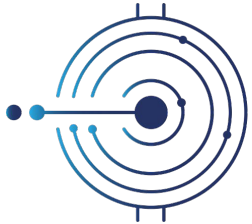
Josephson Junctions Measures

Substrates #07, #11

february 2022



DART WARS

INFN
Istituto Nazionale di Fisica Nucleare

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

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substrates

Substrate #07:

- run 1 (no markers)
- oxidation pressure: $1.36 \cdot 10^{-3}$ mTorr
- oxidation time: 742 s
- oxidation process: ?

} $p^{1/2} \cdot t$ [mTorr · s] = 27.37

Substrate #11:

- run 4 (with markers)
- oxidation pressure: $9.41 \cdot 10^{-4}$ mTorr
- oxidation time: 2 677 s
- oxidation process: ?

} $p^{1/2} \cdot t$ [mTorr · s] = 82.12

rate ~ 1/3

Substrates #02 and #05 had the same oxidation parameter and we expected to observe $R_{\#02} = R_{\#05}$.

→ Do we expect to observe $R_{\#07} < R_{\#11}$?

substrates

One substrate consists in **12 devices** (A,-,L) with **14 arrays of Josephson junctions** (20 overall) each.

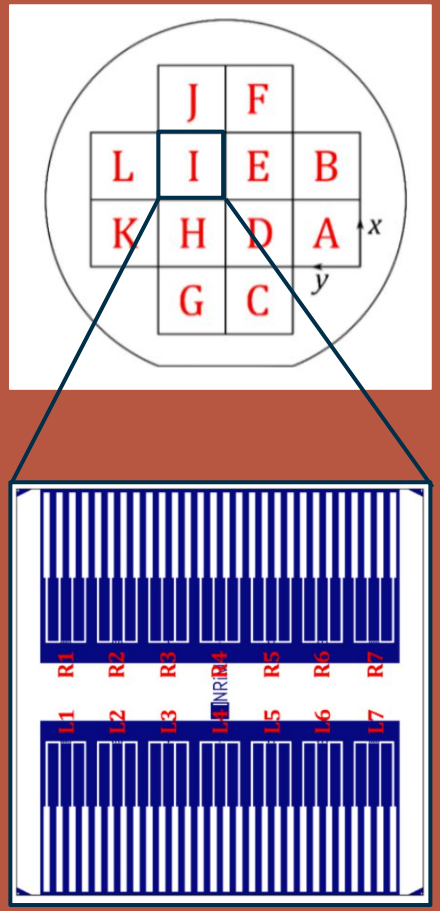
→ 168 measures of resistance for each substrate

junctions #	5	4	1	short	2	3	5
array ID	L1/R1	L2/R2	L3/R3	L4/R4	L5/R5	L6/R6	L7/R7

The short resistance (L4/R4) is required to compute the parasitic impedance introduced by the conductive trails.

series R_{par}	110/250	138/250	222/250	1	194/250	166/250	110/250

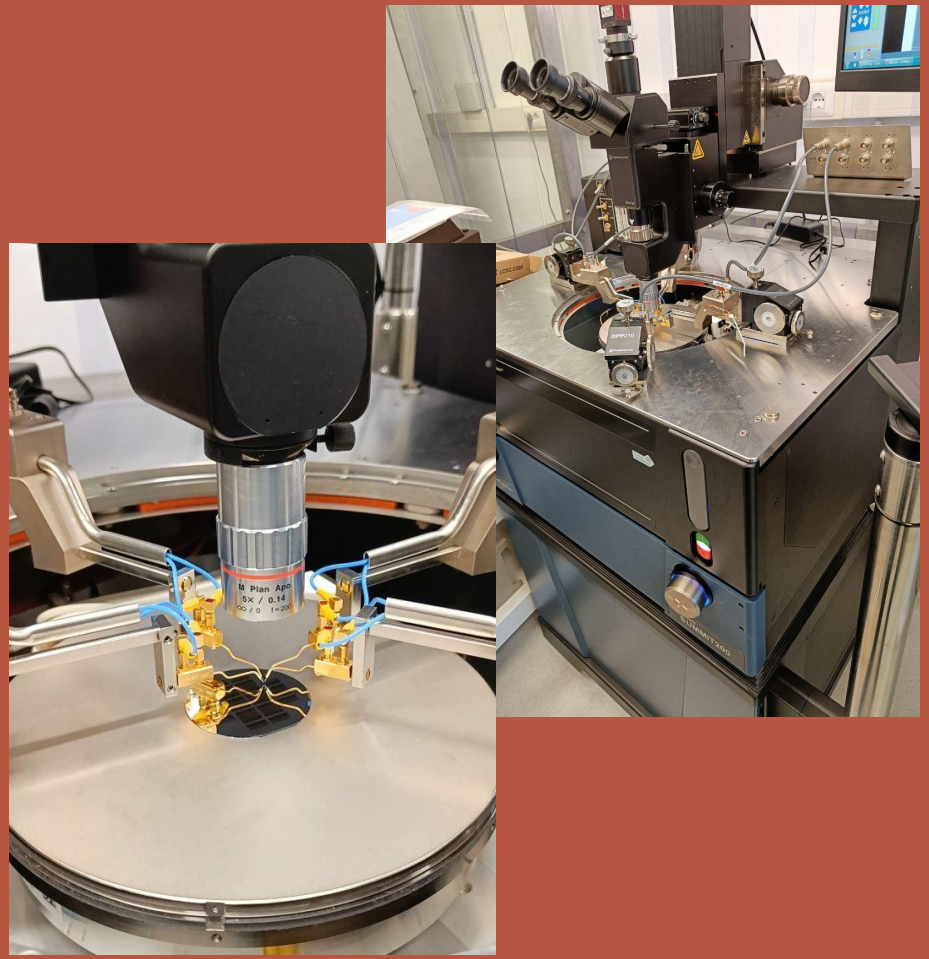
Of course, these factors depend on the junctions #.
We used them to correct the resistance measures.



the measurement

4 terminal sensing measurement

→ current sweep up to 10 μA, with a 0.1 μA step.



