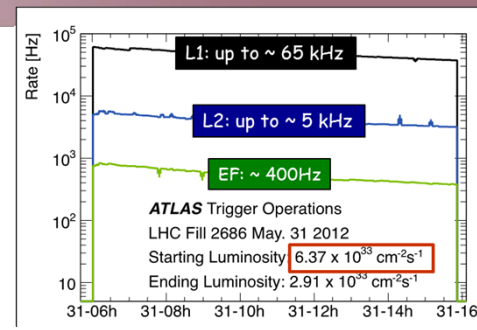
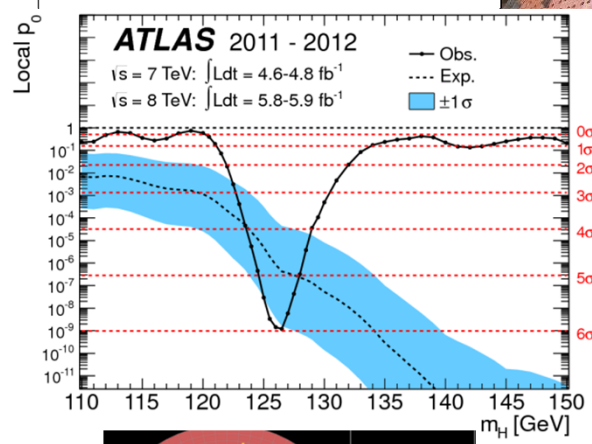
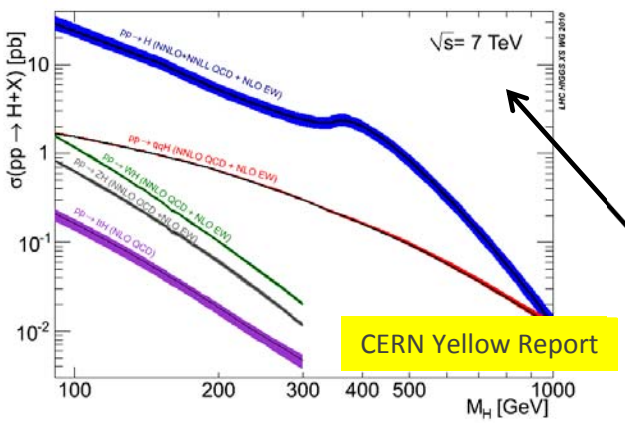
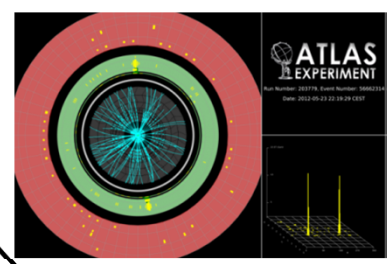
ATLAS Program

People
Activities and Tasks
Physics: past present & future
Analysis Support Center
Detector System Responsibilities
Upgrade R&D
Summary

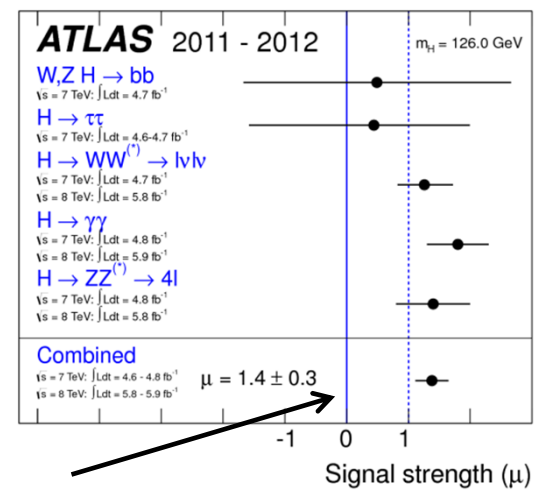








From calc. by Anastasiou, **Boughezal, Petriello**, Stoeckli; and de Florian, Grazzi



Research Staff

Bob Blair
Sergei Chekanov
Tom LeCompte
Larry Nodulman *(shared with CDF) => transition to 100% ATLAS*
Larry Price (retired Oct 2011, now IPA at DOE) => New Hire in progress
Jimmy Proudfoot *(Group Leader)*
Bob Stanek (reduced schedule)
Rik Yoshida *(Deputy Group Leader)*
Jinlong Zhang (Early Career Award, 2011-2016)
Esteban Fullana (postdoc, left for Marie-Curie Fellowship 2010)
Belen Salvachua (postdoc, left for CERN Fellowship, 2011)
Lily Asquith (postdoc, joined 2010)
Ben Auerbach (postdoc, joined 2011)
Duong Ngyuen (postdoc, joined 2011)
Jeremy Love (postdoc, joined 2012)

Support provided by Argonne Laboratory funds:

Sasha Paramonov (Argonne Named Fellow, Joined 2009)
=> Replace with group postdoc when he leaves in fall 2012
Eric Feng (Argonne Named Fellow, Joined 2012)

Computing and Technical Support Staff

These staff are integral contributors to our research program. They provide the expertise that is needed to develop software, and invent and develop the detector hardware (in the past we also made extensive use of the Mechanical Support Group in the Division).

ATLAS Software and Computing Group

Jack Cranshaw
Peter van Gemmeren
David Malon ***(Group Leader)***
Sasha Vaniachine (@CERN)
Qizhi Zhang

Electronics Group

Engineer Gary Drake ***(Group Leader)***
Engineers John Anderson, Pat di Lurgio and Andrew Kreps
Engineering Associates Tim Cundiff, Mike Oberling and Denis Fellman (left laboratory in June 2012)
Technician Carolyn Adams

Tier 3 Computing System Support

Evan Sather (50%)

Group Secretary

Nancy Rezek

Activities and Tasks in ATLAS and US-ATLAS:

Physics & Performance

Contributed to several published papers, with several analyses in progress

http://atlaswww.hep.anl.gov/asc/Analyses.php

Analysis Support Center

Started as an idea and a couple of potential students, now a thriving and vital community

http://atlaswww.hep.anl.gov/asc/index.php

Tier 3 Computing Development

ANL was leader in ATLAS and in USATLAS Tier 3 Hardware and infrastructure design and development

