



DAMARA

The beginning of experimental Dark Matter research in Norway ...

Outline of this talk

- Introduction to Dark Matter
- Project plan and organisation
- Project team and organisation
- What we have worked on the first 18 months of the project
- Summary of research results so far
- Future prospects and conclusion

A deep space photograph showing a vast field of stars against a black background. The stars vary in brightness and color, with some appearing as distinct points of light and others as faint, diffuse clouds. A prominent, bright yellow-orange star is located near the center of the image. The text 'Introduction to Dark Matter' is overlaid in the center in a white, sans-serif font.

Introduction to Dark Matter

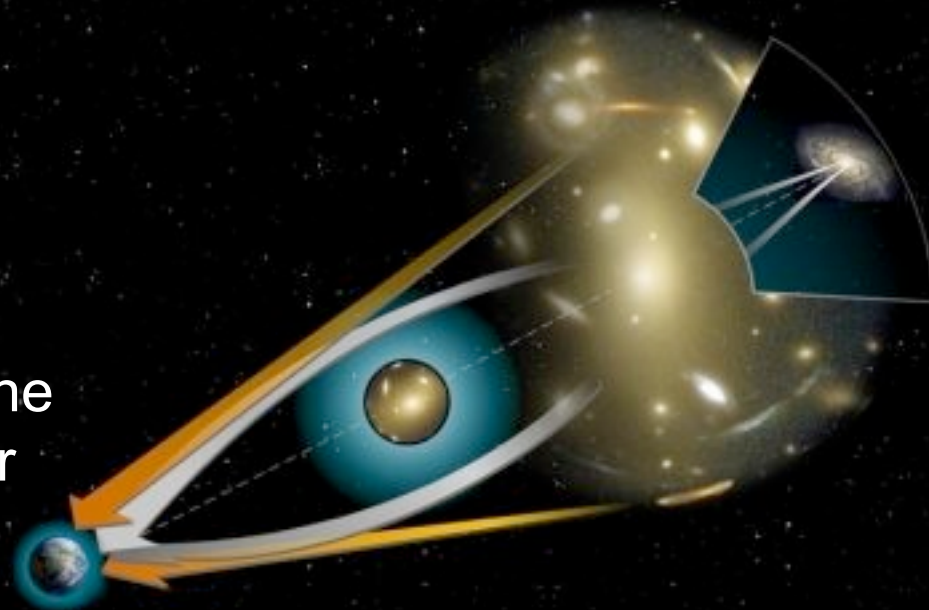
Observational evidence of Dark Matter



Picture of the galaxy cluster ZwCl0024+1652, 5 billion light years away, showing one of the strongest evidence for dark matter !



Pictures from the Hubble telescope
Gravitational lensing makes the galaxies appear as disks



Observational evidence for Dark Matter

No doubt that dark matter exists - there is a multitude of direct observational evidence (since the 1930s):

- Galactic rotational curves
- Velocity dispersion of galaxies
- Galaxy clusters and *gravitational lensing*
- Cosmic microwave background
- Sky surveys and baryon acoustic oscillations



Fritz Zwicky

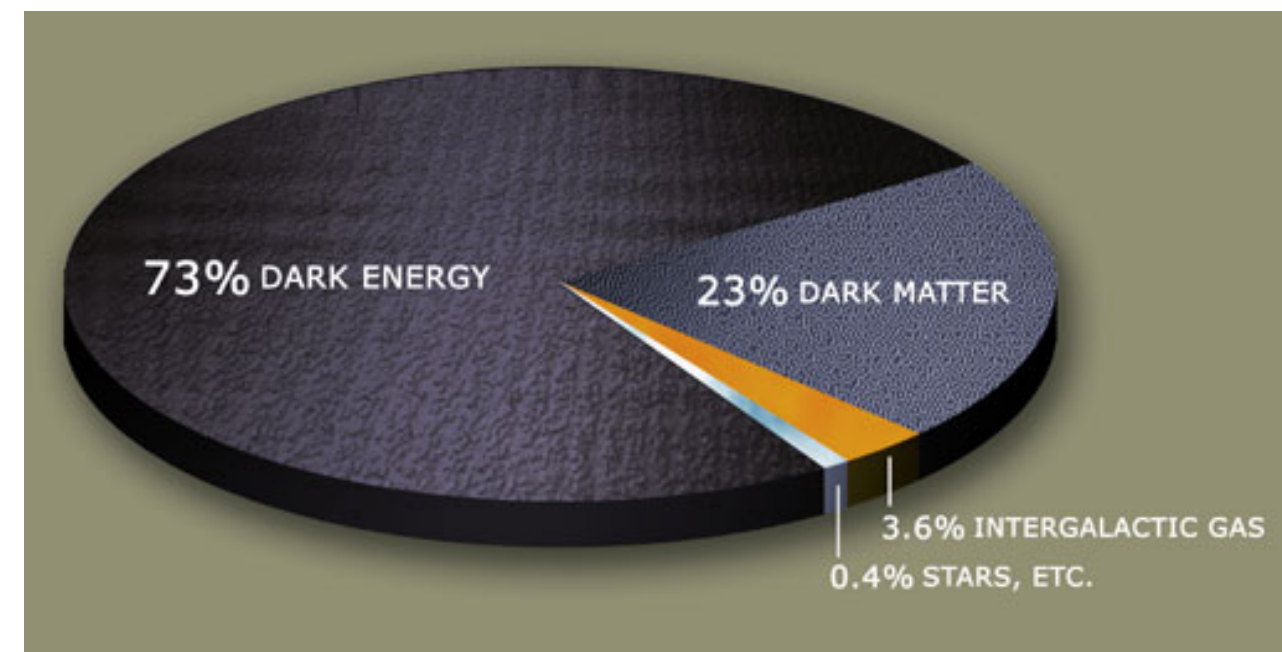


Vera Rubin

Studies of the universe show that it consists of :

