10th Network Meeting, March 31st - Apr 2nd 2014, CERN

Welcome + Activities at CERN

Peter Skands (CERN)

PRACTICAL INFOS

Coffee Breaks: in TH Common Room (downstairs, across from the secretariat)

Lunch Breaks: on your own (e.g. in R1)

Laptops: open browser → fill form → contact = Peter Skands (PH-TH)

Discussion session on Shower / MC Uncertainties:

Tuesday from 13-15 in *TH Common Room*

Dinner Tuesday Evening: Restaurant de l'Aviation (tram stop Blandonnet)

If you did not register for the dinner but would like to attend, ***contact me!***

LHC Physics Center at CERN

MCnet at CERN

Fellows
Simon Badger (NJETS)
Rikkert Frederix (aMC@NLO)
Benjamin Fuks (FEYNRULES, MADANALYSIS)
Anton Karneyeu (CMS, MCPLOTS)
Hendrik Mantler (SUSHI, VINCIA)
Andreas Papaefsthathiou (HERWIG++)
Juan Rojo (NNPDF)
Korinna Zapp (JEWEL, SHERPA)

Staff
Stefano Frixione (MC@NLO)
Michelangelo Mangano (ALPGEN, LPCC, …)
Gavin Salam (FASTJET, CAESAR)
Peter Skands (MCPLOTS, PYTHIA, VINCIA)
Giulia Zanderighi (CAESAR, POWHEG, QCDLOOP)

+ Not *just* calculations …

MCnet Shorties
Jesper Christiansen (Lund)
Simone Amoroso (Freiburg)
Emma Kuwertz (KTH Stockholm)

PH-SFT / GENSER
Witek Pokorski
Mikhail Kirsanov
Dmitri Konstantinov

Juan Rojo (CERN & Oxford U)

Parton Distribution Functions (PDFs)

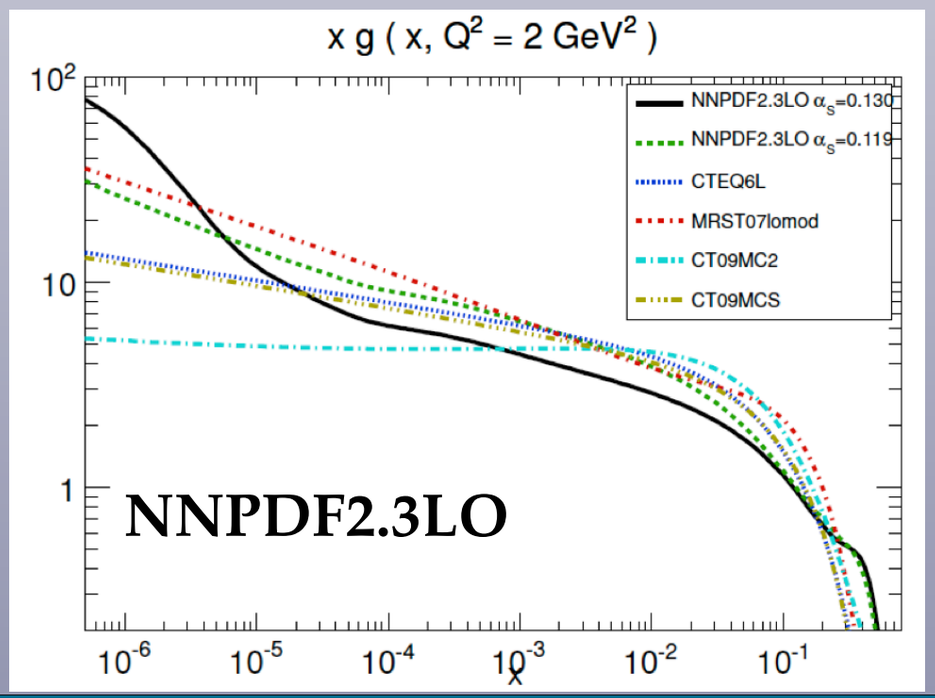
- Accurate PDFs required for Higgs couplings, high-mass BSM production and precision SM observables
- **NNPDF developments**: PDFs with LHC data, PDFs with QED corrections
- LO PDFs: new **Pythia8 Monash 2013 Tune** based on **NNPDF2.3LO** (with P. Skands and S. Carrazza)

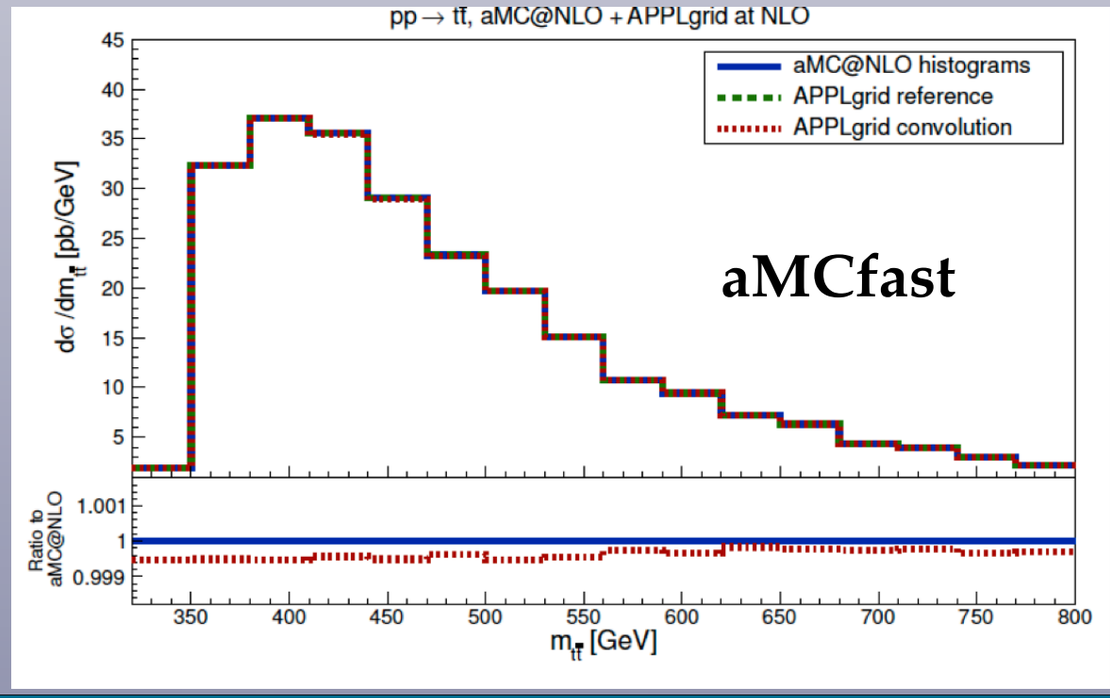
NLO Event Generators

- **aMCfast:** Fast interface to automated NLO and NLO+PS calculations in the **aMCatNLO** framework using **APPLgrid** (with V. Bertone, S. Frixione and R. Frederix, in preparation)
- Allow to include in PDF fits a **much wider range of exclusive observables** that with fixed order calculations
- Develop **PDFs specific for NLO event generators**

