Closing remarks

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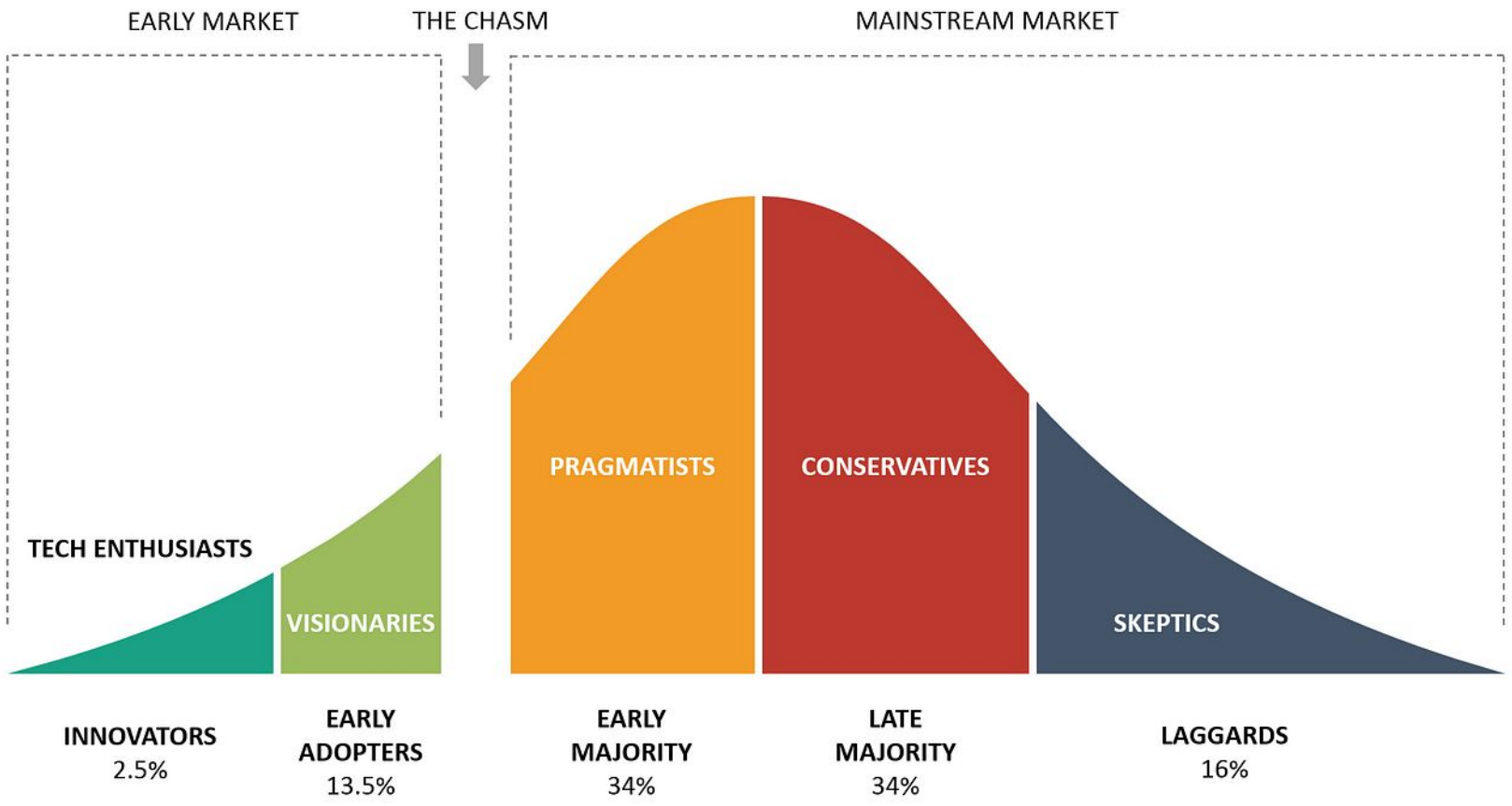
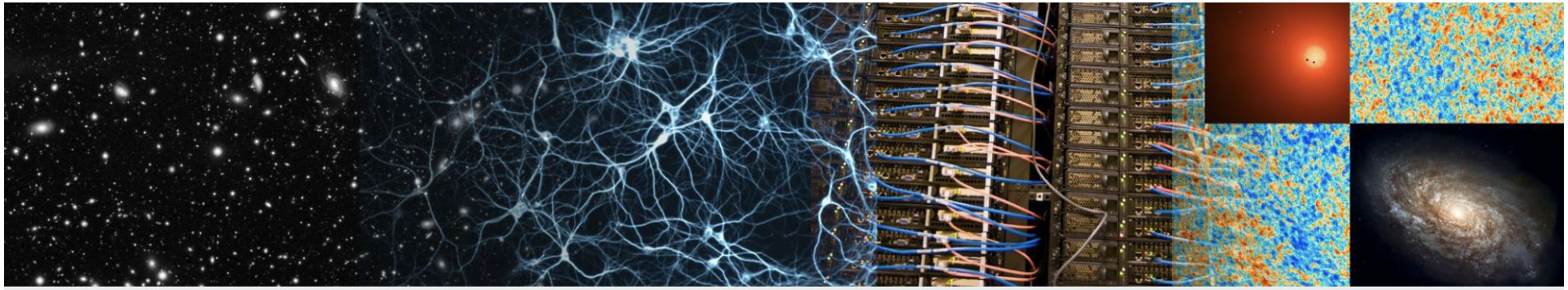
The view from the tail, no, not that tail, the other tail



