MACHETE: Technical solution and rough cost estimate

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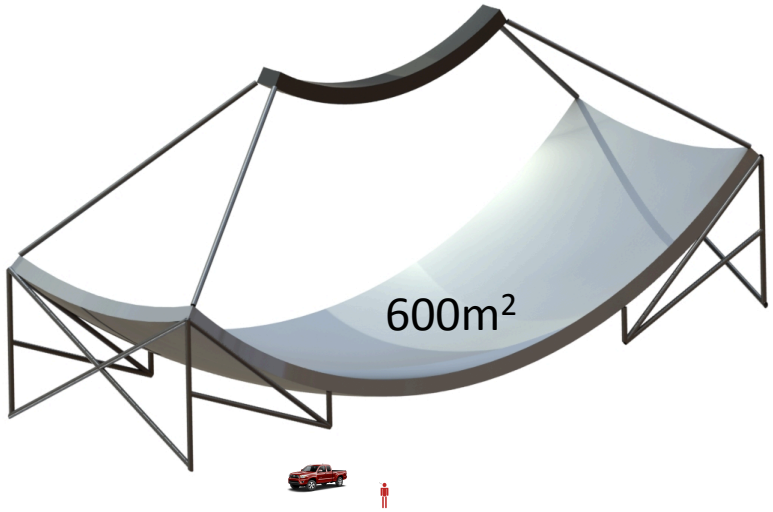
Mechanics

- Essentially undefined: bury mirror under the ground at least partially? We may get dust or water. Just to dig the hole and provide draining pipes may be too expensive.
- How to protect it from the sun? Big flat cover? Just something like a “rolling canvas”?
- How to hold the camera?
- How to make it aerodynamic?
- How large a foundation?

Mirrors

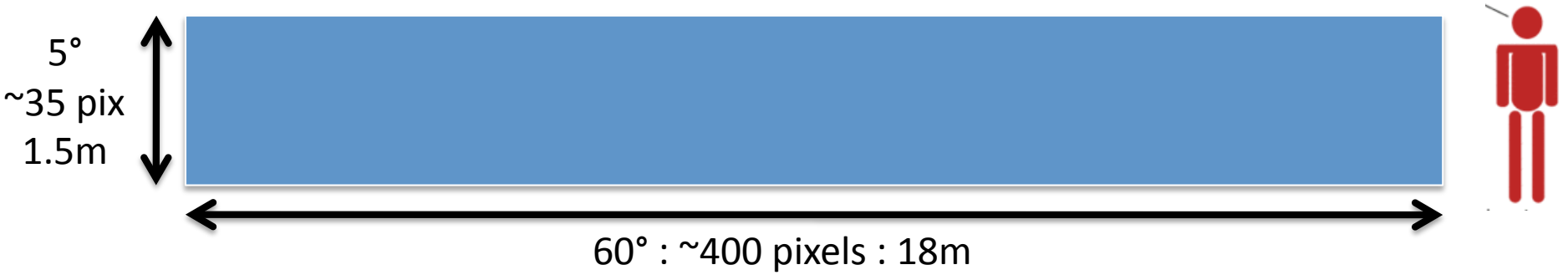
- Main differences with “tracking IACTs”:
  - We can reduce the weight constraint (but reduction factor is undefined!).
  - All mirror facets are spherical and equal, so easier to produce, test, install and maintain.
- In CTA the goal is 2000 €/m^2. After conversations with Mosè and Michele: 1000 €/m^2 can be achieved when reducing weight constraint. Specific solution is undefined.



Mirror alignment

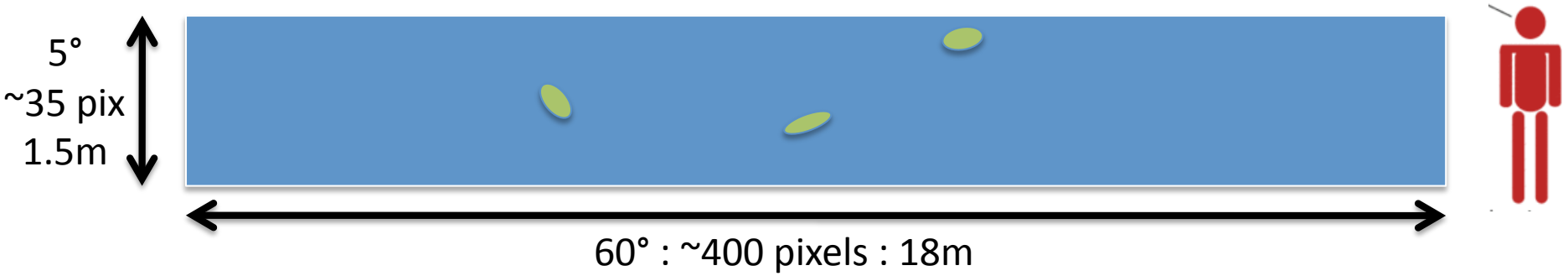
- My hope: a telescope fixed to the ground needs to mirror re-alignment in time scales of ~10 years, so we don't need any AMC.
- By the way: how does one align the mirrors if one cannot track a star or point to a lamp far away? Light source at 2D? Photogrammetry? Open question!

