LATTES RPC update

Luis Lopes

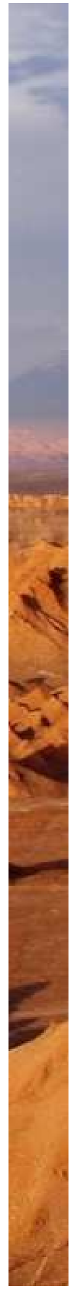
Are the RPCs capable to work there @ 5200 m

?

MARTA @ 1400 m, avalanche mode at “room” temperature

ARGO @ 4000 m, streamer mode at “room” temperature

Both give good indications



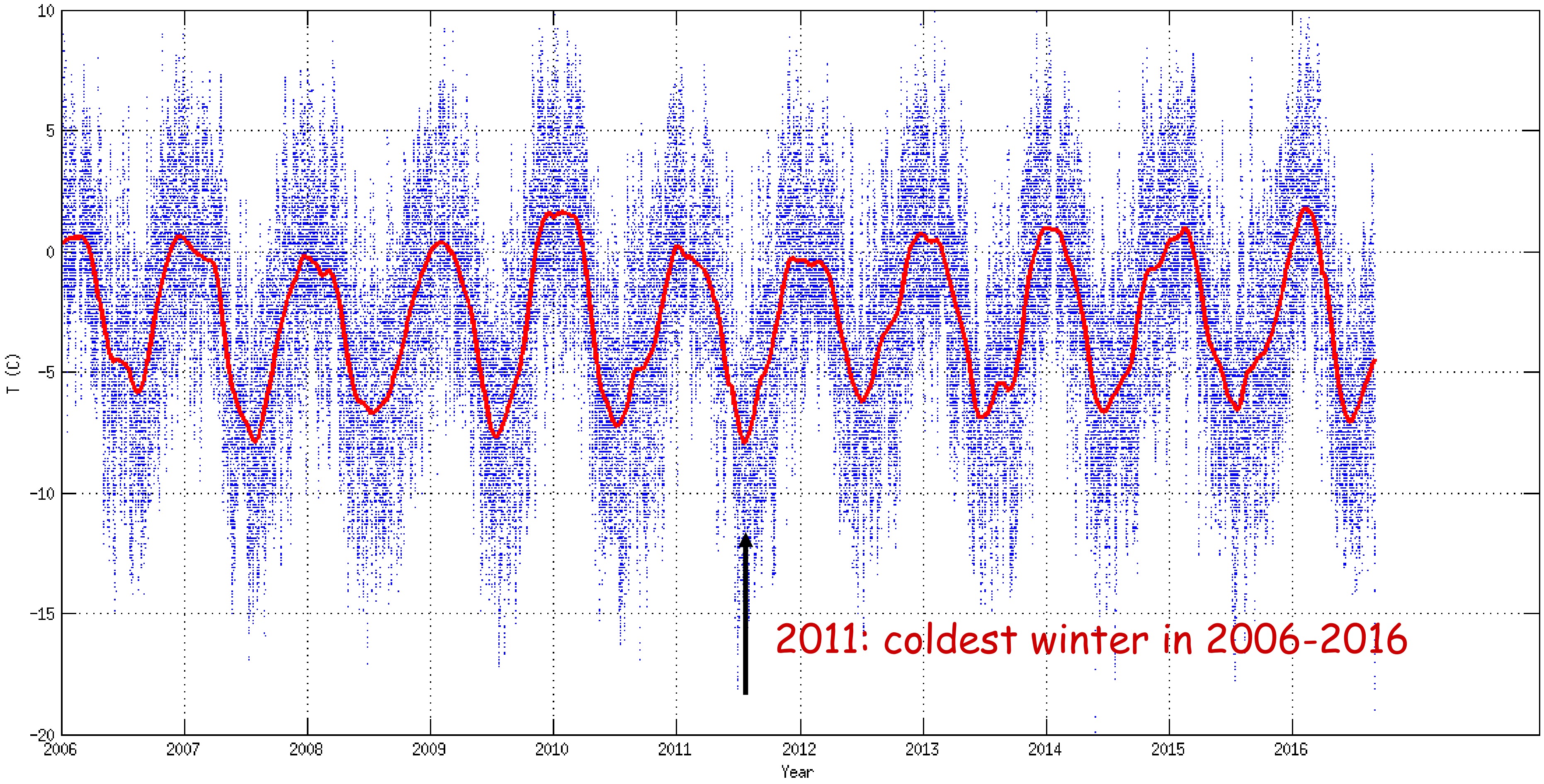
Some simulations using ALMA (@ 5058 m in the ATACAMA desert) temperature data

Three ALMA antennas linked together as an interferometer for the first time

On 4 March 2011, ten Antennas are installed at Chajnantor.

Some simulations using ALMA (@ 5058 m in the ATACAMA desert) temperature data

Data from the ALMA site (provided by Ron Shellard)