Back to 2021



Debate #4:

What would it take for the community to accept the findings?

37th IAP conference - Oct 18th - 22th 2021

it all really depends on the question: what is the question? (A finding is always an answer to a question)

what is the smallest possible error on parameter x within a given model (don't care if right or wrong)?

I'd like to understand the physical processes at play in the Universe.

is there a sign for new physics?

is the LCDM model completely correct?

I want to classify objects

I want to model my instrument response

I want to sift through huge amount of data and find relatively rare "events" of interest (trigger)

I have a complex exact model (say N-body simulations, or stellar models) and I need a fast way to interpolate/emulate

do we want something that works or something that describes nature?

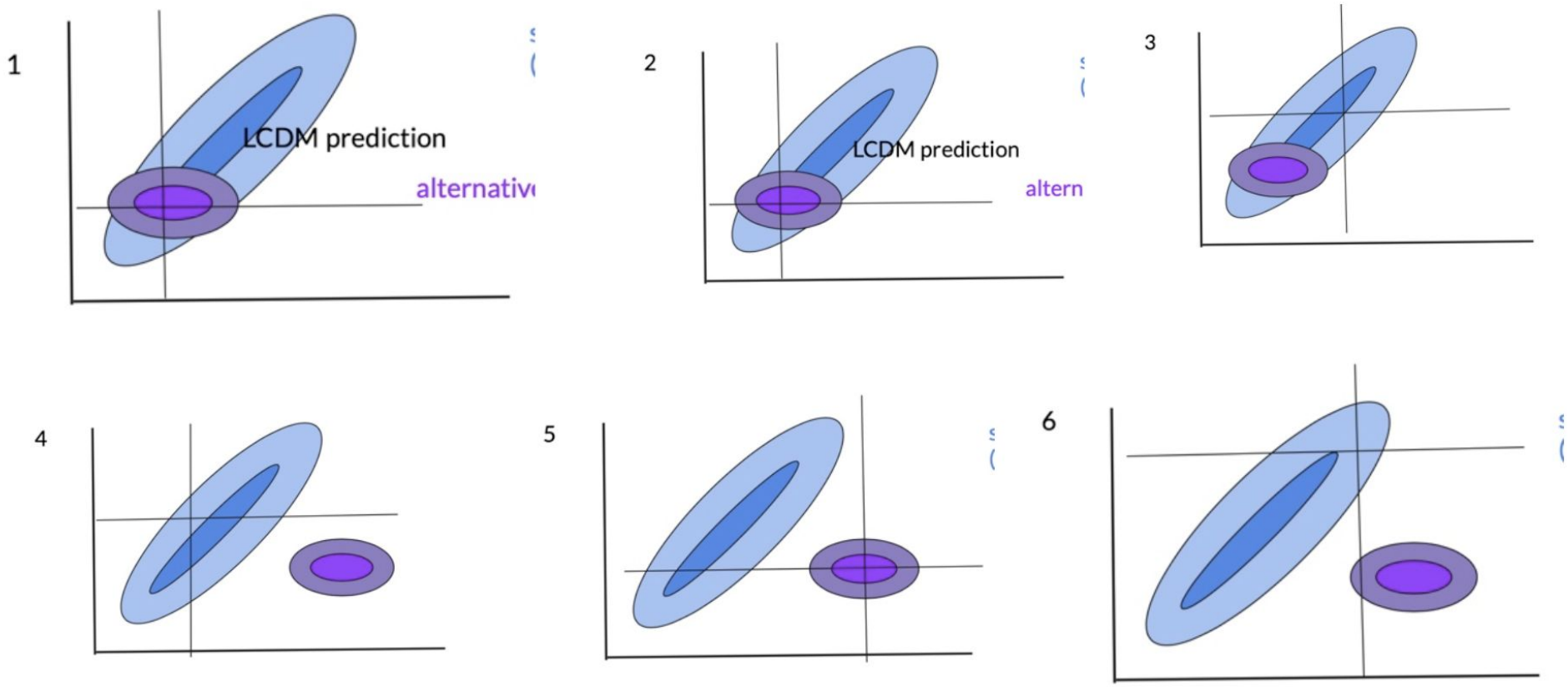
I set up a trap: I made the audience vote (anonymously)

Blue: traditional analysis

Purple: ML

Black +: LCDM prediction

Hypothetical scenario 10 years from now, axes are two parameters (you choose)



Should the acceptance depend on the agreement of the finding with pre-conceptions (expectations)?

