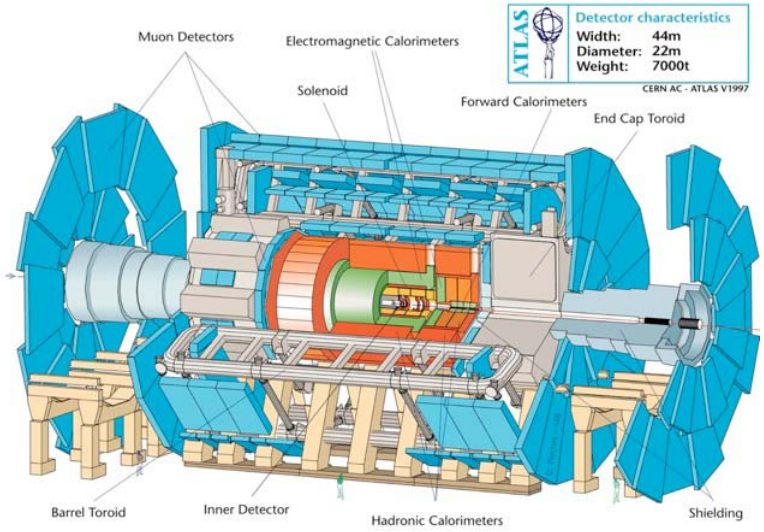


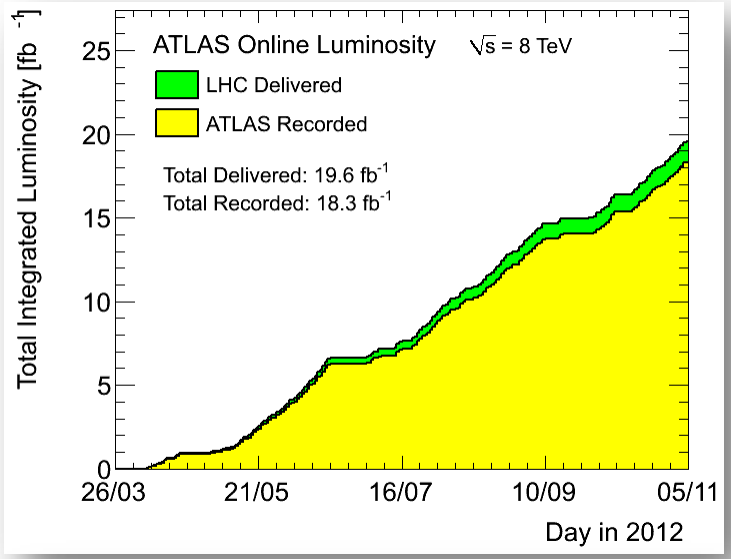
Status Report from DESY ATLAS Group

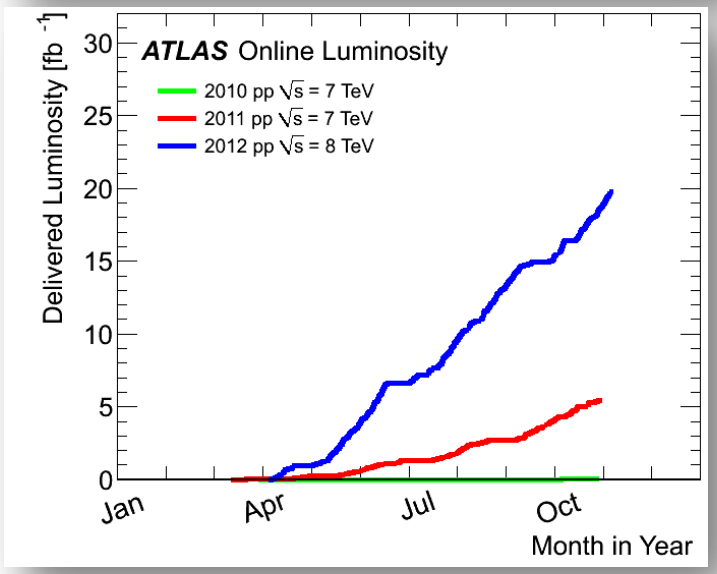
Peter Vankov

on behalf of the DESY ATLAS Group

74th DESY *P*hysics *R*esearch *C*ommittee, Open Session, 08 November 2012

ATLAS Performance



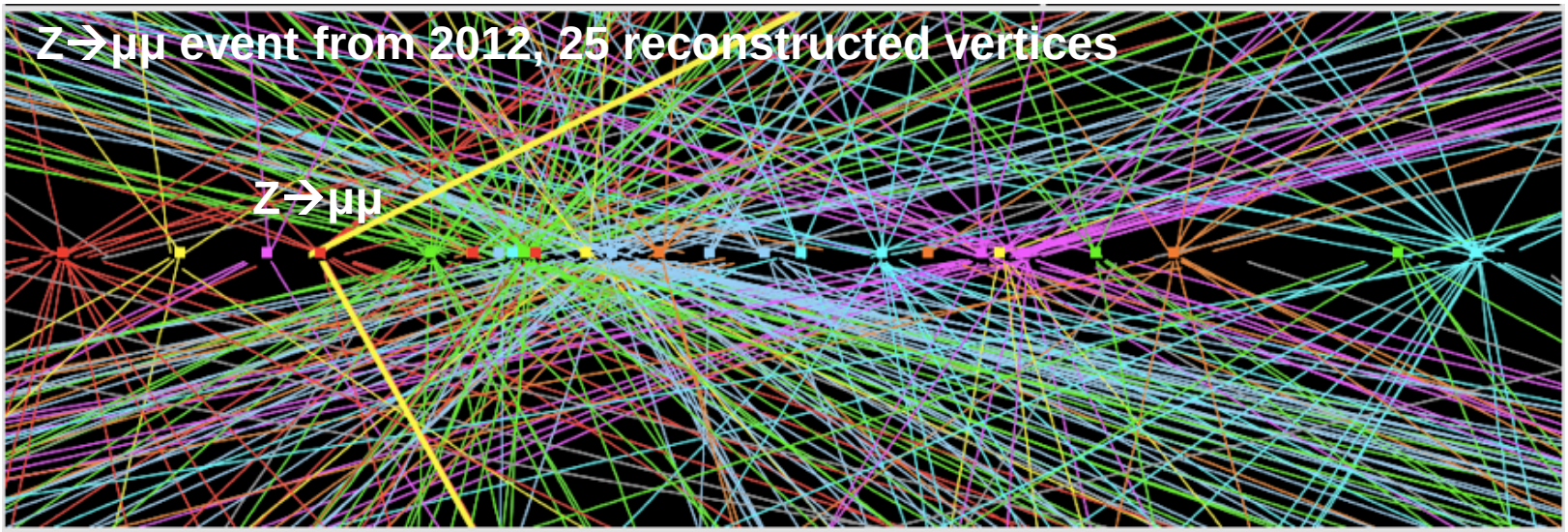


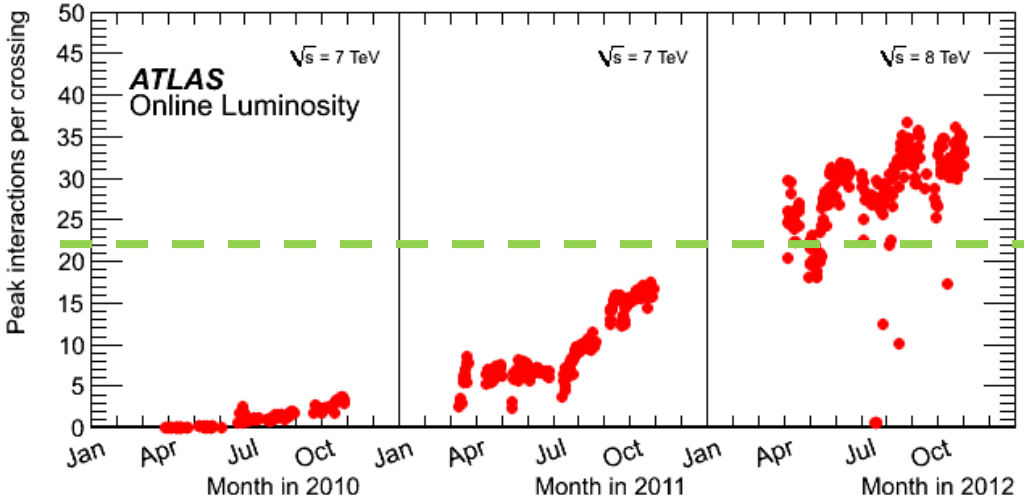
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	95.0%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	97.5%
LAr EM Calorimeter	170 k	99.9%
Tile calorimeter	9800	98.3%
Hadronic endcap LAr calorimeter	5600	99.6%
Forward LAr calorimeter	3500	99.8%
LVL1 Calo trigger	7160	100%
LVL1 Muon RPC trigger	370 k	100%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	96.0%
RPC Barrel Muon Chambers	370 k	97.1%
TGC Endcap Muon Chambers	320 k	98.2%

