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Negative charge measurements with ATLAS SCT readout

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Introduction

ATLAS SCT readout for strip detectors is designed for reading positive charge collected on strips on p in n type silicon detectors

Some features of ABCD chips give possibility to readout also negative charge from n in p type silicon detectors

Changes in software and obtained results are presented in this talk

Steps of readout

TRIGGER delay setting of edge for negative calibration pulse
Trigger burst for negative calibration pulse
Threshold scan for negative calibration pulse
Fit of threshold scan
Strobe delay for negative calibration pulse
Three point gain scan
Response curve (RC) scan
Time walk scan
Noise occupancy scan
Trimming
Comparison of gain and noise
Code and macros
Installation notes

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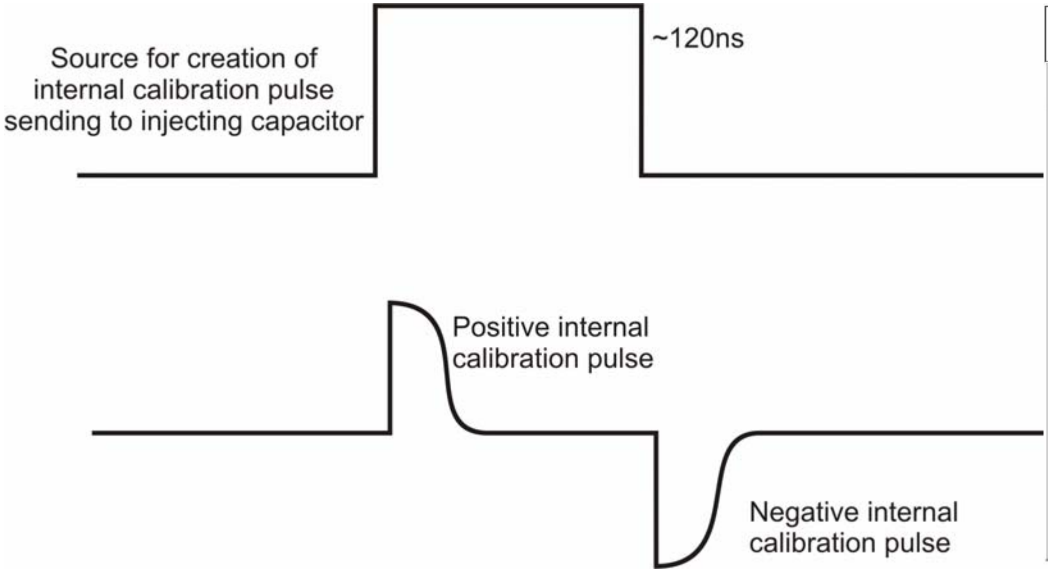
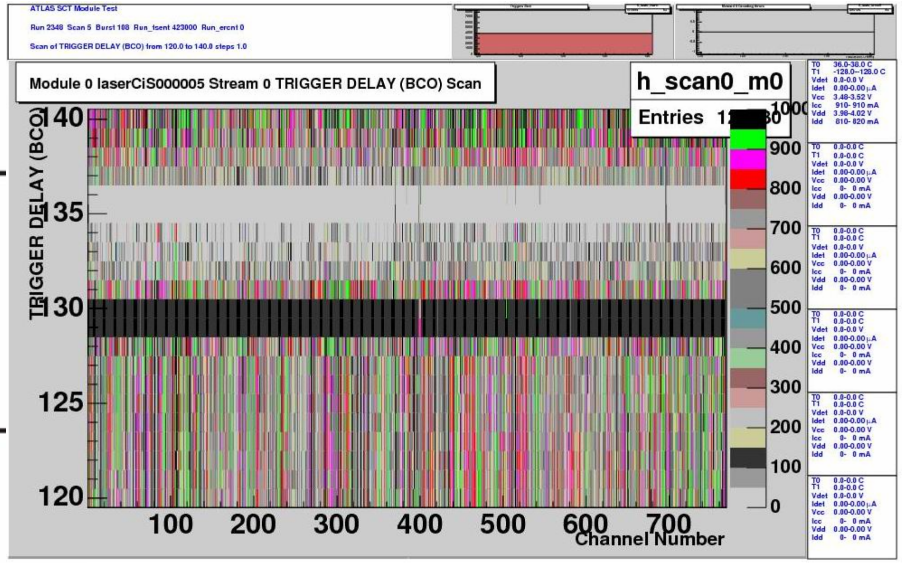
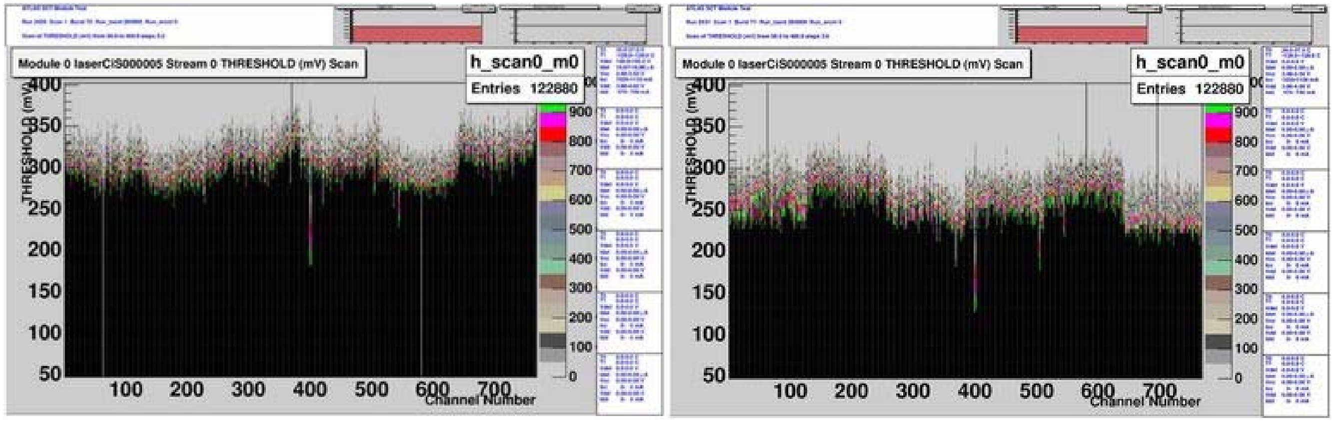
TRIGGER delay setting of edge for negative calibration pulse





