



Status of the Compact Linear Collider (CLIC) project

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on behalf of the CLICdp Collaboration*

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The CLICdp Collaboration



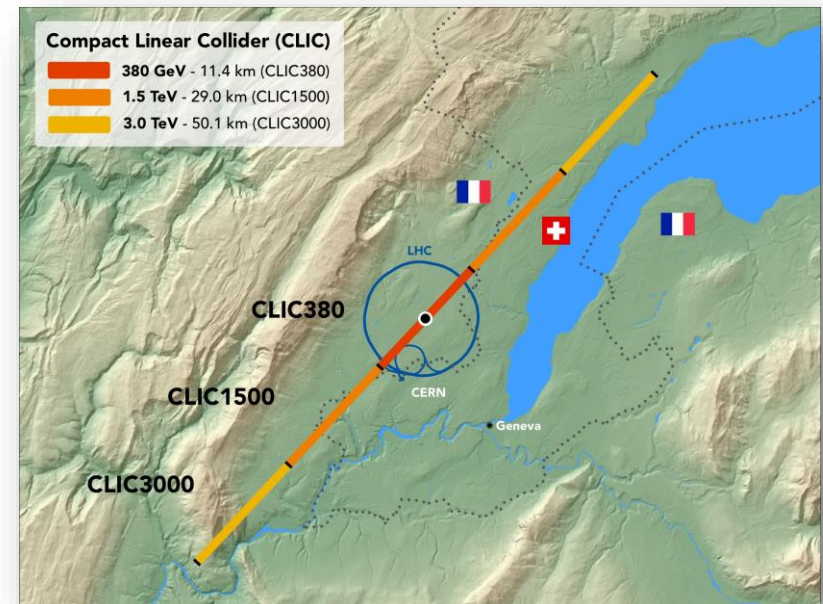
CLIC detector and physics study (CLICdp)

- Physics studies
- Detector technology R&D
- Close connection to ILC detector concepts, CALICE, FCAL, AIDA-2020 project



158 members from 30 institutes in 18 countries

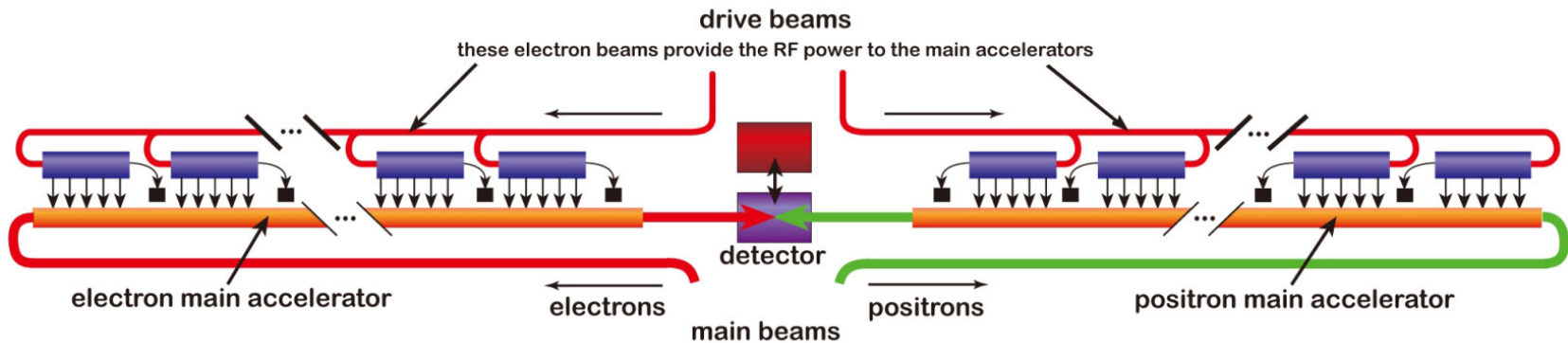
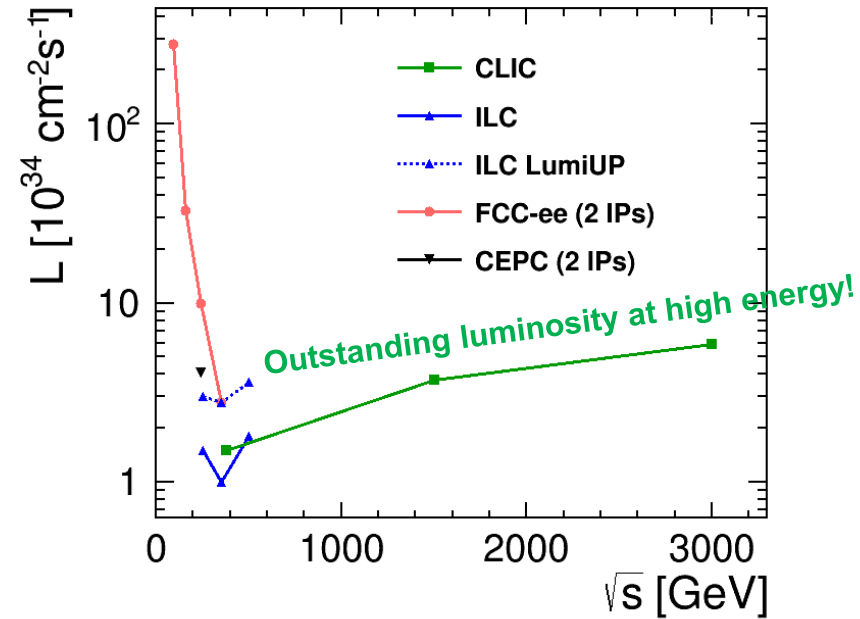
CLICdp and accelerator collaboration: <http://clic.cern/>



