BNL Role in ATLAS Computing

DOE Annual HEP Program Review

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April 27, 2005

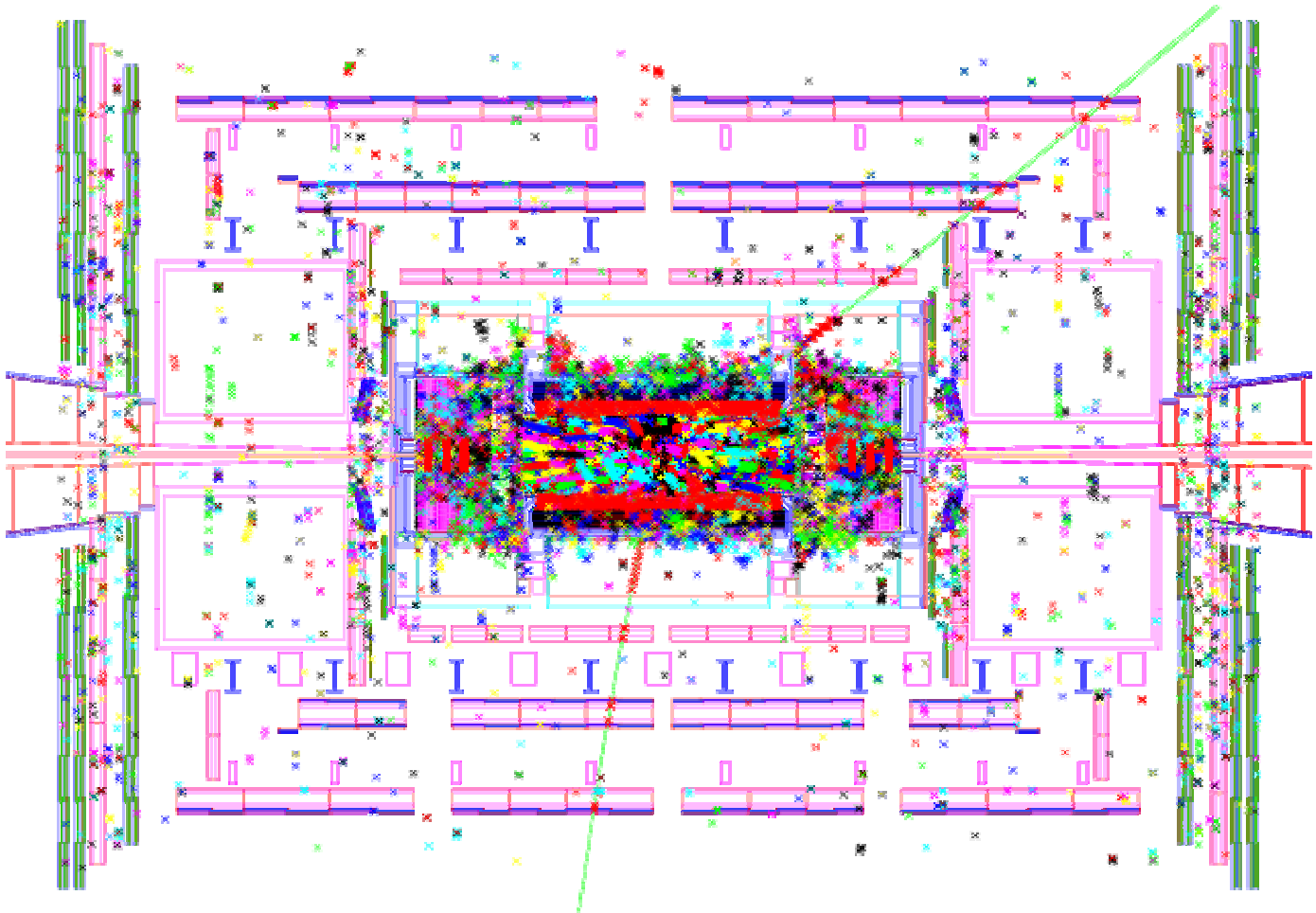
The timeline

- Physics TDR 1999
  - Based on Fast and G3 simulation
  - Migration to new C++ framework, reconstruction and G4 simulation since then
- Data Challenge 1 Exercise (G3 based): Completed 2003
- Data Challenge 2 Exercise (G4 based): Completed 2004
  - DC2 G4-simulation and digitization, Tier-0 exercise
- Combined Test-beam run 2004
  - Data taking completed in November. Analysis ongoing
- Rome Physics Workshop 6/2005
  - Simulation based on “initial-layout”, reconstruction & analysis
- Data Challenge 3 1/2006
- Commissioning 2005-06
  - Cosmic rays for some sub-systems should start Autumn-2005
- LHC turn-on (current official date) 7/2007

