Status of the LHC and of ATLAS at DESY.

Elin Bergeaas Kuutmann
on behalf of the DESY ATLAS group

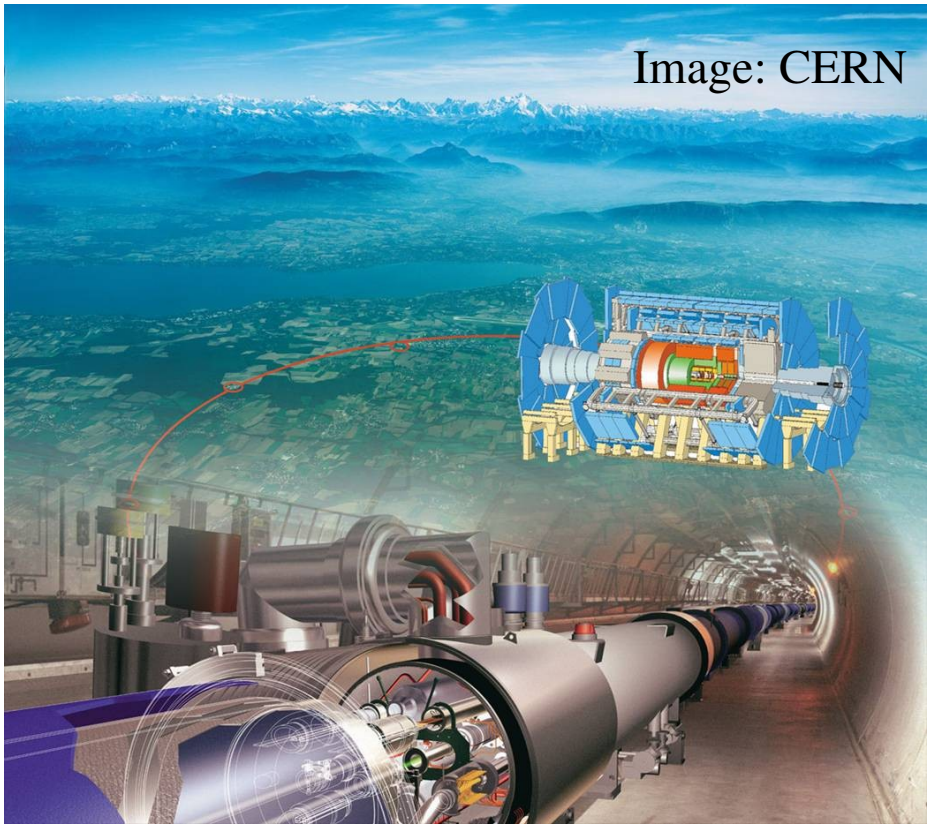
Outline

Current LHC status

Status of ATLAS

DESY ATLAS activities:

- Hardware and tools
- Measurements of the SM
- Search for new physics
- Detector upgrade

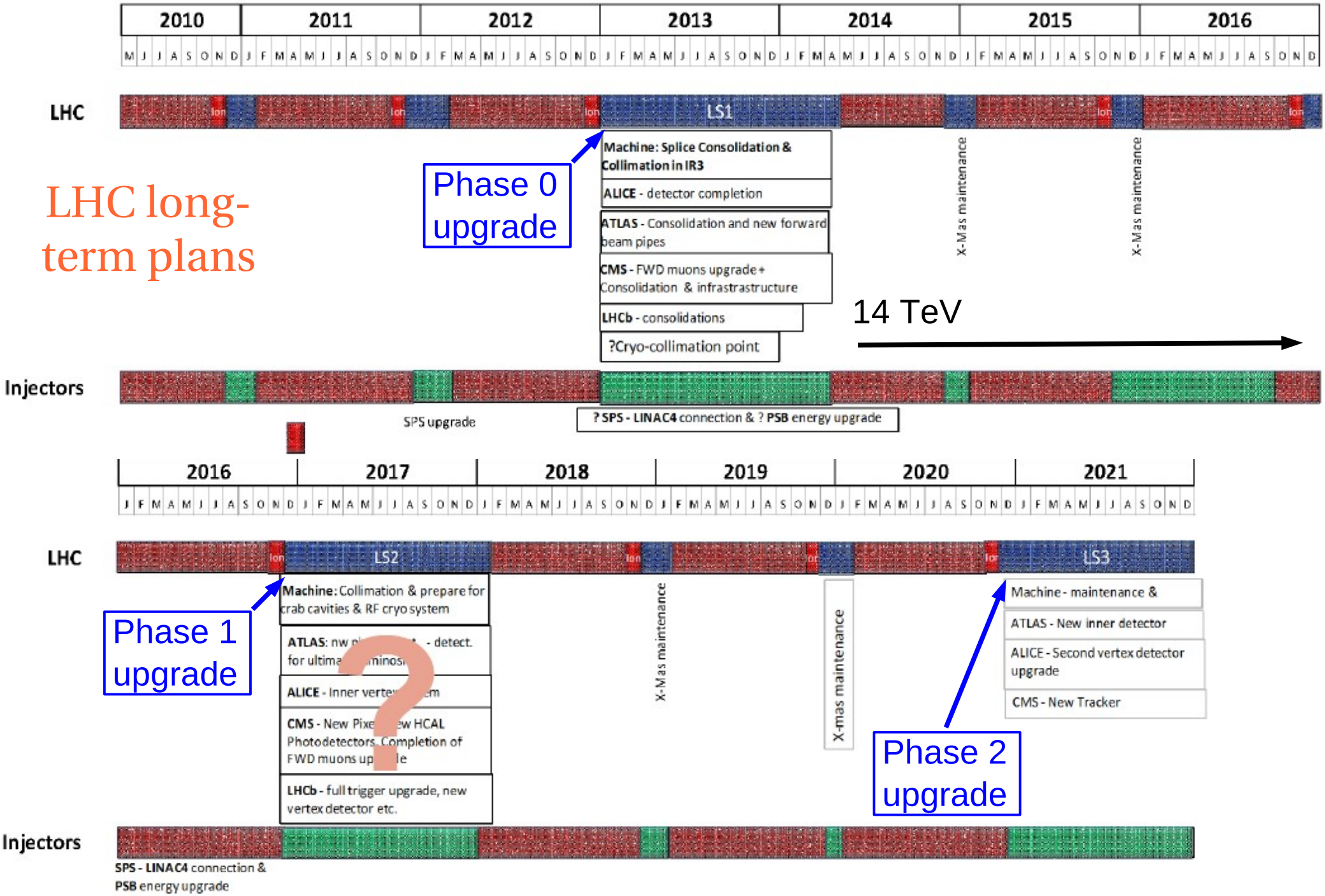


LHC status & 2011/12 plans

http://lpcc.web.cern.ch/LPCC, Chamonix workshop 24-28 Jan 2011

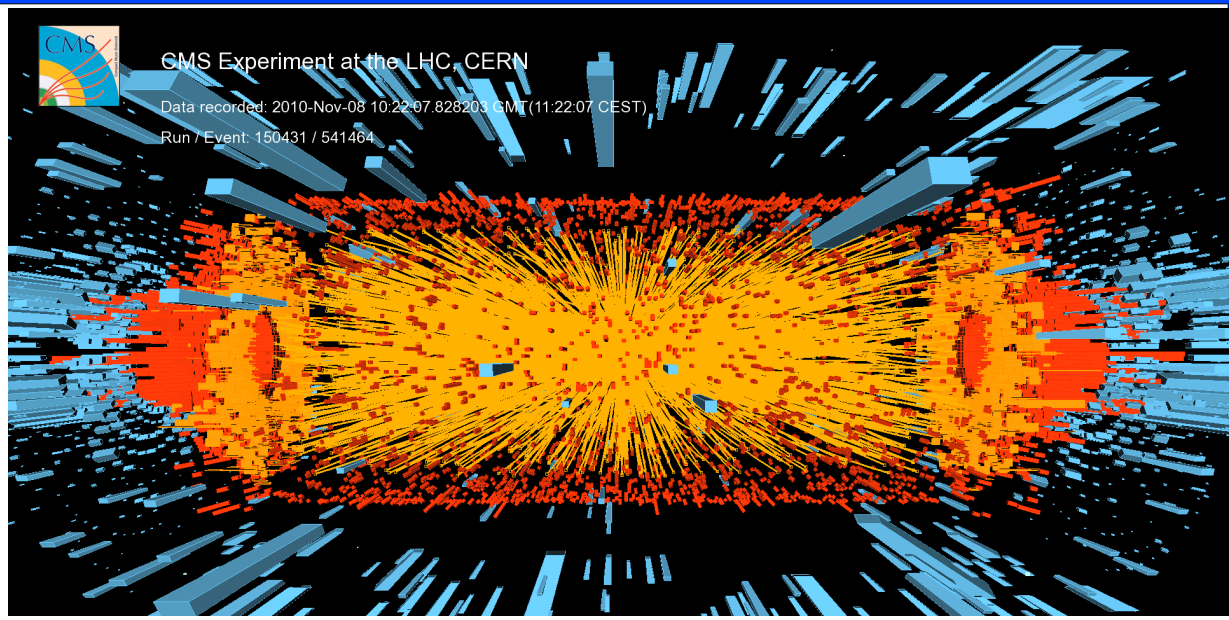
- 2010 results
  - ~48 pb^{-1} of pp collisions delivered.
  - Heavy ion (Pb-Pb) collisions
- Run plans for 2011
  - pp collisions (3.5 TeV per beam) resumed on 13 March.
  - Will run pp collisions until mid-November 2011, with short reoccurring technical stops.
  - HI collisions for about a month.
  - Technical stop and Christmas shut-down.
  - 1 fb^{-1} of integrated (pp) luminosity foreseen for 2011 (up to 3 fb^{-1} possible). Target for summer conferences: 500 pb^{-1}.
- LHC will run at (at least) 3.5+3.5 TeV in 2012.

