Cosmic Rays:
a second career

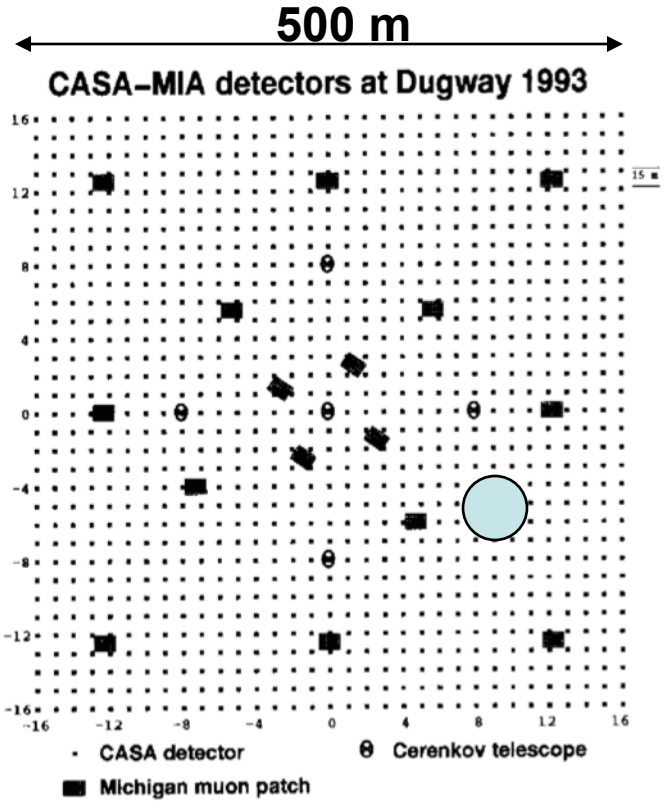
James W. Cronin
Lecture Honoris Causa
Karlsruhe
February 1, 2013

This talk dedicated

to

Murat Boratav

The Chicago Air Shower Array (CASA)



1089 detectors with 15 m spacing covering an area of ~ 500 m x 500 m

Expected ~20 events/day from Cygnus X-3

1988-1993

My first venture into cosmic ray physics in collaboration with University of Michigan

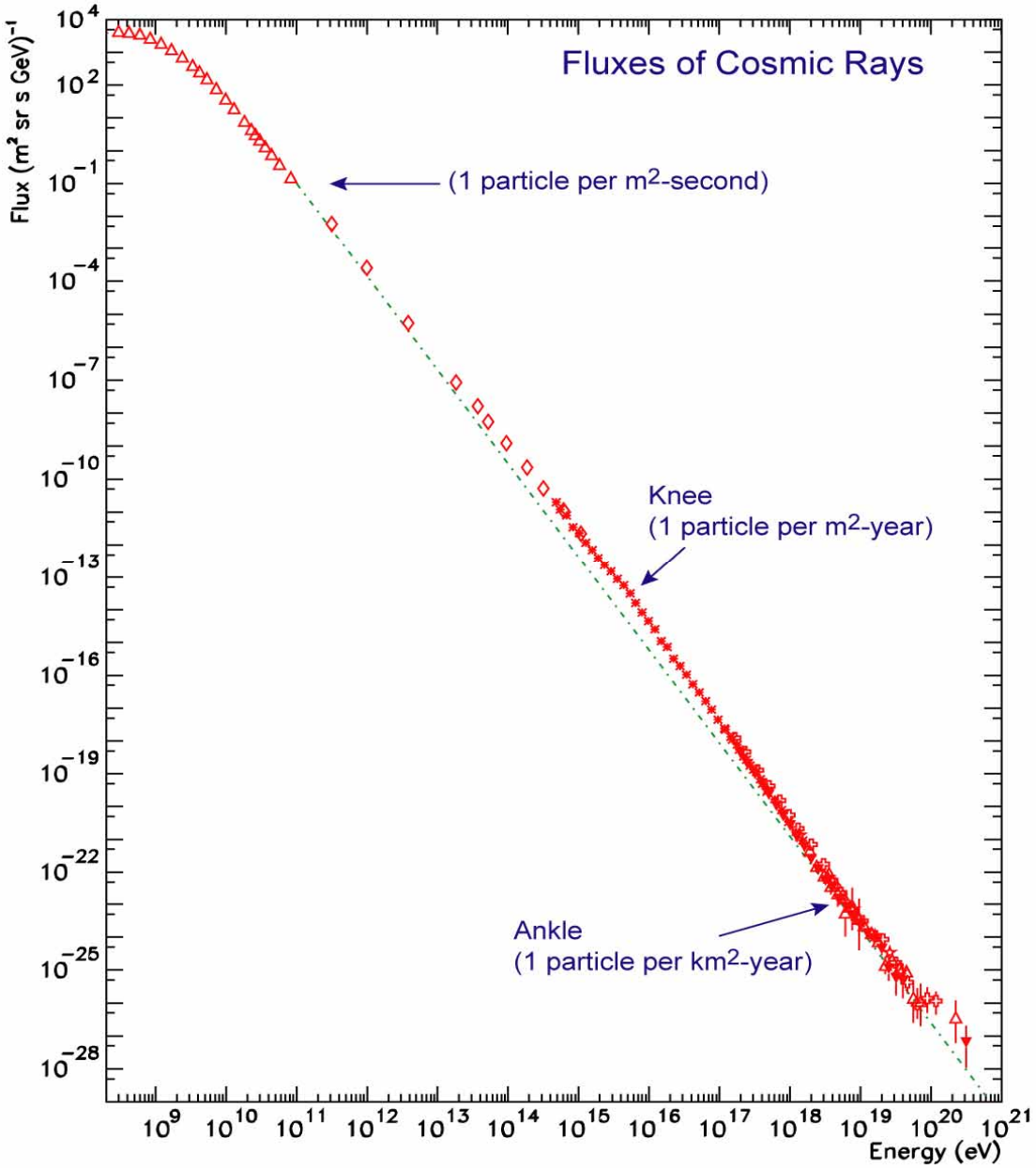
10^{20} eV proton

16 joules energy

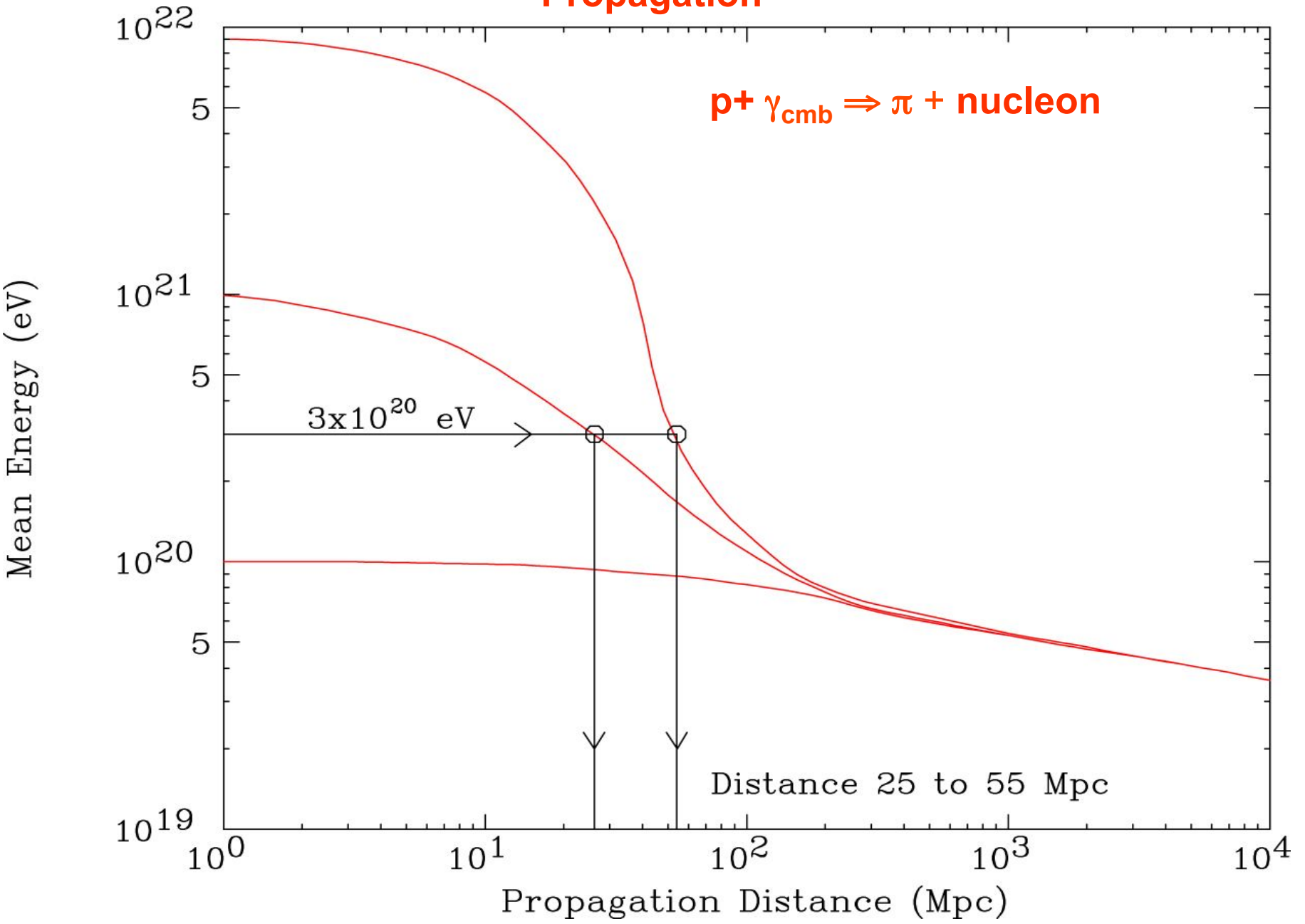
Macroscopic energy

Microscopic particle

Kinetic energy of Andy Roddick's second serve

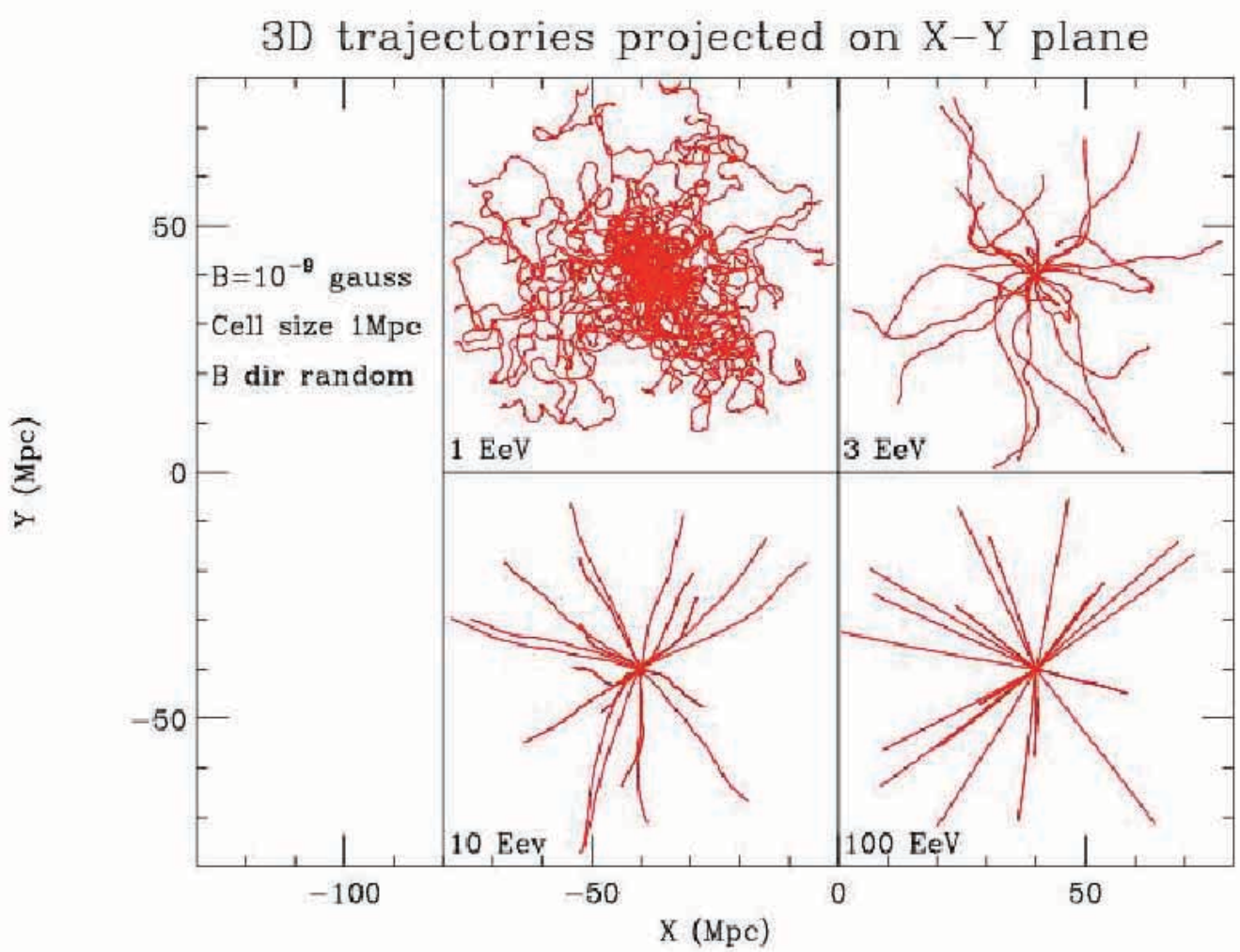


Propagation



• **Inter-Galactic magnetic fields:**

A 10^{20} eV proton is almost not deflected in the inter-galactic magnetic field (nG)



Nuclear Physics B (Proc. Suppl.) 28B (1992) NOVEMBER 1992

Major Meeting in Paris in April 1992 organised by Murat Boratav

COSMIC RAYS ABOVE 10^{19} eV - 1992

Proceedings of the International Workshop on Techniques to Study Cosmic Rays with Energies Greater than 10^{19} eV

