2018/12/11

Hillas of the Antarctic

Or... Michael's impact on Nigel Smith's transition to the Dark Side.

SNOLAB

The context for the South Pole telescope

AMH started talking about the idea in 1985

‘Observations’ of UHE gamma rays from Cygnus X-3

New arrays being built around the world

GREX array in construction at Haverah Park

Noted that all observations were bursts

Wanted to have an observatory that could

- see sources all the time (with overlap)
- have a low energy threshold
- see the Galactic centre
- (SN198a)

Initial thoughts

These notes form a numerical elaboration of an informal proposal made by the author to some participants at the 1985 La Jolla cosmic ray conference.

I am grateful to J. McMillan for South Pole barometric information, to A. Lambert for information on timing jitter in scintillator signals as actually observed, and to T. K. Gaisser, M. A. Pomerantz and A. A. Watson for encouragement.

Haverah Park internal note

Initiated informal discussions at La Jolla ICRC

Talk at Vulcano workshop 1985

- discussions underway between Leeds and Bartol group on running an experiment

ON THE ADVANTAGES OF MONITORING GAMMA-RAY BINARIES FROM THE SOUTH POLE

A. M. Hillas

Physics Department, University of Leeds, Leeds, UK

TeV and PeV gamma-ray sources are highly variable, and astronomers argue about which are real. This is reminiscent of the early days of X-ray astronomy, when sources were observed from rockets which spent only a few minutes above the atmosphere, and one observer could not find a source reported by another. We need an UHURU.

How should we find the real pattern behind these variations? We need

1) Detectors placed where several sources are always in view.
2) The declination band viewed should contain many potential sources.
3) A high altitude, allowing a scintillator array to have a low threshold energy, to increase the counting rate.

The above requirements were obvious, but this visit to Vulcano has provided the final constraint that confirms completely the choice of site:

4) The climate and general environment should differ as much as possible from Vulcano, or very little work would be done after the first week.

....

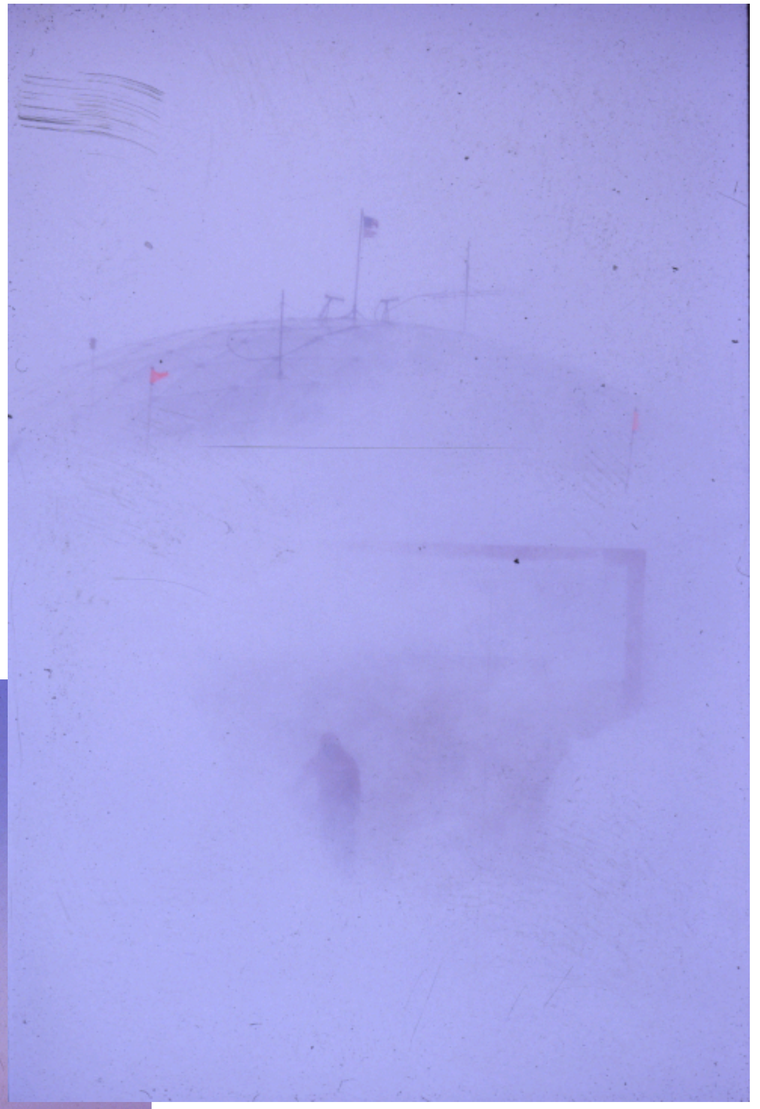
One would not see Cygnus X-3, of course, but there are LMC X-4, Vela X-1 and Cen X-3 before we consider all the other binaries.

3) The South Pole is at a very high altitude - 695 g cm^{-2} atmospheric depth (cf 1036 g cm^{-2} at sea level). This makes possible a threshold energy around 10^{14} eV for a simple scintillator array. (Only a scintillator array can view many sources continuously, as required.)

4) No distractions: no warm, sunny beach.

He was right...

Volcano



South Pole

Initial thoughts

ON THE ADVANTAGES OF MONITORING GAMMA-RAY BINARIES FROM THE SOUTH POLE

A. M. Hillas

epartment, University of Leeds, Leeds, UK

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4) No distractions: no warm, sunny beach.

Change in location for my PhD

My PhD coincided with these thoughts

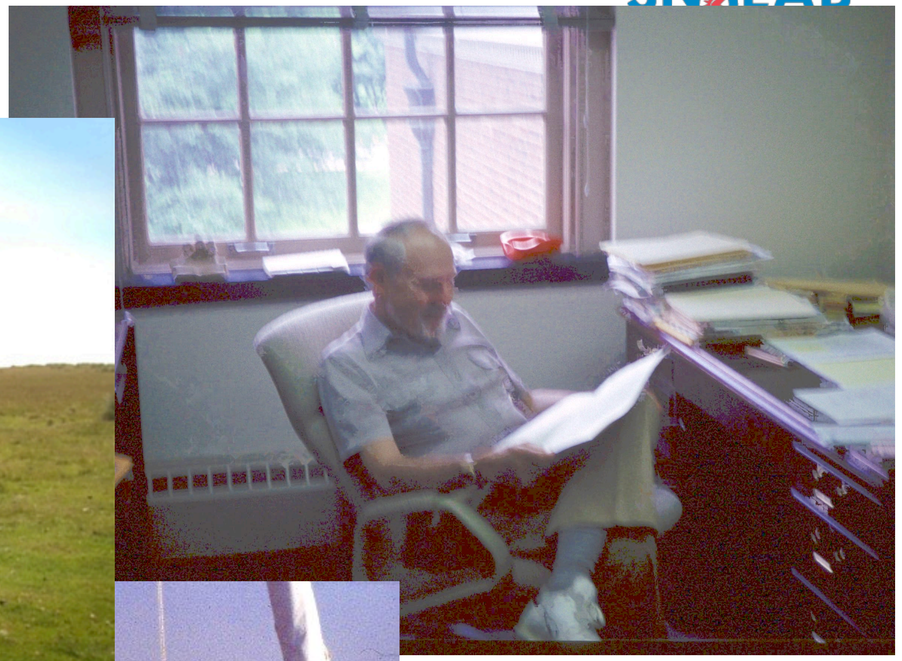
Haverah Park GREX array (digging trenches)

