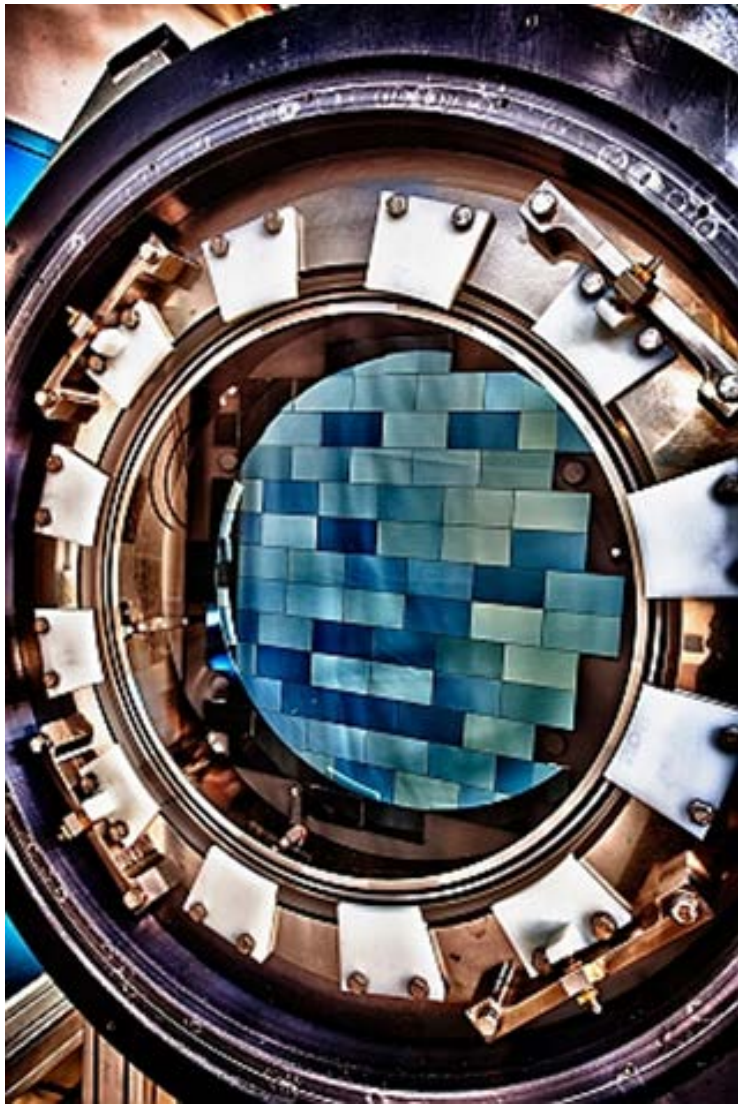
High Energy Physics (HEP) Cosmic Frontier

report to

HEPAP



11 December 2015

Kathy Turner

HEP Cosmic Frontier Program Managers:
Anwar Bhatti (IPA), Eric Linder (IPA), Michael Salamon, Kathy Turner

- **Program Model**
- **Program Guidance, Planning**
- **Budget**
- **Cosmic Frontier Program Funding & Activities**
  - Projects, Experimental Operations, Research, R&D
- **Cosmic Frontier Program Future Planning**

Office of Science - Mission & Program Planning

Office of Science is part of a Mission Agency

- Provides science leadership & support to enable significant advances in specific science areas
- Develops and supports a portfolio of selected facilities & experiments to obtain the science
- Laboratory System
  - Comprehensive resources to design, build, operate selected facilities, projects and instrumentation
  - Infrastructure, including computing facilities (NERSC, SCiDAC program etc)
- Interagency & International partnerships as needed to leverage additional science & expertise

Program Planning, Management & Execution

- Strategic planning process with community input to develop science drivers and a portfolio of facilities & experiments to obtain significant advances in these science areas.
- **HEP Program Office follows the strategic plan to carry out a specific portfolio of selected facilities & experiments to obtain the science.**

HEP Program Model, Execution

➔The Mission Emphasis translates in to how the HEP Program is managed:

- HEP uses the P5 strategic plan recommendations to develop and carry out a specific portfolio of selected facilities & experiments to obtain the science.

Considerations:

- P5 criteria used to determine which projects and at what level to invest in
- Staged implementation & results
- Complementary approaches using different technologies & methods
- Balance between science areas, project types & sizes

Support:

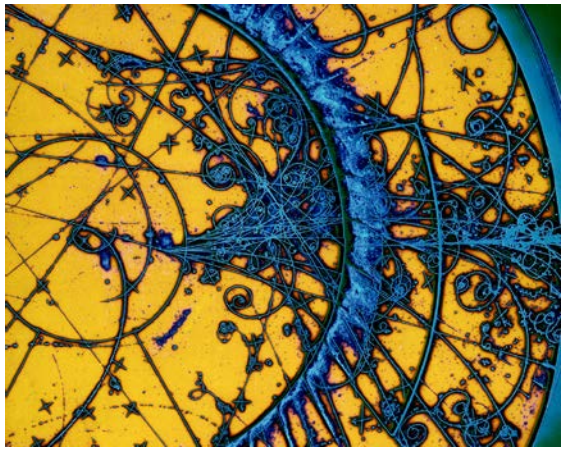
- Collaborations: Support scientific teams with expertise in required areas to participate in all phases of a project/experiment, in order to produce the best possible science results
- Projects: Provide long-term support for our responsibilities in designing, building and operating projects

