

Overview of Budget and Schedule for FCPA Initiatives

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FCPA Retreat

June 5, 2009

Who determines budget and schedule for particle astrophysics at FNAL?

- FCPA
 - Scientific leadership and management of particle astrophysics at Fermilab
 - Provide advice on priorities ‘up the chain’
 - Modest M&S budget supplies ‘seed’ funding for initiatives at level <\$100K total
 - Help secure external funding (NSF, NASA, ...)
 - Hire Research Associates for particle astrophysics
 - Office space, admin support,....

Who determines budget and schedule for particle astrophysics at FNAL?

- Divisions (Mainly PPD, CD, with some TD, AD)
 - Provide most of the scientific and technical personnel for particle astrophysics efforts
 - Also supply R&D funding for new initiatives which can total up to ~\$2M over several years
 - Vehicle for operations funding for established experiments, EAG and astro theory group
 - Admin and project support personnel

Who determines budget and schedule for particle astrophysics at FNAL?

- Directorate
 - Supplies direction on laboratory priorities
 - Main interface to DOE
 - Must approve any major new initiatives
 - Informally done for R&D level (<\$100K)
 - Director will usually seek PAC approval for larger efforts
 - Must have proposal to DOE for >\$2M
 - Director's reviews and project office used to help projects navigate DOE process

Who determines budget and schedule for particle astrophysics at FNAL?

- DOE
 - Shares funding of astrophysics with NSF, NASA
 - Main funding agency for Fermilab work
 - R&D (KA 15) funding up to \$2M
 - Small project \$2M-\$10M (MIE)
 - Requires Major Item of Equipment
 - Usually at least 2 years between proposal and funding
 - Review process within Office of High Energy Physics
 - Critical Design project >\$10M
 - Requires MIE and several CD hurdles
 - Usually takes 3-4 years from time of proposal till construction
 - Review process within DOE Project Office

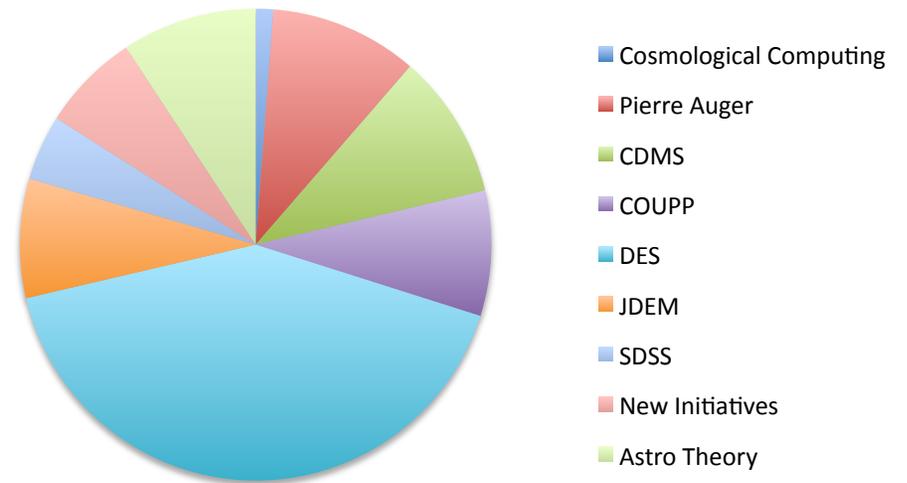
Who determines budget and schedule for particle astrophysics at FNAL?

- National Advisory Panels
 - NRC Astro 2010 Decadal Survey
 - Weighted towards astronomy but includes astrophysics
 - Recommendations due next year
 - HEPAP
 - PASAG (2009)
 - Particle Astrophysics Scientific Assessment group
 - Report due in August
 - P5 (2008)
 - Dark matter SAG (2008)
 - DETF (2008)

FNAL Particle Astrophysics Program as seen by DOE

Astrophysics Project	FY2009 Budget
Cosmological Computing	315
Pierre Auger	2,660
CDMS	2,600
COUPP	2,247
DES	10,850
JDEM	2,138
SDSS	1,170
New Initiatives	1,764
Astro Theory	2,425
Total	26,169