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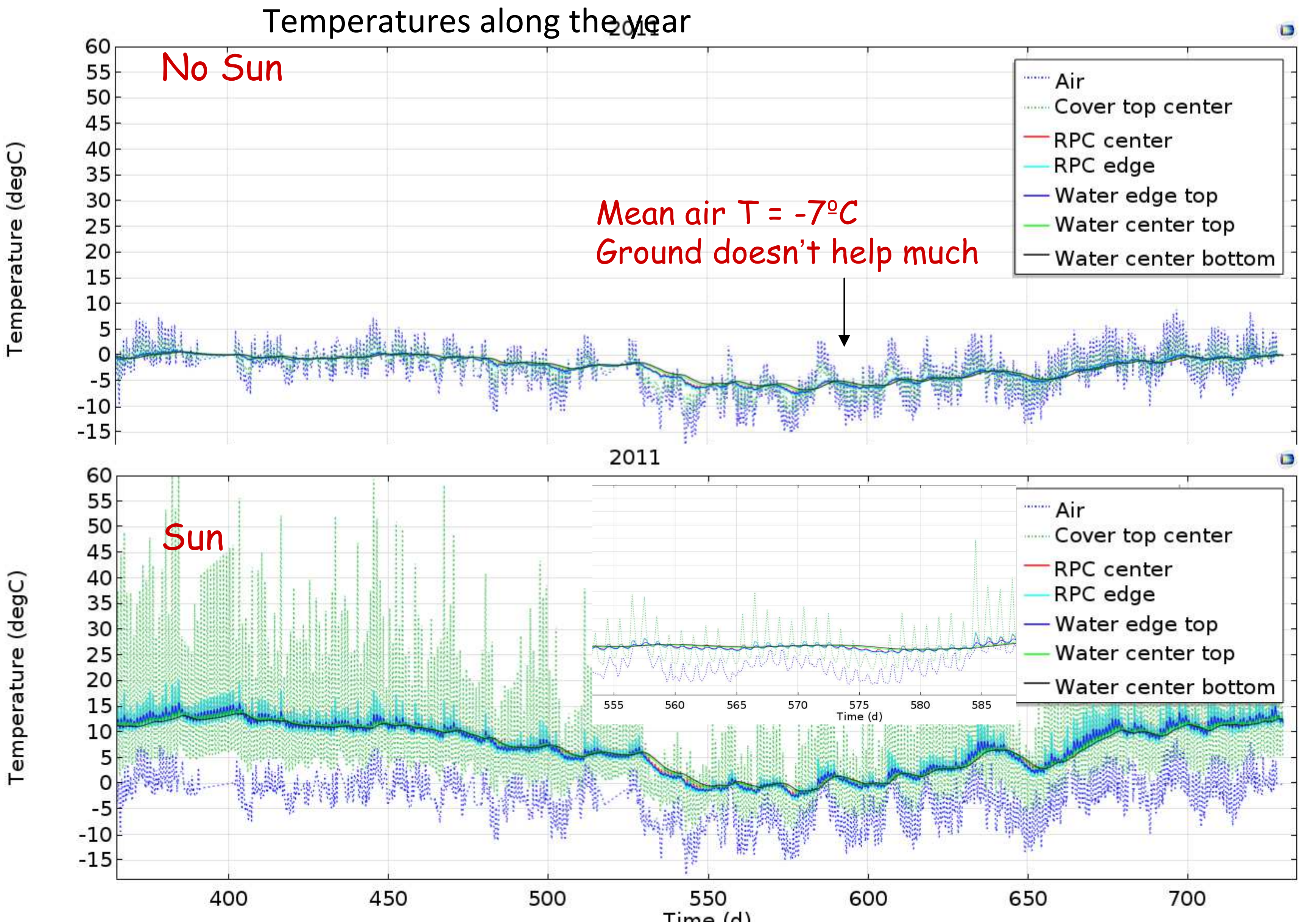
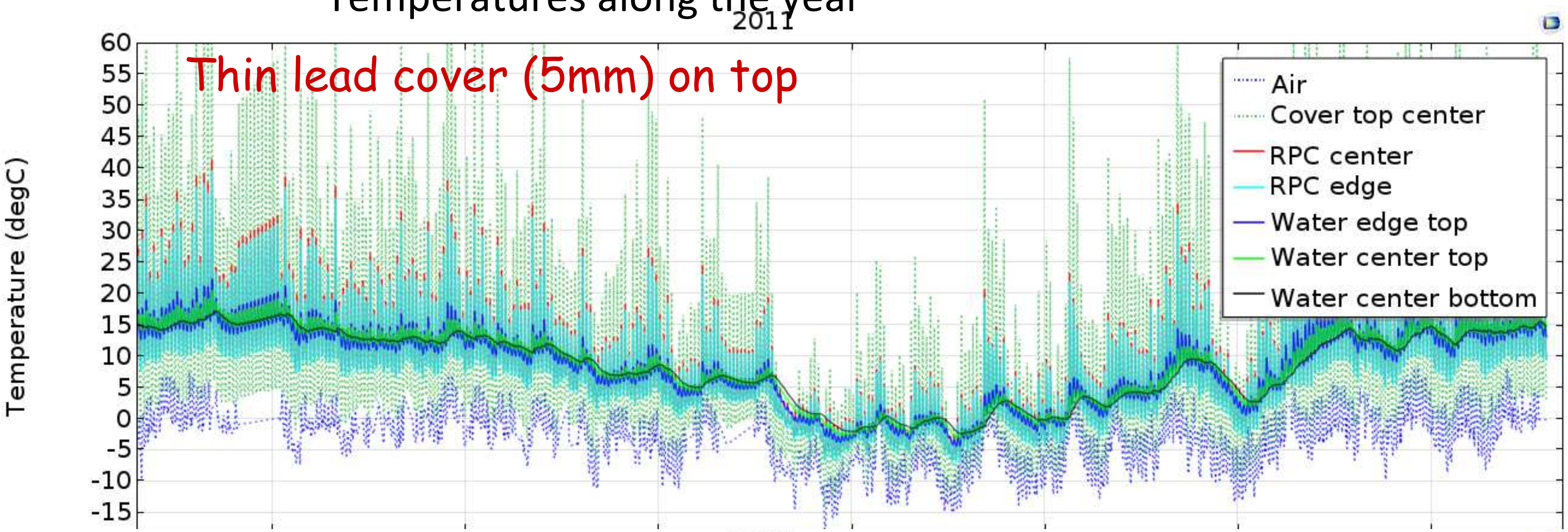
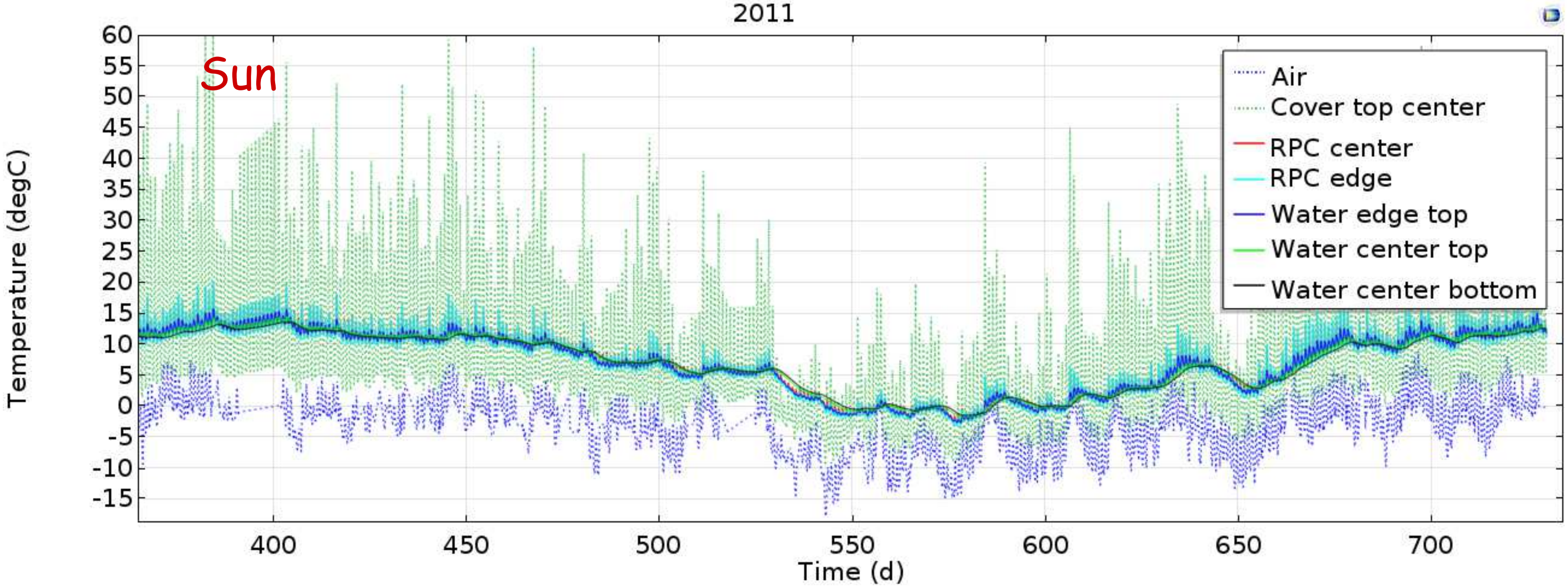


