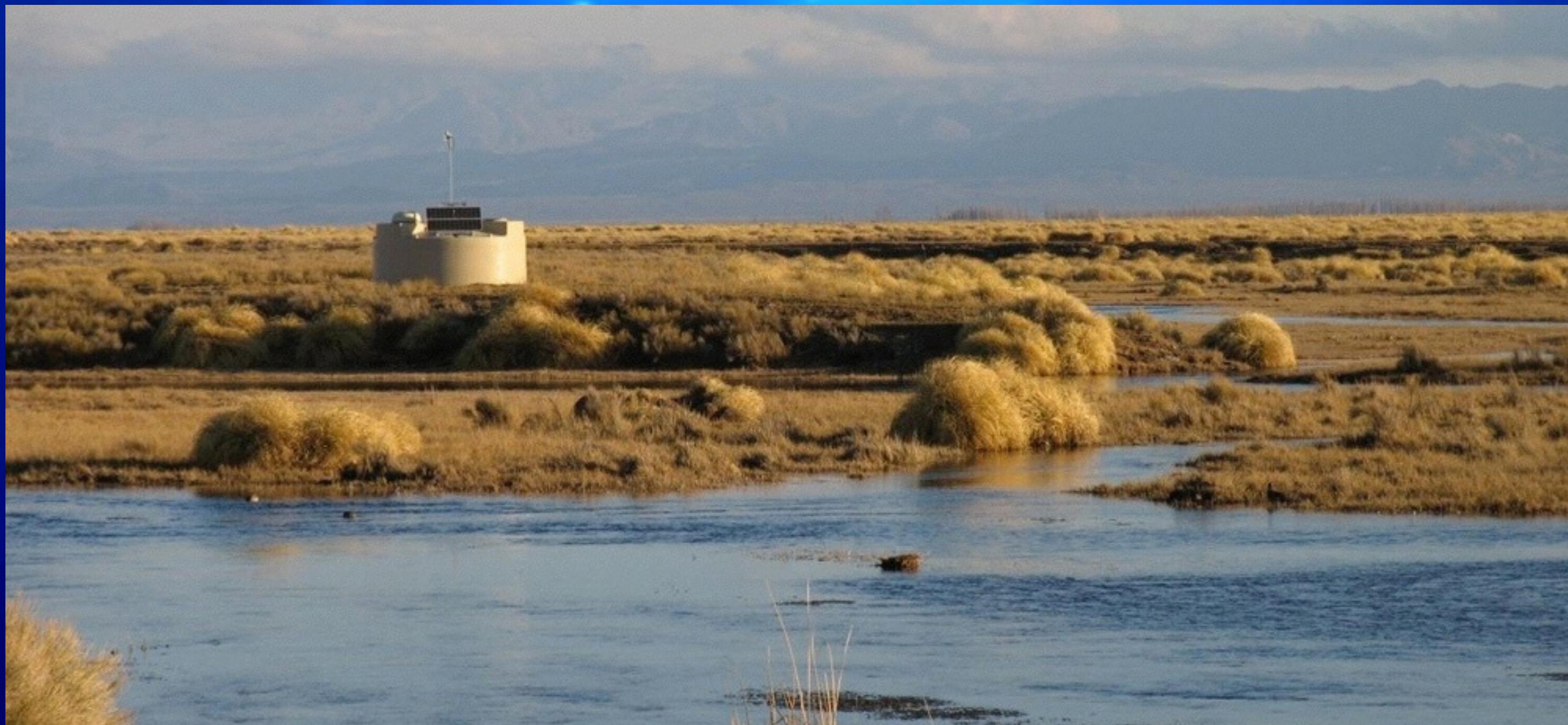


UNE HISTOIRE DES RAYONS COSMIQUES ET DE L'OBSERVATOIRE PIERRE AUGER

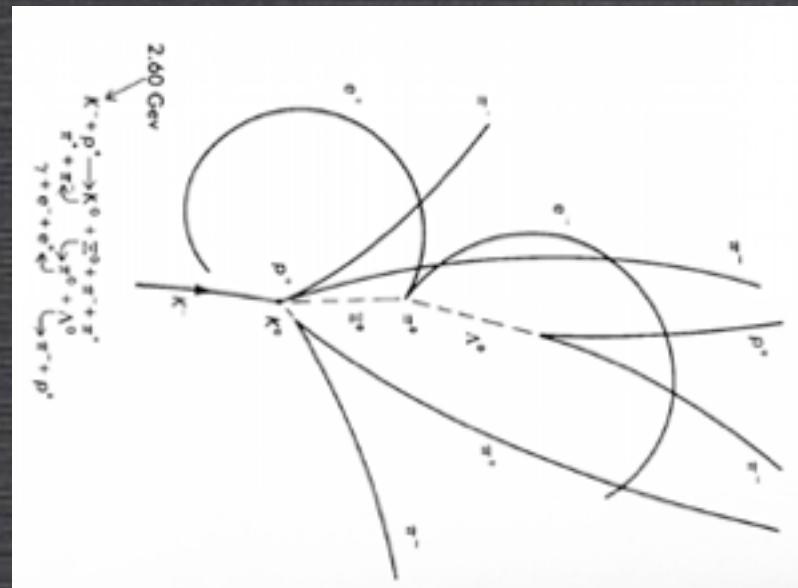
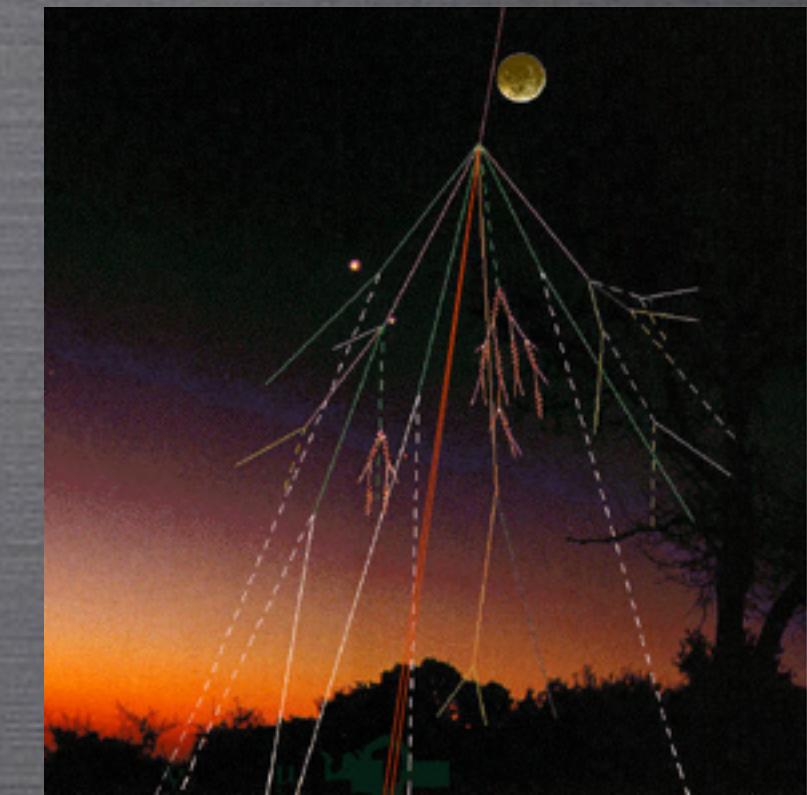


CHEMINEMENT

RADIATIONS

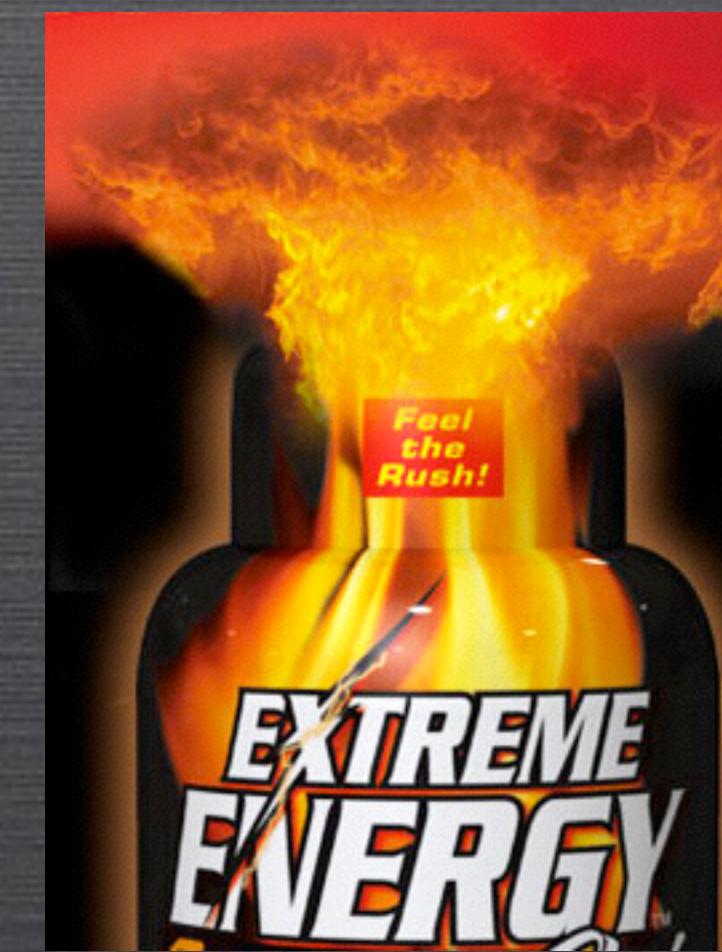


PREMIERS PAS



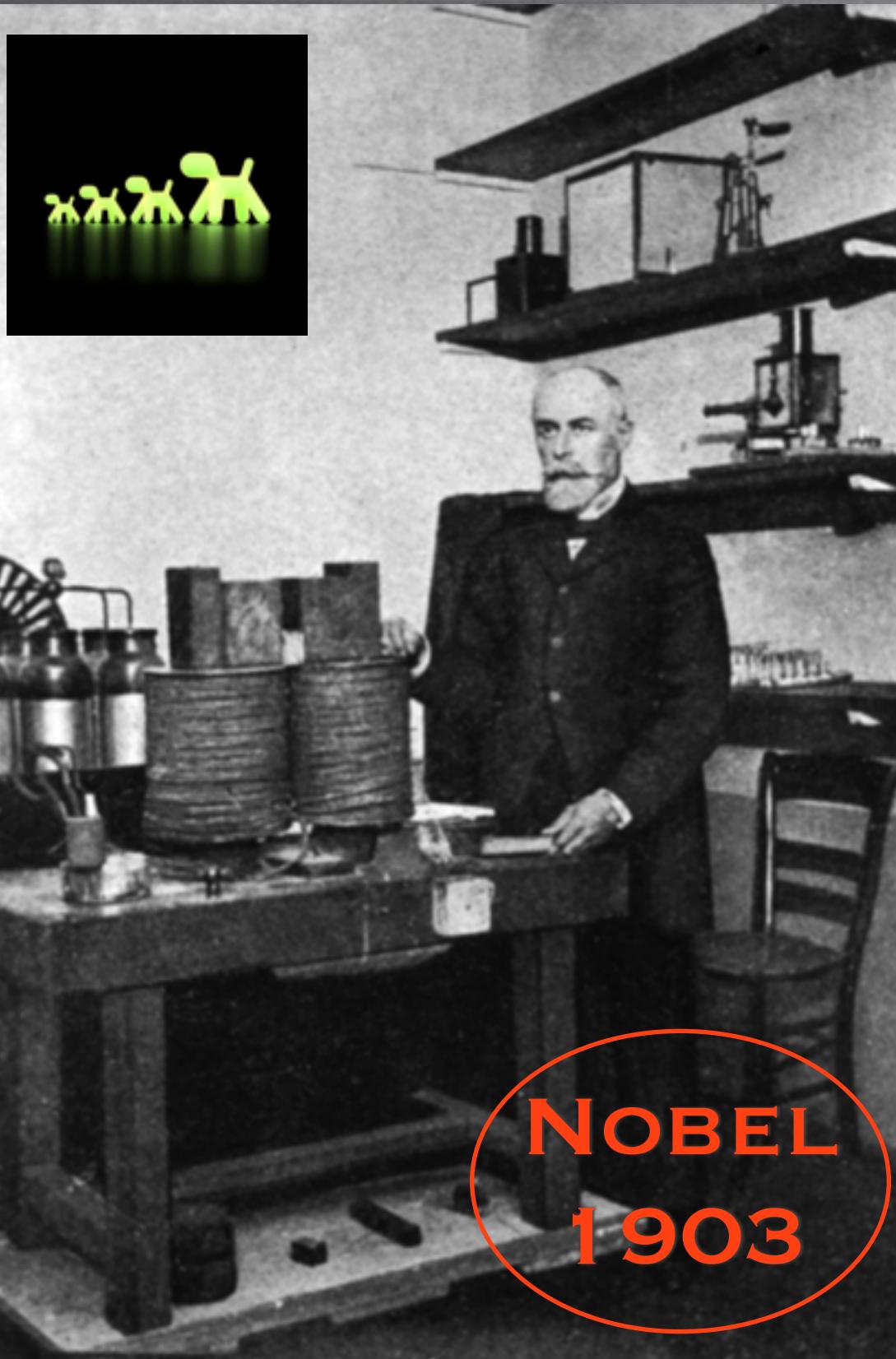
BESTIAIRE

DE PLUS EN PLUS GRAND

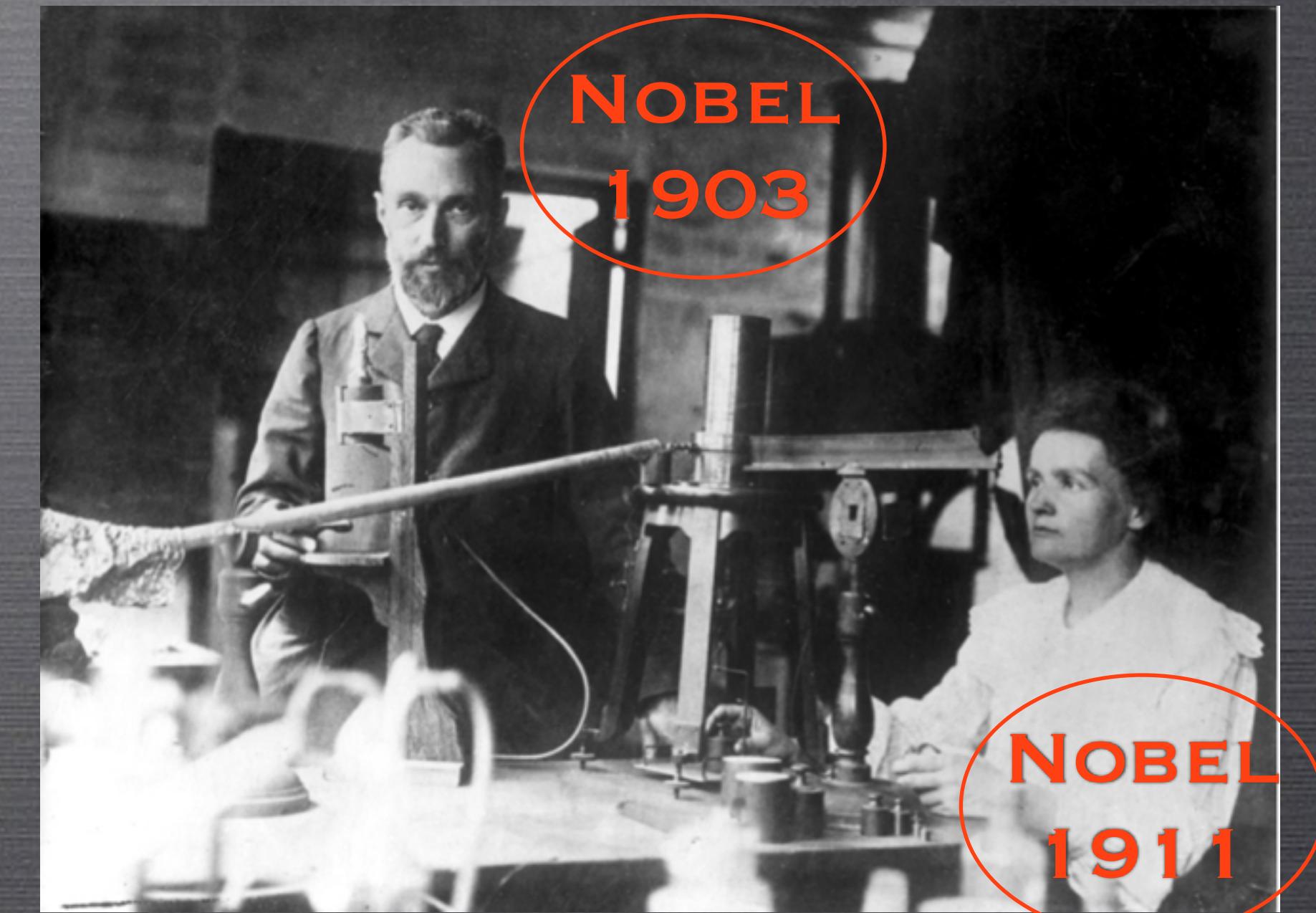


LES ÉNERGIES EXTRÊMES

RADIATIONS



Antoine Henri Becquerel

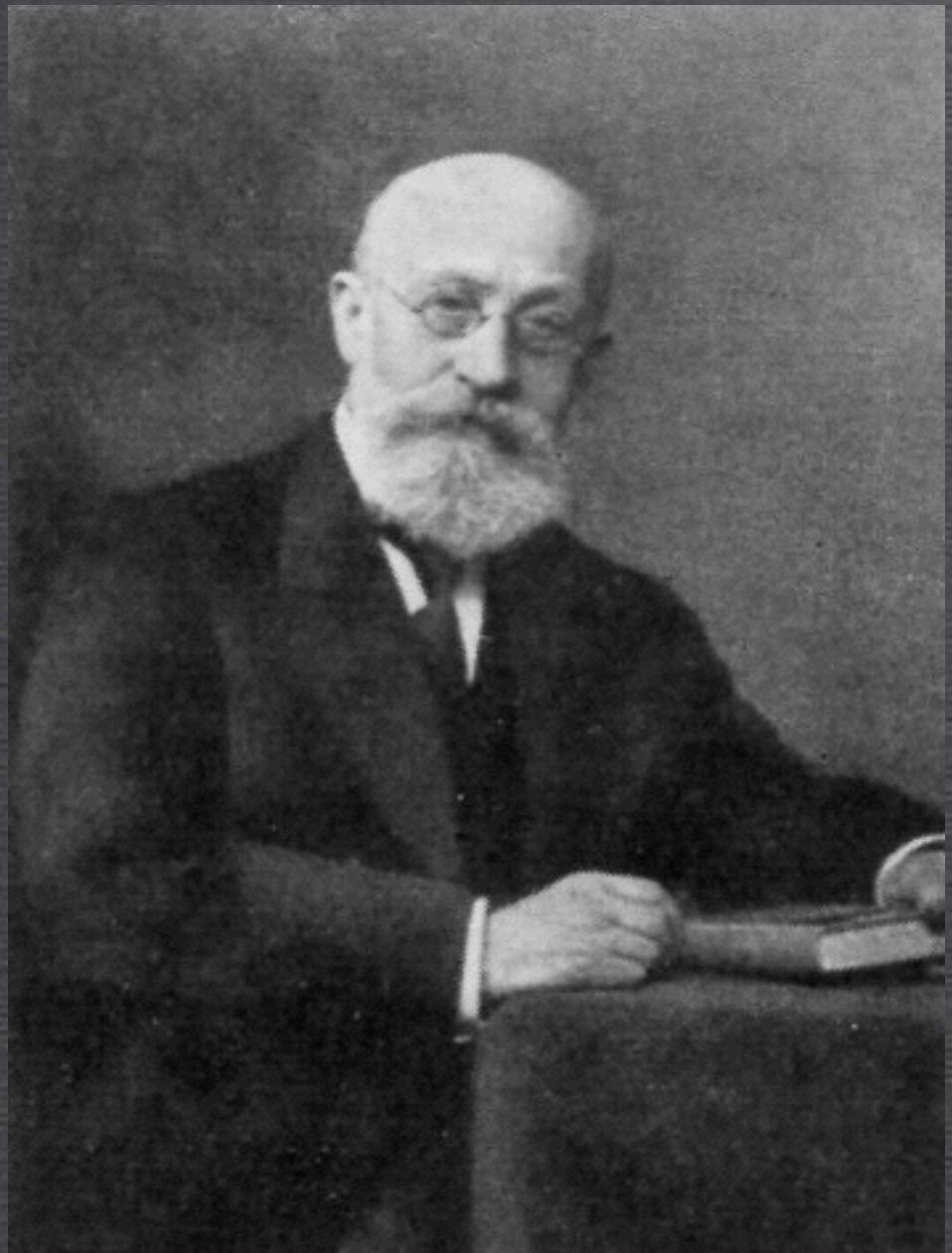
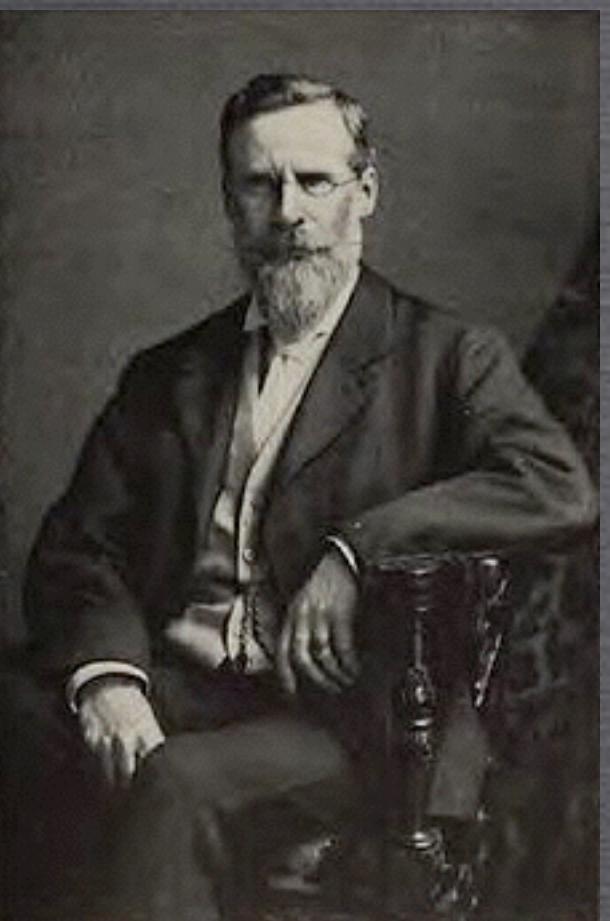


Pierre et Marie Curie

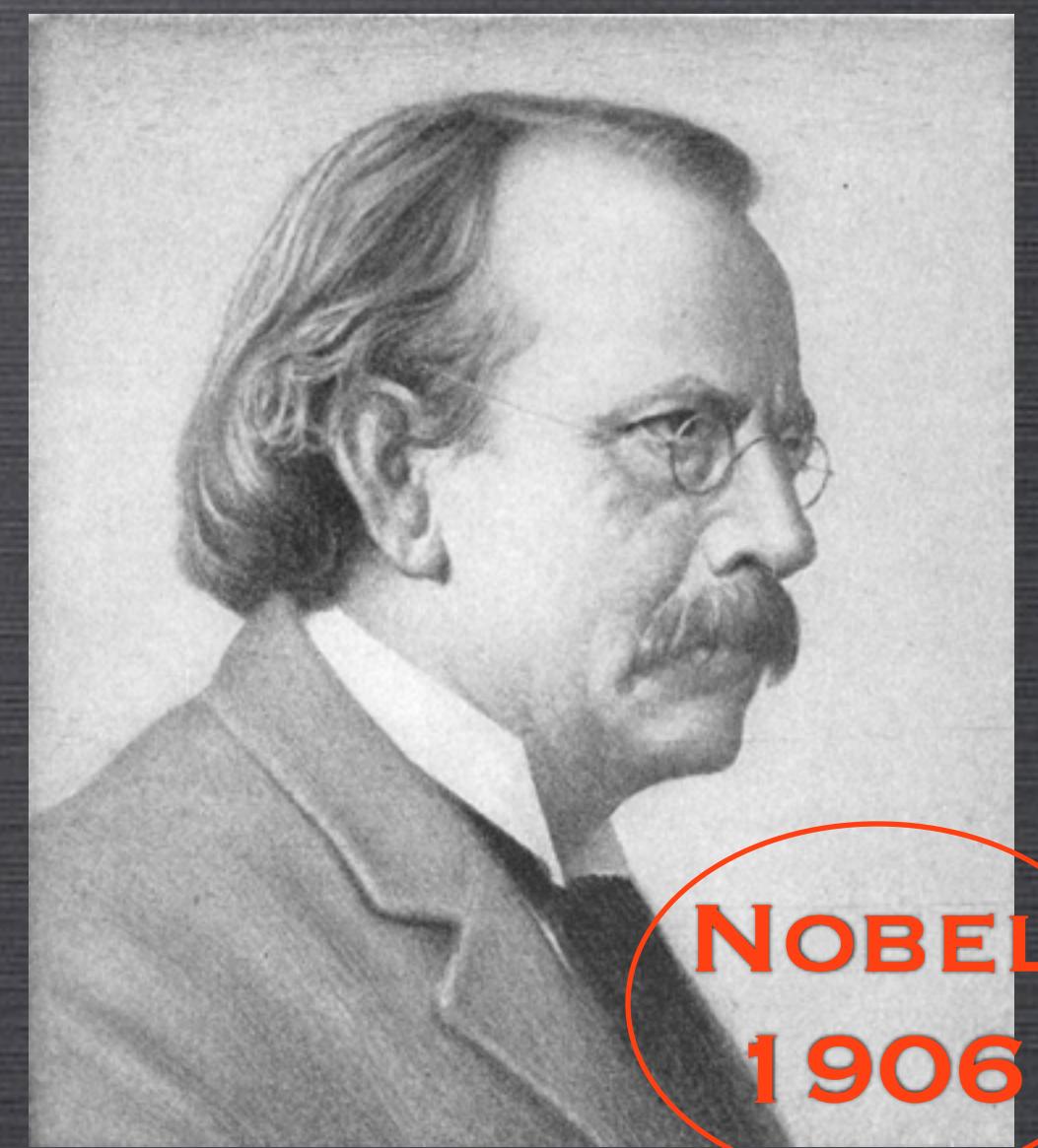


RAYONS CATHODIQUES (1870) & ÉLECTRONS (1897)

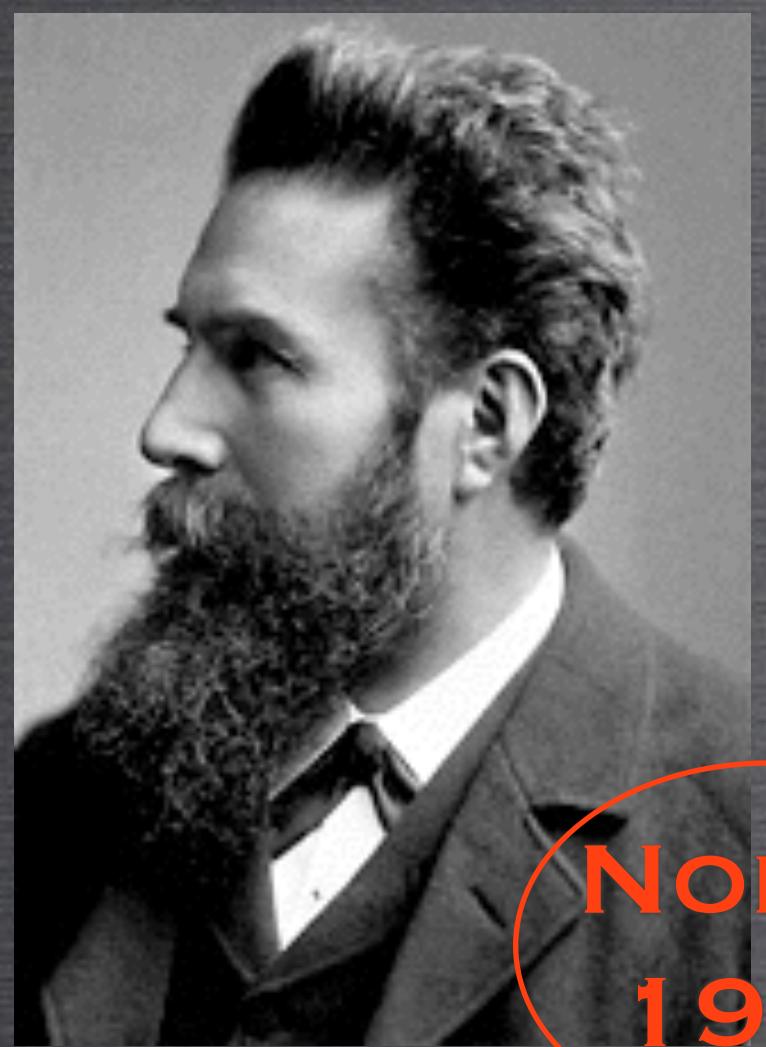
Sir William Crookes



J. J. Thomson.



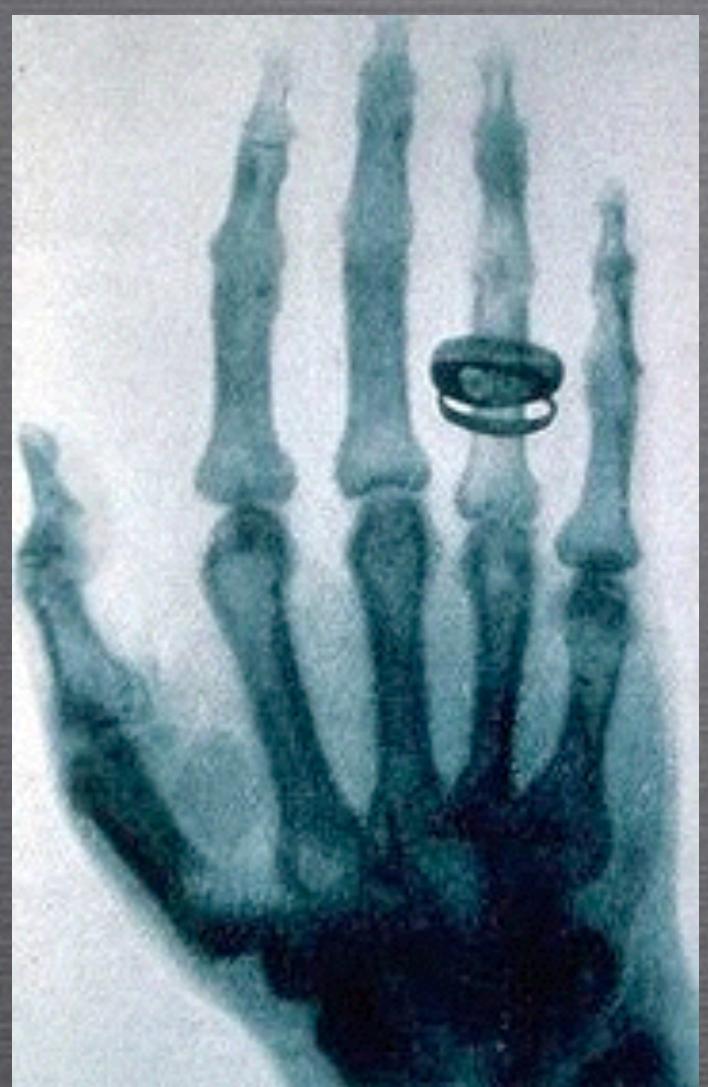
RAYONS X (1895)



W. RÖNTGEN



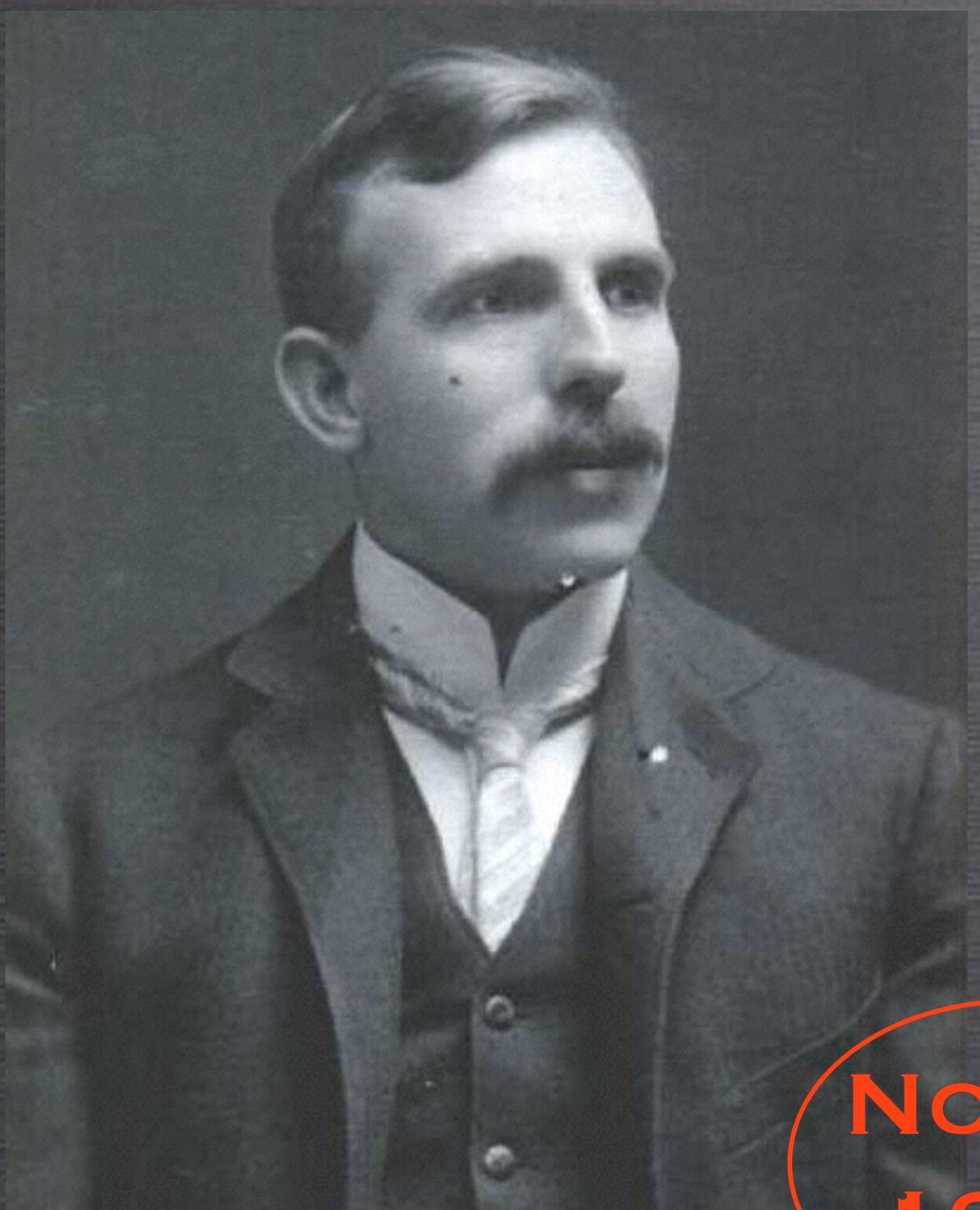
1895



1896

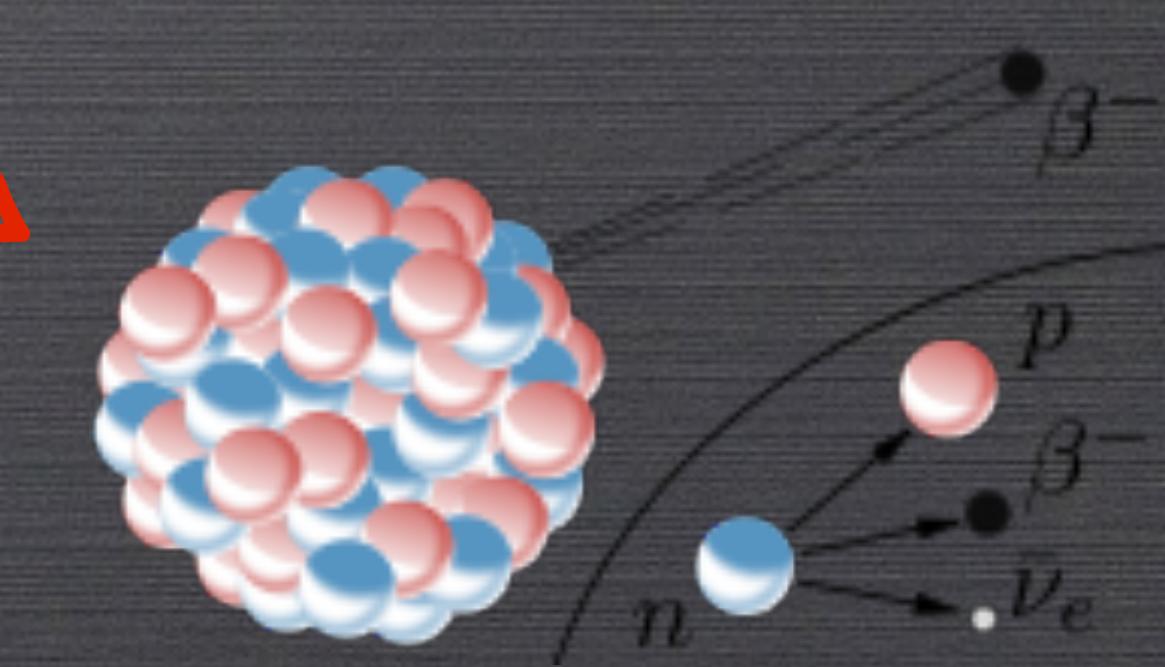
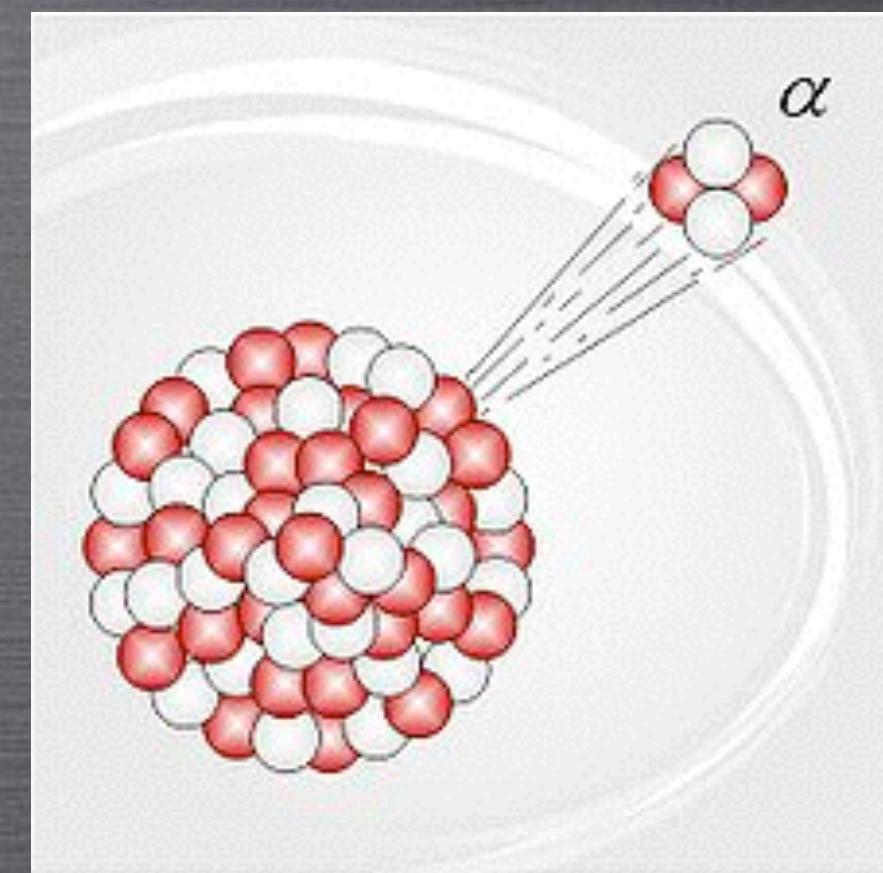
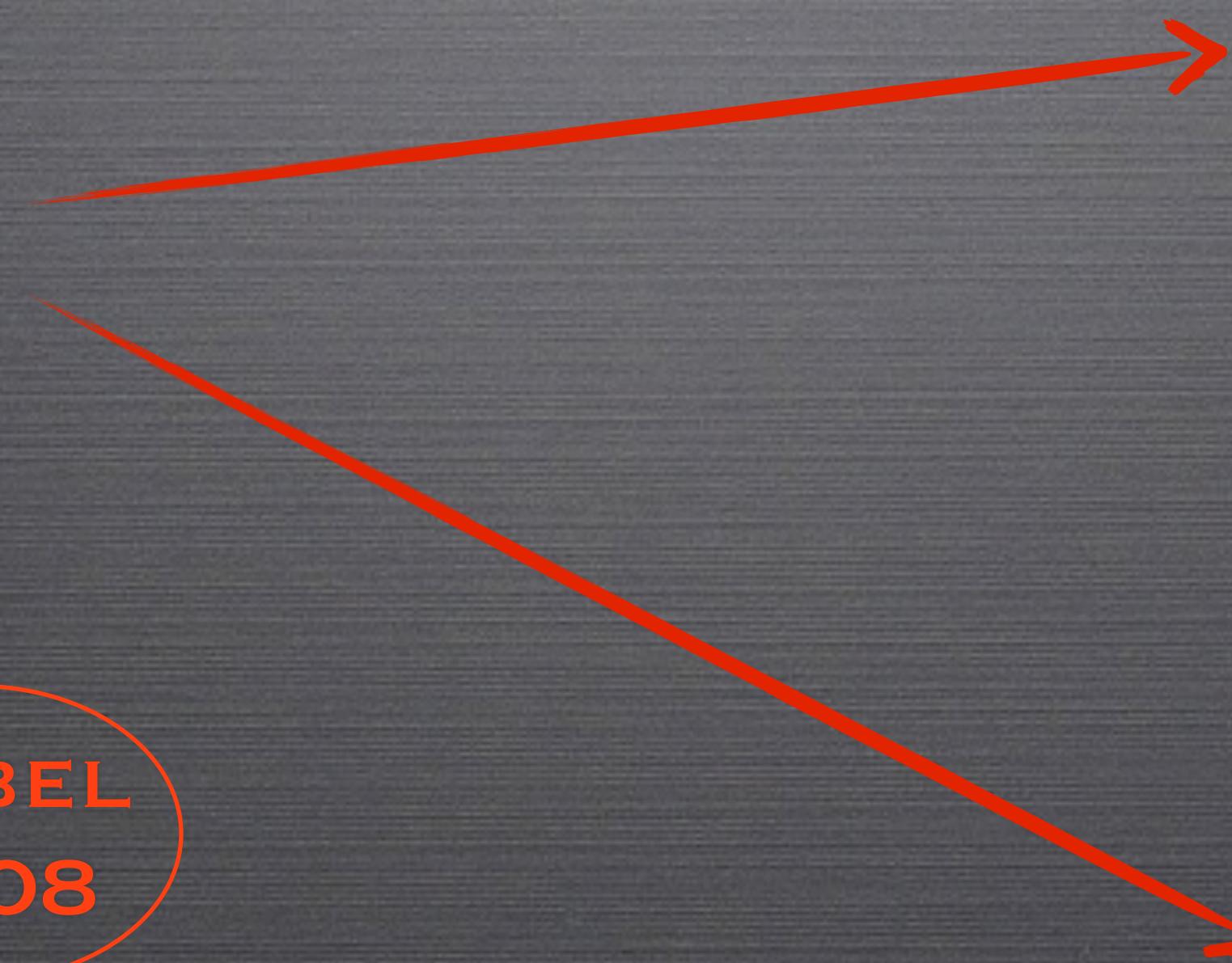


