


O'REILLY®

# Strata

CONFERENCE

Making Data Work

 11–13 Nov 2013

 LONDON, ENGLAND

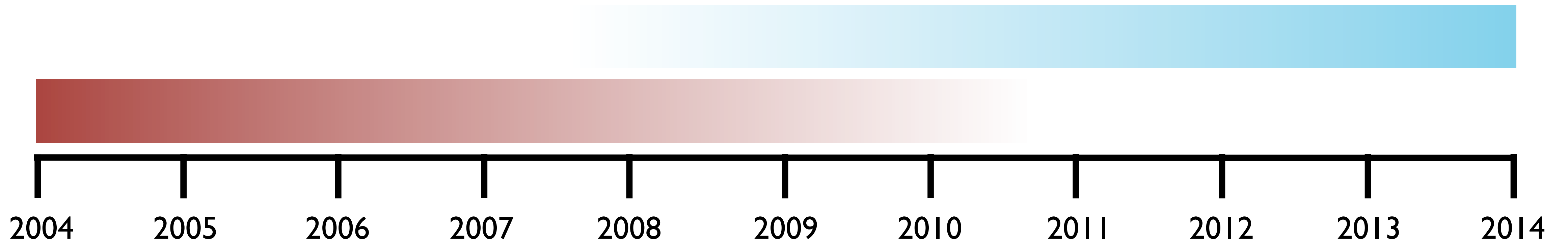
#strataconf  
[strataconf.com/london](http://strataconf.com/london)

# A Physics Approach to “Big Data”

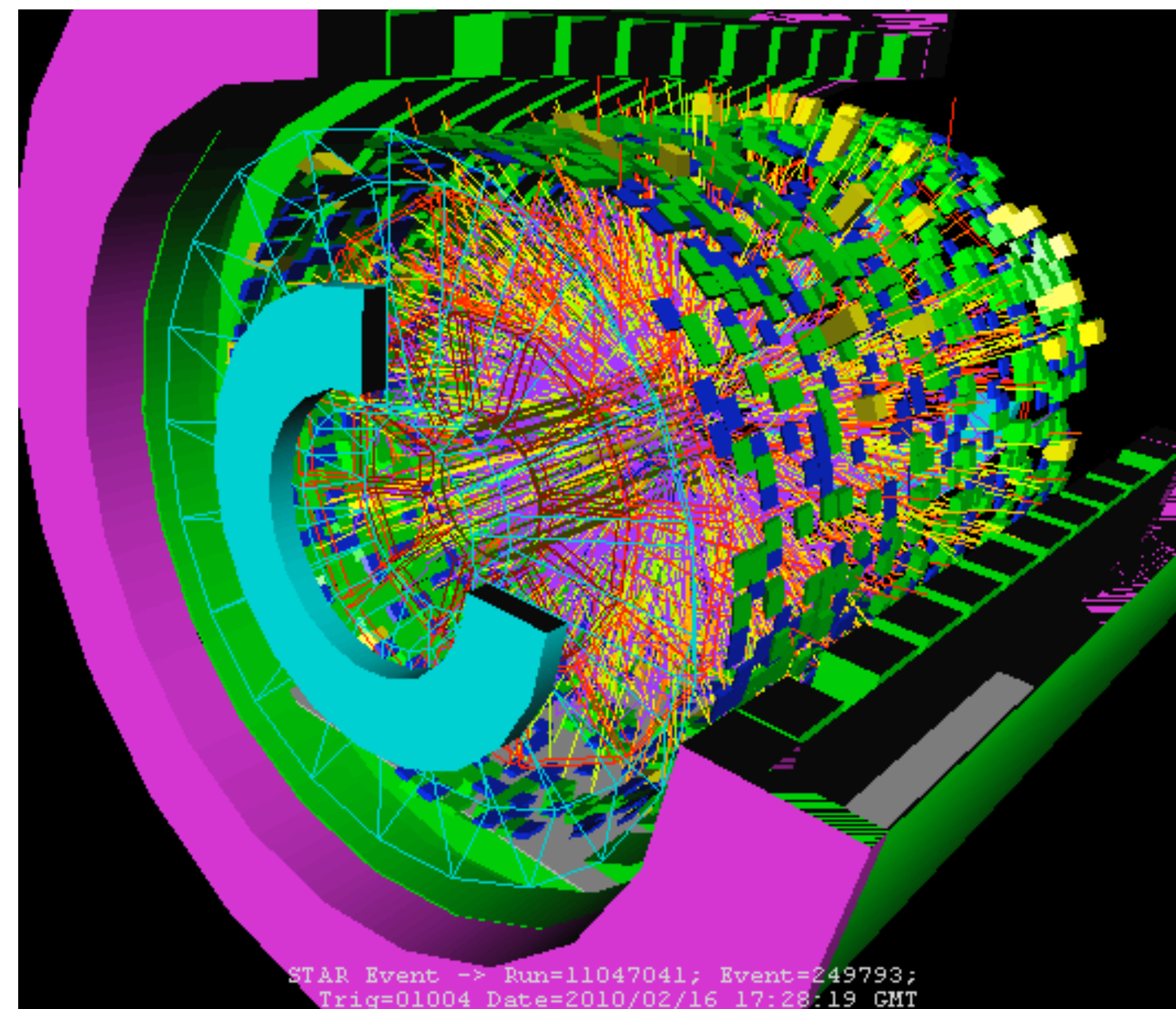
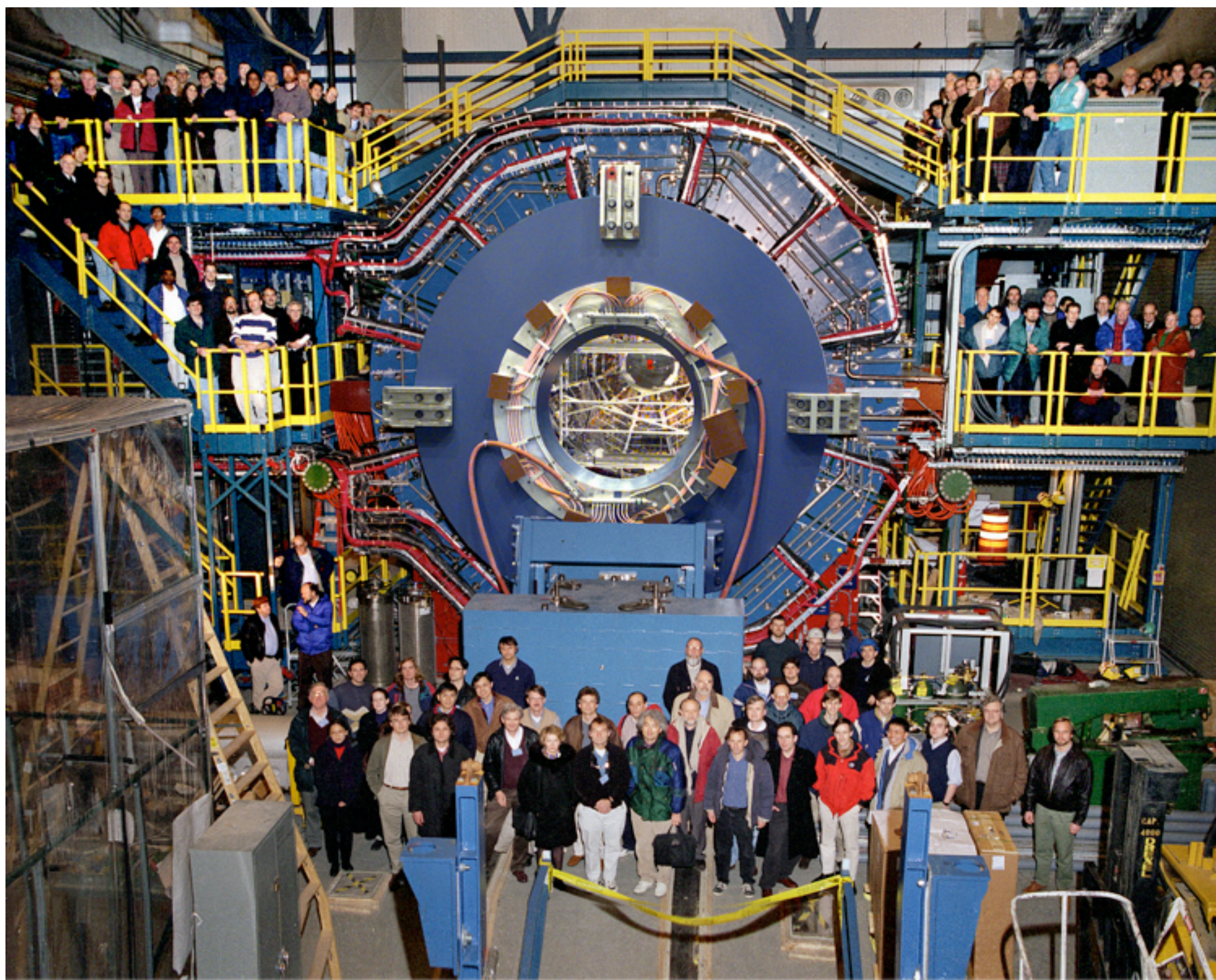
Adam Kocoloski, PhD  
CTO  
Cloudant



