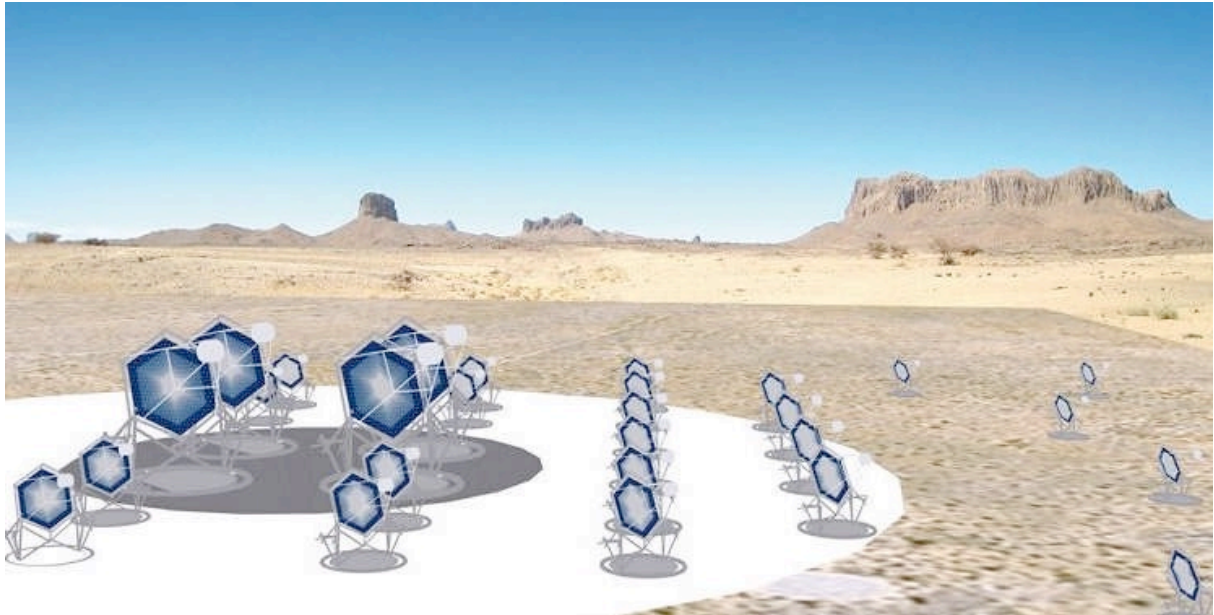

OSSERVATORIO ASTROFISICO DI CATANIA

MPPCs Electrical Characterization Report

Device: S11828-3344M monolithic array 16ch (4x4)



Osservatorio Astrofisico di Catania

G. ROMEO⁽¹⁾, G. BONANNO⁽¹⁾

(1) INAF - Osservatorio Astrofisico di Catania

Rapporti interni e tecnici
N.12/2013

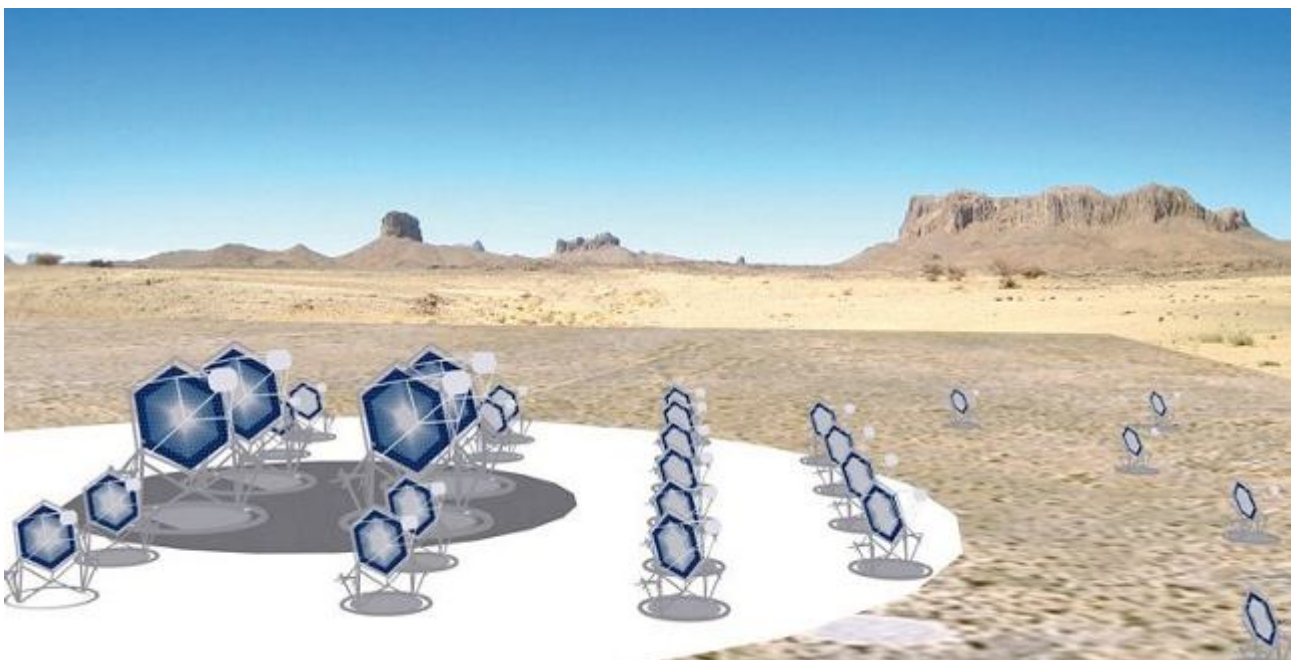
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MPPCs Electrical Characterization Report



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DATE

22/10/2013

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DOCUMENT HISTORY

Version	Date	Modification
1.0	Date	first version
		update



LIST OF ACRONYMS

SiPM	Silicon Photo Multiplier
MPPC	Multi Pixel Photon Counter
SPAD	Single Photon Avalanche Diode
G-APD	Geiger-mode Avalanche Photo-Diode
HV	High Voltage
FEE	Front-End Electronics
BEE	Back-End Electronics
FPGA	Field Programmable Gate Array
PDM	Photon Detection Module
PCB	Printed Circuit Board
OACT	Osservatorio Astrofisico di Catania
IFC-PA	Istituto di Astrofisica Spaziale e Fisica Cosmica di Palermo
SW	Software
ASIC	Application Specific Integrated Circuit
EASIROC	Extended Analogue Silicon-pm Integrated Read-Out Chip
Op-AMP	Operational Amplifier
COLD	C atania A strophysical O bservatory L aboratory for D etectors

APPLICABLE DOCUMENTS

[AD1] AD1

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REFERENCE DOCUMENTS

[RD1] RD1

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1. INTRODUCTION

In this document are presented the results of the electrical characterization of some MPPCs 4433 that will be used for the ASTRI camera focal plane.

In particular, the operating voltage of each pixel has been evaluated by using the I-V method.

For each I-V acquired data the corresponding derivative has been evaluated in order to terminate the value of the operating voltage at which the Gain is 7.5×10^5 .

We characterized all the 50 MPPCs received in advance and 63 MPPCs over the 500 received on the basis of the INAF-Hamamatsu contract.

The setup used for these measurements is described in Section 3.

At the end of this document a summary table showing, for each pixel, the operating voltage reported on the Hamamatsu test sheet and that measured is presented.

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2. SCOPE

The aim of the electrical characterization carried out and here described on the 113 selected devices, is to compare and validate the operating voltages suggested by Hamamatsu to work in the best conditions. The difference of the two voltages is also reported on the final table in order to give an idea of the data sheet correctness.

3. Laboratory I-V measurements: Set-up

To evaluate the operating voltage through the I-V method, we implemented the set-up showed in figure 1 consisting in an Agilent 6634B DC power supply and a Keithley 487 Pico-ammeter). A black box (see figure 2) specially designed for this purpose and provided directly by Hamamatsu is also used. The box allows to connect each MPPC pixel to the measurement set-up through a set of connectors. Furthermore the box is light-tight and inside is placed a blue LED for electrical measurements under illumination conditions.

In figure 3 the detector replacing procedure is shown. Appropriate tweezers have to be used.

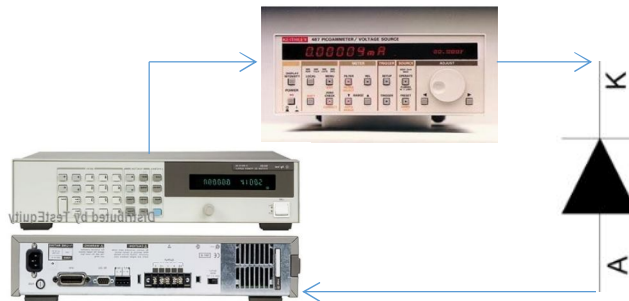


Figure 1



Figure 2

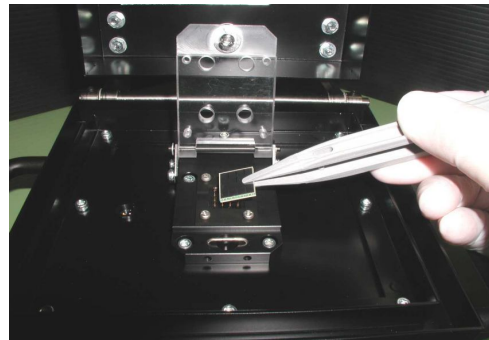


Figure 3



Figure 4

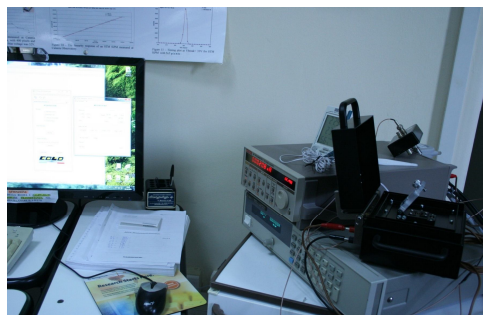


Figure 5

4. I-V measurements of the individual pixels

With the set-up described in section 3, we measured the current of each pixel in dark and under illumination conditions by varying the operating voltage. Subsequently we evaluated the best conditions through an IDL procedure that automatically computes the derivative of the signal and establish the Vop corresponding to the maximum of the curve.

For each MPPC seven pixels have been characterized, they are:

B2 - B3 - C1 - C2 - C3 - D1 - D2.

Figure 6 shows where the pixels are located on the MPPC.

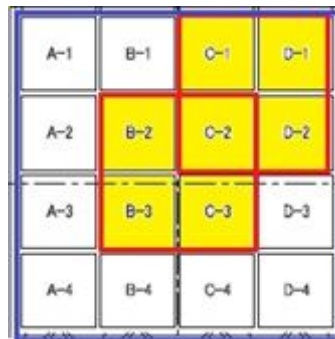
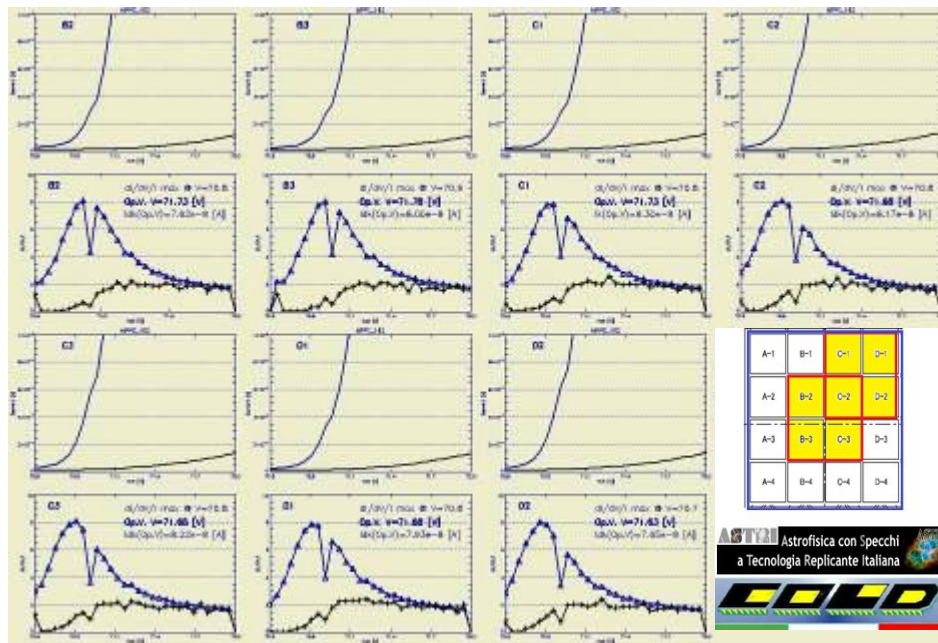


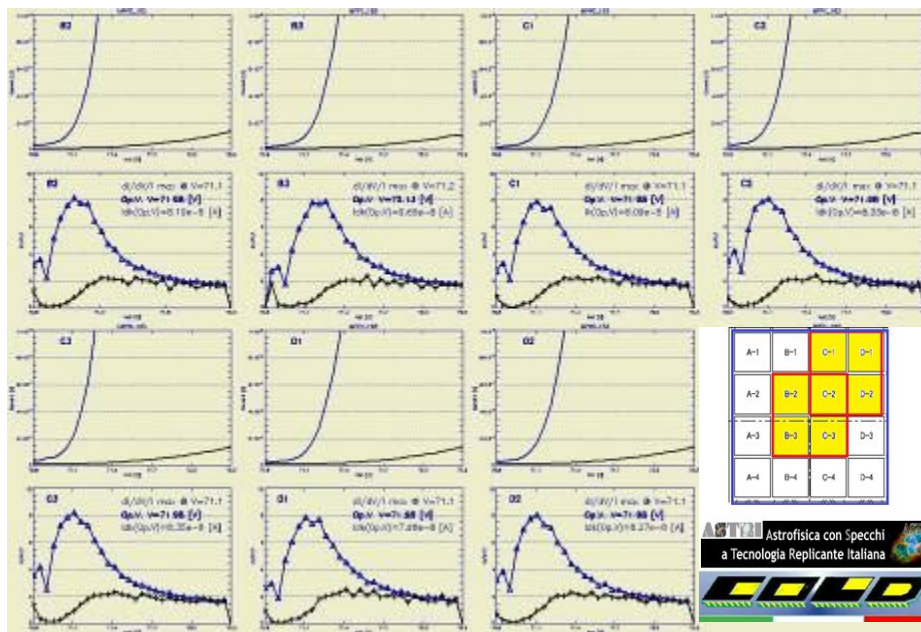
Figure 6

In the next paragraph the obtained I-V plots and the derivative results for each pixel are reported.

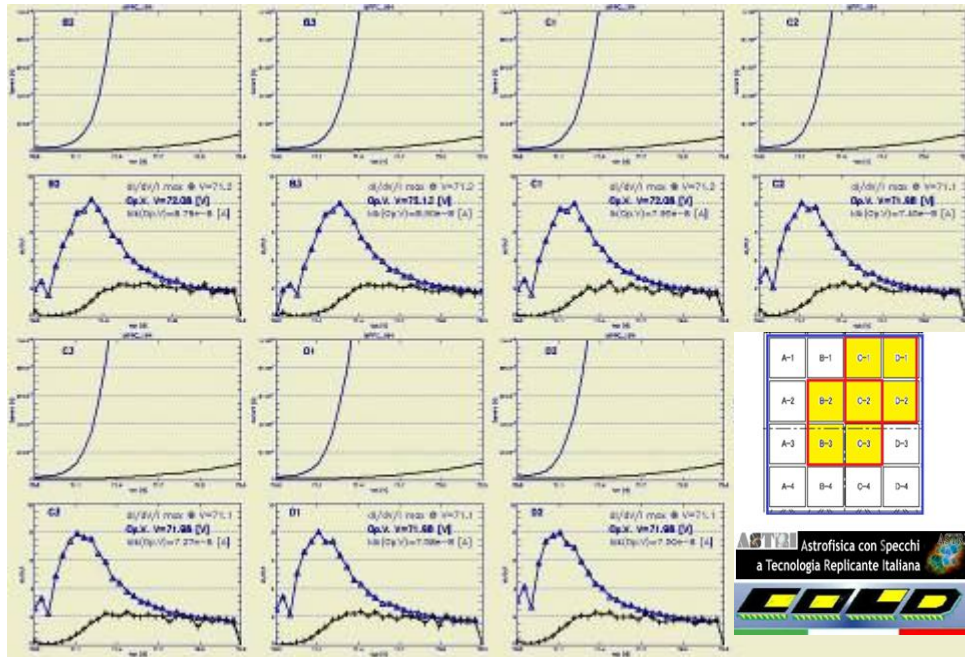
4.1 Obtained Vop for each pixel through the I-V measurements and the IDL procedure.



