ECFA EUROPEAN COMMITTEE FOR FUTURE ACCELERATORS

EIGHTY-EIGHTH PLENARY ECFA MEETING

25-26 November 2010, CERN

THE CORNESTONE OF THE TAC PROJECT: LINAC-RING TYPE SUPER-CHARM FACTORY

Saleh Sultansoy

TOBB ETÜ, Ankara

Institute of Physics, Baku

Introduction

- Accelerator technology ➲ a generic technology ➲ locomotive of the development in almost all fields of science and technology.
- Accelerator technology should become widespread all over the world.
- Existing situation: a large portion of the world (the South Hemisphere, Mid-East and Central Asia) is poor on the accelerator technology.
- Worldwide strategy covering developing countries is needed (under the leadership of ICFA, ECFA, ACFA)

Birth of TAC

Region means: Mid East + Balkans + Caucasus + Central Asia

Doğa – Tr. J. of Physics
17 (1993) , 591 – 597.

Regional Project for Elementary Particle Physics Linac-Ring Type c-τ-Factory *

Saleh F. SULTANSOY
Institute of Physics, Academy of Sciences,
Baku-AZERBAIJAN

Received 25.1.1993

Abstract

Linac-ring type e^+e^- collider with $\sqrt{s} = 3 - 5$ GeV is proposed as the regional project for elementary particle physics. It is shown that modern accelerator technology makes it possible to achieve luminosity $\mathcal{L} = 10^{34} cm^{-2} S^{-1}$. The possible physical goals of this machine in investigation of charmed particles, τ-lepton and ν_τ properties is briefly discussed.

1. Introduction

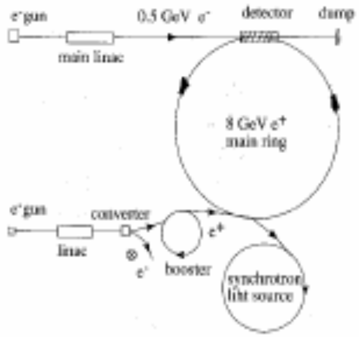


Figure 1. The proposed scheme for linac-ring c-τ-factory

Table 1. Basic parameters of linac-ring c-τ-factory

Parameters	e^--linac		e^+-ring
Energy (GeV)	0.5		8.0
$\sqrt{s}$ (GeV)		4	
Radius (m)	-		100
Length (m)	50		-
Particles per bunch, n (10^{10})	0.1		10
Collision rate, f_c (MHz)		30	
Bunches per ring, k	-		60
Current, I (mA)	5		500
Energy loss/turn, ΔE (MeV)	-		3.6
Power (MW)	2.5		> 1.7
Beam size at IP, $\sigma_{x,y}(\mu m)$	1		1
$\beta_{x,y}$ at IP (cm)	-		0.25
Bunch length, σ_z (cm)	0.1		0.2
Luminosity, $\mathcal{L}(cm^{-2}S^{-1})$		$2.4 \cdot 10^{34}$	

d) Synchrotron radiation. There are two possibilities: 1)to use the main positron ring as the source of synchrotron radiation; 2) to construct a new ring for this purpose. Let

Classification of colliders

1. Colliding particles
- hadrons
- leptons
- lepton-hadron

2. Collider schemes
- ring-ring
- linear
- linac-ring

The ring-ring colliders are the most advanced ones from technology point of view and are widely used around the (developed) world.

The linear (linac-linac) colliders are less familiar; however, a lot of experience is gained through Standard Linear Collider (SLC) operation and ILC/CLIC related workout.

The linac-ring colliders require more R&D.

Linac-ring type colliders: two directions*

Lepton-hadron and photon-hadron colliders:

UNK+VLEPP (Mid 1980's) → THERA (End 1990's) → LHeC → Energy Frontier / QCD Explorer

THERA → eRHIC/EIC/ELIC

Factories:

B-factory (Grosse-Wiesmann) → c-τ-factory → Super-Charm factory (TAC project)

c-τ-factory → φ-factory (Ankara group)

* For details and ref's see: A. Akay, H. Karadeniz and S. Sultansoy, Review of Linac-Ring-Type Collider Proposals, Int. J. Mod. Phys. A 25 (2010) 4589

Future LR type lepton-hadron colliders

The QCD Explorer stage of the LHeC is almost mandatory:

- PDF's for LHC (especially upgraded)
- QCD basics (especially small x_g)

LR type machines provide a unique opportunity for *γp* and *γA* collisions with real HE *γ*-beams. Especially *γA* collider has a great potential for nuclear physics research (e.g. QGP at high energy and low parton densities).

