Snowmass Highlights and Message Distillation

What did we learn and how can we communicate it?
Next Steps….

Prisca Cushman July 26, 2022


Timetable
Mon 18/07
Tue 19/07
Wed 20/07
Thu 21/07
Print
Timetable
Sat 16/07
Sun 17/07
Mon 18/07
Timetable
Sun 17/07
Mon 18/07
Tue 19/07
Wed 20/07
Thu 21/07
Fri 22/07
Sat 23/07
Print
PDF
Full screen
Detailed view
Filter
OMG
Sun 24/0
Print
PDF
Full screen
Detailed view

Goal of the Snowmass Community Study

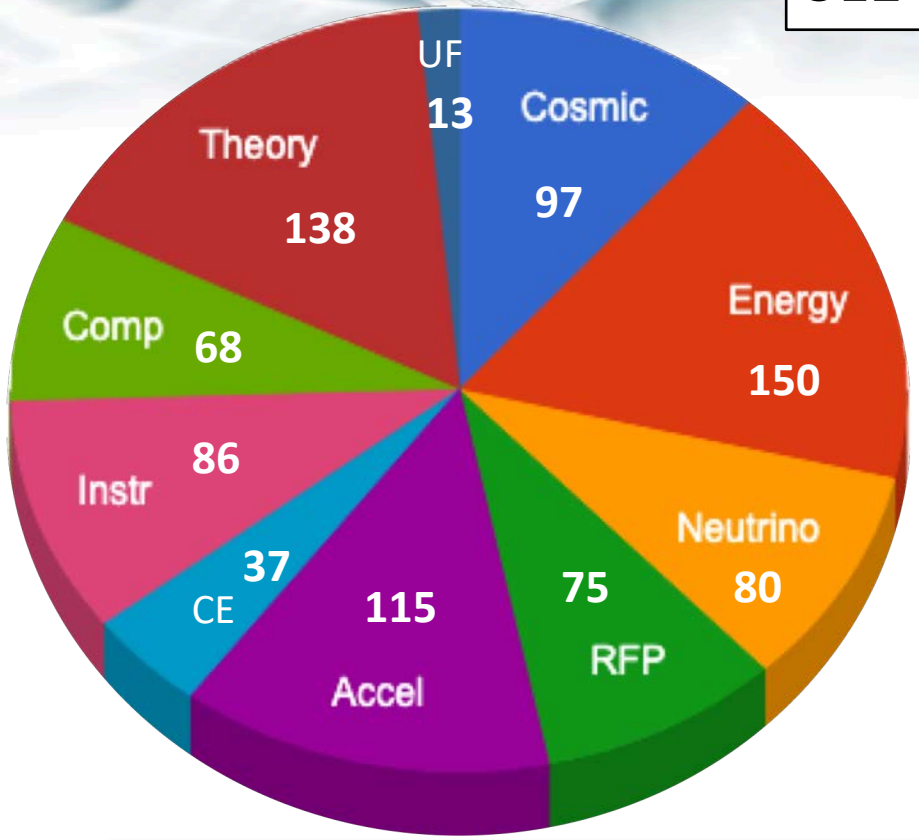
To identify the most important questions in Particle Physics and the tools and infrastructure required to address them

The Science ➔ Elucidate the major questions and map their connections across research areas

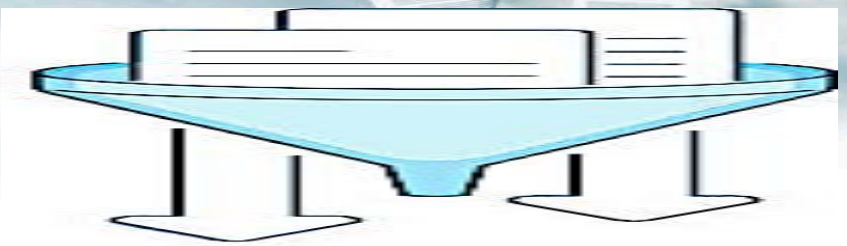
The Process ➔ Define the tools (Accelerators, Detectors, Computation, Theory)
Enable the Researchers (Training, DEI, Outreach)

The Message ➔ Frame these into a compelling and shared scientific vision for the field
Communicate our vision to different stakeholders
e.g. P5, NASEPP, US HEP community, International Partners, law makers, tax payers….

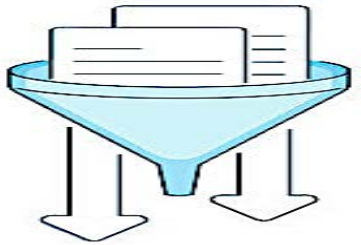
Getting there…



512 White Papers



79 topical group reports



10 Frontier Summaries

And lots of meetings and presentations and plots along the way

Executive Summary by October

Bottoms-up Exercise: View from the Frontiers

1. Write down the one or two most important messages coming out of your frontier.
   Imagine writing it to your departmental chair or lab head

2. Name the frontier whose activities (science, technology, human resources) will be ***most*** impacted by progress in your frontier, with enough detail to remind people why.

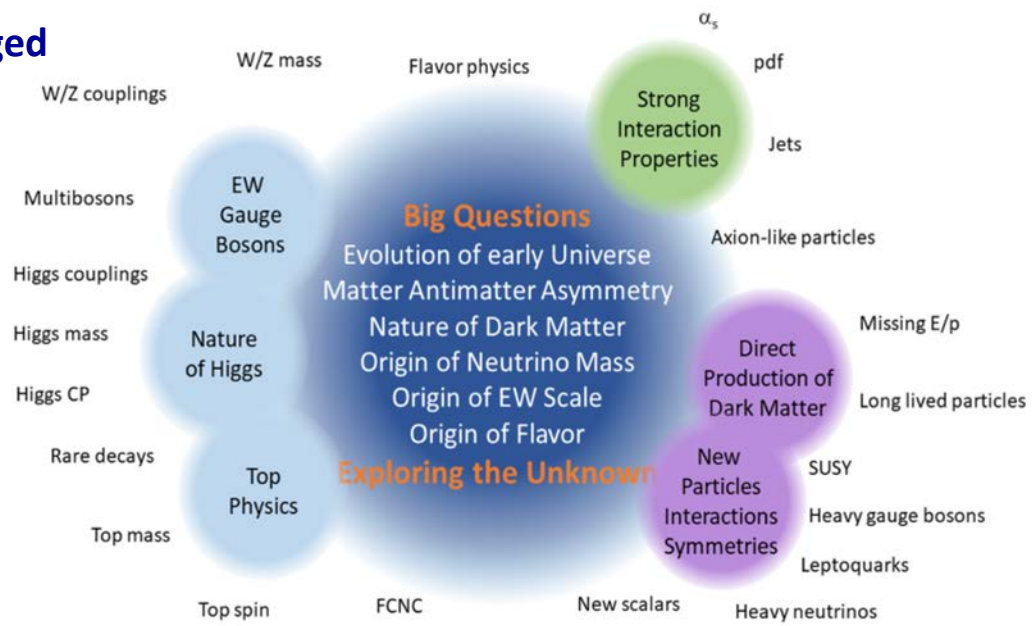
3. What was the most surprising thing about your frontier that you learned at Snowmass?

Energy Frontier (Message)

- **Compared to Snowmass 2013 the physics landscape has significantly changed**
  - The program of measuring the Higgs boson properties is well underway at the LHC with growing precision
  - A broad range of searches have explored multiple BSM scenarios without convincing evidence of new physics
  - The HL-LHC is an approved project

- **Without a robust support for the HL-LHC and a clearly defined path towards a Higgs factory we leave critically important physics unchecked and crucial questions unanswered**

- **The EF community should be prepared to explore a broad range of BSM phenomena at the 10 TeV mass scale**



The Energy Frontier community voices a strong support for

1. **HL-LHC operations and 3 ab^{-1} physics program, including auxiliary experiments**
2. **The fastest path towards an e^+e^- Higgs factory (linear or circular) in a global partnership**
3. **A vigorous R&D program for a multi-TeV collider (hadron or muon collider)**

Energy Frontier

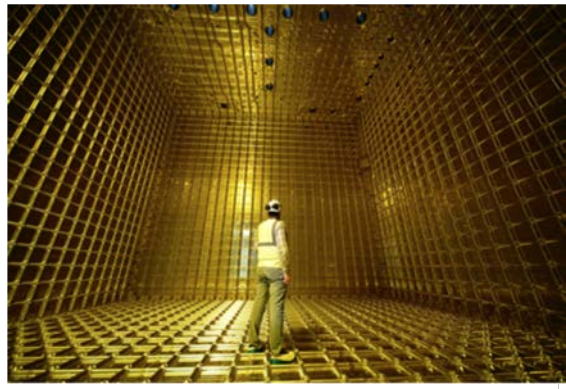
The Energy Frontier is >50% of the US HEP community, therefore the potential impact on CEF (governmental advocacy, workforce training, diversity and inclusion) are critical to the progress of HEP

The most surprising thing that emerged from Snowmass was an <u>overwhelming sentiment to engage in hosting a future collider in the US</u>