Coordinated the deployment of 30 systems for US groups

Trigger and Tile detector operations

Leading key tasks – RoIB/TDAQ operations, replacement TileCal LVPS

Software & Computing

THE group responsible for the I/O framework and event store infrastructure

ATLAS Detector Upgrades

FTK (Phase 1); Tile QIE ASIC, Redundant LVPS, Optical Modulators, VIPRAM (Phase 2)

I/O architecture, persistence technology, distributed computing developments

Leadership in ATLAS and US-ATLAS

Stanek is former Tile Calorimeter Project Leader (2005-2009)

LeCompte was ATLAS Physics Coordinator for 2 years ending Sept. 2010 – an intensely active period – ATLAS produced of order [100] CONF notes and several papers

Yoshida is currently US ATLAS Analysis Support Manager

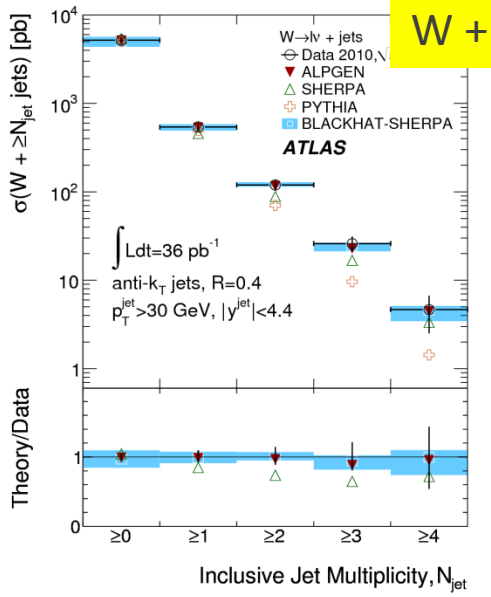
Price was US-ATLAS Tile L2 Manager for Maintenance and Operations until Dec 2011 -> position now held by Proudfoot

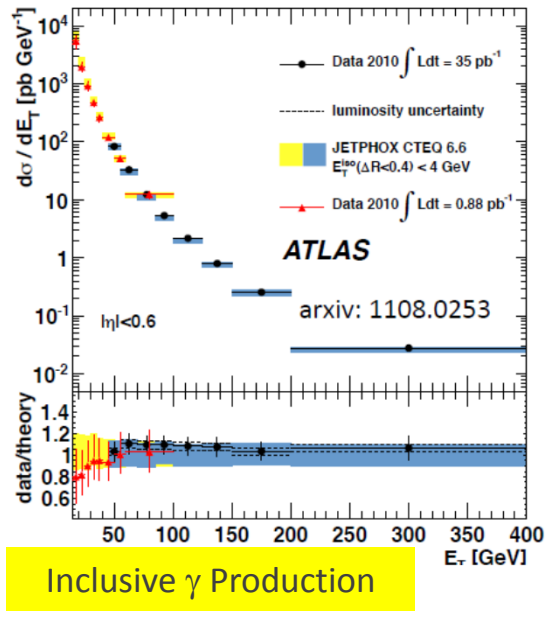
Price was US-ATLAS Tile L2 Manager for Upgrades until Dec 2011

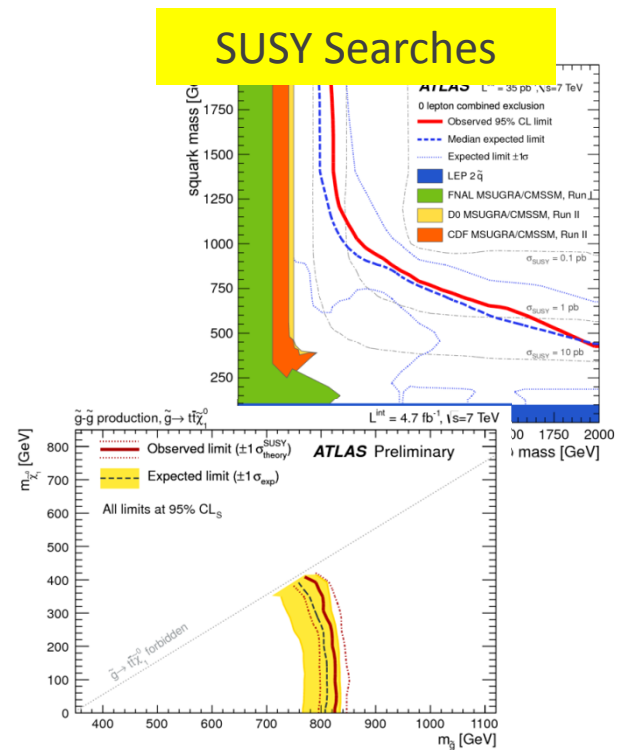
Yoshida was US-ATLAS Tier-3 Manager (2009-2010)

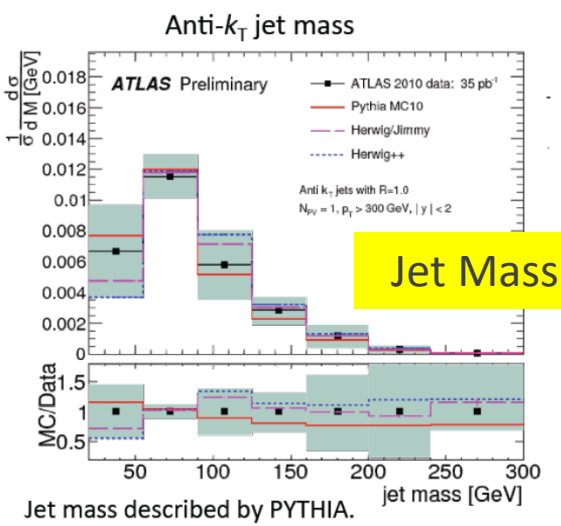
Group has provided members of many ATLAS Editorial Boards: of note, Yoshida chaired the Ed Board for $H \rightarrow \gamma\gamma$ paper in Feb 2012,and a member of the Ed Board for the CONF note and combined paper in summer 2012

Physics: "past"

