Virtual Colliders for Citizen Scientists

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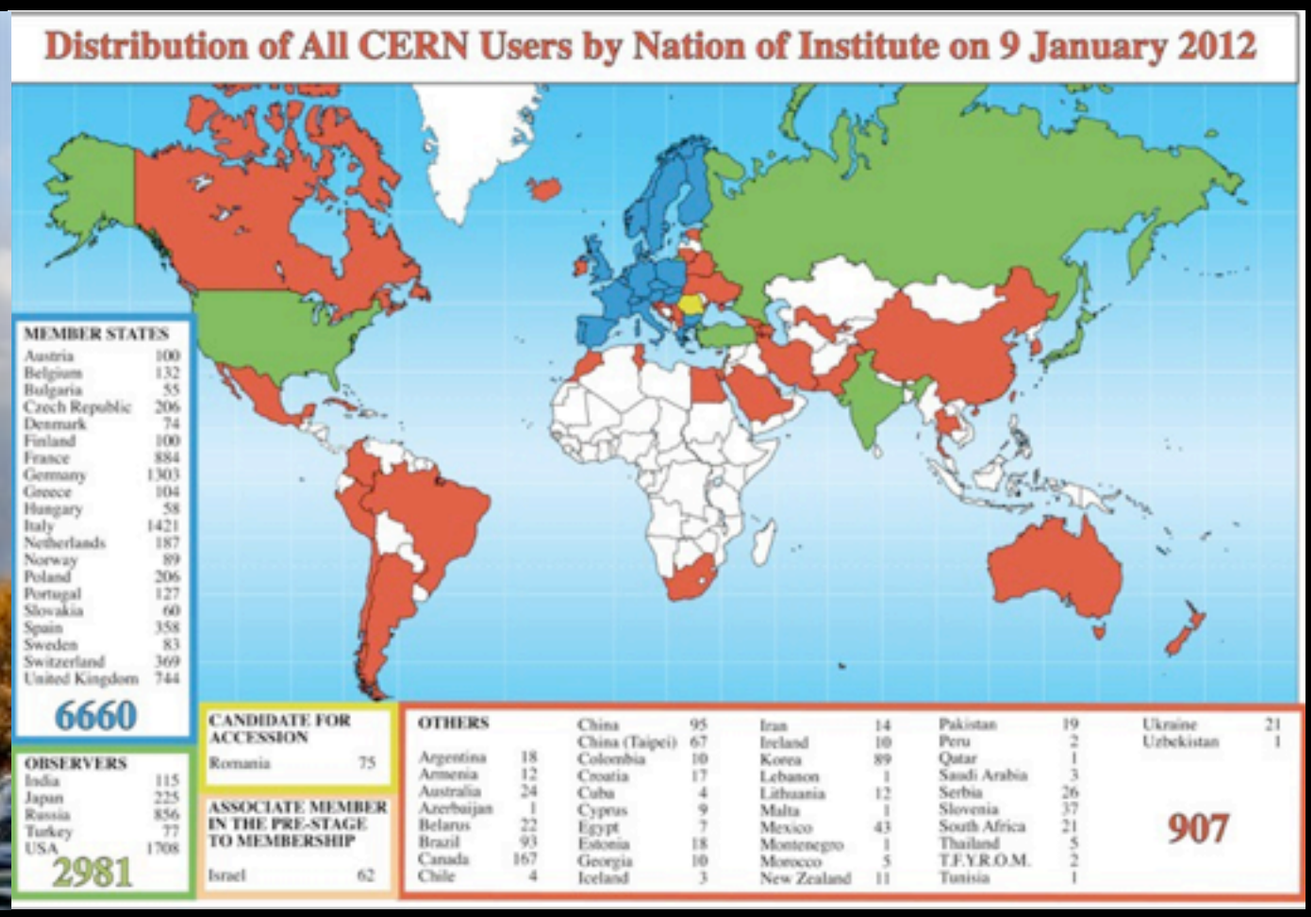
CERN: European Organization for Nuclear Research

Every day, around 10 000 scientists
from all over the world.