**Cloudbant**



# Solenoidal Tracker at RHIC (STAR)



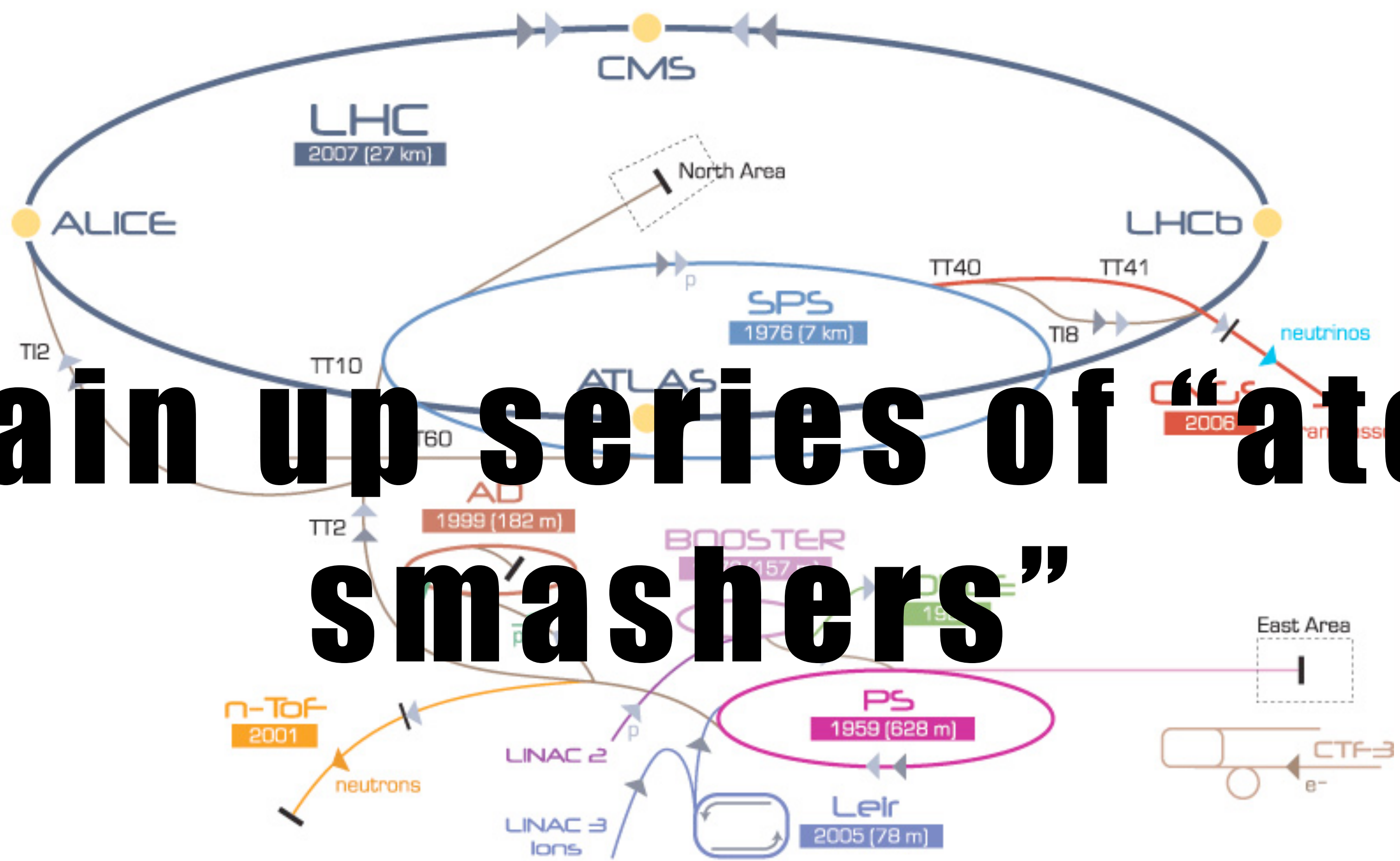
# The life of LHC data

- **Detected by experiment**
- “Online” filtering (hardware and software)
- Transferred to CERN main campus, archived & reconstructed
- Transferred to T1 sites, archived, reconstructed & skimmed
- Transferred to T2 sites, reconstructed, skimmed, filtered & analysed
- Written into locally analyzable files, put on laptops
- Turned into a plot in a paper

An aerial photograph of a rural landscape, showing a patchwork of green and brown fields, small clusters of buildings, and a winding road. A large, semi-transparent red circle is overlaid on the image, with several smaller red circles at its top and bottom points. The text "Dig big tunnels" is centered in the middle of the image in a bold, white, sans-serif font.