Photosensors



- We have not selected a specific photosensor.
- **PMTs** are standard in IACTs and reach QE>~40% these days, but they are expensive (~300 € / unit) and bulky.
- **Silicon PMs** (aka G-APDs) deliver even higher QE, would cost ~200 € for a MACHETE pixel (assuming 1 $/mm^2) and would allow smooth observations with strong Moon (important for such a telescope), but spectral response not optimal and unavailable for the necessary pixel size.

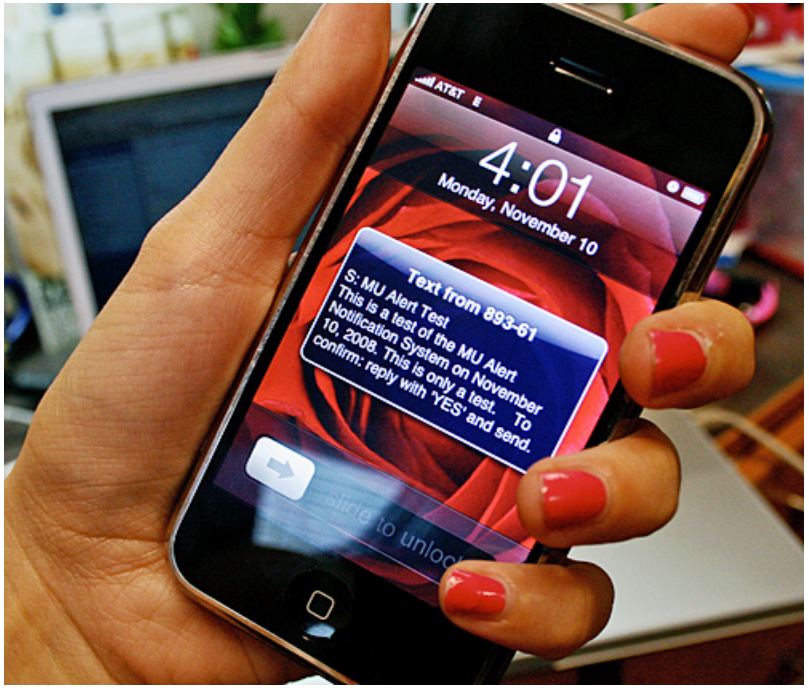
Readout



•Showers have a typical size ~<1°, so we only need to read out a small fraction of the camera (2°x2° = 256 pixels?).
•A fast local trigger identifies those channels and selects a Region of Interest (RoI). We only need to digitize/record the RoI.
•A possible solution (R. Paoletti, INFN Pisa): install cheap digitizers (TARGET5) in all pixels, break up camera in tiles, digitize tile if local trigger, keep only digitized information if stereo trigger.
•Challenge: 9 kHz proton stereo trigger rate (but each CTA-SCT has 11k pixels and is designed for 10 kHz trigger rate).

Data processing

- 9 kHz proton stereo trigger, but we want MACHETE to deliver alerts in a matter of 1-2 minutes. Need a quick onsite analysis.
- We would like to produce a survey and a collection of light curves for a set of objects. We want to keep vast amounts of data and analyze. Rate is >10 times higher than MAGIC. What do we save to disk?
- What storage and computer system do we need?



Robotic operation

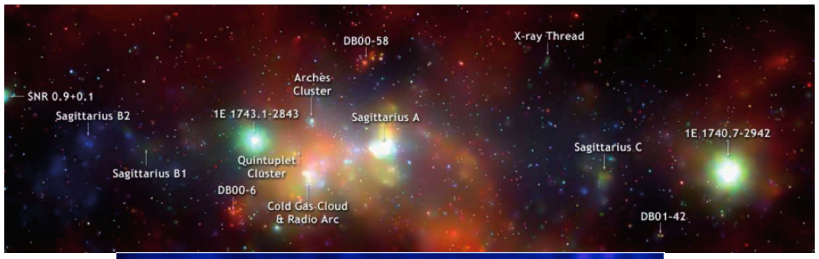
- Telescope doesn't move. Only moving parts: cover/uncover mirror, open/close camera. Surely this can be operated remotely.
- Only thing preventing totally automatic operation: weather conditions and hardware failures.
- FACT has a long experience with robotic operation. Learn from them!