Some simulations using ALMA (@ 5058 m in the ATACAMA desert) temperature data

Temperatures along the year





Some simulations using ALMA (@ 5058 m in the ATACAMA desert) temperature data

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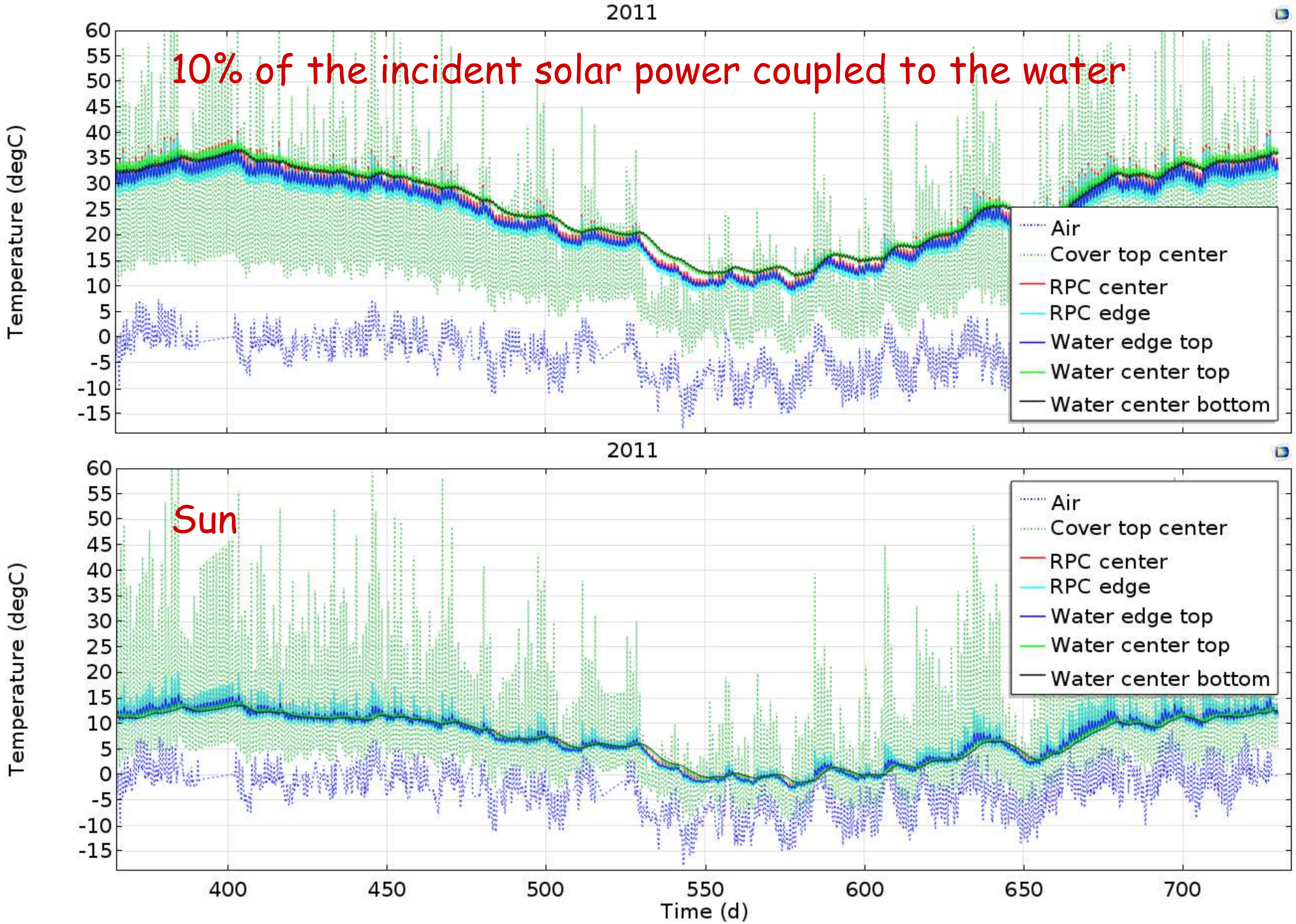
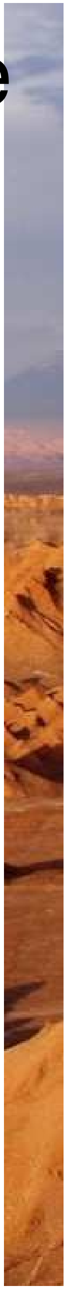
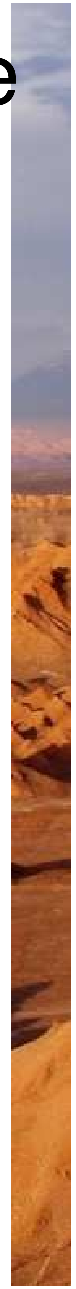




Some simulations using ALMA (@ 5058 m in the ATACAMA desert) temperature data

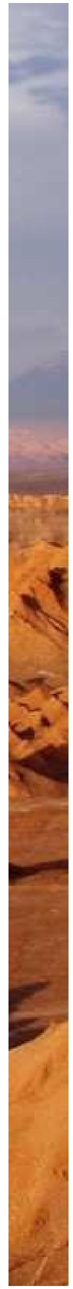


Main preliminary conclusions

- Temperature quite uniform inside the insulating cover (5 cm Styrofoam)
- Daily transients strongly damped
- In Summer RPC T varies by ~5ºC
- Follows yearly cycle

- Minimum Winter temperature of water close to -2ºC
- Within modelling uncertainties it cannot be decided if freezing will actually occur
- coupling 10% of the incident solar power to the water raises the T by ~ 10 ºC

Are the RPCs capable to work there @ 5200 m



?

@ minimum temperatures of -5 ºC

@ pressure around 500 mbar, with stable efficiency

With time resolution of 1 ns

With position resolution below 15 cm in both coordinates

Are the RPCs capable to work there @ 5200 m

@ minimum temperatures of -5 ºC

$$\frac{E}{N} = 0.0138068748 \times \frac{V_{\mathrm{eff,Volts}}}{d_{\mathrm{cm}}} \frac{(T_{^\circ\mathrm{C}} + 273.15)}{P_{\mathrm{mbar}}} \; [Td],$$

$$V_{\mathrm{eff}} = V_{\mathrm{applied}} - R_{\mathrm{cm}^2} I_{\mathrm{cm}^2}$$

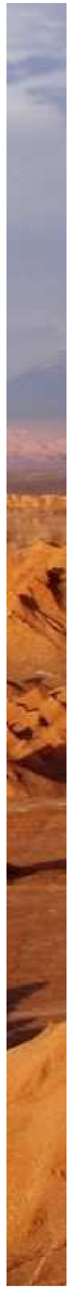
$$\begin{cases} \rho(T) \cong \rho_{20} \times 10^{(20-T)/24.3} \\ R_{\mathrm{cm}^2}(T) = \rho(T) \frac{t \times l}{A} \end{cases} \Leftrightarrow R_{\mathrm{cm}^2}(T) = 10.5 \times 10^{12} \times 10^{(20-T)/24.3} \frac{t \times l}{A}$$

Glass resistance could play a important role

$$I_{\mathrm{cm}^2} = f_{\mathrm{cm}^2} \times Q_{\mathrm{median,\ self-trigger}}$$