# Dig big tunnels

# CERN Accelerator Complex



**Chain up series of “atom smashers”**

▶ p [proton] ▶ ion ▶ neutrons ▶  $\bar{p}$  [antiproton] ▶ ++▶ proton/antiproton conversion ▶ neutrinos ▶ electron

LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron  
 AD Antiproton Decelerator CTF3 Clic Test Facility CNGS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice  
 LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight

**Put sensitive cameras in  
awkward places**





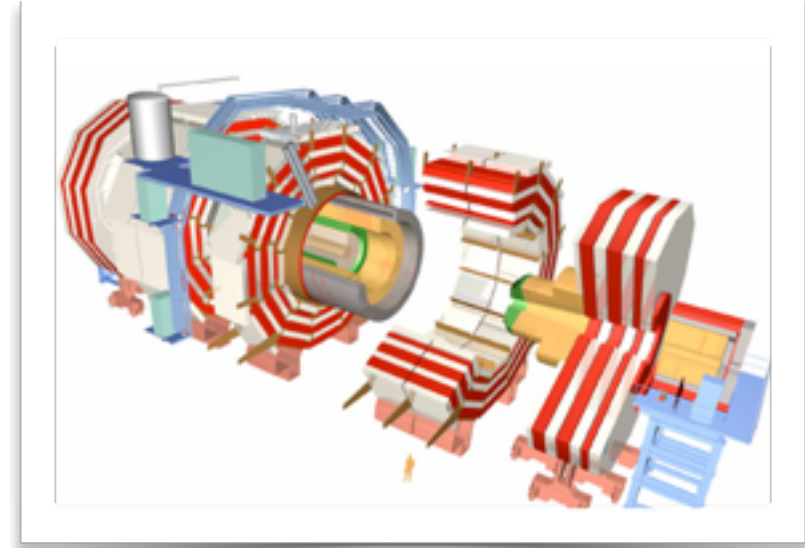
# Record events



# The life of LHC data

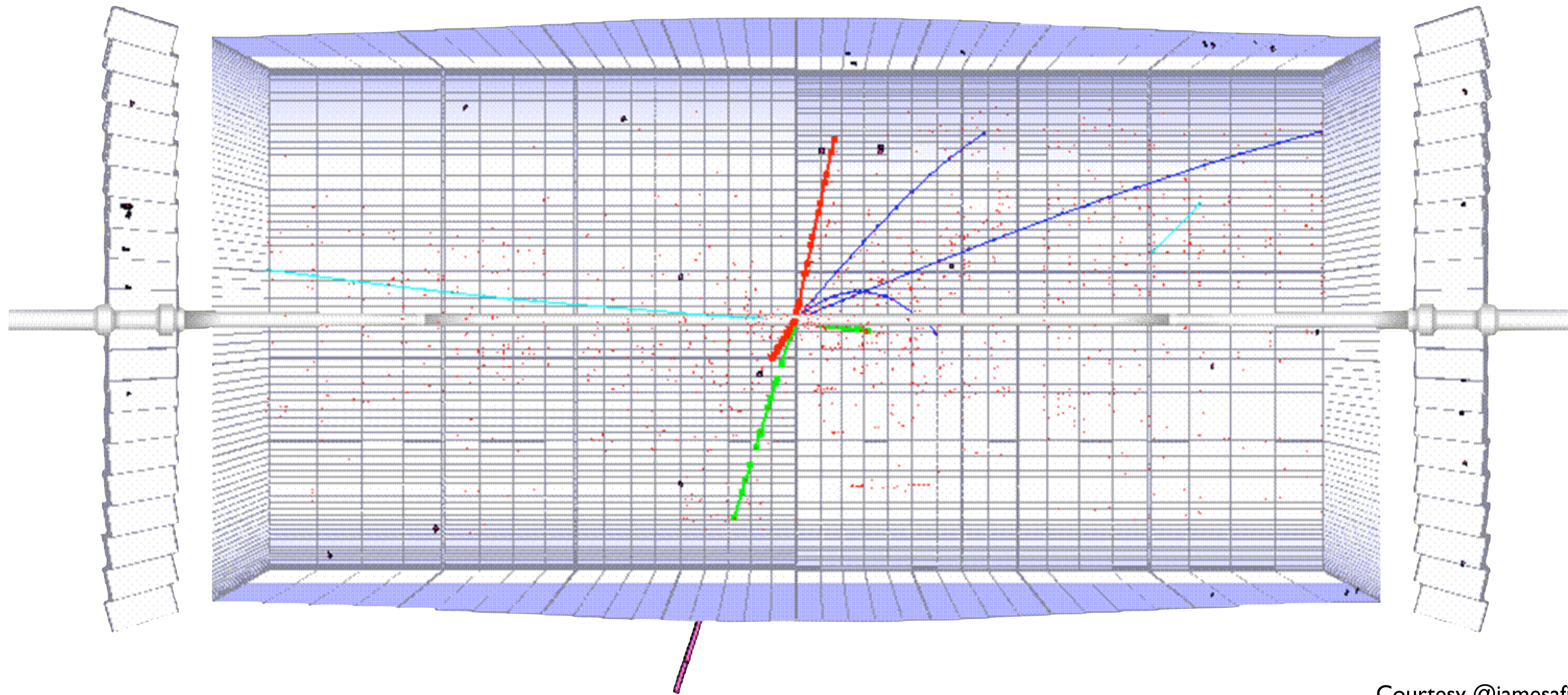
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# CMS Data Flow