Jet Reconstruction and Substructure

- Boosted final states crucial in many relevant SM and Higgs measurements and in BSM searches
- **Scale-invariant resonance tagging**: matching boosted and resolved regimes
- New Physics in **boosted Higgs pair production**





VINCIA (C++ plug-in to PYTHIA 8)

"Interleaved": do everything in one Markov chain

Giele, Kosower, Skands, PRD 84 (2011) 054003

Antenna-based parton shower

With "interleaved" ME corrections

Reinterpret higher-order matrix elements as radiation functions
Subleading singularities → more precise radiation functions
+ helicity and mass dependence

Shower generates phase space

+ Automated uncertainties

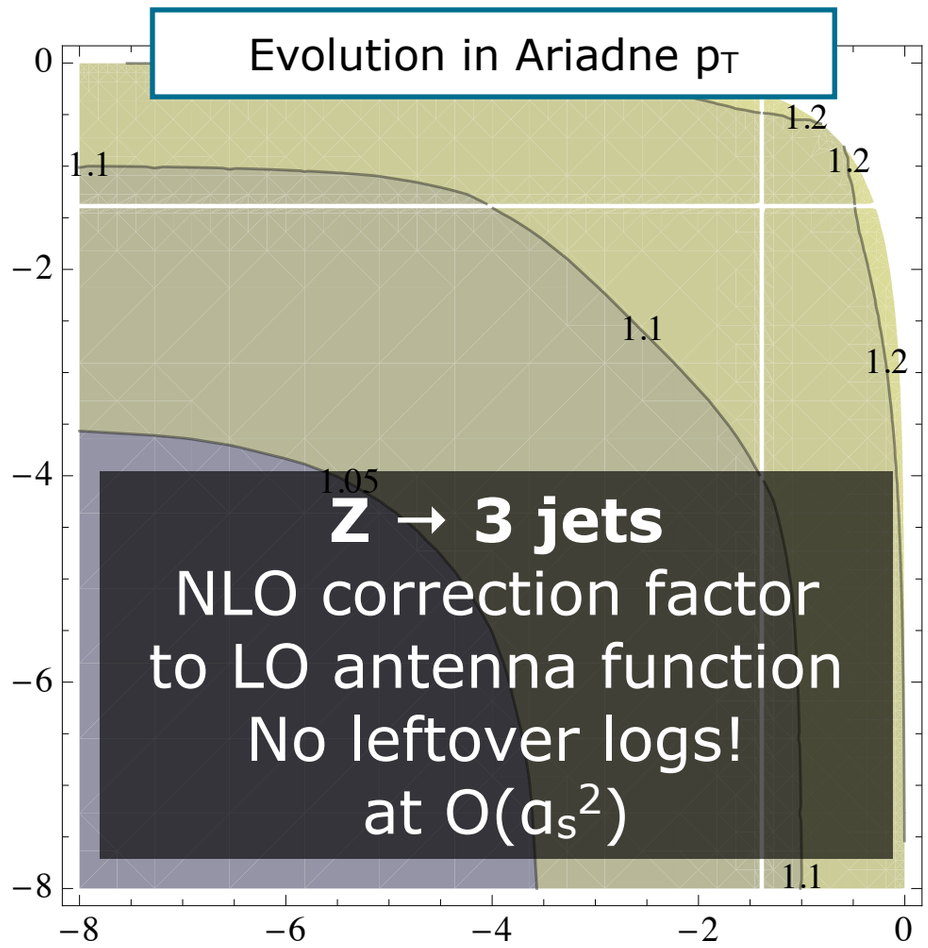
(+ runtime ROOT interface)

Virtues of starting from a fractal

Quasi-scale-invariant: intrinsically multi-scale (resums logs)

Unitary: automatically unweighted (& IR divergences → multiplicities)

Fast: No additional phase-space generators, no σ_{X+n} calculations



$\alpha_S(M_Z) = 0.12$, $\mu_R = p_{Tg}$

Hartgring, Laenen, Skands, JHEP10(2013)127

What does it buy?

Hartgring, Laenen, Skands, arXiv:1303.4974

SPEED

	LO level $Z \to$	NLO level $Z \to$	**Time / Event [milliseconds]**
PYTHIA 8	$2, 3$	2	**0.6**
VINCIA (NLO off)	$2, 3, 4, 5$	2	**2.5**
+ uncertainties	$2, 3, 4, 5$	2	**2.9**
VINCIA (NLO on)	$2, 3, 4, 5$	$2, 3$	**3.9**
+ uncertainties	$2, 3, 4, 5$	$2, 3$	**4.0**

Speed relative to PYTHIA

$\frac{1}{\text{Time}}$ / PYTHIA 8

1 ← pure PYTHIA

$\sim 1/4$, $\sim 1/5$ ↔ incl $Z \to 5_{LO}$

$\sim 1/7$, $\sim 1/7$ ↔ incl $Z \to 3_{NLO}$

+ CONSISTENCY

New VINCIA NLO Tune

$\alpha_s(M_Z)^{CMW} = 0.122$

(with 2-loop running)

LO Tunes

(both VINCIA and PYTHIA)

$\alpha_s(M_Z)^{MSbar} \sim 0.139$

(LO matrix elements give similar values, and also LO PDFs)