The CLIC accelerator concept

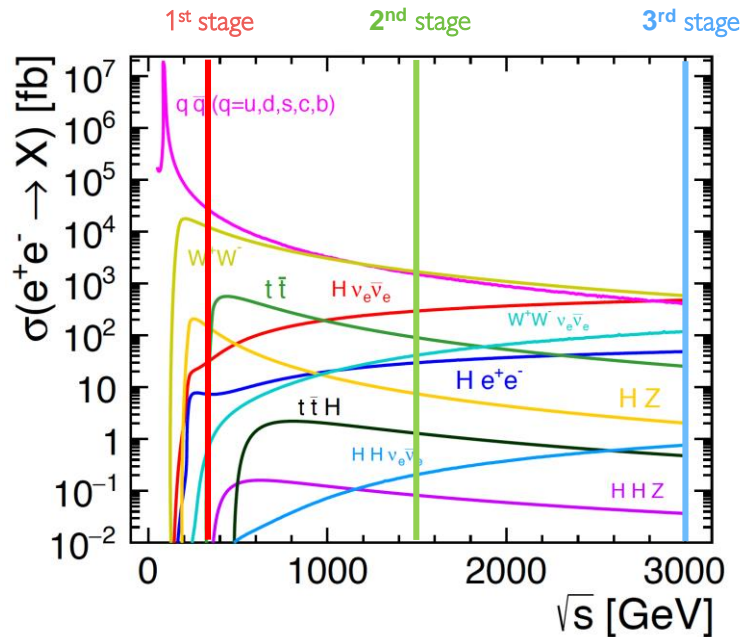


- Two-beam acceleration scheme (drive/main beams)
 - High accelerating gradient of 100 MV/m
 - Allows a 3 TeV collider to be built in only 50 km (compact)
- Electron beam polarization at all energies
- Energy staging from 380 to 3000 GeV



Conceptual Design Report: [CERN-2012-007](https://cds.cern.ch/record/1218007)

A Staged Physics Program



1) $\sqrt{s} = 380$ GeV ($500 + 100$ fb $^{-1}$)

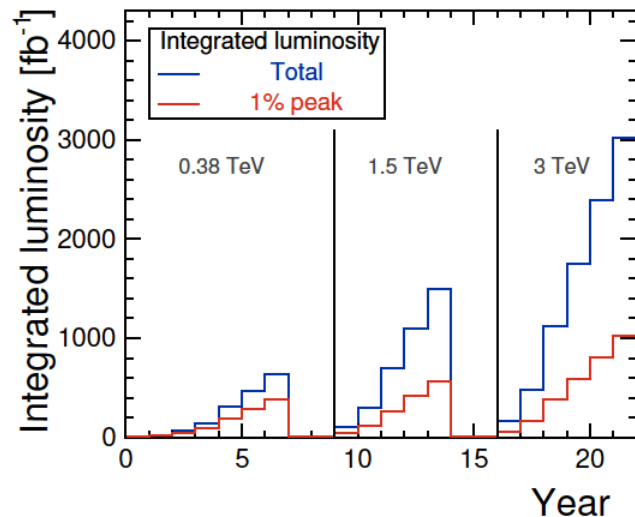
- Higgs/top precision physics
- Top mass threshold scan