RAYONS ALPHA & BETA (1899)

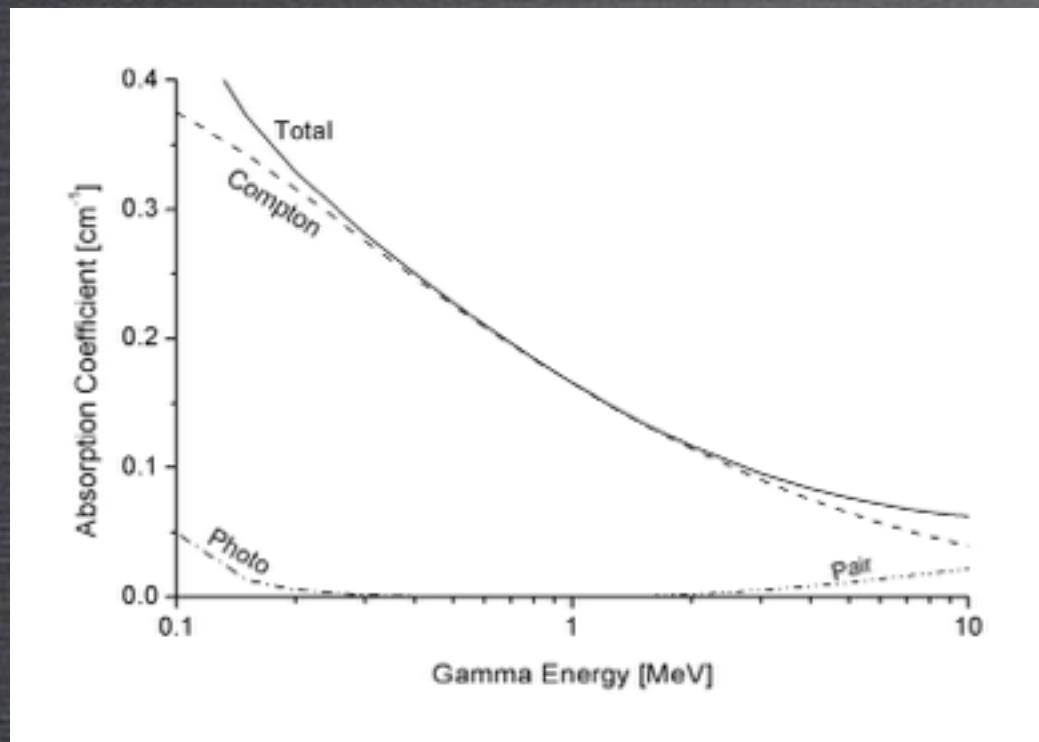


NOBEL
1908

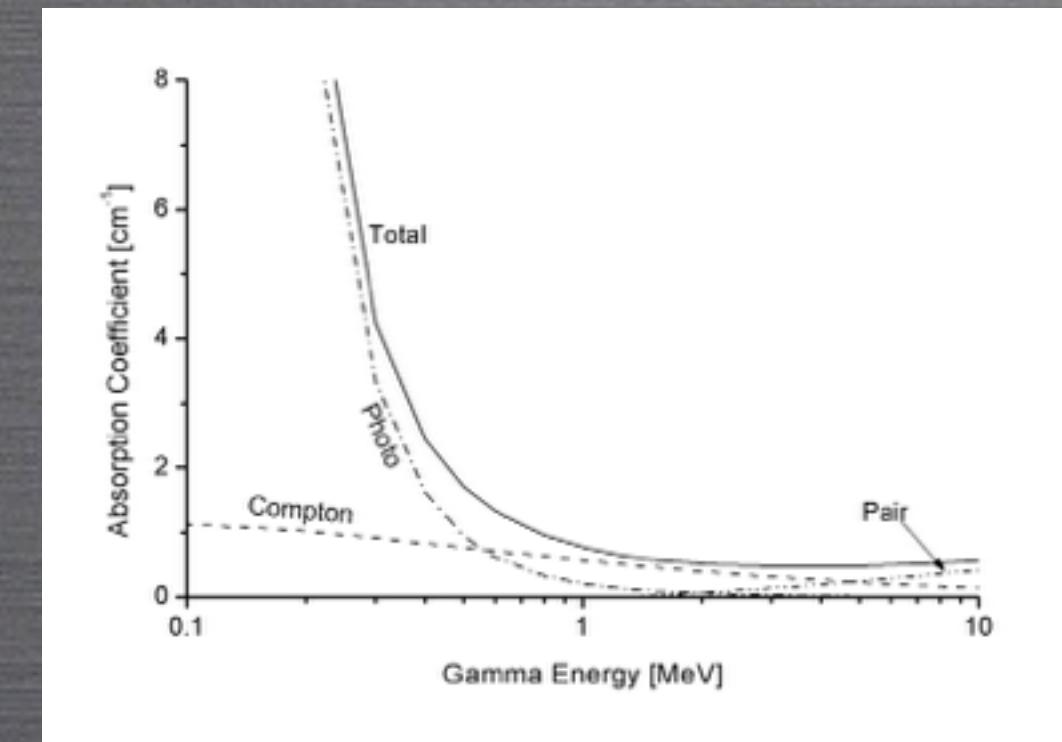
Rutherford



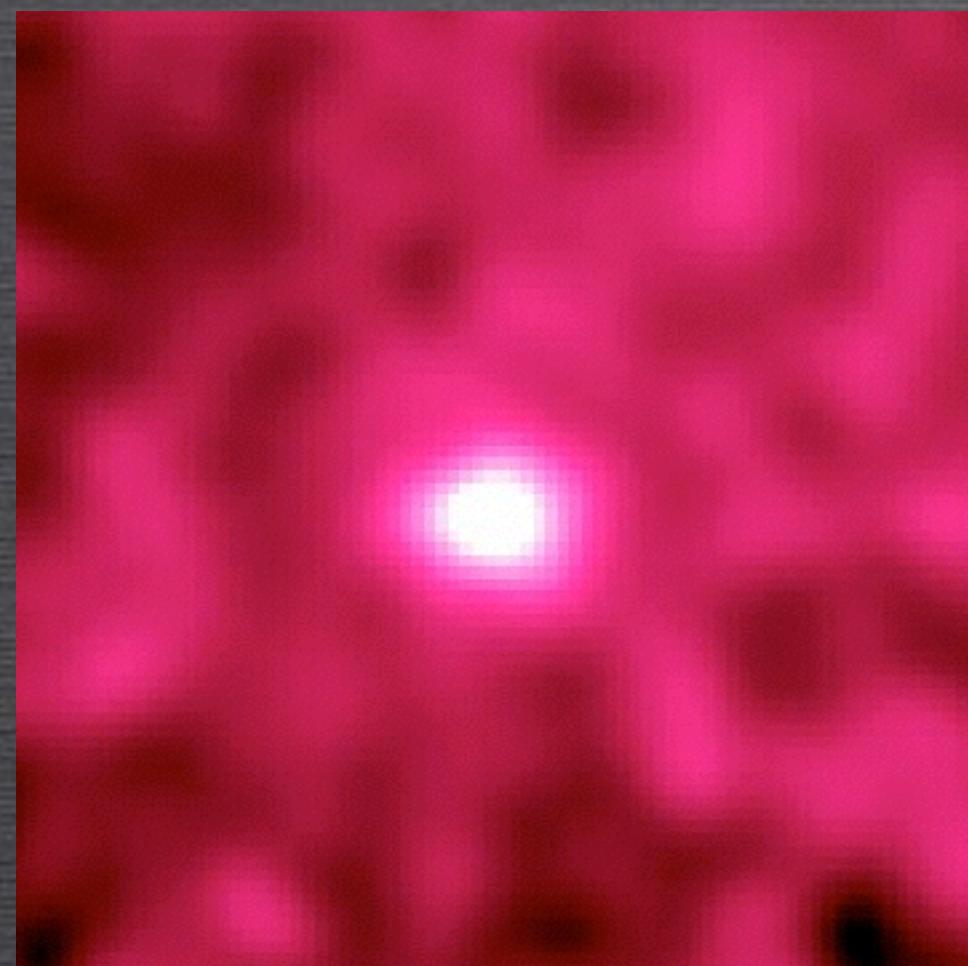
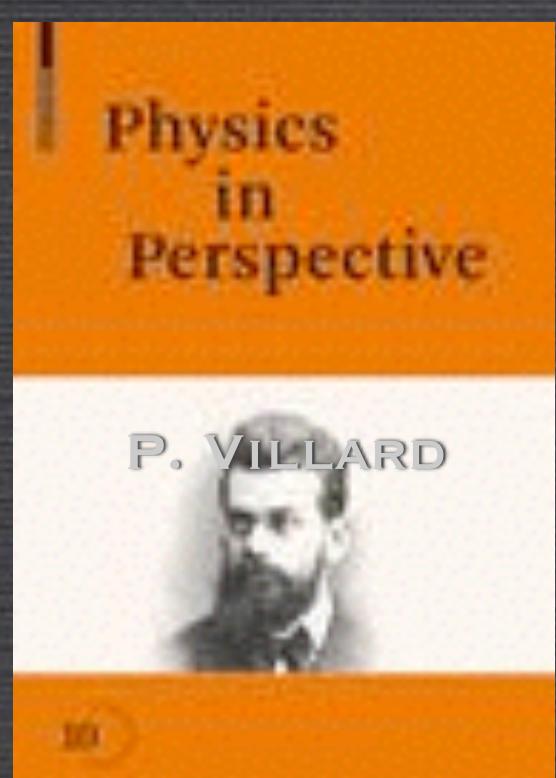
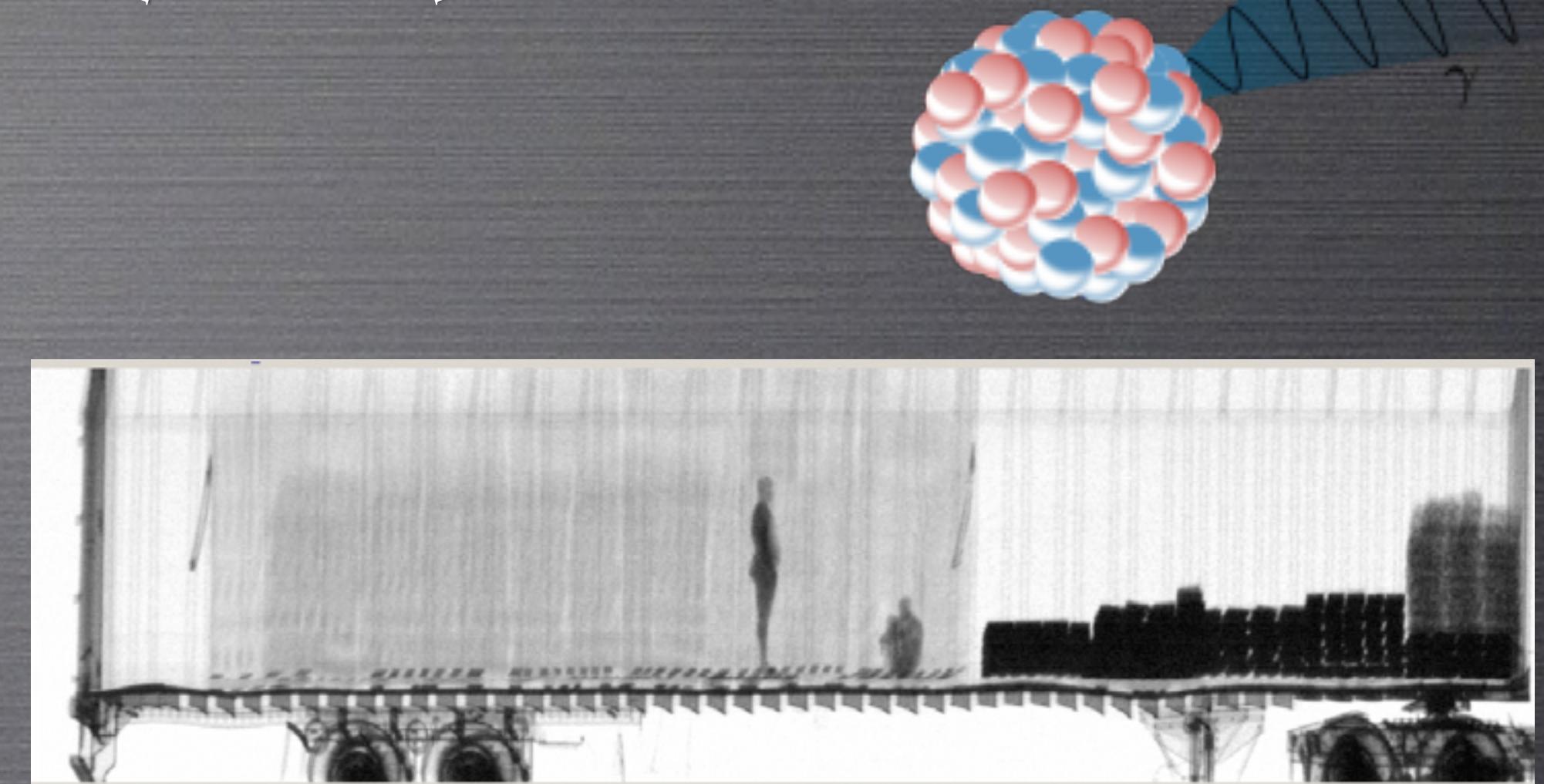
RAYONS GAMMA (1900)



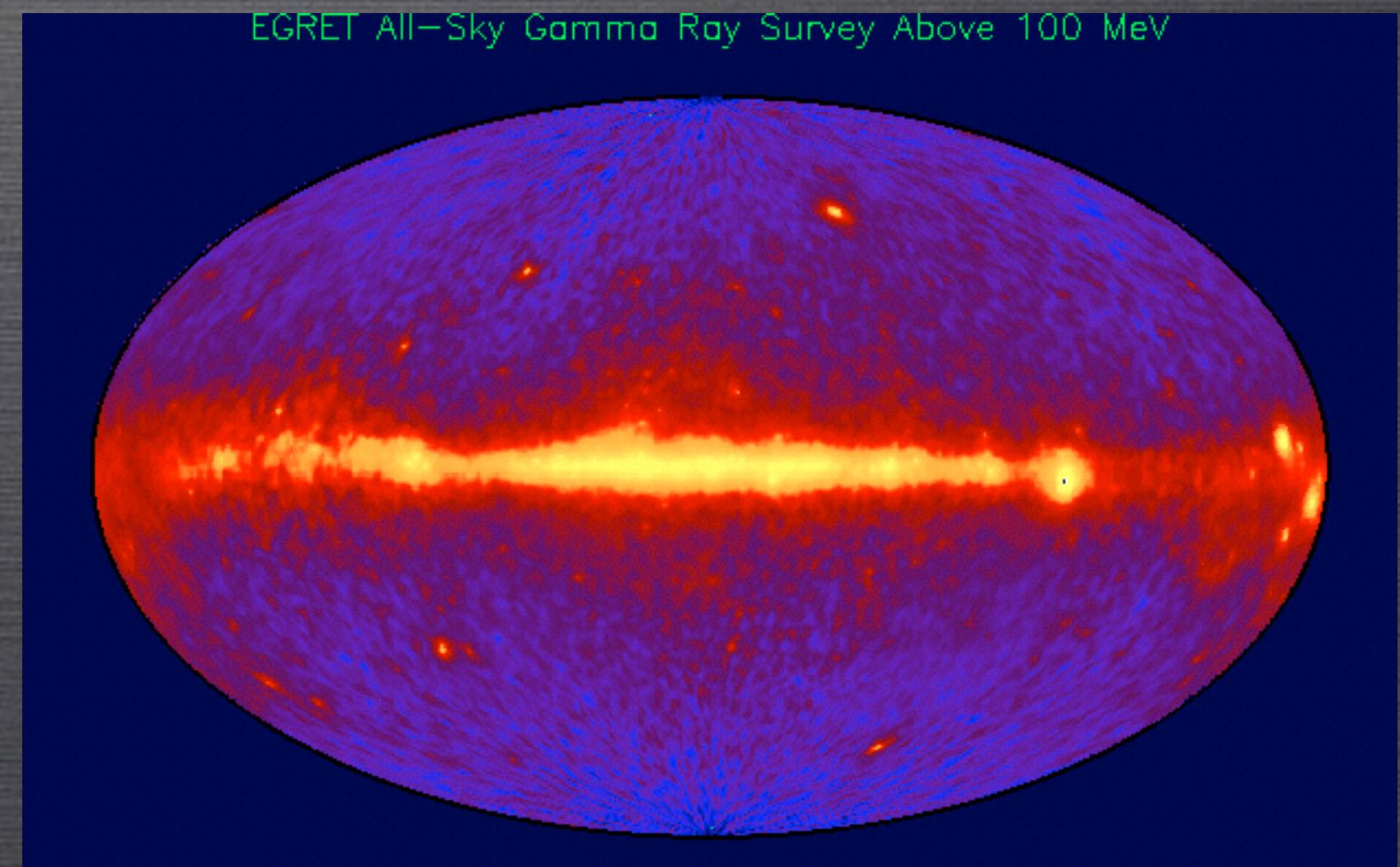
Aluminium



Plomb

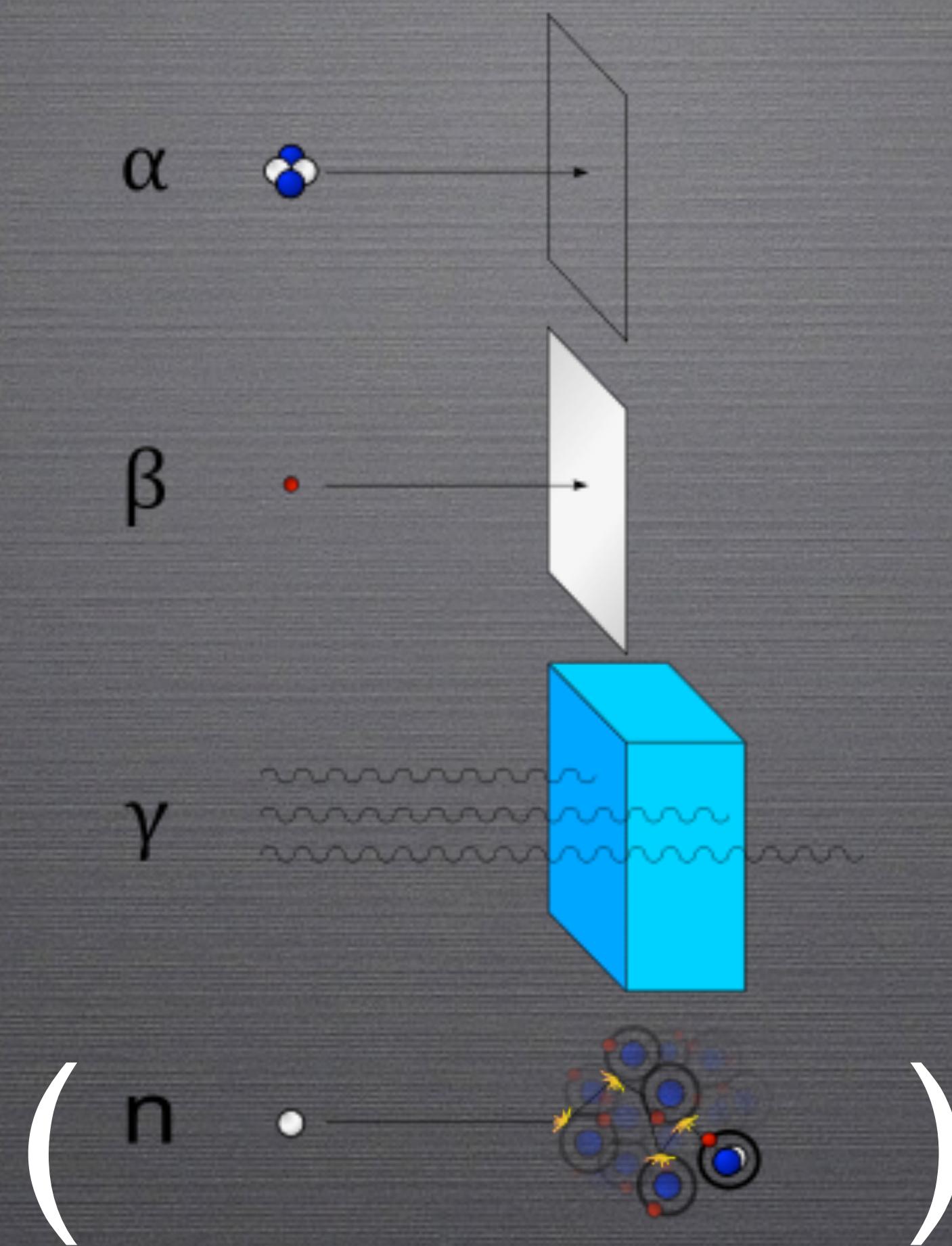
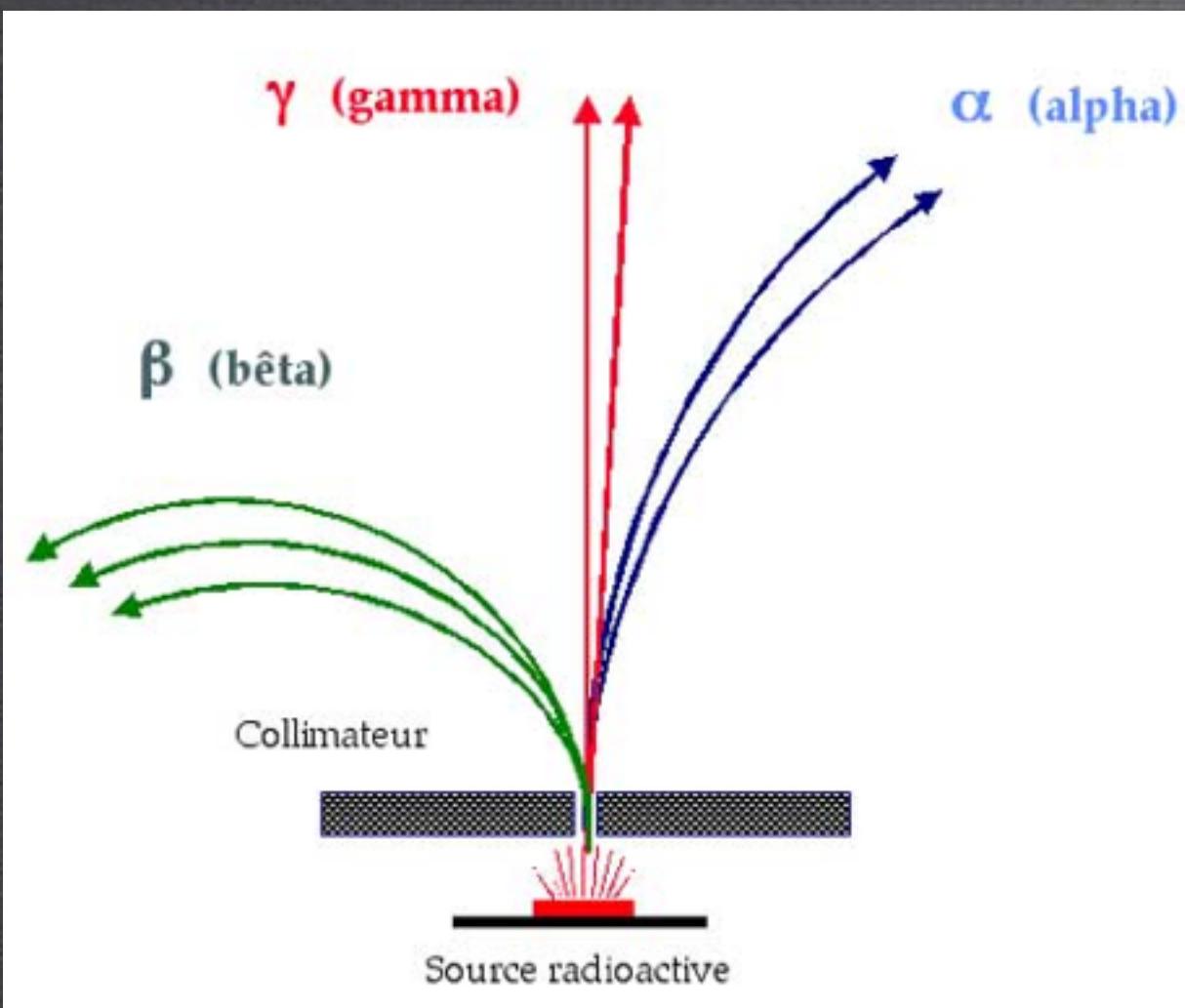


La Lune



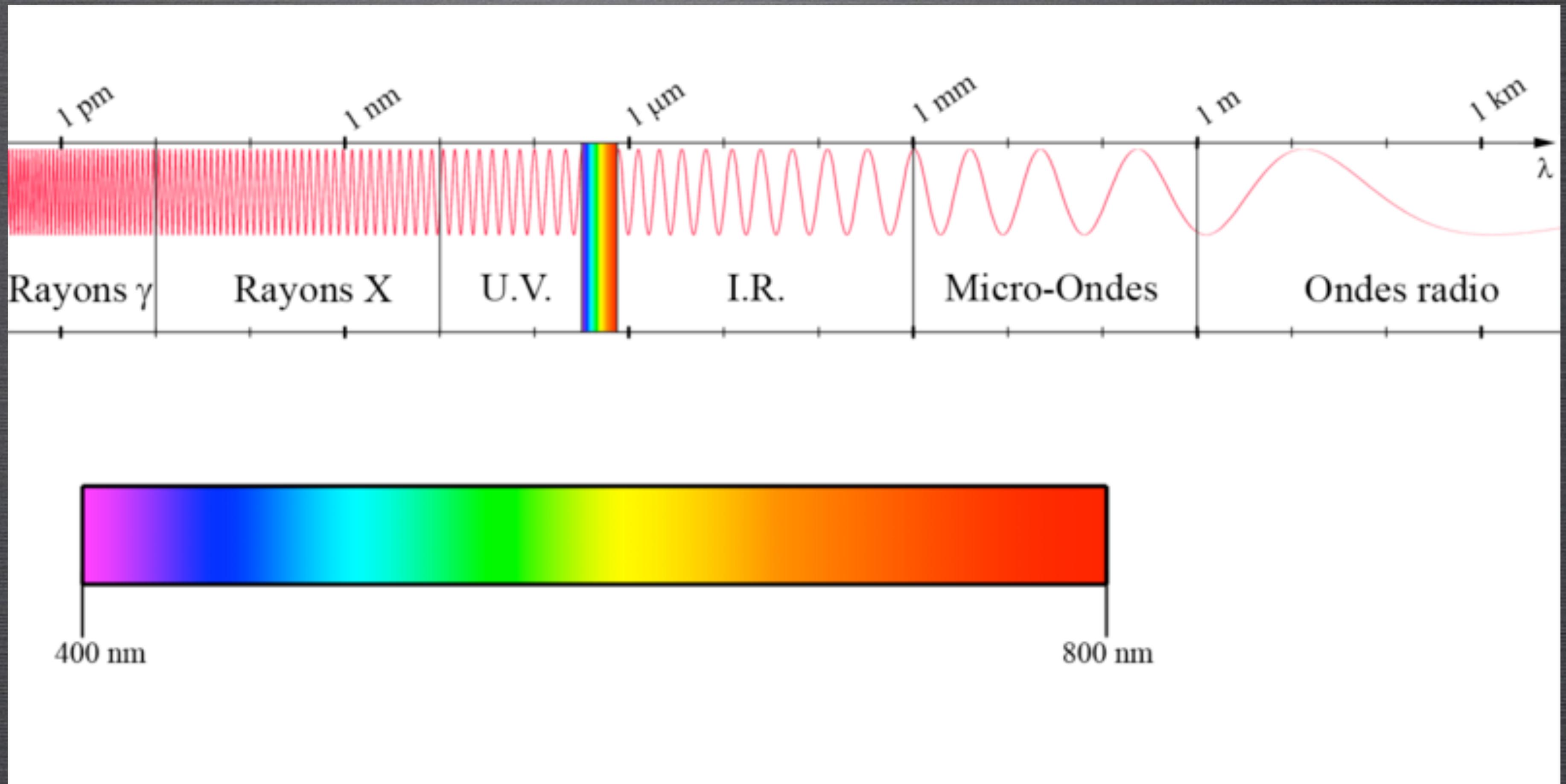
EGRET instrument aboard the Compton Gamma Ray Observatory

LES RAYONNEMENTS AU DÉBUT DU XXIÈME SIÈCLE



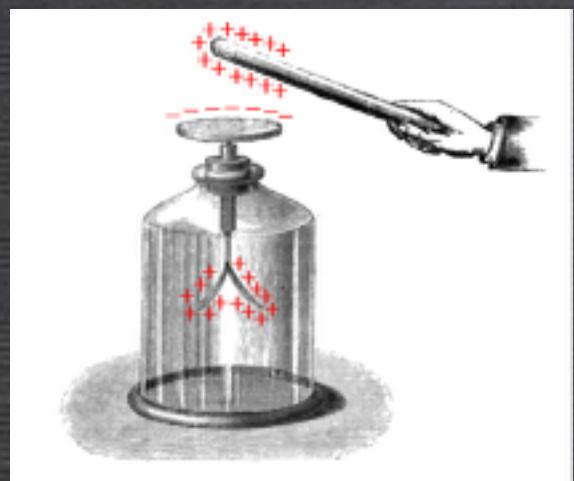
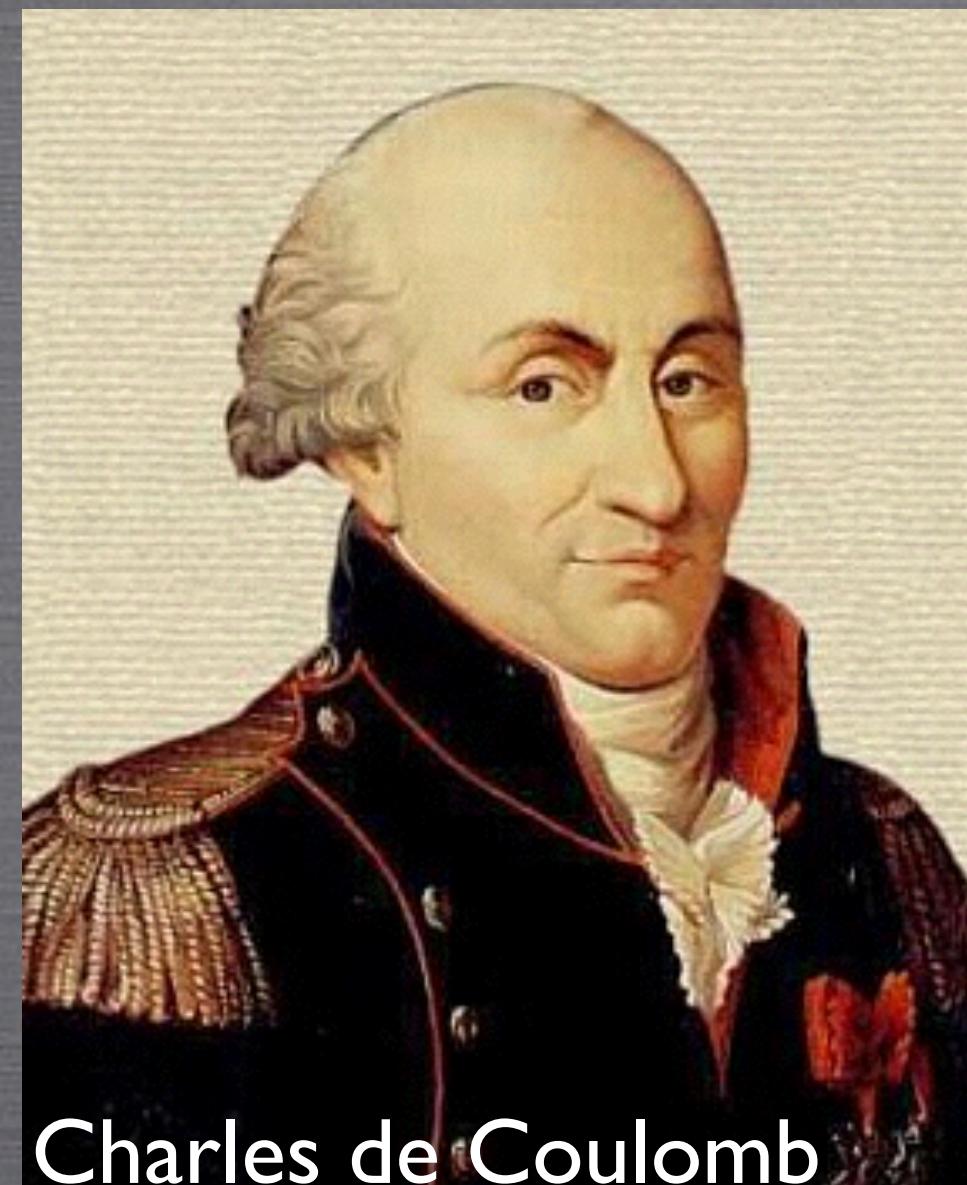
DIFFÉRENTS TYPES DE RADIATIONS
PLUS OU MOINS PÉNÉTRANTES

QUELQUE TEMPS PLUS TARD ...