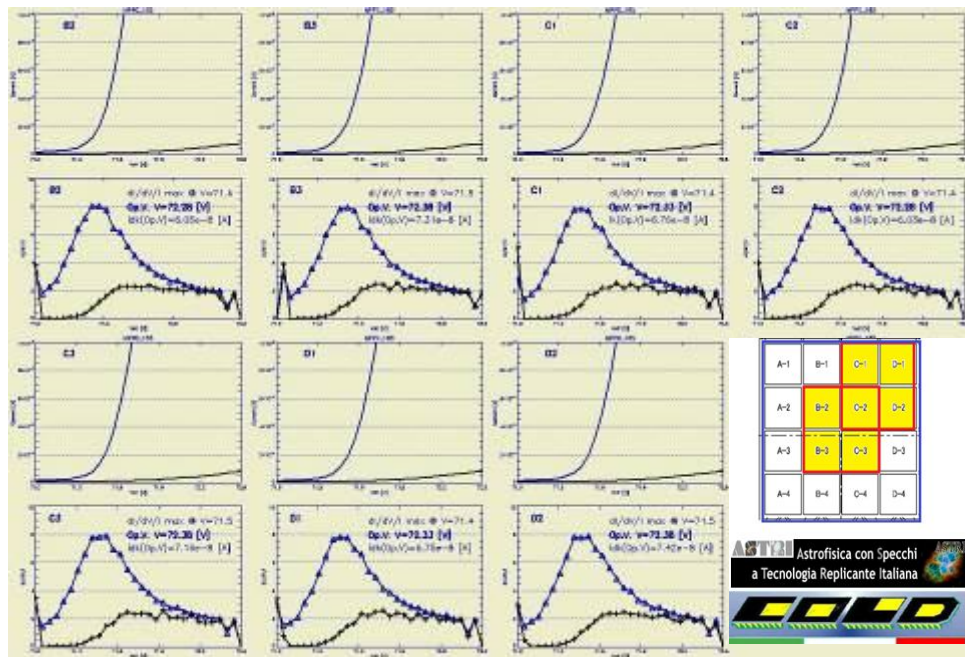
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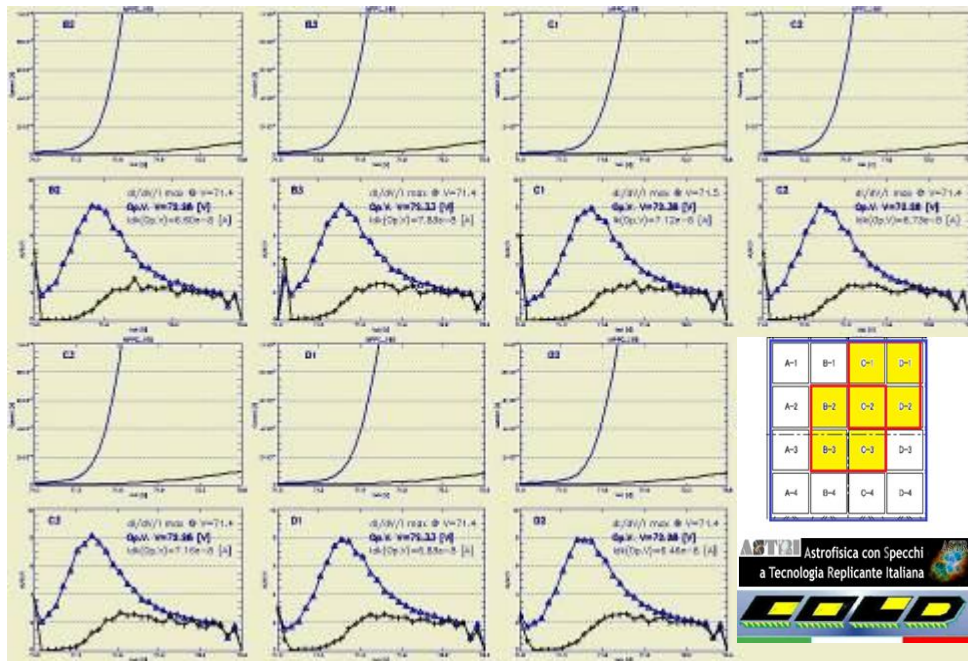
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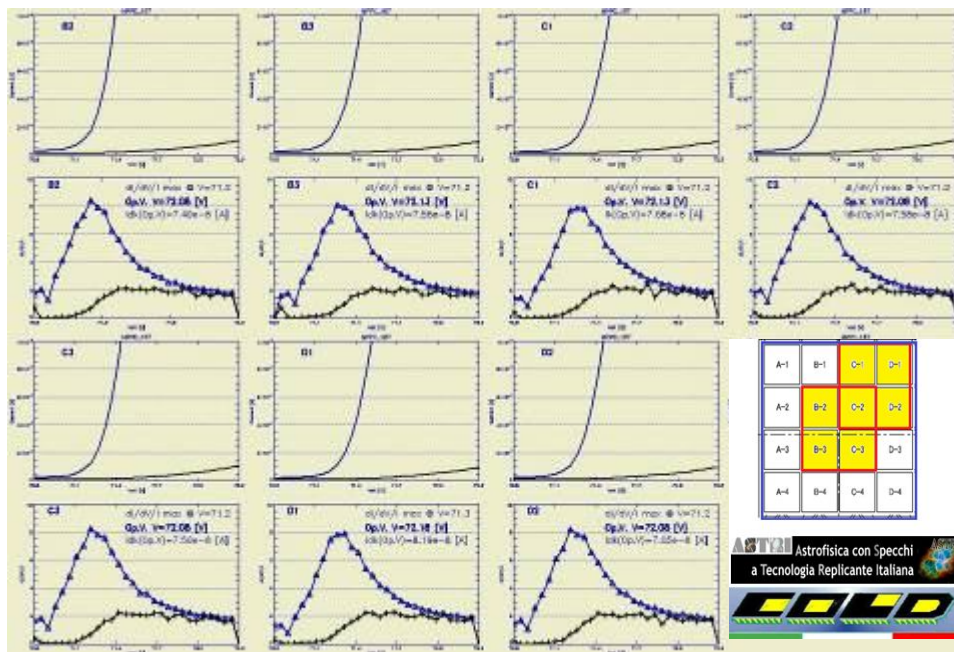
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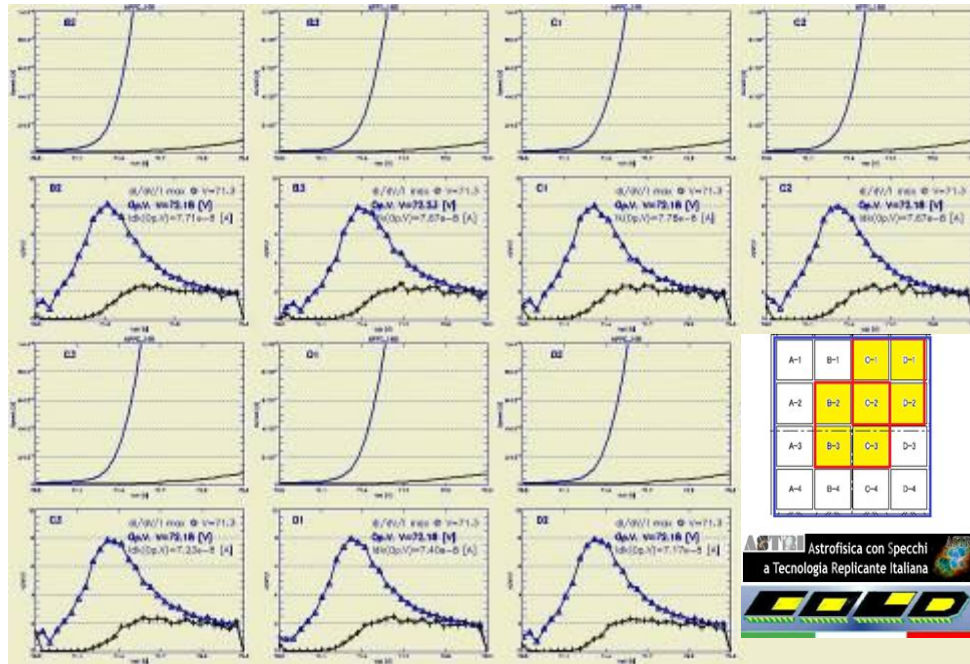
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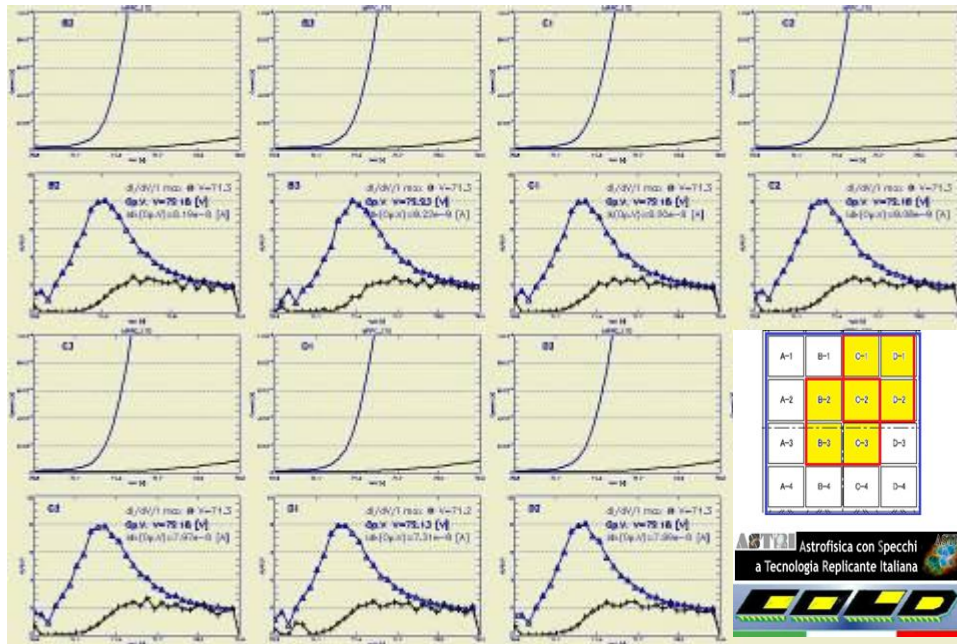
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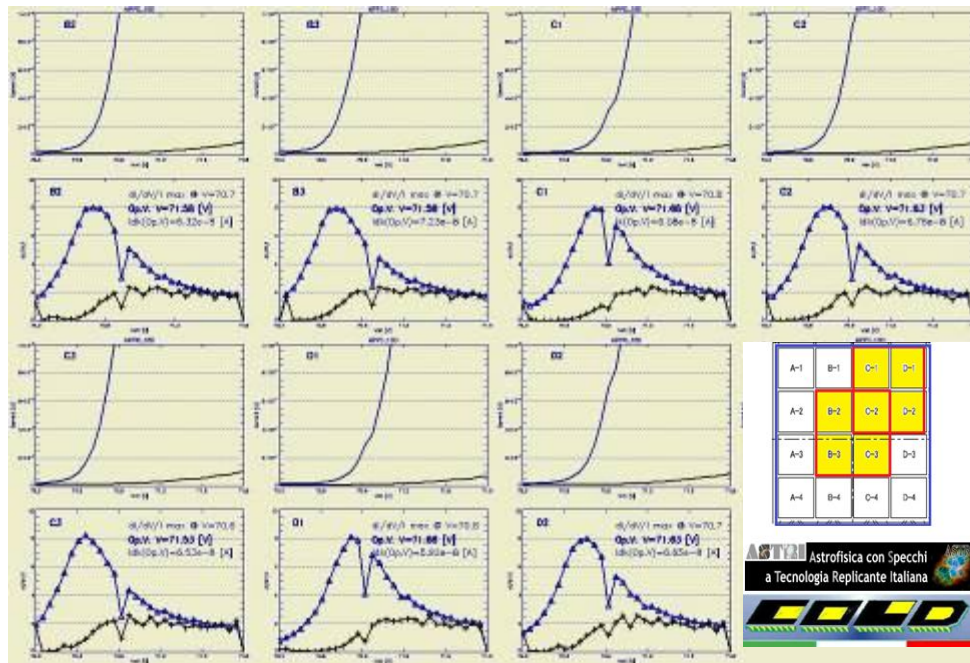
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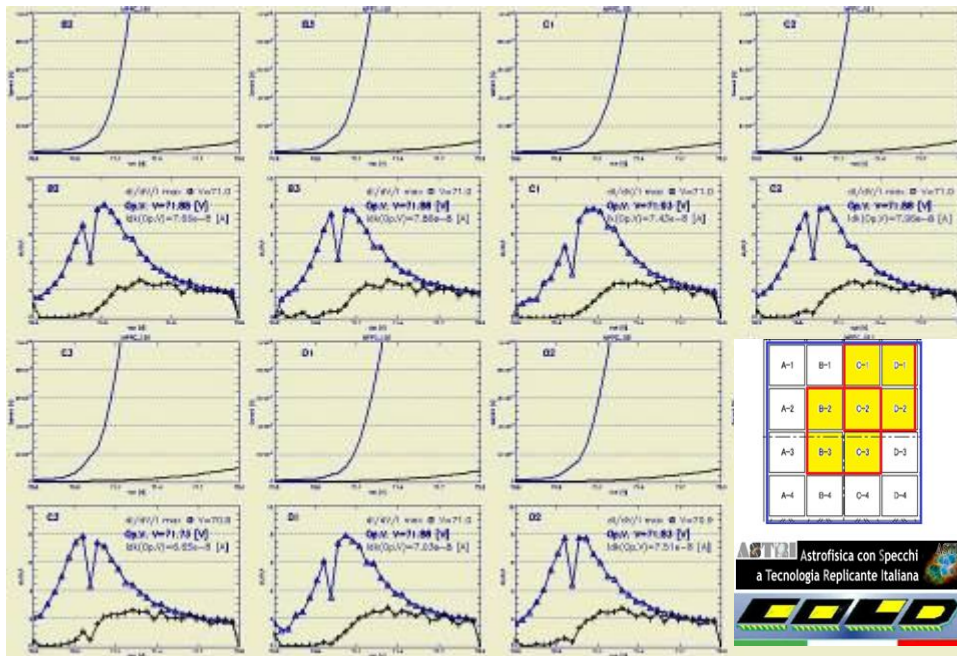
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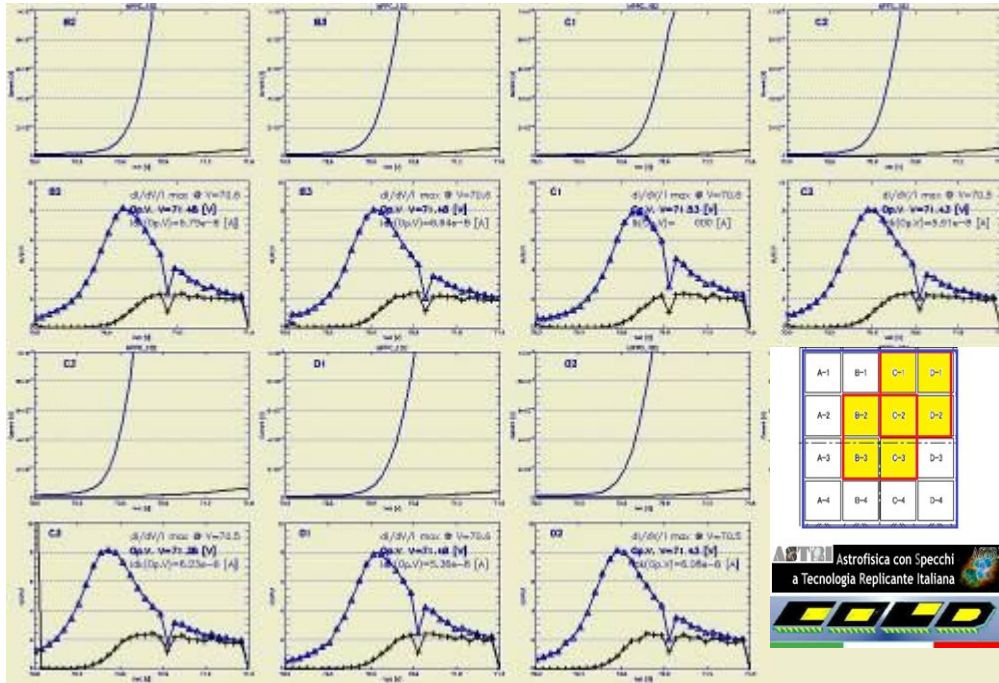
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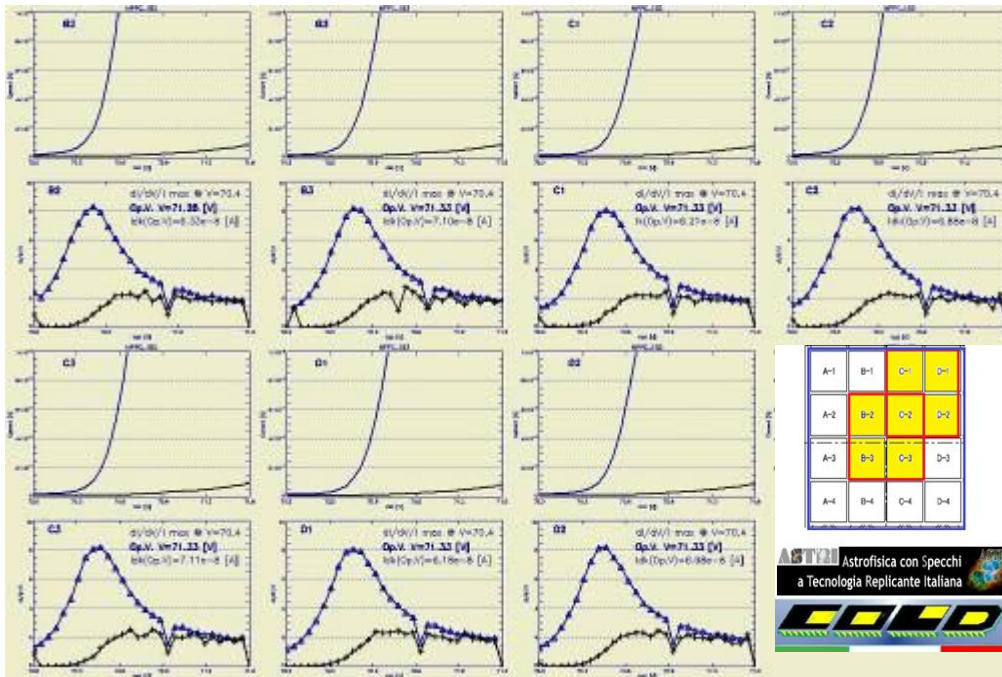
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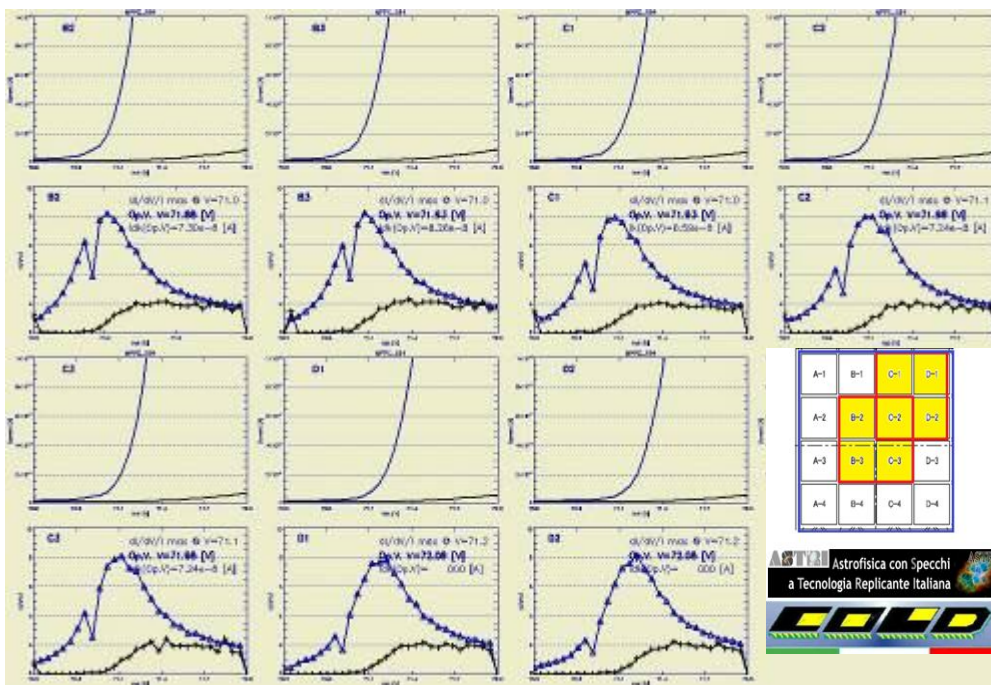
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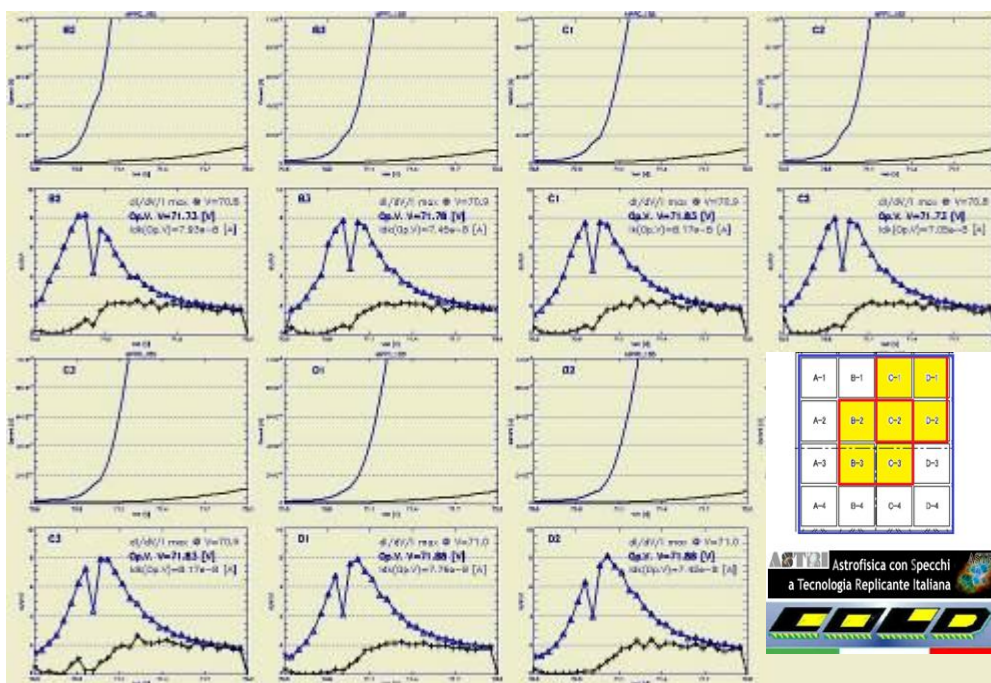
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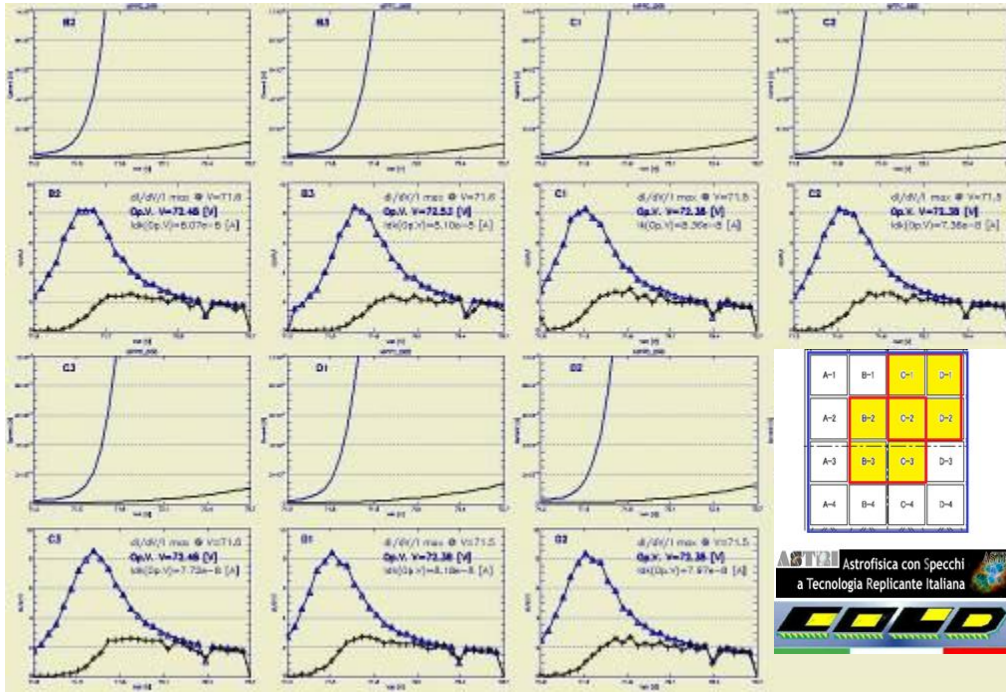
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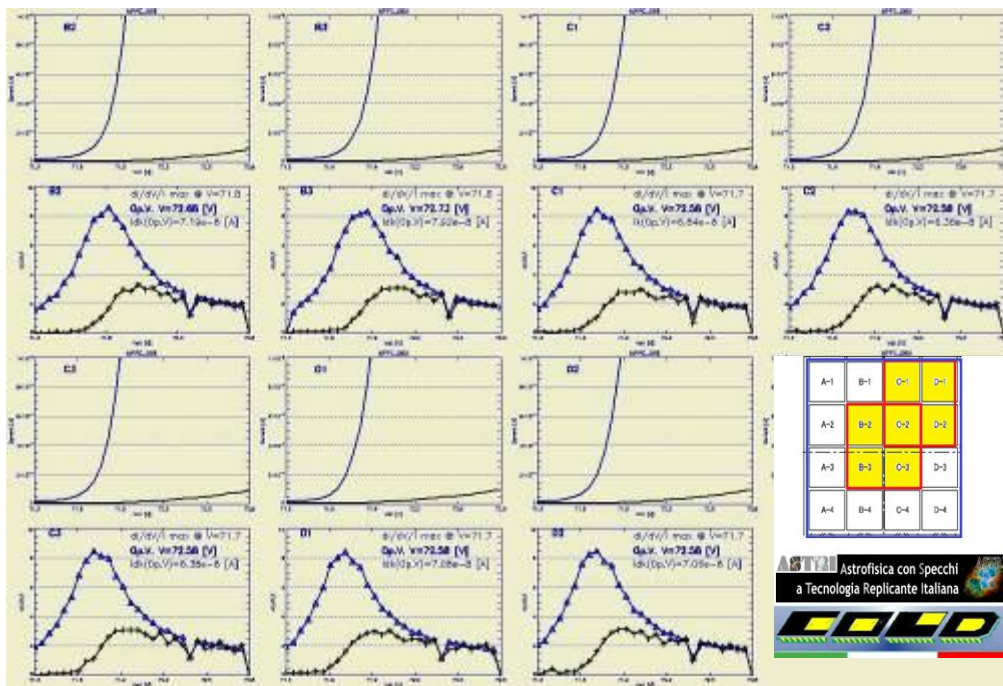
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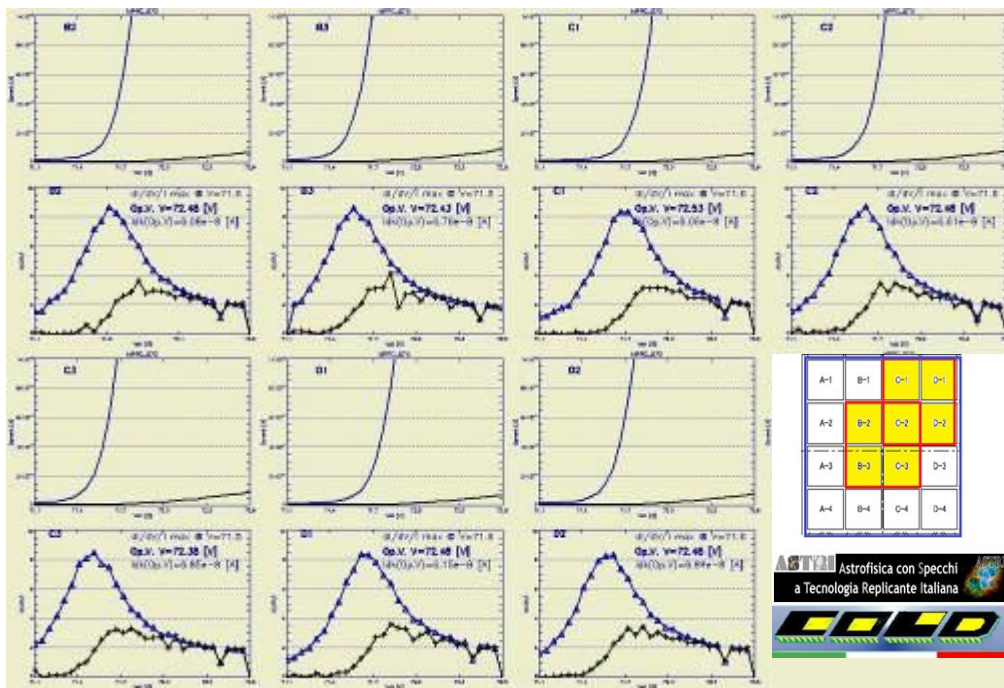
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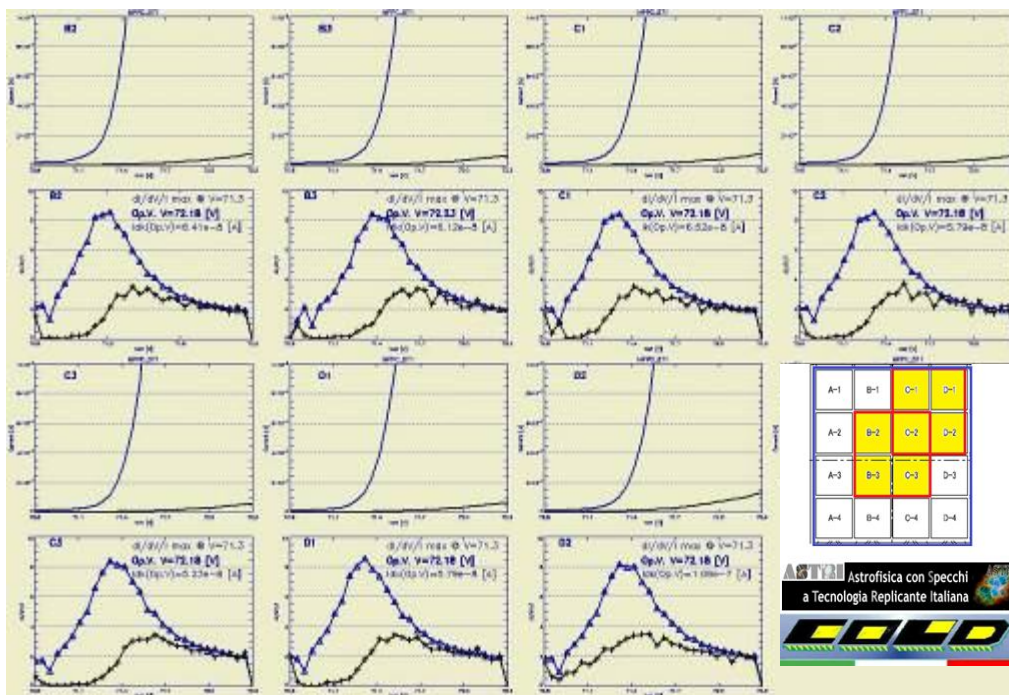
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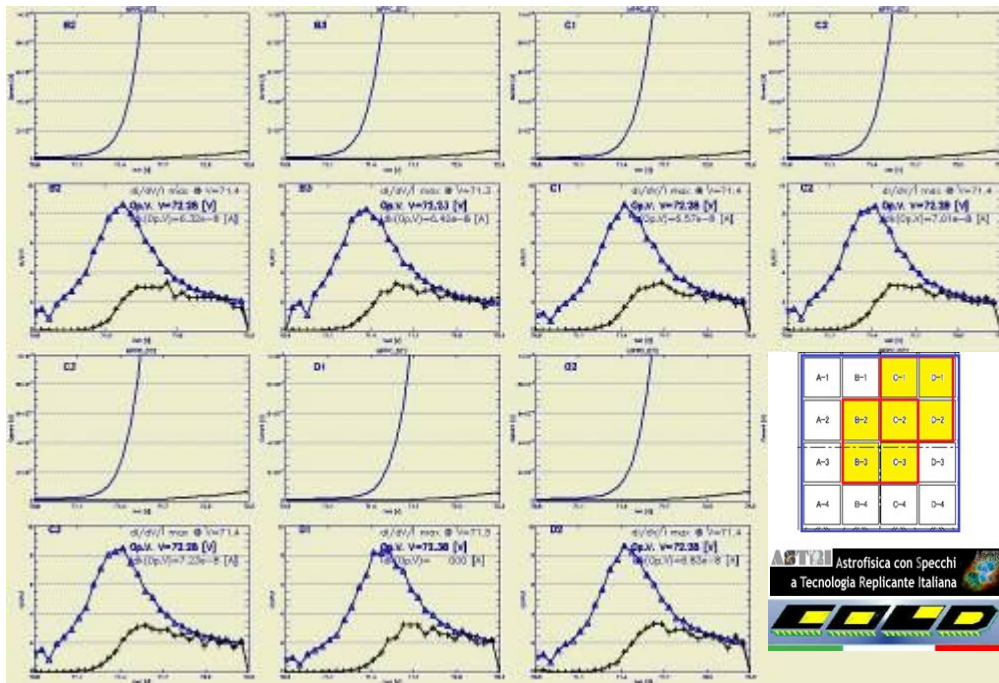
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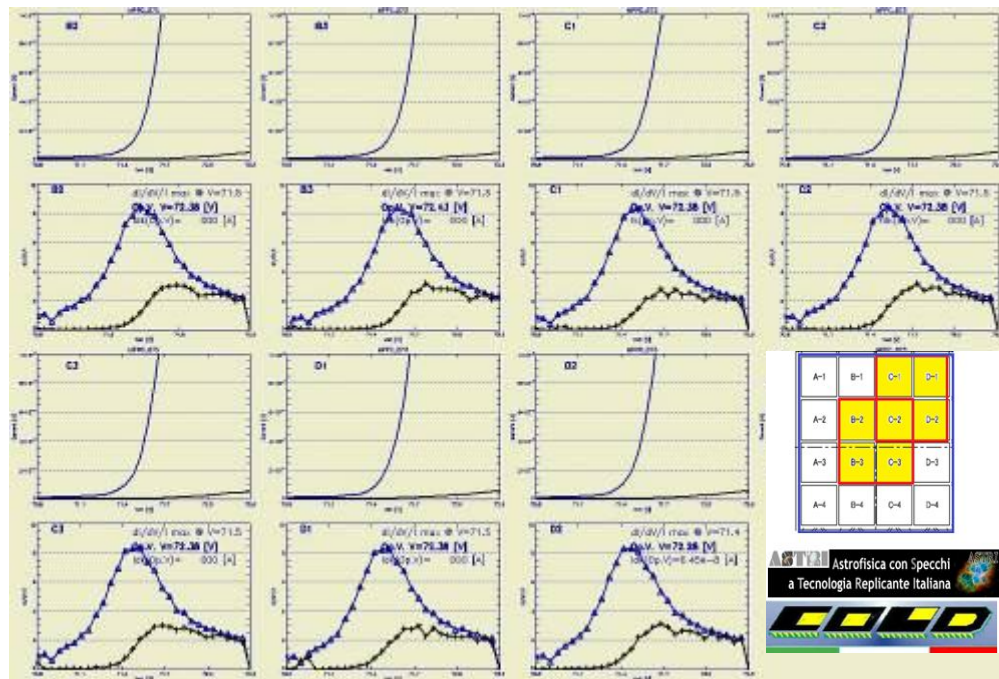
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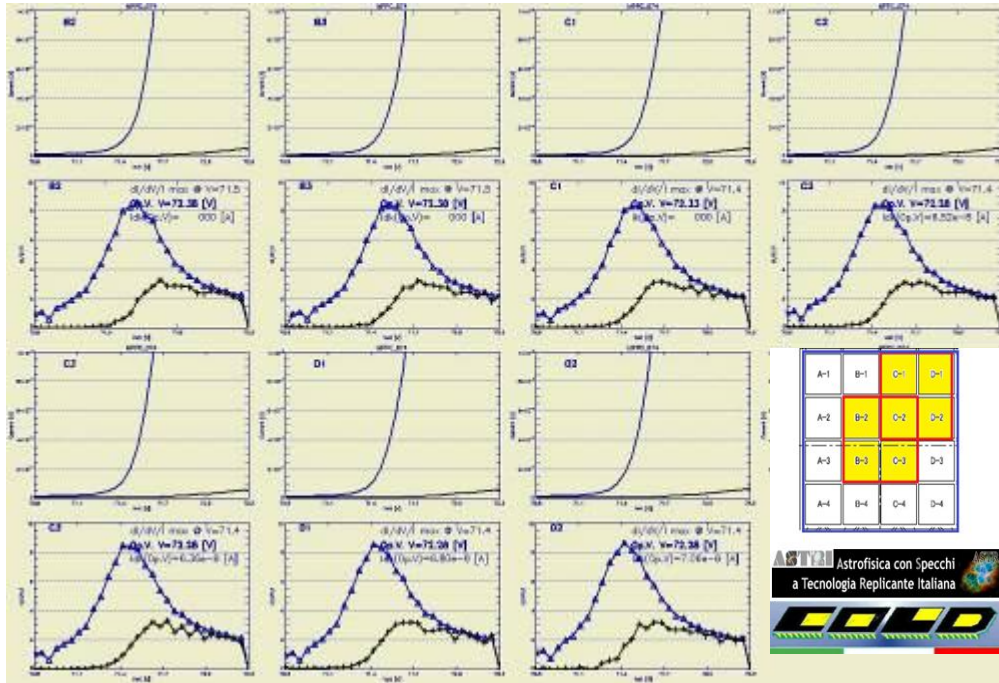
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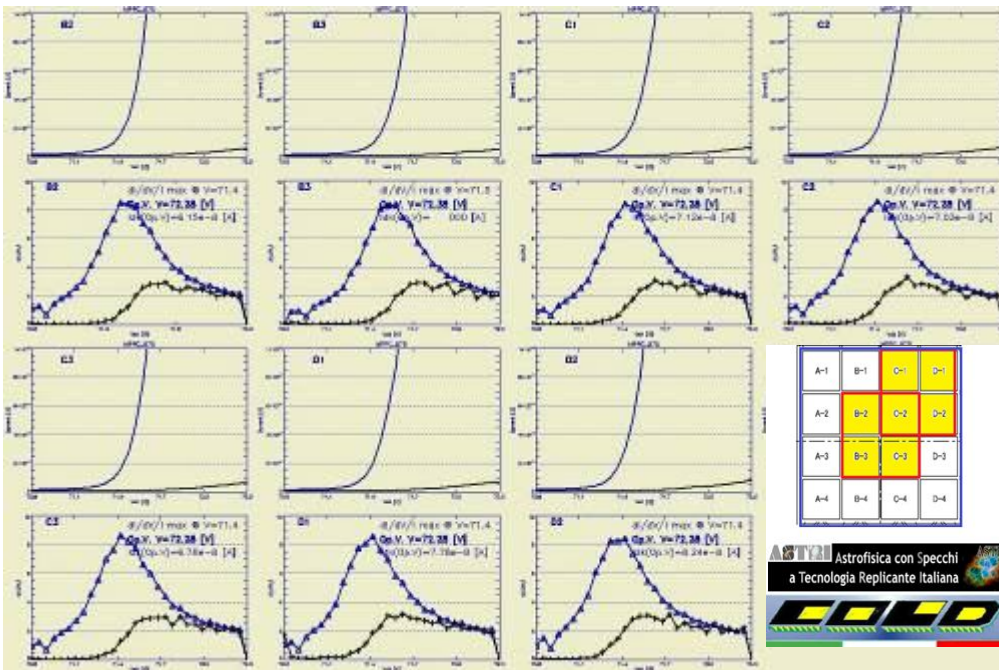
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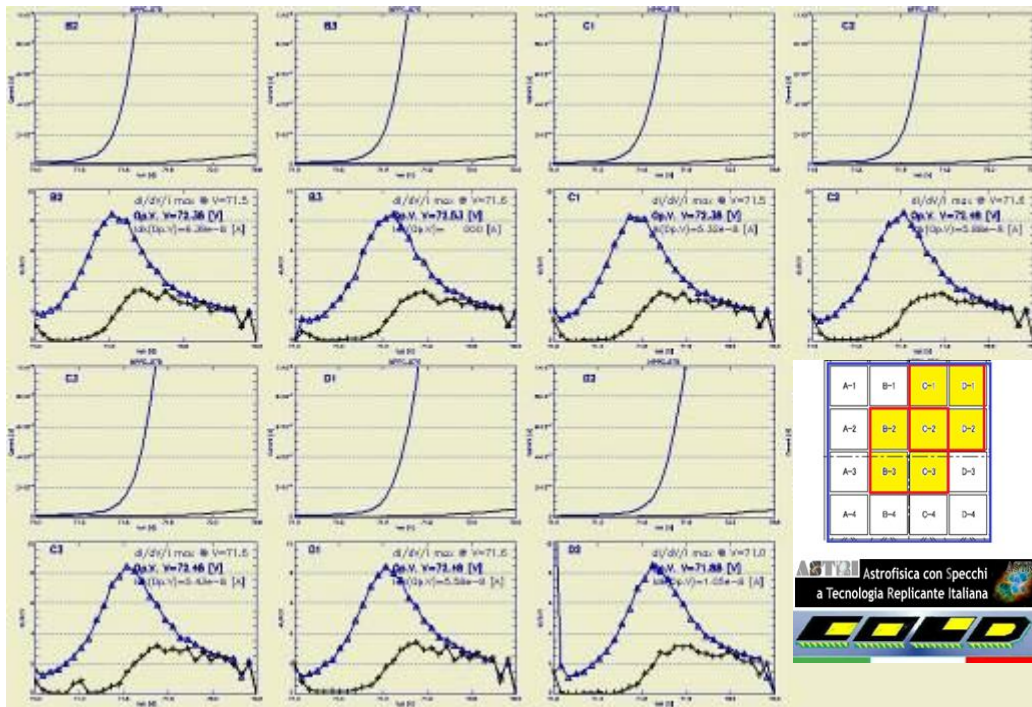