- 4 % matter
- 23 % dark matter
- 73 % dark energy

DARK MATTER IS THE NAME ONE HAVE GIVEN TO THE EXTRA MASS OBSERVED IN THE UNIVERSE - ASSUMING THAT OUR UNDERSTANDING OF GRAVITY IS CORRECT



What can dark matter be?

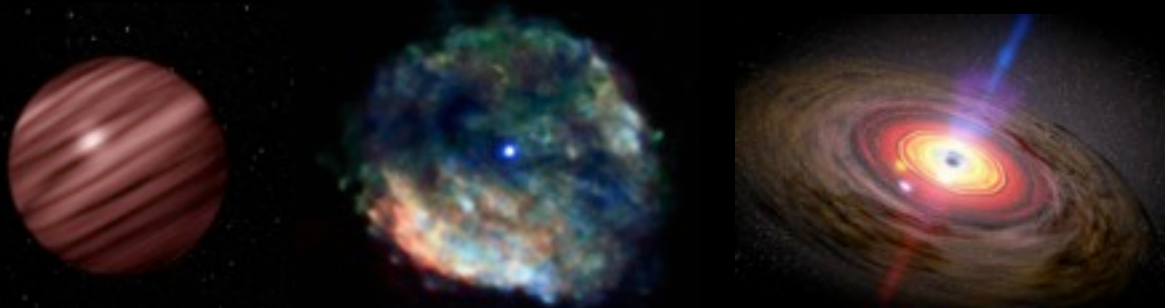
DIFFERENT THEORIES

Multitude of models providing candidates as to what dark matter could be,
from astrophysics, cosmology and particle physics

MACHOS

Massive, Compact Halo Objects

Brown dwarfs Neutron stars Black holes



→ not likely to account for
more than a small fraction

→ not likely to clump
as DM do

WIMPS

Weakly Interactive Massive Particles

Known particle

Neutrino



Unknown particle !

Supersymmetry

...

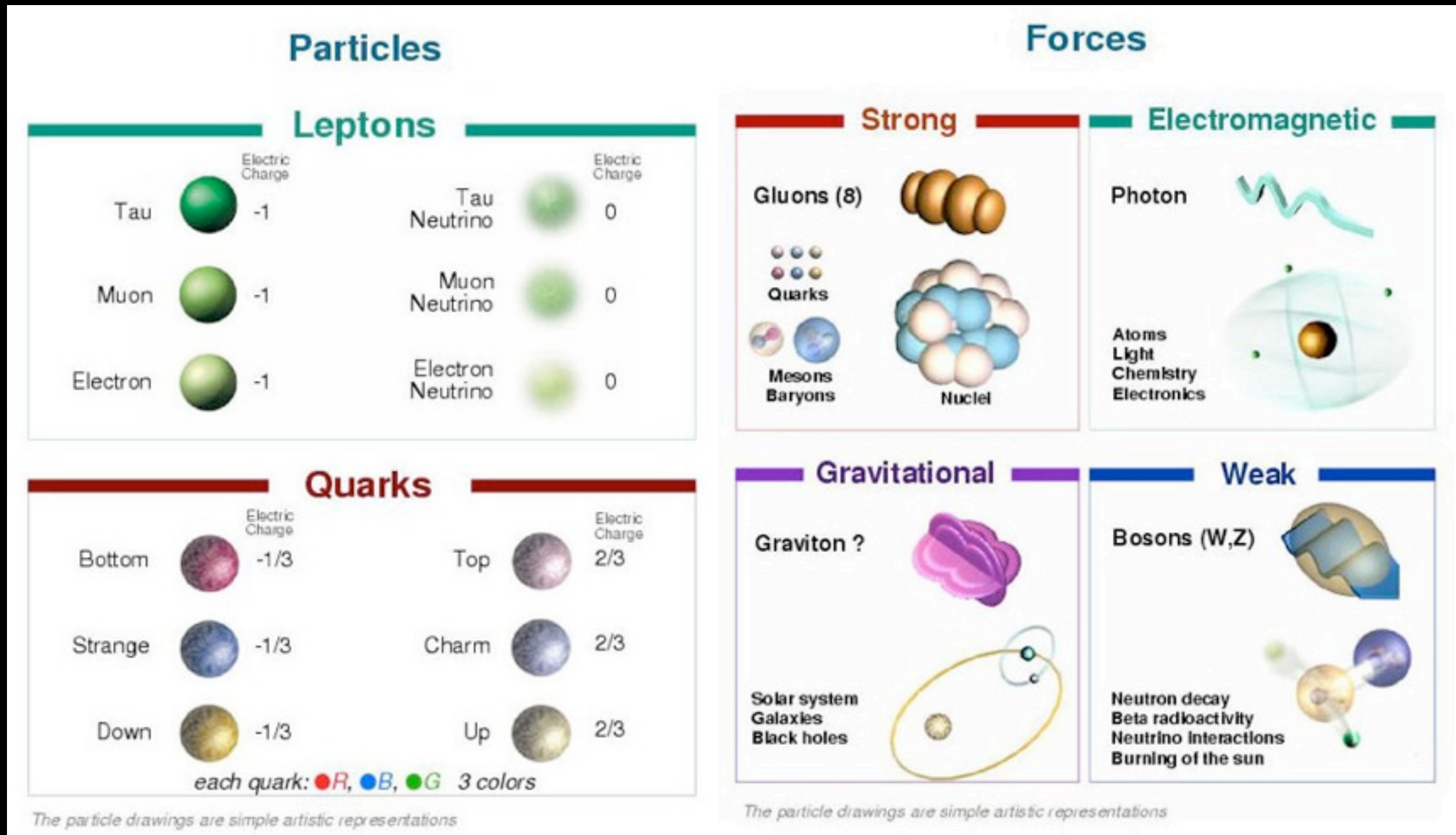
→ DM
candidates !

