

Krakow and Silesia involvement in FCC project



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FCC Polish Day, January 2021

The teams

IFJ PAN



Leader: Marcin Chrzaszcz
Staff: Tadeusz Lesiak, Stanisław Jadach, Zbigniew Was, Andrzej Siodmok, Jihyun Bhom, Tomasz Wojton.
PhD students: Jozef Borsuk, Sergiej Antropov.

US



UNIVERSITY OF SILESIA
IN KATOWICE

Leader: Janusz Gluza
Staff: Ievgen Dubovyk, Bartosz Dziewit, Jacek Holeczek
PhD students: Magda Kordiaczynska, Wojciech Flieger, Krzysztof Grzanka

FCC activity of the University of Silesia group

Engaged since 2015.

Signed Addendum CERN-US for years 2017-2020 and 2020-2023

Activity:

1. calculation of higher-order EW corrections to pseudobservables (EWPOs) and processes needed to estimate sensitivities of FCC-ee (JG, ID, KG)
 - 2-loop EW correction to the Z-decay (finished)
 - 3-loop EW-QCD corrections (in progress)
2. phenomenological studies for FCC-hh, FCC-eh, FCC-hh, e.g. Higgs BSM phenomenology (JG, MK, WF, BD)
3. development of the software needed for FCC (JG, ID, BD, JG)

Two Polish grants connected with FCC activity:

- "The Z-boson resonance at three loops and New Physics effects"
(2018-2021)
- "Non-standard neutrinos and CP-violating effects in the leptonic sector"
(2021-2024)

Reports:

- Report "1", CERN Yellow Report: A. Blondel et al., "Standard model theory for the FCC-ee Tera-Z stage",
<https://e-publishing.cern.ch/index.php/CYRM/issue/view/89>
- Report "2", CERN Yellow Report: A. Blondel et al., "Theory for the FCC-ee : Report on the 11th FCC-ee Workshop Theory and Experiments",
<https://e-publishing.cern.ch/index.php/CYRM/issue/view/110>
- Report "3", Input to the European Strategy Particle Physics 2018-2020
A. Blondel et al., "Theory Requirements and Possibilities for the FCC-ee and other Future High Energy and Precision Frontier Lepton Colliders",
<https://inspirehep.net/literature/1712839>
- Report "4", A. Freitas et al., "Theoretical uncertainties for electroweak and Higgs-boson precision measurements at FCC-ee",
<https://arxiv.org/abs/1906.05379>

Main activity: calculation of higher order radiative corrections with direct numerical approach

- Sector decomposition (SD)
 - FIESTA 3 [2014], FIESTA 4 [2016] [A.V.Smirnov, V.A.Smirnov]
 - SecDec 3 [2015], pySecDec [2017] [S. Borowka, G. Heinrich, et. al.]
- The Mellin-Barnes (MB) method:
 - ▶ PlanarityTest [I.Dubovyk, K.Bielas, 2013]
 - ▶ AMBRE 2 [J.Gluza, et. al., 2011], AMBRE 3 [I.Dubovyk, et. al., 2015]
 - ▶ MB [M.Czakon, 2006], MBresolve [A.V.Smirnov, V.A.Smirnov, 2009]
 - ▶ MBnumerics [J.Usovitsch, I.Dubovyk, T.Riemann, 2015] – Minkowskian kinematics
 - ▶ QMB (MB+quasiMC) [I.Dubovyk, JG, T.Riemann, 2019] – Minkowskian kinematics
- ▶ Computation: integrals [Fleischer, Kotikov, Veretin 99]

NNLO Z-pole SM completed: 10^{-8} accuracy achieved for most of Feynman diagrams and at least 10^{-6} for the few worst integrals with one of the methods.

- ▶ Challenge for NNNLO Z-pole: further exploration MB & SD methods along with IBP reductions and Differential Equations method (numerical approach).

Main publications:

- I. Dubovyk, A. Freitas, J. Gluza, T. Riemann and J. Usovitsch, "The two-loop electroweak bosonic corrections to $\sin^2 \theta_{eff}^b$ ", Phys. Lett. B **762** (2016), 184, [doi:10.1016/j.physletb.2016.09.012](https://doi.org/10.1016/j.physletb.2016.09.012)
- I. Dubovyk, A. Freitas, J. Gluza, T. Riemann and J. Usovitsch, "Complete electroweak two-loop corrections to Z boson production and decay", Phys. Lett. B **783** (2018), 86, [doi:10.1016/j.physletb.2018.06.037](https://doi.org/10.1016/j.physletb.2018.06.037)
- I. Dubovyk, A. Freitas, J. Gluza, T. Riemann and J. Usovitsch, "Electroweak pseudo-observables and Z-boson form factors at two-loop accuracy", JHEP **08** (2019), 113 [doi:10.1007/JHEP08\(2019\)113](https://doi.org/10.1007/JHEP08(2019)113)



