Cosmic Frontier Research at Fermilab

Craig Hogan, Director
Dan Bauer, Deputy Director
Fermilab Center for Particle Astrophysics
DOE Non-Accelerator Review, September 2010

Presentations

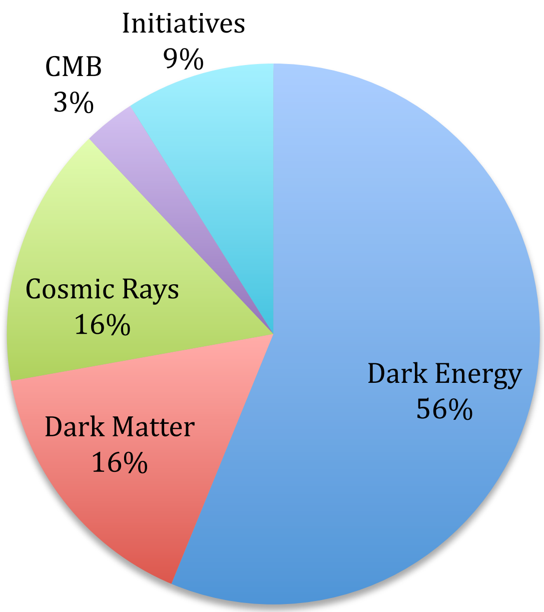
Craig Hogan: Overview

Josh Frieman: Dark Energy

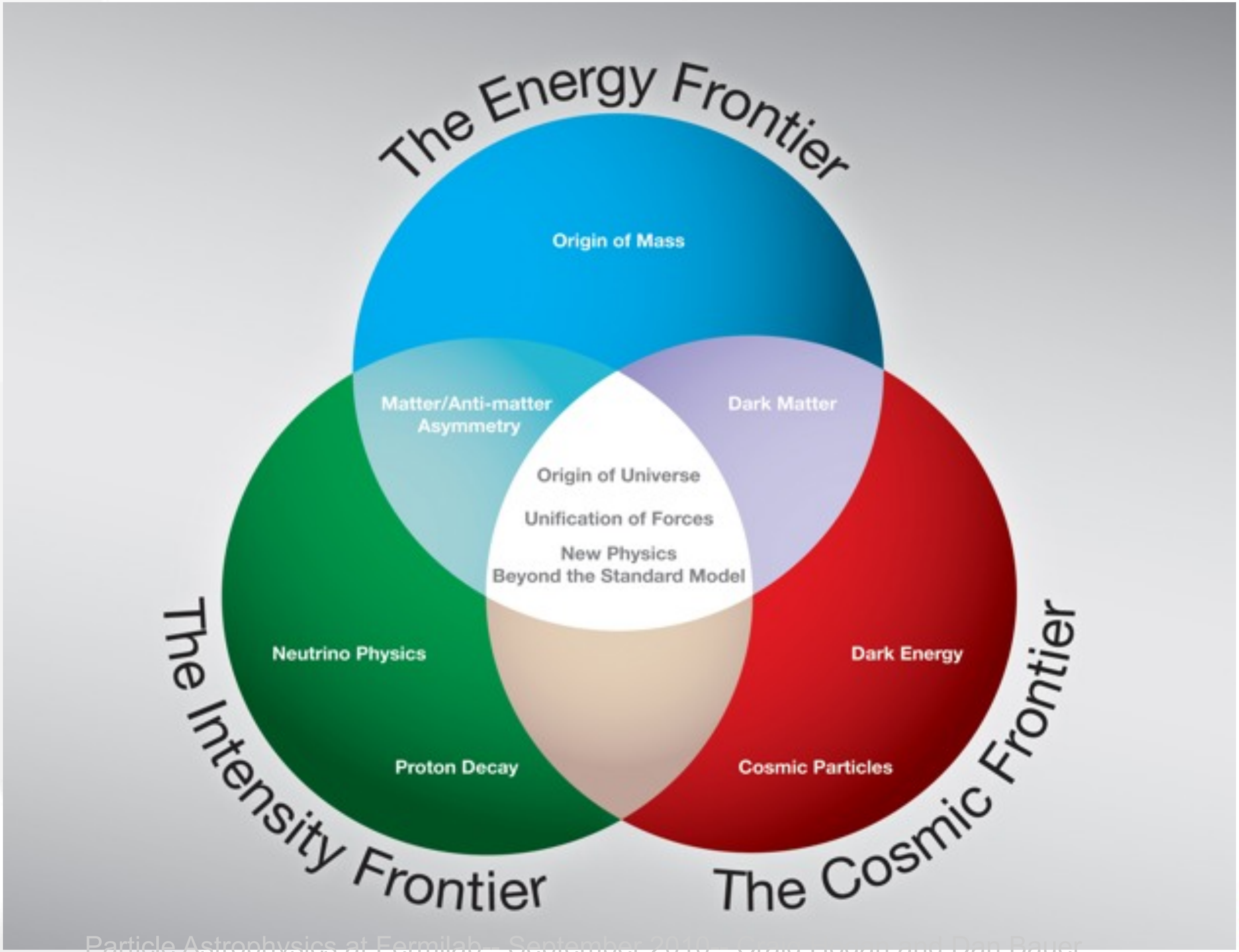
Dan Bauer: Dark Matter

Sein Ahn: Cosmic Particles

Aaron Chou: New Initiatives



Frontiers of Fundamental Physics (from P5, 2008)



DOE/OHEP Mission

The mission of the High Energy Physics program is to understand how our universe works at its most fundamental level. We do this by discovering the most elementary constituents of matter and energy, exploring the basic nature of space and time itself, and probing the interactions between them.

---Mission Statement, DOE Office of High Energy Physics

History of Particle Astrophysics at Fermilab

- Kolb & Turner: Theoretical Astrophysics Group (1983)
- Sloan Digital Sky Survey (1990)
- Pierre Auger Observatory (1994)
- Cryogenic Dark Matter Search (1997)
- Dark Energy Survey (2003)
- Chicagoland Observatory for Underground Particle Physics (2004)
- Fermilab Center for Particle Astrophysics (2007)
  - Established to coordinate and manage this program for the future

Fermilab

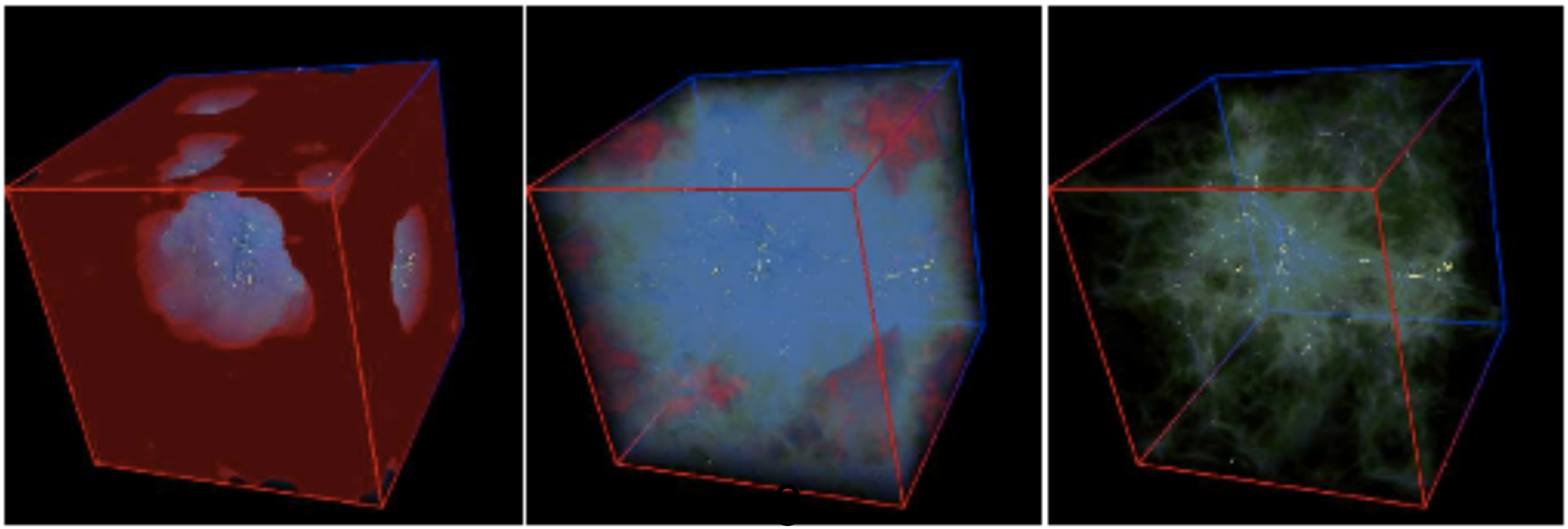
Theoretical Astrophysics Group

Leaders in theory, phenomenology

Science ideas, analysis, tools, leadership for experimental program

Next step: expanded cosmological computing capabilities in partnership with other labs

Critical to program-- but not part of KA-13!



Sloan Digital Sky Survey

Highest-impact observatory of the decade

Fermilab: anchor institution for technical infrastructure, operations, computing

Directors from FNAL: Peoples, Kron

SDSS-II: SDSS Supernova survey

SDSS-III: Fermilab no longer an institutional partner (but still maintains data stewardship role)

Group now transitioning to Dark Energy Survey

Core program: ongoing experiments

Dark Energy

Dark Energy Survey (DES)

Dark Matter

Cryogenic Dark Matter Search (CDMS)

Chicagoland Observatory for Underground Particle Physics (COUPP)

Ultra high energy cosmic rays

Pierre Auger Observatory (PAO)

Dark Energy Survey

Next big step in cosmic surveys after SDSS

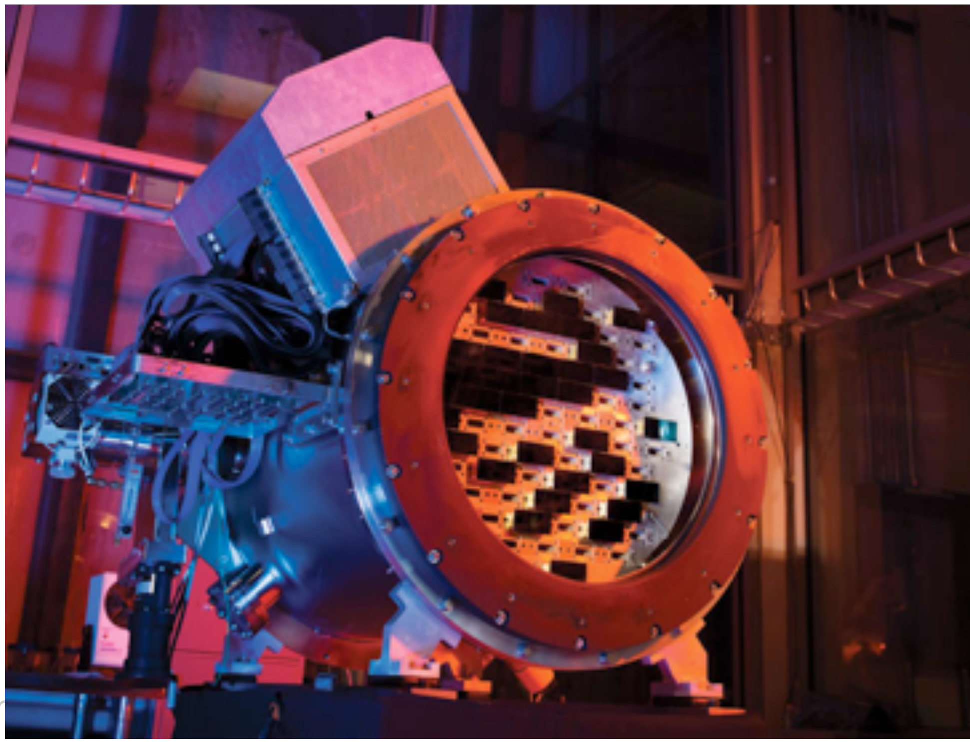
DE Camera under construction at Fermilab

New Director: Josh Frieman, succeeds John Peoples

Survey starts in 2012, then runs 5 years

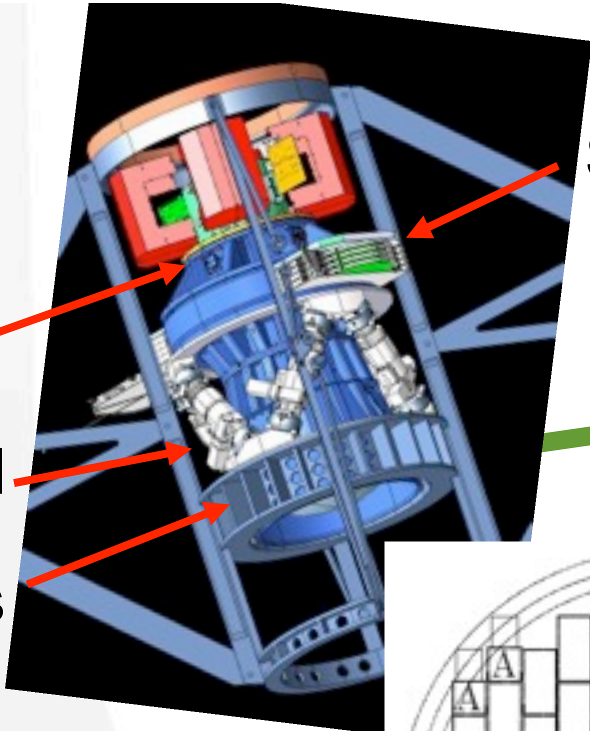
4m Blanco telescope at CTIO

DECam under construction at Fermilab



DECam : new instrument for Dark Energy

Replace Prime Focus cage on the CTIO Blanco 4m telescope with a new optical imager now being built at Fermilab

