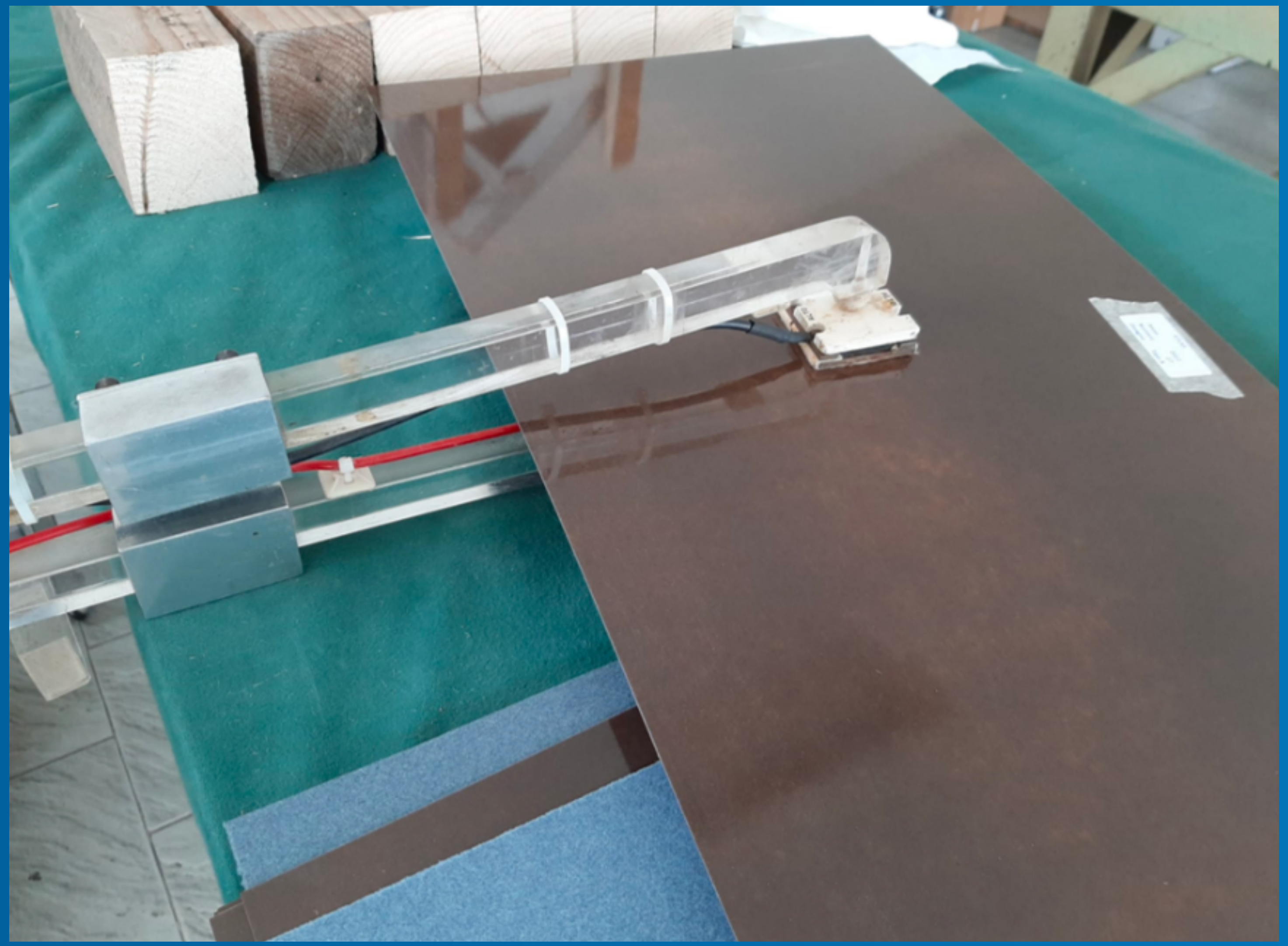
INFN
Roma
Tor Vergata

QA/QC of HPL plates and RPC gas volumes for ATLAS Phase II upgrade

con il contributo di tutto il gruppo RPC di Tor Vergata

QA/QC of HPL plates



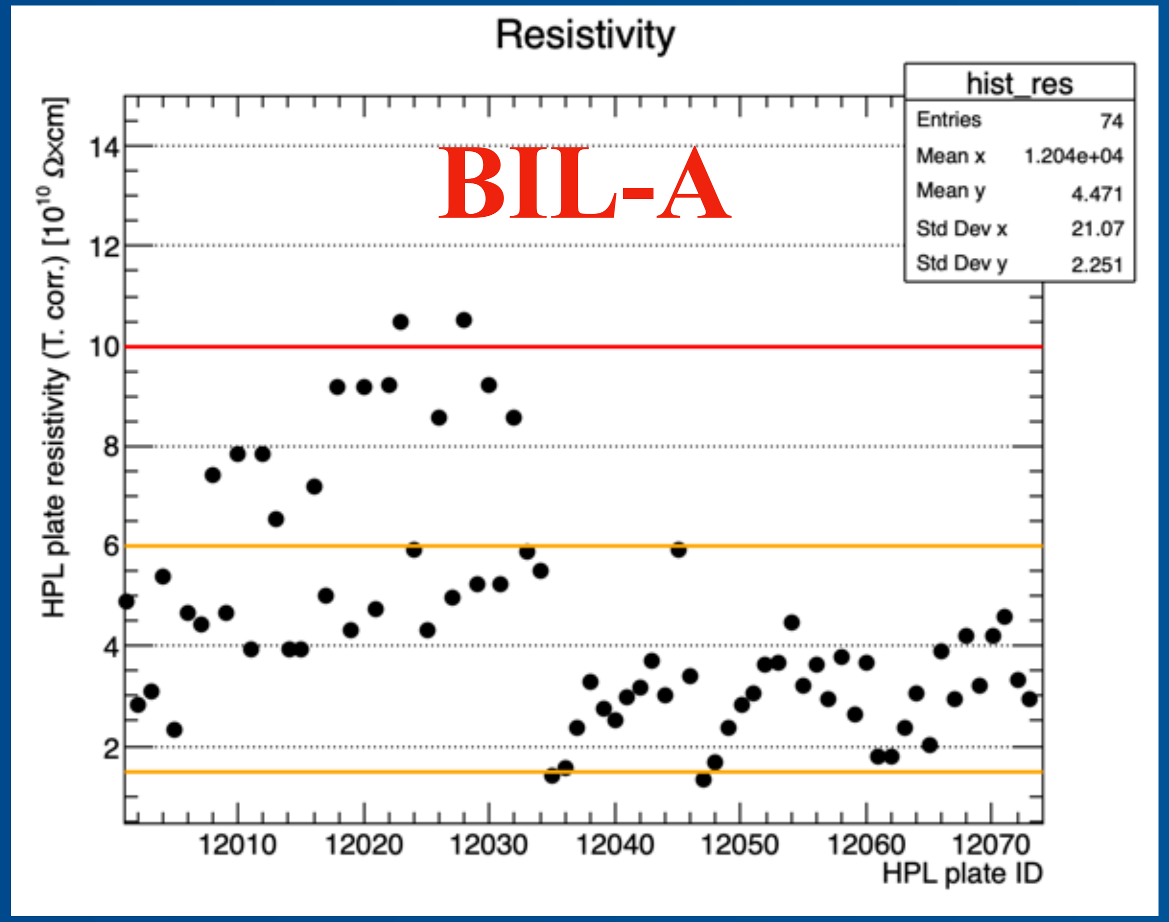
- HPL plates produced by Teknemika (Cinisello Balsamo, IT) and delivered to GTE
- We measure at GTE the bulk resistivity and thickness of each single HPL plate
- Tested so far the first two batches of HPL plates: 494 over 1332 ~ 37%

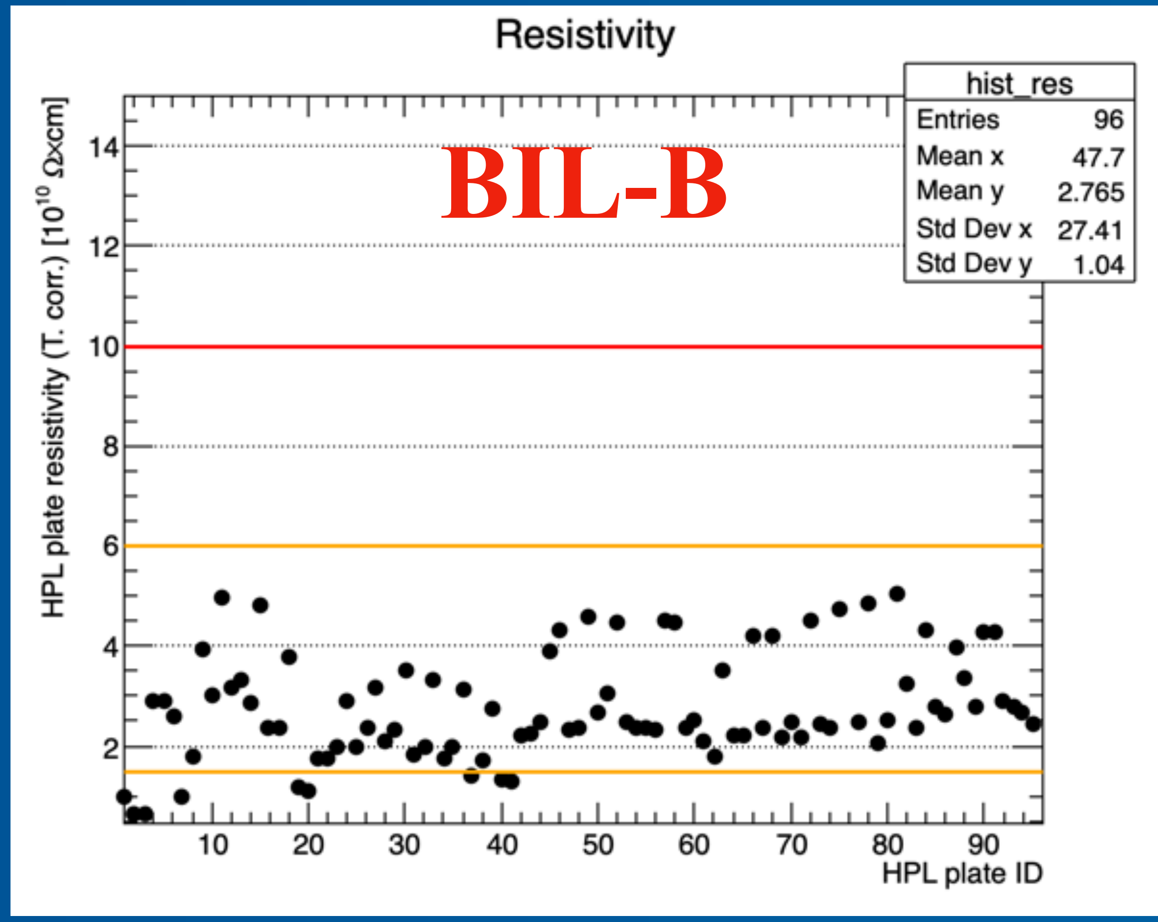
	Aug 2023	Sept-Oct	Jan		Mar-Apr	May-Jun
HPL	EDH9502173	EDH9823644				
BIL1A	126	74	96		40	
BIL1B		96	96			60
BIS2A BIS1	90	12				
BIS2B BIS2-6		96	192		192	
BIL D E X Y Z					66	
BIL C					48	
BIS78 T7-1 (7L)					18	
BIS78 TZ-2 (7S)						30
Total	216	278	384	0	364	90

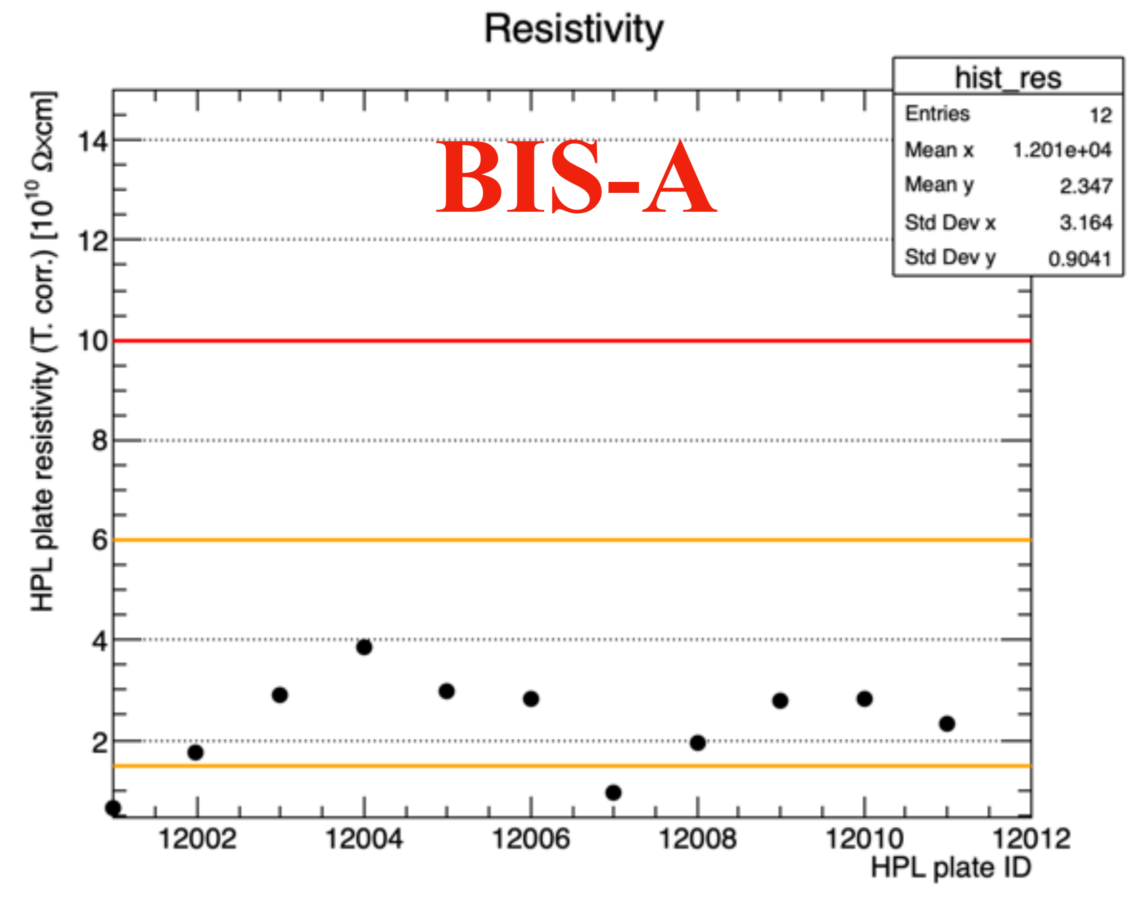
- **Requirements**
  - Bulk resistivity → 1.5 - 6 · 10^{10} Ω·cm
  - Thickness → between 1.33 mm and 1.50 mm

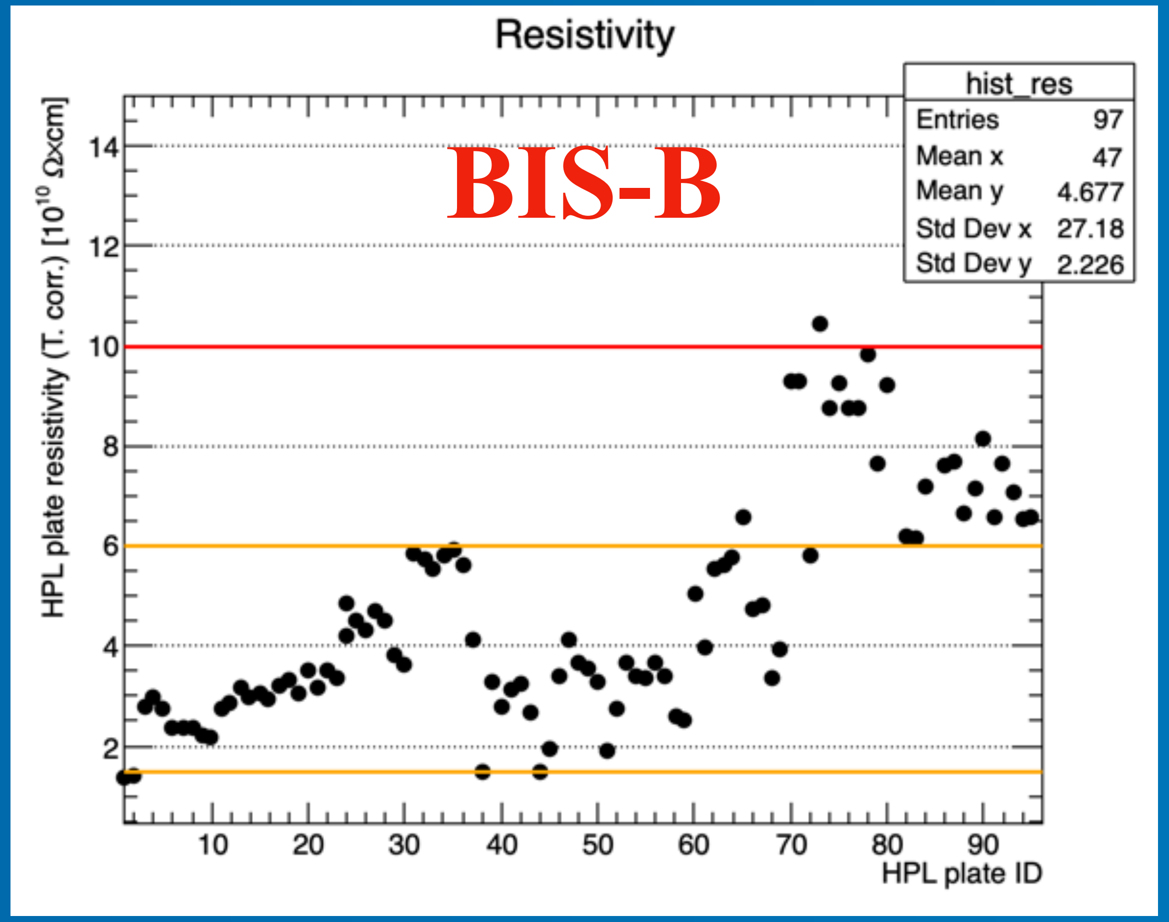
- First batch: discarded up to 70% of the plates → replaced by the company after a fine tuning of the production parameters → all accepted
- Second batch: tested last week → only 15 plates discarded over 278
- In both cases, HPL plates with resistivity slightly out of range accepted

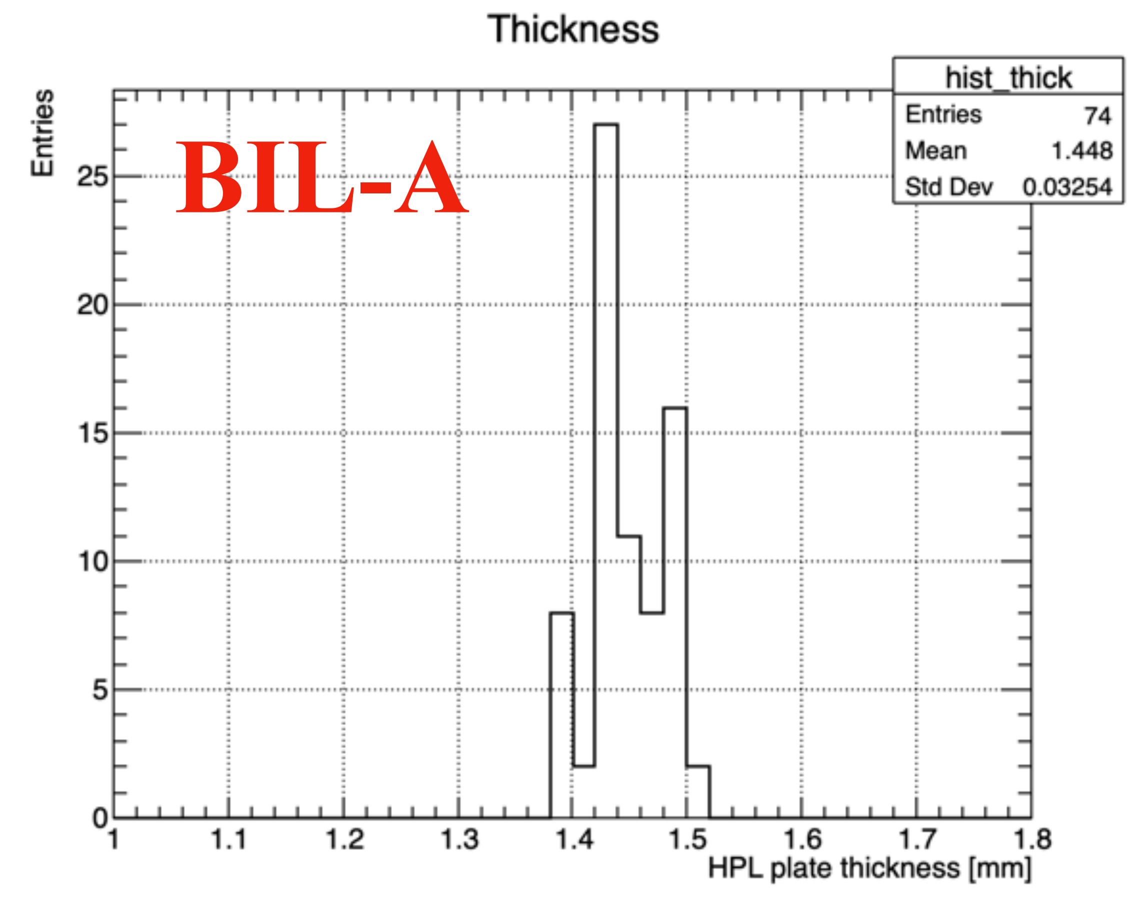
QA/QC of HPL plates - 2nd order - tested between November and December
278 plates

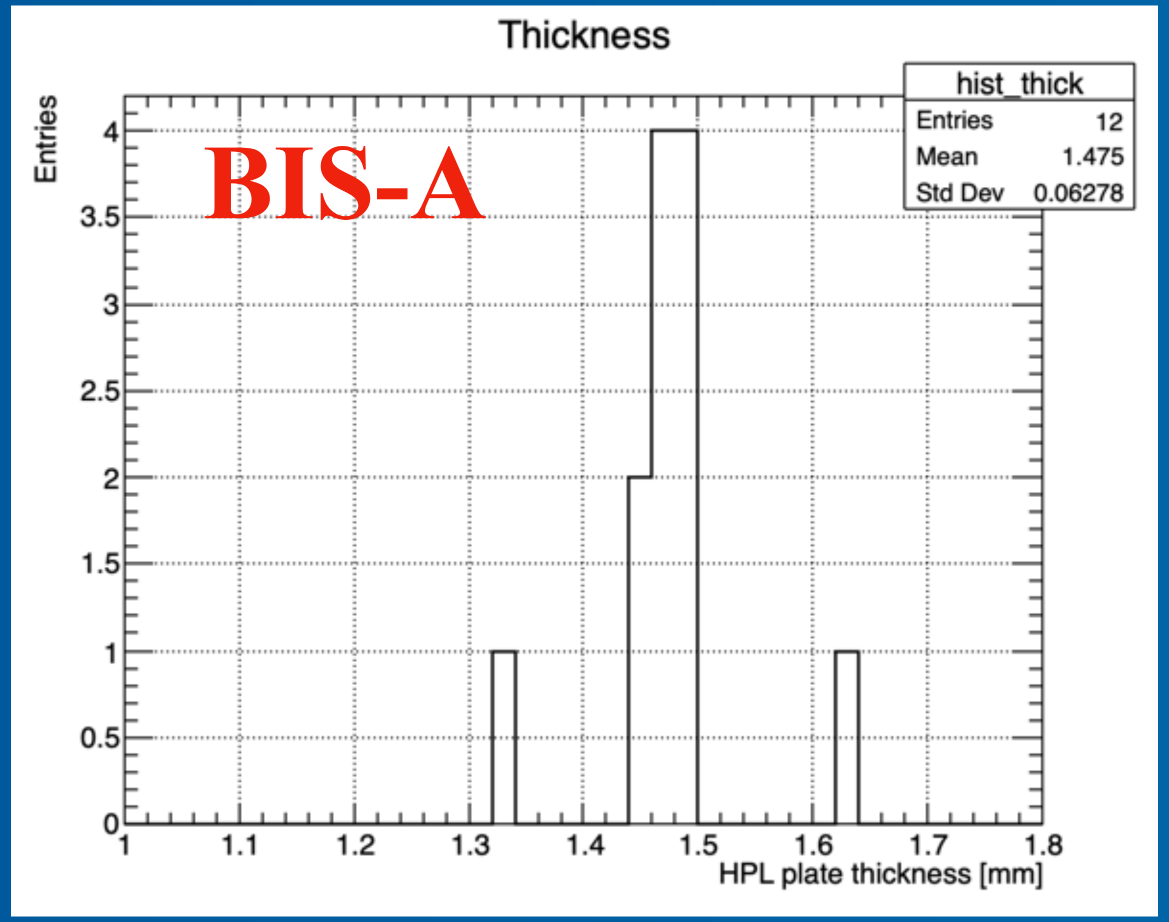


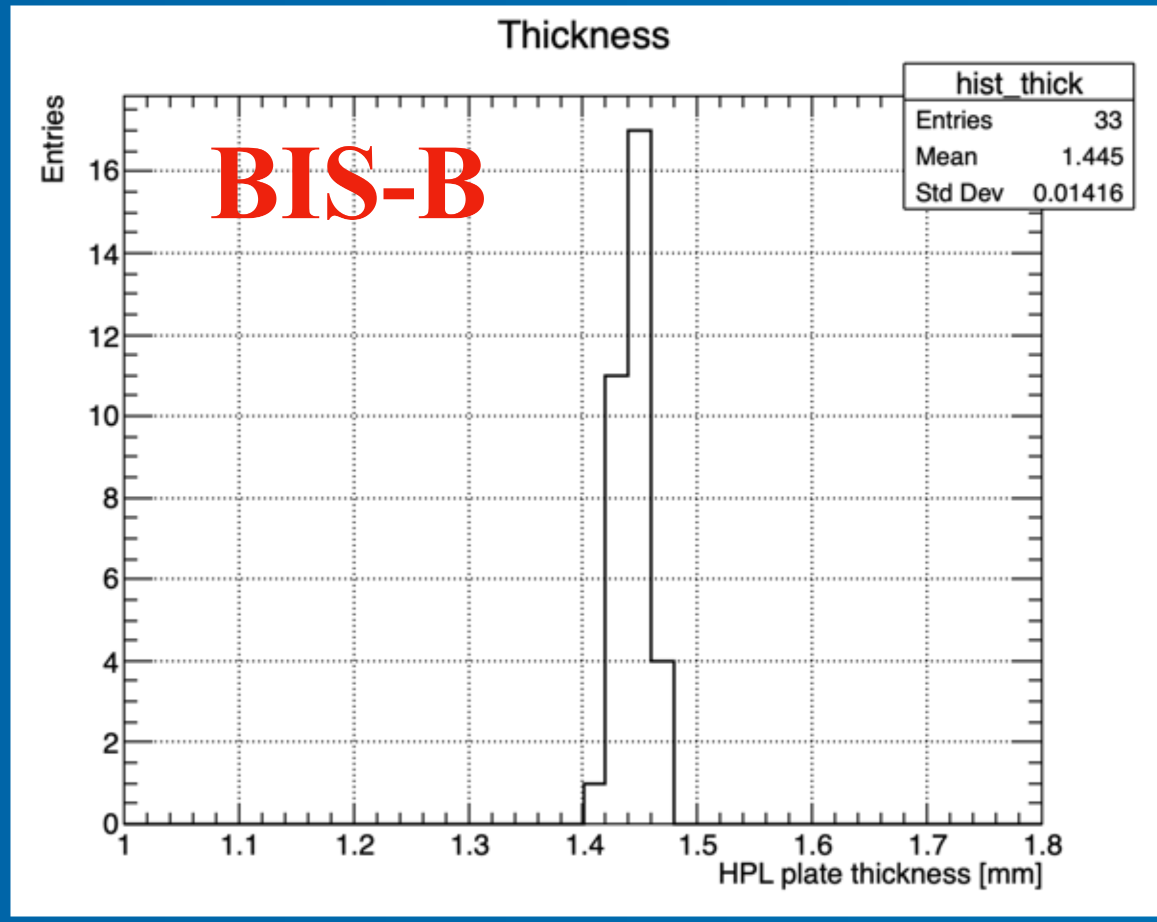












Tested last week → only 15 plates discarded over 278 (low resistivity, high resistivity and thickness out of range)

Gas volume production at GTE

- First order of gas volumes (DAI 9852953) consists of:
  - 63 BIL-A (126 HPL plates ordered - 124 delivered)
  - 45 BIS-A (90 HPL plates)

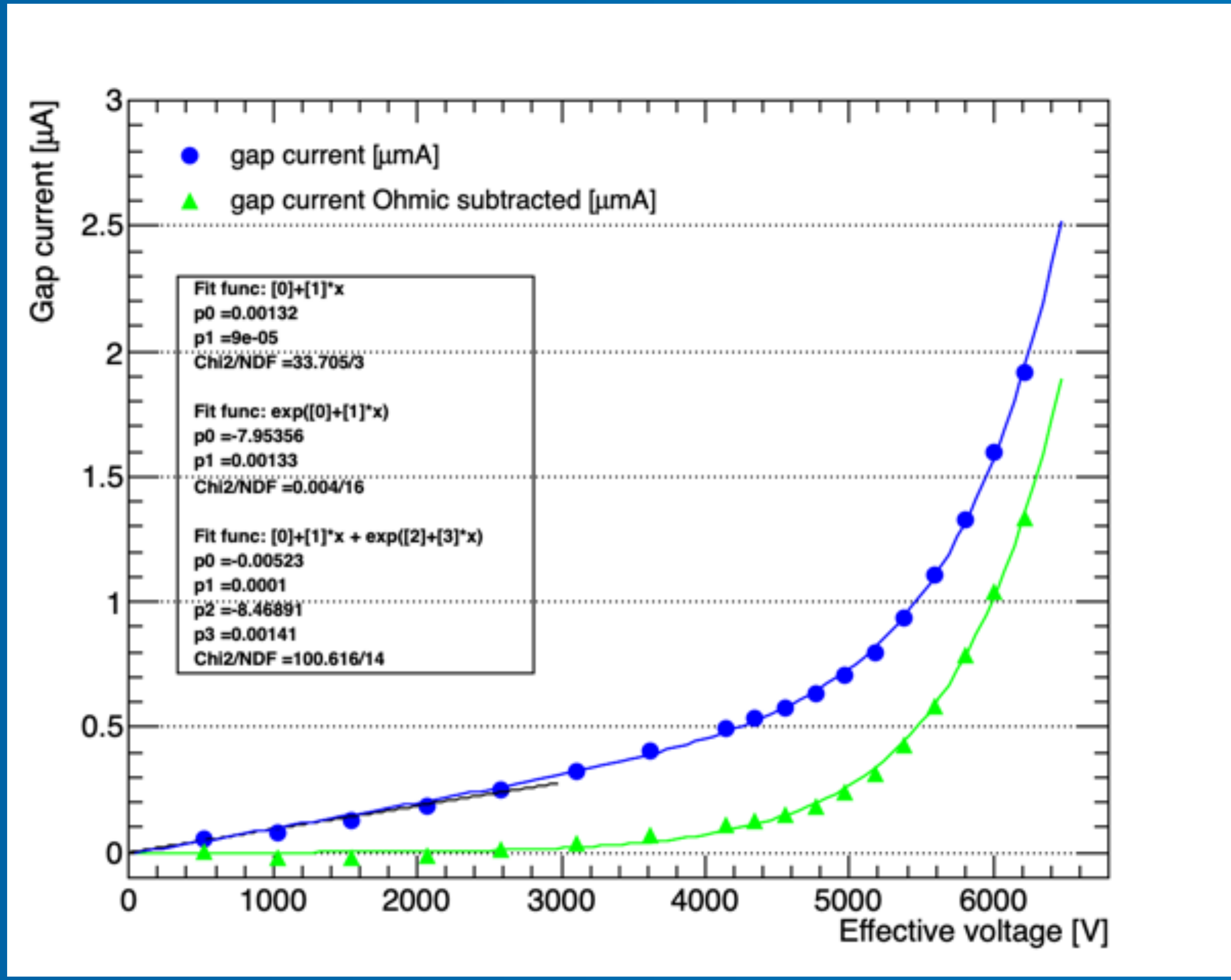
- Produced
  - 43 (tested) + 10 (to be tested) + 1 half-glued BIL-A —> 54/63
  - 37 (tested) + 1 half-glued BIS-A —> 38/45

- Discarded HPL plates during production
  - 16 BIL-A (~13%)
  - 13 BIS-A (~14%)

QA/QC of gas volumes

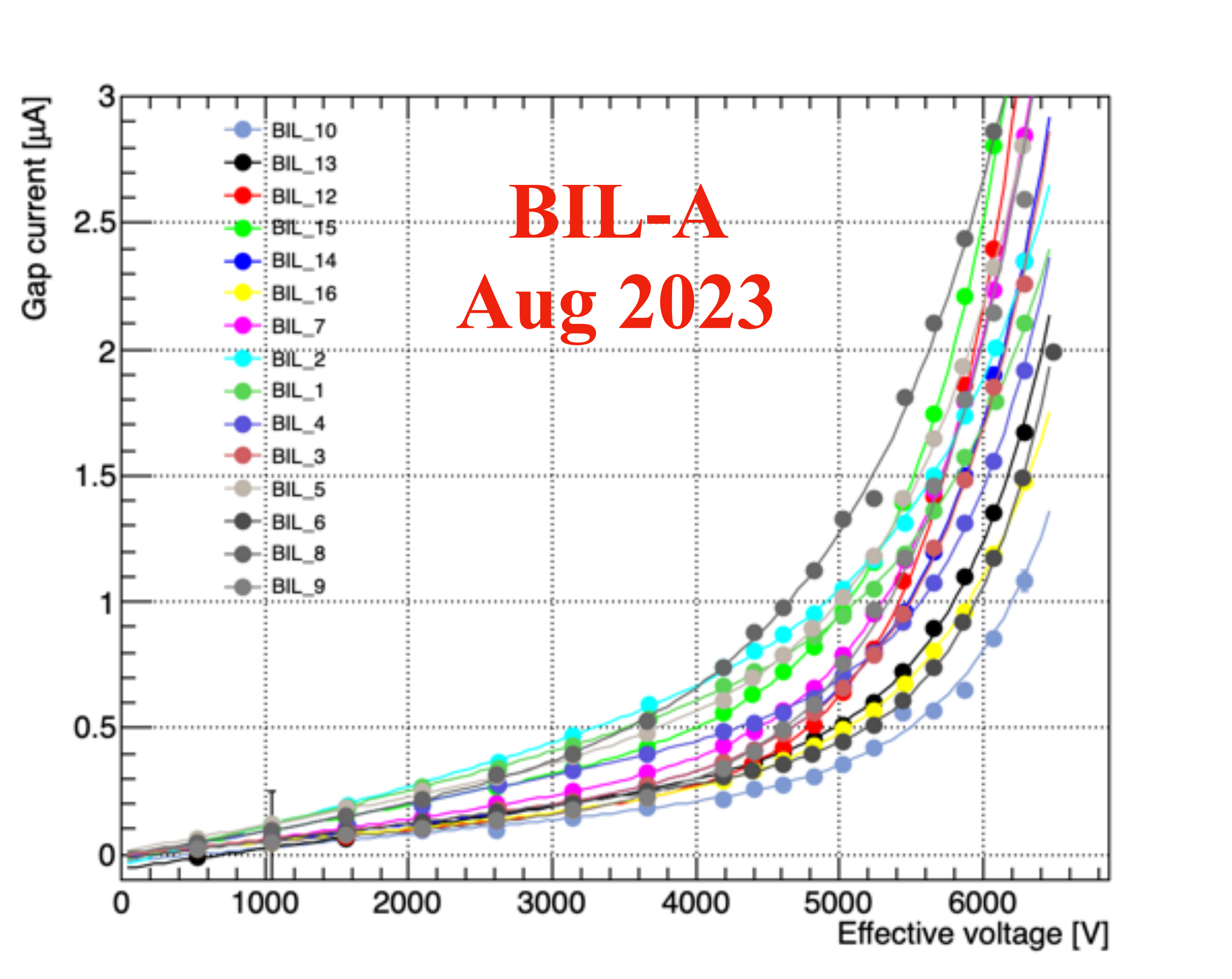
- 9 QA/QC tests carried out by the factory (GTE)
  - Graphite coating
  - Absence of scratches
  - Absence of bubbles
  - Glue producer recommendations
  - Envelope dimensions
  - Gas tightness before applying kapton
  - Mechanical rigidity
  - Current leakage before applying kapton
  - Oiling test using mock up gas volumes

