

The Ongoing Strategy Discussion in the U.S.

Joint ECFA-EPS session at EPS-HEP 2013

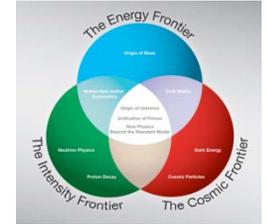
Stockholm; July 20, 2013

Andrew J. Lankford

HEPAP Chair

University of California, Irvine

The Ongoing Strategy Discussion in the U.S. - **Background**



U.S. particle physics is funded by two agencies:

- **Department of Energy (DOE) Office of High Energy Physics**
- **National Science Foundation (NSF) Physics Division**

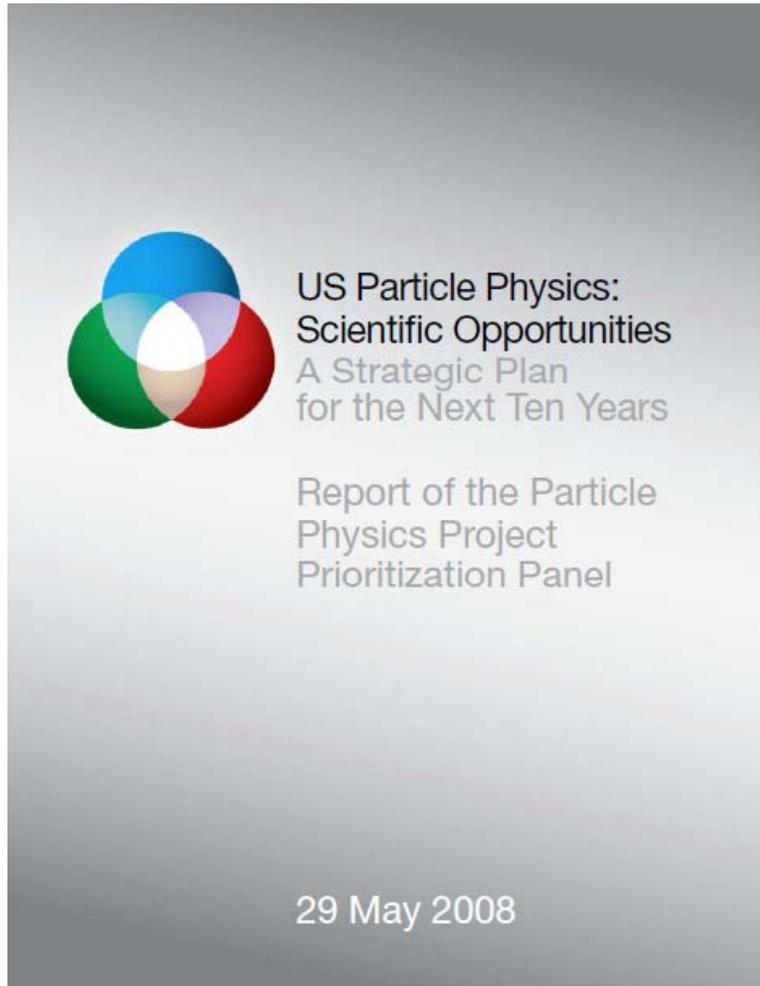
DOE & NSF advised by High Energy Physics Advisory Panel (HEPAP)

HEP program is guided by a “roadmap.”

- **Roadmap is traditionally prepared by a HEPAP “subpanel”**
 - **Subpanel is dubbed “P5” - Particle Physics Project Prioritization Panel**
- **Present roadmap dates from 2008**
- **Now involved in new multi-step planning process, to chart new roadmap**

The Goal of the “Roadmap”

Address fundamental questions about the laws of nature & the cosmos



The Quantum Universe

<http://www.interactions.org/quantumuniverse/qu/index.html>

**ARE THERE UNDISCOVERED PRINCIPLES OF NATURE:
NEW SYMMETRIES, NEW PHYSICAL LAWS?**

HOW CAN WE SOLVE THE MYSTERY OF DARK ENERGY?

ARE THERE EXTRA DIMENSIONS OF SPACE?

DO ALL THE FORCES BECOME ONE?

WHY ARE THERE SO MANY KINDS OF PARTICLES?

WHAT IS DARK MATTER?

HOW CAN WE MAKE IT IN THE LABORATORY?

WHAT ARE NEUTRINOS TELLING US?

