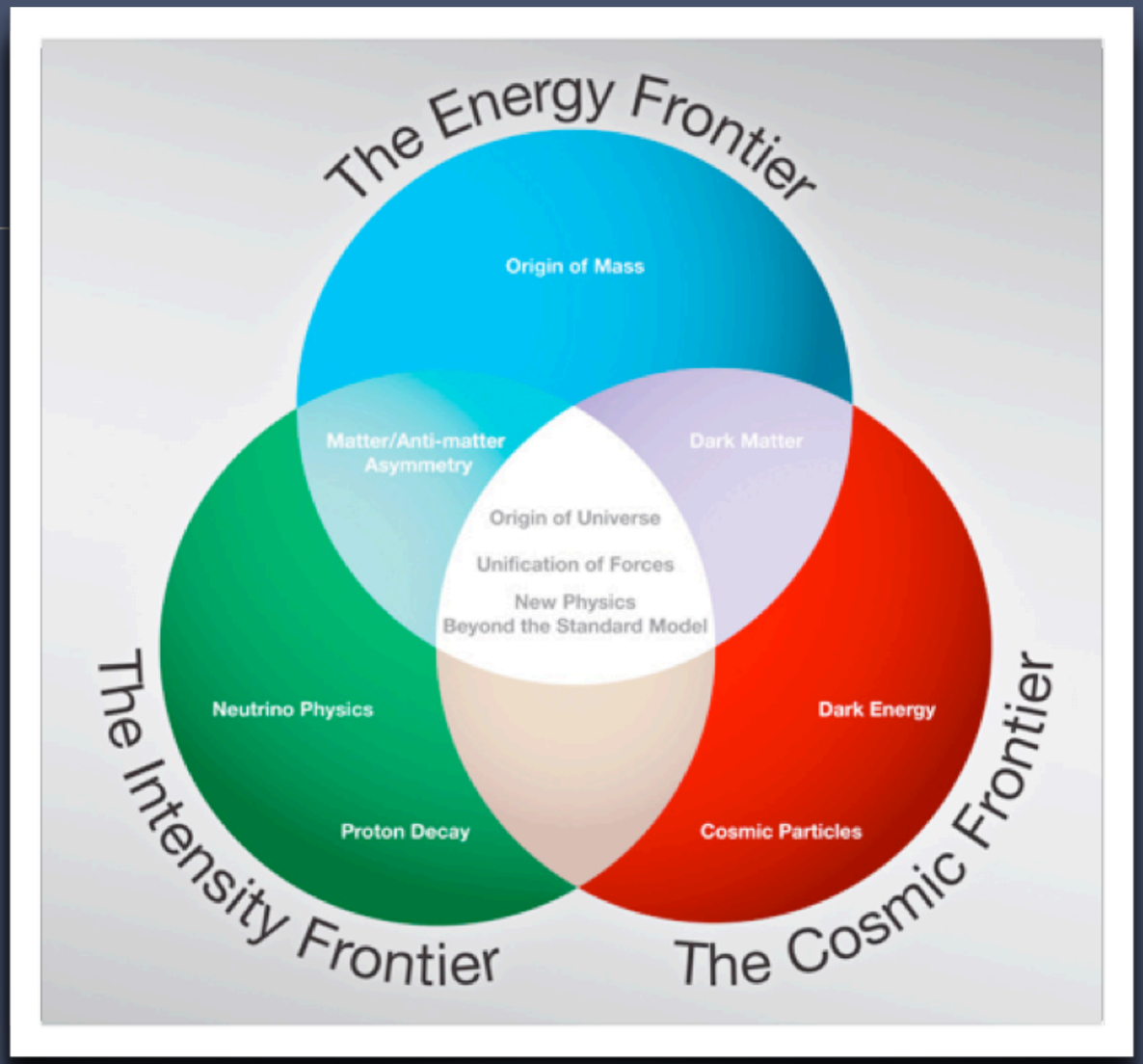
Snowmass Energy Frontier

FNAL PAC

June 7, 2013
Michael Peskin (SLAC)
Chip Brock (MSU)

Snowmass

A venerable meeting
in a new venue
and organized around the frontiers



Snowmass

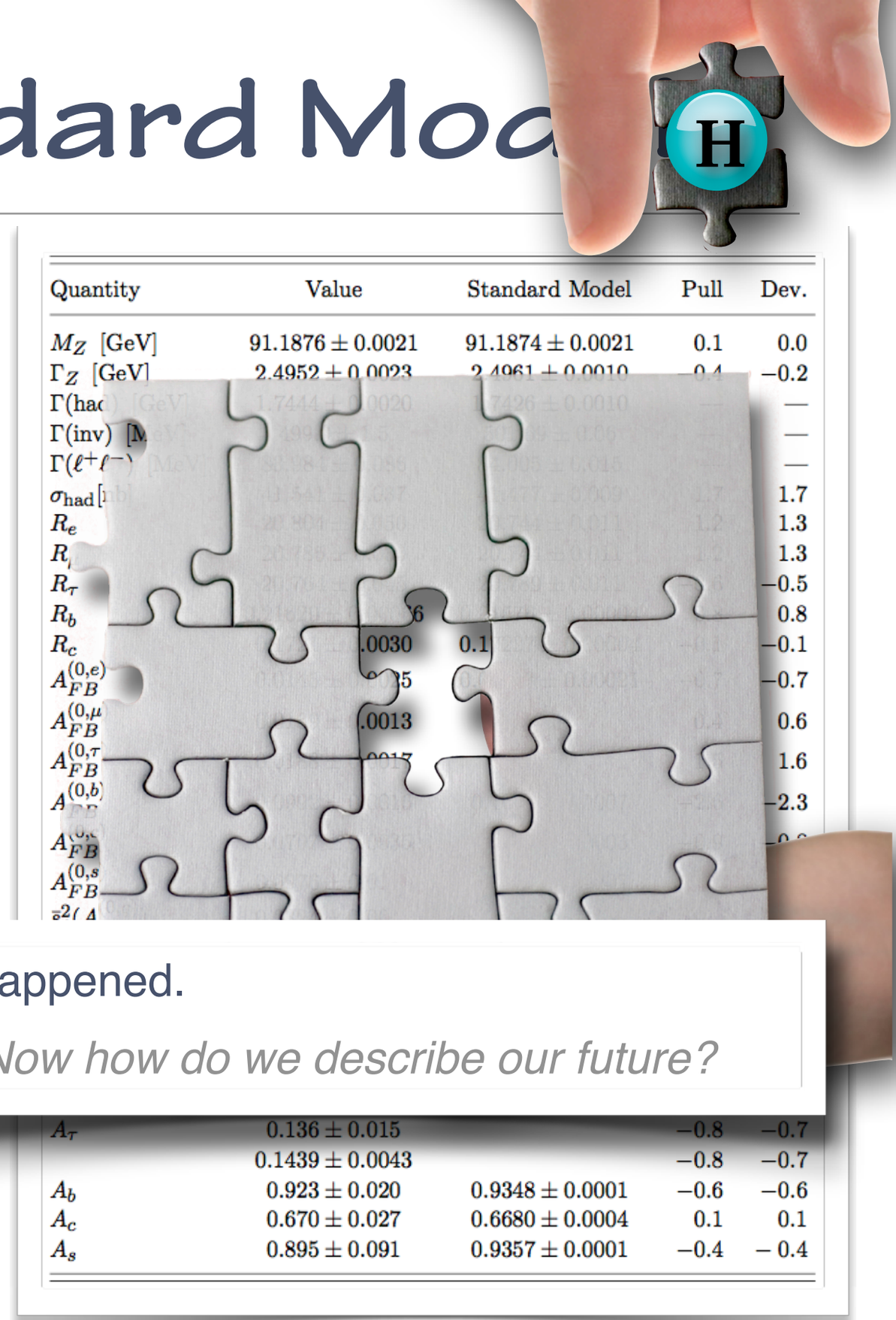
A venerable meeting
in a new venue
and organized around the frontiers

