Update of leak current and 3PtGain noise (rev. 2)

SCT meeting

May 26, 2011

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assisted by
Paul Dervan and Ian Dawson

Results on Barrel modules on recent 4 measurements:

date	2010.11.4	2010.12.3	2011.1.25	2011.2.15	2011.5.9
Integrated L	51.2 pb^{-1}	51.2 pb^{-1}	51.2 pb^{-1}	51.2 pb^{-1}	325.0 pb^{-1}
B3 average	124.9 nA	109.3 nA	88.0 nA	79.6 nA	769.5 nA
B4 average	98.1 nA	83.9 nA	67.7 nA	61.1 nA	593.3 nA
B5 average	81.8 nA	69.5 nA	56.4 nA	47.4 nA	463.4 nA
B6 average	62.2 nA	53.4 nA	47.8 nA	42.7 nA	374.9 nA

Note:

(1) Leak current results at -10^{o}C were provided by Paul.

(2) Integrated Luminosity is now total delivered 7TeV collisions at Point-1 including non-Stable beam collisions, thanks to Eric Torrence [1].

[1] /afs/cern.ch/atlas/www/GROUPS/DATAPREPARATION/DataSummary/
The quantity "lhcall_7 tev <delivered> " in the file daylist.xml is used.

- Radiation fluences in ID part at 7 TeV pp collision have been calculated by Ian Dawson et al. using FLUKA [1].

Layer	Fluence at 1 pb^{-1} pp 7TeV
B3	$1.65 \cdot 10^8$ n_{eq}/cm^2
B4	$1.29 \cdot 10^8$ n_{eq}/cm^2
B5	$1.07 \cdot 10^8$ n_{eq}/cm^2
B6	$9.00 \cdot 10^7$ n_{eq}/cm^2

- Sensor Temperature
  - When cooled, it is estimated from the average Temperature [2] of two thermistors on the module hybrid by subtracting 3.6°C, the delta-T obtained by FEA [3].
  - When the cooling is off, the environmental temperature (17.5°C during the last winter shutdown) is used.

[1] https://twiki.cern.ch/twiki/bin/viewauth/Atlas/BenchmarkingAtTheLHC
[2] https://pc-sct-www01.cern.ch/CalibMonitor/
[3] https://indico.cern.ch/getFile.py/access?contribId=4&resId=0&materialId=0&confId=47816

- Leak current formula by R. Haper [1] is used for prediction.
  ϕ : n_{eq} fluence, V: volume

$$I = g(\Theta(T_A)t_{ir}, \Theta(T_A)t')\alpha\phi V$$

$$g(\Theta(T_A)t_{ir}, \Theta(T_A)t') = \sum_{i=1}^{n}\left\{A_i \frac{\tau_i}{\Theta(T_A)t_{ir}}\left[1-\exp\left(-\frac{\Theta(T_A)t_{ir}}{\tau_i}\right)\right]\exp\left(-\frac{\Theta(T_A)t'}{\tau_i}\right)\right\}$$

$$\Theta(T_A) = \exp\left(\frac{E_I}{k_B}\left[\frac{1}{T_R}-\frac{1}{T_A}\right]\right)$$

$$\alpha_{eq}(-7°C) = (6.90 \pm 0.20)\times 10^{-18}\ \mathrm{A\cdot cm^{-1}}$$

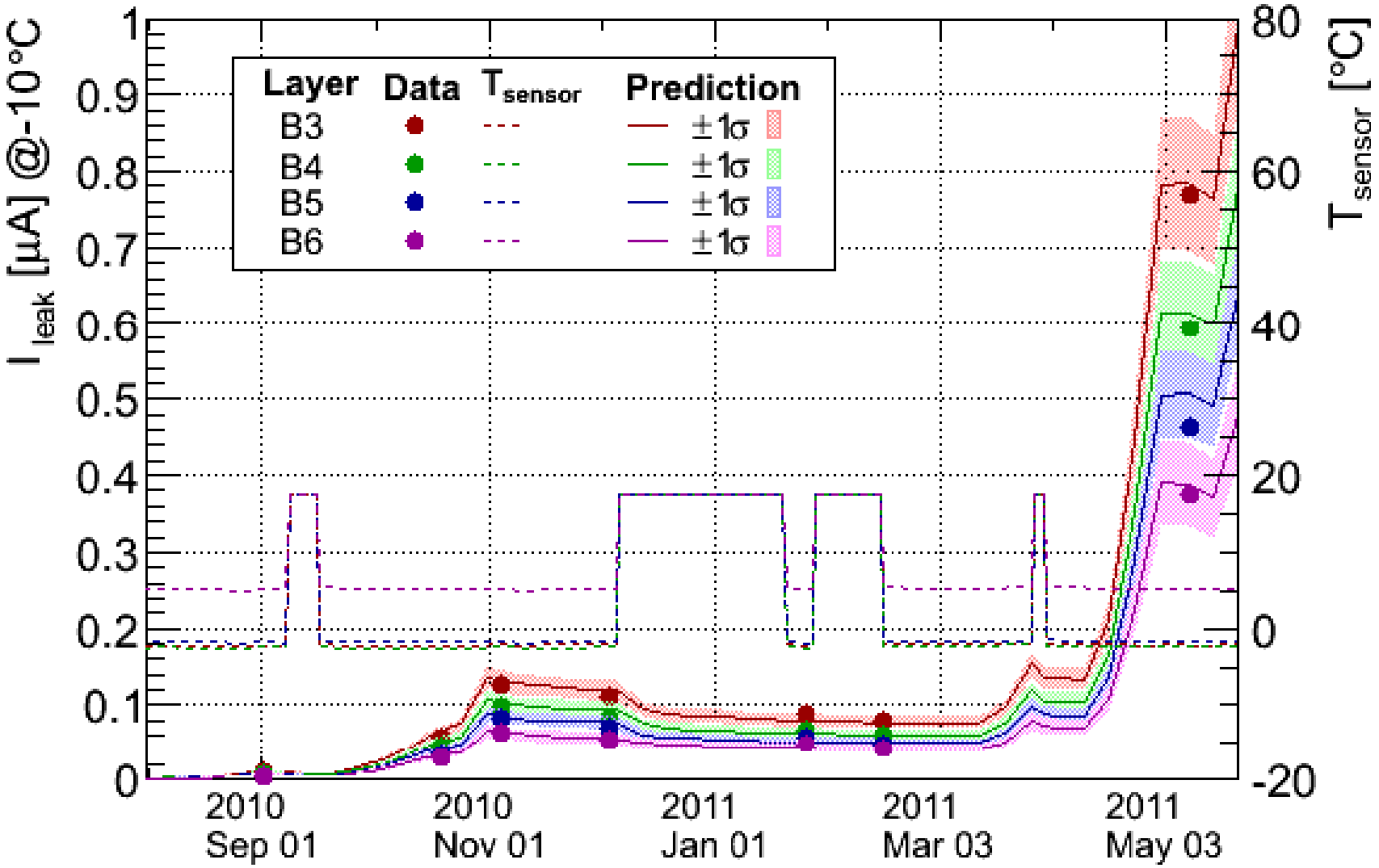
i	τ_i (min)	A_i
1	$(1.2\pm0.2)\times10^{6}$	0.42 ± 0.11
2	$(4.1\pm0.6)\times10^{4}$	0.10 ± 0.01
3	$(3.7\pm0.3)\times10^{3}$	0.23 ± 0.02
4	124 ± 25	0.21 ± 0.02
5	8 ± 5	0.04 ± 0.03

