New Ideas for Detecting Dark Matter

Speakers:

Gianluca Cavoto	INFN Roma
Giovanni Carugno	Università di Padova
Cristiano Galbiati	Princeton University
Flavio Gatti	Università di Genova
Francesco Giazotto	CNR-NEST Pisa
Antonio D. Polosa	Sapienza Univ Roma /CERN
Paolo Spagnolo	INFN Pisa

Scuola Normale Superiore
Palazzo della Carovana
Piazza dei Cavalieri, Pisa

24 February 2016, 9 a.m.

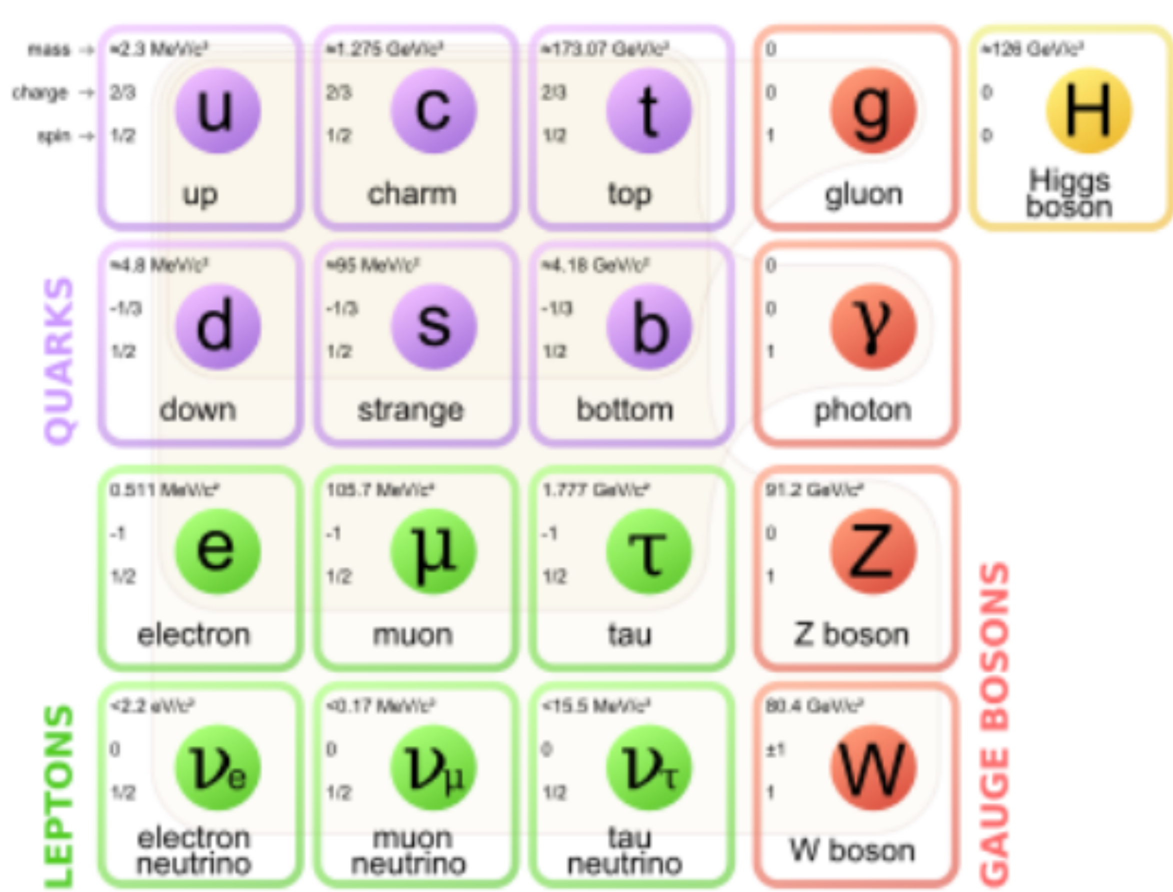
SCUOLA NORMALE SUPERIORE

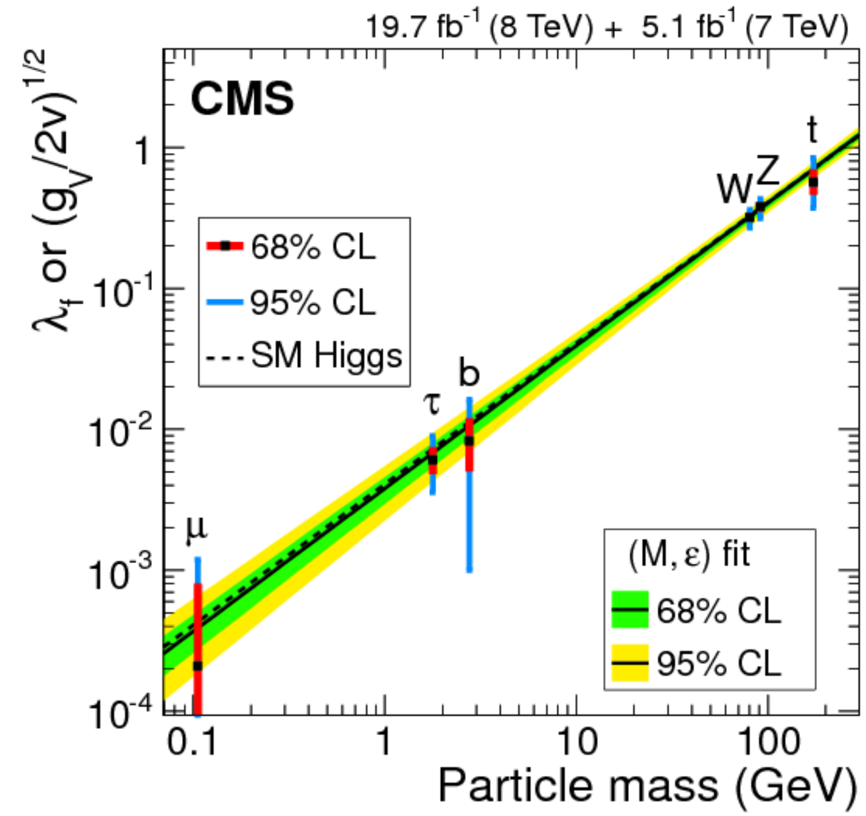
P. SPAGNOLO

Particle Physics

The Standard Model of Particle Physics is a very accurate theory (tested up to 10^{-5} precision)