Fermilab Particle Astrophysics Projects
FY2009



FNAL Particle Astrophysics Budget as seen by FCPA

Project	R&D	Conceptual Design	Technical Design	Construction	Operating	FCPA role
Cosmic Surveys						
SDSS					X	Major
DES				X	2011	Major
JDEM	X				?	?
LSST			X		2015	?
Dark Matter Direct Detection						
CDMS				X	X	Major
SuperCDMS Soudan				X	2009	Major
SuperCDMS SNOLAB		X			2012	Major
SuperCDMS DUSEL	X				2016	?
COUPP 1-4 kg					X	Major
COUPP 60 kg				X	2010	Major
COUPP DUSEL	X				2016	?
Liquid Argon	X				?	?
Solid Xenon	X					?
CCDs	X					?
High Energy Cosmic Particles						
Auger South					X	Major
Auger North	X					?
ACTs (AGIS, Delta)	X					?
New Cosmic Frontier						
Holographic Noise	X					?
QUIET1 (CMB polarization)					2009	Minor
QUIET2 (CMB polarization)	X					?
21 cm Baryon Acoustic Oscillations	X					?
GammaEv2 (Axions)	X					?
Theoretical Astrophysics						
Cosmological Computing					2009	Major

Established FCPA Projects

- SDSS
 - Project finished but physics continues for 1-2 years
- DES
 - Project under construction; budget from DOE
- CDMS
 - Running at Soudan with operating budget from FNAL
- COUPP R&D
 - Moving out of R&D category into project (see new initiatives)
- JDEM
 - Design and political situation are fluid. FNAL wants Science Operations Center. Funding is coming direct from DOE.
- Pierre Auger South
 - Construction complete; operating in Argentina with FNAL operating budget.
- Astro Theory
 - Soon to be back up to full strength (three new RAs)

New Initiatives

- Informally handled in the past
- First FCPA retreat (2007) began Center evaluation process
- Now formalizing process towards a new initiative
 - Present to FCPA and request seed money
 - FCPA helps to secure Division R&D resources
 - Develop R&D until an experiment looks feasible
 - Propose experiment to FNAL Director/PAC
 - If approved, proceed to DOE proposal
 - Wade through review process
 - If lucky, build and operate the experiment

Key questions for each new initiative

1. Will the proposed science goal be seen as compelling on the national scene (i.e. to PASAG) and within the DOE mission?
2. What is the main science goal and what is the expected timescale for achieving it?
3. What are the risks that the main science goal will not be achieved?
4. How does the planned program address these risks?
5. Why is Fermilab the best place to take this initiative?
6. What are the chances that others will reach the main science goal before we do?
7. What is the anticipated schedule for the project?
8. How will the project be funded?

Pierre Auger North

1. DOE supports Auger South. North adds full sky coverage
2. Understand cosmic rays beyond GZK cutoff and look for sources. Array complete by 2017 and final physics by 2037
3. Technical risks mostly addressed by South.
4. Financial risk due to multi-national funding.
5. Leadership of Auger South and interactions with Chicago
6. No real competition of this size

