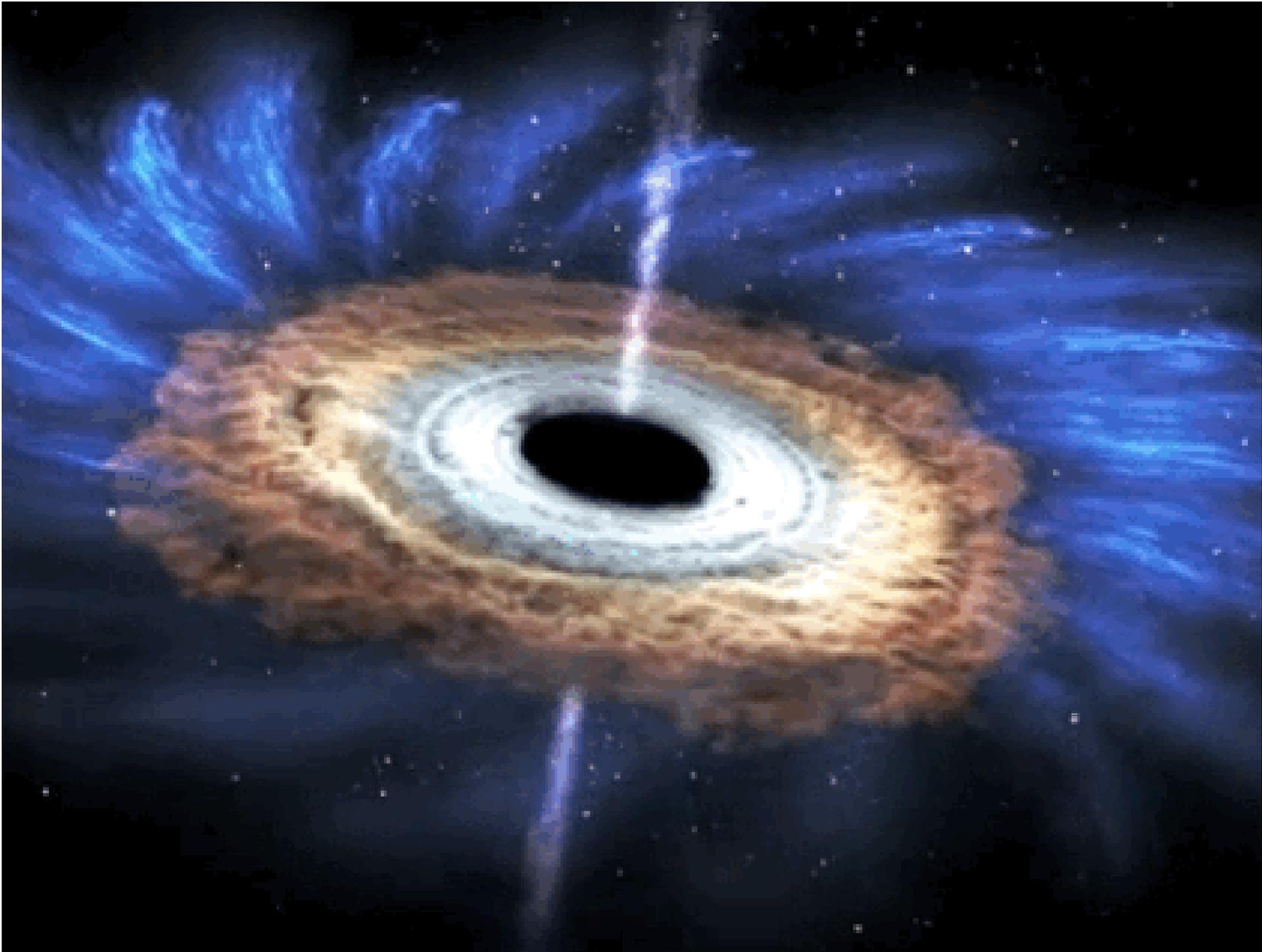


**Quo Vadis Fisica Moderna:
dai buchi neri alla terapia dei tumori
018/01/2020 – Velletri 2030
Le vie della scienza**

Catalina Curceanu, INFN-INFN, Frascati



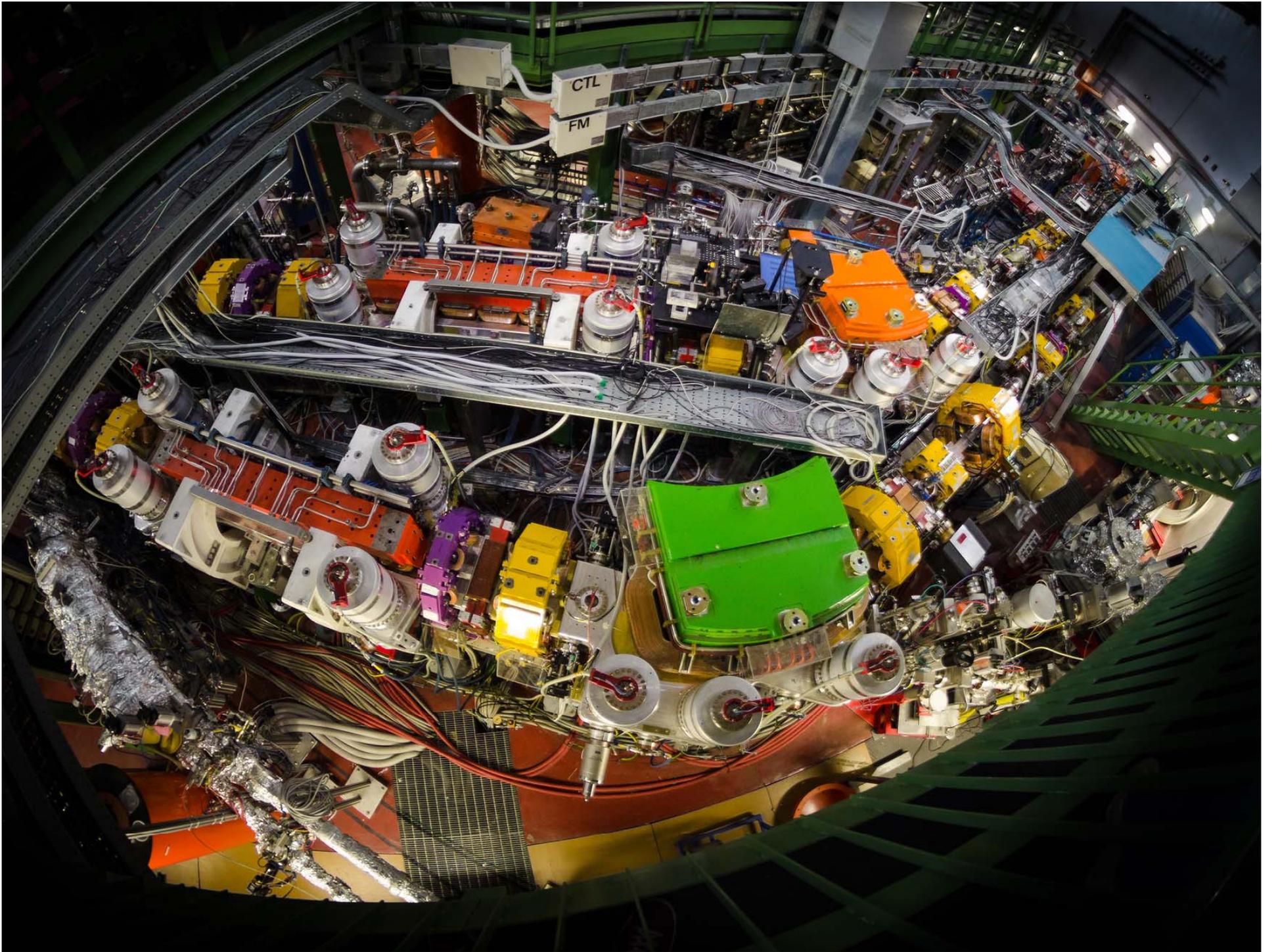


BUON 2020!

DAΦNE – LNF-INFN

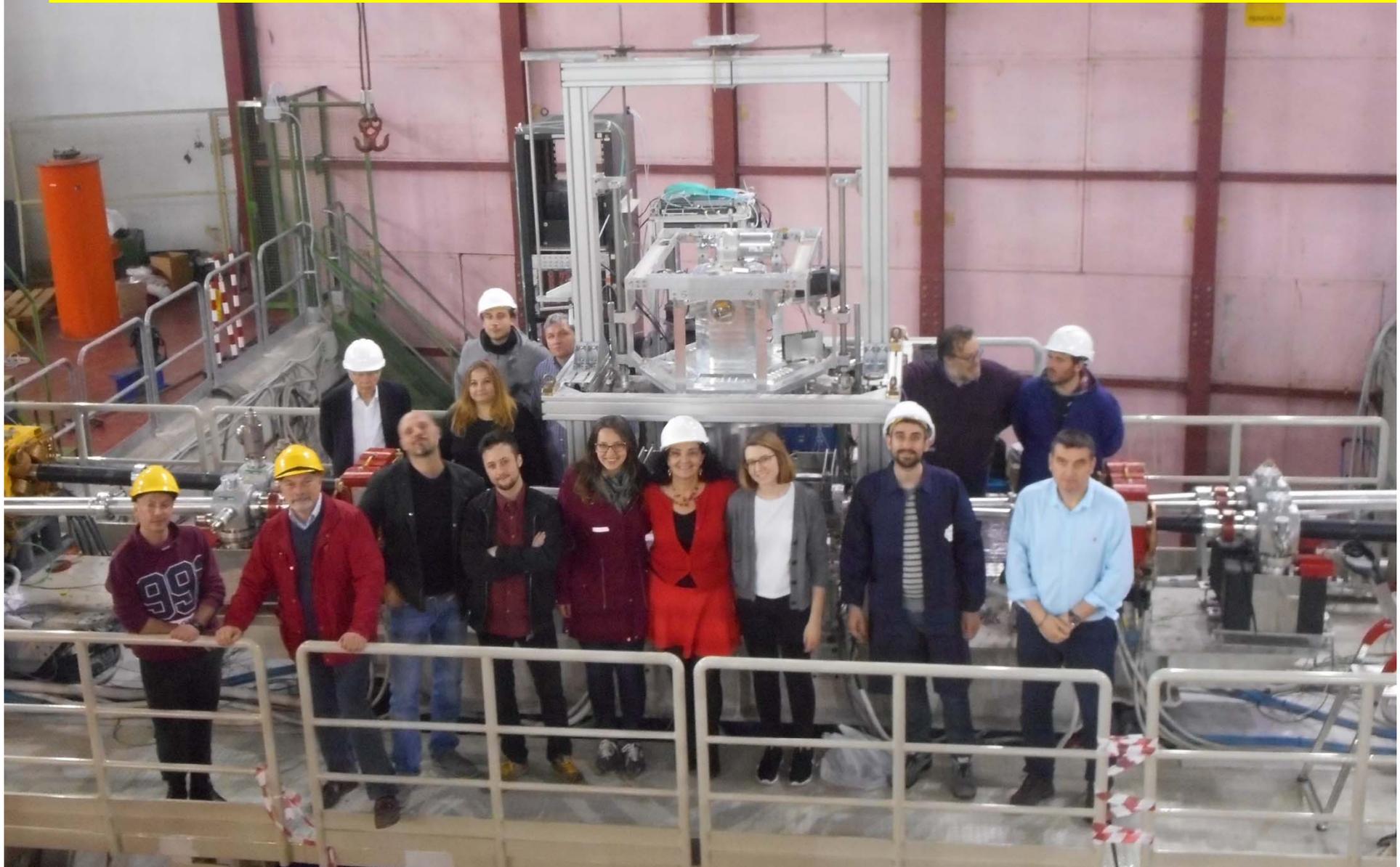


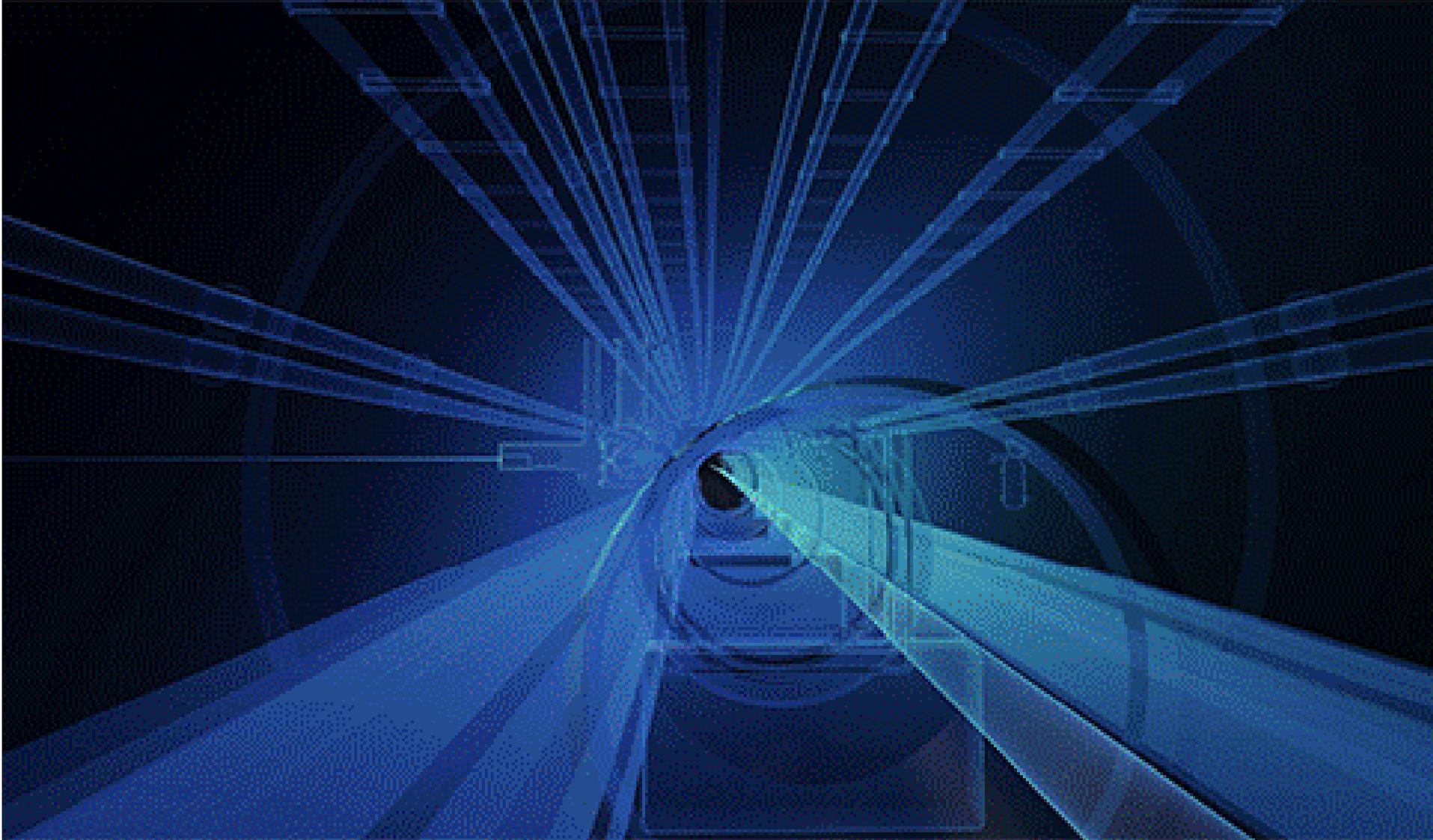


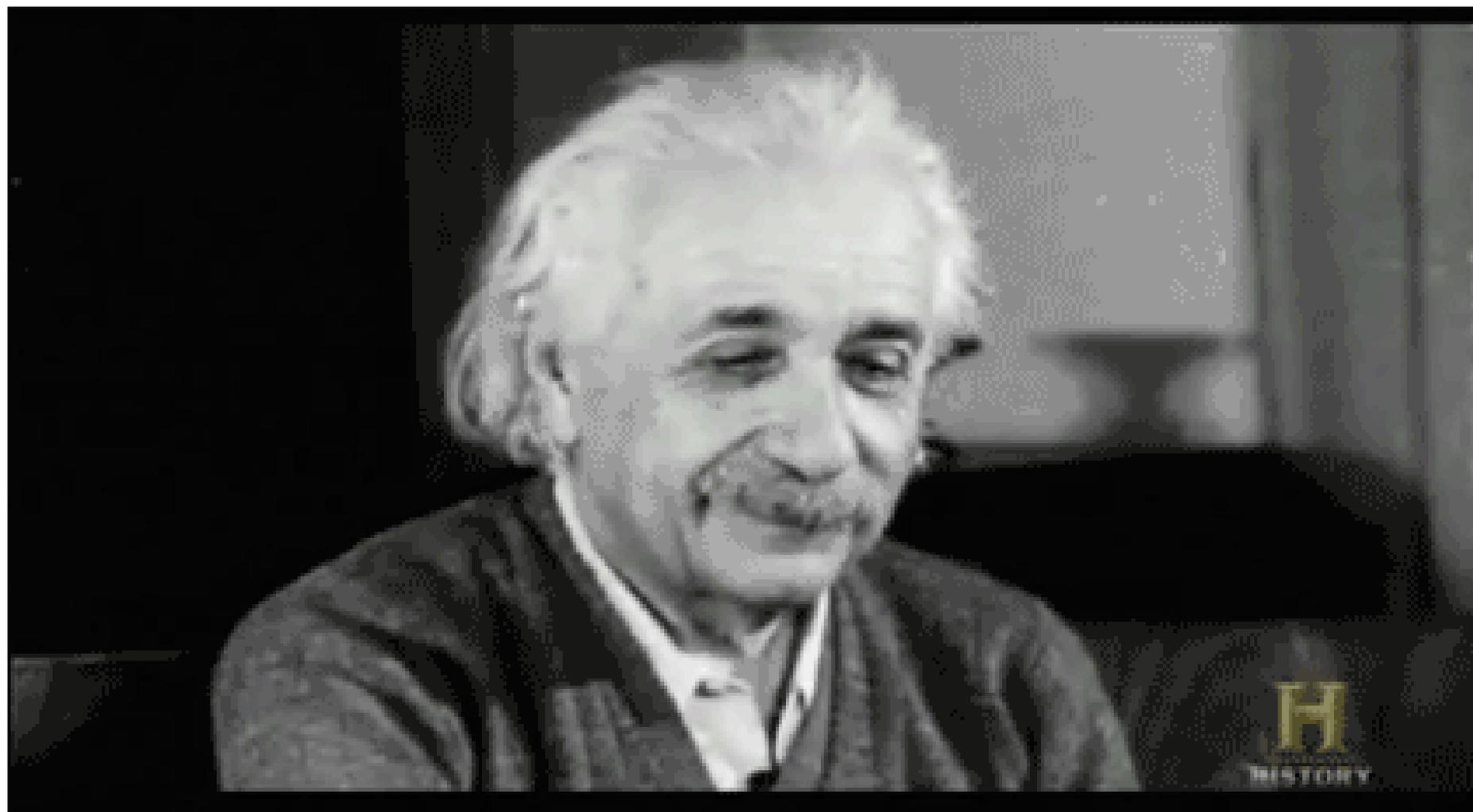


SIDDHARTA

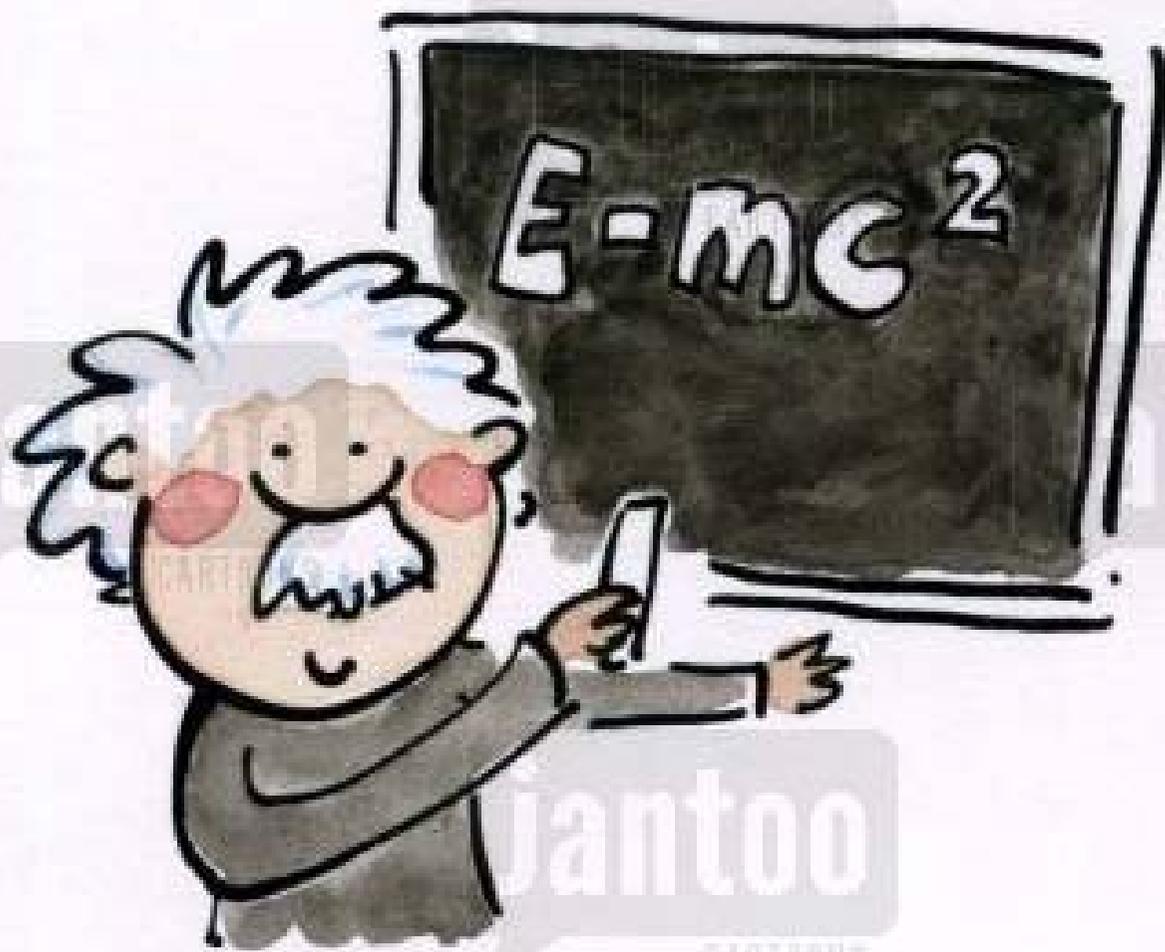
Si Silicon Drift Detector for Hadronic Atom Research by Timing Applications