Alan and I deciding to change my PhD

Setting the South Pole 1987/88

A collaboration forms

Alan Watson
@Haverah Park

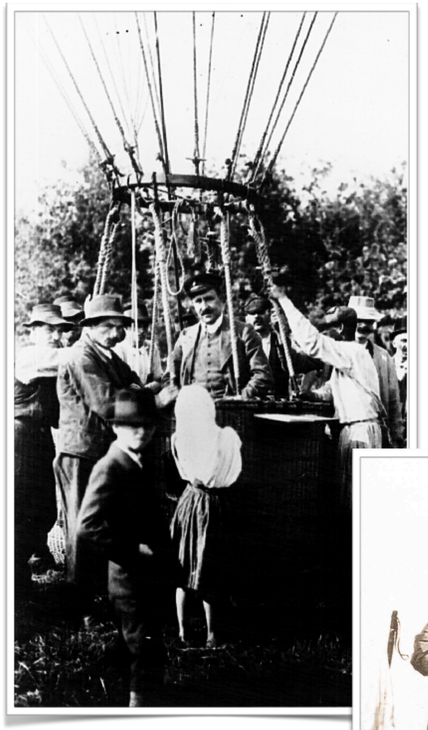


Training for the Pole -
Setting things on fire

Martin Pomerantz
- Mr. South Pole

My interview
process

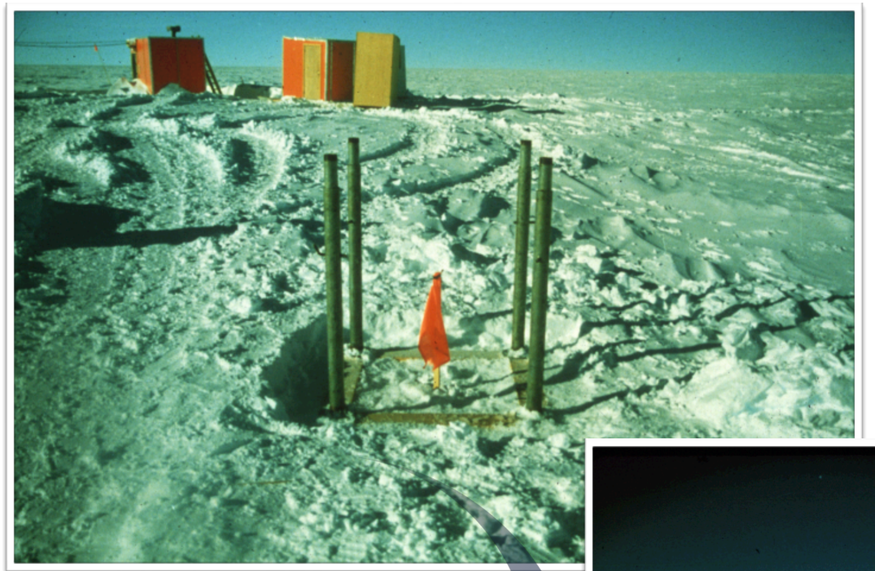
The South Pole has a history of science

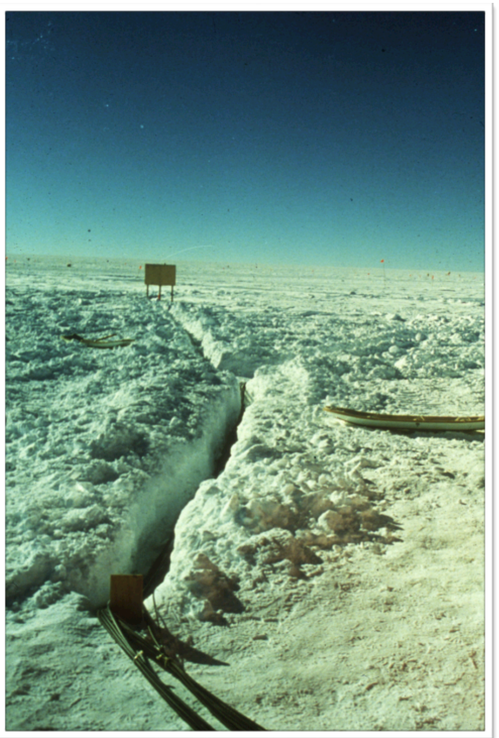


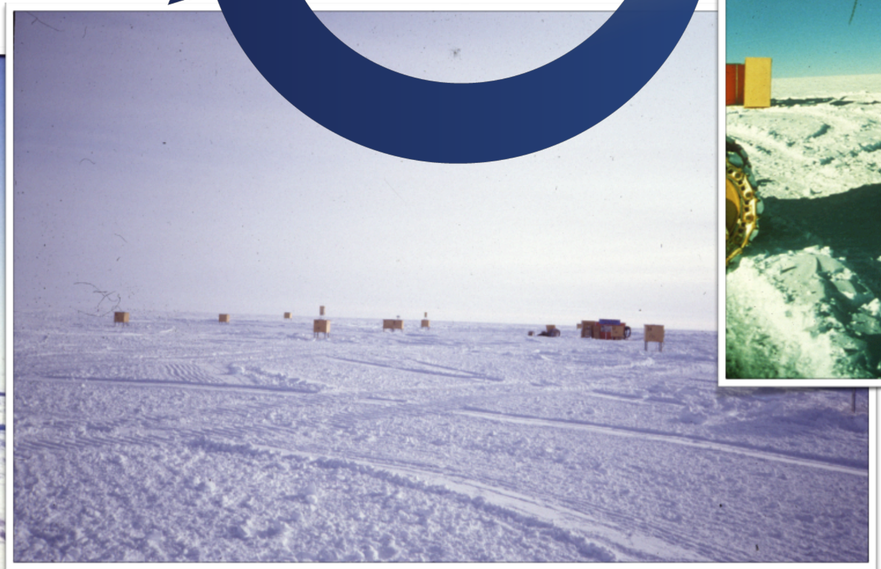
1912 saw the discovery of cosmic rays and the first British scientists to reach the South Pole

