ATLAS

Director's Review

November 2003

M. Gilchriese

ATLAS LBNL Group

J. Alonso, M. Barnett, A. Ciocio, A. Clark, **D. Costanzo**, *S. Dardin*, *A. Deisher,* **M. Dobbs**, K. Einsweiler, R. Ely, M. Garcia-Sciveres, M. Gilchriese, F. Goozen, C. Haber, J. Haller, I. Hinchliffe, **H.-C. Kaestli,** S. Lee, S. Loken, J. Lys, R. Madaras, *F. McCormack,* *J. Muelmenstaedt,* J. Richardson, **A. Saavedra**, M. Shapiro, J. Siegrist, G. Stavropoulos, G. Trilling, **S. Vahsen,** *J. Virzi,* *T. Weber, R. Witharm*

Physics Division and UC Berkeley

E. Anderssen, L. Blanquart, N. Hartman, *J. Hellmers*, *T. Johnson, D. Jones,* J. Joseph, E. Mandelli, G. Meddeler, *R. Post, R.Powers,* A. Smith, *C. Tran, J. Wirth, G. Zizka*

Engineering Division

P. Calafiura, W. Lavrijsen, C. Leggett, M. Marino, D. Quarrie

NERSC

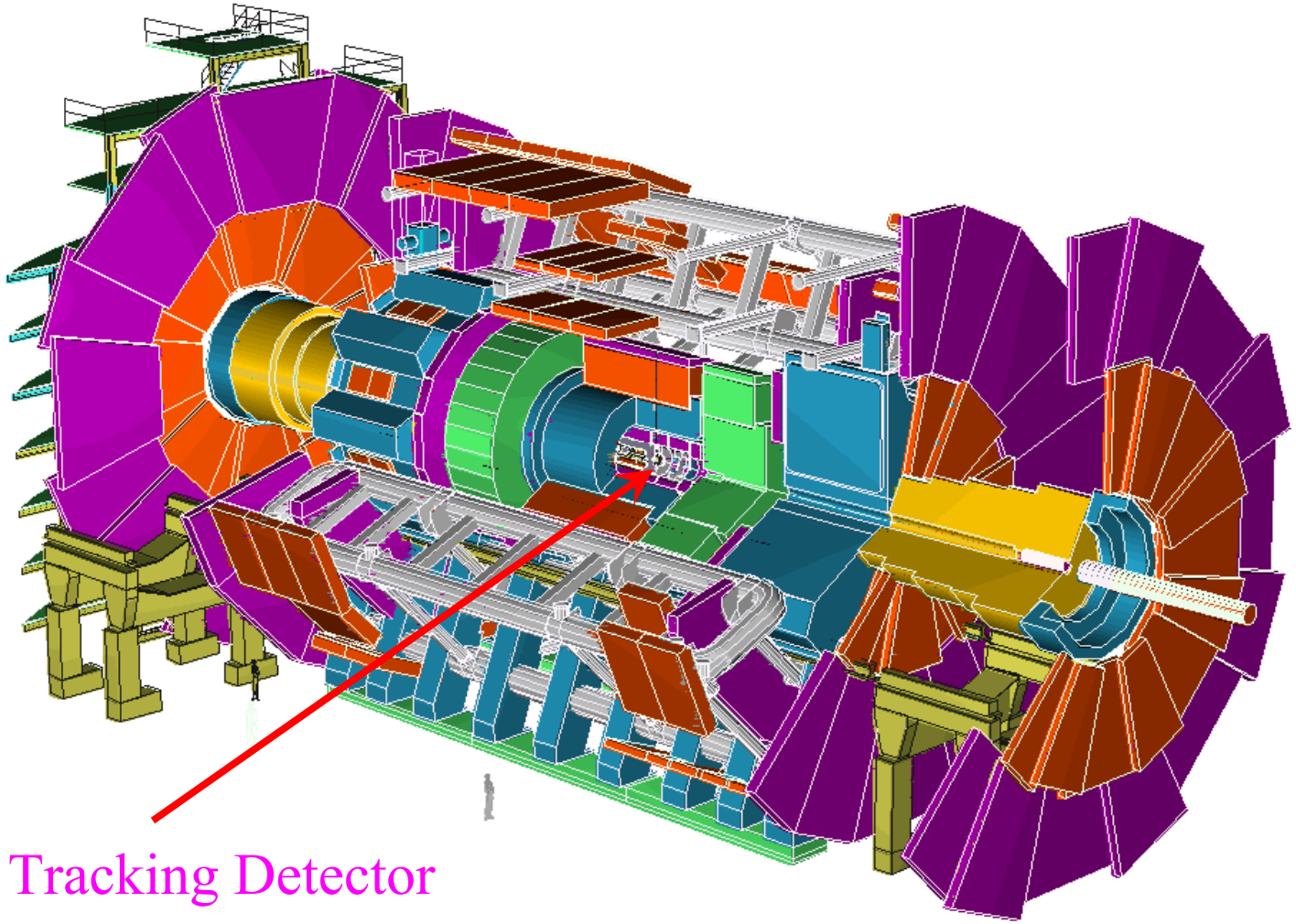
Physicist **Postdoc** *Grad Student* Undergraduate Engineer *Technician*

ATLAS Overview

- Production is complete or in progress for most ATLAS components.
- Underground installation has been underway for some months.
- The schedule continues to be tight, but it is feasible for ATLAS to be ready for first LHC beam as planned in 2007.

http://atlas.web.cern.ch/Atlas/TCOORD/Activities/TcOffice/Scheduling/Installation/UX15webcams.html

