Краткие сообщения ОИЯИ № 2[65]-94 *JINR Rapid Communications No.2[65]-94*
УДК 539.172.8

AN EXPERIMENTAL RUN ON THE NEW SUPERCONDUCTING ACCELERATOR NUCLOTRON AT 3.8 AND 6.2 GeV/c DEUTERON MOMENTUM

A.M.Baldin, Kh.U.Abraamyan, S.V.Afanasiev, Yu.S.Anisimov, V.V.Arkhipov, A.S.Artyomov, V.V.Avdeichikov, V.K.Bondarev, A.F.Elishev, A.Yu.Isupov, V.A.Kashirin, A.N.Khrenov, V.I.Kolesnikov, A.D.Kovalenko, V.A.Kuznetsov, A.G.Litvinenko, A.I.Malakhov, P.K.Maniakov, E.A.Matyushevsky, G.L.Melkumov, I.I.Migulina, A.S.Nikiforov, V.A.Nikitin, P.V.Nomokonov, V.G.Perevozchikov, S.G.Reznikov, I.A.Rufanov, A.Yu.Semenov, V.A.Smirnov, P.I.Zarubin, I.Atanasov[1], V.N.Penev[1], A.I.Berlev[2], V.A.Krasnov[2], A.I.Maevskaia[2], S.V.Zadorozhny[2]

The new superconducting accelerator Nuclotron has been operated for the first time at 3.8 and 6.2 GeV/c deuteron momentum and the run on the internal target has been carried out in March'94. The measurements were done in the framework of SPHERE, SYaO and DELTA (INR, Troitsk) projects. There were used various scintillation counters for $\Delta E-E$ and time-of-flight (TOF) measurements, the silicon and CsI crystal detectors for $\Delta E-E$ measurements as well, and the lead glass EM calorimeters. The secondary particles γ, π, K, p, d, and t as well as He fragments produced by deuterons on the internal targets were detected and identified reliably, thus manifesting a broad perspective of the relativistic nuclear physics research on Nuclotron in the nearest future.

The investigation has been performed at the Laboratory of High Energies, JINR.

Эксперимент на новом сверхпроводящем ускорителе Нуклотрон при импульсе дейтронов 3,8 и 6,2 ГэВ/с

А.М.Балдин и др.

На новом сверхпроводящем ускорителе Нуклотрон в марте 1994 года впервые ускорены дейтроны с импульсами 3,8 и 6,2 ГэВ/с и выполнены измерения с использованием внутренних мишеней. Работа осуществлена в рамках проектов СФЕРА, СЯО и ДЕЛЬТА (ИЯИ, Троицк). Были использованы различные сцинтилляционные детекторы для измерения $\Delta E-E$ и времени пролета частиц, кремневые детекторы и детекторы на основе кристаллов CsI, также для измерения $\Delta E-E$, и электромагнитные

[1]Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria
[2]Institute for Nuclear Research of the Russian Academy of Sciences, Moscow, Russia

калориметры из свинцового стекла. Зарегистрированы и надежно идентифицированы вторичные частицы γ, π, K, p, d и t, а также He фрагменты, рожденные дейтронами на внутренних мишенях, демонстрируя тем самым широкую перспективу для исследования релятивистской ядерной физики на Нуклотроне в ближайшем будущем.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

A specialized superconducting strong-focusing accelerator of nuclei Nuclotron [1] is proposed, constructed and commissioned at the Laboratory of High Energies of the Joint Institute for Nuclear Research in order to continue a wide programme of relativistic nuclear physics started in 1971 at Dubna Synchrophasotron [2]. The main research goals are the study of the quark-gluon degrees of freedom in nuclei and the excited nuclear matters [3].

