

The BuckArray

Detecting cosmic rays with smartphones

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¹The Ohio State University

²Center for Cosmology and AstroParticle Physics (CCAPP)

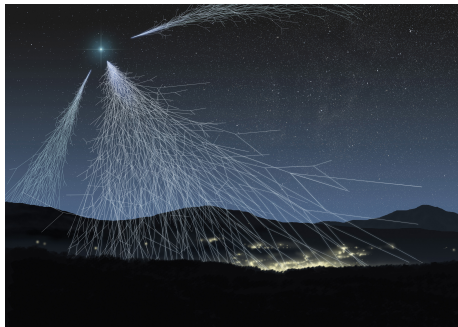
August 24, 2016



THE OHIO STATE UNIVERSITY

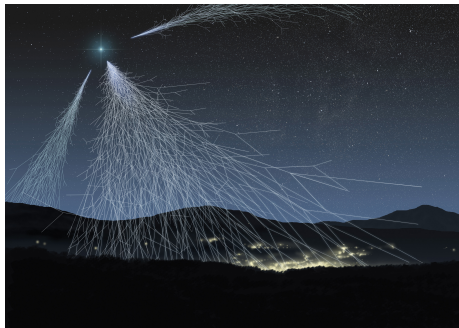
Introduction

- Cosmic rays create a cascade of relativistic secondary particles that can be detected at the Earth's surface.
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- Novel idea: Observation of secondary particles by using an array of cellphones.
- Detection by the CMOS¹ sensors of smartphone cameras: CRAYFIS (See D. Whiteson, et al., 2016).
- Same principle as taking photos.
- Efficiency allows to detect photons and minimally-ionizing particles such as γ 's , μ^\pm , and e^\pm .

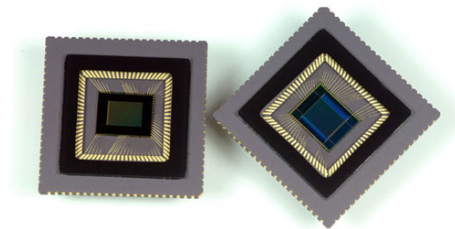


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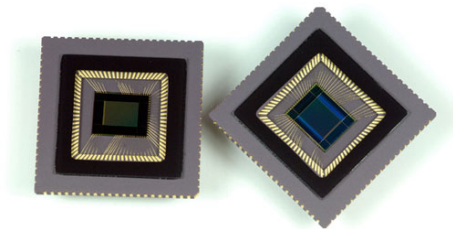


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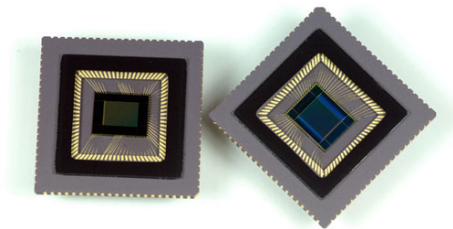


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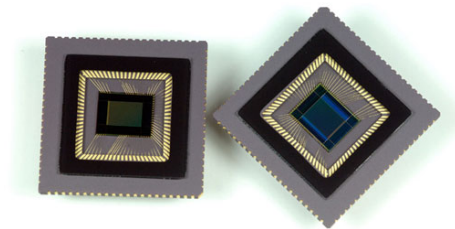


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- Very large area (or very long run) needed to accumulate a sufficient number of observed events.
- Large network of phones: cheap (relatively) & sufficient to detect air showers from UHECRs.

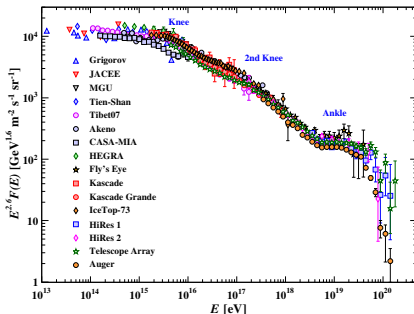


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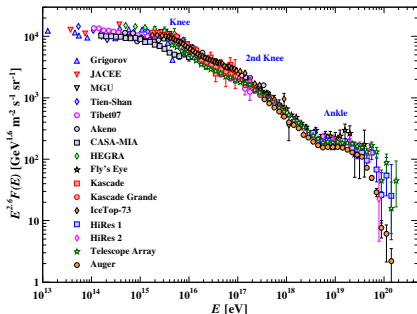


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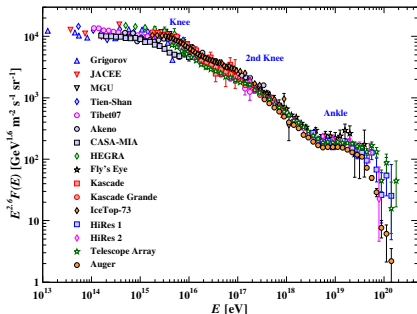


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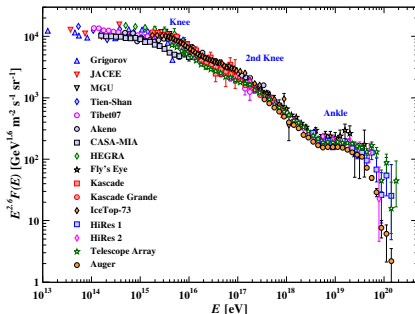


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Maybe people at concerts (?)