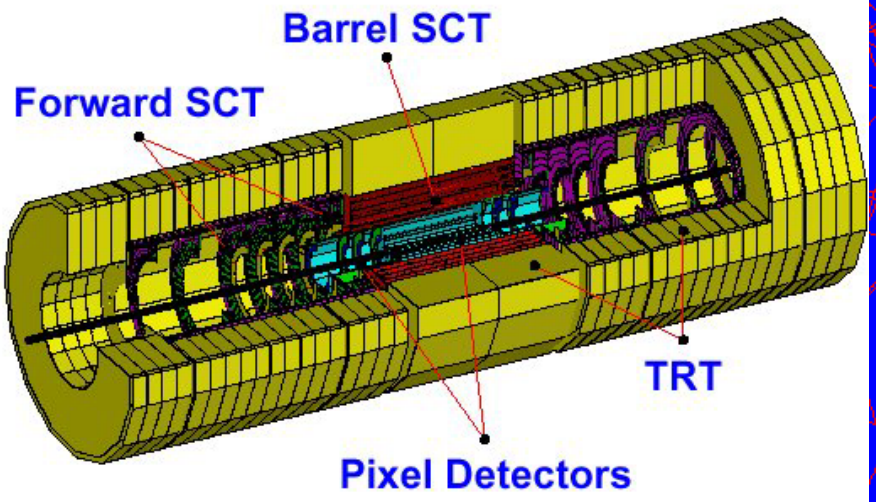
ATLAS Detector

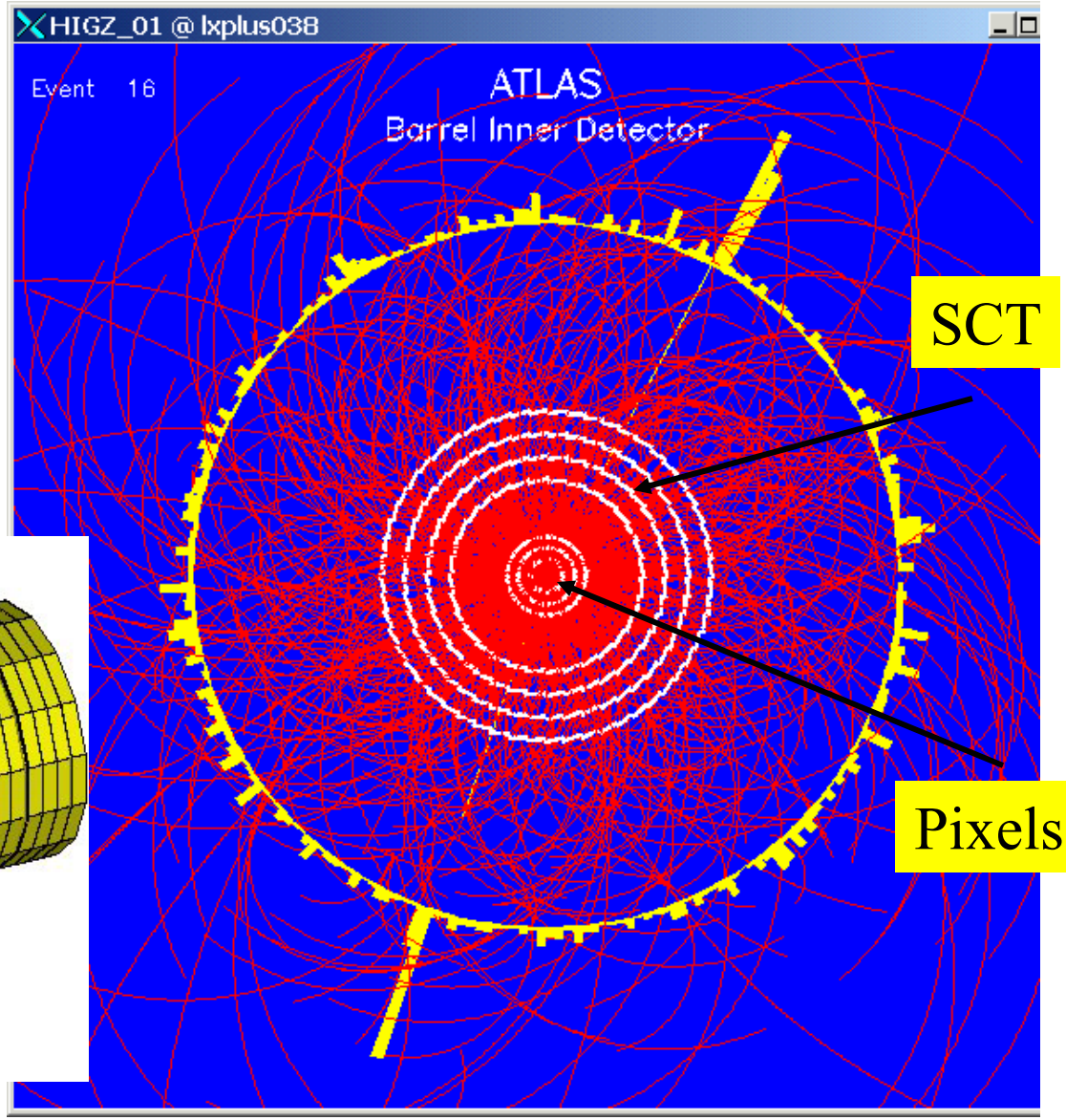


Inner Tracking Detector

ATLAS Tracking

- Silicon pixels
- Silicon strips(SCT)
- Straw tubes with transition radiation(TRT)

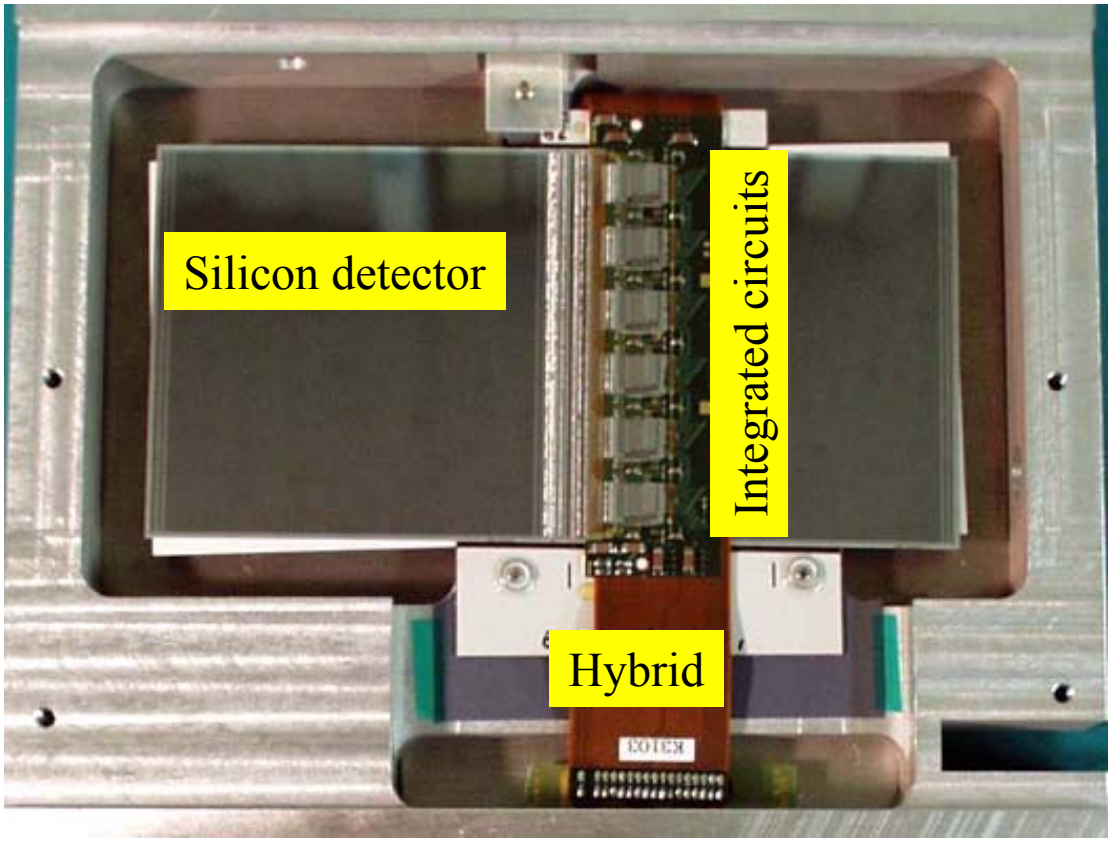




Silicon Strip Detector(SCT)

- About $6x10^6$ channels, $60m^2$
- Radiation hardness up to 10 MRad(roughly a decade at 10^{34} luminosity).
- About 4000 modules to be built world-wide.
- Production is well underway.
- Integration with mechanical structures, cables etc to begin in 2004

