

INSTITUTE FOR PARTICLE PHYSICS PHENOMENOLOGY

NEWSLETTER
AUTUMN 2026



Ogden Centre
for
Fundamental
Physics

WELCOME TO THE IPPP!

Welcome to the Autumn 2026 IPPP newsletter. As a new academic year begins, this issue looks back on a busy spring and summer at the institute and across our wider community.

Over the summer the IPPP hosted the 2026 STFC HEP Summer School, as well as two workshops in Durham: *Effective Theories for Nonperturbative Physics* and *High Precision Experiments for Light Dark Matter*. We also report from the fourth Dark Matter beyond the Weak Scale workshop in Liverpool and the Exotic Hadron Spectroscopy 2026 Workshop in Cambridge, which the IPPP was pleased to sponsor, and feature two research highlights: neural-network contour deformations for loop integrals, and resonance-aware matching of QCD and electroweak corrections to parton showers. Looking ahead, we hope to see many of you at the UK HEP Forum 2026 in November.

We would like to thank all contributors for their time and effort in putting this issue together.

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Hosted at the IPPP

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RESEARCH HIGHLIGHT

Resonance-aware matching of NLO QCD+EW corrections to parton showers

ANNOUNCEMENTS

01

The IPPP is pleased to announce the following workshop: the **UK HEP Forum 2026** will take place between 23–25 November 2026 at the Cosener’s House in Abingdon.

THIS YEAR’S TOPIC

“WILL THE LLM REVOLUTION UNCOVER THE SECRETS OF THE UNIVERSE?”

The forum is sponsored by the IPPP and STFC. There is no registration fee, but registration is open to participants with UK affiliation only. Accommodation will be free of charge for all attendees. Travel expenses within the UK (ground transport only) will be reimbursed to students who present a talk.

02

The Associateship, Durham IPPP Visiting Award, and Senior Experimental Fellowship programmes are continuing. We encourage applications for all three schemes and invite you to consult the following web pages for application deadlines:

IPPP Associateship

www.ippp.dur.ac.uk/ippp-associateships

DIVA

www.ippp.dur.ac.uk/diva

Senior Exp. Fellowship

www.ippp.dur.ac.uk/senior-experimental-fellowships

Our next intake will be in March 2027.

03

We encourage organisers of workshops related to HEP theory to reach out for support. The IPPP can help organise workshops in the UK, administratively and financially.



STFC HEP SUMMER SCHOOL 2026

The IPPP hosted the 2026 STFC summer school, with lectures on Introduction to QFT (Silvia Nagy), QED/QCD (Yannick Ulrich), the Standard Model (Bipasha Chakraborty), Collider Phenomenology (Ken Mimasu), Neutrinos (Ivan Martinez), and Dark Matter (Martin Bauer).

INTRODUCTION TO QFT

Silvia Nagy

QED/QCD

Yannick Ulrich

THE STANDARD MODEL

Bipasha Chakraborty

COLLIDER PHENOMENOLOGY

Ken Mimasu

NEUTRINOS

Ivan Martinez

DARK MATTER

Martin Bauer

WORKSHOP REPORT

EFFECTIVE THEORIES FOR NONPERTURBATIVE PHYSICS 2026

24 August – 4 September 2026 • IPPP, Durham

From 24 August to 4 September this year, the IPPP hosted the annual Effective Theories for Nonperturbative Physics workshop, following previous instalments at CERN and the MITP, Mainz. Organised at the IPPP, with additional funding from our colleagues at Mainz, the workshop brought together theorists studying nonperturbative phenomena in quantum field theory using many different approaches across a wide range of energy scales, reflecting the full generality of quantum field theory itself. The idea was to bring communities using different methods into the same room, compare what each approach can teach us, find new problems to attack, and hopefully start a few new collaborations along the way.

BRINGING COMMUNITIES THAT USE DIFFERENT METHODS INTO THE SAME ROOM





Cosmological phase transitions were one of the biggest themes of the workshop, particularly their dynamics and the exciting possibility that a transition in the early universe could leave an observable gravitational-wave signal. Talks on cosmological phase transitions covered tunnelling rates, bubble-wall dynamics, and the calculation of thermal plasma effects. A parallel strand of the programme focused on methods beyond conventional perturbation theory, including Hamiltonian truncation, resurgence, the functional renormalisation group and talks exploring the consequences of generalised symmetries. The two-week format left plenty of time for discussions exploring connections between these subjects, while breakfast in Durham Castle provided a memorable start to each day.