- Luminosity recorded by ATLAS (pp runs)
  - 2010: 0.05 fb^{-1} @ 7 TeV
  - 2011: 5.6 fb^{-1} @ 7 TeV
  - 2012: 19.0 fb^{-1} @ 8 TeV
- Peak Luminosity: 7.73 x 10^{33} /cm^2 s
- ATLAS good physics data: 93.7%
  (Good quality data delivery during 2012 stable beams in pp collisions at $\sqrt{s}$ = 8 TeV between Apr 4th and Sep 17th, corresponding to 14 fb^{-1} → *the HCP'12 dataset*)

ATLAS Performance

- Challenge: Pileup events (multiple events per BX)





Design value:
23 for $L=10^{34}$ /cm^2 s

DESY ATLAS Group

- DESY ATLAS group (both Hamburg and Zeuthen sites) consists of **57** people
  - **10** staff, **2** YIG
  - **22** postdocs, **18** PhD students, **5** support staff

ATLAS positions

Joao Firmino da Costa, ***Prompt reconstruction operations coordinator***
Wolfgang Ehrenfeld, ***MC production coordinator, ATLAS-D CRB chair***
Alexander Glazov, ***Standard model group co-convener***
Karl-Johan Grahn, ***Top-jet liaison***
Ingrid-Maria Gregor, ***Upgrade strip module co-convener***
Karl-Heinz Hiller, ***ALFA project leader***
Marcos Jimenez, ***Photon id group co-convener***
Thorsten Kuhl, ***MC group co-convener***
Elin Bergeaas Kuutmann, ***Boosted top reconstruction co-liaison***
Ewelina Lobodzinska, ***ATLAS MC software manager***
Voica Radescu, ***SM PDF Forum co-convener, Dep. Cond. DB coordinator,*** *HERAFitter co-convener*
David South, ***Conditions DB coordinator***
Pavel Starovoitov***, Cross-section group co-convener,*** *APPLGRID author*
Nick Styles, ***Upgrade simulation co-convener***
Kerstin Tackmann, ***H→γγ group co-convener***
Peter Vankov, ***Upgrade simulation co-convener***

DESY ATLAS Activities

→ ***Physics analyses and performance studies***

- Standard model: W/Z production, constraining PDFs, High(Low)-Mass DY, Incl. jets
- Top: $t\bar{t}$-resonance search, $t\bar{t}$-asymmetry, *t*-polarization, $t\bar{t}$ spin correlations, $t\bar{t}$*+jets*
- Higgs: $H \rightarrow \gamma\gamma$, $H \rightarrow 4\gamma$
- SUSY: Searches in di-lepton and di-photon channels (+MET)
- MC tuning, new generator validation, model uncertainties for top, jet-multiplicities
- Performance studies: focused on electron and photon
- European strategy studies, Higgs Self-Couplings with HL-LHC

→ ***Detector operation & performance***

- Semi-Conductor Tracker (SCT)
- ALFA (Absolute Luminosity For ATLAS)
- Trigger
- Computing
- Reconstruction software

→ ***ATLAS Upgrade projects***

- Insertable B-layer (IBL) for Phase-0 upgrade
- Tracker upgrade for Phase-2 (HL-LHC) upgrade – R&D hardware and simulations

Publications: Papers

Papers with significant DESY contribution

- *Observation of a New Particle in the Search for the Standard Model Higgs Boson with the ATLAS Detector at the LHC*, (Phys. Lett. B 716 (2012) 1-29), *arXiv:1207.7214 [hep-ex]*
- *A search for ttbar resonances with the ATLAS detector in 2.05 fb^{-1} of proton-proton collisions at $\sqrt{s}$ = 7 TeV* , (EPJ **C72** (2012) 2083), *arXiv:1205.5371 [hep-ex]*
- *A search for ttbar resonances in lepton+jets events with highly boosted top quarks collected in pp collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector*, (JHEP **1209** (2012) 041), *arXiv:1207.2409 [hep-ex]*
- *Jet mass and substructure of inclusive jets in $\sqrt{s}$= 7 TeV pp collisions with the ATLAS experiment*, (JHEP **1205** (2012) 128), *arXiv:1203.4606 [hep-ex]*
- *Planar pixel sensors for the ATLAS upgrade: beam tests results*, (2012 JINST 7 P10028), doi:10.1088/1748-0221/7/10/P10028
- *Search for diphoton events with large missing transverse momentum in 7 TeV proton-proton collision data with the ATLAS detector,* (Accepted by Phys. Lett. B), *arXiv:1209.0753 [hep-ex]*
- *Search for direct slepton and gaugino production in final states with two leptons and missing transverse momentum with the ATLAS detector in pp collisions at $\sqrt{s}$ =7 TeV*, (Submitted to Phys. Lett. B), *arXiv:1208.2884 [hep-ex]*
- *Prototype ATLAS IBL Modules using the FE-I4A Front-End Readout Chip*, (Submitted to JINST), *arXiv:1209.1906 [physics.ins-det]*

Publications: PUB/CONF Notes

Pub/Conf Notes with significant DESY contribution

ATLAS Public Notes:

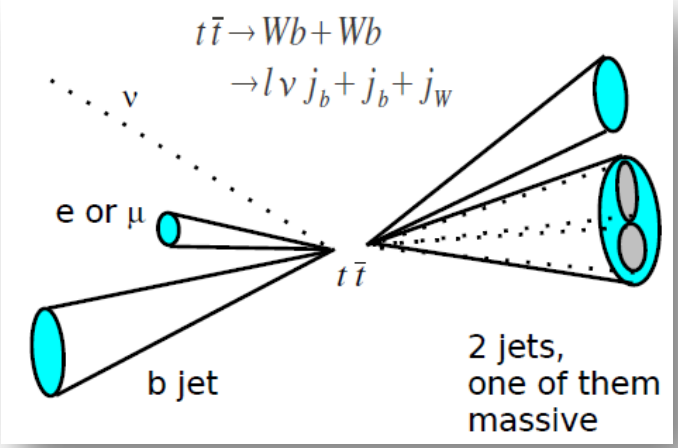
- *Physics at a High-Luminosity LHC with ATLAS (Update)*, (ATL-PHYS-PUB-2012-004)
  https://cdsweb.cern.ch/record/1484890/files/ATL-PHYS-PUB-2012-004.pdf
- *ATLAS Phase II Letter of Intent: Backup Document*, (ATL-UPGRADE-PUB-2012-004)
  https://cdsweb.cern.ch/record/1482960/files/ATL-UPGRADE-PUB-2012-004.pdf
- *Physics at a High-Luminosity LHC with ATLAS*, (ATL-PHYS-PUB-2012-001)
  https://cdsweb.cern.ch/record/1472528/files/ATL-PHYS-PUB-2012-002.pdf

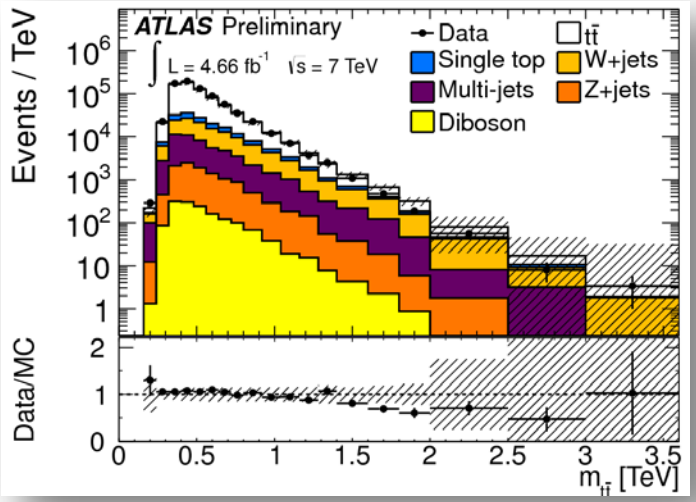
ATLAS Conference Notes: (https://twiki.cern.ch/twiki/bin/view/AtlasPublic/CONFnotes)

