

Part I: Identifying and counting $K_S \rightarrow 2\pi^0$ KL crash

Pre-selection and definitions:

for any of the unordered $\binom{4}{N_{cl}}$ combinations of 4 from N_{cl} clusters in the event:

(to ease calculations only events with $N_{cl} \leq 30$ are considered ($\leq 0.1\%$ events rejected))

CUTS:

$$20 \text{ MeV} \leq E_{cl,i} \leq 300 \text{ MeV} \quad i = 1, 4$$

$$\theta_{cl,i} \geq 21^\circ \quad i = 1, 4$$

Constructed variables for each 4 cluster combination

$$T_{av} = \frac{1}{4} \sum_{i=1}^4 \left(T_{cl,i} - \frac{R_{cl,i}}{c} \right)$$

$$\sigma(T_{av}) = \sqrt{\left(T^2 \right)_{av} - T_{av}^2}$$

Assuming the 4 clusters correspond to 4 photons emitted from IP,

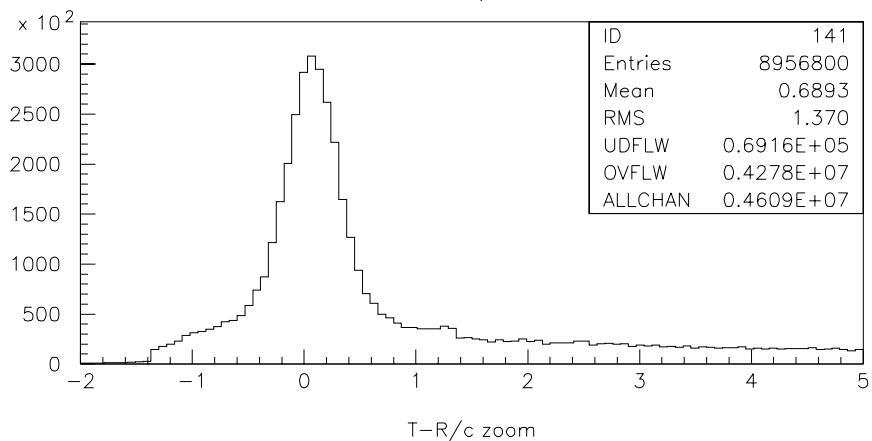
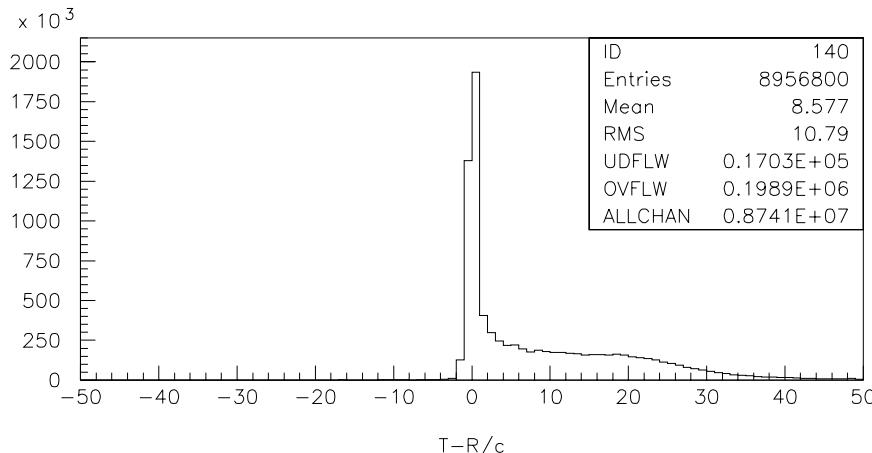
$E_{TOT}, M_{INV}, \vec{P}_{TOT}$ are also defined accordingly.

Note: (i) definition of $\sigma(T_{av})$ independent of T_0 .

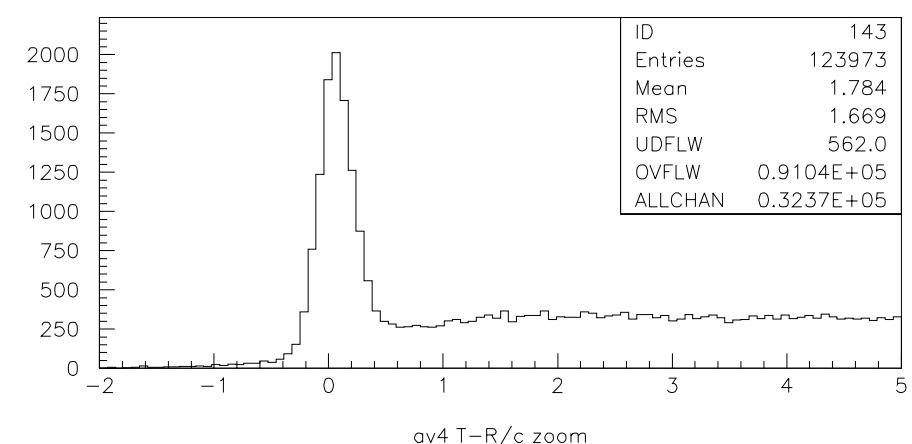
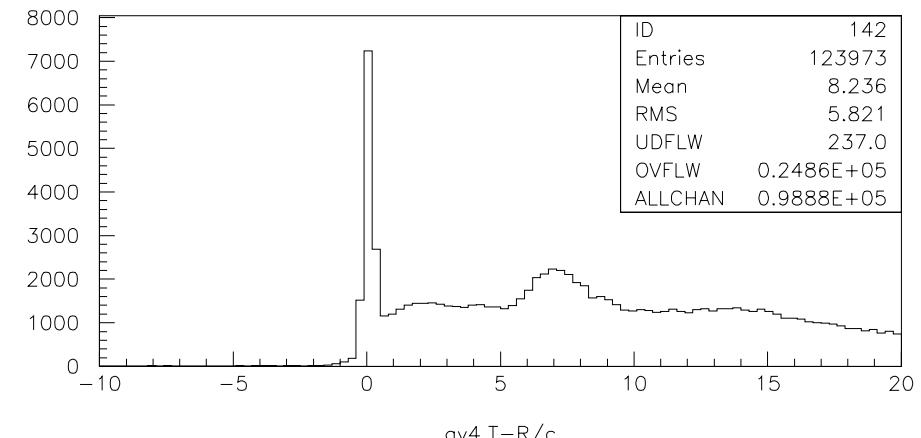
(ii) no use of definition of neutral cluster (no use of Track-to-Cluster TCA algorithm)

AFTER PRESELECTION

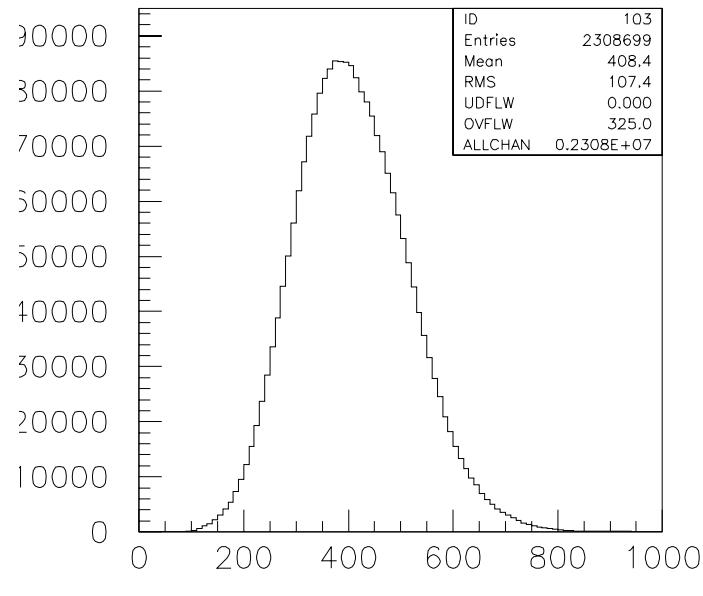
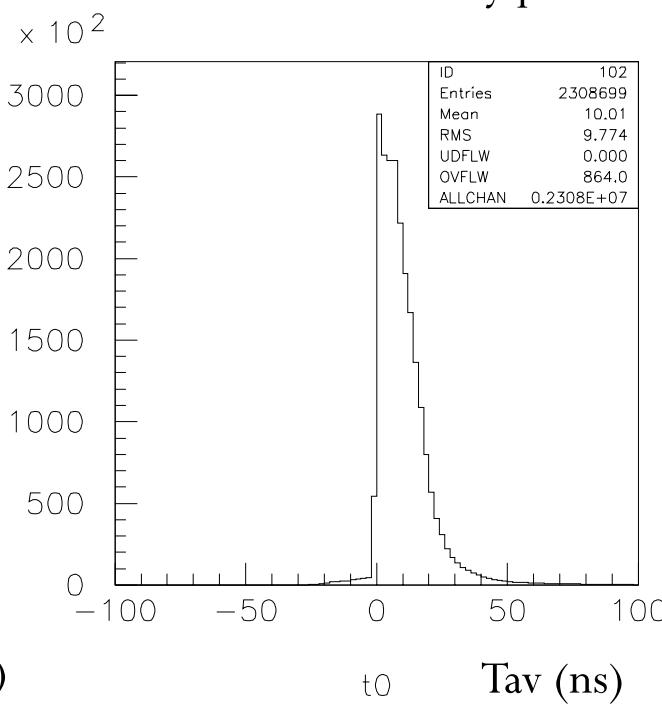
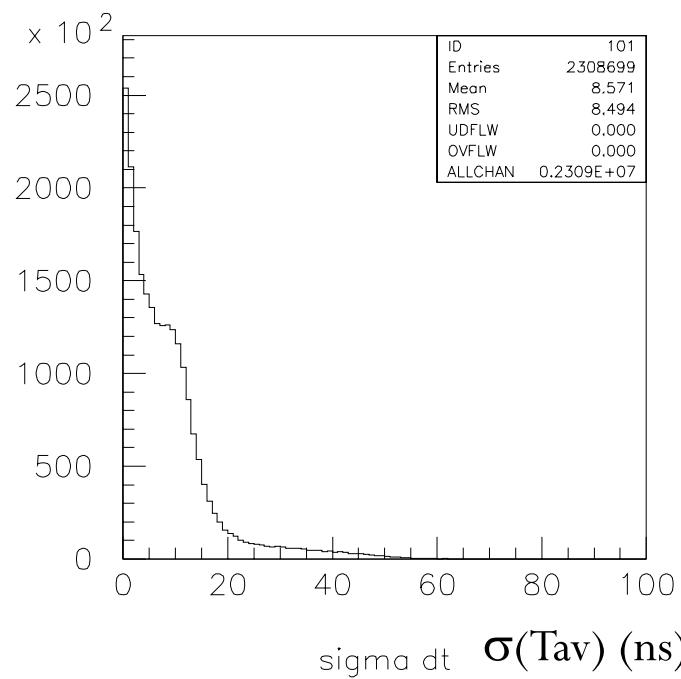
In these histograms: all 4 clusters combinations
 => more than 1 entry per event



