

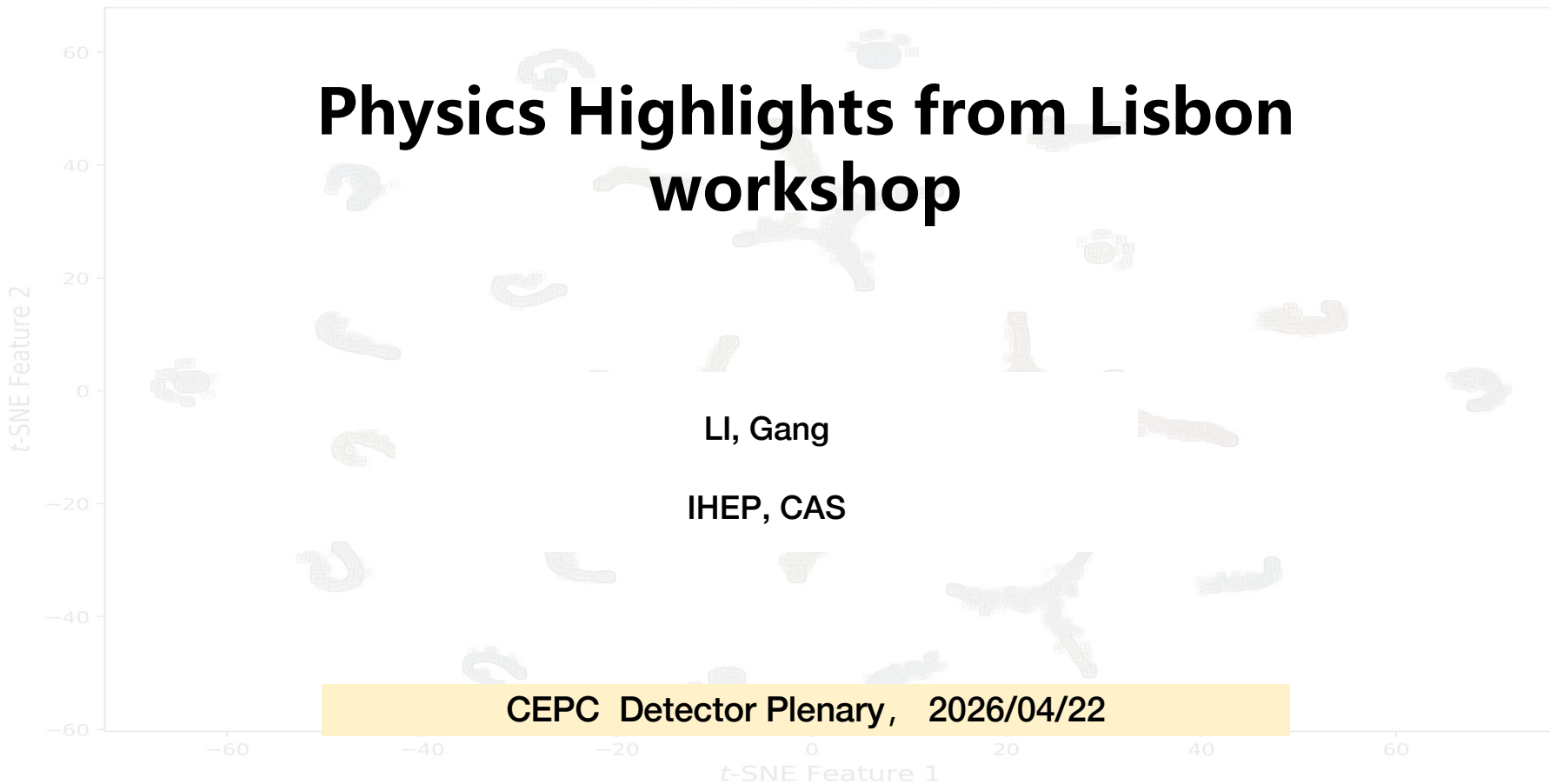
ParticleNet features: t-SNE

Physics Highlights from Lisbon workshop

LI, Gang

IHEP, CAS

CEPC Detector Plenary, 2026/04/22



召集人: Gustavo Branco (Instituto Superior Tecnico)

16:00 Highlights of the HL-LHC Reach
 报告人: Roberto Salerno (CNRS/IN2P3 - LLR, École polytechnique)
[Roberto_HLHLC.p...](#)

16:30 Physics potential at e+e- colliders
 报告人: 教授 Fabio Maltoni (Université Catholique de Louvain (UCL) (BE) and Univ
[lisbon-maltoni-w...](#)

17:00 QCD Theoretical Calculations Challenges
 报告人: Huasheng Shao (Centre National de la Recherche Scientifique (FR))
[Shao_CEPC2026_...](#)

17:30 QED Theoretical Calculations Challenges
 报告人: Alan Price (Jagiellonia University)
[aprice_lisbon_cep...](#)

Physics

召集人: Margarida Nesbitt Rebelo (CFTP/IST/Univ. Lisboa)

