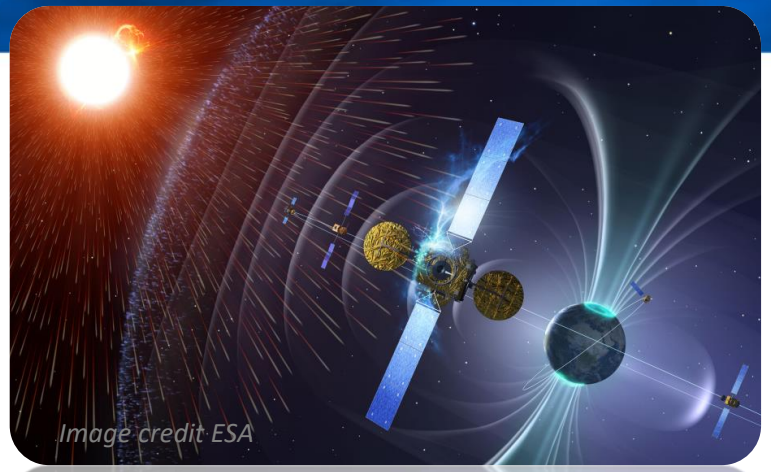

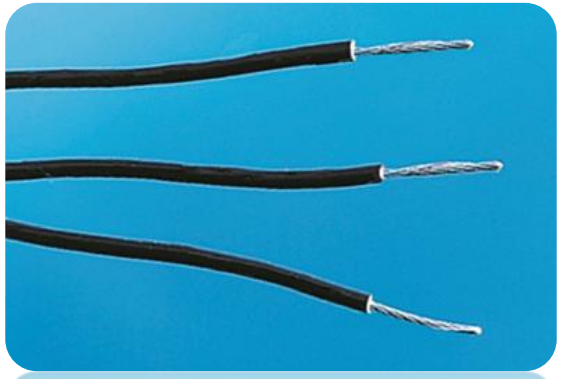

Toward New Space ESD-resistant antistatic cables

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R&D Materials dpt. Manager

13/10/2022 – 4th Space Passive Component Days (SPCD2022) ESA/ESTEC Noordwijk

Space ElectroStatic Discharge (ESD) Resistant solutions

esa

ITT AO/1-7877/14/NL/RA

Image credit:
Daniel Grohmann

NEW SMART ANTISTATIC MATERIAL & LOW VOLTAGE INSULATED WIRES

→ NEW SPECIAL
BULK RESISTIVITY RANGE:
$\rho \approx [10^8 - 10^{14}]$ ohm.cm

→Insulative at Operative Voltage (<100V)
→ANTISTATIC if voltage increase (anomaly)

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Project objectives and context

- **Development of Space ESD-resistant antistatic Cables and insulations materials for Space applications**

Two related recent ESA projects:

- RFQ/3-14156/14/NL/BW) **(LIST + Axon')**
  - → **Result presented by Dr Addiego (LIST) at 3rd SPCD (2018)**
- ITT AO/1-7877/14/NL/RA **(Axon')**
  - → **This presentation**

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LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