Paris, France
22–24 April 1992

Edited by

Murat BORATAV
University of Paris 6
Paris, France

James W. CRONIN
University of Chicago
Chicago, IL, USA

Alan A. WATSON
University of Leeds
Leeds, United Kingdom

Followed by workshops

Adelaide (January 1993)

Tokyo (September, 1993)

Snowmass (July 1994)

PROBLEMS TO BE OVERCOME

- LACK OF MONEY TO DO ANYTHING
- Fight for recognition that the project was worthy of attention
- Site surveys
- Develop a collaboration of critical mass and competence and with money to build a capital project of ~$100M
- How was the worth of the project to be assessed?
- A vulnerability, as with neutrino astronomy and, to a lesser extent, ground based gamma ray astronomy, that there are no hard theoretical numbers demanding the construction of an instrument of a certain size

- Contrast search for the W and Z, or the Higgs particle

August 1994

Naming of the project:

A Unique **G**iant **E**AS **R**ecorder A.U.G.E.R

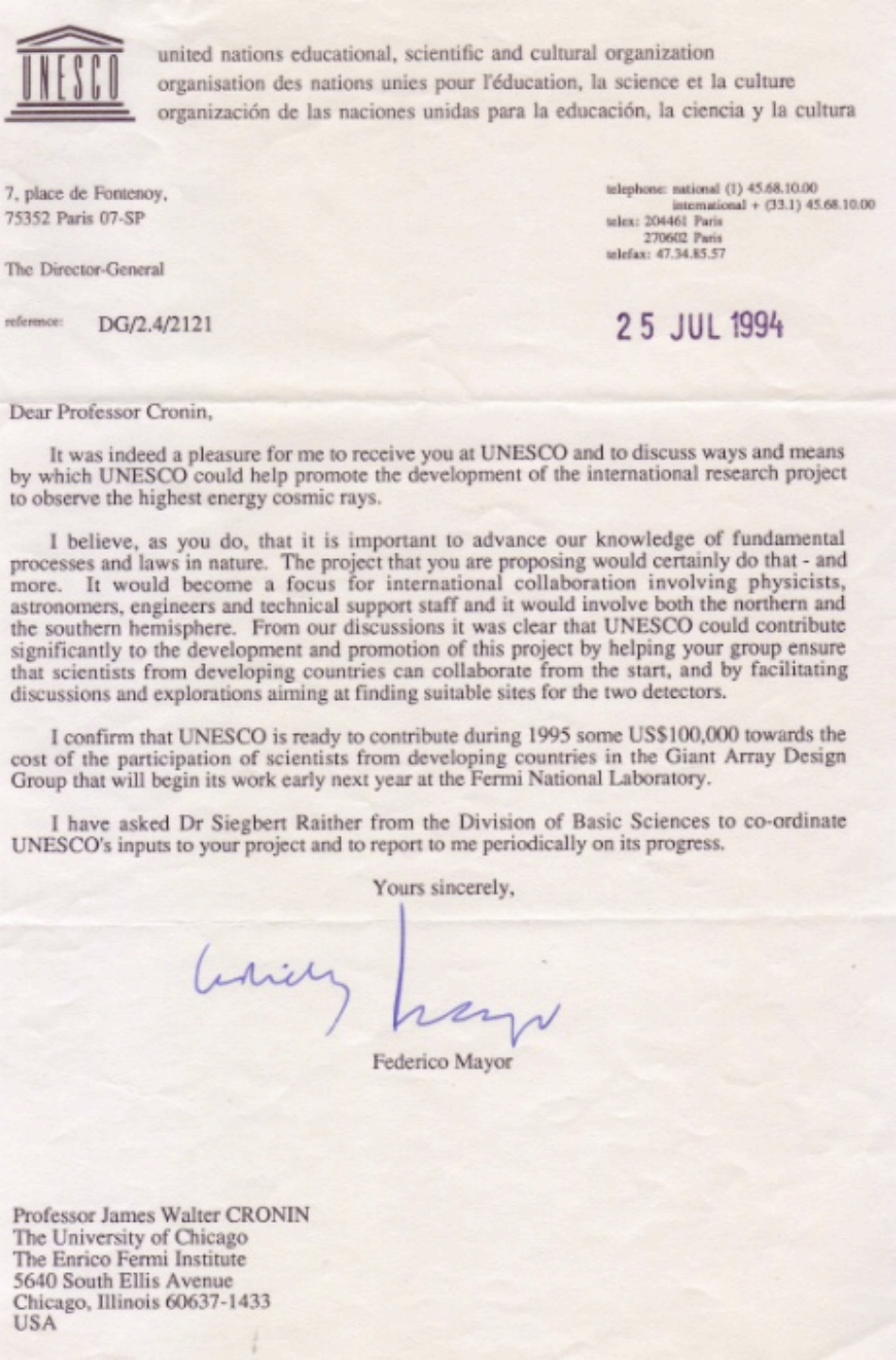
No acronyms!

Pierre Auger Observatory

Pierre Auger, Paris 1981

Seed money for 6 month design study at Fermilab

Anonymous gift	$50,000
Grainger Foundation for site survey	$100,000
UNESCO	$100,000
NSF	$30,000
Universities Research Association	$50,000
University of Chicago	$25,000



UNESCO

united nations educational, scientific and cultural organization
organisation des nations unies pour l'éducation, la science et la culture
organización de las naciones unidas para la educación, la ciencia y la cultura

7, place de Fontenoy,
75352 Paris 07-SP

telephone: national (1) 45.68.10.00
international + (33.1) 45.68.10.00
telex: 204461 Paris
270602 Paris
telefax: 47.34.85.57

The Director-General

reference: DG/2.4/2121

25 JUL 1994

Dear Professor Cronin,

It was indeed a pleasure for me to receive you at UNESCO and to discuss ways and means by which UNESCO could help promote the development of the international research project to observe the highest energy cosmic rays.

I believe, as you do, that it is important to advance our knowledge of fundamental processes and laws in nature. The project that you are proposing would certainly do that - and more. It would become a focus for international collaboration involving physicists, astronomers, engineers and technical support staff and it would involve both the northern and the southern hemisphere. From our discussions it was clear that UNESCO could contribute significantly to the development and promotion of this project by helping your group ensure that scientists from developing countries can collaborate from the start, and by facilitating discussions and explorations aiming at finding suitable sites for the two detectors.

I confirm that UNESCO is ready to contribute during 1995 some US$100,000 towards the cost of the participation of scientists from developing countries in the Giant Array Design Group that will begin its work early next year at the Fermi National Laboratory.

I have asked Dr Siegbert Raither from the Division of Basic Sciences to co-ordinate UNESCO's inputs to your project and to report to me periodically on its progress.

Yours sincerely,

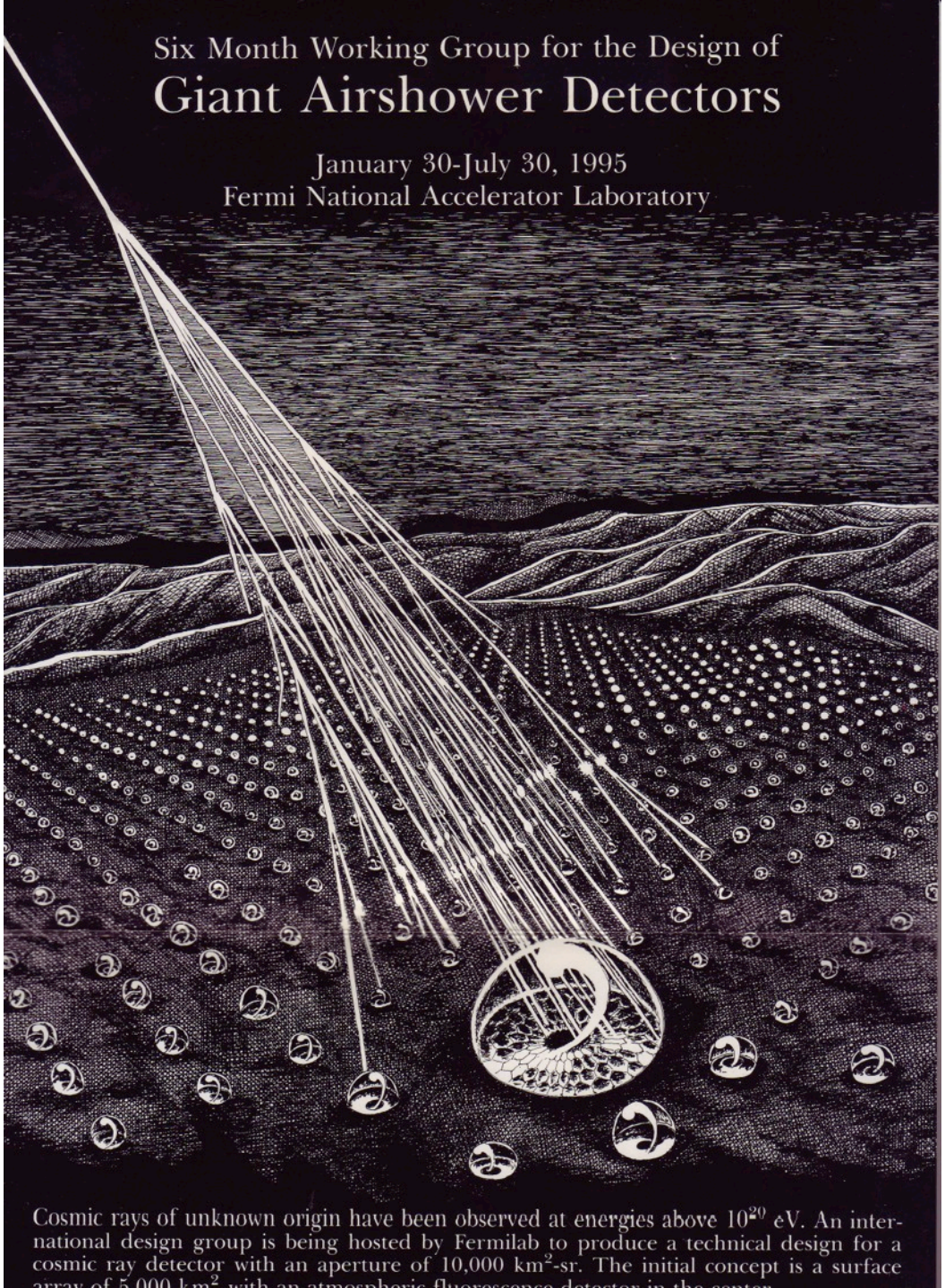
Federico Mayor

Professor James Walter CRONIN
The University of Chicago
The Enrico Fermi Institute
5640 South Ellis Avenue
Chicago, Illinois 60637-1433
USA

Role of Fermilab director John Peoples

We requested that Fermilab sponsor a 6 month long design study for the giant array. The director, John Peoples was supportive. He was convinced that this was important work. He agreed to support the workshop, provided space and people to help organize it. There was a cost to John in all of this as there was a lot of hostility at Fermilab toward resources diverted from anything other than maintaining the machine and the big collider detectors. This hostility was running particularly high because of other non-accelerator projects undertaken by Fermilab.

Also significant was the fact that Paul Mantsch of Fermilab became the Auger Project Manager. Paul was an expert on super-conducting magnets and large detectors. As a refugee from the failed SSC he was attracted to the uniqueness of the project and its challenge. Without Paul's leadership the project would not exist!


Six Month Working Group for the Design of
Giant Airshower Detectors
January 30-July 30, 1995
Fermi National Accelerator Laboratory
Cosmic rays of unknown origin have been observed at energies above 10^{20} eV. An international design group is being hosted by Fermilab to produce a technical design for a cosmic ray detector with an aperture of 10,000 km^2-sr. The initial concept is a surface

The Fermilab Design Study

Studies of various surface detector designs:

RPCs, water-Cherenkov, scintillators, radio….
"Let a thousand flowers bloom…."

Hybrid approach: ground array and fluorescence detectors
- chose water as surface detector

Very extensive Monte Carlo calculations

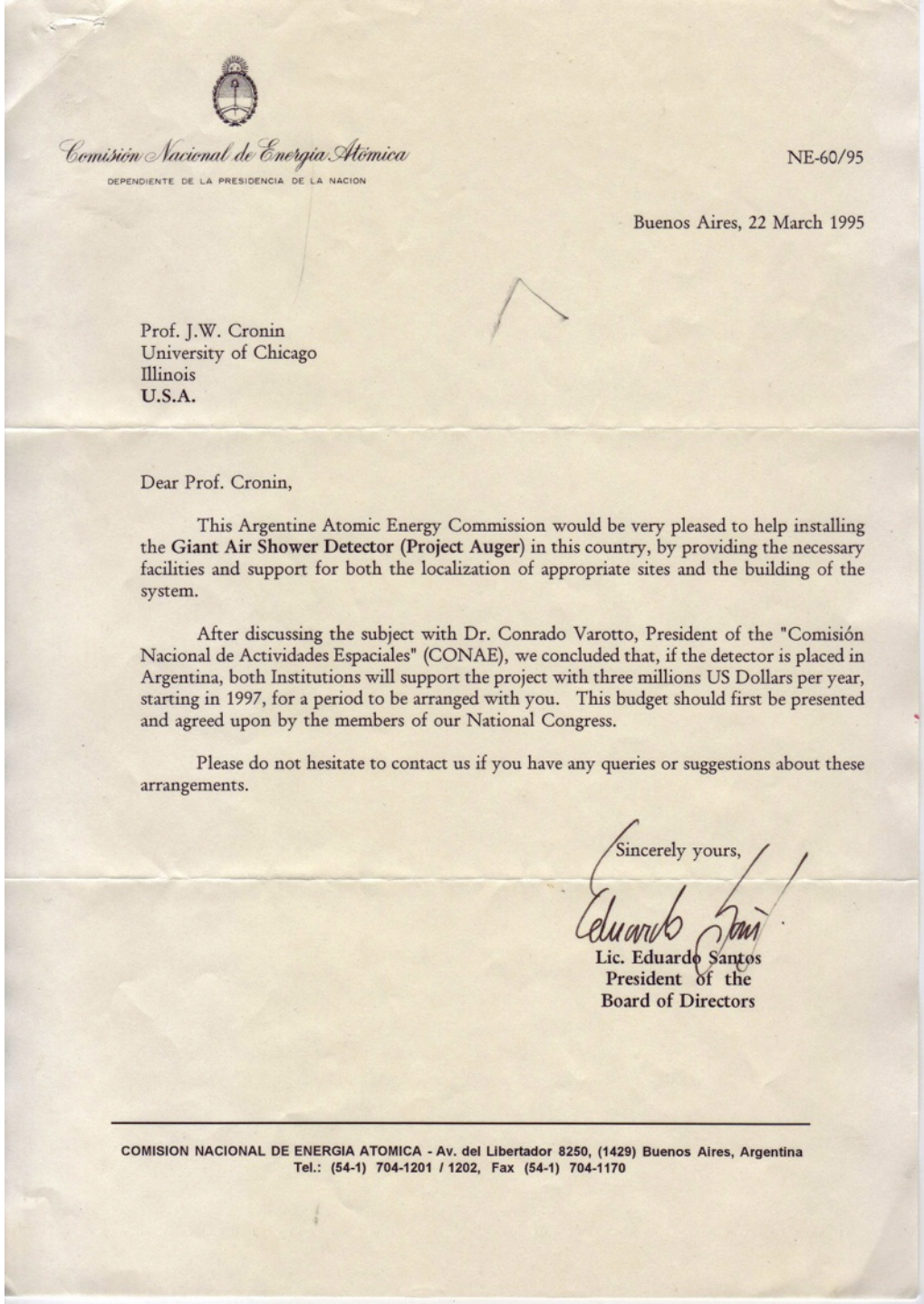
Two sites to give all sky coverage

Each site ~3000 km^2 : site survey was contemporaneous
Approximate cost ~$100M

Design Study document completed in October 1995

March 1995

Unsolicited letter from Argentine Atomic Energy Agency (CNEA) offering 3M US dollars/year for Auger!



