The Third MODE Workshop

on Differentiable Programming

for Experiment Design

Closing session, Princeton University

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Supported by project
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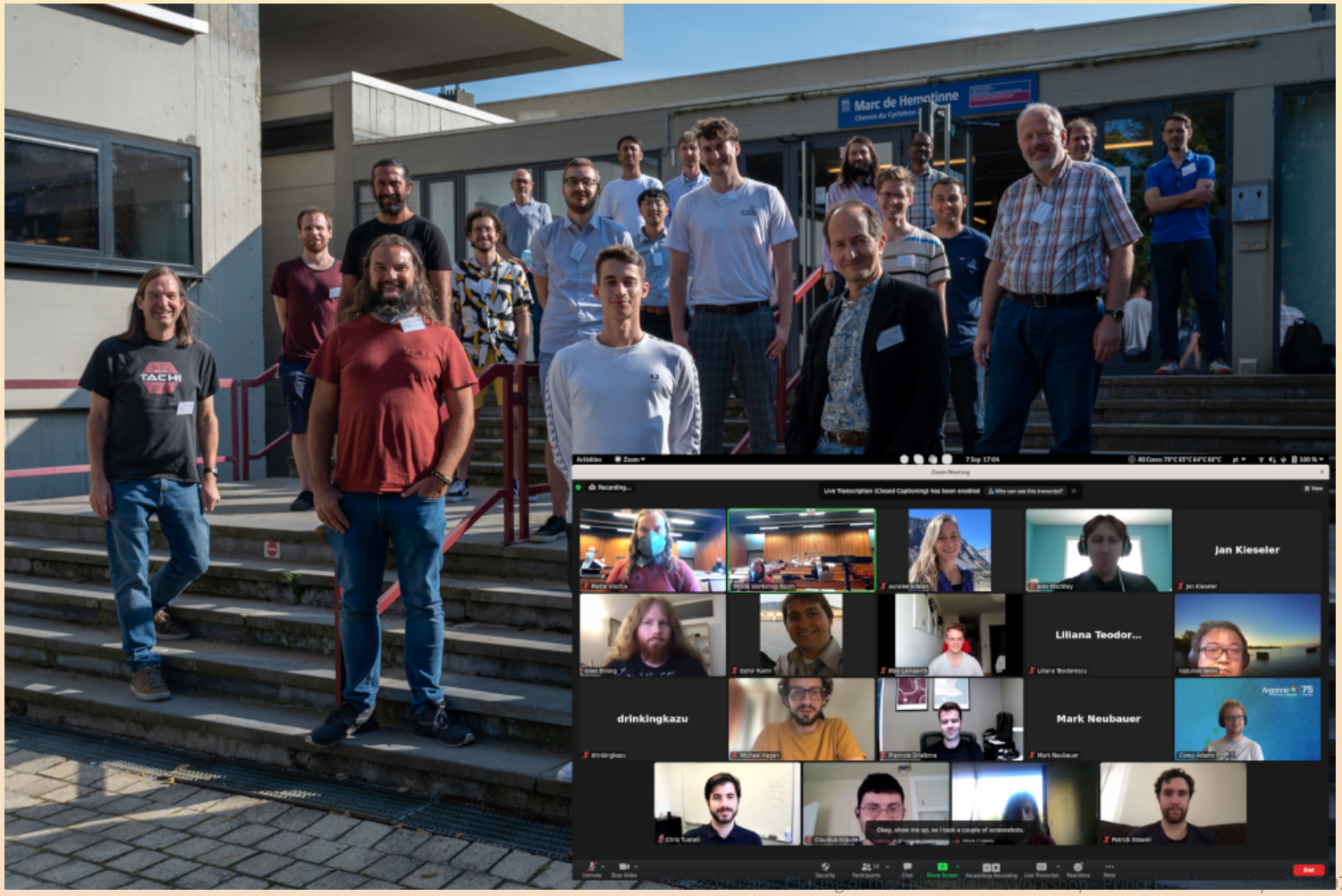
funded by

First MODE Workshop (2021)

- In Louvain-la-Neuve (Belgium)



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**

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

Significant efforts ongoing

Where we stand today

Significant progress in a number of applications of interest, e.g.

- Optimization of EM calorimeter for upgrade of LHCb
- Scattering tomography with cosmic muons
- Proof of INFERNO on LHC data
- Optimization of pCT

More such studies have started / are planned:

September 2022

- Optimization of EM calorimeter for Muon Collider project
- Optimization of SWGO water tanks and layout
- Optimization of LEGEND detector for double beta decay studies

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[r], 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]

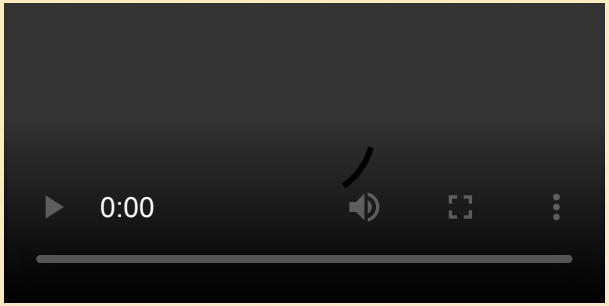
[a] *MODE Collaboration, https://mode-collaboration.github.io/*

Work in Progress!

