Brighter-Fatter Correction with the LSST Stack

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Acknowledgements:
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Outline

- Summary of proposed changes to makeBrighterFatterKernel.py.
- Explanation of the proposed changes.
- Comparison of results.
- Discussion and next steps.

Proposed changes to makeBrighterFatterKernel.py - I

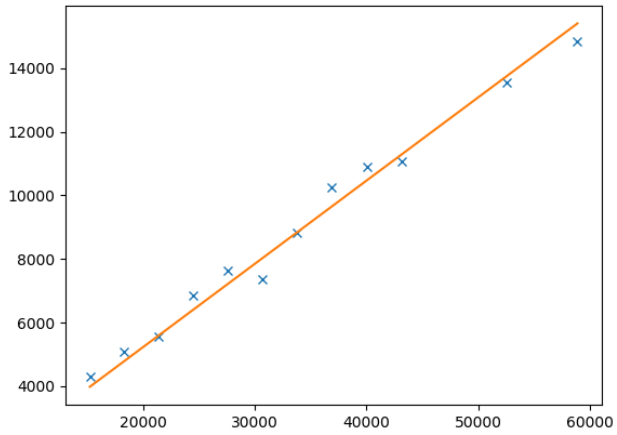
- Non-optional changes:
  - Current code calculates the correlations twice, once to determine the gain, and once to calculate the kernel. I have reduced this to once, and use the same correlations to determine both.
  - Current code finds the gain as a linear fit to the PTC. I propose using the linear part of a cubic fit.
  - I have added code to save more of the intermediate results, including the flux, raw correlations, and mean correlations. Current code only saves the kernel.

Proposed changes to makeBrighterFatterKernel.py - II

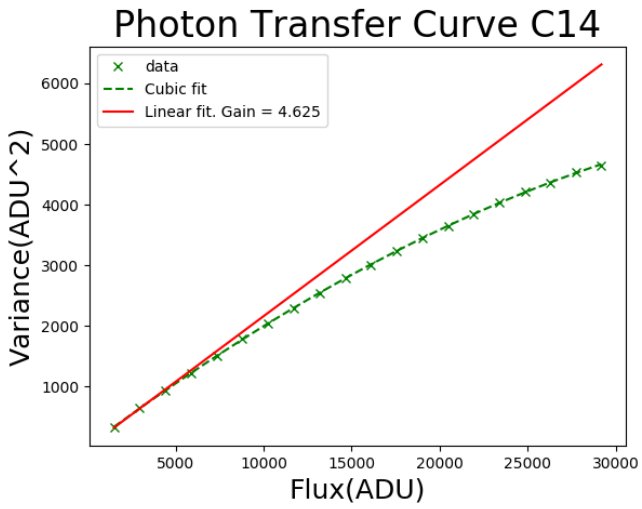
- Options:
  - correlationQuadraticFit: Fit correlations vs flux with a quadratic fit instead of simple averaging.
  - forceZeroSum: Adjust the C_{00} correlation value to force the correlation matrix to sum to zero.
  - buildCorrelationModel: Build a model of the correlations vs radius and use the model for correlations beyond some radius instead of the noisy data.
- The code proposed here is in a fork of cp_pipe at `https://github.com/craiglagegit/cp_pipe`. There are also scripts that extract the kernel and apply the correction to spots. I am ready to submit a pull request, but would like discussion and consensus in the community first.