First 3 years of LHC Run lead to the Higgs discovery and the early studies of the Higgs couplings show no evidence of deviation from SM

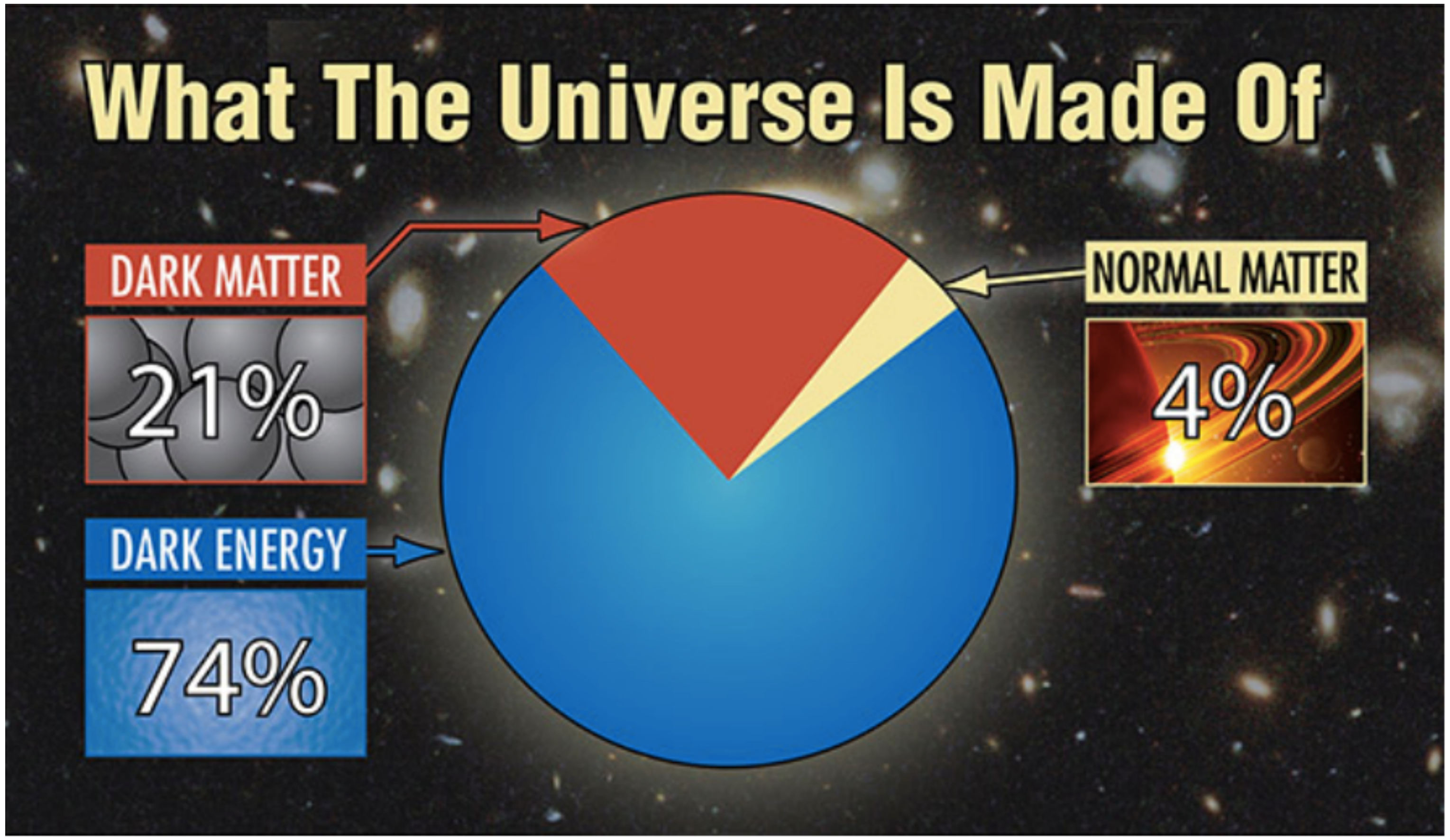




Nevertheless, important open questions in Particle Physics are still there

Open Questions

- Gravity is not included in the Standard Model
- Hierarchy problem for the 3 leptons/quarks families
- Asymmetry Matter vs Anti-matter
- Baryonic matter (atoms, nuclei) we know is only 4% of the Universe



The Dark Matter Problem

THE FATHER OF DARK MATTER—
AND MORE

The **DARK MATTER** problem has been with us **since 1930's**, name coined by Fritz Swicky in Helvetica Physica ActaVol6 p.110-127, 1933

Used the Virial theorem in the Coma Cluster: found its galaxies move too fast to remain bounded by the visible mass only

in the first 40 y his seminal paper had ONLY 10 citations!