ATLAS SCT ASIC was designed to measure positive pulse. It can be used to measure negative charge using ABCD trimming feature. But in order to calibrate the FE using internal calibration circuit further tricks must be performed. This is schematically shown at the figure. Here discharging of the capacitor is used instead of charging up.

Trigger burst, threshold scan and fitting for negative calibration pulse



Threshold scan with fit of S-curves for positive charge (left) and negative charge calibration (right)

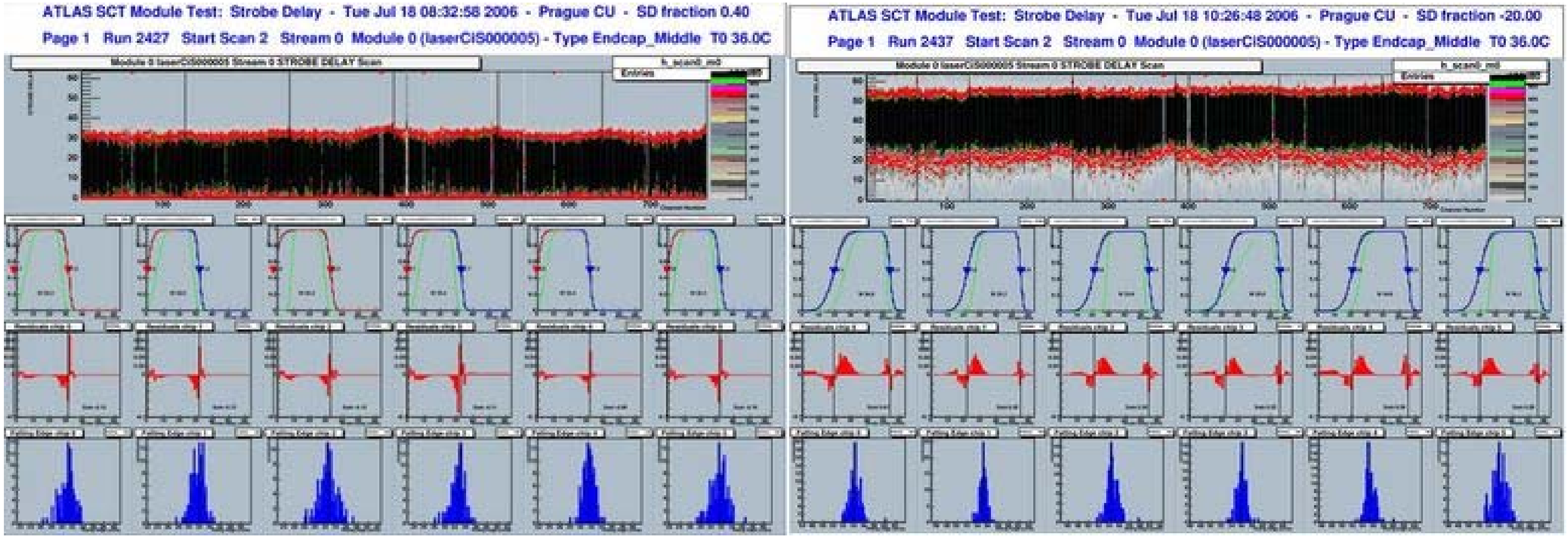
Threshold setting is transformed using formula:

$$thr_{neg} = zero_{thr} + slope_{thr} * thr_{pos}$$

Next important change is in masking of problematic channels: after receiving of histogram from MUSTARD we mask list of channels and set than to 0 in trigger burst, so all next steps work with masked channels. This is different to positive charge, when channels were masked in ABCD chips in hardware level.

For fitting threshold scan standard SCTDAQ macros are used

Strobe delay for negative calibration pulse



Strobe delay for positive charge (left) and negative charge calibration (right)

This scan requires change in Edge mode and Compression. Value of calibration pulse and threshold had to be returned. Final value of strobe delay is calculated as a position of falling edge minus 20 units.

