JEM-EUSO on ISS explores the origin of the highest energy particles in the Universe

EUSO-Balloon: Observation and Measurement of Tracks from a laser in a Helicopter

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EUSO-Balloon

Fig1: EUSO balloon launch August 24th /25th 2014

- JEM-EUSO prototype:
  - Instrument testing for ISS
  - Measuring UV-background
  - Testing calibration system
- **First flight: 24th/25th August 2014**
- Properties:
  - Aperature: 1m²
  - FoV: 11° x 11°
  - 2304 pixel
  - Single photon counting
  - 5h at float altitude (38km)
  - 2.5h helicopter+laser underflight
  - 270 recorded laser tracks

The laser system

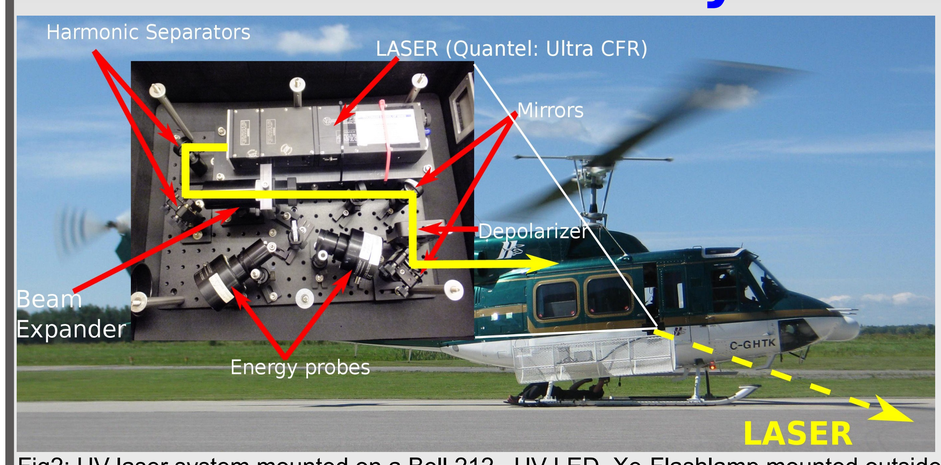

Fig2: UV-laser system mounted on a Bell 212. UV-LED, Xe-Flashlamp mounted outside in the basket.

LASER:
355nm
E_1 = 15mJ
E_2 = 10mJ
Rep. Rate: 19Hz
Relative energy measurement every shot (PickOff probe)

The helicopter underflight

- 3 light sources (UV-LED, UV-laser, Xe-Flashlamp)
- Tracking balloon with GPS tracker
- Circular flight pattern (R< 4km): laser points always into the FoV
- Laser fired horizontally

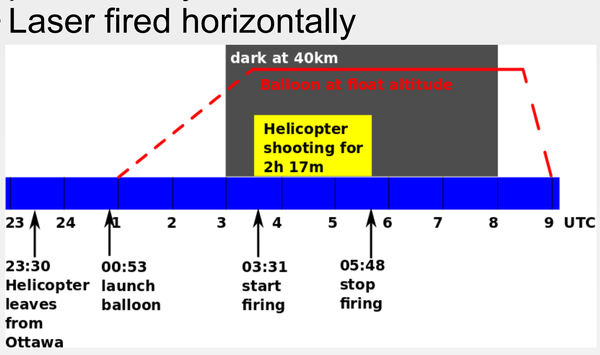

Fig5: Timeline of the balloon and helicopter mission

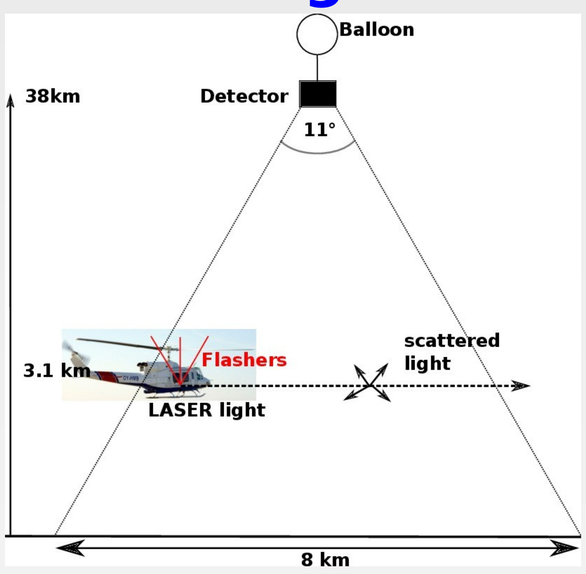

Fig6: Sketch of the helicopter underflight.

