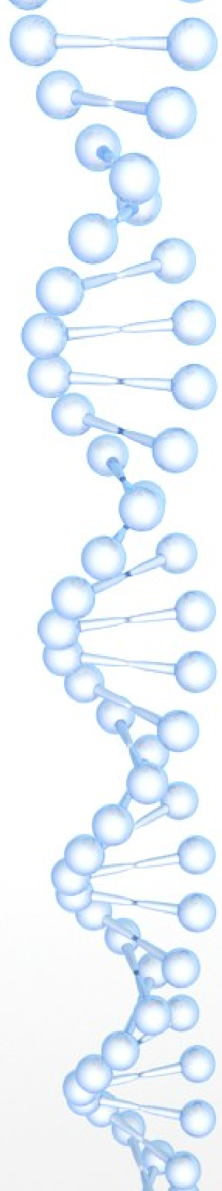
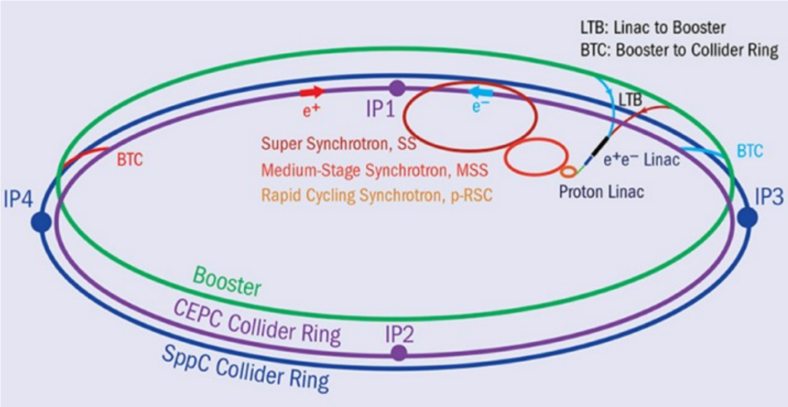


Study of electroweak processes for future e+e- colliders

Joint project with Chinese colleagues

CEPC project

- It is widely believed that the next (post-LHC) major HEP project will be an e+e- collider
- 4 mature projects are now under development:
  - ILC (linear, 250/500 GeV)
  - CLIC (linear, 380/3000 GeV)
  - FCC (circular, 91/250/360 GeV)
  - CEPC (circular, 91/240 GeV)



- CEPC is a 80 km circular collider to be built in China
- CEPC is expected to deliver 5.6 ab^{-1} at 240 GeV (1M Higgs bosons)
- Running at Z-pole is expected to collect up to 1T (10^{12}) Z-bosons

Our team

- We are the group of experimentalists and theoreticians, including senior scientists, postdocs and students.
- We have the experience in LEP (DELPHI), LHC (ATLAS), HERA, BESIII experiments.
- Our plans for the next few years are the theoretical support of CEPC experiments and Monte-Carlo based development of the experimental program.
- We are working in cooperation with our Chinese colleagues from IHEP and Sun Yat-Sen University.

Project participants

Principal investigators from JINR:

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Prof. Zhang Honghao, Ph.D students: Zhang Zhao, Su Yuhang (Sun Yat-Sen University, Guangzhou)

First paper on experimental program

Chinese Physics C

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Two-photon physics at future electron-positron colliders

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Two-photon physics at future electron-positron colliders

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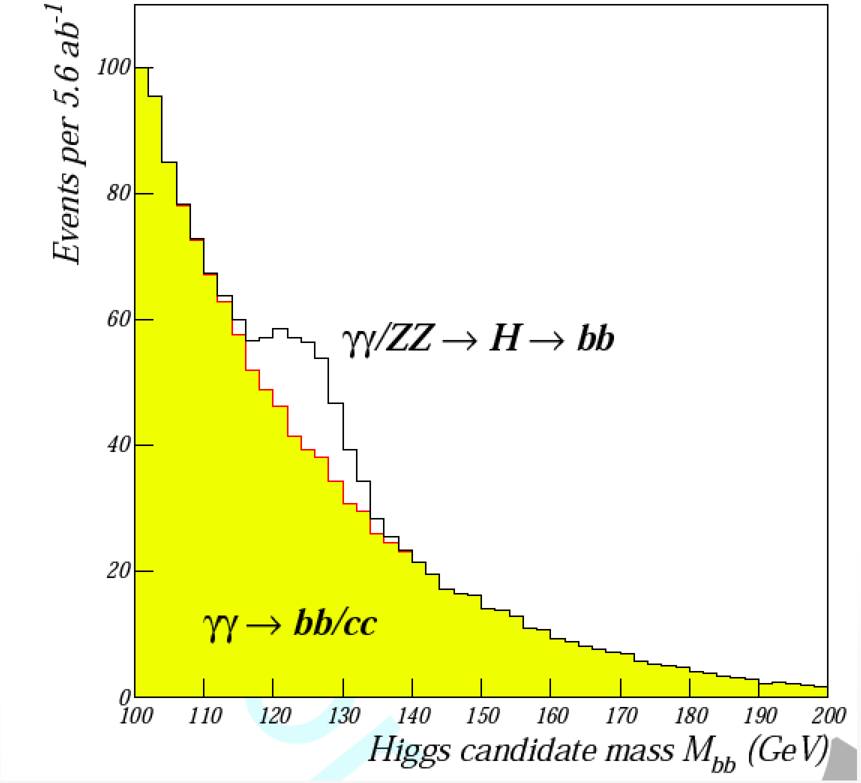
September 15, 2022