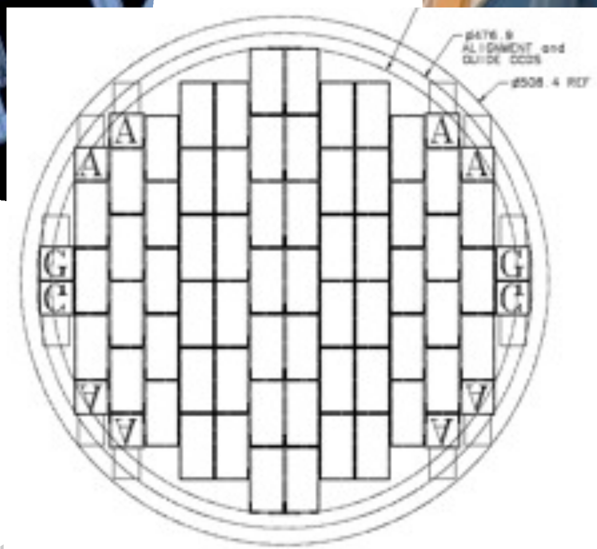


Filters, Shutter

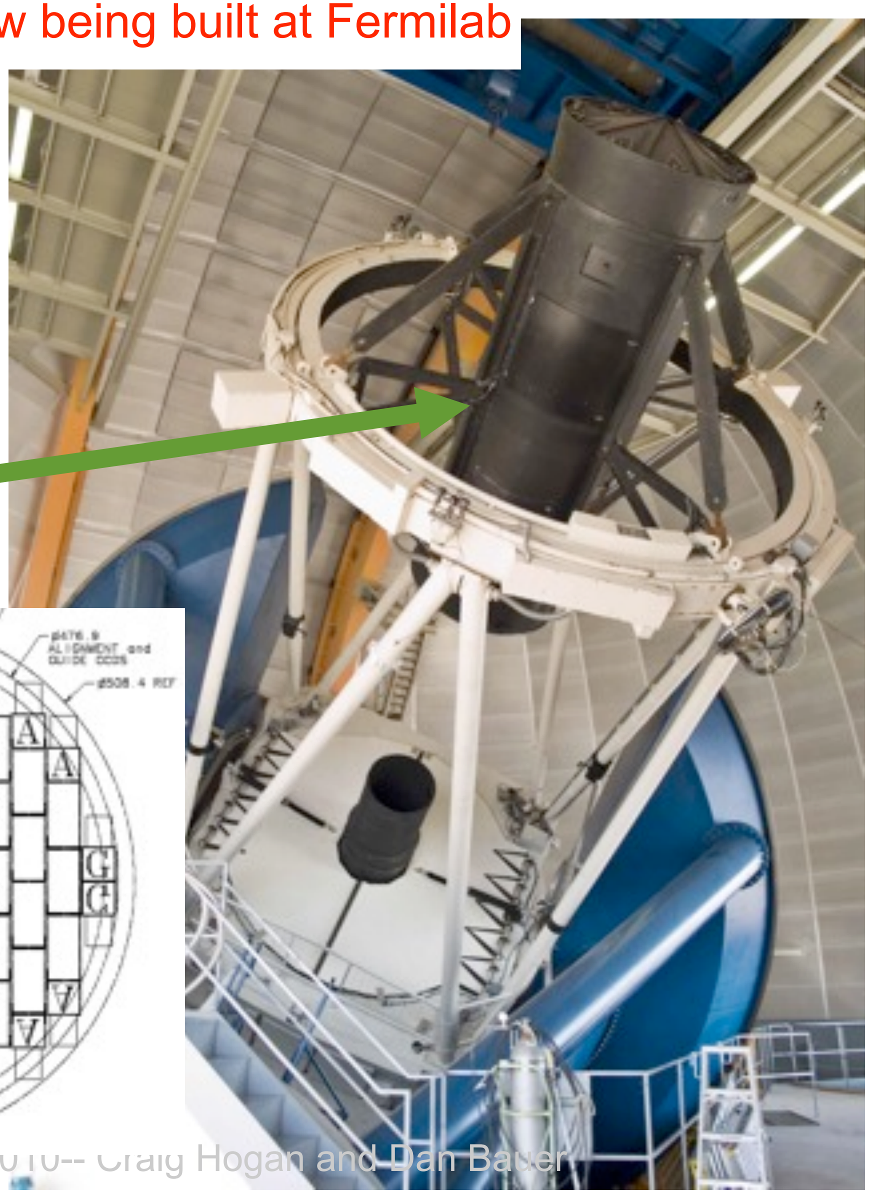
CCD

Hexapod

lenses

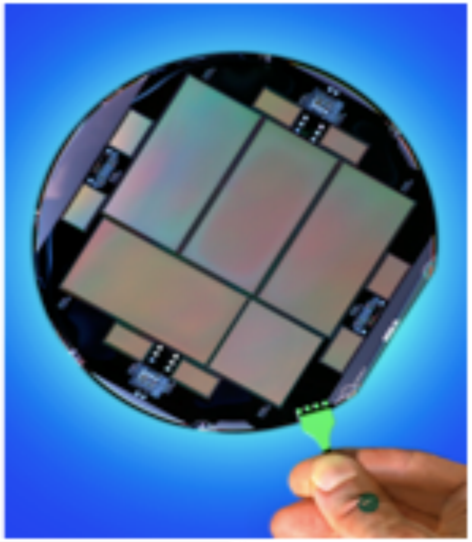


diameter = 48 cm

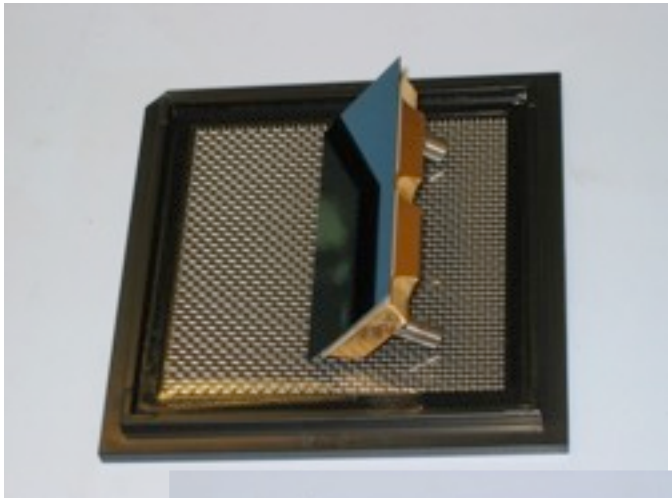


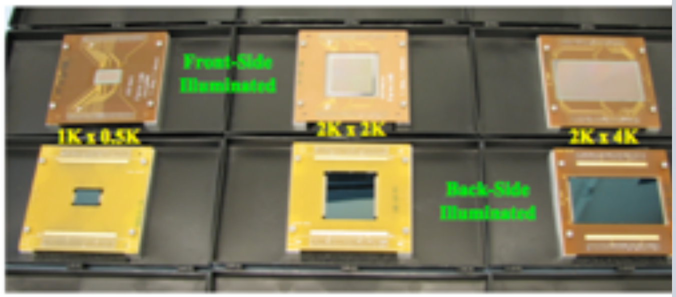
Fermilab's Silicon detector technology

DECam wafer



DECam detector developed with LBNL

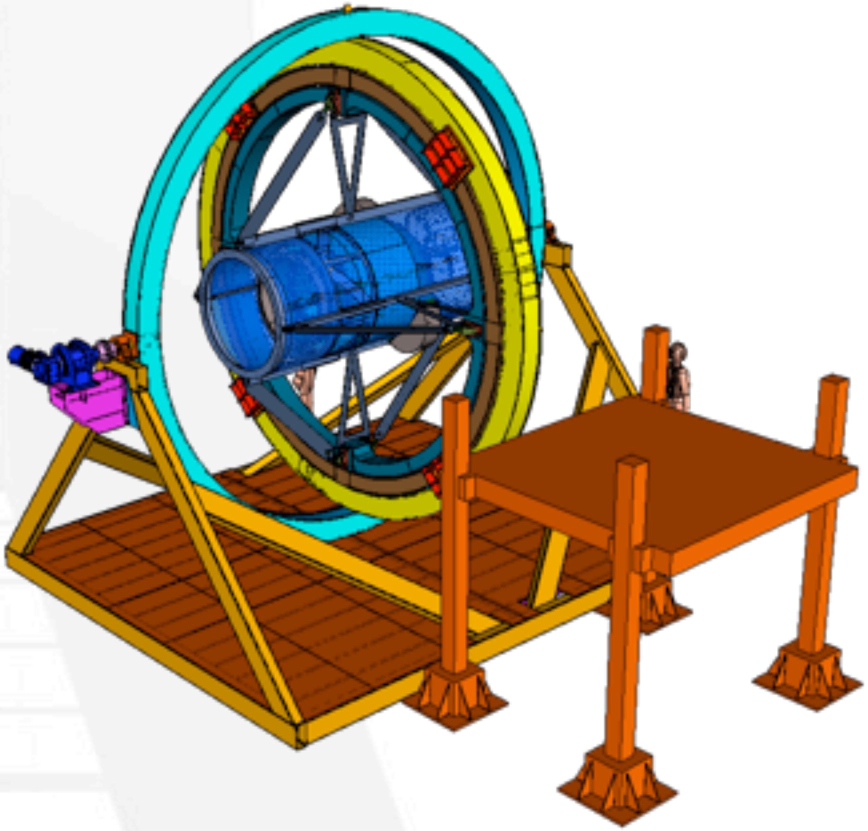




Fermilab's expertise in building silicon trackers has transferred to the design and fabrication of these CCDs

Telescope Simulator at Fermilab

Testing at Fermilab saves time, reduces risk



Dark Energy Science Program

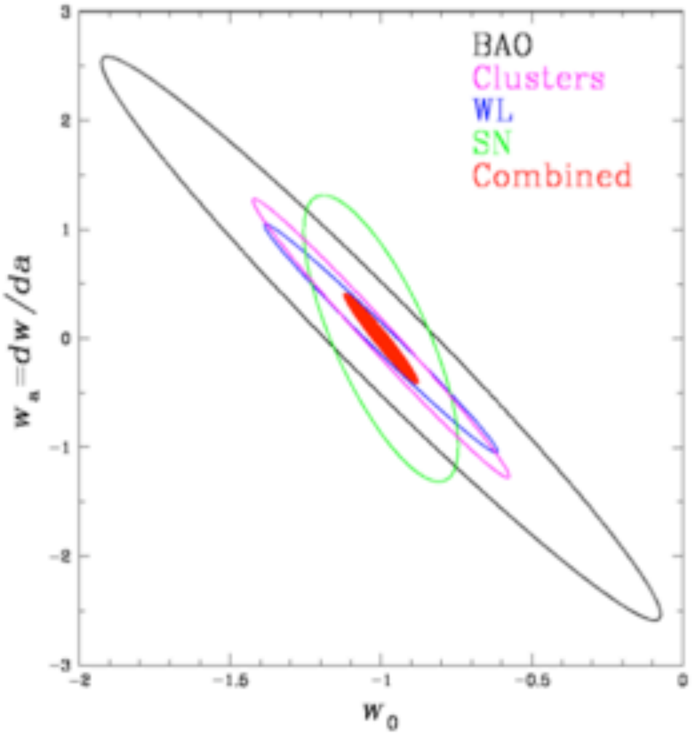
DARK ENERGY SURVEY

Four Probes of Dark Energy

- **Galaxy Clusters**
  - clusters to z>1
  - SZ measurements from SPT
  - Sensitive to growth of structure and geometry
- **Weak Lensing**
  - Shape measurements of 300 million galaxies
  - Sensitive to growth of structure and geometry
- **Large-scale Structure**
  - 300 million galaxies to z = 1 and beyond
  - Sensitive to geometry
- **Supernovae**
  - 15 sq deg time-domain survey
  - ~3000 well-sampled SNe Ia to z ~1
  - Sensitive to geometry

Plus QSOs, Strong Lensing, Milky Way, Galaxy Evolution

Forecast Constraints on DE Equation of State



Stage III project (DETF)

Dark Energy Figures of Merit

DES will be the world leader in Dark Energy precision

Multiple modalities will test different ideas for Dark Energy including modifications of gravity

Method	$\sigma(\Omega_{DE})$	$\sigma(w_0)$	$\sigma(w_a)$	z_p	$\sigma(w_p)$	$[\sigma(w_a)\sigma(w_p)]^{-1}$
BAO	0.010	0.097	0.408	0.29	0.034	72.8
Clusters	0.006	0.083	0.287	0.38	0.023	152.4
Weak Lensing	0.007	0.077	0.252	0.40	0.025	155.8
Supernovae	0.008	0.094	0.401	0.29	0.023	107.5
Combined DES	0.004	0.061	0.217	0.37	0.018	263.7
DETF Stage II Combined	0.012	0.112	0.498	0.27	0.035	57.9

Dark Energy Camera Deployment

DECam in the past year

Passed Lehmann review (June): on track

All CCDs verified

Built telescope simulator, testing components

Now shipping parts to Chile

DECam in the next year

All parts to CTIO

Assembly and commissioning start

First light in early FY 12 (just over a year from now!)

DES operations: 2012-2017

DECam construction will be “finished” in summer 2011

Then requires assembly, integration, commissioning

5 years of operations requires both NSF and DOE support

DES Collaboration

(119 scientists)

Fermilab (22 members)

University of Illinois Urbana-Champaign (10)

University of Chicago (9)

Lawrence Berkeley National Lab (9)

University of Michigan (7)

NOAO/CTIO (3)

Spain-DES Consortium: (7)

Institut d'Estudis Espacials de Catalunya, Institut de Fisica d'Altes Energies, CIEMAT

United Kingdom-DES Consortium: (22)

University College London, University of Portsmouth, University of Cambridge, University of Edinburgh, University of Sussex, University of Nottingham

Brazil-DES Consortium (6)

Ohio State University (6)

Argonne National Lab (3)

Santa Cruz-SLAC-Stanford Consortium (7)

Universitats-Sternwarte Munchen (6)

Texas A&M University (6)

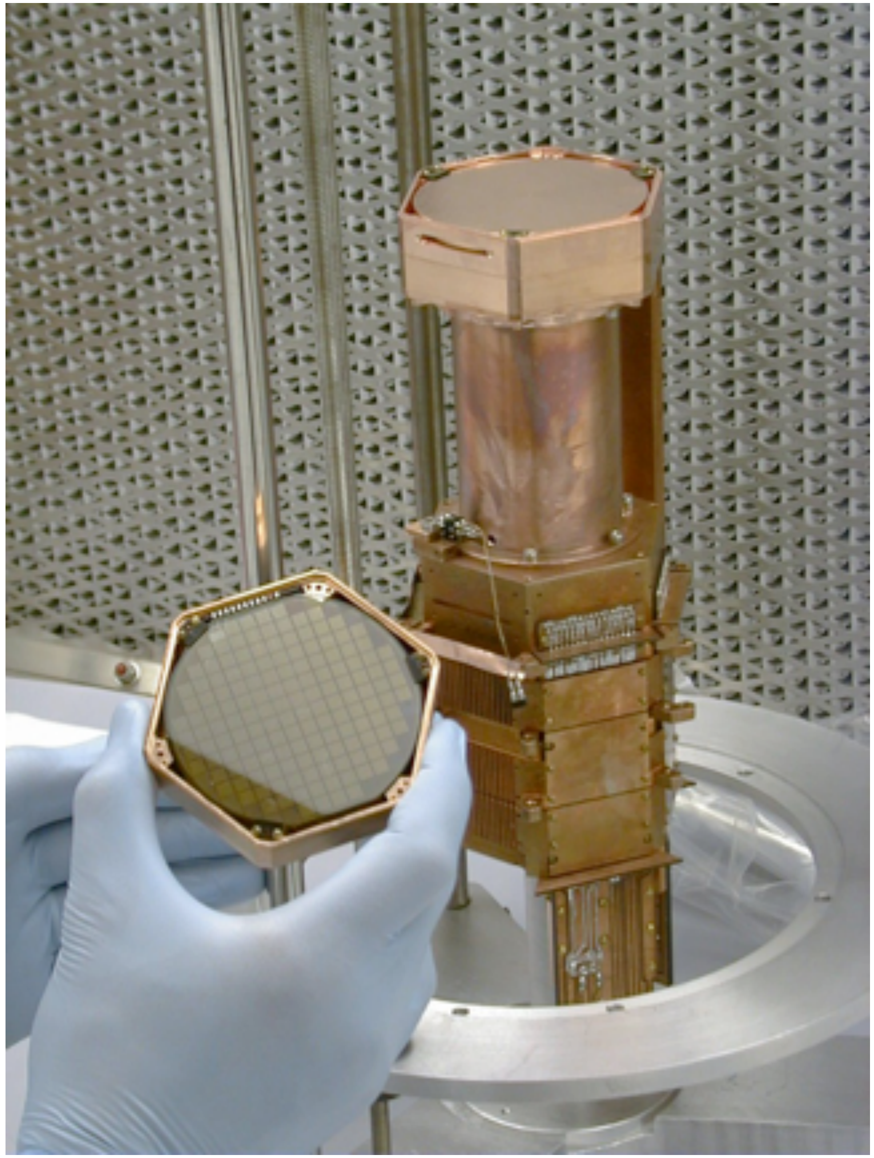
Dark Matter with Cryogenic Crystals: CDMS

Search for rare collisions of Galactic halo dark matter particles with nuclei

State of the art in direct detection and background rejection

Recent press attention: two events (maybe not background?)