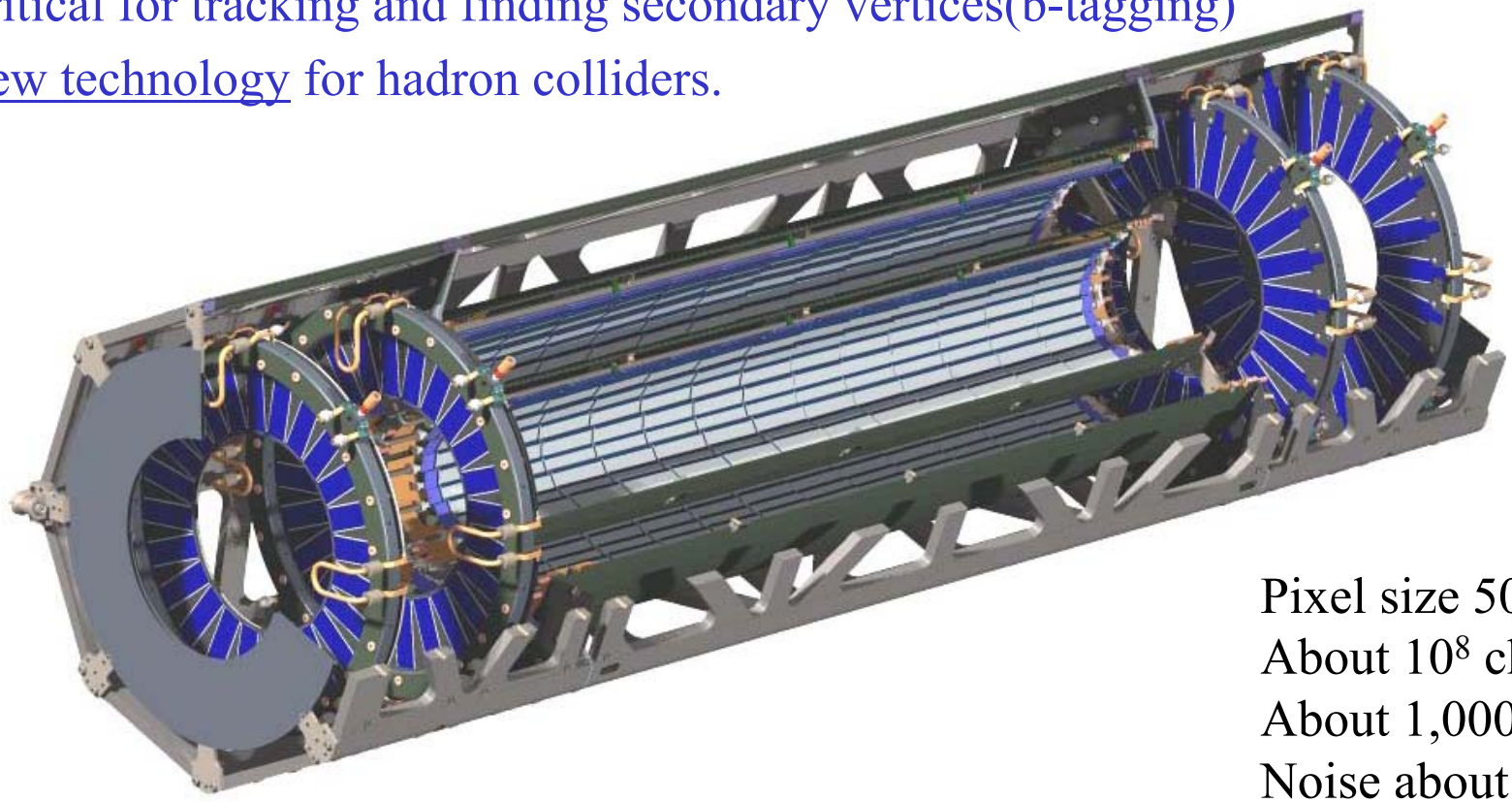
SCT Barrel Module



Strip pitch 80μ(barrel), 12cm long, noise about 1500e^-

Pixel Detector

- LHC radiation levels at $10^{34}cm^{-2}sec^{-1}$ prevent long-term operation of silicon strip detectors for R< 25 cm.
- Pixel detectors have much smaller cell size, lower capacitance and thus noise, that results in signal-to-noise(unirradiated) about 10 times better than silicon strip detectors..
- Critical for tracking and finding secondary vertices(b-tagging)
- New technology for hadron colliders.



Pixel size 50x400μ
About 10^8 channels
About 1,000 modules
Noise about $150e^-$

Current LBNL Roles in ATLAS

- Silicon strip detector
  - Test system for integrated circuits(ICs) completed and nearly all ICs tested.
  - Module production for barrel region is well underway.
  - Strong collaboration with UC Santa Cruz in ICs and module production.
  - All VME readout boards for SCT(and pixels) in collaboration with Wisconsin.
- Pixel detector
  - Leadership roles in electronics, modules and mechanics
  - Production complete or underway of mechanical supports, silicon detectors, ICs and hybrids
  - Module preproduction underway, final production about to begin
  - Collaborate with Albany, Iowa State, New Mexico, Ohio State, Oklahoma
- Software, computing and physics simulation
  - Lead role in the development of the Athena framework
  - Lead role in development and maintenance of physics simulation tools. U.S. Physics Coordinator.
  - Overall ATLAS software coordinator.

Highlights Since Last Review

- Most of the pixel detector components are in production or complete.
- In particular, the critical path item for the pixel detector, the front-end electronics, has been led by LBNL and is in production.
- About ½ of the silicon strip modules are started in the production pipeline and about 1/3 are done.
- The ATLAS software organization has been improved. D. Quarrie is the overall Software Project Leader.
- ATLAS has completed a significant data challenge DC1 and re-evaluation of the physics potential of ATLAS(Physics Workshop) in which LBNL had a major role.
- M. Barnett re-elected to be outreach co-coordinator for ATLAS.

SCT at LBNL

- LBNL designed and built custom, high-speed test systems for the SCT integrated circuits (ABCDs), about 1000 wafers. Nearly all of the ICs needed have been tested at Santa Cruz and RAL.
- LBNL is responsible in the US for module assembly and testing. We have mostly transferred the process of hybrid assembly/testing to Santa Cruz to speed up the production rate.
- Approximately ½ of the total modules to be be built(of about 500) are at the start of the production pipeline and about 1/3 have been completed. We are on track to finish by about July 2004.
- The SCT(and pixel) systems are read out using VME boards located about 100m from the experiment.
- The design work is largely done by LBNL engineering funded through the University of Wisconsin but there is also involvement of Physics Division staff.
- Prototypes of these boards have been tested and the final production is just about to start.