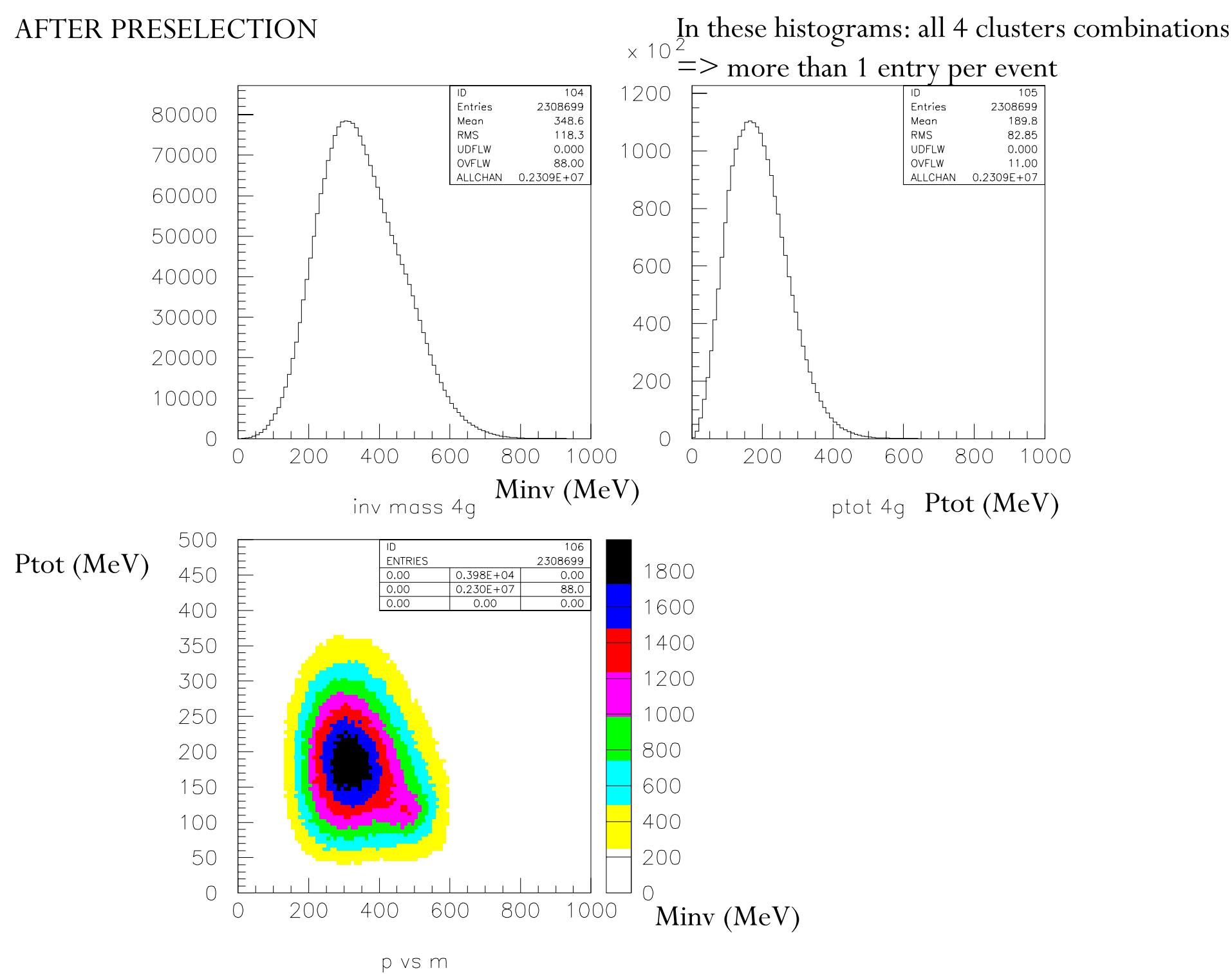
In these histograms: one 4 clusters combination
 => 1 entry per event



AFTER PRESELECTION



AFTER PRESELECTION

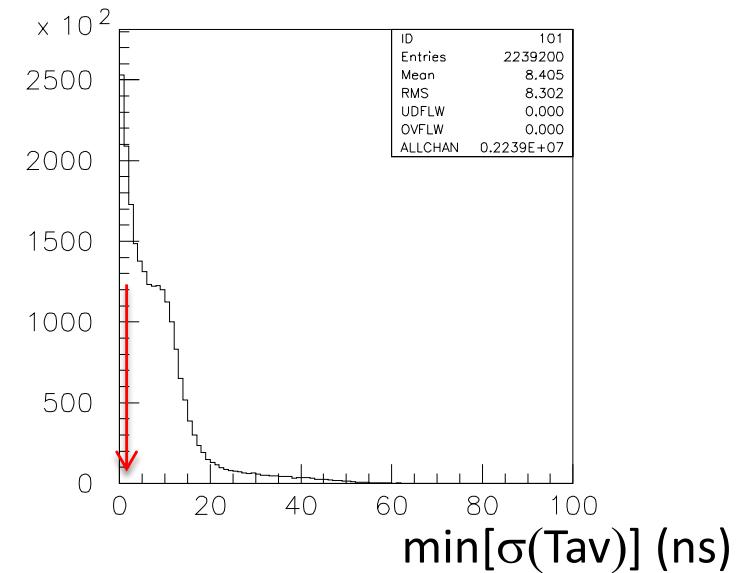


Selection:

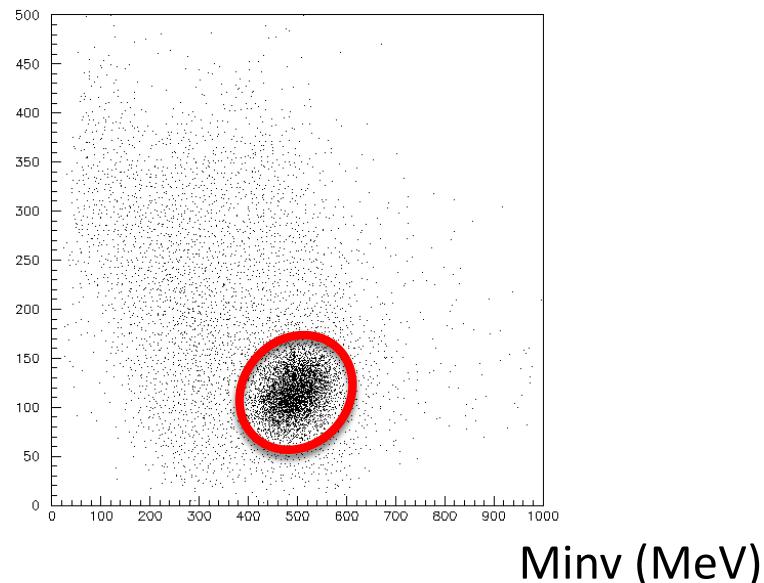
cut 1) $\min[\sigma(T_{av})] < 600 \text{ ps}$

cut 2) Ellipse cut in the plane $\{M_{INV}, |\vec{P}_{TOT}| \}$

to select neutral kaons around the point (498 MeV, 110 MeV)

