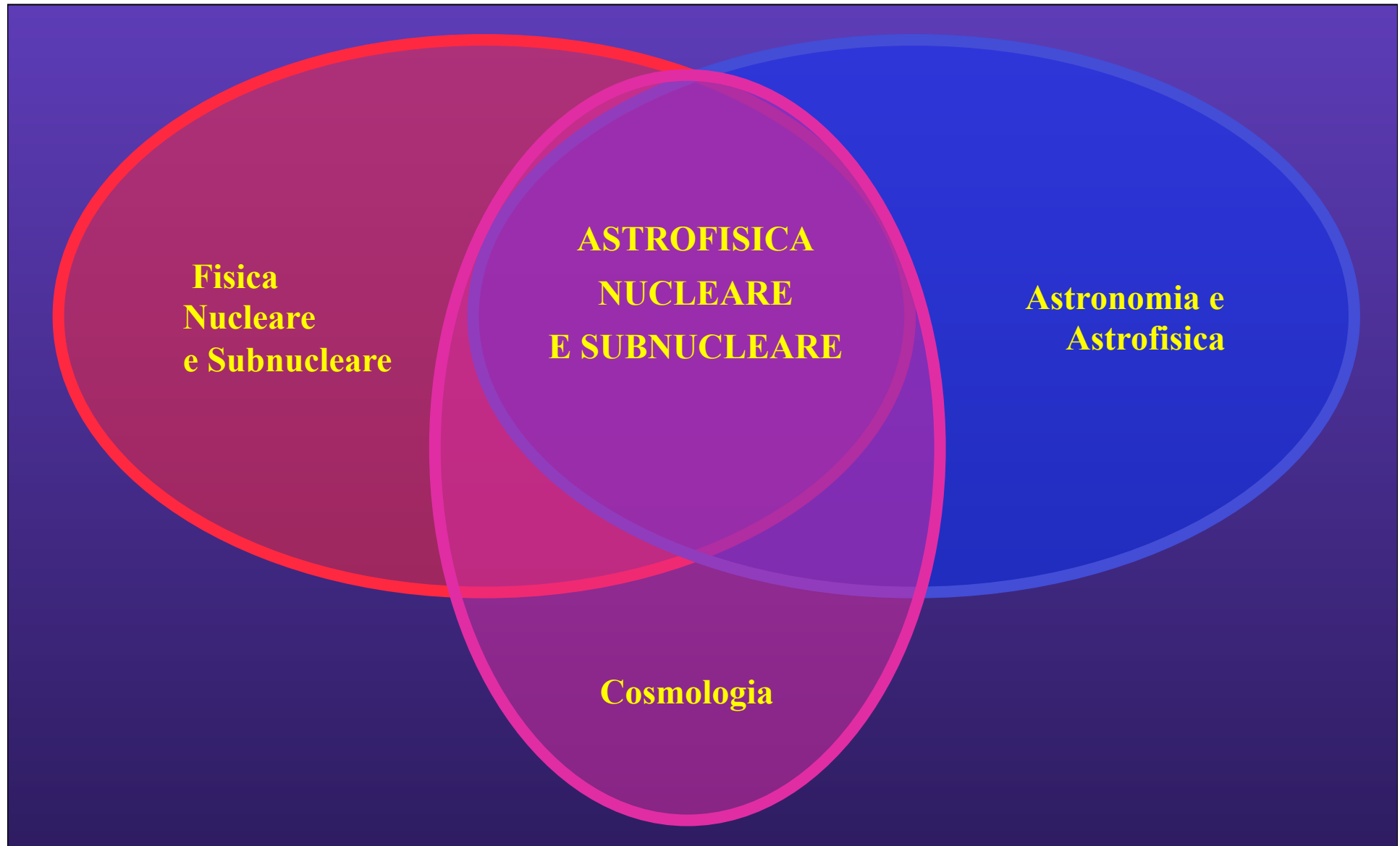


Astrofisica Nucleare e Subnucleare

Introduzione

Astrofisica Nucleare e Subnucleare

(Fisica Astroparticellare/Astrofisica Particellare)



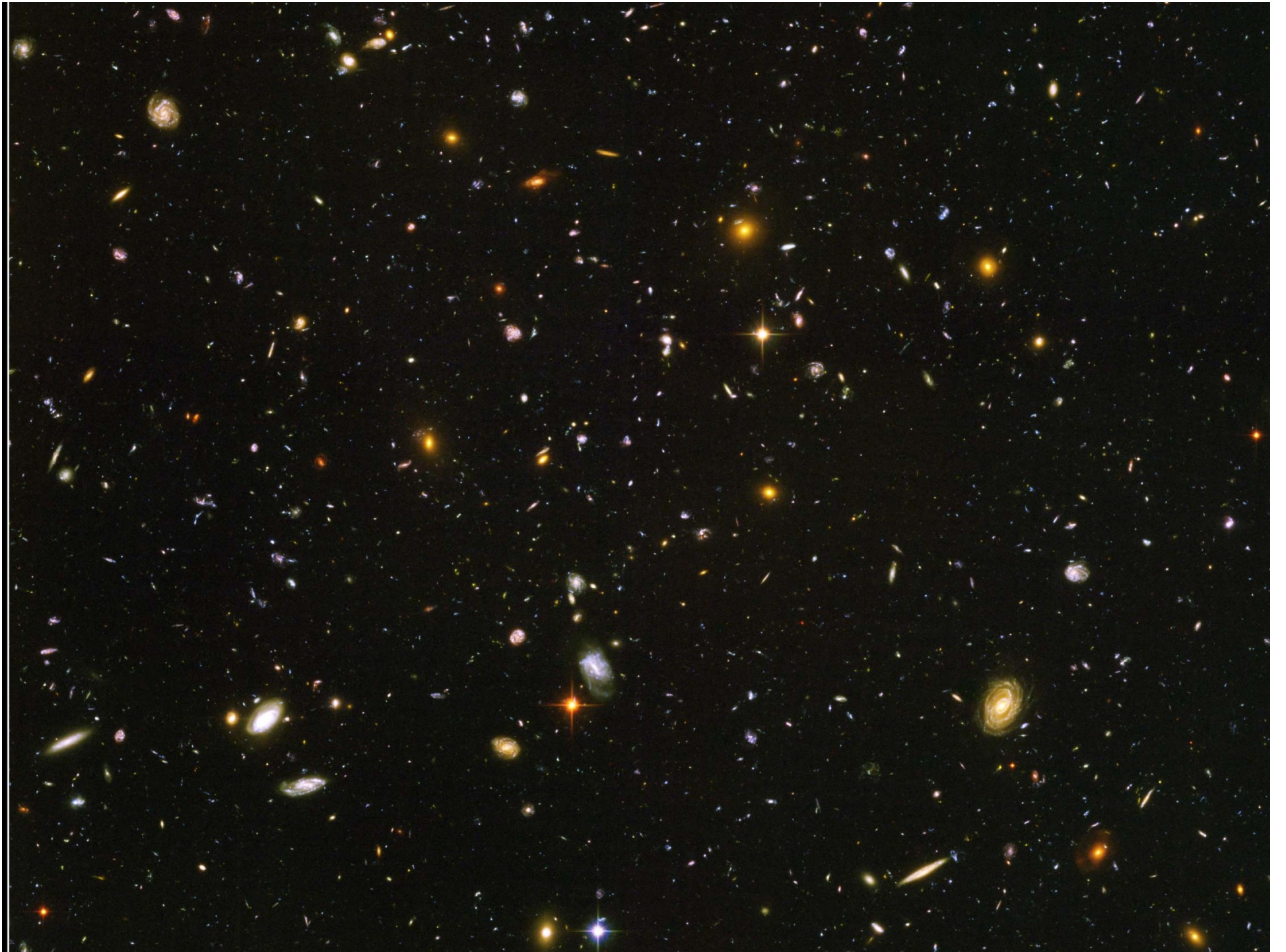
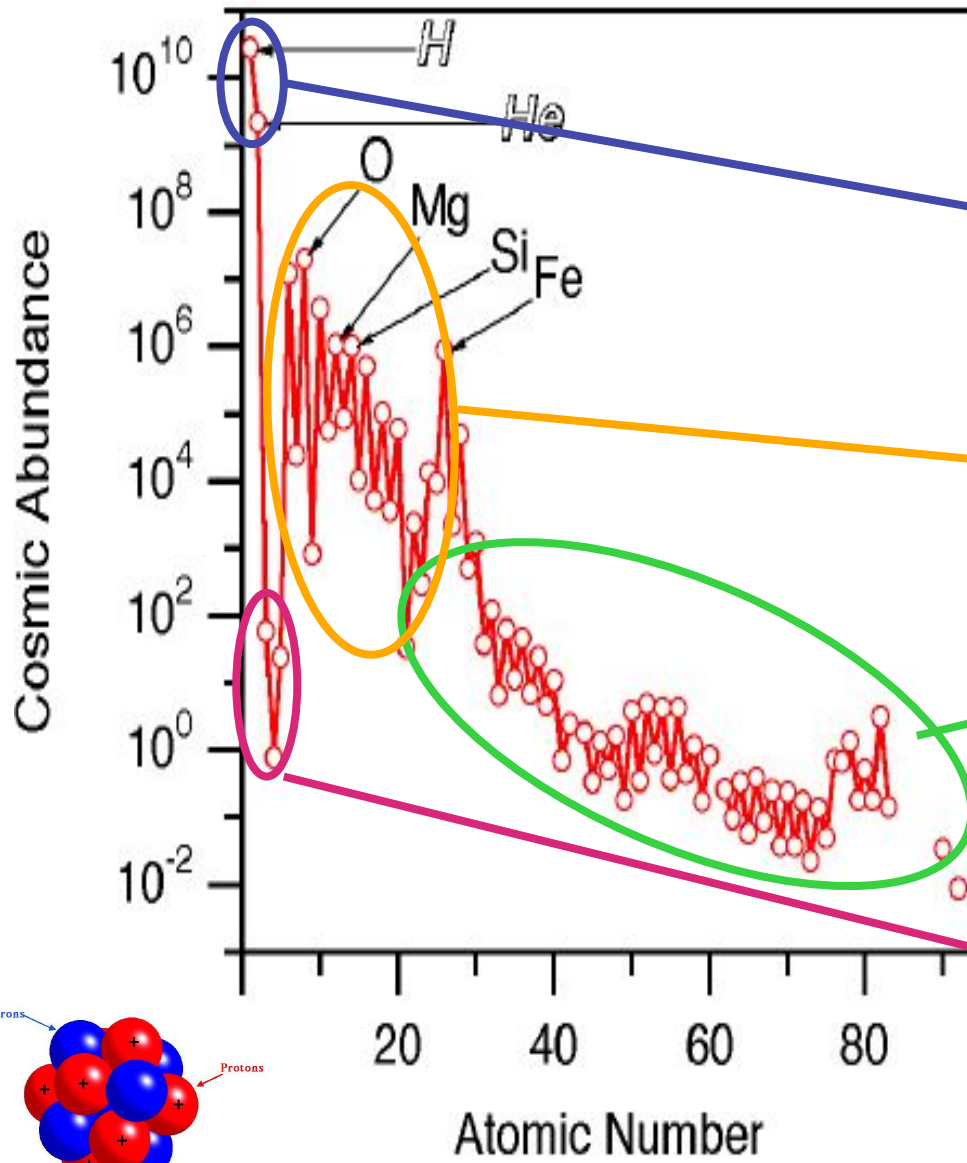


Tavola periodica degli elementi

Periodic Table of the Elements

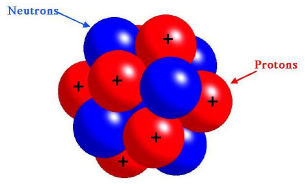
1	2											18	19	20																																			
3	4											13	14	15	16	17	18																																
11	12											31	32	33	34	35	36																																
19	20	21	22	23	24	25	26	27	28	29	30	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54																						
37	38	39	40	41	42	43	44	45	46	47	48	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86								
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	
87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136



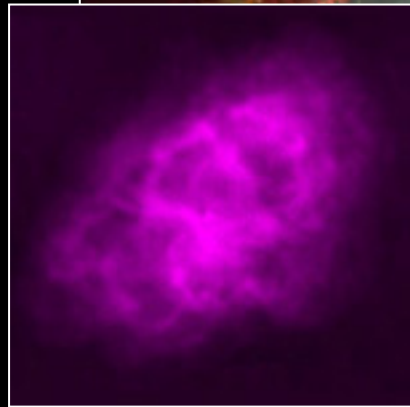
- Origine:**
- Big Bang Nucleosintesi
 - Stelle massive
 - Esplosioni di Supernova / Merging di Stelle di Neutroni
 - Interazioni con raggi cosmici

*Lanthanide Series
+ Actinide Series

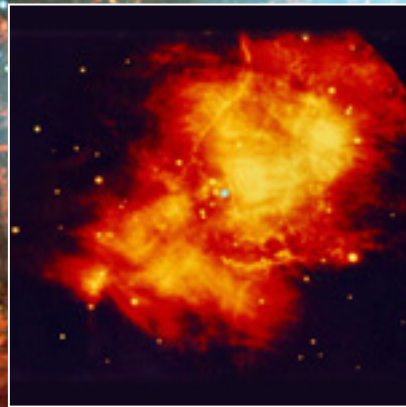
58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr



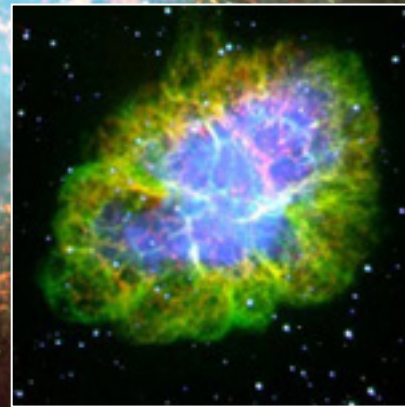
La nebulosa del Granchio (Crab Nebula) Supernova osservata dalla Cina nel 1054



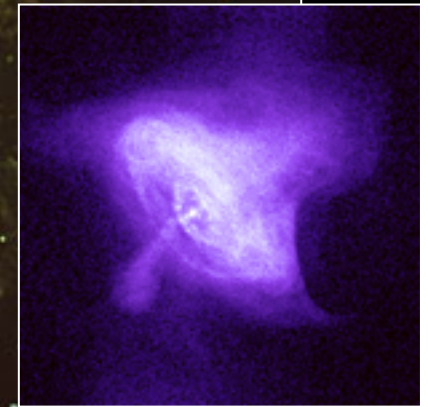
Radio



Infrarossi



Ottico



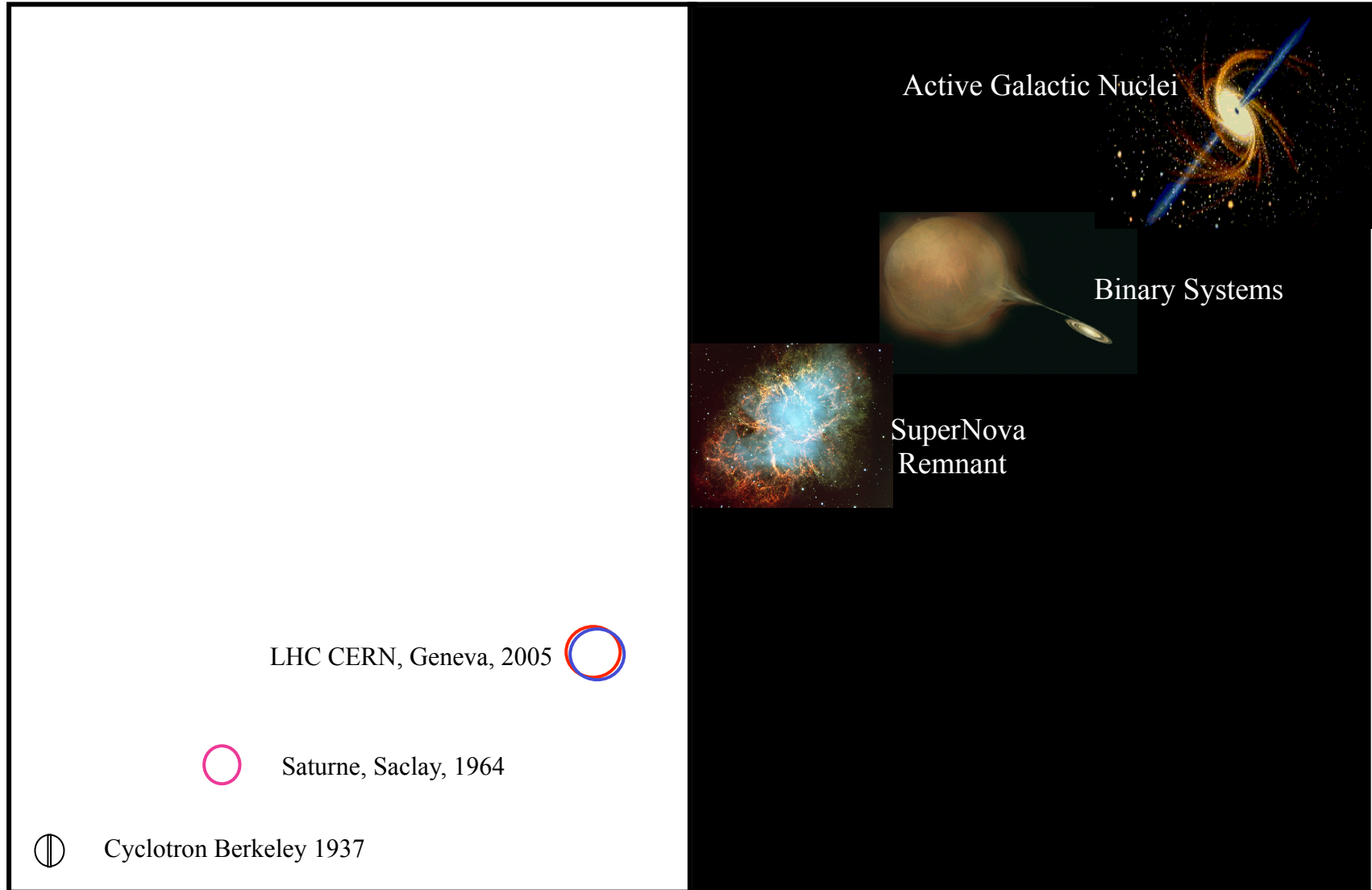
Raggi-X

Fisica Nucl. e S. \Rightarrow Astrofisica Nucl. e S.

Acceleratori Terrestri

Acceleratori Cosmici

Diametro dell'acceleratore



Energia delle particelle accelerate

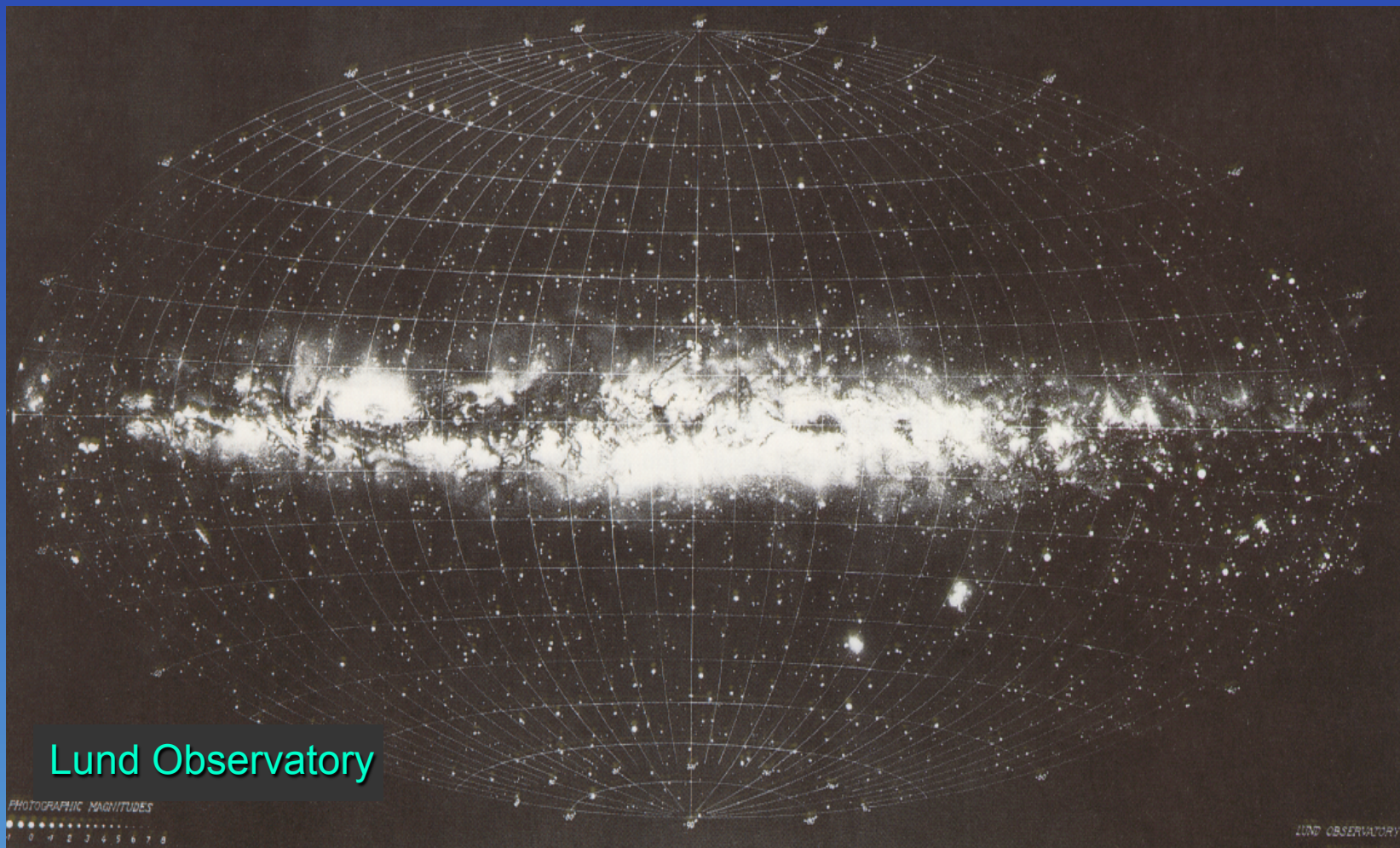
Astronomia



Comprendere l'Universo



VIA LATTEA: La nostra Galassia



Lund Observatory

PHOTOGRAPHIC MAGNITUDES
●●●●●●●●●●
1 0 1 2 3 4 5 6 7 8

LUND OBSERVATORY



Galassia simile alla Via Lattea



Galassia
Spirale
NGC 628

Il sole sarebbe
circa qui

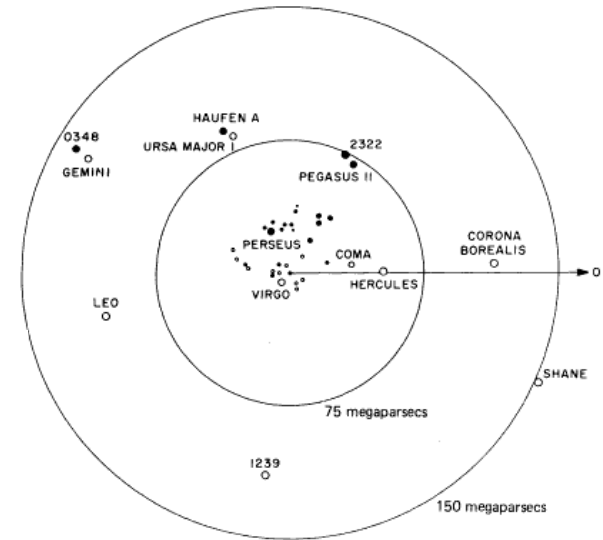
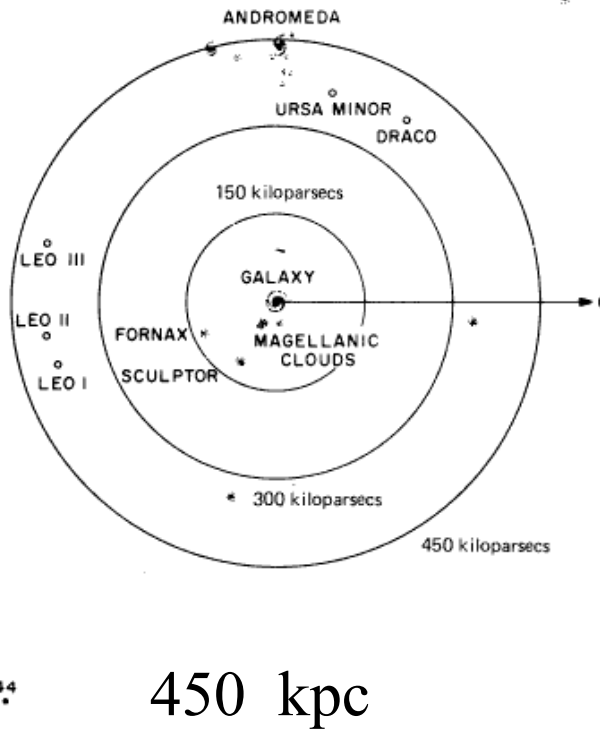
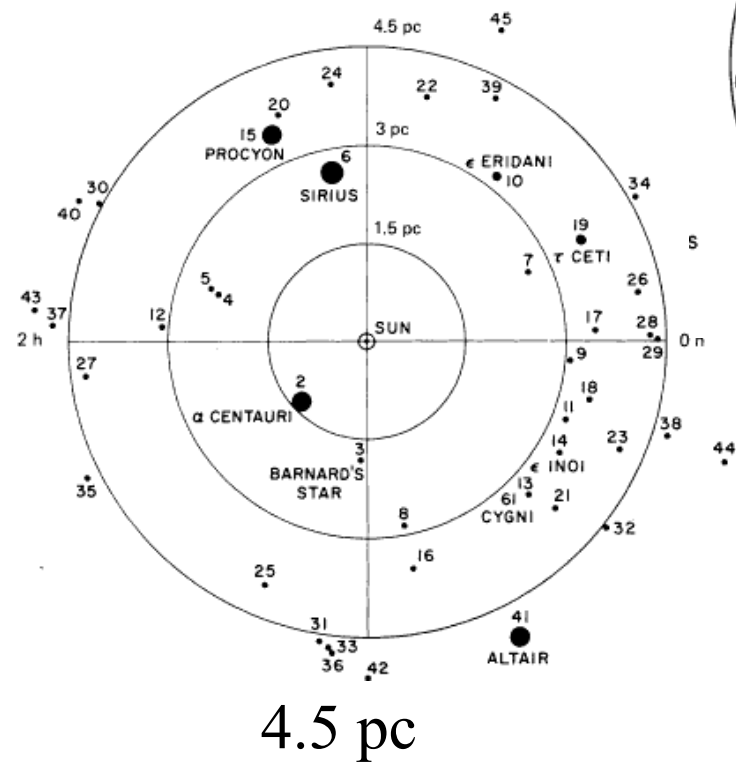
Gemini North

Scale Astronomiche

Gruppi di Galassie

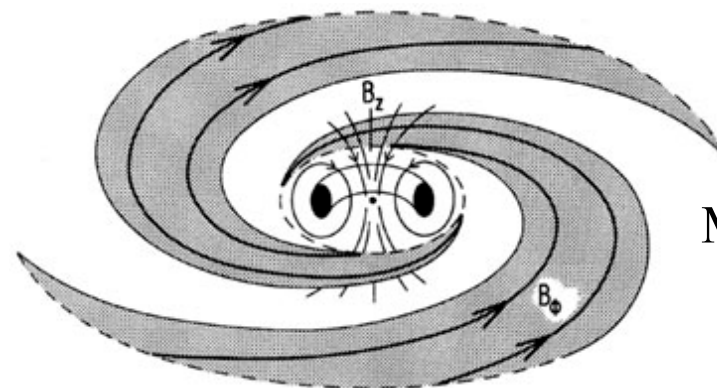
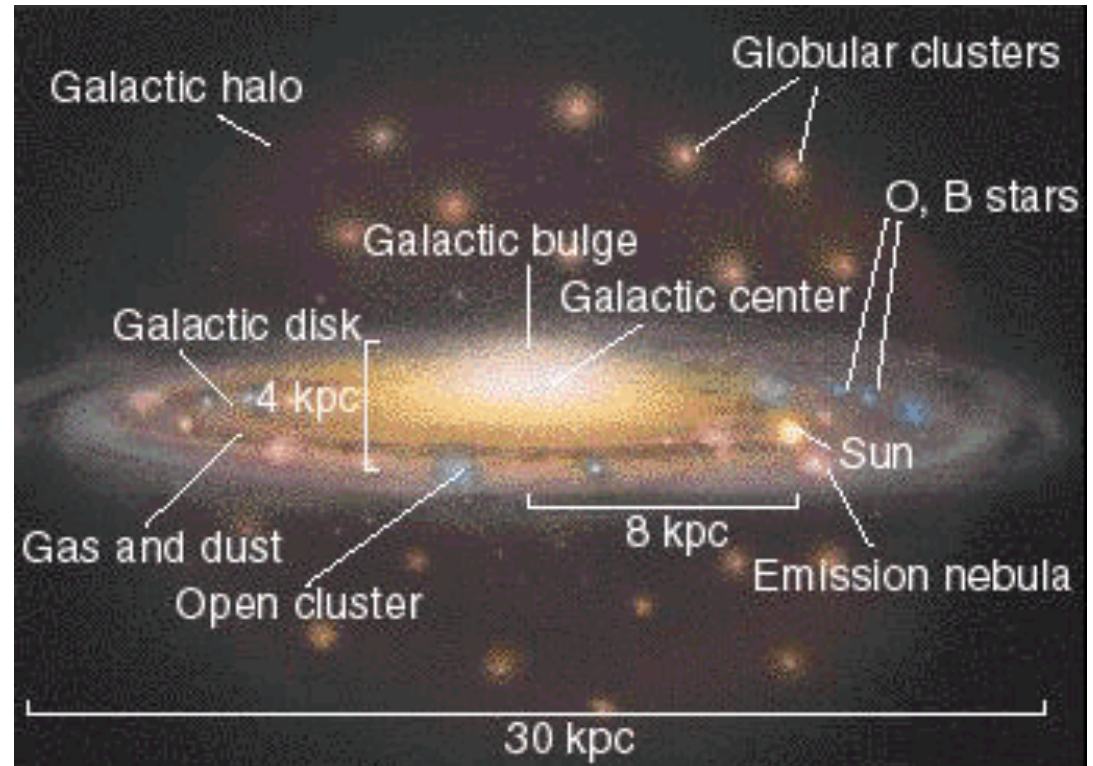
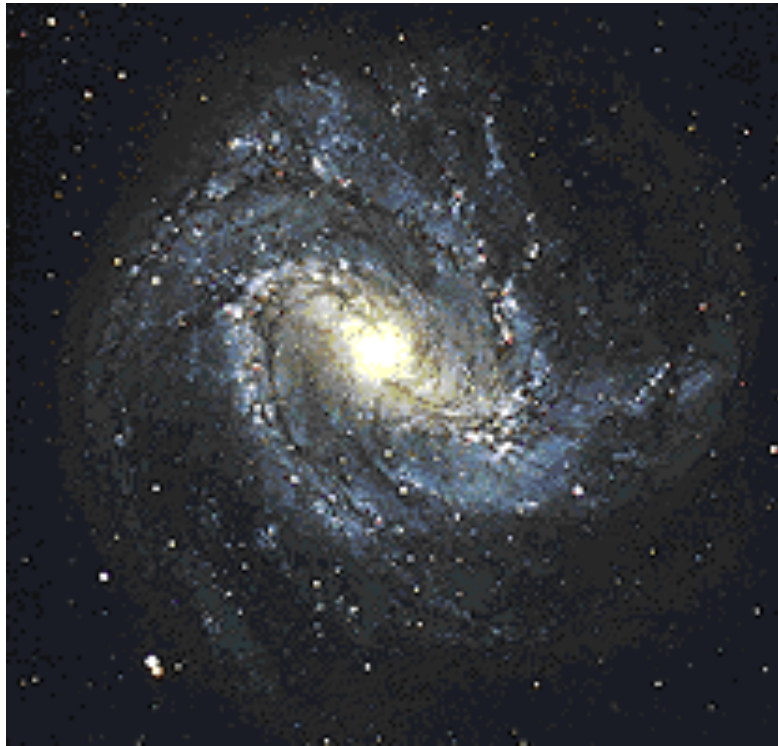
Galassie

Stelle



1 pc (1 parsec) = 3 anni luce

Milky Way Galaxy



Magnetic field
~ few μG

Gruppi (Cluster) di galassie

circa 50 volte le dimensioni della Via Lattea.