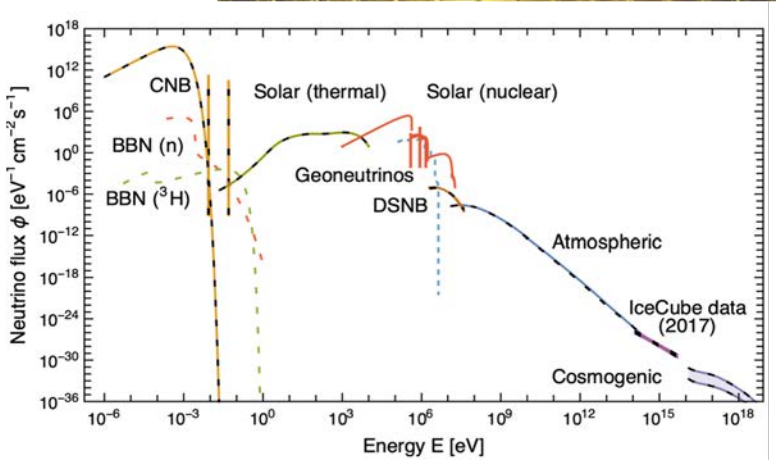
…and the public praising of EF by Michael Peskin for enabling a vigorous discussion on future multi-TeV colliders

Neutrino Frontier

* We need to **finish DUNE**, and its broad physics program.
  Both Phase I and Phase II are required to complete the original DUNE design.
* We are excited about long-term, broader possibilities that make use of our investment in the facility and could expand the DUNE scope beyond that originally envisioned.
* A healthy program of projects of different sizes and time scales, with wide-ranging connections is highly desired and very much needed.



Impacts everywhere! But if we have to choose it's the Cosmic Frontier, due to deep connections and intertwined BSM searches in multiple areas.



Neutrinos are tools for astrophysics and cosmology. Astrophysics and cosmology provide insight into NF physics.

<u>What surprised us?</u> Great technical progress on the detectors!
Well, that was not totally a surprise– but it was even more impressive than expected!

Rare And Precision Frontier

Message

The physics of flavor must have greater emphasis in the US program
with a **new science driver** to uncover the mystery of generations and probe new physics

Flavor Physics, Dark Sector searches, studies of exotic hadrons, and fundamental symmetry tests make unique contributions to the science driver ”explore the unknown: new particles, interactions and physical principles”

Intersections Outward

- Neutrino and Energy Frontier physics will be profoundly affected by what we learn
- Experimental synergies with nuclear and AMO will enrich our program
- Phenomenology and lattice QCD calculations are key to achieving our goals
- Synergies with instrumental & computing efforts will improve sensitivities and cost

Most Surprising

- How unified we really are – even without the focus of a machine or particle, we found we have a shared sense of purpose and intellectual questions
- How well we did despite COVID. You’re all amazing! (especially UW!! 👏)

Cosmic Frontier

The Cosmic Frontier is the bedrock of the field in the 21st century. CF realizes the HEP vision in all its scales and provides a compelling science case on which much of the current HEP program is based. In the next decade, CF will address the most pressing questions facing fundamental physics today, aiming to discover the identity of dark matter, understand the physics of cosmic acceleration, and search for new particles, new forces, and new principles of Nature.

CF seeks increased research support to execute the science goals of all projects in its portfolio, including new funding for cross-survey science leveraging the recently-completed projects DESI and LSST.

Our top project priority is to complete construction CMB-S4, while launching new projects to delve deep and search wide for dark matter, as well as to make the next leap in dark energy and cosmic acceleration research.

Cosmic Frontier

Intersections outward

A discovery in CF would have huge effects on many other frontiers.

* Observation of a WIMP-like particle would clarify the needs for a new accelerator to serve the Energy Frontier as a 'Dark matter factory'.
* Discovery of new weakly-interacting particles and forces would sharpen searches for long-lived particles in forward facilities (EF) and beam dump experiments (RPF and NF).
* Cosmic Frontier offers a unique probe of the neutrino masses, which would also impact the prospects for study of the properties of neutrinos (NF).

Surprising lessons learned at Snowmass

Significant inroads will be made into the vastly expanded dark matter parameter space in the next decade. The CF experimental program for dark matter has grown in maturity and discovery potential since the last Snowmass. We may be on the brink of discovery!

Cosmic surveys are advancing in leaps towards understanding dark energy and cosmic acceleration.
With CMB-S4, for example, we are progressing beyond just measuring the energy scale of inflation to also measuring its dynamical interactions by measuring scattering amplitudes via events imprinted in the sky!

Theory Frontier

- Theory is essential to the field of particle physics, unifying the frontiers and producing transformative science both in connection to projects and in its own right.
- It is central to the motivation, analysis, and interpretation of experiments; lays the foundations for future experiments; and advances our understanding of Nature in regimes that experiments cannot (yet) reach.

Intersections Outward					
AF	CompF	CF	EF	NF	RPF
Motivation	Motivation, algorithms, tools	Motivation, analysis, interpretation			

Biggest surprise: how deeply interconnected the many facets of theory truly are, from fundamental to phenomenological to computational theory, and how completely interwoven they are with the other frontiers.

Image Credits: Flip Tanedo (L) and Jesse Thaler (R)

Accelerator Frontier

Message

- The accelerator community has technology and expertise to address the next generation accelerator.

- By the time of next Snowmass/P5 a National Future Colliders R&D program (new initiative!) should consider international and US based options and carry out technical and design studies sufficient to make informed decision on future directions toward
    - Higgs/EW factories
    - 10 TeV/parton colliders.

Intersections: Progress in accelerators will critically impact all future particle physics endeavors (neutrinos, colliders, DM) and therefore R&D should be prioritized by P5 inclusively

accelerators need to be part of the P5 charge.

Full utilization of the unique proton power capability of the upcoming PIP-II accelerator should be developed by the HEP community (use remaining 98% of full beam power).

Surprising Thing this week at Snowmass:

We seem to be clever enough to be seriously taken by the Theory Frontier (they even did argue with us)…

Instrumentation Frontier

- We need to *double* the US Detector R&D budget over the *next five years* and modify existing funding models to enable R&D Consortia along critical key technologies for the planned long term science projects, and sustain the support for such collaborations for the needed duration and scale.

- Develop and maintain the critical and diverse technical workforce and enable careers for technicians, engineers and scientists across disciplines working in HEP detector instrumentation, at laboratories and universities.

Intersections: *CF, EF, NF and RPF are most affected by progress in IF, since advances in detector instrumentation enable scientific advances in ALL science frontiers.*

Comparing to 2013 Snowmass, we independently came to the same five key messages. Nothing has changed and significant investment is still needed for instrumentation.

➔ Strong turnout for IF at Snowmass. Now we need equally strong support from the community!

Computation Frontier

Message: The size and complexity of the Software and Computing (S&C) is commensurate with that of the experimental instruments, but S&C changes on a faster timescale than facilities, experiments, and surveys. We need an entity that can continuously promote, coordinate, and assist on S&C needs. We propose a new DPF panel that can inform HEPAP.

Intersection outward: Everyone needs software and computing, even instrumentation and theory. Without computing, there will be a higher cost or lost science.

- TF report states they would like computers at the 10 exaflop speed, just as we get the first exaflop computing
- Both CMS and ATLAS see a large gap between how much storage (disk) they can afford and what will be required, unless they engage in R&D to improve storage efficiency.
- Tools like Geant4 that are critical for the work of the four physics frontiers, instrumentation, and underground facilities are largely unfunded. This is one example of a tool that is really critical to HEP (in fact, it is one of the most cited HEP papers of all time!) and yet does not squarely fit into an existing funding structure.

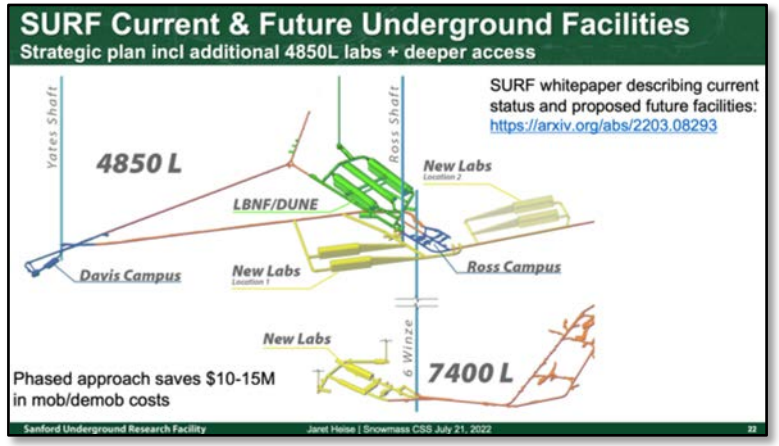
Surprisingly, some colleagues seem to fail to recognize the enormous physics content of the software and computing endeavor within HEP, unlike the case of instrumentation, where the physics content is recognized.