2) $\sqrt{s} = 1.5$ TeV (1.5 ab $^{-1}$)

- Focus: BSM searches
- Higgs/top precision physics

3) $\sqrt{s} = 3$ TeV (3.0 ab $^{-1}$)

- Focus: BSM searches
- Higgs/top precision physics



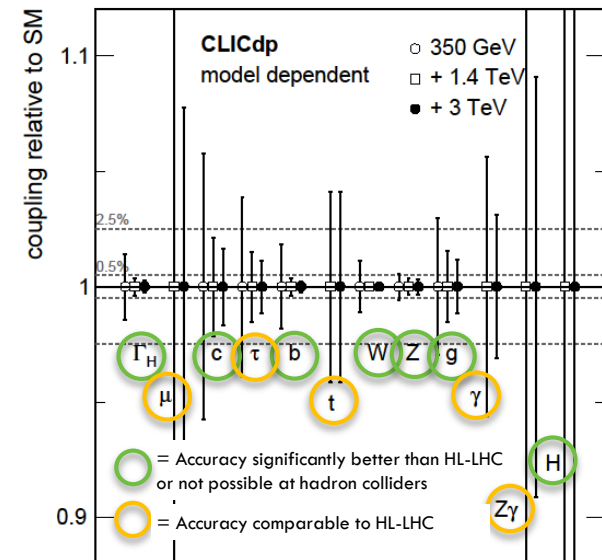
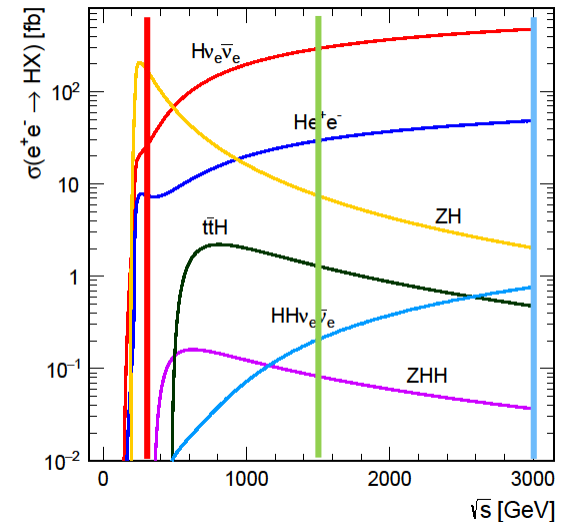
Staging can be adapted to possible discoveries at LHC and CLIC:

[CERN-2016-004](https://cds.cern.ch/record/2270000/files/CERN-2016-004)

Higgs Physics at CLIC



- CLIC covers several Higgs production processes
- Highlights:
 - **Vector-boson fusion** (dominates at high energies) to Higgs
 - Higgsstrahlung $e^+e^- \rightarrow ZH$: **model independent measurement of Higgs properties** using the Z-recoil mass (unique to lepton colliders)
 - Double Higgs production: simultaneous extraction of **model-independent tri-linear self-coupling** ($\Delta\lambda$ CLIC: $\sim 10\%$ from differential distributions) and **quartic coupling** (g_{HHWW} : $\sim 3\%$)
 - Higgs couplings and width can be determined with a **percent-level statistical uncertainty**
 - in many cases **significantly better than or not even possible at HL-LHC**