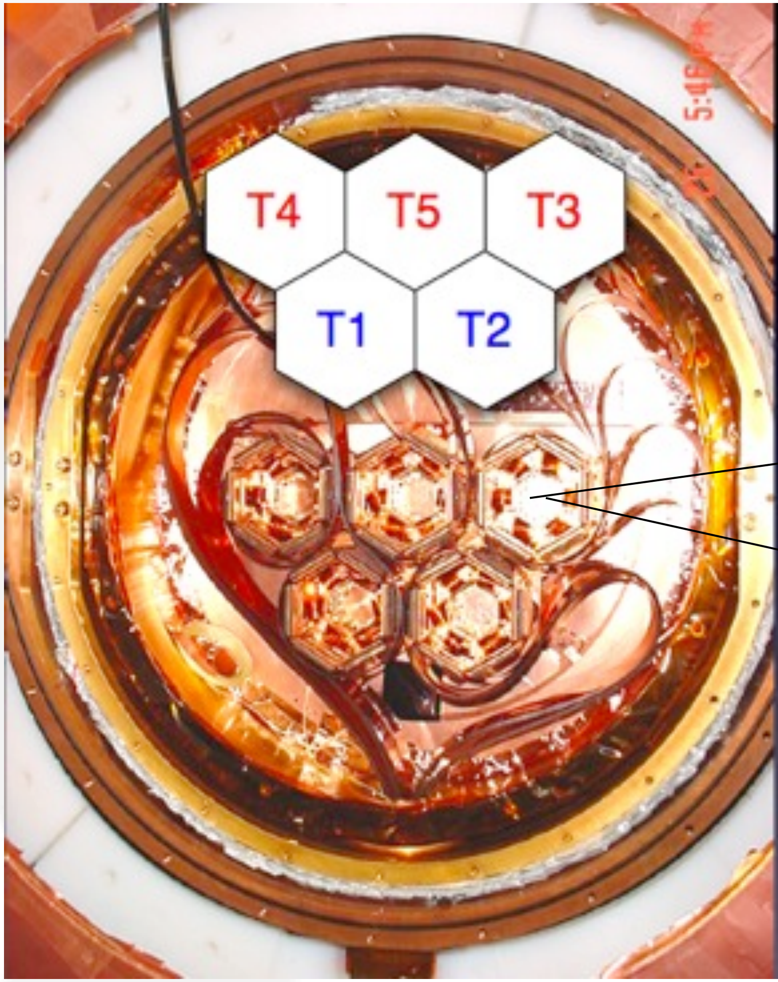
Near future: 15kg at Soudan with better detectors, background rejection

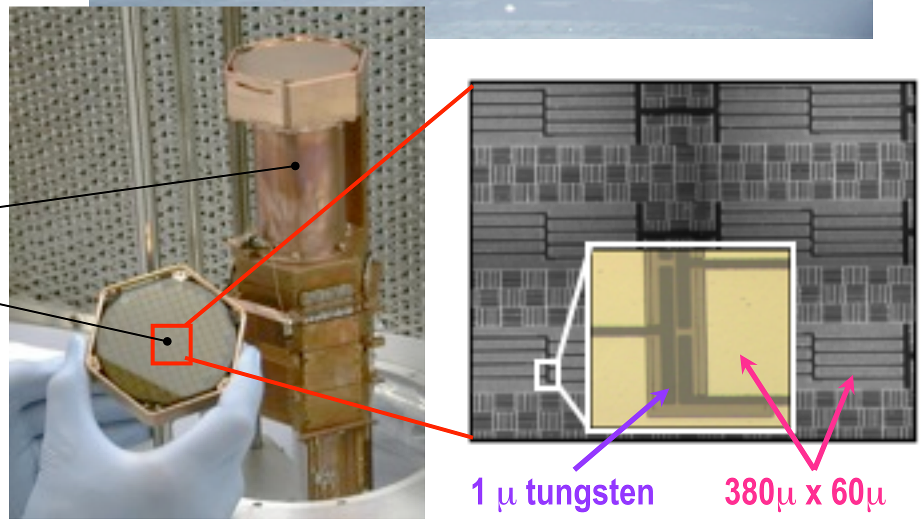


CDMS-II Experiment at Soudan

Five Towers (30 ZIPS)

operating since June '06

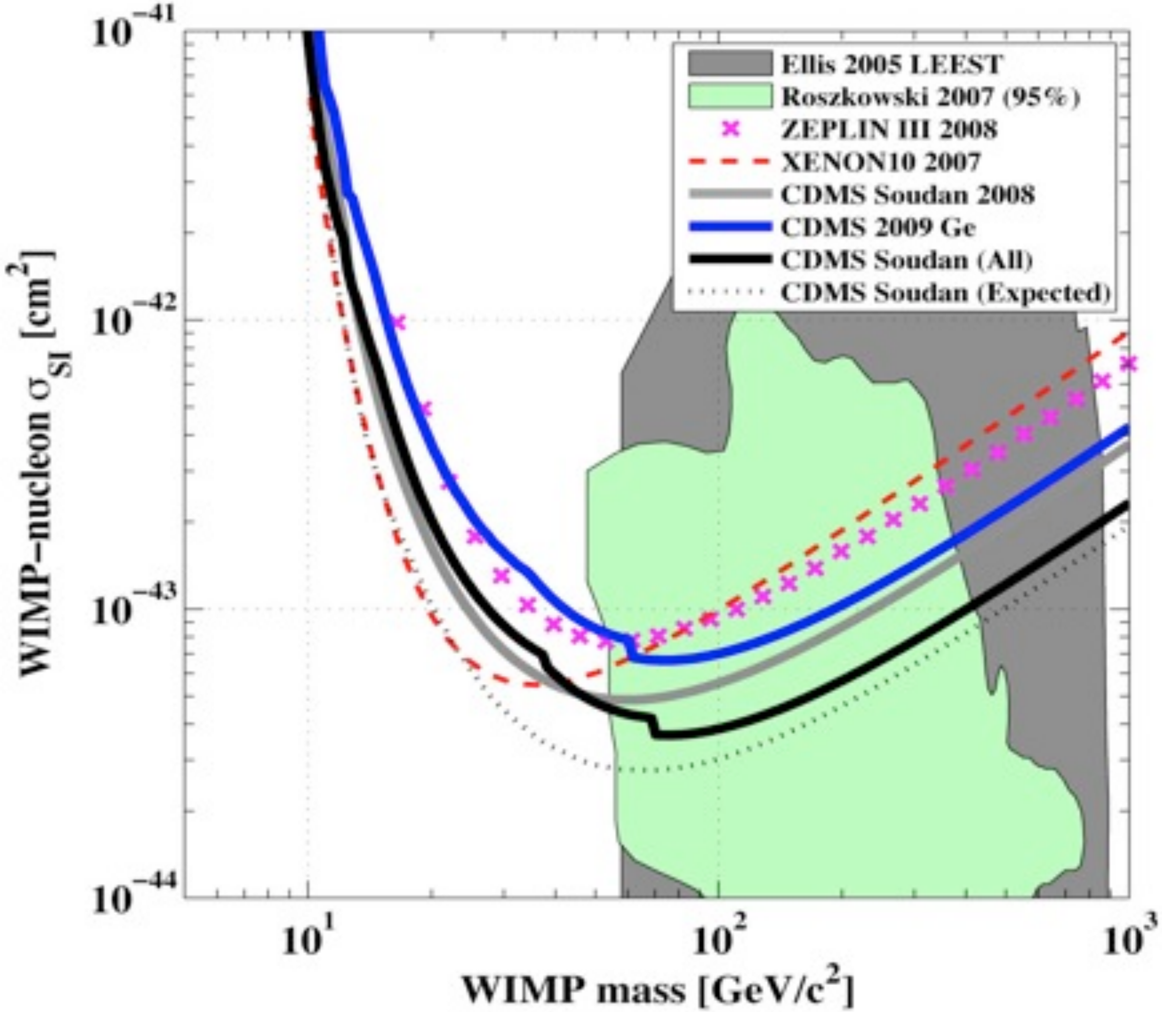




Z-sensitive Ionization and Phonon detectors

CDMS Sensitivity

- 2 events with an exposure of 200 kg days
- Low expected background of 0.9 events
- Leading the world in sensitivity to spin-independent WIMP-nucleus elastic scattering



Recent CDMS Results

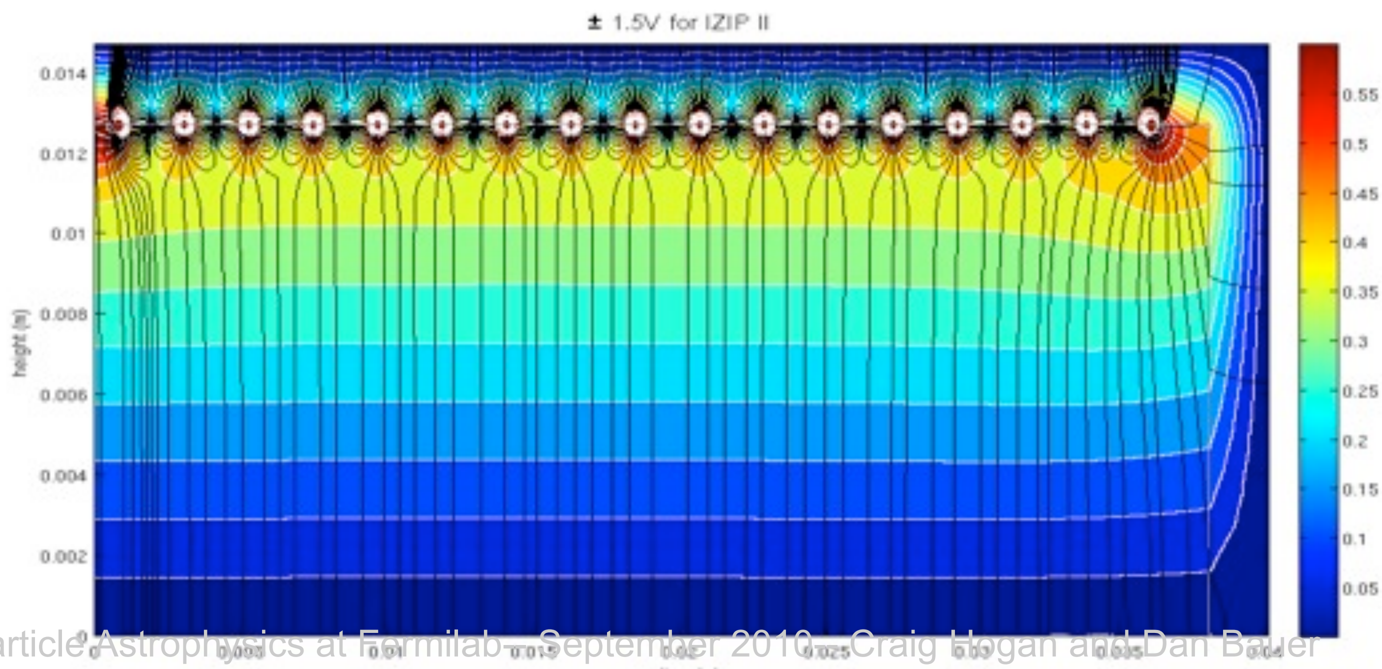
- Dark Matter Search Results from the CDMS II Experiment
  - *Science* 10.1126/science.1186112 (2010)
- Analysis of the Low-Energy Electron-Recoil Spectrum of the CDMS Experiment
  - *Physical Review D* **81**, 042002 (2010)
- Search for Axions with the CDMS Experiment
  - *Physical Review Letters* **103**, 141802 (2009)
- Search for Weakly Interacting Massive Particles with the First Five-Tower Data from the Cryogenic Dark Matter Search at the Soudan Underground Laboratory
  - *Physical Review Letters* **102**, 011301 (2009)

CDMS Technology Breakthrough

New symmetric detectors (iZIP) have demonstrated a background rejection improvement of more than an order of magnitude (ton scale CDMS style experiment now feasible); production of iZIPs now ongoing

Coming year:

- iZIP trial run this fall in Soudan facility
- Science run begins next summer



The Cryogenic Dark Matter Search

California Institute of Technology
Z. Ahmed, J. Filippini, S.R. Golwala, D. Moore, R.W. Ogburn

Case Western Reserve University
D. Akerib, C.N. Bailey, M.R. Dragowsky, D.R. Grant, R. Hennings-Yeomans

Fermi National Accelerator Laboratory
D. A. Bauer, F. DeJongh, J. Hall, D. Holmgren, L. Hsu, E. Ramberg, R.L. Schmitt, J. Yoo

Massachusetts Institute of Technology
E. Figueroa-Feliciano, S. Hertel, S.W. Leman, K.A. McCarthy, P. Wikus

NIST *
K. Irwin

Queen's University
P. Di Stefano *, N. Fatemighomi *, J. Fox *, S. Liu *, P. Nadeau *, W. Rau

Santa Clara University
B. A. Young

Southern Methodist University
J. Cooley

SLAC/KIPAC *
E. do Couto e Silva, G.G. Godrey, J. Hasi, C. J. Kenney, P. C. Kim, R. Resch, J.G. Weisend

Stanford University
P.L. Brink, B. Cabrera, M. Cherry *, L. Novak, M. Pyle, A. Tomada, S. Yellin

Syracuse University
M. Kos, M. Kiveni, R. W. Schnee

Texas A&M
J. Erikson *, R. Mahapatra, M. Platt *

University of California, Berkeley
M. Daal, N. Mirabolfathi, A. Phipps, B. Sadoulet, D. Seitz, B. Serfass, K.M. Sundqvist

University of California, Santa Barbara
R. Bunker, D.O. Caldwell, H. Nelson, J. Sander

University of Colorado Denver
B.A. Hines, M.E. Huber

University of Florida
T. Saab, D. Balakishiyeva, B. Welliver *

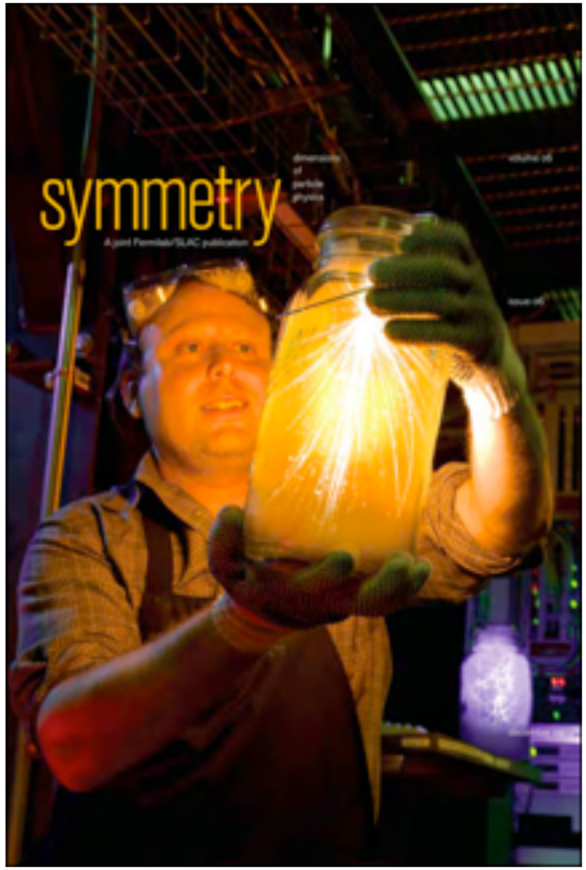
University of Minnesota
J. Beaty, P. Cushman, S. Fallows, M. Fritts, O. Kamaev, V. Mandic, X. Qiu, A. Reisetter, J. Zhang

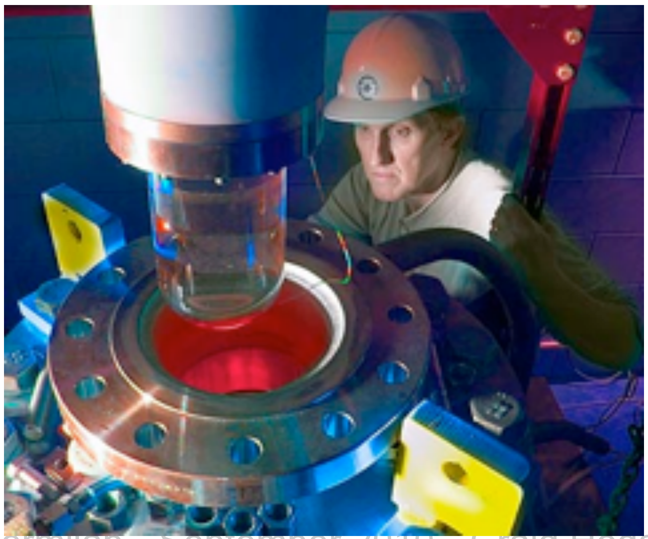
University of Zurich
S. Arrenberg, T. Bruch, L. Baudis, M. Tarka

* new collaborators or new institutions in SuperCDMS

Dark Matter with Bubble Chambers: COUPP

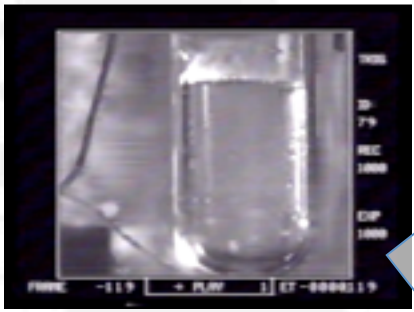
- Old technique applied with stunning early success
- High-purity 4kg and 60kg chambers, new acoustic rejection
- Now: 4kg at SNOLab, 60kg at FNAL
- Future: 60kg to SNOLab, then 500 kg





COUPP Bubble Chamber Program

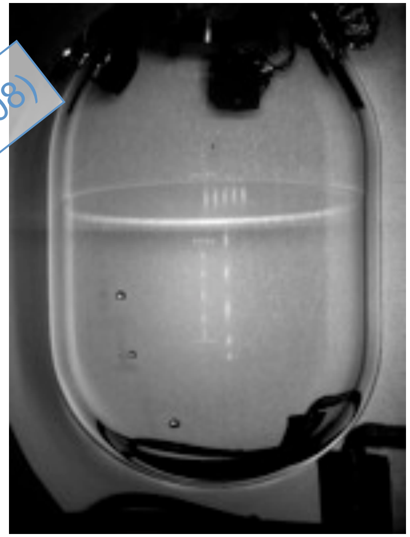
Take long runs with smaller chambers to understand backgrounds, operations, and for research and development while developing and commissioning an order of magnitude larger chamber