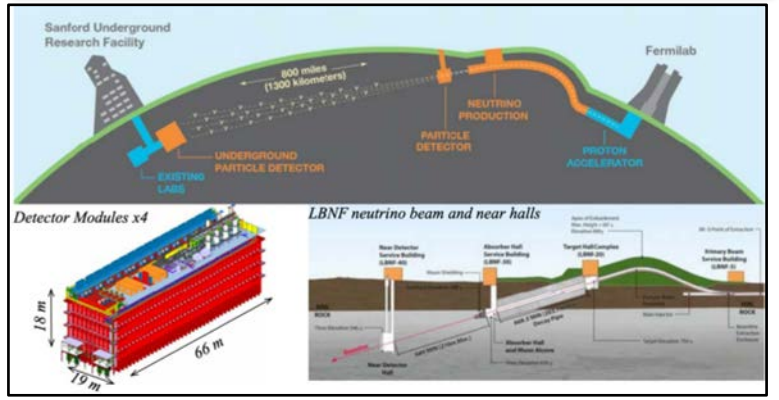
Underground Facilities & Infrastructure Frontier

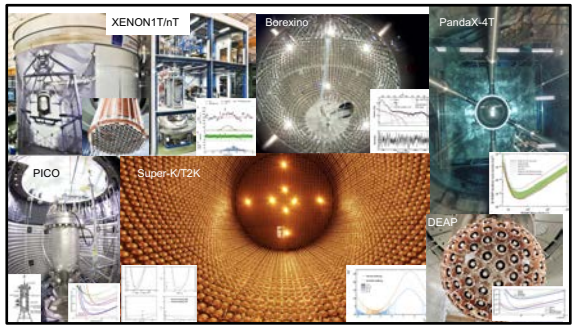
1. **Key message:**
   - Establish *SURF as an underground User Facility*.
   - Ensure support to *complete and operate LBNF and DUNE*.
   - Immediately pursue opportunities to create *underground facility space for G3 dark matter* as recommended in 2014 P5 report.

2. **Intersections outward:**
   - **Neutrino Frontier:** LBNF and DUNE, *long-baseline neutrino science*, are key U.S. high energy physics programs relying on underground facilities.
   - **Cosmic Frontier:** Establishing a commitment to underground facilities for a large-scale *third generation direct detection dark matter* program is a major impact of planning efforts.

3. **Most surprising ("Most exciting" is more apt):**
   - Incredible *progress* in performing research science in underground facilities since Snowmass 2013.
   - Incredible *opportunity* on horizon for high energy physics and other research using underground facilities.
   - Physics *karaoke* is a thing and it happened at Snowmass.

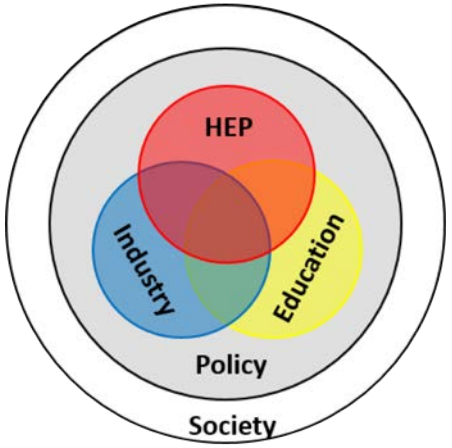






Community Engagement Frontier

1. Our goal and hope is that by the end of Snowmass 2021, all of us will be convinced of and committed to the following propositions:
   1. It is critical that we all agree on the importance of *everyone* working together in *CEF* to organize and develop our ongoing *CE* efforts in a *coherent* manner focused on improving our HEP community and achieving the vision we are defining for our field.
   2. A *structure* must be established within HEP for taking ownership and responsibility for *implementing* CEF recommendations and *monitoring* their progress across the entire field.
2. CEF is a Frontier that cuts across all other Frontiers, and *everyone* in HEP works within and is a part of CEF. Furthermore, there is no activity within our field that lies outside CEF. For these reasons, every activity in every Frontier is dependent on progress in the work of CEF.



Community Engagement Frontier

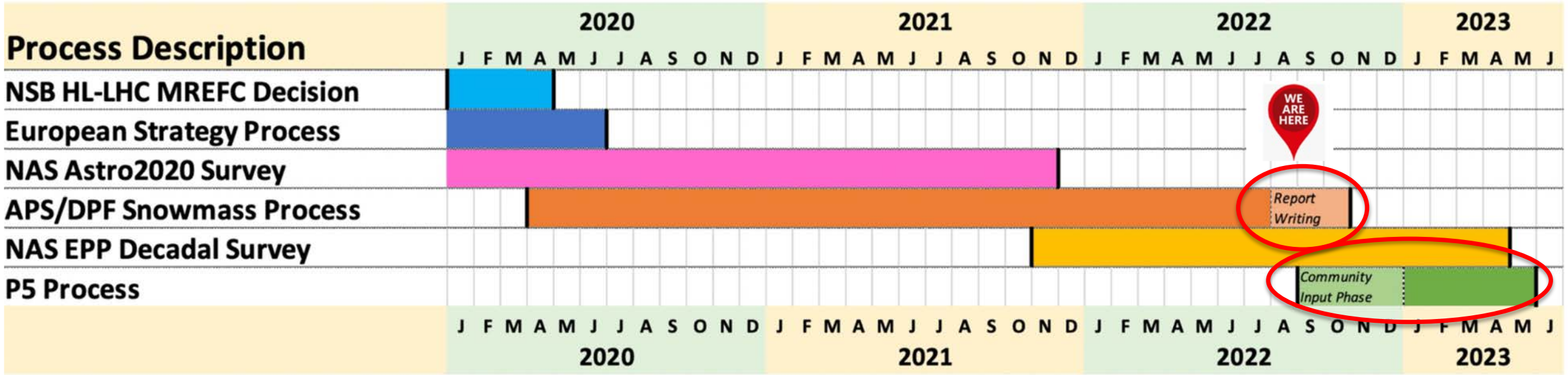
3. By far the most surprising thing we encountered is the extremely low participation in CEF by members of our field, particularly senior members, even though every one of us is a part of and responsible for work in CEF (and many are doing great work in CE!). There are certainly understandable reasons for this associated with time commitment and career advancement concerns. But this needs to change for the sake of the few, particularly EC colleagues who are sacrificing much to do this work for all of us, or else our field will suffer.

Actual quote from a few weeks ago:

"Speaking as one of those early career members, it's very disheartening to not see more senior folks in the community buying into this work, and I think that lack of support is going to have a measurable impact on how many of the currently motivated younger folks choose to stay in the field. It's not really good enough to say that the next generation is going to take care of everything."

- **But solutions do exist!! Structural changes could help address this.**
  - **Perhaps main CEF planning and development could cycle asynchronously with Snowmass, avoiding tough time commitment choices.**
  - **Implement real career benefits/rewards for CEF work.**

Now the distillation begins



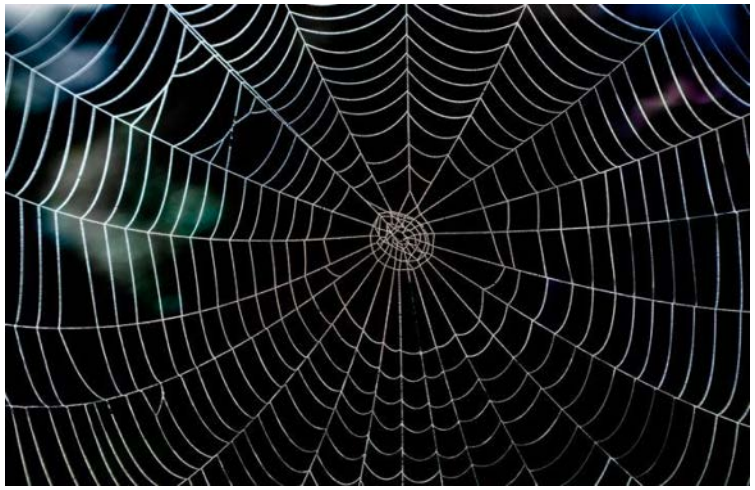
But the product is not just an executive report or even P5

It is all the new work over the last 2 years represented in the treasure trove of white papers

- A detailed summary of all the science accomplished since the last Snowmass
- New models and phenomenology linking frontiers
- A data-driven road map for future exploration and the tools required to accomplish it.
- Specific recommendations from CEF as well as AF, IF, CF, UF and the Science Frontiers

Our Science is fundamentally linked

Silos and Webs are *both* necessary



New Snowmass buzz words: ***ecosystem*** and ***complementarity***

This has become fully realized in Snowmass 2022

- Frontiers defined common problems
- Liaisons kept the frontiers connected throughout the process
- Specific cross-cutting studies yielded new collaborations (they should continue!)
- Model building linked potential new physics signatures in one field with their consequences in another

Some Practical Lessons Learned

Promotion of cross-cutting groups to Frontiers changed the character of the process

This worked well for ”tools” like Accelerators, Instrumentation, Computation

- Identify common problems and advance enabling technologies within the “silo”
- Define specific training and CE required for the enabling technology
- Information exchange with other frontiers prioritizes the programs.