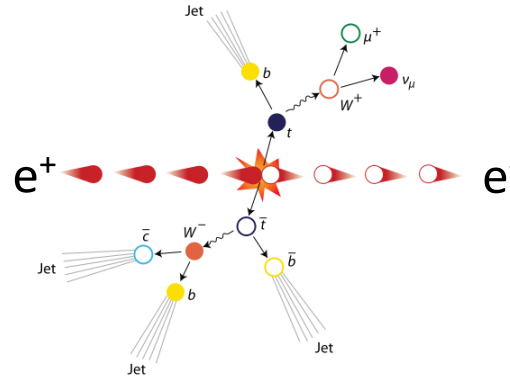


Comprehensive report on our Higgs studies in [Eur. Phys. J. C 77 \(2017\) 475](https://arxiv.org/abs/1703.05447)

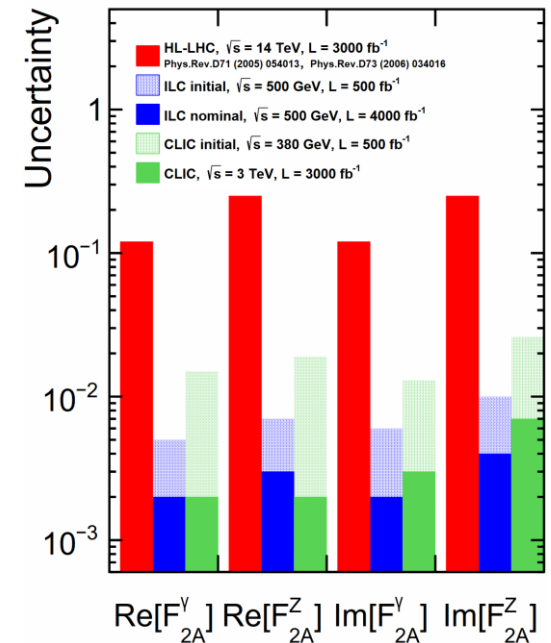
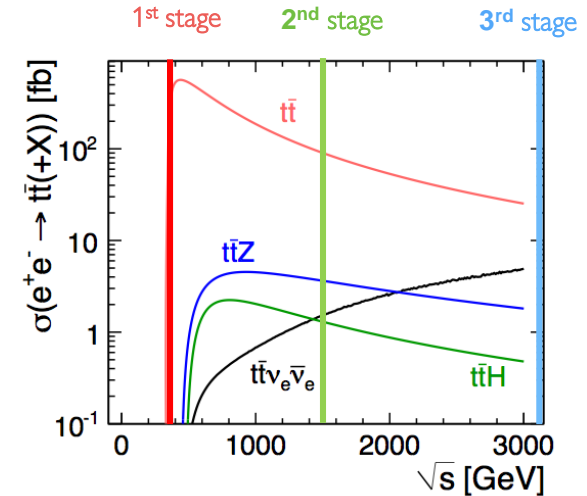
Top Physics at CLIC



- Several hundreds of thousands of top quark pairs are produced at CLIC
- Top quarks have not been studied in e^+e^- collisions yet
- CLICdp is preparing a comprehensive top physics report



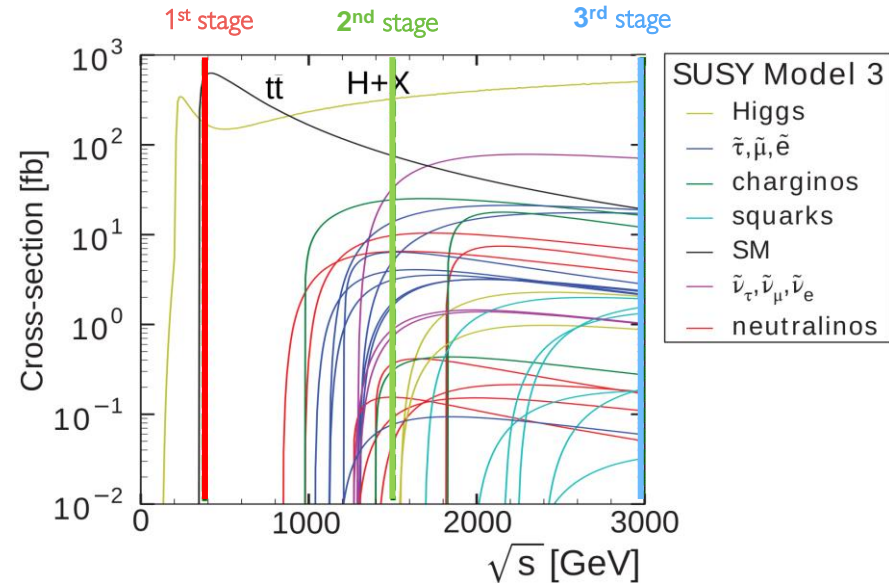
- Selected highlights
 - **Complete $t\bar{t}$ study at all three stages:** 380 GeV (resolved), 1.5 TeV (semi-boosted), 3 TeV (boosted)
 - **Threshold scan:** top mass with precision of about 50 MeV
 - **Top couplings at high precision**
 - e.g. **top Yukawa coupling** ($e^+e^- \rightarrow t\bar{t}H$)