Comisión Nacional de Energía Atómica
DEPENDIENTE DE LA PRESIDENCIA DE LA NACION

NE-60/95

Buenos Aires, 22 March 1995

Prof. J.W. Cronin
University of Chicago
Illinois
U.S.A.

Dear Prof. Cronin,

This Argentine Atomic Energy Commission would be very pleased to help installing the **Giant Air Shower Detector (Project Auger)** in this country, by providing the necessary facilities and support for both the localization of appropriate sites and the building of the system.

After discussing the subject with Dr. Conrado Varotto, President of the "Comisión Nacional de Actividades Espaciales" (CONAE), we concluded that, if the detector is placed in Argentina, both Institutions will support the project with three millions US Dollars per year, starting in 1997, for a period to be arranged with you. This budget should first be presented and agreed upon by the members of our National Congress.

Please do not hesitate to contact us if you have any queries or suggestions about these arrangements.

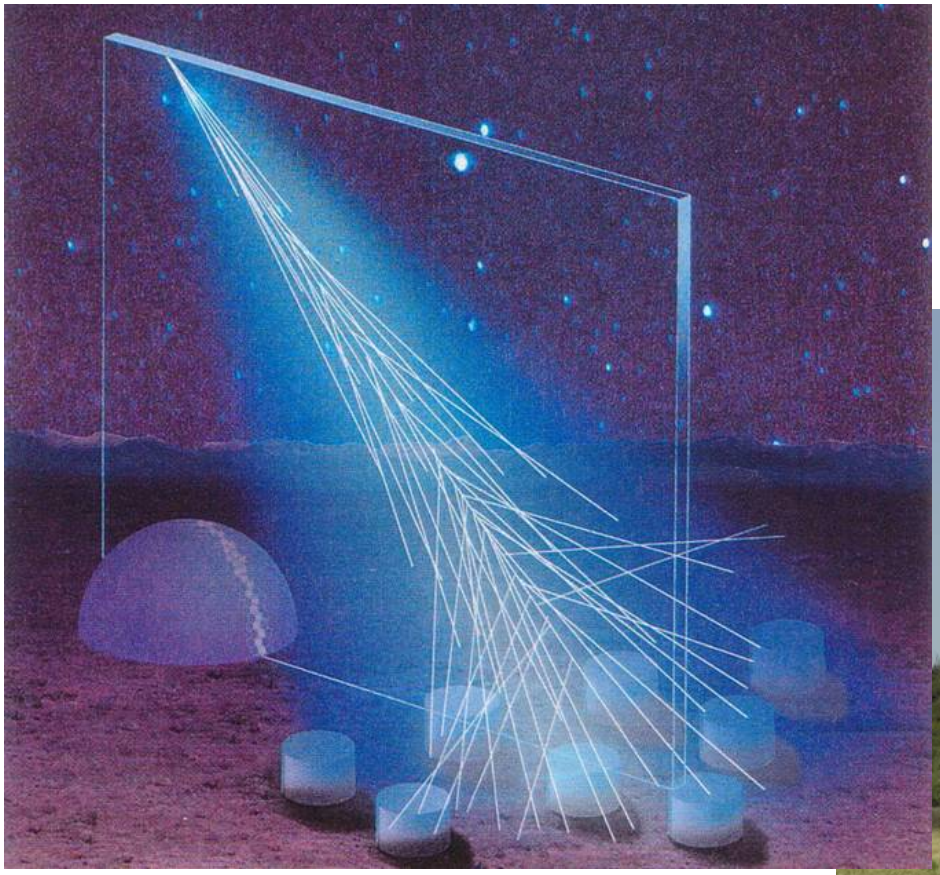
Sincerely yours,

Eduardo Santos

Lic. Eduardo Santos
President of the
Board of Directors

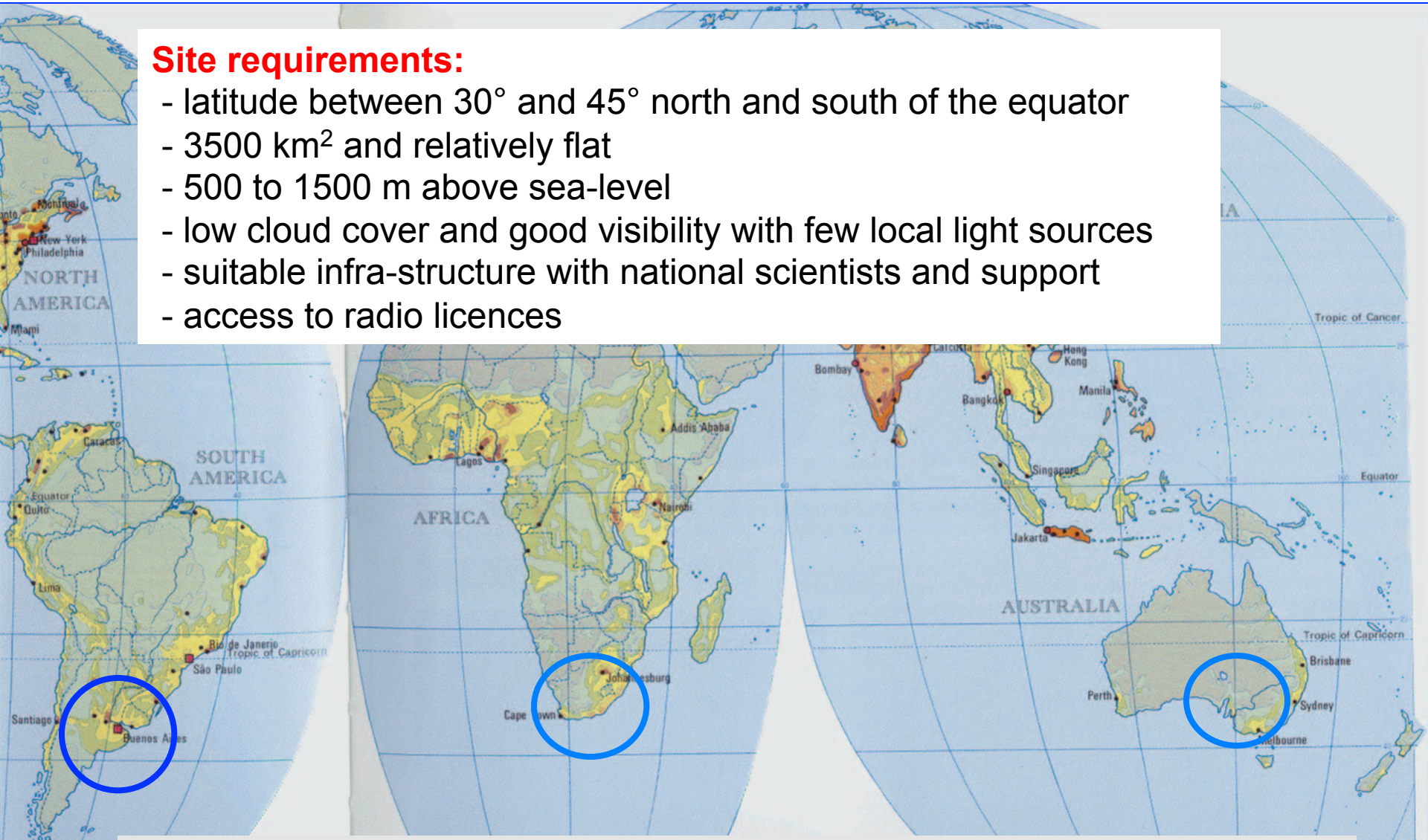
COMISION NACIONAL DE ENERGIA ATOMICA - Av. del Libertador 8250, (1429) Buenos Aires, Argentina
Tel.: (54-1) 704-1201 / 1202, Fax (54-1) 704-1170

The Design



Site requirements:

- latitude between 30° and 45° north and south of the equator
- 3500 km^2 and relatively flat
- 500 to 1500 m above sea-level
- low cloud cover and good visibility with few local light sources
- suitable infra-structure with national scientists and support
- access to radio licences



Site surveys, north and south, made by **Ken Gibbs** (Chicago) and **Antoine Letessier-Selvon** (Paris) during 1994 and 1995.

Argentina selected for South during meeting at UNESCO in November 1995

UNESCO
November 1995

President *Republic of South Africa*

Dear Sir

Scientific and engineering achievements are the cornerstones upon which the future generations in Southern Africa will attain their goals for the successful development and upliftment of our peoples. There is consequently an urgent need for South Africa to be at the leading edge of expertise in the world of technological endeavour.

Recently I have been informed of the Giant Air Shower Array project which is truly an international project destined to become one of the scientific highlights of this and the next decade and that South Africa has one of the favoured sites in the southern hemisphere.

I am placing my full weight behind the sitting of the project in South Africa as it is clear to me that it will provide an exciting new focus for our young potential scientists and enhance our Reconstruction and Development Program. Just as important however is that our own expertise could significantly contribute to the international community in the spheres of science, training and facilities.

As a developing country with a good foundation in the sciences and related technologies, South Africa will be in a favourable position to extend our knowledge base into the Southern African subcontinent to the mutual benefit for all should we be successful in being awarded the project.

I wish to reassure you of our total commitment should you consider South Africa as the site for this prestigious undertaking.

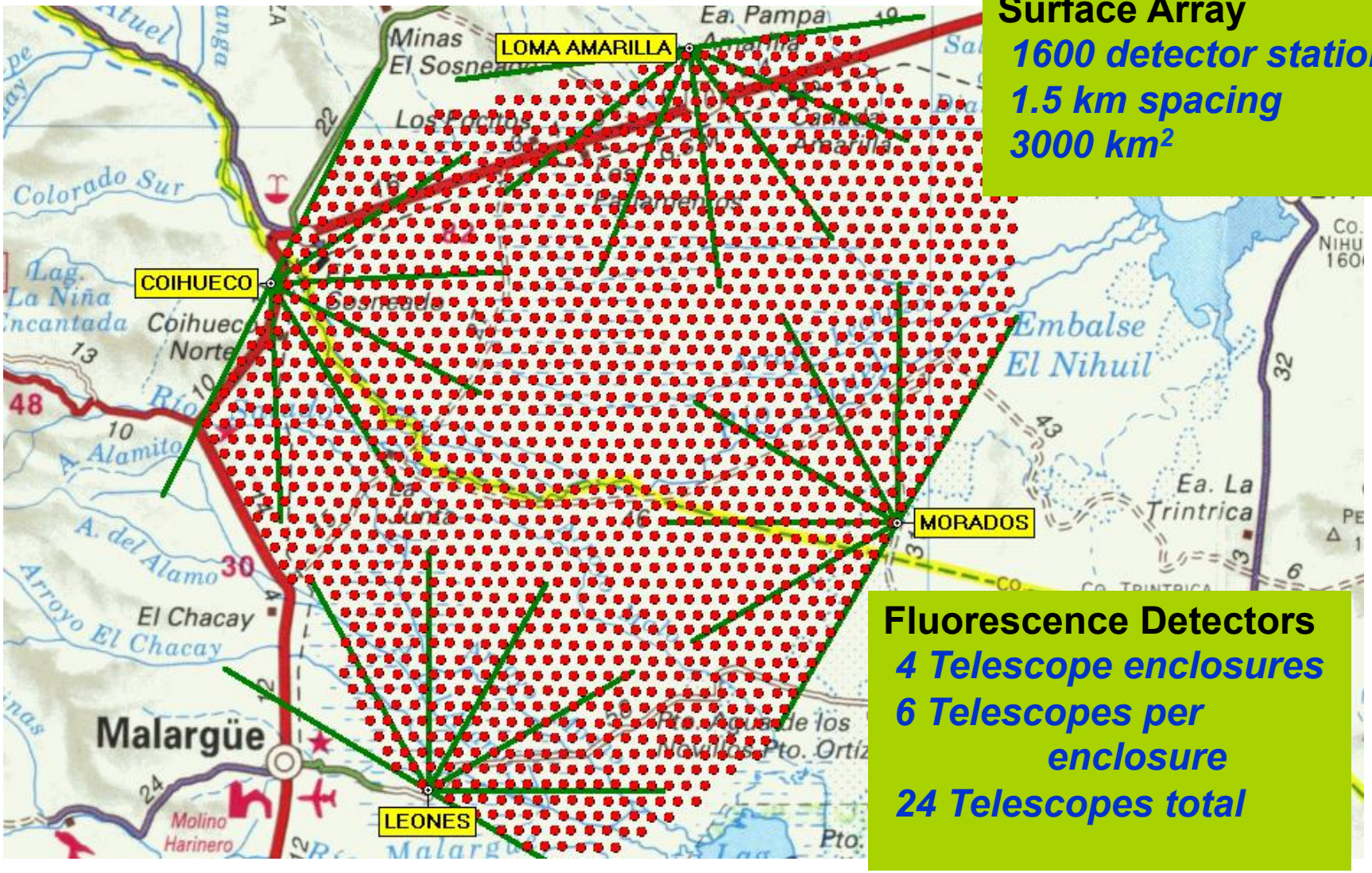
With best wishes to you and your colleagues.