NO

does/will the acceptance depend on the agreement of the finding with pre-conceptions?

The results of the poll indicated the contrary

In 2023 edition language
Beware of confirmation bias!

so … what would it take for the community to accept it ?

independently of the outcome but especially if the outcome is :“new physics!!!”

- **explain exactly how ML was used**
- one thing is to sift through large amount of data (similar to triggers), or “interpolation”, classification which would be otherwise impossible 
- another is to substitute the end to end process (that “black box feeling”)
- **explain what is the feature that ML picks up**
- **explain what is the physical meaning of the feature**
- **convincing use of the ML within the boundary of the training set**
- **convincing error budget**

how to get there?

- a **good track record of outperforming "standard" analysis** on "validation" sub sets of the **data** (where sub set is so that standard analysis in the full sample has similar error bars as the alternative analysis on the sub set) No, only on simulations is not enough.
- perform on "cuts" of the data that capture more(or less) of the known (or unknown) physics
- a **good track record** in terms of **coverage of the declared errors** (on data) and **full pdf**
- a clear demonstration of **robustness** (to changes in the training set, and other choices in the model)
- build physical understanding into the model.
- can one (softly) impose physics (e.g., symmetry) in the ML approach?
- blind analyses**

Now in 2023 do we add other entries?

better start now, 10 years go by relatively fast

there's work to do ...better start now...

There is a **program to develop**....

Beside what I mentioned here there is surely more that can (should) be done, so that the community accepts the findings.

Please share your thoughts of what should go in this "program" in the discussion.

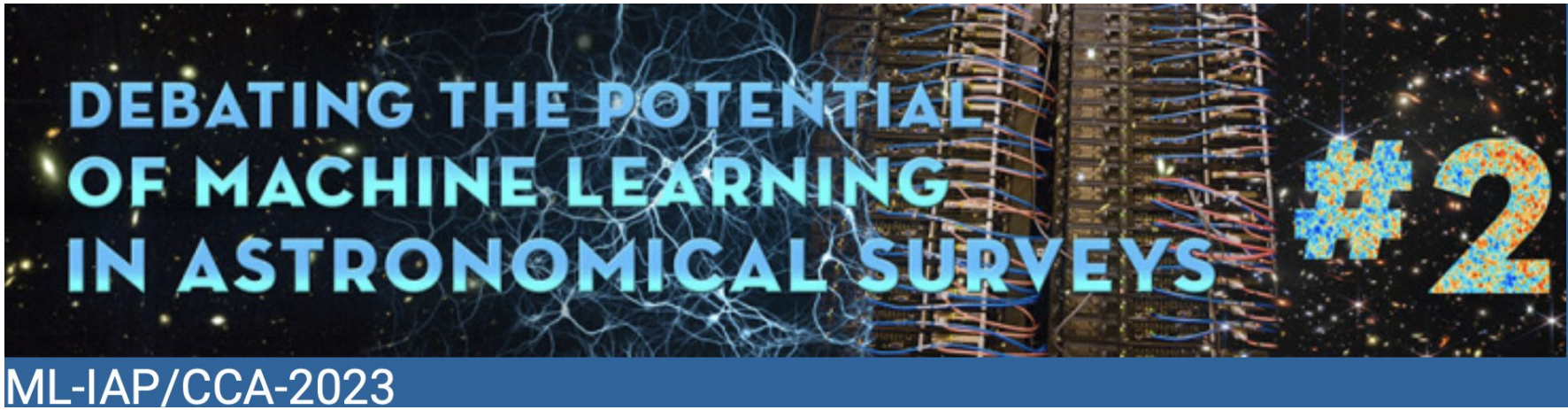
I am also interested on your thoughts on the type of questions that are better suited to different approaches.

