

Test-Beam Results of the AMS 180 HVCMOS prototypes

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- Telescope overview
- HVCMOS v2 and v4 designs and samples
- Efficiency, timing and ToT results
- Threshold and Bias scans



IBL Modules Telescope

- 6 DoubleChip IBL modules (2 x 2 cm²/FE)
- Pixel size of 250 x 50 µm (x-y) for non rotated planes (0,2,3 and 5)
- Trigger on planes 0 and 5 or Scintillators
- ROI can be defined on planes 0 and 5
- RCE readout up to 8 FE (6 telescope planes + 2 DUT) giving thanks to SLAC for the support.





IBL Modules Telescope

- 100 kHz trigger rate during data taking
- >10% of triggers had a hit on the DUT thanks to the ROI definition





Reconstruction Software

- Reconstruction software: JUDITH
- Adapted to handle the telescope geometry (pixel asymmetry and plane rotations) and additional control plots





HVCMOS v2

- HV-CMOS version 2
- Sensor Size (2.2 x 4.4 mm²):
 - 36 x 36 sub-pixels (864) each pixel of 33 x 125 µm
- Merged pixels during reconstruction to handle "chest" structure



Pixels of 100 x 250



v4 structure

• Several HVCMOS pixels flavours in the HVCMOS v4 structure:





v4 structure

- Stime HVCMOS pixels
- Standard pixels with new voltage-mode amplitude or pulse length coding
- 16 x 5 unit cell, containing 6 HVCMOS pixels 33 x 125 µm
- Different inner pixel connection with respect to v2. Not needed to be taken into account on the reconstruction thanks to the merging



Pixels of 100 x 250

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HVCMOS samples



12 Billion triggers during 2014 SPS data taking



AMS 180 v2 efficiency

C19, unIrradiated Bias 90 V, Th 0.94 V

Υ position [μm] 0.9 2600 0.8 2400 0.7 2200 0.6 2000 0.5 0 658458 0.4 1800 0.3 1600 0.2 1400 0.1 500 -2000 -1500 -10000 -500X position [µm] Special pixels not tuned

C22, 10¹⁵ n_{eq}/cm² Bias 80 V, Th 0.94 V

Few HVCMOS pixels showed no output signal

Ē		0.82635	0.898517	0.88002	0.895143	0.87852	0.86863	0.833914	0.839073	0.823537	0.851828	0.855695	0.855477		
Y position [µ	800	0.912136	0.949819	0.928985	0.931607	0.959665	0.961356	0.919326	0.944467	0.966543	0.934977	0.945035	0.959217		0.9
	600	0.914185	0.962991	0.947067	0.521502	0.917955	0.973328	0.969942	0.977456	0.933459	0.924262	0.973085	0.926926		<u> </u>
		0.869508	0.969125	0.950827	0.927902	0.960451	0.933516	0.947005	0.957862	0.967497	0.905624	0.963215	0.953271		0.8
	400	0.479134	0.946105	0.948976	0.92976	0.951863	0.513783	0.894175	0.924123	0.911758	0.944184	0.944885	0.947677		0.7
		0.823125	0.96612	0.944193	0.534255	0.942167	0.5248	0.933204	0.887004	0.878222	0.907009	0.938456	0.919506		
	200	0.908571	0.959217	0.925157	0.918949	0.936572	0.926218	0.946749	0.913011	0.957926	0.886528	0.964152	0.954961		0.6
		0.913194	0.95006	0.953328	0.930623	0.956684	0.923557	0.911474	0.5379	0.889129	0.915523	0.94492	0.949588		0.5
	~	0.917146	0.963199	0.940399	0.934954	0.954574	0.542169	0.875766	0.884615	0.919285	0.937285	0.904715	0.945136		
	0	0.921599	0.981609	0.970476	0.951146	0.954112	0.913782	0.943186	0.893009	0.482303	0.913683	0.54831	0.929115		0.4
	000	0.874977	0.964516	0.91282	0.940127	0.968067	0.962392	0.796752	0.524499	0.807026	0.894958	0.909157	0.923796		0.2
	-200	0.838248	0.896902	0.530244	0.877468	0.913678	0.885329	0.887661	0.867019	0.87947	0.867338	0.912401	0.90017		0.3
	-400	0.273595	0.24574	0.270091	0.187385	0.232387	0.243297	0.236141	0.208368	0.24861	0.217429	0.274891	0.306391		0.2
Ĉ		0.276284	0.3015	0.254219	0.241911	0.295946	0.246995	0.262213	0.209917	0.235688	0.248006	0.275823	0.305896		
	600	0.245354	0.247309	0.270305	0.246487	0.245917	0.314421	0.275097	0.193197	0.295594	0.245172	0.286942	0.339064		0.1
		0.224858	0.271644	0.234735	0.260906	0.276295	0.277517	0.222455	0.175206	0.228041	0.173441	0.241345	0.214219		0
			500		1000		1500		2000		2500 X por		3000		•
	Special pixels not tuned													μΠ	

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AMS 180 v2 efficiency

C19, unIrradiated Bias 90 V, Th 0.94 V

C22, 10¹⁵ n_{eq}/cm² Bias 80 V, Th 0.94 V







v2 InPixel eff.