Also worked well for Theory

- Formal theory and other tools are often broadly applicable
- Training and community engagement can look different in theory
- A career in theory will naturally span frontiers
- Phenomenology becomes both an enabling tool and a physics driver

Some Practical Lessons Learned

Worked less well for Community Engagement

Contributions to Snowmass CEF was overwhelmingly by topical group conveners themselves
+ contributing early career members

CE topics were addressed by individual frontiers instead of being organized through CEF

Physicists interact with multiple overlapping communities and can point to progress since 2014 in

Funding Agencies (DOE, NSF, NASA…): e.g. Broader Impact, Recruitment, Mentoring, Early career

Projects and Collaborations: Code of conduct , Ombudsperson, various outreach efforts

Professional Societies: APS (DPF, DAP, DNP…) AAS, AAPT…. provide resources and allies

Workplace: Universities are at the forefront of public engagement, DEI and Industry Initiatives

But doing something coherent for Particle Physics as a whole still needs work.

➔ The CEF Report is extremely valuable for knitting this together

Provides a clear list of priorities to P5 that must be folded into any project structure

Defines a road map for a coordinating body from the community

Willing to create (today!) a DPF entity, able to also draw from APS resources

for surveys and data driven work, for getting stakeholders together, defining the next step

Our Process is fundamentally linked

Our science is multiply-connected, but our funding is siloed

Within our custodial funding divisions

- Panels need better structures for reviewing proposals that include several frontiers
- Create binding Inter-agency agreements for projects, commit to their successful conclusion
- New proposals should state how they align with our community-wide vision

  ➔ *This requires regular updates to Snowmass/P5. All updates need to cross frontiers.*

Our horizon is wider than HEP, so we need to tap other funding sources in a coordinated way

- Support existing OS-wide new initiatives
- Create R&D funding structures across instrumentation frontiers
- If we are a consumer, create a conduit for buying/sharing
- If we are a producer, advertise and promote our contribution
- Work together over multiple agencies to identify which is which.

Enabling these fundamental linkages

Emergence of coordinating panels across enabling tools

CPAD (DPF, from 2012) continues to provide a forum for Instrumentation advances across frontiers

- How should we improve it?
- How do we foster inter-lab complementarity?
- IF suggests a CERN model of R&D (and the funding to make it happen)

CF suggests a similar CPSC (Coordinating Panel for Software and Computing)
Examine and collect all such suggestions to promote further coordination

Strategic Planning for Emerging Dark Sector Complementarity
Support further funding for theory tied tightly to the Snowmass Vision and BSM modeling

People are the ultimate enabler:

Bring all the great CE ideas up from the frontier level and unite under the CE report to create a coherent Particle Physics CE program

The Science Message

The 2014 P5 Physics Drivers

- Use the **Higgs boson** as a new tool for discovery.
- Pursue the physics associated with **neutrino mass.**
- Identify the new physics of **dark matter.**
- Understand **cosmic acceleration**: dark energy and inflation.
- **Explore the unknown**: new particles, interactions, physical principles

These are STILL the physics drivers because we have not answered ANY of the questions we posed in Snowmass 2013.

All that money and you still don't know the answers?

Potential pitfall if we concentrate only on BSM physics, rather than on our achievements in measuring Standard Model parameters and expanding our dizzying array of new detectors, accelerators, and cosmic probes.

The 2013 Snowmass Summary Questions

1. How do we understand the Higgs boson? What principle determines its couplings to quarks and leptons? Why does it condense and acquire a vacuum value throughout the Universe? Is there one Higgs particle or many? Is the Higgs particle elementary or composite?

2. What principle determines the masses and mixings of quarks and leptons? Why is the mixing pattern apparently different for quarks and leptons? Why is there CP violation in quark mixing? Do leptons violate CP?

3. Why are neutrinos so light compared to other matter particles? Are neutrinos their own antiparticles? Are their small masses connected to the presence of a very high mass scale? Are there new interactions that are invisible except through their role in neutrino physics?

4. What mechanism produced the excess of matter over anti-matter that we see in the Universe? Why are the interactions of particles and antiparticles not exactly mirror opposites?

5. Dark matter is the dominant component of mass in the Universe. What is the dark matter made of? Is it composed of one type of new particle or several? What principle determined the current density of dark matter in the Universe? Are the dark matter particles connected to the particles of the Standard Model, or are they part of an entirely new dark sector of particles?

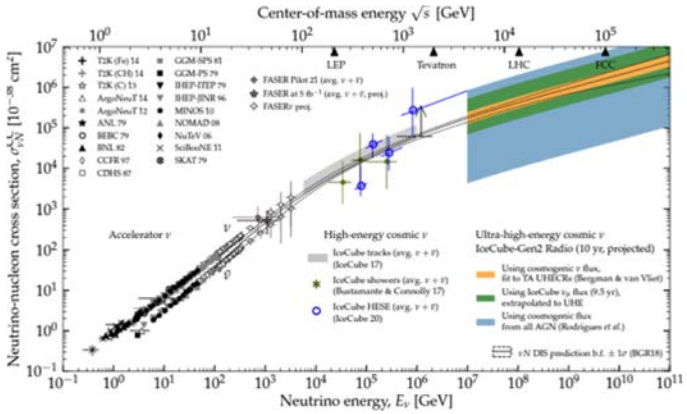
The Science Message

The landscape has changed,
but the fundamental physics drivers have not

Paradigms have shifted, requiring new search strategies

Changed Landscape in science

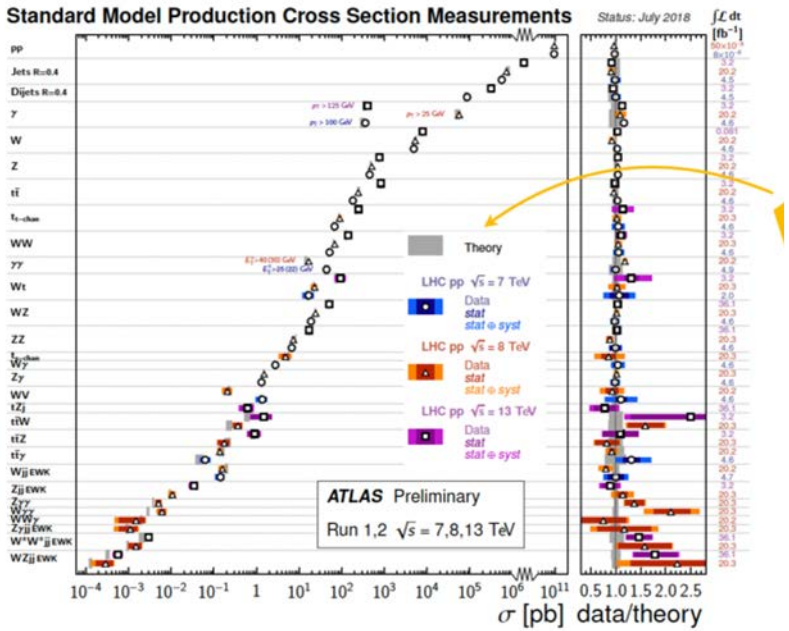
Concentrate on measurements, not limits

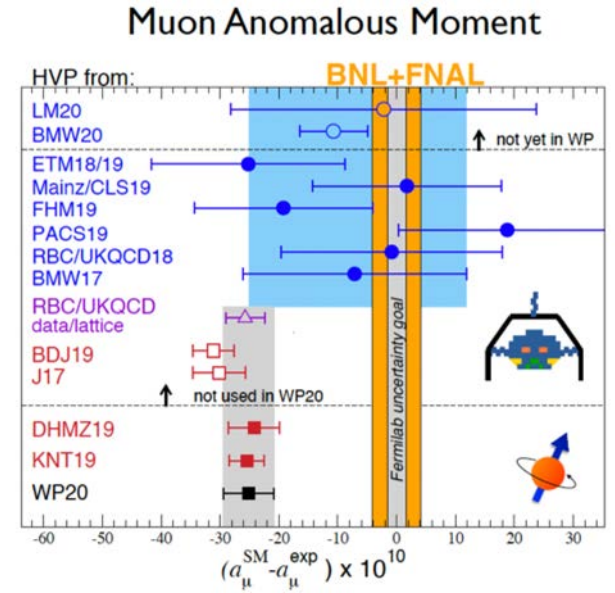


Our knowledge of the cosmos and its connection to particle physics has increased tremendously.

We continued to improve our knowledge of the Standard Model
We've measured couplings, particle masses and the structure of interactions
New quark and gluon combinations, magnetic and electric dipole moments

Glory in our successes – and shamelessly promote them

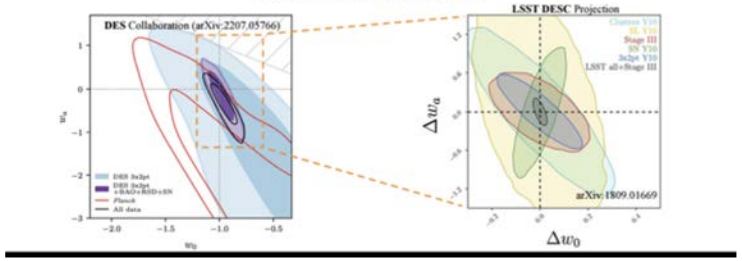




LHC Run 1 & 2: **Experimental** and **Theoretical** triumph (see J. Thaler talk)

Precision cosmology

The discovery of **dark energy** led to a **precision measurement program** to understand its physics.



