DARMSTADTON HUNTING IN γ-CRYSTAL INTERACTION

NA46 Collaboration

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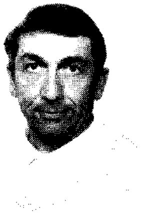

ABSTRACT:

Preliminary results from the experiment NA46 at the CERN SPS are presented.The (e^+e^-) mass spectra give indications for a mass at 2.2 Mev $\tau \approx 2.10^{-13}$s (4σ) and a mass at 10.1 Mev $\tau \approx 10^{-13}$s (3σ).A mass at 3.4 Mev with $\tau \approx 3.10^{-12}$s would fit the observed remaining events between 3.2 and 7.4 Mev.

A limit for the observation of the 1.8 Mev mass seen at Darmstadt is given.

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The experimental observation of correlated e^+e^- peaks obtained in heavy ion collisions has been interpreted as the decay of an hypothetical neutral object at a mass of 1.8 Mev [1] having an extended size of ≈1000 fermi [2] and therefore escaping to sensitive beam dump experiments.

Its observation in the interaction of photons in a crystal has two distinctive advantages (as already discussed in [3]&[4]): - i)the strong coulomb field,if it is the clue of the production(there will be in the crystal a strong field of the same order of that involved in heavy ions collisions) - ii)the rather wide free space between the crystal rows;the extended size of this object does not make its detection so difficult as in the case of ordinary matter : it will have the possibility to escape out of a crystal before decaying.

We report here on the preliminary results obtained by the experiment NA46 carried out at CERN SPS,in the interaction of γ (≈100 Gev) on a Ge crystal <110>,400 μm,100 ^{0}K.The set-up is shown on Fig.1.A beam of 150 Gev e^- of low divergence (50 μrad) , with a diameter of 8 mm is incident on a lead converter 0.5 mm thick.The resulting photons are tagged by the e^- bent by the magnet B1.A further magnet B2 is used to clean up the beam from all remaining charged particles.The photons encounter a Ge<110> crystal 400 μm thick where they produce e^+e^- pairs and possibly new neutral particles.The production of Bethe-Heitler e^+e^- pairs and the pair creation in strong field have already been studied using a similar set-up [5].The e^+e^- pairs travel in a vacuum pipe ≈78 meters long and under a residual magnetic field of less than 20 mGauss obtained by a μ metal shielding.They pass through a vacuum mylar window 100 μm thick and are detected by a set of

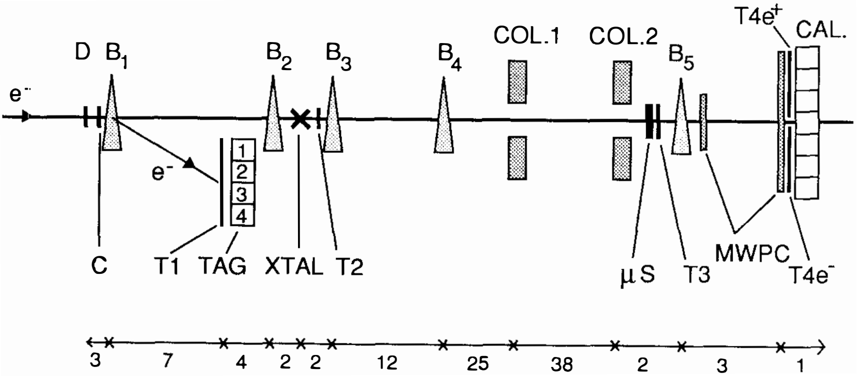

Fig 1.Experimental set-up.B1,B2,B3,B4,B5=magnets;D,C,T1,T2,T3,T4 =scintillation counters;COL1,COL2=collimators;μS=silicon μstrips; CAL=lead glass calorimeter;"short lifetime" mode=B3"off",B4 "off" "long lifetime" mode=B3"on",B4(160 Gauss-m).Distances in meters

silicon μstrips 20*20 mm^2 wide with a pitch of 50 μm.The energy of each e$^+$ and e$^-$ is measured by an analysing magnet B5 in a set of MWPC,and then absorbed in a lead glass detector where they are subsequently idendified.A "short lifetime" mode is defined by the magnets B3 "off" and B4 "off".A "long lifetime" mode is defined by the magnets B3 "on" (used to sweep out all pairs produced in the crystal) and the magnet B4 "on" working with a small field (160 Gauss-m)in order to limit the decay path:the mass measurement has thus to be corrected for the deviation.