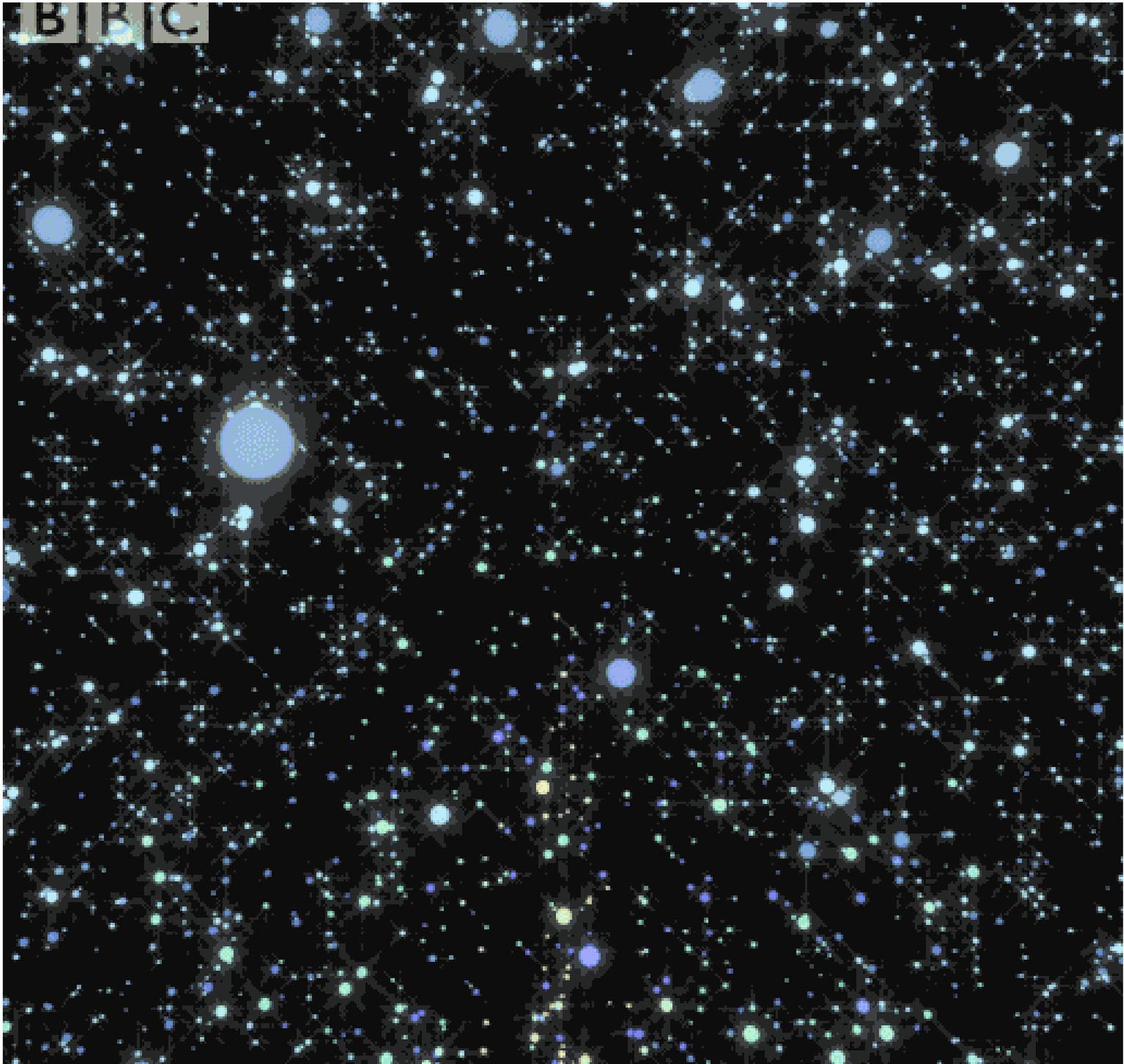




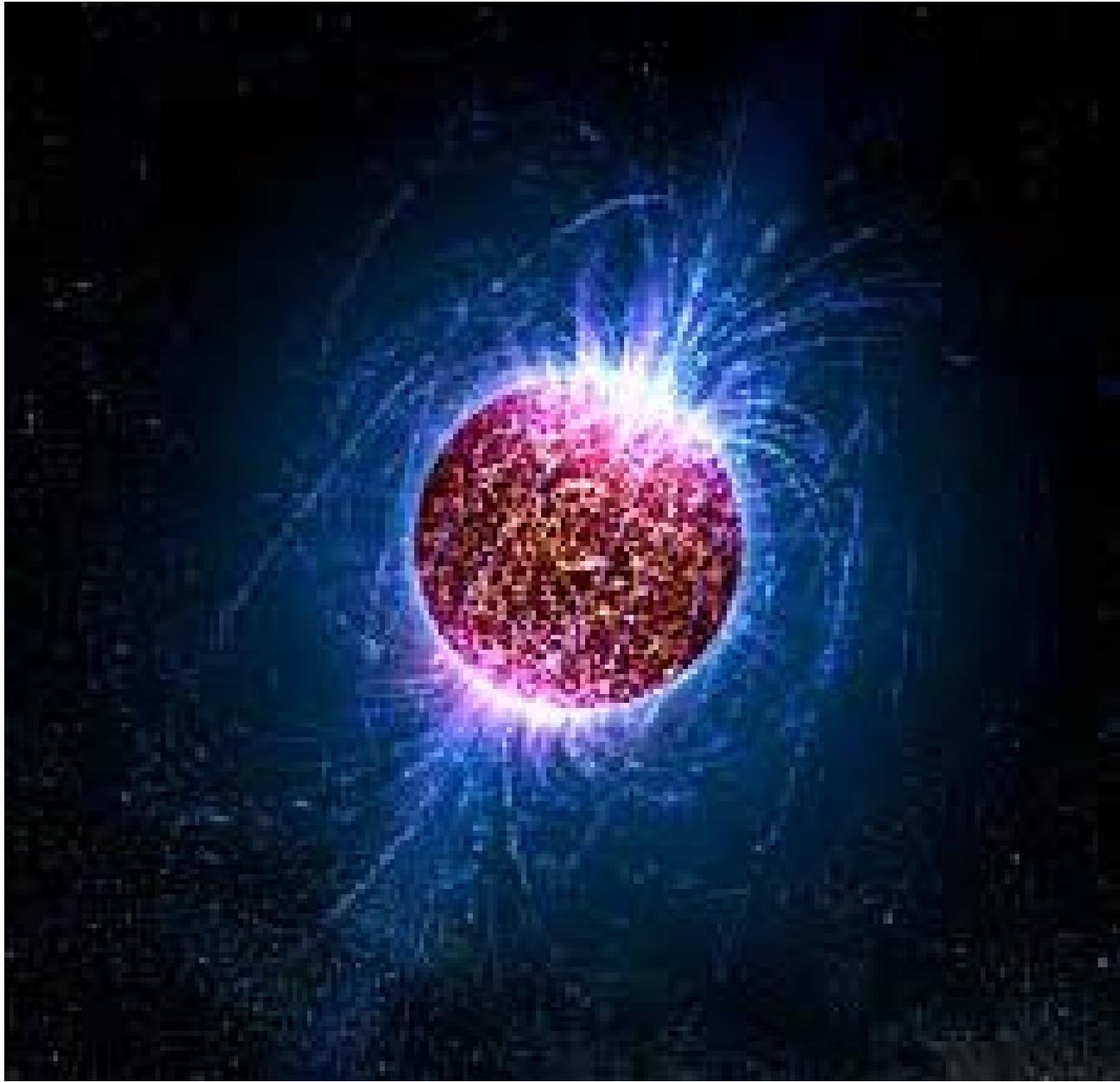
Search: 30430174



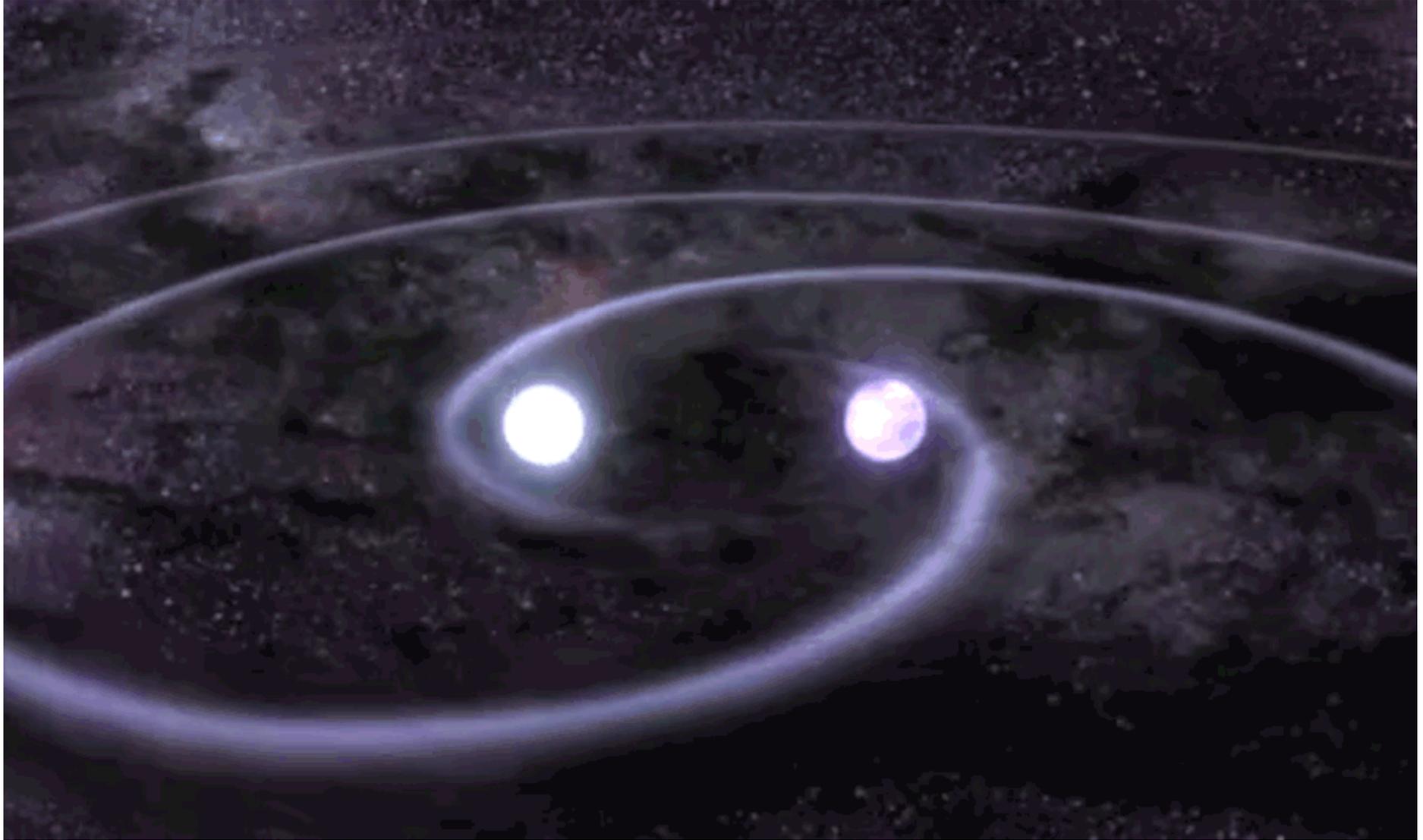




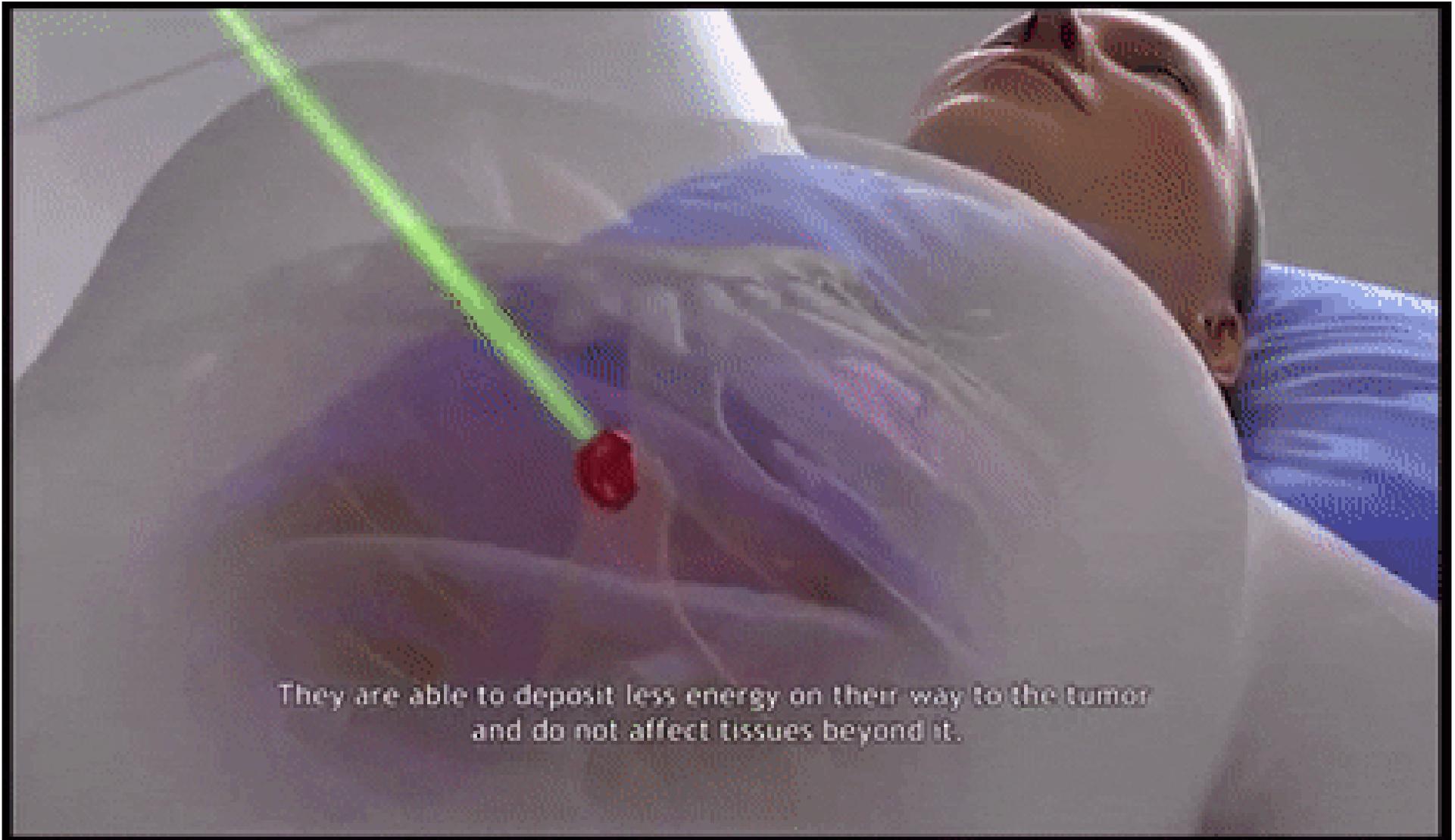












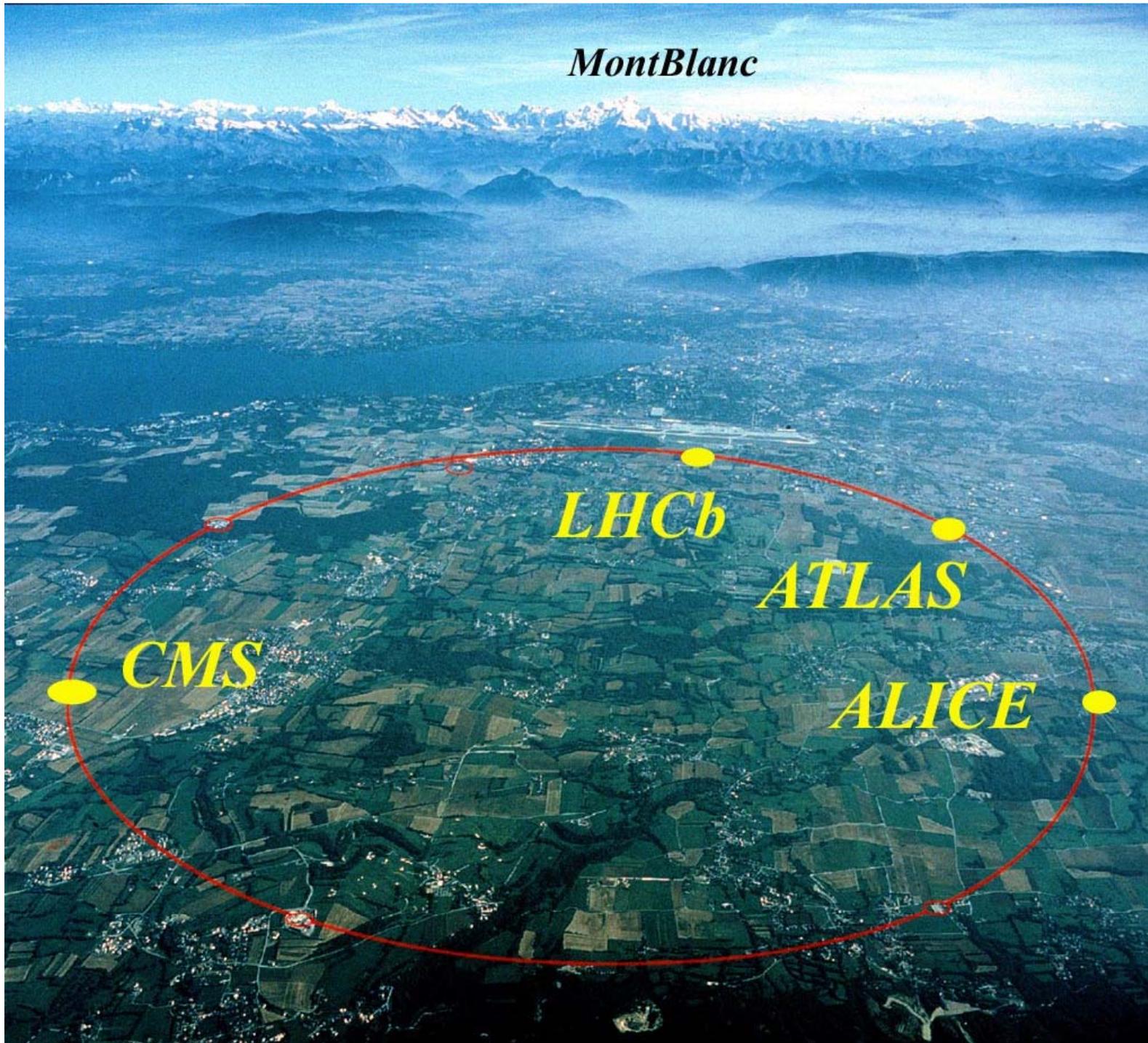
They are able to deposit less energy on their way to the tumor and do not affect tissues beyond it.

Particle-antiparticle colliders

LEP at CERN 1988



MontBlanc



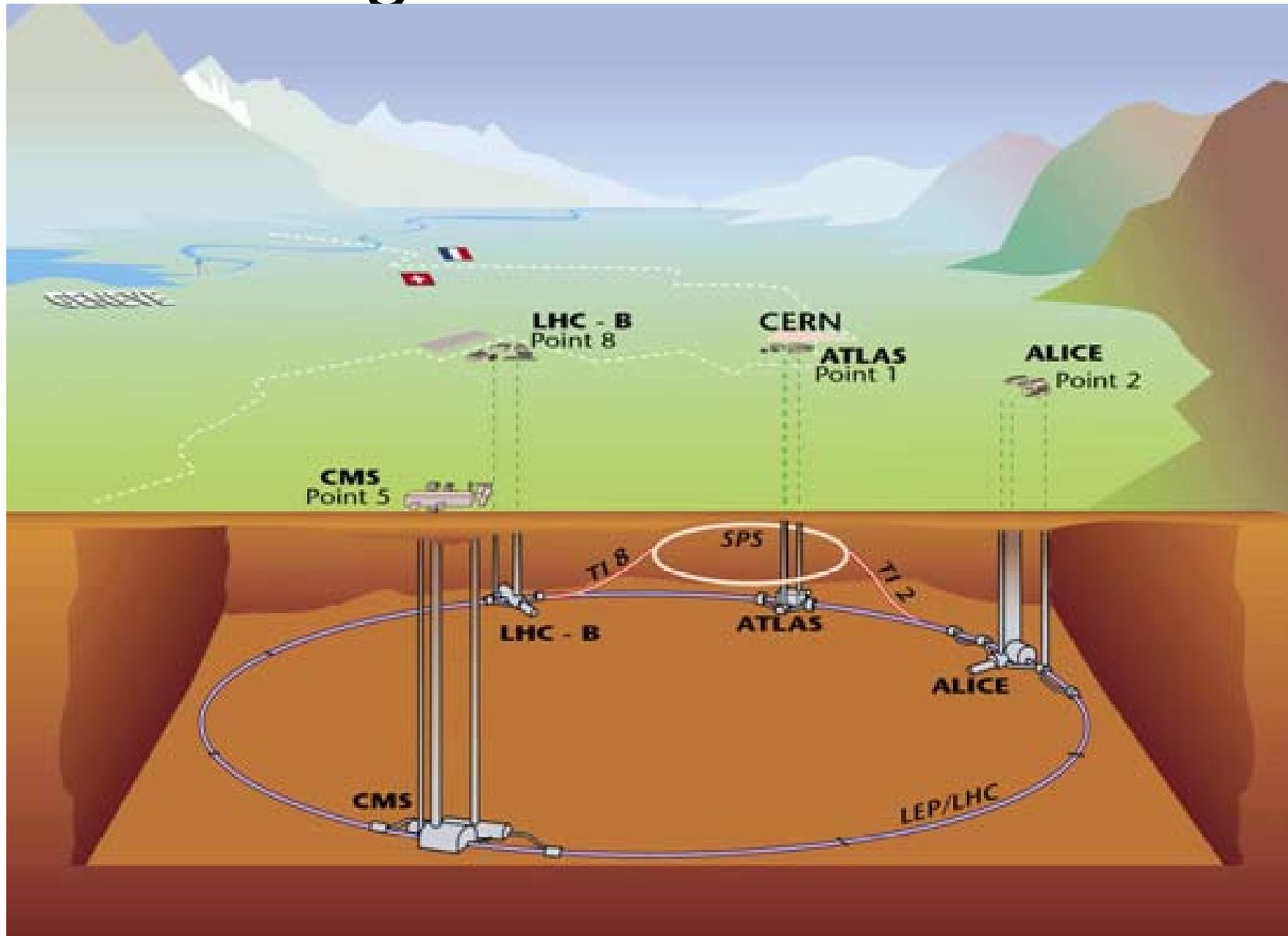
CMS

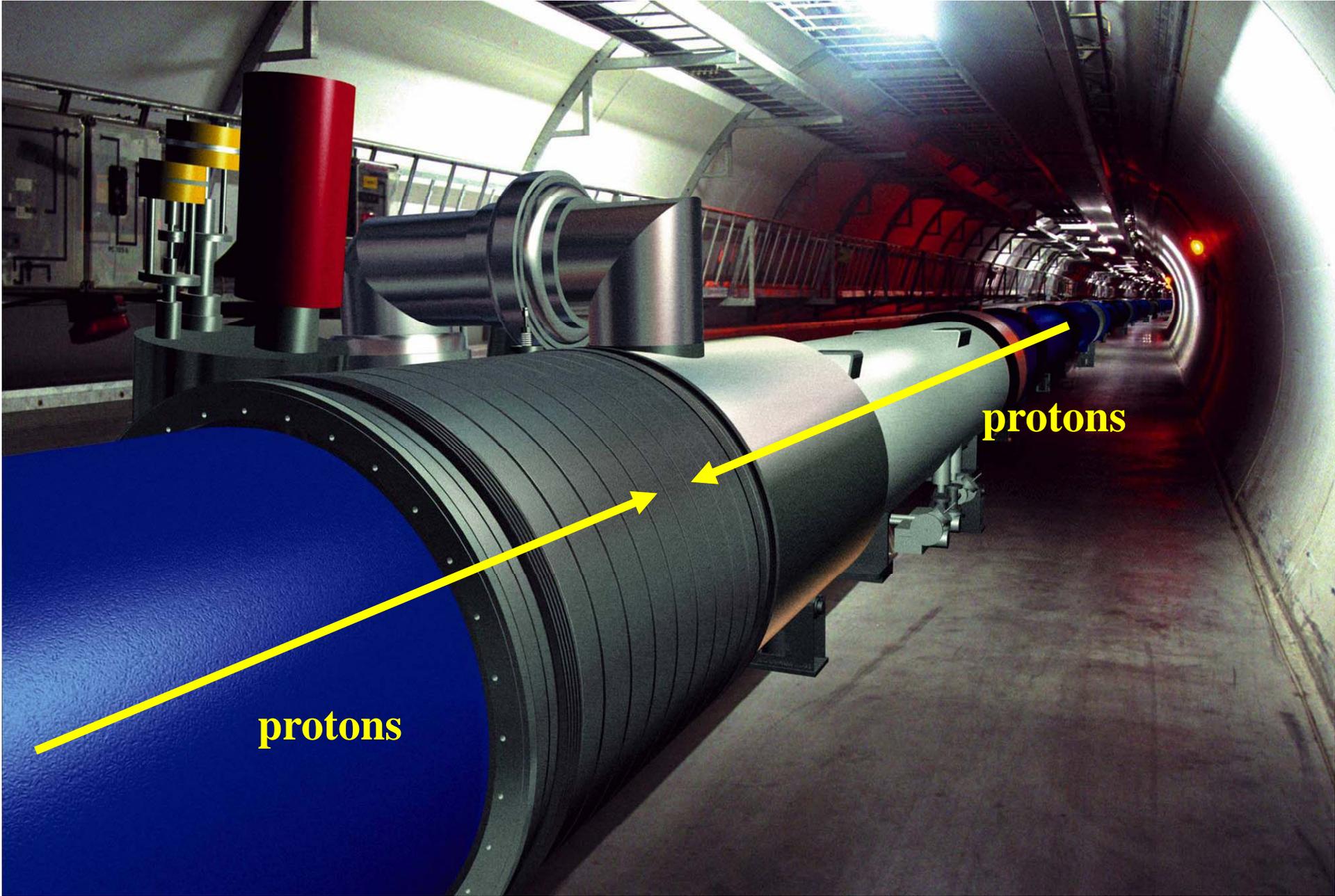
LHCb

ATLAS

ALICE

Large Hadron Collider

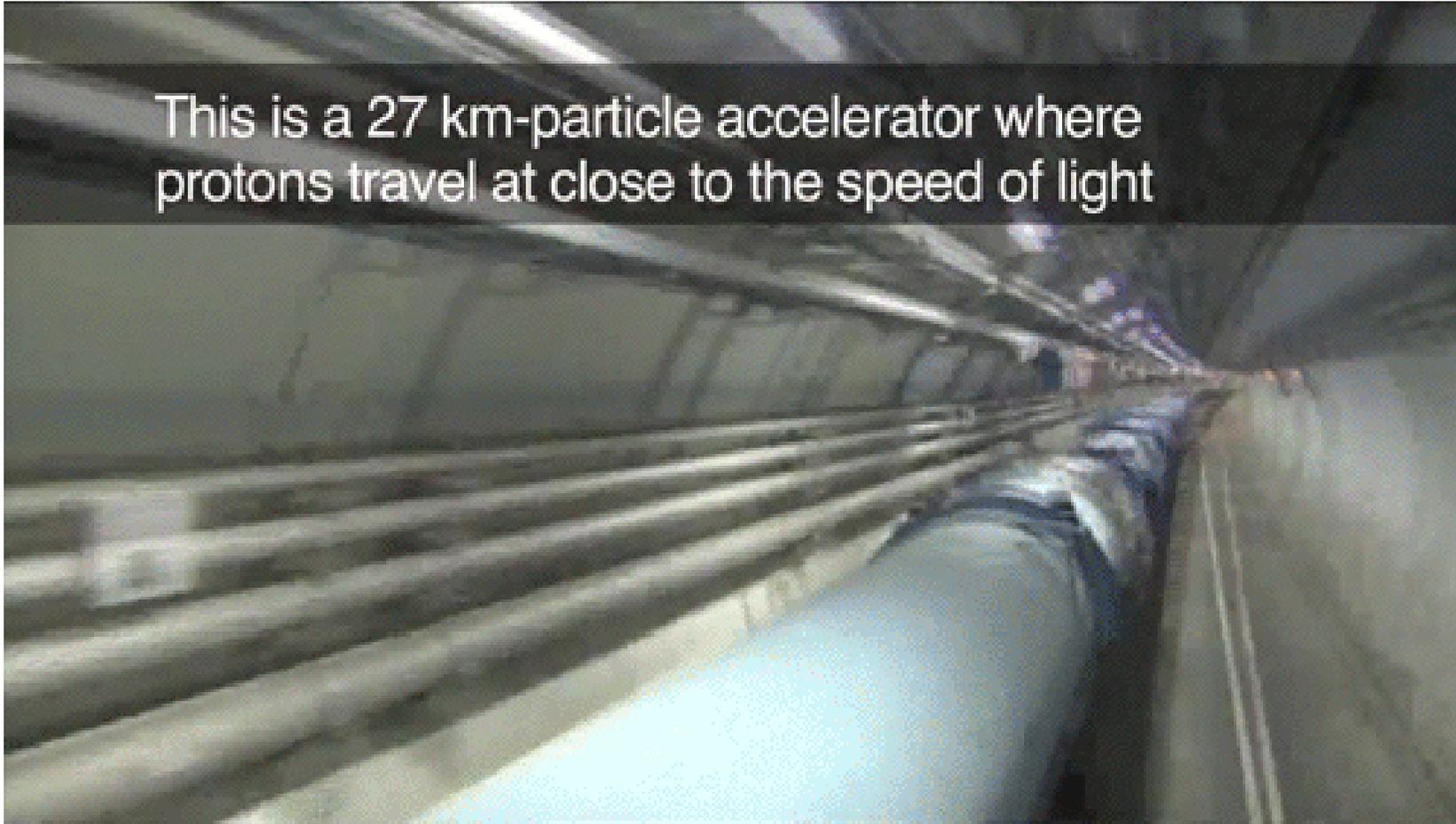




protons

protons

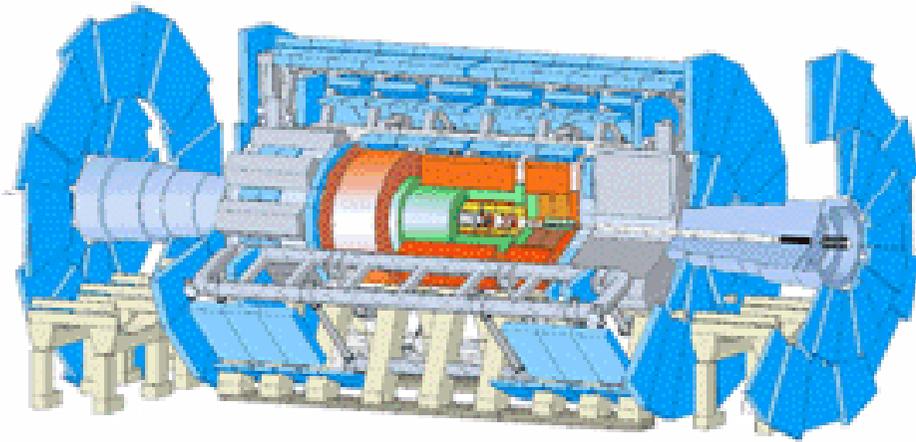
This is a 27 km-particle accelerator where protons travel at close to the speed of light