SCT Module Production and Testing

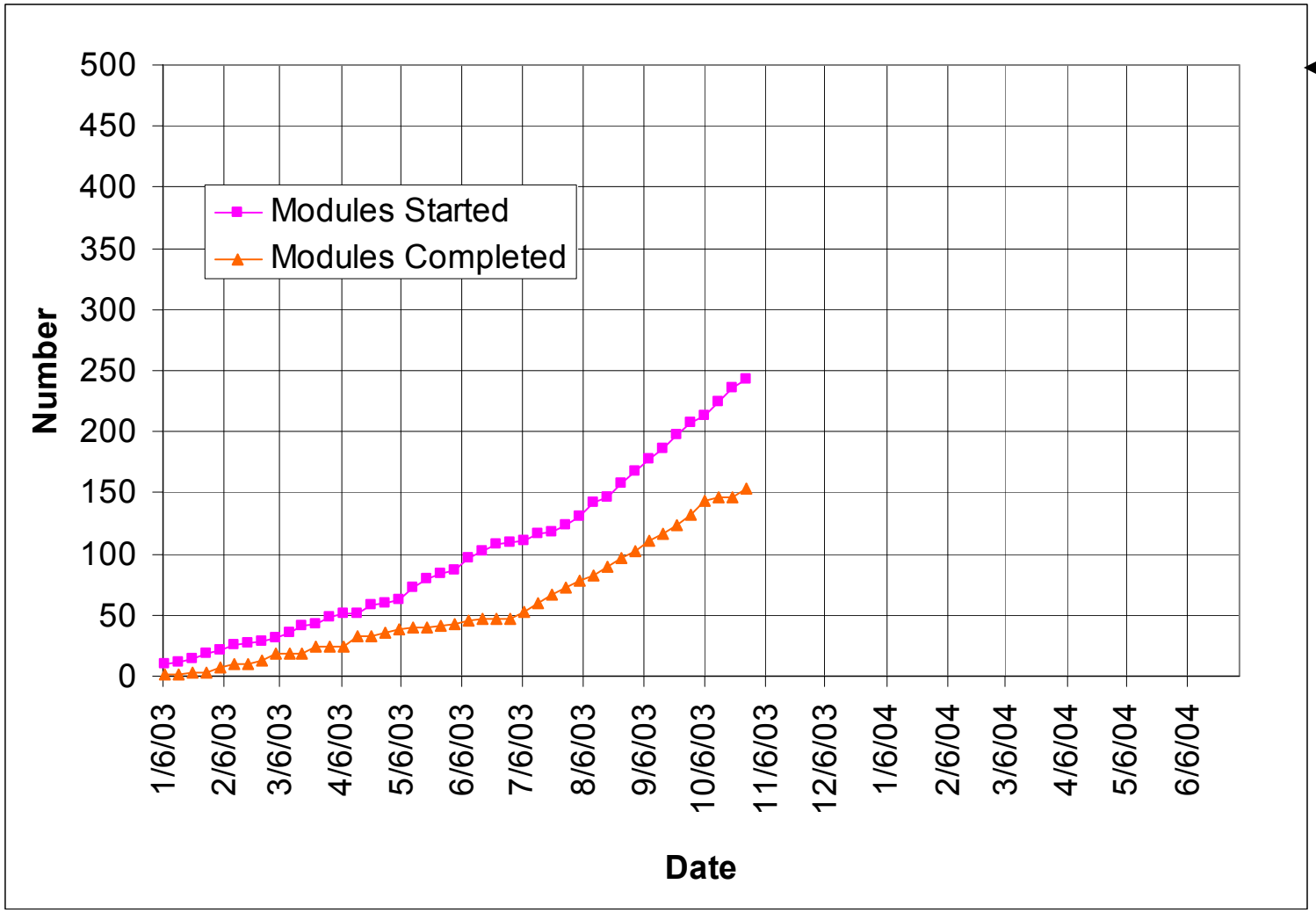
Wire Bonding

The Crew

Module Metrology

Electrical Testing

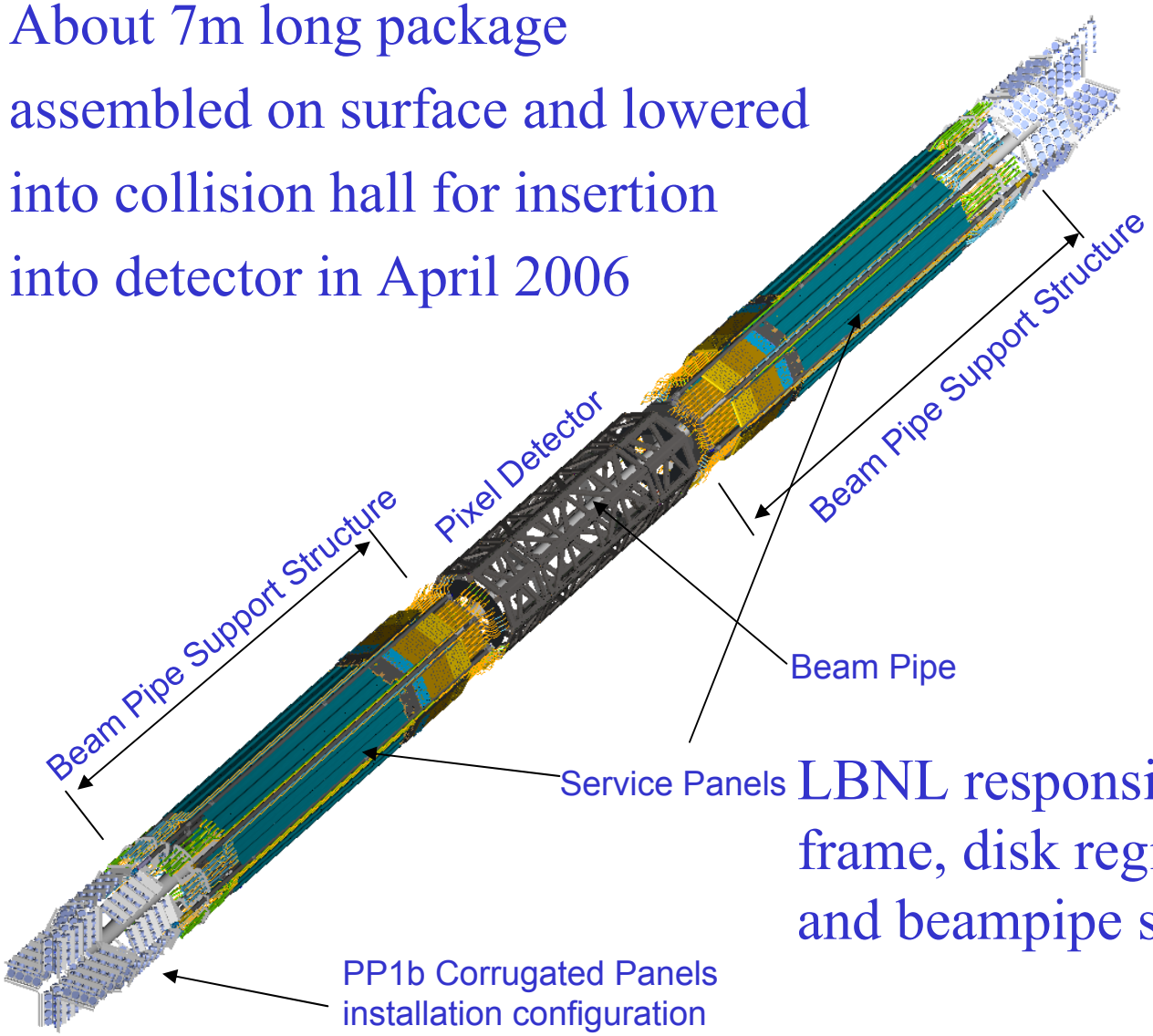
SCT Module Production



GOAL

Pixel and Beam Pipe Assembly

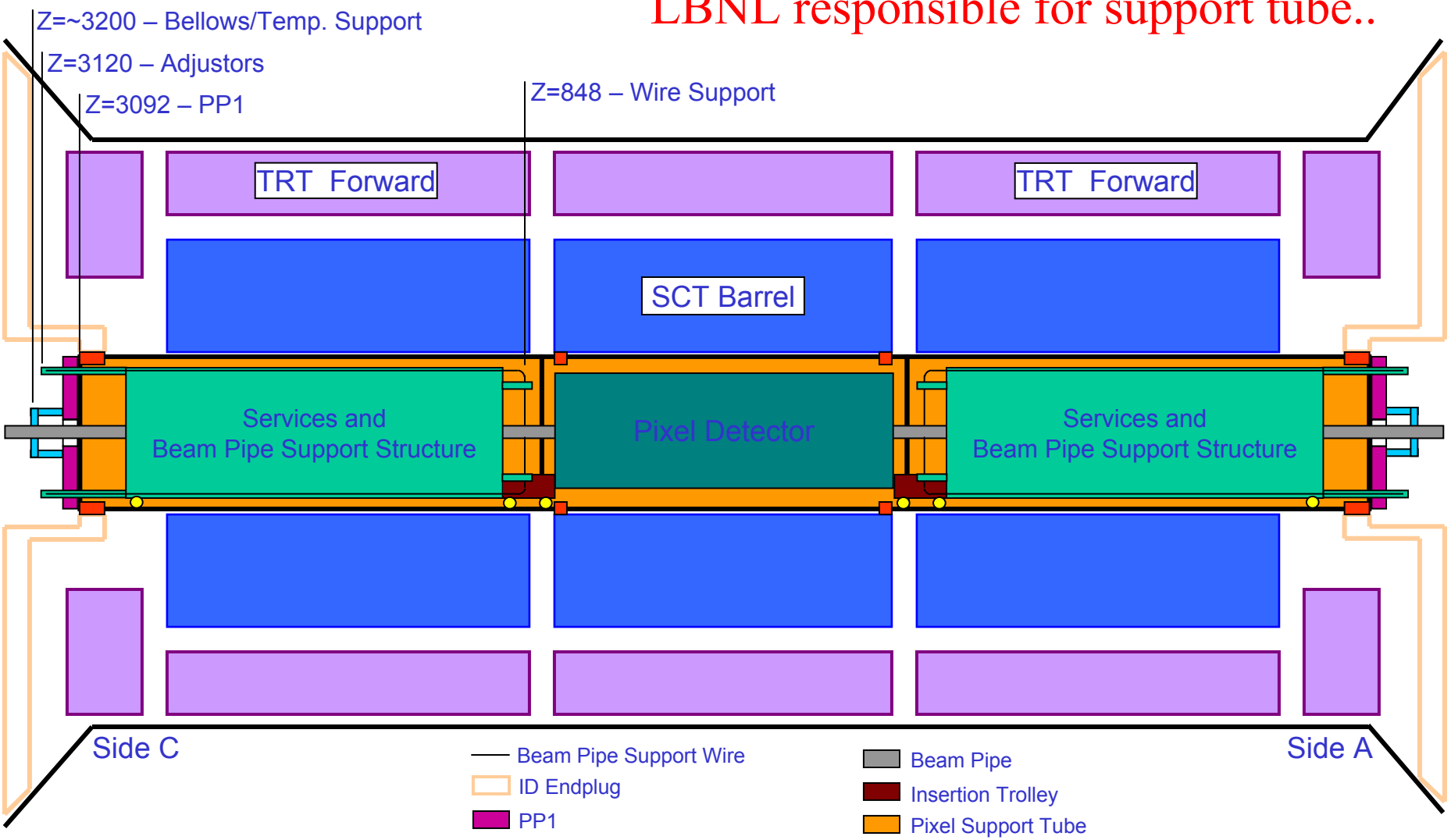
About 7m long package
assembled on surface and lowered
into collision hall for insertion
into detector in April 2006



LBNL responsible for support frame, disk region, service panels and beampipe support structures