→ DM
candidates

WE NEED TO LOOK FOR NEW PHYSICS BEYOND THE STANDARD MODEL !

What can we learn from Dark Matter ?

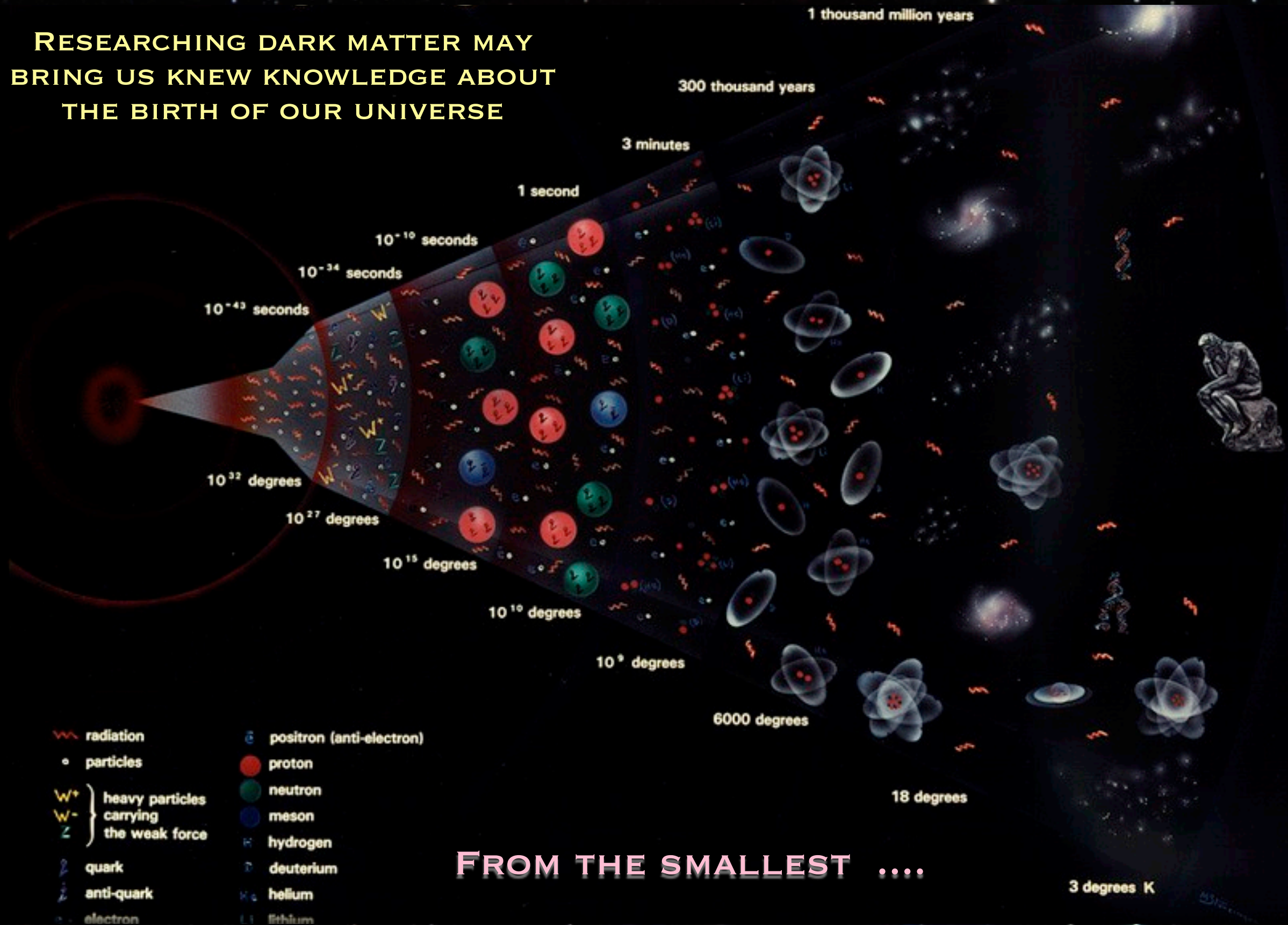
ALL WE KNOW ABOUT MATTER IS DESCRIBED BY THE STANDARD MODEL
- MEASURED WITH EXTRAORDINARY PRECISION



