The Fourth MODE Workshop

on Differentiable Programming

for Experiment Design

Closing session, Valencia

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If you are reading this as a web page: have fun! If you are reading this as a PDF: please visit

https://www.hep.uniovi.es/vischia/persistent/2024-09-25_MODEWorkshopClosing_vischia.html

to get the version with working animations

The MODE Goals

The goals of MODE

- *"We aim to create a versatile, scalable, customizable infrastructure, where a generic detector design task can be encoded, along with all the players (pattern reco, nuisances, cost constraints, a well constructed objective function).Then automatic scanning of the space of design solutions becomes possible!"*
- This doesn't replace the work of the physicist! We aim at **extending the physicist's abilities** by producing **design assistance tools**, focussing on **diagnostic tools and visualizations** for interpretability
- We don't propose *the one optimal solution* to a given problem, we aim at proposing **a distribution of solutions** in a region of optimality, to assist design choices!
- Optimization targets are not only strictly physics-related (e.g. significances): we consider also **financial cost** and other constraints in the optimization

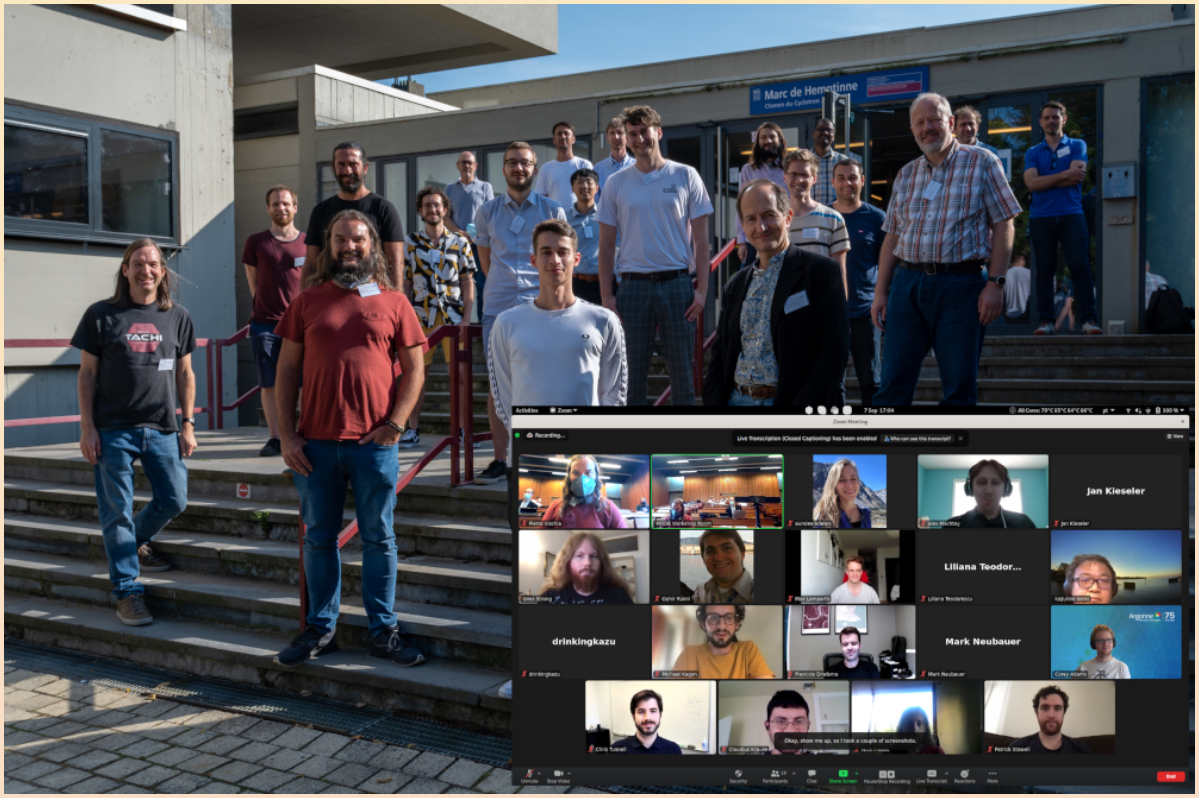
The MODE Goals

Begin simple, proceed towards complexity

- We identified and started studying some **relatively simple use cases**: muon tomography detector optimization, calorimeter optimization
- Plan to proceed to other simple use cases (e.g. small detectors for HL-LHC), providing **proofs of concept of increasing complexity**
- *“Every problem is difficult if you want to solve it well and make an impact”*