ATLAS early running conditions

- Low luminosity : 10^{33} (2.3 int./crossing)
  - Can expect considerably lower luminosities during first few months
  - Design luminosity: 10^{34} : (23 int/crossing)
- Initial layout: Some detector elements missing
- Staging based on physics priorities: Minimize impact on early discovery channels. Rome physics workshop to address the impact of staging.
  - Simulation based on initial-layout in progress
- Understanding the detector performance is key to our Day 1 success
  - What is the effect of "non perfect" performances on Day 1 on Physics.
  - How best to get the optimal performance out of the detector.
    - e.g. Strategy for EM & Hadronic calibration that need Physics
    - Muon calibration and alignment
    - Inner Detector performance
    - What can we realistically expect from the trigger

Looking for Interesting Events



Higgs → ZZ → 2e+2μ

23 min bias events

At BNL

- We are focusing on gaining the expertise in:
  - Core Software infrastructure
  - Calorimeter, Muons, Trigger sub-systems
  - Combined Reconstruction and Analysis Tools
  - With participation in Higgs, SUSY and Heavy Ions physics groups
- This wide range of expertise will allow us to :
  - Establish a critical mass of physicists to exploit the physics at LHC
  - Prepare for the Day 1 data taking scenarios → sub-system expertise
  - Help other U.S. ATLAS physicists to avail themselves of the BNL expertise and strengthen the overall U.S. ATLAS physics program

BNL personnel in analysis/software

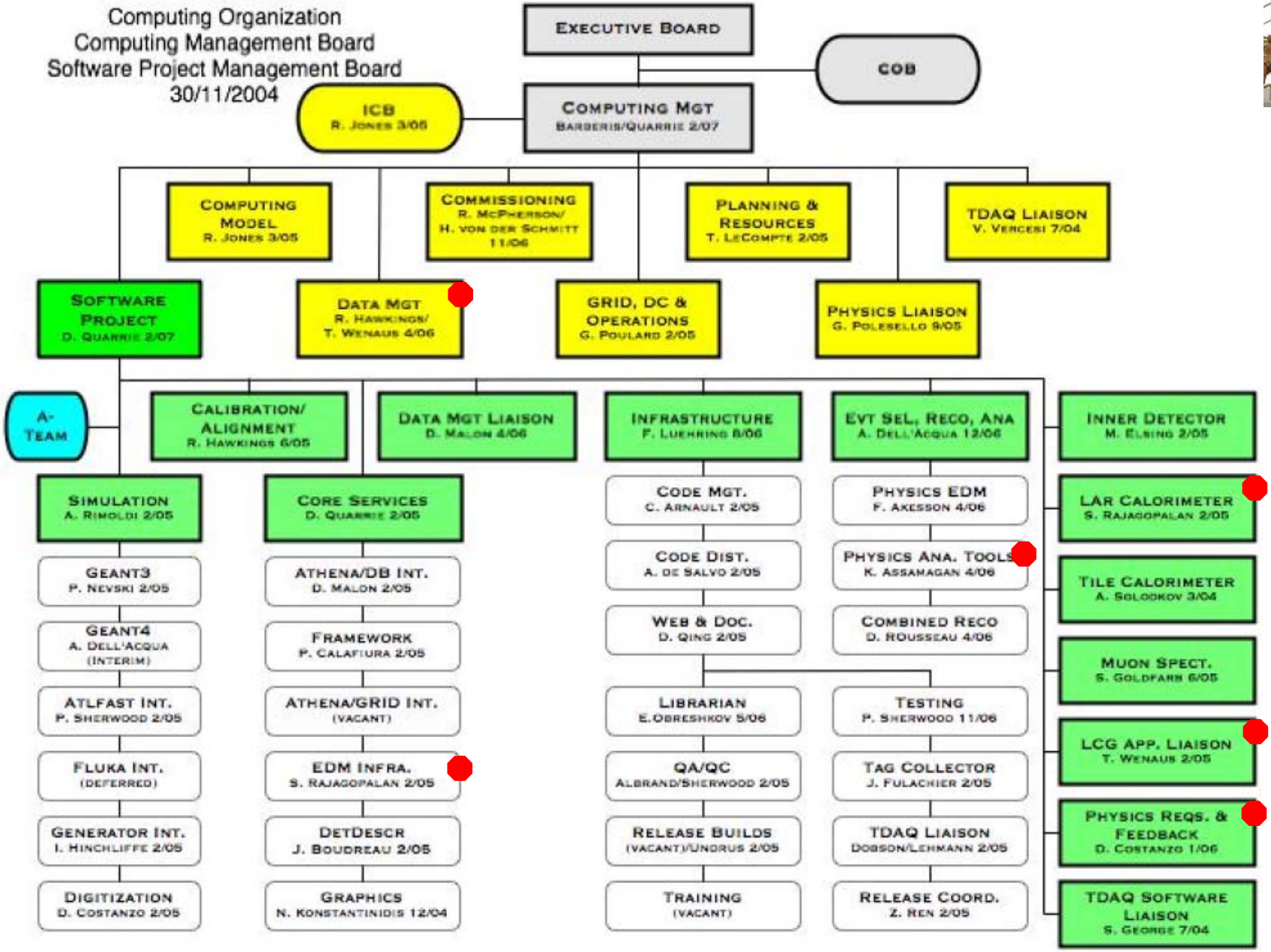
- Physics Analysis Support (PAS) Group:
  - Primarily engaged in core software development and data production
  - Headed by T. Wenaus + 7 FTE (current)
  - D. Adams, P. van Gemmeren, A. Undrus, P. Nevski, M. Nowak*, T. Maeno*, W. Deng (* hires in the past month)
  - Expecting A. Klimentov + an additional librarian person to join soon
- Theory Group
  - F. Paige: Jet calibration and SUSY analysis
- Omega Group
  - Primarily engaged in software development and analysis
  - S. Armstrong, K. Assamagan, D. Costanzo*, K. Cranmer*, H. Ma, S. Padhi, S. Rajagopalan, S. Snyder, H. Takai (* hires in the past 2 months)
  - 9 people (~7 FTE)
- Close interactions with the ATLAS Facility group

