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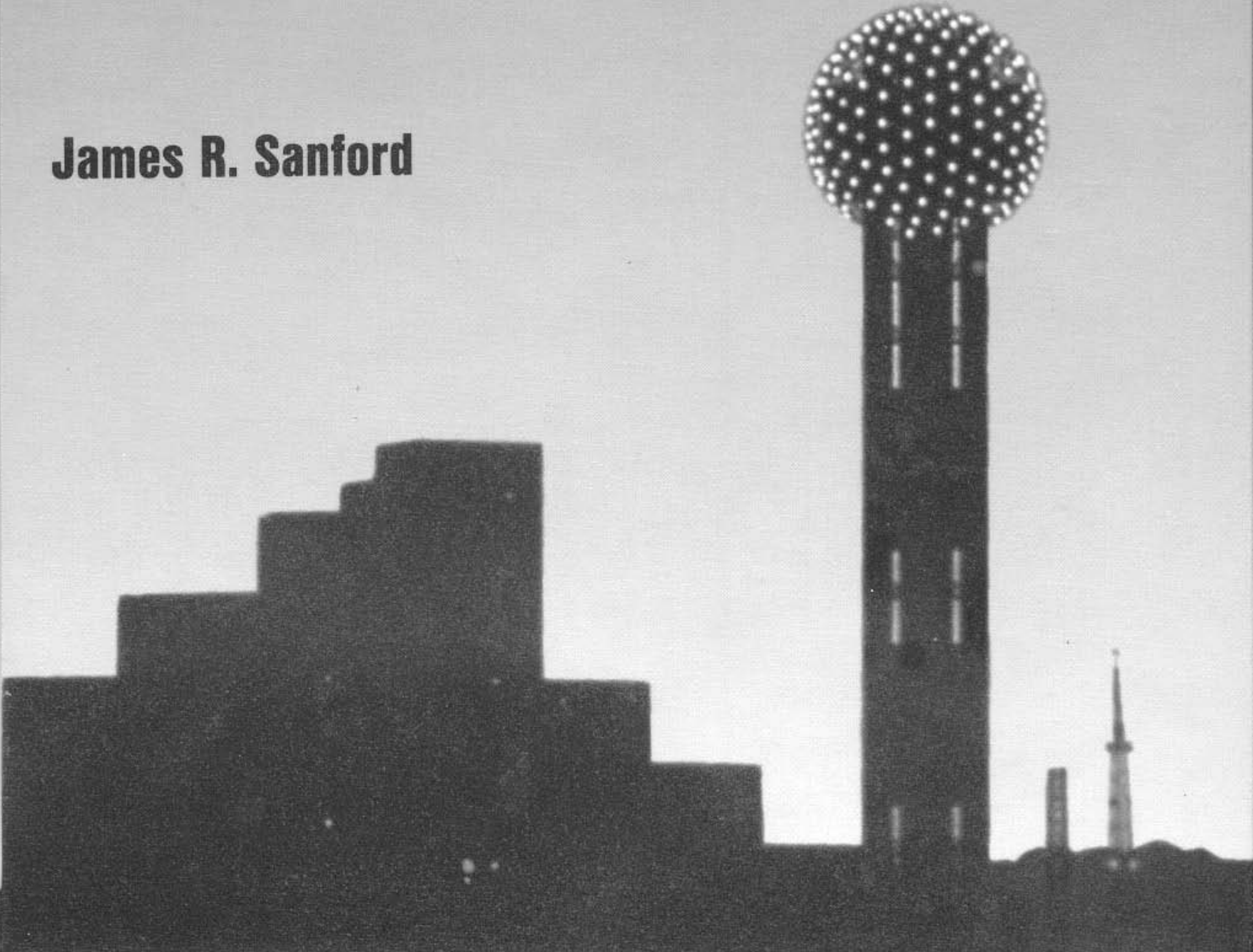

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JINR STORAGE ACCELERATOR COMPLEX: C-TAU FACTORY

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INTRODUCTION

During the last year a storage accelerator project was studied in the JINR [1]. This complex is expected to allow promising investigations in the Institute's traditional fields of elementary particle physics, nuclear physics condensed matter physics, as well as applied investigations.

The new compex is to attract wide international cooperation.

The project discussed involves:

- a $c\tau$-factory with the total energy of colliding particles up to 5 GeV;
- a high resolution neutron source (IREN);
- a heavy-ion storage accelerator of energy up to 1 GeV/nucleon, which allows electron-nucleus collisions (K4-K10) [2];
- an 8—10 GeV positron (electron) storage ring (NK-10).

The scientific research programme for the $c\tau$-factory includes τ-lepton and τ-neutrino physics, charmonium spectroscopy, CP violation experiments, charmed baryon physics, and meson spectroscopy.

The HRNS will make it possible to raise the level of investigation of parity violation in neutron-nucleus interactions, p and α decay channels of excited nuclei in reactions (n, p) and (n, α), γ-ray cascades in capture of resonance neutrons, etc.

The positron (electron) storage ring NK-10 will allow fundamental and applied research in nuclear physics, elementary particles physics, atomic and molecular physics, chemistry, condensed matter physics, biology, materials technology, X-ray lithography, etc.

The idea of building in JINR a storage accelerator complex for ions, electrons and positrons was put forward by Academician A.N.Skrinsky at the 66th session of the JINR Scientific Council in 1989. The JINR experts have optimized the layout of the complex. The JINR Scientific Council and the Committee of Plenipotentiaries of the JINR approved the designing activities for the complex.

This report has been made as a development of the previous one [3] and is based on the materials of the JINR $c\tau$-factory Workshop [4] held on 29—31 May 1991 in Dubna, other papers [5,6,7,8,27,28].