The BuckArray

- Proposal: Prototype array to be deployed at the OARDC² in Wooster, OH.
- Two-fold purpose:
 - ① prototype for future, larger-scale arrays.
 - ② educational outreach opportunity for local students.



Figure: Secret Arboretum, OARDC/OSU.

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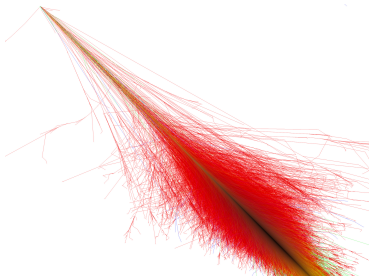


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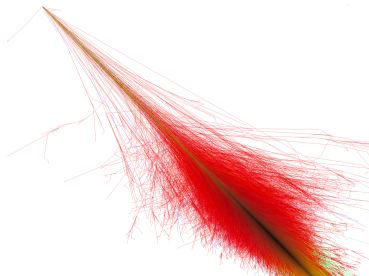
The BuckArray

- Array of phones and 200-400 MHz radio antennas for detection of **particle flux** and **RF radiation** (geosynchrotron emission), respectively.
- Physics goal: to detect cosmic ray **extensive air showers** through both signals simultaneously.
- 1st stage: Particle flux study (**work underway...**)



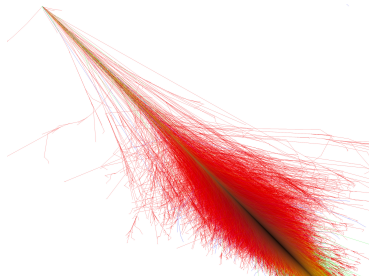
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The BuckArray (Simulation)

- 50×50 m rectangular geometry.
- 143 cellphones distributed as shown in the Figure.
- CORSIKA(MC simulation for EAS): 100 cosmic showers (primary particle: $10^{15} - 10^{17}$ eV proton.)
- Will go to greater energies in a future.

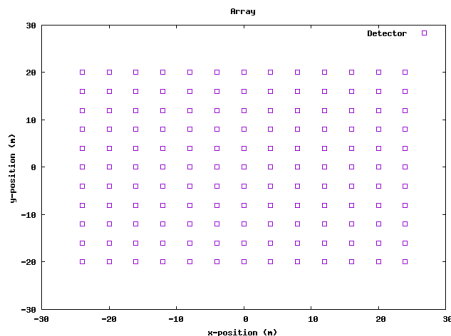


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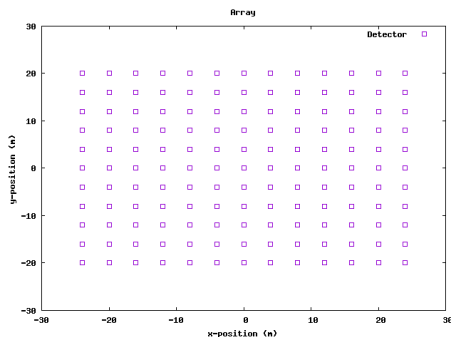


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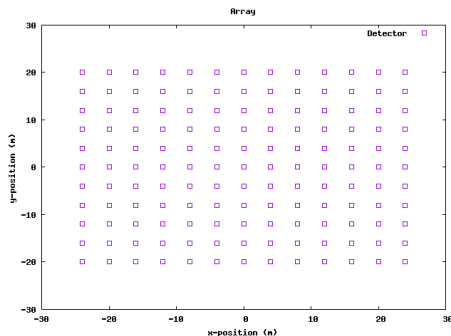


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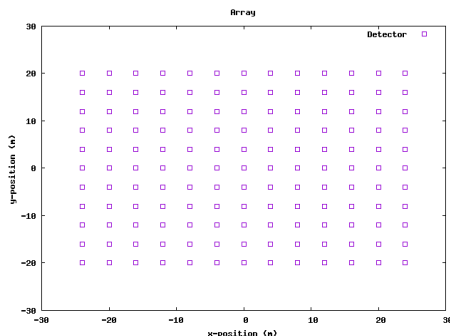


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Simulation

- CORSIKA output: particle ID, momentum components, coordinates at observation level (ground).
- Discard particles with $E < 1\text{MeV}$ (accounting for energy loss when crossing the glass)
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³actually 1 mm³

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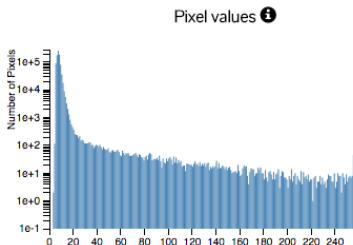
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Buckeye01 & Buckeye02