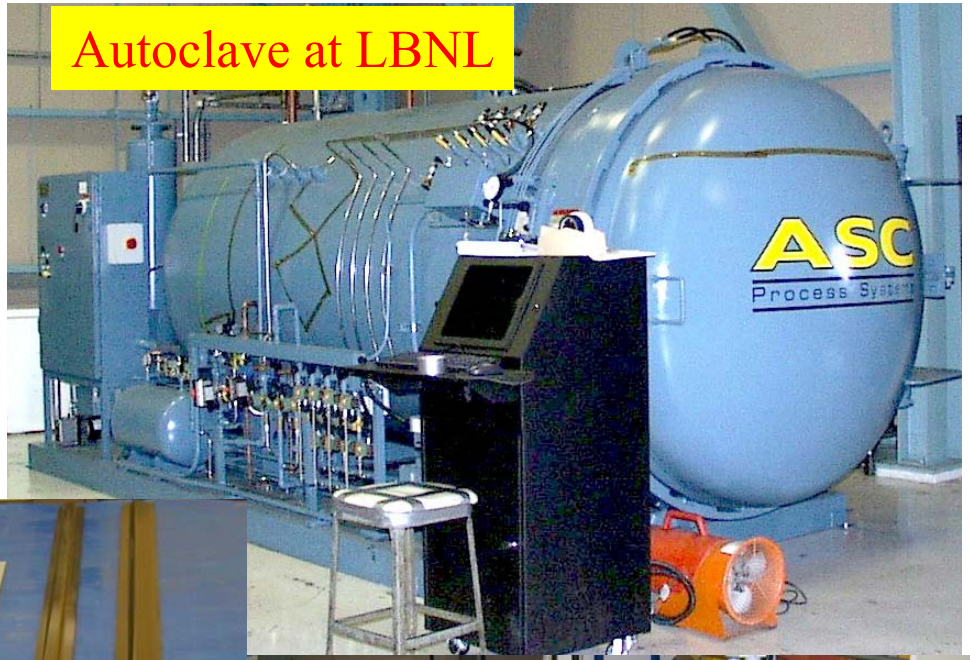
Pixels and Inner Detector

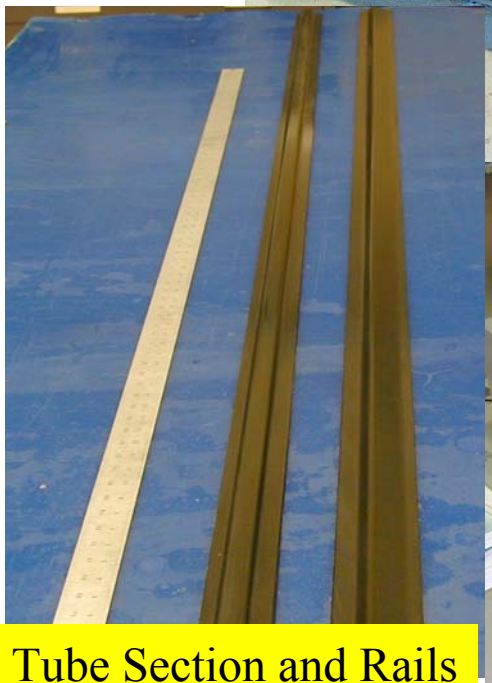
LBNL responsible for support tube..



Composite Structures

- We have developed the capability to make custom composite structures and production is underway.
- Combined thermal, structural and electrical properties to meet the pixel needs.





Prototype Support Tube Section and Rails

Ply Cutter at LBNL

Support/Cooling Structures

Disk Support Rings

Global Support Frame

Disk Module Support/Cooling

New cleanroom provided via Lab infrastructure/bldg renovations will be used for final assembly

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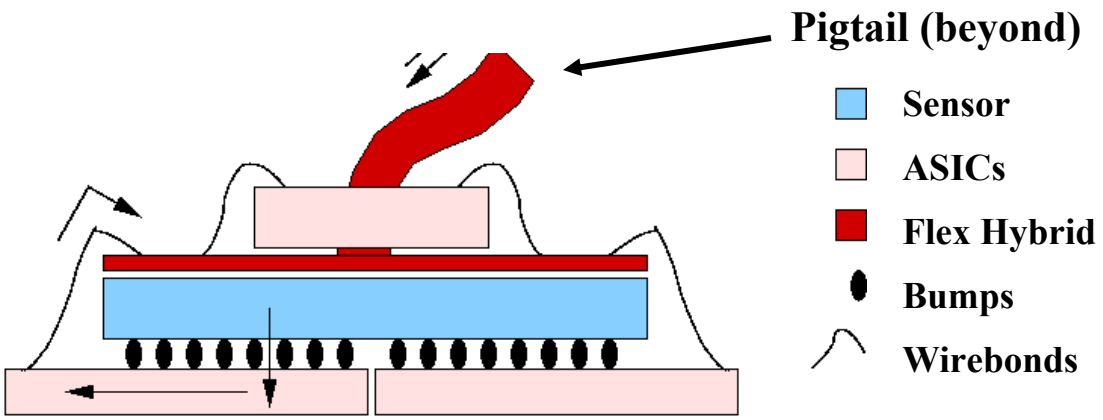
Pixel Hybrids and Modules

- M. Garcia-Sciveres from LBNL is the overall ATLAS module coordinator.



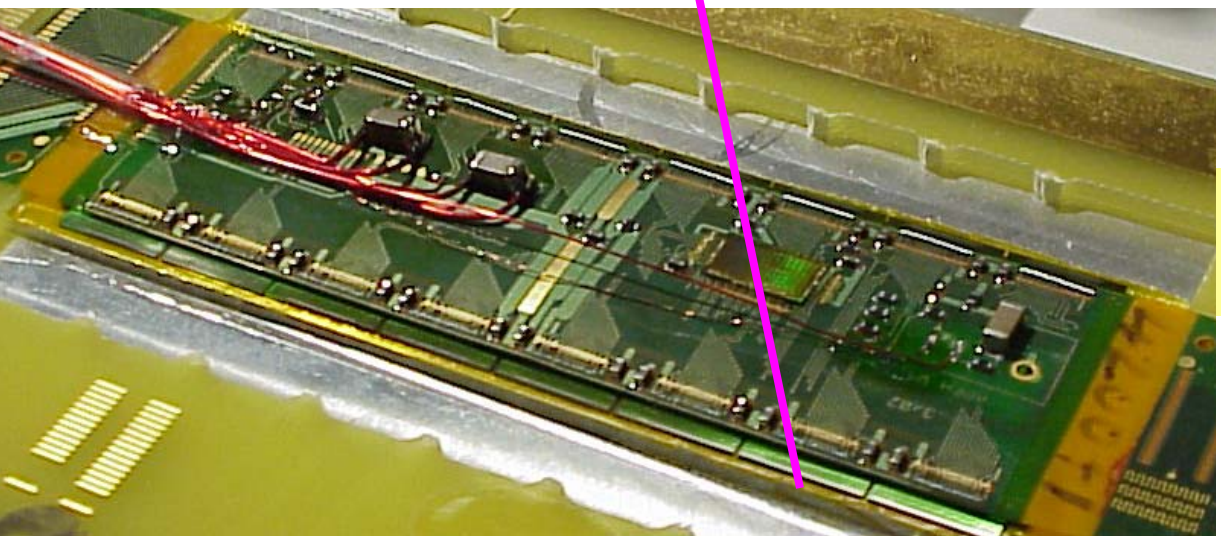
Schematic Cross Section
(through here)

About ½ of sensors(detectors) have been produced.

About 1000 flex hybrids made

About 250 modules(25%) to be assembled at LBNL

Preproduction has started



Electrical ⇔ optical conversion at end of pigtail

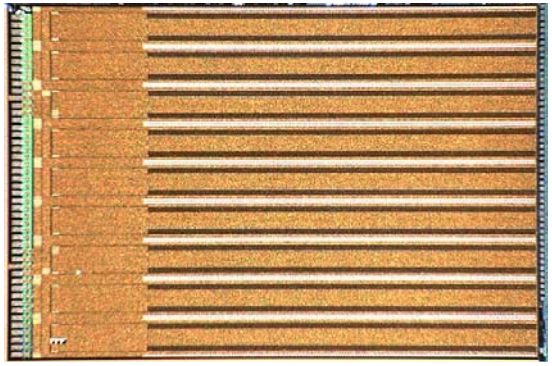
Pixel Electronics

- K. Einsweiler is the overall ATLAS pixel electronics coordinator.
- The strong LBNL IC group has allowed us to lead the pixel electronics effort, in particular the design of the front-end chip that is on the critical path for the project.
- In addition, we are responsible for providing most of the IC and all of the module tests systems for the collaboration, and these have also been designed and implemented by LBNL.
- The pixel ICs designs has been extensively validated by laboratory, irradiation and beam tests over the last two years.
- LBNL has led the way to show that pixel technology will work at the LHC.

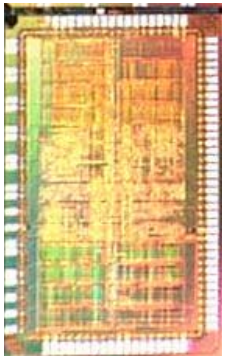
Pixel Integrated Circuits

- Fabrication of the module control chip and optical ICs is complete and testing underway. Final production quantities available.
- Iterations of front-end chip(FE-I2 and FE-I2.1) since last year. Irradiation and beam test validation -> production version, FE-I3.
- Production of FE-I3 in progress and first wafers will be delivered in about two weeks with more to follow next year.

