Beamtest at KEK in Feb. 1998

Analysis status - Sep. 98

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Introduction

- **Motivation**

  - Beamtest of irradiated detectors

  - Comparison of p-in-n and n-in-n detectors from Hamamatsu Photonics

  - Comparison with SINTEF p-in-n detectors

- **Status in Sep. 98**

  - Fluence evaluation

  - Bug identification and corrections

  - Data analysis with calibration

  - Charge collection comparison

Fluence evaluation

- **Irradiation with 12 GeV protons**

  Brief history:

  - Jan. 24, 1998 -- Irradiation execution

  - Temperature: -5 °C (average)

  - Stayed in the beamline till Feb. 4

  - 5 days in room temp & 6 days warm-up at 28 °C

  - Beamtest: at -17 °C

- **Fluence evaluation with Al foils**

  - 5 x 5 matrix

  - Absolute fluence was evaluated for the centre foil for the Be-7 activity

  - Rest of the foils for relative fluence over the detector

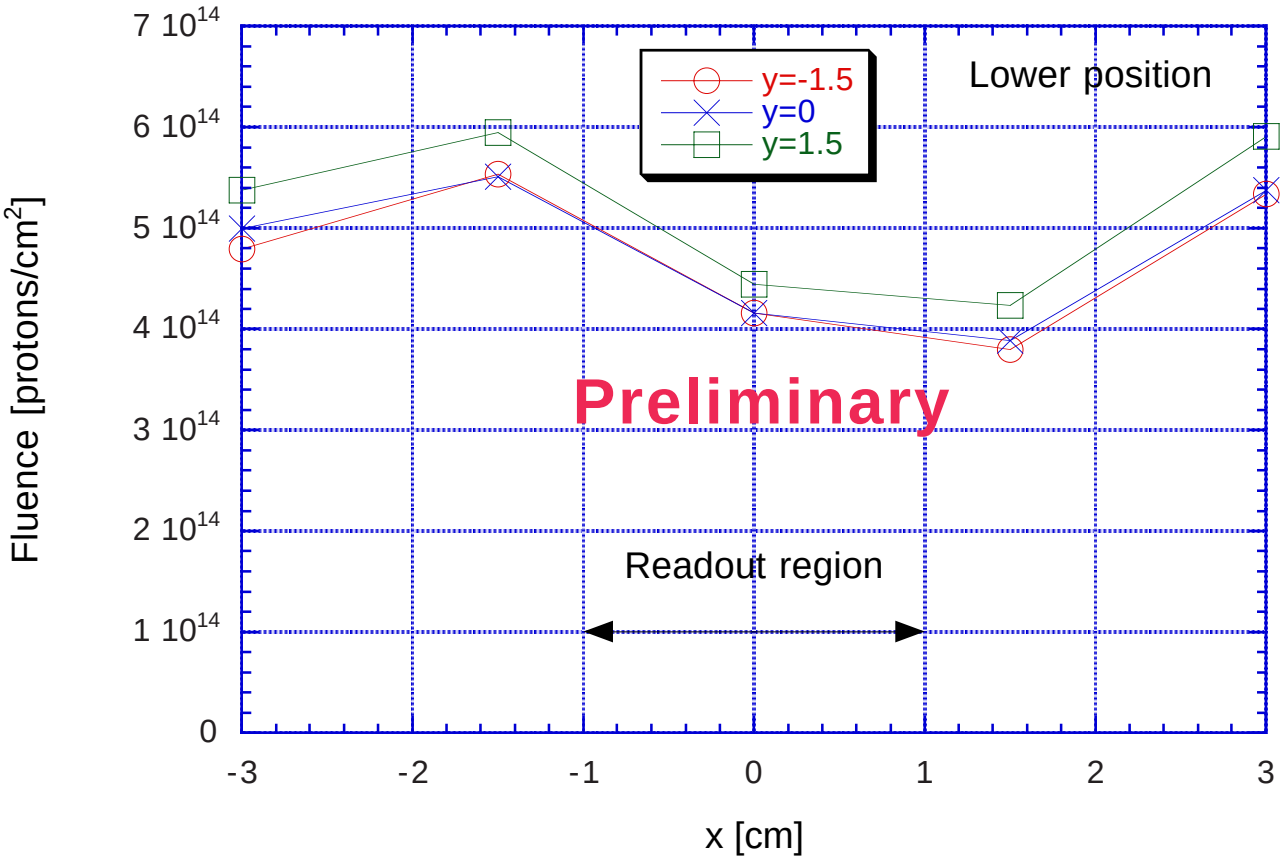
  - 4.16 x 10^{14} protons/cm^2, with an error of ~10%, i.e.,

  (4.2 ± 0.4) x 10^{14} protons/cm^2

  - Fluence variation in positions (Fig.)

  - In the beamtest, the beam was set to hit the centre of the detectors in an area of 2 cm x 2 cm

  - The variation of fluence was from 4 to 5 x 10^{14} p/cm^2


Fluence [protons/cm^2]
7 10^{14}
6 10^{14}
5 10^{14}
4 10^{14}
3 10^{14}
2 10^{14}
1 10^{14}
0
-3
-2
-1
0
1
2
3
x [cm]
y=-1.5
y=0
y=1.5
Lower position
Preliminary
Readout region

Detector-Hybrid Assembly

- **Irradiated detectors**

Sample ID		Description
1)	SINTEF-p10	SINTEF p-in-n detector (labelled: p10, 293 μm)
2)	STX41578-7	ATLAS97P p-in-n low resistivity (1kΩ•cm resistivity, Vdep=280 V measured)
3)	SDX35232-12	ATLAS97 n-in-n baseline

- **Detector-Hybrid combination**

SINTEF p-in-n ----------	Hybrid#1(4 chips)
Ham p-in-n(1kΩ•cm resistivity) --------	Hybrid#5 (4 chips but...)
Ham n-in-n baseline ----------	Hybrid#2 (2 chips)

- Readout was arranged so that the centres of the detectors were to be read out (Figure)

- Chips were labelled with LBIC's (64 channels/chip)

Setup

- **Thermo-box**

  - Bottom plate: cooled with liquid cooling pipe

  - Air volume: cooled with “refrigerator”

  - Temperature: -17 °C

- **Telescope - Detector sequence**

  1) Telescope

  2) SINTEF p-in-n -- Hybrid#1

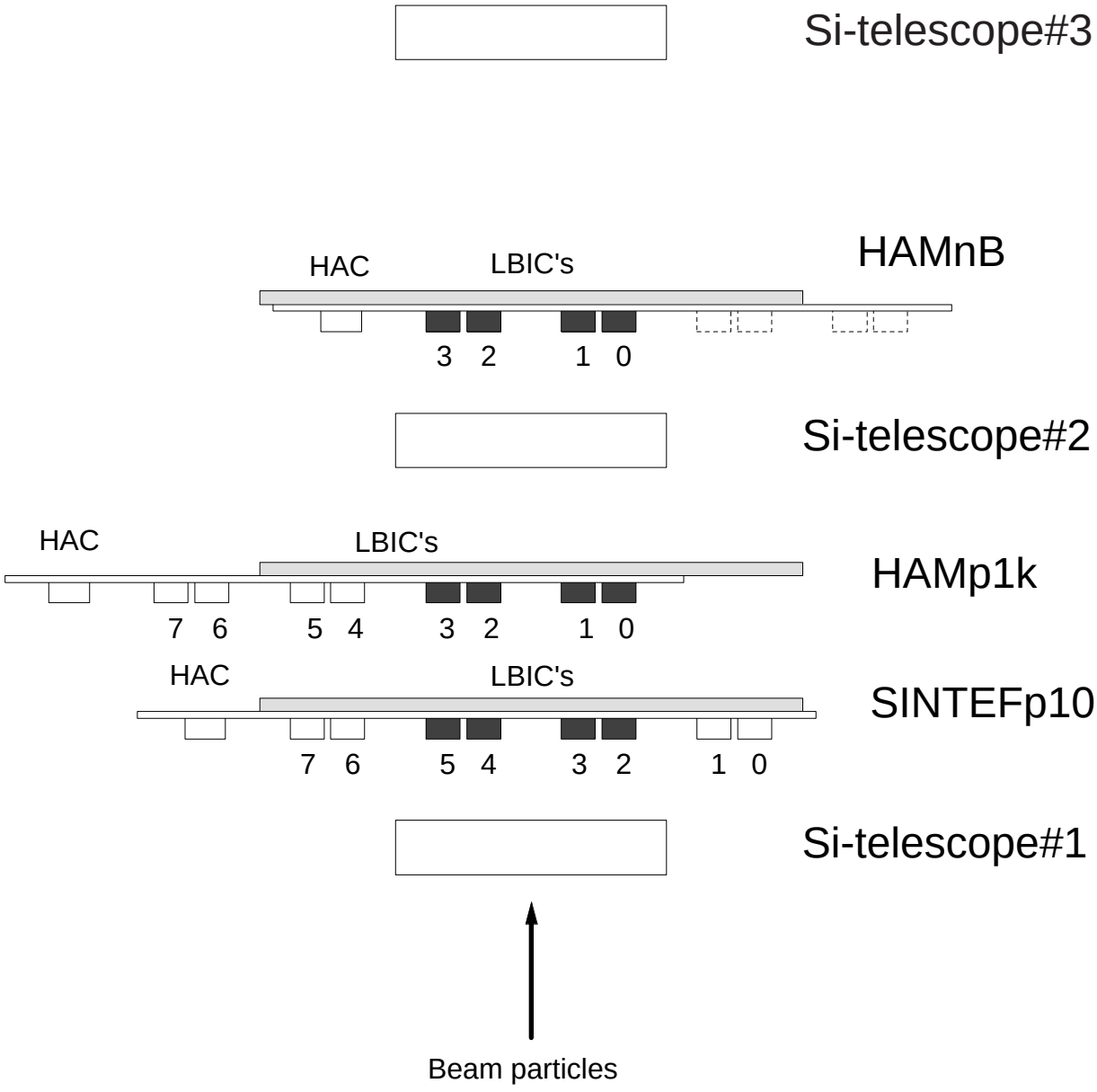
  3) Ham p-in-n (low resistivity) -- Hybrid#5

  4) Telescope

  5) Ham n-in-n baseline -- Hybrid#2

  6) disconnected

  7) Telescope -- disconnected


Si-telescope#3
HAMnB
HAC
LBIC's
3 2 1 0
Si-telescope#2
HAMp1k
HAC
LBIC's
7 6 5 4 3 2 1 0
SINTEFp10
HAC
LBIC's
7 6 5 4 3 2 1 0
Si-telescope#1
Beam particles

Data

- **Temperature: -17 °C**

- **Thresholds: 0.6 - 4.5 fC (nominal)**

  - 0.6, 0.8, 1.2, 1.6, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

  - 30k events / threshold

- **- Bias voltages: 125 - 500 V**

  125, 150, 175, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450, 475, 500

Preliminary results

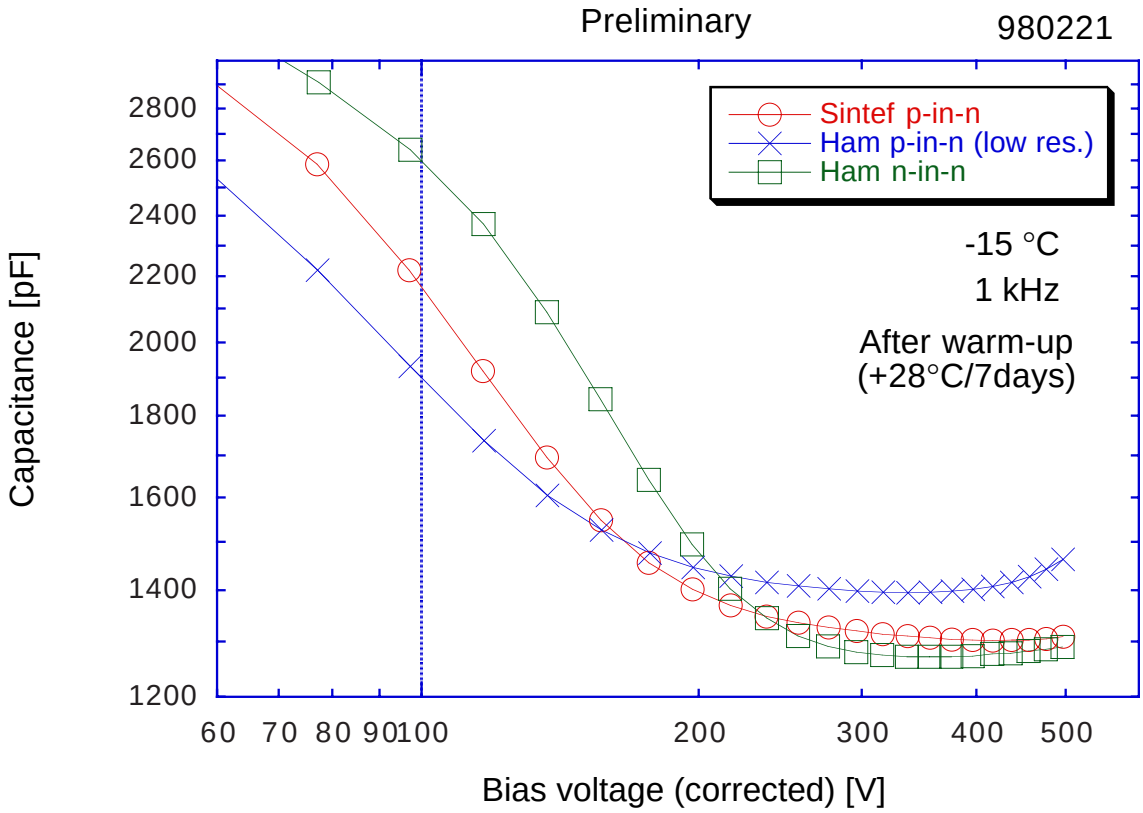
- **CV measurements**

  - After warm-up (4 days room & 6 days at 28 °C)

  - Temperature: -15 °C

  - Depletion ~300 V in the n-in-n?

  - No clear turning point in the p-in-n



Preliminary results (2)

- **Bug identification and corrections**

  - Data communication errors, bits shifts -- This explained the loss of the efficiency of about 10%. Most of the corrupt data were excluded but there still corrupt data unidentified (There is no error detector code...)

  - Wire-bonding sequence correction -- In a chip, there was a swap of bonds in a bunch

  - After these corrections, most of the chips showed efficiency near 100% (at saturation)

- **Electronics calibration with charge injection**

  - Looks reasonable, but,...

- **Threshold scans and the medians**

  - Nominal thresholds were corrected with the electronics calibrations

  - Threshold curves were fitted with an modified Error function

  - 50% efficiency threshold was defined as the median, which is the median of the collected charges

  - Efficiencies were obtained for

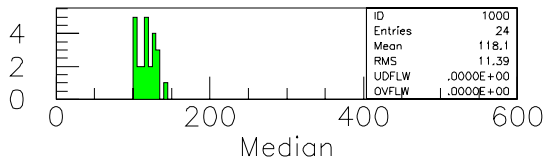
  1) Average (or "all") region: without specifying the position between the strips

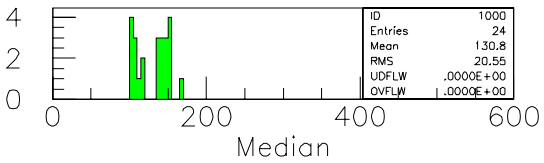
  2) Strip region: $\pm$20 μm around the strip

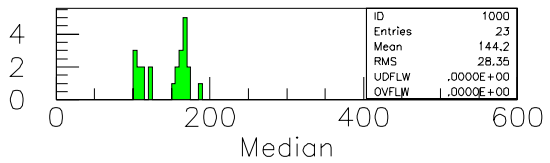
  3) Inter-strip region: $\pm$10 μm around the midway between the strips