Yours sincerely

N R MANDELA

Dr M Boratav

The observatory plan after choosing the Malargue site



Surface Array

1600 detector stations

1.5 km spacing

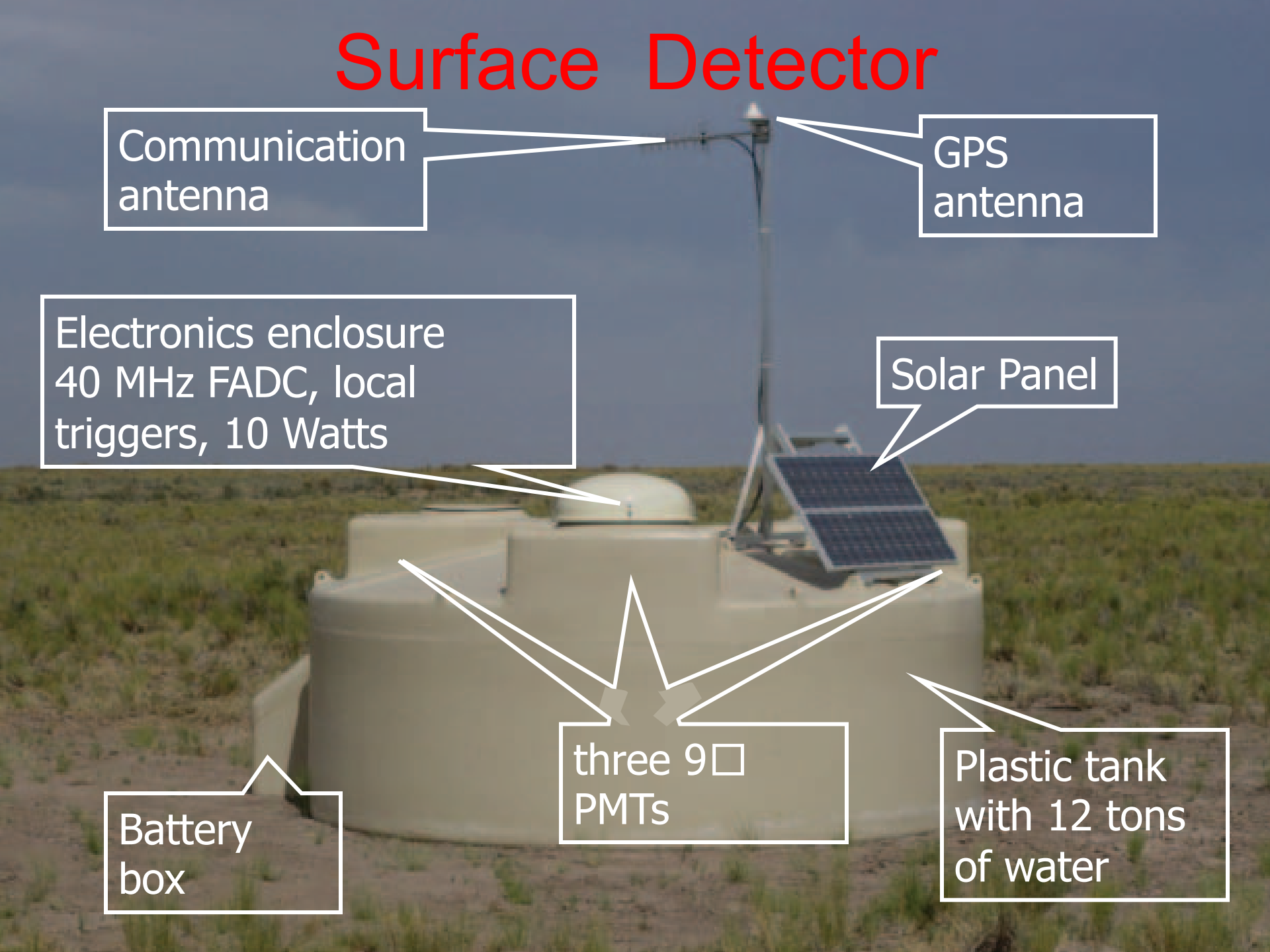
3000 km²

Fluorescence Detectors

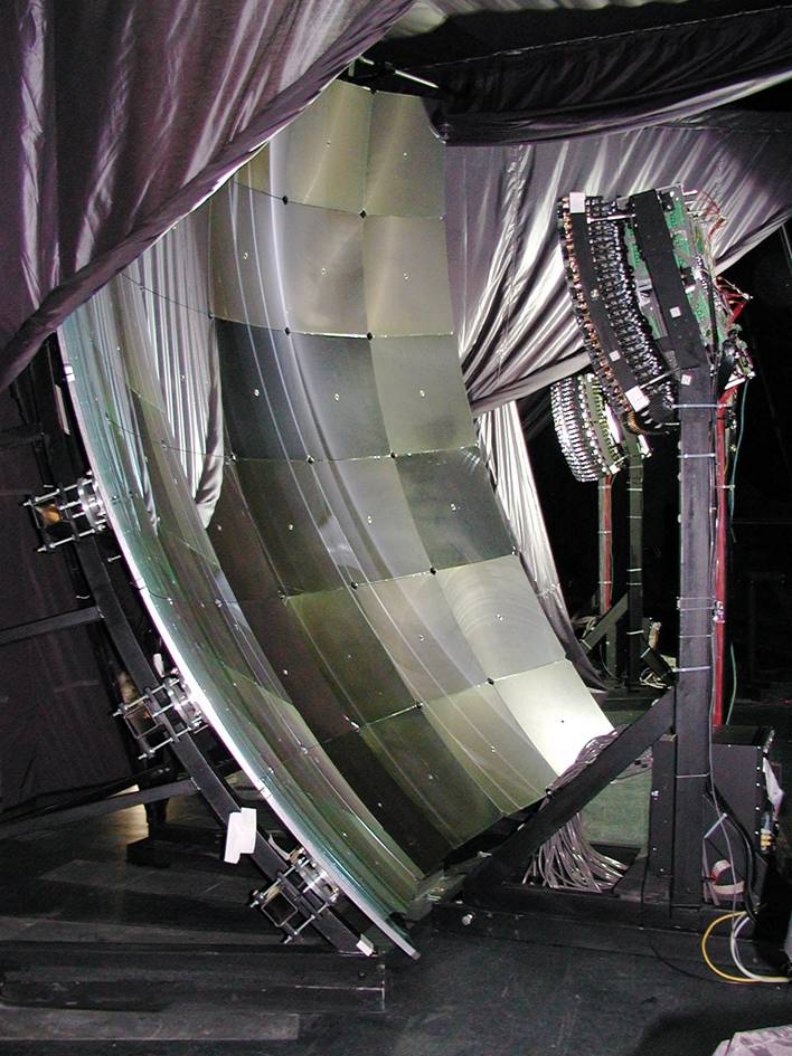
4 Telescope enclosures

6 Telescopes per enclosure

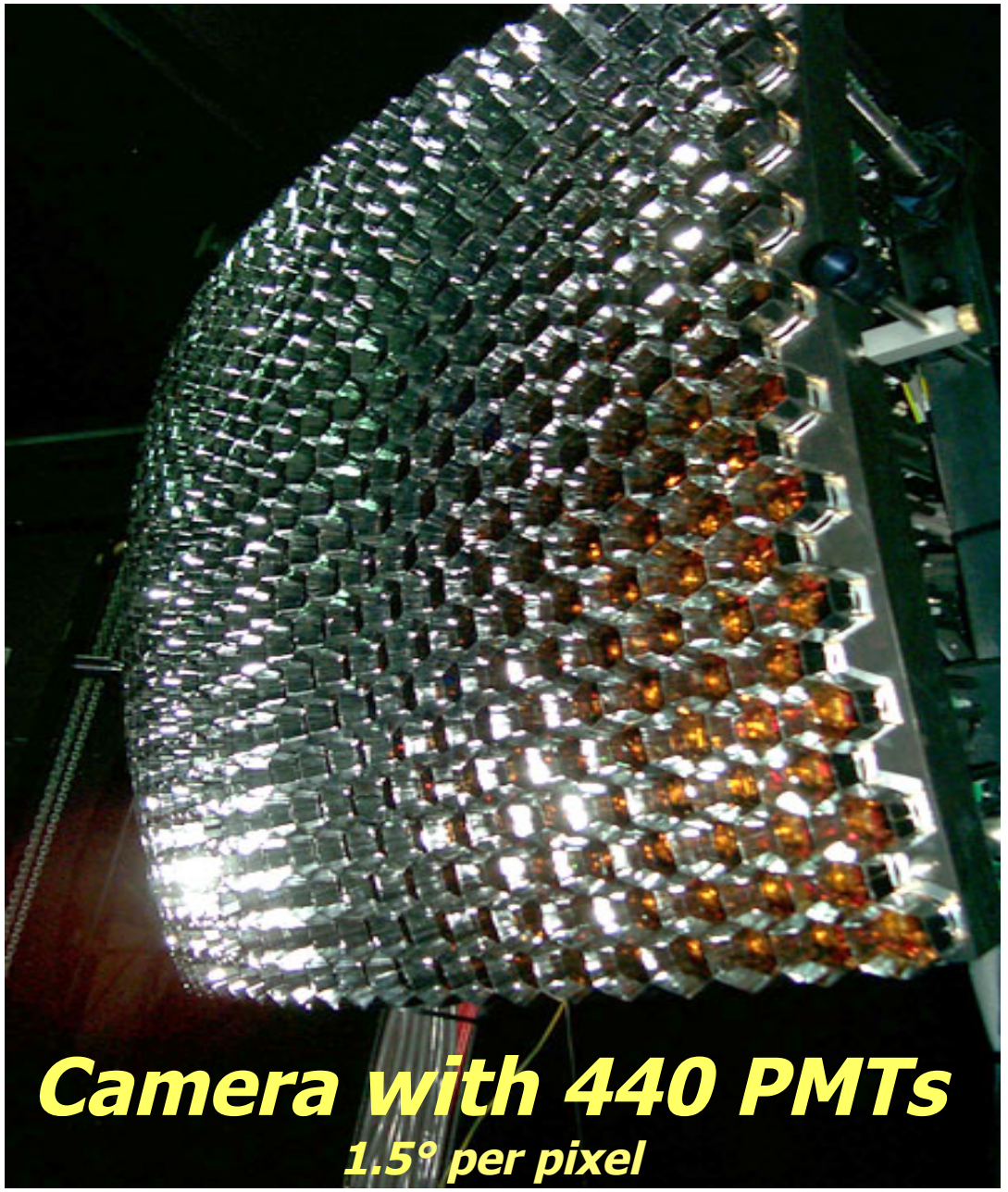
24 Telescopes total


Surface Detector
Communication antenna
GPS antenna
Electronics enclosure 40 MHz FADC, local triggers, 10 Watts
Solar Panel
three 9□ PMTs
Plastic tank with 12 tons of water
Battery box

The Fluorescence Detector



Schmidt optics
30^0x30^0 fov
UV filter
corrector "ring"



Assessment of the Project (November 1995)

No host institution (unlike new project at CERN, ESA, ESO, FNAL)

Formed own Review Committee

W I Axford (MPI: Director, Katlenburg-Lindau): Chair
R Cowsik (Indian Institute for Astrophysics, Bangalore, India)
M Demassieux, ENST (France)
R Eckers (Autralian National Telescope, Australia)
M-T Koshiba (Japan)
J Steinberger (CERN, Switzerland)

'Entirely favourable' report used to help with agencies

"But of course it is a favourable report: you chose the committee"

- an agency that will remain anonymous

Date: Sat, 09 Sep 1995 12:41 -0800 (PST)
From: DIRECTOR@SLACVM.BITNET
To: JWC@UCHEP.UCHICAGO.EDU

To: James W. Cronin
From: Burton Richter

Dear Jim:

I've just seen the article in the 1 September 1995 issue of SCIENCE on your proposal for a very large array to detect ultra-high energy cosmic rays. I think it's a terrific idea.

As you may know, for the last few years I've been telling O'Fallon, Hess, and HEPAP that I felt we were not spending enough money on non-accelerator experiments. Your's is just the kind of large-scale program that I had in mind, and you should feel free to call on me if you need any help in twisting arms in the Administration, Congress, or our high energy physics community.

I would like to keep up with what you are doing and perhaps, if I can arrange my schedule, attend your next workshop. If you have such a thing, please put me on your mailing list for papers (scientific or political) and meeting announcements.

With best regards,

Burt

The Search for Funding in the USA

All countries watched what the US was doing

Significant promises of funding from Argentina, Brasil and Mexico

US assessment by SAGENAP committee:

DIFFICULT! Third time lucky (April 1998)

BUT:

BUILD ONLY ONE ARRAY and GO SOUTH

US Proposal rejected in1996 and 1997. Accepted with reduction in 1998 to build in southern hemisphere only.

Department of Energy
Germantown, MD 20874-1290

November 21, 1997

Professor James W. Cronin
Department of Physics
University of Chicago
933 East 56th Street
Chicago, Illinois 60637

Dear Professor Cronin:

I regret to inform you that the Department of Energy is not able to support the proposal "Construction of the Pierre Auger Observatory" submitted by the University of Chicago.

We have carefully considered the proposal, taking into account its scientific quality and its priority relative to other currently supported or proposed activities. In addition to our standard peer review by mail, we have, as you well know, solicited the recommendations of the members of the Scientific Assessment Group for Experiments in Non-accelerator Physics (SAGENAP). In light of our existing commitments, and because of the limited funds available, we find it necessary to decline support of your proposal. The relevant program managers from this office would be pleased to explore with you appropriate next steps.