Front End Chip
2880 channels



Module Control Chip
Manages data & control between module's 16 chips



Optical interface chips

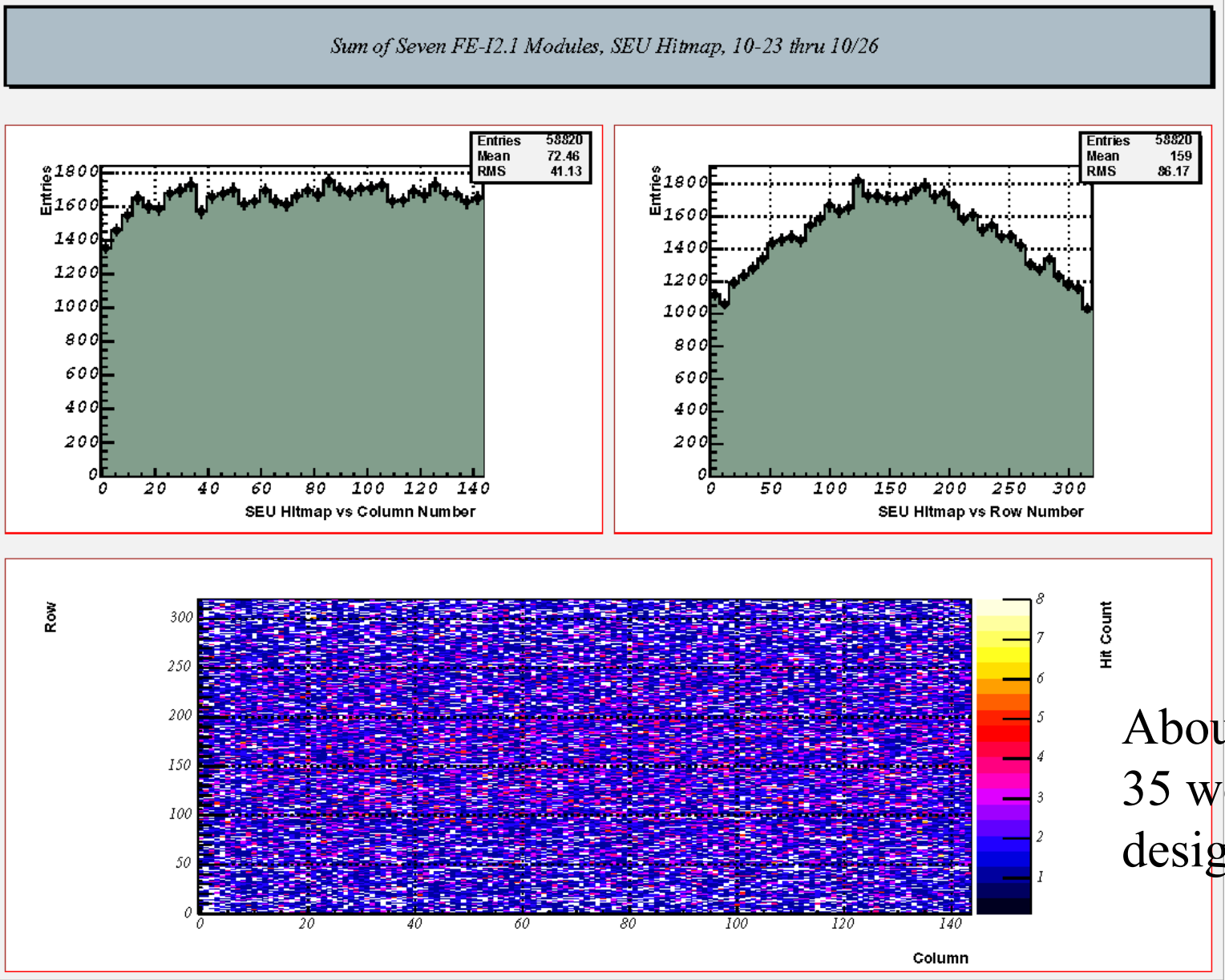
Doric
(from PIN diode to decoded LVDS)

VDC array
(from LVDS to laser diodes)

2003 Irradiations and Beam Tests

When	Type	
May	Irradiation	7 FE-I1 modules. Average of 1.1×10^{15} protons, 30 MRad.
May	Test Beam	Un-irradiated FE-I1 modules with high statistics.
July	Irradiation	6 FE-I2 chips and 4 MCC-I2 chips to 60 MRad.
July	Test Beam	Irradiated FE-I1 modules. Beam problems.
August	Test Beam	Irradiated FE-I1 modules.
September	Test Beam	FE-I2 modules at high intensity, 3×10^7 pions/cm^2-sec, about innermost layer at design luminosity
October	Irradiation	7 FE-I2.1 modules to about 2×10^{15}or 55 MRad. Intensity about 1×10^{14} p/cm^2-hr. Online results good.
November	Irradiation	1-2 modules, fast extract of $10^{10} - 10^{11}$ protons/cm^2 in two 42 ns. bunches separated by 250 ns.

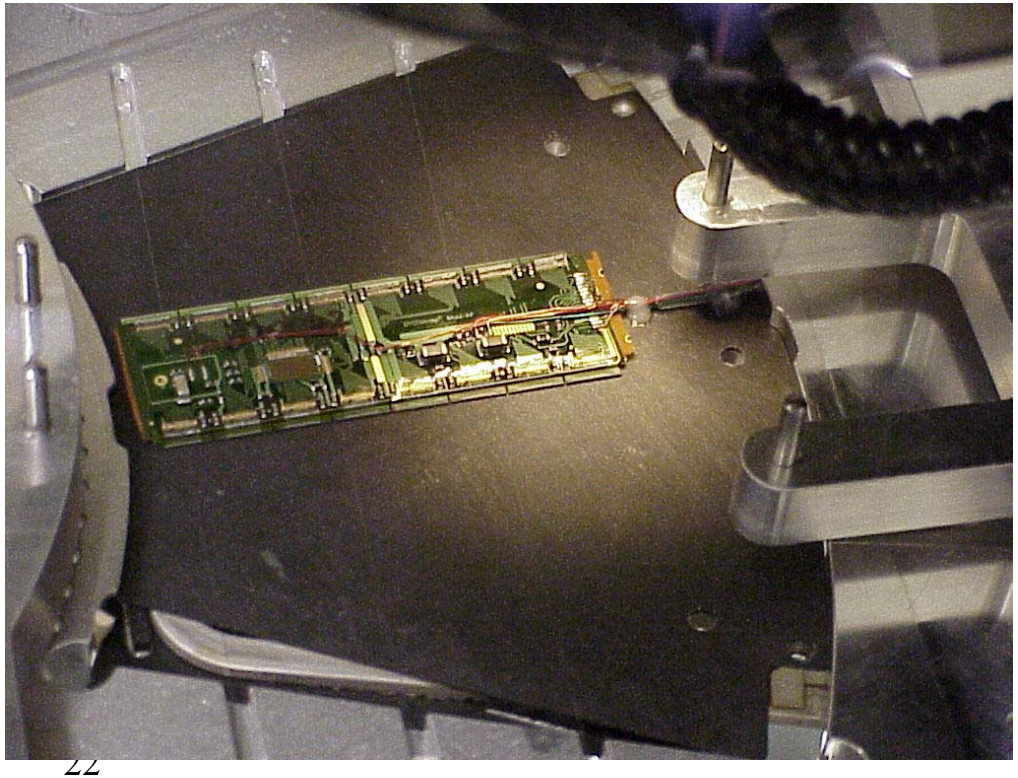
Example – Single Event Upset(SEU)

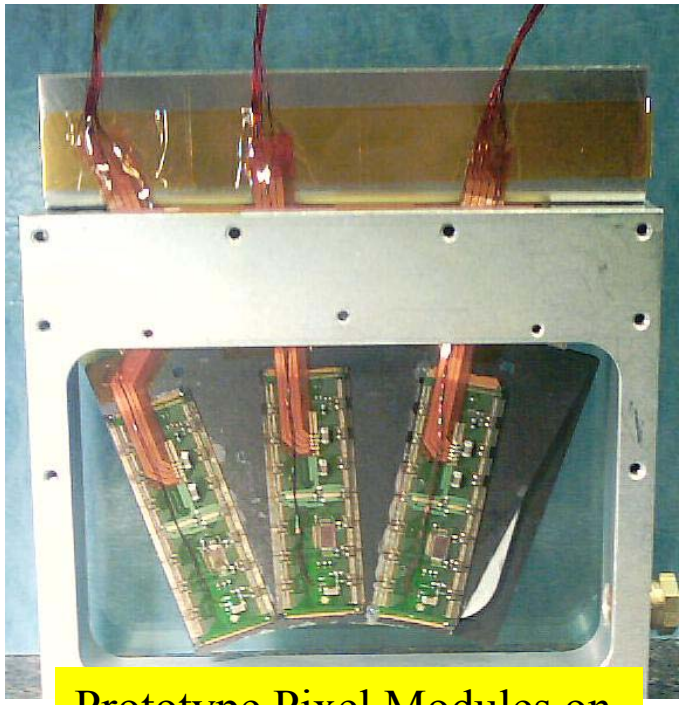


About = to 35 weeks at design L

Module Production

- Assembly and testing of modules using the preproduction front-end IC(FE-2.1) is underway at LBNL(and in Europe).
- Module mounting on support/cooling structures just underway at LBNL in pre-production mode to be ready for FE-I3 modules.