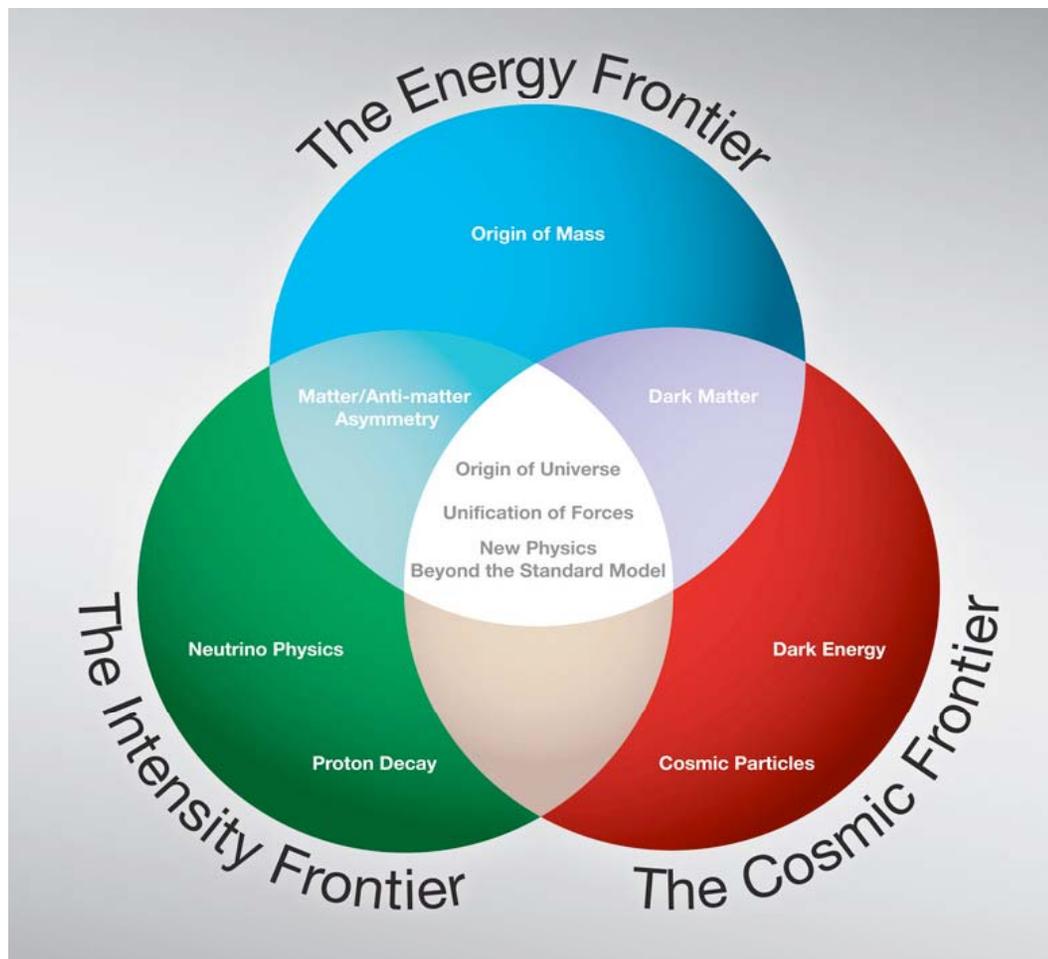
HOW DID THE UNIVERSE COME TO BE?

WHAT HAPPENED TO THE ANTIMATTER?

http://science.energy.gov/~media/hep/pdf/files/pdfs/p5_report_06022008.pdf

Vision of 2008 P5 :

To address these most important science questions through a balanced program on 3 frontiers



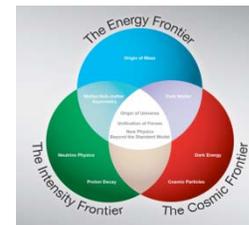
The three frontiers of research form an interlocking framework.

“The panel recommends a strong, integrated research program at the three frontiers of the field: the Energy Frontier, the Intensity Frontier and the Cosmic Frontier.”

A program that:

- continuously produces important results on each frontier
- harmonizes with the worldwide program

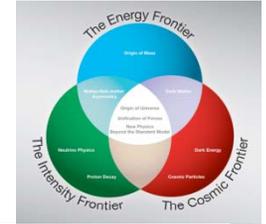
Major Recommendations of 2008 P5



- A strong, integrated research program at the three frontiers of the field: **the Energy Frontier, the Intensity Frontier, and the Cosmic Frontier.**
- **Energy Frontier:** Support for the US LHC program, including US involvement in the planned detector and accelerator upgrades. (**highest priority**)
- **Intensity Frontier:** A world-class neutrino program as a core component of the US program, with the long-term vision of a **large detector in the proposed DUSEL and a high-intensity neutrino source at Fermilab.**
- **Intensity Frontier:** Funding for **measurements of rare processes** to an extent depending on the funding levels available... (Mu2e)
- **Cosmic Frontier:** Support for the study of **dark matter and dark energy** as an integral part of the US particle physics program.
- A **broad strategic program in accelerator R&D**, including work ..., along with support of **basic accelerator science.**
- **These are still relevant, and this is still the plan.**

Strategic Planning

The need to prepare for the future

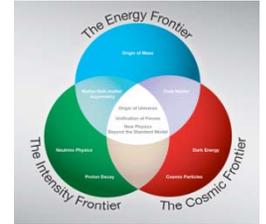


- **U.S. presently has a comprehensive program across the three frontiers,**
 - **In five years, initiatives now in progress will be largely complete,**
 - CMS and ATLAS Phase I detector upgrades will be installed at CERN.
 - NOvA, Belle-II, Muon g-2 will be running on the Intensity Frontier.
 - Mu2e will be in commissioning preparing for first data.
 - DES will have completed its science program, and new mid-scale spectroscopic instrument and DM-G2 should begin operation.
 - The two big initiatives, LSST and LBNE, will be well underway.
 - **Need to start planning now for what comes next**
- **Planning for the future is a multi-step process, in which each step will inform and prepare for the next.**
 1. **HEP Facilities Subpanel** (completed March 2013)
 2. **DPF/CSS2013 “Snowmass”** (culminates Summer 2013; report Nov 2013)
American Physical Society Division of Particles and Fields
Community Summer Study 2013
 3. **HEPAP/P5** (report mid-2014)

HEPAP FACILITIES SUBPANEL

HEPAP Facilities Subpanel

March 22, 2013



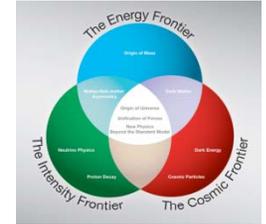
Provided advice to DOE Office of Science (SC) management

- “Letter” reports from advisory committees of each office in SC
HEPAP, NSAC, BESAC, etc.
http://science.energy.gov/~media/hep/hepap/pdf/Reports/HEPAP_facilities_letter_report.pdf
- In order to develop coherent 10-yr facilities plan across SC

Classified planned & proposed facilities

- Scientific impact
- Technical maturity
- More narrow in scope than Snowmass & P5 steps
 - Only facilities > 100 M\$ and ready for construction by ~2023
 - NOT intended to preclude add’l. ideas that emerge in subsequent planning
 - No rank ordering