Large *x* region will be explored by eRHIC/EIC/ELIC

Realization of the Energy Frontier stage of the LHeC will be determined by the future LHC results. Nevertheless, it is useful to compare physics search potential of three colliders which can be considered as energy frontiers in foreseen future. Namely,

(i) $\sqrt{s} = 14$ TeV pp collider with $L = 10^{34}\ \mathrm{cm^{-2}s^{-1}}$ (LHC);
(ii) $\sqrt{s} = 0.5$ TeV e^+e^- collider with $L = 10^{34}\ \mathrm{cm^{-2}s^{-1}}$ (ILC);
(iii) $\sqrt{s} = 3.7$ TeV ep collider with $L = 10^{32}\ \mathrm{cm^{-2}s^{-1}}$ ("ILC" × LHC)

Rough estimations show that the total capacity of *ep* and *γp* options of the Energy Frontier stage of the LHeC for BSM physics research essentially exceeds that of 0.5 TeV linear collider.

c–τ–factory proposals in 1990's

- Ring–Ring: Spain (1991), JINR and BINP (1994)

$$L = 10^{33} cm^{-2} s^{-1}$$

- Linac–Ring: Ankara group (1993)

$$L = 10^{34} cm^{-2} s^{-1}$$

Before Crab–Waist scheme (2006) LR seemed to provide about 10 times higher Lumi.

ICFA Statement on a Tau Charm Factory 31 January 1996

ICFA has noted that several intensive workshops have been held on the physics potential of a tau-charm factory. This collider is intended to operate at a luminosity of 10^{33} $cm^{-2}s^{-1}$, one hundred times the luminosity of the Beijing Electron-Positron Collider. The conclusion of these workshops is that a tau-charm factory can address issues concerning the tau, charmed particles, and light quark spectroscopy in a unique manner. Many of the issues can only be addressed by a tau-charm factory and cannot be fully addressed by B factories now under construction, or by high energy fixed target experiments.

There has been strong interest in a tau-charm factory by physicists from all regions of the world. Physicists from two nations, China and Russia, are seriously developing plans to construct such a facility. ICFA is pleased to note that the Chinese government has awarded funds of 5 million Yuan to the Institute of High Energy Physics in Beijing for the purpose of designing a tau-charm factory.

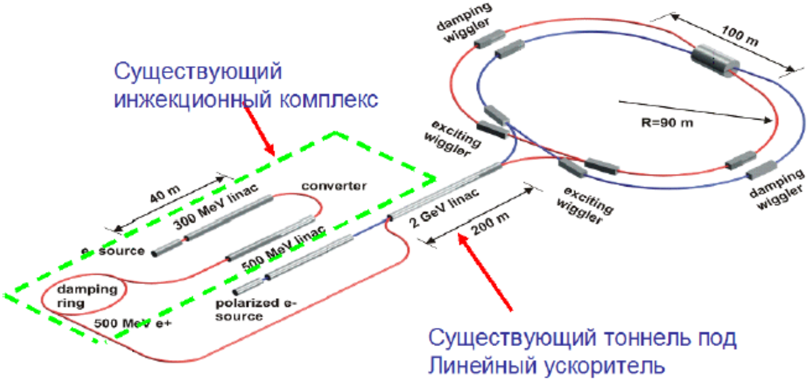
ICFA Statement on a Tau Charm Factory 31 January 1996 (cont.)

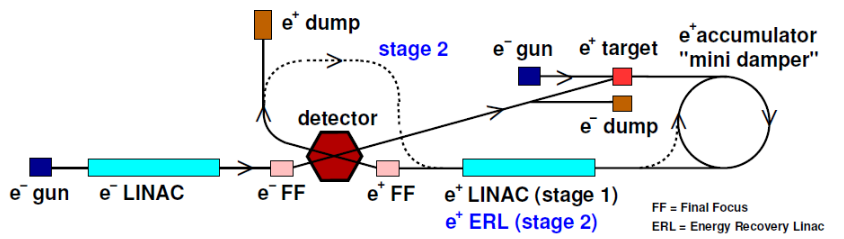
ICFA is pleased that international workshops on a tau-charm factory have been held over the past several years and that there are plans to hold additional ones in the future. In addition, the ICFA Beam Dynamics Panel is in the process of establishing a subpanel to assist in identifying and solving the beam dynamics issues associated with a tau-charm factory. ICFA supports the planning that must be done in advance of the construction of such a facility, and supports its construction, since there is ample justification for one such facility.

