NOTAS DE FÍSICA

VOLUME VII

Nº 17

ON THE OBSERVATION OF FAST Σ HYPERONS EMITTED FROM THE INTERACTIONS OF K⁻ MESONS WITH EMULSION NUCLEI

by

B. D. Jones, B. Sanjeevaiah, J. Zakrzewski, P. G. Bizzeti, J. P. Lagnaux, M. René, M. J. Beniston, S. A. Brown, E. H. S. Burhop, D. H. Davis, D. Ferreira, E. Frota Pessoa, W. B. Lasich, N. N. Raina, M. C. Amerighi, A. Bonetti, M. Di Corato, C. C. Dilworth, C. A. Fedrighini, E. Quereigh, A. E. Sichirollo and G. Vegni

CENTRO BRASILEIRO DE PESQUISAS FÍSICAS

Av. Wenceslau Braz, 71

RIO DE JANEIRO

1960

Notas de Física Volume VII - Nº 17

ON THE OBSERVATION OF FAST Σ HYPERONS EMITTED FROM THE INTERACTIONS OF K^- MESONS WITH EMULSION NUCLEI *

B. D. Jones, B. Sanjeevaiah **, and J. Zakrzewski ***
H. H. Wills Physical Laboratory, Bristol

P. F. Bizzeti +, J. P. Lagnaux, and M. René ++
Laboratoire de Physique Nucléaire, Université Libre de Bruxelles

M. C. Amerighi, A. Bonetti, M. Di Corato, C. C. Dilworth,
C. A. Fedrighini, E. Quereigh, A. E. Sichirollo and G. Vegni
Istituto di Scienze Fisiche dell'Università, Milano
Istituto Nazionale de Fisica Nucleare - Sezione di Milano

M. J. Beniston, S. A. Brown ‡, E. H. S. Burhop, D. H. Davis,
W. B. Lasich, and N. N. Raina
Physics Department, University College, London

D. Ferreira ‡‡
Centro Brasileiro de Pesquisas Físicas

E. Frota-Pessoa ‡‡
Centro Brasileiro de Pesquisas Físicas and
Faculdade Nacional de Filosofia, Rio de Janeiro, Brazil

(Received January 3, 1961)

---

* Submitted to Il Nuovo Cimento.

** On leave from the University of Mysore.

*** On leave from the University of Warsaw.

\+ Now at Istituto di Fisica dell'Università, Firenze.

++ Now at Centre d'Études Nucleaires, Saclay.

‡ Now at University College, Ibadan, Nigeria.

‡‡ This work was performed when the authors (E.F.P. and D.F.) were at the University College, London.

SUMMARY

A study of fast baryons emitted from 12150 K^- meson interactions at rest in emulsion has been made in order to determine the nature and extent of K^- meson-multinucleon capture processes. Fast Σ hyperons are produced in at least 9 per cent of all interactions while direct Λ^0 hyperon production is indicated by the presence of 3 protons with energies exceeding 200 MeV. An upper limit of 30% is obtained for processes producing fast hyperons from consideration of π meson emission. The energy spectra for fast Σ hyperons and fast protons are given and mass determinations on a sample of so-called fast protons have revealed about 10% of deuterons and tritons. The suggestion in K^- European Collaboration Part II of an apparent infrequency of the reaction $K^- + n + n \longrightarrow \Sigma^- + n$ has been confirmed and an α-particle model of K^- meson multinucleon interaction has been put forward to explain both this and the emission of deuterons and tritons.

..*.*.*

Introduction

In continuation of the work of the K^- European Collaboration an effort has been made to study K^- meson multinucleon interactions at rest with emulsion nuclei. For this purpose a search has been made for fast Σ-hyperons of energies exceeding 60 MeV, since the presence of such a fast hyperon is the only certain indication that the capture has not taken place via a one-nucleon process. The experimental procedure and the results of the study of fast Σ

hyperons are given below.

Experimental Method

A stack of Ilford K5 emulsion of dimensions 18 × 20 × 18 cms. exposed to the filtered 300 MeV/c K^--meson beam from the Bevatron was used for this experiment. Grey tracks in the beam direction were picked up at about 1 cm. from the entrance edge of the stack and followed to their end points. Those track endings falling within 50 μm (unprocessed) of either emulsion interface were discarded, as were also K^-_ρ's or K^-_σ's whose only charged secondary was found to be a π meson. The number of K^-_σ stars so obtained has been corrected using the results presented elsewhere [1].