The invariant mass is reconstructed using the separation in the μstrips,the momentum of e$^+$ and e$^-$,and assuming a decay length of 78 m for the "short lifetime" mode and 70 m for the "long lifetime" mode.The overall relative mass resolution is σ=4% for the "short lifetime" mode.

The mass spectrum of e$^+$e$^-$ pairs obtained for a run of 10 hours (10^4 γ/burst) in the "short lifetime mode" is shown on Fig.2.It shows a wide spectrum due to the "normal" production of e$^+$e$^-$ pairs in the crystal enlarged by the multiple scattering.This is in agreement with previous calculations.

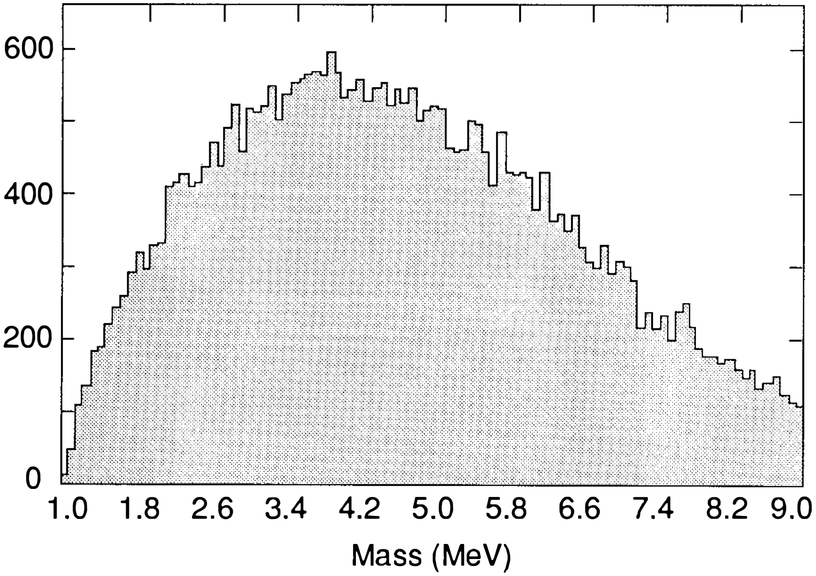

Fig 2. (e$^+$e$^-$)mass spectrum in "short lifetime" mode.

In order to improve the sensitivity to extra signals,we use the distribution of the distance between e$^-$ and e$^+$ in the horizontal plane (Fig 3).This distribution is not symetric, due to a possible slight tilt (20 μrad) of the crystal,which does not change much the alignment for strong field (200 μrad).This distribution shows that the e$^-$ spot is slightly displaced to the right and the e$^+$ one to the left.It could be used to enrich a signal from a possible neutral mass decay after the crystal(this neutral mass is assumed to have a symetric distribution around the beam direction).This is obtained in Fig.4

where a cut off at Y(e$^-$)-Y(e$^+$)>0 is applied.A signal at 2.2 Mev is then obtained with a statistical significance of 4σ.It should be pointed out that this signal is not a result of the above cut off.This is shown by a Monte Carlo calculation of the spectrum shape(Fig.4).The same spectrum is shown on