Test tube
(U Chicago)

Science 319:933-936 (2008)

COUPP 2kg

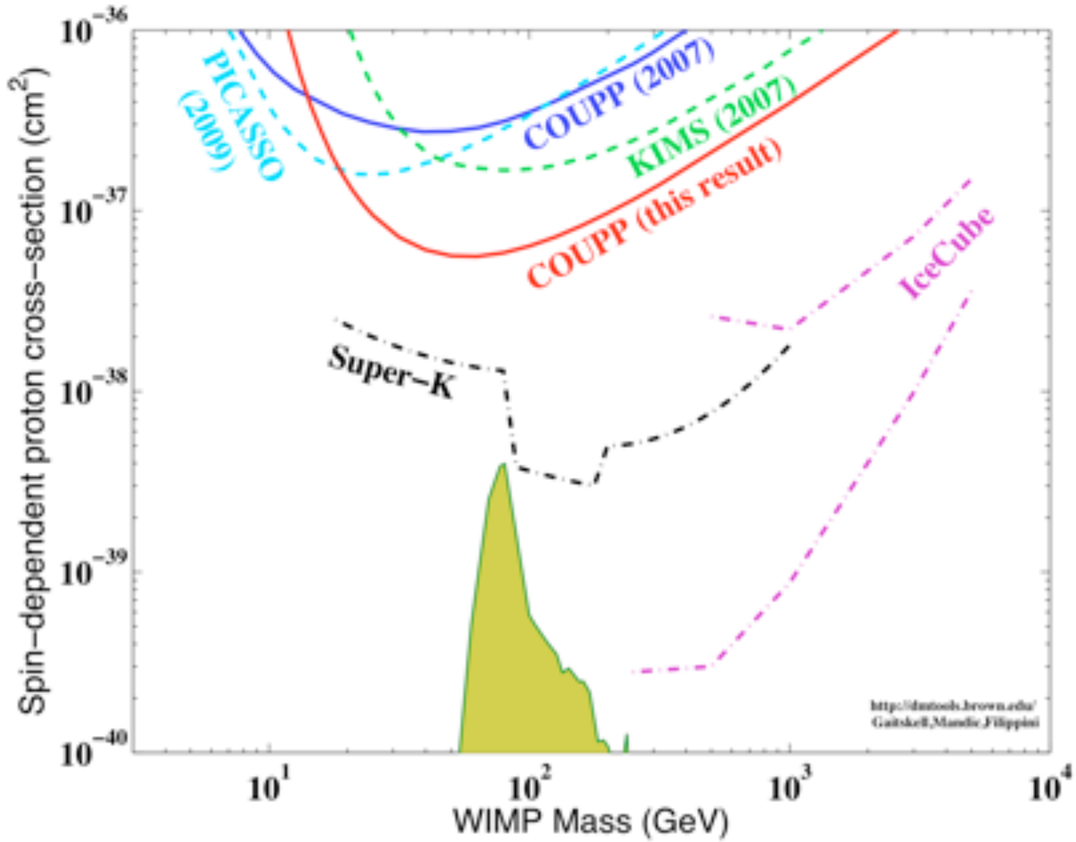


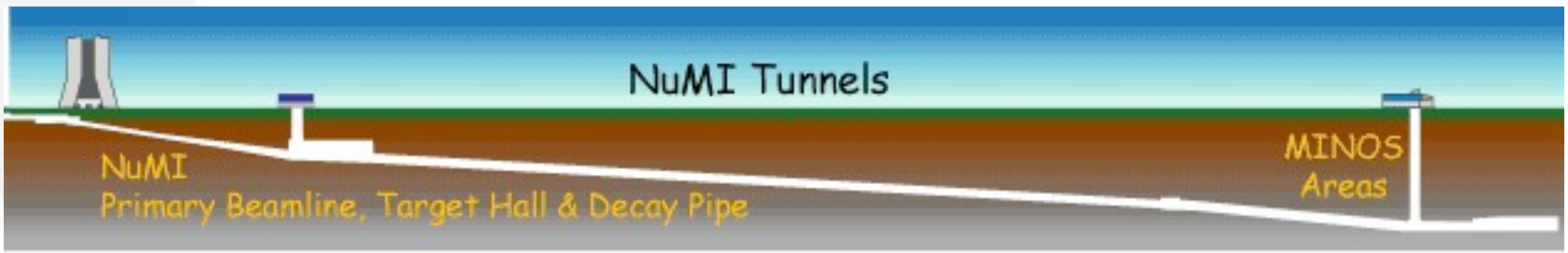
COUPP 4kg

COUPP 60kg

COUPP Results

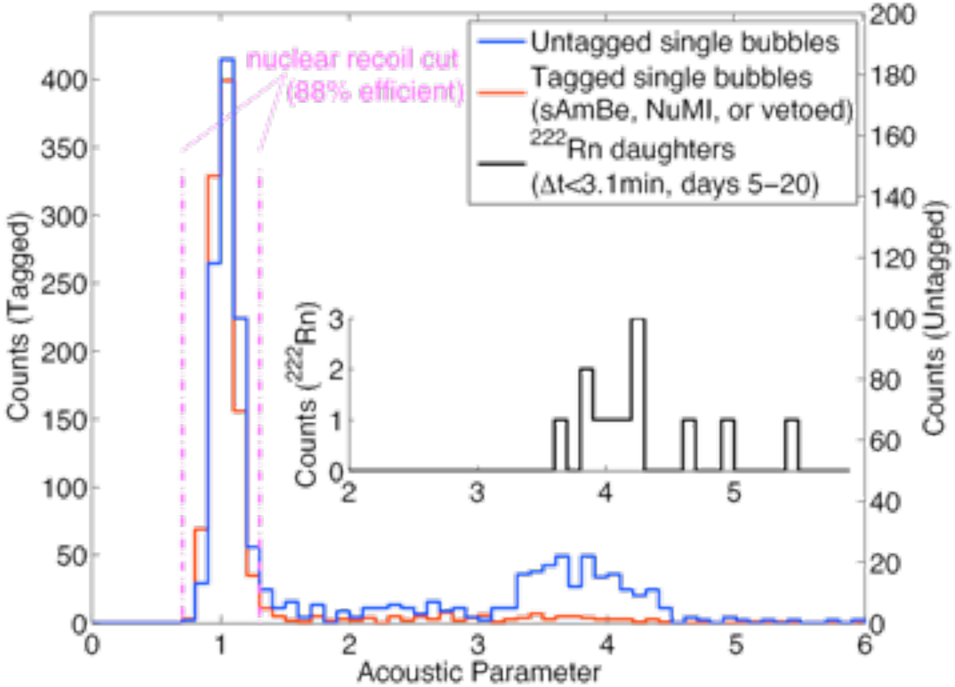
- Blue line –*Science* **319**:933-936 (2008)
- Red line – latest result (2010)
- Latest results limited by cosmic radiation in the NUMI tunnel, 350 foot depth

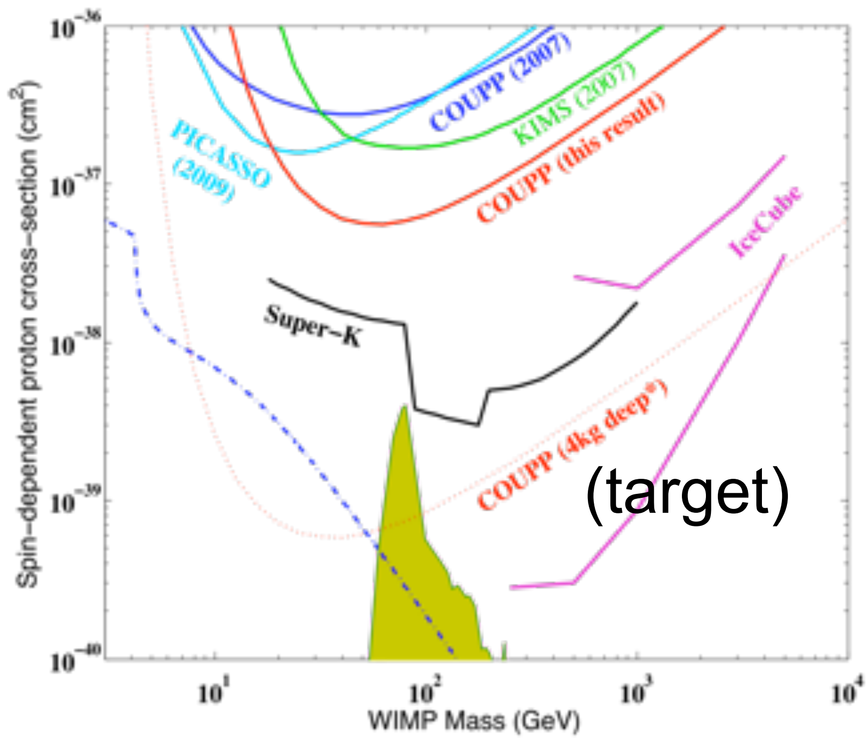




COUPP Technological Advance

- Ultrasound transducers reduce the alpha decay backgrounds by 2-3 orders of magnitude





COUPP

Kavli Institute for Cosmological Physics at the University of Chicago

University of Chicago
J. Collar, C.E. Dahl, D. Fustin, M. Szydagis

Indiana University South Bend
I. Levine

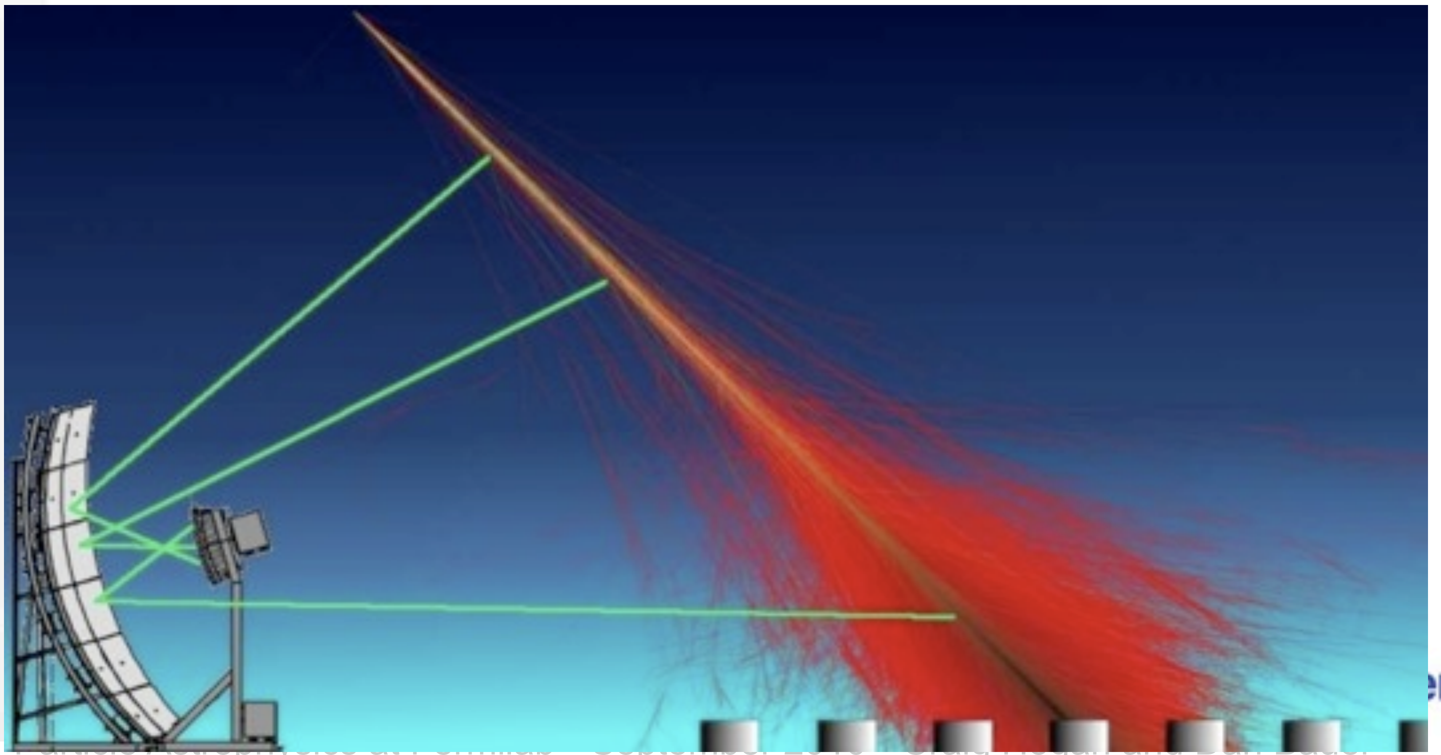
Fermi National Accelerator Laboratory
S. Brice, D. Broemmelsiek, P. Cooper, M. Crisler, J. Hall, H. Lippincott, E. Ramberg, A. Sonnenschein

Pierre Auger Observatory

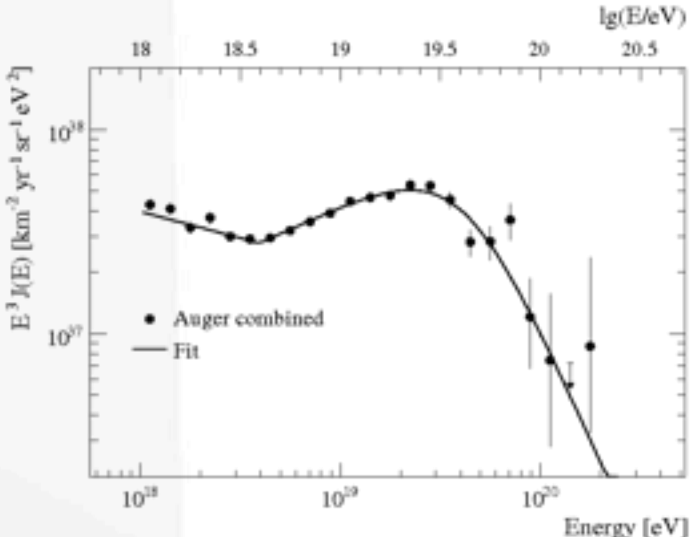
World’s leading observatory for highest energy particles

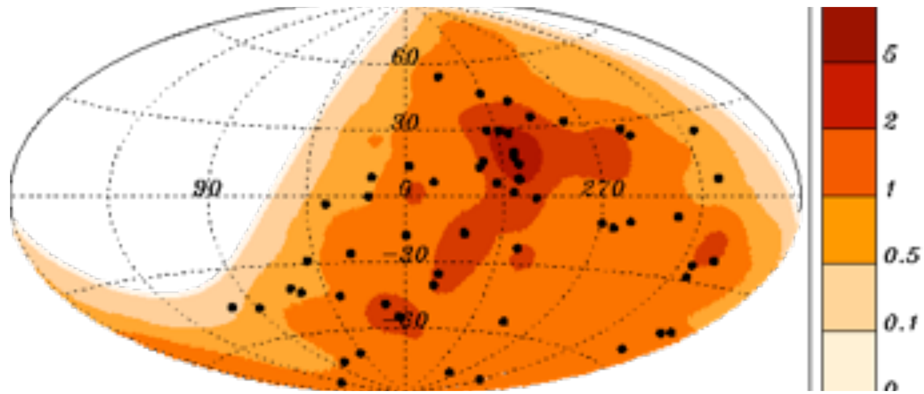
US agencies plan at least 5 more years of operations

Discoveries: high energy spectral cutoff from CMB interactions, anisotropy from sources, new composition puzzle

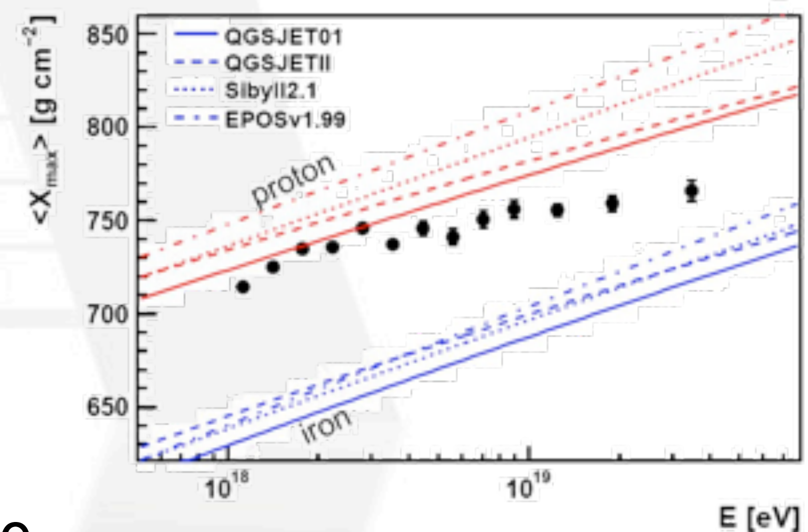


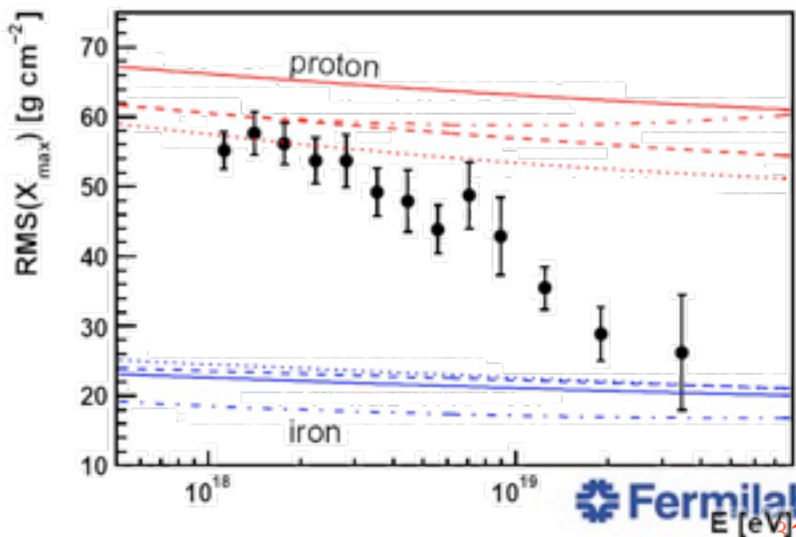
Auger results and puzzles





Energy cutoff in spectrum, correlation with local AGN suggest extragalactic sources and proton composition. Shower penetration depth and fluctuations suggest either violation of unitarity or iron composition.