Photon Transfer Curves and Gain

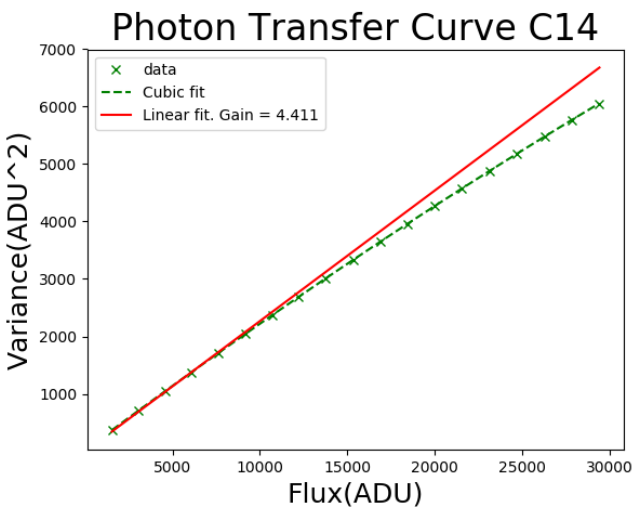
ITL-Baseline - Gain = 3.822



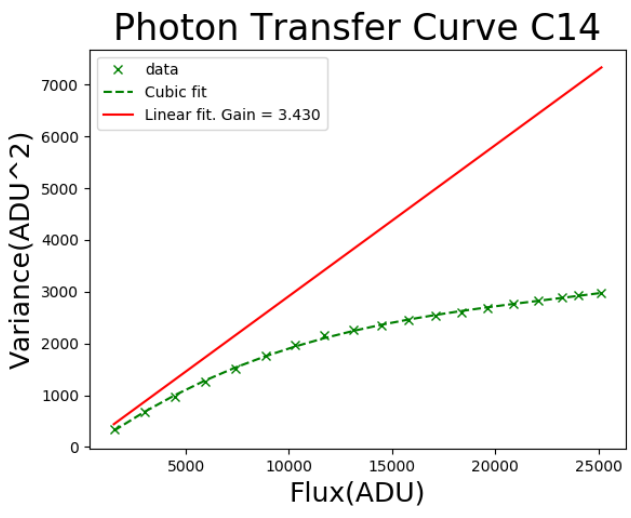
E2V-Bipolar-New Code



ITL-New Code - Gain = 4.411



E2V-Unipolar-New Code



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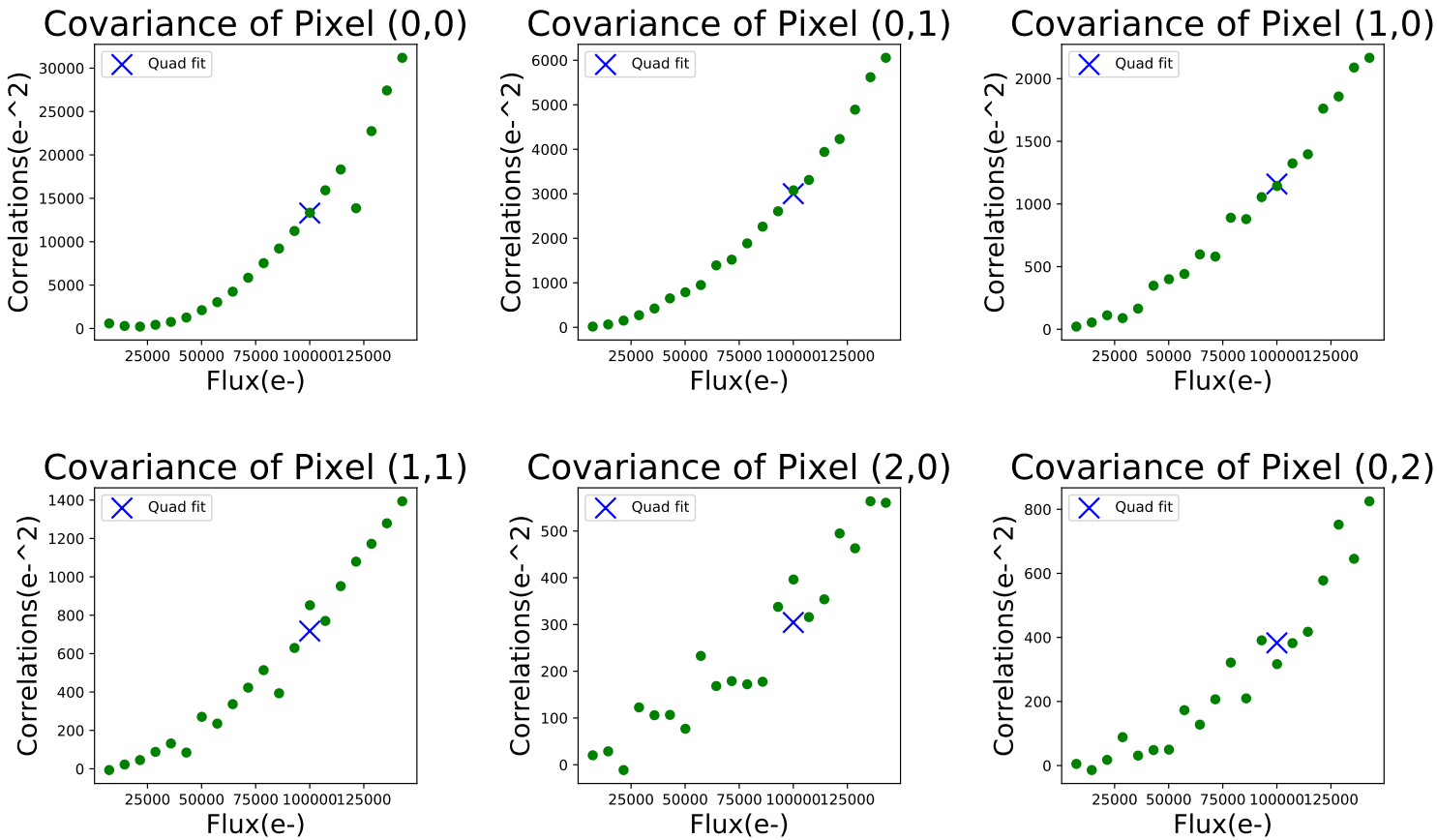
- Note that both ITL curves use the same data.
- E2V Unipolar is still not working well because of large curvature. I need more points at low flux.