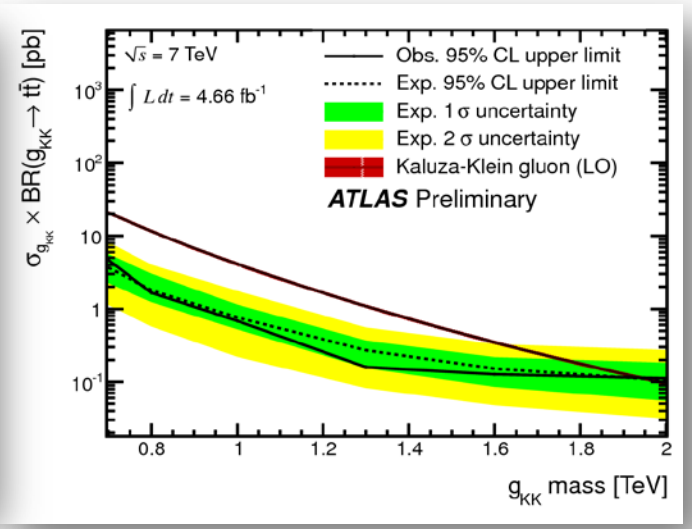
- *Improved electron reconstruction in ATLAS using the Gaussian Sum Filter-based model for bremsstrahlung*, (ATLAS-CONF-2012-047)
- *Search for a Higgs boson decaying to four photons through light CP-odd scalar coupling using 4.9 fb^{-1} of 7 TeV pp collision data taken with ATLAS detector at the LHC*, (ATLAS-CONF-2012-079)
- *Observation of an excess of events in the search for the Standard Model Higgs boson in the gamma-gamma channel with the ATLAS detector*, (ATLAS-CONF-2012-091)
- *Measurements of the photon identification efficiency with the ATLAS detector using 4.9 fb^{-1} of pp collision data collected in 2011*, (ATLAS-CONF-2012-123)
- *A search for tt resonances in the lepton plus jets final state using 4.66 fb^{-1} of pp collisions at $\sqrt{s}$ = 7 TeV*, (ATLAS-CONF-2012-136)
- *Measurement of the inclusive jet cross section in pp collisions at $\sqrt{s}$ = 2.76 TeV and comparison to the inclusive jet cross section at $\sqrt{s}$ = 7 TeV using the ATLAS detector*, (ATLAS-CONF-2012-128)
- *Measurement of top quark polarisation in tt events with the ATLAS detector in proton-proton collisions at $\sqrt{s}$ = 7 TeV*, (ATLAS-CONF-2012-133)
- *Performance of the Electron and Photon Trigger in p-p Collisions at $\sqrt{s}$ = 7 TeV with the ATLAS Detector at the LHC in 2011*, (ATLAS-CONF-2012-048)

Search for ttbar resonances

- Search for $X \rightarrow t\bar{t}$, X could be g_{KK}, G_{KK}, Z', …?
  $t\bar{t} \rightarrow l\,\nu\,j_b\;\;j\,j\,j_b$
- "Resolved" case: 1 *e* or *μ*, E_T^{Miss}, 4 (3) jets, 1 b-tag.
- "Boosted" case: the decay products may overlap, reconstruct the leptonic side with *l+ν+jet* (anti-kt 4), hadronic side with 1 fat jet (anti-kt 10) with substructure
- Look for deviations in the spectra, set limits if no deviation is found







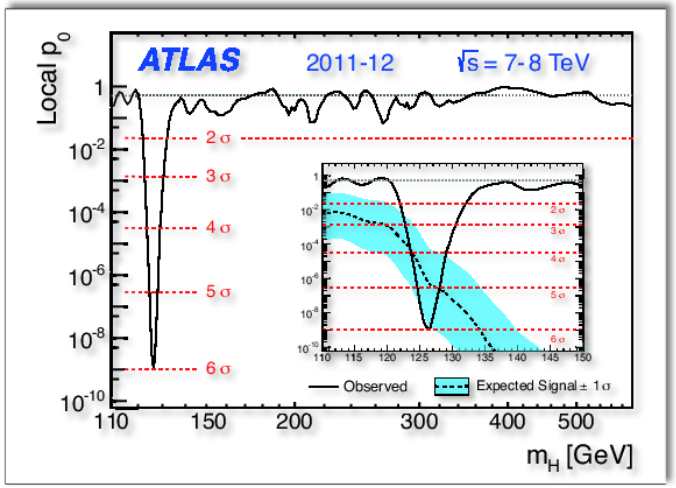
ATLAS-CONF-2012-136

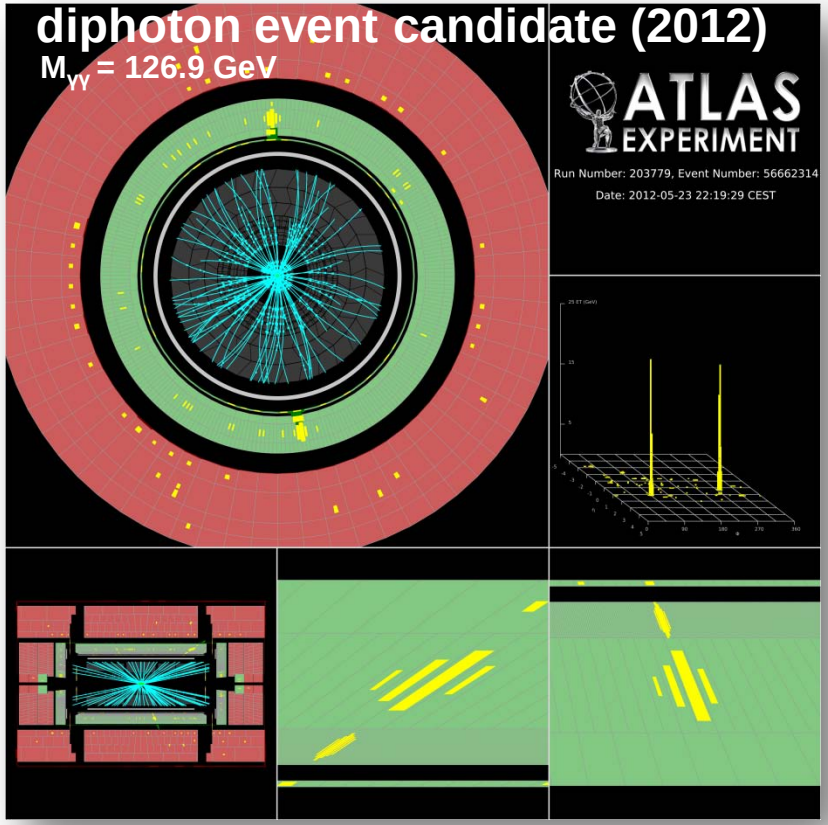
- No excess of events beyond the SM backgrounds is observed in the $t\bar{t}$ invariant mass spectrum
- The existence of the narrow leptophobic topcolor Z' is excluded at 95% CL in the range: $0.5\ \text{TeV} < m_{Z'} < 1.7\ \text{TeV}$
- g_{KK} is excluded for: $0.7\ \text{TeV} < m_{gKK} < 1.9\ \text{TeV}$