$\langle\chi^2\rangle$ **Shapes**	T	C	D	B_W	B_T
PYTHIA 8	0.4	0.4	0.6	0.3	0.2
VINCIA (LO)	0.2	0.4	0.4	0.3	0.3
VINCIA (NLO)	0.2	0.2	0.6	0.3	0.2

$\langle\chi^2\rangle$ **Frag**	N_{ch}	x	Mesons	Baryons
PYTHIA 8	0.8	0.4	0.9	1.2
VINCIA (LO)	0.0	0.5	0.3	0.6
VINCIA (NLO)	0.1	0.7	0.2	0.6

$\langle\chi^2\rangle$ **Jets**	r_{1j}^{exc}	$\ln(y_{12})$	r_{2j}^{exc}	$\ln(y_{23})$	r_{3j}^{exc}	$\ln(y_{34})$	r_{4j}^{exc}	$\ln(y_{45})$	r_{5j}^{exc}	$\ln(y_{56})$	r_{6j}^{inc}
PYTHIA 8	0.1	0.2	0.1	0.2	0.1	0.3	0.2	0.3	0.2	0.4	0.3
VINCIA (LO)	0.1	0.2	0.1	0.2	0.0	0.2	0.3	0.1	0.1	0.0	0.0
VINCIA (NLO)	0.2	0.4	0.1	0.3	0.1	0.3	0.2	0.2	0.1	0.2	0.1

PYTHIA

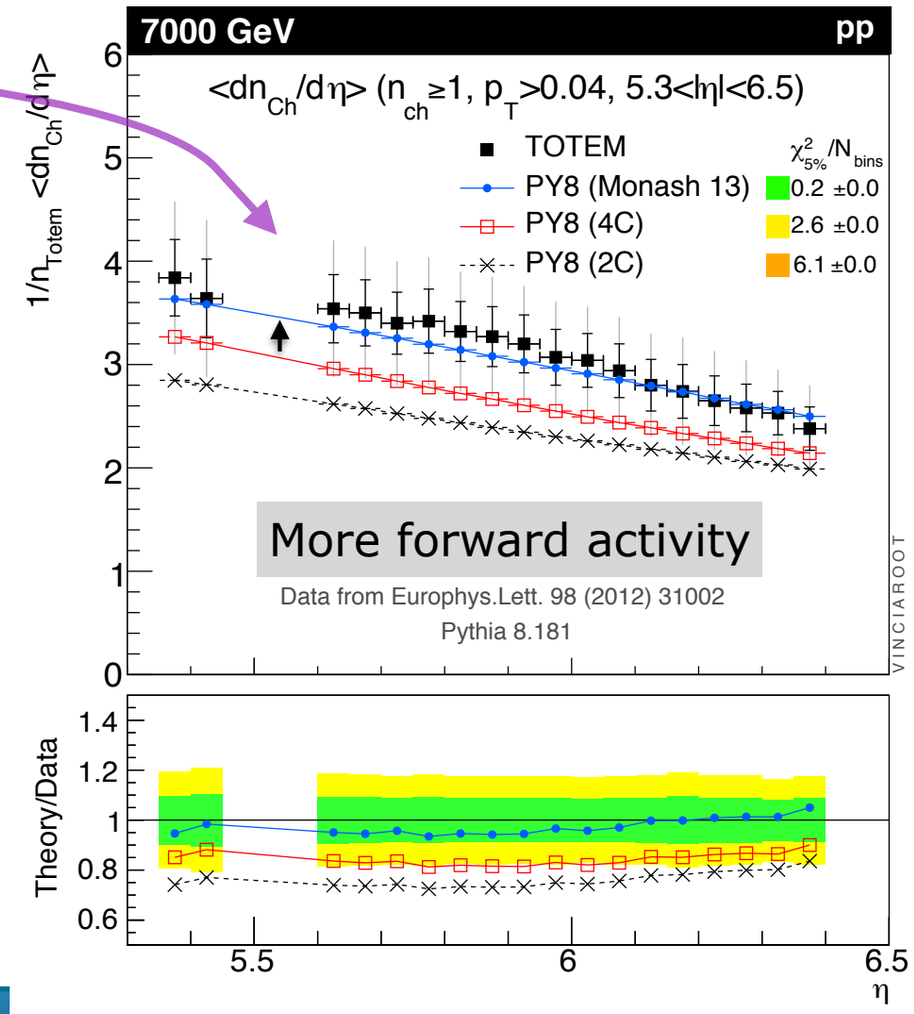
New **Monash 2013** Tune (for ee and pp)

Full Writeup ~ ready

- Uses new NNPDF 2.3 LO QED+QCD set
- Overhaul of e^+e^- constraints
  - 10% increased strangeness
  - Softer c and b fragmentation
- Updated MB+UE parameters
  - Slightly higher UE at 7 TeV
  - More forward activity
  - Still interesting discrepancies in strangeness and baryon sectors
  - → more interesting physics?