We work proactively with our labs & community to:

- Carry out the near-term projects recommended by P5
  - Plan funding for Project activities (R&D, Fabrication, Operations) and Research activities (scientist support) & shepherd projects through the DOE process; plan operations & science research efforts
- Plan path forward for future directions & projects for priority P5 directions
  - Develop science case, technology needs, programmatic issues & considerations for projects

➢ **Both Agency and Community have roles in carrying out the P5 plan!**

HEP Program Guidance



FACA panels & subpanels provide official advice:

→High Energy Physics Advisory Panel (HEPAP)

- Reports to DOE and NSF
- Provides the primary advice for the HEP program

→Astronomy and Astrophysics Advisory Committee (AAAC)

- Reports to NASA, NSF and DOE on areas of overlap
- Writes an annual report to Congress – status & recommendations
- "Principles for Access to Large Federally Funded Astrophysics Projects and Facilities" (2014) report

FACA Subpanels are convened for detailed studies, e.g.

- HEPAP: Particle Astrophysics Science Assessment Group "PASAG" (2009)
- HEPAP: Particle Physics Project Prioritization Panel "P5" (2014) – Our **Strategic Plan**
- HEPAP/AAAC joint studies – TFCR (2004), DETF (2006), DMSAG (2007)

National Academy of Sciences

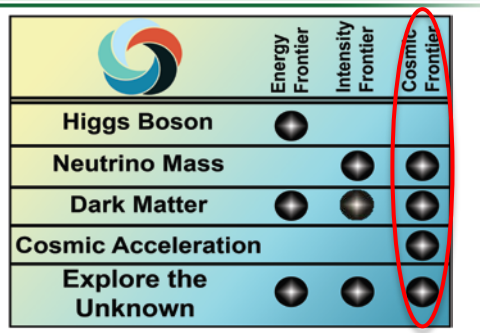
- New Worlds New Horizons (2010) – "Decadal Review" of Astronomy/Astrophysics for NASA, NSF, DOE
- Current study: NASA, NSF, DOE charged "Mid-decade review" of astronomy/astrophysics
- Ongoing: Board on Physics & Astronomy (BPA), Committee on Astronomy & Astrophysics (CAA)

Other: community science studies, reviews, DPF input, etc.

May 2014 P5 Report – Cosmic Frontier Recommendations

Dark Energy - Precision measurements to differentiate between Cosmological Constant, new fields or modification to General Relativity

- P5 #17: Complete LSST as planned.
- P5 #16: Build DESI as a major step forward in dark energy science, if funding permits
  - DESI should be the last project cut if budgets move from Scenario B to Scenario A (lowest)



Dark Matter (Direct Detection) - Learn the identity and nature of Dark Matter

- P5 #19: Proceed immediately with a broad second-generation (G2) dark matter direct detection program with capabilities described in the text. Invest in this program at a level significantly above that called for in the 2012 joint agency announcement of opportunity.
- P5 #20: Support one or more third-generation (G3) direct detection experiments, guided by the results of the preceding searches. Seek a globally complementary program and increased international partnership in G3 experiments.
  - (DM-G3 Project is in the P5 plan later in the decade.)

Cosmic-ray, Gamma-ray Astrophysics - Explore particle acceleration mechanisms and perform indirect searches for dark matter candidates

P5 #21: Invest in CTA as part of the small projects portfolio if the critical NSF Astronomy funding can be obtained.

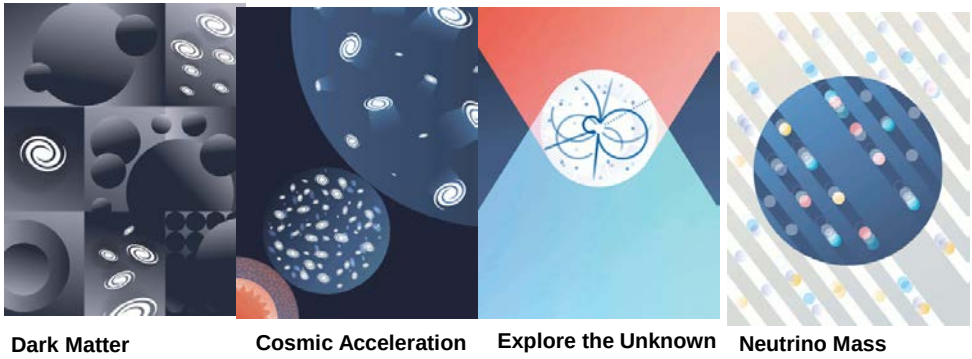
P5 comments:

– CTA has a broad science reach that transcends fields, with the dark matter detection capabilities of direct importance to particle physics
– Using P5 Criteria, a de-scoped US component should be shared by NSF-AST, NSF-PHY and DOE.

CMB - Gain insight into **inflationary epoch** at the beginning of the universe, **dark energy,** and **neutrino properties** by studying the oldest visible light.

P5 #18: Support CMB experiments as part of the core particle physics program. The multidisciplinary nature of the science warrants continued multi-agency support. (CMB-S4 Project is in the P5 plan later in the decade.)

Cosmic Frontier Program



Through ground-based telescopes, space missions, and deep underground detectors, research at the cosmic frontier aims to explore dark energy and dark matter, which together comprise approximately 95% of the universe.