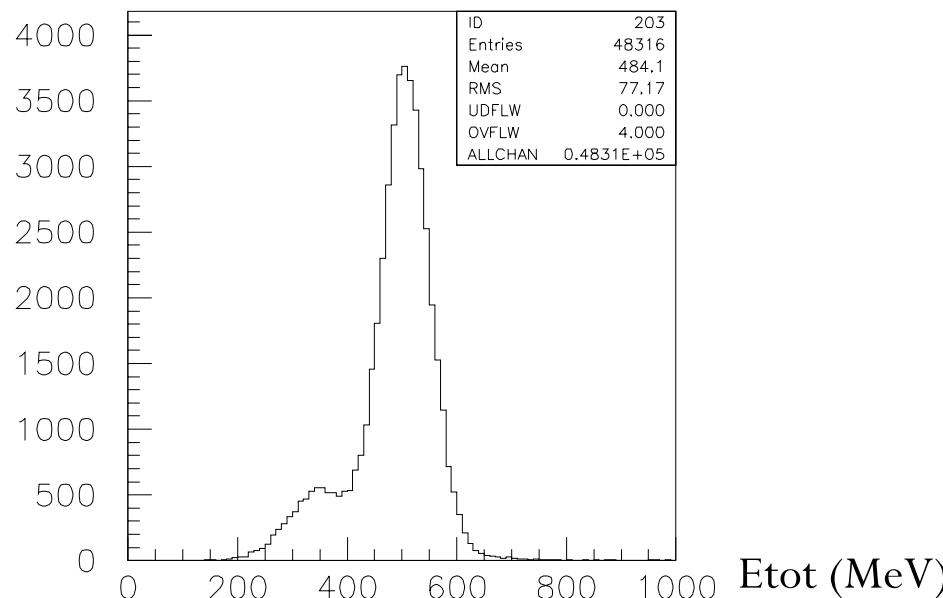
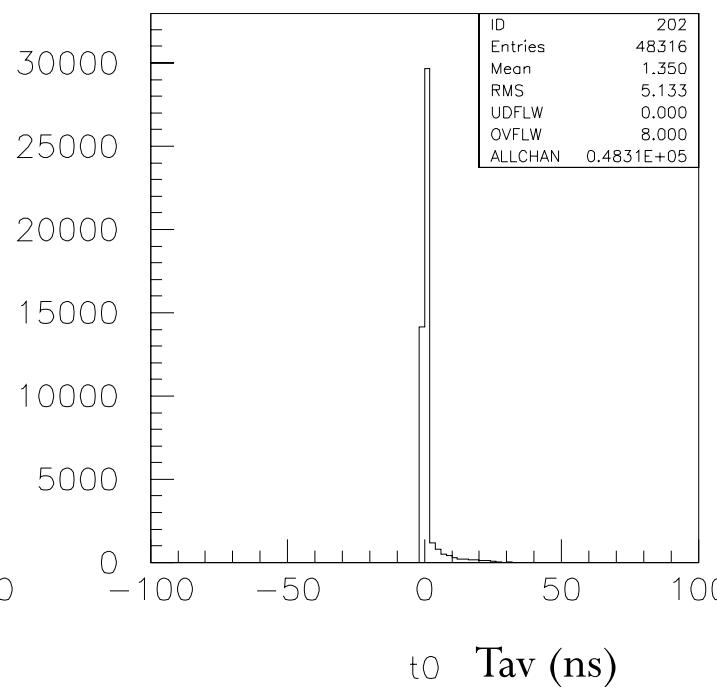
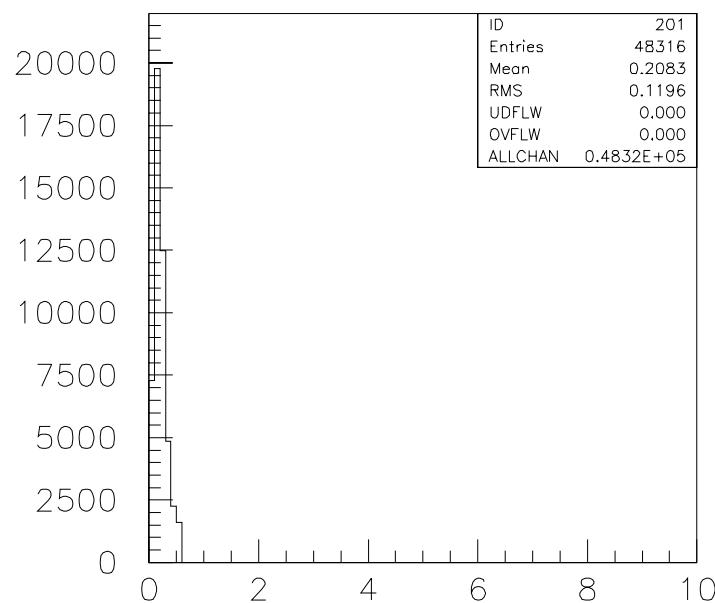


Ptot (MeV)

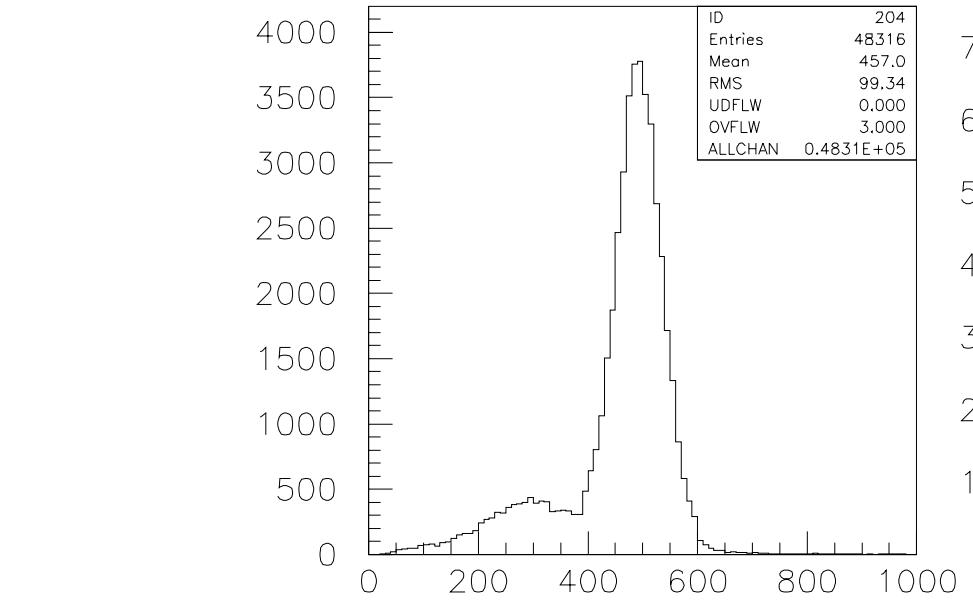


AFTER CUT 1)

In these histograms: one 4 clusters combination
=> 1 entry per event

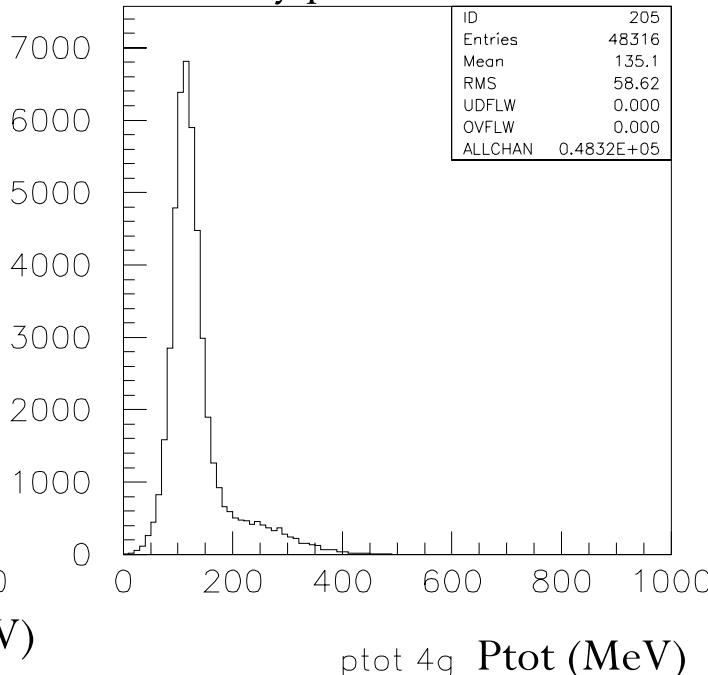


AFTER CUT 1)

