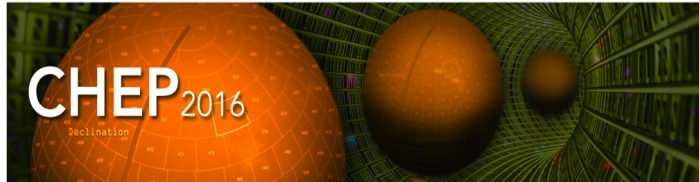


HiggsHunters - a citizen science project for ATLAS

Andy Haas (NYU)
and Alan Barr (Oxford)
on behalf of the ATLAS Collaboration

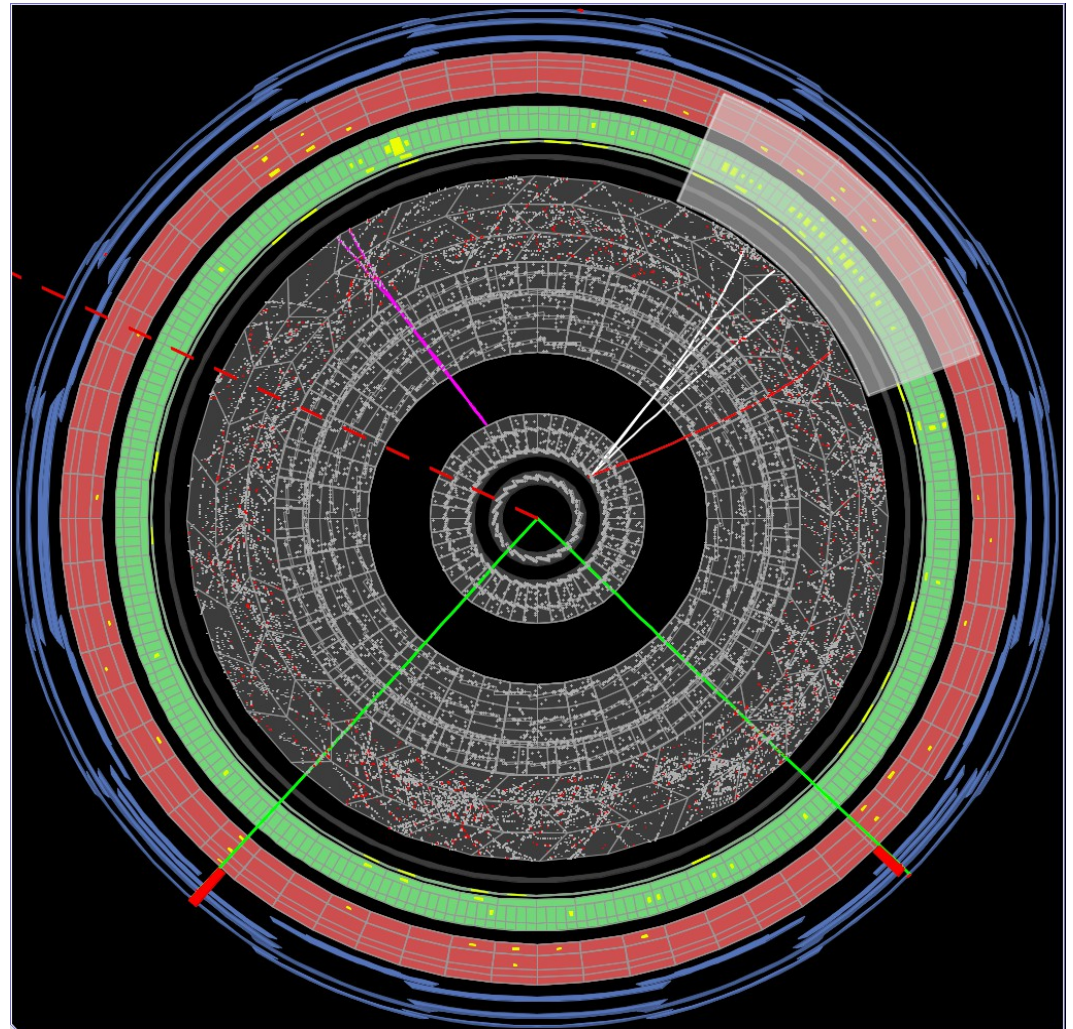
October 10, 2016



22nd International Conference on Computing in High Energy and Nuclear Physics, Hosted by SLAC and LBNL, Fall 2016