BNL people in ATLAS software/analysis leadership positions

- D. Adams — Distributed Analysis Coordinator
- S. Armstrong — Calorimeter Trigger Software coordinator
- K. Assamagan — Physics Analysis Tools coordinator
- D. Costanzo — ATLAS Physics Validation coordinator
- H. Ma — LAr Database coordinator
- F. Paige — SUSY physics co-coordinator
- S. Rajagopalan — Calorimeter performance co-coordinator
- H. Takai — Heavy Ions co-coordinator
- T. Wenaus — ATLAS Database co-Leader
  (LCG Applications Area coordinator until 3/2005)

- With representation in LAr Management, Physics Coordination, Software and Computing management boards

Computing Organization
Computing Management Board
Software Project Management Board
30/11/2004



Core Software activities

- BNL is primarily involved in developments of core software activities that are most crucial to effective physics analysis:
  - Software Infrastructure Support
    - A. Undrus
  - Database and Distributed Data Management
    - T. Wenaus, P. van Gemmeren, H. Ma, M. Nowak
    - R. Hackenburg, S. Kandasamy (LAr calorimeter specific)
  - Event Data Model Architecture
    - P. van Gemmeren, H. Ma, T. Maeno, S. Rajagopalan, S. Snyder
  - Physics Analysis Tools
    - K. Assamagan, K. Cranmer, T. Maeno, S. Snyder
  - Distributed Analysis Tools
    - D. Adams, T. Maeno
  - Data Production tools and validation

    D. Costanzo, W. Deng, P. Nevski + U.S. ATLAS Tier 1 facility group

Software Infrastructure Support

- Supporting ATLAS Software in U.S.:
  - Alex Undrus (BNL) serves as the U.S. ATLAS librarian
    - ATLAS software installation and support at the BNL Tier 1 facility for U.S. physicists.
    - Development of an automated nightly build system of ATLAS software (now also in use by CERN-ATLAS)
    - Member of the ATLAS Software Infrastructure team.
- Leading roles in US and international ATLAS offline data production
  - co-leadership of the activity, operations, quality assurance
  - P. Nevski, A. Undrus, W. Deng

Data Management

- ATLAS has successfully integrated the LCG (LHC Computing & Grid) POOL and SEAL developments.
  - ATLAS Event Data persistency established with POOL
  - Prototype for conditions data with relational POOL
  - T. Wenaus co-leads the ATLAS database effort
- Principal responsibility for Event data store core software development
  - Integrating the LCG products (POOL) with the ATLAS software
  - Total data saved to POOL for DC2 and Rome = 65 TB
  - P. van Gemmeren, H. Ma
- BNL also plays a major role in supporting database needs for the ATLAS Liquid Argon Calorimeter group
  - H. Ma, R. Hackenburg, S. Kandasamy