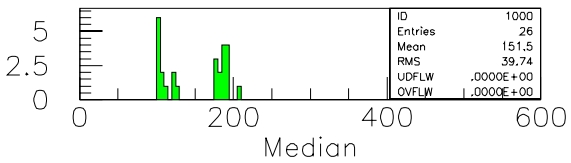
CalFits: Chip 0 Runs 4100 to 4111

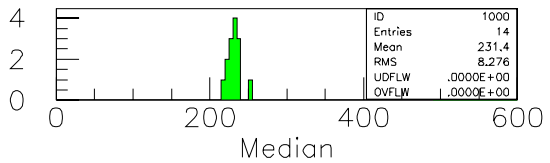
98/08/25 21.36

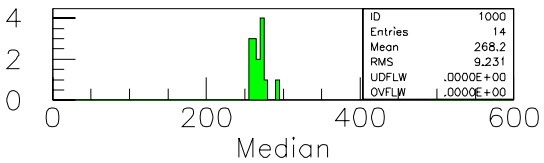


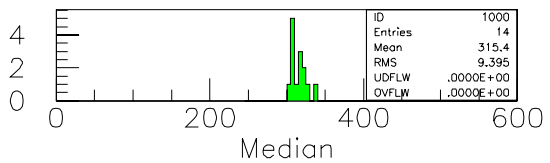


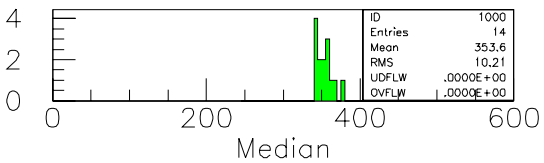


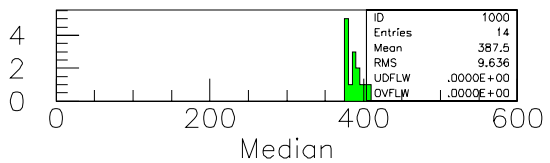


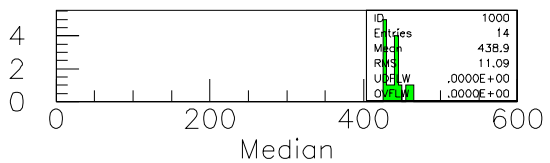






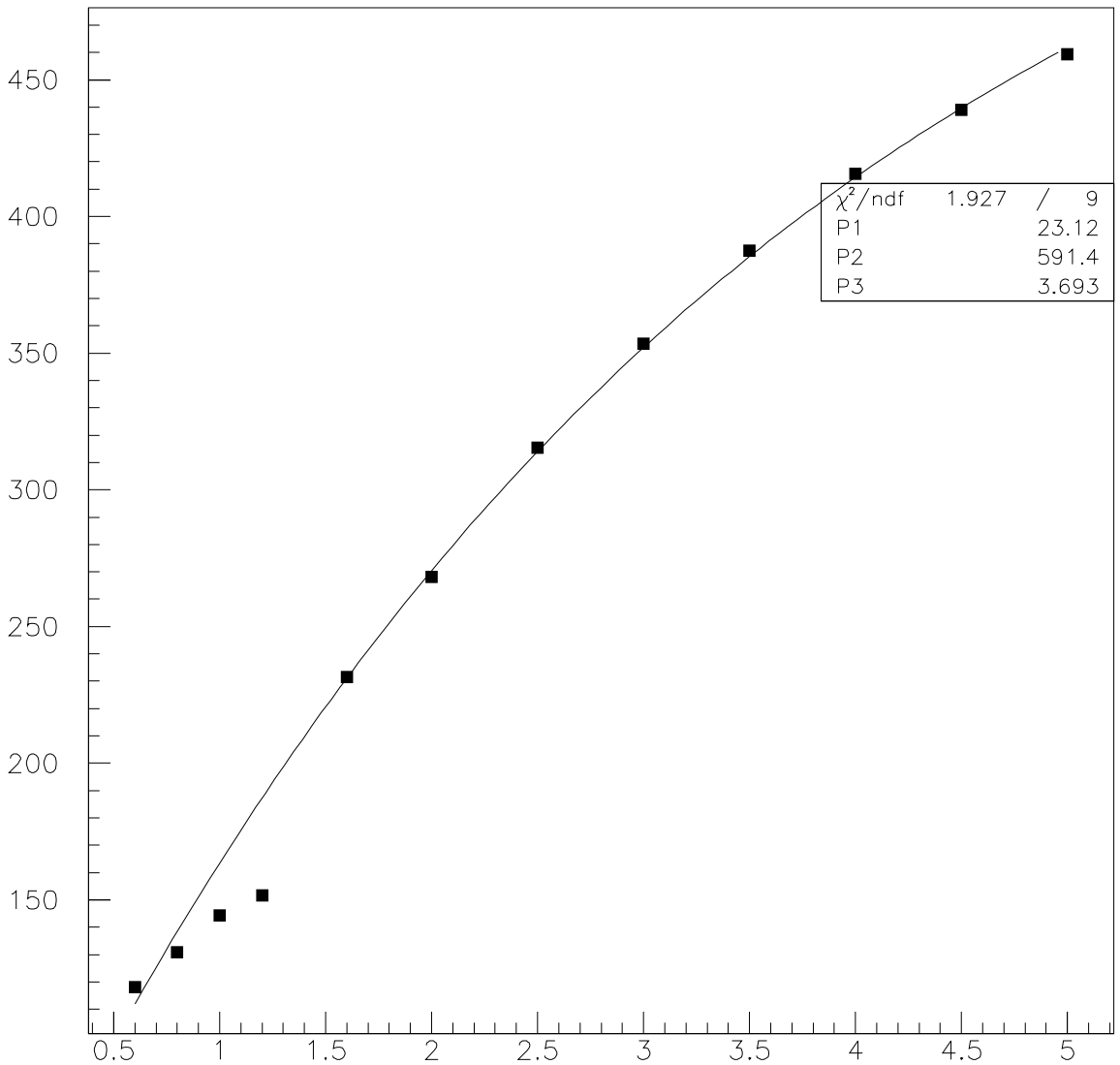






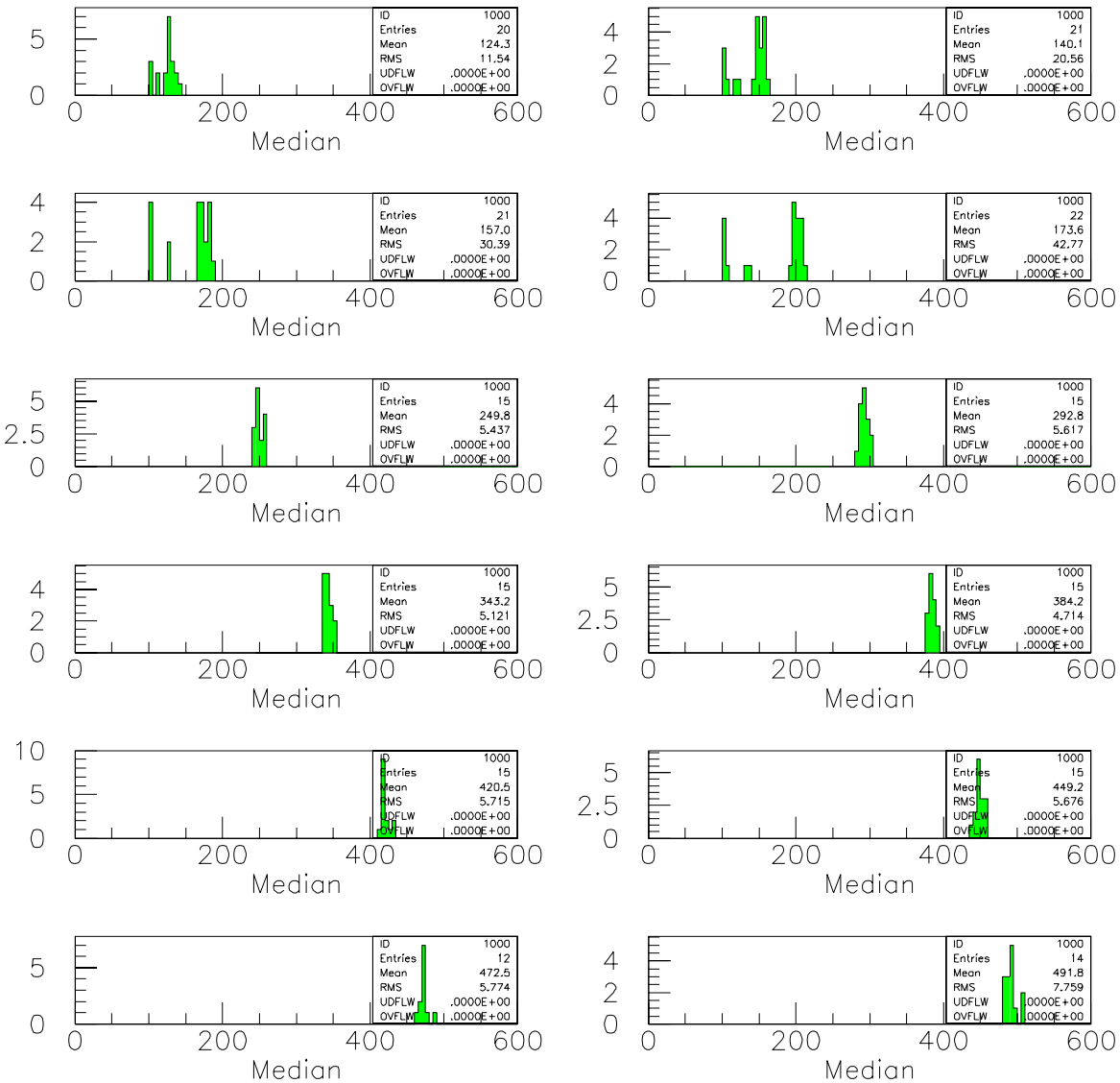
CalFits: Chip 0 Runs 4100 to 4111

98/08/25 21.36



CalFits: Chip 1 Runs 4100 to 4111

98/08/25 21.37



CalFits: Chip 1 Runs 4100 to 4111

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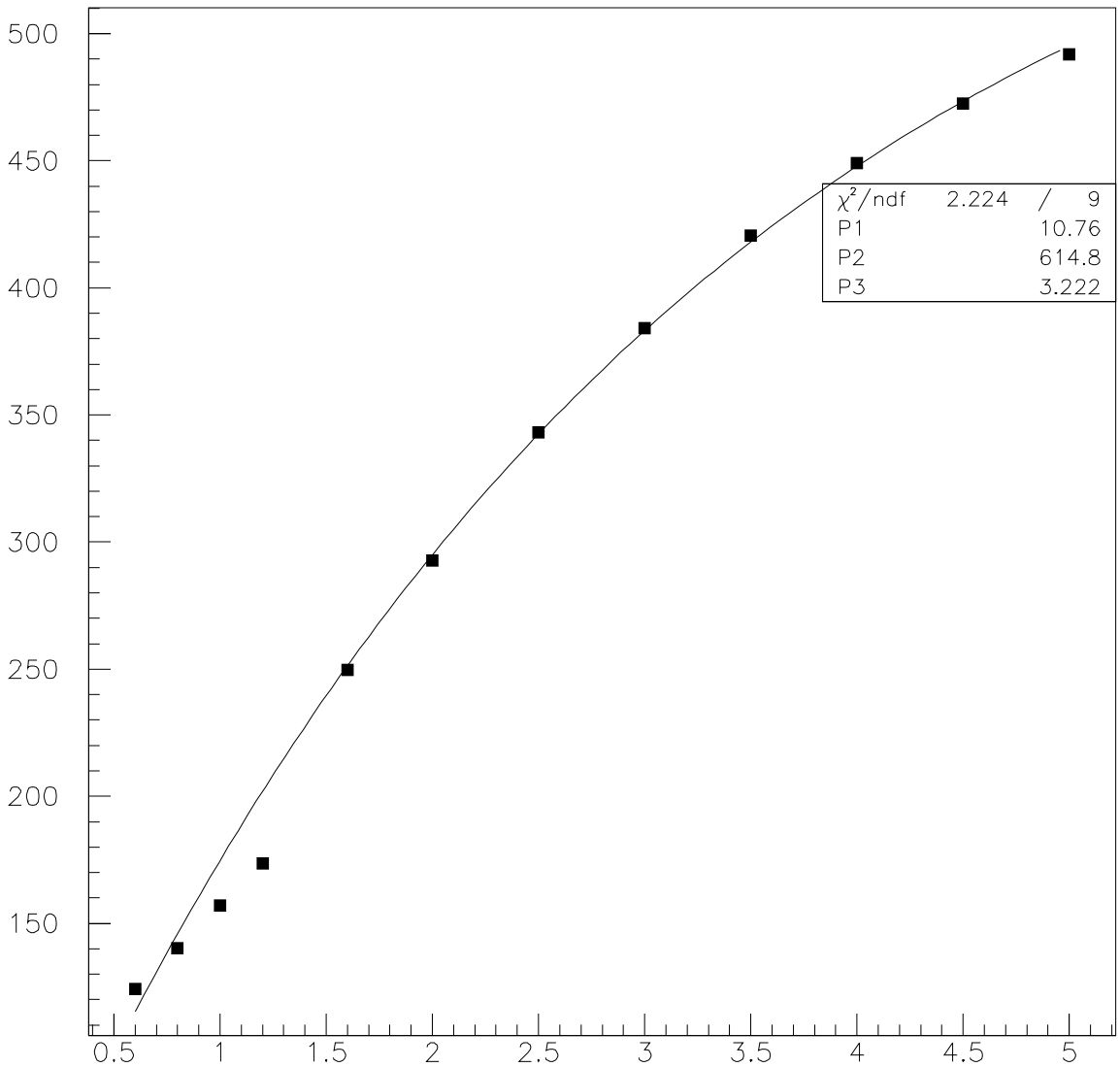

CalFits: Chip 2 Runs 4100 to 4111

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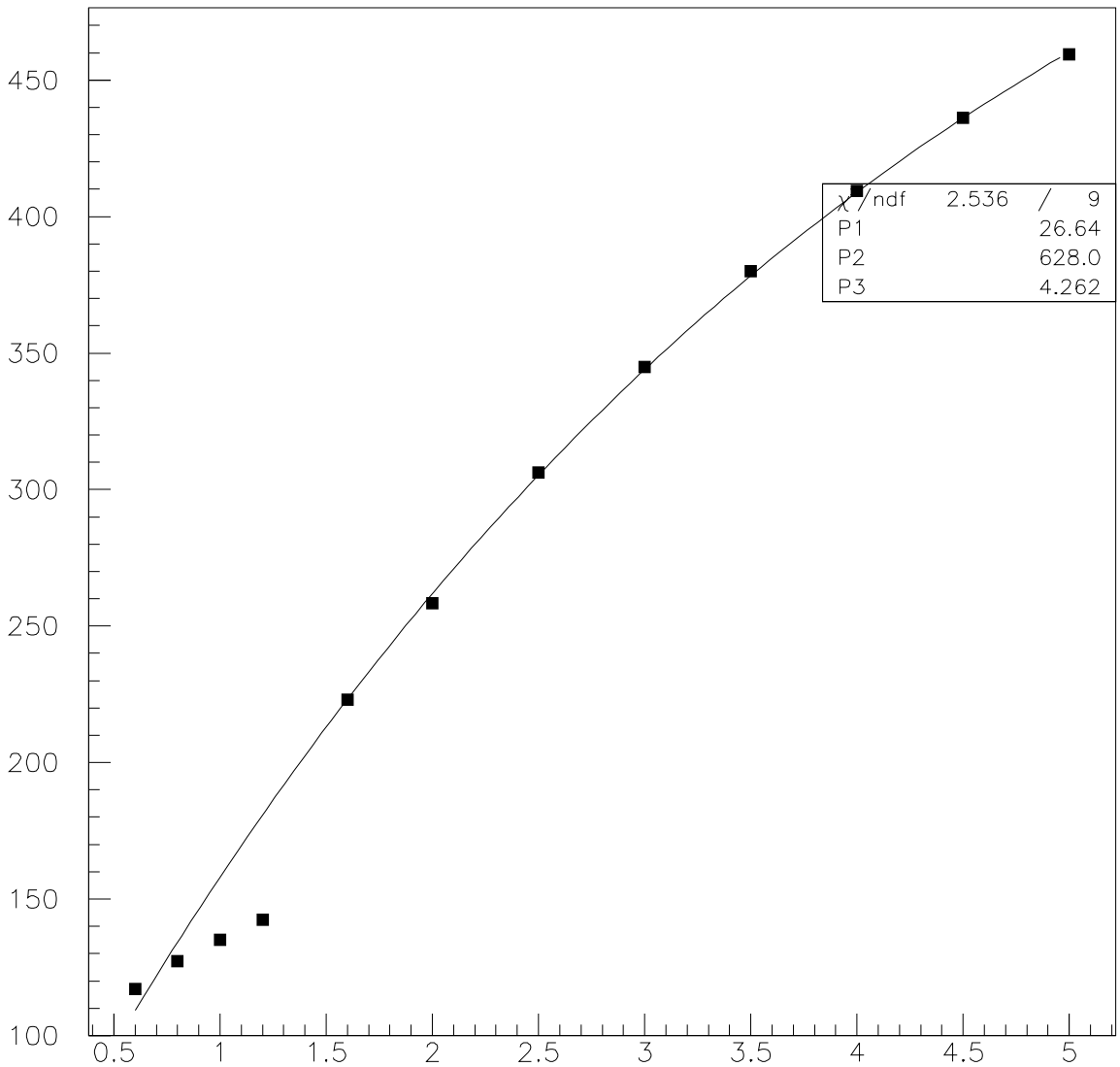
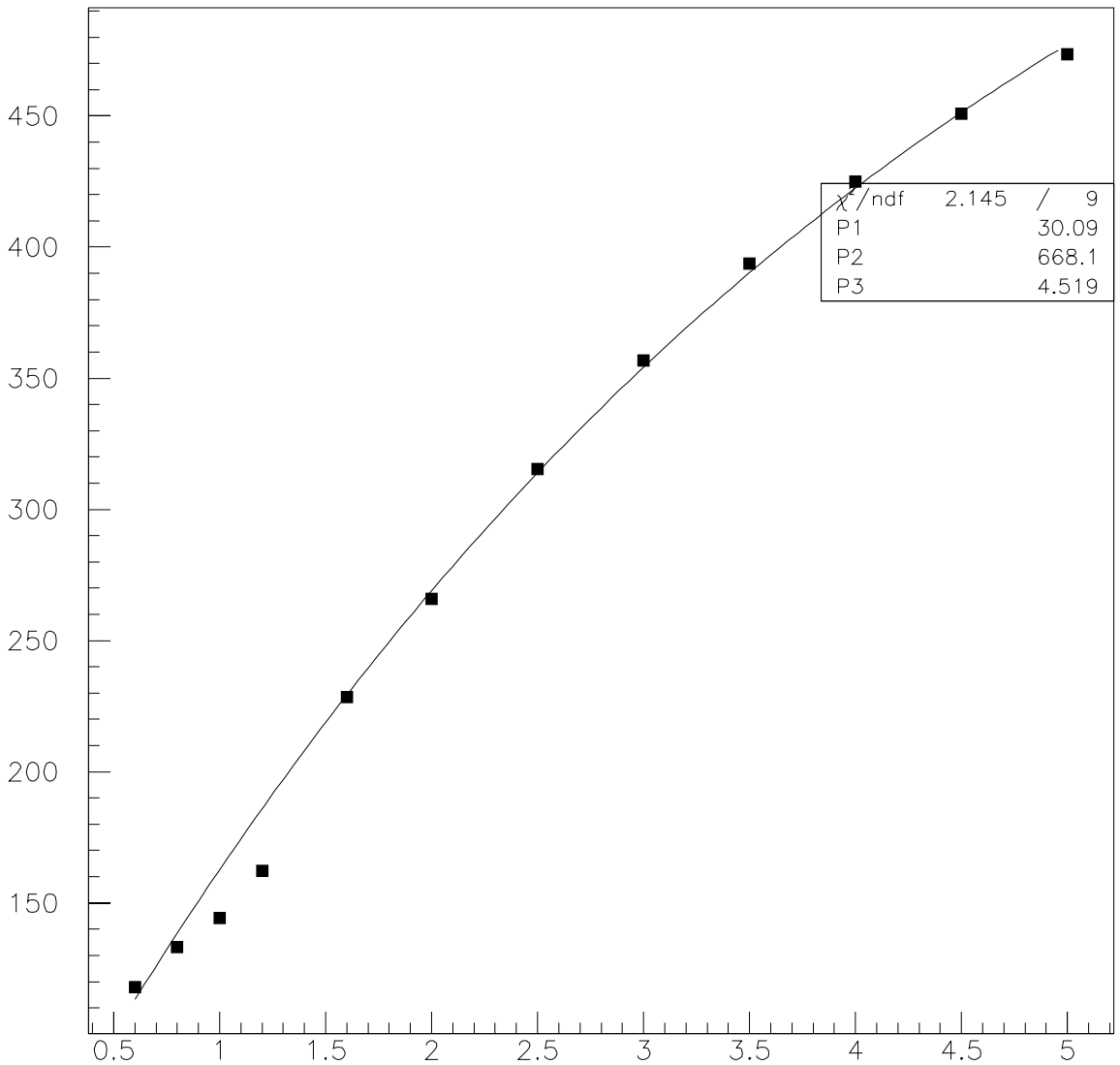
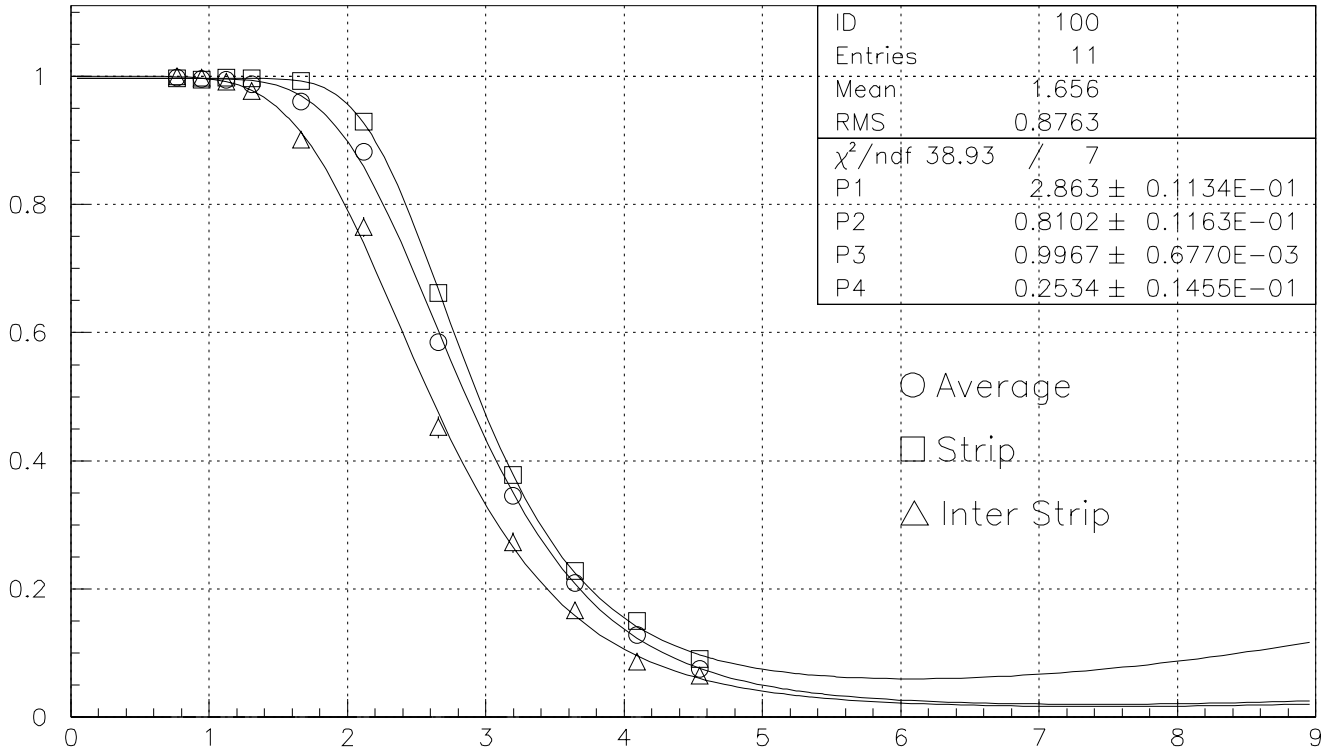