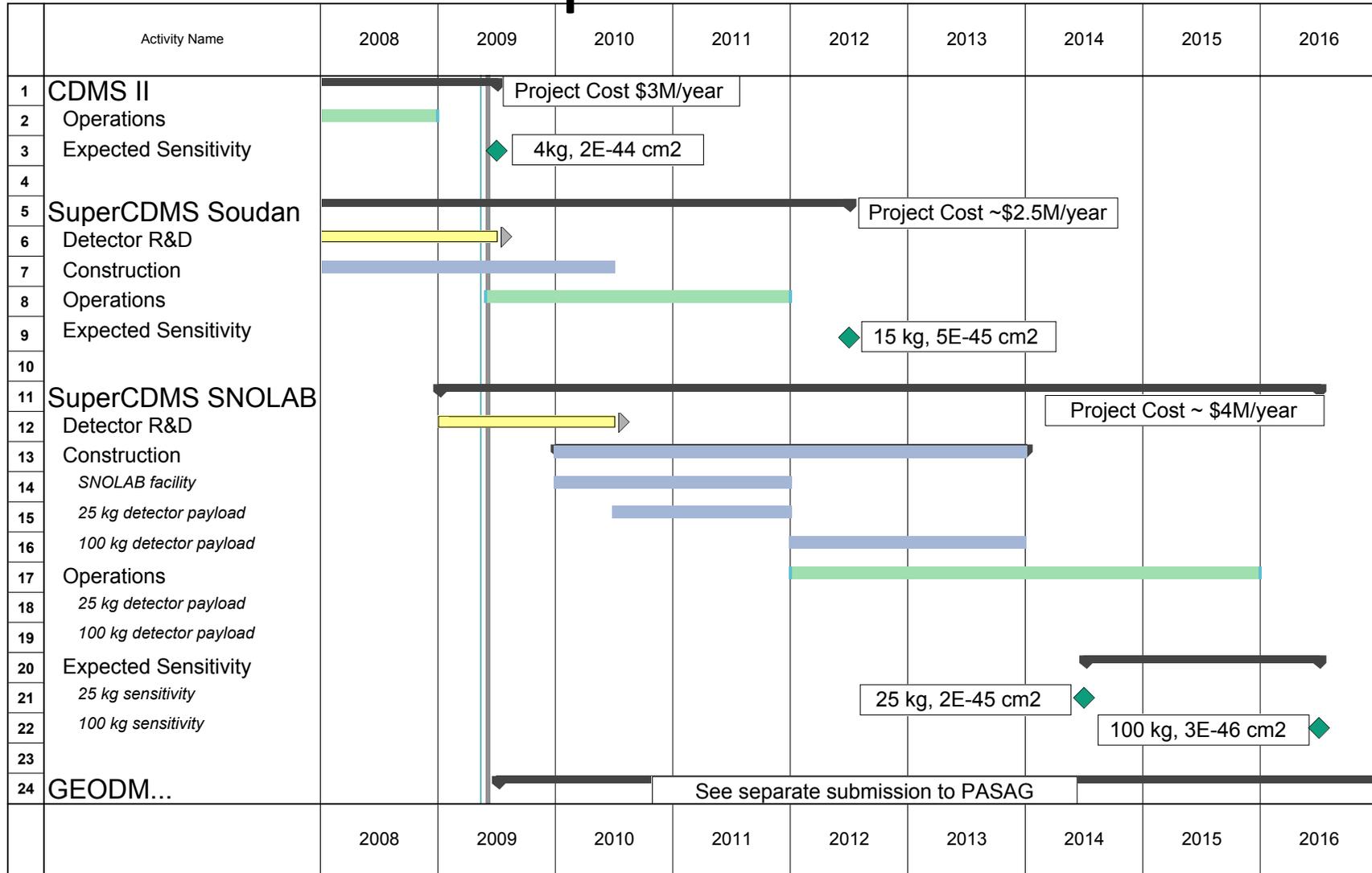
Pierre Auger North

- Expected Schedule
 - 2009-2011
 - Detector R&D, Engineering Array, production engineering.
 - 2012-2016
 - Auger North Construction
 - 2017-2037
 - Data taking and analysis

SuperCDMS

1. Supported by all advisory panels and DOE
2. WIMP sensitivity down to $1\text{E-}46 \text{ cm}^2$
3. Backgrounds. Also detector mass hard to scale up.
4. Excellent detector discrimination and recent improvements in detector fab, promise of larger crystals
5. Fermilab already provides leadership in CDMS for all areas except detectors
6. Possible, but CDMS is the only zero-background background as yet.

SuperCDMS



COUPP 60 kg

1. Bubble chamber is an accepted path towards higher spin-dependent sensitivity
2. Three order of magnitude increase in sensitivity with 1 year deep running (>2011)
3. Alpha background reduction requires state of the art liquid radiopurity
4. Fluid handling from solar n experiments, acoustic discrimination from Picasso
5. Invented technique locally and have invested heavily already at Fermilab
6. Not much competition for spin-dependent measurement if alpha background controlled

COUPP

- Expected schedule
 - 2009
 - NUMI run of 60 kg
 - 2010
 - Deep site run of 60 kg if DOE approves
 - Proposal submitted for 500 kg
 - 2012
 - Possible construction start on 500 kg

Liquid Argon for Dark matter

1. Liquid Argon also accepted for WIMP searches
2. Ultimate goal is $1\text{E-}47$ cm² cross section at DUSEL
3. Low ³⁹Ar required and must address liquid purity and light collection issues
4. R&D efforts aimed at all of these things
5. Synergy with LAr for long-baseline neutrinos. National Lab resources required
6. There are other strong players but LAr has potential to be the best.