which sometimes feels like:

Higgs

Amazing Standard Mod

The most precise scientific model in the history of mankind



Quantity	Value	Standard Model	Pull	Dev.
M_Z [GeV]	91.1876 ± 0.0021	91.1874 ± 0.0021	0.1	0.0
Γ_Z [GeV]	2.4952 ± 0.0023	2.4961 ± 0.0010	−0.4	−0.2
$\Gamma(\mathrm{had})$ [GeV]	$1.7444 \pm$ [illegible]	1.7426 ± 0.0010	—	—
$\Gamma(\mathrm{inv})$ [MeV]	[illegible]	[illegible]	—	—
$\Gamma(\ell^+\ell^-)$ [MeV]	[illegible]	[illegible]	—	—
σ_{had} [nb]	[illegible]	[illegible]	[illegible]	1.7
R_e	[illegible]	[illegible]	[illegible]	1.3
R_μ	[illegible]	[illegible]	[illegible]	1.3
R_τ	[illegible]	[illegible]	[illegible]	−0.5
R_b	[illegible]	[illegible]	[illegible]	0.8
R_c	[illegible].0030	0.1	[illegible]	−0.1
$A_{FB}^{(0,e)}$	[illegible]	[illegible]	[illegible]	−0.7
$A_{FB}^{(0,\mu)}$	[illegible].0013	[illegible]	[illegible]	0.6
$A_{FB}^{(0,\tau)}$	[illegible]	[illegible]	[illegible]	1.6
$A_{FB}^{(0,b)}$	[illegible]	[illegible]	[illegible]	−2.3
$A_{FB}^{(0,c)}$	[illegible]	[illegible]	[illegible]	[illegible]
$A_{FB}^{(0,s)}$	[illegible]	[illegible]	[illegible]	[illegible]
$\bar{s}^2_\ell(A_{FB})$	[illegible]	[illegible]	[illegible]	[illegible]
A_τ	0.136 ± 0.015		−0.8	−0.7
	0.1439 ± 0.0043		−0.8	−0.7
A_b	0.923 ± 0.020	0.9348 ± 0.0001	−0.6	−0.6
A_c	0.670 ± 0.027	0.6680 ± 0.0004	0.1	0.1
A_s	0.895 ± 0.091	0.9357 ± 0.0001	−0.4	− 0.4

it happened.

Now how do we describe our future?

J. Beringer *et al.*(PDG), PR **D86**, 010001 (2012) (http://pdg.lbl.gov)

Broadly the EF's job is

to figure out the best way to:

Higgs Top EW QCD NP Flav

1. Study the Higgs-like state at 125 GeV

Higgs
Top
EW
QCD
NP
Flav

2. Answer some troublesome questions

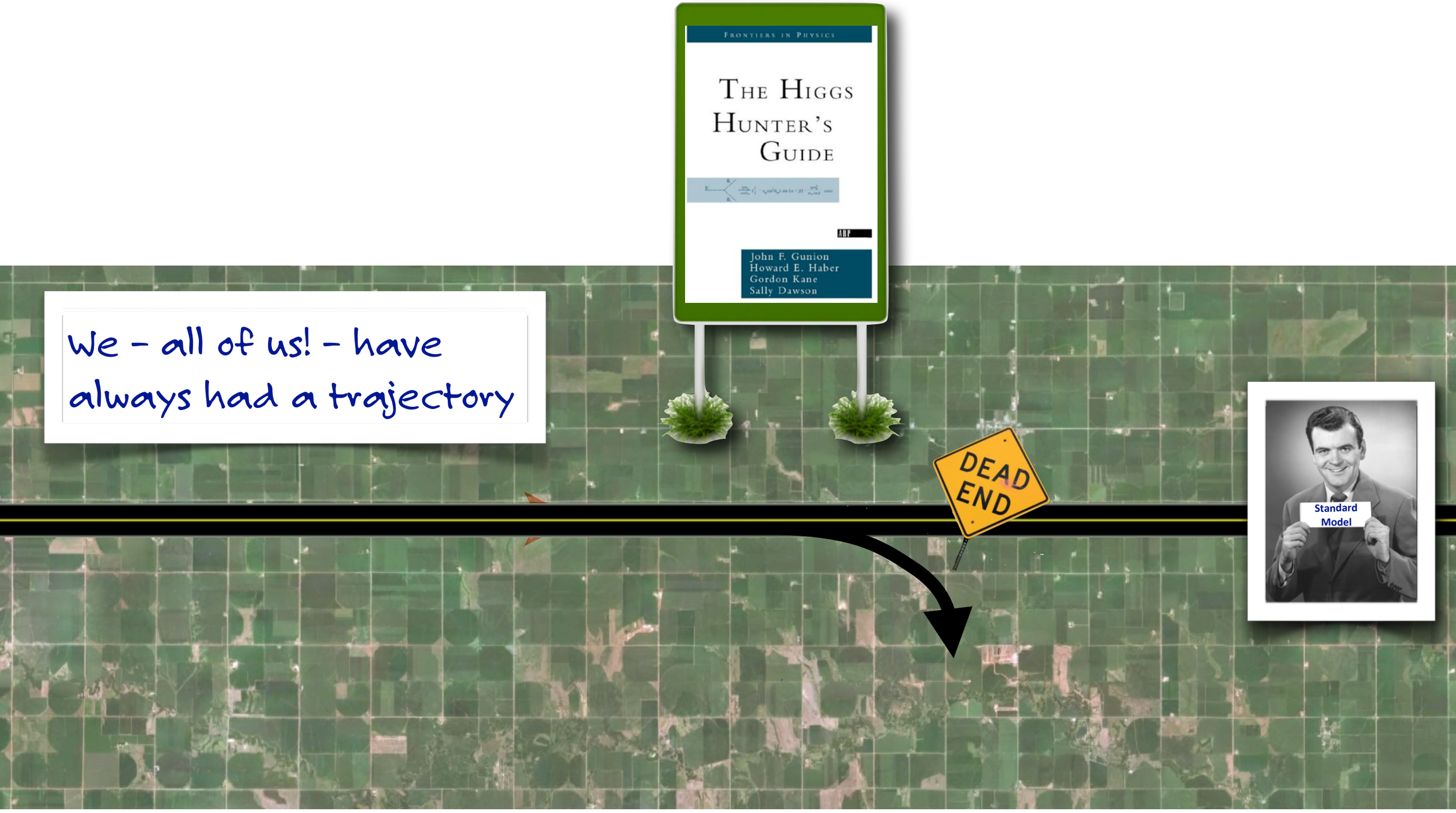
3. Write the new story Beyond the SM

Higgs Top EW QCD NP Flav

4. Be nimble & ready for surprises

Higgs Top EW QCD NP Flav

history suggests

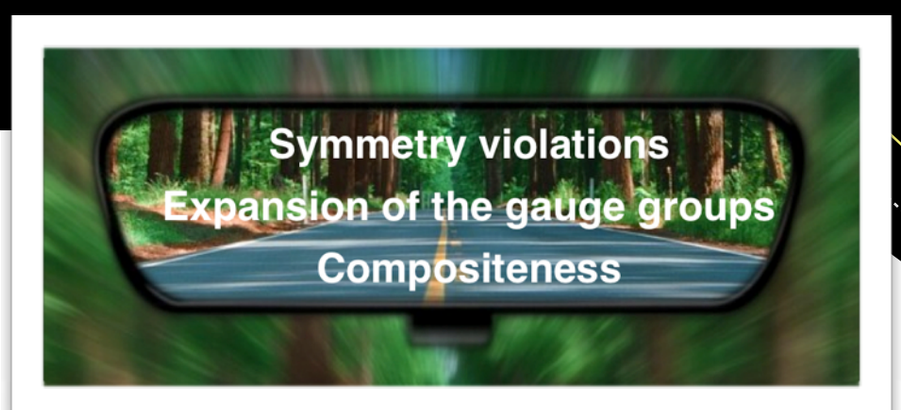

Frontiers in Physics
The Higgs Hunter's Guide
John F. Gunion
Howard E. Haber
Gordon Kane
Sally Dawson
We – all of us! – have always had a trajectory
DEAD END
Standard Model

we had a map

now we're on our own!

sort of unnerving

That's a big deal.



Snowmass 2013
Energy Frontier Process

as a project

EF Goals:

Concrete Goals: the science cases

I. What scientific targets can be achieved before ~2018?

at design specifications with $\int \mathcal{L}\, dt$ ~100 fb^{-1})?

II. What are the scientific cases which motivate HL LHC running:

"Phase 1": circa 2022 with $\int \mathcal{L}\, dt$ of approximately 300 fb^{-1}

"Phase 2": circa 2030 with $\int \mathcal{L}\, dt$ of approximately 3000 fb^{-1}

How do the envisioned upgrade paths inform those goals?
Specifically, to what extent is precision Higgs Boson physics possible?

III. Is there a scientific necessity for a "Higgs Factory"?

IV. Is there a scientific case today for experiments at higher energies beyond 2030?

A high energy LHC?
High energy lepton collider?
Lepton-hadron collider?
VLHC?

EF Goals:

Community Goals: the context for this science

I. Articulate to scientific audiences

To other Particle Physicists:

EF science in the context of the Intensity and Cosmic Frontiers' goals

To other scientists

II. Justify to governmental audiences

OHEP, EPP, OSTP, Congress...beyond our direct agencies

Not only science, but the internationalization of science

III. Explain to non-specialist audiences

Universities

Public

Lectures
Written documentation
Attractive on-line presence

we accomplish the goals by evaluating the physics

Organization:

Identified terrific subgroup conveners

meeting since December

Created necessary correlations among groups

Technical groups, accelerators, simulations

Explicit liaisons between EF and other frontiers

Additional group "infrastructure"

established direct connection with the established collaborations:

"Advisors": ATLAS: Ashutosh Kotwal; CMS: Jim Olsen; LHCb: Sheldon Stone; ILD: Graham Wilson; SiD: Andy White;CLIC: Mark Thomson; Muon Collider: Ron Lipton

Working groups

The Higgs Boson

Quantum Chromodynamics and the Strong Interactions

Precision Study of Electroweak Interactions

Fully Understanding the Top Quark

Flavor Physics and CP Violation at High Energy

The Path Beyond the Standard Model–New Particles, Forces, and Dimensions

All have had workshops

All have been meeting ~weekly

We meet with conveners weekly

Yesterday we saw the preparations for next meeting

EF working groups

EF1: The Higgs Boson

Jianming Qian (Michigan), Andrei Gritsan (Johns Hopkins), Heather Logan (Carleton), Rick Van Kooten (Indiana), Chris Tully (Princeton), Sally Dawson (BNL)

EF2: Precision Study of Electroweak Interactions

Michael Schmitt (Northwestern), Doreen Wackeroth (Buffalo), Ashutosh Kotwal (Duke)

EF3: Fully Understanding the Top Quark

Robin Erbacher (Davis), Reinhard Schwienhorst (MSU),
Kirill Melnikov (Johns Hopkins), Cecilia Gerber (UIC), Kaustubh Agashe (Maryland)

EF4: The Path Beyond the Standard Model–New Particles, Forces, and Dimensions

Daniel Whiteson (Irvine), Liantao Wang (Chicago), Yuri Gershtein (Rutgers), Meenakshi Narain (Brown), Markus Luty (UC Davis)

EF5: Quantum Chromodynamics and the Strong Interactions

Ken Hatakeyama (Baylor), John Campbell (FNAL), Frank Petriello (Northwestern), Joey Huston (MSU)

EF6: Flavor Physics and CP Violation at High Energy

Soeren Prell (ISU), Michele Papucci (LBNL), Marina Artuso (Syracuse)

candidate accelerator parameterizations

Original “future machines” have evolved into a final list

A. hadron colliders

1. *LHC 14 TeV, 300/fb , spacing: 25 ns, pileup: 50 events/crossing*
2. *LHC 14 TeV, 3000/fb (HL-LHC) , spacing: 25 ns, pileup: 140 events/crossing*
3. *LHC 33 TeV, 3000/fb (HE-LHC) , spacing: 50 ns, pileup: 225 events/crossing*
4. *VHE-LHC 100 TeV, 3000/fb, spacing: 50 ns, pileup: 263 events/crossing*
5. *VLHC at 100 TeV, 1000/fb , spacing: 19 ns, pileup: 40 events/crossing*

pileup numbers are the average number of interactions per crossing at the peak luminosity, as explained