The Nuclotron beams can be used for studying practically all characteristics of highly excited nuclear matter including the asymptotic value estimated roughly as 3.5 GeV/c per nucleon for projectile nucleus momentum. This value was obtained from the universal approch [4] to the analysis of multiparticle production processes based on the relativistic invariant quantities $b_{ik} = -(p_i/m_i - p_k/m_k)^2$ in four-dimensional velocity space of particles involved in the reaction, as well as from the experiments

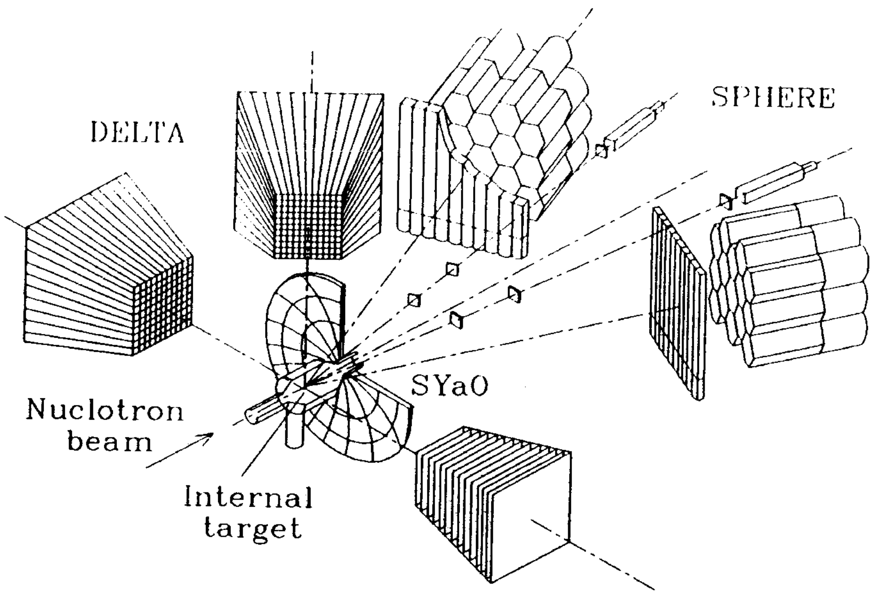


Fig.1. Experimental setup

on the inclusive pion production [5,6]. The experiments on the Nuclotron internal beams make it possible to study a large variety of nucleus-nucleus collisions with changing continuously the kinetic energy of incident nucleus, thus to research «the transition regime» from nucleon to quark-qluon matter grounding QXD primarily.

We announced already on successful operation of Nuclotron and the first experiments on deuterons at 200 MeV/nucleon kinetic energy in July 1993 [7].

This report is dedicated to the measurements carried out on the Nuclotron using the internal targets at deuteron momentum of 3.8 GeV/c in March 1994. Moreover, it was succeeded at the end of the run to accelerate deuterons up to 6.2 GeV/c momentum for short running period, thus to reach the half maximum of the energy designed for Nuclotron.

Three experimental groups SPHERE, SYaO and DELTA (INR, Troitsk) have been joined in performing the measurements on the Nuclotron using the internal targets.

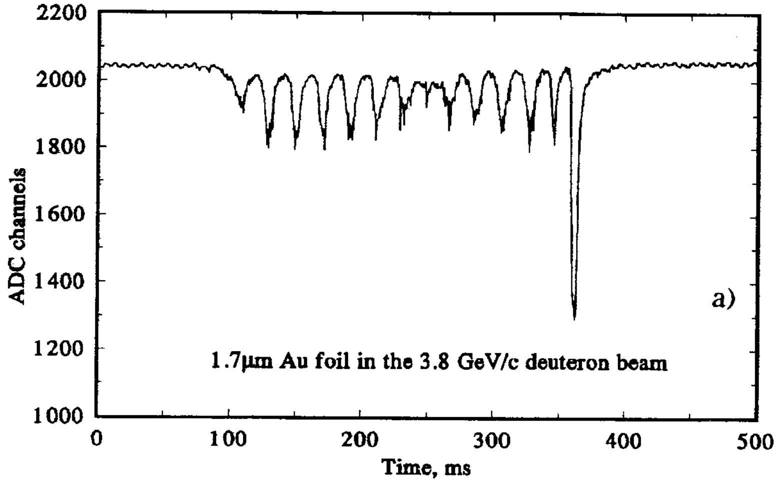
The schematic diagram of the present and future status of the experimental setup is shown in fig.1. The setup includes:

SPHERE:	multichannel lead glass EM calorimeter, $\Delta E-E$ and TOF scintillation counters.
SYaO:	$\Delta E-E$ telescopes of silicon detectors and CsI or BGO crystals, and plastic scintillators.
DELTA:	high granularity lead glass EM calorimeter, multiplate $\Delta E-E$ and TOF scintillation counters.

