Distant arcs on solar array coupons:

Is the ESD in the gap the most critical situation?

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return on innovation

Outline

- Context, objectives
- Set-up
  - physical FO simulator
- Results
- Discussion

Context - Objectives

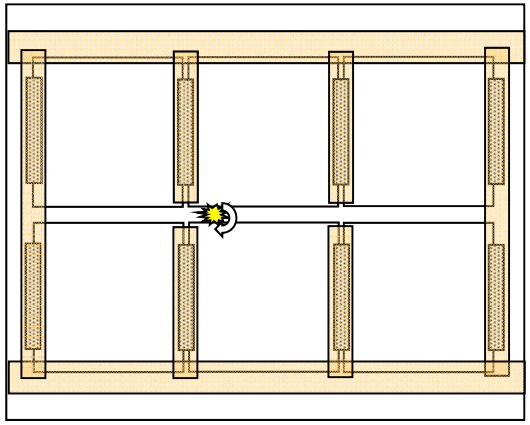
- ESD qualification of solar array coupons
- Constant discussions/reflexions on the qualification set-up
  (ex ISO doc)

- Most critical situation is generally agreed to be the ESD in the gap

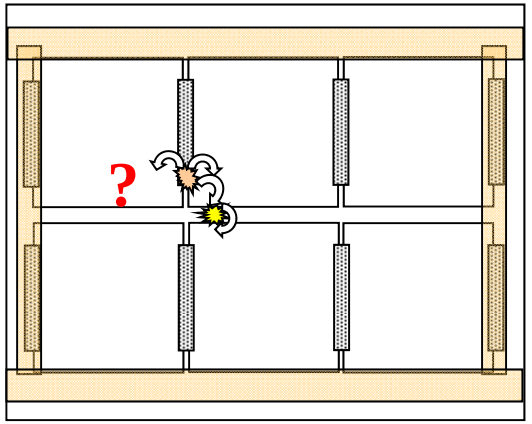
- Does a discharge elsewhere can provoke an arc between cells?
  - Does distant arcs exist?
  - If yes, can it be more critical?

Test conditions

- Reproduce the situation usually used for solar arrays coupons qualification (against ESD risk)
  - Inverted voltage gradient
  - SAS
- Instead of leaving only the gap apparent, leave also interconnectors