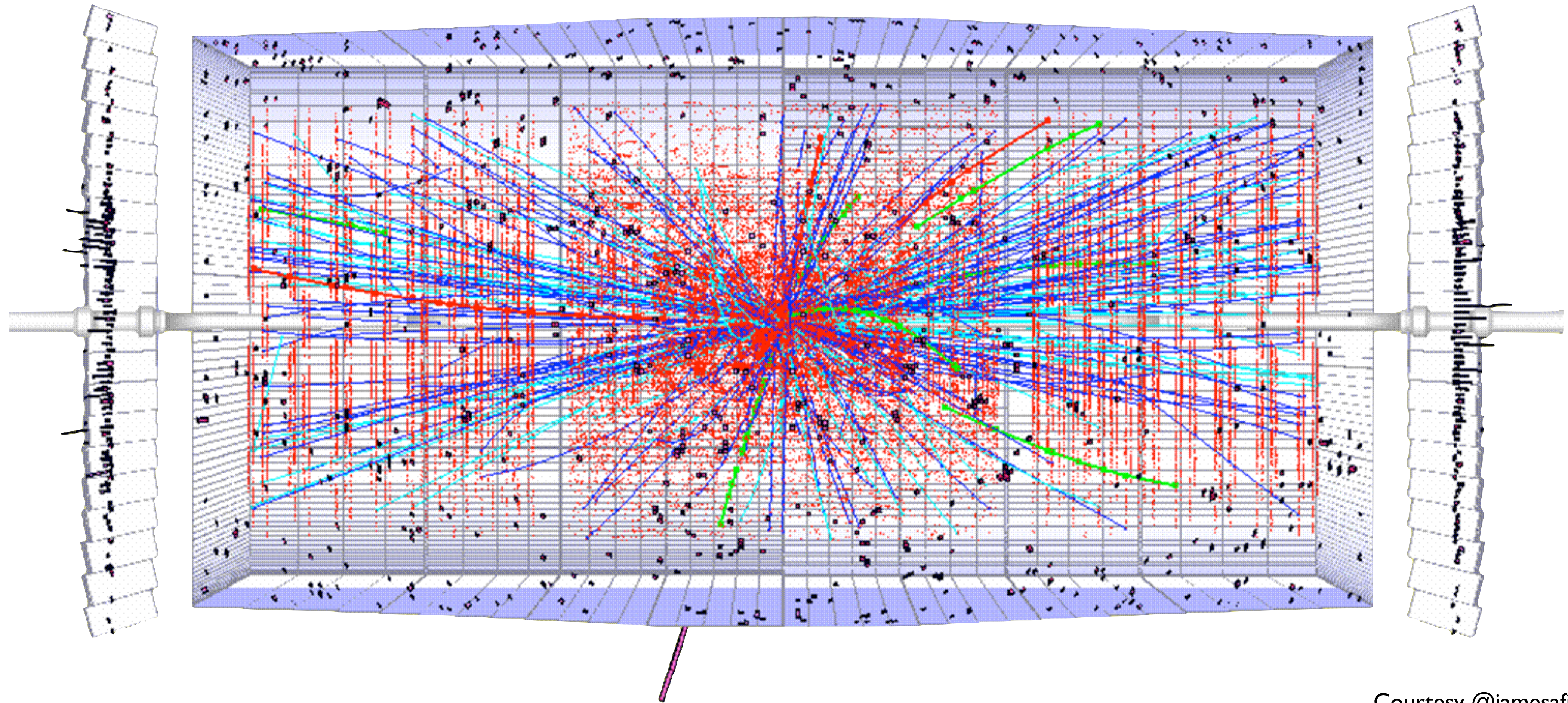
**We have a big digital camera**

# It takes photos of this



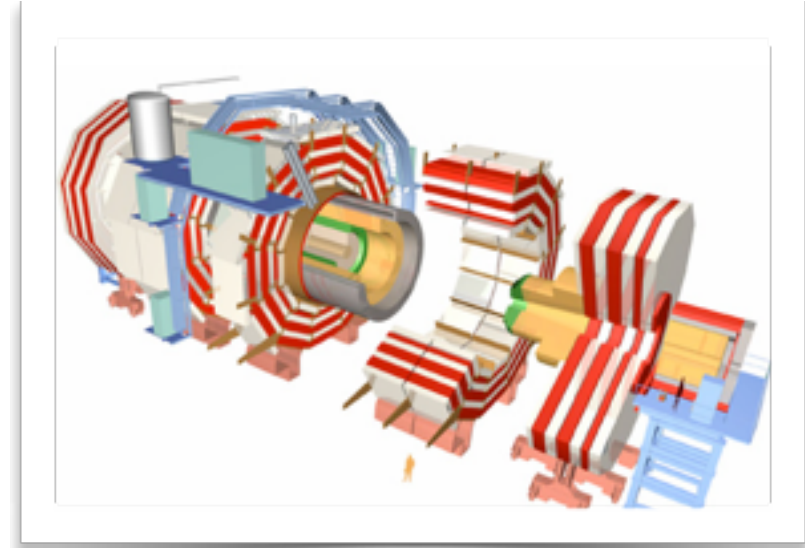
Courtesy @jamesafackson

# Which come out looking like this



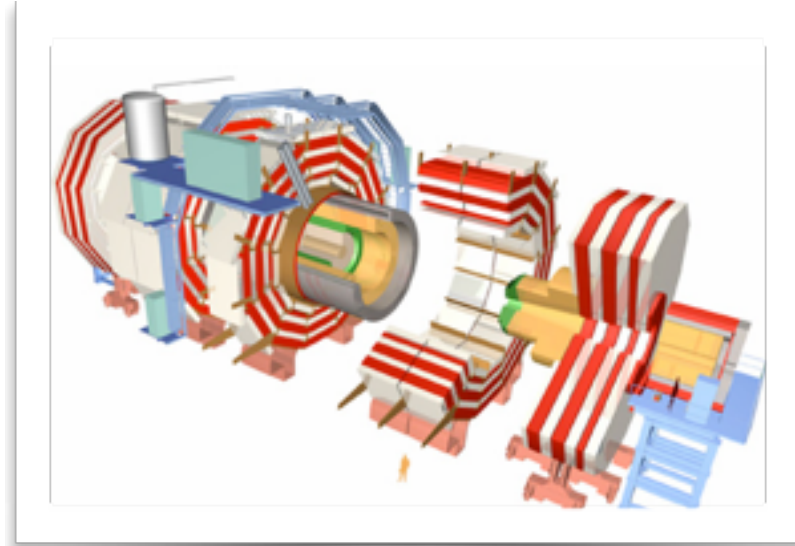
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# CMS Data Flow