Facilities Considered by Subpanel



Energy Frontier

Hi Lum LHC Accelerator
Hi Lum LHC detectors - ATLAS
Hi Lum LHC detectors - CMS

ILC (hosted in Japan) Accelerator
ILC (hosted in Japan) ILC Detectors

Higgs Factory

Intensity Frontier

Mu2e
LBNE

Project X Accelerator
Project X Detectors
nuSTORM

Cosmic Frontier

LSST
G3 Dark Matter
Next Generation Dark Energy

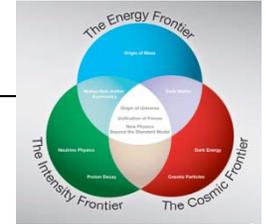
*facility plan not sufficiently well
defined to assess at this time
→ expect discussion at Snowmass*

Some projects that might be considered as particle physics are “stewarded” by DOE Office of Nuclear Physics, not OHEP: *e.g.*:

- Neutrinoless double-beta decay
- Relativistic Heavy Ions (RHIC, LHC)
- QCD at CEBAF

The facilities on list have generally been in planning, discussion, and on HEP roadmap for considerable time; those previously judged to be needed to address the most important science questions, on the 3 frontiers, in the near or longer term.

Summary of Facilities Subpanel Classifications



HL-LHC – *accelerator, ATLAS, CMS upgrades*

- Each: *absolutely central*
- Each: *significant scientific/engineering challenges to resolve before initiating construction*

Note: Classifications defined by charge.

ILC (hosted in Japan) - *accelerator, detectors*

Please read full report at:

http://science.energy.gov/~media/hep/hepap/pdf/Reports/HEPAP_facilities_letter_report.pdf

- Each: *absolutely central*
- Accelerator: *technically ready to initiate construction*
- Detectors: *significant scien./engin. challenges to resolve before initiating construction*

Mu2e: *absolutely central; ready to initiate construction (CD-1)*

LBNE:

- **1st stage (as defined by US scope):** *Important; ready to initiate construction (CD-1)*
Additional participation from international collaborators could significantly extend the science program of this first stage.
- **Full vision:** *Absolutely central*

Project X – *accelerator, experiments*

- Accelerator: *absolutely central; ready to initiate construction*
- Experiments: *absolutely central; mission & technical requirements not yet fully defined*

nuSTORM: *don't know enough yet; mission & technical requirements not yet fully defined*

DM-G3: *absolutely central; significant S&E challenges to resolve before initiating const'n*

LSST: *absolutely central; ready to initiate construction (CD-1)*

Next-Gen DE: *absolutely central; mission & technical requirements not yet fully defined*

SNOWMASS



SNOWMASS CSS 2013

ON THE MISSISSIPPI

JULY 29 – AUGUST 6, 2013

ORGANIZED BY THE DIVISION OF PARTICLES AND FIELDS OF THE APS
HOSTED BY THE UNIVERSITY OF MINNESOTA

STUDY GROUPS

- Energy Frontier
 - Chip Block (Michigan State)
 - Michael Peskin (SLAC)
- Intensity Frontier
 - JoAnne Hewett (SLAC)
 - Harry Weerts (Argonne)
- Cosmic Frontier
 - Jonathan Feng (University of California, Irvine)
 - Steve Ritz (University of California, Santa Cruz)
- Frontier Capabilities
 - William Barletta (MIT)
 - Murdoch Gikchese (LBNL)
- Instrumentation Frontier
 - Israel Duenyas (Argonne)
 - Howard Nicholson (Mt. Holyoke)
 - Ron Lipton (Fermilab)
- Computing Frontier
 - Lothar Bauerndick (Fermilab)
 - Steven Quisenberry (Indiana)
- Education and Outreach
 - Alger Bardeen (Fermilab)
 - Dan Cronin-Hennessy (Minnesota)
- Theory Panel
 - Michael Dine (University of California, Santa Cruz)

LOCAL ORGANIZING COMMITTEE

- Marcela Carena (Fermilab and University of Chicago)
- Dan Cronin-Hennessy (Minnesota, Chair)
- Prisca Cushman (Minnesota)
- Lisa Everett (Wisconsin)
- Alec Habis (Minnesota, Duluth)
- Ken Heller (Minnesota)
- Judy Kaplan (Minnesota)
- Yuichi Kubota (Minnesota)
- Jeremy Mans (Minnesota)
- Bridget McCoy (Minnesota)
- Marvin Marshak (Minnesota)
- Jarek Nowak (Minnesota)
- Keith Olive (Minnesota)
- Gregory Pawloski (Minnesota)
- Ron Poling (Minnesota)
- Marco Peloso (Minnesota)
- Yongzhong Qian (Minnesota)
- Roger Russek (Minnesota)
- Wesley Smith (Wisconsin)

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 - Lynne Orr (University of Rochester)
 - Yuri Gershtein (Rutgers University)
 - Nikos Varelas (University of Illinois, Chicago)
 - Robert Bernstein (Fermilab)
 - Sally Seidel (University of New Mexico)

WWW.SNOWMASS2013.ORG

POSTER DESIGN BY
KATIE SCHALOW

Goal: Identify compelling HEP science opportunities over an approximately 20-yr time frame

Not a prioritization, but can make scientific judgments

Deliverables:

“White papers”

Input to working group write-ups

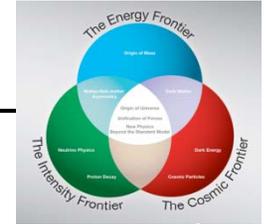
Report:

- **7x 30-page group write-ups + theory report**
w/ executive summaries input to overview

- **30-page Overview**

Analogous to Briefing Book of European Strategy Update

Snowmass - Overview



An extended program of work & discussion over many months culminating in a 9-day summer workshop

Organization:

7 groups: 3 research frontiers + 4 “infrastructure” areas

Energy	Instrumentation
Intensity	Facilities (“Capabilities”)
Cosmic	Computation
	Education & Outreach

Subgroups – each group has several subgroups

Timeline:

Initial plenary meeting – Fermilab, Oct. 2012

Many preparatory meetings held since

Snowmass on the Mississippi – Univ. of Minnesota, 29 July – 6 August 2013

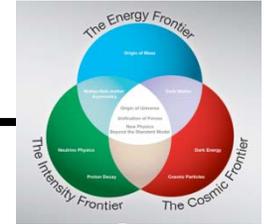
Mo 29 July - plenary talks set forth physics questions

30 July – 4 August - inter-frontier discussions; plenary panels

Mo-Tu 5-6 August - plans to address physics questions

<https://indico.fnal.gov/conferenceTimeTable.py?confId=6890#20130729.detailed>

Snowmass - Energy Frontier Goals



Energy Frontier Goals:

Concrete Goals: the science cases

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

at design specifications with $\int \mathcal{L} dt \sim 100 \text{ fb}^{-1}$?