Your interest in submitting this proposal to the Department of Energy is appreciated.

Sincerely,

John R. O'Fallon

John R. O'Fallon
Director
Division of High Energy Physics

cc:
Frederick M. Bernthal, President

Department of Energy
Germantown, MD 20874-1290

Professor James W. Cronin
University of Chicago
Department of Physics
5640 S. Ellis Ave.
Chicago, IL 60637

JUL 24 1998

Dear Professor Cronin,

DOE and the NSF have agreed to proceed with the Pierre Auger Project, with detector engineering and pre-construction commencing on the first array at the southern site in Argentina in FY 1999. The construction funding profile is tentatively planned as follows($K):

	FY99	FY00	FY01	FY02	Total
DOE	$750	$1250	$1250	$500	$3750
NSF	750	750	1250	1000	3750
Total	$1500	$2000	$2500	$1500	$7500

It is possible that this profile could be accelerated somewhat, depending on developments at the two agencies.

Two reviews are required at a minimum. First, a "Technical, Cost, Schedule, Management" review during the fall of 1998, before any funding is committed to detector engineering and pre-construction. Secondly, a review during FY00 of progress, etc.

Finally, upon submission of a proposal for the northern site detector, a review will take place, in FY01 or FY02, on the progress and physics at the southern site, the prospects for physics at the northern site, and developments in the field.

We will be in touch.

Congratulations and best wishes,

P.K. Williams

Patricia Rankin

P.K. Williams
Division of High Energy Physics
U. S. Department of Energy

Patricia Rankin
Division of Elementary
Particle Physics
National Science Foundation

Prof. Dr. Manfred Popp

Vorsitzender des Vorstandes
Forschungszentrum Karlsruhe GmbH

Postfach 3640
D-76021 Karlsruhe
Tel. (07247) 82 2000
Fax (07247) 82 6123
E-mail: manfred.popp@vorstand.fzk.de

~~FAX: (7 73) 7 02-66 45~~

James W. Cronin
Univesity of Chicago
Enrico Fermi Institute
5640 South Ellis Avenue

Chicago, Illinois 60637-1433
U.S.A.

September 18, 1998

Dear Dr. Cronin,

Thank you for your letter of September 2, 1998.

At the moment we are in the process of restructuring our Institute of Nuclear Physics and important questions to the future program and the negotiation with the foreseen director of the Institute are yet to be solved. The participation in the Pierre Auger Project is under consideration in this process, but at this stage it would be premature to enter into any kind of discussions of financial contributions. I hope our discussion will be more advanced in December.

I will not be able to participate in the UNESCO-meeting and have asked Professor Kampert to attend.

Yours sincerely,

Forschungszentrum Karlsruhe
Technik und Umwelt

Institut für Kernphysik I

Leiter: Prof.Dr.H.Blümer

Forschungszentrum Karlsruhe GmbH, Postfach 3640, D-76021 Karlsruhe

Prof.Dr.James W. Cronin
Enrico Fermi Institute
University of Chicago
5640 S. Ellis Ave.

Chicago Illinois 60637
USA

Datum: 09.02.99
Bearbeiter/-in:
Telefon 07247/82-3545
Telefax 07247/82-3548
E-mail:
Ihre Mitteilung:

Dear Prof.Cronin,

this letter outlines the present funding situation for the Pierre Auger Project concerning the Institute for Nuclear Physics (Institut für Kernphysik, IK) and the Department for Process Data Handling and Electronics (Hauptabteilung Prozeßdatenverarbeitung und Elektronik, HPE). Both groups are part of Forschungszentrum Karlsruhe (FZK) and participate in the Auger Project in close collaboration with Universität Karlsruhe (TH).

The Pierre Auger Project has been supported since 1996 in FZK-HPE as given below in K$.

Year	1996	1997	1998	Total
Contribution HPE	60	120	120	300

For the following years the expected funding profile for IK and HPE is given below in K$ per year following US accounting rules:

Year	1999	2000	2001	2002	2003	Total
Contribution	620	810	1600	1900	630	5560

The sum for the current year '99 is part of the annual budget for the cosmic ray research programme. It is readily available by means of internal restructuring. The Pierre Auger Project is now being established as a distinct group in this programme, including 7 physicists, 3 engineers and 6 technicians. The group is expected to grow further.

Funds for 2000 and beyond are expectations based on the Auger spending profile in the Fluorescence Detector. We are very confident that committments on the level described above can be made. A very positive vote of our advisory committee for a commitment of FZK in Auger-FD was given last week.

(Prof.Dr.H.Blümer)

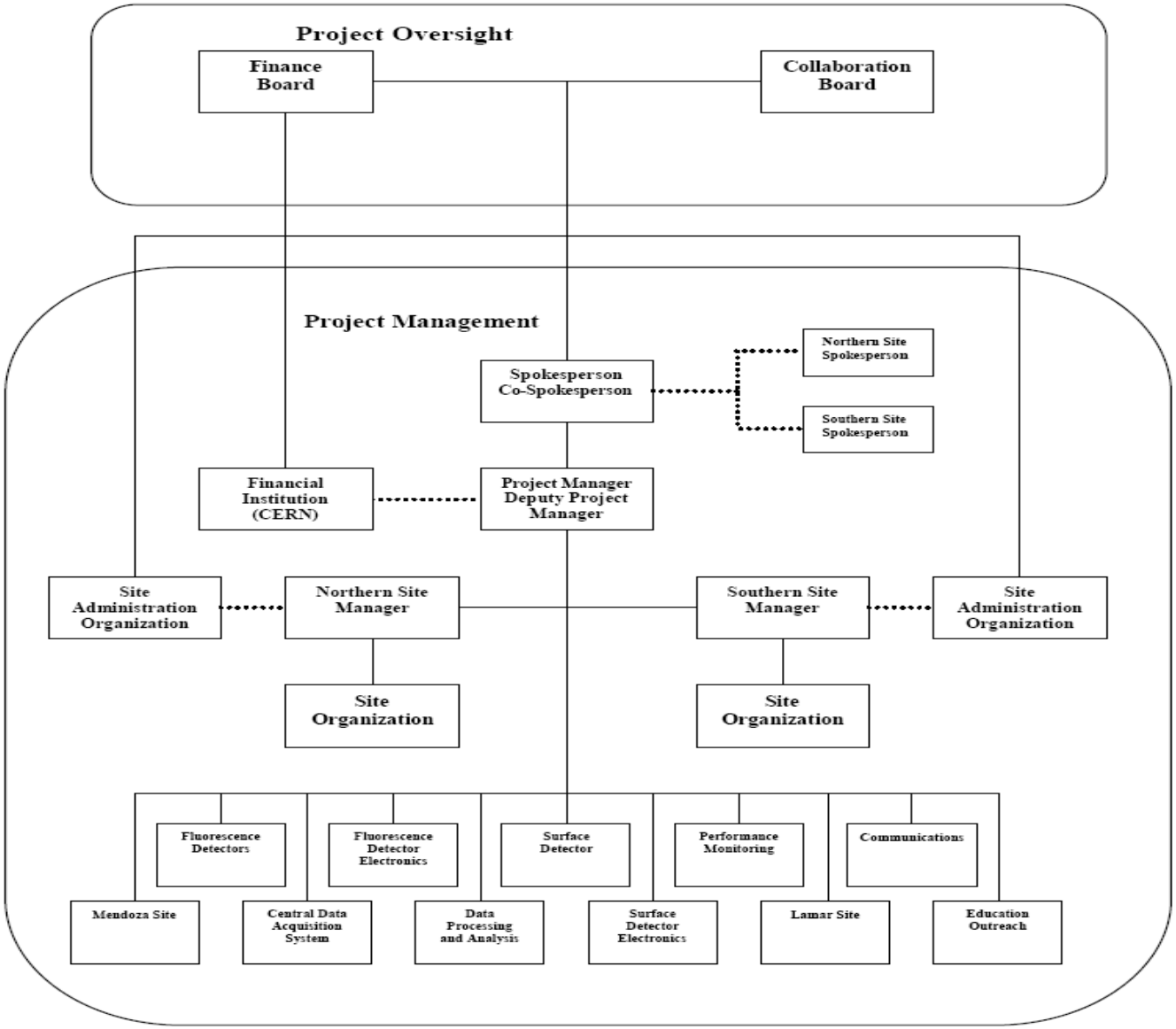
(Prof.Dr.H.Gemmeke)

After US funding announced in 1998, funding from European Countries came relatively quickly.

October 1998 a two day meeting at UNESCO to produce a draft International Agreement. Temporary chairman for this meeting was Professor Herwig Schopper.

Ground breaking Ceremony in March 1999. First signatures of the International Agreement

Organization

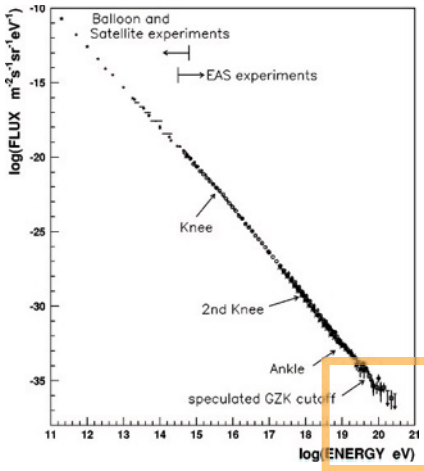


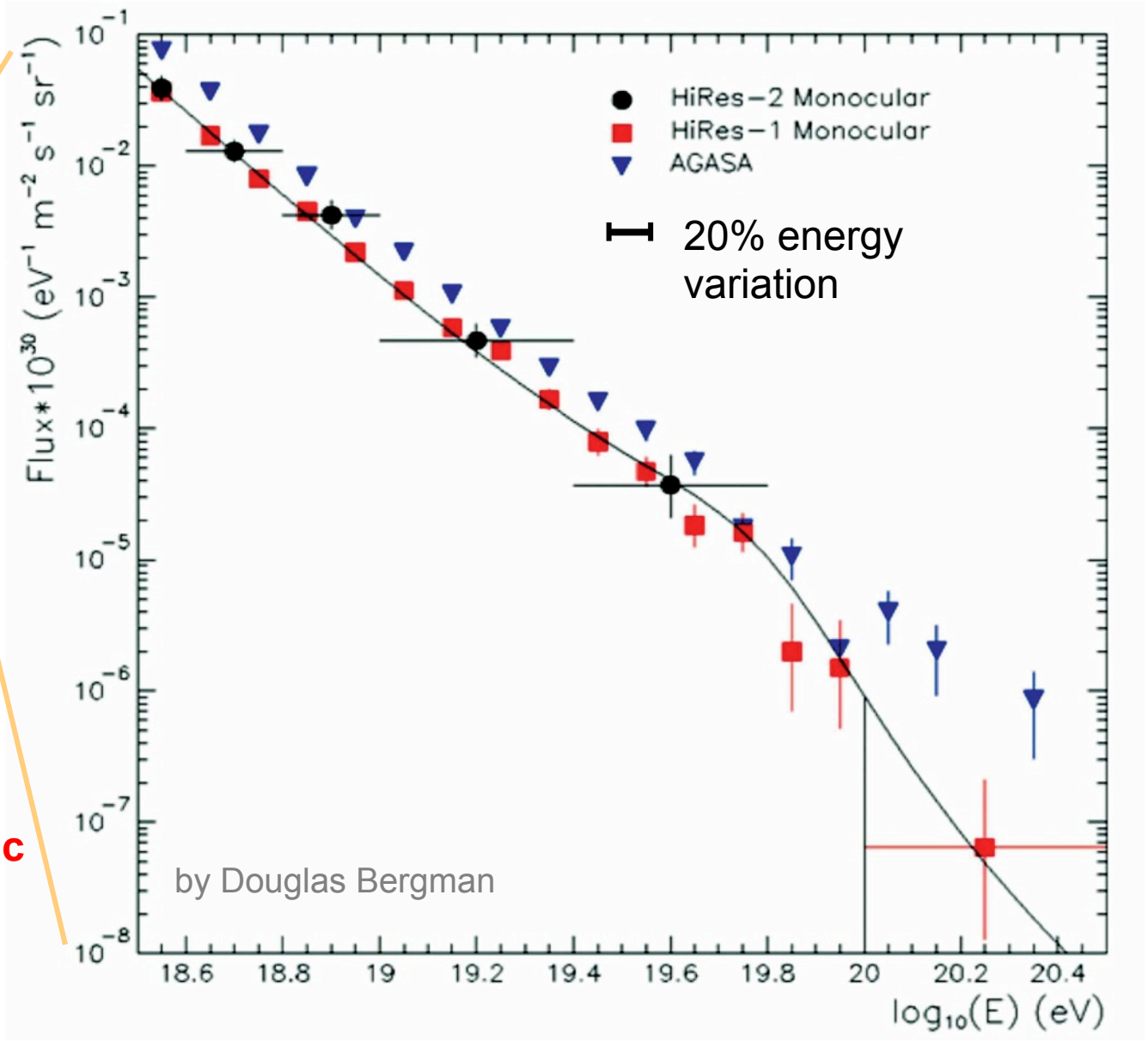
17 March 1999: Ground Breaking Ceremony


SITIO INAUGURADO POR
PRESIDENTE DE LA NACION
DR. CARLOS SAUL MENEM
GOBERNADOR DE LA PROVINCIA
DR. ARTURO LAFALLA
DIRECTORES DEL PROYECTO
DR. JAMES CRONIN Y DR. ALAN WATSON
INTENDENTE DE MALARGÜE
CONT. CELSO JAQUE
INTENDENTE DE SAN RAFAEL
CONT. VICENTE RUSSO
OBSERVATORIO
PIERRE AUGER
DE RAYOS COSMICOS
MENDOZA, 17 DE MARZO DE 1999


SITIO INAUGURADO POR
OBSERVATORIO
PIERRE AUGER
DE RAYOS COSMICOS

Spectrum about the year 2000





This disagreement stimulated the scientific interest in the Auger Observatory.