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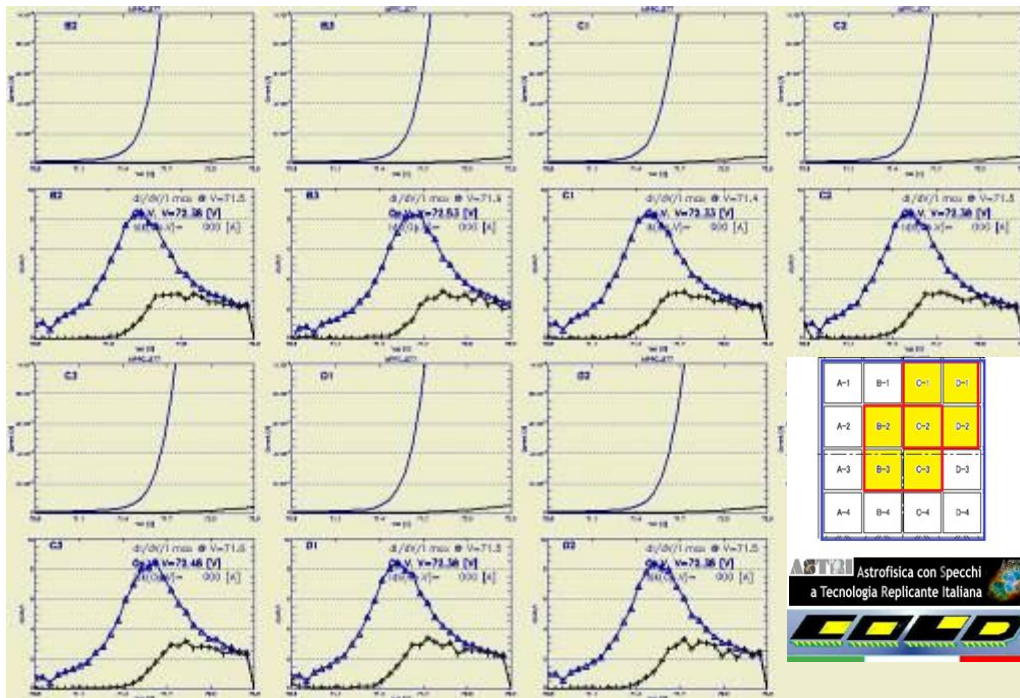
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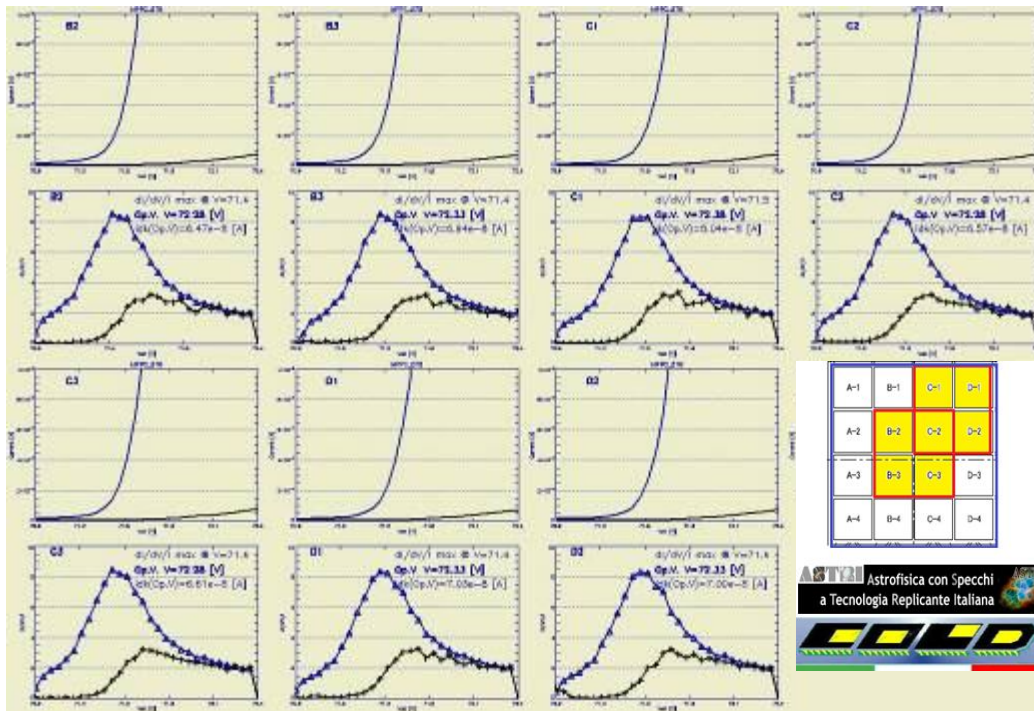
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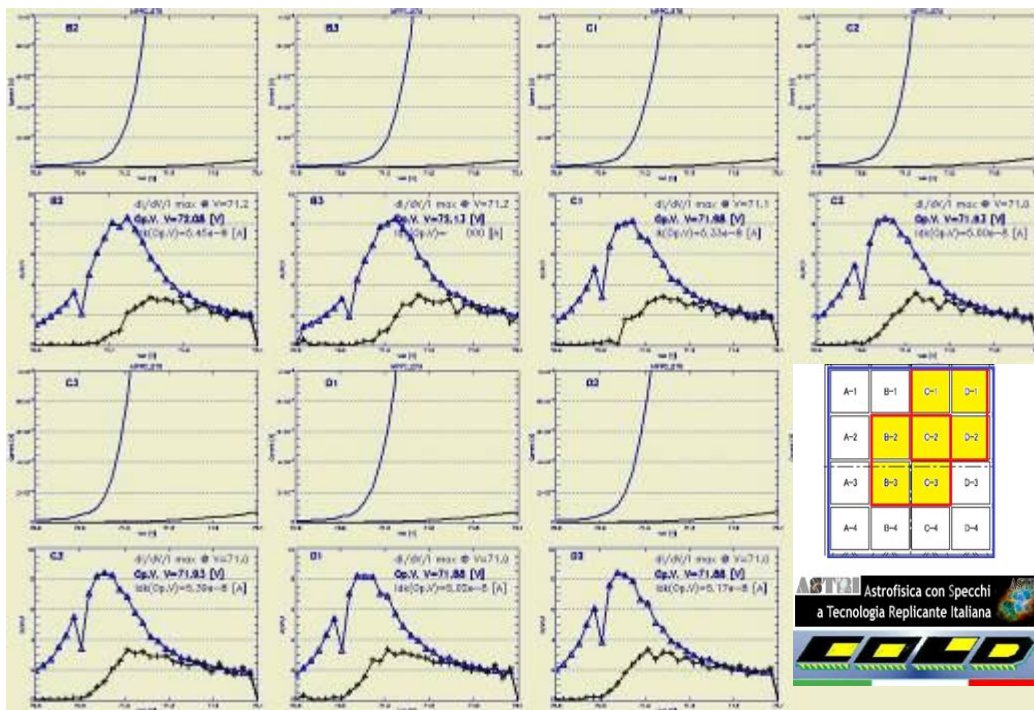
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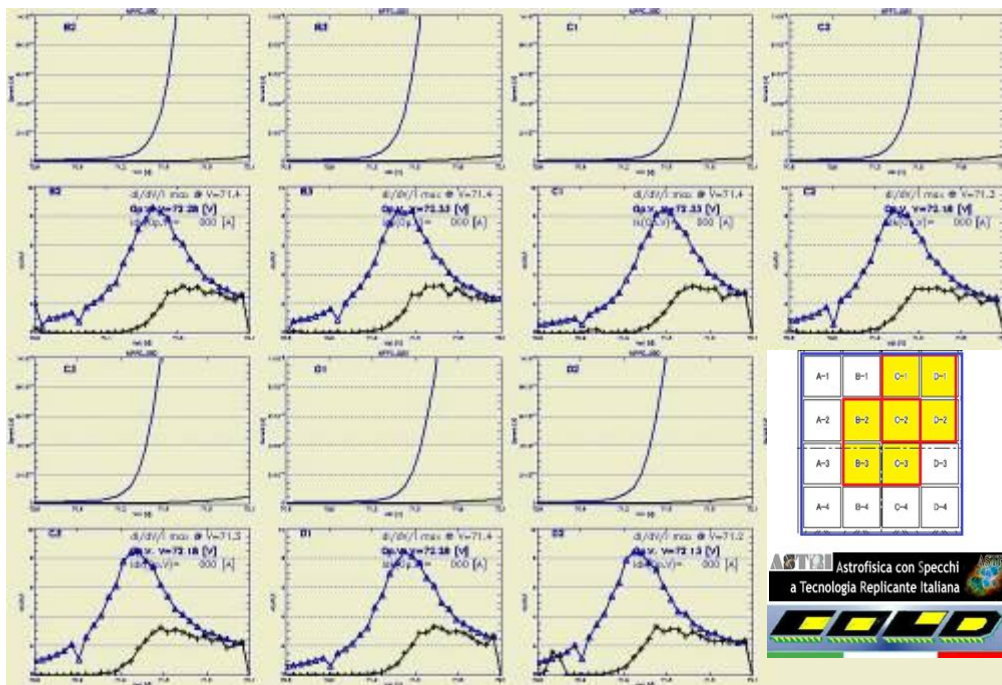
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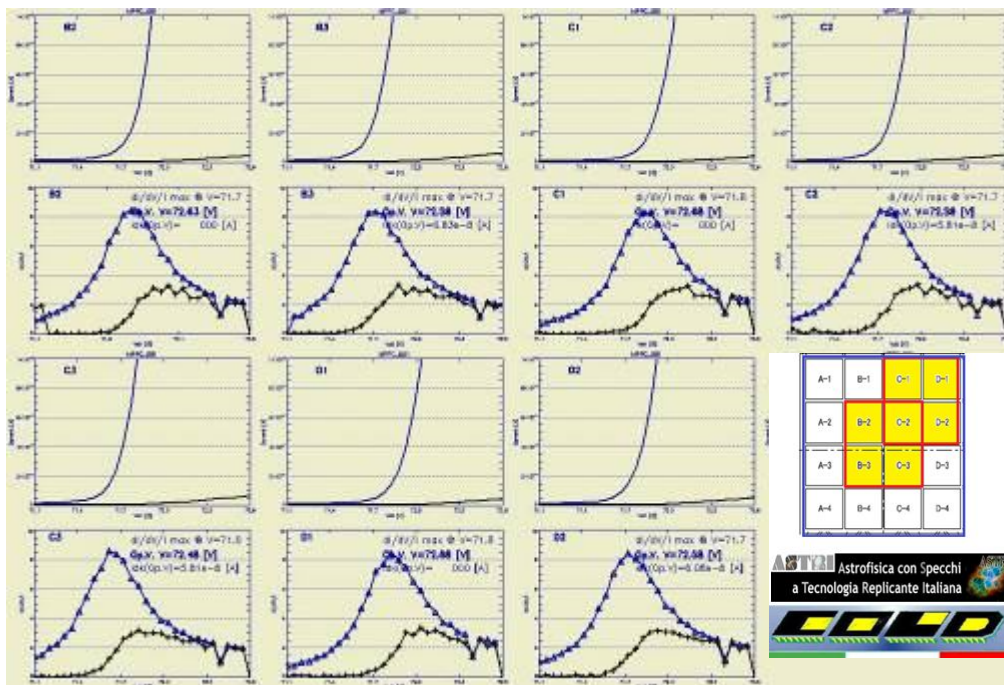
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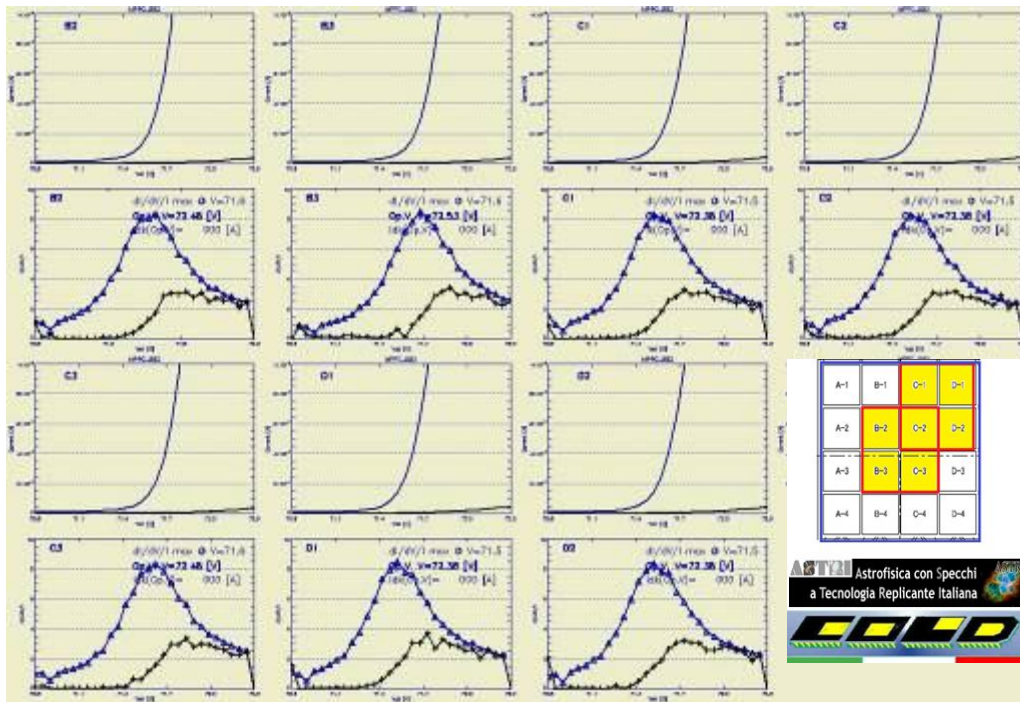
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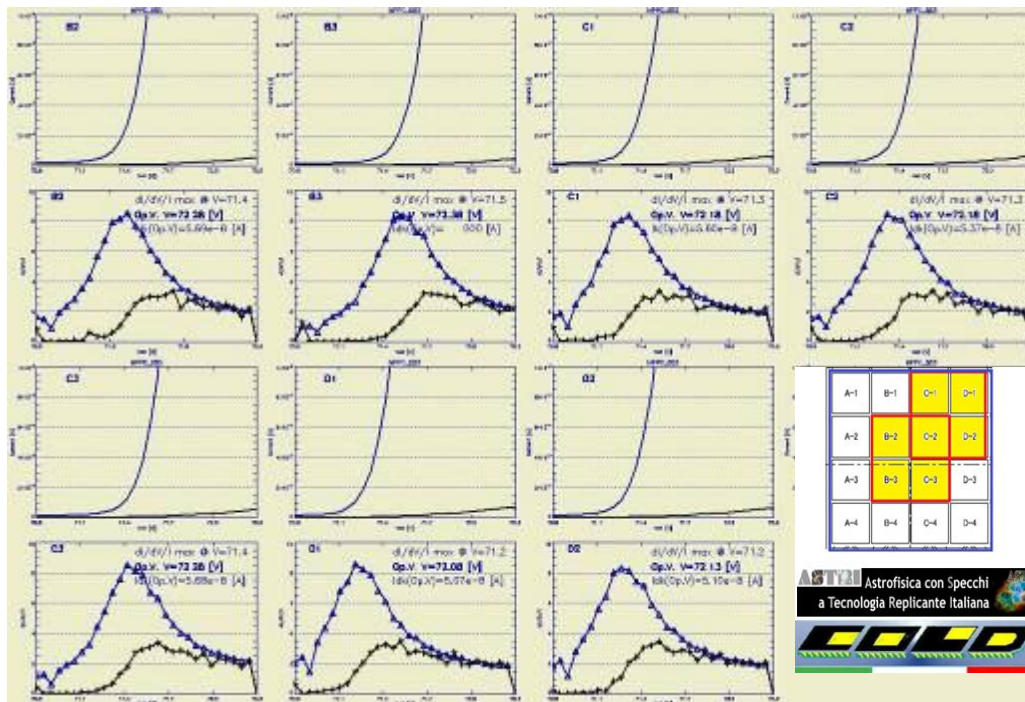
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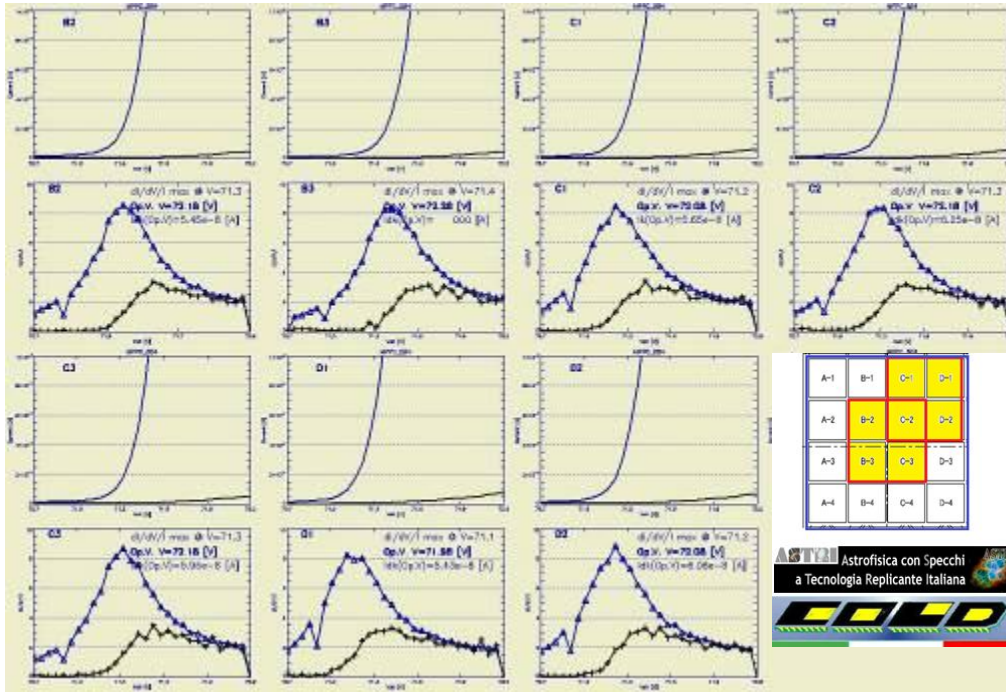
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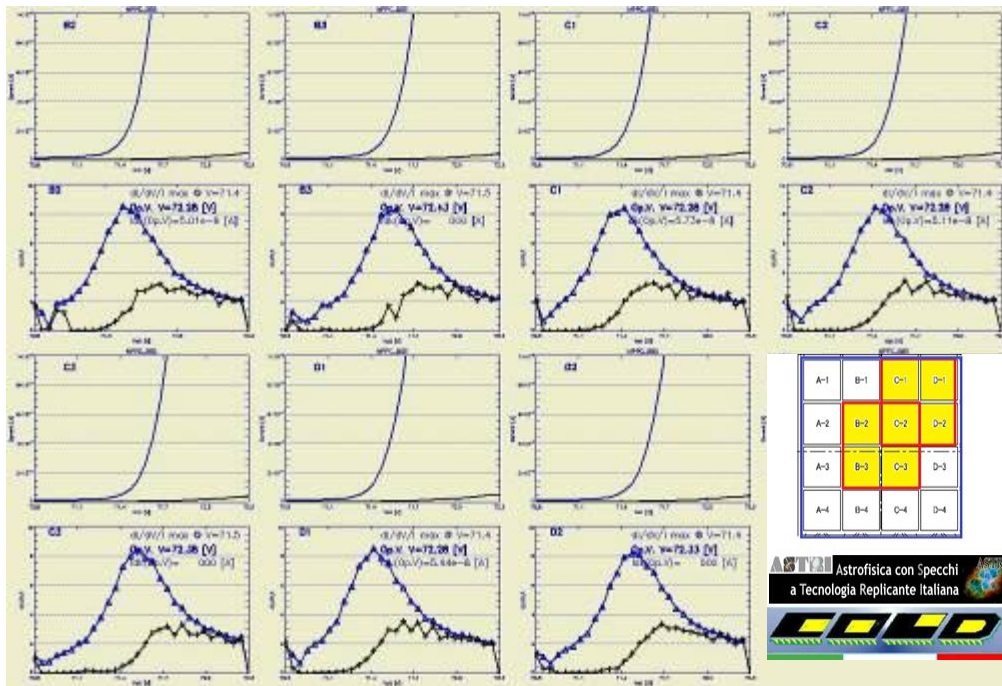
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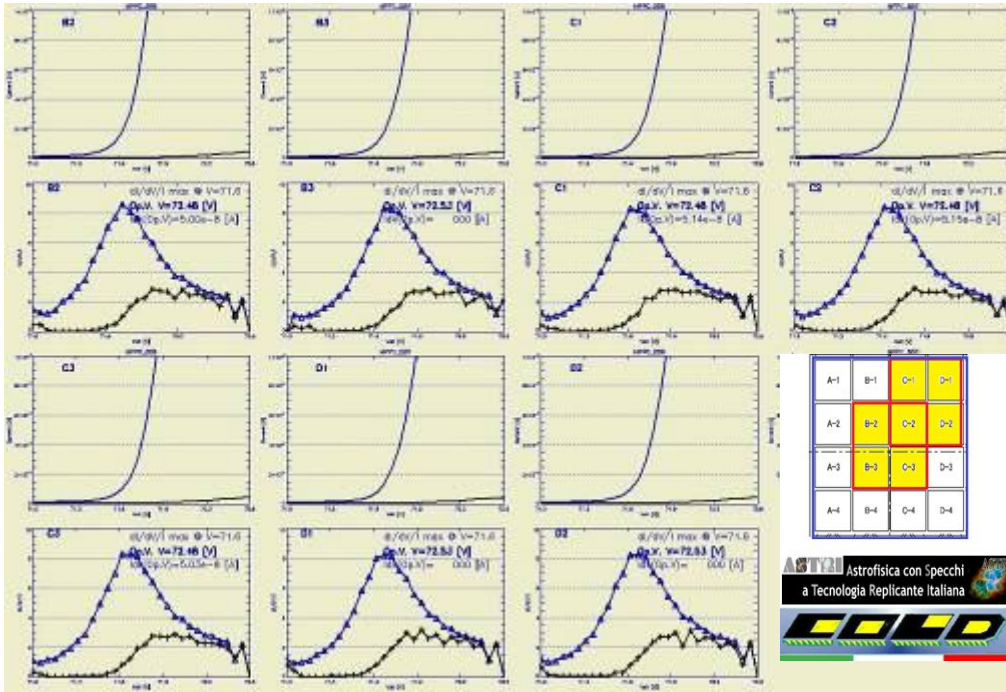
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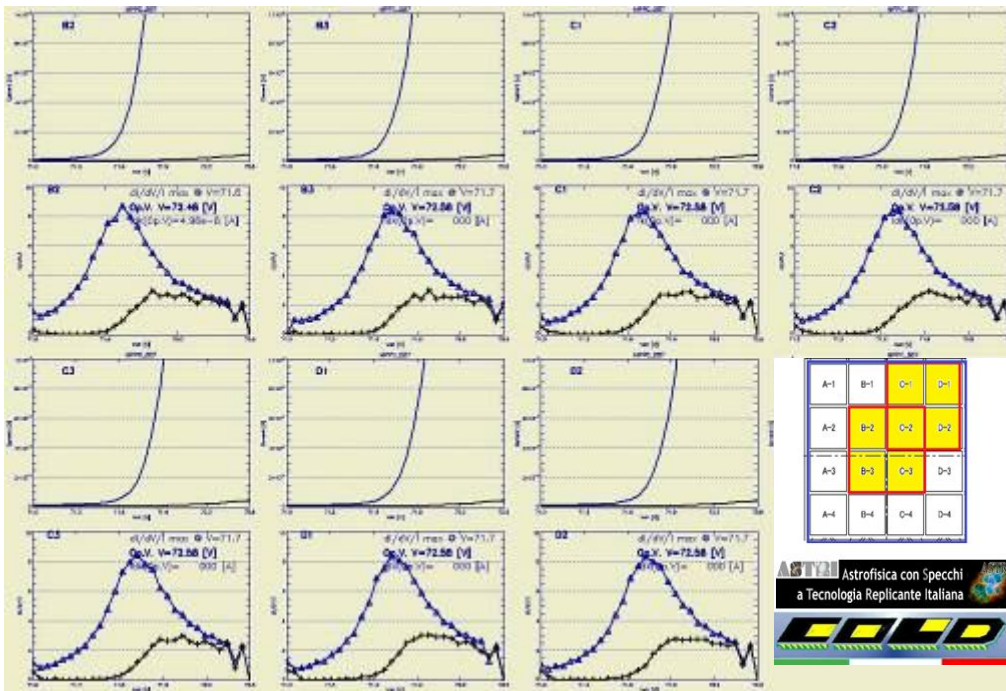
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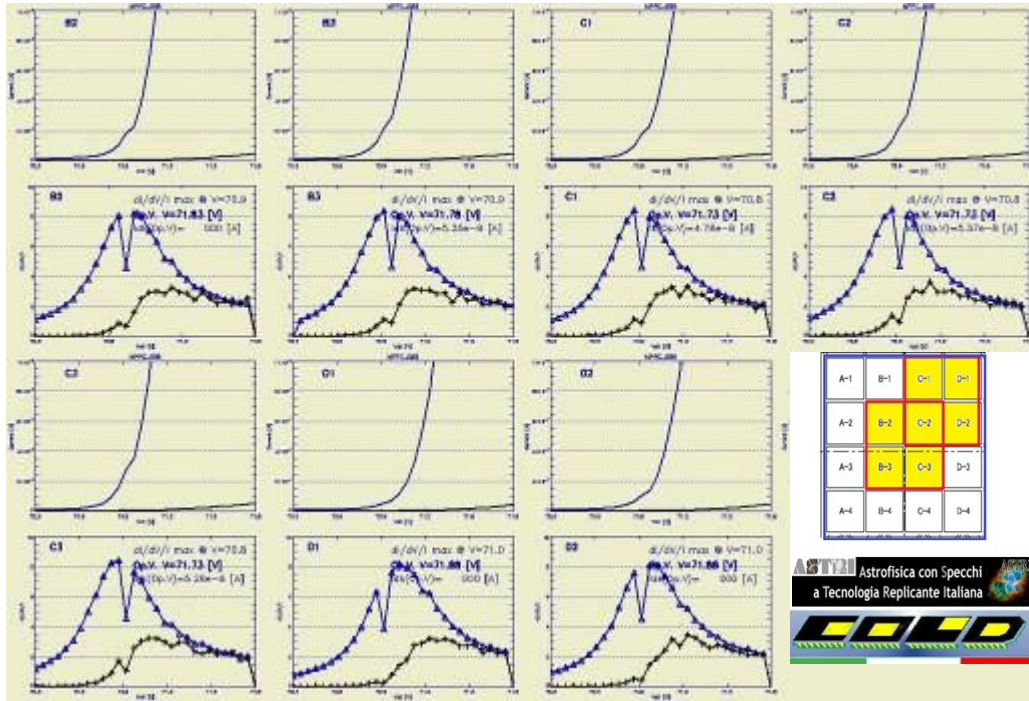
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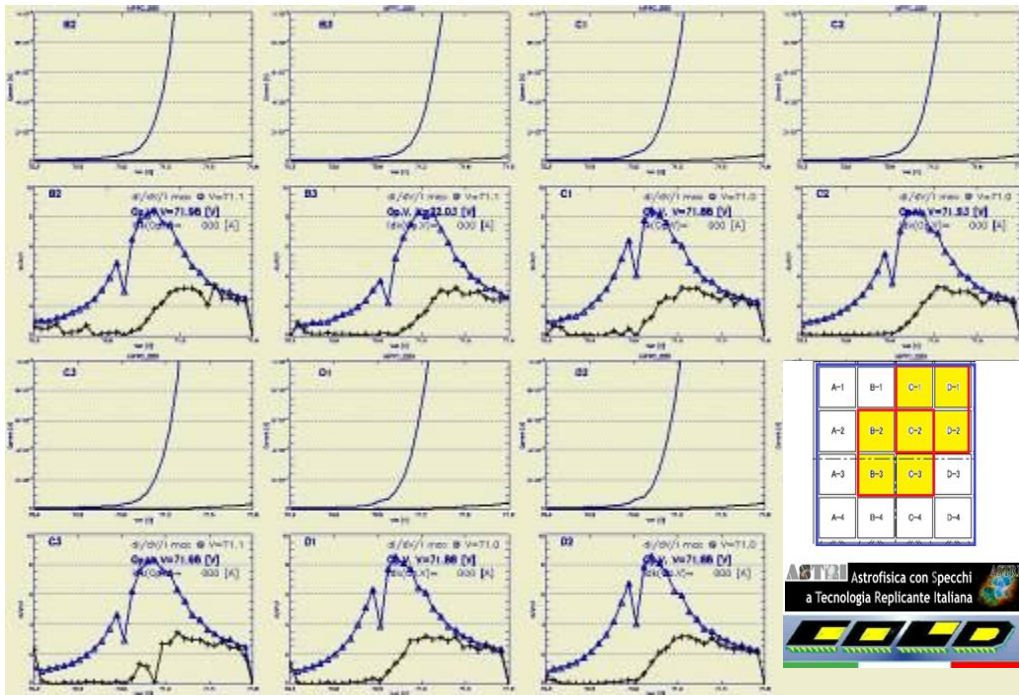
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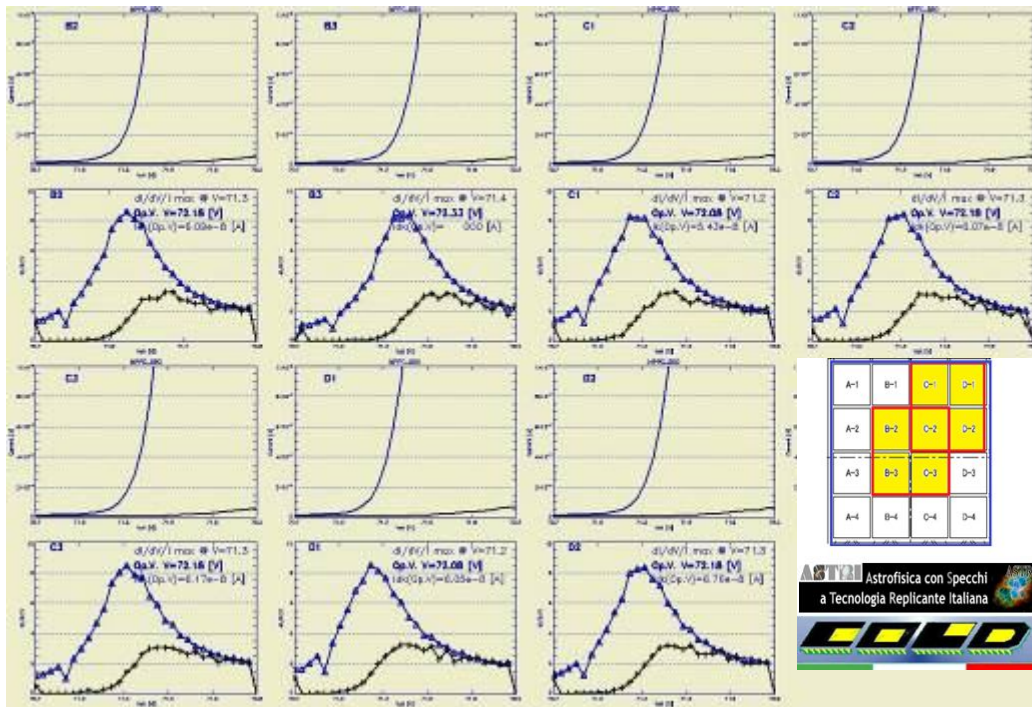
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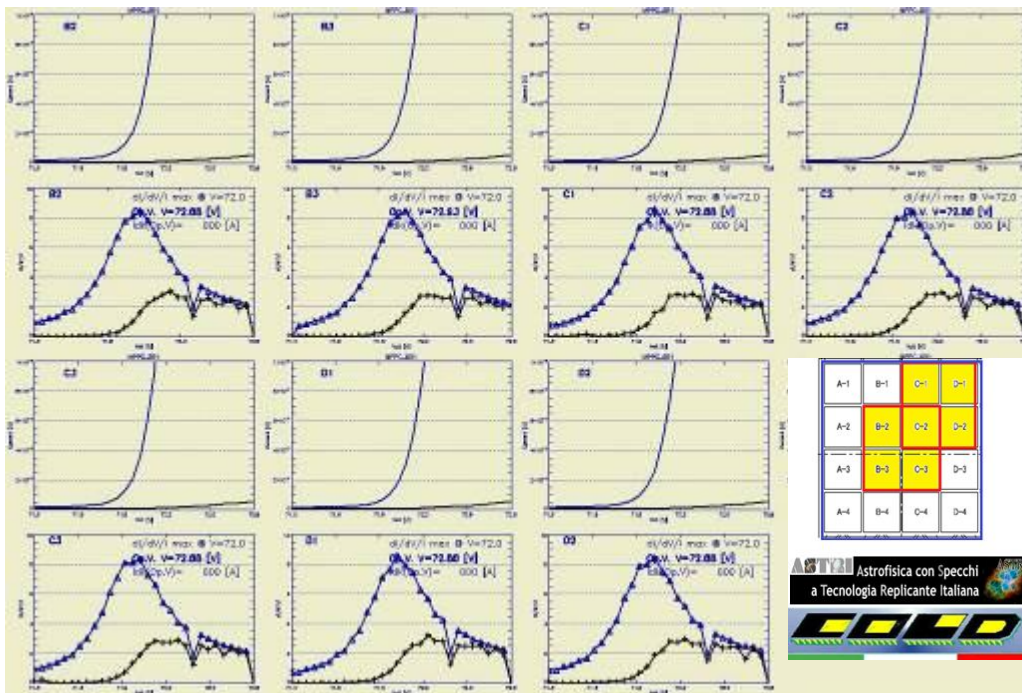
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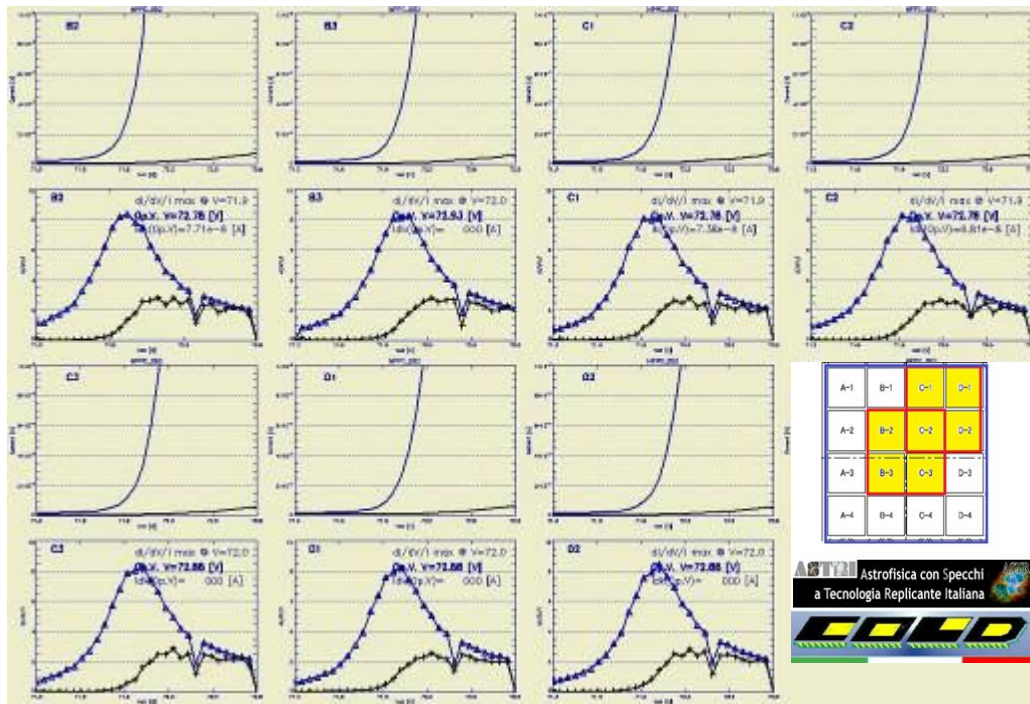
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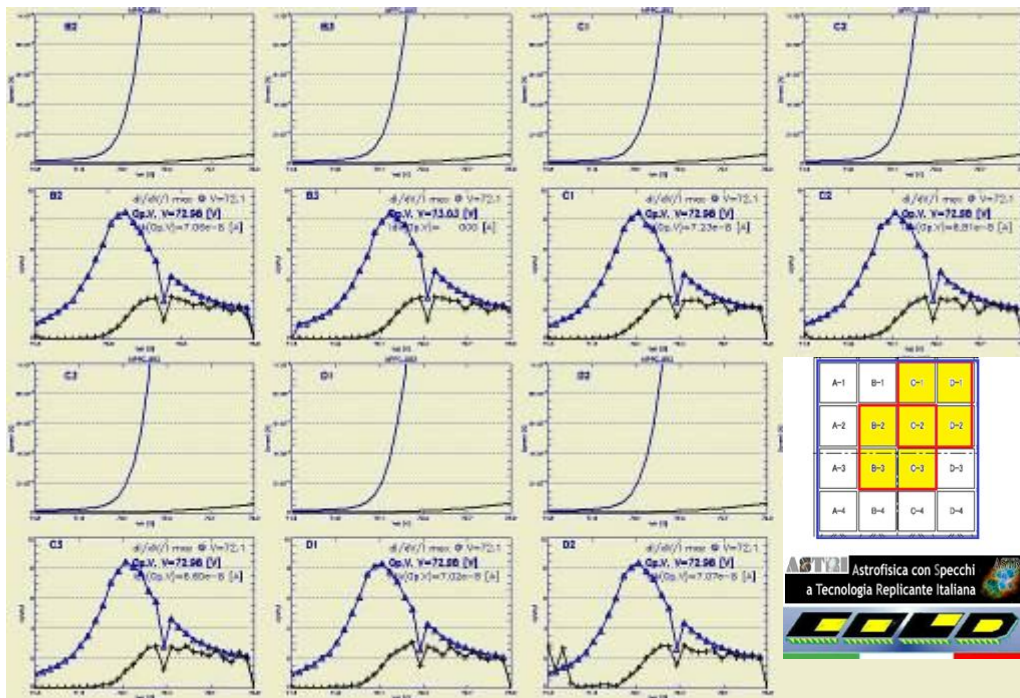
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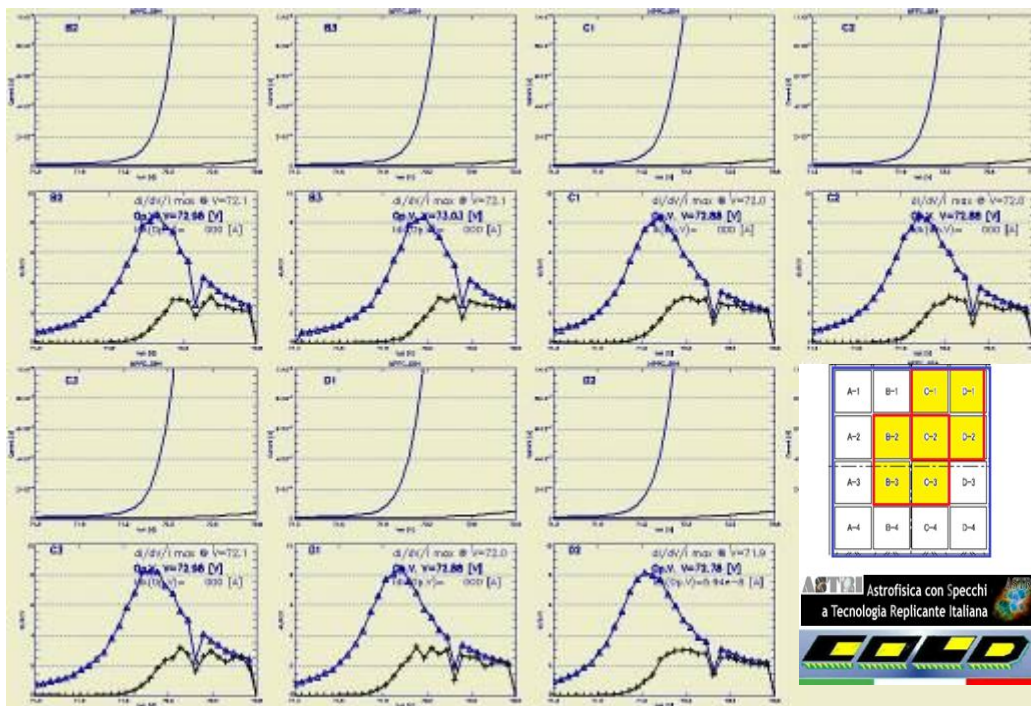