- In this workshop we aimed at starting to build **a community of interested peers** and identify **problems that we may tackle alltogether**

First MODE Workshop (2021)

- In Louvain-la-Neuve (Belgium)
  - 34 talks
  - 22 in person participants



Outcome of the First Workshop!

Reviews in Physics
Volume 10, June 2023, 100085

Toward the end-to-end optimization of particle physics instruments with differentiable programming

Tommaso Dorigo [a b x], Andrea Giammanco [a c x], Pietro Vischia [a z c], Max Aehle [d], Mateusz Bawaj [e], Alexey Boldyrev [a f], Pablo de Castro Manzano [a b], Denis Derkach [a f], Julien Donini [a g x], Auralee Edelen [h], Federica Fanzago [a b], Nicolas R. Gauger [d], Christian Glaser [a i], Atılım G. Baydin [a j], Lukas Heinrich [a k], Ralf Keidel [l], Jan Kieseler [a m], Claudius Krause [a n], Maxime Lagrange [a c], Max Lamparth [a k]...Haitham Zaraket [a w]

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Second MODE Workshop (2022)

- In Kolymbari (Crete)
  - 37 talks, 9 posters, one data challenge with prizes
  - 44 in person participants

Outcome of the Second Workshop!

Progress in End-to-End Optimization of Detectors for Fundamental Physics with Differentiable Programming

Max Aehle[d], Lorenzo Arsini[r,s], Anastasios Belias[a], Alexey Boldyrev[a,e], Konstantin Borozdin[o], Susana Cebrian[l], Remco de Boer[p], Alexander Demin[e], Julien Donini[a,f,v], Tommaso Dorigo[a,b,v], Nicolas R. Gauger[d], Andrea Giammanco[a,c,v], Christian Glaser[a,g], Borja S. González[p,q], Lisa Kusch[d], Marcus Liwicki[i], Philipp Munkes[k], Federico Nardi[a,f,j], Alberto Ramos[h], Fedor Ratnikov[a,e], Ryan Roussel[m], Roberto Ruiz de Austri[h], Fredrik Sandin[i], Bruno Scarpa[j], Giles C. Strong[a,b], Andrey Ustyuzhanin[a,t], Pietro Vischia[a,u]

[a] *MODE Collaboration, https://mode-collaboration.github.io/*

Work in Progress!