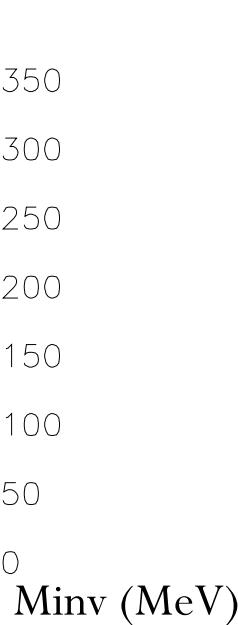
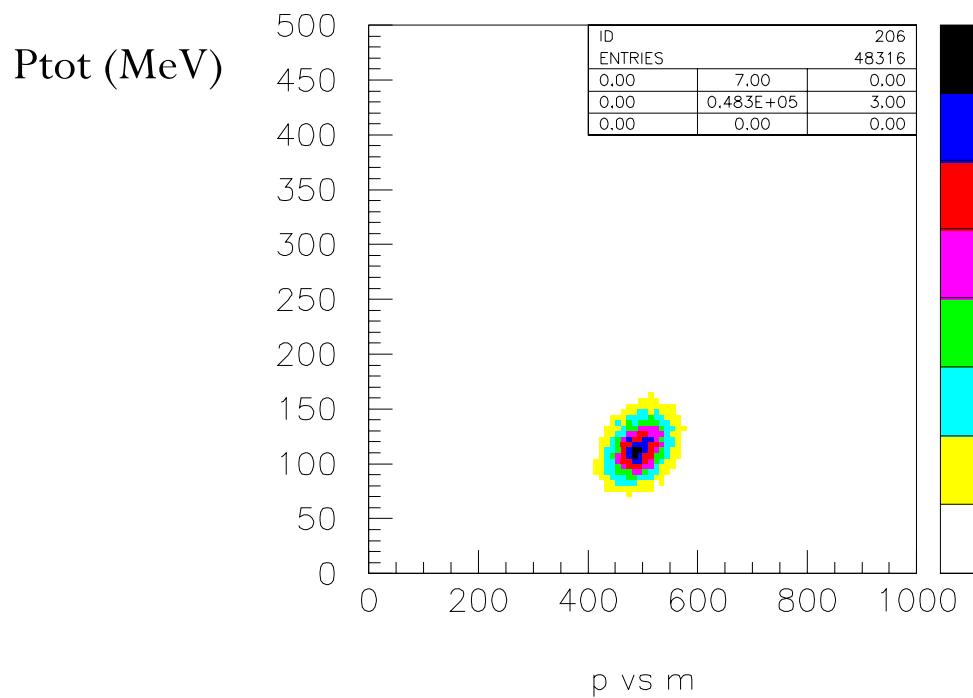


inv mass 4g M_{inv} (MeV)

In these histograms: one 4 clusters combination
=> 1 entry per event

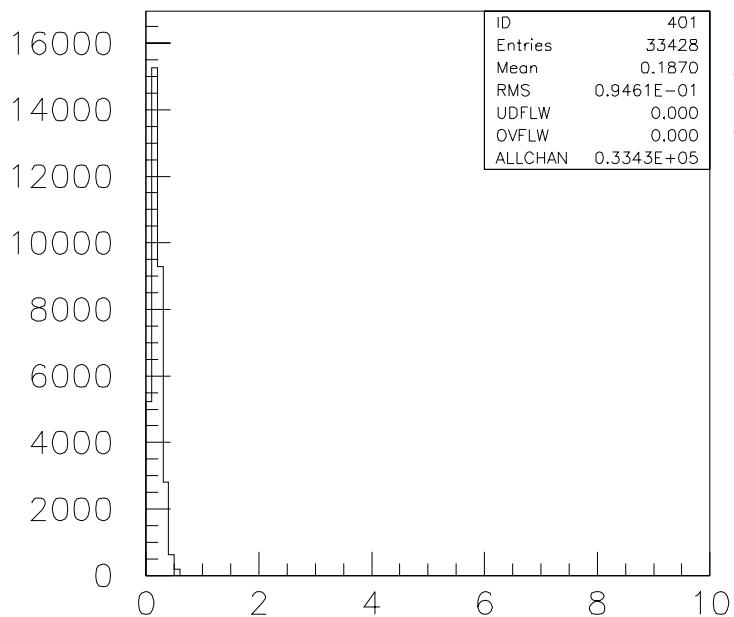


ptot 4g P_{tot} (MeV)

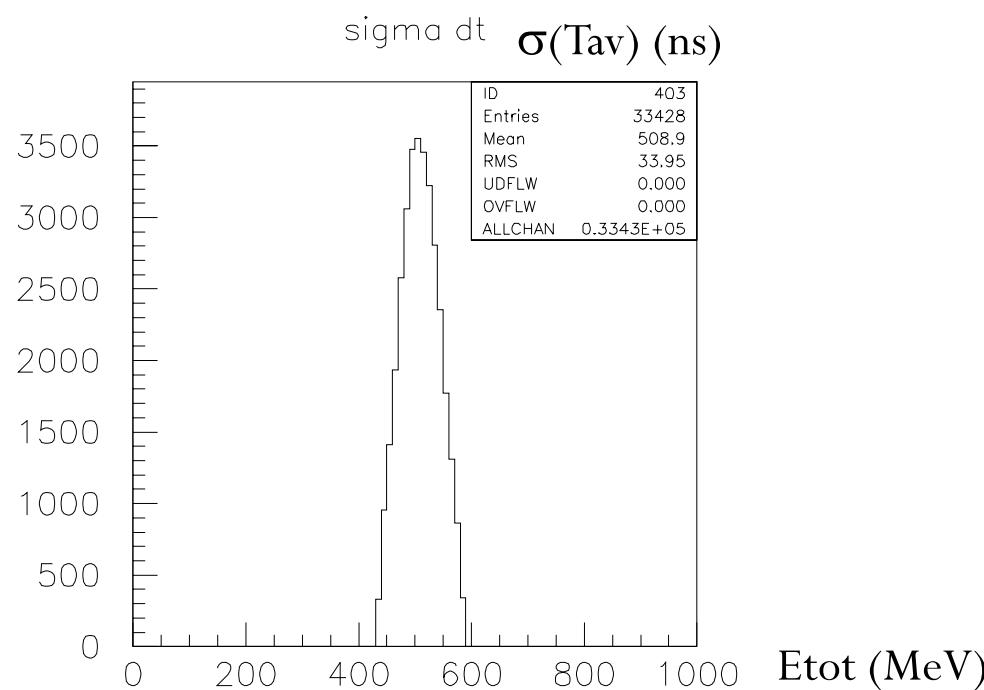
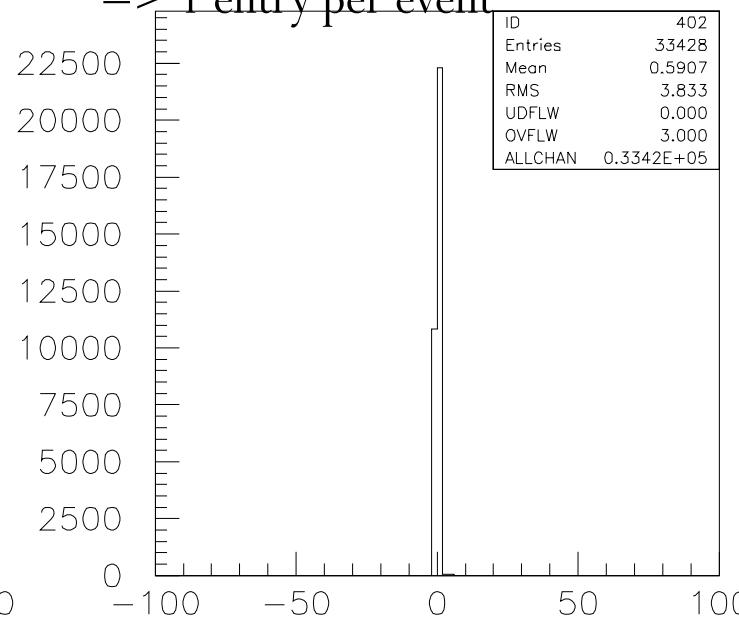


p vs m

AFTER CUT 2)