Physics Analysis Tools

- During the past year, reconstruction output have been classified and streamed (ESD & AOD streams)
  - ESD ~ 700 kB/event, AOD ~ 100 kB/event
  - ESD typically contain output of detector & combined reconstruction
  - AOD typically contain the output of particle identification
- A suite of physics analysis tools have been developed which allow generation of identified objects in AOD
  - K. Assamagan has been leading this effort at the ATLAS level with involvement from several other BNL colleagues.
  - These tools are now available to end physicists and being used for physics studies for the upcoming Rome physics workshop

Analysis Tools (2)

- 3-day Analysis Tools workshop in Tucson, April 6-9
- Several longer term issues discussed, including analysis models:
  - C++ analysis algorithms, analyzing AOD and writing out ROOT-tuples
    - Can be “plugged” into the ATLAS framework (Athena)
  - Python scripts that bind Athena and ROOT worlds together
    - Can be used to analyze ESD/AOD directly and make use of ROOT functionalties
    - T. Maeno and S. Snyder have developed many of these python tools
- Distributed analysis
  - D. Adams, T. Maeno
  - Provides a simple client interface for the distribution of end analysis jobs and collects all output for further examination
  - A first generation of this system has been developed
    - Integrating on and off-grid interactive physics analysis capability

Event Data Model Architecture

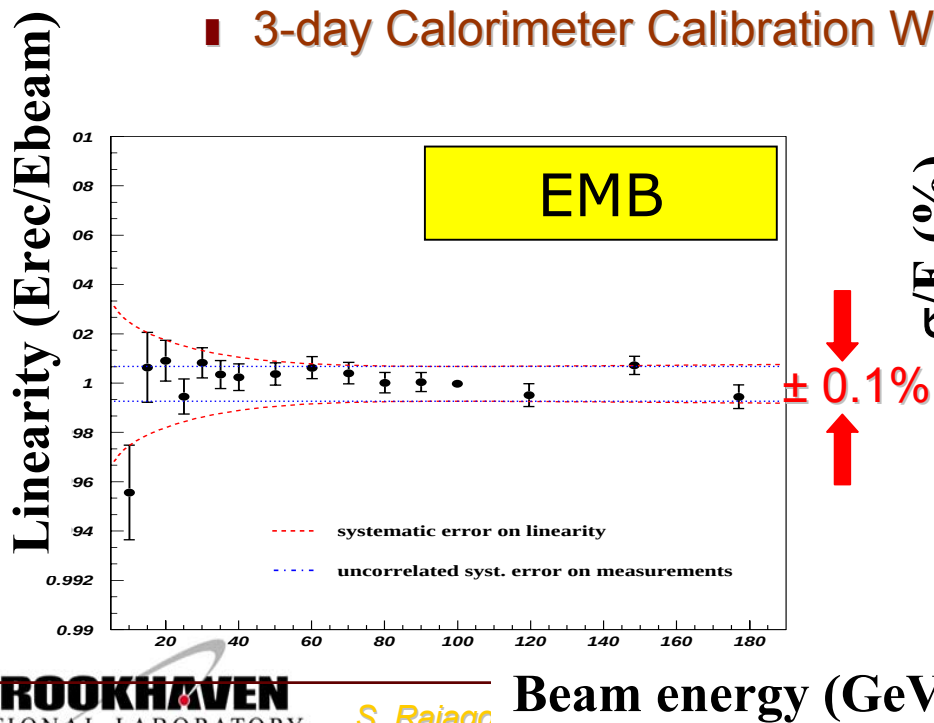
- Management of event data in transient memory
  - And necessary interfaces to persistency to support on-demand access.
  - Matured product in use by ATLAS
- Further requirements are being addressed
  - Arising from developments in Analysis Tools groups
  - And requirements coming from the High Level Trigger community
- Primary BNL people involved:
  - P. van Gemmeren, H. Ma, T. Maeno, S. Rajagopalan

