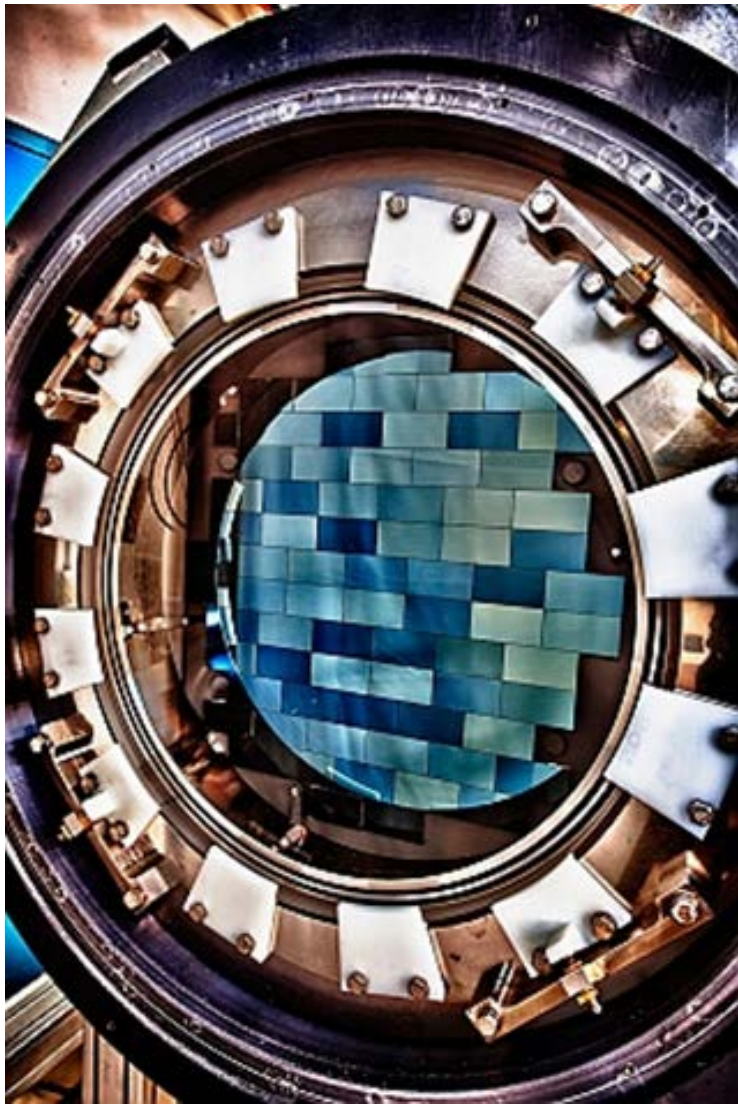
DOE High Energy Physics (HEP)

report to the

AAAC Panel



28 January 2016
Kathy Turner

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

Outline

- **Budgets**
- **Program & Project Status**
- **Future planning**

FY 2014-2016 HEP Program - Budget Status

HEP Budget History ($K)	FY 2014 Request	FY 2014 Actual	FY 2015 Request	FY 2015 Enacted	FY 2016 Request	FY 2016 House Mark (~ 5/6/15)	FY 2016 Senate Mark (~ 5/27/15)	FY 2016 Approved (12/16/15)
Energy Frontier	154,687	152,386	153,639	147,584	154,555			
Intensity Frontier	271,043	250,987	251,245	264,224	247,196			
Cosmic Frontier	**99,080**	**96,927**	**101,245**	**106,870**	**119,325**			
Theoretical and Computational	62,870	64,275	58,850	59,274	60,317			
Advanced Technology R&D	122,453	150,270	114,242	120,254	115,369			
Accelerator Stewardship	9,931	9,075	*19,184*	*10,000*	*14,000*			
Construction	35,000	51,000	25,000	37,000	56,100			
Total	755,064	774,920	723,405	745,206	766,862			
SBIR/STTR*	21,457	0	20,595	20,794	21,138			
HEP Total	**776,521**	**774,920**	**744,000**	**766,000**	**788,000**	**776,000**	**788,100**	**795,000**
Office of Science Total	5,152,700		5,111,155	5,067,738	5,339,800	5,100,000	5,143,900	5,350,200

*FY14 SBIR/STTR was ~ $21M, so FY2014 actual was ~ $796M.

FY2016 Budget Notes

The FY16 budget was approved on 12/16/15.

