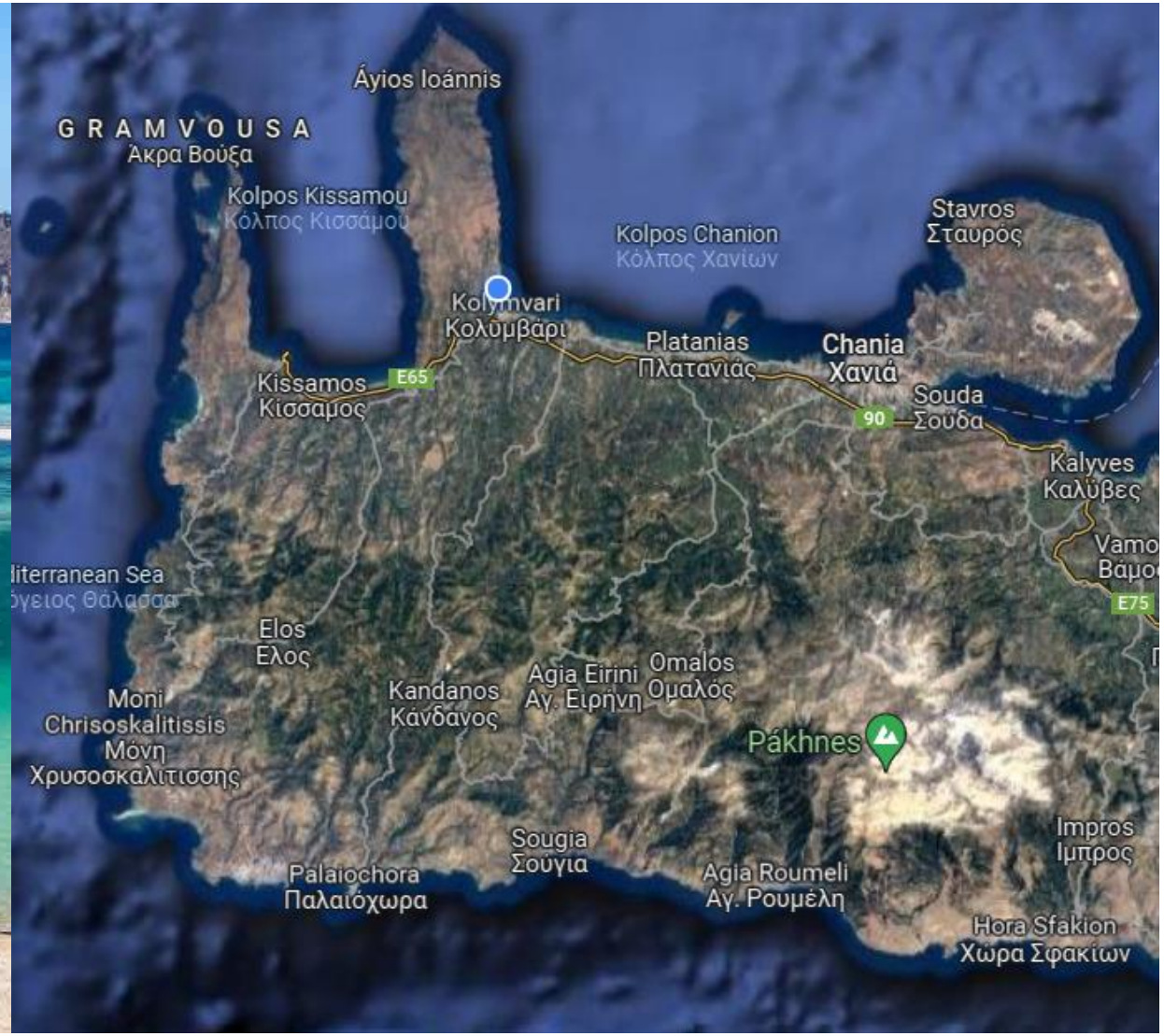
2nd MODE Workshop
Kolymbari, Sep 13-15 2022

Tommaso Dorigo, INFN - Padova

Welcome to Kolympari!