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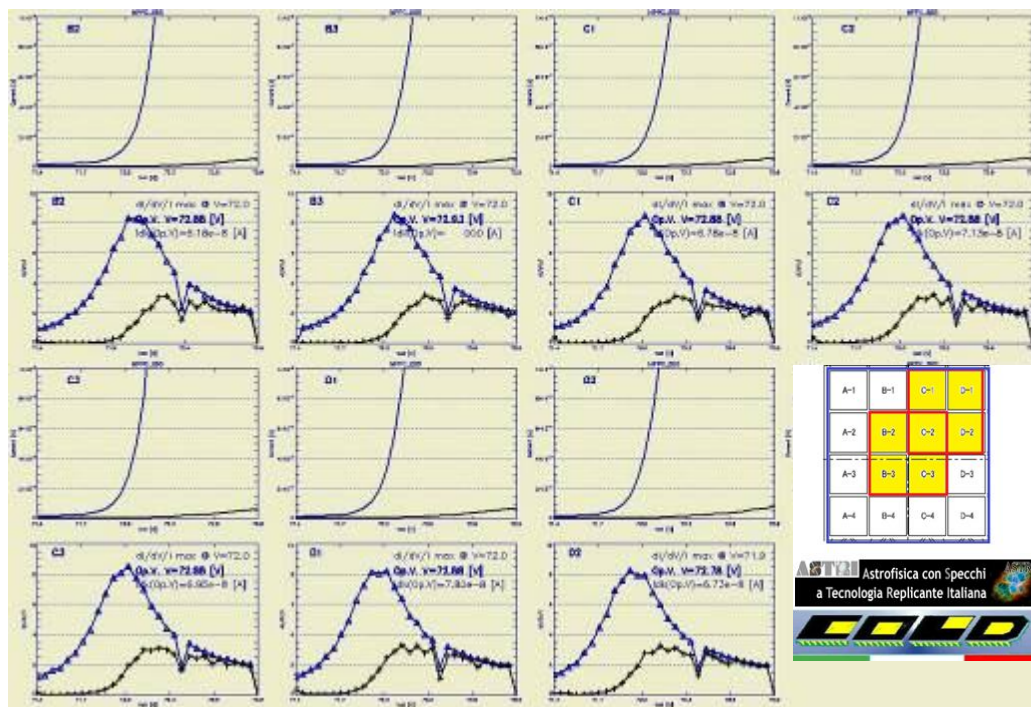
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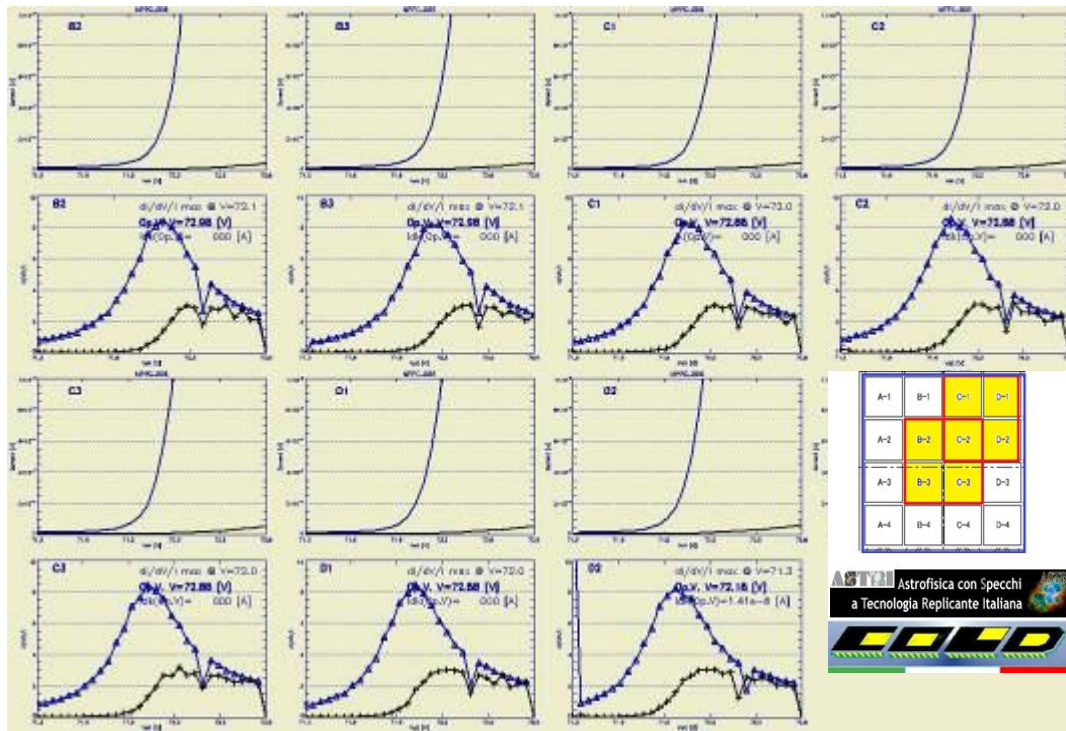
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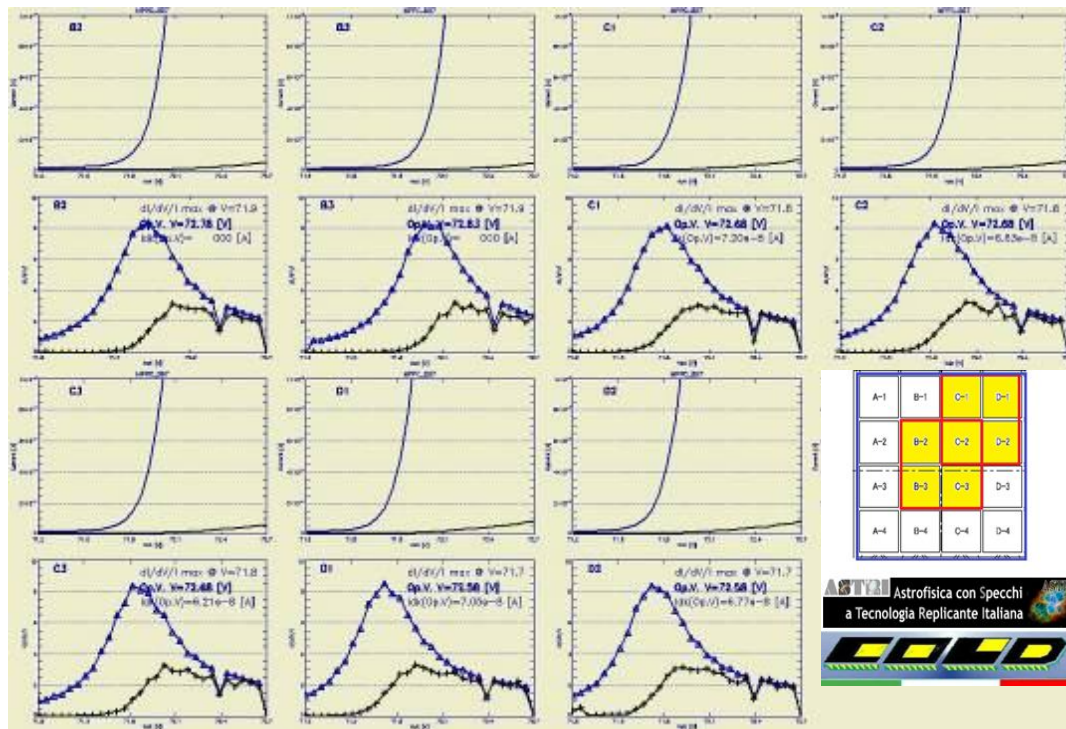
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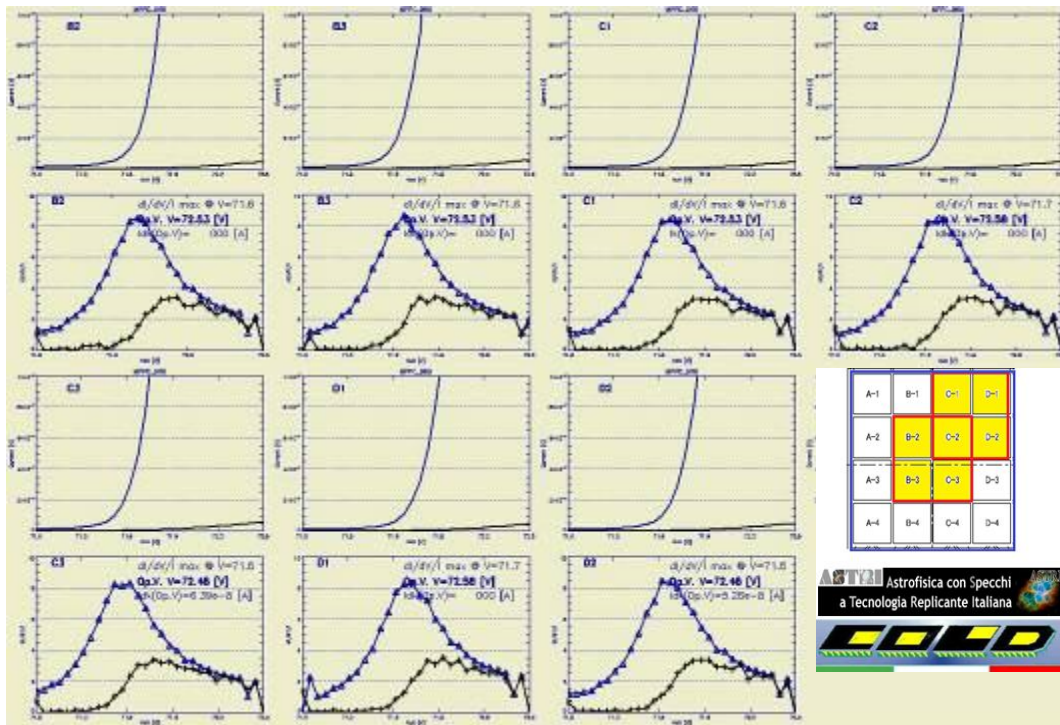
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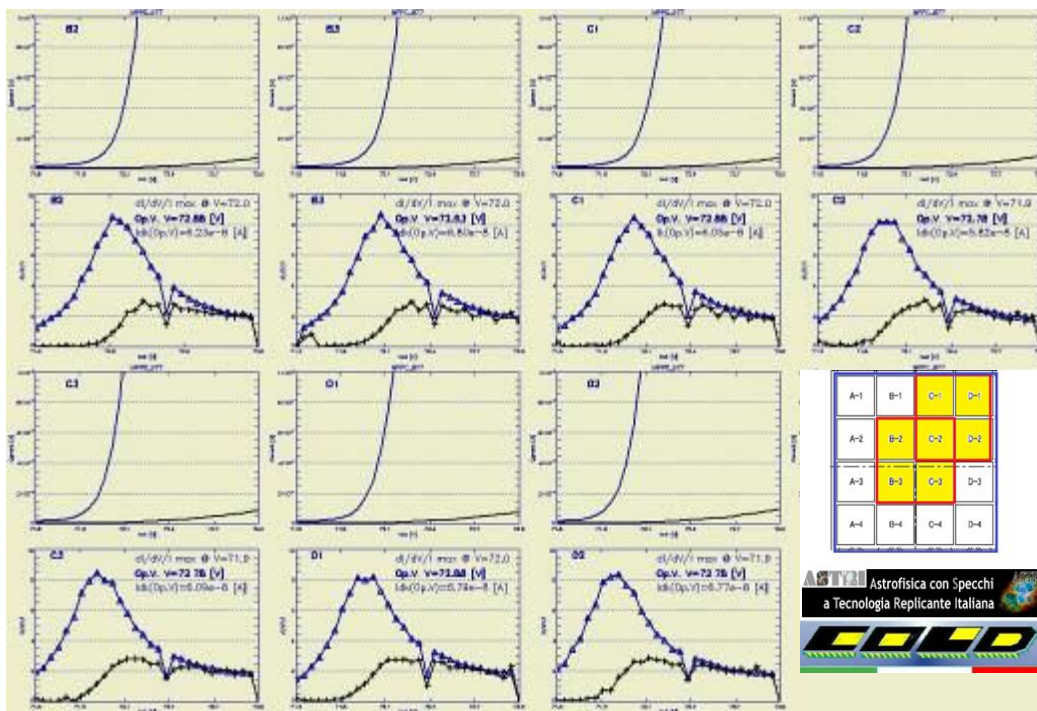
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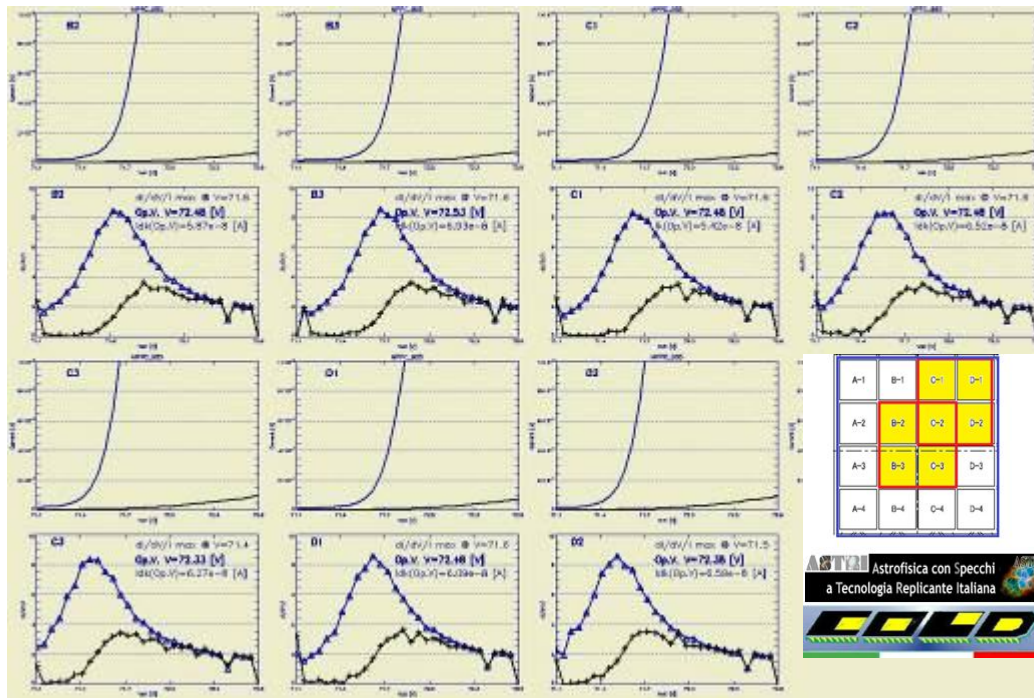
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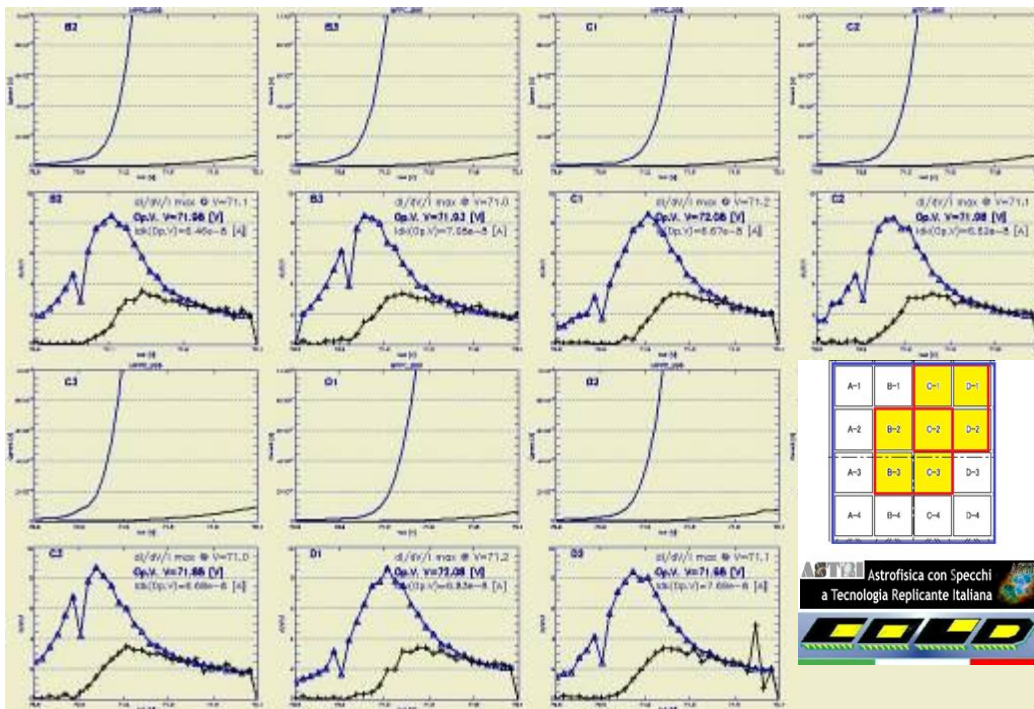
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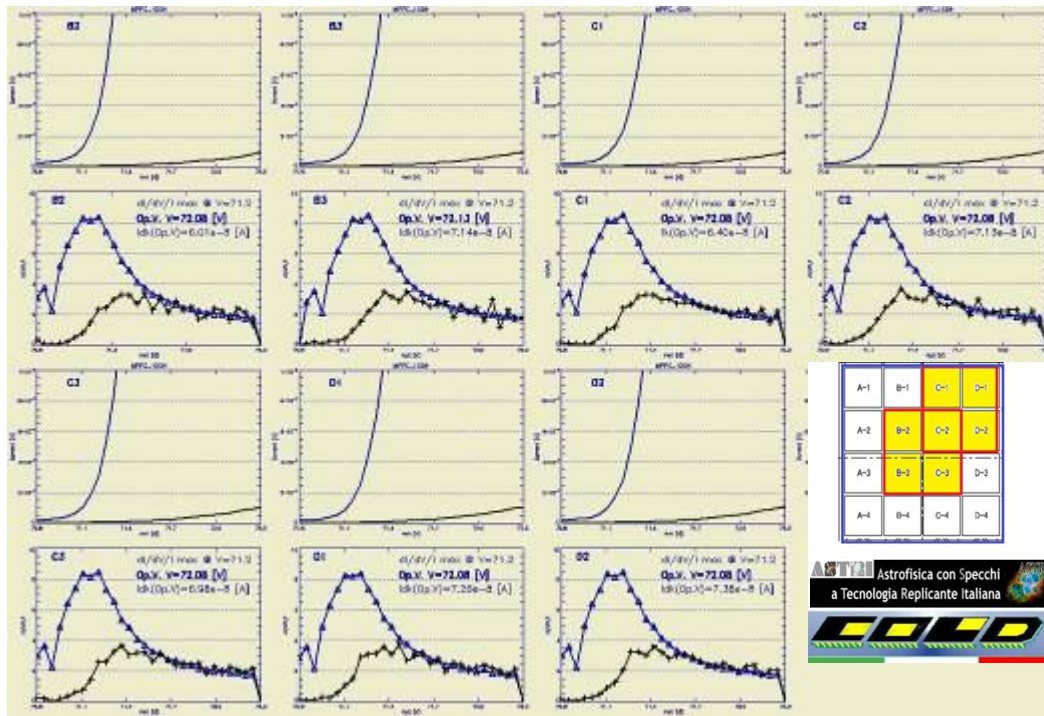
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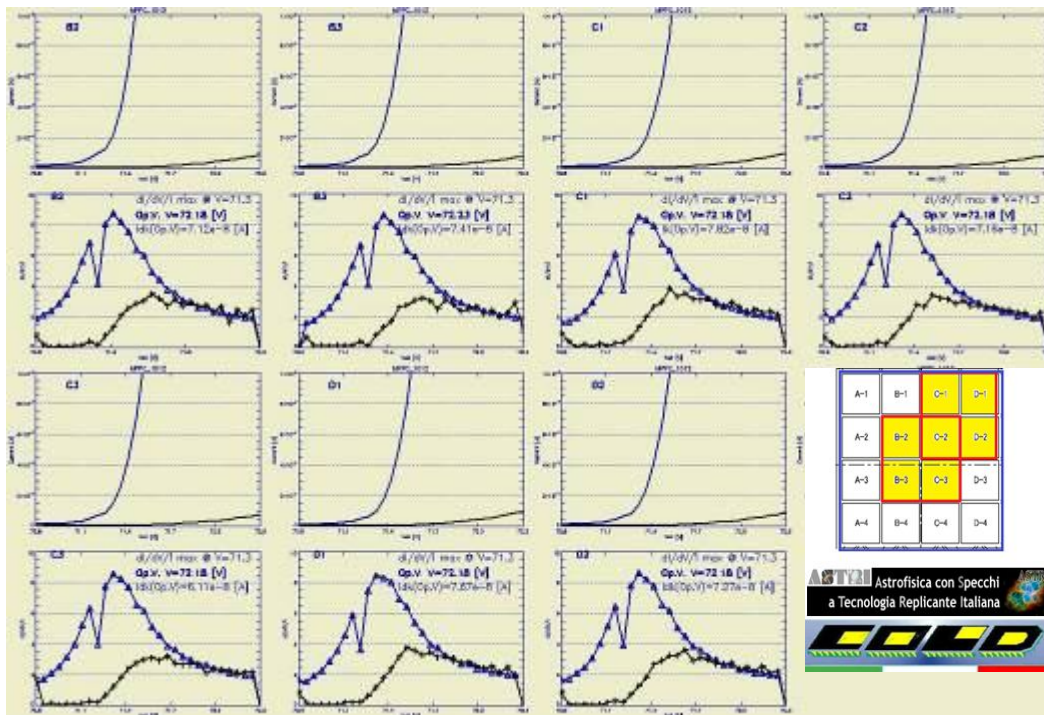
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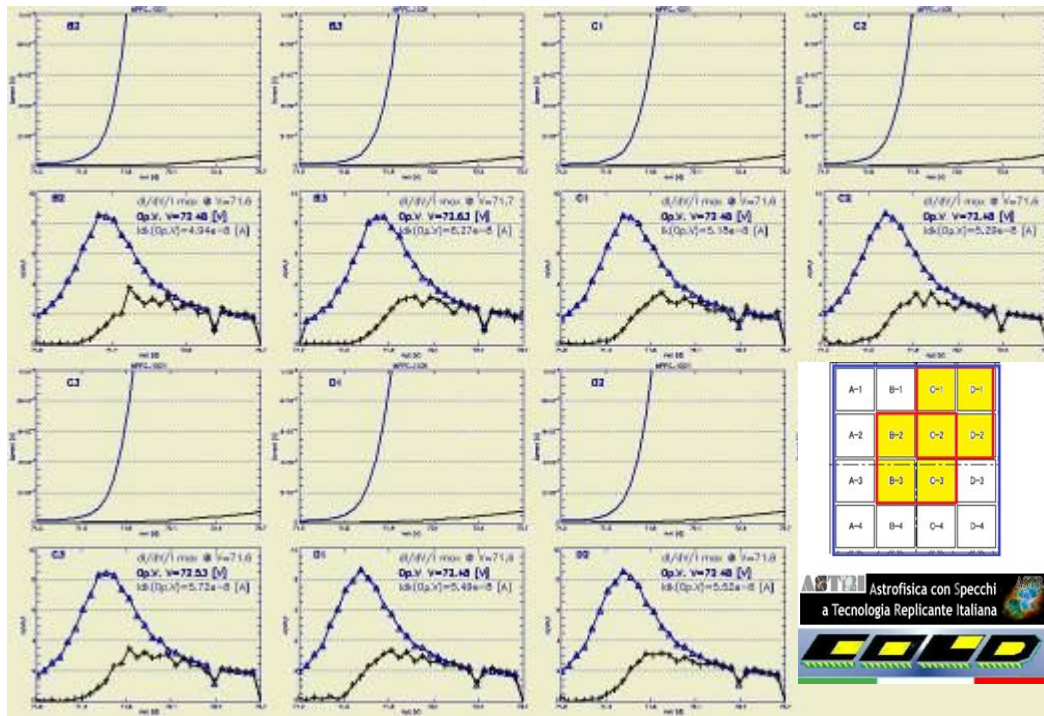
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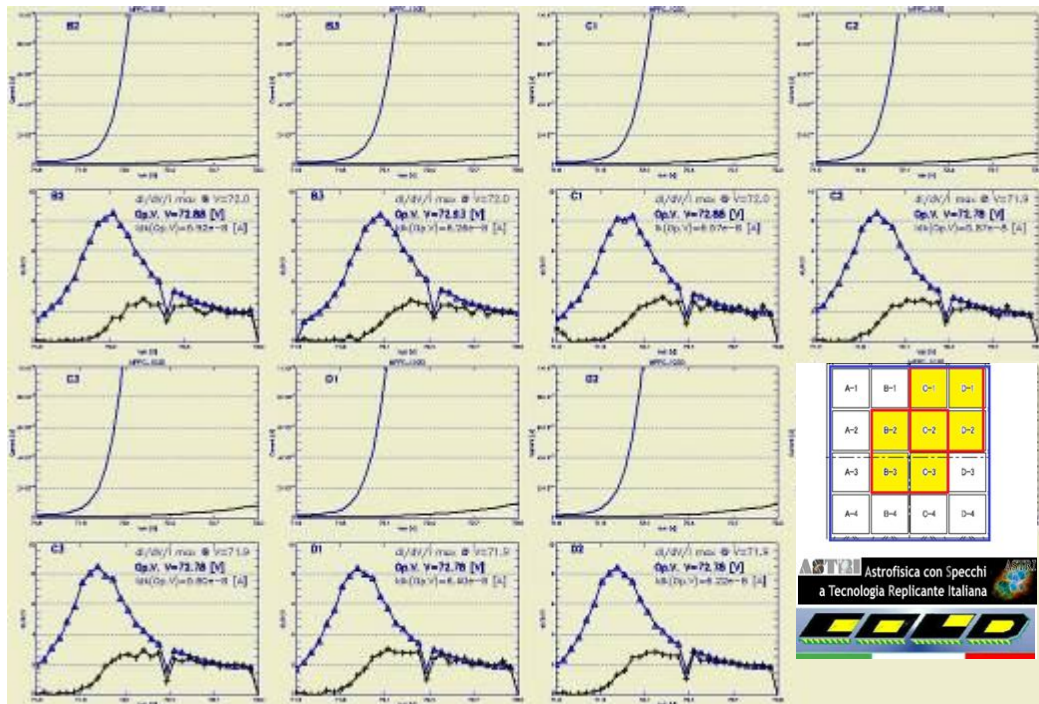
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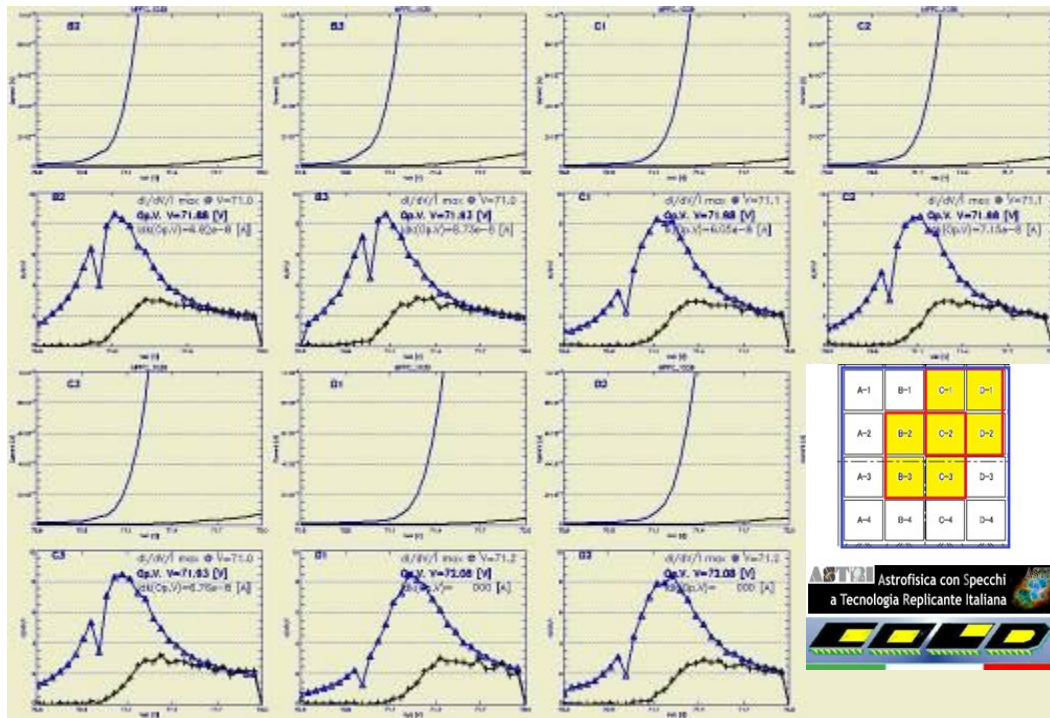
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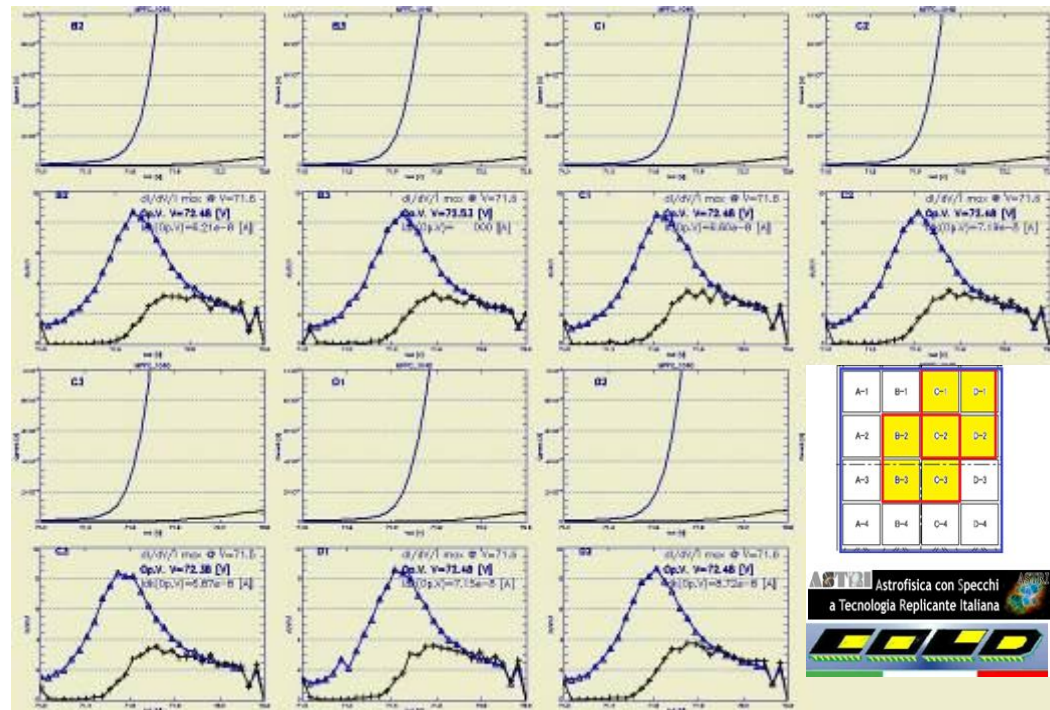
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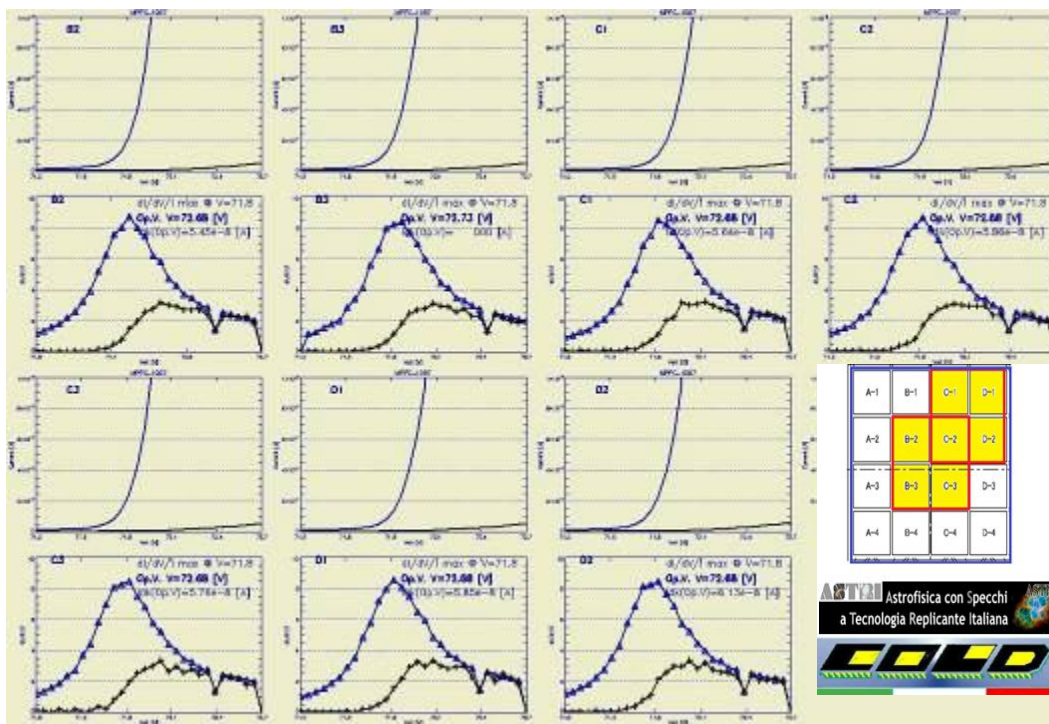
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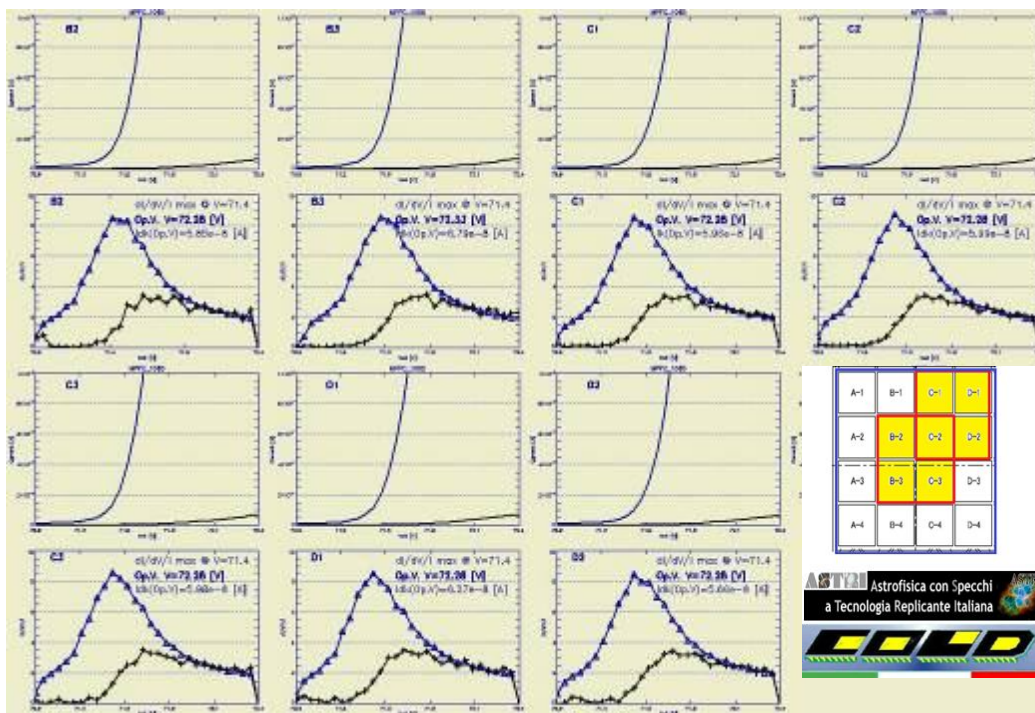
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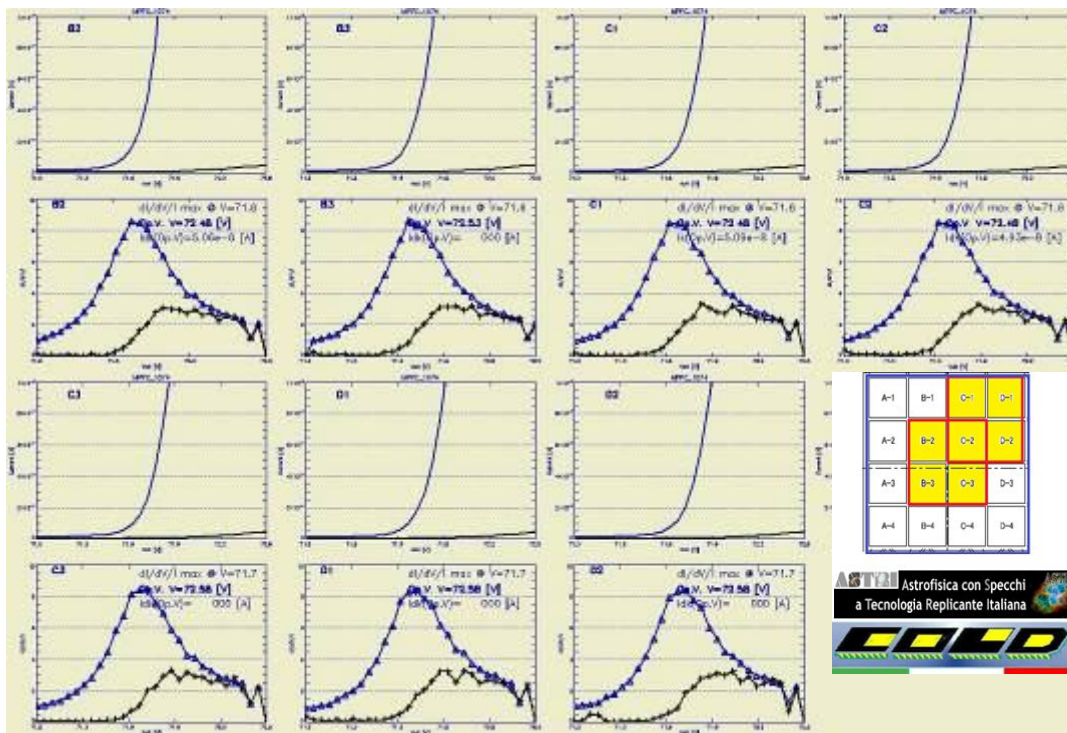
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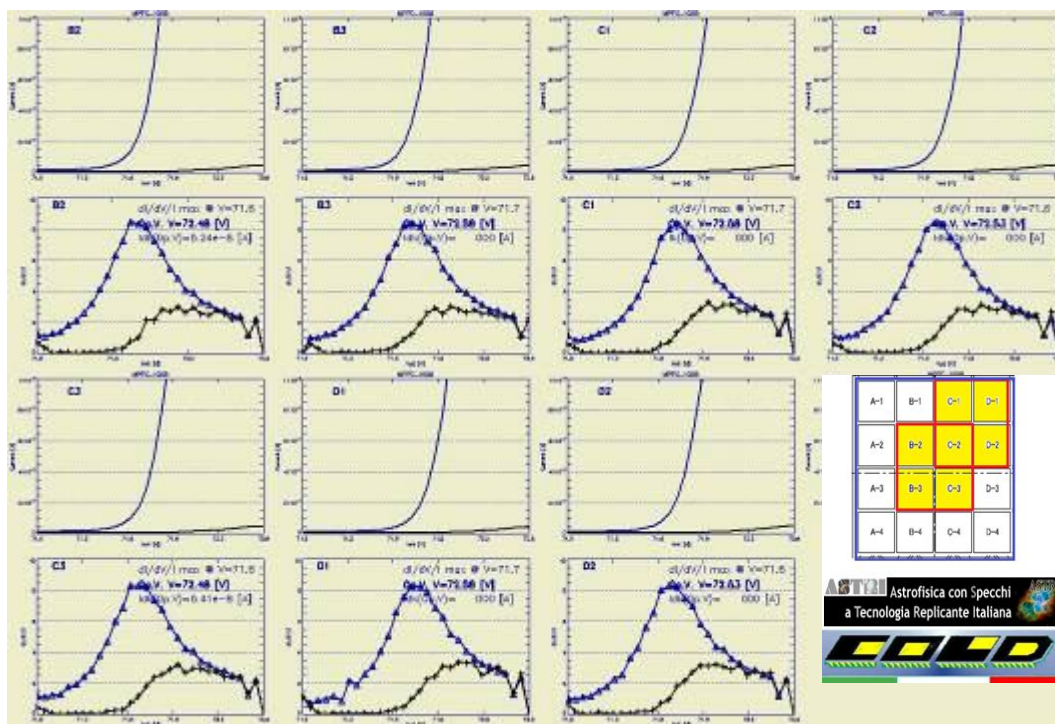
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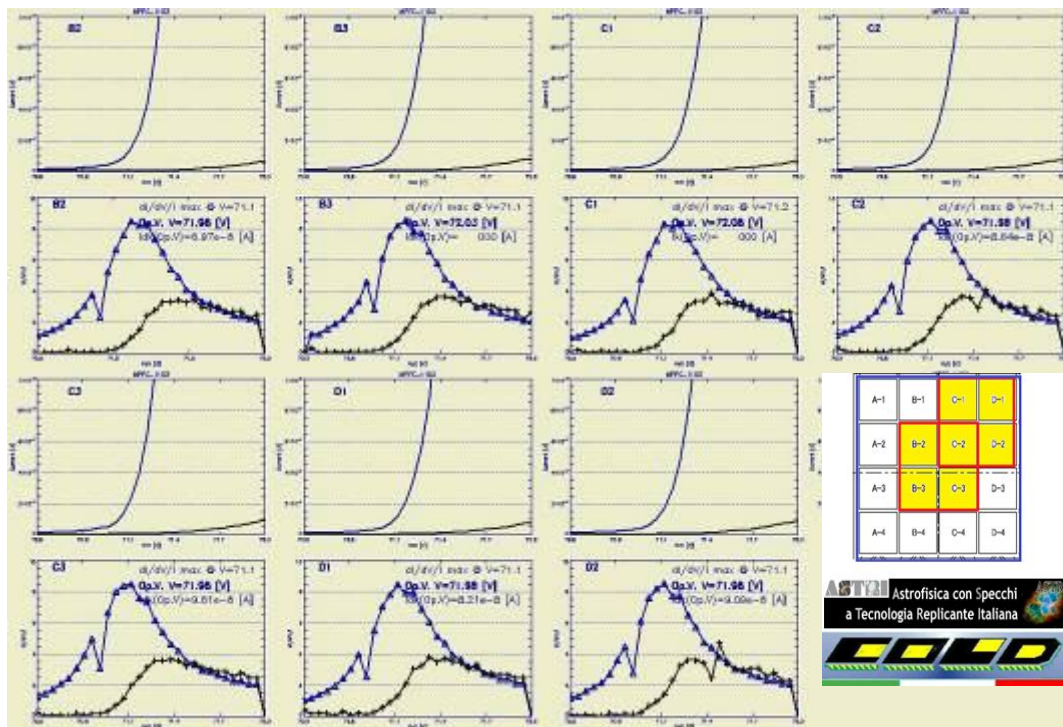
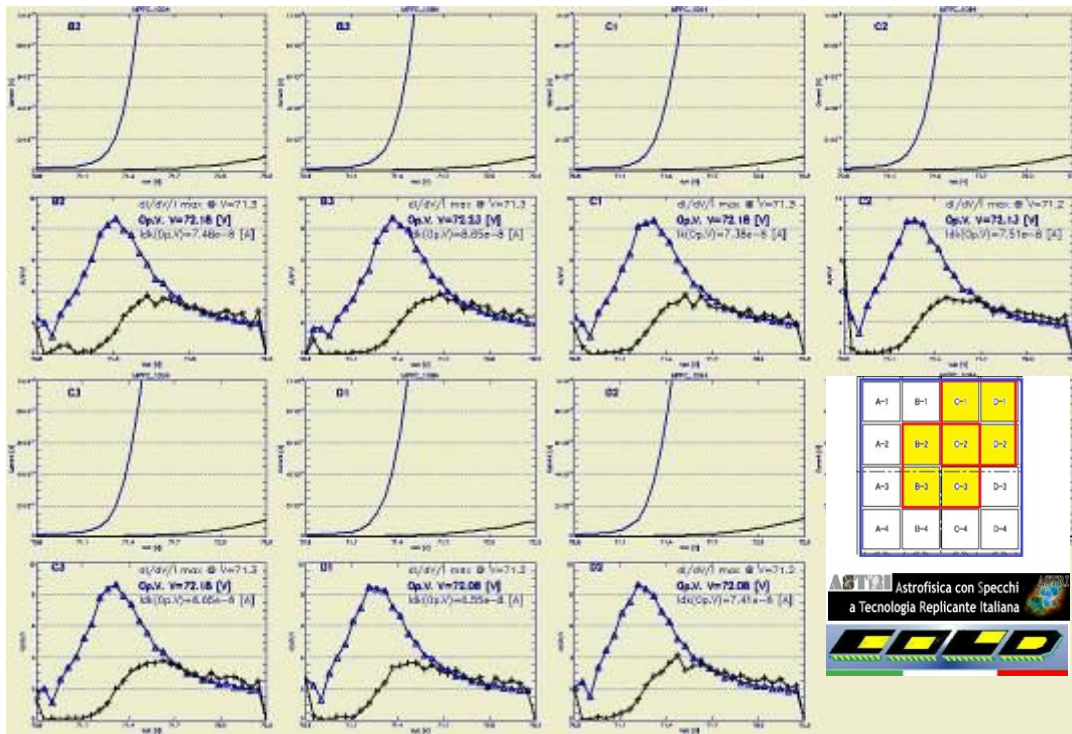
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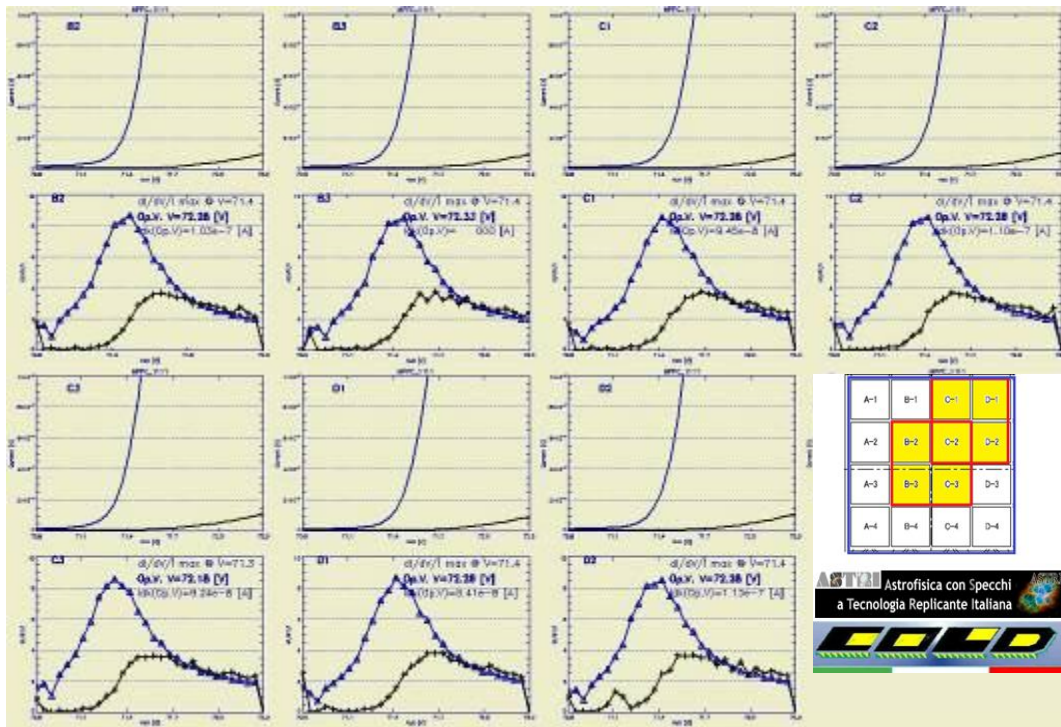