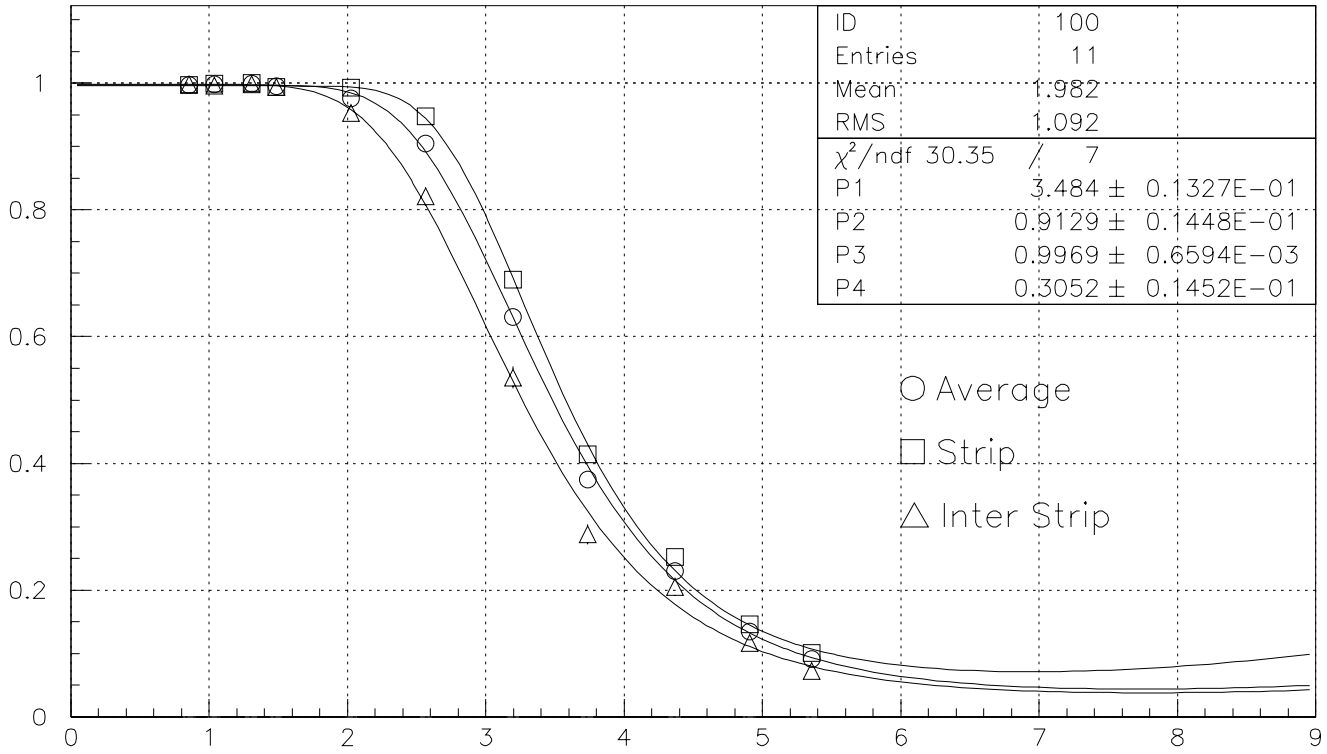
CalFits: Chip 3 Runs 4100 to 4111

98/08/25 21.37





eff.vb500.det1.chip1.



eff.vb500.det1.chip2.

Charge collection as a function of bias voltage

- **Median vs. Bias voltage**

- By detectors and chips

- Sintef p10: det 0, chip 2, 3, 5 (4 was sick and excluded)

- HamP: det 1, chip 0, 1, 2, 3

- HamN: det 2, chip 0, 1, 2, 3

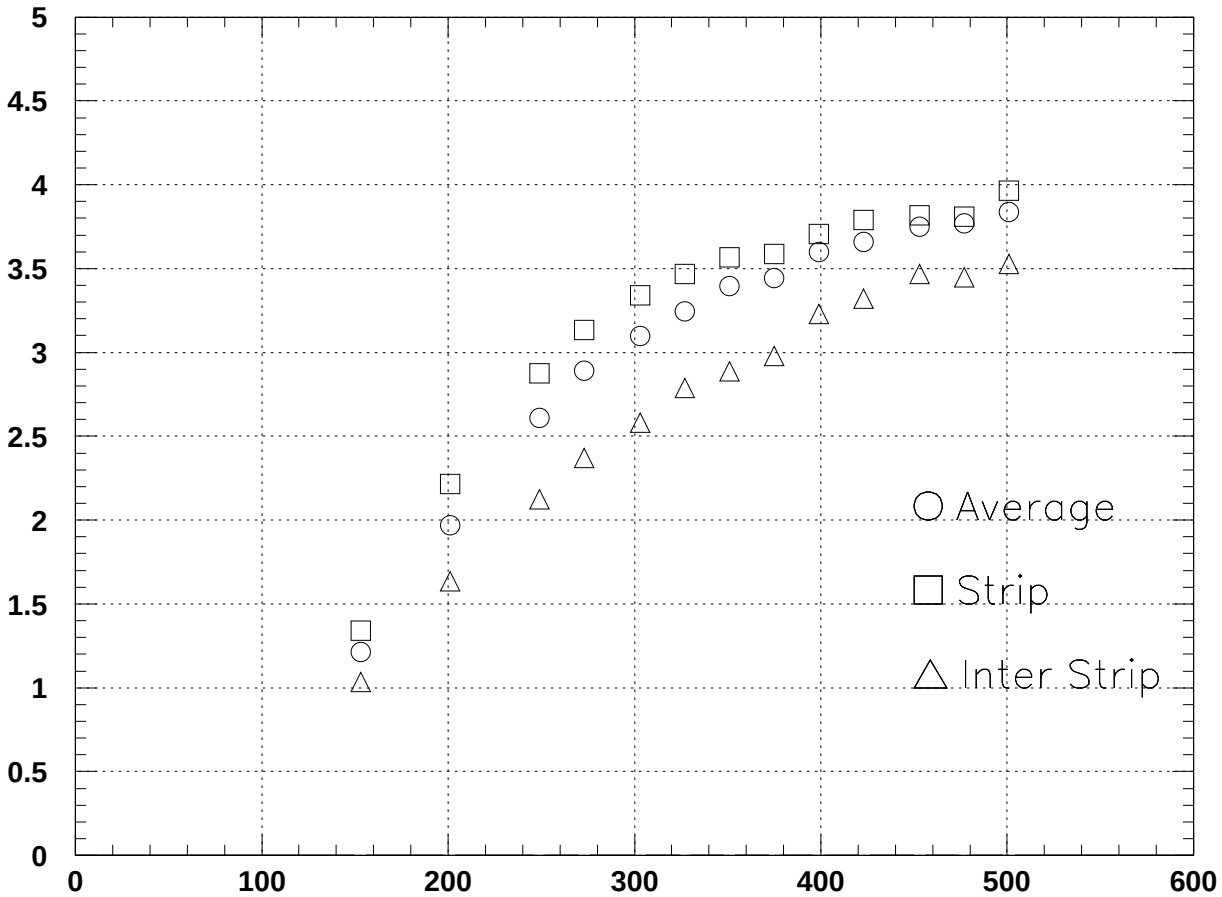
(Figures)

- Charge collection of the p-on-n detectors did not saturate even at 500V

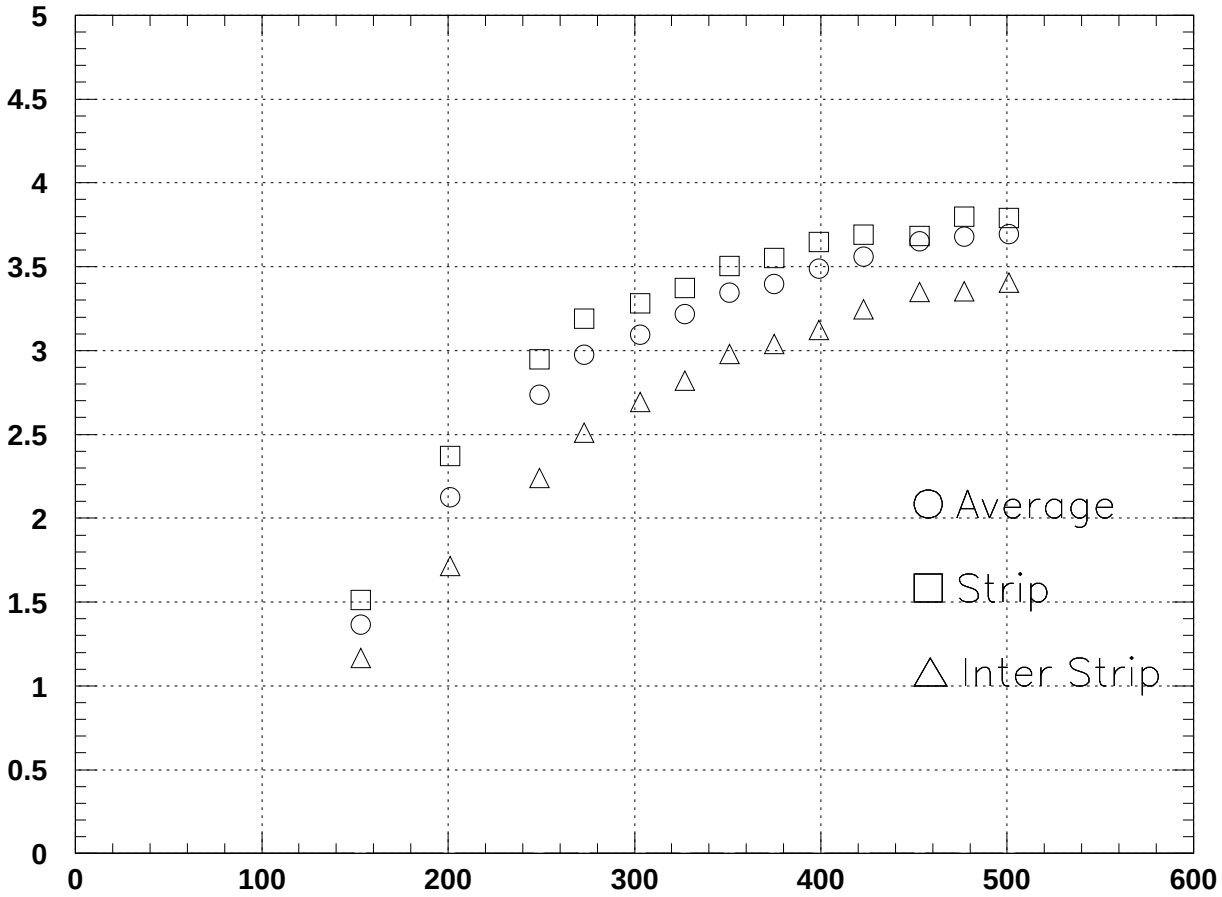
- Charge collection of the n-on-n detector showed saturation above 300 V, although there were very slow increases up to 500 V

- At 500V, the medians reached at 3.5 fC in most of the chips

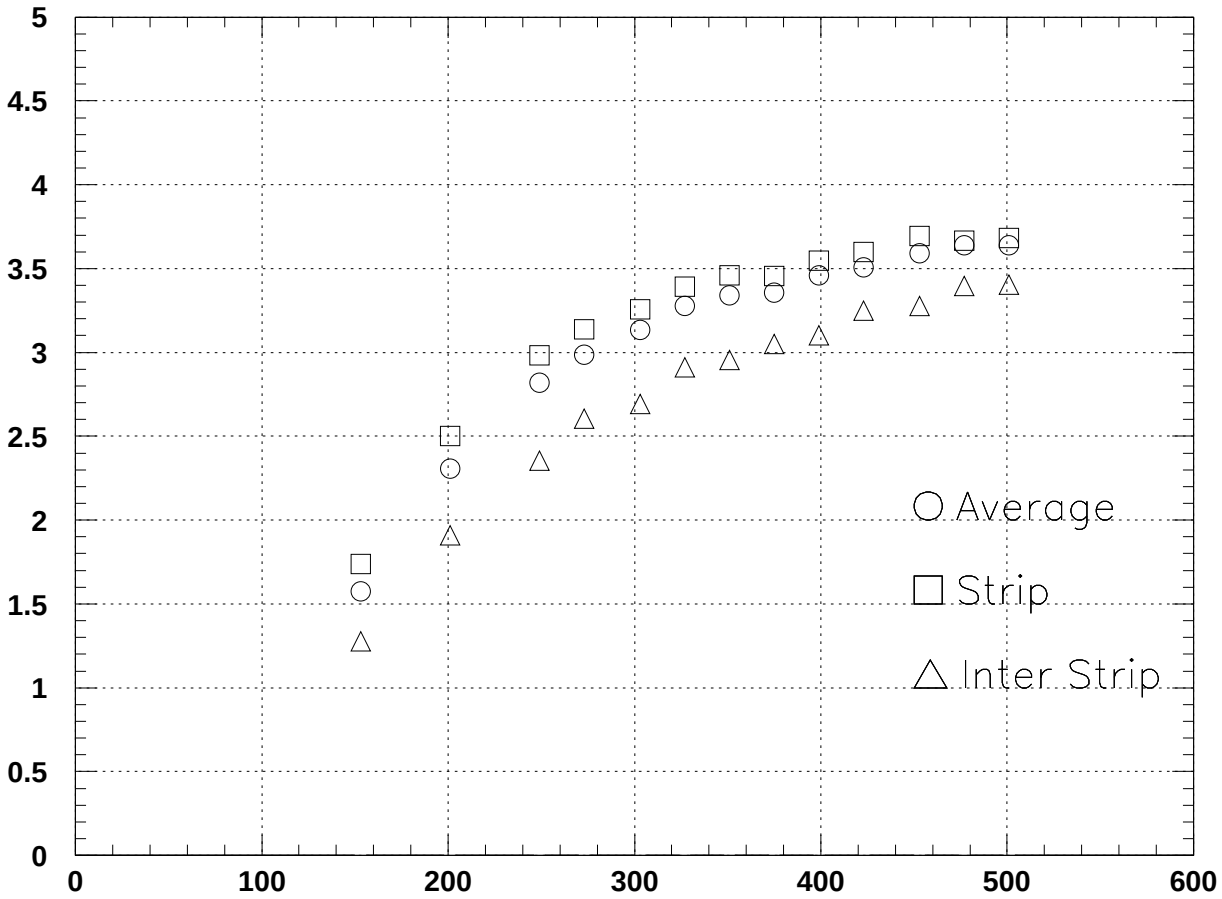
- A few chips showed discrepancy, saturation at 3 fC, 4 fC, 4.5 fC, e.g.