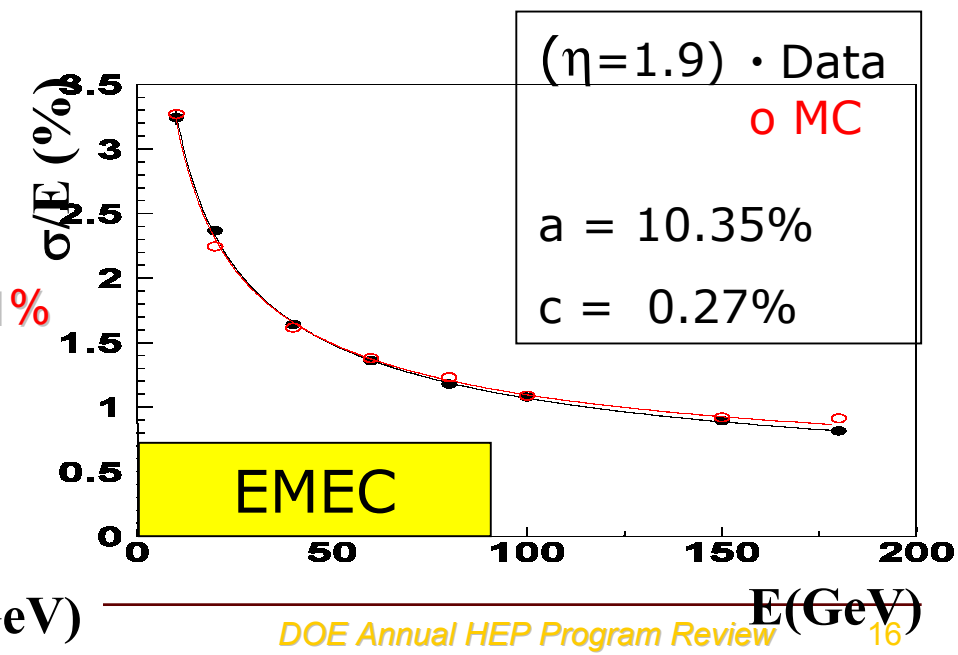
Calorimeter Software & Performance

- Major coordination responsibility in the Liquid Argon Group
- Calorimeter performance co-coordinator: S. Rajagopalan
  - Previously served as the LAr software & performance coordinator
  - New organization is “physics driven” bringing the test-beam, commissioning and performance groups together to drive software
- LAr Database coordinator : H. Ma
  - Includes providing database needs for “construction” project
- Calorimeter Trigger Software & Performance: S. Armstrong
  - Providing software needs for L1 (sim), L2 and Event Filter
  - And understanding their performance wrt to Calorimeter
  - BNL has formally joined the ATLAS TDAQ group

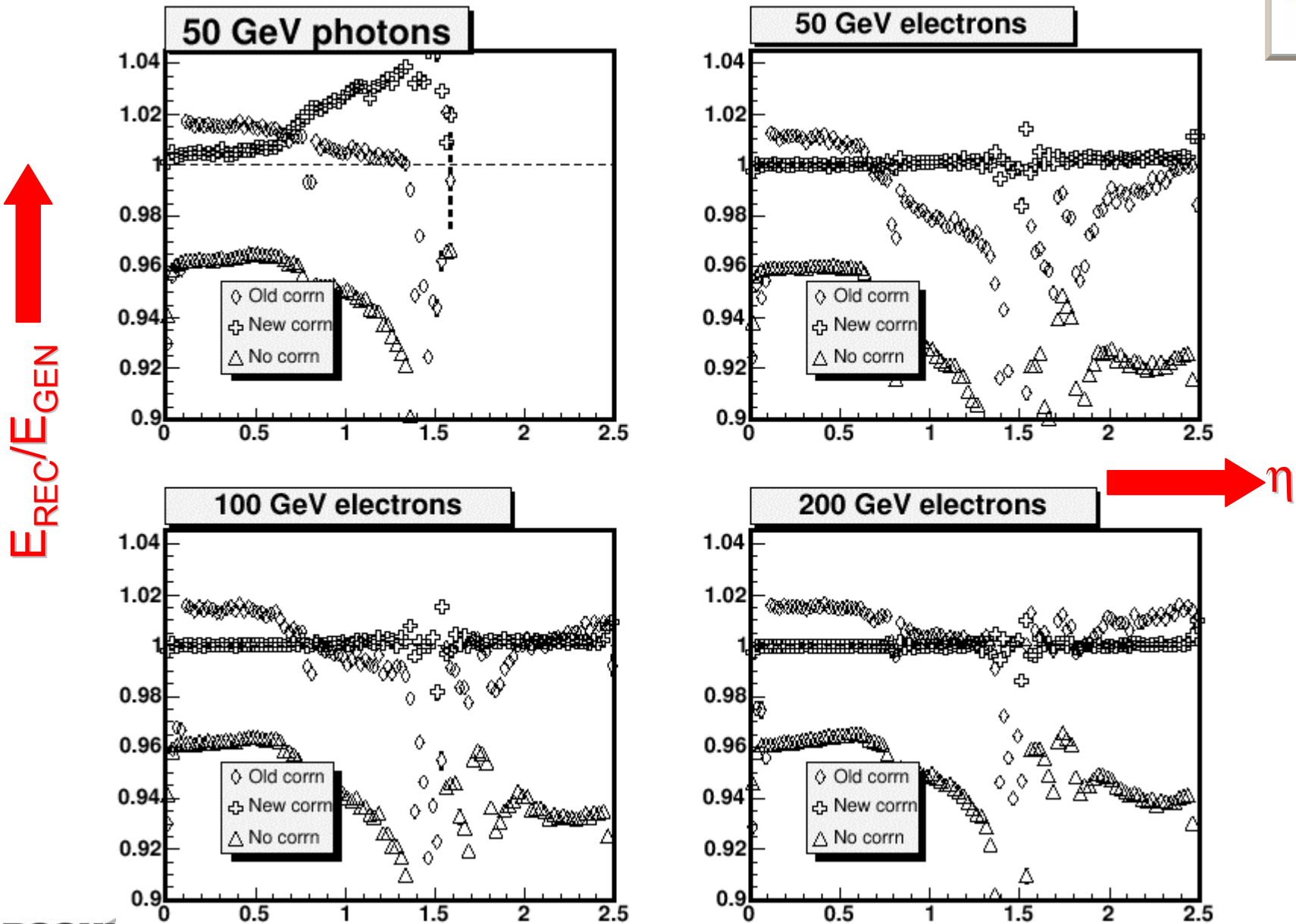
Calorimeter software & performance (2)