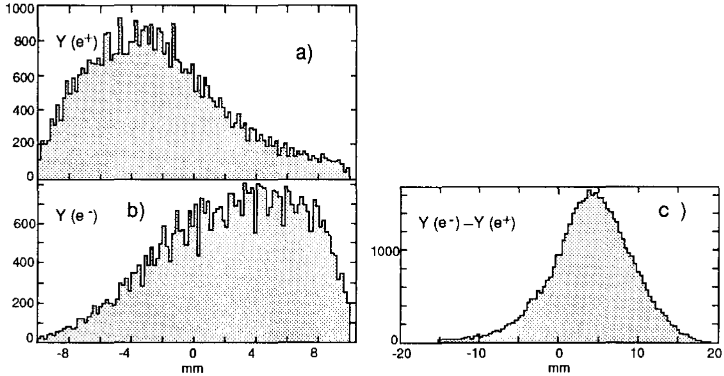

Fig 3.Histograms of the µstrips hits in the horizontal plan : 3a)Y(e$^+$); 3b)Y(e$^-$) ;3c)Y(e$^-$)-Y(e$^+$),i.e.difference between e$^-$ hit and e$^+$ hit.

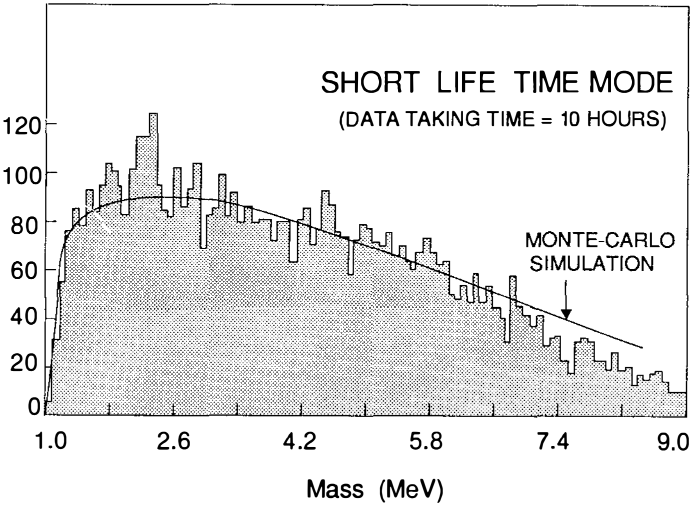

Fig 4.(e$^+$e$^-$) mass spectrum in "short lifetime" mode after a cut off at Y(e$^-$)-Y(e$^+$)>0.

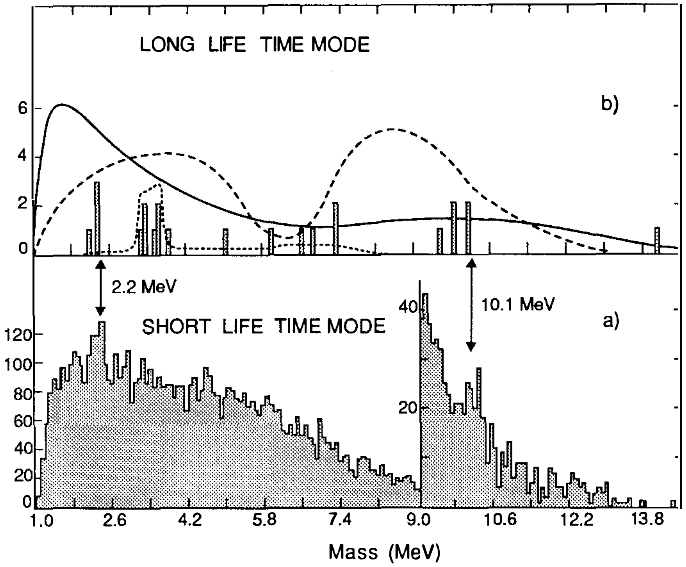

Fig 5.(e^+e^-) mass spectra :5a)"short lifetime" mode as Fig 4 ;5b)"long lifetime" mode [full line=mass acceptance; dashed line=*100 double bremstrahlung background; dotted line=*2 spectrum of a 3.4 Mev (e^+e^-) mass with $\tau=3.10^{-12}$ s decaying before or after the magnet B4].