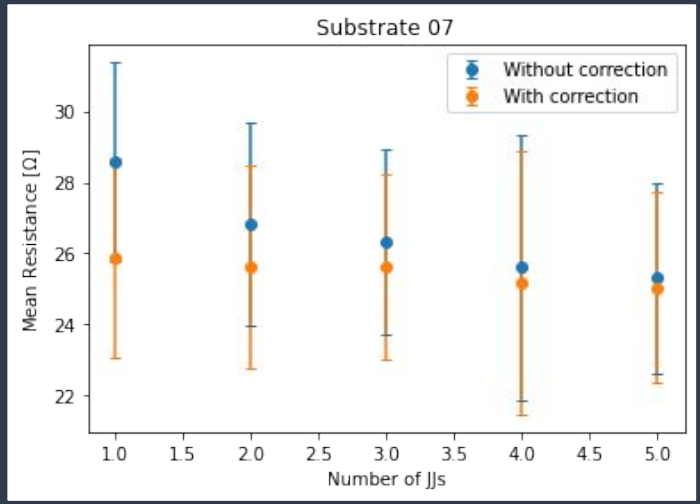
The data taking has been improved.
Now the procedure is less time consuming than it was before (~2h / substrate).

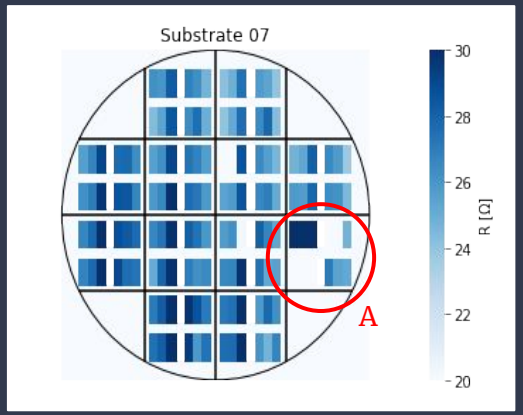
Substrate #07

resistance correction

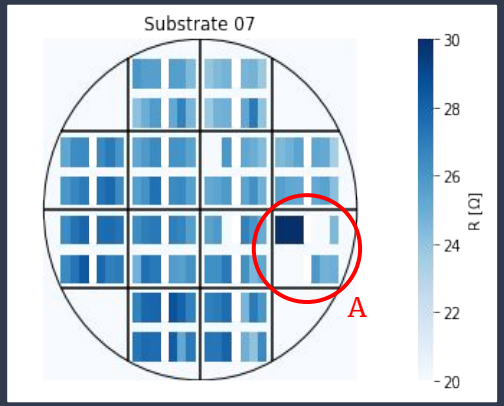
The correction works!

But some devices (A,D,E) show sparse low resistances. In addition, the device A is partially faulty and some of its arrays (R1, R2, R3) show open circuit properties.





correction



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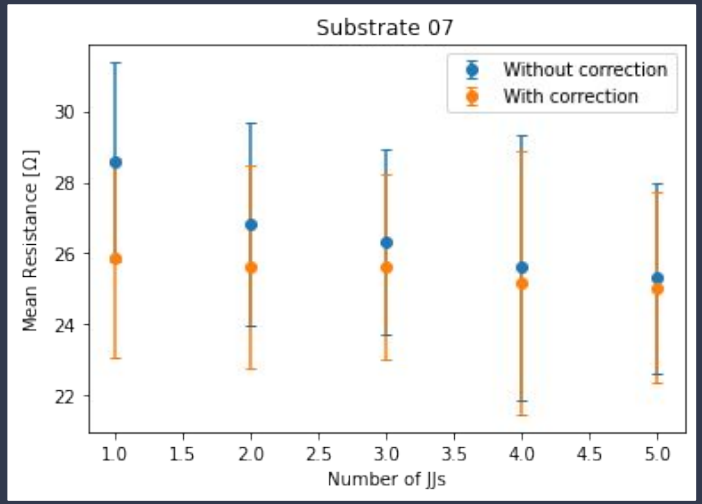
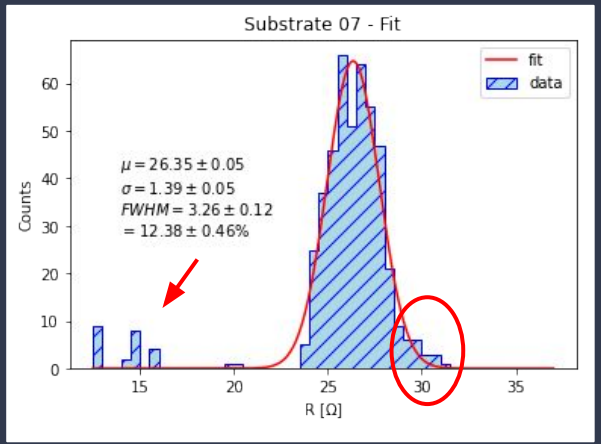
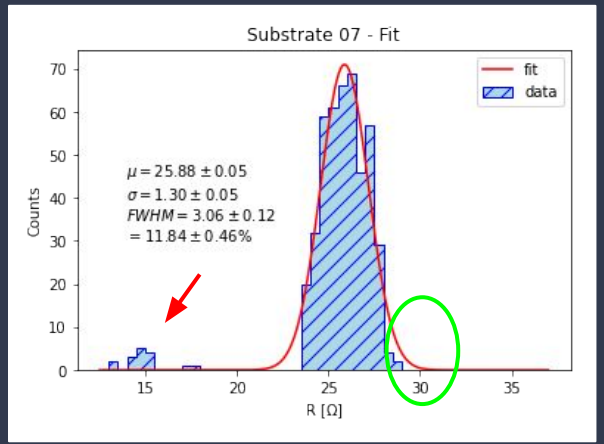