- Usual configuration

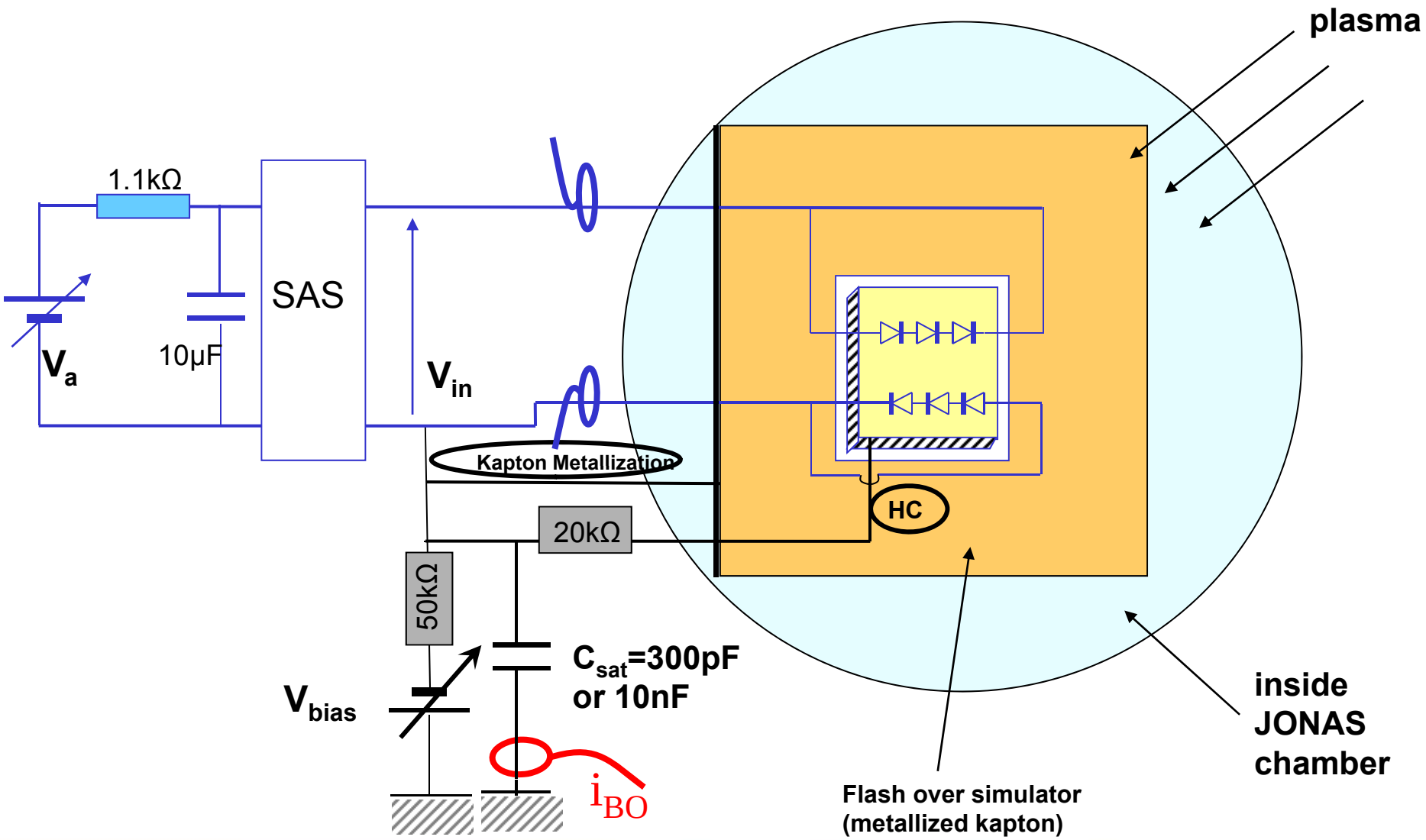


configuration of this test

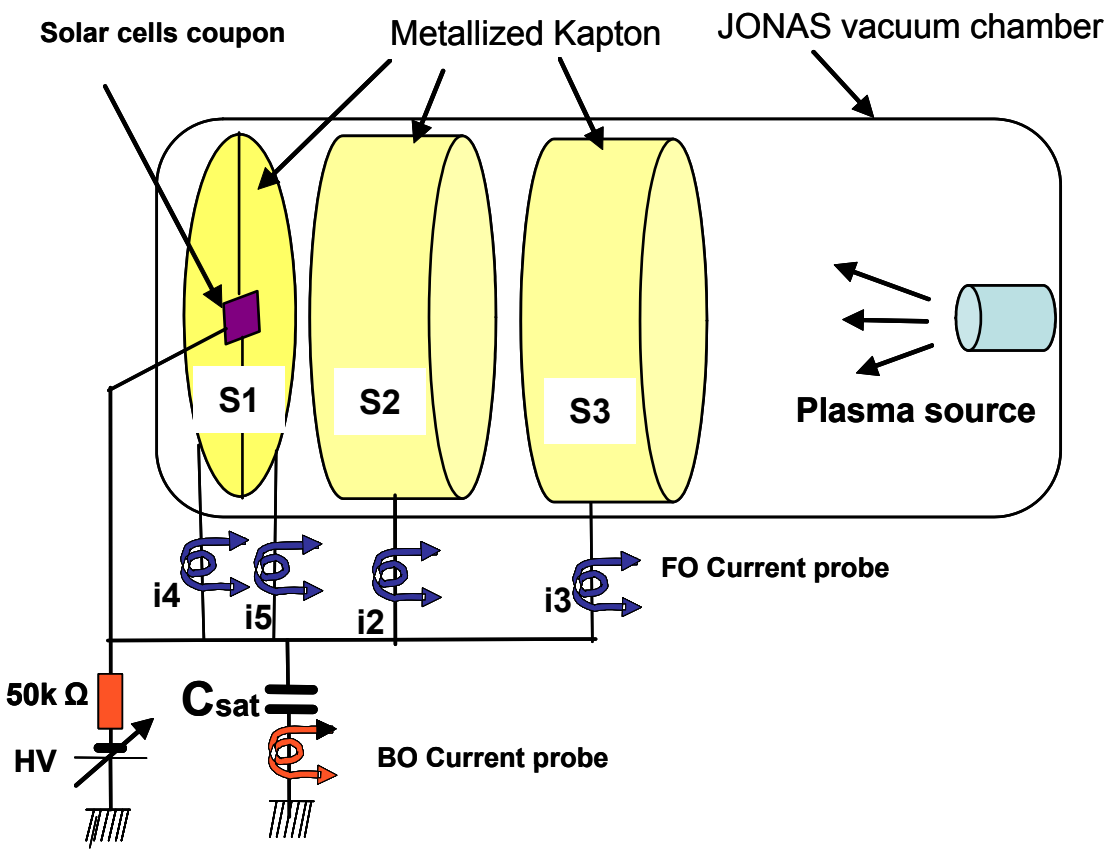
- Use FO simulator developped by ONERA/CNES