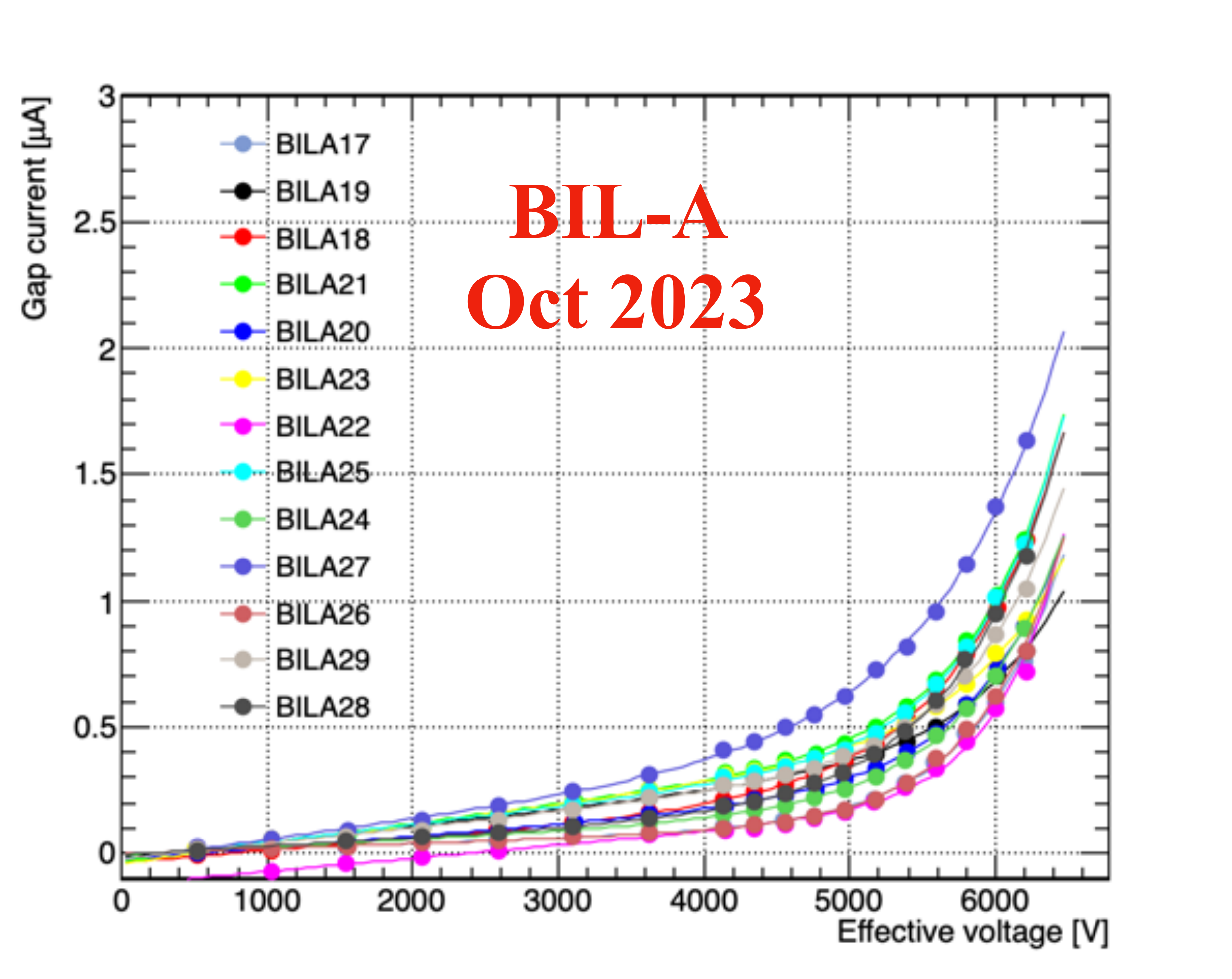
- QA/QC test carried out by CERN
  - Volt-Amperometric characteristic

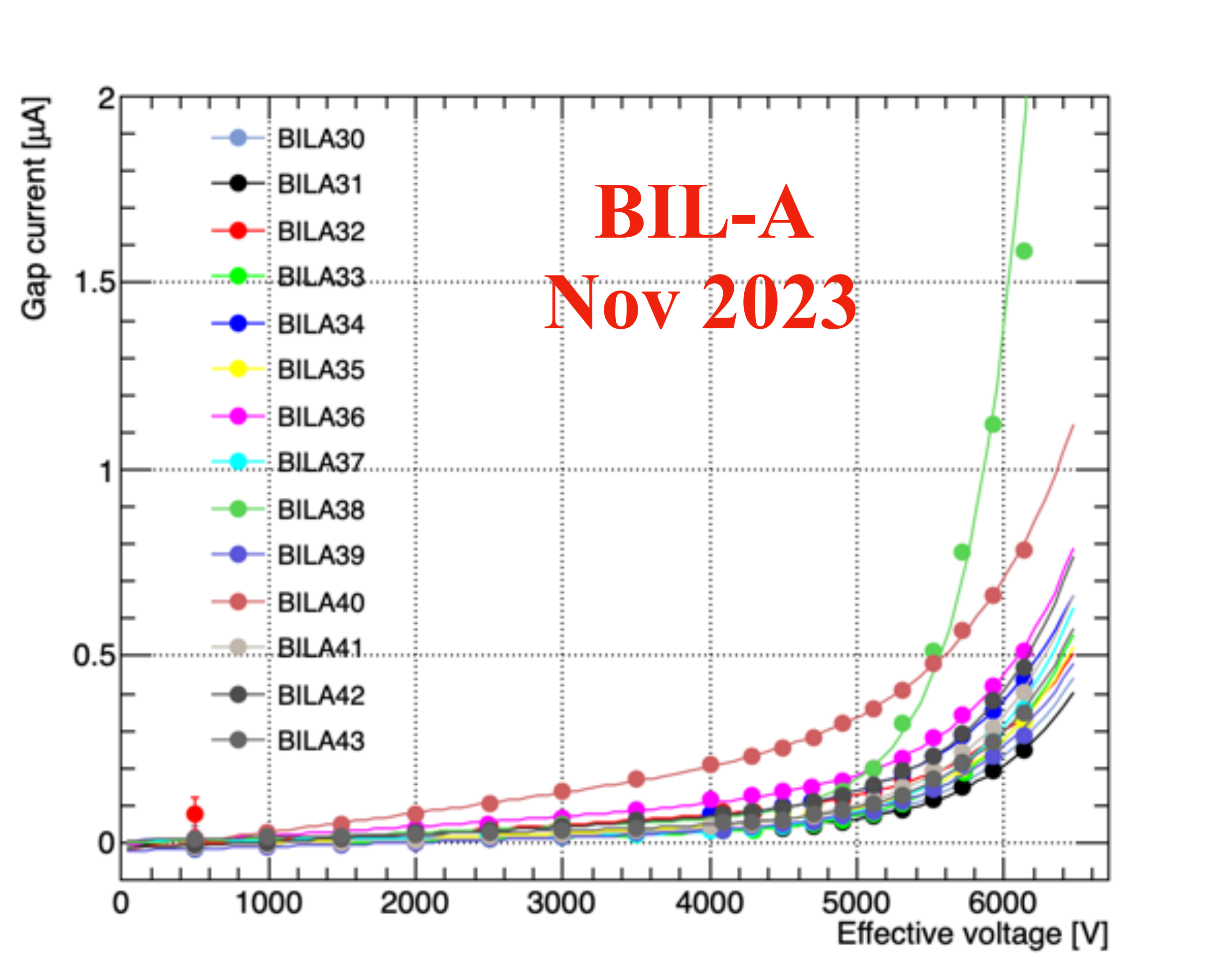


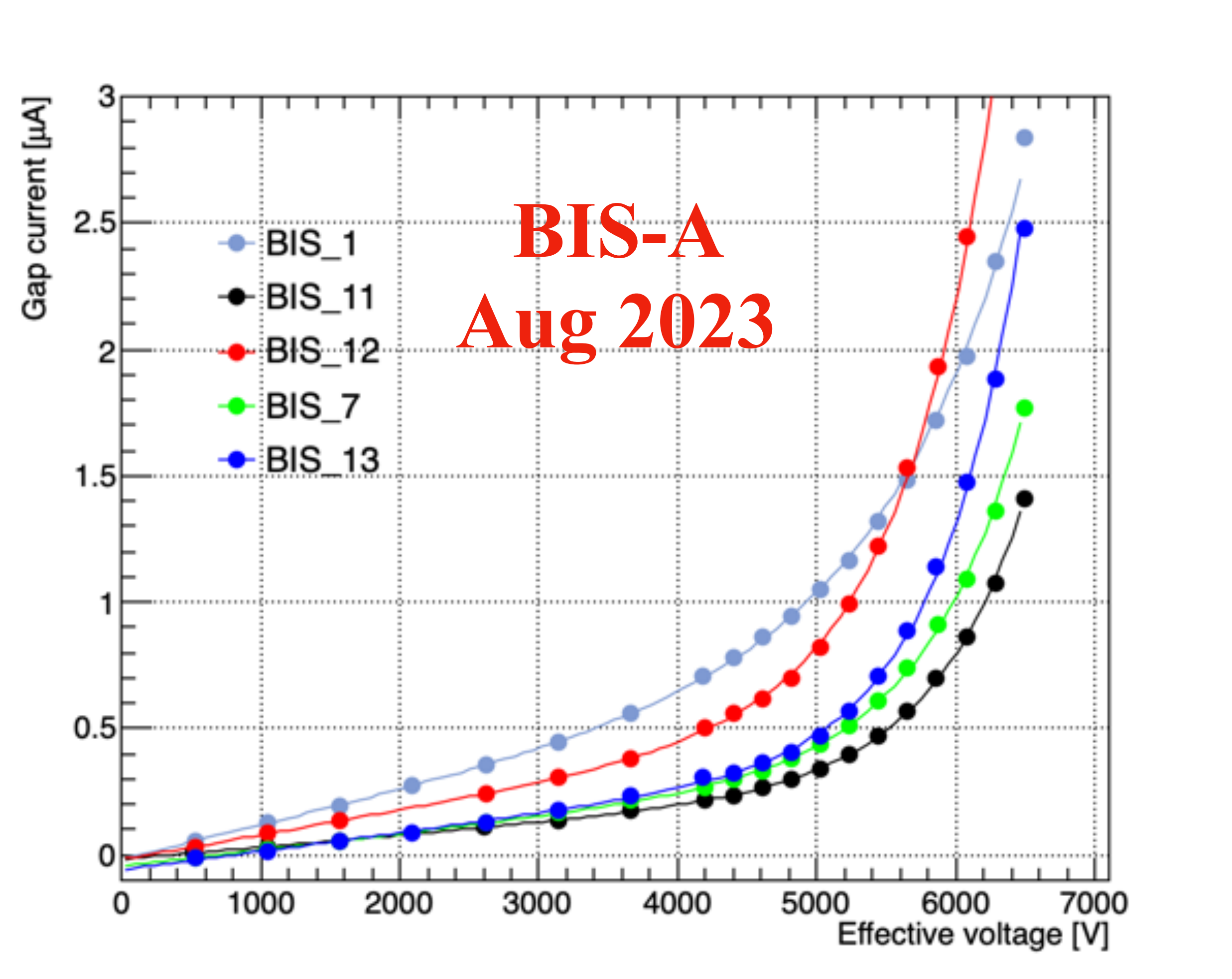
Total current

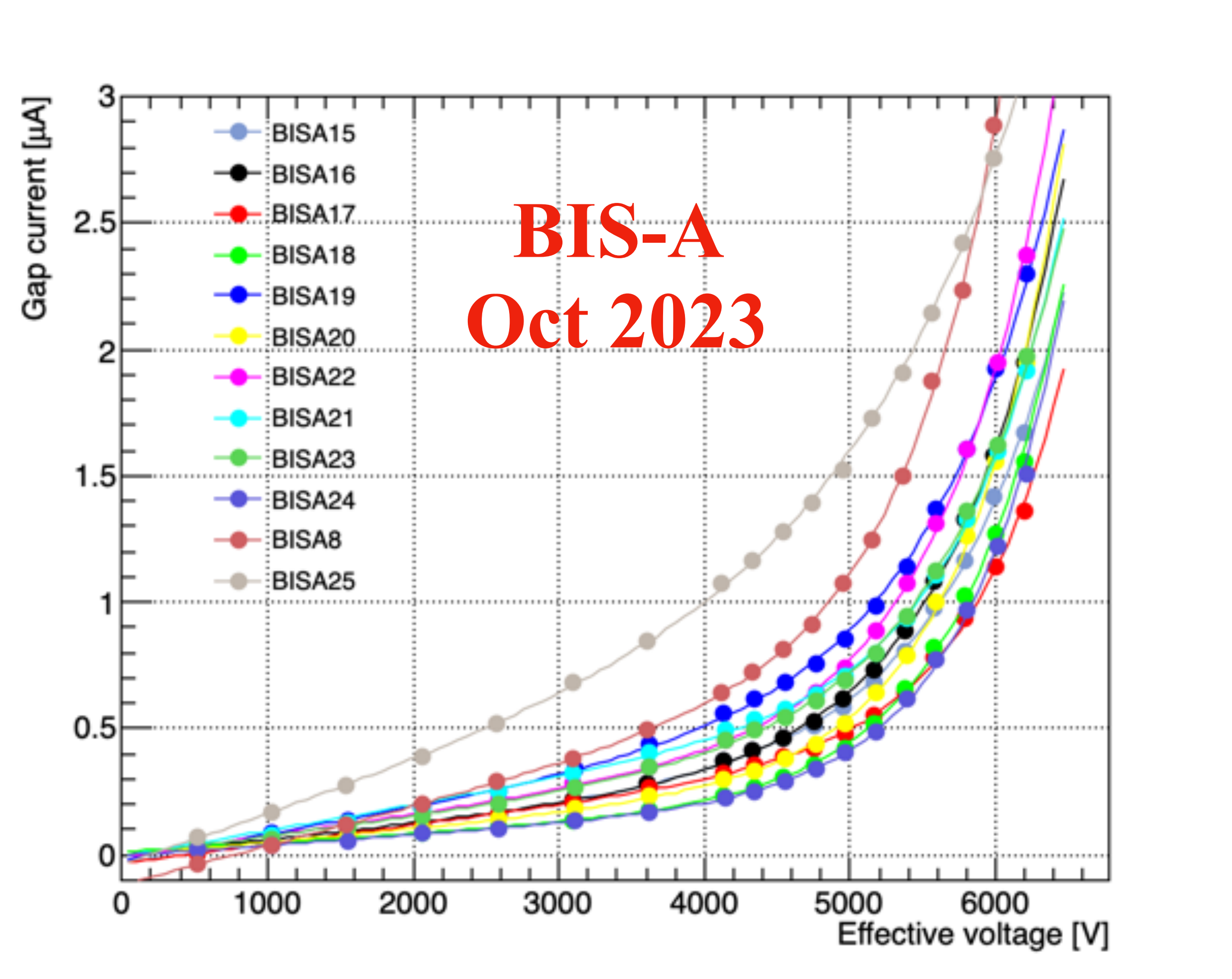
- Igap < 1 μA @3.5 kV
- Igap < 3 μA @6.1 kV (after ohmic current subtraction)

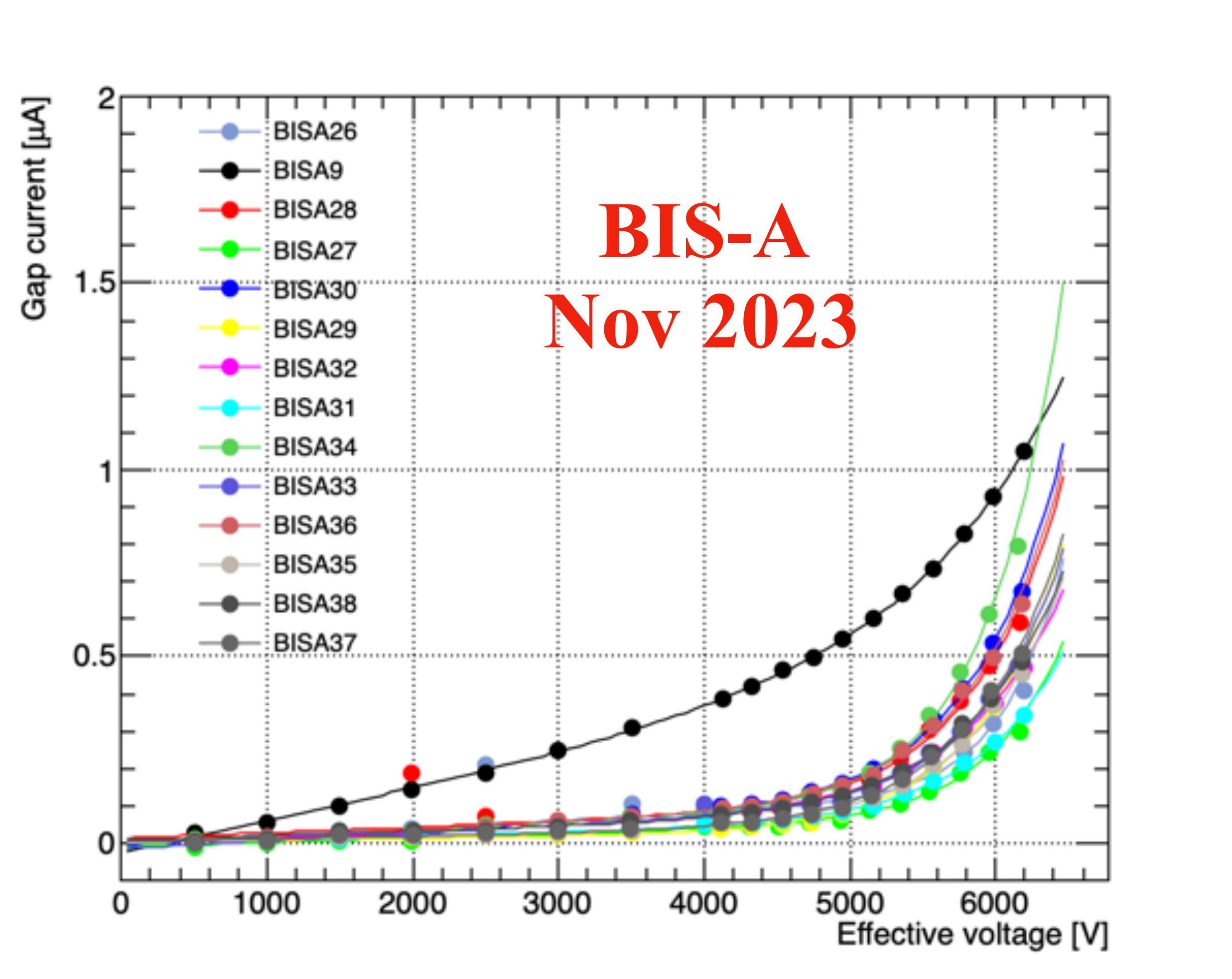






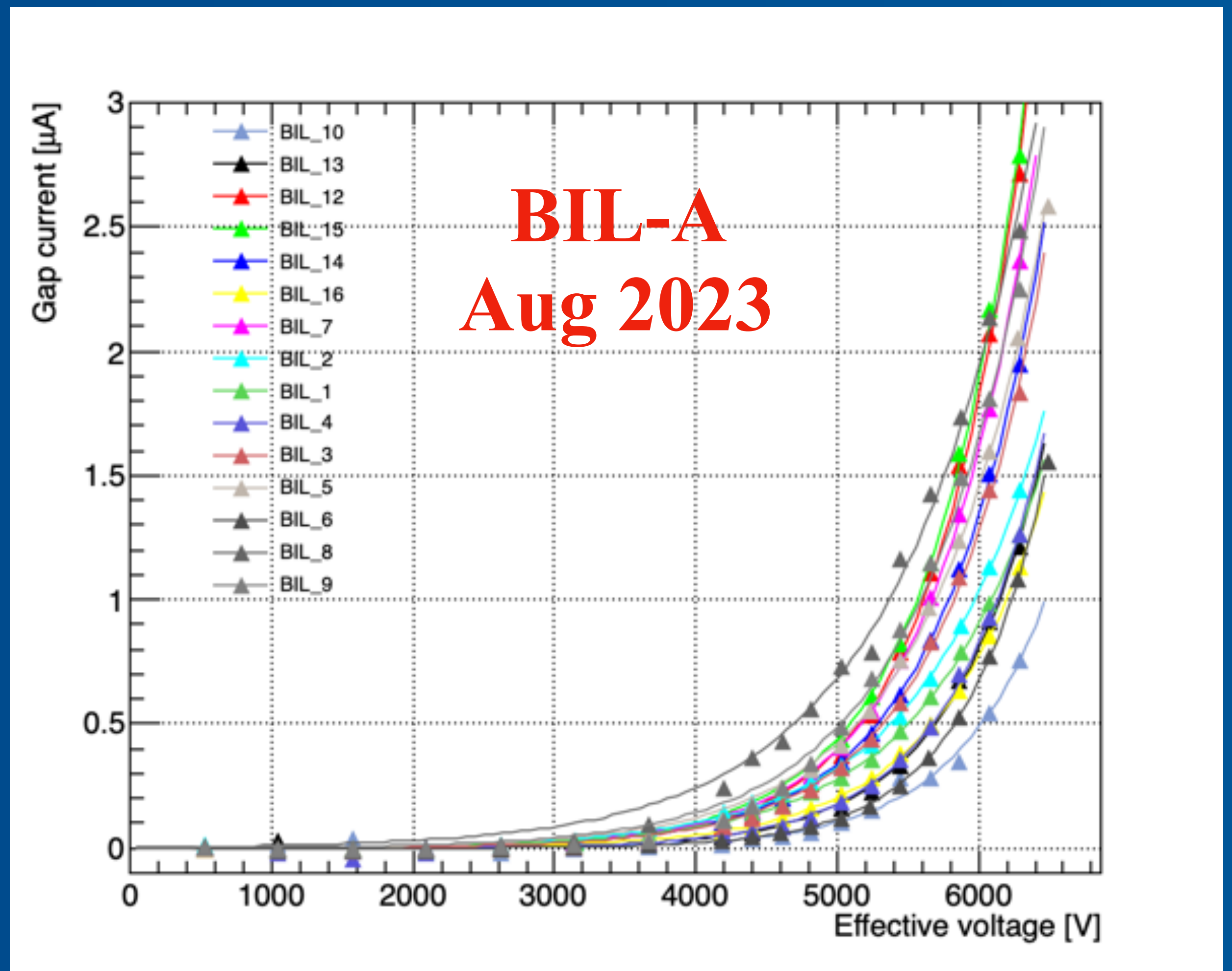


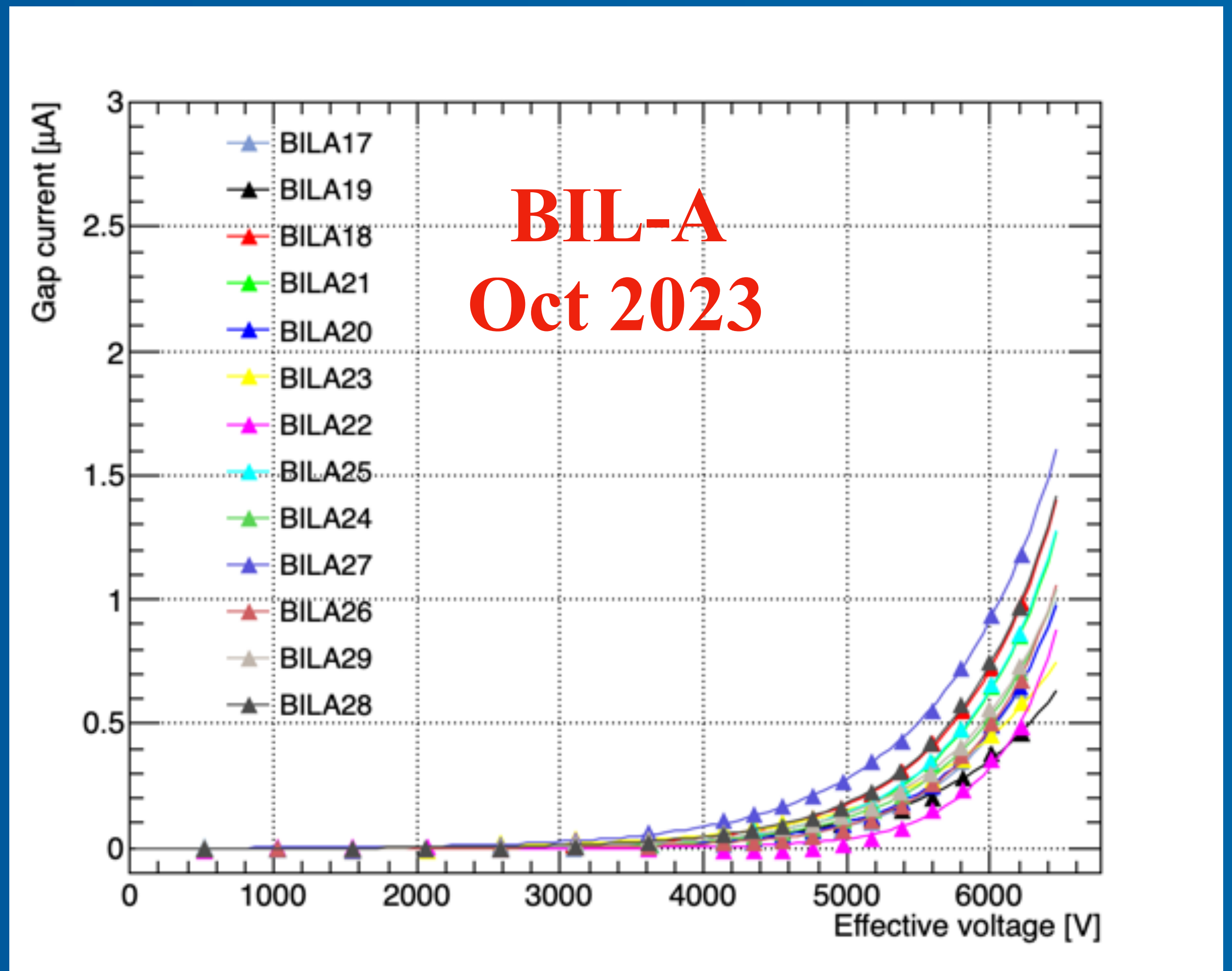


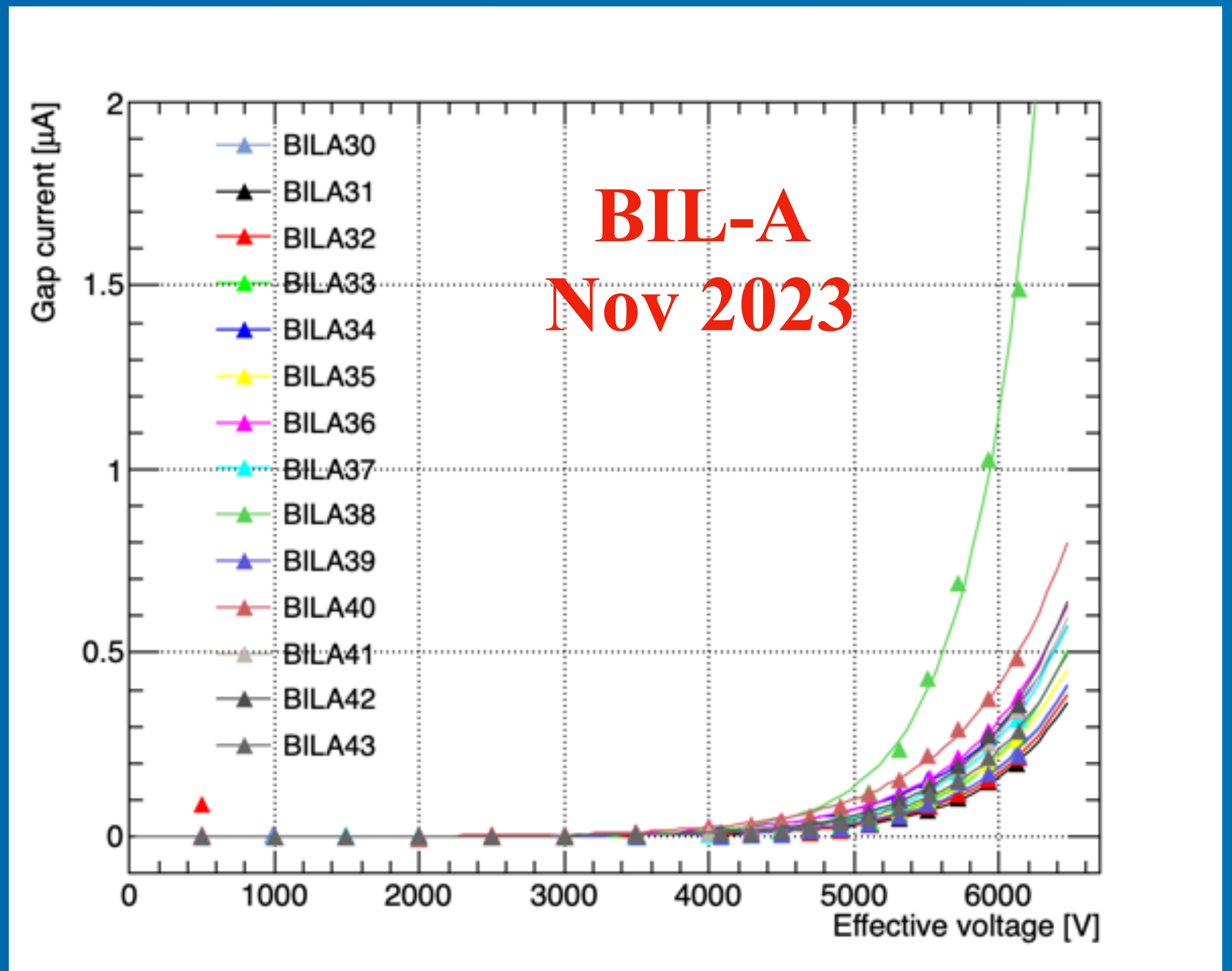


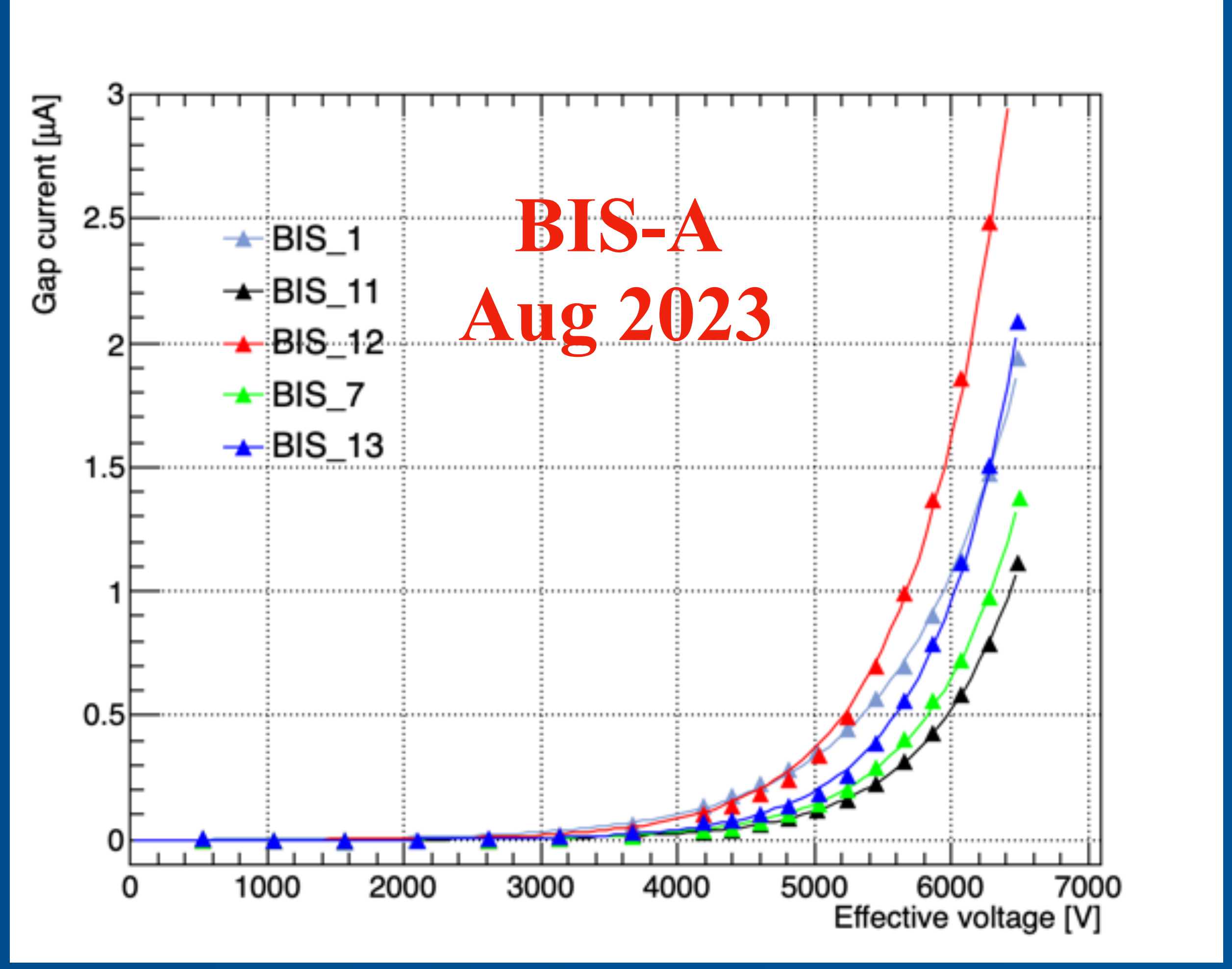
Current after ohmic subtraction

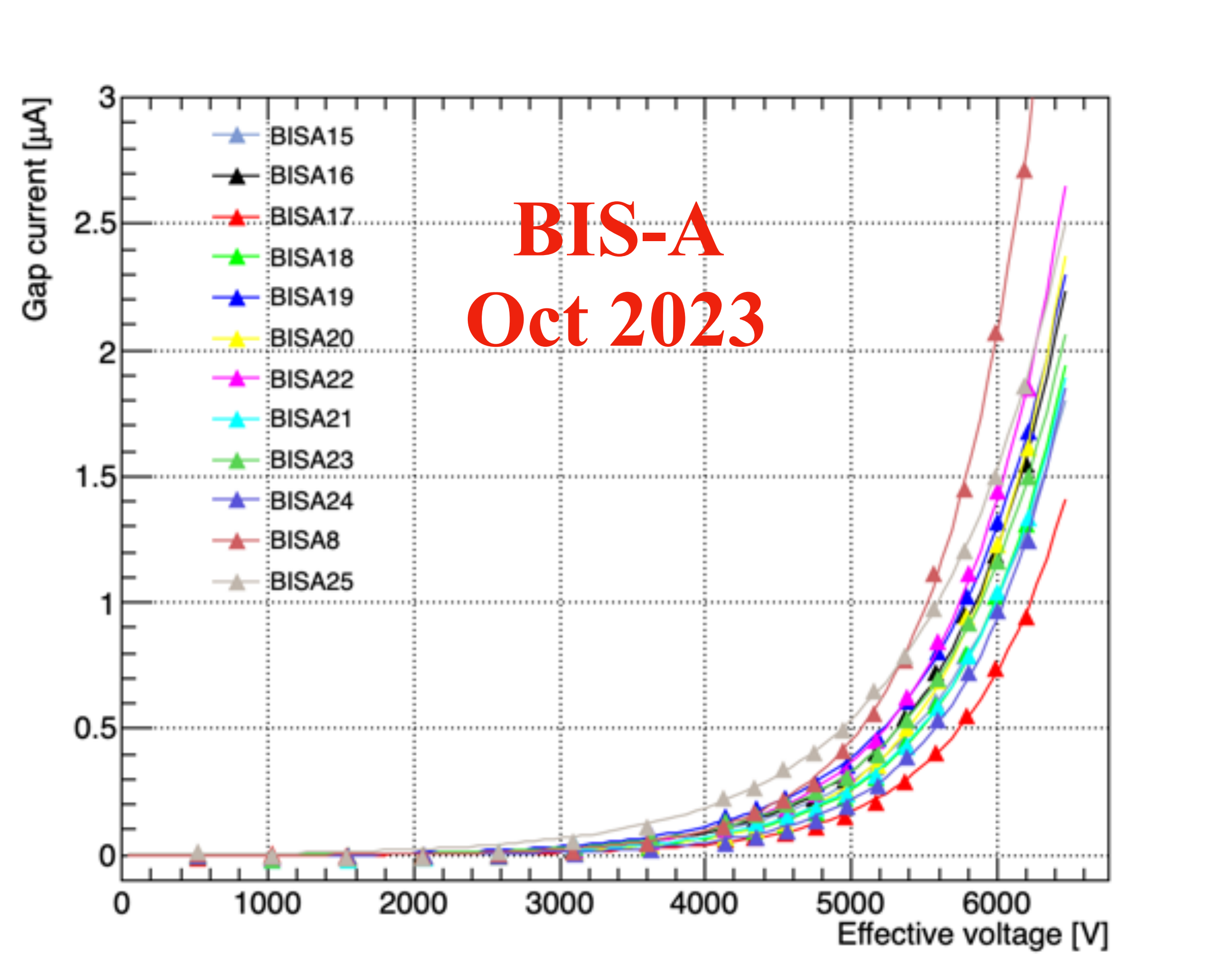
- Igap < 1 µA @3.5 kV
- Igap < 3 µA @6.1 kV (after ohmic current subtraction)

