Summary of the 2010 ANL HEP Division Retreat

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18 May 18011

1 Executive Summary

The Argonne High Energy Physics Division conducts basic research in Experimental, Theoretical, and Accelerator Physics. The research program is carried out in close cooperation with other high energy physics personnel throughout the United States and the world. The Division supports and works closely with university groups and other national labs in all of our subprograms and projects. The field benefits from the physics and instrumentation expertise of the staff, from the capabilities in mechanical, electrical and software engineering, and from the resources available at the multi-program facilities available throughout Argonne Lab.

In December 2010, the Argonne High Energy Physics Division met for two days to discuss planning for the future. This "retreat" followed a tradition of previous retreats that the Division held in 1986, 1990, 1998 and 2004 to discuss ways to maximize future research achievements. The 2010 retreat was organized by a committee appointed by Division Director Harry Weerts and listed in Appendix I. In preparation for the retreat, over a period of a year, there were a series of seminars highlighting the current plans and achievements of each group in the Division. There were also reports from potential new projects that the Division might join, such as the $\mu 2e$ experiment at Fermilab, rare K decay experiments and LBNE. At the conclusion of the retreat was a seminar at which each member of the Division's theory group contributed an idea for emphasis within the future experimental program. Ideas ran the gamut of the *Energy Frontier*, the *Intensity Frontier* and the *Cosmic Frontier*. This report summarizes the views of the committee on the outcome of the retreat exercise.

The current experimental program is well aligned to the three-pronged priorities of the US HEP program as outlined in the 29 May 2008 Report "US Particle Physics: Scientific Opportunities, A strategic Plan for the Next Ten Years" from the Particle Physics Project Prioritization Panel (P5), available at http://www.science.energy.gov/∼/media/hep/pdf/files/pdfs/p5_report_06022008.pdf at **P5 2008 Report**. Building from the successful programs at CDF and ZEUS, the ATLAS group is involved in collider physics at the highest center-of-mass energy at the Large Hadron Collider (LHC), our continuing emphasis at the *Energy Frontier*. Building off a long and successful program of experiments in atmospheric and accelerator neutrinos, the neutrino group is helping lead Fermilab to its new role as the home of the *Intensity Frontier*, using high power beams to study neutrinos near and far. And teaming with others at ANL and the University of Chicago, the astrophysics group is participating in those astrophysics experiments that address particle physics goals, and helping to define the *Cosmic Frontier*. For many years all of the experimental groups have been conducting research on new detector techniques, but recently this has been recognized within the ANL HEP Division organization as a group unto itself, with a variety of novel detector opportunities currently under investigation. The experimenters have the opportunity to work closely with the theory group within ANL HEP, providing mutual benefits so that theoretical and experimental particle physics can both make progress. In addition, ANL HEP has a strong group working on novel acceleration techniques that offer the possibility of extending the *Energy Frontier* in the future in a cost effective way.

Besides maintaining a vibrant program well aligned with the goals of the national US High Energy Physics program, ANL HEP Division physicists are constantly looking for new ways to push the boundaries of knowledge. On the LHC, the ATLAS group is keeping a keen eye open to the most appropriate opportunities for upgrades. As the opportunity for an international linear collider has receded into the future, our accelerator group has become involved in related issues of cavity design, and our detector R&D efforts towards energy flow algorithms for future colliders have been redirected towards calorimeters that could be used in other HEP programs. The neutrino group continues to be a leader in the MINOS and NOvA long-baseline experiments, but is already actively helping to develop the proposed LBNE experiment. And the astrophysics group is examining the full range of possible ways that the tools of high energy physics can be utilized to better understand issues of dark matter and dark energy. As the field continues its trend toward fewer larger experiments, it is inevitable that additional time and effort is expended on evaluating and designing experimental programs that may never be realized. This is not necessarily a bad thing, but it does produce challenges and therefore we must constantly reevaluate our efforts and priorities. The December retreat accomplished exactly that - a full discussion of the probable and possible future directions for our groups and field and how the ANL HEP Division should adapt in this ever-changing environment.

The rest of this document summarizes some of the main points that were discussed during the retreat. It doesn't represent a plan for the Division, but rather evidences one step in the continuous planning environment that we have to engage in to maintain a healthy and vibrant research environment for which ANL has long been known.

2 Summary Evaluation of Division Projects

2.1 Collider Physics

The collider group has a full time challenge participating in the analysis of ATLAS data and managing the ATLAS analysis support center to maximum benefit.