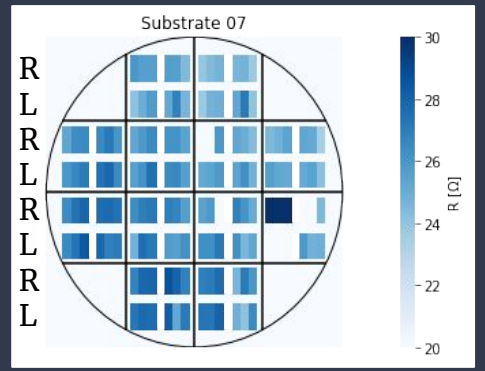


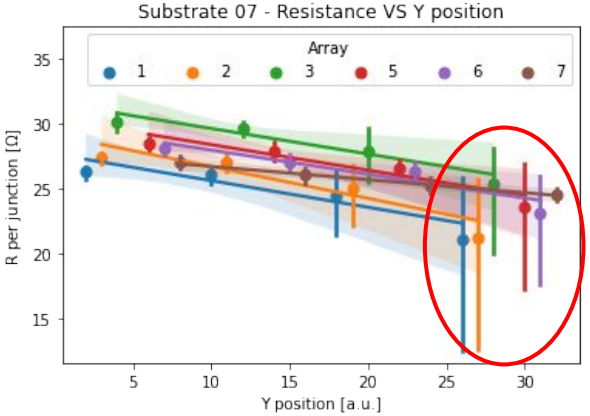
correction

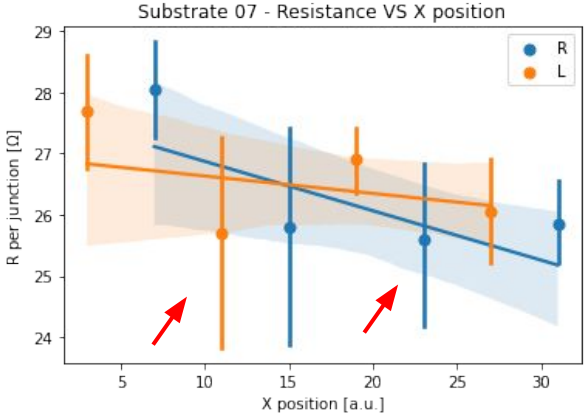


substrate gradients

Both the gradients are descending.
The wide dispersions are due to the faulty arrays.

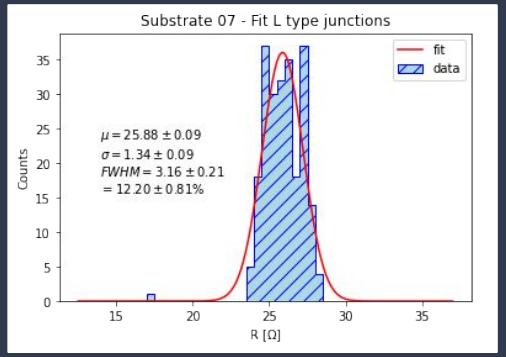


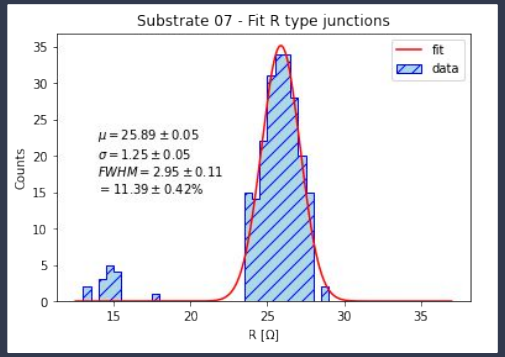


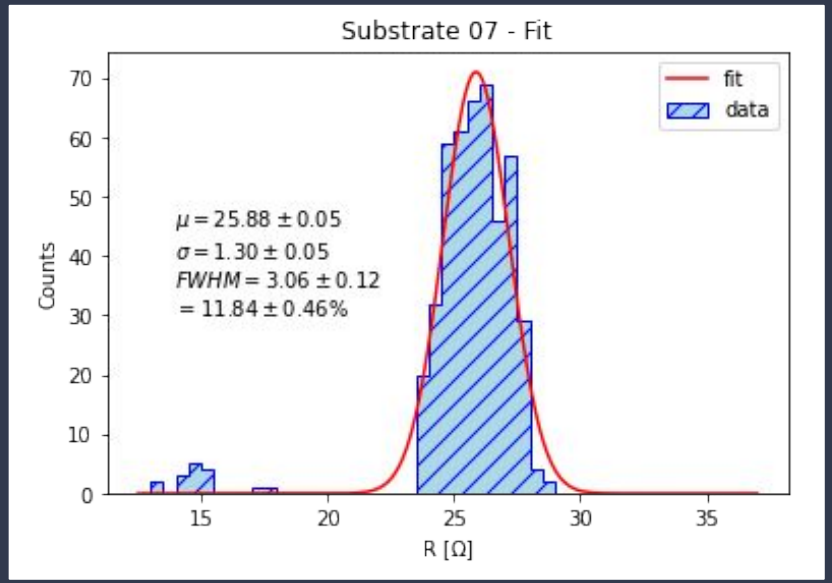


average resistance

	Substrate #07	
	R	ΔR
	25.88 Ω	3.06Ω (11.84%)
type L	25.88 Ω	3.16 Ω (12.20%)
type R	25.89 Ω	2.95 Ω (11.39%)





