FCC-ee INJECTOR COMPLEX: STATUS, HIGHLIGHTS AND OUTLOOK

P. Craievich, PSI, Villigen PSI, Switzerland
A. Grudiev, CERN, Geneva, Switzerland
I. Chaikovska, CNRS/IN2P3, IJCLab, Orsay, France
C. Milardi, INFN-LNF, Frascati, Roma
on behalf of the CHART/FCC-ee Injector collaboration

Abstract

The FCC-ee demands an injector complex capable of delivering high-current, high-brightness electron and positron beams with exceptional efficiency. Within the CHART/FCC-ee Injector Study collaboration, a revised injector layout has been developed to optimize performance, cost, and power consumption. A central pillar of this effort is the tuning-free, high-gradient normal-conducting RF structure technology pioneered at PSI for SwissFEL and since extended across S-, C-, and X-band systems. This scalable approach underpins future developments in the FCC-ee linacs, enabling reliable acceleration. In parallel, the P^3 program at PSI is advancing the positron source, with commissioning foreseen in 2026, while upcoming work will enhance the electron source and refine RF requirements for the positron linac. This contribution presents the current injector complex status, key design highlights, and the outlook toward the FCC-ee injector technical design report.

INTRODUCTION

Following the conclusion of the Feasibility Study (FS) phase of the Future Circular Collider project, culminating in the publication of the Feasibility Study Report (FSR) in April 2025 [1], the project will enter the next phase focused on the preparation of the Reference Design Report (RDR) and the development of functional specifications for the subsystems of the FCC-ee injector complex. The main objective of the injector RDR is to finalise the physics design of the injector complex, including linacs, particle sources, damping ring (DR) and polarisation schemes. The RDR will also address the integration of the injector complex within the CERN site, including civil engineering requirements, siting constraints, surface integration, and technical infrastructure needs.

Figure 1 illustrates the baseline layout of the injector complex as presented in the FSR. The injector architecture has been developed to support operation at repetition rates of up to 100 Hz with trains of four bunches separated by 25 ns, thereby satisfying the demanding filling requirements of the Z running mode [1]. Table 1 summarizes the main collider and booster parameters that define the injector requirements. The injector is also designed to deliver high-brightness electron and positron beams for both filling-from-scratch and continuous top-up operation of the collider. Owing to the relatively short beam lifetime and stringent luminosity requirements, the injector must sustain frequent alternating injections of electrons and positrons while maintaining a controlled charge balance between the two beams in the collider ring. The baseline configuration comprises dedicated electron and positron linacs operating up to 2.86 GeV, followed by a damping ring for emittance reduction and a high-energy linac that boosts the beam energy to 20 GeV prior to injection into the booster ring. The positron source baseline is based on a conventional target-driven production scheme in which electrons from the electron linac impinge on a tungsten target. In this context, high-temperature superconducting (HTS) solenoids surrounding the target region play a key role in maximizing positron capture efficiency.

The present injector design also reflects a broader optimization effort focused on operational reliability, efficiency, cost, and power consumption. In particular, the RF systems are being reconsidered toward commercially available S-band technologies while preserving compatibility with the operational flexibility required by the collider complex. Special attention is devoted to the reliability of the RF systems under continuous top-up operation, where injector interruptions caused by RF breakdowns could directly impact collider performance. Consequently, experimentally validated low-breakdown-rate accelerating structures constitute a key requirement for the injector design.

A major contribution to this effort comes from the PSI-developed tuning-free, high-gradient normal-conducting RF technology initially developed for SwissFEL and subsequently extended to S-, C-, and X-band accelerating systems [2]. This tuning-free and scalable approach provides an attractive solution for the FCC-ee injector linacs, offering both operational robustness and reduced maintenance.

The injector complex will be constructed primarily within the existing CERN Prévessin site. The civil engineering infrastructure foreseen for the injector complex includes dedicated tunnels for the high-energy, electron and positron linacs, the damping ring, and the transfer lines connecting the injector systems to the booster. The underground structures will extend over approximately 1.2 km and will mainly rely on cut-and-cover construction techniques using reinforced concrete tunnels buried up to 15 m below ground level.