Liquid Argon for Dark Matter

- Expected schedule
 - 2009
 - DUSEL S4 NSF award
 - 2010
 - 500 kg NSF award
 - CD-0 for 5-ton DUSEL project
 - 2011-2012
 - 500 kg construction
 - CD-1/2 for 5-ton DUSEL project

DAMIC

1. Another direct detection search but aimed at low mass with low-noise CCDs.
2. Reduce background sufficiently to achieve world's best limits below few GeV WIMP mass
3. CCDs may have intrinsic background that limits sensitivity
4. Use clean copper dewar and see what background does
5. FNAL has the spare DES CCDs and it was Juan's idea
6. Probably CDMS will do better except at the very lowest masses.

DAMIC

- Expected Schedule
 - Low-level R&D funding for another year to see if backgrounds can be reduced sufficiently to get a good physics result
 - May go deep in 2010 if it looks promising

ACTs for Dark Matter

1. Compelling astrophysics. DOE supports Veritas.
2. Study of TEV astrophysical sources. Dark Matter annihilations may be detectable.
3. Astronomy goals lead to design which may compromise dark matter detection.
4. Need a strong DM advocate in AGIS.
5. Fermilab has both technical expertise and computing facilities to deal with large data sets.
6. European CTA is more advanced, but AGIS could catch up.

ACTs for Dark Matter

- Expected Schedule
 - 2009-2010
 - Work on specific dark matter design
 - 2011-2012
 - Engineering studies
 - Submit project proposal

Solid Xenon

1. DOE has supported many axion and DM technologies.
2. Dark matter, solar axions, double beta decay.
Competitive results possible within 5 years.
3. May not be able to grow large crystals, multiple readout techniques not yet demonstrated
4. R&D phases (crystal growing, charge readout, phonon readout)
5. Idea originated here and substantial cryogenic and low background expertise
6. No known competition for solar axions, strong efforts on DM and double beta decay elsewhere

Solid Xenon

- Expected schedule
 - 2009
 - Phase 1 - Demonstrate crystal growth
 - 2010
 - Phase 2 – Demonstrate charge, light readout
 - 2012
 - Phase 3 – Phonon signal readout

Resonant Regeneration

1. Improve limits on axion-photon coupling or discover axionlike particles. OJI grant shows DOE support!
2. Coupling sensitivity of $g=10^{-11} \text{ GeV}^{-1}$. Achievable by 2012
3. High finesse cavity is technically challenging
4. Cavity prototyping in conjunction with holographic noise
5. Fermilab is the only place with spare magnets of the size needed
6. Eventually possible at DESY/CERN, but not likely on this time scale.

Resonant Regeneration

- Expected Schedule
 - 2009
 - Build laser lab and prototype interferometer
 - 2010
 - Build tabletop prototype of axion experiment
 - Occupy larger lab space to use Tevatron magnets
 - 2011
 - First results on axion/photon mixing
 - Propose full experiment to FNAL
 - 2012
 - Construction and start of running

Chameleons

- Expected Schedule
 - 2009
 - Finish design, construction and begin taking data
 - 2010
 - Finish running and publish result

QUIET II

1. Discover B-mode polarization pattern in the CMB, the smoking-gun for gravitational waves during the inflationary era.
2. Tensor/Scalar ratio sensitivity of 0.01 by 2015
3. Foregrounds, thermal noise, telescope mechanics. B modes might be too small.
4. Quiet I is working. Correlating with other measurements should help understand foregrounds.
5. Engineering and technical expertise
6. Other ground-based instruments with similar sensitivities.

QUIET II

- Expected Schedule
 - 2009
 - Submit NSF proposal
 - Develop FNAL expertise
 - 2010
 - R&D to develop tooling for assembly, characterization
 - 2011
 - Production assembly; similar scale to DECAM
 - 2012
 - Continue production assembly
 - Assembly and commissioning of cryostats

21 cm for BAO

1. BAO are on the cosmic frontier
2. BAO in redshift range 0.5-2. 6 years to get results from start of funding.
3. Foregrounds may be too hard to subtract
4. Studying with simulations
5. Fermilab not the lead but has experience in cosmology, r.f. technology, computing, and project planning.
6. At least two other efforts, not as advanced.

21 cm BAO

- Expected Schedule
 - 2009-2010
 - Complete conceptual design and simulations
 - Develop funding plan
 - 2011-2012
 - Construction
 - 2012-?
 - Operations

LSST

1. Dark Energy goals ok, but astronomy is not DOE's mission
2. LSST science goals include Dark Energy, Solar System objects, optical transient and Galactic Structure. The time scale is 2016 - 2026.
3. Technical and also systematics
4. <http://www.lsst.org/lsst/science/technology>
5. Fermilab has lots of experience in sky surveys, simulations, calibrations, astronomical data processing, and science analysis.
6. PanStarrs4 and JDEM could do the Dark Energy science first if funded first.