- Past year focused on the development of software tools for:
  - Combined Test-beam (concluded 11/04)
    - Analysis of test-beam data ongoing
  - Data Challenge activities and the Rome physics workshop
  - Optimization of calorimeter calibration
    - 3-day Calorimeter Calibration Workshop in Slovakia in December 2004





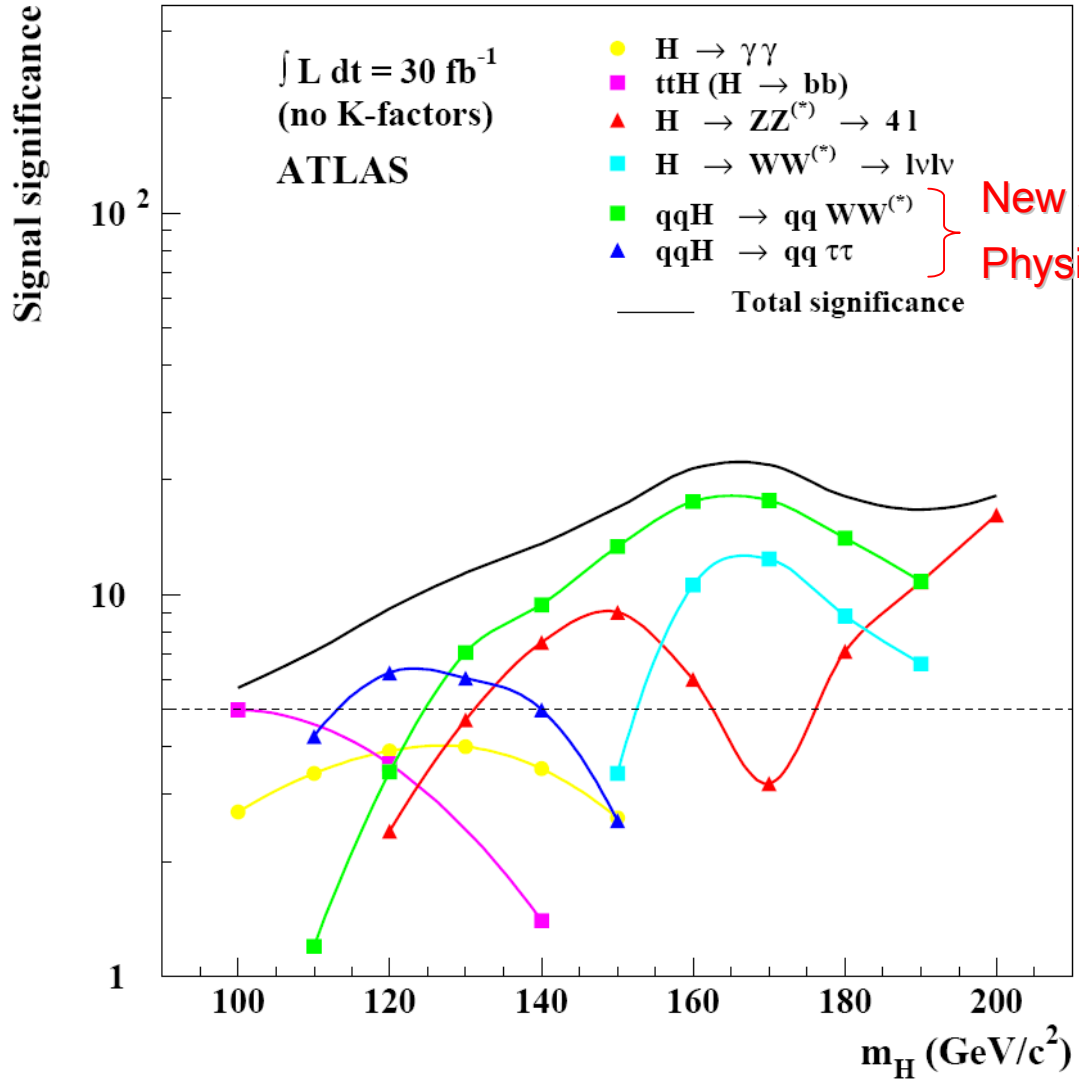
Effect of EM Cluster corrections derived with single G4 electrons (S. Snyder, BNL)