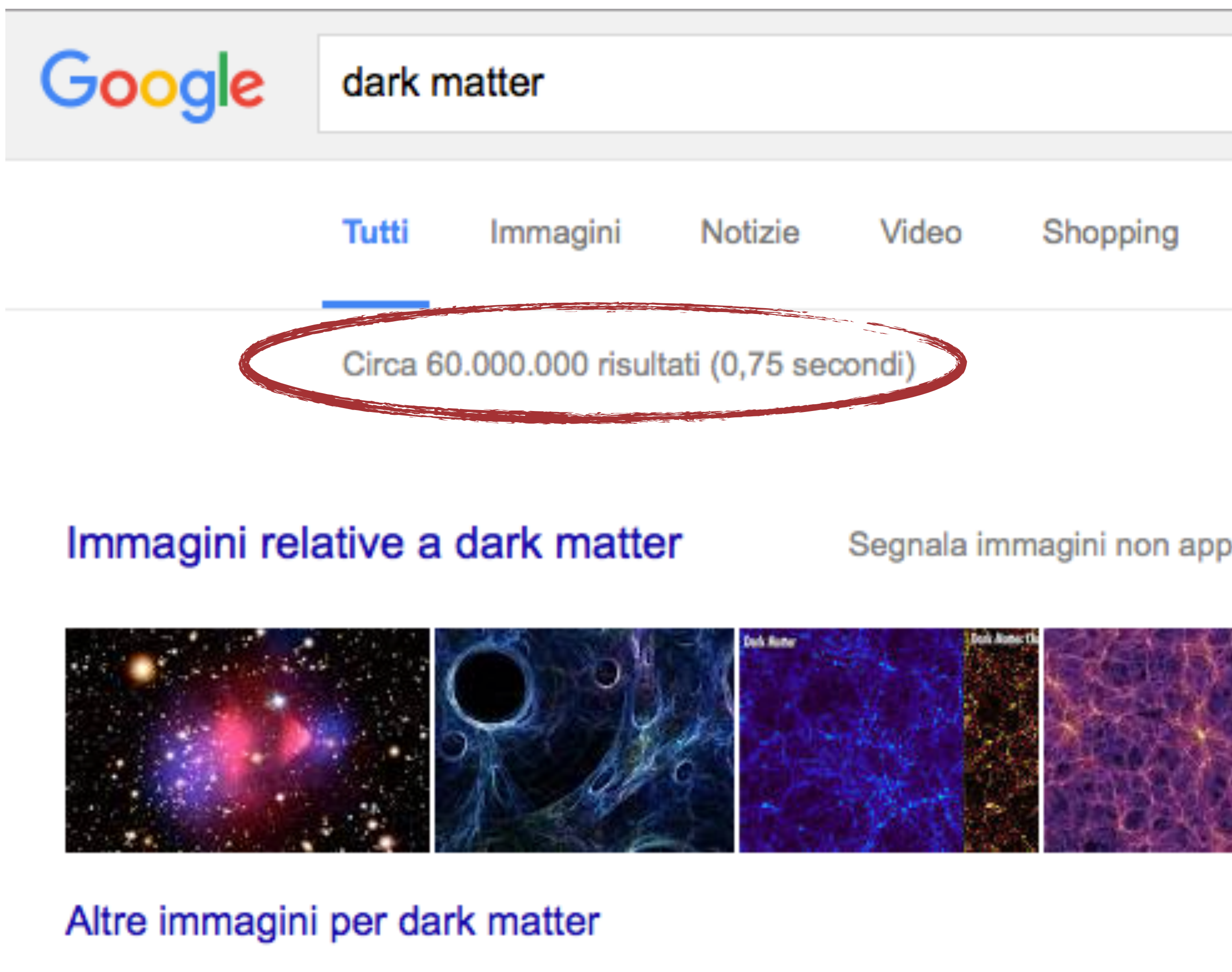
The Dark Matter Problem

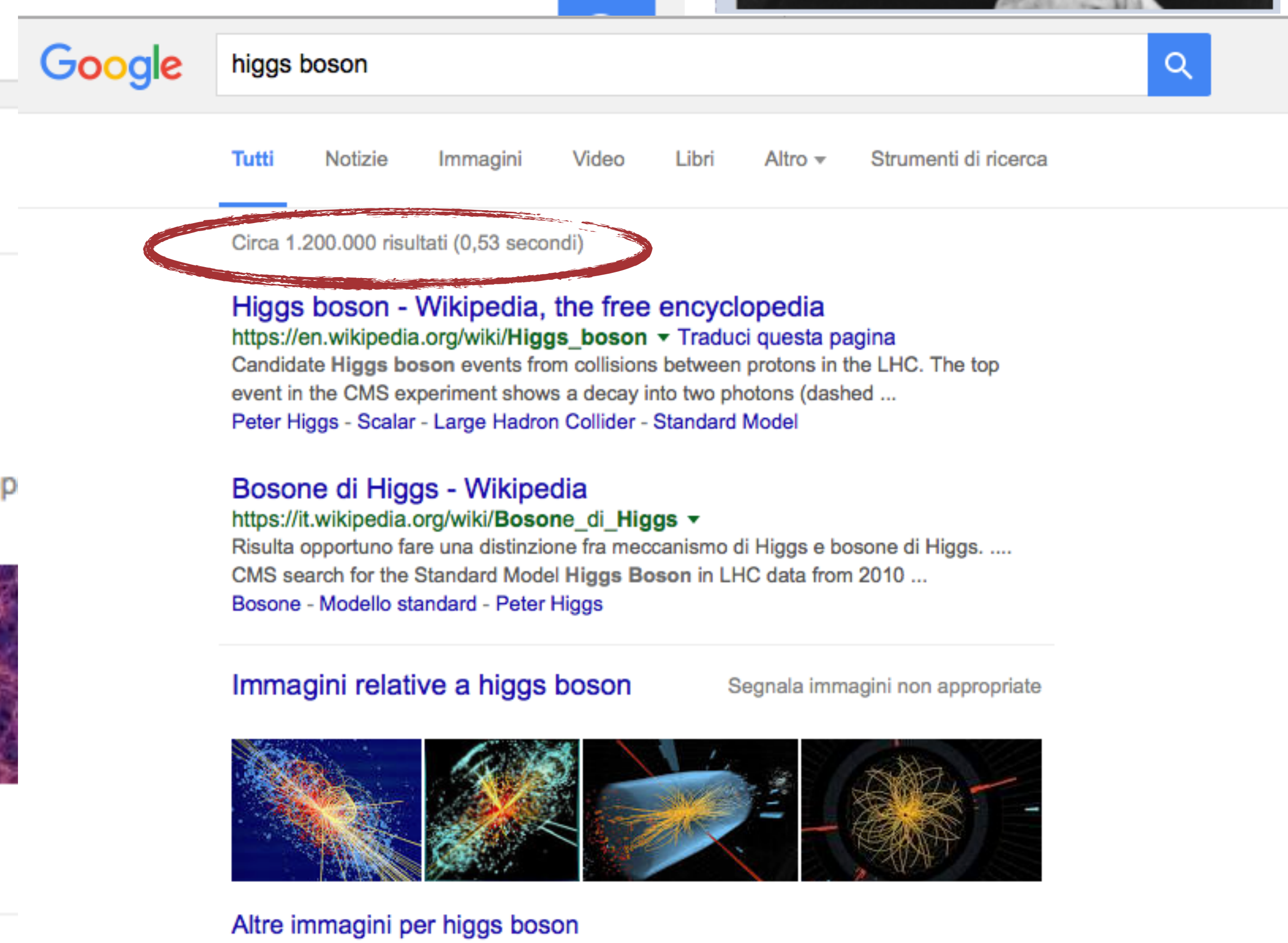
The **DARK MATTER** problem has been with us **since 1930's**, name coined by Fritz Swicky in Helvetica Physica ActaVol6 p.110-127, 1933