The aim of this study was the identification of every baryon which had at emission, a residual range in emulsion exceeding 1 cm. In order to distinguish between tracks of baryons and π mesons the scanning procedure was as follows:

(i) The dip angle of each track which was possibly due to a fast baryon was measured. Since previous experience [2] has shown that it is difficult both to identify hyperons dipping steeply, and to measure their energies, tracks for which the dip angle exceeded 40° were discarded from the analysis. However, in the stars in which a fast baryon of dip < 40° was emitted, all prongs were followed to their ends.

(ii) 200 blobs of each light track were counted in the first instance. If the blob density was less than 25/100 μm, the track was taken to be that of a π meson. If the blob density exceeded 25/100 μm a further 400 blobs were counted. If the blob density was less than 30/100 μm the track was again taken as that of a π meson, if greater than 30/100 μm the track was followed to its end point.

The blob density of the most energetic hyperon expected is 36/100 μm and all tracks with blob densities greater than 30/100 μm were followed. Therefore it is concluded that the loss of fast hyperons by these procedures is negligible.

All baryon tracks whose lengths exceed 1 cm., or would have exceeded one cm., had the baryons not decayed or interacted in flight, were followed under high magnification and these features recorded:

(i) All changes in direction, greater than 10° for a residual range exceeding 2 mm., or greater than 45° for residual range less than 2 mm., whether or not accompanied by a change in grain density.

(ii) All observable changes in grain density.

(iii) Length of track followed in emulsion.

(iv) Co-ordinates and depth of each ending.

The grain densities of tracks of particles decaying or interacting in flight were measured by appropriate methods at the end points such that the energies at emission could be determined with standard errors less than 10% whenever possible. (For $F\Sigma^+_\pi$, in 27 cases the error was less than 5 per cent, in 20 cases it lay between 5% and 10% and in 8 cases it was greater than 10%). For $F\Sigma^+_p$ events the energies were also obtained from decay dynamics and the better estimates are quoted.

The endings of these tracks have been examined for evidence of either a nuclear interaction or a decay secondary. All recorded changes in grain density and/or direction have been checked for compatibility with the dynamics of $F\Sigma^+_p$ decay.

In order to reduce the effects of observational loss of fast hyperons, the following depth cut-offs have been applied to their end points:

(i) For $F\Sigma^{\pm}_\pi$ and $R\Sigma^+_\pi$ (also stops in flight)
.... 50 μm (unprocessed)

(ii) $F\Sigma^+_p$, $R\Sigma^+_p$, $R\Sigma^-$ and $F\Sigma^{\pm}_\alpha$ interactions (also fast baryon interactions in flight)
.... 20 μm (unprocessed)

Since the observational loss of light tracks in this stack is small [1] and the number of stops in flight is consistent with that expected from the observed proton track length, no correction for π meson loss has been made to the number of Σ hyperons. The decay angle distribution of $F\Sigma^+_p$ events in the C. M. system was consistent with isotropy, (7 forward, 8 backward) so that no correction has been applied to the observed numbers of such events. However, since confusion often exists between events classed as $F\Sigma_p^+$ decays and proton scatterings, the details of the 15 quoted $F\Sigma_p^+$ decays are presented in Table I. The number of observed Σ^- hyperon interactions at rest ($R\Sigma_\sigma^-$), defined as previously [2], needs correcting for $R\Sigma_\rho^-$ events and 1 prong capture stars where the length of the prong is less than 200 μm. A correction factor of $2.8 \begin{smallmatrix} + 0.6 \\ - 0.4 \end{smallmatrix}$ obtained from a recent compilation of $K^- + H$ capture data [3], has been applied to these events.

All K^- meson capture stars which were found to emit a fast baryon have been fully analysed, looking particularly for the presence of π mesons and strange particles.

Results

The results presented here have been obtained from 9,130 K^- meson interactions at rest. The relevant data from 3,020 K^- meson captures analysed in the previous work [2] are included separately. The prong distribution of K^- meson stars seen to emit Σ hyperons of energies exceeding 60 MeV are presented in Table II. This table is subdivided to show whether or not an accompanying proton of energy greater than 30 MeV was emitted.

