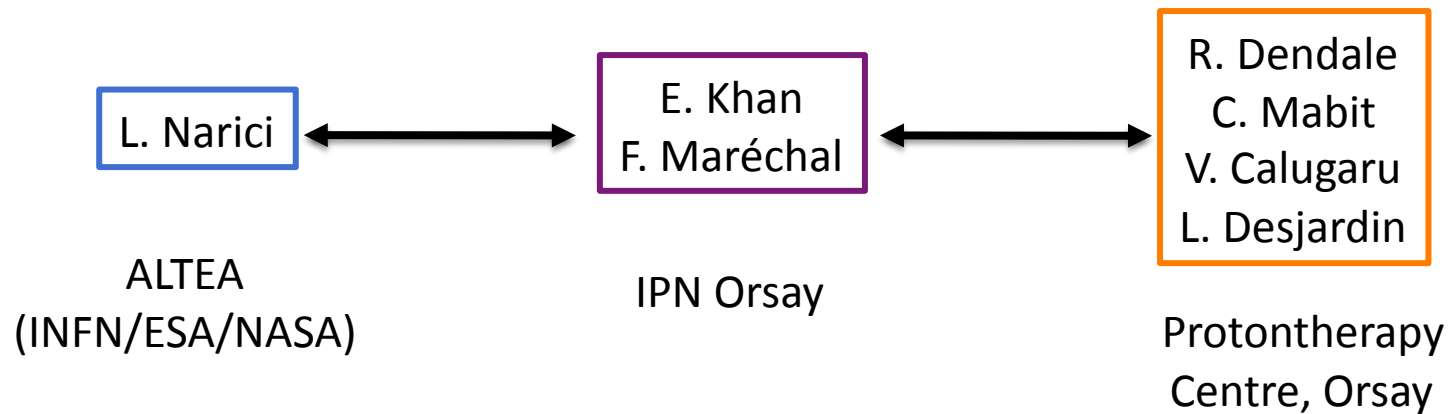


Anomalous light flashes: from astronauts to protontherapy

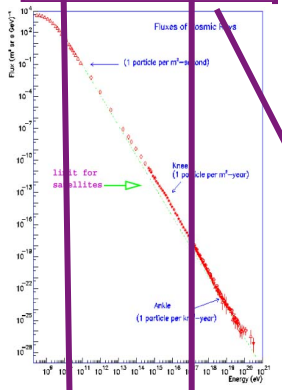


E. Khan



Cosmic rays (p, Nuclei, ...)

Spectrum



Interaction in space

Nucleosynthesis (spallation)



Satellites



Astronauts



Interaction in atmosphere

Lightning bolt?



Life on Earth ?



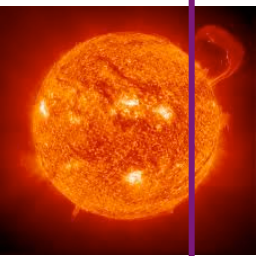
Clouds ?



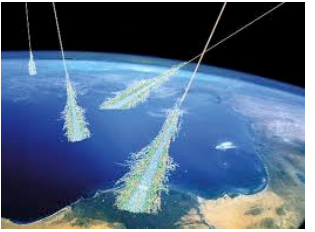
Aurora borealis



Solar



UHECR



Galactic



Anomalous light flashes: Phosphenes

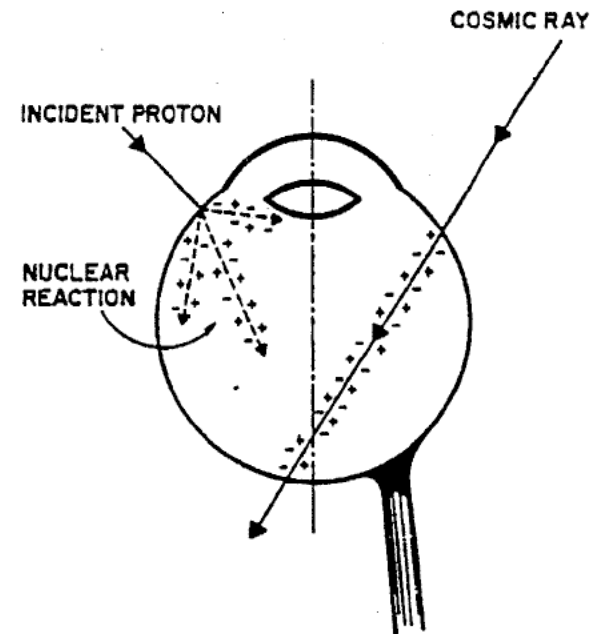
Predicted by Tobias in 1952
C.A. Tobias et al., Nature 230, 596 (1971)
M. Casolino et al., Nature 422, 680 (2003)