Flags of CERN's Member States



20 European Member States and around 60 other
countries collaborate in our scientific projects.

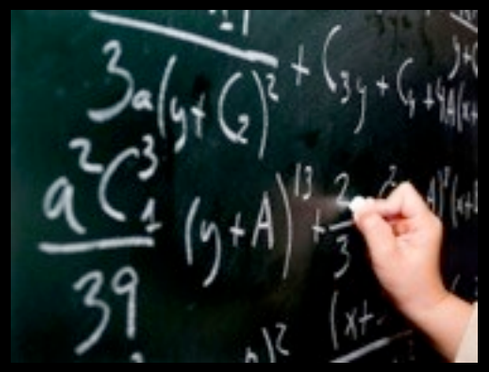
the Tools of the trade

1. Accelerators : powerful machines to accelerate particles up to extremely high energies and bringing them into collision with other particles.

2. Detectors : gigantic instruments recording the particles spraying out from the collisions.

3. Computers : collecting, stocking, distributing and analyzing the enormous amounts of data produced by the detectors.

Nutshell



Theory

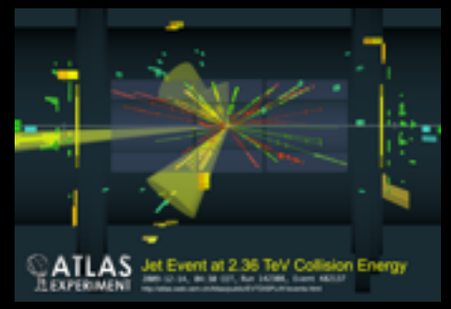
Experiment

Adjust this to agree with this

→ Science

In Practice

• • •



"Virtual Colliders"
= Simulation Codes

Real Universe
→ Experiments & Data

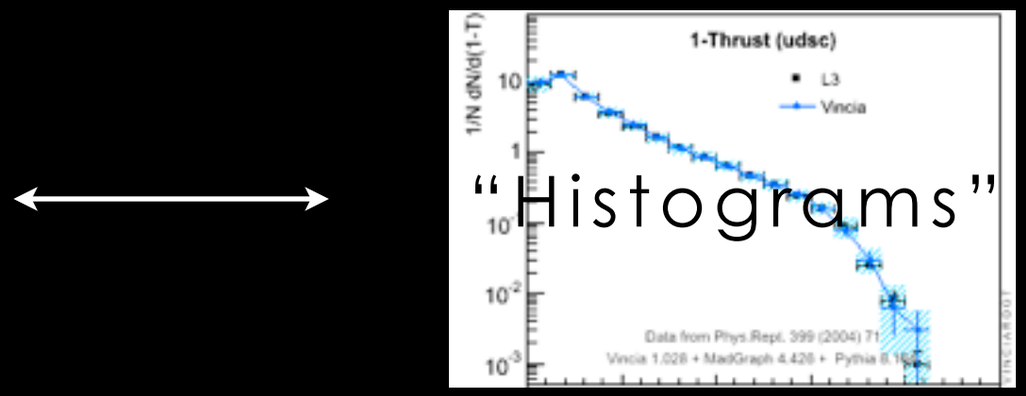
Relativity, Quantum Theory,
Physics Models, Algorithms, ...