Switzerland and the Paul Scherrer Institute (PSI) continue to play a central role in supporting the FCC-ee injector activities through the *CHART collaboration*. The injector design presented in the Feasibility Study Report (FSR) was developed within the framework of the FCC-ee injector studies conducted under the CHART 2020–2024 programme, while the next stage of development toward the Reference Design Report (RDR) and Technical Design will be carried

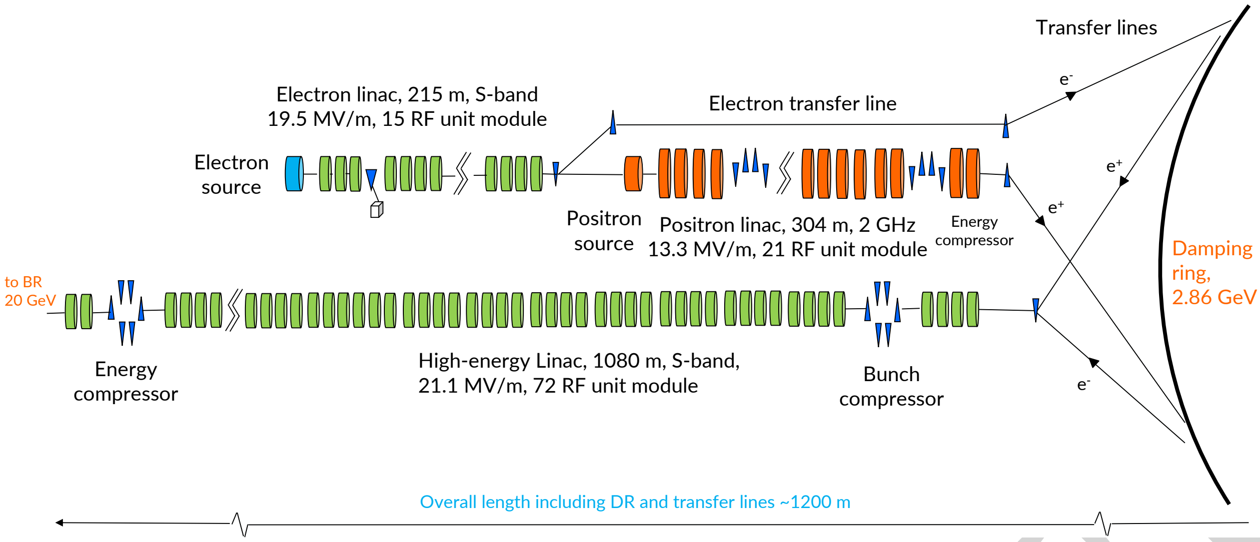

Figure 1: Baseline layout of the pre-injector complex.

Table 1: Collider and booster parameters used as specifications for the injector design. Bunch charge is the maximum bunch charge to be injected into the collider ring. Emittance, bunch length and energy spread are the specifications at the injection into the Booster ring.

Running mode	**Z**	**W**	**ZH**	**tt**	**Unit**
Number bunches in collider	11200	1856	300	64	
Nominal bunch charge in collider	34.40	22.08	27.04	23.68	nC
Allowable charge imbalance	5	3	3	3	%
Beam lifetime, lumi 4 IPs (q, BS, lattice)/4	916	517	428	497	s
Trains/Bunches per booster cycle	40×280	8×232	2×150	2×32	
Max injected bunch charge	3.43	3.43	1.60	1.60	nC
Number of bunches	4	4	2	2	
Linac rep. rate	100	100	50	50	Hz
Bunch spacing	25				ns
Beam energy at BR	20				GeV
Norm. emittance (x, y) (rms) (BR)	<20,2				mm mrad
Bunch length (rms) (BR)	~4				mm
Energy spread (rms) (BR)	~0.1				%

out within the CHART 2025-2028 programme. The collaboration brings together PSI and CERN, together with major international partners, including CNRS-IJCLab (Orsay, France) and INFN-LNF (Frascati, Italy). Additional contributions are provided by KEK (Tsukuba, Japan), which participates as an external observer and consultant for the P^3 project, and by SLAC, which provides selected technical developments of the injector complex and to the experimental programme at FACET-II. The combined expertise of these institutes is essential for addressing the remaining scientific and technical challenges and for consolidating the injector design toward the RDR and subsequent technical design phase. In parallel, CERN has established a dedicated organizational structure, the *Injector Pillar*, integrated within the overall FCC project and CERN organization. Its role is to coordinate the integration of the injector subsystems toward the completion of the RDR and the technical design.