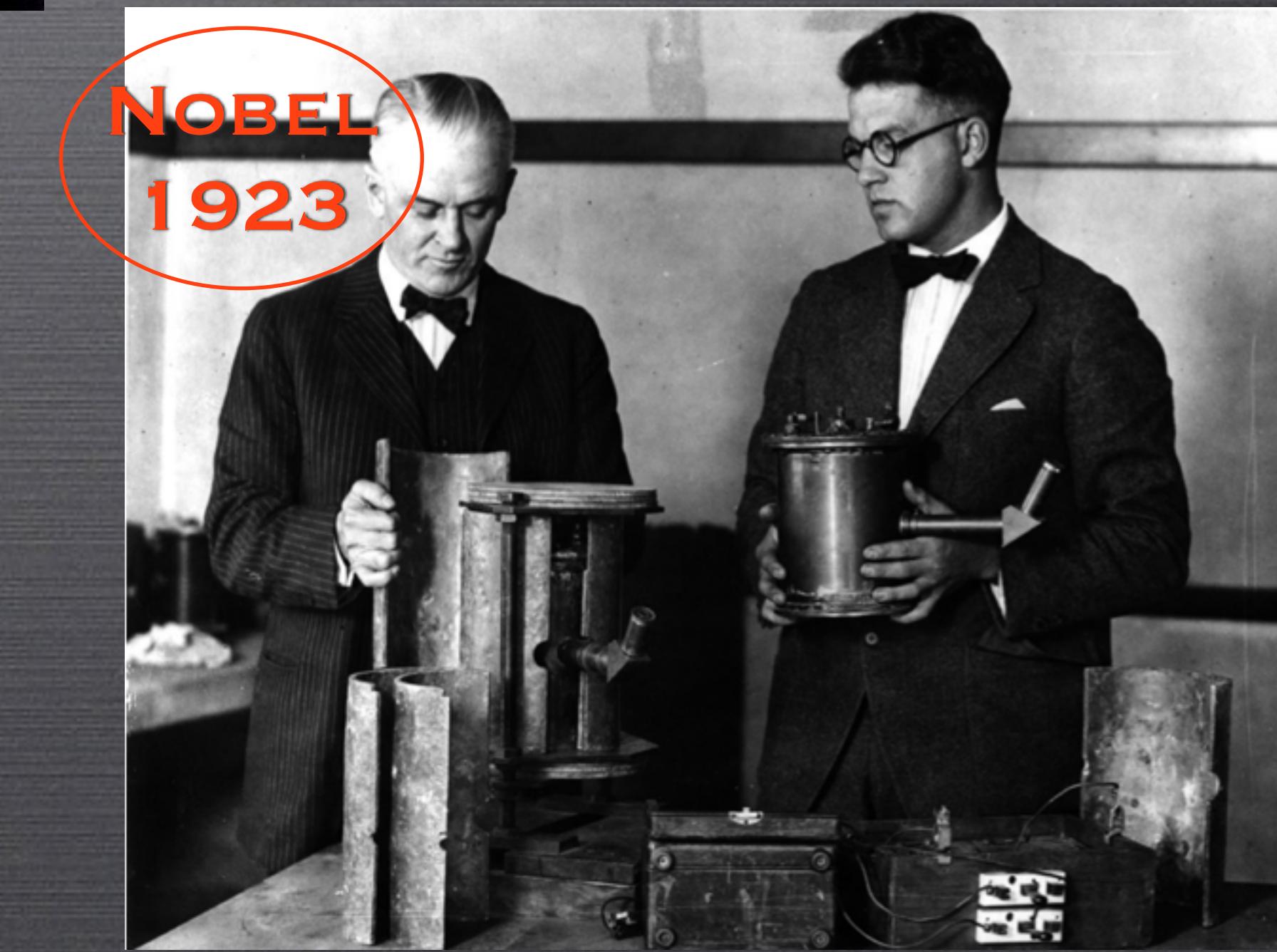
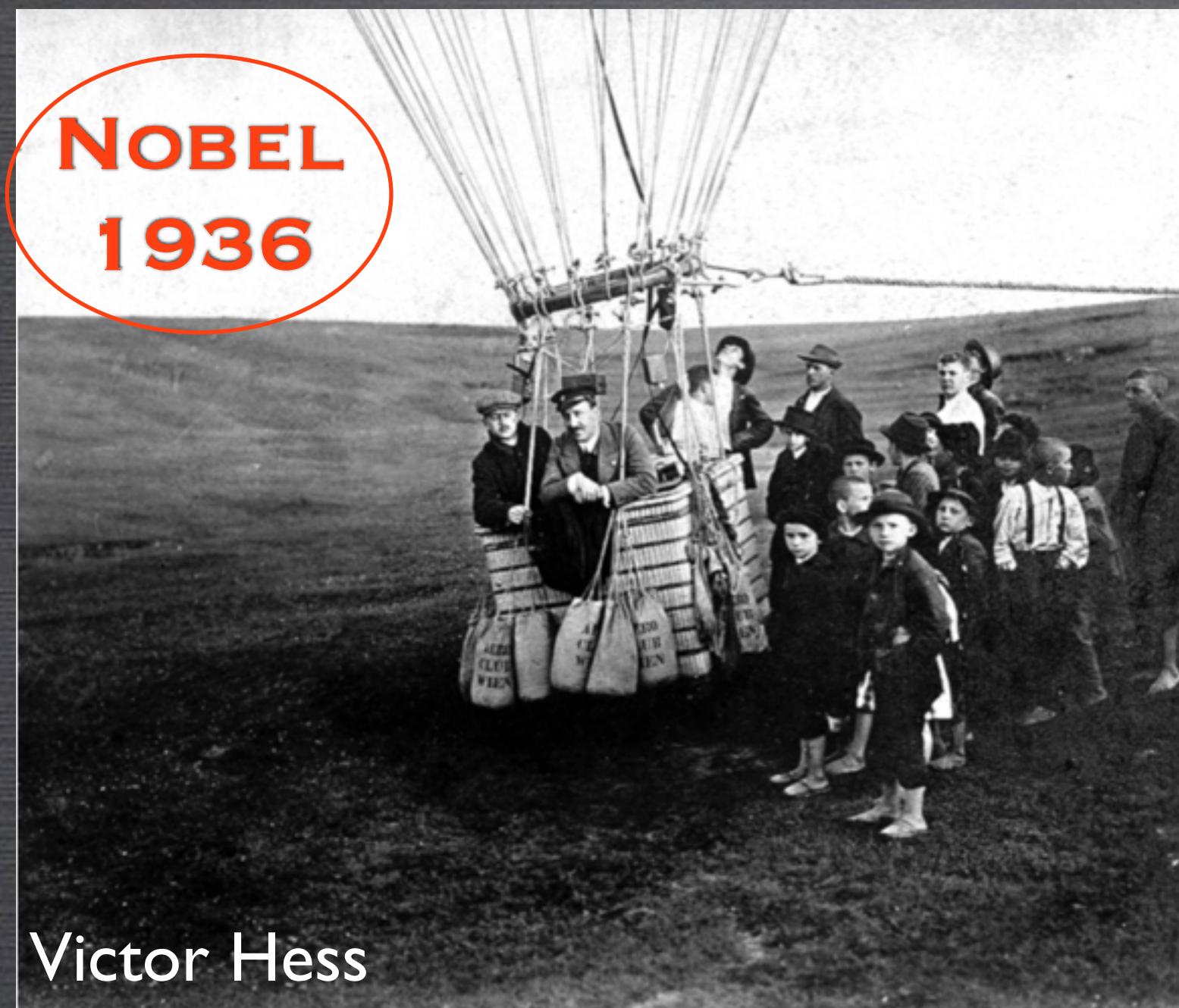


β = électron, α = Hélium, γ = photons, X = photons + neutrino

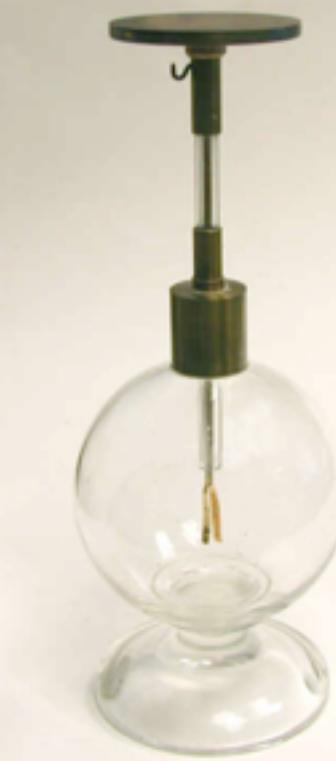
DÉCHARGE



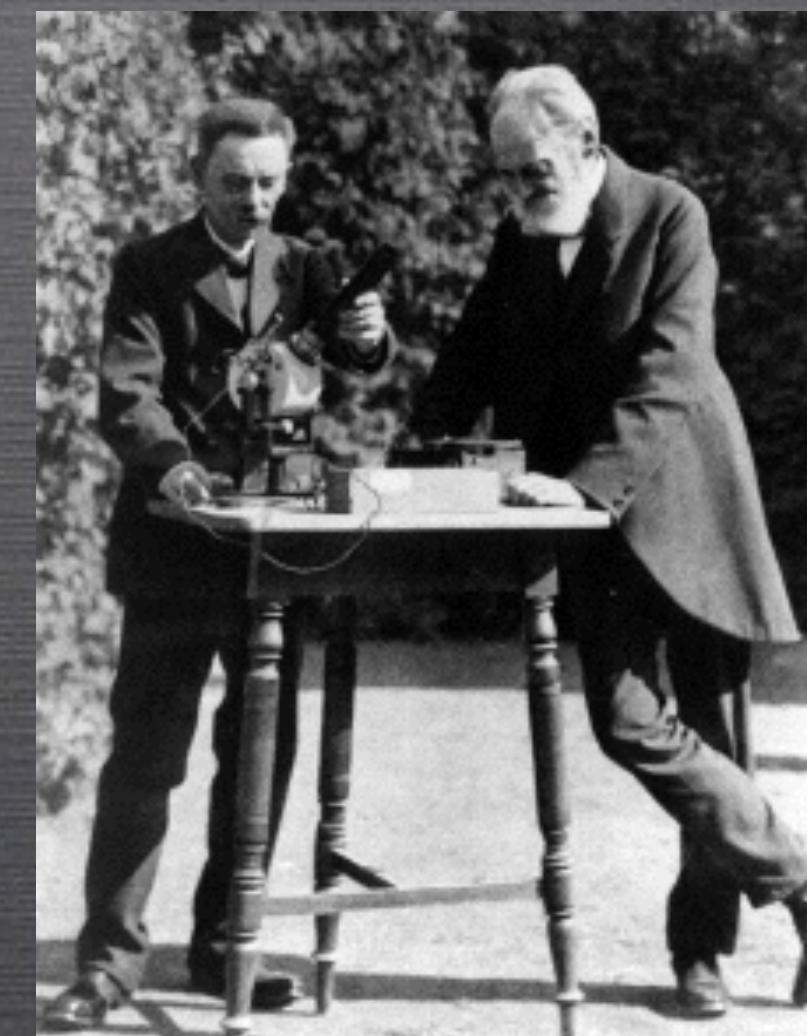
NOBEL
1936



PREMIERS PAS



LA DÉCHARGE DES ÉLECTROSCOPES...

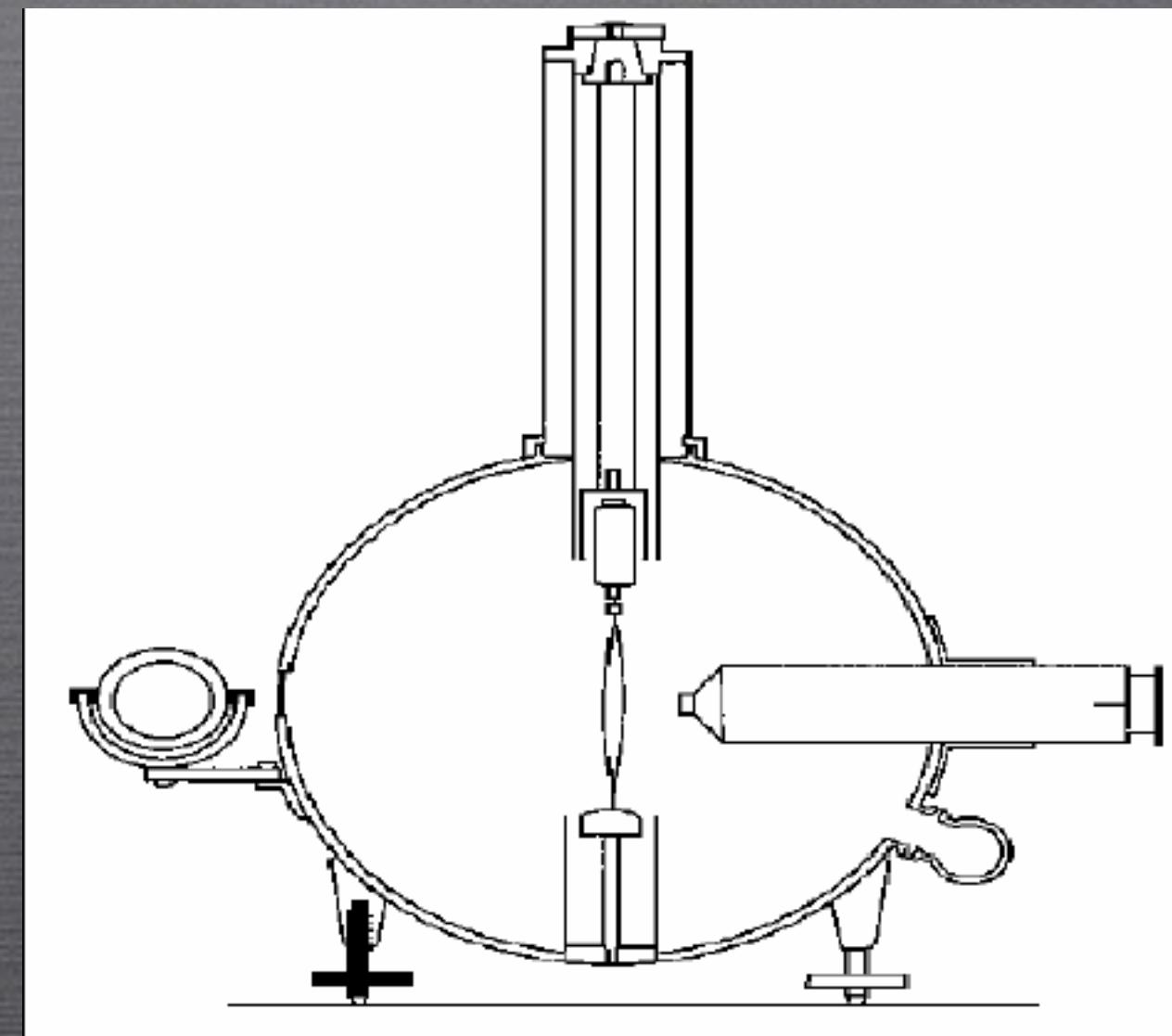


ELSTER & GEITEL

THÉODORE WULF (1907)



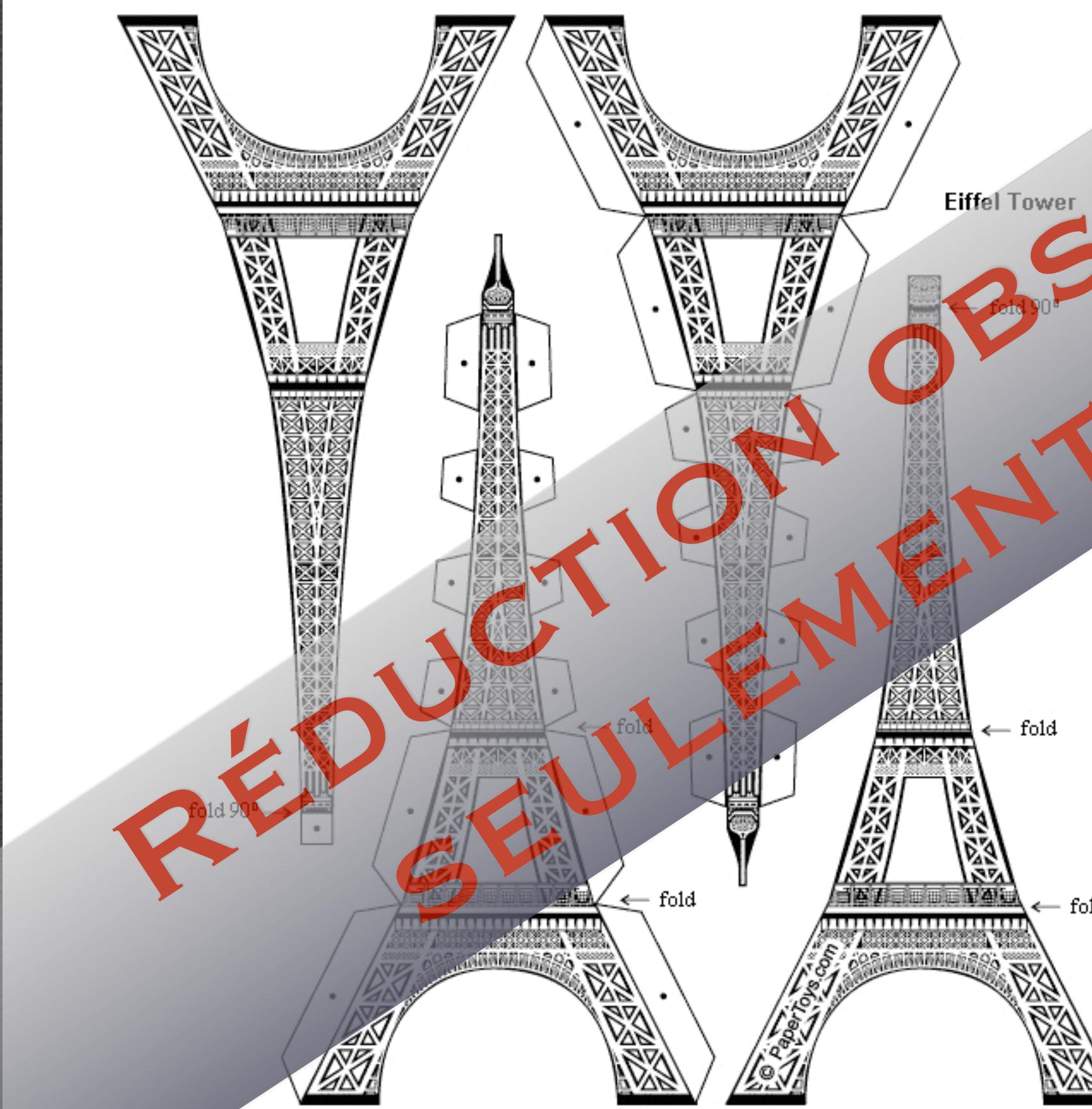
330 M



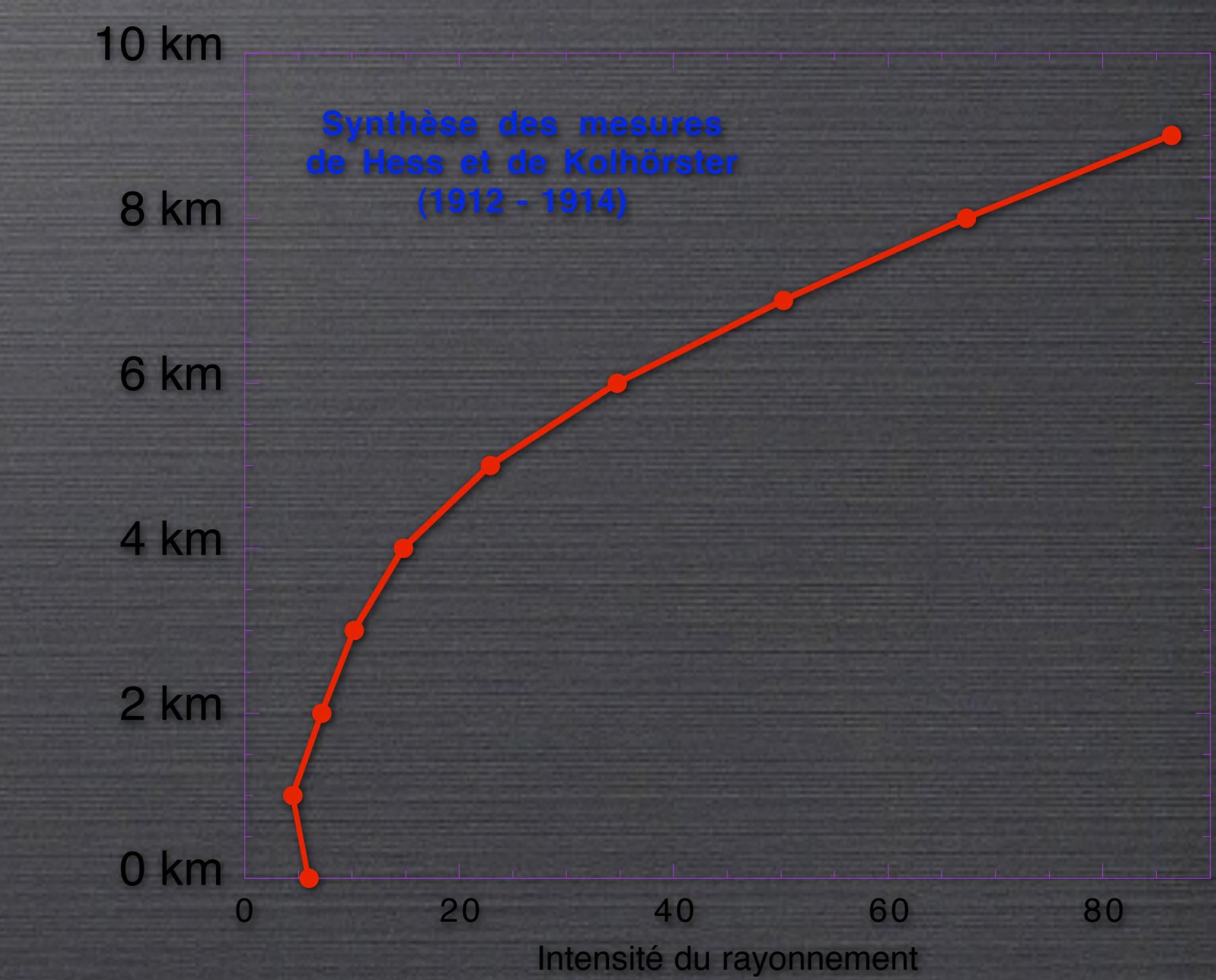
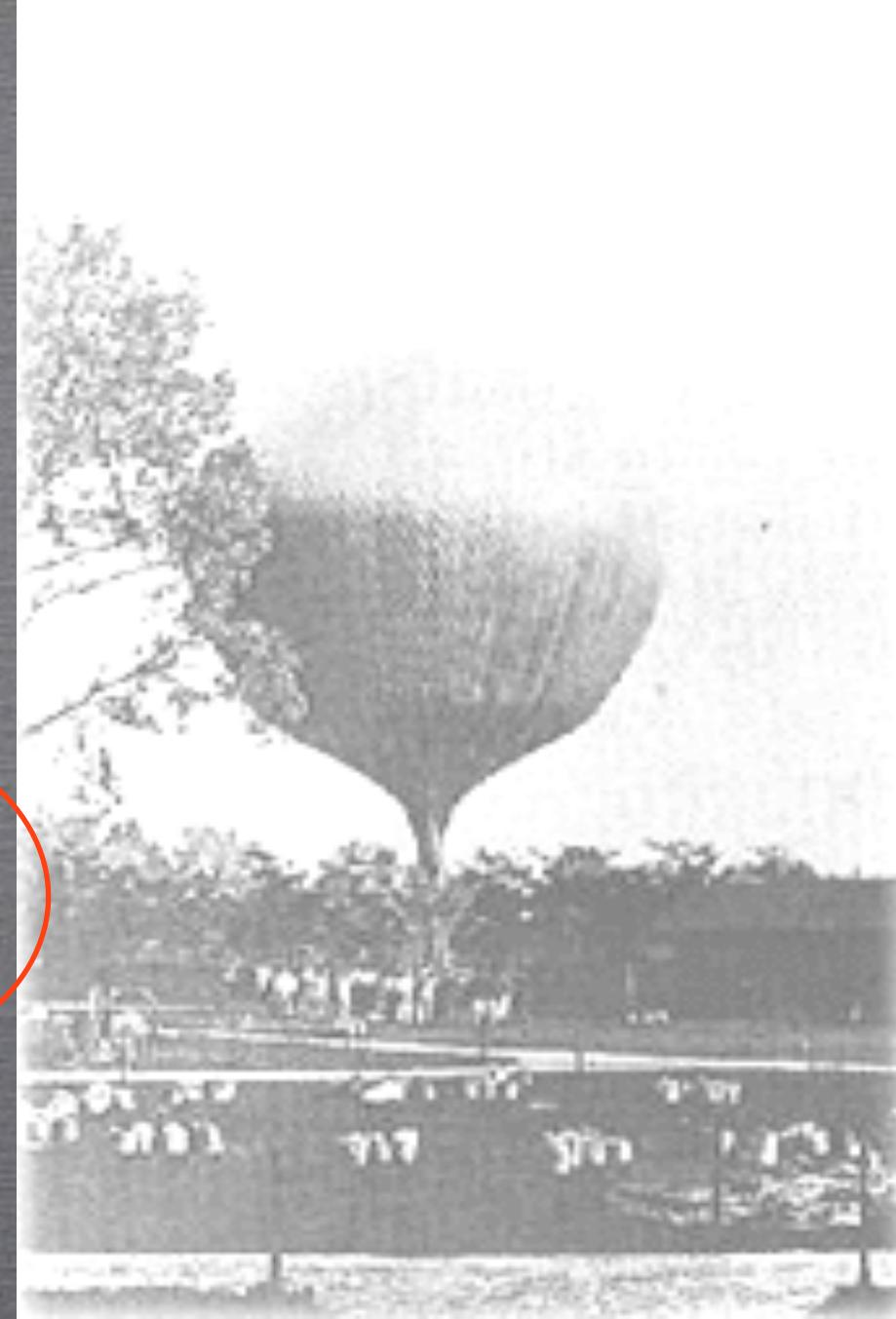
RÉDUCTION ATTENDUE:

50% TOUS LES 80M SOIT PLUS DE 90% AU SOMMET

THÉODORE WULF (1907)



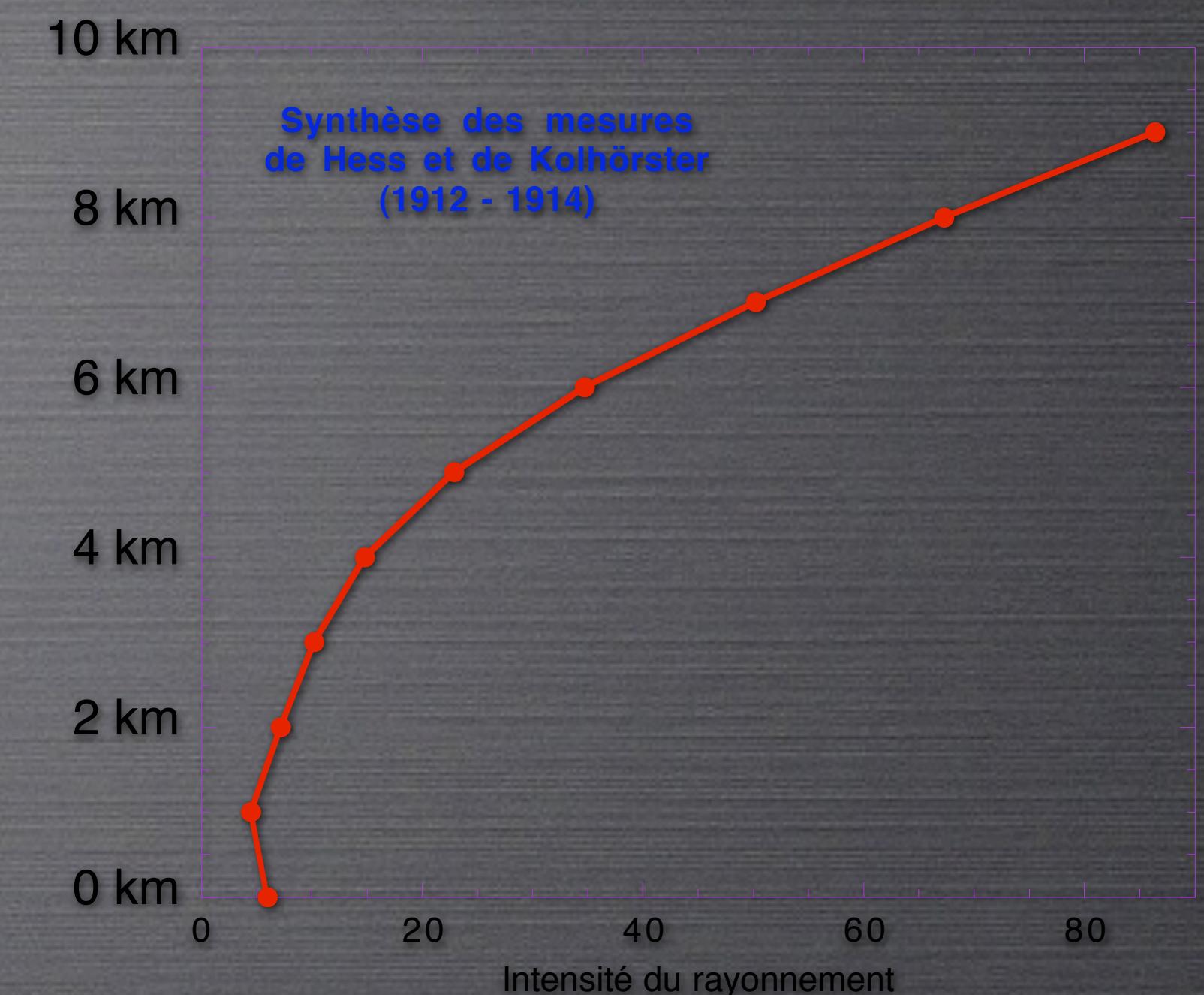
VICTOR HESS (1912)



VICTOR HESS (1912)



« Theses observations can be most simply explained assuming that an extremely penetrating radiation is coming from above » (V. Hess)

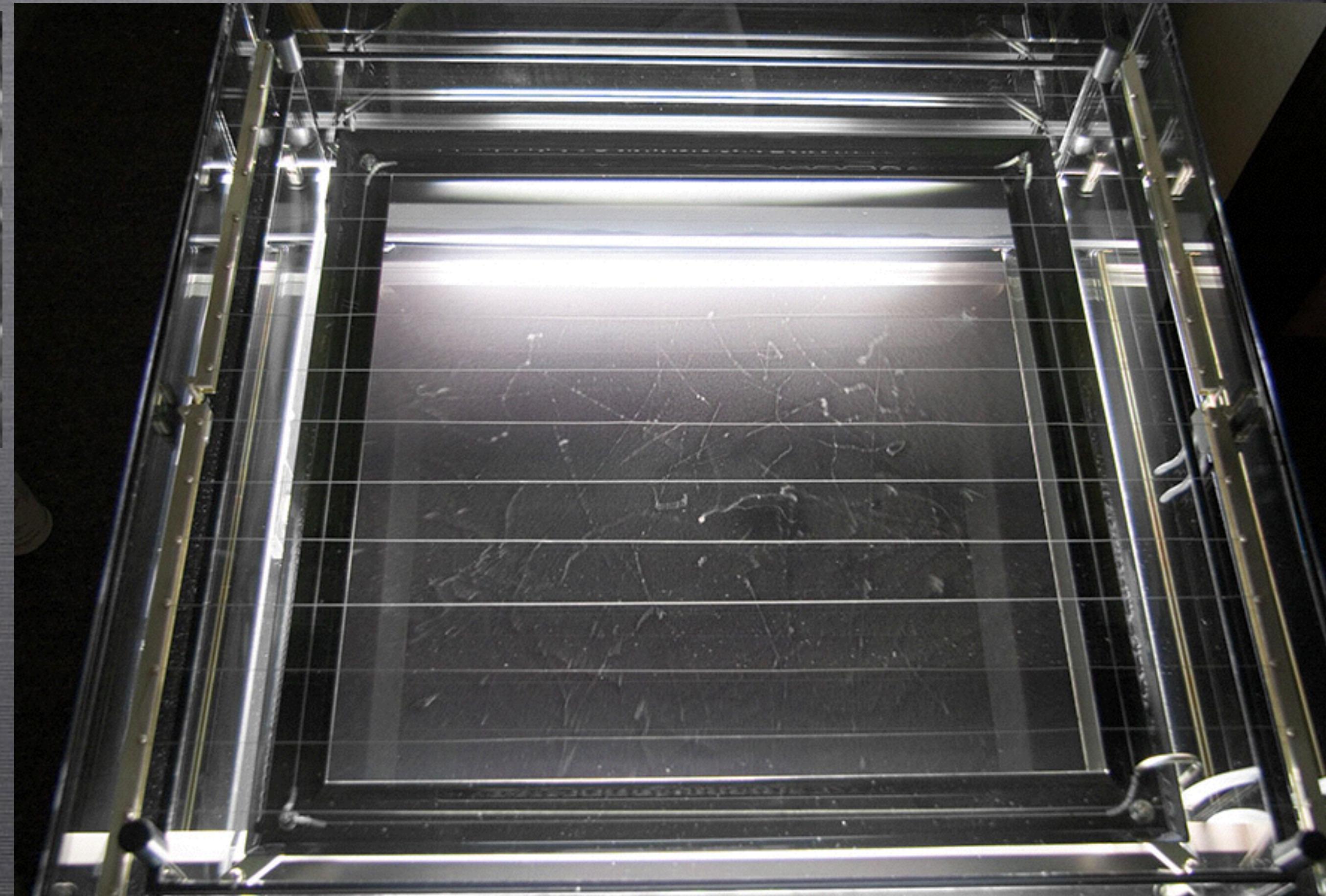


CES OBSERVATIONS S'EXPLIQUE LE PLUS SIMPLEMENT SI ON ADMET QU'UNE RADIATION EXTRÊMEMENT PÉNÉTRANTE ARRIVE PAR LE HAUT

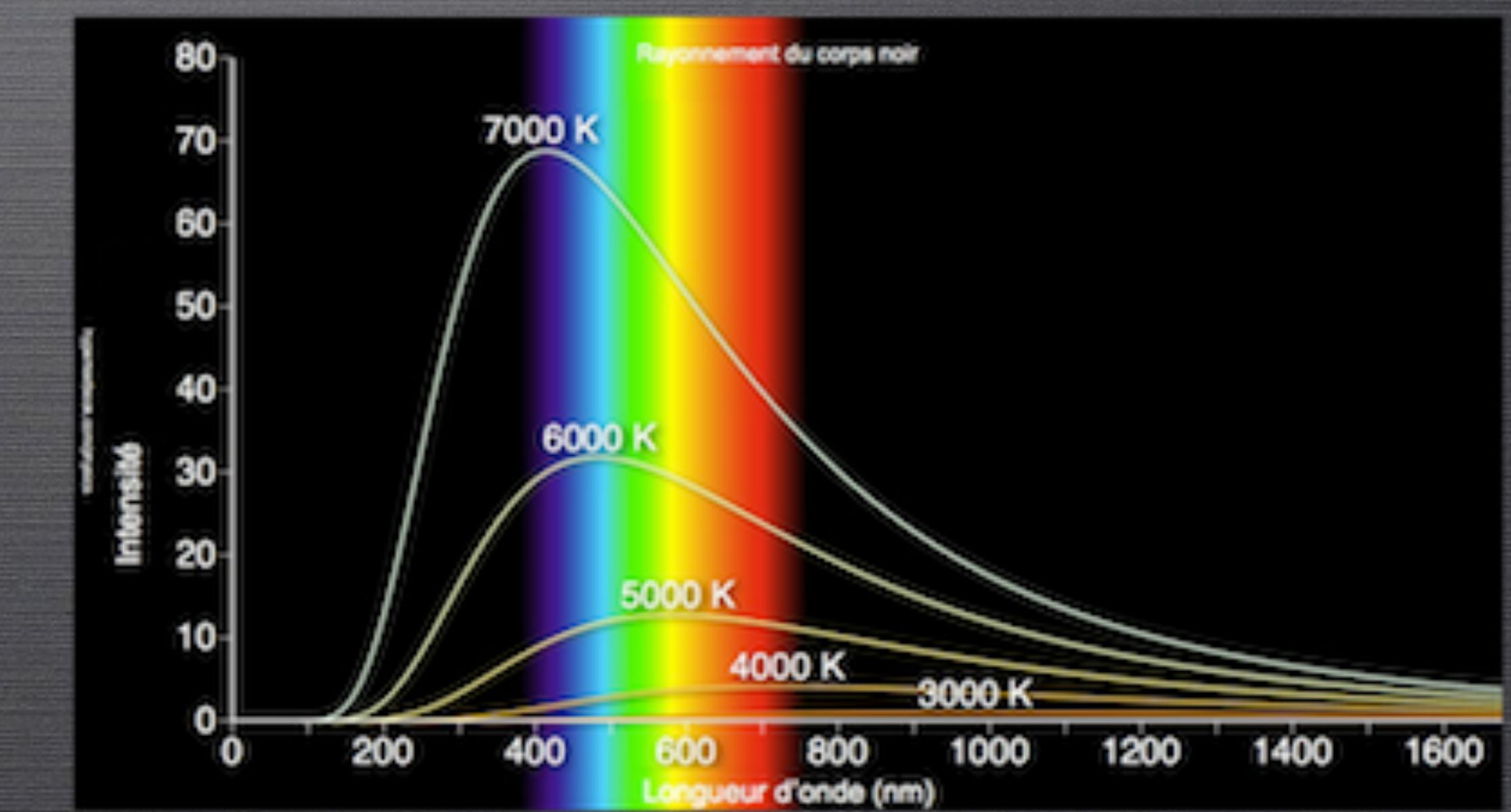
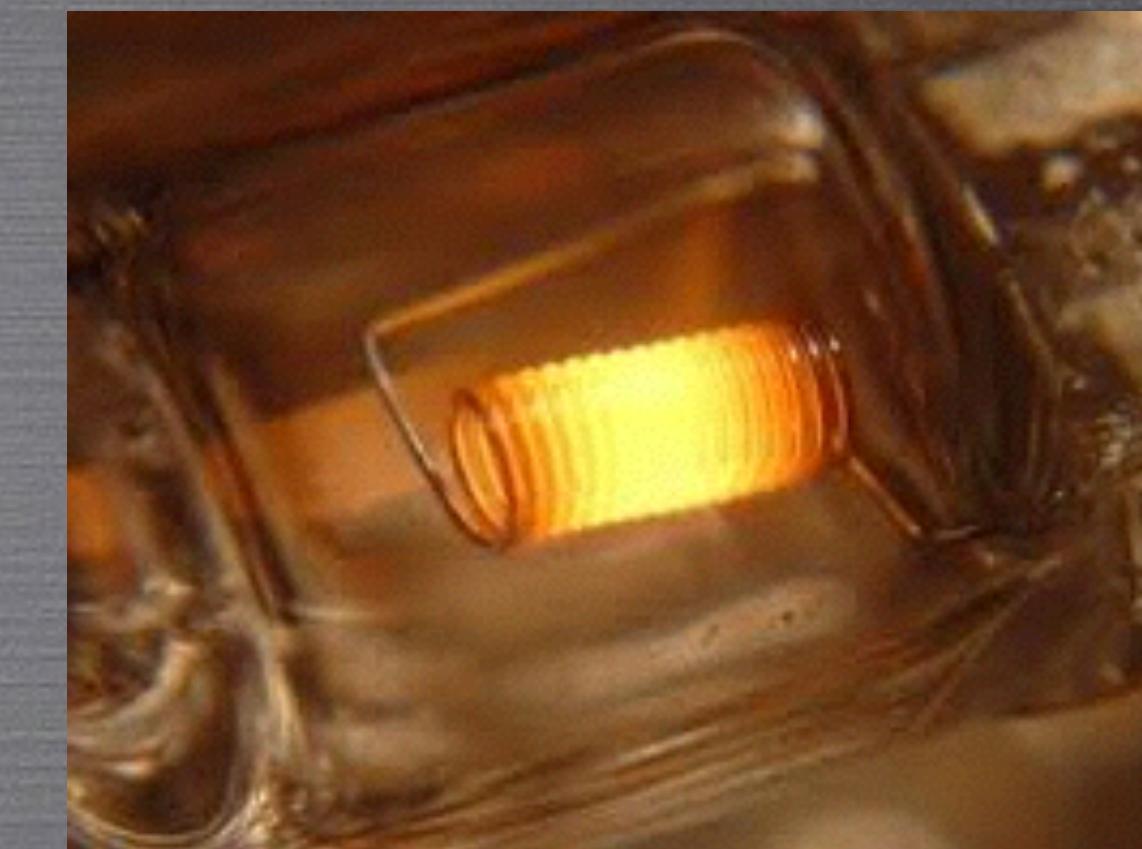
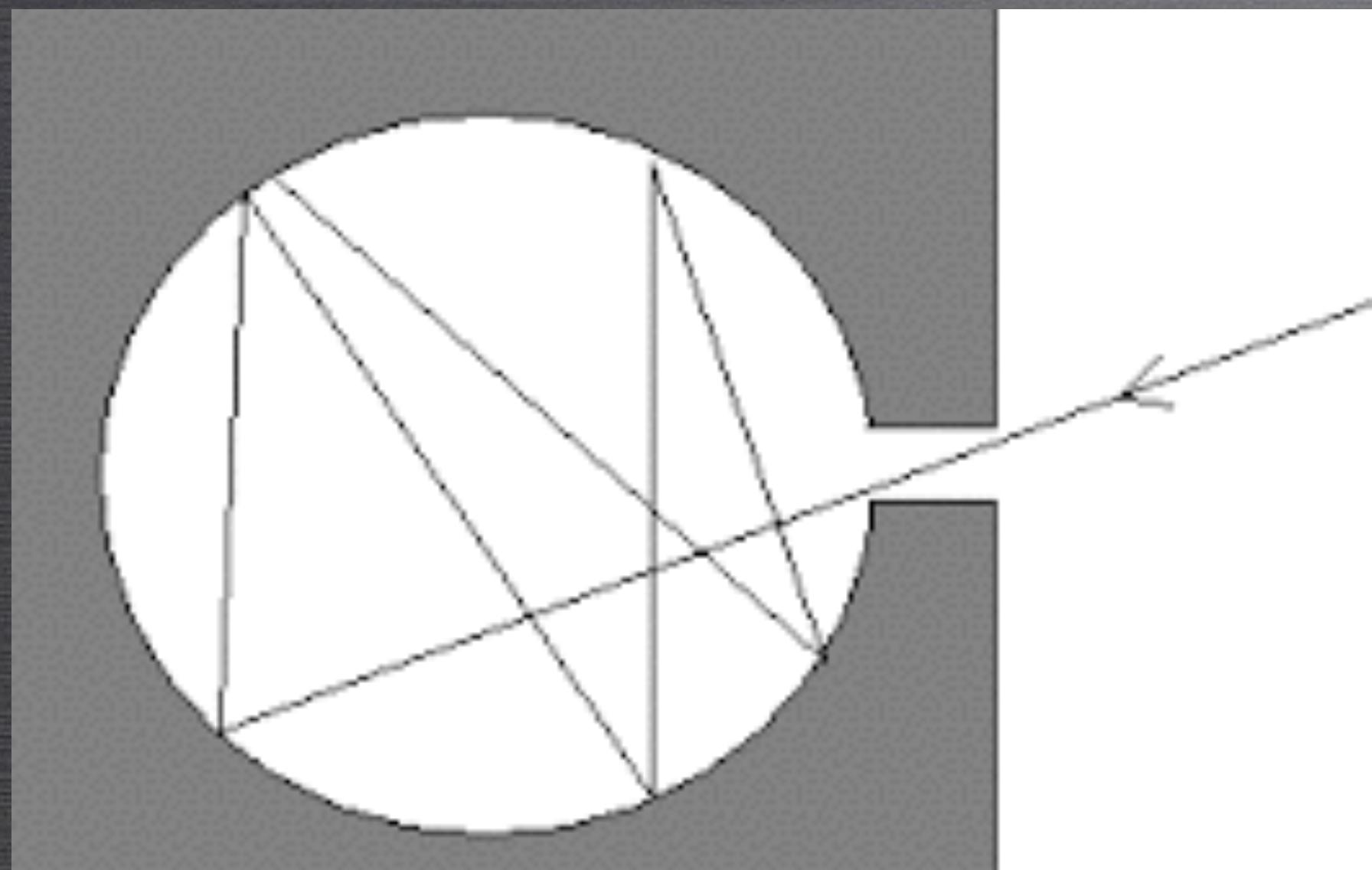
LES NUAGES!