B. Lepton colliders

1. *e+e- at 250 GeV (ILC: 500/fb , LEP3: 500/fb, TLEP: 2500/fb),*
   e-/e+ polarization: ILC: 80%/30%, LEP3, TLEP: 0/0

2. *e+e- at 350 GeV (ILC: 350/fb, CLIC: 350/fb, TLEP: 350/fb) ,*
   e-/e+ polarization: ILC: 80%/30%, CLIC: 80%/0, TLEP: 0/0

3. *e+e- at 500 GeV (ILC: 500/fb),*
   e-/e+ polarization: ILC: 80%/30%

4. *e+e- at 1000 GeV (ILC: 1000/fb) ,*
   e-/e+ polarization: ILC: 80%/20%

5. *e+e- at 1400 GeV (CLIC: 1400/fb) ,*
   e-/e+ polarization: CLIC: 80%/0%

6. *e+e- at 3000 GeV (CLIC: 3000/fb) ,*
   e-/e+ polarization: CLIC: 80%/ 0%

7. *mu+mu- at 125 GeV 2/fb , 0 polarization*

8. *mu+mu- at 1500 GeV 1000/fb , 0 polarization*

9. *mu+mu- at 3000 GeV 3000/fb , 0 polarization*

C. Gamma colliders

1. *gamma-gamma at 125 GeV, 100/fb ,*
   80% e- polarization to generate the photon beams

2. *gamma-gamma at 200 GeV, gamma-e at 225 GeV, 200/fb ,*
   80% e- polarization to generate the photon beams

3. *gamma-gamma at 800 GeV, gamma-e at 900 GeV, 800/fb ,*
   80% e- polarization to generate the photon beams

D. e-hadron collider

1. *LHeC 60 GeV e- or e+ on 7 TeV p 50/fb ,*
   90% e- / 0% e+ polarization

fast simulation tools

Much work

LHC simulation strategies

A Generic DELPHES 3 detector

a Frankenstein of ATLAS and CMS performance parameters

freeing up people to work off of their reservations

Background simulations through a devoted OSG VO - FNAL led this

Lepton Collider simulation strategies

ILC, CLIC, and muon collider

many useful fast simulation tools exist

what Snowmass is not

We don’t make recommendations

what Snowmass is

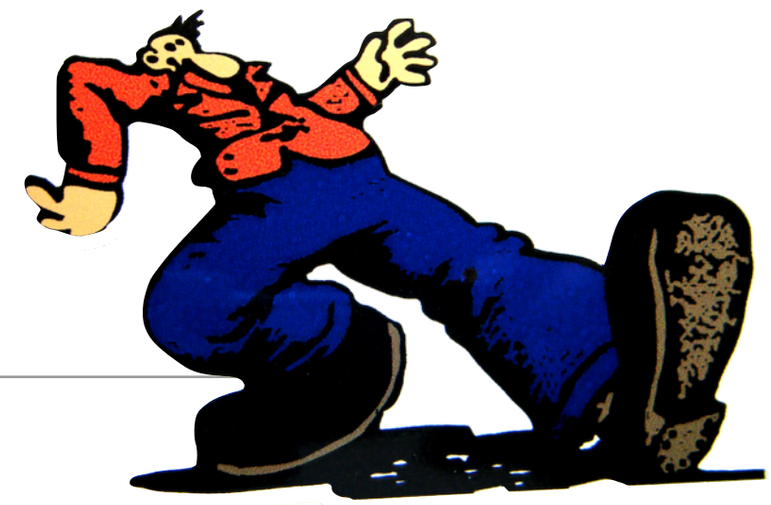
We evaluate by benchmarking

We speculate by calculating

We dream about following the physics

We imagine discovery

our goal should be:

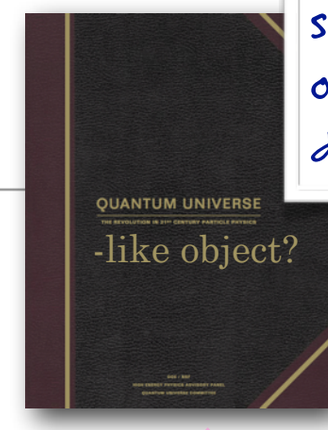


Put our best foot forward

corollary: enthusiastically, but carefully

this is more touchy than you might think.

long process



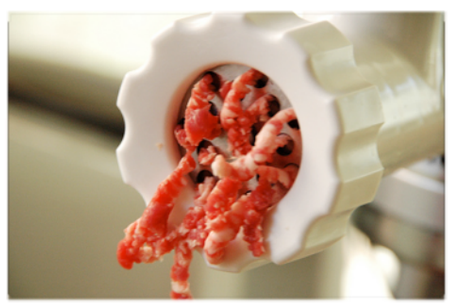
some public-oriented EF document?

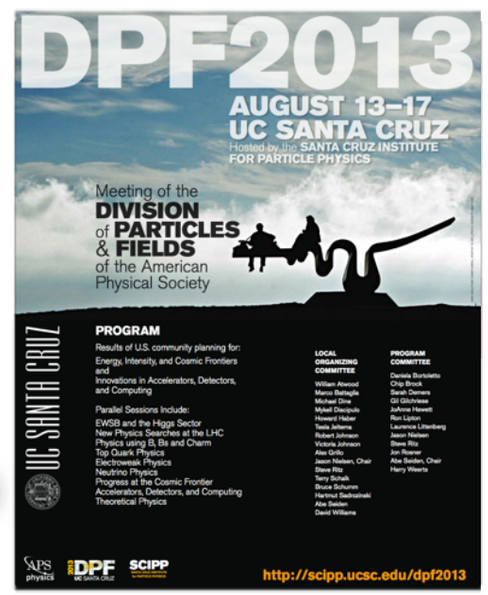
now-July

August

September 30?

?





APS physics
Division of Particles and Fields

http://scipp.ucsc.edu/dpf2013

Snowmass@ CERN

long process

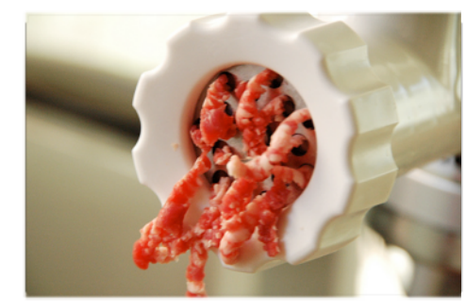
September?

HEPAP

P5

Spring 2014?