Used the Virial theorem in the Coma Cluster: found its galaxies move too fast to remain bounded by the visible mass only

in the first 40 y his seminal paper had ONLY 10 citations!

THE FATHER OF DARK MATTER—AND MORE





The Dark Matter Problem

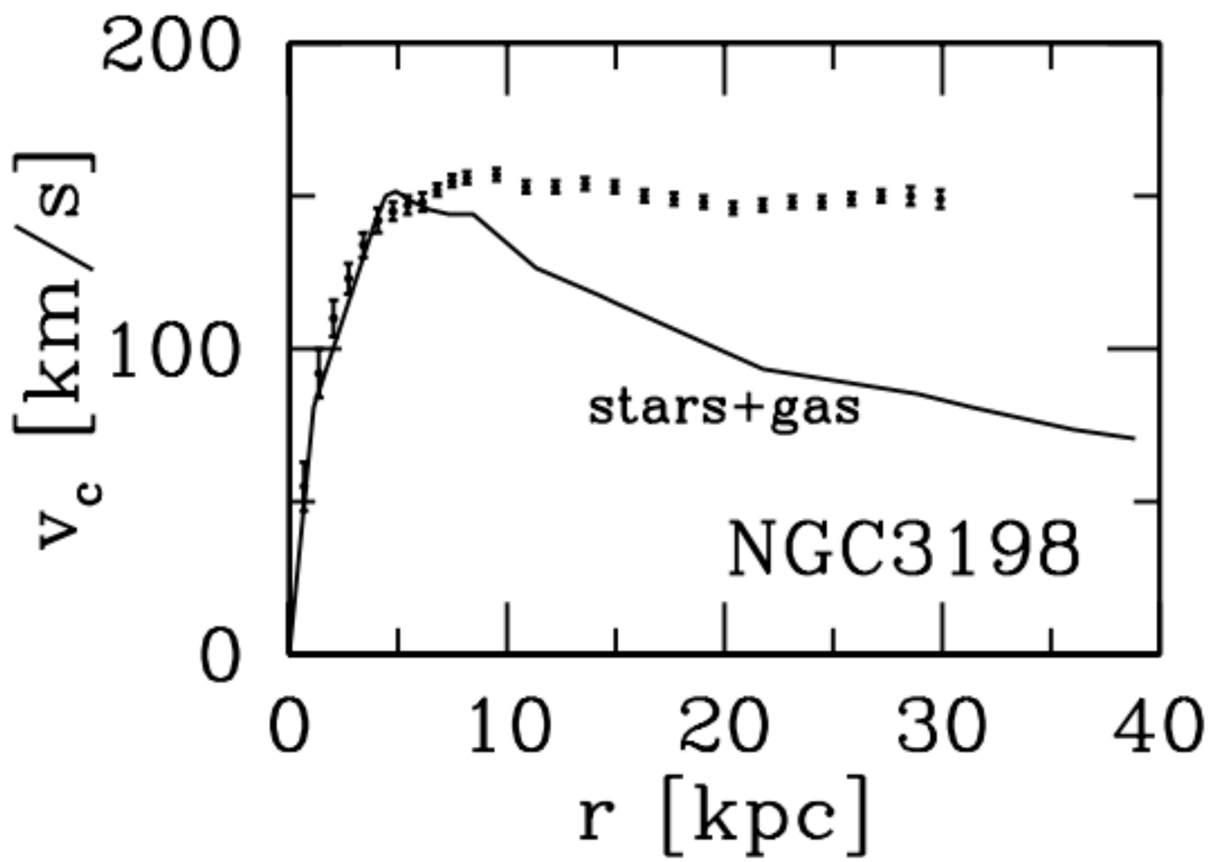
Dark Matter rediscovered

In 1970's Vera Rubin found that the rotation curves of galaxies ARE FLAT!

$$\frac{GMm}{r^2} = m\frac{v^2}{r} \Rightarrow v = \sqrt{\frac{GM(r)}{r}}$$

$$v = const. \Rightarrow M(r) \sim r$$

even where there is no light!