LSST

- Expected schedule
 - 2009
 - Call for new members of science collaborations
 - FCPA must decide whether to join a collaboration
 - 2011
 - FNAL institutional membership in LSST if we decide to do it

Low-Noise CCDs for Spectroscopy

1. DOE funded this as an R&D effort for SNAP
2. Goal is to demonstrate low-noise readout of CCDs useful for 'photon-starved' spectroscopy
3. It might turn out the noise isn't low enough to be compelling
4. Should know with another year of R&D
5. The DES CCDs and the people who know how to study them are at Fermilab
6. It appears nobody else is doing this

Low noise CCDs for Spectroscopy

- Expected Schedule
 - 2009
 - Finish filter algorithm
 - 2010
 - Finish low noise board
 - Field test on a telescope

Cosmological Computing

1. Simulations needed for Dark Energy, which is supported by DOE
2. Extract Dark Energy information from DES, JDEM over next decade or so
3. Some performance increases needed and multiple simulation codes required
4. Clear pathway with support from CD
5. CD expertise and numerical code experts
6. US university groups do not have the resources

Cosmological Computing

- Expected schedule
 - 2009
 - Have 250 computing nodes in place
 - 2010
 - Provide some simulations for DES
 - 2011-2012
 - Main simulations source for DES

Holographic Noise

1. One of the few approaches to Planck-scale physics
2. Does holographic shear noise with Planck spectral amplitude exist? 2-3 years to answer
3. Unexpected sources of correlated MHz noise
4. Close attention to isolation and controls
5. Scale too big for a university group but uses the Fermilab workforce and facilities well. It is a pathfinder for the resonant regeneration effort.
6. LIGO could take it on but its main business is gravitational waves. Hanover group may take it on.

Holographic Noise

- Expected Schedule
 - 2009
 - Seek PAC and Director's approval in June
 - Finalize design
 - 2010
 - Construct 'in-line' system
 - 2011
 - Reach Planck sensitivity
 - Build transverse extension
 - 2012
 - Reach 0.1 Planck sensitivity

Collected data from new initiatives

- Provide best estimates for manpower over next 3 years
 - Scientific
 - Technical (Engineers, techs, CPs of various types)
- Provide best estimates for Equipment and M&S over next 3 years
 - Separately by Division or FCPA seed funds
- Provide best estimate of schedule
 - Transition from seed to R&D to Project
- Give some idea of how you expect all this to be funded!