[1] R. Harper, Thesis of University of Sheffield, Oct. 2001

Estimate of errors in prediction, taken independently

Error source	value	+ 1σ	I_{leak} at B3	I_{leak} at B6
No error			1011.3 nA	486.5 nA
α_{eq}(-7°C)	6.90×10^{-18}	0.20×10^{-18}	1040.6 (+2.9%)	500.6 (+2.9%)
A_1 (note)	0.42	0.11	1100.8 (+8.8%)	547.1 (+12.5%)
A_2(note)	0.10	0.01	1014.6 (+0.3%)	488.5 (+0.4%)
A_3(note)	0.23	0.02	1011.1 (+0.0%)	482.5 (-0.8%)
A_4(note)	0.21	0.02	989.0 (-2.2%)	474.7 (-2.4%)
A_5(note)	0.04	0.03	980.0 (-3.1%)	471.3 (-3.1%)
τ_1	1.2×10^{6}	0.2×10^{6}	1012.04 (+0.1%)	487.01 (+0.1%)
τ_2	4.1×10^{4}	0.6×10^{4}	1012.6 (+0.1%)	487.5 (+0.2%)
τ_3	3.7×10^{3}	0.3×10^{3}	1015.5 (+0.4%)	490.1 (+0.7%)
τ_4	124	25	1015.2 (+0.4%)	487.4 (+0.2%)
τ_5	8	5	1011.6 (+0.0%)	486.5 (+0.0%)
Luminosity	3.2% (2010), 4.5% (2011)		1055.8 (+4.4%)	507.8 (+4.4%)
T_{hybrid}-T_{sensor}	3.6°C	1°C	997.6 (-1.4%)	476.7 (-2.0%)
T_{env}	17.5°C	2°C	1006.9 (-0.4%)	484.9 (-0.3%)
Adding percent deviations quadratically			**11.1 %**	**14.3 %**

Note: under the constraint of $A_1+A_2+A_3+A_4+A_5=1.0$



The errors do not include ~50% uncertainties in the fluence simulation using FLUKA and min. bias EG. This plot indicates the uncertainty of the fluence simulation is much less.

Reports so far:

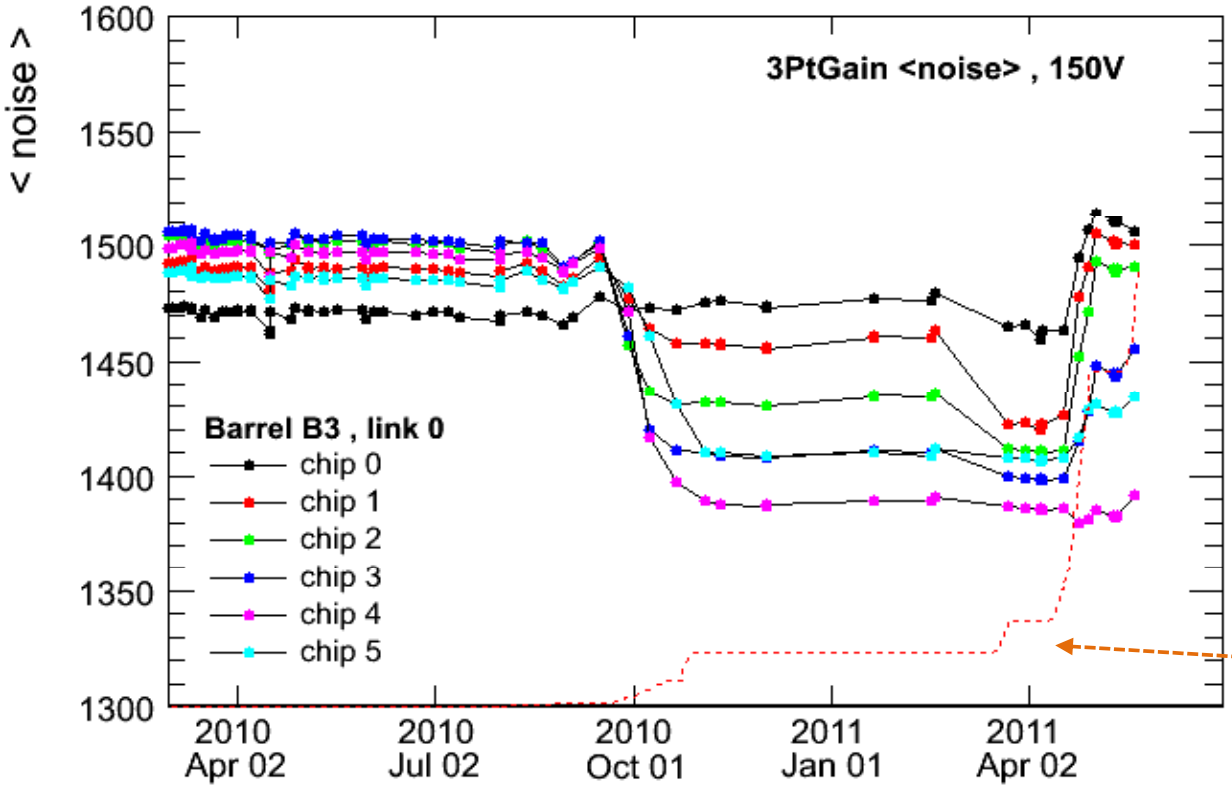
- Nov. 25, 2010 in SCT Performance meeting
- Feb. 10, 2011 in SCT Performance meeting
- Feb. 23, 2011 in ATLAS ID week meeting
- Mar. 17, 2011 in SCT Performance meeting
- Apr. 14, 2001 in SCT Performance meeting

chip numbering

chip 0…….5 6……..11

link 0 link 1

Typical plot



Integrated stable beam delivered

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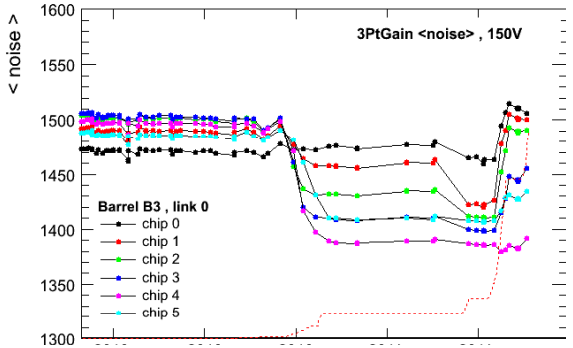

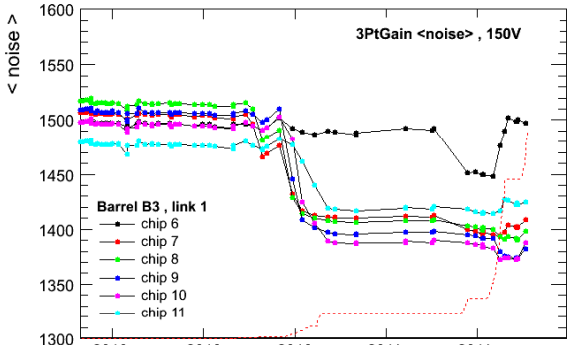

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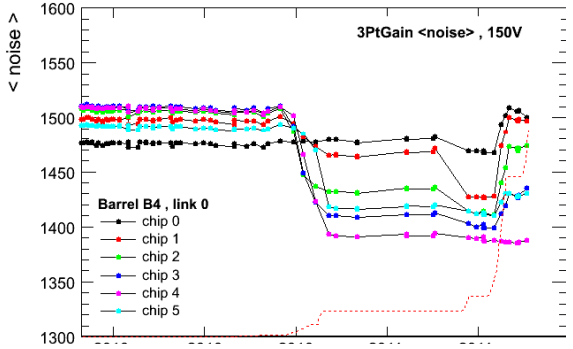

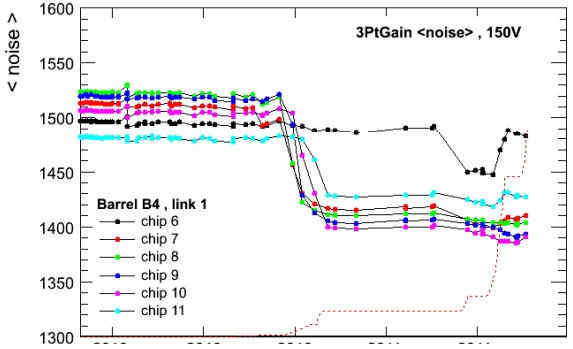

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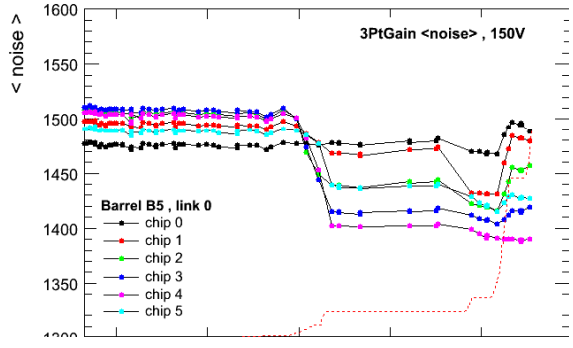