Up to the moment of this publication hard work on projecting and annotating of this suggestion had taken place. By March 1992 technical and economic substantiation of the project (TES) and the draft of the $c\tau$-factory had been completed. In December 1991 the JINR entered into an Agreement with INP (Novosibirsk) and ITEP (Moscow) of the $c\tau$-factory project collaboration. The first steps on the collaboration with LNS (Cornell University), LAL (France) and others have been taken.

In January—February 1992 an approbation of the conceptual $c\tau$-factory project

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*This talk prepared in cooperation with V.S.Alexandrov, V.A.Bednyakov, G.A.Chelkov, V.M.Kotov, A.K.Krasnykh, E.A.Perelstein, N.A.Russakovich, Ts.D.Vylov was organized. We received positive conclusions from SSC Lab, AUSTRON, INFN (Frascati), TRUIMF, LNS (Cornell) and others.

As a result we believe the interest in physics at the $c\tau$-factories is increasing. It is explained by «its big universality» compared to physics on B- and Φ-factories. Though nowhere else in the world where the decision of the construction of $c\tau$-factories has been taken does there exist the necessity to construct at least two such factories to secure high luminosity in different experimental intervals (as is known, the Spanish project is now being carefully studied). At the first stage of the project (1,5 years) it is reasonable (with scientific and economic considerations taken into account, in cooperation with INP (Novosibirsk)) to elaborate the injector of the $c\tau$-factory as the common part of the complex. The preinjector of the factory is practical and HRNS (with insignificant exceptions); the possible start-up of which in 1993—1994 is of independent scientific interest. The decision on this part of the problem can be taken in the nearest future and important work will be started.

While the $c\tau$-factory and detector projects are developed to select a more reliable version, we shall continue to unite the European and world collaborators and determine their contribution. Also, a detailed technical examination of the project will be organized to reduce its price (in particular through the use of the available buildings, facilities and ready projects). It will take us 1 to 1,5 years to do this. At present it cannot be realized owing to economic difficulties. But we expect this problem to have been settled by the end of 1993.

The construction of the $c\tau$-factory during the following ≈ 5 years is not only possible and interesting for physicists but also necessary for the JINR's prestige in the world scientific community.

Short-term plans can certainly be based on the collaboration with another accelerator centre while the long-time programme is sure to involve the construction of our own attractive scientific basis.

At present and in the future young JINR scientists must know the prospects of the institute, otherwise JINR will not be a competent partner of world institutes for nuclear physics.

In this paper we consider possible experiments at the $c\tau$-factory, the acceleration concept of the $c\tau$-factory, and the scheme of a universal detector for studying e^+e^- annihilation in the $c\tau$-factory energy range.

$c\tau$-FACTORY PHYSICS PROGRAMME

The research programme for $c\tau$-factories has already been discussed in remarkable survey papers [9—20] and is practically ready. So we confine ourselves to a brief description of the problems to be solved.

The core of the experimental programme for $c\tau$-factories must be the study of properties of the second-generation quarks and the third-generation leptons through investigations in

- tau-lepton physics;
- charmed meson physics;
- charmonium physics;
- charmed baryon physics.

Fig.1 shows the behaviour of the hadron production cross section as a function of the muon production cross section for the energies available at $c\tau$-factories. Remember, that it is in this field that the most outstanding discoveries were made in the 1970s. The J/ψ particle and then a whole family of hadrons with hidden charm and a $c\bar{c}$ quark system were found. Then the third-generation lepton and the heavy τ-lepton were found. Charmed hadrons with a single c-quark, i.e. hadrons with open charm, were discovered. This is the energy region where the BEPC facility recently built in Beijing (China) operates. Nevertheless, the experimental statistics for this energy region is far from being rich because the existing colliders have low luminosity. So, one of the reasons for building $c\tau$-factories is to get higher luminosity. The luminosity of $c\tau$-factories is planned to be 200 times higher than that of the BEPC.

In Table 1 there are the assumed production rates of events that can be studied

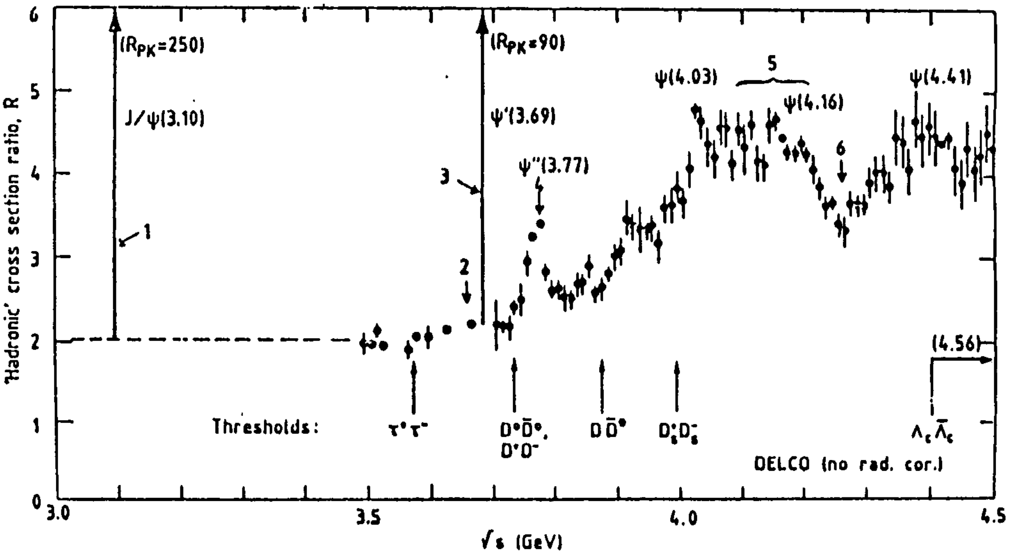

Figure 1. Relative cross section for hadron production as a function of the colliding beam energy