Pythia 8.185 Monash 2013

```
Tune:ee=7; Tune:pp = 14;
```



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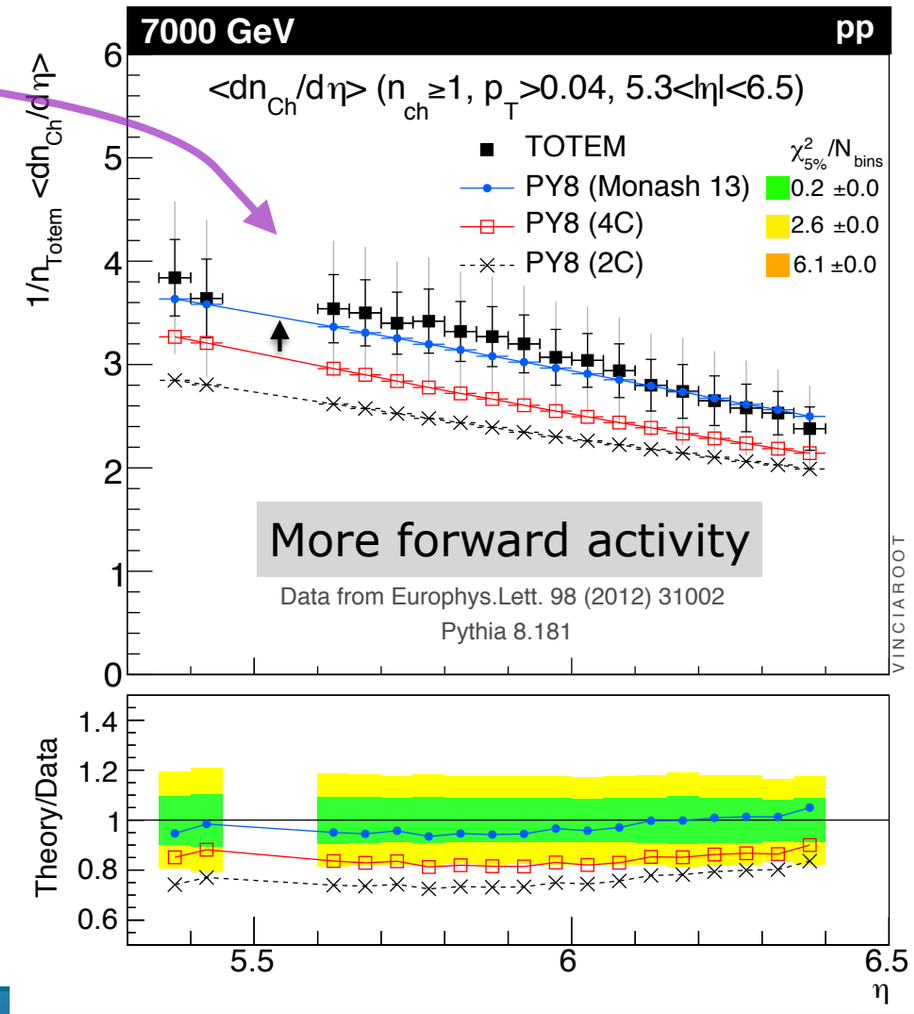


Projects underway or soon to begin

With Jesper Christiansen *(MCnet shortie from Lund)*: colour coherence in MPI and colour reconnections

With Emma Kuwertz *(MCnet shortie from KTH Stockholm)*: subleading-log sensitive observables in pp jets.

LHC Physics Centre at CERN (LPCC)

Slide stolen from Michelangelo Mangano

- Umbrella for activities of common interest to all LHC experiments:
  - contacts/interactions with the theory community, via Workshops or Working Group activities:
    - discussion/interpretation of data
    - development of theory tools used by the experiments
    - combination of experimental results from different experiments
      - LHC WG's (e.g. Top, EW, etc)
  - definition of common physics programmes (e.g. Forward Physics)
  - discussion and support for the development of tools. Examples: Detector Simulation tools (Geant), B-decay tables and generators (EvtGen), Statistical analysis tools (RooStat, etc)
  - organization of tutorials (e.g. Rivet 2 tutorial scheduled for November 21)
  - organization of seminars by the LHC experiments (Tue at 11am)

FCC

Future **Circular** Collider

50-100 km ring : two steps

FCC-ee: from Tera-Z, up to 350 GeV (?)

FCC-hh: 50 - 100 TeV pp

Kickoff meeting in Geneva, February

New institute in Beijing chaired by Arkani-Hamed

What does this mean for us? (MCnet)

Let your imaginations run free = support the physics case!

What could *you* do with 1,000 billion Z events?

Statistics will be no problem → important to ask what detectors (resolutions, systematics) are needed to improve eg on important LEP and SLD constraints?

+ lower/higher ee CM energies

(+ let me know: chairing a study group on QCD pheno at FCC-ee)

Include 30 - 100 TeV energies in pp pheno studies

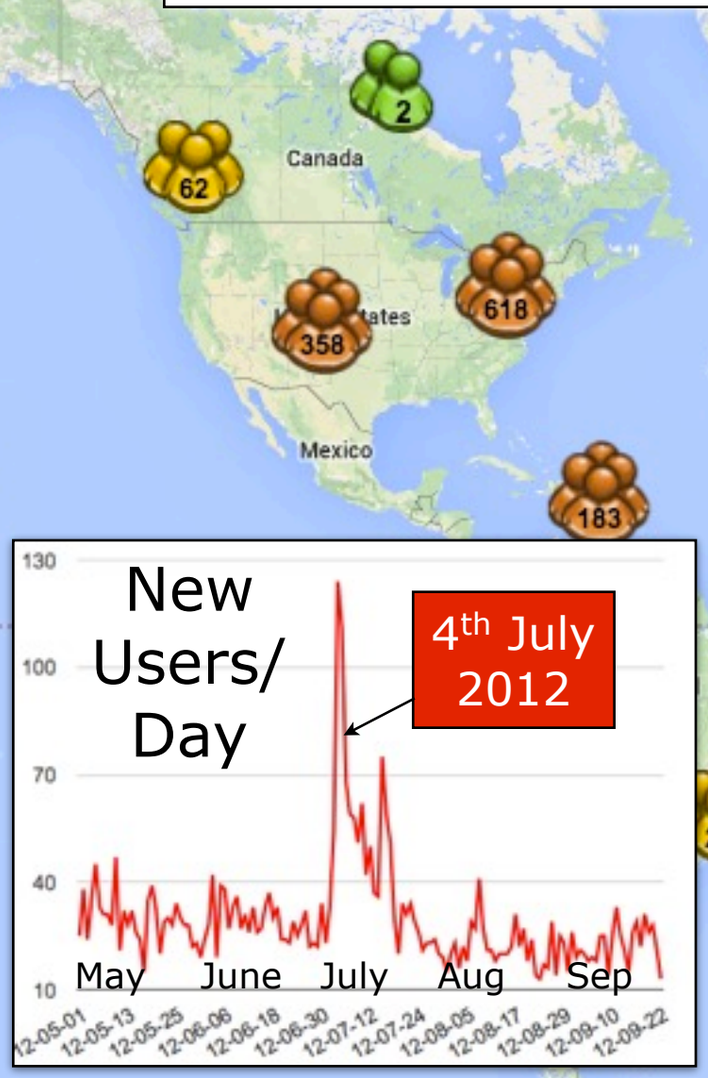
+ (how well) does *your* generator/tool work for 100 TeV?

Test4Theory

LHC@home 2.0 Test4Theory volunteers' machines seen since Mon Mar 24 2014 21:00:00 GMT+0100 (CET) (3126 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.