In the following sections, the current status of the main subsystems of the injector complex is described, highlighting the key design developments achieved during the ongoing optimisation phase and outlining the outlook toward the RDR, expected by the end of 2027.

HIGH-ENERGY (HE) LINAC

The optimisation of the HE-linac for the injector complex has focused on transverse single- and multi-bunch beam dynamics, RF structure design, and longitudinal beam manipulation through dedicated energy and bunch compression systems. Extensive simulation studies were carried out to identify a configuration capable of satisfying the stringent requirements on emittance preservation, beam stability, and operational robustness. A comprehensive optimisation campaign was performed using RF-Track [3]. The main optimisation parameters included the RF iris aperture, RF structure length, phase advance per cell, and the number of quadrupoles per RF structure. The iris aperture primarily affects the strength of transverse wakefields, while the remaining parameters determine the focusing properties and beam optics of the accelerator lattice [4].

The final lattice configuration was selected taking into account both static and dynamic beam dynamics effects. In particular, the optimisation relied on the evaluation of the jitter amplification (JA) parameters, together with dedicated mitigation strategies discussed in [5]. The adopted baseline solution consists of one quadrupole per RF structure, which provides reduced beam size and shorter betatron wavelength compared with alternative layouts. Although this solution requires stronger quadrupole strength, it offers improved performance in terms of jitter amplification over the investigated parameter range. However, the final HE-linac configuration was therefore chosen as a compromise between transverse stability, emittance preservation, RF performance, technical feasibility, and overall cost. A detailed comparison of the different configurations investigated is presented in [4].

Overall, the proposed HE linac design satisfies both the static and dynamic beam dynamics requirements with significant operational margin, providing tolerance against possible variations of the incoming beam parameters. The resulting lattice configuration also serves as the basis for the RF design and optimisation of the 3 GHz accelerating structures.

RF Structure Optimization at 3 GHz

The study presents an updated design of 3 GHz traveling-wave accelerating structures for the HE-linac, comparing two variants with average iris apertures of 0.12λ (baseline) and 0.13λ (alternative), building on earlier work. Both 3 m-long structures are optimized for operation with 14.2 MW klystrons and incorporate tapered geometries to reduce wakefield and enhance multi-bunch stability. The baseline design achieves superior RF efficiency, reaching an average loaded gradient of 22.08 MV/m and a peak gradient of 79 MV/m, while the alternative reduces peak fields to 60 MV/m and surface power to 399 mW/μm^2 with only a slight reduction in gradient (21.15 MV/m). After RF pulse optimization, both structures demonstrate excellent beam-loading compensation, limiting energy variation across four bunches to about 0.06% [6, 7].

Wakefield analyses, validated against ECHO2D [8] simulations, confirm compliance with the transverse wakefield limit of 0.2 V/pC/mm/m for 25 ns bunch spacing, with flexibility down to 10 ns. The transverse wake potentials for baseline design is illustrated in Fig. 2. Sensitivity studies further show that geometric deviations up to 50 μm have minimal impact, although the cavity radius is the most critical parameter, leading to a recommended fabrication tolerance of ±10 μm. More details on the RF design and optimization of 3 GHz Traveling-Wave structures for the HE-Linac can be found in [9].

Overall, the proposed HE linac layout meets the current injector performance requirements for efficient and reliable injection into the booster ring. The design also preserves sufficient operational flexibility and performance margin to accommodate future refinements of the beam parameters. Future studies will focus on coherent synchrotron radiation (CSR) effects, multi-bunch collective effects, and the experimental validation of the correction and bunch-compression schemes.

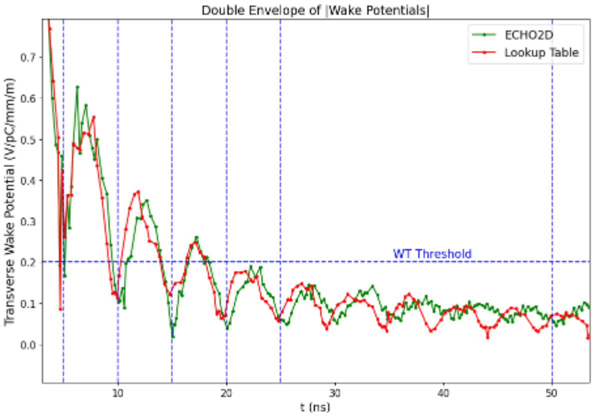

Figure 2: Envelope-of-the-envelope transverse wakefield potentials for the 0.12λ structure.