09:00 Top measurements at the CEPC
 报告人: **Leyan** Li (Peking University (CN))
[cepc_top_mass_s...](#) [cepc_top_mass_s...](#)

09:20 Measuring CKM matrix at FCC-ee
 报告人: Xunwu Zuo (EPFL - Ecole Polytechnique Federale Lausanne (CH))
[Measuring CKM ...](#)

09:40 FCCee sensitivity to symmetry protected UVs: the case of charged lepton mixing
 报告人: Guilherme Guedes
[CEPC_Lisbon26G...](#)

10:00 DELIGHT
 报告人: Rhitaja Sengupta (BCTP and Physikalisches Institut der Universität Bonn, Germany)
[CEPC_workshop_...](#)

Physics

召集人: Sven Heinemeyer (CSIC (Madrid, ES))

16:10 Precision predictions in SMEFT
 报告人: LIVIA,ELENA,GIORGIA MASKOS
16:30 Amplitude e+e- in QED at 3-loop
 报告人: Jonathan Ronca

16:50 Two-loop fermionic corrections to fermion pair production
 报告人: Ernest Wallace (University of Pittsburgh)
[CEPCWorkshopLI...](#)

17:10 Precision QCD/higher order calculations and phenomenology
 报告人: Joao Pires (LIP - Laboratório de Instrumentação e Física Experimental de Partículas)

17:30 (Online) Threshold scan
 报告人: MARCO GHILARDI
[BabaYaga_radiati...](#)

Physics

召集人: Sven Heinemeyer (CSIC (Madrid, ES))

10:50 BSM physics at the CEPC
 报告人: Rui Santos (ISEL and CFTC-UL)
[Santos_CEPC_IS...](#)

11:10 Higgs global analysis single-purpose optimization
 报告人: Gang Li
[gli_lisbon.pdf](#)

11:30 Future Collider Perspectives on Higgs CP Violation
 报告人: Julia Manuela Cardoso Silva (The University of Edinburgh (G))
[CEPCWorkshop_...](#)

11:50 h95 at the CEPC
 报告人: 教授 Pedro Ferreira (ISEL and CFTC-UL, Lisbon)
[CEPC IST Worksh...](#)

12:10 Determination of kappa_lambda at CEPC
 报告人: Murillo Vellasco (University of Bonn (DE))
[Vellasco_CEPC_k...](#)

Physics

召集人: Manqi Ruan (Chinese Academy of Sciences (CN))

14:00 Higgs Shift-Symmetries at Future Colliders
 报告人: Maria Ramos
[ShiftSymmetries...](#)

14:20 BSM Higgs production at 1-loop
 报告人: Sven Heinemeyer (CSIC (Madrid, ES))
[cepcworkshopslid...](#)

14:40 Portals at FCC-ee
 报告人: Giacomo Polesello (INFN, Sezione di Pavia (IT))
[polesello_lisbon.p...](#)

15:00 LRSM at CEPC
 报告人: Jonathan Kriewald (Jožef Stefan Institut)
[kriewald_CEPC_2...](#)

15:20 CEPC as a LLP factory
 报告人: Yuanzhen Li
[New particles at Z...](#)

Physics

召集人: Manqi Ruan (Chinese Academy of Sciences (CN))

09:00 From the LHC to Future Colliders
 报告人: Michele Gallinaro (LIP Lisbon)
[gallinaro.pdf](#)

09:20 Fast Kalman tracking and vertexing in DELPHES
 报告人: Franco Bedeschi (Università & INFN Pisa (IT))
[BedeschiKalmanT...](#) [BedeschiKalmanT...](#)

09:40 (Online) EW physics at CEPC
 报告人: Yong Du (TD Lee Institute)

10:00 Quantum entanglement at higgs factory
 报告人: Hao Zhang

Joint Session with Physics and Detectors

召集人: Nuno Leonardo (IST/LIP)

10:50 Offline Software Development for CEPC Reference Detector (including CyberPFA)
 报告人: 博士 Weidong Li (Chinese Academy of Sciences (CN))
[Software_CepcRe...](#)

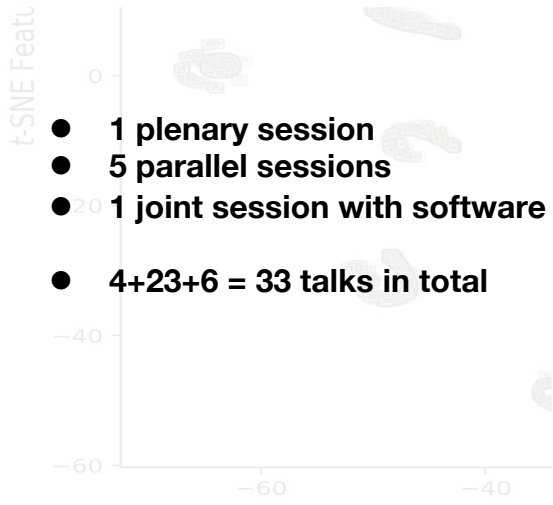
11:10 ARBOR
 报告人: Manqi Ruan (Chinese Academy of Sciences (CN))
[Learning From all ...](#)