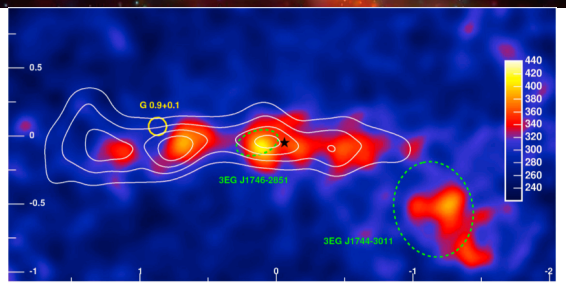
Physics

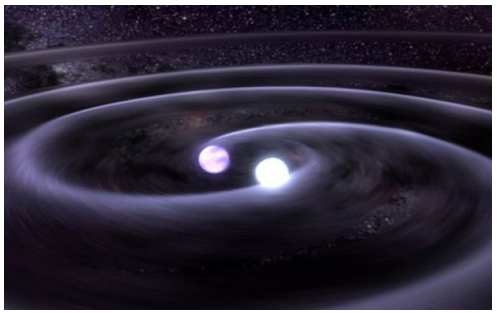
- No Time Allocation Committee.
- But it's important to evaluate what physics we can make with MACHETE if we want any funding...
- Specifically: is it worth the effort when confronted with CTA? How does it overlap? Where does it add something new? Synergies!
- How to maximize physics impact: how to make sure e.g. that our alerts are followed-up and we get something out of it? Organize MWL campaigns? Set up deals with other instruments?

Beyond the baseline design?

- Does it make sense to make the FOV smaller, larger? Shadowing is a problem but…
- FOV along the meridian. Javi suggested to align it so that the Galactic Center can be observed for many hours (Dark Matter, galactic sources). Other options?
- Can MAGIC hardware by re-used for MACHETE or a MACHET-ito?
- Always in my mind, but never explicit: constantly sampling optical pulse of photodetectors turn MACHETE into a survey telescopes at optical wavelengths. Makes sense for very fast transients, i.e. faster than 1 s. There is no competition at <1 s scales with such a huge FOV.







Cost estimate (1/3)

Mechanics:

- No mirror actuators.
- No steering (no motors, corresponding electronics and power).
- Hard to estimate with no full design, because it's different than most IACTs.

Let's assume a rather simple steel construction. Guess: 0.5 M€ for both MACHETE telescopes.

Foundation: forces are reduced because

- Mirror is horizontal (and could be shielded) so wind force is small.
- No acceleration forces.

- Mirror surface of LST is 400 m2 and foundation costs 0.5 M€/LST. Let's assume 0.5 M€ for both MACHETE telescopes.

Mirrors:

- Mirrors or camera can be heavier: assuming 1k€/m^2 for mirrors and 619 m^2/ telescope, it's 1.2 M€ for two telescopes.

Cost estimate (2/3)

Camera:

• Number of pixels similar to CTA SCT (15000 in MACHETE and 11328 in SCT) and planned readouts are almost identical.

• They are already building a prototype so their cost estimate is solid. Let's consider CTA cost book (MAN-PLANS/140505) and V. Vassiliev, SCT presentation at CTA STAC meeting, June 2015.

• Cost of camera, including photosensors (6.2mm side SiPM), readout electronics et al, plus **labor** and **contingency = 0.9 M$ =0.8 M€. Scaling with number of pixels in MACHETE, 2.1 M€ for** two telescopes.

• However MACHETE's pixels would be larger by factor 5.9. For an SCT, photosensors represent 41% of the camera cost. Assuming SiPM cost scales linearly, MACHETE photosensors would cost 5.3 M€/2 telescopes.

• In conclusion cost of the 2 MACHETE cameras is estimated as 7.1 M€.

• There's significant potential to reduce the cost of the SiPM: e.g. FBK is advertising 0.3 $/mm2 and even lower prices.

Cost estimate (3/3)

Item	Capital cost for 2 telescopes
Mirrors	1.2 M€
Camera: photosensors	5.3 M€
Camera: readout and others	1.8 M€
Foundation	0.5 M€
Mechanical structure	0.5 M€
Auxiliary, computing and others	0.5 M€
TOTAL	**9.8 M€**