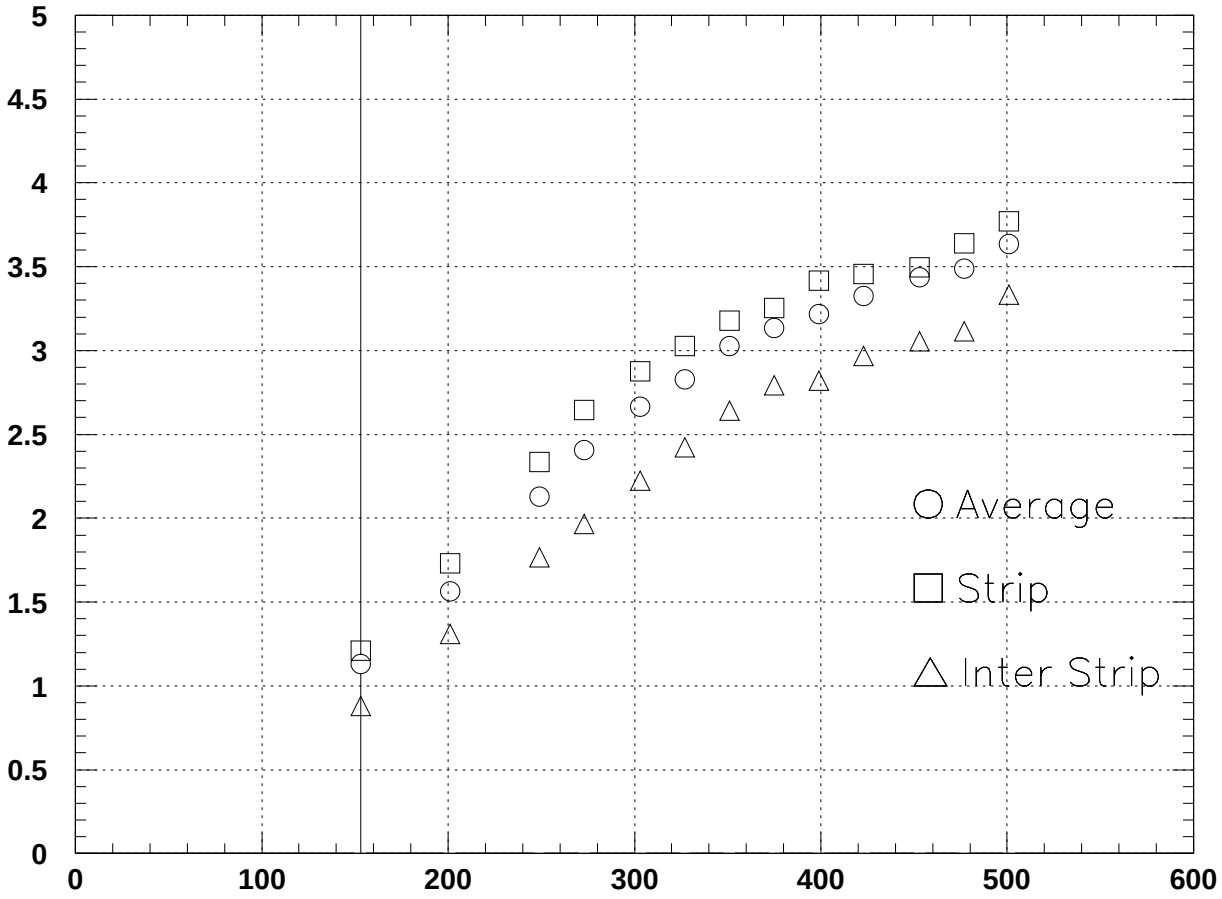
zq50detz0.zchipz2.



zq50detz0.zchipz3.



zq50detz0.zchipz5.



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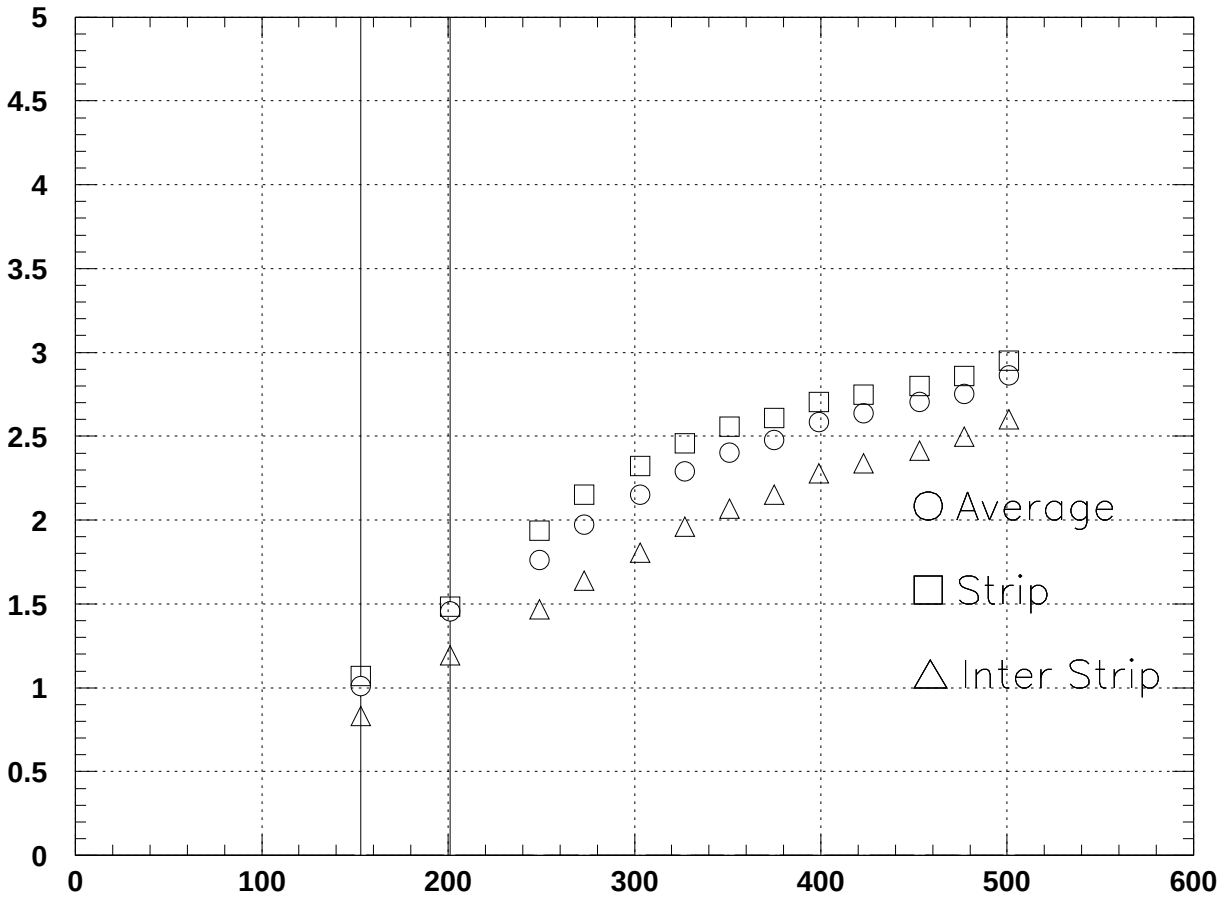

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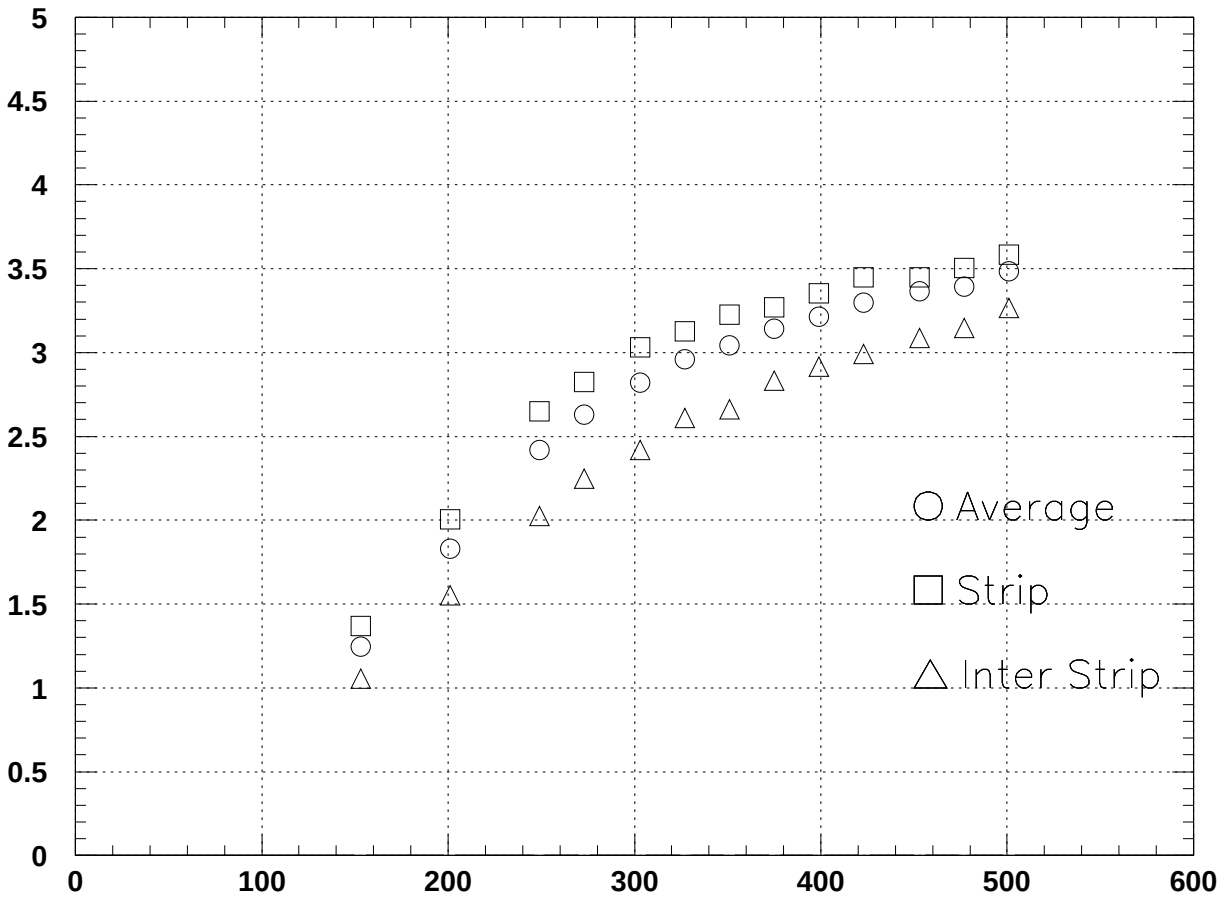

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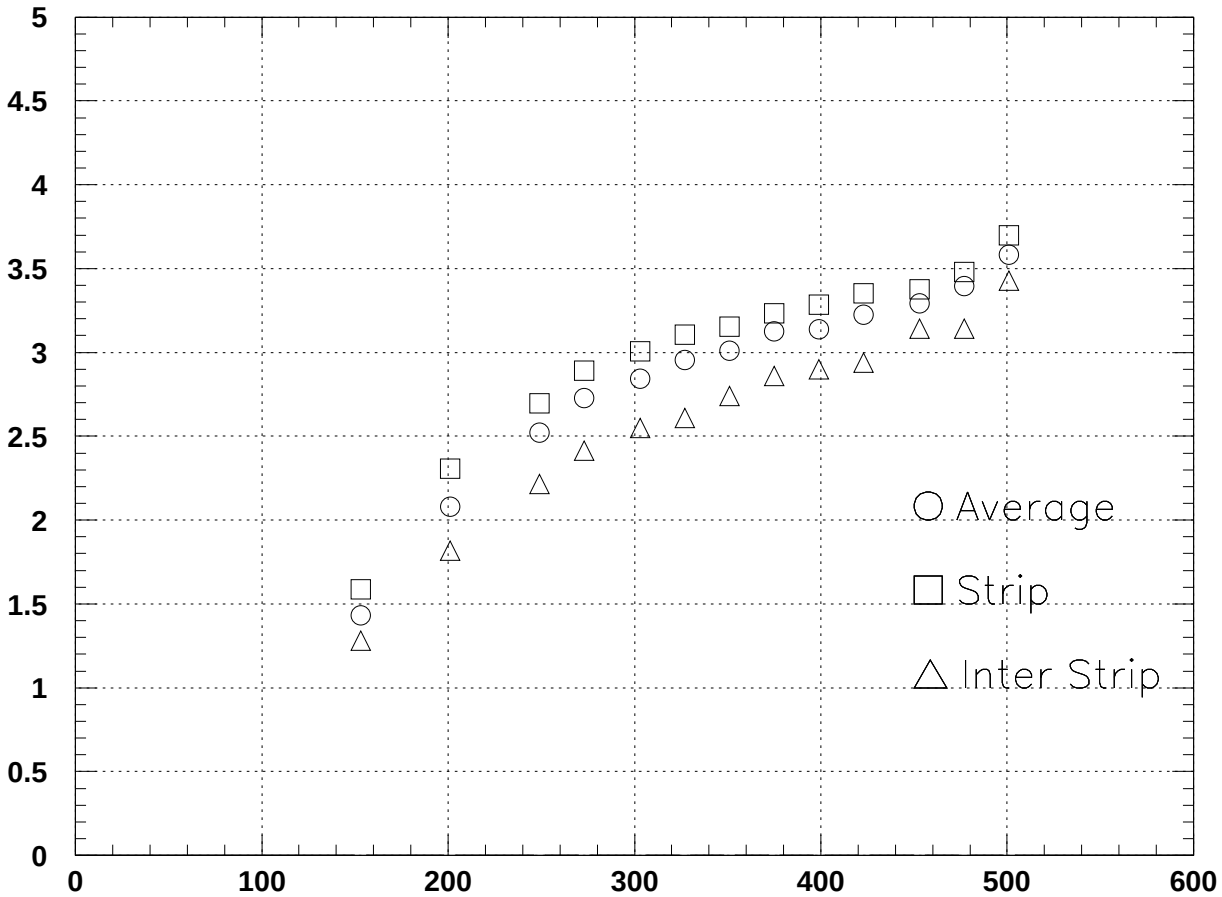

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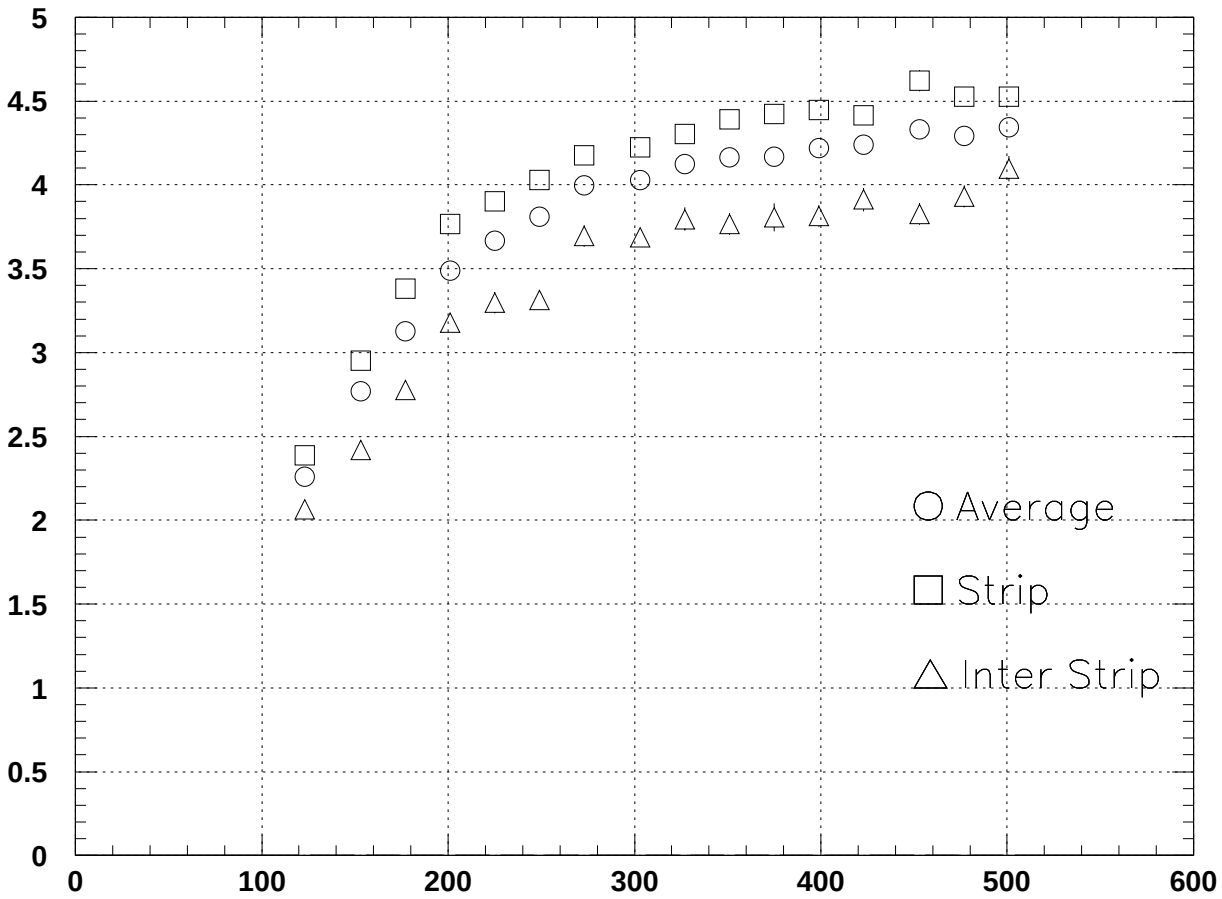

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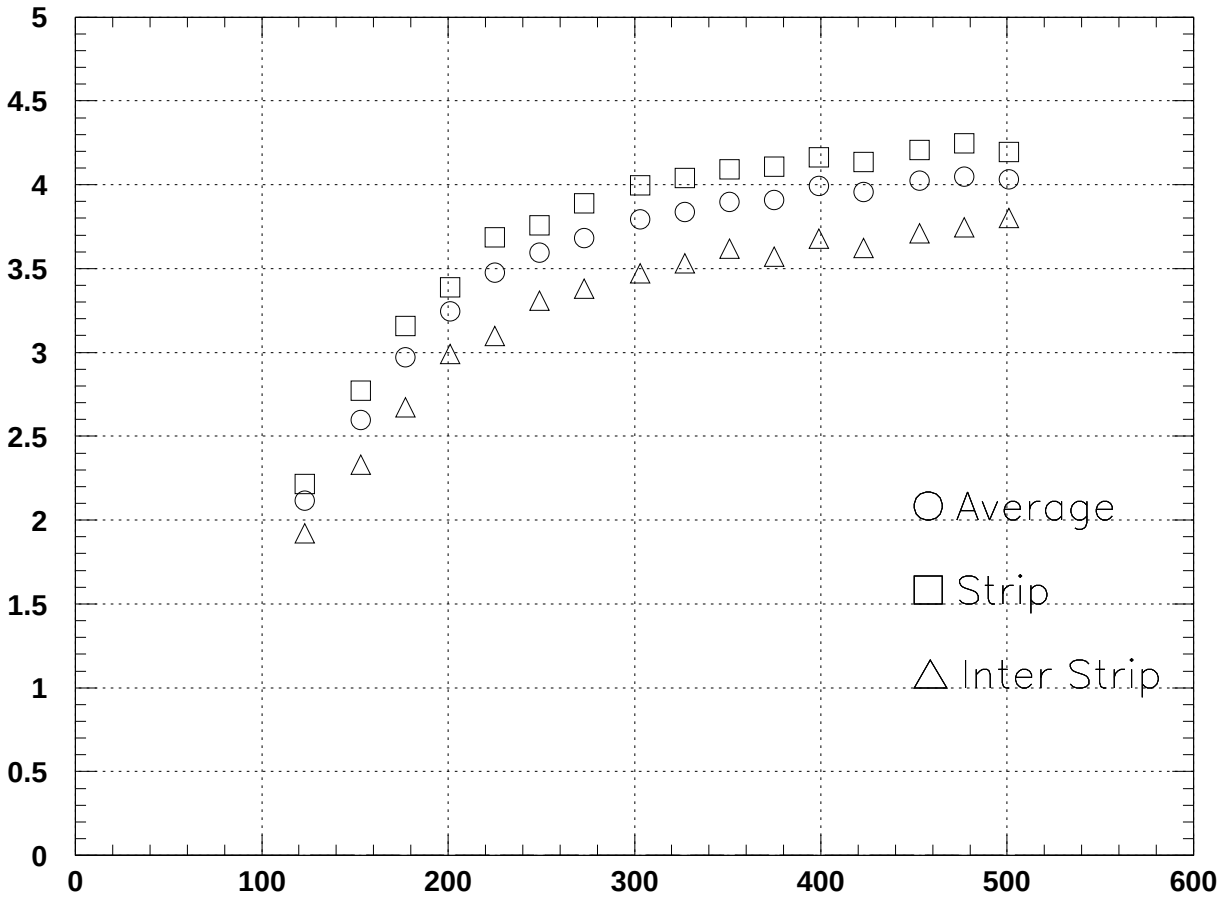