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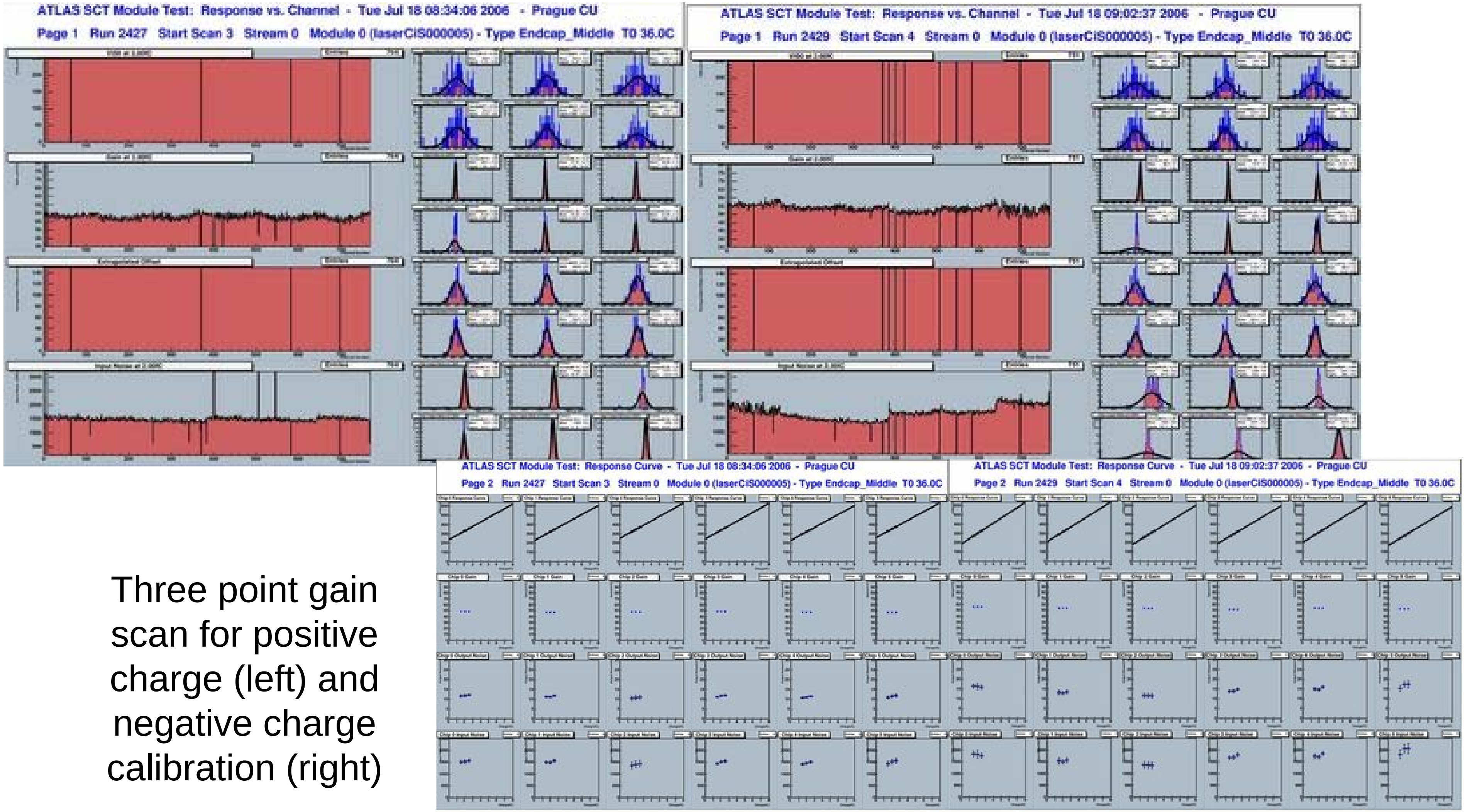
Three point gain scan



Three point gain scan for positive charge (left) and negative charge calibration (right)

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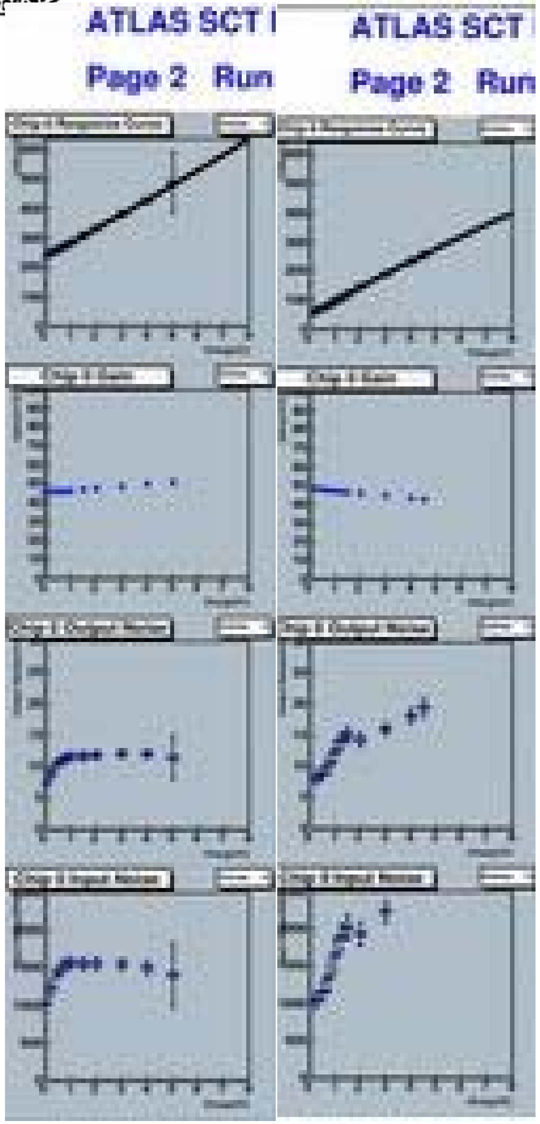
Response curve (RC) scan