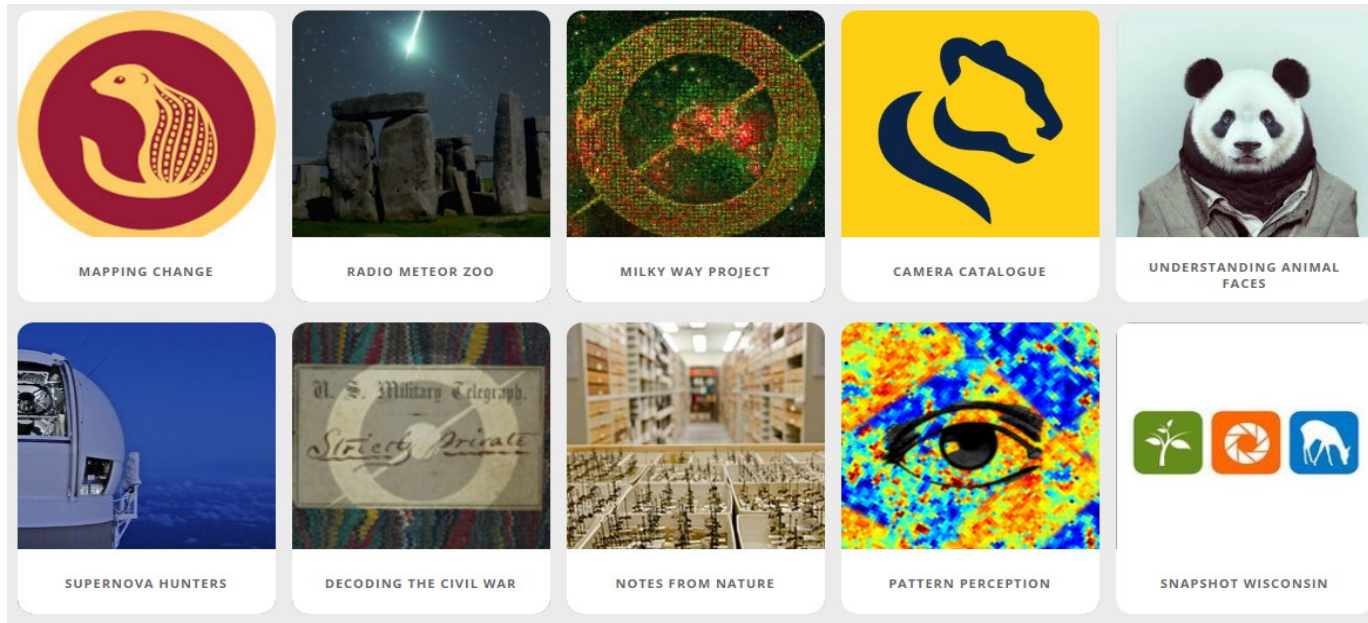
NEW YORK UNIVERSITY



<https://indico.cern.ch/event/505613/contributions/2227692/>

The Zooniverse and Citizen Science

- Citizen Science allows people to *participate* in scientific studies
- [Zooniverse.org](https://www.zooniverse.org) series of web-based projects makes it *easy* to join in