FCPA New Initiative Requests

Initiative	Auger North	Super CDMS	Liquid Argon			DM ACTs	Solid Xenon	Resonant Regen.	Chameleons	Quiet	21 cm	LSST	Low-noise CCDs	Cosmological Computing	Holographic Noise	Total Requested
			COUPP	DM	DAMIC											
PI	Mantsch	Bauer	Sonnensche	Sonnenschei	Estrada	Hall	Yoo	Chou	Steffen	Nguyen	Marriner	Kron	Diehl	Dodelson	Hogan	
Scientific Personnel																
FY2009 FTE	1.2	1.5	2.6	1.2	0.1	0.05	0.5	0	0.6	0.8	3.5	0	0.1	1	2	15
FY2010 FTE	1.7	1.5	4	2.2	0.2	0.2	0.7	0	0.3	2	4	0.1	0.1	1	2	20
FY2011 FTE	2.4	3	5	3.2	0.2	0.5	1.5	1.5	0	4	5	0.2	0.2	1	2	30
FY2012 FTE	2.6	3	5	5	0	1	1.5	1.5	0	5	5	0.3	0	2	2	34
Technical Personnel																
FY2009 FTE	0.3	2.25	6	1	0	0	0.1	0	0.78	1.92	0	0	0.1	1	0.1	14
FY2010 FTE	1.8	3.25	2.95	3.25	0.43	0.1	0.6	1	0.08	3.5	1.4	0	0.9	3.5	2.75	26
FY2011 FTE	2.3	3.75	6	6.5	0.2	1.1	1	2	0	3.5	4	0	0.08	3.5	2.6	37
FY2012 FTE	2.3	3.25	6	6.5	0	1.1	1	2	0	4.5	6.5	0	0	3.5	1	38
SWF (K\$)																
FY2009	48.6	532	841	50	0	0	16	0	78	300	0	0	10	150	15	2041
FY2010	412.6	860.5	420	571	60	15	102	100	10	500	200	0	90	500	400	4241
FY2011	549.2	1233	900	1120	30	150	171	200	0	500	600	0	10	500	400	6363
FY2012	659.7	1161	900	1173	0	150	171	200	0	700	1000	0	0	500	150	6765
FCPA M&S (K\$)																
FY2009	32	20	30	60	0	10	41	0	0	15	25	0	0	205	0	438
FY2010	0	0	0	20	0	30	80	0	0	10	0	1	0	200	0	341
FY2011	0	0	0	20	0	40	80	0	0	10	0	27	0	300	0	477
FY2012	0	0	0	20	0	50	80	0	0	10	0	28	0	500	0	688
Division M&S (K\$)																
FY2009	35	160	268	125	0	0	10	100	20	15	0	0	70	0	200	1003
FY2010	50	200	150	300	7.5	0	20	100	0	50	50	0	30	0	600	1558
FY2011	50	50	400	700	2.5	0	330	200	0	50	0	0	25	0	650	2458
FY2012	50	50	400	700	0	0	330	500	0	50	0	0	0	0	50	2130
Total FNAL M&S (K\$)																
FY2009	67	180	298	185	0	10	51	100	20	30	25	0	70	205	200	1441
FY2010	50	200	150	320	7.5	30	100	100	0	60	50	1	30	200	600	1899
FY2011	50	50	400	720	2.5	40	410	200	0	60	0	27	25	300	650	2935
FY2012	50	50	400	720	0	50	410	500	0	60	0	28	0	500	50	2818
External Funding (K\$)																
FY2009	160	1000	300	1000	0	0	45	0	0	0	0	0	0	125	0	2630
FY2010	50	2000	300	2539	0	40	15	100	0	359	0	0	0	439	0	5842
FY2011	50	4000	500	2541	0	50	100	100	0	516	500	0	0	500	0	8857
FY2012	25000	4000	500	1348	0	50	100	200	0	687	500	0	0	1000	0	33385

Response to Requests

- Everybody wants to ramp up as quickly as possible; no surprise there!
- Requests would clearly exceed resources the lab is willing to devote to particle astrophysics
 - Doubling of scientific FTEs, tripling of technical FTEs
 - Doubling of M&S budget
- Pier has made it clear we will not grow that fast!

FCPA Recommendations

- Very few efforts we would like to cut
 - Science on all of these things is compelling
 - Might choose not to start anything new like LSST, ACTs, but it wouldn't save much
- Have to slow things down and stage them so only a few projects are growing rapidly at any given time
 - Time-dependent prioritization

Draft Recommendations

Initiative	Auger North	Super CDMS	COUPP	Liquid Argon DM	DAMIC	DM ACTs	Solid Xenon	Resonant Regen.	Chameleons	Quiet	21 cm	LSST	Low-Noise CCDs	Cosmological Computing	Holographic Noise	Total
PI	FCPA	FCPA	FCPA	FCPA	FCPA	FCPA	FCPA	FCPA	FCPA	FCPA		FCPA	FCPA	FCPA	FCPA	FCPA
Scientific Personnel																
FY2009 FTE	1.2	1.5	2.6	1.2	0.1	0.05	0.5	0	0.6	0.8	3.5	0	0.1	1	2	15
FY2010 FTE	1.5	1.5	3	2	0.2	0.2	0.5	0	0.3	2	4	0.1	0.2	1	2	18
FY2011 FTE	2	3	3	2	0.2	0.5	1	1.5	0	2	4	0.1	0	1	2	22
FY2012 FTE	2	3	3	2	0	1	1	1.5	0	2	4	0.1	0	2	2	24
Technical Personnel																
FY2009 FTE	0.3	2.25	6	1	0	0	0.1	0	0.78	1.92	0	0	0.1	1	0.1	13
FY2010 FTE	1	3.25	3	2	0.43	0.1	0.6	1	0.08	2	1.4	0	0.9	2	1	19
FY2011 FTE	1	3.75	3	2	0.2	1	1	2	0	2	2	0	0	3	2	23
FY2012 FTE	2	3.25	3	2	0	1	1	2	0	2	2	0	0	3	2	23
SWF (K\$)																
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FCPA M&S (K\$)																
FY2009	32	20	30	60	0	10	41	0	0	15	25	0	0	205	0	438
FY2010	0	0	0	0	0	20	30	0	0	10	0	1	0	200	0	261
FY2011	0	0	0	0	0	20	0	0	0	0	0	1	0	300	0	321
FY2012	0	0	0	0	0	20	0	0	0	0	0	1	0	300	0	321
Division M&S (K\$)																
FY2009	35	160	268	125	0	0	10	100	20	15	0	0	70	0	50	833
FY2010	50	200	150	200	7.5	0	20	100	0	50	50	0	50	0	200	1078
FY2011	50	50	100	200	2.5	0	50	200	0	60	0	0	0	0	500	1213
FY2012	50	50	200	200	0	0	50	200	0	60	0	0	0	0	500	1310
Total FNAL M&S (K\$)																
FY2009	67	180	298	185	0	10	51	100	20	30	25	0	70	205	50	1271
FY2010	50	200	150	200	7.5	20	50	100	0	60	50	1	50	200	200	1339
FY2011	50	50	100	200	2.5	20	50	200	0	60	0	1	0	300	500	1534
FY2012	50	50	200	200	0	20	50	200	0	60	0	1	0	300	500	1631