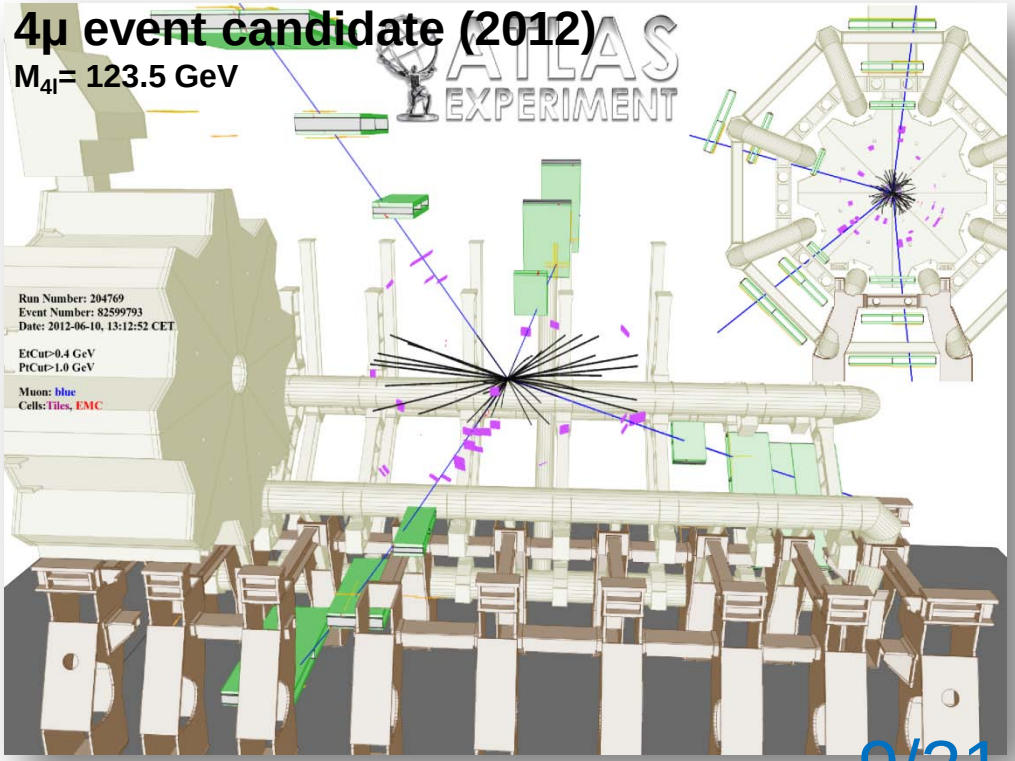
Higgs

arXiv:1207.7214 [hep-ex]

- **Discovery of a Higgs-like boson**
  - Discovery significance: 5.9 σ
  - m = (126.0 ± 0.4_{stat} ± 0.4_{syst}) GeV
  - Decaying into *γγ*, *ZZ* and *WW*
    → consistent with SM Higgs boson



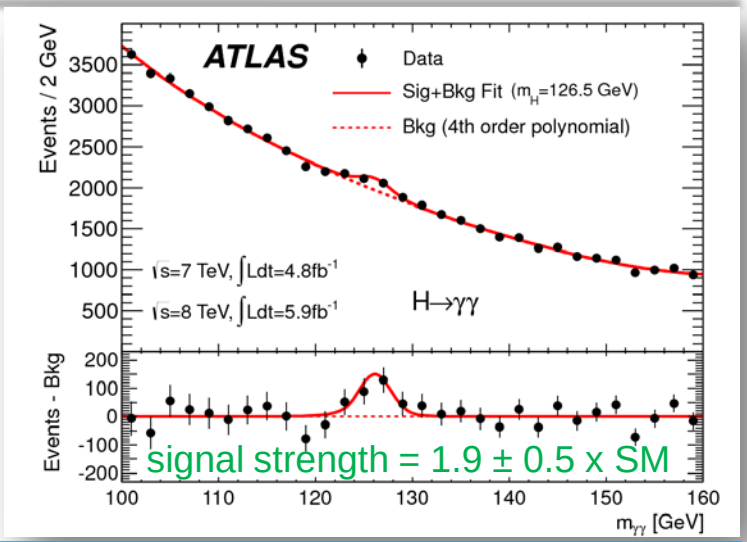


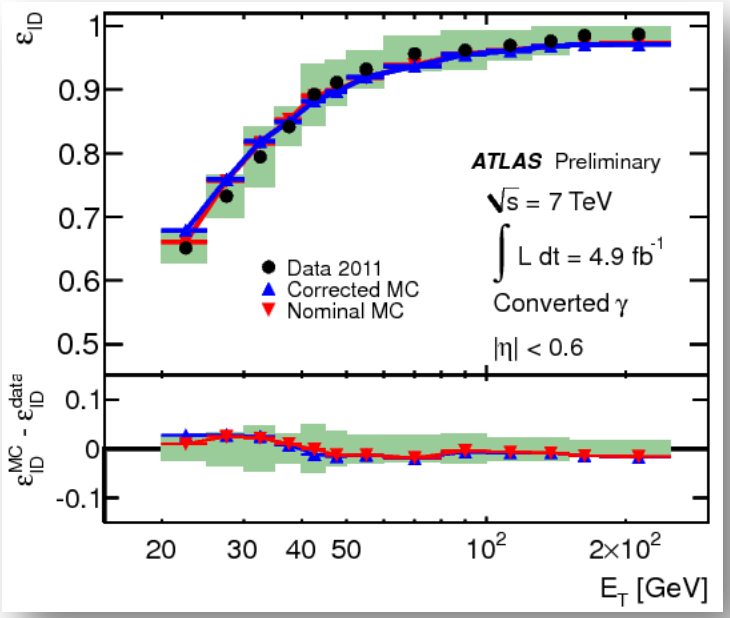


Higgs → γγ

- DESY contributes to H→γγ analysis

- Signature: 2 high-p_T isolated photons
- Small Br. frac., but good event yield (expect 185 events for SM Higgs) and high resolution
- Significance in γγ alone 4.5 σ at M_H = 126.5 GeV





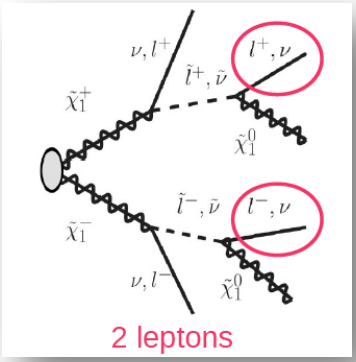
- After discovery: property measurements
- Well-understood photon id necessary for good measurement of signal strength
- DESY: Measurement of photon id efficiency extrapolating from $Z \rightarrow e^+e^-$ electrons and combination with other methods

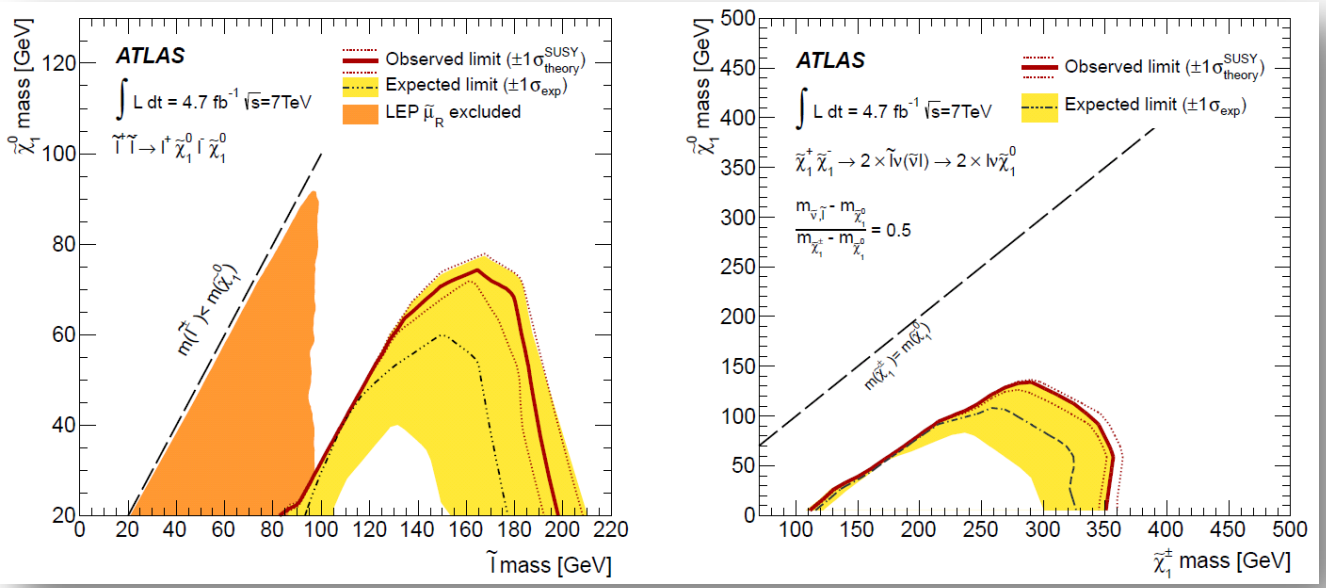
  Also: Limits on potential $H \rightarrow aa \rightarrow 4\gamma$ decay predicted in extensions of SM (for 100 MeV < m_a < 400 MeV)