The experimental facility involves also the internal target operation equipment and the system to control the intensity and the lifetime of the beam interacting with the target operated inside the accelerator vacuum tude [8]. The principle of the beam control is based on detection of the target material radiation by means of the photomultiplier and tandem-microchannel-plate detector in vacuum. The corresponding time structure of the beam interaction with target foils as well as its fine structure are presented in fig.2a and fig.2b, respectively.

General information on the run is:

Beam	deuterons.
Momentum:	3.8 GeV/c at B = 0.6 Tesla, 6.2 GeV/c at B = 1.0 Tesla.
Beam intensity:	~ 10^9/spill.
Beam duration:	~ 300 ms.
Target foils:	1.57 μkm CH_2 and 1.72 μkm Au.
Exposition of detectors:	~ 8 hours.
Triggers:	~ 10^5/detector.



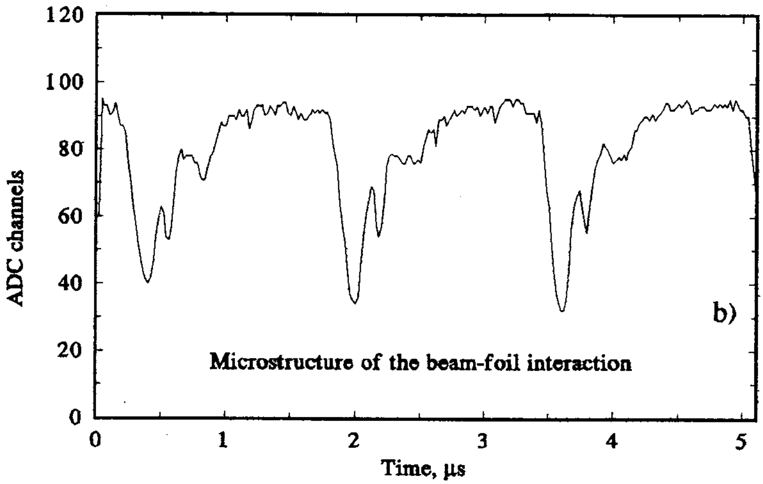


Fig.2. a) Time structure of the beam-target interaction. b) Time microstructure of the beam-target interaction

The following detectors operated at the present run:

— Two identical telescopes containing four scintillation counters each with $2\times2\times0.5$ cm^3, $3\times3\times0.5$ cm^3, $4\times4\times0.5$ cm^3 and $7.5\times7.5\times65$ cm^3, respectively. The first three counters are aimed for ΔE and TOF measurements, and the last one for the measurement of charge particle energy E. The on-line scatter plot of TOF vs energy loss on fig.3a demonstrates qualitatively the π, p, d, t, and He separation capability.