11:30 (Online) APRIL (PFA Lyon)
 报告人: Tanguy Pasquier
[CEPC_2026_APRIL...](#)

11:50 Key4HEP
 报告人: Thomas Madiener (Deutsches Elektronen-Synchrotron (DESY))
[key4hep_cepcli...](#)

12:10 Physics Performance of CEPC Reference Detector TDR
 报告人: Mingshui Chen (Chinese Academy of Sciences (CN))
[CEPC Reference ...](#)

12:30 Detector geometry and event visualization for the CEPC RefDet
 报告人: Zhengyun You (Sun Yat-Sen University (CN))
[20260409_CEPC...](#)

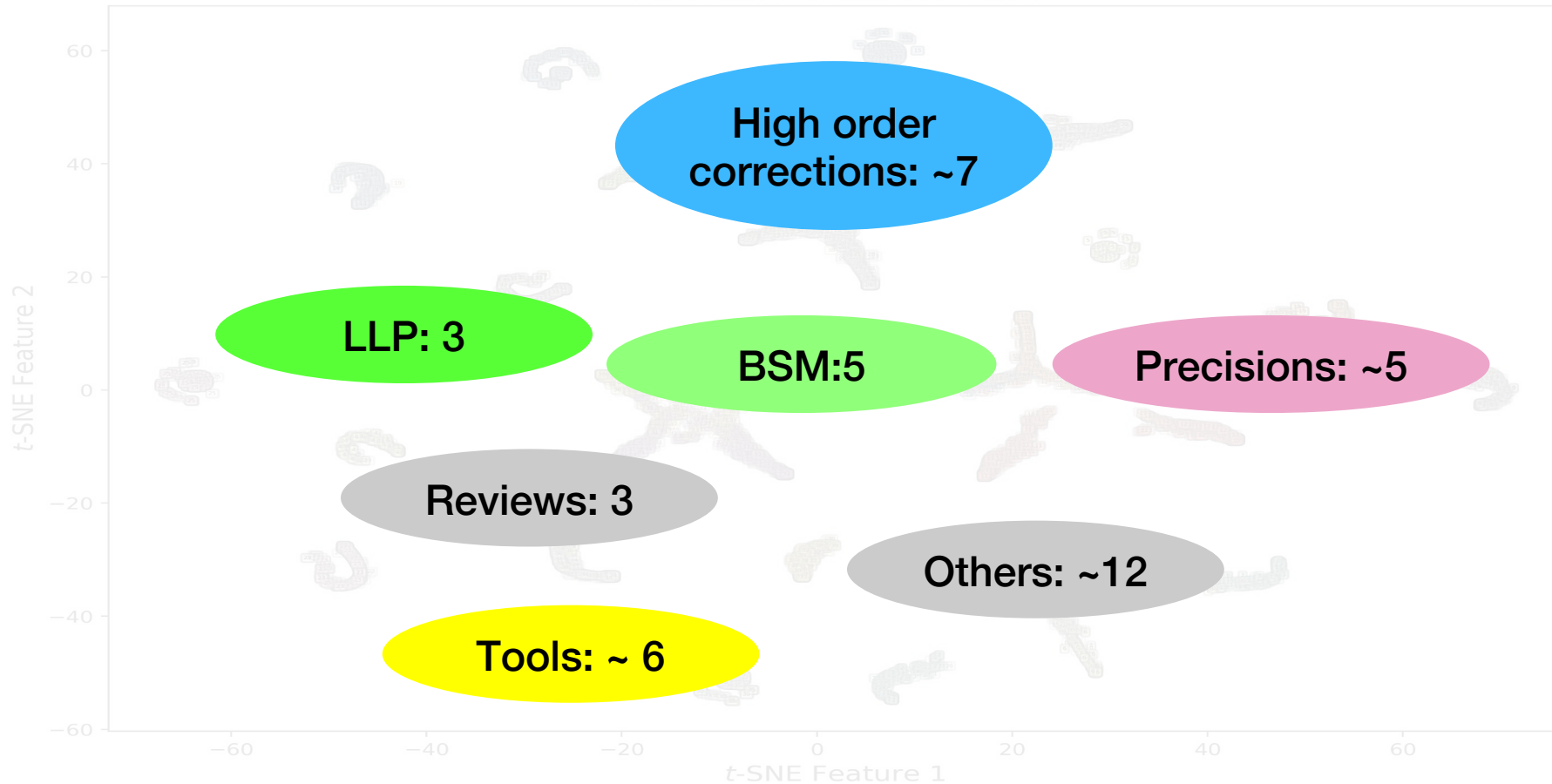


- 1 plenary session
- 5 parallel sessions
- 20 1 joint session with software
- 4+23+6 = 33 talks in total

t-SNE Fe

Main topics

ParticleNet features: t-SNE



BSM: LLP

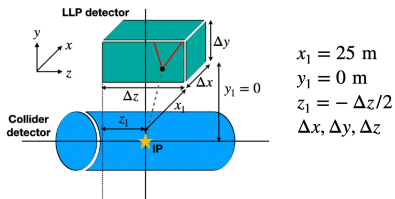
ParticleNet features: *t*-SNE

Optimisation of dedicated detectors

(A) Transverse detector:

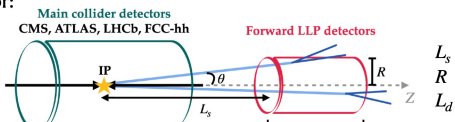
DELIGHT
Detector for long-lived particles
at high energy of 100 TeV

Biptob Bhattacharjee, Shigeki Matsumoto, RS,
e-Print: 2111.02437, PRD 2022



(B) Forward detector:

FOREHUNT
Forward Experiment
for Hundred TeV

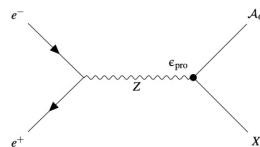


Conclusion

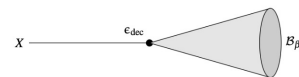
LR symmetry

- ▶ **Left-Right symmetric model** well motivated theory for m_ν
New states at $\Lambda_{EW} - \Lambda_{TeV}$
- ▶ **Future e^+e^- collider experiment** uniquely capable of discovering LLPs
Reconstruct full 4-momenta: leverage full event kinematics
- ▶ Different **gauge & scalar channels** largely complementary
Sensitive to gauge mixing $\tan \beta$, scalar mixing $\sin \theta$, ...
- (Indirectly)
- ▶ For $m_N \in [5 \text{ GeV}, 80 \text{ GeV}]$: probe $SU(2)_R$ -breaking scale beyond 100 TeV!

A Generic Framework for LLPs



- ❖ new particle X coupled to Z boson via **small coupling parameter** $\epsilon_{pro} \ll 1$.
- ❖ produced together with some SM particle A_α .
- ❖ Monochromatic kinematics ensure accurate analytic estimates.
- ❖ Particle X flies through the detector over a **macroscopic distance l**.
- ❖ X then decays back into SM particles B_β .
- ❖ Decay of X suppressed by $\epsilon_{dec} \ll 1$.



Detectors, models, and statistical tool

t-SNE Feature 2

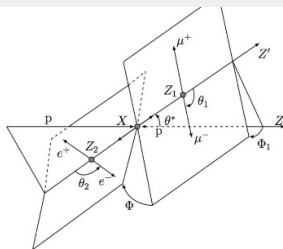
t-SNE Feature 1

BSM: CPV, differential, ...

CPV in Higgs couplings to Z bosons at FCC-ee and FCC-hh

Arun Atwal, Jessica Burridge, António Costa, Christoph Englert, Sinead Farrington, Jay Nesbitt, Leonor Pereira, Andrew Pilkington, Aidan Robson, **Júlia Silva**, Sarah Williams, Yuyang Zhang

Europe



CEPC Workshop

LEVERHULME TRUST



BSM physics at the CEPC?