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# CMS Data Flow

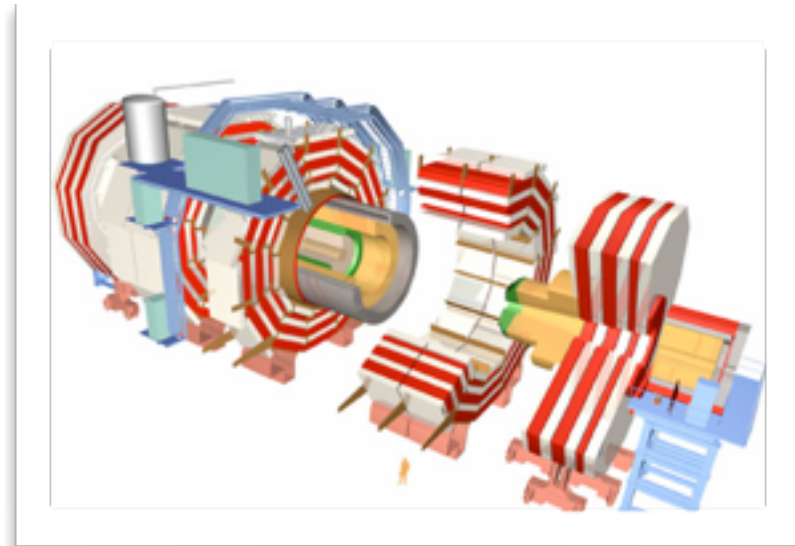


**We have a big digital camera**



**Which goes into lots of computers (HLT)**

# CMS Data Flow



**We have a big digital camera**

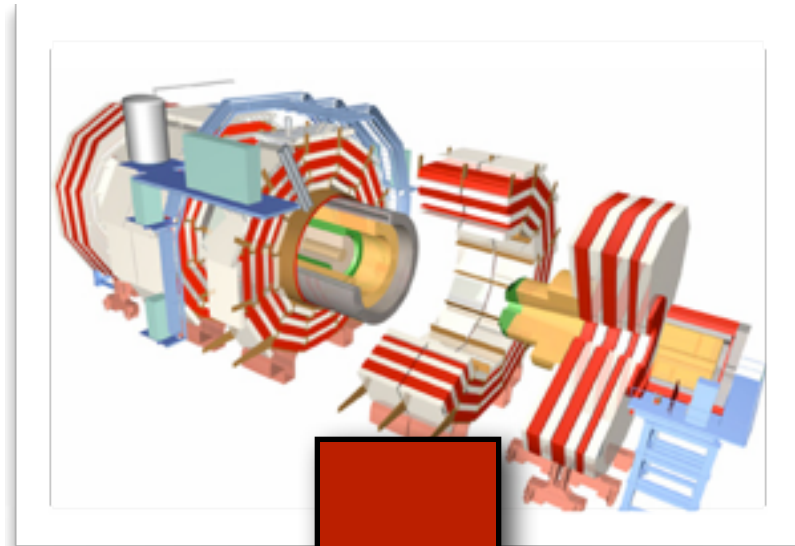


**Which goes into lots of computers (HLT)**



**And then into lots of disk (Storage Manager)**

# CMS Data Flow



**We have a big digital camera**

*~200 GB/s*



**Which goes into lots of computers (HLT)**

*~2 GB/s*



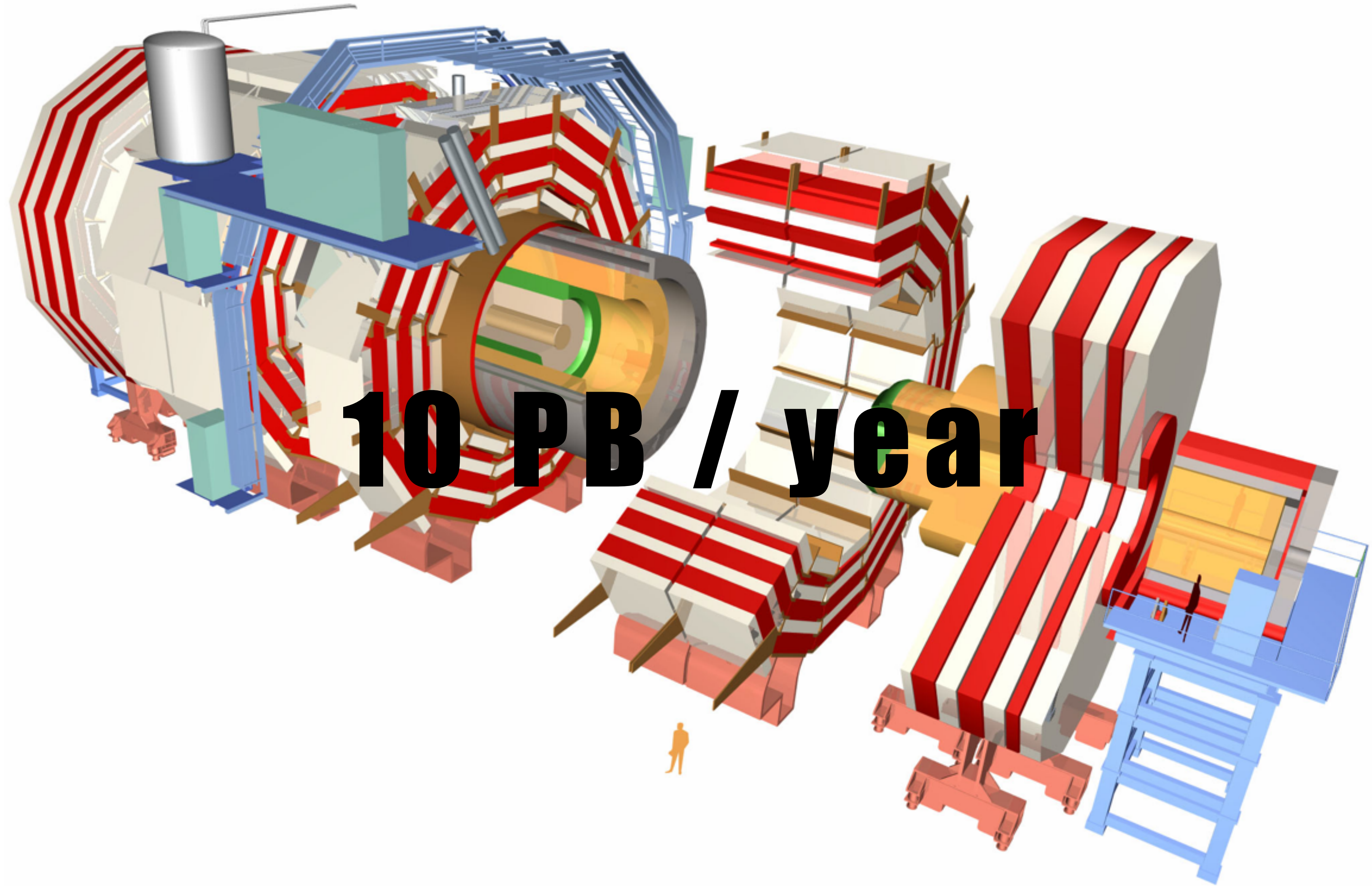
**And then into lots of disk (Storage Manager)**



**Throw away data ASAP**

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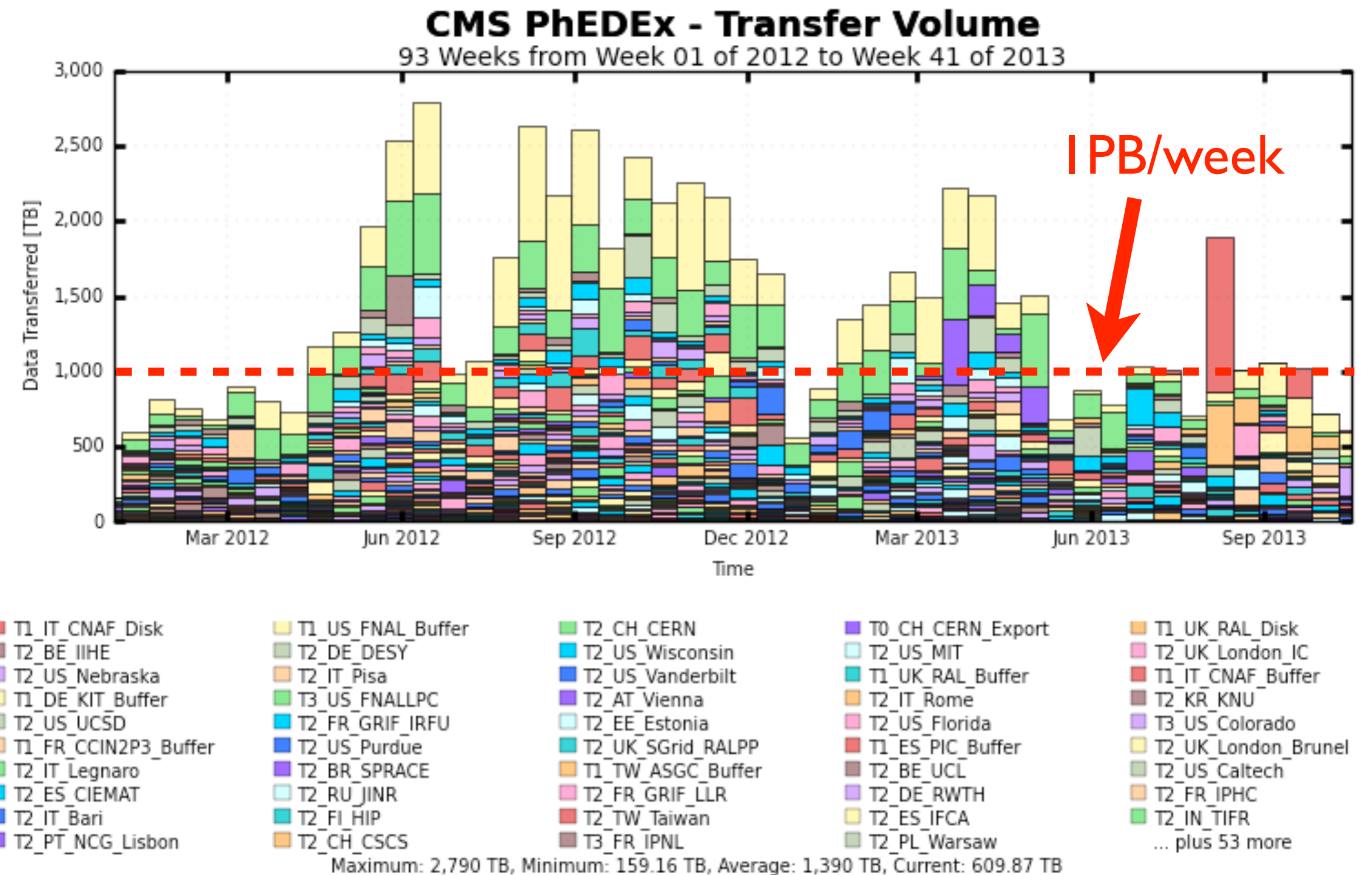
**10 PB / year**

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# Tiers

- Maybe a bit different
- Many (>100) sites with 100's TB storage, 10000's worker nodes
- Why so many? Politics, power budget, cost