BSM Physics at CLIC



- Indirect searches via precision observables
 - Discovery beyond the center-of-mass energy
- Direct production of new particles
 - Up to the kinematic limit ($\sqrt{s}/2$ for pair production)
 - Precision measurements - measure the mass and production cross-sections to percent-level
 - Complements the HL-LHC program
- Highlights:
 - Lepton colliders offer **superior sensitivity to EW** state
 - Indirect searches give access to **new physics scale** $O(10)$ TeV
 - **Tests of EW symmetry breaking** (vector boson scattering)
 - **Test deviations from QED** (Di-photon production at 3 TeV)



New particle/scenario	CLIC @ 3000 GeV reach
Anomalous gauge couplings	$-0.001 < a_4 < 0.0011$ $-0.00070 < a_5 < 0.00074$
Extra dimensions $M_S/\lambda^{1/4}$ (95% CL)	~ 16 TeV
Contact interactions (Λ^2) (95% CL)	~ 21 TeV
Chargino, neutralinos	≤ 1.5 TeV
Sleptons	≤ 1.5 TeV
Z' (SM couplings)	~ 20 TeV
Triple gauge coupling (95% CL)	$\lambda_\gamma: 0.0001$
Higgs composite scale	~ 70 TeV

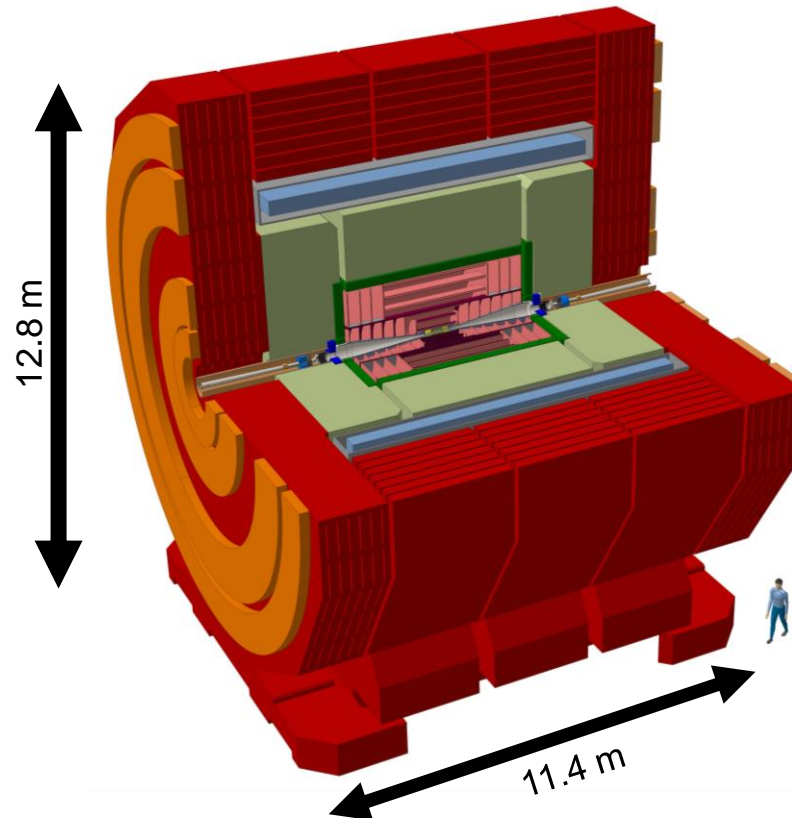
Example models, CLIC 3 TeV, up to 2 ab^{-1}

More information on BSM physics at CLIC: [CLICdp-Conf-2017-018](https://arxiv.org/abs/1701.02804)