Followed at ESA by: **Denis Lacombe & Léo Farhat**

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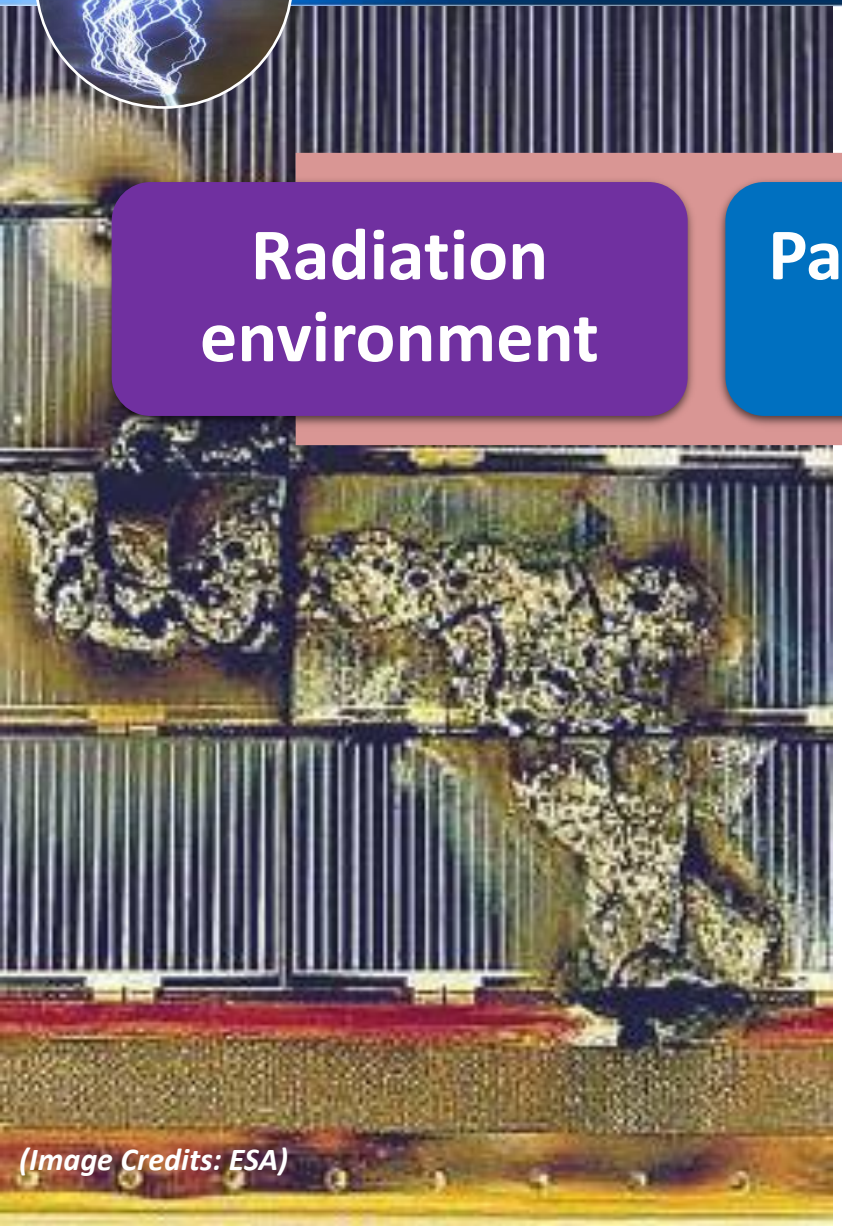
ElectroStatic Discharge (ESD) risks in Space



ESD RISK IN SPACE

Radiation environment → **Particles energy and fluxes** → **Charge build-up in insulations** → **ESD/Arcing risk**

MAIN REASON:

→Too good insulations materials!

- Ex: Electrons trapped inside the dielectrics
- Risk function of Materials electrical properties, Particles Flux & Energy at the specific localization, ...

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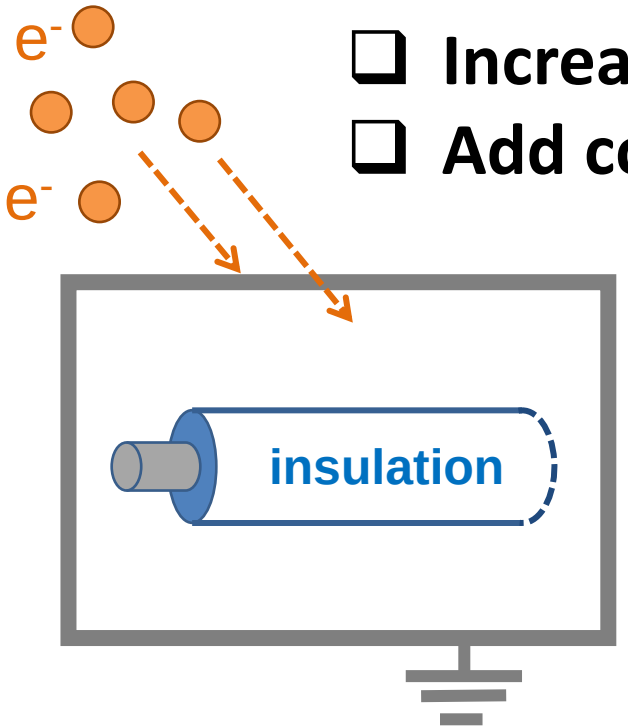
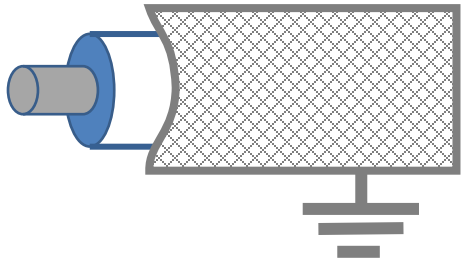
ESD Risks Mitigation Strategies

HOW TO PREVENT WIRE INSULATION CHARGING ?