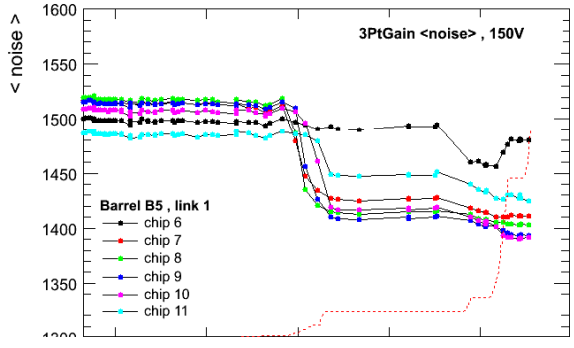

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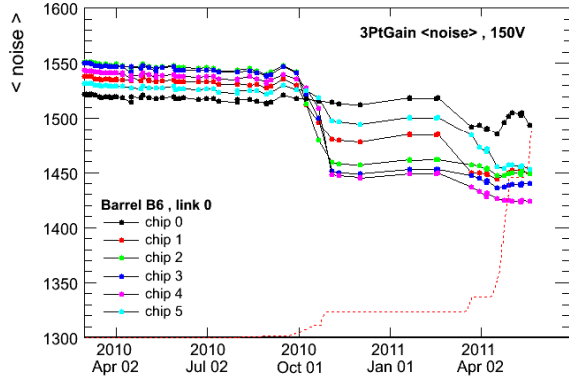

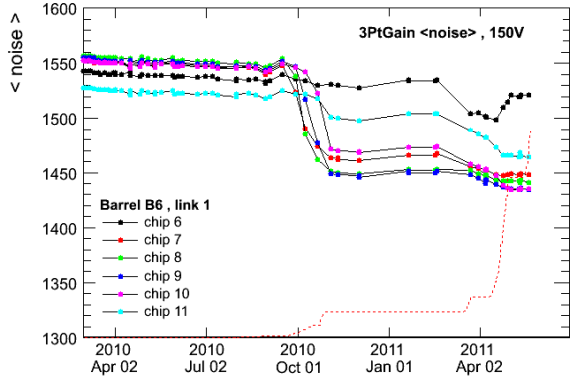

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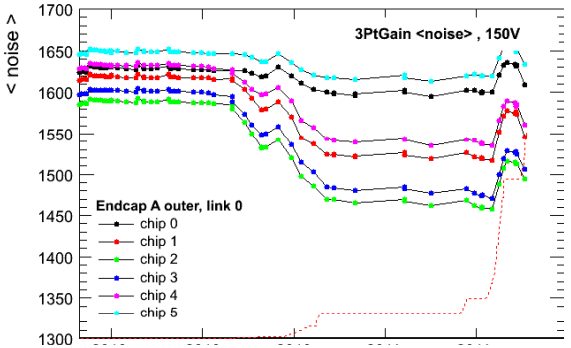

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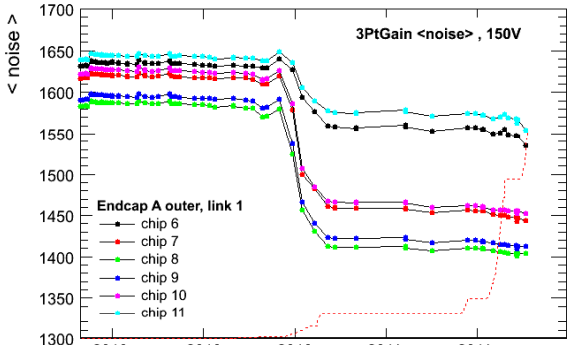

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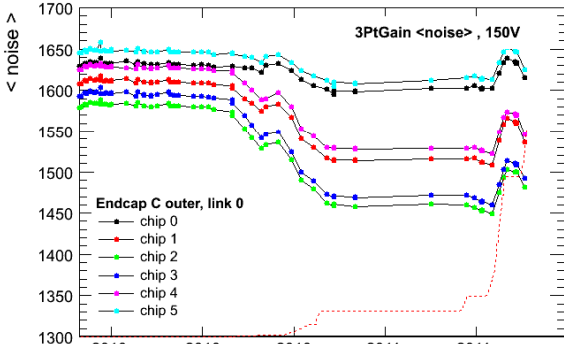

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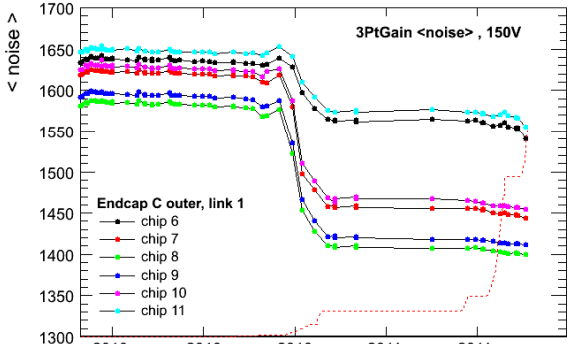

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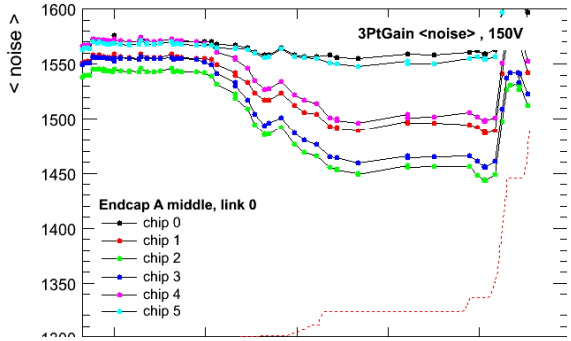