48 projects so far

Millions of participants

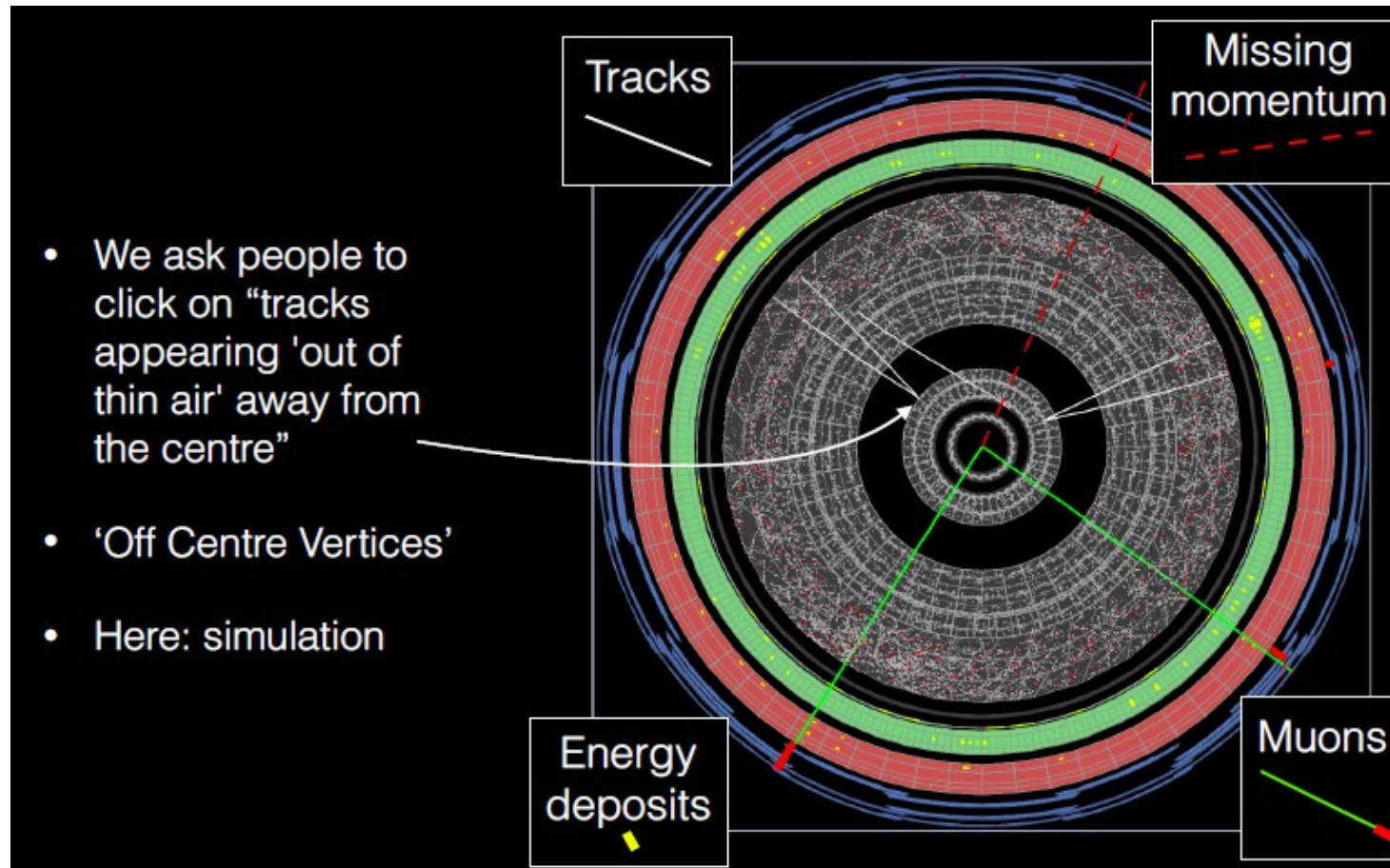
Hundreds of publications

- Being *hands-on* allows participants to understand *interesting details* of how the science works
- Participants give back by *contributing* to the scientific study, helping to make *real discoveries*

How do we make this model work for ATLAS?

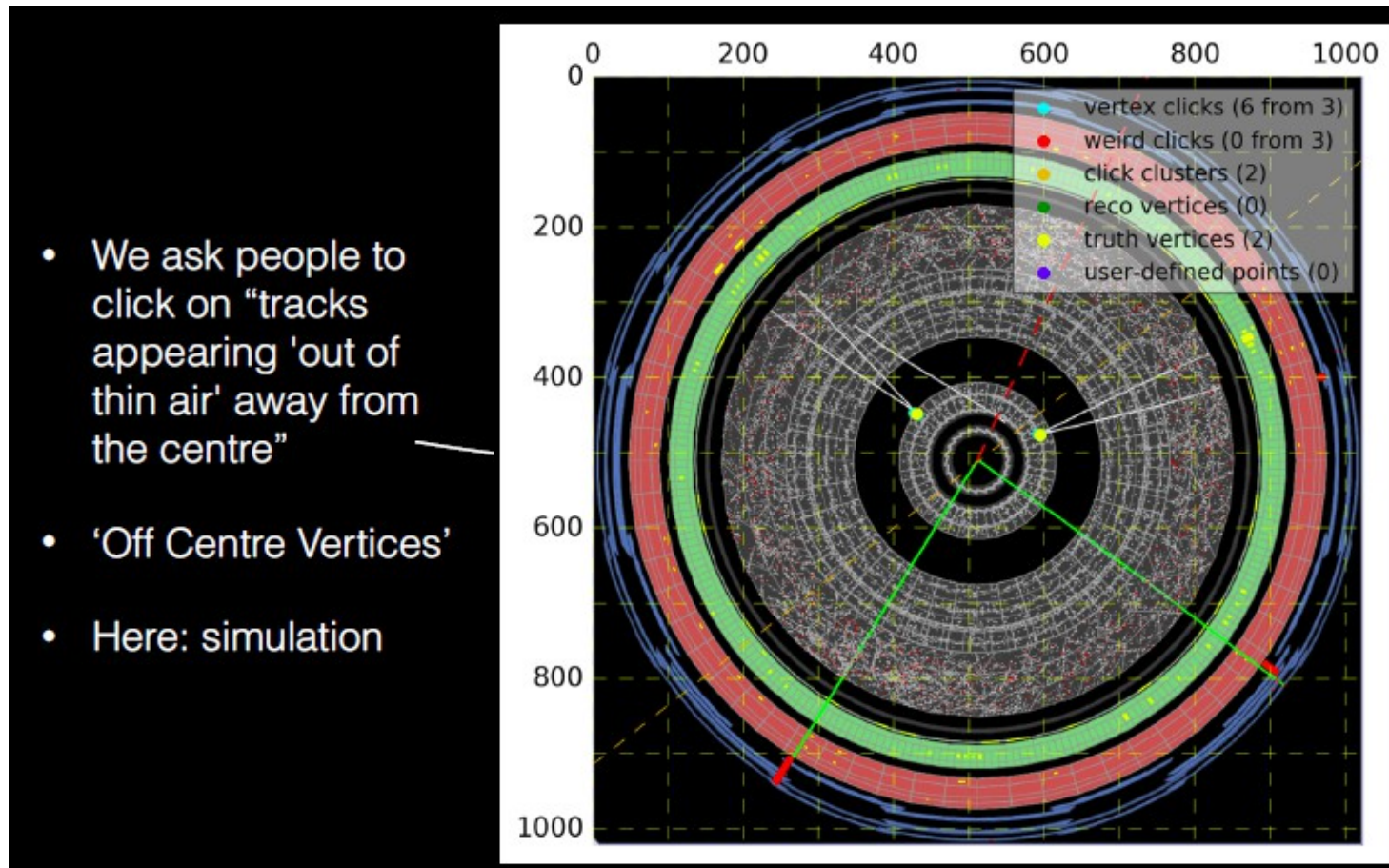
HiggsHunters

- Project must be interesting, with real scientific goals, but also fun and easy to understand!
- We made it *visual* and *interactive* using clickable event displays
- Can people help us find new long-lived particles we may have missed?