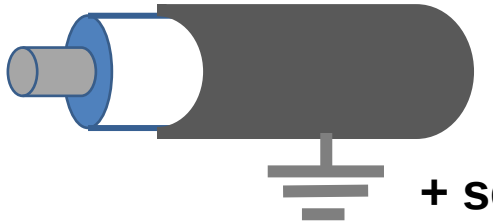


Indirect shielding

- ❑ Increase shielding thickness
- ❑ Add conductive layers



+ local shielding (braids, tapes,…)



+ semi-conductive layer

→ Add weight & complexity (grounding, termination, bonding,..)

- ❑ Use “leaky” dielectrics

Modified « Antistatic » Insulation This ESA Project Target

→ Mass saving
→ Flexibility / easy to use
→ No grounding required

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Antistatic insulation concept

Concept :

→ **Control of the charge decay rate through the insulation**

How?

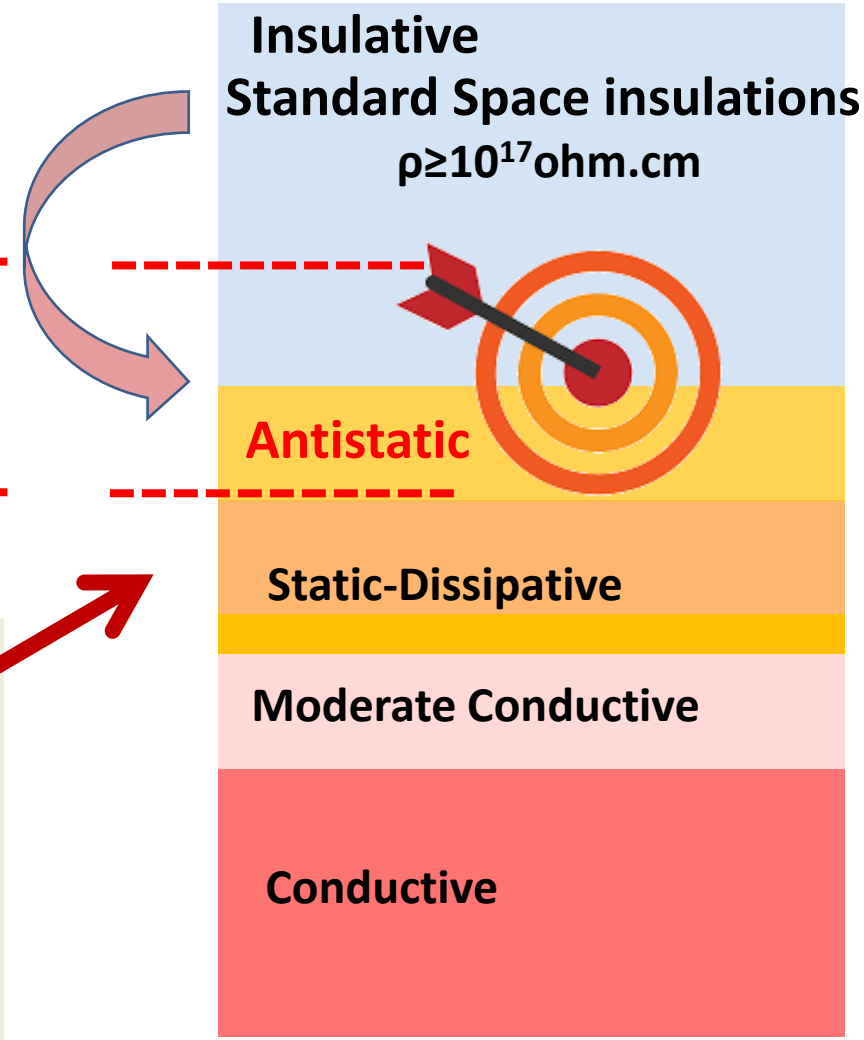
→ **Modified insulation for specific volume resistivity**