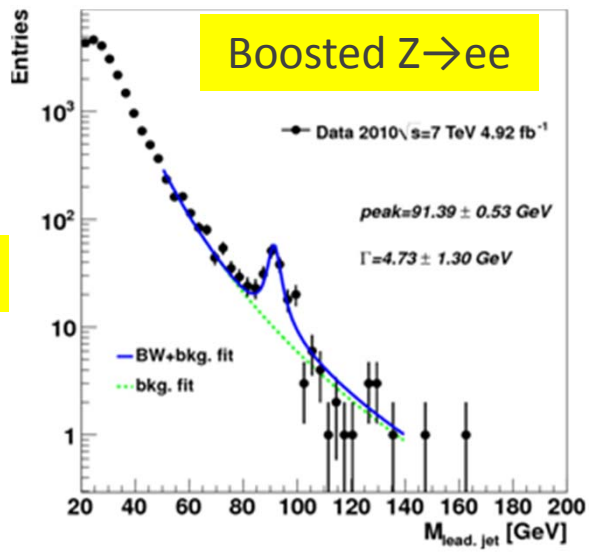


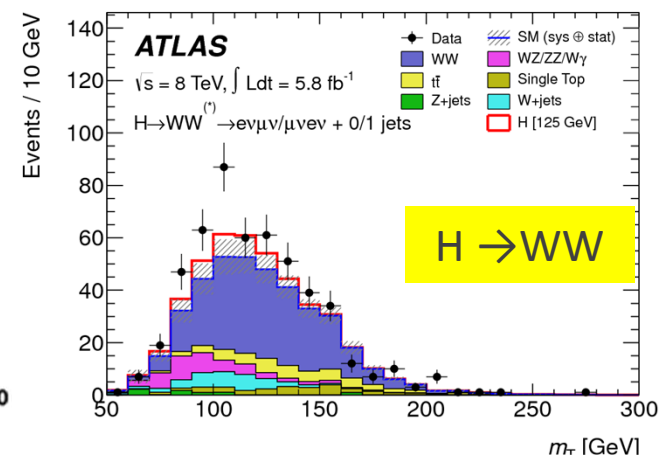






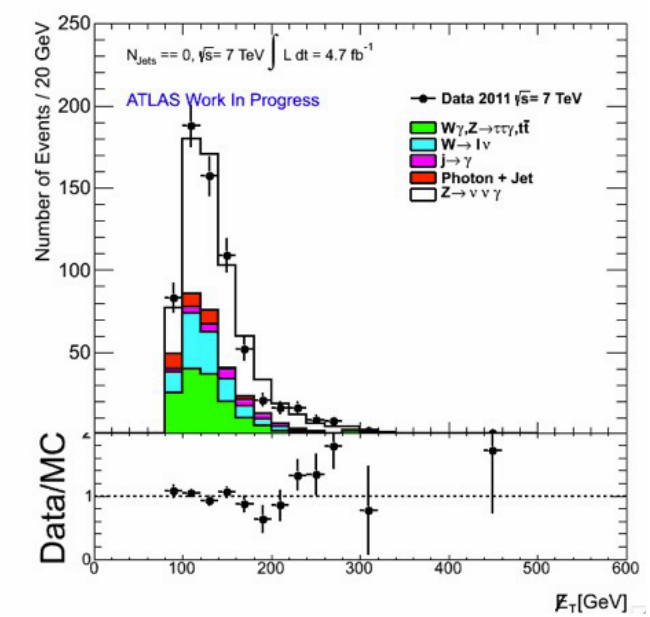
Jet mass described by PYTHIA.



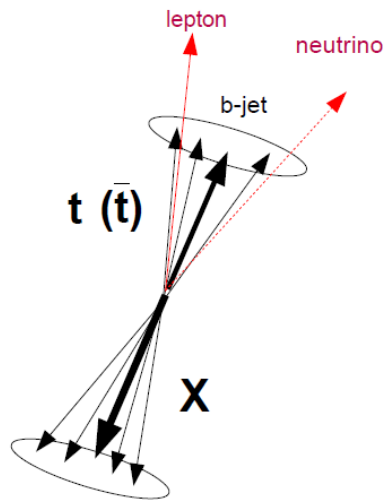


Physics: "present"

Study and develop jet characterization variables for use in boosted object Reconstruction to search for decays of heavy objects, boosted Higgs→bb/ττ

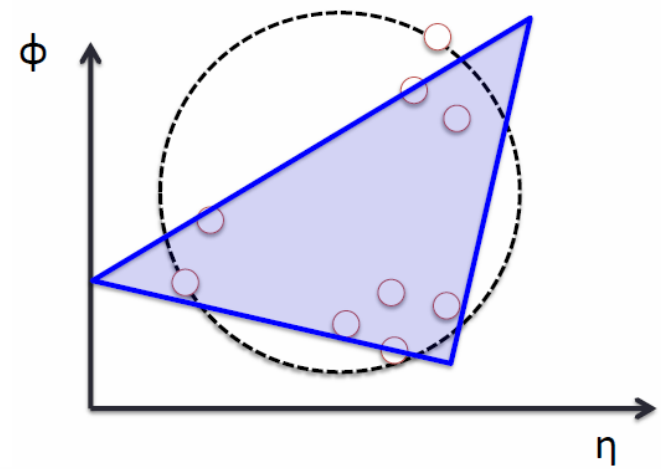


From Z(νν)γ to Z(ll)γ from Higgs

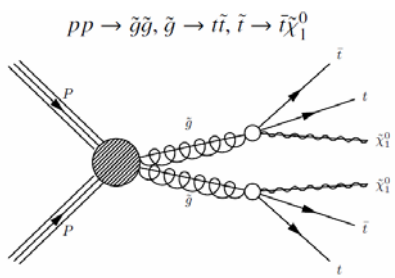


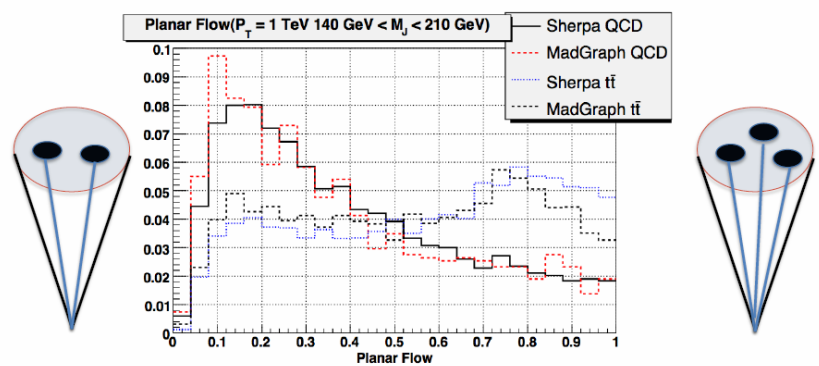
R ~ 2m/pT

Planar Flow



Planar flow can distinguish between three-body (top) jets and two-body (light quark/ gluon) jets.