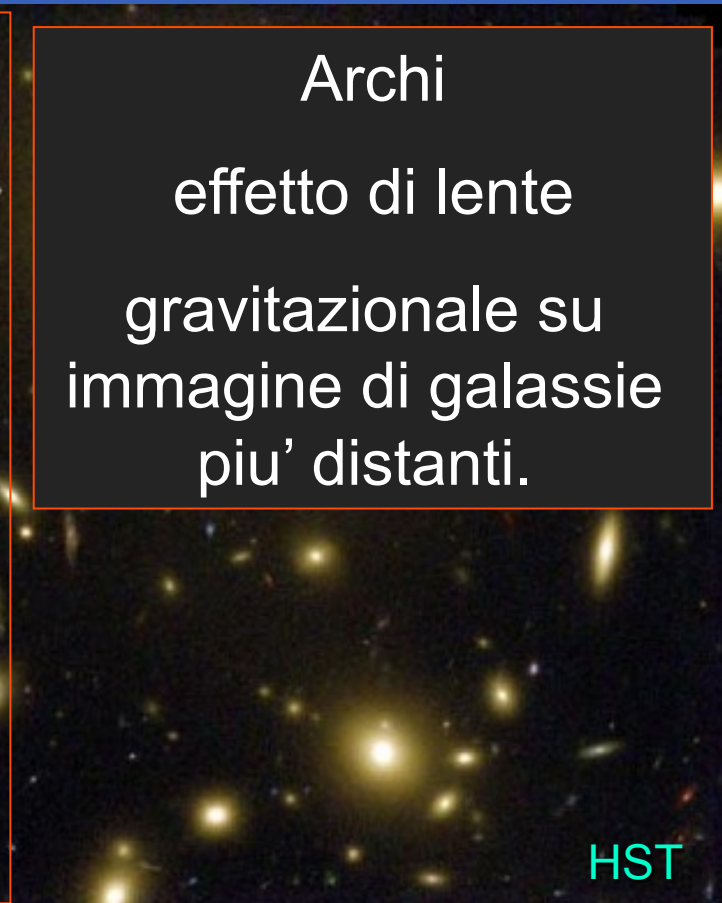
Abell2218



Archi

effetto di lente

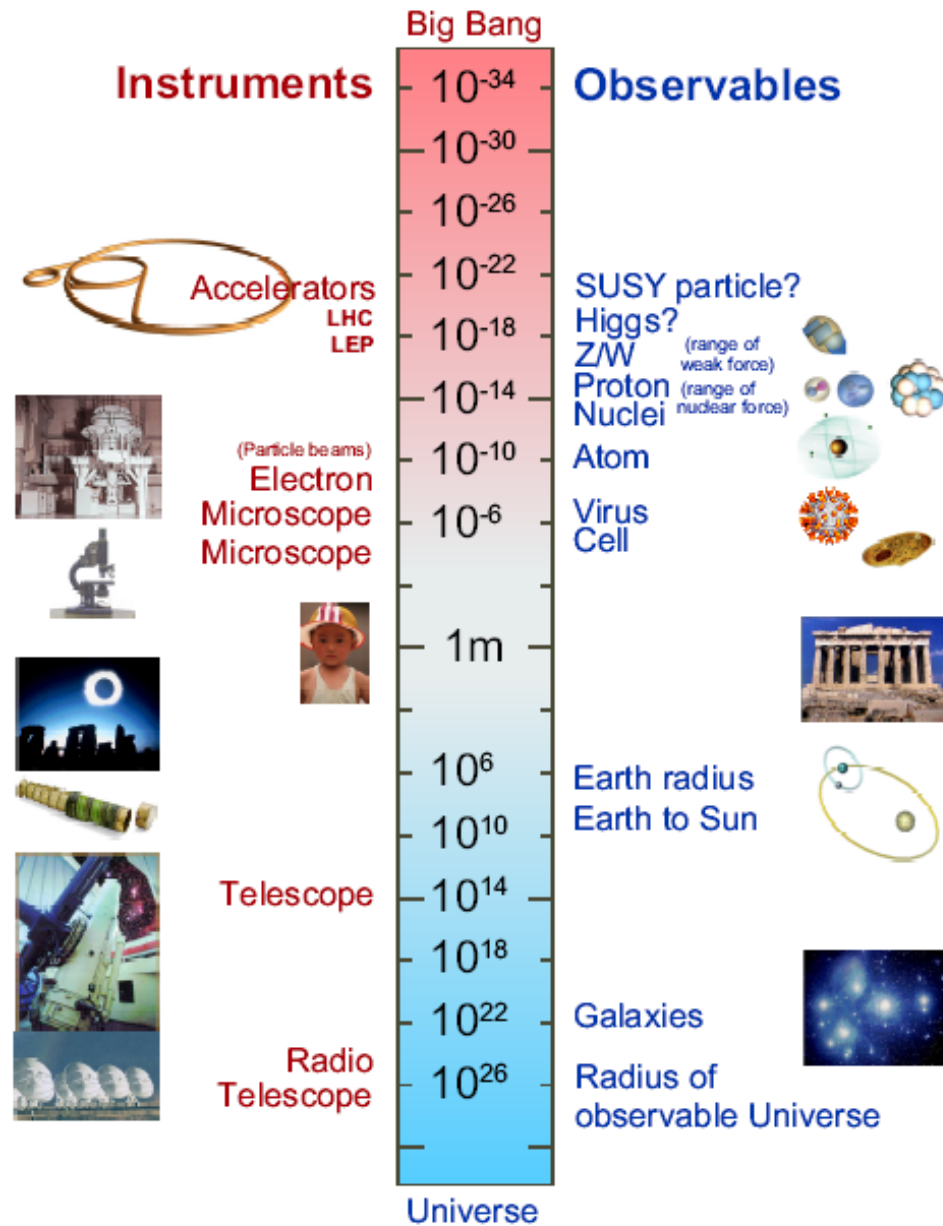
gravitazionale su
immagine di galassie
piu' distanti.

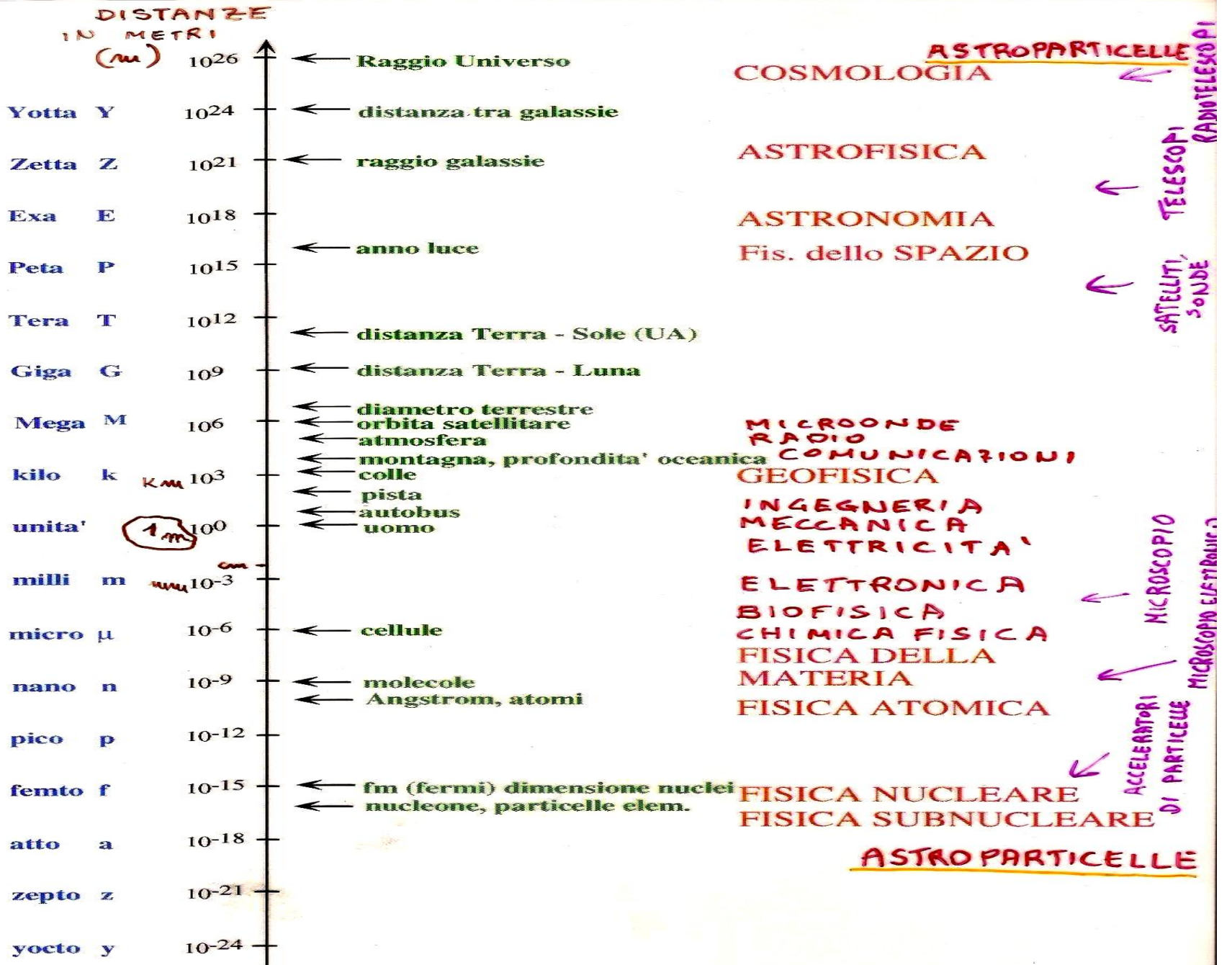


HST



The size of things

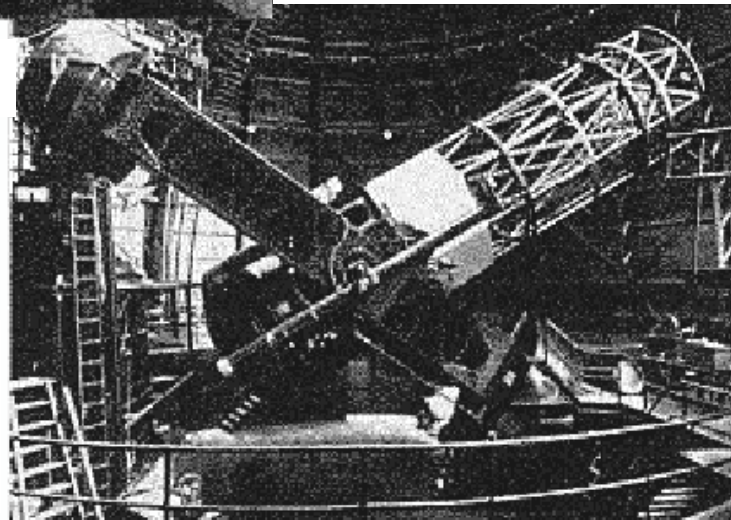
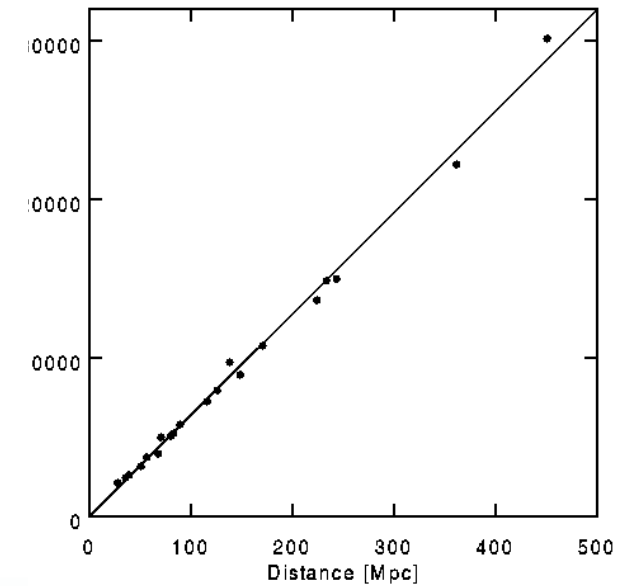
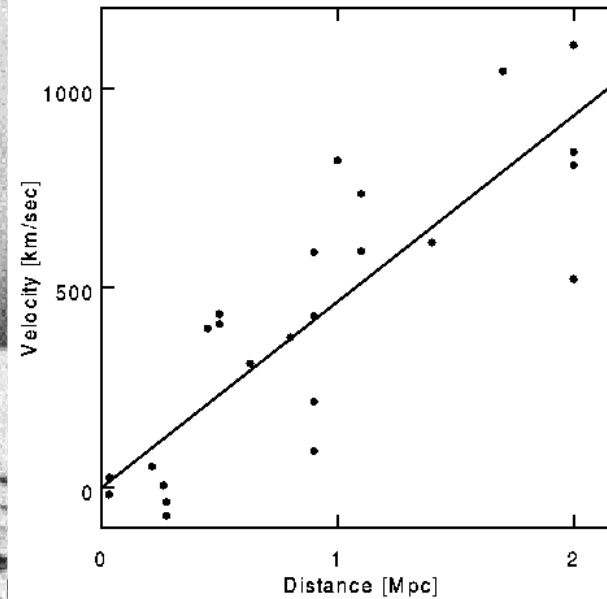




Espansione dell'universo



Edwin Hubble

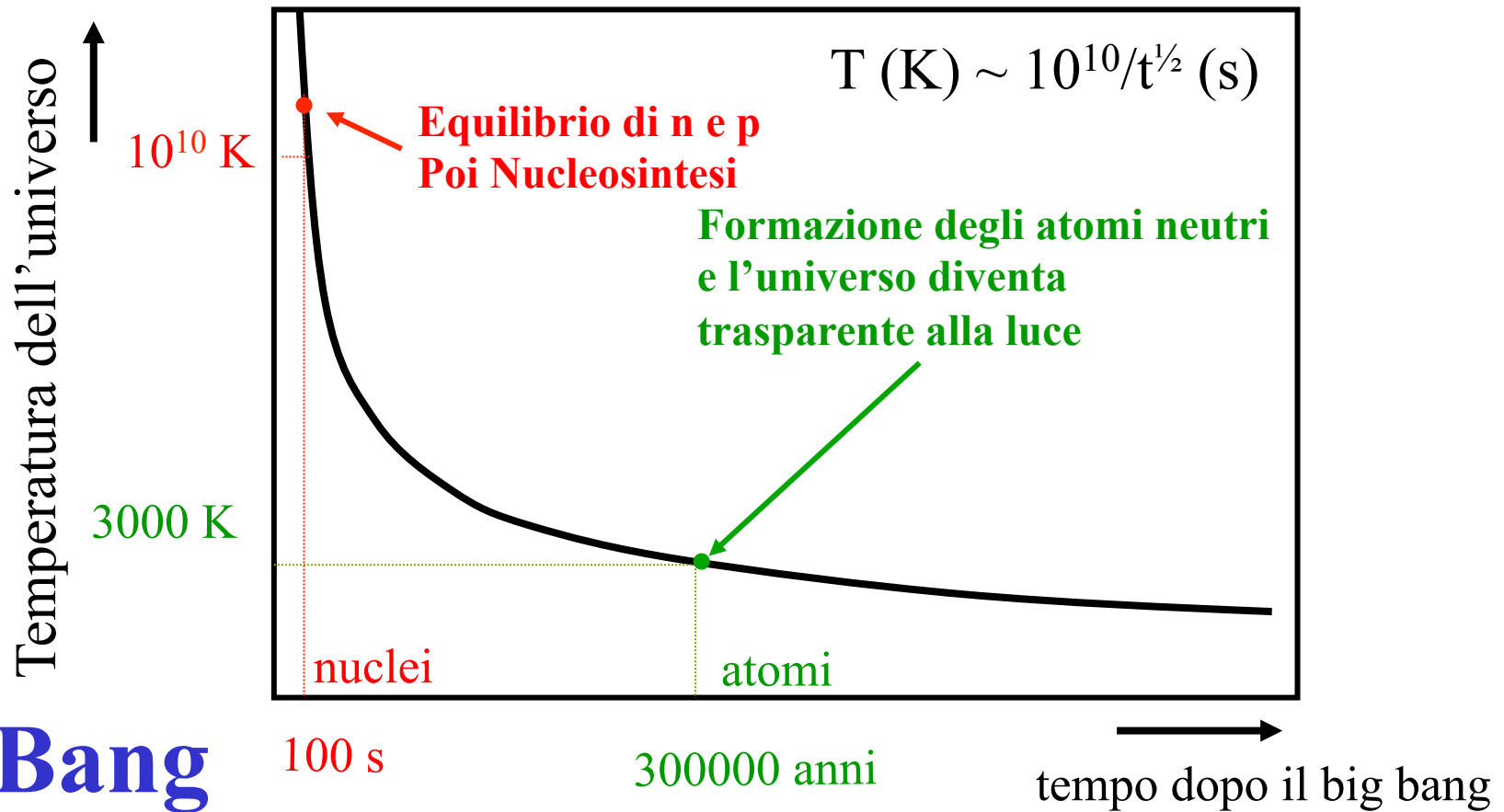
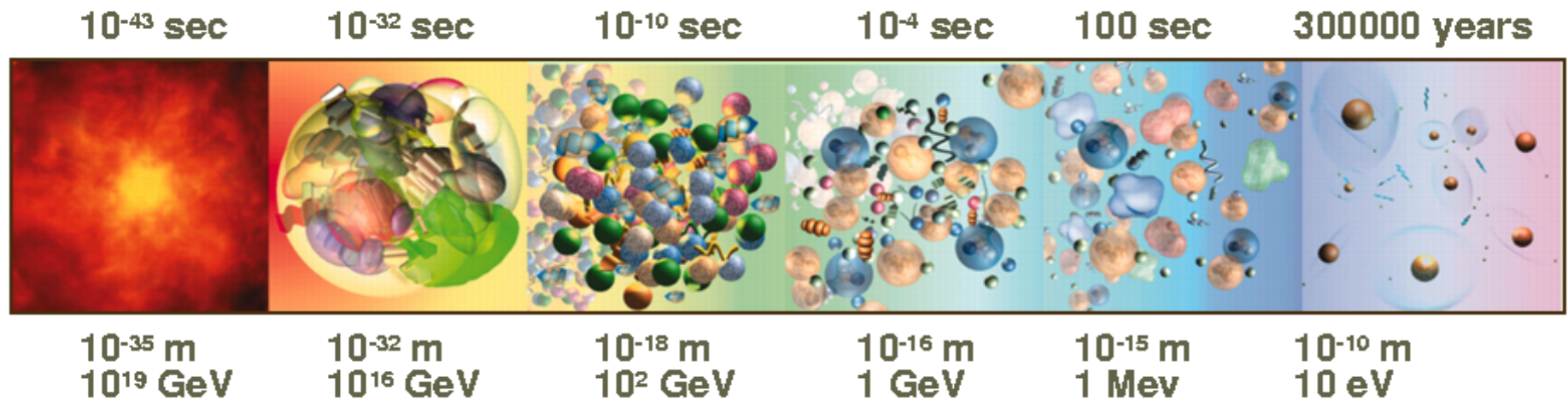


Mt. Wilson
100 Inch
Telescope

Velocita' delle galassie
proporzionale alla distanza:

$$v = H r$$

$$H \sim 70 \text{ km/sec / Mpc}$$



Big Bang

Modello Standard:

FERMIONI

Leptoni e quark

Costituenti Della Materia

e BOSONI

Fotoni/W,Z, gluoni

Portatori di Forza:

Elettromagnetica/

Nucleare Debole,

Nucleare Forte

Gravitazionale?

FERMIONS

matter constituents
spin = 1/2, 3/2, 5/2, ...

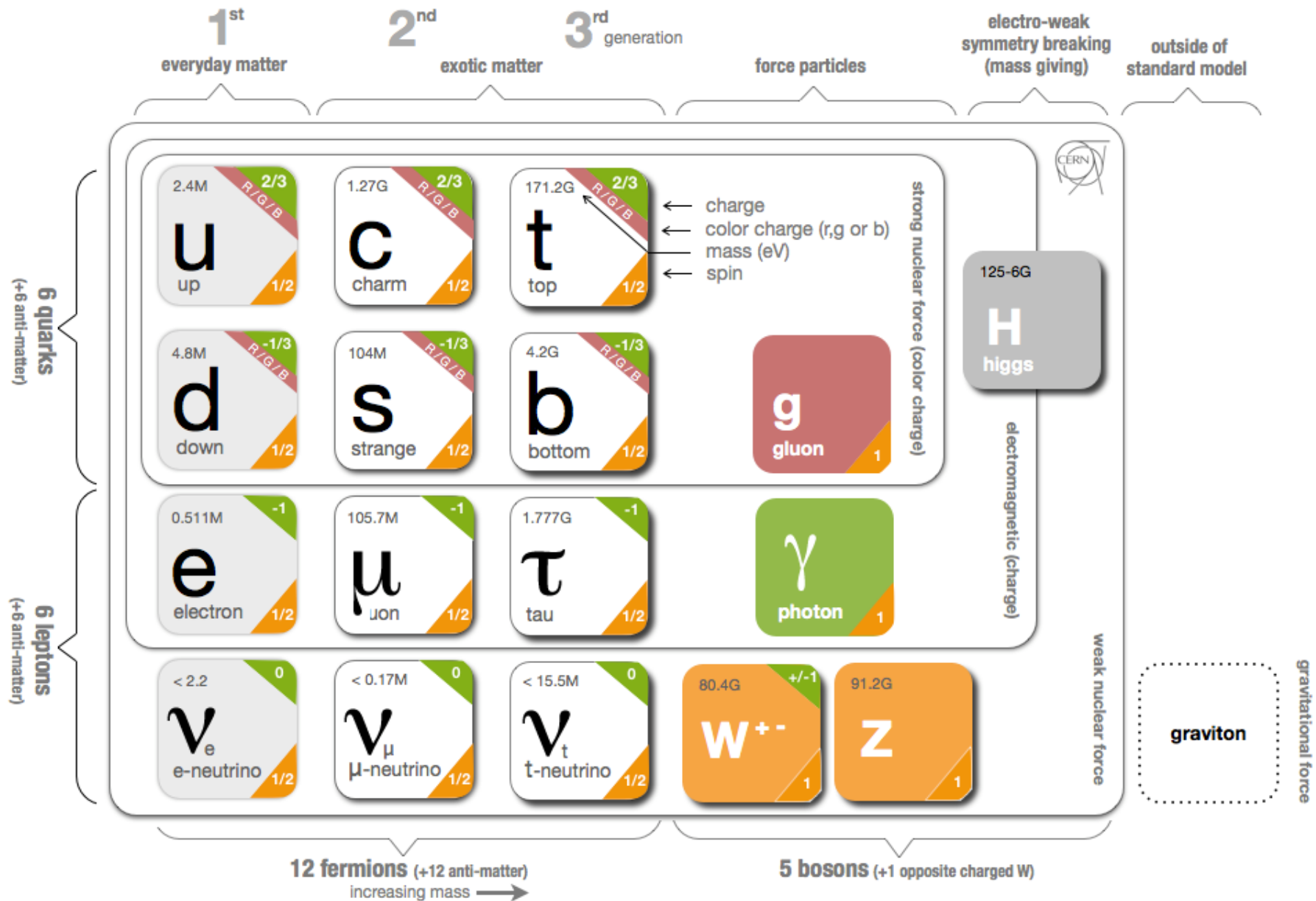
Leptons spin = 1/2			Quarks spin = 1/2		
Flavor	Mass GeV/c ²	Electric charge	Flavor	Approx. Mass GeV/c ²	Electric charge
ν_e electron neutrino	$<1 \times 10^{-8}$	0	U up	0.003	2/3
e electron	0.000511	-1	d down	0.006	-1/3
ν_μ muon neutrino	<0.0002	0	C charm	1.3	2/3
μ muon	0.106	-1	S strange	0.1	-1/3
ν_τ tau neutrino	<0.02	0	t top	175	2/3
τ tau	1.7771	-1	b bottom	4.3	-1/3

BOSONS

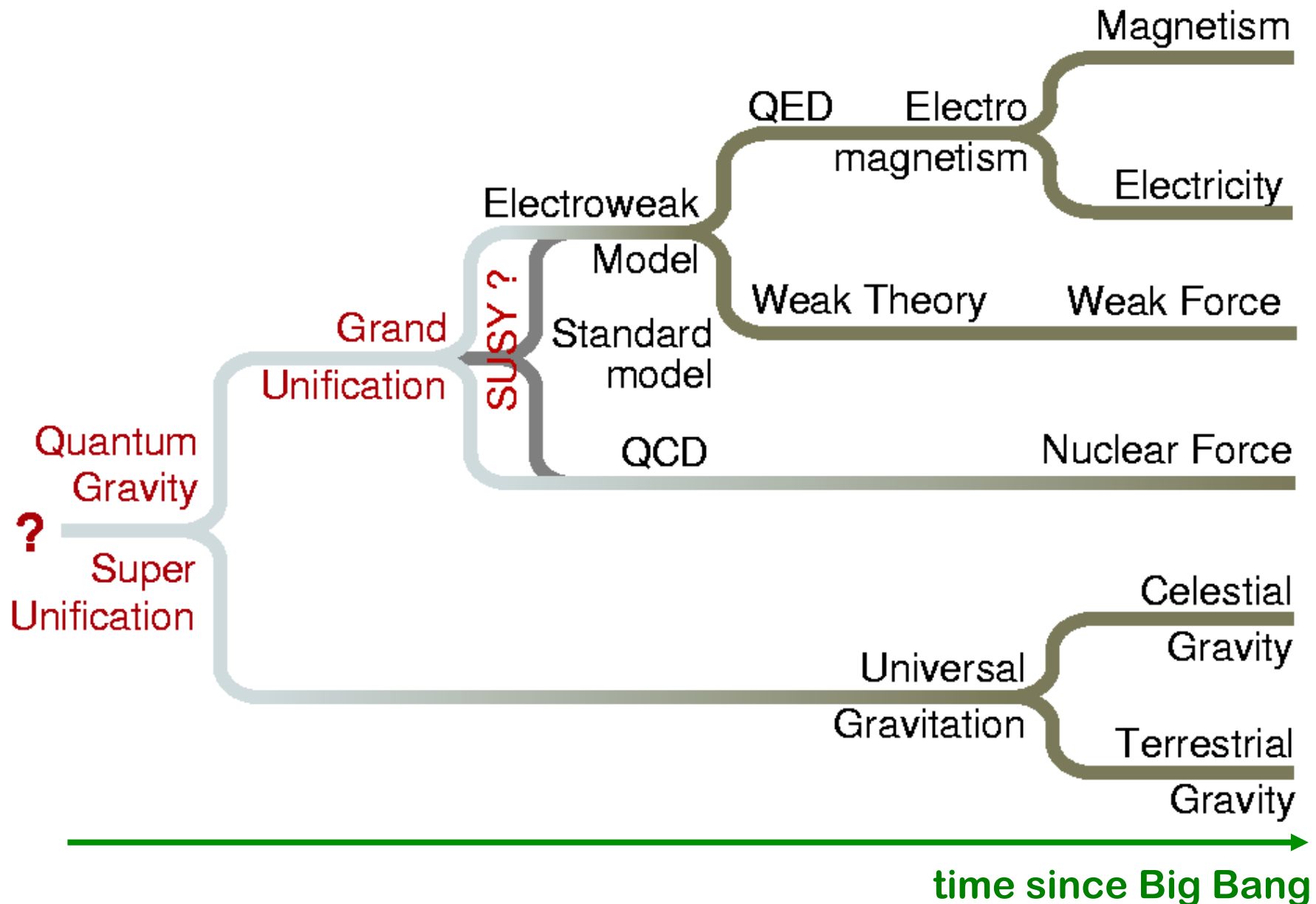
force carriers
spin = 0, 1, 2, ...

Unified Electroweak spin = 1			Strong (color) spin = 1		
Name	Mass GeV/c ²	Electric charge	Name	Mass GeV/c ²	Electric charge
γ photon	0	0	g gluon	0	0
W⁻	80.4	-1			
W⁺	80.4	+1			
Z⁰	91.187	0			

MODELLO STANDARD : Fermioni (Costituenti) e Bosoni (Mediatori)

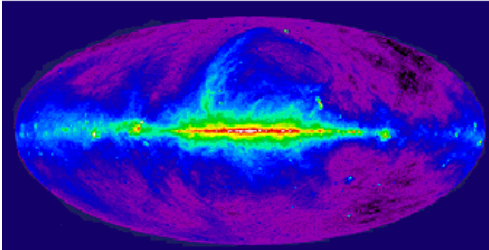


Unificazione delle Forze



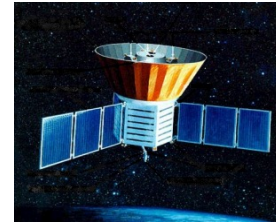
Multi-Wavelength Photons

Radio



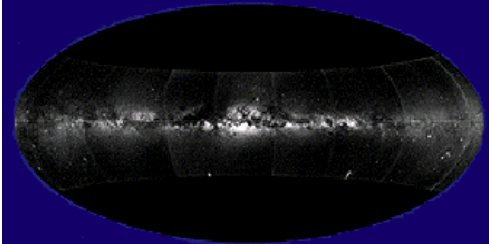
Radio télescope
de Bonn

Infrared



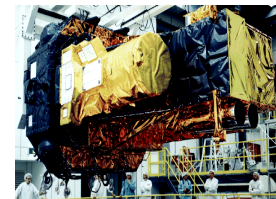
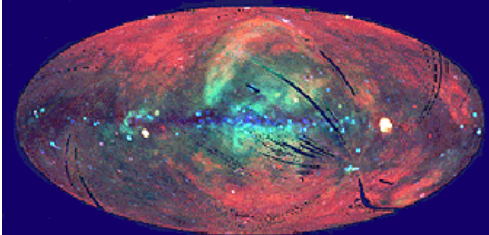
Satellite
COBE

Visible light



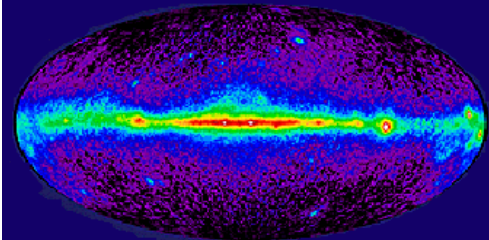
Télescope du
Mont Palomar

X-ray



Satellite
INTEGRAL

Gamma Ray

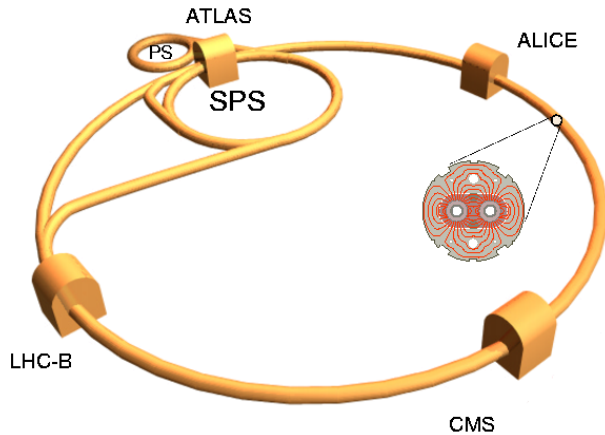


Satellite
CGRO

Particle Acceleration

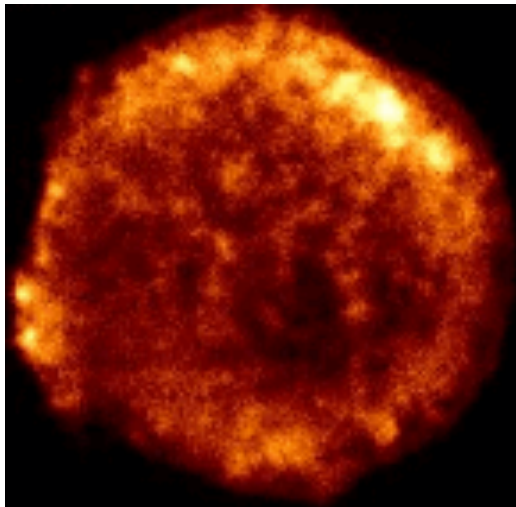
$$E \propto BR$$

Large Hadron Collider



$$R \sim 10 \text{ km}, B \sim 10 \text{ T} \quad \Rightarrow \quad E \sim 10 \text{ TeV}$$