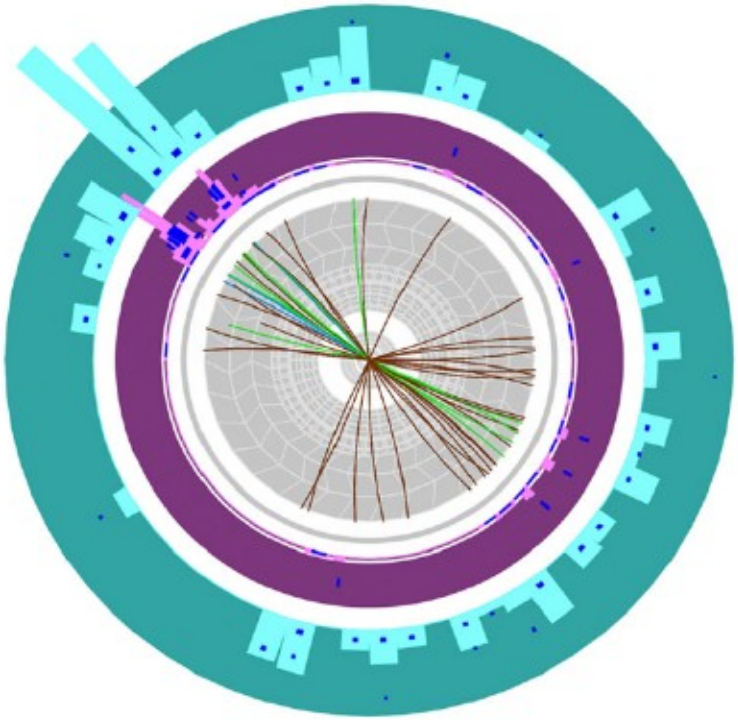
LHC long-term plans



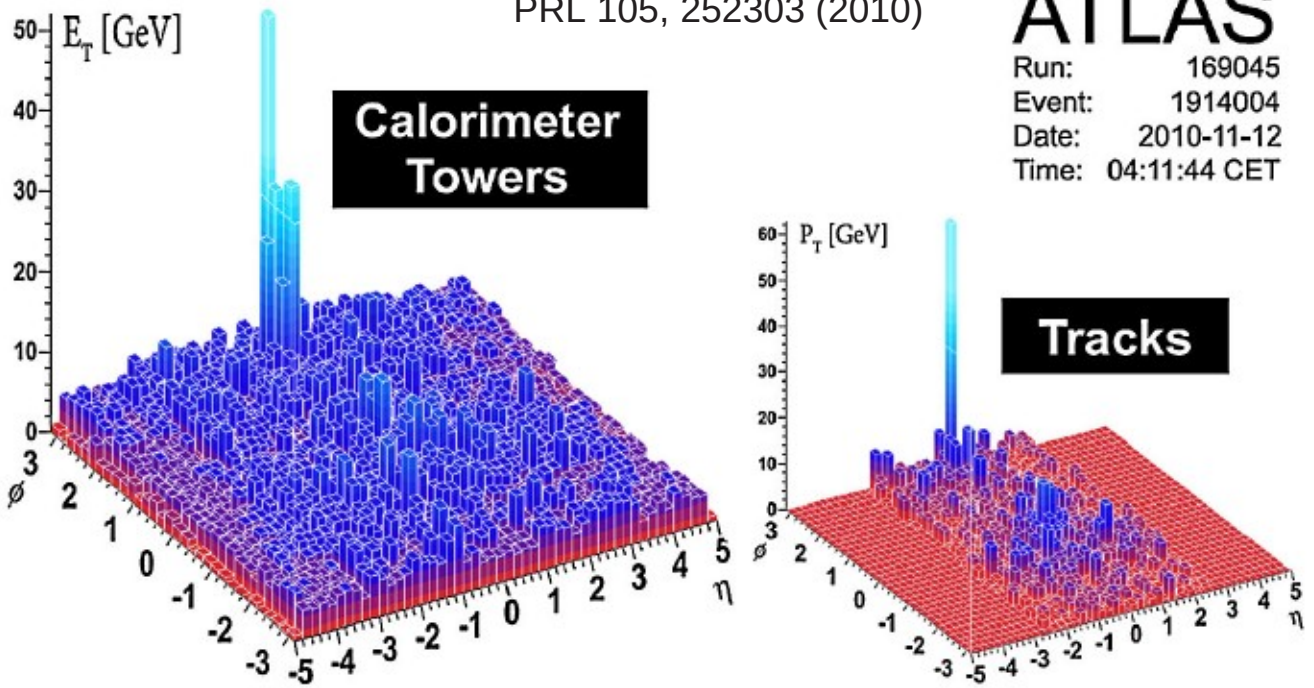
The heavy ion collisions 2010

- $\sqrt{s_{NN}}$ = 2.76 TeV
- 9.69 μb^{-1} delivered.
- Led to the observation of a centrality-dependent dijet asymmetry in lead-lead collisions.



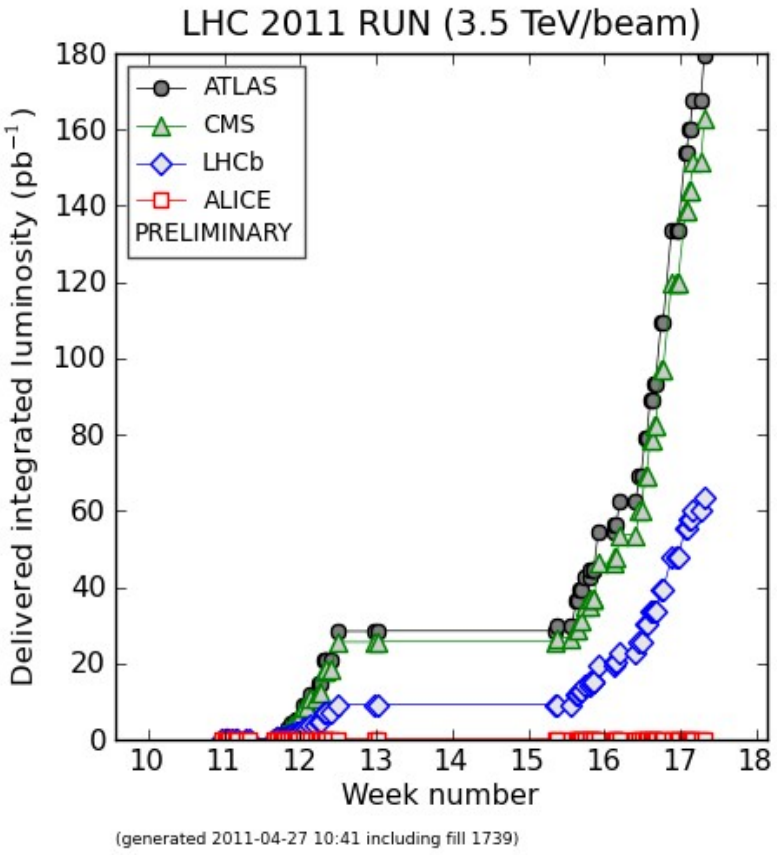


PRL 105, 252303 (2010)



LHC status in numbers

- ~48 pb^{-1} delivered in 2010.
- ~170 pb^{-1} recorded so far in 2011.
  Twice the lumi of 2010 delivered during Easter!
- On April 22, LHC set the world record in instantaneous luminosity at hadron colliders:
  $4.67 \cdot 10^{32}$ $cm^{-2}s^{-1}$.
  (Broken again on April 26:
  $5.20 \cdot 10^{32}$ $cm^{-2}s^{-1}$).
- Maximum Colliding Bunches:
  425
- Maximum Peak Events per Bunch Crossing: 14.01