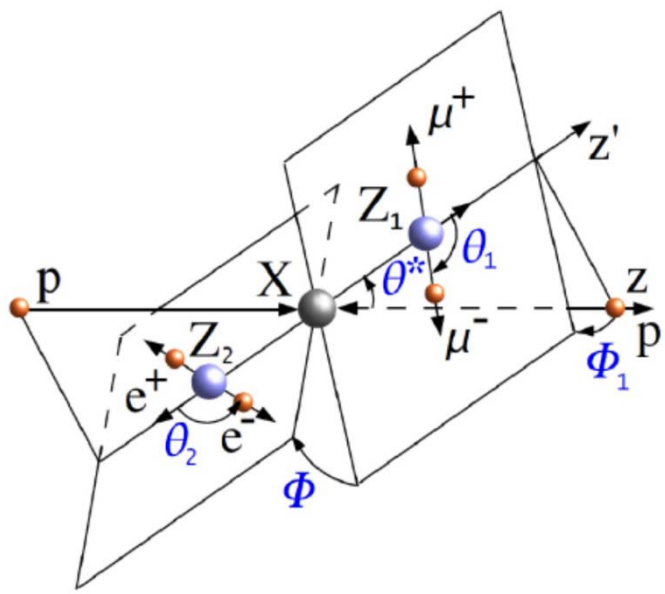
arXiv:0807.0234

Analysis to search for SUSY in tri-lepton final states

Physics: "future"

Properties of Higgs-like Boson

spin, CP, couplings to b's, τ's, Zγ, γγ etc.



AND
Continue to look for signals of physics beyond the Standard Model (SUSY, Boosted tops)

Discriminating power TODAY

Single-variable asymmetries for measuring the 'Higgs' boson spin and CP properties

Radja Boughezal,[1,*] Thomas J. LeCompte,[1,†] and Frank Petriello[1,2,‡]

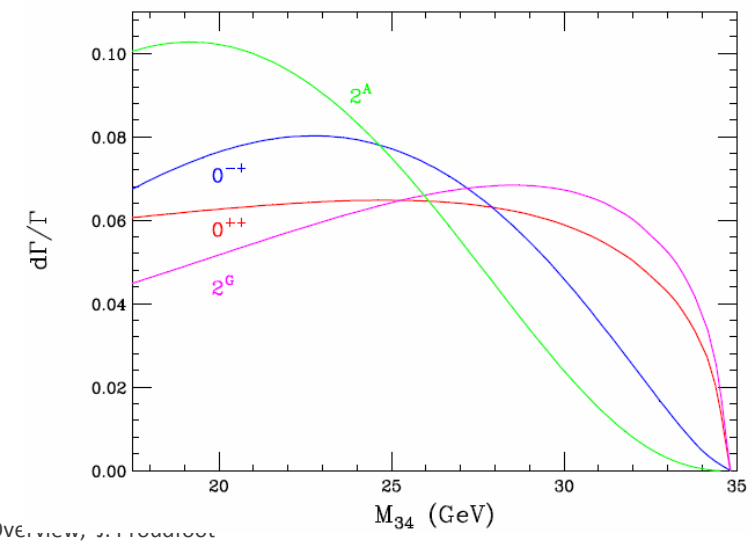
[1] *High Energy Physics Division, Argonne National Laboratory, Argonne, IL 60439, USA*

[2] *Department of Physics & Astronomy, Northwestern University, Evanston, IL 60208, USA*

Abstract

We introduce a class of asymmetries sensitive to the spin and CP properties of the new boson discovered by the ATLAS and CMS experiments. These asymmetries can be measured in the four-lepton final state, and are defined by integrating the invariant masses of the lepton pairs over specified ranges. We outline a program of measurements using initial LHC data to determine the various hypotheses for spin, CP and couplings. These "high-low" asymmetries are defined as follows:

$$\mathcal{A}_{M_{cut}} = \frac{N(M_{34} > M_{cut}) - N(M_{34} < M_{cut})}{N(M_{34} > M_{cut}) + N(M_{34} < M_{cut})}. \quad (1)$$



Analysis Support and ANL Analysis Support Center

A snapshot of people at the ASC this summer (July 16th to be precise):

17 ANL Staff

12 Visitors (including 4 summer interns)

Not in the picture:

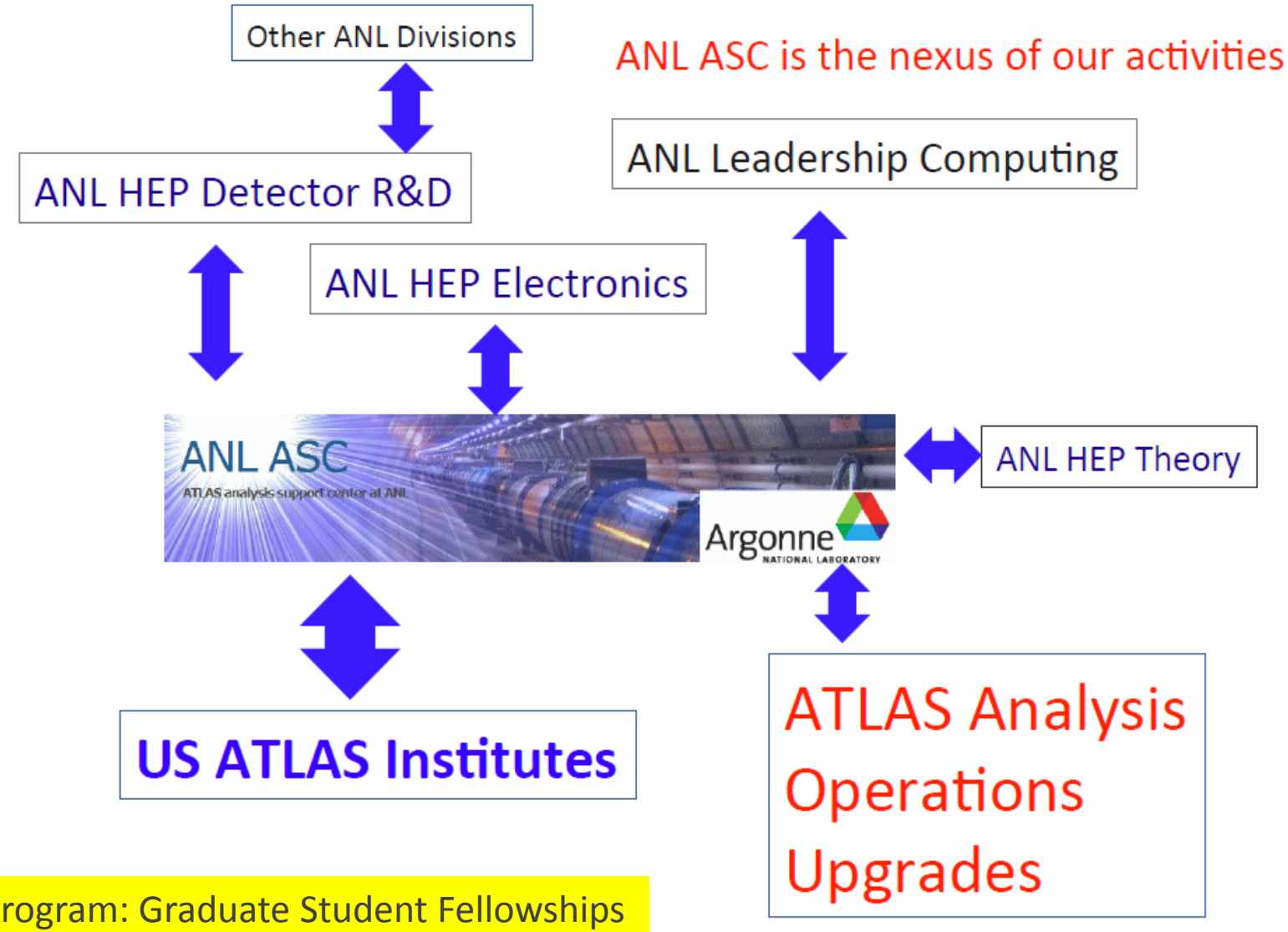
5 ANL staff on travel

7 long term visitors

Established cooperation with faculty/staff

- Chicago: Analysis, FTK, Upgrade R&D [Pilcher, Kim, Oreglia + students]
- MSU: Analysis and operations [Huston, Hauser + Students]
- Oklahoma: Analysis and Operations [Abbott + student]
- ISU: so far on analysis only [Chen + students]
- Duke: Tier3, physics analysis, upgrades [Goshaw, M. Kruse, Benjamin + students]
- NIU: Physics analysis, operations, upgrades [Chakraborty, Lima, Yurkewicz, Zutshi + students]
- Wisconsin: Physics analysis, operations [Mellado + students]

ANL Analysis Support Center Opportunities



Key program: Graduate Student Fellowships

ASC Opportunities translate into physics

Published Physics analysis :

- Soft QCD / Underlying Event (Chekanov, Proudfoot, Yoshida +.) Two Published Papers
- W->μ +Jets (Paramonov + *Johnson* with Martin + Huston from MSU +.) Two Published
- Jet Shapes for TeV scale particle searches (Chekanov, *Levy,* Proudfoot +.) Published
- Prompt photon/photon + Jet (Chekanov, Blair + Norberg from UOk +.) 1 Published + 1 in Ed Board process
- Jet inclusive cross section (Fullana , Salvachua, +)
- Compressed SUSY (LeCompte + Ngyuen with + S. Martin (NIU)) 1 Published + 2 in Process
- H-> WW (Feng +)

Active Analyses:

- Jet Substructure (Chekanov, Asquith, Proudfoot, Yoshida +.) 1 in Process
- Boosted Tops (Chekanov, Auerbach, Chen (ISU) , Proudfoot, Yoshida +.)
- TeV Scale Photons Chekanov, Norberg (U. Ok.) , Blair +.)
- Trilepton Searches (Paramonov, + Nyguen with Pilcher and Fiascaris (UC))
- Zγ (Auerbach, Blair, Chekanov, with Goshaw and students (Duke)) - initial motivation following discussions with Ian Low
- H-> γγ+Njet, bbar, $\tau^+\tau^-$ (Kruse + Mellado (U. Wisc) + Chekanov; Zhang, Asquith)
- Higgs spin, CP, Couplings, (Feng, LeCompte, Asquith +)
- W-prime (Love + Ho Ling (Chicago) + Huston, Tollefson + student (MSU))

See poster in 366 for more details on some of the ongoing physics research

ASC Opportunities translate into detector operations and upgrade R&D

Tier 3 Development

-> Key expertise [Yoshida, Chekanov, Benjamin - Duke]

- Developed solutions
- Deployed at 42 US Institutes

Tile Operations and Upgrade

ANL Expertise [Proudfoot, Chekanov, Nodulman, LeCompte, Ngyuen, Drake]

- Developed diagnostics for power supplies (Norberg –Oklahoma)
- Characterized power supply reliability (Mellado + engineering students from Wisconsin)
- Radiation damage analysis (Mellado + engineering students from Wisconsin)
- Signal reconstruction (Lima – NIU; A. Kruse – Wisconsin)