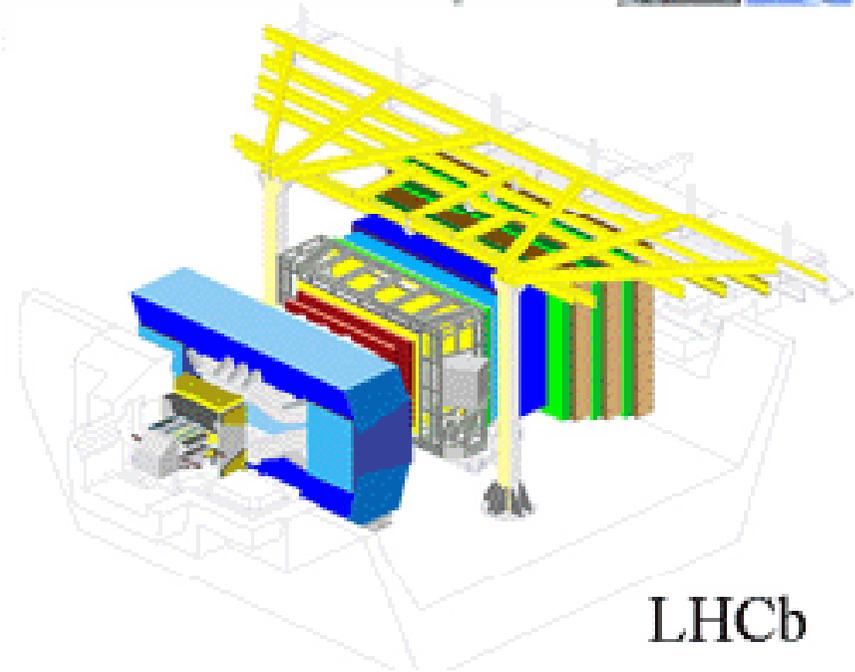
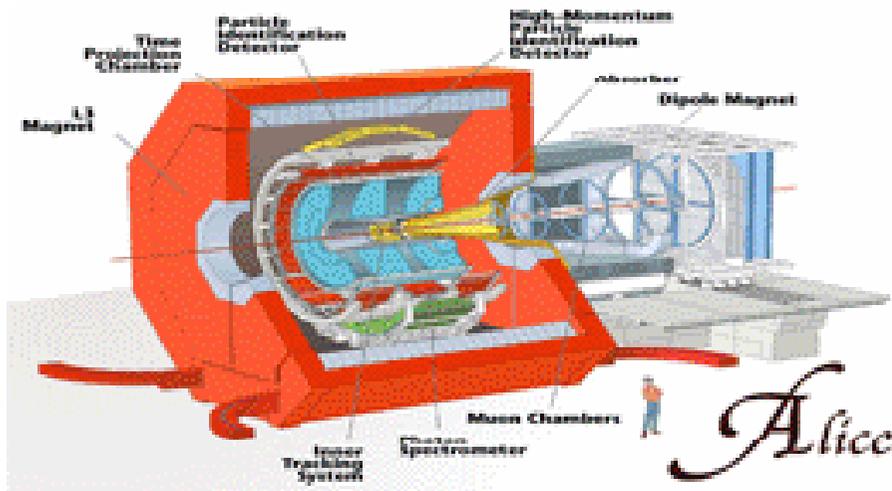


Large Hadron Collider

ATLAS

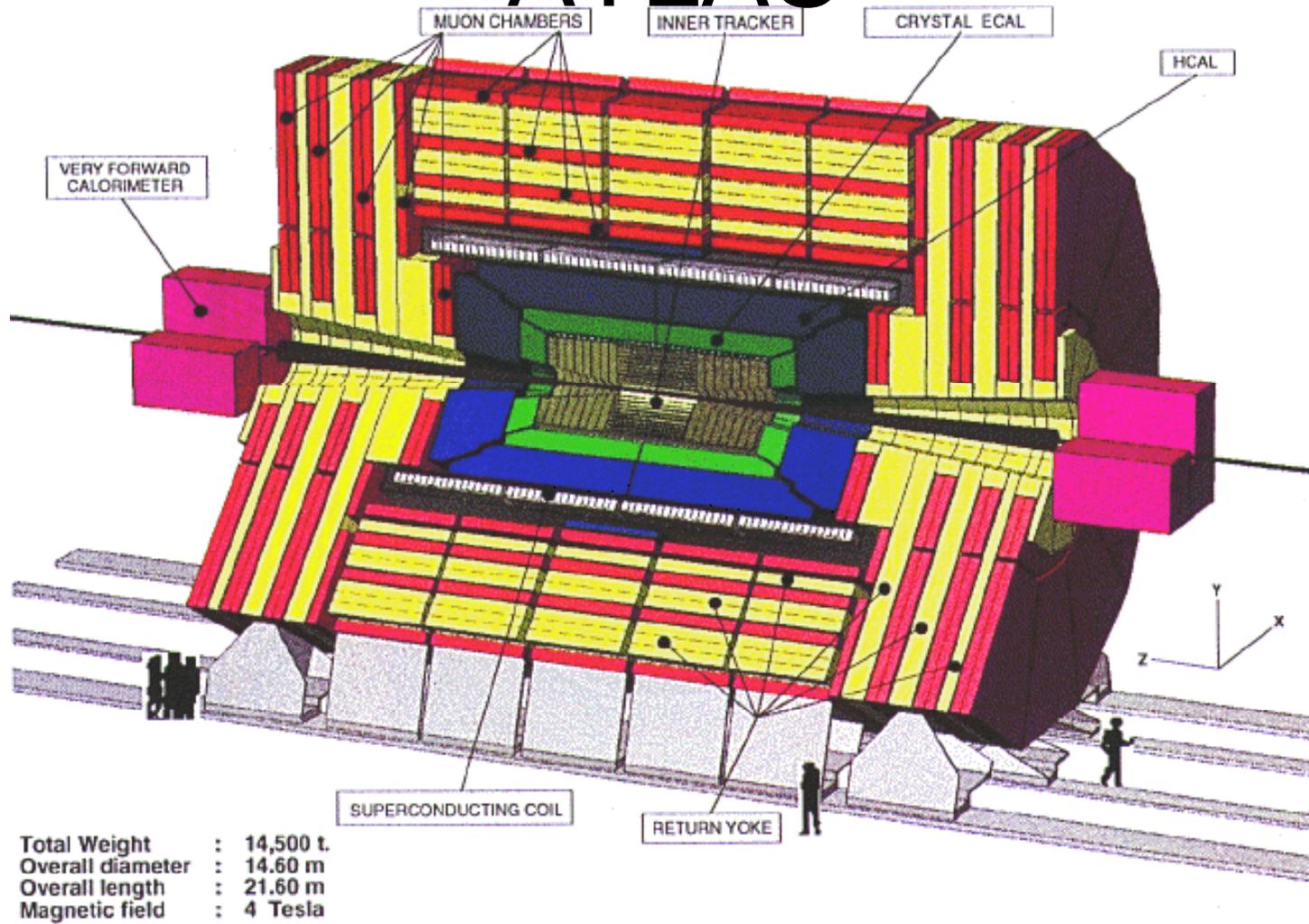


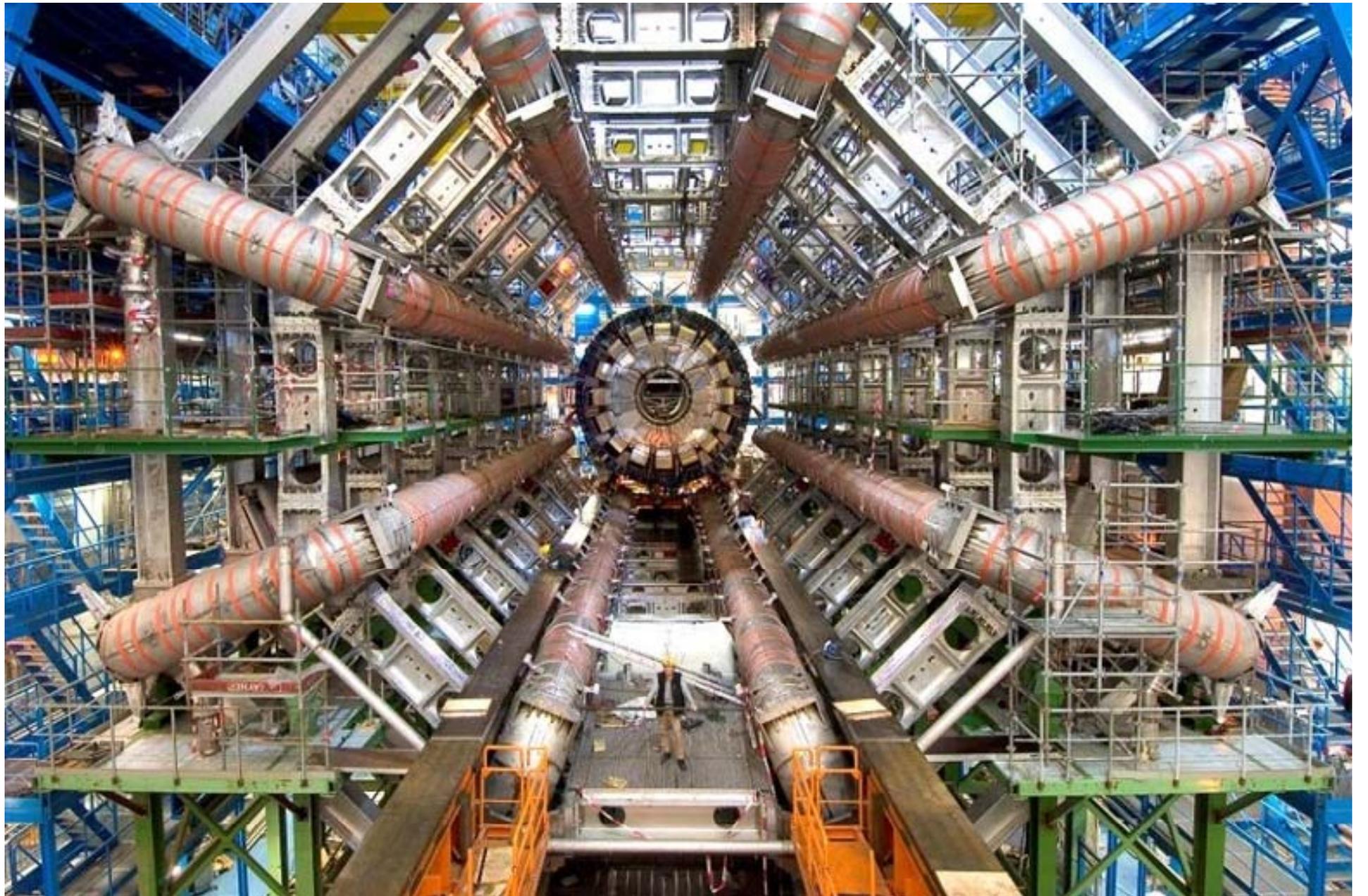
CMS



LHCb

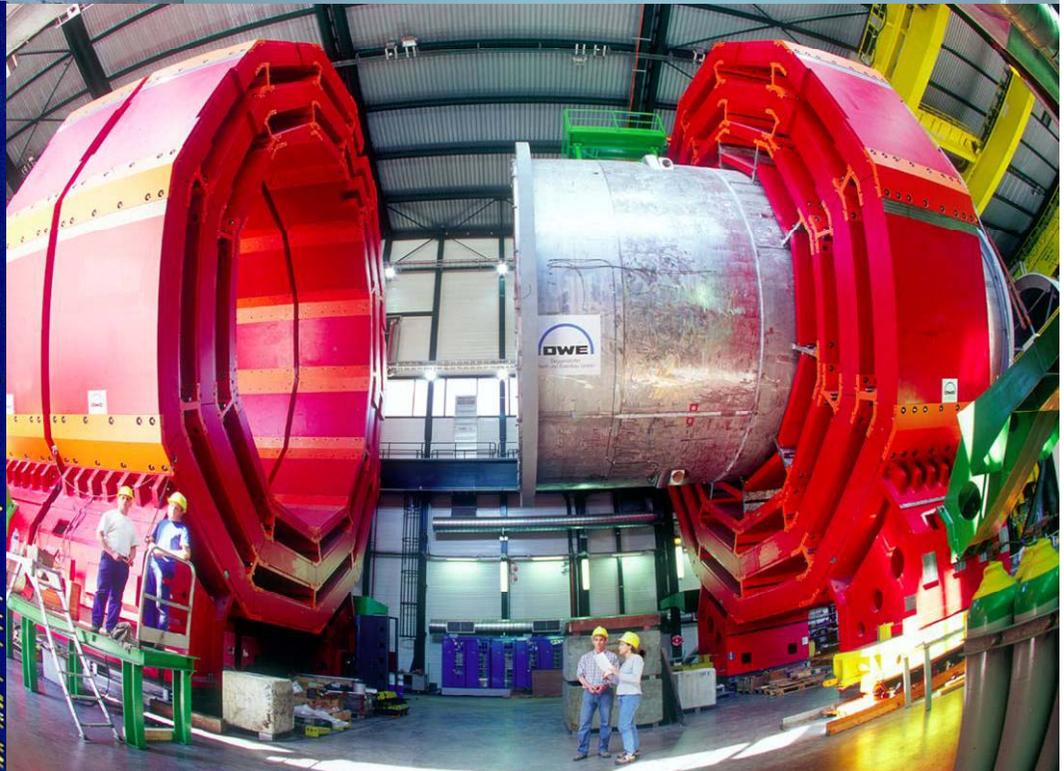
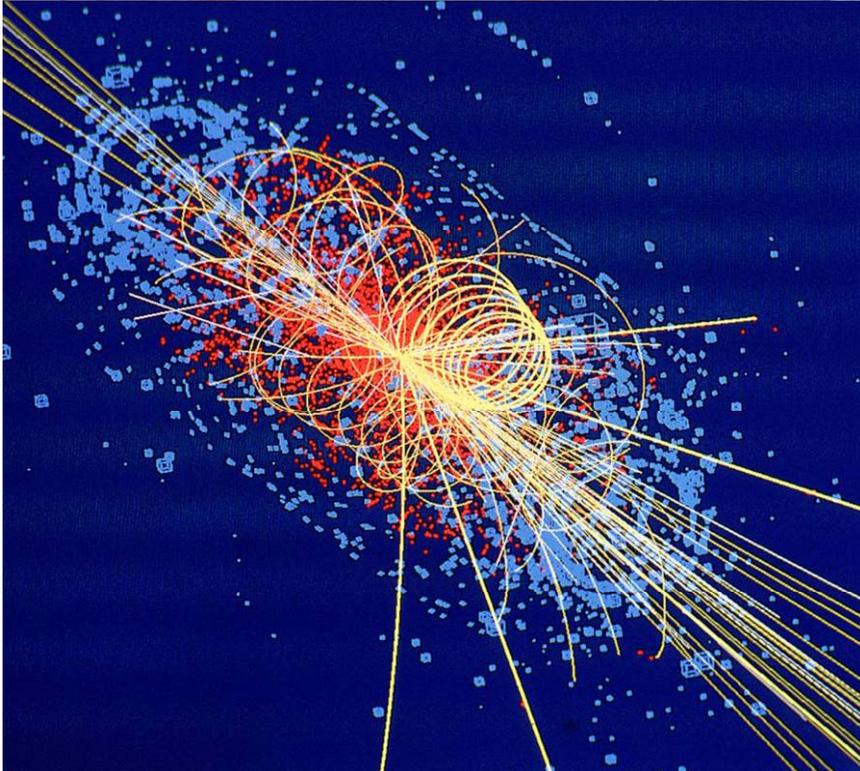
Large Hadron Collider - ATLAS





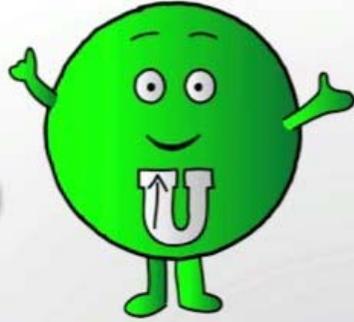


The particle accelerators and the huge detectors are demanding technological breakthrough effort as space research does





Up



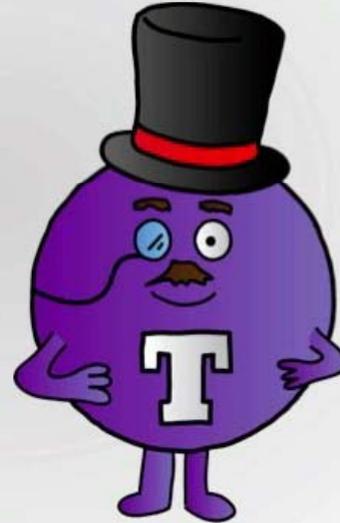
Down



Strange



Charm



Top



Bottom



$$(\mathcal{D}_\mu \phi)^\dagger \mathcal{D}^\mu \phi - \mathcal{U}(\phi) - \frac{1}{4} F_{\mu\nu} F^{\mu\nu}$$

$$\mathcal{D}_\mu \phi = \partial_\mu \phi - ie A_\mu \phi$$

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

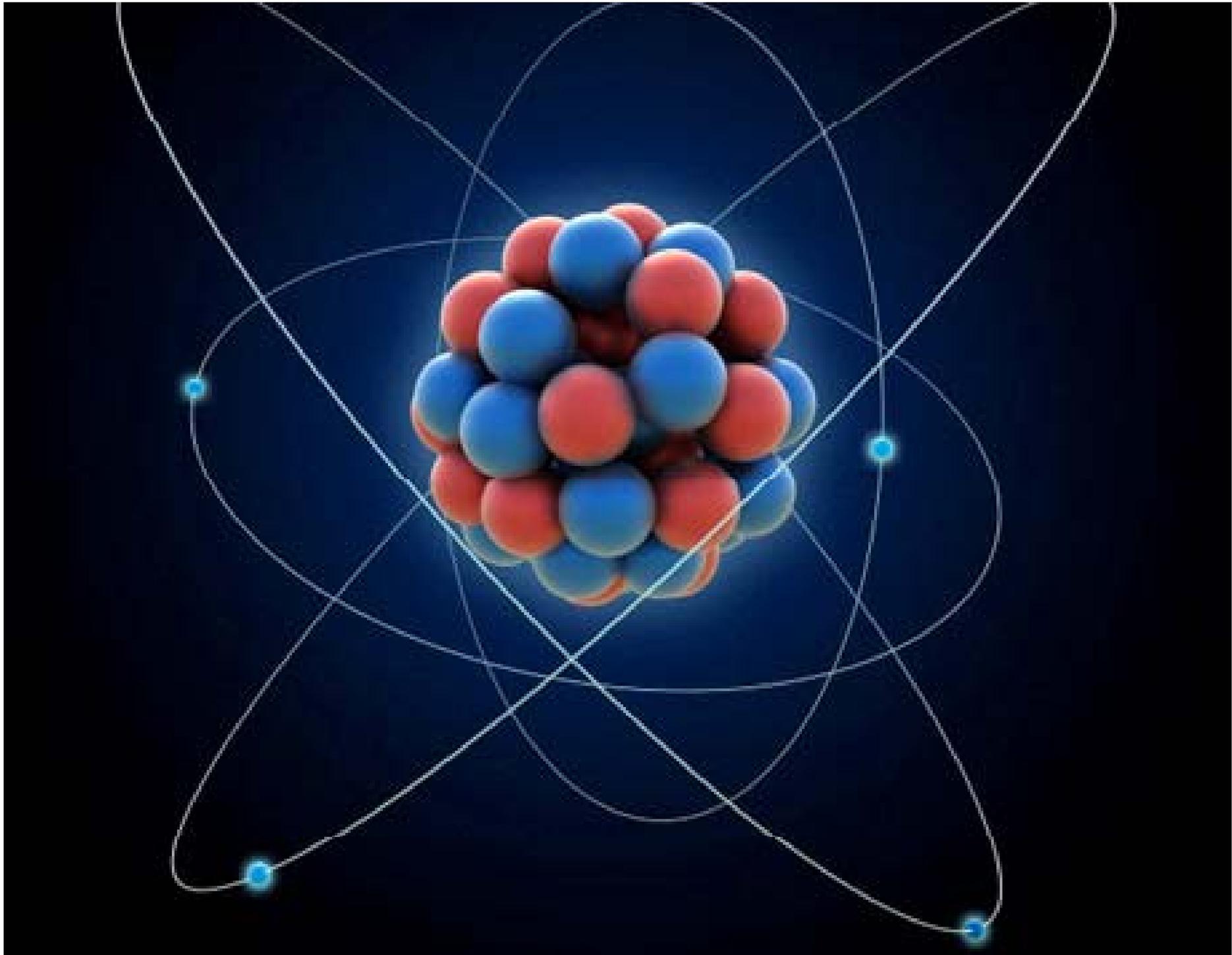
$$\mathcal{U}(\phi) = \alpha \phi^\dagger \phi + \beta (\phi^\dagger \phi)^2$$