→ Simulated Particle Collisions

Particle Accelerators,
Detectors, and Measurements

→ Published Measurements

"Events"



"Histograms"

CERN - The Large Hadron Collider (LHC)

The ATLAS Experiment at the LHC

ATLAS collision event at 7 TeV from March 2010

http://atlas.ch

LHC Collision at 7 TeV
ATLAS, March 2010

Theory ↔ Data

Global Comparisons

Task: determine "best" parameters for theory models

→ Compare against thousands of measurements, taken under different conditions, by different experiments, at different colliders

+ do this for many simulators & versions, with different setups

LEP Tevatron SLC LHC ISR HERA SPS RHIC

Quite technical
Quite tedious
→
Ask ~~someone~~ else
everyone

LHC@home 2.0
TEST4THEORY

citizen cyberscience centre

CERN

J. Blomer,
P. Buncic,
I. Charalimpidis,
F. Grey,
A. Haratyunyan,
A. Karneyeu,
D. Lombrana-Gonzalez,
M. Marquina,
B.Segal,
P. Skands,

7000 Volunteers - 20000 Hosts
Over 700 billion simulated collision events

LHC@Home 2.0 - Test4Theory

Idea: ship volunteers a virtual atom smasher
(to help do high-energy theory simulations)

Runs when computer is idle. Sleeps when user is working.

Problem: Lots of different machines, architectures (tedious, technical)

Use Virtualization (CernVM) → provides standardized computing environment on *any* machine (in our case: Scientific Linux)
→ replica of our normal working environment. Factorization of IT and Science

Infrastructure; Sending Jobs and Retrieving output

Based on BOINC platform for volunteer clouds (but can also use other distributed computing resources, like GRID or traditional farms)

New aspect: virtualization, never previously done for a volunteer cloud

http://lhcathome2.cern.ch/test4theory/

Test4Theory

LHC@home 2.0 Test4Theory volunteers' machines seen during the past **24** hours (7011 machines overall)

The LHC@home 2.0 project Test4Theory allows users to participate in running simulations of high-energy particle physics using their home computers.

The results are submitted to a database which is used as a common resource by both experimental and theoretical scientists working on the Large Hadron Collider at CERN.

Monday Feb 18 2013 9:28 PM

Map data ©2013 MapLink, Tele

Results → mcplots.cern.ch

Menu

- Front Page
- LHC@home 2.0
- Generator Versions
- Generator Validation
- Update History

Analysis filter:

- ALL pp/ppbar
- ALL ee

Specific analysis:

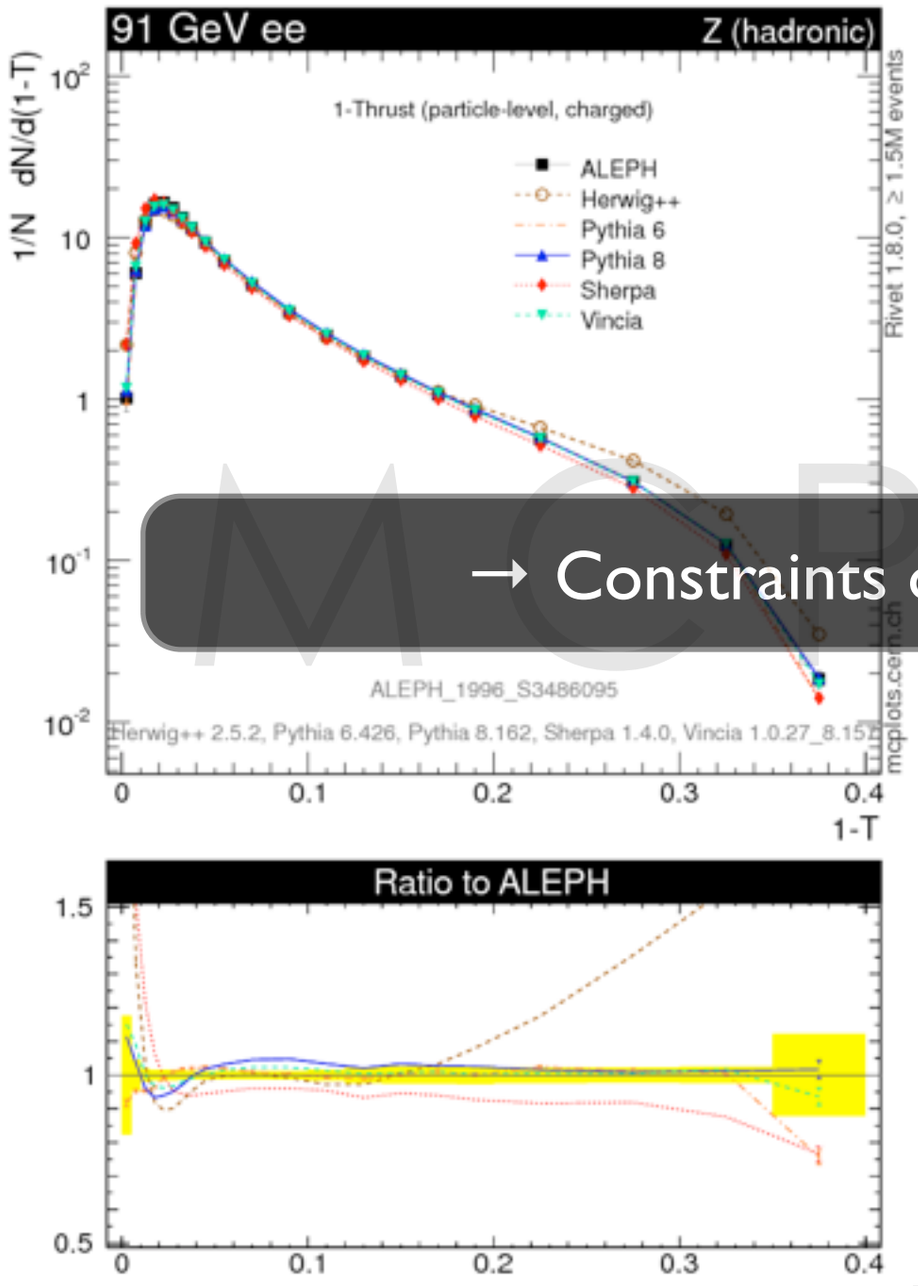
Z (hadronic)