CPV-DM

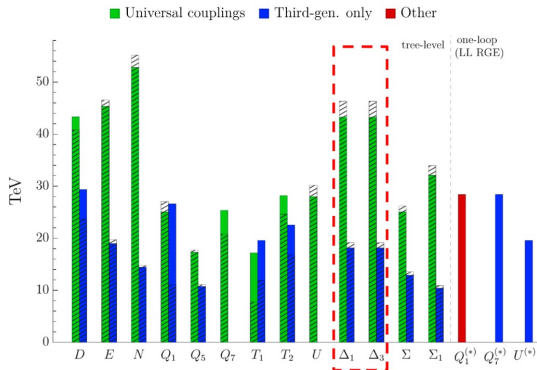
R. Santos

CFTC-University of Lisbon

CEPC26LIS

8 April 2026

Lepton Mixing at FCC



Allwicher, McCullough, Renner, 2408.03992

h_{95} at CEPC

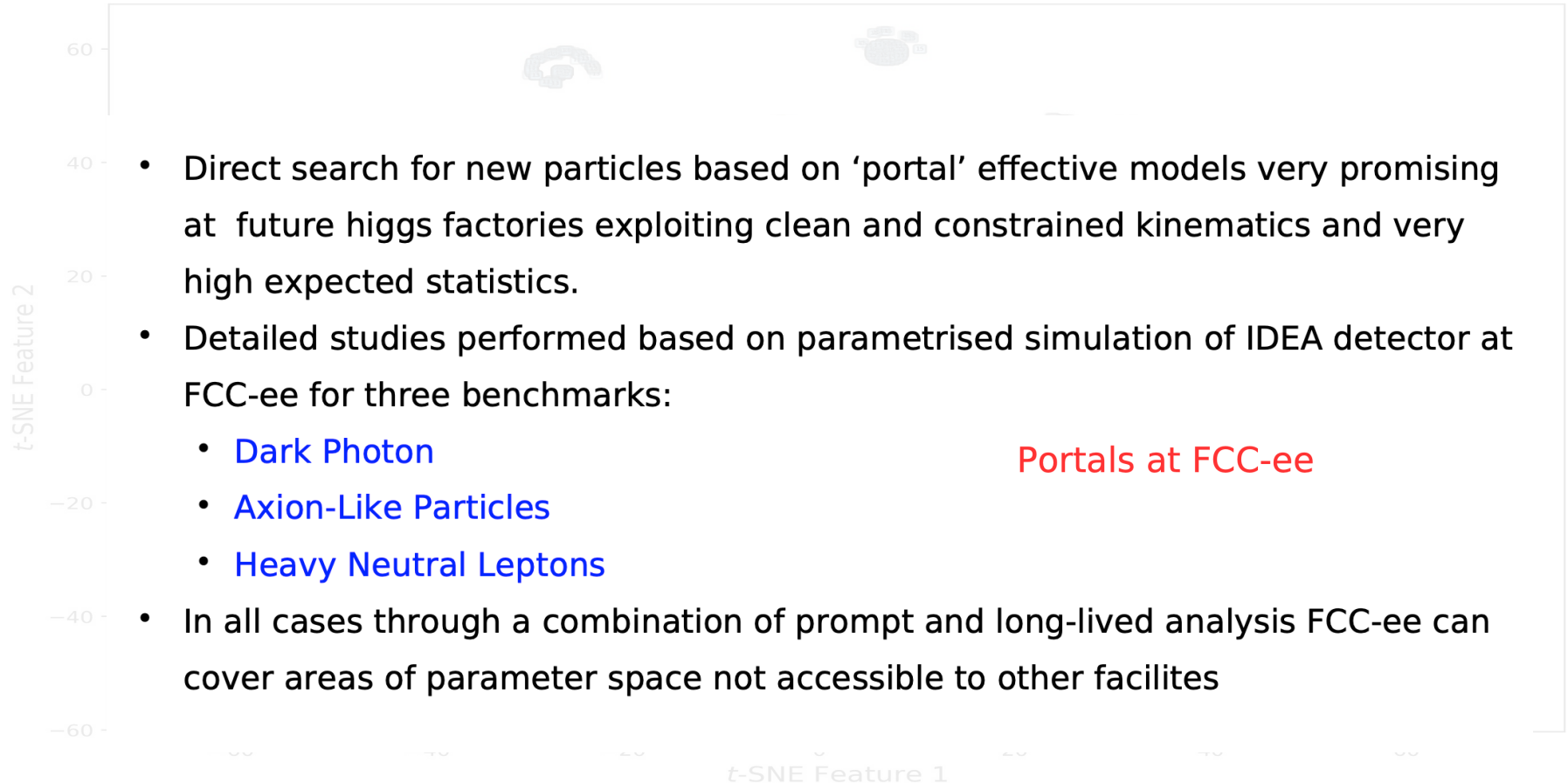
CEPC Workshop, 8/04/2025

Pedro Ferreira

DF, ISEL and CFTC, UL

D. Azevedo, T. Biekotter, PF, JHEP11 (2023) 017

BSM: more portals



- Direct search for new particles based on ‘portal’ effective models very promising at future higgs factories exploiting clean and constrained kinematics and very high expected statistics.
- Detailed studies performed based on parametrised simulation of IDEA detector at FCC-ee for three benchmarks:
 - Dark Photon
 - Axion-Like Particles
 - Heavy Neutral Leptons
- In all cases through a combination of prompt and long-lived analysis FCC-ee can cover areas of parameter space not accessible to other facilities

Precision measurements: top mass, CKM

Threshold scan @ ~340 GeV

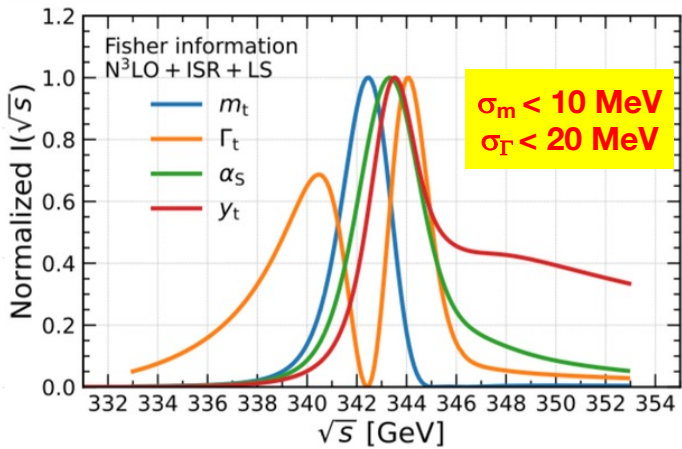
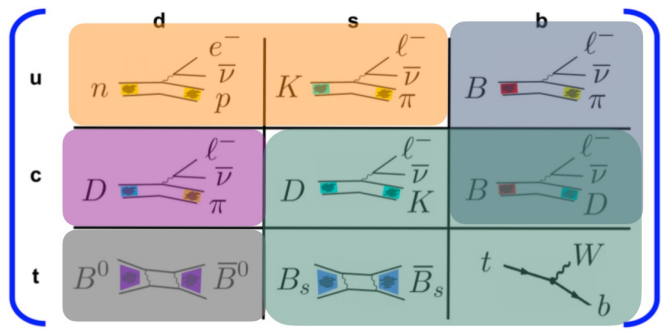


Fig 2. Normalized Fisher information for the four parameters.