THEMES OF THE PROGRAMME

Cosmological phase transitions

Bubble-wall dynamics

Thermal plasma effects

Hamiltonian truncation

Resurgence

Functional renormalisation group

Generalised symmetries

WORKSHOP REPORT

HIGH PRECISION EXPERIMENTS FOR LIGHT DARK MATTER

7–9 September 2026 · Durham University

The High Precision Experiments for Light Dark Matter workshop took place at Durham University from 7–9 September, bringing together theorists and experimentalists interested in an increasingly diverse question: how can high-precision experiments look for some of the lightest possible forms of dark matter? The three-day programme reflected the breadth of the field, moving between ultralight particle searches, levitated systems and quantum sensors, atomic and nuclear spectroscopy, clocks and other precision probes.

Rather than packing the timetable with short presentations, the main programme consisted largely of hour-long talks in which theorists and experimentalists could introduce their respective areas in some depth, with plenty of room left for questions and discussion. Shorter contributed sessions gave early-career researchers the opportunity to present their own work, adding topics ranging from thorium clocks and ultralight dark matter haloes to antimatter spectroscopy. The meeting brought together groups from across the UK, Europe and the US, and much of the discussion naturally crossed the boundary between proposing new signatures and understanding what experiments can actually measure.

The final day brought that theory–experiment exchange particularly close to home, with members of Durham’s quantum light and matter community discussing complementary theoretical and experimental perspectives on atomic spectroscopy and cold-atom searches for new physics. The programme also looked beyond individual searches to the possibilities offered by experimental infrastructure itself, with Boulby Underground Laboratory presenting its current programme, future plans and opportunities for fundamental physics.

HOW CAN HIGH-PRECISION EXPERIMENTS LOOK FOR SOME OF THE LIGHTEST POSSIBLE FORMS OF DARK MATTER?

WORKSHOP REPORT

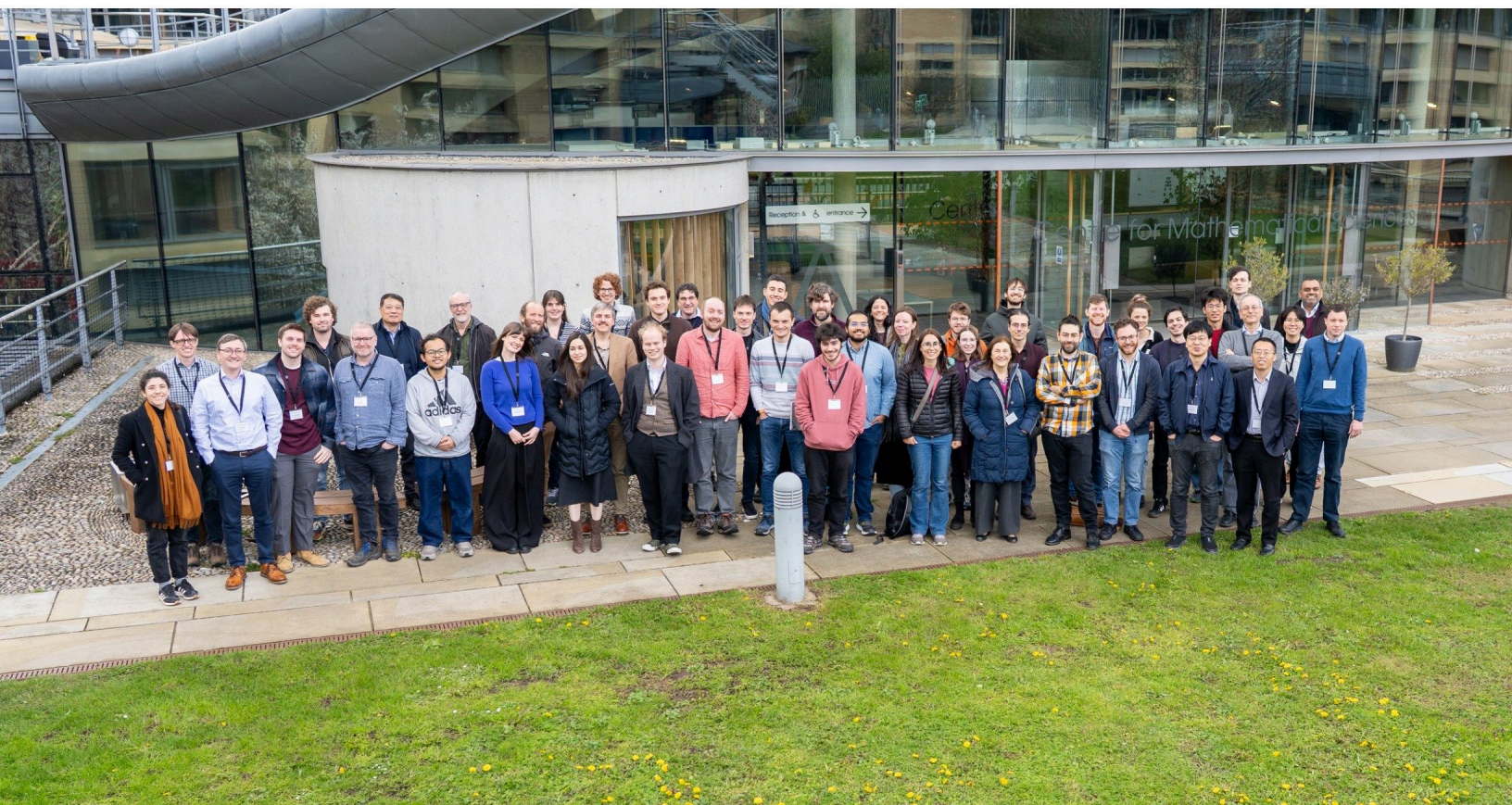
EXOTIC HADRON SPECTROSCOPY 2026 WORKSHOP