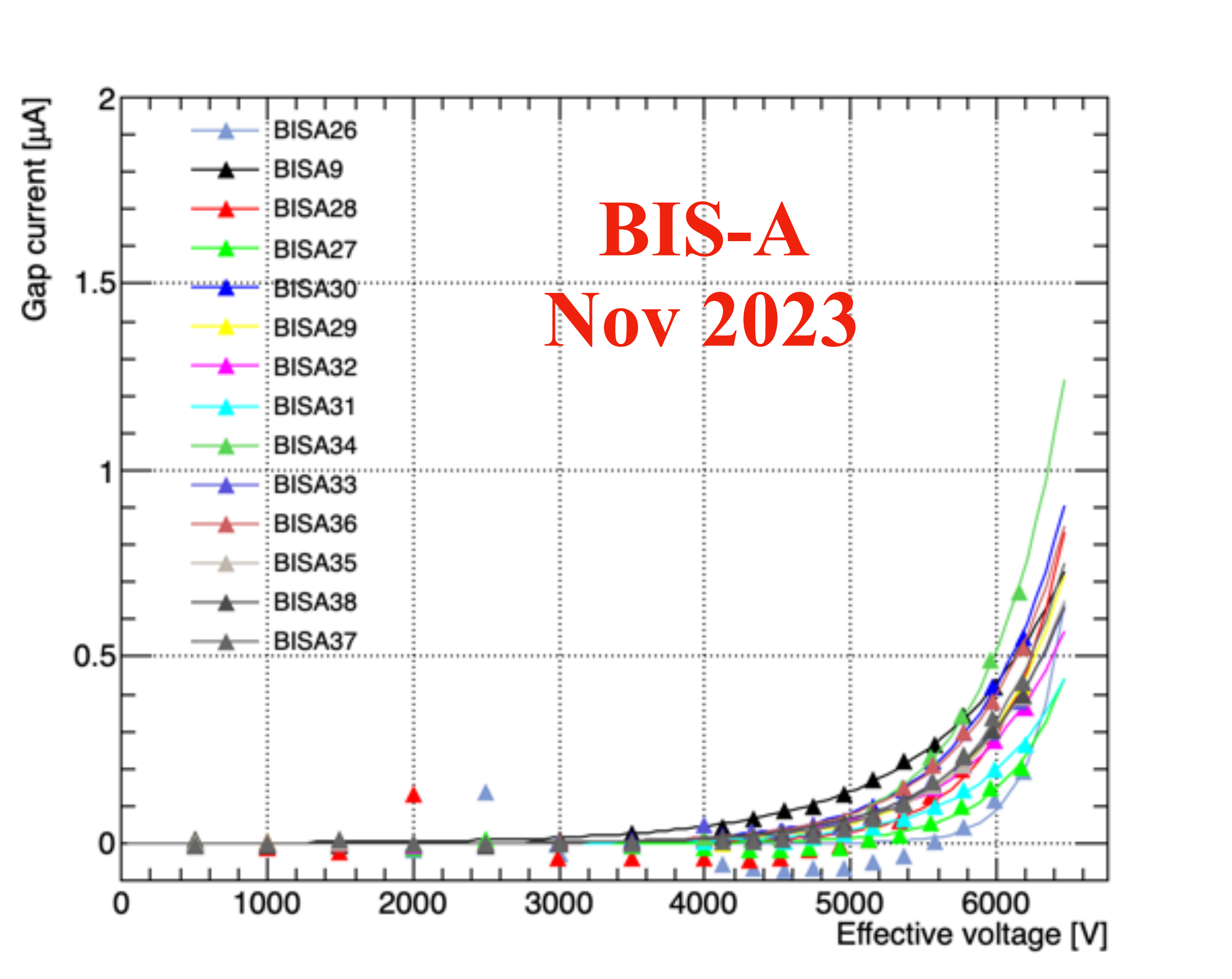












Production yield

- Produced (for the BI project) and tested
  - 43 BIL-A
  - 37 BIS-A

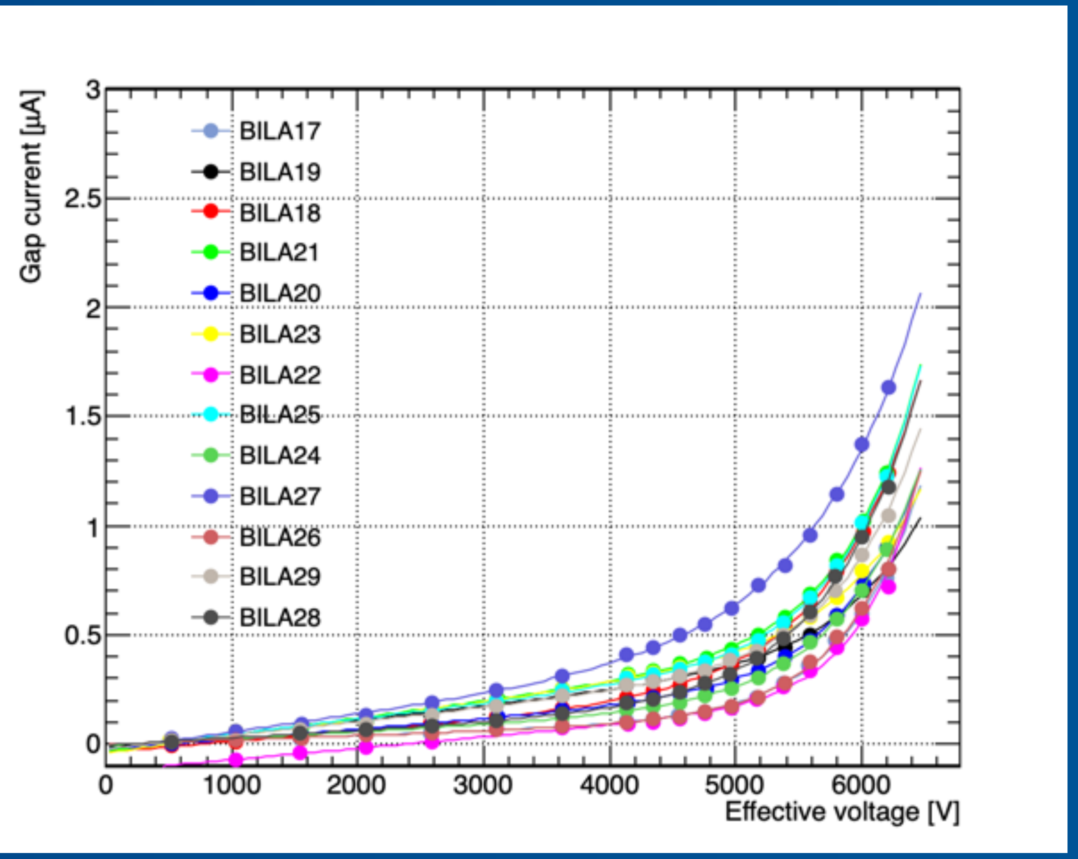
- 2 BIS-A gas volumes (5/23 and 10/23) do not pass the GTE QA/QC tests (current leakage test)
- 1 BIL-A gas volume (11/23) failed our test (high current at low voltage)

- Yield
  - 42/43 ~ 98% for BIL-A
  - 35/37 ~ 95% for BIS-A

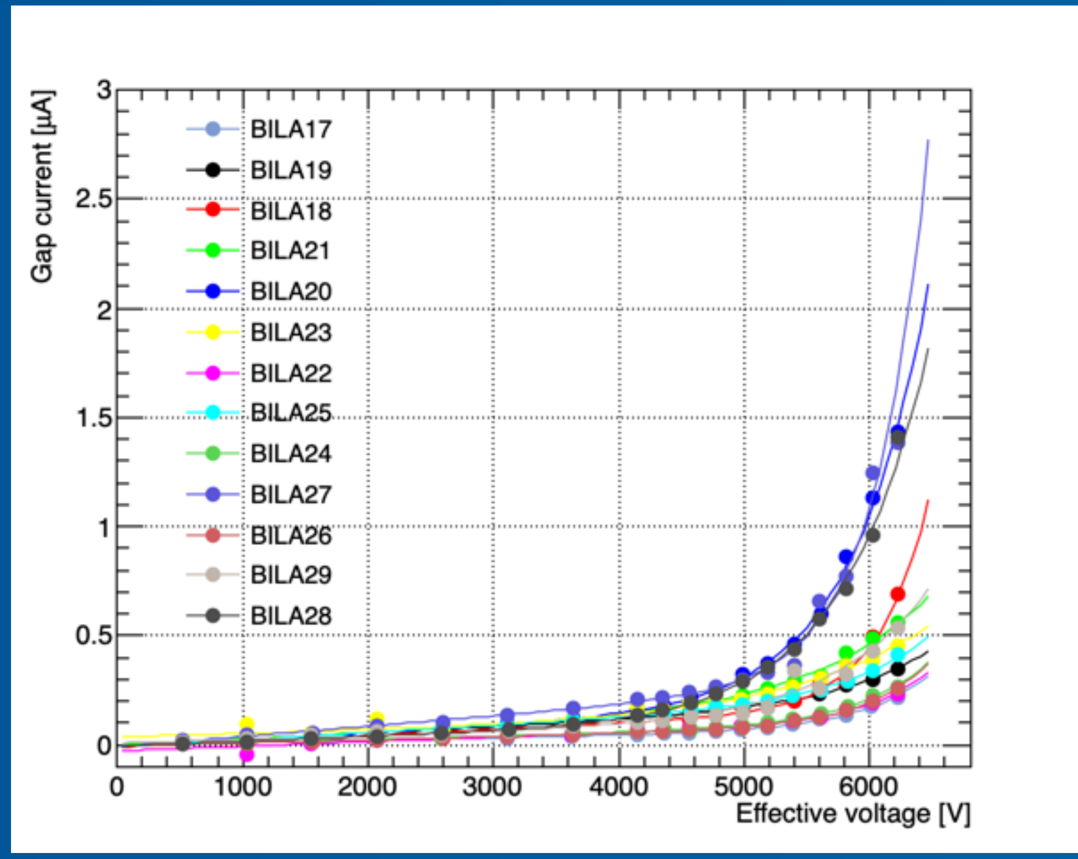
Conditioning: BIL-A October 2023

- Alternative conditioning procedure tested at GTE with 3 set of gas volumes
  - Approximately one week per each batch
  - Working-point HV applied but low currents (no irradiation)

Total current

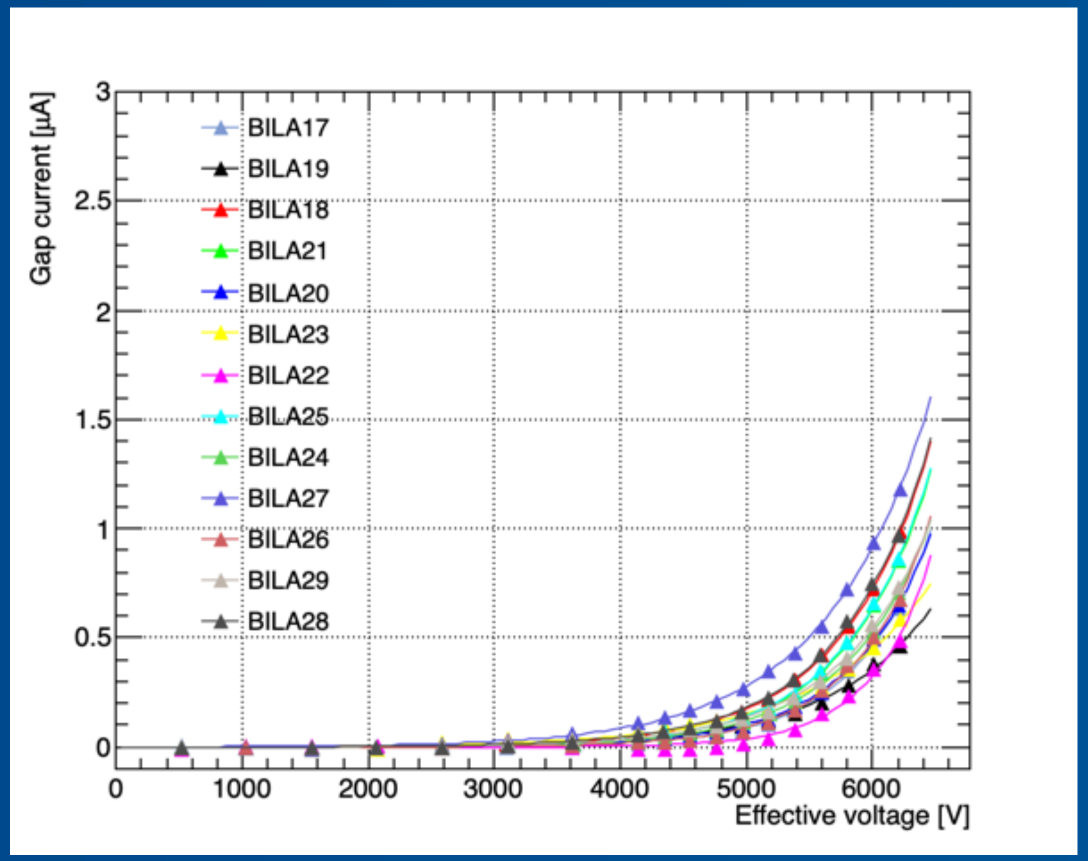


Total current

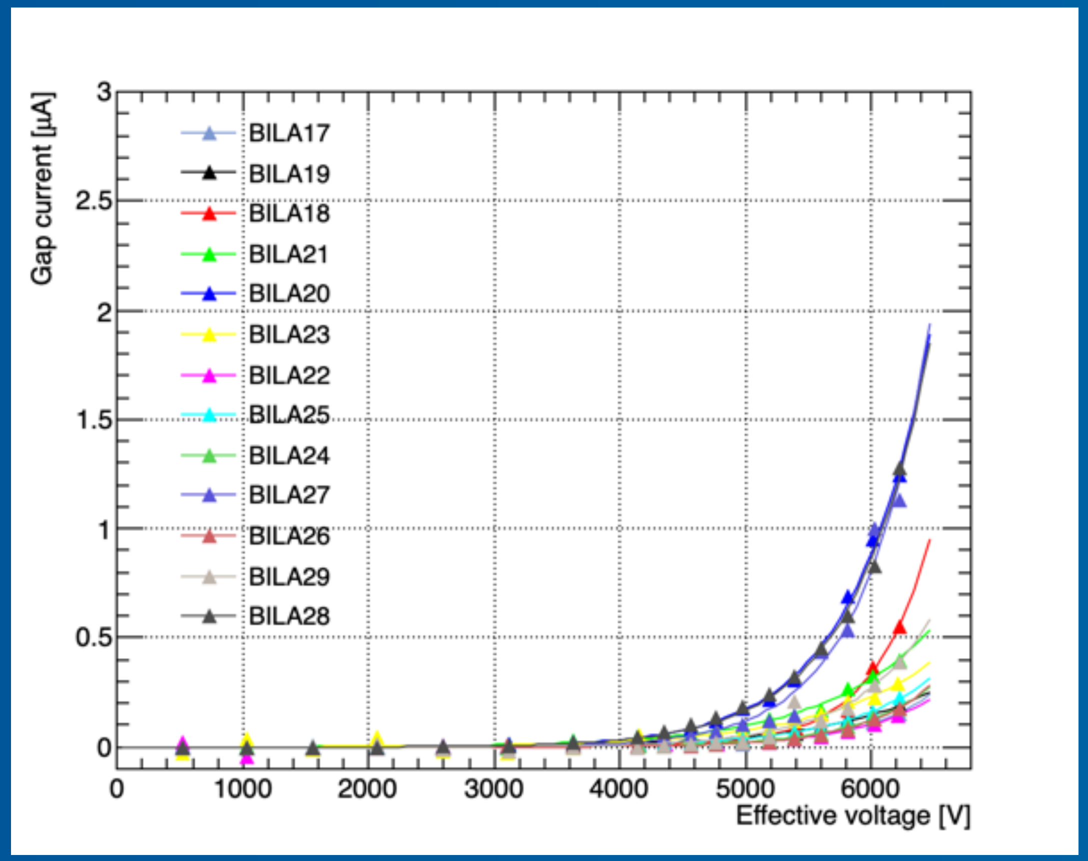


Mean current ratio at 3.5 kV:
0.15 / 0.08 = 1.84

Current after ohmic subtraction



Current after ohmic subtraction

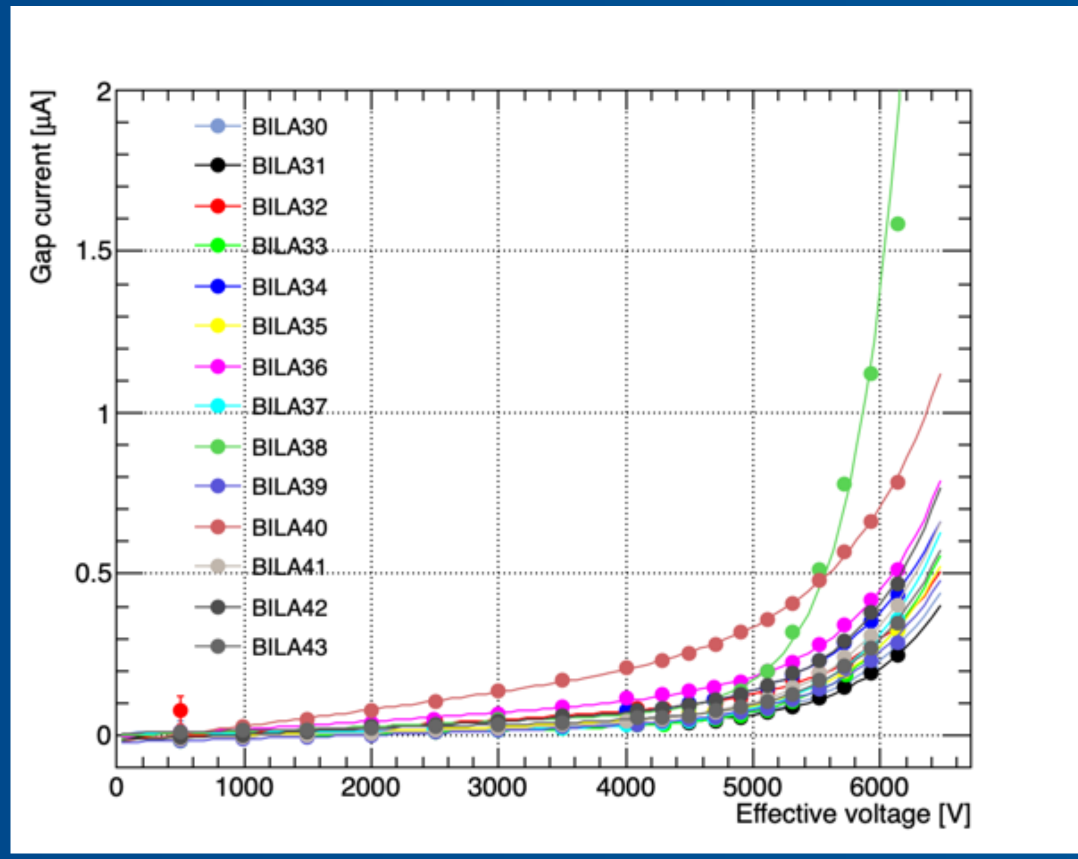


Mean current ratio at 6.1 kV:
0.65 / 0.40 = 1.61

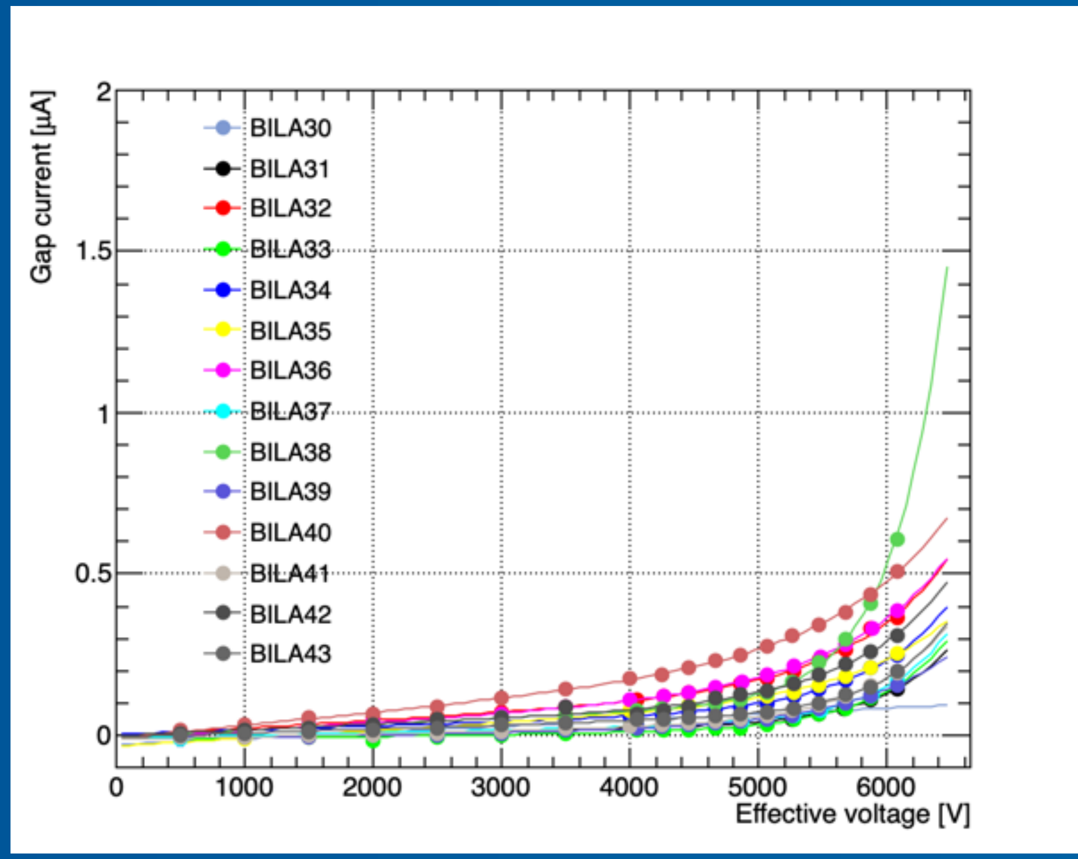
Conditioning: BIL-A November 2023

- Alternative conditioning procedure tested at GTE with 3 set of gas volumes
  - Approximately one week per each batch
  - Working-point HV applied but low currents (no irradiation)

Total current

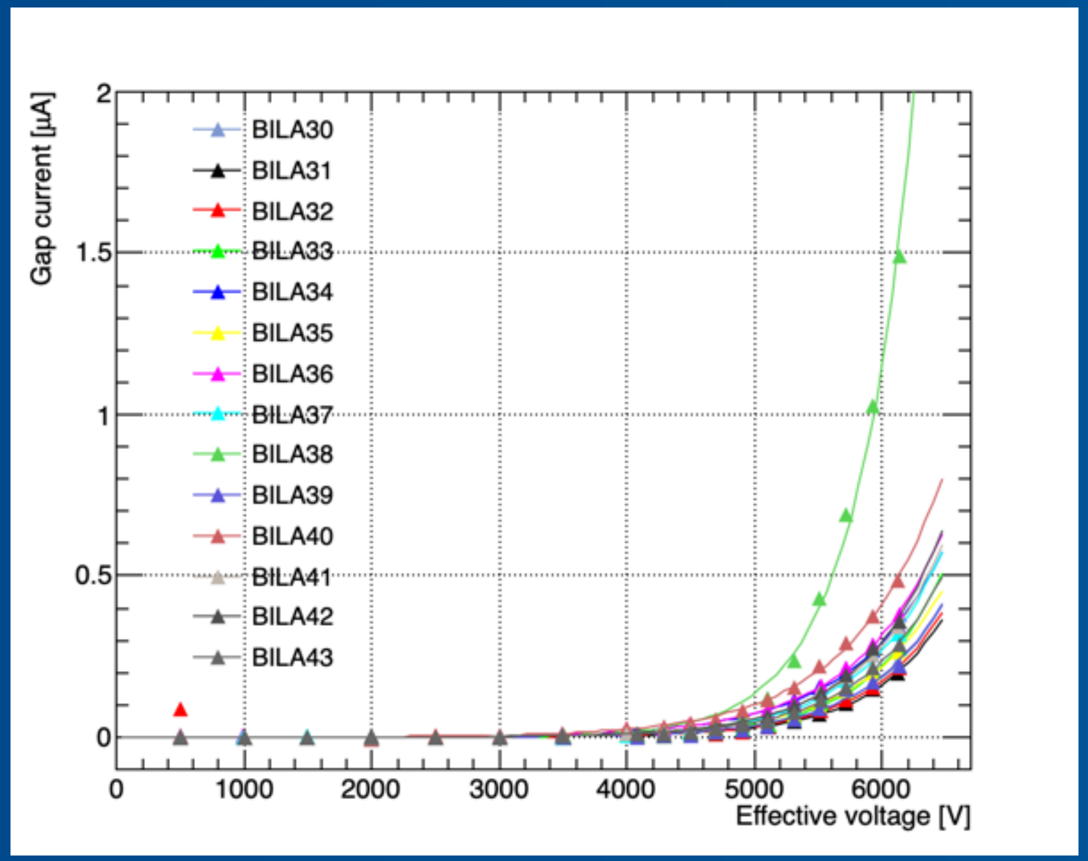


Total current

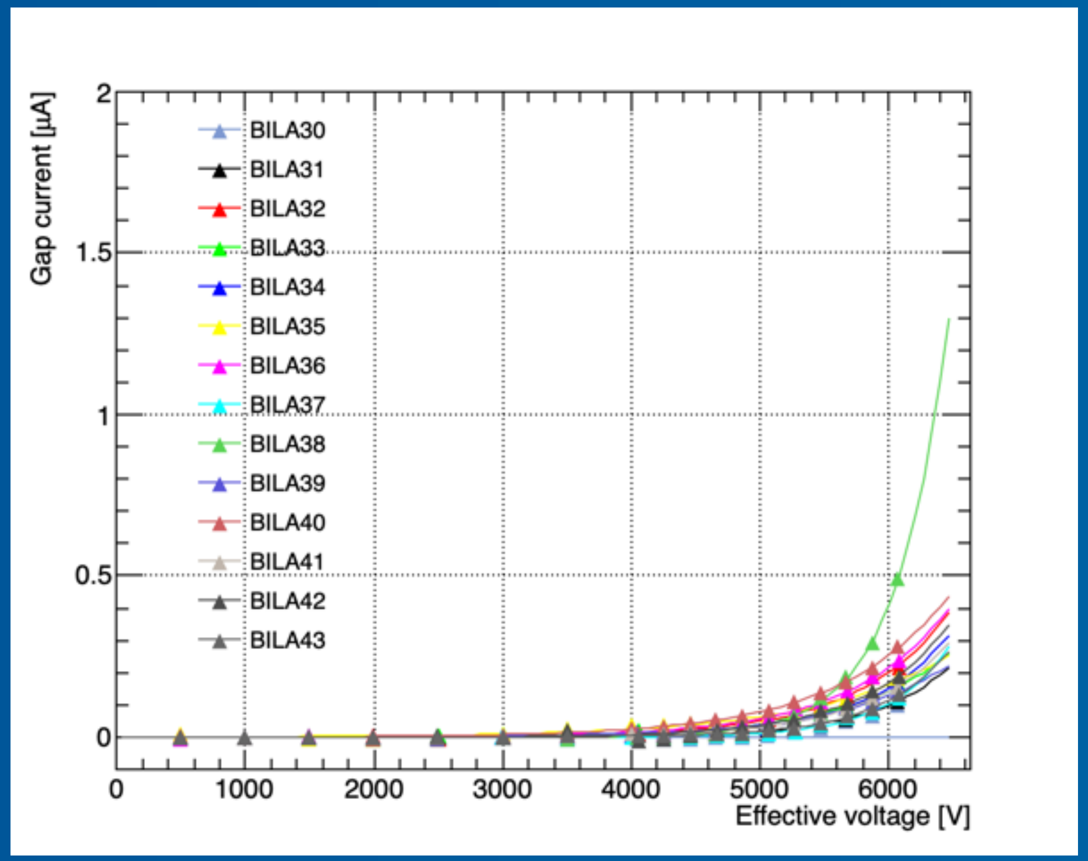


Mean current ratio at 3.5 kV:
0.0614 / 0.059 = 1.04

Current after ohmic subtraction



Current after ohmic subtraction

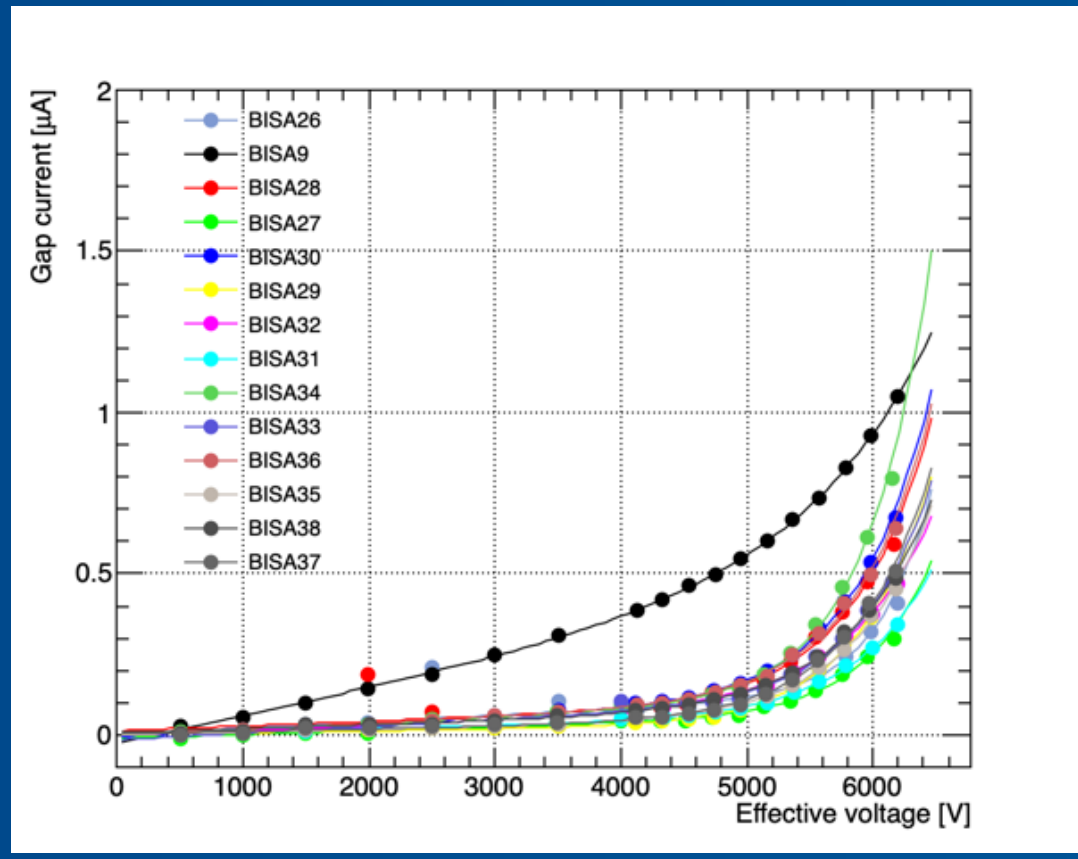


Mean current ration at 6.1 kV:
0.37 / 0.19 = 1.93

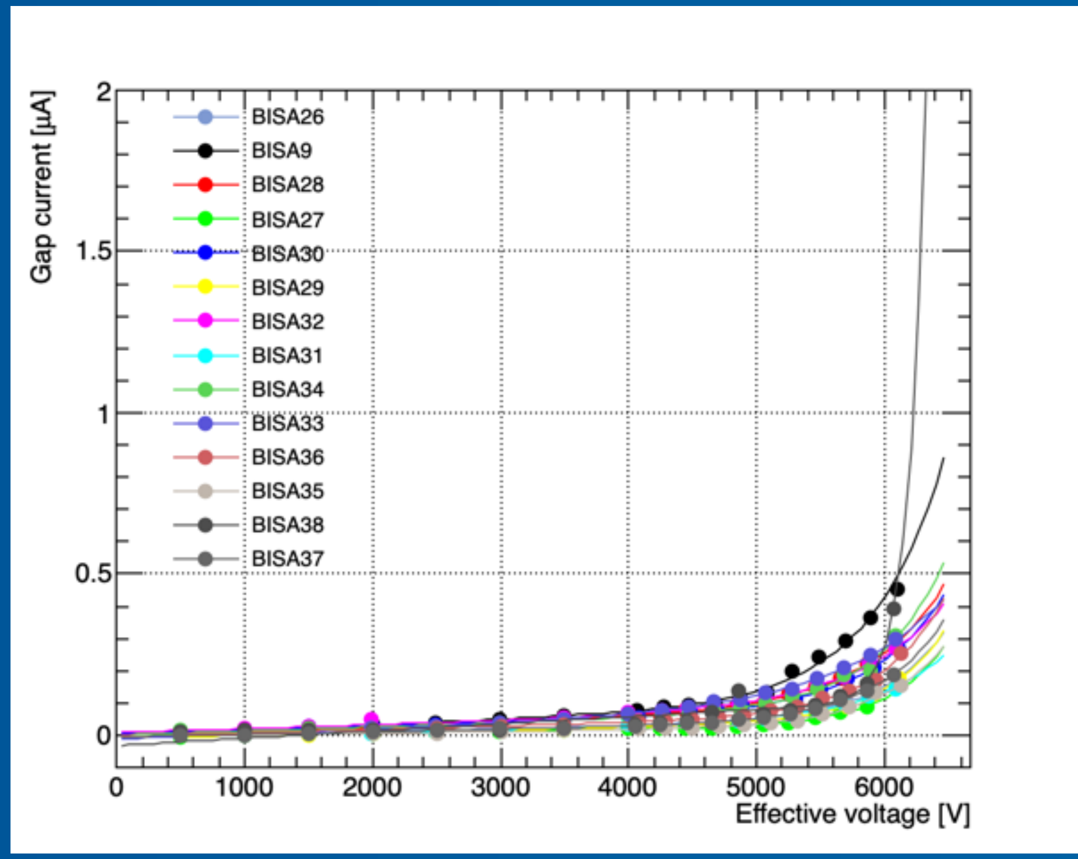
Conditioning: BIS-A November 2023

- Alternative conditioning procedure tested at GTE with 3 set of gas volumes
  - Approximately one week per each batch
  - Working-point HV applied but low currents (no irradiation)