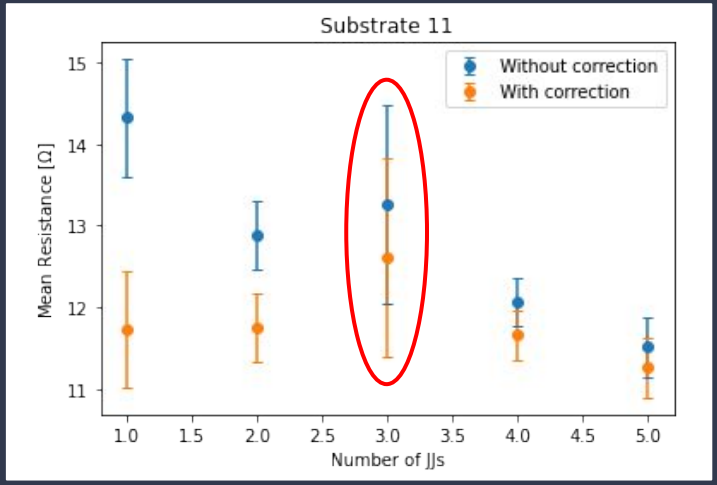


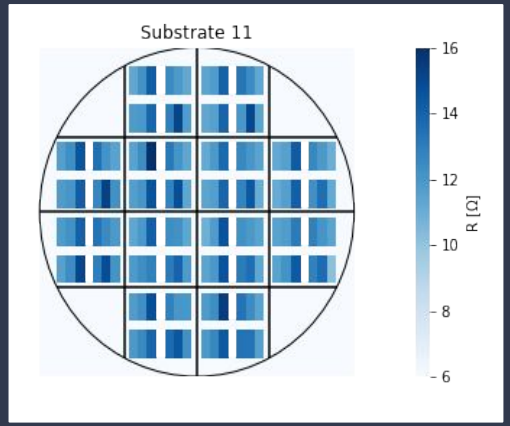
Substrate #11

resistance correction

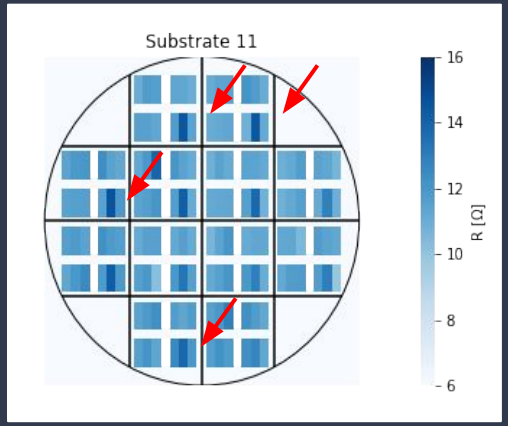
The correction works!

But the arrays with 3 junctions seem to have a very wide distribution...





correction



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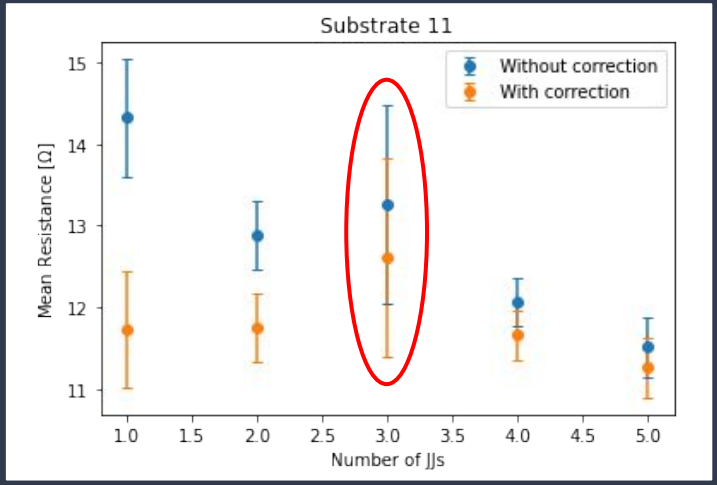
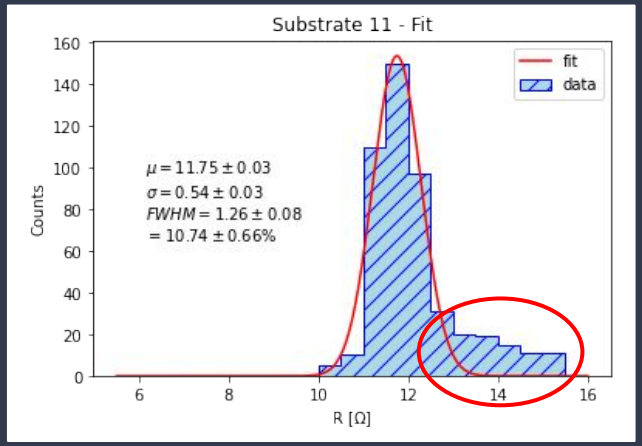
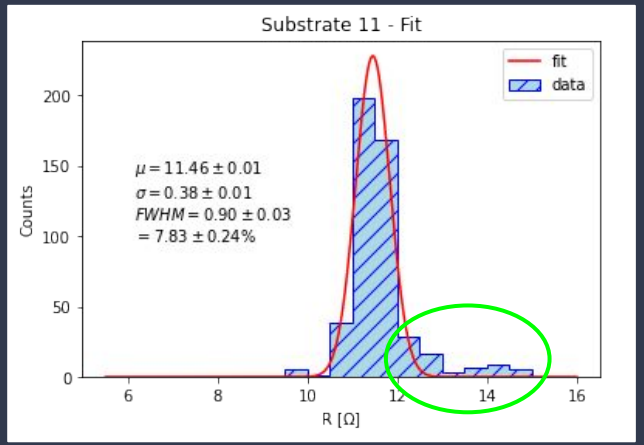


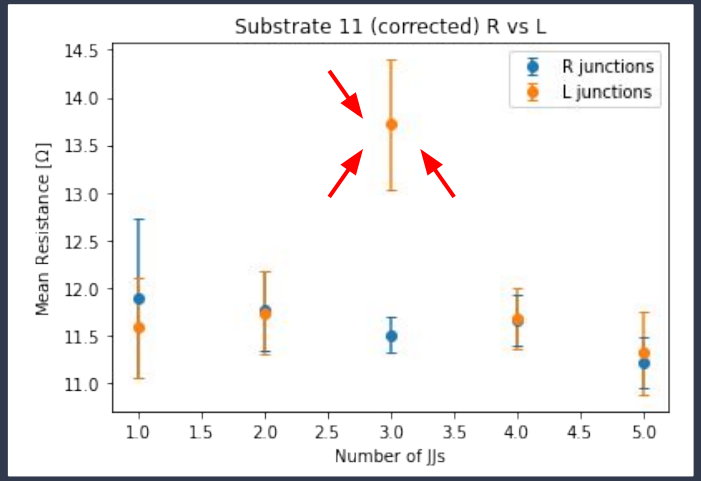


correction



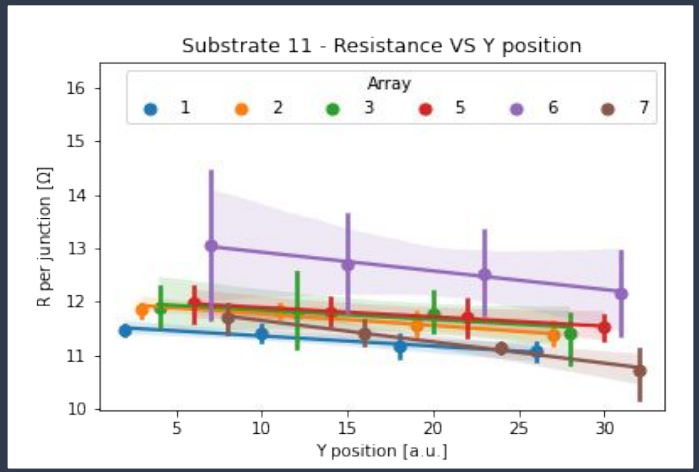
the L6 problem

In details, we observe that the L6 triple junction arrays show a way higher resistance value.