HiggsHunters

- Project must be interesting, with real scientific goals, but also fun and easy to understand!
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Users click image locations with:

- vertices
(2,3,4,5-10,10+ tracks)
- “something weird”

We get back meta-data monthly with this info

Compare to truth info coordinates of vertices (for simulated events)

Real Science

- Select **ATLAS data events** enriched in Higgs decays
- Look for new displaced vertices, or something unexpected
- Test participant efficiency on MC signal samples

- $Z \rightarrow \mu\mu$ trigger, $p_{T\mu} > 20$, $|\eta\mu| < 2.5$, $\Sigma p_{T\mu} > 60$, $E_T^{\text{miss}} > 40$, $|m_{\mu\mu} - 90| < 20$

- Expect ~ 60 Zh events from 60,000 data events (full 2012)

- 'Trained' on simulations with 9 α parameter sets, ~ 3000 per set

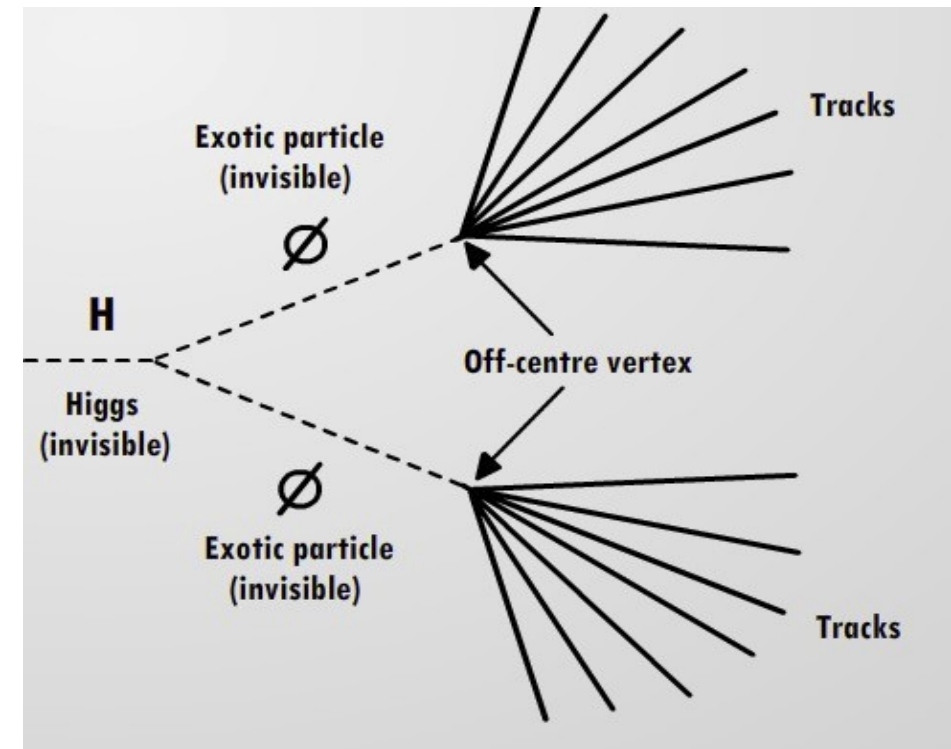
- mass = 8, 20, 50 GeV
 - decays to $\tau\tau$, $b\bar{b}$, $b\bar{b}$
- $c\tau = 1, 10, 100$ mm

arXiv.org > hep-ph > arXiv:hep-ph/0605193

High Energy Physics - Phenomenology

Discovering the Higgs Through Highly-Displaced Vertices

Matthew J. Strassler, Kathryn M. Zurek (U.Washington)