Total current

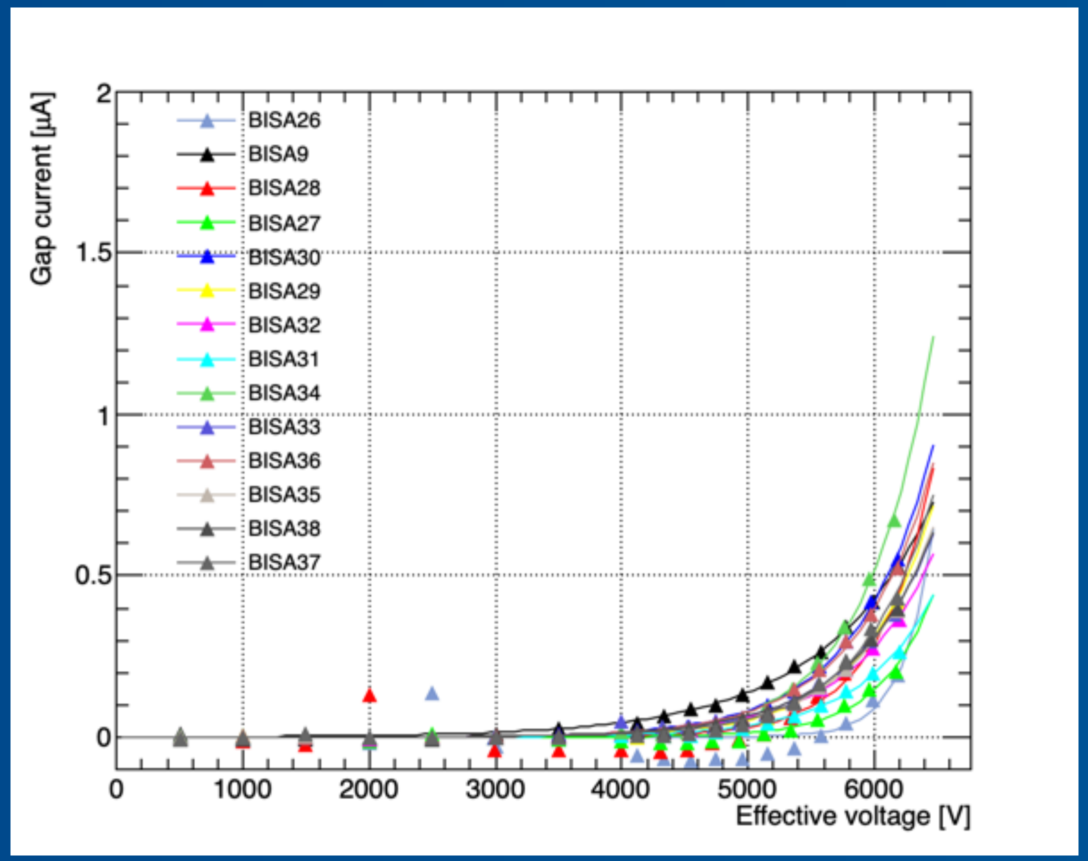


Total current

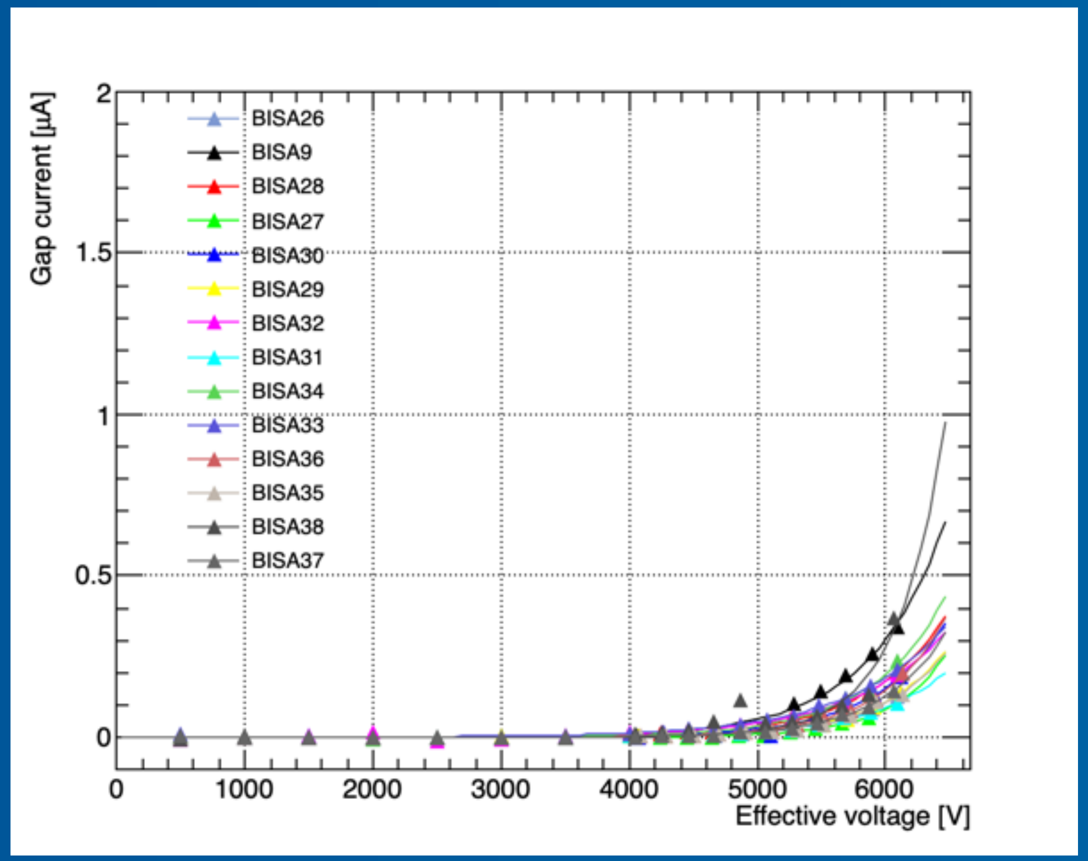


Mean current ratio at 3.5 kV:
0.084 / 0.034 = 2.5

Current after ohmic subtraction



Current after ohmic subtraction



Mean current ration at 6.1 kV:
0.37 / 0.19 = 1.9

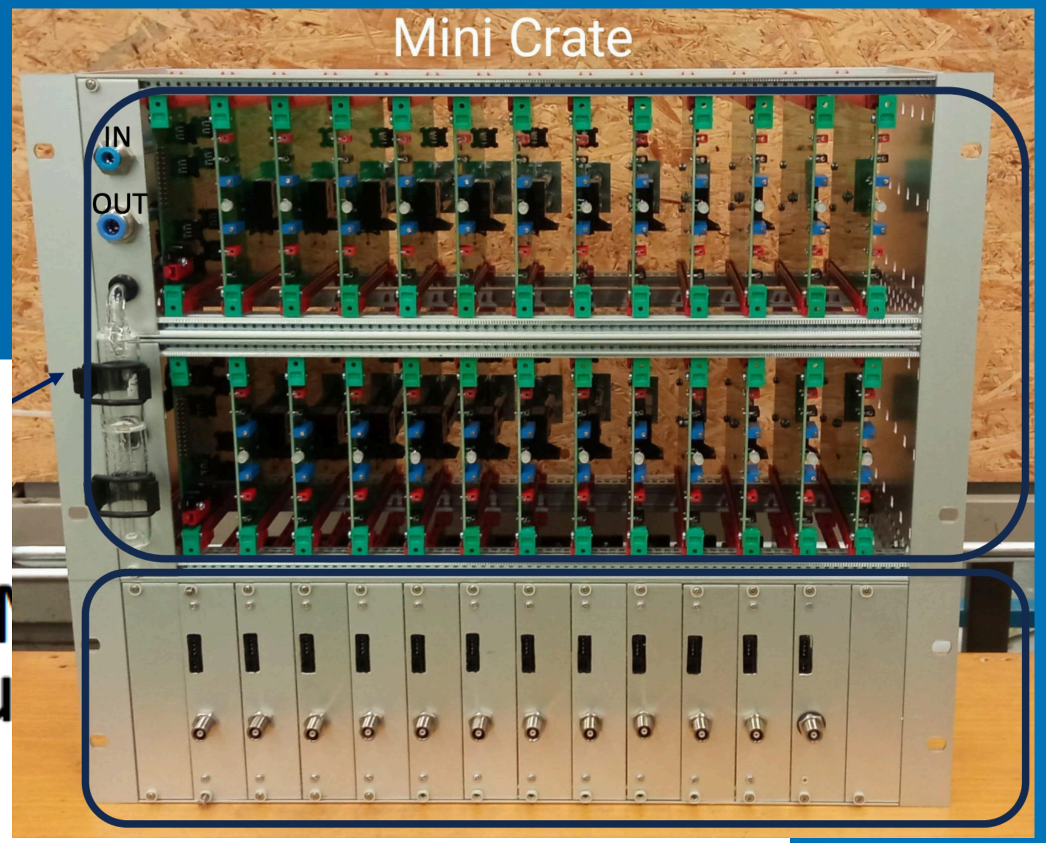
Lavori da terminare alla GTE

- **Obiettivi per inizio 2024**
  - Avere due carrelli (BIL e BIS) totalmente equipaggiati, ciascuno con il proprio mini-crate per HV, monitoring delle correnti e del flusso di gas
  - Avere il nostro sistema di distribuzione del gas in funzione, che ci consentirebbe la totale gestione da remoto (gas del progetto Tecnomuse attualmente in uso)
  - Avere un monitoring più affidabile della temperatura → leggere la temperatura del gas in uscita dalle gaps invece della temperatura nella stanza (bombole all'esterno)

- **Cose da fare**
  - Riparazione del minicrate attualmente sul carrello BIL (connessione tra gas pipe ed distributore del gas rotta)
  - Installazione miminicrate sul carrello BIS, portato da Alessandro dal CERN a Roma
  - Sensore di temperatura sull'uscita del gas
  - Sistema del gas: come metterlo a norma?
    - Varie idee: box chiusa collegata con l'esterno? mixer all'esterno? Rivelatore fughe di gas?
    - Chi lo certifica?
  - Test delle 10 BIL prodotte a Dicembre → da fare il prima possibile a Gennaio

Back-up slides

Stato dei minicrates (by Alessandro)



Costs:

1 minicrate costs around 4k€. The expense was shared between the institutes (USTC 8785€, I
3334€). INFN had already financed the construction costs of the first prototype currently in u

Person-Power :

The design and assembly of the minicrate required a great effort in terms of person-power, as all the components were custom made. The design of the entire system and the development of the PCB boards involved 2 Roma 2 technicians for a few months. The technical support of three technicians from Bologna and a mechanical technician from MPI made it possible to speed up the component assembly phase in the last month.

Status:

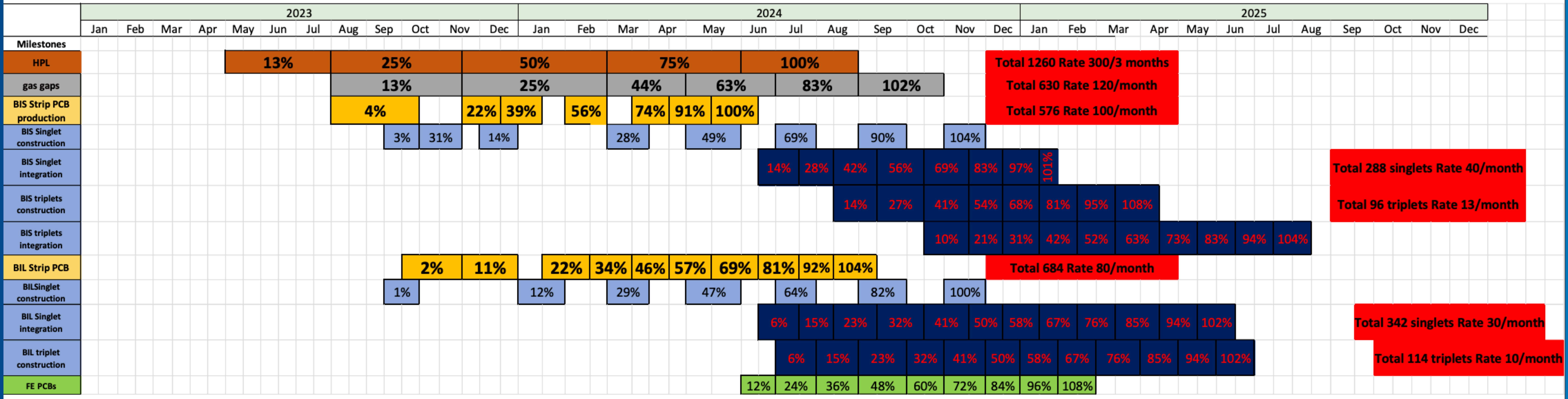
- Almost all components for the assembly of 5 minicrates have been ordered (pending order of approximately €1k).
- Most of the components for the assembly of one minicrate have been shipped to Rome for the assembly at GTE as part of the BIS trolley.
- Some components ordered from RS and not yet delivered are causing assembly delays
- A test is pending to evaluate the impedances to be used for testing at GIF++, where a gas flow 10 times higher than that used at the production site is expected.

	Pre-production 2023			2024					2025				
	Aug 2023	Sept-Nov		Dec-Feb	Mar-Apr	May-Jun	Jul-Sept	Oct-Nov	Dec-Feb	Mar-Apr	May-Jun	Jul-Sept	Total
Gas Gaps													
BIL 1A BIL680		63		37		48	20						168
BIL 1B BIL520				48	48				30				126
BIS 2A BIS1		45		6									51
BIS 2B BIS2-6				48	48	48	48	48					240
BIL D E X Y Z								33					33
BIL C							24						24
BIS78 T7-1 (7L)							9						9
BIS78 TZ-2 (7S)								15					15
Total		108	0	139	96	96	101	96	30	0	0	0	666
# weeks						52+9=61							

	Aug 2023	Sept-Oct	Jan		Mar-Apr	May-Jun	Jul-Sept	Oct-Nov	Dec-Feb	Mar-Apr	May-Jun	Jul-Sept	Total
HPL	EDH9502173	EDH9823644											
BIL1A	126	74	96		40								336
BIL1B		96	96			60							252
BIS2A BIS1	90	12											102
BIS2B BIS2-6		96	192		192								480
BIL D E X Y Z					66								66
BIL C					48								48
BIS78 T7-1 (7L)					18								18
BIS78 TZ-2 (7S)						30							30
Total	216	278	384	0	364	90	0	0	0	0	0	0	1332

Version 13 Nov 2023

BIS and BIL optimal plan for integrated singlets



RPC chamber production

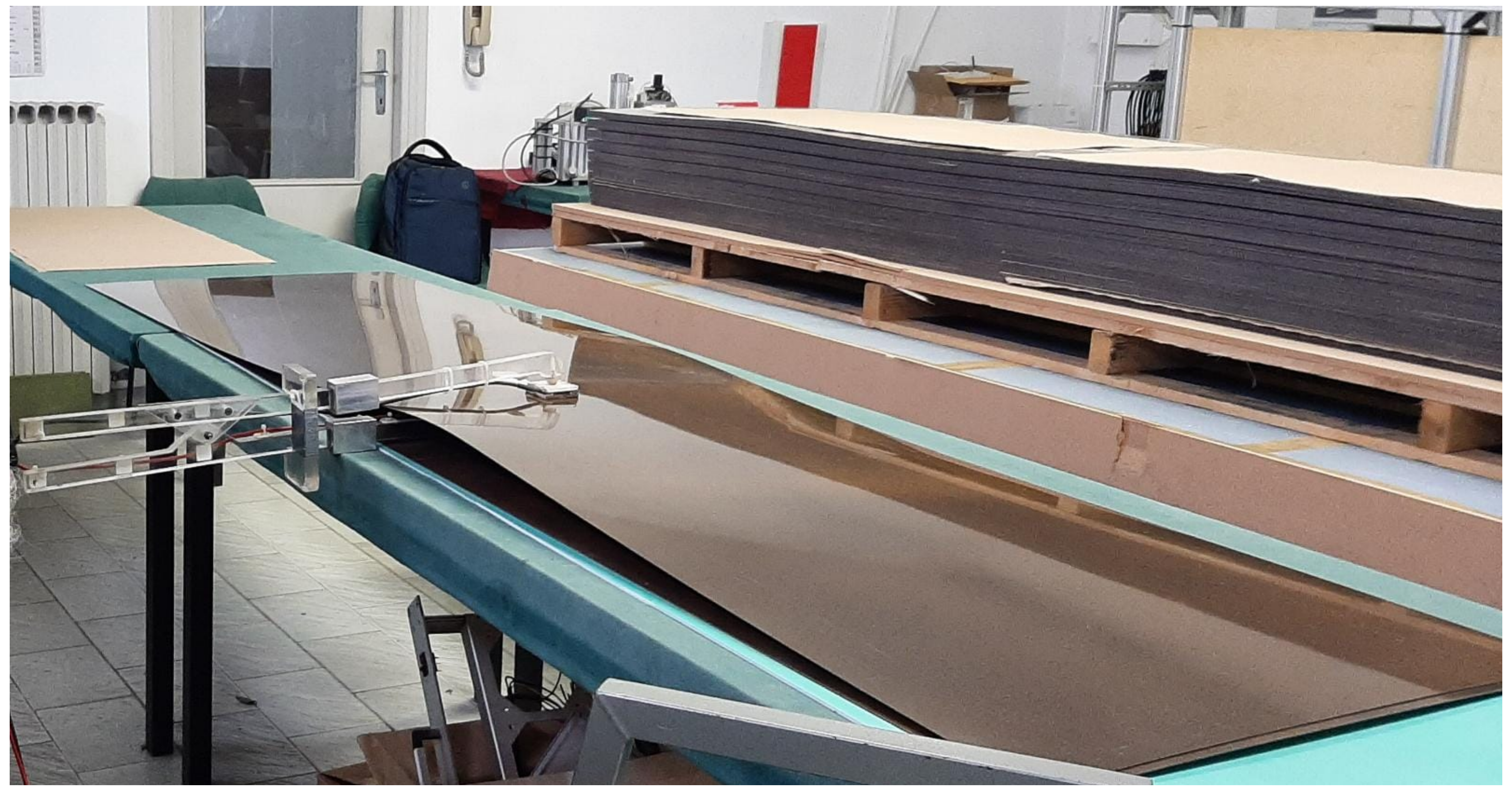
	BIL CHAMBER TYPES											BIS chamber	
Type	A	B	C	D	E	X	Y	Z	Special chambers Sector 9			A	B
	680	**520**	**680C**	**520C**	**680Z**	**520X**	**520BY**	**520Y**	**520S**	**320S**	**320SS**	**BIS 1**	**BIS 2-6**
Length	2650	2650	2218	2218	2340	2650	2650	2218					
Width	680	520	680	520	680	520	520	520					
Special feature						YES	YES	YES					
Prototypes	1	1	0	0	0	0	0	0	0	0	0	1	0
Total # of chambes excluding prototypes	55	42	16	2	2	1	4	2	4	1	1	16	80
Gas Gaps	**165**	**126**	**48**	**6**	**6**	**3**	**12**	**6**	**12**	**3**	**3**	**48**	**240**
HPL panels	**330**	**252**	**96**	**12**	**12**	**6**	**24**	**12**	**24**	**6**	**6**	**96**	**480**

- Full list of BIL and BIS chambers, gas volumes and HPL plates (divided in different types)
- BIL-680 and BIS-1 are the gas volumes currently in production at GTE

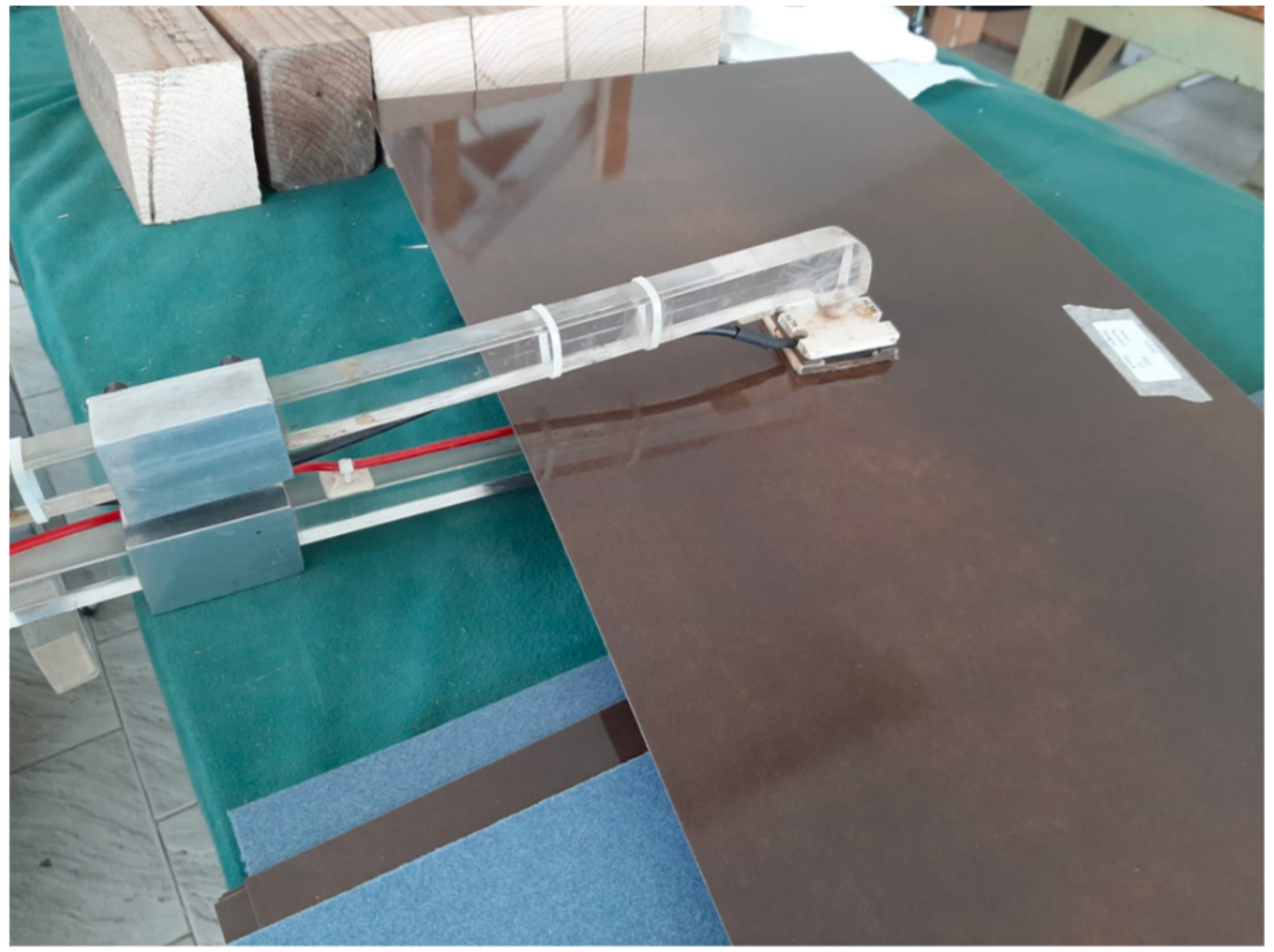
HPL plates

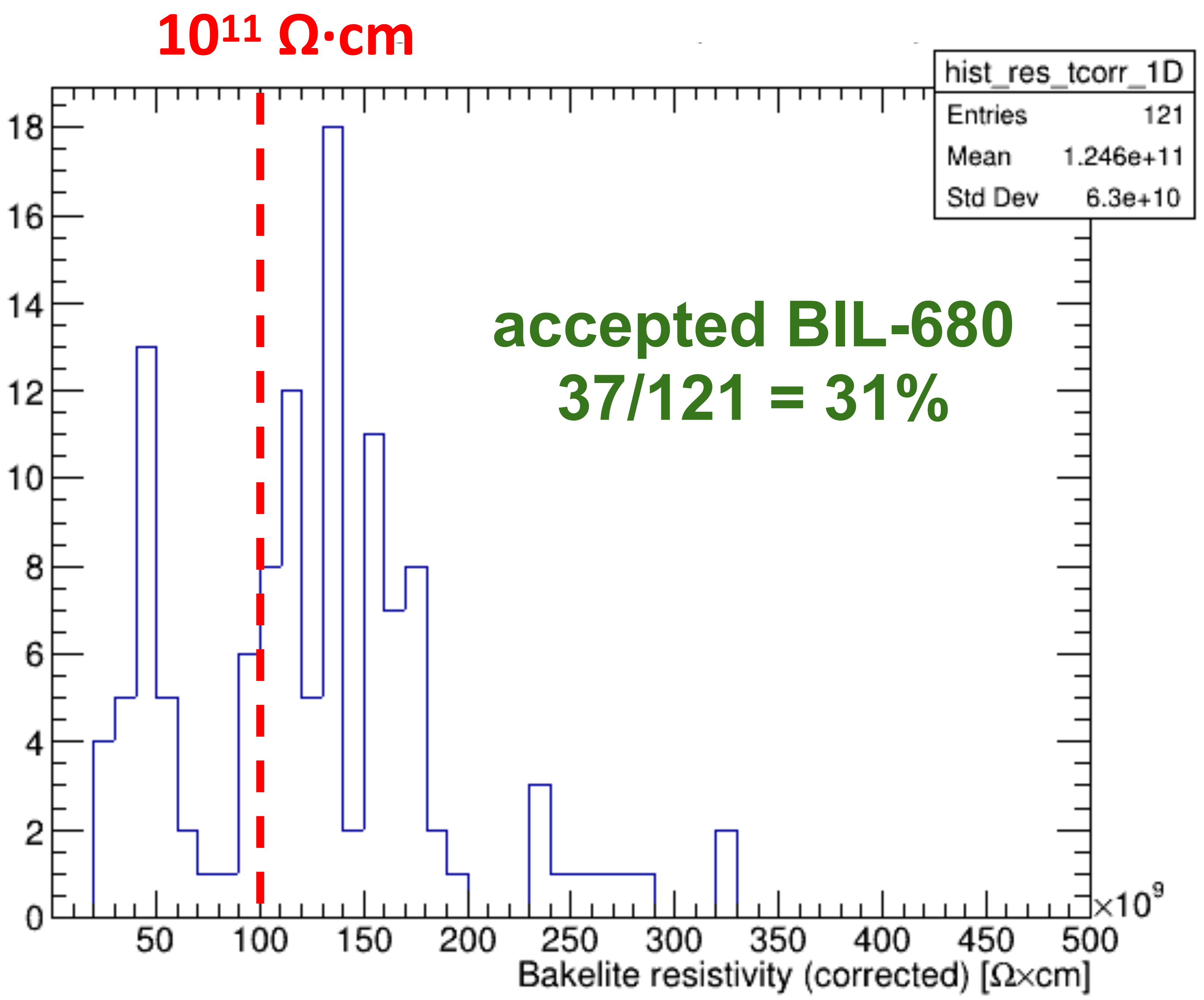
Teknemika (Milan, Italy)

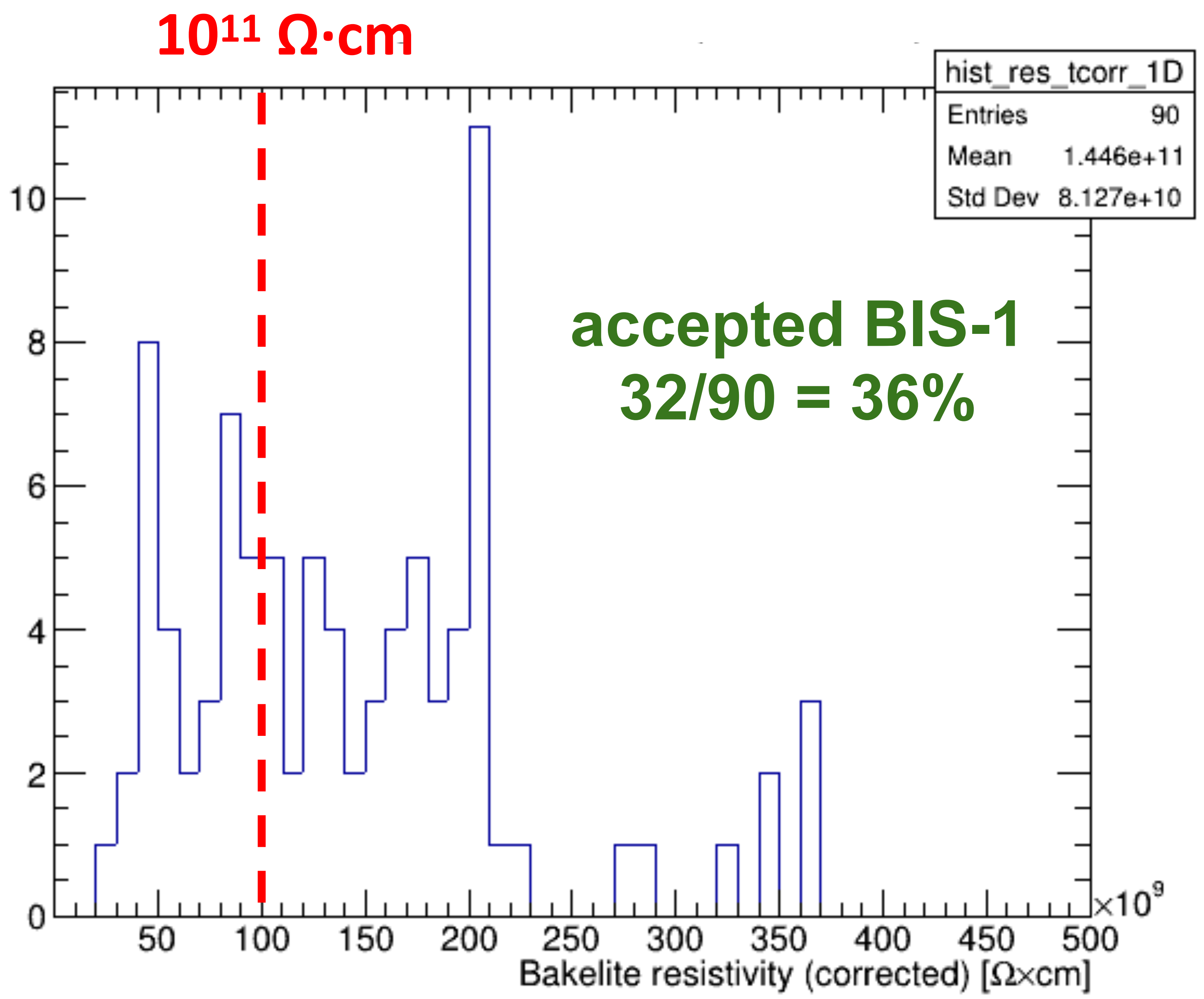
HPL plates: resistivity measurement



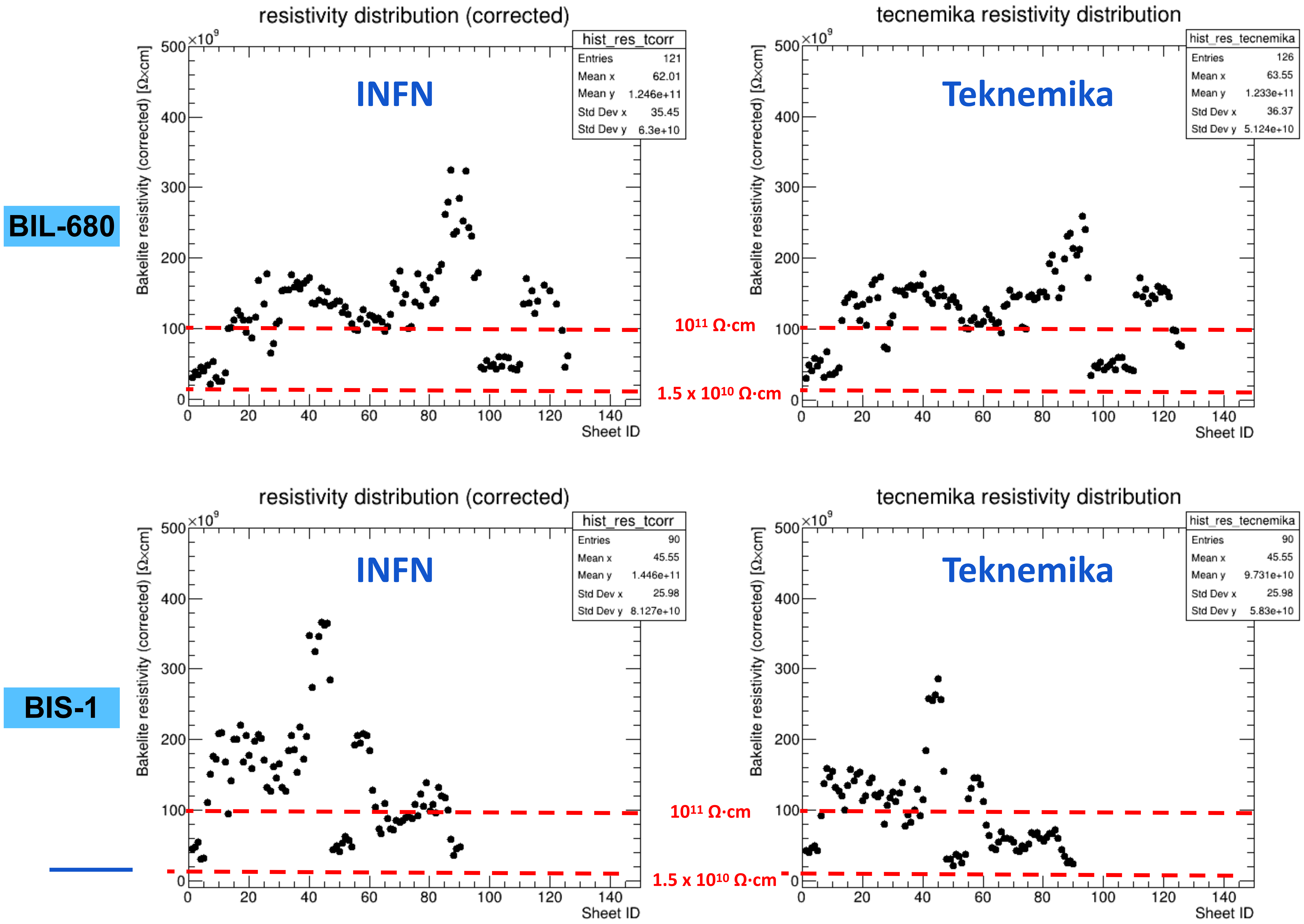
- The requirement on the HPL bulk resistivity is 1.5 - 6 · 10^{10} Ω·cm
- Specific resistivity values can be achieved tuning the parameters (time, temperature and pressure) during production and are measured by Tecknemika
- First batch of HPL delivered in March: 126 BIL-680 and 90 BIS-1 type. The resistivity of most of the plates was off, but the plates were shipped anyhow to GTE
- At GTE the resistivity was checked by INFN and found to be comparable with Teknemika measurement
- HPL plates with resistivity above 10^{11} Ω·cm were rejected and were replenished by Teknemika in July