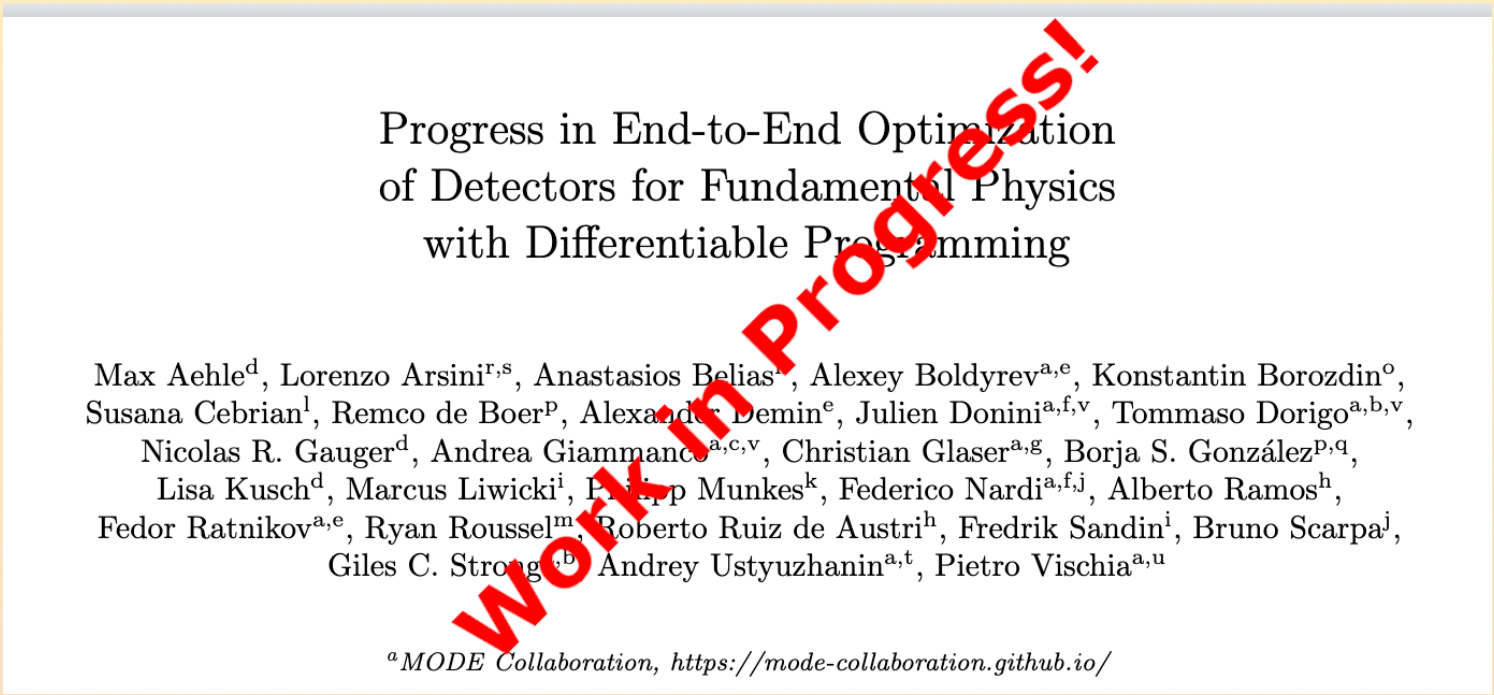
- Submitted to Reviews in Physics

Third MODE Workshop (2023)

- At Princeton University (USA)
  - 37 talks
  - 26 in person participants

Outcome of the Third Workshop!

- Additions to:



Progress in End-to-End Optimization of Detectors for Fundamental Physics with Differentiable Programming

Max Aehle[d], Lorenzo Arsini[r,s], Anastasios Belias[a], Alexey Boldyrev[a,e], Konstantin Borozdin[o], Susana Cebrian[l], Remco de Boer[p], Alexander Demin[e], Julien Donini[a,f,v], Tommaso Dorigo[a,b,v], Nicolas R. Gauger[d], Andrea Giammanco[a,c,v], Christian Glaser[a,g], Borja S. González[p,q], Lisa Kusch[d], Marcus Liwicki[i], Philipp Munkes[k], Federico Nardi[a,f,j], Alberto Ramos[h], Fedor Ratnikov[a,e], Ryan Roussel[m], Roberto Ruiz de Austri[h], Fredrik Sandin[i], Bruno Scarpa[j], Giles C. Strong[a,b], Andrey Ustyuzhanin[a,t], Pietro Vischia[a,u]

[a] *MODE Collaboration, https://mode-collaboration.github.io/*

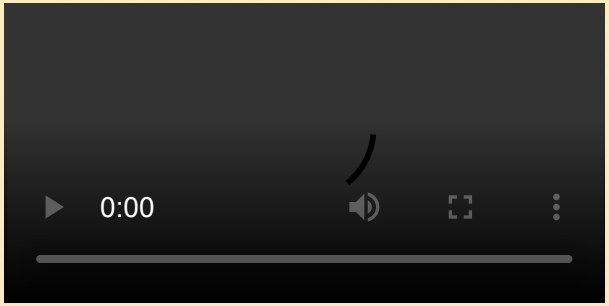
Work in Progress!