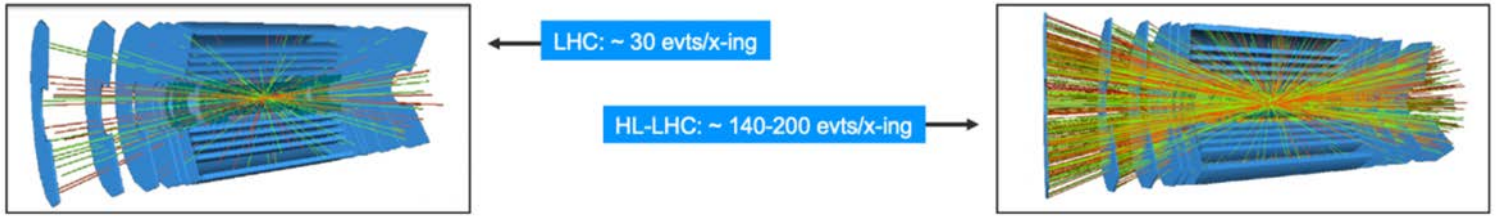
And in what we can build

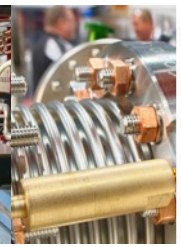
New capabilities

New accelerators and detectors

R&D in AF, IF, CF

Face of computing has changed





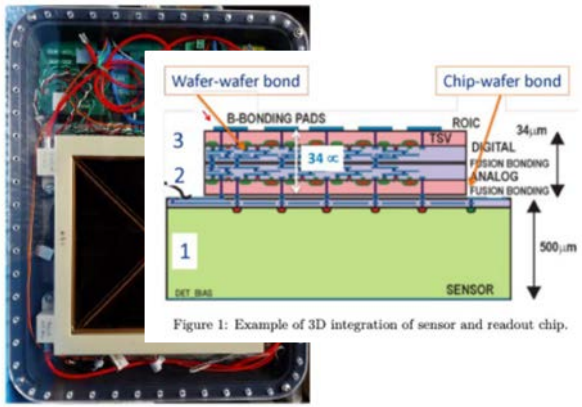
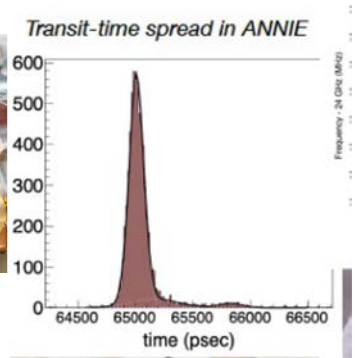
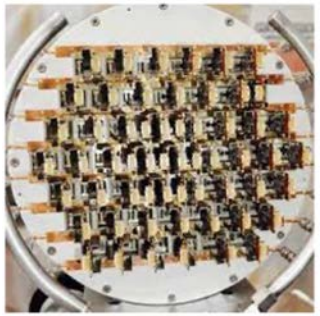
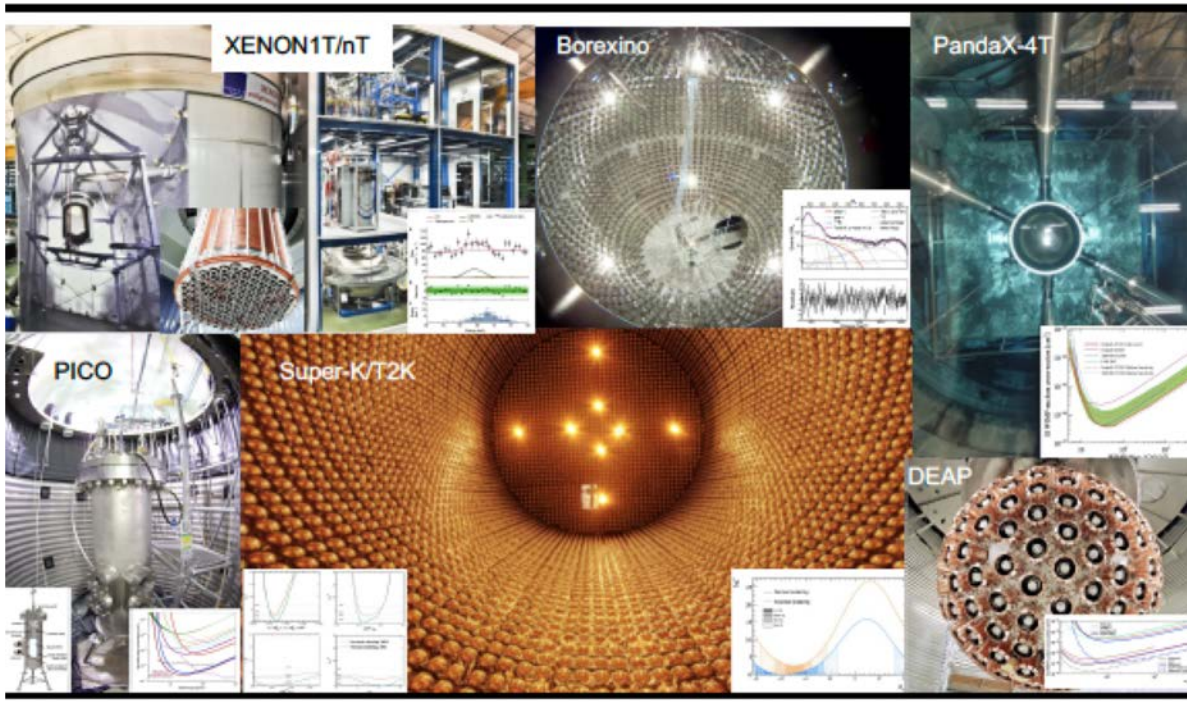


Figure 1: Example of 3D integration of sensor and readout chip.







P5 will define the 2023 Physics Drivers

But a clear take-away from Snowmass is that the 2014 Physics Drivers still guide our future

Great Message: We are making steady progress on a path which is **still** a community priority

There may be some room for tweaking

suggestions I have heard: "explore the unknown" could be sharpened

"Understand the physics of flavor"

Include Theory and Community Engagement in our Big Picture

- Use the Higgs boson as a new tool for discovery
- Pursue the physics associated with neutrino mass
- Identify the new physics of dark matter
- Understand cosmic acceleration: dark energy and inflation
- Explore the unknown: new particles, interactions, and physical principles

- Develop transformative concepts and technologies to enable future discoveries
- Cultivate a vibrant, inclusive, and supportive scientific community

Snowmass maps HOW we do that

A better emphasis than simply listing the questions
This is a work in progress

Use the Higgs boson as a new tool for discovery

- Continue to measure Higgs boson properties at the LHC with growing precision
- Exploration of multiple BSM scenarios eliminates classes of possible SM extensions
- With the approval of the HL-LHC, we enter an era pf precision Higgs physics
- A clear roadmap for future accelerator properties - Directed research in the accelerator frontier is required

- Specify the New instrumentation and computational tools will be required to meet that roadmap

Snowmass maps HOW we do that

A better emphasis than simply listing the questions
This is a work in progress

Pursue the physics associated with neutrino mass

- Build DUNE, participate in host of oscillation experiments. Determine hierarchy, CP,
- Measure neutrino mass in direct detection and cosmic probes
- Ton scale 0nuBB experiments will cover the inverted hierarchy by 2035
- Multi-messenger Astro: neutrinos in solar physics, core collapse SN, neutron and BH mergers

- Specify the New instrumentation and computational tools will be required to meet that roadmap

Snowmass maps HOW we do that

A better emphasis than simply listing the questions
This is a work in progress

Identify the new physics of dark matter.
Understand cosmic acceleration dark energy and inflation

- Get to the neutrino fog with WiMP searches, cover huge swaths of lighter DM particles
- Get to the QCD axion line with ADMX, deploy a host of technologies for wavelike DM
- A wealth of data from DESI, LSST, construct CMB-S4
- Spectroscopic surveys (Spec-S5 and future large projects), collaborate with GW, 21 cm..
- Explore the phenomenology of the dark sector across all frontiers

- Specify the New instrumentation and computational tools will be required to meet that roadmap

Snowmass maps HOW we do that

A better emphasis than simply listing the questions

This is a work in progress

Explore the unknown: new particles, interactions, physical principles

This is a hard one to match to a plan because every frontier will do this: Either make that an explicit general statement in the following list, or revise the physics driver to be more specific. Perhaps "Explore the Unknown" is more of a united message above all drivers.

Nonetheless, I included mostly FP frontier projects here.

- Follow up on hints from BaBar, Belle, LHCb, CMS, ATLAS
- A suite of heavy flavor experiments taking data and coming on line: BEPCII, SuperKEKB, STCF
- Lepton flavor universality violation in light meson decays (REDTOP, PIONEER)
- Precision measurements of dipole moments, fundamental symmetries, GR
- New theoretical work on quantum gravity, new forces, advances in lattice gauge theory, etc.

- Specify the New instrumentation and computational tools will be required to meet that roadmap

BSM as the guide for the future

We are not shooting in the dark.