Experienced by N. Armstrong and E. Aldrin in 1969
L.S. Pinsky et al., Science 183, 957 (1974)

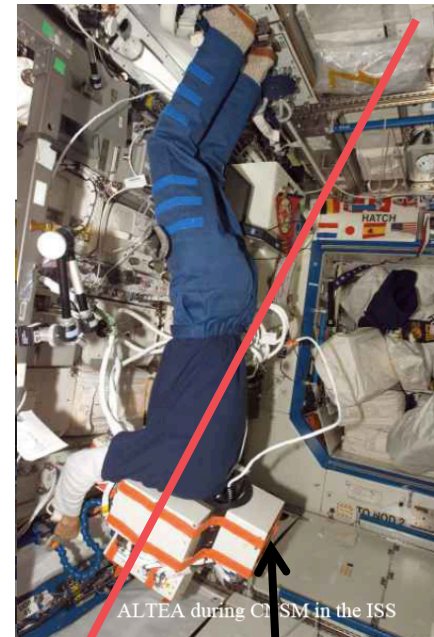
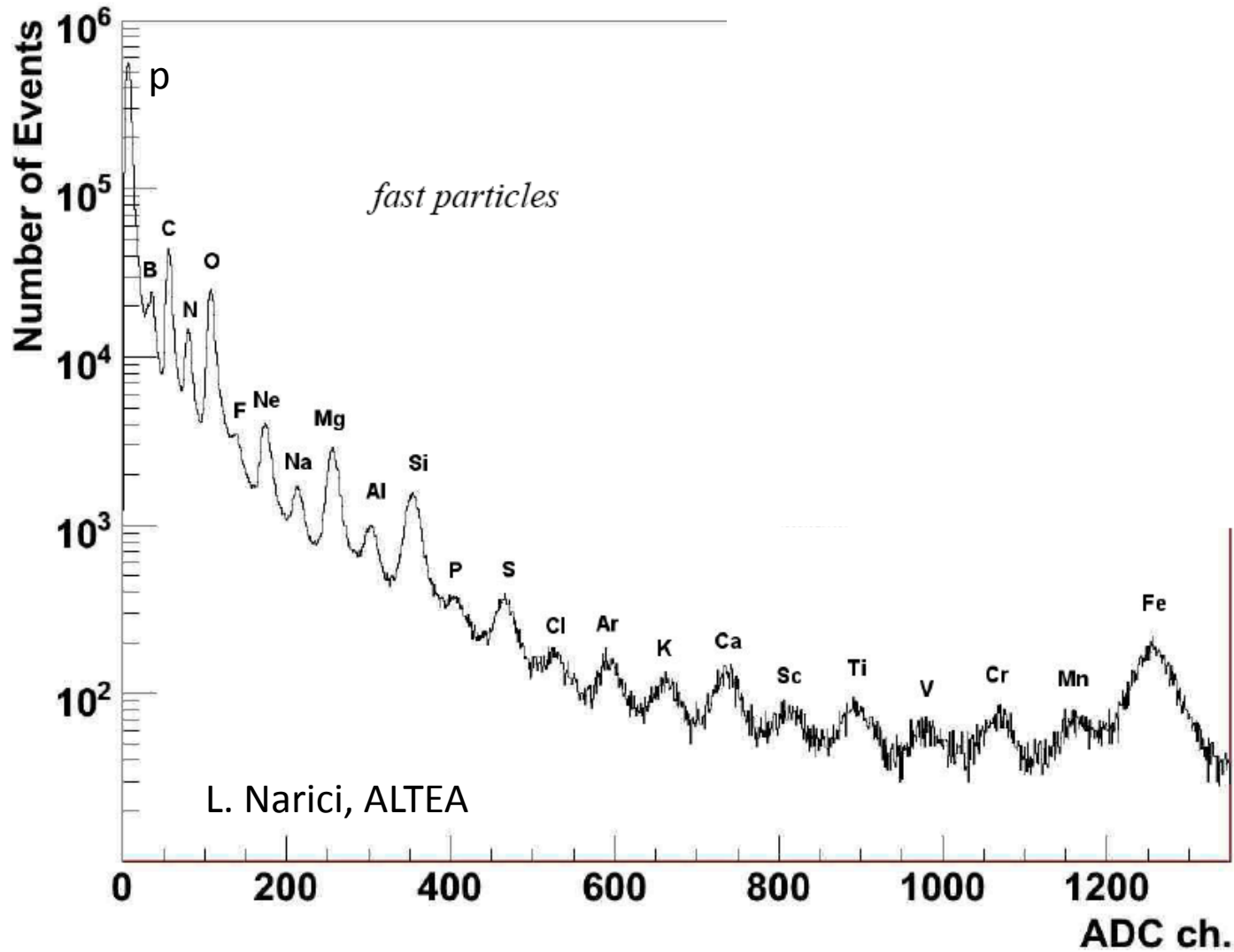
P.J. McNulty,
Single-events effects experienced by astronauts and microelectronic circuits flown in space
IEEE Transactions on Nucl. Sci. 43, 475 (1996)