BUT TO EXPLAIN DARK MATTER THERE MOST LIKELY MUST BE MORE
NEW PHYSICS IS NEEDED

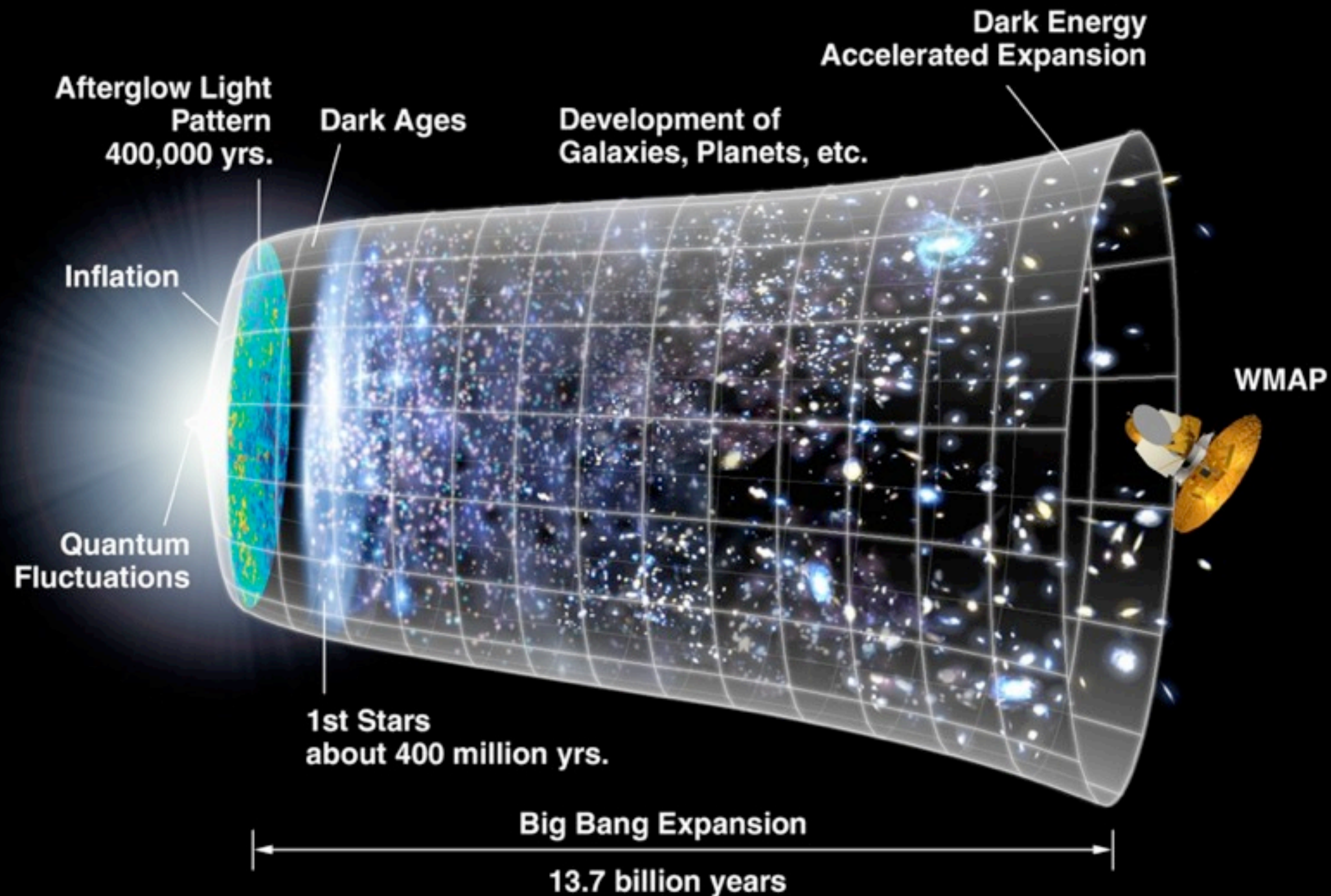
Particle physicists view of the Big Bang