30 March – 1 April 2026 • DAMTP, University of Cambridge

The [Exotic Hadron Spectroscopy 2026 Workshop](#) was held at the Department of Applied Mathematics and Theoretical Physics (DAMTP) at Cambridge University (30 March to 1 April).

This was the sixth in a series of workshops which bring together the nuclear and particle physics communities to discuss the latest developments (experimental and theoretical) in exotic and conventional hadron spectroscopy, with a particular focus on analysis methods and search strategies for current and future experimental facilities. With 25 speakers from the UK and abroad, ranging from early-career researchers to established leaders in the field, topics included updates and new results from all major experiments, progress in lattice quantum chromodynamics, and developments in phenomenological models and other theoretical approaches. Participants also enjoyed a workshop dinner at Christ's College and a public lecture, as part of the Cambridge Festival, from Prof. Frank Close: “Destroyer of Worlds: the prequel and sequel to Oppenheimer”.

The workshop was sponsored by IPPP Durham University, IoP HEPP Group, IoP NP Group, UKRI-STFC, and the [Virtual Centre for UK Lattice Field Theory \(UKLFT\)](#).



WORKSHOP REPORT

DARK MATTER BEYOND THE WEAK SCALE 2026

23–26 March 2026 • University of Liverpool

From 23–26 March 2026, the [fourth Dark Matter Beyond the Weak Scale \(BeyondWimps\) workshop](#) took place at the University of Liverpool. The meeting brought together researchers working across particle physics, astrophysics and cosmology to discuss the growing range of theoretical ideas and experimental searches for dark matter beyond the traditional WIMP paradigm.

The programme covered topics including low-threshold direct detection, sub-GeV and ultralight dark matter, axions, compact dark-matter structures and primordial black holes, astrophysical and cosmological probes, quantum sensors, and other novel search strategies. It also included discussion sessions on the changing funding landscape and the future of the astroparticle community.

Participants received a suitably authentic introduction to west-coast weather on the first day, braving wind and rain on the walk into Liverpool city centre, but were rewarded with a very enjoyable evening together once they arrived. The social programme also included a conference dinner at the Philharmonic Dining Rooms. During the workshop, lunches were served on the top floor of the department, offering a chance to continue discussions while enjoying views across the city.