1957/58 IGY saw the development of the first research station at the South Pole

SPASE array



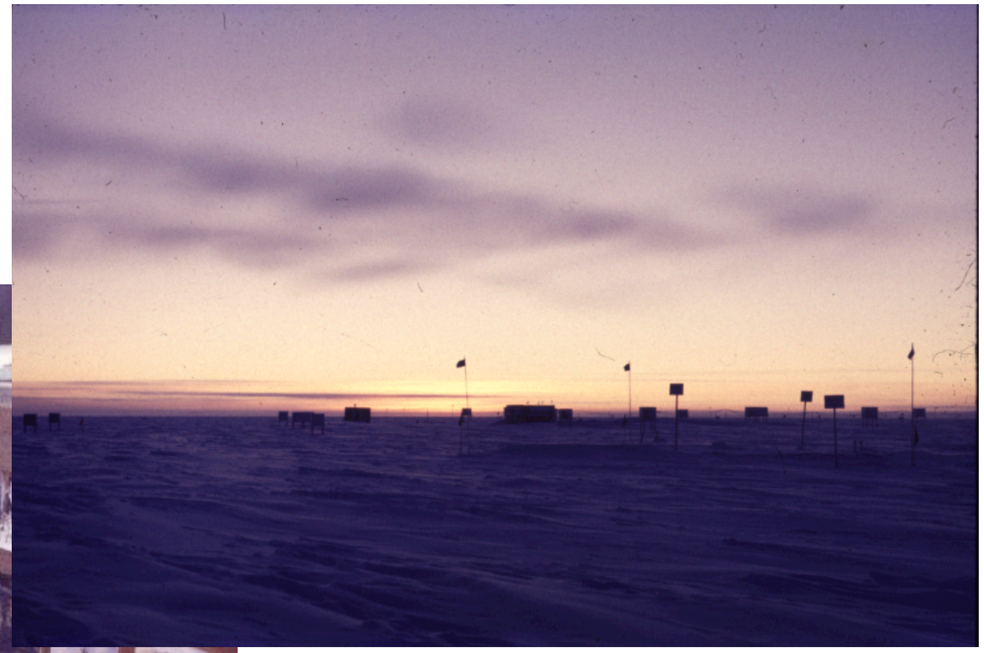




Completion of the array

South Pole Air Shower Experiment: SPASE
Ran 1988 - 1994
16 element detector array
6400 square metre enclosed area
One event observed per second

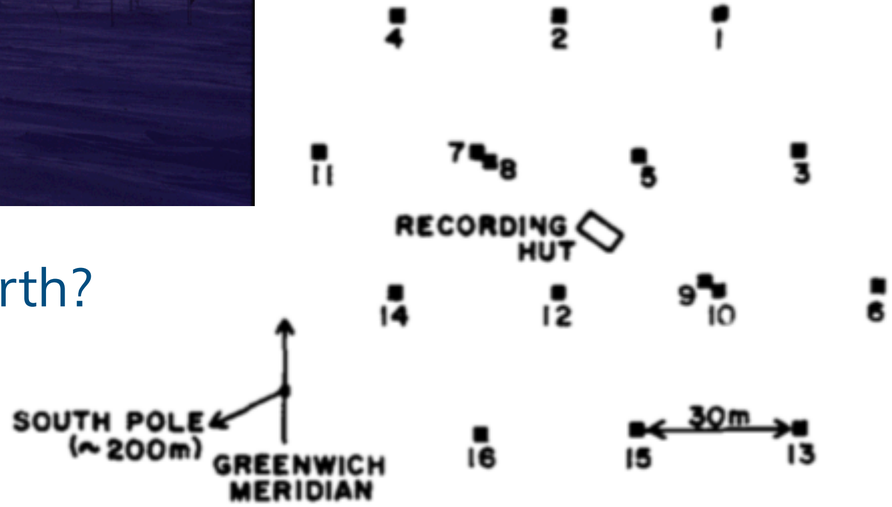
AMH worked on unique way to determine the orientation of SPASE



Surveyed during summer

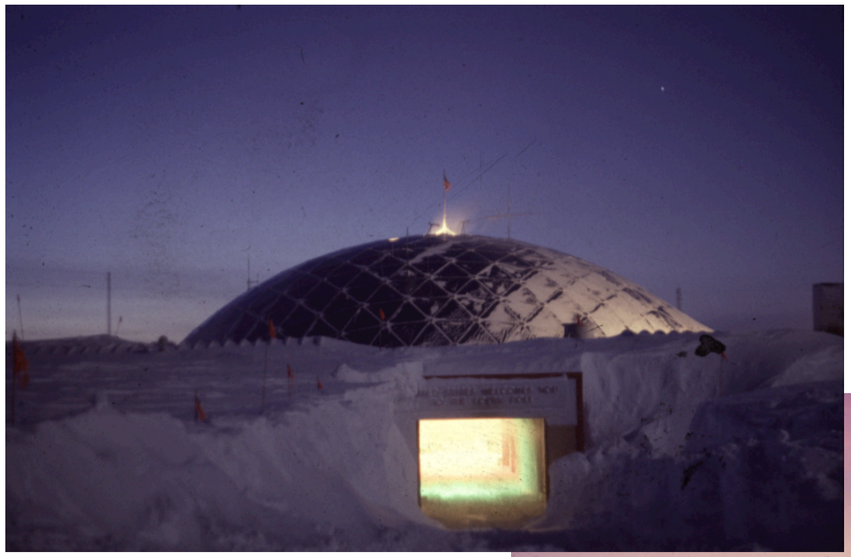
Use Sun as a survey tool during dawn and dusk

Which way is North?



First foray into the Dark…

Last Flight



The longest night

Reagan's pleasure

Mid-winter's Day message from the Commander-in-Chief

Note the focus on climate!

FM: THE WHITE HOUSE, RONALD REAGAN
TO: SOUTH POLE STATION ANTARCTICA, NIGEL SMITH
SUBJ: MIDWINTER'S DAY MESSAGE 1988

DEAR NIGEL,

I AM VERY PLEASED TO GREET THE MEN AND WOMEN CONDUCTING IMPORTANT SCIENTIFIC RESEARCH AT INSTALLATIONS ACROSS THE DARKENED SEVENTH CONTINENT.