Goals of this workshop

- Discuss progress in end-to-end optimization of experiments
- Identify potential problems of common interest
- Bring more attention to DP techniques from fundamental science practicioners, involve them
- Create the conditions for successful grant applications
- Strengthen synergies between computer scientists and physicists, LEARN stuff from CS experts

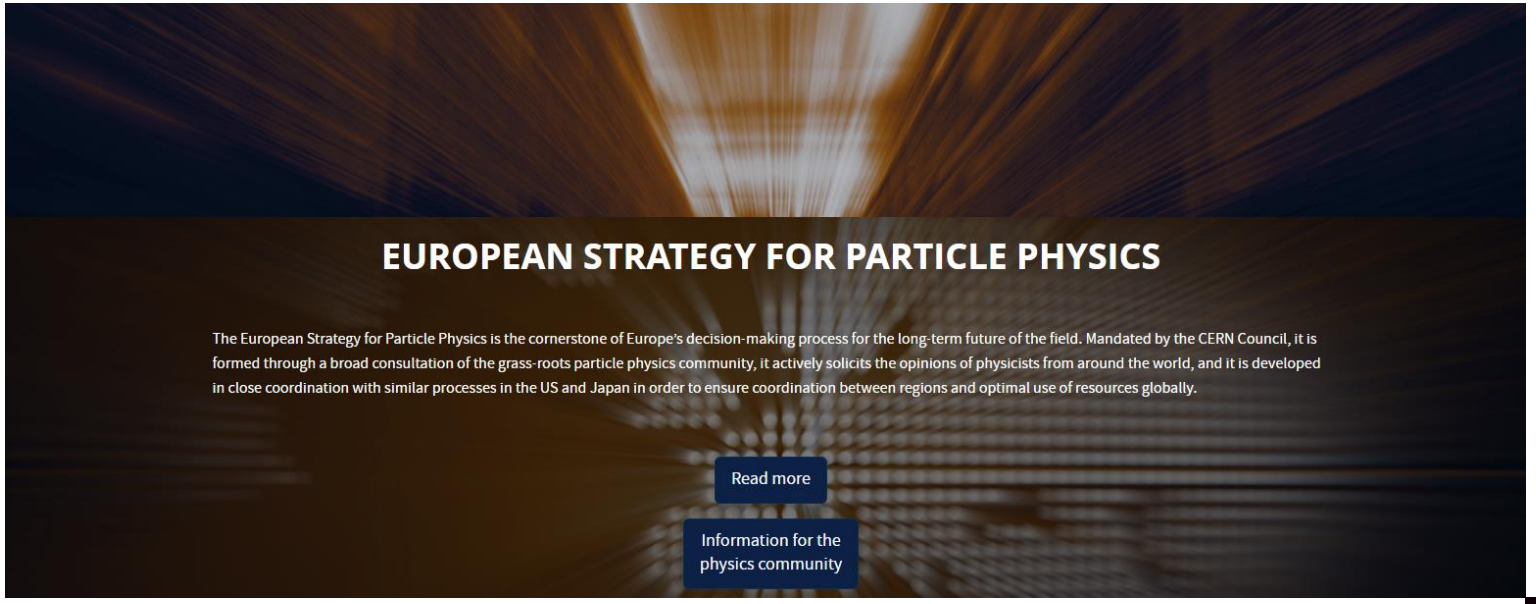
How we got here

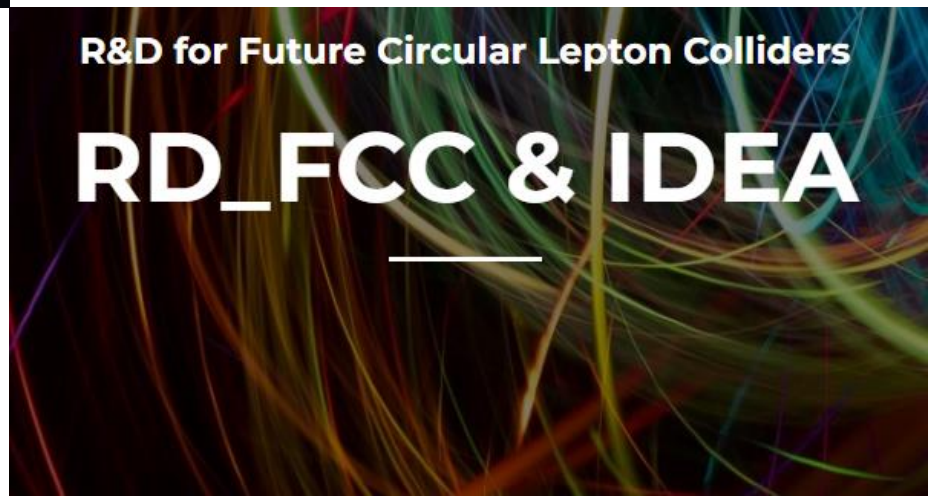
To introduce this workshop, I thought I would give you my very personal, very brief, recollection of how we got to organize our efforts and create the MODE collaboration

As with any personal recollection, it will be full of ex-post adjustments and slight mischaracterisations...