correlationQuadraticFit



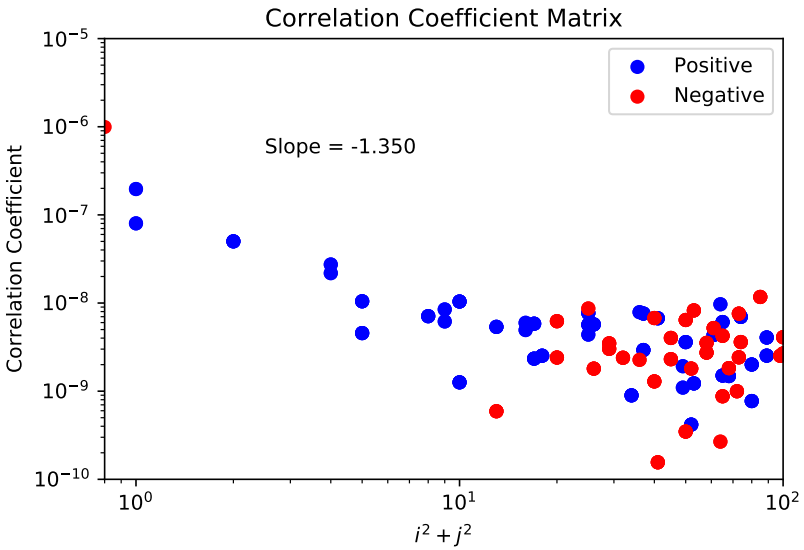
- The blue X shows the result of fitting a curve with $\mathrm{Cij} \propto \mathrm{flux}^2$.
- I believe this does a better job of fitting the correlations, especially when the data gets noisy.