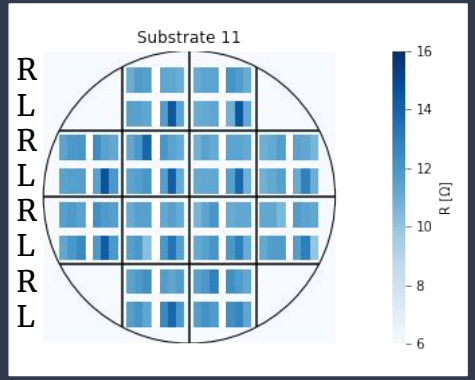
We can point out this anomaly also studying the gradient on the y direction of the substrate.

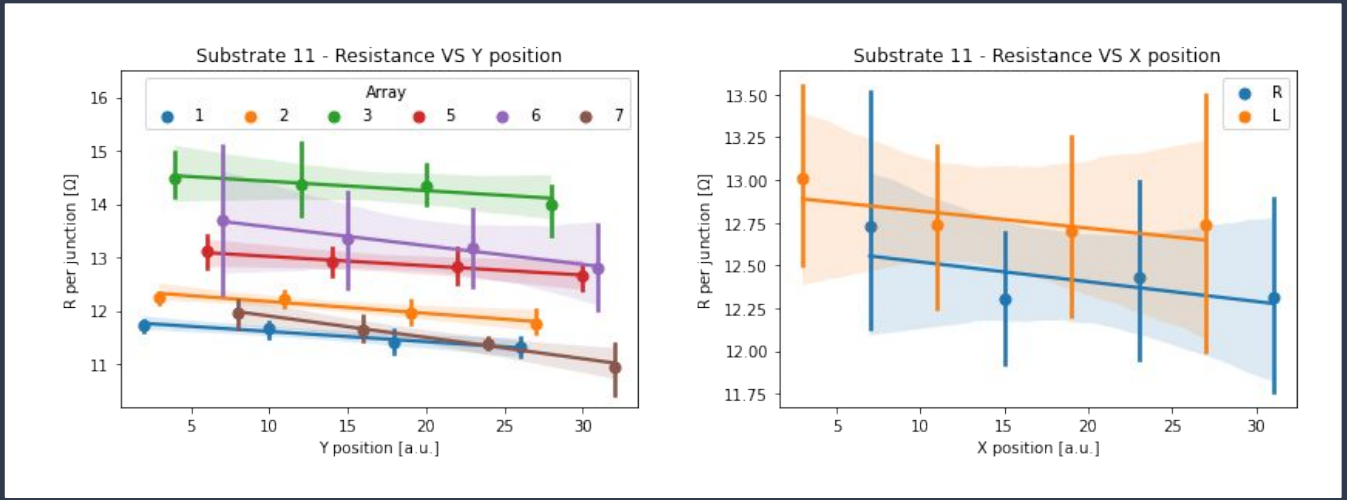
(This is the corrected plot that highlights the difference shifting the offsets of the lines)



substrate gradients

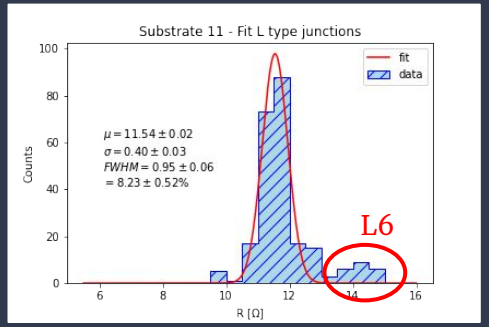
Both the gradients are slightly descending.

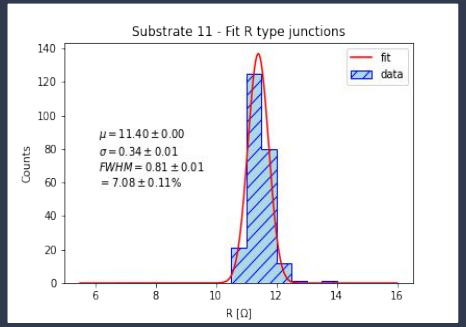


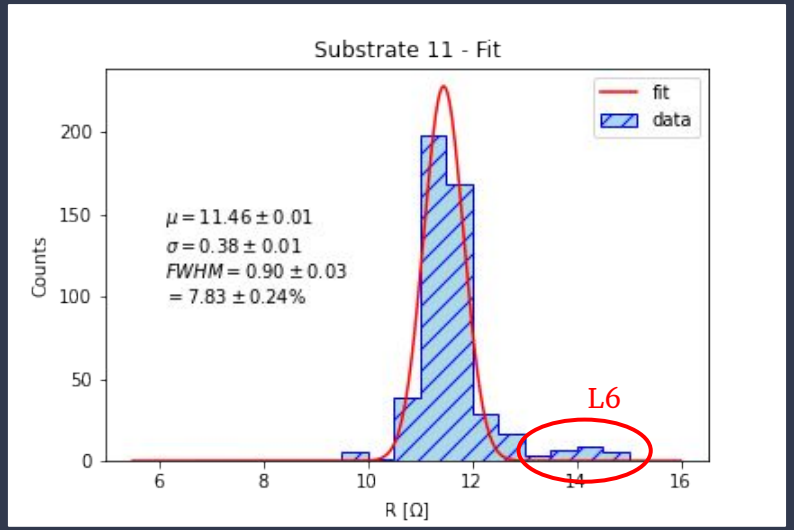


average resistance

	Substrate #11	
	R	ΔR
	11.46 Ω	0.9Ω (7.83%)
type L	11.54 Ω	0.95 Ω (8.23%)
type R	11.40 Ω	0.81 Ω (7.08%)







The small amount of counts in the right tail of the distribution are caused by the left component (more precisely by L6).

substrates comparison

The substrate #07:

- shows an average resistance of ~26 Ω while the substrate #11 is ~11 Ω.
- has a more broadened resistance distribution.
- has a steeper descending gradient on both x and y directions.