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?

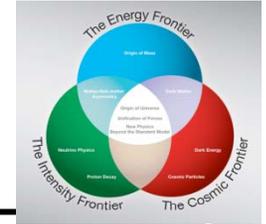
A high energy LHC?

High energy lepton collider?

Lepton-hadron collider?

VLHC?

Energy Frontier – Physics Studies



Physics studies for science cases:

Higgs:

- clarification of Higgs coupling accuracies obtainable from proposed machines
- prospects for discovery of additional Higgs bosons

Electroweak:

- future accuracies in measurement of EW observables (esp. m_W)
- prospects for measurement of W boson interactions and couplings

Top:

- future accuracies in the measurement of the top quark mass and couplings
- search for new particles related to top (vectorlike T, resonances)

New Particles, Forces, and Dimensions:

- searches for all new particles not mentioned above, up to 100 TeV pp
- implications of particle discoveries in terms of a future program

QCD:

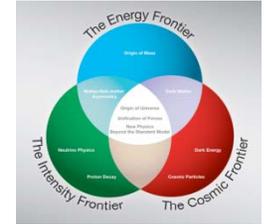
- future accuracies in parton distributions, α_s , multijet observables

Flavor at High Energies:

- sources of flavor violation from new physics, and collider observables

Snowmass - Cosmic Frontier

Scope & Organization



Dark Matter

CF1: WIMP Dark Matter Direct Detection

CF2: WIMP Dark Matter Indirect Detection

CF3: Non-WIMP Dark Matter

CF4: Dark Matter Complementarity

CF5: Dark Energy and CMB

Cosmological distances

Growth of structure

Cross-correlations

Novel probes of dark energy

Inflation

Neutrinos in the cosmos

CF6: Cosmic Particles and Fundamental Physics

Cosmic rays, gamma rays, and neutrinos

The matter of the cosmological asymmetry

Exploring the basic nature of space & time

Cosmic Frontier



Snowmass on the Mississippi a.k.a CSS 2013

Log In

Quick Links

▼ TWiki registration

▼ Pre-meetings

Community Planning Meeting
All pre-Snowmass Meetings

▼ Big Questions

Groups

Energy Frontier
Intensity Frontier
Cosmic Frontier
Frontier Capabilities
Instrumentation
Frontier
Computing Frontier
Education and Outreach
Theory Panel

Google Search

www.snowmass2013.org
WWW

Cosmic Frontier

Conveners: [Jonathan Feng](#) (UC Irvine), [Steve Ritz](#) (UC Santa Cruz)

ANNOUNCEMENTS

June 11, 2013: The [Snowmass in Minnesota agenda](#) is online and under construction.

May 28, 2013: [Snowmass on the Pacific](#) takes place this week at KITP Santa Barbara. For the talks and discussions, see the [videos](#) and [slides](#).

May 15, 2013: [Registration for Snowmass in Minnesota](#) is now open for non-DOE lab employees.

May 7, 2013: [Dark Matter in the Coming Decade: Complementary Paths to Discovery and Beyond](#) now available at [arxiv:1305.1605](#).

February 14, 2013: [Cosmic Frontier Workshop](#) participants are encouraged to [register](#) as soon as possible. For the meeting schedules, see the [Cosmic Frontier Workshop agenda \(Wed-Fri\)](#) and the [DURA Annual Meeting agenda \(Tues\)](#) and the [AARM Agenda \(Monday\)](#). The [Intensity Frontier's Neutrino Subgroup Workshop \(Wed-Thu\)](#) will also be running concurrently with the [Cosmic Frontier Workshop](#).

October 20, 2012: The [Cosmic Frontier Workshop](#) will be held March 6-8, 2013 at SLAC. SLAC Guest House rooms may be reserved now through the [workshop website](#); registration will be open in December. The meeting will be joint with the [Non-Accelerator Subgroup of Frontier Capabilities](#), and is being organized in coordination with meetings of DURA on March 5 and AARM on March 4.

October 13, 2012: Thanks to all who participated in the Cosmic Frontier sessions of the Community Planning Meeting. Talks given there are posted on the [CPM agenda page](#).

October 3, 2012: Drafts of all subgroup charges are posted. Comments to subgroup conveners welcome.

August 3, 2012: Subgroup Conveners are now posted. Many thanks to all who provided inputs and especially to all those who have agreed to serve as conveners.

June 20, 2012: We are currently soliciting community input for subgroup conveners, topics, and experiments (see below).

For each area, a census of projects (current and planned), with common metrics.