HEPAP



exhausting

we accomplish the goals by telling stories

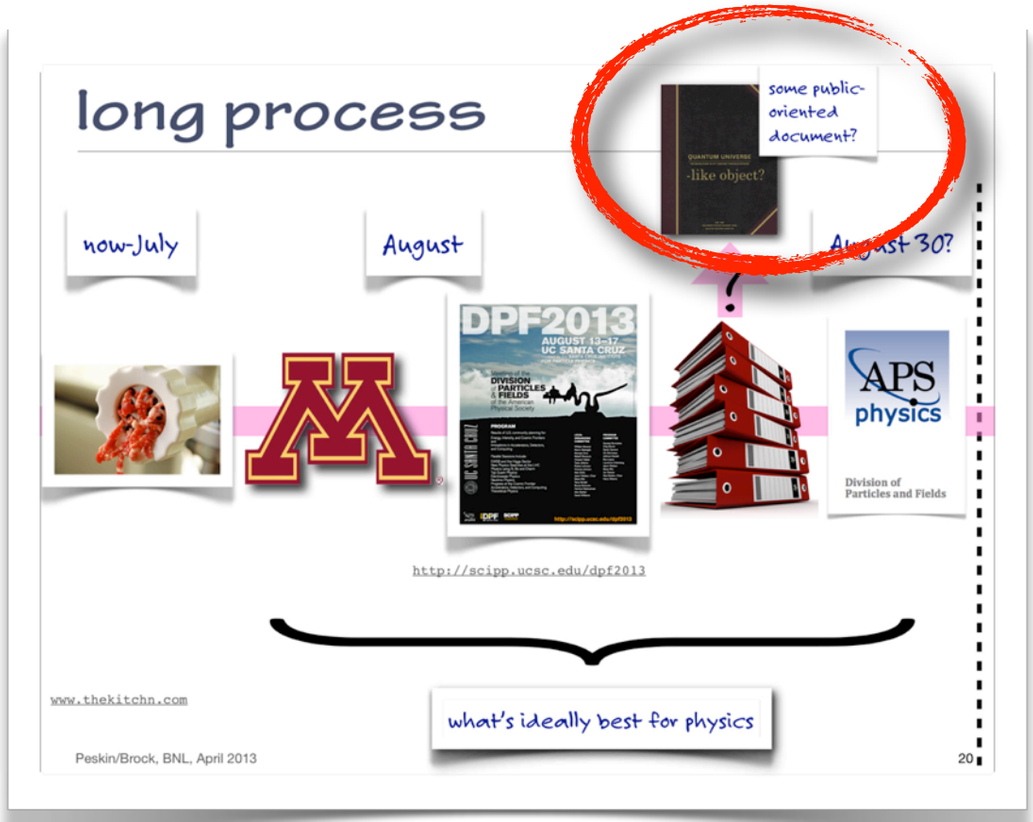
about Discovery

We’re suggesting narratives that describe potential discoveries

For agency use

For public consumption

For fun.



the idea: tell some stories

Take a handful of plausible discovery channels

which might show up as anomalous observables

Flesh them out as a sequence of events:

What would an experiment need to do to be convincing?

highlights detector capabilities

What could it be?

highlights the variety of physics directions

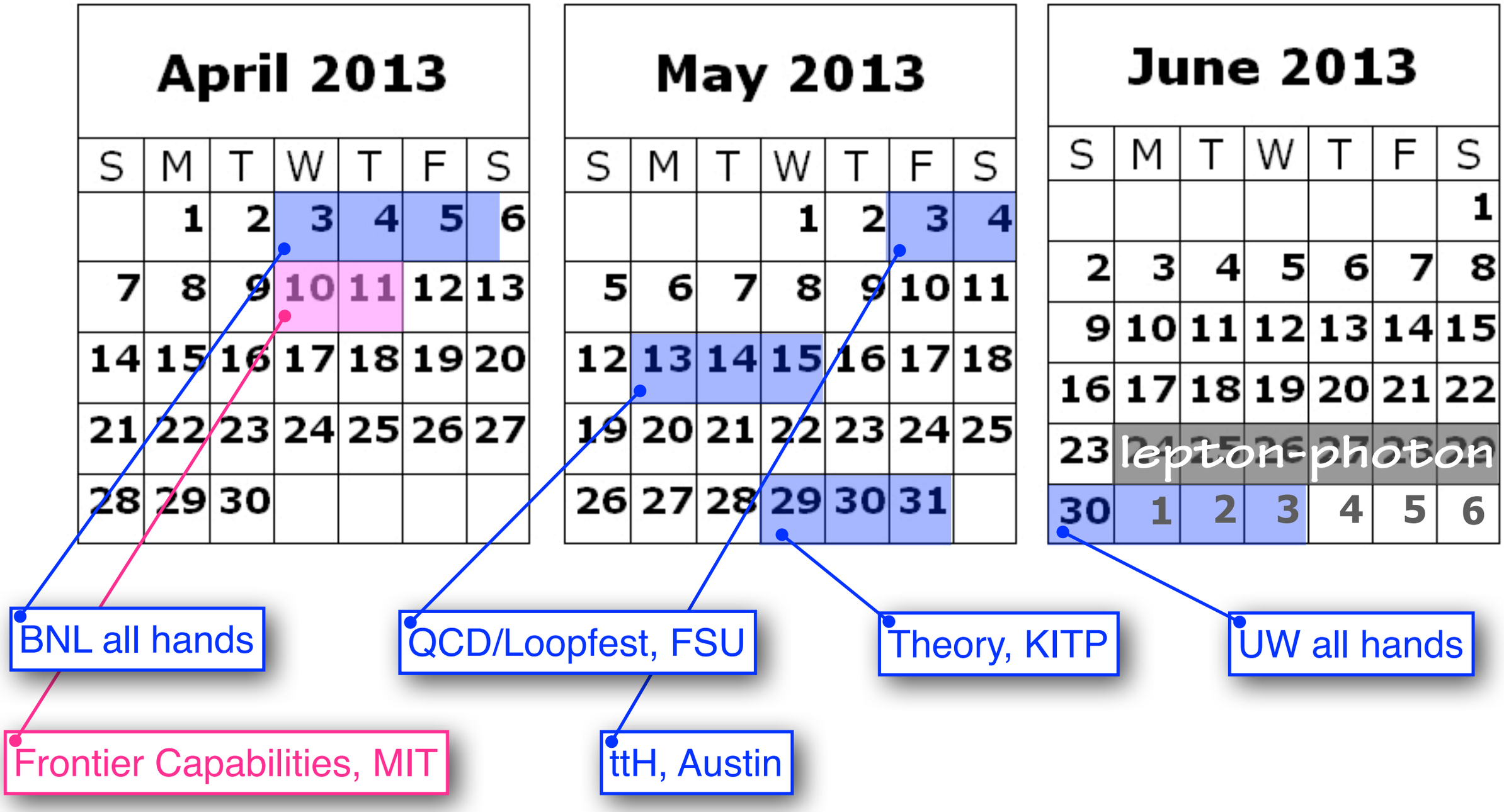
What other measurements should show evidence?

highlights the whole program, cross-frontier?