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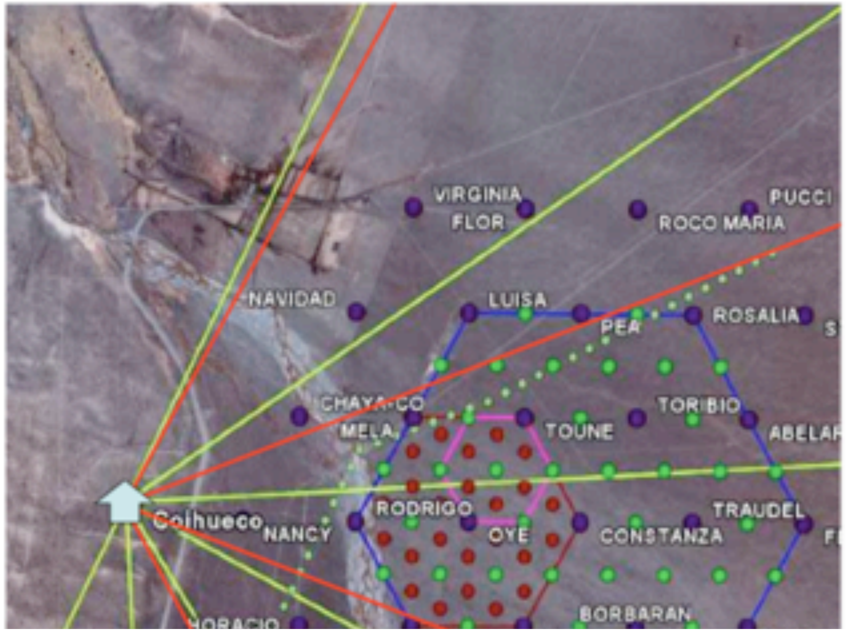
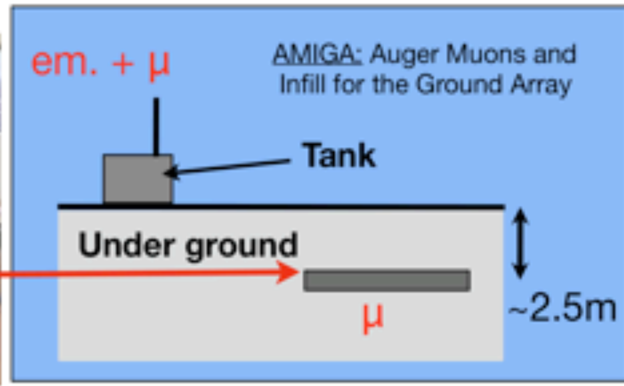
Pierre Auger Observatory — Science Results

- *Measurement of the energy spectrum of cosmic rays above 10^{18} eV using the Pierre Auger Observatory*, Phys. Lett. B **685** (2010) 239-246
  - First 'hybrid' (fluorescence+ground) and updated surface detector spectrum
- *Measurement of the depth of maximum of extensive air showers above 10^{18} eV*, Phys. Rev. Lett. **104** (2010) 091101
  - Shows a significant difference in shower properties from proton-only model expectation
- *Limit on the diffuse flux of ultrahigh energy tau neutrinos with the surface detector of the Pierre Auger Observatory*, Phys. Rev. D **79**, 102001 (2009)
  - Best experimental limit on neutrino flux at EeV energies
- *Upper limit on the cosmic-ray photon fraction at EeV energies from the Pierre Auger Observatory*, Astro. Part. Phys. **31** (2009) 399-406
  - First experimental limits on photons at energies at 10 EeV

Pierre Auger Observatory — Enhancements

- Upgrades further widen the gap between the PAO and other experiments
  - Auger Muon and Infill for the Ground Array — AMIGA
  - FNAL supporting AMIGA by providing scintillators and manpower — still under construction
  - Muon to electron ratio important for composition measurement — independent of fluorescence measurements

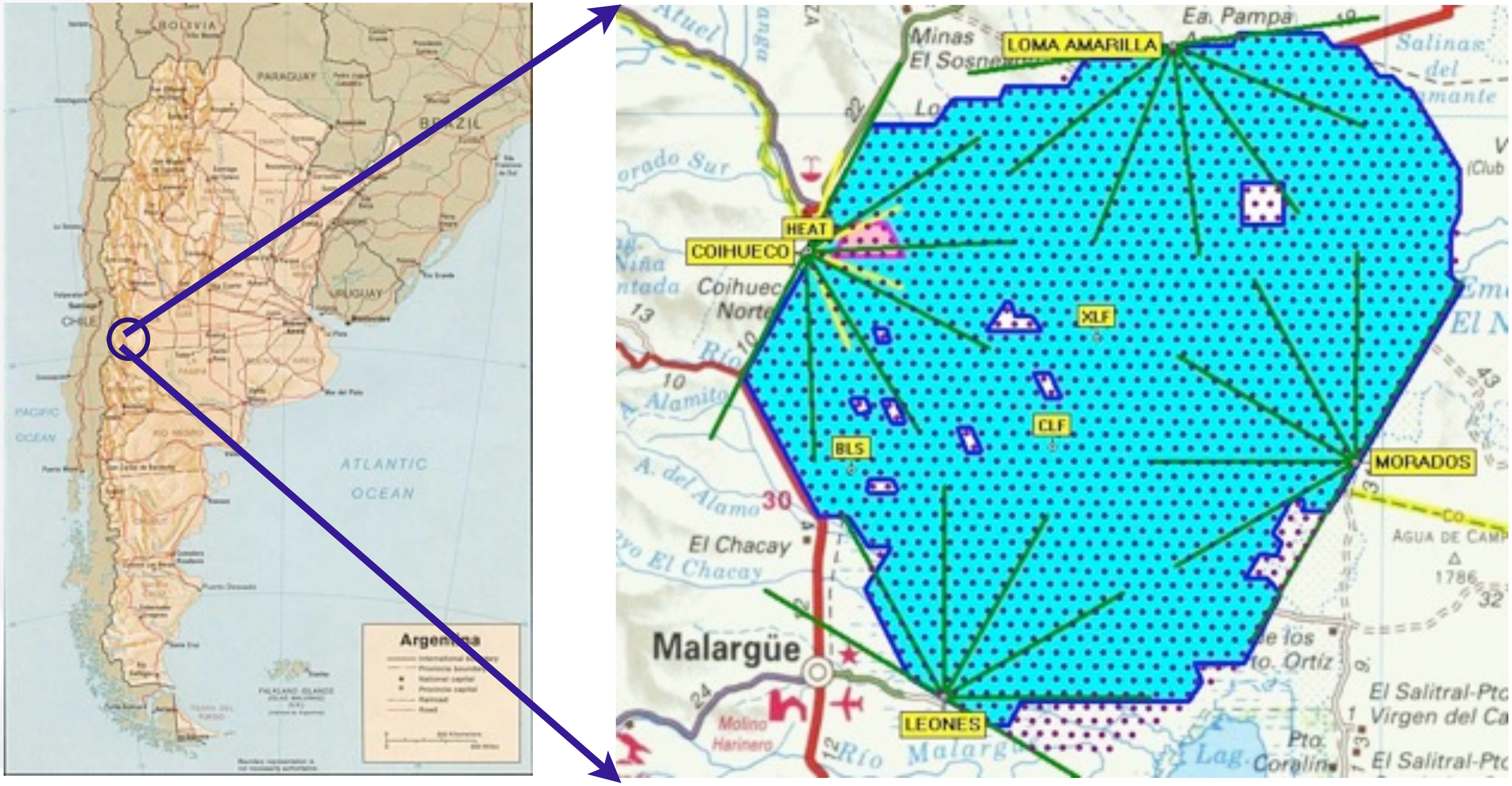




Friday, September 24, 2010

Pierre Auger Collaboration

487 scientists from 18 countries including Argentina, Australia, Bolivia, Brazil, the Czech Republic, France, Germany, Italy, Mexico, Netherlands, Poland, Portugal, Slovenia, Spain, the United Kingdom, the United States, and Vietnam



Fermilab Center for Particle Astrophysics

Established by Fermi Research Alliance (U. Chicago and 87 URA universities) in 2007:

To unify the astrophysics program at Fermilab, thereby enhancing the overall intellectual environment and the talent available to individual projects;

To provide a framework for initiating new ideas and developing new techniques;

To become an international center where scientists from Fermilab and the world user community can come to learn about and participate in the interface of particle physics and cosmology.

FCPA Experiment Prioritization process

FCPA planning retreats, strategic plan

Apply strategic criteria

- Fundamental Physics: matter, energy, space and time
- Key lab role, strong external collaboration, etc.

Process for new initiatives:

- internal review
- Early development via KA15
- review with external experts
- PAC review
- Director's review
- Directorate approval
- Field Work Proposal
- Funded through KA 13

Fermilab

What the KA-13 budget pays for at Fermilab

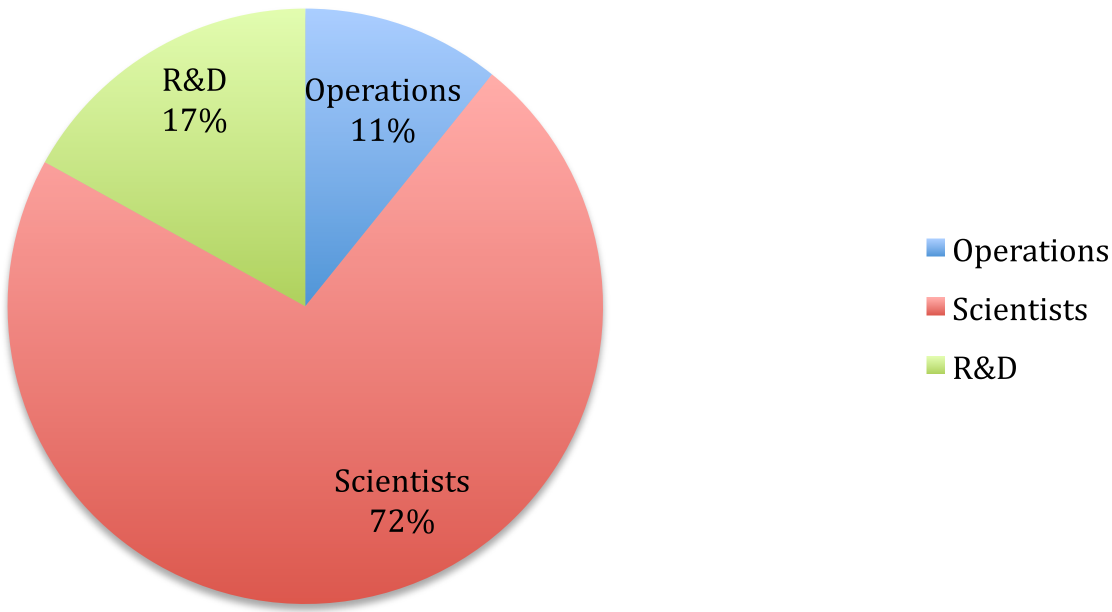
89% "base" (scientists' salaries)

72% core experiments

17% R&D on future experiments

11% operations of experiments

Project construction, non-scientist R&D are separate



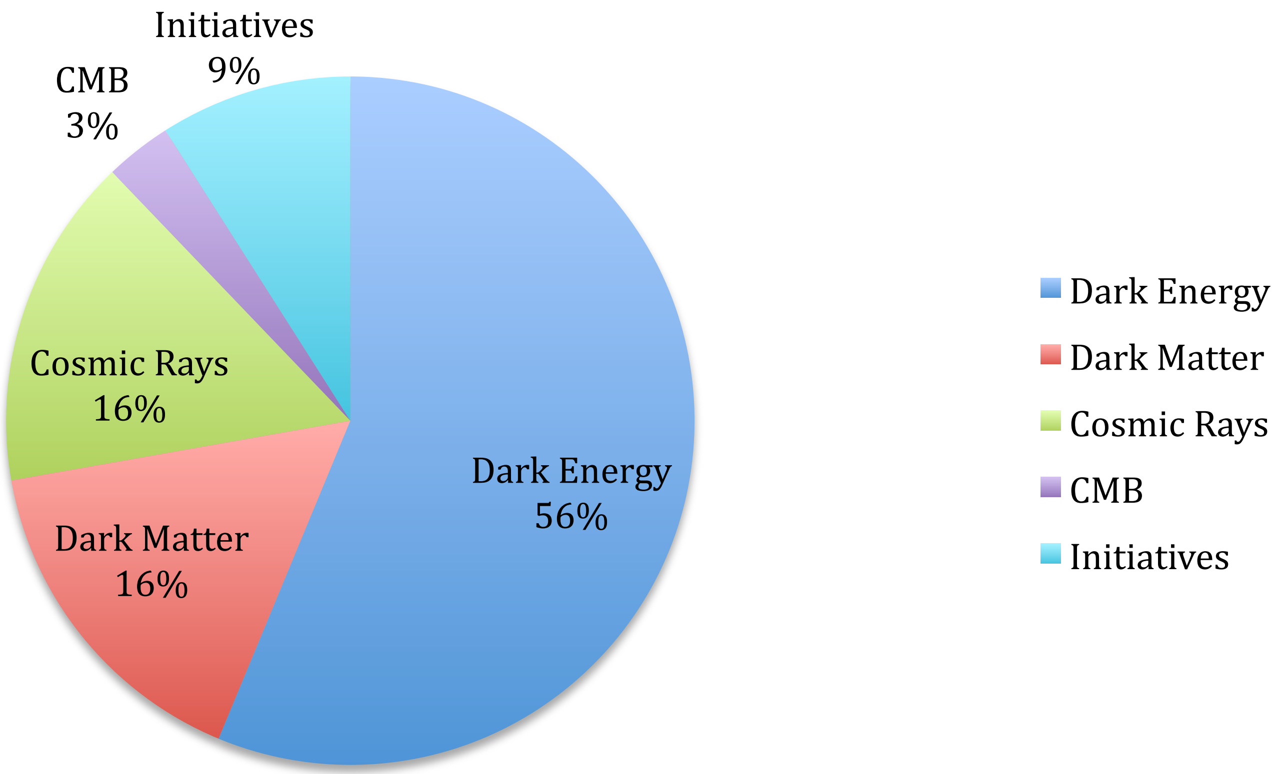
Fermilab

Friday, September 24, 2010

Program balance by thrust

Staff scientist FTEs indicate areas of emphasis

Project and non-scientist detector R&D costs are not included



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HEPAP Particle Astrophysics Scientific Assessment Group (2009): Concise summary

"Dark matter and dark energy remain extremely high priorities."