Table 1. Production Rates of Events at $c\tau$-Factory

Type of particle	E_{cm}, GeV	Production frequency 1/s	Events per year (10^7 s)
J/Ψ	3.10	1000	10^{10}
Ψ'	3.69	600	$6\cdot 10^9$
$\tau^+\tau^-$	3.57	0.4	$4\cdot 10^6$
$\tau^+\tau^-$	3.67	2	$2\cdot 10^7$
$\tau^+\tau^-$	4.25	4	$4\cdot 10^7$
D^+D^-	Ψ'' (3.77)	2	$2\cdot 10^7$
$D^0\overline{D}^0$	Ψ'' (3.77)	3	$3\cdot 10^7$
$D_s^+D_s^-$	4.03	0.7	$7\cdot 10^6$
$D_sD_s^*$	4.14	1	10^7
$L = 10^{33}$ cm^{-2} s^{-1}; $E_{cm} = 4$ GeV			

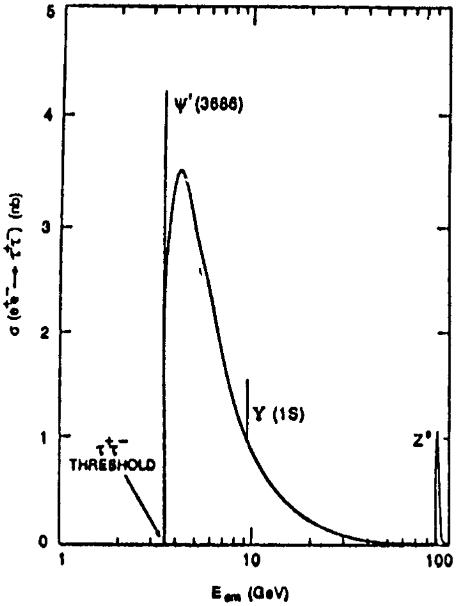

Figure 2. Cross section for $\tau^+\tau^-$ production as a function of the energy.

at $c\tau$-factories. Undoubtedly, an essential increase in luminosity is important. However, proving the necessity of $c\tau$-factories,we would like to show that the investigations to be carried out at $c\tau$-factories are impossible, for example, at B-factories with the same luminosity.

In Fig.2 there is the production cross section of $\tau^+\tau^-$ pairs as a function of the energy. It is well seen that the cross section at B-factory energies, though smaller than at $c\tau$-factory energies, is large enough to carry out serious investigation. As to the charmonium ($J/\psi, \psi', \psi'', \ldots$), it is produced resonantly and therefore is a «privilege» of this energy region. Besides, the $c\tau$-factory allows one to study properties of τ-leptons and charmed baryons near their production threshold and thus obtain high-quality information at a uniquely slow background.

To study τ-lepton physics, there are three optimal energy regions:

- near the $\tau^+\tau^-$ production threshold (E_{cm} = 3.57 GeV) the number N_τ of the τ-lepton pairs expected is $\approx 4\times10^6$ per year;
- under the production threshold of the charmed $c\bar{c}$-quark pair (E_{cm} = 3.67 GeV), here $N_\tau \approx 4\times10^6$ per year;
- near a local minimum in the production cross section for the $c\bar{c}$-quark pair (E_{cm} = 4.25 GeV), at this energy the $\tau^+\tau^-$ production crossed section reaches its maximum and $N_\tau \approx 5.6\times10^7$ per year.

The work in these energy regions has the following advantages:

- at (E_{cm} = 3.57 GeV) it is possible to calibrate the background by transition to point E_{cm} = 3.55 GeV, where $\tau^+\tau^-$ pairs are not produced while the background does not practically charge and the systematic errors are greatly reduced;
- at E_{cm}= 3.57 GeV and E_{cm}= 3.67 GeV there are no background processes from decays of charmed mesons and charmonia ($E_{th}(\psi')$ = 3.69 GeV, $E_{th}(D\bar{D})$ = 3.73 GeV);
- a typical feature of $c\tau$-factory experiments is a possibility of labelling τ-leptons. For example, when the accelerator energy is 3.57 GeV, which is several MeV higher that the production threshold, $\tau^+\tau^-$-pairs are produced practically at rest in the lab frame, and products of their two-particle decays are almost monoenergetic and well distinguished kinematically from the products of multi-particle decays.

It allows one to make the background extremely low and to carry out absolute normalization of the quantities measured [21];

- at the $c\tau$-factory energies, the τ-lepton decay products have small momenta, which improves the efficiency of their detection. A small momentum spread (2.4%) for the products of two-particle τ decays creates good conditions for τ-neutrino mass measurement;

Table 2.

Examples of physical problems to investigate at $c\tau$-factory	
τ-lepton physics	
$c\tau$-factories are the best facilities for precision investigations of τ-lepton properties!	
1. Measurement of τ-lepton mass with accuracy	≤ 0.2 MeV^2/c
Current accuracy is	3.2 MeV^2/c
2. Measurement of τ-neutrino mass to level of	≤ 4.0 MeV^2/c
Current level is	≤ 35 MeV^2/c
3. Measurement of branching ratio with accuracy	$\leq 1\%$
Current accuracy is	(3—25) %
4. Search for rare τ-lepton decays at level of	$\approx 10^{-7}$
Current level is	$\approx 10^{-5}$
D-meson physics	
1. Observation of pure lepton decays	
2. Measurement of mixing matrix elements V_{cs} and V_{cd}	
3. Search for rare D-meson decays at level of $\approx 10^{-7}$	
J/Ψ and Ψ'-meson physics	
1. Search for new states of the $c\bar{c}$-system	
2. Search for glueballs in radiative decays	
Investigation of charmed baryons	
1. Spectroscopy of charmed baryons	
2. Study of charmed baryon decay modes	
3. Study of production mechanism of charmed baryons	
«New» physics	
1. Search for second-class current effects	
2. Search for supersymmetric gluinos and photinos	
3. Search for manifestations of charged Higgs particles and leptoquarks	

- a contribution of radiative corrections to $\tau^+\tau^-$ production is small. It is very important, for example, in precise measurement of electron energy spectrum in the decay $\tau \to e\bar{\nu}_e\nu_\tau$.