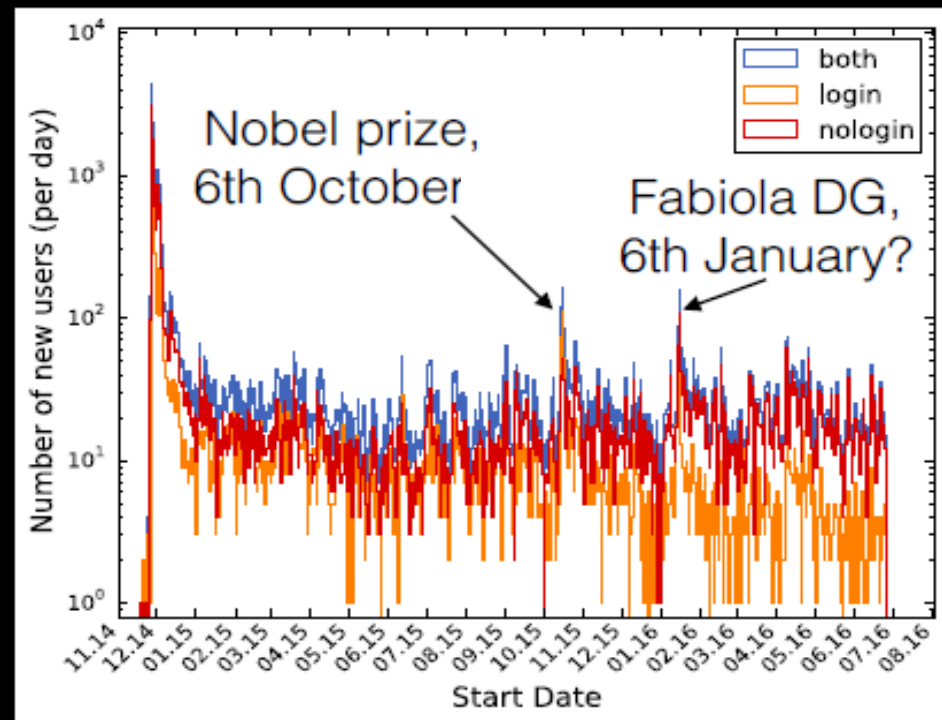


Like a standard search for exotics particles, except using crowd-sourced human eyes, rather than computer algorithms!

HiggsHunters Numbers

- Launched in November, 2014
- More than 30,000 participants so far, from 179 countries
- About 85,000 available images
- Nearly 700,000 images viewed and 1.2 million clicks so far (each event is viewed multiple times, and the clicks are clustered...)

- Large initial peak, lower level sustained interest thereafter
 - Now: ~10-20 new people and ~200 images per day
- 230,000 page views longer than one minute
- Not shown: recent spike in clicks (not signups) thanks to survey



Supporting Resources

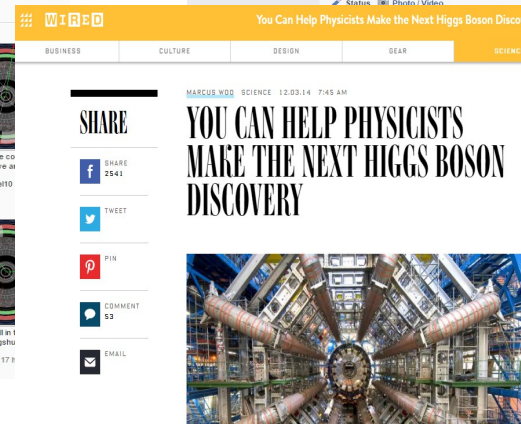
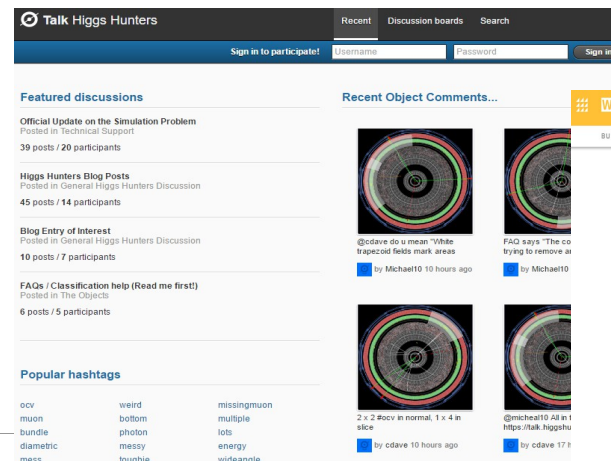
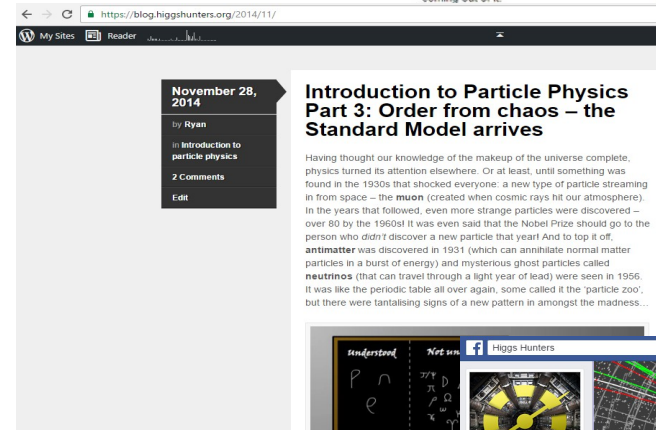
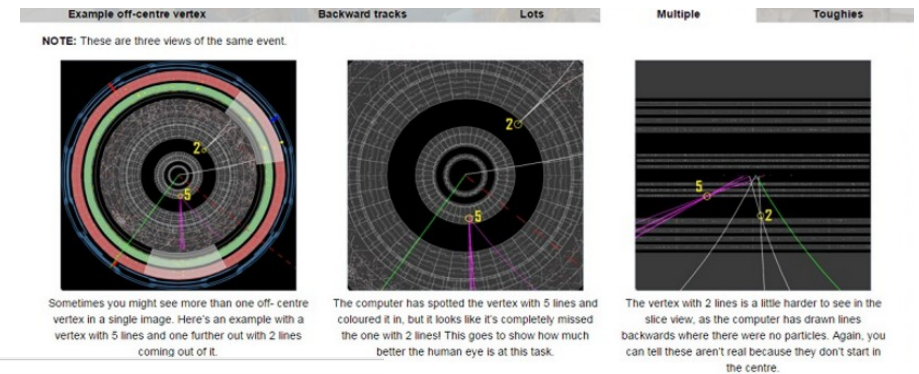
- Introductory tutorials and *videos* about the LHC, HEP, ATLAS, and the HiggsHunters science