- Meaningful contributions to ATLAS analysis will need large groups of individuals on each topic: twenty or more. The analysis support center can provide the computing and impetus to make this happen.
- There are strict rules about the openness of data, but theorists can get involved at an early level as analyses develop.
- ANL physicists are not currently leading any LHC or Super-LHC tracking upgrades. This might be the correct strategy at the moment, but we must remain open to appropriate opportunities in the near future.
- Future high energy colliders will be e^+e^- and/or $\mu^+\mu^-$. Several physicists in the division are involved and will help us guide this future opportunity as appropriate.

2.2 Accelerator Physics

The Accelerator Group has an ambitious near and mid term wakefield development program which requires the bulk of their attention for the foreseeable future.

- The wakefield group will finish their upgrade in 2011 and perform high-gradient and high-gain experiments on the witness beam in 2012.

- The CLIC effort is growing, and our group has a good communication channel with them; but we should figure out a strategy to the extent that the efforts are complementary or competitive.

2.3 Detector R&D

The efforts at Detector R&D within the ANL HEP Division at Argonne are expected to become an increasing part of the Division's effort as the field continues to move toward fewer but larger experimental projects.

Previously, detector R&D has been undertaken by each of the physics research groups as part of the design of specific experiments. In accordance with new DOE HEP funding procedures, the ANL HEP Division has increased the scope of novel detector R&D activities.

- Large Area Picosecond PhotoDetector (LAPPD): new, large, cheap and fast.
- RPC based digital hadron imaging calorimeter: $1m^3$, 350K channels.
- Signal transport via modulated laser and MEMS mirror arrays.
- Millimeter wave($\sim$90GHz), threshold edge sensors(TES) for CMB B-mode polarization.
- Topological trigger for VERITAS and possible future ground-based Cherenkov arrays.
- New telescope designs: Schwarzschild-Couder and Davies-Cotton.
- Wireless DAQ and Power: use of cell phone technology for signals and advanced batteries for power to eliminate cables.
- Pattern recognition for tracking in complicated environments; development of associated memory devices for ATLAS.

2.4 Neutrino

The neutrino group is well positioned to strongly participate as the US changes its facilities focus from the *Energy Frontier* to the *Intensity Frontier* at Fermilab.

The ANL HEP neutrino group is actively participating in the MINOS, NOvA and Double Chooz experiments, as well as the LBNE Project. The group recently added two scientists, and now has a total of 5 scientists and 3.5 postdocs.

The group continues to contribute to NOvA project and engineering management, and is involved in the development of DAQ and offline reconstruction and analysis software. Construction and commissioning of the prototype Near Detector On the Surface (NDOS) will be complete this year (2011), and construction of the Far Detector should begin later this year as well. NuMI neutrinos have already been observed in the partially instrumented NDOS.

The Double Chooz reactor experiment has completed instrumenting and filling its Far Detector. Neutrinos from the reactor have already been observed and effort is now focused on commissioning the Far Detector.

Although the MINOS experiment will be ramping down operations in the near future, the group will have its hands full over the next 5 years with MINOS, NOvA and Double Chooz operations and data analysis.

- Analyses on MINOS data continue to benefit from additional statistics.
- The analysis of early data from Double Chooz is a high priority.

- There is considerable work to do on the building of the NOvA near and far detectors, as well as analysis of appropriate data from the Near Detector On the Surface (NDOS).
- Assuming that the LBNE Project continues on its current path, the group will likely be spending ∼50% of its effort on LBNE after 2015.
- The group is active in both LBNE detector technologies being considered:
  - LAPPD and Wireless data transmission R&D projects are closely linked to the Water Cherenkov option.
  - Argonne has a management position within the Liquid Argon TPC Far Detector subproject, with Paley as the Level 3 Manager of the Veto subsystem (needed for proton decay).
- There are significant concerns about the future of the Homestake Lab as a site for LBNE.
- There is some overlap in physics topics between the astrophysics group and the neutrino group. There should be an appropriate relationship among these two groups which takes advantage of this to the mutual benefit of both groups.

2.5 Astrophysics

The astrophysics effort at Argonne has as a major goal to understand the nature of Dark Matter and Dark Energy and, most recently, the study of Inflation.