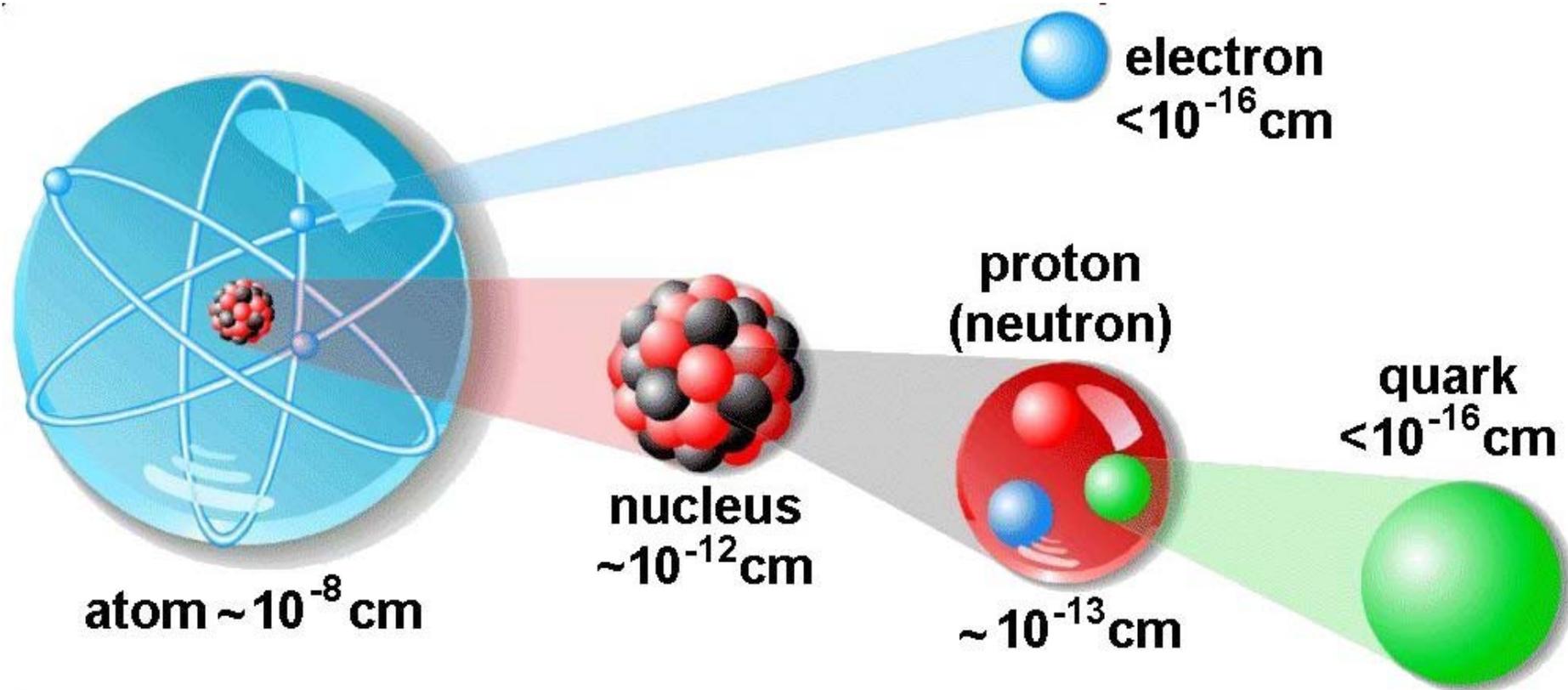
$$\alpha < 0, \beta \geq 0$$

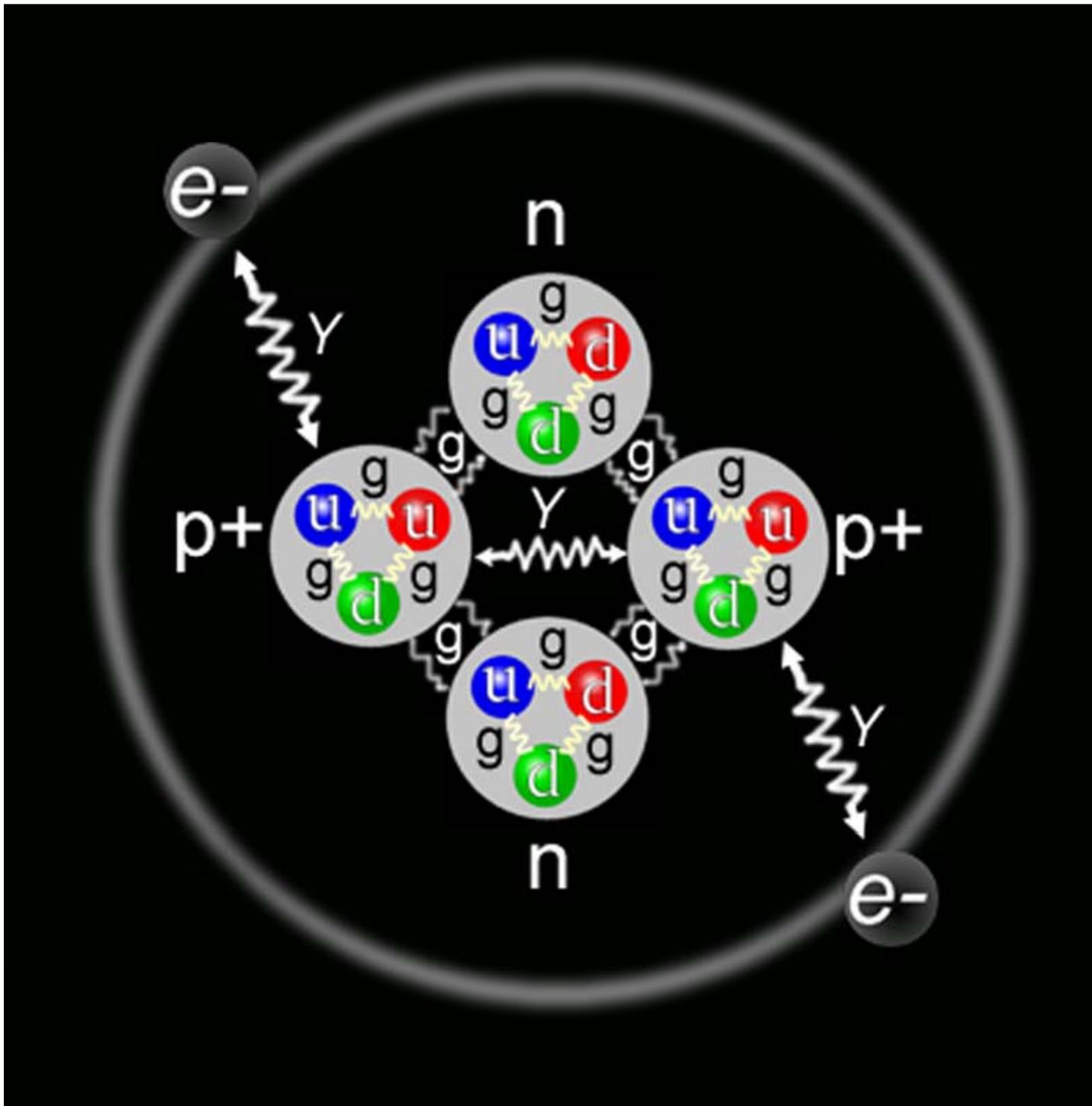


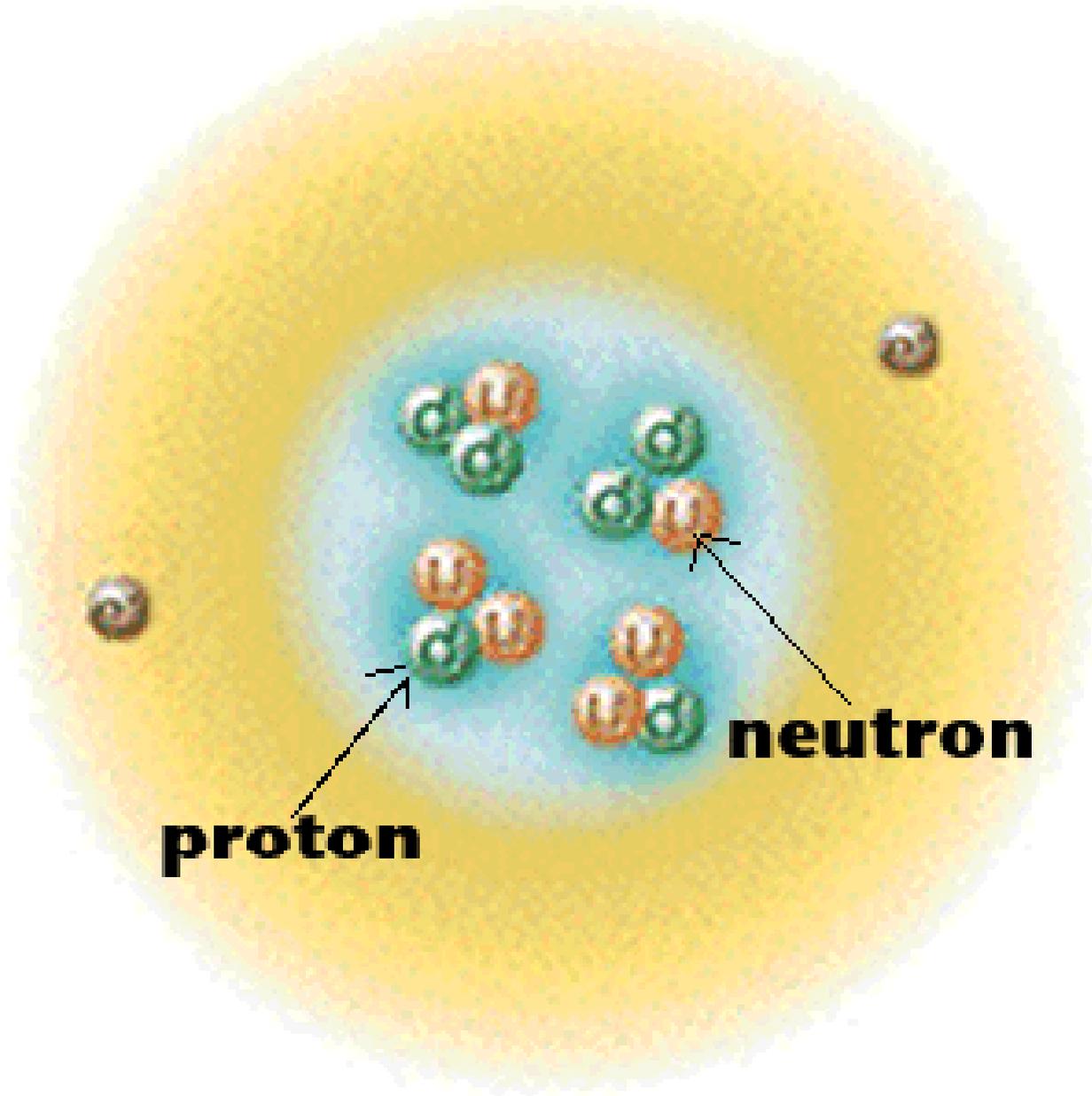
@NOWTHISNEWS











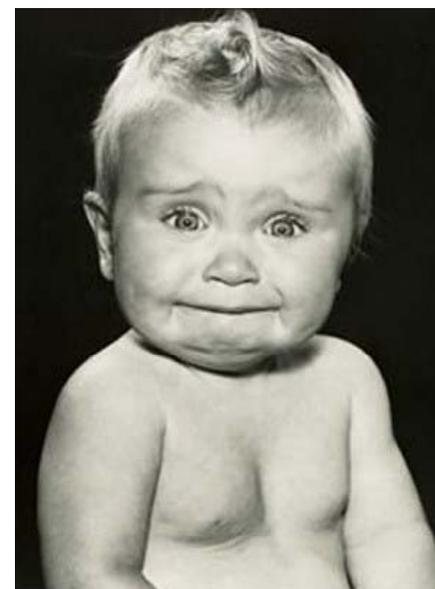
proton

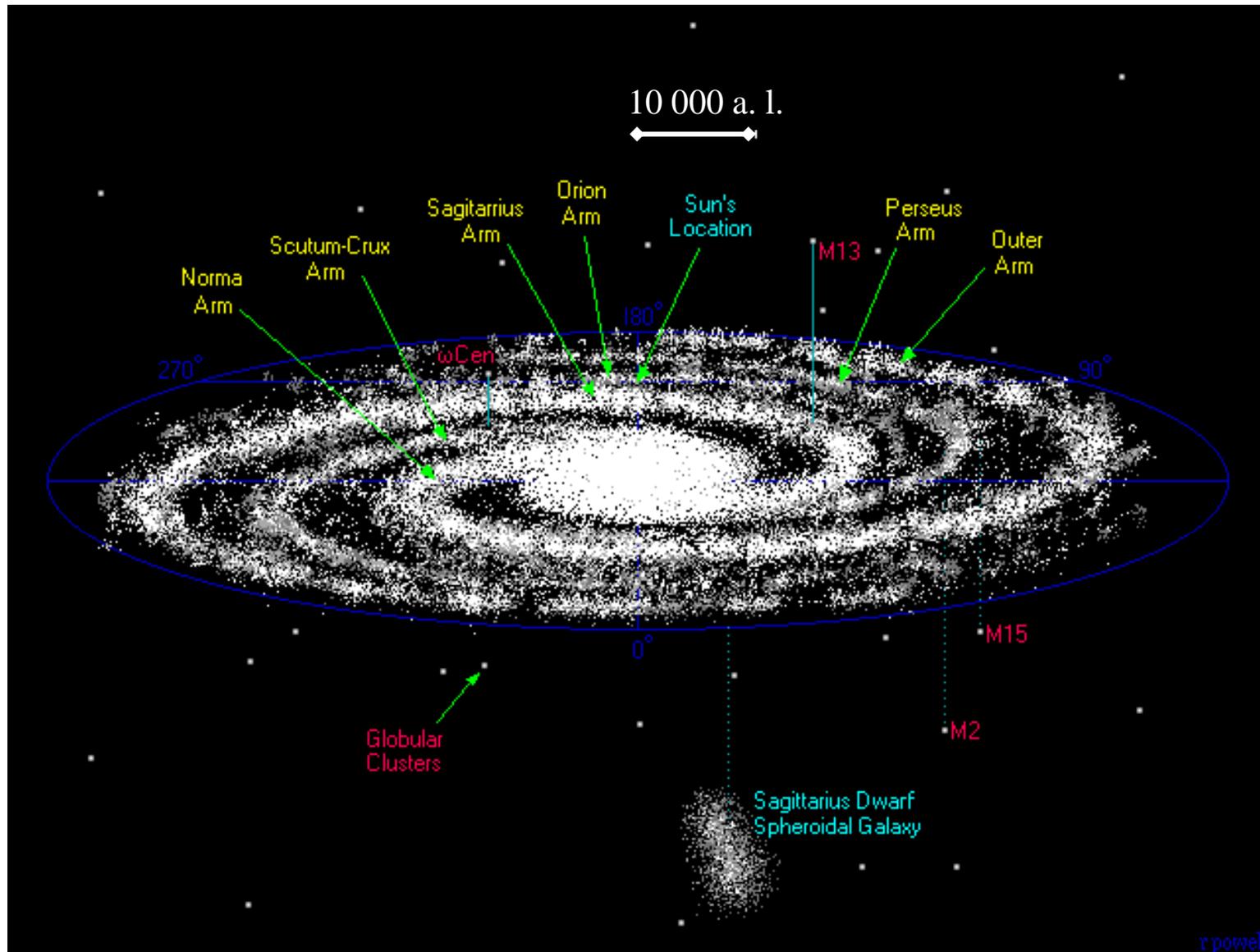
neutron

Modello standard della fisica delle particelle



NON include la gravita'!

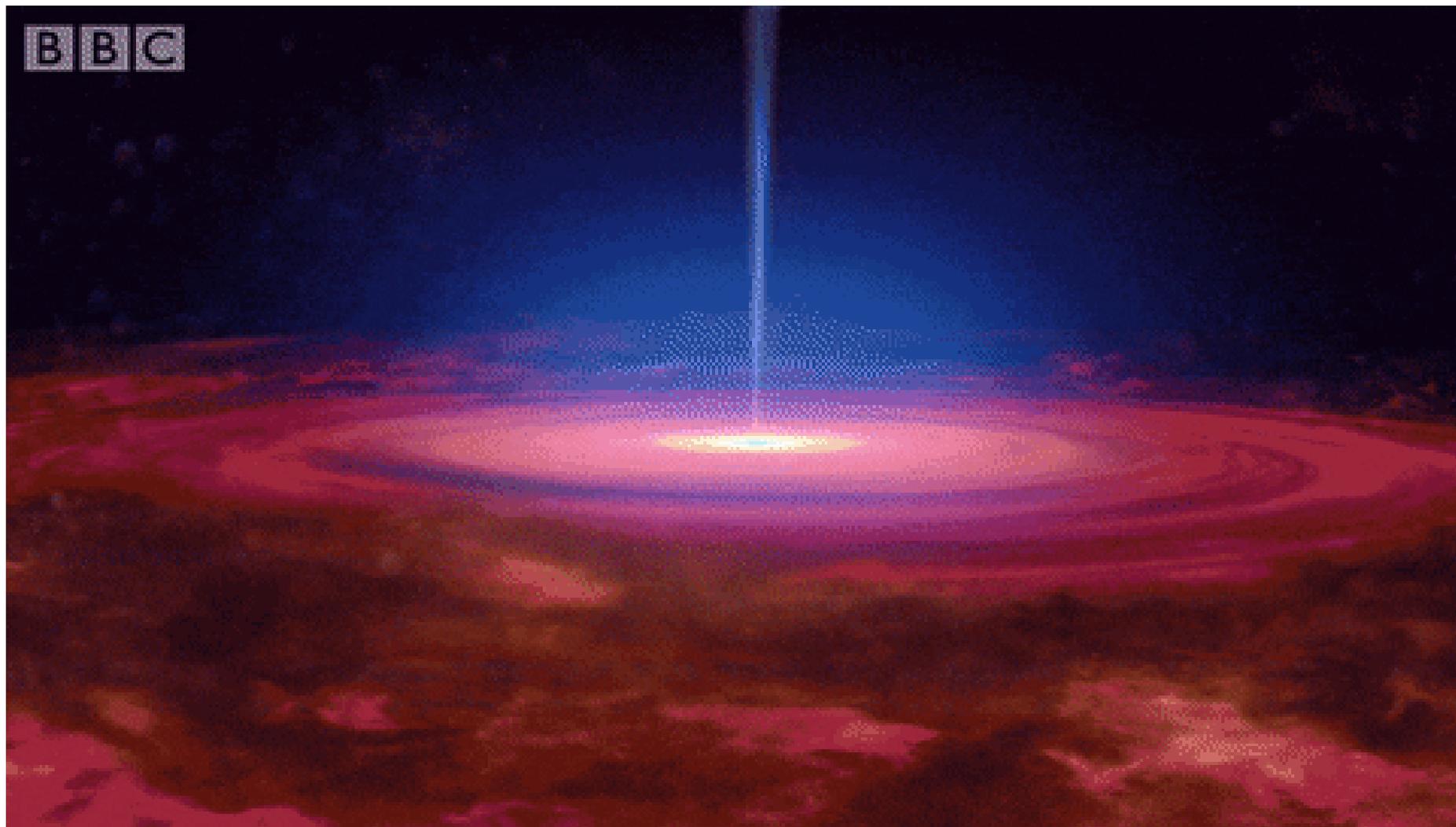


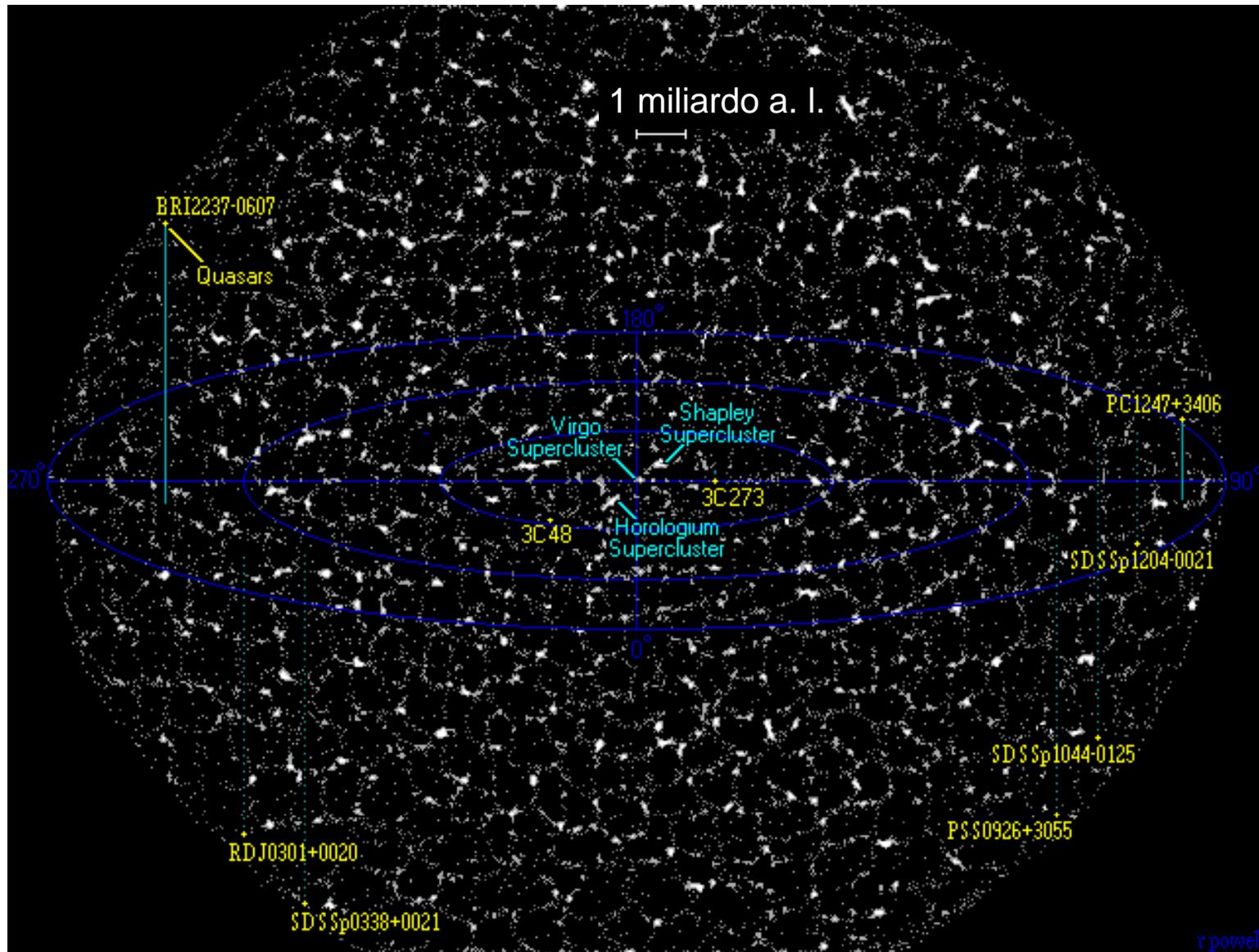


Zoom In x10

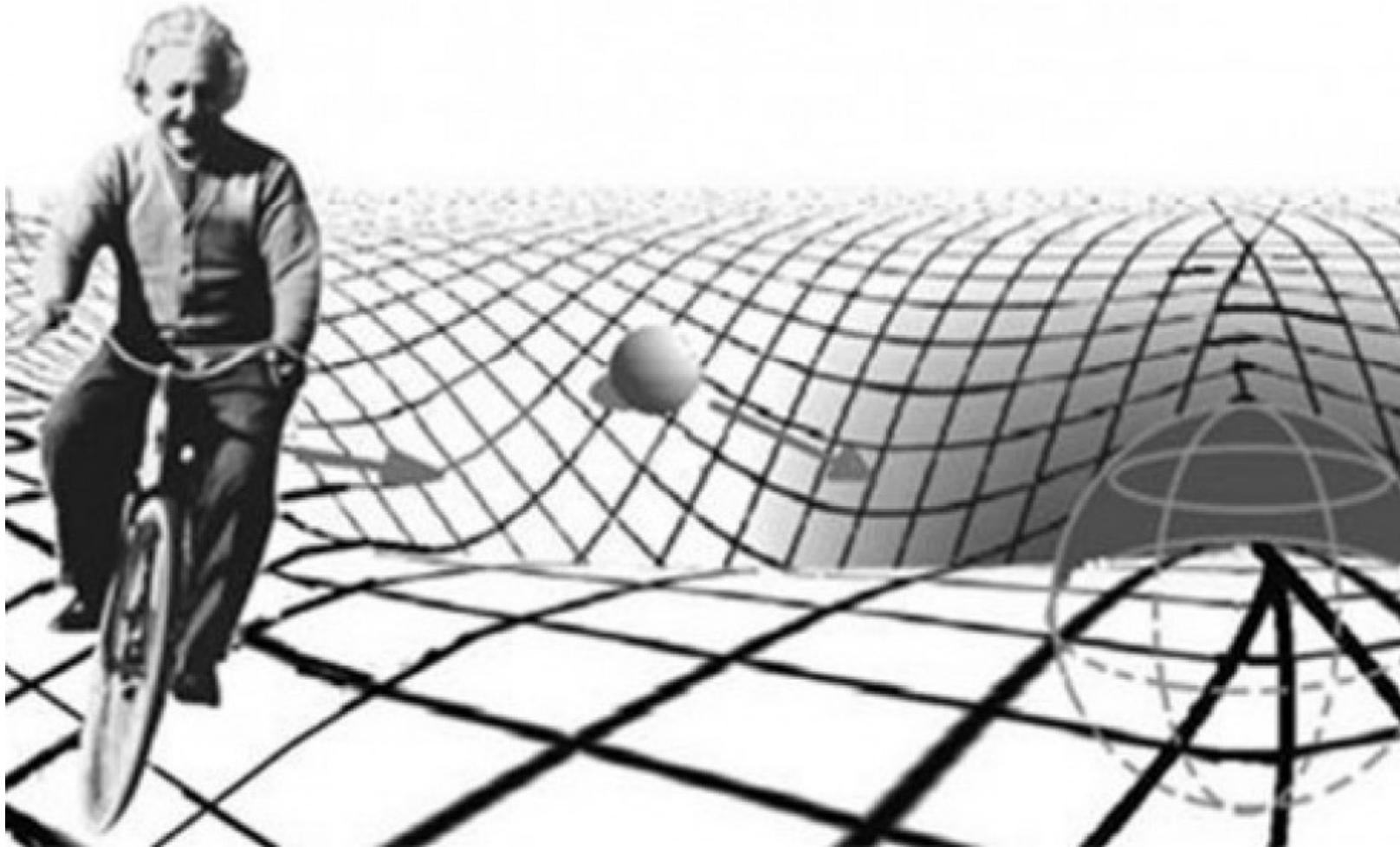
Zoom Out x10

BBC





Zoom In x15



La Relativita'

Imagine travelling through space on a beam of light at the speed of light.



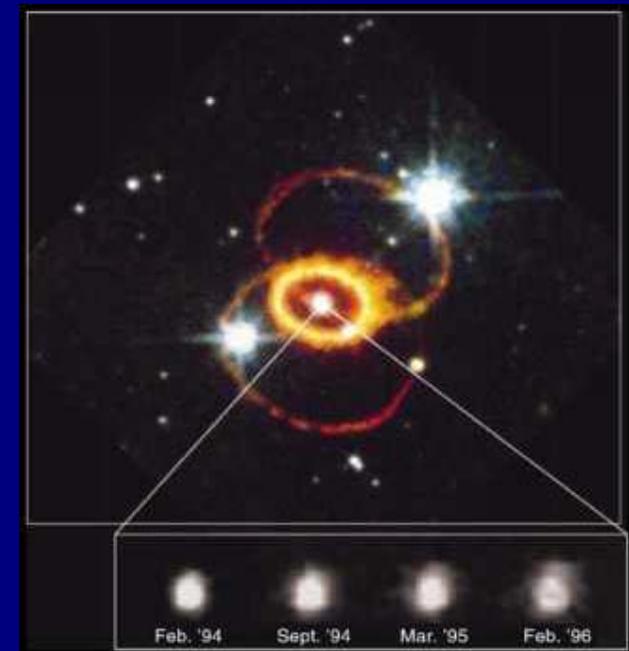
Albert Einstein, theory of relativity, gravity, velocity, energy, mass, speed, time, $E=mc^2$ Albert Ein

Bobonart

Esplosione di una SuperNova



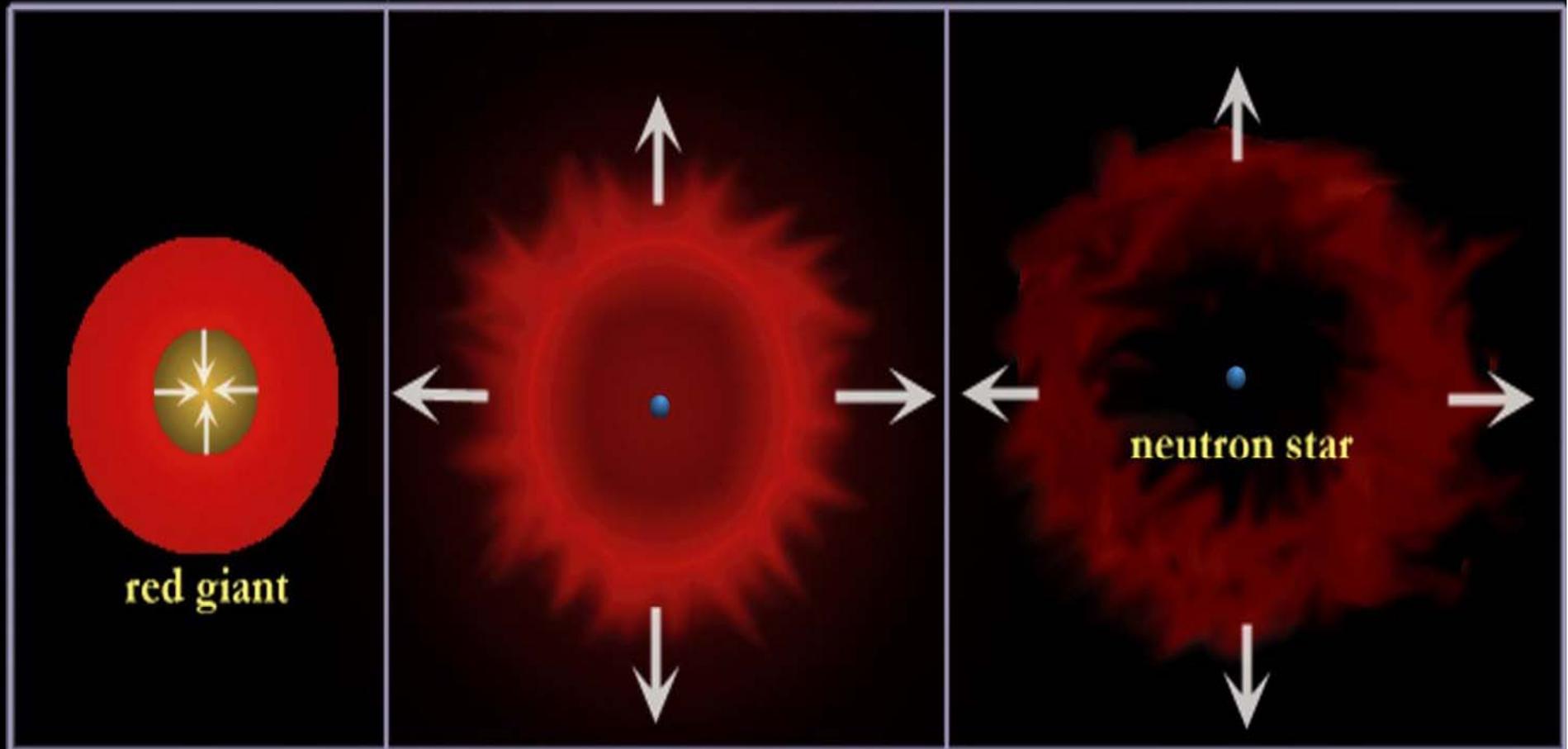
SN 1987A



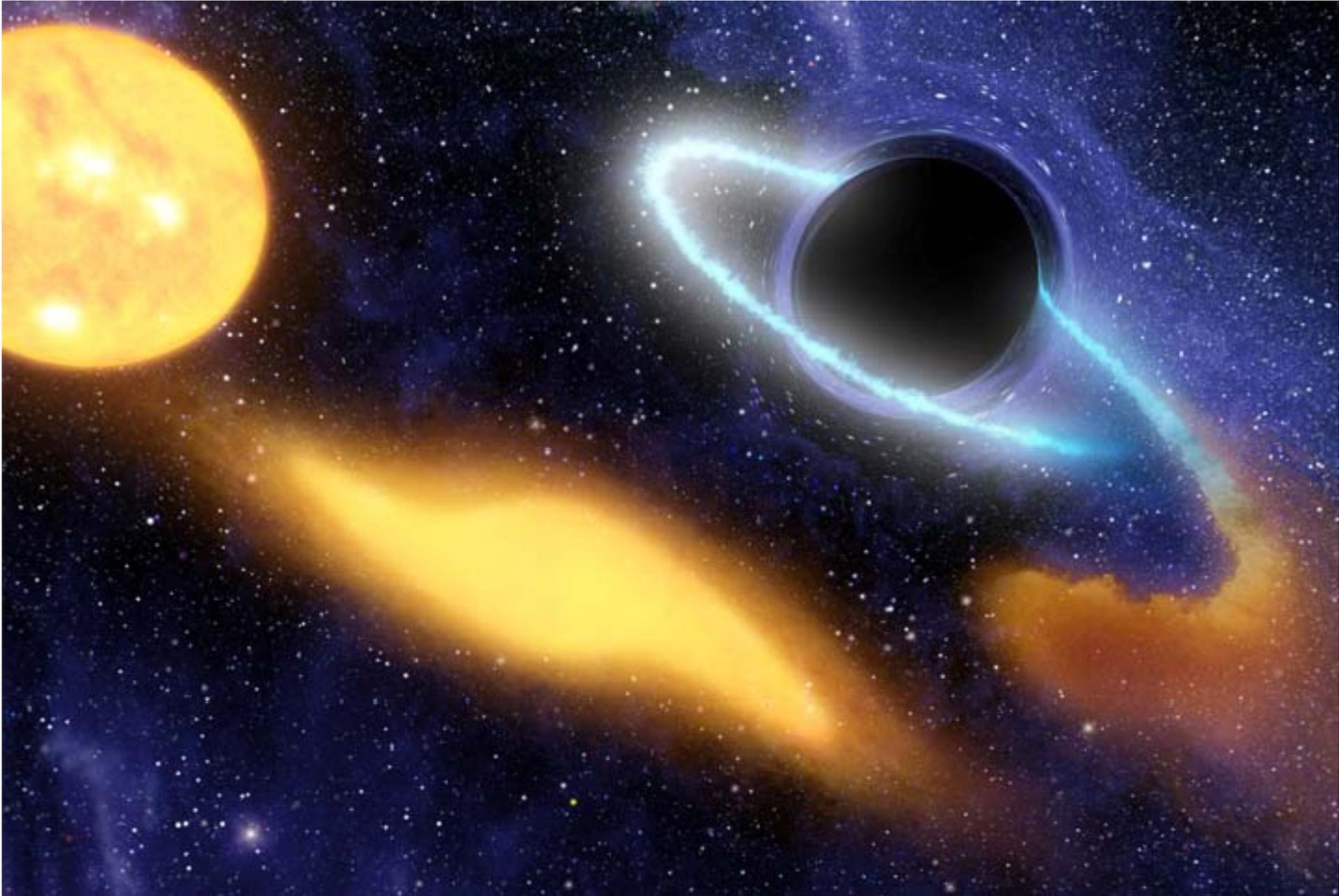
* Emissione di neutrini ed onde gravitazionali*