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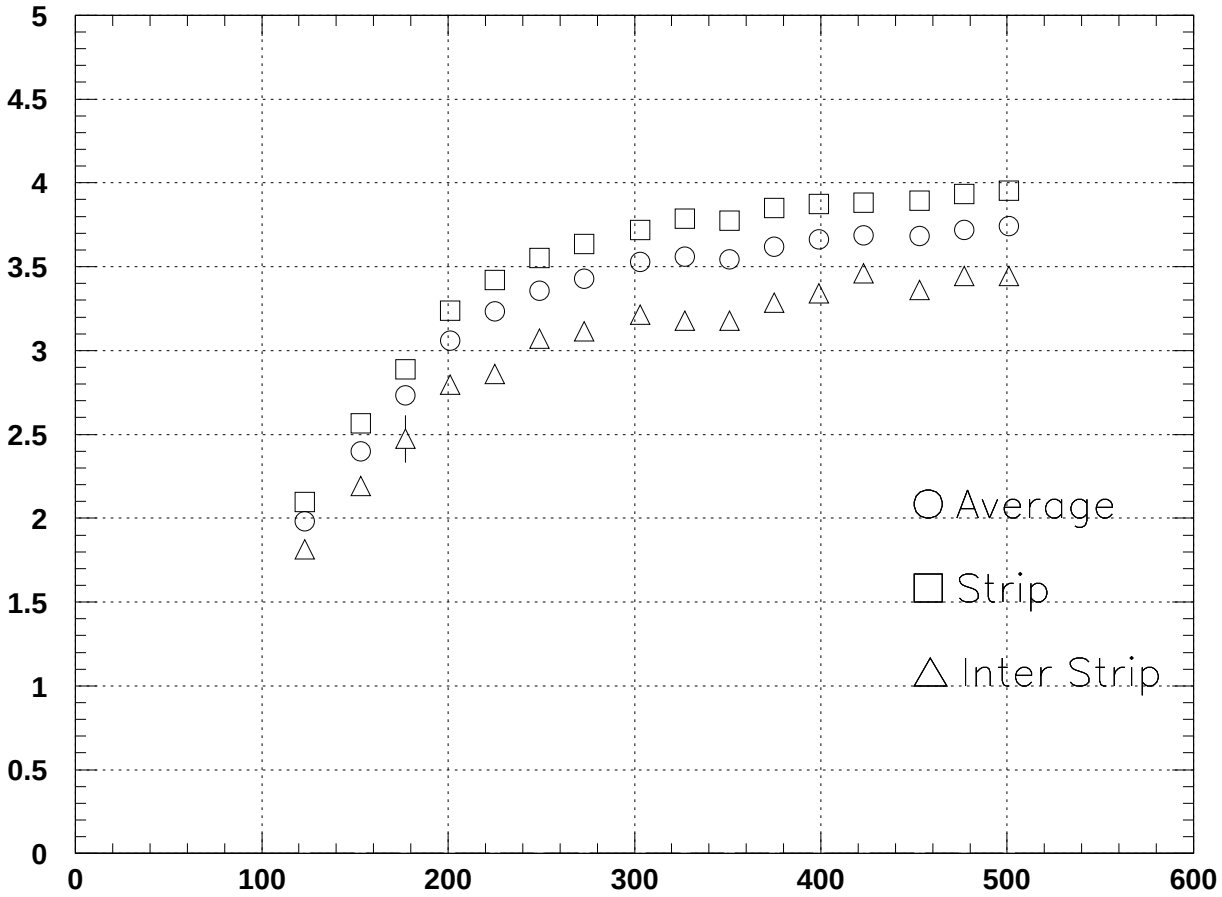

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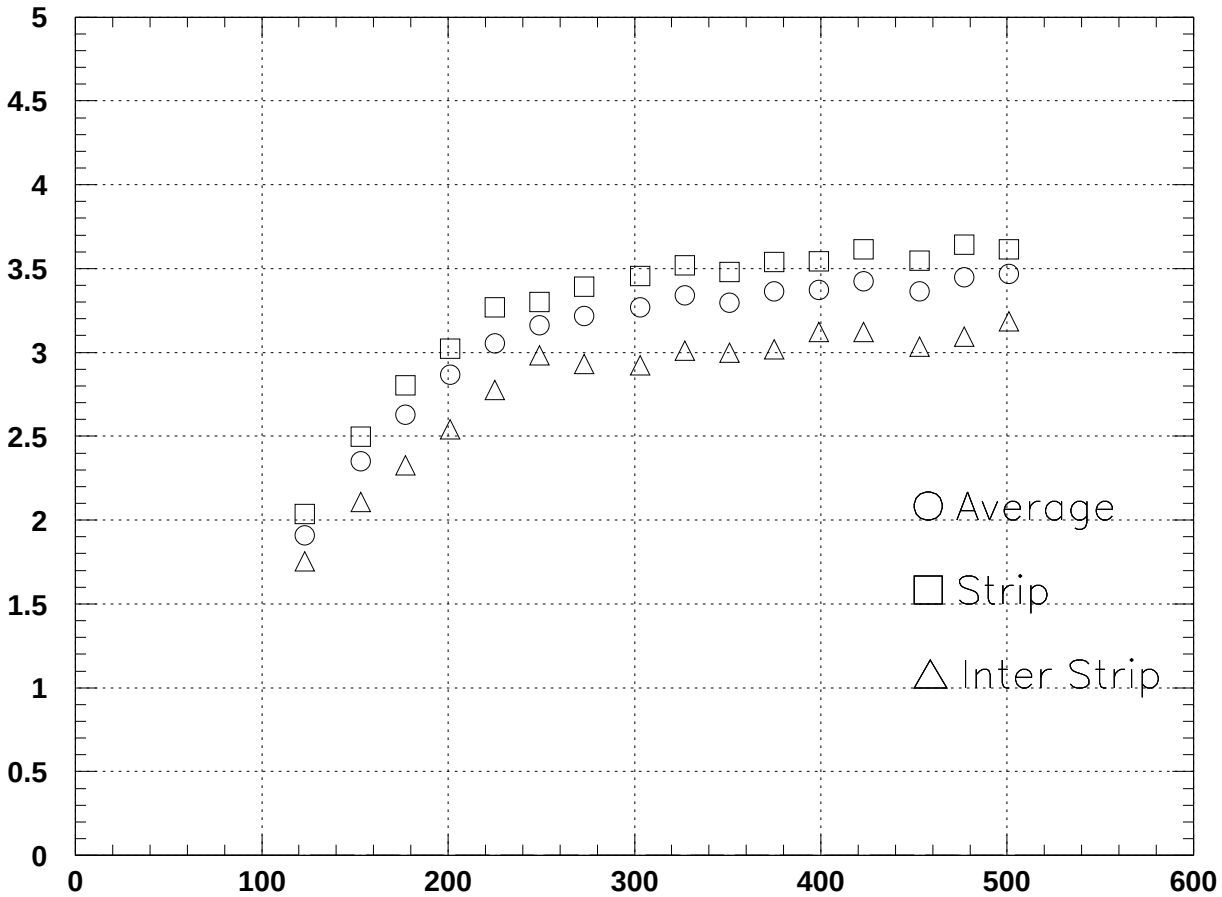
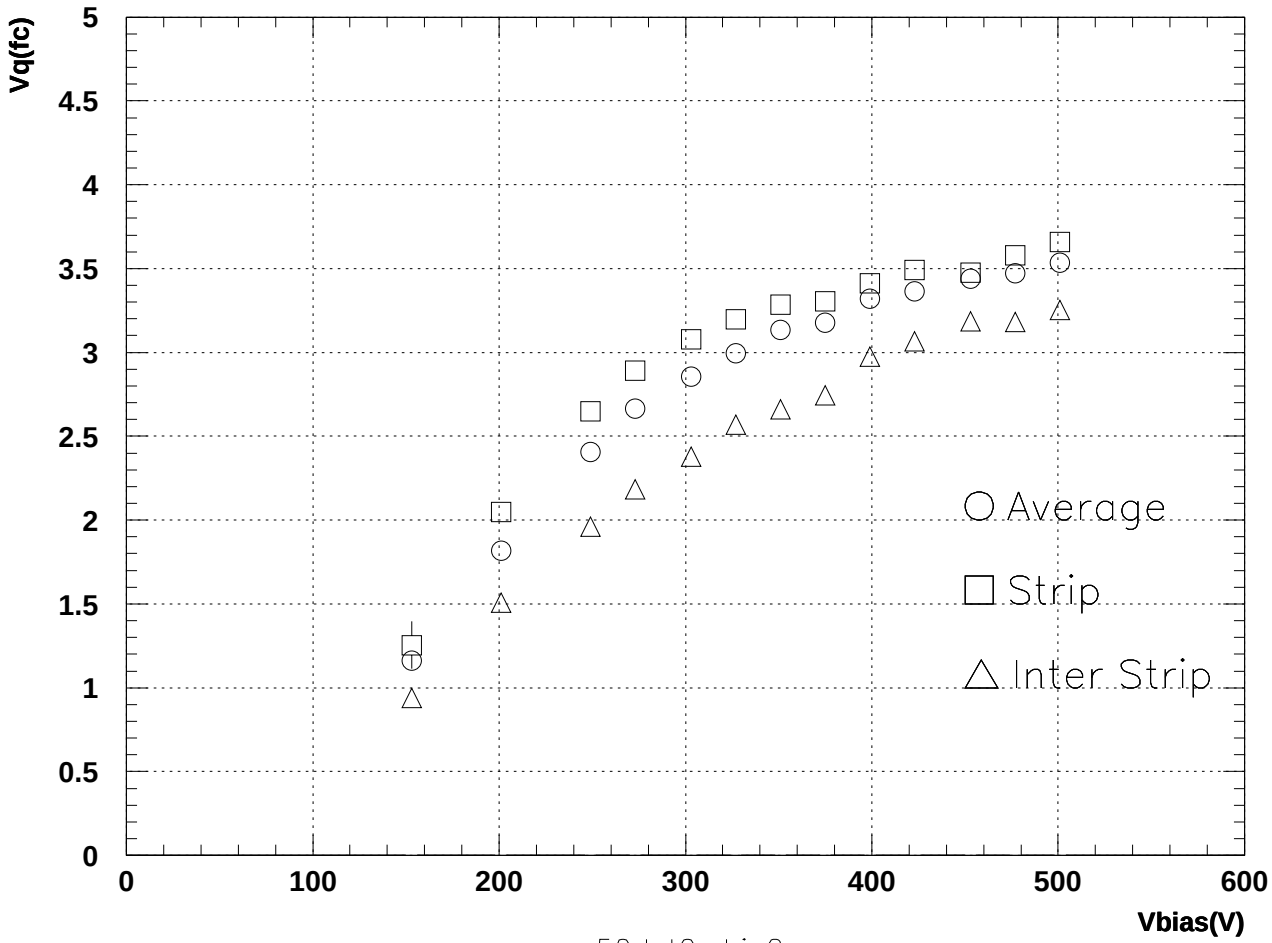


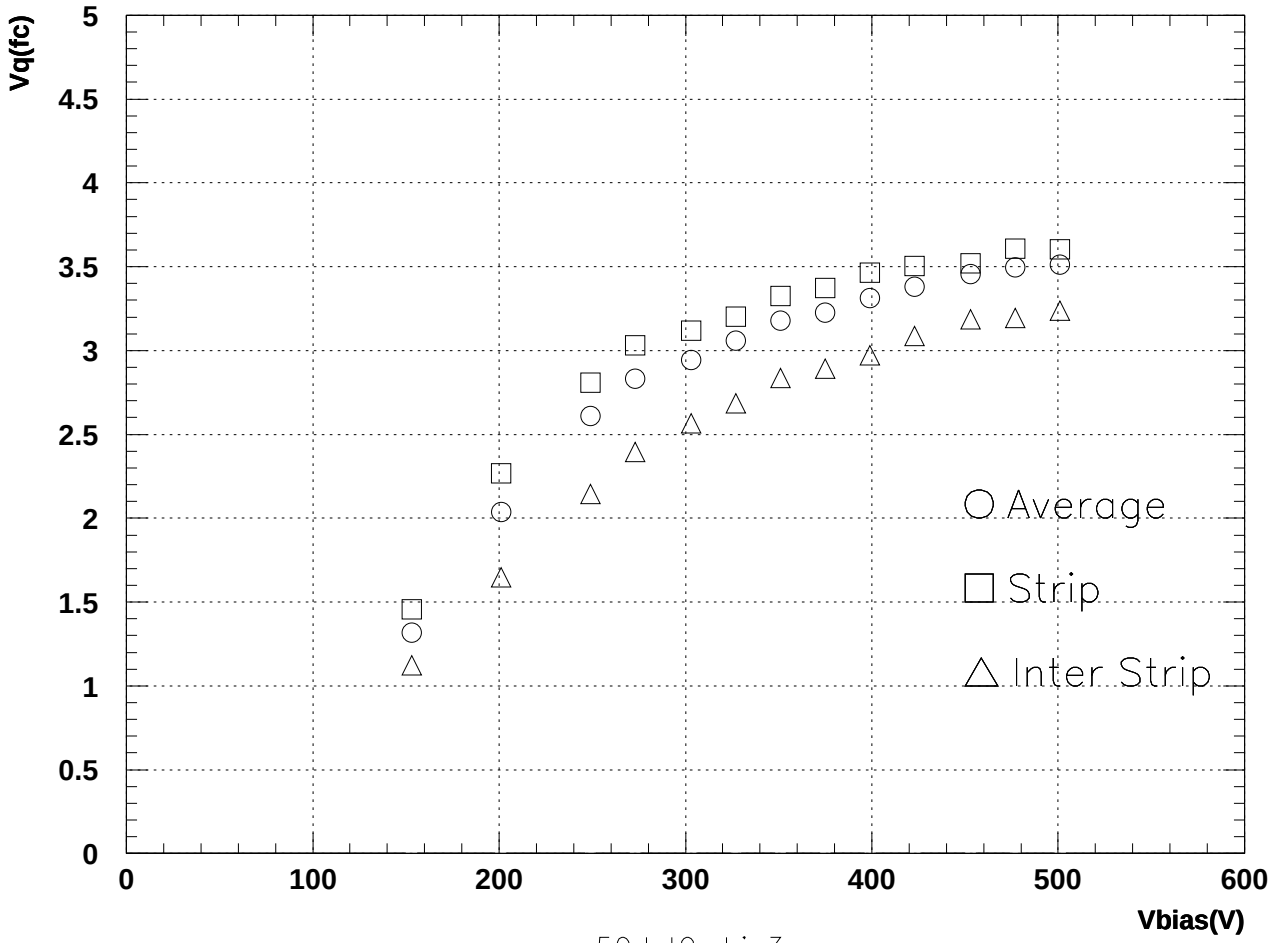
zq50detz2.zchipz3.

Rescaling the charge scale

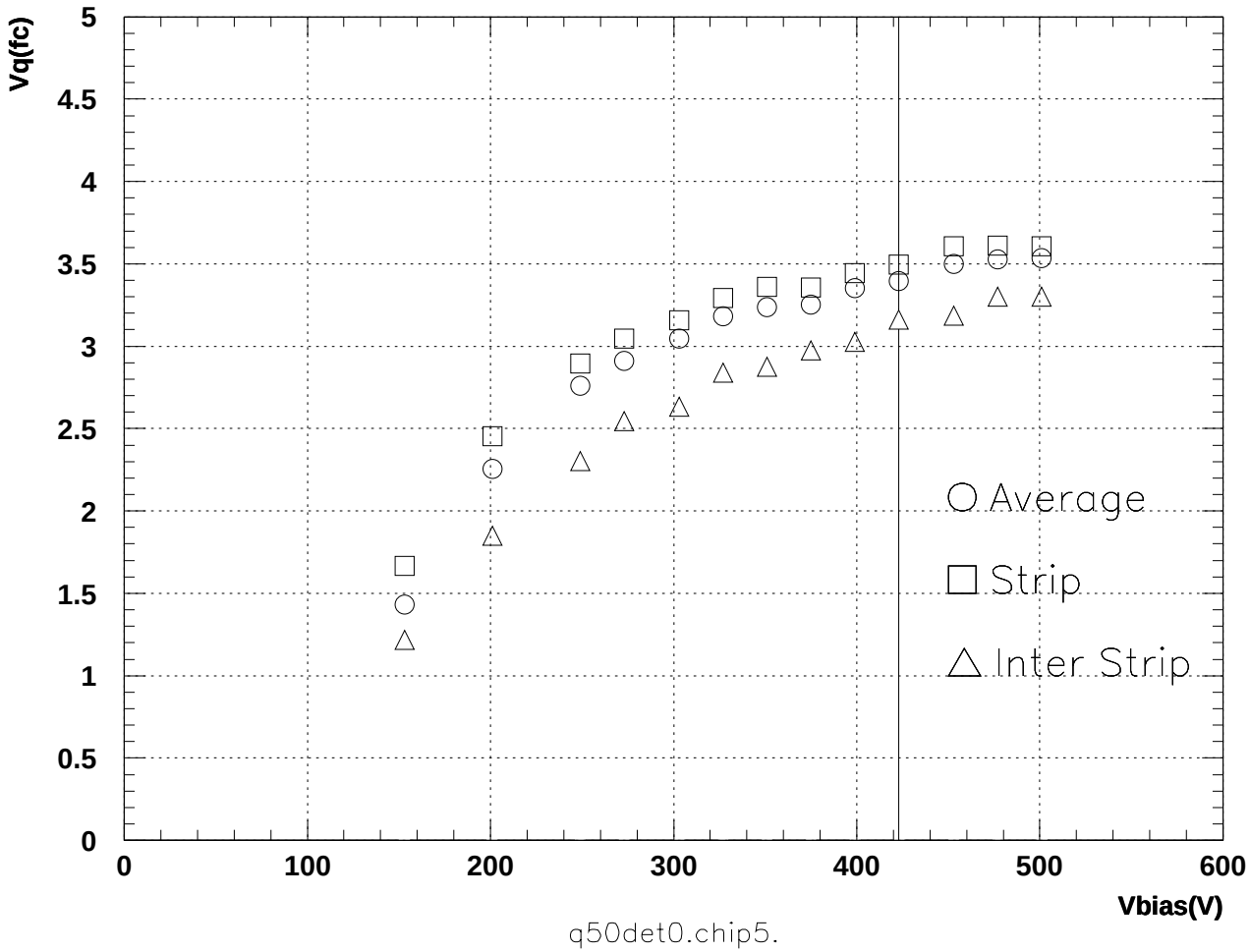
- **Average of the medians of 450, 475, 500 V to be 3.5 fC**



q50det0.chip2.



q50det0.chip3.