Stay aware

- **3rd FCC physics workshop**The third FCC physics workshop took place in Geneva from 13 to 17 January 2020.
- **FCC Software Workshop and Hands-on Tutorial**The first FCC Software Workshop and Hands-on Tutorial took place in Geneva

The FCC-ee in a few words

The **FCC-ee, formerly known as TLEP**, is a high-luminosity, high-precision e^+e^- circular collider envisioned in a new 80-100 km tunnel in the Geneva area. With a centre-of-mass energy from 90 to 400 GeV, the physics program could pave the way towards the discovery of physics beyond the Standard Model, casting light on unanswered questions, such as dark matter, the baryon asymmetry of the Universe, the hierarchy problem, the stability of the Universe or the nonzero neutrino masses.

The FCC-ee project is part and parcel of the Future Circular Collider design study (FCC) at CERN, and could be the first step towards the long-term goal of a 100 TeV collider.

Next events

WG12: Beam Energy Calibration and Polarization

lepton beam polarization at EIC and FCC

Thursday, November 5, 2020 - 15:00

Conferences and Workshops

FCC November Week 2020

Monday, November 9, 2020 - 08:30

- The indico meetings are grouped into 4 categories:
 - General FCC Physics, experiments, detectors and WG
 - Physics performance meetings
 - Conferences and workshops
 - Monthly physics meetings.

Stay aware

- **The general FCC physics, experiments, detectors and WG**
Please see the upcoming [FCC meetings](#)
- **FCC-ee physics performance** Please see the upcoming [Physics Performance meetings](#)
- **FCC-ee monthly physics meetings** Please see the upcoming [Physics meetings](#)
- **FCC conferences and workshops** Please see the upcoming Physics conferences and workshops: [Conferences & Workshops](#)

Next events

- Next events:
 - Now they are long list.
 - Only future events show
 - Automatically generated from the indico.

Conferences and Workshops

FCC November Week 2020

Mon, 11/09/2020 - 08:30

Conferences and Workshops

**4th FCC Physics and Experiments
Workshop**

Tue, 11/10/2020 - 09:00

The FCC-ee in a few words

The idea of a large circular e⁺e⁻ collider as Higgs Factory came from a conjunction of circumstances: i) the need of a large tunnel for the continuation of the high energy exploration after the LHC; ii) the new 'nano-beam' designs proposed for the 'super' B factories; iii) and of course the discovery of the Higgs boson with a mass that could have been reached (with efforts) at LEP2. The idea of such a machine as a first step toward a 100TeV pp collider was submitted to the ESPP2013/13 and led to the FCC study, launched in 2014. The study concluded in its FCC-int submission to the ESPP2020 that the *"The most effective and comprehensive approach to thoroughly explore the open questions in modern particle physics is a staged research programme, integrating in sequence lepton (FCC-ee) and hadron (FCC-hh) collisions"*.

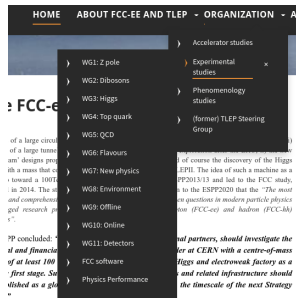
The ESPP concluded: ***"Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update."***

The FCC-ee is a high-luminosity, high-precision e⁺e⁻ circular collider. Two separate e⁺ and e⁻ storage rings with very strong focusing, fed by a full size continuous injector, provide e⁺e⁻ collision luminosities ranging from (per interaction point) 230 10³⁴ /cm² /s at the Z pole, 8 10³⁴ /cm² /s at the ZH production maximum (240 GeV) and 1.7 10³⁴ /cm² /s at the tt threshold and up to 365 GeV. Two to four interaction points are considered. The run plan of 15-20 years yields 5 10¹² Z bosons, 108 W pairs, 1.3 10⁶ Higgs bosons and 106 top quark pairs. Thanks to the availability of transverse polarization, the energy calibration

Next steps

- ⇒ The Organization card is starting to be updated.
- ⇒ Continue with updates of context.
- ⇒ Include the FCC talks on the main page.
- ⇒ Start Twitter account?

Please let us know your awesome idea!!!
All feedback for improvements is more than welcomed!



Many thanks to Alain, Patrick and Emmanuel for useful feedback!