SUSY Searches

- Direct *slepton* and *gaugino* production in final states with 2 and 3 leptons

- If squarks/gluinos are heavy, direct gaugino/slepton production may be the dominant production process at the LHC
- Consider final states with E_T^{Miss} and leptons (e, μ)
- Separate 2 and 3 leptons final states, define signal regions with and w/o jet veto
- Set exclusion limits for different models, for example pMSSM
- Full 2011 dataset analysed, 2 papers submitted to PLB

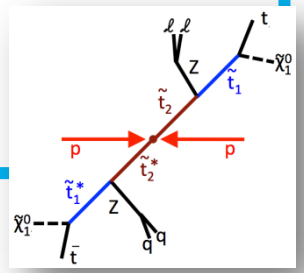




Other SUSY analysis (Update):

- Diphoton+E_T^{Miss} (4.8 fb^{-1},7 TeV)
- → accepted for publication in PLB
- Work on the full 2012 dataset continues

- New ideas: Stop2 search with 3 leptons + E_T^{Miss}



ATLAS Computing: Tier-2 and NAF

- **DESY T2's at Hamburg and Zeuthen well established in ATLAS!**
- T2D (good data connectivity)
- Multi-cloud production sites
- High analysis availability: >95%

  (for both HH and ZN, averaged over the last 6 months)
  → data acceptance status and share: alpha
- Better utilisation of dCache storage resources: merging of DATADISK and GROUPDISK space tokens

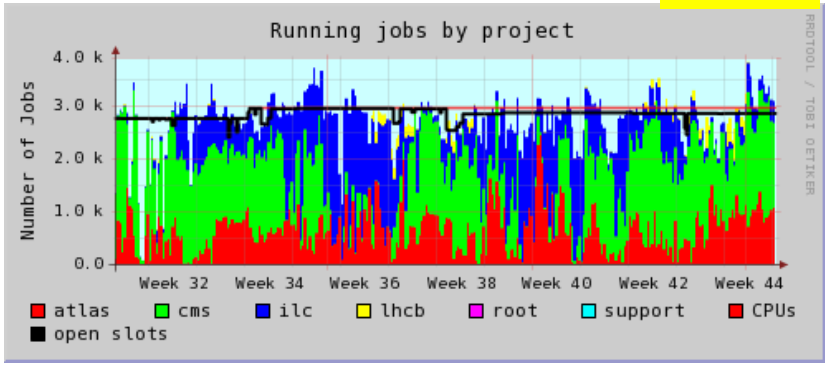
data acceptance status and share derived from analysis availability (9/12) for DE

T2

CSCS-LCG2_DATADISK	2.2 %	alpha
CYFRONET-LCG2_DATADISK	1.1 %	delta
DESY-HH_DATADISK	2.2 %	alpha
DESY-ZN_DATADISK	2.2 %	alpha
GOEGRID_DATADISK	2.2 %	delta
HEPHY-UIBK_DATADISK	0 %	delta
LRZ-LMU_DATADISK	2.2 %	charlie
MPPMU_DATADISK	2.2 %	alpha
PRAGUELCG2_DATADISK	1.1 %	bravo
PSNC_DATADISK	0 %	delta
UNI-FREIBURG_DATADISK	0.5 %	alpha
WUPPERTALPROD_DATADISK	2.2 %	alpha

- **The NAF is essential for the DESY ATLAS group and important for the German ATLAS Institutes**
- The assigned CPU resources (~29%→~900 slots) and storage resources are well utilised
- Deployed resources (CPU/storage) so far sufficient for partial 2012 data and MC set.

NAF



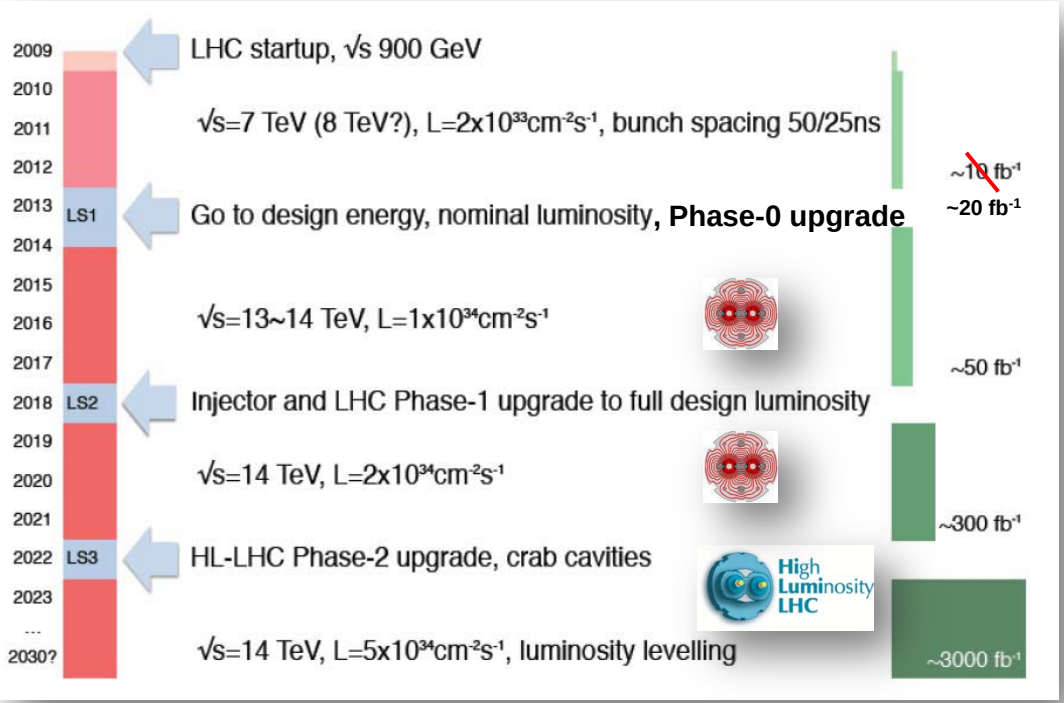
Detector Activities

Current ATLAS

- Semi-Conductor Tracker (SCT)
  - Operation/Calibration/Monitoring
  - Performance studies
- ALFA
  - Commissioning and Calibration
  - Operation and Analysis

Upgrades

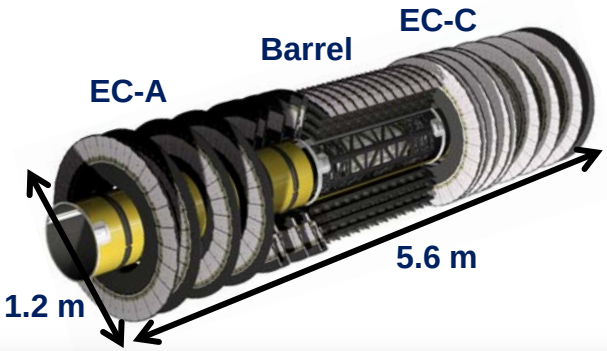
- Phase-0 Upgrade: Insertable B Layer
  - Test-Beam Support
  - Optical fibre procurement & QA
- Phase-2 Upgrade: Inner Tracker
  - Simulation and Detector Design
  - Endcap R&D and Construction