ELECTRON SOURCE(S)

The electron source for the FCC-ee injector complex must satisfy demanding operational requirements driven by the collider top-up injection scheme. Depending on the operating mode and the charge imbalance between electron and positron bunches in the collider, the charge of each individual bunch within the injected train must vary from a few hundred pC up to approximately 5 nC per injection. Since the lifetimes of the individual bunches in the collider rings are different, the filling pattern also changes dynamically from one injection cycle to another. Consequently, the electron source must be capable of independently modulating the charge of each bunch within the four-bunch train at repetition rates of up to 100 Hz.

Because the electron beam will also pass through the damping ring (DR), alternative electron source technologies are under evaluation. A comprehensive review of possible solutions has therefore been initiated, with particular focus on DC and RF thermionic guns capable of producing bunch charges above 5 nC while preserving the required charge modulation flexibility at 100 Hz.

The present baseline solution under investigation is based on a photocathode RF gun derived from the SwissFEL RF photogun design [11]. The source consists of a 2.5-cell S-band RF gun operating with a peak cathode field of approximately 100 MV/m and equipped with Cs_2Te semiconductor photocathodes loaded through a dedicated load-lock system. To experimentally validate the feasibility of this concept for the FCC-ee injector, a dedicated test stand is being prepared at PSI using a spare SwissFEL S-band gun, combined with a focusing solenoid and a dedicated diagnostic beamline.

Current R&D activities at PSI and CERN focus on techniques for shaping and modulating the laser pulse in order to achieve bunch-by-bunch charge modulation at 100 Hz directly at the photocathode level. The proof-of-principle experiment will initially demonstrate charge modulation for a single bunch and will subsequently be extended to the generation of two bunches with variable temporal separation.

The development of suitable photocathodes is also a major challenge for the injector source. The objective is to achieve reliable high-charge extraction while maintaining sufficiently long operational lifetime and stable performance. This effort is being pursued through collaboration between PSI and CERN, combining expertise in material science, photocathode fabrication, and operational optimisation. The goal is to develop high-performance photocathodes suitable for operation and validation at the PSI electron source test stand.

In parallel, complementary studies at CERN investigate the limitations of charge extraction from photocathodes at high laser intensities, where collective effects can significantly affect emission performance. A dedicated model has been developed to describe the dependence of the photocathode quantum efficiency (QE) on laser pulse energy, pulse duration, and transverse spot size. This model provides improved predictions of the achievable bunch charge from copper cathodes and constitutes an important input for the optimisation of the electron source design [12].

POSITRON SOURCE AND LINAC

Over the past year, substantial progress has been achieved in the development and optimisation of the positron source for the FCC-ee injector complex, with particular emphasis on the complete production chain from the positron target to injection into the damping ring (DR). The baseline configuration established during the Feasibility Study is based on a conventional positron production scheme in which a 2.86 GeV electron drive beam impinges on a 15 mm thick tungsten target. The produced positrons are subsequently captured and accelerated through a system composed of an adiabatic matching device, a solenoid-based capture linac, a separator chicane, a positron linac, and an energy compression system (ECS) upstream of the DR. This configuration was shown to satisfy the FCC-ee performance requirements with operational margin, while also identifying the positron acceptance of the DR as one of the most critical parameters determining the overall system efficiency [13].

An important milestone achieved during this period was the validation of the start-to-end simulation framework used for positron source studies. The simulation chain combines Geant4 for particle production in the target and RF-Track for beam dynamics simulations through the capture and acceleration systems. The framework was benchmarked against experimental measurements from the SuperKEKB positron source [14], including scans of the primary electron impact position, magnetic field in the capture section, and RF phases. The excellent agreement observed for the positron yield after the capture section provides strong confidence in the simulation tools now employed for FCC-ee optimisation studies.