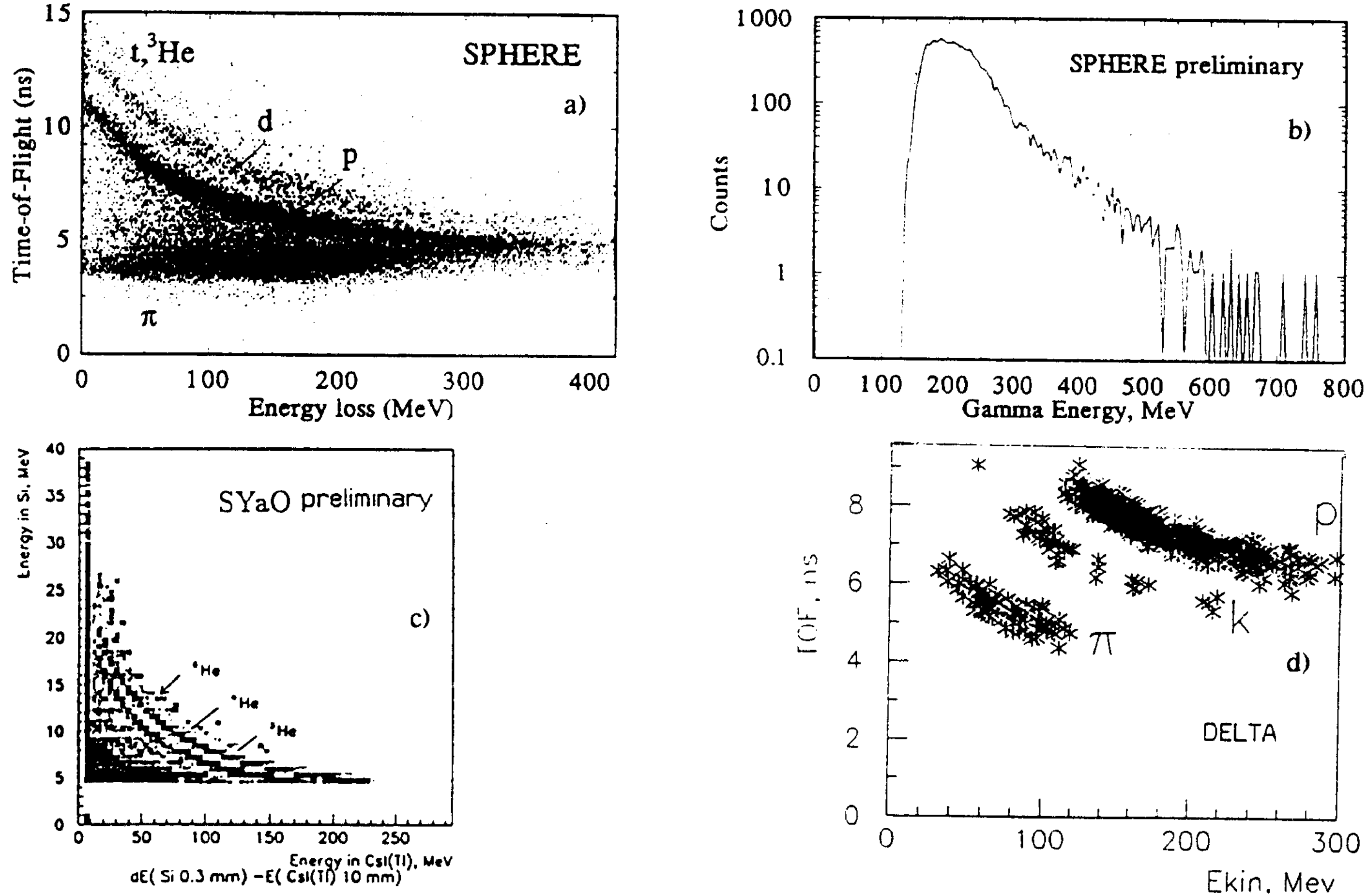


Fig.3. March'94 Nuclotron run on the internal target d + Au → ... at P_d = 3.8 GeV/c: a) scatter plot TOF vs energy loss for secondary π, p, d, t, and He, b) lead glass calorimeter spectrum for γ-quanta, c) $\Delta E - E$ scatter plot for secondary He fragments, d) TOF vs E_{kin} scatter plot for π, K and p. Kaons are subthreshold ones

— Two arms of 36 lead glass EM calorimeter modules are located behind 1m×1m scintillation hodoscopes. Each module radiator 35 cm (14 r.l.) long is hexagonal in form with 17.5 cm inscribed circle diameter. The one-line spectrum of gamma-quanta detected by EM calorimeter is shown in fig.3b and it looks rather reasonable for having no visible overlaps of two particle hits.