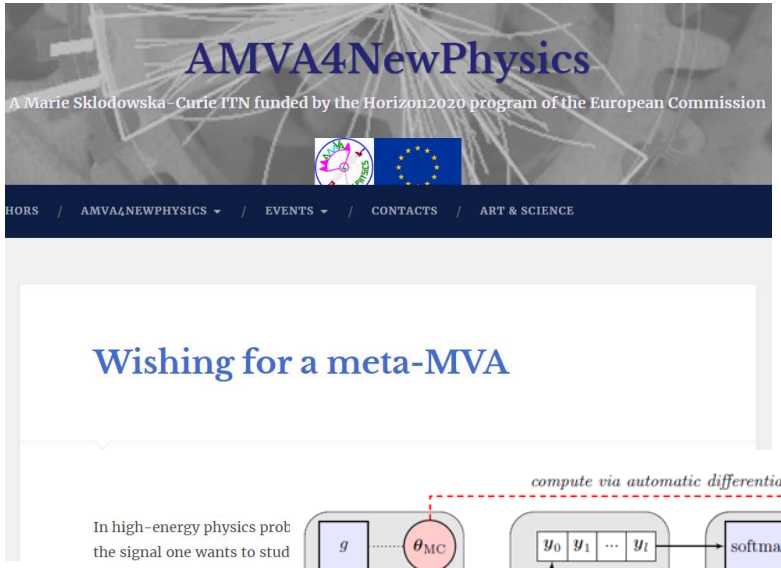
The advantage is to have a story to support and motivate our action!

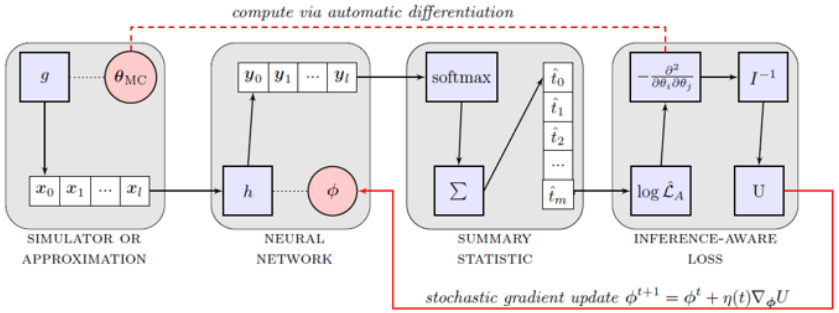
How we got here – 1: thinking long term





How we got here – 2: INFERNO





*Top: Control flow of INFERNO algorithm, which extracts optimal NN parameters given a final analysis objective, such that the resulting measurement becomes maximally robust to nuisance parameters. Data **x** generated by a*

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INFERNO: Inference-Aware Neural Optimisation