- Submitted to Reviews in Physics

Fourth MODE Workshop (2024)

- Here at IFIC/UV
  - 51 talks, 12 posters!!!
  - 76 in person participants!!!

Rich program, thanks to you!!!



Impossible without our funding agencies!

- In particular, we hugely appreciate the sustained support by NuPECC, APPEC, and IRIS-HEP across the years!!!

This workshop is partially supported by:

- the joint ECFA-NuPECC-APPEC Activities (JENAA);
- the National Science Foundation cooperative agreement PHY-2323298 (IRIS-HEP);
- the Ministerio de Ciencia y Innovación, under the network RED2022-134769-T (COMCHA);
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- the Ministerio de Ciencia y Innovación and by the European Union NextGenerationEU/PRTR under the grant RYC2021-033305-I (NeuroModelling);
- the Particles journal.

We had a wonderful time in Valencia!

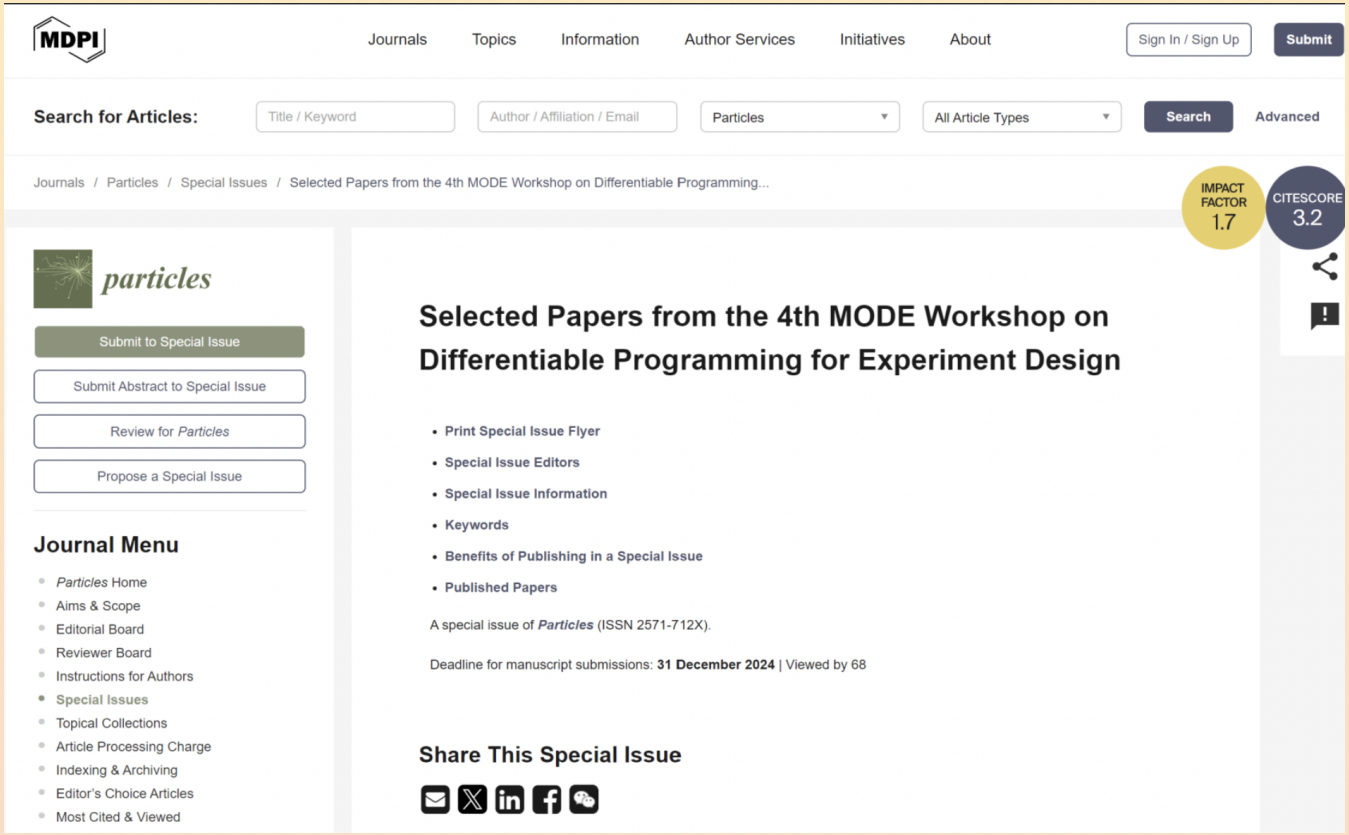
...huge thanks to the local organizers!!!