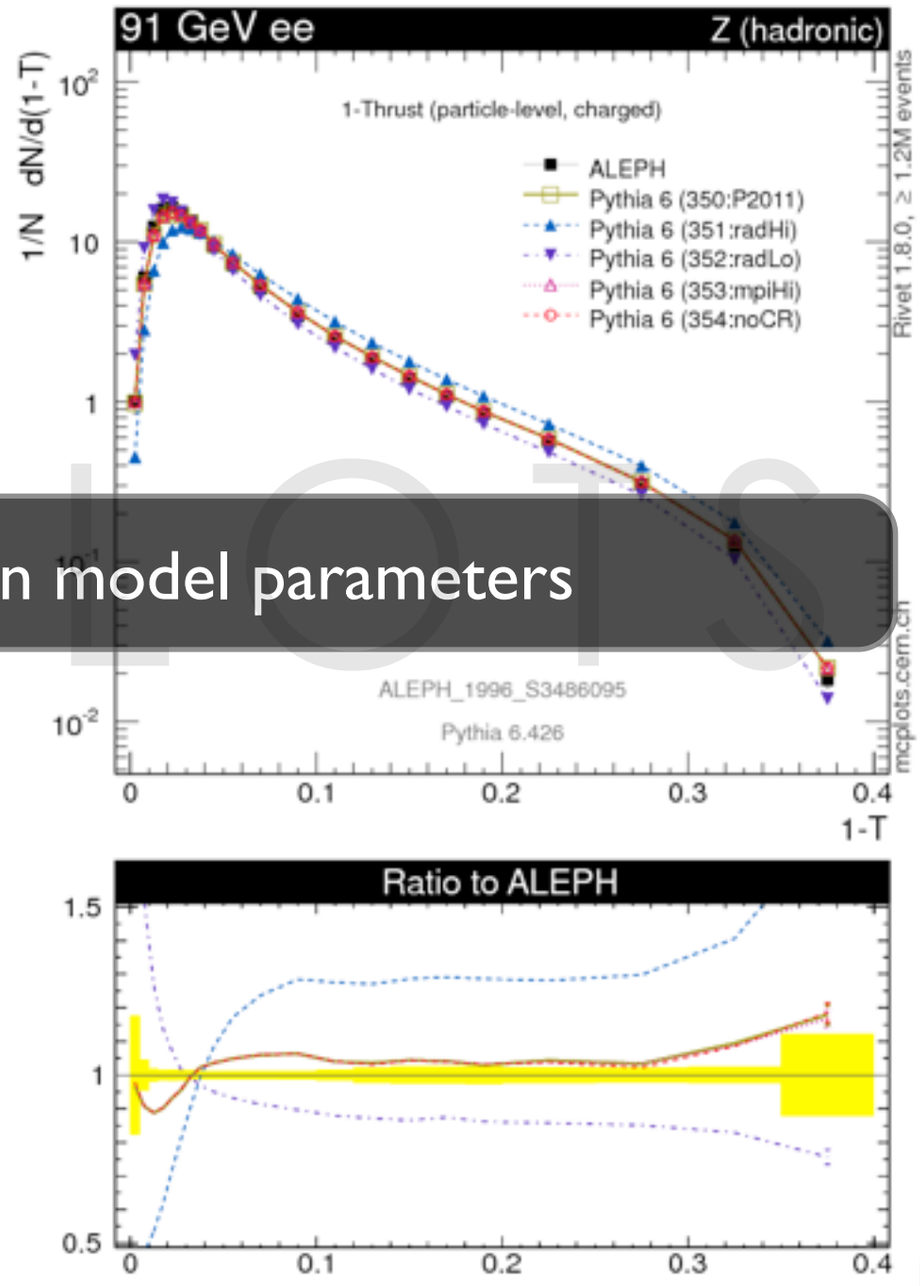
- Aplanarity
- B(Total)
- B(Heavy Hemisph)
- B(Light Hemisph)
- C parameter
- D parameter
- M(Heavy Hemisph)
- M(Light Hemisph)
- ΔM(Heavy-Light)
- Multiplicity Distributions
- Planarity
- pTin (Sph)
- pTin (Thrust)
- pTout (Sph)
- pTout (Thrust)
- Sphericity
- Thrust
- 1-Thrust
- Thrust Major
- Thrust Minor

Z (hadronic) : 1-Thrust

(Total number of plots ~ 500,000)