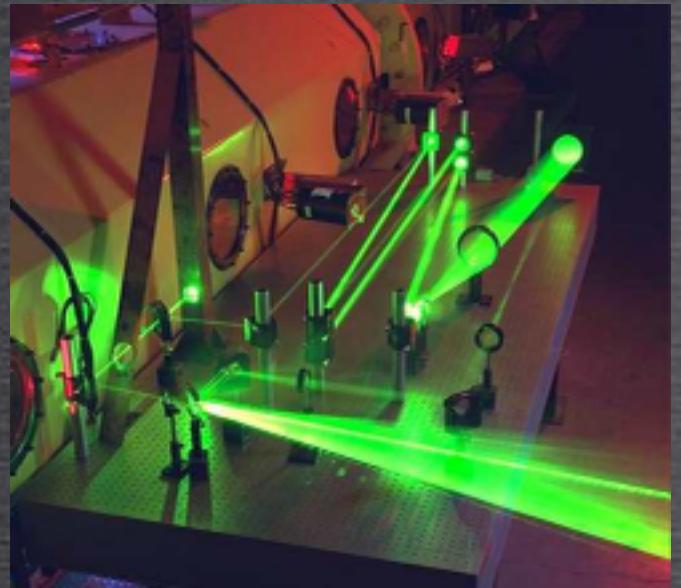
Charles Wilson



CORPS NOIR



QUANTIQUE



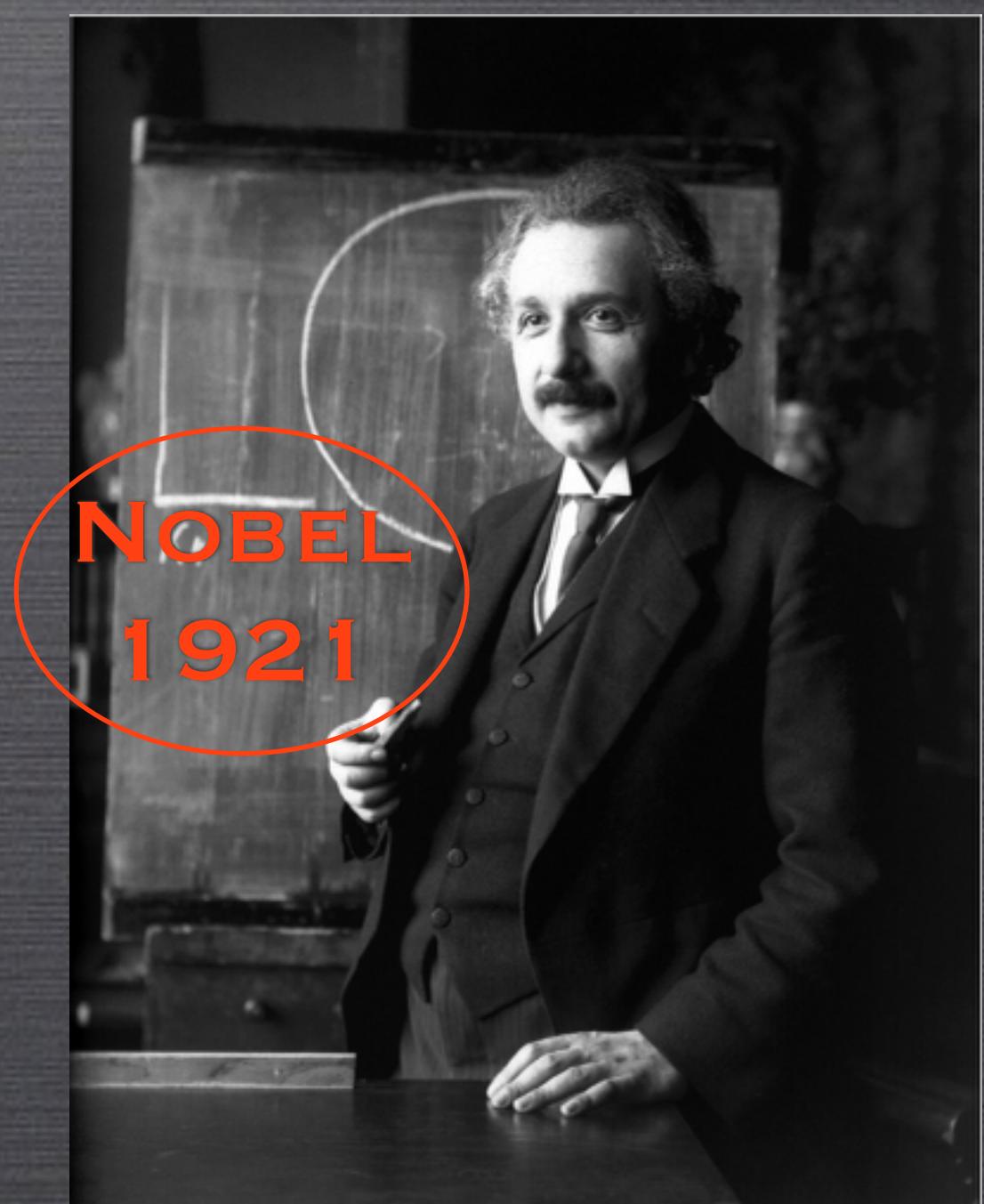
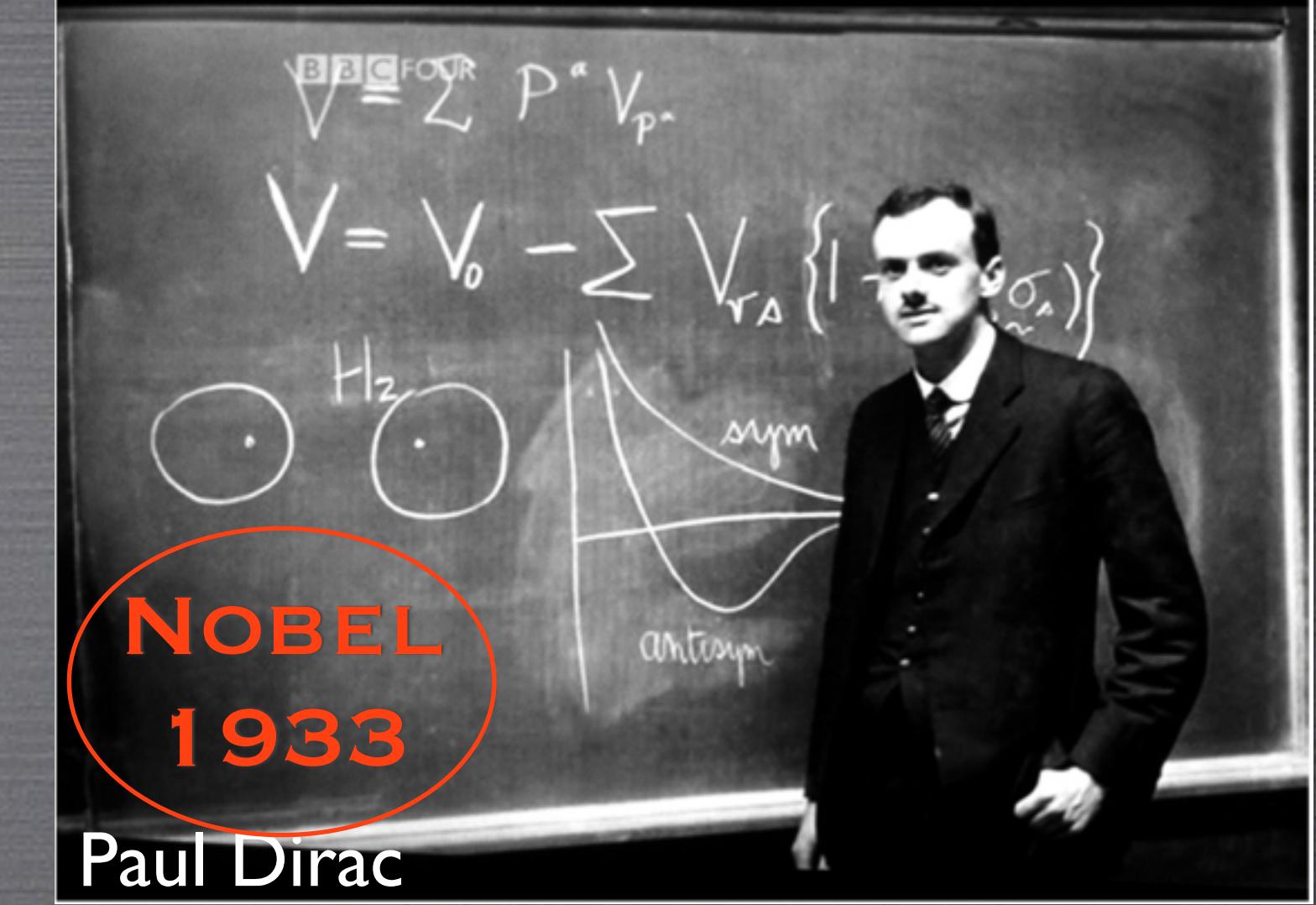
NOBEL
1918

Max Planck

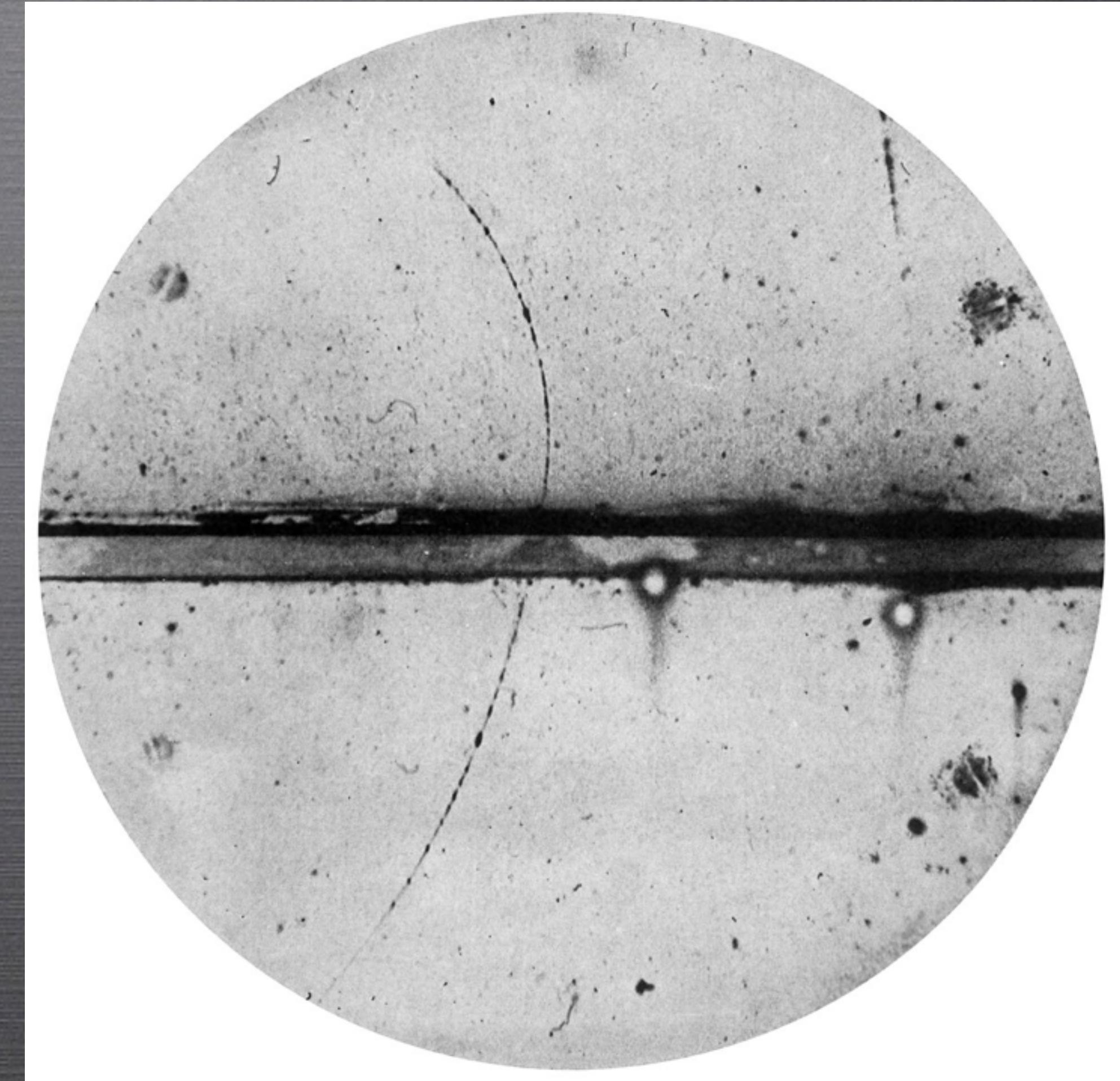
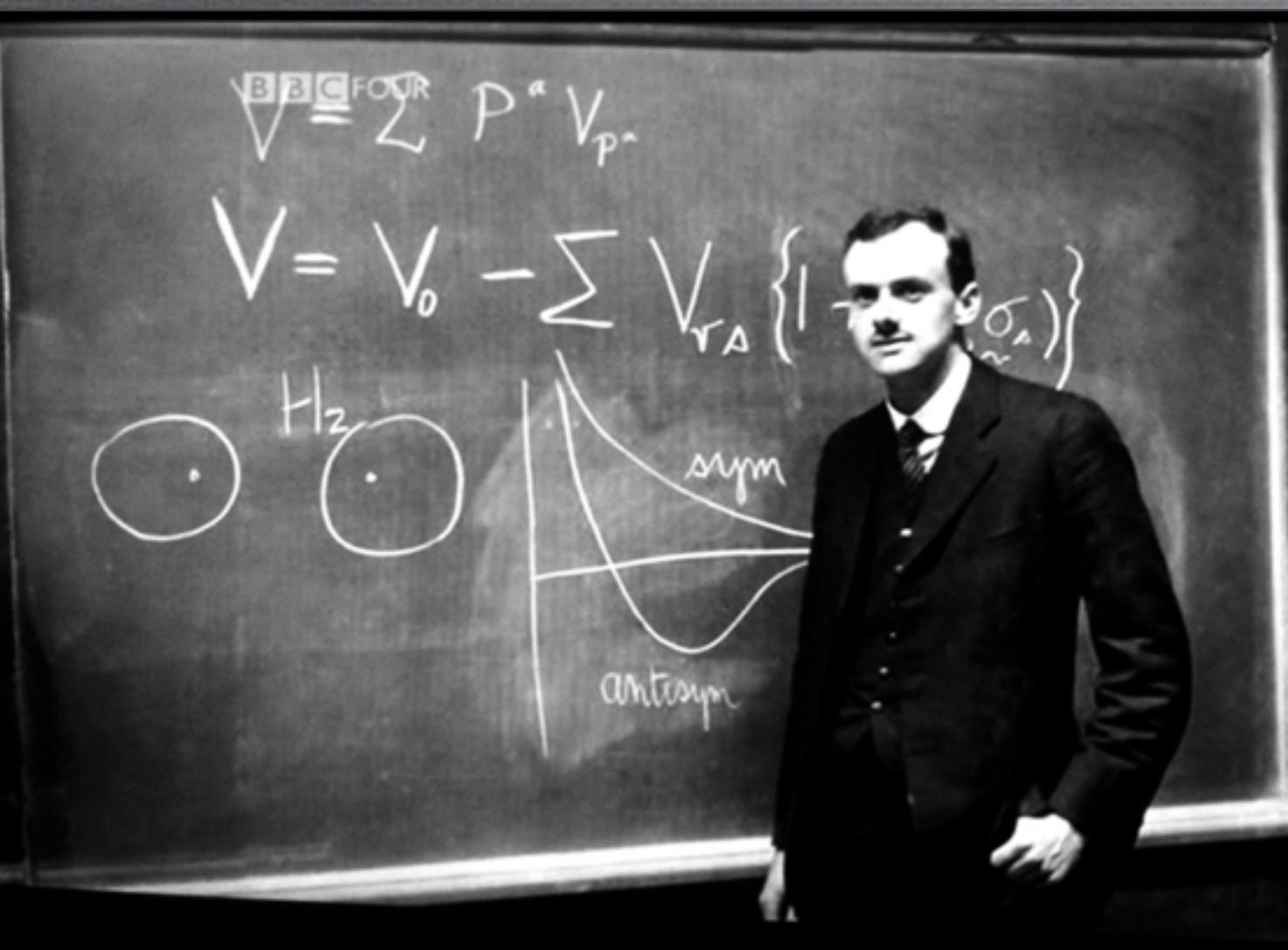
Carl Anderson

NOBEL
1936

James Maxwell



L'ANTIMATIÈRE !



NAISSANCE DE LA PHYSIQUE DES PARTICULES

30 ANS DE DÉCOUVERTES MAJEURES

1913-1914 KOLHÖRSTER CONFIRME L'AUGMENTATION DE L'IONISATION (x7 à 9 KM)

1923-1926 MILLIKAN, BOWEN, CAMERON OBSERVENT À 15KM (COUPURE GÉOMAGNÉTIQUE) MILLIKAN, BOWEN, CAMERON OBSERVENT À 15KM (COUPURE GÉOMAGNÉTIQUE) MILLIKAN, BOWEN, CAMERON OBSERVENT À 15KM (COUPURE GÉOMAGNÉTIQUE)

NOBEL
1923

RAYON GAMMA TRÈS PÉNÉTRANTS DE HAUTES ÉNERGIES

LES RAYONS COSMIQUES

CRI DE NAISSANCE DES ATOMES

1927 CLAY EFFET GÉOMAGNÉTIQUE

1930-1933 ROSSI, JOHNSON, ALVAREZ, COMPTON

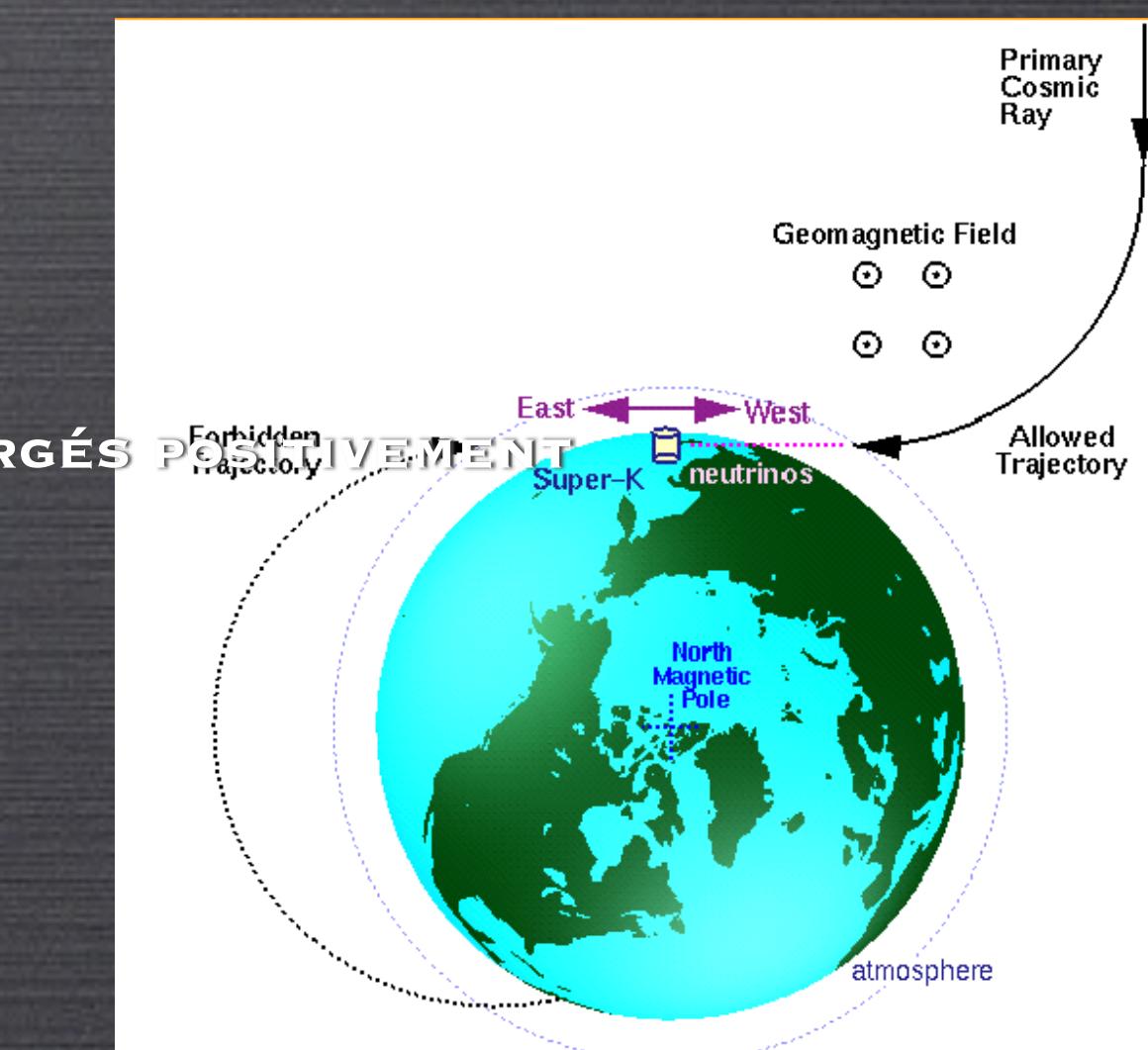
NOBEL
1927

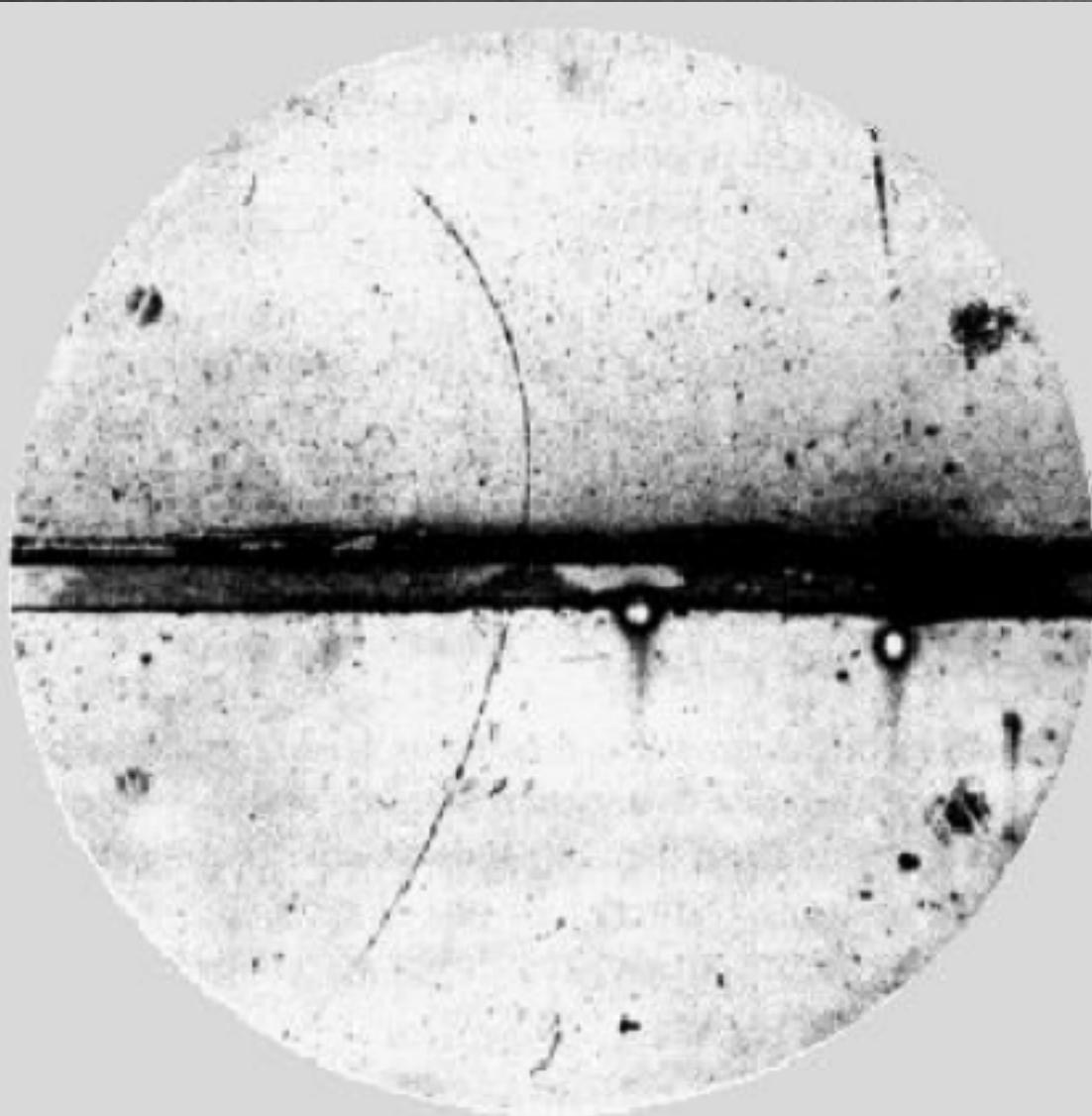
LES R.C. SONT PRÉFÉRENTIELLEMENT CHARGÉS POSITIVEMENT

1927: During his trip from Amsterdam to Java, J. Clay – by carrying ionization detectors onboard ships – discovered that the ionization rate increased with latitude. It was the first observation of a **geomagnetic latitude effect** and very important evidence that the sources of ionization were, at least in part, **charged particles** deflected by an external field. In the period from 1928 to 1932 Clay investigated the latitude effect further by taking the ionization camber on 3 sea voyages between Europe and Java via the Suez Canal. He again found a consistently lower intensity near the equator.

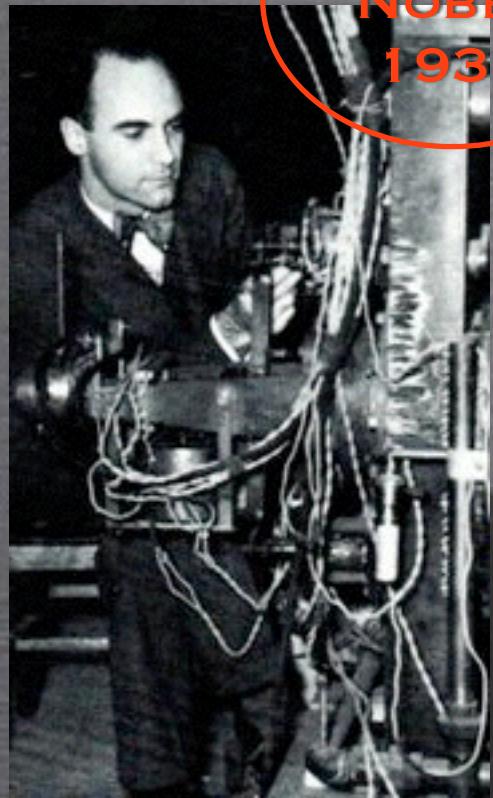
1930: Bruno Rossi, using Störmer's theory, showed that if the cosmic rays were predominantly of one charge or the other there should be an **east-west effect**.

1933: Two American groups, Thomas H. Johnson of the Bartol Research Foundation and Luis Alvarez and Arthur H. Compton of the University of Chicago, simultaneously and independently measured the east-west effect (the east side of the detector was more active). They showed the cosmic radiation to be predominantly **positively charged**.





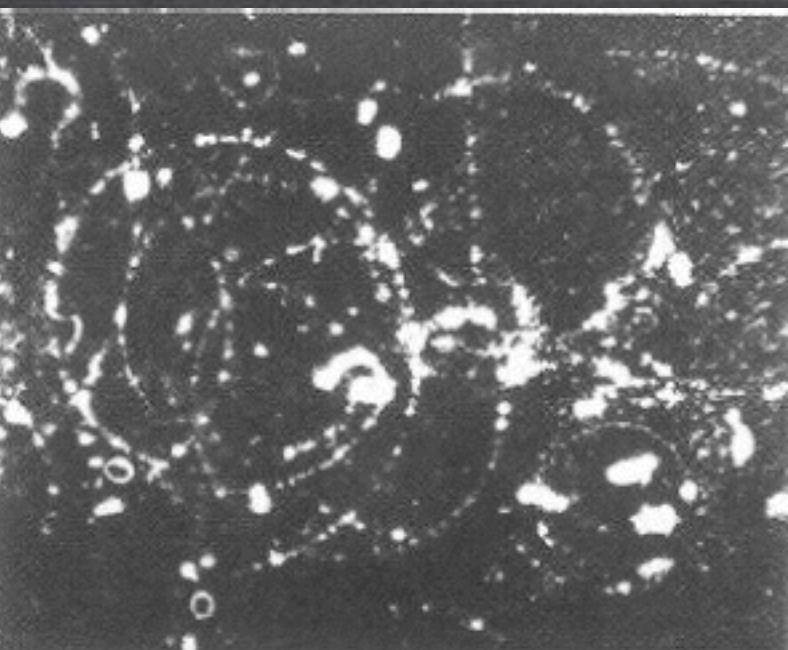
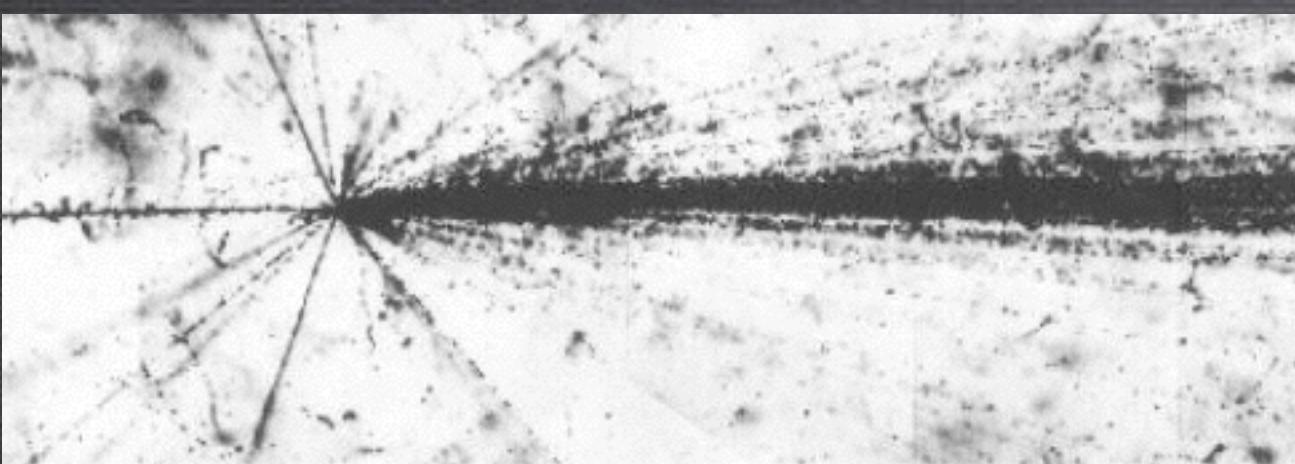
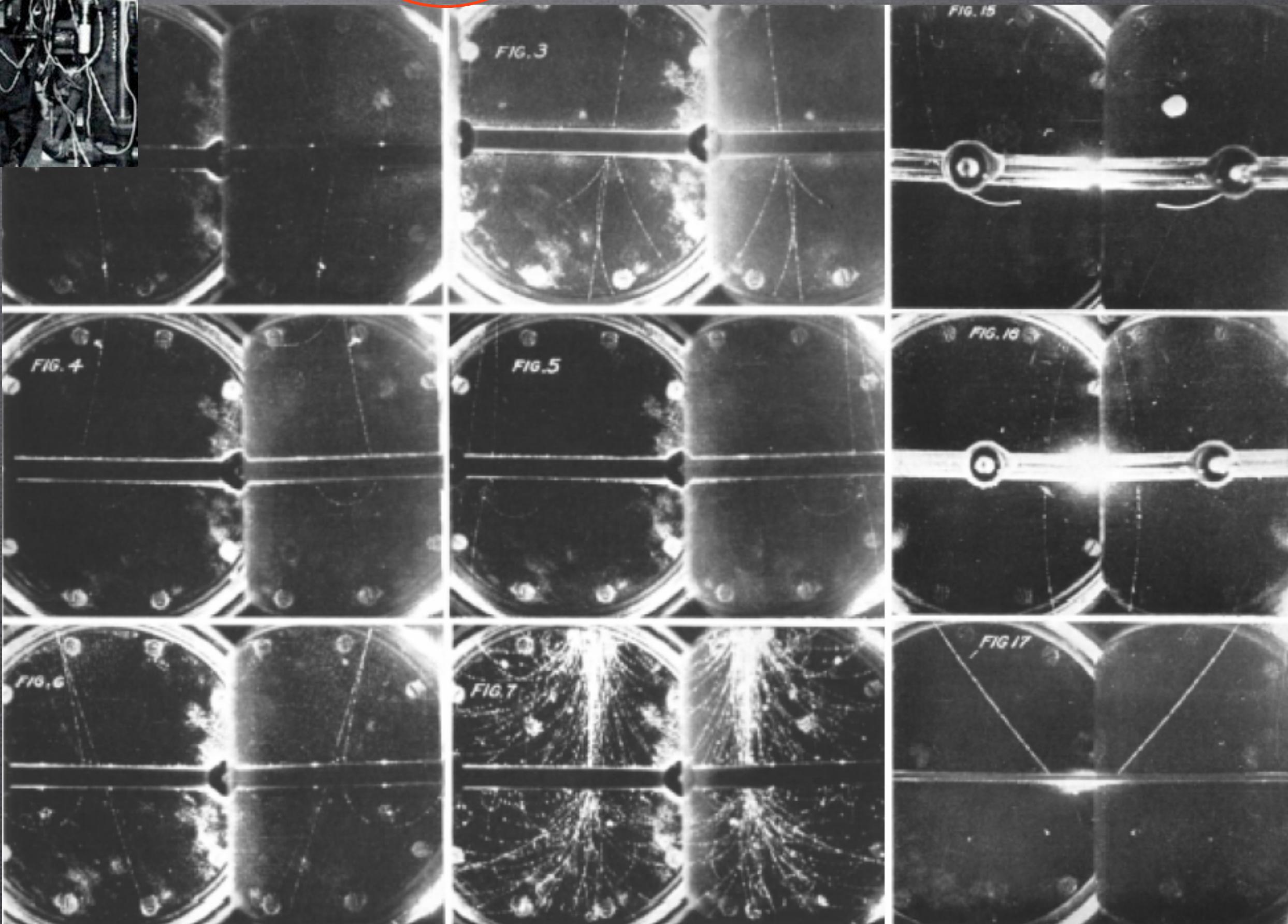
1932 **ANDERSON** DÉCOUVRE L'ANTIMATIÈRE (LE POSITRON) ORÉDIT PAR DIRAC EN 1928
NOBEL 1936