Free data @ 240 GeV

$V =$
Possibility with
W decay,
precision to be
studied



New, complementary, model-independent approaches.

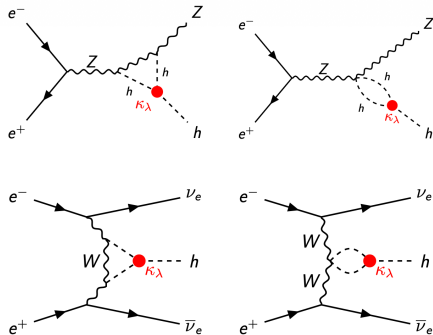
Jet-taggers calibration

Higgs couplings, ... as well

Precision measurements: Higgs self coupling

Alternative: precision measurements of **single h** observables

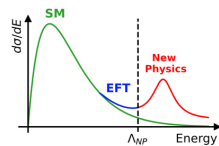
- κ_λ only present at **loop-level**
 - Need **high precision!**
- **Profits greatly** from measurements at **two different energies** (e.g. 240 & 360 GeV)
 - **Disentangle κ_λ** from other couplings
- **"Indirect"** or **loop-level** sensitivity
 - **Circular e^+e^-** colliders
 - Studied by several groups [deBlas.2025, ter Hoeve.2025, Maura.2025]



The SMEFT

Standard Model Effective Field Theory (SMEFT)

- Define Λ_{NP} : typical **New Physics energy scale**
- SMEFT can **parametrize** BSM physics at energies $\ll \Lambda_{\text{NP}}$