Generator Group: Main Herwig++ Pythia 6 Pythia 8 Sherpa Vincia Custom





→ Constraints on model parameters

The "Jeppsson" Project

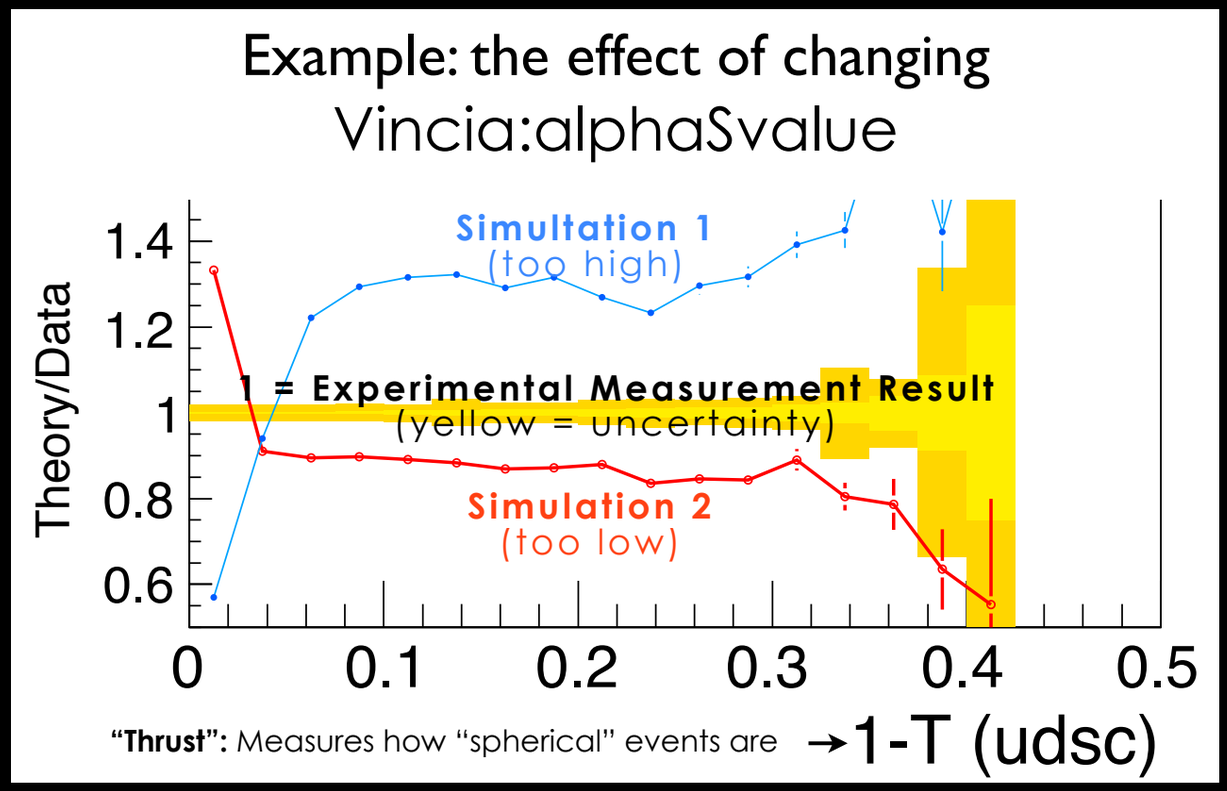
April 2010

The Jeppsson Project

April 2009: FB message from friend of friend: can a 15-yr old be a one-week intern at CERN?

We were developing a run-time display for our simulation anyway.

April 2010: simple text editor to edit input cards. Run-time display to compare output histograms to data.




```
! * Strong-force Coupling
Vincia:alphaSValue       = 0.138

! * Hadronic Energy Scale
Vincia:cutoffScale       = 0.45

! * String parameters
StringZ:aLund            = 0.38
StringZ:bLund            = 0.62
StringPT:sigma           = 0.26

! * Quark flavor parameters
StringFlav:probStoUD     = 0.21
StringFlav:mesonUDvector = 0.35
StringFlav:mesonSvector  = 0.55
StringFlav:probQQtoQ     = 0.08
StringFlav:probSQtoQQ    = 1.00
StringFlav:probQQ1toQQ0  = 0.03
StringFlav:decupletSup   = 1.00
StringFlav:etaSup        = 0.60
```

The Jeppsso

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April 2010: simple text editor to edit input cards. Run-time display to compare output histograms to data.

May 2010: Parameters released as new defaults.

Atom Smashers

The Citizen Cyberlab EU ICT Project - CERN's Contribution

Starting May 2013

LHC Physics Center at CERN

The Citizen Cyberlab ICT Project

Standalone 3-yr Project funded by EU (2012-2015)

CERN Task: create citizen science pilot project in particle physics

The EU funds a 2-year "fellowship" starting in May: Ioannis Charalimpidis

We will

Develop an application that lets citizen scientists **learn about, interact with, and optimize high-energy physics simulations**, by **comparing them to real data**

→ feedback to scientists

How?

Combine the framework and lessons from Test4Theory / LHC@home 2.0 with those from the Jeppsson project → **Atom Smasher Application**

Provide content, explanations, visualizations (**mod**ifiable and open)

Organize one or more **citizen-science events** at CERN (e.g., for the CERN open day in September), host a **summer student** (e.g., a 4th year IT or Physics student) next year, …

Structure

Start simple:
one physics parameter and one measurement.