The energy spectra of observed fast charged Σ hyperons are shown in Table III. The corrected spectra for both Σ^+ and Σ^- hyperons are given in figs. 1a and 1b. To obtain these, the numbers of $R\Sigma^-$ have been corrected for observational loss, geometrical corrections have been applied and a value of unity accepted for the branching ratio $\Sigma^+ \rightarrow p + \pi^0$: $\Sigma^+ \rightarrow n + \pi^+$ [5]. The final corrected results of the energies exceeding 60 MeV emitted from 12150 K^- meson absorptions at rest is thus found to be 275, of which 96 are Σ^+ and 179 are Σ^- hyperons.

All baryons other than identified hyperons have been regarded as protons and their spectra are given in figs. 2a, b and c. Fig. 2a is the spectrum of protons accompanying fast charged Σ hyperons and is extended down to 30 MeV, fig. 2b is that of protons unaccompanied by any other charged particles at the parent K^- meson star, whilst fig. 2c is a composite spectrum of all protons except those emitted in association with hyperfragments, charged π mesons or Σ hyperons.

The masses of a sample of particles which came to rest in emulsion after a range exceeding one centimetre have been determined from ionization and range measurements. Fig. 3 shows the resulting mass distribution.

No further example of an exothermic interaction [4] has been found but two Σ^+ hyperon inelastic scattering have been reported [6]. A total of 1328 cms. of baryon track length in the energy range 52-210 MeV has been followed and the mean free path for interaction (including inelastic scattering) in emulsion is found to be $(33.2 {+5.9 \atop -4.3})$ cms. [7].

Discussion

From Table II it can be seen that identified fast Σ^- hyperons are often associated with protons of energy greater than 30 MeV whereas identified Σ^+ are in general not. There are 15 cases of Σ^- hyperons of energies $\geqslant$ 60 MeV and of these 10 have a fast proton $\geqslant$ 30 MeV in association and mone was emitted without other charged particles [8].

Further, there are only two examples of a fast Σ^+ hyperon accompanied by a fast proton but 11 cases where the fast Σ^+ is the only charged secondary. This suggests that the Σ hyperons associated with protons $\geqslant$ 30 MeV are mostly negative, whereas those emitted alone are positive.

Assuming the fast hyperons arise from K^- meson interactions with two nucleons, the Σ^- hyperons could be produced in the following two reactions:

$$K^- + n + n \longrightarrow \Sigma^- + n \qquad (1)$$
$$K^- + n + p \longrightarrow \Sigma^- + p \qquad (2)$$

The non-observation in this investigation of fast Σ^- emitted without other accompanying prongs [9] could then be interpreted to mean that the transition amplitude leading to (1) is much smaller than that leading to (2). The interpretation has in fact been advanced previously [10]. The results could also be explained, however, if the K^- interaction with more than one nucleon occurs predominantly with a cluster of nucleons in which at least one is a proton [2, 11]. In particular the results are consistent with the assumption that the commonest cluster with which K^- interactions occur is the alpha particle. Recent observations in the helium bubble chamber have indicated that a considerable fraction of Σ^+ hyperons observed following K^- capture at rest originated from multi-nucleon interactions [12]. This has to be compared with the observations that less than 1 in 250 K^- interactions [13] at rest in the deuterium bubble chamber involve both nucleons in the deuteron. The emission of energetic deuterons and tritons, as observed, is to be expected if the K^- mesons sometimes interact with α particles.

The direct estimate of the fraction of multi-nucleon K^- meson absorptions is restricted by the following uncertainties:

(i) The energy distribution at creation of the Σ hyperons.

(ii) The extent of the degradation of the fast Σ hyperon energy distributions by inelastic scattering processes within the parent nuclei.

(iii) The absorption probabilities applicable to Σ hyperons.

(iv) The fraction of direct Λ^0 hyperon production.

If it is assumed that the multi-nucleon processes do in fact take place with two nucleons and the calculated spectra [2] are correct, and that charge independence holds, on applying the Σ hyperon absorption probabilities obtained from a study of one nucleon processes (i.e. ~ 0.5), 9% of K^- meson interactions at rest occur with two nucleons to produce Σ hyperons. This value must be considered a lower limit of K^- meson multi-nucleon capture processes since resolution of the uncertainties mentioned above seems likely to increase this value. Also the contribution from direct Λ^o hyperon production has to be added and the presence of three fast protons in the sample with energies exceeding 200 MeV suggests that this process does occur.