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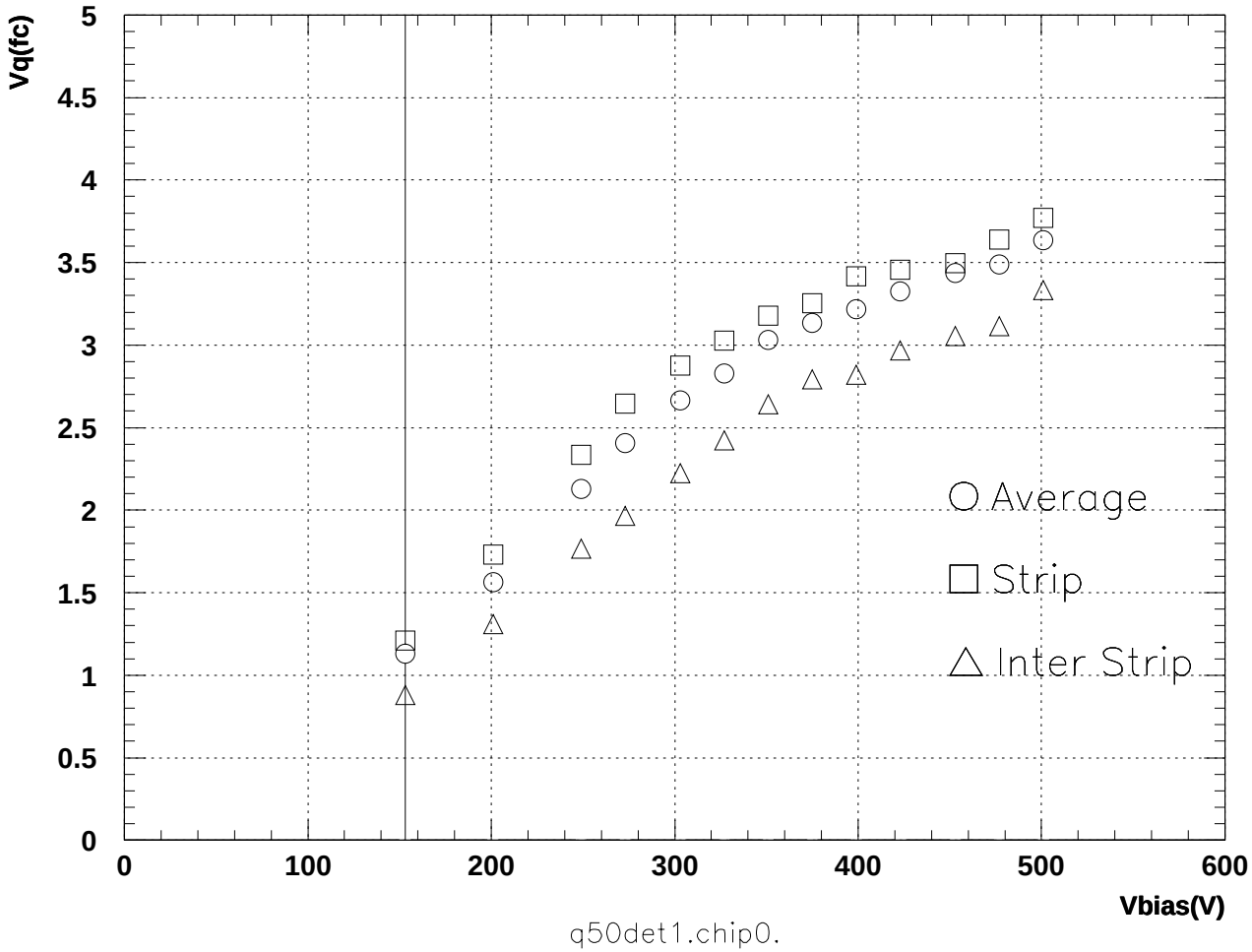
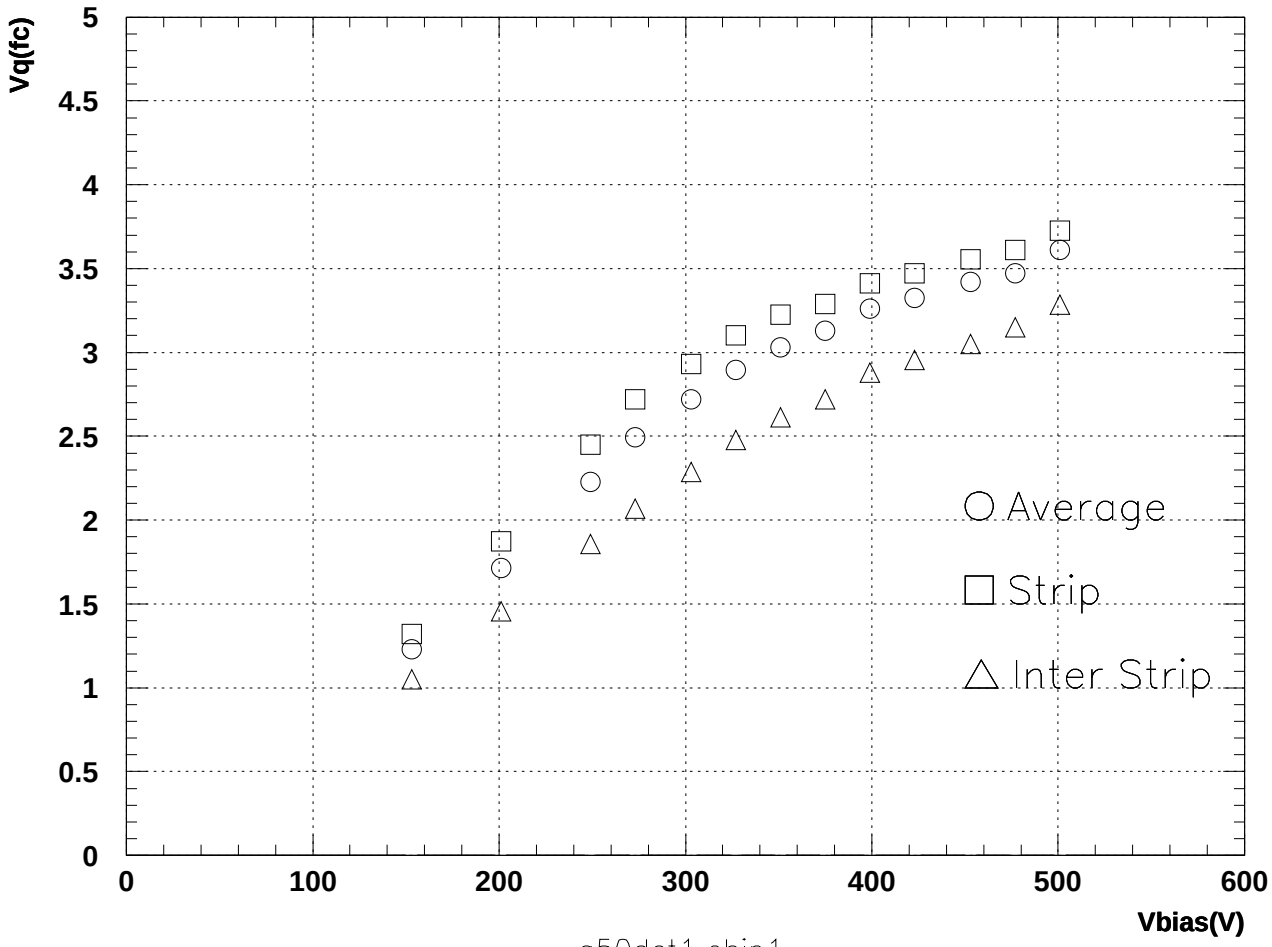


q50det1.chip0.



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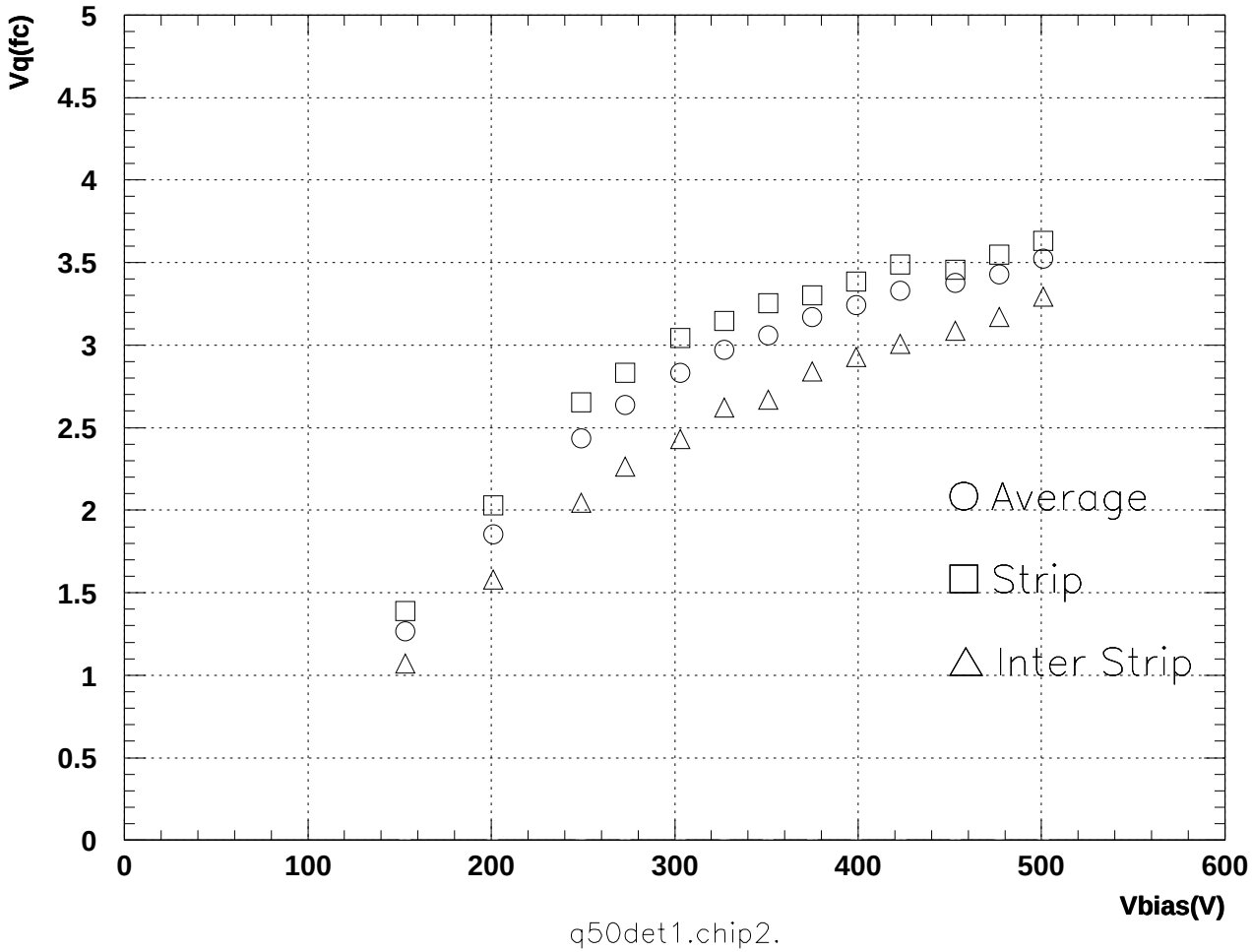

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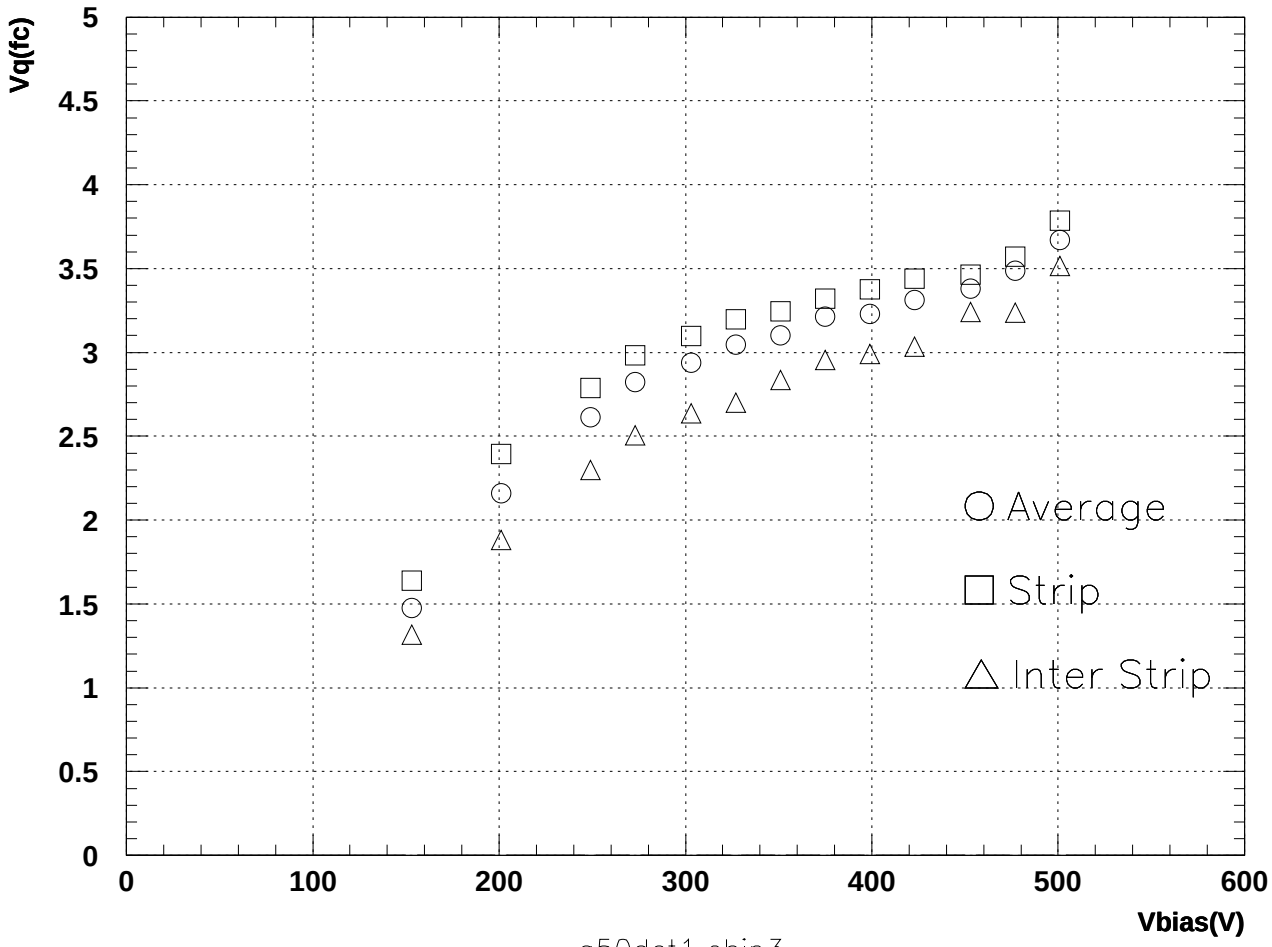