Requirements

Based on Spacecraft charging Standards:

- ***ESA*** *ECSS-E-ST-20-06C*
- **NASA**-HDBK-4002
- ***JAXA****-JERG-2-211A*

Electrical classification of insulation materials



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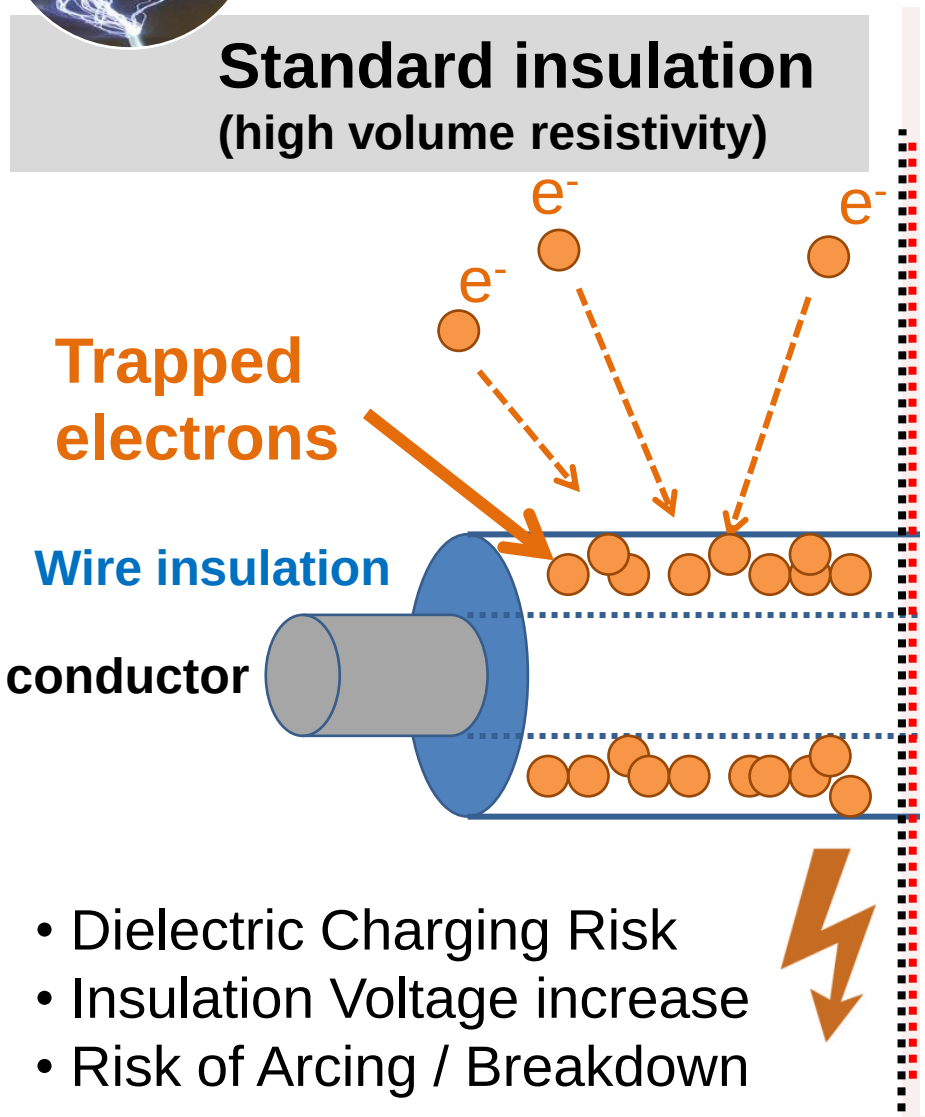
Innovative ESD-resistant wires concept

Standard insulation
(high volume resistivity)



- Dielectric Charging Risk
- Insulation Voltage increase
- Risk of Arcing / Breakdown

New Concept

for mass saving, easy integration, and flexibility

→ **Control** of the electrical **charge decay rate through the insulation** to nearest conductor