forceZeroSum

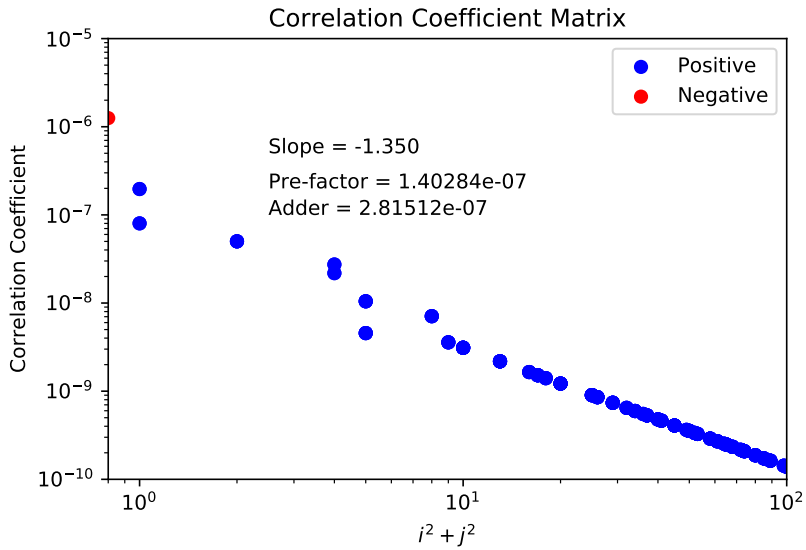
- The correlation matrix should sum to zero, with C_{00} having a large negative value equal to the sum of the $\mathrm{C}_{\mathrm{ij}}, (\mathrm{i}, \mathrm{j}) \neq (0, 0)$, which should all be positive.
- This doesn't always happen for several reasons.
- The kernel calculation is basically the same as solving Poisson's equation with the correlations representing the charge. If the sum is non-zero, the kernel has a long range component which does not belong.
- This option adjusts the C_{00} value to force the sum to be zero.
- I have found this to be the most important thing to getting the correction right.

buildCorrelationModel

ITL-Quad_Zero



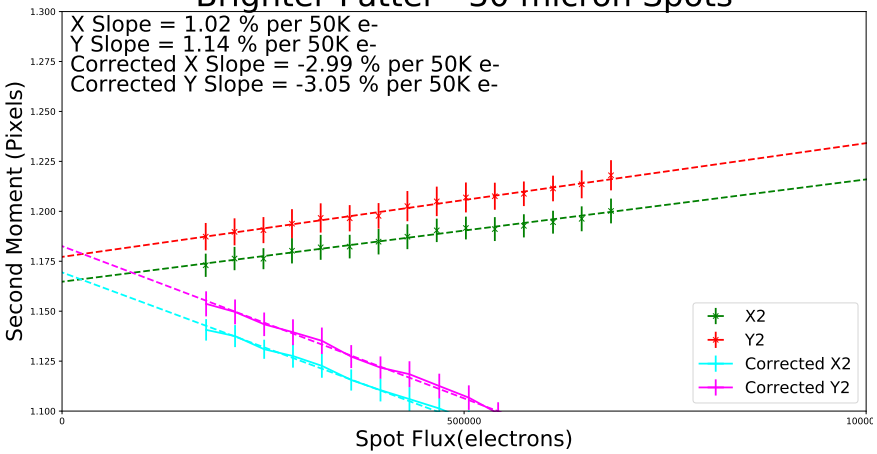
ITL-Quad_Zero_Model



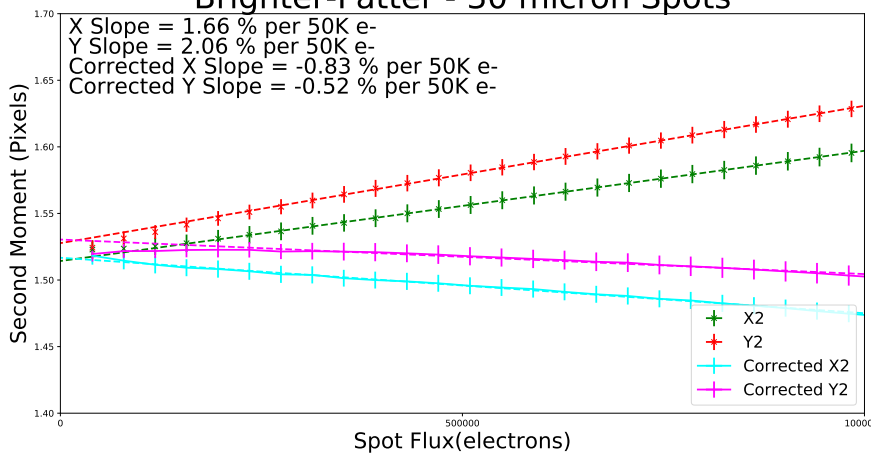
- This option replaces the correlations beyond some radius with a model value.
- This smooths the correlations and the resulting kernel.
- Having a model also allows one to calculate the "sum to infinity", by integrating the model beyond the measured radius. This makes a small, but not insignificant, correction to the correlation sum.