Including sets of “tough questions”

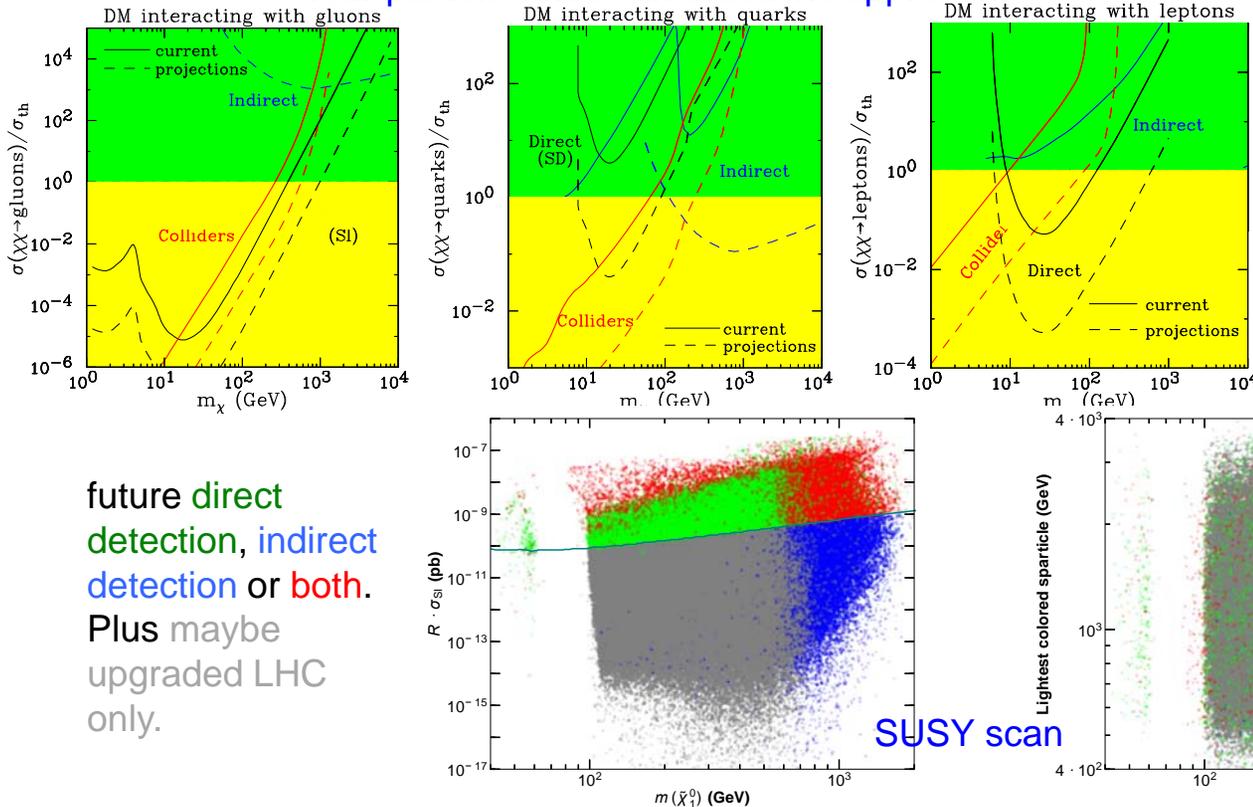
Dark Matter Complementarity

See arXiv:1305.1605

Direct Detection

Relic scattering locally, at low energy. Push to larger target mass, lower backgrounds, directional sensitivity

four-particle contact interactions approach:



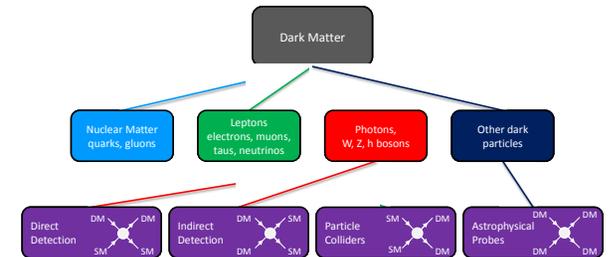
future **direct** detection, **indirect** detection or **both**. Plus maybe upgraded LHC only.

Indirect Detection

Interactions (via annihilations, decays) with SM particles. Understand the astrophysical backgrounds in signal-rich regions, and reveal the distribution of dark matter.

Accelerators

Direct production. Push to higher energy



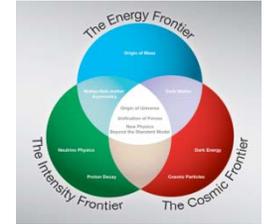
Observations

Push toward finding and studying galactic halo objects and large scale structure.

Simulations

Large scale structure formation. Push toward larger simulations, finer details.

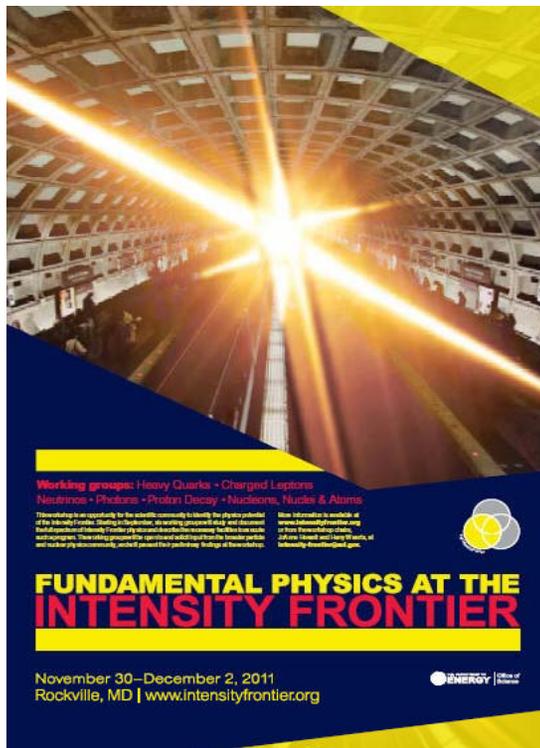
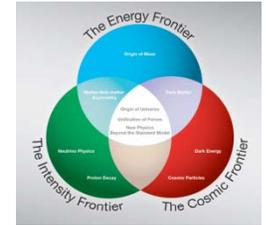
Cosmic Frontier: Sample “Tough Questions”



- **What would it take to convince ourselves that we have:**
 - a discovery of dark matter?
 - discovered two different species of DM?
 - discovered ALL of the dark matter?
 - a false signal of a dark matter discovery?
- **If the dark matter particle is detected through non-collider experiments, what can we learn about its properties? (e.g., can we learn its spin?)**
- **If there is more than one type of dark matter particle, how can we discover this in Cosmic Frontier experiments? Can we measure the dark matter fraction from different sources?**
- **What are the roles of optical and CMB surveys for particle physics?**
 - **What, specifically, can we learn about neutrino properties, dark energy, dark matter, and inflation, and to what precision?**
- **What are the roles of cosmic-ray, gamma-ray, and neutrino experiments for particle physics? What future experiments are needed in these areas and why? Are there areas in which these can have a unique impact?**

Intensity Frontier

Snowmass IF activity builds on the work accomplished by the 2011 IF workshop & 2012 report.