BNL participation in Performance and Physics

- BNL is primarily involved in:
  - Software Development & Performance studies of:
    - e-gamma identification (H. Ma, S. Rajagopalan, S. Snyder)
    - Hadronic calibration, jet identification (S. Padhi, F. Paige)
    - Missing ET and tau identification (K. Cranmer)
    - Muon identification (K. Assamagan, D. Costanzo)
    - Trigger Software & Performance (S. Armstrong, K. Cranmer, D. Damazio)
  - Physics Studies:
    - $Z \rightarrow ee$ (D. Damazio)
    - SUSY studies at co-annihilation point (D. Costanzo, F. Paige)
    - $H \rightarrow \tau\tau$ with forward jets (K. Cranmer)
    - $H \rightarrow ZZ^{(*)} \rightarrow ll\ \tau\tau$ (K. Assmagan, S. Snyder)
    - Charged Higgs studies (K. Assamagan)
    - Heavy Ions (H. Takai, P. Nevski)

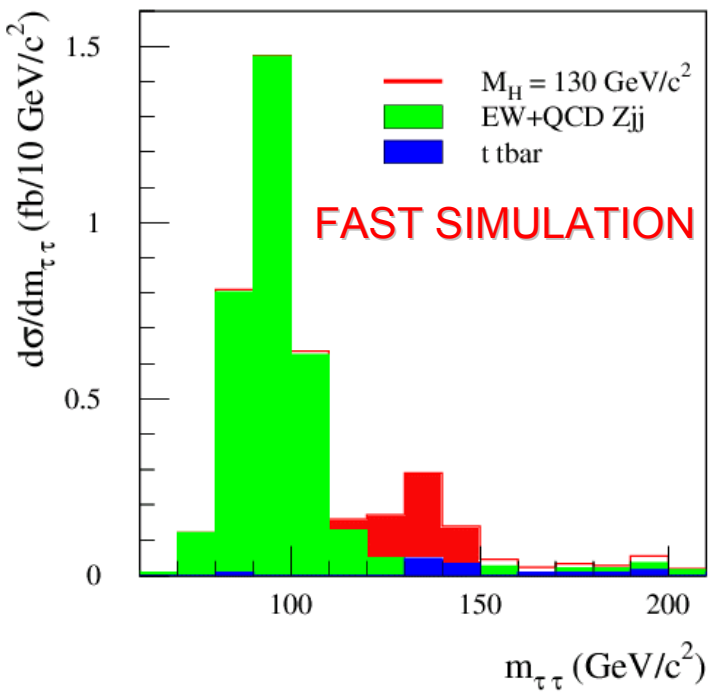
SM Higgs discovery potential

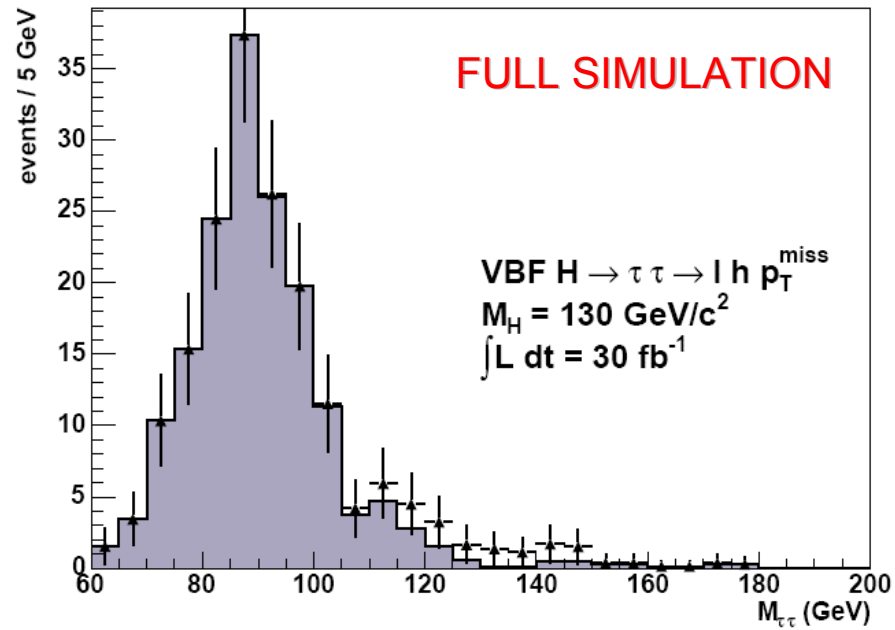


New studies since Physics TDR report

Contributions to studies of Higgs with forward jet tagging from K. Cranmer

H → ττ analysis with forward jet tagging





- 5σ significance for VBF H→ττ expected with 30 fb^{-1} (fast simulation)
- Studies with full simulation foretell smaller significance
  - → realistic tau efficiencies and Missing E_T resolutions
  - Cuts need to be re-optimized to reflect realism
  - Possibility to recover 30% more events which have unphysical solution
  - These are being investigated by K. Cranmer

ATLAS Commissioning

- Detector Commissioning begin later this year
  - Electronics calibration
  - Data taking with cosmic begin as early as November 2005
  - Integrated cosmic system test
  - Data taking with single beams (beam-gas, beam-halo)
- Computing System Commissioning
  - Full Software chain
  - Tier0 scaling
  - Calibration & Alignment
  - Full Trigger Chain, including monitoring
  - Distributed Data Management (T. Wenaus)
  - Physics Analysis (K. Assamagan/D. Adams)
  - Distributed Production
  - TDAQ/Offline full chain
- BNL (and U.S. ATLAS) must play a significant role in these activities

BNL supporting U.S. physicists

- Organization of U.S. (/Canada) level meetings