Resistivity measurements of the HPL plates delivered in March



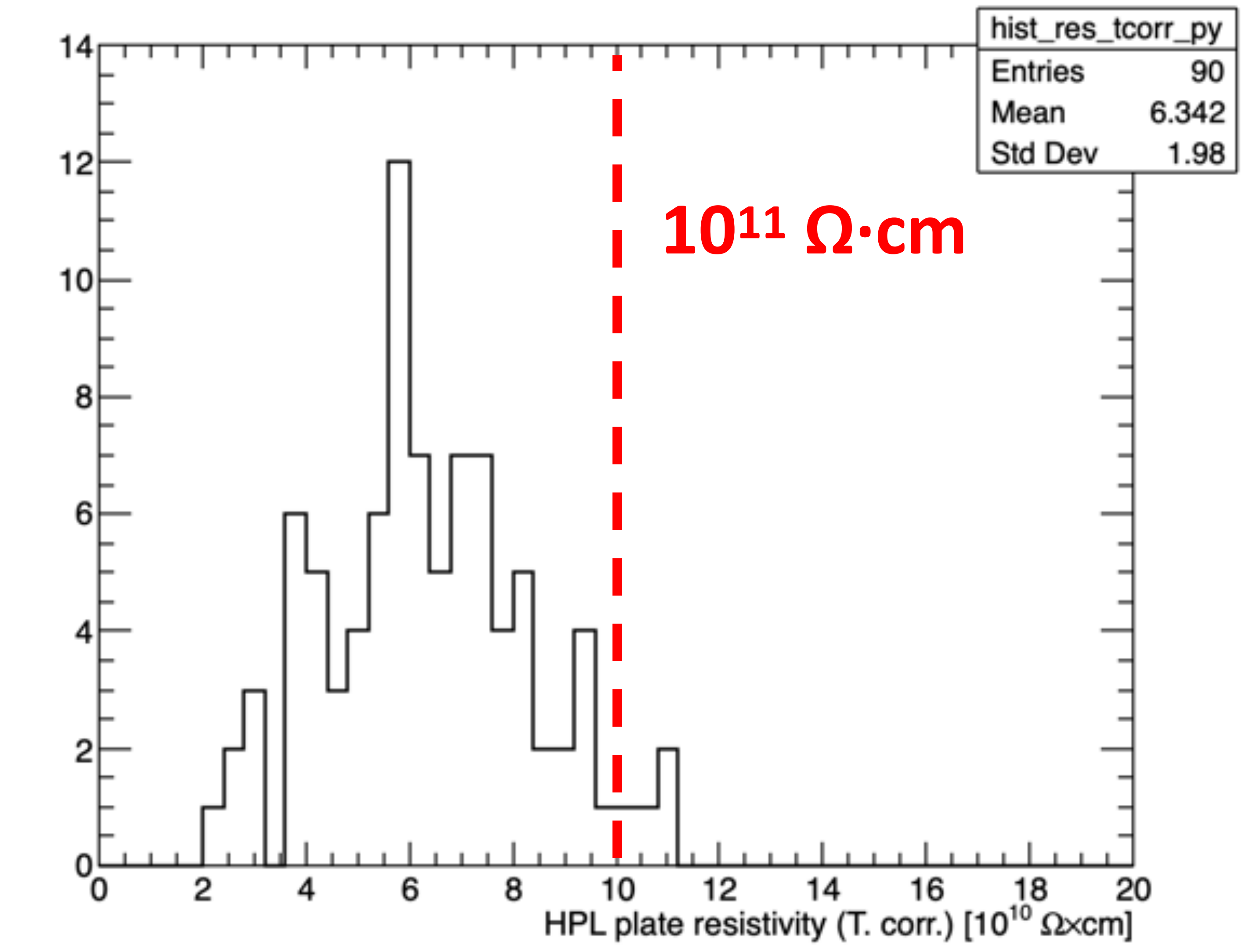
- Very good agreement between the measurements performed by Roma Tor Vergata group and Teknemika company
- As indicated in the contract, the acceptance criteria are based on measurements performed by ATLAS

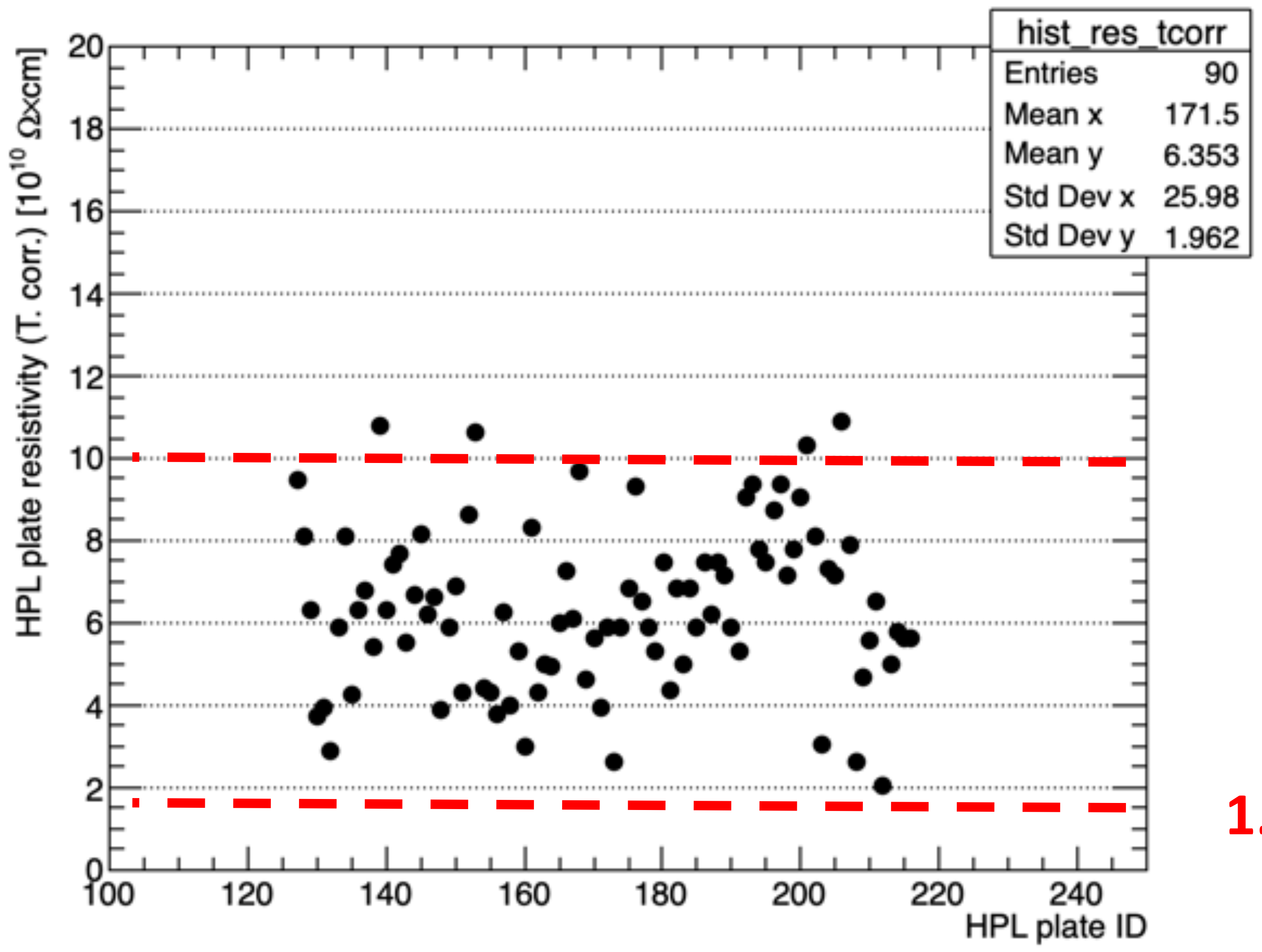
HPL plate production at Teknemika

- Teknemika company accepted to replace the discarded HPL plates —> new plates received in July 2023
- For the new production, the production parameters (time, temperature, pressure) were tuned
- Almost all the HPL plates had a bulk resistivity $< 10^{11}\ \Omega\cdot cm$, within the required range —> see next slide
- <u>Contract with CERN finally signed in mid of July 2023</u>
- New HPL order submitted in August: 278 plates of BIL and BIS types; delivery expected in November
- Currently, production at GTE ongoing for 63 BIL-680 and 45 BIS-1 gas volumes (first HPL order)

Resistivity measurements of the HPL plates delivered in July

BIL-680

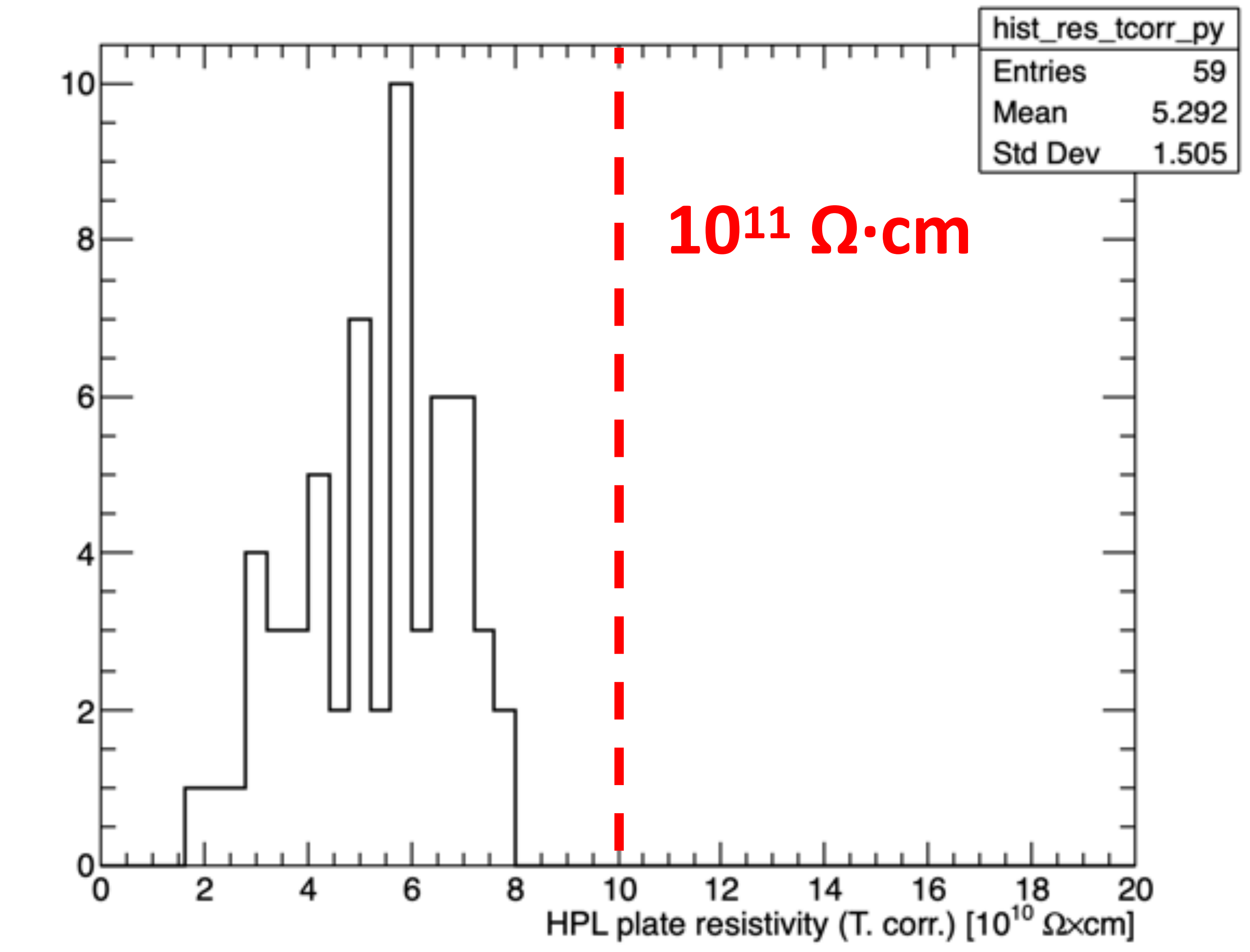


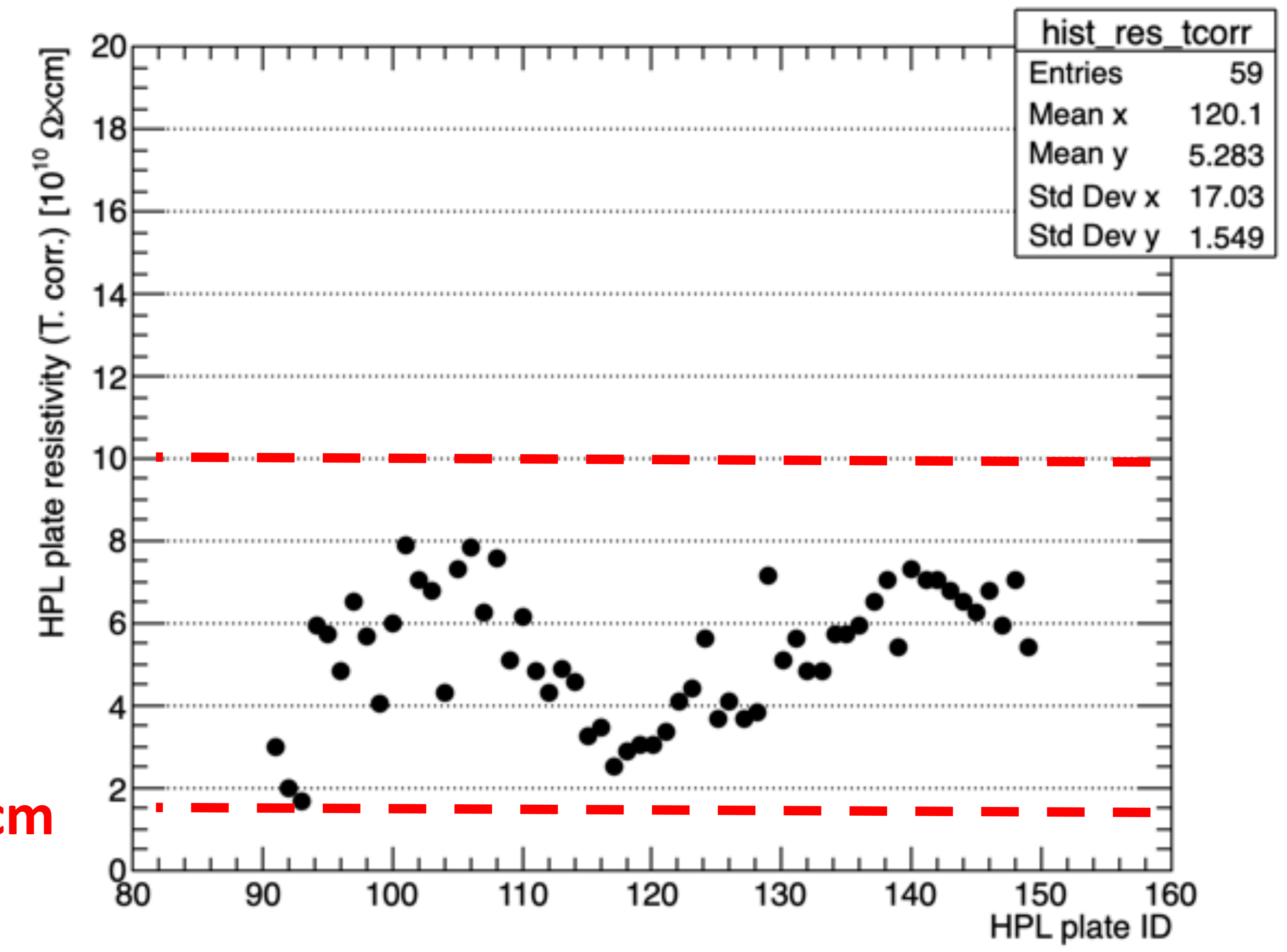


10^{11} Ω·cm

1.5×10^{10} Ω·cm

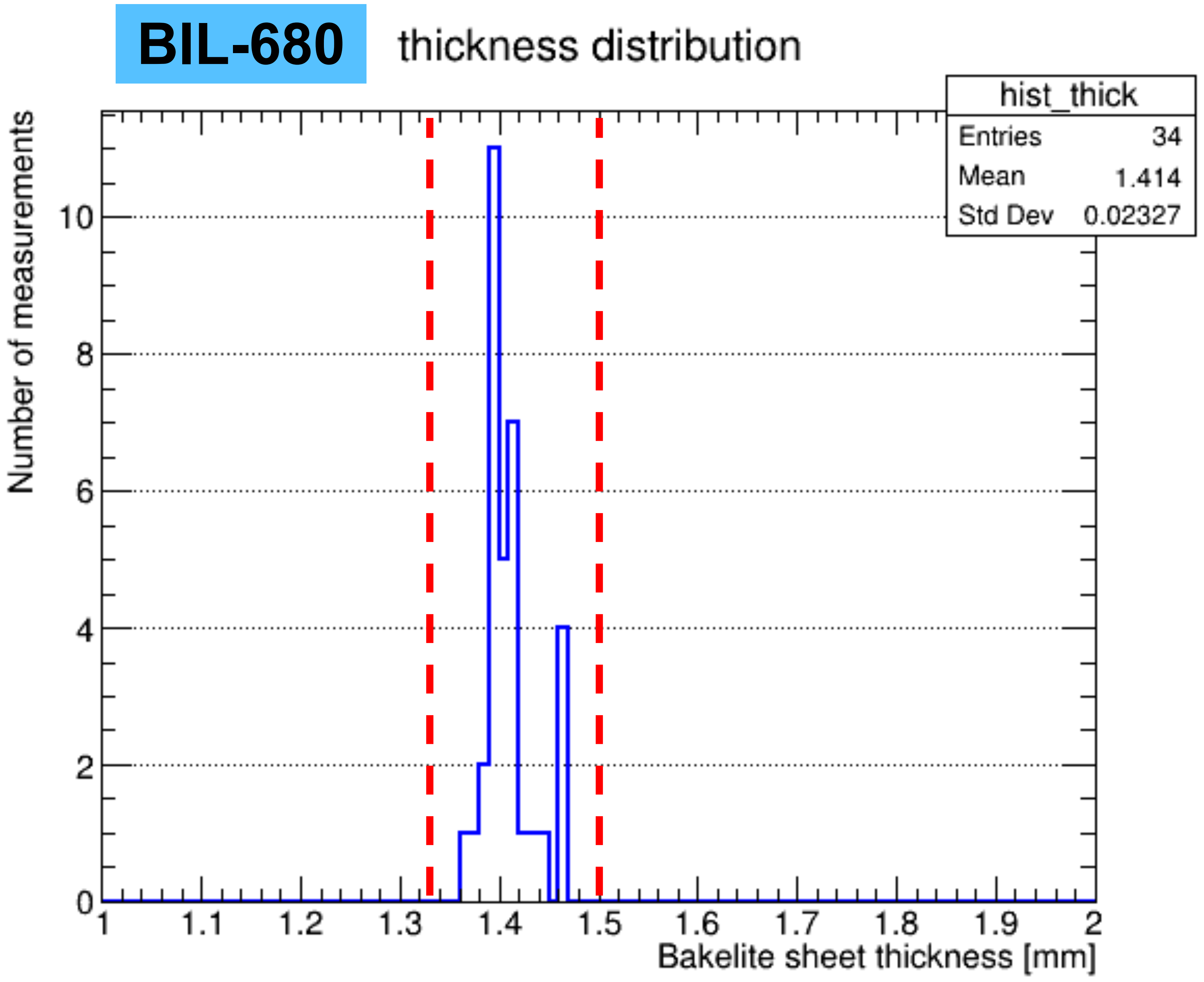
BIS-1

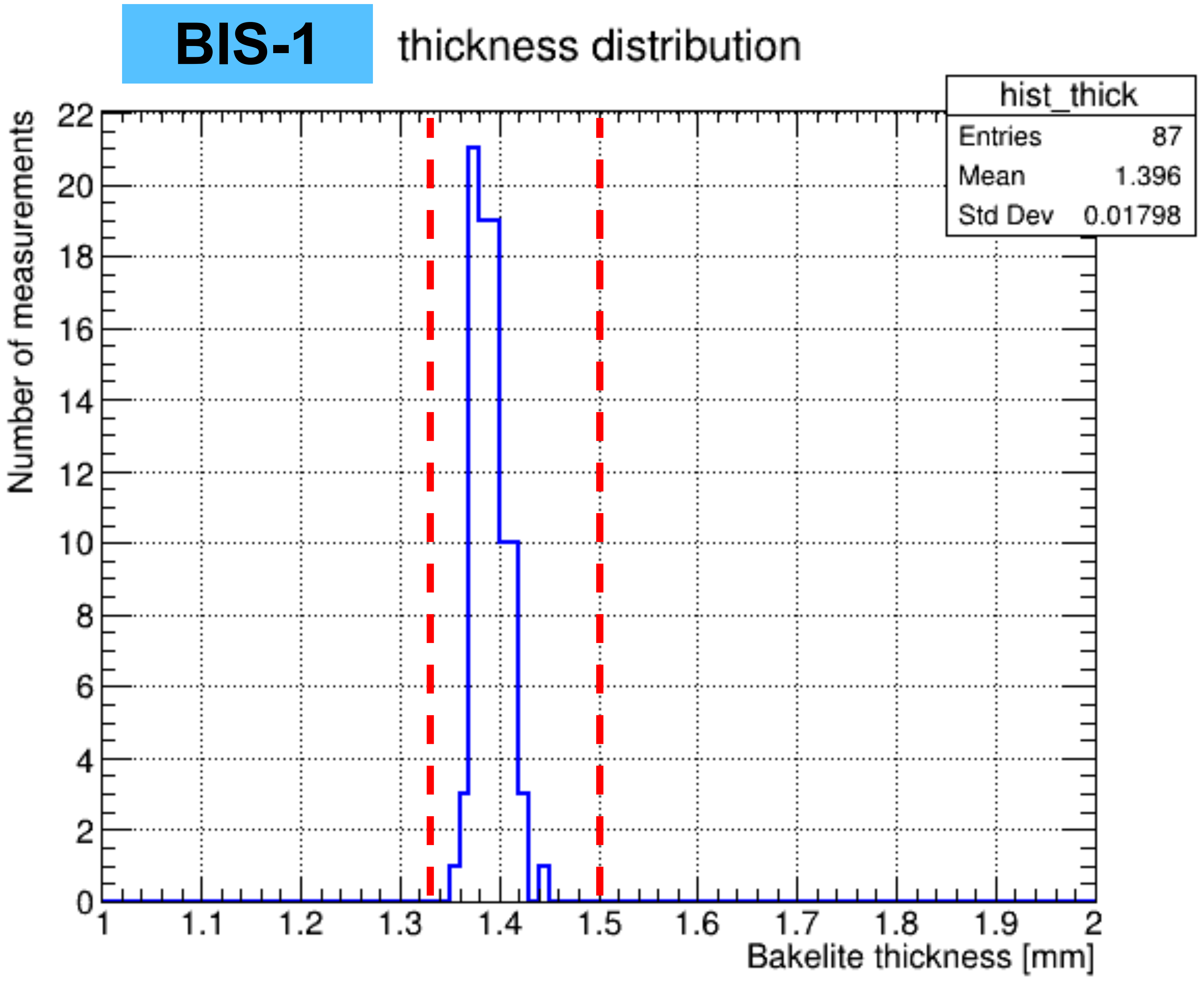




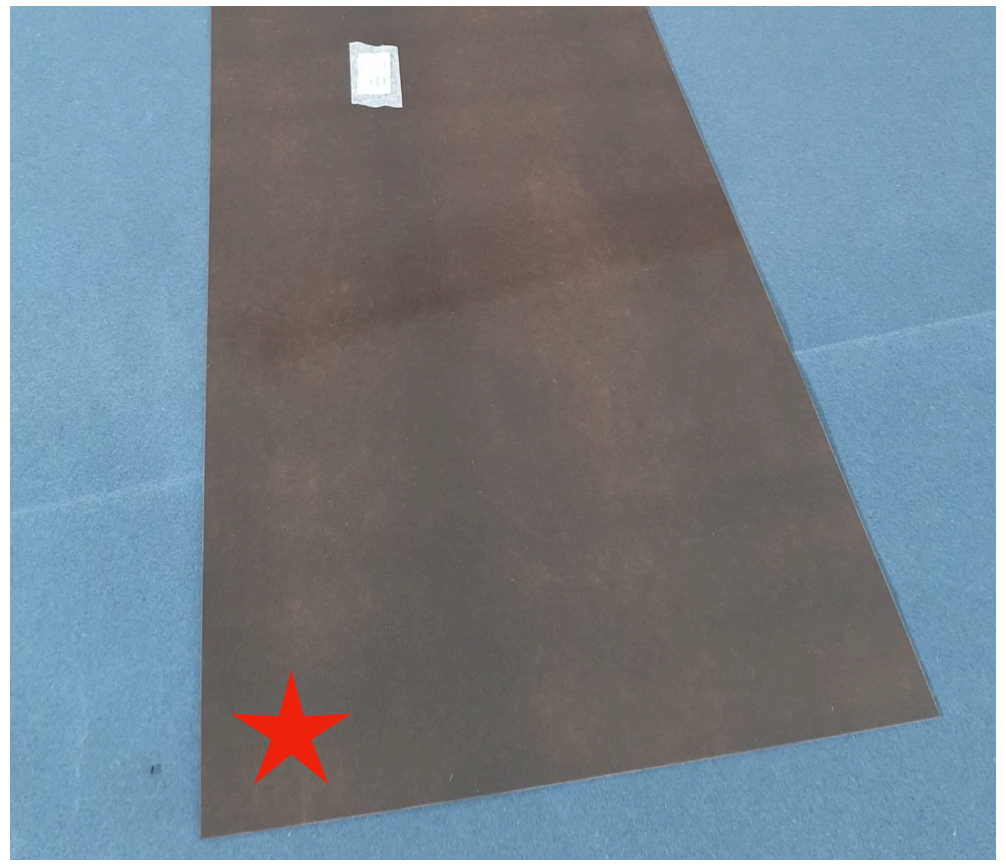
- The distribution of the resistivity values appears to be reasonable and within the within the acceptance limits
- None of 149 plates was discarded

HPL plates: thickness measurement





- The nominal HPL panel thickness is required to be between 1.33 mm and 1.50 mm
- Thickness measured for most of the plates in a position close to the corner using a gauge —> mean value of 1.40 mm with st. dev. of 0.02 mm
- HPL thickness determines the gas volume thickness, which is required to be 4.66 mm (see Alessandro Rocchi presentation)



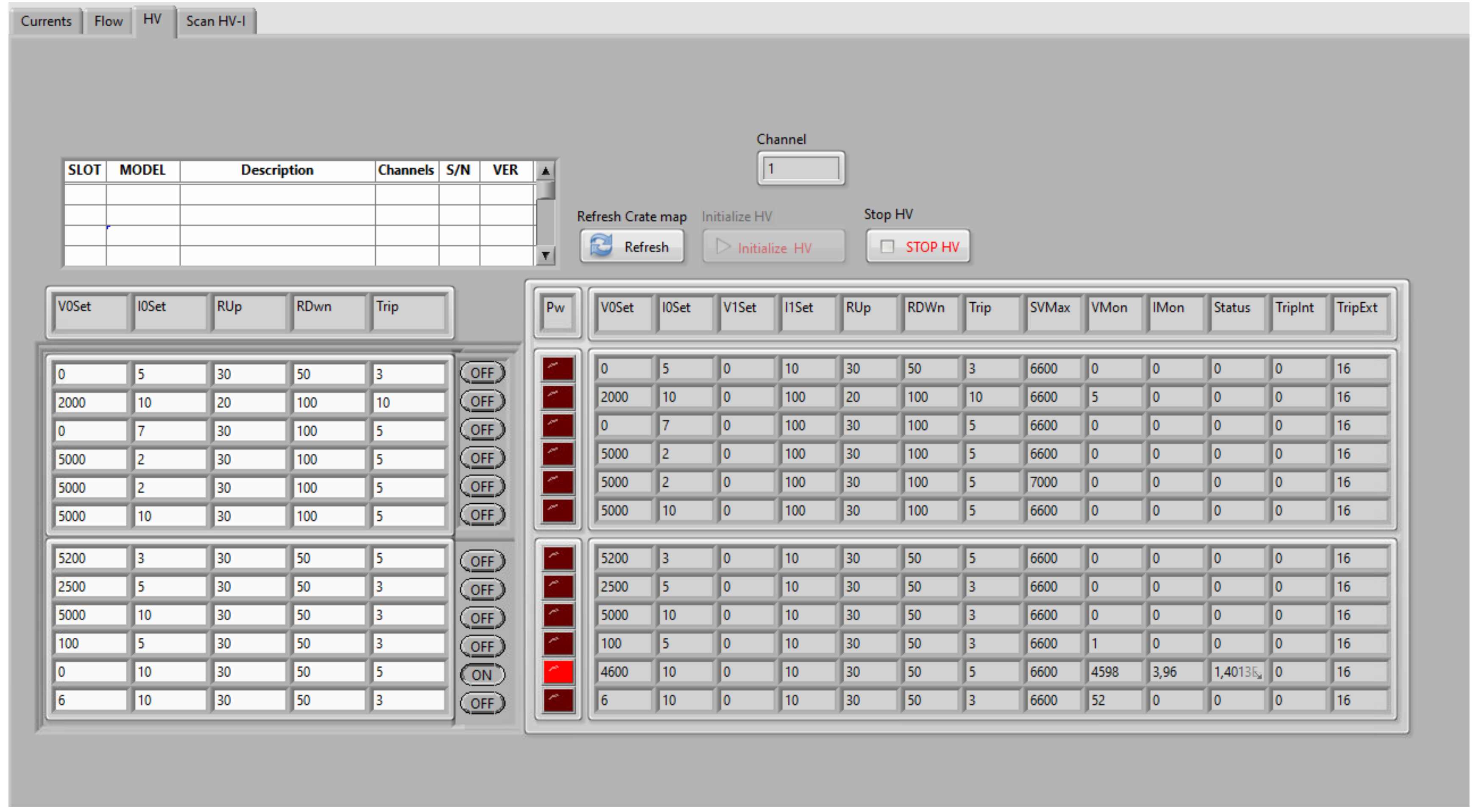
Gas volumes

General Tecnica Engineering (Frosinone, Italy)

DAQ LabView software and test infrastructure at GTE

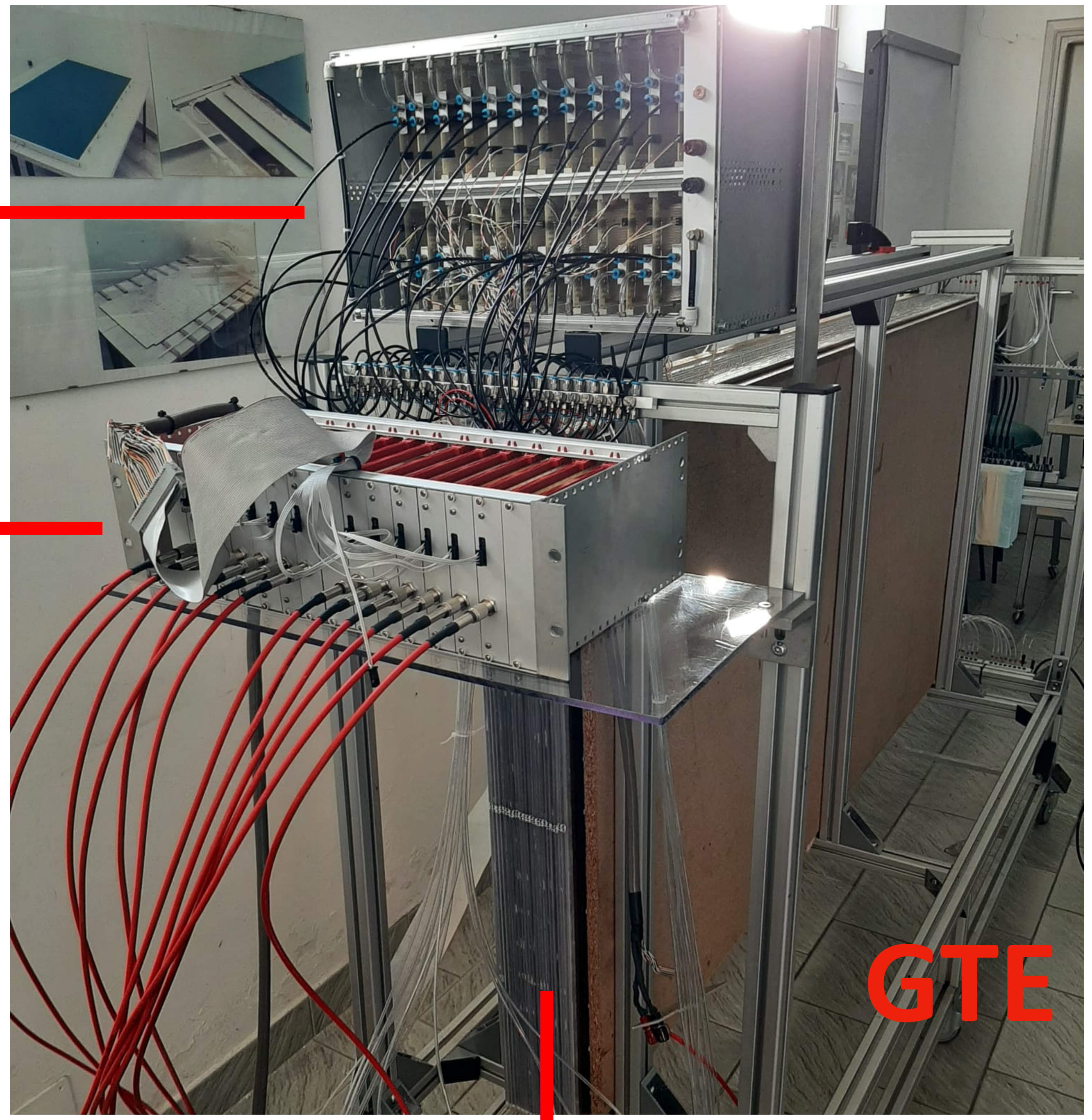
- Hardware and software developed ad hoc to test batch of 24 gas volumes all at once
- Copies of the same tools currently under production to be used by other groups

HV interface

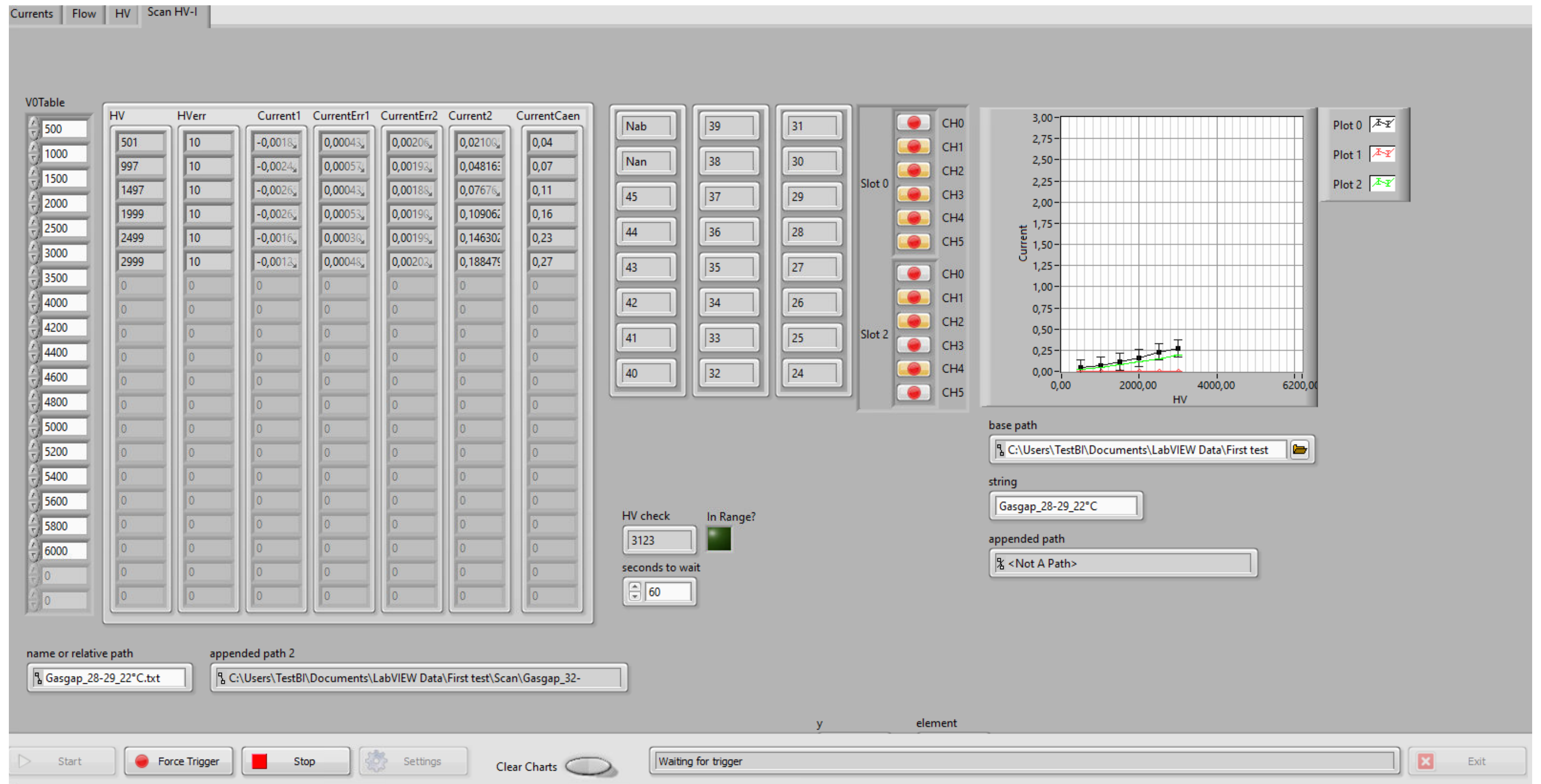


Mini crate equipped with 24 flowmeters to measure the output gas flow

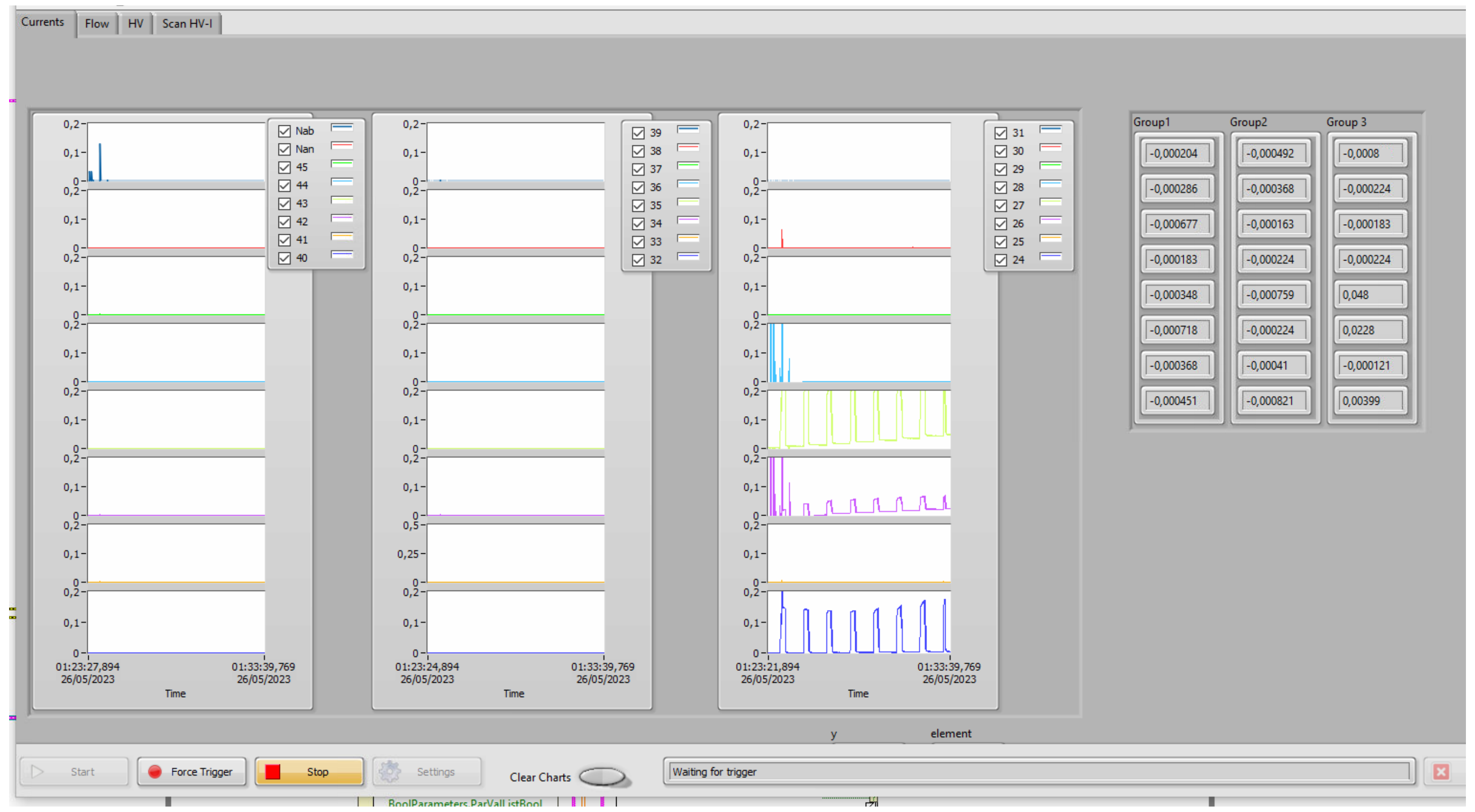
Mini crate for power supply (12 HV channels) and current read-out (24 channels)