With respect to the substrates #02 and #05:

- The L and R resistances are equally distributed around the same substrate-average-value.
- The new wafers show a steeper gradient on y direction and a gradient on the x direction which is now shared by both L and R type of junctions.

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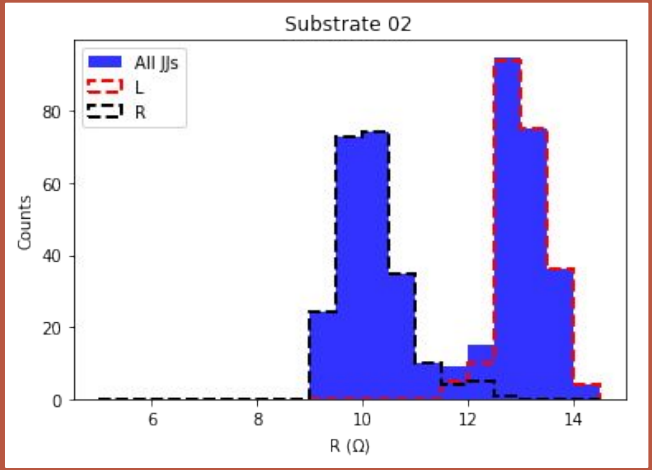
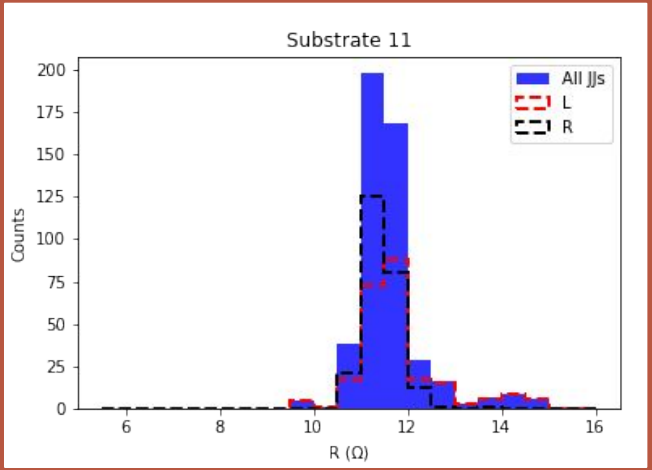
before



vs

now



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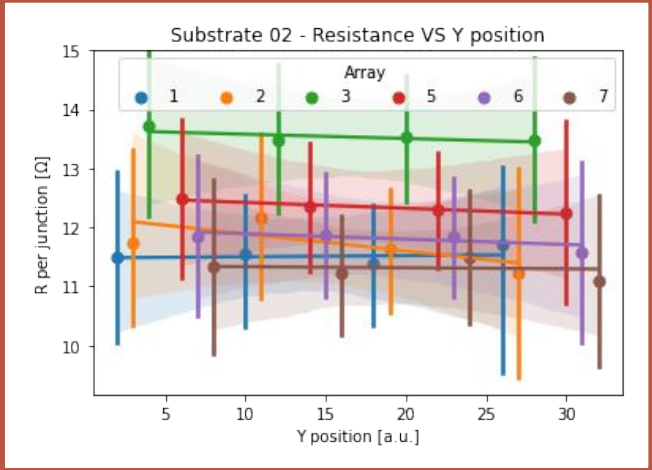
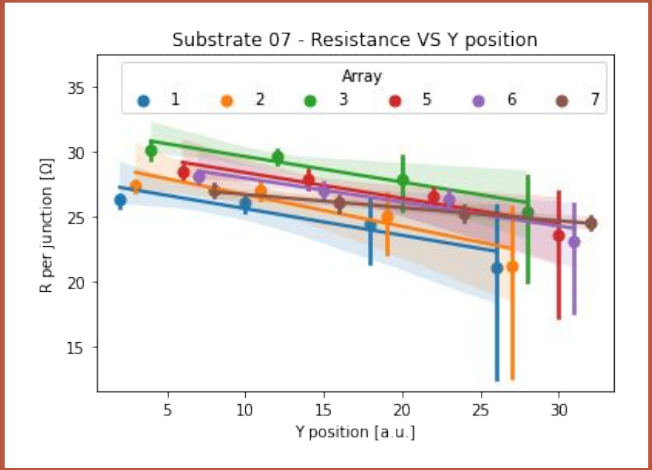


vs

now



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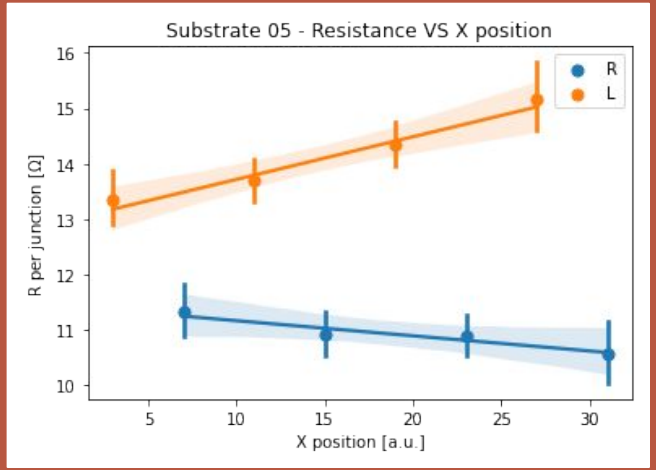
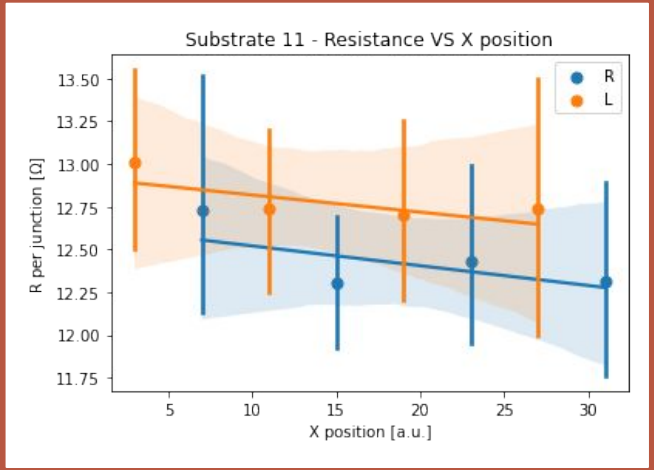
before