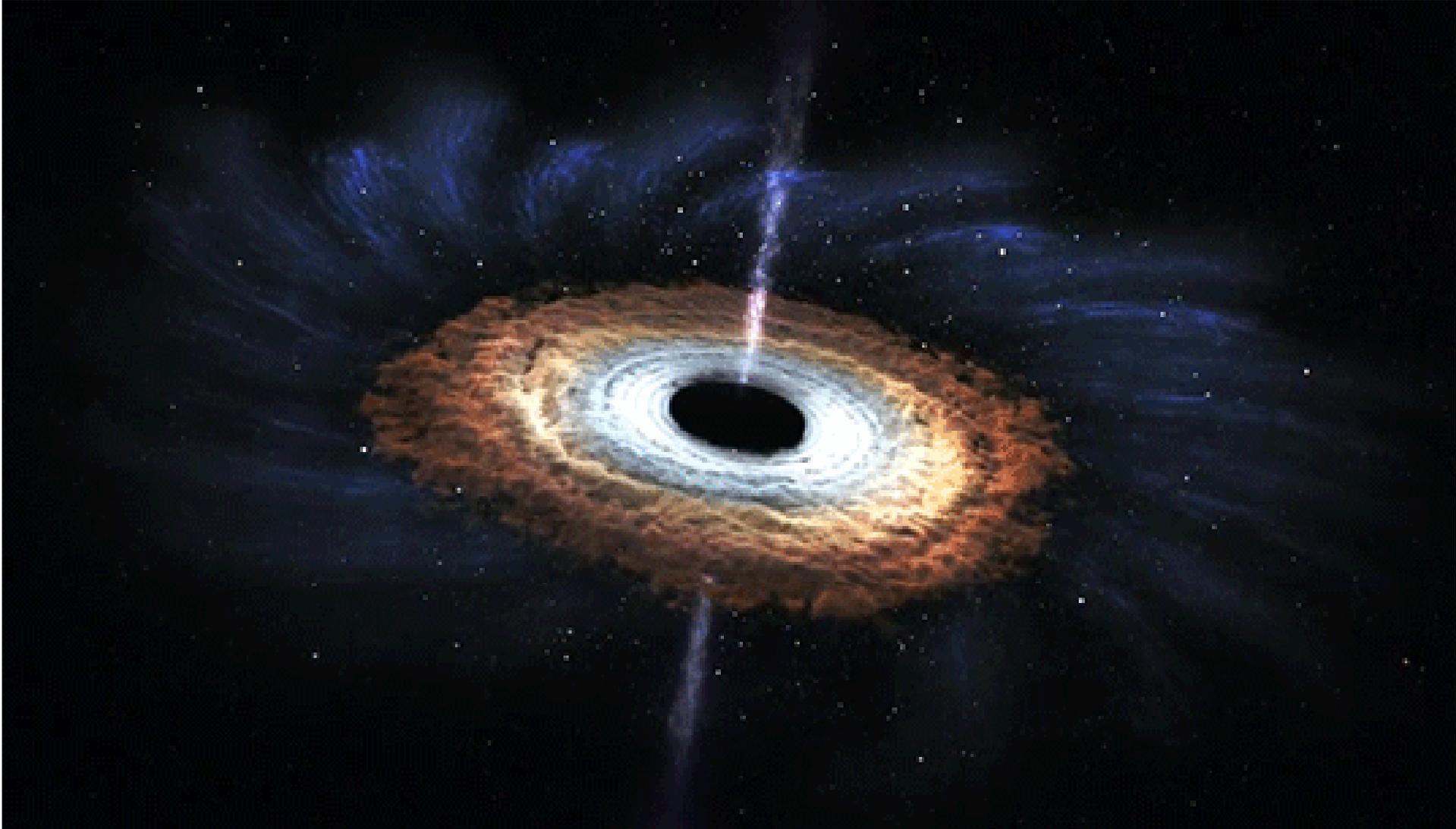
Birth of a Neutron Star and Supernova Remnant

(not to scale)

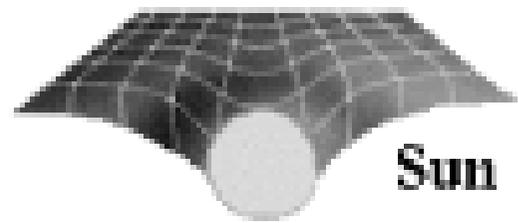


Core Implosion → Supernova Explosion → Supernova Remnant









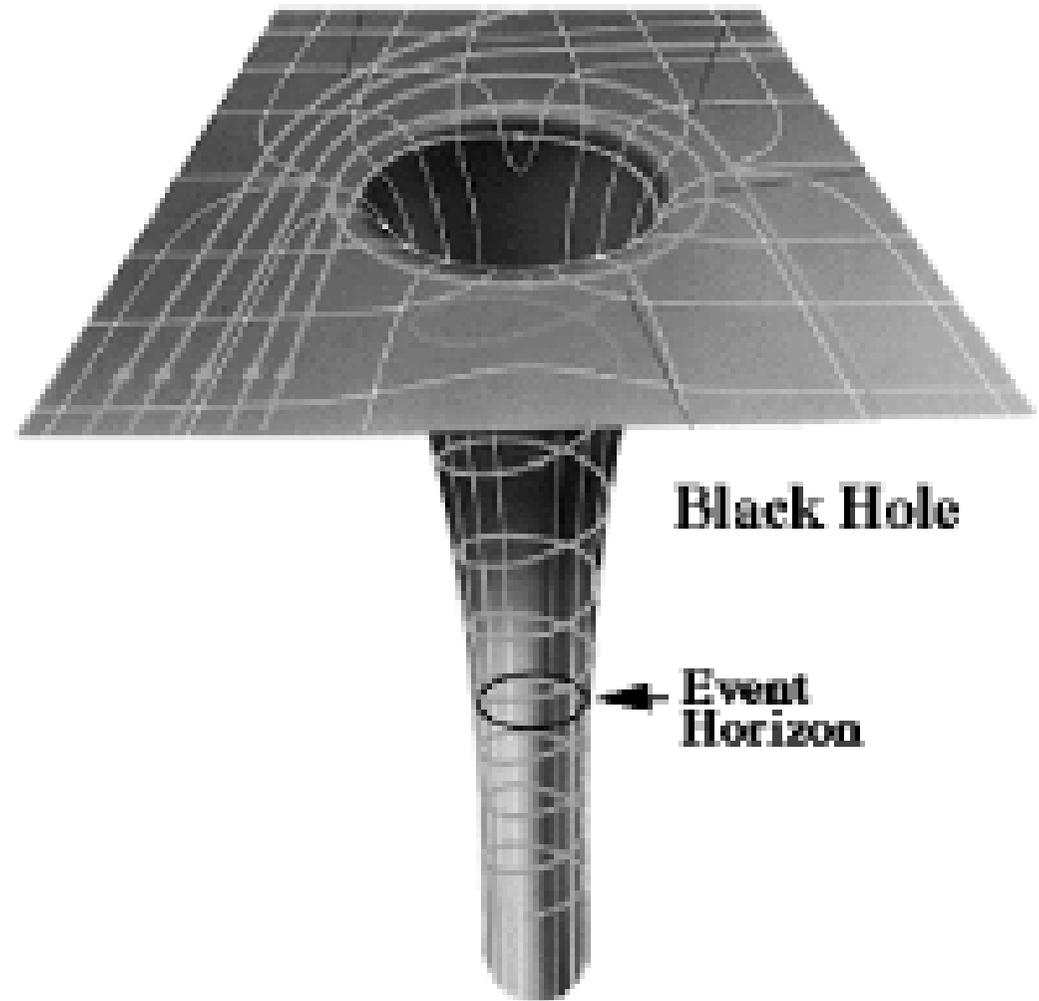
Sun



**White
Dwarf**



**Neutron
Star**



Black Hole

**Event
Horizon**

Credit: Adam Apollo

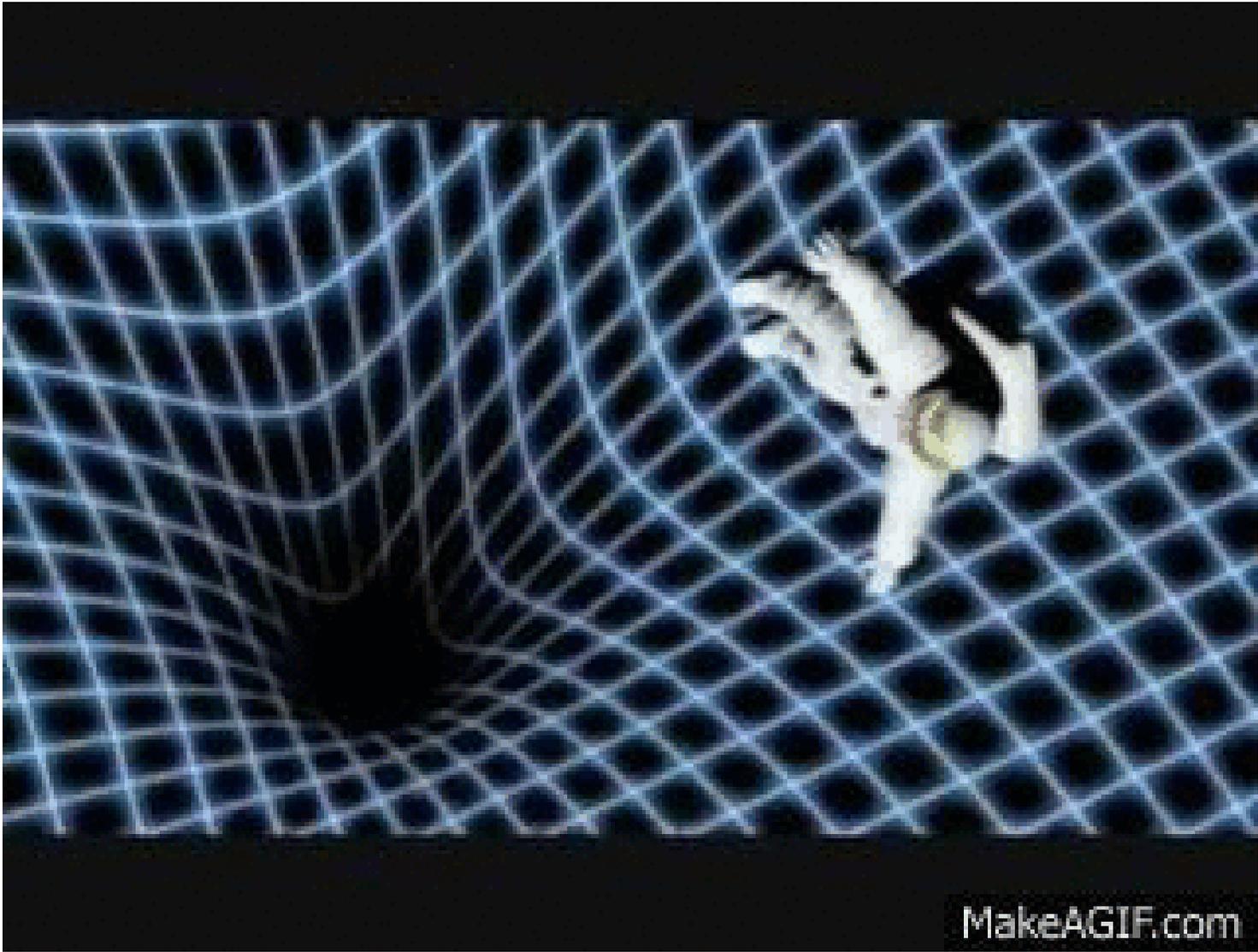
Lanciarsi in un buco nero?



Spaghettification!



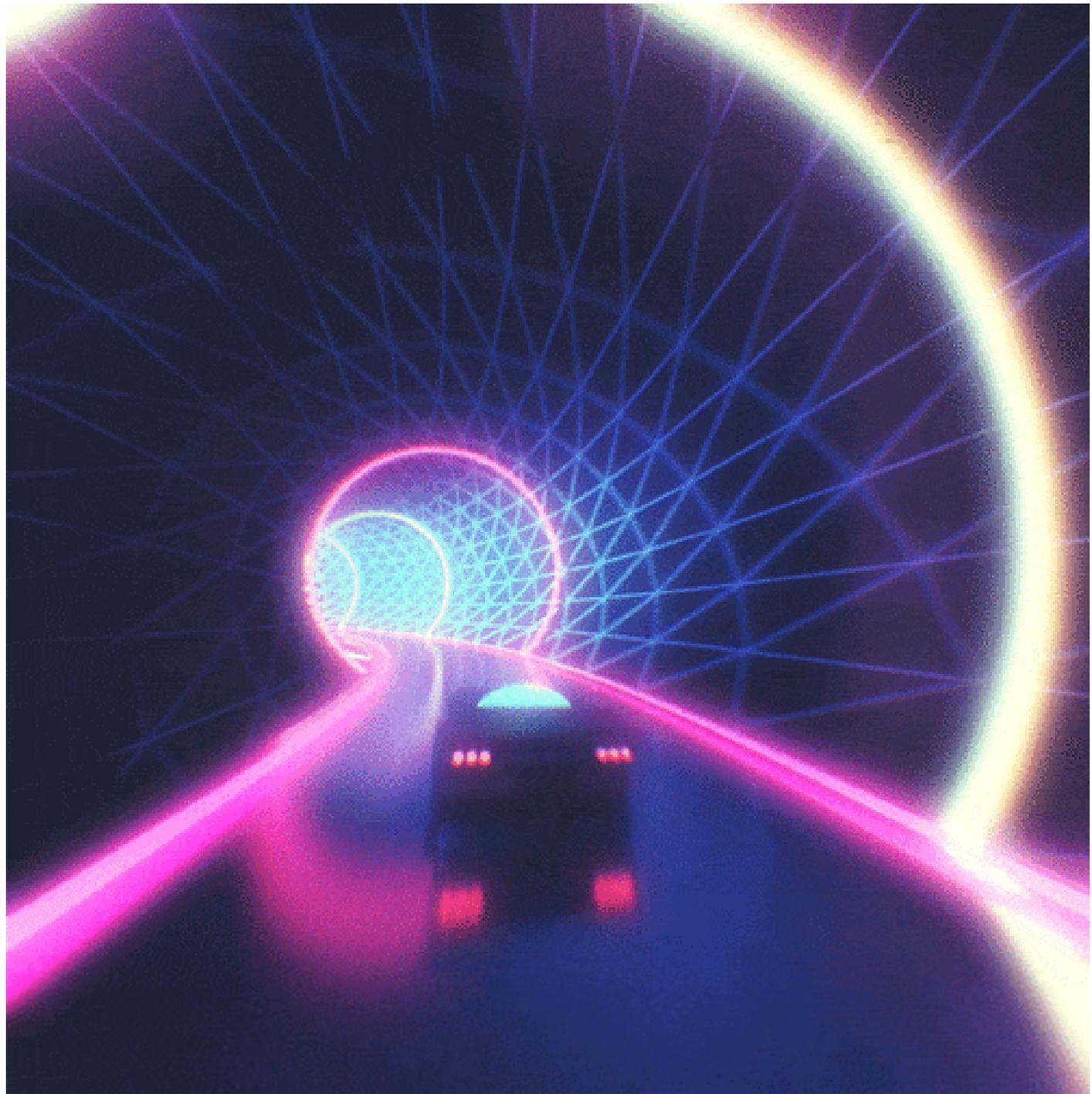
To Black Hole



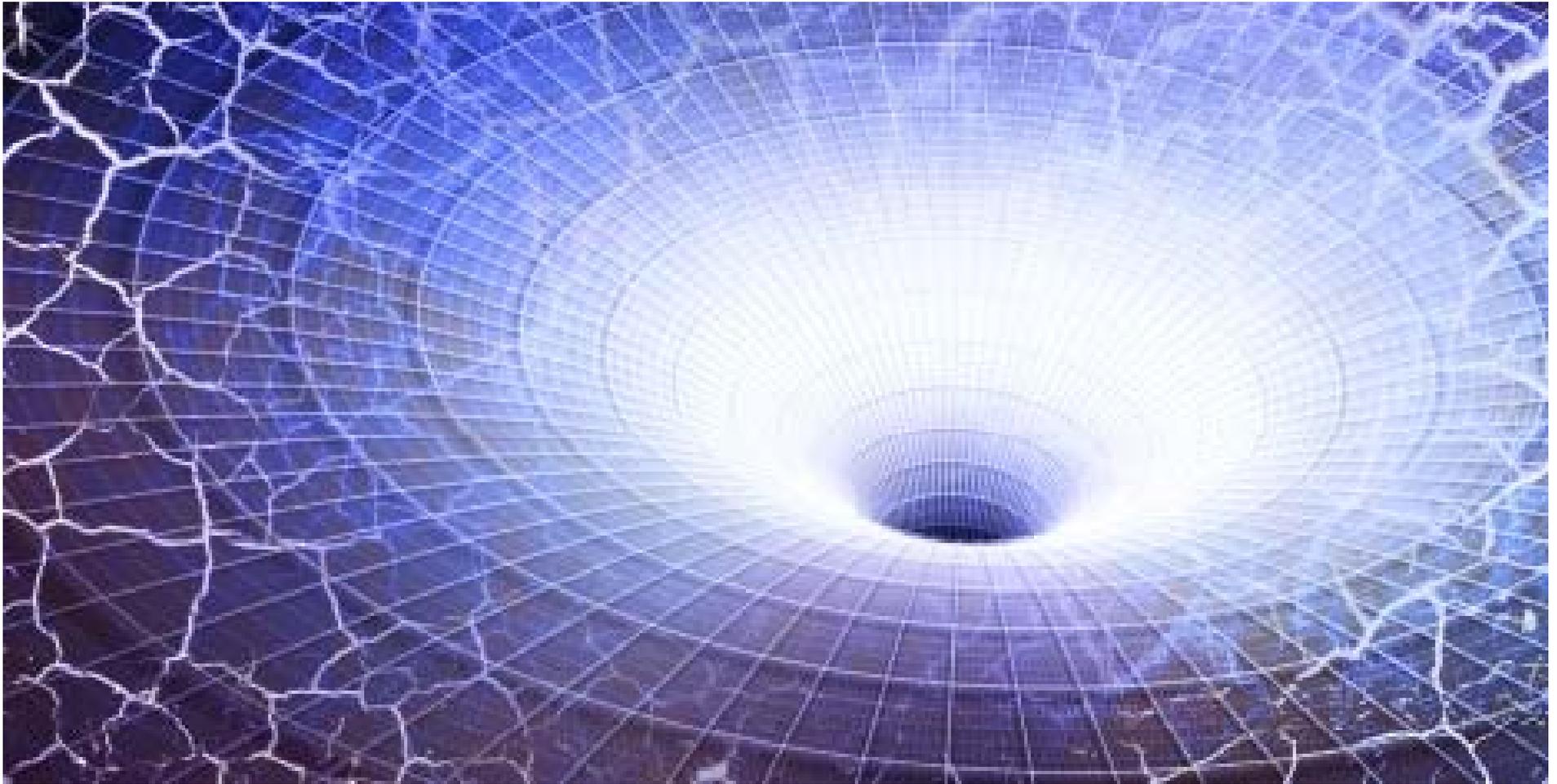
MakeAGIF.com

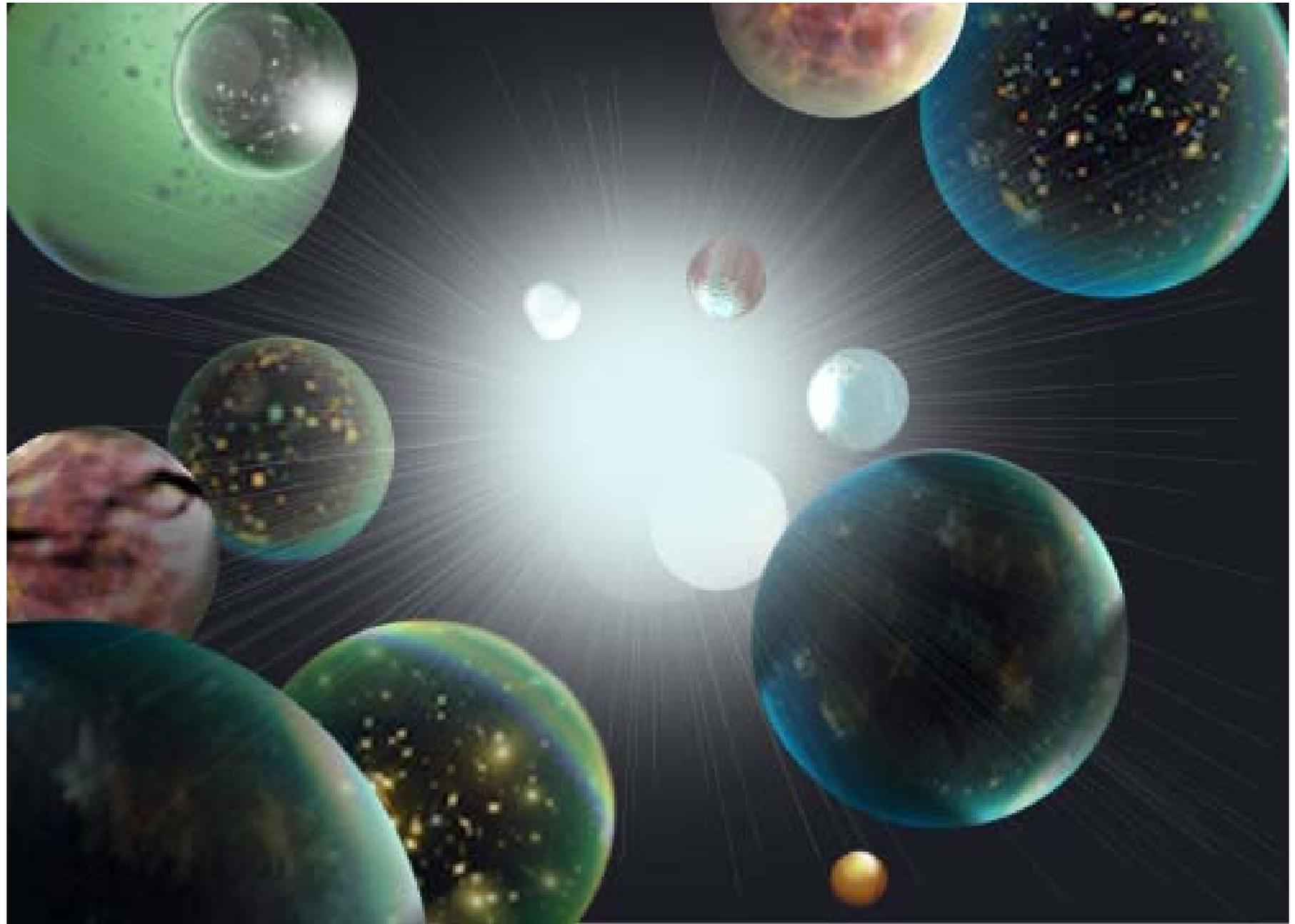
Viaggi interstellati?





Per capire i buchi neri: gravita' quantistica!