Building on this validated framework, recent work has focused on estimating the fraction of positrons accepted by the DR, which represents the most relevant figure of merit for the source performance. Several complementary approaches have been developed, including direct tracking within the DR, reconstruction of an effective six-dimensional acceptance (“6D sphere”), and a machine-learning-based model trained to reproduce the DR acceptance behaviour. Results obtained for both the 2.86 GeV and 1.54 GeV DR configurations are summarised in [15].

In parallel, studies of possible upgrades and alternative configurations for the capture system have continued. In particular, new concepts based on 3 GHz S-band RF structures are under investigation, including travelling-wave (TW), standing-wave (SW), and hybrid SW-TW accelerating schemes. Different focusing approaches are also being evaluated, such as superconducting solenoid channels and downstream FODO lattices, with the goal of defining a technically realistic alternative baseline solution.

These studies indicate that the different configurations provide distinct trade-offs between positron yield, transverse emittance, and energy spread. Ongoing optimisation efforts aim to identify a solution capable of matching or exceeding the performance of the FCC Feasibility Study baseline while preserving technical feasibility and operational robustness. In addition, exploratory investigations of alternative positron production concepts, including crystal-assisted positron generation, have also been initiated [16].

P^3 project at PSI. The PSI Positron Production (P^3) project [17–19] has reached key milestones during the last period. The full experimental setup has been installed in the SwissFEL tunnel at PSI, with the completion of the dedicated bunker in early 2026 [20].

Dedicated R&D activities have also been pursued on target optimization and beam diagnostics. Studies of alternative target geometries, including conical designs, indicate potential improvements in positron yield and operational robustness [21]. A key component of the P^3 experiment is the diagnostics system, which has been tested at the Beam Test Facility (BTF) at INFN-LNF using electron and positron beams with energies of 50–300 MeV. The goal of these measurements was to validate the performance of scintillator-based diagnostics for beam profile and charge measurements. The scintillator fiber system demonstrated high sensitivity and a clear linear response as a function of beam charge and energy. The fiber-based diagnostics also enabled reconstruction of the transverse beam profile through controlled scanning.

Overall, the P^3 project is progressing according to schedule and is expected to provide the first experimental validation of a high-yield positron source. The first positron production is expected by 2026.

DAMPING RING AND TRANSFER LINES

The positron bunch trains, four bunches separated by 25 ns at 100 Hz, are generated using conventional source, accelerated in the linac, and subsequently injected into a damping ring (DR), where synchrotron radiation damping is exploited to reduce the large emittance of the injected beams. The DR design must satisfy competing requirements: First, the ring must provide very fast damping rates to sustain the injector repetition rate and limit the overall system cost; second, it must achieve very low equilibrium emittances to meet the injector beam quality specifications. These objectives strongly constrain the lattice design, further challenged by limitations related to dynamic aperture, alignment tolerances, injection and extraction kicker systems, and overall machine cost.

During the Feasibility Study phase, several DR configurations and operating energies were investigated before converging toward the present baseline solution. The current design is based on a 2.86 GeV lattice compatible with the injector staging scenario and operational flexibility requirements discussed in [1]. The adopted geometry consists of a compact hexagonal ring with six arcs and six straight sections, providing both high symmetry and flexibility for the integration of RF systems, damping wigglers, and injection and extraction hardware, with a circumference approximately of 370 m. The DR is required to deliver beams with geometric transverse emittances of approximately 1.8 nm·rad horizontally and 0.18 nm·rad vertically. The present lattice design ensures sufficient positron acceptance during injection and achieves damping times of about 6 ms in both transverse planes. However, the equilibrium horizontal emittance currently remains approximately a factor of two above the target specification, and further optimisation is ongoing [22].

Given the high positron charge requirements, particular attention has been devoted to maximising the dynamic aperture and overall positron acceptance of the DR. To validate the design, start-to-end simulations have been performed, including the positron target, capture section, positron linac, energy compressor, transfer lines, injection into the DR, and tracking of the surviving particles over approximately 1000 turns. These studies confirm the viability of the present approach and provide important input for the ongoing optimisation work [15].

Collective effects is also a critical aspect of the DR design. Initial studies of fast ion instability and electron cloud effects are reported in [23,24]. Future work include nonlinear lattice optimisation, sensitivity to alignment and magnetic errors, collective effects mitigation, and further reduction of the equilibrium horizontal emittance toward the design target.