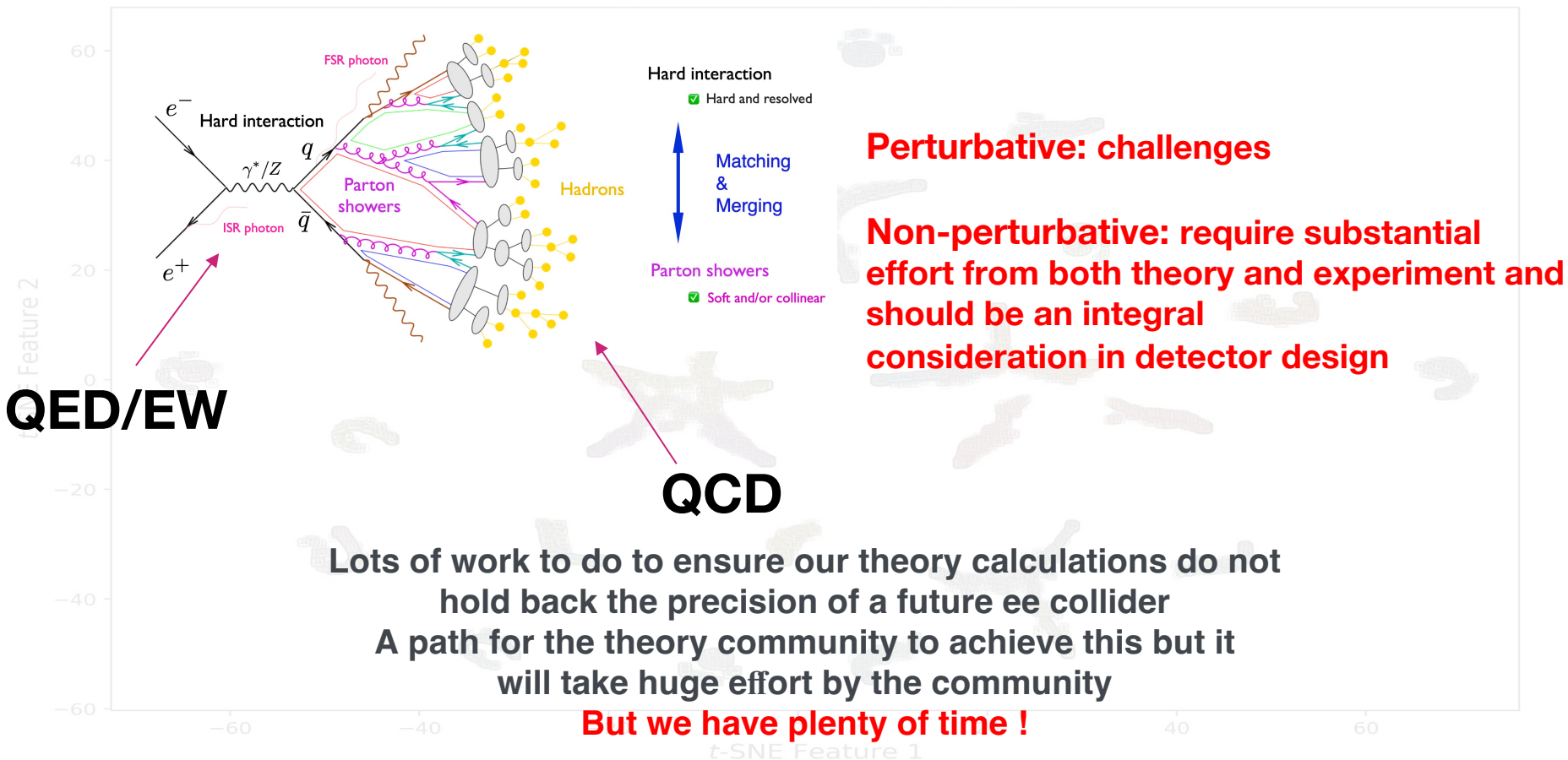


$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}}^{(4)} + \frac{1}{\Lambda_{\text{NP}}} \sum_k \boxed{C_k^{(5)}} \mathcal{O}_k^{(5)} + \frac{1}{\Lambda_{\text{NP}}^2} \sum_k \boxed{C_k^{(6)}} \mathcal{O}_k^{(6)} + \mathcal{O}\left(\frac{1}{\Lambda_{\text{NP}}^3}\right)$$

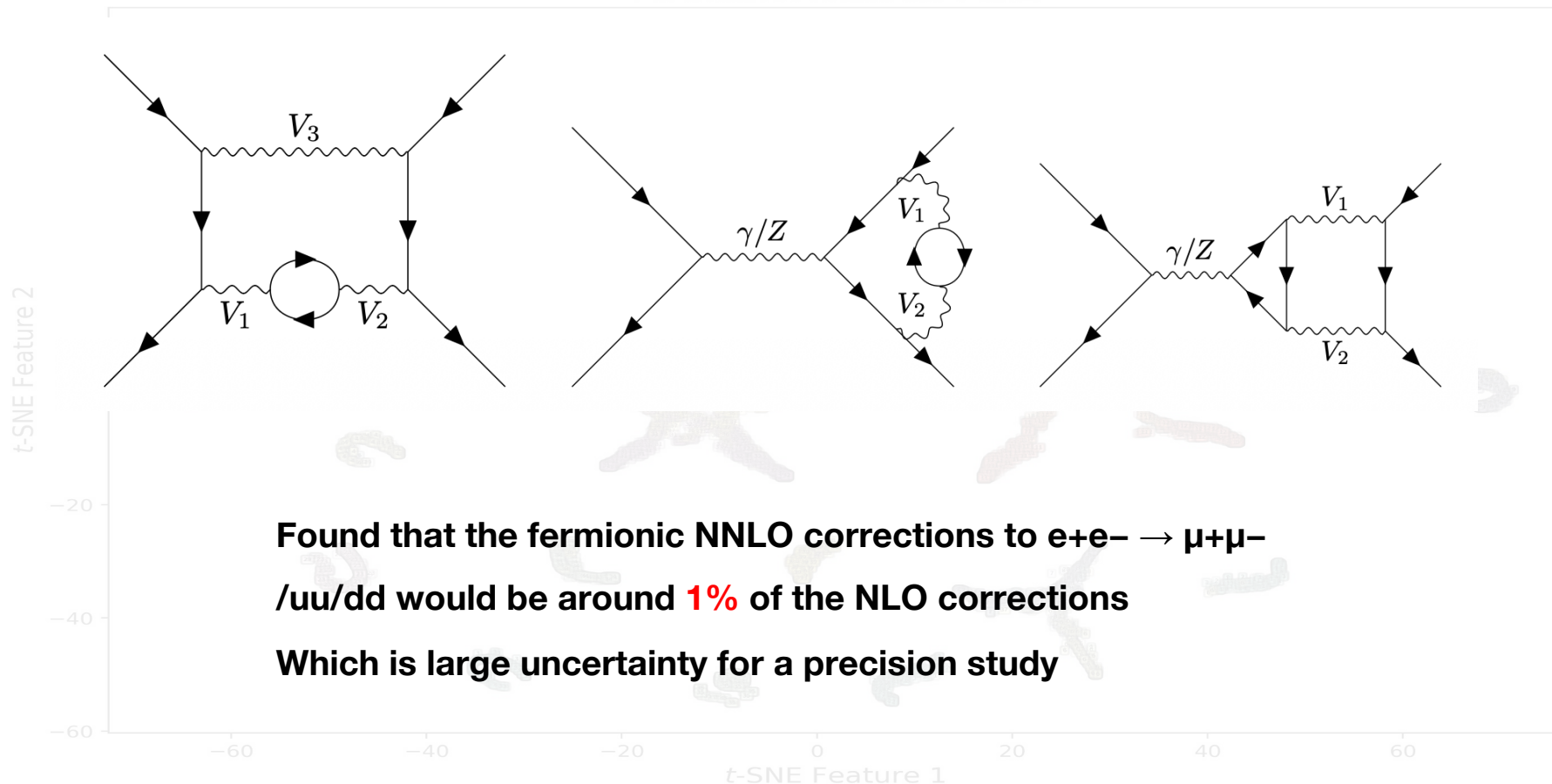
- Includes **all possible (nonrenormalizable) operators** consistent with Lorentz and SM gauge symmetries
- The C_k are called **Wilson Coefficients (WC)** → Dimensionless!