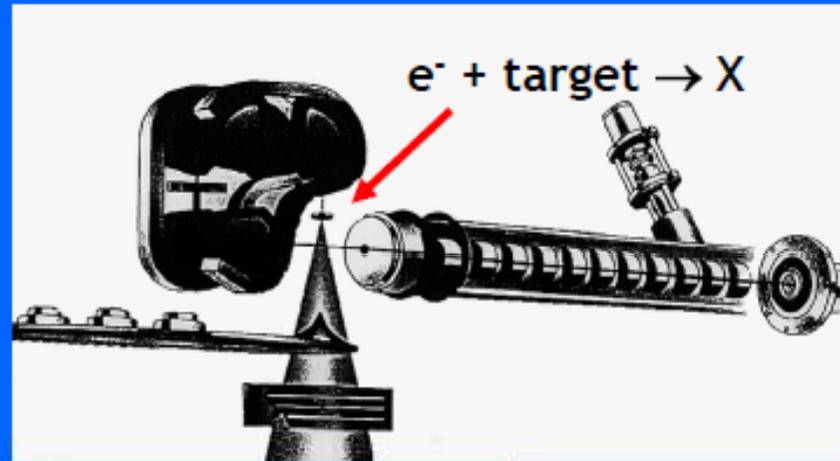
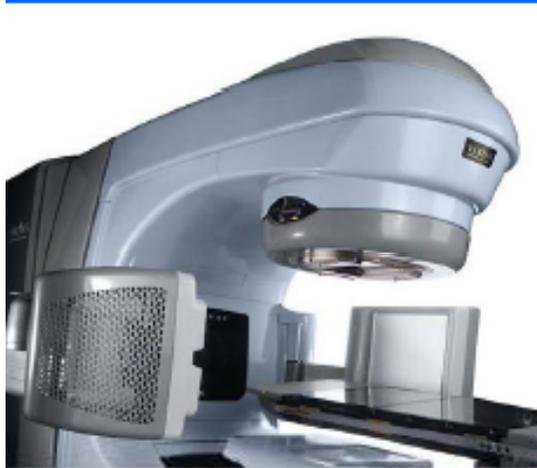




Protonterapia (hadrotherapy)

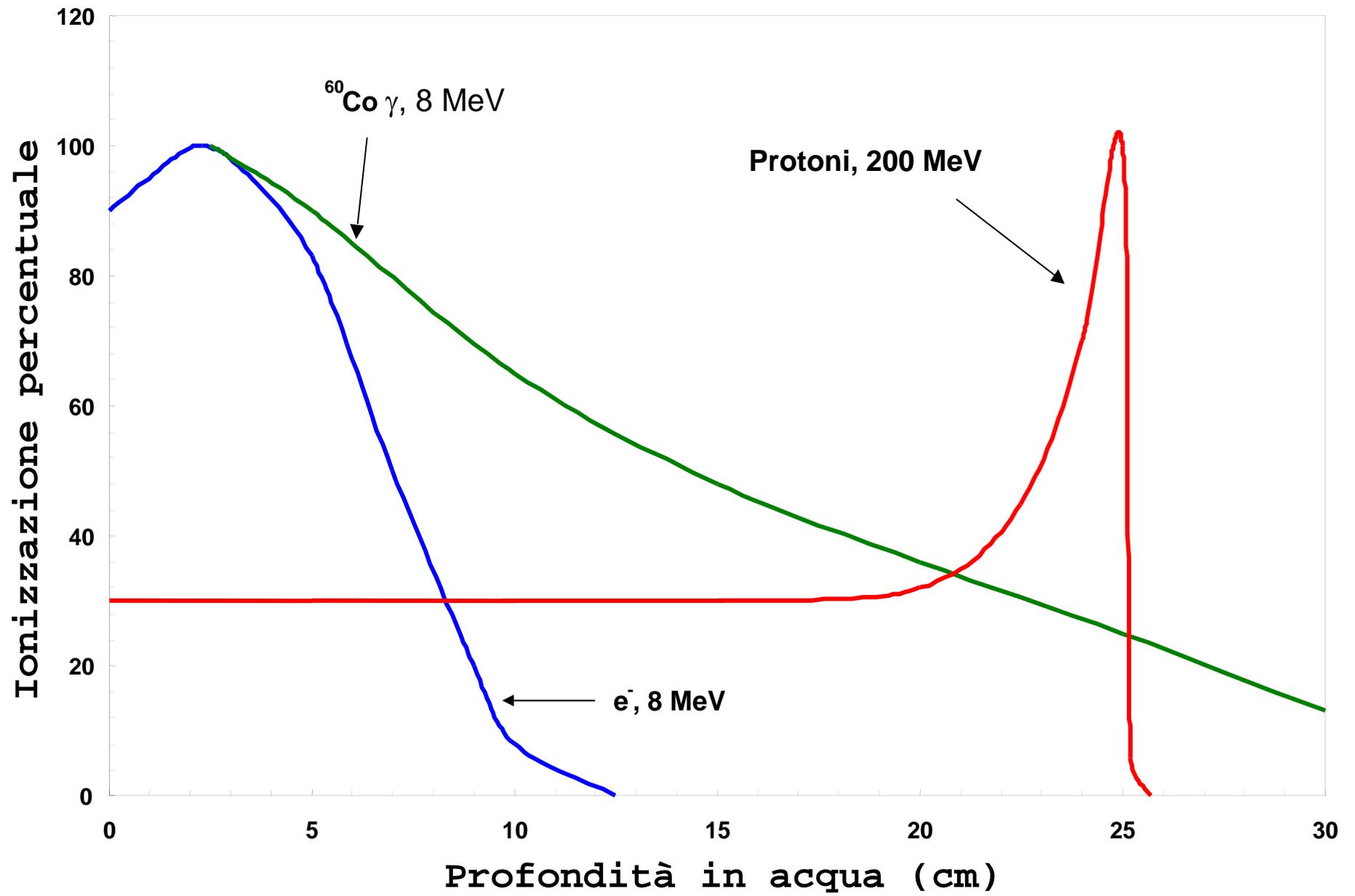


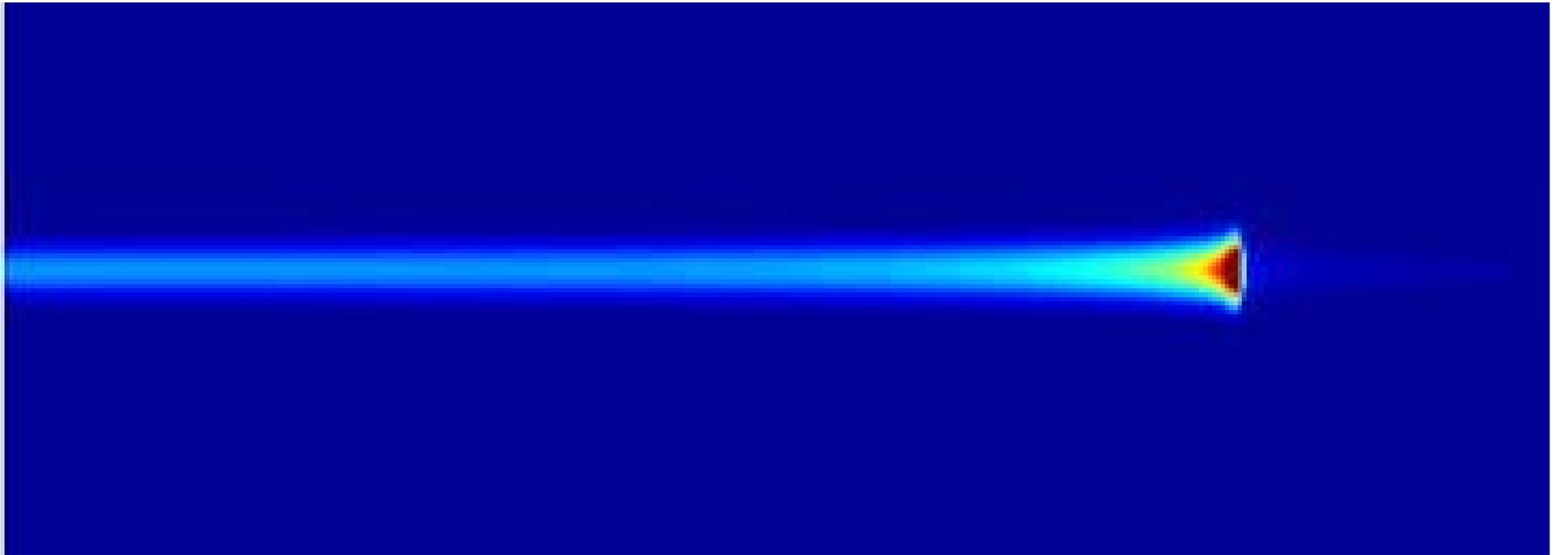
GLI STRUMENTI DELLA RADIOTERAPIA CONVENZIONALE



**circa 200
linac negli
ospedali italiani**

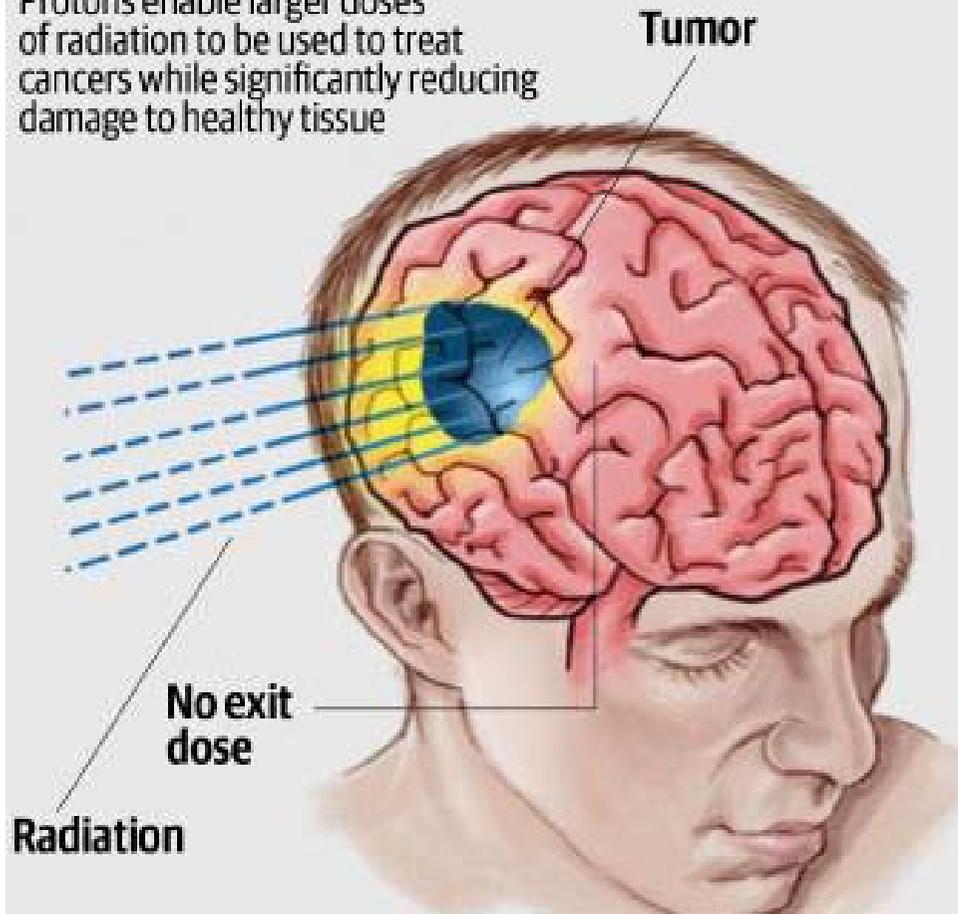
**120'000
pazienti all'anno**





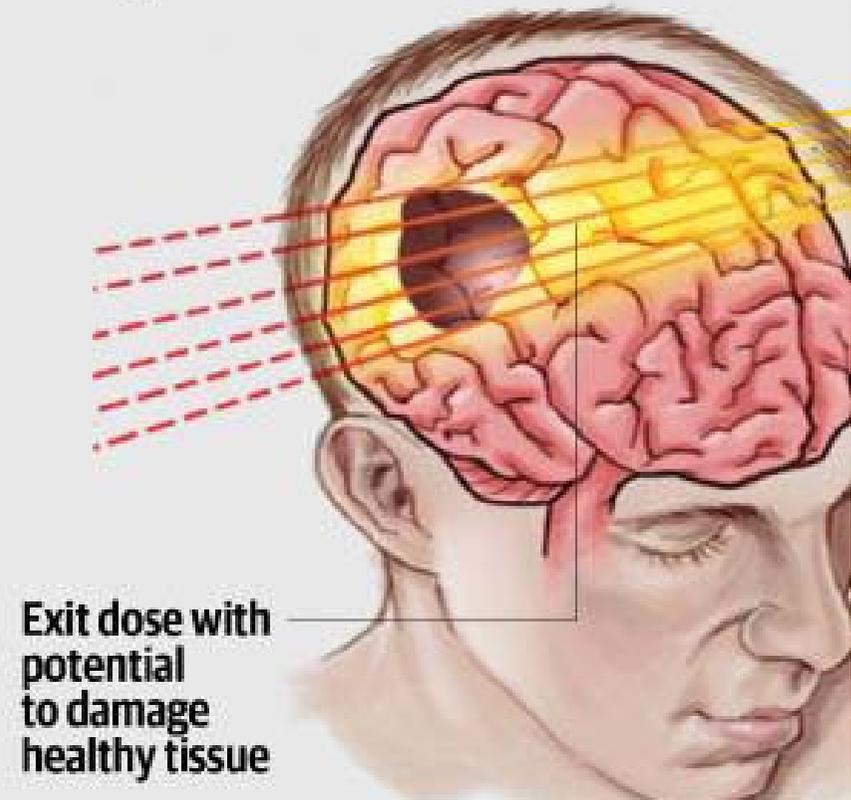
PROTON THERAPY

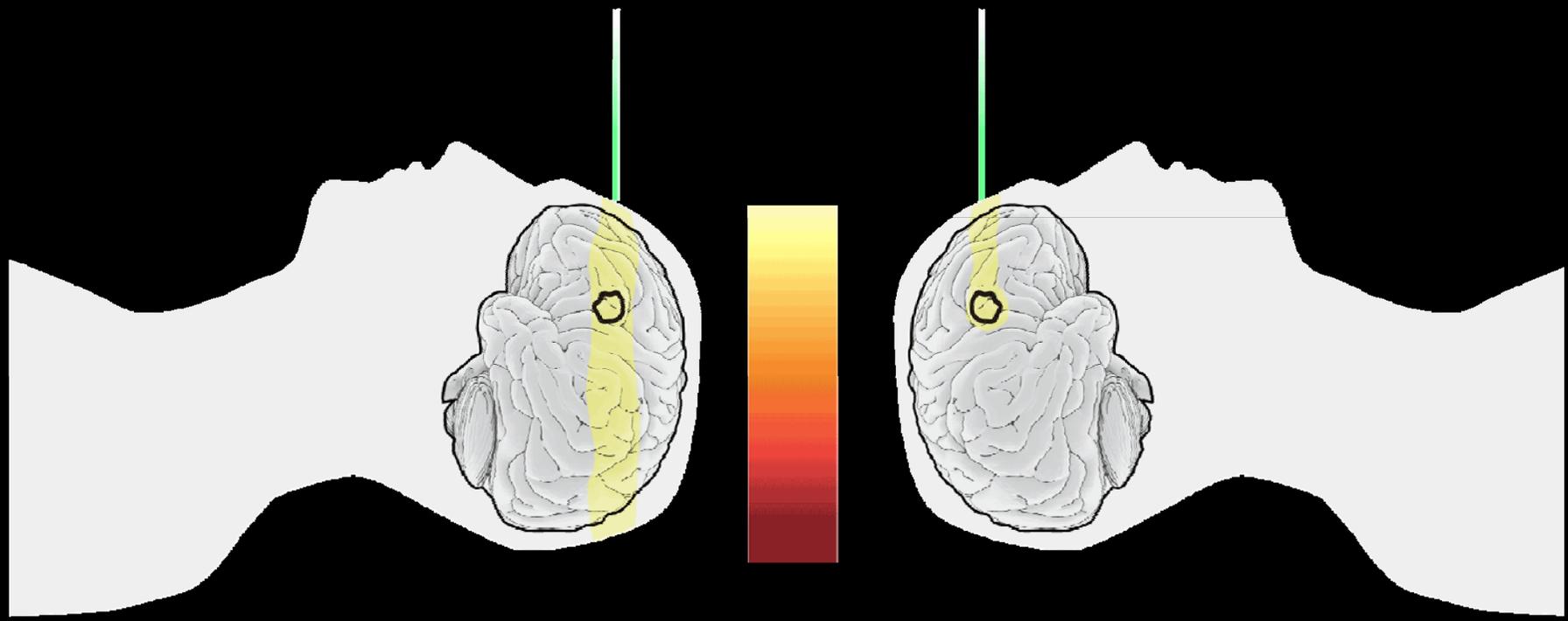
Protons enable larger doses of radiation to be used to treat cancers while significantly reducing damage to healthy tissue



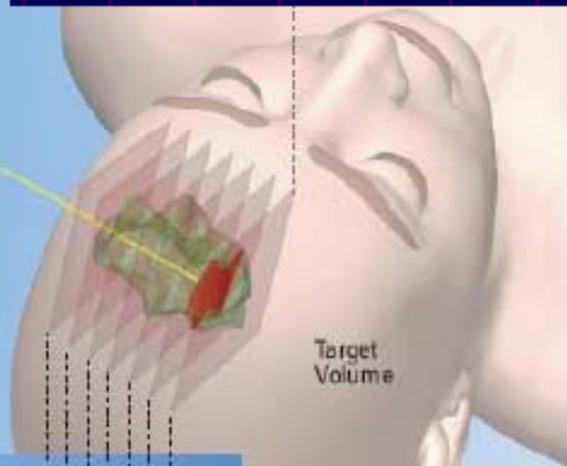
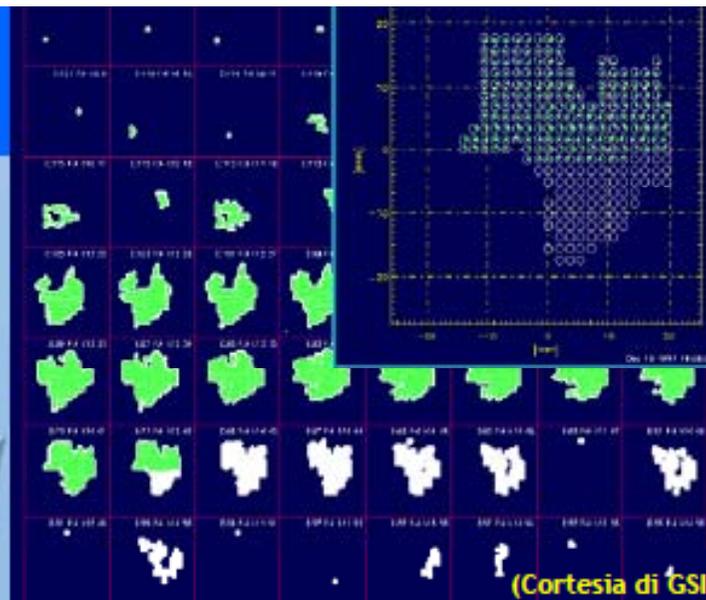
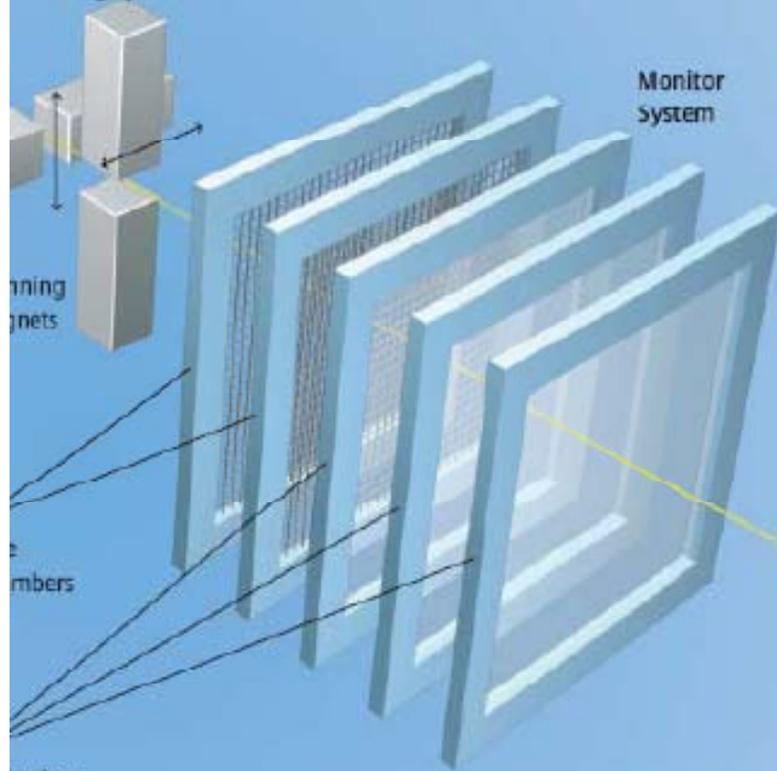
TRADITIONAL X-RAY THERAPY

Smaller doses of radiation are used to reduce damage to healthy tissue due to the inability to restrict radiation pattern to cancerous tissue





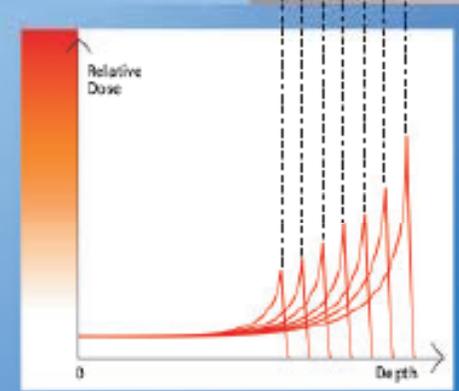
Scanning System



Example:

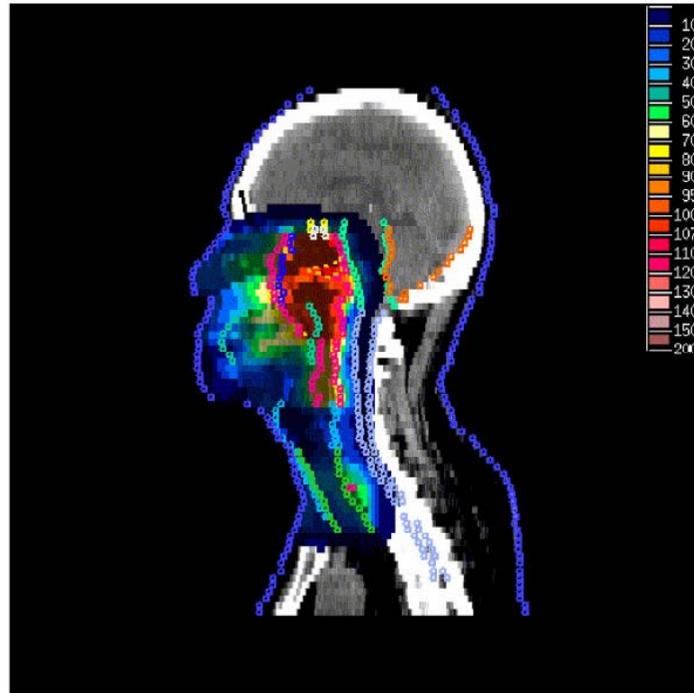
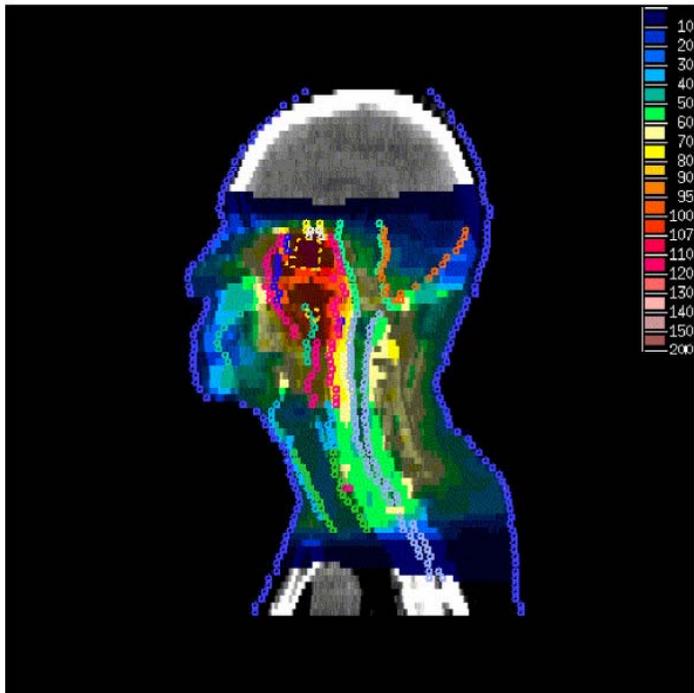
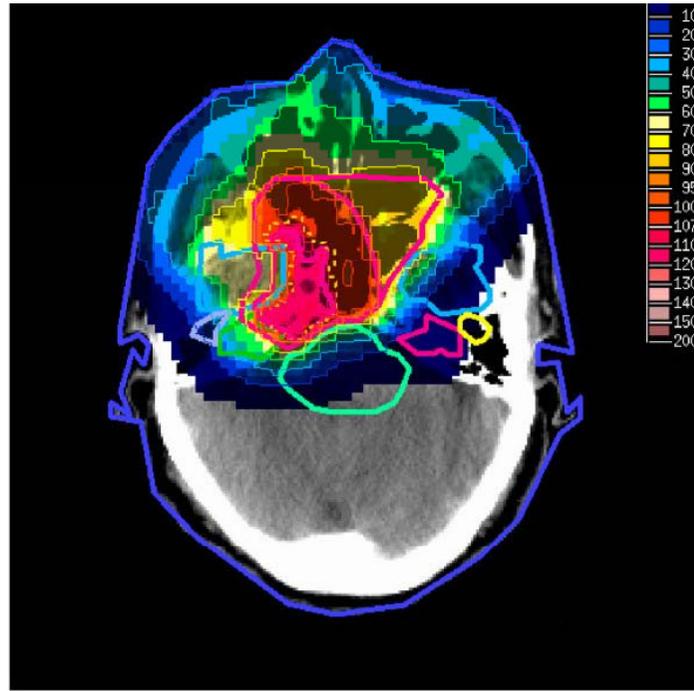
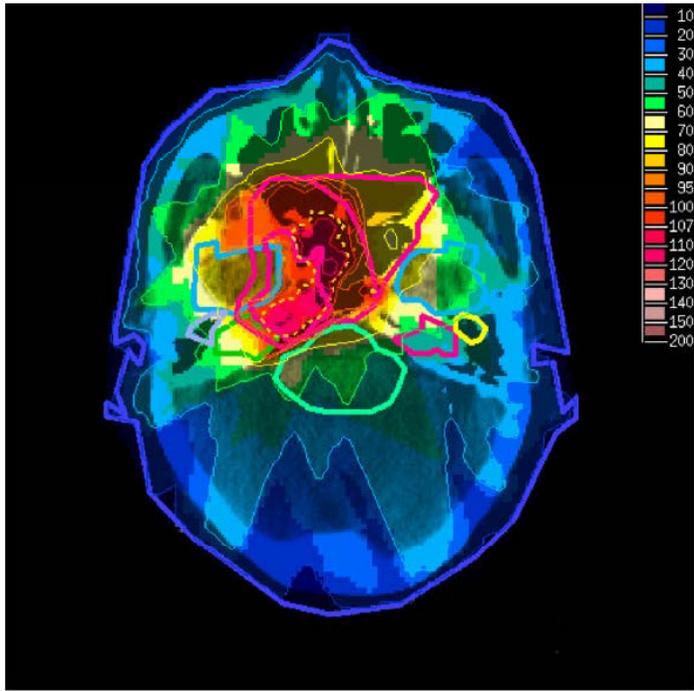
Depth 5 cm:
Proton 80 MeV
Carbon 150 MeV/u

Depth 25 cm:
Proton 105 MeV
Carbon 380 MeV/u



(Cortesia di Siemens Medical)