Let's move away from "The SM is incomplete" and "we need to search everywhere"

Instead, we might say

We have made the following discoveries, which will enlarge our model of the Universe once we figure out how it fits into what we already know.

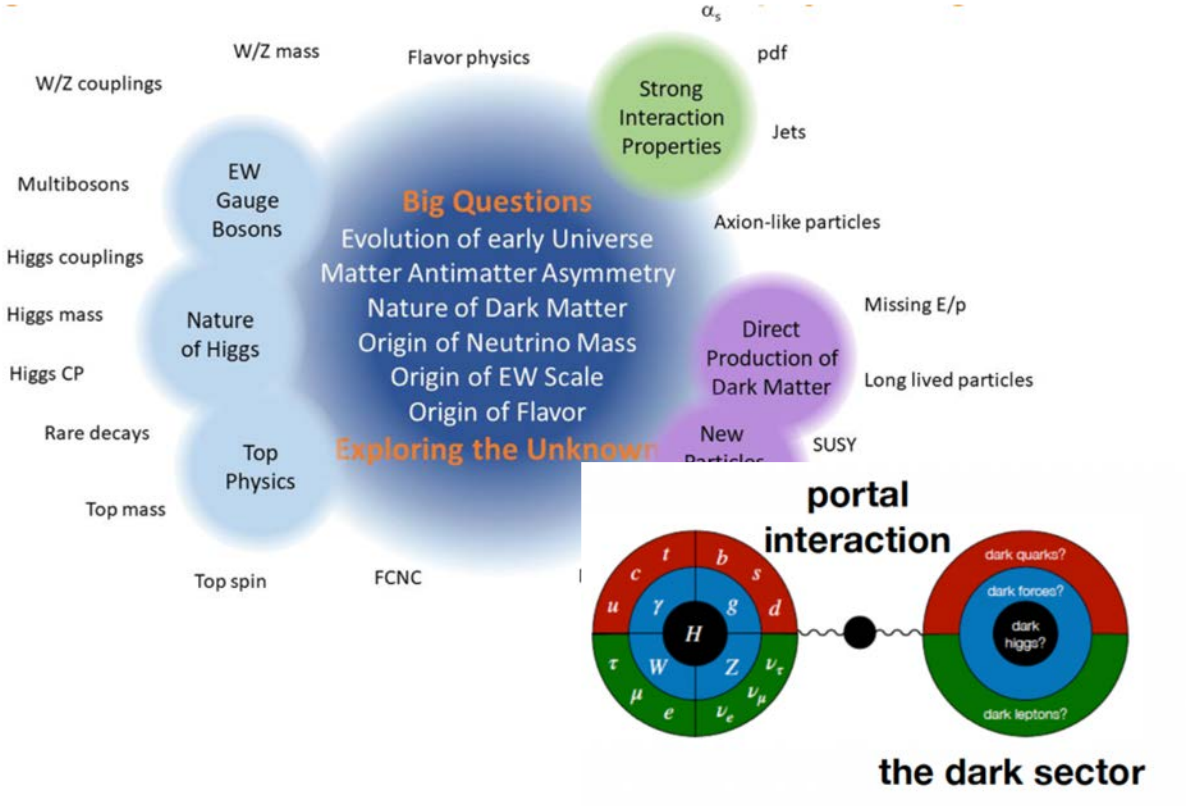
(1) Dark matter exists and its gravitational interactions are being mapped by a host of cosmic probes
(2) Neutrinos have unusually small mass and interact with the weak force, and we are measuring their interactions and generational properties and narrowing down their masses.
(3) Our Universe has an anti-matter deficit, is accelerating, and is filled with ancient thermal radiation, and we have new tools to measure matter, energy and space-time at all epochs

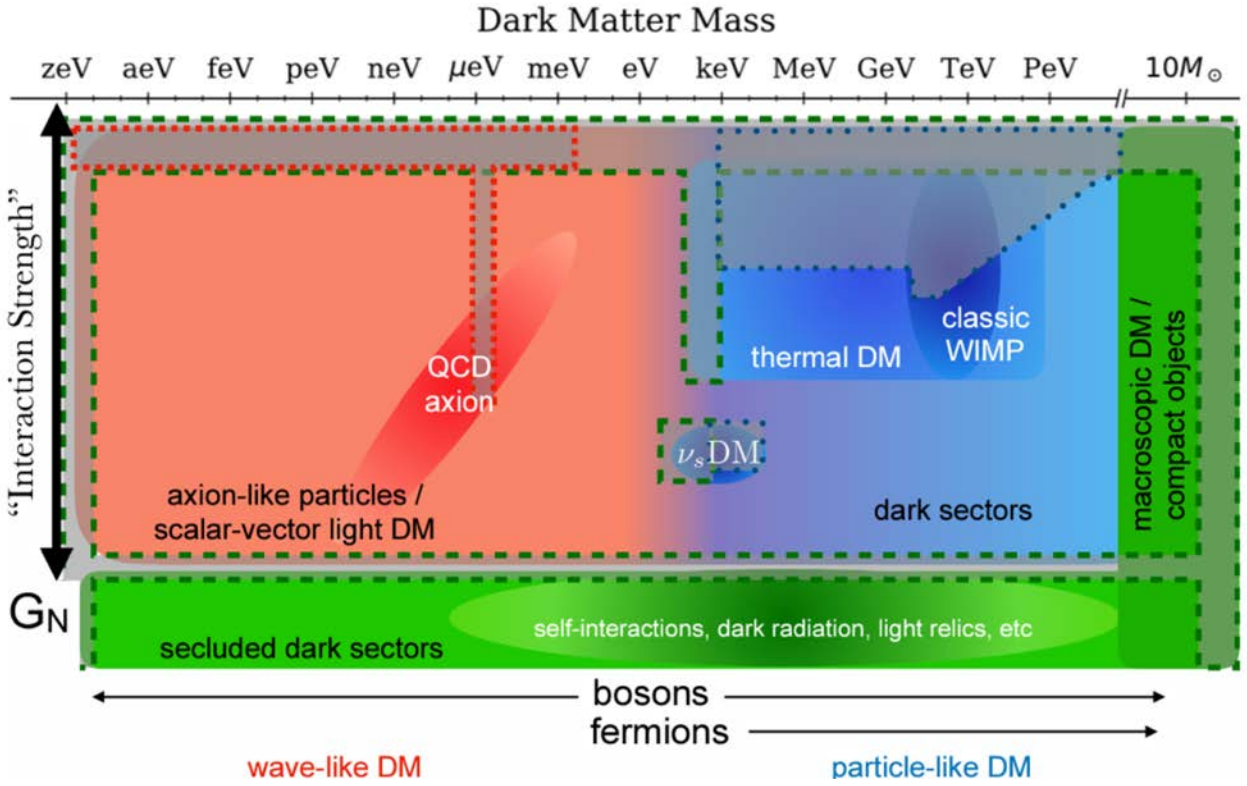
We have seen many examples in this summer study of how these are all connected.
For example: Exploring the Dark Sector has the potential to address the hierarchy problem, neutrino masses, baryon asymmetry, and even strong CP. Signatures will show up in all the frontiers.
Cosmic probes and GW are an orthogonal approach to some of the same questions
tying the accelerating Universe and large scale structure to fundamental questions in particle physics

This type of message, coupled with specific ***benchmark paths*** is most compelling (a la T.Slatyer's talk)

The best cartoons!

The Snowmass process was longer than expected or desired, but one advantage is that the Particle Physics Community has synthesized the message and communicated it already to ourselves.