1 pc = 3.2 ℓy

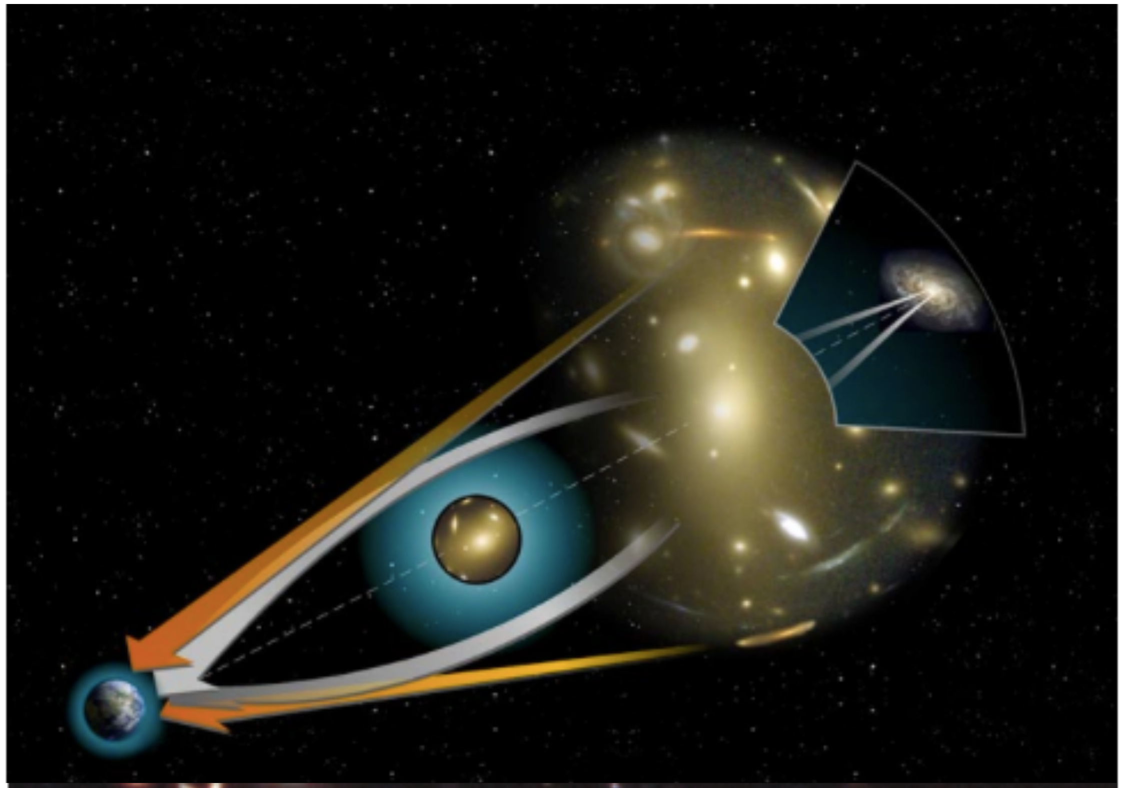
Dark Matter dominates in galaxies e.g. in NGC3198

$$M = 1.6 \times 10^{11} M_\odot (r/30\ \text{kpc})$$

$$M_{stars+gas} = 0.4 \times 10^{11} M_\odot$$

$$\frac{M}{M_{vis}} > 4$$

Other Evidences of Dark Matter



Many other phenomena confirm the presence of a large amount of Dark Matter in our Universe, among them:

- Gravitational Lensing
- Cosmic Microwave Background

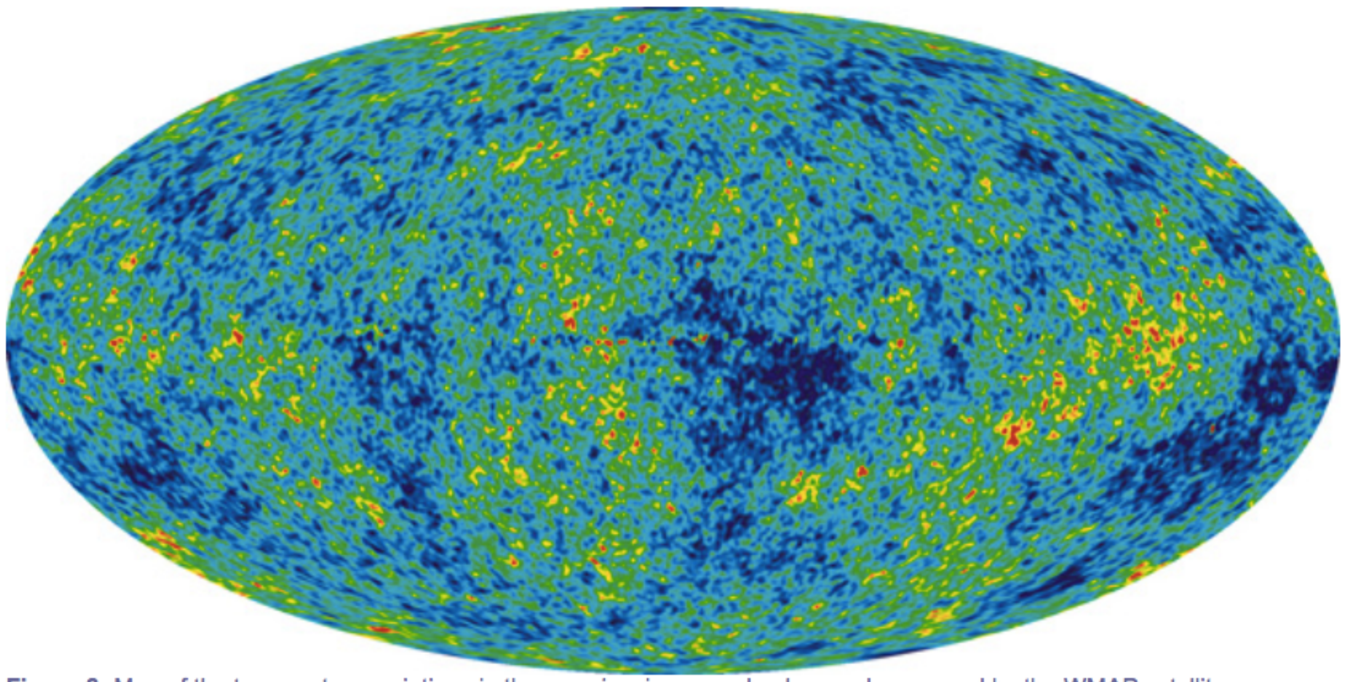
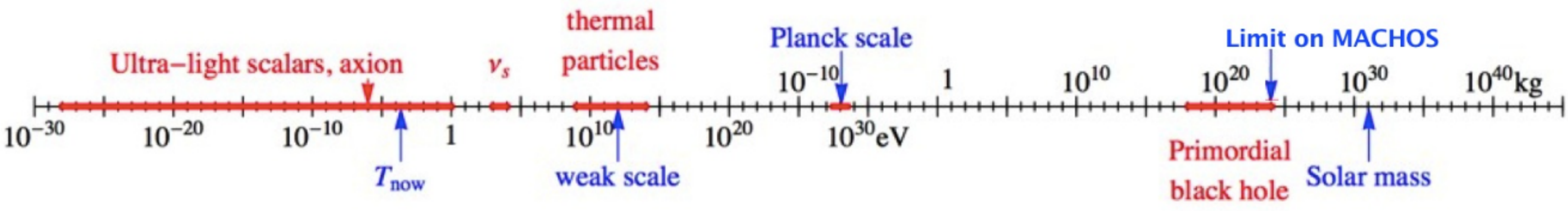