Cosmic Frontier Program is aligning with P5 plan:

→Advance our understanding of dark matter and dark energy
Highest priorities are continuing studies & development of new capabilities in direct dark matter detection & dark energy exploration

- **Near term Cosmic Frontier projects are being started; studying the nature of dark energy & direct detection searches for dark matter particles**

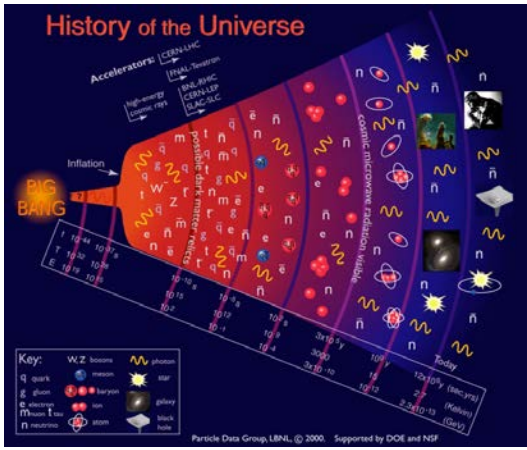
- **Lay the ground work & for future projects → including in CMB**
  - Planning activities to support P5 recommendations later in the decade.

Cosmic Frontier Research Areas & Status

Dark Energy – Staged, complementary program with to obtain precision measurements to differentiate between Cosmological Constant, new fields or GR modification

– Operating suite of imaging, spectroscopy surveys - BOSS (completed FY14), eBOSS, DES; and supernova surveys

– "Stage-IV" projects in development: DESI (spectroscopic), LSST (imaging)



Dark Matter (direct detection) - Staged program with multiple technologies to determine the identity and nature of Dark Matter WIMPs or Axions

- Suite of 1st Generation (G1) experiments operating is completing in FY16
- Portfolio of 2nd Generation (G2) started development: ADMX-G2, LZ, SuperCDMS-SNOLAB

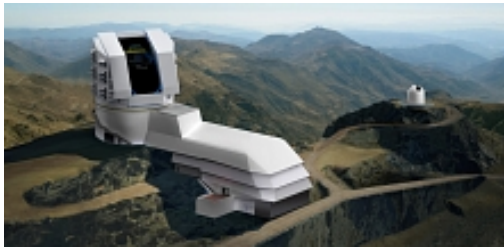
Cosmic-ray, Gamma-ray - Explore high energy particle acceleration mechanisms and perform indirect searches for dark matter particles

- Operating ground-based arrays (Auger, VERITAS, HAWC), space missions (Fermi/LAT) & AMS-02 experiment on International Space Station

Cosmic Microwave Background (CMB) - Gain insight into inflationary epoch at the beginning of the universe, dark energy, and neutrino properties by understanding the oldest visible light

- *South Pole Telescope polarization (SPTpol)* continues operations
- *SPT-3G* upgrade is underway
- CMB-S4 Collaboration - community planning continues for a CMB Stage IV experiment

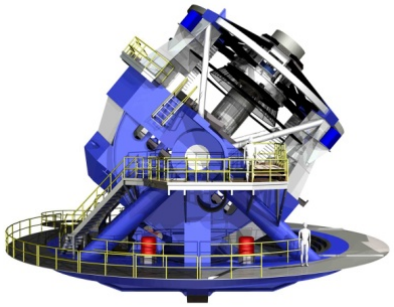
Cosmic Frontier - Major Item of Equipment (MIE) Projects (FY16 Request $57.1M)



→There are 4 MIE Projects – DESI, LSST, LZ, SuperCDMS-SNOLAB

***Large Synoptic Survey Telescope* (LSST)**

- Stage IV imaging experiment
- Partnership with NSF-AST (lead agency); NSF is responsible for the new te in Chile and the Data Management system
- HEP responsible for LSST camera fabrication (SLAC Project Office)
  - Responsibility includes integration, test, commissioning, which will be c funding
- LSST Dark Energy Science Collaboration (DESC) developing plan for dark science studies
- Oversight: Weekly NSF-AST & HEP JOG calls; Twice-yearly meetings with OSTP & OMB



LSST-camera (HEP)

Total Project Cost $168M (FY11-FY18)

Schedule: Camera ship to summit 2QFY20; CD-4 in 2QFY22

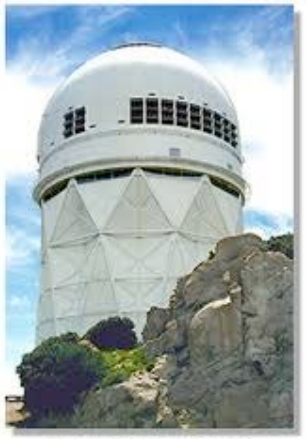
- Approved in FY14 as MIE project with long-lead procurements
- CD-2 “baseline” approved Jan 2015; CD-3 full fabrication approved August 2015

LSST Project Overall Budget includes NSF $473M (MREFC), Private $40M

Cosmic Frontier - Major Item of Equipment (MIE) Projects (FY16 Request $57.1M)

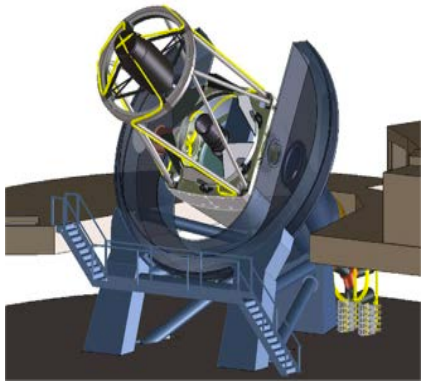
Dark Energy Spectroscopic Instrument **(DESI) - Stage IV experiment**