Tycho SuperNova Remnant



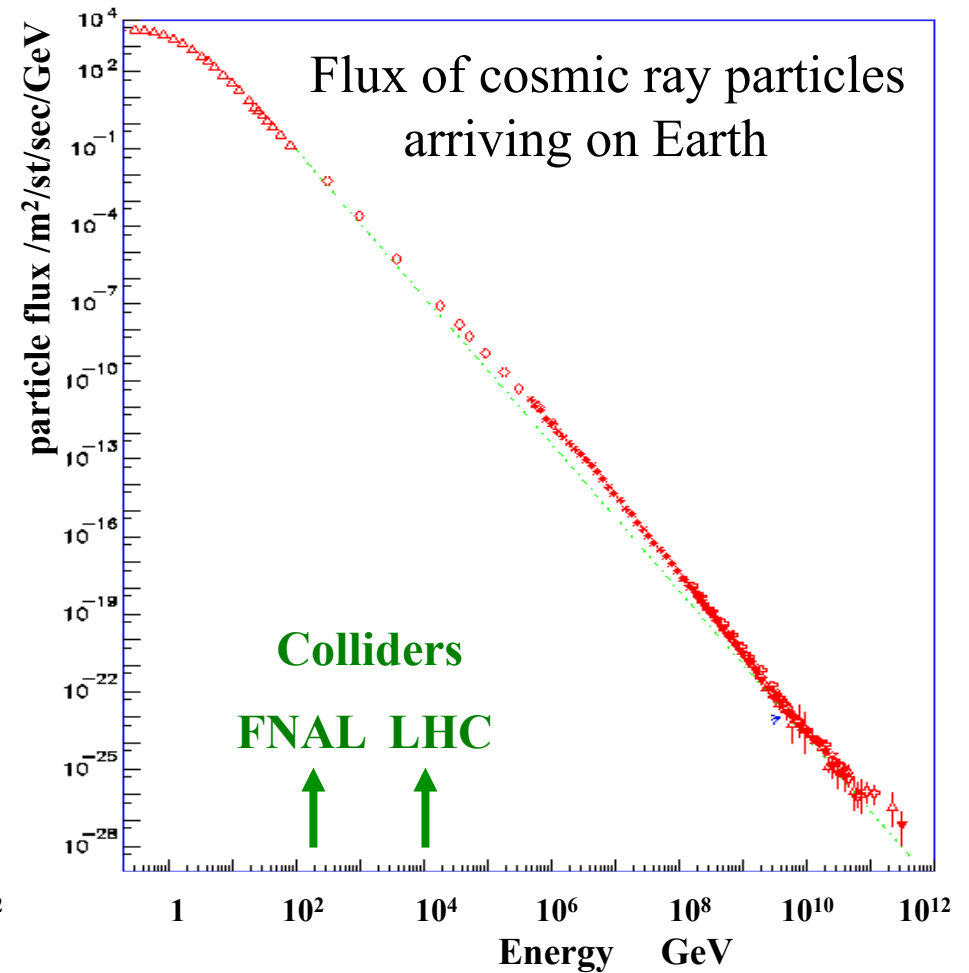
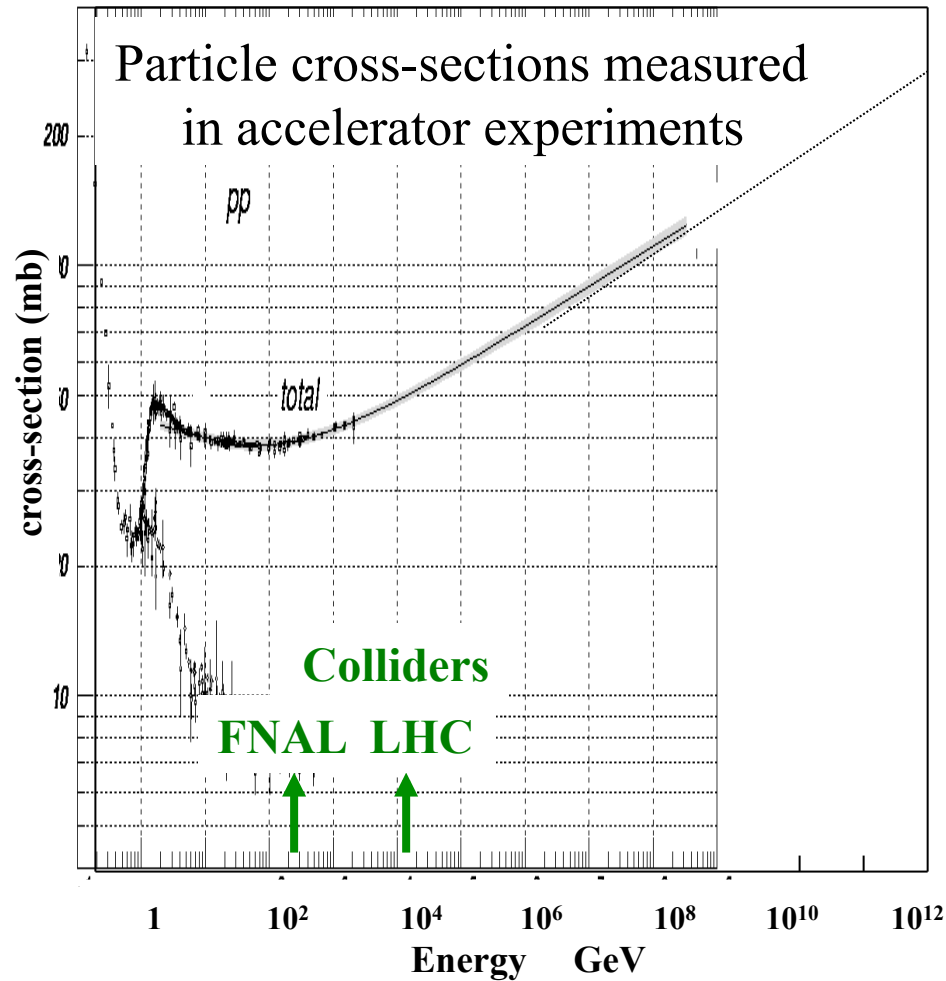
$$R \sim 10^{15} \text{ km}, B \sim 10^{-10} \text{ T} \quad \Rightarrow \quad E \sim 1000 \text{ TeV}$$

(NB. $E \propto Z \rightarrow$ Pb/Fe higher energy)

Ultra High Energy from Cosmic Rays

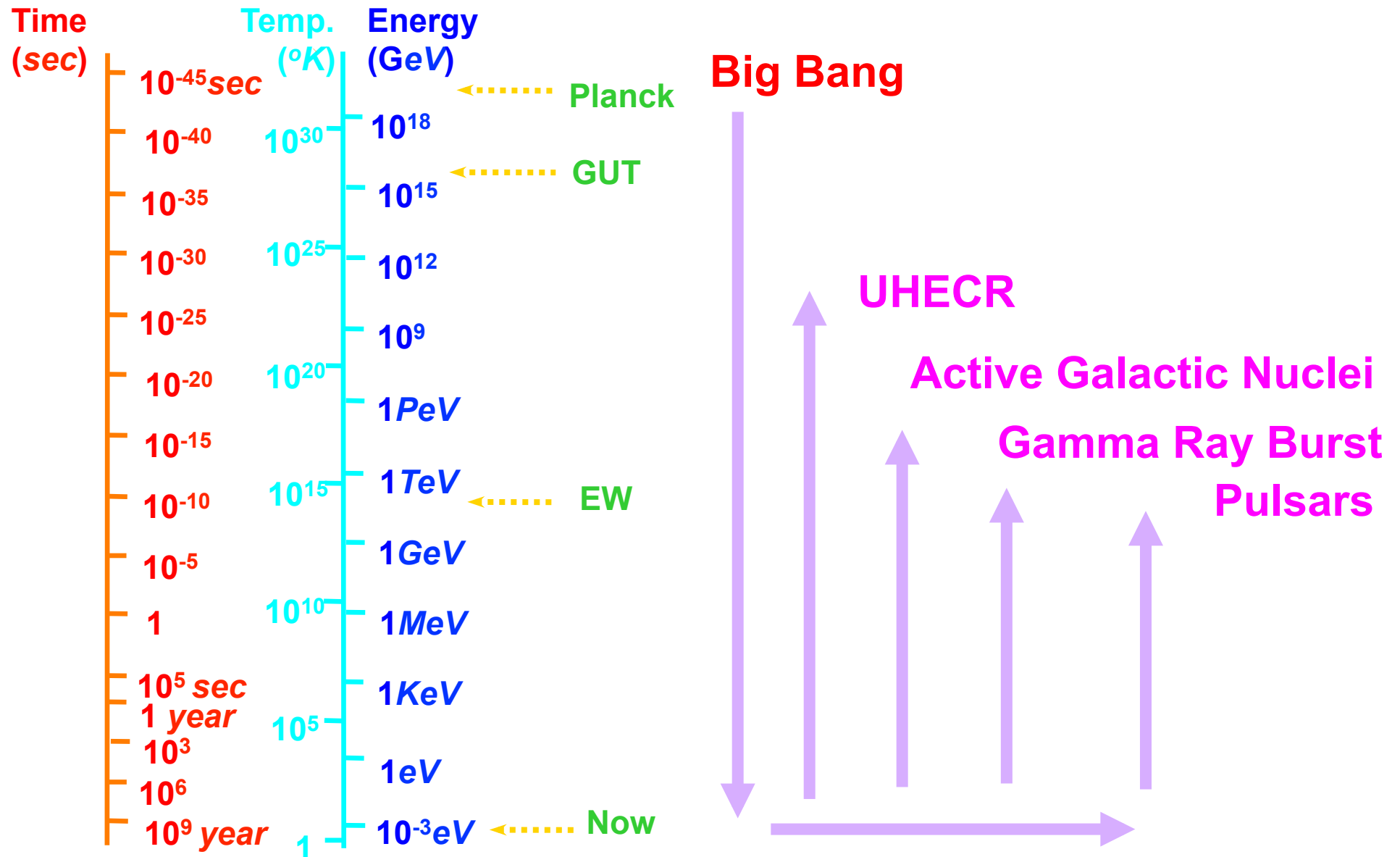
From laboratory accelerators

From cosmic accelerators



Ultra High Energy Particles arrive from space for free: make use of them

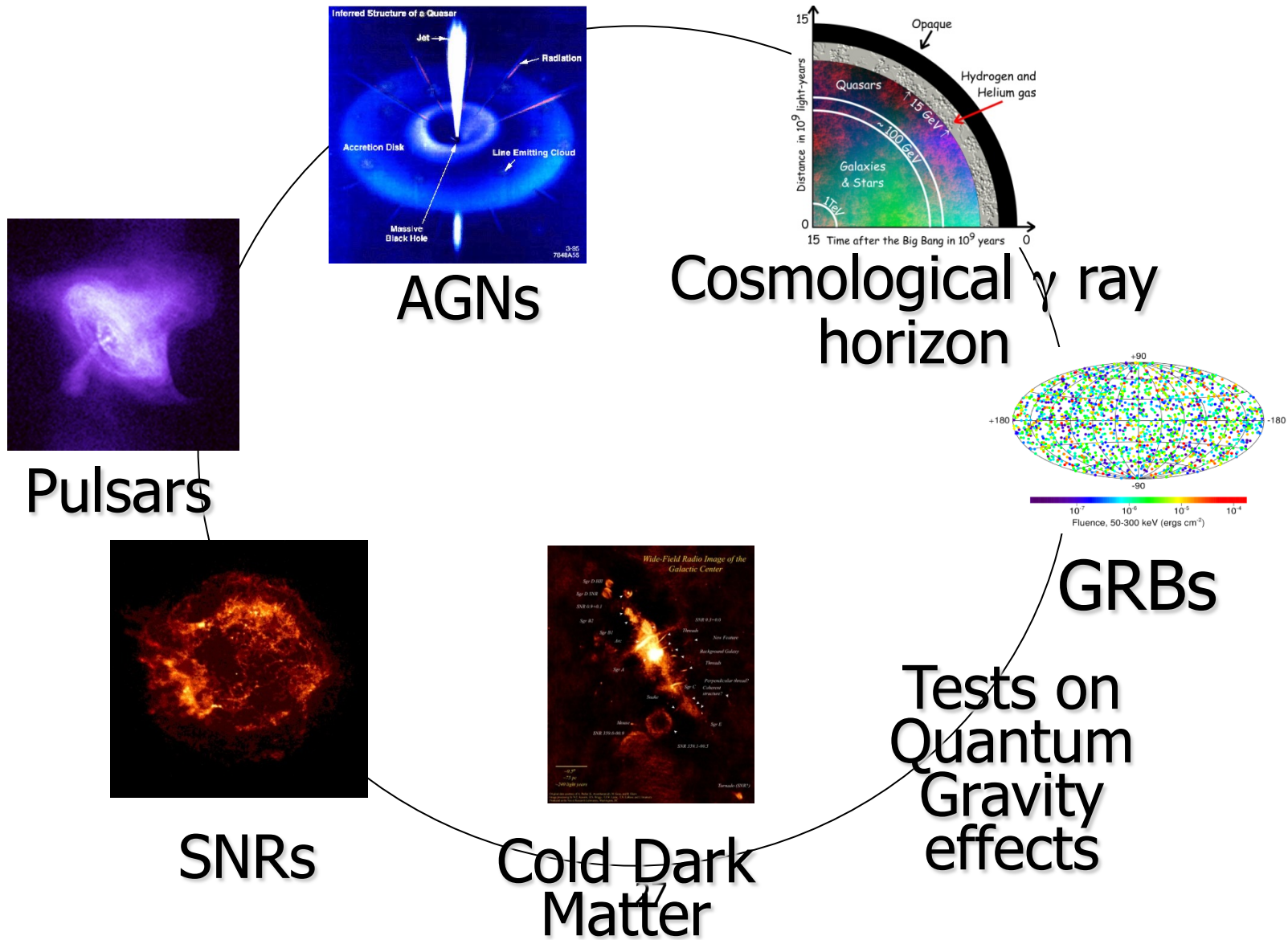
Extreme Universe Scales



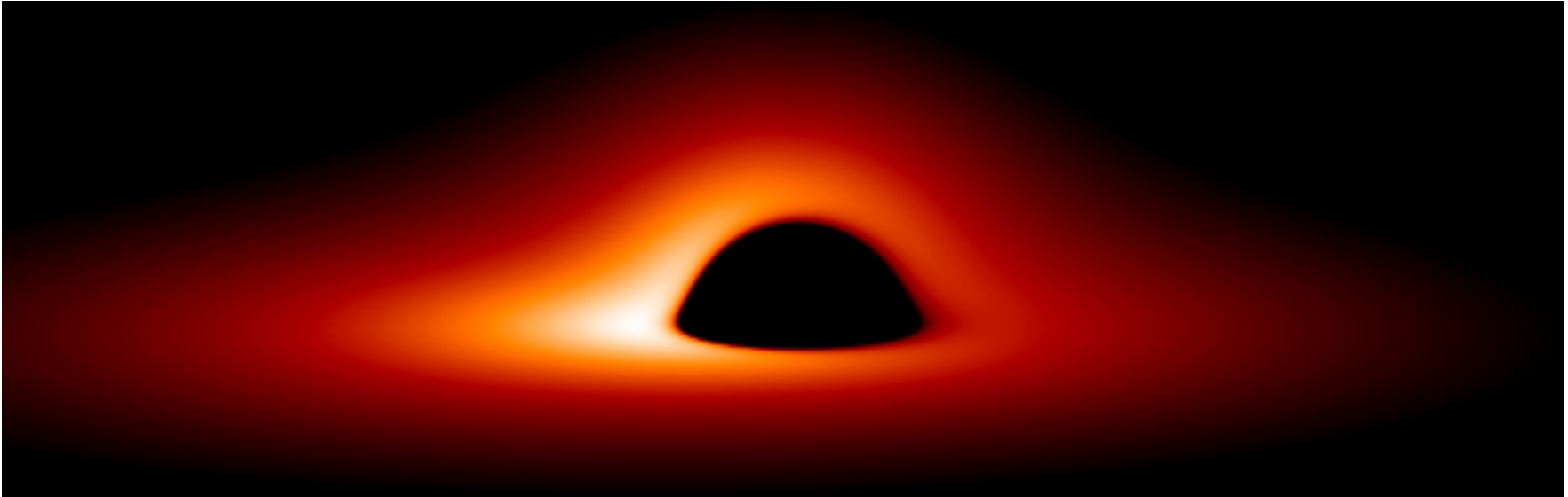
Astrofisica Nucleare e Subnucleare

Astrofisica Gamma – Overview

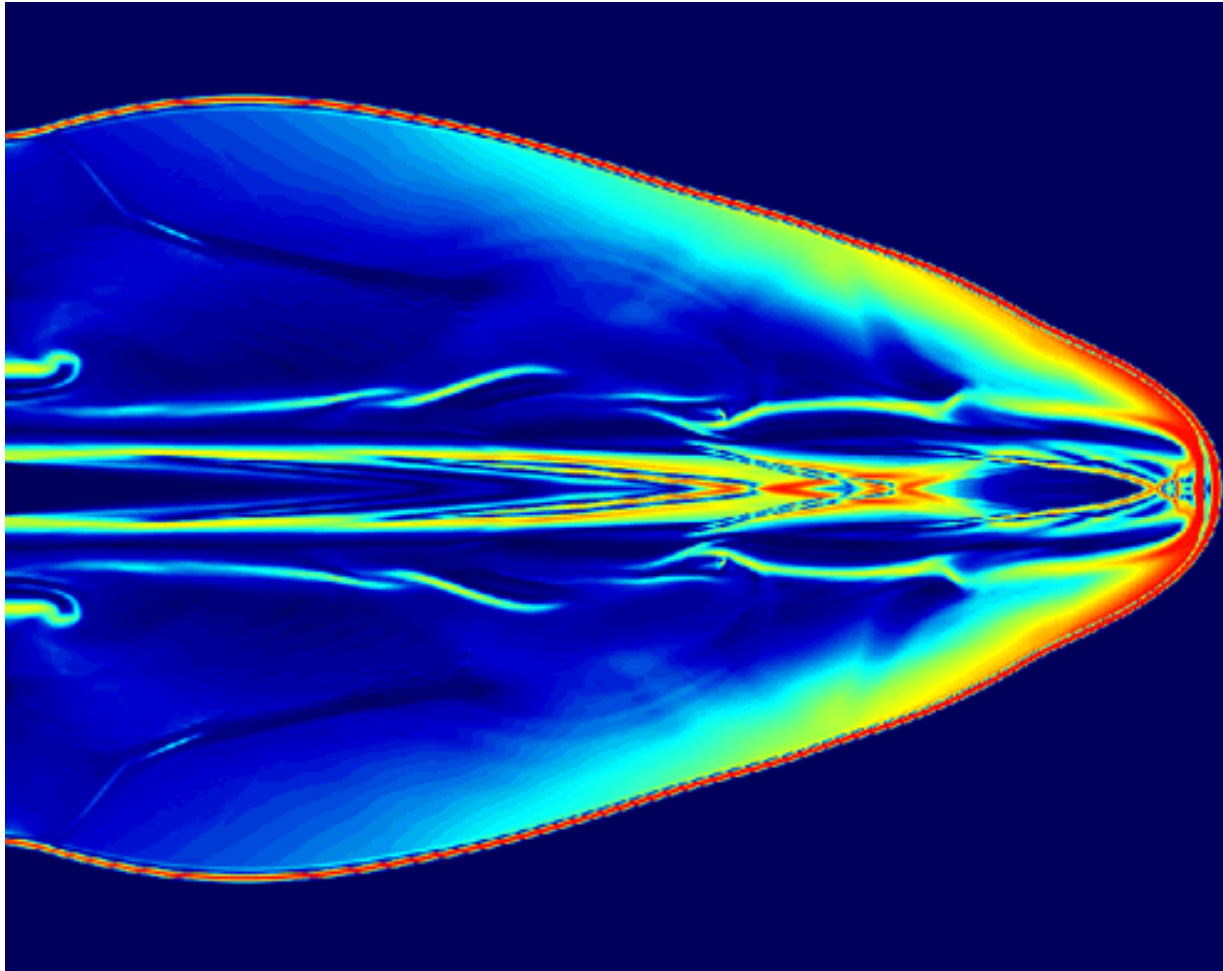
Science Objectives



Compact objects



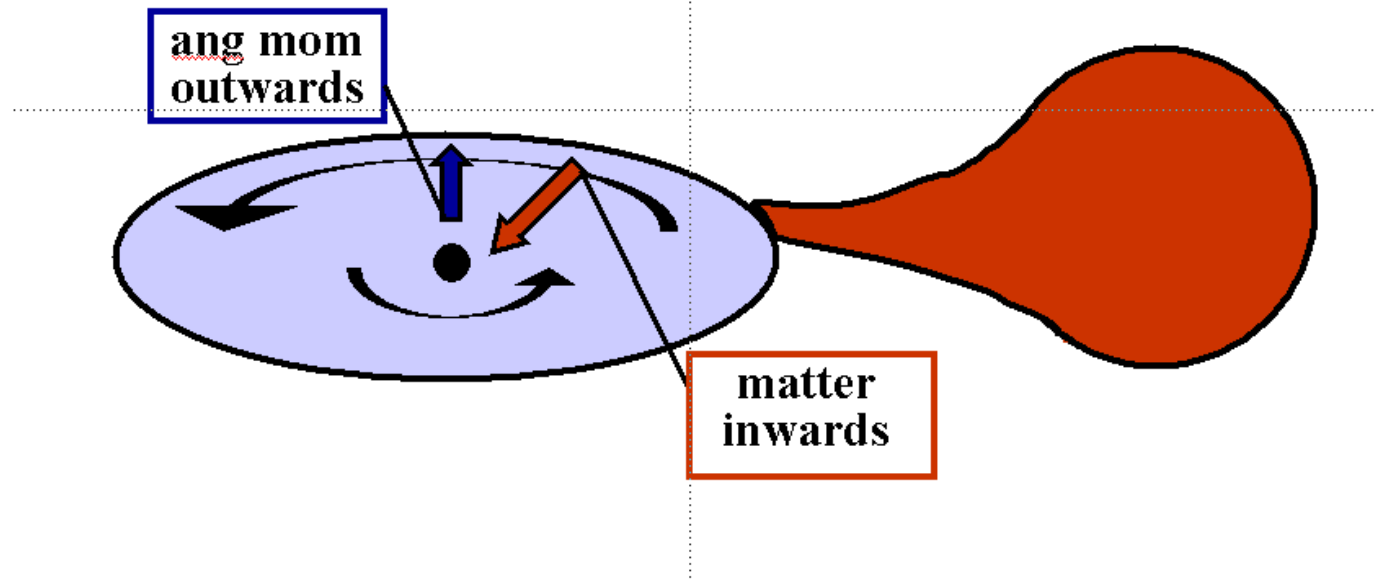
Jets



Accretion

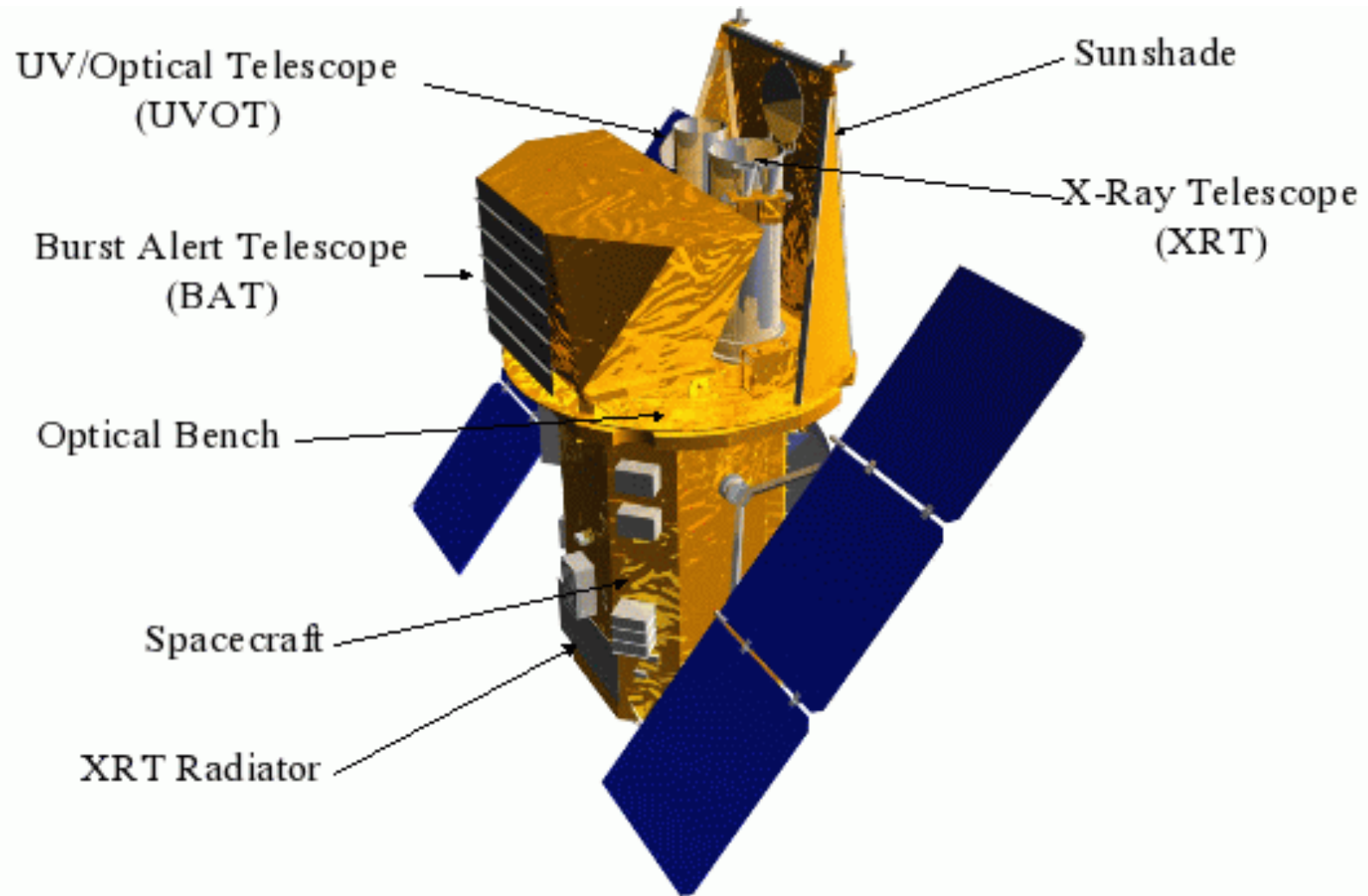
Accretion disk formation

Matter circulates around the compact object:

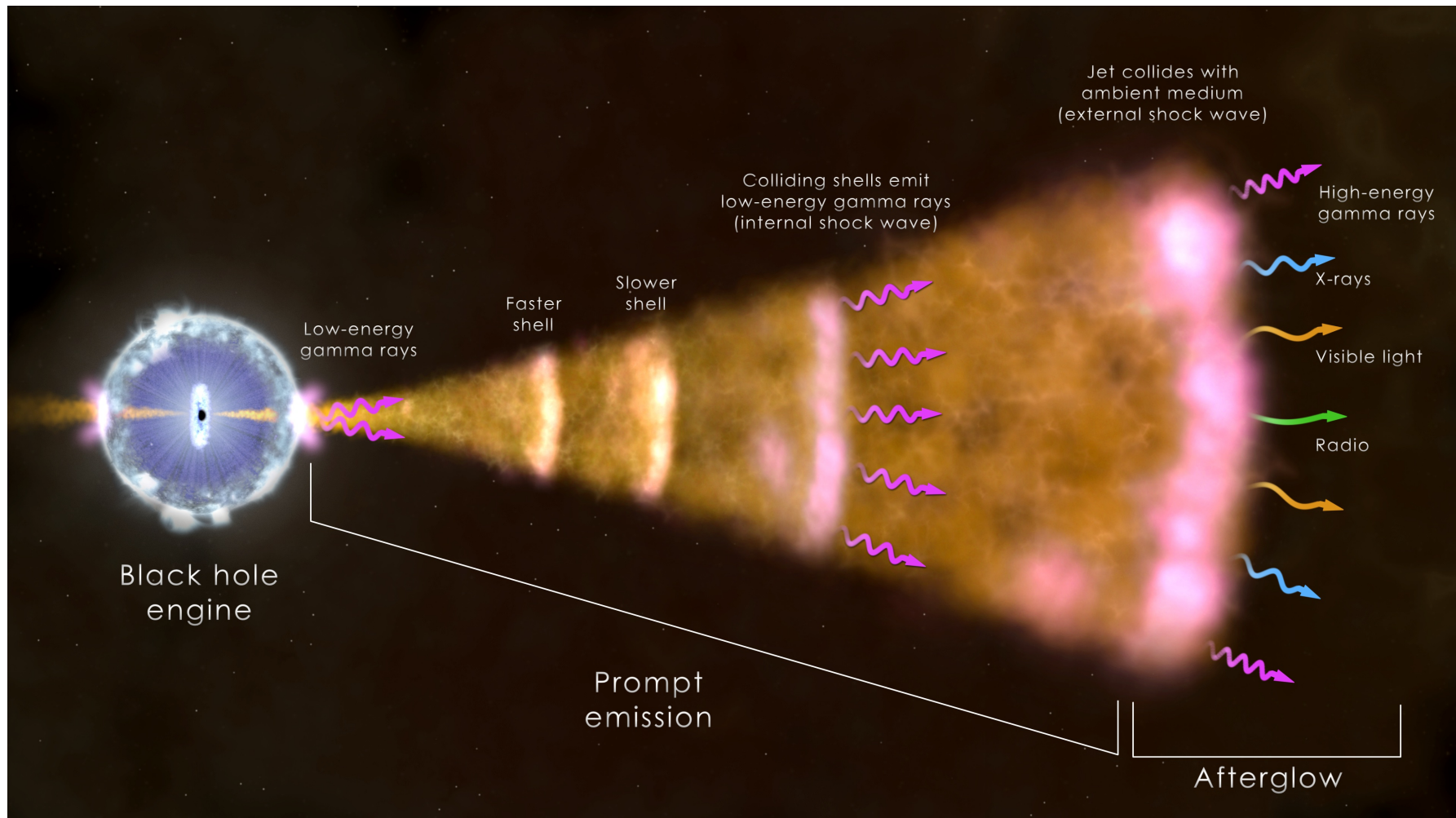


keV-MeV gamma-ray astrophysics

Swift



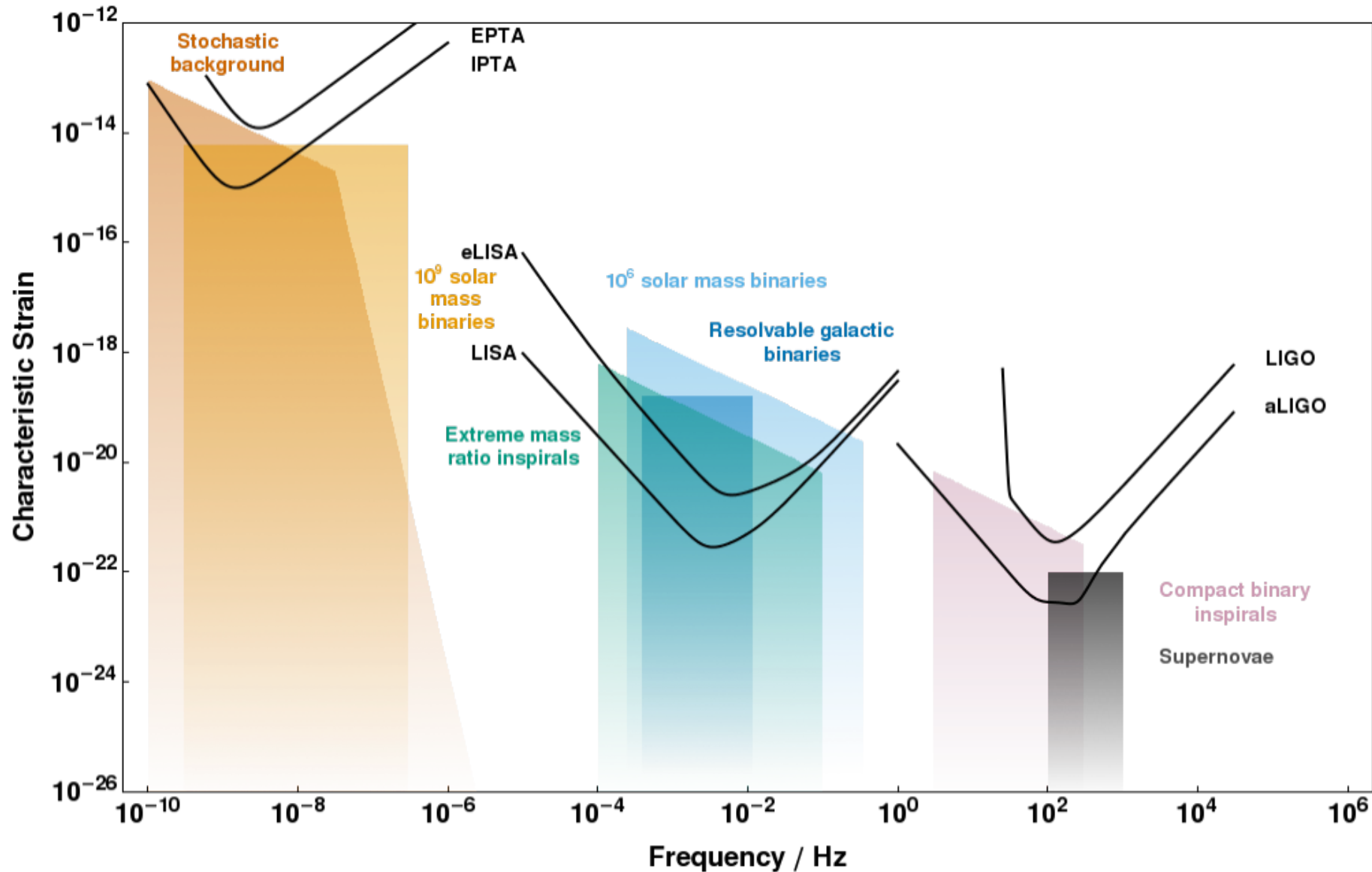
GRB



Gravitational Waves



Gravitational Waves

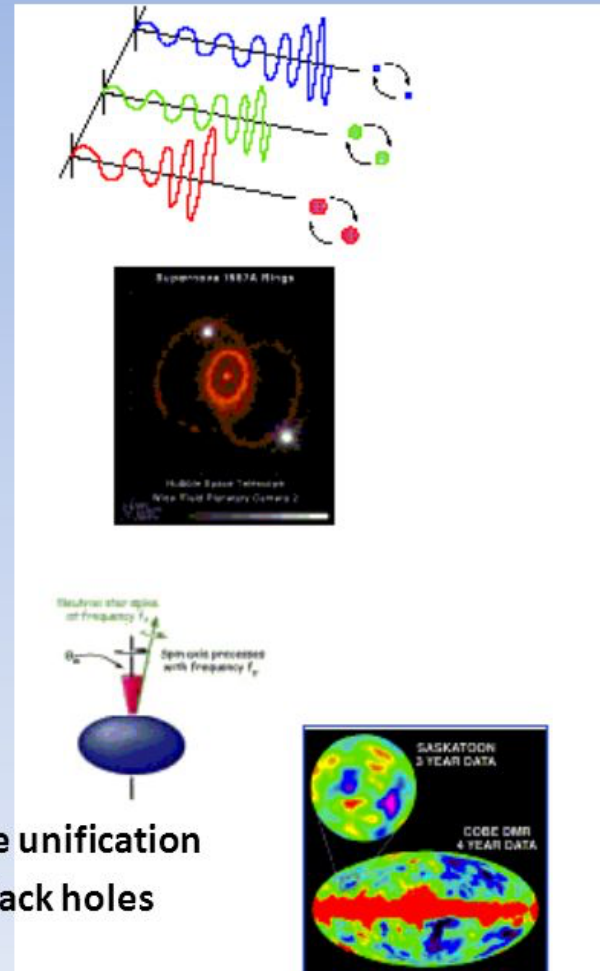


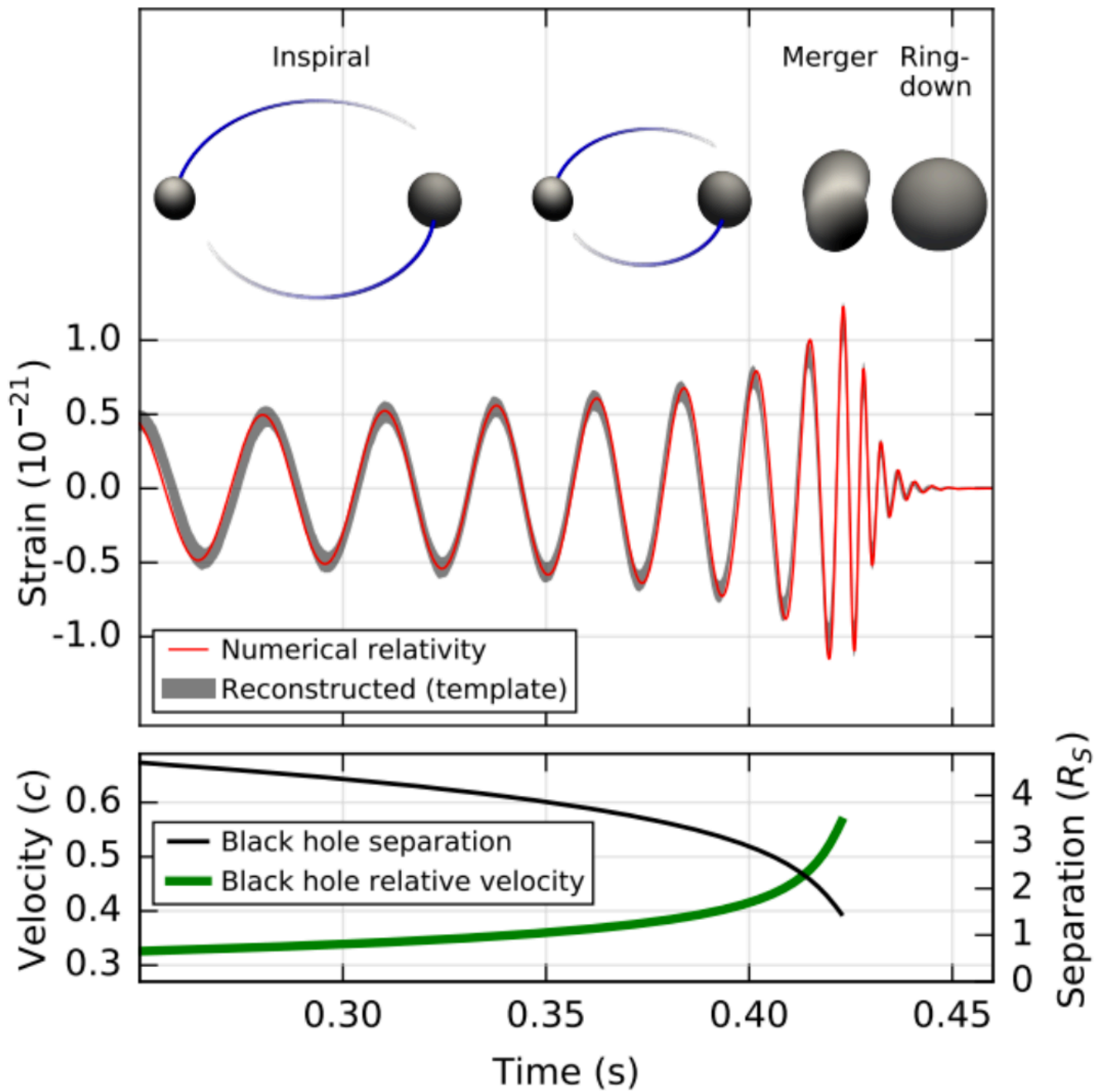
Gravitational Waves

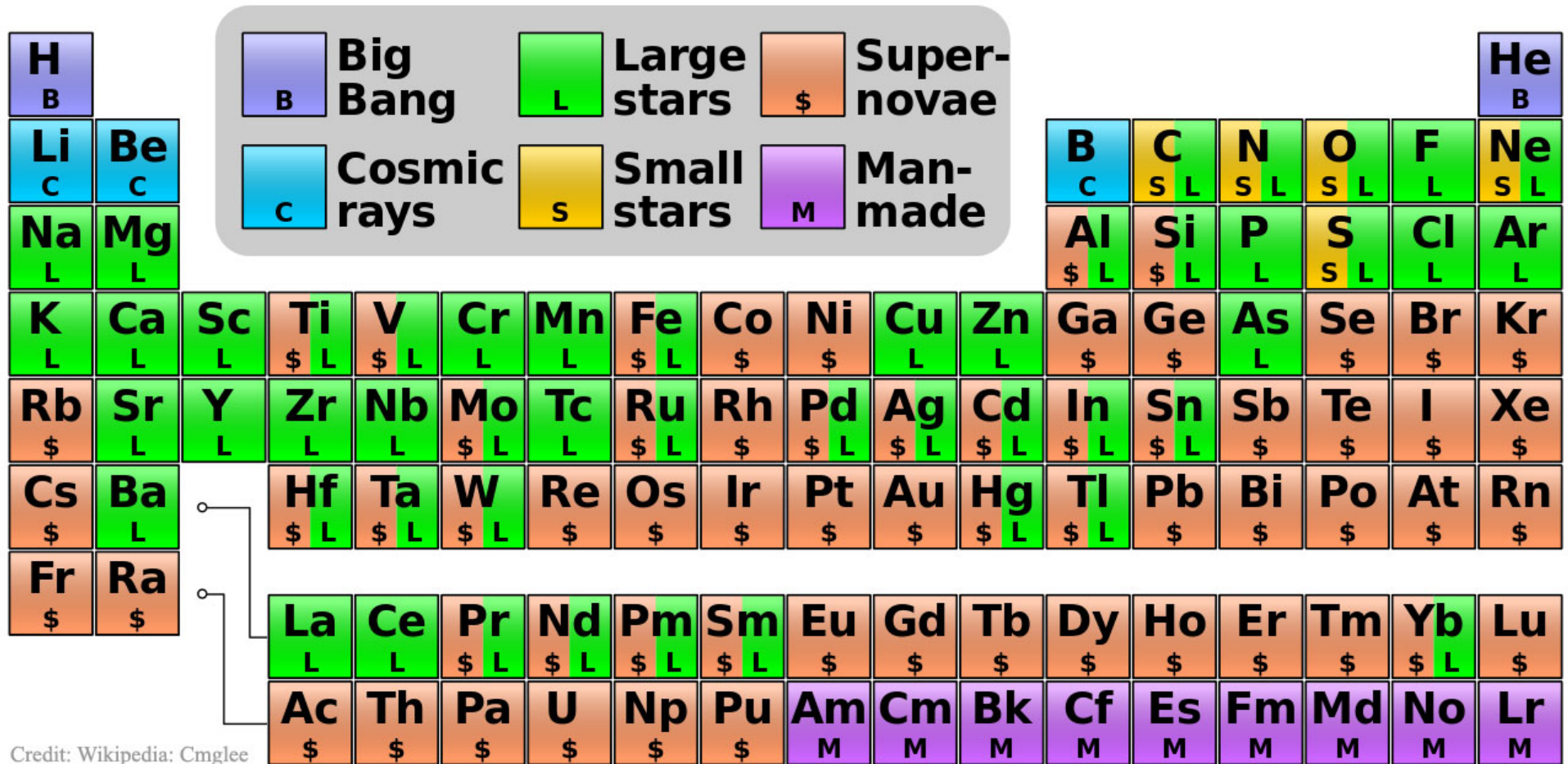
Astrophysical Sources for Terrestrial GW Detectors

- Compact binary inspiral: **“chirps”**
 - NS-NS, NS-BH, BH-BH
- Supernovas or GRBs: **“bursts”**
 - GW signals observed in coincidence with EM or neutrino detectors
- Pulsars in our galaxy: **“periodic waves”**
 - Rapidly rotating neutron stars
 - Modes of NS vibration
- Cosmological: **“stochastic background”** ?
 - Probe back to the Planck time (10^{-43} s)
 - Probe phase transitions: window to force unification
 - Cosmological distribution of Primordial black holes

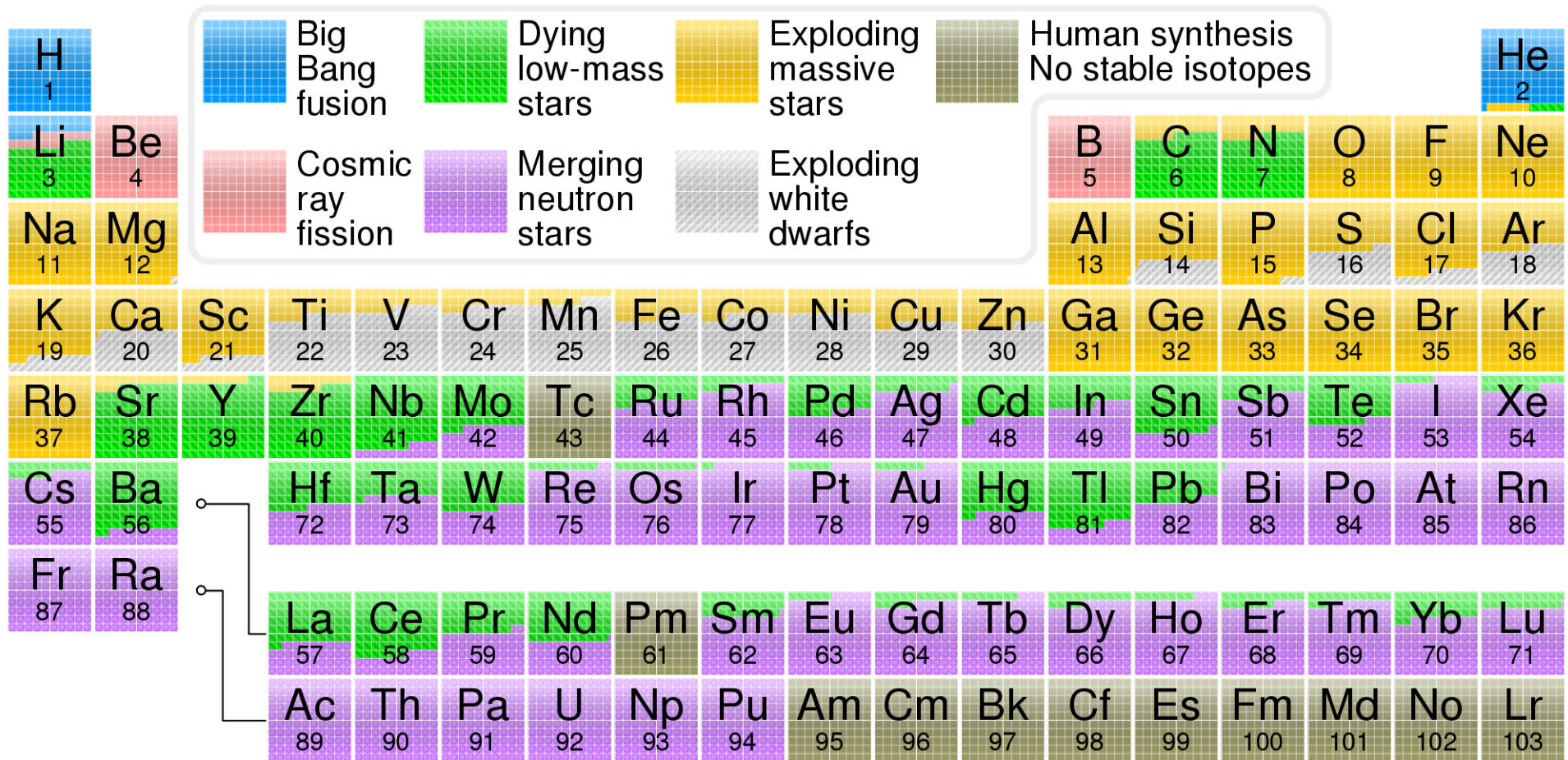
Courtesy: Stan Whitcomb





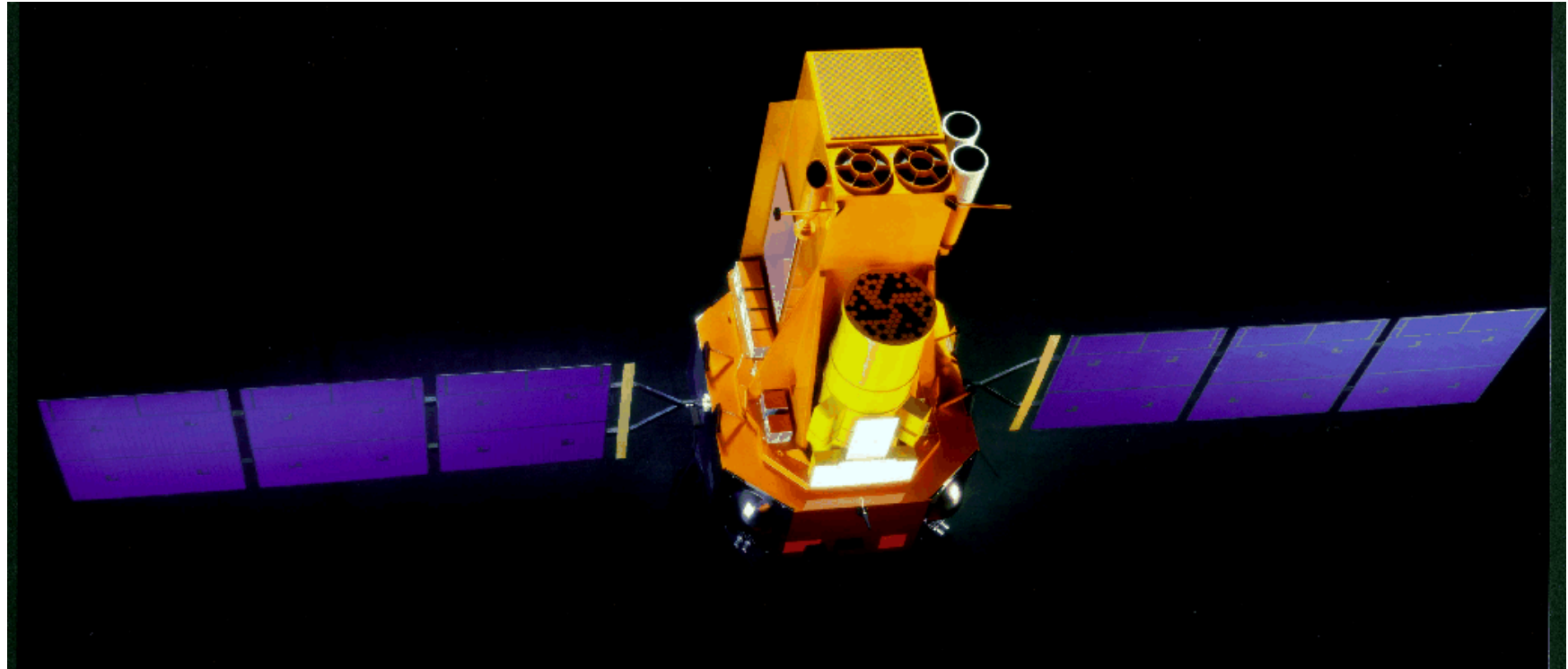


Credit: Wikipedia: Cmglee

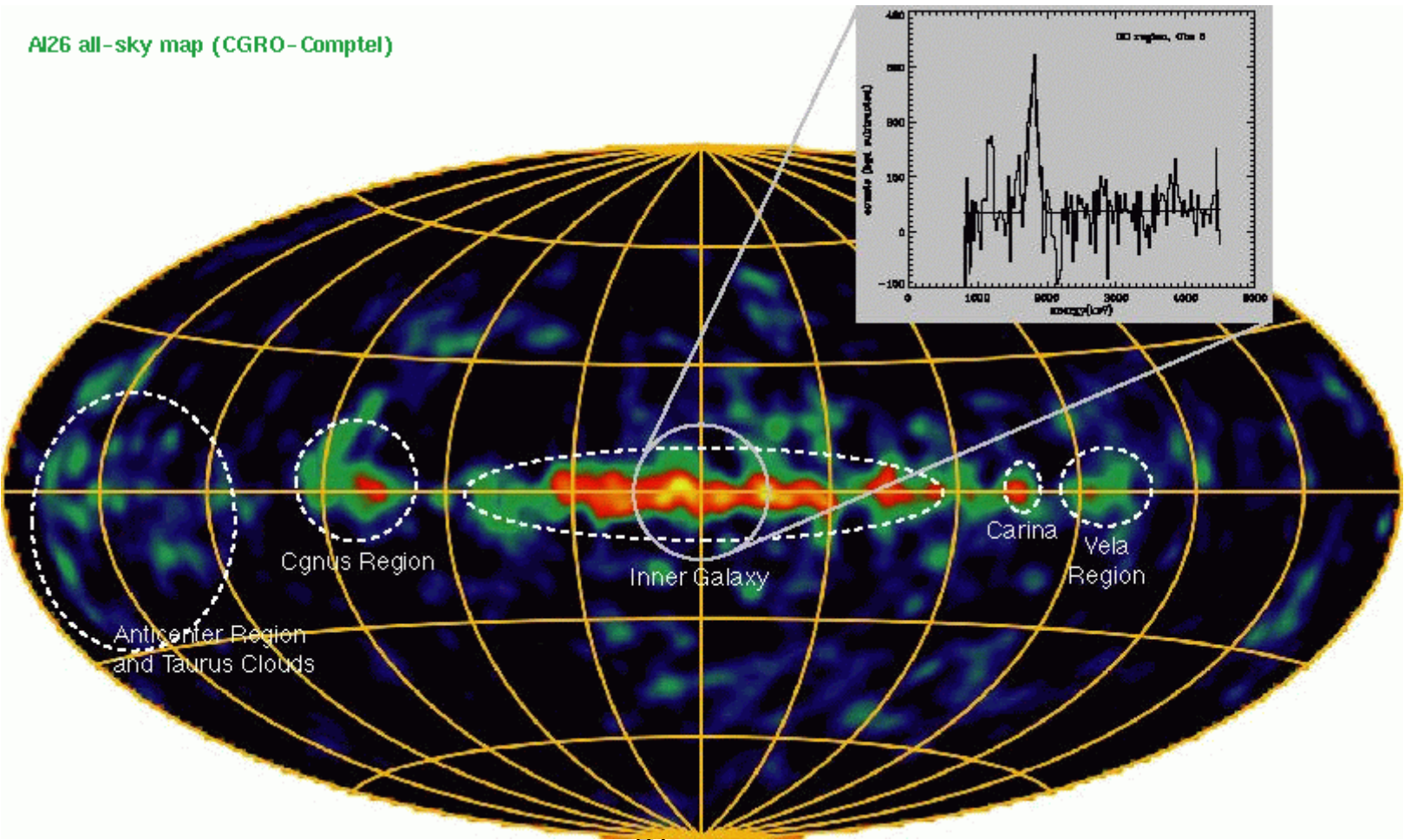


Dopo GW 170817

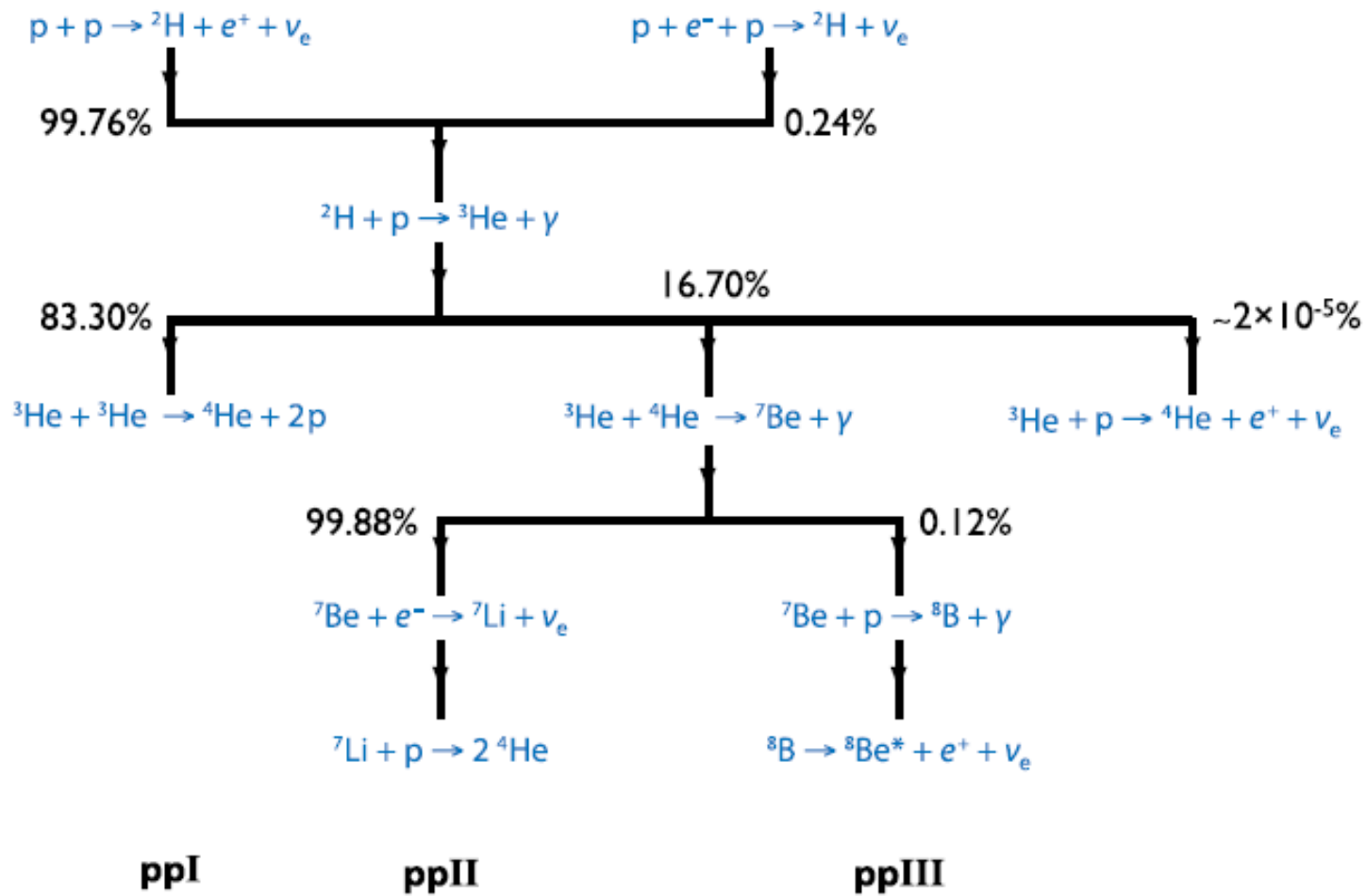
INTEGRAL



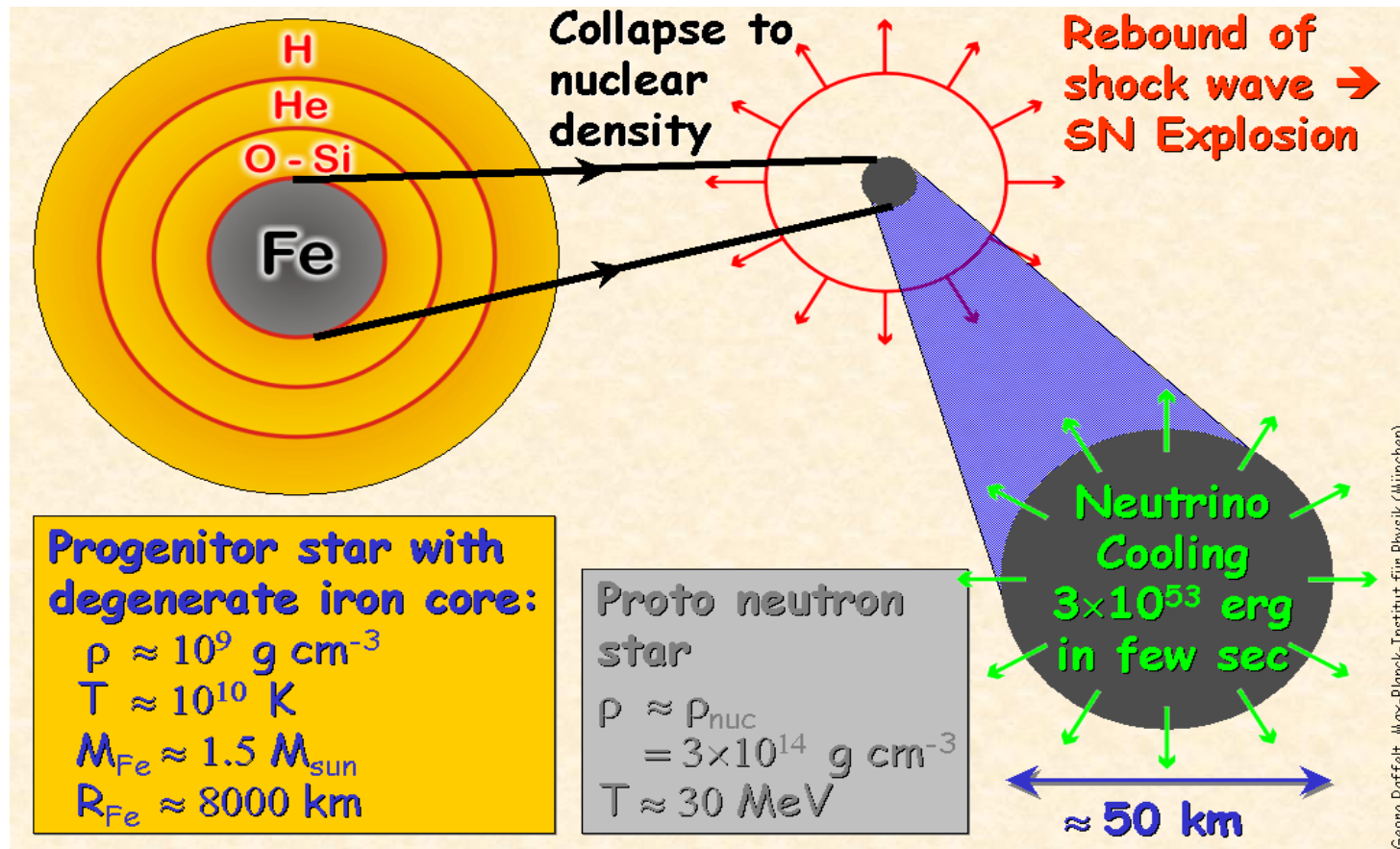
INTEGRAL



Solar Thermonuclear Cycles



Stellar collapse and neutrinos



GeV gamma-ray astrophysics

AGILE



agile

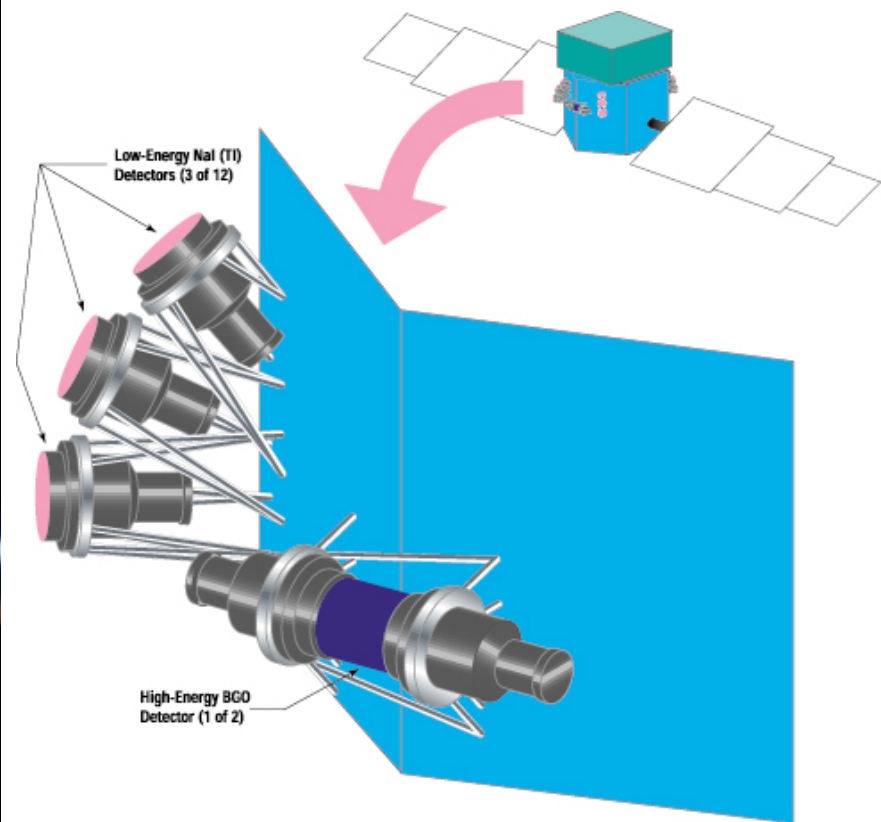
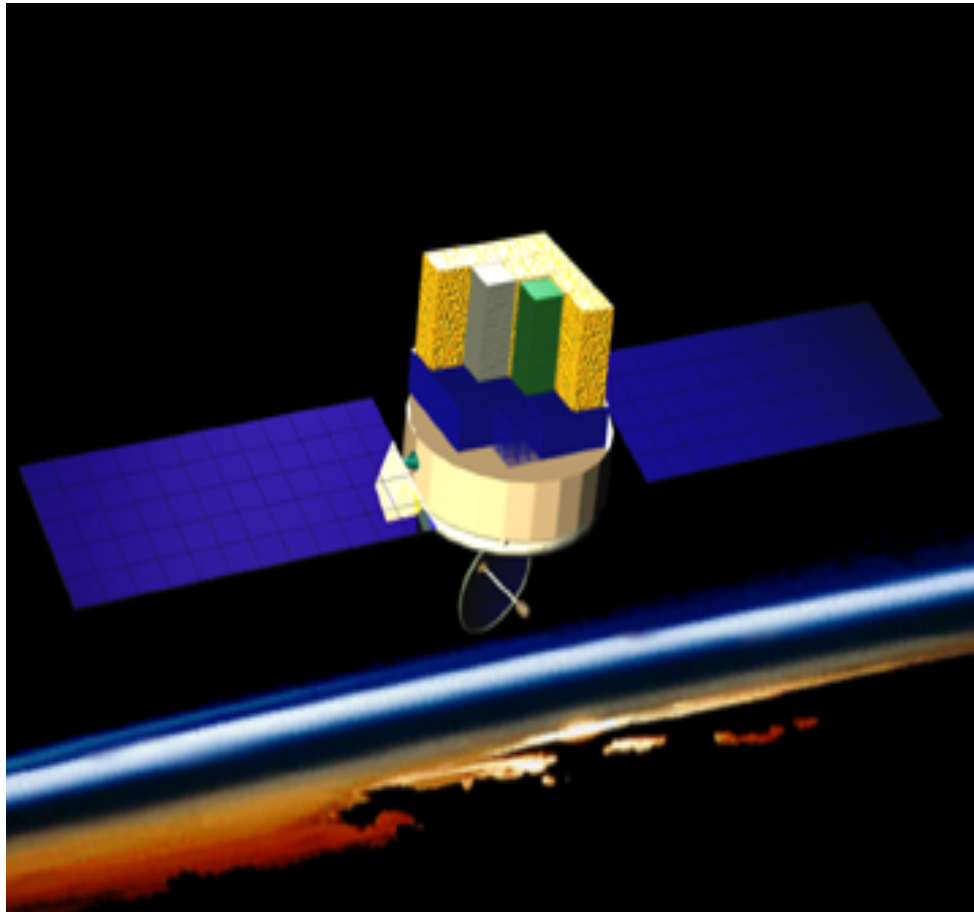
Astro-rivelatore Gamma a Immagini LEggero

Home
AGILE Team
AGILE System Team
AGILE in ASI
AGILE Industrial Partners
AGILE Progress Status
Science with AGILE
AGILE Sensitivity
AGILE Selected Publications
AGILE latest review paper
Highlights
Education & Public Outreach
Public Information
AGILE Site

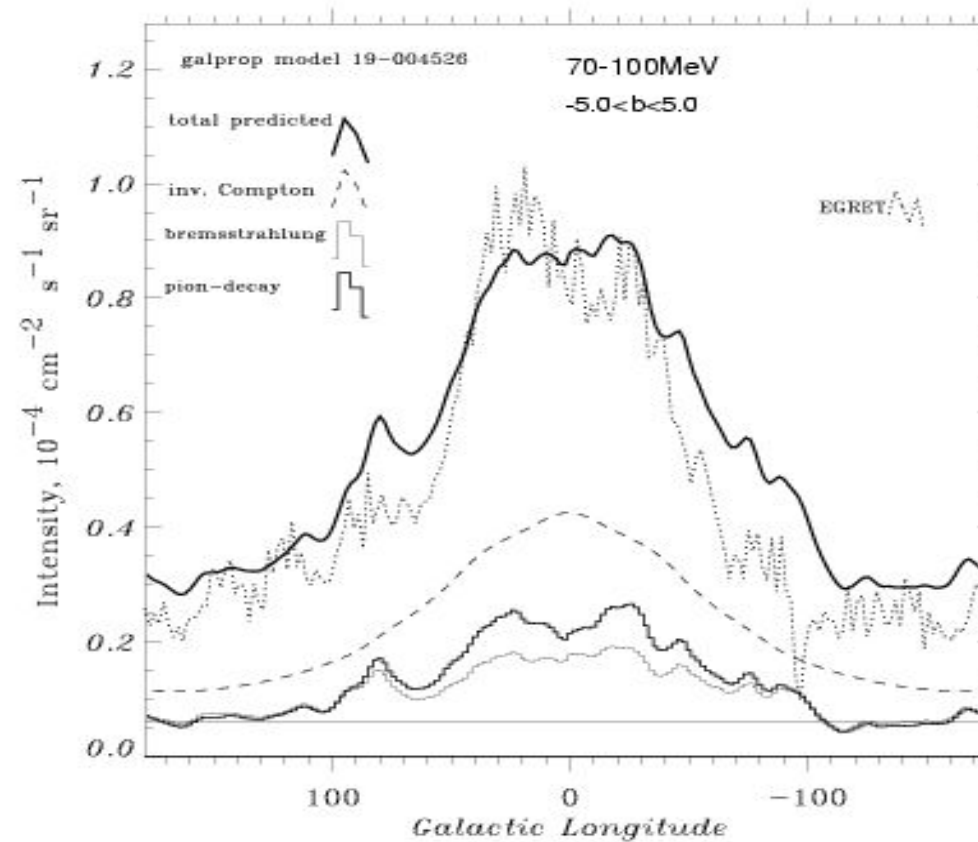


Logo:         