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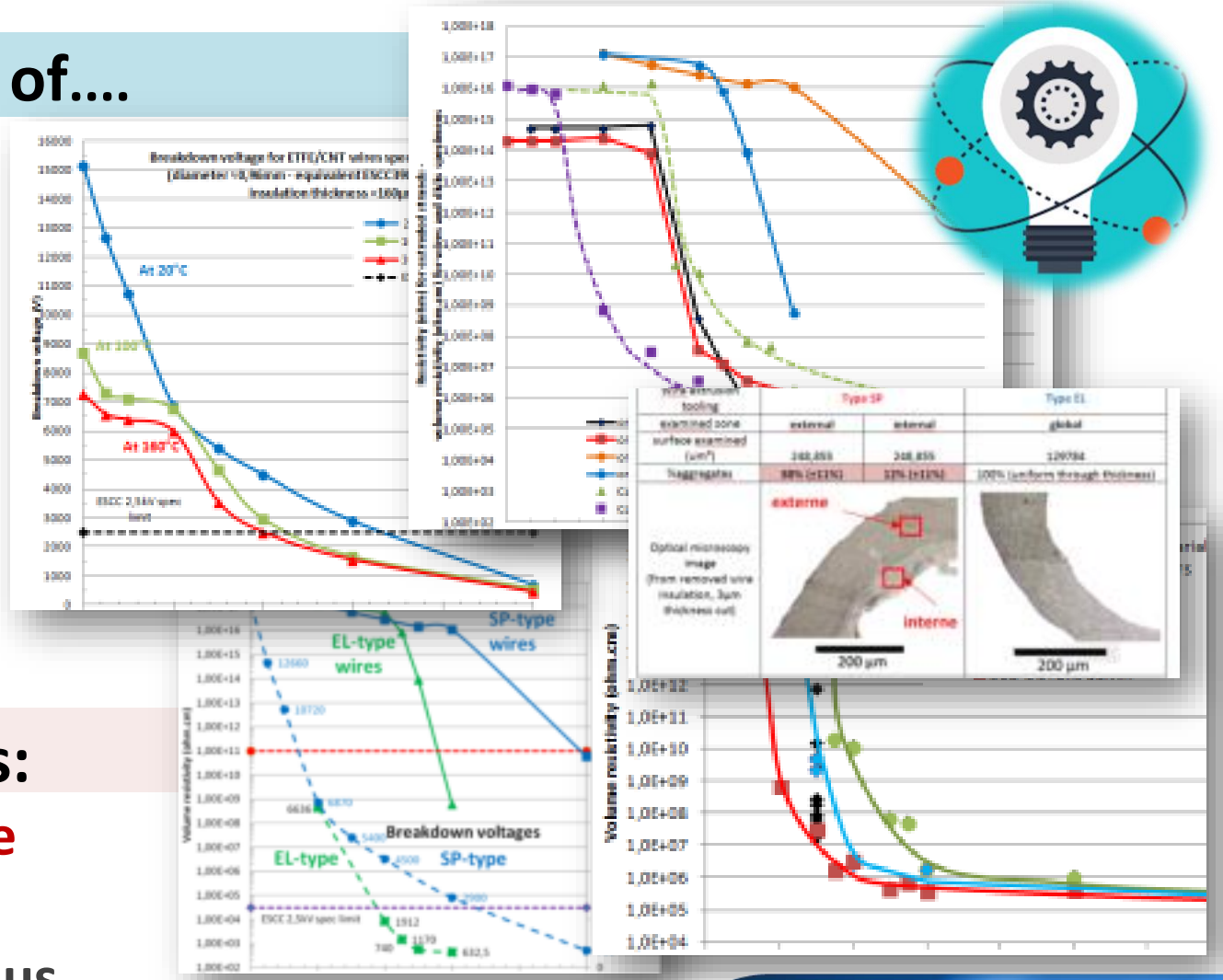
ESA AO/1-7877/14/NL/RA -

R&D - Study of the Influence of….