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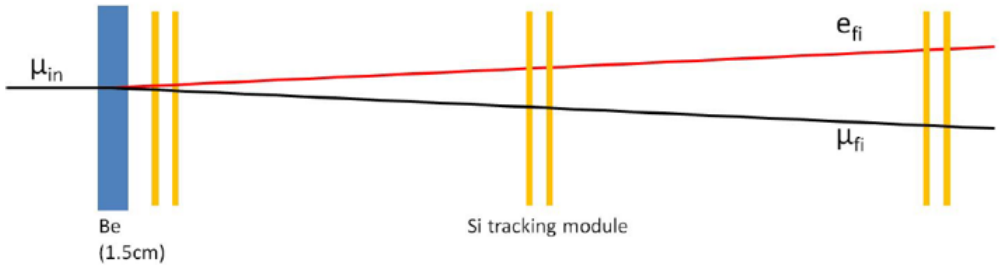
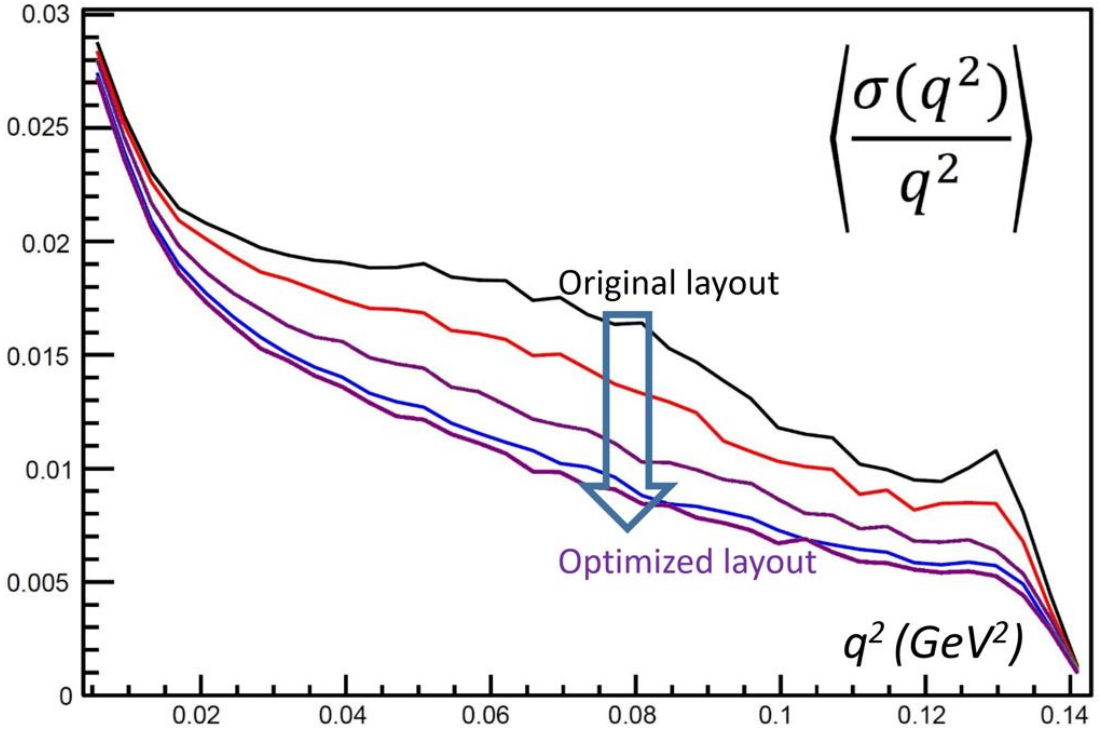
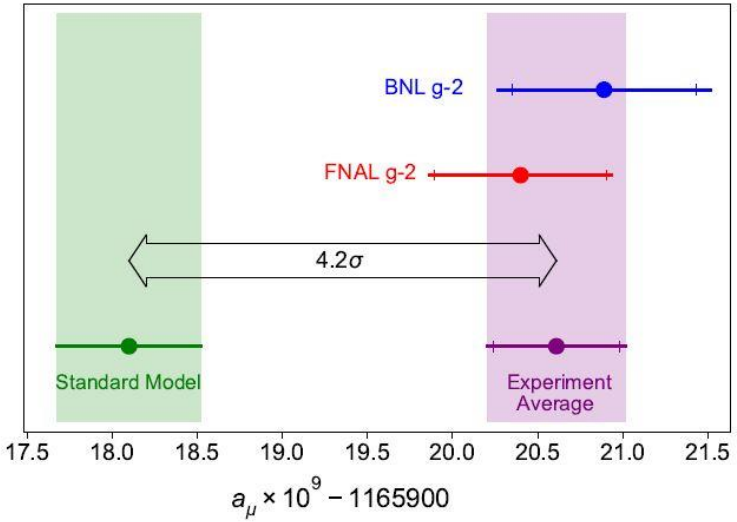
ABSTRACT