Tecnica di irraggiamento sistema attivo



Conosciamo il CNAO





IL SISTEMA MAGNETICO

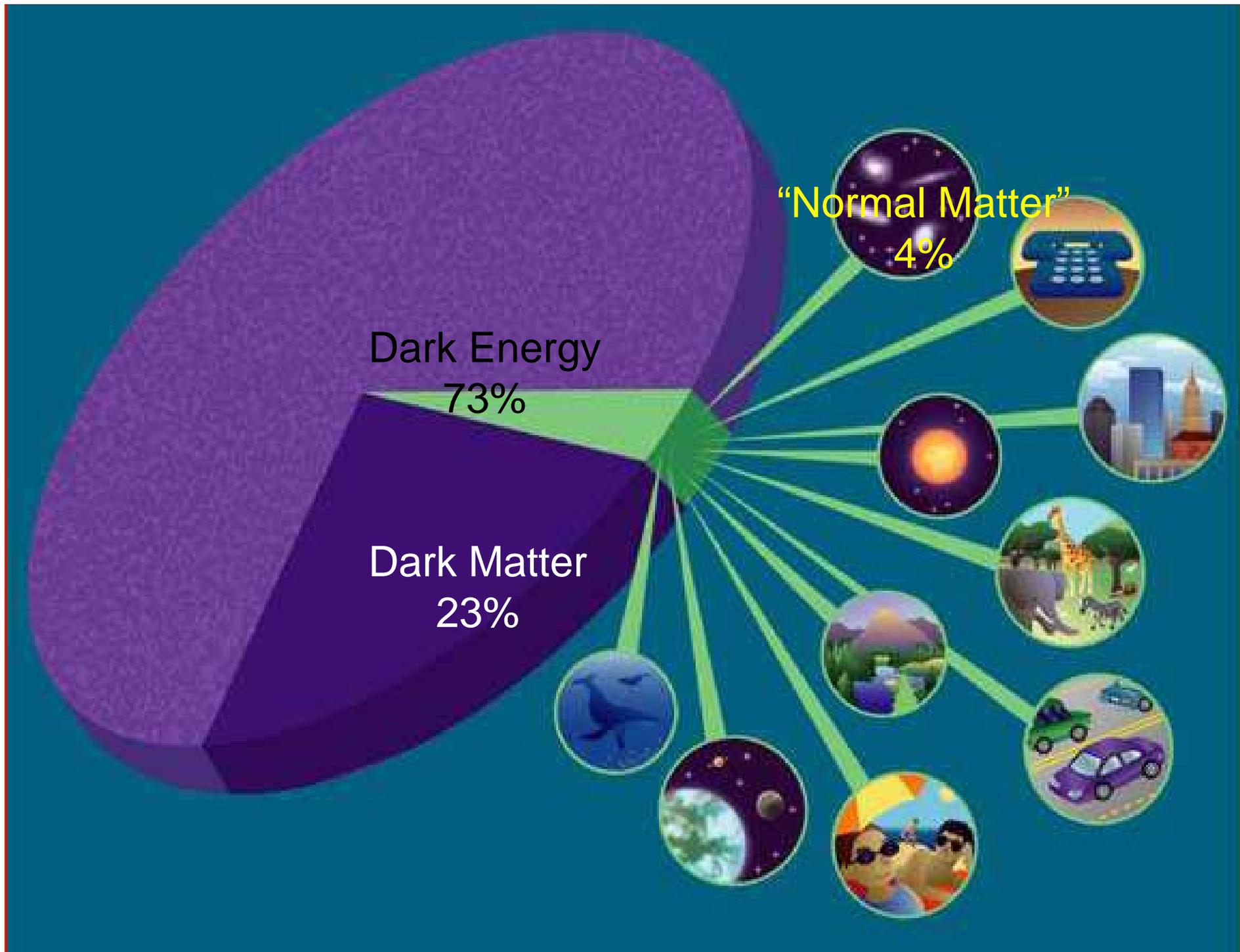
LA FORZA CRESCE CON L'AUMENTARE DELLA VELOCITA'
SINCRO-TRONE

20 Correttori
per guidare

24 Quadrupoli
per contenere

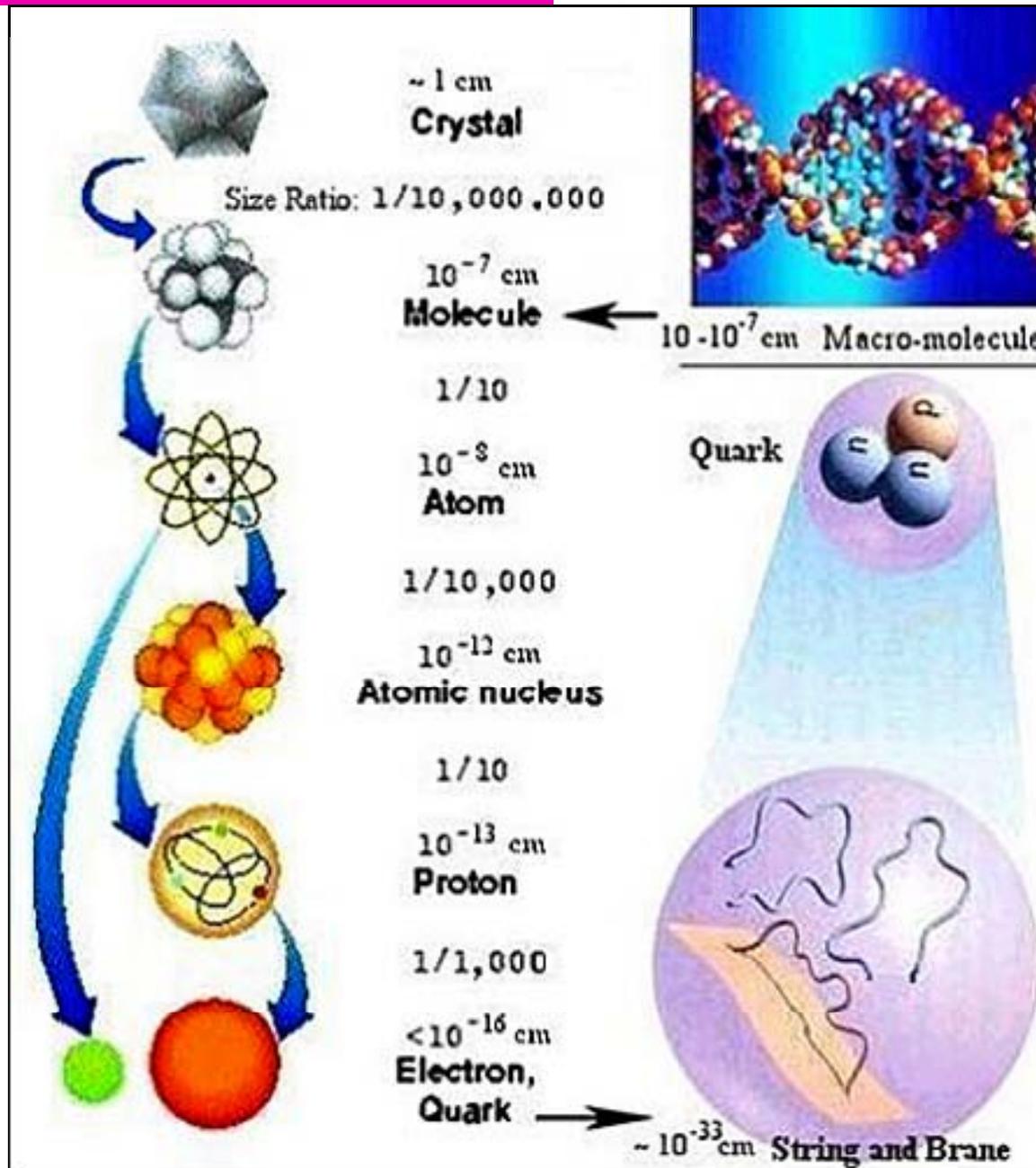
16 Dipoli
per curvare





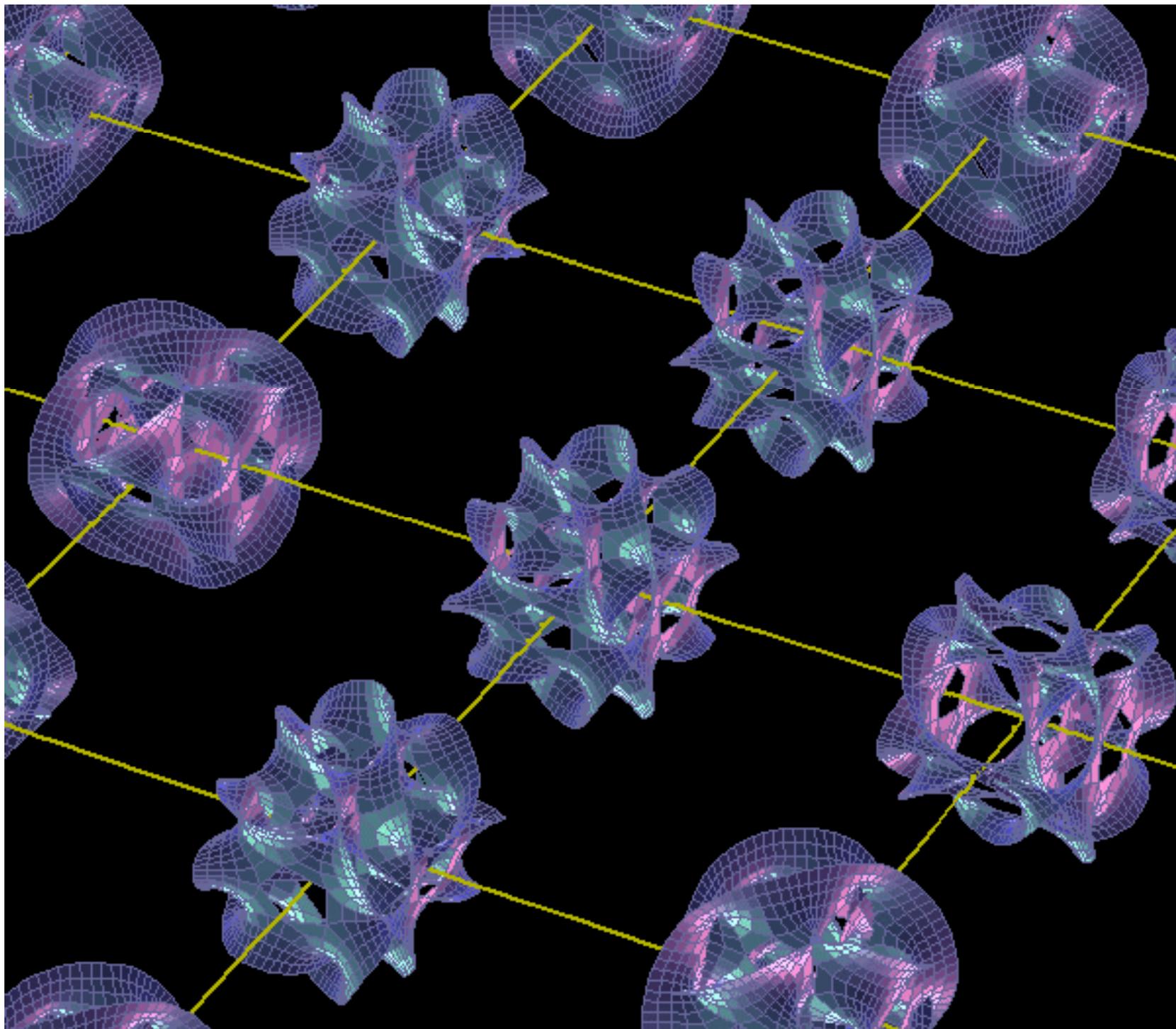
Open questions

String theory



Einstein – l'ultima lavagna

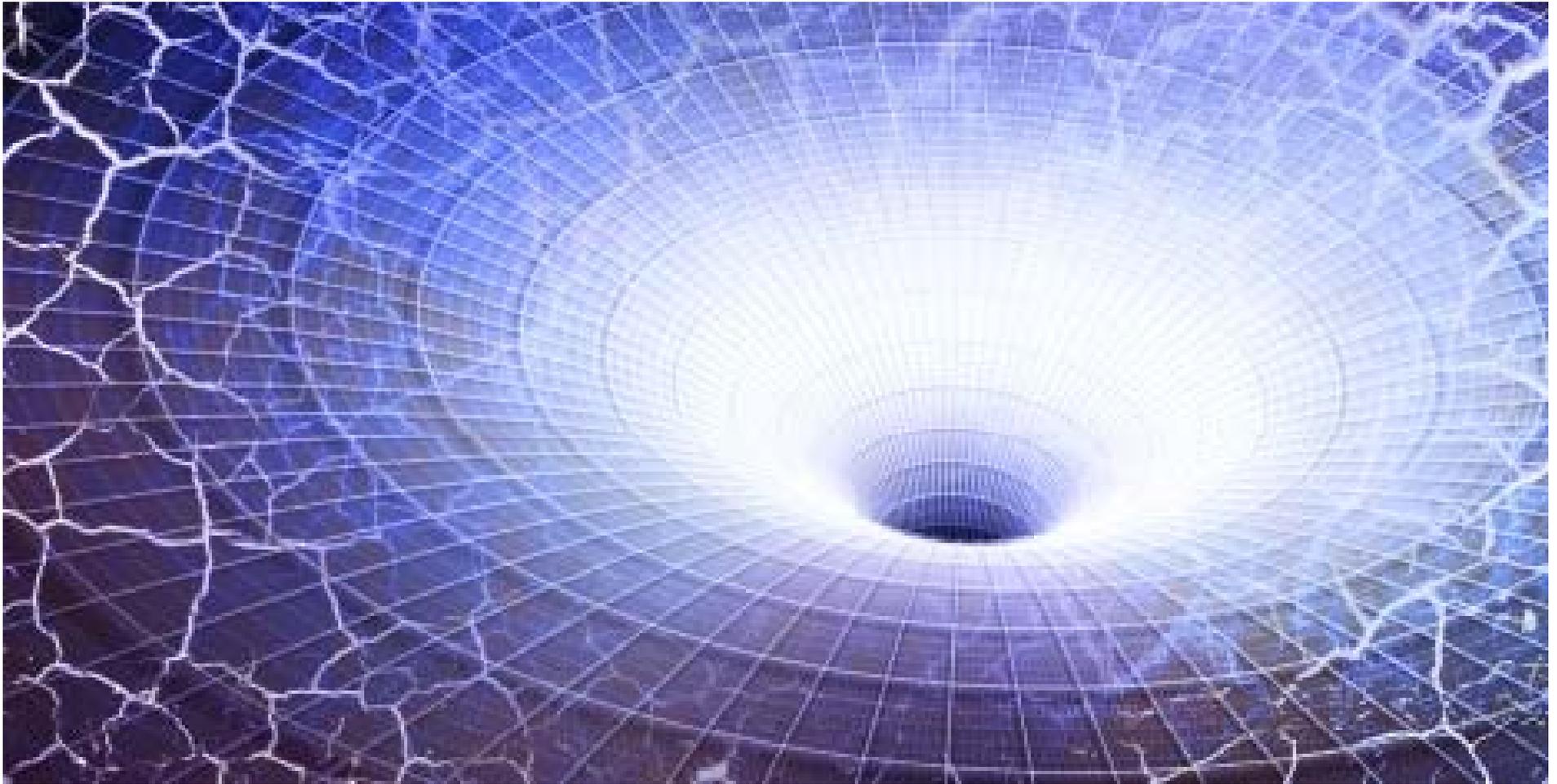




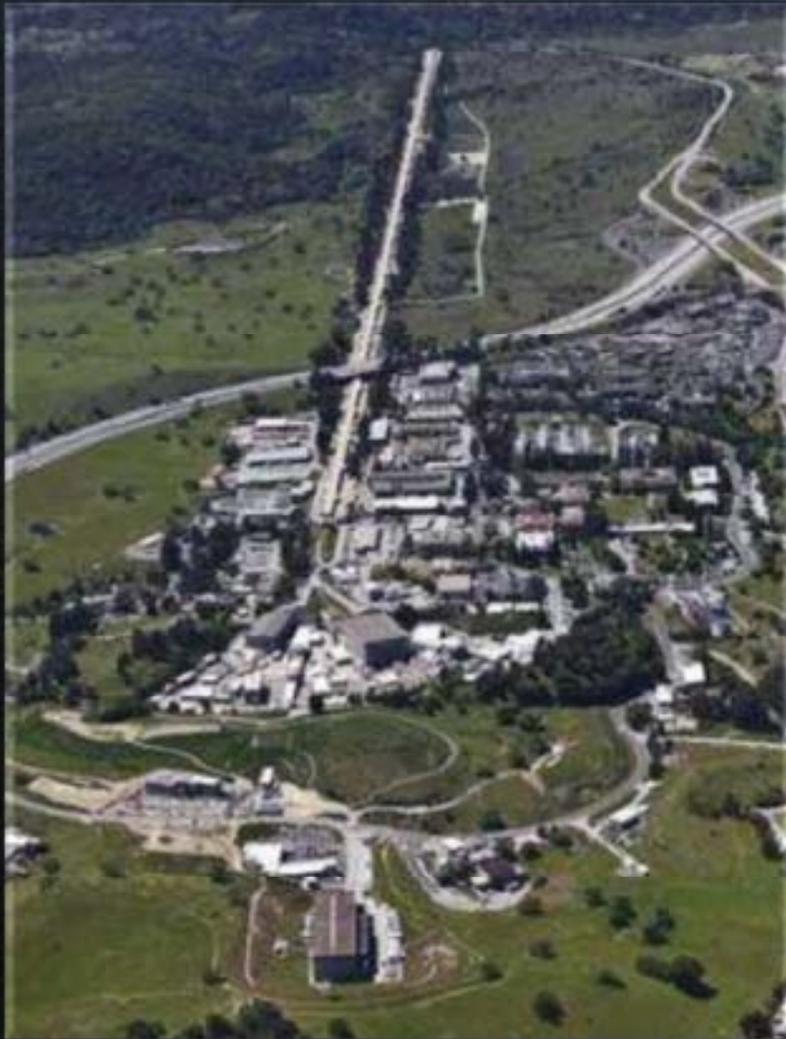
Cosa accade all'interno di un buco nero?



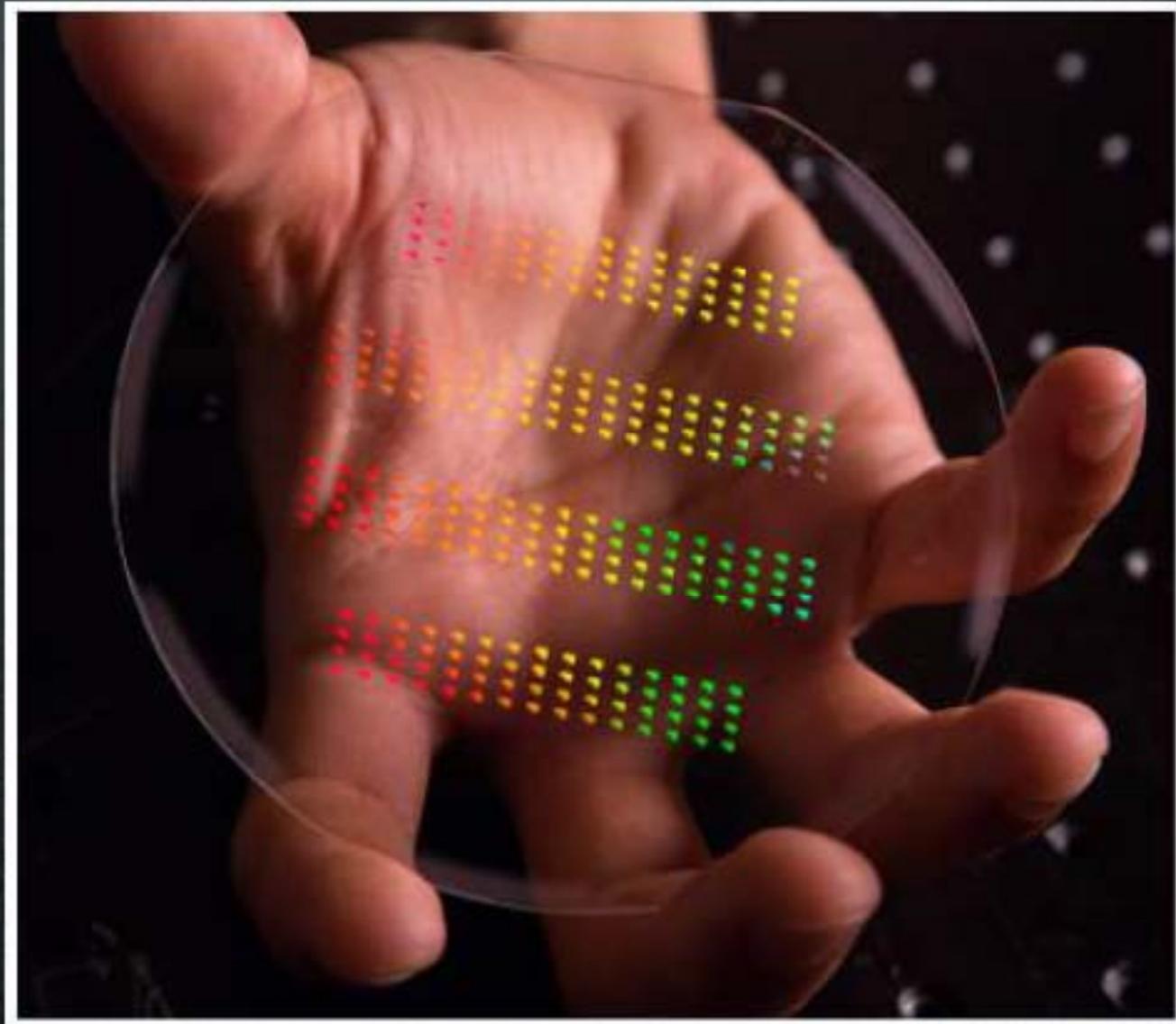
Gravita' quantistica?



SLAC Now and Tomorrow?

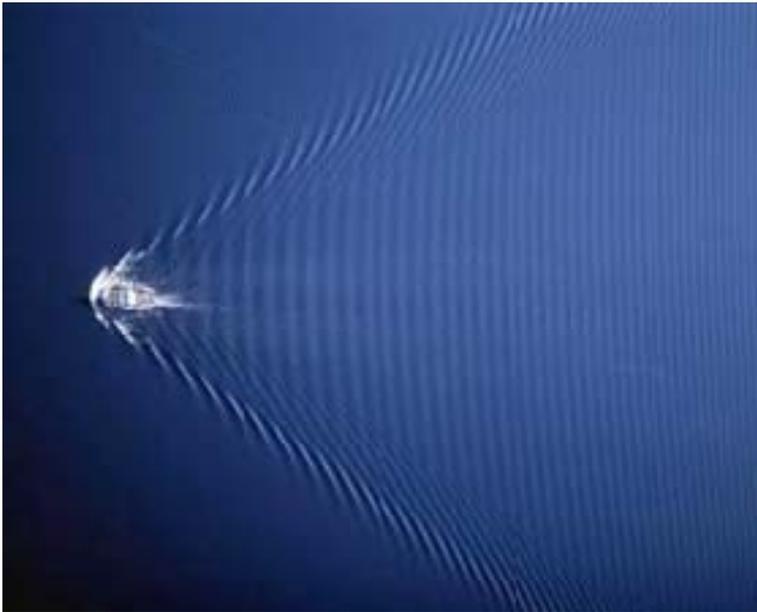


Accelerator on a Chip?



New acceleration technique

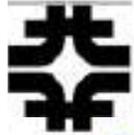
Laser pulse creates a wave



Particles get accelerated

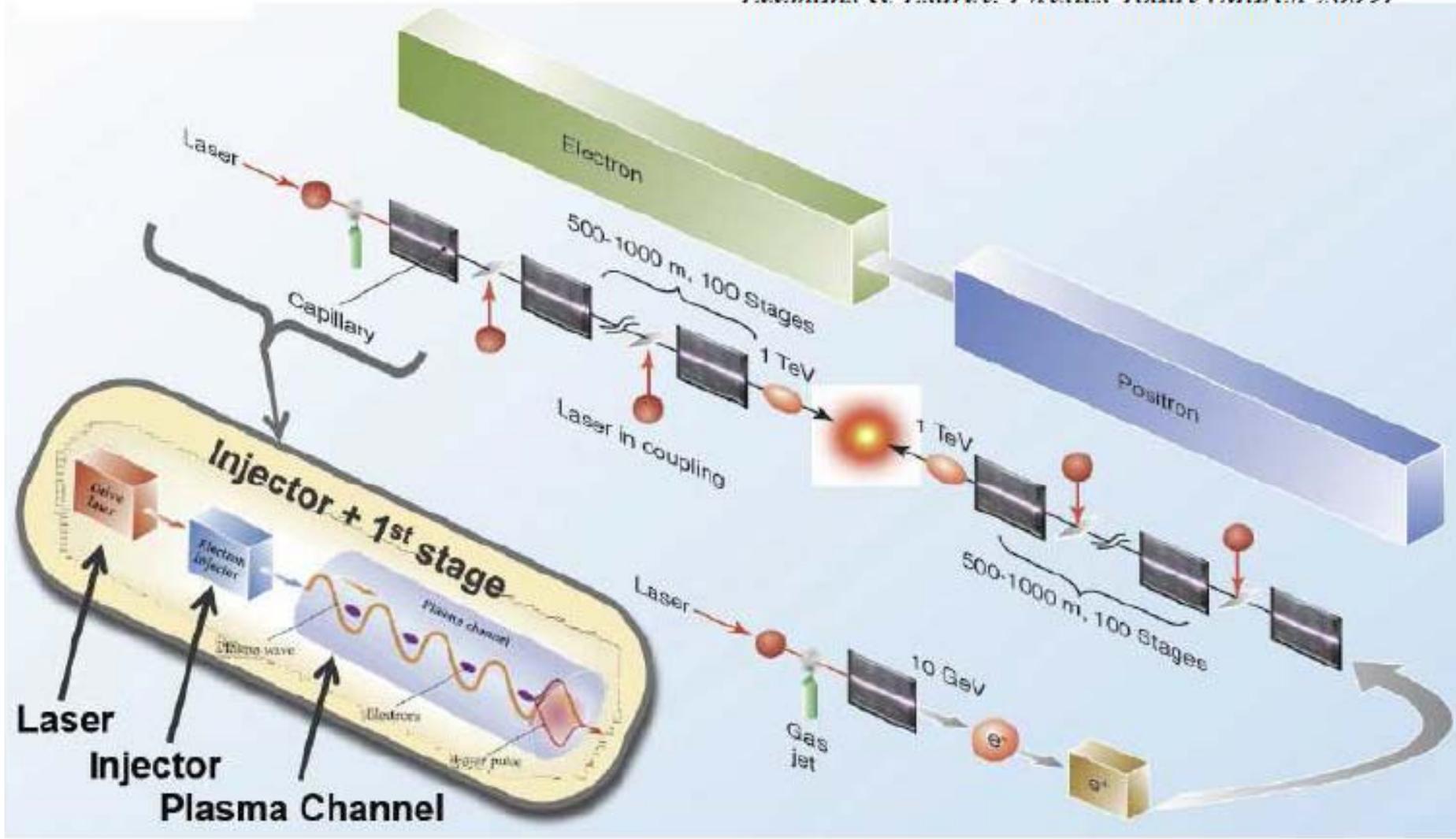


In few cm electrons get accelerations as in present accelerators of hundred meters



Laser-Plasma-Accelerator LC

Leemans & Esarev. Physics Today (March 2009)