"Dark energy funding, which receives the largest budget portion, should not significantly compromise U.S. leadership in dark matter, where a discovery could be imminent."

"Dark energy and dark matter funding together should not completely zero out other important activities in the particle astrophysics program."

PASAG high-level criteria

- **The science addressed by the project is necessary**

– Addresses **fundamental physics (matter, energy, space, time)**.
– Anticipated results: either at least one **compelling result** or a preponderance of solid, important results. Check that anticipated results would not be marginal, either in statistics or in systematic uncertainties, relative to the needed precision for clear science results.
– Discovery space: large **leap in key capabilities, significant new discovery space, and possibility of important surprises**.

- **Particle physicist participation is necessary**

– **Transformative techniques** and know-how to have a major, visible **impact**; project would not otherwise happen.
– **Leadership** is higher priority than participation

- **Scale matters, particularly for projects at the boundary between particle physics and astrophysics**.

– Relatively **small projects with high science per dollar** help ensure scientific breadth while maintaining program focus on the highest priorities.

- Programmatic issues:

– International context: cooperation vs. duplication/competition.

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Proposed Program for the next 3 years

On-going experiments: Dark Energy (DES), Dark Matter (CDMS, COUPP), High Energy Particles (PAO)

Will remain the core Particle Astrophysics program

Future projects within core thrusts:

Next Generation Dark Matter

Dark Matter is the primary emphasis for new experiments

Planning and R&D for Dark Energy after DES

Dark Energy after DES is still unformed; explore options

Fermilab is committed to advancing the OHEP DE program

Small exploratory initiatives:

Cosmic Microwave Background Polarization (QUIET-II)

Depends on NSF funding

Planck scale spacetime measurement (Holometer)

Axion-Like Particles (REAPR)

Low-cost but potentially transformative experiments

PASAG/HEPAP recommendations (2009)

“In all budget scenarios, the Xenon100 upgrade, the LUX350 detector, an effort on DAr, funding for the MiniCLEAN detector, the additional towers in SuperCDMS Soudan, the COUPP 500 construction, the 100-kg SuperCDMS- SNOLAB experiment and the phase II upgrade to ADMX are supported.”

Fermilab is committed to establish a leading “WIMPstitute”

“PASAG recommends that QUIET II be supported at the proposed scope under all budget scenarios.”

Fermilab is committed to participate in QUIET-II if it is funded by NSF

“Auger North addresses questions of great interest... Given its relative science priority for HEP and the funding constraints, PASAG recommends significant HEP support for the construction of Auger North in budget Scenarios C and D.”

Fermilab is concentrating on Pierre Auger South

Future Dark Matter

Program aligned with PASAG priorities:

SuperCDMS: 100 kg at SNOLab

Expect CD0 this fall, MIE in FY12

COUPP: 60kg, then 500kg to SNOLab

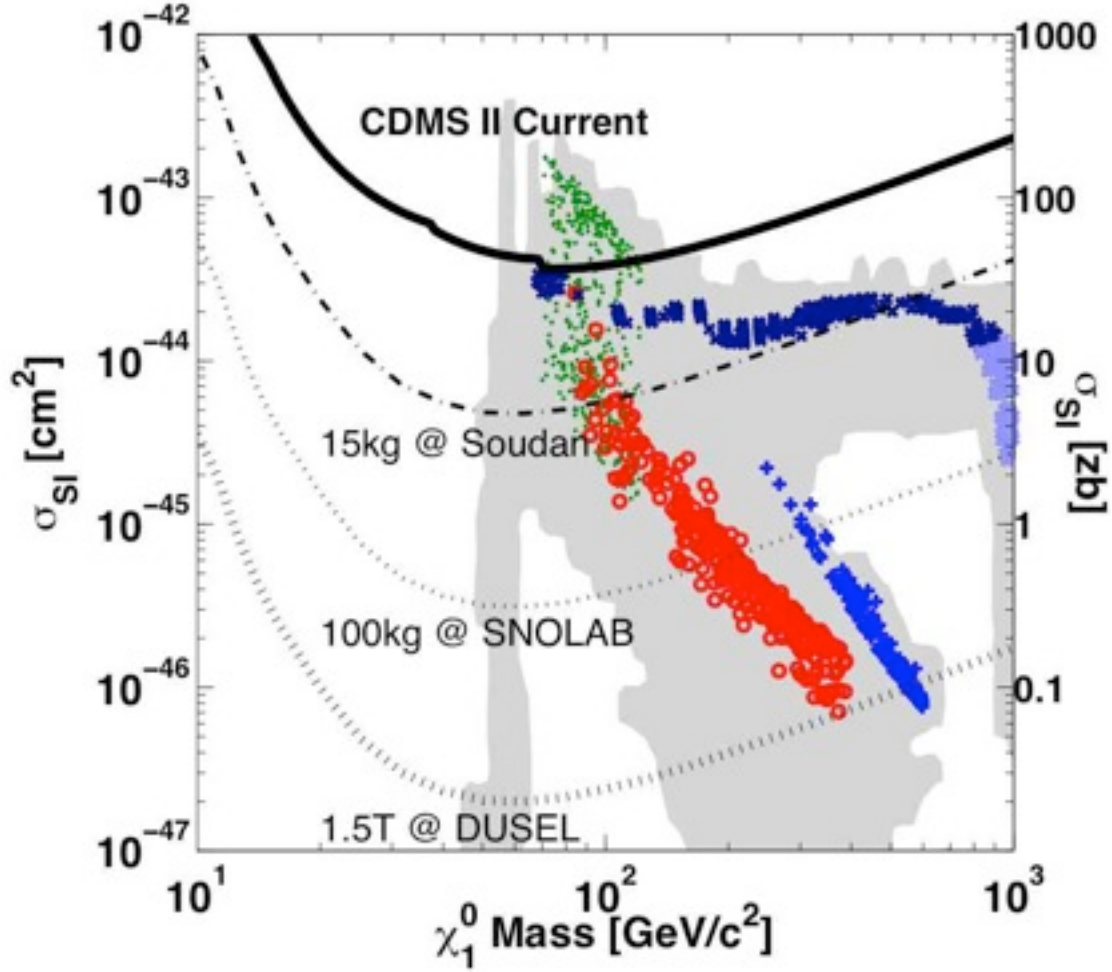
Liquid Argon (Darkside): Likely Gran Sasso

Far future: ton-scale, but not in all techniques

Fermilab is prepared to advance HEP's program to the next level in any of these technologies

Experiments will directly confront theory

Program will probe the parameters expected for supersymmetric WIMPS



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Darkside at Fermilab: Technical Capabilities and Synergies in both directions

Princeton noble liquid distillation column, now at Fermilab

LAr neutrino program (LBNE, MicroBoone, ArgoNeut)

Purification, DAQ, Electronics, Material Qualification, Wavelength Shifters, Optical Measurements, Data Storage, Analysis, electrostatics design,...

CDMS

Neutron veto, Low background materials, cryogenics, electronics

COUPP

Neutron veto, Quartz vessel, electronics

PASAG Dark Energy Recommendations

"PASAG recommends funding to complete those Stage III dark energy experiments receiving particle astrophysics (PA) support, i.e., DES and BOSS."

"For all budget scenarios, timely pursuit of a Stage IV program that can obtain another order of magnitude or more improvement beyond Stage III in metrics for dark energy and gravity tests."

"Formulation of a detailed plan for achieving a comprehensive and optimal dark energy portfolio under all funding scenarios is needed."

"The JDEM design process should be coupled to plans for ground-based projects to ensure that JDEM offers the possibility to significantly extend the capabilities of ground-based experiments."

Fermilab will actively study future Dark Energy options and help formulate the best path along with other labs

Fermilab

Astro 2010: DOE/HEP projects on top

"The top rank of LSST is a result of its capacity to address so many of the identified science goals and its advanced state of technical readiness."

"DOE is a minor partner in the two largest projects that the survey committee has recommended—LSST and WFIRST—and it is likely that the phasing will involve choices by NSF and NASA, respectively. Other considerations being equal, **the recommended priority order is to collaborate first on LSST because DOE will have a larger fractional participation in that project, and its technical contribution is thought to be relatively more critical**."

LSST is the top priority for DOE

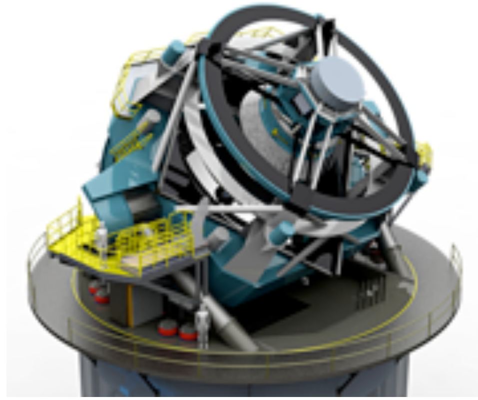
WFIRST is the top priority for NASA

DOE role not yet defined; ESA collaboration also possible

Mission not yet defined

Medium-scale program also recommended, at lower priority for DOE

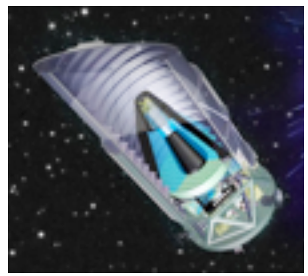
Fermilab will build on SDSS, DES experience



LSST: next major advance after DES

- *Work on defining Fermilab role*
- *Slow start until DES is underway*
- *Possible Fermilab roles in calibration, data access, database architecture, analysis*
- *build on CMS capabilities, NCSA partnership*
- *Will apply for membership in LSST Corporation in 2010*

JDEM (WFIRST): wide field IR, spectra



- *Fermilab will continue to participate in mission definition, science analysis plans*
- *JDEM Science Operations Center may merge with DES and LSST Dark Energy analysis support*

Future Dark Energy: medium scale possibilities

21cm BAO "intensity map"

Map atoms (not galaxies) over very large volume

Angular and spectral resolution sufficient for BAO

Fermilab R&D on concept, technical feasibility

Awaits formation of viable collaboration and funding model

Big Boss

Collaboration with LBNL just formed

FNAL contributes to telescope interface

Dark Energy Camera Spectrograph (DESpec)

Upgrade to DECam after DES completion: add new multi-fiber focal plane and spectrographs

Southern hemisphere followup to DES, LSST

conceptual design and costing

Dark Energy strategy

LSST: many optical photons, many galaxies

WFIRST: IR imaging, spectra

BigBoss/DESpec: optical spectra, different hemispheres

21cm map resolution: high spectral, low angular

Cannot afford all of these experiments

Need precise probes of structure growth and gravity, as well as expansion behavior

Need multiple modalities, versatility

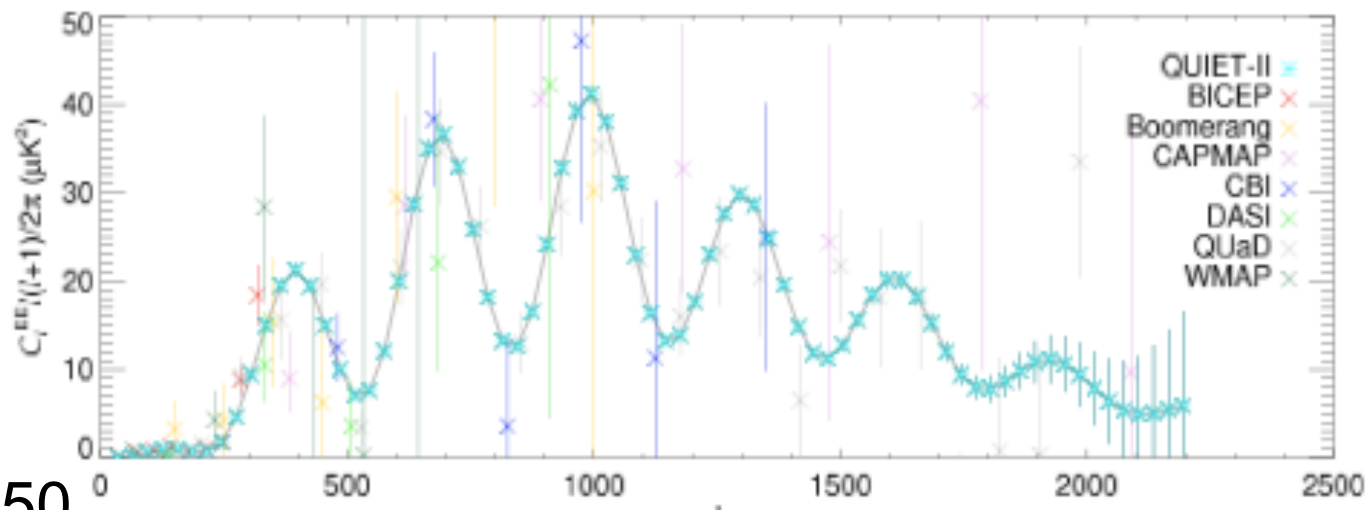
No one technique is conclusive

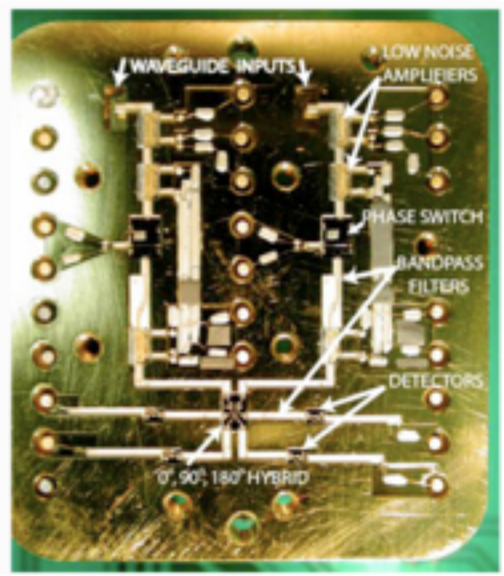
Not captured by simple FOM criterion

Choices will be informed by new data

Cosmic Microwave Background : QUIET-II

- Next generation CMB polarization experiment led by B. Winstein (U Chicago)
- Probes cosmic inflation
- Contingent on NSF funding; await concrete plan
- Possible Fermilab roles: assembly of detector modules, focal plane elements (SiDet facility), science analysis





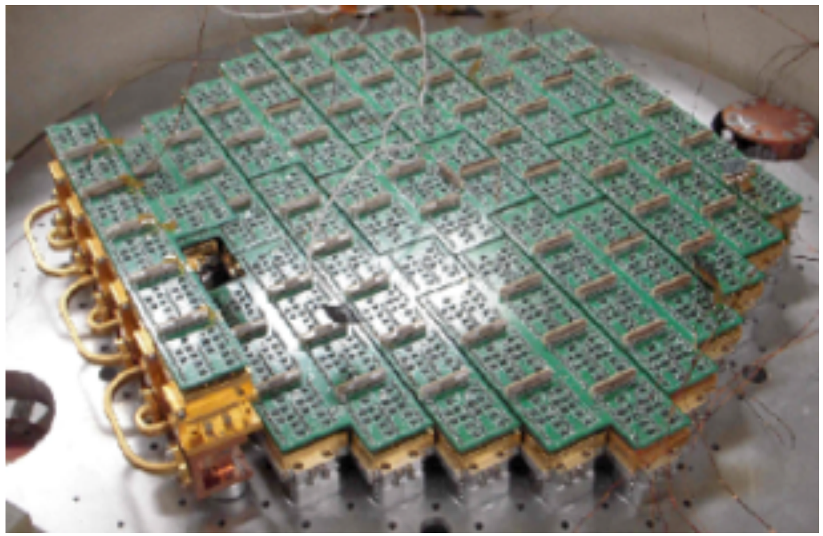
QUIET-II at Fermilab

Fermilab group proposes to provide mass production and testing of detector modules using existing precision assembly tools at Silicon Detector Facility (SiDet)