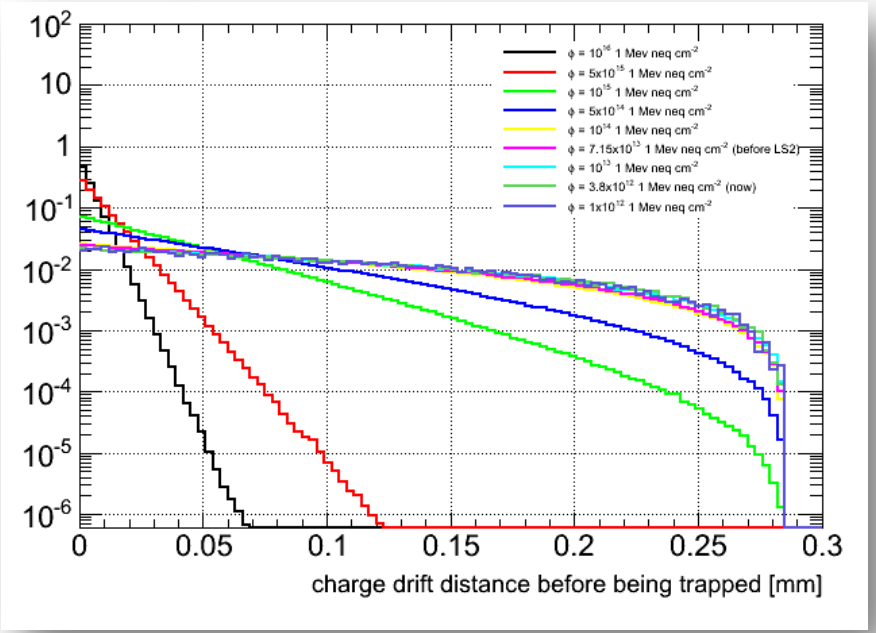


Semi-Conductor Tracker (SCT)

- DESY plays a leading role in SCT operations and performance studies
- Responsible for prompt calibration loop at Tier0 (expert level)
  - Calibration code improvements
  - Factor 3 time reduction
  - Survey of communication to DB
- Radiation damage studies
  - Improved modeling in MC Simulation
  - Charge Trapping in SCT digitization
- Modelling energy losses (dE/dx) in SCT
- Combination of all monitoring inner detector shifts into a single one is foreseen
  - Could be done at DESY after the shutdown (LS1)

- 4088 silicon modules
- 6.3 million readout channels (~ 61 m² of silicon)
- 4 barrel layer, 9 disks/endcap

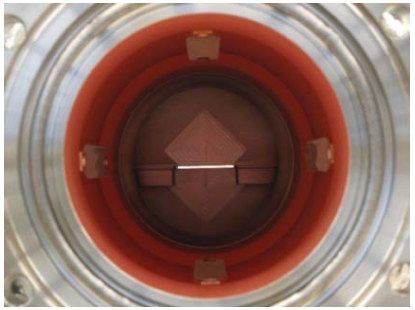




ALFA

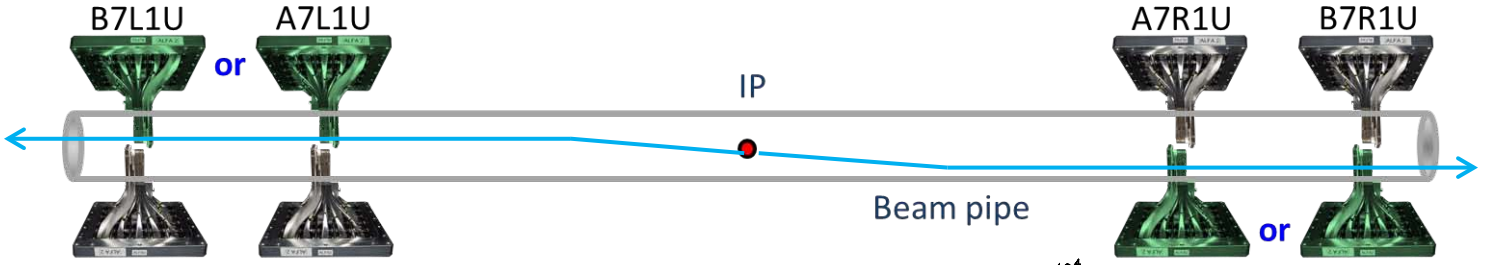
Detection of small angle proton scattering to measure at LHC energies:

1) Total / elastic / inelastic cross sections
2) Luminosity
3) Diffractive processes



Detector:

Fiber detectors in 4 Roman Pot stations at about 240 m from ATLAS IP

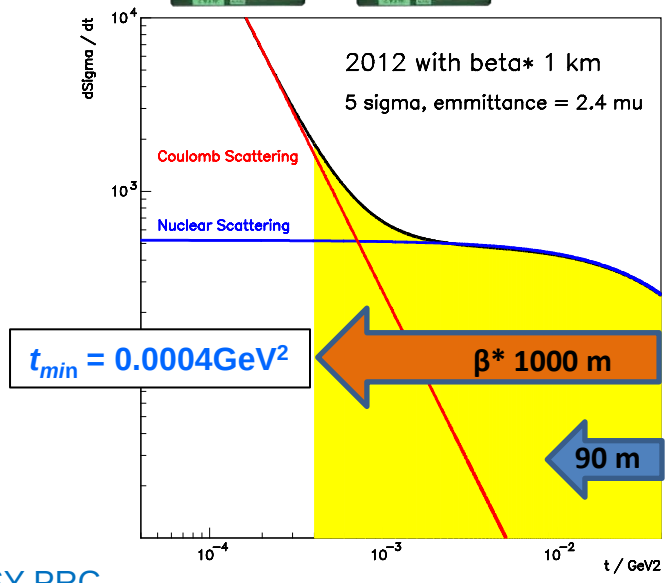


Status of physics data taking & analysis:

Oct 2011: β*= 90m, 3.5 TeV, detectors at 6.5 σ
analysis for σ_{tot} close to end

July 2012: β* = 90m, 4 TeV, detectors at 9.5 σ
for σ_{tot} at higher energy

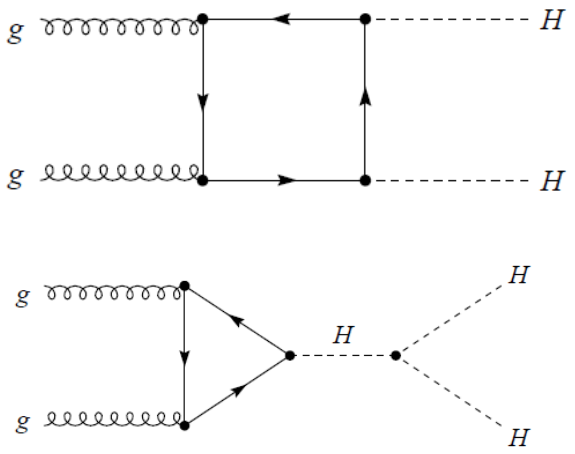
Oct 2012: β* = 1000m , 4 TeV, detectors at 3σ ~ 0.8mm to beam
1st measurement in the Coulomb-Nuclear interference region for σ_{tot} and luminosity



Higgs Self-Coupling at HL-LHC

- HL-LHC project is not approved yet
- Well justified physics case is needed, e.g, Measuring the Higgs-Self Coupling

- Self-interaction is a fundamental property of the SM Higgs
  - Can be observed as a destructive interference contribution to the total Higgs pair production cross section
  - 3000 fb^{-1} HL-LHC data sample would provide a good opportunity to measure this, therefore studied as input for ATLAS contribution to European Strategy Preparatory Group
- DESY contributed analysis of *HH → bbγγ*
  - Generator-level study, using parameterised smearings of efficiencies/fake rates/resolutions to approximate expected detector performance under HL-LHC conditions
  - Predict ~15 signal events with S/B ~0.6 ($S/\sqrt{B}$ ~3)
- Assuming that combining other channels gives sensitivity at same level as *HH→bbγγ*, and combining ATLAS and CMS results, 30% measurement of self-coupling strength λ_{HHH} may be possible