- Cesar Domingo (IFIC, CSIC-UV)
- Gabriela Llosá (IFIC, CSIC-UV)
- Roberto Ruiz de Austri (IFIC, CSIC-UV)
- José Salt (IFIC, CSIC-UV)
- Michel Sorel (IFIC, CSIC-UV)
- Emma Torró (IFIC, CSIC-UV)
- Miguel Villaplana (IFIC, CSIC-UV)

- María José García Fortea (ADEIT)
- José Martínez Sáez (ADEIT)

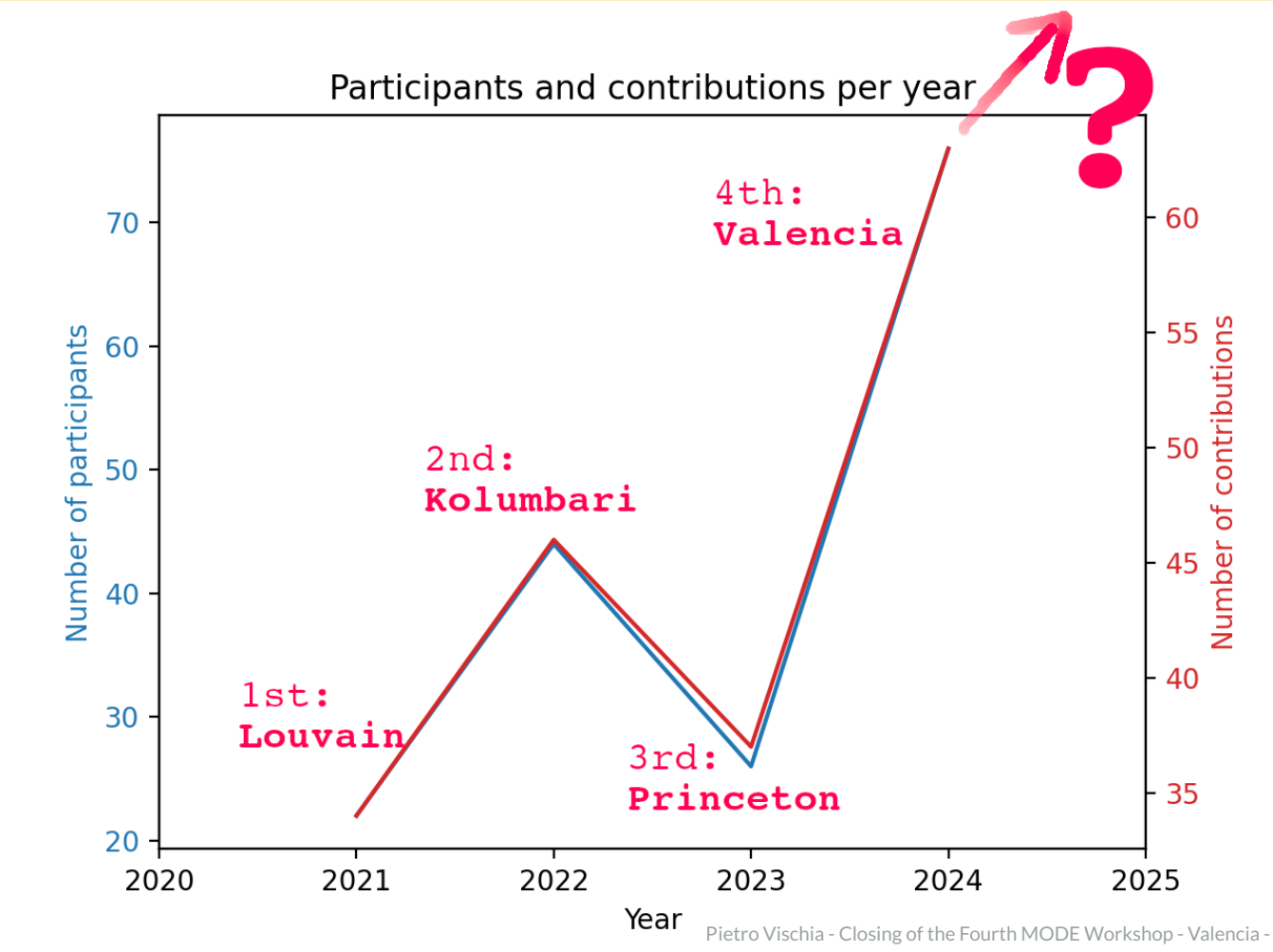
Outcome of the Fourth Workshop

- We plan to publish all contributions to this workshop (talks and posters) in a special issue of MDPI Particles
  - Deadline 31/12/2024 (not negotiable)



Growth

- This year, 19 early career researchers!!! Almost 1/4th of the participants!