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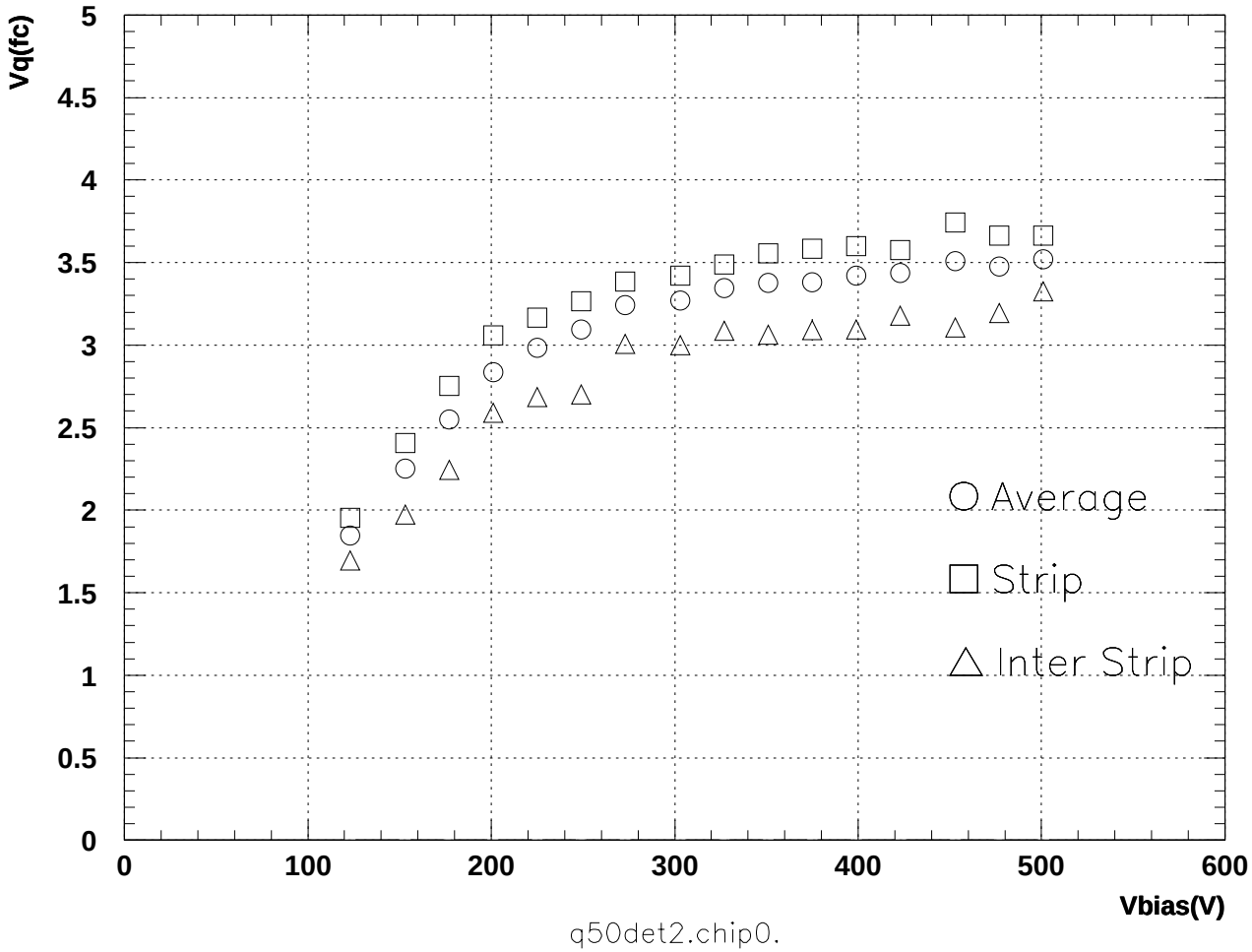
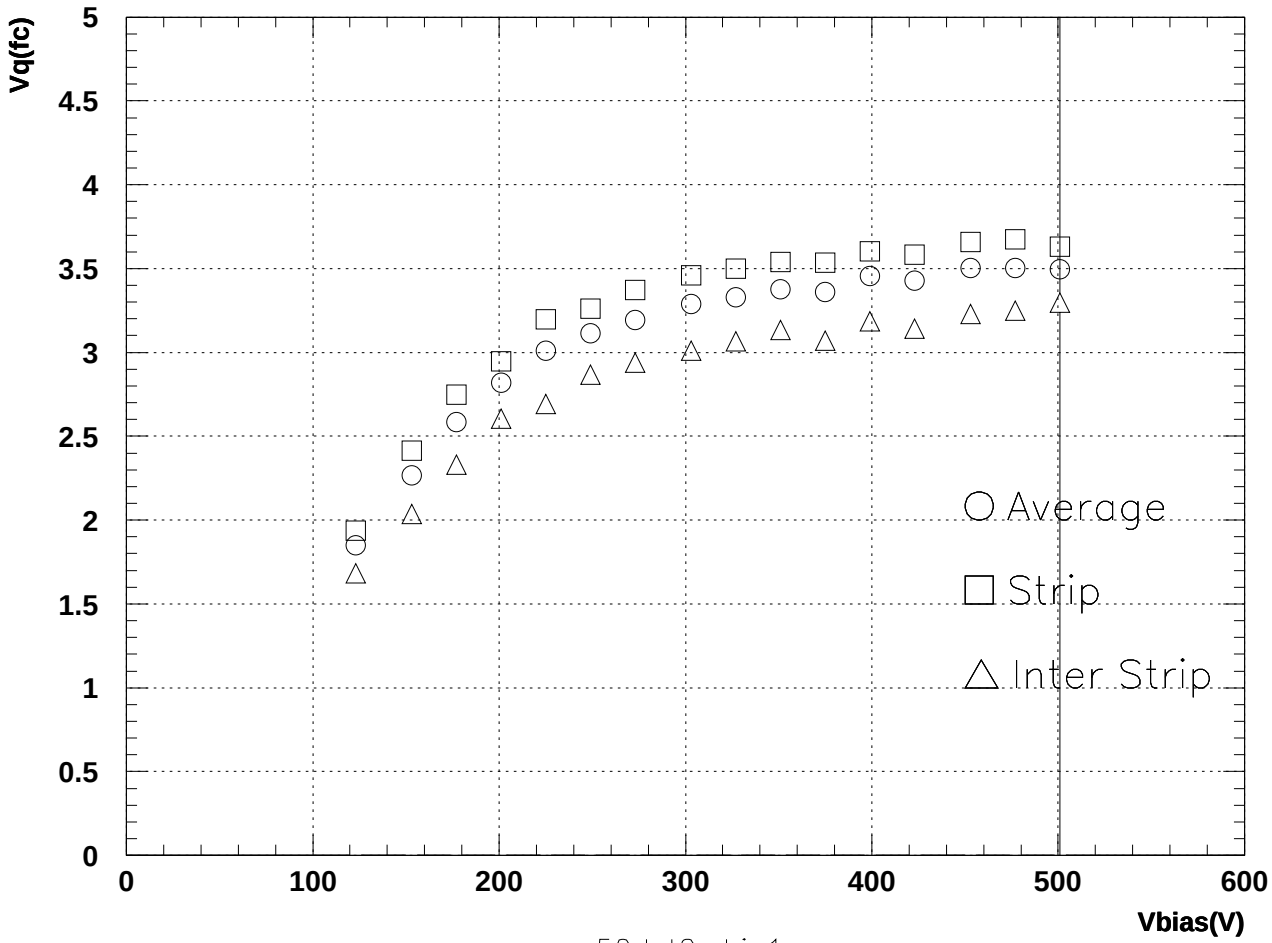


q50det2.chip0.



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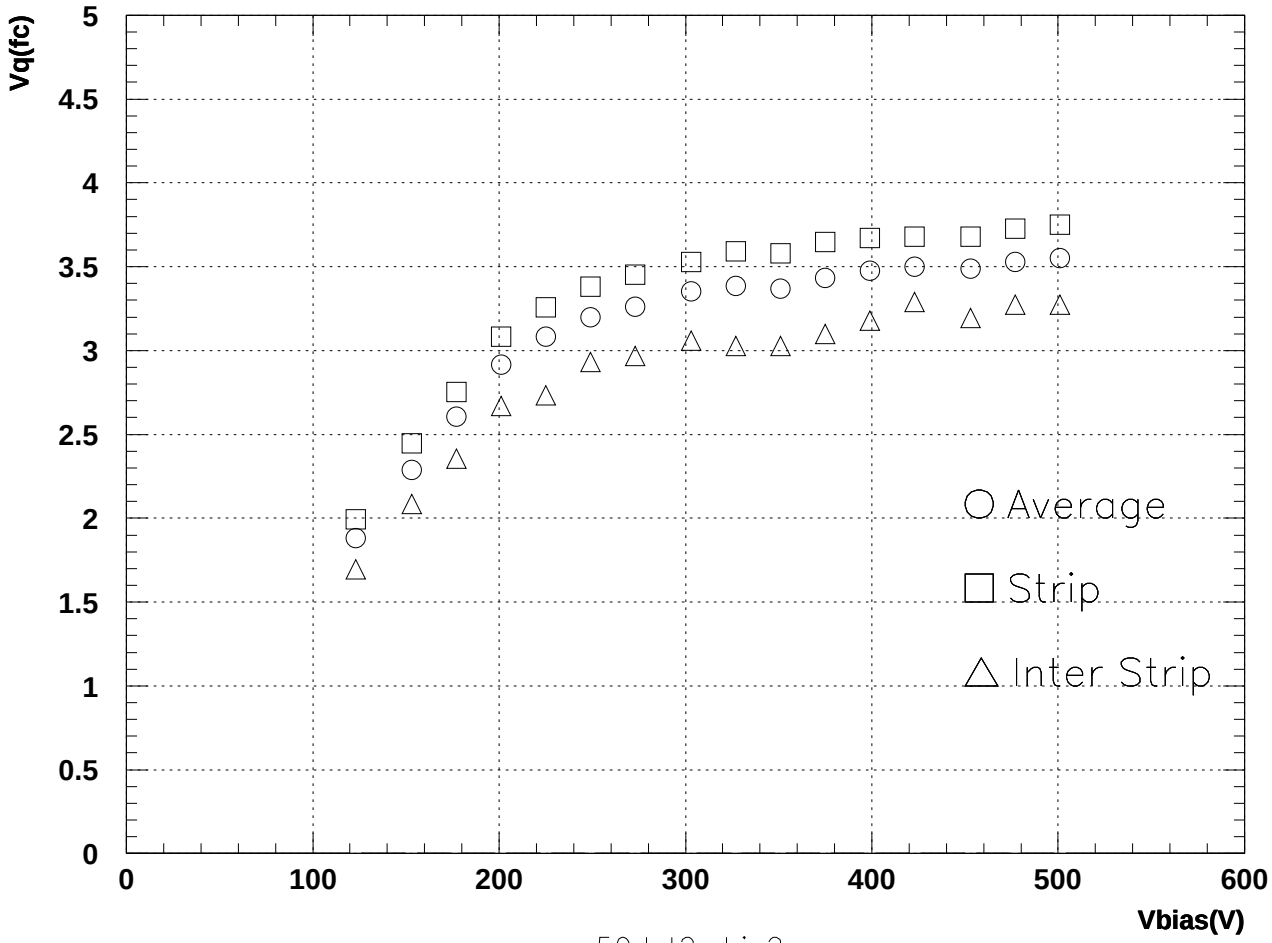
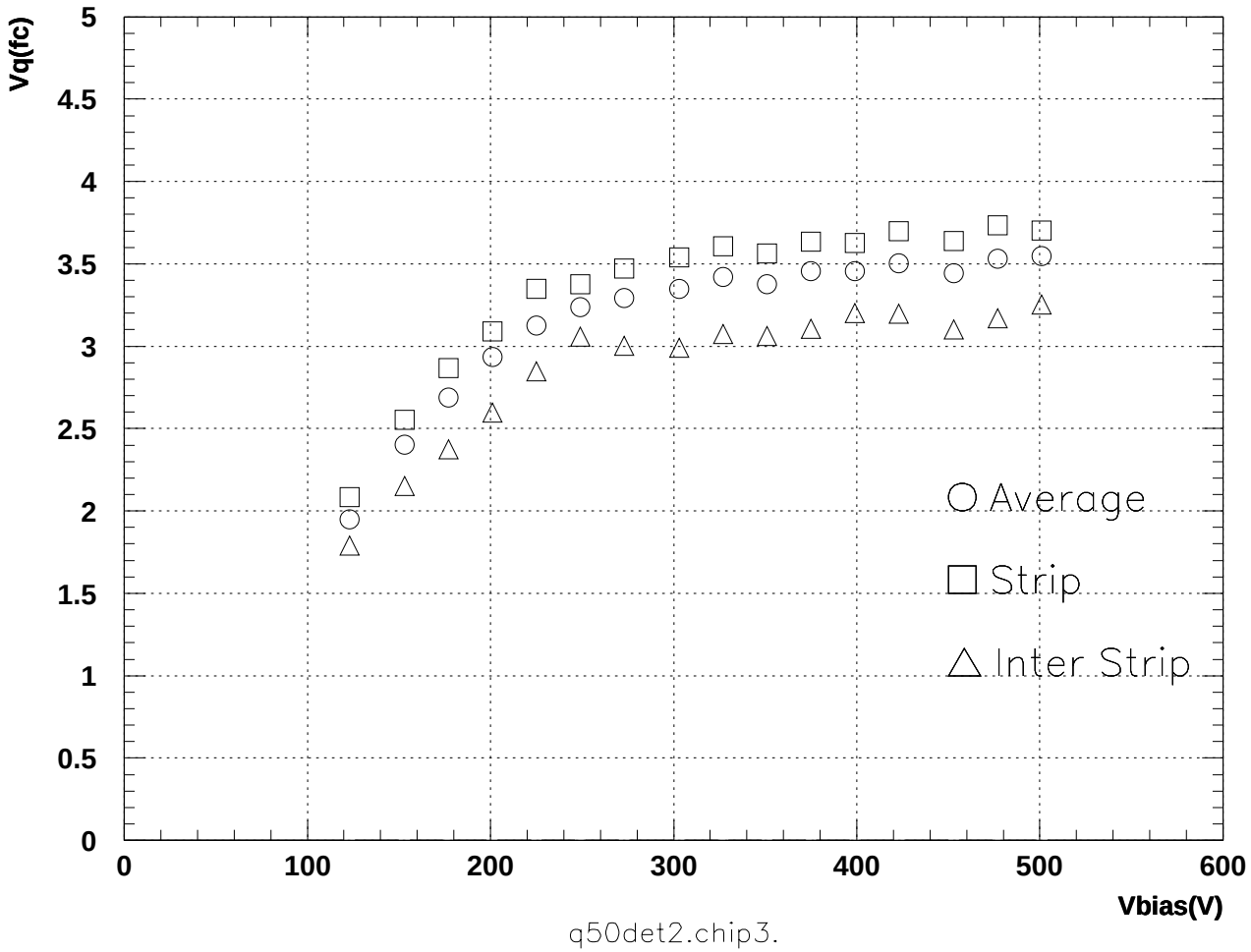


q50det2.chip2.


Vq(fc)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
Vbias(V)
Average
Strip
Inter Strip
q50det2.chip3.

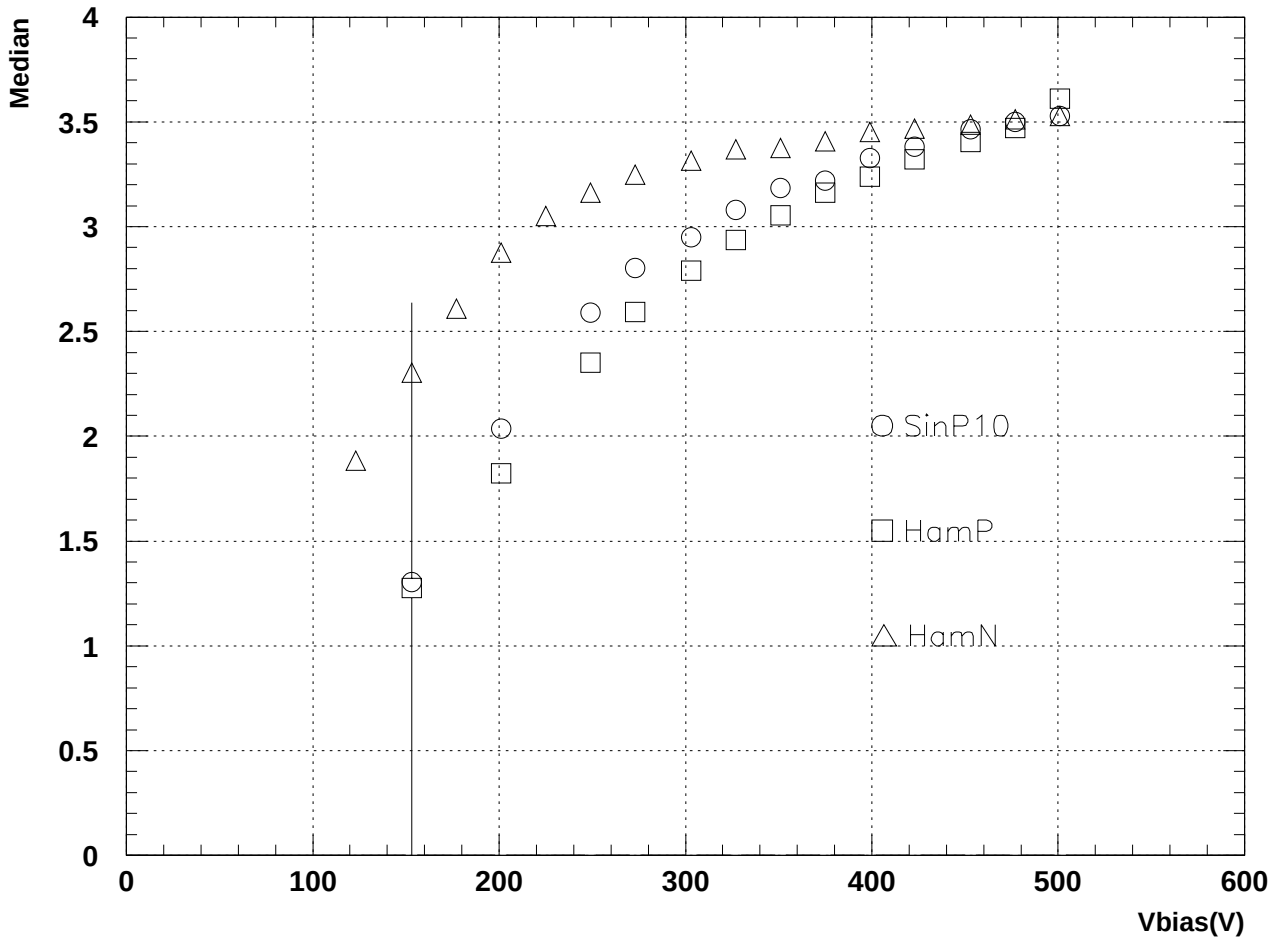
Comparison of charge collection averaged over the detectors

(Figure)

- There was a clear difference in the charge collection (per single strip) between the n-on-n and the p-on-n detectors

- From the n-on-n detector, the full depletion voltage would be estimated to be about 350 V