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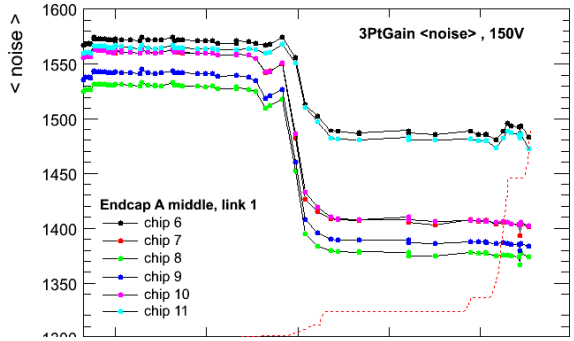

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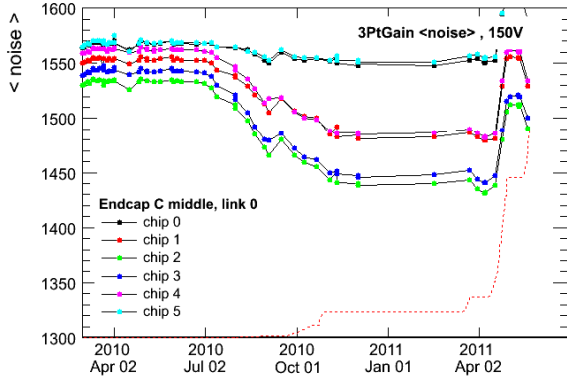

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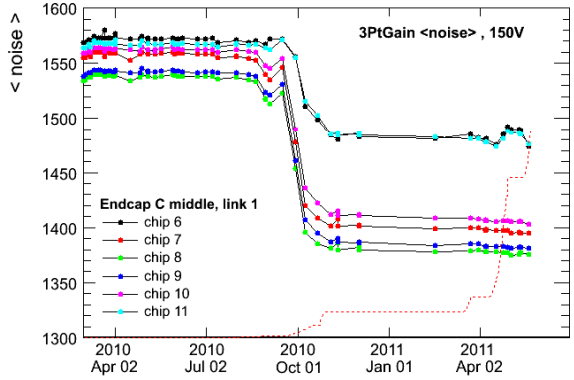

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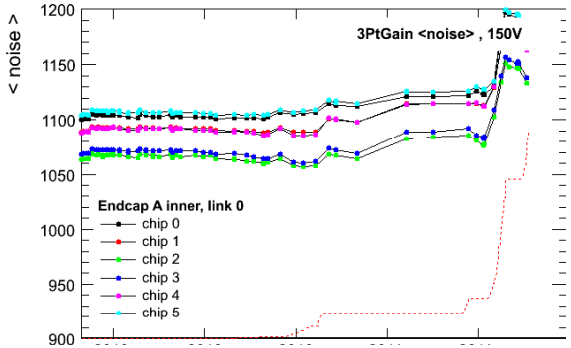

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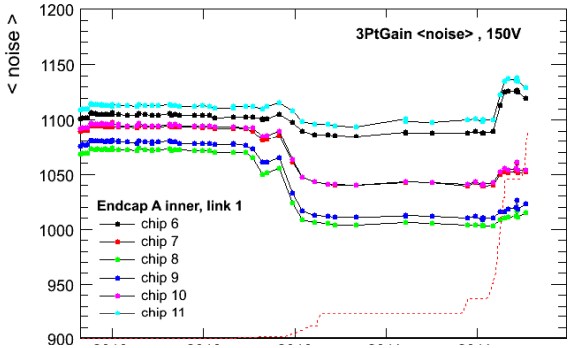

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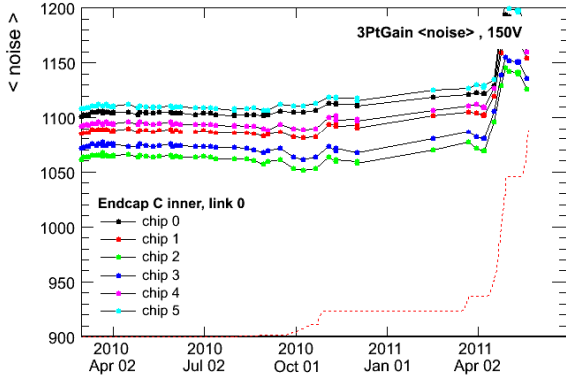

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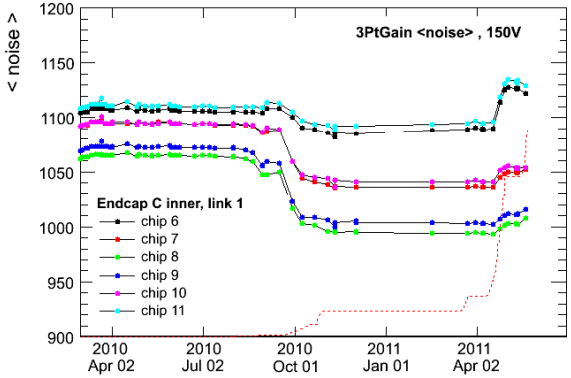

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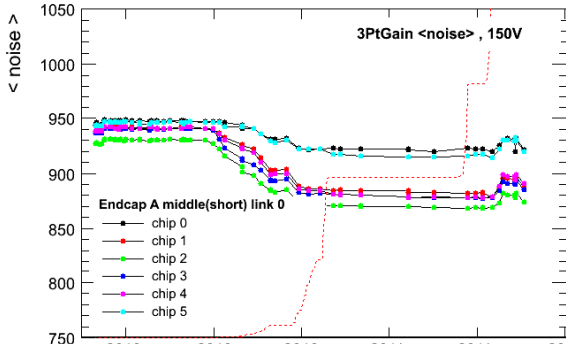