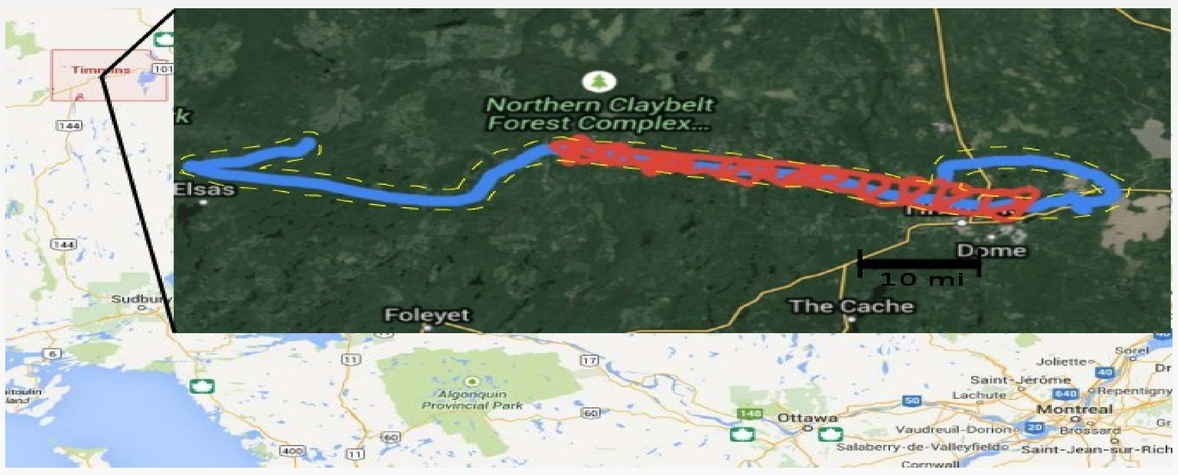

Fig2: Flight of balloon(blue) and helicopter (red)

Geometric reconstruction

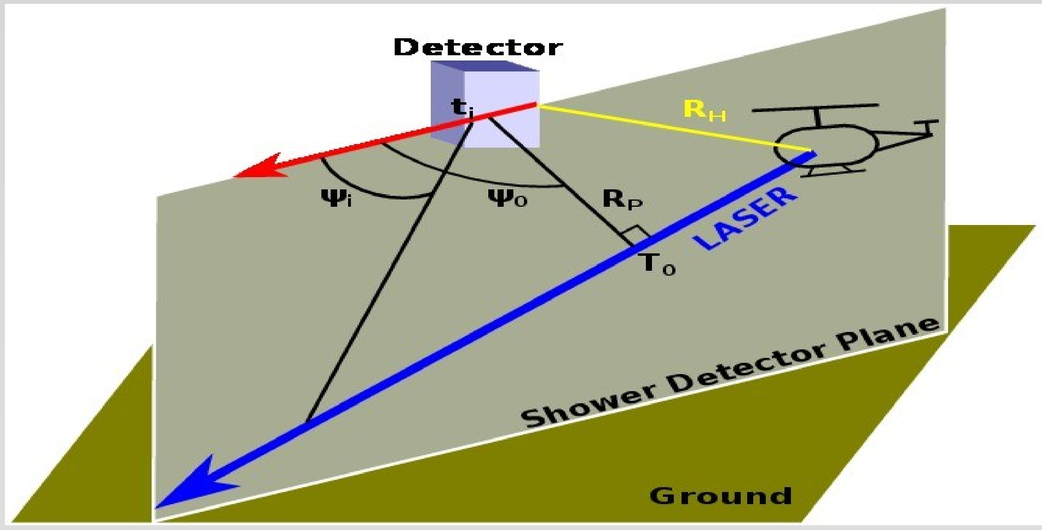

Fig7: Illustration of the geometrical direction reconstruction of the laser tracks fired from the helicopter with observables of the balloon.

$$t_{i,expected} = T_0 + \frac{R_P}{c}\tan\left(\frac{\pi}{4} + \frac{\psi_0 - \psi_i}{2}\right)$$

T_0: time of closest approach R_p: distance of closest approach Ψ_0:angle to R_P in SDP
Ψ_i:angle between shower and detector in SDP

- Small change in angular speed over observed track length (low curvature time vs angle)