— Telescope is assembled of Si (0.3 mm) transmission detector and CsI(Tl) (10 mm) crystal for ΔE and E measurements of the nuclear fragments, respectively, as it's already evidenced on the sample of ^{3}He, ^{4}He and ^{6}He secondaries in fig.3c. CsI(Tl) detector was provided with the silicon photodiode readout.

— Scintillation spectrometer for multiple sampling is assembled of 14 layers of scintillator with dimensions increasing gradually from 16×16×2 cm^3 for the 1st to 27×27×4 cm^3 for the 14th plate. The scintillation TOF detector is placed between the target and this spectrometer. The scatter plot of the charge particle kinetic energy E (MeV) vs TOF (ns) is shown in fig.3d. Being very preliminary this off-line data show, nevertheless, a clear separation of pions, kaons, and protons. The most remarkable is that all kaons are subthreshold ones.

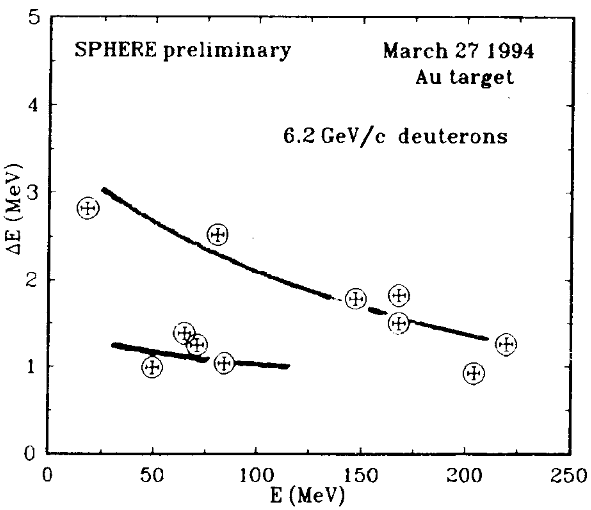


Fig.4. March'94 Nuclotron run on the interal target d + Au → ... at P_d = 6.2 GeV/c. $\Delta E-E$ scatter plot for secondary particles

Finally, we show ΔE vs E scatter plot (fig.4), which is unique one although it contains few events, as they are the first pions and protons produced on Nuclotron at deuteron momentum of 6.2 GeV/c.

In conclusion, the main goal of the run was considerable increasing of the accelerated particle energy, thus all detectors and internal target system operated in tuning regime of accelerator complex. Nevertheless, the above-mentioned data manifest the reliable perspective of relativistic nuclear physics research on Nuclotron in the nearest future.

This work has been carried out owing to the great effort and support of the numerous staff of engineers, physicists and technicians at the Laboratory of High Energies (JINR) and we are very much obliged to them for it could not have been done without their assistance.

The experiment was promoted by the Russian Grant for Fundamental Research (93-02-3773).

References

1. Baldin A.M. et al. — IEEE Trans. Nucl. Science, 1983, vol.NS-30, No.4, p.3247.
2. Baldin A.M. — Kratkije Soobshchenija FIAN, Moskva, 1971, p.35;
   — Proc. Rochester Meeting APS/DPF, 1971, p.131.
   — JINR Preprint P1-5819, Dubna, 1971.
3. Baldin A.M., Malakhov A.I. — JINR Rapid Commun., No.3[60]-93, Dubna, p.52.
4. Baldin A.M. et al. — Zeitschrift für Physik, 1987, C33, p.363.
5. Baldin A.M. et al. — Yadernaja Fizika, 1974, 40, p.1201.
6. Shroeder L.S. et al. — Phys. Rev. Lett., 1979, 43, p.24.
7. Baldin A.M. et al. — JINR Rapid Commun., No.4[61]-93, Dubna, p.13.
8. Artiomov A.S. — JINR Rapid Commun., No.4[61]-93, Dubna, p.6.

Received on May 26, 1994.