RESEARCHING DARK MATTER MAY
BRING US NEW KNOWLEDGE ABOUT
THE BIRTH OF OUR UNIVERSE



Astrophysicist view of the Big Bang

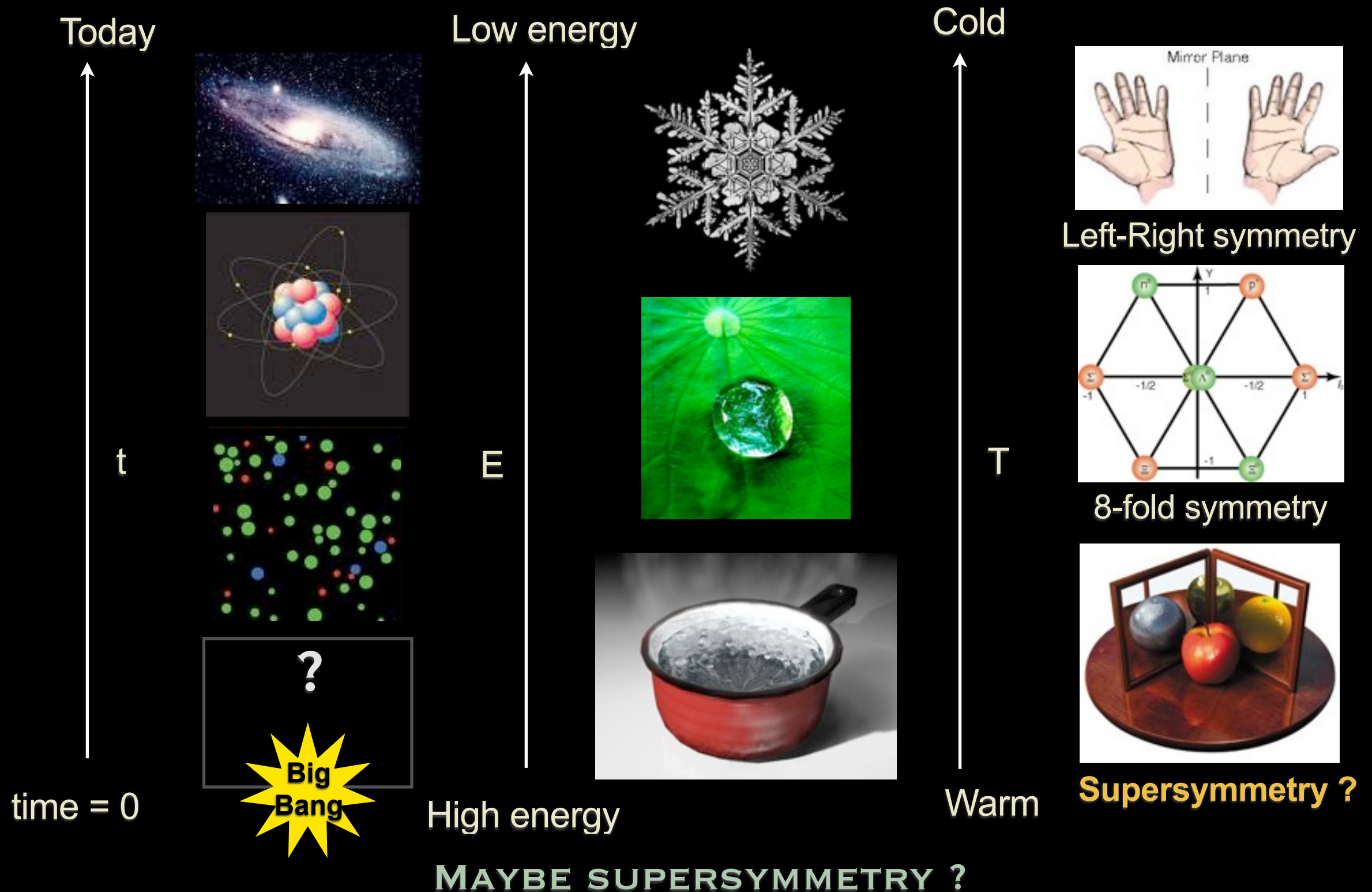
.... TO THE BIGGEST !