5 days

12 h talks

8 h review talks

4.5 h of debates



Striking: low average age of participants

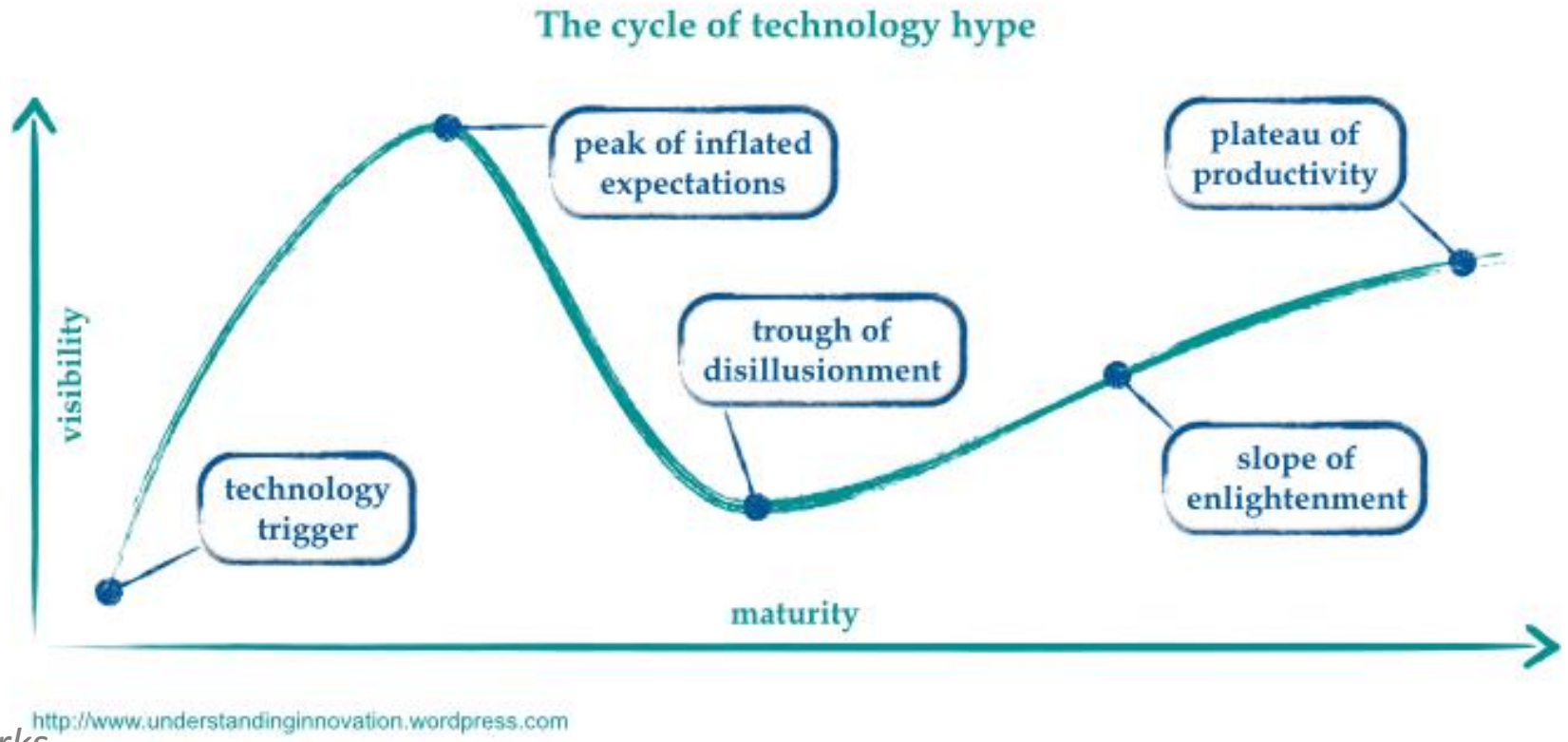
The Planck principle

A new scientific truth does not triumph by convincing its opponents and making them see the light,
but rather because its opponents eventually die and a new generation grows up that is familiar with it ...

Some considerations….

Two years later…
much much more awareness, maturity

- While not a coherent “program” a lot of work has been done.



Dunning-Kruger effect

- A “Snowmass”?

Some considerations….

On data…

ML thrives on big data (training, making “sense” of, sifting through,…). “complexity”

- Simulations are not data

- There are mock data (end-to-end), there are idealized data (model-generated data), and there are data-data (“real” data).

These are NOT the same thing, they are PROFOUNDLY different

Proposal: m-data, i-data, data

On priors (or biases?)

- The traning (m-,i-)data → in-built prior

This is not good or bad, but it is there!

- The architecture → in-built prior

On.. The Universe

ML thrives on big data (training, making “sense” of, sifting through,…)

- We only have one Universe. (d’oh)
- Complexity (see opening talk)
- Not all astronomy contexts/applications deal with this in the same way: repeated observations, contexts when confirmation/follow up is the aim, [planets, transits,…], photo-z vs cosmological parameters

It all depend on the question one is trying to answer.

It is very important to specifiy extremely well what is the question and why the answer is of value.