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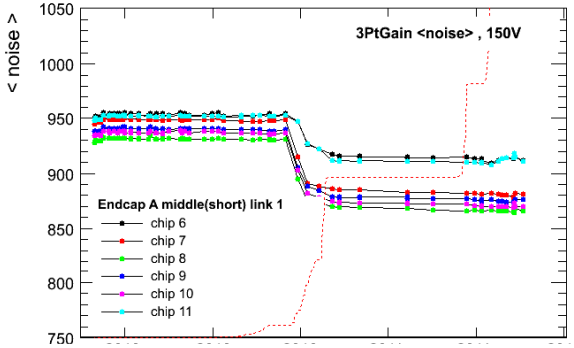

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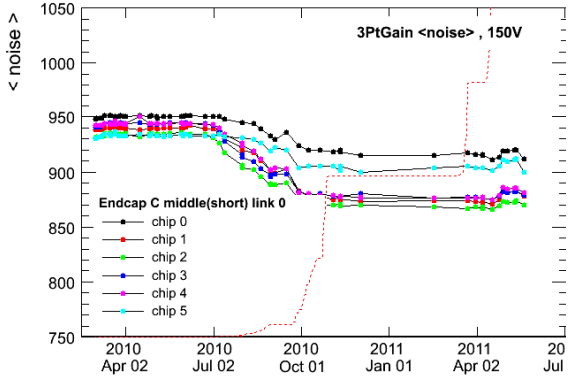

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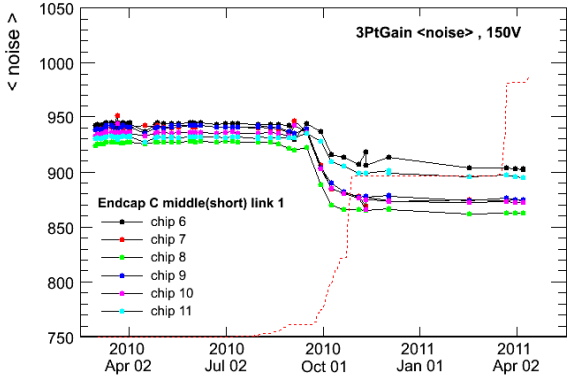

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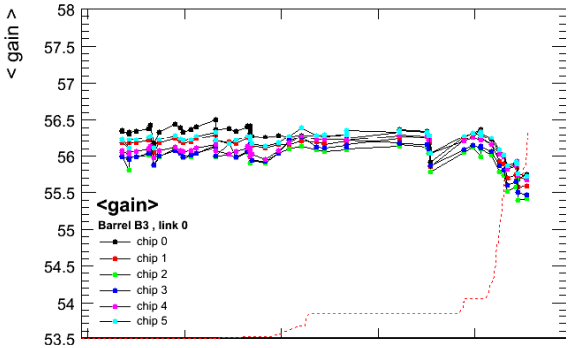

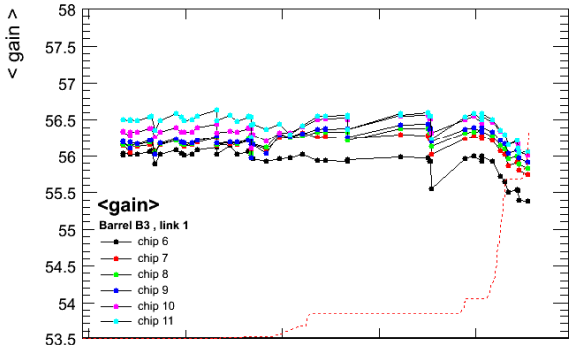

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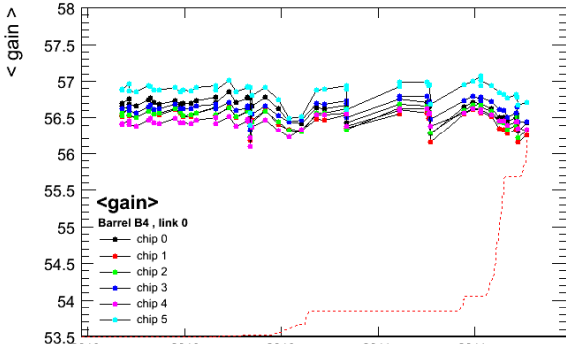

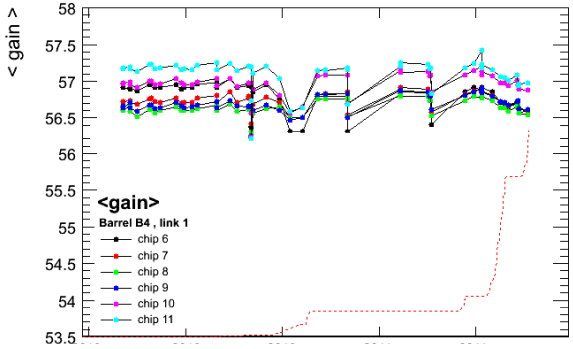

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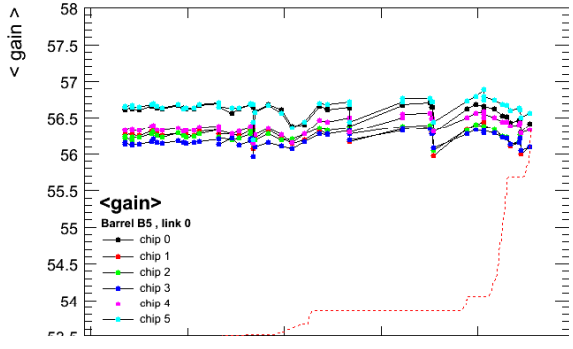