ICFA looks forward to the day when a tau-charm factory can begin operation, and encourages exploitation open to an international team in accordance with the existing ICFA Guidelines for Utilization of Major Regional Experimental facilities for High Energy Particle Physics.

BEPC II srarted in 2008

c–τ–factory proposals 2010

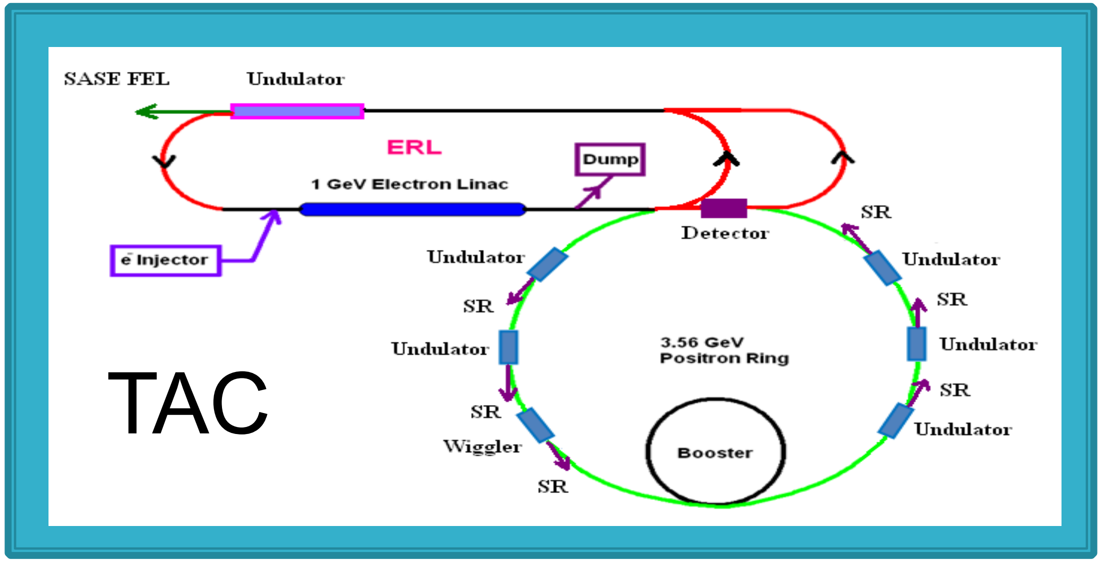




A. Schöning / Nuclear Physics B (Proc. Suppl.) 169 (2007) 387–392

All three proposals promise

$$L = 10^{35} cm^{-2} s^{-1}$$



Tentative parameter list for TAC Super-C Factory

Positron ring	
Positron beam energy (GeV)	**3.56**
Number of positrons per bunch (10^{11})	2
Beta functions at IP β_x / β_y (mm)	80/5
Normalized emittances ε_x^N / ε_y^N (μm)	110/0.36
σ_x / σ_y (μm)	36/0.5
σ_z (mm)	5
Beam-beam tune shift	0.012/0.13
Energy loss / turn (MeV)	0.7
Number of buches, n_b	300
Revolution frequency (MHz)	0.5
Circumference, C (m)	600
Beam current (A)	4.8

Electron ERL	
Electron beam energy (GeV)	**1**
Number of electrons per bunch (10^{10})	2
Beta functions at IP β_x / β_y (mm)	80/5
Normalized emittances ε_x^N / ε_y^N (μm)	31/0.1
σ_x / σ_y (μm)	36/0.5
σ_z (mm)	5
Disruption Dx/Dy	0.33/60
Beam current (A)	0.48
Collider Parameters	
Crossing angle (mrad)	34
Collision frequency (MHz)	150
Luminosty	$1.4 \cdot 10^{35}$

Studies for reducing Dy are continuing

Further Lumi increase could be achieved by:
- increasing collision frequency
- shortening electron bunches with subsequent use of "dynamic focusing" (Brinkmann-Dohlus, DESY-M-95-11 (1995))