Tracker Firmware development

So far Benjamin and Zhou – Duke

- Exploring additional interests within ASC collaborators and at ANL

Detector Systems

Software And Computing

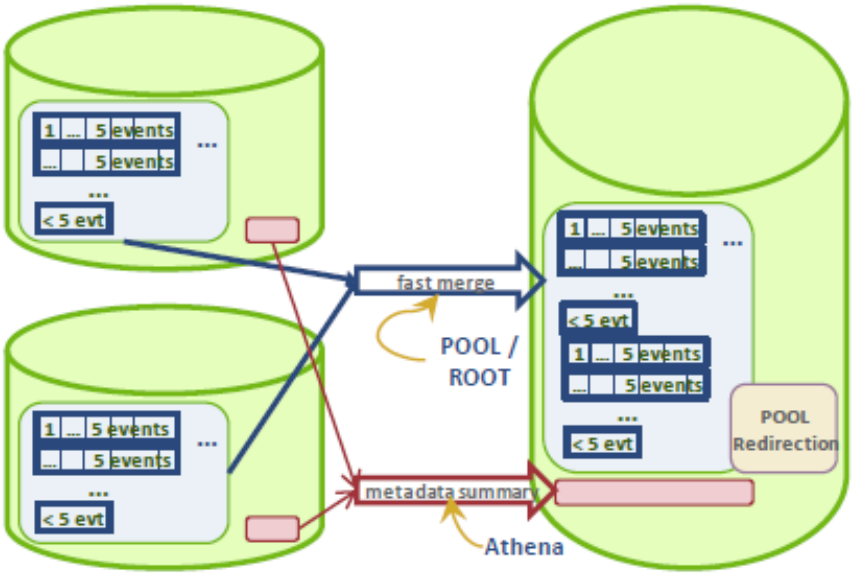
ANL Group holds lead responsibility in the international ATLAS collaboration for: Design, Implementation and Operation of a distributed data store and supporting infrastructure for the ATLAS experiment with more than 100 PB of data, including:

- Metadata and its integration from a variety of sources,
- Analysis I/O performance,
- I/O Framework and persistence,
- Event Reprocessing,
- integration of many of the above services with analysis tools.

Ongoing (recent) activity:
I/O Components for Parallel Event Processing

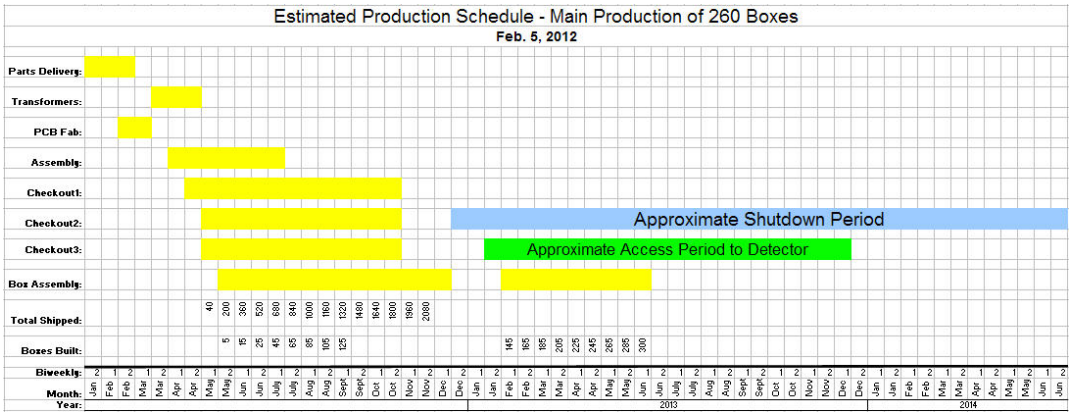
- Implemented extensions to the existing I/O framework to support the first implementation of a multi-core event processing framework

Next step will require dedicated parallel I/O components



Tile Calorimeter

Replacement LVPS Production



The production numbers as of 8/20 are:

1768/2080 logged in
1721/2080 tested
1375/2080 burned in
1230/2080 shipped
1 (dead) dog to date

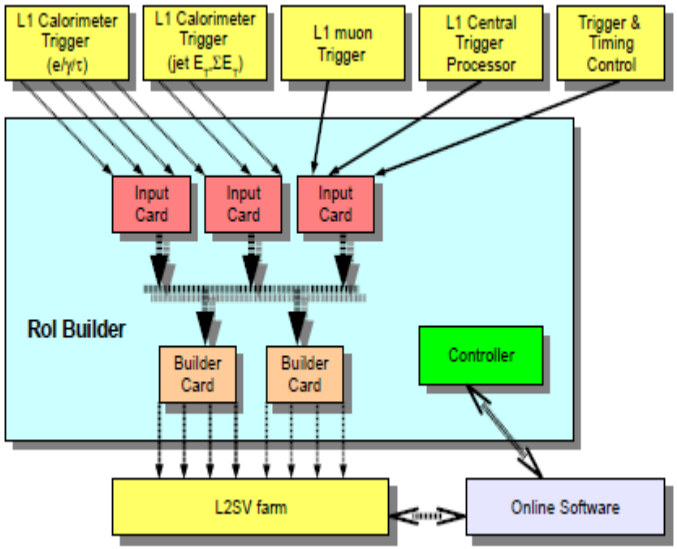
Testing done primarily by technicians from collaborating institutes:

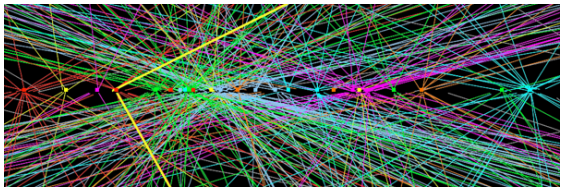
Vlastimil Zamaza, Prague June-July
Thomas Styk, Bratislava Aug-Sept
Deborah Capecchi, Pisa Aug-Sept
Luis Gurriana, LIP Oct-Nov

See poster in 366 for more details on brick production and testing, reliability studies and analysis, and radiation testing

Trigger and Data Acquisition System

Region of Interest Builder





Fast TracKer: Provide Offline quality tracks to HLT to improve triggering in high pile-up events

Data Rates @ $\mathcal{L}$ = 3E34

- 100 KHz max. trigger rate
- ~300 tracks/event
- 11 hits/track
- ~100 bytes/track + 40/event