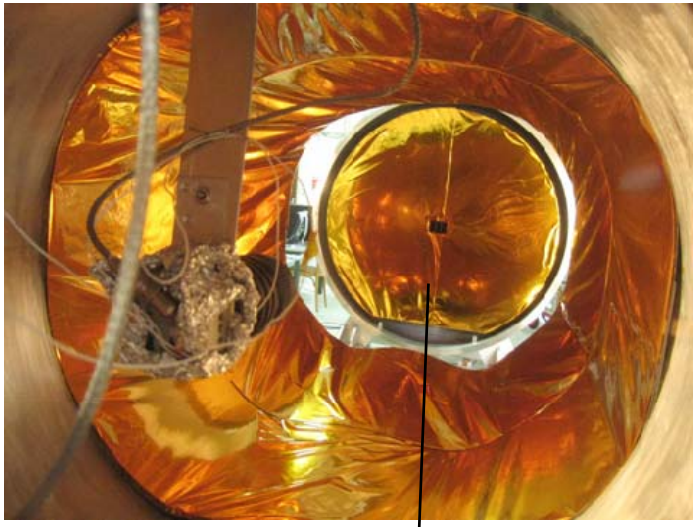
JONAS

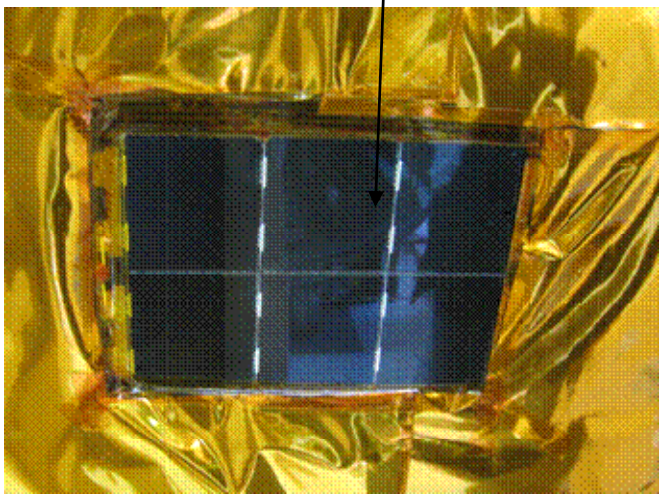
Experimental set-up



Experimental set-up



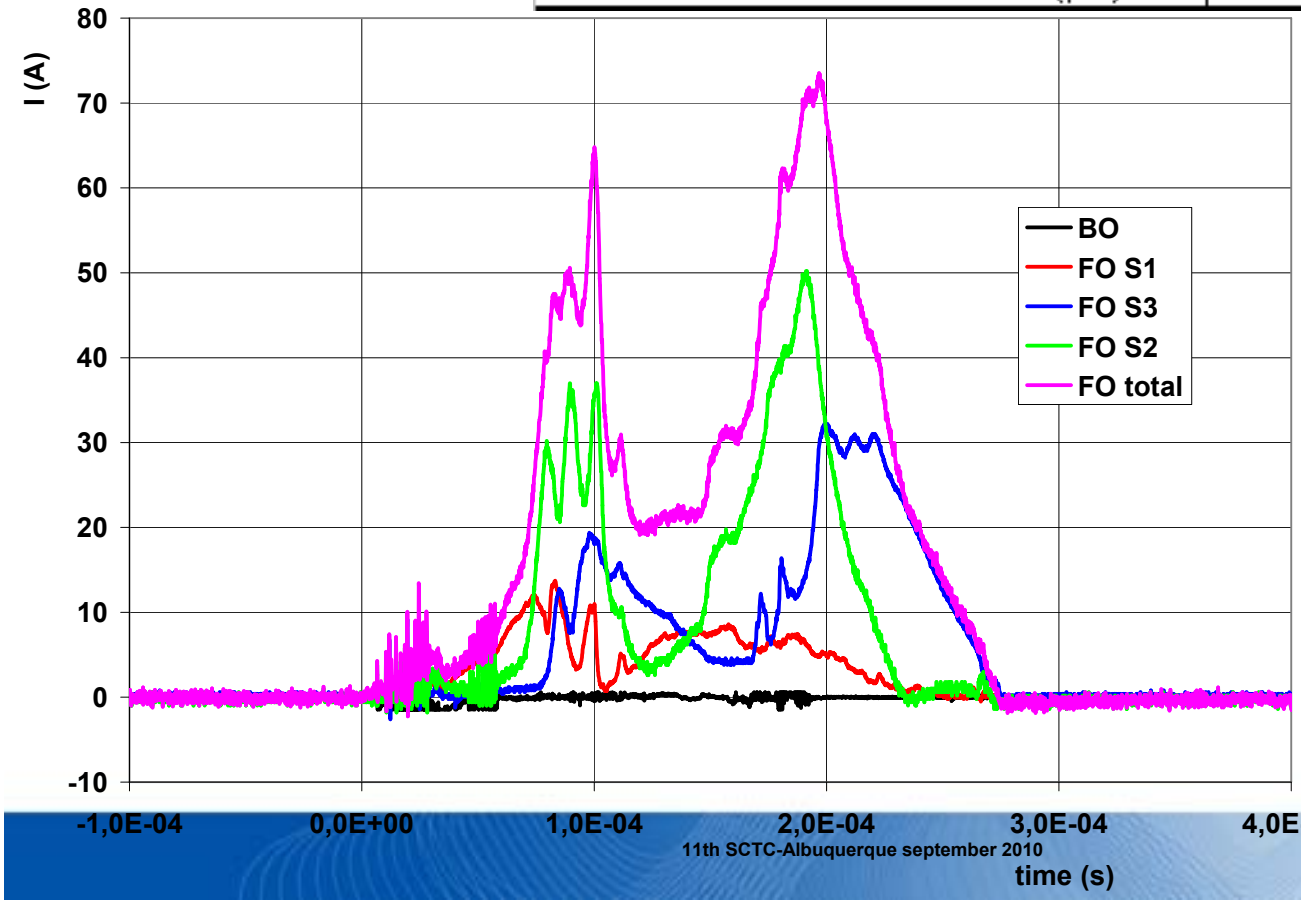




See poster n°49

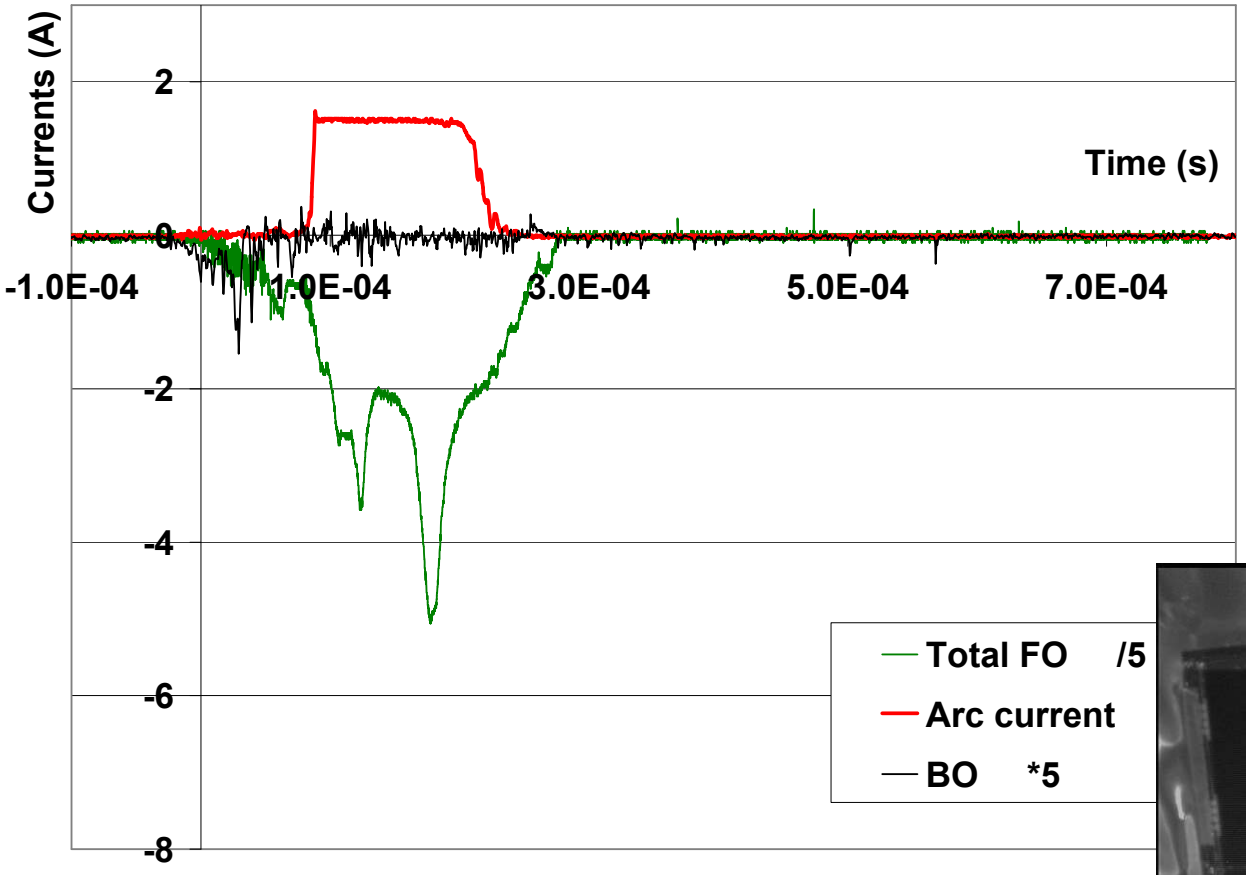
FO signals

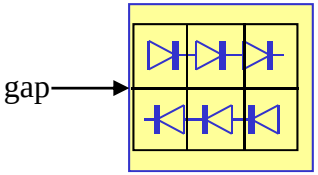
	S1	S2	S3	S1+S2+S3
considered surface (m2)	2,4	6,6	4,4	13,4
capacitance (µF):	1,5	4,1	2,7	8,3
stored charge Q = C.V(µC)	750	2050	1350	4100
measured charge Q = ∫ i.dt (µC)	702	1500	1207	3409
Q standard deviation(µC)	110	230	45	128
% of neutralization	94	73	89	**82**
% standard deviation	15	11	3	**3**
FO duration (µs)				**310**
standard deviation duration (µs)				**39**

