \ 0.48$

total efficiency:

$$\varepsilon_{tot} \ = \ \varepsilon_{trig} * \varepsilon_{pres} * \varepsilon_{fit} * acceptance * [1 \ - \ P_{decay}]$$

$$\Rightarrow \quad \varepsilon_{tot} \ = \ 0.039 \quad (P(\chi^2) > 0.4)$$

$$\varepsilon_{tot} \ = \ 0.033 \quad (P(\chi^2) > 0.5)$$

$$\varepsilon_{tot} \ = \ 0.025 \quad (P(\chi^2) > 0.6)$$

Measured cross section

$$\sigma_{\phi\phi} \;=\; \frac{N_{\phi\phi}}{\varepsilon_{tot} \cdot \int \mathcal{L} dt}$$

The luminosity collected $\int \mathcal{L}\, dt$ is $280.2\, nb^{-1}$ so:

$$\sigma_{meas} \;=\; \frac{33 \pm 15}{0.039 \cdot 280.2} \;=\; (3.0 {\pm} 1.4) nb \qquad (P(\chi^2) > 0.4)$$

$$\sigma_{meas} \;=\; \frac{27 \pm 13}{0.032 \cdot 280.2} \;=\; (3.0 {\pm} 1.4) nb \qquad (P(\chi^2) > 0.5)$$

$$\sigma_{meas} \;=\; \frac{27 \pm 11}{0.025 \cdot 280.2} \;=\; (3.9 {\pm} 1.6) nb \qquad (P(\chi^2) > 0.6)$$

if we take the mean value:

$$\boxed{\sigma_{meas} \;=\; 3.3 \pm 1.5\, nb}$$

Expected cross section

From the *Breit-Wigner*, we can calculate the cross section for the process:

$$\bar{p}p \to \eta_c \to \phi\phi \to 4K^{\pm}$$

If we take the following values for the branching ratios (from PDG):

$$B_{in} = BR(\eta_c \to \bar{p}p) = (1.2 \pm 0.4) \times 10^{-3}$$

$$B_{out} = BR(\eta_c \to \phi\phi) = (7.1 \pm 2.8)) \times 10^{-3}$$

$$BR(\phi \to K^+K^-) = (0.49 \pm 0.006)$$

we get an expected cross section of:

$$\boxed{\sigma_{exp} = (1.85 \pm 0.9)\, nb}$$

Value measured by R704

R704 is the only experiment that measured the $\phi\phi$ cross section

The analysis is quite similar (variation of M_ϕ method)

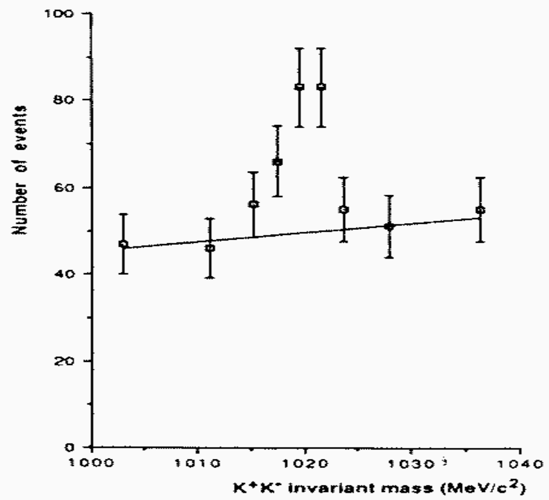


Fig. 3. Number of fitting (CL > 0.3) events as a function of the K^+K^- invariant mass. The line is the result of a straight-line fit to the first and last two points.

The value measured by R704 is:

$$\boxed{\sigma_{R704} \;=\; (6.0 \pm 2.0)\, nb}$$

R704 scanned the energy region:
$E_{cm} = (2967 \div 3024)\, MeV$, collecting $497\, nb^{-1}$.