Cosmic Frontier MIE projects:

- **LSST is being funding according to its planned profile.**
- **DESI is being funded at $5M more than requested in FY16 (budget guidance)**
- **LZ is being funded at $1.5M more than requested in FY16 (budget guidance)**
- **SuperCDMS-SNOLAB is being funded at $1M over the requested amount.**

Research budgets:

Even though the FY16 approved budget is more than the requested amount, due to the budget guidance we received and other constraints, the research budget is still planned at the Continuing Resolution (few % reduced) levels.

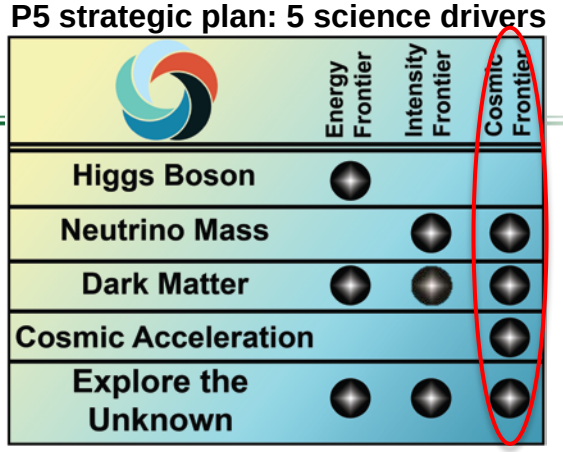
→ The program managers for each Frontier are preparing requests for additional funds available within HEP, there there still is the possibility of *limited* funds moving into Cosmic Frontier research from the overall HEP funds during FY16.

Cosmic Frontier Budget History

Cosmic Frontier Budget History ($K)	FY13 Actual	FY14 Actual	FY15 Request	FY15 Actual	FY16 Request	FY16 Approved
Research	**48,652**	**52,712**	**45,435**	**48,779**	**50,079**	**46,545**
Grants		**13,157**	**11,422**	**11,773**	**12,565**	**11,595**
National Laboratories		**39,555**	**34,013**	**37,006**	**37,514**	**34,950**
Facility Ops & Exp. Support	**10,111**	**10,357**	**7,238**	**9,185**	**7,120**	**9,190**
Projects	**19,159**	**30,660**	**41,000**	**46,403**	**58,701**	**66,835**
MIE	**9,500**	**22,900**	**41,000**	**44,178**	**57,100**	**64,600**
HAWC	*1,500*					
LSST camera	*8,000*	*22,000*	*35,000*	*35,000*	*40,800*	*40,800*
DM-G2		*900*	*6,000*		*11,000*	
LZ				*3,050*		*10,500*
SuperCDMS-SNOLAB				*2,250*		*3,000*
DESI				*3,878*	*5,300*	*10,300*
Small Project Fabrication: SPT-3G, ADMX-G2				**1,025**	**1,601**	**2,035**
Future Project R&D: SPT-3G, ADMX-G2, etc	**9,359**	**7,760**		**1,200**		**200**
TOTAL – Cosmic Frontier	**77,922**	**93,729**	**93,673**	**104,367**	**115,900**	**122,570**

*Totals are slightly less than shown in the HEP budget because there are extra funds in each HEP budget line for program reviews, direction, early career etc.

May 2014 P5 Report – Cosmic Frontier Recommendations

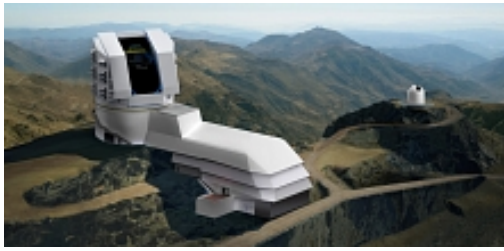


P5 report recommendations addressed to the Cosmic Frontier ➔

- **Dark Energy**
  - Build DESI as a major step forward in dark energy science
  - Complete LSST as planned
- **Dark Matter**
  - 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
  - Support one or more third-generation (G3) direct detection experiments
    - Guide G3 by the results of the preceding (G1, G2) 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 Microwave Background (CMB)**
  - 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 Rays and Gamma Rays**
  - Invest in CTA only if the critical NSF Astronomy funding can be obtained
    - 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.