Together with high luminosity ($L = 10^{33}$ cm^{-2} s^{-1}) all the features allow one to deal with many physical problems which cannot be solved at the existing facilities.

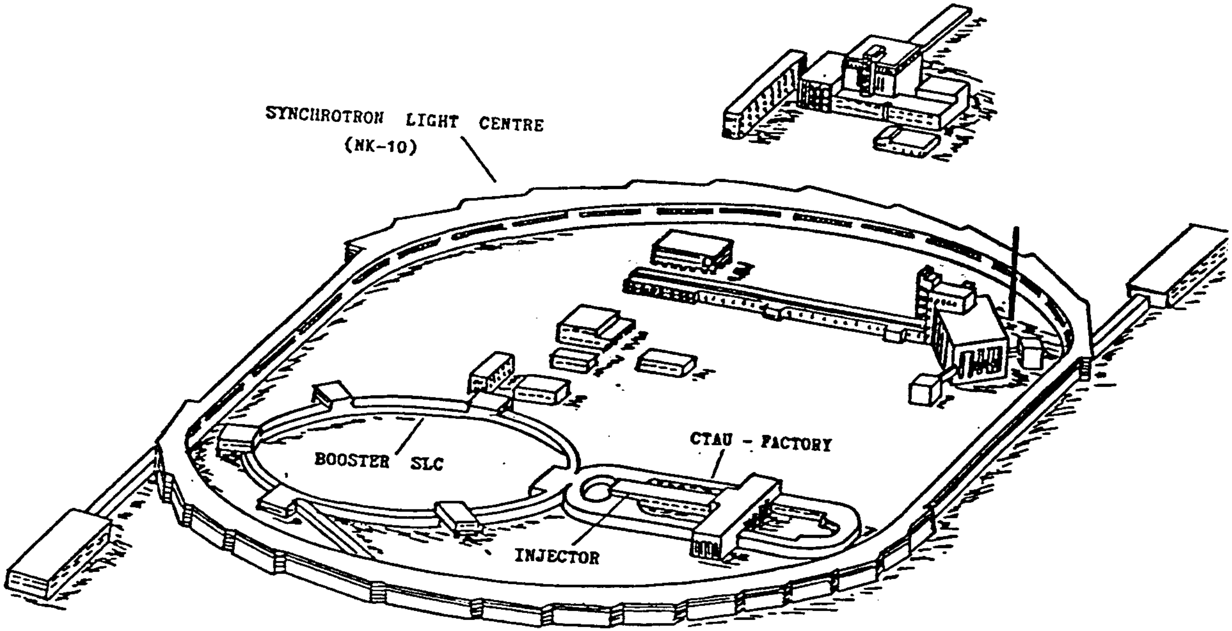

Figure 3. Electron-positron storage complex in JINR. CTau-factory — electron-positron collider ($c\tau$-factory); Injector, Booster — injection complex for the factory; HRNS — high-resolution neutron source; NK–10 — synchrotron light source; Booster SB–10 — injector for NK–10.

- $c\tau$-factories create unique possibilities for physicists to carry out highly precise measurements under good background conditions; no other accelerators can allow such possibilities.

In Table 2 there are examples of physical problems that can be solved at $c\tau$-factories.

$c\tau$-FACTORY ACCELERATION CONCEPT

Two variants of the electron-positron storage ring complex disposals were studied at JINR. The first $c\tau$-factory disposal was on the spare territory of the JINR, while NK-10 was around the existing laboratory buildings. To meet the short construction time, with allowance for the current situation and the infrastructure available, there was an idea to assemble the common preinjector for the $c\tau$-factory and the NK-10 in the linear accelerator (LIU-30) building. This variant had failed by reason of existing building and civil engineering site. Now the third variant of a storage ring complex disposed as the whole on the spare JINR territory (Fig.3) is under examination.

The electron-positron collider ($c\tau$-factory) is expacted to provide high luminosity (about 10^{33} cm^{-2} s^{-1}) in the energy range of colliding particles 1.5–2.5 Gev. Following recommendations [13,20], we plan the maximum luminosity at 2.2 GeV. The energies close to it are necessary for experiments on τ-lepton and τ-neutrino physics. The factory must also have high integral luminosity, i.e., high reliability of all facilities involved and high injector capacity. According to the universally accepted principle [11,19, 20,22,23], the JINR factory design is based on conservative solutions; i.e., the high luminosity is obtained with systems, principles and devices tested in various scientific centres.

Now two versions of the $c\tau$-factory are examined: one is similar to that described in ref. [11,15,18,21,23]; the other is based on the monochromatization scheme [24].

In the first version, high luminosity is obtained by using:

- multi-bunch mode of storage device operation with separation of bunches after collision;
- minimum possible value of the vertical β-function at the collision point (about 1 cm) due to superconducting lenses (micro-beta insertions);
- higher number of particles stored, owing to through correction of the magnetic field and suppression of coherent instabilities using feed-back systems;
- magnetic structure that provides sufficiently large beam emittance.

The scheme of the $c\tau$-factory with an injection complex and the main ring is shown in Fig.4. The injection complex consists of a preinjector and a fast booster synchrotron, where electrons and positrons are finally accelerated to the main ring storage energy. The preinjector is expected to be also used for initial acceleration of particles in the NK-10. It should be noted that the preinjector is actually HRNS, mentioned in the introduction before.