Volt-Amperometric characteristic



Current/gas flux monitoring



Trolley with gas volumes under test at GTE

QA/QC tests on RPC gas volumes

- QA/QC tests carried out by the factory (GTE)
  - Graphite coating
  - Absence of scratches
  - Absence of bubbles
  - Glue producer recommendations
  - Envelope dimensions
  - Gas tightness before applying kapton
  - Mechanical rigidity
  - Current leakage before applying kapton
  - Oiling test using mock up gas volumes

- QA/QC test carried out by CERN
  - Volt-Amperometric characteristic

QA/QC tests on RPC gas volumes

- **Test of graphite coating** —> to check the surface resistivity value (350±100 kΩ/□) and the goodness of the coating (resistivity must not vary by more than 100 kΩ/□ when the surface is scrubbed with a soft tissue)
- **Absence of scratches** —> visual inspection of internal surfaces before the closure of the gas volume, ensuring that no visible scratches are present
- **Absence of bubbles** —> to check the absence of air bubbles, with surface larger than 2-3 mm^2, between the insulating PET foil and the graphite layer
- **Glue producer recommendations** —> the pillars gluing strength shall resist to a traction force of 30 N and the glue curing process shall respect the producer recommendations
- **Test of the envelope dimensions** —> to guarantee that the gas volume sizes are within the tolerance
- **Gas tightness before applying kapton** —> the gas volume must be over pressurized by 3 mbar and the measured loss of pressure after three minutes must be less than 0.1 mbar

QA/QC tests on RPC gas volumes

- **Mechanical rigidity** —> a volume of air equal to one percent of the gas volume is injected inside the gap. One minute later, the increase of pressure inside the gas volume shall be not less than two per-mil ($\Delta P > 2$ mbar)

- **Current leakage before applying kapton** —> conductive foam pressed along the edges used to force the discharge towards ground —> **new method** —> both electrodes at 7 kV, no electrical field through the gap, gas not needed, test in air —> big advantage! Since the leakage of **both** electrodes is measured, the current leakage is a **factor two larger** **I_{leak} must be < 0.2 µA = 20 mV/10^5 Ω for BIS and < 0.3 µA = 30 mV/10^5 Ω for BIL** (to take into account the ratio between the long edges of BIL-680 and BIS-1 —> 2466 mm / 1660 mm ~ 1.5)

- **Oiling test using mock up gas volumes** —> mock-up volume must be subjected to the same oiling operations as any gas volume. After opening the mock up, the dry oil surface for resistance to scratches is checked (no oil remains stuck to the blade and no visible track is left over the scraped surface)

QA/QC tests carried out by GTE

QUALITY ASSURANCE

Factory tests on ATLAS RPC Phase-2 gas volumes

Date: 11/10/2023

Gas gap ID: BIS2A_15/23

HPL foils employed: 104 **and** 141

1) Graphite coating ☒ PASSED ☐ NOT PASSED

2) Absence of scratches ☒ PASSED ☐ NOT PASSED

3) Absence of bubbles ☒ PASSED ☐ NOT PASSED

4) Glue producer recommendations ☒ PASSED ☐ NOT PASSED

5) Envelope dimensions ☒ PASSED ☐ NOT PASSED

6) Gas tightness before applying kapton (ΔP after 3 minutes must be < 0.1 mbar)

ΔP after 3 minutes [mbar]: < 0.1 ☒ PASSED ☐ NOT PASSED

7) Mechanical rigidity, with the injection of a volume of air equal to 1% of the gas volume (ΔP after 1 minute must be ≥ 2 mbar)

ΔP after 1 minute [mbar]: 2.1 ☒ PASSED ☐ NOT PASSED

8) Current leakage before applying kapton (using a conductive foam pressed along the edges) with both electrodes at 7 kV (I_{leak} must be < 0.2 μA = 20 mV/10^5 Ω for BIS and < 0.3 μA = 30 mV/10^5 Ω for BIL)

Current 16.7 [mV/10^5 Ω] at HV 7 [kV] ☒ PASSED ☐ NOT PASSED

9) Oiling test using mock up gas volume ☒ PASSED ☐ NOT PASSED

Further comments

-
-
-

Signature of the responsible person

RPC DB Phase2

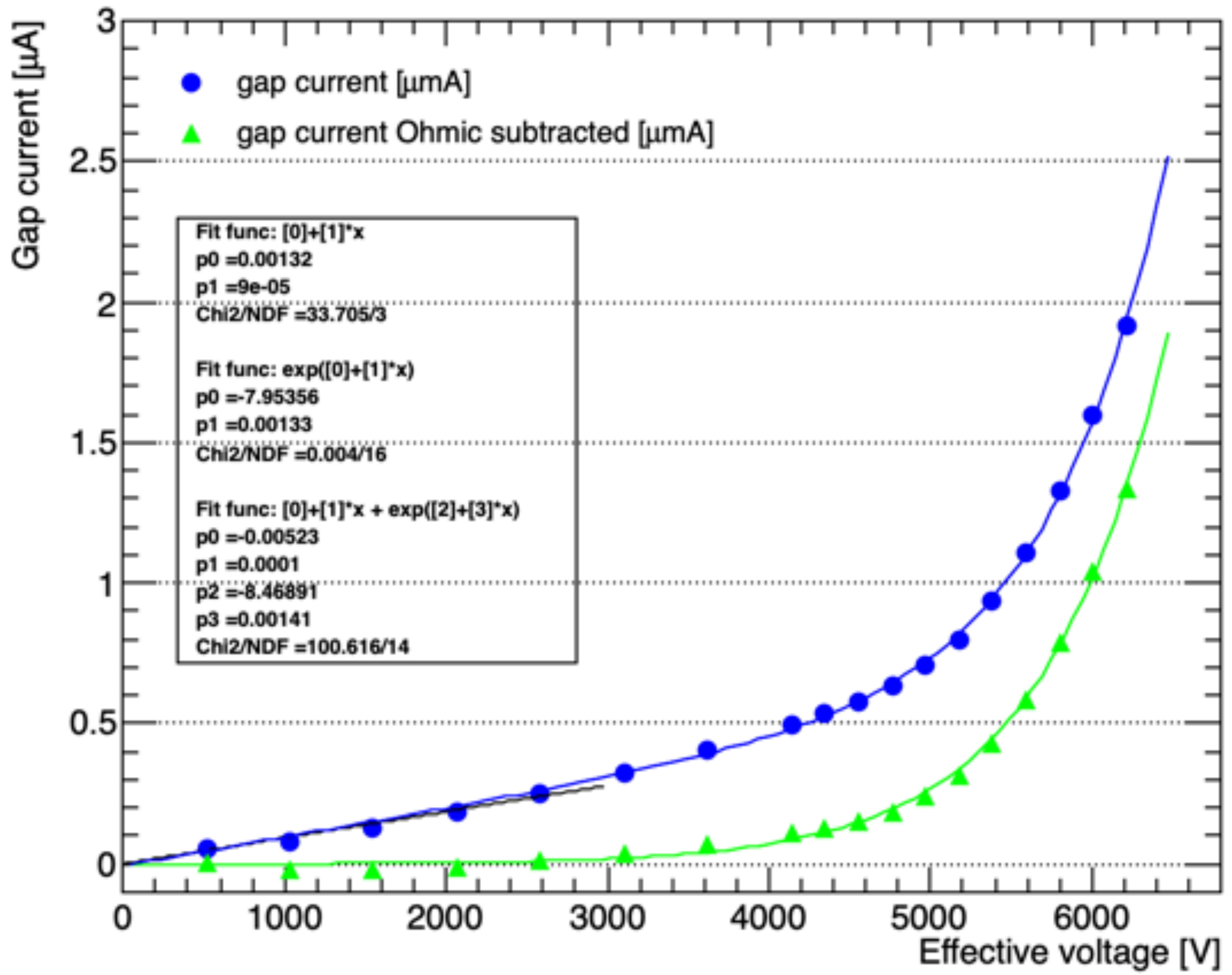
Home | Add HPL | Add Gas Gap | Sites | People | Events | Modify component

Filter

NAME	VALUE	STATUS
Graphite coating		passed
Absence of scratches		passed
Absence of bubbles		passed
Glue producer recommendations		passed
Envelope dimensions		passed
Gas tightness (before kapton)	3	passed
Mechanical rigidity	2.6	passed
Current leakage (before kapton)	0.07 - 7000	passed
Oiling test using mock up gas vo…		passed
Volt-Amperometric characteristic		passed

Production DB developed to include the QA/QC data of all production components

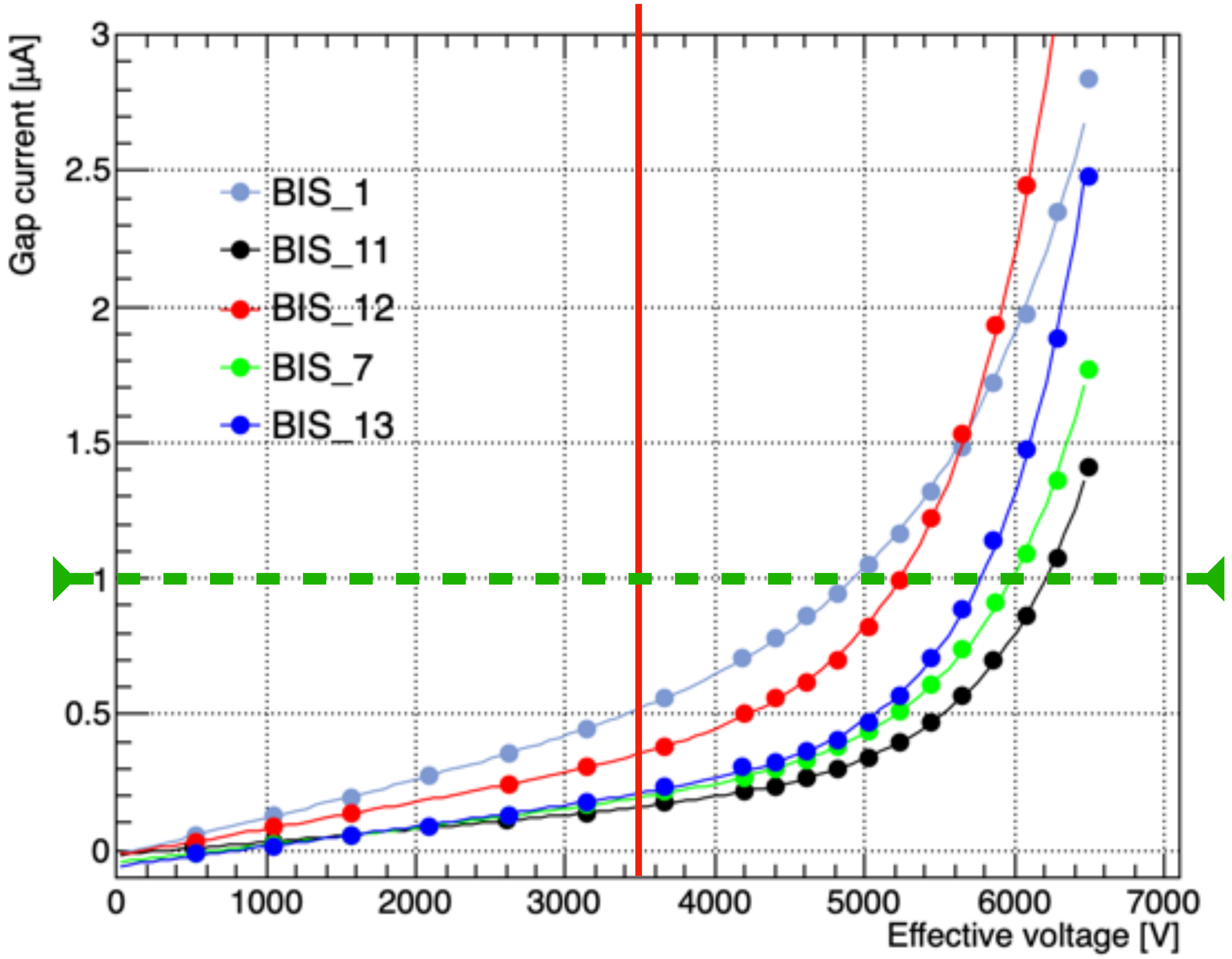
QA/QC test carried out by CERN: I-V characteristic



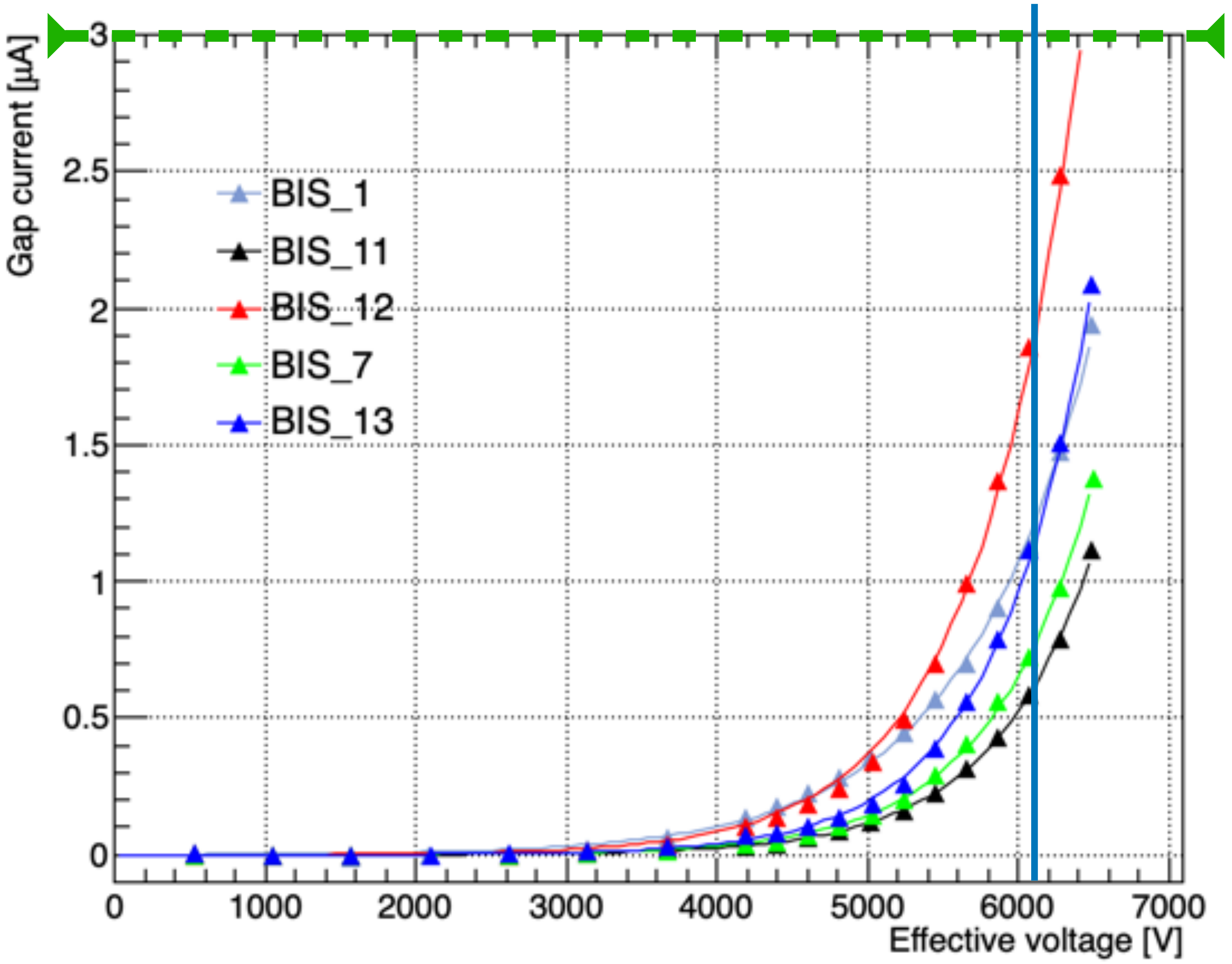
- Example for one BIS-1 gas volume
- Linear fit up to 3000 V to subtract the Ohmic current contribution and evaluate the gas current contribution only
- Applied voltage corrected by temperature and pressure —> $V_{\text{eff}}[V] = V_{\text{app}}[V] \times \frac{1010}{P[\text{mbar}]} \frac{T[\text{K}]}{293}$

Results from the first production of ATLAS gas volumes - Aug 2023
BIS-1

Total current



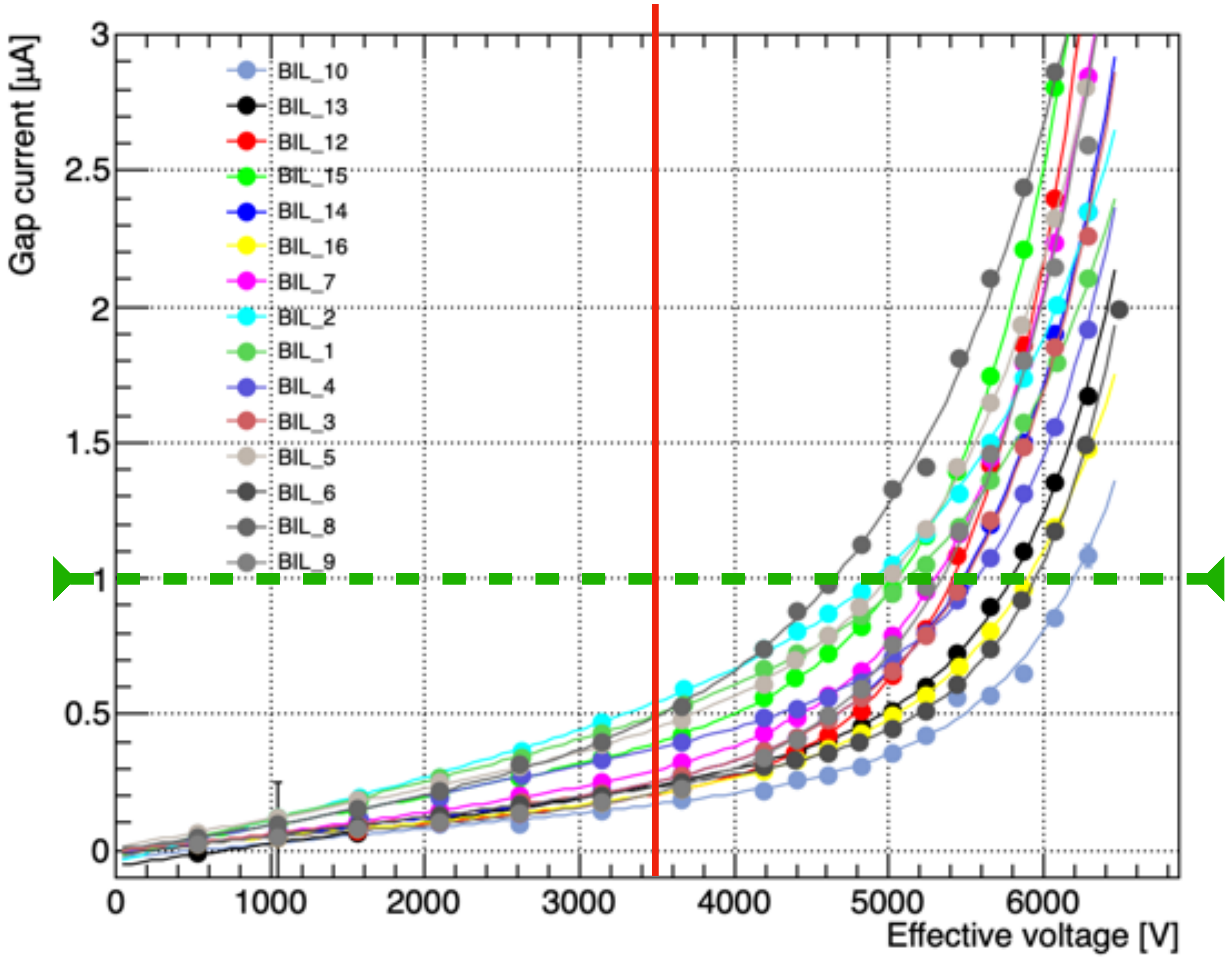
After Ohmic subtraction



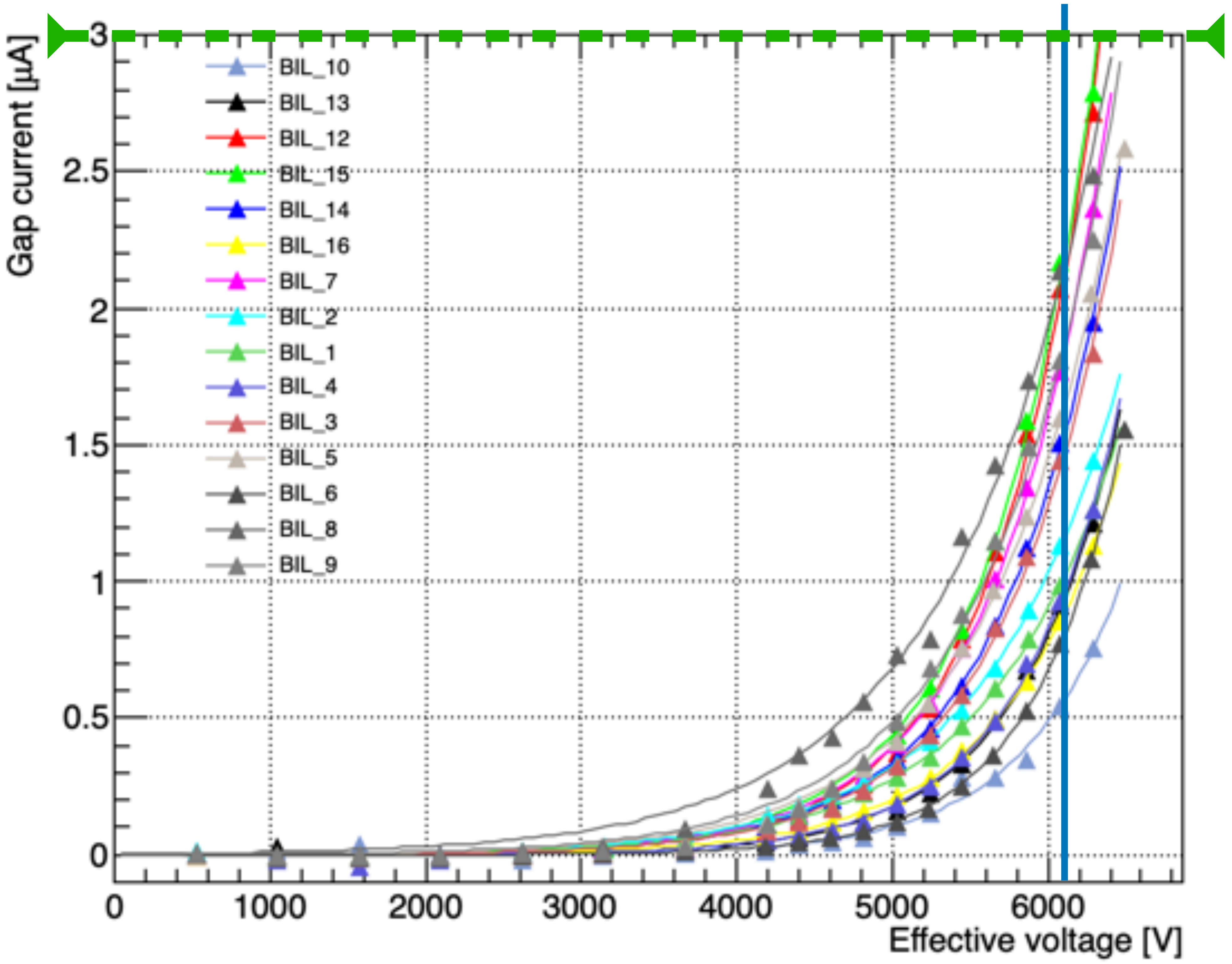
- Igap < 1 μA @3.5 kV
- Igap < 3 μA @6.1 kV (after Ohmic current subtraction)

Results from the first production of ATLAS gas volumes - Aug 2023
BIL-680

Total current



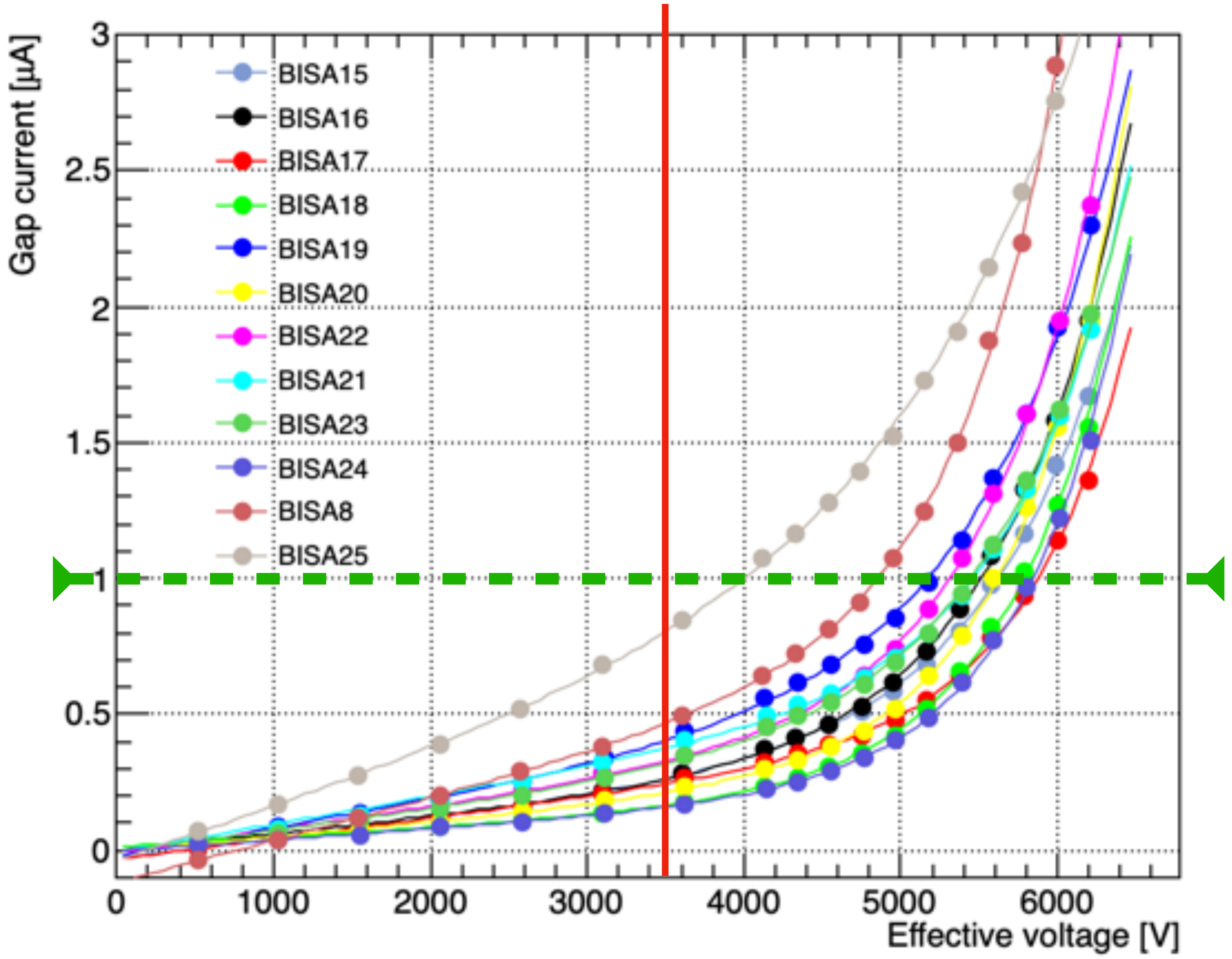
After Ohmic subtraction



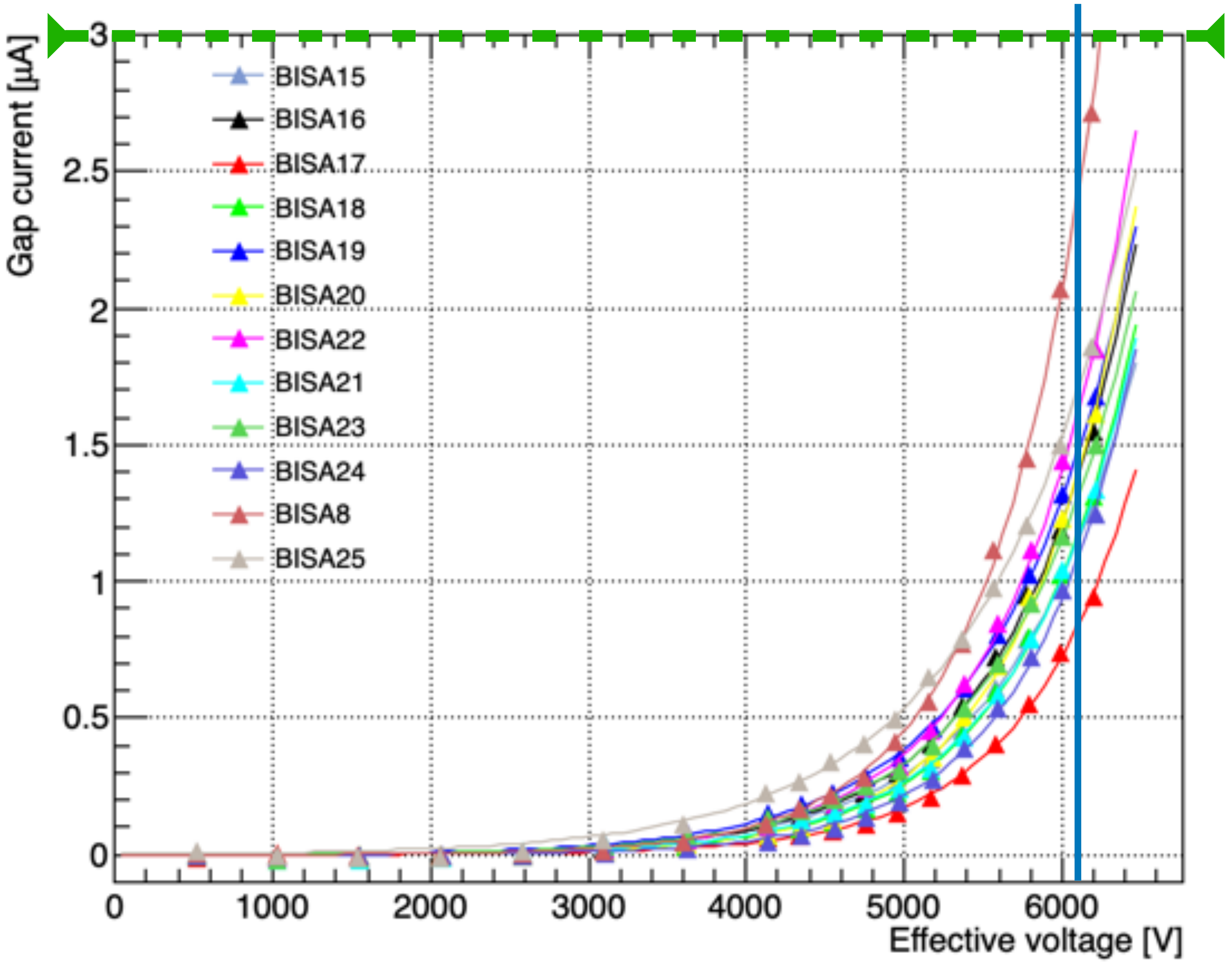
- Igap < 1 μA @3.5 kV
- Igap < 3 μA @6.1 kV (after Ohmic current subtraction)