Princeton Particle Accelerator (1970)



Cosmic rays identification



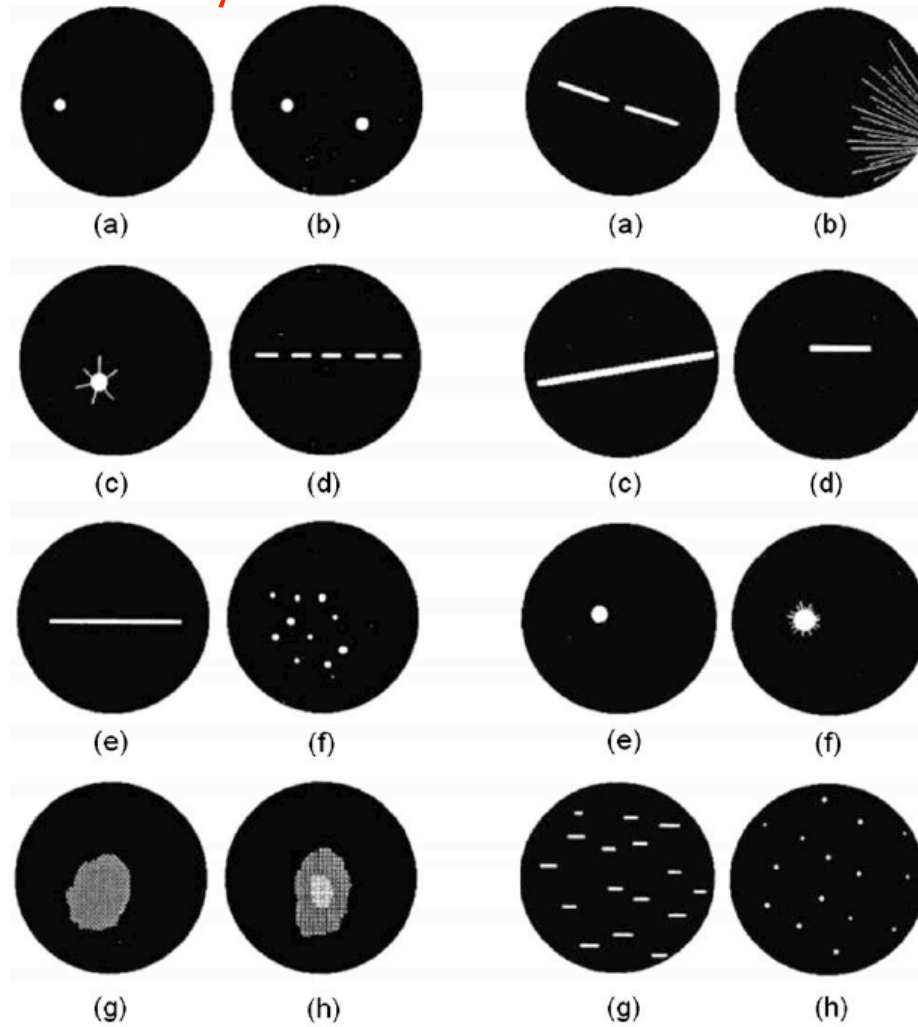
Cosmic rays

6 DSSSD
380 μ m

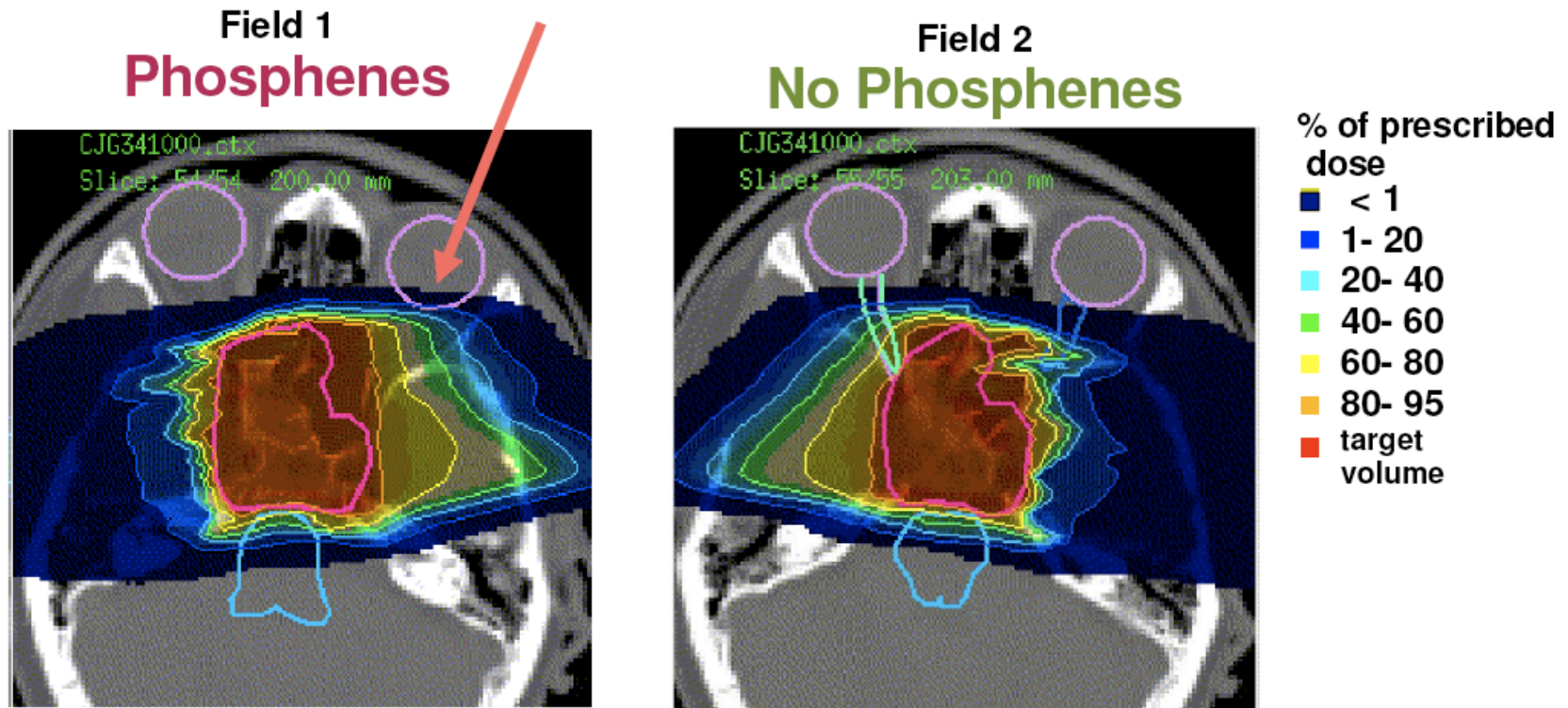
What do they see ?

Apollo
Skylab

MIR



Eye or brain ?



39 patients studied at GSI (O.Kavatsyuk, D.Schardt,M.Krämer)

Protons or nuclei ?