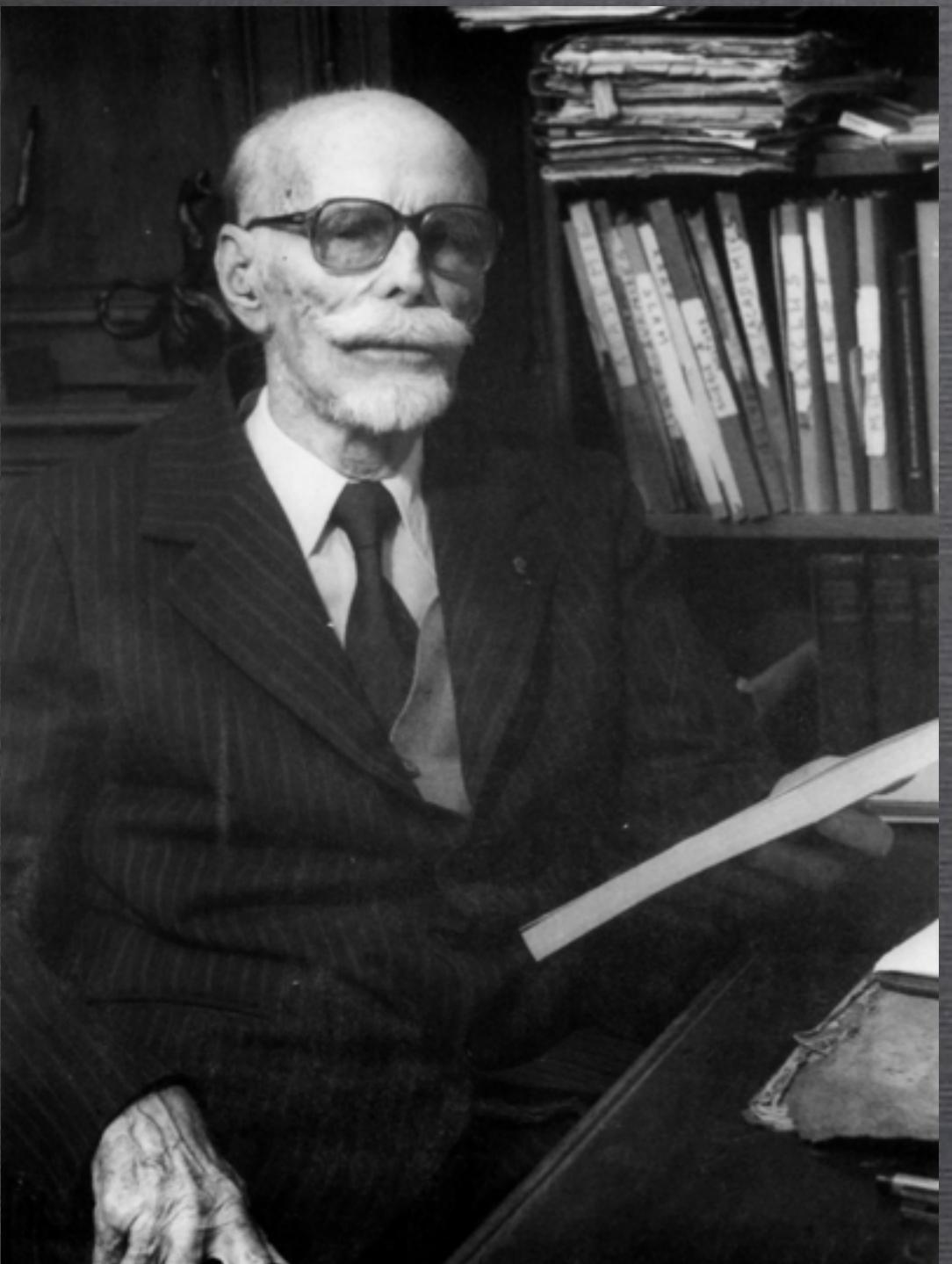
1932 **ANDERSON & NEDDERMEYER** DÉCOUVRE LE MUON

1947 **POWELL, LATTES & OCCHIALINI** DÉCOUVRE LE PION
NOBEL 1950

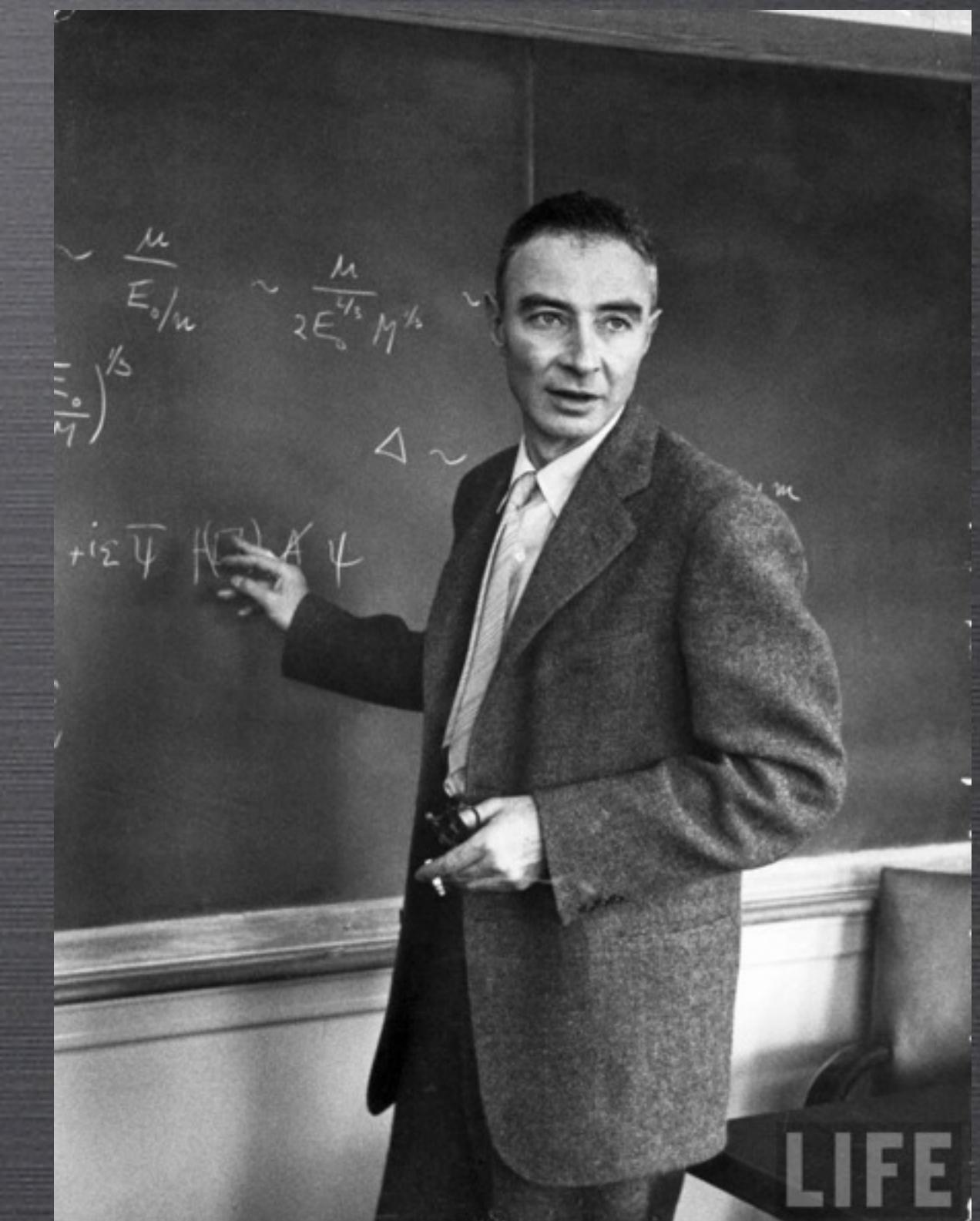
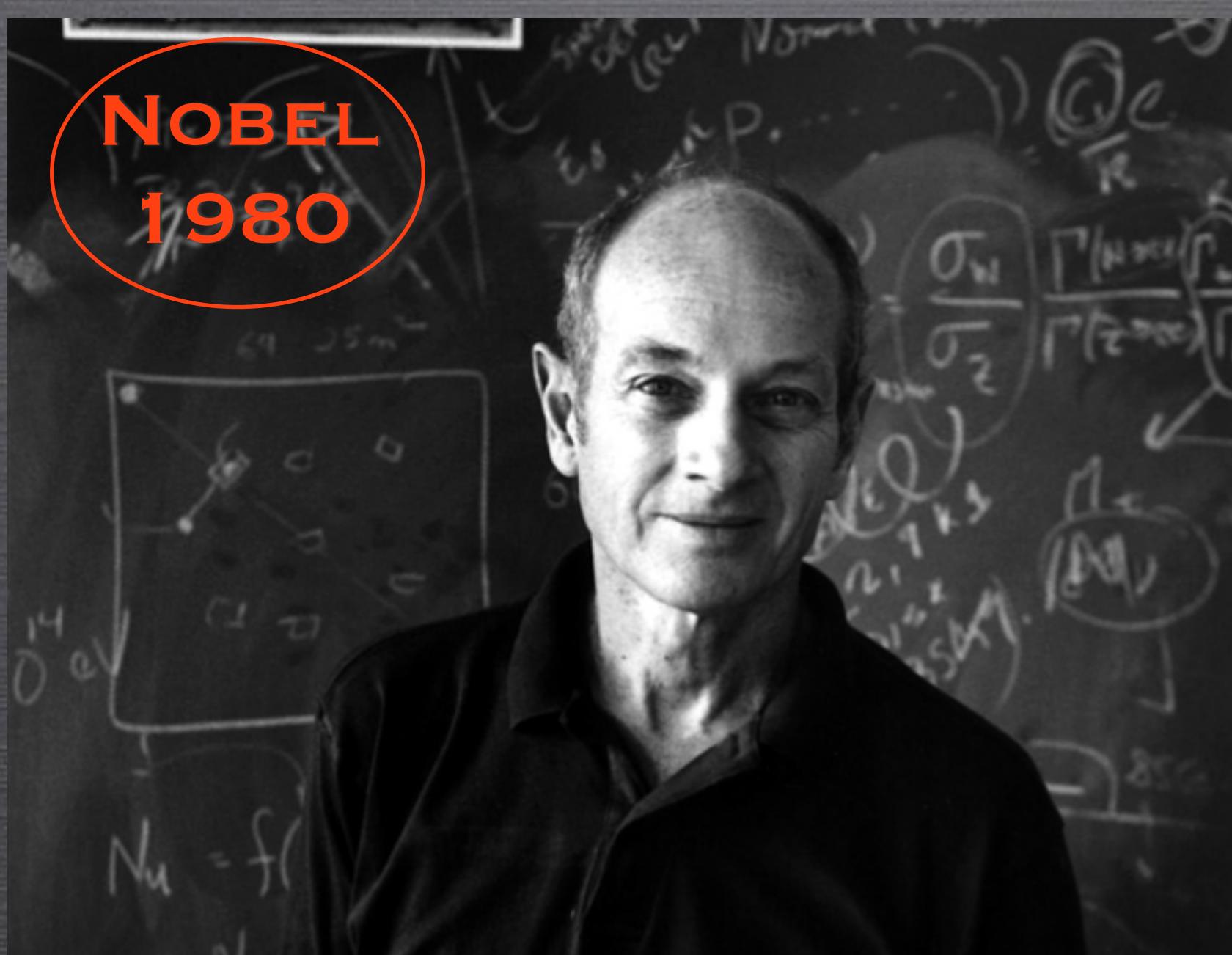
+ ...



CASCADES

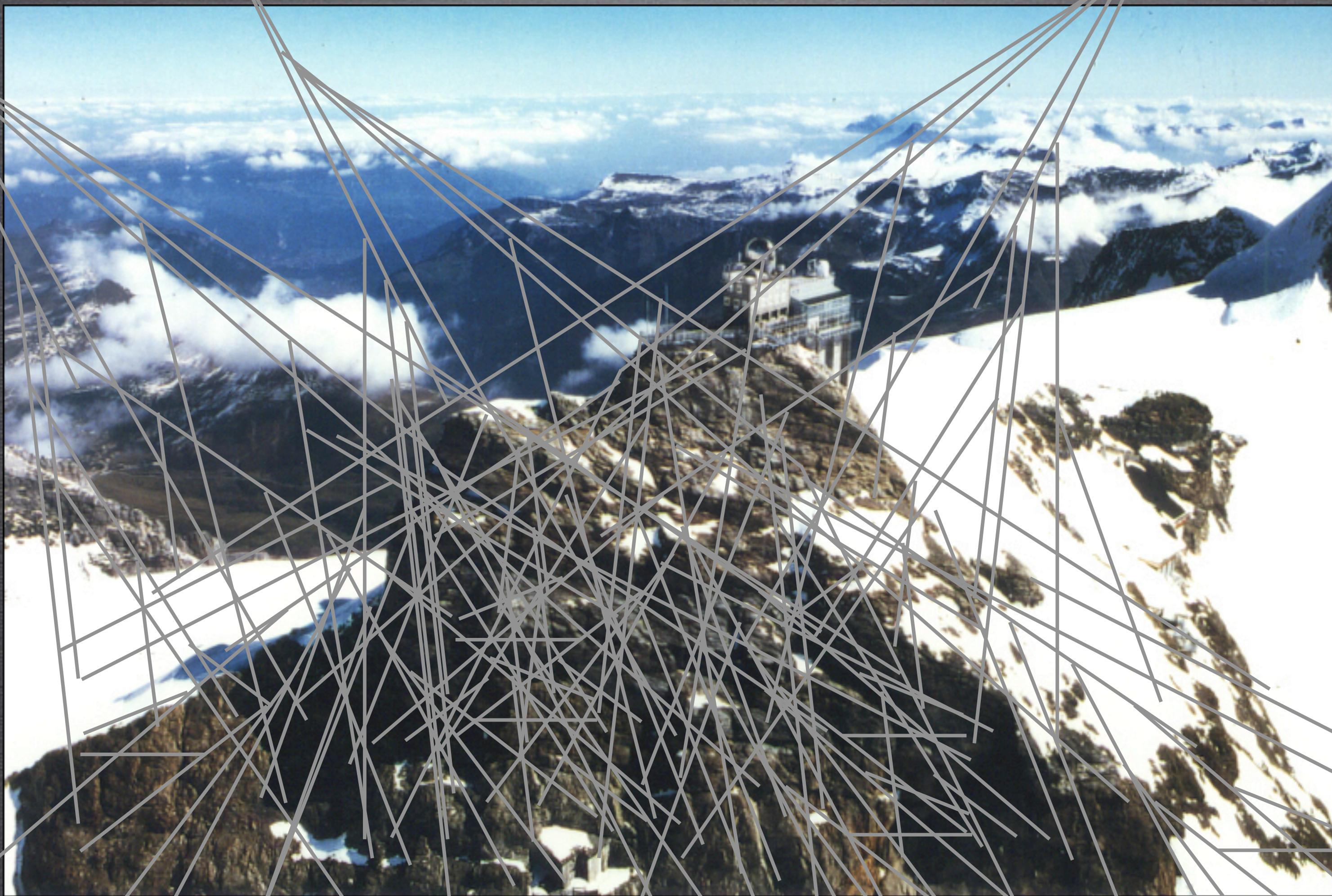


NOBEL
1980



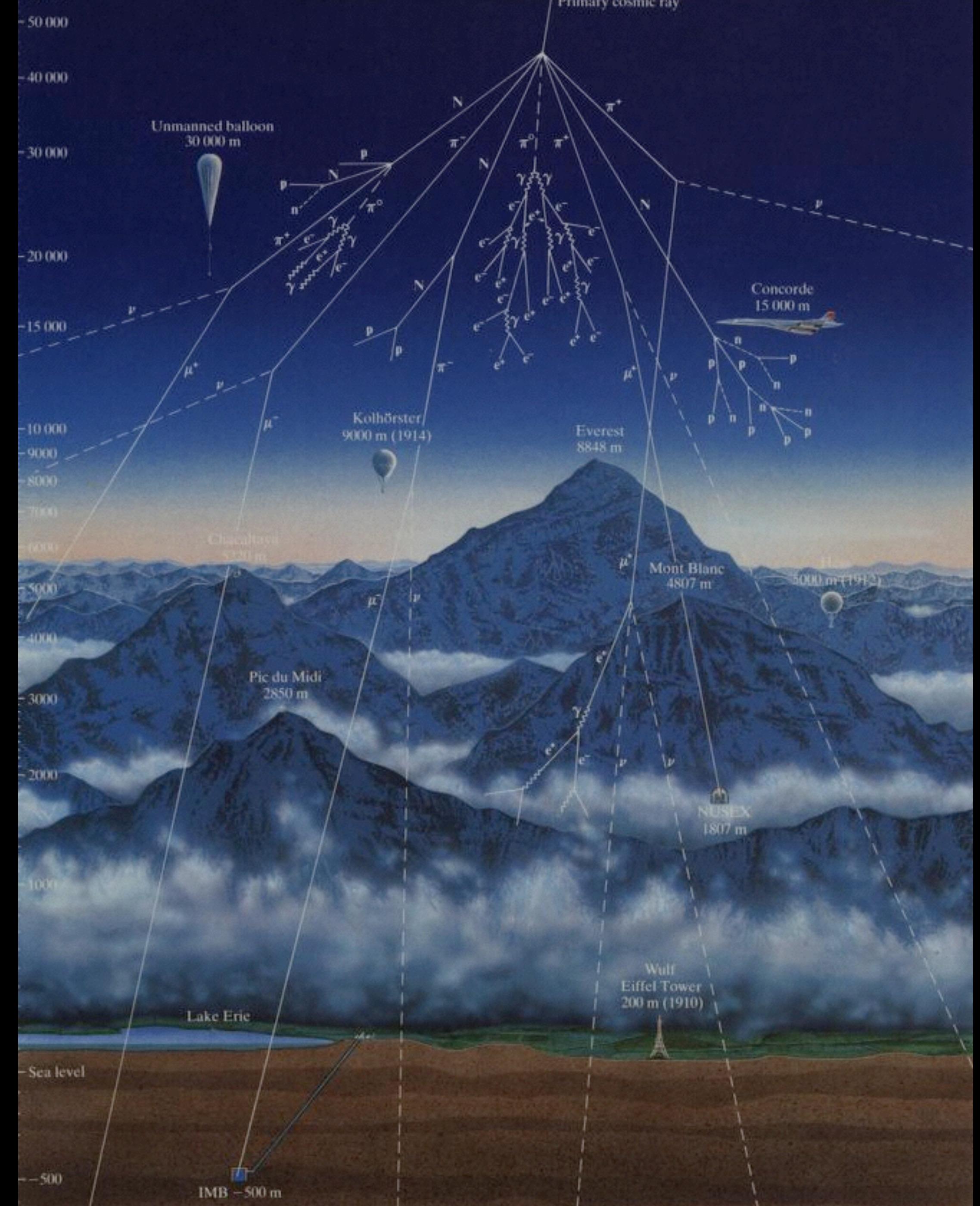
PIERRE AUGER (1938)

DÉCOUVERTE DES GRANDES GERBES
ATMOSPHÉRIQUES



1960

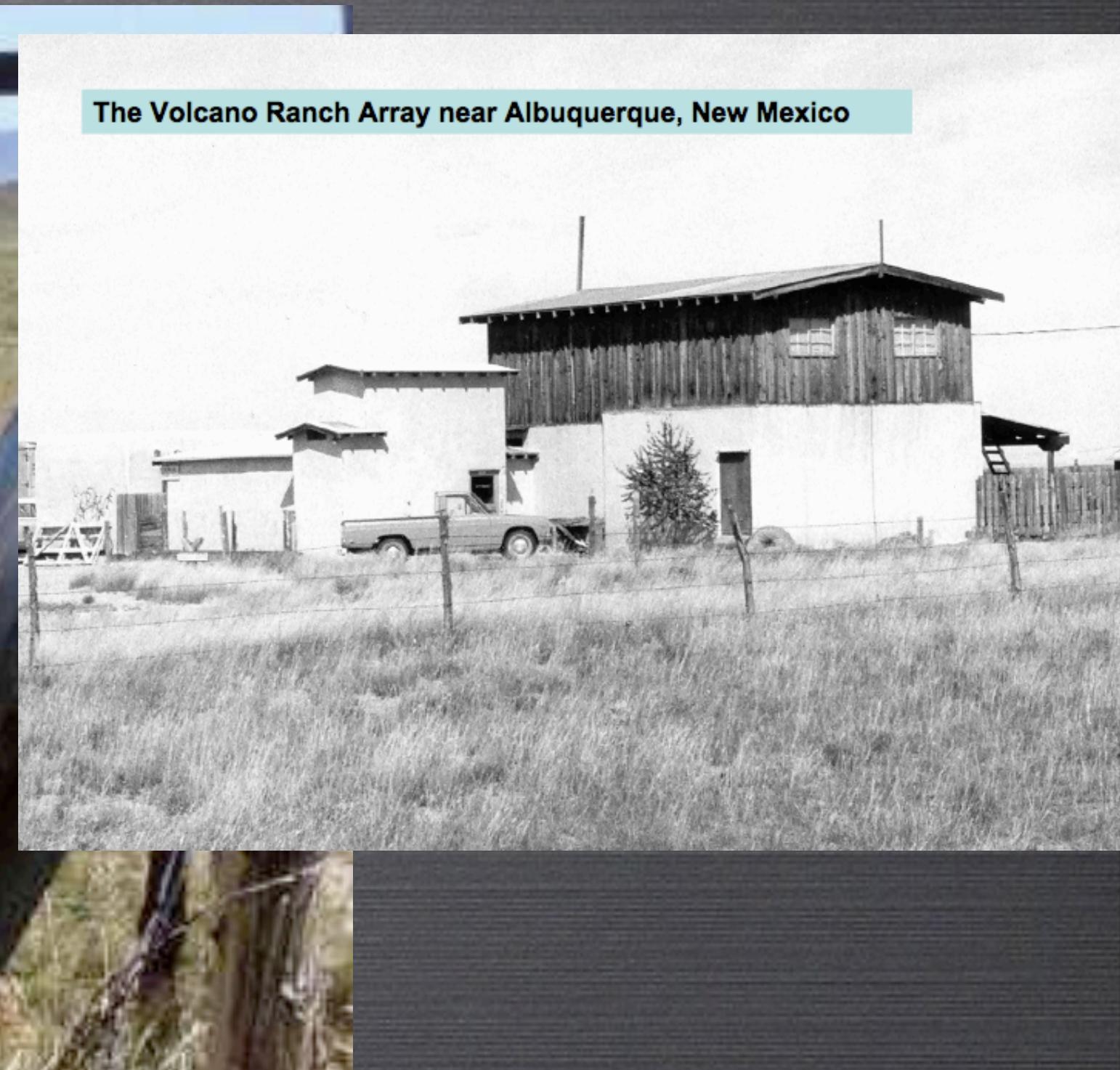
GRAND



JOHN LINSLEY (1962) - VOLCANO RANCH - NOUVEAU MEXIQUE



The Volcano Ranch Array near Albuquerque, New Mexico



UN PROTON DE 10^{20} EV
(100 000 000 000 000 000 000 EV)

C'EST :



L'ÉNERGIE DE **MYKE TYSON** DANS UNE PARTICULE
ÉLÉMENTAIRE

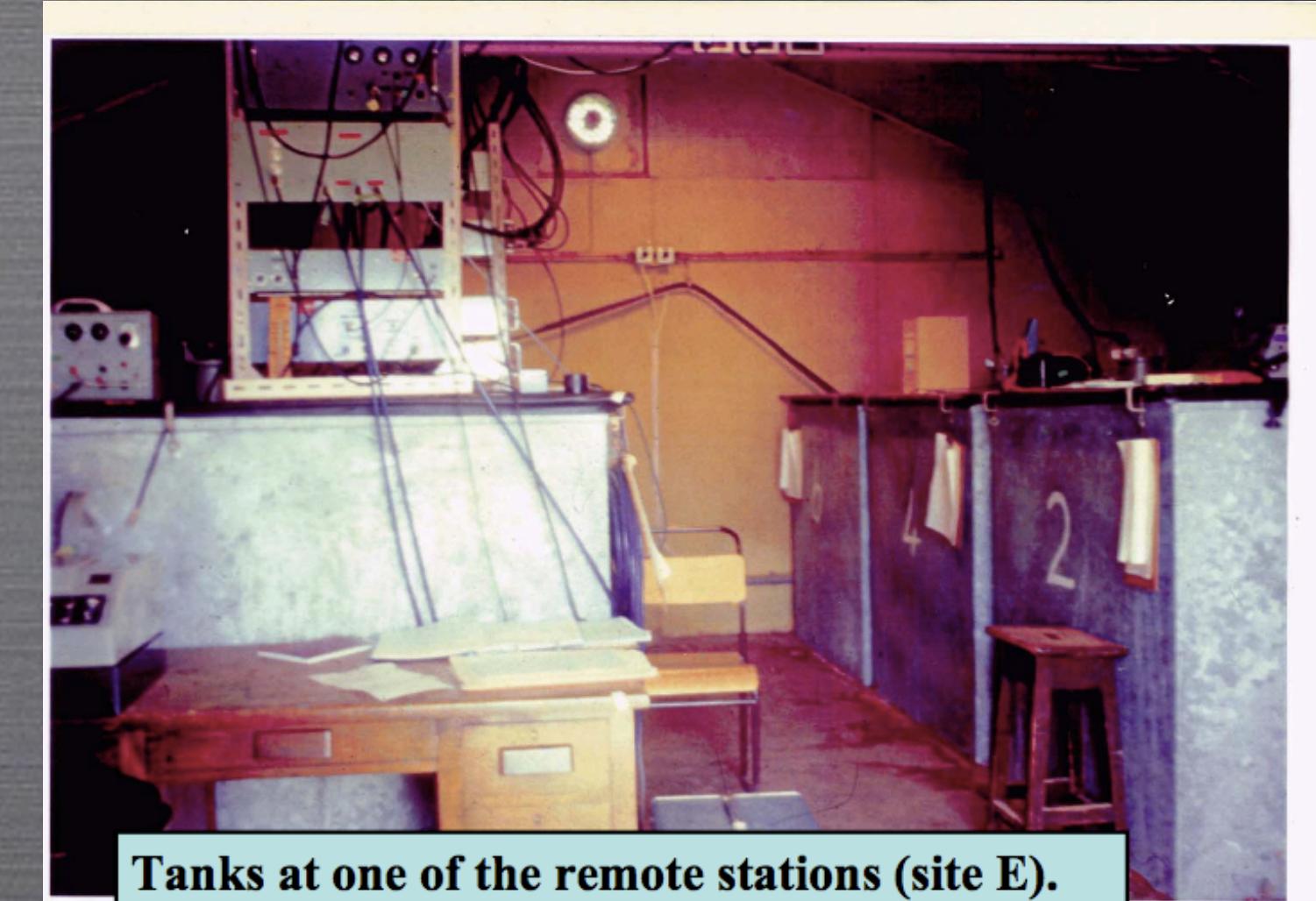
3×10^{20} eV = 50 joules = 1 Tyson ©

250 TONNES POUR UN SIMPLE MOUSTIQUE S'IL VOYAGEAIT À
LA MÊME VITESSE QUE CES PROTONS COSMIQUES

1G D'ENTRE EUX PERMETTRAIT D'ALIMENTER LA FRANCE EN
ÉLECTRICITÉ PENDANT PRÈS DE 6 MILLIONS D'ANNÉES.

(MAIS ILS SONT RARE, IL FAUDRAIT PLUS DE DIX MILLIONS DE
FOIS L'ÂGE DE L'UNIVERS POUR EN RECUEILLIR AUTANT)

LE RÉSEAU D'HAVERAH PARK - ÉCOSSE - 1960-1987



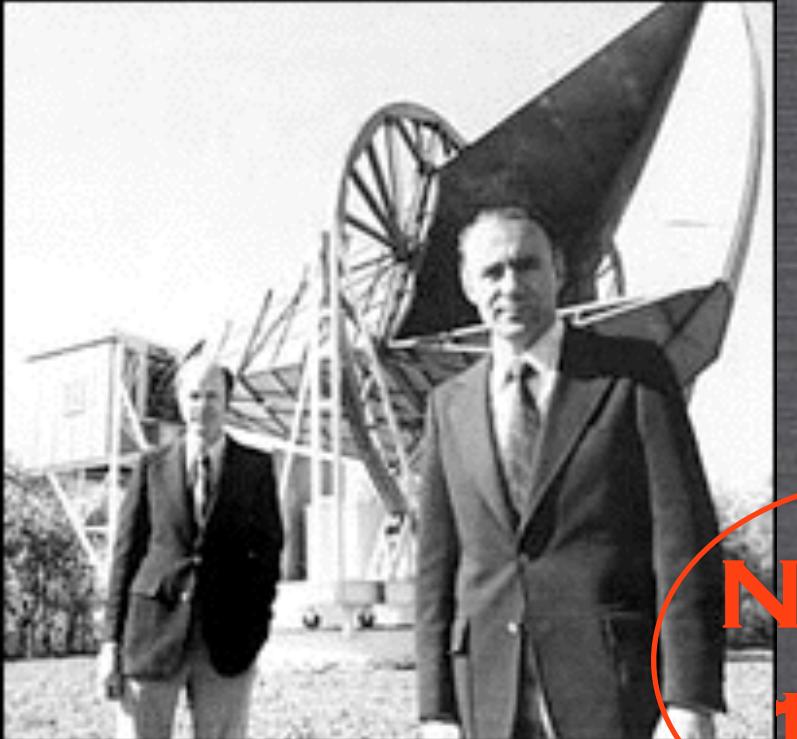
Tanks at one of the remote stations (site E).



YAKUTZ

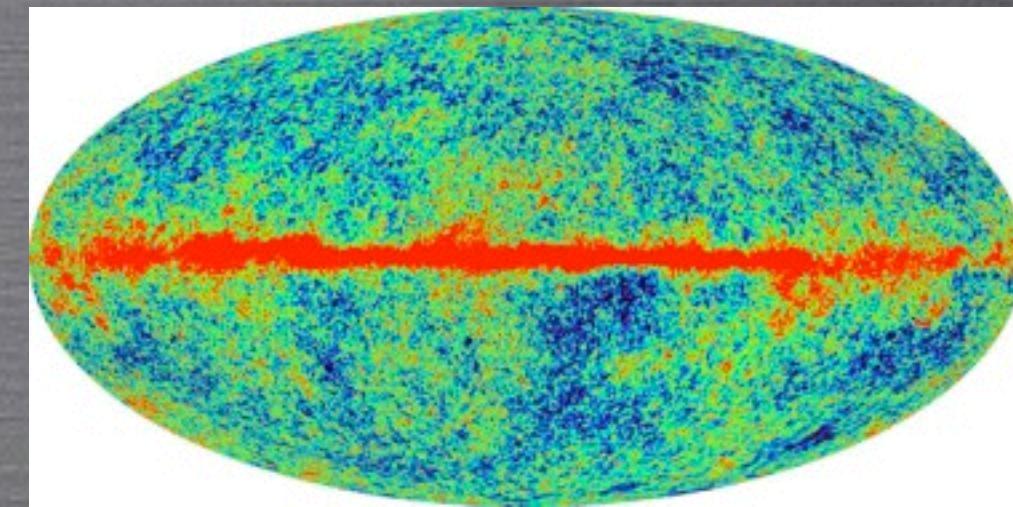


EN 1966 DÉCOUVERTE DU FOND COSMOLOGIQUE DE RADIATION



PENZIAS & WILSON

NOBEL
1978



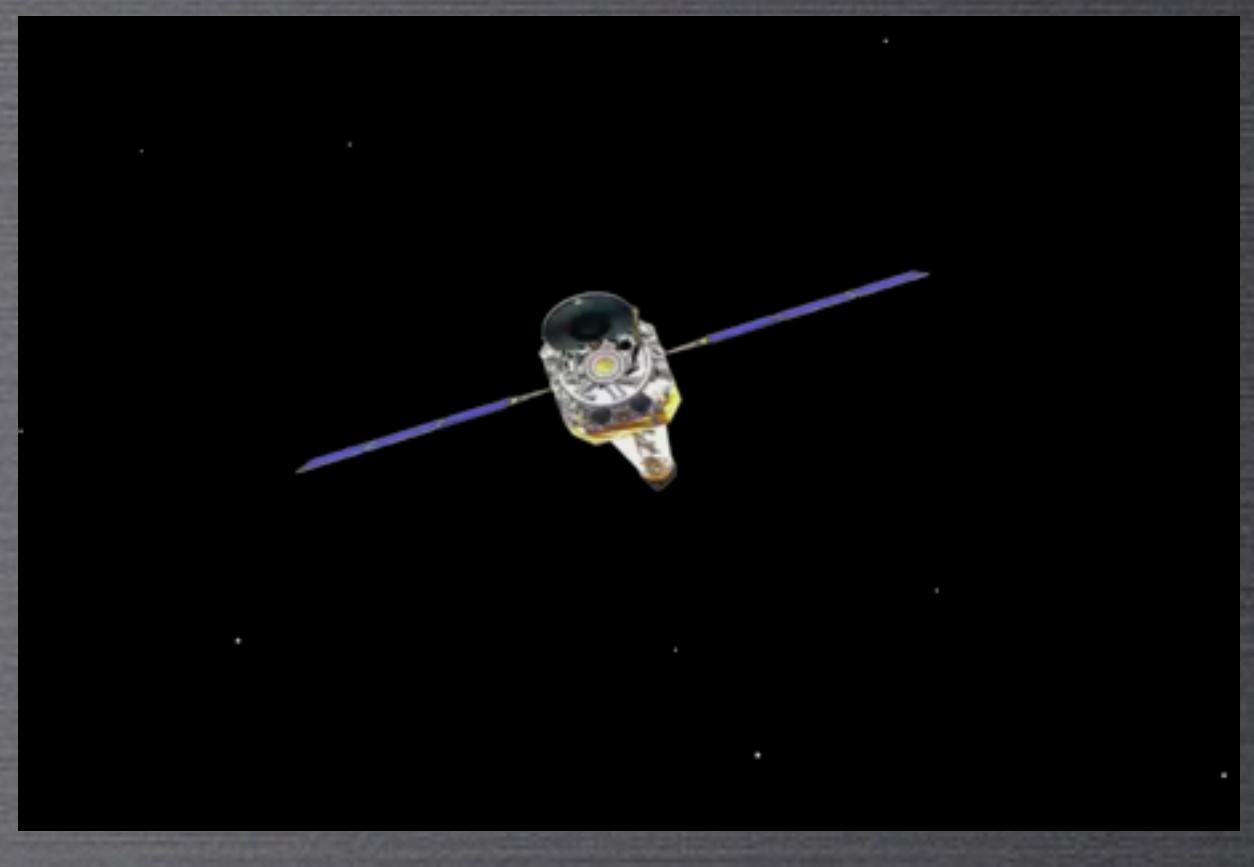
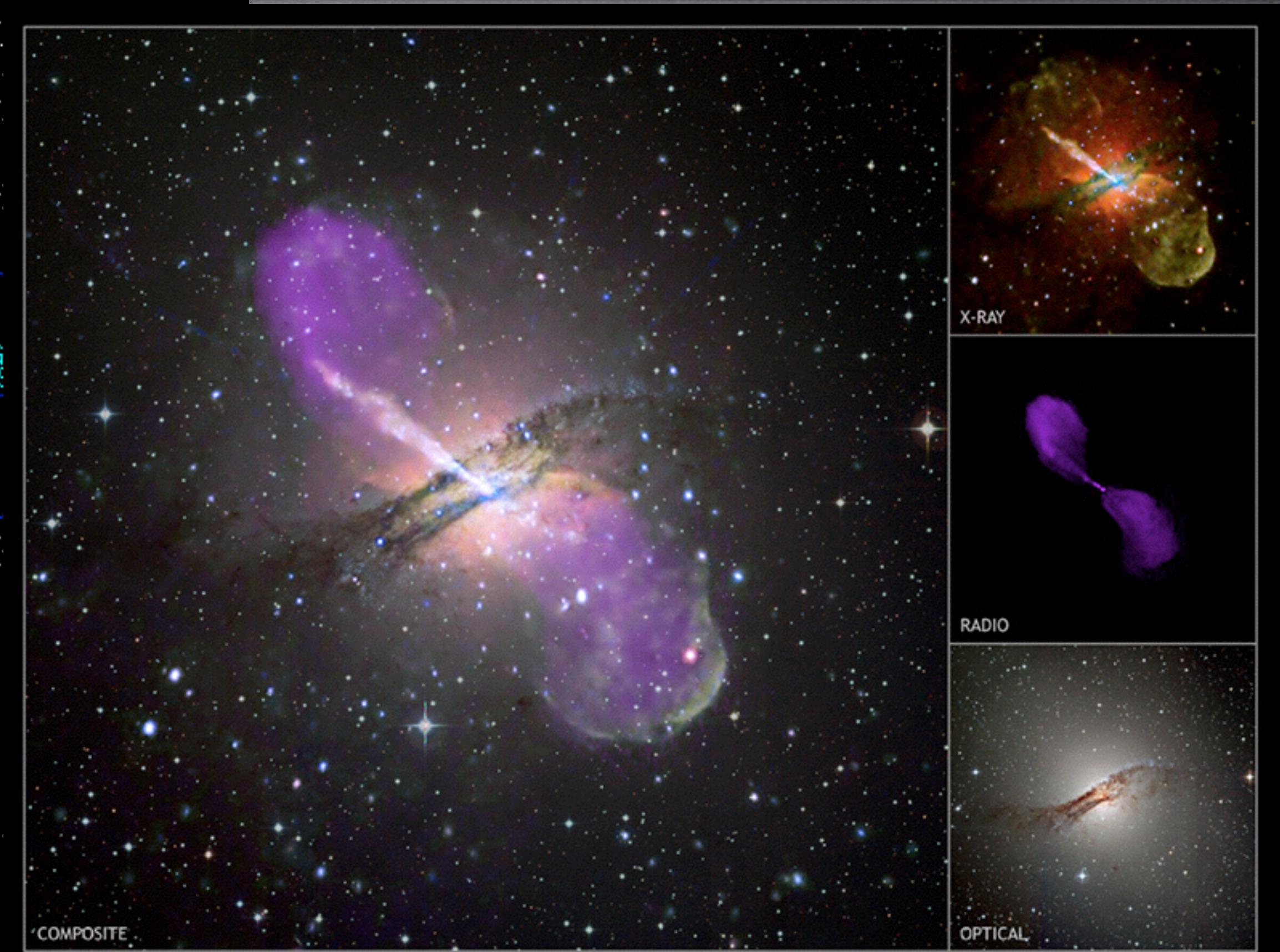
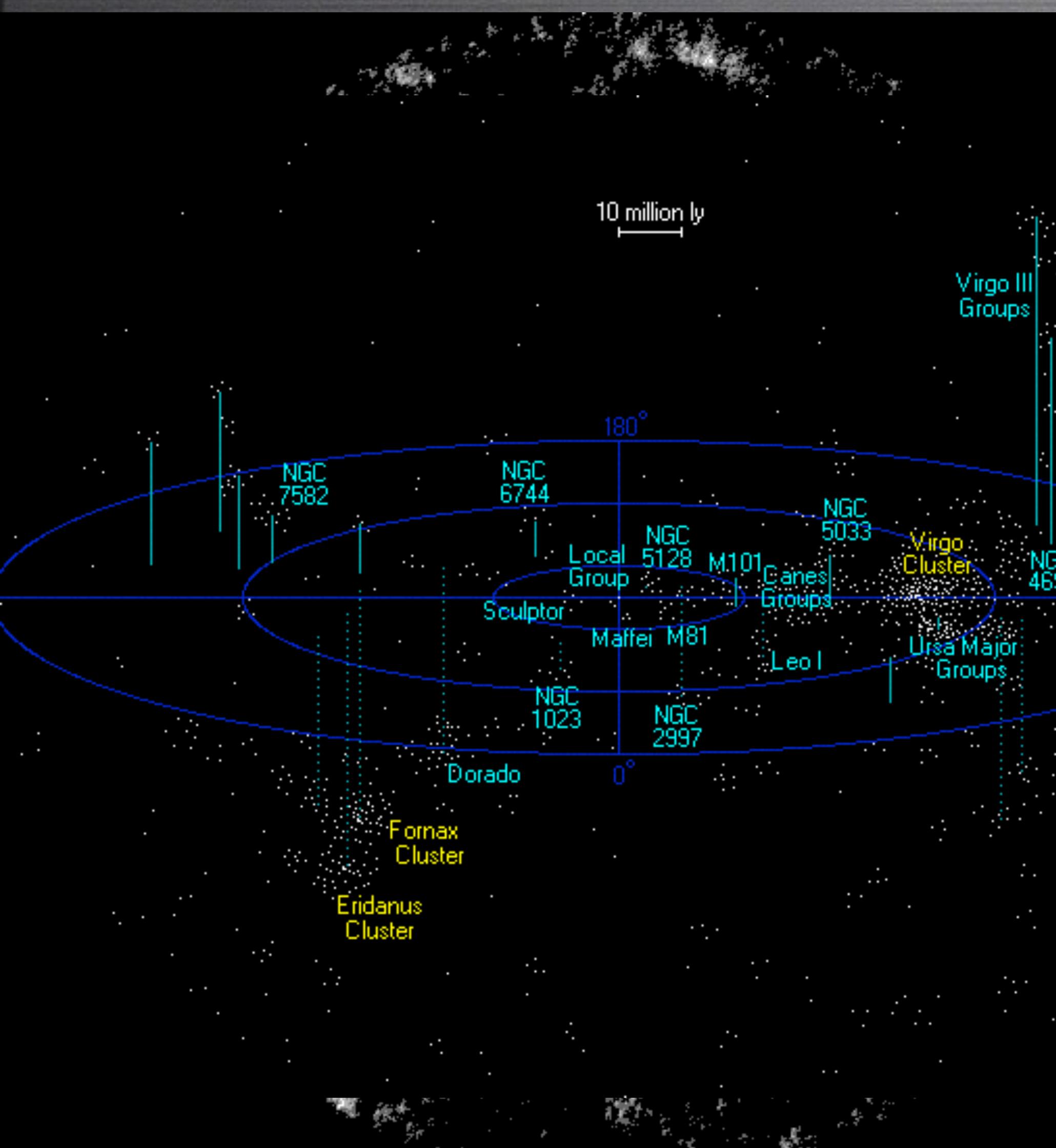
A TRÈS HAUTES ÉNERGIES L'UNIVERS DEVIENT OPAQUE

• LE FLUX DE RAYONS COSMIQUE DEVRAIT DISPARAÎTRE
PRÉDICTION DE GREISEN ZATSEPIN & KUZMIN [GZK]

• SI DES PARTICULES DE TRÈS HAUTES ÉNERGIES
SUBSISTENT LES SOURCES SONT PROCHES

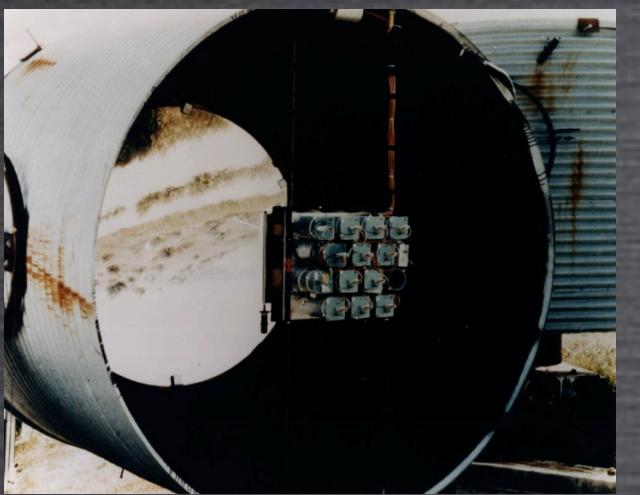
ON PEUT LES RECHERCHER SUR LE CIEL !