MPPC n° 1074

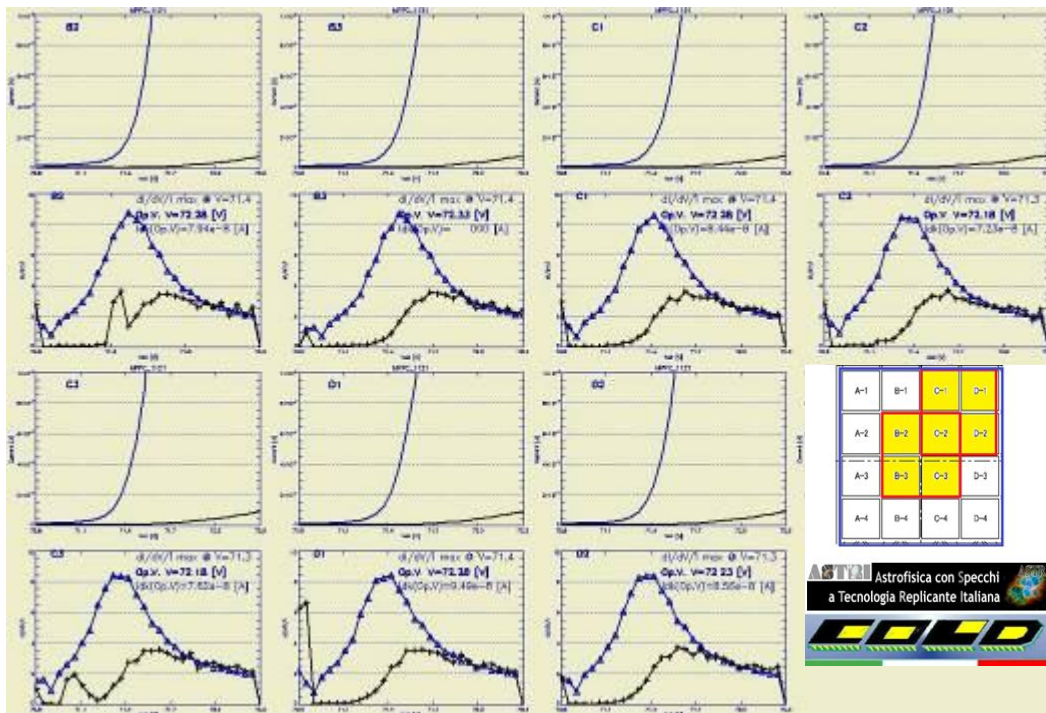


MPPC n° 1085

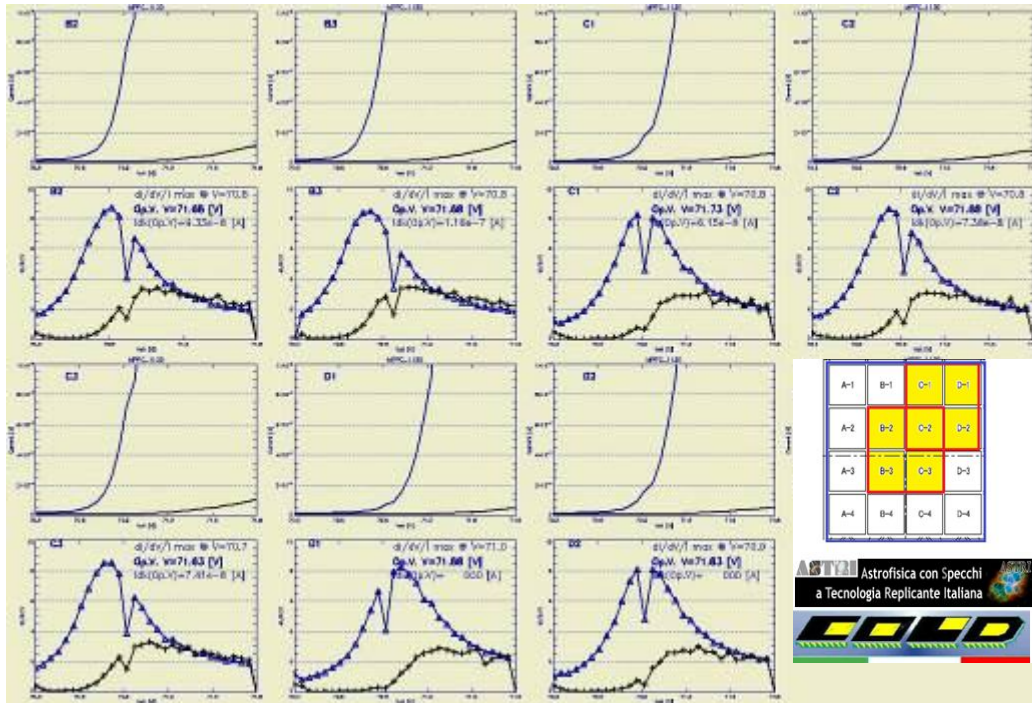




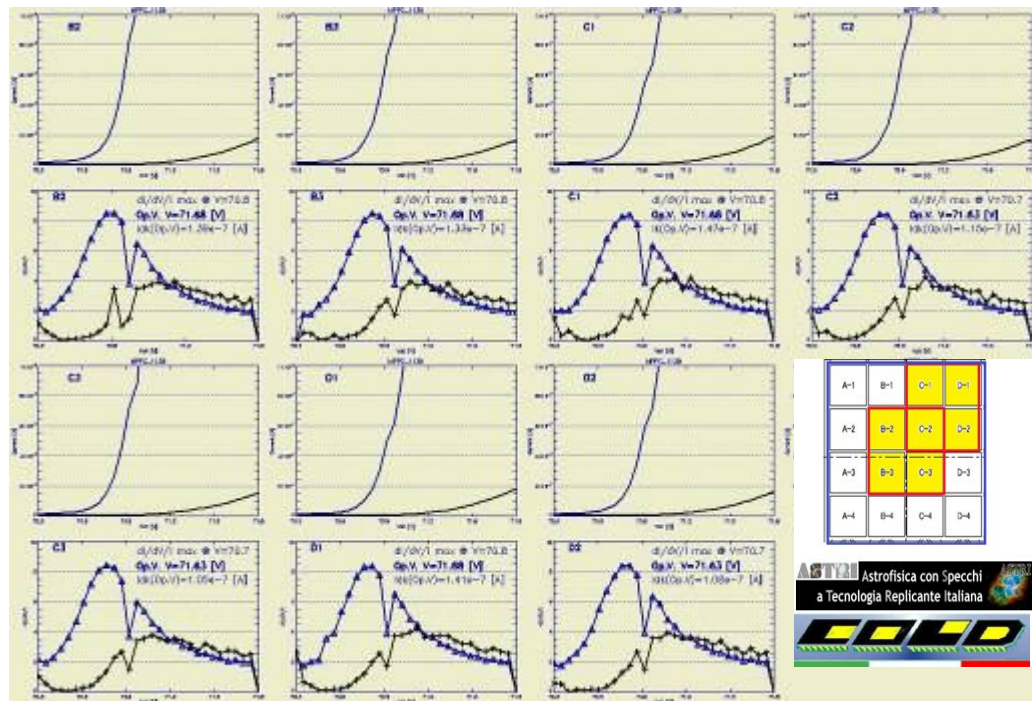
MPPC n° 1111



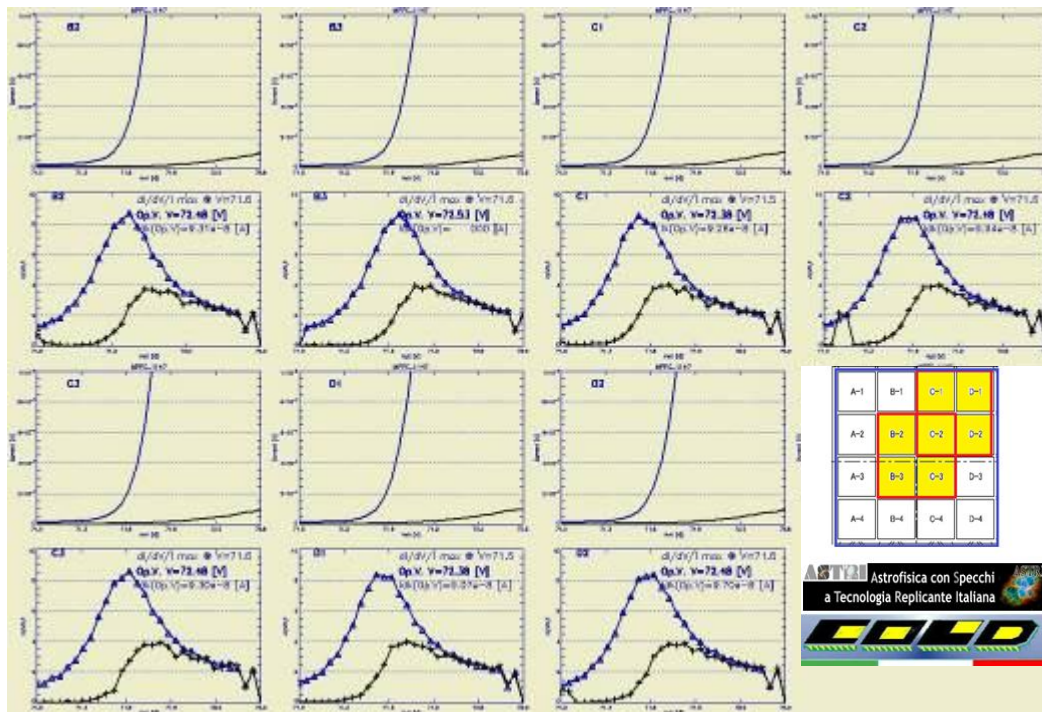
MPPC n° 1121



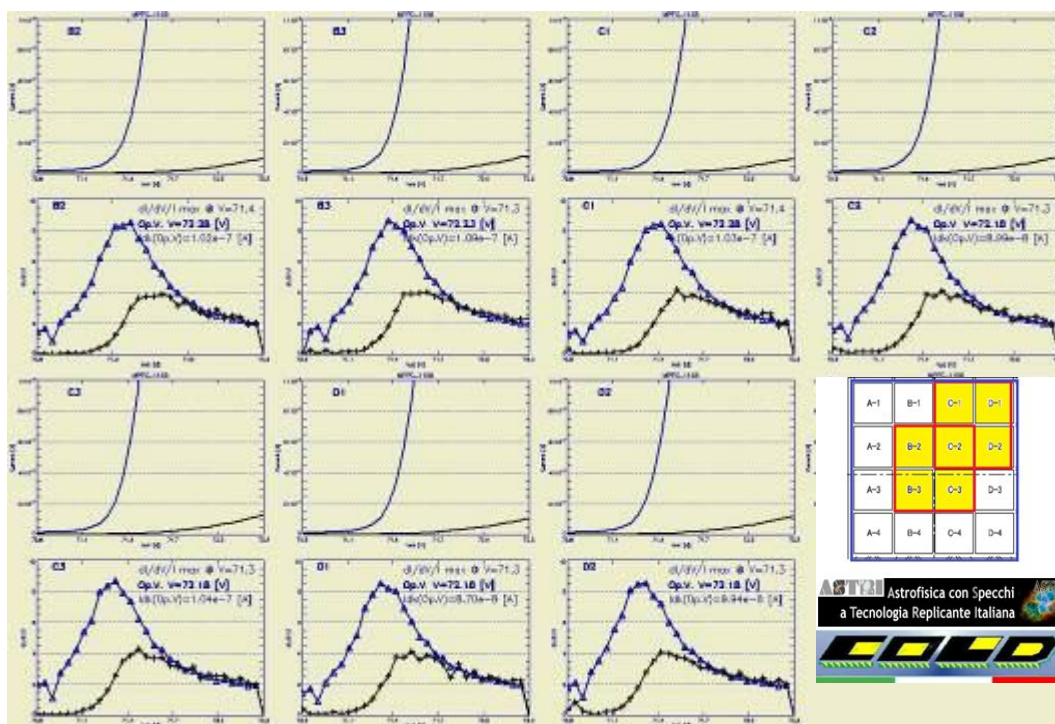
MPPC n° 1130



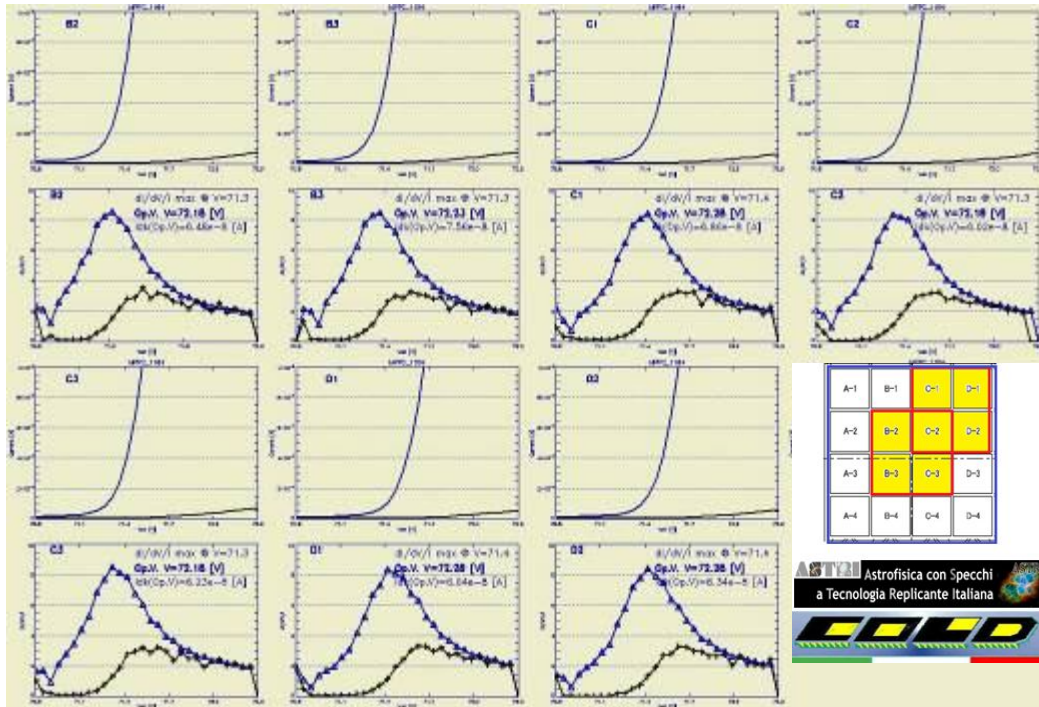
MPPC n° 1139



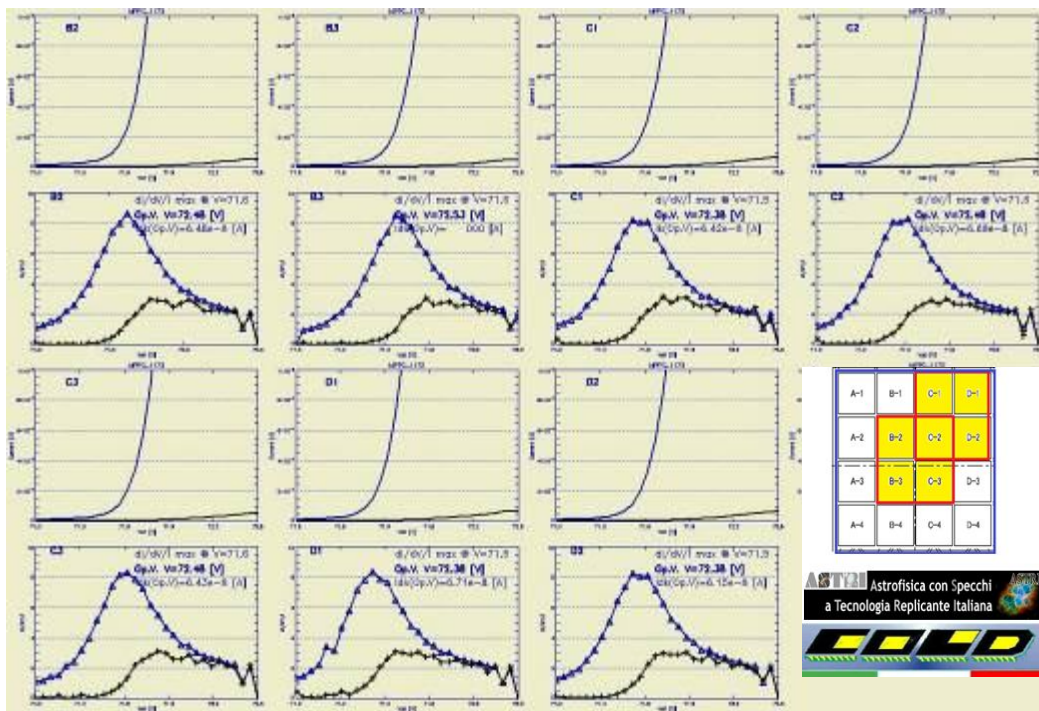
MPPC n° 1147



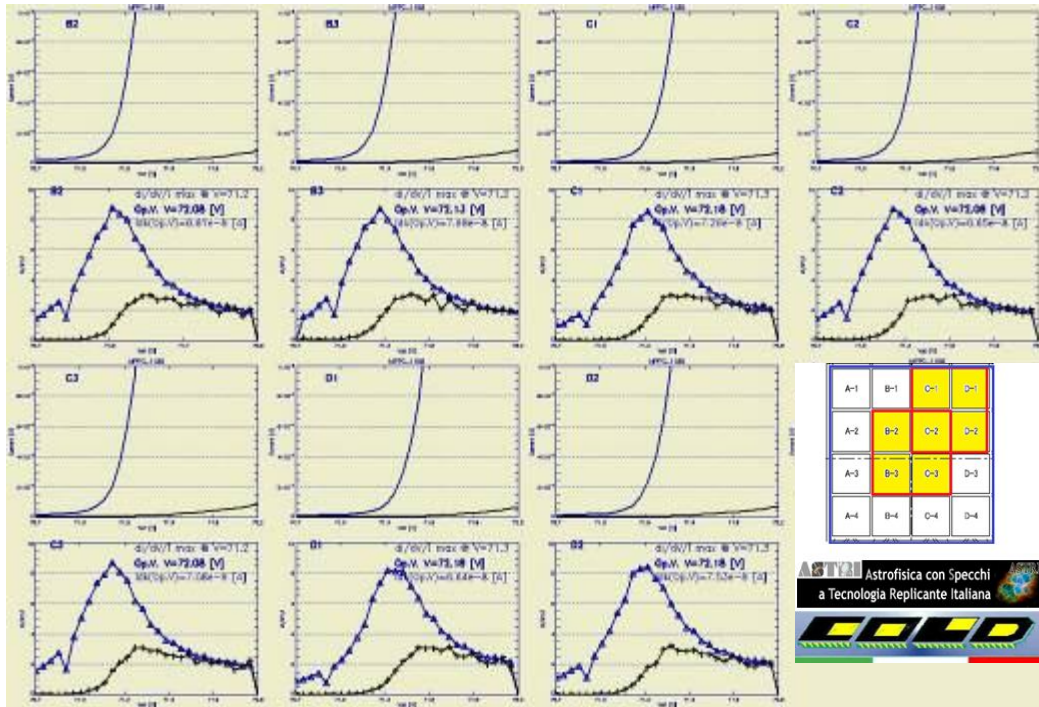
MPPC n° 1155



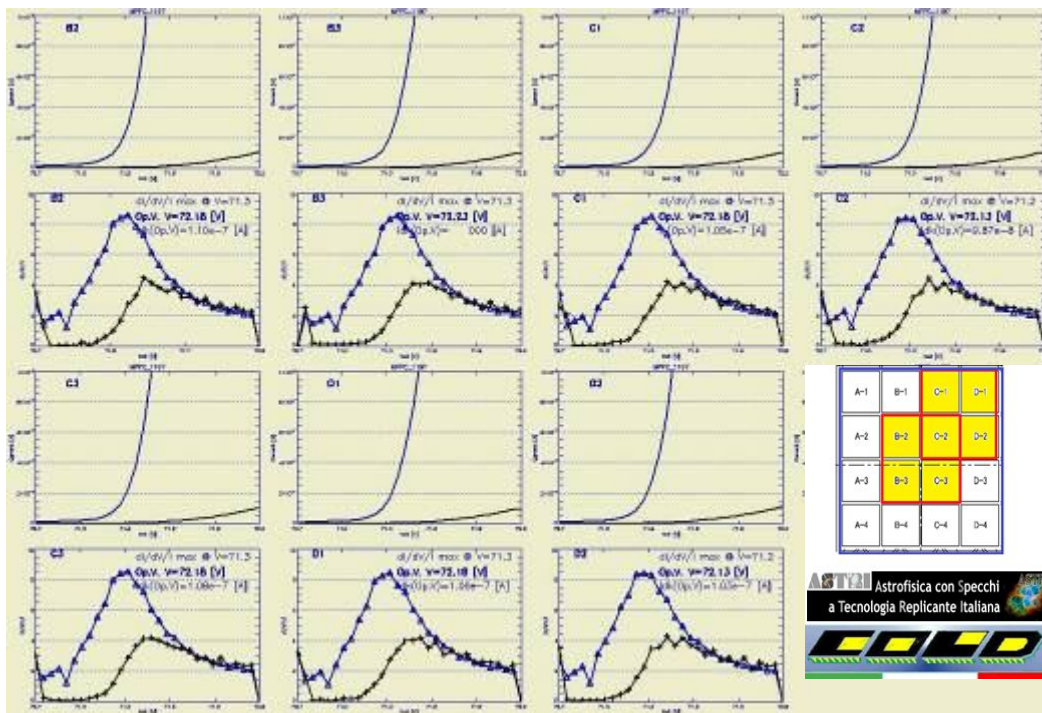
MPPC n° 1164



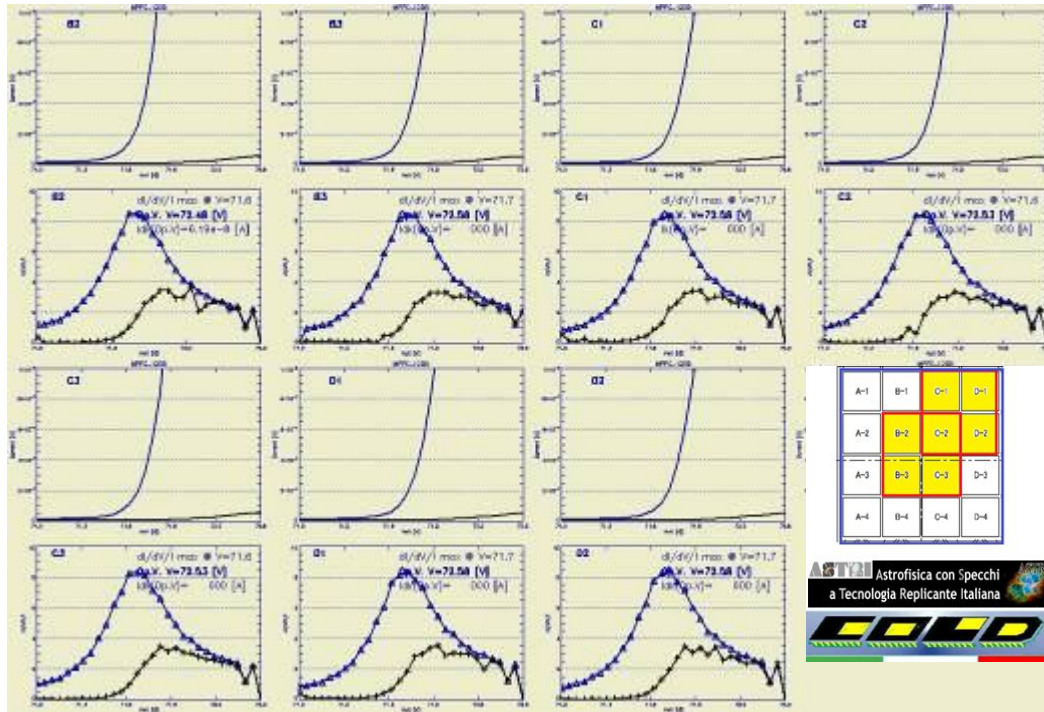
MPPC n° 1172



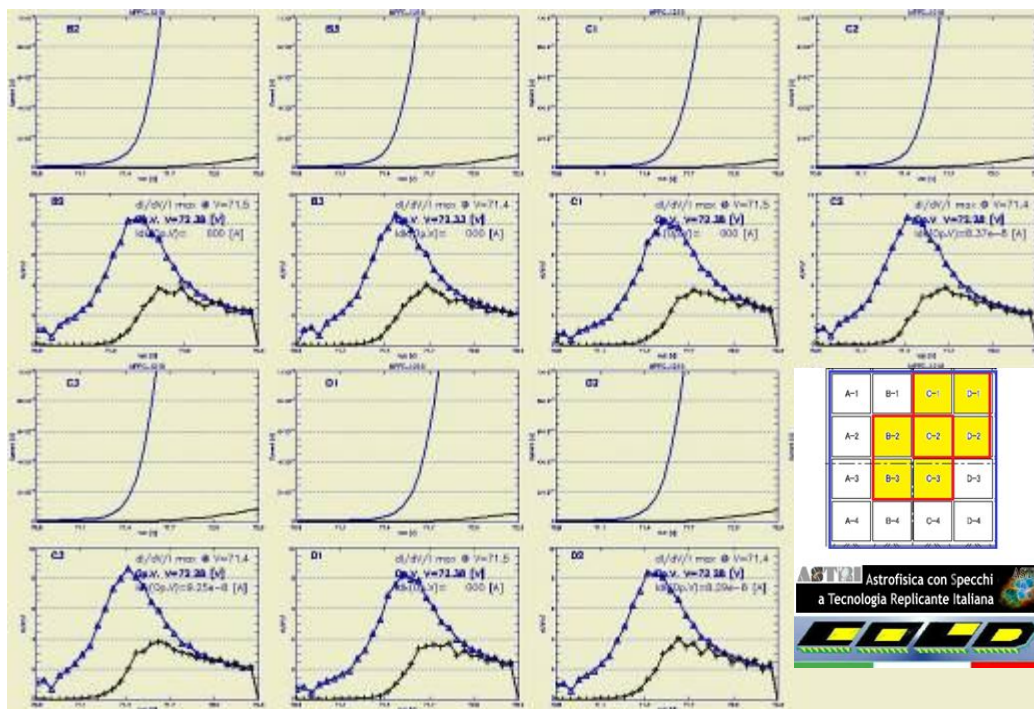
MPPC n° 1188



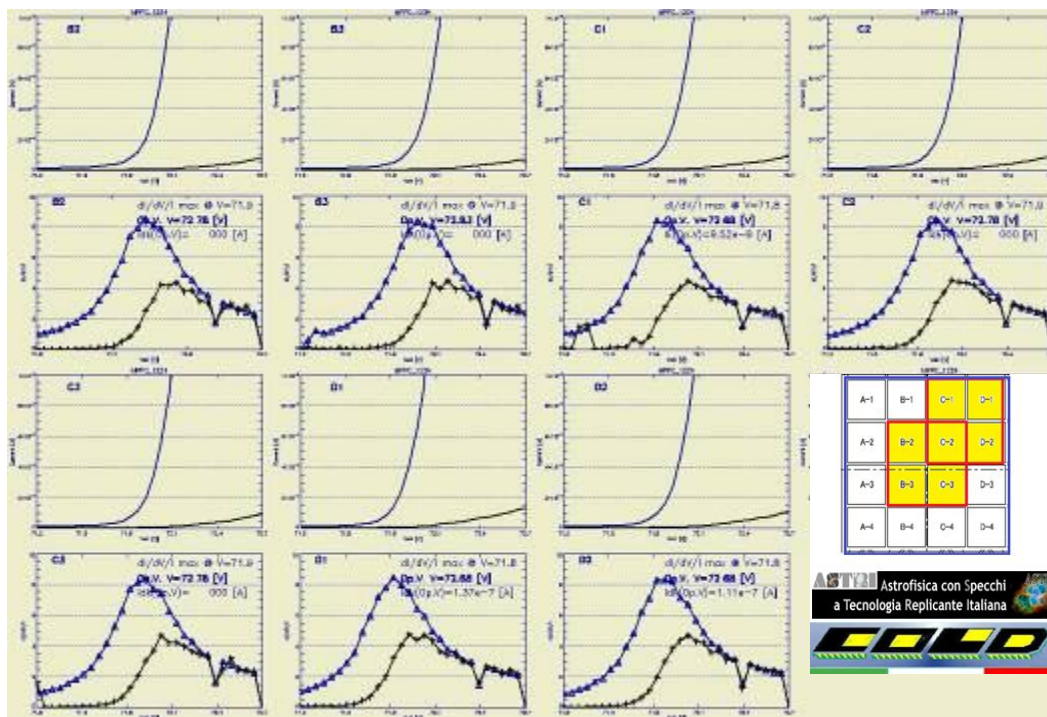
MPPC n° 1197



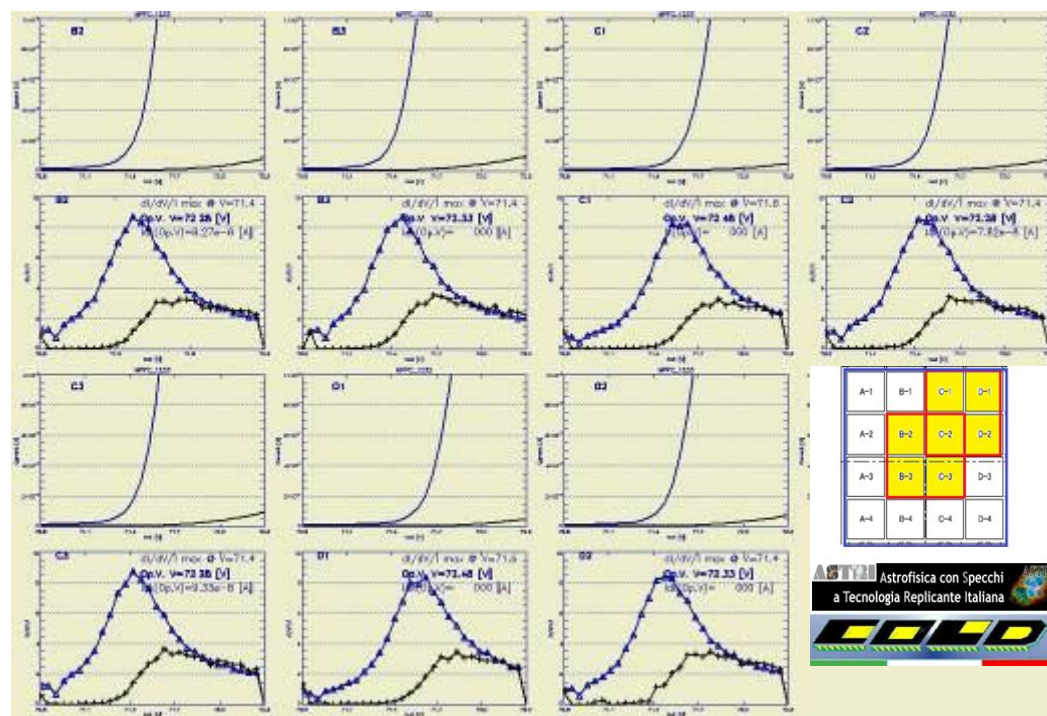
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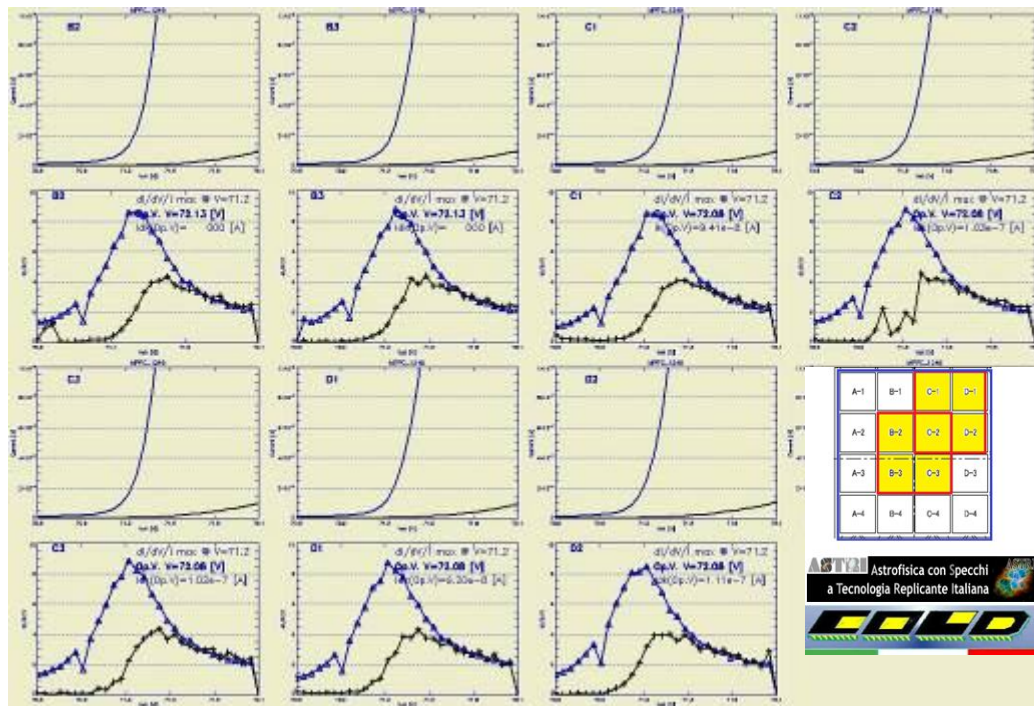
MPPC n° 1215