Precision: indirect detection of NP

High order corrections: QCD, QED, general



High order corrections: loop to 2 fermions



High order corrections: ISR return, high precision

Radiative return at NLOPS accuracy in e^+e^- collisions

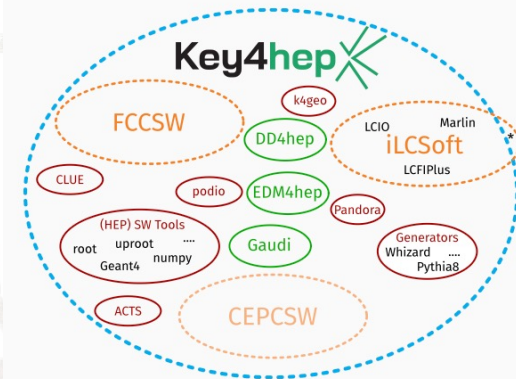
- Multiple photon contributions are in general important for radiative return experiment.
- GVMD structure dependent corrections can be of the same order of HO radiative corrections.
 - An independent study of a subset of GVMD corrections has appeared recently in arxiv:2603.13171.
- This is part of a **common effort** (arxiv:2410.22882) to reduce and to better estimate theoretical uncertainties using precision MC generators: AfkQED, BabaYaga@NLO, KKMC, MCGPJ, McMule, Phokhara and Sherpa.

Tools: lots of progresses in CEPCSW

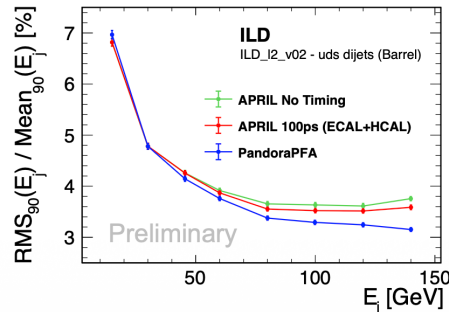
New plugin for the DELPHES

- ❖ Complete package provided in DELPHES for tracking and vertex fitting
 - IDEA geometry card tailored to match GEANT4 simulation
- ❖ Vertex fitting package consists of 3 independent classes and can be used outside DELPHES
 - Only assumption is uniform B field and perfect helix
 - Only dependency is on ROOT library

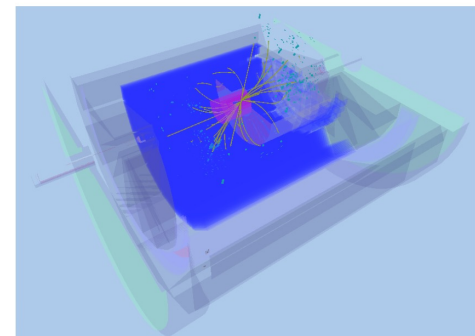
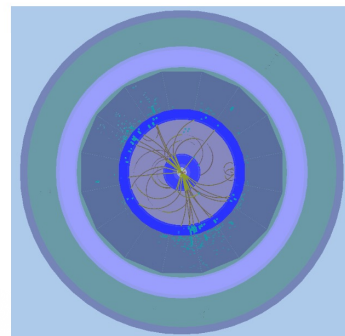
Matured software stack: Key4hep



Visible	Reco	Trk	Clu	
±	±	✓	✓	Well-reconstructed
±	±	✓	✓	Charged without cluster
±	0	✓	✓	Charged without track
±	±	✓	×	Charged with cluster lost
±	0	×	✓	Lost
±	0	×	×	Fake (only increase multiplicity)
±	±	✓	✓	Fake (enrichment)
±	±	✓	✓	Charged
0	0	✓	✓	Neutral
±	0	✓	✓	1-1 correction
±	0	✓	✓	1-n correction
±	0	✓	✓	n-1 correction



Visualization of a $e^+e^- \rightarrow ZH, Z \rightarrow \mu^+\mu^-, H \rightarrow b\bar{b}$ event in Unity



CEPC detector visualization

Not covered (talk not uploaded)

- **Quantum entanglement**
- **Precision predictions in SMEFT**
- **Precision QCD/higher order calculations and phenomenology**
- **Amplitude $e+e^-$ in QED at 3-loop**