R704 didn't analize the η_c peak region and the off-resonance region separately

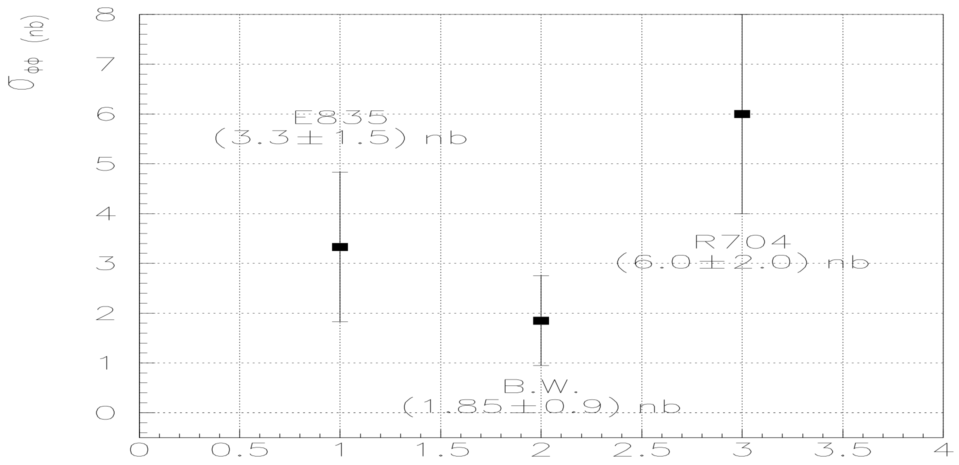
Comments to the η_c result

The fact that there are no event in the off-resonance region means that all the events stem from the resonant process:

$$\overline{p}p \to \eta_c \to \phi\phi \to 4K^{\pm}$$

the continuum is negligible

$$\begin{aligned} \sigma_{\phi\phi} &= (3.3 \pm 1.5)\ nb && (E835) \\ \sigma_{\phi\phi} &= (1.85 \pm 0.9)\ nb && (B.W.) \\ \sigma_{\phi\phi} &= (6.0 \pm 2.0)\ nb && (R704) \end{aligned}$$



The result is compatible with the expected value (from the Breit-Wigner) and with R704.

Analysis of the η_c' data

Four energy points have been analyzed:

- $E_{cm} = 3620\, MeV \Longrightarrow 1273.7\, nb^{-1}$
- $E_{cm} = 3630\, MeV \Longrightarrow 1189.6\, nb^{-1}$
- $E_{cm} = 3635\, MeV \Longrightarrow 971.4\, nb^{-1}$
- $E_{cm} = 3644\, MeV \Longrightarrow 1723.2\, nb^{-1}$

The number of events that passed the pre-selection is about 16000

There are three more points with the trigger not prescaled:

- $E_{cm} = 3625\, MeV \Longrightarrow 1637.3\, nb^{-1}$
- $E_{cm} = 3615\, MeV \Longrightarrow 1538.0\, nb^{-1}$
- $E_{cm} = 3604\, MeV \Longrightarrow 1478.7\, nb^{-1}$

Cross section estimate

Since there are no data available for the η_c', we can only give an estimate of the cross section

From the *Breit-Wigner*, for the process:
$\overline{p}p \to \eta_c' \to \phi\phi \to 4K^{\pm}$

With the hypothesis:

$$BR(\eta_c' \to \phi\phi) \;=\; B.R.(\eta_c \to \phi\phi) \;=\; (7.1 \pm 2.8) \times 10^{-3}$$

and

$$BR(\eta_c' \to \overline{p}p) \;=\; \left(\frac{M_{\eta_c}}{M_{\eta_c'}}\right)^8 \cdot BR(\eta_c \to \overline{p}p) \;=\; (2.4 \div 2.9) \times 10^{-4}$$

we get:

$$\boxed{\sigma_{(\overline{p}p \to \eta_c' \to \phi\phi \to 4K^{\pm})} \;=\; (0.22 \div 0.27)\, nb}$$

Efficiency of the analysis at the η_c'

- ε_{trig} = 0.3
- ε_{pres} = 0.51
- assuming (preliminarly) the same ε_{fit}:

  $P(\chi^2) > 0.4 \Rightarrow \quad = 0.40$

  $P(\chi^2) > 0.5 \Rightarrow \quad = 0.33$

  $P(\chi^2) > 0.6 \Rightarrow \quad = 0.26$
- $acceptance(\phi\phi)$ = 0.49
- $[1 - P_{decay}]$ = 0.59

total efficiency:

$$\varepsilon_{tot} = \varepsilon_{trig} * \varepsilon_{pres} * \varepsilon_{fit} * acceptance * [1 - P_{decay}]$$

$$\Rightarrow \quad \varepsilon_{tot} = 0.018 \quad (P(\chi^2) > 0.4)$$

$$\varepsilon_{tot} = 0.015 \quad (P(\chi^2) > 0.5)$$

$$\varepsilon_{tot} = 0.012 \quad (P(\chi^2) > 0.6)$$

Expected number of events

The number of events that we expect to see is:

$$N_{expected} = \sigma_{(\overline{p}p \to \eta_c' \to \phi\phi \to 4K^{\pm})} \cdot \int \mathcal{L}\, dt \cdot \varepsilon_{tot}$$

with the efficiencies calculated and for $\int \mathcal{L}\, dt = 1000\, nb^{-1}$ we have:

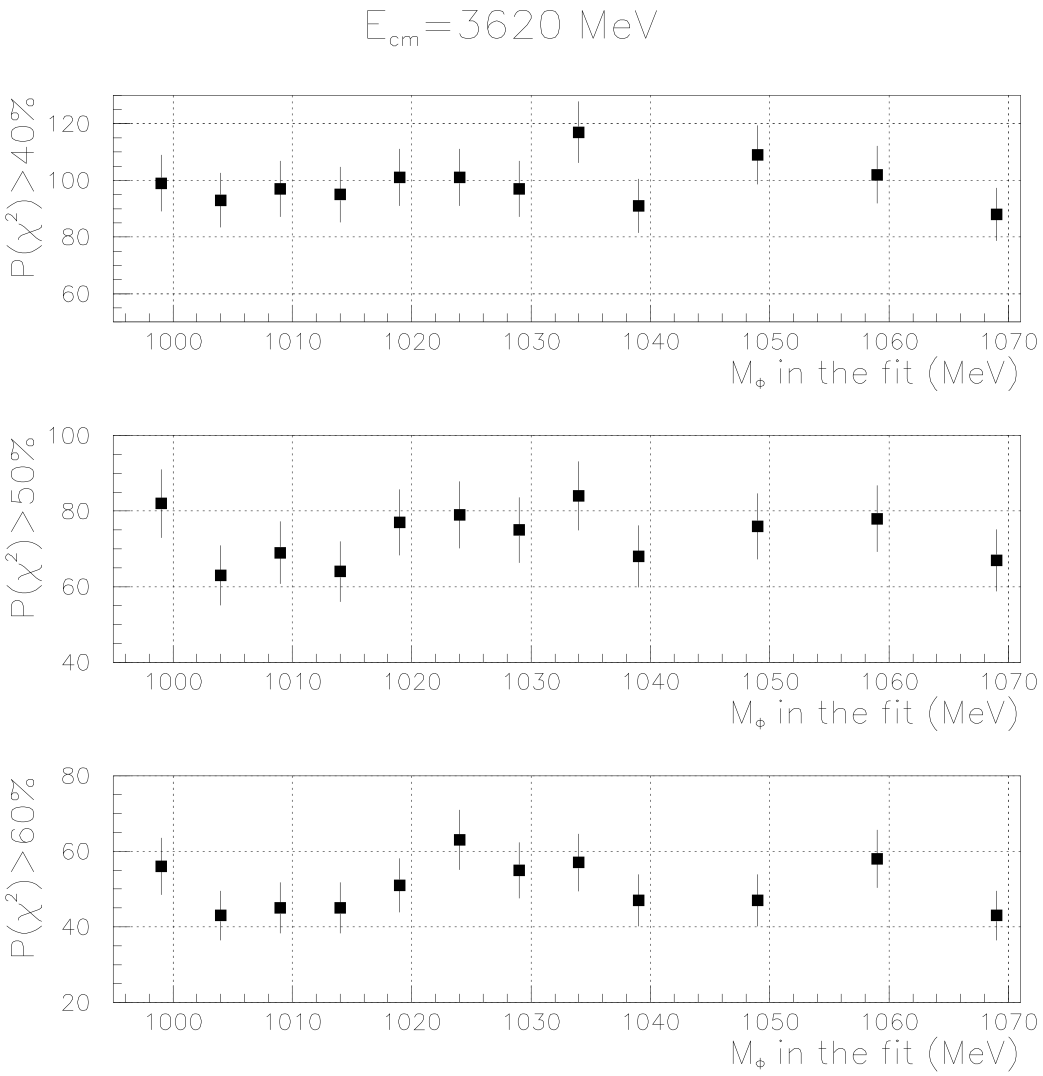
$$N_{exp} = (4 \div 5) \text{ events}/pb^{-1} \qquad (P(\chi^2) > 0.4)$$