Status of ATLAS

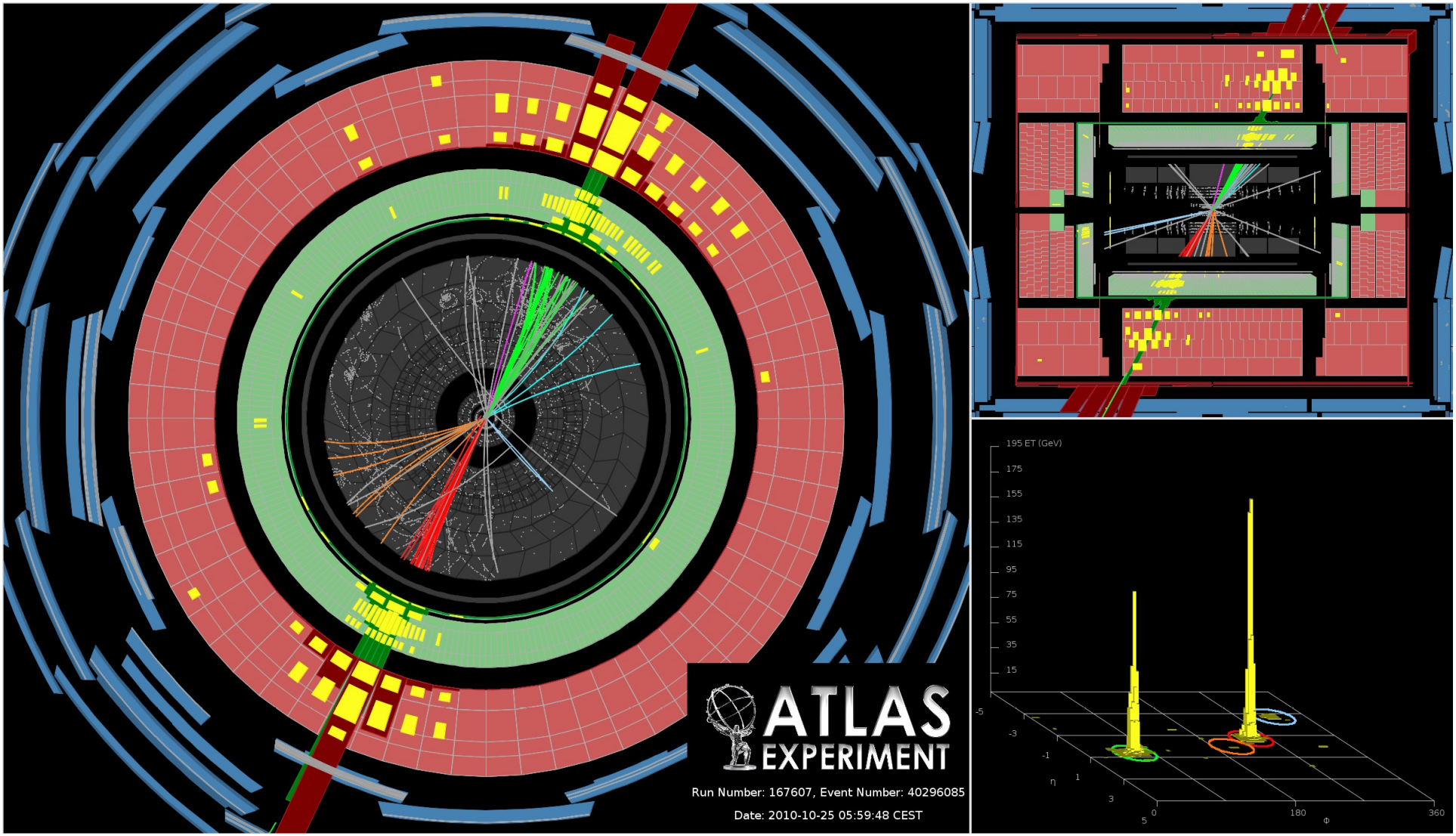
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.2%
SCT Silicon Strips	6.3 M	99.2%
TRT Transition Radiation Tracker	350 k	97.5%
LAr EM Calorimeter	170 k	99.9%
Tile calorimeter	9800	98.8%
Hadronic endcap LAr calorimeter	5600	99.8%
Forward LAr calorimeter	3500	99.9%
LVL1 Calo trigger	7160	99.9%
LVL1 Muon RPC trigger	370 k	99.5%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.8%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.0%
TGC Endcap Muon Chambers	320 k	99.1%

- Data-taking efficiency >97% for all systems

- Using the 2010 data set, a very large range of physics has been investigated: SM: soft QCD, jet physics, c, b, t, g, γ, W, Z, e, μ, τ. Searches for H, SUSY, Z', W', q*, ...
- 67 conference notes, 33 physics publications and 11 performance papers have been published using 2010 ATLAS data.

ATLAS at the Terascale

dijet mass = 3.1 TeV $p_T^{jet1,2}$ = 1.3 TeV



ATLAS at DESY – people

- 9 permanent positions
  of which one starts May 1
- Two tenure track in Zeuthen
  (starting May 1 and June 1)
- 3 YIGs.
  (U. Husemann will leave for a professorship July 1;
  K. Tackmann started April 1).
- 16 postdocs
- 19 PhD students
- 10 Diploma/master students

Key people in ATLAS

- Publication committee chair and EB member (K. Mönig)
- Top reconstruction convener (U. Husemann)
- Trigger coordinator (D. Strom – guest from Oregon)
- Module convener for Phase 2 (I.M. Gregor)
- Egamma Signature Group Coordinator (T. Kono)
- MC Tuning Forum Convenor (J. Katzy)
- Top MC Contact (L. Mijovic)
- MC Software Manager (J. Kotanski)
- ATLAS-D SM convener (T. Kuhl)
  ATLAS-D top convener (U. Husemann)
- Coordination of German LHC communication (T. Naumann)

DESY ATLAS activities

Hardware and tools

- ALFA luminosity measurement
- Computing: ATLAS software infrastructure, CutFlowService, DDM operations, TAGs for physics analysis, NAF support
- Trigger Menus, Configuration, egamma HLT selection, DQ monitoring
- ID material mapping with photon conversions
- Calibration work for the LAr energy scale
- Radiation-damage effects of SCT in the SCT digitization model
- Pixel and Silicon strips operation

Upgrade

Hardware and simulation

Physics analysis

- MC tuning
- Multijet cross section
- $W \rightarrow \tau\nu$
- $Z \rightarrow \tau\tau$, $Z \rightarrow ee$, Z p_T; combination of e-μ channels
- inclusive photon cross section
- ttbar cross section + QCD background, e and μ SFs
- $H \rightarrow \gamma\gamma$
- SUSY analyses: di-lepton, 0-lepton, di-photon, di-τ.
- Fittino: interpreting signals of new physics
- jet substructure for boosted tops
- ttbar resonances

Recent ATLAS notes with significant DESY contribution

Diagnostic Systems and Resource Utilisation of the ATLAS High Level Trigger, ATL-DAQ-PROC-2010-047.

Diagnostic and Monitoring Systems of the ATLAS High Level Trigger, ATL-DAQ-PROC-2010-006

Observation of Z->tau_h tau_l Decays with the ATLAS detector, ATLAS-CONF-2011-010

Measurement of the top quark-pair cross-section with ATLAS in pp collisions at sqrt(s) = 7 TeV in the single-lepton channel using b-tagging, ATLAS-CONF-2011-035

A combined measurement of the top quark pair production cross-section using dilepton and single-lepton final states, ATLAS-CONF-2011-040

Determination of the Top-Quark Mass from the ttbar Cross Section Measurement in pp Collisions at sqrt(s)=7 TeV with the ATLAS detector, ATLAS-CONF-2011-054

Measurement of multi-jet cross-sections in proton-proton collisions at 7 TeV center-of-mass energy, ATLAS-CONF-2011-043

Measurement of the inclusive isolated prompt photon cross section in pp collisions at sqrts=7 TeV with the ATLAS detector using 35 pb^{-1}, ATLAS-CONF-2011-058

New ATLAS event generator tunes to 2010 data, ATL-PHYS-PUB-2011-008

Measurement of the backgrounds to the H→γγ search and reappraisal of its sensitivity with 37 pb^{-1} of data recorded by the ATLAS detector, ATLAS-CONF-2011-004

Search for the Higgs boson in the diphoton final state with 38 pb^{-1} of data recorded by the ATLAS detector in proton-proton collisions at $\sqrt{s}$=7 TeV, ATLAS-CONF-2011-025

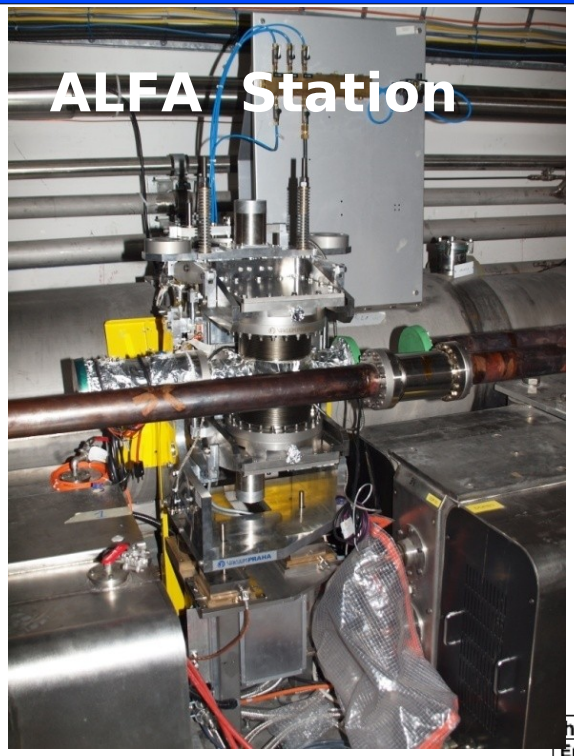
Search for an excess of events with an identical flavour lepton pair and significant missing transverse momentum in sqrt{s} = 7 TeV proton-proton collisions with the ATLAS detector, arXiv:1103.6208 (submitted to EPJ C).

