Solar panel as cosmic ray detectors

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Outline

- Solar panel array detector concept
- Proposal for the development of a detector unit prototype

Solar panel array detector concept

Solar panel array detector concept

Solar cells are n-i-p junction with:

- High quantum efficiency
- Sensitivity in Cherenkov spectral range

These considerations and recent technological developments make the use of solar panel arrays as cosmic ray detectors a possible choice!

Detection with solar panels – 4 factors to consider

- Primary cosmic ray

Proton-initiated shower of 1 EeV => 1-2 Mphoton/m^2 with Δt = 10 ns

- Solar panel

Typical commercial solar panel efficiency is 15% and time integration of 50-100 ns

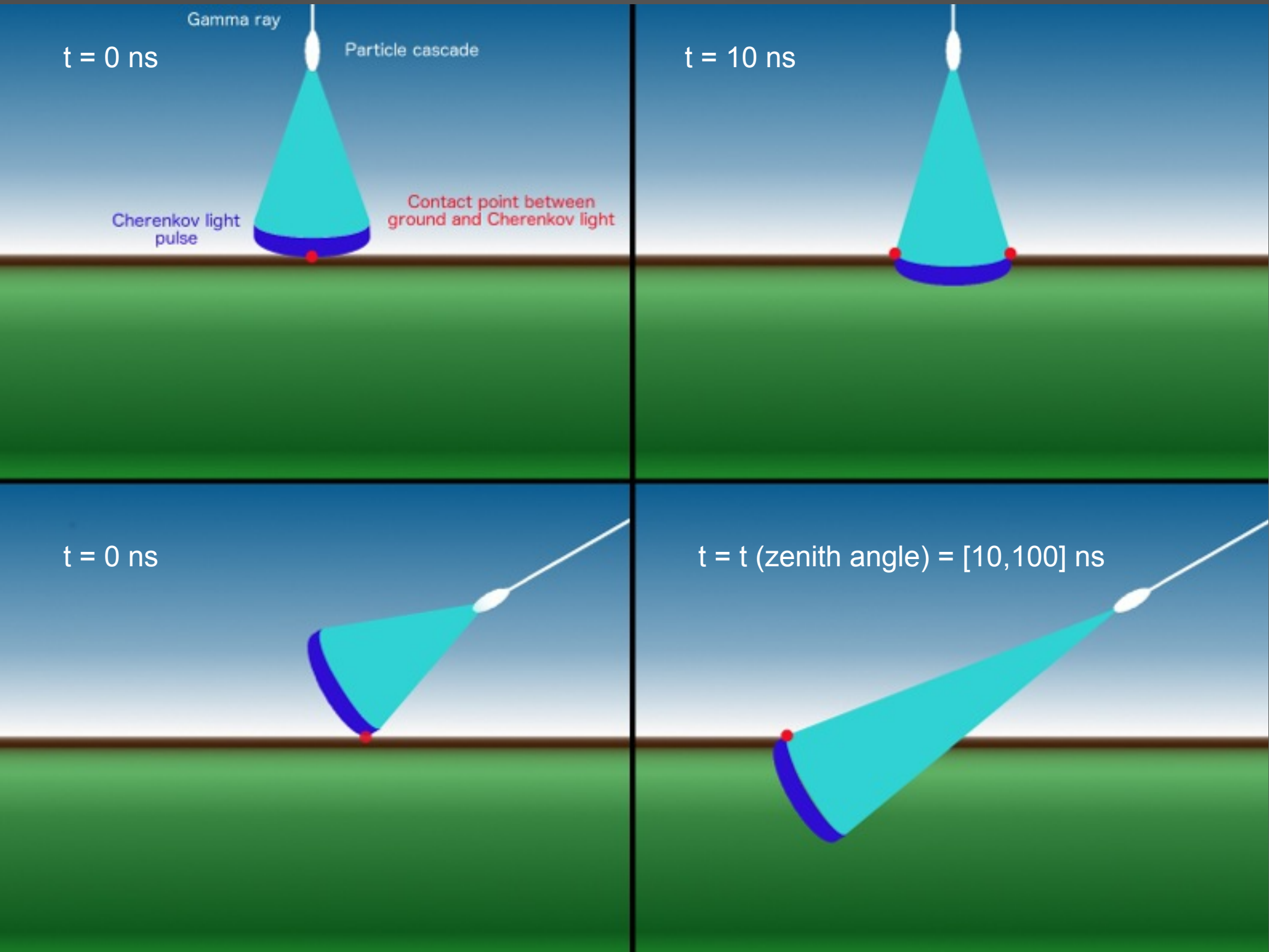
- Noise

Moon => 100 Mphoton/m^2 in 100 ns in visible

Detection with solar panels – 4 factors to consider

- Impact parameters

Zenith angle and distance between the shower core and the detector influence the detection, for example the FWHM duration of the signal @ ground is of the order of 10-100 ns, depending on the zenith angle.