$$N_{exp} = (3 \div 4) \text{ events}/pb^{-1} \qquad (P(\chi^2) > 0.5)$$

$$N_{exp} = (2.5 \div 3) \text{ events}/pb^{-1} \qquad (P(\chi^2) > 0.6)$$

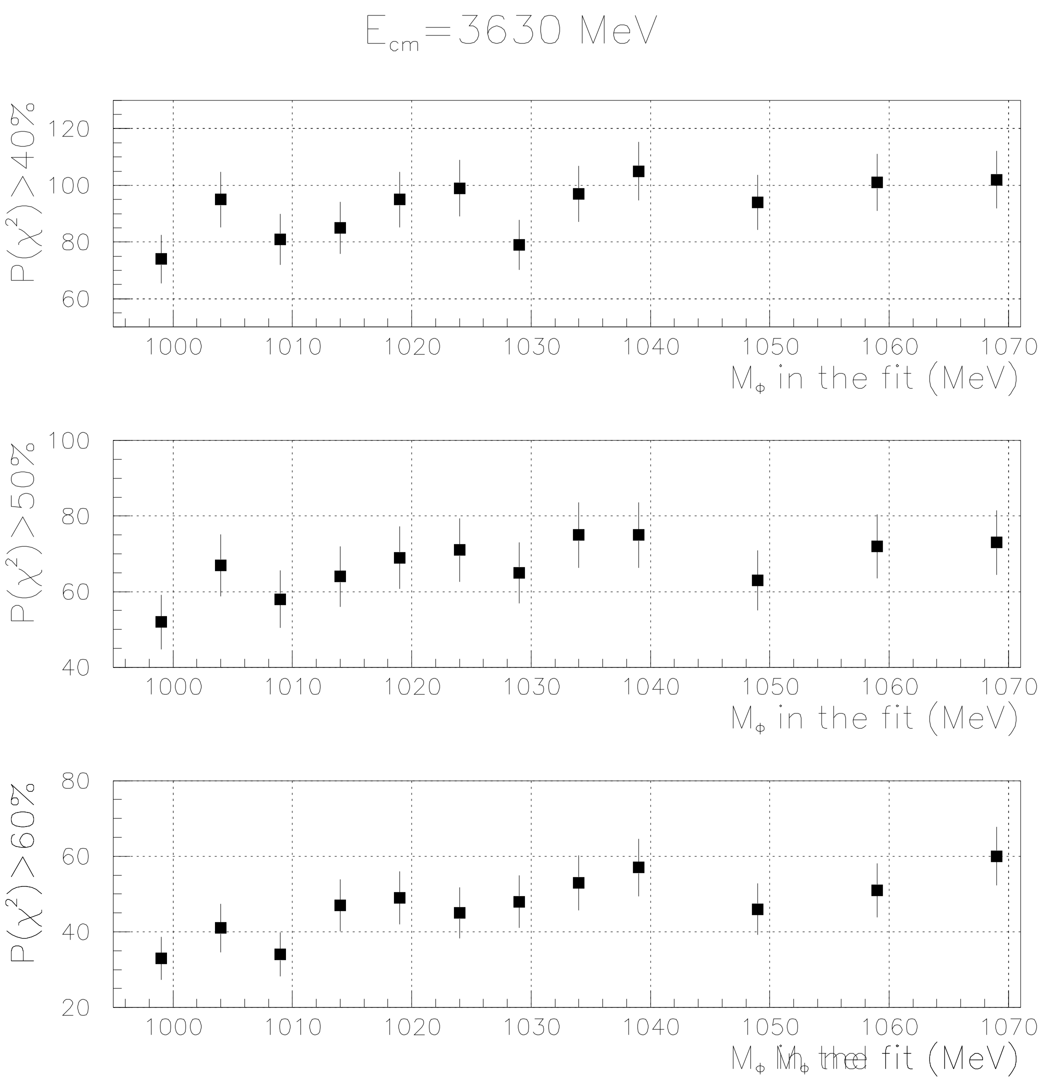
$\Longrightarrow$ It will be tough to distinguish a $\phi\phi$ signal, unless the background is very low