- ✓materials nature & formulations
- ✓manufacturing parameters
- ✓re-processing stages and methods
- ✓measurements methods
- ✓temperature (-200°C +160°C)
- ✓material thickness & structure

…



→ …on Materials & Wires Properties:

- Volume Resistivity / Insulation resistance
- Breakdown voltage / Dielectric Strength
- Tensile and elongation at break, E modulus
- Abrasion, cut-through, shrinkage, …

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ESA AO/1-7877/14/NL/RA -

Study of the influence of:

- ✓ materi… ulation
- ✓ manuf… …ers
- ✓ reproc… methods
- ✓ measu…
- ✓ tempe… 60°C)
- ✓ material thickness & st…

…

on

→ Materials & Finished wires properties

- Volume Resistivity / Insulation resistance
- Breakdown voltage / Dielectric Strength
- Tensile and elongation at break, E modulus
- Abrasion, cut-through, shrinkage, …

…AFTER FEW YEARS OF RESEARCH AND DEVELOPMENT…

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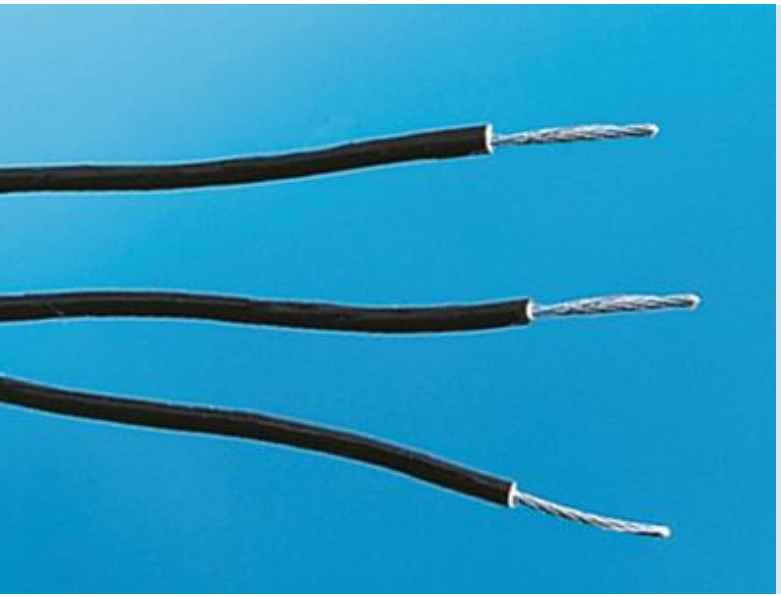
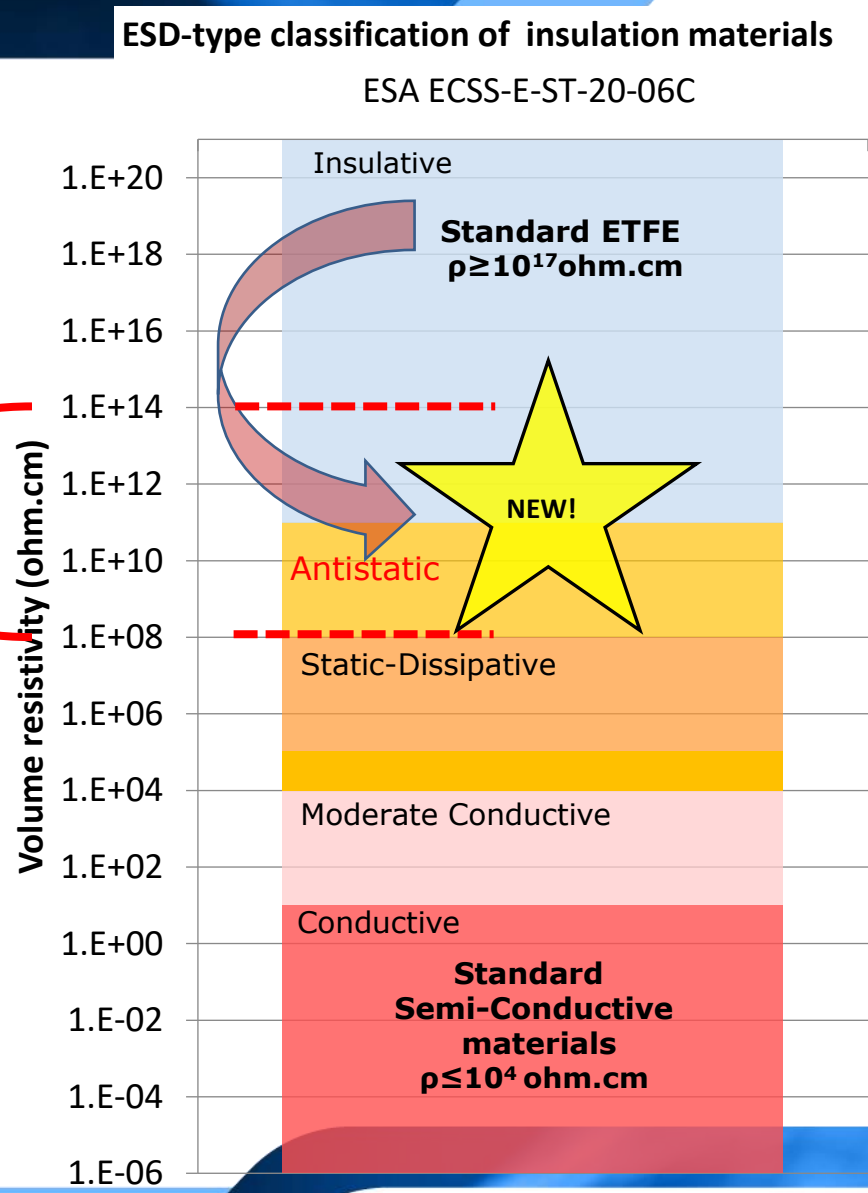
Main Results