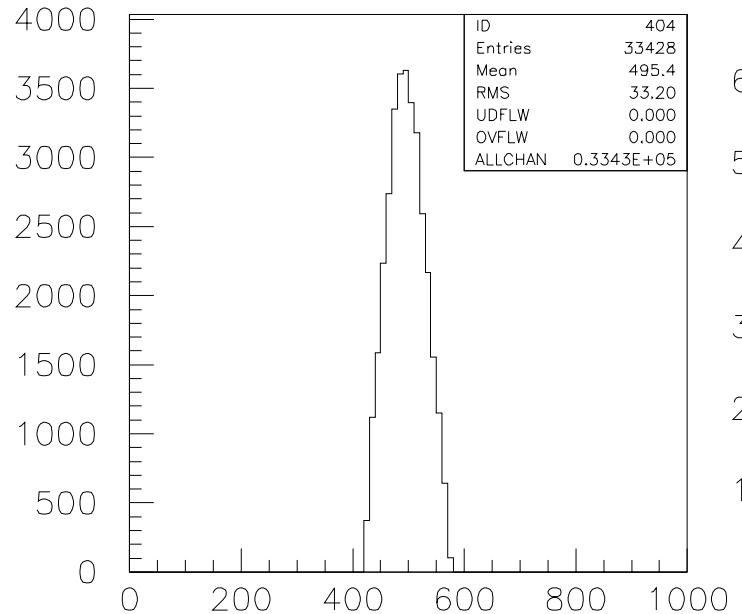


In these histograms: one 4 clusters combination
=> 1 entry per event

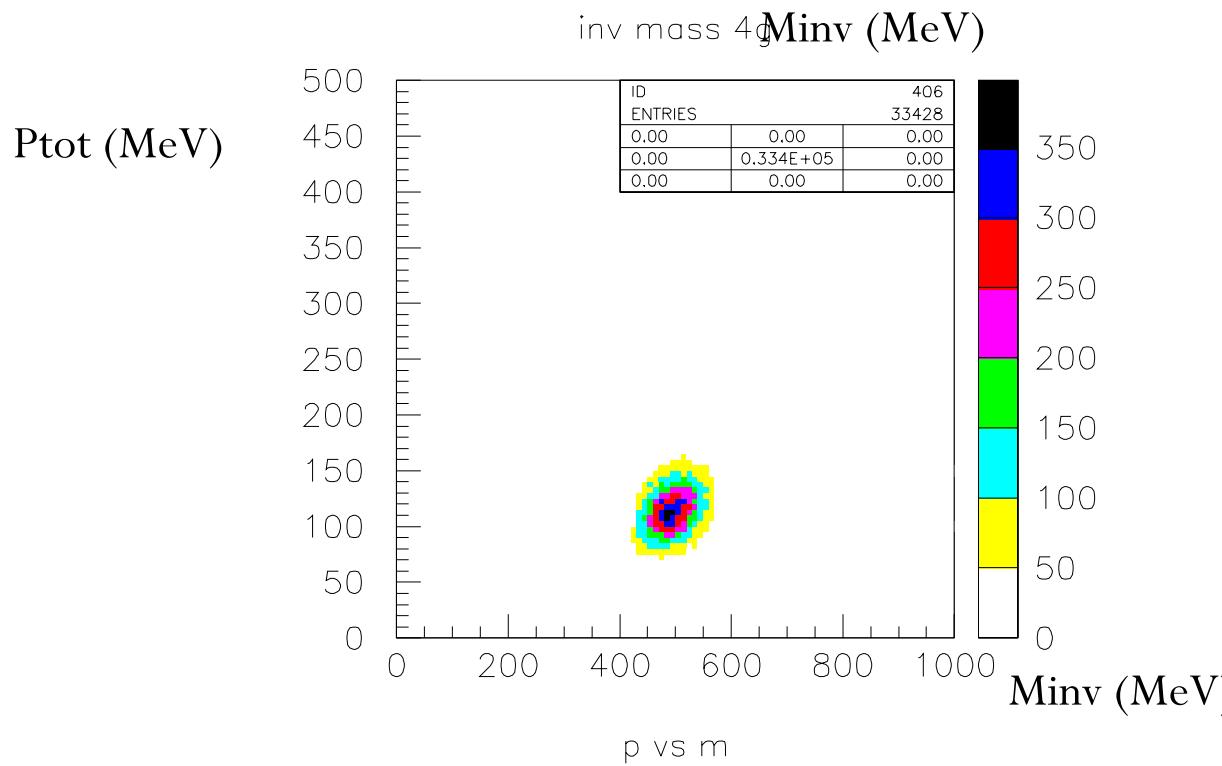
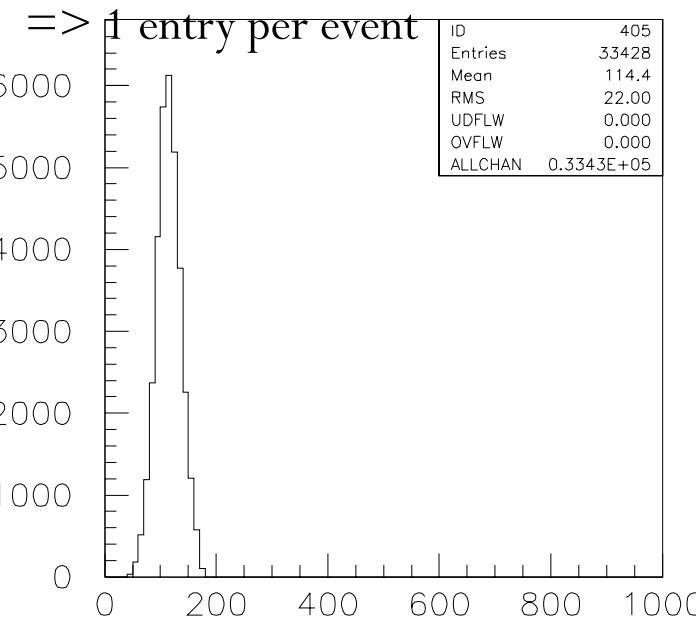


t₀ Tav (ns)

AFTER CUT 2)



In these histograms: one 4 clusters combination



Selection of a “clean” sample of KS->2pi0 Klcrash
with no use of TCA algorithm and independent of T0:

cut 3)

Find one among the “remaining” Nclu-4 clusters that satisfies:
 $E_{\text{clu}} > 150 \text{ MeV}$

Cut 4)

$$\begin{aligned} \cos \alpha &> 0.99 \\ |\Delta T| &< 5 \text{ ns} \end{aligned}$$

with $\Delta T = T_{\text{av}}(\text{KS}->2\pi 0) - [T(\text{Klcrash}) - R/c \beta_{KL}]$

and

$$\cos \alpha = \frac{\vec{R}_{KLcrash} \cdot \vec{p}_{KL}}{|\vec{R}_{KLcrash}| |\vec{p}_{KL}|}$$

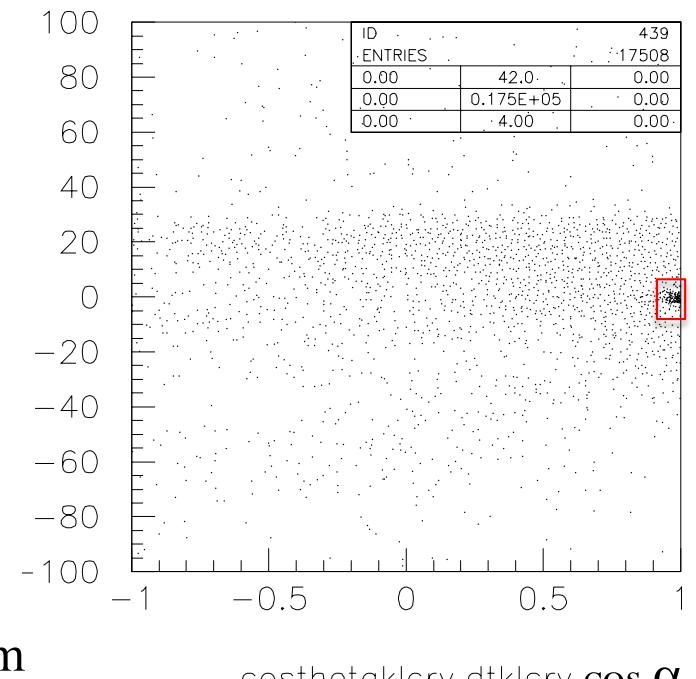
with

$\vec{R}_{KLcrash}$ KL crash direction

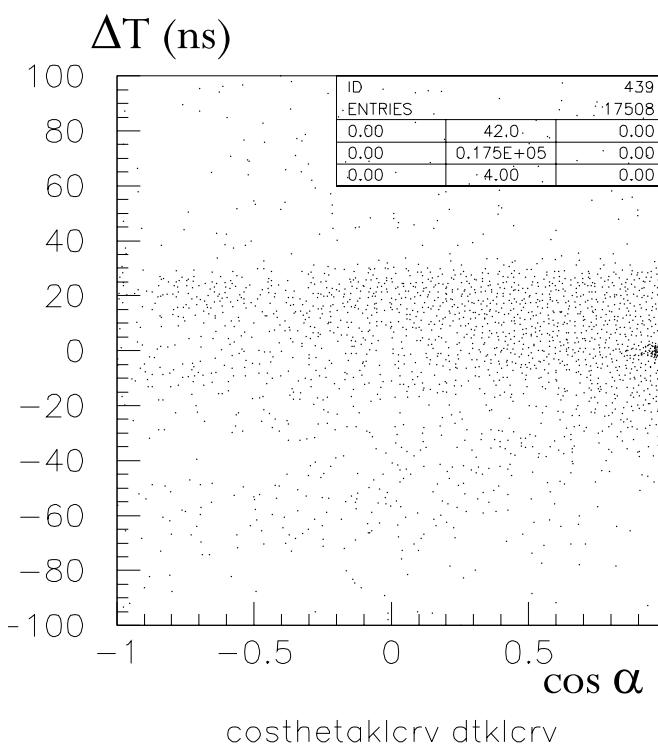
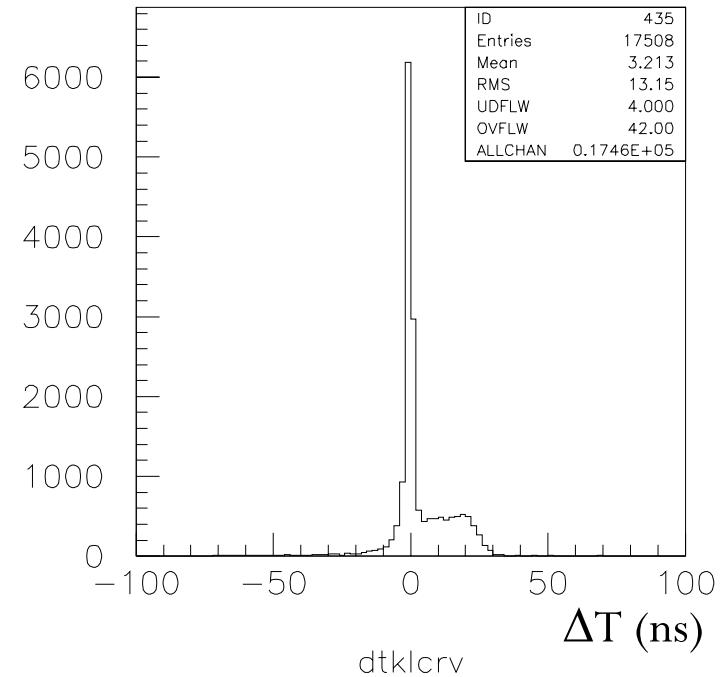
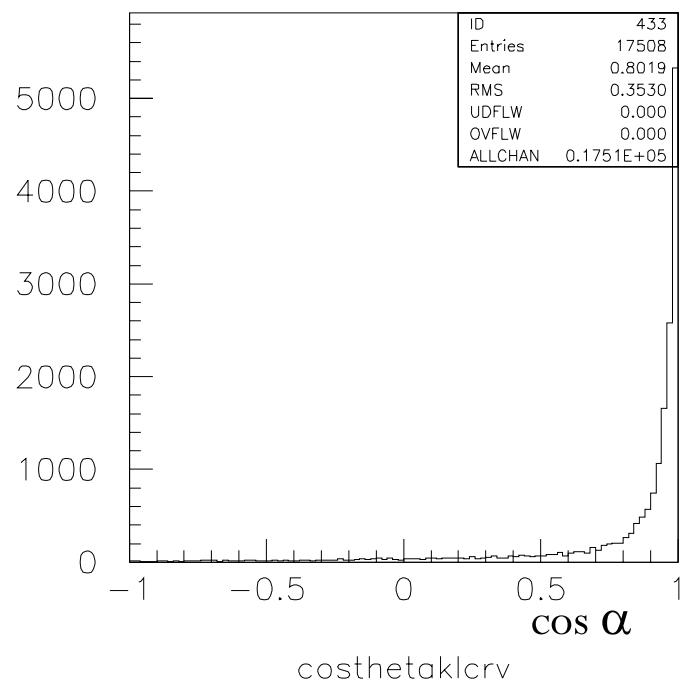
\vec{p}_{KL} reconstructed from the KS-> $2\pi 0$, the ϕ momentum