#Loop B - Gain, Offset, Noise at 1.00fC

#	vt50	gain	offset	outnse	innse
#M0	137.1	48.0	89.9	13.87	1727
#S1	143.7	50.1	94.8	12.71	1584
#S2	142.8	45.1	97.2	10.14	1359
#S3	141.0	43.5	95.6	12.11	1528
#S4	137.6	46.3	92.3	13.39	1725
#E5	135.4	47.2	90.8	14.23	1824
#M8	132.1	45.3	88.7	13.69	1799
#S9	136.0	49.0	89.7	14.86	1865
#S10	145.5	48.1	97.3	13.31	1676
#S11	141.3	44.7	96.6	10.89	1474
#S12	136.3	48.0	89.9	11.68	1519
#E13	138.8	46.9	93.7	14.20	1830

Response curve scan for positive charge (left) and negative charge calibration (right)

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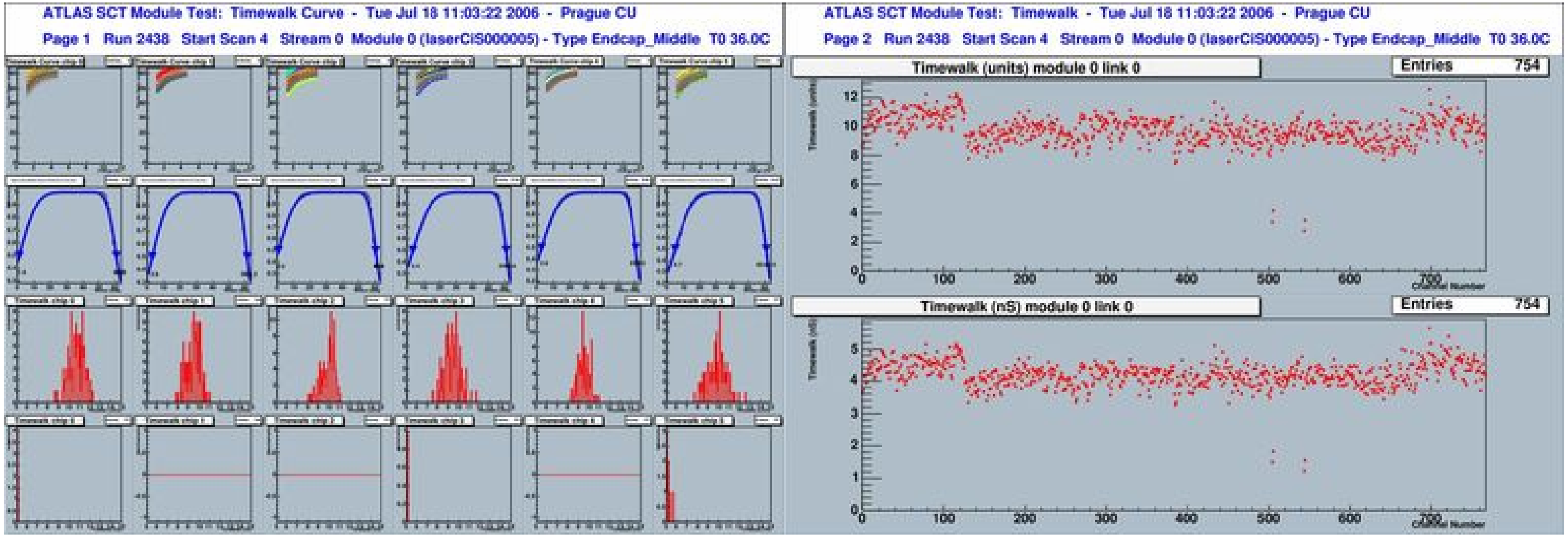