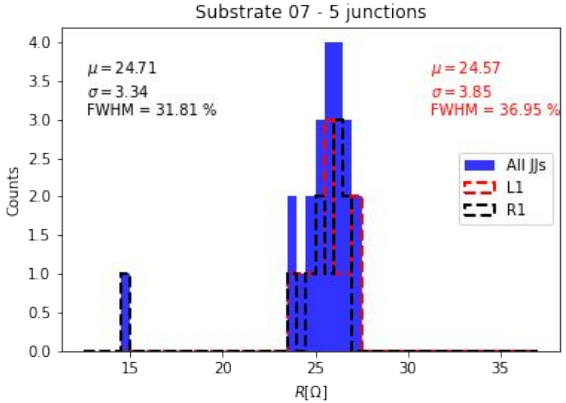


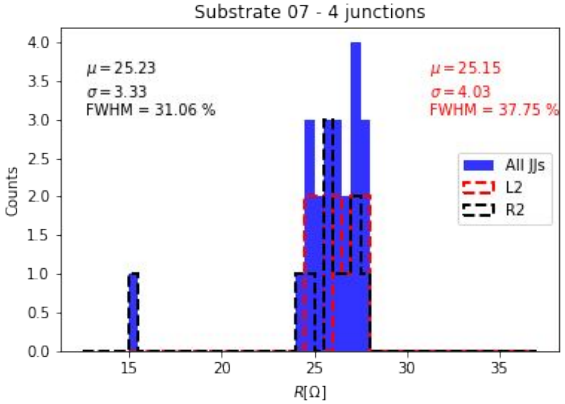
vs

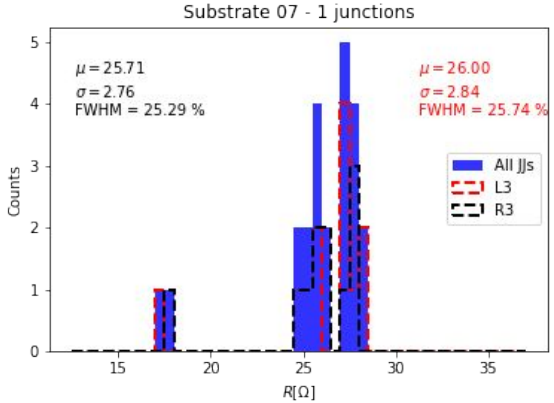
now

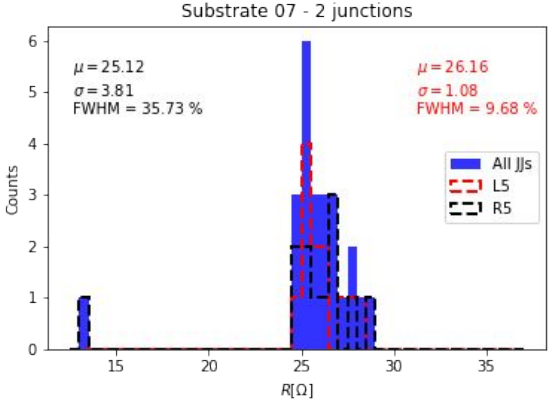


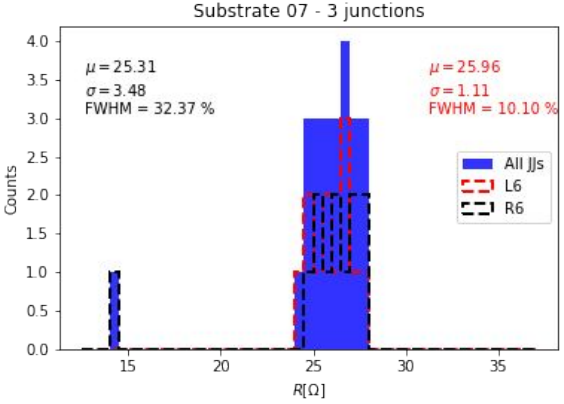
Backup slides

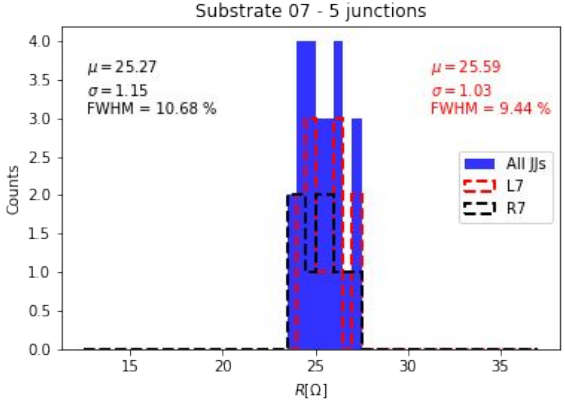

Substrate 07 - 5 junctions
μ = 24.71
σ = 3.34
FWHM = 31.81 %
μ = 24.57
σ = 3.85
FWHM = 36.95 %
All JJs
L1
R1
Counts
R[Ω]

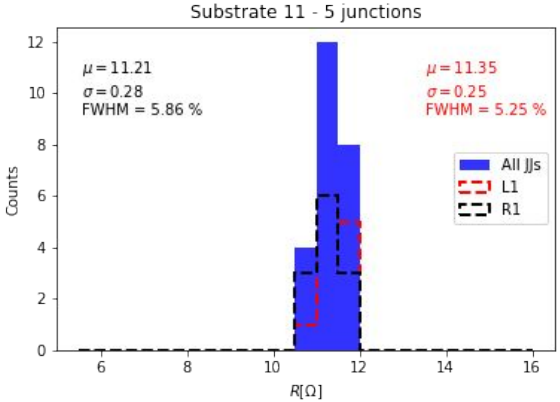

Substrate 07 - 4 junctions
μ = 25.23
σ = 3.33
FWHM = 31.06 %
μ = 25.15
σ = 4.03
FWHM = 37.75 %
All JJs
L2
R2
Counts
R[Ω]