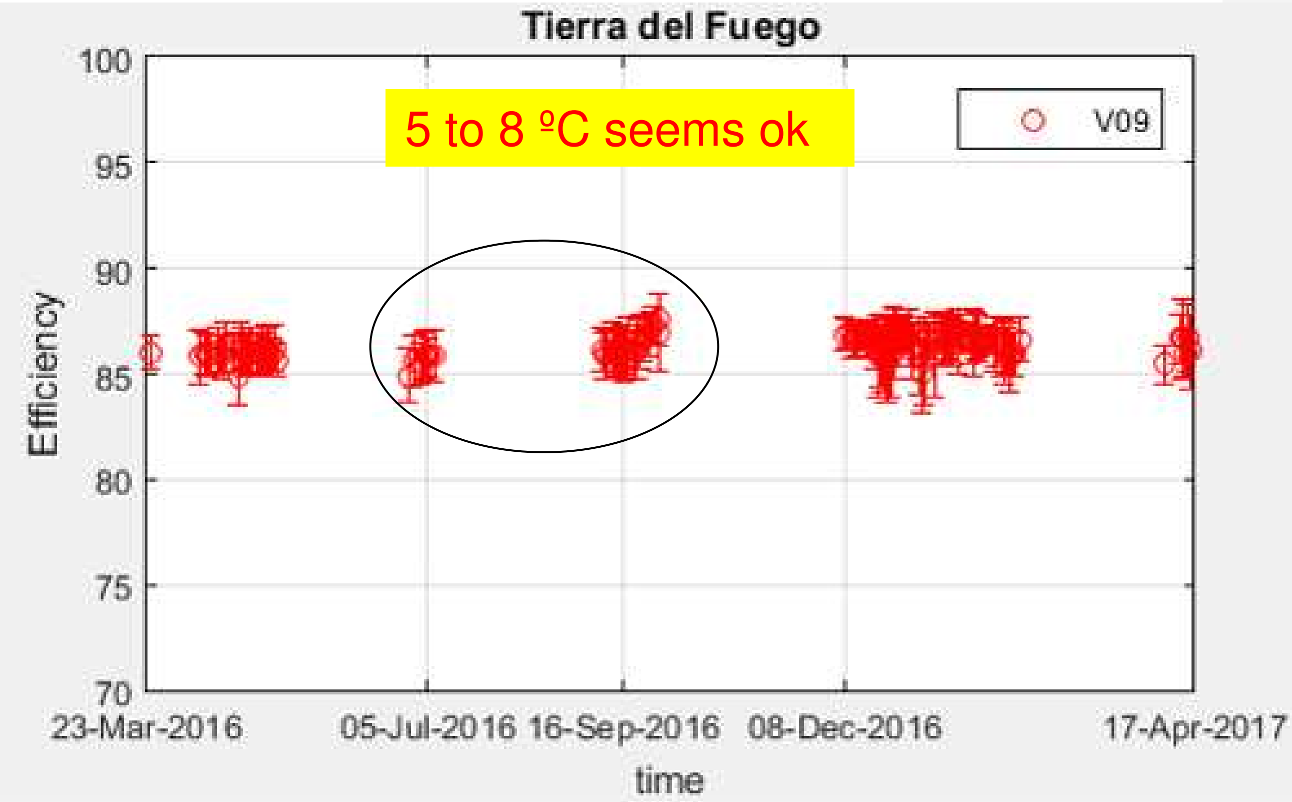
$$\frac{E}{N} \cong 0.01381 \times \frac{V_{\mathrm{ap}} - 10.5 \times 10^{12} \times 10^{\left(\frac{20-T_{^\circ\mathrm{C}}}{24.3}\right)} \times 1.5 \times 0.19 \times (f_{\mathrm{cm}^2} \times Q_{\mathrm{median}})}{d_{\mathrm{cm}}} \frac{(T_{^\circ\mathrm{C}} + 273.15)}{P_{\mathrm{mbar}}}$$

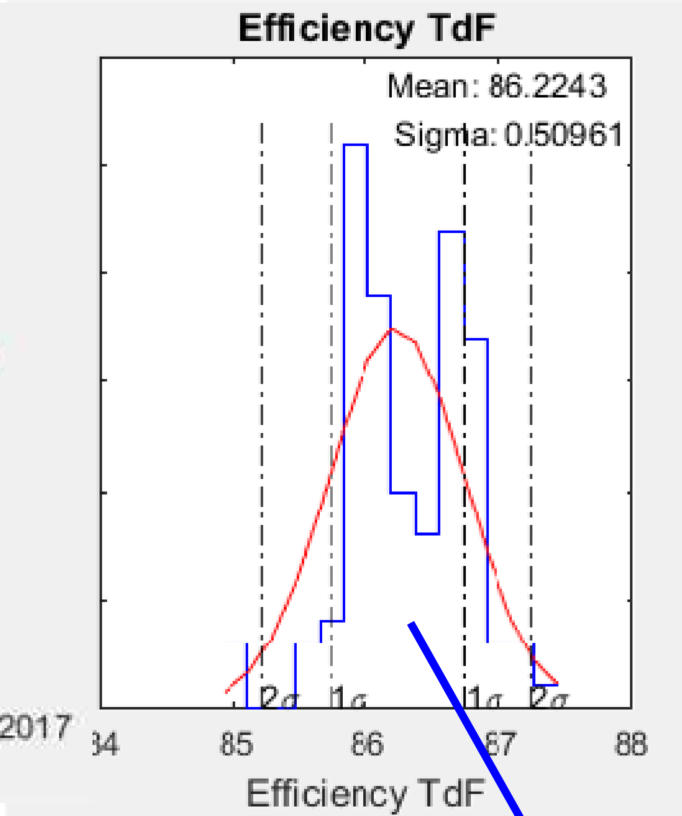
- Probably temperature will influence more through the glass resistance than through the gas density, depending on the counting rates.
- Some tests in the lab will be done at low temperature to clarify this point.
- No major influence in the needed HV to compensate E/N from low temperature, about 10% correction only.