Prototype Pixel Modules on Support/Cooling Structure

ATLAS Software

- ATLAS has completed two phases of significant data challenges(DC0 and DC1) to exercise the simulation, reconstruction and analysis codes and the computing infrastructure.
- Major software re-organization about one year ago, D. Quarrie from LBNL now resident at CERN as Software Project Leader
  - Leads the developments of ATLAS software, as the Chief Architect of the Software Project.
  - Is member of the ATLAS Executive Board.
  - Participates in the LCG Architects Forum and other LCG activities.
  - Chairs the Software Project Management Board and the Architecture Team.
- The U.S. currently provides about ½ of the core software engineering, and LBNL about 1/3 of the U.S. effort.
- Although ATLAS is estimated to be short by a factor of about two in the number of software engineers, LBNL staff in this area has been reduced by 1 FTE in FY04 from lack of funds.
- The next major milestone is Data Challenge 2 to occur Spring-Summer 2004

Software/Simulation Team

- Software Project Leader (Quarrie)
- Physics Generators Coordinator (Hinchliffe)
  - U.S. ATLAS Physics Coordinator and overall Deputy Physics Coordinator
- Physics Generator Maintenance(Stavropoulos)
- Standard Model Co-coordinator(Dobbs)
- GEANT4 and Digitization Coordinator for Silicon(Costanzo)
- Framework Coordinator (Calafiura)
  - Transient storage management
  - Pileup in G4
- Core Libraries and Services(LCG SEAL) (Lavrijsen)
- Software training coordinator (Marino)
  - Resident at CERN. Also working on LCG SEAL project.
- Calibration/Alignment and Histogramming Infastructure (Leggett)

Some Highlights in Last Year

- Software re-organization – a major improvement
- DC1 production, reconstruction and analysis of 100K SUSY events
  - Used U.S. grid test bed of which LBNL PDSF was a major part
- Use of core software for DC1 production for High Level Trigger Technical Design Report completed
- Reconstruction software validation during DC1
  - LBNL only site able to provide quick feedback(SUSY events)
  - Costanzo presentation to LHCC Review on behalf of Collaboration
- Little Higgs study led by Hinchliffe
  - ATL-COM-PHYS-2003-040, October 2003
  - Exploring Little Higgs Models with ATLAS at the LHC
  - To be published

SUSY Simulation

$m_0 = 100$ GeV
$m_{1/2} = 300$ GeV
$A_0 = -300$ GeV
$\tan\beta = 6$
$\mathrm{sgn}\,\mu = +$

Point chosen similar to an ATLAS Physics TDR case
Adjusted to have m_h=115GeV (not excluded by LEP)

100K events corresponding to about 5fb^{-1},
(Perhaps what one might expect by end 2007)

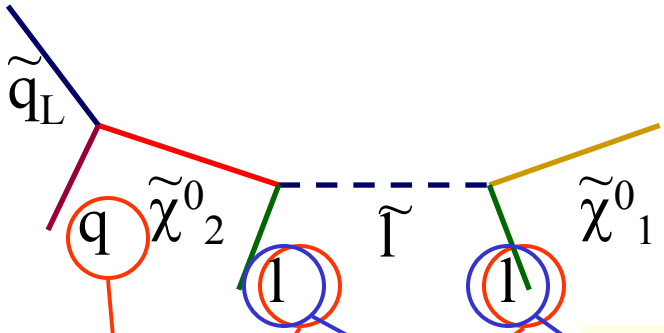
-- 100K events simulated with Geant3 (just 1% of the total DC1 production)

-- 1 Tbyte of data Simulation: ~15minutes/event (1Ghz PentiumIII)
US Grid (50K), LBNL(10K), Cambridge(10K), Copenhagen(10K), Sheffield (10K), Weizmann(10K)

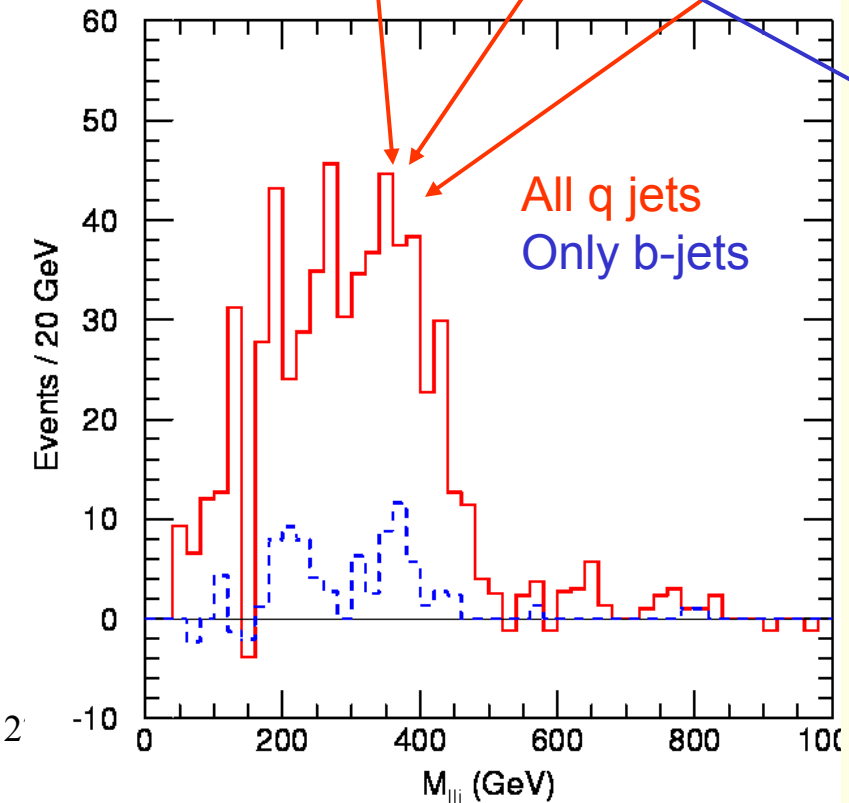
-- Re-digitization: very fast, but disk intensive (LBNL, Chicago)

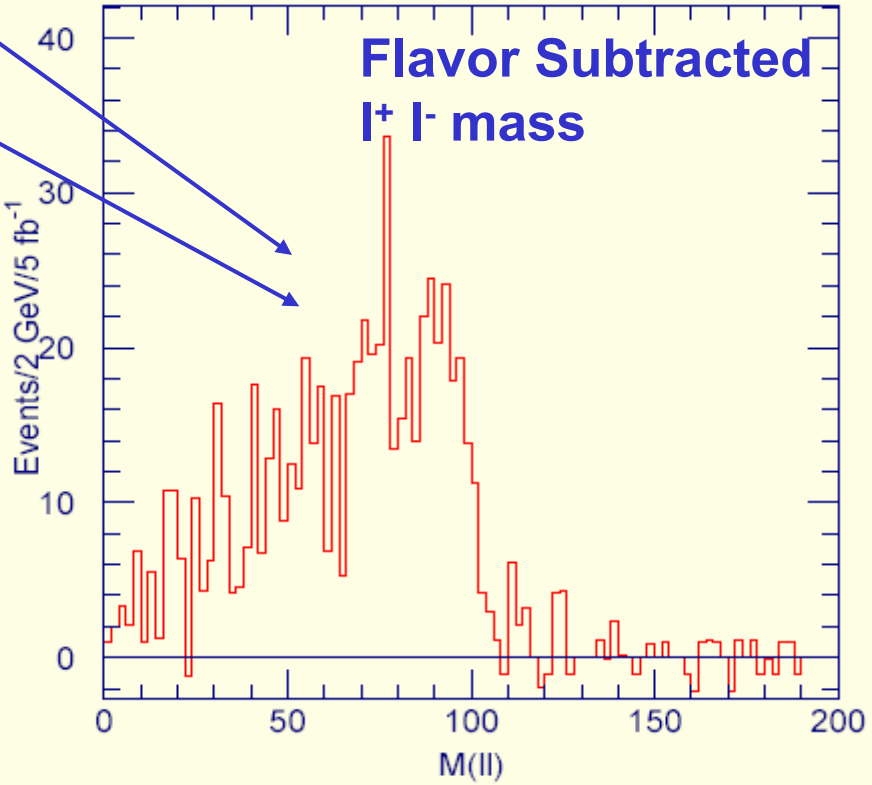
-- Reconstruction ~ 1minute/event (LBNL) ~ 12 times (lots of bugs…)