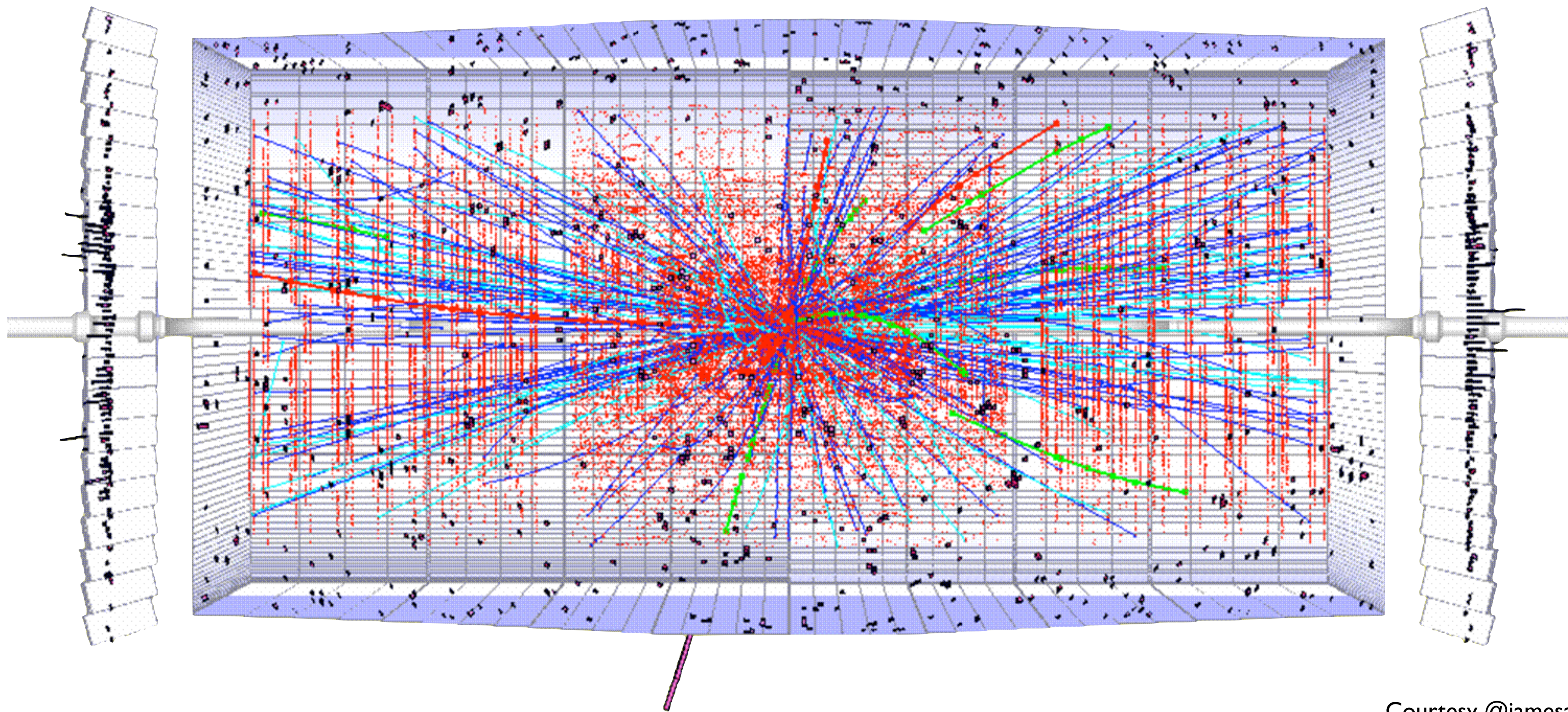


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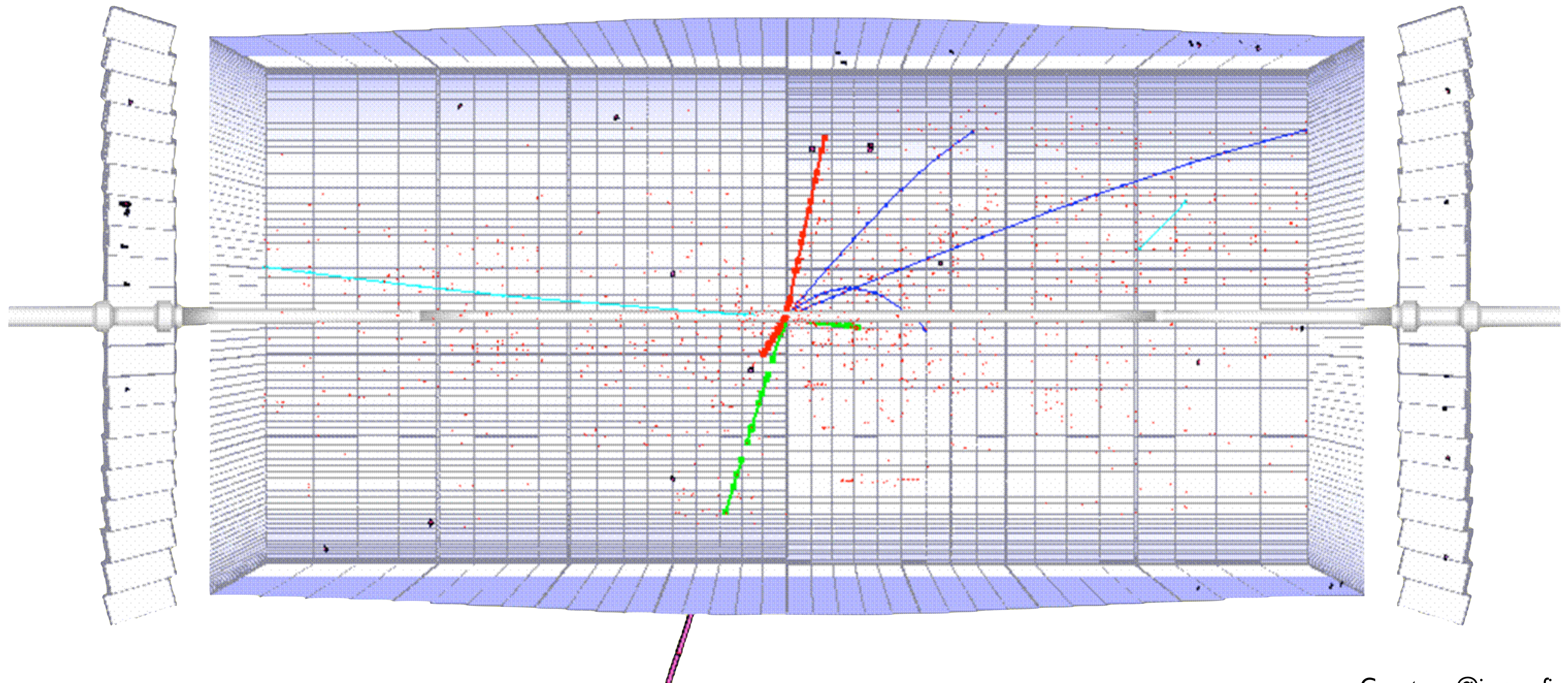
# Analysis Workflow

- Each analysis is ~unique
- Query language is C++
- Runs on distributed and local resources
- Myriad “cut” selections to identify interesting events
- Data in final plot substantially reduced from the original dataset