On “truth” (see dabate #1,2)

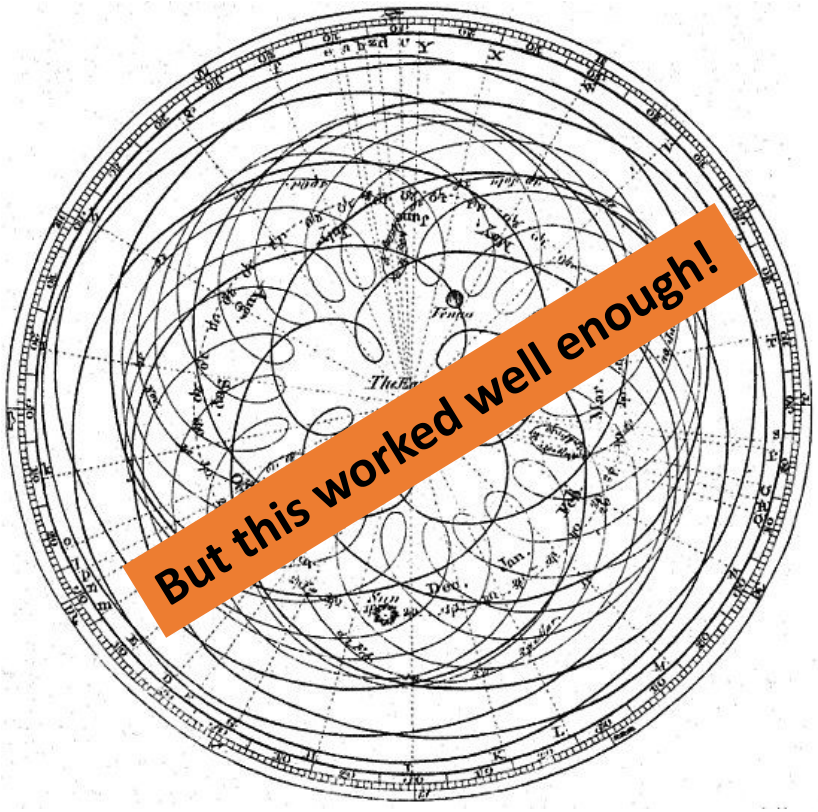
- we are after fundamental physics (and we look up at the sky to find it)
- Physical law vs symmetries vs conceptual framework (GR, QM) vs theory (string theory, inflation…) vs model (LCDM, wCDM...) vs effective model (cz=H0 d) vs empirical relation (PL relation, Phillps relation)

(not all models are created equal)

Understanding is not describing

Fitting cosmological parameters is not understanding

On epicycles….



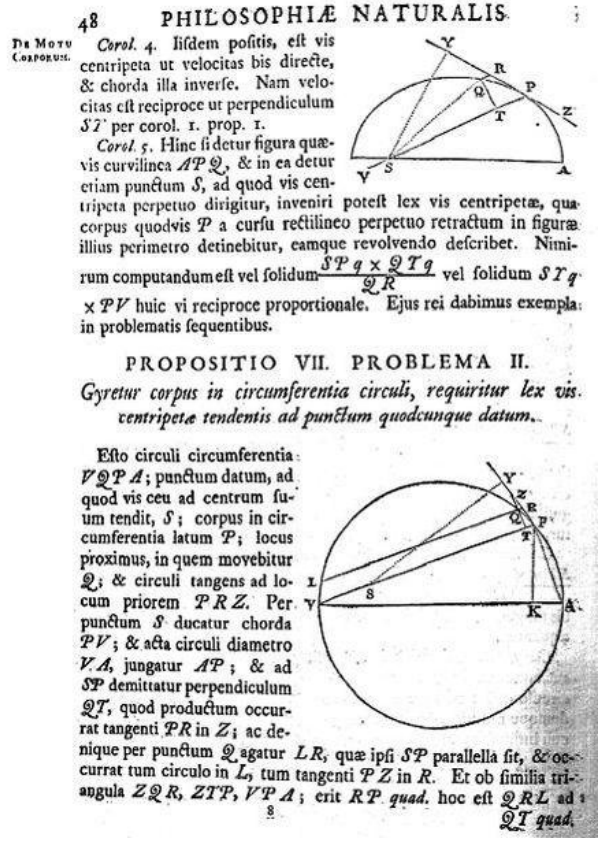
Geocentric model


NICOLAI COPERNICI

quoq; epicyclum hoc modo. Sit mundo ac Soli homocentrus AB, & ACB diameter, in qua ſumma abſis contingat. Et facto in A centro epicyclus deſcribatur DE, ac rurſus in D centro epicycli um FG, in quo terra uerſetur, omniaq; in eodem plano zodiaci. Sitq; epicycli primi motus in ſuccedētia, ac annuus ferè, ſecūdi q̄q; hoc eſt D, ſimiliter annuus, ſed in præcedentia, ambo rumq; ad AC lineam pares ſint reuolutiones. Rurſus cētrum terræ ex F in præcedentia addat parumper ipſi D. Ex hoc

Heliocentric model

Fundamental principles


48 PHILOSOPHIÆ NATURALIS

De Motu Corporum.

Corol. 4. Iiſdem poſitis, eſt vis centripeta ut velocitas bis directe, & chorda illa inverſe. Nam velocitas eſt reciproce ut perpendiculum *ST* per corol. 1. prop. 1.