Other DESY (contribution) publications:

Boosted objects: a probe of beyond the Standard Model physics, arXiv:1012.5412 (accepted by EPJ C)

What if the LHC does not find supersymmetry in the sqrt(s)=7 TeV run? arXiv:1102.4693 (submitted to PRL)

HiggsBounds 2.0.0: Confronting Neutral and Charged Higgs Sector Predictions with Exclusion Bounds from LEP and the Tevatron, arXiv:1102.1898 (submitted to CompPhysComm)

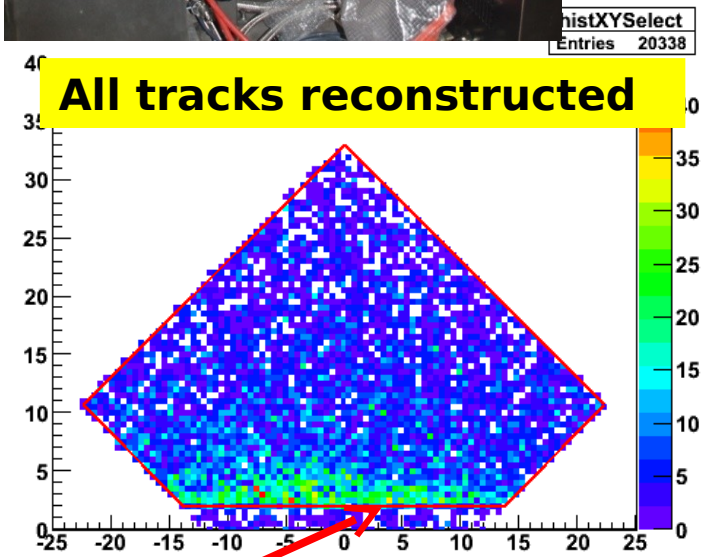


ALFA Status and Plans 2011

Commissioning: completed
- mechanics and electronics fully installed.
- survey of movable detectors finished.
- readout tested and functioning by pulsed LEDs.
- slow control integrated in ATLAS DCS.
- TDAQ with latest version presently standalone.
- implementation in ATLAS central trigger processor ongoing.
- interlocks test for position limits and beam modes finished.

Commissioning: next weeks
- perform a scraping run for beam based alignment
- integrate fully into ATLAS TDAQ
- implement ALFA triggers in ATLAS menu

Plans for data taking
- move detectors out of garage position in a distance of ~ 10mm to the beam for halo particles
- run with ATLAS latency adjusted for final proof all systems
- physics run with beta = 90m optics and detectors as close as possible to the beam

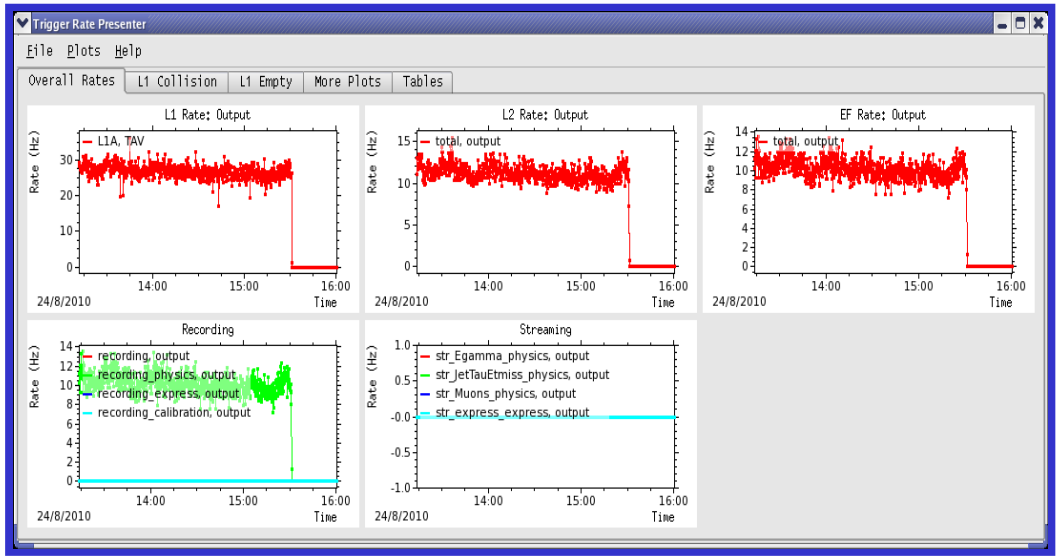


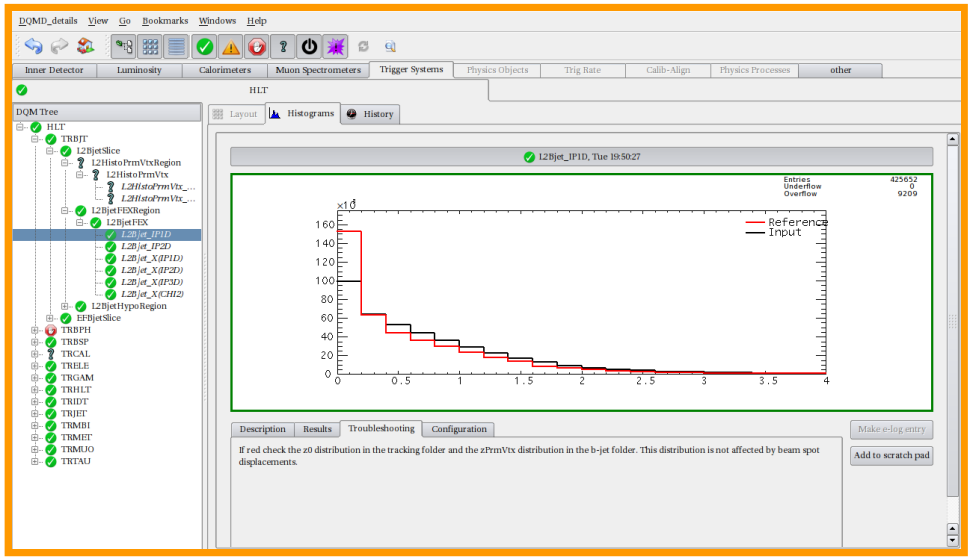
Allows measurement of the total cross section using external luminosity. Rel error ~5%.