Choosing the variant of the preinjector, we took into consideration the possibility of having the most advanced design and building it in a relatively short time. The analysis showed that it is reasonable to have a preinjector similar to that of the VEPP-5 complex to be built in the Institute of Nuclear Physics (Siberian Div. of the Russian Academy of Science, Novosibirsk) under the State Scientific and Technical Programme «High Energy Physics» [25].

The INP preinjector provides single-bunch acceleration and thus single-bunch filling and compensation for losses in the $c\tau$-factory and NK-10. A possibility of bunch sequence acceleration and multibunch injection is also discussed [19,22,23].

The energy at the preinjector output is ≅500 MeV and the number of particles must be such that the simultaneous work of the cτ-factory and the NK-10 ring could be ensured. In order to ensure high average luminosity, we demand that the variation of the luminosity in time be small (not more than 10%) when the cτ-factory works. The beam lifetime is about 240 min and it is determined mainly by particle bremsstrahlung radiation at the injection point. We suppose to obtain vacuum in the storage ring chamber at the level of $3 \cdot 10^{-9}$ Torr. The positron number is the cτ-factory storage ring must be $4.8 \cdot 10^{12}$ for ensuring the necessary luminosity value. Then taking in account that the whole efficiency of

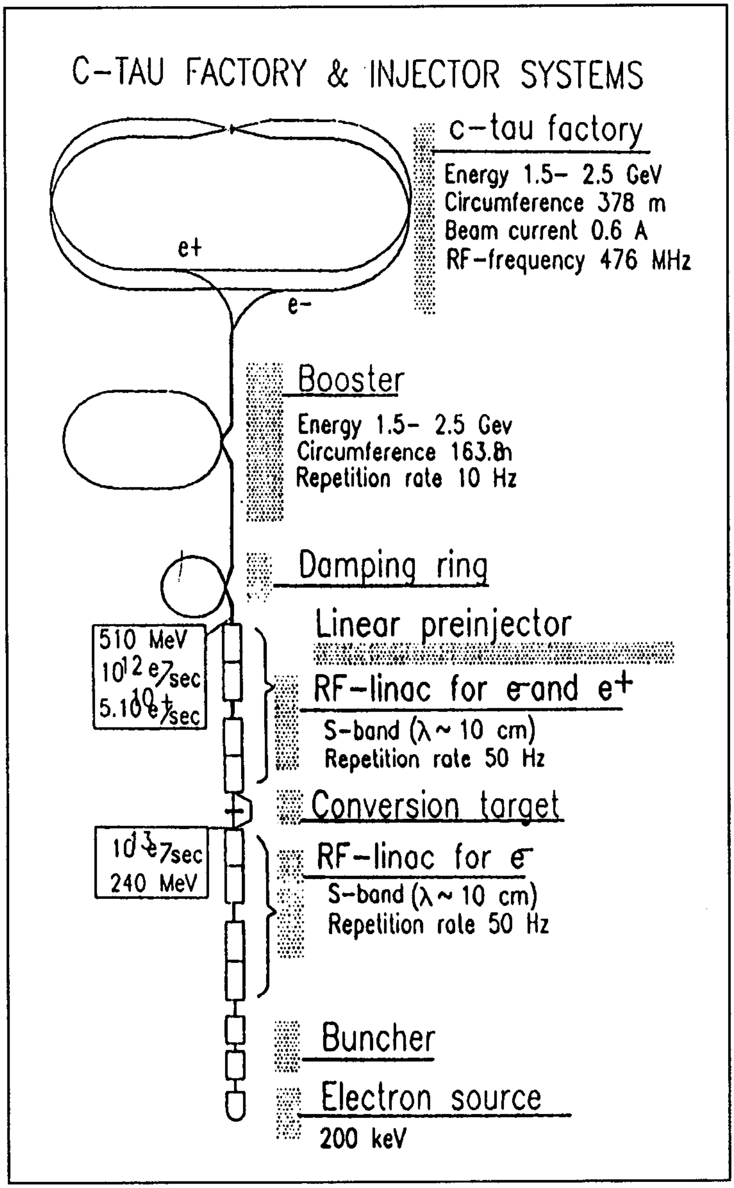

Figure 4. The scheme of the cτ-factory with an injection complex and the main ring

the injection into the $c\tau$-factory from the injection complex through the cooler and booster is supposed to be 10% and the refilling time is chosen equal to 480 seconds, we find that the necessary productivity of the injection complex ought to be $5 \cdot 10^{10}\ e^+/s$. One expects the efficiency of the conversion to be source impinging the conversion target must be about $10^{13}\ e^-/s$.

The preinjector comprises two resonant travelling-wave linacs similar to those of ref. [25] with the working frequency 2856 MHz. One accelerator of energy 240 MeV is to produce positrons in the conversion target of tungsten and the other is to accelerate electrons and positrons up to the final energy. The electron flux the preinjector output is equal to $10^{12}\ e^-/s$, the expected positron emittance value $3 \cdot 10^{-3}$ cm·rad, and their energy spread is about 1%. The total length of the preinjector is about 40 m. Microwave power is supplied to accelerating waveguides by klystron amplifiers which ensure the accelerating gradient up to 25 MeV/m.

The conversion target is installed behind the first accelerator. We suppose to use a quarter-wave transformer (QWT) in order to match the positron beam emittance with acceptance or the second linac. The conversion efficiency will be experimentally refined in the future.