DES SOURCES PROCHES DE LA TERRE ?

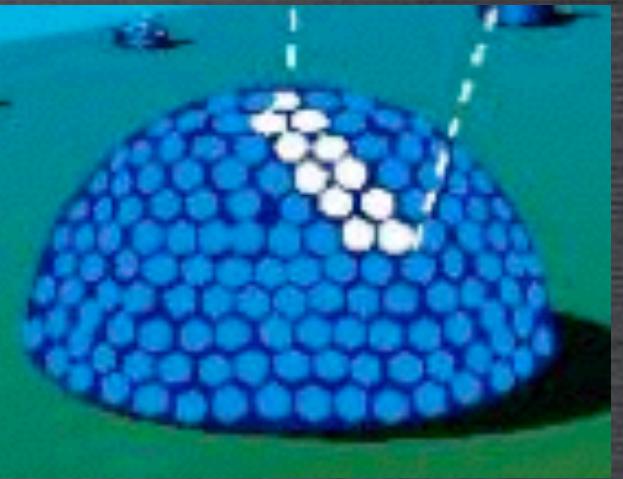


1980

PLUS GRAND



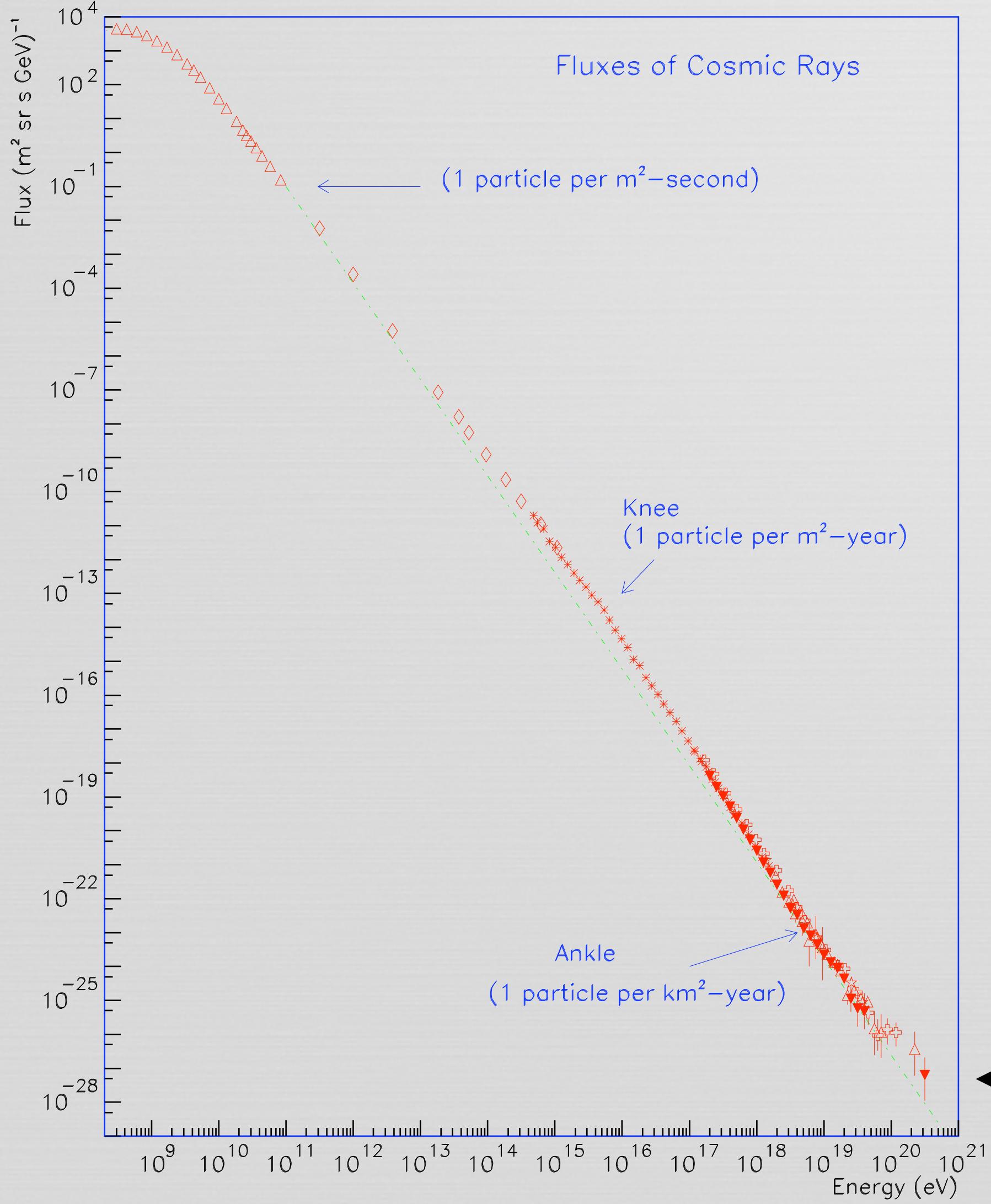
L'OEIL DE MOUCHE



LE RÉSEAU AGASA - JAPON 1990-2001



LE FLUX DES RAYONS COSMIQUES

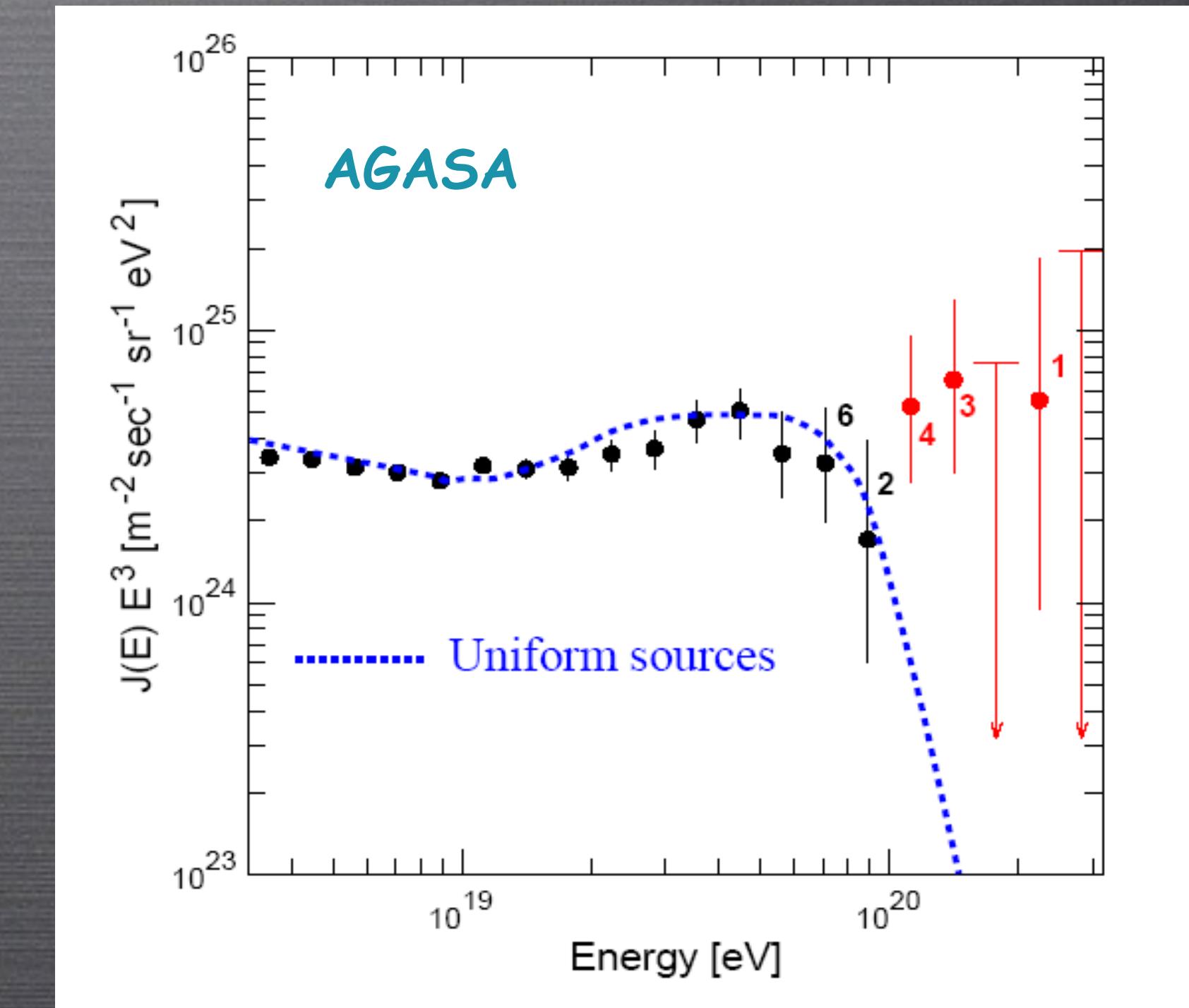
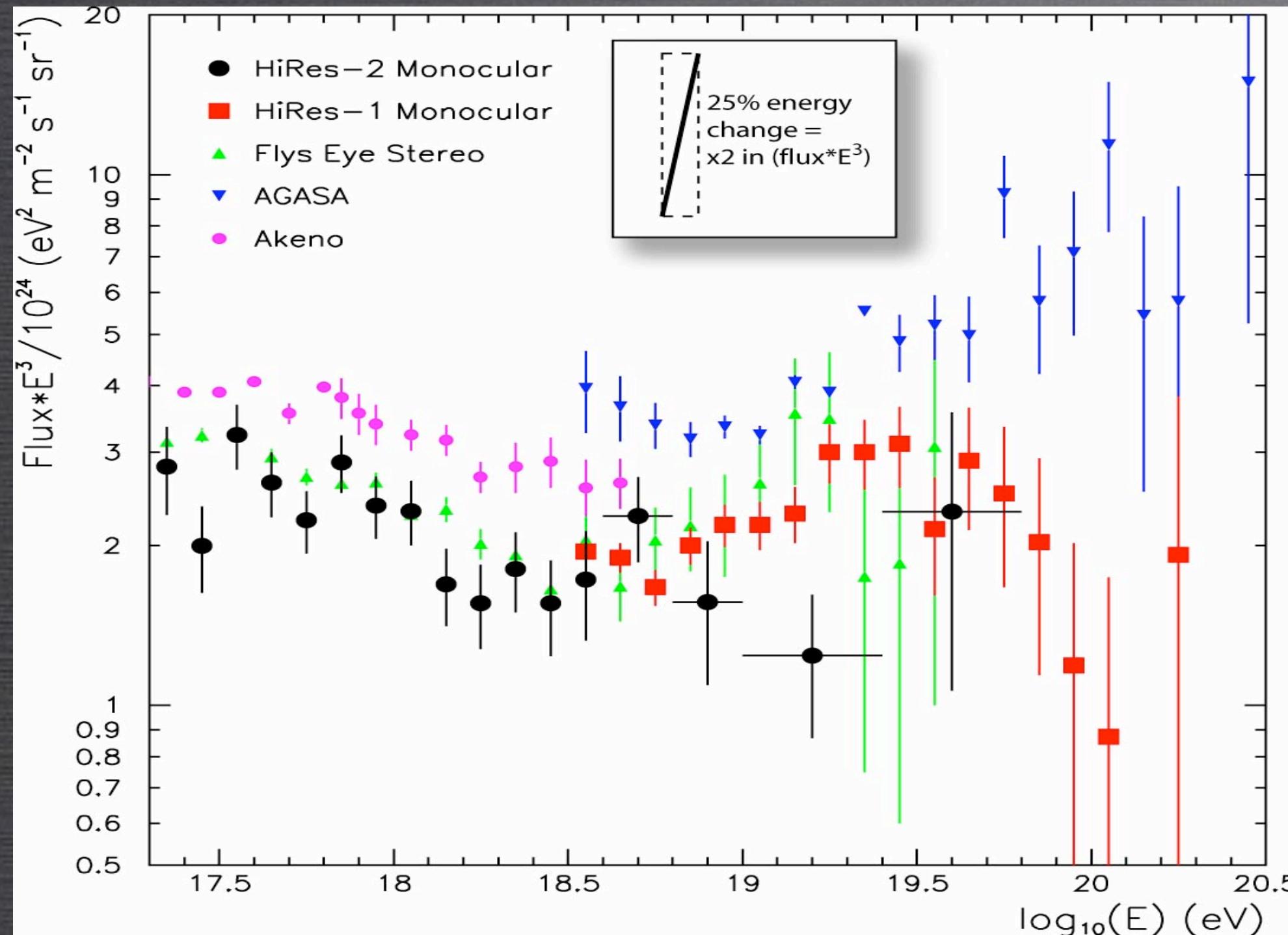


$3 \times 10^{20} \text{ eV} = 50 \text{ joules} = 1 \text{ Tyson } \odot$



ANNÉES 1990 : UNE SITUATION CONFUSE

OÙ S'ARRÊTE LE SPECTRE ?



OÙ SONT LES SOURCES ET QUE SONT-ELLES ?



ACCÉLÉRATEURS COSMIQUES

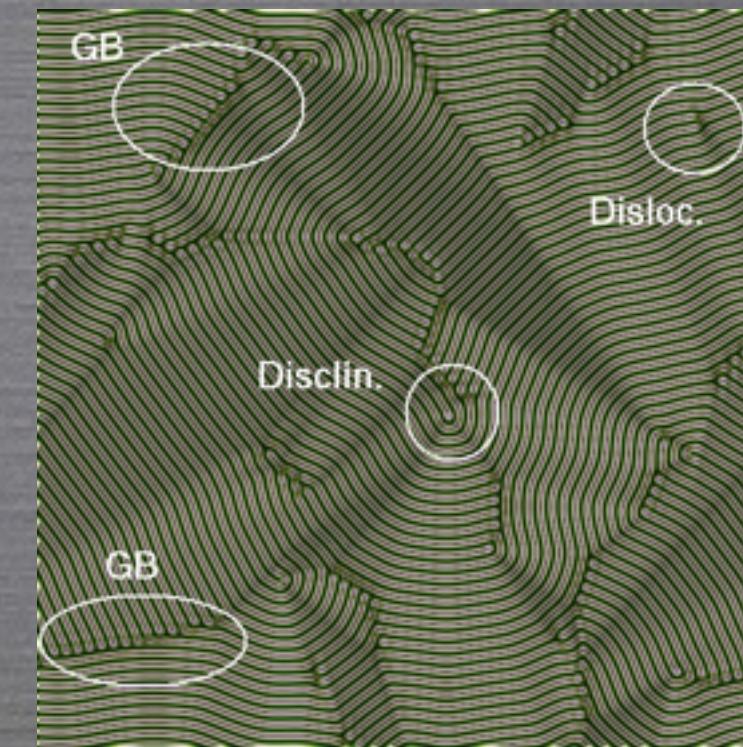
AGN

GALAXIES RADIO

JEUNES ÉTOILES À NEUTRONS

SURSAUTS GAMMA

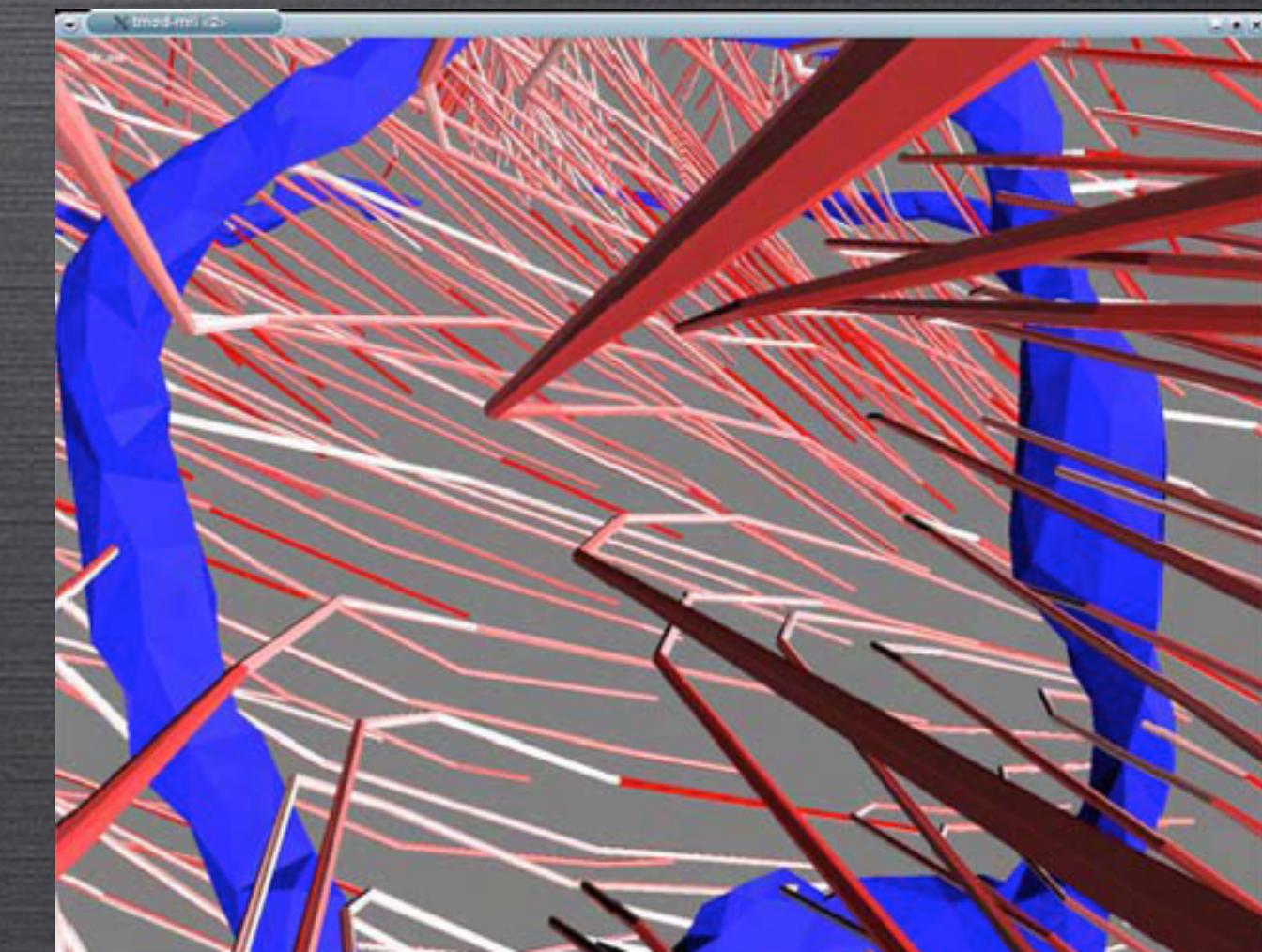
LES PROTONS ET LES NOYAUX DOMINENT



PRODUCTION DIRECTE
DÉFAUTS TOPOLOGIQUES

RELIQUES (SUPER) MASSIVE DU BIG BANG

LES PHOTONS ET LES NEUTRINOS DOMINENT



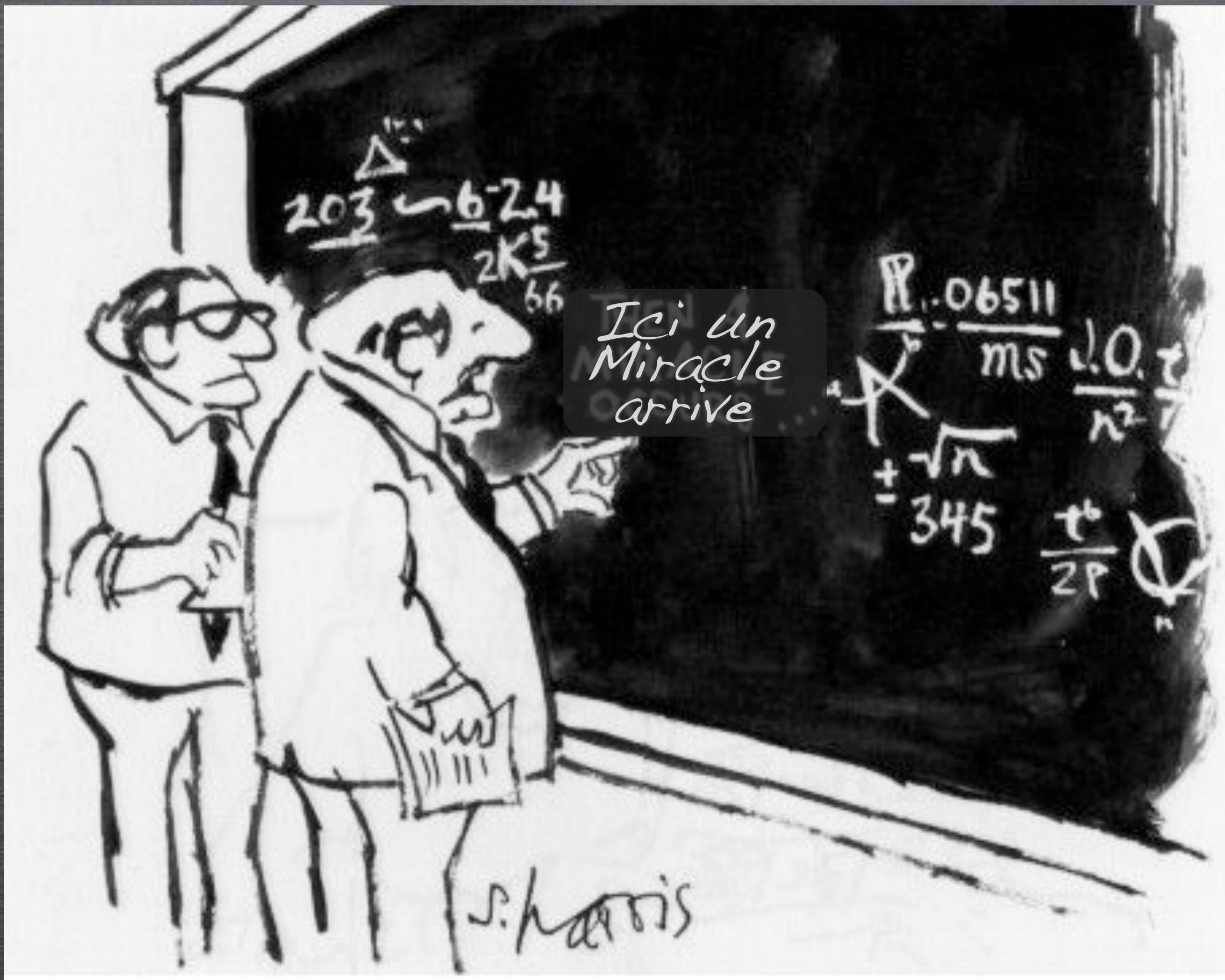
A LA FIN DES ANNÉES 1990

IL Y A DES ÉVÉNEMENTS AU DELÀ DE 5×10^{19} EV
(TROP ?)

MAIS

ON LES DIRECTIONS D'ARRIVÉE SUR LE CIEL SONT UNIFORME
(OÙ SONT LES SOURCES ?)

LES EFFORTS THÉORIQUES SONT NOMBREUX
MAIS PEUT CONVAINCANTS...



“JE PENSE QUE VOUS DEVRIEZ ÊTRE PLUS EXPLICITE SUR LA 2IÈME ÉTAPE”

From Sidney Harris

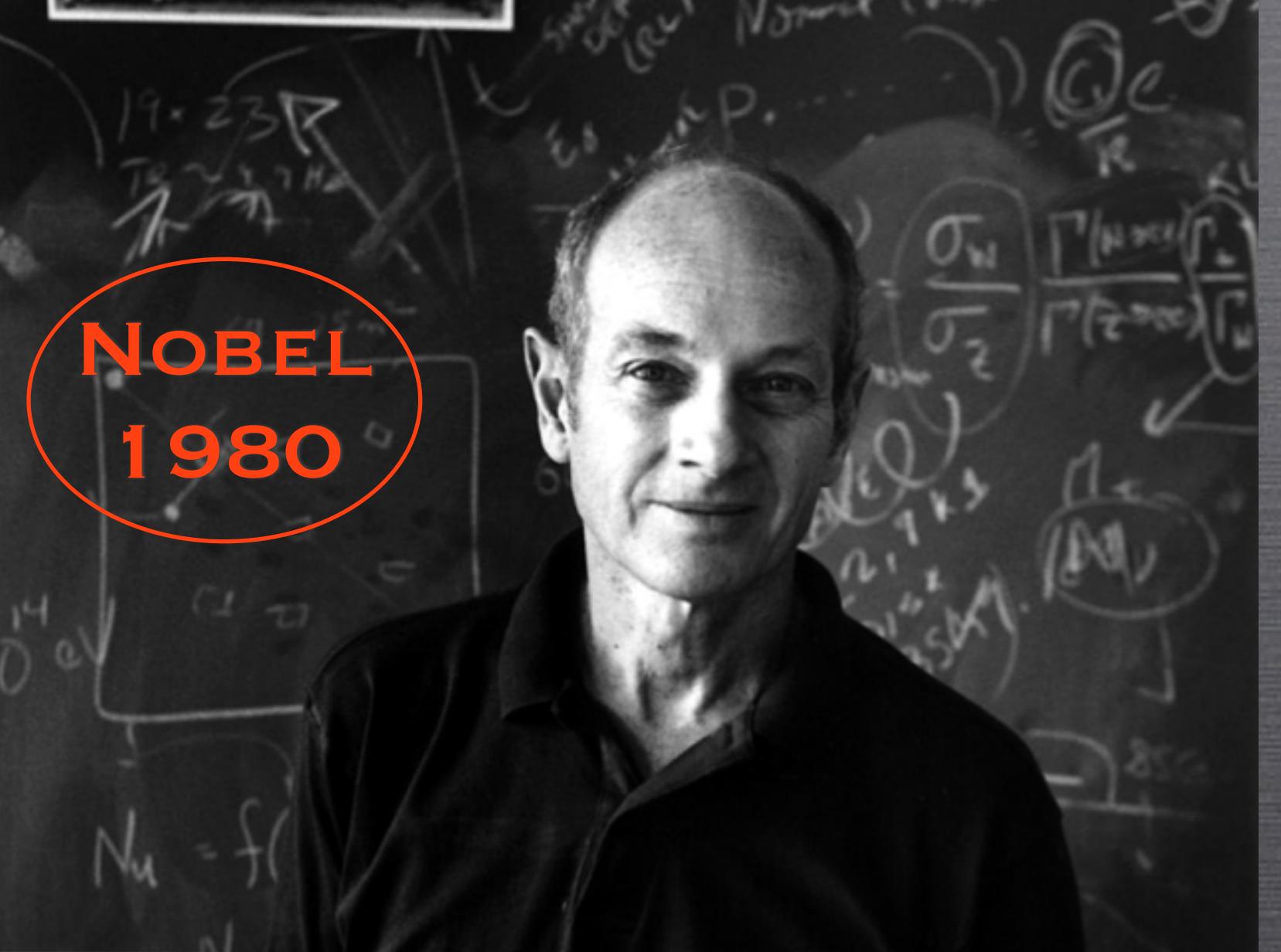
1990

ENCORE

PLUS

GRAND

JIM CRONIN PROPOSE UN DÉTECTEUR DE 5000 KM² :
C'EST LA NAISSANCE DU PROJET AUGER

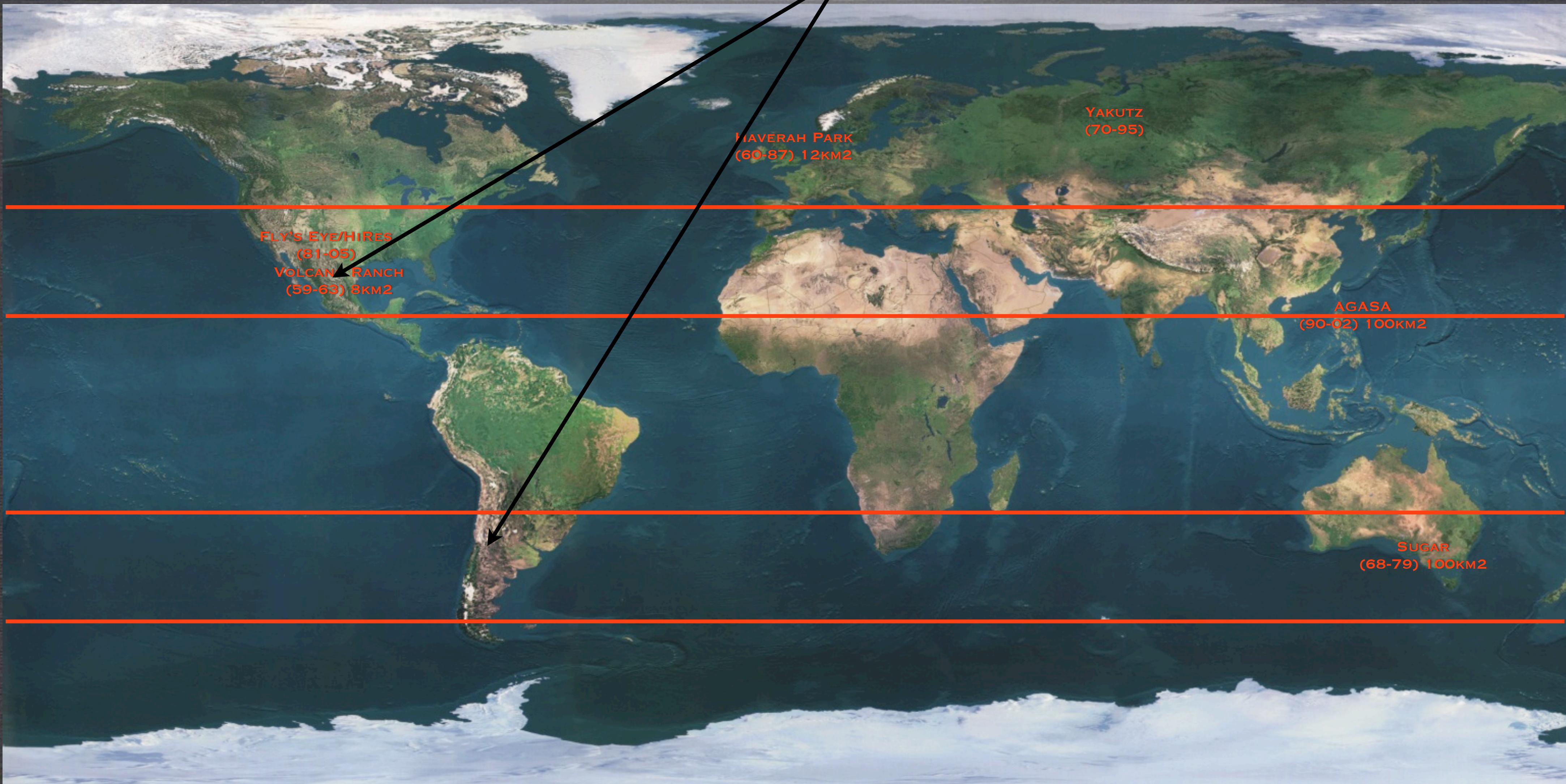


NOBEL
1980

PROBLÈMES :

- ❖ PAS D'ARGENT POUR FAIRE QUOI QUE CE SOIT
- ❖ IL FAUT CONVAINCRE LA COMMUNAUTÉ QUE CELA VAUT LA PEINE ET QU'ON SAURA LE FAIRE
- ❖ IL FAUT TROUVER UN SITE
- ❖ MONTER UNE COLLABORATION ET RÉUNIR 100M\$
- ❖ VA-T-ON MESURER QUELQUE CHOSE ?
- ❖ EST-CE QUE 5000 KM² SUFFIRONT ?

2 SITES SÉLECTIONNÉS 1995/1996

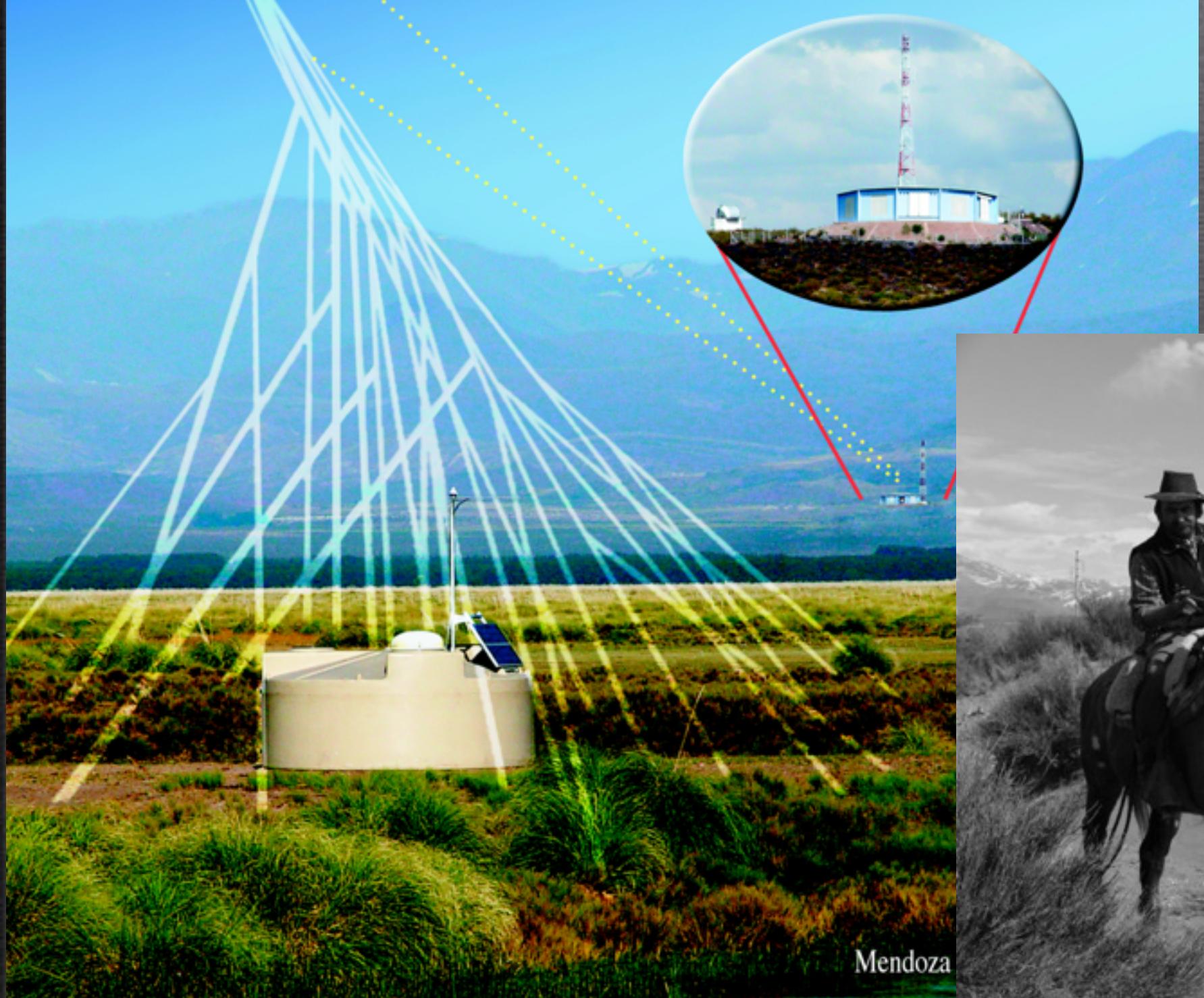


2 CHERCHEURS [AMÉRICAIN/FRANÇAIS] ONT EUT LE MEILLEUR TRAVAIL DU MONDE :
VOYAGER SUR TOUTE LA PLANÈTE POUR RENCONTRER LES GENS ET ÉVALUER LES SITES. 20 SITES VISITÉS DANS 7 PAYS.