GLOBALLY OPTIMAL CONTOUR DEFORMATIONS WITH NEURAL NETWORKS

Loop integrals appearing in perturbative approaches to Quantum Field Theory can be formulated as an integration of a set of auxiliary (Feynman) parameters over the unit hypercube. This integration can be performed numerically, but sometimes it must be evaluated along a contour in the complex plane in order to avoid singularities on the real axis, as dictated by the Feynman causal prescription. Numerical codes that perform this kind of integration, such as pySecDec, construct this contour using tunable deformation parameters, λ , which must both keep the contour valid (λ not too large) and keep the numerical behaviour of the integrand under control for efficient numerical integration (λ not too small). Existing tools typically determine values of λ from scratch for every phase-space point, via an expensive pre-sampling step — a cost paid again and again across a full computation.

Rather than optimising the contour parameters point-by-point, Anton Olsson, Stephen Jones and Daniel Maître explored the possibility of training a neural network once for an entire kinematic region to predict good deformation parameters directly from the external kinematics — removing the need to retrain or re-sample for each new phase-space point.

Their paper investigates two network designs: the first, dubbed $\lambda(s)$, predicts the magnitude of the standard deformation from the kinematics s . The second, dubbed $\lambda(x; s)$, provides a richer, point-dependent deformation function of both the Feynman parameters x and s , giving more freedom to optimise the contour. In the paper, they explore the performance of contours determined using these network variants for MC and RQMC integration and compare them with the regular method used by pySecDec and another method using neural networks (but trained on each individual phase-space point).

Networks trained once per kinematic region produce contours with better variance than the standard pySecDec method and on par with contours optimised individually per phase-space point. For Randomised Quasi-Monte Carlo (RQMC) integration, the truly optimal contour depends on the specific lattice generating vector and grid size — no single fixed λ is optimal for all lattices. Despite this, the trained networks still yield contours that are competitive with existing heuristic, per-point methods. The $\lambda(s)$ variant offers the best practical trade-off between ease of implementation and performance, while $\lambda(x; s)$ achieves the lowest variance. The approach described in the paper can be generalised beyond Feynman integrals to any problem requiring a non-trivial, constrained integration path.