In parallel, a first concept for the DR injection and extraction systems has been developed, including the layout, optics design, and identification of the main hardware constraints [25]. The beam dynamics and operational scenarios of the transfer systems are under study to define a robust baseline configuration for integration within the injector complex. In addition to positron beam configuration, the DR is also foreseen to stabilise the electron beam before injection into the HE-linac. This additional operational requirement increases the complexity of the transfer line system and will require further optimisation in the next design phase.

CONCLUSION AND OUTLOOK

The activities carried out within the CHART collaboration have substantially advanced the design, optimisation, and validation of the FCC-ee injector complex. The studies performed to date confirm the feasibility of the baseline solutions for the linacs, electron and positron sources, and the positron production chain. At the same time, ongoing work on the damping ring is progressively converging toward a baseline configuration, with few options still under evaluation, particularly concerning positron acceptance and emittance damping performance.

The results achieved so far provide a strong basis for the next phase of the project, which will focus on consolidating the injector reference design toward the Reference Design Report (RDR), improving operational robustness and reliability, and preparing the subsequent technical design phase.

In parallel with the beam physics and system integration studies, the CHART programme is also supporting the development and validation of key injector subsystems. These activities include the design, construction, and testing of prototype accelerating structures for the HE-linac together with an S-band RF pulse compressor, including high-power validation and performance measurements. A major objective of this work is the definition of a scalable industrialisation process for the large-scale production of RF accelerating structures, ensuring cost-effective and reproducible manufacturing. Additional activities include the installation, commissioning, and testing of the electron source, as well as the completion and operation of the positron source test facility at PSI.

Looking ahead, several new specifications and requirements currently under discussion at the FCC project level may have a significant impact on the injector design and optimisation strategy. In particular, the nominal bunch spacing, presently set at 25 ns, could evolve toward values ranging from 10 ns to 50 ns. Furthermore, the implementation of electron and positron beam polarisation for collider energy calibration is under active investigation. This would introduce new injector requirements, including the possible integration of a polarised electron source and a dedicated positron polarisation ring, both currently being studied at CERN. In addition, alternative RF frequencies for the collider and booster rings are being evaluated and could affect both the bunch structure and the RF frequency choices for the injector complex.

These evolving requirements will require continued optimisation and flexibility in the injector design over the coming years. Nevertheless, the work performed within CHART has established a robust technical and scientific foundation to address these future challenges and support the successful development of the FCC-ee injector complex toward the RDR phase and beyond.

ACKNOWLEDGEMENTS

This work was done under the auspices of CHART (Swiss Accelerator Research and Technology) Collaboration, https://chart.ch.

REFERENCES

[1] M. Benedikt *et al.*, “Future Circular Collider Feasibility Study Report volume 2”, *Eur. Phys. J. Spec. Top.*, vol. 234, no. 19, pp. 5713-6197, 2025. doi:10.17181/CERN.EBAY.7W4X

[2] T. G. Lucas *et al.*, “Review of the high field performance of normal-conducting, tuning-free RF technology developed at the Paul Scherrer Institute”, *Eur. Phys. J. Spec. Top.* 234, pp. 8173–8180, 2026. doi:10.1140/epjs/s11734-025-01919-y

[3] A. Latina, “RF-Track v2.5.5”, Zenodo, Dec. 2020. doi:10.5281/zenodo.3887084

[4] S. Bettoni *et al.*, “Beam dynamics optimization of the high energy linac of the FCCee injector”, presented at the 17th International Particle Accelerator Conf. (IPAC’26), Deauville, France, May 2026, paper WEP5054, this conference.

[5] S. Bettoni, A. Latina, and A. Grudiev, “Transverse beam jitter damping along the FCC-ee injector linacs”, *Phys. Rev. Accel. Beams*, vol. 28, p. 061601, 2025. doi:10.1103/8wx6-9spr

[6] A. Kurtulus *et al.*, “RF design and optimization of the high-energy linac for the FCC-ee injector complex”, *Phys. Rev. Accel. Beams*, vol. 28, p. 101601, 2025. doi:10.1103/x2rz-2qxj

[7] A. Kurtulus, “Impedance studies of the HL-LHC collimators & RF design and optimization of the next-generation injector linacs”, Ph.D thesis, Dept. of Information Technology and Electrical Engineering, ETH Zurich, Switzerland, 2026.