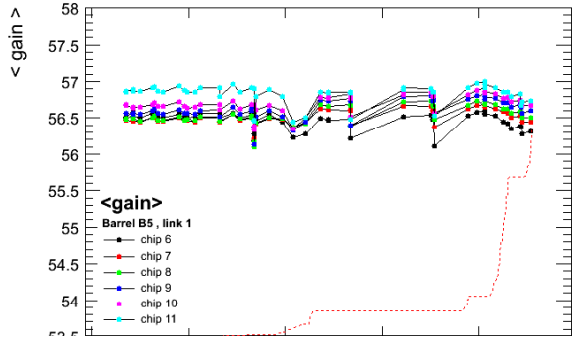

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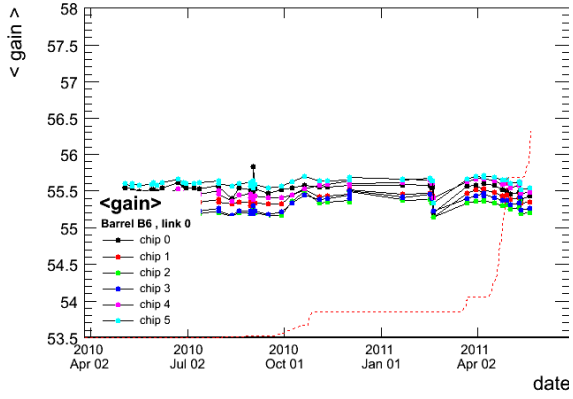

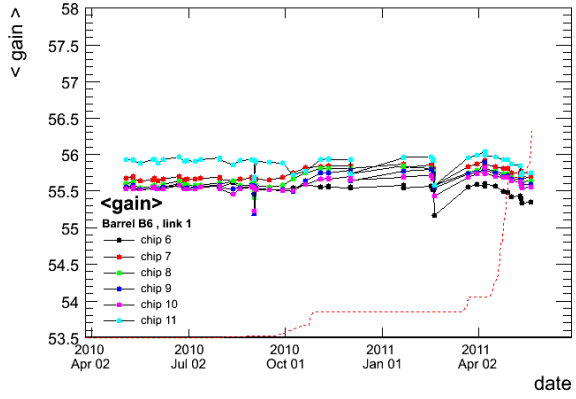

Barrel 6 link 1

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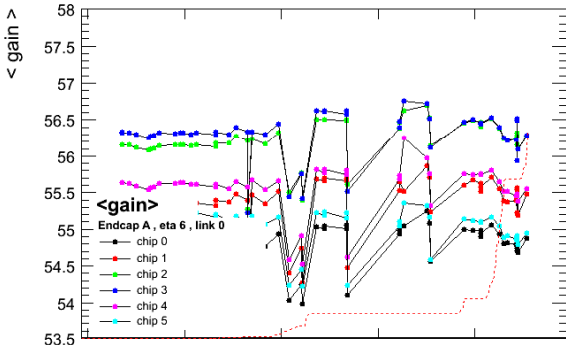

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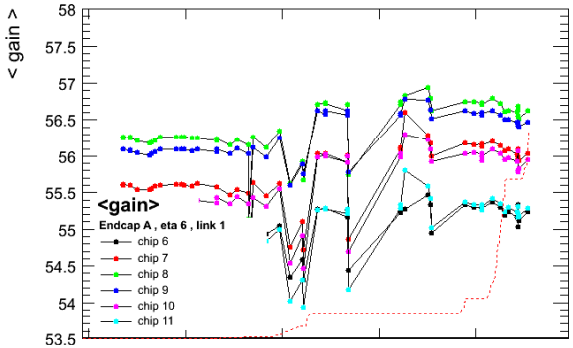

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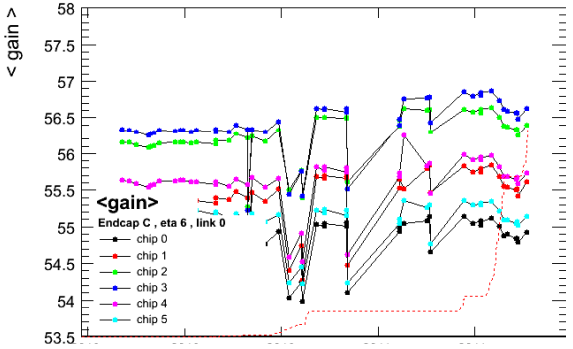

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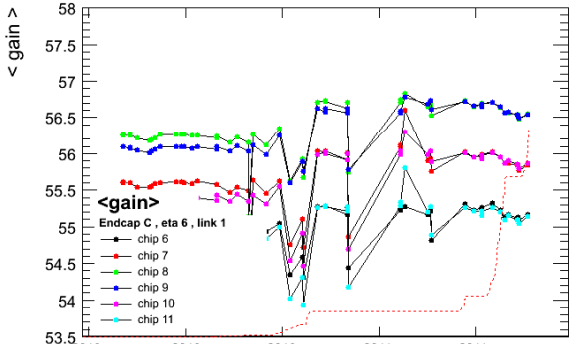

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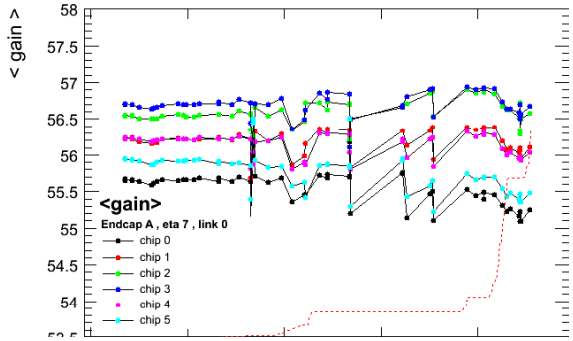