L'OBSERVATOIRE PIERRE AUGER

Pierre Auger Observatory

*An International Experiment to Study
the Highest Energy Cosmic Rays*



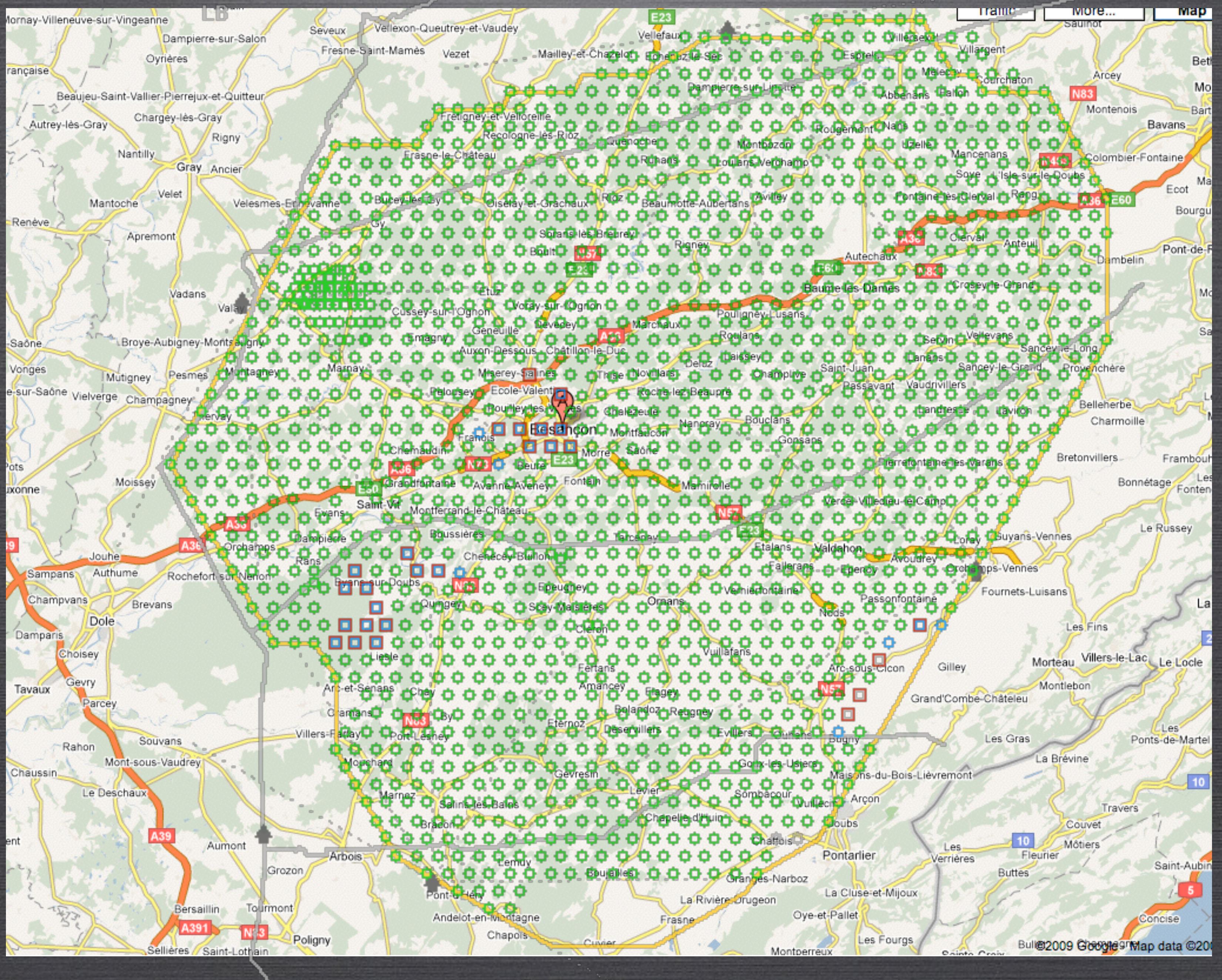
UN DÉTECTEUR HYBRIDE

RÉSEAU DE SURFACE :
1600 CUVES CHÉRENKOV RÉPARTIES
TOUS LES 1,5 KM SUR UNE SURFACE
DE 3 000 KM²

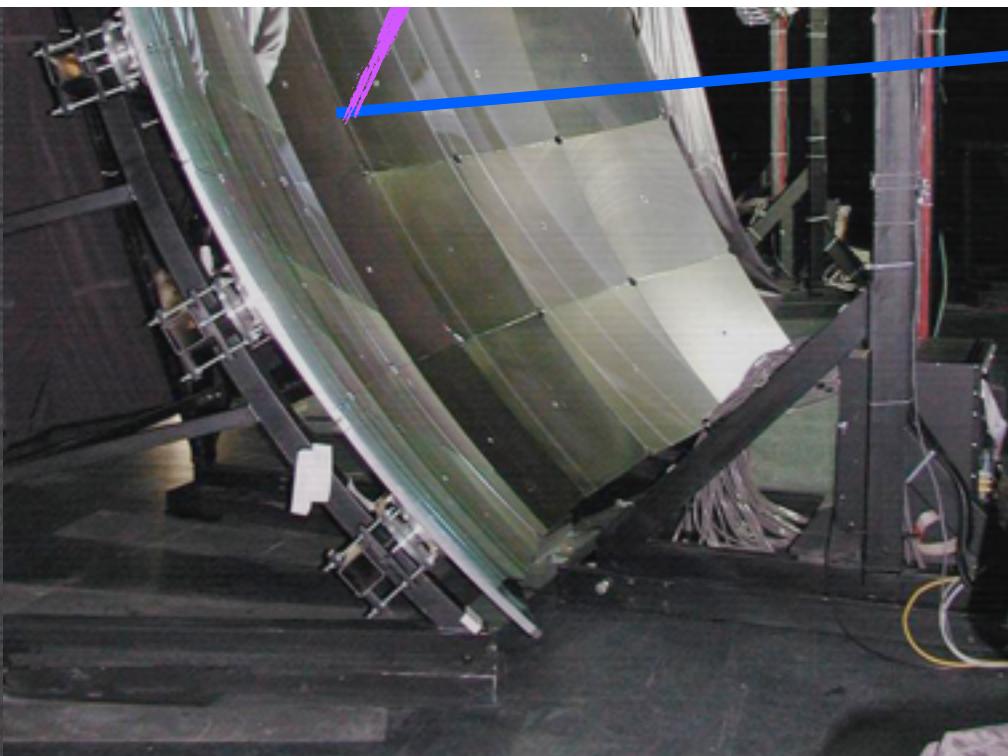
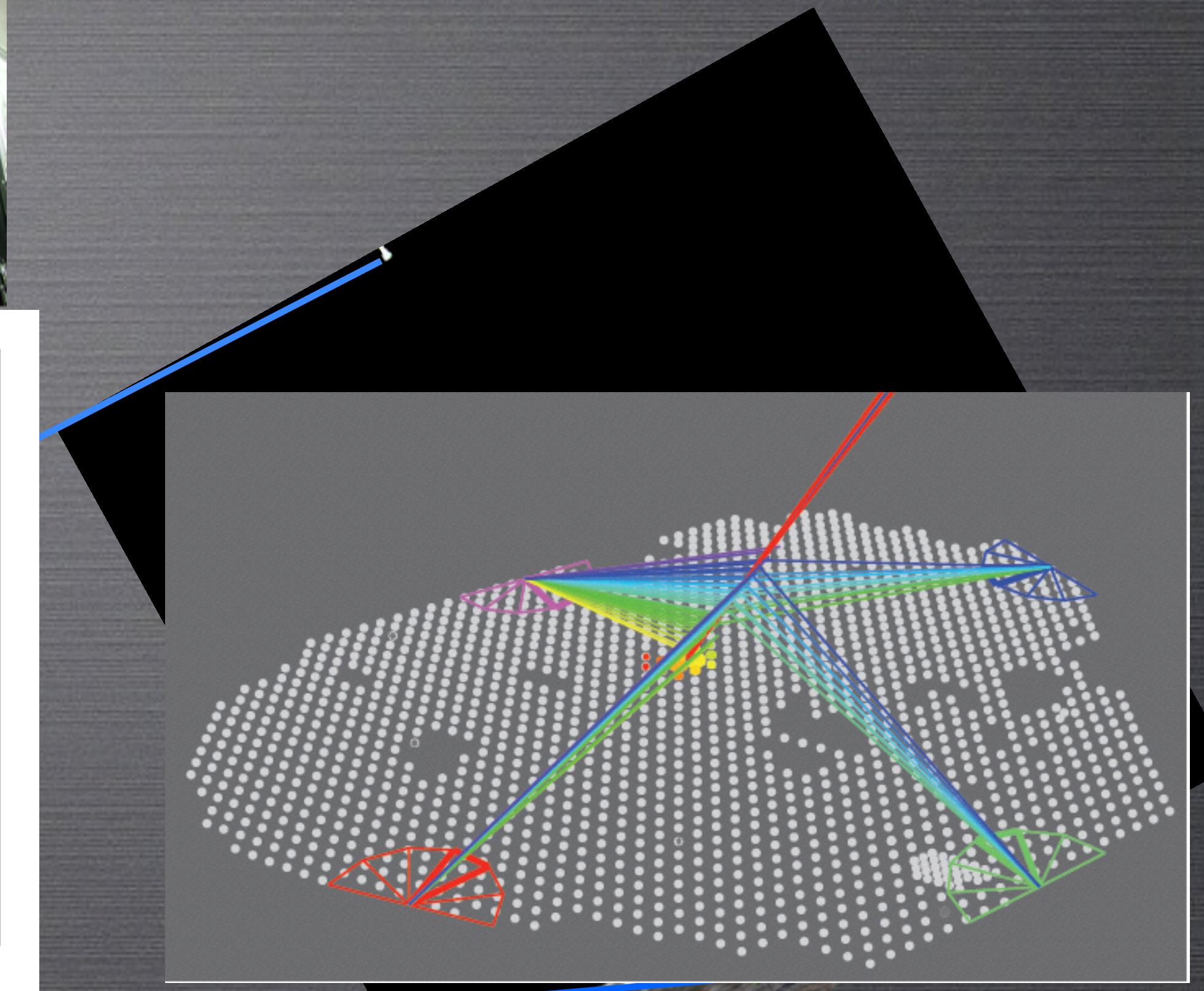
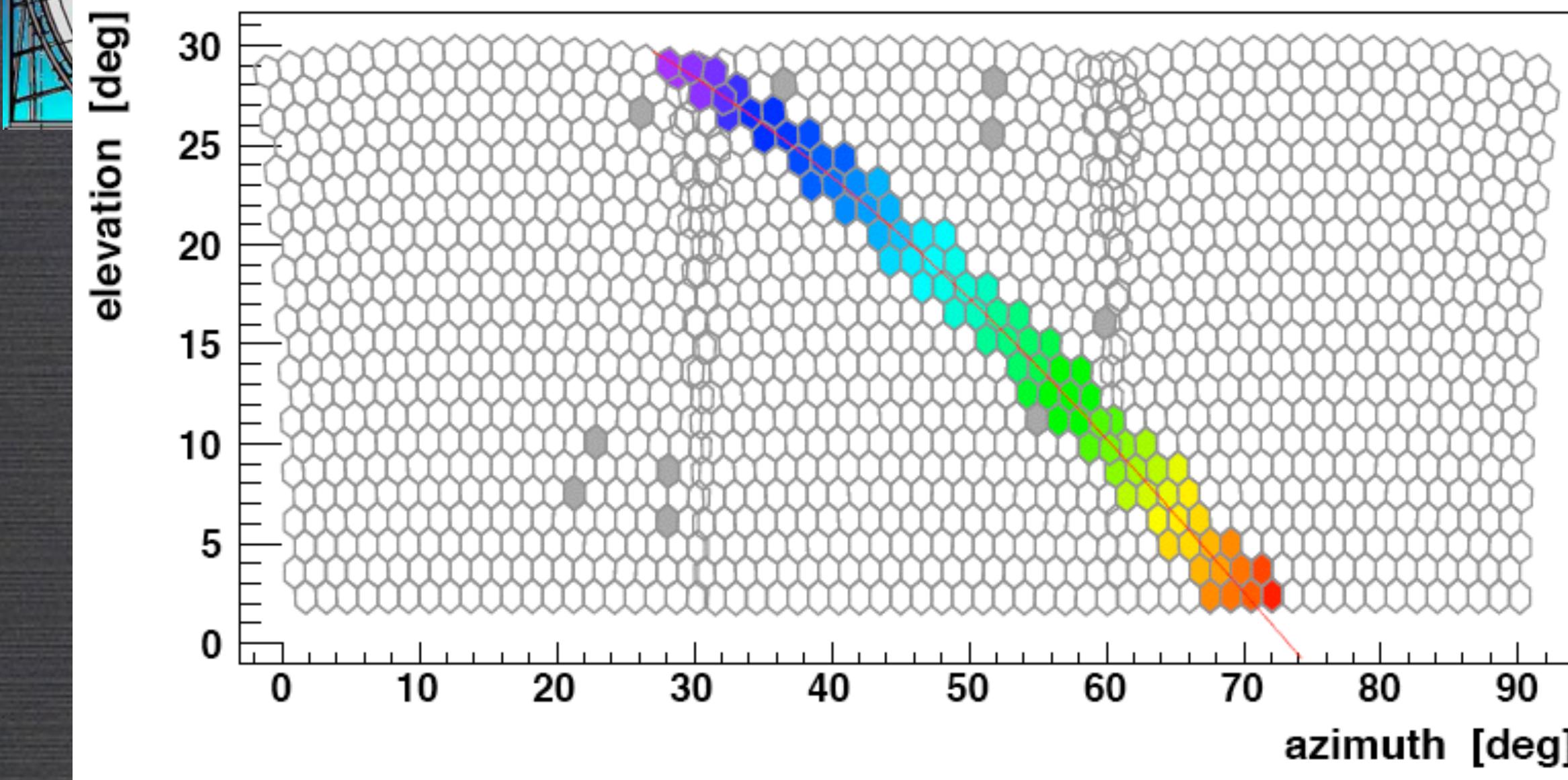
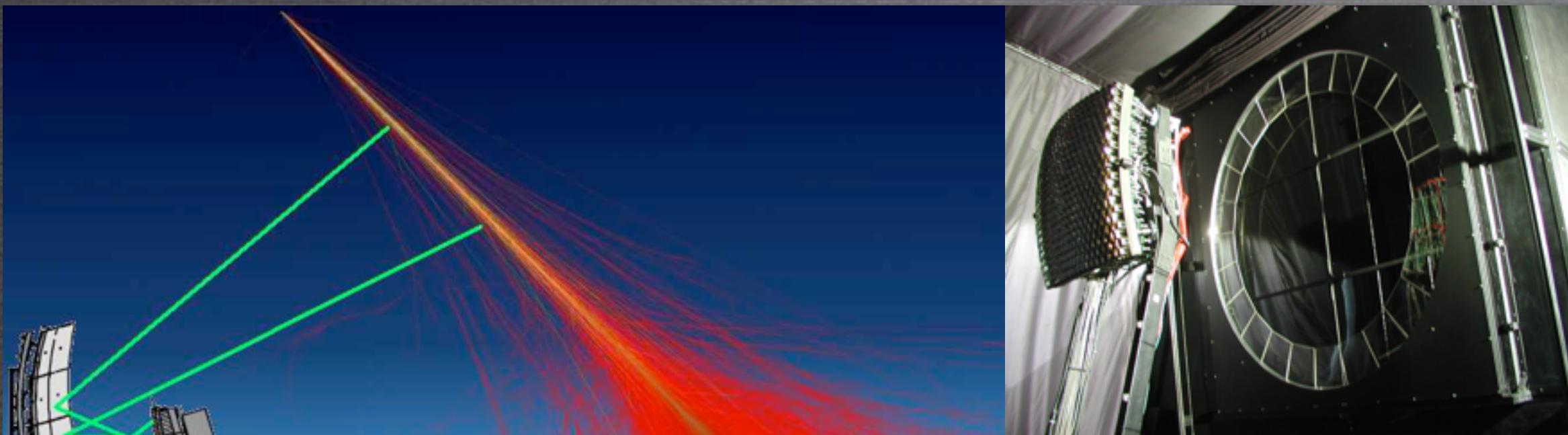
DÉTECTEUR DE FLUORESCENCE :

4 SITE DE 6 TÉLESCOPES À
FLUORESCENCE POUR REGARDER
L'ATMOSPHÈRE AU DESSUS DU
RÉSEAU DE SURFACE

INTER CALIBRAGE / PRÉCISION /
STABILITÉ & EFFICACITÉ

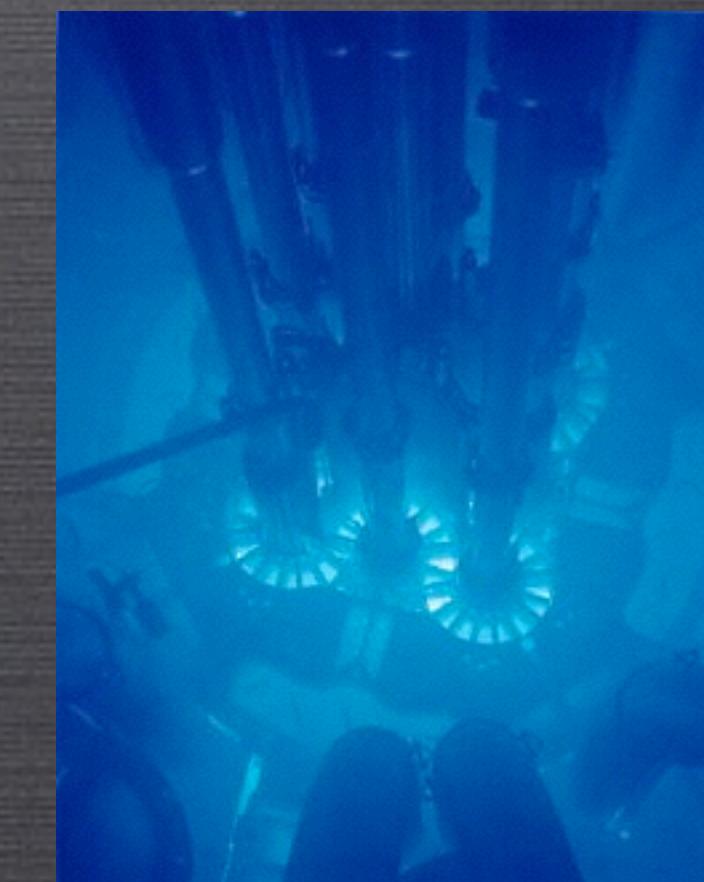
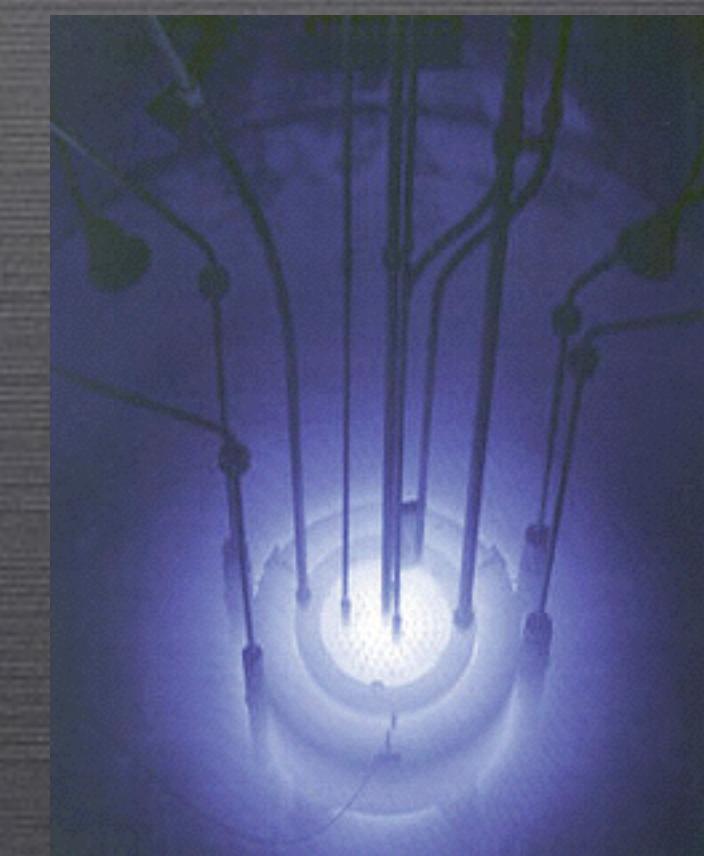
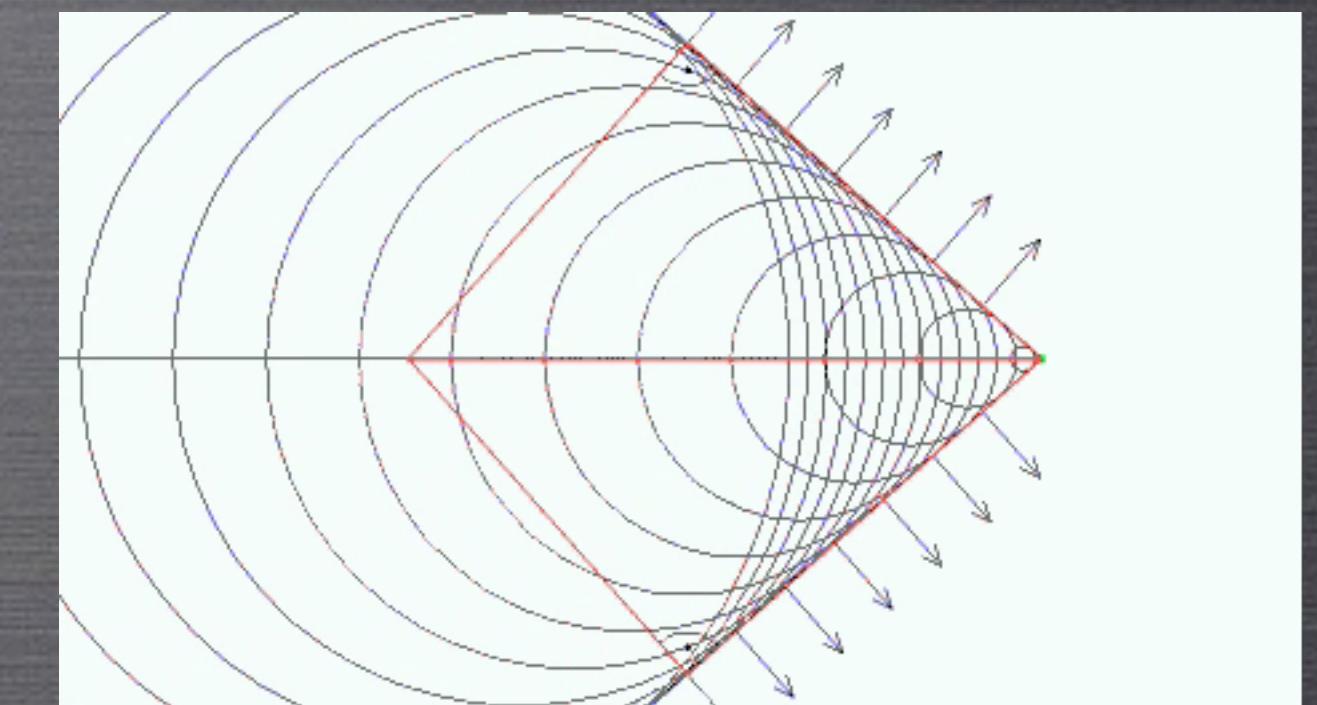
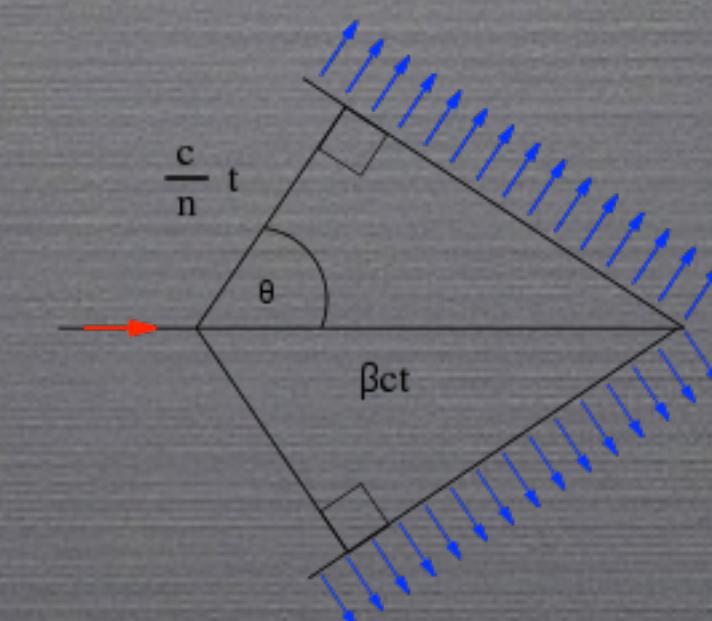
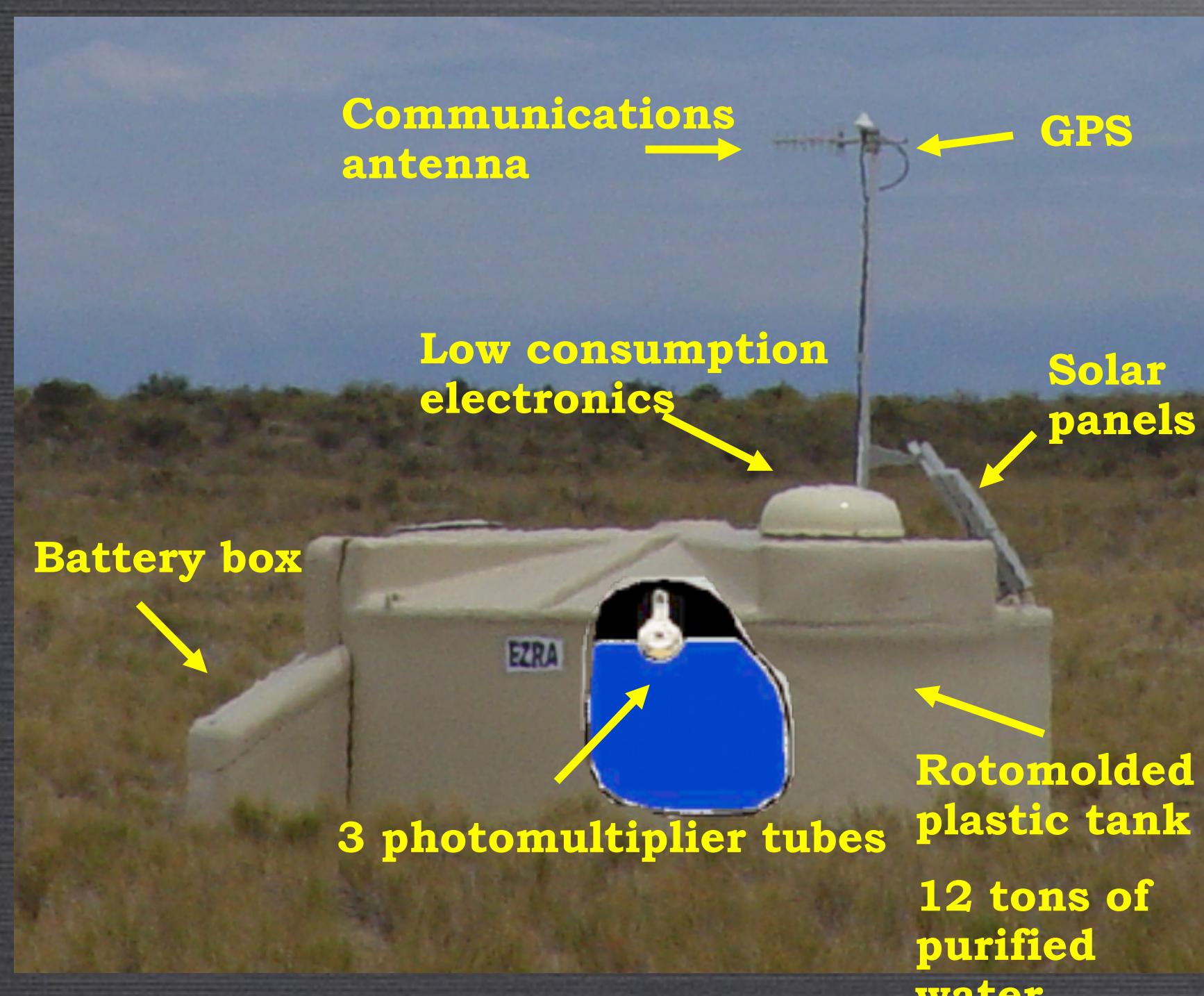
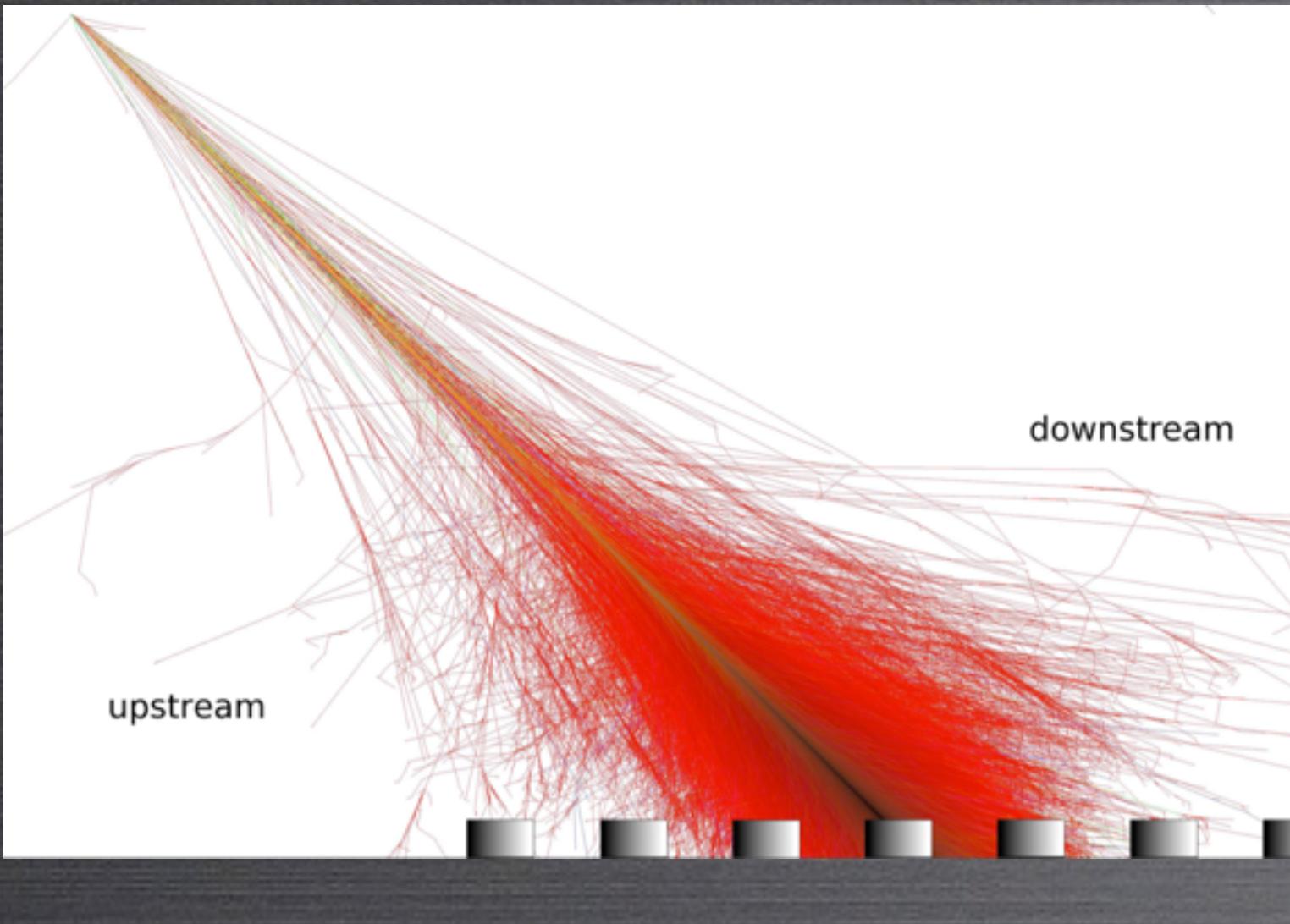






UN DÉTECTEUR DE FLUORESCENCE

UN DÉTECTEUR DE SURFACE & L'EFFET CHERENKOV





FAUT PAS RÊVER - ARNAUD BLIN - FR3 AUTOMNE 2008

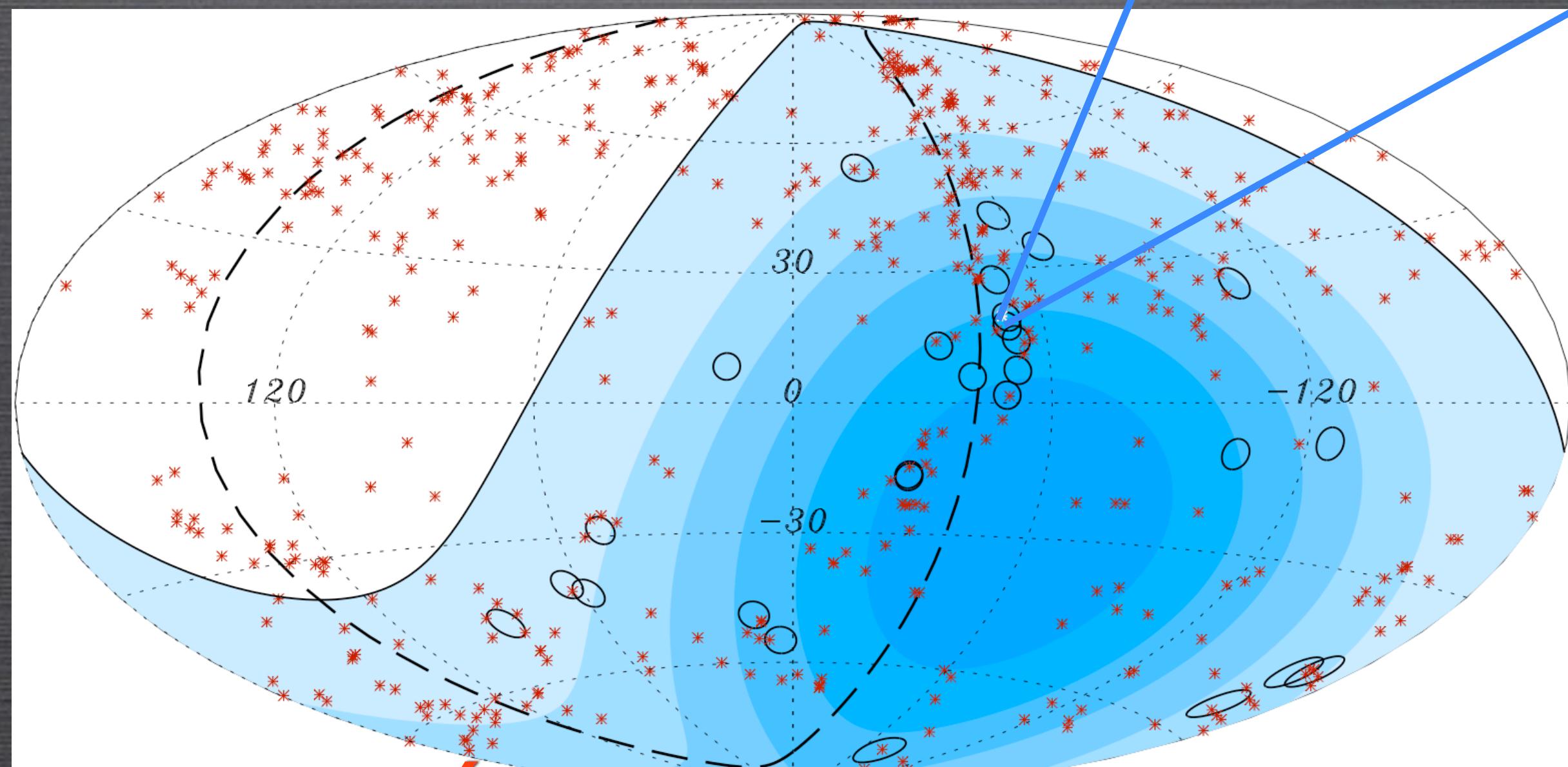
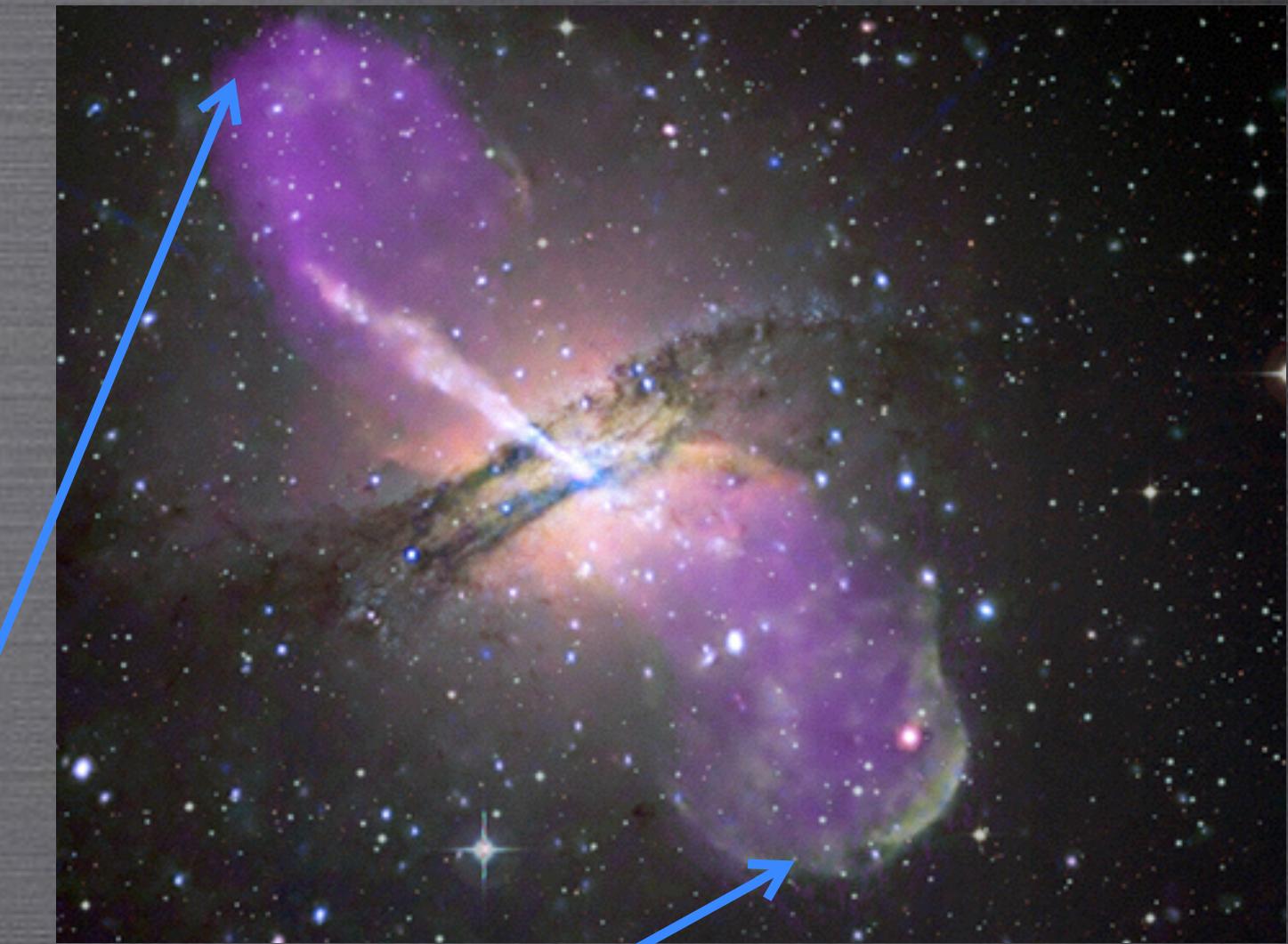
NOVEMBRE
2007

LES
SOURCES
APPARAISSENT-
-ELLES ENFIN ?