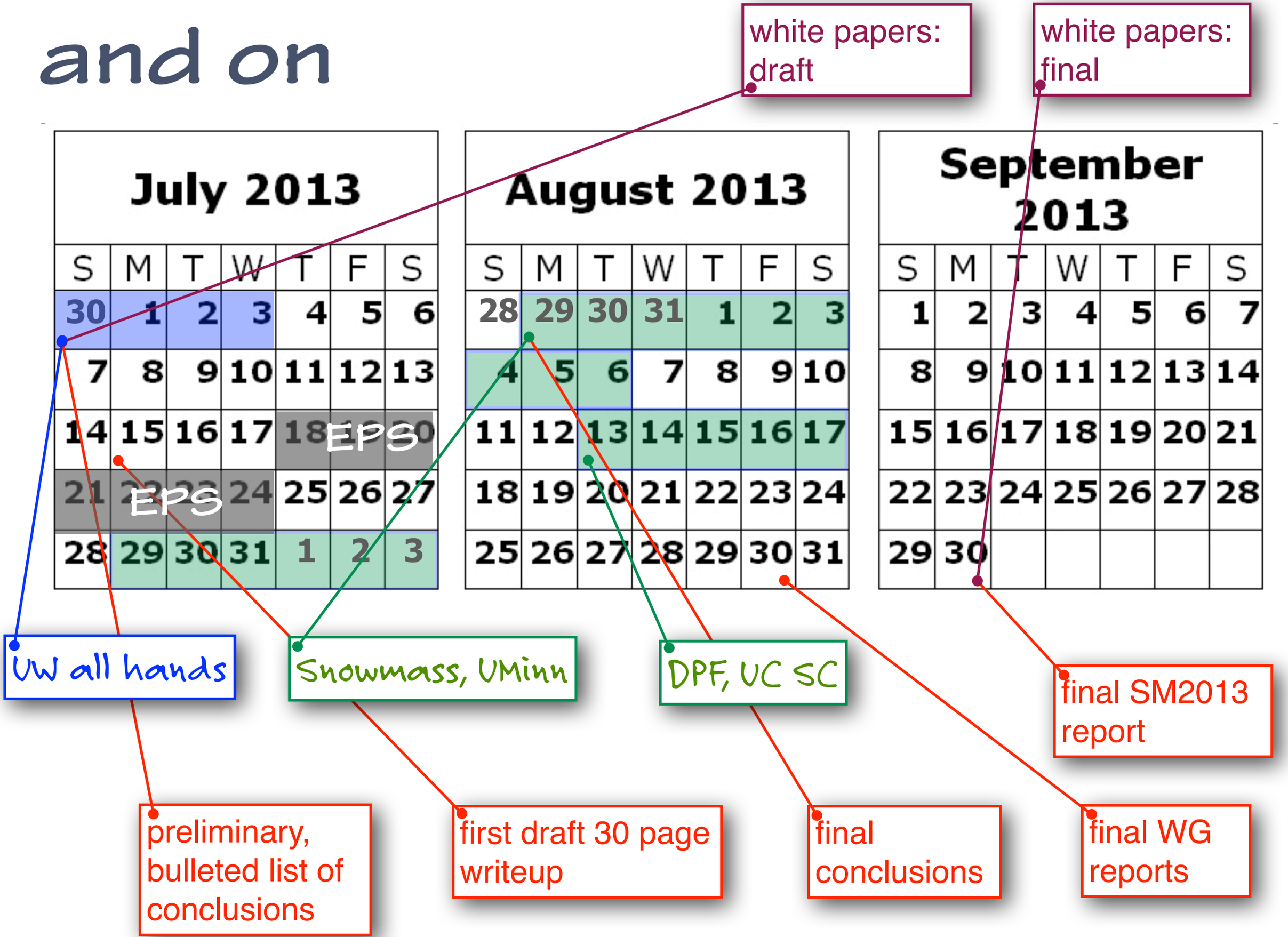
We suggested some examples.