"HEP experiment" → HEP is fabricating the DESI instrumentation (including integration, test, commissioning) and supporting instrument + telescope operations (LBNL Project Office)


Mayall 4-Meter Telescope

HEP coordinating with NSF-AST to use ("lease") the Mayall telescope

- DOE/NSF MOA for FY16-18 signed - to support Mayall operations for FY16-18 transition phase (HEP ramp up, NSF ramp down)
- DOE/NSF MOU for FY19+ being planned – HEP will provide full Mayall costs for dark energy science operations starting in FY19



Total Project Cost = $56.3M (FY15-19)

<u>Schedule:</u>

- Approved as an MIE project in FY15; with long lead procurements
- CD-2 "baseline" approved in Sep 2015; CD-3 review planned for May 2016
- Mayall shutdown, ready for DESI 1QFY18
- DESI+Mayall commissioning complete & data-taking starts 1QFY20
- CD-4 in 4QFY21

<u>Current:</u>

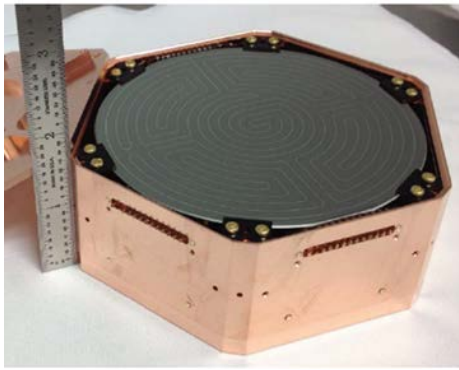
→Project on track – lenses, sensors

DESI is supporting wide-area public target imaging surveys: DECaLS, BASS, MzLS; combined they expect to cover 14,000 sq deg in 3 bands; includes upgrade of NOAO Mosaic camera with LBNL CCD's, electronics and computing analysis and support & NERSC hours

Cosmic Frontier - Major Item of Equipment (MIE) Projects (FY16 Request $57.1M)

Dark Matter Direct Detection: 2 MIE and 1 small project

HEP and NSF-PHY have a coordinated Dark Matter Generation 2 (DM-G2) program plan; jointly selected a suite of 3 experiments to move forward to fabrication (July 2014)
- 2 WIMP searches w/complementary technologies & mass ranges; 1 axion search



LZ at Homestake Mine

- WIMP search through dual phase liquid Xe – higher mass range

HEP leads, LBNL Project Office
→CD-1/3a approved April 2015; CD-2/3b planned for late FY16 (HEP)
Project is not baselined yet; Preliminary Cost/Schedule:
Total Project Cost Range is $46-$59M (FY14-19)
Preliminary Schedule :
Detector complete 3QFY19; CD-4 planned 4QFY21

SuperCDMS-SNOLAB

- WIMP search through cryogenic solid-state crystals; detects both ionization and phonon signals.

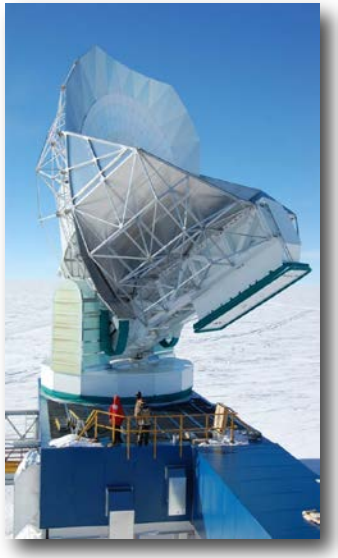
HEP+NSF-PHY partnership, SLAC Project Office
→CD-1 review held Nov 2015; expecting CD-1 approval in Dec. 2015
Project is not baselined yet; Preliminary Cost/Schedule:
Total Project Cost Range is $16-$21M for DOE (FY15-19)
Preliminary Schedule :
CD-2 planned 3QFY17, Detector Installation complete 4QFY19; CD-4 planned 4QFY20

Cosmic Frontier - Small Fabrication Projects

Axion Dark Matter eXperiment Generation 2 (ADMX-G2)

- HEP leads; U. Washington Project Office
- Set of 5 mini experiments to search for axions: One frequency range is operating, while resonators and amplifiers are being fabricated for next year's frequency range and the resonators for the following year are being designed.
- HEP funded a 3-year grant (ends summer 2017) with R&D plus fabrication = $2.7M.
    - Grant renewal needed to cover full schedule of planned scope of the experiments.

Status: New dilution refrigerator is taking longer than expected so original schedule is pushed out. HEP is reviewing the project's new plan.



South Pole Telescope Generation 3 (SPT-3G)

CMB experiment - major upgrade of the camera to greatly increase sensitivity; will have 15,234 bolometers at 95, 150, 220 GHz to cover 2500 deg^2 to 3.5μK'.