- p: larger flux, lower LET

LET: 60 MeV p : 2 keV/ μ m

250 MeV ^{12}C : 12 keV/ μ m

- Phosphenes protontherapy centres status

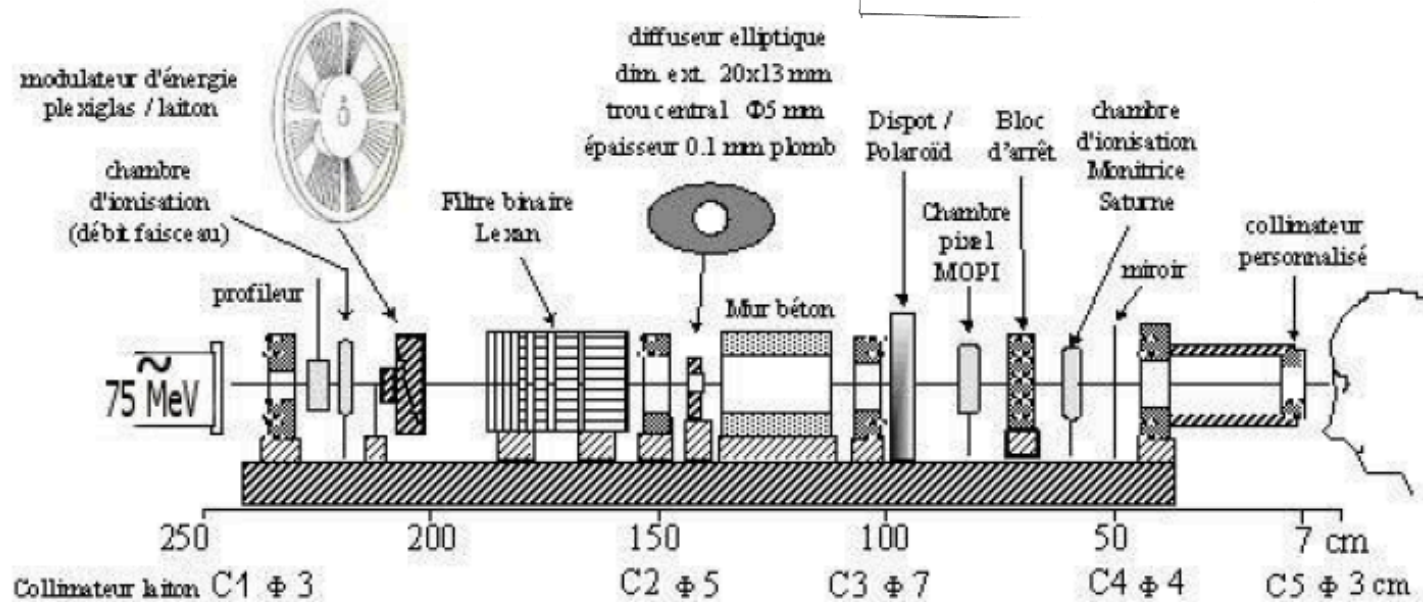
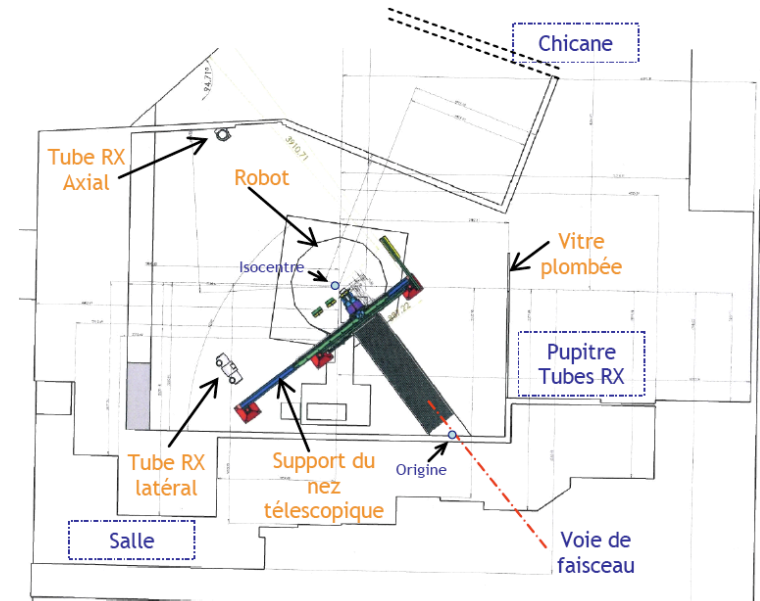
LNS (Catania): No phosphenes

Loma Linda (CA): No ->Maybe ?

ICPO (Orsay): See next slides ...

Study at Orsay protontherapy centre

- 4x1 min 55 MeV protons in eye tumour, 10^{10} pps
- Questionnaire at the end of each session
- First study : 70 patients



Results

- **43% see at least one flash during the treatment**
- Colors: blue (61%), white, yellow, purple
- Shapes: clouds (39 %), dot-like, linear

- Irradiation on the retina is not sufficient to trigger flash
- Contamination by X-rays and Cerenkov photons: blue cloud, also discarded by simulation

Conclusions

- Database 500 patients
- Beam Tracking
- Comparison with other facilities
- Contamination by secondary X rays or Cerenkov photons
- Role of the flux, the LET and physiology ?