Medical diagnosis

Mamography

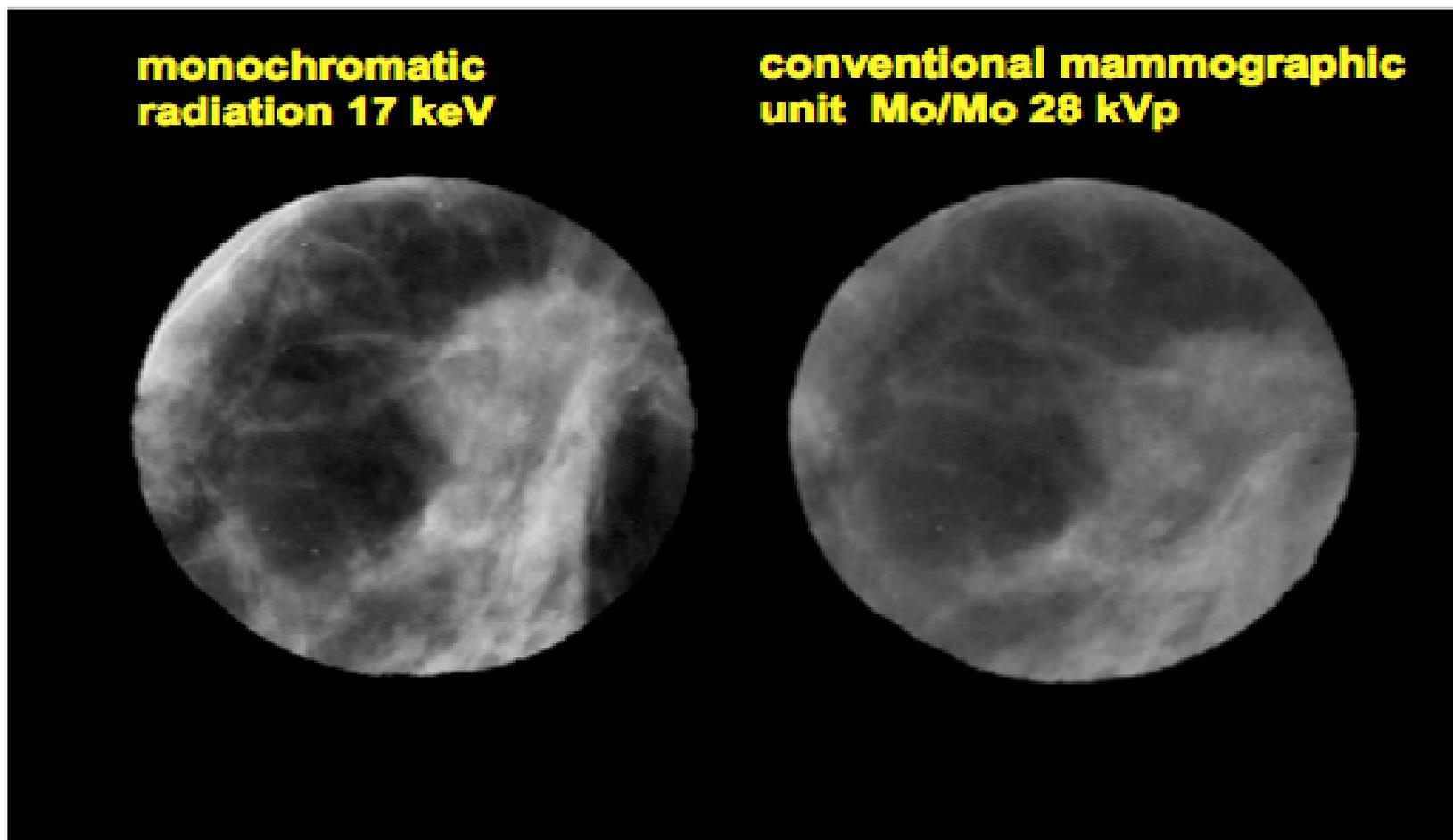
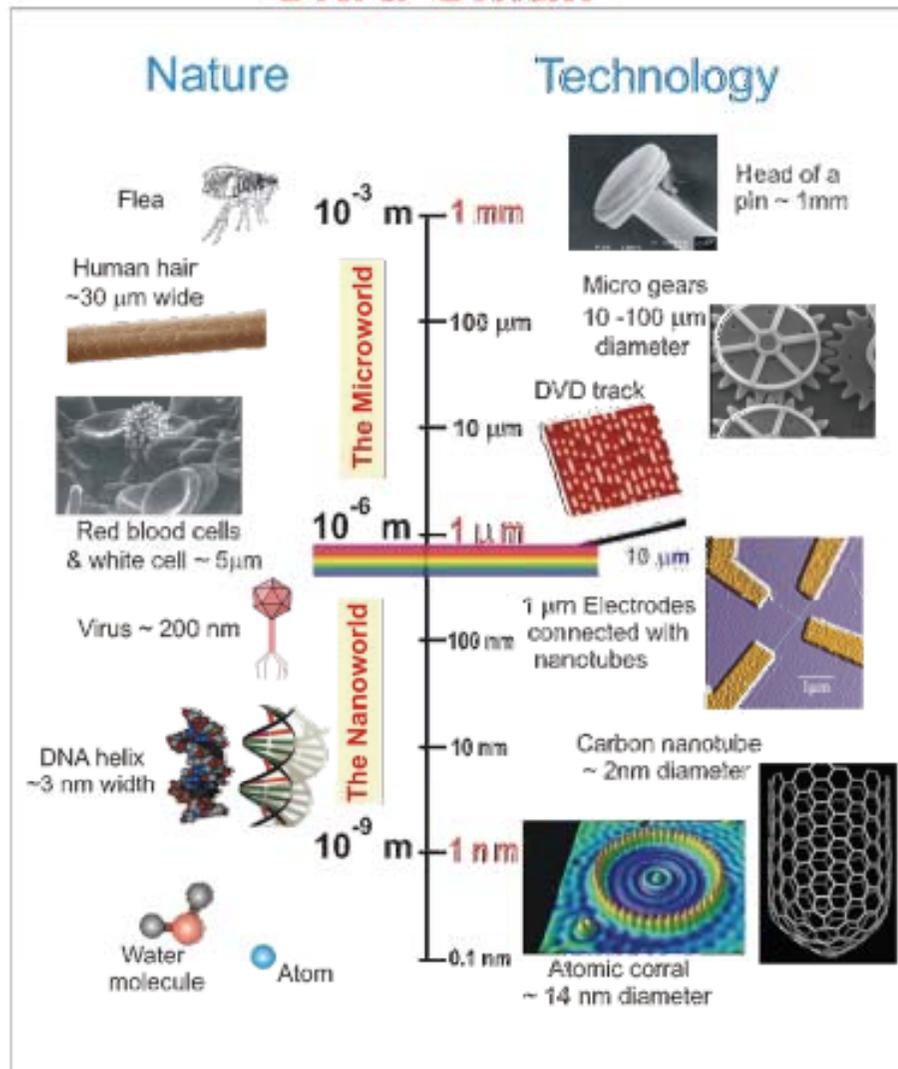


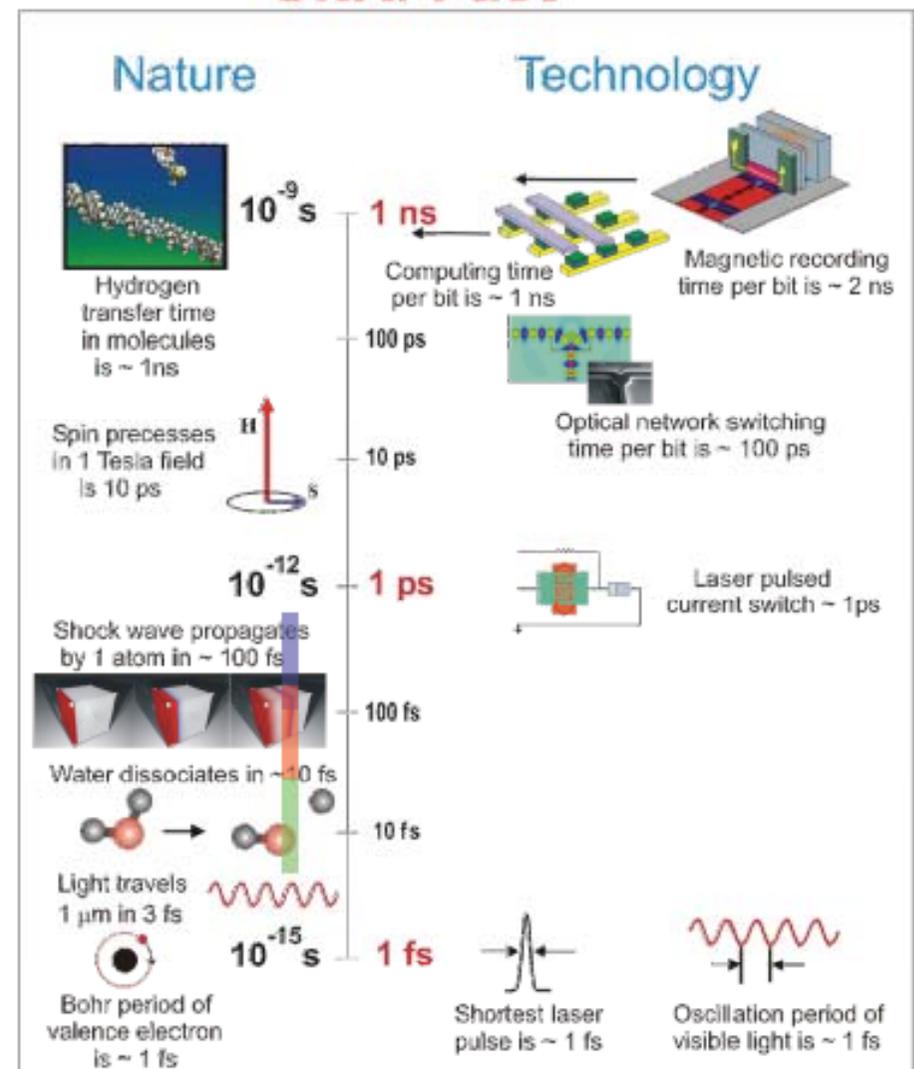
Fig. 3 – Confronto fra una mammografia monocromatica (sinistra) con una tradizionale (destra).

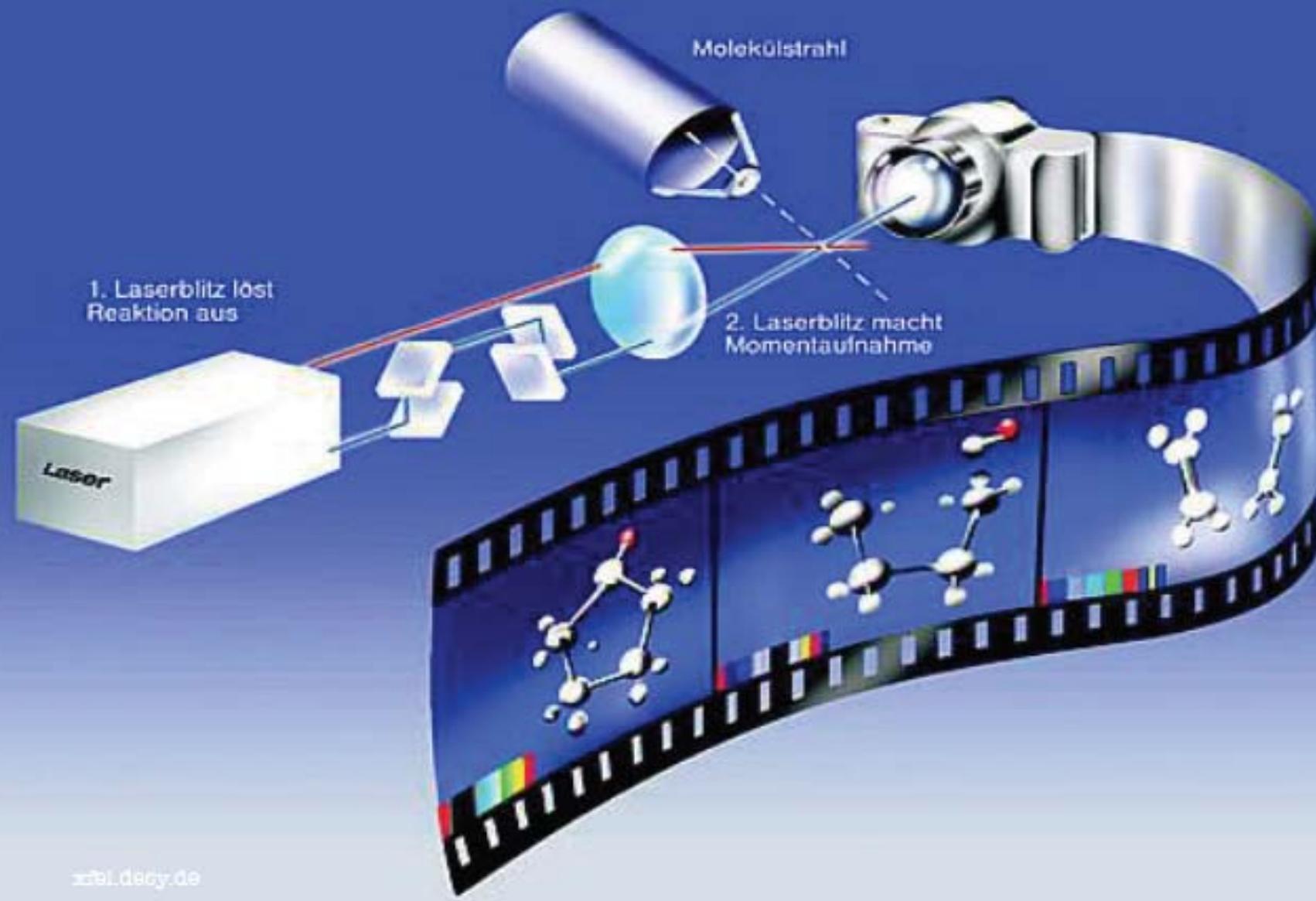
X-Rays have opened the Ultra-Small World X-FELs open the Ultra-Small and Ultra-Fast Worlds

Ultra-Small

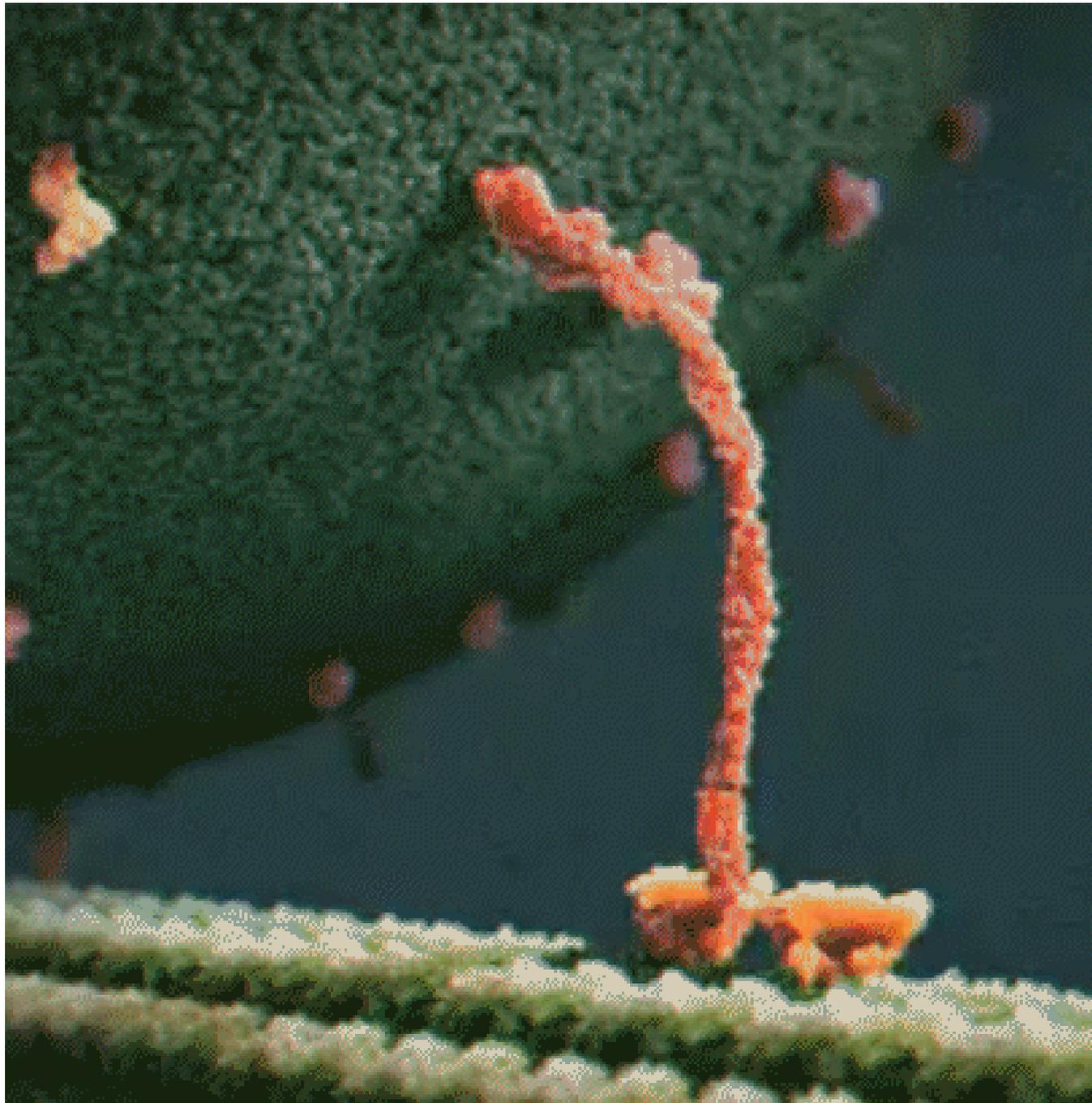


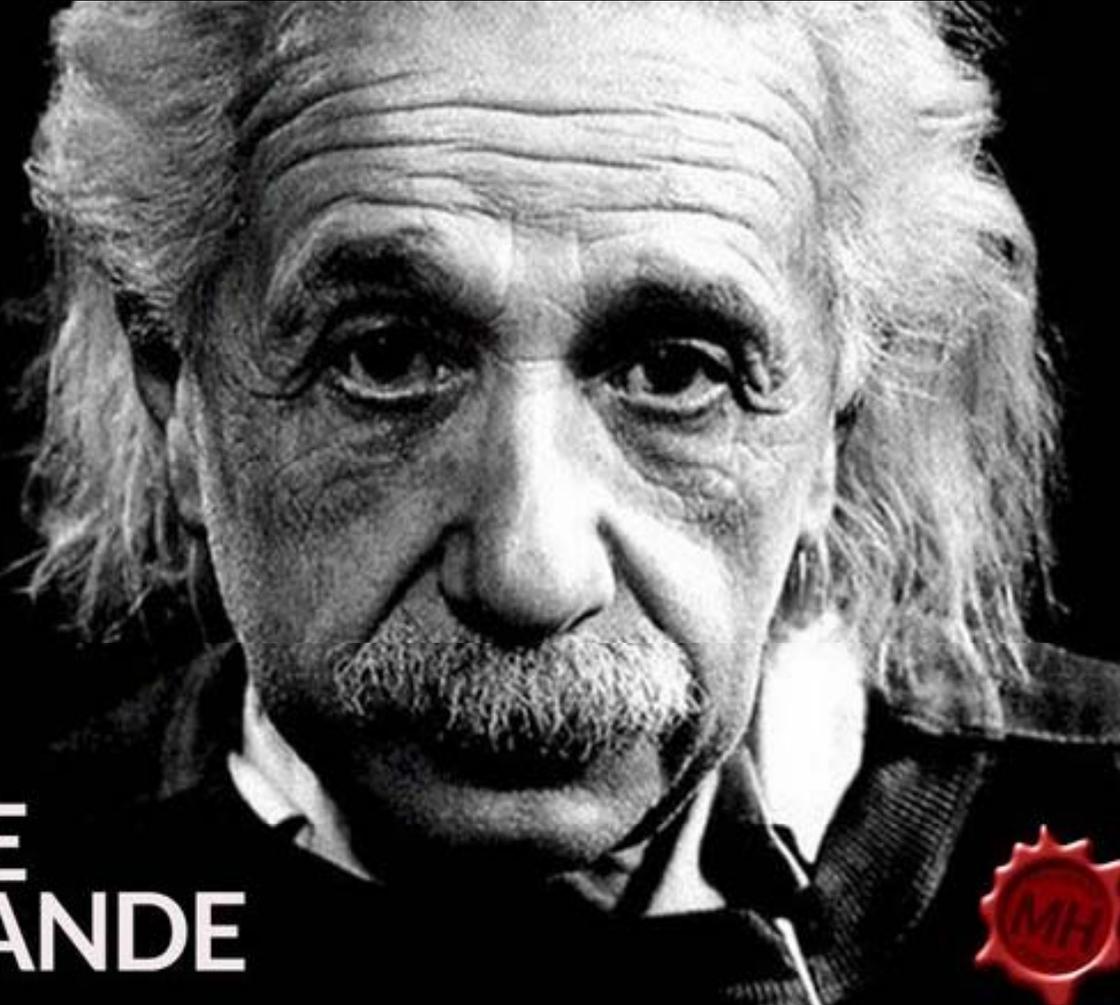
Ultra-Fast









A black and white close-up portrait of Albert Einstein, showing his characteristic wild hair and mustache. He is looking directly at the camera with a serious expression. The background is dark.

IMPARA da ieri
VIVI oggi
SPERA per domani

Ma la cosa più importante è

**NON SMETTERE
DI PORTI DOMANDE**

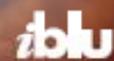


Dai buchi neri all'adroterapia

Un viaggio nella Fisica Moderna



 Springer

 zblu



Catalina Oana Curceanu, nata in Transilvania (Brasov, Romania), è Primo Ricercatore dell'Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati. Dirige un gruppo di ricercatori che lavorano nel campo della fisica sperimentale adronica e nucleare, conducendo esperimenti sia in Italia sia all'estero, e coordina vari progetti europei. Ha organizzato varie conferenze internazionali ed è autrice di più di 200 pubblicazioni scientifiche in riviste internazionali. Svolge un'intensa attività di formazione e divulgazione scientifica e scrive per vari giornali e riviste italiane e rumene. Ha la passione di spiegare a tutti quanto sia bello e affascinante il mondo della scienza.



Acknowledgements



Farnesina
*Ministero degli Affari Esteri
e della Cooperazione Internazionale*



ECOST
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY



Istituto Nazionale di Fisica Nucleare



John
Templeton
Foundation

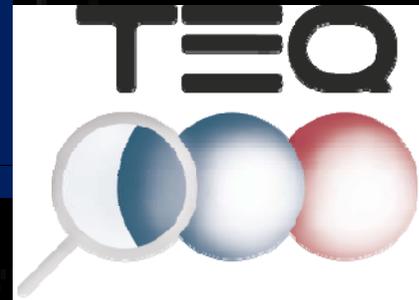
**CENTRO
FERMI**

Enrico Fermi

MUSEO
STORICO DELLA FISICA
E
CENTRO
STUDI E RICERCHE
ENRICO FERMI

FQXi

FOUNDATIONAL QUESTIONS INSTITUTE



FLAME: Frascati Laser for Acceleration and Multidisciplinary Experiments

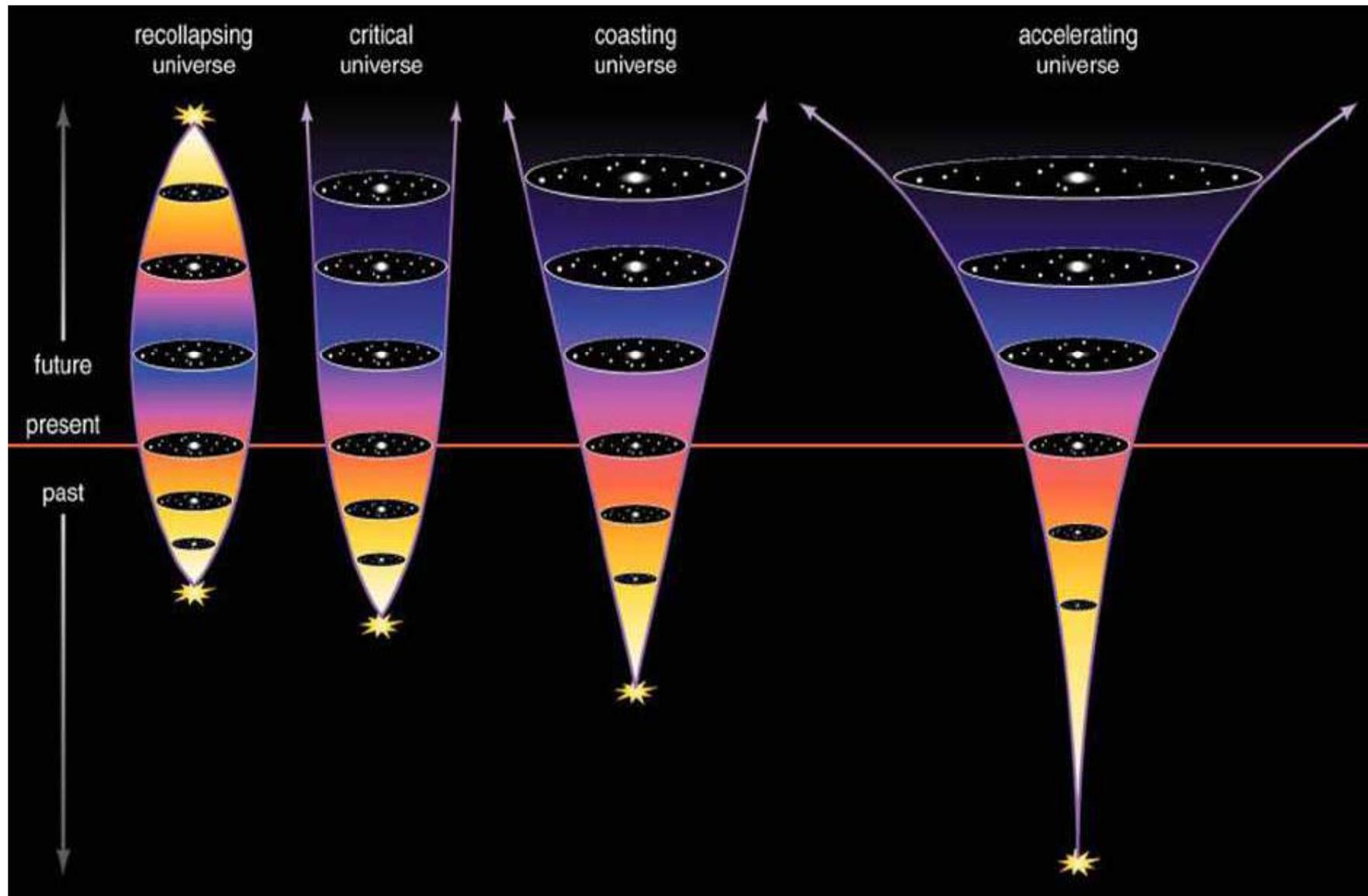
Laser of high power (> 100 TW), able to produce pulses of 6 J in 20 fs at 10 Hz



1) If FLAME beam is injected into a gas the electrons inside get highly accelerated (new acceleration technique)

2) If FLAME beam is colliding head-on with an electron beam (SPARC) an intense source of X rays is produced

Che fine fara' l'Universo?



Large Hadron Collider - ALICE