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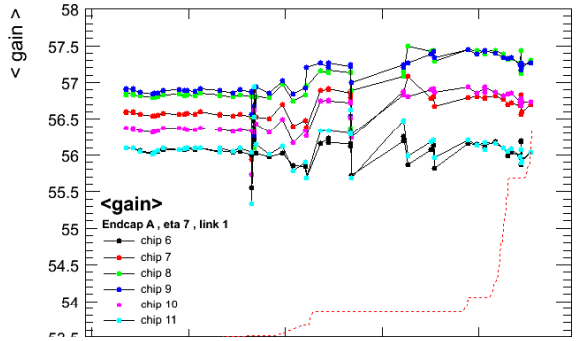

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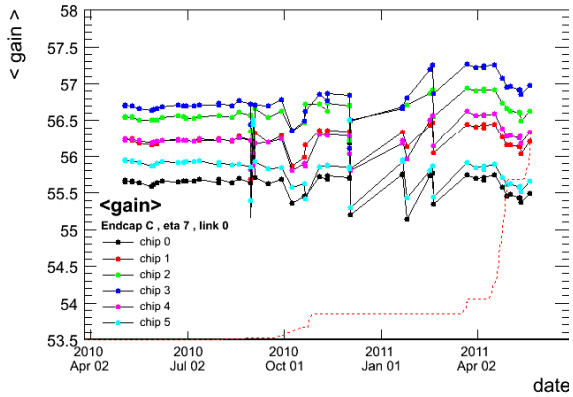

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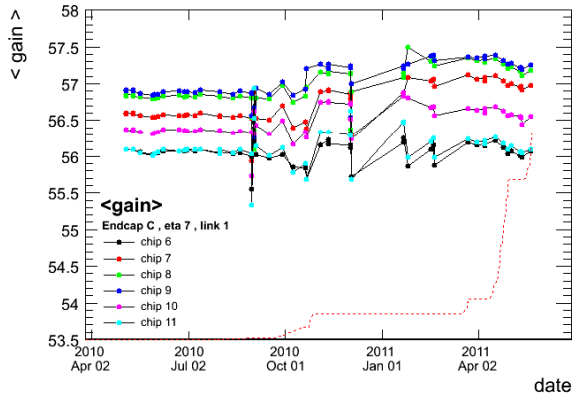

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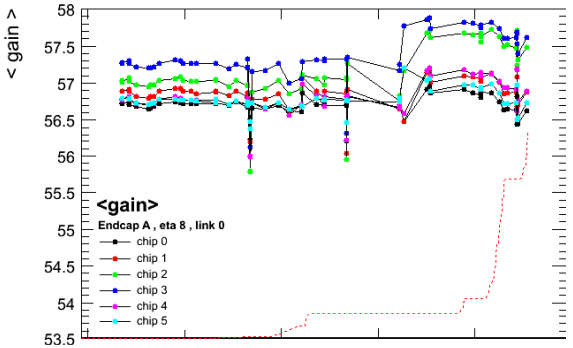

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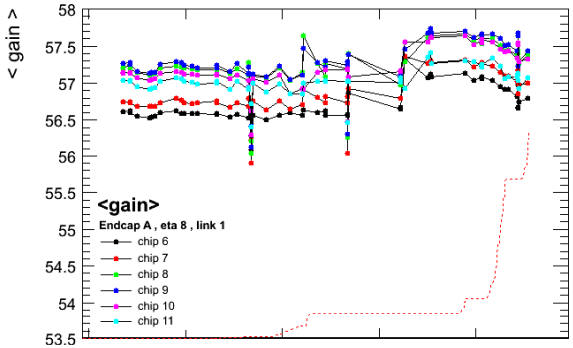

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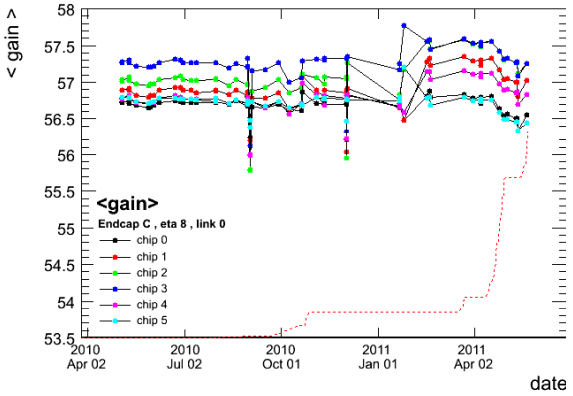
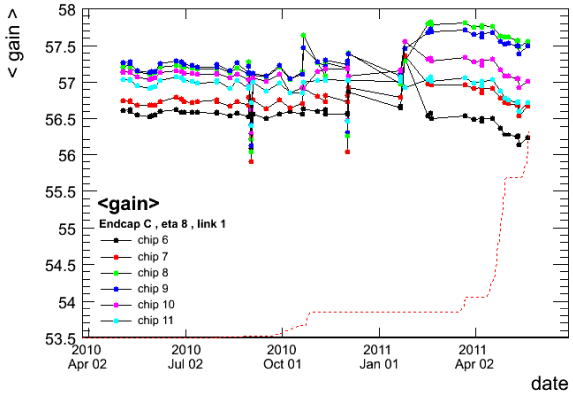


ECC inner link 1



Summary:

(1) Large int-luminosity increase in April and May 2011.
(2) <noise> increase in link-0, but not in link-1.
(3) <gain> more or less stable, need more detailed study.

Summary

- Leak current of SCT Barrel was measured on 2011 May 9.
- The uncertainty of the leak current prediction is estimated, excluding the 50% uncertainty of the fluence simulation.
- The prediction agrees well with data within 1 sigma uncertainty. This indicates the fluence simulation is quite accurate, say within 10% .
- <noise> of 3PtGain showed increase in link-0, but not in link-1.