C19, unIrradiated Bias 90 V, Th 0.94 V

2x3 HVCMOS pixels in 1 unit-cell



eff. all Lv1: 99.7%

C22, 10¹⁵ n_{eq}/cm² Bias 80 V, Th 0.94 V



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v4 Global eff.

402, unIrradiated Bias 12 V, Th 0.84 V

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404, 10¹⁵ n_{eq}/cm² Bias 30 V, Th 0.84V



1 HVCMOS Row was off during data taking







v4 InPixel eff.

402, unIrradiated Bias 12 V, Th 0.84 V



Possible misalignment on Y axis observed

404, 10¹⁵ n_{eq}/cm² Bias 30 V, Th 0.84V



InPixel lower efficiency in the HVCMOS pixel boundaries



v4 Timing vs Bias V.

402, unIrradiated Th 0.84 V



404, $10^{15} n_{eq}/cm^2$

Th 0.84V

Higher Bias show sharper timing distributions



v4 Timing vs Bias V.

402, unIrradiated Th 0.84 V



404, $10^{15} n_{eq}/cm^2$

Th 0.84V

Higher Bias show sharper timing distributions

Higher Bias show smaller tails, Indication for possible diffusion effect.



v4 Timing vs Bias V.

Integrated signal fraction over X of the most populated bins, from 1 single BC to 16 BC in 25 ns units





v4 Timing vs Threshold.

402, unIrradiated Th 0.84 V 404, 10¹⁵ n_{eq}/cm², Bias 30 V



Low threshold show smaller tails, indication of a time-walk effect.



v4 Timing vs Threshold.

402, unIrradiated Th 0.84 V 404, 10¹⁵ n_{eq}/cm², Bias 30 V



Low threshold show smaller tails, indication of a time-walk effect. High threshold reduces the diffusion contribution (low Amplitude).



v4 Timing comparison





402, unIrradiated Bias 12 V, Th 0.84 V

404, $10^{15} n_{eq}/cm^2$ Bias 30 V, Th 0.84V



InPixel Timing inhomogeneities showing later events in the HVCMOS pixel boundaries. Not present on irradiated sample



402, unIrradiated Bias 12 V, Th 0.84 V



Observing this in pixel timing inhomogeneity for the unIrradiated sample and the presence of a tail at higher Lv1 values, we've decomposed the in pixel eft for each Lv1:















DUT Plane0 In Pixel Timing plap for Ivl= 4 bc









DUT Plane0 In Pixel Timing Map for Ivl= 2 bc



Contribution from the pixel edges for the non-irradiated sample. Consistent with diffusion effects.





DUT Plane0 In Pixel Timing Map for Ivl= 4 bc



DUT Plane0 In Pixel Timing Map for lvl= 5 bc



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v4 ToT inPixel

402, unIrradiated Bias 12 V, Th 0.84 V Run: 3911 - 3915 404, 10¹⁵ n_{eq}/cm² Bias 30 V, Th 0.84V Run: 4074



InPixel ToT inhomogeneities, under investigation with the unit-cell design



Bias Scan



- Need to reach higher depletion voltages. Limited availability of prototypes during data taking.
- Full range will be scanned with source measurements on new samples.



Threshold Scan





Conclusions

- Efficiency before irradiation >99%
- Decrease of efficiency to 96% at 10¹⁵ n_{eq}/cm², irradiated samples efficiency can be increased with higher depletion voltages.
- Diffusion component seen for the unirradiated sample.
- Timing dependence on Threshold tuning indicates some time walk
- This time features will be addressed in next AMS prototypes.



v4 structure

• Several HVCMOS pixels flavours





v4 ToT vs Lv1

402, unIrradiated Bias 12 V, Th 0.84 V Run: 3911 - 3915

404, 10¹⁵ n_{eq}/cm² Bias 30 V, Th 0.84V Run: 4074





v4 structure

• Several HVCMOS pixels flavours





Analog pixel - ToT vs Lv1

402, unIrradiated Bias 12 V, Th 0.84 V Run: 3966 - 3967