- Blog with posts from ATLAS researchers

- Twitter, Facebook, ...

- Talk forums where users post and discuss #images with other users and ATLAS experts

- Good media coverage



People vs. Algorithms

Analysis still ongoing, but some preliminary findings...

		Rzzoom	XY	Xyzoom			Rzzoom	XY	Xyzoom
people algorithm	20 100	32	79	80	20 100		0	1	1
		290	250	239			0	1	1
	10	181	259	343	10		0	1	1
		870	589	504			0	1	1
	1	118	144	148	1		0	0	0
		821	877	738			0	0	0
	50 100	43	77	84	50 100		0	1	1
		417	306	284			0	1	1
	10	94	116	167	10		0	0	0
		1059	926	737			0	0	0
	1	56	60	60	1		0	0	0
		979	1023	956			0	0	0
	8 100	10	58	62	8 100		0	2	2
		42	33	31			0	2	2
	10	133	386	448	10		1	1	2
		342	523	216			1	1	2
	1	91	115	160	1		1	1	2
		175	169	131			1	1	2

people /
algo <
0.25 :-)

people /
algo >
0.25

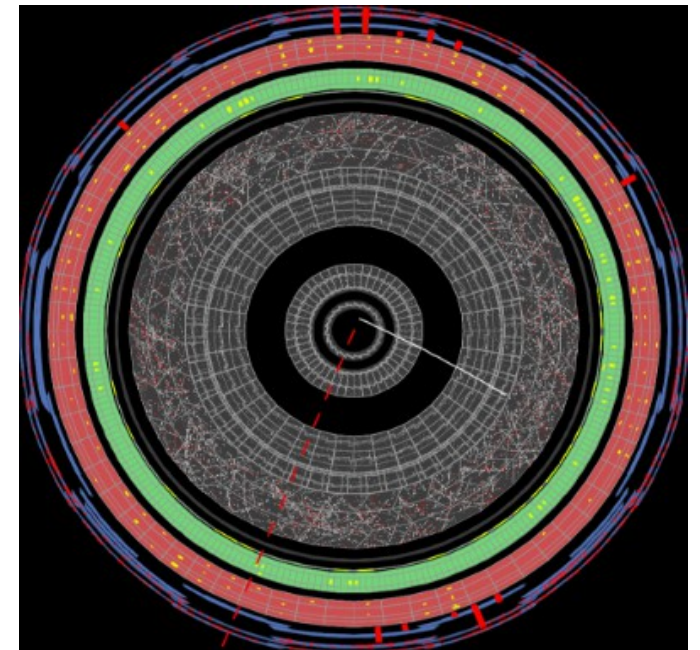
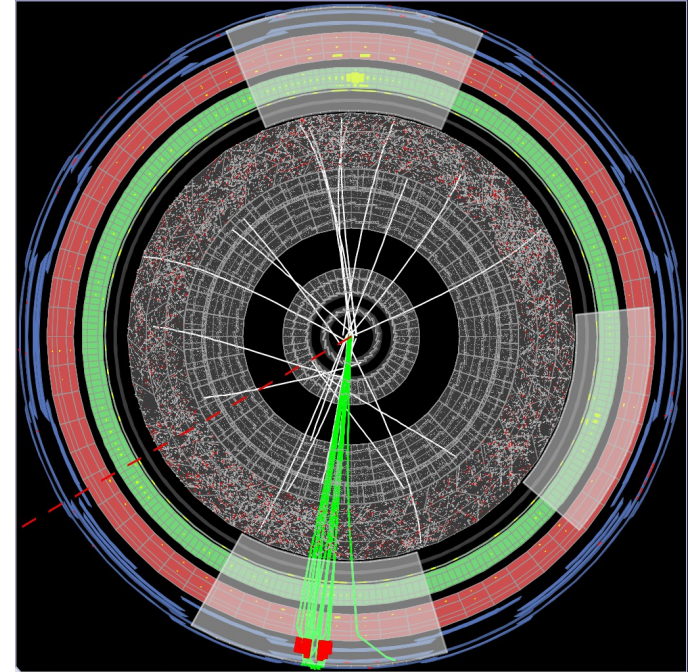
people
better :-)

People do beat the algorithms in some cases!