Backgrounds:
ttH, H→gg, H→bb, ZH, Z→bb

ATLAS Inner Tracker Upgrade

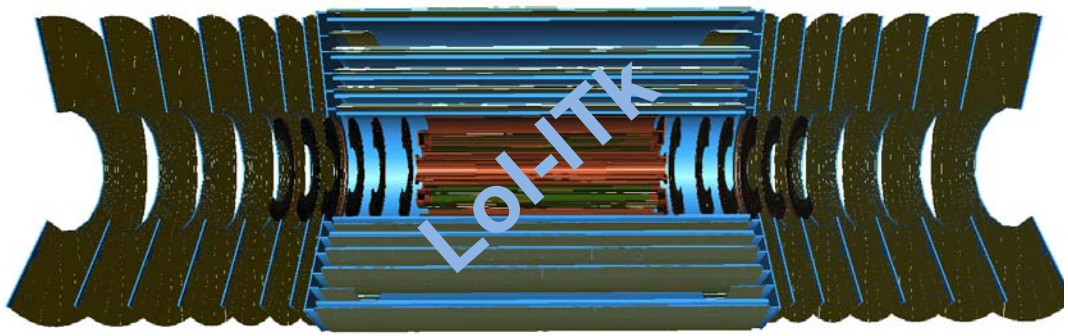
- ***ATLAS Phase-2 Plans***, 2022-2023 → ***Full tracker replacement***
- All new tracker, completely made of silicon, no TRT
- Higher granularity
- Improved material budget
- Baseline: Layers of pixels and micro-strips
- DESY is involved in the Layout design and MC Simulations and Optimization and in the R&D for the Si-strip Endcaps (made of Si Petals)
- Recent developments:
  - The final Letter-of-Intent Tracker layout (*LoI-ITk*) has been defined
  - Implemented in the ATLAS software for full simulation
- Performance studies should validate this layout and provide more concrete numbers for the ATLAS LoI for Phase-2 (under preparation)

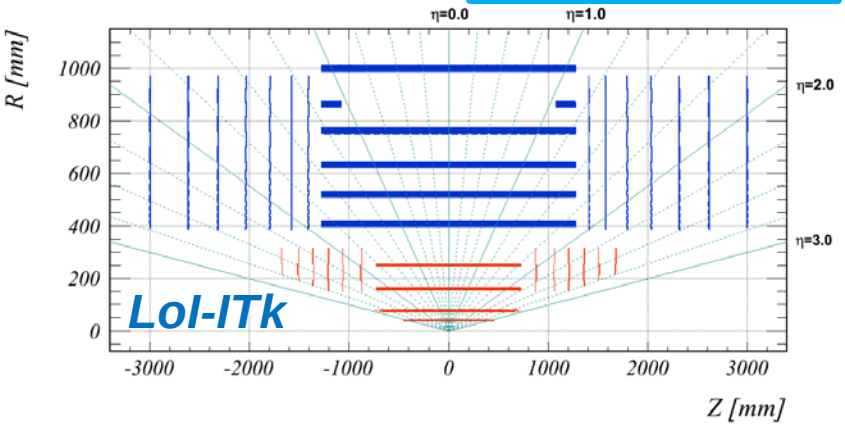
LoI-ITk

Pixels:
- Barrel: 4 layers
- Pixel sizes:
  - 25x150μm
  - 50x250μm
- Endcap: 6 discs
  - Rings of hex and quad mods

Si-Strips:
- Module:
  - 2 Si-sensors at 40 mrad
- Barrel: 5 layers
  - 2 short strip (23.82 mm)
  - 3 long strip (47.64 mm)
  - 74.5 μm pitch, 1280 strips/mod
- Endcap: 7 discs

strip sizes
– from 8.1mm to 58.3mm



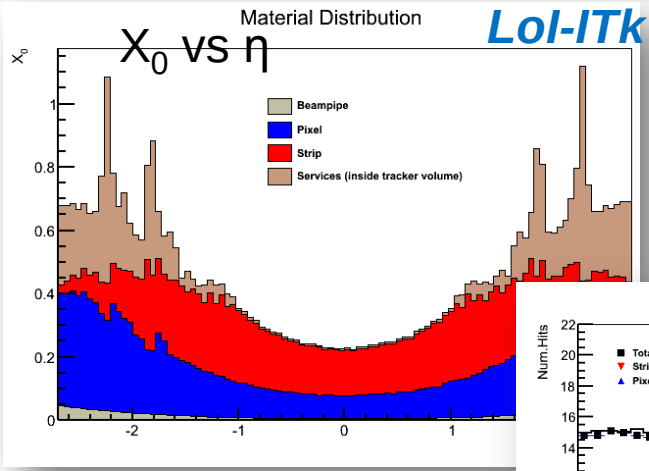


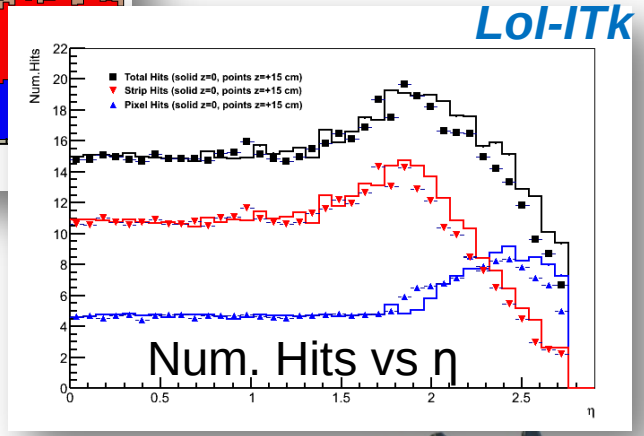
Simulations for ATLAS Inner Tracker Upgrade

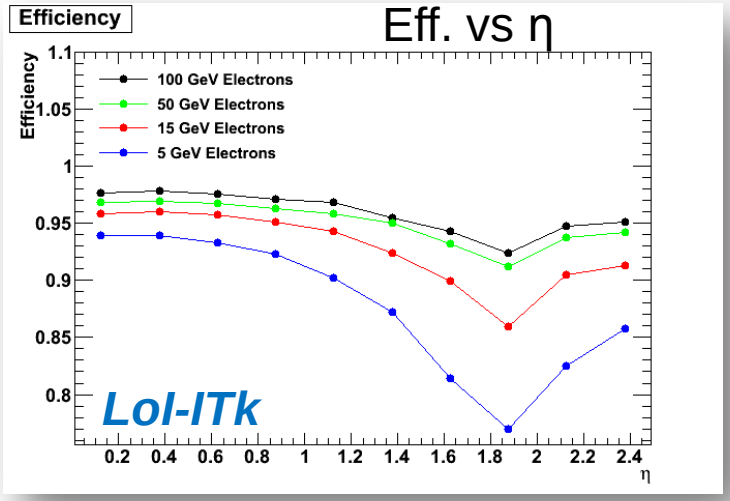
- DESY is leading the simulation effort for the Tracker Upgrade
- Both conveners are from DESY

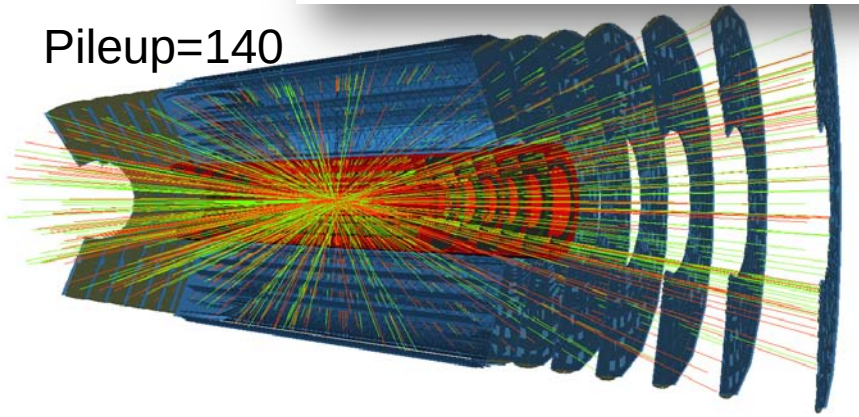
DESY activities:

- Layout Design
- B-tagging/Vertexing
- Pixel Cluster Splitting
- New Pixel Service Routings
- Performance analysis