NSF leads (3 divisions) with HEP contributions – U.Chicago Project Office (ANL for HEP contribution)

- HEP responsibilities for fabrication of detectors: $3.7M in FY13 – FY16

Cosmic Frontier - Experimental Operations (FY16 Request $7.1M)

Activities

Each Project/Experiment provided a summary-level Data Plan to HEP
- Use for referencing in research proposals; also to check against **AAAC Principles for Access in Astrophysics** and **SC Statement on Digital Data Management**

HEP Review of Cosmic Frontier Operating Experiments (Dec. 2014)

Purpose was to assess the current status and future plans for each of 16 experiments' operating phase separately (i.e. not a comparative review). Members of the review panel individually assessed the overall science goals and operations activities of the experiment, with a concentration on the HEP-supported roles, responsibilities and commitments.

→ We are working with the experiments to assess their responses to the recommendations.

➔Operating Experiments

– currently have 14 operating experiments; planned to go down to 5 by end FY17

Dark Energy:

Baryon Oscillation Spectroscopic Survey "BOSS" – in New Mexico; ended in FY14; final data publicly released & final results out soon

Extended-BOSS (eBOSS) – HEP provided 3-year grant starting in 2015

La Silla/QUEST – nearby supernova search; HEP support ending in 2017

Cosmic Frontier - Experimental Operations
Current Operations continued

Dark Energy cont:
Dark Energy Survey "DES" – HEP camera installed and operated on Blanco telescope in Chile; partnership with NSF-AST; started 5-year imaging survey in late FY13

Dark Matter: Suite of Generation 1 (DM-G1) experiments: **ADMX-II, LUX, CDMS-Soudan, DarkSide-50, COUPP/PICO-60, DAMIC;** partner with NSF-PHY on most
→ HEP completing operations funds & activities for each by the end of FY2016

Cosmic-ray, Gamma-ray
Fermi Gamma Ray Space Telescope "FGST" *(w/NASA)* – currently approved through FY18
NASA leads the mission; HEP is supporting the Instrument Science Ops Center at SLAC
AMS *(w/NASA & International)* - operations continuing on the International Space Station
VERITAS *(w/NSF) – in Arizona; HEP grant will support their operations into FY17*
Auger *(w/NSF-PHY + International)* – in Argentina; Project office moved to Germany in 2014; HEP participation in operations ramping down in FY16; no participation planned on upgrade
HAWC *(w/NSF-PHY, Mexico)* – 5 year ops started 2015; no participation planned on upgrade

CMB: ***South Pole Telescope polarization*** **(SPTpol)** w/NSF – ends when SPT-3G starts

Other: ***Holometer*** at Fermilab – HEP support ends with completion of Early Career award (FY15, with budget period ending summer 2016)

Science Advances 2011-2015

Dark Energy

DES –

- In 3rd season
- Largest weak lensing sky map of dark matter
- Discovery of 17 new Milky Way dwarf galaxy satellite candidates – prime homes for dark matter detection; stringent constraints from joint DES-FGST analysis

BOSS –

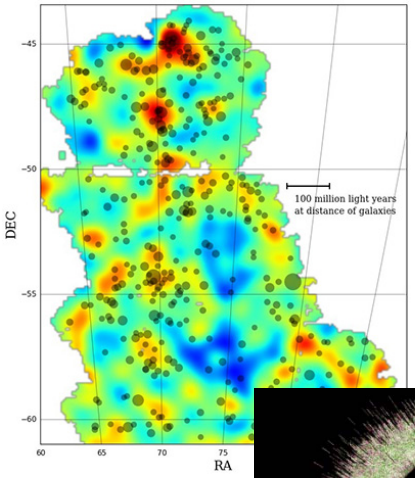
- Completed full survey on time; final data publicly released
- 1-3.5% constraints on distances, Hubble parameter at 3 redshifts
- Successful use of Lyman alpha forest as cosmology probe

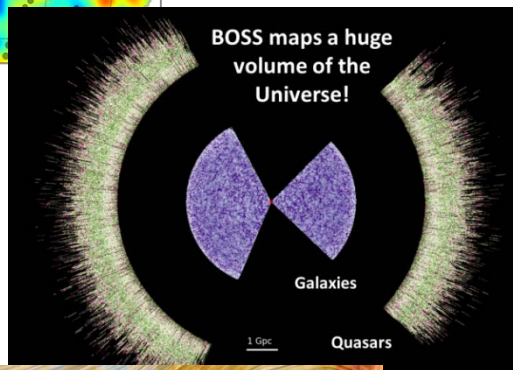
Supernovae –

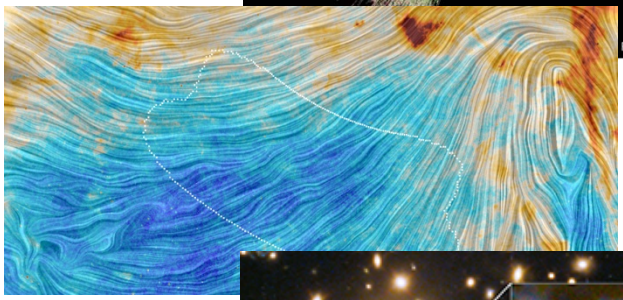
- Joint Lightcurve Analysis (SDSS-SN/SNLS) expansion history
- Supernova-host mass correlation correction to Hubble constant, agreeing with Planck
- First strongly lensed multiple image (Einstein cross) supernova discovered

CMB

- CMB lensing detected, used as cosmology probe
- B-mode polarization measured, constraining inflation
- Kinematic Sunyaev-Zel'dovich effect measured







Science Advances 2011-2015

Direct Detection Dark Matter searches with "Generation 1" experiments:

LUX, SuperCDMS, DAMIC and PICO

Significant improvements in previous limit on for both spin-dependent and spin-independent cross WIMP-nucleon cross section.