Gamma ray
t = 0 ns
Particle cascade
Cherenkov light pulse
Contact point between ground and Cherenkov light
t = 10 ns
t = 0 ns
t = t (zenith angle) = [10,100] ns

Energy threshold of CR
(with S/√B = 3 @ 500m from shower core)

$$E_{thr}\ (EeV) \sim 0.08\ \ (5m^2/A)^{1/2}\ (30\%/\varepsilon)^{1/2}\ I$$

ε = Solar panel efficiency A = Detector sensitive area

I = square root of the number of background photon in visible per square meter normalized to full moon condition

- Energy threshold in different situations (1 EeV = 10^{18} eV)

	Dark night	Full moon	Dusk/dawn	Average sunlight
E (EeV)	0.03	0.08	0.3	10

Duty cycles and possible enhancements

- Duty cycles

  For E_{thr} = 0.3 EeV ⟹ 50% duty cycle

  For E_{thr} = 10 EeV ⟹ 100% duty cycle

- Possible enhancements
  - Reduce distance between detectors:

    interaction @ 300m = 5 x interaction @ 500m
  - Improve time resolution

    O(20 ns) ⟹ relation between time and height
  - Develop multi-junction solar cells with better efficiency

Proposal

Proposal

- Challenge

  $S/\sqrt{B} \alpha (\text{Sensitive area})^{1/2}$ but Large area increases solar panels capacitance

- Scope
  - Test this concept profiting from the recent developments in solar panels
  - Develop an optimized system to filter the faint light fast signals from the background

- Multi-junction cells
  - A new interesting technology with high efficiency (40%) and sensitive in the UV

Possible tests

- In lab

  2 different light sources => background light + Cherenkov light pulse

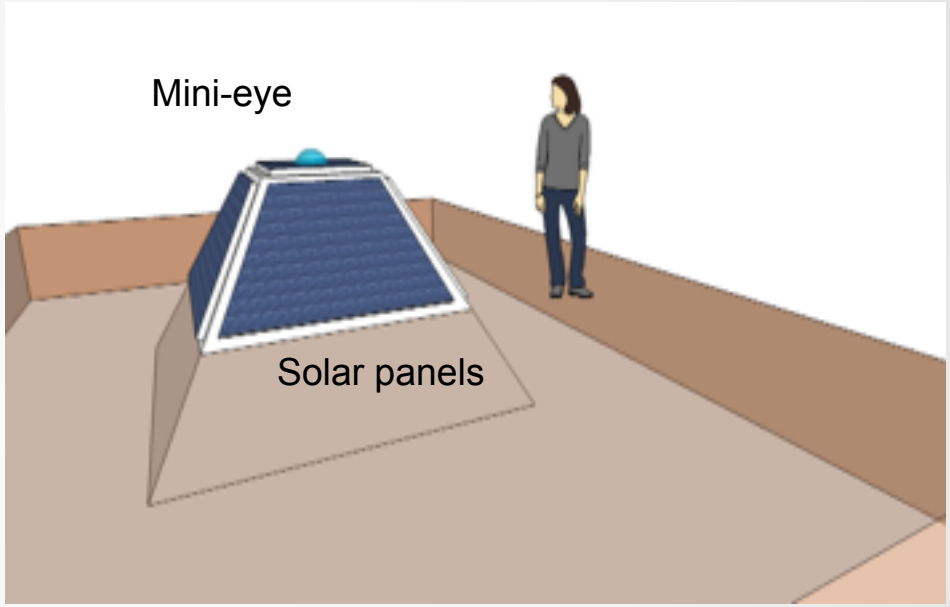
  with cherenkov light pulse produced by calibrated led @ different frequency, with different duration and variable number of photons

- Outside

  tests under field conditions in coincidence with ground array detectors

Prototype design

- Baseline
  - Truncated pyramid (high geometrical efficiency)
  - 5 panels: 9 m^2 area
  - Time resolution O(50 ns)
  - Solar panels will also power supply the detector



- Evolution = Baseline + SiPM mini-eye with full sky coverage
  - Fast response O(10 ns)
  - High angular resolution
  - In dark night sensitive to shower fluorescence light

Goal

- Produce a detector unit with all the developed technology to create a “real life” scenario
- Challenge to integrate different aspects:
  - Geometry
  - Electronics
  - Shadow shielding effects
  - …
- Global optimization of design parameters
- Solar Panel Array performance studies will contribute for the next generation of Cosmic Ray Detectors!