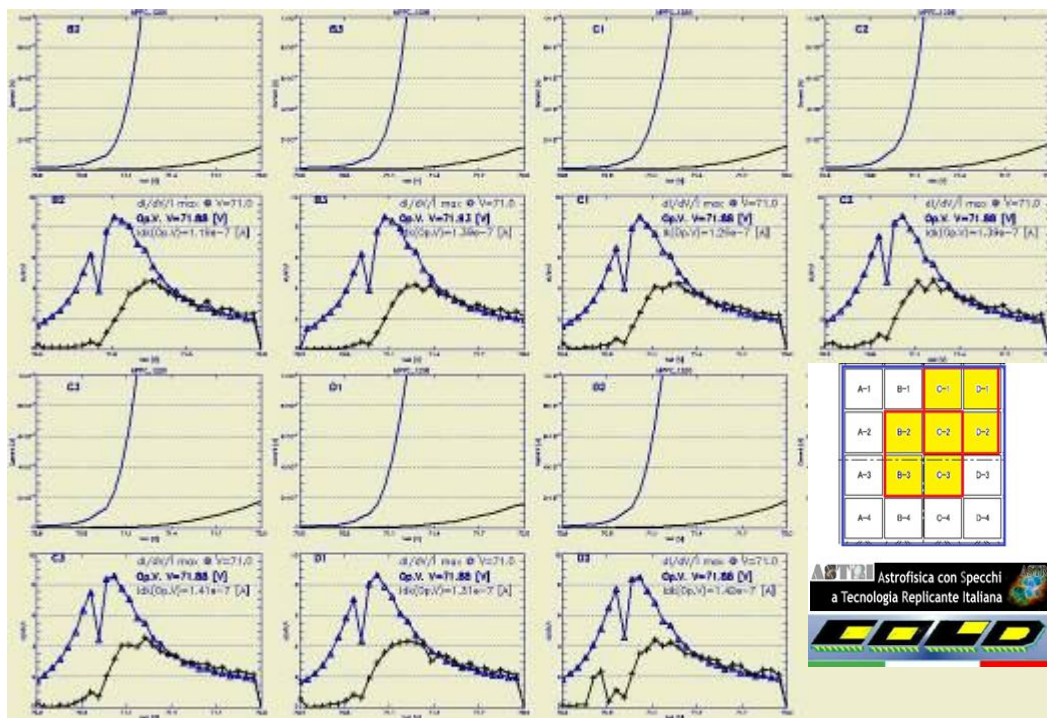
MPPC n° 1224



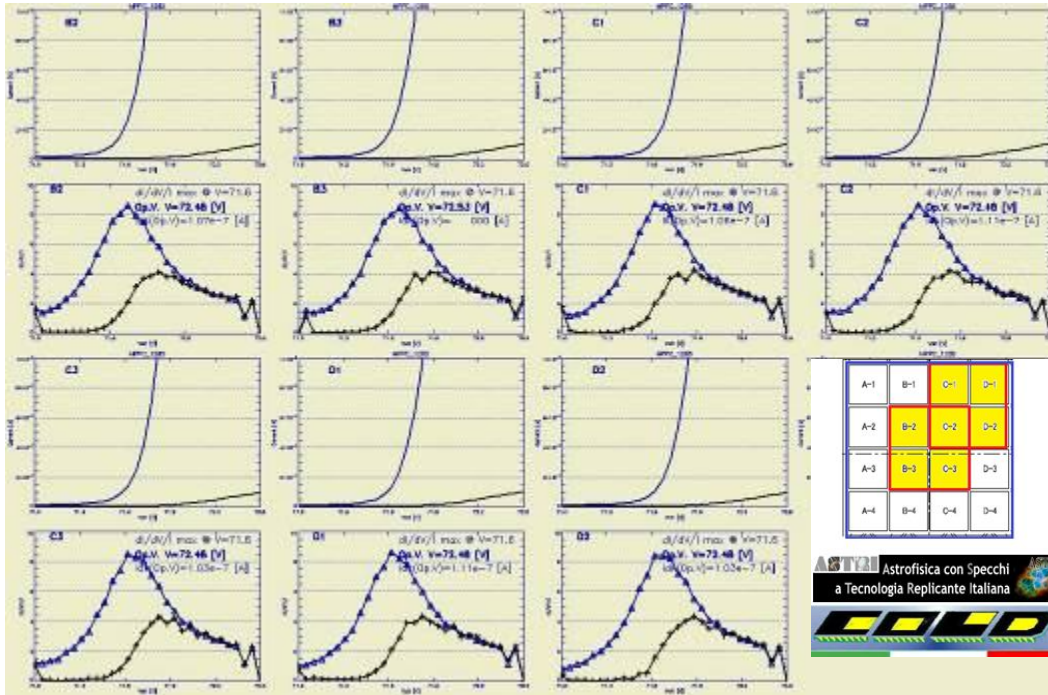
MPPC n° 1233



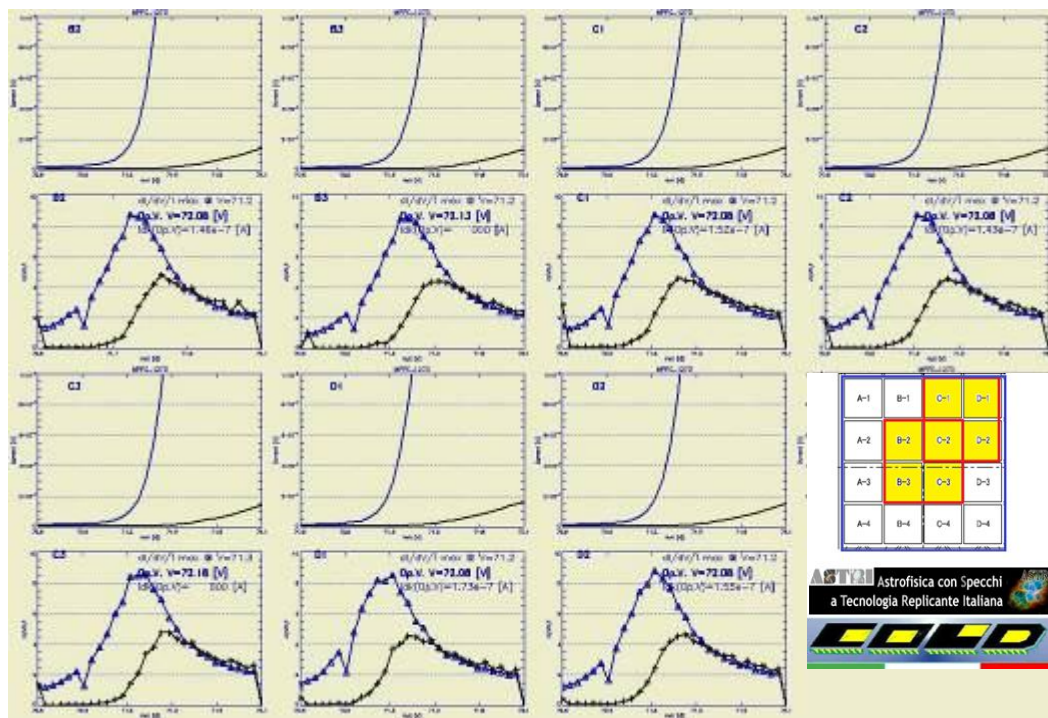
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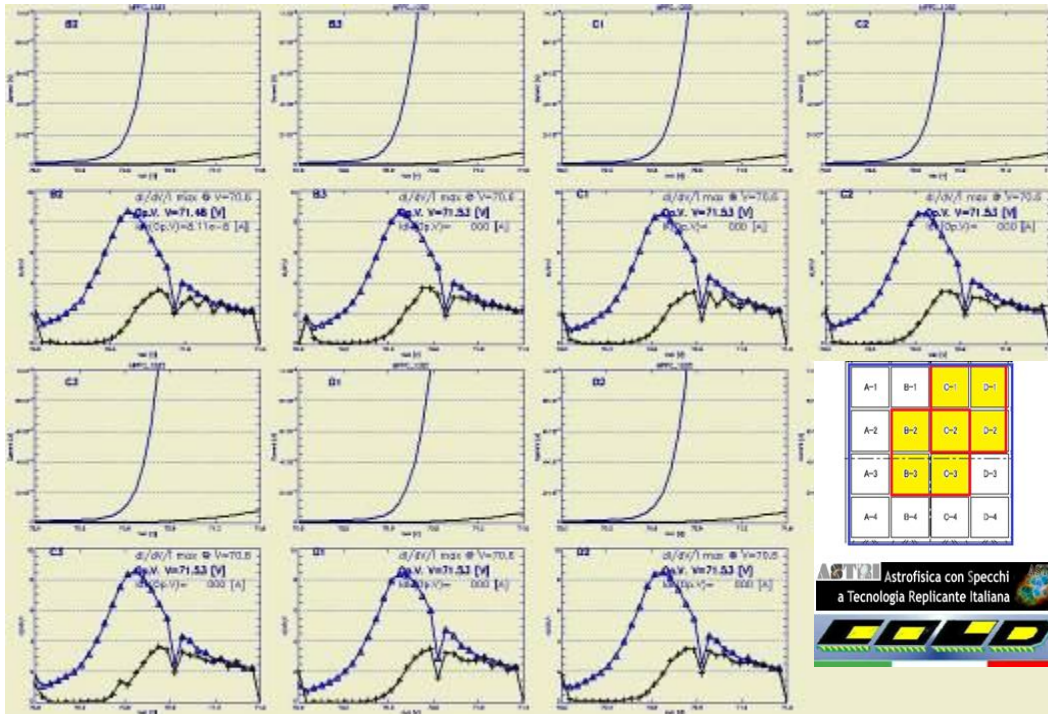
MPPC n° 1256



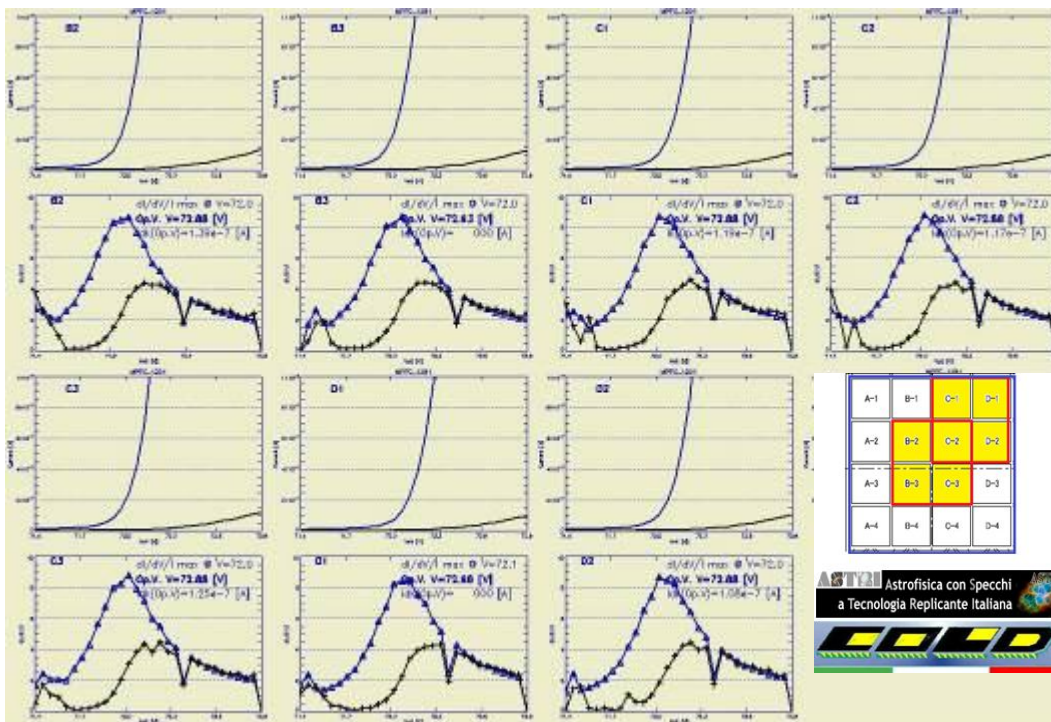
MPPC n° 1265



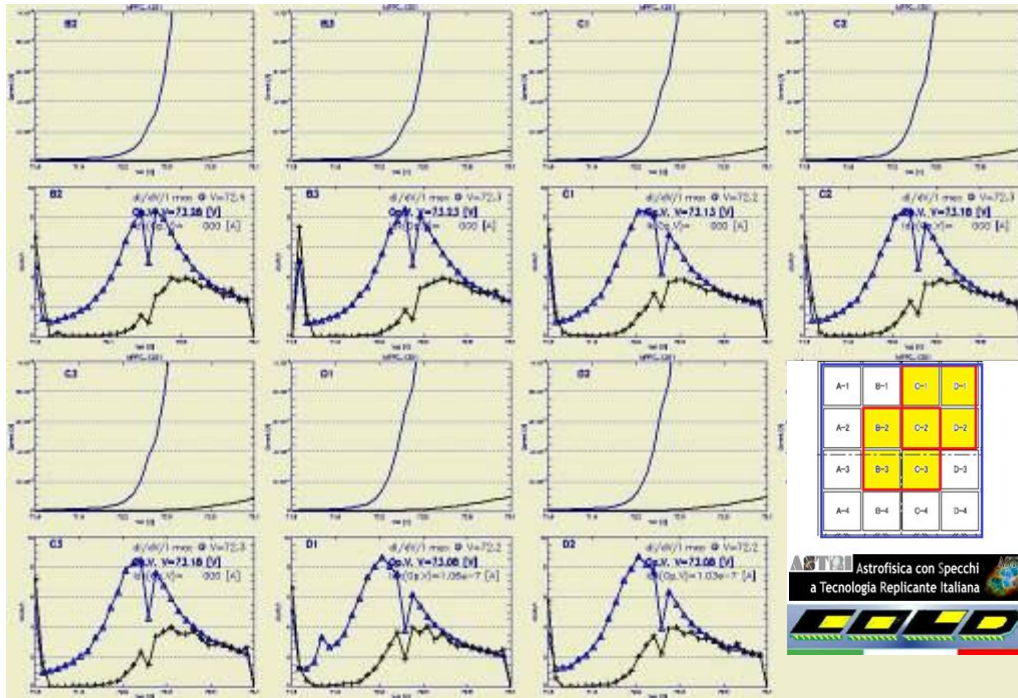
MPPC n° 1273



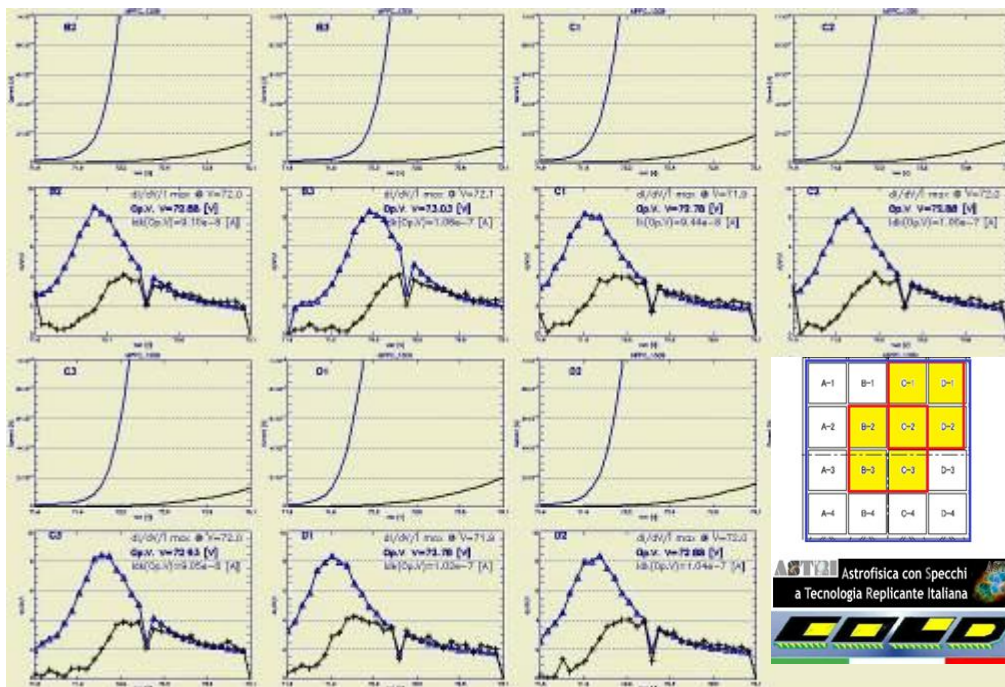
MPPC n° 1282



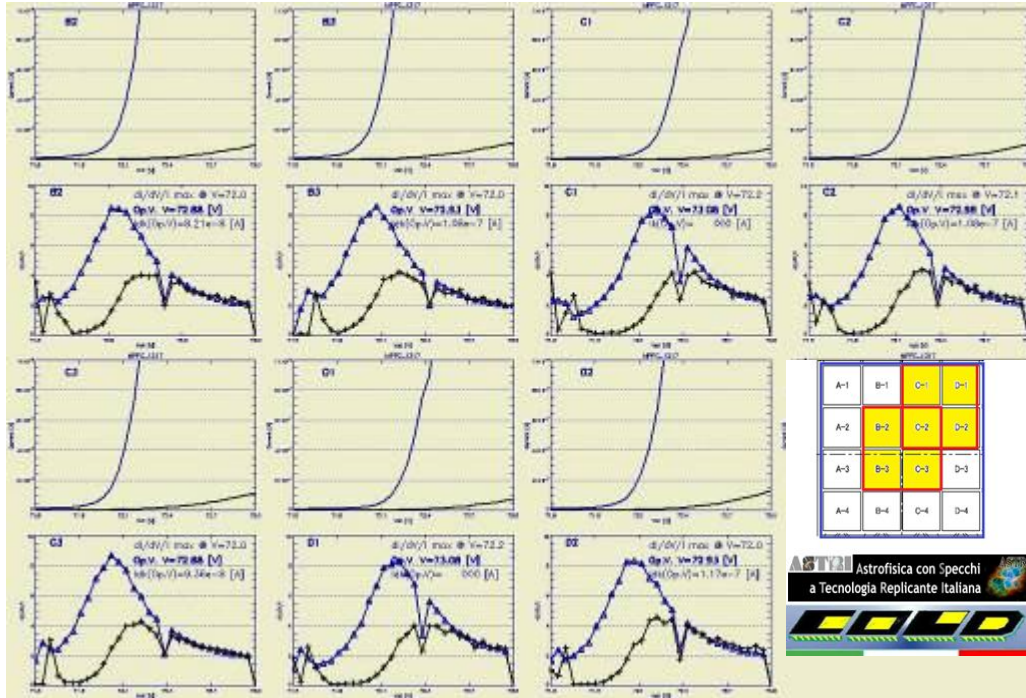
MPPC n° 1291



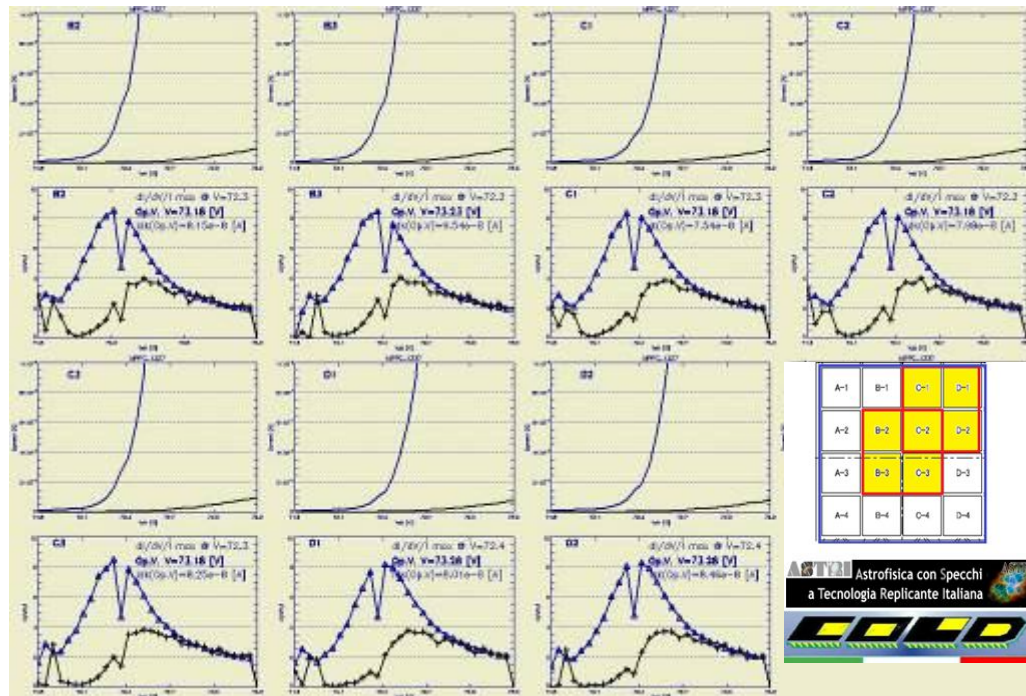
MPPC n° 1301



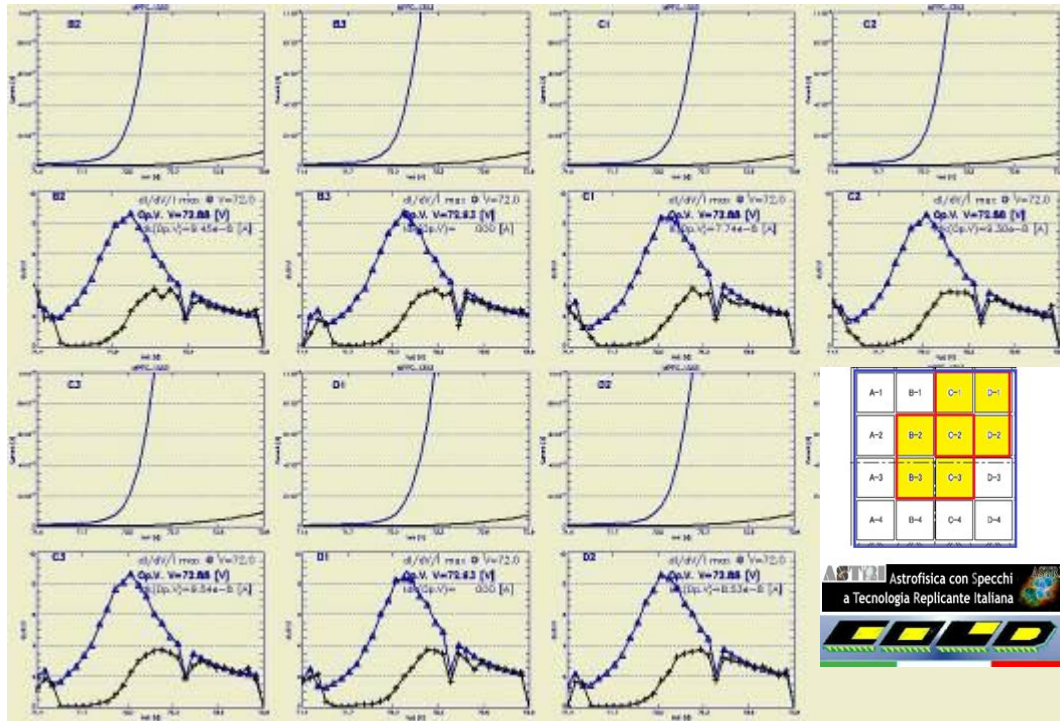
MPPC n° 1309



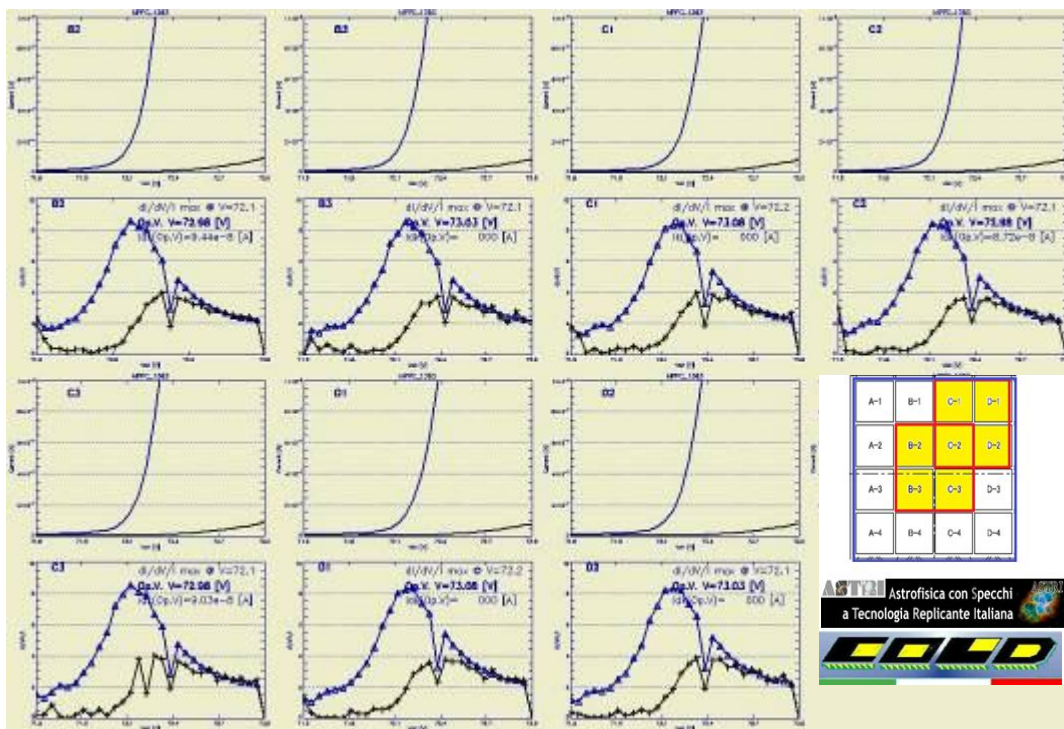
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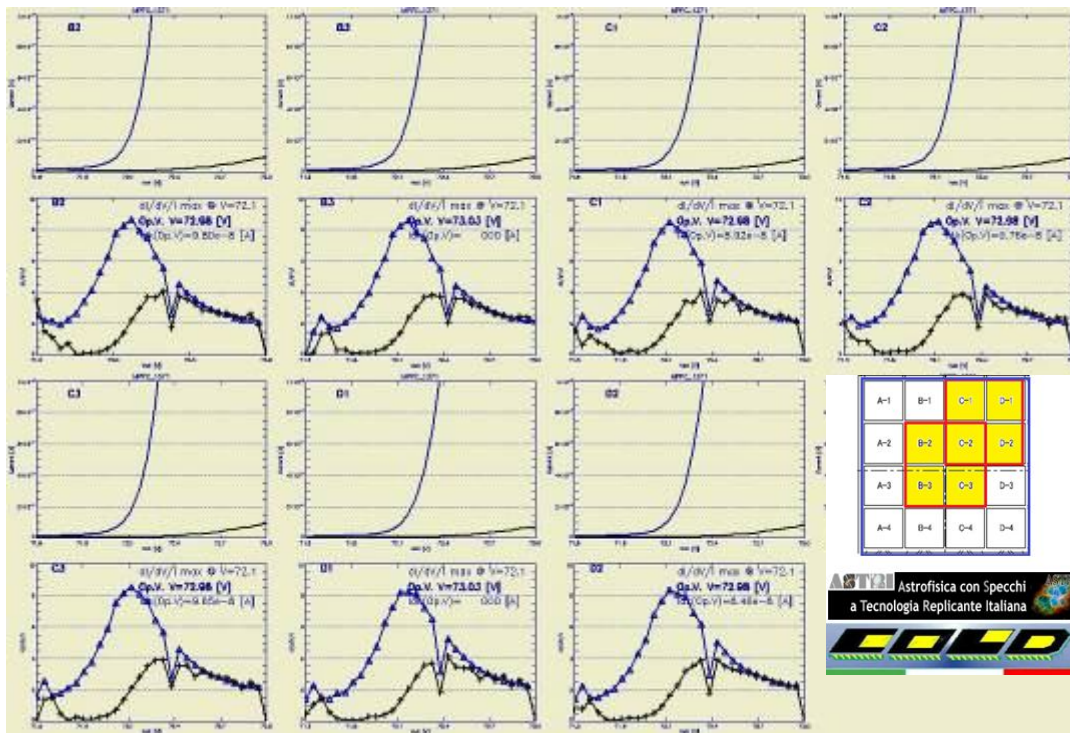
MPPC n° 1327