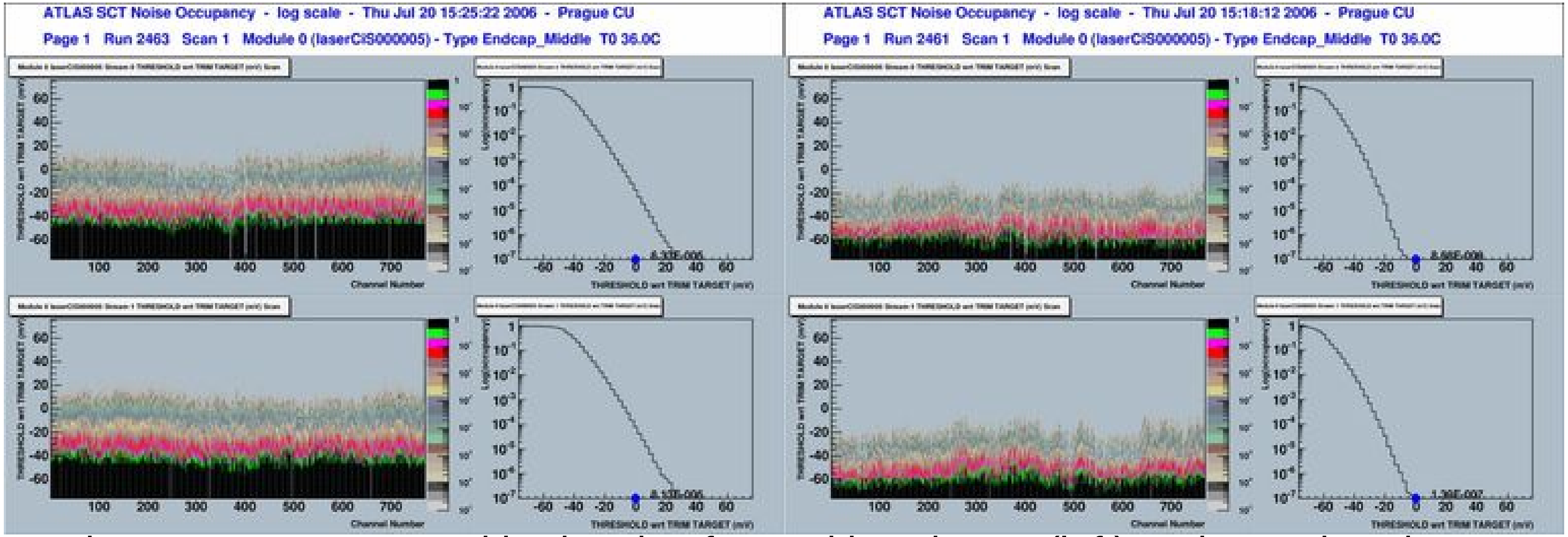
Time walk scan



Time walk scan for negative charge calibration

Different range of scaning charges (1.25 - 4.5), Edge detection is off, compression mode is x1x.

Noise occupancy scan



Noise occupancy scan with trimming for positive charge (left) and negative charge calibration (right)

* **Trim target had to be manually set based on 1 fC threshold scan**
* **Masked channels were inverted in all Noise-type bursts**
Negative charge regime of SCTDAQ shows lower noise occupancy, this can be partially explained by less accurate 1 fC target (taken from simple threshold scan).