Discussion

- Recommendations will be seen as reasonable growth of particle astrophysics program
 - Even these will strain available manpower, M&S
- Must be an evolving plan
 - React to advisory groups, DOE and Lab feedback
 - Technical obstacles or failure to progress to project status may change things significantly
 - Reevaluate at least yearly, prior to lab budgets

Strategic Plan – Cosmic Surveys

- Fermilab should continue its leading role in DES and in a wide range of DES science. The ongoing commitment includes support for the new Director of DES as a Fermilab senior staff scientist.
- Fermilab should stay involved with the JDEM design and keep open the option of hosting a Science Operations Center.
- Fermilab should continue its development of CCD technology for survey cameras to the point where its future use for astronomy can be demonstrated. If JDEM is configured to have a large number of CCDs, Fermilab should play a major role in packaging.
- Fermilab should pursue in-common work for DES and LSST in areas such as calibration and simulation. Formal linkages between the projects should be pursued if they increase the science impact of DES.

Strategic Plan – Dark Matter

- Fermilab should participate in the next generation versions of COUPP and CDMS. Both of these projects are scientifically productive and show promise for significantly better sensitivity with future expansion, including the real possibility of a confirmed detection.
- Commitments to future expanded versions of COUPP and CDMS should be contingent on ongoing contextual review by an FCPA working group for this purpose.
- The same working group should evaluate status and progress of liquid argon technology, and R&D for solid xenon and CCD technology, before significant lab commitments are made to these endeavors.
- Fermilab should plan on a leading role in at least one major dark matter experiment at DUSEL. This implies early participation in relevant aspects of DUSEL planning.
- Fermilab should continue modest investments in R & D for new detection technologies, including the possibility of Atmospheric Cherenkov Telescopes for indirect detection

Strategic Plan – High Energy Particles

- Fermilab should continue support of Pierre Auger Observatory and its science.
- Planning efforts for Pierre Auger North should follow priorities set by agency review processes that should clarify its future within the next year. FCPA should support modest R&D at least until then.

Strategic Plan – New Initiatives

- Fermilab should continue in the short term exploration of 21cm Intensity Mapping design studies and R& D.
- Fermilab should continue partnership with the QUIET team on R & D for CMB polarization technology. Involvement in QUIET II will depend on the outcome of our internal review process, as well as external advice and funding decisions.
- Fermilab should continue exploration of GammeV concepts and technology R & D.
- Fermilab should collaborate on development of experiments designed to test the holographic noise hypothesis, and advance theoretical studies on connections of this idea with string and M theory.
- Expansion of any of these efforts beyond R & D will follow the lab review process, guided by overall directions at the national level.

Strategic Plan - Theory

FCPA should continue its seed funding, and CD should continue its technical support of the Cosmological Computing Initiative for another year. Continued commitment should be contingent on DOE funding of the initiative, or other external funding.

- Theoretical Astrophysics should further reinvigorate its connections with particle theory. Activities to pursue include additional venues for gathering the groups, shared appointments of postdocs, and possibly joint appointment of new scientific staff.
- Future growth should include gravitational theory.