~440 participants

IF Working Groups

Quark Flavor Physics

K,D,B meson decay/properties

Charged Lepton Processes

Precision w/ muons, taus

Neutrinos

Accelerator & non-accel.

Baryon Number Violation

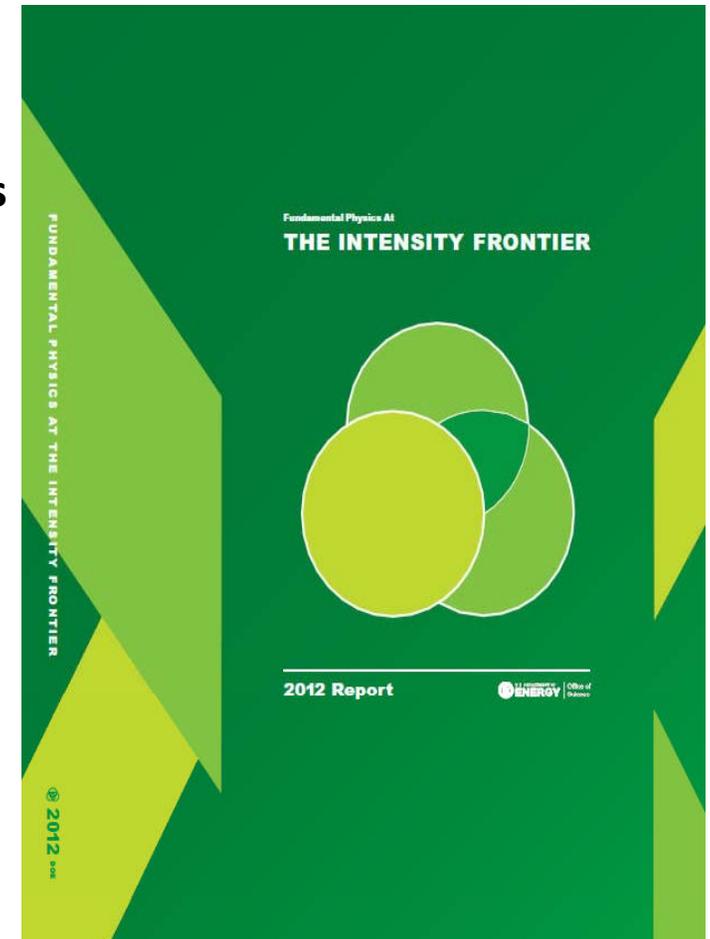
p-decay, n-oscillation

New Light, Weakly Coupled Particles

“dark” photons, paraphotons, Axions, WISPs

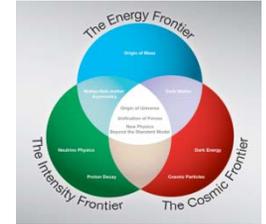
Nucleons, Nuclei & Atoms

Properties as related to HEP
e.g. EDM



arXiv:1205.2671

Intensity Frontier

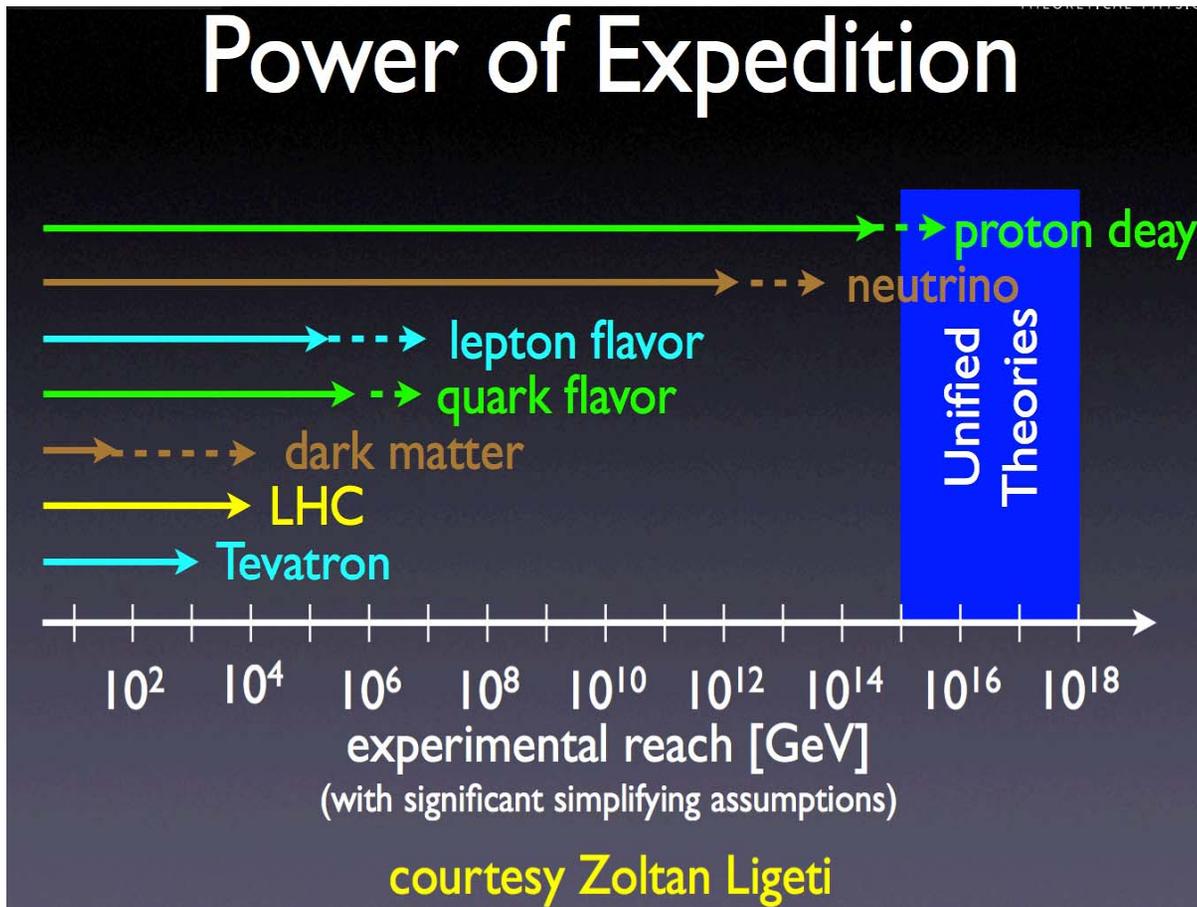


Two main themes of the Intensity Frontier:

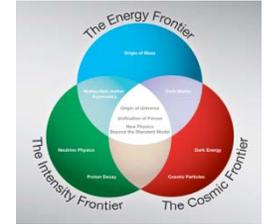
- Explore Symmetry Violation in Nature
 - *CP, baryon, lepton number violation*
- Explore High Energy Scales
 - *IF explores very, very, very high energies!*

Many interesting, fundamental questions:

- Are there new sources of CPV?
- Is there CPV in the leptonic sector?
- Are ν 's Majorana or Dirac?
- Do the forces unify?
- Is there a weakly coupled Hidden Sector linked to DM?
- Are apparent symmetries (B,L) violated at high scales?
- What is the flavor sector of new physics?
- Can we expand the new physics reach of the EF?



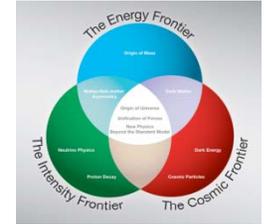
Accelerator Capabilities



R&D needs to address the “big questions” of the field.

- **Highest priority for accel. R&D is strong support for US participation in HL-LHC**
 - *An additional high priority: enhanced SC magnet R&D for a possible LHC energy upgrade or new machine*
 - *Strong interest shown in the opportunity for developing 80 - 100 TeV proton collider*
- **Strong support for a Japanese ILC initiative**
 - *Critical supporting R&D for US to perform: Superconducting RF, high power targetry*
 - *Super flavor factories provide accelerator physics relevant to EF colliders*
- **Are multi-TeV lepton colliders possible? Practical?**
 - *Increase muon accelerator R&D to determine TeV collider feasibility within 10 years*
