Virtual Colliders for Citizen Scientists

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

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

Adjust this to agree with this

→ Science
In Practice

“Virtual Colliders” = Simulation Codes

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

→ Simulated Particle Collisions

Real Universe → Experiments & Data

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
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

Quite technical
Quite tedious
→ Ask someone else everyone

LHC@home 2.0
TEST4THEORY

7000 Volunteers - 20000 Hosts
Over 700 billion simulated collision events
**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

- 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;

**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

[Link](http://lhcathome2.cern.ch/test4theory/)
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.
Results → mcplots.cern.ch

**Constraints on model parameters**

(Total number of plots ~ 500,000)

- **Z (hadronic): 1-Thrust**
  - Generator Group: Main Herwig++ Pythia 6 Pythia 8 Sherpa Vincia Custom
  - 91 GeV ee

- **Ratio to ALEPH**
  - Thrust
  - Thrust Major
  - Thrust Minor
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.

Example: the effect of changing
Vincia:alphaSValue

<table>
<thead>
<tr>
<th>Theory/Data</th>
<th>Simulation 1</th>
<th>Simulation 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = Experimental Measurement Result (yellow = uncertainty)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

"Thrust": Measures how "spherical" events are

! * 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
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May 2010: Parameters released as new defaults.
Atom Smashers
The Citizen Cyberlab EU ICT Project - CERN's Contribution
Starting May 2013
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 (*modifiable 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, ...
1. Immediately present user with interesting and interactive content.

Start simple:
- one physics parameter and one measurement.

Adjust parameter to agree with measurement.

Level 1

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

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)

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

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*