Trigger Monitoring

common project DESY/Humboldt

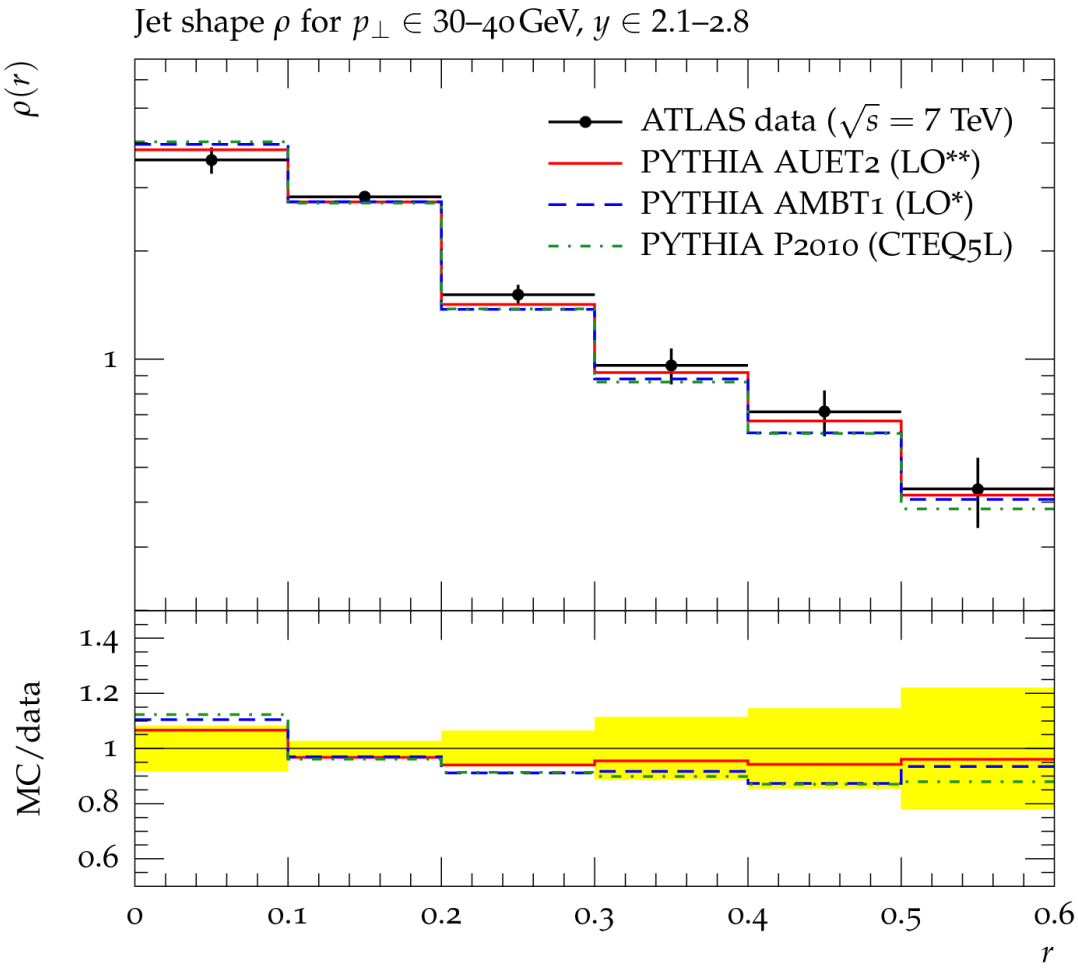
- Well established resources:
  - **Trigger Rate Presenter TRP.** Main diagnostic tool in ATLAS control room.
  - **Trigger Data Quality Monitoring.** Automatic checks (online and offline) delivery of DQ-flags.
  - Online Histogram Presenter OHP.
- in stable and smooth running
- fully integrated in standard TDAQ
- 2 published conference contributions in 2011 (ATL-DAQ-PROC-2010-047, ATL-DAQ-PROC-2010-006)





MC tuning

- ATLAS tuning effort of Pythia6 and Herwig/Jimmy to further improve description of ATLAS 2010 data.
- Tunes are performed to LEP, Tevatron and LHC data using the Professor and Rivet tools. Significant amount of MC production run on NAF.
- Pythia6 tune involving tuning the shower model to hadron collider data for the first time in ATLAS in order to describe the jet measurements (DESY contribution).
- Resulting tunes give good description of ATLAS data.



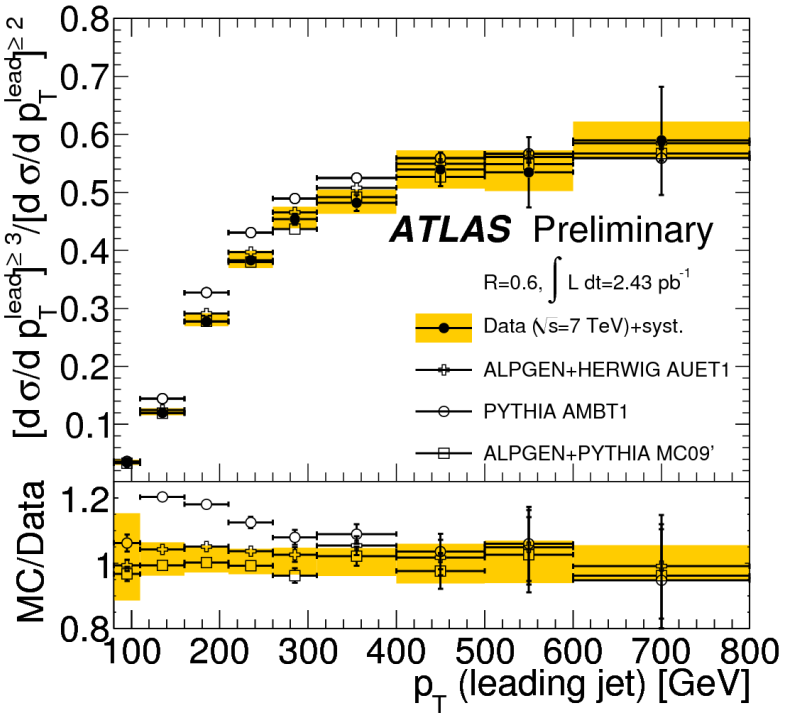
ATL-PHYS-PUB-2011-008

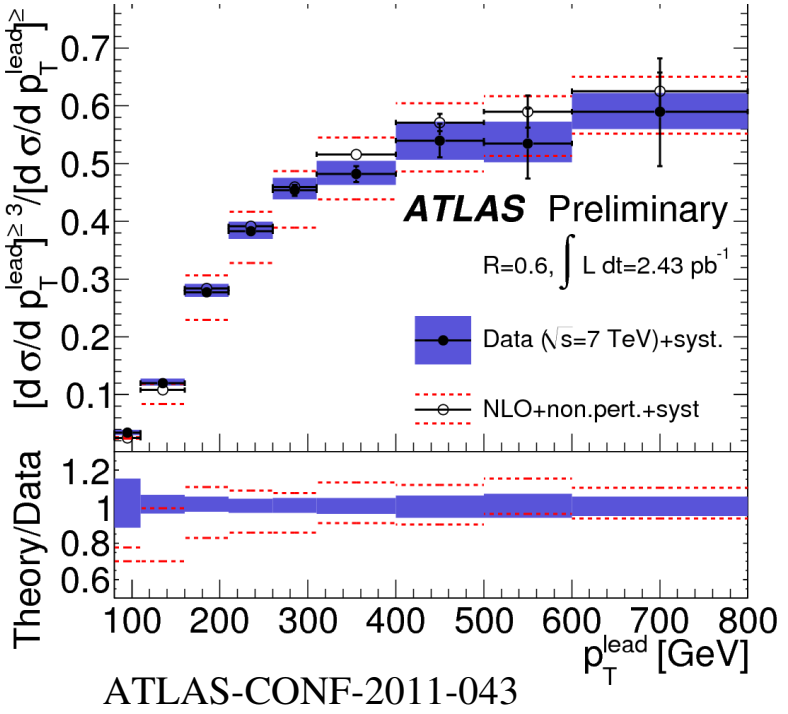
Multijet cross section

- Measuring the differential cross section of N jet events ($N \geq 2$) as a function of p_T^{lead}, $p_T^{lead+second}$, H_T
- Multi-jet triggers.
- Event selection: p_T>60GeV (p_T^{lead}>80GeV), $|y|$<2.8. Standard jet quality selection.
- Unfolded to the particle level (bin-by-bin, ALPGEN).
- Comparisons with full simulation MC and NLO calculations (NLOjet++ by Z. Nagy, Analysis Centre).
- Cross section ratio, sensitive to α_s and MC tuning.

$$R_{32} = \frac{d\sigma^{N\geq 3}/dp_T}{d\sigma^{N\geq 2}/dp_T}$$

- The first part of the 2010 data set used. After this, the triggers were prescaled and the pile-up increasing.