Tuesday Mar 25 2014 8:28 PM

→ mcplots.cern.ch

MCPLOTS: a particle physics resource based on volunteer computing; Eur.Phys.J. C74 (2014) 2714

Menu

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

Analysis filter:

- → ALL pp/ppbar
- → ALL ee

Specific analysis:

→

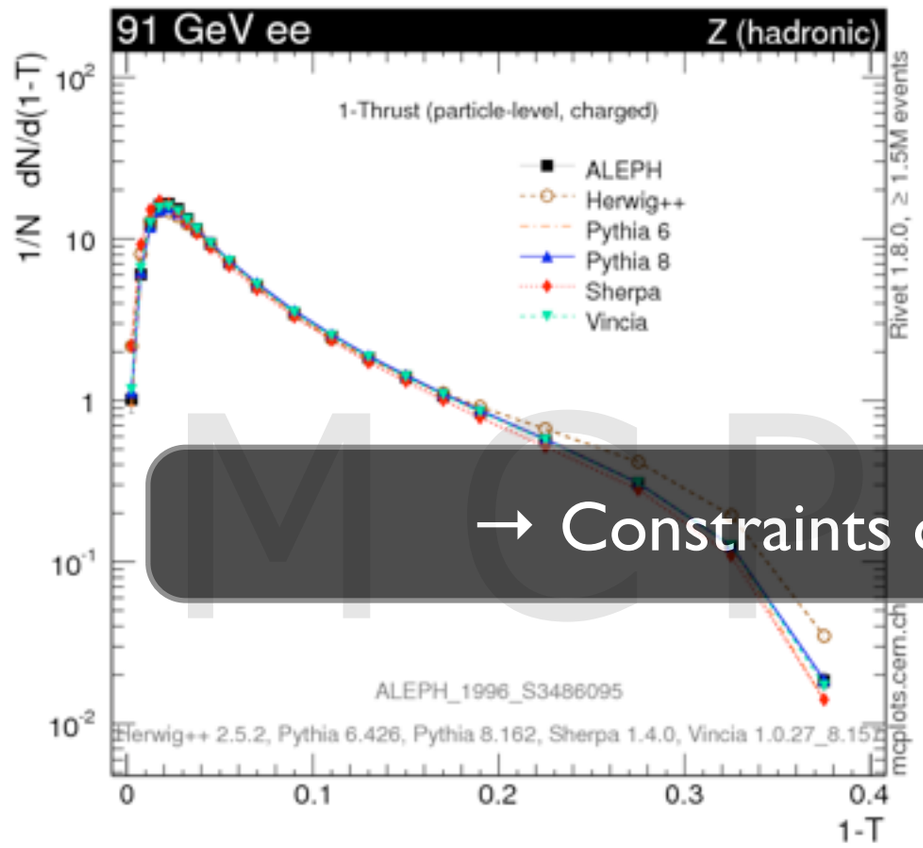
Z (hadronic)

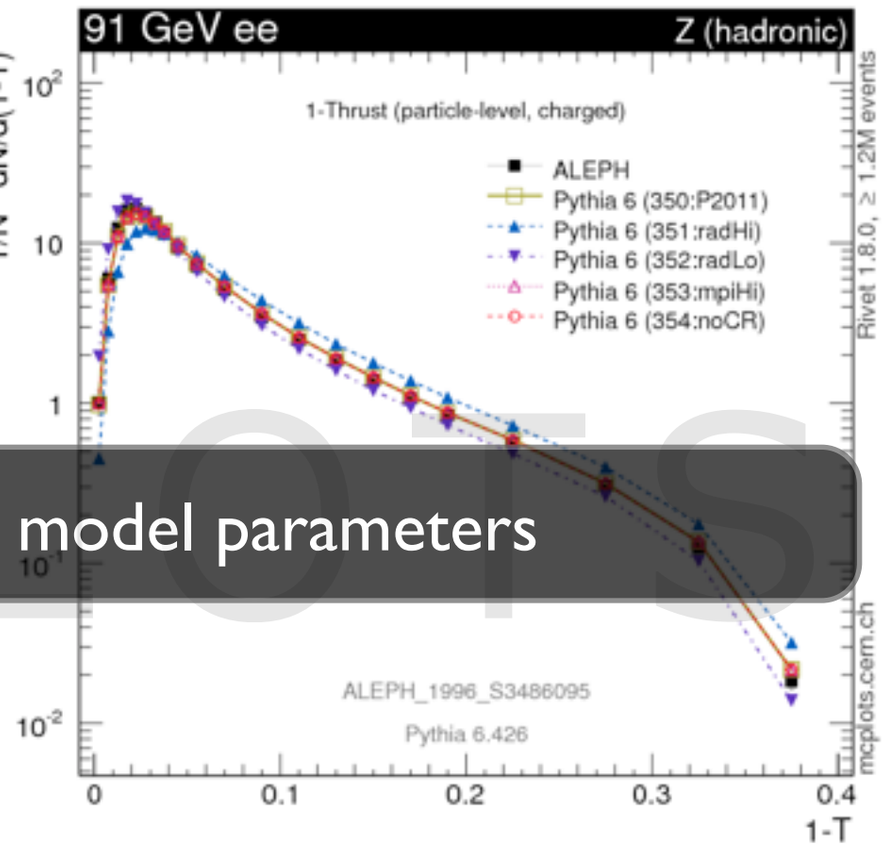
- → Aplanarity
- → B(Total)
- → B(Heavy Hemisph)
- → B(Light Hemisph)
- → C parameter
- → D parameter
- → M(Heavy Hemisph)
- → M(Light Hemisph)
- → ΔM(Heavy-Light)
- → Multiplicity Distributions
- → Planarity
- → pTin (Sph)
- → pTin (Thrust)
- → pTout (Sph)
- → pTout (Thrust)
- → Sphericity
- → Thrust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