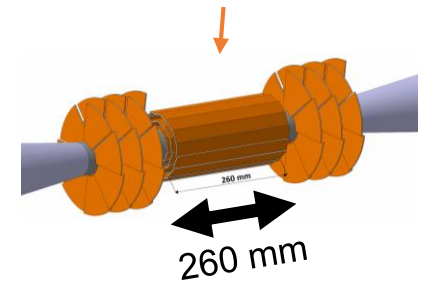
CLIC detector model 'CLICdet'



- **Iron return yoke**
instrumented with muon detectors, for muon identification
- 4 T superconducting **solenoid magnet**
($R_{in} = 3.4$ m, $L = 8.3$ m)
- Fine grained **calorimetry system** (ECAL and HCAL) using particle flow approach
- Strong contribution to the CALICE and FCAL calorimeter R&D collaborations



- Low-mass all-silicon **tracking system** with separate tracker and **vertex detector**



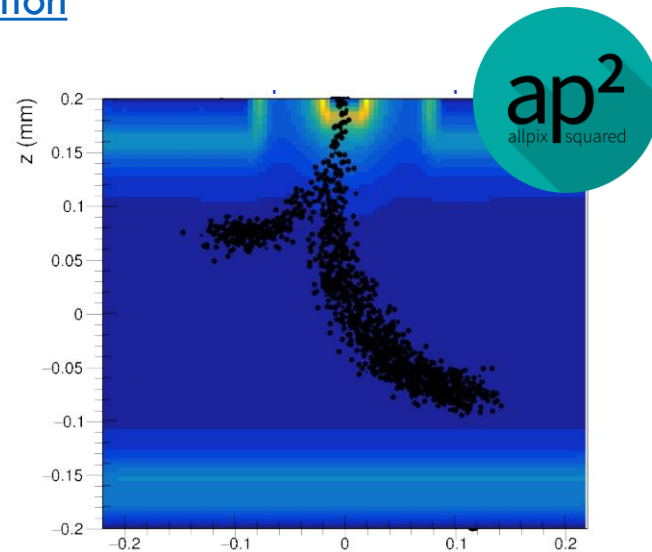
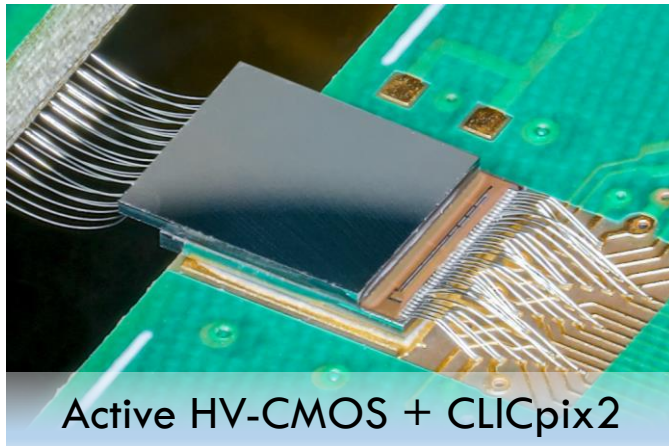
More details: "CLICdet: The post-CDR CLIC detector model", [CLICdp-Note-2017-001](#)

Hardware R&D



Example: Silicon pixel detector technology

- Research areas: sensors, readout, powering, mechanical integration and cooling
- Beam tests: of both hybrid (readout ASICs down to 65 nm) and monolithic assemblies
- Challenging: position-resolution target of $\sim 3 \mu\text{m}$ for the vertex detector
- Software development:
 - CaRIBOu – detector readout system
 - [Allpix² - generic pixel detector simulation](#)