Also assembly and testing of an integrated W-band receiver

FY11-13: continued R&D with emphasis on noise and cost reduction

Future depends on NSF



Laboratory probes beyond the Terascale

Non-accelerator laboratory experiments can address new fundamental physics (matter, energy, space and time), far beyond the TeV scale

At Fermilab, we are pursuing a program using laser cavities and interferometers

Responsive to high-level PASAG criteria:

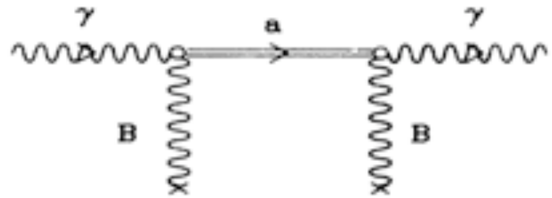
Addresses fundamental physics
compelling result
discovery space, possible important surprises
DOE lab leadership and critical role
small projects, high science per dollar

Axion-like particle searches: GammeV

- Mediate interactions of light with magnetic fields
- This year: chameleon search (CHASE); trapped particle afterglow, results pending
- Future: resonant regeneration (REAPR), “light through a wall”, laser cavities in Tevatron magnets
- Reach to ~10^11 GeV scale in the lab
- requires development of high Q optical cavity technology

Axion-Like-Particles: Light shining though walls

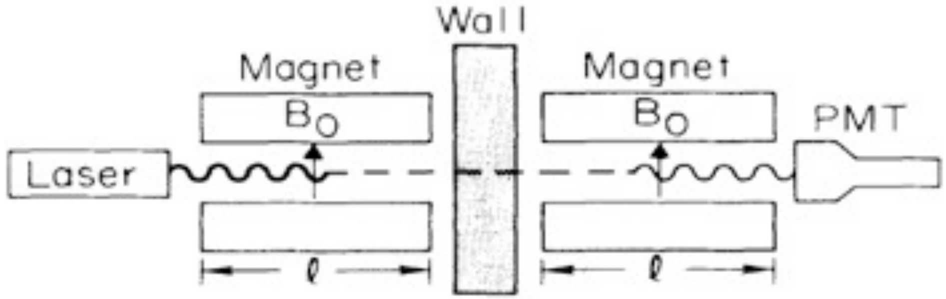
Experimental configuration inspired by a Feynman diagram



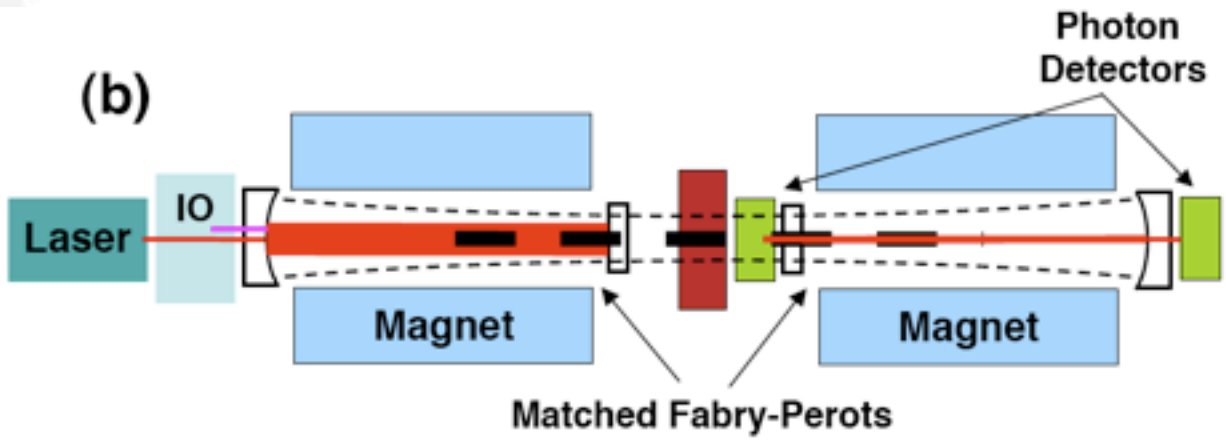
K. Van Bibber, et. al., PRL 59, 759 (1987)

$$P_{\rm regen} \approx \left(\frac{1}{4} g^2 B^2 L^2\right)^2$$

g=coupling constant



orders of magnitude improvement with resonant cavities on both sides

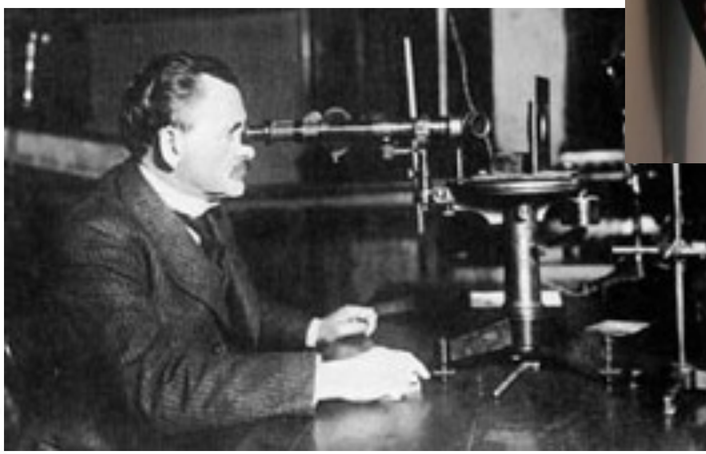


Measuring spacetime on a light-crossing time

Holometer prototype cavity in Fermilab MP8 beamline

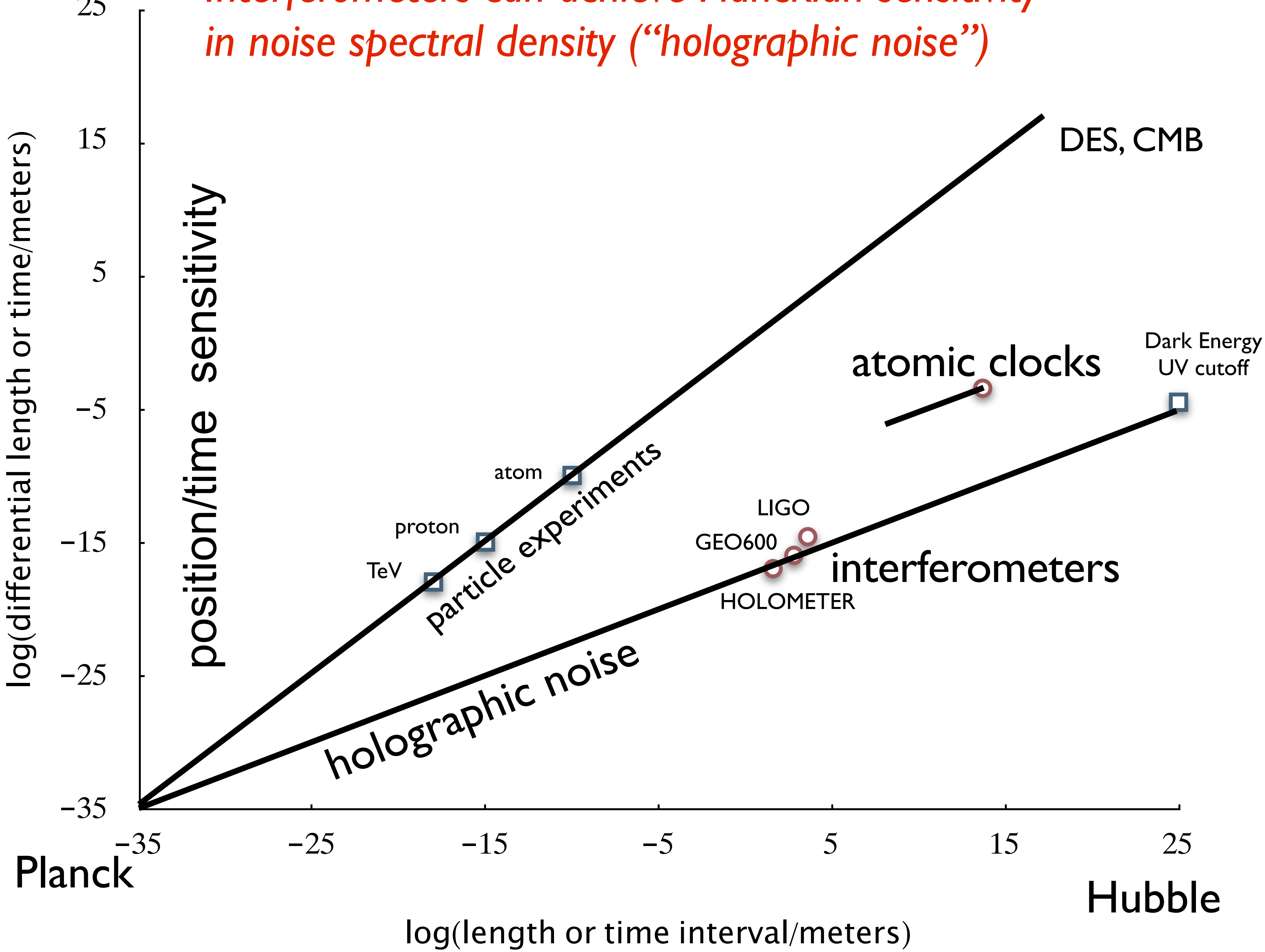
Albert Michelson's interferometers:

First precision probes of spacetime



Modern technology can attain Planck sensitivity in noise spectral density

Interferometers can achieve Planckian sensitivity in noise spectral density ("holographic noise")

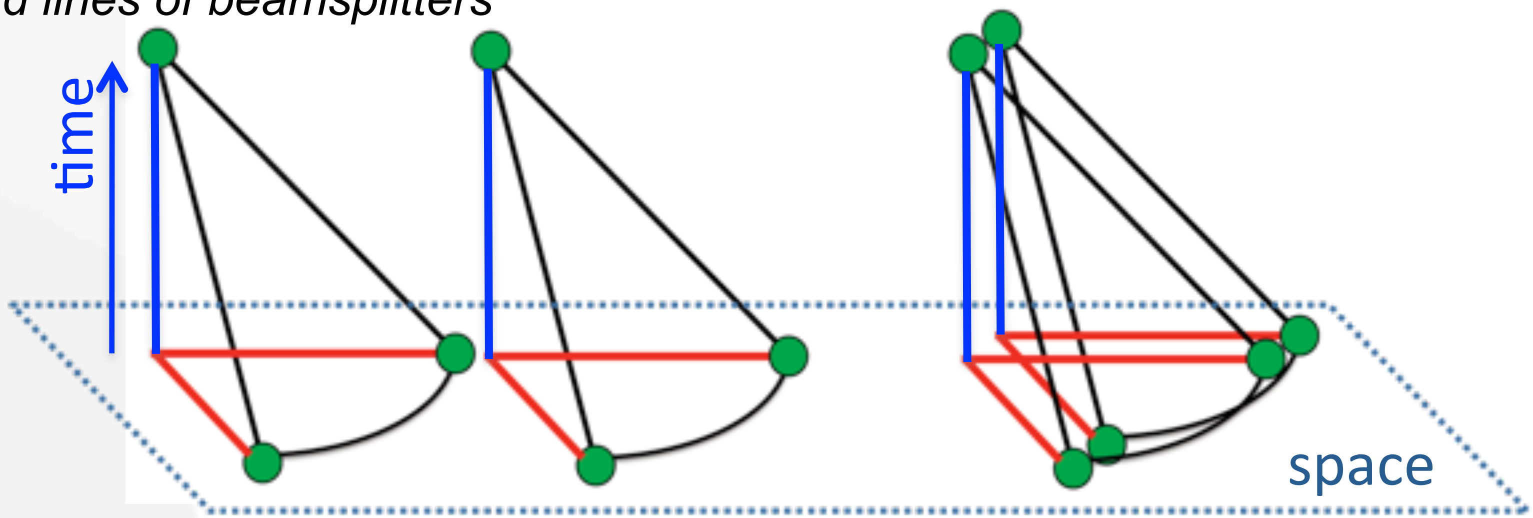


Conceptual Design of the Fermilab Holometer

Correlate two Michelson interferometers at high (MHz) frequency

noncommutative geometry: null wave phases in different directions random-walk by a Planck length per Planck time

World lines of beamsplitters

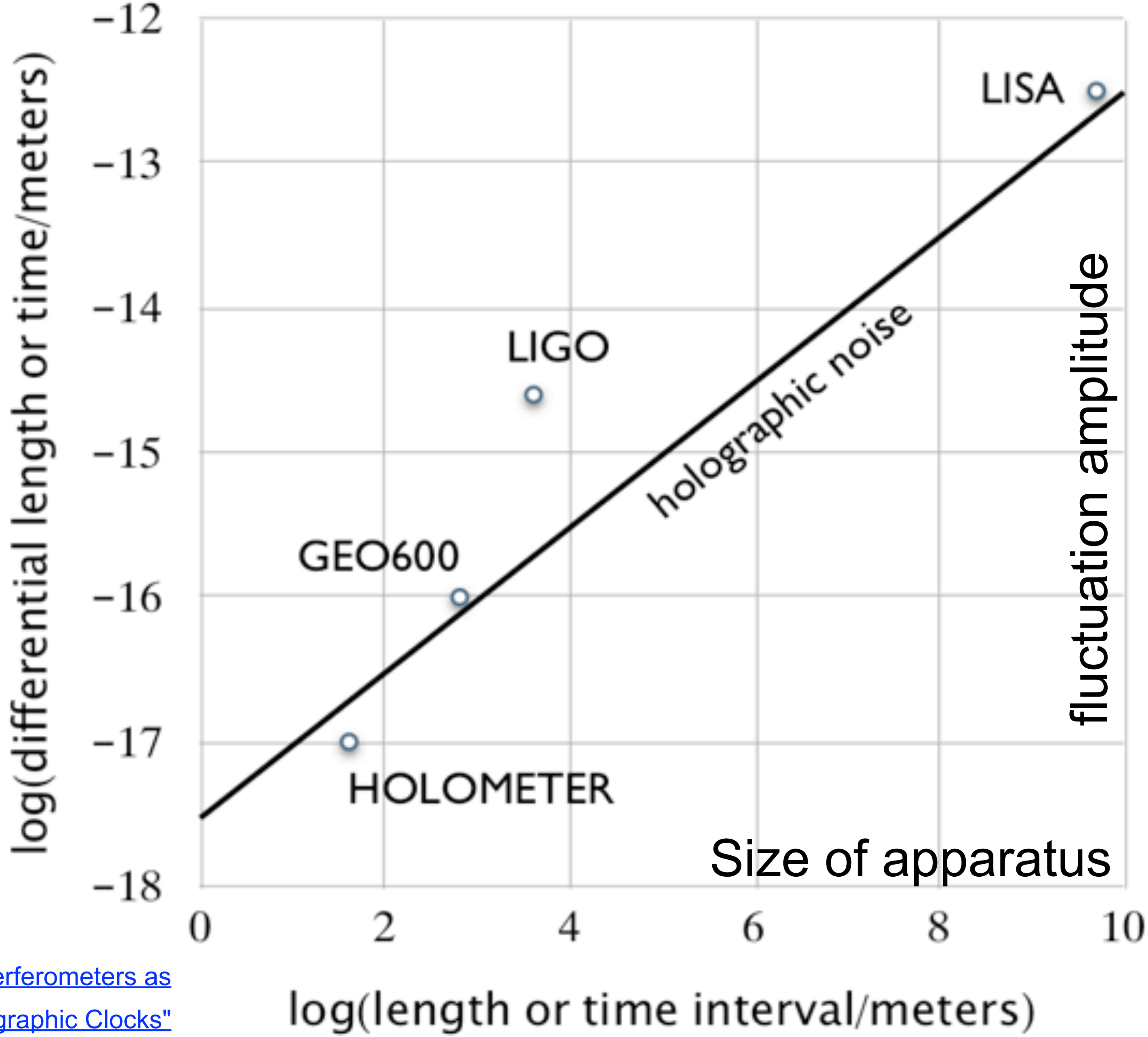


Separate spacetime volumes: No correlation

Overlapping spacetime volumes: Correlated holographic noise

Collaborators: FNAL team (Chou et al.), S. Meyer et al. (U Chicago), & LIGO experts R. Weiss, S. Waldman (MIT), R. Gustafson (Michigan)

Probe of Planckian fluctuations: Fermilab Holometer



[CJH, "Interferometers as Holographic Clocks"]

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Why do these experiments at Fermilab?