 - *Can plasma accelerators deliver luminosity relevant to HEP? Perhaps an ILC afterburner post-2025?*
- **Linacs & cyclotrons can provide multi-MW beams for several proposed experiments in US & overseas (strongest emphasis is neutrino physics)**
 - *R&D identified to quantify limiting physics and technologies*
 - *Target design is highly expt.-dependent. How long can multi-MW targets survive?*
 - *Can accelerators be made much cheaper to build & operate? per GeV? Per MW?*
- **Integrated system tests are needed for several promising accel. technologies**

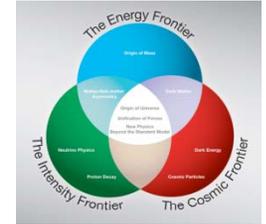
Non-Accelerator Capabilities



- **Focus on underground facilities that are critical to science goals: direct dark matter experiments, important aspects of neutrino physics and astrophysics, proton decay and others.**
- **About 1000 U.S. scientists are currently working underground (and ice)**
 - **About ½ currently work at U.S. run facilities (including Antarctica)**
 - **Indications of 30-50% growth desired over the next decade**
- **Substantial expansion in undergrd labs in last 3-4 years (Canfranc, CJPL, Snolab, SURF...)**
- **Expansion of underground facilities outside the US is planned to continue (INO, CJPL expansion, Modane extension, YKK in Korea, ANDES, repurposing at Gran Sasso areas now serving neutrino beam from CERN,...) and potentially big underground detectors (Hyper-K, Daya Bay II,...)**
- **Space, depth and other requirements under study for Snowmass meeting.**
- **Evolution of undergrd. facilities in US is related to future of LBNE at Homestake**
 - **Location of LBNE underground, with substantial intl. participation, is strongly desired**
 - **Would potentially enable a broader program of science at an undergrd facility in the US**

Community Summer Study 2013

Snowmass - Summary



Goal: Identify compelling HEP science opportunities over an approximately 20-yr time frame

Preparations: A massive study by a large number of people

Thank you to DPF, conveners, and all participants!