Are the RPCs capable to work there @ 5200 m

@ minimum temperatures of -5 ºC





MARTA RPC @ TdF, Auger BATATA site

2 “peaks” probably due to different HV power supply offsets

Are the RPCs capable to work there @ 5200 m

@ pressure around 500 mbar, with stable efficiency

Streamer mode

Nuclear Instruments and Methods in Physics Research A 394 (1997) 341–348

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

ELSEVIER

Resistive plate chambers performances at low pressure

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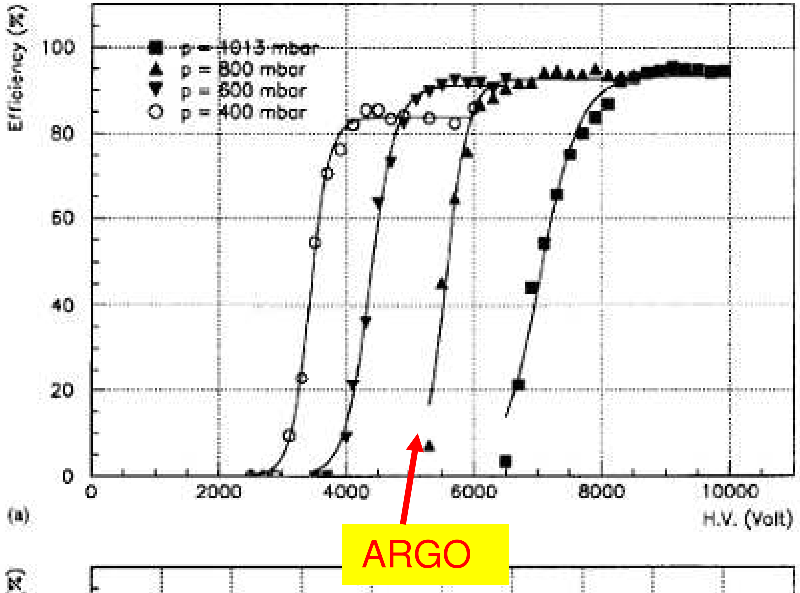
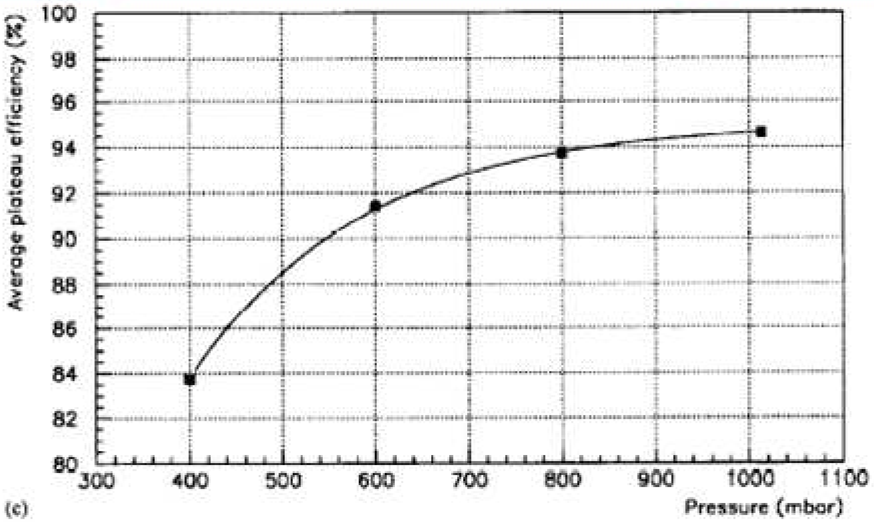
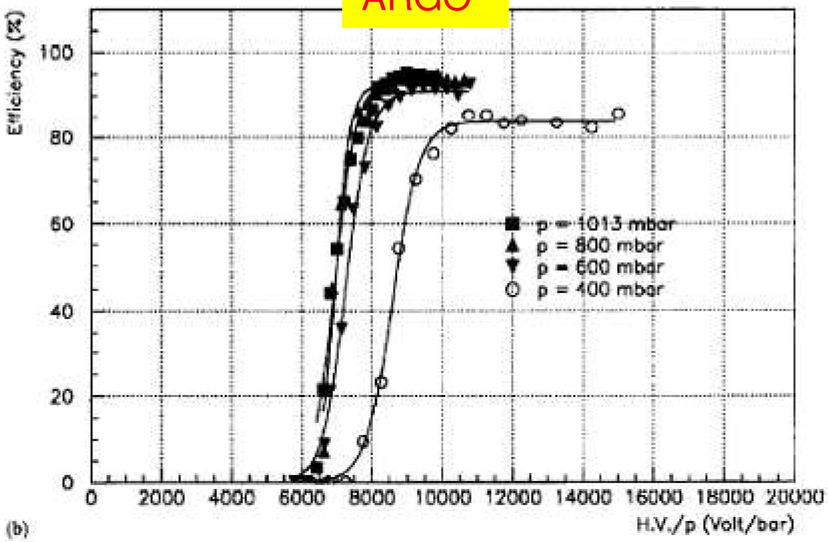
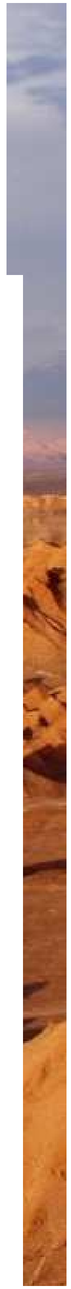
Received 30 December 1996



Lower pressure ⇒ Lower efficiency plateau







Are the RPCs capable to work there @ 5200 m

@ pressure around 500 mbar, with stable efficiency

Compensation of low pressure $\Rightarrow$ reduced λ
(in the proportional-avalanche limit)

$$1-\varepsilon \approx G^{-\nu} + \frac{1}{\nu\,\Gamma(\nu)}\left(\frac{N_{e,th}}{G/r}\right)^{\nu} \qquad \text{if} \left(\frac{N_{e,th}}{G/r}\right) << 1$$

$$G = e^{\alpha g} = \text{maximum gas gain;} \quad \nu = n\lambda/\alpha \text{ shape parameter}$$

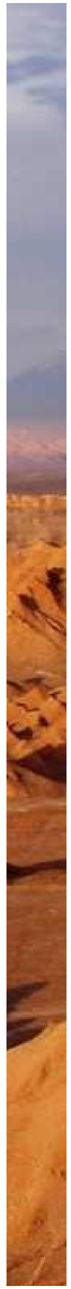
$$\nu = \frac{n\lambda}{\alpha} = \frac{\overbrace{\lambda}^{\text{ionization density} \propto \text{pressure}} \quad ng}{\underbrace{\alpha g}_{\sim cte}} = \frac{\#\,of\ \ primary\ ionization\ clusters}{\#\,of\ \ gas\ ionization\ steps}$$

$$(n = n^{o}\ of\ \ gaps)$$

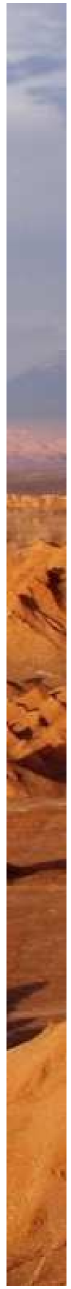
To keep everything constant with pressure

- Adjust voltage to keep αg constant: in principle keep E/p constant
- Increase the total gap width ng to keep ν constant

M. Abbrescia et al., NIM A 431 (1999) 413 *P.Fonte, 2013 JINST P11001*



Are the RPCs capable to work there @ 5200 m



With time resolution of 1 ns

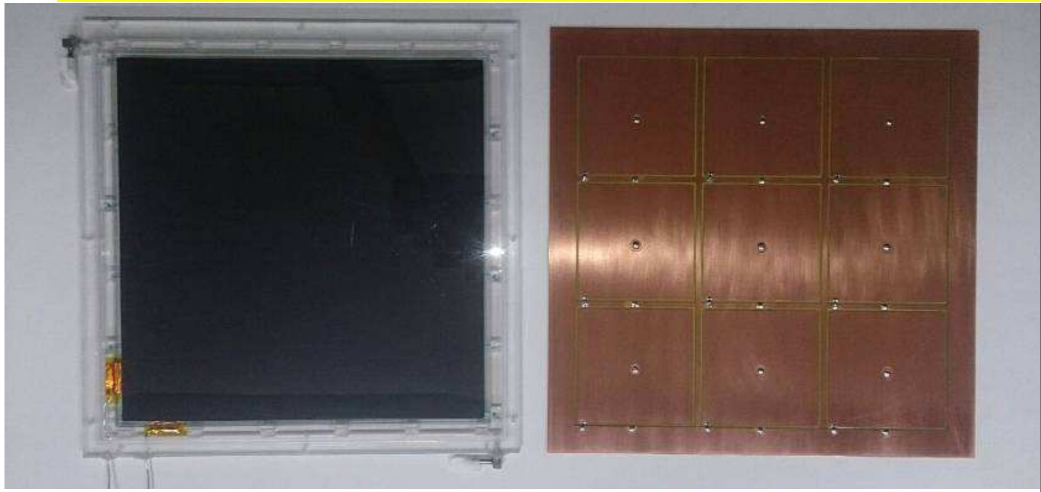
Should not be a problem, once lower density, higher velocity, higher diffusion, bigger avalanches.