Results from the second production of ATLAS gas volumes - Oct 2023
BIS-1

Total current



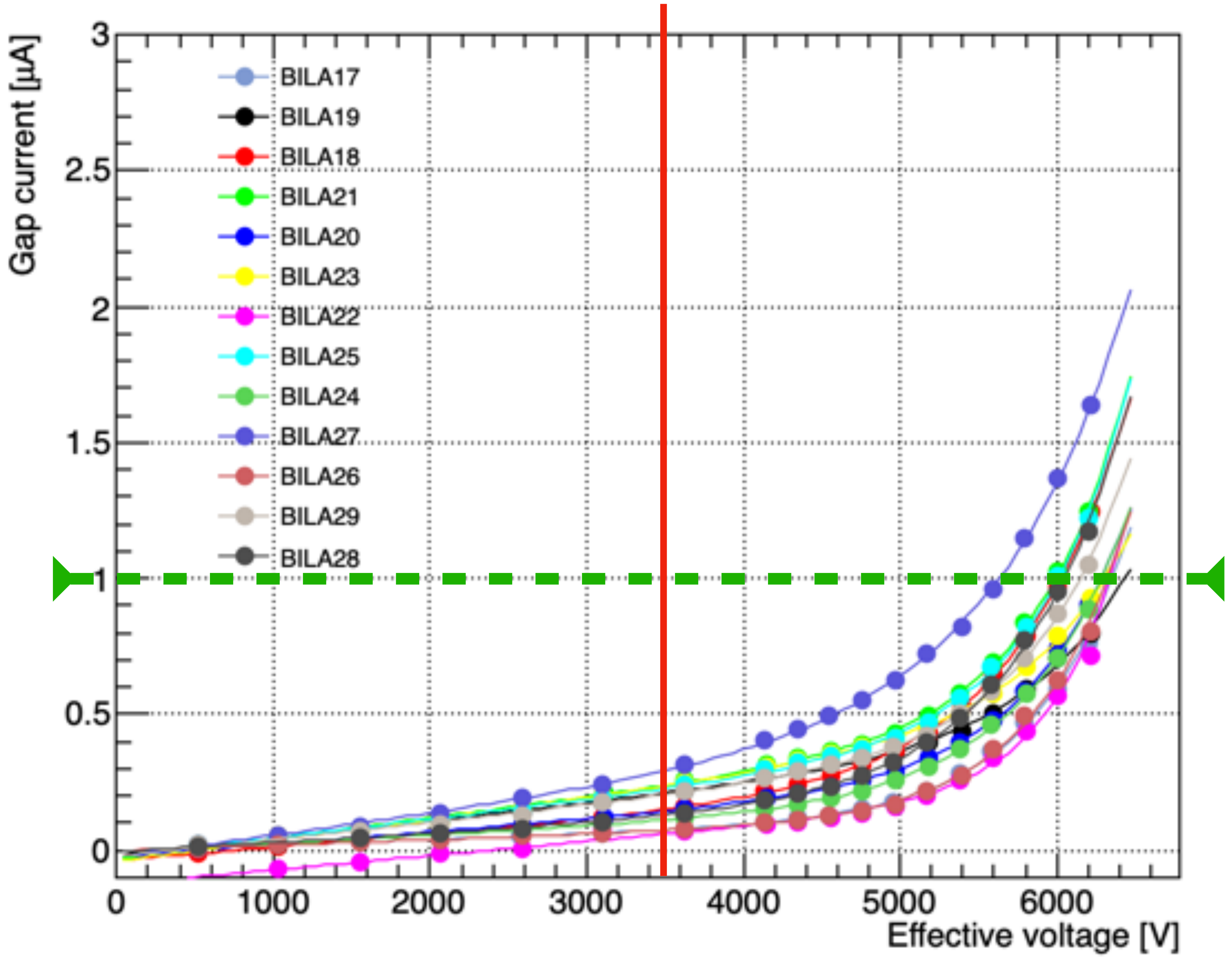
After Ohmic subtraction



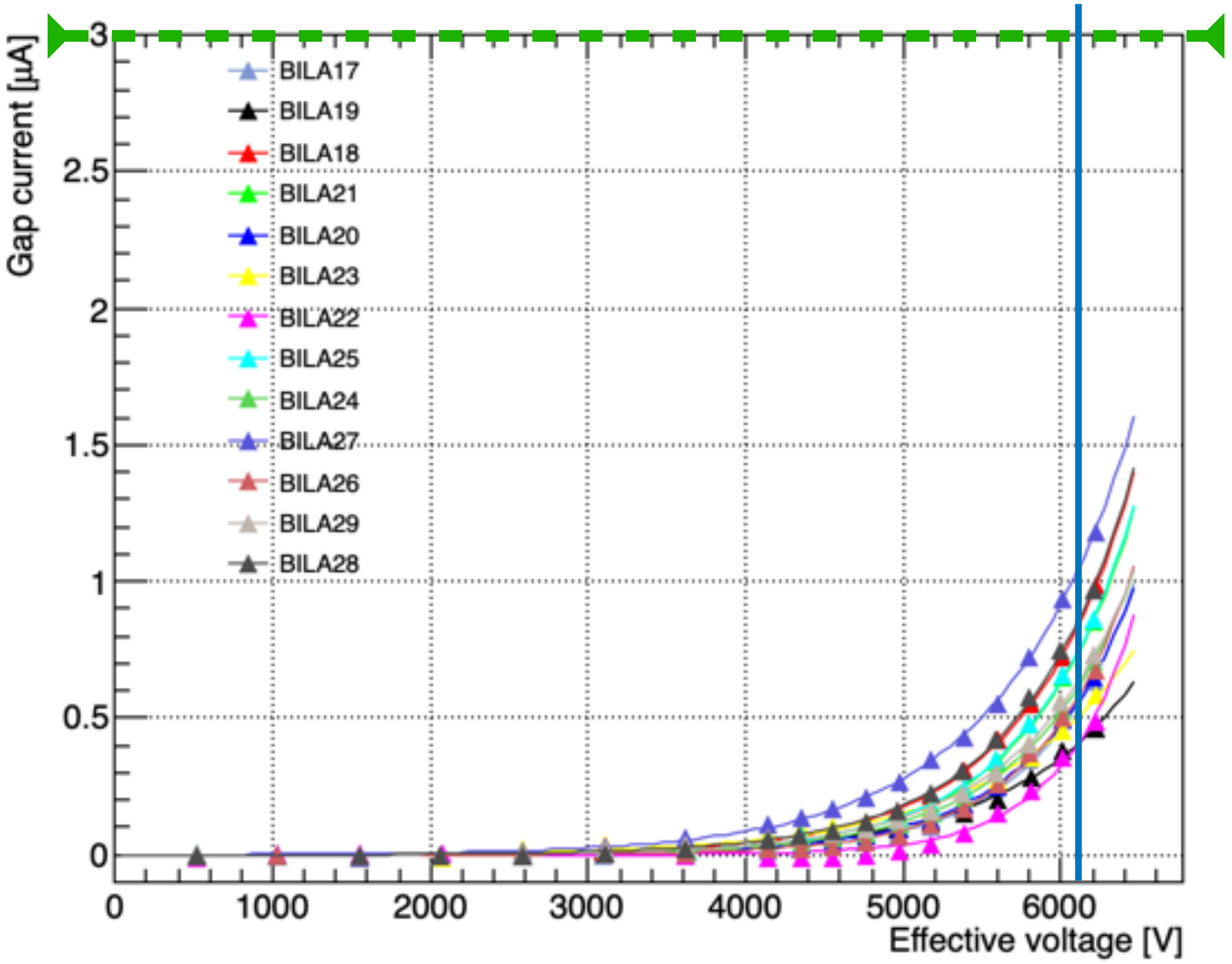
- Igap < 1 μA @3.5 kV
- Igap < 3 μA @6.1 kV (after Ohmic current subtraction)

Results from the second production of ATLAS gas volumes - Oct 2023
BIL-680

Total current



After Ohmic subtraction



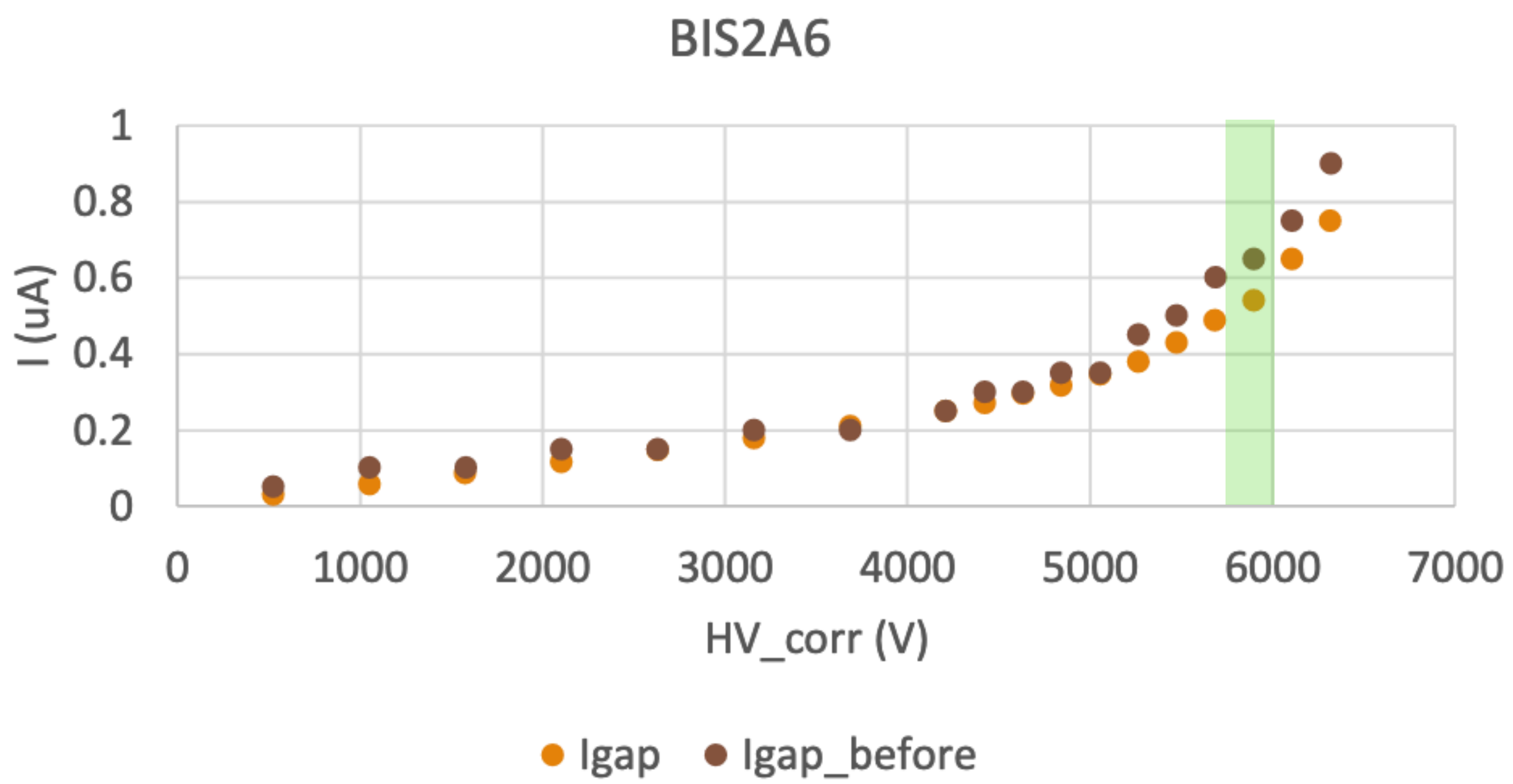
- Igap < 1 μA @3.5 kV
- Igap < 3 μA @6.1 kV (after Ohmic current subtraction)

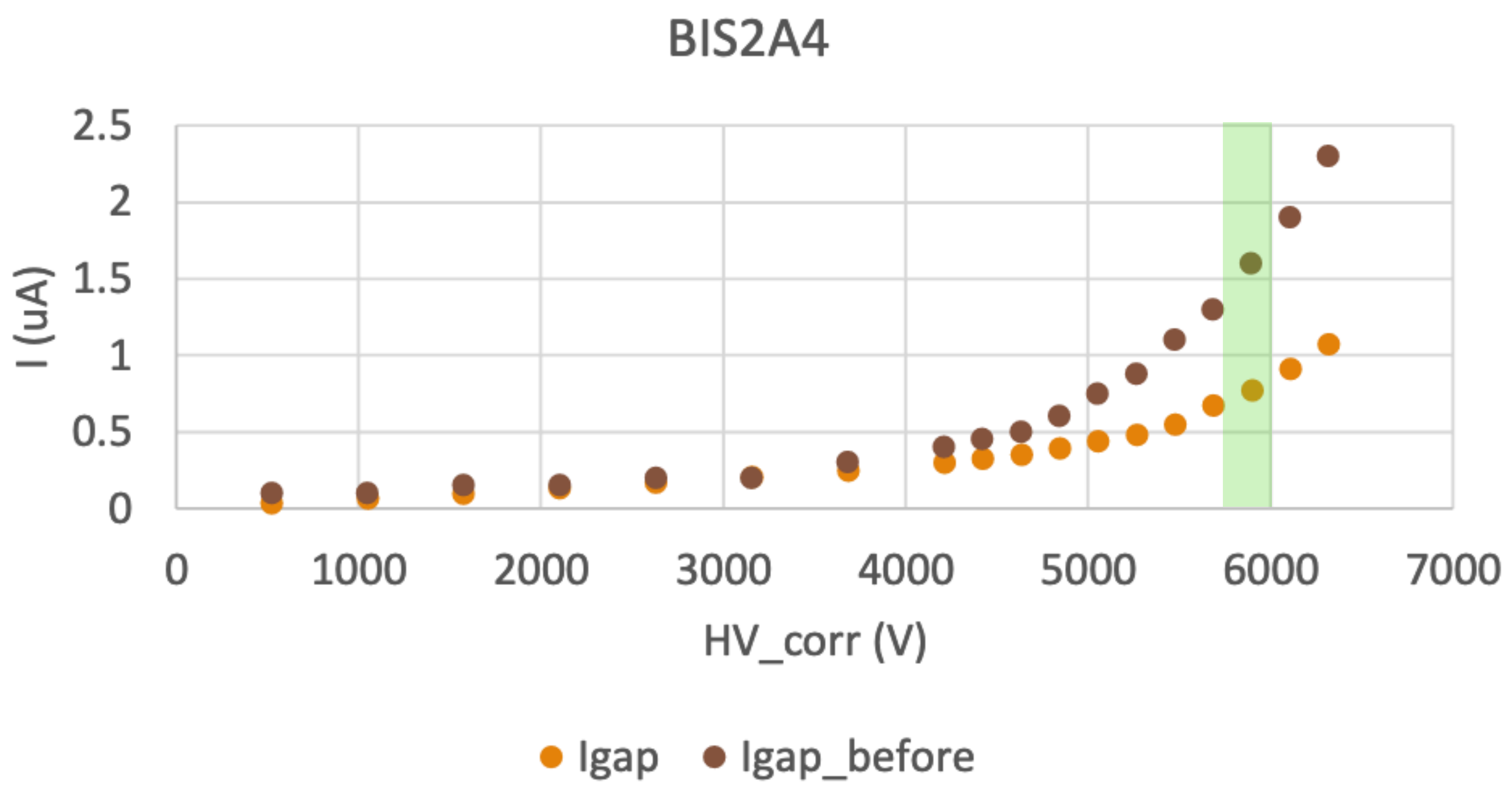
Summary of the gas volume production at GTE

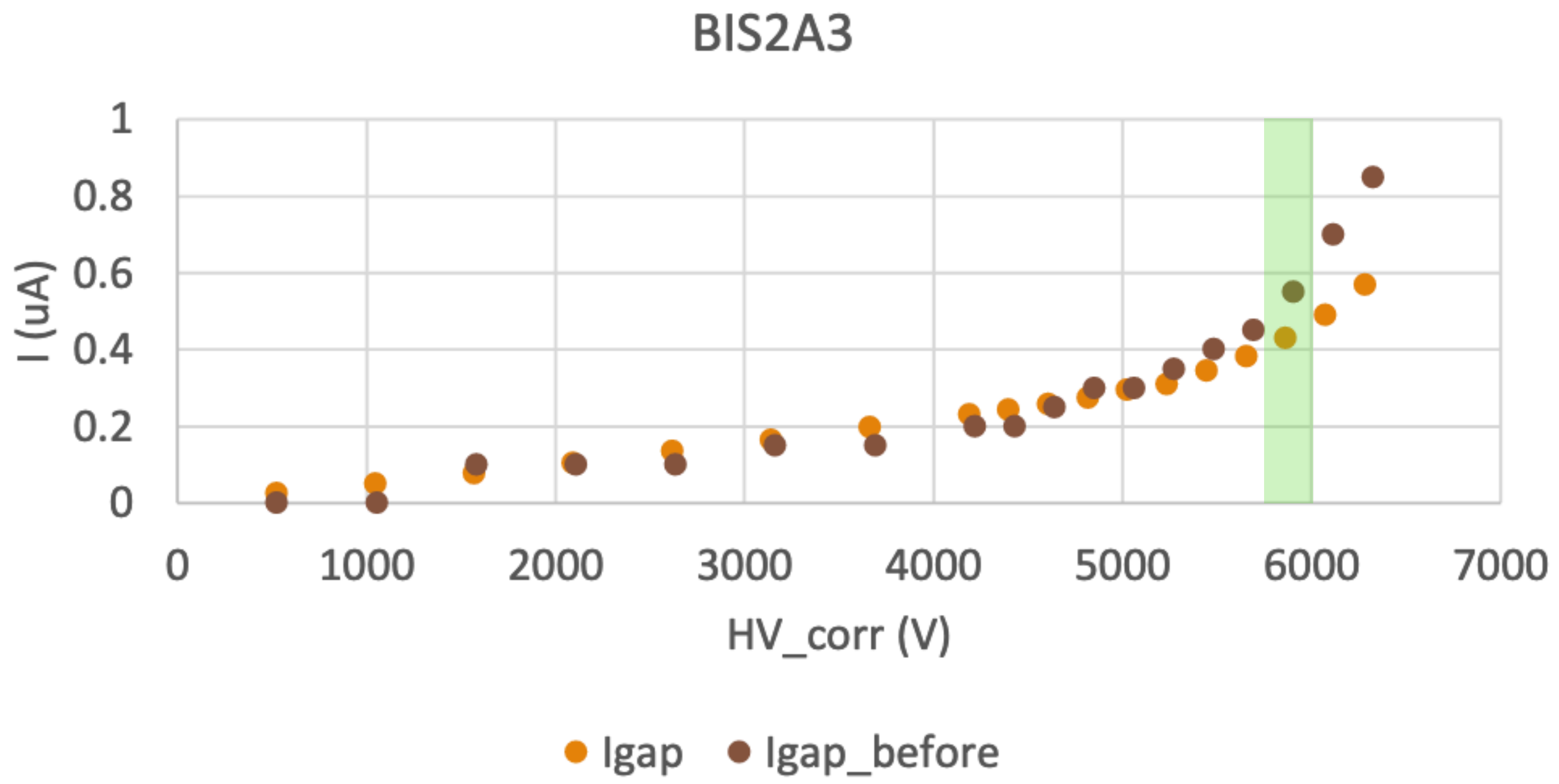
- **First batch (Jul-Aug 23)**: 15 BIL-680 and 10 BIS-1 tested at GTE -> only 1 BIS-1 gas volume discarded
- **Second batch (Oct 23)**: 13 BIL-680 and 12 BIS-1 tested at GTE -> no gas volumes discarded
- Total yield (15+9+13+12)/(15+10+13+12) = **49/50 = 98%**

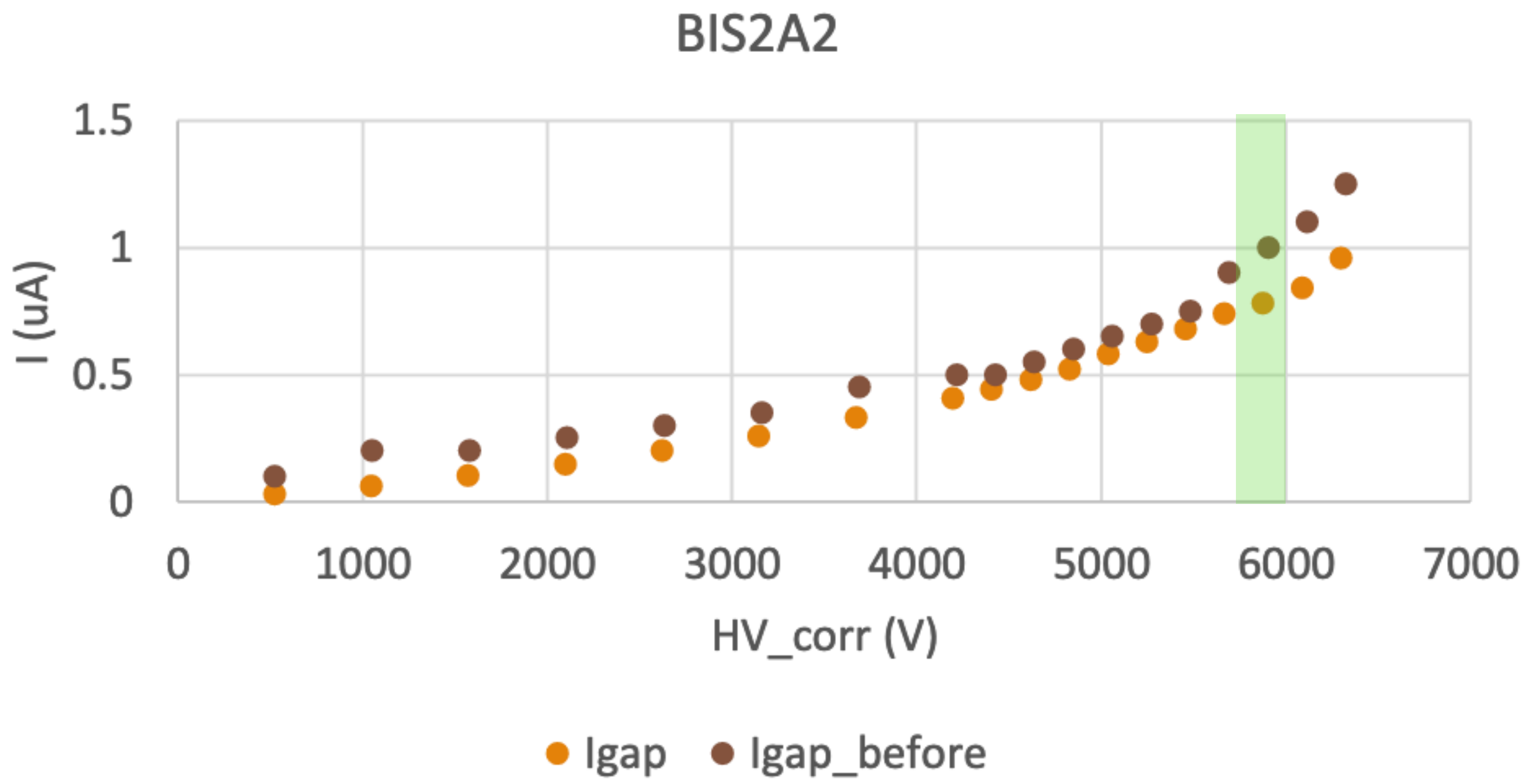
Gas volume conditioning

- A conditioning with radiation is proposed to spot potential construction defects. For BIS78 side-A (48 gas gaps) the conditioning was performed at GIF++ (for one week at a working current of about 25-30 μA obtained at low applied voltage and very intense irradiation)
- 4 BIS-1 gas volumes tested at GIF++ in September 2023 measuring Igap vs V before and after one week irradiation and observing the expected current decrease in the region 5800-6000 V, where the working plateau is expected









Gas volume conditioning

From the Singlet FDR report

- **GIF++ tests:**
  - **A-18:** For gas volumes, a period of conditioning at GIF++ is foreseen. No further details were presented. At the PRR, the team shall present a detailed plan for this activity (number of gaps to be irradiated, duration per gap, ...), and confirm that the required space and irradiation time at GIF++ have been reserved. A plan was mentioned to transport the gas gaps with gas mixture, it needs to be detailed how this will be done.

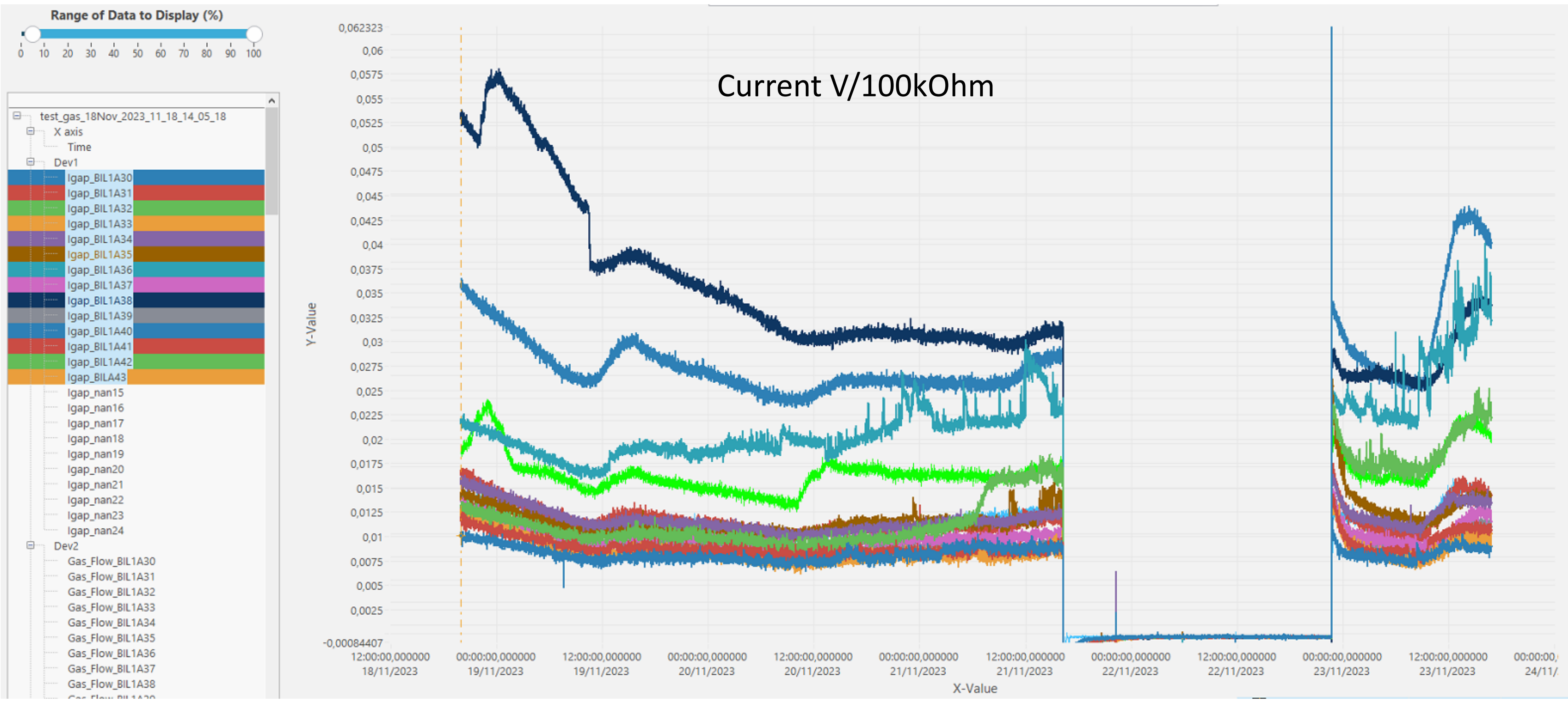
- What we know today
- The test of 1000 gas gaps in batch of 24 gaps requires ~ 50 tests of 1 week, with a gas flux of 86 l/h (2 gas volume changes per hour)
  - At GIF++ there are 2 gas mixers shared by ATLAS and CMS, one with standard gas (100 l/h) and one for eco gas studies (80 l/h)
  - Evaluation of the infrastructure availability, the gas consumption, the available manpower and the financial costs still underway

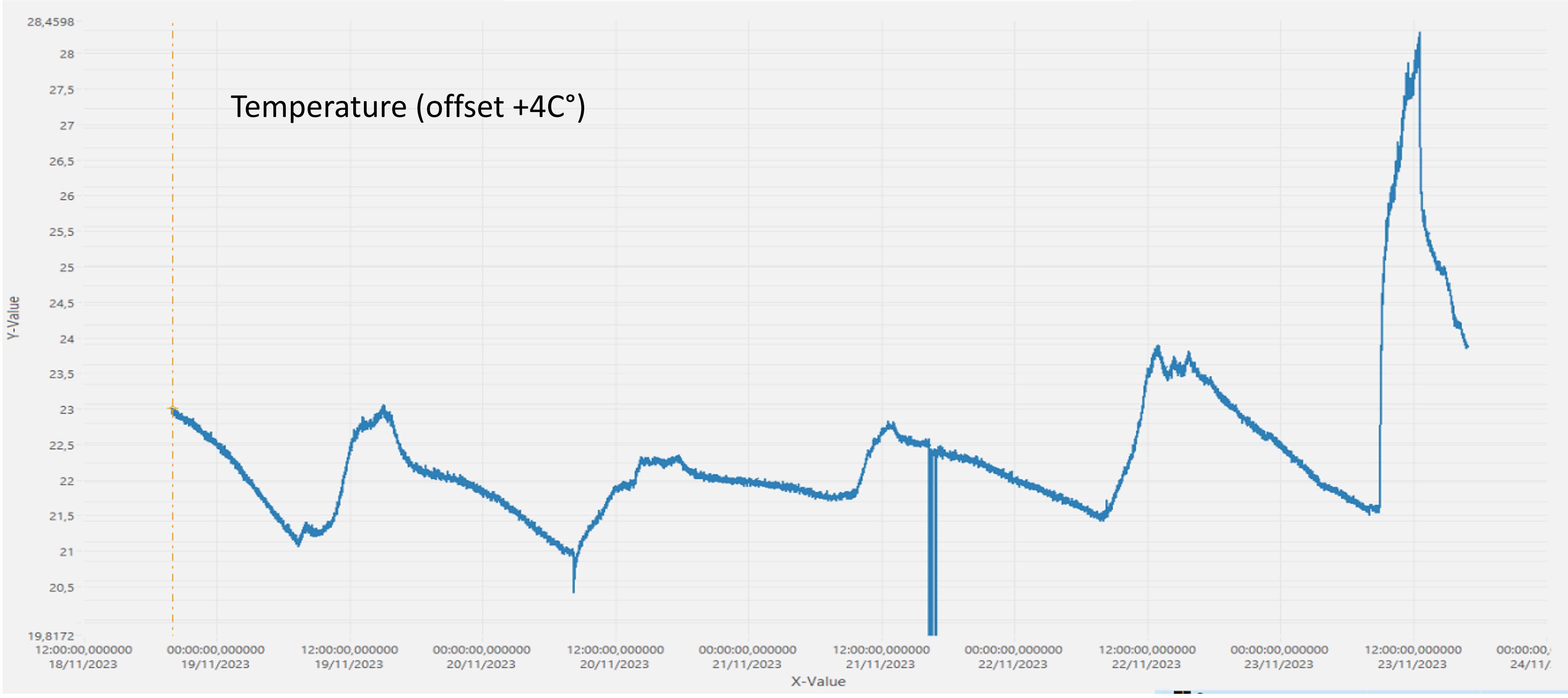
- <u>An alternative conditioning, to be carried out at GTE or BB5, has been proposed by Rinaldo Santonico. The community will take a decision based on solid scientific motivation by comparing the behaviour of gas volumes conditioned at GTE/BB5 with others conditioned at GIF++</u>

Current monitoring at GTE

BIL-A

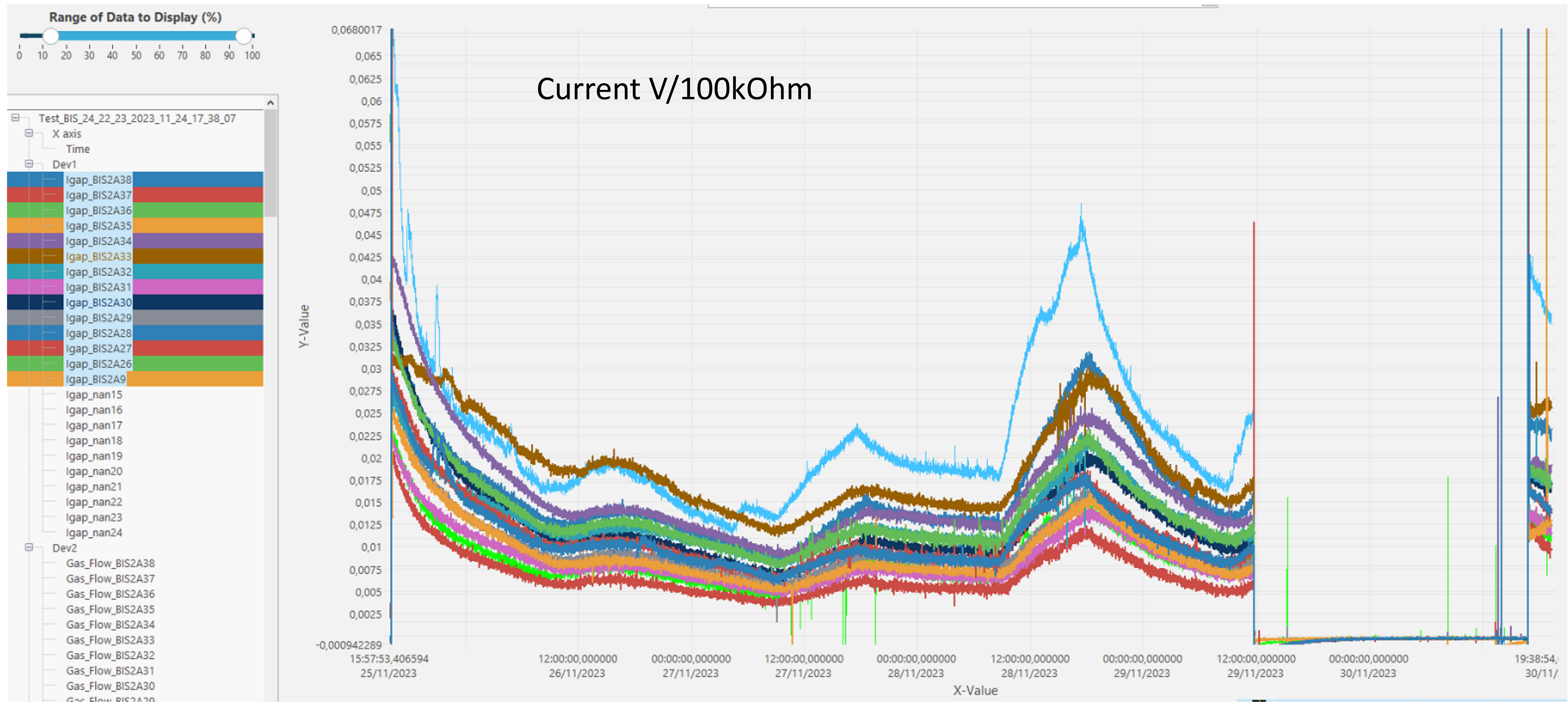
Started 18/11/2023 HV = 5600 V

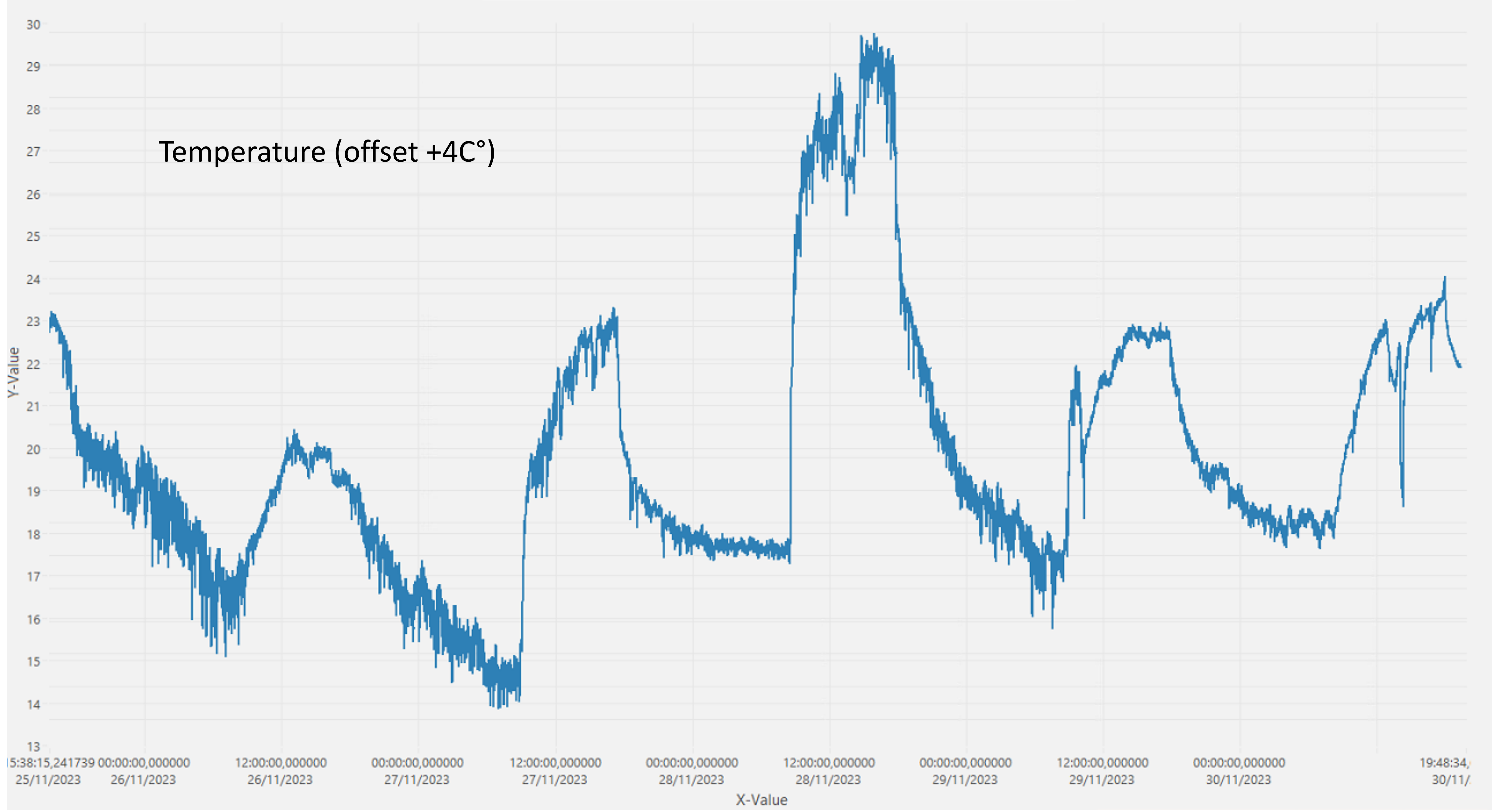




BIS-A

Started 25/11/2023 HV = 5600 V





Conclusions

- After initially encountering an issue in the HPL plate production, which has since been successfully resolved, the production process is now proceeding seamlessly for both HPL plates and gas volumes