An alternative method of estimating the fraction of multi-nucleon K^- meson absorptions is provided by the study of π mesons emitted from K^- meson captures. The $\pi^{\pm}/K^-$ ratio has been found to be 40% [1] and after allowance for π meson absorption and assuming charge independence, this implies that at least 70% of K^- meson captures at rest create π mesons. If any π loss remains and/or the absorption probability assumed for π mesons created with Λ^o hyperons is too low, this figure will increase. Thus the upper limit for multi-nucleon processes which do not produce π mesons deduced from our work is 30% [15]. This is consistent with the result quoted in Part II [2] on incomplete data.

Conclusions

(i) 2.3% of K^- meson interactions at rest with emulsion nuclei are seen to emit charged Σ hyperons of energies greater than 60 MeV.

(ii) In general fast hyperons accompanied by protons $\gtrsim$ 30 MeV are negative whereas those emitted with no other charged secondaries are positive.

(iii) The above results could indicate an intrinsic infrequency of the reaction

$$K^- + n + n \rightarrow \Sigma^- + n$$

They could also be explained however in terms of a K^- meson α particle interaction model. In support of such a hypothesis is the observation of a substantial admixture of deuterons and tritons amongst the so-called fast protons.

(iv) The upper limit of the frequency of multi-nucleon processes producing fast hyperons as deduced from the $\pi^{\pm}/K^-$ work is 30%. The lower limit obtained from this study of fast Σ hyperons is 9%.

(v) Also the production of Σ^- hyperons occurs with about twice the frequency of that of Σ^+ hyperons.

(vi) The presence of protons with energies greater than 200 MeV strongly suggests direct Λ^0 hyperon production in K^- meson multi-nucleon interactions.

* * *

ACKNOWLEDGEMENTS

We wish to thank Professor E. J. Lofgren and the Bevatron crew for the exposure and Professor A. J. Herz and G. P. S. Occhialini and Drs. D. Evans and W. M. Gibson for many helpful discussions. We thank also Dr. R. C. Kumar for his contributions in the early stages of this work.

Acknowledgement is also made to D.S.I.R. for a special development grant to University College London and research studentships to B.D.J. and M.J.B., to the Indian Ministry of Education and University of Mysore for an overseas scholarship to B.S., to the Conselho Nacional de Pesquisas (Brasil) for a fellowship to E.P.P., to the Institute for Nuclear Research, Warsaw, for a grant to J.Z., and to the Istituto Nazionale di Fisica Nucleare - Solto sezione di Firenze for a grant to P.G.B., B.S. and J.Z. also wish to express their gratitude to Professor C. F. Powell for the hospitality extended to them at Bristol.

Finally, we wish to thank the many scanners and microscopists for their diligent work.

..X..X..X..X..

REFERENCES

1. M. C. Amerighi, M. J. Beniston, A. Bonetti, D. H. Davis, M. Di Corato, C. C. Dilworth, D. Ferreira, E. Frota-Pessoa, W. B. Lasich, N. N. Raina, M. René, J. Sacton and A. E. Sichirollo: Nuovo Cimento 12, 91 (1959).

2. K^- European Collaboration Part II. Nuovo Cimento 14, 315 (1959).

3. 107 events quoted by M. Nikolic, Y. Eisenberg, W. Koch, M. Schneeberger, H. Winzeler, in Part V (preprint) and 21 events found in this stack .

4. K^- European Collaboration Part III. Nuovo Cimento 15, 873 (1960).

5. Glaser, Kiev Conference Reports (1959).

6. D. H. Davis, B. D. Jones and J. Zakrzewski. Nuovo Cimento 14, 265 (1959).

7. One interacting primary was too short to enable distinction between π meson or baryon to be made. If a baryon the interaction length would become 32.5 cms

8. 3 further Σ^- hyperons of energies just less than 60 MeV were each accompanied by a fast proton.

9. Two events of this type have in fact been found by the Rehovoth group (private communication), but this is not in conflict with the conclusion that they are rare.