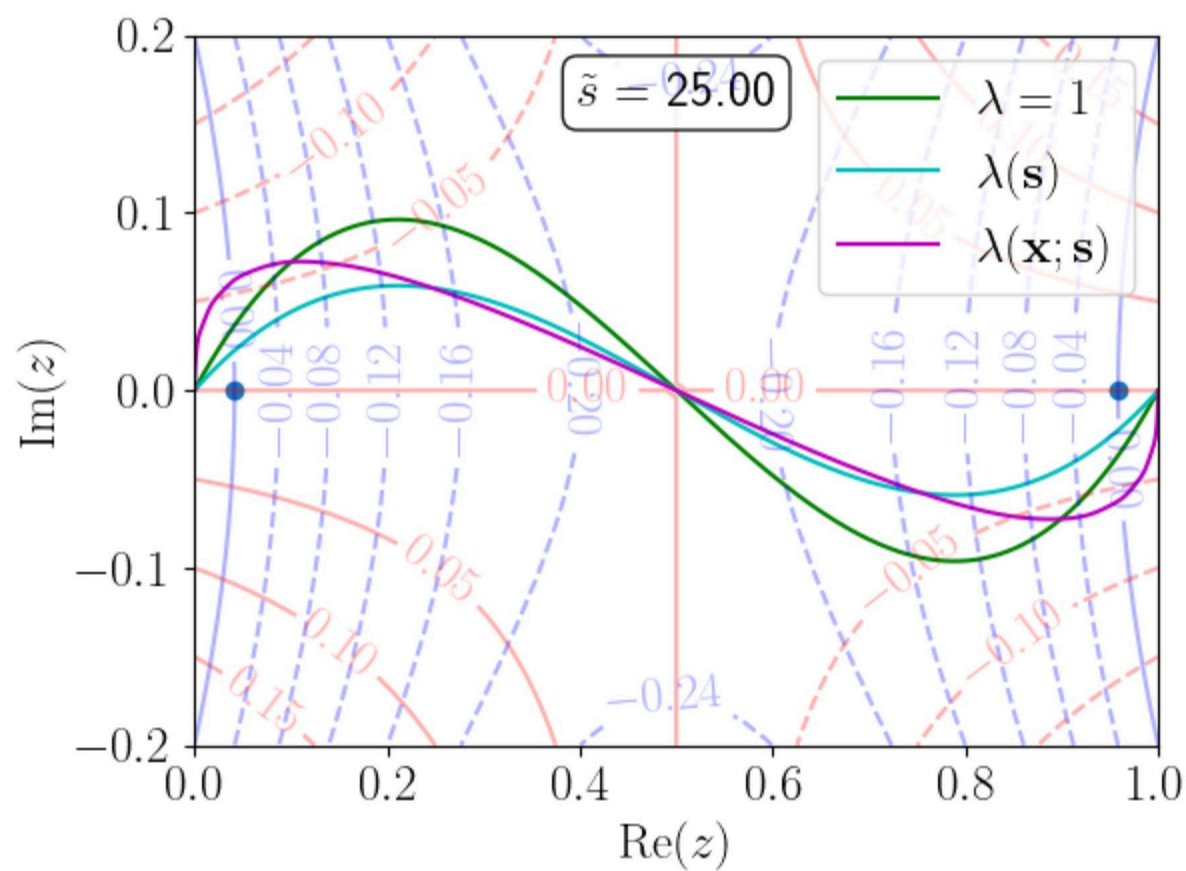


Fig. 1: Integration contours in the complex z -plane at $\tilde{s} = 25$ for the standard deformation ($\lambda = 1$) and the two network designs, $\lambda(s)$ and $\lambda(x; s)$.

Reference: A. Olsson, S. Jones, D. Maître, [arXiv:2601.11448](https://arxiv.org/abs/2601.11448)

RESONANCE-AWARE MATCHING OF NLO QCD+EW CORRECTIONS TO PARTON SHOWERS

Precision measurements of lepton-pair production at the LHC provide stringent tests of the Standard Model and enable precise determinations of its fundamental parameters, from the strong coupling constant to the parameters of the electroweak sector like the weak boson masses and the effective weak mixing angle. Their clean experimental signatures and large datasets, in particular in view of the upcoming HL-LHC data-taking period, facilitate stringent constraints on parton distribution functions and QCD dynamics. Achieving sub-percent precision requires accurate modelling of higher-order QCD and electroweak corrections, photon radiation and parton-shower effects. These measurements also provide indirect sensitivity to new physics through deviations from Standard Model predictions across complementary kinematic regions.

In this paper, we develop an automated framework for matching next-to-leading-order (NLO) QCD and electroweak (EW) corrections to an interleaved QCD+QED parton shower using a generalisation of the MC@NLO method. We implemented it in the widely used Sherpa Monte-Carlo event generator, facilitating straightforward use in the LHC experiments, foremost ATLAS, CMS, and LHCb. The central development is a resonance-aware treatment of Catani–Seymour dipole subtraction and the formulation of a resonance-aware parton shower evolution. They are designed to prevent otherwise arbitrary recoil assignments from distorting resonance virtualities and generating spurious higher-order effects that, while residing beyond the target accuracy, have a habit of spoiling a physical interpretation.

We demonstrate the effect of the new framework by applying it to Drell–Yan lepton-pair production,

$$pp \rightarrow Z/\gamma^* \rightarrow \ell^+ \ell^-$$

a key benchmark process for precision collider phenomenology. Interleaving resonance-aware QCD and QED emissions allows the shower to describe their competition and correlations consistently, ensuring that while hard photons that can resolve the Z resonance are radiated incoherently from production and decay, soft photons are susceptible to initial–final interference effects. Fig. 1 details the precision of the resulting calculation with respect to its improved resonance treatment. This newly designed framework is an important step towards automated precision event generation, combining higher-order QCD and electroweak effects in the presence of resonances.