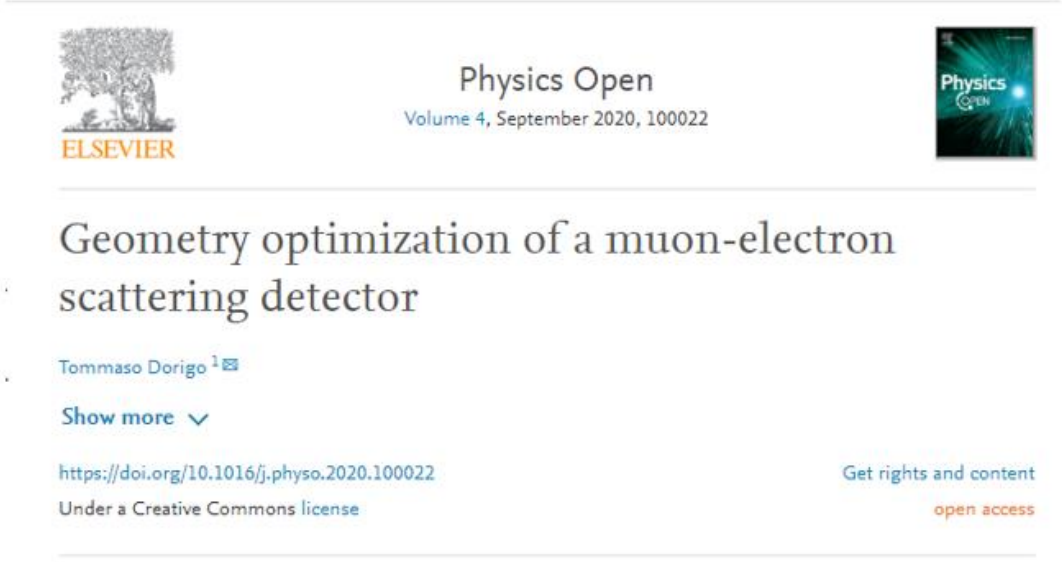
Complex computer simulations are commonly required for accurate data modelling in many scientific disciplines, making statistical inference challenging due to the intractability of the likelihood evaluation for the observed data. Furthermore, sometimes one is interested on inference drawn over a subset of the generative model parameters while taking into account model uncertainty or misspecification on the remaining nuisance parameters. In this work, we show how non-linear summary statistics can be constructed by minimising inference-motivated losses via stochastic gradient descent such that they provide the smallest uncertainty for the parameters of interest. As a use case, the problem of confidence interval estimation for the mixture coefficient in a multi-dimensional two-component mixture model (i.e. signal vs background) is considered, where the proposed technique clearly outperforms summary statistics based on probabilistic classification, a commonly used alternative which does not account for the presence of nuisance parameters.

How we got here – 3: MUonE





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Physics Open
Volume 4, September 2020, 100022

Geometry optimization of a muon-electron scattering detector

Tommaso Dorigo [1]

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https://doi.org/10.1016/j.physo.2020.100022