→ Large uncertainties possible for 3 parameter fit

- Reduce fit to one parameter using the known position of the helicopter

$$t_{i,expected} = t_H - \frac{R_H}{c}\left(1 - \sin(\psi_H - \psi_0)\right) + \frac{R_H \cos(\psi_H - \psi_0)}{c}\tan\left(\frac{\pi}{4} + \frac{\psi_0 - \psi_i}{2}\right)$$

R_H : distance helicopter detector, t_H : time of first appearance in the camera,
Ψ_H:angle between helicopter and detector in SDP

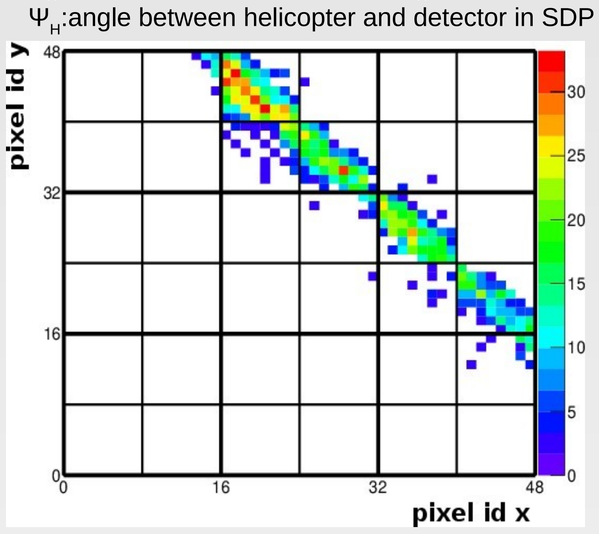

Fig8: Laser track in the PDM. Pixel size 0.23°. Color represents the relative charge

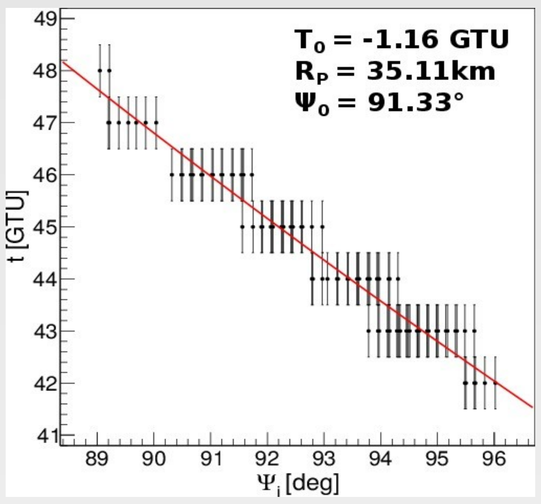

Fig9: Timing profile of a laser event with constant 0.5 GTU timing error.

Preliminary results

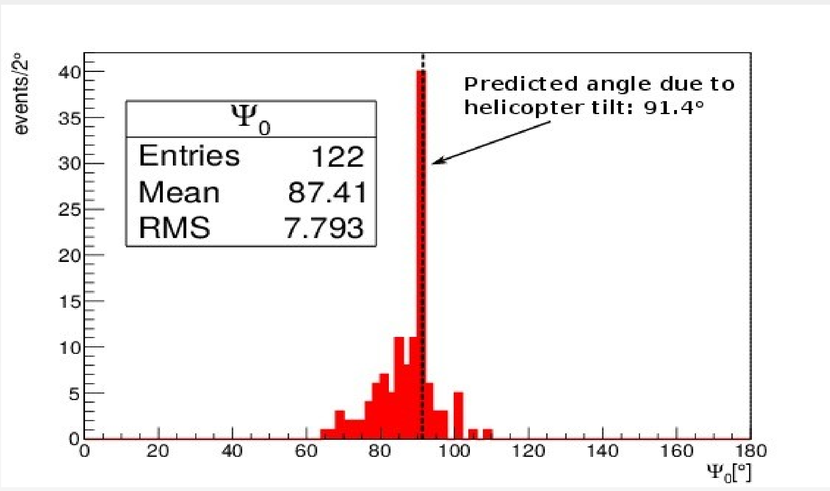

Fig10: Zenith angle reconstruction of the helicopter laser shots with the 1 parameter fit method

- Improvement: applying calibration and IR data
- Most common value 90°-92° consistent with expected value due to helicopter tilt

Conclusion

- Developing of reliable laser system to be used in a helicopter
- Successful tracing of balloon
- Successful and first helicopter underflight (pattern)
- 270 recorded tracks
- **First tracks measured from above**
- Zenith angle reconstruction
  - current resolution 7.8°
- Most common value agrees with expectation due to helicopter tilt

JEM-EUSO collaboration 16 Countries, 93 Institutes, 351 people

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