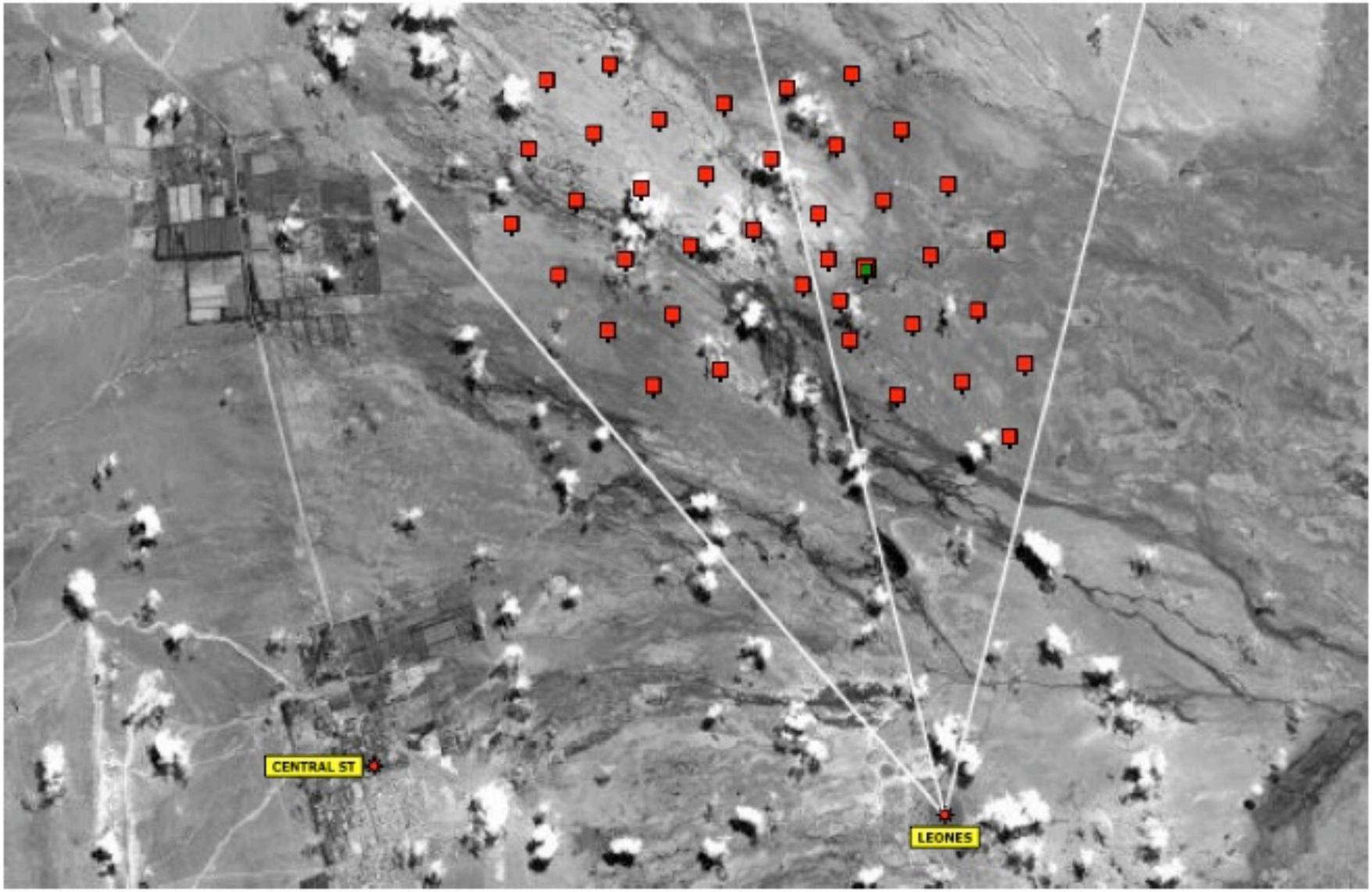
The Auger Collaboration

67 Institutions, ~400 Collaborators

Argentina
Australia
Bolivia*
Brazil
Czech Republic
France
Germany
Italy
Mexico
Netherlands
Poland
Portugal
Spain
United Kingdom
USA
Vietnam*

* *associate*

Engineering array 2000 - 2001



First tank in the field

Assembly building on Malargue campus funded by Argentina

Building on Malargue campus – offices, data collection, visitor center funded by The University of Chicago

Argentine crisis rattles cosmic-ray hunters

Carol Marzuola

Astrophysicists awaiting the Pierre Auger Observatory's high-energy cosmic-ray data are keeping a nervous eye on the political and economic crisis in Argentina, where the Southern Hemisphere arm of the observatory is due to be completed by 2005.

Two hundred and fifty researchers from 19 countries are involved in the US$50-million project to build the world's largest cosmic-ray observatory. It will study cosmic radiation — the flow of charged particles from space that streams through the Earth's atmosphere — and, in particular, the rare and mysterious particles of very high energies.

The southern part of the observatory, in Argentina's Mendoza province, is being built first. The northern arm, to be located in the United States, will come later. Argentina had pledged $15 million to the project, but since December 2001, when the Argentinian peso was devalued, the country has plunged deeper into economic and political crisis (see *Nature* **415**, 104; 2002) and is unlikely to fulfil all of its obligations.

High-energy cosmic rays intrigue physicists because they cannot identify astrophysical objects or events, such as colliding galaxies, that are sufficiently violent to explain the rays' origins. But high-energy particles of 10^{20} electron volts or more hit the Earth's atmosphere only rarely — about once per km^2 per century.

The Auger observatory will use two sets of detectors to find these cosmic rays. At each site, 1,600 surface detectors — large above-ground water tanks equipped with photo-multipliers — will identify secondary cosmic-ray showers produced in the atmosphere by incoming rays. Additionally, 24 special telescopes will detect fluorescence produced by the particles as they pass through the atmosphere.

A prototype array of 30 detectors and two telescopes was completed last year in Argentina and has already produced useful data, says James Cronin of the University of Chicago, a joint leader of the Auger project.

Alberto Etchegoyen, an official at Argentina's atomic-energy commission and the project's southern spokesman, says that the transitional Argentinian government has no clear long-term plans for science or technology, and admits that the project may have to find some of the promised funding from other sources. Project supporters in Argentina and Brazil, for example, are jointly seeking a $3-million grant from an international development bank fund for Brazil to enable them to participate.

Optimists also point out that the devaluation of the peso will make the dollars and euros of the project's other contributing nations go further in Argentina. Paul Mantsch, a project manager for Auger at the Fermi National Accelerator Laboratory in Batavia, Illinois, says: "We're really optimistic that when the time comes to make up what's missing, we can do that."

Nonetheless, Auger's participants continue to worry. At the April meeting of the American Physical Society in Albuquerque, New Mexico, physicist Michael Turner of the University of Chicago urged US funding agencies to "ensure timely completion and operation" of the observatory in case there was a problem. "The whole future of this field hinges upon the result of the southern Auger," he said. ■

www.auger.org

Cosmic detection: a surface detector (left) and telescope camera (above) in place in Mendoza.

PIERRE AUGER OBSERVATORY

Devaluation of Argentine peso by factor 3 on Dec 1 2001

June 2000 President Clinton urges President de la Rua to support Auger

LOS ANDES

Mendoza

Apoyo de Clinton al observatorio del sur mendocino

▸ Los presidentes estuvieron reunidos a solas y con sus gabinetes ▸ Pleno respaldo de los Estados Unidos al plan económico de la Alianza.

Juan Pablo II y Alí Agca, en la prisión de Ancona.

Perdonan al turco que casi mata al Papa

Iglesias trata

Letter from Koichiro Matsuura, Director General of UNESCO, offering assistance to obtain duty free importation of scientific equipment for the Auger observatory

UNESCO

The Director-General

COPY FOR INFORMATION

DG/2.12/00-217

24 JUN 2000

Your Excellency,

I recently met with Professor James W. Cronin, spokesperson of the Pierre Auger project which, as you are certainly aware, is an international collaborative effort to study the most energetic cosmic rays. These studies promise to give new insights into the nature of our universe.

UNESCO is pleased to have played an important role in setting up this project. It was at our Headquarters in 1995 that the collaboration formally began, and where Argentina's offer to be the host country for the southern Pierre Auger Observatory was gratefully accepted by all parties. In November 1998, again at UNESCO Headquarters, an international agreement between the funding agencies of the participating countries was drafted following the visit of your predecessor to support this initiative, and subsequently signed by most of the participating countries in Mendoza, immediately prior to the dedication of the project in Malargue, Mendoza Province, on 17 March 1999.

Professor Cronin has briefed me on the present status of the project, which is now under construction at the 3000 square kilometre site north-west of Malargue. I am thankful to Argentina for hosting this important international scientific project. Professor Cronin informs me, however, that it is proving difficult to import the necessary scientific components for the project because we have not been able to benefit from an expected waiver of duty and taxes.

I am ready to offer the help of UNESCO to arrange an agreement with the appropriate authorities of your country whereby the Auger equipment would be exempt from import duty and taxes. The pursuit of science is one of the great unifying forces between countries and I sincerely hope that you will give your full support to the advancement of this great project under the best possible conditions.

Please accept, Your Excellency, the assurances of my highest consideration.

Koïchiro Matsuura

H. E. Mr Fernando de la Rúa
President of the Argentine Republic
Buenos Aires

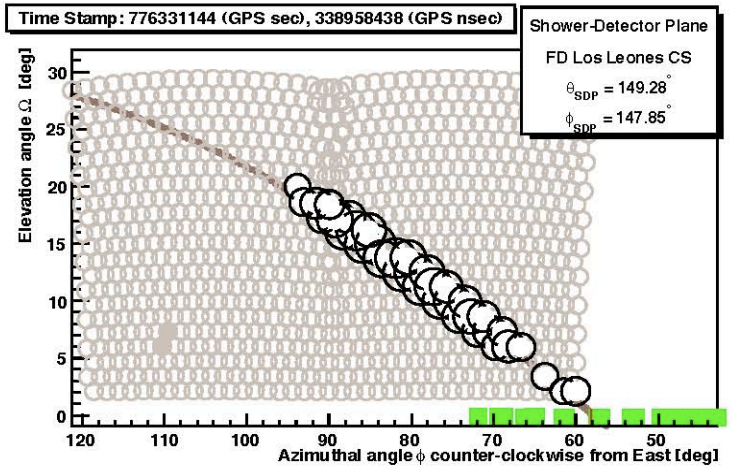
Number of tanks vs time

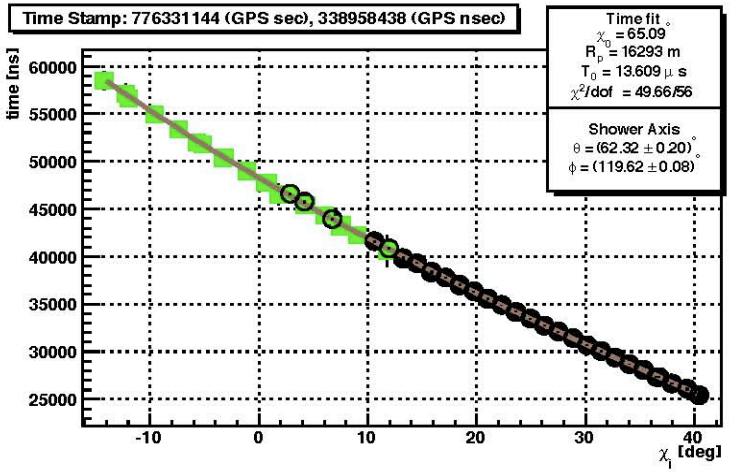
June	2001	40 (engineering array)
July	2003	100
January	2004	300
August	2005	905
July	2007	1438
December	2007	1589
June	2008	1637
November	2008	dedication

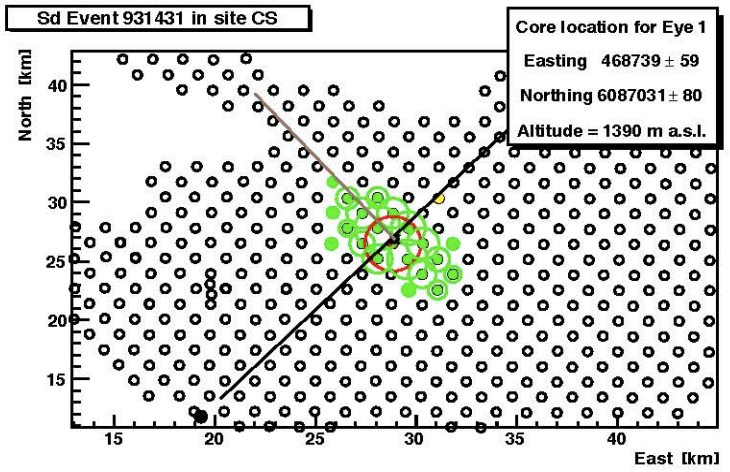
November 2008
Paul Mantsch at dedication the completed Auger Observatory

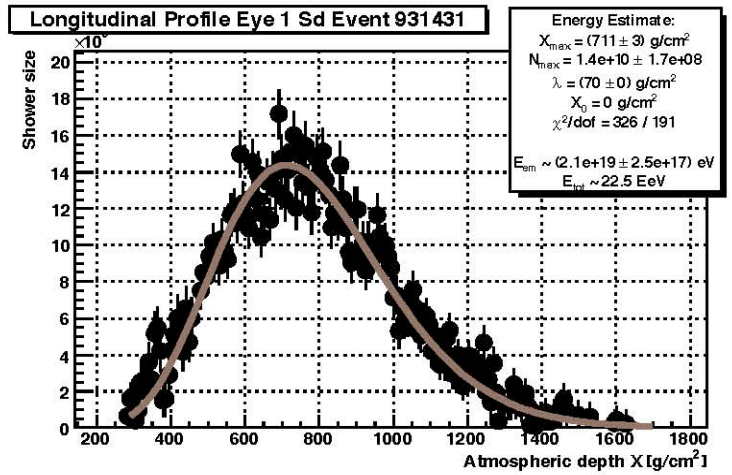
A visit to a tank during 2006 celebration

A “perfect” hybrid event: few are as beautiful as this one !