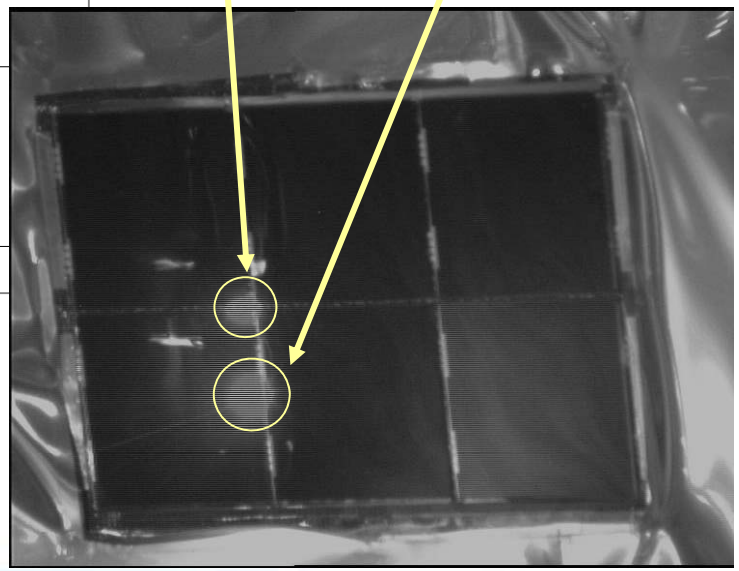


See poster n°49

ESD 165 (Csat = 10 nF) – on IC

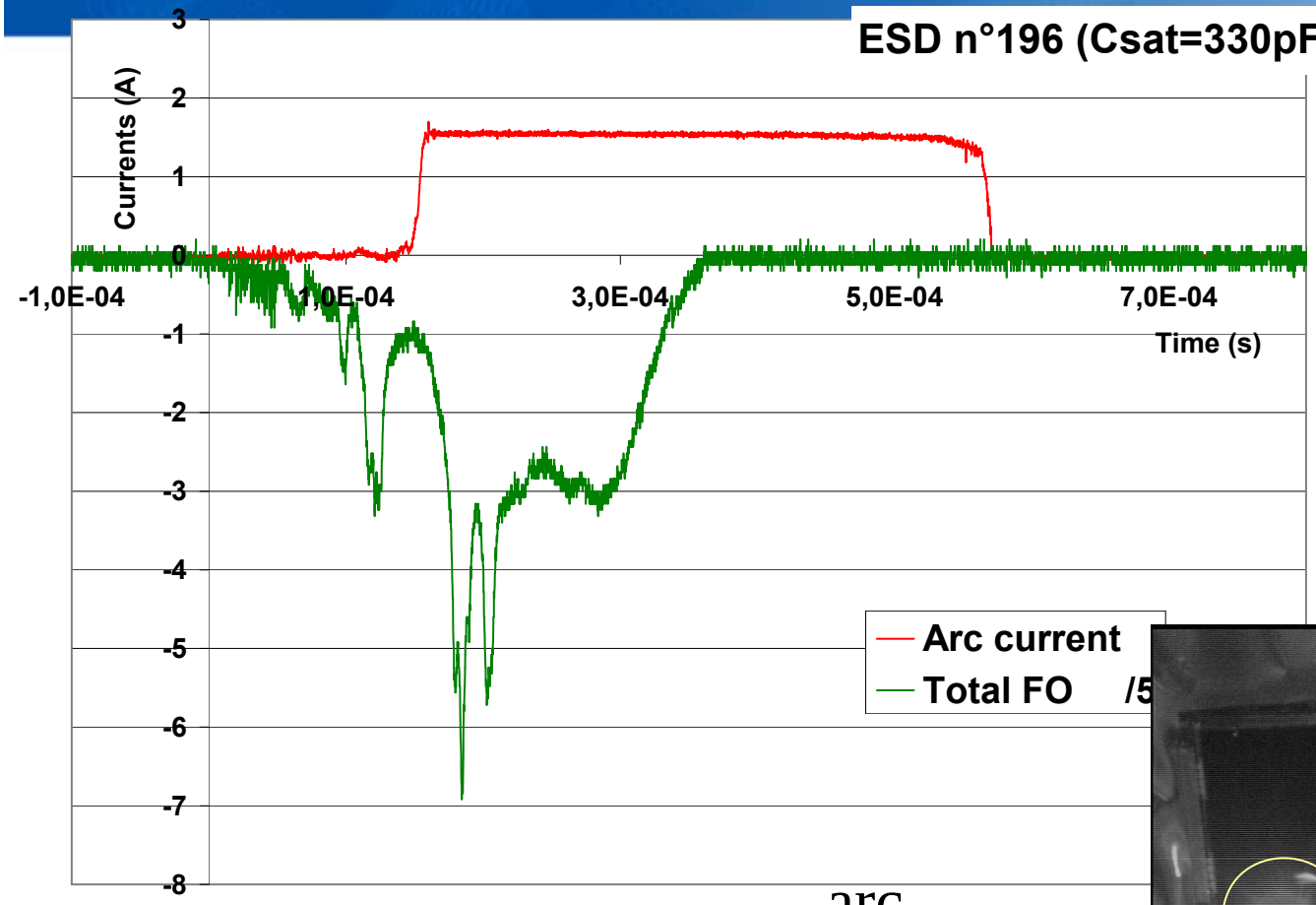


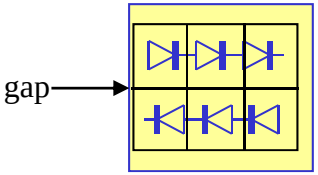


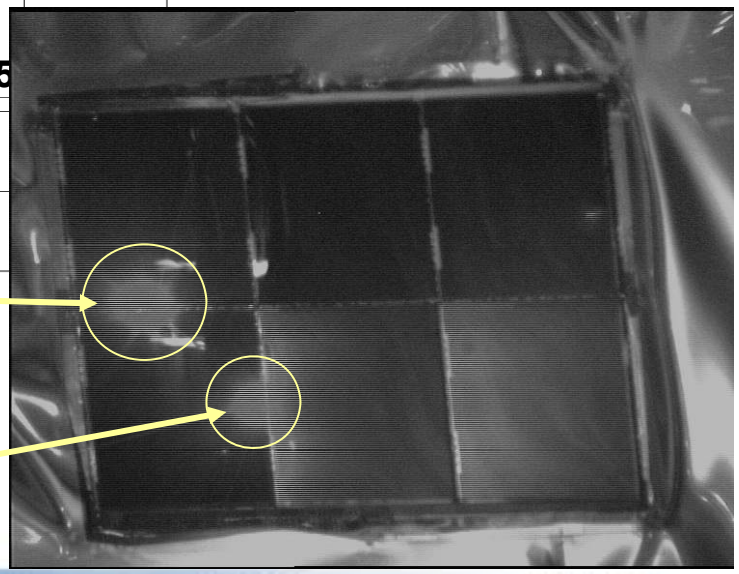


arc duration = 150µs
delay = 41µs
distance = 19mm

ESD196 (Csat = 330pF) – on IC

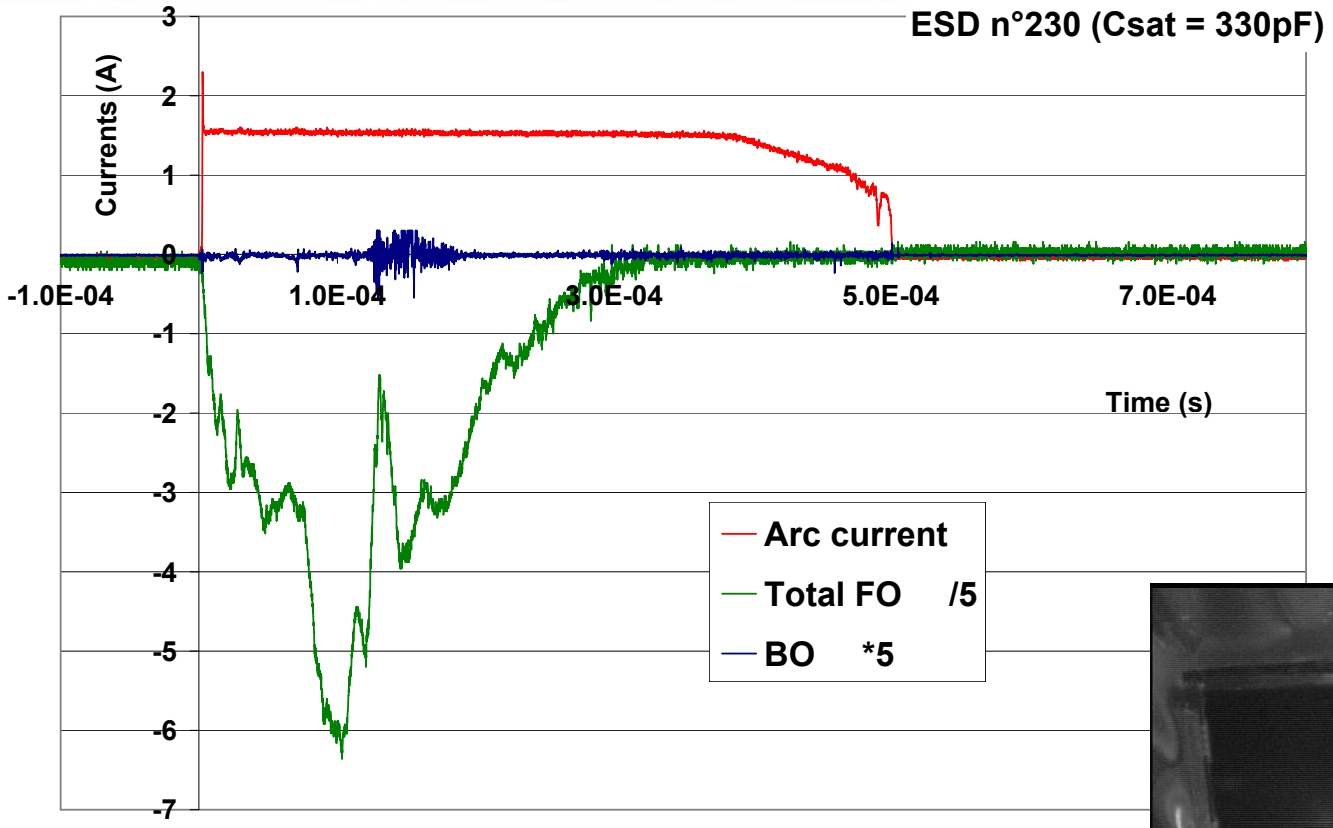




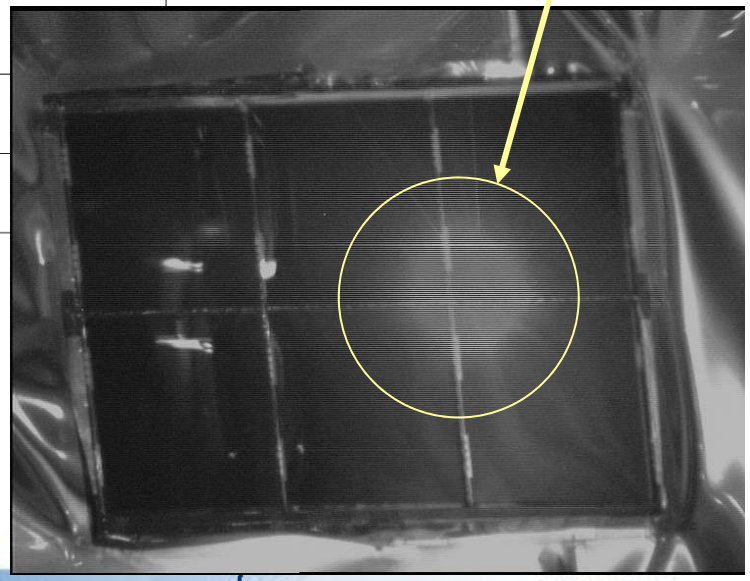


arc duration = 420µs
delay = 160 µs
distance = 32 mm

ESD 230 (Csat = 330pF) – in the gap

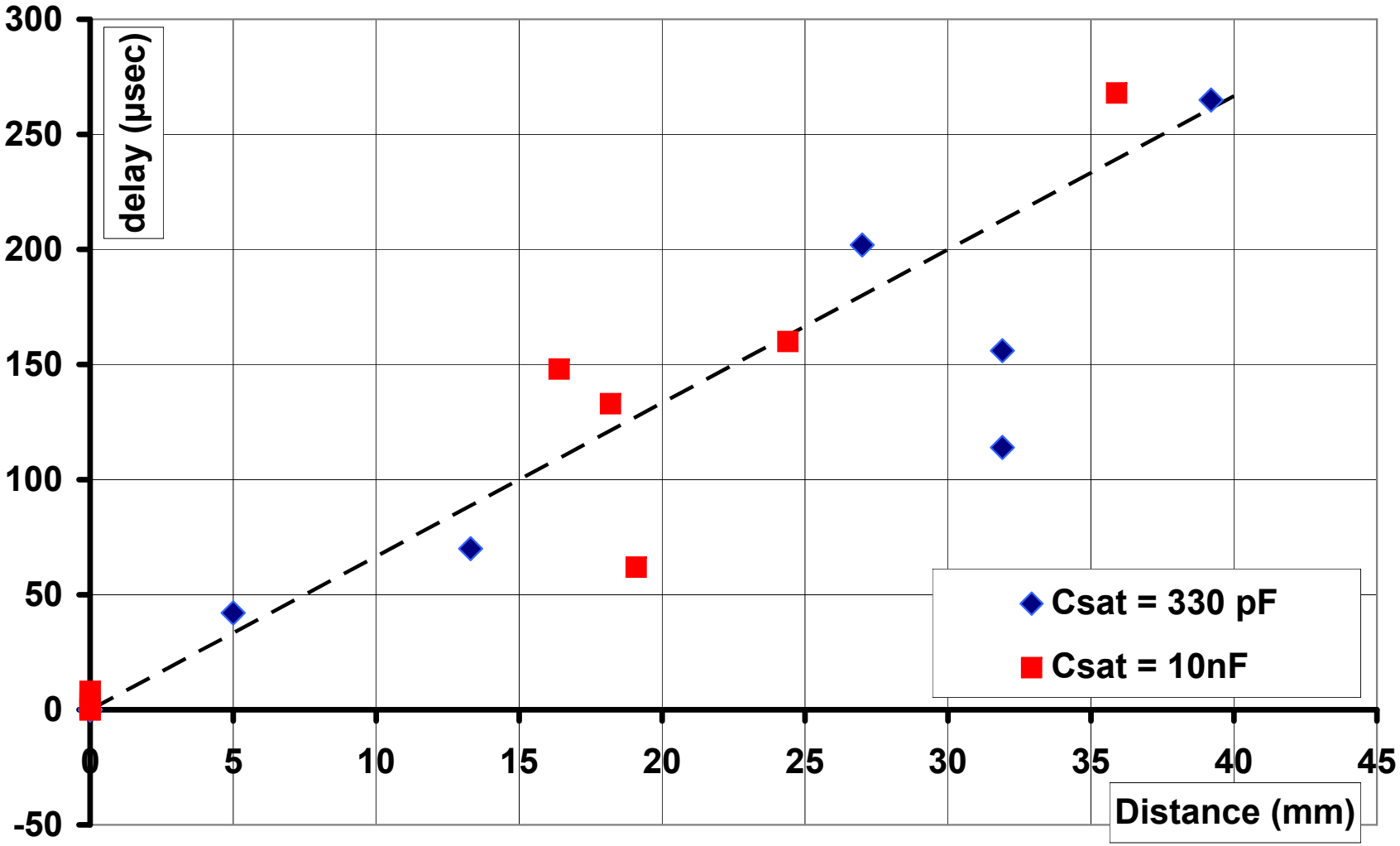


ESD and arc



arc duration = 500µs
delay = 2.5 µs
distance = 0 mm

Summary of results



Discussions

- Phenomenon?
  - cathode shifting with creation of a second cathodic spot?