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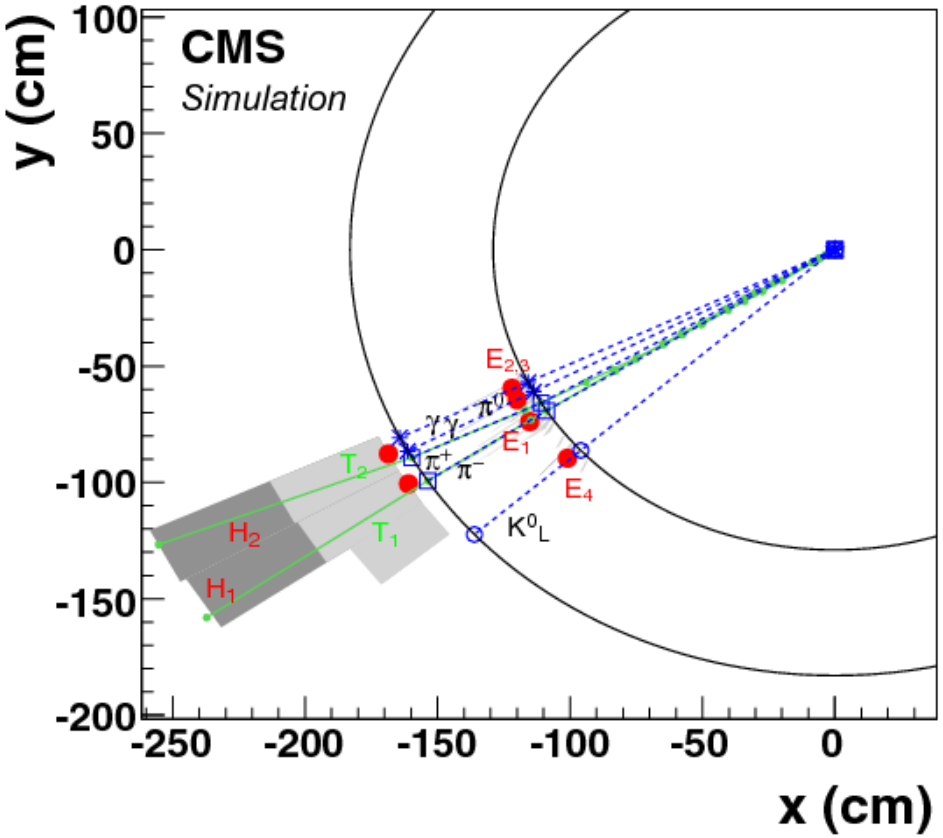
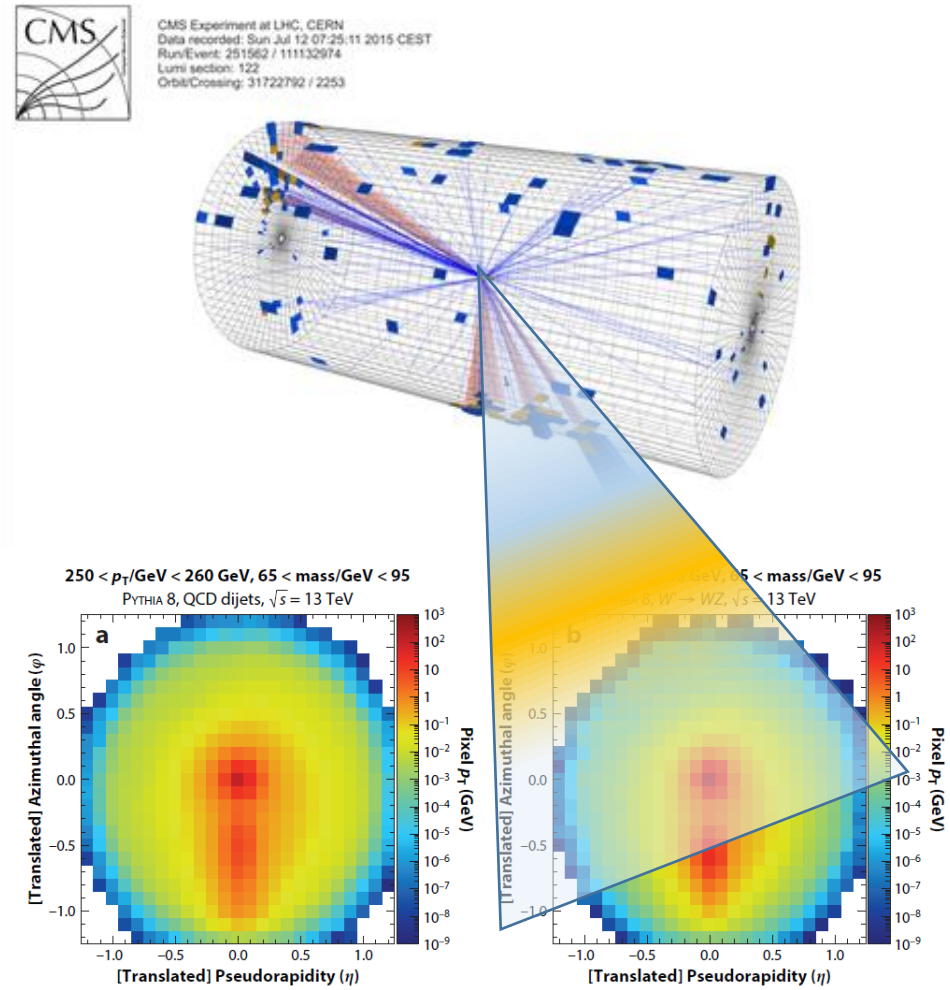
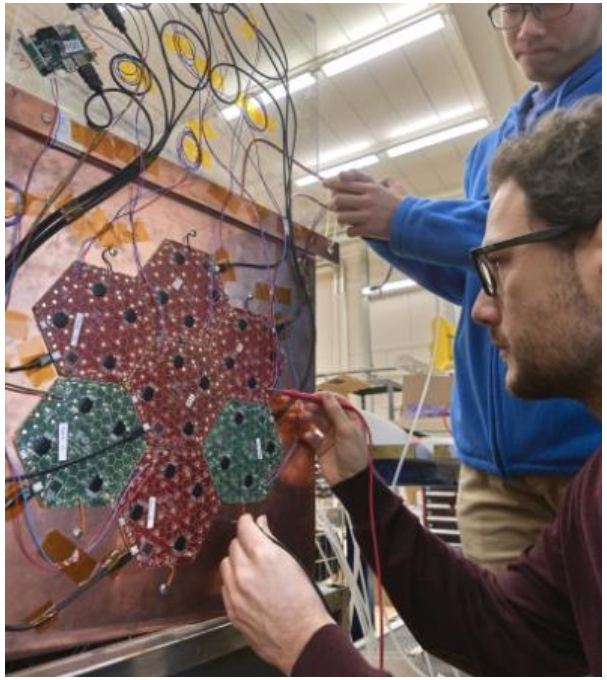
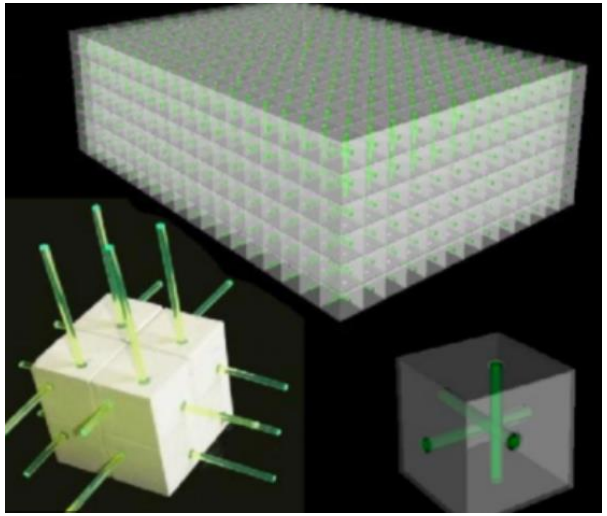
How we got here – 4: misalignments, serendipity, and opportunities