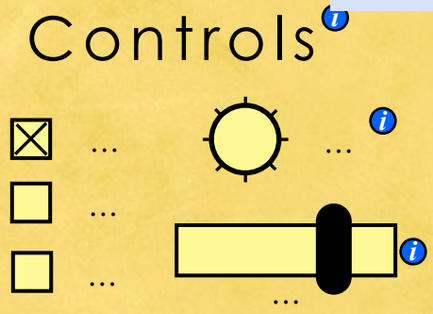
Adjust parameter to agree with measurement

1. Immediately present user with interesting and interactive content.

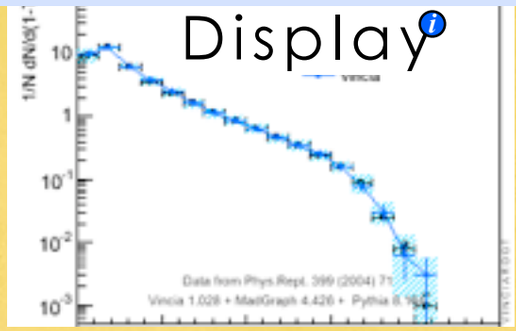
Level 1

Controls are used to set the simulation parameters

Controls



Display



Task:

Use the controls (left) to make the simulation agree with the data (right)

Rollover tooltips
+
Click for more

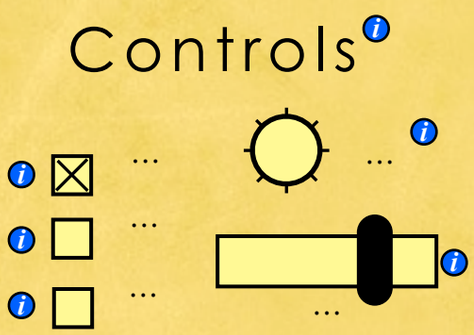
More detailed explanations can be clicked into
→ Explanation → Elaboration → Engagement

Context Example

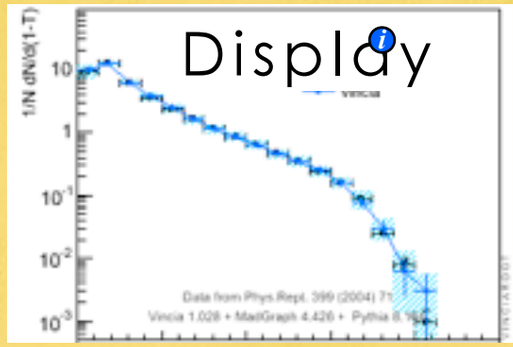
2. Provide deeper levels of context, user extensions, and discussion
(divided into levels: citizens, phys students, experts)

Level 1

Controls



Display



Rollover tooltips + Click for more

Controls

Are used to set the simulation parameters. More elaboration … .