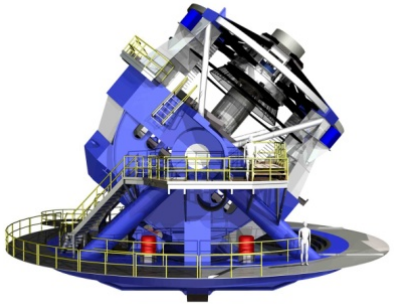
Cosmic Frontier - Major Item of Equipment (MIE) Projects



→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)

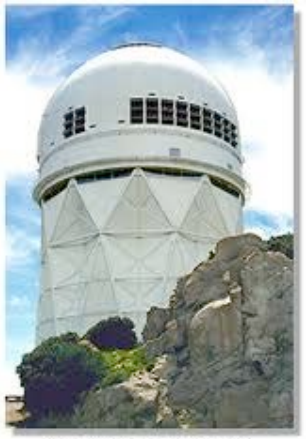
Schedule: Camera ship to summit 2QFY20; CD-4 in 2QFY22

- 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

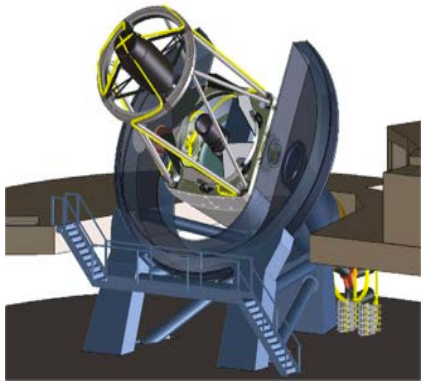
Cosmic Frontier - Major Item of Equipment (MIE) Projects

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)

Schedule:

- 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

Current:

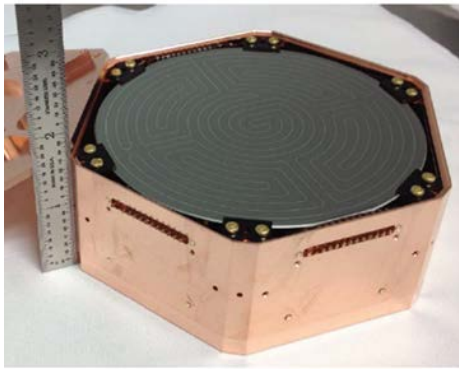
→Project on track – lenses, sensors

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

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 review planned for April
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.

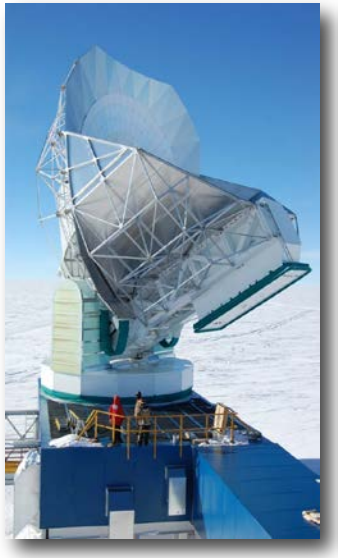
HEP+NSF-PHY partnership, SLAC Project Office
→ CD-1 approval in Dec. 2015
Project is not baselined yet; Preliminary Cost/Schedule:
Total Project Cost Range is $16-$21M for DOE (FY15-19)
Preliminary Schedule :
CD-2 planned 3QFY17, Detector Installation complete 4QFY19; CD-4 planned 4QFY20

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

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

➔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
- ***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

Cosmic Frontier - Experimental Operations
Current Operations continued

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)* –NASA leads the mission; HEP is supporting the Instrument Science Ops Center at SLAC
- - proposal submitted to 2016 Senior Review; recent dark matter search results; "Pass 8" software leading to significant improvement in science results
- ***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)

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

- LSST camera 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 2017

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

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
- 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).

FY16 Comparative Review process: Recommendations for funding going out soon.

FY16 Early Career – review panel in February

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 experiments 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, PLR: 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

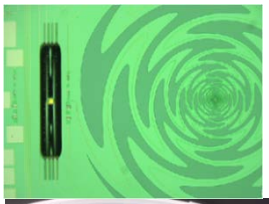
International Efforts

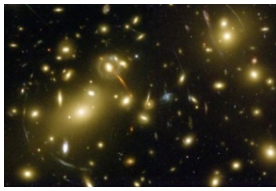
- DOE making country-level agreements to allow science partnerships to move forward.
- HEP participating on the Global Science Forum's Astro-particle Physics International Forum (APIF)

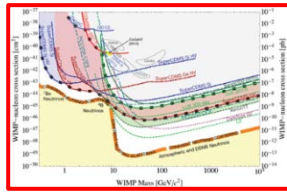
Cosmic Visions – looking towards the future

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!**
- **P5 developed compelling, realistic strategic plan with a consensus vision for US HEP**
  →HEP is moving forward to implement it.
- **Close coordination with the other agencies.**