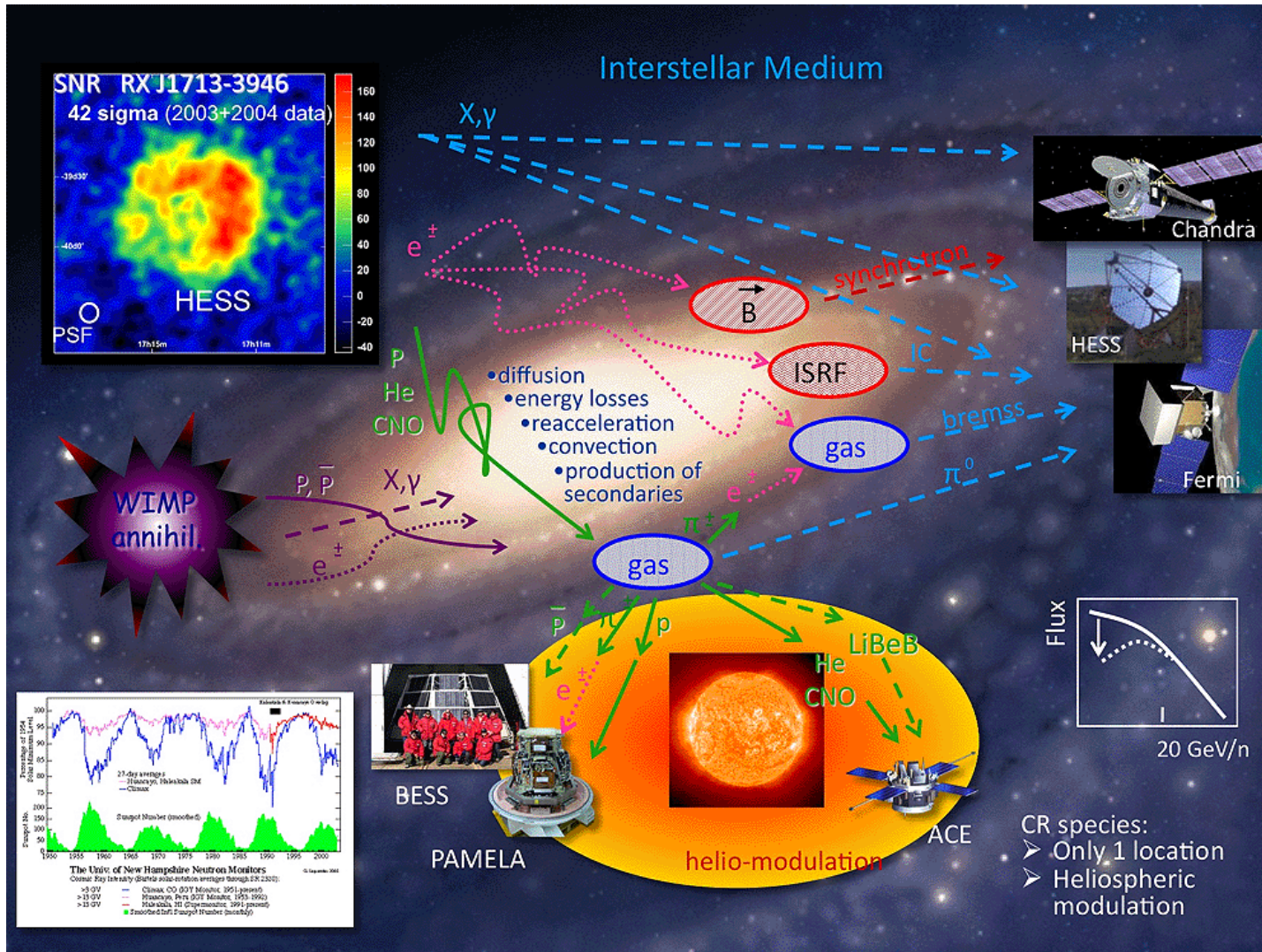
Fermi/GLAST



The galactic plane

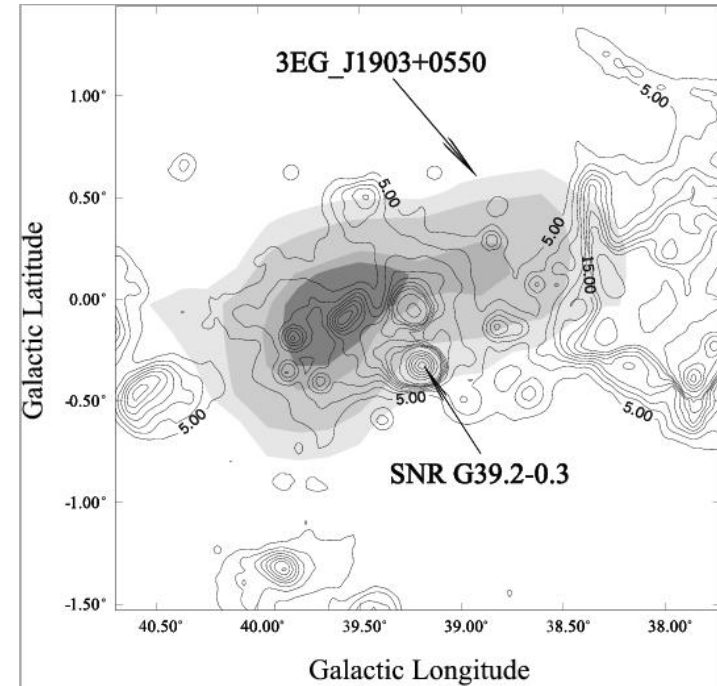
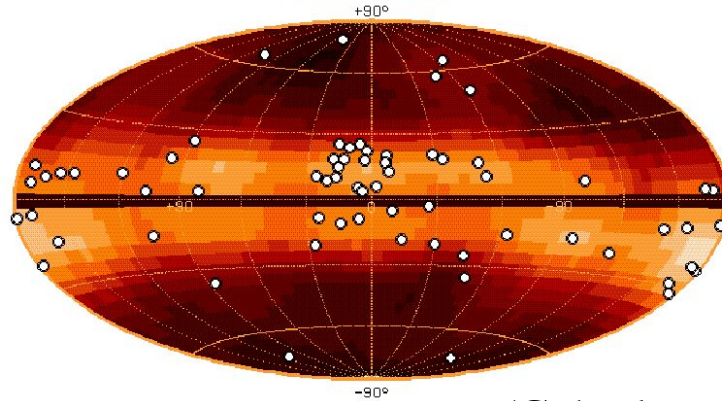
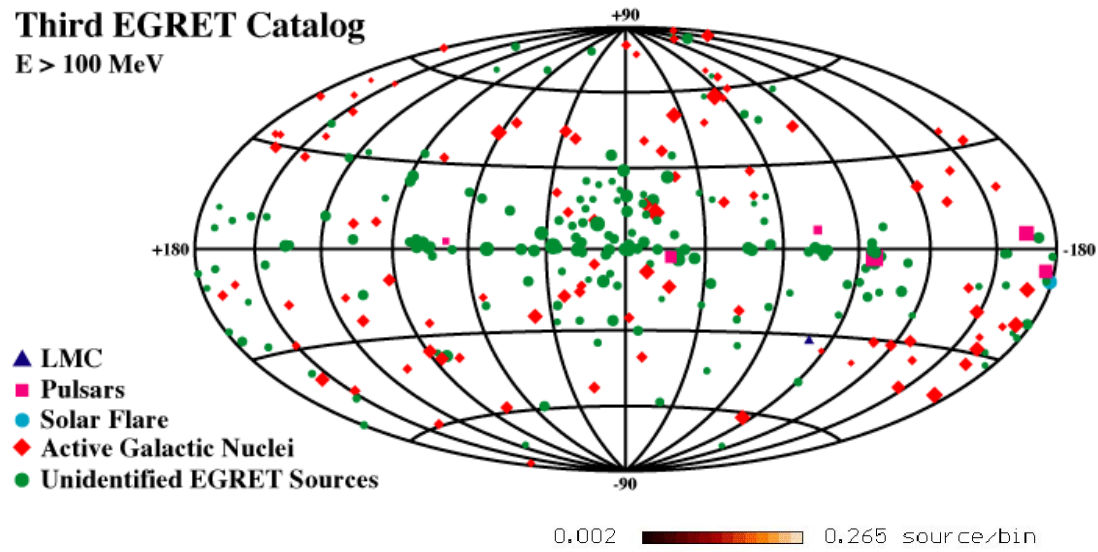


Cosmic Rays Propagation



Unidentified Gamma-Ray Sources

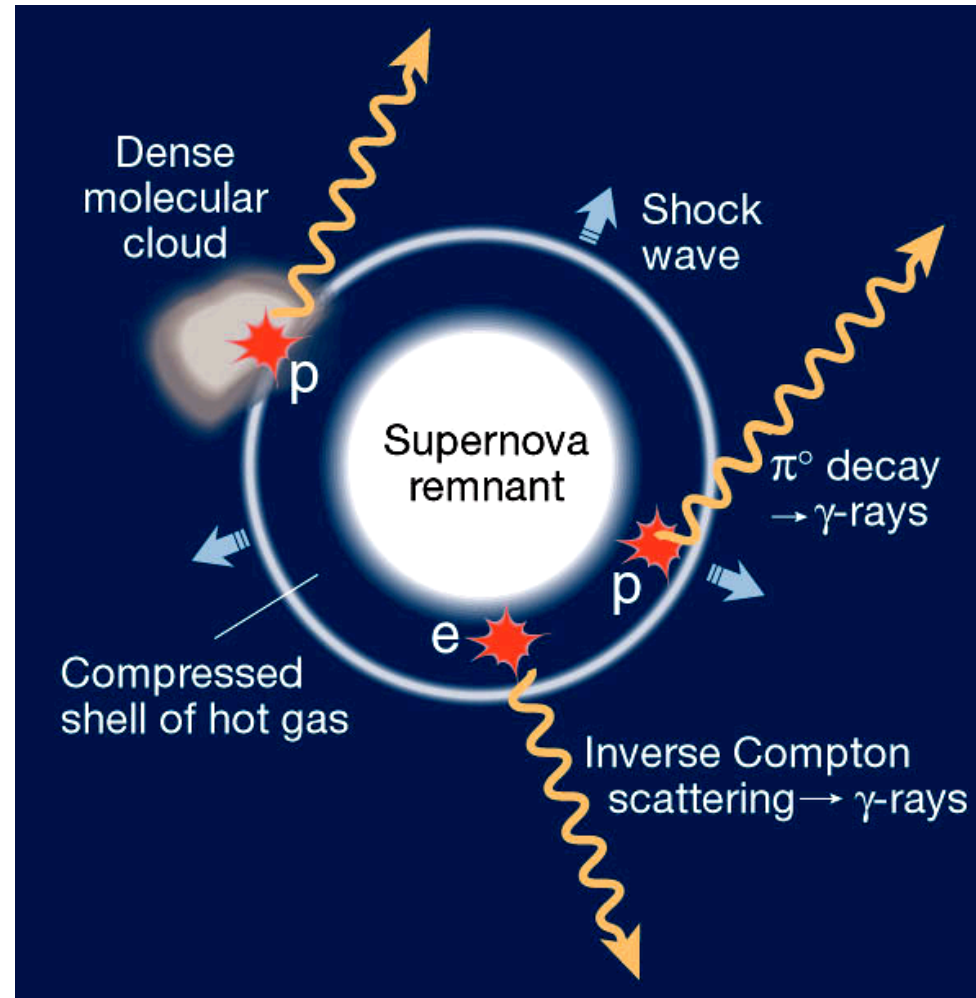
Third EGRET Catalog
E > 100 MeV



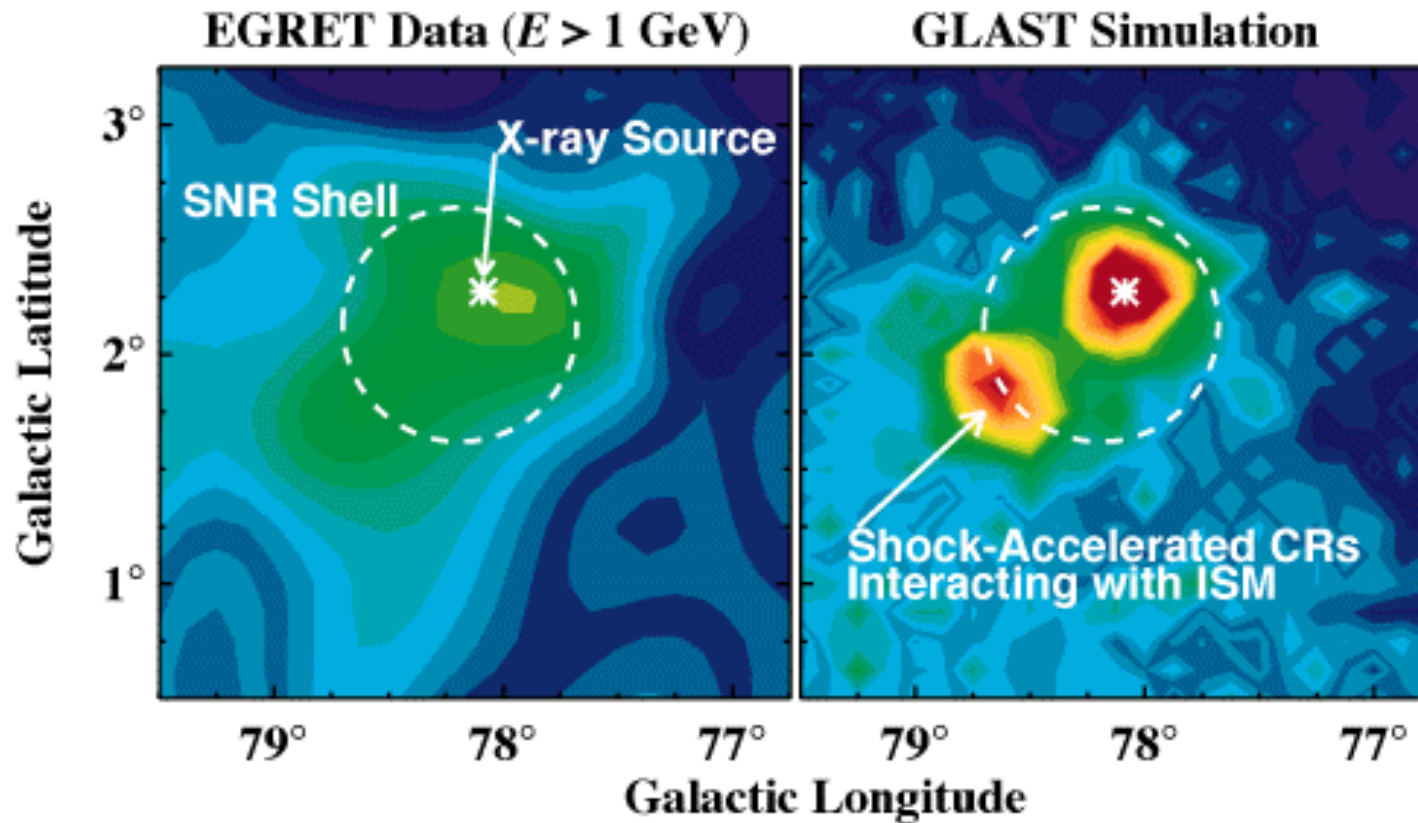
(Butt et al. 2002)

(Gehrels et al. 2000)

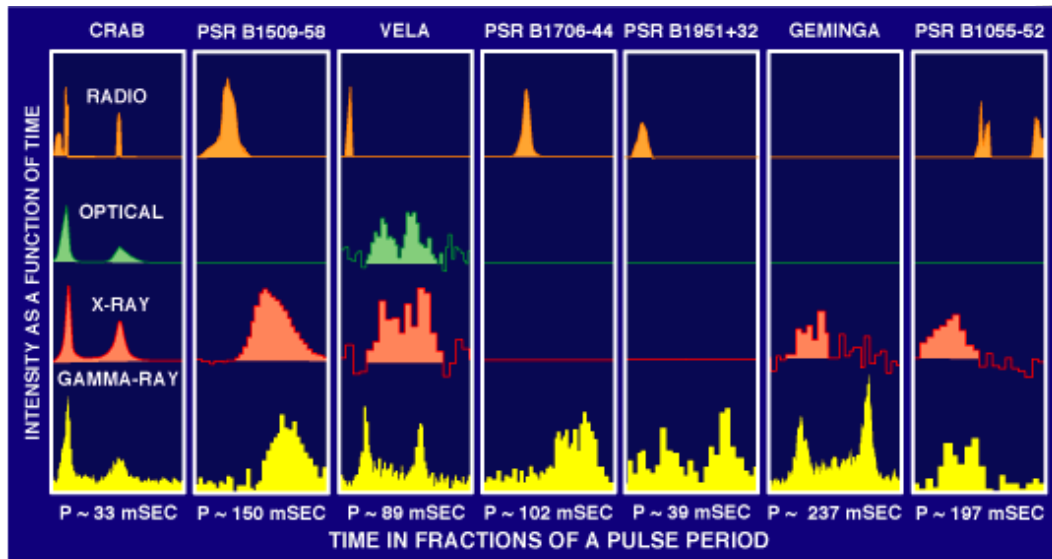
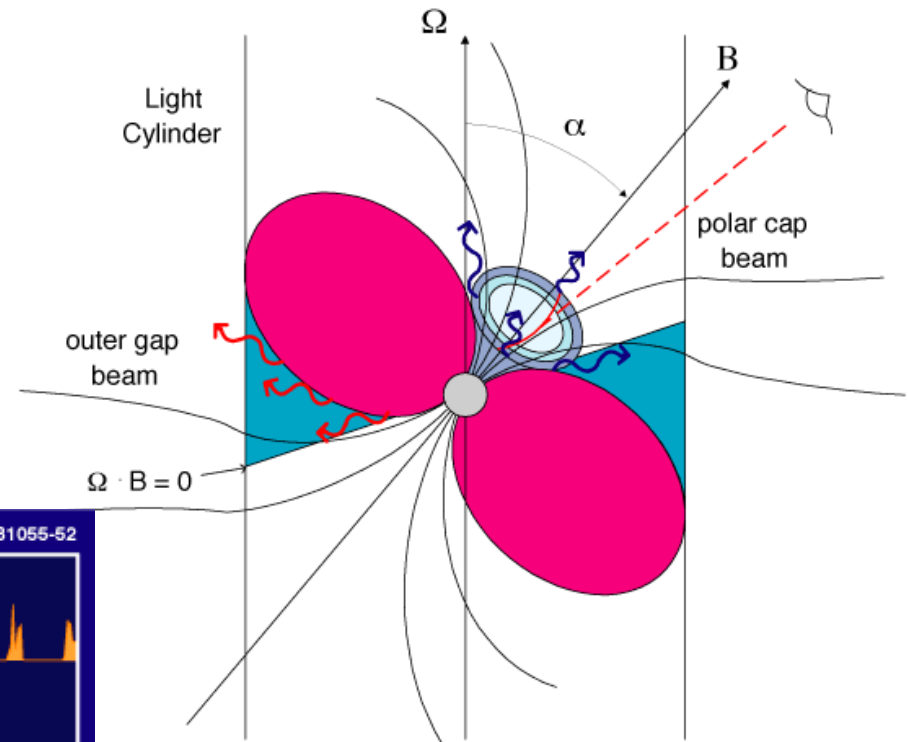
Supernova Remnants



CR acceleration and interactions



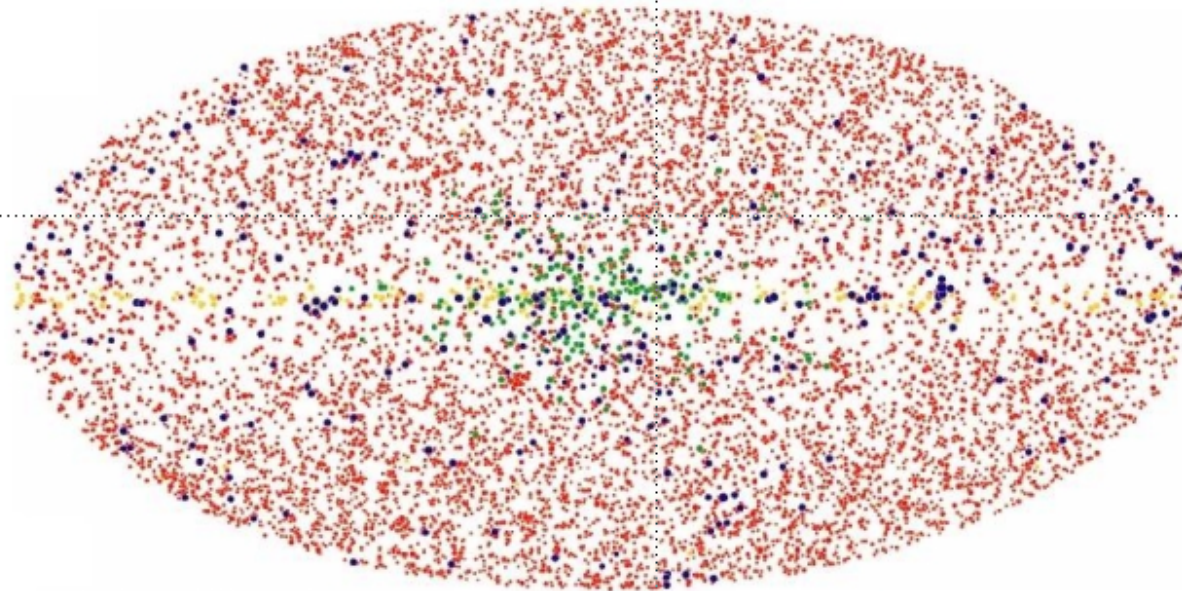
Pulsars



Active Galactic Nuclei

**5 σ Sources from Simulated
One Year All-sky Survey**

LAT 1st Catalog:
>9000 sources
possible

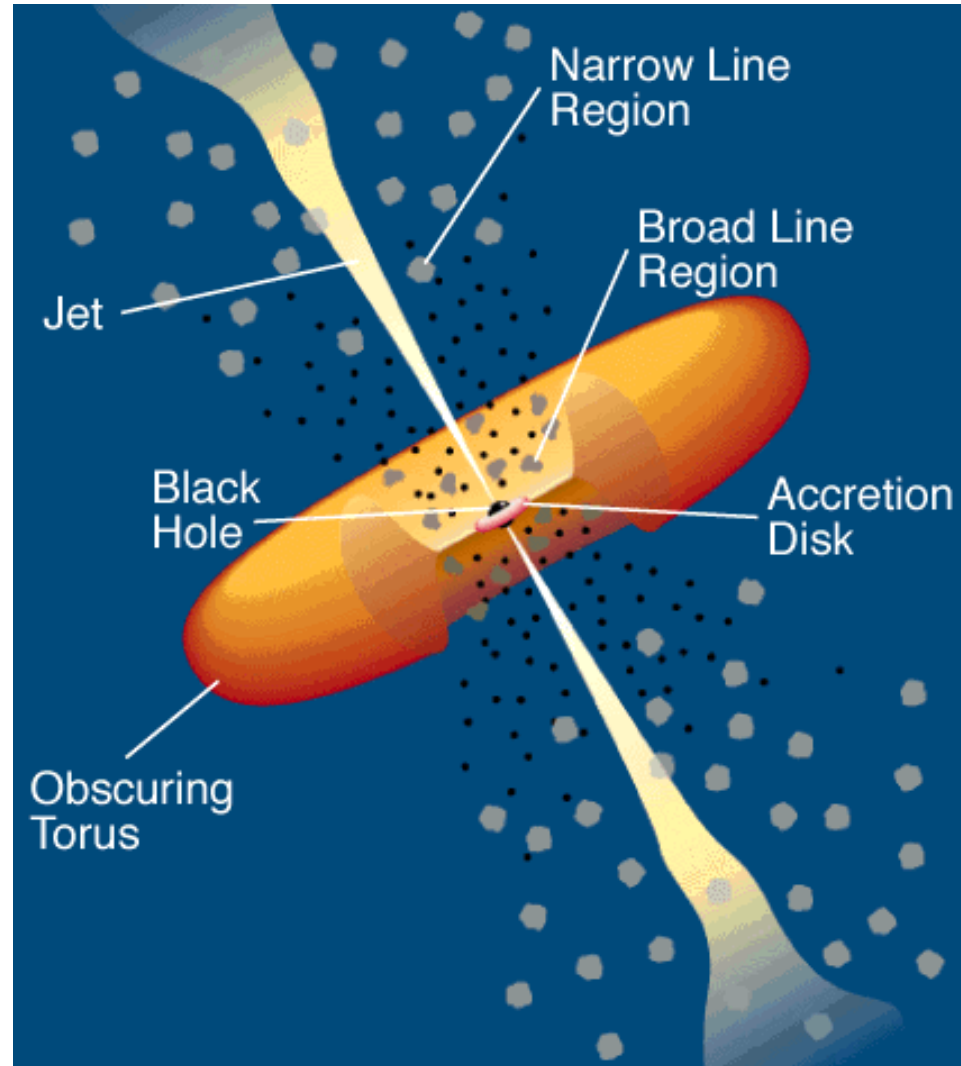


Results of one-year
all-sky survey.
(Total: 9900 sources)

● AGN
● 3EG Catalog

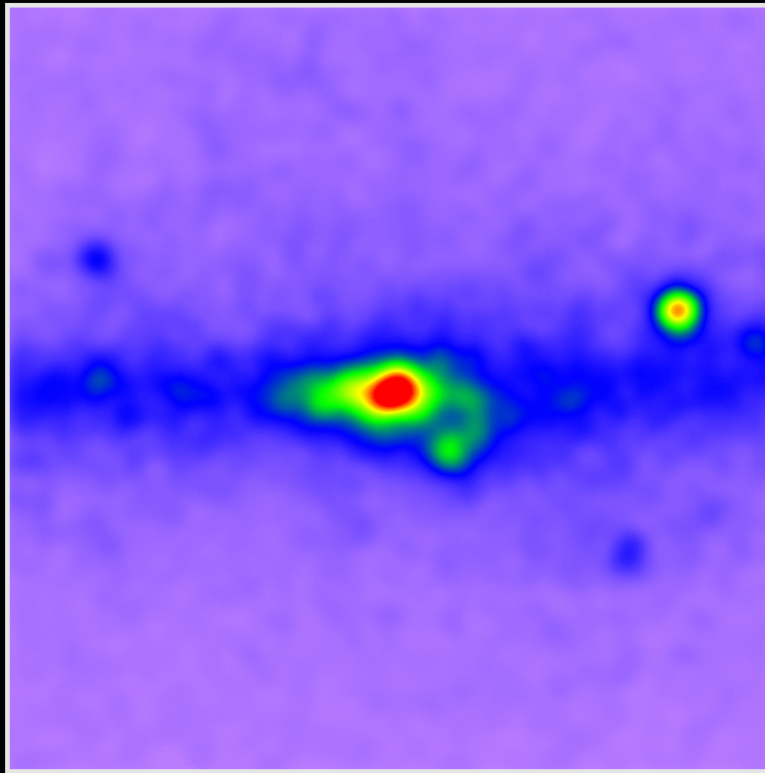
● Galactic Halo
● Galactic Plane

Active Galactic Nuclei

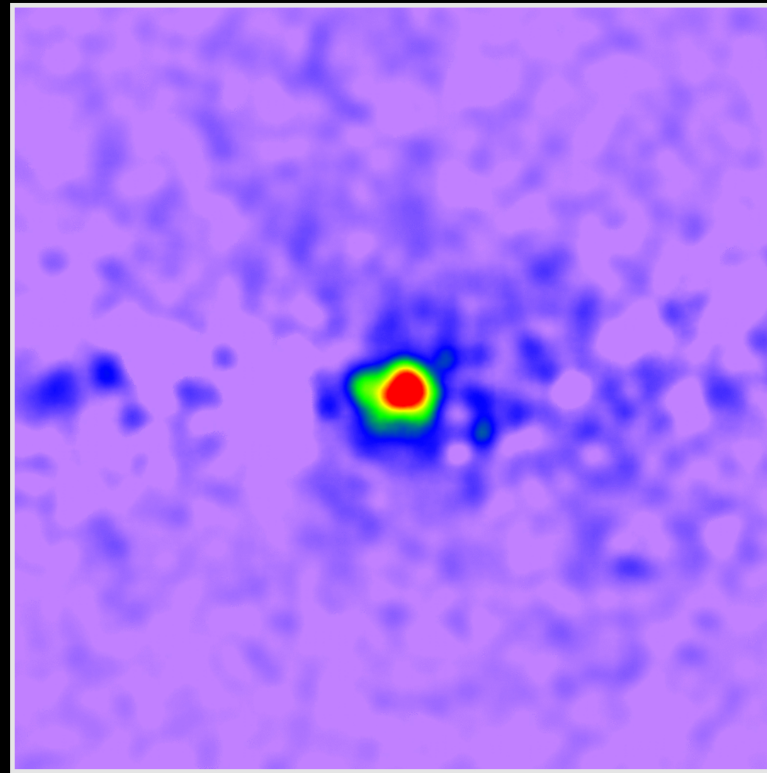


Dark Matter

Uncovering a gamma-ray excess at the galactic center

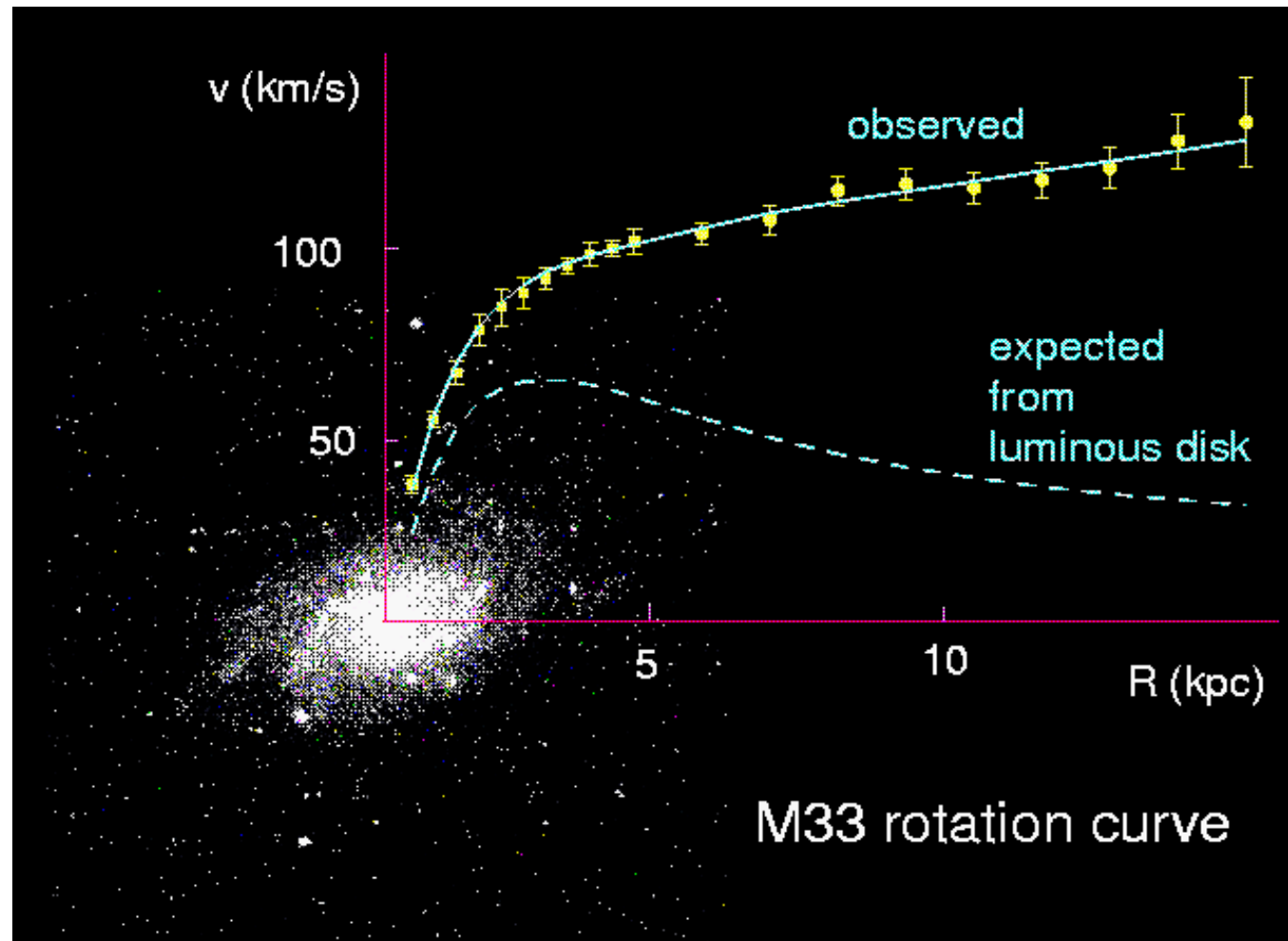
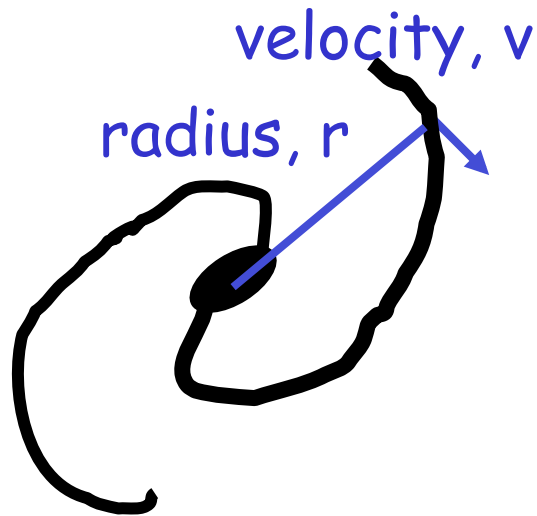


Unprocessed map of 1.0 to 3.16 GeV gamma rays



Known sources removed

Rotazione delle Galassie



Luminous stars only small fraction of mass of galaxy

Dark Matter

Evidence :

- Need to hold together Galaxy Clusters
- Explain Galaxy Rotation velocities

Astronomy object candidates :

Brown Dwarfs (stars mass $< 0.1 M_{\text{sun}}$ no fusion)

- some but not enough

White Dwarfs (final states of small stars)

- some but not enough

Neutron Stars/Black Holes (final states of big stars.)