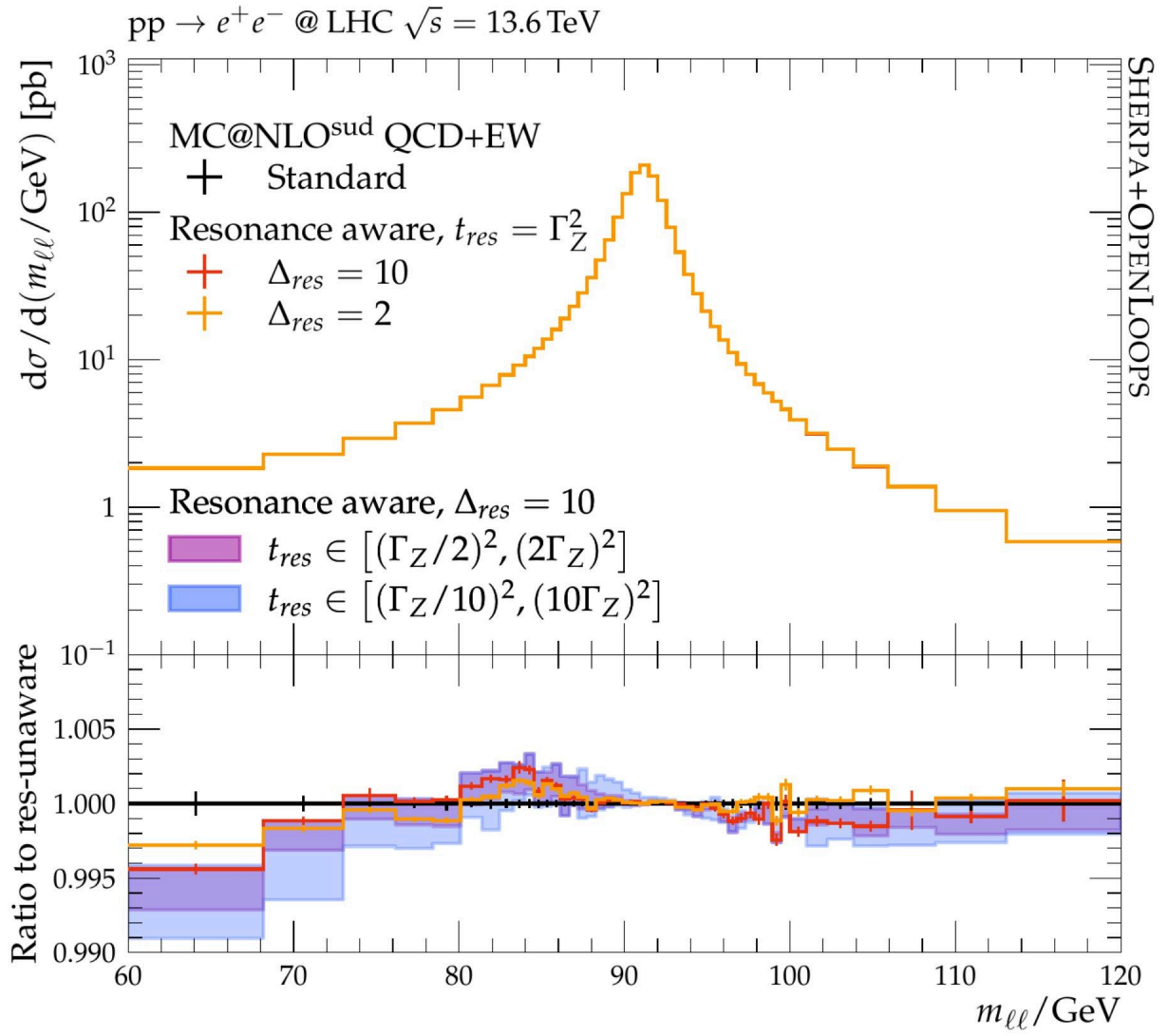


Fig. 1: Dilepton invariant-mass distribution for $pp \rightarrow e^+e^-$ at the LHC ($\sqrt{s} = 13.6$ TeV), computed with Sherpa+OpenLoops at MC@NLO QCD+EW accuracy. The lower panel shows the ratio of the resonance-aware predictions to the resonance-unaware result.

Reference: L. Flower, J. Roper, M. Schönherr, [arXiv:2607.06059](https://arxiv.org/abs/2607.06059)