Indirect Dark Matter searches:

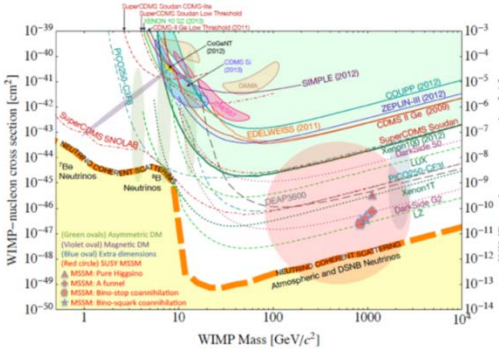
Fermi-LAT, VERITAS, HAWC

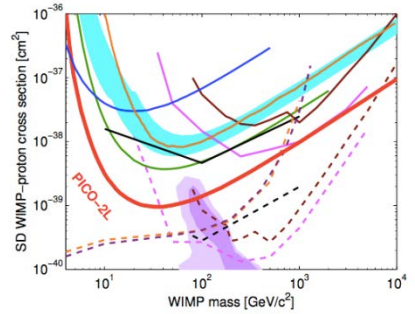
- First exclusion of thermal DM-nucleon cross section consistent with relic density (Fermi)
- Exclusion of DM in 1-10 TeV scale by HAWC

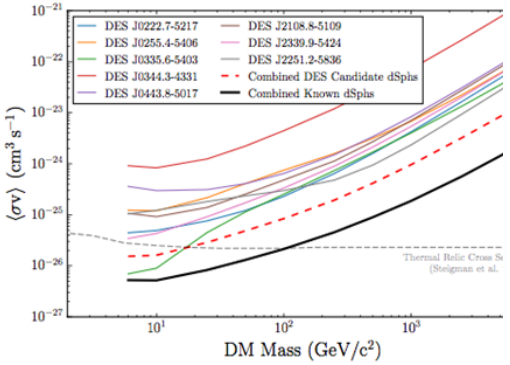
Gamma Ray/Cosmic Rays:

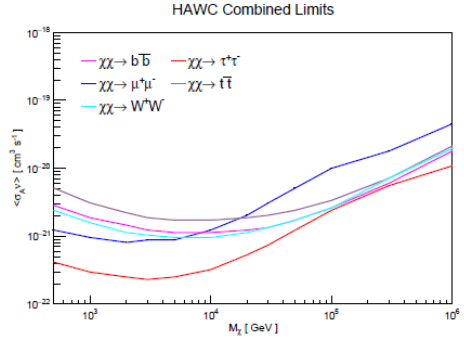
AMS, Auger, Fermi, VERITAS, HAWC

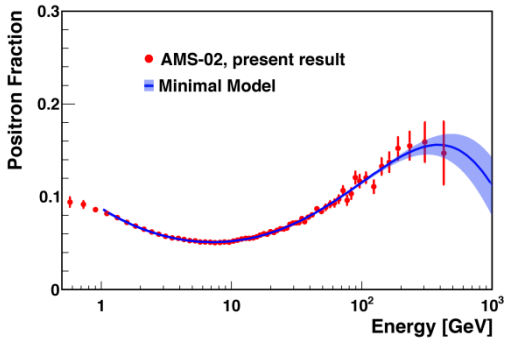
- Leveling off of positron fraction at ~300 GeV reported (Sep 2014) , consistent with either dark matter or pulsar origin. (AMS)
- Observation of anti-proton spectrum up to (AMS)
- VERITAS - Detection of pulsed gamma rays above 100GeV from Crab Pulsar (wasn't expected - reported in Science 2011)
- Origin of Cosmic Rays (Fermi GST) was chosen as one of the Top 10 Science Breakthroughs of the Year by Science magazine (AAAS) (2013)

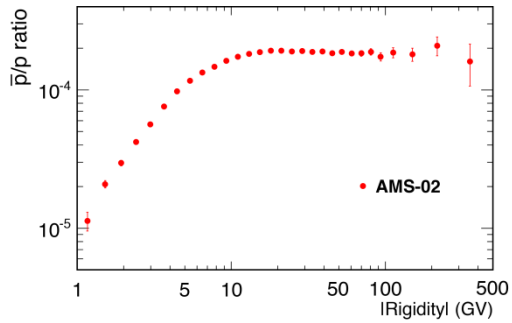












Cosmic Frontier - Experimental Operations Future Planning

➔**Planning for operations phase of current fabrication projects starting now!**

- Including pre-operations costs
- Computing resources – need to plan and optimize using existing facilities if possible (e.g. NERSC); also coordinate with ASCR efforts

→ Funds will ramp up to support these experiments as their fabrication phases end.

LSST: 3 distinct activities to be planned and supported on Operations funds

- LSSTcamera installation, commissioning (HEP)
- LSST facility operations (HEP agreed to ~ 25% of facilities operations, NSF ~ 50%, rest international)
- DESC collaboration operations – includes computing and collaboration costs (HEP)

→ LSST Project and LSST-DESC are developing operations model, organization and a timeline for detailed operations planning and review -- have started discussions with NSF and DOE; proposal expected in 2016

DESI: Activities to be planned and supported on Operations funds (all are HEP responsibilities!)