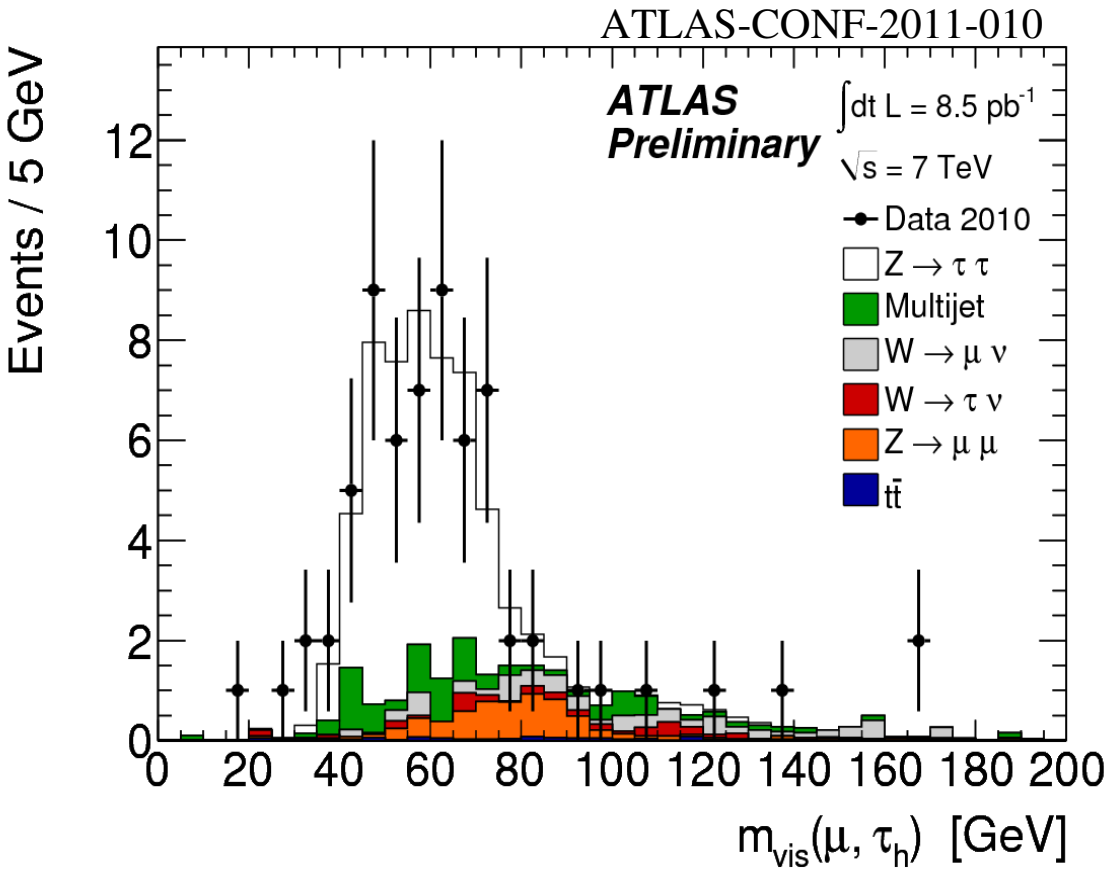


ATLAS-CONF-2011-043

Observation of $Z \rightarrow \tau\tau$

- Proof that ATLAS can measure τ. Important background to many BSM searches (SUSY etc).
- One τ decays leptonically, one hadronically.
- Event signature: 1 e/μ, E_T^{miss}, 1 hadronic τ.
  Single lepton trigger used.
  Provides unbiased τ_h sample.
- Multijet suppression: lepton isolation, τ identification
- W suppression: dilepton veto, $\Delta\phi(l / \tau_h - E_T^{miss})$ cut,
  $35 < m_{vis} < 75$ GeV,
  1 or 3 tracks to the tau-jet,
  $q_{\tau h} = \pm 1$.
  Opposite charges: $l^{\pm}, \tau^{\mp}$

- Multijets and W bkg modelled with data-driven methods.
- Data agrees well with SM prediction.



Top quark cross section

- Lepton+jets channel: single lepton trigger.
- Objects selected:
  1 electron or muon, trigger matched
  Jets, p_T > 20 GeV.
  E_T^{miss} > 35 (20) GeV in ele (muo) channel.
- Combination of 6 channels.
  Continuous *b*-tagging.
- Selection through a multivariate likelihood discriminant using 4 variables: pseudorapidity of the lepton, aplanarity, $H_{T,3p}$, average of the two lowest light-jet probabilities
  DESY/Göttingen development: best ATLAS measurement!
- Profile likelihood fit – constrain systematics from data.
- This result basis for combination with the dilepton channel, and the top mass measurement.

Cross section value (M_t = 172.5 GeV):

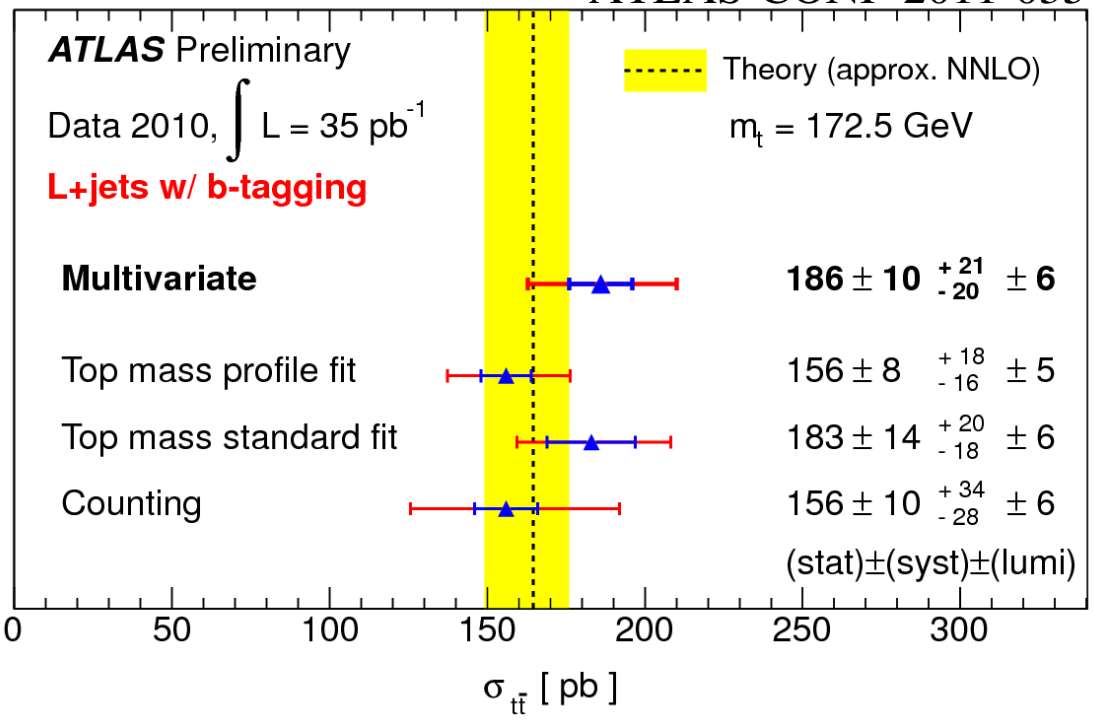
$$\sigma_{t\bar{t}} = 186 \pm 10\,(\text{stat.})^{+21}_{-20}\,(\text{syst.}) \pm 6\,(\text{lumi.})\ \text{pb}.$$

Theory: $\sigma_{t\bar{t}} = 164.6^{+11.4}_{-15.7}\ \text{pb}$

Comb. with dileptons:

$$\sigma_{t\bar{t}} = 180 \pm 9\,(\text{stat.}) \pm 15\,(\text{syst.}) \pm 6\,(\text{lumi.})\ \text{pb}.$$