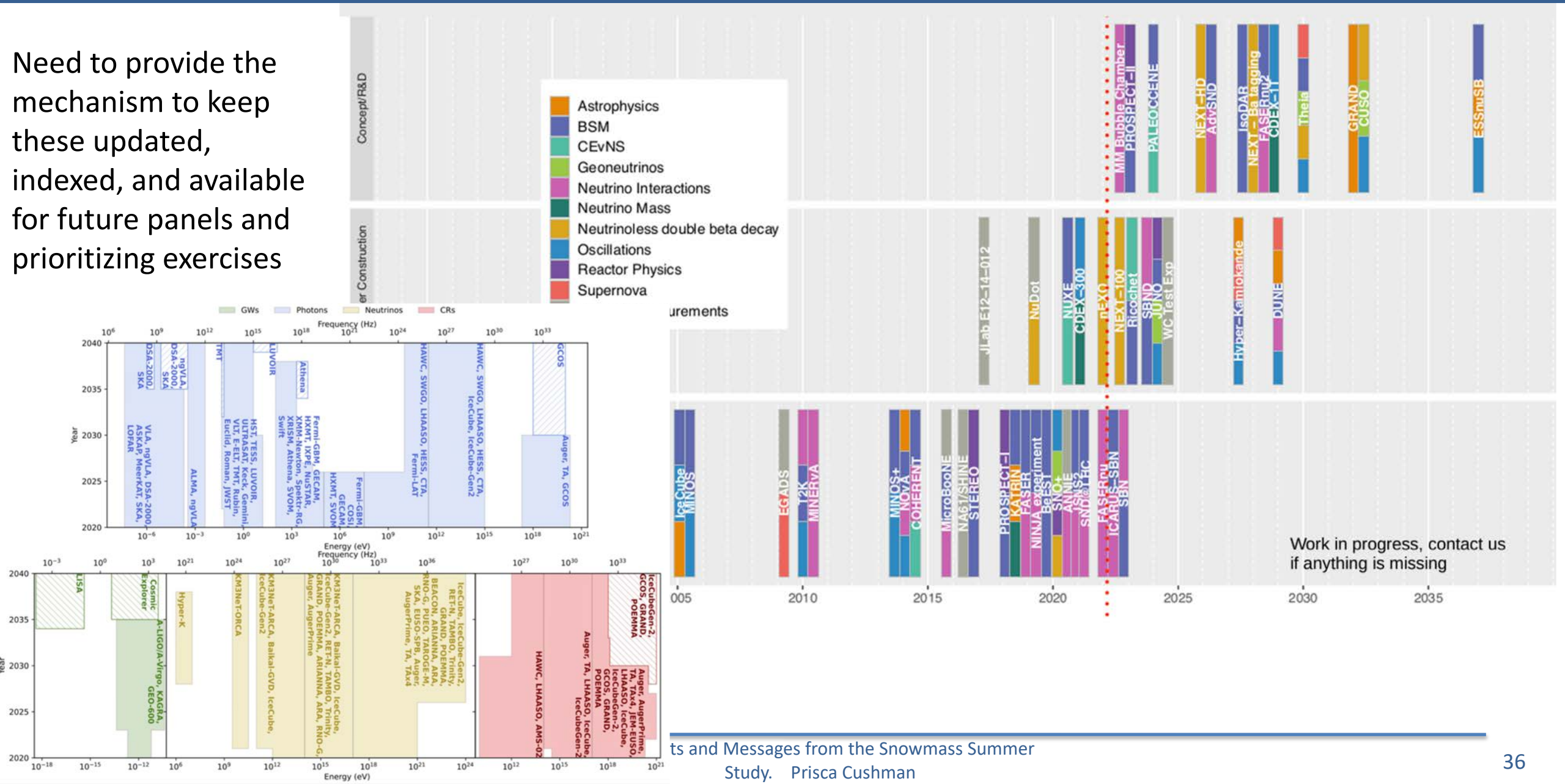




A compendium of the best slides and communication tools will be compiled and indexed.
They will provide input to our outreach effort beyond P5 to congress and the general public

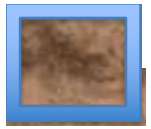
And the densest summaries

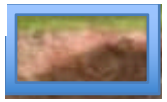
Need to provide the mechanism to keep these updated, indexed, and available for future panels and prioritizing exercises

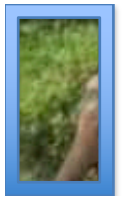


Data-driven ***and*** theory motivated

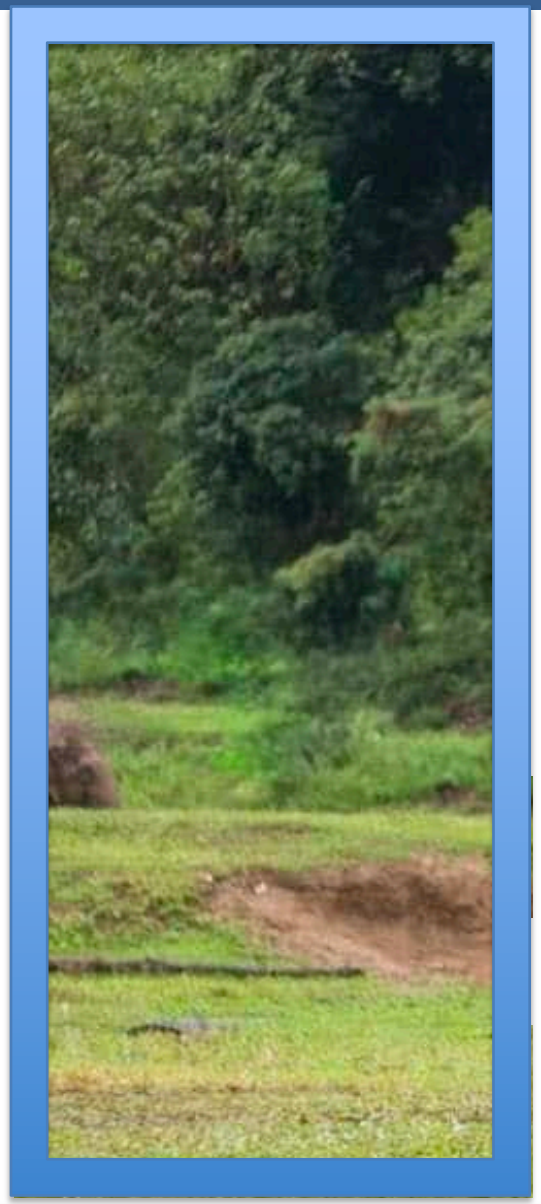
Search Wide



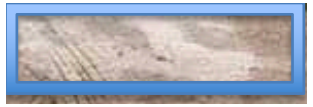


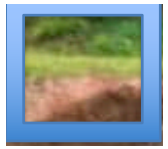


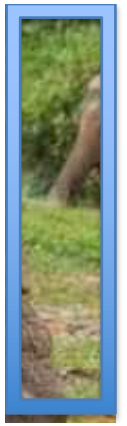
Data-driven and theory motivated



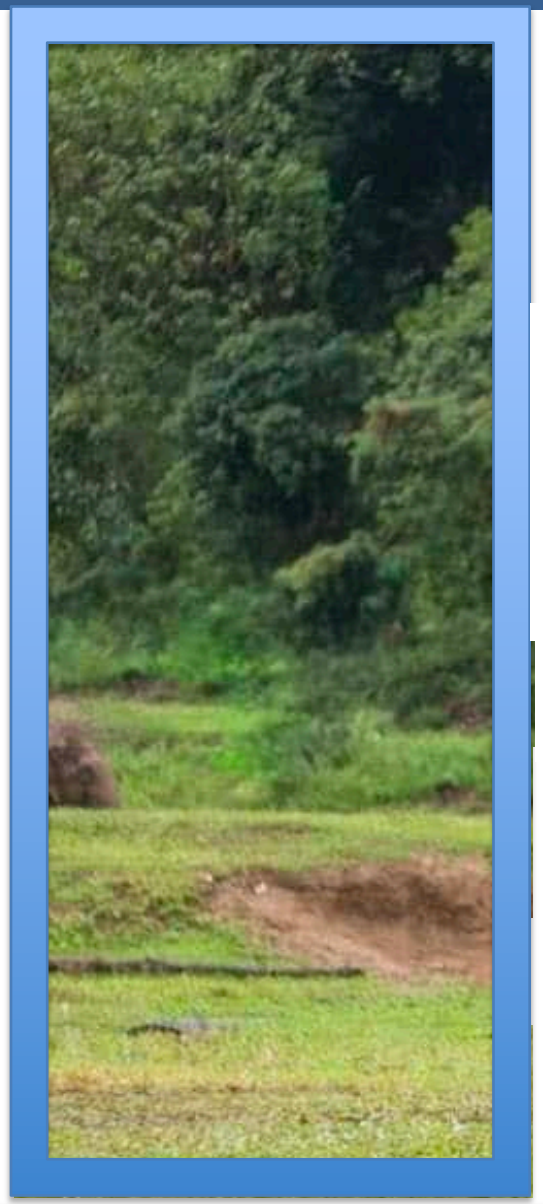
Delve Deep



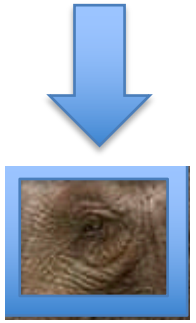


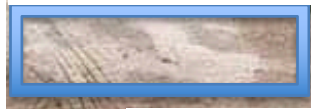


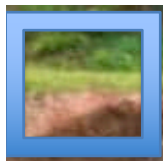
Data-driven and theory motivated

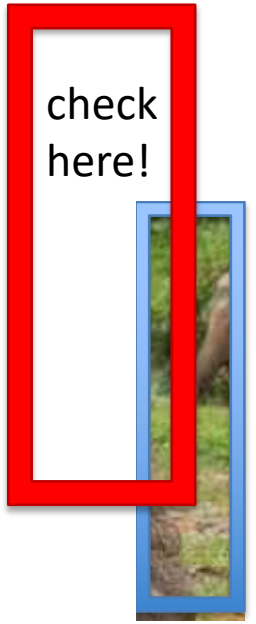


A signal! An eye fits into the theory of an animal.
Use its size and what you know about
animals to look for where the tail should be