Third MODE Workshop (2023)

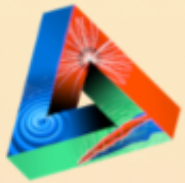
- Here, at Princeton University (USA)

Rich program, thanks to you!!!



Impossible without our funding agencies!

- We hugely appreciate the sustained support by NuPECC, APPEC, IRIS-HEP across the years!!!



JENAA
Joint ECFA-NuPECC-APPEC Activities

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NuPECC APPEC

We had a wonderful time in Princeton!

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

- Maureen Carothers (Princeton University)
- Florevel Fusin-Wischusen (Princeton University)
- Andrea Rubinstein (Princeton University)

- Peter Elmer (Princeton University)
- Gordon Watts (University of Washington)

Participants report having met Michael Jordan

...now known as Robinson 😜

- Thanks to Robinson, María, and all the staff of the receptions!

Ultimately, thank YOU!!!

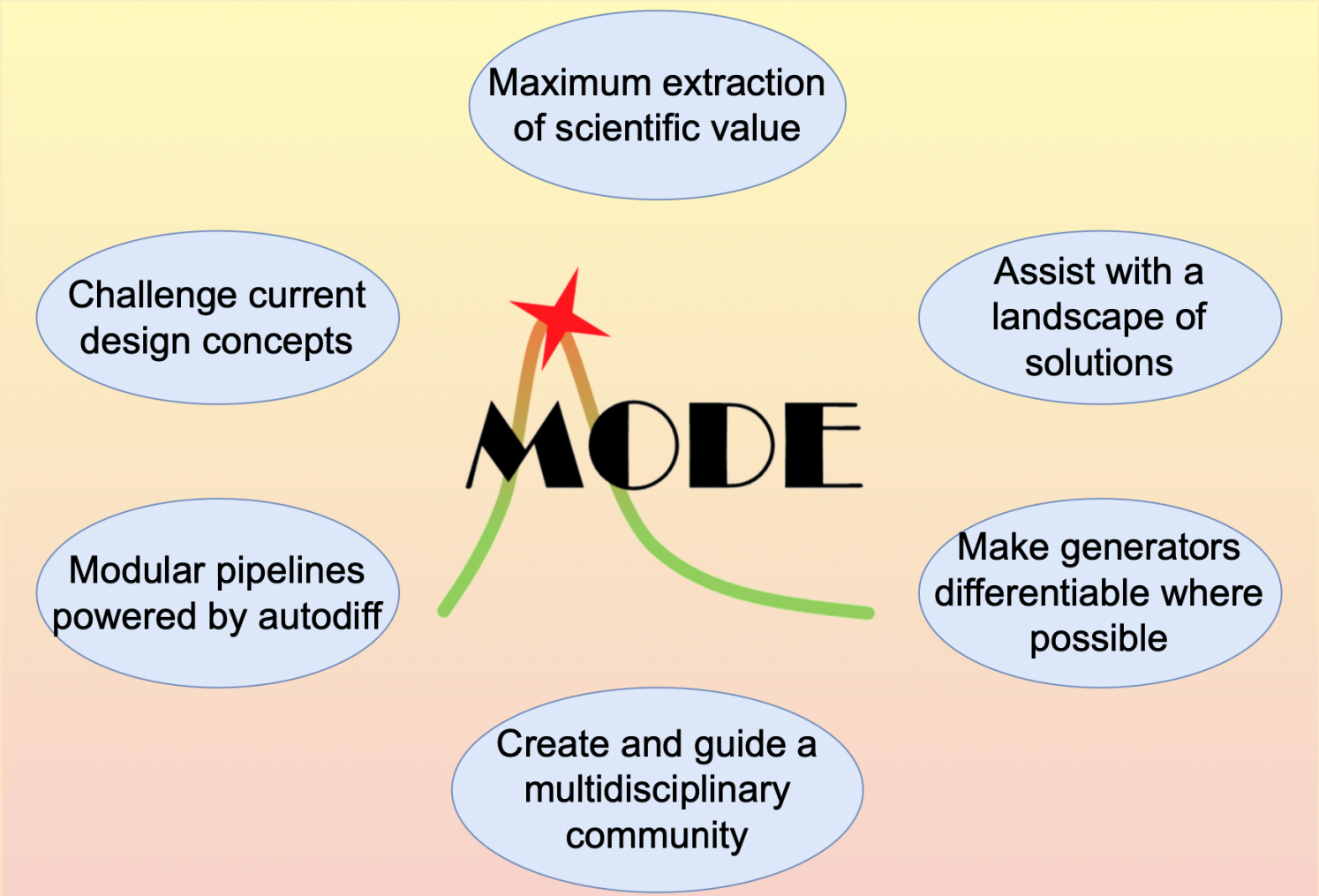
- Photo can be downloaded from the Workshop Participants page

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


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