(from Bhabha - run-by-run) and imposing the ϕ 2-body kinematics.

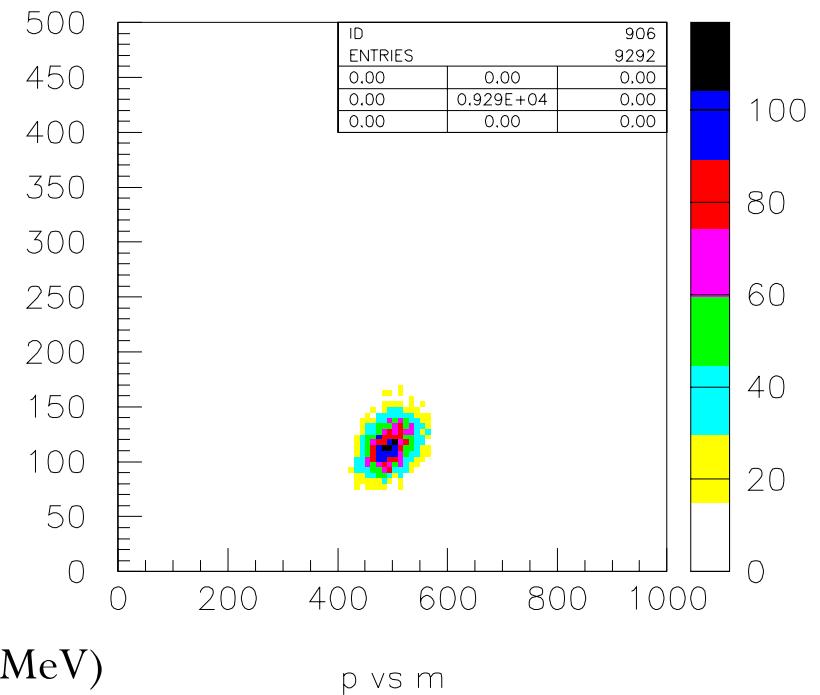
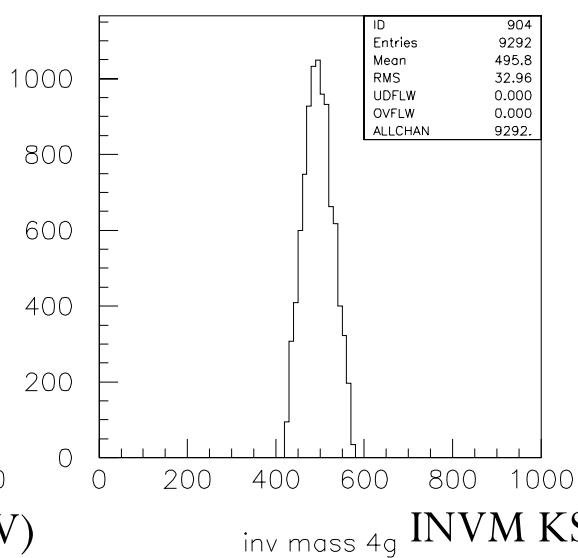
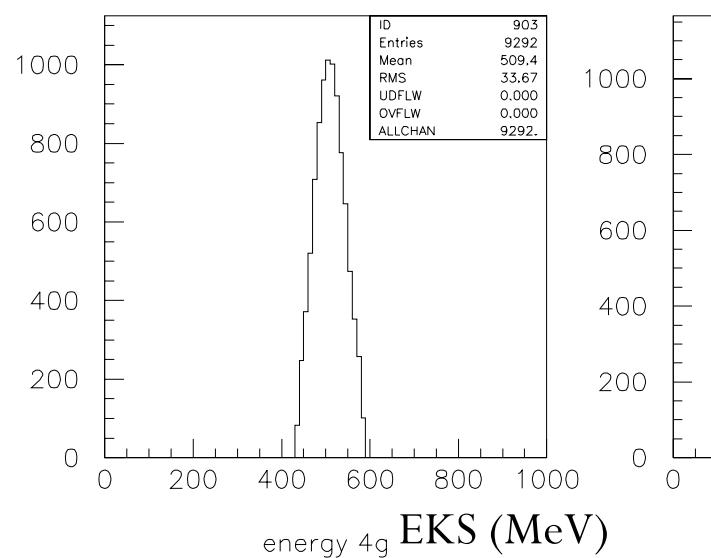
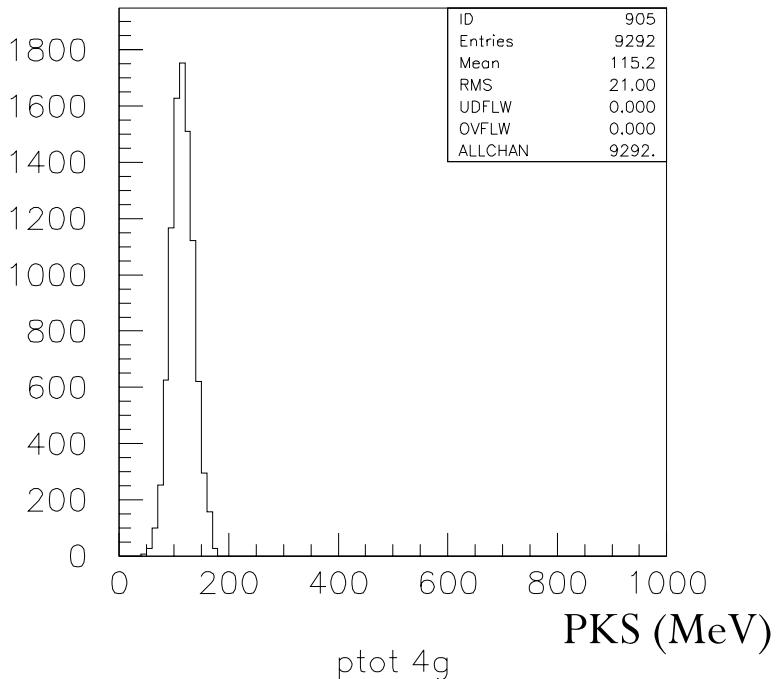
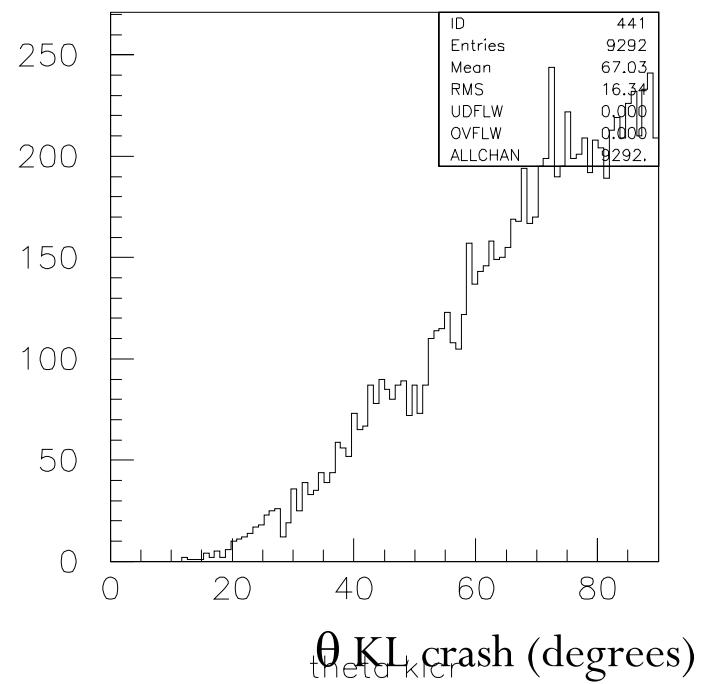
$\Delta T \text{ (ns)}$