The beam is produced by a grid-controlled gun. Together with the systems of subharmonic and working-frequency bunching, it provides the obtaining of two single bunches with bunch spacing 42 ns (every bunch having 16 nC) or a multibunch train with time duration 100 ns and with total charge 32 nC. The electron source generates five such multibunch trains with the time distance 20 ms. The generated positron bunches are stored in the damping ring after capture and

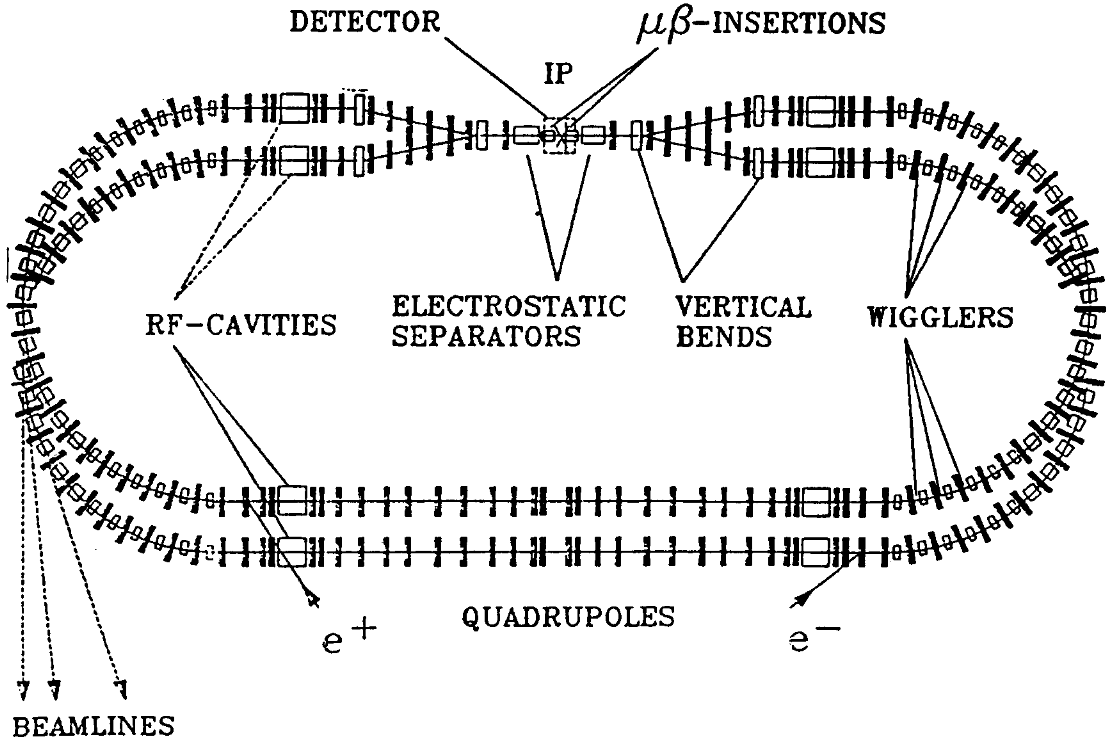

Figure 5. Schematic design of the storage rings.

accelerating in the second linac. This opearting mode of generating of five multibunch trains with the charge 32 nC is repeated with the frequency 10 Hz. Similar devices are widely used in leading physical centres [22,23,24].

The booster synchrotron is designed as the injector of cτ-factory. It will be used for acceleration of 500 MeV electrons and positrons which have been injected from the damping ring up to the full energy of the cτ-factory. With the repetition rate of 10 Hz the booster provides 0.6 A. positron current to be stored in the cτ-factory within about 8 minutes and the 10^{33} cm^{-2} s^{-1} luminosity to be effectively maintained.

The magnetic structure of the booster consists of six superperiods, each containing four FODO-type cells. The hexagonal shape of the booster is determined by the positions of the injection channels in the configuration chosen for the complex. Two long straight sections house injection devices, three others are for extraction to the injection channels of the cτ-factory and the NK-10 booster. The sixth section houses an RF station. The electron-positron collider comprises two storage rings (see Fig.5), each with a perimeter of 378 m. They are assembled at different levels in the same tunnel with 1.3 m gap between tracks. In the middle of two 102.9 m straight sections there are places for two universal detectors, one being designed in JINR now. Structurally combined with the detector are micro-beta insertions (two triplets of superconducting quadrupole lenses) installed symmetrically about the collision point to make the vertical β-function about 1 cm at this point).

The straight sections also house electrostatic separators, magnets of vertical deflection, beam splitting lenses, injection devices, RF cavities to compensate for synchrotron radiation losses of particle energy and to maintain the longitudinal bunch dimension less than 1 cm, and dipole wigglers for obtaining the necessary energy spread at energies below 2.2 GeV. The electric field strength in the separator and the separator length are chosen to make the distance between the bunches about 12.6 m. There are 30 bunches of each component in the ring.

The design of the cτ-factory radio frequency system meets the strict requirements of providing single-bunch and multibunch stability of the beams. Superconducting cavities are planned to be used together with special measures for suppression of the modes higher than the basic one. Like the design of the vacuum chamber and built-in devices, the design of the cavity must ensure the radiation losses of the passing particle bunches to be small. Excitation of the superconducting cavities by the passing bunches arouses a difficult problem of removing heat. The measures planned must allow the use of tolerably fast feed-back systems in order to achieve stable motion of bunches.

The Radio Frequency system for the cτ-factory must compensate the particle energy losses arising from the Synchrotron Radiation and HOM excitation in RF-cavities (SR losses power is equal to 110 kW for particle energy 2.2 GeV). The RF system consists of four superconducting acceleration cavities (per one ring), which are placed at the ends of the long straight sections. Each cavity consists of three or four cells. The radio frequency is chosen equal to 476 MHz. It provides the single and multibunch beam stabilities with the help of the feedback systems. The choice of this frequency also permits one to maintain the necessary longitudinal bunch dimensions under achievable accelerating voltage in the superconducting cavities. The longitudinal bunch size is equal to 7 mm for total RF-voltage amplitude about 18 MV. It is sufficient for obtaining the necessary luminosity.