$E_{cm} = 3620\ MeV$



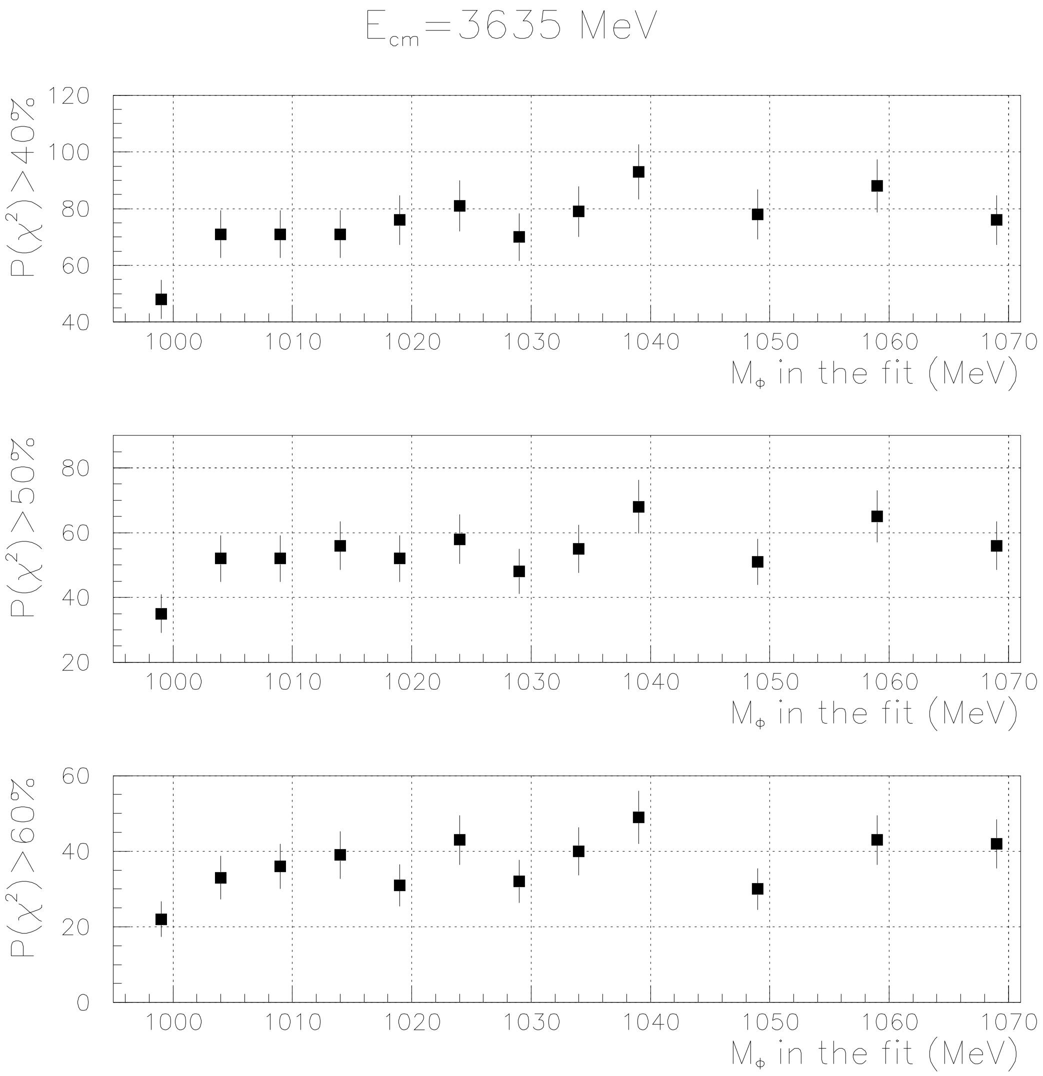
E_cm=3620 MeV
P(χ²)>40%
120
100
80
60
1000
1010
1020
1030
1040
1050
1060
1070
M_Φ in the fit (MeV)
P(χ²)>50%
100
80
60
40
1000
1010
1020
1030
1040
1050
1060
1070
M_Φ in the fit (MeV)
P(χ²)>60%
80
60
40
20
1000
1010
1020
1030
1040
1050
1060
1070
M_Φ in the fit (MeV)