  - U.S. ATLAS meeting at BNL, 2003
  - North American Physics Meeting, Tucson, Az, December 2004
    - Focus on preparation for the Rome physics workshop
  - North American Meeting, Toronto, August 2005
    - Focus on upcoming ATLAS commissioning
- Formation of working support groups
  - Muons, E-gamma, JetEtMiss, SUSY, Exotics
  - These groups have met since face to face since Tucson meeting
  - Identified topics and associated people in U.S.
  - Many of these groups have regular phone meetings
    - Follow up on U.S. activities and ensuring that U.S. physicists are getting the help they need to make progress
    - Technical support, Facilitation of analysis activities of US physicists
    - Not intended to create a parallel structure to ATLAS organization

BNL supporting U.S. physicists (2)

- Hands-on tutorials:
  - Using ATLAS software and Analysis Tools at:
    - General U.S. level meetings
    - Visitations to U.S. institutions
    - Accommodating visitors at BNL for tutorials
- One on one discussions:
  - Help new people get involved or follow up help with software & analysis
- Helping U.S. physicists with access to Tier 1 resources:
  - Support with use of Tier 1 resources
  - Software support: Availability of latest software releases
  - Data Production
  - Documentation
- Critical mass with wide range of expertise to support this role essential

Institutes who have benefited from BNL help

- UT Arlington
- Duke
- Boston Area : Boston U, Brandeis, Harvard, U Mass, MIT, Tufts
- U. of Michigan
- Hampton
- Southern Methodist
- Stony Brook
- Columbia
- Iowa State University
- U. Arizona

Conclusion

- BNL is involved in key areas of ATLAS software development and physics analysis
  - Has and will continue to maintain leadership roles in U.S. and ATLAS computing
- With its Tier 1 resources, it is providing the software and analysis support for U.S. physicists
- BNL has the critical mass and resources to become a leading analysis center
  - Has already taken active steps to strengthen U.S. role in ATLAS physics and computing.
  - Must continue to build on its strength