⇨ ~3 GByte/Sec input rate

⇨ ~3 Gbps per Core Crate

Has Operated flawlessly for 8 years
Evaluating options for long term reliable operation:

- Maintain present system
- Develop software based RoIB to run on commodity pc
- Develop a hardware replacement (such as based on FLIC board)

Test bed at Argonne to develop readout board (FLIC).
Leading role in pre-prototype system at CERN (Vertical Slice)

See poster in 366 for more details

Upgrade R&D

Tilecal Upgrade demonstrator
- QIE
- Optical Modulators
- LVPS

TDAQ Upgrade -> “evolution”

FTK -> see poster
FTK Demonstrator (Vertical Slice)

Optical modulators as option to all of ATLAS (LHC)

Vertically Integrated Pattern Recognition Associative Memory (VIPRAM) for track trigger in Phase II upgrade

TileCal Demonstrator

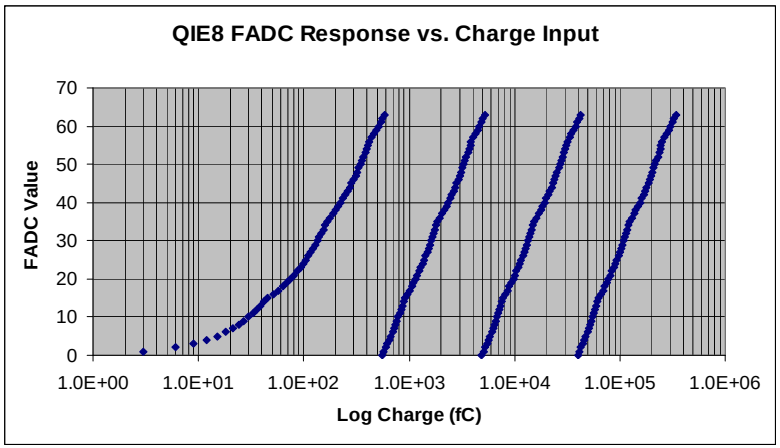
Run analog and digital systems in parallel

Development and testing ongoing

- Near-term target is functional test system in Bt175 in summer 2013
- Plan (hope) is to instrument one or two modules and run on detector in 2014

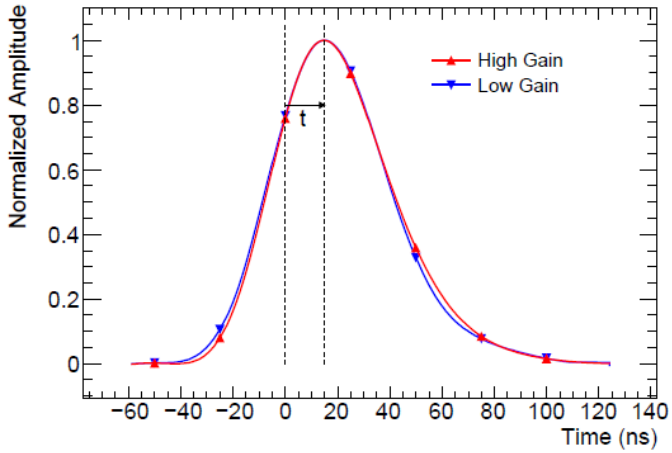
ANL Participation

- QIE option for front end readout (one of 3 options) - Collab. With Fermilab/CMS

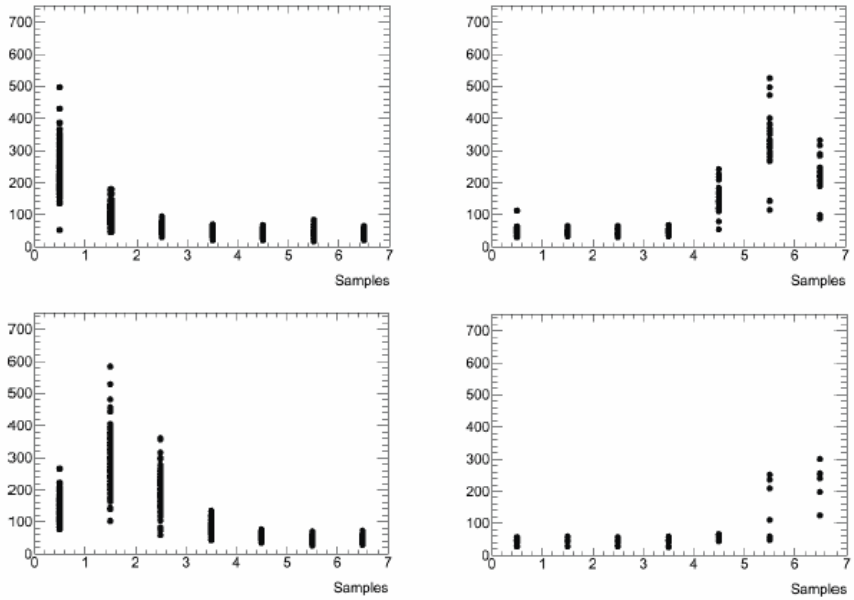


"Current Splitter" with gated integrator

Readout PMT charge in ~50ns (2 samples)



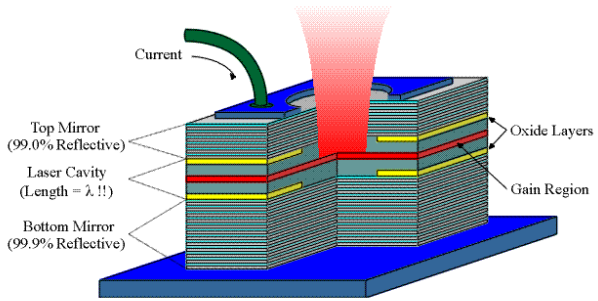
Baseline recovery over ~2μsec



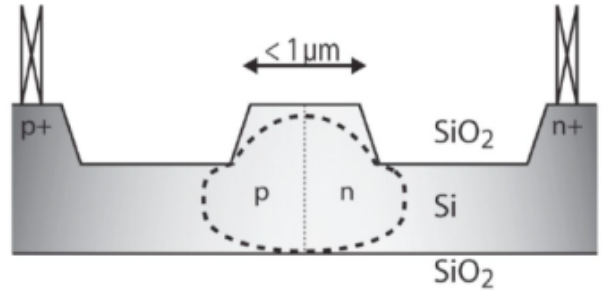
Sample waveforms for Tile Calorimeter

Optical Modulators

- Modulators are very simple and reliable. No known failure mechanisms



VCSEL



Photonic Si modulator

- Luxtera transceiver MTBF > 2.3 x 10^9 hrs (300 million device hours accumulated without a single intrinsic failure)
  - 1 device failure in TileCal >34 years (9 months running, 1024 transceivers)
- Tiny bit error rate (10^{-18}); low power; uses single mode fiber (i.e. cheap)
- We have coordinated with Stockholm group to include a Luxtera device on the link interface board for the demonstrator
- BUT we need more testing, radiation studies, and changes to micro-controller
- Hard going….. funding for this is presently through the generic R&D program