Corol. 5. Hinc ſi detur figura quævis curvilinea *APQ*, & in ea detur etiam punctum *S*, ad quod vis centripeta perpetuo dirigitur, inveniri poteſt lex vis centripetæ, qua corpus quodvis *P* a curſu rectilineo perpetuo retractum in figuræ illius perimetro detinebitur, eamque revolvendo deſcribet. Nimirum computandum eſt vel ſolidum $\frac{SP\,q \times QT\,q}{QR}$ vel ſolidum $ST\,q \times PV$ huic vi reciproce proportionale. Ejus rei dabimus exempla in problematis ſequentibus.

PROPOSITIO VII. PROBLEMA II.

Gyretur corpus in circumferentia circuli, requiritur lex vis centripetæ tendentis ad punctum quodcunque datum.

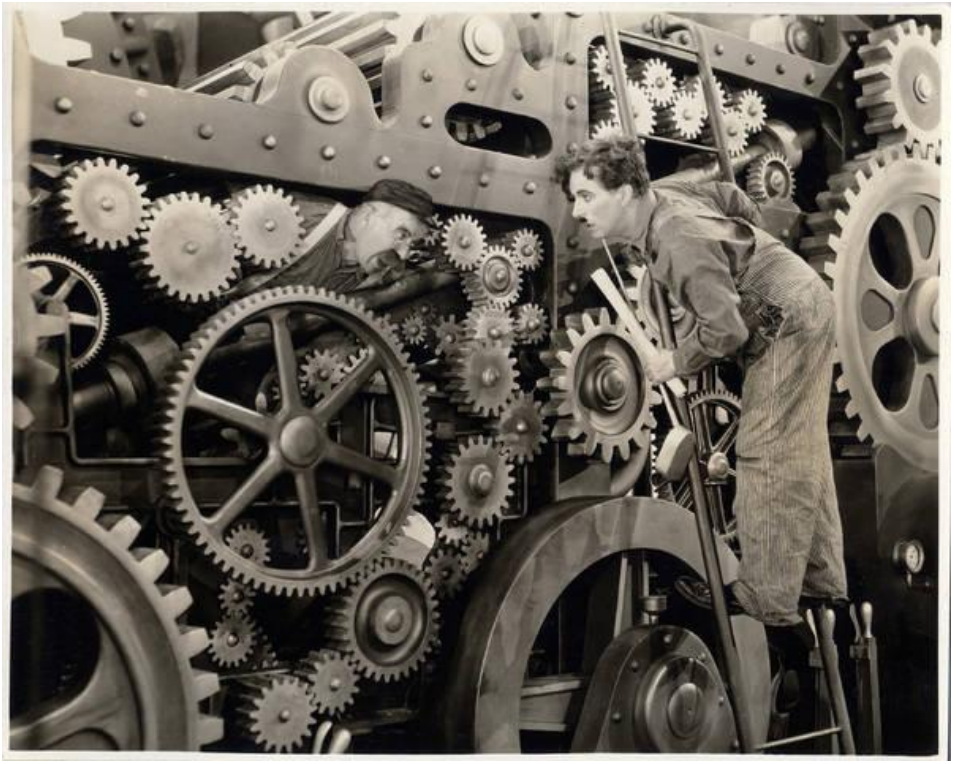
Eſto circuli circumferentia *VQPA*; punctum datum, ad quod vis ceu ad centrum ſuum tendit, *S*; corpus in circumferentia latum *P*; locus proximus, in quem movebitur *Q*; & circuli tangens ad locum priorem *PRZ*. Per punctum *S* ducatur chorda *PV*; & acta circuli diametro *VA*, jungatur *AP*; & ad *SP* demittatur perpendiculum *QT*, quod productum occurrat tangenti *PR* in *Z*; ac denique per punctum *Q* agatur *LR*, quæ ipſi *SP* parallela ſit, & occurrat tum circulo in *L*, tum tangenti *PZ* in *R*. Et ob ſimilia triangula *ZQR*, *ZTP*, *VPA*; erit *RP quad.* hoc eſt *QRL* ad *QT quad.*

8

Kelper, Newton

Licia Verde

On… different contexts



- Discover the physics
- Know the physics
- Have a fiducial model
- Have no clue and no fundamental principle model but a) don’t care b) still have to deal with it
- Know it all but want to be fast/cheap
- Summarize/search…

“the ML cog”

On new results… (or opening talk question)