The MODE Collaboration

COLLABORATION

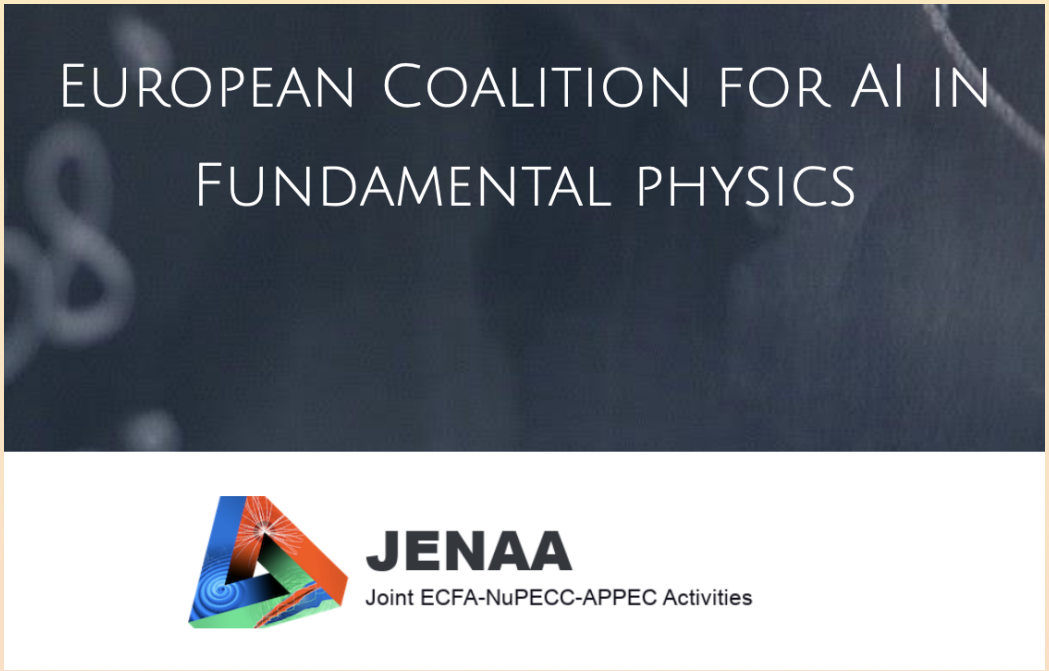
At INFN and Università of Padova Dr. **Tommaso Dorigo**, Dr. **Pablo De Castro Manzano**, Dr. **Federica Fanzago**, Dr. **Lukas Layer**, Dr. **Giles Strong**, Dr. **Mia Tosi**, and Dr. **Hevjin Yarar**
At Université catholique de Louvain Dr. **Andrea Giammanco**, Prof. **Christophe Delaere**, and Mr. **Maxime Lagrange**
At Universidad de Oviedo and ICTEA Dr. **Pietro Vischia**
At Université Clermont Auvergne, Prof. **Julien Donini**, and Mr. **Federico Nardi** (joint with Universitá di Padova)
At the Higher School of Economics of Moscow, Prof. **Andrey Ustyuzhanin**, Dr. **Alexey Boldyrev**, Dr. **Denis Derkach**, and Dr. **Fedor Ratnikov**
At the Instituto de Física de Cantabria, Dr. **Pablo Martínez Ruíz del Árbol**
At CERN, Dr. **Sofia Vallecorsa**
At Karlsruher Institut für Technologie, Dr. **Jan Kieseler**
At University of Oxford Dr. **Atilim Gunes Baydin**
At New York University Prof. **Kyle Cranmer**
At Université de Liège Prof. **Gilles Louppe**
At GSI/FAIR Dr. **Anastasios Belias**
At HEPHY Vienna (OeAW) Dr. **Claudius Krause**
At Uppsala Universitet Prof. **Christian Glaser**
At TU-München, Prof. **Lukas Heinrich** and Mr. **Max Lamparth**
At Durham University Dr. **Patrick Stowell**
At Lebanese University Prof. **Haitham Zaraket**
At University of Kaiserslautern-Landau Mr. **Max Aehle**, Prof. **Nicolas Gauger**, Dr. **Lisa Kusch**
At University of Applied Sciences Worms Prof. **Ralf Keidel**
At Princeton University Prof. **Peter Elmer**