IN 1931, LAWRENCE GOULD, CHIEF SCIENTIST OF ADMIRAL BYRD'S FIRST EXPEDITION, SAID THAT SCIENTIFIC RESEARCH IN ANY NEW FIELD "WORKS BY TRIAL AND ERROR AND NATURALLY OFTEN FINDS ITSELF RUNNING UP BLIND ALLEYS. POLAR RESEARCH HAS PASSED THE BLIND ALLEY STAGE...LITTLE AS WE KNOW ABOUT THE ANTARCTIC, WE...KNOW ENOUGH TO REALIZE THAT WE CAN GO LOOKING FOR SPECIFIC THINGS."

TODAY, MORE THAN 50 YEARS LATER, DR. GOULD'S WORDS REMAIN TRUE. THROUGH SCIENCE WE HAVE SEEN THAT ANTARCTICA IS CRITICAL TO THE COMPLEX SYSTEM INTERACTING PROCESSES THAT GOVERN OUR ENVIRONMENT. SCIENCE AND SUPPORT PERSONNEL LIKE YOU WHO ARE IN ANTARCTICA NOW HELP US LEARN MORE ABOUT OUR PLANET AND ITS ENVIRONMENT.

AS YOU CELEBRATE MIDWINTER'S DAY 1988, YOU MAY THINK OF THE SUN'S RETURN. FOR YOU THIS DAY REPRESENTS A TURNING FROM THE DARK WINTER NIGHT TOWARD THE FIRST SUNRISE. BUT IT ALSO SUGGESTS A DIFFERENT TYPE OF LIGHT--THE KNOWLEDGE YOU GAIN WILL GUIDE THE WORLD TOWARD GREATER UNDERSTANDING OF COSMIC, CLIMATIC, AND GEOLOGICAL PRINCIPLES. ON BEHALF OF THE PEOPLE OF THE UNITED STATES, I COMMEND YOUR DEDICATION. YOU HAVE MY BEST WISHES FOR CONTINUED SUCCESS DURING THE COMING MONTHS AND FOR A SAFE RETURN TO YOUR HOME.

GOD BLESS YOU
SIGNED RONALD REAGAN

First year’s data challenges

(NSF-7)

During the winter months Spase attained an ontime of 90%, analysis up to the end of September. This gives a projected ontime of over 5 500 hours, or 16 million events. Data were recorded onto 2400´ magnetic tapes in 4kbyte data blocks at 1600 bpi and, although an event is recorded in squashed format in 124 bytes, 58 data tapes were recorded during the winter (with an additional nine tapes recorded at the end of the summer season). This gives a total of approximately 2 gigabytes of data recorded.

A few issues needed to be resolved

- temperature gradient in Cell
- static build-up from wind
- no ground!
- latching of DAQ
- ‘missing’ events
- failure of hard drive controllers

Communication through ATS-3 satellite (tumbled orbit)

Up to two weeks to exchange

AMH involve in the initial SPASE Analysis

Conclusion — the time-fitting process used in the Bartol program manifestly does not minimise the deviations : it results in a fitted plane that is tilted with respect to the best plane (θ less than true θ).

Some events in the short list of 10 had opposite shifts in θ : these proved to be very bad core fits, and drew attention to the fact that the core & density fitting process also does not produce the best fit to the data — much worse discrepancies between observed & fitted densities than I get.

(Again there is a bias — in many cases most of the fitted densities are less than the observed densities, inordinate weight being placed on matching one density close to the axis in some cases.

Because of this big bias (S_{30} too small), the quoted χ^2 can be much too small so χ^2_{actual} appears to be $\left(\sum_{S_{obs} \geq 1} \frac{(S_{obs} - S_{pred})^2}{\alpha . S_{obs}} \right) / N_{deg\text{-}f.}$ (when $\alpha > 1$)

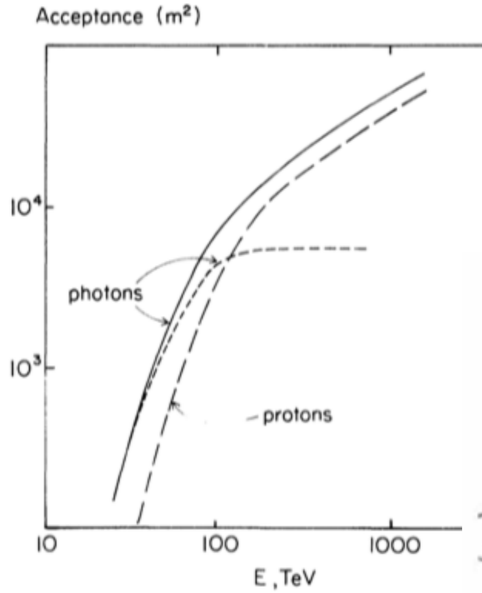
instead of the true $\chi^2 = \left(\sum \frac{(\ldots\ldots)^2}{\alpha . S_{pred}} \right) / N_{deg\text{-}f.}$

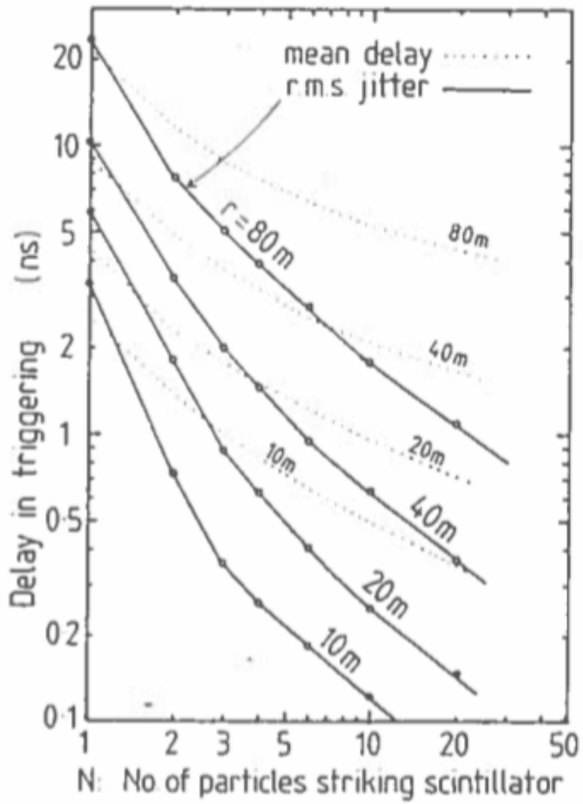
With Spred being systematically very small in many cases, the true χ^2 is much bigger (worse) than even the poor figures tabulated.