Courtesy @jamesafjackson

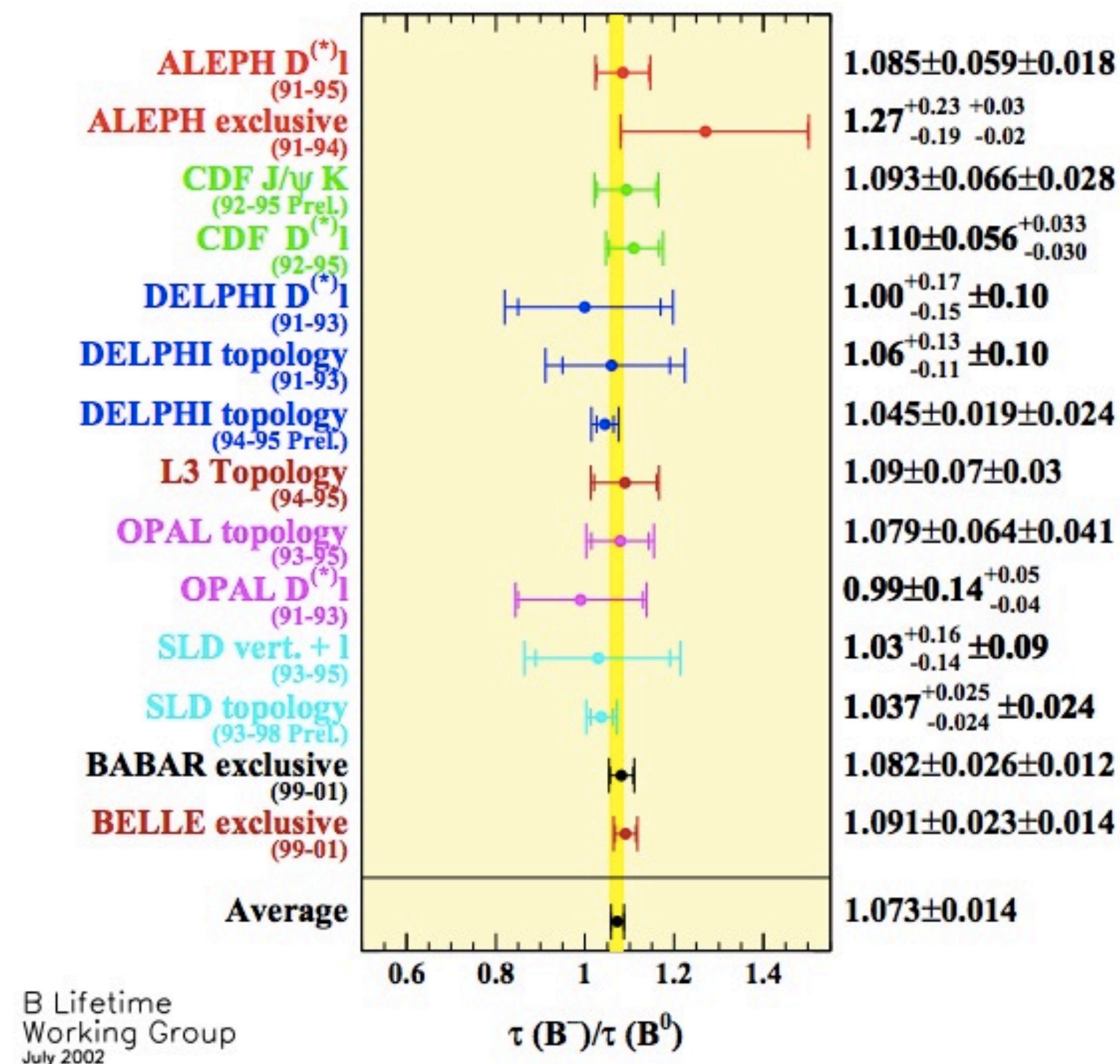
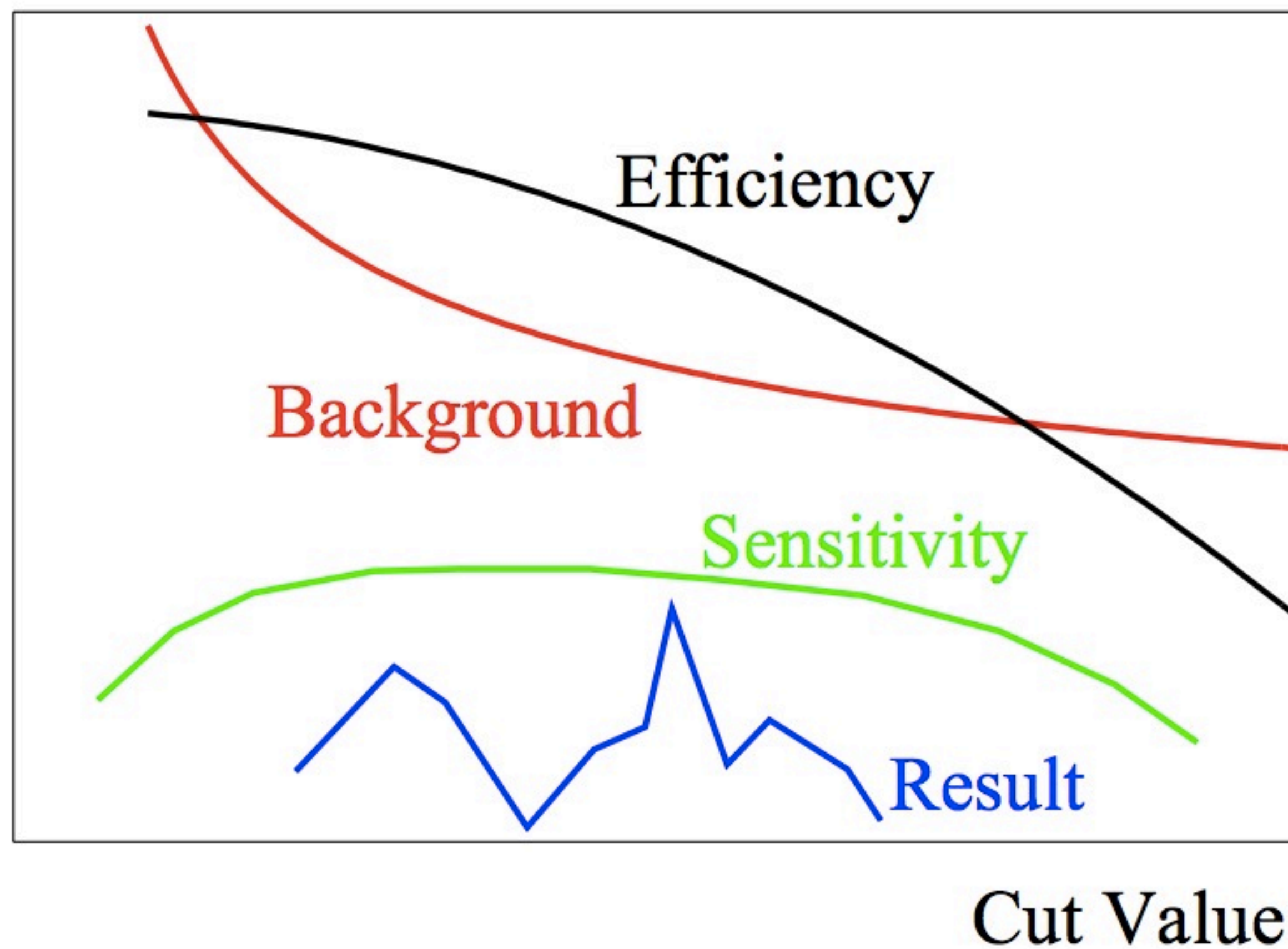