AFTER CUT 3)



AFTER CUT 4)



L= 201.9 nb-1

SUMMARY

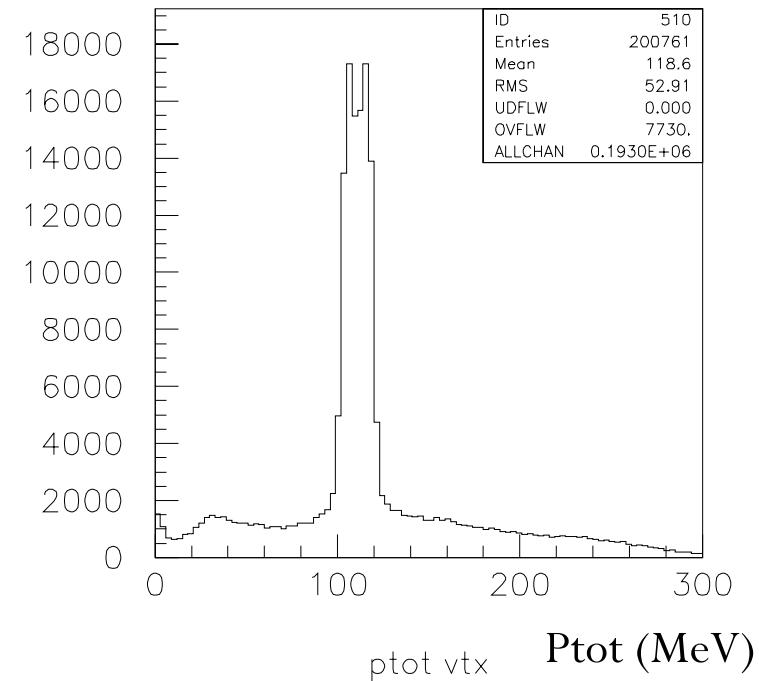
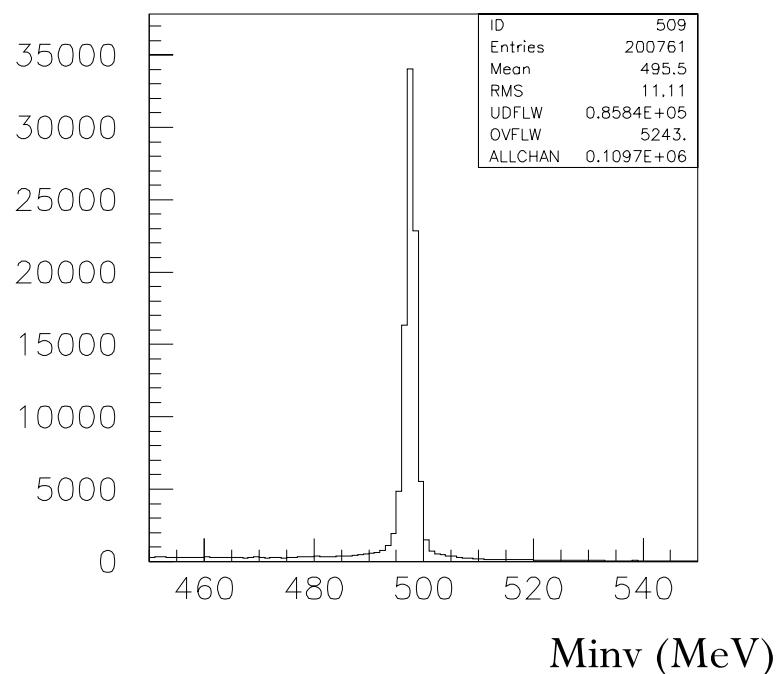
Selection	# KS 2p0 signal candidate events	# ev./nb-1	cut relative efficiency (%)	total relative efficiency (%)
ksl stream	254328	1260	-	-
preselection	123973	614	48.7	48.7
after cut 1)	48316	239	38.9	19.0
after cut 2)	33428	165	69.2	13.1
after cut 3)	17508	86.7	52.4	6.88
after cut 4)	9292	46.0	53.1	3.65

Part II: Identifying and counting $K_S \rightarrow \pi^+ \pi^-$ KL crash

Preselection:

At least one vertex with 2 tracks of opposite curvature
If more than one vertex is found, the closest to IP is selected.

AFTER preselection



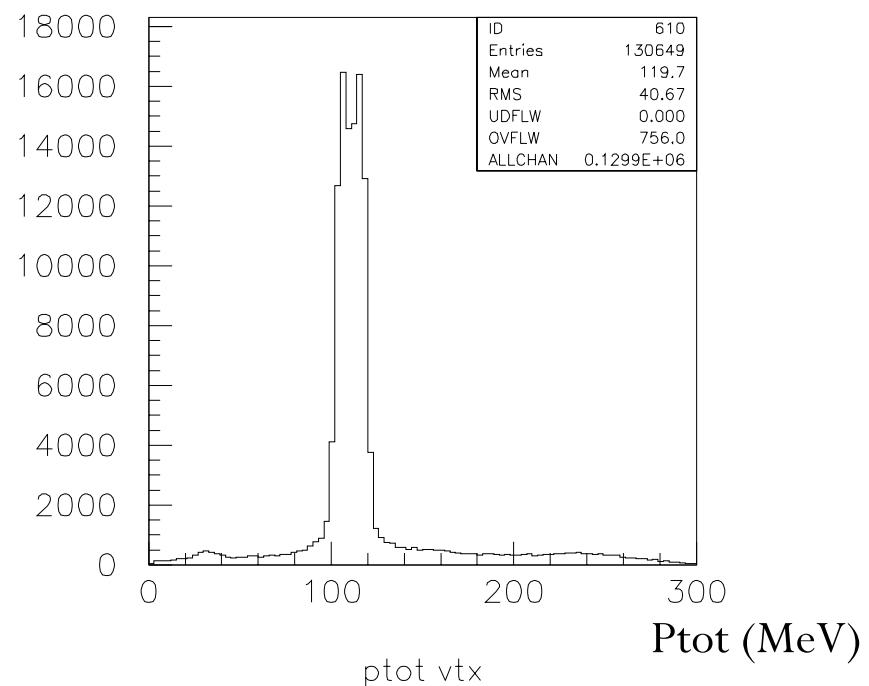
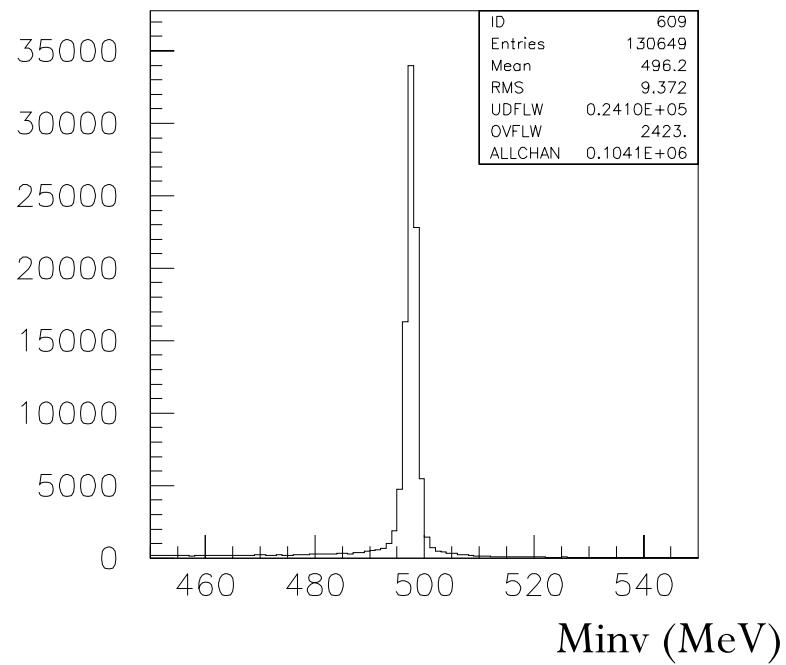
Selection:

Selection Cut 1) (1 vtx close to IP)

2 tracks of opposite curvature forming a vertex in the fiducial volume :

- Rhovtx <15 cm
- |zvtx|<10 cm

AFTER CUT 1)



Selection Cut 2) (Klcrash)