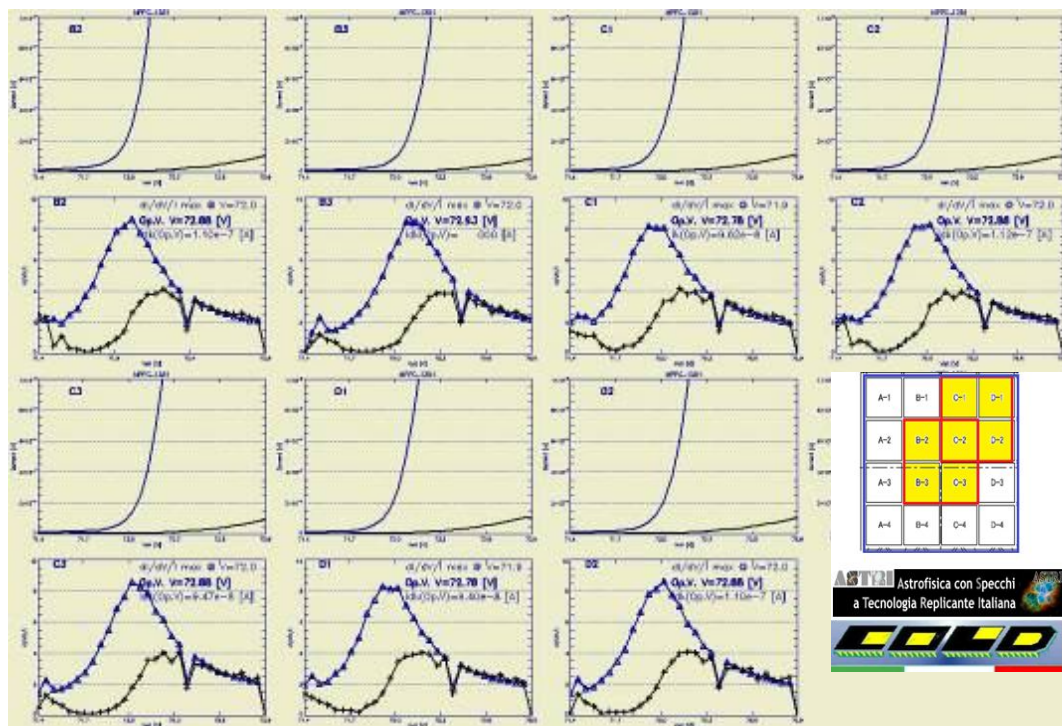
MPPC n° 1353



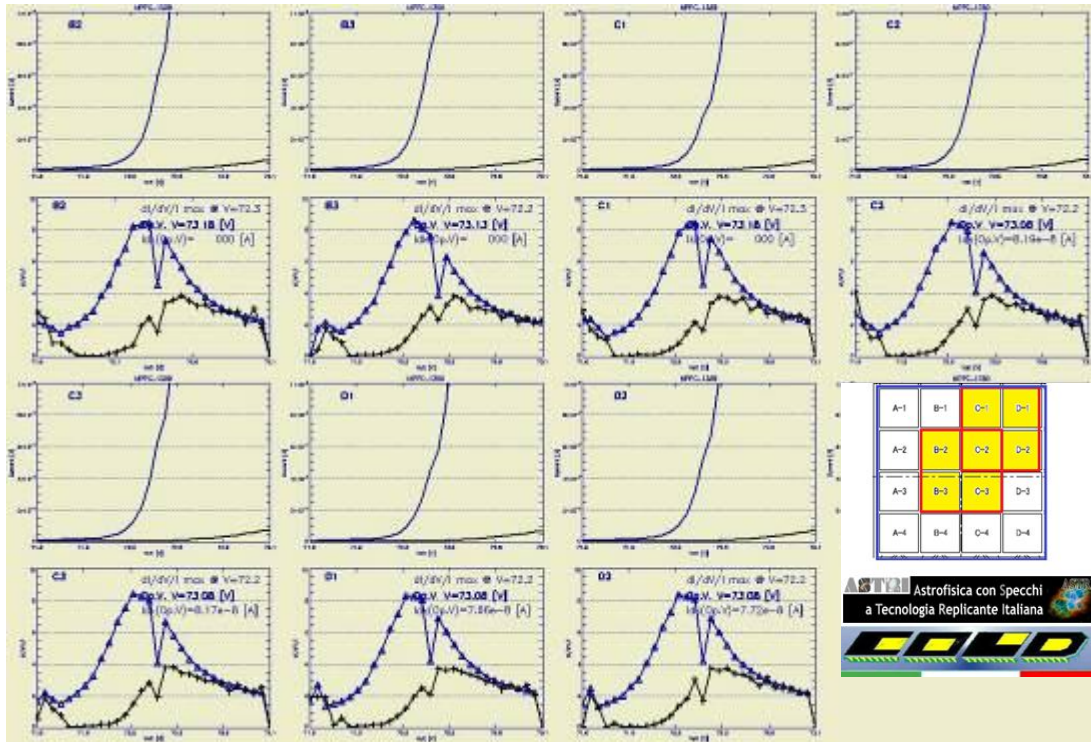
MPPC n° 1363



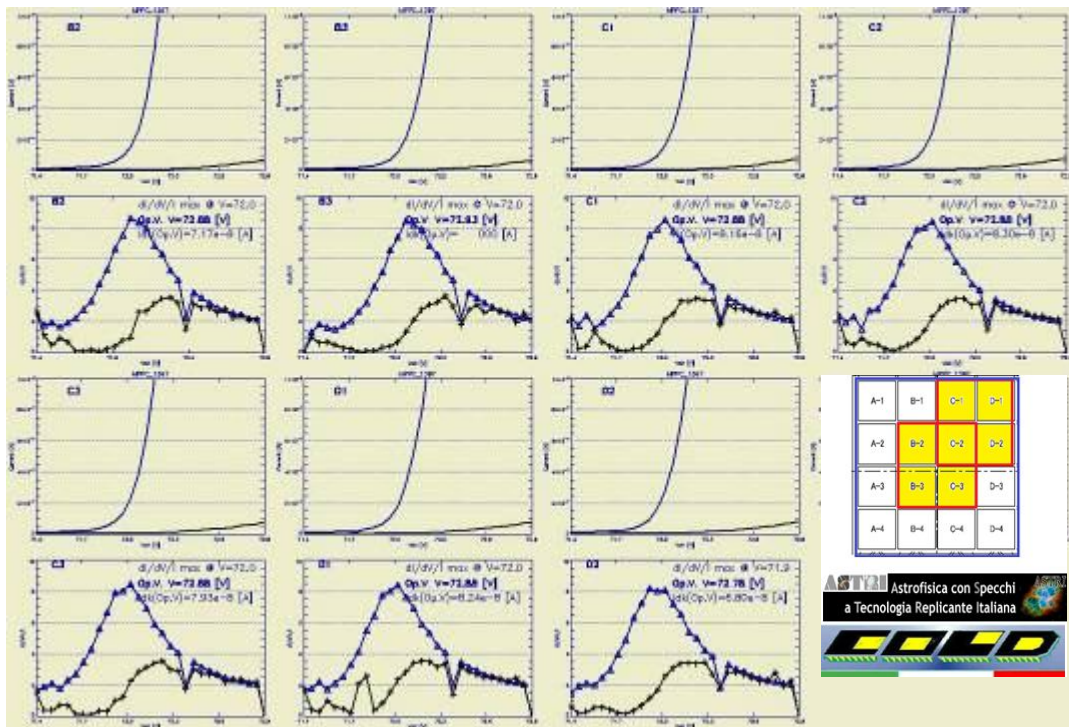
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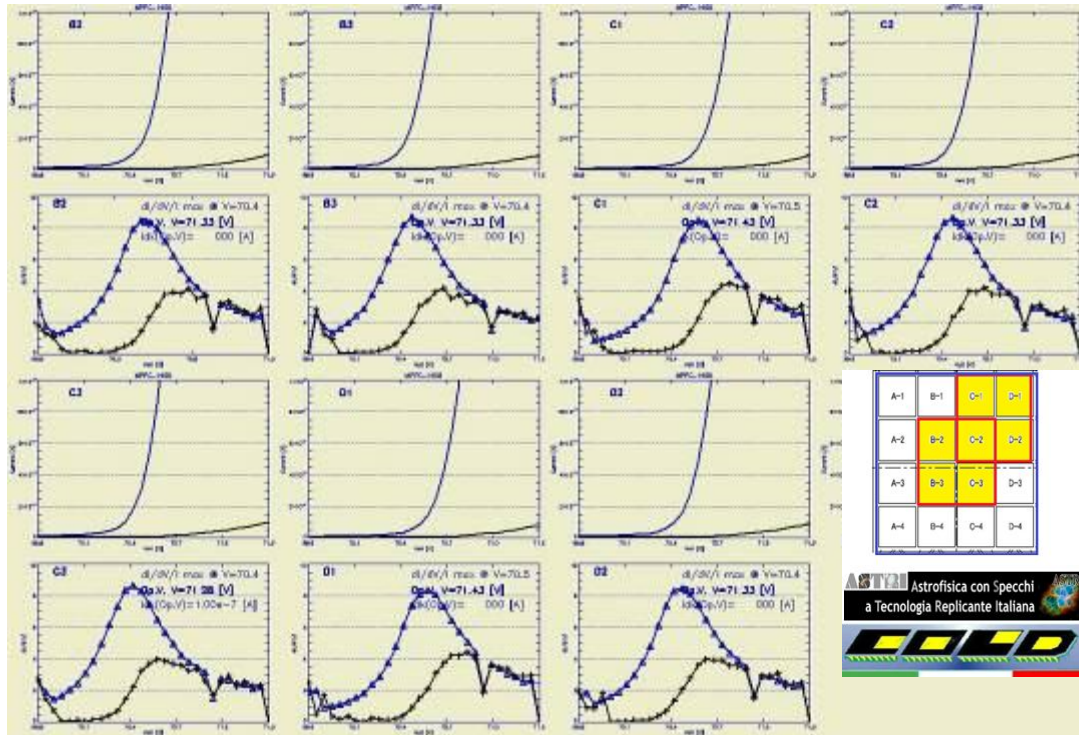
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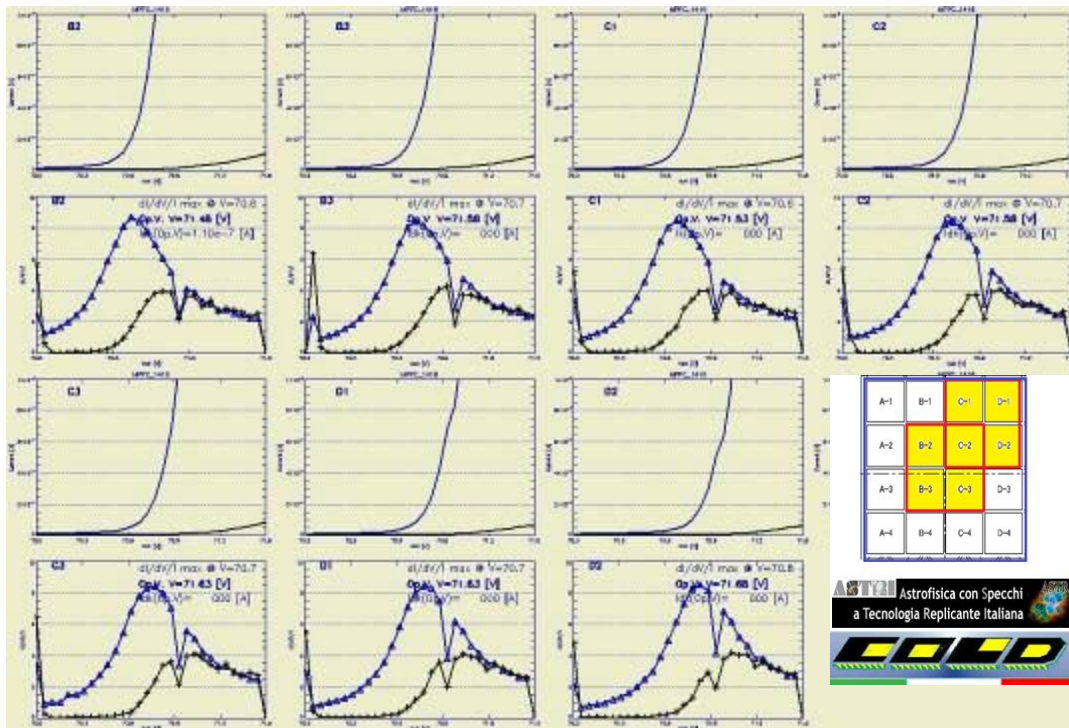
MPPC n° 1389



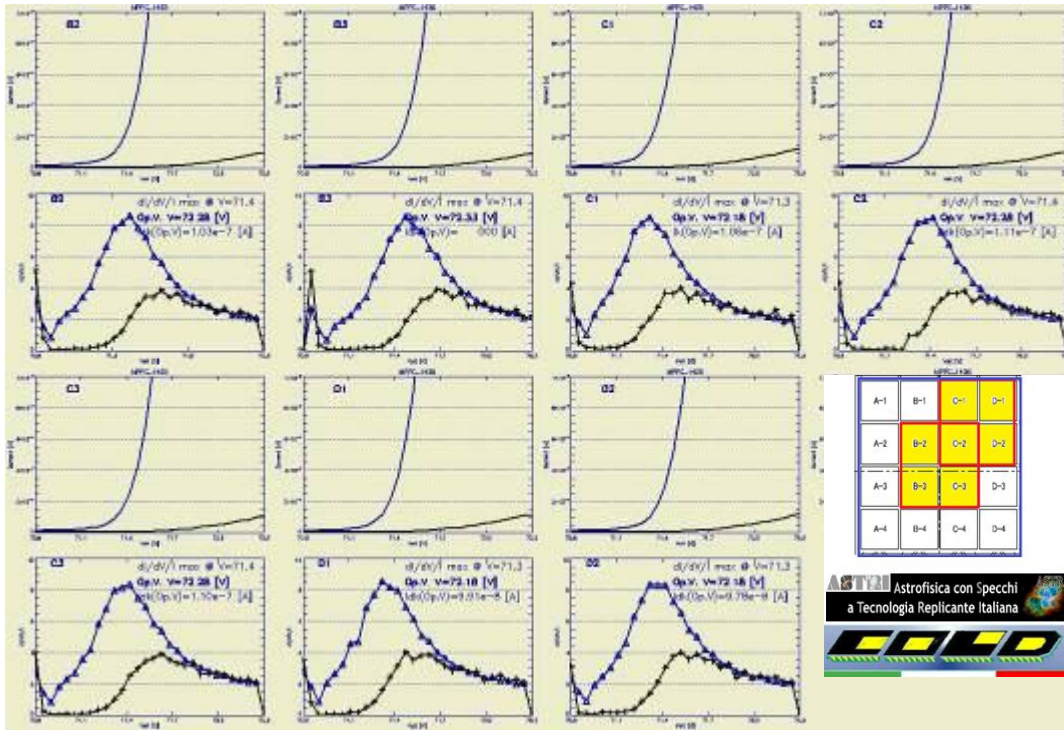
MPPC n° 1397



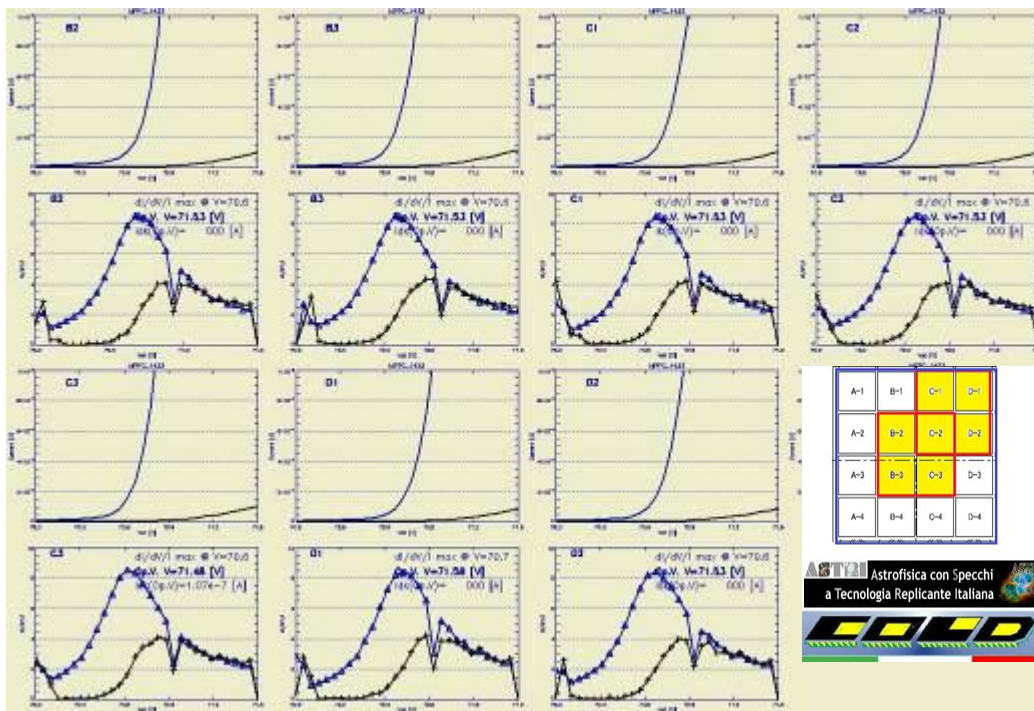
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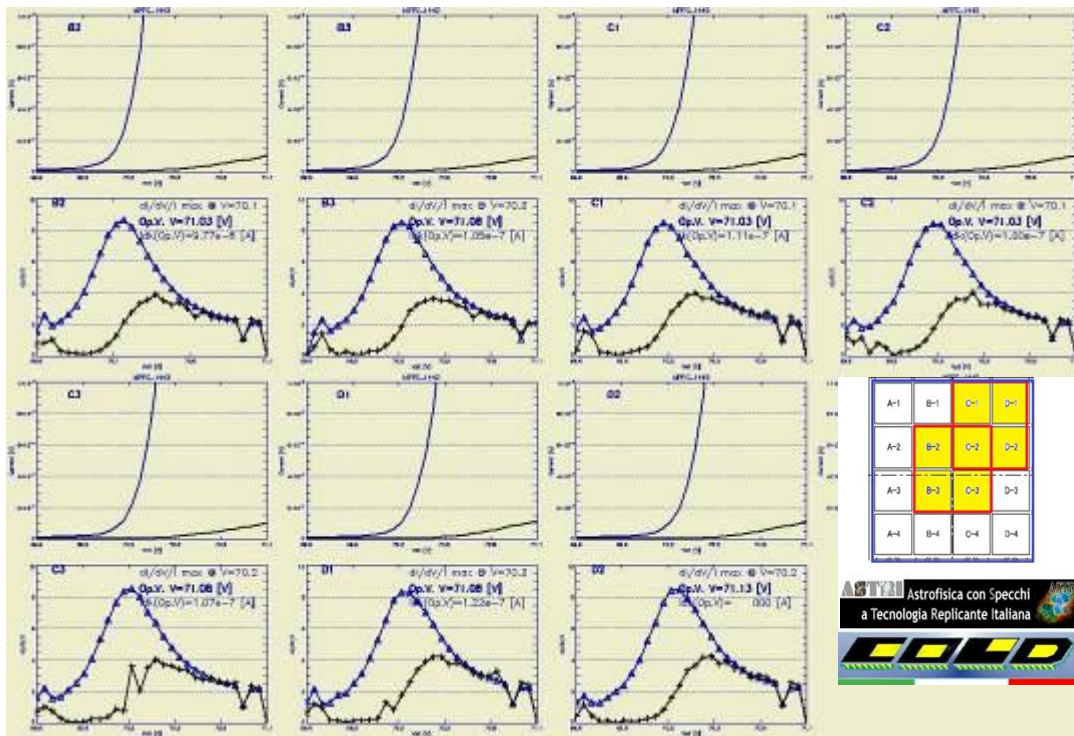
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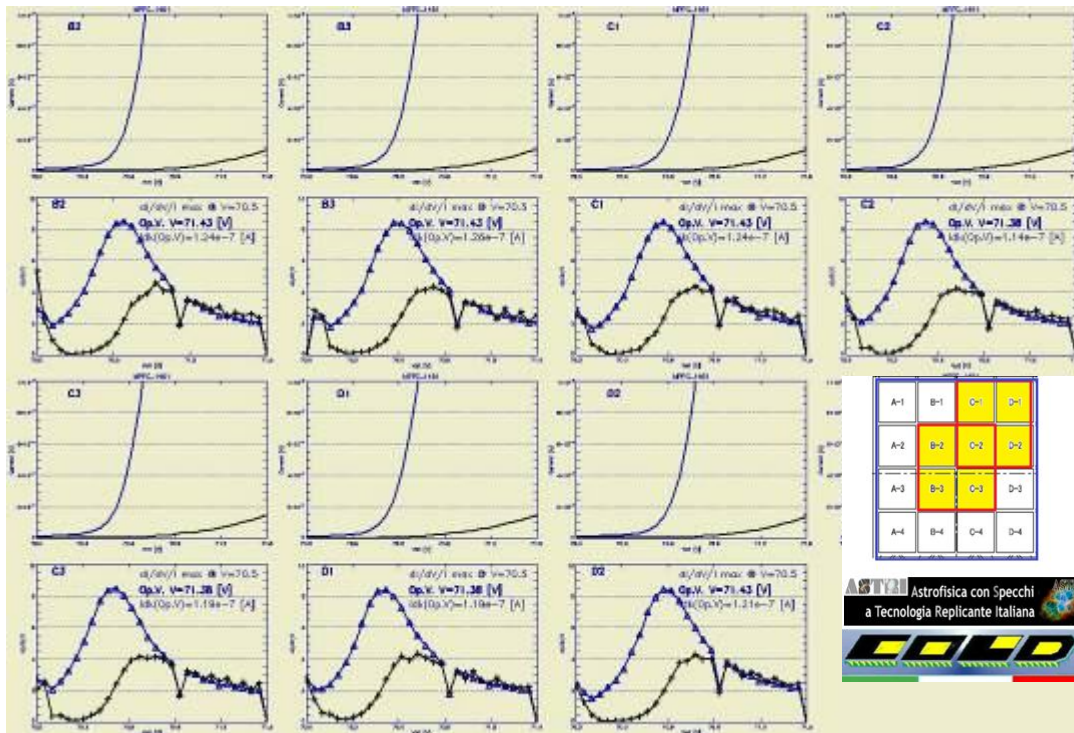
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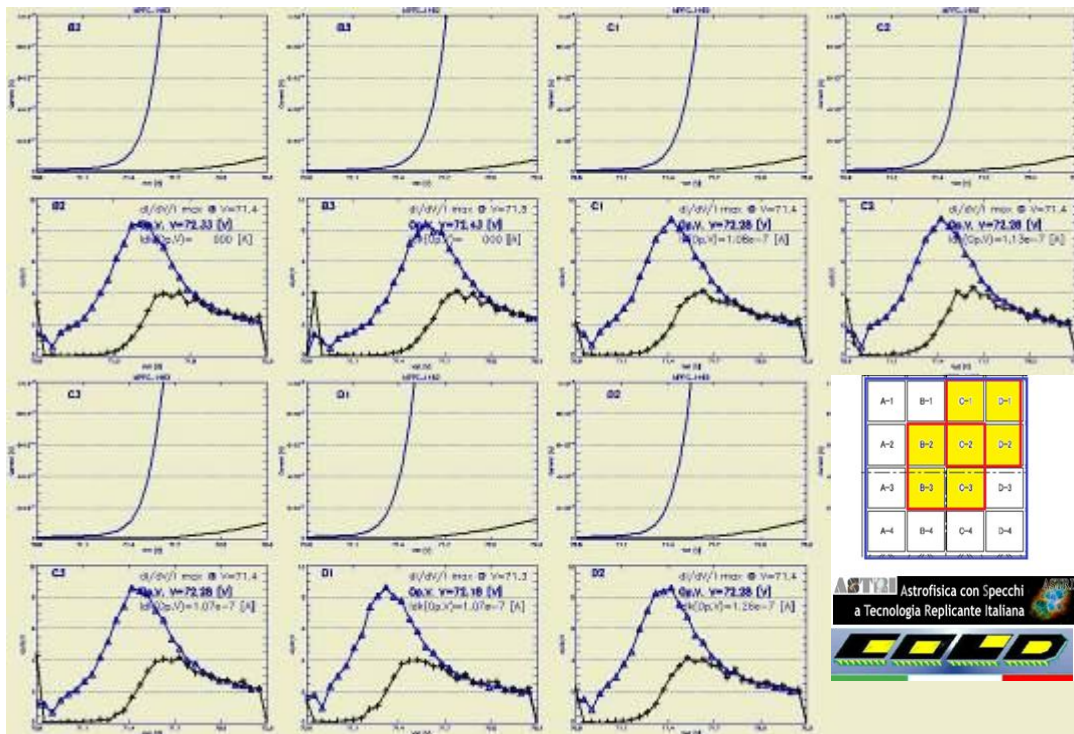
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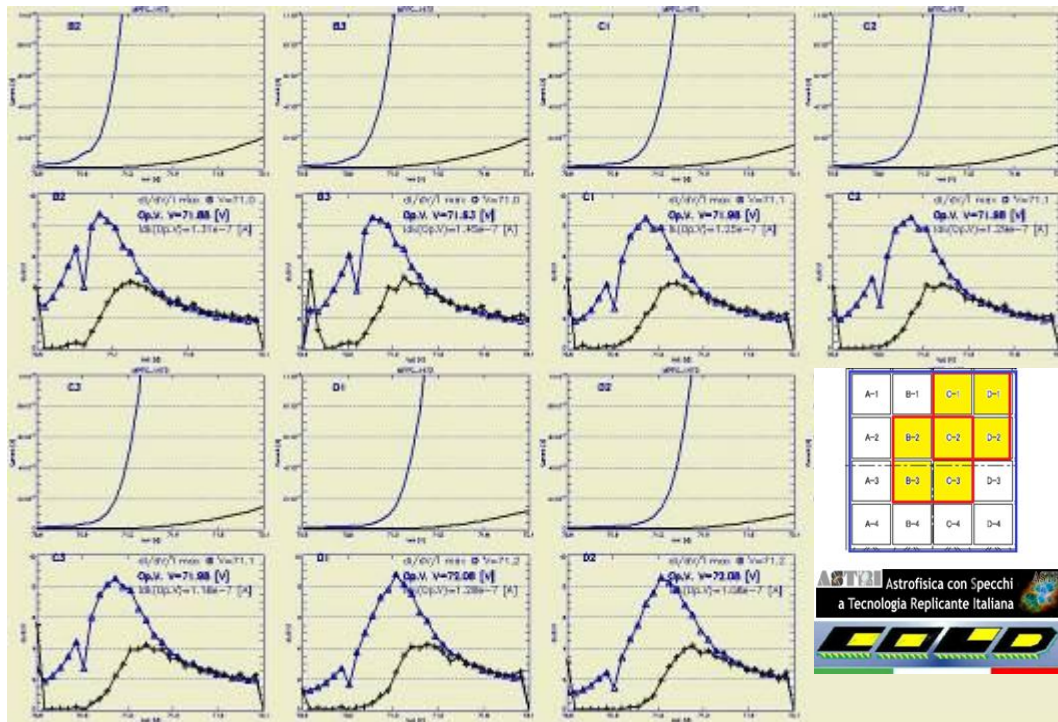
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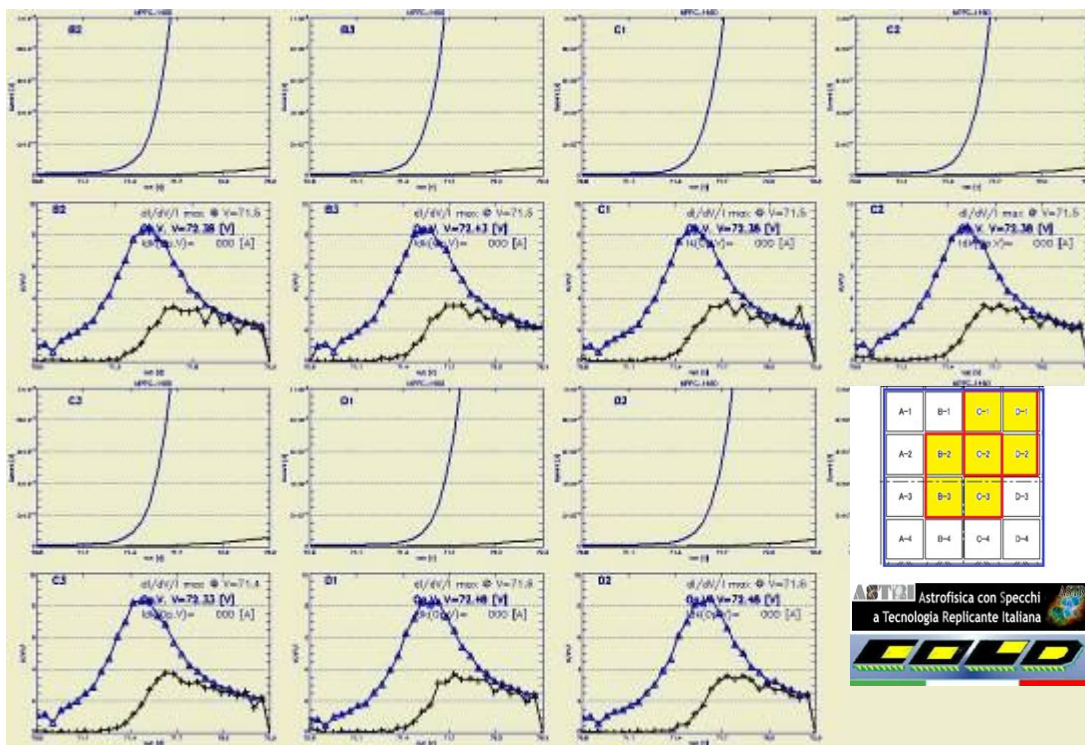
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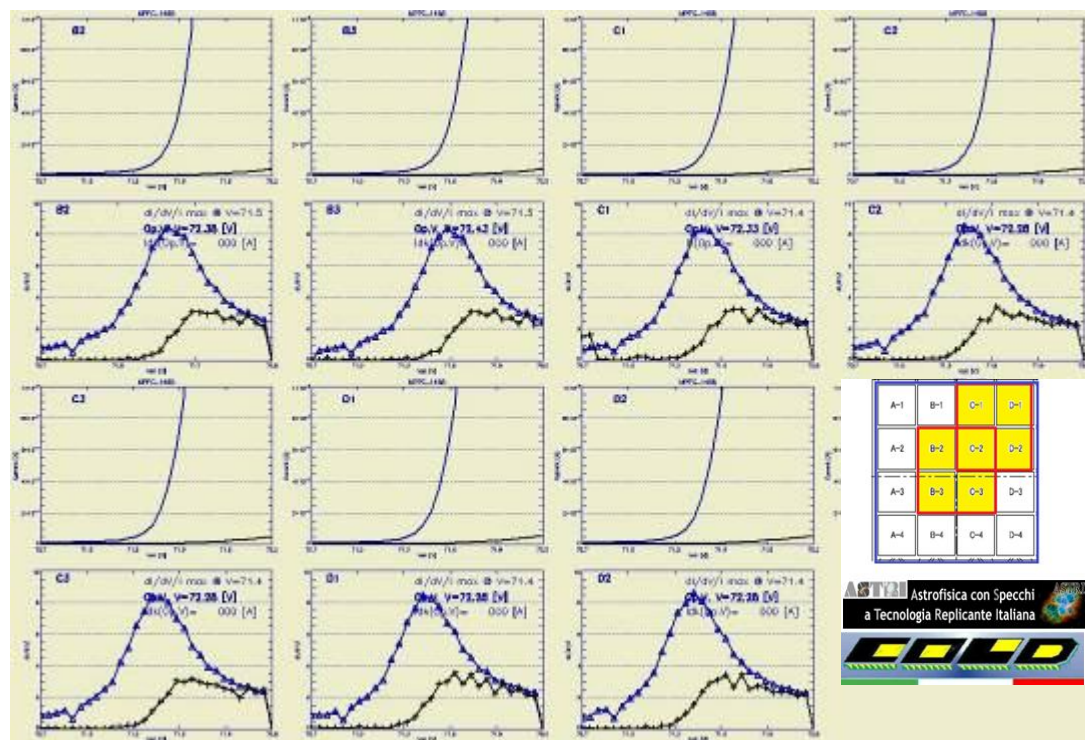
MPPC n° 1462