At University of Washington Prof. **Gordon Watts**
At SLAC Dr. **Ryan Roussel**
At Lulea University of Technology Prof. **Fredrik Sandin** and Prof. **Marcus Liwicki**
At IGFAE and Universidad de Santiago de Compostela Prof. **Xabier Cid Vidal**

The Scientific Coordinator of the MODE Collaboration is Dr. **Tommaso Dorigo**, INFN-Sezione di Padova
The Steering Board of the MODE Collaboration includes:

- Prof. **Julien Donini**, UCA
- Dr. **Tommaso Dorigo**, INFN-PD
- Dr. **Andrea Giammanco**, UCLouvain
- Dr. **Fedor Ratnikov**, HSE
- Dr. **Pietro Vischia**, UniOvi

Broader efforts

- European initiative for advancing the use of AI in Fundamental Physics
  - The First EuCaif conference took place in Amsterdam beginning of May
  - Work Package 2: Experiment Design



Ultimately, thank YOU!!!

- Additional photos will be downloadable from the Workshop Page in the next few days

Want to join us?

- According to our Statute, you need to:
  - be interested in our research plan, and to produce research in that area
  - bring competence of relevance, or vow to acquire it
  - aim to contribute to it within your (time and resource) possibilities
- If you are interested, send the MODE Steering board (Dorigo, Donini, Giammanco, Ratnikov, Vischia) an email with confirmation of the above and a short bio/CV: chances are we'll get you in!

https://mode-collaboration.github.io/

Addresses for the steering board are at https://mode-collaboration.github.io

Fifth MODE Workshop (2025)

At 95% confidence level...

