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The ATLAS Pixel Detector

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ATLAS

1st collisions expected in Summer 2005

The ATLAS Detector





all purpose particle detector

1700 scientists from 33 countries

pixel detector (3 barrel and 10 disks) closest to interaction point (hot (300kGy), hard to access) ~0.35m

1.6m

-30m Pixel must be ready 1/2004 for insertion in ID, 4-6/2004 barrel ID inside experimental area.

pp collisions at 14 TeV





pp collisions every 25 ns, ~1000 tks per 25 ns, 6 x 10¹⁰ per second **Þ** high radiation dose @10cm 300 kGy or 10¹⁵ n_{eq} / cm²



mandatory to: minimise scattering \Rightarrow thin low-Z materials know pixel coordinates \Rightarrow stability & alignment

The Hybrid Pixel Technique





sensor and FE-chip are 2D matrices connected using bump and flip chip technology. Pixel size driven by electronics integration, in ATLAS : 50 x 400 mm (50x300 mm in the innermost (B_)layer). Single sensor and multiple electronics chips = module.



The Sensor

2D matrices of diodes on high resistivity silicon.

4" wafer 250 m thick with 2 "tiles" and some smaller devices to tune the technology. There will be 3 tiles in production.

Tiles ~10 cm², ~50k channels (pixels). The starting point for a "module"

Sensors satisfactorily tested up to full fluence (10¹⁵/cm²). Production Readiness Review (PRR) recently passed. Order will be placed in June.





Threshold: 3 Ke

	Old Design 280 µm		New Design 200 µm		Old Design 10 ¹⁵ n/cm ²	
	T2	T1	T2 bg	T2 nbg	T2	T2 x,y cut
1 hit	82.0	72.0	81.8	84.4	86.3	94.2
2 hits	14.6	25.2	15.6	15.0	7.6	3.1
≥3 hits	2.2	2.4	1.7	0.1	1.4	1.1
Efficiency	98.8	99.6	99.1	99.5	95.3	98.4
Losses	1.2	0.4	0.9	0.5	4.7	1.6
0 Hits	0.4	0.1	0.4	0.4	2.2	0.4
Not matched	0.2	0.2	0.1	0.0	0.1	0.0
Not in time	0.6	0.1	0.4	0.1	2.4	1.2

The Front-End electronics



Rad soft electronics was built, bump bonded on sensor and operated on beam.

LHC specs have been met.

Routine operation at 3000 e⁻ threshold with both \mathbf{s}_{noise} and $\mathbf{s}_{thr} \sim 150e^{-}$. Small timewalk: need ~600e⁻ above threshold to have signal inside 25ns.







Several single and multiple assemblies operated on beam with also the Module Control Chip (MCC), a controller and event building asic which must stay on the module.

Efficiency and resolution of assemblies as expected.

Transition to rad-hard is still ongoing and has proven to be more difficult than anticipated.

First complete FE chip design in DMILL showed poor yield and some behaviour not explained by simulation, while the MCC controller chip did work as expected.

Next rad-hard iteration at beginning of May.

Final Design Review (FDR) of front-end electronics: Sept 00, PRR March 01.

Module is the basic building element



Module = 1 silicon tile + 16 FE chips + fan-out bussing + control chip (MCC) + data transmission (not shown)



PRR (bare module)=9/00, PRR(flex)=5/01

Bump-bonding



Good quality high density bump-bonding has been obtained with 2 firms, a 3rd one under study.

Example of source scan at boarder of 2 chips



INFN-Alenia



bumps: 50 µm pitch, PbSn or Indium, 7-20 µm high, ~3000/chip, 48000/module

Overall Layout (mosaic of modules)





structure, 3 parts, very stiff

2 x 5 disks

- 3 barrel layers (1 & 2, B-layer)
- 2100 modules (~1000 4" wafers) , ~2 m^2
- ~ 10⁸ pixel (50 x 400/300 µm²)
- hermetic down to 15 deg. (|h|<2.5)use low-Z and thin material (C, Si).



Openings needed for services

Mechanics (local supports)



Local supports made of carbon-carbon, coolant flows in CFR or in Al tubes. Modules are glued on c-c surface. Overlap of modules allows hermeticity down to 2 GeV/c p_T and $|\mathbf{h}|$ <2.5.



Cooling



Baseline is evaporative C_3F_8 , possible to cool two staves in series (simplify services). Stave is the most critical for cooling (more power, asymmetry).

Low stave deformations during cool-down





Pixel Detector: Participating Institutes



Canada

• University of Toronto

Czech Republic

• Academy of Sciences - Institute of Physics of Prague, Charles University of Prague, Czech Technical University of Prague

France

• CPPM, Marseille

Germany

• Bonn University, Dortmund University, Siegen University, Bergische University -Wuppertal, MPI Munich (R&D only)

Italy

• INFN and University of Genova, INFN and University of Milano, INFN and University of Udine

Netherlands

• NIKHEF - Amsterdam

8US labs/20 all labs

Taiwan

• Taiwan University

USA

 University of New York - Albany, LBL and University of California - Berkeley, Ohio State University, Iowa University, University of New Mexico, University of Oklahoma, University of California - Santa Cruz, University of Wisconsin - Madison