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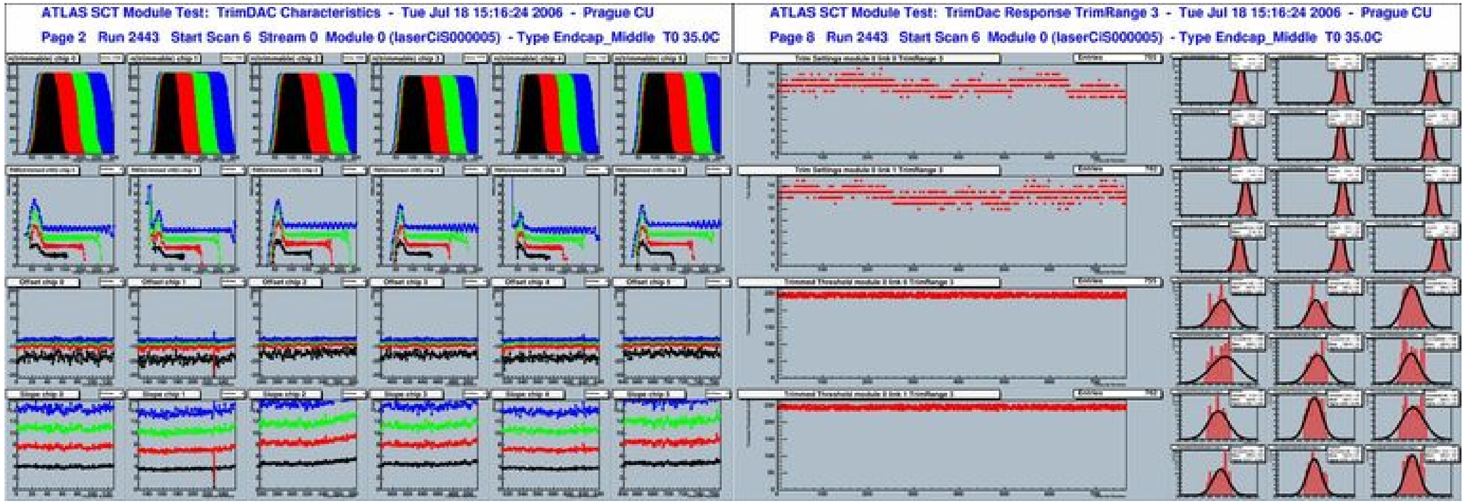
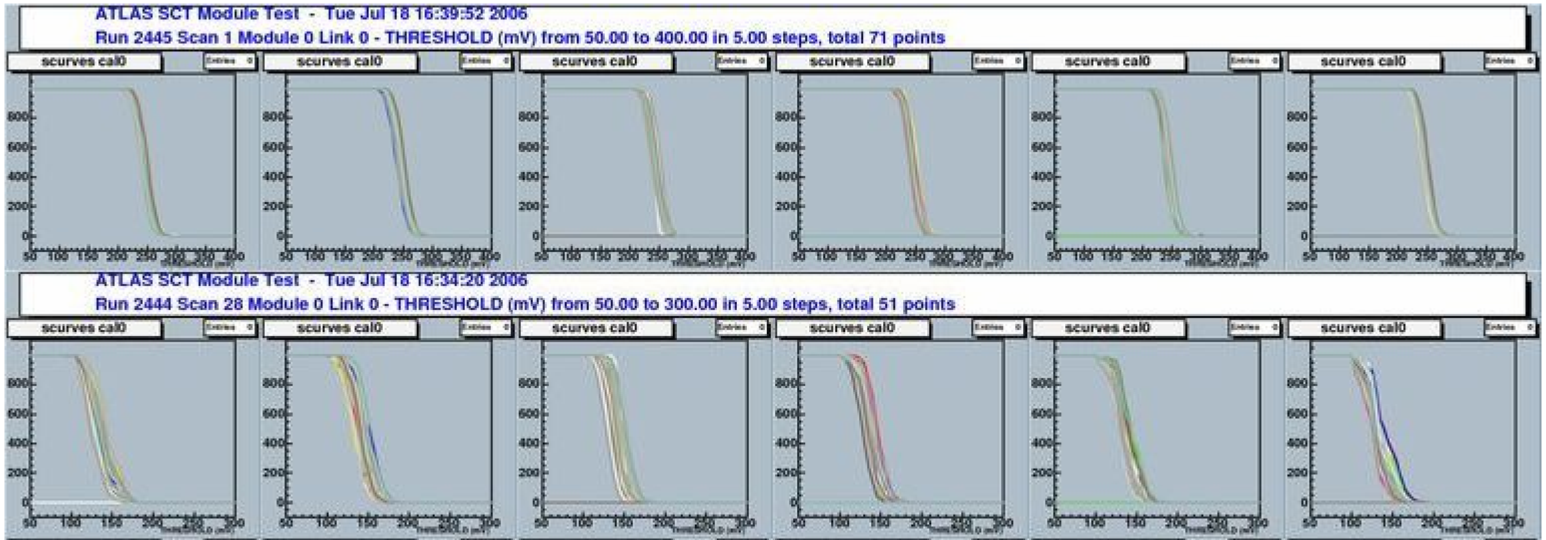
Trimming