we accomplish the goals by sticking to the calendar

time marches on



and on

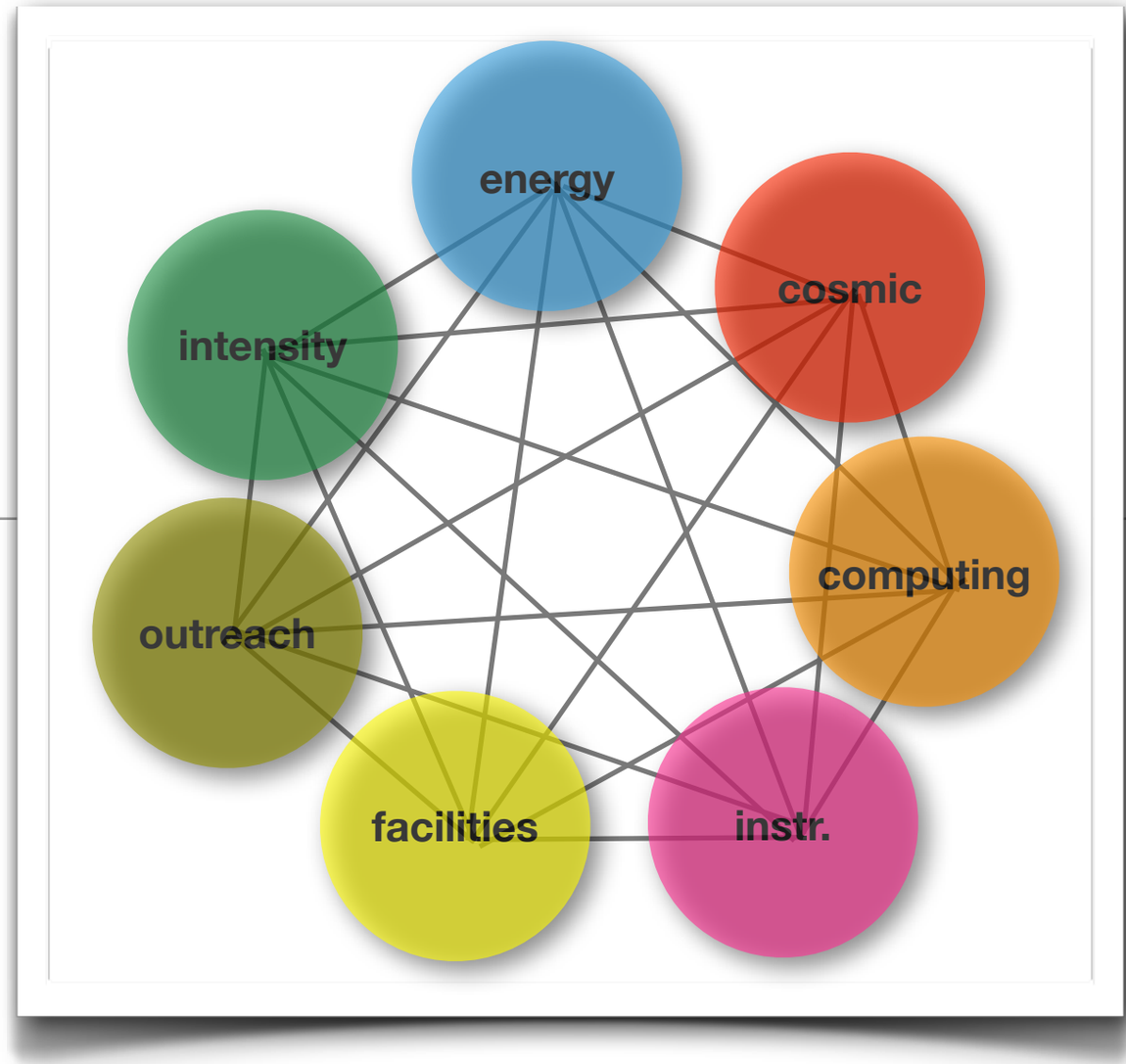

white papers: draft
white papers: final
July 2013
August 2013
September 2013
EPS
EPS
UW all hands
Snowmass, UMinn
DPF, UC SC
final SM2013 report
preliminary, bulleted list of conclusions
first draft 30 page writeup
final conclusions
final WG reports

problems/worries/ disappointments

- LHC physicists' participation in Snowmass is not proportional to LHC physicists' participation in LHC.*
- Europe has done its forward planning and seems not to understand Snowmass.*
- Overlap with the Instrumentation Frontier has not been as good as it should have been.*
- There have been some who publicly expressed disappointment that they weren't explicitly invited.
- There has been a reluctance to work outside of one's LHC tribe.
- Attention to the muon collider has been insufficient.*
- Angst about the future is mixed with giddiness about the future. We almost don't know how to talk.
- The three circles are simultaneously brilliant and terrible.

*Ask me if you want more detail.

we're currently trying to connect:



But we're considering additional connectivity

with 3 steps to get there:

1. We recognize and embrace

our new, exciting scientific reality

that now we're no longer guided by just 1 map

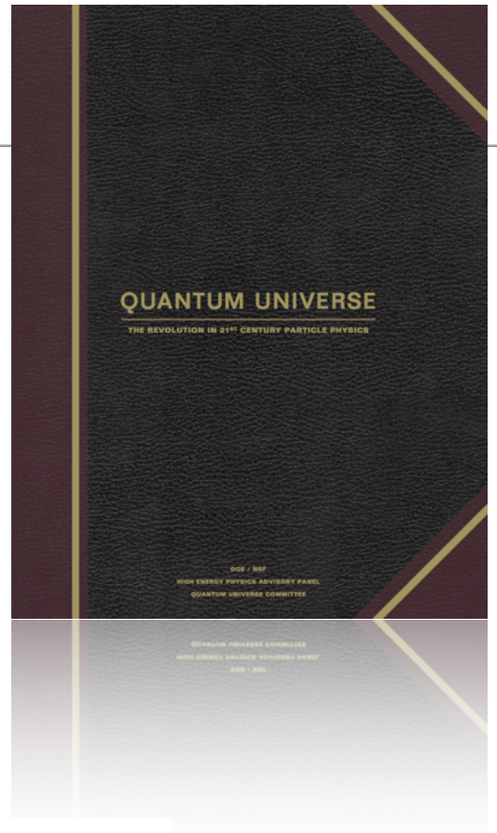
We're exploring among many paths

...to an unknown destination!

2. We agree on our shared challenges

Write down our "**Big Questions**"

to replace the famous HEPAP document



But I'm **NOT** proposing another glossy exercise

No.

I mean a professional enumeration of
the Primary Scientific Questions facing Particle Physics

We avoid things like:

Question: “Which is more important, measuring Higgs properties or neutrino properties?”

Our answer is of course: “Yes.”

Because the new physics

could come from anywhere

that’s **the point** of The Questions, plural

then:

3. We wrap all of Snowmass around them

The conclusions?

all point back to The Questions

The document?

prefaced by and organized around The Questions

The public rollout and subsequent publicity?

motivated by The Questions

a common theme

simple. easier to understand. easier to explain.

easier to use outside of hep. easier to track.

Different from Quantum Universe:

More professional

More specialized

We should include Big Questions of Computing, Instrumentation, and Accelerators!

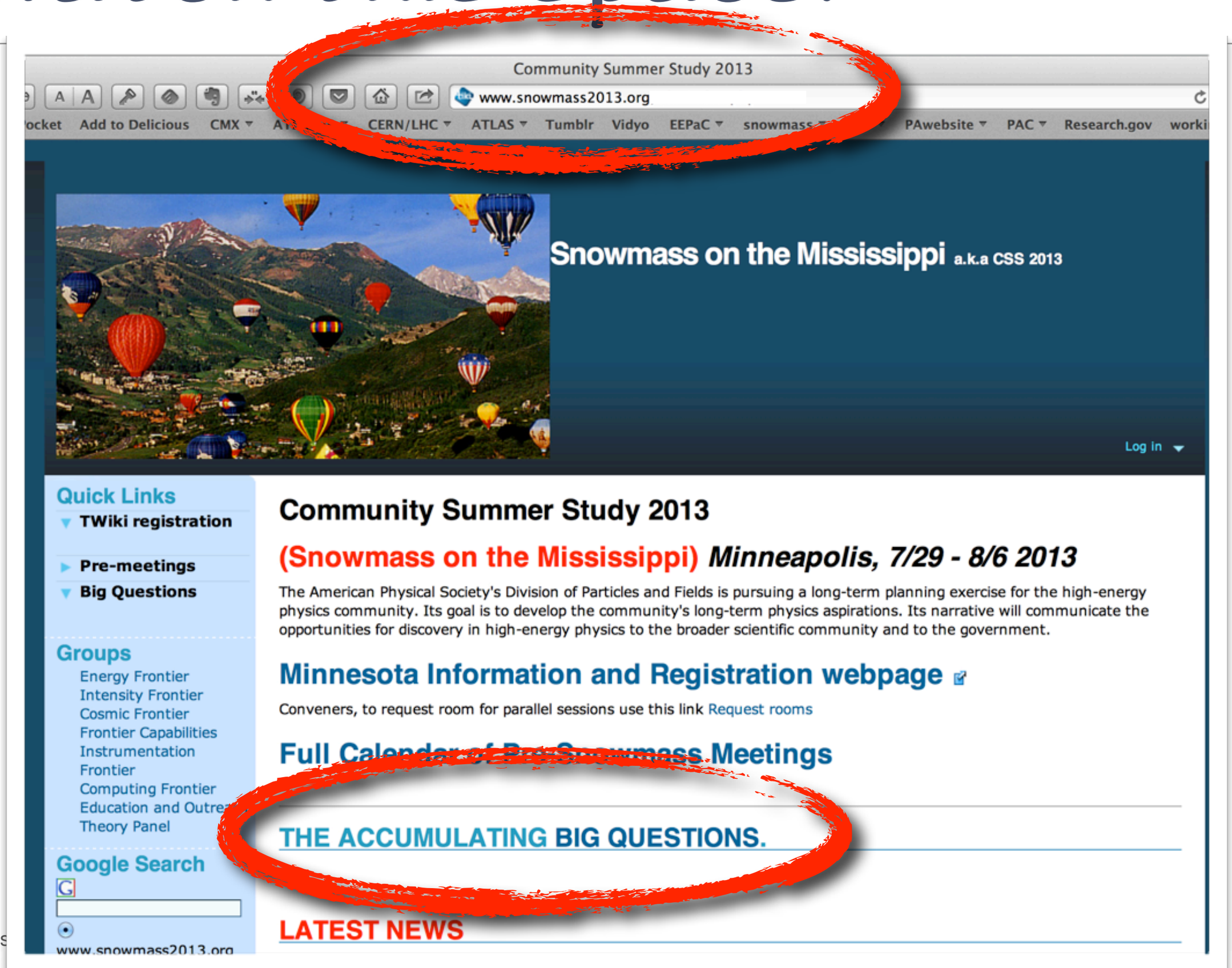
What Technical Questions stand in the way of answering the Physics Questions?