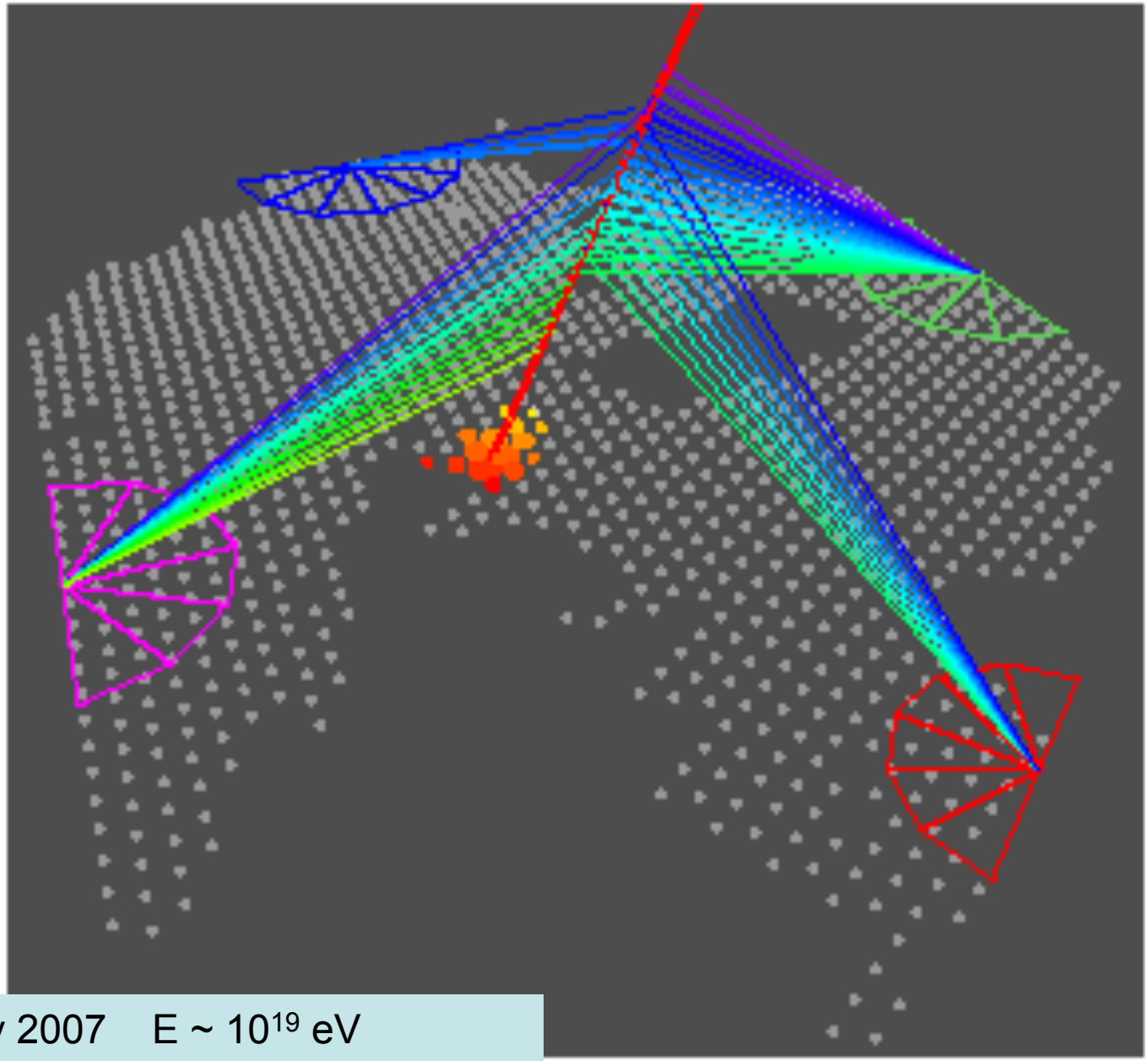






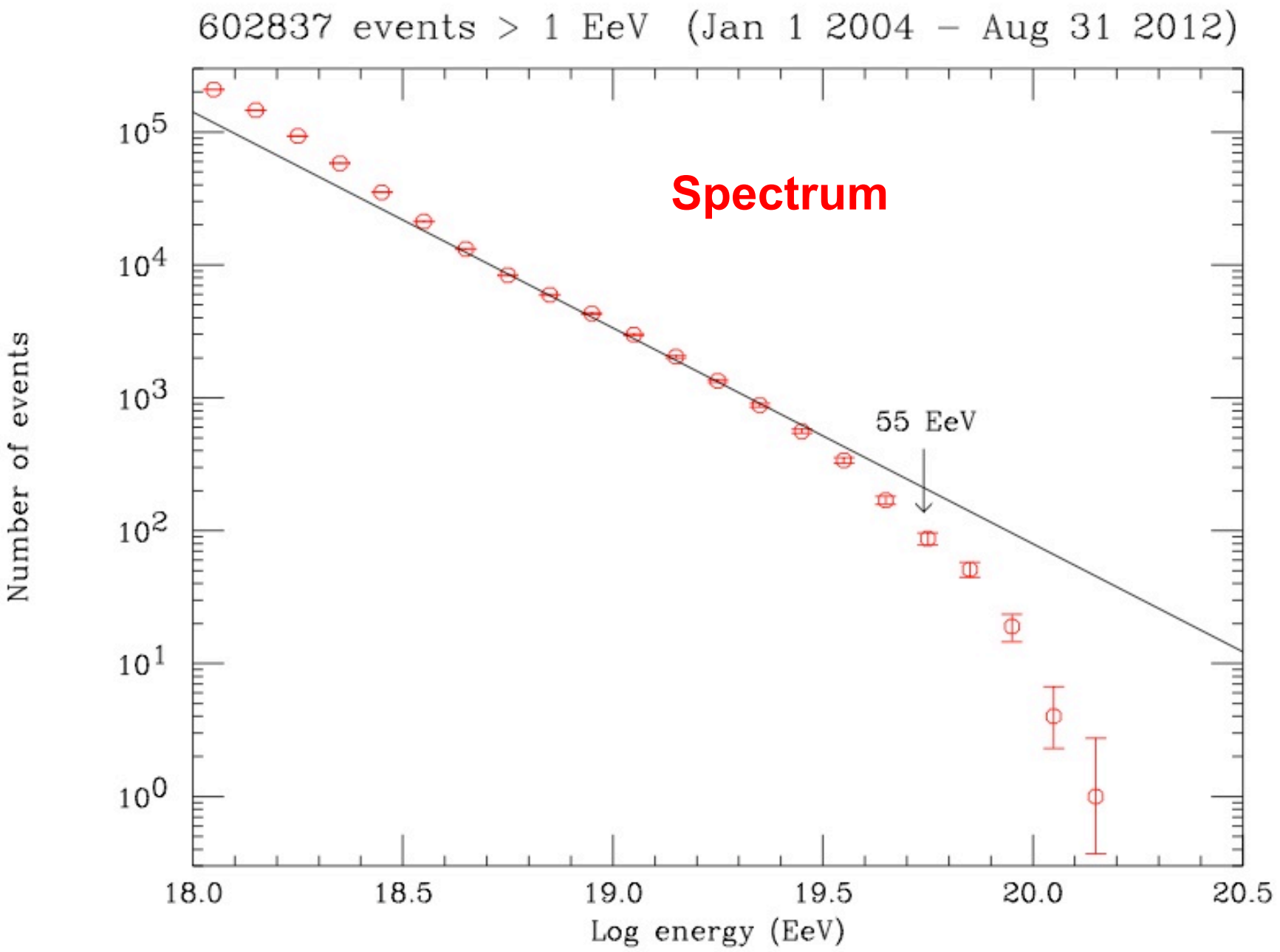


Miguel Mostafa
New Mexico/Utah

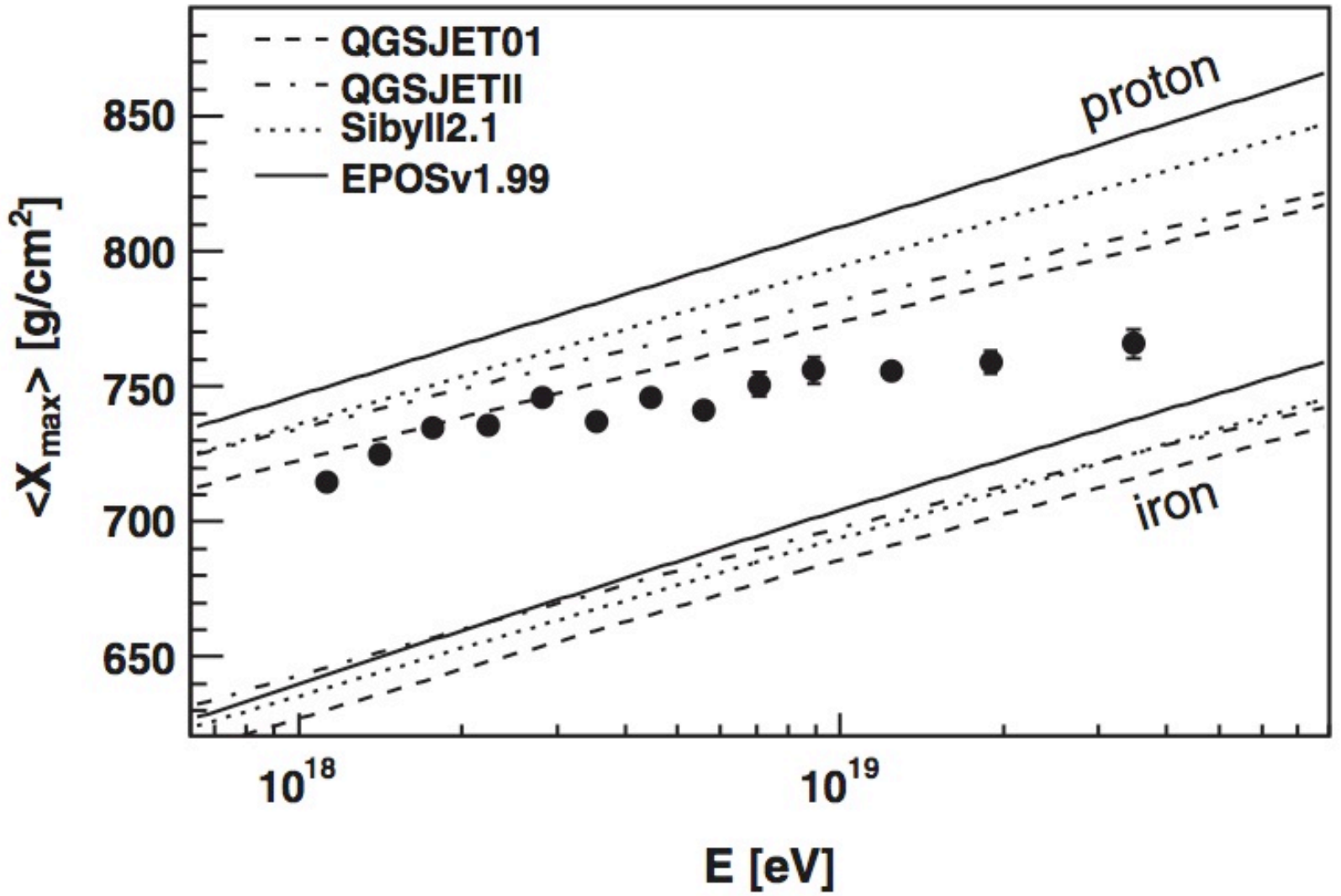


20 May 2007 E ~ 10^{19} eV

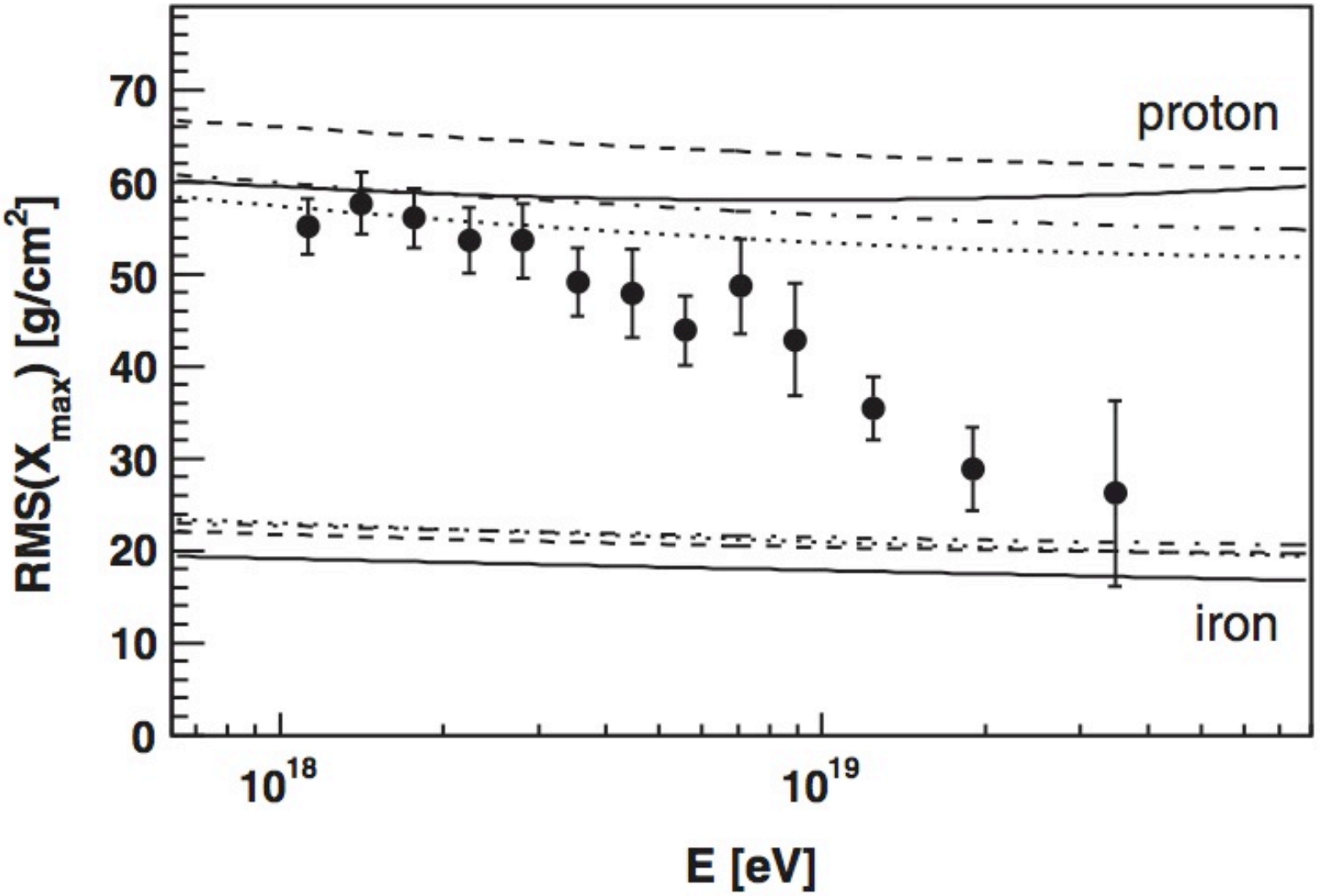
A few scientific results


602837 events > 1 EeV (Jan 1 2004 – Aug 31 2012)
Spectrum
55 EeV
Number of events
Log energy (EeV)
10^5
10^4
10^3
10^2
10^1
10^0
18.0
18.5
19.0
19.5
20.0
20.5