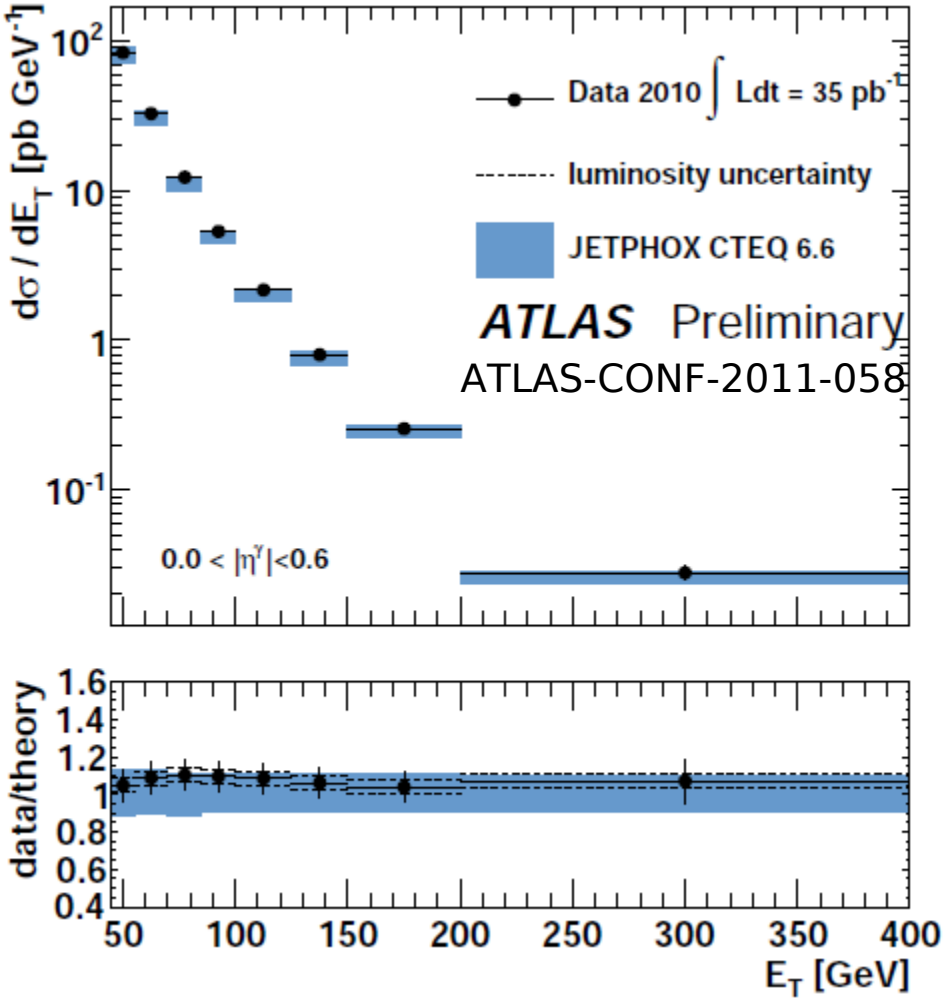
ATLAS-CONF-2011-035



Inclusive photon cross section and $H \to \gamma\gamma$

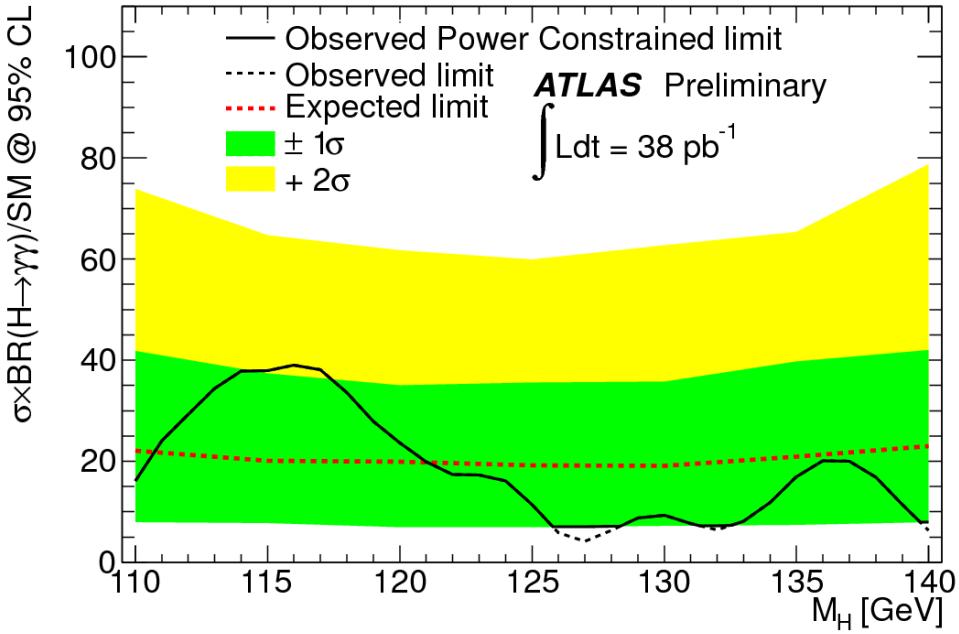
(K. Tackmann, recently joined DESY)

- Prompt photon production can be used to test pQCD.
  Important background for H → γγ.



- $H \to \gamma\gamma$ search
- Higgs signal modelled as a Crystal Ball / Gaussian on top of the $\gamma\gamma$ background.
- Limits set with PCL_{s+b}.
- Exclusion in units of SM Higgs xsec.

ATLAS-CONF-2011-025



Beyond the Standard Model: SUSY

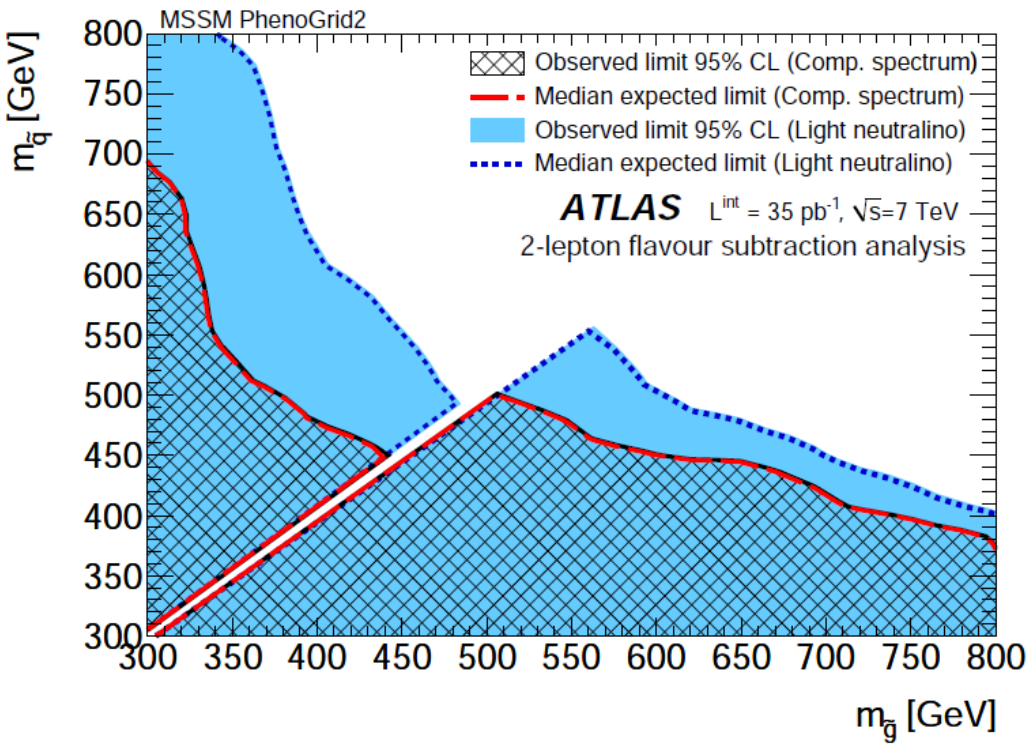
Di-lepton analysis opposite signs.

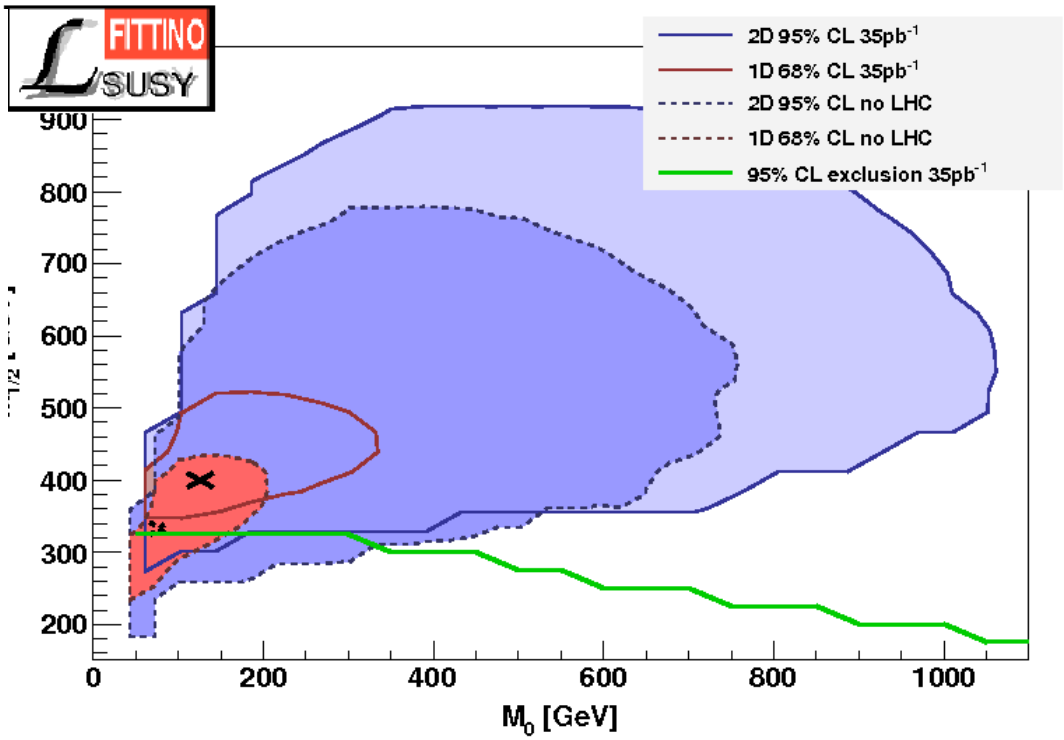
Exclusion plot for a phenomenological MSSM scenario which allows sleptons in the decay chains M(Squark/gluino) → M(chi2) → M(slepton) → M(chi1)

Compressed ("soft" particles) and "harder" particles (favorable)

Interpretation: using FITTINO to search for SUSY.

Combined fit using low-energy measurements, the dark matter relic density constraint and potential LHC exclusions.