- expected to be rarer than white dwarfs

Gas clouds

- $\sim 75\%$ visible matter in the universe, but observable

Particle Physics candidates:

Neutrinos

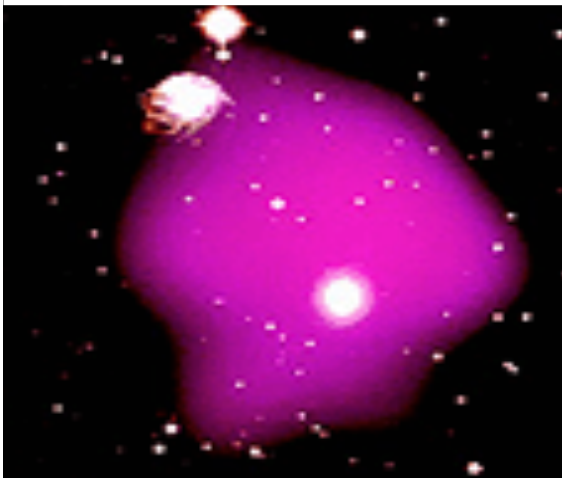
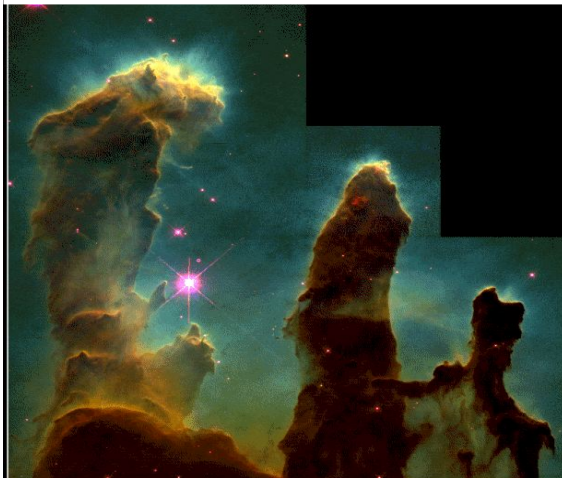
- Evidence for mass from oscillation, not enough

Axions

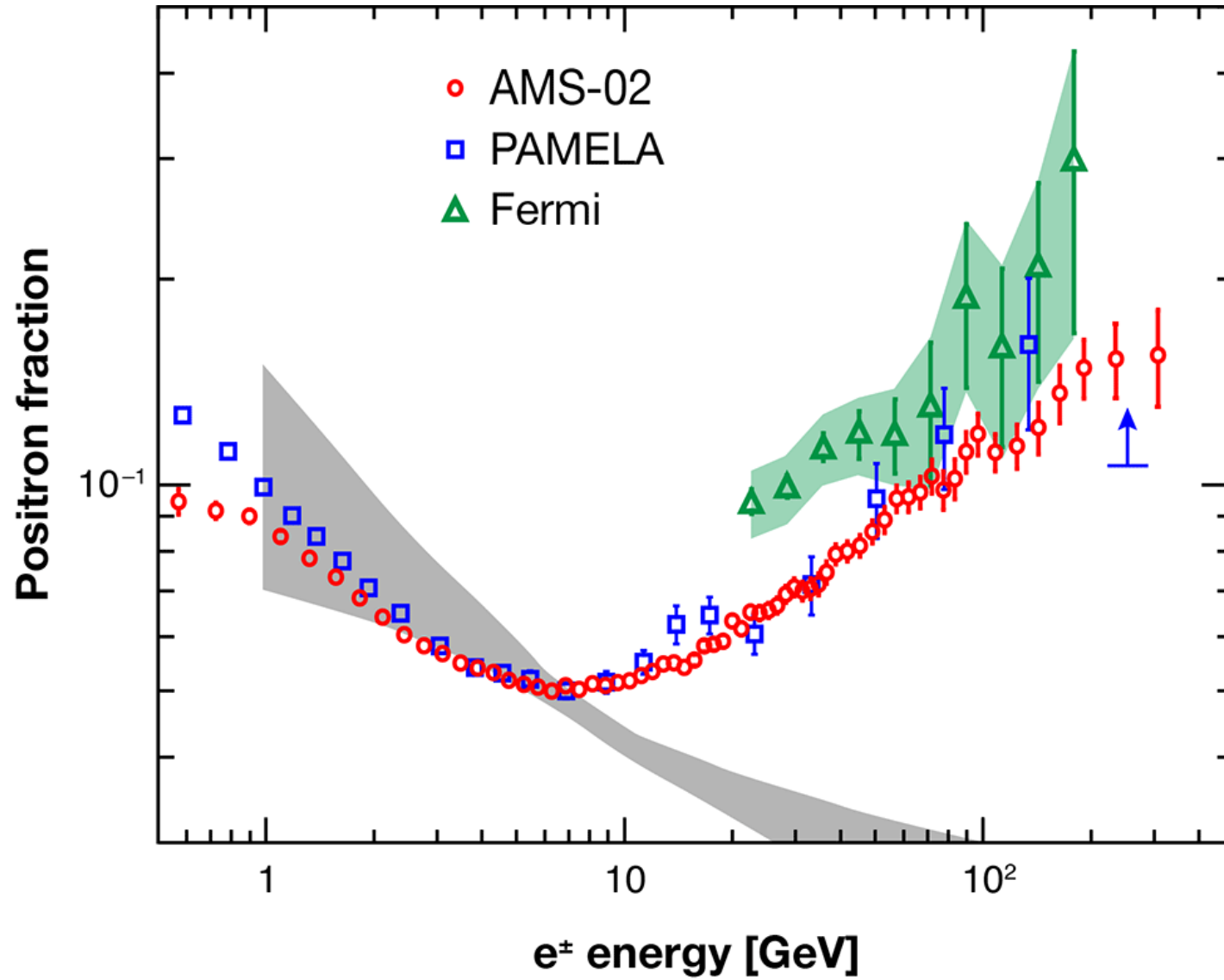
- Difficult to detect

Neutralinos

- Particle Physicist Favourite !



AntiMatter



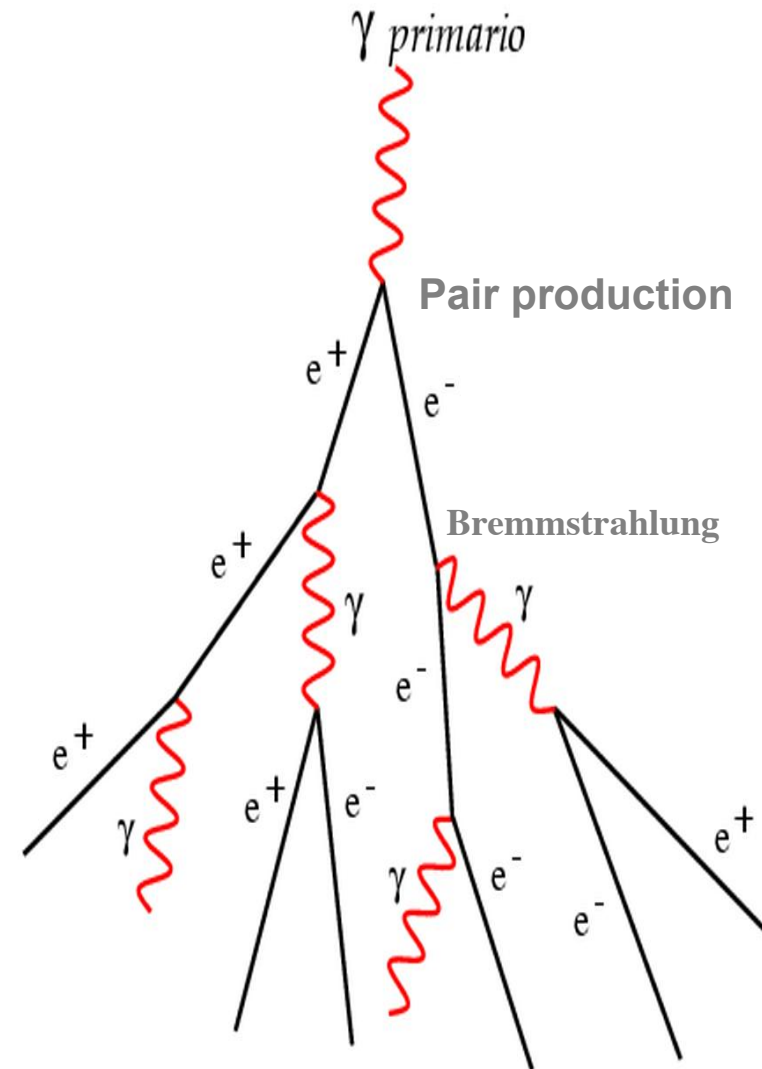
TeV astrophysics

Extensive Air Showers

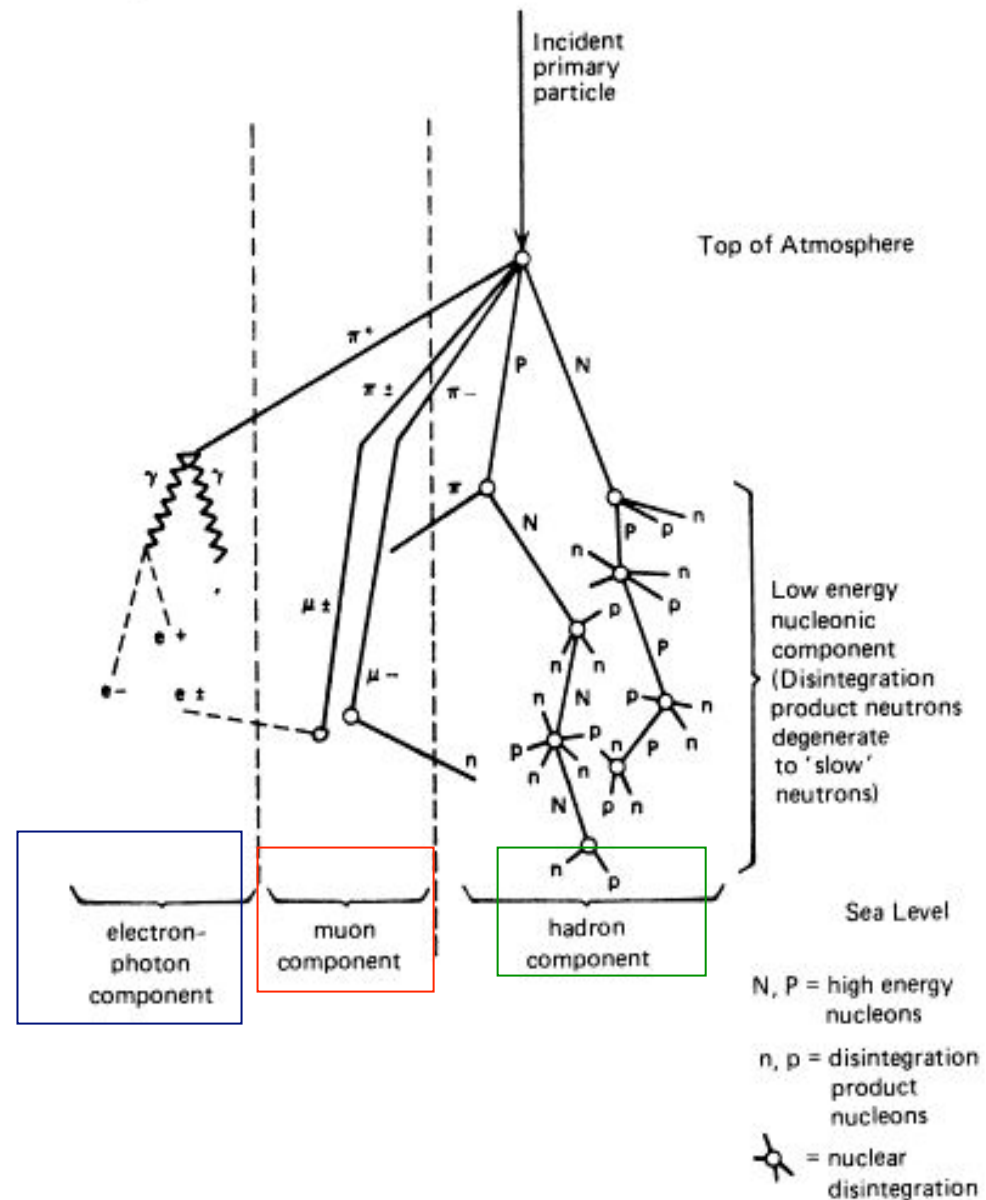
Gamma rays initiate showers of charged particles (mainly e^\pm) on entering the atmosphere

The air shower develops along the direction of the primary gamma

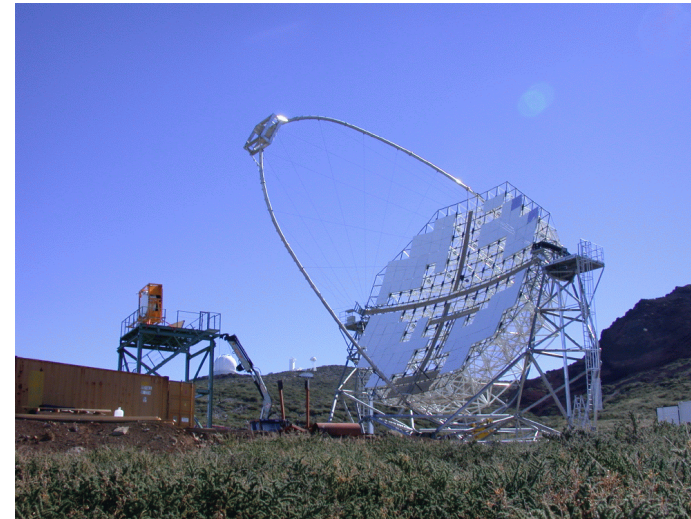
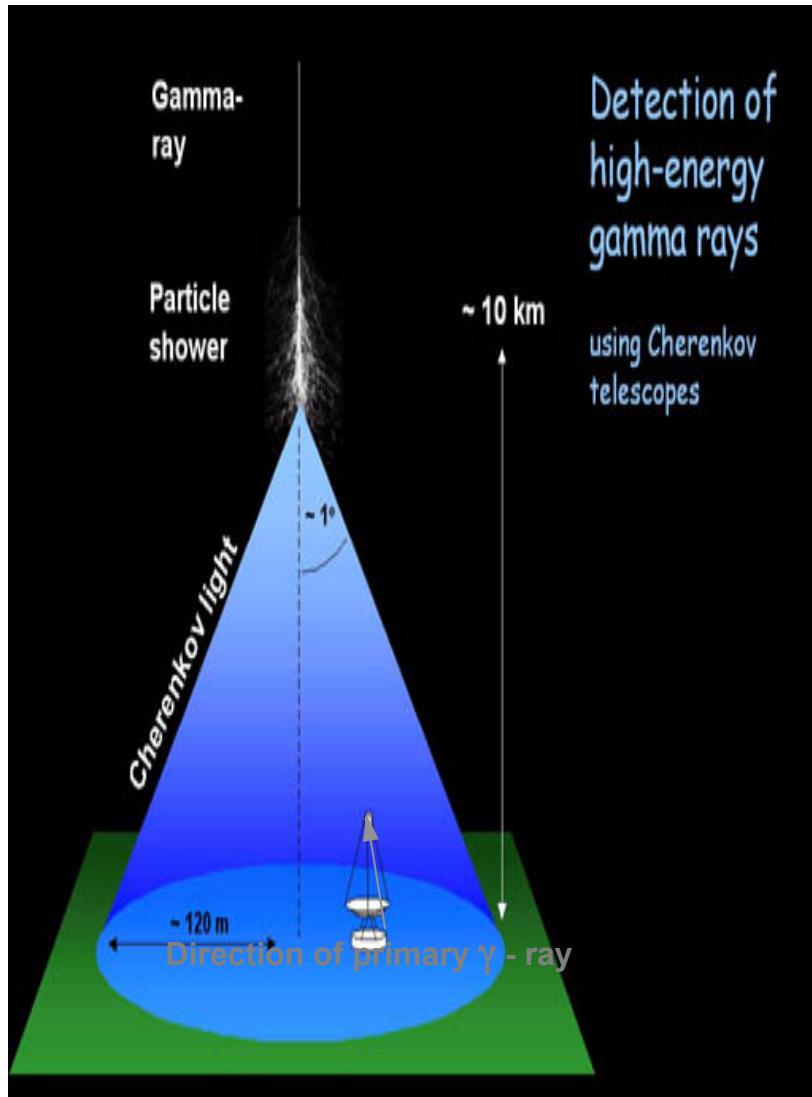
High energy e^\pm with $v > c/n$ emit Cherenkov light which reaches ground level as a short flash (≈ 3 ns)



CR shower in the atmosphere



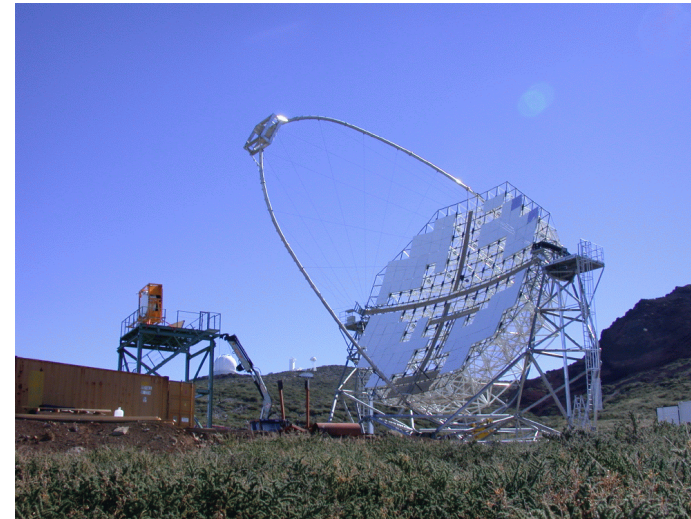
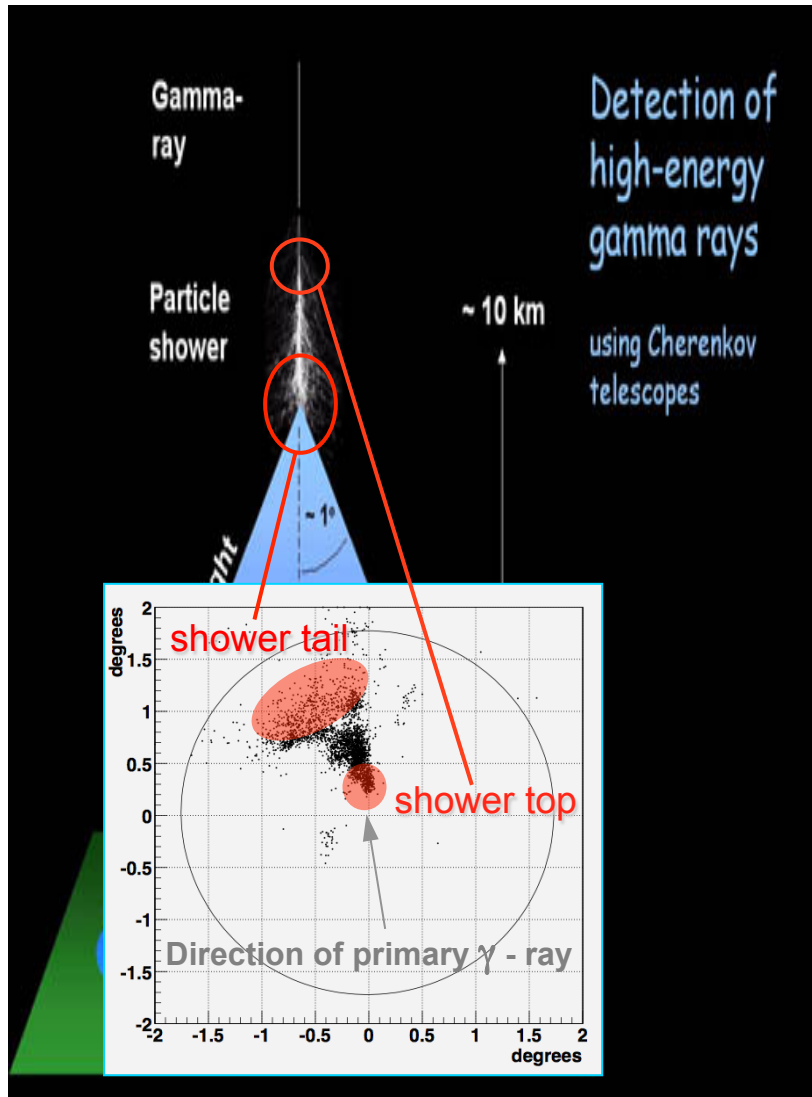
Imaging Atmospheric Cherenkov Telescopes



The principle:

A telescope placed inside the (huge) Cherenkov light pool can obtain an image of the development of the shower above the LONS fluctuations

Imaging Atmospheric Cherenkov Telescopes



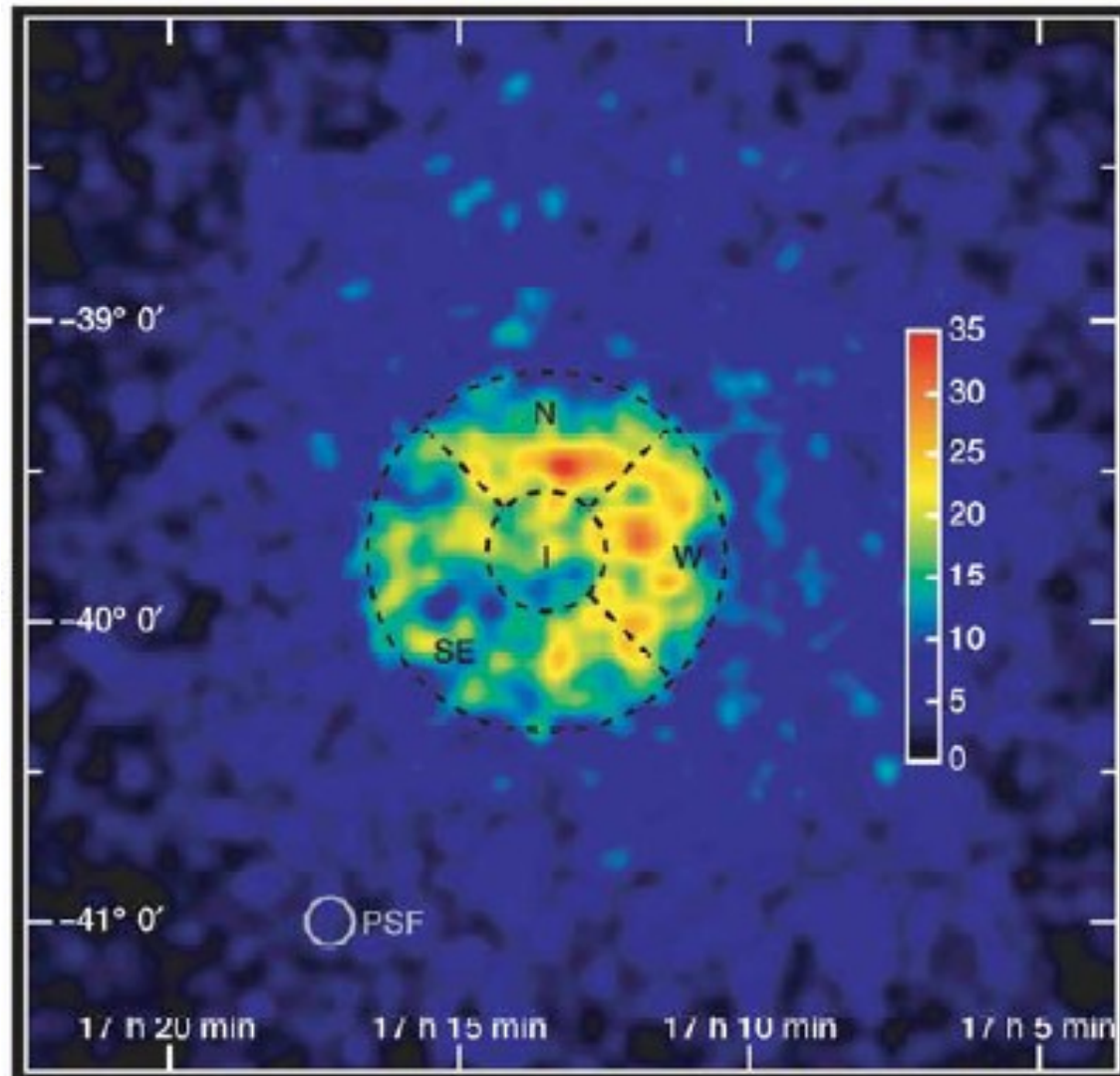
The principle:

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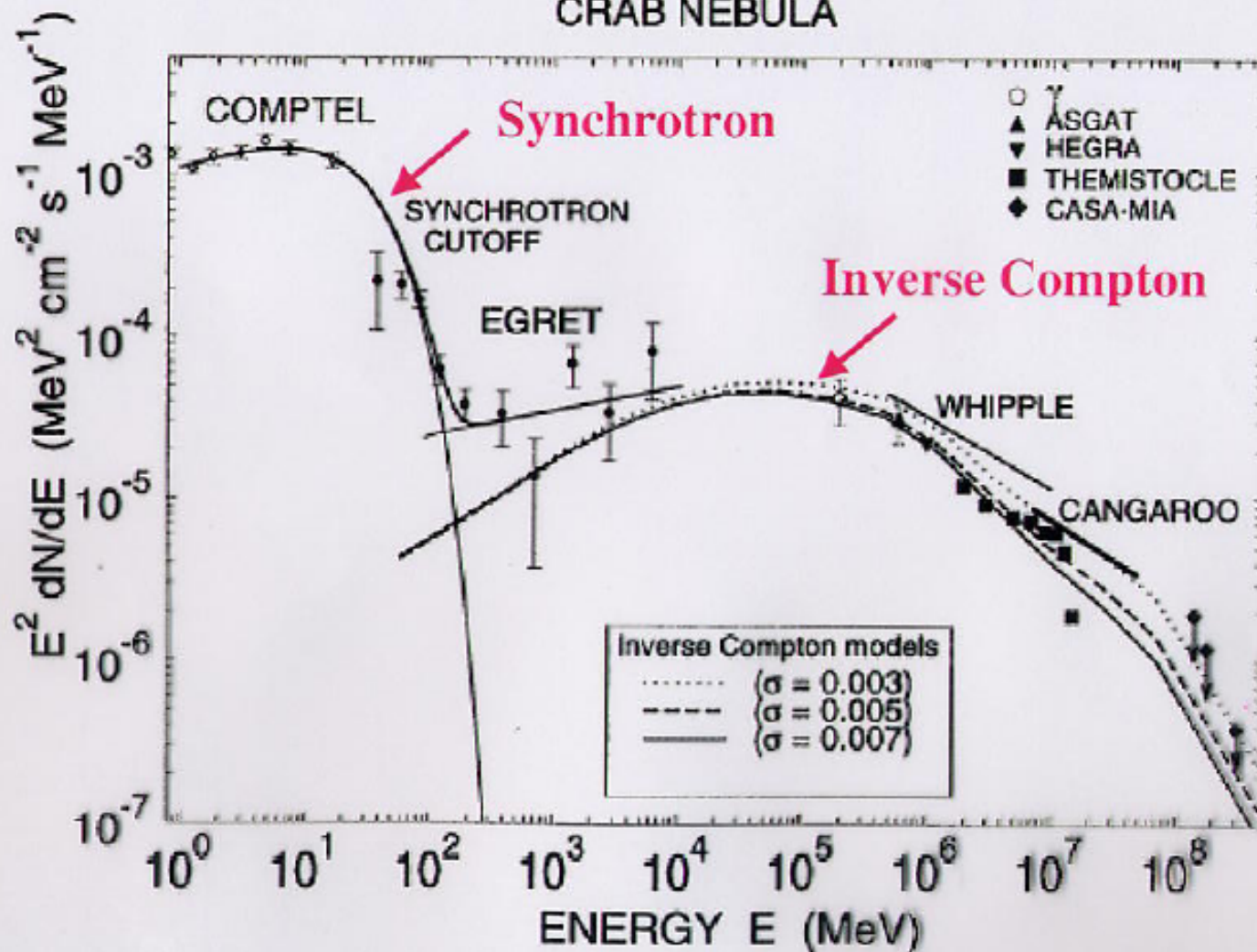
MAGIC