Fig.5a together with the high part of the spectrum.This region of more limited statistic shows an other signal at 10.1 Mev,with a statistical significance of 3σ.

Fig.5b shows the spectrum obtained in the "long lifetime" mode after a run of 30 hours.The background coming from interactions with the vacuum residual gas is negligible.The background coming from interactions with the vacuum pipe and with the collimators is negligible.A more sophisticated kind of background comes from 2 γ interactions in the detectors.These 2 γ originate in the lead converter ("double bremstrahlung") and produce 2 (e^+e^-) pairs in the μstrips.Only one e^+ and one e^- are detected in the MWPC,the others are lost. This background was independently measured and calculated.It is estimated to be 3.5 events in Fig.5b.The mass spectrum shows again at 2.2 Mev a signal of 4 events in coincidence with the signal of Fig.5a,and a signal of 5 events in coincidence with the signal at 10.1 Mev of Fig.5a.The signals of Fig.5b taken alone would be of little statistical significance.However ,when they are associated with the spectrum of Fig.5a,they are taken as an indication for the decay of a mass at 2.2 Mev with $\tau\approx2.10^{-13}$s and a mass at 10.1 Mev with $\tau\approx1.10^{-13}$s.We should notice that the remaining events between 3.2 Mev and 7.4 Mev could be interpreted as the decay of a mass at 3.4 Mev with a lifetime of 3.10^{-12}s,some of which decay before the magnet B4 and some after,as represented on Fig.5b.

Ref.[6] [7] reported the possibility for mass values close to ours.

CONCLUSION:

In the interaction of 100 Gev photons with the strong field of a crystal (Ge<110>,400 μm,100 ^{0}K),we observed indications of the production of two neutral particles which decay into e^+e^-:

$m_1=2.2$ Mev $\tau\approx 2.10^{-13}$s "relative yield"(m_1/e^+e^- pairs)$=2.10^{-3}$ (4σ)

$m_2=10.1$ Mev $\tau\approx 1.10^{-13}$s "relative yield"(m_2/e^+e^- pairs)$=1.10^{-3}$ (3σ)

A possible further signal at 3.4 Mev with $\tau\approx 3.10^{-12}$s is seen in "long lifetime" only.

The signal at 1.8 Mev seen at Darmstadt correspond in our "short lifetime" mode to a 2.4σ signal only,$\approx$30 times lower than the signal seen at Darmstadt.A diagram "lifetime/relative yield" is shown on Fig.6 for both mode of operation.The Bhabha scattering limit seems to exclude a large region of the plot,living "relative yield" $<10^{-4}$ and 7.10^{-12}s $< \tau <$ 10^{-10}s.However the Bhabha scattering limit is controversial for such an exotic object.

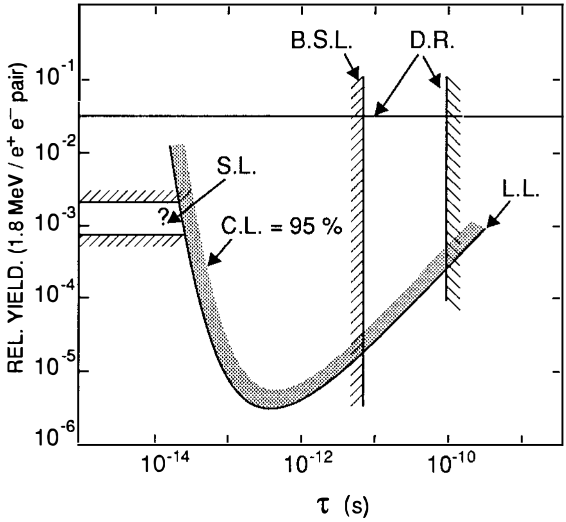

Fig 6.Lifetime and "relative yield" of the "Darmstadton" (1.8 Mev).[L.L.="long lifetime" mode ; S.L.="short lifetime" mode ; B.S.L.=bhabha scattering limit ; D.R.=Darmstadt results].

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