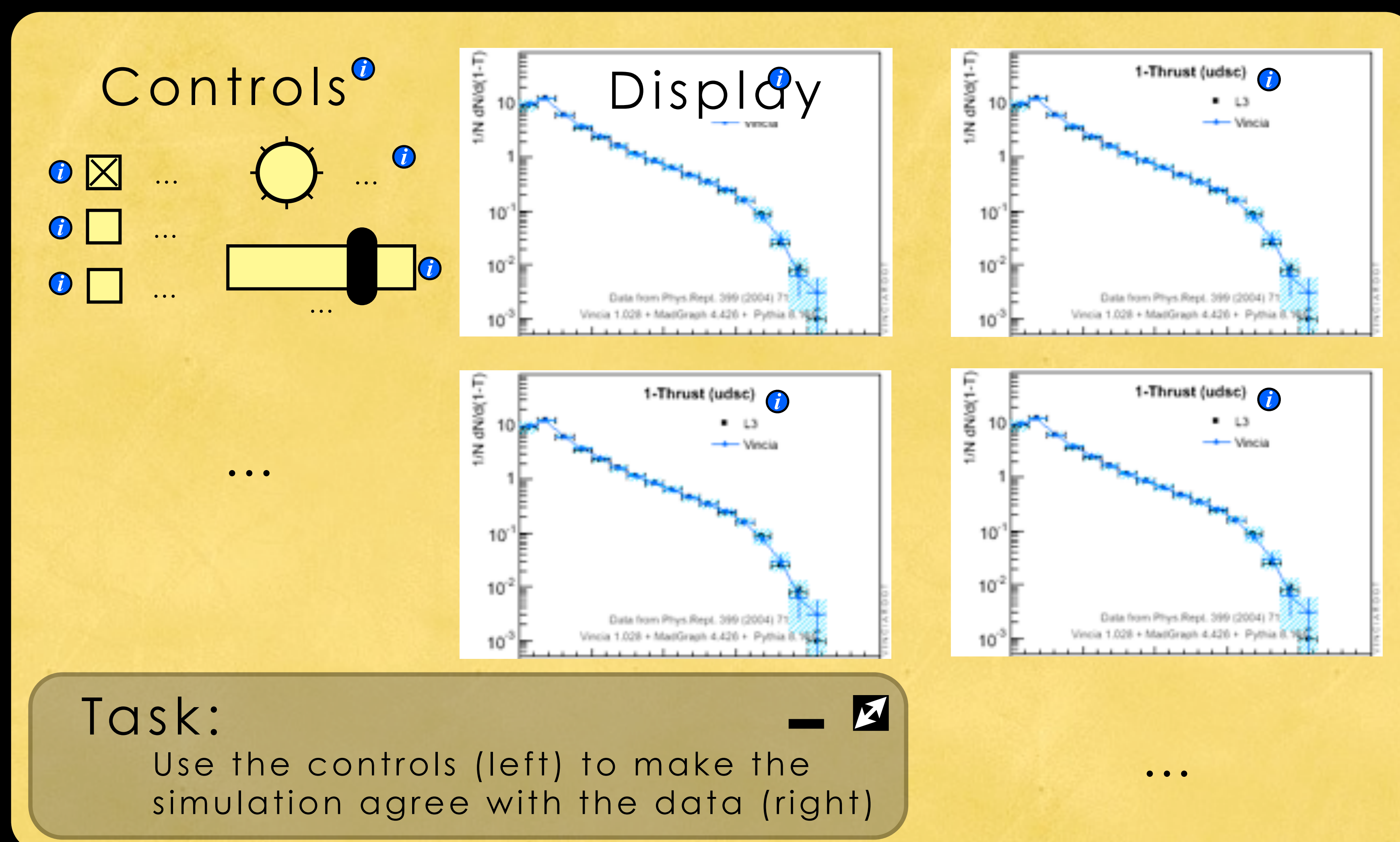
3. Users create their own annotations too (private / shared)
+ Combine with vote good/bad (incl *our* explanations)
+ Forums for further detailed discussion of issues

Progress

4. As user learns, unlock more distributions & parameters (with explanations)
(Ultimately → LHC)

Compare against current simulation defaults → feedback to scientists

Level 23



What's the Goal(s)?

(citizen science) : beat the state of the art → feedback to scientists

Won't happen every day, and not early.

Contributing something real to the scientists is main motivator.

(learning) : people will learn about particle physics. Can also be used for outreach, and even for physics teaching

Progress markers may be useful, even desirable. How well am I doing?

→ *Develop extra context layer (and targets) for university-level online course (for future)*

(visualization) : scientists also get a nice UI. It then needs to be close enough to the "real deal" that scientists can use it too.

Visual design (plots) must be professional and modifiable, usable in scientific publications.
Bonus: can point to same graphics in real science papers