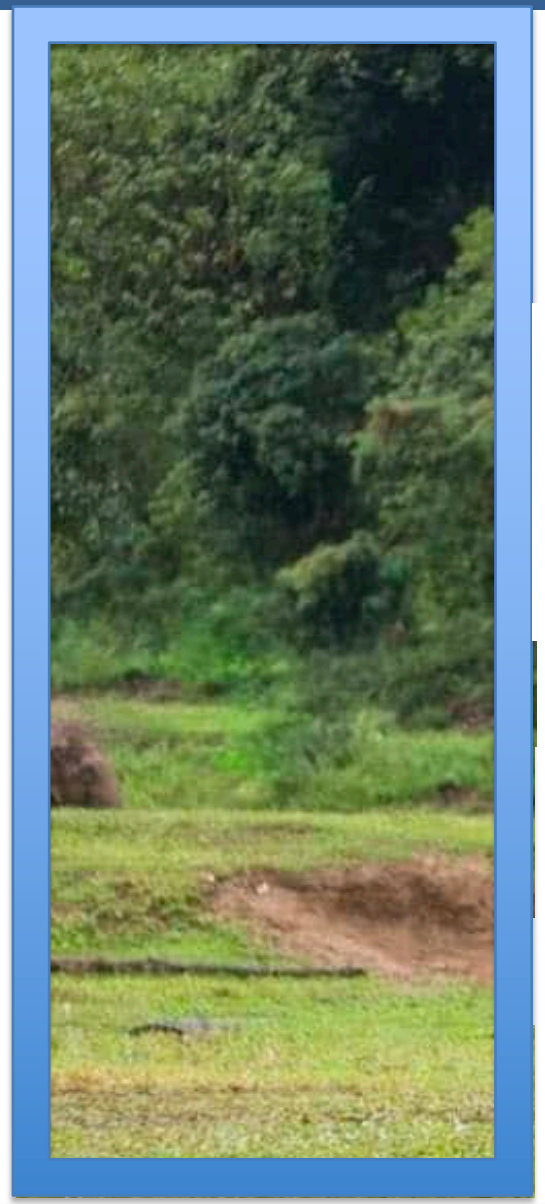


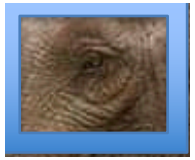


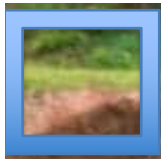


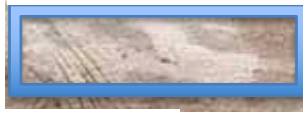
The region without an animal now
tells you which direction it is facing
and its environment

Data-driven and theory motivated

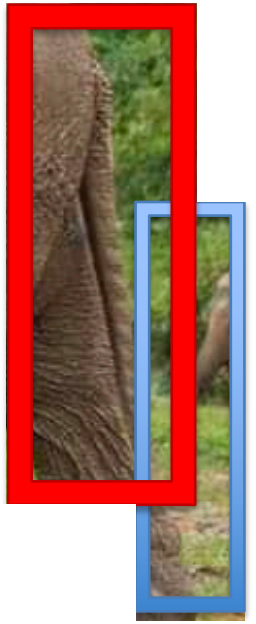




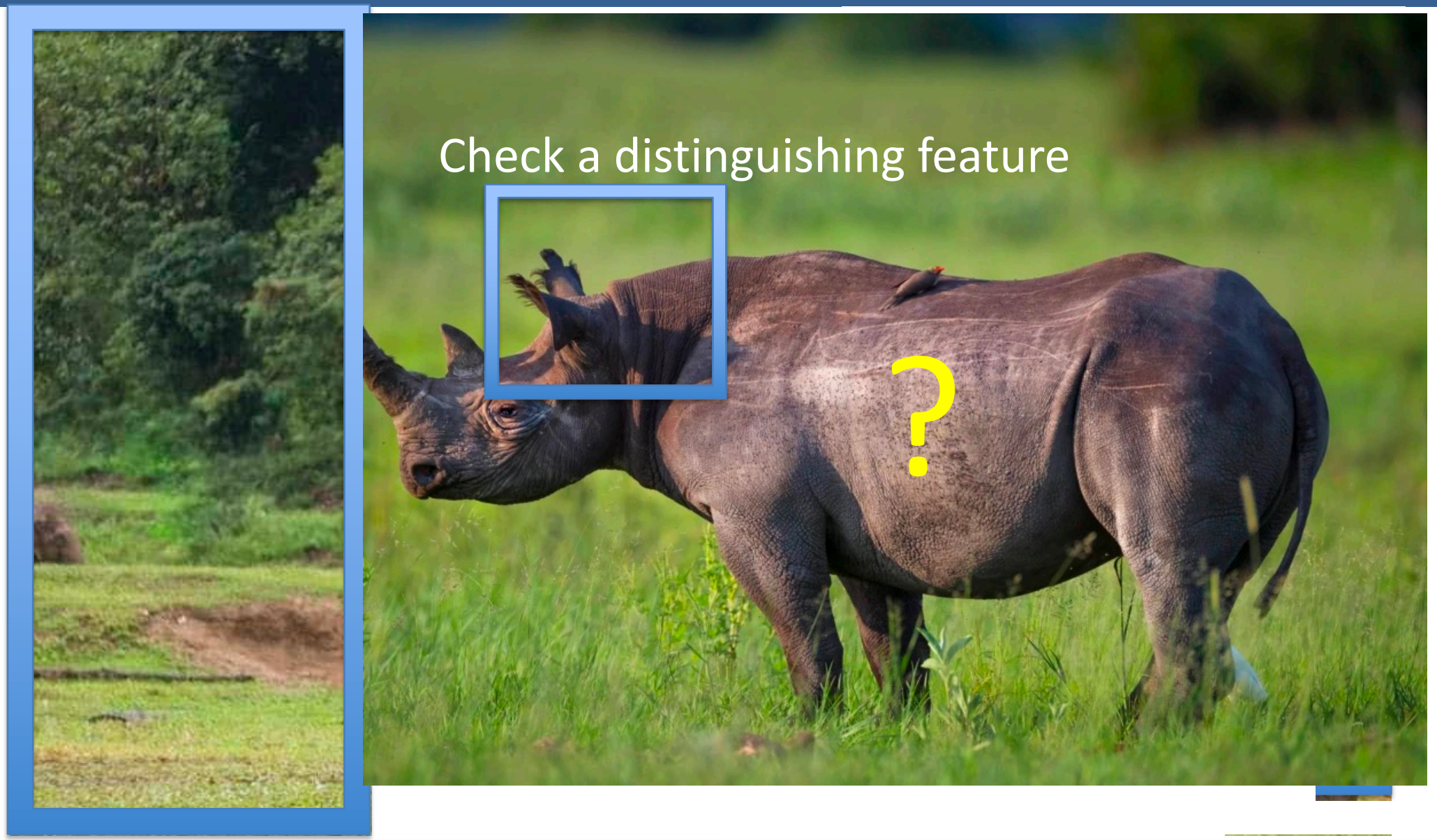




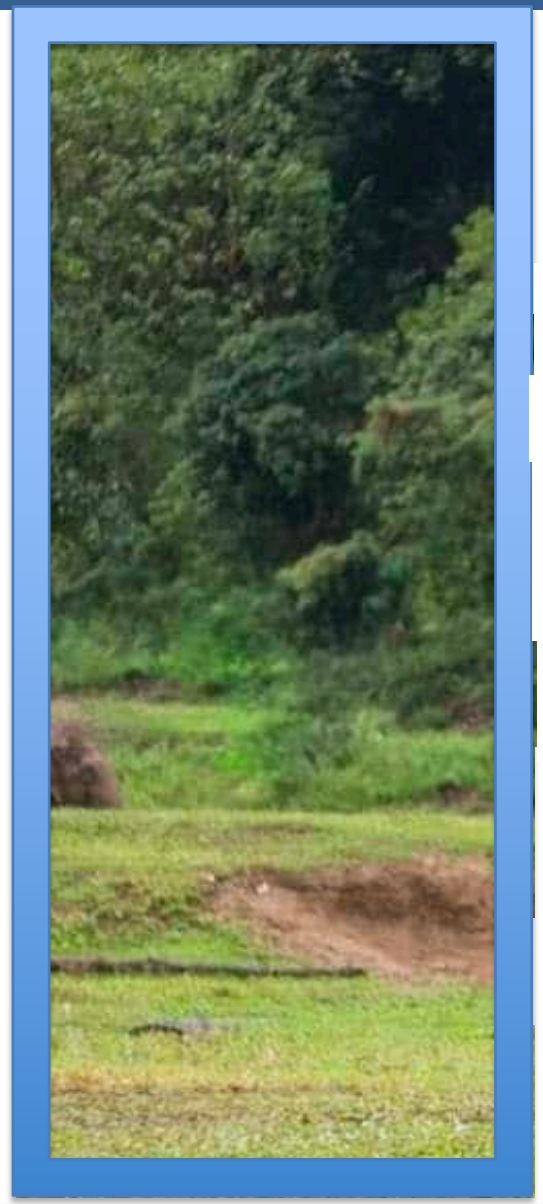
A tail!



Data-driven and theory motivated



Data-driven and theory motivated



An ear fits the elephant model better than the rhino model

Data-driven and theory motivated

The Beginning of a new era

The underlying landscape is becoming visible

The peak is fundamentally connected to the unseen mountain range

The failure of minimal extensions to the Standard Model implies a much richer sector to explore.

With all the new experiments ready to push deeper into every frontier, we all feel the excitement of being poised for an explosion of new data and answers to the questions posed a decade ago.

Let's go out and convince the rest of the world!