    - Observed when the primary discharge occurs on the string +
    - Observed inside slip-rings
  - anode spot creation on the adjacent cell?
  - Relation distance/delay?

- Velocities :
  - fast electrons : ~ $10^6 - 10^7$ m/s
  - FO plasma : ~ 10^4 m/s

- Creation of an anodic spot :
  - maybe possible if the collected current is > current threshold
  - i.e. if local plasma density is > density threshold n_0
  - $n(x,t) \sim 1/x^2 * i(t)$ (i(t) source of plasma at discharge point (~ t^2))
  - $n(x,t) \sim t^2/x^2$ $n(x,t) > n_0$ => $t > x * \text{Constant}$
    - => linear dependance between the delay and the distance

-

Discussion - conclusion

Position ESD	In the gap	Elsewhere (identified)*	Elsewhere (non identified)
Number of identified discharges	20	17	53
Number of induced secondary arcs	19	11*	7
%	95%	65%	

* those which did not induce arcs where situated at a distance < 40mm from the closest gap

• All ESDs in the gap induced long arcs (stopped by current limiter)

Conclusion

- Distant arcs are possible
- They appear after a certain delay related to distance
  - Delay attributed to the time needed to obtain a sufficient plasma density to create an anodic spot

- ESD in the gap is the most probable to induce an arc

Flash-Over evaluation on large solar panels "EMAGS 3"

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+ many others

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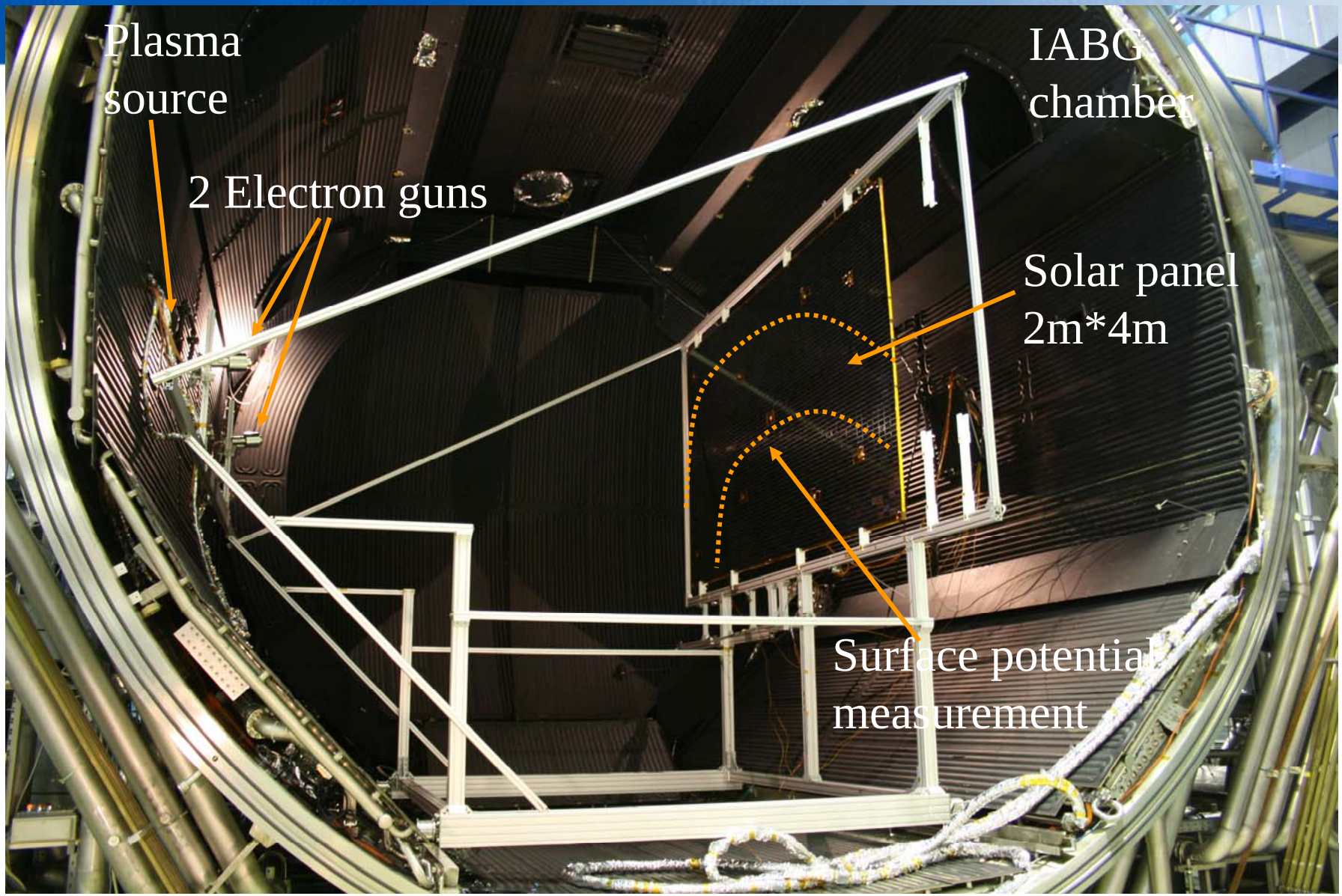
EADS astrium
ThalesAlenia Space
IABG