$E_{\text{clu}} > 150 \text{ MeV}$

$\cos \alpha > 0.99$

$|\Delta T| < 5 \text{ ns}$

with $\Delta T = [T(\text{Klcrash}) - R/c \beta_{KL}]$

and

$$\cos \alpha = \frac{\vec{R}_{KLcrash} \cdot \vec{p}_{KL}}{|\vec{R}_{KLcrash}| |\vec{p}_{KL}|}$$

with

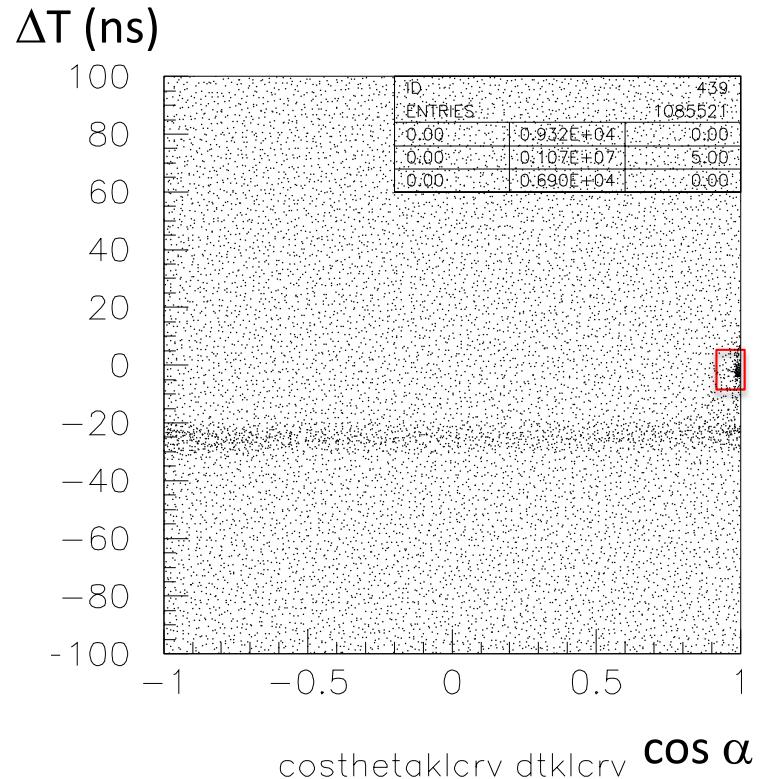
$\vec{R}_{KLcrash}$ KL crash direction

\vec{p}_{KL} reconstructed from the $\text{KS} \rightarrow \pi\pi$, the ϕ momentum

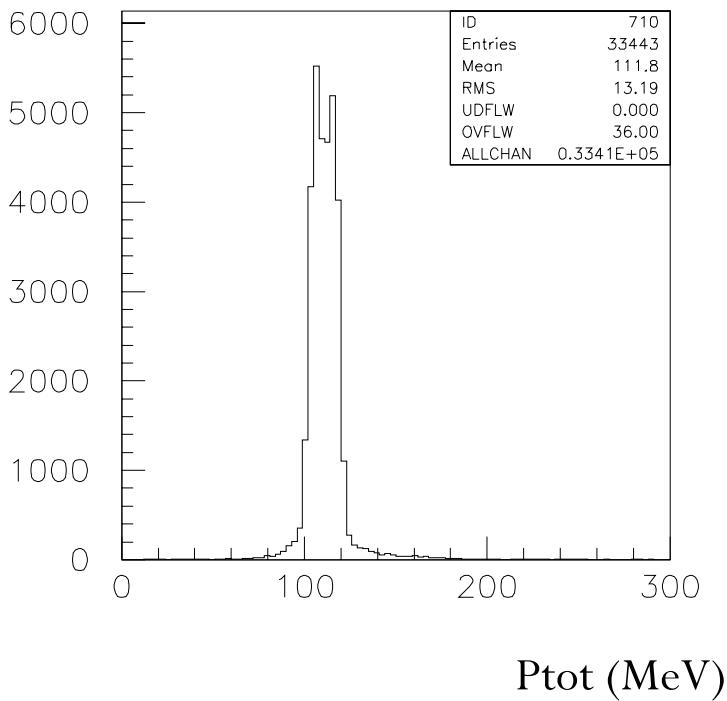
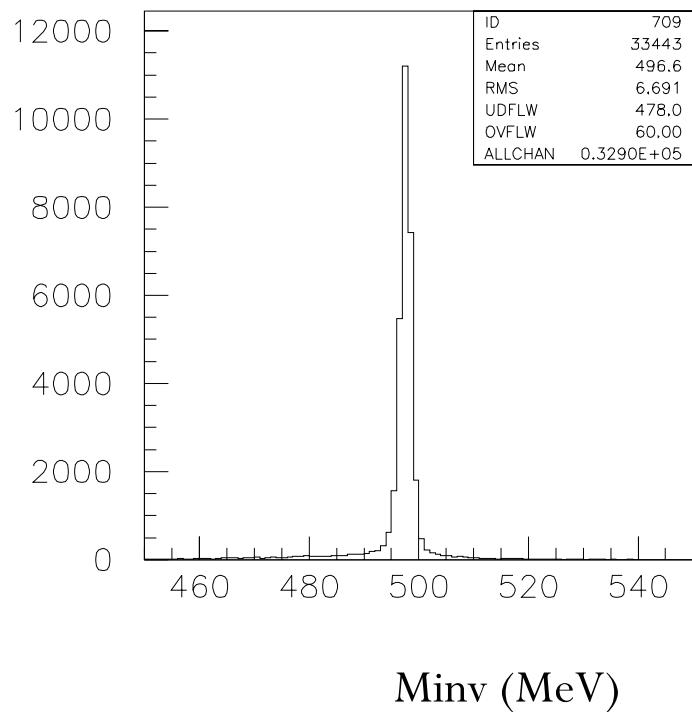
(from Bhabha - run-by-run) and imposing the ϕ 2-body kinematics.

No use of TCA algorithm.

Klcrash selection might be improved using TCA time of at least one pion track with $\Delta T = T(\text{KS} \rightarrow p+p-) - [T(\text{Klcrash}) - R/c \beta_{KL}]$ which is independent of T_0 .



AFTER CUT 2)



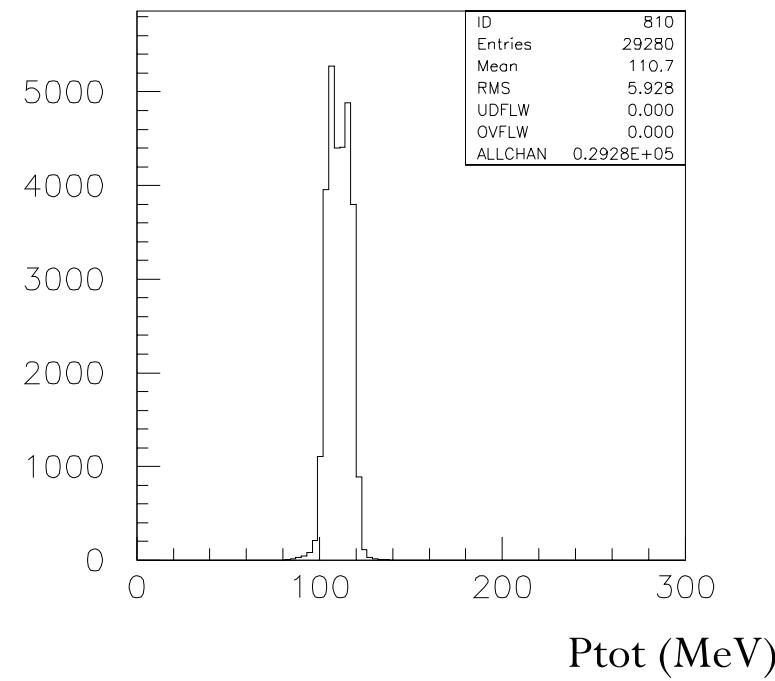
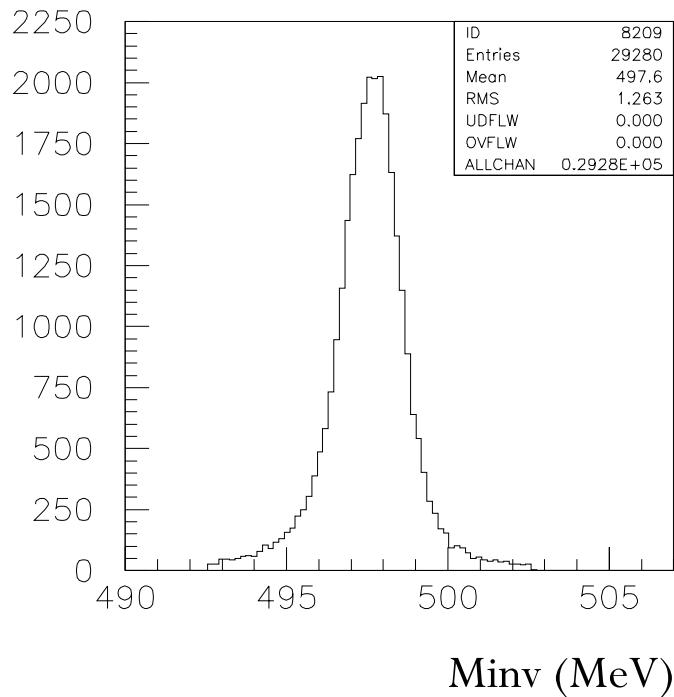
Selection Cut 3)

Counting events $K_S \rightarrow p + p^-$

$$|M_{inv} - M_{K^0}| < 5 \text{ MeV}$$

$$80 \text{ MeV} < P_{tot} < 140 \text{ MeV}$$

AFTER CUT 3)



L= 201.9 nb-1

SUMMARY

Selection	# KS p+p- signal candidate events	# ev./nb-1	cut relative efficiency (%)	total relative efficiency (%)
ksl stream & preselection	200761	994	-	-
after cut 1)	130649	647	65.1	65.1
after cut 2)	33443	166	25.6	16.7
after cut 3)	29280	145	87.6	14.6