**DARK MATTER PLAYS A CENTRAL ROLE IN THE MODELING OF
STRUCTURE FORMATION AND THE EVOLUTION OF GALAXIES**

Possible new physics

NEW STATES AND NEW SYMMETRIES COULD HAVE EXISTED JUST AFTER THE BIG BANG



Supersymmetry

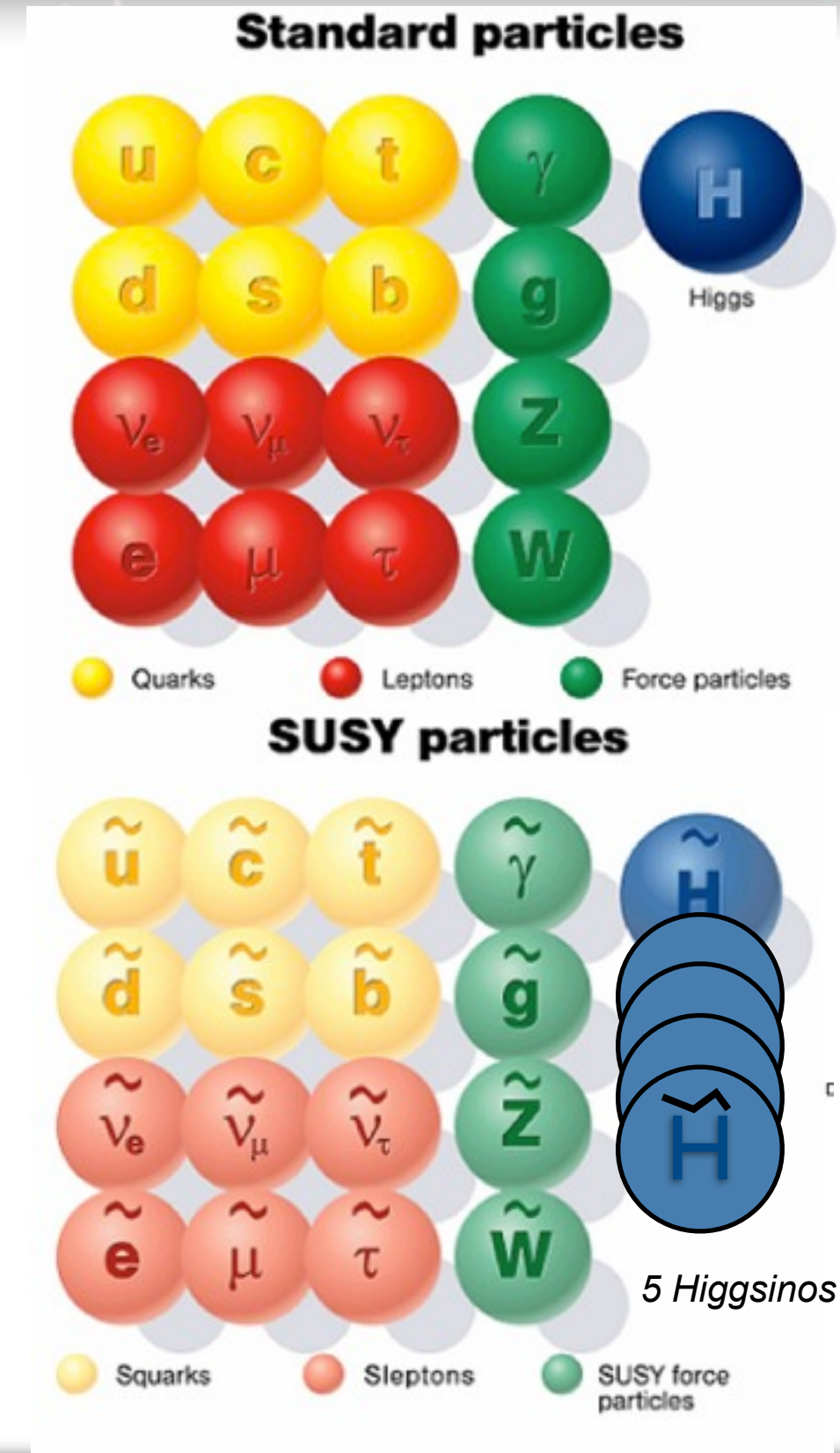
A very attractive model to explain the caveats of the SM

- Hierarchy problem is solved
- Natural cancellations of corrections to the Higgs mass
- Unification of the three gauge couplings at the GUT scale
- **And it provides three Dark Matter candidates !**
 - **Sneutrino** - spin 0 (largely excluded)
 - Lightest **neutralino** - spin 1/2 (WIMP candidate)
 - **Gravitino** - spin 3/2 (Gravitationally interacting)

What is Supersymmetry

- Each SM particle has a superpartner providing boson \leftrightarrow fermion symmetry
- All internal quantum numbers are the same but with different spin (differs by 1/2 unit)
- No SUSY particles observed so far \rightarrow SUSY must be broken and sparticle masses high
 - \rightarrow breaking mechanism determines phenomenology

→ **More on Supersymmetry in Jan's talk**



How to detect Dark Matter

- DM accounts for the additional gravitational effects observed in the universe
- DM interacts only weakly with regular matter
- DM also interact with other dark matter particles only through gravity

THIS MAKES DARK MATTER VERY HARD TO DETECT AND STUDY !

LHC

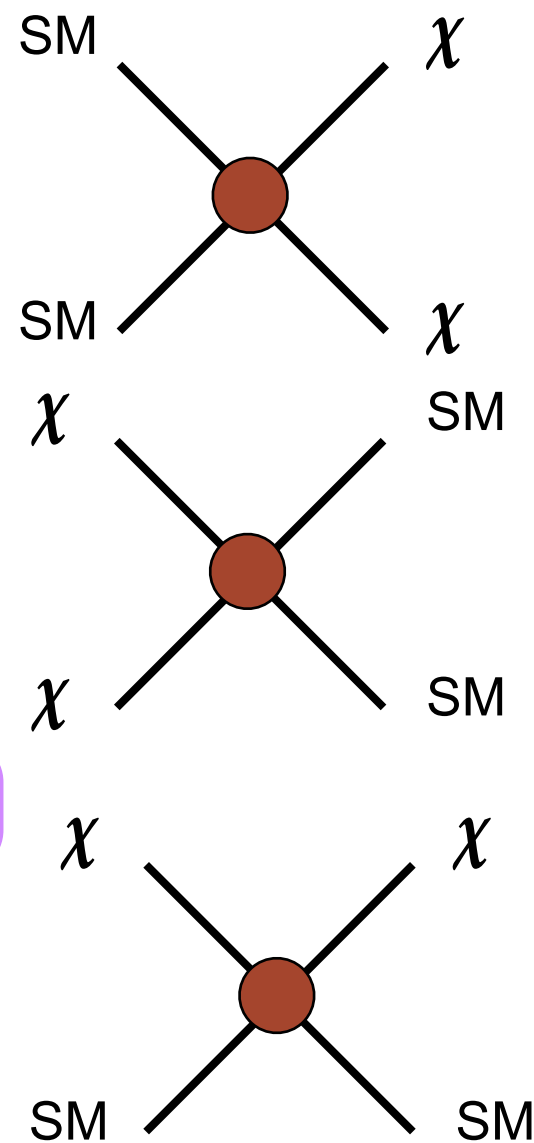
Direct production made in high energy laboratories on earth
(e.g. CERN, **LHC / ATLAS**, Tevatron)