objectives

- Perform a test on a large solar panel to measure FO propagation:
    - maximum surface/distance
    - velocity
    - effect of different parameters
        such as plasma/electrons IVG, low temperature…

- Consolidate ESD/arcing qualification test setup for solar array coupons

Set-up


Plasma source
2 Electron guns
IABG chamber
Solar panel 2m*4m
Surface potential measurement

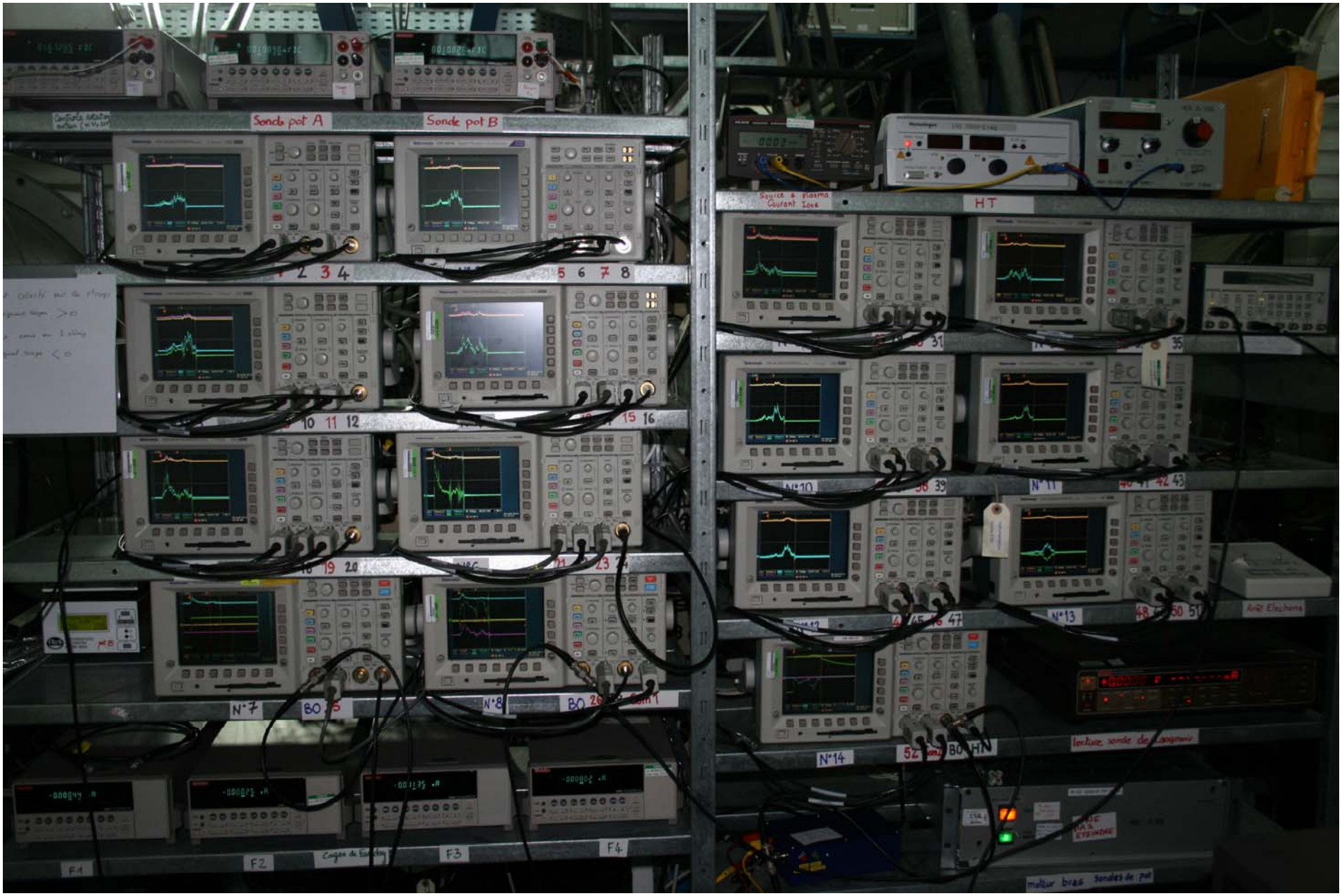
Preliminary Results

- we have performed a test on a panel 4*2 m

- we have observed discharges with a collection of current on every string

- no major difference between test in plasma and tests in electrons has been observed

- a further analysis has to be done on the corresponding neutralised charge and on propagation velocity
(papers to be published soon)


Sonde pot A
Sonde pot B
HT
N°7
N°8
N°10
N°11
N°13
N°14
F1
F2
F3
F4