Astrophysics at the ANL HEP Division has been a growing activity, which solidified thanks to LDRD support and joint initiatives with nearby institutions, in particular, Fermilab and the University of Chicago. The astrophysics group has taken part in different activities, including the participation in the high energy cosmic ray experiment Auger, located in Mendoza, Argentina, a strong involvement with the ground based high energy gamma ray experiment VERITAS, participation in the Dark Energy Survey DES and, most recently, a collaboration with the Cosmic Microwave Background experiment led by John Carlstrom from the University of Chicago.

With input from the DOE non-accelerator review held in Washington DC in September 2010, the astrophysics group is in the process of reevaluating the proper mix of effort and priorities.

- The Auger effort has come to an end.
- ANL HEP Division personnel are providing novel telescope detector designs for the next generation CTA and AGIS high energy gamma ray experiments. This is an opportunity for ANL to provide management for an ambitious new program in gamma ray astrophysics.
- The Argonne astrophysics group has joined the DES effort playing a relevant role on the supernova data analysis. It has a close collaboration with the Fermilab group and has also taken significant engineering roles, including the mirror handling system built at Argonne. It is also planning to be part of the LSST effort.
- The CMB activities are somewhat new, and the ANL HEP Division has no relevant involvement in them yet. However, John Carlstrom and Clarence Chang of Chicago have recently taken joint appointments with Argonne, and it is expected that these efforts will grow in the near future. At present, the CMB group is working with the MSD Division, and is looking for opportunities to become more integrated with the ANL HEP Division.

- In spite of the successes in gamma ray and Supernova analyses, DOE has provided only weak support for the continuation of these activities. The ANL HEP Division will continue with these efforts, but must look for other opportunities as well.
- DOE is interested in a growing Argonne involvement in the CMB efforts, which represents a possible interesting opportunity for the ANL HEP Division.
- At the same time, Argonne has just hired two computational cosmologists from Los Alamos, who are bringing two postdocs and are planning to hire two more by the end of 2011. They are working with ALCF, and for the coming years their positions will be funded through a strategic initiative at the leading computing facility. A long term funding model will need to be developed.

2.6 Theory

The theory group at Argonne has in recent years concentrated their main efforts on the phenomenology of the Standard Model and theories that extend its description beyond the electroweak scale and also a relatively minor effort on more formal physics.

Six staff members work on phenomenology and one on formal theory. Three of the seven members have joint positions at nearby Universities: Northwestern University and the University of Chicago. ANL HEP theory has been very successful in the supervision of young students and postdocs. Many of the former theory postdocs and students play now leadership roles in a wide range of US research institutions.

- The theory efforts have been historically well aligned with the experimental hadron collider effort within the ANL HEP Division and the group has positioned itself as one of the best theoretical groups in the US to confront the coming LHC era.
- The group covers a wide range of subjects in high energy physics. These include:
  - higher order QCD corrections to precision observables at hadron colliders,
  - QCD and collider physics,
  - QCD effects on quarkonia production,
  - the study of new phenomena beyond the Standard Model and implications for collider physics.
- There is an interest in getting a stronger interaction between the theory group and the ATLAS analysis groups. There are already relevant interactions at the individual level, but a more systematic collaboration would be desirable.
- An outstanding question that has remained for many years is the possible hire of a theorist working on neutrino and lepton flavor physics. This would be a natural decision, considering the growing importance of the lepton flavor experimental program at Fermilab.
- Salman Habib and Katrin Heitman would like to have a close relation to the ANL HEP theory group.
- In general, the incorporation of new staff members imply also a growing number of postdocs and students, which has created an office space problem that has to be addressed.

Appendix I: The 2010 Retreat Committee

The 2010 Retreat Committee consisted of

- Karen Byrum
- Manoel Conde
- Maury Goodman* (chairman)
- Steve Kuhlman
- Jon Paley*
- Frank Petriello
- Carlos Wagner*
- Barry Wicklund*
- Rik Yoshida

* members of the report subcommittee.

Raquel Young and Jennifer Seivwright provided valuable administrative support.

Appendix II Goals

Collider Goals

- Analyze remaining CDF data in B and electroweak physics.
- Contribute to the smooth operation of the Atlas Detector.
- Fulfill operational responsibilities on TileCal and L2 Trigger.
- Complete replacement of TileCal power supplies during 2013 shutdown.
- Redesign power supplies for 2021/22.
- Participate in level 1.5 fast track trigger for 2013.
- Stay involved for the evolution of the higher level trigger.
- Provide expected deliverables over next three years in event store design and optimization, event selection services and distributed database services.
- Support and build upon successes in the Analysis Support Center (ASC).
- Grow the ASC to a regular user base of 30 with at least 3 analysis teams by 2013.
- Ultimately grow the ASC to >50 users and >5 analysis teams.
- Identify ANL contributions to possible future LHC upgrades.
- Pursue software and hardware options involved in a linear collider if and when it becomes more concrete again.