[8] I. Zagorodnov and T. Weiland, “TE/TM field solver for particle beam simulations without numerical Cherenkov radiation”, *Phys. Rev. ST Accel. Beams* vol. 8, p. 042001, 2005. doi:10.1103/PhysRevSTAB.8.042001

[9] A. Kurtulus *et al.*, “Updated RF design and optimization of 3-GHz traveling-wave structures for the FCC-ee high-energy linac”, presented at the 17th International Particle Accelerator Conf. (IPAC’26), Deauville, France, May 2026, paper MOP7013, this conference.

[10] S. Bettoni *et al.*, “Toward the experimental validation of the beam transverse stabilization: FACET-II and FCCee synergy”, presented at the 17th International Particle Accelerator Conf. (IPAC’26), Deauville, France, May 2026, paper WEP5053, this conference.

[11] Z. Vostrel and S. Doebert, “Design of an electron source for the FCC-ee with top-up injection capability”, *Nucl. Instrum. Methods Phys. Res. A*, vol. 1063, p. 169261, 2024. doi:10.1016/j.nima.2024.169261

[12] A. Omoumi *et al.*, “Collective and surface charge effects in high-brightness ultrafast electron sources,” submitted for publication to *Phys. Rev. Accel. Beams*.

[13] F. Alharthi, “Design and validation studies of the FCC-ee positron source: from advanced simulations to proof-of-principle experiments at PSI”, PhD thesis, Accelerator Physics, Université Paris-Saclay, CNRS, France, 2025.

[14] F. Alharthi *et al.*, “Modeling of the positron sources: Experiment-based benchmarking using SuperKEKB”, *Phys. Rev. Accel. Beams* vol. 28, p. 111601, 2025. doi:10.1103/csyg-chyj

[15] Y. Wang, “FCC-ee positron capture system based on 3 GHz RF structures”, presented at the 17th International Particle Accelerator Conf. (IPAC’26), Deauville, France, May 2026, paper TUP3080, this conference.

[16] F. Alharthi *et al.*, “FCC-ee positron source from conventional to crystal-based”, *Nucl. Instrum. Methods Phys. Res. A*, vol. 1075, p. 170412, 2025. doi:10.1016/j.nima.2025.170412

[17] N. Vallis *et al.*, “Proof-of-principle e+ source for future colliders”, *Phys. Rev. Accel. Beams*, vol. 27, p. 013401, 2024. doi:10.1103/PhysRevAccelBeams.27.013401

[18] J. Kosse *et al.*, “Design of NI HTS solenoid for PSI positron production experiment”, *Supercond. Sci. Technol.*, vol. 38, p. 035008, 2025. doi:10.1088/1361-6668/ada9d3

[19] R. Mena-Andrade *et al.*, “Design and development of the P-cubed Target Insertion Device (P^3-TID)”, submitted for publication to Journal of Instrumentation (JINST).

[20] I. M. Besana *et al.*, “Shielding calculations and activation studies for the PSI Positron Production experiment”, presented at the 17th International Particle Accelerator Conf. (IPAC’26), Deauville, France, May 2026, paper TUP3081, this conference.

[21] N. Vallis *et al.*, “Conical targets for enhanced high-current positron sources”, *Nucl. Instrum. Methods Phys. Res. B*, vol. 568, p. 165854, 2025. doi:10.1016/j.nimb.2025.165854

[22] A. De Santis, C. Milardi, S. Bilanishvili, and M. Zobov, “Damping ring for FCC-ee injector complex”, presented at the 17th International Particle Accelerator Conf. (IPAC’26), Deauville, France, May 2026 paper MOP1047, this conference.

[23] C. Bayar *et al.*, “First results on fast ion instability in the FCC-ee injector complex damping ring”, presented at the 17th International Particle Accelerator Conf. (IPAC’26), Deauville, France, May 2026, paper MOP1108, this conference.

[24] O. Etisken *et al.*, “An updated assessment of the electron cloud effects in the damping ring of the FCC-ee injector complex”, presented at the 17th International Particle Accelerator Conf. (IPAC’26), Deauville, France, May 2026, paper WEP1014, this conference.

[25] Y. Dutheil and S. Yue, “Beam transfer concept at the FCC-ee injector complex”, presented at the 17th International Particle Accelerator Conf. (IPAC’26), Deauville, France, May 2026, paper MOP1114, this conference.