Physics at Super-Charm Factory

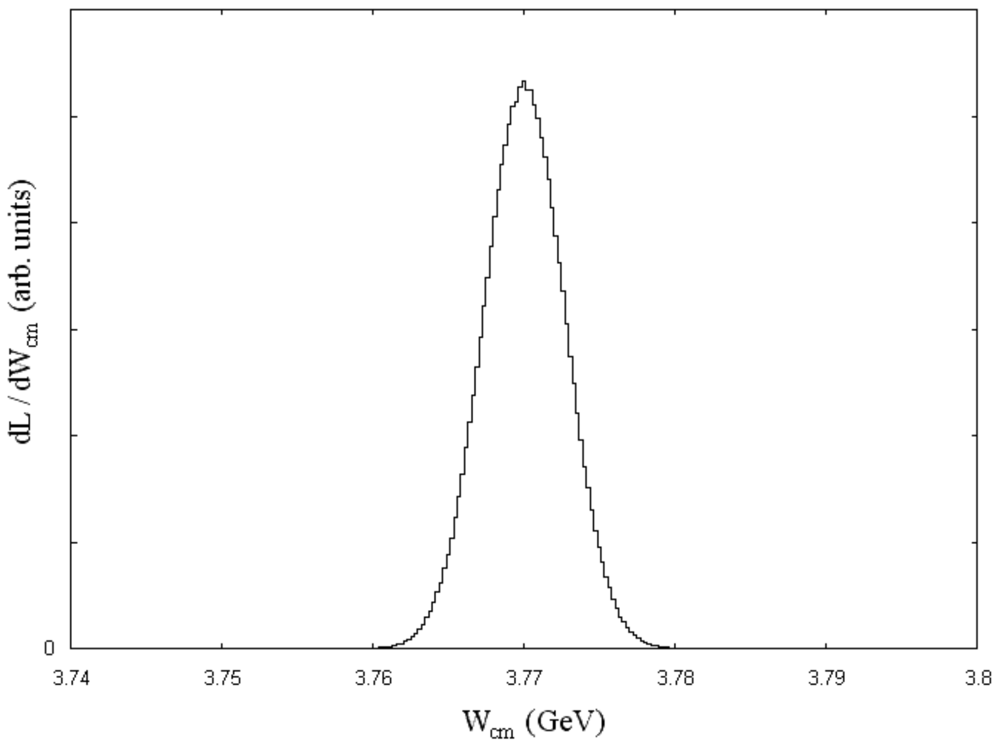
- τ option is weak.
  SuperB vs Super-c-τ: 2.5 times lower σ, but 10 times higher L

- Basic operation at Ψ(3S)

- Energy asymmetry is essential for time-dependent CPV analysis
  - Boost examples from *B*-factories are:
  - KEKB, the boost is $\beta\gamma = 0.43$.
  - PEP-II, used a slightly larger boost $\beta\gamma = 0.55$.

In TAC/PF, the boost is $\beta\gamma = 0.68$.

Luminosity spectrum for the TAC charm factory.



- Center of mass energy spread $< \Gamma_{\Psi(3S)} \approx 24$ MeV.
- $\Psi(3S)$ is about 10^{10} per working year (10^7 s)
- D^+D^- and D^0D^0 decay modes are dominant channels for $\Psi(3S)$ decays.

Outlook

For Charm Factory

Benchmark physics processes should be reviewed for a factory with asymmetrical beam energies.

Various synergy options within the TAC project should be evaluated.

- TAC SR (same e+ ring vs dedicated ring, sharing infrastructure)
- TAC FEL (time, infrastructure, expertise etc... sharing)

International collaborations with similar projects will be mutually beneficial:

- LHeC LR option, eRHIC LR option

For TAC in general

1 GeV SNS (based on TAC PA) is mandatory.

ADS studies (based on TAC PA) should be intensified.

Strong international cooperation opportunities should be seized.

We are seeking ECFA support for LR type colliders in general and for TAC project in particular.

Back-up slides

Synchrotron Light Source

- Is additional positron storage ring dedicated for production of synchrotron radiation necessary?
- Ring-ring collider: beam-beam tune shift restriction ➲large emittance ➲ high luminosity:

$$L = f_c \frac{4\pi\gamma_p\gamma_e\Delta Q_p\Delta Q_e\varepsilon_p}{r_0^2\beta_e^*}$$

SR in linac-ring type machines

- Luminosity independent of emittance⮋

$$L = f_c \frac{\gamma_p \Delta Q_p N_p}{r_0 \beta_p^*}$$

- Chosen emittance (3 nm·rad) of the positron small enough ➲ a third generation light source (< 20 nm·rad)
- Number of insertion devices and beam lines of TAC SR Facility and their specifications depend on realization of SESAME and CANDLE projects as well as on user potential in our region.