Simultaneously, running CRAYFIS (since Jun 14) on two cellphones (just for fun!⁴)

Buckeye02



Exposure	Events
Total	399,541 / 0

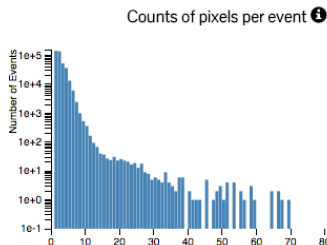
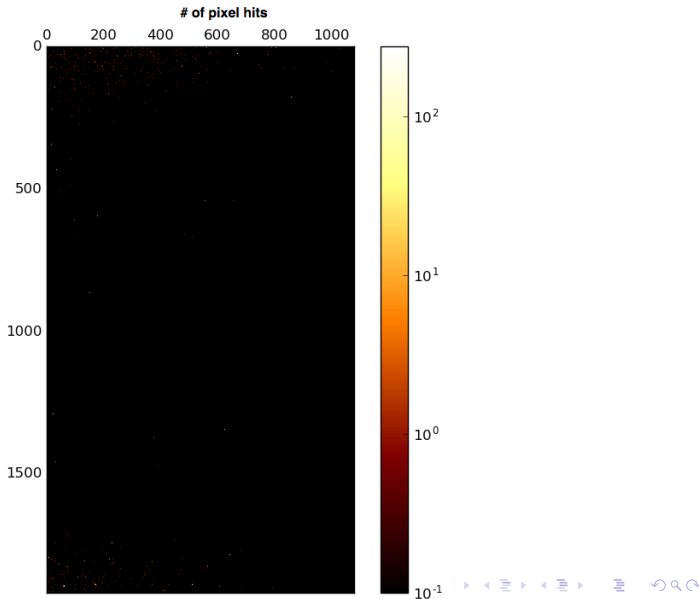


Figure: pixel intensity values in candidate muon events (left), number of above threshold pixels in candidate events (right)

⁴and for trying to understand CRAYFIS.

Debug mode



Results (so far, e.g.)

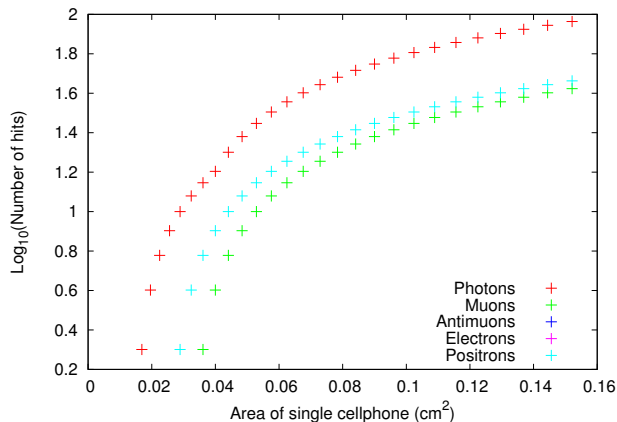


Figure: Number of particles detected as a function of area for a 10^{16} eV proton (random event), 1 MeV threshold.

Results (expectations)

- Obtain $\text{hits} \times \text{phone}^{-1} \times \text{event}^{-1}$
- Furthermore: $\text{hits} \times \text{phone}^{-1} \times \text{day}^{-1}$

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- Time-factor: is the project feasible i.e. $\#particles/day$?
- Account for noise.
- Get more cellphones.
- Compare simulations with real results.
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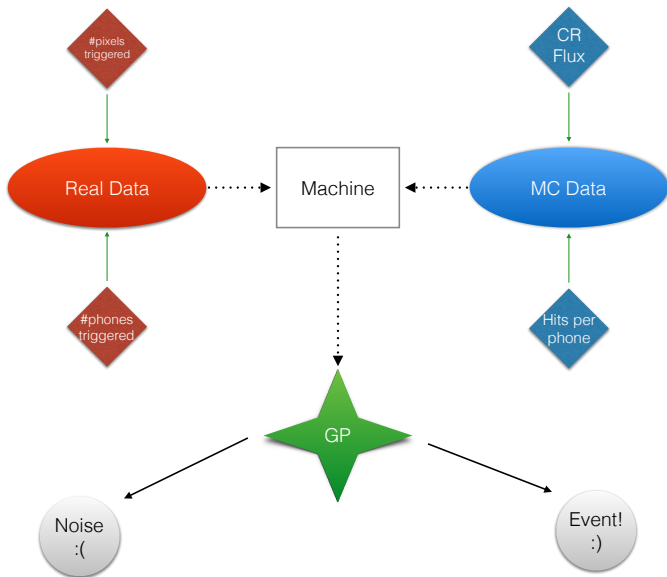
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How can involve machine learning in our project?



Thanks!