MPPC n° 1472



MPPC n° 1480



MPPC n° 1488



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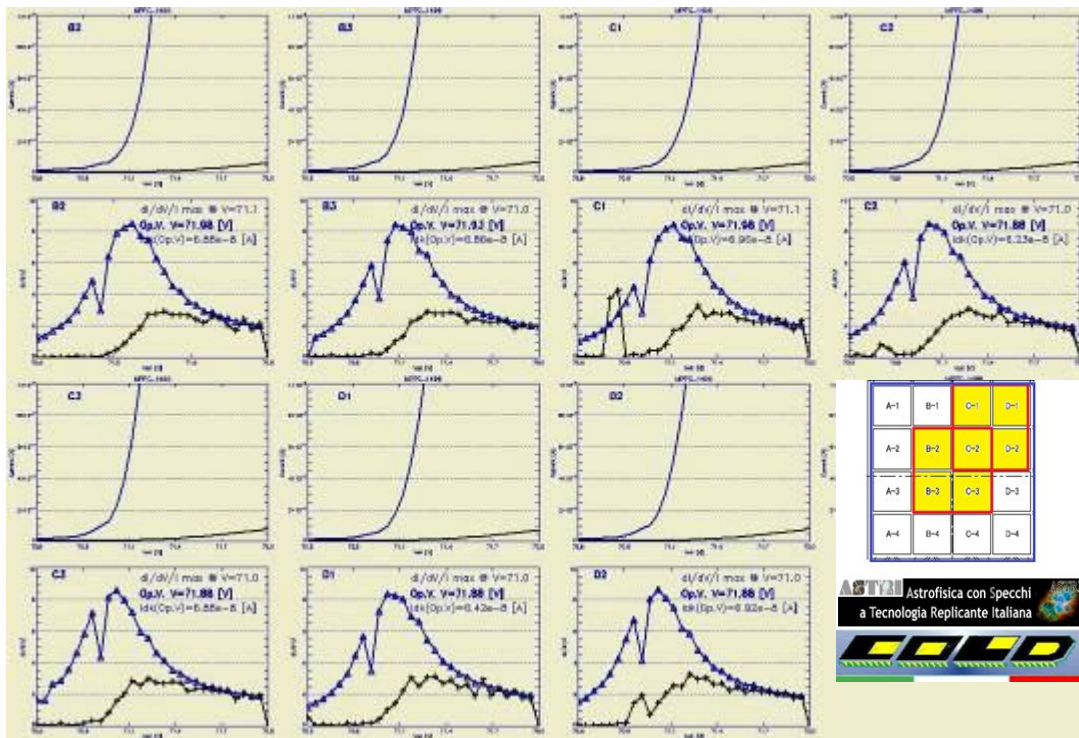
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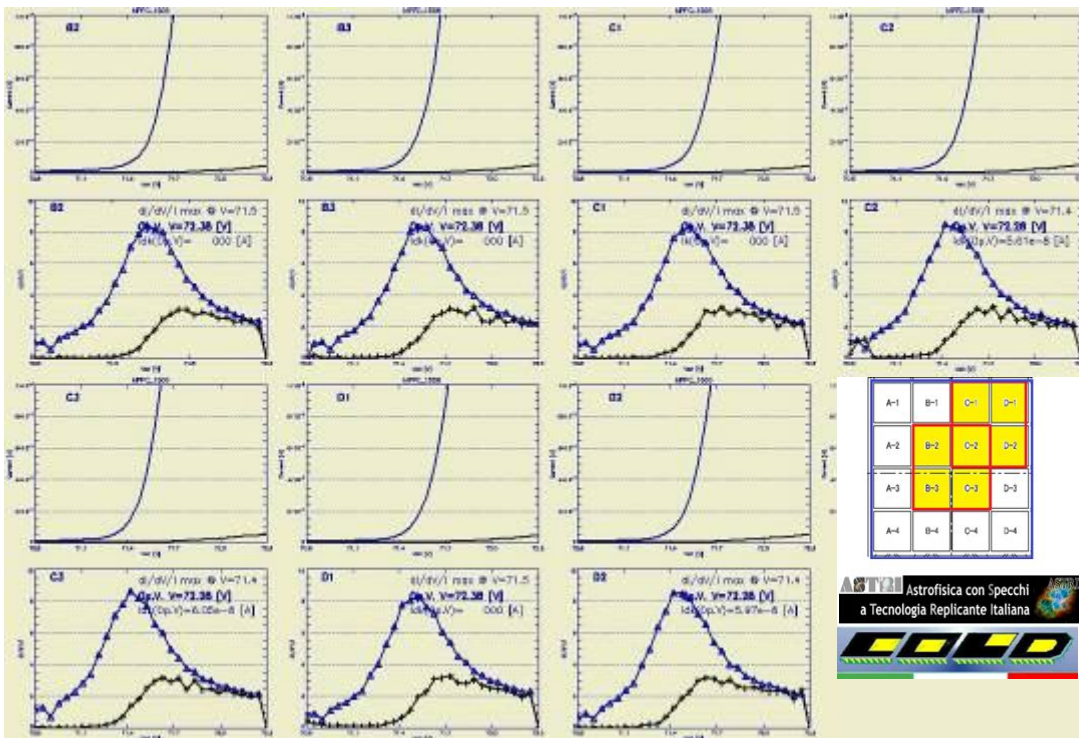
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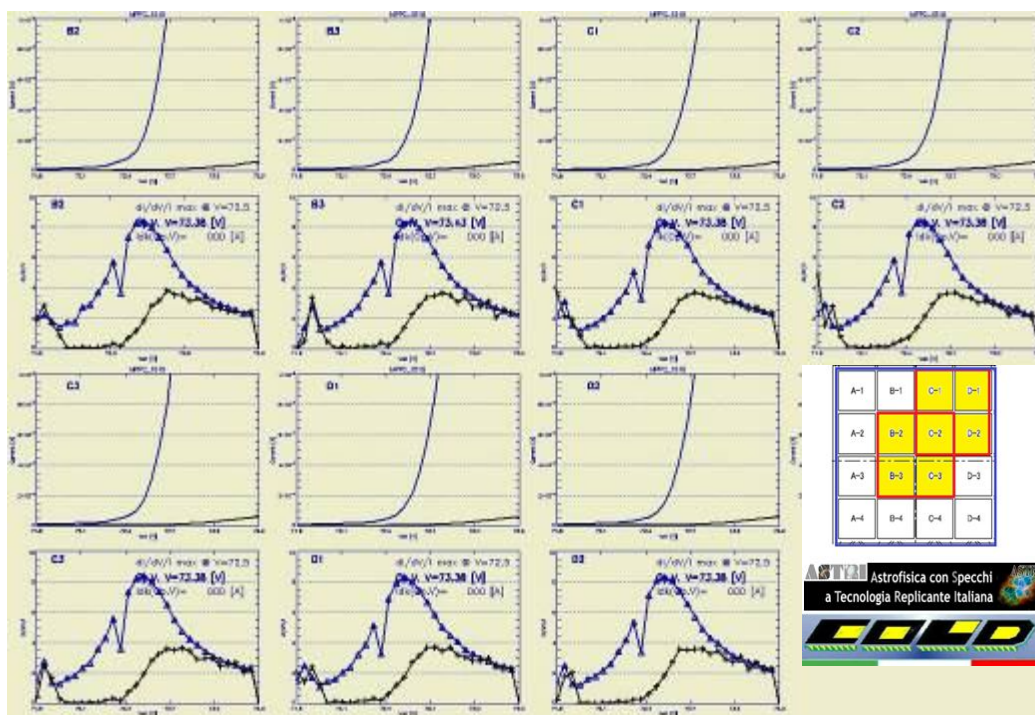
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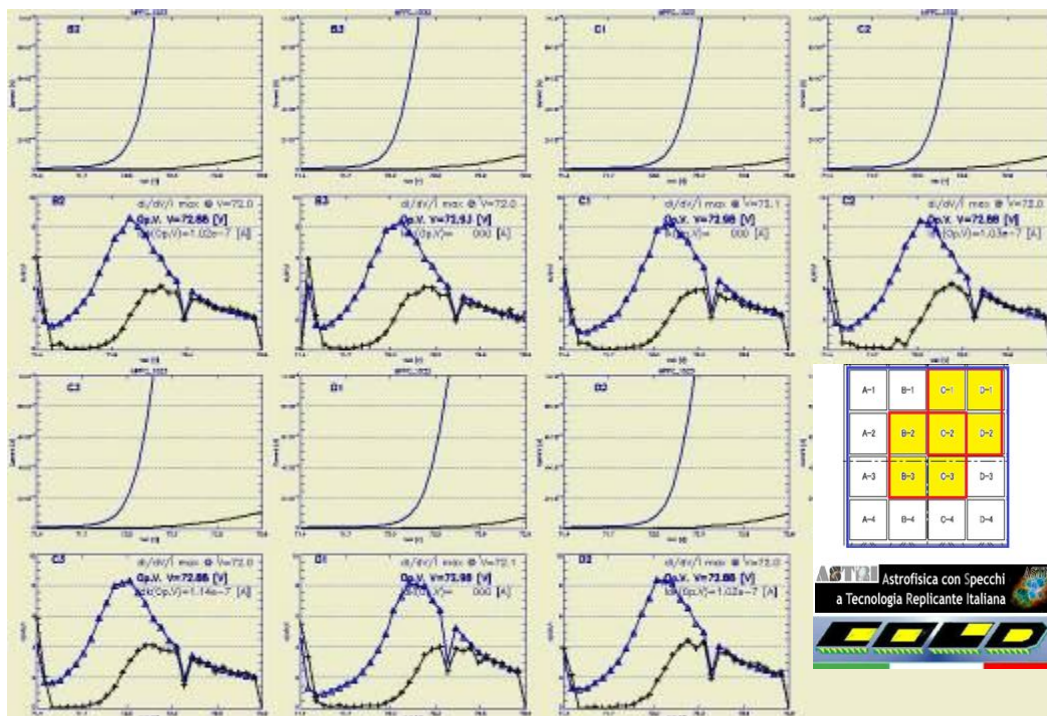
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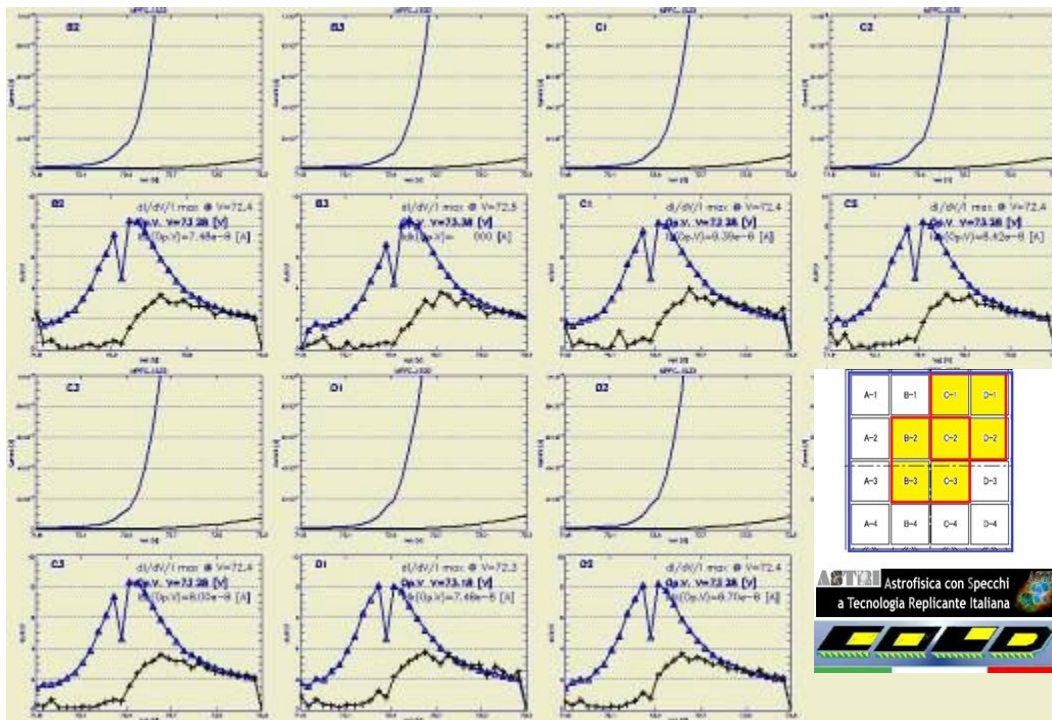
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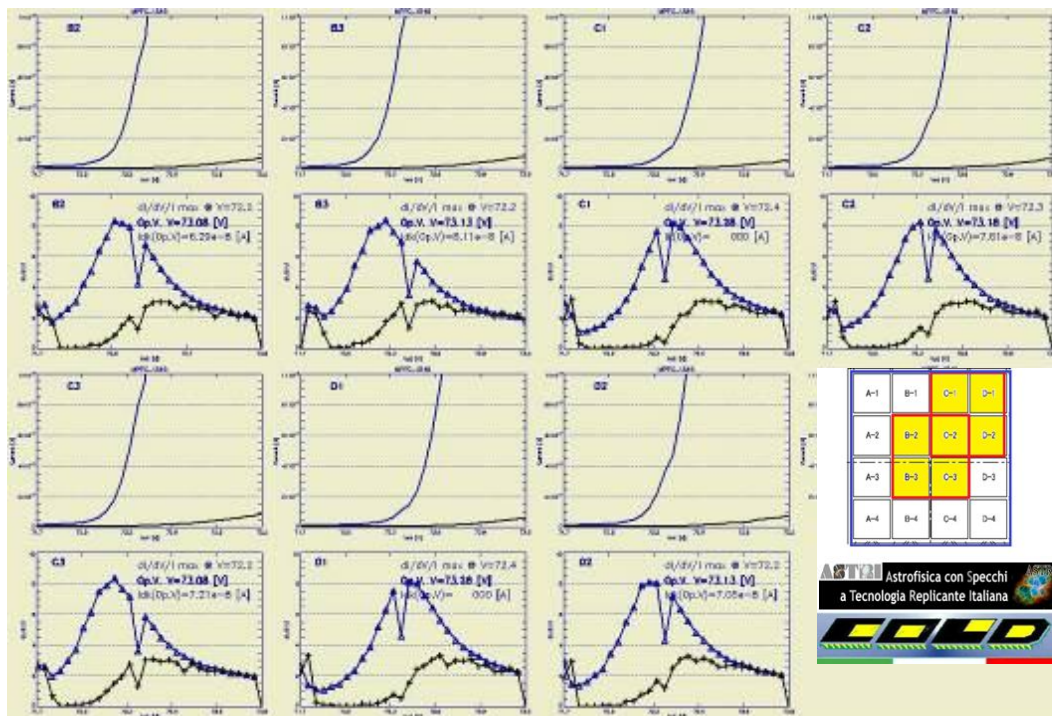
MPPC n° 1515



MPPC n° 1523



MPPC n° 1532



MPPC n° 1545

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5. Obtained operating voltages for the seven pixels compared with those given by Hamamatsu

The table below shows both the values of the Hamamatsu operating voltages derived by the data sheets and those obtained at our laboratory. The differences between the two voltages ($V_{op\text{Hamamatsu}} - V_{op\text{COLD}}$) or (H - C) is also reported. It is clearly evident that the two values are practically equal. This demonstrates the good agreement between the Hamamatsu measurements and ours.

The first 17 MPCCs have been marked in the "NOTE" with N.A. (Not Available) because they have been used in other experiments and not reusable.



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	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	
162	71,73	71,74	0,01	71,78	71,73	-0,05	71,73	71,71	-0,02	71,68	71,66	-0,02	71,68	71,64	-0,04	71,68	71,71	0,03	71,63	71,63	0	N.A.
163	71,98	71,97	-0,01	72,13	72,01	-0,12	71,98	71,98	0	71,98	71,98	-0,03	71,98	71,97	-0,01	71,98	72	0,02	71,98	71,95	-0,03	N.A.
164	72,08	72,05	-0,03	72,13	72,03	-0,1	72,08	72,02	-0,06	71,98	72,02	0,01	71,98	71,97	-0,01	71,98	71,96	-0,02	71,98	71,93	-0,05	N.A.
165	72,28	72,35	0,07	72,38	72,34	-0,04	72,33	72,35	0,02	72,28	72,35	0,07	72,38	72,34	-0,04	72,33	72,34	0,01	72,38	72,34	-0,04	N.A.
166	72,28	72,31	0,03	72,33	72,27	-0,06	72,38	72,36	-0,02	72,28	72,3	0,02	72,28	72,27	-0,01	72,33	72,35	0,02	72,28	72,32	0,04	N.A.
167	72,08	72,07	-0,01	72,13	72,07	-0,06	72,13	72,12	-0,01	72,08	72,07	-0,01	72,08	72,08	0	72,18	72,13	-0,05	72,08	72,09	0,01	N.A.
168	72,18	72,17	-0,01	72,23	72,19	-0,04	72,18	72,17	-0,01	72,18	72,17	-0,01	72,18	72,18	0	72,18	72,17	-0,01	72,18	72,17	-0,01	N.A.
170	72,18	72,14	-0,04	72,23	72,17	-0,06	72,18	72,14	-0,04	72,18	72,12	-0,06	72,18	72,12	-0,06	72,13	72,12	-0,01	72,18	72,12	-0,06	N.A.
180	71,58	71,61	0,03	71,58	71,53	-0,05	71,68	71,71	0,03	71,63	71,71	-0,01	71,53	71,53	0	71,68	71,71	0,03	71,63	71,61	-0,02	N.A.
181	71,88	71,85	-0,03	71,88	71,79	-0,09	71,93	71,89	-0,04	71,88	71,89	-0,08	71,73	71,73	0	71,88	71,85	-0,03	71,83	71,77	-0,06	N.A.
182	71,48	71,53	0,05	71,43	71,46	0,03	71,53	71,59	0,06	71,43	71,59	0,06	71,38	71,42	0,04	71,48	71,54	0,06	71,43	71,45	0,02	N.A.
183	71,28	71,34	0,06	71,33	71,33	0	71,33	71,36	0,03	71,33	71,36	-0,01	71,33	71,32	-0,01	71,33	71,34	0,01	71,33	71,32	-0,01	N.A.
184	71,88	71,89	0,01	71,93	71,89	-0,04	71,93	71,92	-0,01	71,98	71,95	-0,03	71,98	71,96	-0,02	72,08	72	-0,08	72,08	72,03	-0,05	N.A.
185	71,73	71,71	-0,02	71,78	71,76	-0,02	71,83	71,77	-0,06	71,73	71,76	0,03	71,83	71,82	-0,01	71,88	71,81	-0,07	71,88	71,84	-0,04	N.A.
868	72,48	72,39	-0,09	72,53	72,48	-0,05	72,38	72,34	-0,04	72,38	72,37	-0,01	72,48	72,44	-0,04	72,38	72,34	-0,04	72,38	72,37	-0,01	N.A.



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	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	
869	72,68	72,63	-0,05	72,73	72,61	-0,12	72,58	72,57	-0,01	72,58	72,58	0	72,58	72,57	-0,01	72,58	72,54	-0,04	72,58	72,54	-0,04	N.A.
870	72,48	72,46	-0,02	72,43	72,34	-0,09	72,53	72,52	-0,01	72,48	72,52	-0,05	72,38	72,32	-0,06	72,48	72,47	-0,01	72,48	72,4	-0,08	N.A.
871	72,18	72,11	-0,07	72,23	72,19	-0,04	72,18	72,12	-0,06	72,18	72,12	-0,02	72,18	72,22	0,04	72,18	72,17	-0,01	72,18	72,21	0,03	
872	72,18	72,29	0,11	72,18	72,22	0,04	72,28	72,28	0	72,18	72,28	0,06	72,18	72,2	0,02	72,28	72,3	0,02	72,28	72,24	-0,04	
873	72,38	72,4	0,02	72,43	72,39	-0,04	72,38	72,36	-0,02	72,38	72,36	-0,03	72,38	72,35	-0,03	72,38	72,32	-0,06	72,28	72,32	0,04	
874	72,38	72,29	-0,09	72,38	72,28	-0,1	72,33	72,29	-0,04	72,28	72,27	-0,01	72,28	72,27	-0,01	72,28	72,25	-0,03	72,28	72,26	-0,02	
875	72,28	72,29	0,01	72,38	72,32	-0,06	72,28	72,28	0	72,28	72,26	-0,02	72,28	72,27	-0,01	72,28	72,23	-0,05	72,28	72,19	-0,09	
876	72,38	72,41	0,03	72,53	72,44	-0,09	72,38	72,43	0,05	72,48	72,46	-0,02	72,48	72,49	0,01	72,48	72,51	0,03	71,88	72,53	0,65	
877	72,38	72,35	-0,03	72,53	72,4	-0,13	72,33	72,32	-0,01	72,38	72,36	-0,02	72,48	72,4	-0,08	72,38	72,32	-0,06	72,38	72,34	-0,04	
878	72,28	72,27	-0,01	72,33	72,26	-0,07	72,38	72,28	-0,1	72,28	72,28	-0,02	72,28	72,26	-0,02	72,33	72,29	-0,04	72,33	72,3	-0,03	
879	72,08	72,13	0,05	72,13	72,13	0	71,98	72,02	0,04	71,93	72,02	0,08	71,93	72	0,07	71,88	71,97	0,09	71,88	71,94	0,06	
880	72,28	72,29	0,01	72,33	72,22	-0,11	72,33	72,35	0,02	72,18	72,35	0,04	72,18	72,17	-0,01	72,28	72,3	0,02	72,13	72,19	0,06	
881	72,63	72,64	0,01	72,58	72,54	-0,04	72,68	72,7	0,02	72,58	72,7	0,03	72,48	72,5	0,02	72,68	72,67	-0,01	72,58	72,58	0	
882	72,48	72,41	-0,07	72,53	72,46	-0,07	72,38	72,38	0	72,38	72,39	0,01	72,48	72,45	-0,03	72,38	72,35	-0,03	72,38	72,37	-0,01	
883	72,28	72,29	0,01	72,38	72,36	-0,02	72,18	72,18	0	72,18	72,22	0,04	72,28	72,3	0,02	72,08	72,14	0,06	72,13	72,19	0,06	
884	72,18	72,2	0,02	72,28	72,22	-0,06	72,08	72,07	-0,01	72,18	72,12	-0,06	72,18	72,15	-0,03	71,98	71,99	0,01	72,08	72,04	-0,04	



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S/N	PIXEL B2			PIXEL B3			PIXEL C1			PIXEL C2			PIXEL C3			PIXEL D1			PIXEL D2			NOTE
	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	
885	72,28	72,32	0,04	72,43	72,39	-0,04	72,28	72,27	-0,01	72,28	72,33	0,05	72,38	72,41	0,03	72,28	72,3	0,02	72,33	72,36	0,03	
886	72,48	72,53	0,05	72,53	72,55	0,02	72,48	72,53	0,05	72,48	72,53	0,03	72,48	72,53	0,05	72,53	72,52	-0,01	72,53	72,51	-0,02	
887	72,48	72,54	0,06	72,58	72,55	-0,03	72,58	72,56	-0,02	72,58	72,56	-0,04	72,58	72,57	-0,01	72,58	72,56	-0,02	72,58	72,57	-0,01	
888	71,83	71,87	0,04	71,78	71,84	0,06	71,73	71,83	0,1	71,73	71,83	0,09	71,73	71,79	0,06	71,88	71,92	0,04	71,88	71,85	-0,03	
889	71,98	71,92	-0,06	72,03	71,96	-0,07	71,88	71,88	0	71,93	71,88	-0,03	71,98	71,93	-0,05	71,88	71,87	-0,01	71,88	71,89	0,01	
890	72,18	72,1	-0,08	72,33	72,16	-0,17	72,08	72,05	-0,03	72,18	72,09	-0,09	72,18	72,11	-0,07	72,08	72,02	-0,06	72,18	72,08	-0,1	
891	72,88	72,78	-0,1	72,93	72,79	-0,14	72,88	72,8	-0,08	72,88	72,77	-0,11	72,88	72,76	-0,12	72,88	72,8	-0,08	72,88	72,77	-0,11	
892	72,78	72,69	-0,09	72,93	72,75	-0,18	72,78	72,74	-0,04	72,78	72,74	-0,04	72,88	72,78	-0,1	72,88	72,78	-0,1	72,88	72,78	-0,1	
893	72,98	72,89	-0,09	73,03	72,91	-0,12	72,98	72,89	-0,09	72,98	72,91	-0,07	72,98	72,92	-0,06	72,98	72,88	-0,1	72,98	72,89	-0,09	
894	72,98	72,83	-0,15	73,03	72,81	-0,22	72,88	72,76	-0,12	72,88	72,76	-0,1	72,98	72,81	-0,17	72,88	72,76	-0,12	72,78	72,75	-0,03	
895	72,88	72,8	-0,08	72,93	72,78	-0,15	72,88	72,75	-0,13	72,88	72,75	-0,14	72,88	72,74	-0,14	72,88	72,69	-0,19	72,78	72,67	-0,11	
896	72,98	72,83	-0,15	72,98	72,81	-0,17	72,88	72,79	-0,09	72,88	72,79	-0,12	72,88	72,76	-0,12	72,88	72,73	-0,15	72,18	72,68	0,5	
897	72,78	72,61	-0,17	72,83	72,65	-0,18	72,68	72,48	-0,2	72,68	72,48	-0,15	72,68	72,54	-0,14	72,58	72,41	-0,17	72,58	72,42	-0,16	
969	72,53	72,52	-0,01	72,53	72,45	-0,08	72,53	72,51	-0,02	72,58	72,52	-0,06	72,48	72,4	-0,08	72,58	72,53	-0,05	72,48	72,49	0,01	
977	72,88	72,88	0	72,93	72,84	-0,09	72,88	72,86	-0,02	72,78	72,79	0,01	72,78	72,75	-0,03	72,88	72,8	-0,08	72,78	72,72	-0,06	
985	72,48	72,47	-0,01	72,53	72,46	-0,07	72,48	72,49	0,01	72,48	72,41	-0,07	72,33	72,32	-0,01	72,48	72,46	-0,02	72,38	72,35	-0,03	



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	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	
996	71,98	71,95	-0,03	71,93	71,87	-0,06	72,08	72,04	-0,04	71,98	71,95	-0,03	71,88	71,84	-0,04	72,08	72,04	-0,04	71,98	71,96	-0,02	
1004	72,08	72,1	0,02	72,13	72,09	-0,04	72,08	72,1	0,02	72,08	72,1	-0,01	72,08	72,06	-0,02	72,08	72,06	-0,02	72,08	72,05	-0,03	
1012	71,88	71,88	0	71,93	71,88	-0,05	71,88	71,89	0,01	71,88	71,89	0	71,88	71,89	0,01	71,88	71,92	0,04	71,88	71,89	0,01	
1021	72,48	72,52	0,04	72,63	72,53	-0,1	72,48	72,49	0,01	72,48	72,49	-0,01	72,53	72,51	-0,02	72,48	72,46	-0,02	72,48	72,46	-0,02	
1030	72,88	72,84	-0,04	72,93	72,86	-0,07	72,88	72,82	-0,06	72,78	72,82	0	72,78	72,77	-0,01	72,78	72,78	0	72,78	72,76	-0,02	
1039	71,88	71,88	0	71,93	71,82	-0,11	71,98	71,98	0	71,98	71,92	-0,06	71,93	71,89	-0,04	72,08	72,07	-0,01	72,08	72,01	-0,07	
1048	72,48	72,49	0,01	72,53	72,46	-0,07	72,48	72,51	0,03	72,48	72,47	-0,01	72,38	72,39	0,01	72,48	72,5	0,02	72,48	72,45	-0,03	
1057	72,68	72,7	0,02	72,73	72,67	-0,06	72,68	72,72	0,04	72,68	72,68	0	72,68	72,67	-0,01	72,68	72,69	0,01	72,68	72,66	-0,02	
1065	72,28	72,32	0,04	72,33	72,29	-0,04	72,28	72,31	0,03	72,28	72,3	0,02	72,28	72,29	0,01	72,28	72,29	0,01	72,28	72,32	0,04	
1074	72,48	72,51	0,03	72,53	72,52	-0,01	72,48	72,53	0,05	72,48	72,53	0,06	72,58	72,56	-0,02	72,58	72,57	-0,01	72,58	72,57	-0,01	
1085	72,48	72,53	0,05	72,58	72,52	-0,06	72,58	72,57	-0,01	72,53	72,57	0	72,48	72,52	0,04	72,58	72,59	0,01	72,53	72,54	0,01	
1094	72,18	72,17	-0,01	72,23	72,18	-0,05	72,18	72,14	-0,04	72,13	72,14	-0,02	72,18	72,14	-0,04	72,08	72,1	0,02	72,08	72,08	0	
1103	71,98	71,97	-0,01	72,03	71,92	-0,11	72,08	71,99	-0,09	71,98	71,99	-0,04	71,98	71,91	-0,07	71,98	71,94	-0,04	71,98	71,92	-0,06	
1074	72,48	72,51	0,03	72,53	72,52	-0,01	72,48	72,53	0,05	72,48	72,54	0,06	72,58	72,56	-0,02	72,58	72,57	-0,01	72,58	72,57	-0,01	
1085	72,48	72,53	0,05	72,58	72,52	-0,06	72,58	72,57	-0,01	72,53	72,53	0	72,48	72,52	0,04	72,58	72,59	0,01	72,53	72,54	0,01	
1094	72,18	72,17	-0,01	72,23	72,18	-0,05	72,18	72,14	-0,04	72,13	72,11	-0,02	72,18	72,14	-0,04	72,08	72,1	0,02	72,08	72,08	0	



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	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	
1103	71,98	71,97	-0,01	72,03	71,92	-0,11	72,08	71,99	-0,09	71,98	71,94	-0,04	71,98	71,91	-0,07	71,98	71,94	-0,04	71,98	71,92	-0,06	
1111	72,28	72,22	-0,06	72,33	72,2	-0,13	72,28	72,27	-0,01	72,28	72,27	-0,07	72,18	72,14	-0,04	72,28	72,25	-0,03	72,28	72,19	-0,09	
1121	72,28	72,24	-0,04	72,33	72,23	-0,1	72,28	72,21	-0,07	72,18	72,21	0	72,18	72,18	0	72,28	72,2	-0,08	72,23	72,19	-0,04	
1130	71,68	71,73	0,05	71,68	71,65	-0,03	71,73	71,81	0,08	71,68	71,81	0,05	71,63	71,68	0,05	71,88	71,88	0	71,83	71,8	-0,03	
1139	71,68	71,64	-0,04	71,68	71,62	-0,06	71,68	71,64	-0,04	71,63	71,64	-0,01	71,63	71,61	-0,02	71,68	71,63	-0,05	71,63	71,62	-0,01	
1147	72,48	72,42	-0,06	72,53	72,43	-0,1	72,38	72,36	-0,02	72,48	72,39	-0,09	72,48	72,41	-0,07	72,38	72,37	-0,01	72,48	72,4	-0,08	
1155	72,28	72,22	-0,06	72,23	72,17	-0,06	72,28	72,21	-0,07	72,18	72,16	-0,02	72,18	72,12	-0,06	72,18	72,16	-0,02	72,18	72,11	-0,07	
1164	72,18	72,13	-0,05	72,23	72,1	-0,13	72,28	72,22	-0,06	72,18	72,17	-0,01	72,18	72,16	-0,02	72,28	72,26	-0,02	72,28	72,25	-0,03	
1172	72,48	72,45	-0,03	72,53	72,47	-0,06	72,38	72,4	0,02	72,48	72,41	-0,07	72,48	72,43	-0,05	72,38	72,35	-0,03	72,38	72,37	-0,01	
1180	72,18	72,2	0,02	72,23	72,18	-0,05	72,18	72,21	0,03	72,18	72,21	-0,01	72,13	72,14	0,01	72,18	72,19	0,01	72,18	72,14	-0,04	
1188	72,08	72,06	-0,02	72,13	72,04	-0,09	72,18	72,13	-0,05	72,08	72,13	-0,02	72,08	72,03	-0,05	72,18	72,18	0	72,18	72,12	-0,06	
1197	72,18	72,11	-0,07	72,23	72,12	-0,11	72,18	72,12	-0,06	72,13	72,12	-0,04	72,18	72,11	-0,07	72,18	72,1	-0,08	72,13	72,08	-0,05	
1205	72,48	72,51	0,03	72,58	72,5	-0,08	72,58	72,51	-0,07	72,53	72,51	-0,05	72,53	72,5	-0,03	72,58	72,53	-0,05	72,58	72,53	-0,05	
1215	72,38	72,36	-0,02	72,33	72,32	-0,01	72,38	72,43	0,05	72,28	72,35	0,07	72,28	72,31	0,03	72,38	72,43	0,05	72,28	72,35	0,07	
1224	72,78	72,78	0	72,83	72,8	-0,03	72,68	72,73	0,05	72,78	72,79	0,01	72,78	72,77	-0,01	72,68	72,69	0,01	72,68	72,74	0,06	
1233	72,28	72,27	-0,01	72,33	72,22	-0,11	72,48	72,41	-0,07	72,28	72,29	0,01	72,28	72,25	-0,03	72,48	72,41	-0,07	72,33	72,31	-0,02	



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	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	
1245	72,13	72,08	-0,05	72,13	72,05	-0,08	72,08	72,07	-0,01	72,08	72,03	-0,05	72,08	72,04	-0,04	72,08	72,03	-0,05	72,08	72	-0,08	
1256	71,88	71,88	0	71,93	71,85	-0,08	71,88	71,84	-0,04	71,88	71,84	-0,06	71,88	71,8	-0,08	71,88	71,81	-0,07	71,88	71,79	-0,09	
1265	72,48	72,43	-0,05	72,53	72,43	-0,1	72,48	72,46	-0,02	72,48	72,46	-0,02	72,48	72,49	0,01	72,48	72,45	-0,03	72,48	72,49	0,01	
1273	72,08	72,07	-0,01	72,13	72,08	-0,05	72,08	72,04	-0,04	72,08	72,04	-0,02	72,18	72,1	-0,08	72,08	71,97	-0,11	72,08	72,02	-0,06	
1282	71,48	71,48	0	71,53	71,48	-0,05	71,53	71,51	-0,02	71,53	71,51	-0,04	71,53	71,51	-0,02	71,53	71,54	0,01	71,53	71,5	-0,03	
1291	72,88	72,82	-0,06	72,93	72,83	-0,1	72,88	72,9	0,02	72,88	72,88	0	72,88	72,84	-0,04	72,98	72,94	-0,04	72,88	72,9	0,02	
1301	73,28	73,2	-0,08	73,23	73,17	-0,06	73,13	73,09	-0,04	73,18	73,13	-0,05	73,18	73,13	-0,05	73,08	73,04	-0,04	73,08	73,05	-0,03	
1309	72,88	72,88	0	73,03	72,96	-0,07	72,78	72,78	0	72,88	72,84	-0,04	72,93	72,91	-0,02	72,78	72,76	-0,02	72,88	72,82	-0,06	
1317	72,88	72,9	0,02	72,93	72,83	-0,1	73,08	73,04	-0,04	72,98	72,94	-0,04	72,88	72,85	-0,03	73,08	73,03	-0,05	72,93	72,9	-0,03	
1327	73,18	73,2	0,02	73,23	73,19	-0,04	73,18	73,22	0,04	73,18	73,22	0,03	73,18	73,19	0,01	73,28	73,25	-0,03	73,28	73,24	-0,04	
1353	72,88	72,81	-0,07	72,93	72,83	-0,1	72,88	72,88	0	72,88	72,88	-0,04	72,88	72,82	-0,06	72,93	72,9	-0,03	72,88	72,87	-0,01	
1363	72,98	72,96	-0,02	73,03	72,96	-0,07	73,08	73	-0,08	72,98	73	0	72,98	72,96	-0,02	73,08	73,01	-0,07	73,03	73	-0,03	
1371	72,98	72,95	-0,03	73,03	72,94	-0,09	72,98	72,98	0	72,98	72,98	-0,04	72,98	72,95	-0,03	73,03	73	-0,03	72,98	72,98	0	
1381	72,88	72,83	-0,05	72,93	72,9	-0,03	72,78	72,79	0,01	72,88	72,81	-0,07	72,88	72,87	-0,01	72,78	72,78	0	72,88	72,82	-0,06	
1389	73,18	72,97	-0,21	73,13	72,94	-0,19	73,18	73,03	-0,15	73,08	73	-0,08	73,08	72,94	-0,14	73,08	73,08	0	73,08	73,05	-0,03	
1397	72,88	72,9	0,02	72,93	72,9	-0,03	72,88	72,86	-0,02	72,88	72,83	-0,05	72,88	72,83	-0,05	72,88	72,84	-0,04	72,78	72,81	0,03	



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	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	COLD	HAM	H-C ΔV	
1408	71,33	71,35	0,02	71,33	71,26	-0,07	71,43	71,41	-0,02	71,33	71,31	-0,02	71,28	71,27	-0,01	71,43	71,42	-0,01	71,33	71,31	-0,02	
1416	71,48	71,48	0	71,58	71,53	-0,05	71,53	71,53	0	71,58	71,53	-0,01	71,63	71,6	-0,03	71,63	71,62	-0,01	71,68	71,66	-0,02	
1425	72,28	72,23	-0,05	72,33	72,25	-0,08	72,18	72,14	-0,04	72,28	72,14	-0,06	72,28	72,21	-0,07	72,18	72,17	-0,01	72,18	72,2	0,02	
1433	71,53	71,55	0,02	71,53	71,49	-0,04	71,53	71,53	0	71,53	71,53	-0,01	71,48	71,49	0,01	71,58	71,56	-0,02	71,53	71,52	-0,01	
1442	71,03	70,99	-0,04	71,08	70,99	-0,09	71,03	71	-0,03	71,03	71	-0,03	71,08	71,03	-0,05	71,08	71,07	-0,01	71,13	71,08	-0,05	
1451	71,43	71,46	0,03	71,43	71,44	0,01	71,43	71,47	0,04	71,38	71,45	0,07	71,38	71,41	0,03	71,38	71,43	0,05	71,43	71,42	-0,01	
1462	72,33	72,33	0	72,43	72,39	-0,04	72,28	72,27	-0,01	72,28	72,28	0	72,28	72,31	0,03	72,18	72,17	-0,01	72,28	72,22	-0,06	
1472	71,88	71,88	0	71,93	71,86	-0,07	71,98	71,94	-0,04	71,98	71,94	-0,04	71,98	71,95	-0,03	72,08	72,04	-0,04	72,08	72,09	0,01	
1480	72,38	72,34	-0,04	72,43	72,32	-0,11	72,38	72,35	-0,03	72,38	72,34	-0,04	72,33	72,31	-0,02	72,48	72,4	-0,08	72,48	72,4	-0,08	
1488	72,38	72,36	-0,02	72,43	72,36	-0,07	72,33	72,32	-0,01	72,28	72,32	0	72,28	72,29	0,01	72,28	72,27	-0,01	72,28	72,25	-0,03	
1496	71,98	71,91	-0,07	71,93	71,86	-0,07	71,98	71,91	-0,07	71,88	71,91	-0,03	71,88	71,8	-0,08	71,88	71,86	-0,02	71,88	71,81	-0,07	
1506	72,38	72,39	0,01	72,38	72,34	-0,04	72,38	72,39	0,01	72,28	72,39	0,06	72,28	72,3	0,02	72,38	72,39	0,01	72,28	72,34	0,06	
1515	73,38	73,36	-0,02	73,43	73,35	-0,08	73,38	73,38	0	73,38	73,38	-0,03	73,38	73,35	-0,03	73,38	73,36	-0,02	73,38	73,35	-0,03	
1523	72,88	72,87	-0,01	72,93	72,83	-0,1	72,98	72,94	-0,04	72,88	72,89	0,01	72,88	72,82	-0,06	72,98	73	0,02	72,88	72,9	0,02	
1532	73,28	73,26	-0,02	73,38	73,28	-0,1	73,28	73,24	-0,04	73,28	73,25	-0,03	73,28	73,26	-0,02	73,18	73,23	0,05	73,28	73,23	-0,05	

6. CONTACTS

The team working on the electronic design of the ASTRI camera is composed by people from INAF's Catania Astrophysical Observatory and Palermo IFC. It is also referred to as the Electronics Camera Team.

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