BF Kernel Correction Results

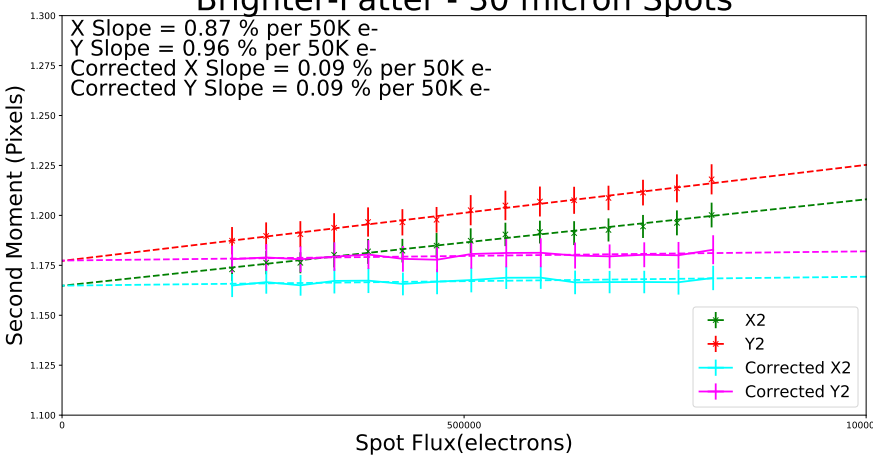
ITL-Baseline



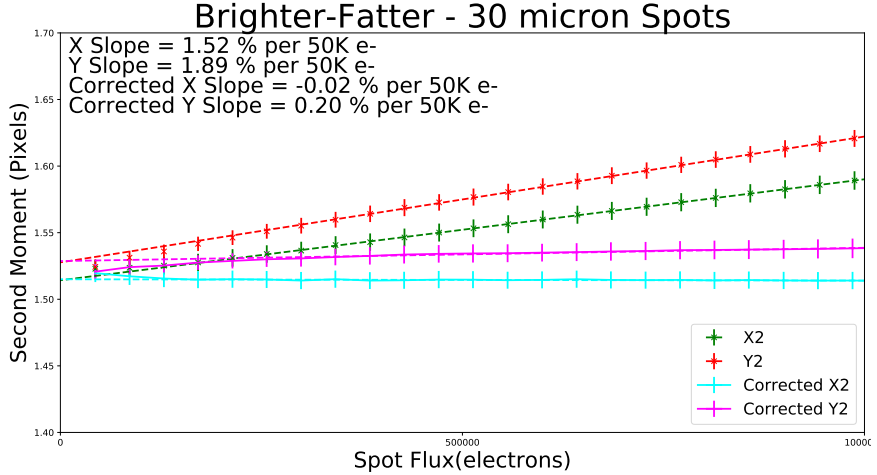
E2V-Bipolar-Baseline



ITL-Quad_Zero_Model



E2V-Bipolar-Quad_Zero_Model



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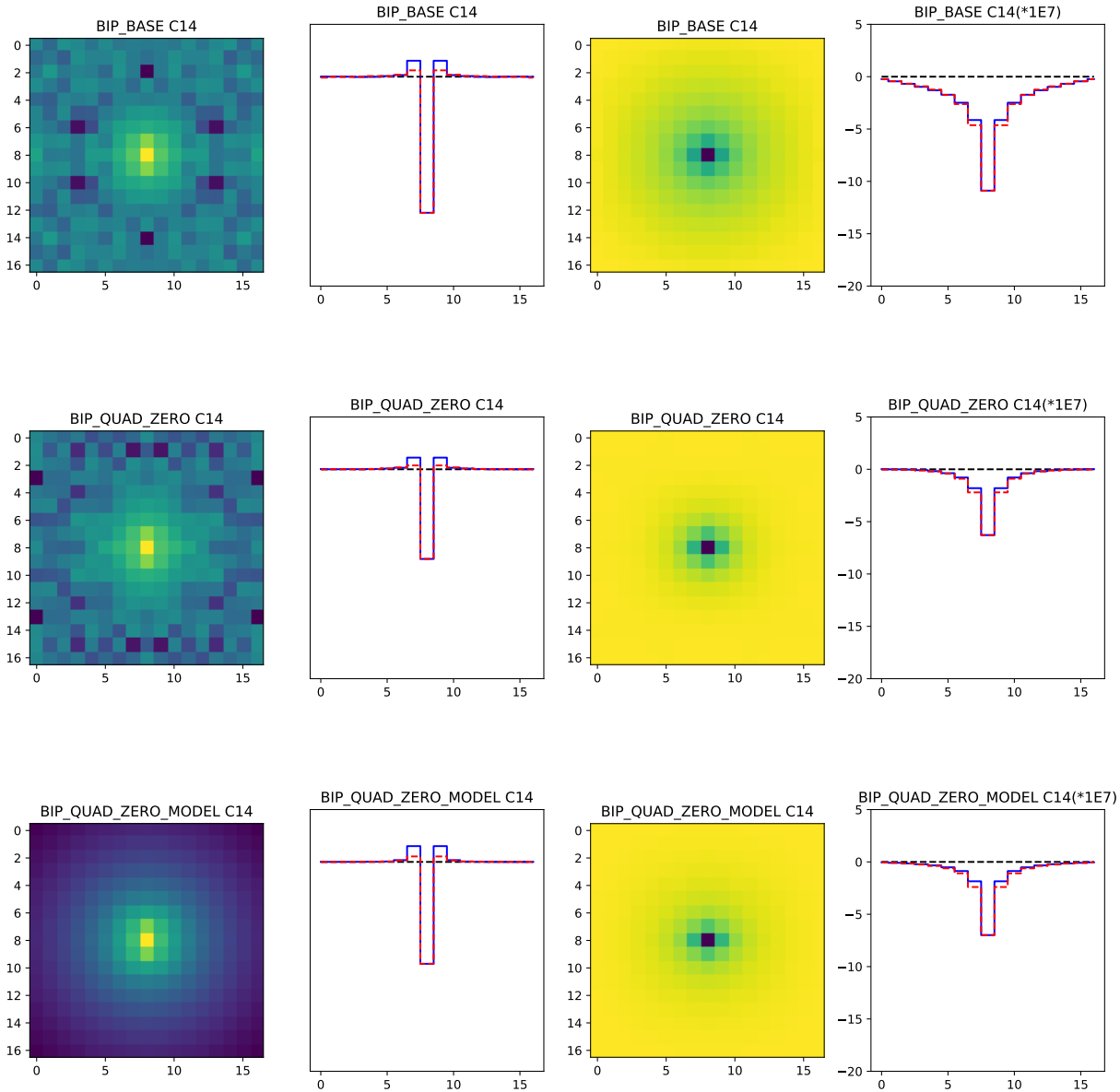
- Note that the same datasets are used in the two comparisons.
- The baseline code over-corrects. the new code does a better job, but is still a little bit under-correcting.

Comparison of Correlations and Kernel

CORRELATIONS KERNEL



Discussion and Next Steps

- We need to get more eyes looking at this code!
- I'm looking forward to spirited discussion of these techniques.

BACK-UP SLIDES

Measurement conditions

- ITL
  - Vbb=-60;Par = +3.0/-8.0;Ser=+6.0/-8.0;RG=+8.0/-2.0;RD=+13.0;GD=+19.0;OD=+25.0;OG=-2.0.
- E2V Unipolar
  - Vbb=-50;Par = +9.0/0.0;Ser=+9.5/0.0;RG=+10.0/0.0;RD=+14.0;GD=+26.0;OD=+30.0;OG=+4.0.
- E2V Bipolar
  - Vbb=-70;Par = +3.5/-7.2;Ser=+4.5/-5.0;RG=+7.4/-3.2;RD=+12.6;GD=+26.0;OD=+24.5;OG=-2.3.