Courtesy @jamesafackson

**Multivariate analyses extract signals that are impossible to find via “hand-drawn” cuts**

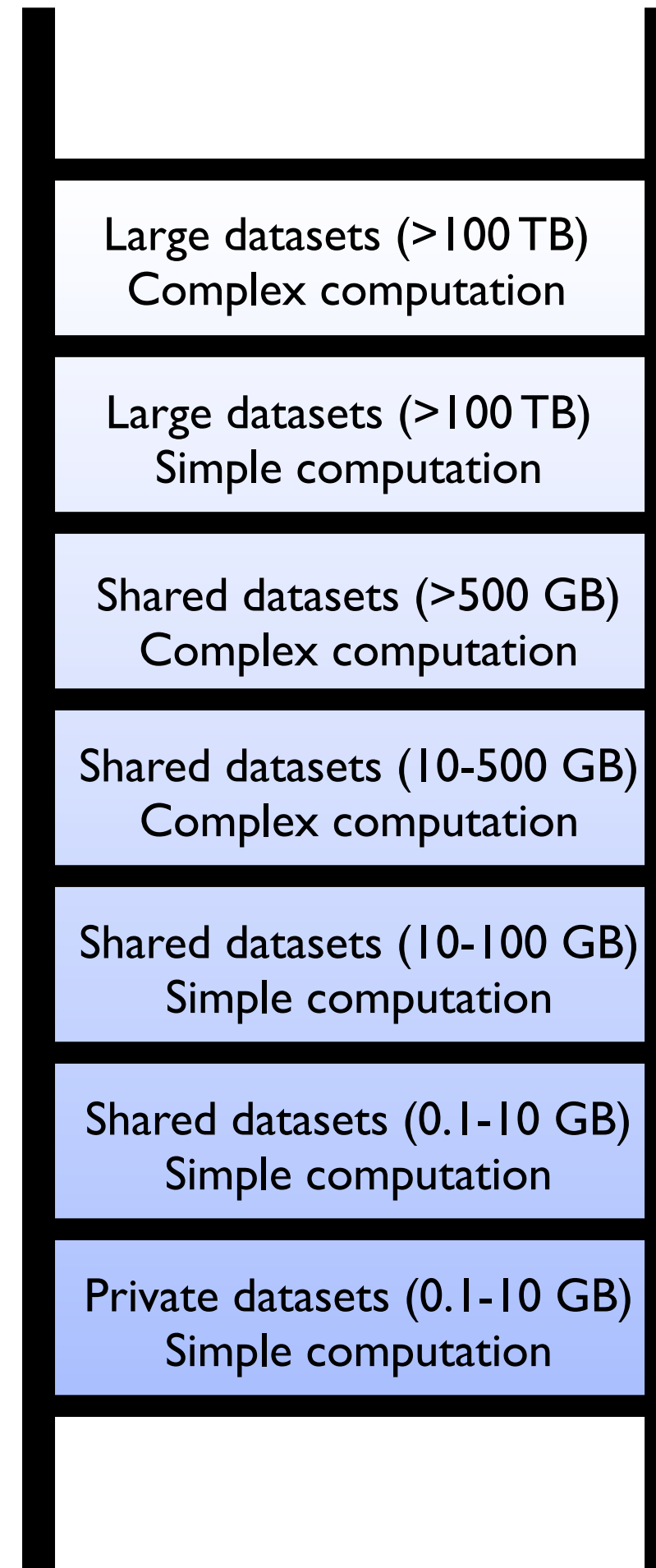
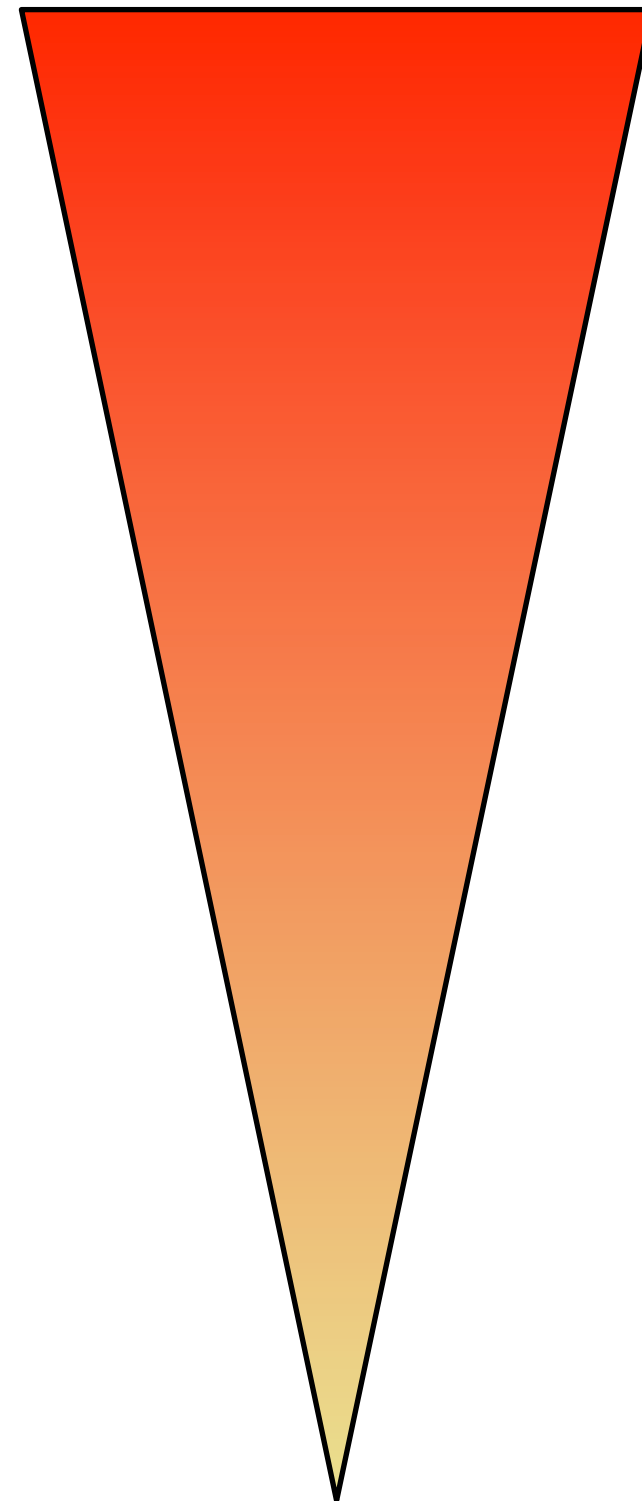
**Humans find signals even when none exist**



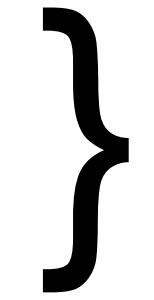
<http://www.slac.stanford.edu/econf/C030908/papers/TUIT001.pdf>

# Workflow Ladder

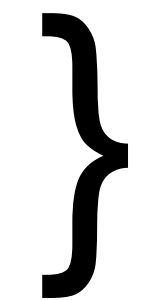
Number of users



**Use Grid compute and storage exclusively**



**Work on departmental resources,  
store resulting datasets to Grid storage**



**Work on laptop/desktop machine,  
store resulting datasets to Grid storage**

**Collaborative “skimming” remains valuable**

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- And that's a good thing
- Keep only the data you can analyze
- Remember that we're biased to find patterns, and lots of data means lots of patterns
- Multivariate analyses win in the end
- Skim datasets for fun and profit

# Thanks!

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