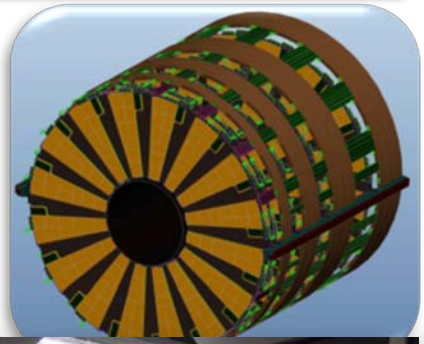


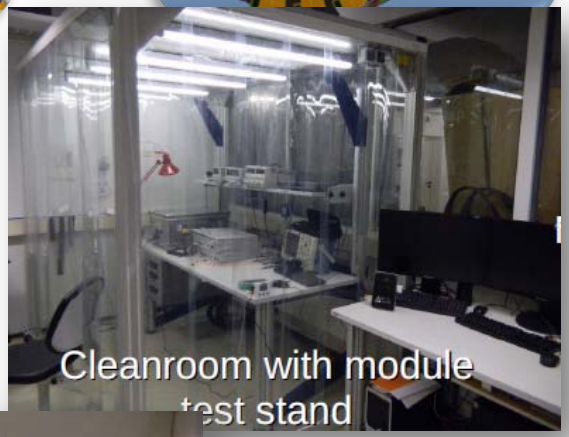


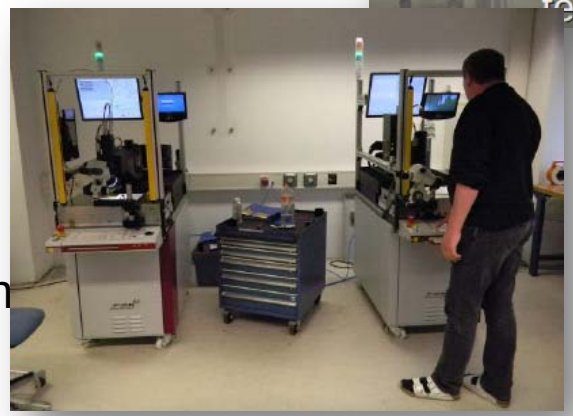


Tracker Upgrade for Phase-2

- Build complete prototype endcap sector (PETAL 2014)
- Lab Infrastructure
  - New wire bonding machines delivered (Hamburg shared with CMS, Zeuthen with HU)
  - Electronics labs now well advanced, more infrastructure to be installed soon
  - Identical DAQ setups on both sites
  - Automation of chillers and power supplies completed
- Summer students had successful projects
  - Providing hands-on training & experience
- End of Substructure Readout:
  - DESY is leading design, working on material reduction, close collaboration with integration group



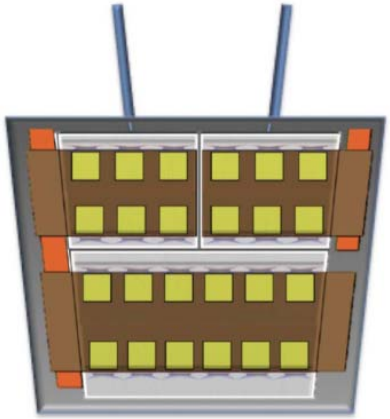




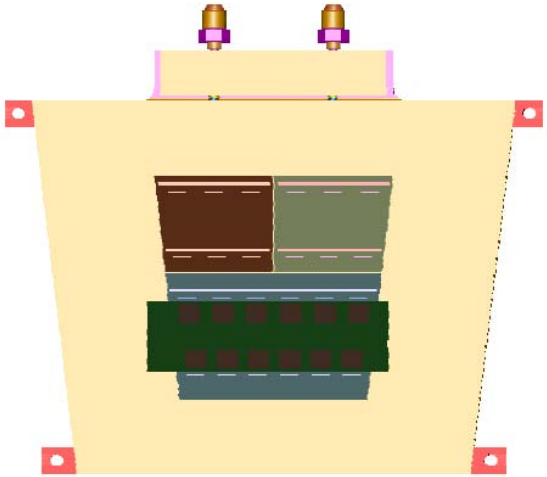
Tracker Upgrade Highlight

The Petalet Project

- Working towards Petal2014 project
- New intermediate step
  "petalet" = a small size petal
- The Petalet project
  - Will address petal specific questions: stereo angle, bonding angles, wedged shaped sensors etc.
  - DESY is working on module production, electrical design, carbon local support and FEA simulations
- Good progress with Petalet mechanics: coordination, drawings completed, manufacturing started
- Titanium tubing work successful
- Petalet preparations progressing, estimated completion early 2013



Petalet



Summary

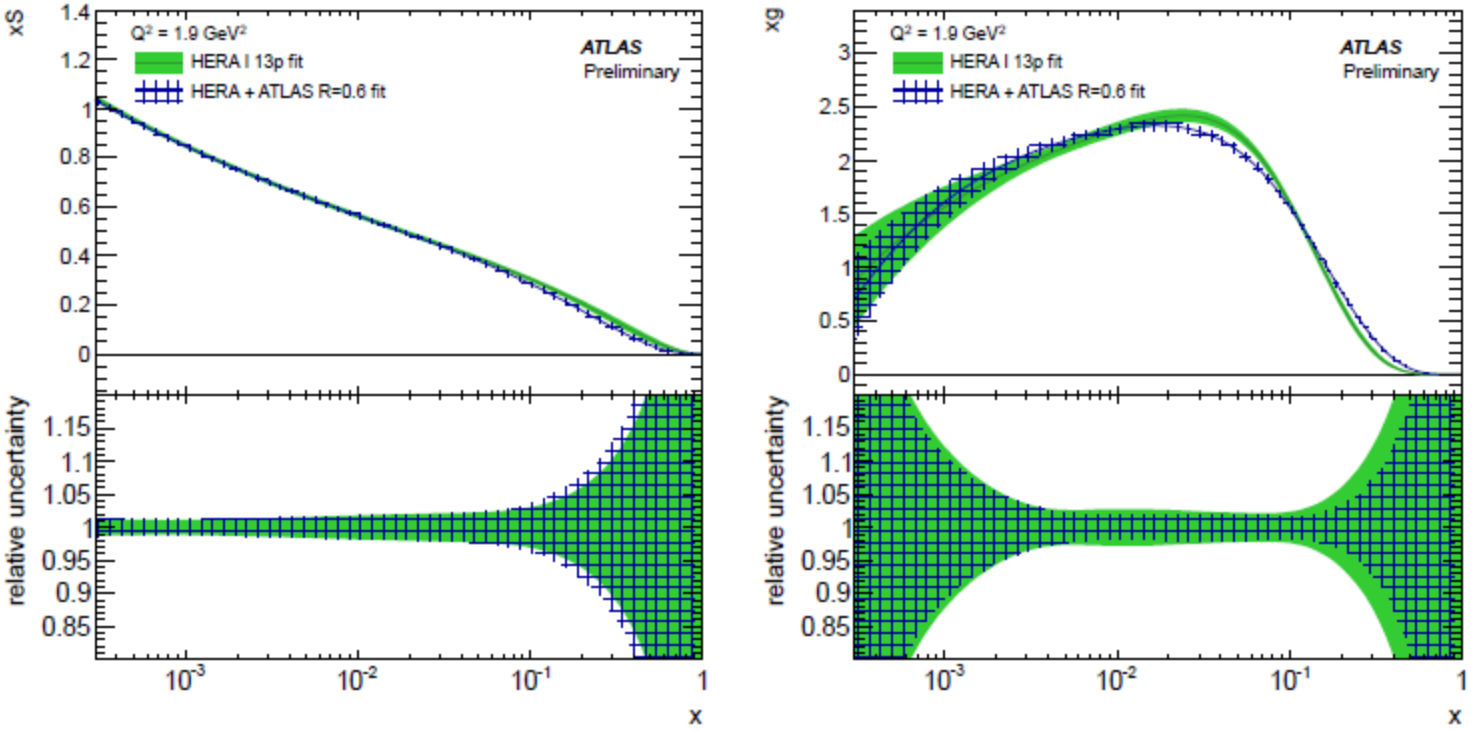
- DESY contributes significantly to ATLAS operation/physics/upgrade
  - Several DESY members occupy coordinating positions
- Involved in many interesting physics analysis
  - SM measurements and MC tuning
  - Top measurements
  - Higgs
  - SUSY searches
- Contributes to ATLAS operation via
  - SCT, ALFA → high β* run performed
  - Trigger, Performance optimizations and Computing
- Actively involved in the Tracker Upgrade simulations towards Phase-2 LoI
- The PETAL R&D is progressing → ”petalet” project develops well

Additional Material

PDF fit to ATLAS jet data: Fit results

ATLAS-CONF-2012-128

very good fit quality for both distance parameters



By including the ATLAS jet data, a harder gluon distribution and a softer sea quark distribution in the high Bjorken-*x* region are obtained with res pect to the fit of HERA data only.

The presented measurement is an interesting input for various PDF studies.