10. See reference (2), and also report by E. H. S. Burhop to the 9th Rochester Conference, Kiev, 1959.

11. D. H. Wilkinson Phil. Mag. 4, 215 (1959).

12. Helium Bubble Chamber K^- Collaboration, private communication.

13. Alvarez, (Kiev Conference Report 1959).

14. M. Nikolič, Y. Eisenberg, W. Koch, M. Schneeberger and H. Winzeler: Part V. Helv. Phys. Acta 33, 237 (1960).

15. The Berne group, from a similar argument, quote the frequency of multi-nucleon processes to be 37 ± 5%.

* * *

TABLE I

Event No.	Dip of Σ at decay	Dip of proton at decay	Projected laboratory angle	Laboratory space angle	Range of proton	Range of primary if proton in MeV	Energy of Σ at decay from ionization in MeV	E Σ from dynamics in MeV	Comments
UCL 12905	$26\frac{1}{2}^\circ$s	53°s	10°	28 ± 5	26.6 mm.	19.2 ± 3.1	99 ± 9	55-91 forward DK 91-148 backward DK	Only allowed laboratory angles lie in the range 23-26.4° within the quoted errors.
UCL 13610	$31\frac{1}{2}^\circ$s	$15\frac{1}{2}^\circ$s	10°	$18\frac{1}{4}\pm2^\circ$	41.7 ± 2.6	11.8 ± 1.8	73 ± 7	80^{+20}_{-10}	
UCL 11508	38°g	51°g	5°	$14\pm5^\circ$	200 μ	6.7 ± 1.1	54 ± 5	55 ± 1	
UCL 9914	37°s	69°s	14°	$32\pm5^\circ$	8.2 mm.	2.0 ± 1.7	26^{+12}_{-18}	15 ± 6	
UCL 14009	9°g	49°g	43°	$49\pm1^\circ$	2.3 mm.	$5.6^{+1.8}_{-1.1}$	43^{+7}_{-5}	41 ± 2	Σ inelastically scattered before decay.
UCL 14210	35°s	4°g	$2\frac{1}{2}^\circ$	$33^\circ\pm3^\circ$	6.2 ± 1.0 mm.	23 ± 5	104^{+13}_{-19}	79 ± 11	
UCL 14109	21°s	$1\frac{1}{2}^\circ$s	37°	$41\pm1^\circ$	6.2 mm.	4.1 ± 0.8	41^{+6}_{-4}	44 ± 5	
UCL 13103	37°s	38°s	$23\frac{1}{2}^\circ$	$18\frac{1}{4}\pm2$	0.31	6.7 ± 1.8	54 ± 9	64 ± 10	
Br. 179/21	40°s	24°s	13°	$19\pm2^\circ$	30.27 mm.	11.0 ± 2.5	70^{+7}_{-6}	57 ± 10	
Bx. 22	43°g	$36\frac{1}{2}^\circ$g	20°	$17\pm3^\circ$	7 ± 2	38 ± 4	144 ± 9	128 ± 20	Stopping proton of 0.66 mms. range
Bx. 5036	23°s	6°s	17°	$24\pm3^\circ$	32 ± 5	10.5 ± 3	69 ± 12	72^{+30}_{-20}	Proton interacts in flight after 13.1 mms.

TABLE I (cont.)

Mi	610	22½°g	28°g	24½°	23± °	33.7	11.3±2	72±8	77±2		
Mi	1179	12½°s	12°g	7°	25½±2 °	16.8	2.9±0.9	33±7	34^{+6}_{-3}		
Mi	2427	11°g	27°s	8°	38½±3 °	1.64	8.0±1.2	59±6	59±8		
Mi	3887	18°s	7°g	5°	26±2 °	33	24.5±4	112±12	77–105 105–155	forward backward	only allowed angles lie in range 23.2° — 24.6° within quoted errors.
Mi	198	½°g	9°g	80°	80±1°	0.67	(0.67)	16	15±1		Velocity of primary at decay not directly measurable, no visible change in ionization as required by decay dynamics.