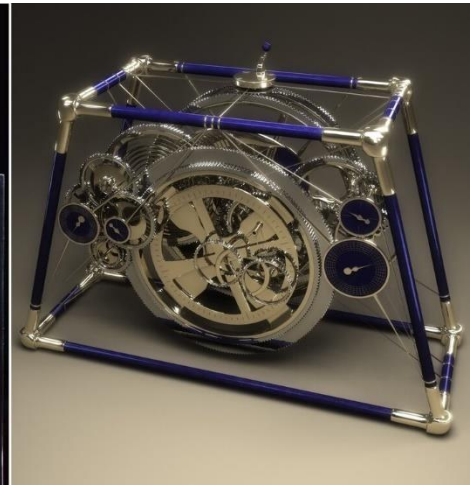




How we got here – 5: when technology exists, and it is not used…

The 1901 discovery of a wrecked ship in front of Antikythera, a Greek island south of the Peloponnese, brought evidence that the ancient Greeks could craft very complex instruments to predict eclipses and the position of planets, moon and sun at the turn of a crank

It has been argued that such technological marvels could have spurred a revolution that would have brought us to the technology level we're at now in 300 years, but it did not – there were not enough use cases to attract those early inventors' wits, nor resources to support basic research.



I'm not saying we run the same risks as the Greeks (and humanity) of 2500 years ago, but **revolutions do not start by themselves** – we have to take the new technology and adapt it to our use cases!

Machine-Learning Optimized Design of Experiments

MODE Collaboration

https://mode-collaboration.github.io

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4 Laboratory for big data analysis of the HSE, Russia
5 University of Oxford
6 Université de Liege
7 CERN
8 New York University
9 IFCA, Spain
10 GSI, Germany
11 Uppsala Universitet, Sweden
12 TU Munchen, Germany
13 Rutgers University, US
14 Università di Padova, Italy
15 Durham University, UK
16 Lebanese University, Lebanon

Sponsored by

Seeking support: it's hard!