Project main objective = Success!



NEW RANGE OF « ANTISTATIC » WIRES PROTOTYPES WITH

$\rho \approx [10^8 - 10^{14}]$ ohm.cm



Wires designs similar to ESCC 3901/012 style :

- ✓ **PASS all mechanical requirements**
- ✓ **PASS cold bend and thermal ageing tests at 230°C**
- ✓ **PASS voltages tests at 500Vdc**

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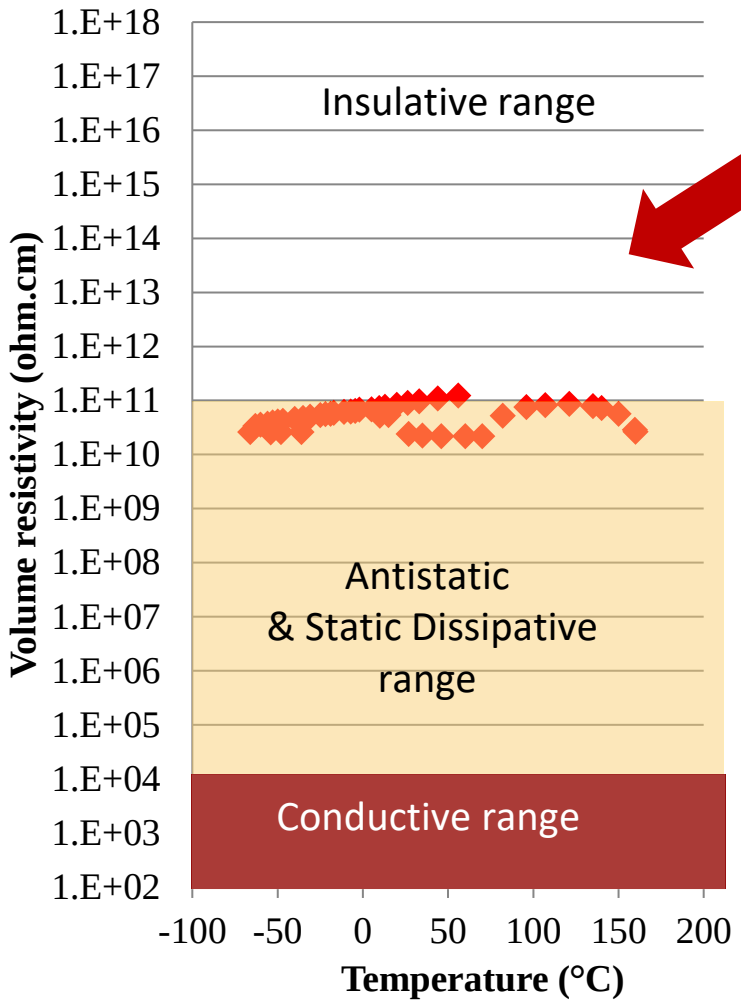
Results examples – Focus:



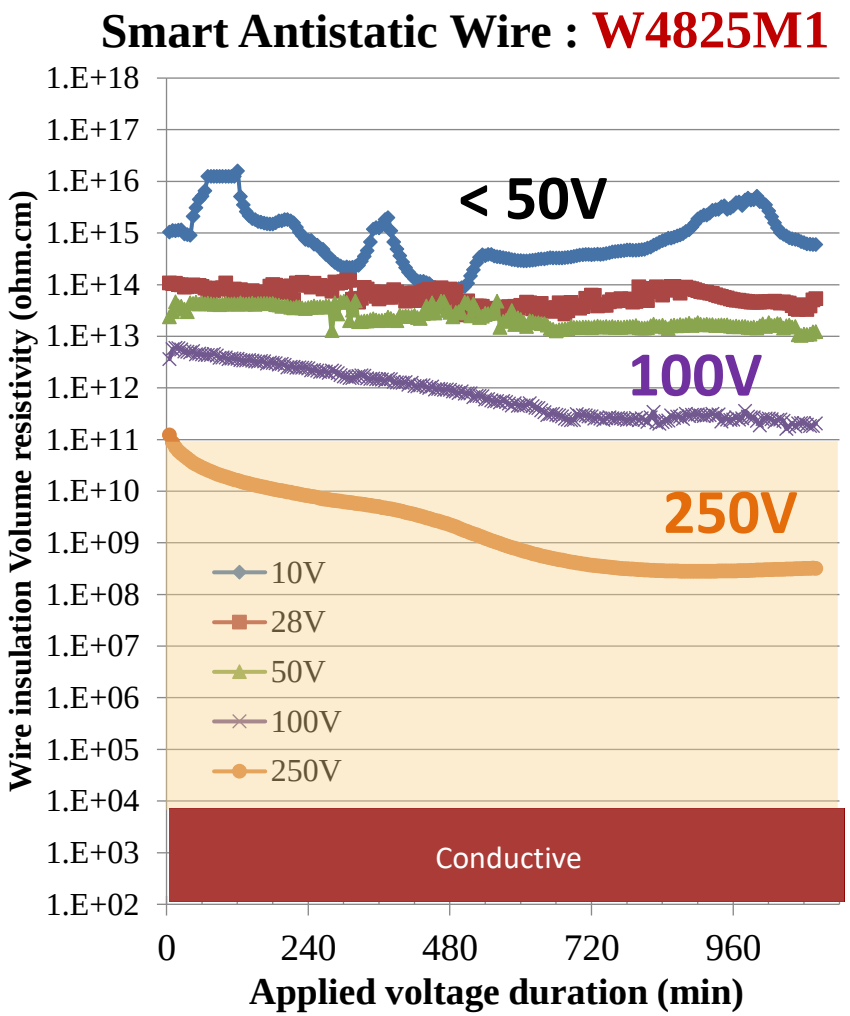
STABLE ELECTRICAL PROPERTIES between at least [-80°C* to +160]°C

*+ similar result immersed at -200°C

"SMART" ANTISTATIC BEHAVIOR

→ Apparent Volume resistivity function of differential Voltage

→"Smart" Dynamic Charge decay rate : **Reach Antistatic range if voltage >100V (Reversible)**



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Main conclusions

→ **Project Success :** New **antistatic wires** prototypes developed in target range (**ρ≈ 10^8 – 10^{14} ohm.cm**)

- Compliant with **low voltage Space systems** (at least 100V)
- Mechanical and thermal performances similar to Standard qualified ETFE insulated wires (ESCC3901/012)
- **Low mass, easy to use, no grounding required** compared to alternative solutions (additional shielding, conductive layers…)

TRL 1 | TRL 2 | TRL 3 | TRL 4 | TRL5 | TRL 6 | TRL 7 | TRL8 | TRL 9

This ESA ITT Objective and Result

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Perspectives

→ **Axon' Antistatic wires prototypes available to Space users**

- **Further testing/development required for higher TRL target**
  - **Investigation of Charging parameters of these new wires and materials** to ensure Space functionality? (example: ONERA SIRENE facility = Thermal Cycling in vacuum + GEO like spectra irradiation)?
  - Influence of **Total Ionizing dose up to X?** (tested up to 30MRad - OK)
  - **Harmonized Space-users requirements** update – for a complete ESCC3901-style qualification – cable design/materials adjustments

TRL 1 | TRL 2 | TRL 3 | TRL 4 | TRL5 | TRL 6 | TRL 7 | TRL8 | TRL 9

This ESA ITT Objective and Result

Next Target?

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Thanks for your attention!

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