- Mayall Telescope facility, including DESI instrumentation, for dark energy science operations
- Data processing & management
- DESI Collaboration costs

→Draft Science Readiness and Experimental Operations plans will be ready for the May 2016 CD-3 review; planning independent review process to follow

LZ, SuperCDMS-SNOLAB

- Starting discussions with projects and collaborations for process and timeline to develop and review the operations plans (HEP for LZ, HEP & NSF-PHY for CDMS)

Cosmic Frontier – Experimental Research (FY16 Request ~$50M)

Budget:

FY16 President's Request budget for Cosmic Frontier is up ~ 2% relative to FY15, but the funding levels being planned to during the Continuing Resolution are down a few %

→Once a budget is passed (soon?!), the Research funding levels will be determined by HEP

Program Planning & Execution

HEP traditionally supports teams/collaborations of scientists with the necessary expertise and responsibilities to take experiments through all phases & to deliver the science

→Peer reviews and program planning reflect this tradition

Research Priorities for funding, aligned with P5

- Provide adequate support for collaborations to carry out our responsibilities and deliver the science for the projects selected for our program
  - For experiments with a broad science program, support the HEP-related science.
  - Also provide limited research-only support for other experiments not in our program or in planning or operating phase (e.g. CMB, Euclid, WFIRST)
- Distribution of research efforts across science topics and projects will necessarily change to support changing priorities and status of the experiment
  - Keep efforts at about current level for operating experiments; Ramp-down for ones completing operations; Ramp-up for projects in fabrication or planning phase, depending on needs

Note: Funding is considered for theory/simulations/phenomenology/computational efforts in direct support of our experiments (otherwise should be proposed to the Theory program).

Cosmic Frontier - R&D

Cosmic Frontier R&D – minimal funding expected for FY16

➔R&D towards P5 recommendations for the future:

Dark Matter (P5 recommended a DM-G3 R&D program)

- HEP concentrating on getting the DM-G2 experiment(s) successfully started
- Limited R&D support planned in FY17+
  - For near term efforts to support optimizations/enhancements for the DM-G2's, technologies for DM-G3; but NOT to design DM-G3 concepts!
  - DM-G1 experiments completing in FY16 can apply for R&D funds for focused technology studies for the future

  →Working on developing a process to consider proposed R&D efforts

CMB-S4

- hope to have some funds available for technology studies in the next few years

➔Cosmic Frontier related R&D also supported by

- Lab Directed R&D (LDRD) - Labs have internal funds to develop new projects, technologies, directions → considerable efforts for future dark matter, dark energy and CMB directions
- Advanced Detector R&D – developing future technologies with broad applications

Cosmic Frontier - Interagency Activities, etc.

Interagency Coordination: NSF, NASA, DOE talk regularly about program planning, overlaps, issues

Interagency Projects: can provide necessary or additional resources leading to opportunities for increased science.

- Depending on science, project, contribution, agency considerations it may make sense to partner, provide facilities, and/or coordinate efforts.

  HEP & NSF/PHY: VERITAS, HAWC, Auger, SuperCDMS-SNOLab
  HEP & NSF/AST: DES, LSST, DESI
  HEP & NSF/PHY, AST, OPR: SPT-3G
  HEP & NASA-AST: FGST

Project Coordination & Oversight:

Joint Oversight Group (JOG) : VERITAS, HAWC, LSST, DES, SuperCDMS-SNOLab
Interagency Coordination Group (ICG): DESI,
Finance Board meetings: Auger, FGST

Tri-Agency Group (TAG) – DOE, NASA, NSF-AST

Meeting monthly with US-leads on LSST, WFIRST, Euclid to discuss commonalities, coordination

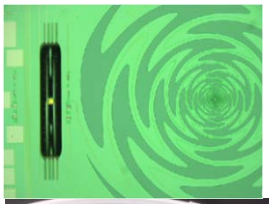
International Efforts

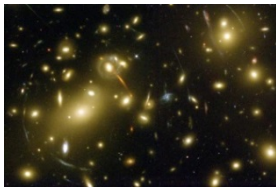
- DOE making country-level agreements to allow science partnerships to move forward.
- HEP participating on the Global Science Forum's Astro-particle Physics International Forum (APIF)

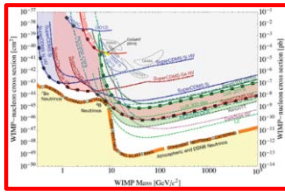
Cosmic Visions – looking towards the future

HEP has started "Cosmic Visions" groups:

- Program Manager planning responsibilities → Follow on from Snowmass, P5 strategic plan.
- Interactions with small community groups (~ monthly) as a 2-way line of communication







CV groups:

- Collect info from community on HEP supported efforts
- Can write white papers, e.g. science case, technology efforts & needs; planning options
- Can take HEP feedback to community and help focus and coordinate HEP community R&D efforts, planning, studies, options for the future.

➔HEP can use info to help guide, develop and coordinate HEP funds and plans for the priority P5 science and technology directions

CV-CMB (started)

- CMB-S4 in P5 plan to probe inflation with ~0.5 million detectors.
- CMB-S4 community-led collaboration planning underway; community spans NSF, NASA, DOE

– CV group to coordinate HEP community and HEP supported efforts and planning for the future

CV-DE (started)

- Plan future directions in research, datasets, experiments, or facilities following the end of construction of DESI and LSST. "Complement, build upon, and extend beyond these experiments in investigating the physics of dark energy."