Figure 8: Map of the temperature variations in the cosmic microwave background measured by the WMAP satellite.
Source: © NASA, WMAP Science Team. More info

Search for Dark Matter

DM particle mass: 80 orders of magnitude!



10^{-31} GeV $\leq$**mass**$\leq 10^{-7} M_\odot = 10^{50}$GeV (limits on MACHOS astro-ph/0607207)

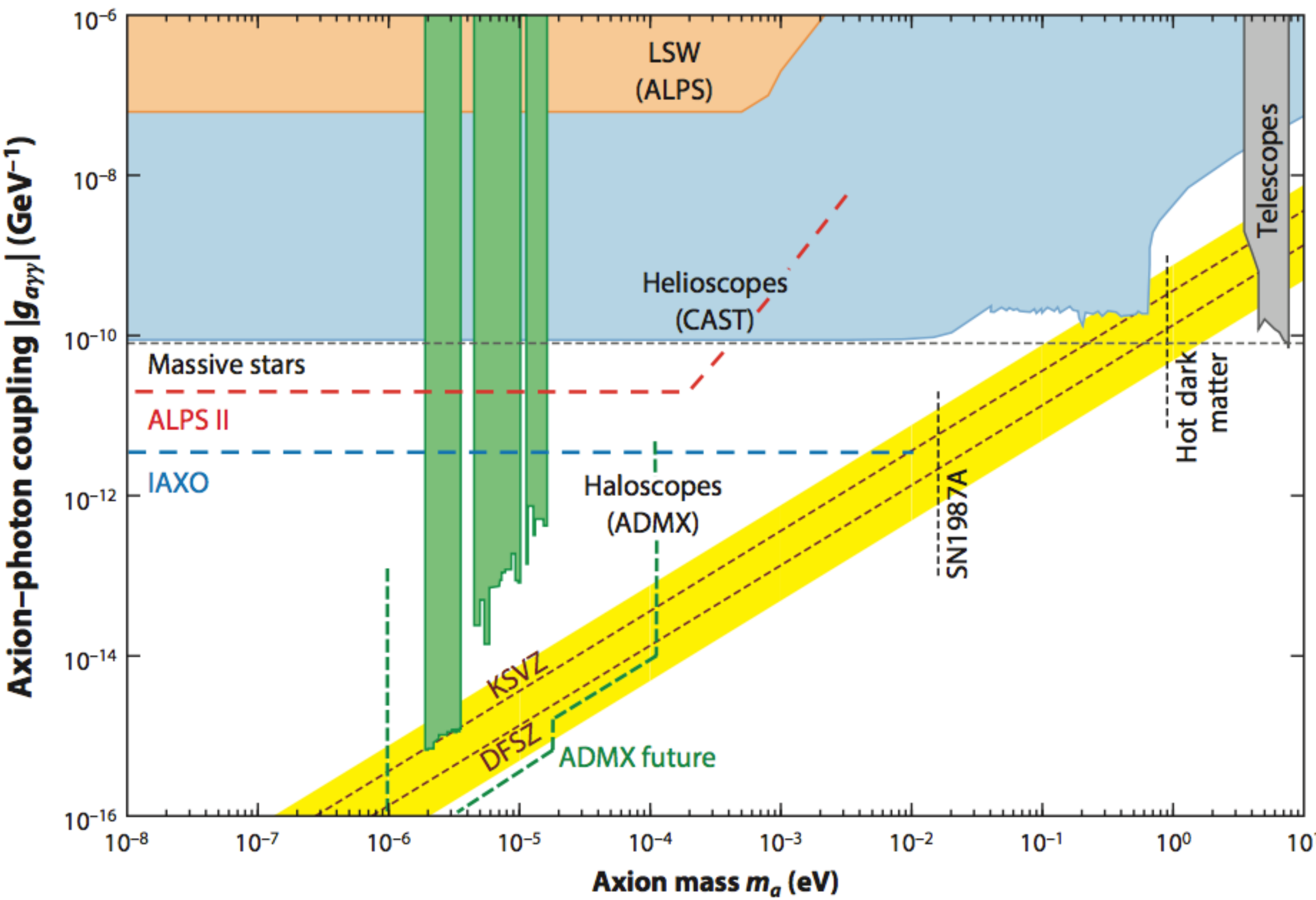
Axions: sub-eV weakly interacting particles called to solve the strong-CP problem