As with any new, far-fetched, vague good idea, it is difficult to win the support of the community

Short history of failures:

- (pre-)MODE asked to be part of AIDA++ → lots of pats in the back but no
- MODE proposed to be an EoI of JENAS → accepted
- MODE proposed an italian group in INFN → rejected
- ERC proposal by TD → rejected
- Funding for workshops asked to INFN → rejected

The reason of the generally negative feedback we are getting is that the detector building community is not very receptive of the kinds of innovations we propose to develop.

This workshop is full with bright young people who will be the leaders in the future

Please remember, when you will get tenure, to keep an open mind and support bold new initiatives – we are researchers, so don't settle to pushing your cart!

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:

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

Our White Paper…

Ended up being a very nice, fat (107 pages) document, thanks to the effort of a few (especially Andrea Giammanco who drew the strings)

… But there are some rough edges to smoothen before we submit it to a journal

- we are working on it

Meanwhile, we plan to produce another publication.

Like the white paper, it will contain material from selected contributions to this workshop

Toward the End-to-End Optimization of Particle Physics Instruments with Differentiable Programming: a White Paper

Tommaso Dorigo[1,2], Andrea Giammanco*[1,3], Pietro Vischia[1,3] (editors) , Max Aehle[4], Mateusz Bawaj[5], Alexey Boldyrev[1,6], Pablo de Castro Manzano[1,2], Denis Derkach[1,6], Julien Donini[1,7], Auralee Edelen[8], Federica Fanzago[1,2], Nicolas R. Gauger[4], Christian Glaser[1,9], Atılım G. Baydin[1,10], Lukas Heinrich[1,11], Ralf Keidel[12], Jan Kieseler[1,13], Claudius Krause[1,14], Maxime Lagrange[1,3], Max Lamparth[1,11], Lukas Layer[1,2,15], Gernot Maier[16], Federico Nardi[1,2,17,7], Helge E. S. Pettersen[18], Alberto Ramos[19], Fedor Ratnikov[1,6], Dieter Röhrich[20], Roberto Ruiz de Austri[19], Pablo Martínez Ruiz del Árbol[1,21], Oleg Savchenko[2,3], Nathan Simpson[22], Giles C. Strong[1,2], Angela Taliercio[3], Mia Tosi[1,2,17], Andrey Ustyuzhanin[1,6], and Haitham Zaraket[1,23]

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March 22, 2022

The 2022 «progress» paper

We propose that the new article be titled «Progress in end-to-end optimization of experiments with differentiable programming» or something similar.

Rules of the game:

- we are happy with an author list as long as it can be
- contributions should be strictly on topic (thus a subset of the contributions to this workshop)

I propose that there be four ways to be authors of this article:

1) We invite you to submit 2/4 pages summarizing a contribution to the workshop we found belongs to the scope of this article
2) You propose to write 2/4 pages on a topic that aligns with the proposed article contents, and we give a green light
3) You offer to review at least two contributions from other authors

   - this means that you are (partly) responsible for the content as well as for the style and editing of the contributions

4) You participate in other ways in the organization of the effort (to be decided by the MODE SB)

The 2022 «progress» paper / cont'd

Similarly to how we organized matters for the white paper, we plan to have «editors» as first signatories of the article. Last time we had myself, Andrea, and Pietro.

I propose that editors be a subset of the reviewers who also contributed text. Editors should define the format and contents, accept proposals for contributions, define deadlines etc.

- natural candidates for editorship are session conveners and topic experts, but we will consider your volunteering anyways

- you can volunteer to be an editor, but I would ask that you become a member of MODE if you aren't already

All these are details subject to be finalized, but I think they summarize the way we want to handle this.

Huge thanks to our sponsors!!

This workshop could not have happened if not for the generous support of Iris-HEP and JENAS

Iris-HEP is the Institute for Research and Innovation in Software for High Energy Physics (IRIS-HEP), https://iris-hep.org/about/overview

JENAS is a consortium of Appec-NuPeCC-ECFA, https://www.appec.org/implementation/joint-ecfa-nupecc-appec-activities

We should also acknowledge Pietro Vischia's contribution with personal research funds from U. cath. Louvain!

Enjoy the workshop!