$$E_{cm} = 3630\, MeV$$



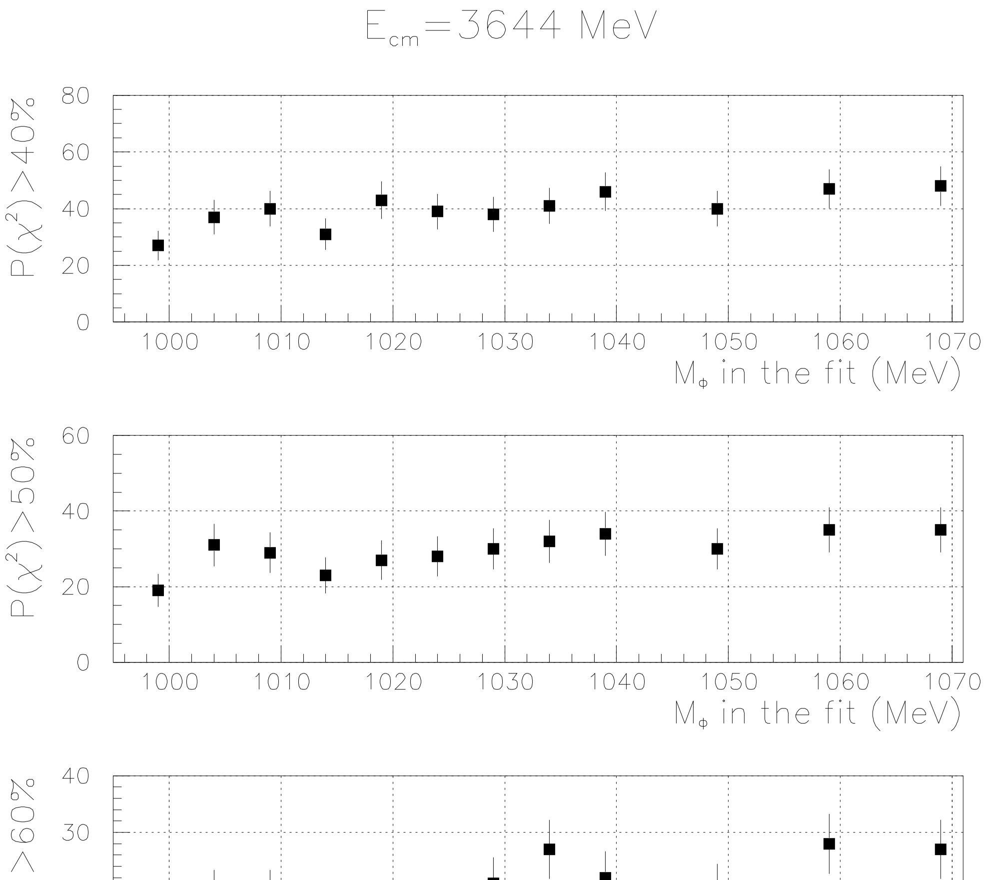
E_cm=3630 MeV
P(χ²)>40%
120
100
80
60
1000
1010
1020
1030
1040
1050
1060
1070
M_φ in the fit (MeV)
P(χ²)>50%
100
80
60
40
1000
1010
1020
1030
1040
1050
1060
1070
M_φ in the fit (MeV)
P(χ²)>60%
80
60
40
20
1000
1010
1020
1030
1040
1050
1060
1070
M_φ in the fit (MeV)