WIMPs: weakly interacting massive particles
M(wimp) up to 100 ÷ 1000 M(proton)
i.e. Supersymmetry Neutralinos

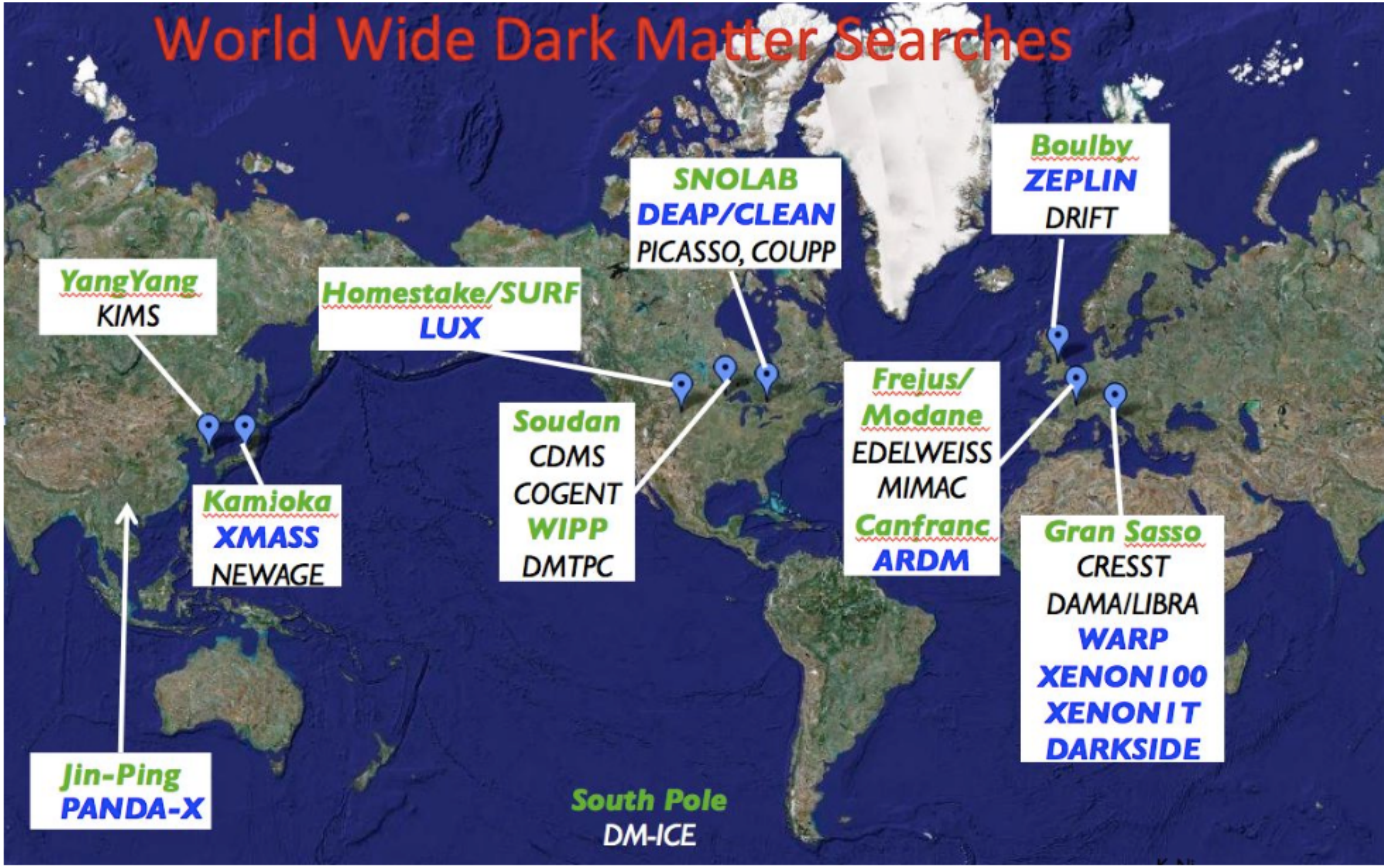
3 kind of searches :

- Direct Searches (Axions, WIMPS)
- Indirect Searches (astronomic searches)
- Searches at Accelerators (missing energy in collisions)