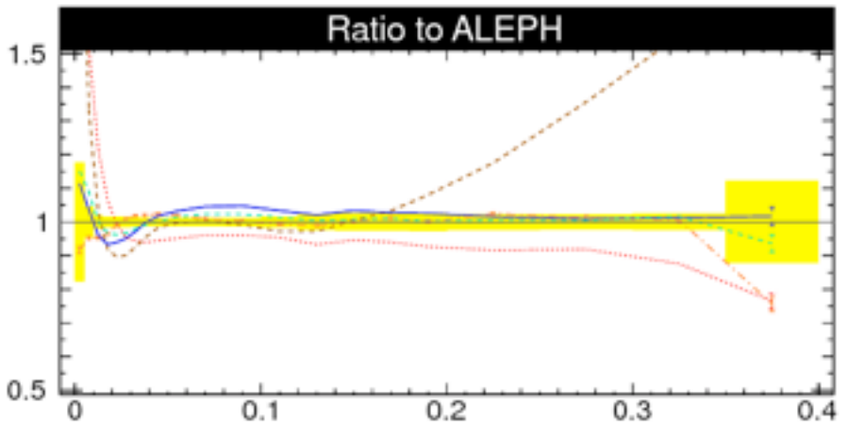
Z (hadronic) : 1-Thrust

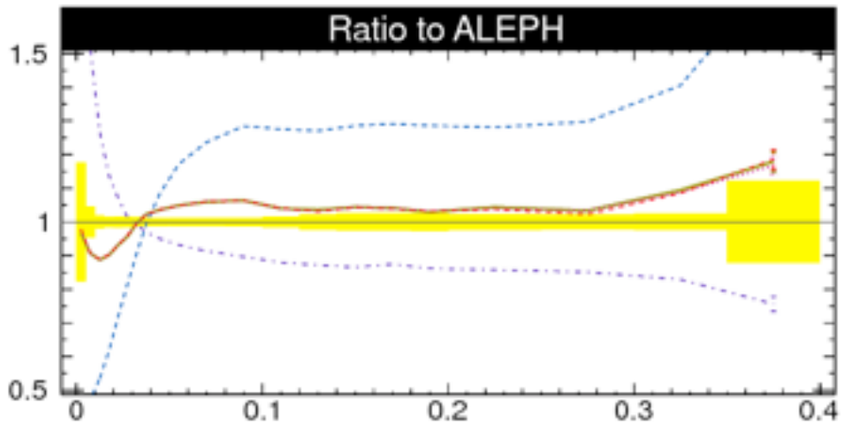
(Total number of plots ~ 500,000)

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









→ Constraints on model parameters

→ mcplots.cern.ch

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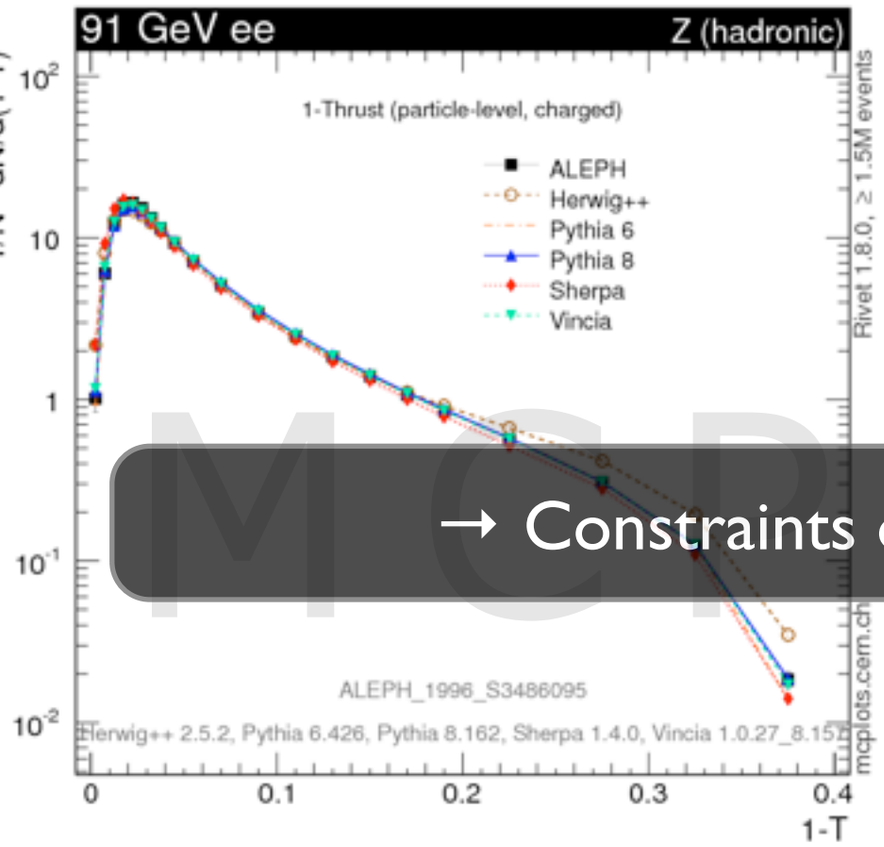
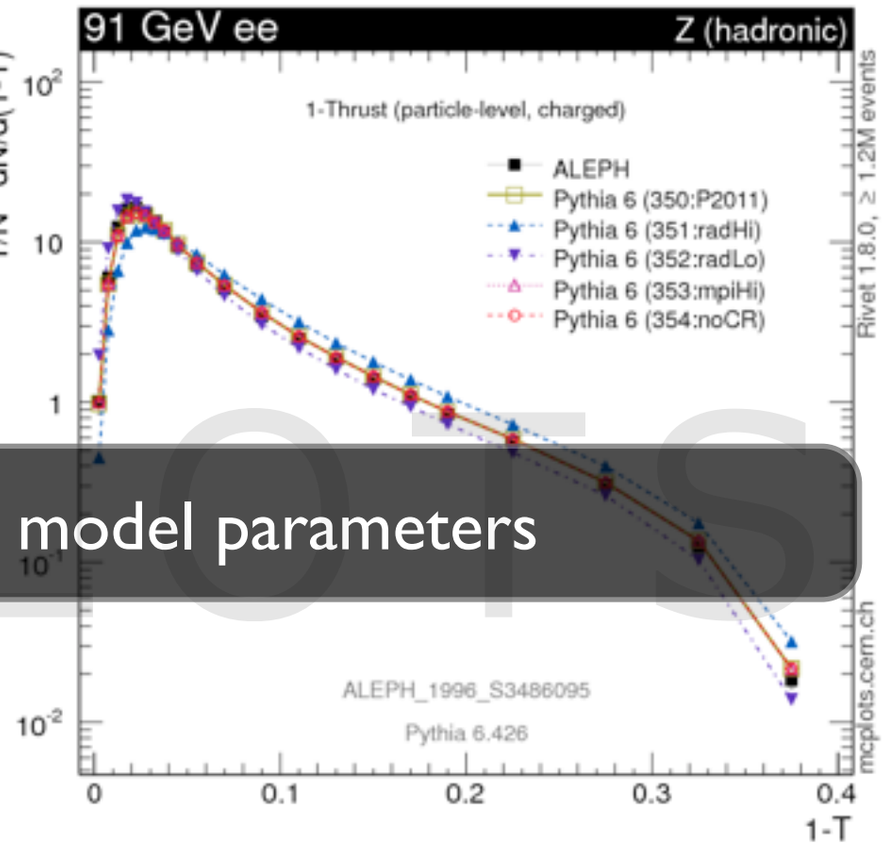