$E_{cm} = 3635\, MeV$



E_cm=3635 MeV
P(χ²)>40%
120
100
80
60
40
1000
1010
1020
1030
1040
1050
1060
1070
M_φ in the fit (MeV)
P(χ²)>50%
80
60
40
20
M_φ in the fit (MeV)
P(χ²)>60%
60
40
20
0
M_φ in the fit (MeV)

$$E_{cm} = 3644\ MeV$$



E_cm=3644 MeV
P(χ²)>40%
80
60
40
20
0
1000
1010
1020
1030
1040
1050
1060
1070
M_φ in the fit (MeV)
P(χ²)>50%
60
40
20
0
1000
1010
1020
1030
1040
1050
1060
1070
M_φ in the fit (MeV)
P(χ²)>60%
40
30
20
10
0
1000
1010
1020
1030
1040
1050
1060
1070
M_φ in the fit (MeV)

Background study

From the background level we can say which is the minimum efficiency of the analysis, that allow us to see a $\phi\phi$ signal

The data have been fitted with a straight line: $y = const$ (where $const$ is the mean background level)

Energy (MeV)	$\int L\,dt$ (pb^{-1})	$< N_{bkg} >$ ($Events$)	$< N_{bkg} > / \int \mathcal{L}\,dt$ ($Events/pb^{-1}$)
3620.6	1.27	98.6 ($P(\chi^2) > 0.4$) 72.9 ($P(\chi^2) > 0.5$) 50.0 ($P(\chi^2) > 0.6$)	77.6 57.4 39.4
3629.7	1.19	91.2 ($P(\chi^2) > 0.4$) 66.3 ($P(\chi^2) > 0.5$) 45.6 ($P(\chi^2) > 0.6$)	76.6 55.7 38.3
3635.4	0.971	73.3 ($P(\chi^2) > 0.4$) 52.6 ($P(\chi^2) > 0.5$) 35.1 ($P(\chi^2) > 0.6$)	75.6 54.2 36.1
3644.2(*)	1.72	38.7 ($P(\chi^2) > 0.4$) 28.6 ($P(\chi^2) > 0.5$) 18.6 ($P(\chi^2) > 0.6$)	22.5 16.6 10.8

(*)For this energy point the trigger efficiency was almost 4 times lower

Possible improvements at the η_c'

In order to distinguish the signal 2σ above the background, for $P(\chi^2) > 0.5$, we have to observe 15 events/pb^{-1}

The total efficiency of the analysis must be at least: $\varepsilon_{tot} = 0.06$ (now is 0.015)

$$\varepsilon_{tot} = \varepsilon_{trig} * \varepsilon_{pres} * \varepsilon_{fit} * acceptance * [1 - P_{decay}]$$

- ε_{trig} can be improved from 0.3 to 0.6 optimizing the logics for the η_c' energy)

- ε_{fit} and $acceptance$ don't change

- $[1 - P_{decay}]$ can be increased from 0.59 to 0.89 if we don't use CCAL

$\Rightarrow$ $\varepsilon_{pres} \geq 0.69$ (now is 0.51)

this value can be reached if $\varepsilon_{4tracks} \geq 0.9$ (now is 0.67 due to association with CCAL that will be removed)

Conclusions

We considered the possibility of studing the reactions:

$$\overline{p}p \to \eta_c, \eta_c' \to \phi\phi \to 4K^{\pm}$$

Monte Carlo study, about the feasibility of a charged trigger to select those events, gave positive results: ($\varepsilon_{trig} \simeq 65\%$, $R \simeq 1000$)

The $\phi\phi$ trigger was built and implemented

The data taken with this trigger have been analyzed with the following results:

$\eta_c \Rightarrow$ $\boxed{\sigma_{\phi\phi} \; = \; (3.3 \pm 1.5)\; nb}$

to be compared with:

$$\sigma_{\phi\phi} = (1.85 \pm 0.9)\; nb \qquad \text{(B.W.)}$$

$$\sigma_{\phi\phi} = (6.0 \pm 2.0)\; nb \qquad \text{(R704)}$$

$\eta_c' \Rightarrow$ no signal (background too high).

The study of the η_c' was beyond the possibility of the $E835$ apparatus.
At the η_c' energy It can be possible to observe a $\phi\phi$ signal, 2σ above the background if we don't use CCAL to associate the tracks.

Status of the new SCI-FI detector costruction

- VLPC: characterized
- FIBERS
  - fiber testing setup: ready
  - polishing machine: ready
  - aluminization: to be checked
  - splicing machine: to be calibrated
- CYLINDERS: ready to be machined
- DISCRIMINATORS: assembling started