Each of the arcs of the cτ-factory has 12 cells with periodicity of FODO type with a 60-degree phase gain in each. The regular part includes 6 cells with a bending angle of 10 deg. at each magnet, and two dispersion suppression sections, each containing 3 cells with a half-bending angle at a magnet. In the dispersion suppression sections there are wigglers to adjust emittance. Chromaticity is corrected by two families of sextupole lenses arranged in a standard way.

The basic parameters of the $c\tau$-factory are given in Table 3. The feasibility studies carried out in 1990—1991 showed that construction of the storage ring complex on the territory of the JINR using its infrastructure would cost for $c\tau$-factory 130 millions of roubles and for NK-10 — 300.3 millions of roubles.

The estimated expenses for the accelerating installations of the JINR storage ring complex are shown in the Table 4.

The consideration of the τ-charm factory project is given in make detail in paper [8]. A group of JINR accelerator physicists is

Table 3. $c\tau$-Factory Parameters

Energy at maximum luminosity	GeV	2.2
Maximum energy	GeV	2.5
Luminosity	cm^{-2} $s^{-1}s$	$1.1 \cdot 10^{33}$
Number of interaction points		1
Beam lifetime	hours	3.5
Circumference	m	378
Momentum compaction		0.0351
Natural emittance	nm	482
Energy spread		$5.87 \cdot 10^{-4}$
RF frequency	MHz	476
RF voltage	MV	18
Harmonic number		600
Bunch length	mm	7.5
Bunch spacing	m	12.6
Number of bunches		30
Total current	mA	614
Energy loss	kV/turn	201
Synchrotron radiation power	kW	123
Damping times $\tau_{x,y}/\tau_{\varepsilon}$	ms	27/14
Horizontal beta at interaction point	m	0.20
Vertical beta at interaction point	m	0.01
Horizontal beam size at interaction point	μ	303
Vertical beam size at interaction point	μ	15
Beam-beam parameter		0.035

Table 4. Estimated Expenses

Estimated cost	$c\tau$-factory (in millions of roubles)	NK-10
Accelerators equipment:		
Linear accelerator	28.7	—
Booster	11.2	39.0
Storage rings	25.4+6 M$	92.8
Building work	7.5	46.1
Installation work	8.5	28.5
Other expenses	9.8	51.0
Total estimated cost of the installations	91.2+6 M$	300.3

Note: Costs are taken in price level of 1990 without taking into account the cost of the detector

working in this problem and together with the group of State Building Design Institute is completing the main and important stage of projecting.

UNIVERSAL DETECTOR

Requirements to the Parameters of a Universal Detector for a $c\tau$-factory

Requirements to the parameters of a universal detector for a $c\tau$-factory have been widely discussed recently [6,7,10,13,18,20]. These problems were also considered at the JINR $c\tau$-factory Workshop, when the physics programme at «factories» and principles of construction of a relevant detector were discussed [4]. And the basic requirements to the detector considered were confirmed. They are given in Table 5.

The main conclusion is that

> **The physical sensitivity of the tau-charm factory will depend on the combination of two aspects of the experimental apparatus: machine luminosity and detector performance.**

Before proceeding to discussion of concrete problems concerning implementation of these requirements, it will be appropriate to recall similar parameters of the detectors,

Table 5.

Physical requirement of the $c\tau$-factory detector design
Requirements to the detector
1. Momentum measurement precision: $[\sigma_p/P]^2 \cong [0.4\% * P\ (\mathrm{GeV}/c)]^2 + [0.3\%/\beta]^2$
2. High resolution of gamma-energies: $[\sigma_E/E]^2 \cong [2\%/\sqrt{E\,(\mathrm{GeV})}]^2 + [1\%]^2$ and low threshold energy: $\{E_\gamma\}_{\min} \approx 10$ MeV
3. Excellent ($\le 10^{-2}$) particle identification (e, μ, π, K, P)
4. Tightness and max. Solid angle ($\cong 90\%\ 4\pi$)
5. Advanced trigger, DAQ and off-line processing

Table 6.

Comparison of performance of detectors

Detector	Design	Momentum resolution	γ-energy resolution
ARGUS (DESY)	1978	$(0.9\%P)^2 + (\frac{1\%}{\beta})^2$	$(\frac{6.5\%}{\sqrt{E}})^2 + (7.2\%)^2$
MARK-III (SLAC)	1978	$(1.0\%P)^2 + (\frac{1.5\%}{\beta})^2$	$(\frac{18\%}{\sqrt{E}})^2$
BES (BEPC)	1985	$(0.7\%P)^2 + (\frac{1.3\%}{\beta})^2$	$(\frac{15\%}{\sqrt{E}})^2$
CLEO-II (CESR)	1985	$(0.2\%P)^2 + (\frac{0.7\%}{\beta})^2$	$(\frac{2\%}{\sqrt{E}})^2 + (2\%)^2$
τCF (???)	1991	$(0.4\%P)^2 + (\frac{0.3\%}{\beta})^2$	$(\frac{2\%}{\sqrt{E}})^2 + (1\%)^2$

either existing or stopped not so long ago, which have been used at colliders in the energy region close to ours.

The data in Table 6 show that performance of most of the existing detectors, except CLEO-II at Cornell University, does not meet the above-mentioned requirements. Thus, the detector planned for the $c\tau$-factory must be a CLEO-type detector with allowance for specific requirements arising from specific features of the energy range studied at the $c\tau$-factory.

It must also allow further development. What is specific about these requirements? The point is that spectra of the particles to be detected are much «softer» than similar spectra typical of B-factories of colliders of very high energy like LEP, SLC.

