Hillas Symposium
Heidelberg: 12 December 2018

Closing Remarks

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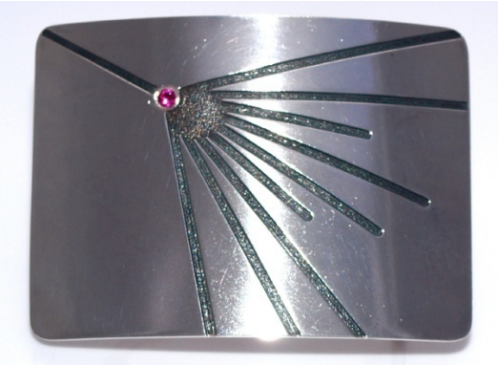

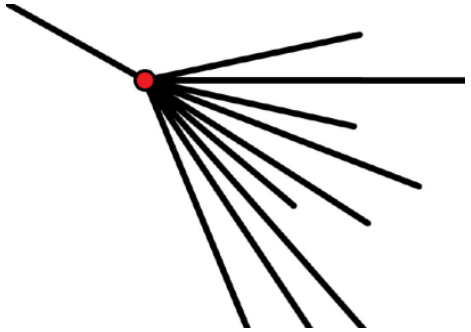

Would have been shocked to know that such a meeting had taken place

Honoured to find that so many people had thought so highly of him

Theorist or experimentalist?

Have theorists done much to steer the direction of studies of UHECR?

Theoretical input? Little impact on direction of experiments

Useful work by Michael

- **Analysis: ρ (500), S(1000)……**
- **MOCCA and earlier simulations**
- **South Pole inspiration and data analysis**
- **Imaging!**

Few that one could identify as his progeny – he influenced a more established generation

Why did he show no interest in radio? Wise at the time

Very sad that he will not be here to enjoy this exciting period in gamma-ray astronomy and cosmic ray physics

Auger Science paper of September 2017

Cosmic Rays in an Evolving Universe 1967

Volume 24A, number 12 PHYSICS LETTERS 5 June 1967

THE ENERGY SPECTRUM OF COSMIC RAYS IN AN EVOLVING UNIVERSE

A. M. HILLAS
Physics Department, University of Leeds, England

Received 20 April 1967

If the most energetic cosmic-ray protons originated in powerfull radio-galaxies, they were probably produced much more abundantly in the past. Their subsequent interactions with the cosmic microwaves could have produced a steepening in the energy spectrum as observed.

Cosmic rays in an evolving universe[1]

ICRC Calgary 1967

A. M. HILLAS
Physics Department, University of Leeds, Leeds, England

Received June 21, 1967

If the most energetic cosmic rays that have been detected are of extragalactic origin, and their sources were strong radio emitters, the radio-astronomical evidence suggests that the output from such sources must have been very much greater in the past than at present, varying roughly as t^{-3} over a long period. In this case, the importance of interactions between the universal flux of microwaves and intergalactic cosmic-ray protons and nuclei above 10^{15} eV is greatly increased, because of "red shifts" in the energies of the nuclei and the microwaves, and changes in density. The probable result is shown to be a steepening in the proton energy spectrum from a slope of -1.5 to -2.2 over the range 10^{16} to 10^{18} eV, as is observed, if the energy spectrum at production is always simply $E^{-1.5}$.