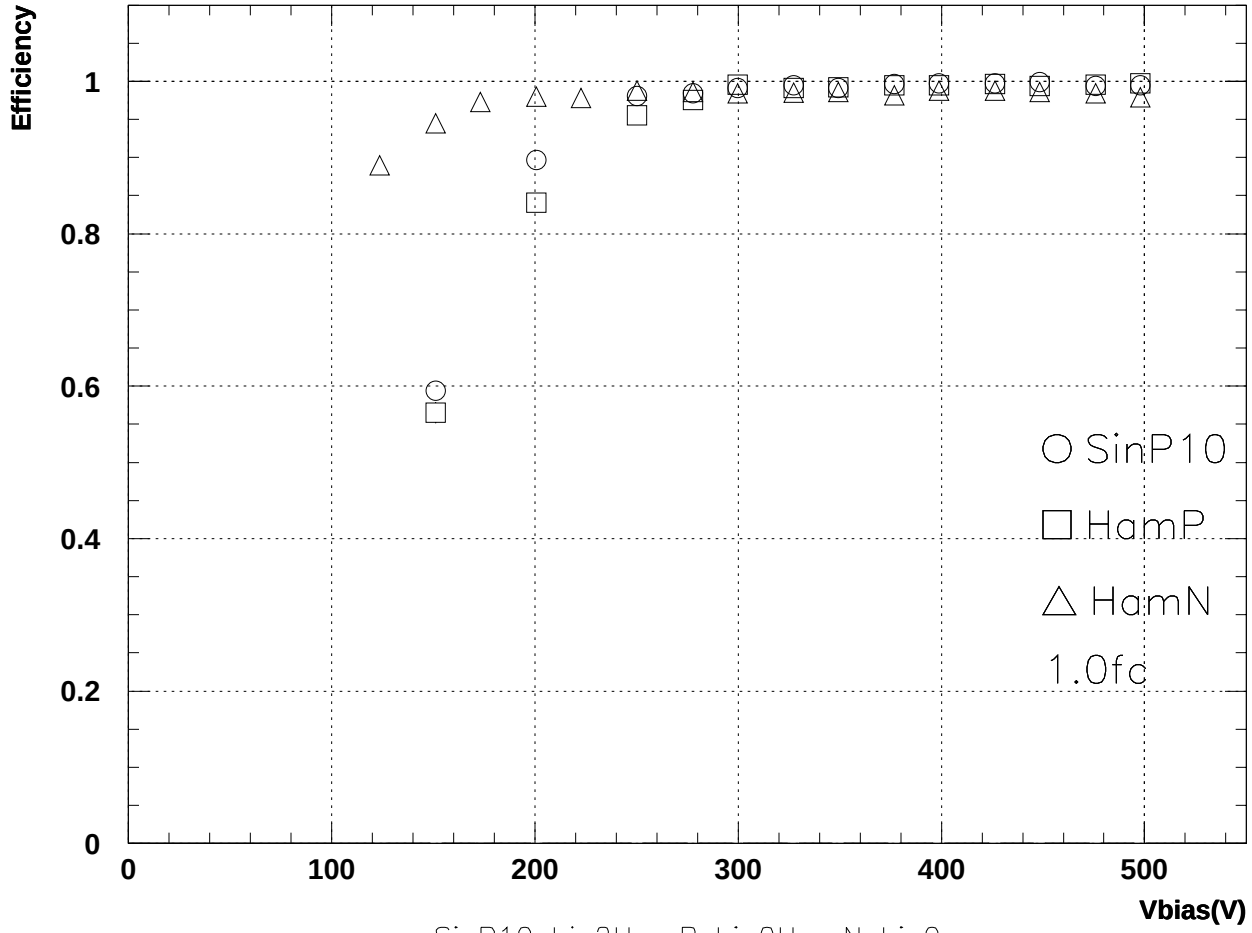
- There was no big difference between the Sintef p10 and HamP, but there was difference, higher charge collection in Sintef


Median
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
Vbias(V)
SinP10
HamP
HamN

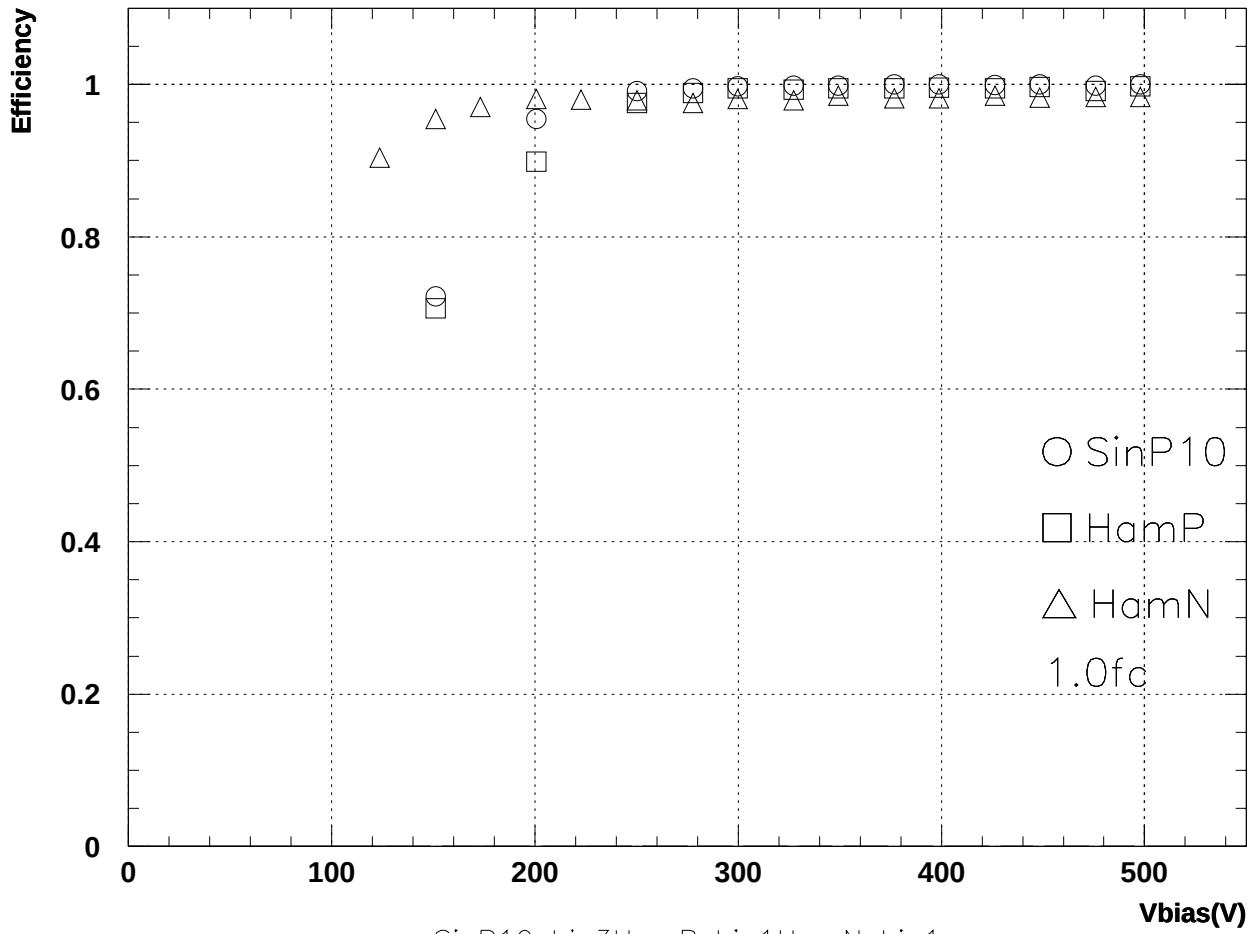
Efficiencies at 1 fC

- Efficiency at 1fC was interpolated from the Efficiencies nearby thresholds

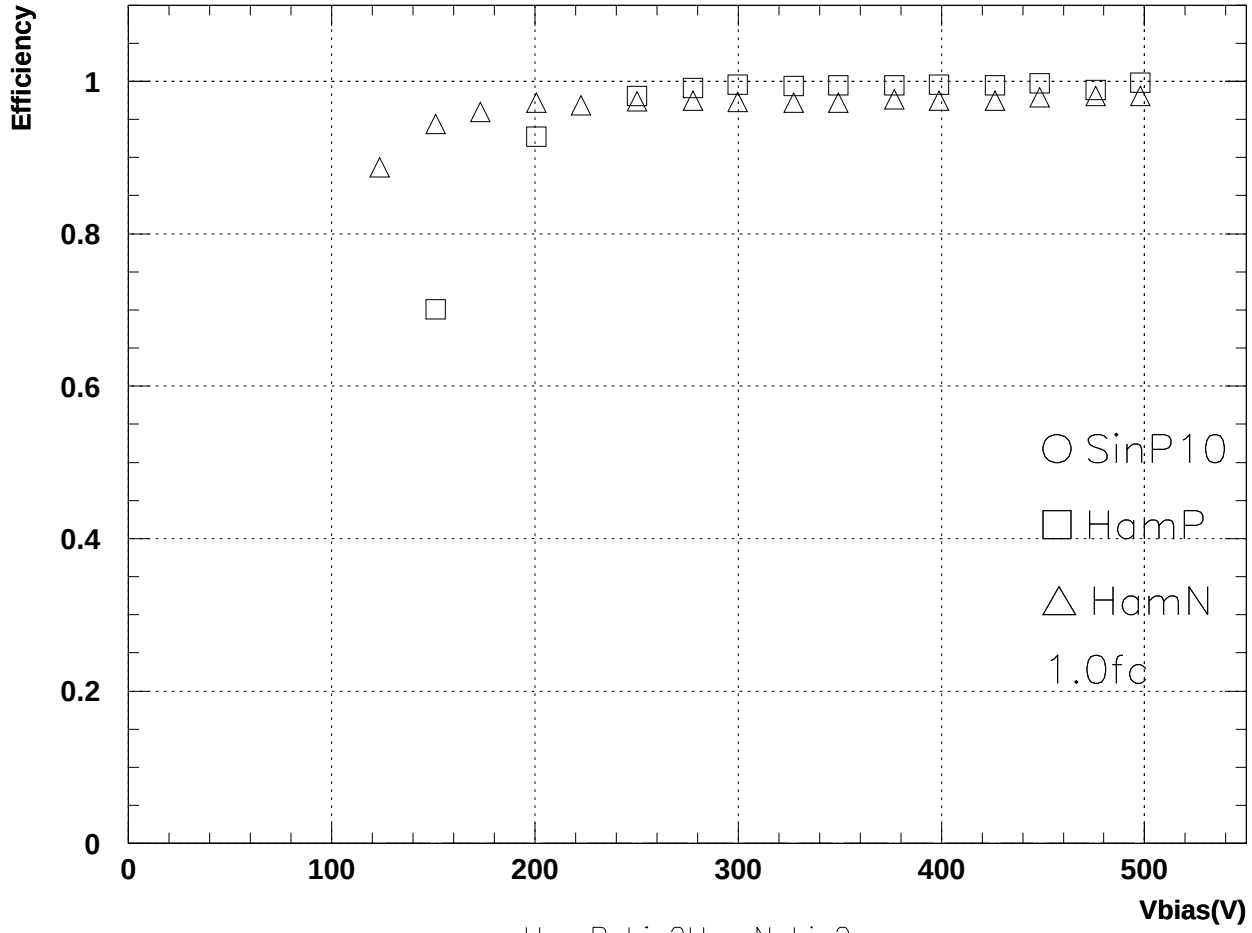
- Figures shown for comparing the chips aligned



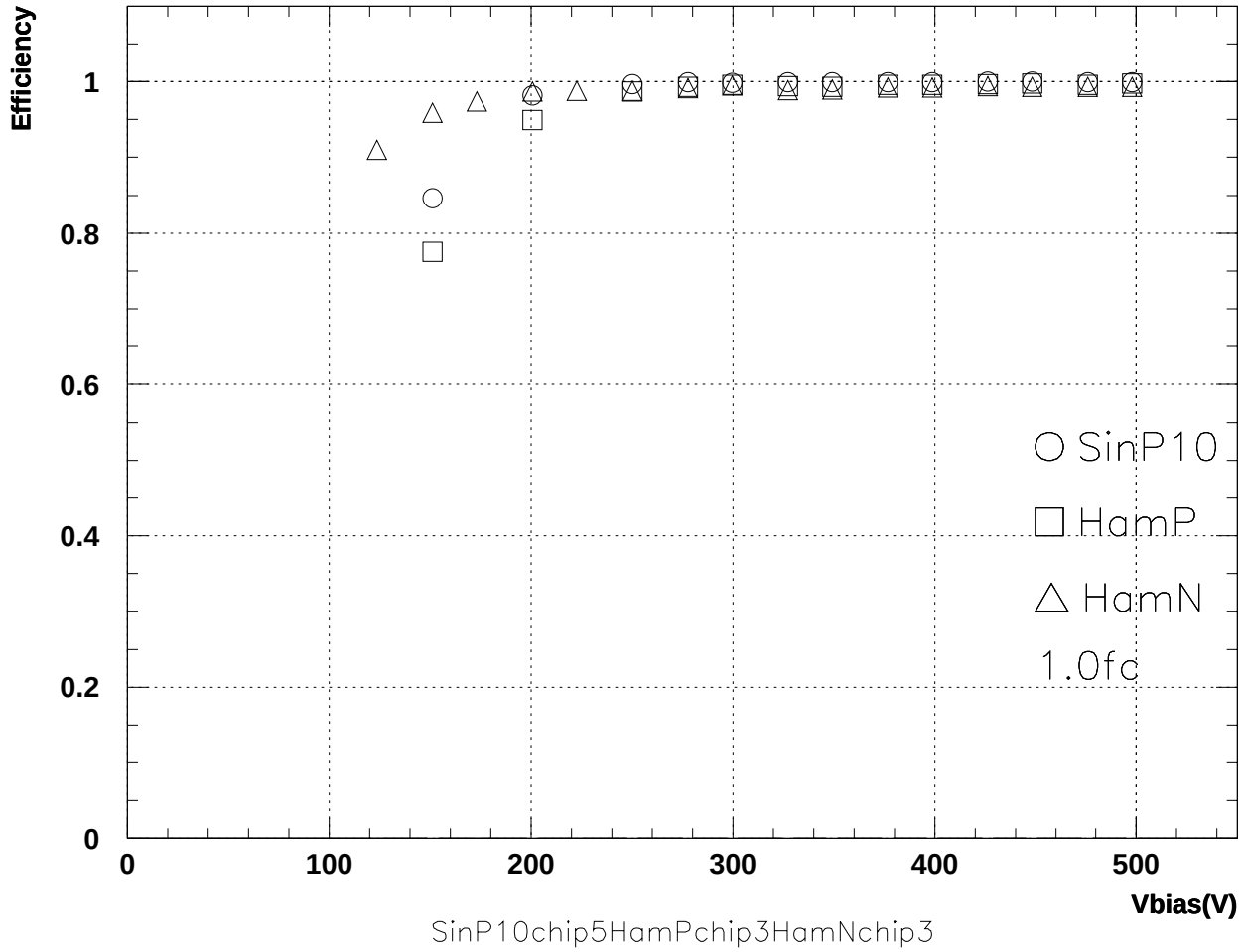
SinP10chip2HamPchip0HamNchip0



SinP10chip3HamPchip1HamNchip1



HamPchip2HamNchip2



SinP10chip5HamPchip3HamNchip3

Charge collection ratios between the strip and the inter-strip regions

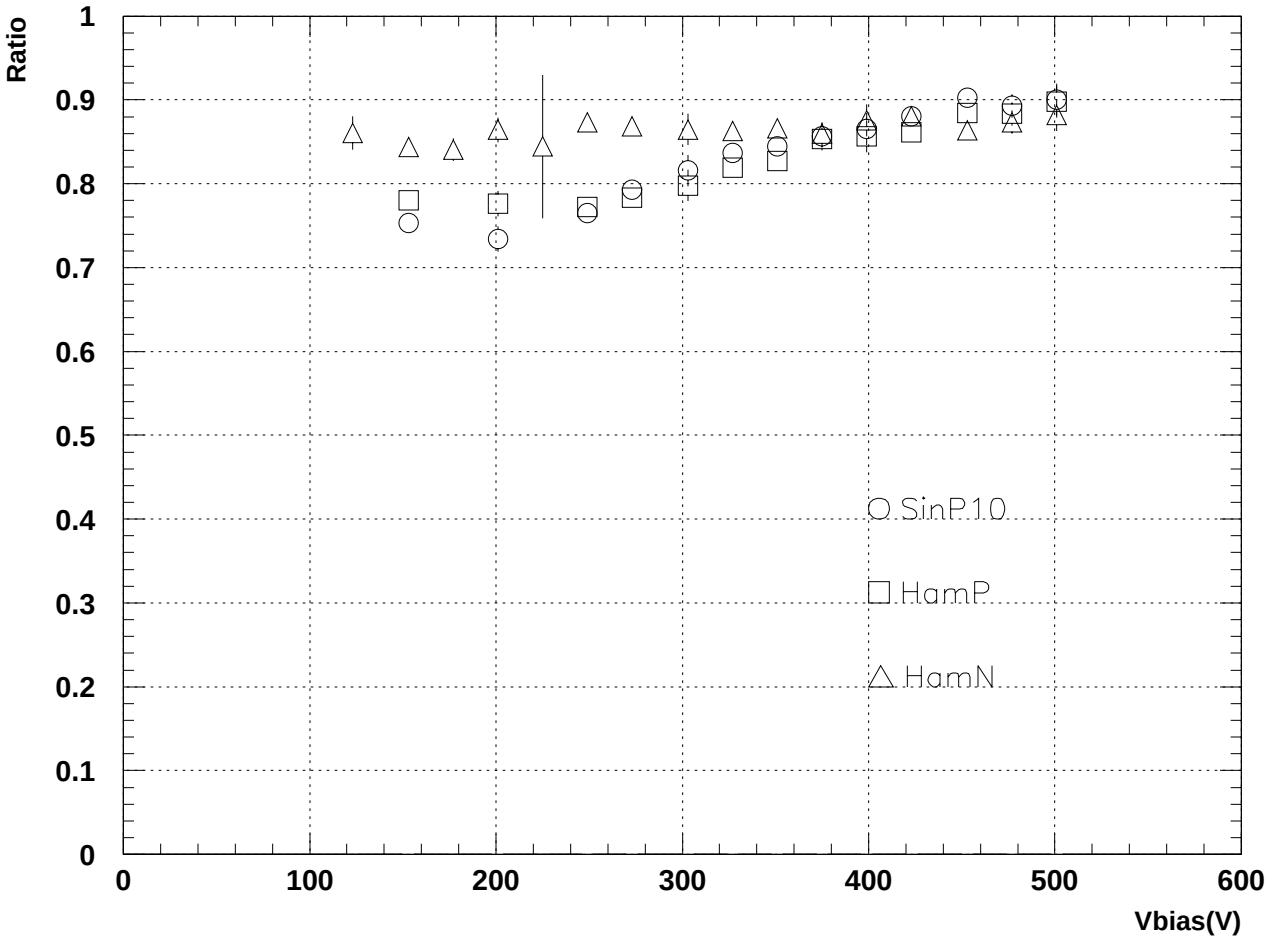
- **Ratio = Median (Inter-strip) / Median (Strip)**

  (Figure)

- **Observations:**

  - n-on-n: Constant ratio over the bias voltages from 100V to 500V

  - p-on-n: Ratio decreased below 400 V, from 0.9 to 0.75 at 200 V


Ratio
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
100
200
300
400
500
600
Vbias(V)
SinP1.0
HamP
HamN

Future plans?

- **More accurate estimation of the bias voltage per detector**

  - Voltage drop by the resistance in the bias supply lines

- **Detector thickness correction**

  - Sintef is 293 μm thickness

  - Hamamatsu ? μm

  - ...