The data obtained by MC simulation with the programme KORALB [26] clearly shown that being a typical 4π-detector, which is usual in collider physics, the detector of the $c\tau$-factory is practically a detector for particles of low and intermediate energy. It is all these features together that determine the specific character of requirements to the parameters of $c\tau$-factory detectors.

Today we see that this factor essentially dominates in requirements to the tracking system of the detector and to the muon identification system. For slightly different reasons stemming from the word «factory», which means that the installation operates at a collider of high luminosity ($L > 10^{33}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$) and is designed for receiving and processing a tremendous amount of information there are specific and high requirements to the data collecting and processing system.

A schematic view of the detector proposed for the $c\tau$-factory at the JINR is shown in Fig.6.

The detailed consideration of the detector project is given in paper [4]. At present a group of JINR scientists in close collaboration with LNP (Novosibirsk) is working out the project for the detector. According to the tentative schedule given below, designing, manufacturing, assembly and adjustment of the detector can be done within five-six years after the financing begins.

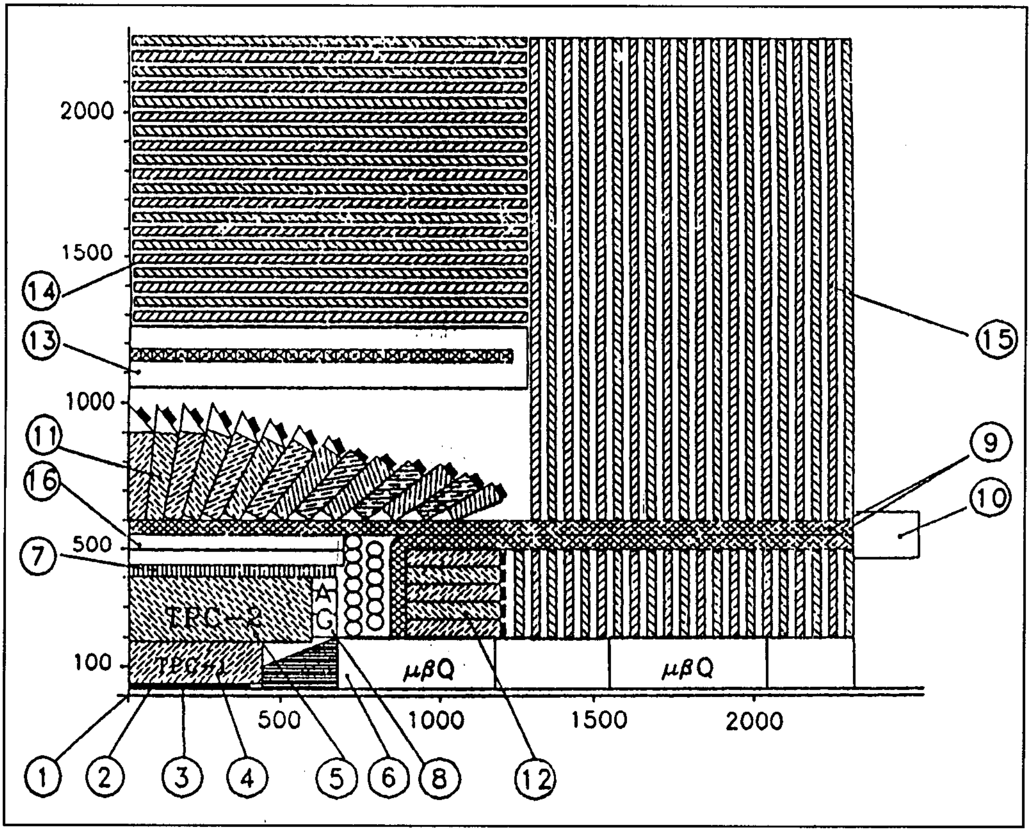

Figure 6. Universal detector. 1 — beam collision point; 2 — vacuum chamber of accelerator; 3,4,5 — track system detectors (TPC-1, TPC-2); 6 — luminosity monitor and front calorimeter; 7,8,9,10,16 — detectors of particle identification system; 11,12 — γ-calorimeter; 13 — superconducting solenoid; 14,15 — path system; $\mu\beta Q$ — micro-beta insertions.

Cost Estimations and Detector Construction Schedule

The tentative estimations of the detector cost at 1990 prices are ~40 mlns of roubles.

According to the tentative schedule given below, designing, manufacturing, assembly and adjustment of the detector can be done within six years after the financing begins.

4. CONCLUSIONS

1. The $c\tau$-factory physics programme for the precision study of the properties of the τ-lepton and c-quark-containing particles near their production threshold is of current importance and aimed at studying the fundamental problems of particle physics. It cannot be implemented at the existing or planned facilities.

2. In general, the research programmes proposed now for high-intensity e^+e^- colliders ($\phi-$, $c\tau-$, B-factories) complement one another and are likely to yield the best results if fulfilled together.

3. Inplementation of this programme will take at least 10 years after putting into operation the above installations.

4. As the research programme is rather wide, it is reasonable to construct at least two installations of each type, which will also ensure the necessary confidence level of the data obtained.

5. Being a project of a perfect facility for modern particle physics, the $c\tau$-factory and universal detector project is relatively cheap and feasible for the JINR.

6. The significance of the project is far beyond the above-mentioned scientific reasons:

- development and construction of this collider allows a new modern basic facility of world class in the JINR for particle physics research;
- participating in this work based on the advanced technological experience many specialists (accelerator and other physicists, engineers, designers, workers) will improve their professional skills, which will raise the general level of the scientific research in the JINR;
- new competitive basic facility will allow the JINR to remain attractive to the scientists of the member-states for another 10—15 years and to attract scientists of other research centres;
- construction of the $c\tau$-factory in the JINR will allow many young specialists of the member-states to be trained according to the present-day requirements and will be helpful in replenishing the JINR staff with talented youth.

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