Detector R&D Goals

- Develop Large-Area Picosecond PhotoDetectors.
- Develop small-scale scintillator based neutrino detector deploying the LAPPD detectors
- Develop high Quantum Efficiency Photo-Cathodes.
- Develop and test digital hadron calorimeters and its application to particle flow calorimetry.
- Develop signal transport via modulated laser and MEMS mirror arrays.
- Develop threshold edge sensors for CMB B-mode polarization.
- Develop wireless DAQ and power for large neutrino detectors.
- Initiate a detector R&D center to promote and develop new technologies for future detectors.

Neutrino Goals

- Work to develop a national and international program which maximizes sensitivity to a non-zero value of θ_{13}.
- Help analyze MINOS results for Δm^2_{32} and θ_{13} as it takes its final data.
- Expeditiously analyze data on θ_{13} from Double Chooz.

- Determine if a reactor experiment larger than Daya Bay makes sense, depending on measurement of backgrounds in Double Chooz.
- Help to build the NOvA near and far detectors.
- Analyze NDOS data for understanding the beam and cosmic backgrounds for NOvA.
- Help Fermilab develop a long-term program at the *Intensity Frontier* as part of LBNE.
- Design a veto counter for the liquid argon option of LBNE.
- Develop lower-cost cabling for the water Cherenkov option of LBNE.

Astrophysics Goals

- Continue searches for Dark Matter at VERITAS using the upgraded detector and trigger.
- Lead the design and construction of mechanical telescope structures for CTA.
- Develop a topological array trigger for CTA.
- Design a Schwarzschild-Couder telescope for CTA.
- Continue management of many aspects of the Dark Energy Camera.
- Find an appropriate project on LSST.
- Deploy SPTpol at South Pole Telescope.
- Expand Argonne bolometer technology for future CMB experiments.

Theory Goals

- Compute higher order QCD correction for relevant Higgs and new physics processes at hadron colliders.
- Continue relevant work on Higgs Physics, within and beyond the Standard Model, at the Tevatron and LHC colliders.
- Work on well motivated new physics scenarios at the weak scale and their possible LHC signatures.
- Analysis of QCD effects in quarkonia physics, including factorization and production at hadron and electron-proton colliders.
- Continue working on formal aspects of physics, including renormalization group functionals and their applications.
- Work on theoretical and computational Cosmology, related to the important questions of Dark Matter and the Matter-Antimatter asymmetry.
- Increase our interactions and collaboration with the ATLAS HEP group, essential to make early HEP progress on weak scale physics.
- Interpret new experimental results at hadron colliders.
- Increase our interactions with the Neutrino and Astrophysics groups, looking for new opportunities in these areas.

Accelerator Goals

- Commission the Cs2Te RF photocathode gun, initial beam testing for the high current beam (2011).
- Construction of two new RF modulators and install two klystrons. (2011).
- Complete the AWA bunker expansion and install drive beam high current linacs (2011-2012).
- Generate and characterize the high current beam at 75 MeV (2011 - 2013).
- Demonstrate high RF power ($\sim$ GW) extraction experiments. (2012 - 2015)
- Starting high gradient wakefield ($\sim$ 0.5 GV/m) experiments using high charge bunch train. (2012-2014).
- Demonstrate critical wakefield accelerating technologies for future ANL HEP linear colliders.
- Complete Technical design report for the International Linear Collider (ILC) positron source design. (2012)

Appendix III: The Panel questions discussed at the retreat

1. Astrophysics: Given the efforts on CMB, gamma ray astronomy and DES, how should the ANL HEP astrophysics group divide its limited resources?

2. Collider: How well do the Atlas group plans mesh with current and future needs and plans at the LHC?

3. Neutrino: How much and how quickly should neutrino group effort be shifted from Double Chooz, MINOS and NOvA to LBNE?

4. Detector R&D: How do we establish a National Detector Center and what follows our current LAPPD funding?

5. Theory: With its recent growth, how does the theory group most effectively support the Division and do great theory?

6. Accelerator: What is the long term goal for the wakefield facility?

The retreat web site with presentations is
https://twindico.hep.anl.gov/indico/conferenceDisplay.py?confId=25 at
ANL HEP 2010 Retreat Web Site