CV-DM (being started)

- Help to coordinate R&D efforts, background and calibration study needs; planning for near term studies, technologies for future DM-G3 and science directions

Summary

- **An exciting time for HEP and the Cosmic Frontier!**
  4 MIE projects and 2 small (below MIE) in development
- **P5 developed compelling, realistic strategic plan with a consensus vision for US HEP**
  →HEP is moving forward to implement it; working with Community
- **Close coordination with the other agencies.**

BACKUPS

P5 Report – Program & Project Criteria

HEP will use P5 criteria to develop the program and determine which projects, and at what level, to invest in.

- **Program optimization criteria**

– **Science**: based on the Drivers, assess where we want to go and how to get there, with a portfolio of the most promising approaches.
– **International context**: pursue the most important opportunities wherever they are, and host world-leading facilities that attract the worldwide scientific community; duplication should only occur when significant value is added or when competition helps propel the field in important directions.
– **Sustained productivity**: maintain a stream of science results while investing in future capabilities, which implies a balance of project sizes; maintain and develop critical technical and scientific expertise and infrastructure to enable future discoveries.

- **Individual project criteria**

– **Science:** how the project addresses key questions in particle physics, the size and relevance of the discovery reach, how the experiment might change the direction of the field, and the value of null results.
– **Timing**: when the project is needed, and how it fits into the larger picture.
– **Uniqueness**: what the experiment adds that is unique and/or definitive, and where it might lead. Consider the alternatives.
– **Cost vs. value**: the scope should be well defined and match the physics case. For multidisciplinary/agency projects, distribution of support should match the distribution of science.
– **History and dependencies**: previous prioritization, existing commitments, and the impacts of changes in direction.
– **Feasibility**: consider the main technical, cost, and schedule risks of the proposed project.
– **Roles**: U.S. particle physics leadership

Cosmic Frontier
Statistics on Comparative Review Research (University) Grants

				FY12	FY13	FY14	FY15
Cosmic CR – $M request (Y1)				$3.3	$7.7	$7.5	$6.8
Cosmic CR – $M funded (Y1)				$1.6	$3.4	$4.4 w/FFF	$3.3 w/FFF
Cosmic CR - proposal counts							
		#proposals	received	11	33	29	27
		#proposals	reviewed	10	28	28	27
		#proposals	funded	6	18	19	14
		#proposals	**success rate**	**60%**	**64%**	**68%**	**52%**
Cosmic CR - PI counts							
		#PI's	received	21	61	40	43
		#PI's	reviewed	20	54	38	43
		#PI's	funded	13	27	25	21
		#PI's	**success rate**	**65%**	**50%**	**66%**	**48%**

Funding:

- Typically the total of all requests is for ~ twice the funds we have available.
- Grants are typically funded at less than their request.
- FY15 Cosmic request was $21.9M (for full grant period) and $6.8M for Year1.
- Funds shown above are for Year 1 of the "Comparative Review" grants approved in that year.
  - ➢ Funds for other types of grants (Early Career, General FOA, conferences) & Years 2 and 3 of previously awarded Comparative Review grants are also provided out of the research budget.

Cosmic Frontier – Statistics on Early Career Awards (Labs & Universities)

	FY10	FY11	FY12	FY13	FY14	FY15
# received - Univ	11	8	12	16	6	7
# received - Lab	10	4	7	9	7	5
# funded - Univ	**2**	**1**	**2**	**1**	**1**	**0**
# funded - Lab	**0**	**2**	**1**	**1**	**0**	**0**

Awards (5-year):

FY10
Newman (Pitt)
Mahapatra (TAMU)

FY11
Chou (FNAL)
Slosar (BNL)
Hall (Maryland)

FY12
Mandelbaum (CMU)
Padmanabhan (Yale)
Carosi (LLNL)

FY13
Bolton (Utah)
Chang (ANL)

FY14
Dahl (Northwestern)

FY15: none

Cosmic Frontier Budget History

Cosmic Frontier Budget History ($K)	FY13 Actual	FY14 Actual	FY15 Request	FY15 Actual	FY16 Request
Research	**48,652**	**52,712**	**45,435**	**48,779**	**50,079**
Grants		**13,157**	**11,422**	**11,773**	**12,565**
National Laboratories		**39,555**	**34,013**	**37,006**	**37,514**
Facility Operations and Experimental Support	**10,111**	**10,357**	**7,238**	**9,185**	**7,120**
Projects	**19,159**	**30,660**	**41,000**	**46,403**	**58,701**
MIE	**9,500**	**22,900**	**41,000**	**44,178**	**57,100**
HAWC	*1,500*				
LSST camera	*8,000*	*22,000*	*35,000*	*35,000*	*40,800*
DM-G2		*900*	*6,000*		*11,000*
LZ				*3,050*	
SuperCDMS-SNOLAB				*2,250*	
DESI				*3,878*	*5,300*
Small Project Fabrication: FY15/16 - SPT-3G, ADMX-G2				**1,025**	**1,601**
Future Project R&D: FY15 - SPT-3G, ADMX-G2, etc	**9,359**	**7,760**		**1,200**	
TOTAL – Cosmic Frontier	**77,922**	**93,729**	**93,673**	**104,367**	**115,900**
TOTAL – Cosmic Frontier w/other costs		96,927	101,245	106,507	119,325
TOTAL – HEP		774,920	744,000	766,000	788,000

FY16 HEP Budget
House/Senate Marks $776M/$788.1M; Currently in a Continuing Resolution