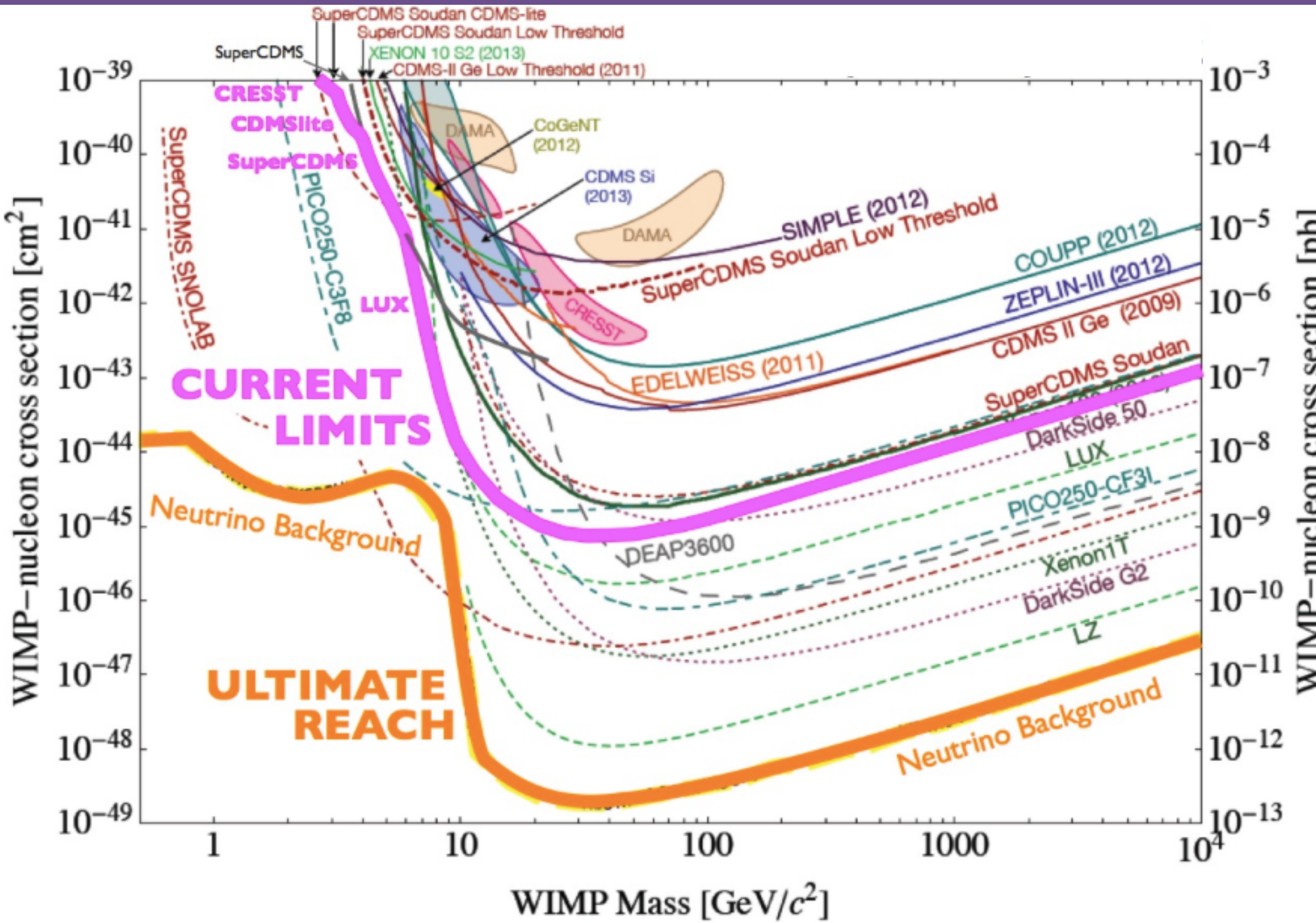
Search for Axions - Limits



Search for WIMPS



Search for WIMPS - Limits



NEW IDEAS for detecting DM

new ideas, cross-field Physics, different approaches and techniques
One Goal: exploring the unknown

This workshop will be focused on new ideas for detecting Dark Matter

- **STAX:** R&D recently approved by INFN for **Axions** detection
- **DCANT:** R&D recently approved by INFN for **WIMPs** detection
- **AXIOMA** and **QUAX**: new experiments for **Axions** detection
- **DarkSide:** running experiment for **WIMPs** detection

ideas at different stages: new concepts, starting experiments, consolidated experiments

STAX …

An improved detection scheme for Sub-THz Axion-like Particles

- new R&D approved by INFN (Pisa-Rome)
- Transition Edge Sensors (TES) as Axion detector

New proposal in start up within the collaboration of NEST and CNR

- Exploring new directions to find new Physics
- People from different scientific background
- Particle Physics meets Quantum Technologies
- Cross-Field expertise to have a global view and build up a new approach

3 presentations related to STAX

- **phenomenology and experiment proposal (Polosa)**
- **TES detectors (Gatti)**
- **NEST cryogenic activities (Giazotto)**

… and our Guests

DCANT (Cavoto)
- a new method for directional WIMPs detection with carbon nanotubes

Axioma and QUAX (Carugno)
- new techniques for Axions detection

DarkSide (Galbiati)
- Underground Liquid Argon TPC experiment at Gran Sasso

New Ideas for Detecting Dark Matter

Wednesday, 24 February 2016 from **09:00** to **13:15** (Europe/Zurich)

Pisa, Scuola Normale Superiore (Sala Azzurra)

Manage

Wednesday, 24 February 2016

09:00 - 09:10	Welcome *10'* Speaker: Prof. Vincenzo Barone (Scuola Normale Superiore, Pisa)
09:10 - 09:25	Introduction *15'* Speaker: Paolo Spagnolo (Universita di Pisa & INFN (IT))
09:25 - 09:50	STAX: a new proposal for detecting ALPS *25'* Speaker: Antonio Polosa (Universita' La Sapienza, Roma - Italy)
09:50 - 10:15	Status of the art of the TES detectors *25'* Speaker: Flavio Gatti (University and INFN of Genova)
10:15 - 10:40	Mesoscopic superconductivity and quantum transport at NEST CNR Nano Lab *25'* Speaker: Francesco giazotto (CNR-NEST)
10:40 - 11:00	Coffee Break
11:00 - 11:25	DCANT: Directional WIMP detection with carbon nanotubes *25'* Speaker: Gianluca Cavoto (Universita e INFN, Roma I (IT))
11:25 - 11:50	Axioma and Quax: new techniques for Axions detection *25'* Speaker: Giovanni carugno (Universita' degli Studi di Padova)
11:50 - 12:15	The DarkSide experiment for WIMPs Detection *25'* Speaker: Cristiano Galbiati (Princeton University)
12:15 - 12:45	Open discussion