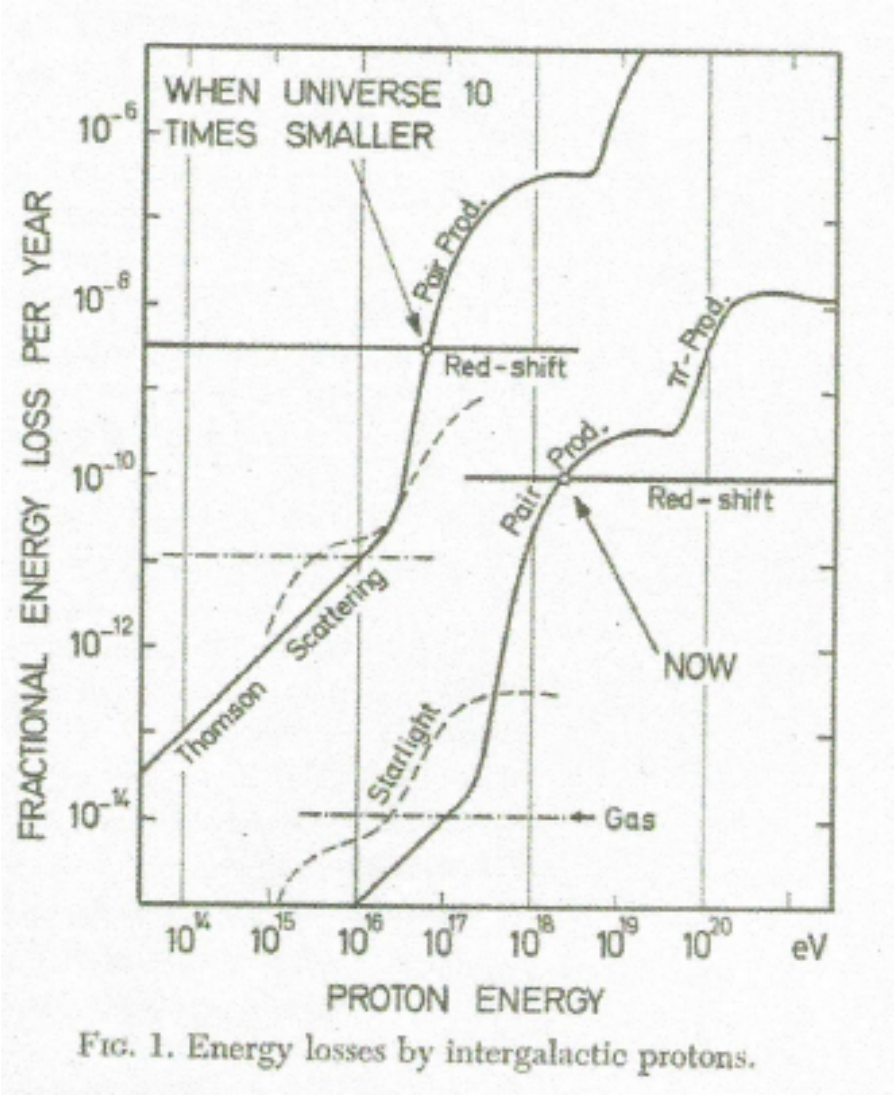

FIG. 1. Energy losses by intergalactic protons.

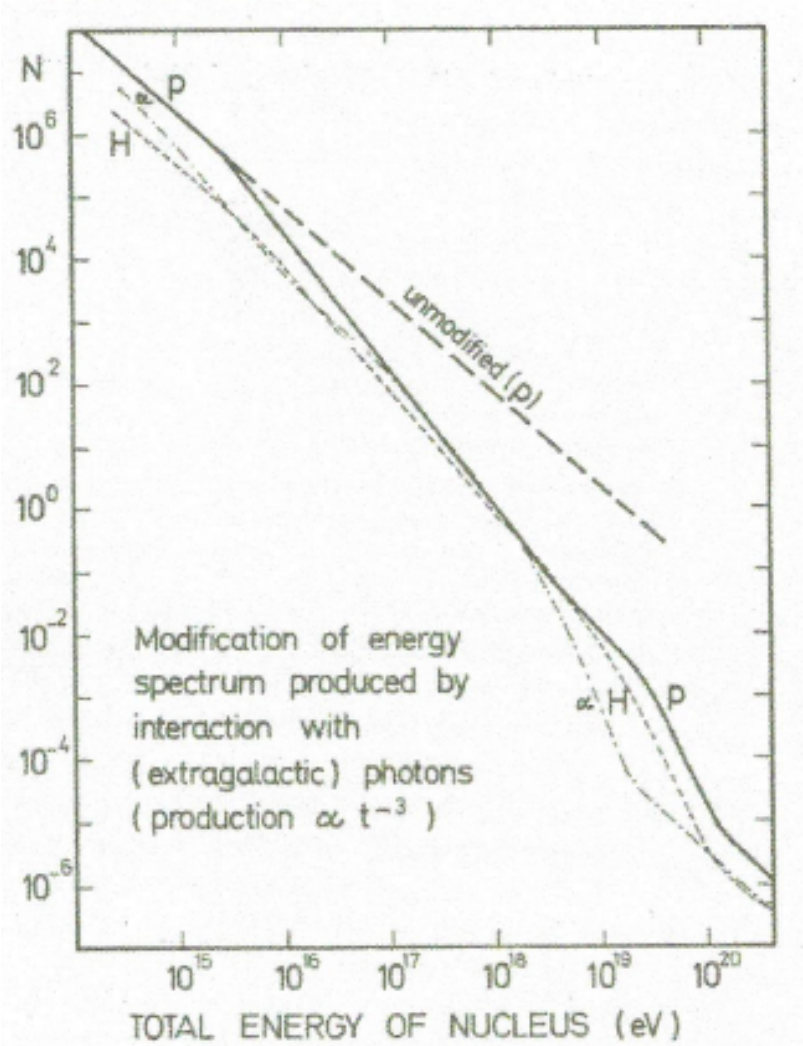

FIG. 2. Present-day spectra of protons (p), α particles, and heavy nuclei (H), predicted if production spectrum is $t^{-3}E^{-1.5}$ (starting at $t = 1.4 \times 10^8$ yr).

1. Energy taken out of proton spectrum by microwaves should appear in another form

Electrons and positrons of ~10^{15} eV and then through inverse Compton to give γ-rays of 10^{11} eV

First discussion of this?

2. Several times expressed to me that the dip in the spectrum due to pair production was never credited to him.

In fact, Hill and Schramm who developed this idea further (Phys Rev D31 564 1985), do give full recognition – but this seems to have been lost subsequently

Is there some way that this paper can be made widely available?

Thanks to many and gute reise!