Taking $\alpha = 1{\cdot}2$, (a rough value of $\chi^2 \rightarrow$) $\chi'^2 = \left\{ \sum_{S_{pred} \geq 0{\cdot}7} \frac{(S_{obs} - S_{pred})^2}{1{\cdot}2\,(S_{pred} + 0{\cdot}2)} \right\} / (N-1)$

← to allow use of smaller densities

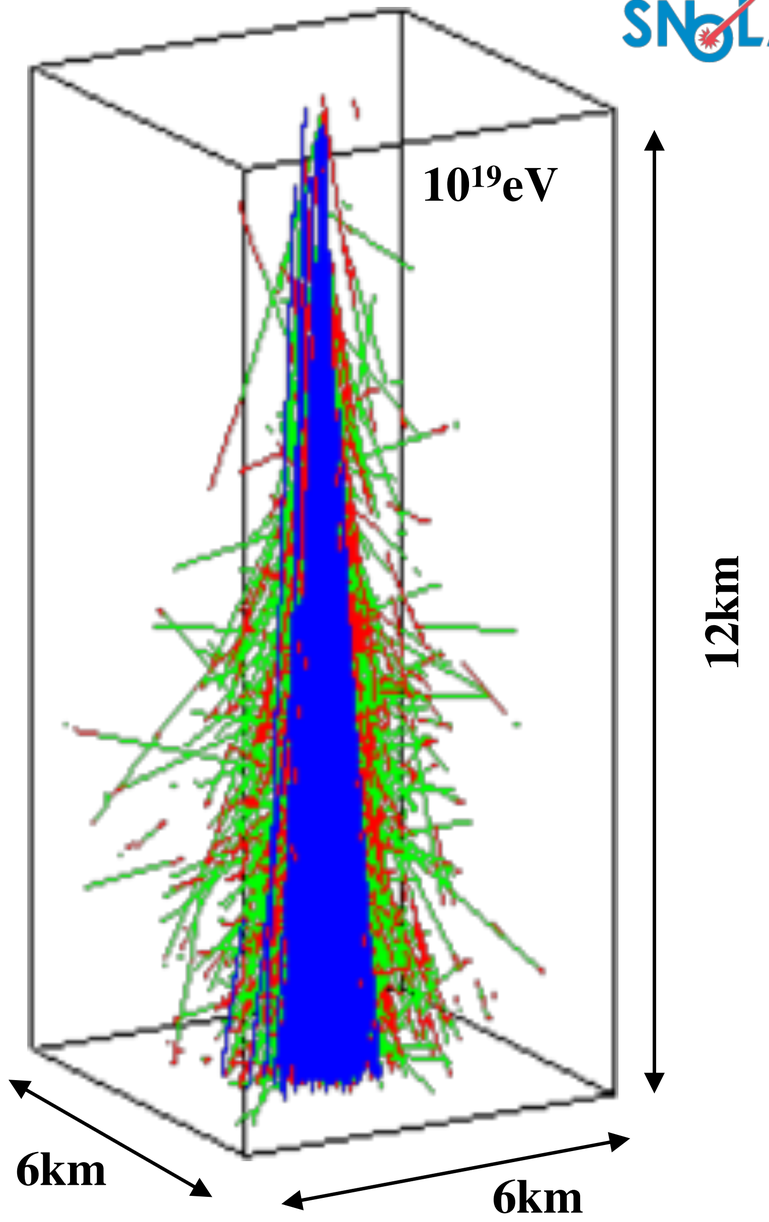
the following conditions of fit





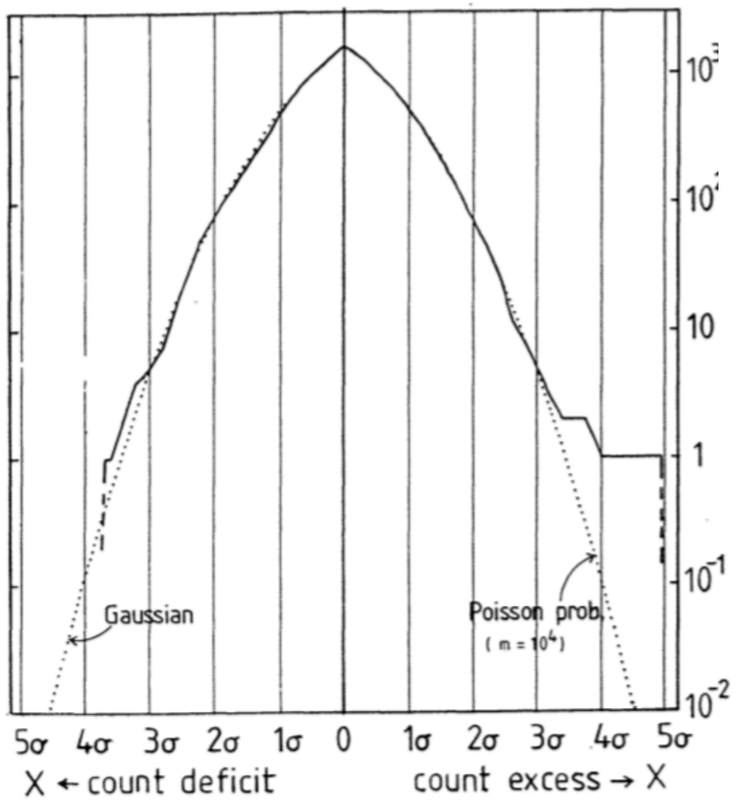
MOCCA used for array design, and analysis comparisons to data

{ Monte-Carlo shower simulation. May 1987. A. M. Hillas.}
{ === }
{ INTRODUCTION - SCOPE OF PROGRAM }
{ === }
{ A feature of this program is "thin sampling " which permits very great reduction in computing time for }
{ very large showers , by following only a reduced proportion of the low - energy particles , but giving }
{ such selectively followed particles a weight > 1 to compensate precisely for their reduced number .All }
{ particles above an energy ETHIN are followed; below this energy a proportion approximately E / ETHIN }
{ of particles of "free energy" E would be followed . ETHIN is selectable by the user .}
{}
{ Ionization loss : Different for positrons and electrons (formula assumes knock - on threshold at 1 MeV)}
{ But electron formula used for mesons etc . Heavy ionizn not used for heavy nuclei . In Pb , constant}
{ 1.1 MeV per gsqcm assumed .}
{ Bremsstrahlung : Elaborate cross - secn includes production angles}
{ Pair production : ditto .}
{ Annihilation : only at rest !!!}
{ Compton scatt : detailed .}
{ Hadronic interactions : Almost simplest splitting representation of scaling}
{ Interations of nucleus : Much simplified .}
{ Magnetic deflections : correct}
{ Coulomb deflections : Details correct for air}
.....