Trimming on module in trim range 3 for negative charge calibration





Trimmed module: S-curves for positive charge (up) and negative charge calibration (down)

Comparison of gain and noise

Gains of the 2 polarities are almost identical. Noise of negative system is 200-300 electrons higher. Further tuning of FE settings may be needed.

	Positive Charge				Negative charge			
	L1A	0 fC	1 fC	2 fC	L1A	0 fC	1 fC	2 fC
Chip0	893	942	1602	1583	827	1083	1873	2126
Chip1	1004	1046	1618	1531	930	1053	1705	1730
Chip2	980	1016	1514	1474	937	951	1390	1473
Chip3	1126	1154	1536	1547	1066	1251	1639	1924
Chip4	1015	1055	1463	1506	950	1137	1825	2094
Chip5	958	998	1499	1528	891	1043	1955	2343
Link0	995	1034	1539	1528	933	1085	1732	1949
Chip6	948	977	1398	1509	891	1058	1863	2237
Chip7	1030	1076	1444	1589	967	1209	1989	2246
Chip8	1128	1157	1576	1586	1085	1346	1782	2089
Chip9	1098	1119	1673	1603	1062	1103	1478	1643
Chip10	972	994	1583	1613	912	968	1583	1682
Chip11	1070	1100	1722	1679	1007	1290	1911	2094
Link1	1041	1070	1567	1597	988	1162	1768	1998
Overall	1018	1052	1553	1563	960	1124	1750	1973

Noise over ~1100ENC is coming from calibration pulse in both positive and negative cases. Without using calibration pulse is negative case slightly better. Worse properties with calibration pulse are also because trimming for negative charge was do for -0.5fC level and not for 1.0fC as for positive charge.

Code and macros & Installation notes

Are collected on:

http://www-ucjf.troja.mff.cuni.cz/kodys/works/laser_test/ATLASHyb_NegativeChargeMeasurement/

Conclusion

SCTDAQ readout of ABCD3T chips is well known fast readout on 25ns clock of strip detectors with many times confirmed properties

Negative readout was added to standard SCTDAQ sw

Comparison between results from original and new readout show no differences in basic parameters of results

Application to laser tests is possible (Prague group)

Application to beta test is possible (Freiburg, Prague group)

Readout is ready to use for new type of detectors

Special thanks to Nobu Unno and Hartmut Sadrozinski for initialization of this work