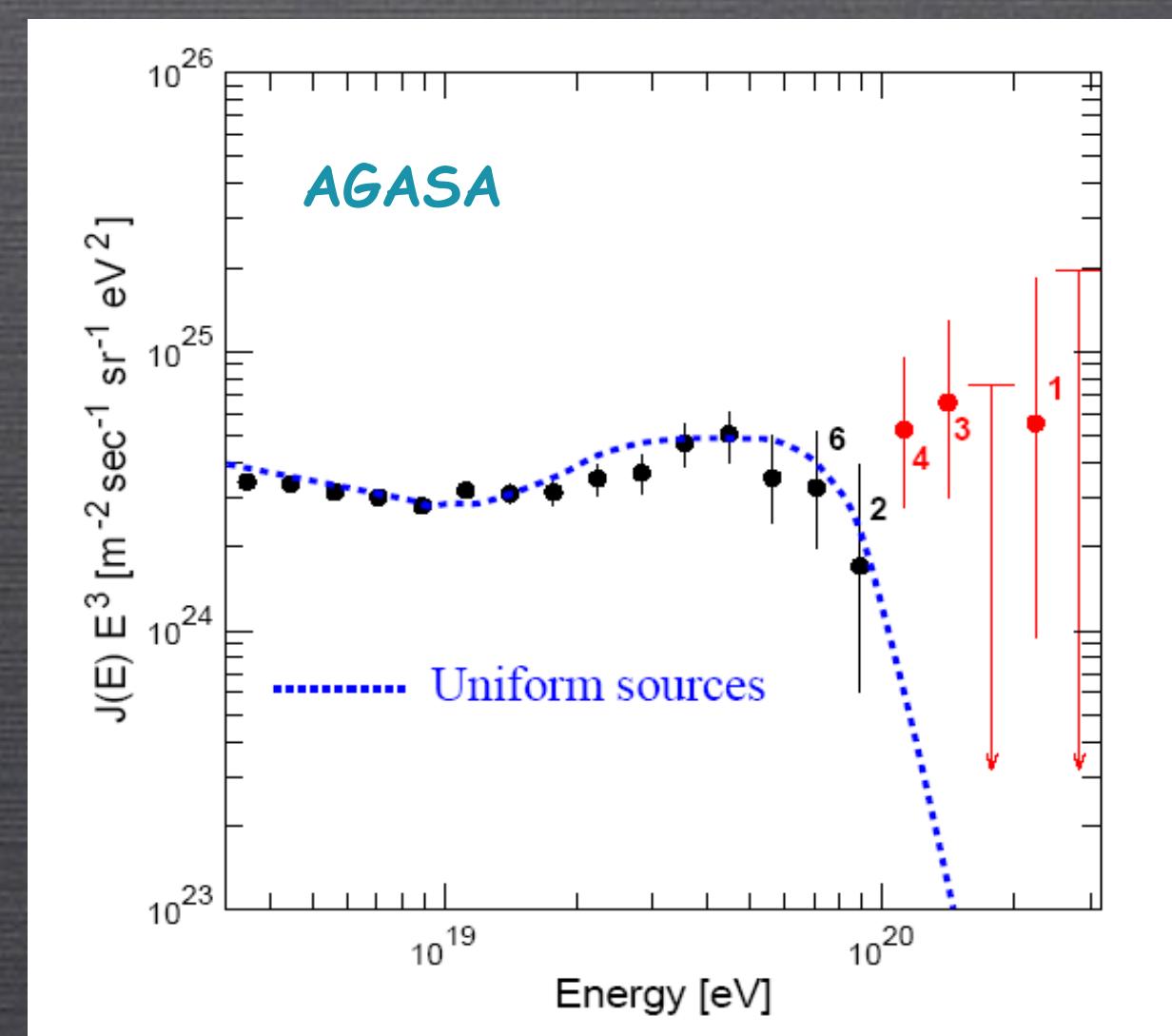
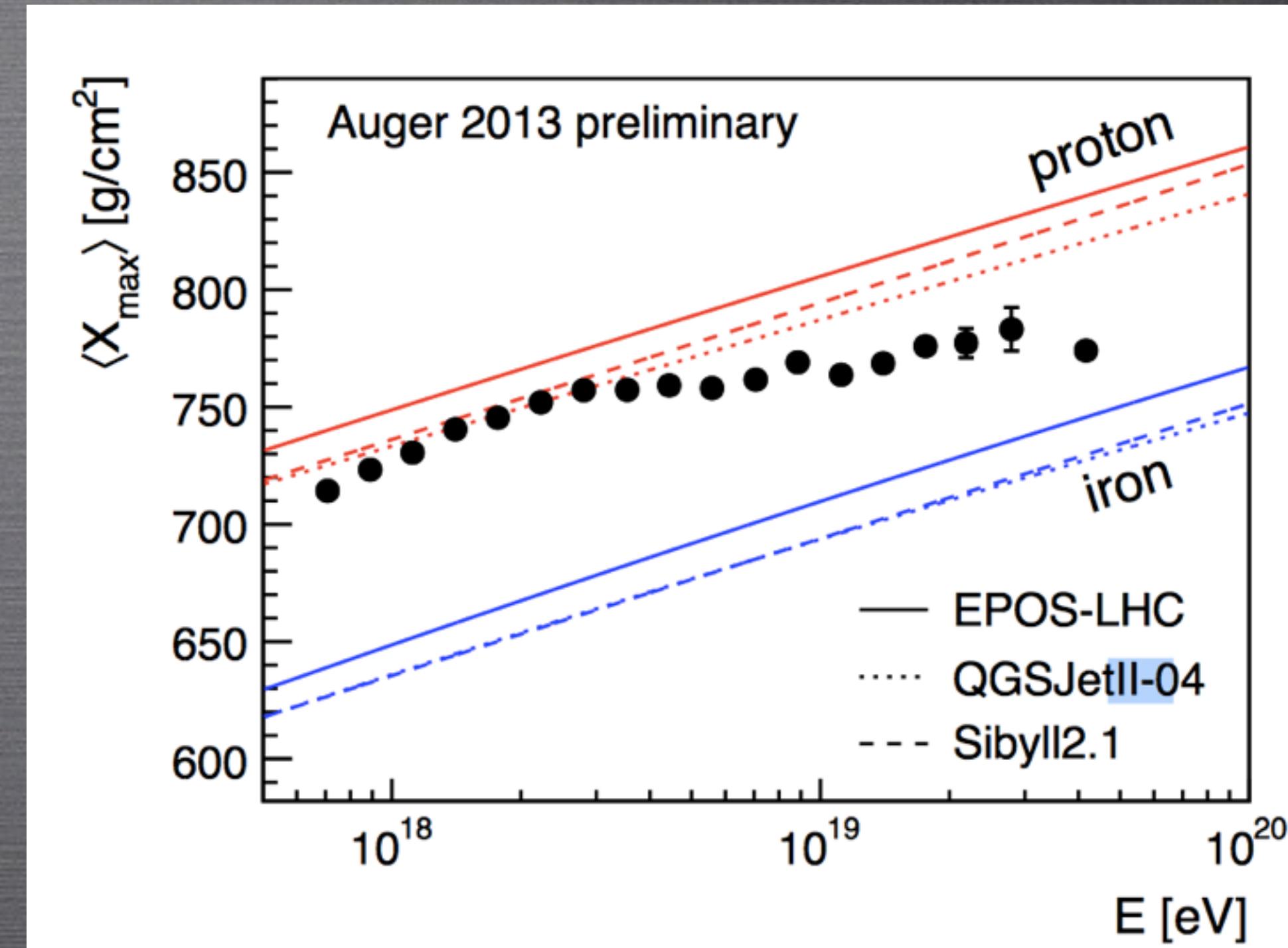
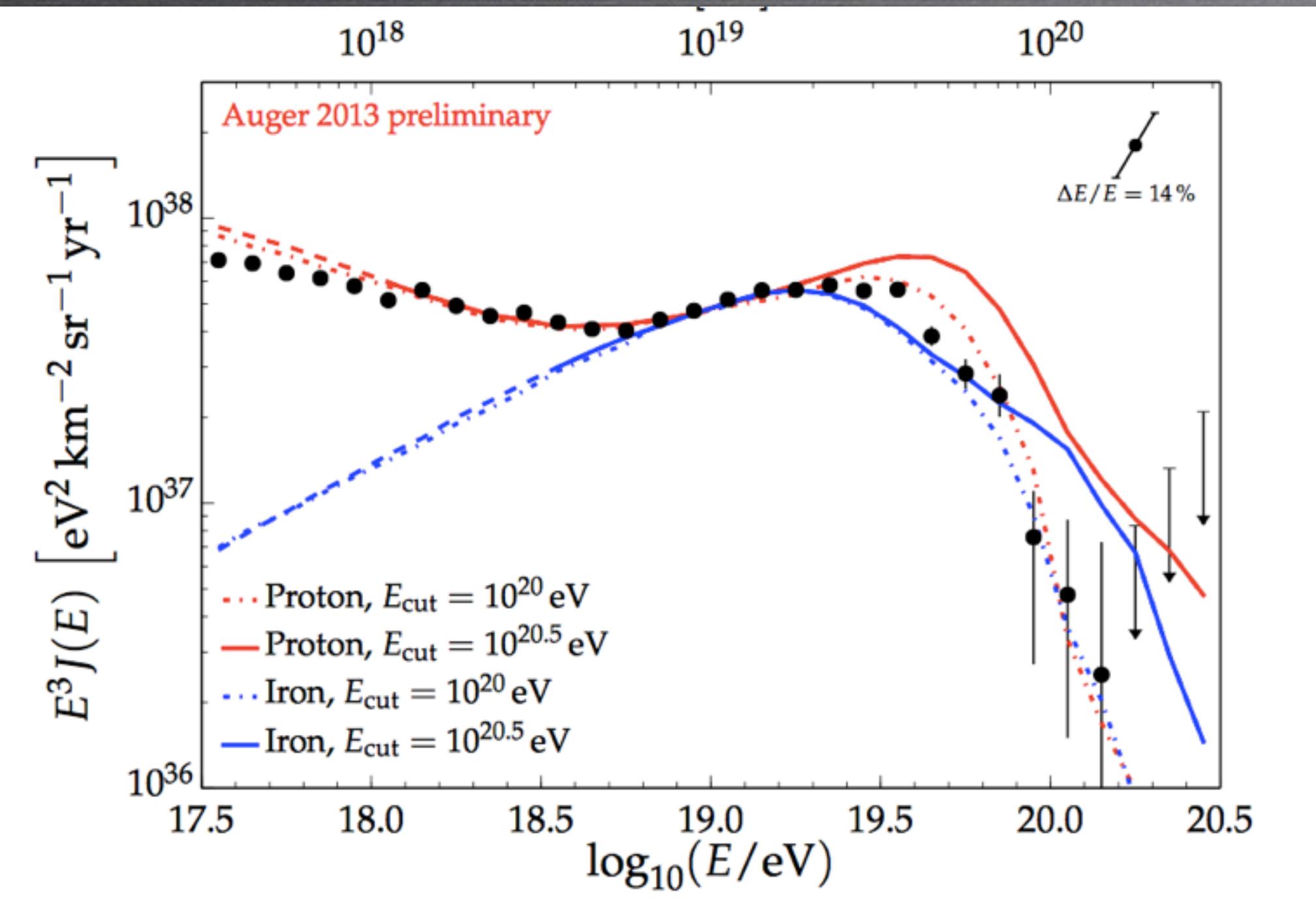
NOYAUX ACTIFS DE GALAXIES

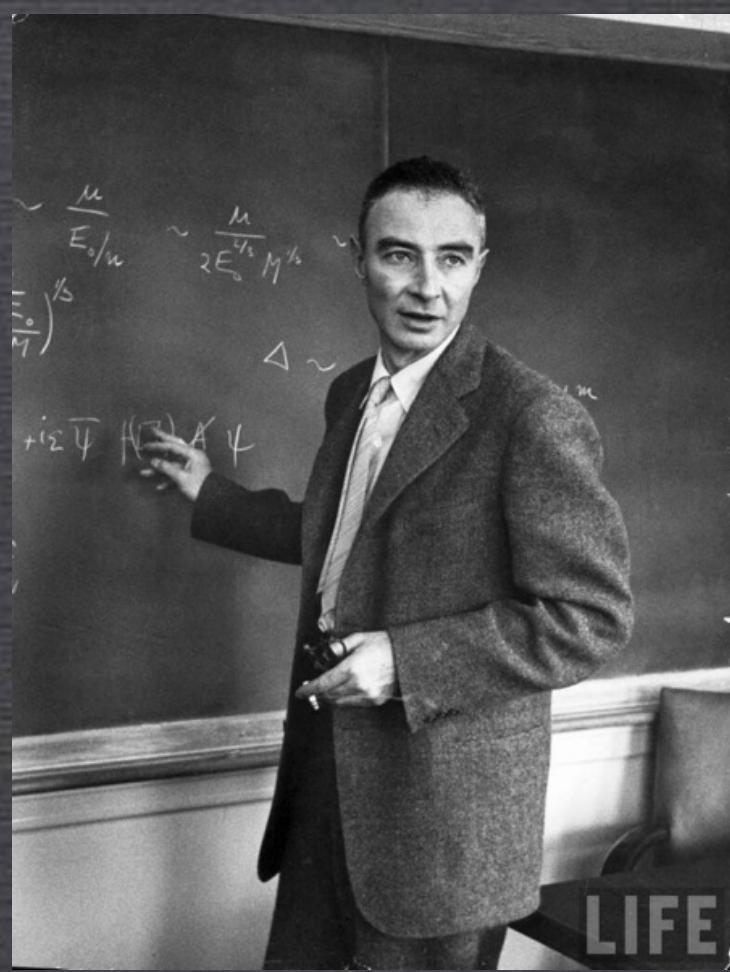
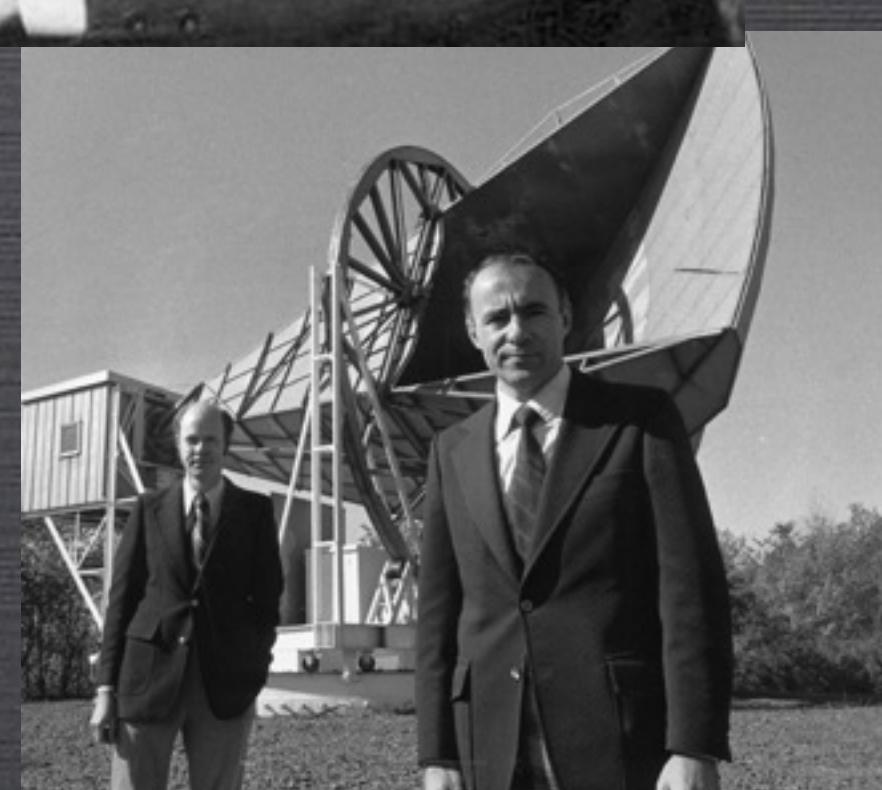
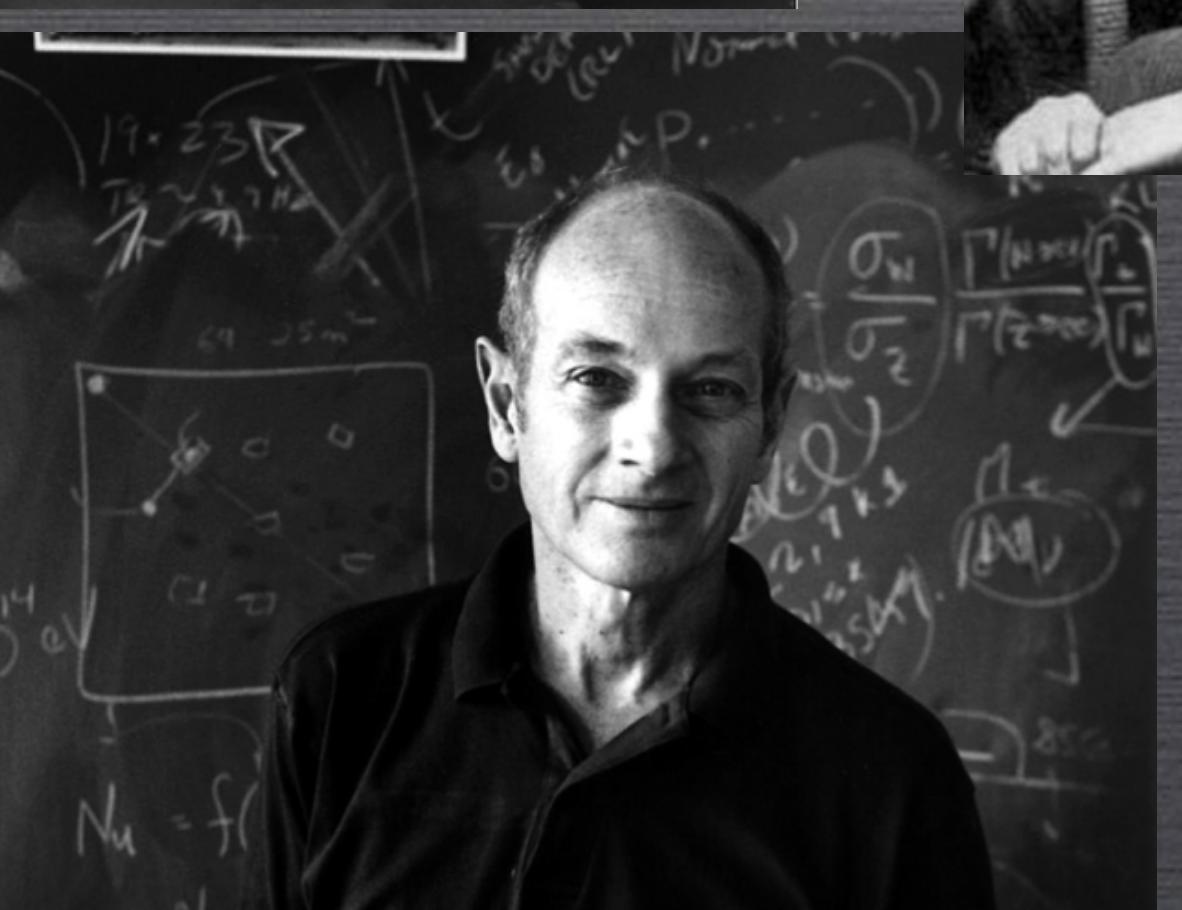
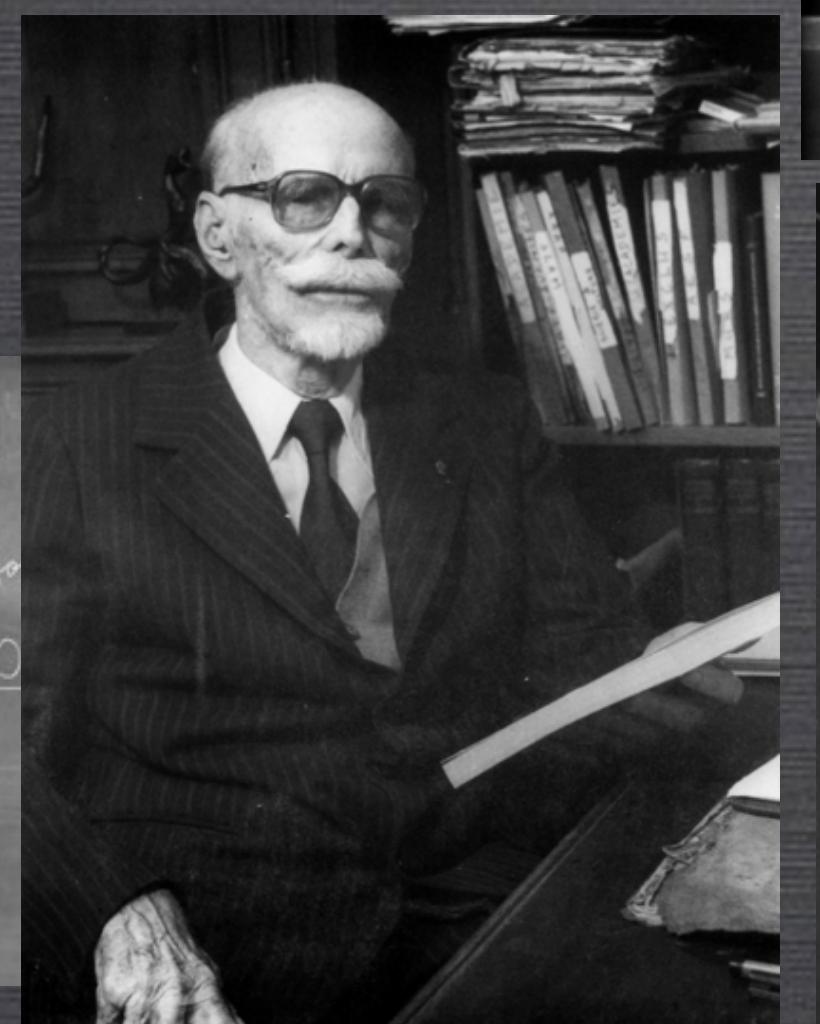
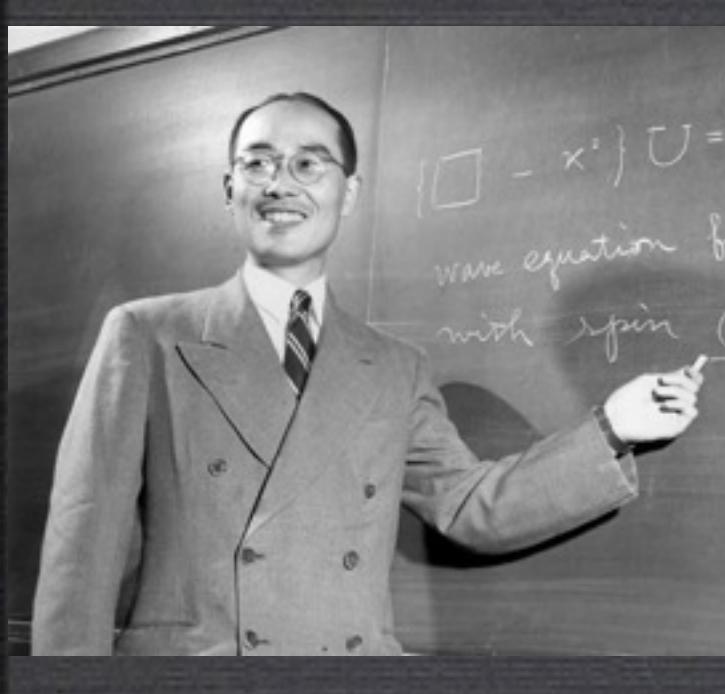
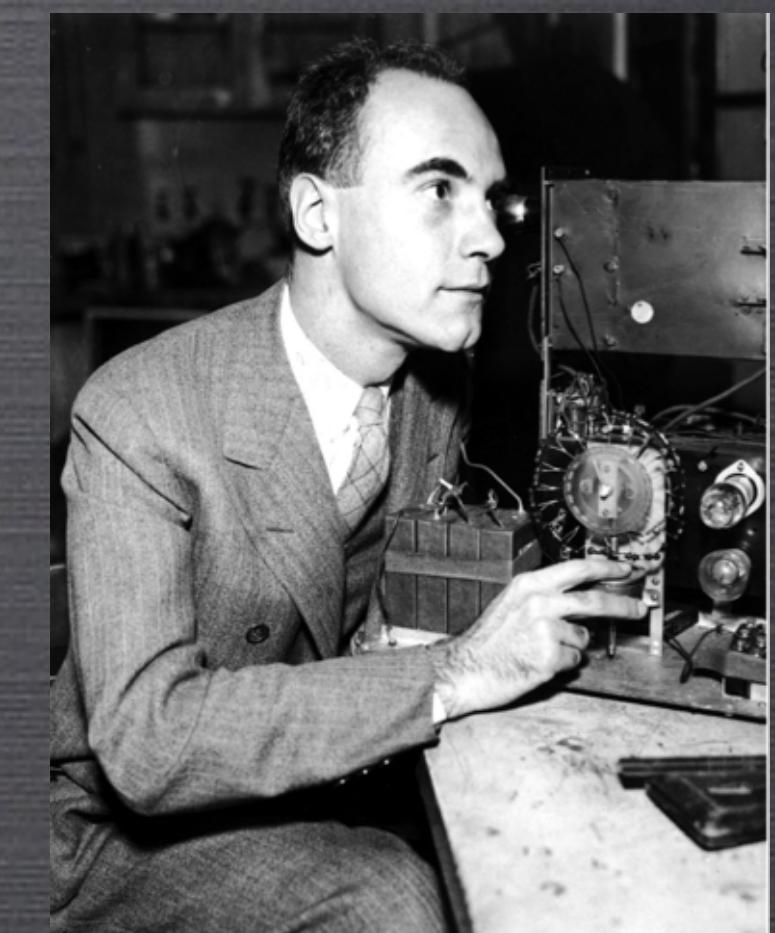
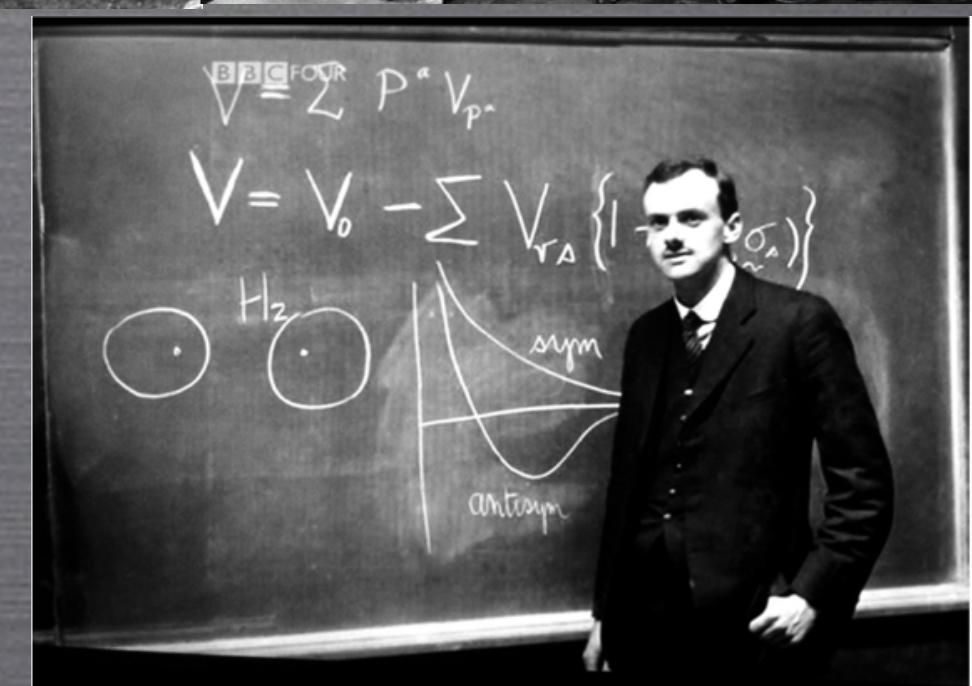
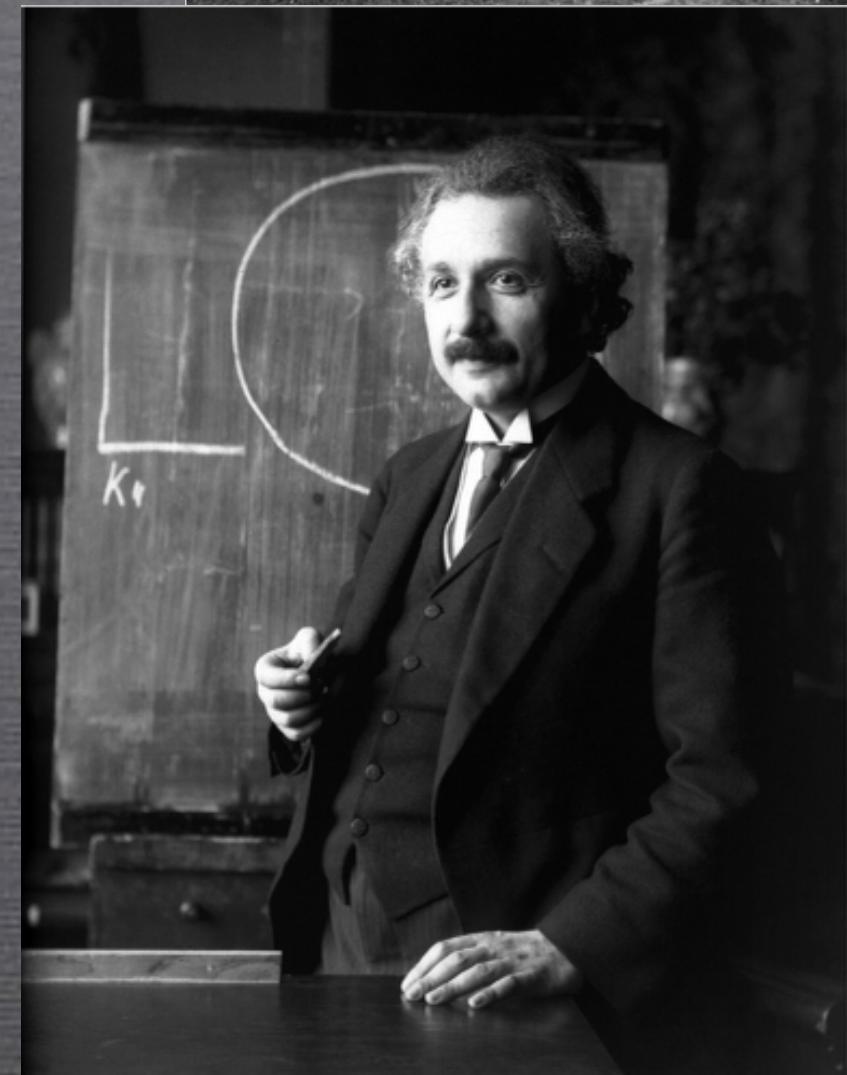
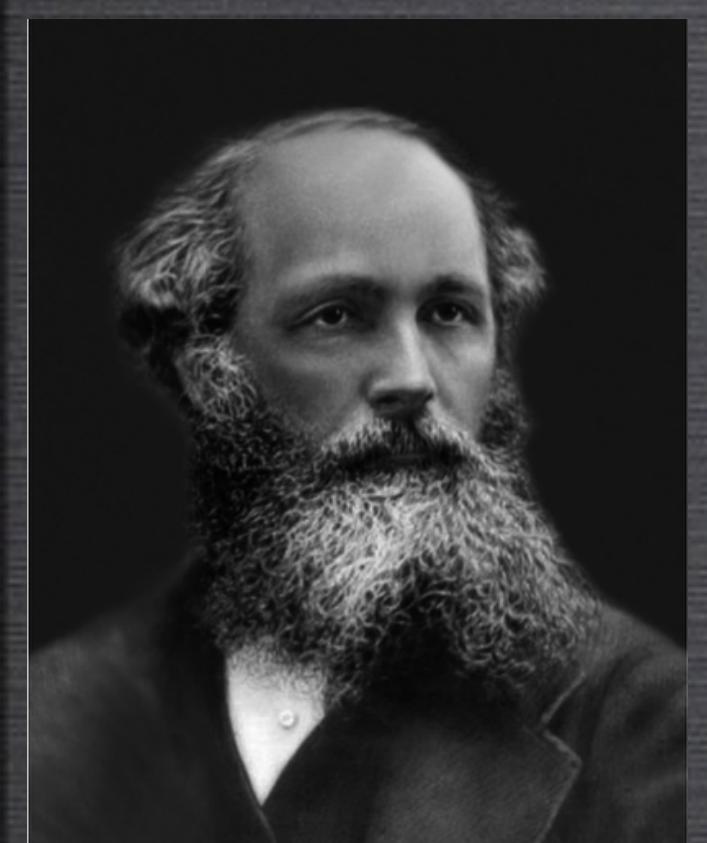
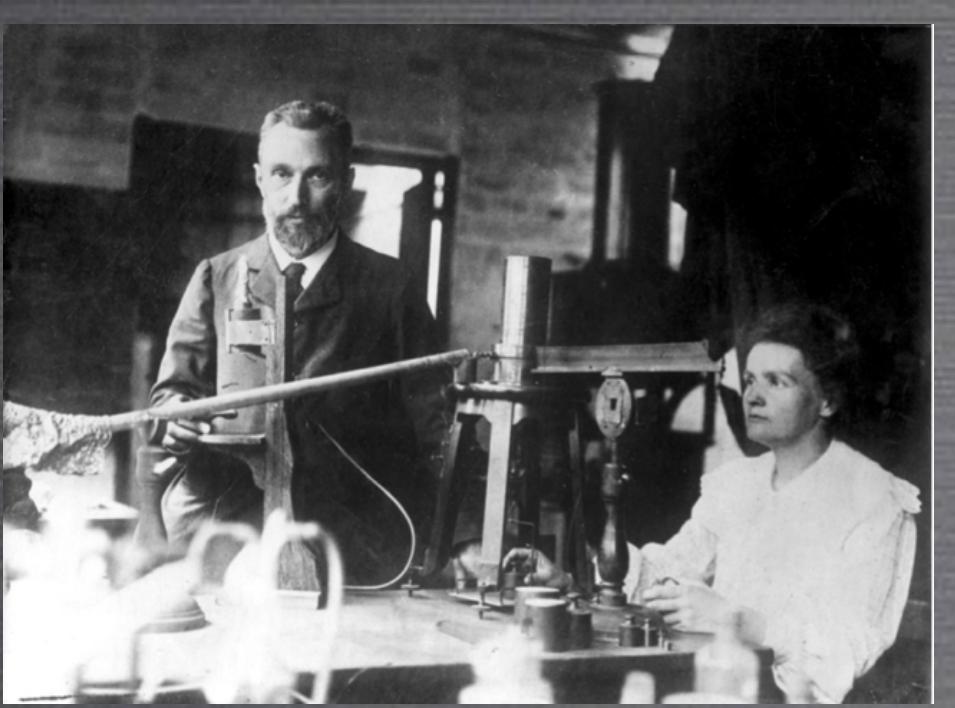
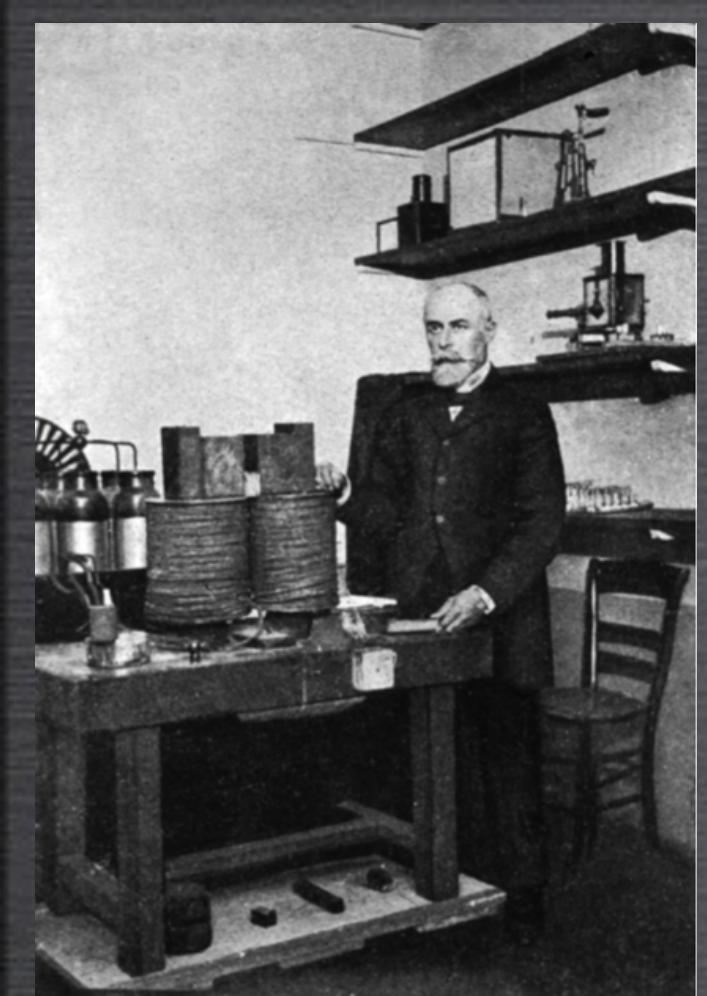
CENTAURUS A



LES NOUVELLES DONNÉES SONT MOINS CONVAINCANTES...
IL FAUT CONTINUER À CHERCHER

LES DONNÉES DE L'OBSERVATOIRE AUGER EN 2013 :





LIFE