- 100% of the HPL plates and 98% (49/50) of gas volumes produced satisfy our quality standards

HPL and gas volume production

Flavour 1: BIL Gas Volumes

Geometries	1A	1B	1E	1X	1Y
Length (mm)	2466	2466	2155	1555	2315
Width (mm)	658	498	658	498	498
Windows in Polycarbonate frame (see § 3.1.9)	4	3	3	3	3
Quantity of Gas Volumes required (excluding prototype and pre-series)	164	135	7	4	13

Table 1: Dimensions and production quantities of BIL Gas Volumes

Numbers not corrected

Flavour 2: BIS Gas Volumes

Geometries	2A	2B
Length (mm)	1660	1660
Width (mm)	1072	890
Windows in Polycarbonate frame (see § 3.1.9)	6	5
Quantity of Gas Volumes required	51	257

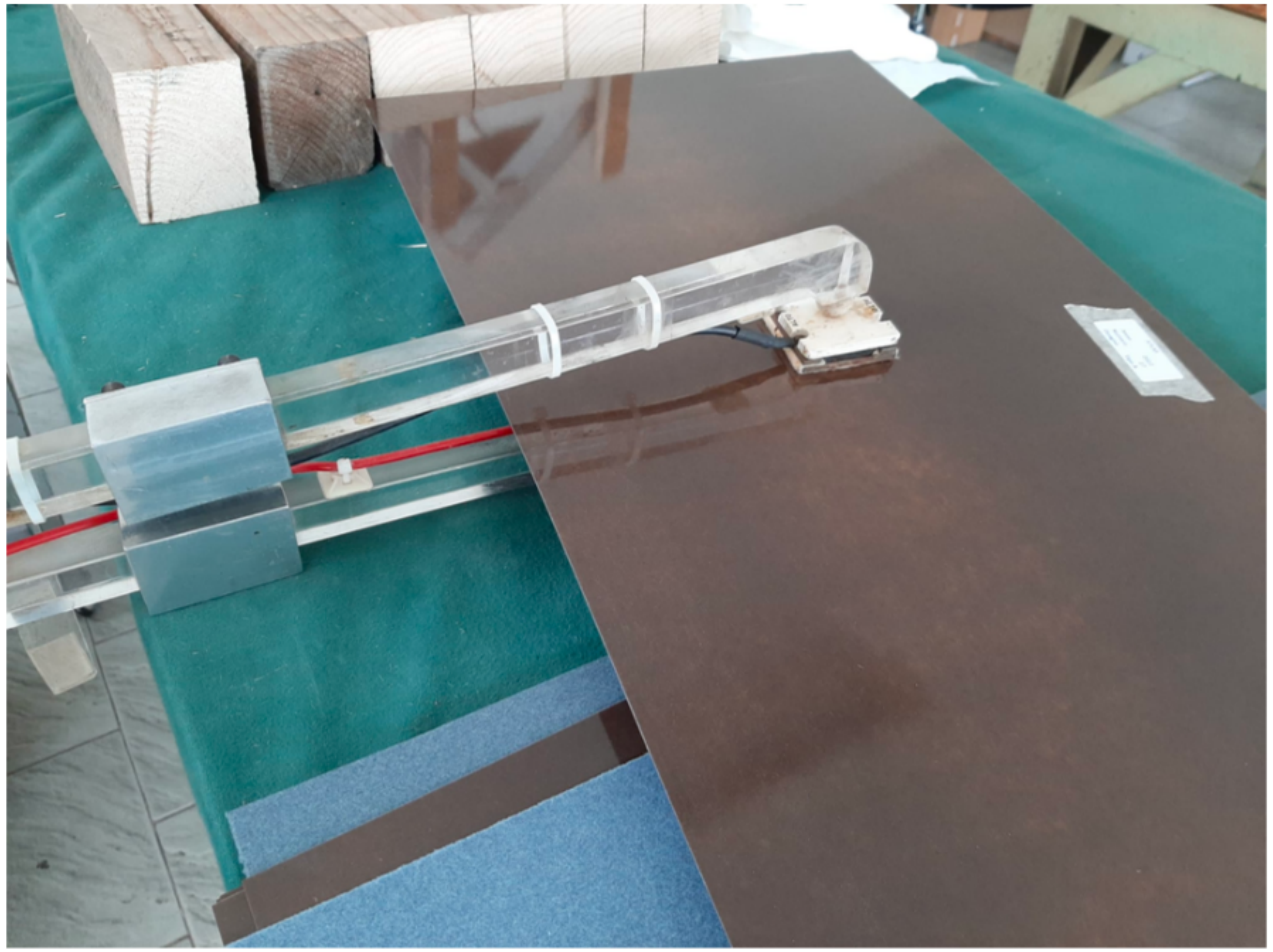
Table 2: Dimensions and production quantities of BIS Gas Volumes

Numbers not corrected

Resistivity measurement

BIL

BIS8



$$R = \rho \times \frac{l}{A}$$

Temperature dependance corrected $$\rho_{20^\circ} = \rho_T \times e^{\frac{T-20}{8.1}}$$

BIS resistivity measurements on the same HPL plate (1st batch)

BIS 2A n.4

4,08E+10	2,35E+10	3,38E+10	4,83E+10	4,06E+10
3,80E+10		Label		4,17E+10
5,16E+10				6,07E+10
8,12E+10	8,34E+10	9,50E+10	9,60E+10	8,34E+10

Highest / Lowest ~ 4.1

BIS 2A n.6

1,54E+11	1,98E+11	1,65E+11
	Label	
1,49E+11		1,65E+11
2,48E+11	2,98E+11	2,98E+11

Highest / Lowest ~ 2

BIS 2A n.67

1,24E+11		1,29E+11		1,28E+11
		Label		
1,14E+11		1,35E+11		1,08E+11

Highest / Lowest ~ 1.3

Requirements on gas volumes

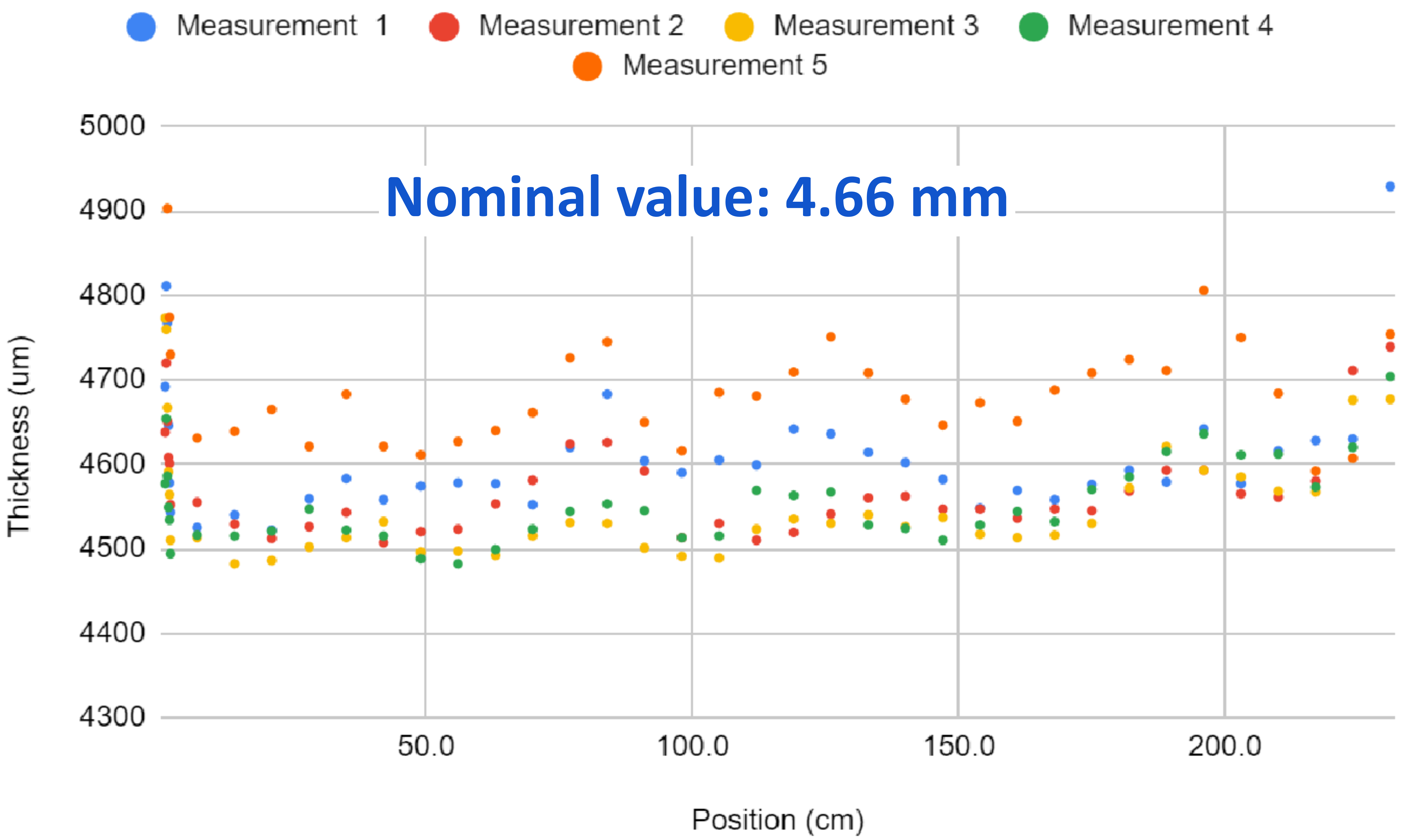
3.1.12 Requirements for the Gas Volumes as a whole

The Supply shall comply with the following requirements:

- The total thickness of the Gas Volume shall be between 4.21 mm and 4.75 mm, with a nominal value of 4.66 mm;
- The lateral dimensions of the Gas Volume shall have ±1 mm tolerance with respect to nominal dimensions defined in this document (length, width);
- The loss of pressure of a Gas Volume over-pressurised by 3 mbar must be less than 0.1 mbar after three minutes;
- The resistance between the two HPL plates must be at least 4 GΩ;
- The type of glue, to be used in the fabrication process, shall be resistant to an integrated dose of radiation up to 1kGy;
- The form factor must be rectangular (see dimensions in Tables 1, 2, 3).

From the Technical Specification document

Envelope tests (Gas-gap BIL)

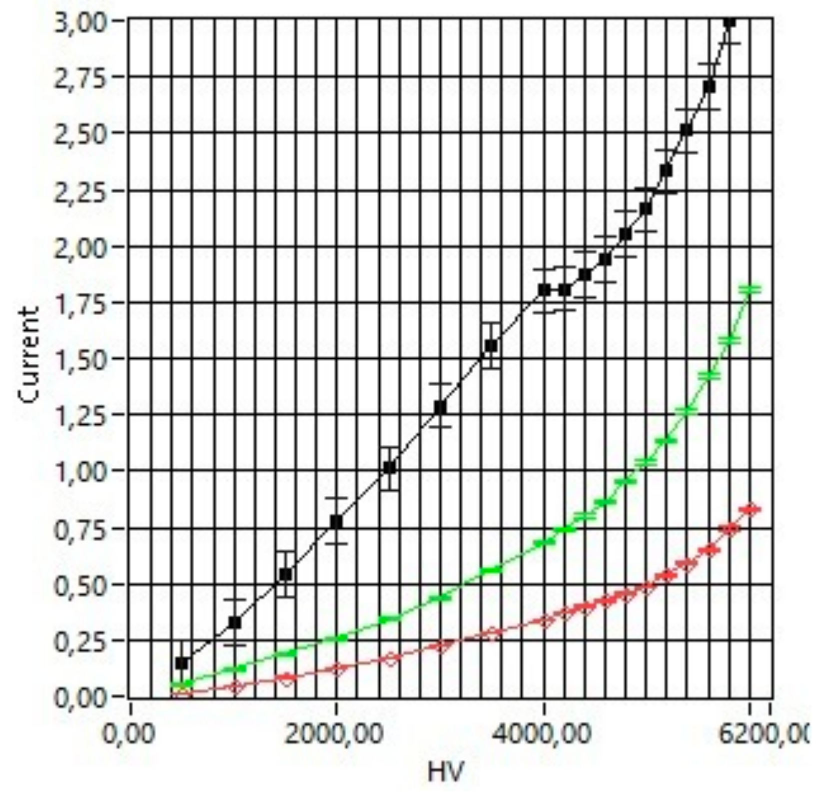


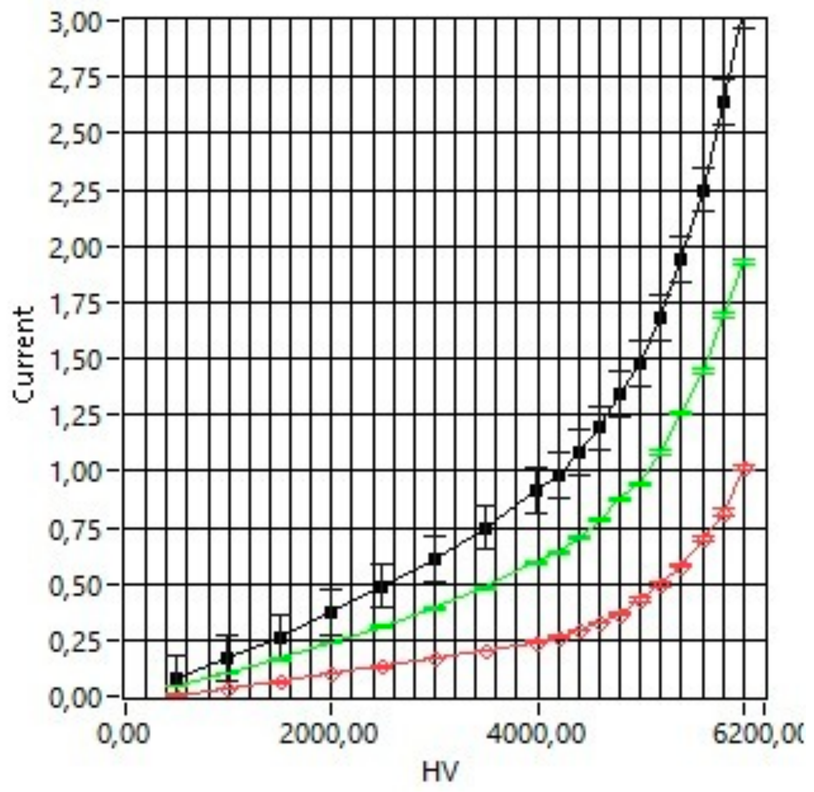
From Alessandro Rocchi

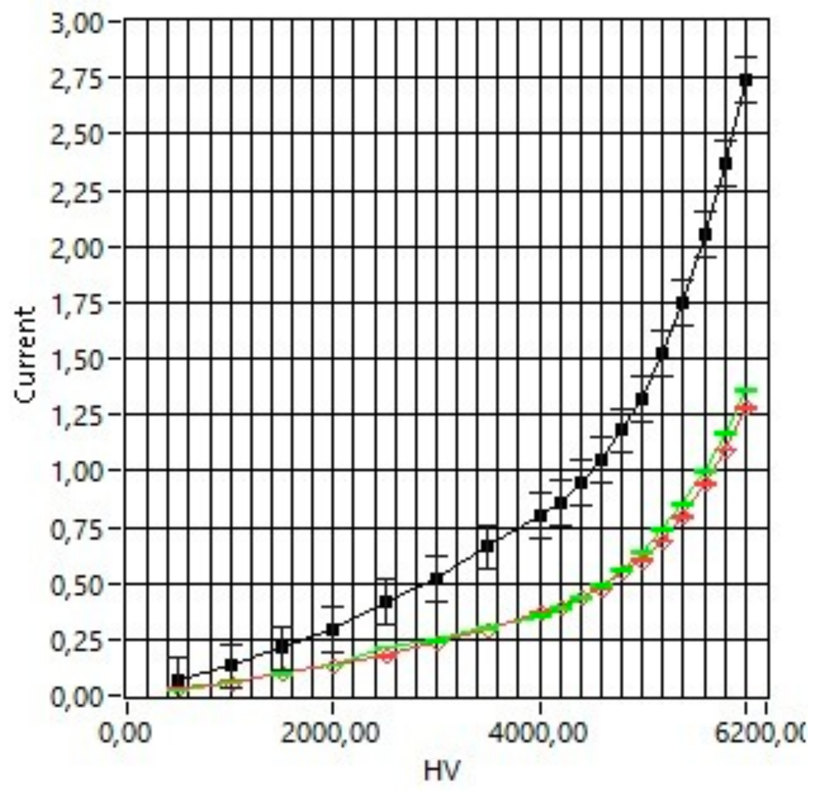
First quality test on CODEX-b gas volumes

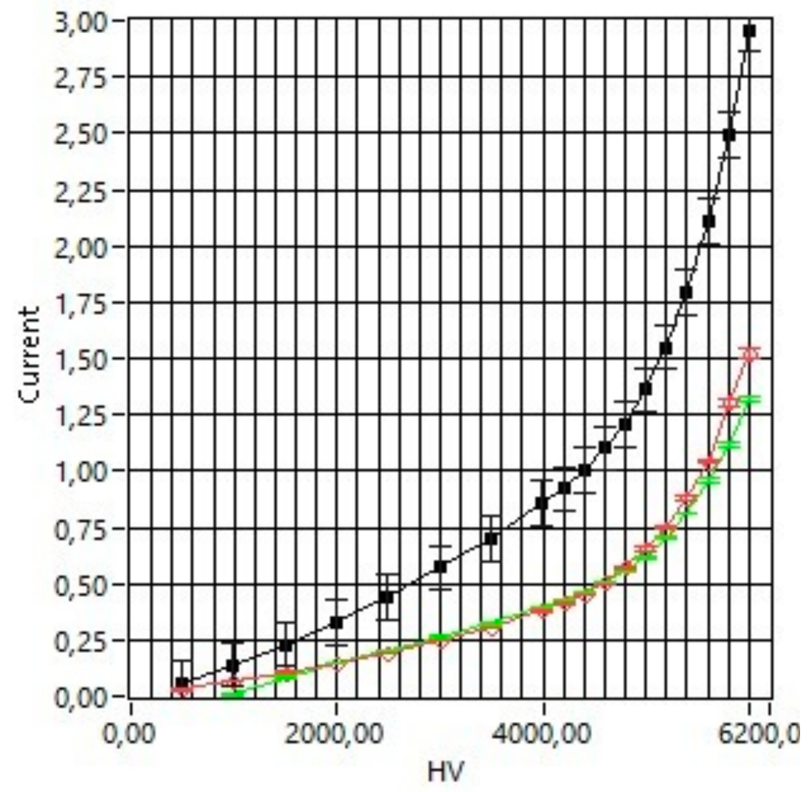
- The first 22 CODEX-b gas volumes (over a total of 50) were tested -> needed for the priming procedure of the gas gap production (to avoid the stop of the production at GTE)
- CODEX-b gas volumes share the same design of ATLS RPC BI gas gaps
- Only two types of tests have been performed on such gaps: **gas leak test** (successful) and **I-V scan**

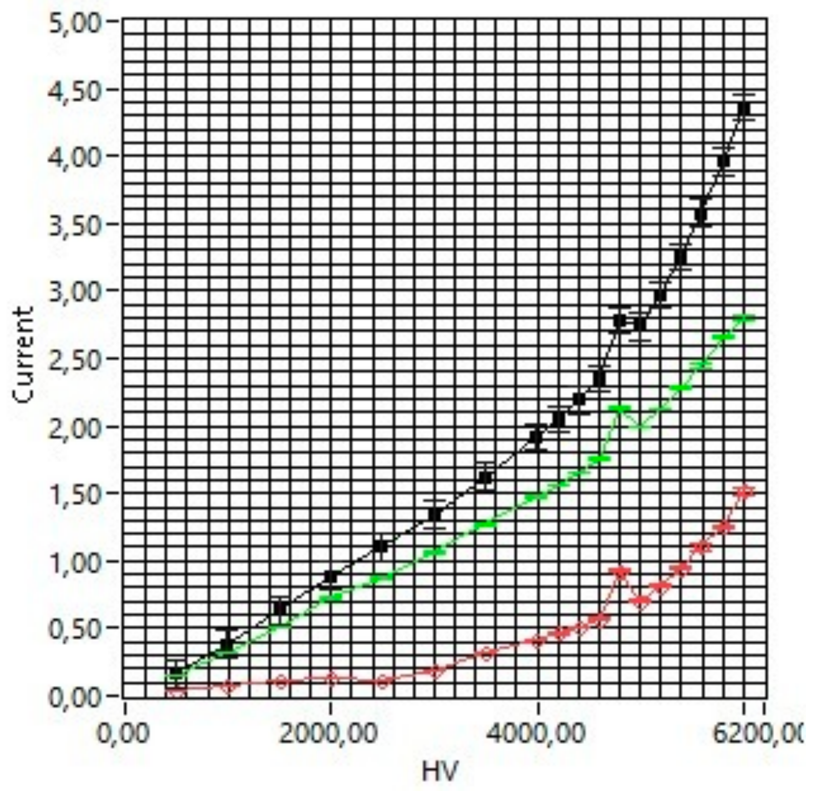
First quality test on CODEX-b gas volumes

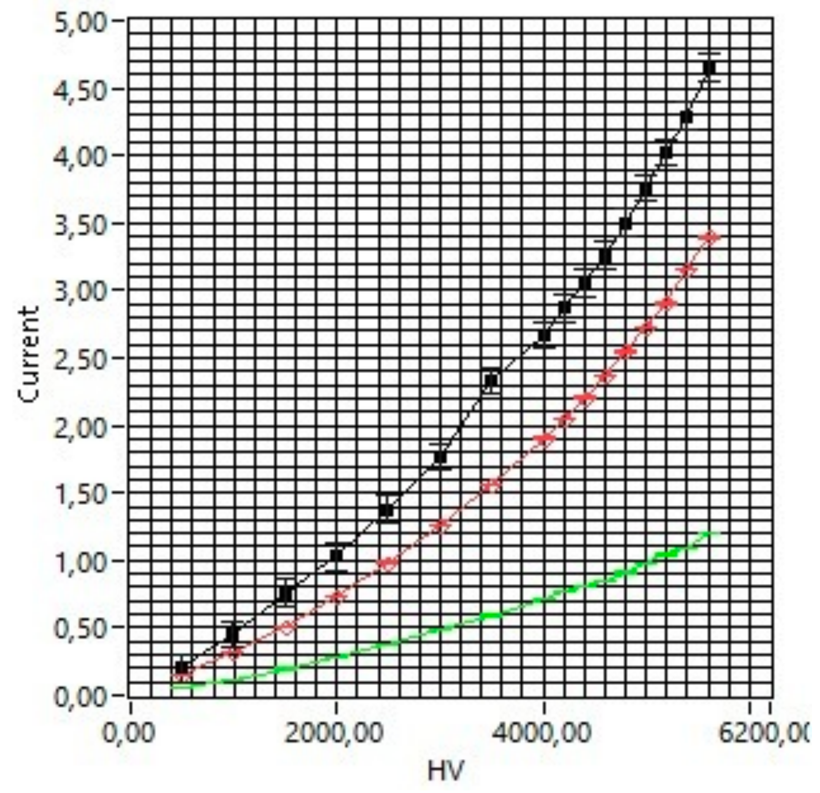
gaps 24-25


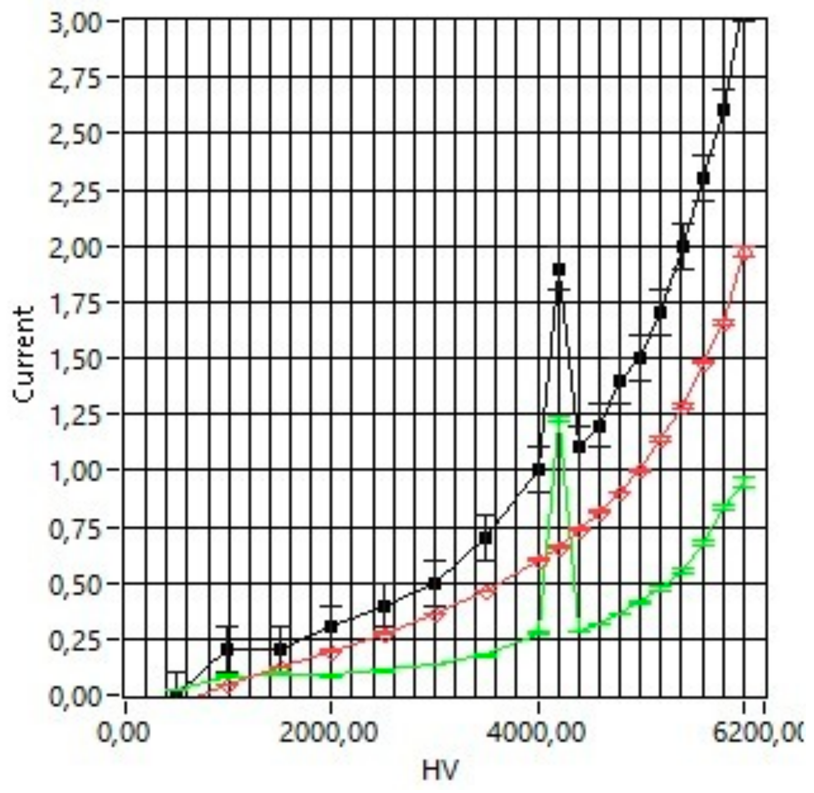
gaps 26-27


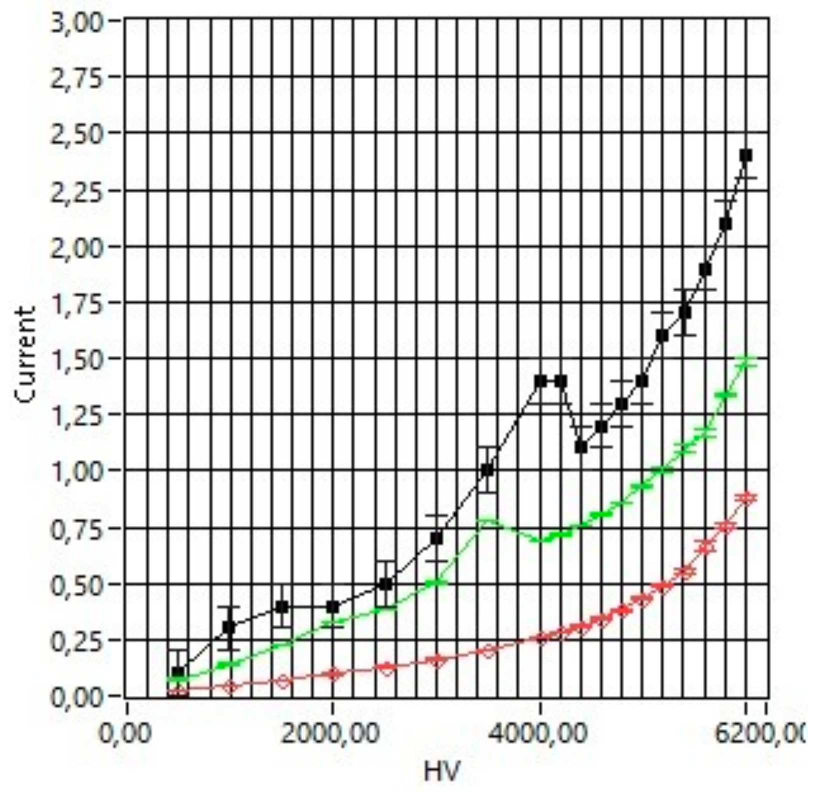
gaps 28-29


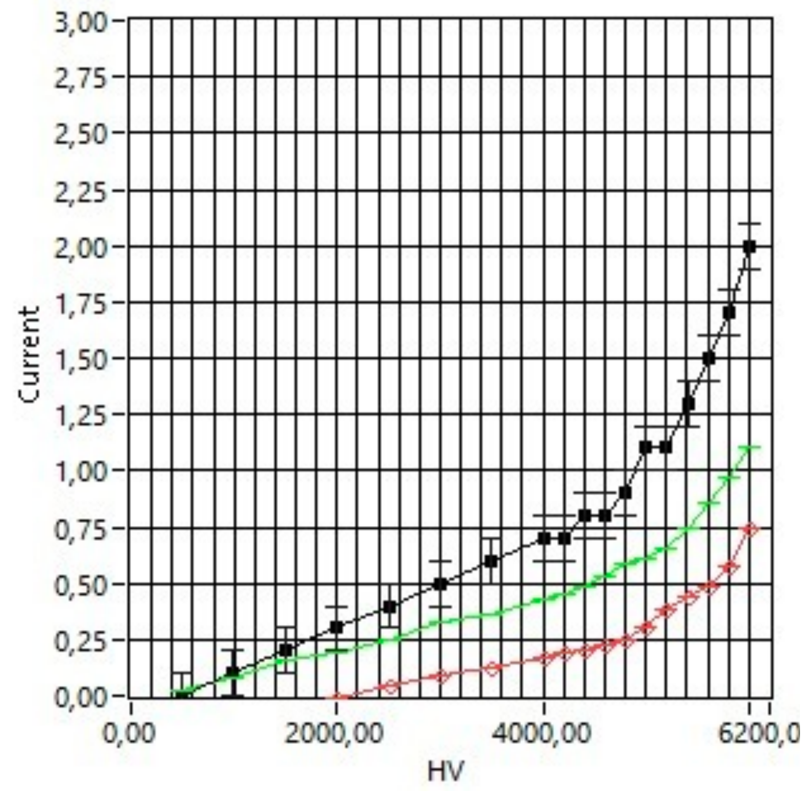
gaps 31-30


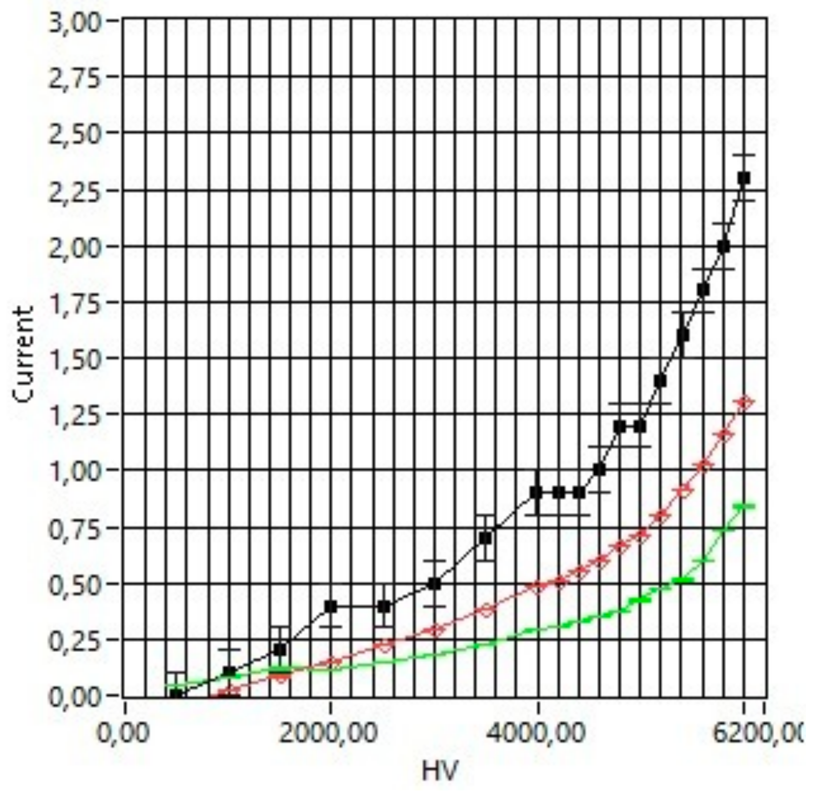
gaps 32-33


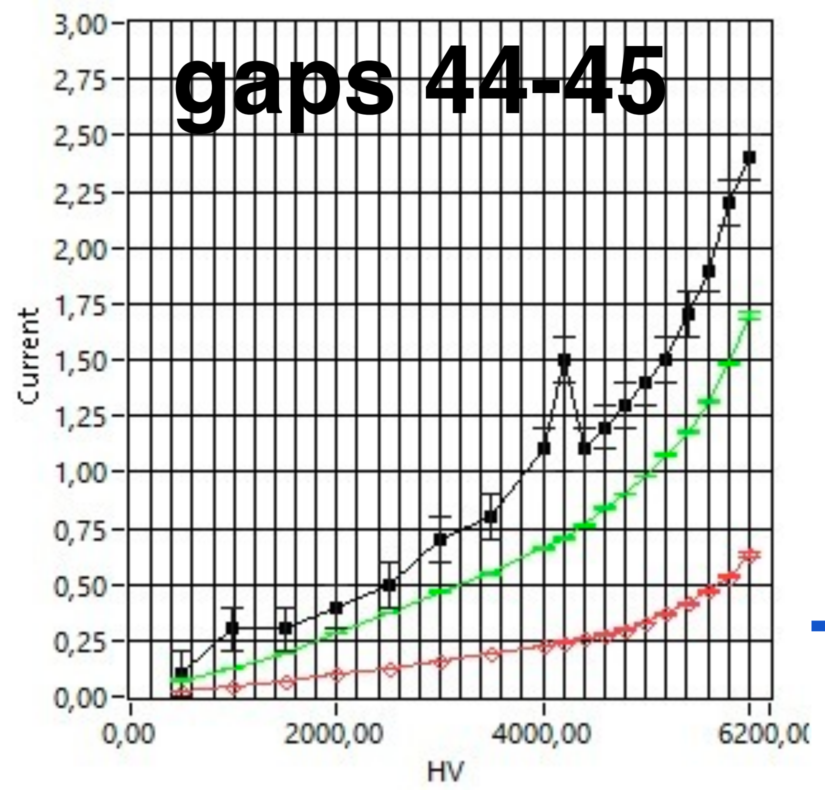
gaps 34-35


gaps 36-37


gaps 38-39


gaps 40-41


gaps 42-43




Black: CAEN current
Red: gap 1 current
Green: gap 2 current

ATLAS requirements

- < 1 μA @3.5 kV
- < 3 μA @6.1 kV (after Ohmic current subtraction)

I-V scan: requirements for acceptance

From the Technical Specification document

> The voltage will be gradually increased up to 6.1 kV, normalized to the environmental standard temperature and pressure of 1000 mb at 20 °C. Two voltage intervals will be analysed: from 0 to 3.5 kV and from 3.5 kV up to the maximum voltage defined above.
>
> - In the first interval, the current must increase linearly with the voltage; the deviation from linearity at 3.5 kV shall be less than 0.1 μA; the corresponding inverse slope is a measure of the quality of the isolation between the two resistive electrodes. For a Gas Volume to be accepted, the maximum linear current must be less than 1 μA at 3.5 kV;
> - In the second interval, the current growth must be approximately exponential indicating that the discharge flows through the gas. The maximum exponential current at the maximum voltage shall be 2 μA after subtraction of the extrapolated linear component at that voltage.