SUSY Study Example Results



$M(\chi_2)$-$M(\chi_1) \approx 105$ GeV





The Next Year

- Data Challenge 2 planned to start April 2004.
- Will use GEANT4 instead of GEANT3
- Exercise Tier 0(=CERN) reconstruction, data to Tier 1(ie. BNL in US) -> Tier 2 and other sites. Test of computing model(and resources).
- Lead again updated SUSY study with different parameter assumptions.
- Hope for LBNL role similar to DC1, but depends on (modest) upgrades to PDSF hardware that must come from Physics Division. In DC1 PDSF was used for
  - GRID production(ie. CPU/storage available to ATLAS GRID usage)
  - Local reconstruction(many times over) of SUSY simulation
  - Fast simulation(Little Higgs study)

On to First Beam

- Complete the fabrication of SCT modules and deliver them to the UK by Fall 2004.
- Complete fabrication and testing of pixel components and begin to deliver them to CERN by early 2005.
- Then assemble, install and commission pixel detector, which will require a continuous presence at CERN by 2005.
- Maintenance and Operation(M&O) follows at CERN with some support from the US ATLAS Research Program.
- Continue to make ATLAS software work for data challenges and then ready for first data.
- Increase LBNL participation in physics analysis, as part of data challenge activity, and be ready for first data.
- New physics possible with very little integrated luminosity!

Beyond The Initial Detector

- ATLAS has been staged to meet funding realities.
- Pixel system(one layer) staged and discussions underway about how and when to recover this layer, which will be essential at design luminosity.
- Innermost layer of pixels will die after some years at 10^{34}. Must be replaced, critical for b-tagging and tracking. Replacement would use new technology (improved ICs, better detectors, lower mass structures, etc) for improved pixel performance, and be step towards SLHC(10^{35}).
- Continued software development will be essential as the luminosity increases towards the design value and to respond to the actual data environment.

Major Upgrades

- A luminosity upgrade to 10^{35}(SLHC) will require the complete replacement of the tracking detectors.
- Tracking is hard at 10^{34} and has required extensive R&D for over 15 years.
- Tracking will be harder at 10^{35} and will require a similar R&D effort => organization for this just starting in U.S.
- LBNL hopes to remain leader in silicon (pixel) detectors for SLHC

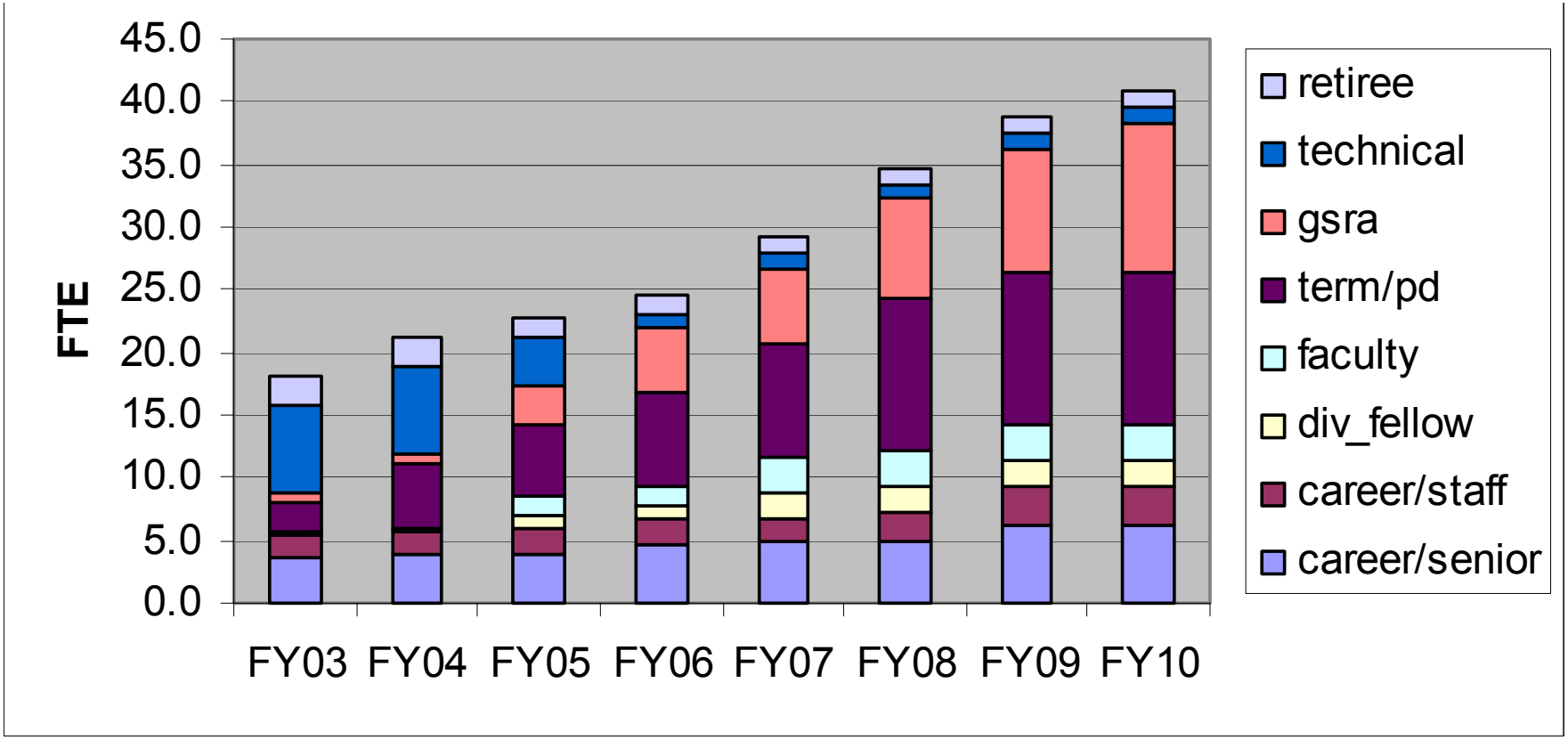
ATLAS Planning(1)

- Budget exigencies in the past two years have prevented us from hiring postdoctoral staff or other new physicists at the rate needed to keep pace with ATLAS needs.
- We have added retirees and redirected senior staff in an attempt to meet our construction commitments.
- But we are still short of physicists to meet all continuing commitments
- As a result, we have chosen to phase out our SCT activity once module production is completed.

ATLAS Planning(2)

- We are now at the time when we MUST also ramp up our effort in physics simulation/analysis AND begin upgrade R&D.
- We cannot continue to meet our (reduced) commitments to the construction project, software and computing and have a role in physics analysis and the challenging upgrades without additional physicist staff.
- The ATLAS staffing plan was developed in last year to provide a coherent framework for personnel in future years.

LBNL ATLAS Plan



Physics Division supported personnel only. Does not include Project, M&O or R&D funded personnel.

Status for 2004

- Current funding allocation in FY04 is at best flat compared to FY03, whereas we planned to be ramping up.
- Practically this means pushing ramp into FY05, unless there is some FY04 relief.
- Additional leadership needed and a search for a Divisional Fellow has been launched with the expectation of arrival in Fall ’04.
- Physics Division contribution to upgrade pixel R&D minimal, perhaps zero, in FY04. At risk to lose our leadership role in pixels.

Concluding Remarks

- ATLAS is on its way to be ready for first LHC beam.
- LBNL is a world-wide leader in silicon detector technology and leads the development of the ATLAS pixel detector.
- We are providing critical leadership in software and physics simulation, the keys to successful data analysis.
- We look forward to first physics with ATLAS!
- Physicist staff must grow very soon to meet our ongoing commitments and to participate in physics analysis at the energy frontier after decades of work.