Faster, cheaper

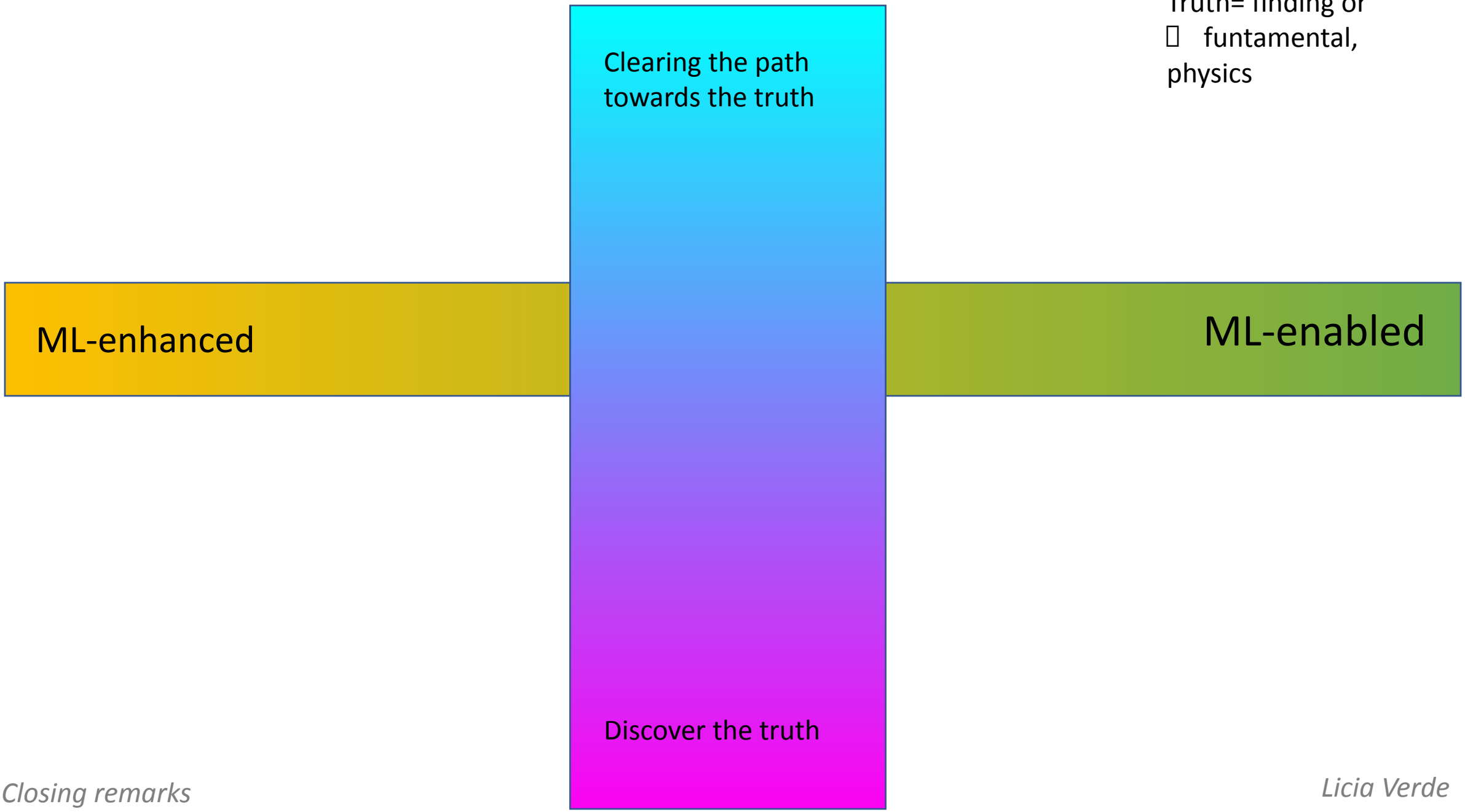
Disruptive
otherwise impossible

Is it “just” a tool?

Think about internal combustion engine

Think about the internet

Truth= finding or
 funtamental,
physics



on

interpretability

Making the black box transparent

- But not only: reducing dimensionality, reducing complexity, connection to the Fisher information matrix.
- Truth in latent space (summarized in debate #1)
- Symbolic regression….
- Contrast learning
- Response…. Saliency maps, sensitivity maps

"I want to believe"

Combination of approaches…

Shaping the box and its content

- Geometric deep learning
- PINN (effort going on at home)
- …..