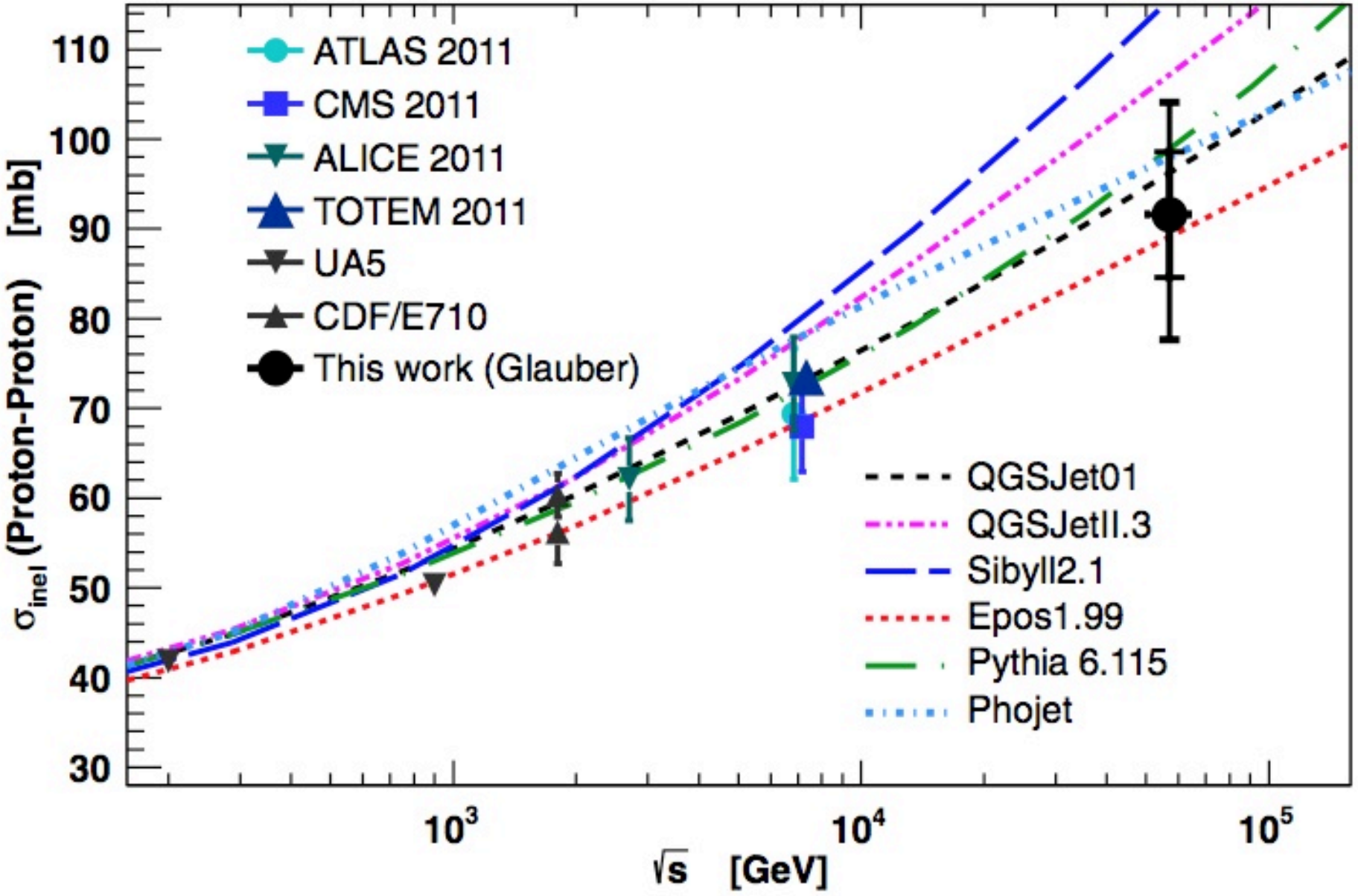
Composition – primaries getting heavier

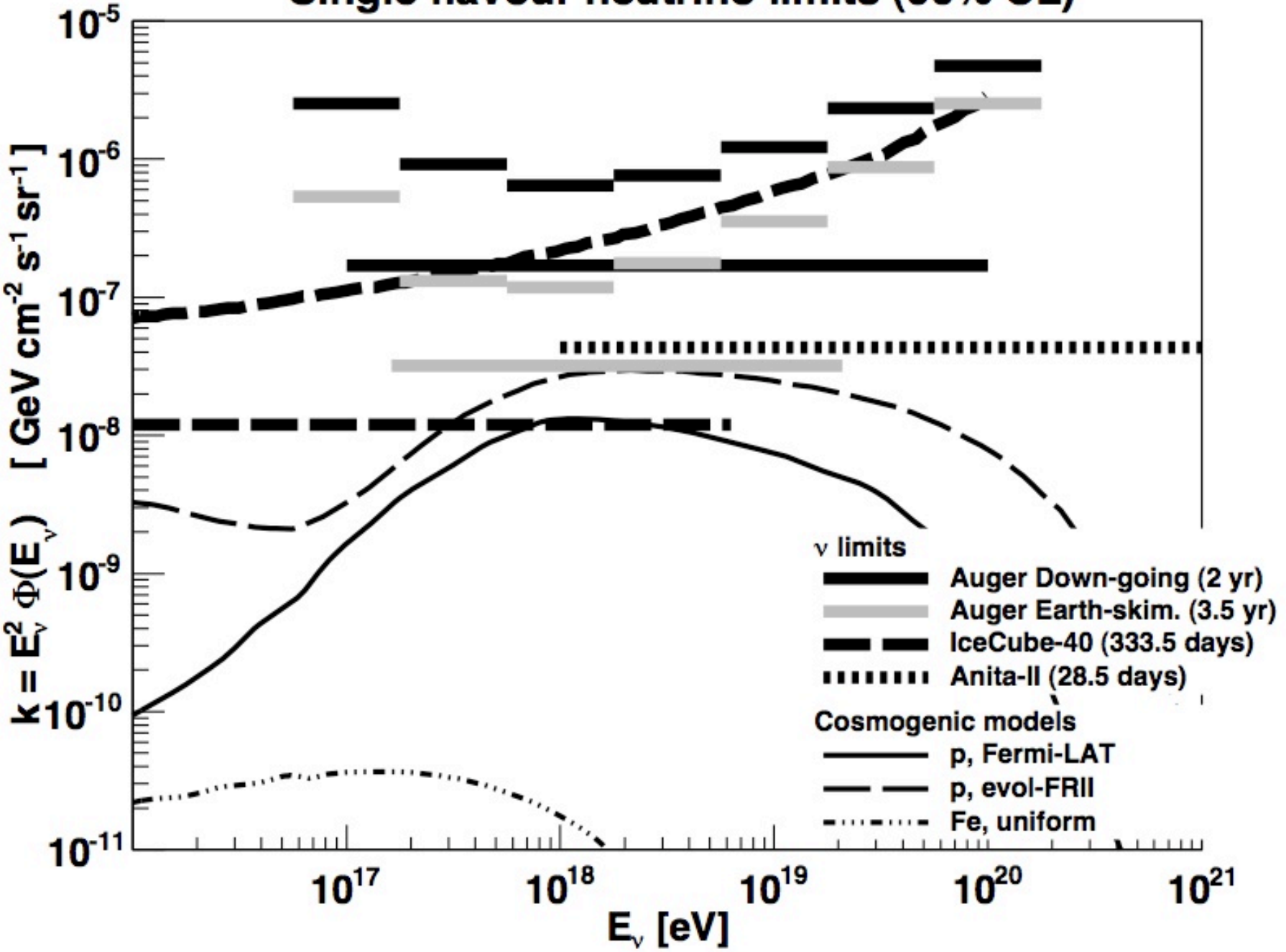


Composition - primaries getting heavier

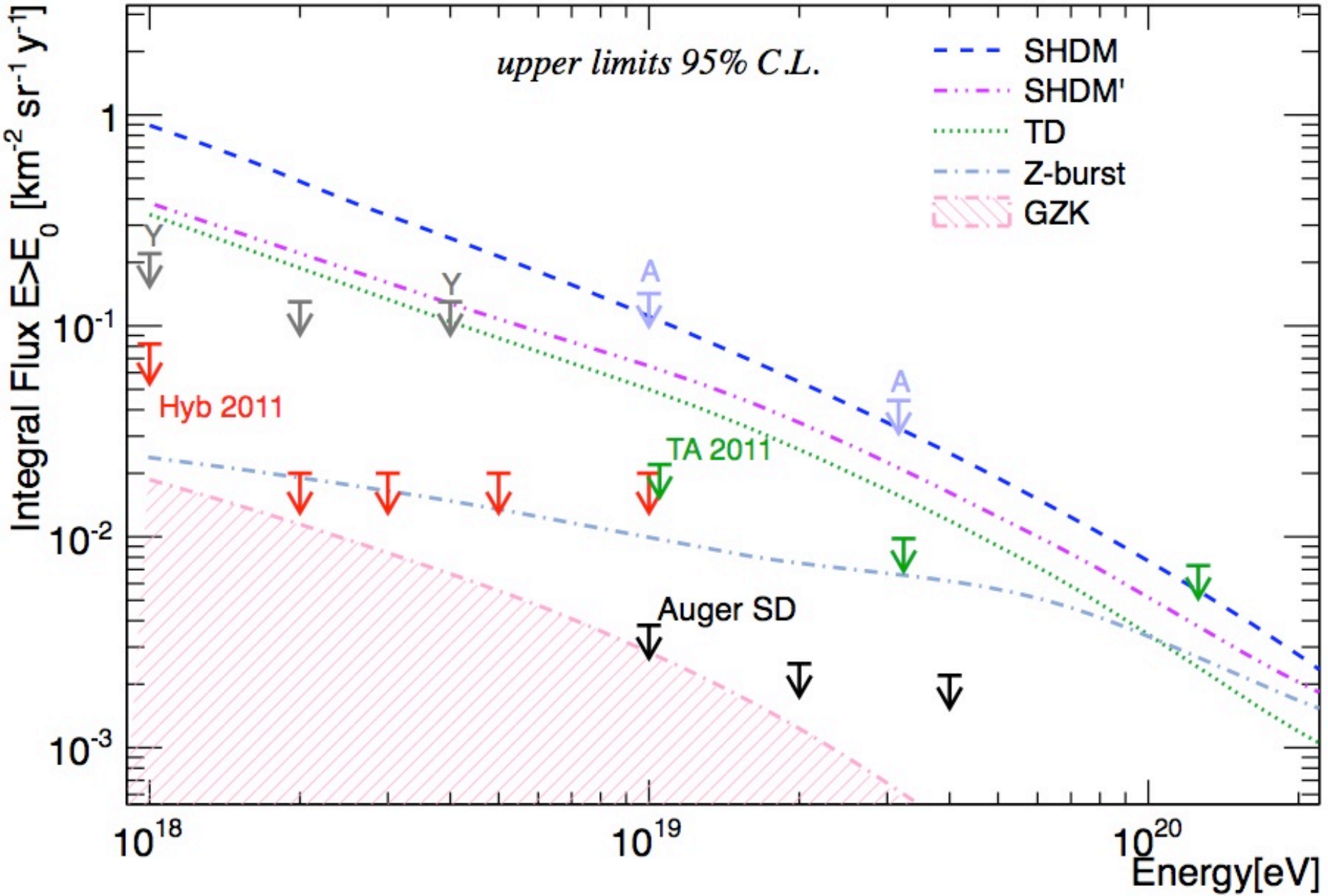


proton-proton total cross section




Single flavour neutrino limits (90% CL)
$k = E_\nu^2\,\Phi(E_\nu)$ [GeV cm^{-2} s^{-1} sr^{-1}]
E_ν [eV]
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{17}
10^{18}
10^{19}
10^{20}
10^{21}
ν limits
Auger Down-going (2 yr)
Auger Earth-skim. (3.5 yr)
IceCube-40 (333.5 days)
Anita-II (28.5 days)
Cosmogenic models
p, Fermi-LAT
p, evol-FRII
Fe, uniform

Upper limits of photon content in cosmic rays



Outreach


Auger Office Building
And Visitor Center
>6000 visitors/yr


J W Cronin School


Malargüe
Planetarium
PLANETARIO
MALARGÜE


OBSERVATORIO DE RAYOS COSMICOS PIERRE AUGER
Malargüe, Provincia de Mendoza, Argentina
Auger collaboration on parade

Many improvements and enhancements

Extension of surface and fluorescence detectors to lower energies

Research on the detection of cosmic rays by radio

The Pierre Auger Observatory

An international project produced from the "grass roots" where no country or institution dominates.