Supernova Remnants



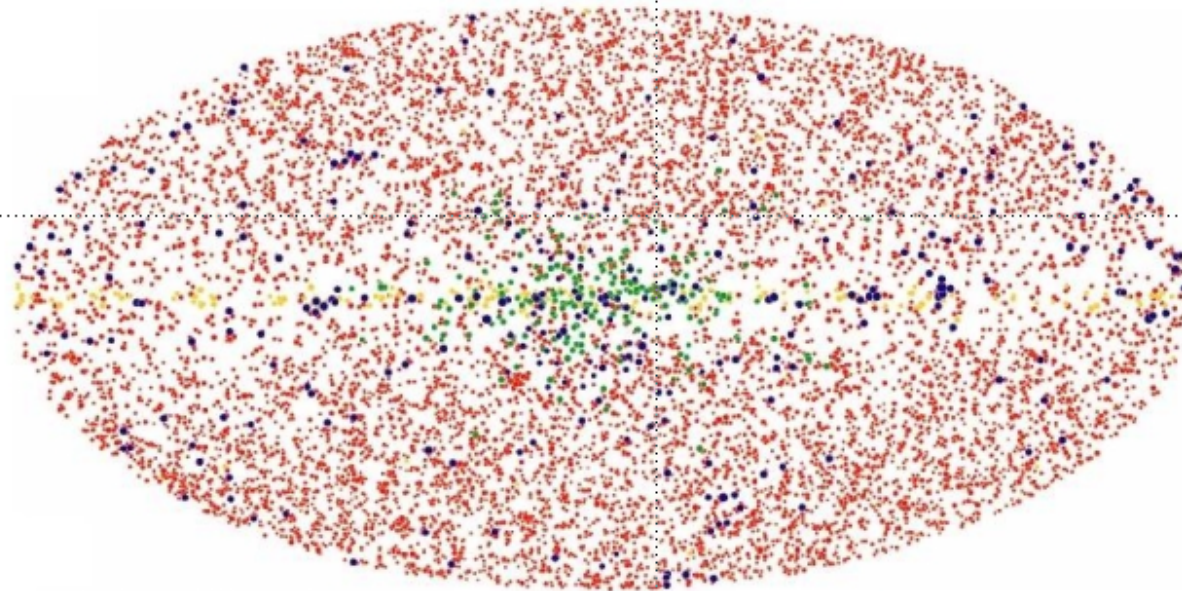
CRAB NEBULA



Active Galactic Nuclei

**5 σ Sources from Simulated
One Year All-sky Survey**

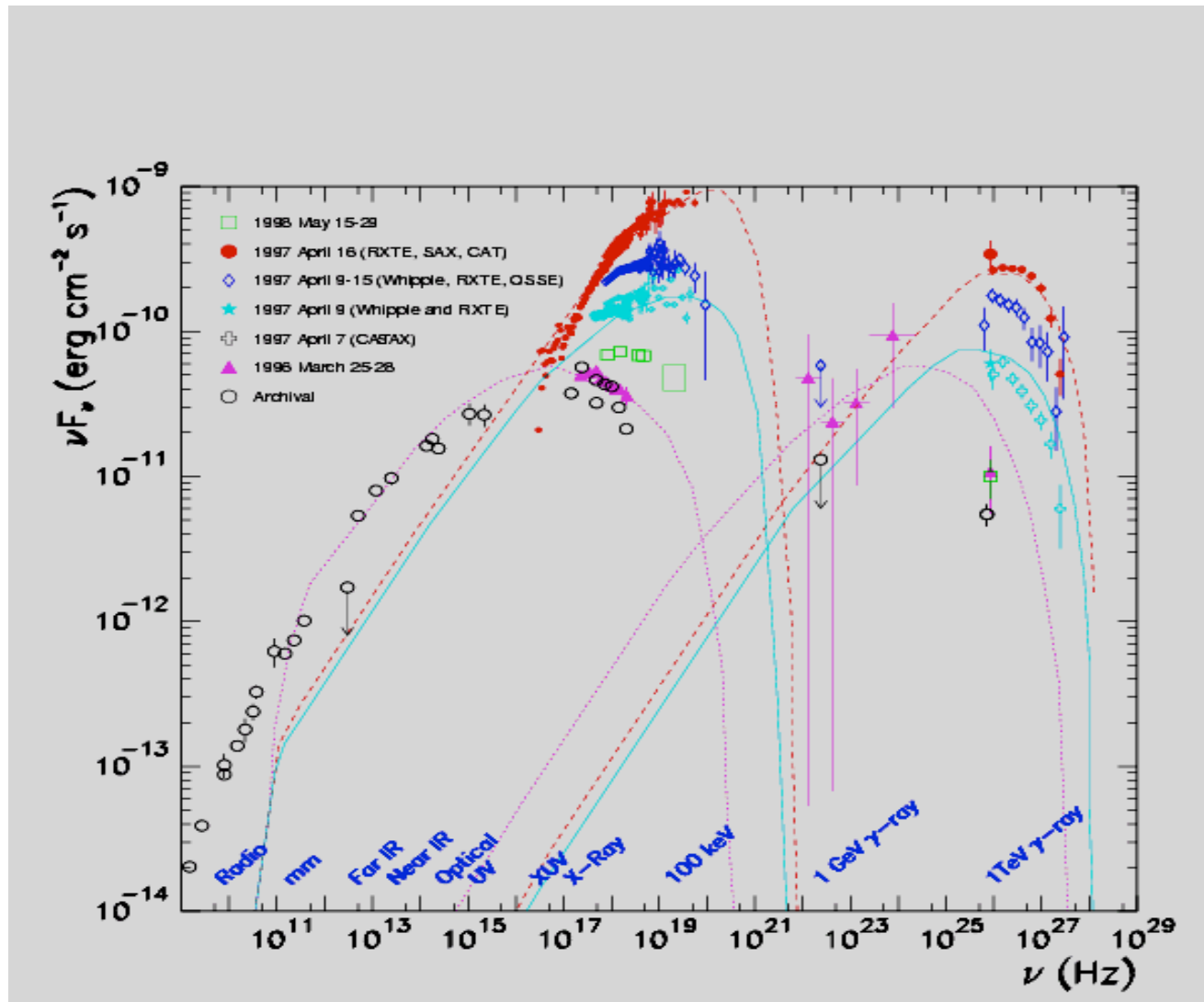
LAT 1st Catalog:
>9000 sources
possible



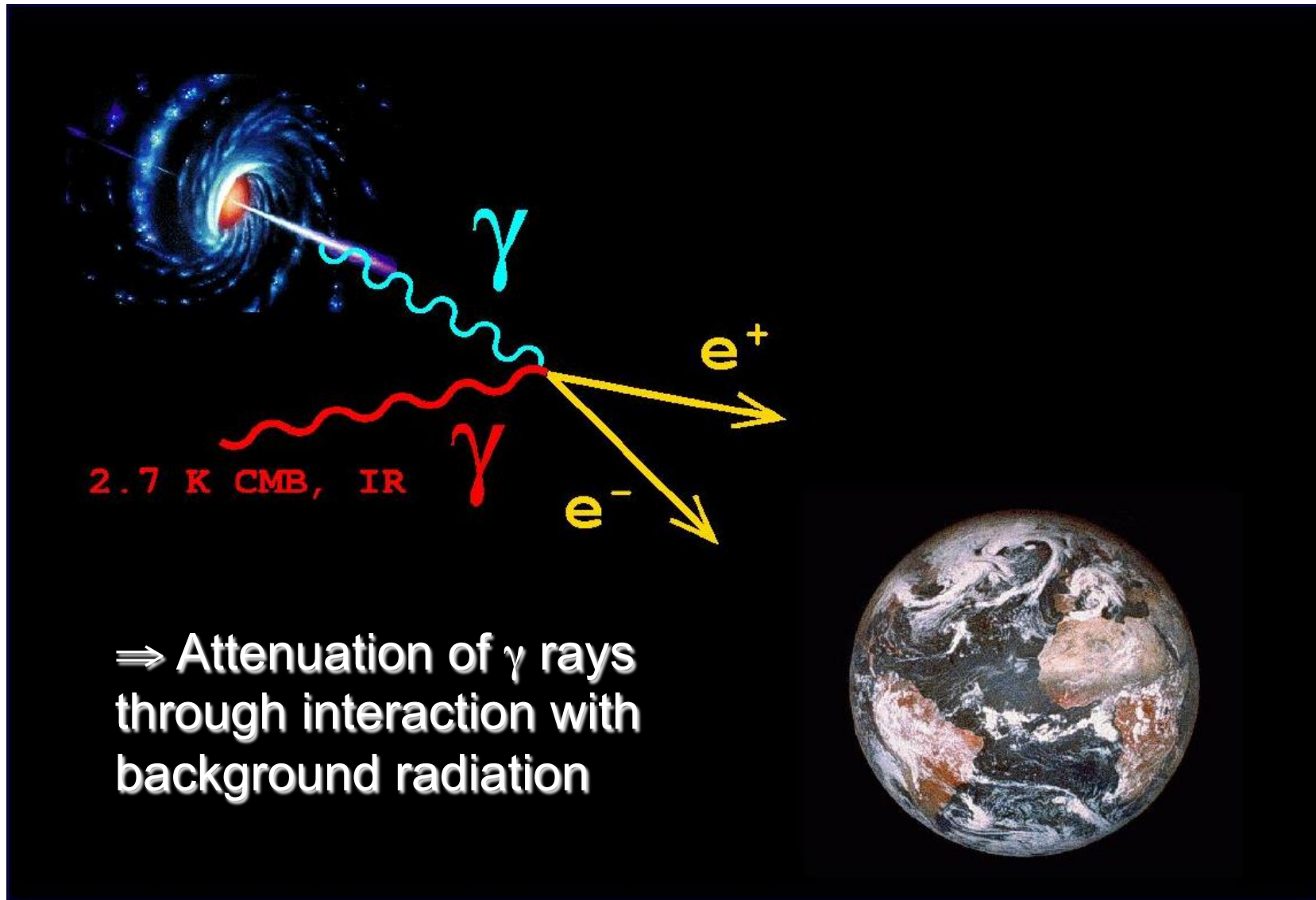
Results of one-year
all-sky survey.
(Total: 9900 sources)

- AGN
- 3EG Catalog
- Galactic Halo
- Galactic Plane

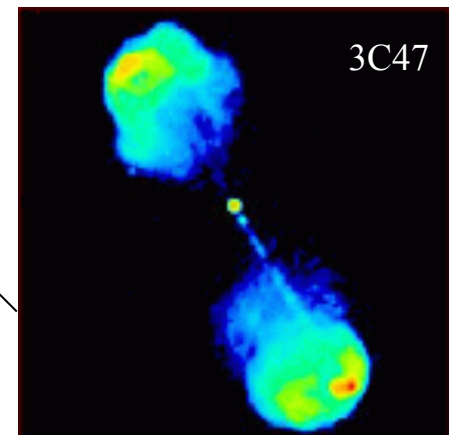
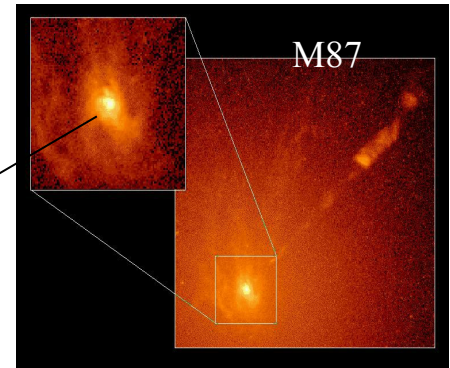
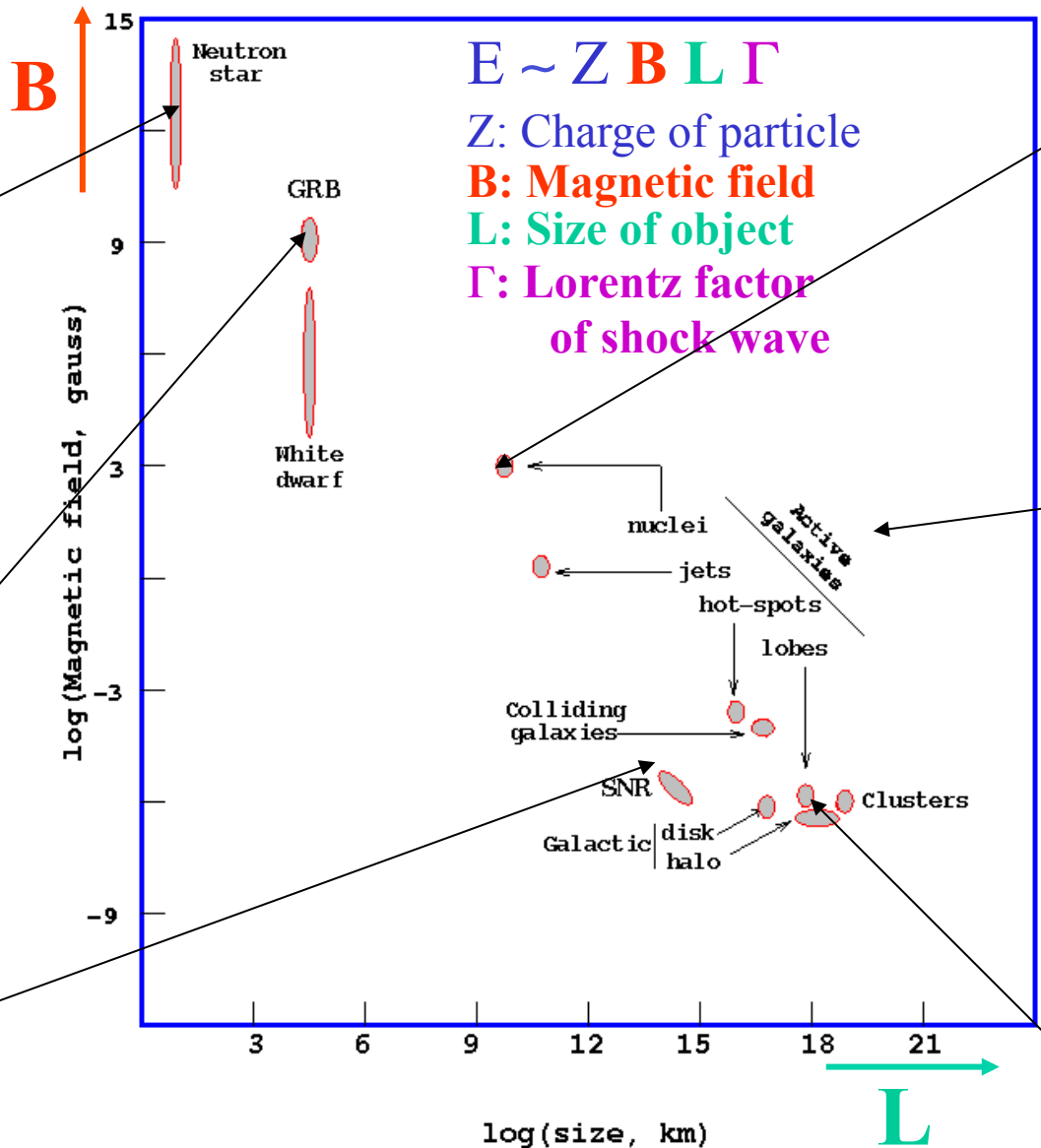
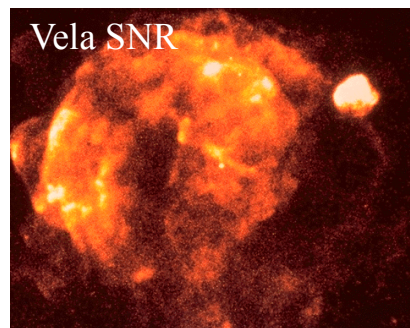
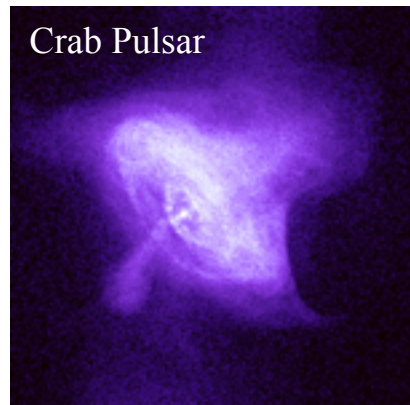
Active Galactic Nuclei



$$\gamma \gamma \longrightarrow e^+ e^-$$



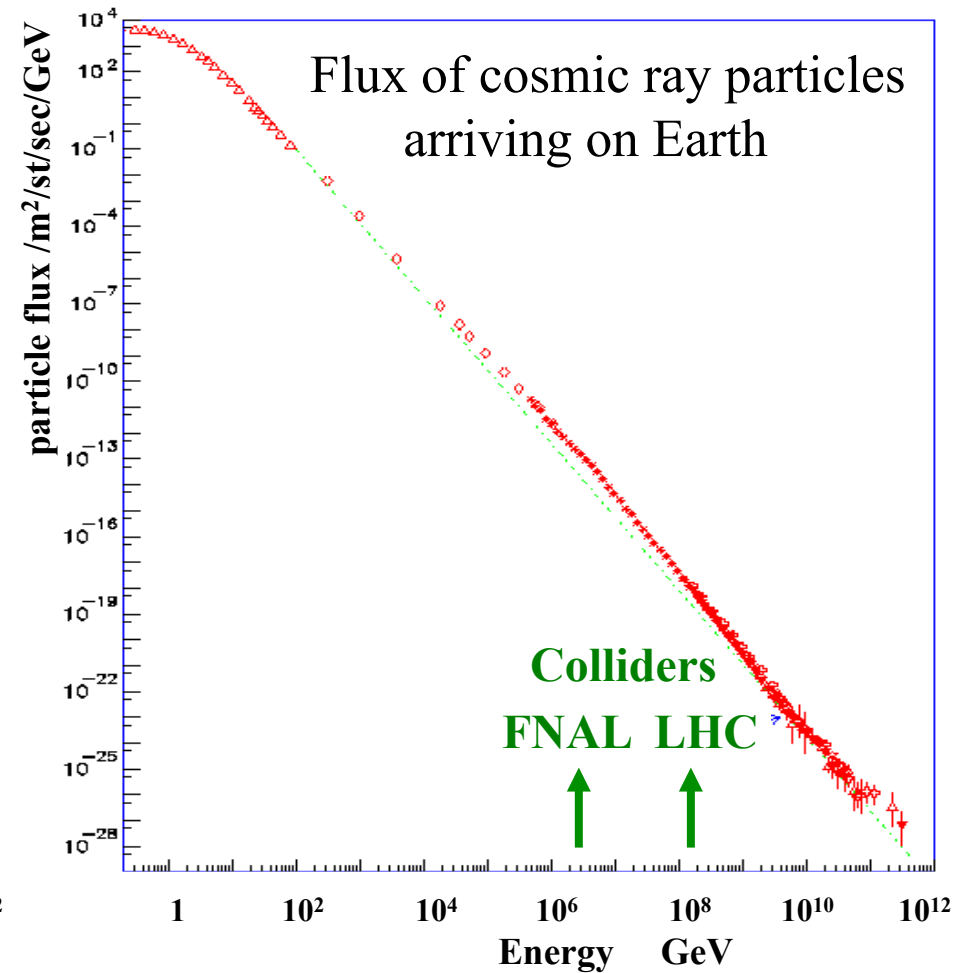
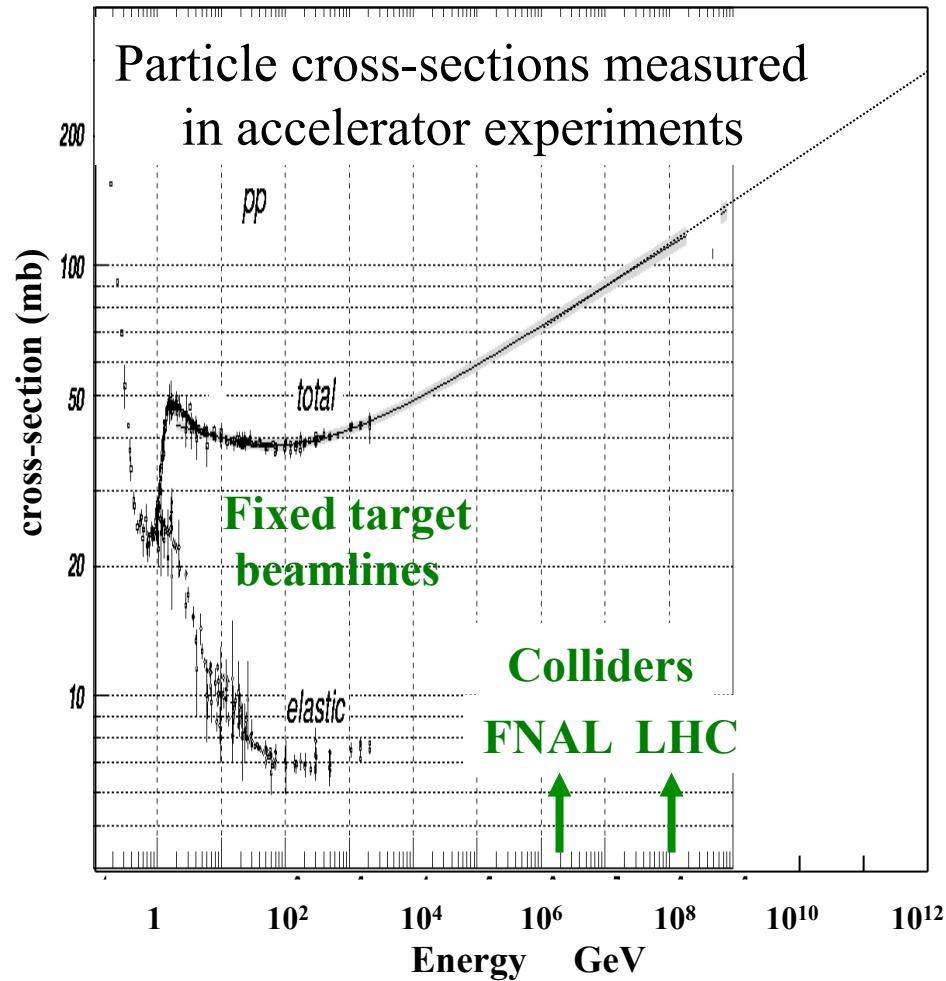
Acceleratori Cosmici: (Hillas Plot)



Ultra High Energy from Cosmic Rays

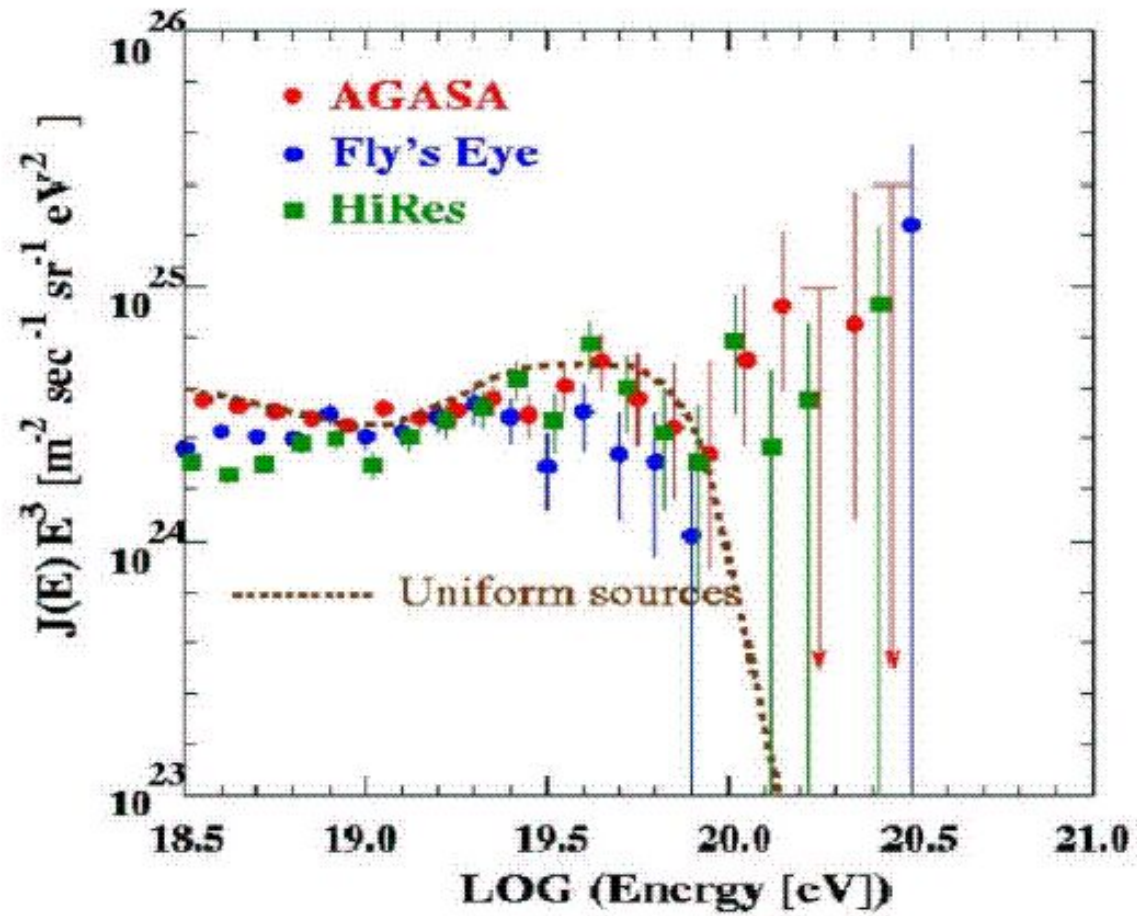
From laboratory accelerators

From cosmic accelerators

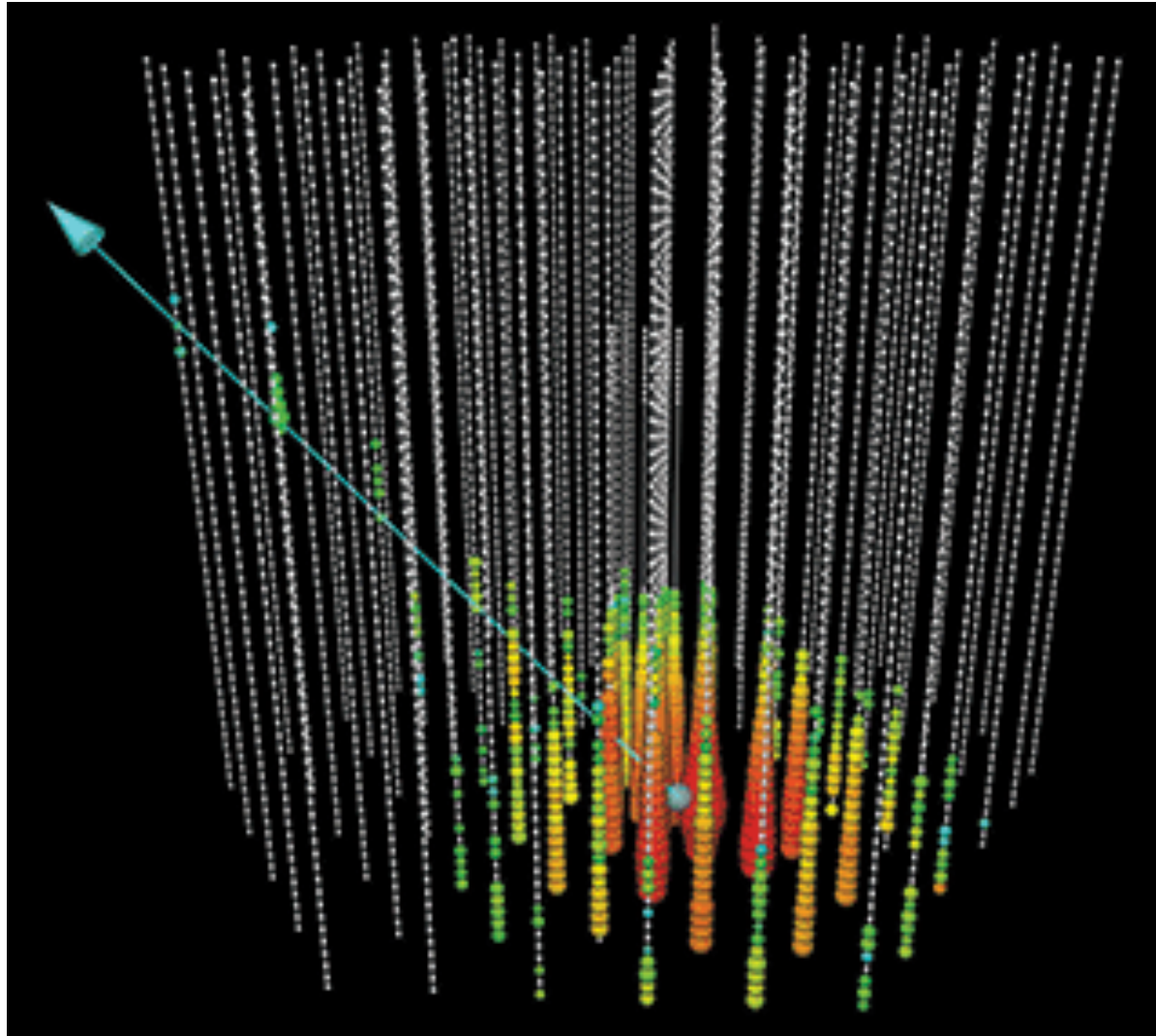


Ultra High Energy Particles arrive from space for free: make use of them

UHECR physics



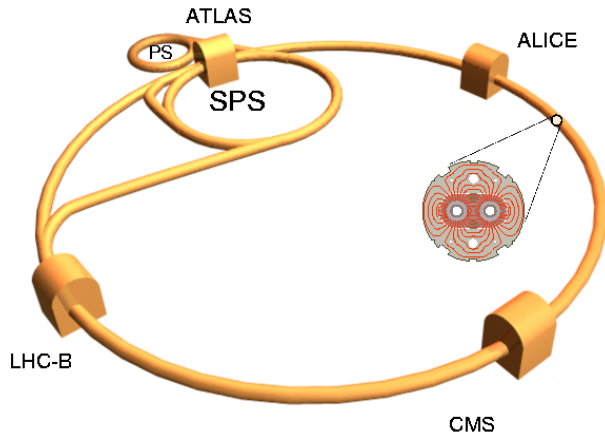
HE neutrinos



Particle Acceleration

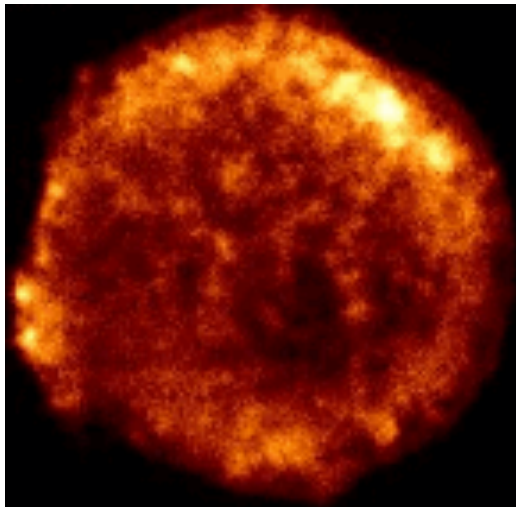
$$E \propto BR$$

Large Hadron Collider



$$R \sim 10 \text{ km}, B \sim 10 \text{ T} \quad \Rightarrow \quad E \sim 10 \text{ TeV}$$

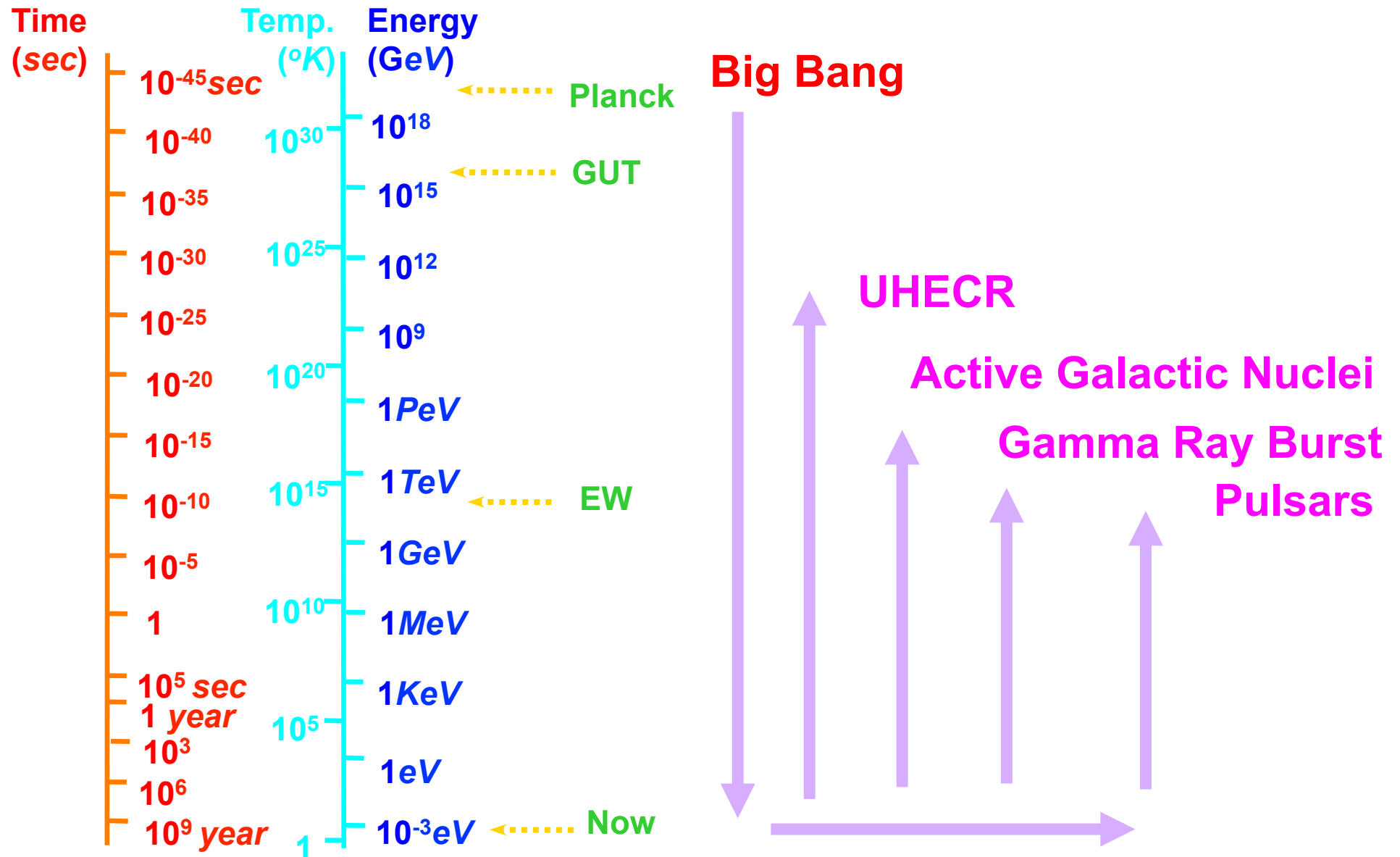
Tycho SuperNova Remnant



$$R \sim 10^{15} \text{ km}, B \sim 10^{-10} \text{ T} \quad \Rightarrow \quad E \sim 1000 \text{ TeV}$$

(NB. $E \propto Z \rightarrow$ Pb/Fe higher energy)

Extreme Universe Scales

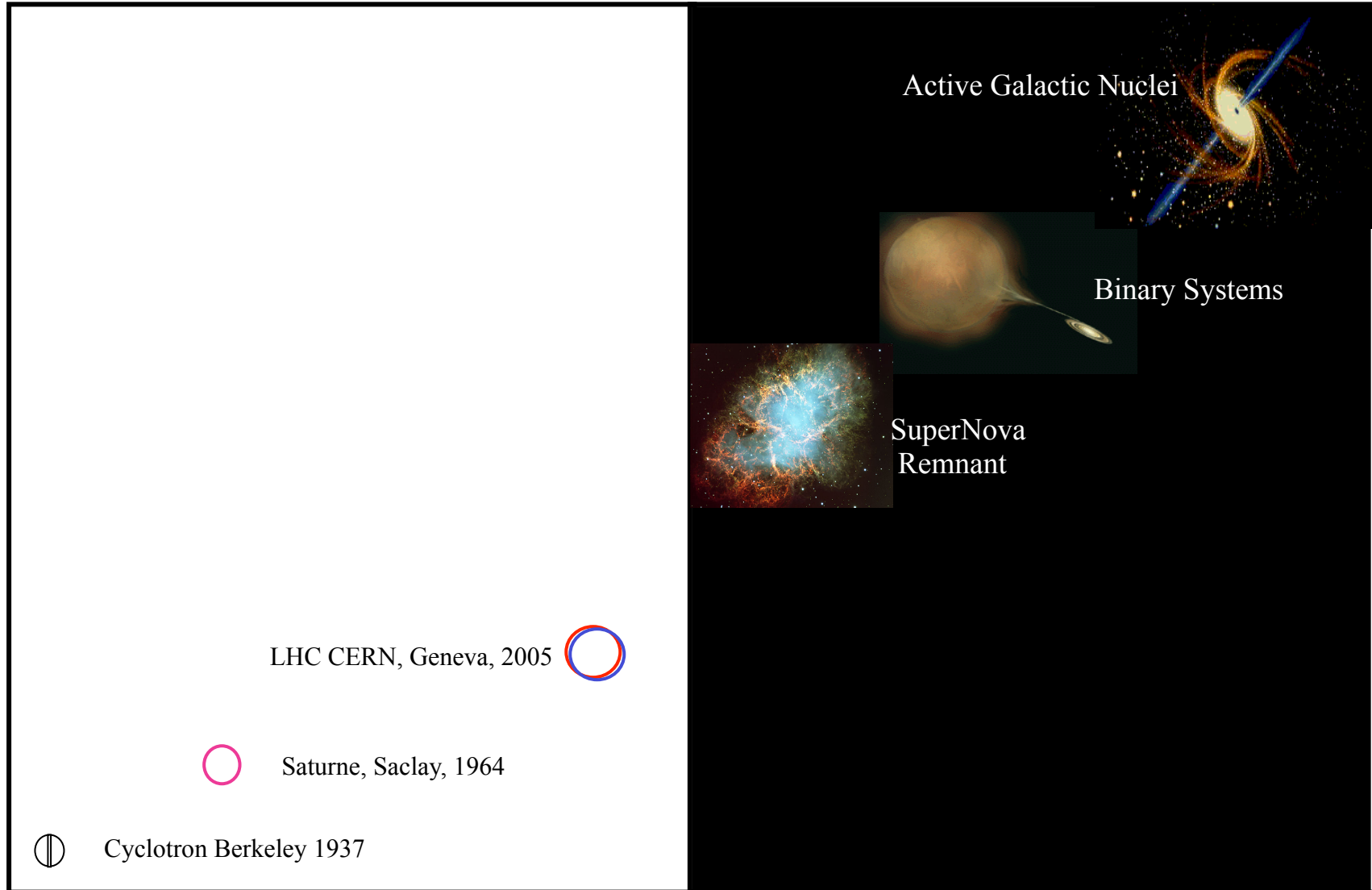


Fisica Nucl. e S. \Rightarrow Astrofisica Nucl. e S.