How do we do this?

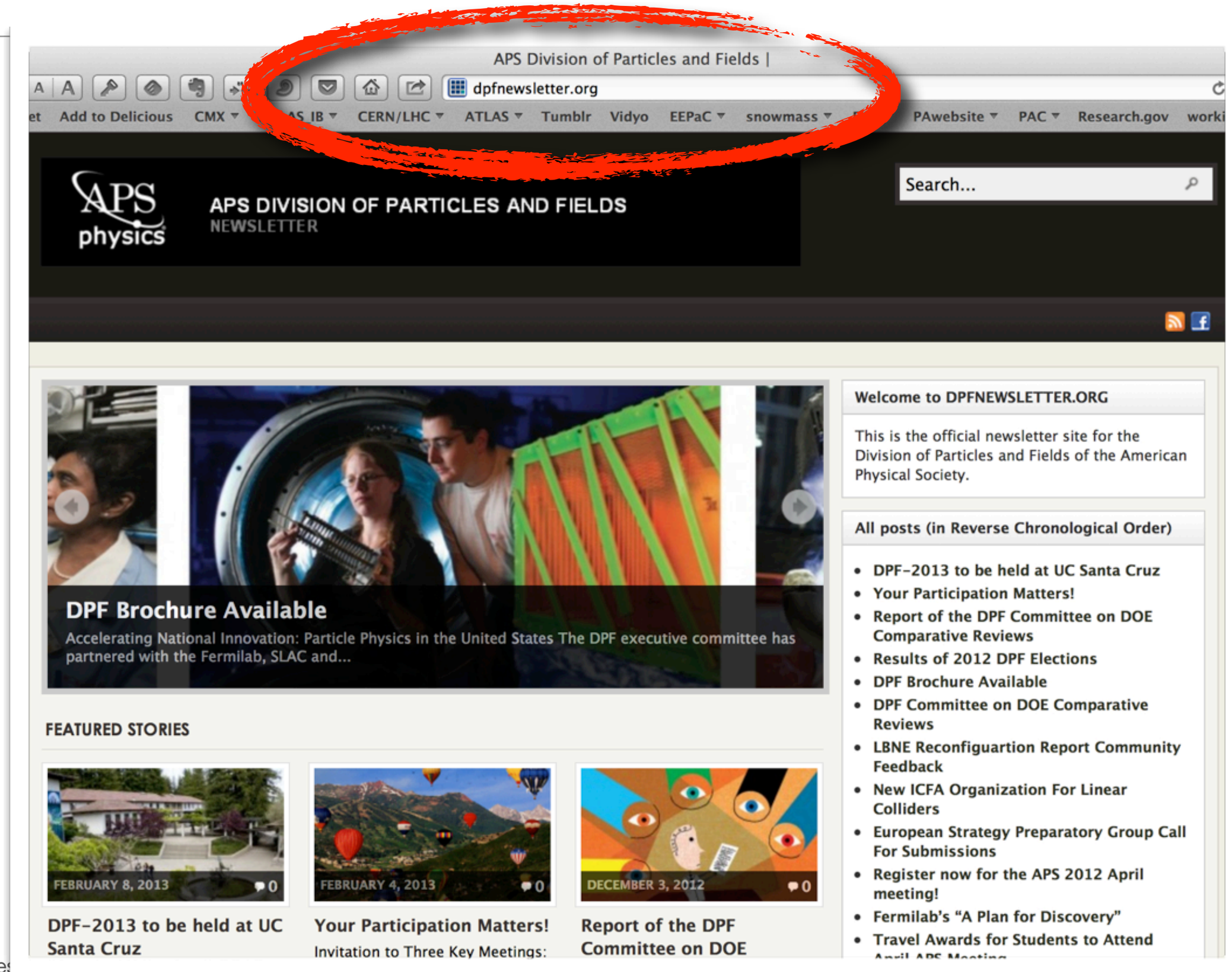
Trying to start a public discussion

http://www.snowmass2013.org/tiki-index.php?page=BigQuestions

watch this space:



and this one:


APS Division of Particles and Fields |
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DPF-2013 to be held at UC Santa Cruz
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Your Participation Matters!
Invitation to Three Key Meetings:
DECEMBER 3, 2012
0
Report of the DPF Committee on DOE
Welcome to DPFNEWSLETTER.ORG
This is the official newsletter site for the Division of Particles and Fields of the American Physical Society.
All posts (in Reverse Chronological Order)
DPF-2013 to be held at UC Santa Cruz
Your Participation Matters!
Report of the DPF Committee on DOE Comparative Reviews
Results of 2012 DPF Elections
DPF Brochure Available
DPF Committee on DOE Comparative Reviews
LBNE Reconfiguartion Report Community Feedback
New ICFA Organization For Linear Colliders
European Strategy Preparatory Group Call For Submissions
Register now for the APS 2012 April meeting!
Fermilab's "A Plan for Discovery"
Travel Awards for Students to Attend

How do we do this?

Trying to start a public discussion

http://www.snowmass2013.org/tiki-index.php?page=BigQuestions

Then plan among conveners on how to proceed

Invite additional people to a Questions Group?

Patty's list was a good group of people who were not asked to be conveners

Identify a facilitator?

In Minneapolis:

Agree on the set of Big Questions

as a committee of the whole

Commit to linking all conclusions to the Big Questions

In summary:

We could still use more participation in EF

esp the physics case for LHC Phase 2 upgrades

esp muon collider simulation (physics & bckgnds)

We would benefit from more wise people capable of enunciating a different kind of future.

But: Active core...the LHC experiments are now involved.

including each producing white papers