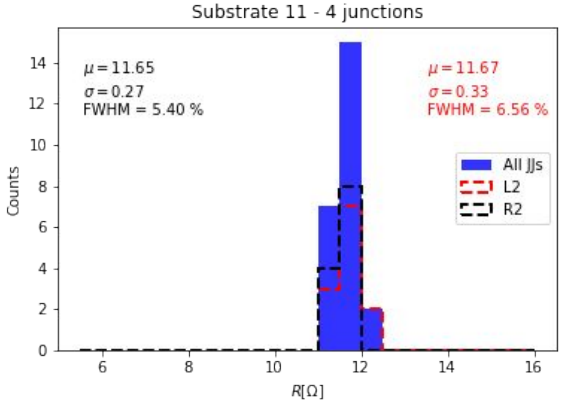

Substrate 07 - 1 junctions
μ = 25.71
σ = 2.76
FWHM = 25.29 %
μ = 26.00
σ = 2.84
FWHM = 25.74 %
All JJs
L3
R3
Counts
R[Ω]

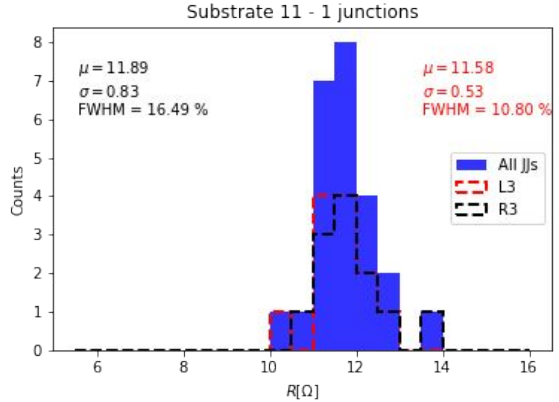

Substrate 07 - 2 junctions
μ = 25.12
σ = 3.81
FWHM = 35.73 %
μ = 26.16
σ = 1.08
FWHM = 9.68 %
All JJs
L5
R5
Counts
R[Ω]

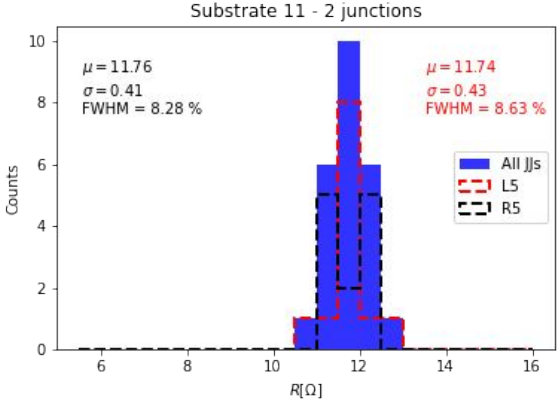

Substrate 07 - 3 junctions
μ = 25.31
σ = 3.48
FWHM = 32.37 %
μ = 25.96
σ = 1.11
FWHM = 10.10 %
All JJs
L6
R6
Counts
R[Ω]

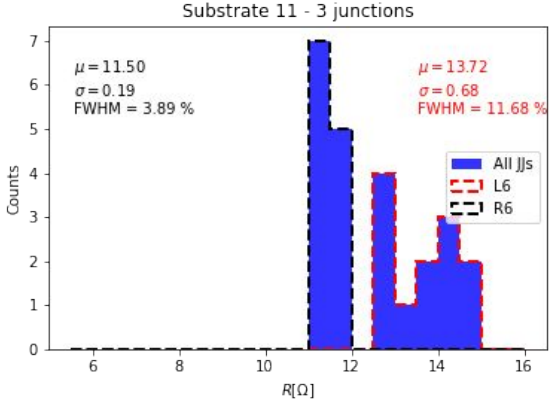

Substrate 07 - 5 junctions
μ = 25.27
σ = 1.15
FWHM = 10.68 %
μ = 25.59
σ = 1.03
FWHM = 9.44 %
All JJs
L7
R7
Counts
R[Ω]

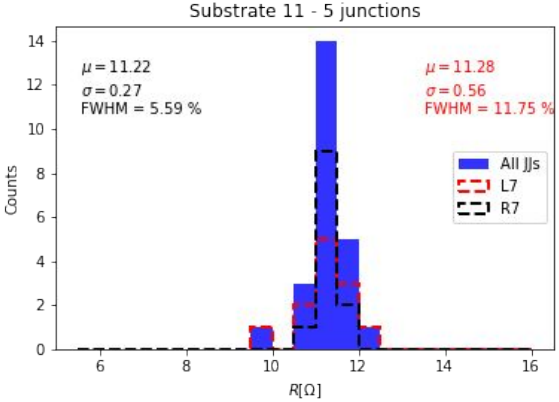

Substrate 11 - 5 junctions
μ = 11.21
σ = 0.28
FWHM = 5.86 %
μ = 11.35
σ = 0.25
FWHM = 5.25 %
All JJs
L1
R1
Counts
R[Ω]


Substrate 11 - 4 junctions
μ = 11.65
σ = 0.27
FWHM = 5.40 %
μ = 11.67
σ = 0.33
FWHM = 6.56 %
All JJs
L2
R2
Counts
R[Ω]


Substrate 11 - 1 junctions
μ = 11.89
σ = 0.83
FWHM = 16.49 %
μ = 11.58
σ = 0.53
FWHM = 10.80 %
All JJs
L3
R3
Counts
R[Ω]


Substrate 11 - 2 junctions
μ = 11.76
σ = 0.41
FWHM = 8.28 %
μ = 11.74
σ = 0.43
FWHM = 8.63 %
All JJs
L5
R5
Counts
R[Ω]


Substrate 11 - 3 junctions
μ = 11.50
σ = 0.19
FWHM = 3.89 %
μ = 13.72
σ = 0.68
FWHM = 11.68 %
All JJs
L6
R6
Counts
R[Ω]


Substrate 11 - 5 junctions
μ = 11.22
σ = 0.27
FWHM = 5.59 %
μ = 11.28
σ = 0.56
FWHM = 11.75 %
All JJs
L7
R7
Counts
R[Ω]