Abstract

Two photon collisions offer a variety of physics studies that can be performed at the future electron-positron colliders. Using the planned CEPC parameters as a benchmark we consider several topics to be studied in the two-photon collisions. With the full integrated luminosity the Higgs boson photoproduction can be reliably observed. A large statistics of various quarkonium states can be collected. The LEP results on the photon structure function and the tau lepton anomalous magnetic moment can be improved by 1-2 orders of magnitude.



Abstract of our project

The main output of the project will be concrete contributions to the physics research programs of the planned electron-positron colliders (FCCee, **CEPC**, ILC, CLIC and Super Charm-Tau Factories). The scientific significance of the project results is due to the critical importance of building a new generation of high energy electron-positron colliders for the study of fundamental physical phenomena. Calculations of cross sections of a number of basic processes for these colliders, taking into account radiation corrections and effects due to the polarization of particles, **will provide a high accuracy** of theoretical predictions. These calculations will be implemented in the Monte Carlo event generator ReneSANCe and integrator MCSANCee, which will be transferred to the experimenters for direct use in the **simulation** and **analysis** of experimental data.

Some general ideas

Analyze the performance of electroweak physics studies at future e+e- colliders:

define the current status of experimental and theoretical precision in particular (pseudo) observables,

point out where and how the precision(s) should be improved,

develop our collaboration (join theory and experiment).

Tasks for the joint project

Principal directions:

1) high-precision electroweak physics, i.e., scrutinize effects of radiative corrections, particle detection conditions etc

2) simulation and analysis of background and signal event, taking into account finite mass effect

3) construction of a software chain (for point 2)

4) concrete results on particular SM observables and parameters

5) implementation of theoretical calculations into full simulation and development of experimental program

Some concrete tasks (1)

I. Luminosity monitoring

1) Small-angle Bhabha scattering
2) Large-angle Bhabha scattering
3) $e^+e^- \to \gamma\gamma$
4) $e^+e^- \to \mu^+\mu^-$

Theoretical support at complete one-loop level, with two-loop leading logarithms.

Analyze experimental and theoretical precision, requirements for detectors and further higher-order calculations.

Not only luminosity, but also detector calibrations (muon system, calorimeter, resolution etc.)

Some concrete tasks (2)

II. Lepton universality tests

1) Z boson partial decay widths

2) asymmetries: forward-backward (A_{FB}) and polarized (A_L, A_{LL})

Analyze experimental and theoretical precision, requirements for detectors and further higher-order calculations.

Some concrete tasks (3)

III. EW pseudo observables

1) $M_{\mathbf{Z}}$, $\Gamma_{\mathbf{Z}}$, partial widths

2) $\sin^{\mathbf{2}} \vartheta_{\mathbf{W}}^{\mathbf{eff}}$ (especially from A_{FB} at the Z-peak)

3) A_{FB} and polarized asymmetries

4) $M_{\mathbf{W}}$ – sensitivity in different processes (observables)

Analyze experimental and theoretical precision, requirements for detectors and further higher-order calculations.

Some concrete tasks (4)

IV. Photoproduction of Higgs boson

The process **$e^+e^- \to e^+e^- \gamma^*\gamma^* \to e^+e^- H$**

is an important channel for CEPC etc. It can be analyzed compared with

the Higgs-strahlung: **$e^+e^- \to ZH$** and **$e^+e^- \to \nu\ \nu H$**

We have published generator-only (PYTHIA) study. Further plan is to analyze experimental and theoretical precision, requirements for detectors and further higher-order calculations.

First year plans

1. **Small-angle Bhabha** scattering (for luminosity monitoring)

   a) starting from the experience of LEP workshops

   b) then include higher-order effects

2. **$e^+ e^- \to \gamma\gamma$** (background for Higgs production etc.)

   with complete 1-loop EW RC + higher order leading effects

3. **$e^+ e^- \to e^+ e^- H$**

Collaboration with Chinese colleagues

2019: Joint workshop in IHEP (April, Beijing). CEPC Topical Workshop: Theoretical Uncertainty Controls for the CEPC measurements.

2020: Implementation of the theoretical calculations for Bhabha scattering (**$e^+ e^- \to e^+ e^-$**), **$e^+ e^- \to ZH, Z\gamma$**,

2021: s-channel (**$e^+ e^- \to \mu^- \mu^+, \tau^- \tau^+$**),

2022: Moller scattering (**$e^- e^- \to e^- e^-$**), polarized **μe** scattering, photon pair production **$e^+ e^- \to \gamma \gamma$**.

2022: Preparation of joint (Russia-China) grant application for RSCF (2023-2026)

end of 2022 or beginning of 2023: Mini Workshop on Bhabha scattering in CEPC