→ Constraints on model parameters

Many analyses added on request by experiments
sometimes also with manpower from experiments
(with thanks to Michelangelo and LPCC for funding help)

→ A Living Review?

Also used for validation and MC tuning

When plots ≠ the published ones

→ bugs in analysis implementations

When new MC versions ≠ older ones

→ physics improvements (intentional) or bugs (unintentional)

Which physics distributions to focus on?

→ Compare χ^2 values over an enormous range of observables and generators. Where do they fail?

Increasing requests from LHC experiments to get their analyses on MCPLOTS

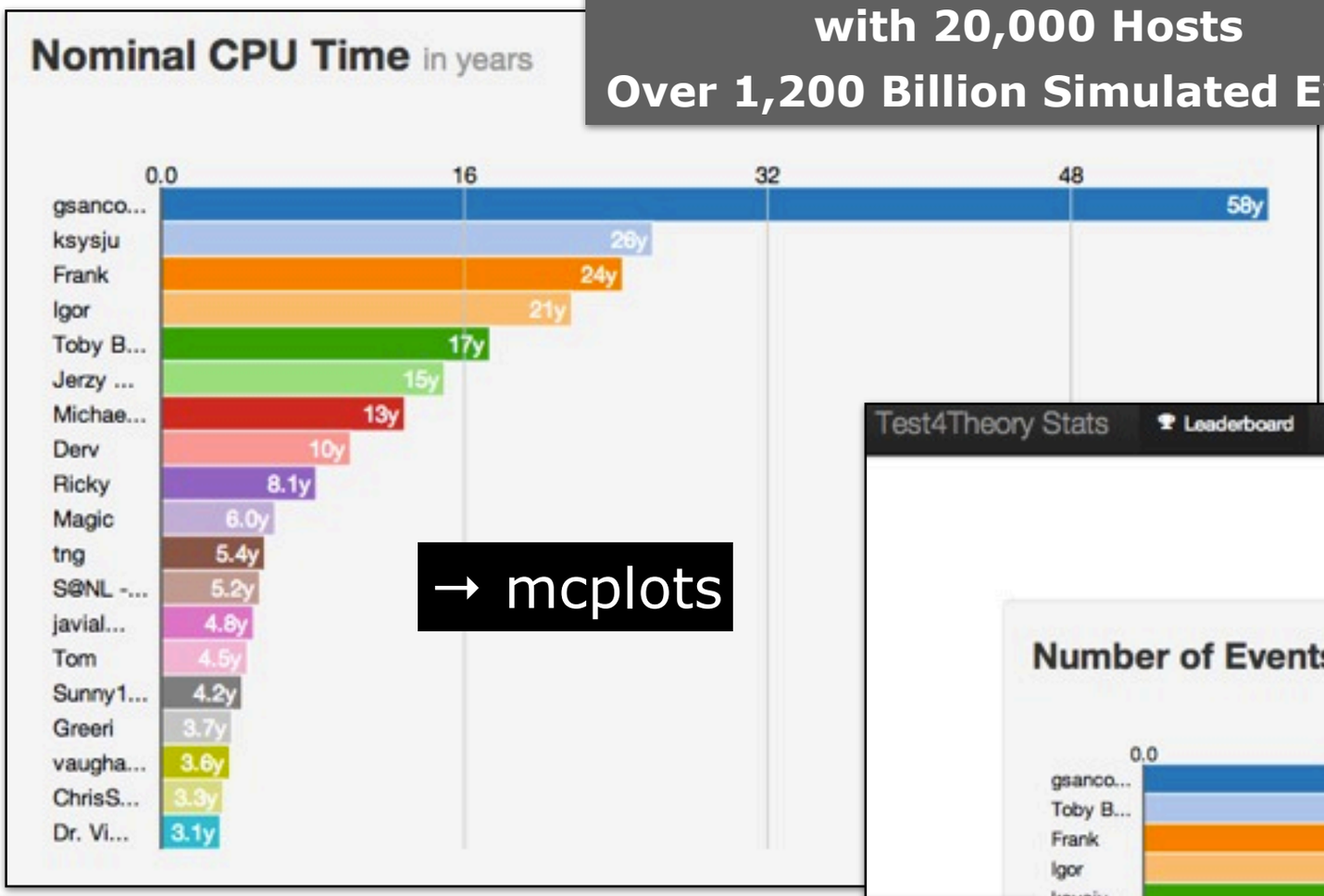
Many more comparisons than in the publications

Can be kept up-to-date ~ a "living" review?