First results (Volcano) were inconclusive

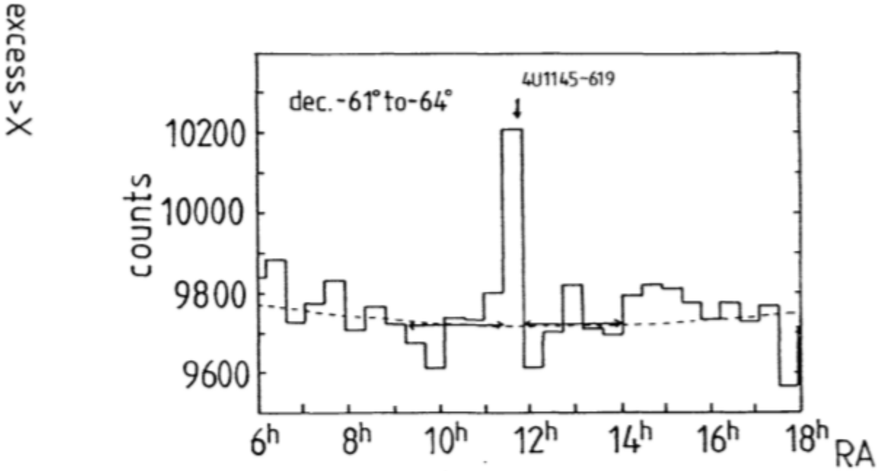
SIF: Conference Proceedings Vol. 28
«Frontier Objects in Astrophysics and Particle Physics»
F. Giovannelli and G. Mannocchi (Eds.)
Bologna, 1990

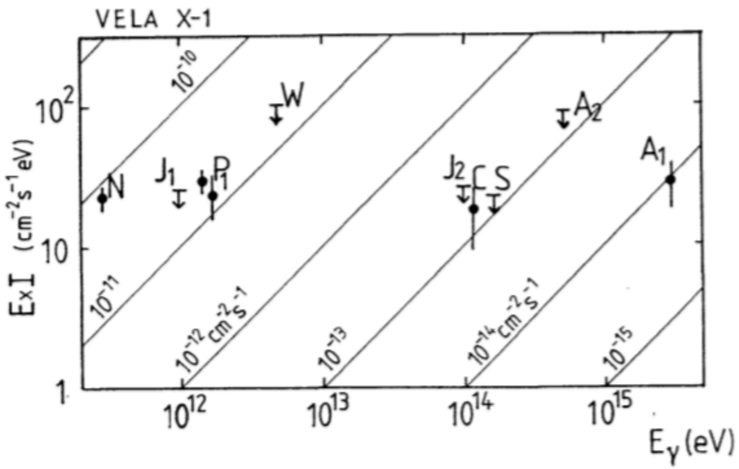


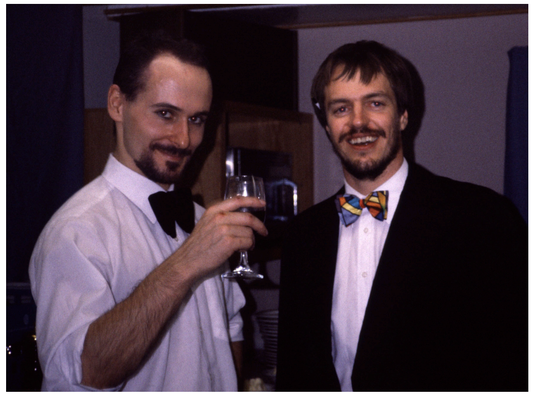
SEARCH FOR 100 TeV GAMMA RAYS WITH AN AIR SHOWER ARRAY AT THE SOUTH POLE

N. J. T. Smith+, T. K. Gaisser*, A. M. Hillas+, P. A. Ogden+, J. C. Perrett*, M. A. Pomerantz*, R. J. O. Reid+, T. Stanev*, A. Walker +, A. A. Watson+ and T. C. Weekes◊

* Bartol Research Institute, University of Delaware, DE 19711, USA
+ Physics Department, University of Leeds, Leeds LS2 9JT, UK
◊ Whipple Observatory, PO box 97, Amado, AZ 85645, USA







Final results were inconclusive

VOLUME 62, NUMBER 13 PHYSICAL REVIEW LETTERS 27 MARCH 1989

Search for Photons of Energy > 50 TeV from SN 1987A in Early 1988

T. K. Gaisser,[1] A. M. Hillas,[2] J. C. Perrett,[1] M. A. Pomerantz,[1] R. J. O. Reid,[2] N. J. T. Smith,[2] Todor Stanev,[1] and A. A. Watson[2]
[1]*Bartol Research Institute, University of Delaware, Newark, Delaware 19716*
[2]*Department of Physics, University of Leeds, Leeds LS29JT, England*
(Received 24 October 1988)

PHYSICAL REVIEW D

PARTICLES, FIELDS, GRAVITATION, AND COSMOLOGY

IRD SERIES, VOLUME 48, NUMBER 10 15 NOVEMBER 1993

Performance of the South Pole Air Shower Experiment during 1987 to 1992

J. Beaman, A. M. Hillas, P. A. Johnson, J. Lloyd-Evans, N. J. T. Smith, and A. A. Watson
Physics Department, University of Leeds, Leeds LS2 9JT, United Kingdom

J. van Stekelenborg, T. K. Gaisser, J. C. Perrett, J. P. Petrakis, and T. S. Stanev
Bartol Research Institute, University of Delaware, Newark, Delaware 19716
(Received 18 June 1993)

PHYSICAL REVIEW D VOLUME 48, NUMBER 10 15 NOVEMBER 1993

Search for point sources of ultrahigh energy γ rays in the southern hemisphere with the South Pole Air Shower Experiment

J. van Stekelenborg, T. K. Gaisser, J. C. Perrett, J. P. Petrakis, and T. S. Stanev
Bartol Research Institute, University of Delaware, Newark, Delaware 19716

J. Beaman, A. M. Hillas, P. A. Johnson, J. Lloyd-Evans, N. J. T. Smith, and A. A. Watson
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(Received 18 June 1993)

THE ANALYSIS TECHNIQUES USED FOR THE SOUTH POLE AIR SHOWER EXPERIMENT

T K Gaisser, J C Perrett*, T S Stanev,
J T P M van Stekelenborg

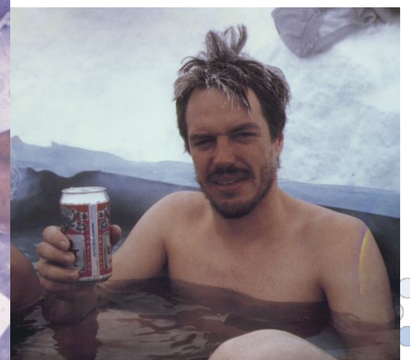
Bartol Research Institute, University of Delaware,
Newark, DE19716, U S A