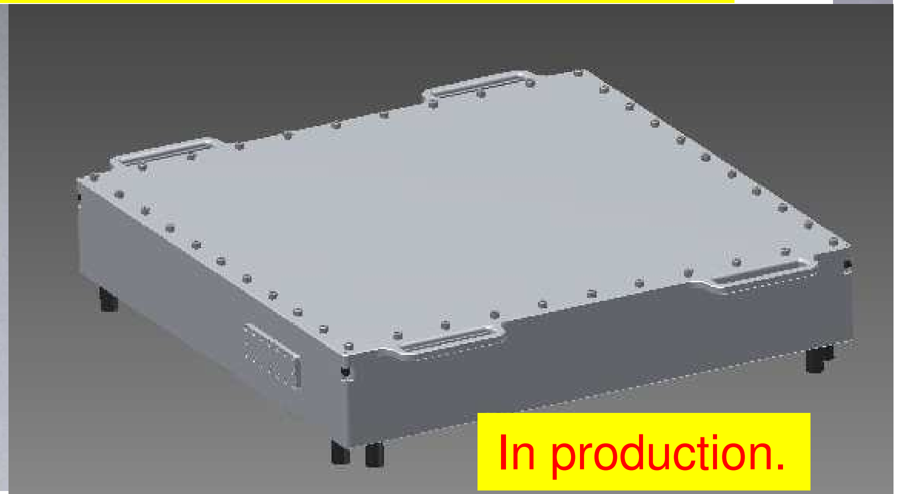
With position resolution below 20 cm in both coordinates

Just a question of pad area, for a sensitive volume of $1.2 \times 1.5\ m^2$, we can use 15 pads of $30 \times 40\ cm^2$

Are the RPCs capable to work there @ 5200 m

Small chamber 300x300 cm^2, same design as MARTA. To be placed inside pressure box and tested until 500 mbar (LATTES site ambient pressure)





Should also be possible to put the "pressure box" inside a chiller to study also the influence of temperature on the detector performance.

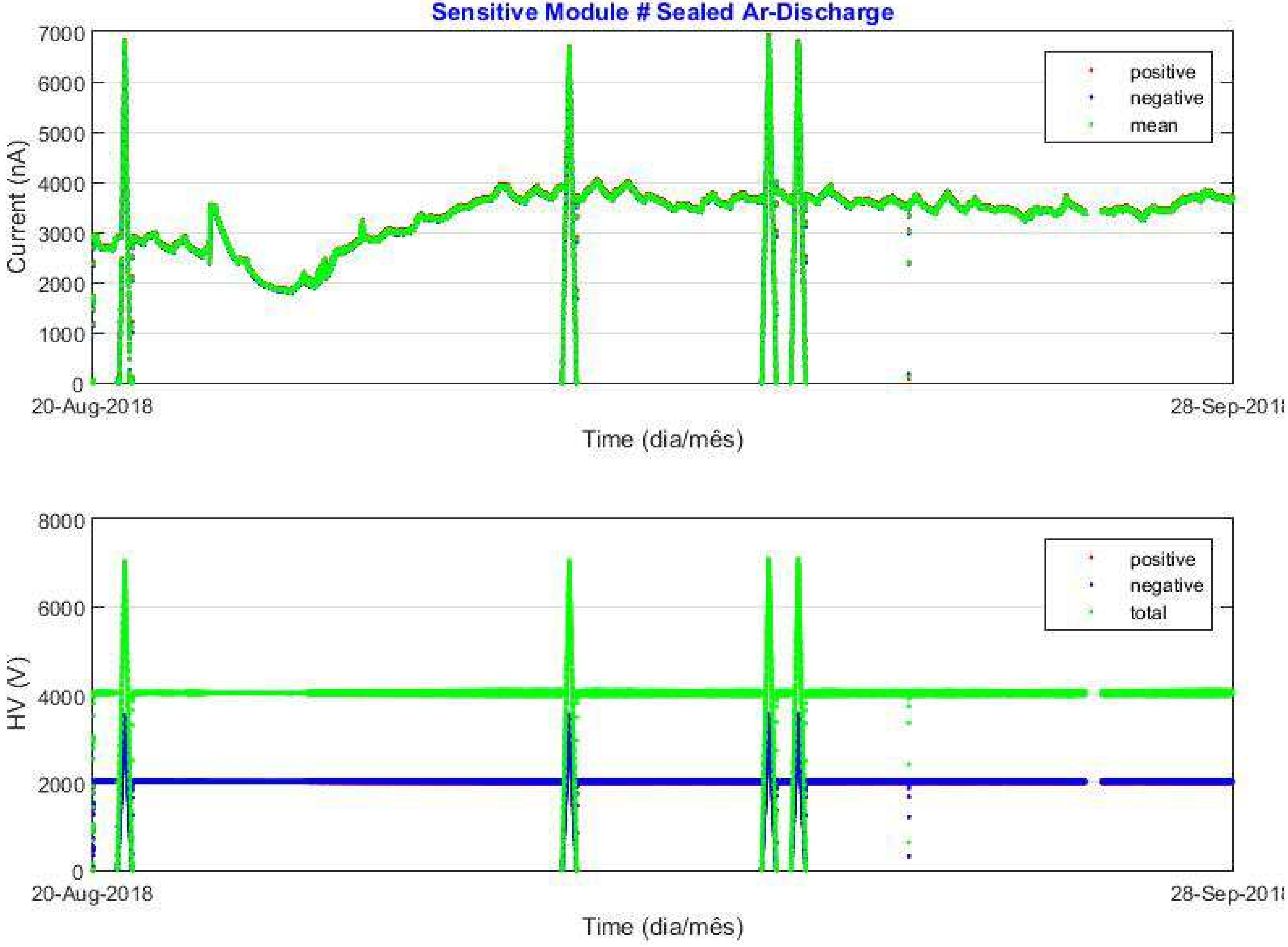
Also the better approach for lower density situation could be study with different sensitive volumes: more number of gaps (this increase the material budget) or wider gap to keep the efficiency at an acceptable value.

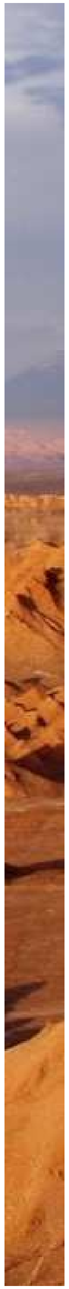
Are the RPCs capable to work there @ 5200 m

Resuming

- ✧ARGO and MARTA, as Lab tests and theory are on our side. So LATTES requirements seems to be achievable from the RPC side.
- ✧Further Lab studies is needed to confirm some open questions that should be clarified at sea level (easy to work than @ 5000 m)
- ✧The effect of temperature could become problematic through the glass resistance, depending on rate.

RPCs “with out” gas flow rate???!!!