Depends on the event view presented, and the signal model ...
(algorithm was tuned for higher-mass vertices)

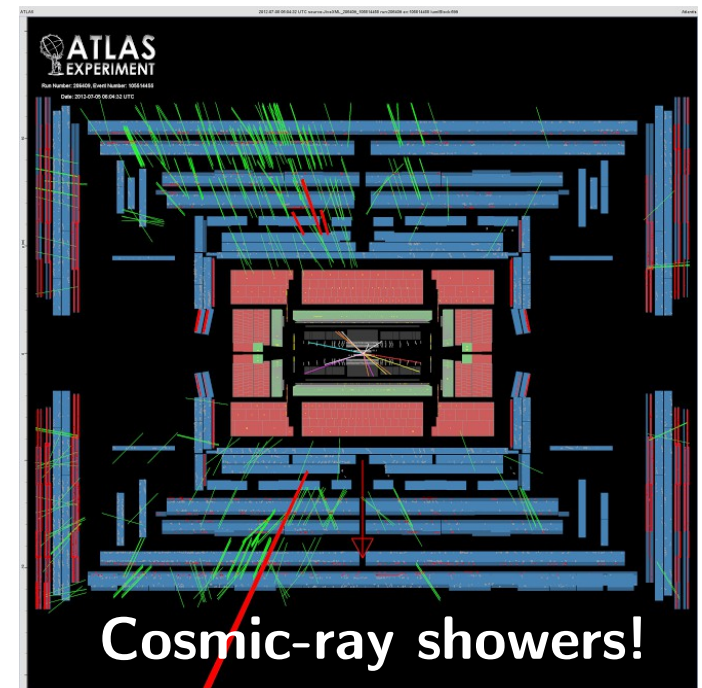
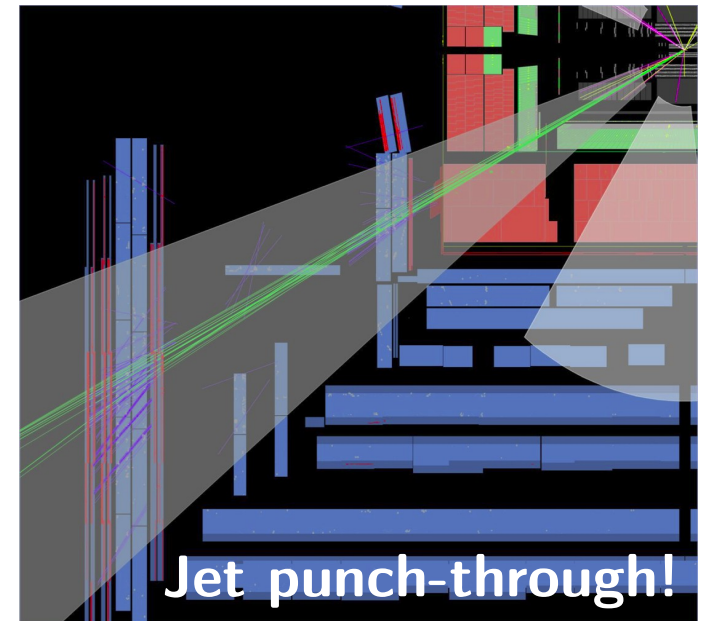
Some Weird Stuff

- People were also *very* good at discovering weird and unexpected stuff in the data
- #muonbundle tagged 397 times on the talk forums
- #weird was tagged 963 times



Some Weird Stuff

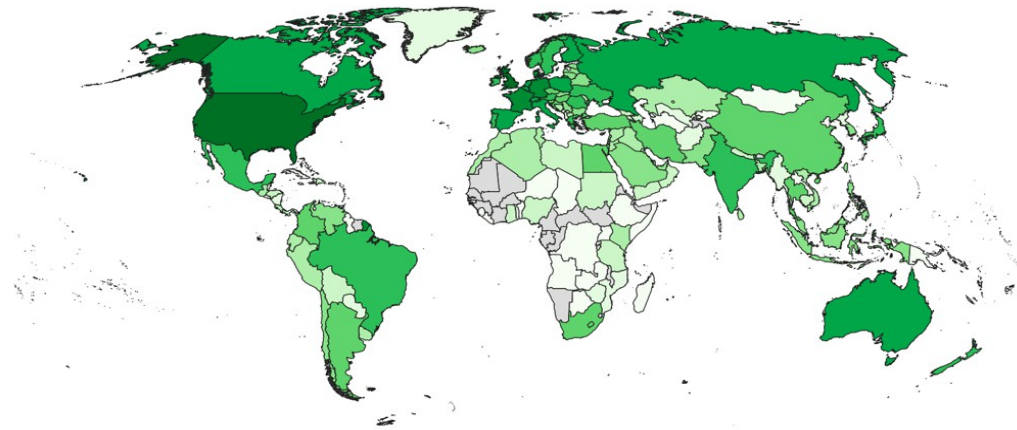
- People were also *very* good at discovering weird and unexpected stuff in the data
- #muonbundle tagged 397 times on the talk forums
- #weird was tagged 963 times
- **Several cases were followed up by ATLAS experts and explained in talk forums and blog posts**
- Encouraging to see that users would have spotted some striking new phenomena we hadn't designed an algorithm to see!
- They really enjoyed the excitement of possibly finding something new!