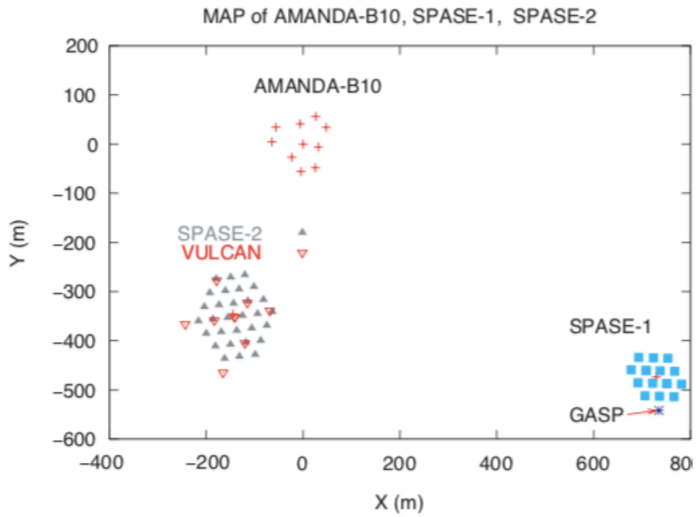
A M Hillas, A W Hull, P A Johnson, J Lloyd-Evans,
N J T Smith, A A Watson

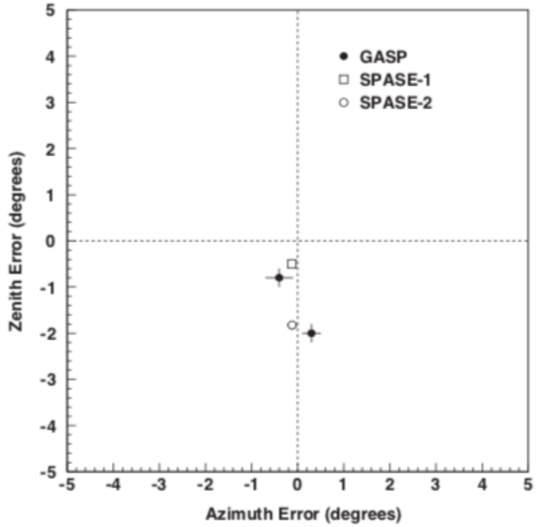
Department of Physics, University of Leeds, Leeds LS2 9JT, UK

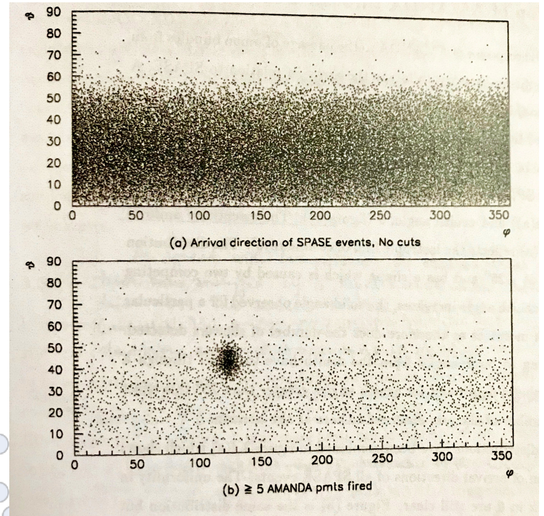
*Now at A T & T, Wiltshire, England

SPASE had a new lease of life in coincidence with AMANDA









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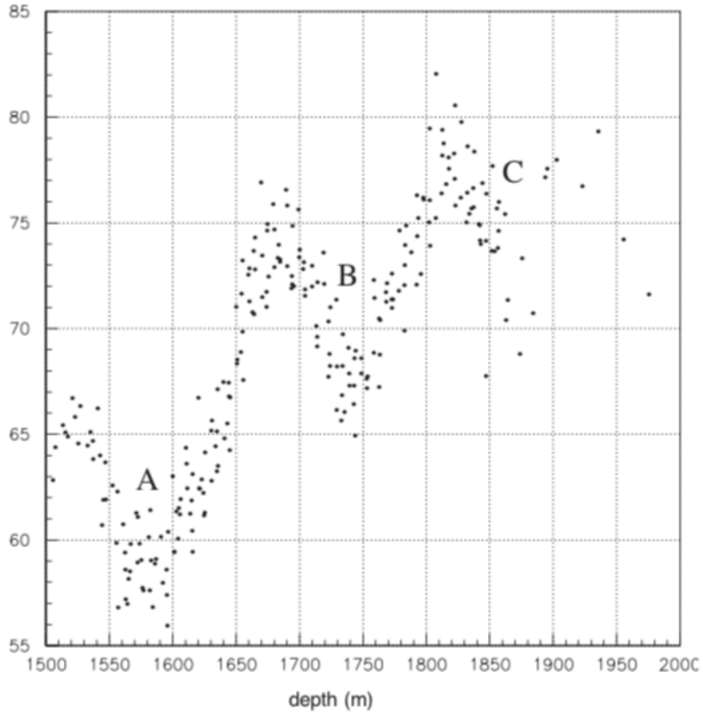
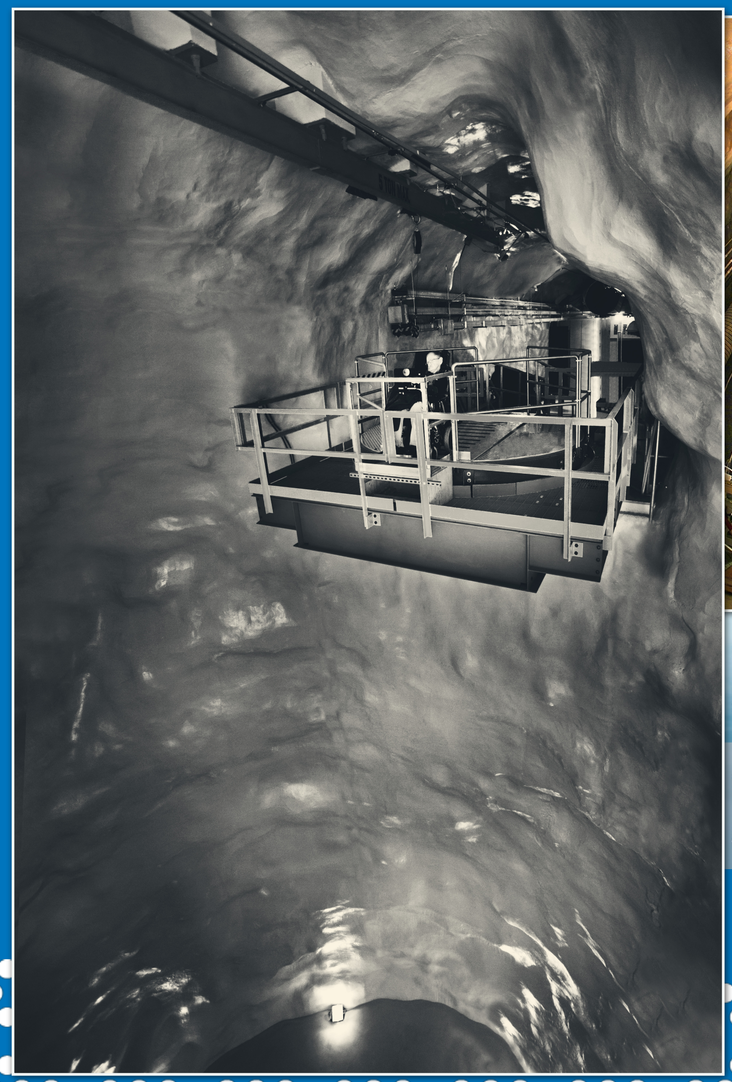
Nuclear Instruments and Methods in Physics Research A 522 (2004) 347–359