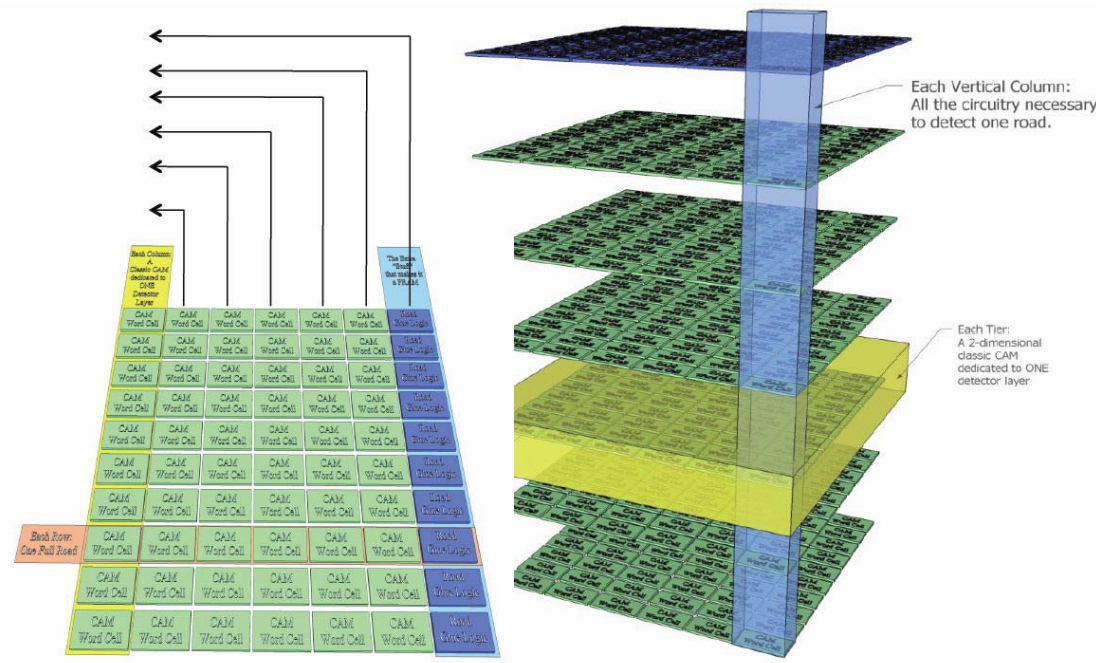
VIPRAM – Associative memory for Phase II Upgrade

R&D collaboration with Fermilab to develop high density, low power associative memory using 3D technology to provide for the ~ 1 billion patterns needed for an ATLAS track trigger in order to handle higher luminosity above 3×1034 cm-2s-1.

The first step will strictly be the design of the CAM cell and the Control logic.

The second step will produce a simple 2-Tier stack prototype with Control layer and CAM layer for initial testing. This prototype will examine the design of the main aspects of a 3D architecture.

The third step will be the production of a multi-tiered VIPRAM with at least three tiers (one Control layer and two or more CAM layers) to demonstrate the “proof-of-principle”.



Summary

Summary I: Past and Present

Research program underpinned by calorimeter: Jets and missing transverse energy

-> underlying event measurements using tracks and calorimeter energy clusters
-> Calorimeter energy clusters in measurement of jet shapes (QCD test)
-> SM tests of W + jets, γ + jets, Z($\nu\nu$)γ
-> Calorimeter clusters in variables used to study decays of boosted objects
-> tri-lepton analysis as a signature for SUSY
-> di-lepton analysis for Higgs-> WW*, di-photon for H->$\gamma\gamma$
-> Jets and EtMiss in searches for "compressed SUSY"

Analysis Support Center:

-> ~15 long--term visitors at any time. (22 total, 33 including undergrad interns)
-> Physics oriented. Strong collaboration with university groups
-> Many analysis teams at ANL ASC, physics papers and internal notes

R&D for detector upgrades:

-> established important roles in Phase 1 (FTK)
-> Optical modulators in TileCal
-> Planning R&D for Phase 2 upgrade (Modulators, VIPRAM)
-> Identified and began initial work on opportunities in software and computing

Summary II - Future

The next 3 years will bring exciting physics opportunities, more data-taking as well as a 2 year shutdown during which the machine will be readied for operation at 13 TeV.

The foundation for this research program has been established through the work done in 2009-11 and the expertise and leadership gained in this period. The Plan for the near future is:

- Study the properties of the Higgs-like boson (spin, CP, couplings to b's, τ's, $Z\gamma$, $\gamma\gamma$ etc.)
- Look for signals of physics beyond the Standard Model (SUSY, Boosted tops)
- Extend Standard Model physics studies
- The Argonne Analysis Support Center will a provide a focus for analysis efforts core software development and hardware activities for students during the long shutdown – expect a 20-30% increase in activities
- Complete construction, installation and commissioning of replacement LVPS for the tile calorimeter
- Continue core software development in support of multi-core cpu's, running GEANT4 on Blue Gene, ROOT I/O optimization
- Continue R&D in support of Phase 1 and Phase 2 upgrades (FTK, Tile Demonstrator, Modulators, VIPRAM)
- Contribute to re-commissioning of ATLAS and preparing for 13 TeV data