Demographics and Surveys

- Large spread of ages
- 1/3 female
- 75% with a college degree, but most had no physics beyond high-school
- 80% had done other Zooniverse projects

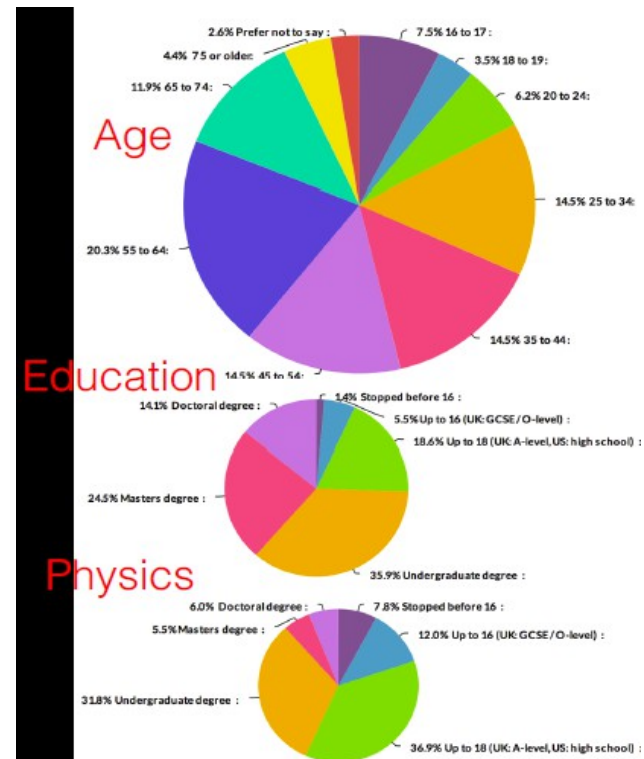
Number of sessions from each country



12. As a result of the HiggsHunters project, have you done any of the following? (Please tick all that apply)

Read or watched more about science	56%		135
Studied science more formally	18%		44
Carried out your own research	12%		28
Attended lectures or similar events	11%		27
Attended science fairs or similar events	9%		21
Visited museums	11%		26

Almost 50% are more likely to study physics - "This actually started to get me into Particle Physics and now I am considering studying it in college", "I was in the PhD already, but this makes me wanna keep going"

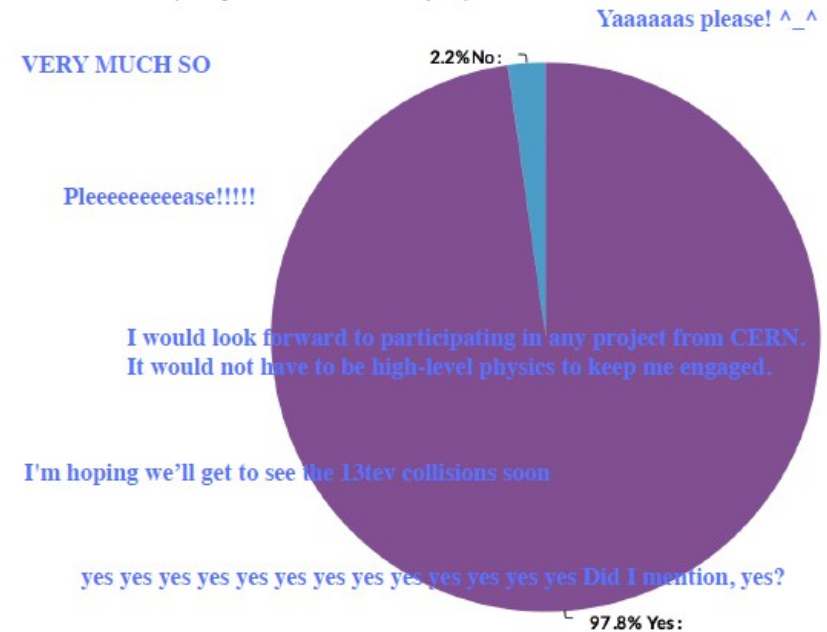


Summary and Future Plans

- Zooniverse and HiggsHunters have successfully engaged the public in ATLAS science!
- New users still joining daily, we're still analyzing clicks
- Overwhelming support for a future LHC Zooniverse project
- Increasing partnerships with schools and HiggsHunters
 - IRIS project has students *analyzing* HiggsHunters user clicks



29. Would you be interested in taking part in another Zooniverse project on CERN physics?



Prof. Higgs helps launch HiggsHunters in Edinburgh schools!