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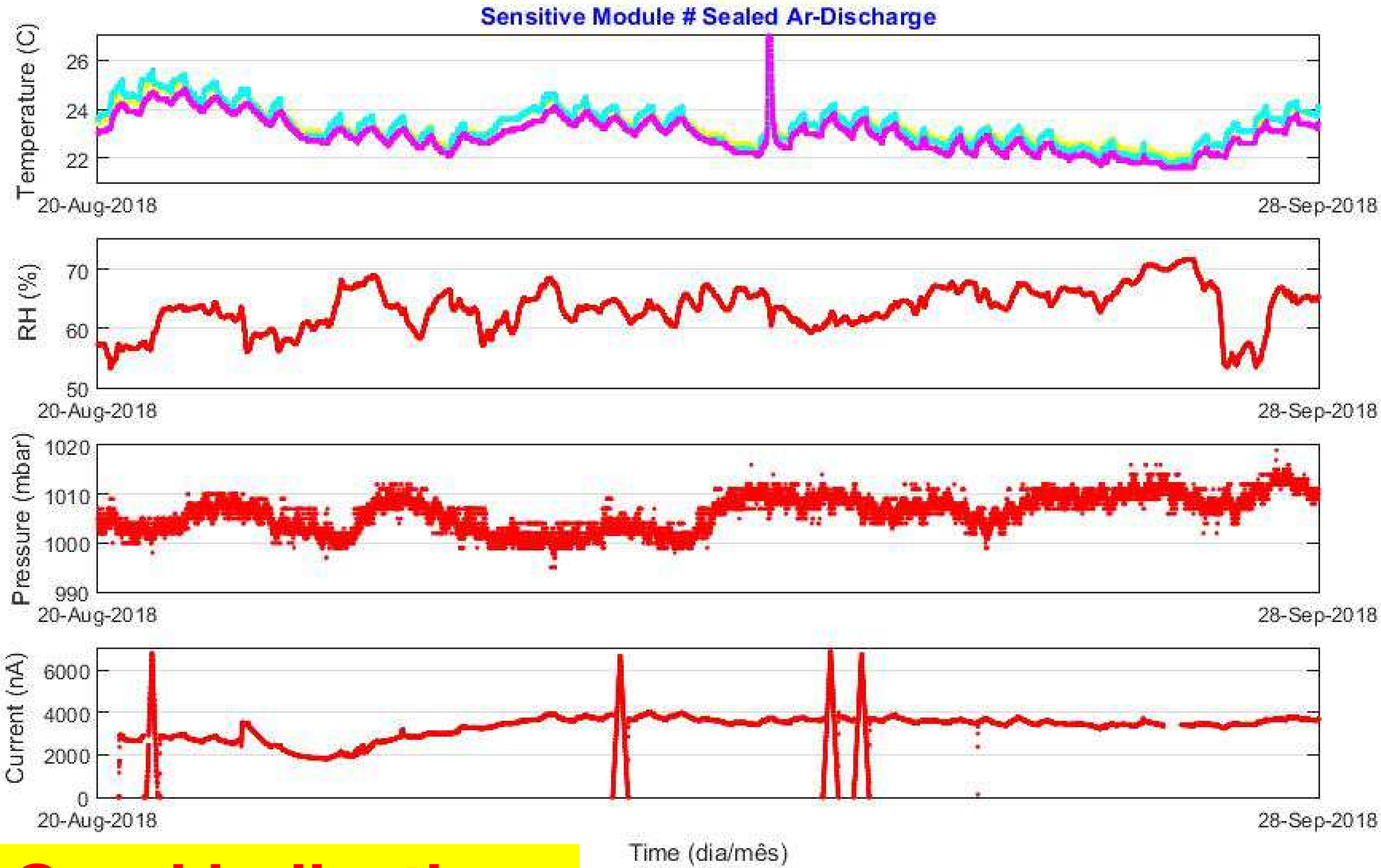

Good indications

Acknowledgements

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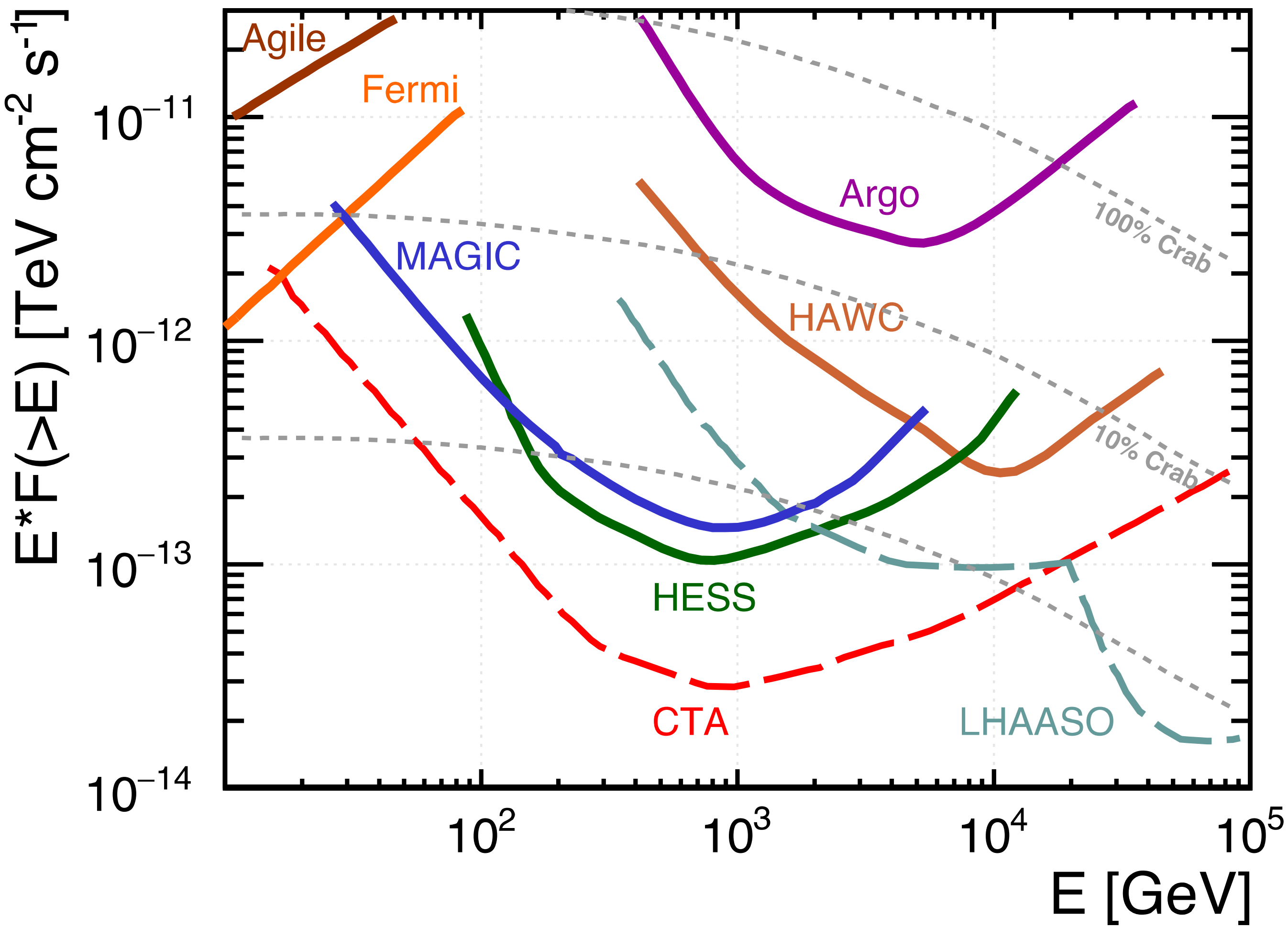
REPÚBLICA PORTUGUESA