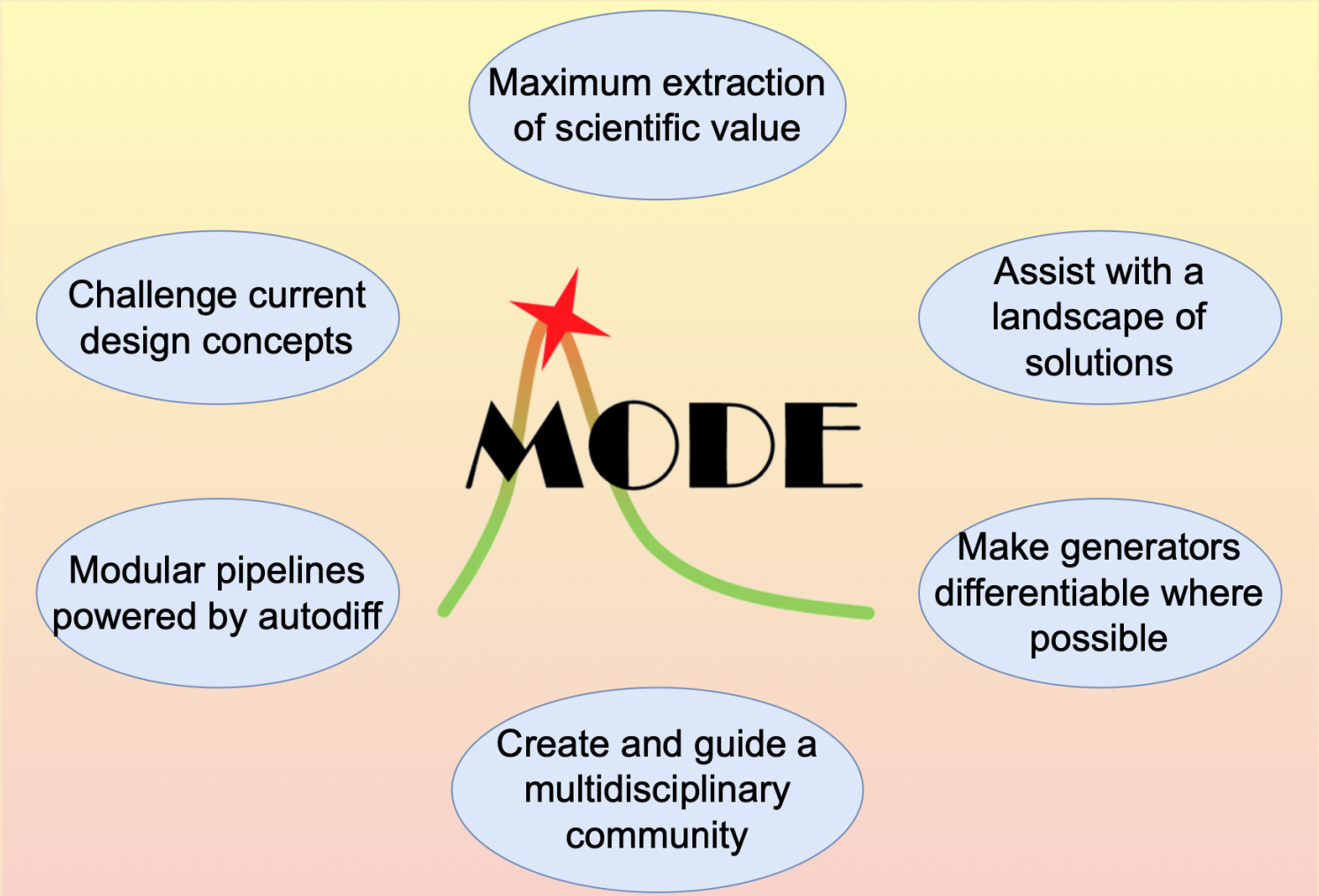
Fifth MODE Workshop (2025)

~~At 95% confidence level...~~ With a prior probability of 95%...

Fifth MODE Workshop (2025)

~~At 95% confidence level...~~ With a prior probability of 95%...

Back to Kolumbari!!!


Maximum extraction of scientific value
Challenge current design concepts
Assist with a landscape of solutions
MODE
Modular pipelines powered by autodiff
Make generators differentiable where possible
Create and guide a multidisciplinary community