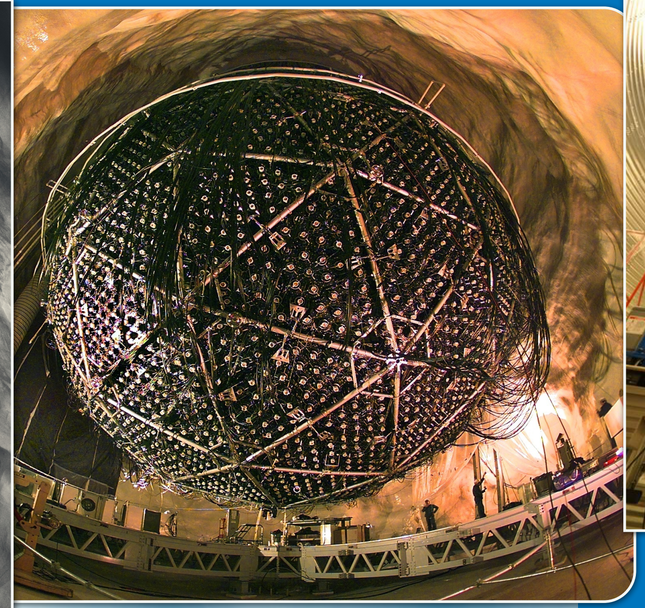
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH
Section A
www.elsevier.com/locate/nima

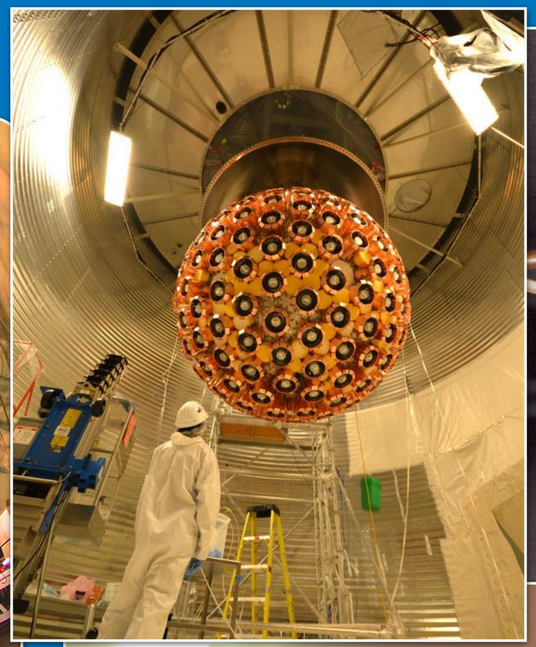
Calibration and survey of AMANDA with the SPASE detectors

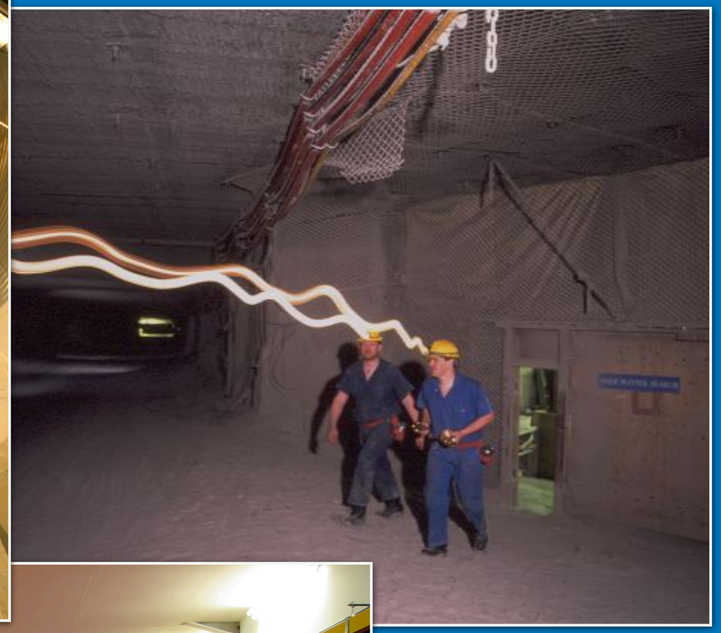


Michael set in motion a project that led me personally to the dark depths (1100m and 2070m)









13:54
Sudbury -24°

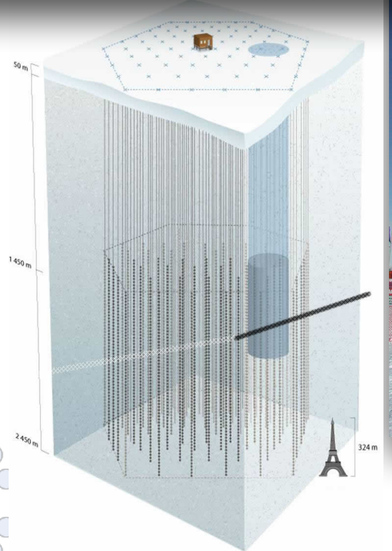
13:54
Antarctica -23°

Last week

Meanwhile…
South Pole goes from strength to strength…

2002 - the new South Pole station

1994: The Martin A, Pomerantz Observatory



According to Google images, art was as important as physics: $N\_photos_{art}=3$; $N\_photos_{physics}=3$

A dungeon horrible,
on all sides round…
No light; but rather
darkness visible…

Paradise Lost - Milton
(1668)