TABLE II

a) No accompanying proton ≥ 30 MeV

	1	2	3	4	5	6	Total
$F\Sigma^{\pm}_{\pi}$	7	13[a]	4	2	3	2[b]	31
$F\Sigma^{\pm}_{p}$	5	5	1	4	-	-	15
$R\Sigma^{\pm}_{\pi}$	1	1	-	-	-	-	2
$R\Sigma^{+}_{p}$	1	2	-	-	-	-	3
$R\Sigma^{-}_{\sigma}$	-	1	-	-	-	-	1

Previous Stack

	1	2	3	4	5	6	Total
$F\Sigma^{\pm}_{\pi}$	4	3	4	1	3	1	16
$F\Sigma^{+}_{p}$	4	2	-	-	1	-	7
$R\Sigma^{+}_{\pi}$	1	-	-	-	-	-	1
$R\Sigma^{+}_{p}$	-	-	-	-	-	-	0
$R\Sigma^{-}_{\sigma}$	-	2	-	1	-	-	3

b) Associated proton ≥ 30 MeV

	1	2	3	4	5	6	Total
$F\Sigma^{\pm}_{\pi}$	-	17[c]	5[d]	7	5	3	37
$F\Sigma^{+}_{p}$	-	-	-	-	-	-	0
$R\Sigma^{+}_{p}$	-	-	-	-	-	-	0
$R\Sigma^{+}_{\pi}$	-	-	-	-	-	-	0
$R\Sigma^{-}_{\sigma}$	-	-	2	2	1	-	5

Previous Stack

	1	2	3	4	5	6	Total
$F\Sigma^{\pm}_{\pi}$	-	5	4	2	2	-	15
$F\Sigma^{+}_{p}$	-	-	1	1	-	-	2
$R\Sigma^{+}_{p}$	-	-	-	-	-	-	0
$R\Sigma^{+}_{\pi}$	-	-	-	-	-	-	0
$R\Sigma^{-}_{\sigma}$	-	1	-	-	1	-	2

a 1 found to be positive by following decay meson.

b 1 found to be negative by following decay meson.

c 1 found to be negative by following decay meson.

d 2 found to be negative by following decay meson.

TABLE III – ENERGY DISTRIBUTION OF OBSERVED Σ HYPERONS

Present stack only

Energy interval MeV		60–70	70–80	80–90	90–100	100–110	110–120	120–130	130–140	140–150	150–160	160–170	170–180	180–190	190–200	> 200
A) Accompanied by proton of energy $\geqslant$ 30 MeV	$F\Sigma^{\pm}_{\pi}$ [a]	7	7	7	4	5	2	3	2	–	–	–	–	–	–	–
	$R\Sigma^{-}_{\sigma}$	3	–	1	–	–	1	–	–	–	–	–	–	–	–	–
	$F\Sigma^{+}_{p}$															
	$R\Sigma^{+}_{\pi}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	$R\Sigma^{+}_{p}$															
B) Unaccompanied by proton of energy $\geqslant$ 30 MeV	$F\Sigma^{\pm}_{\pi}$ [b]	7	6	3	2	2	4	3	1	–	1	–	1	1	–	–
	$F\Sigma^{+}_{p}$	1	4	3	2	–	2	–	–	–	–	–	–	–	2	–
	$R\Sigma^{+}_{p}$	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–
	$R\Sigma^{+}_{\pi}$	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	$R\Sigma^{-}_{\sigma}$	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–

a 3 found to be negative by following decay π meson to rest.

b 1 found negative and 1 positive by following decay π meson to rest.

I N D E X

VOLUME VII

Soluble Model of a Break-up Process.	....	H. M. Nussenzveig.
The Magnetic Fields in Interplanetary Space as Derived from Observations of Cosmic Ray Solar Flare Effects.	....	K. G. McCracken and R. A. R. Palmeira.
Angular Distribution and Polarisation of Λ's in π-p Collisions	....	S. W. MacDowell, A. L. L. Videira and N. Zagury.
On the Observation of fast x Hyperons Emitted from the Interactions of K^- Mesons with Emulsion Nuclei.	....	B.D.Jones, B.Sanjeevaiah, J.Zakrzewski, P.G.Bizzeti, J.P. Lagnaux, M.René, M.J.Beniston, S.A. Brown, E.H.S.Burhop, D.H.Davis, D. Ferreira, E.Frota-Pessoa, W. B. Lasich, N.N.Raina, M.C.Amerighi, A.Bonetti, M.Di Corato, C.C.Dilworth, C.A.Fedrighini, E. Quercigh, A.E.Sichirollo and G. Vegni.

* * *