Hard code in
Or
In the loss function

Combination of approaches…

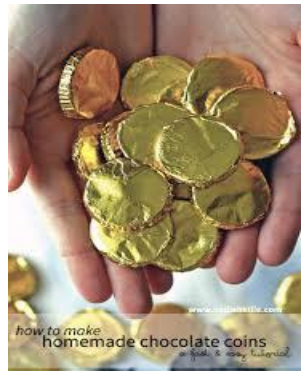
..”attention is all you need”…

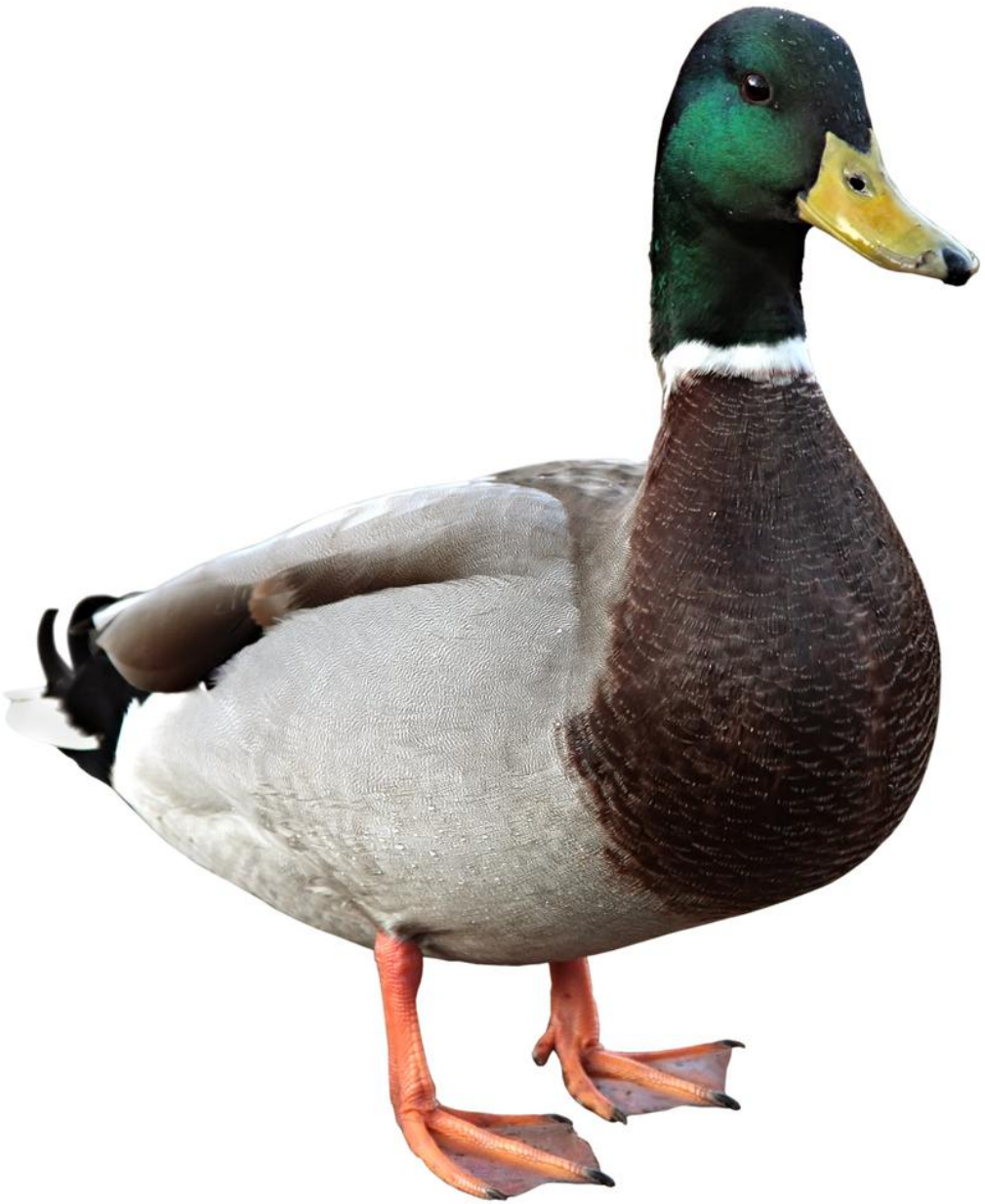
DEEPthink disappoining answer

“Produce new measurements”

Detecting neutrino masses

Say we detect Mv=0.095eV from ….. A galaxy survey
Say we detect Mv=0.06eV from ….. A galaxy survey





Walks like a duck, looks, like a duck, smells like a duck, but I need some more quacking tests

Liskov principle

If it looks like a duck and quacks like a duck but it needs batteries, you probably have the wrong abstraction

features

Robust, consistent across different analyses

With a direct connection to physics (possibly fundamental)

Predictability of other features... Which have a direct connection to other aspects of the physics

Consistency tests
null tests

Generic, not only for ML, but easier to do for more traditional approaches

A question of time?

It changes the type of valuable skills
Forces a re-evaluation of the values and what is of value
Acceleration
Efficiency
Freeing up time/resources for things that ML can't do well

Judea Pearl:" **Current machine learning systems operate, almost exclusively, in a statistical, or model-free mode , which entails severe theoretical limits on their power and performance."..**
humans can imagine alternative hypothetical environments for planning and learning."casuality", "counterfactuals" , "what if". Current algorithms lack causal reasoning.

But… where do you want to go?

Thank you

- To all the speakers, panelists, in Paris/NY.

  I learned a lot I can’t believe it’s already over.
- To the session chairs. Impeccable and we were quite on time!
- To all the participants in all the different timezones, for the lively questions and participation.
- SOC and LOC and the support staff
- and… to the organizers: only few years ago we would not even have imagined possible, but it went flawlessly, which is amazing!