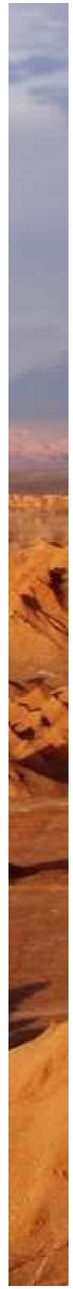
LIP

TÉCNICO LISBOA

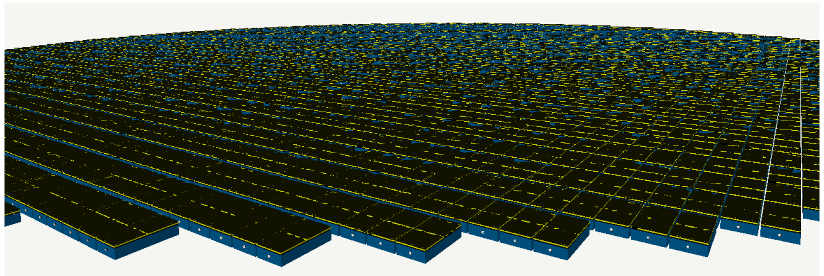
Backup slides

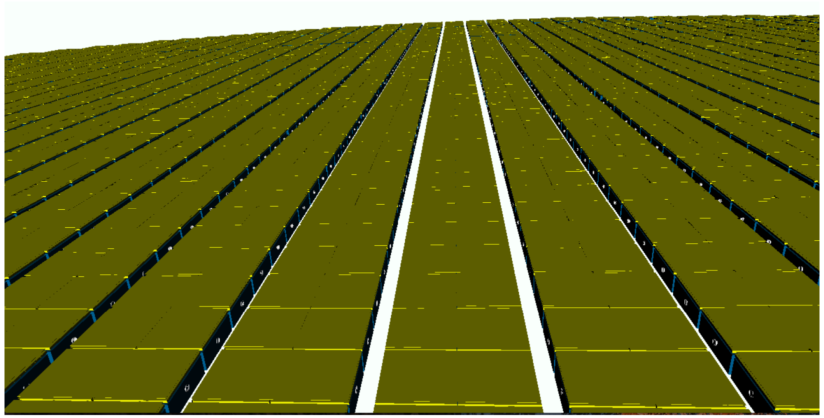
(Very) High-Energy Gamma-Rays



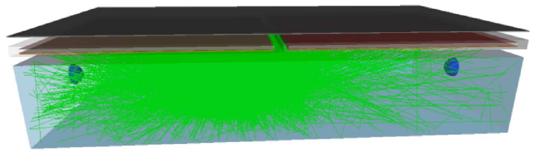


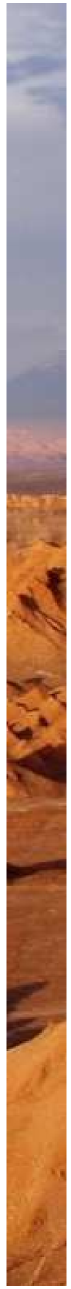
Array configuration





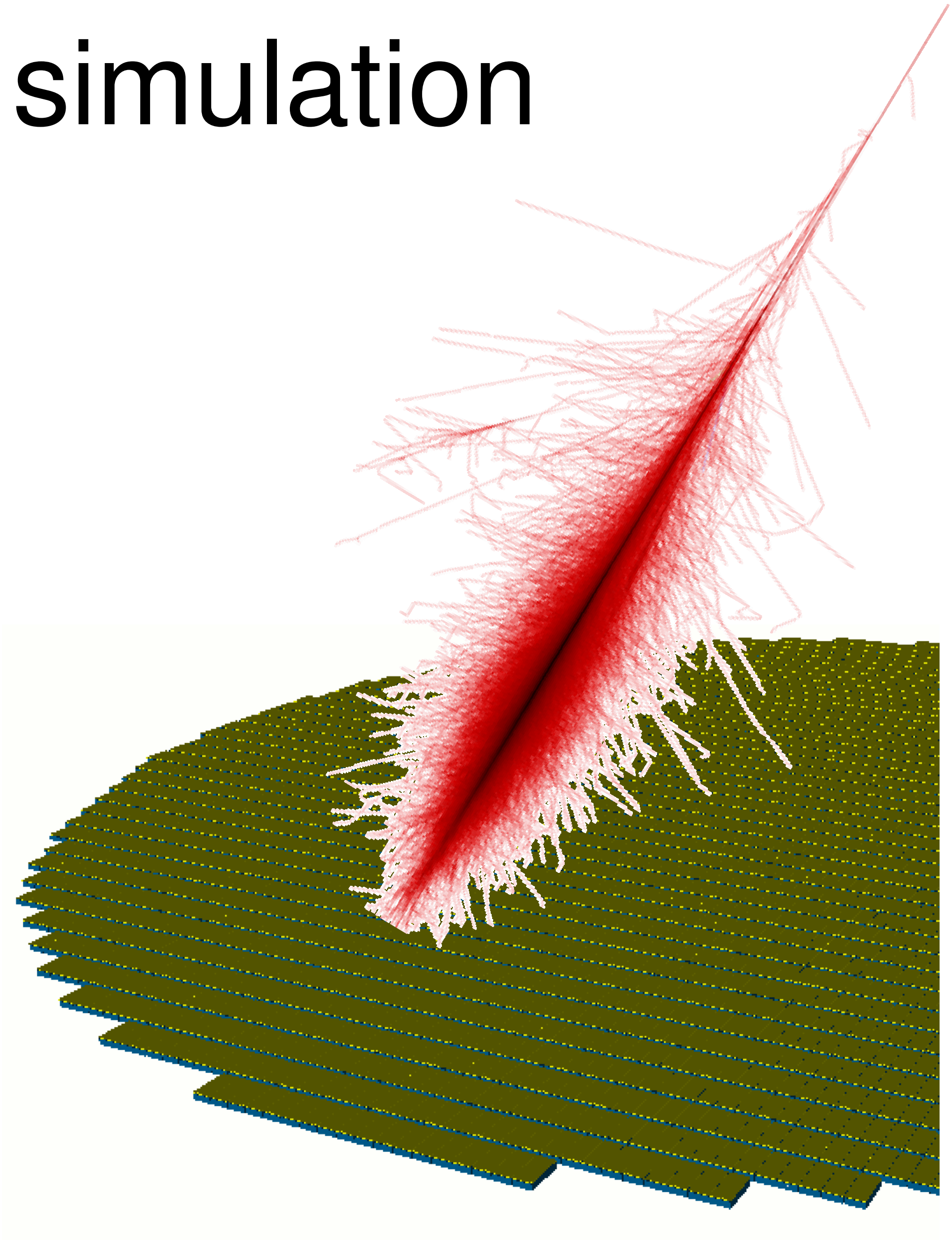
- ✧ LATTES compact array
  - ✧ 3600 LATTES stations
  - ✧ Circular array of radius 70 m
  - ✧ Array of roughly 20 000 m^2
  - ✧ 0.5 m space for access detectors

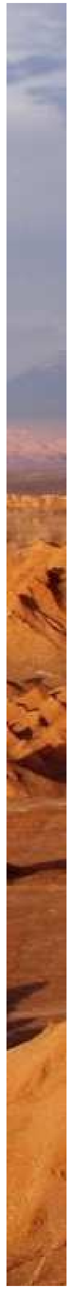




Detector simulation

- ✧ LATTES detector simulation package
  - ✧ Based on the Geant4 toolkit
  - ✧ Interfaced to read directly CORSIKA simulations output binary files
  - ✧ Resampling of the showers with randomized core





Ongoing developments and tests on RPCs, electronics and read-out systems