Main question for future: manpower for day-to-day updates and further development (new generators, etc)

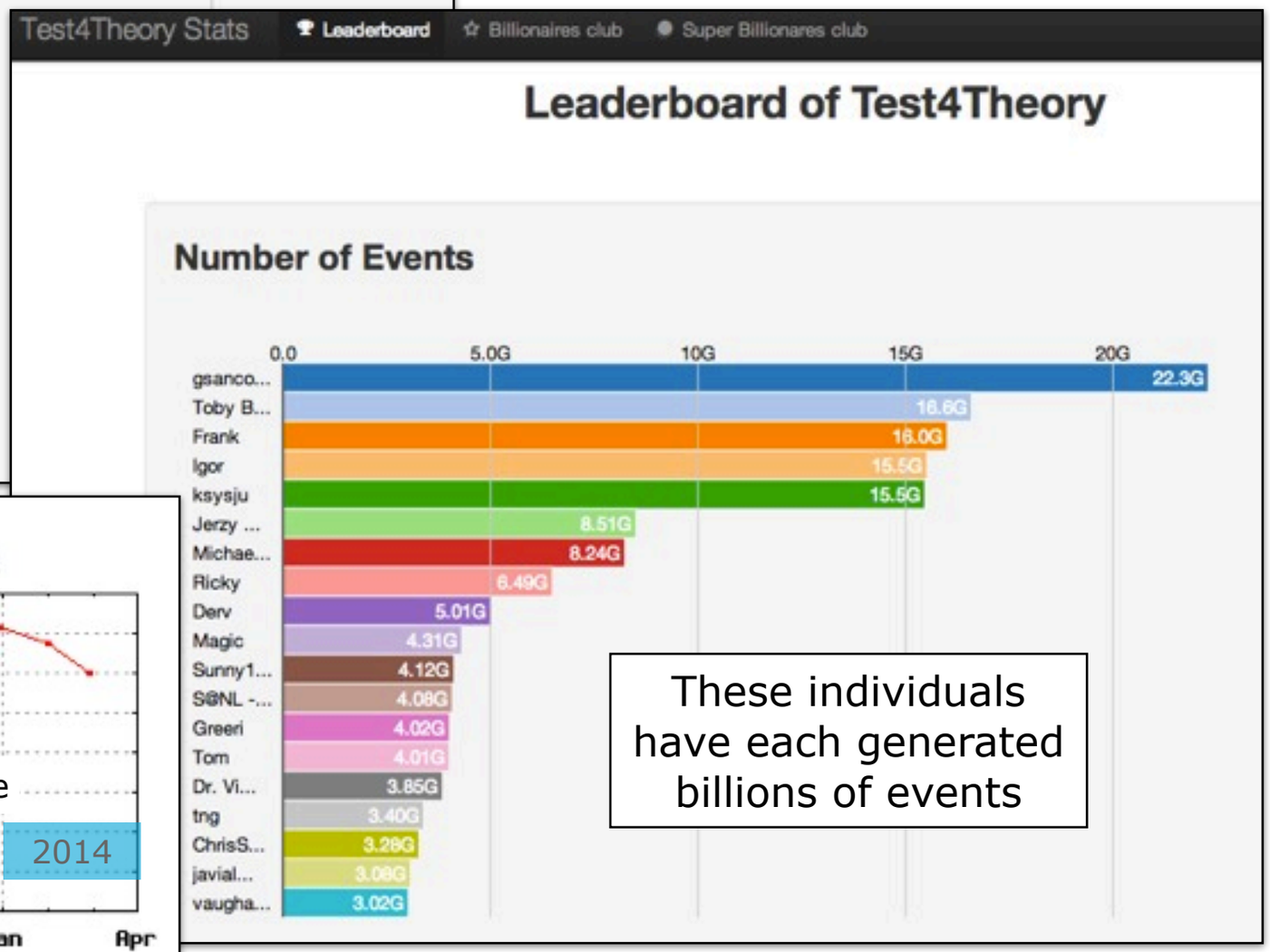
Computing Time

10,000 Volunteers
with 20,000 Hosts
Over 1,200 Billion Simulated Events

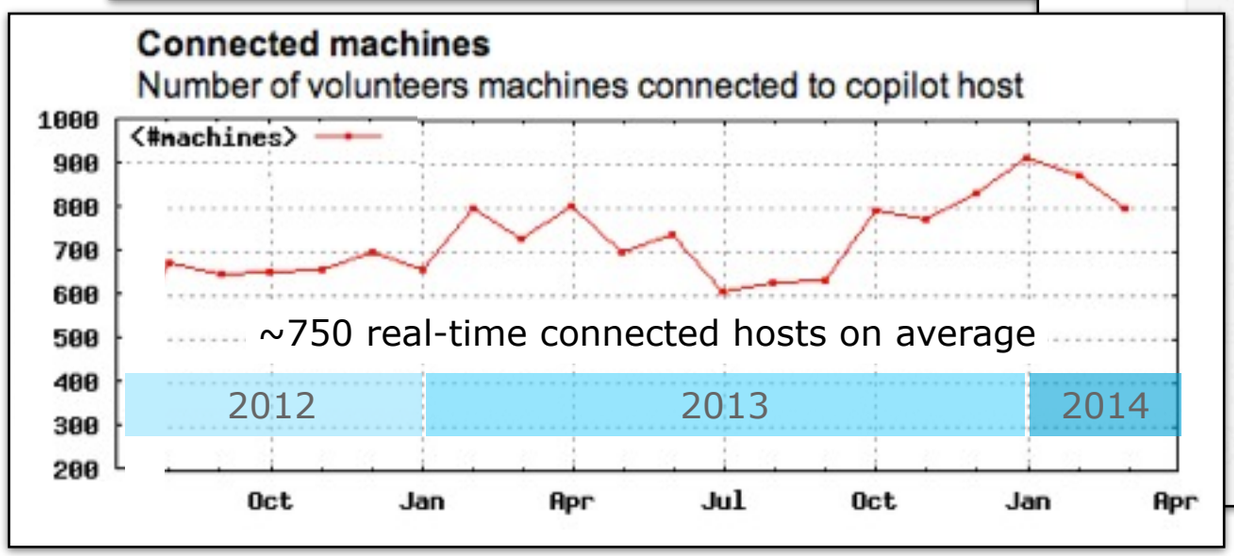


→ mcplots

LHC@home 2.0
TEST4THEORY



These individuals have each generated billions of events



Citizen Cyberlab

Standalone ICT funded by EU FP7 (2012-2015)

From volunteer computing to volunteer thinking

CERN is receiving funding for a 2-year fellow

Ioannis Charalimpidis, started in May 2013

Our Task: develop an application that lets citizen scientists optimize MC parameters by comparing them to real data

~ simplified, pedagogical, interactive Professor

Technical prototype now ready (browser app)

→ next will focus on development of full version

+ Evaluate learning in citizen-science projects

Psychology and Learning (U Geneva)

Human-Computer Interactions (UCL)

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+ ties into "60 Years at CERN" celebrations

Key Aspect: Modern science for everyone