Workshop: 29 July – 6 August 2013; Minnesota

>500 currently registered

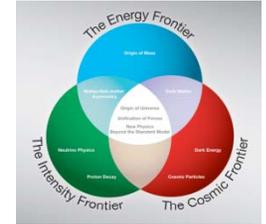
Report: 1 November 2013

~300 pp

Informs the subsequent P5 roadmap (prioritization) process

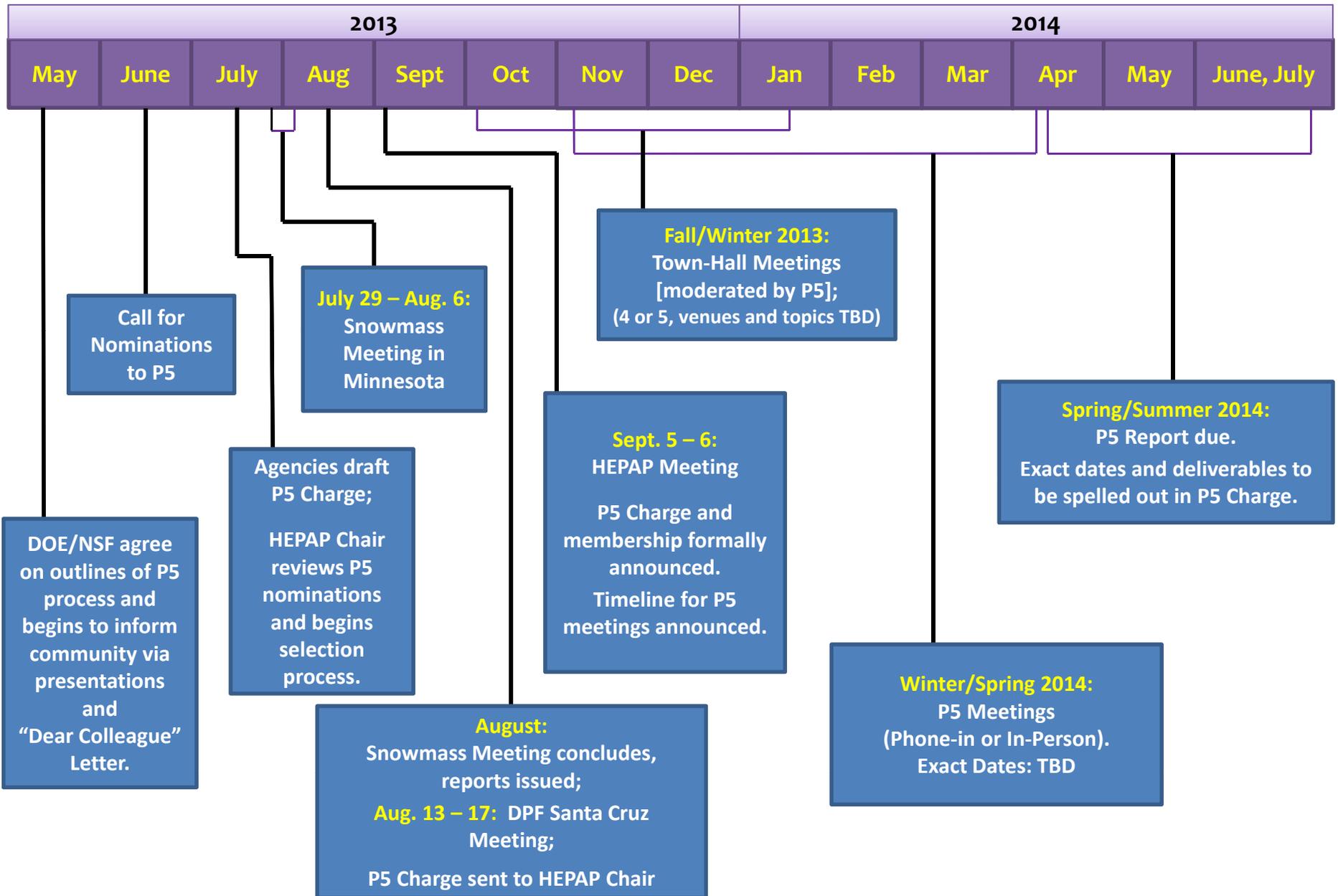
P5

Goal of the P5 Process

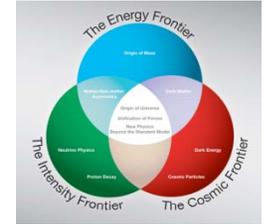


- **The P5 process takes the science vision of the community and turns it into a plan that is feasible and executable over a 10-20 year timescale.**
- **Particle Physics Project Prioritization Panel (P5)**
 - **HEPAP subpanel, appointed by HEPAP Chair**
 - **Reports to HEPAP, which reviews & approves report and submits to agencies**
- **Key elements envisioned for the P5 process:**
 - **Build on the investment in the Snowmass process and outcomes**
 - **4-5 public meetings, w/ “town hall” component for community input/discussion**
 - **Revisit the questions we use to describe the field**
 - e.g., updating those of the *Quantum Universe*
 - **Decide on the project priorities within budget guidance from agencies**
 - in detail for the next 10 years, in broad outline beyond that
 - **Propose best way to describe the *value* of HEP research to society & other science**

DRAFT P5 Timeline



Some Challenges to Strategic Planning



Scientific opportunities & project concepts exceed budget constraints.

- **Prioritization is required**

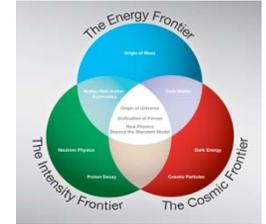
National/regional planning occurs in a global context.

- **Program is global; funding is national/regional.**
- **Optimal progress in HEP requires:**
 - **US access and intellectual contributions to science facilities overseas.**
 - **Offering facilities in the U.S. that fit the global program and that serve the worldwide scientific community, while providing intellectual opportunity within the U.S.**
- **Planning must define US role as a participant in the global HEP program,**
 - **As a participant in international experiments/facilities overseas**
 - **As a host of international experiments/facilities in US**
 - **This model has worked in the past, but is more challenging now w/ big facilities.**

Proper balance is needed between short-term achievements & long-term goals.

- **Steady achievement demanded by decision makers; required for training/career development.**
- **Ongoing investment in R&D and in construction required for long haul.**

Conclusion



Strategic planning for U.S. HEP program is in progress.

- **Community study of scientific opportunities is culminating.**
- **Roadmap (P5) step is in preparation; will complete in Summer 2014.**

Recent HEP results ⇒ An exciting time, of momentous opportunity

Significant, fundamental scientific questions to be addressed

Concepts and technologies exist to address these questions

The challenge (the biggest challenge) is fiscal.

How to mount a program of significant experiments and significant opportunity within funding constraints?

A well-formulated global vision/program is needed to address this challenge.

US planning discusses US facilities and international participation in the context of worldwide program.