Open "Unification Frontier": new probes of Planck scale unification and very high mass fields

Well-defined target: Planck sensitivity appears achievable

Unique Planckian spacetime probe at modest cost

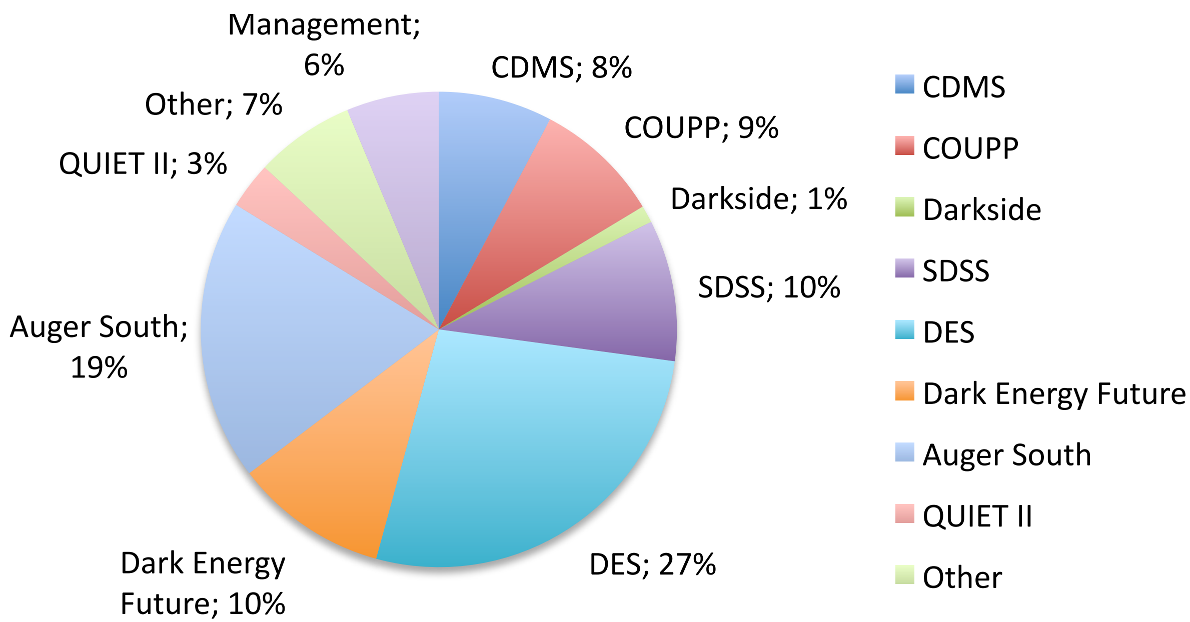
High-Q interferometers & cavities: new tools for Fermilab

Partnerships with LIGO scientists: import new attotechnology and apply directly to fundamental physics

Uses lab infrastructure: large scale tunnels, vacuum system technology, clean rooms, magnets,.....

Programmatic Balance: small and large

High-scientific-risk and far-future programs are a small portion of the budget, but critical



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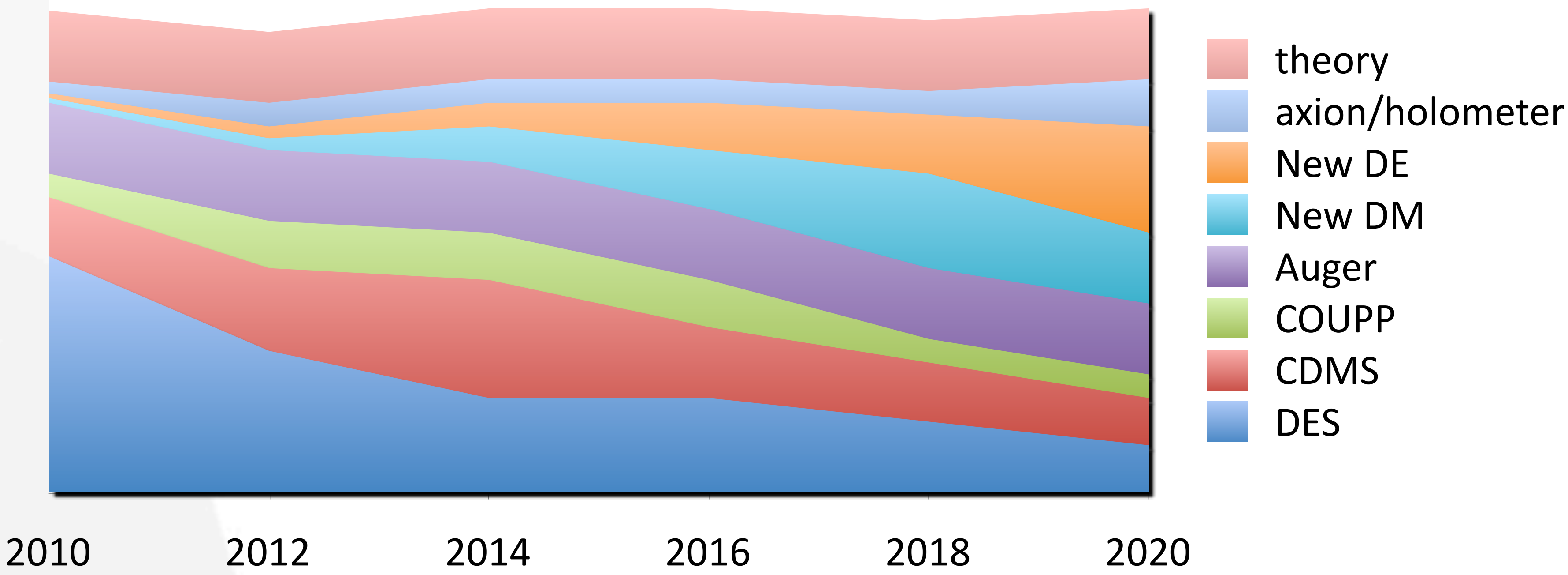
New experiments, constant effort: schematic plan including project funding



Actual program will be shaped by new discoveries!

Budget challenges and issues

Inadequate funding for scientists

- Migration from particle program has led to growth
- FY10 KA13 funding did not cover all scientists

Uncertain schedule for project funding

- Budget stress causes delays
- Scientist effort accompanies projects

Commissioning and operations of experiments

- Construction budgets do not cover commissioning
- Advance planning needed for operations

Budget scenarios

Funding proposed program requires substantial growth in KA-13 at Fermilab

Proposed budget includes field work proposals for R&D on specific experiments, including technical labor and M&S costs, and some growth in scientist effort

budget scenarios, in thousands of dollars:

	FY2011	FY2012	FY2013
Proposed budget	16,930	15,928	15,912
Constant Level of Effort budget	12,840	13,218	13,442
Flat-Flat budget	12,131	12,131	12,131

Fermilab

Scientist effort in proposed program

Proposed scientist FTEs grow, mainly to staff new dark matter experiments

Plan reflects our best guesses about funding prospects

Proposed FTE effort of staff scientists in KA-13:

Program	FY2011	FY2012	FY2013
Dark Energy	15.6	15.6	15.6
Dark Matter	7.5	9.5	10.5
Cosmic Rays	4.5	4.5	4.5
CMB	1.0	0.6	0.6
Initiatives	3.0	2.4	2.3
Total	31.6	32.6	33.5

Effort in flat-flat budget scenario

Erosion in scientist FTE’s causes delay in high priority opportunities

Dark Matter still the top priority for (modest) growth

Program	FY2011	FY2012	FY2013
Dark Energy	14.3	14.3	14.3
Dark Matter	5.8	6.8	7.0
Cosmic Rays	4.5	4.2	4.0
CMB	0.6	0.2	0.1
Initiatives	2.5	1.7	1.5
Total	27.7	27.2	26.9

Flat-flat priorities

- Sustain core program at subsistence level
  - DES commissioning, but operations probably delayed
  - Dark Matter R&D continues, but new projects stall
  - Pierre Auger operates, but no enhancements
- Reduce R&D for future projects to subsistence
  - About 2 FTE to spare for studying:
    - LSST, JDEM, BigBoss, DESpec for dark energy
    - Darkside for LAr dark matter
- Reduce effort on new initiatives
  - down to ~ 1.5 FTE scientists on laser experiments
  - diminish CMB to zero unless QUIET-II is funded

Why does the Cosmic Frontier need Fermilab?

History as anchor institution for large projects

- SDSS, DES, Auger, CDMS

Excellent technical support, lab infrastructure

- Dark Energy Camera: silicon detector technology,CCD packaging, focal plane, electronics, large scale mechanical & cryogenics,….
- COUPP: on-site underground tunnel testing
- CDMS: cryogenic engineering, assembly, electronics
- LAr: purification and handling facilities, distillation column
- Pierre Auger: large scale engineering, test beam
- many projects: large-scale computing support

All projects: management within DOE project system

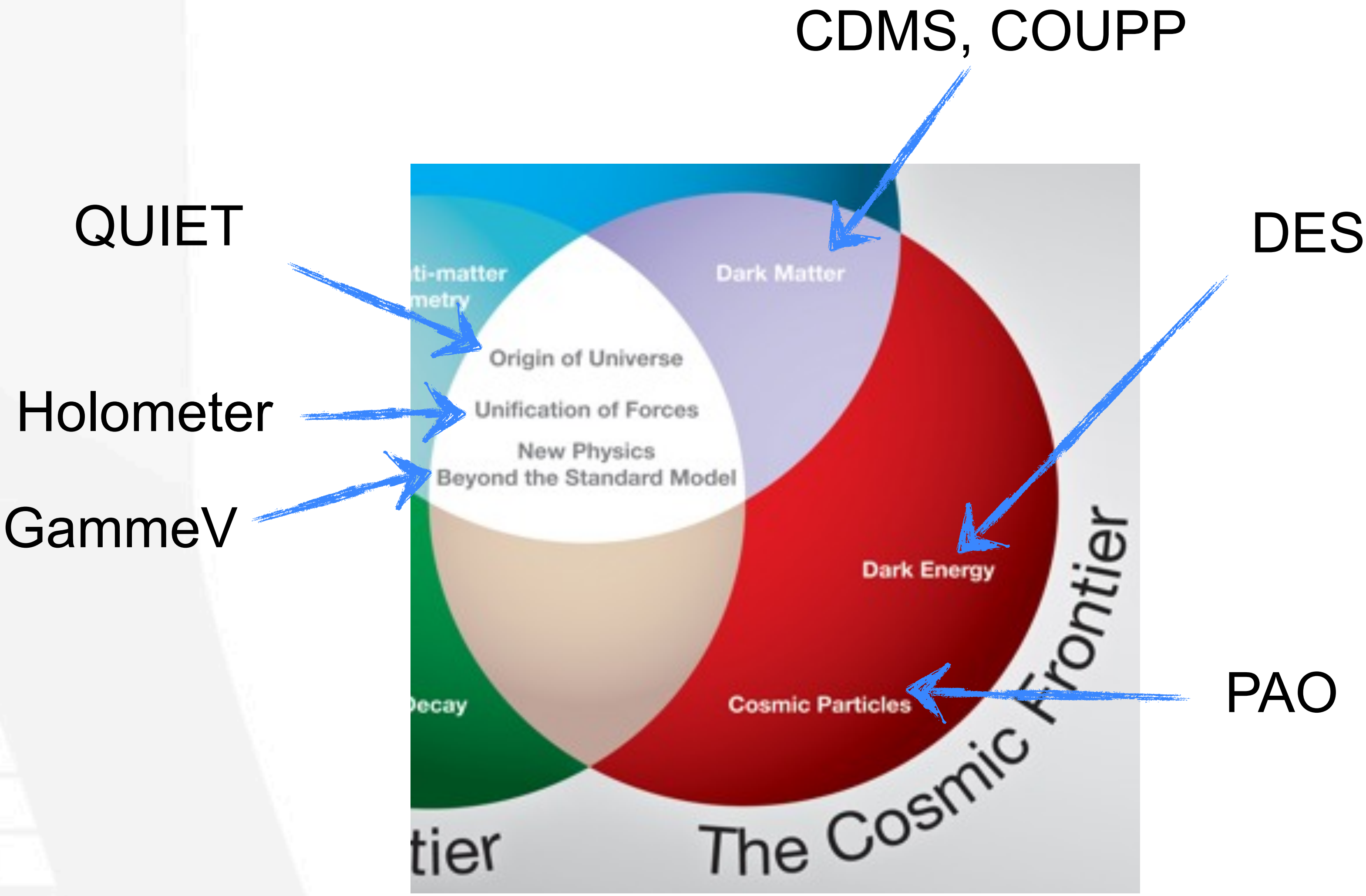
These functions need top quality engineers, technicians,and lab scientists

Coming up

Experiments on the Cosmic Frontier symposium

- Fermilab, March 23 to 26, 2011
- Community planning effort, post-Astro 2010
- Organized with other HEP labs and particle astrophysics university community
- Dialog and Debate to help shape future program

Fermilab Cosmic Frontier Experiments



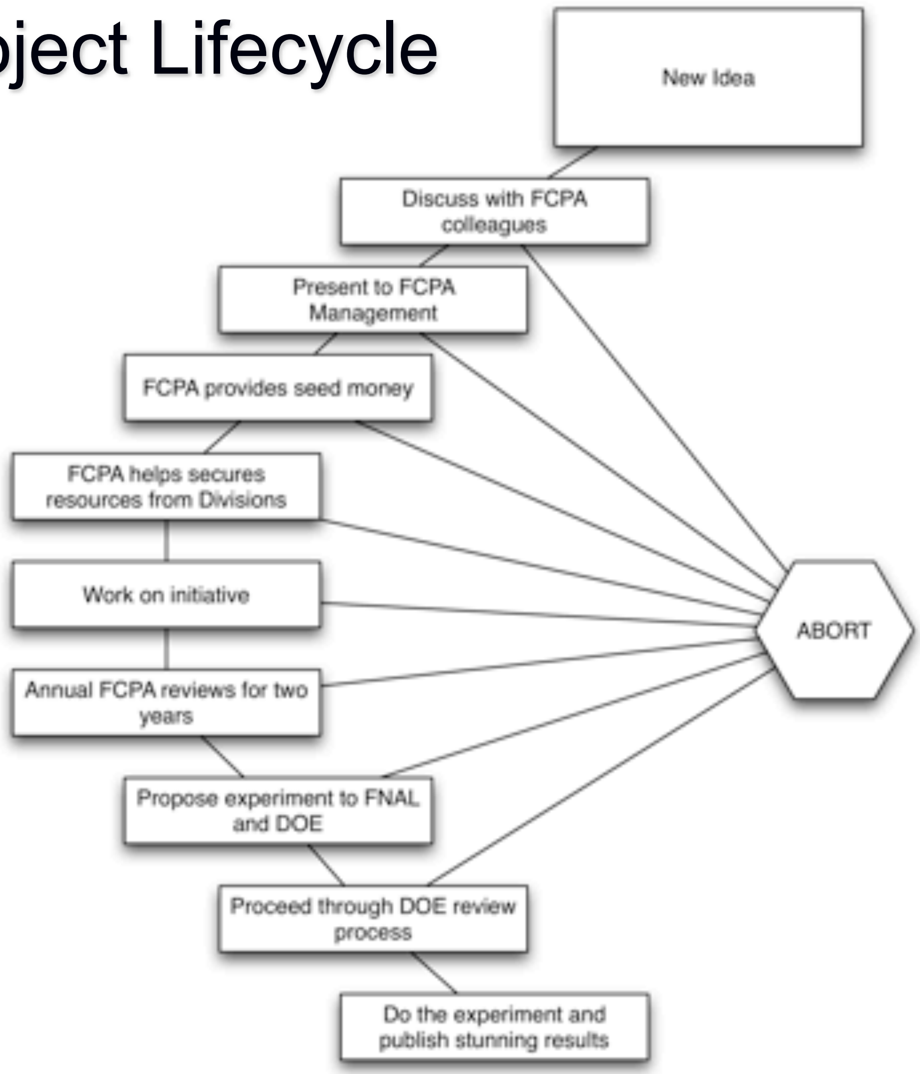
Backup slides

Strategic Planning, Development Process

- FCPA planning retreats
- Strategic plan document, revisited every year
- Overall criteria (PASAG)
  - Physics: matter, energy, space and time
  - Key particle community/ lab role
- Process for new initiatives
  - Alignment with long term lab, DOE program needs
  - Early development through KA15
  - internal review
  - PAC, Directorate approval
  - Field Work Proposal
  - Upon approval, graduate to KA13

Strategic Planning Process

Project Lifecycle



Budget Process