Planning for the future: Upgrade Activities

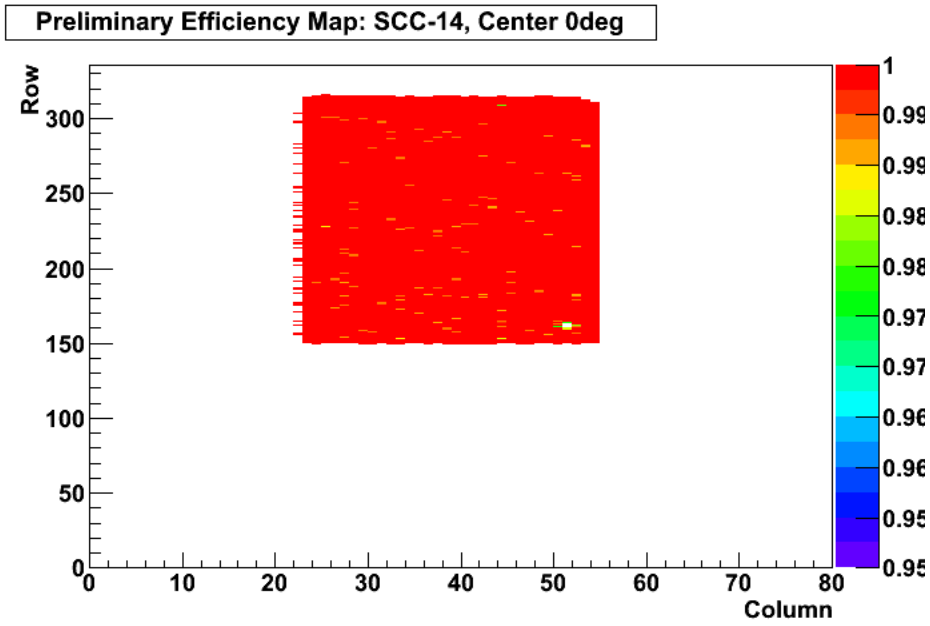
DESY Upgrade Projects

- Phase 0 (2013): Insertable B-Layer (IBL) -> new very tight schedule
  - focusing on test beam studies towards sensor decision (July 2011)
- Phase 2 (2020+): ATLAS Silicon Strip End cap -> Petal2014 integral part of project
  - involvement includes simulation, electronics, modules and mechanics

PETAL2014.

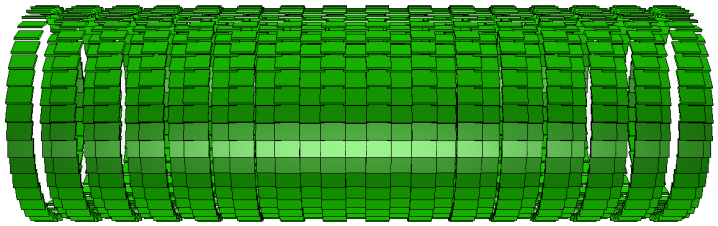
The new FE-I4 readout chip for the **IBL** was successfully tested at the DESY test beam in February and April.

- DESY team involved in the EUDET telescope: support, data taking, reconstruction and analysis.
- Samples irradiated in Karlsruhe and Ljubljana.
- Further studies with and without magnetic field at CERN SPS starting in May; Test beam setup, GEANT4 simulation, and reconstruction software development ongoing.



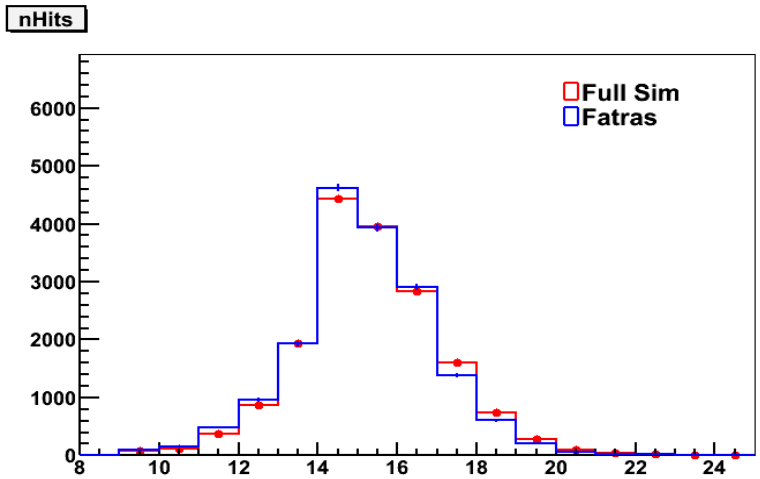
Efficiency map for a sensor-FE-I4 chip assembly (DESY TB data Feb. 2011)

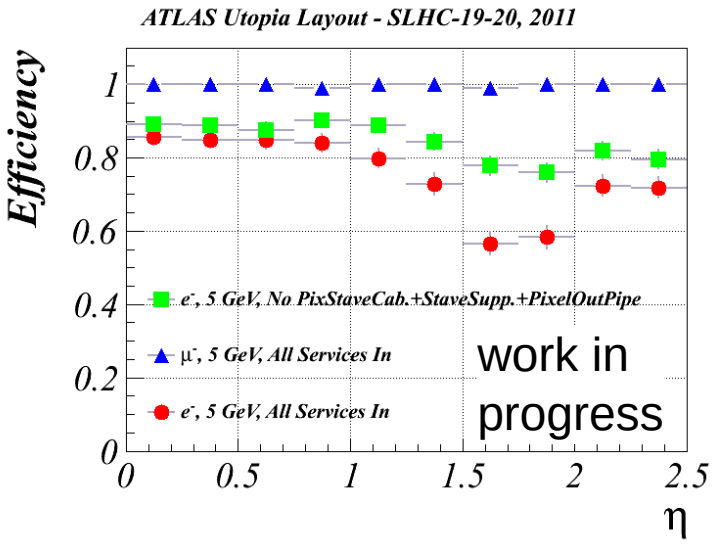
Upgrade Activities – Phase 2 Detector Simulation



Outer Pixel Barrel Layer

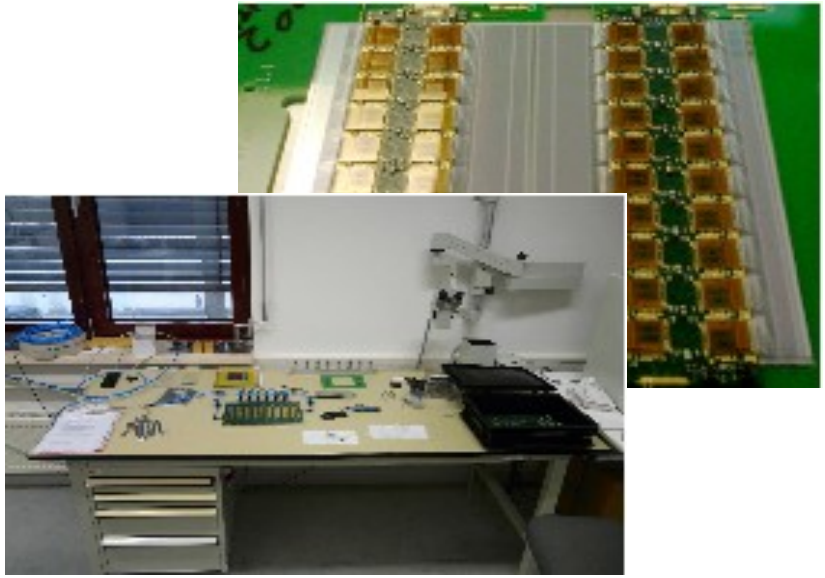
- A new Inner Detector Upgrade Simulation Group was formed
- DESY is playing a significant role in this effort
- Validation of Fast simulation (Fatras) against Full simulation
- Working with ATLAS "Tracking Geometry"
  - simplified geometry description used both by Full Simulation (for track reconstruction) and Fatras (as simulation geometry).
  - Next step: implementing new geometries.
- Electron efficiency studies to understand where material can and has to be reduced
  - main contribution to inefficiency results from the Pixel stave cables and the Pixel stave supports.





Upgrade Activity – End Cap Module Assembly

- Various projects started towards the Petal2014
- Module building
  - building modules for stave09 program use this expertise for future end-cap modules
  - gain expertise in handling of tools, gluing, wire bonding steps and DAQ
  - all tools in hand and assembly of first modules started
- Sensor testing
  - gain experience for tests of future end-cap sensors
  - compare values with measurements of same sensors after having them integrated into modules
- DAQ software / firmware development
  - DAQ system in Zeuthen complete and running
  - first tests with ABCN single chip card have started to gain experience for later tests of hybrids / modules
  - Hamburg system to follow



Module assembly in Zeuthen

PETAL2014.

Summary

- LHC is running well and is planned to continue doing so in 2012.
- DESY is making a significant contribution to ATLAS:
  - Hardware contributions: ALFA
  - Software development
  - Measurements of the Standard Model and MC tuning
  - Searches for “new physics” have started.
    SUSY analysis public, other searches in the pipeline.
  - Detector upgrade: IBL, PETAL2014