Acceleratori Terrestri

Acceleratori Cosmici

Diametro dell'acceleratore



Energia delle particelle accelerate

Conclusions

- Origin of CR: SNR?
- AGN: leptonic or hadronic jet model?
- Unidentified gamma sources: what are they?
- Gamma-ray Bursts: what powers them?
- The transparency of the Universe ...
- What the sources of HE neutrinos?
- What is the nature of DM?
- Are there EM counterparts of GW?

Conclusions

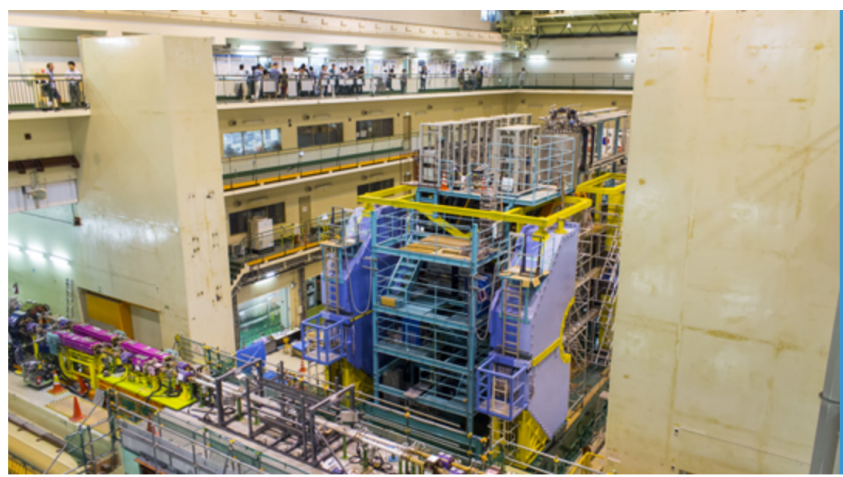
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Astrofisica Nucleare e Subnucleare

Introduzione - 2

L'INFN

La fisica delle Astroparticelle



NEWS INFN 1 2 3 4 5

CIRCOLANO I PRIMI FASCI NELL'ACCELERATORE SUPERKEKB

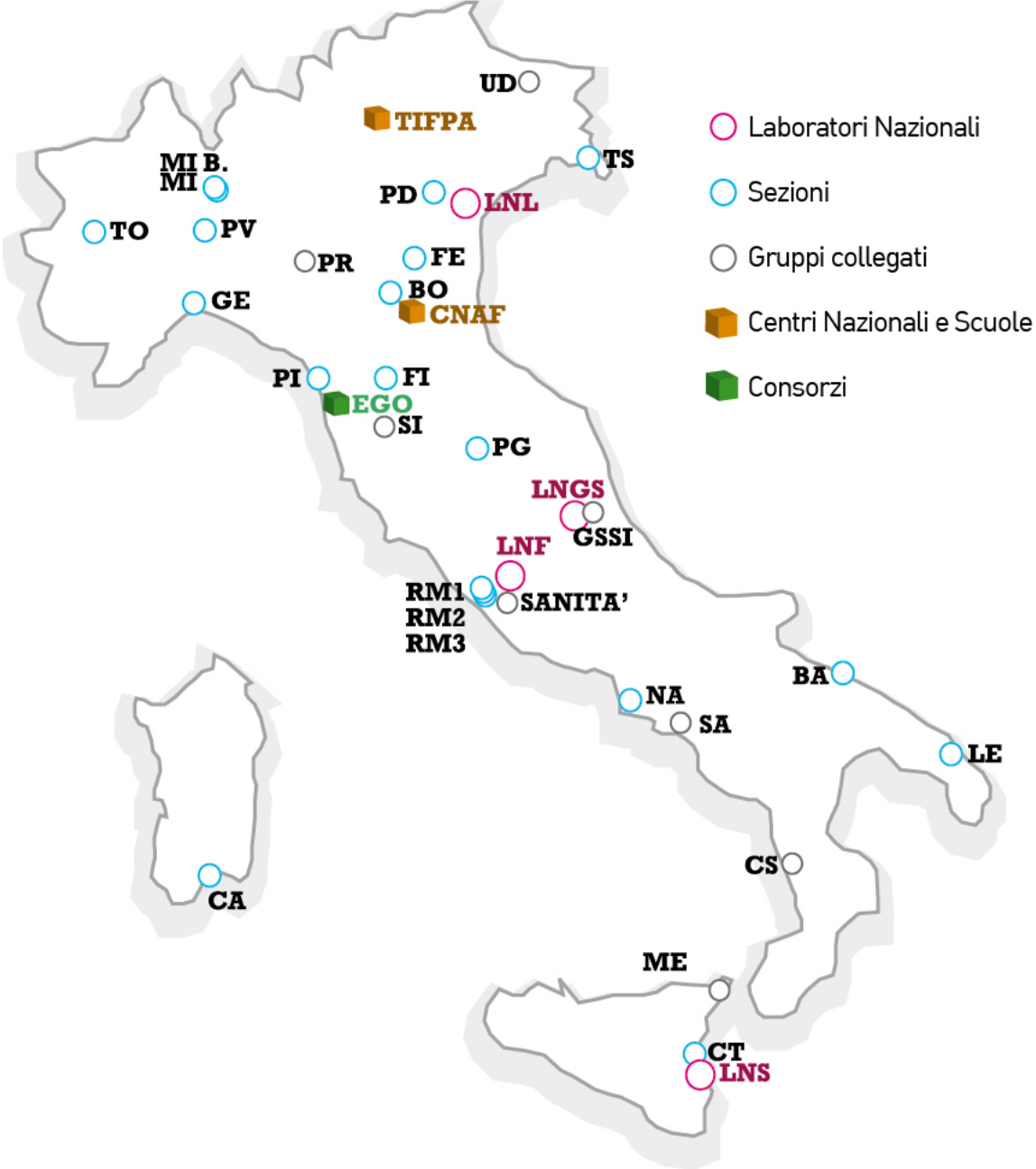
Il 2 marzo 2016 per la prima volta sono stati iniettati e fatti circolare stabilmente dei fasci di particelle negli anelli dell'acceleratore SuperKEKB nel laboratorio KEK a Tsukuba, in Giappone. "È un traguardo importante nella messa a punto della macchina acceleratrice progettata per arrivare a una luminosità mai raggiunta finora, ben quaranta volte più alta..."

[Read more](#)

- LINEE DI RICERCA**
- 1 fisica delle **PARTICELLE** 
 - 2 fisica delle **ASTROPARTICELLE** 
 - 3 fisica **NUCLEARE** 
 - 4 fisica **TEORICA** 
 - 5 ricerca **TECNOLOGICA** 

www.infn.it

L'INFN



I laboratori dell'INFN

Laboratori Nazionali di Frascati

HOME CHI SIAMO RICERCHE ACCELERATORI NOVITÀ EDUCATIONAL LNF USERS



cerca...



Home

Benvenuti ai Laboratori Nazionali di Frascati

I Laboratori Nazionali di Frascati (LNF) sono la più antica struttura di ricerca per la fisica nucleare e subnucleare italiana con macchine acceleratrici e il più grande Laboratorio dell'Istituto Nazionale di Fisica Nucleare (INFN), l'Ente che promuove, coordina e finanzia la ricerca nel campo della fisica subnucleare e nucleare.

LEGGI TUTTO...

Un magnete dal CERN per la ricerca dei dark photon a Frascati



L'INFN ha recentemente approvato un esperimento per la ricerca di una nuova interazione fondamentale in grado di collegare il nostro mondo con la materia oscura, di cui in gran parte è composto l'Universo, ma di cui ignoriamo la natura. L'esperimento PADME è infatti un apparato sperimentale dedicato alla ricerca del mediatore della nuova "forza oscura" ("fotone oscuro" o "dark photon"), simile al fotone dell'ordinaria radiazione elettromagnetica, ma dotato di una piccola massa e molto debolmente interagente con la materia ordinaria.

LEGGI TUTTO...

Contatti



INFN - LNF

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00044 Frascati (Roma) Italy
Tel +39 06 94031
Fax +39 06 9403 2582

Direzione
Direttore: Dr. Pierluigi Campana
Tel. +39 06 94031
e-mail: dirlnf@lnf.infn.it
Lab.Naz.Frascati@pec.infn.it

Menù



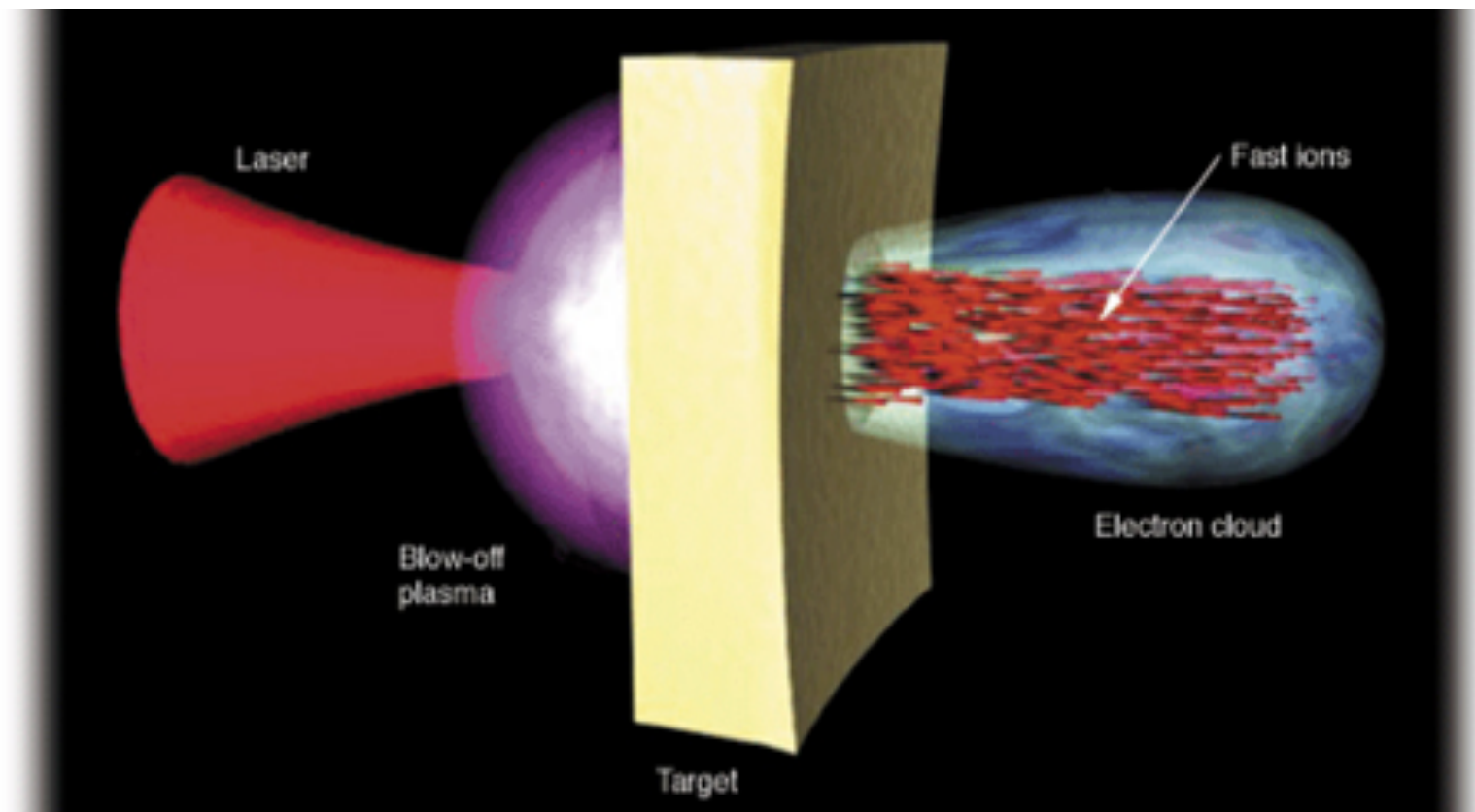
- ▶ Cultura Scientifica
- ▶ INFN
- ▶ Ufficio Comunicazione INFN
- ▶ Pubblicazioni Divulgative INFN
- ▶ LHC Italia
- ▶ InterAction Collaboration
- ▶ Multimedia
- ▶ Link

Scelti per voi

- [Miriam Mafai racconta Bruno Pontecorvo](#)

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Nuovi meccanismi di accelerazione



I laboratori dell'INFN



Laboratori Nazionali del Gran Sasso

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Un detective hi-tech
si è messo sulle
tracce della materia
oscura

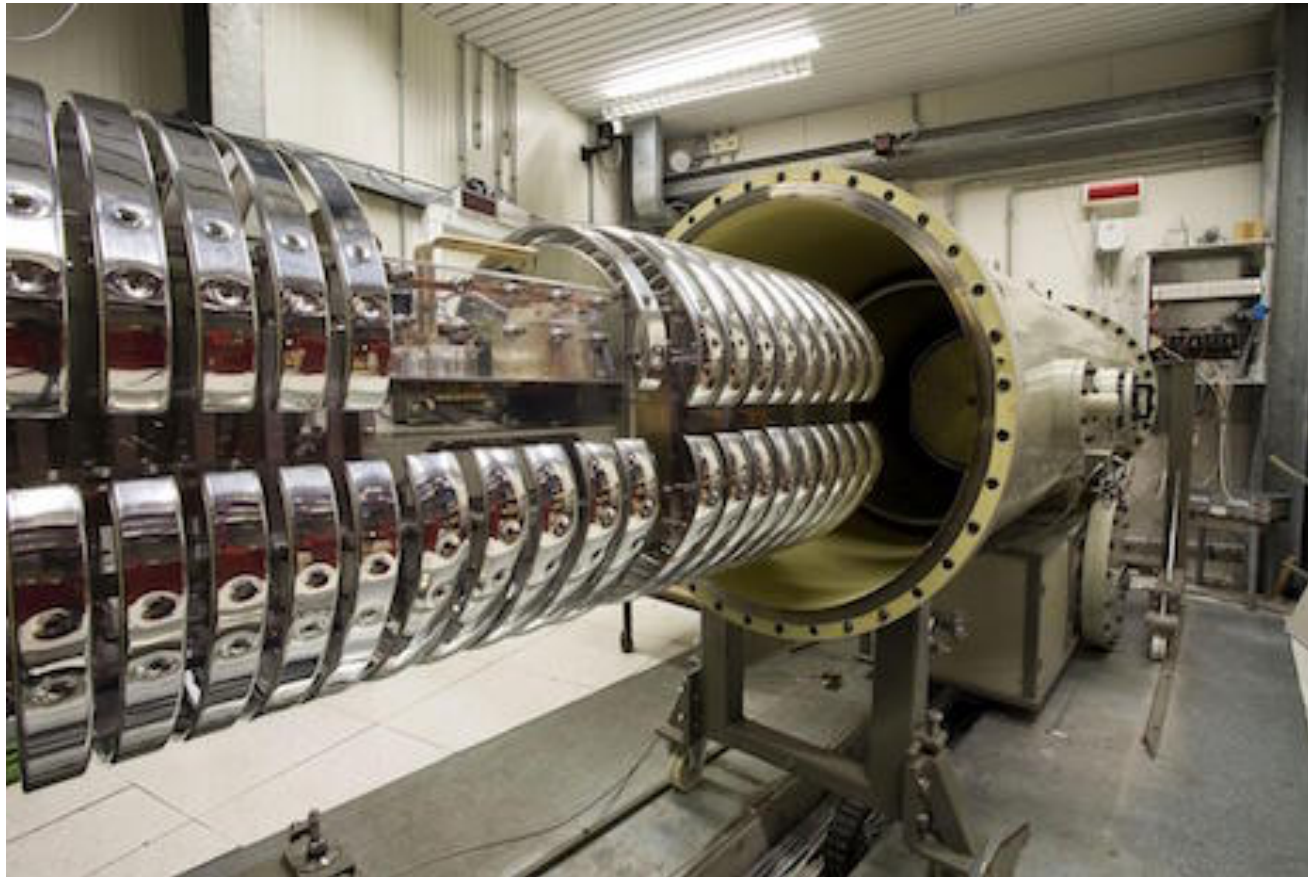
Inaugurato ai Laboratori INFN del Gran Sasso l'esperimento DarkSide-50 [Read More](#)

www.lngs.infn.it

I laboratori del Gran Sasso



I meccanismi delle Stelle



L'esperimento LUNA

La Materia Oscura



L'esperimento DAMA

I neutrini?



L'esperimento Opera

I laboratori Nazionali del Sud



Istituto Nazionale di Fisica Nucleare

Laboratori Nazionali del Sud



[Events](#) [News](#) [Announcements](#) [Today](#) [Scientific info](#) [Publications](#)

Home

Laboratory

- Home
- Accelerators
- Research
- Infrastructure
- Safety
- Gallery
- Virtual tour

Users

- LNS Users Group
- User support
- Access info
- Guest house
- Contacts
- Scientific Committee
- Online Submission

Utilities

- Document server
- Phonebook
- Webmail
- New webmail
- LNS visits calendar

Announcements

Publicati i risultati di una interessante ricerca sui capodogli, in transito nello Jonio, grazie all'ascolto dei loro suoni. Info sulla rivista Plos one.

Upcoming Events

- Tue 26-Apr-2016 Joint LIA COLL--AGAIN
- Wed 7-Sep-2016 III ELIMED Workshop

LNS activity overview

 <p>Nuclear Physics</p>	 <p>Accelerators</p>	 <p>Astroparticle Physics</p>
 <p>Detector systems</p>	 <p>Ion Sources</p>	 <p>Theory</p>
 <p>INFN-Energy</p>	 <p>Protontherapy</p>	 <p>Multidisciplinary facilities</p>



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- Job opportunities
- LNS presentation
- Presentazione LNS
- Recent events/news

Focus on

- SMO
- CATANA
- CHIMERA
- FRIBS
- MAGNEX
- Irradiation Facility
- NUMEN

Service links

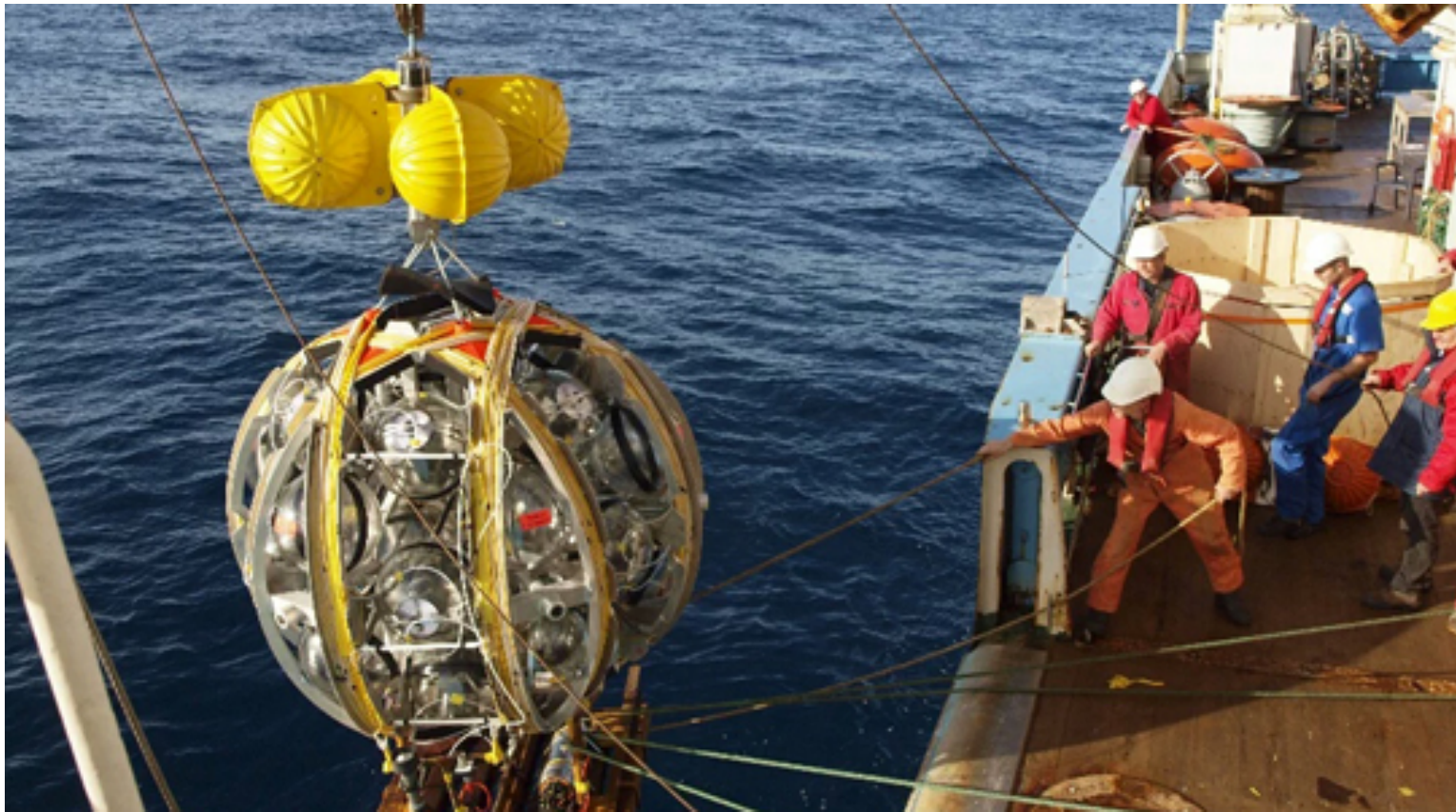
- Avvisi aggiudicazione
- Administration
- Fattura elettronica (e-Invoice)
- Secretariat
- Meeting rooms (internal)

www.ins.infn.it

I neutrini astrofisici



I neutrini astrofisici



I laboratori Nazionali di Legnaro



Laboratori Nazionali di Legnaro

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- ▣ [Eventi speciali](#)
- ▣ [L'ambiente](#)



LNL Seminars

[Managing a high intensity high energy cyclotron for medical applications](#)

Dr. Ferid Haddad and Dr. Nicolas Varmentot (GIP Arronax, France)

Thursday, 21 January 2016 from 15:00 to 16:00 C. Villi meeting room

[Sviluppo e caratterizzazione della sorgente di ionizzazione al plasma del progetto SPES](#)

Dr. Fabio Visentin

Friday, 22 January 2016 from 14:15 to 15:15 Rostagni meeting room

[Archiver Appliance to EPICS control systems](#)

Dr. Thomas Birke (Helmholtz-Zentrum Berlin für Materialien und Energie GmbH)

Sei qui: [Home](#) [Pagina principale](#)

Benvenuti ai Laboratori Nazionali di Legnaro (LNL)



I LNL sono uno dei quattro laboratori nazionali dell'Istituto Nazionale di Fisica Nucleare (INFN). La missione principale dei LNL riguarda la ricerca di base nella fisica e astrofisica nucleare assieme alle applicazioni di tecnologie nucleari.

Più di 800 ricercatori da ogni parte del mondo partecipano ai programmi di ricerca in corso. Ai LNL prestano servizio 250 persone, metà di quali sono dipendenti dell' INFN (fisici, ingegneri, tecnici ...), la restante parte proviene da università e centri di ricerca nazionali o stranieri. Il bilancio dei LNL si aggira sui 20 milioni di Euro all'anno, di cui metà dedicata alle spese di gestione e ricerca, l'altra metà al personale. Punti di forza dei laboratori sono la realizzazione di acceleratori di particelle nucleari e lo sviluppo di rivelatori di radiazioni nucleari.

LNL Events

[Intense and Powerful Accelerator Beams for industrial and energy application \(IPAB2016\)](#)

14 - 15 March 2016, INFN-LNL

[All events](#)

USEFUL LINKS

[INFN Portal](#)

[INFN Amministrazione Centrale](#)

[INFN Presidenza](#)

[Travelling](#)

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Le onde gravitazionali

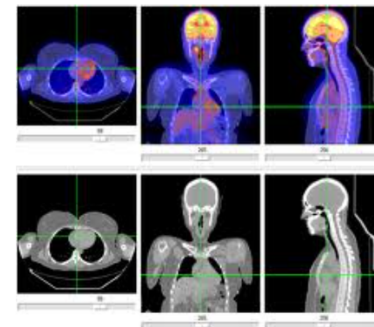


Il progetto SPES



SPES: il progetto principale del laboratorio

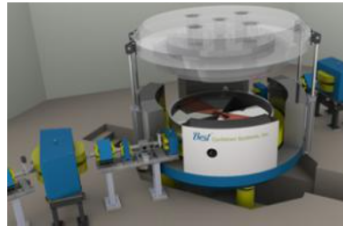
- **SPES= Selective Production of Exotic Species**
- **studio di nuclei atomici prodotti nelle fasi avanzate dell'evoluzione stellare**
- **produzione di radioisotopi di interesse sanitario**
- **In breve , dalle stelle alla società**



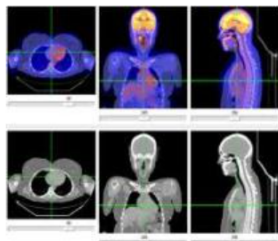
Il progetto SPES



Le quattro fasi del progetto SPES



**Ciclotrone e
infrastruttura**



**Radioisotopi per
la salute**



**Facility per fasci
di ioni radioattivi**



**Sorgenti di
neutroni basate
su acceleratori**

6

Il progetto SPES



Il ciclotrone SPES nel 2016



**il collaudo sarà completato nelle prossime settimane
(test di durata)**

Astrofisica Nucleare e Subnucleare

Introduzione - 3

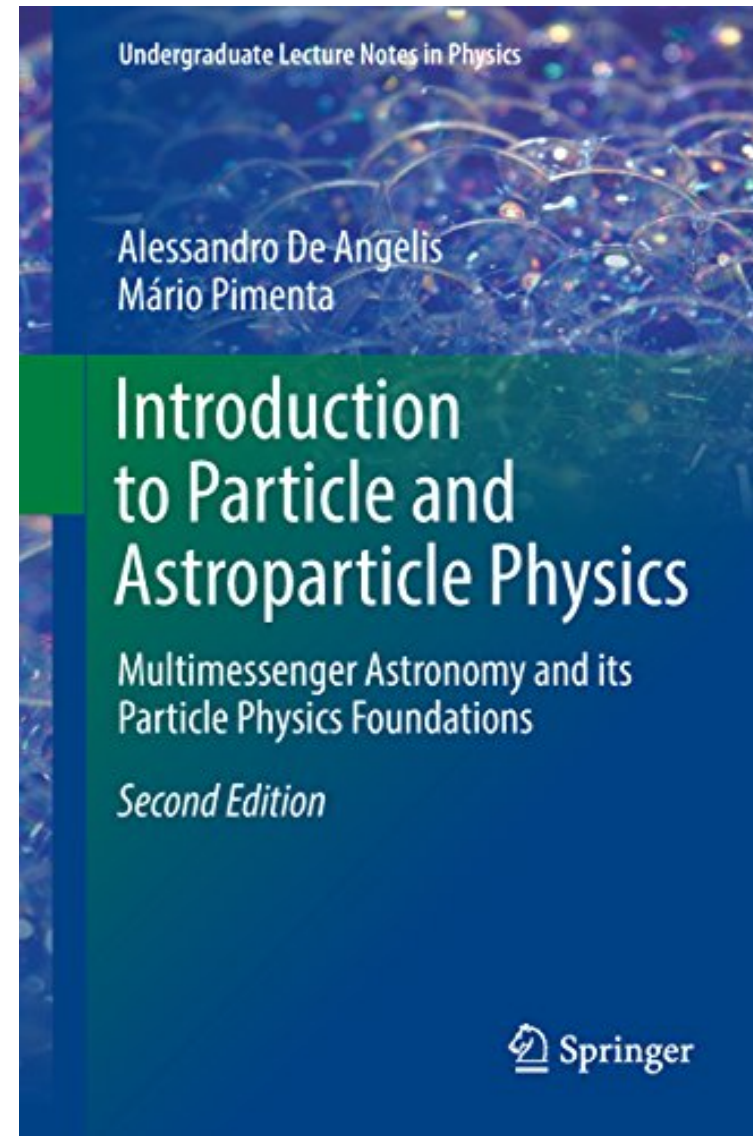
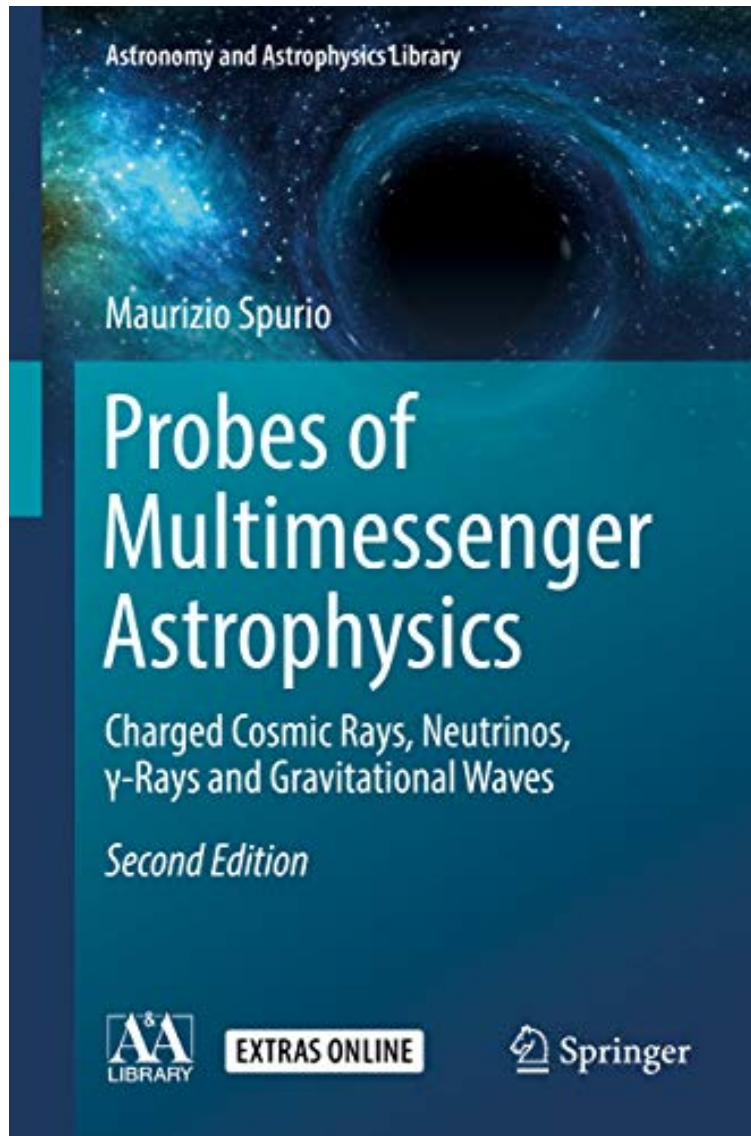
Organizzazione del corso

- Lezioni frontali
 - Introduzione agli argomenti di Astroparticelle e Astrofisica Nucleare
- Journal Club
 - Lettura di articoli di riferimento del settore
 - Discussione a lezione
- Seminari
 - Invito di esperti del settore (presso UniTs / INFN Ts / INAF Ts)

Data Analysis

- Gamma Ray data analysis
 - Analysis of MeV GRB data
 - Analysis of GeV Gamma ray data
 - Analysis of TeV Gamma ray simulated data
- Analysis of Multiwavelength data
 - Open GW data analysis
- Simulations of Astroparticle experiments
 - G4 simulation toolkit introduction

Testi



Testi