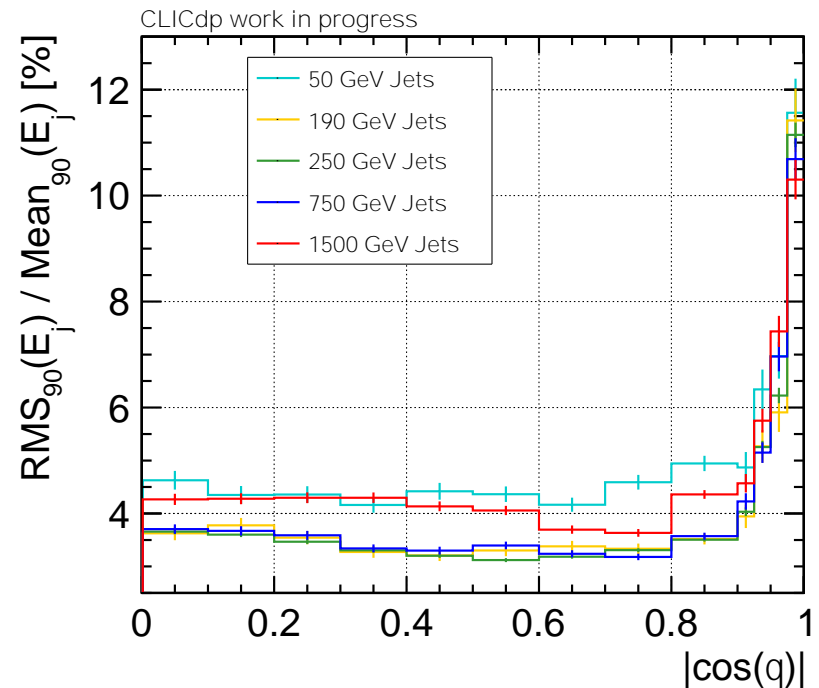
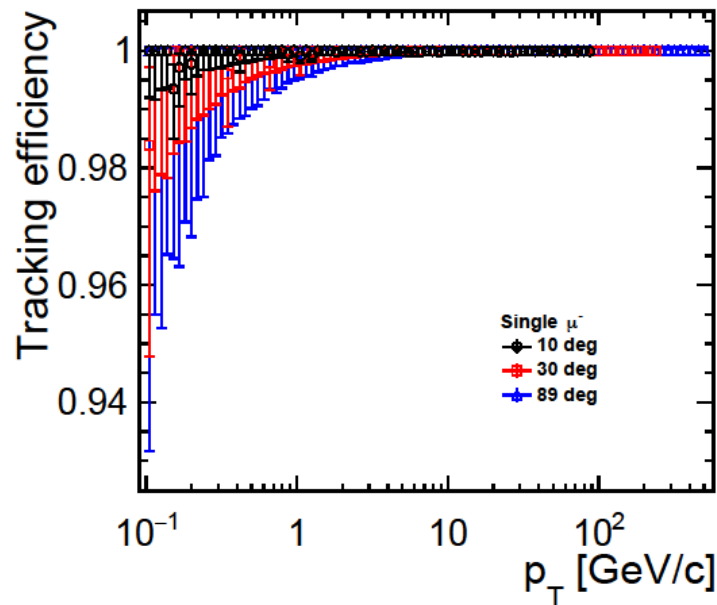


Reconstruction and Simulation



Validation of CLICdet

- Tracking – target muon momentum resolution of $\sigma_{p_T}/p_T^2 < 2 \cdot 10^{-5} \text{ GeV}^{-1}$
- Particle Flow Algorithm (PFA) – target jet energy resolution of $\sigma_E/E < 3.5\text{--}5\%$
- Flavor tagging



Summary and conclusions



Status

- CLIC is a future multi-TeV e^+e^- collider at CERN
 - **Powerful** tool to address the open questions in particle physics
 - **Mature** project with energies between 380 GeV and 3 TeV
 - **Optimized** for a broad precision physics program
 - Well-established and **flexible** physics program (adapt to potential discoveries)
 - Feasibility **demonstrated** through extensive prototyping, accelerator and detector R&D

Outlook

- The CLICdp Collaboration is currently preparing a series of reports and summary documents for the European Strategy Update



Thank you for your attention!

Time plan



2013 - 2019 Development Phase

Development of a Project Plan for a staged CLIC implementation in line with LHC results; technical developments with industry, performance studies for accelerator parts and systems, detector technology demonstrators

2020 - 2025 Preparation Phase

Finalisation of implementation parameters, preparation for industrial procurement, Drive Beam Facility and other system verifications, Technical Proposal of the experiment, site authorisation

2026 - 2034 Construction Phase

Construction of the first CLIC accelerator stage compatible with implementation of further stages; construction of the experiment; hardware commissioning