→ *More on ATLAS in Ørjan's talk*

Indirect searches for the products of dark matter particle annihilation
(e.g. **CTA**, IceCube, GLAST-FERMI, EGRET)

→ *More on CTA in Trygve's talk*

Direct searches for the atom recoil energy when a WIMP is passing
(e.g. DAMA, CDMS, Xenon-10)



GLAST-FERMI



CDMS

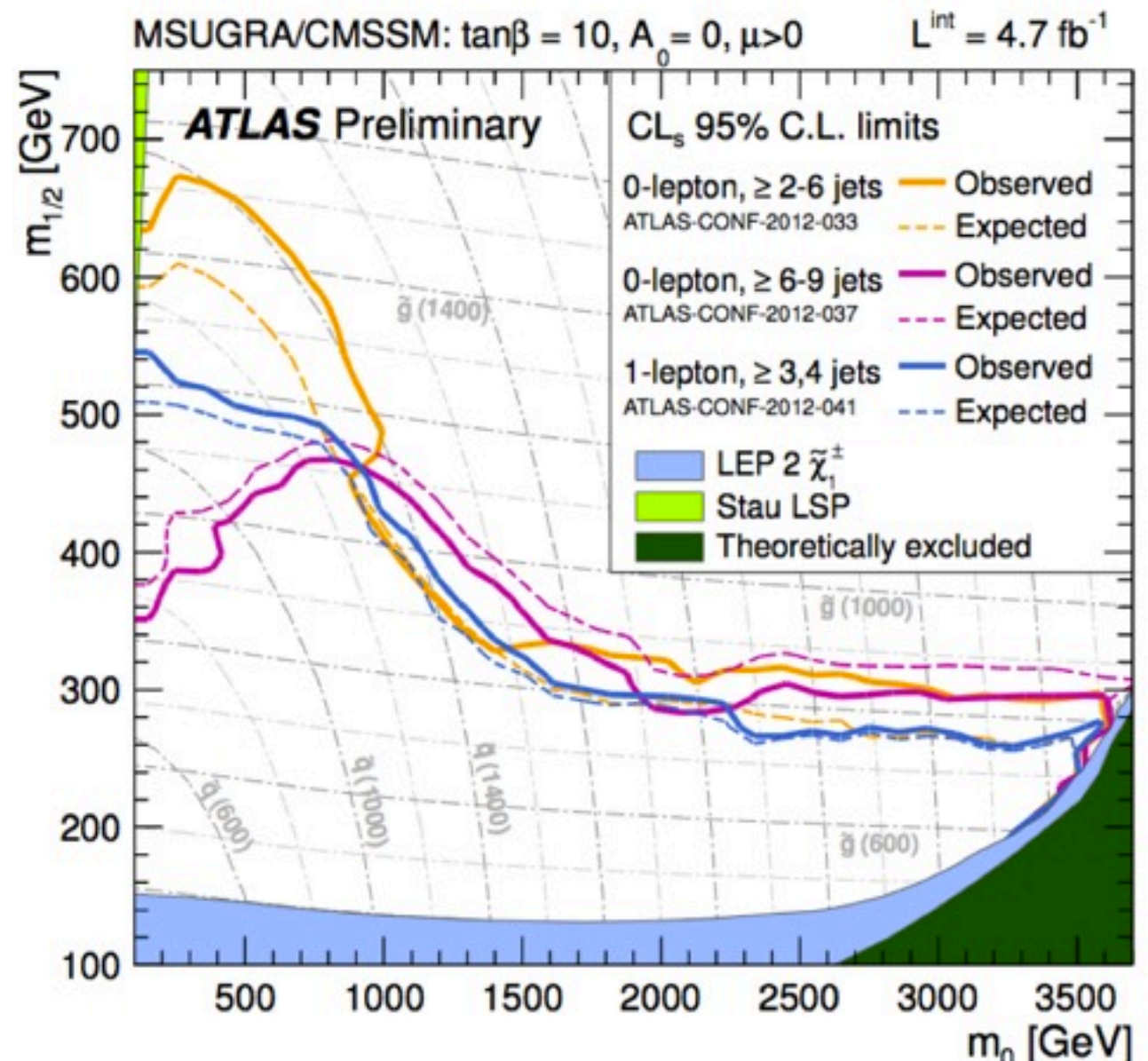
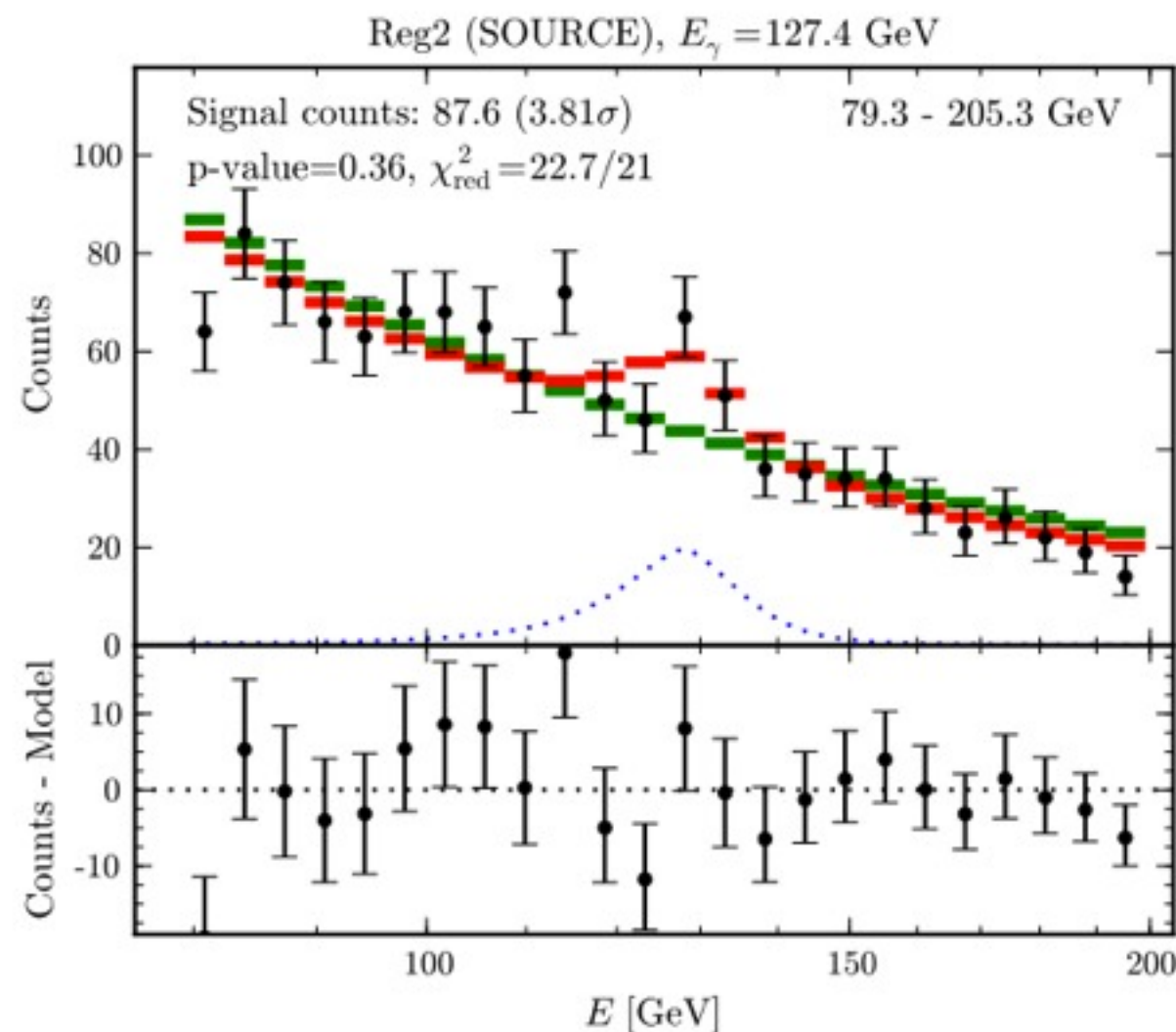
Latest news about Dark Matter

News from LHC

A new boson, probably Higgs is found

Supersymmetry is increasingly excluded in various limits in various models

No sign of Dark Matter signals in model “independent searches” like monojets and monophotons



News from Fermi

Intriguing signal at 130 GeV found by several teams, Fermi will recalibrate and perform a new search for this gamma emission line

A deep space photograph showing a vast field of stars against a black background. The stars vary in brightness and color, with some appearing as sharp points of light and others as soft, glowing clouds. A prominent, bright yellow-orange star is located near the center of the image. The text "Project plan and organisation" is overlaid in a white, sans-serif font, centered horizontally and slightly above the vertical center.

Project plan and organisation

Main research goals - from proposal

ESTABLISH AND OPERATE A CENTRE FOR DARK MATTER RESEARCH AT UIB (THE FIRST IN NORWAY)

- Study dark matter and its properties
- Participate in the discovery of new particles which may be dark matter candidates
- Develop improved detectors to study these particles
- Diversify our knowledge and research interdisciplinary applications
→ medical imaging, space applications

BE PART OF THE EUROPEAN RESEARCH ON DARK MATTER

PROJECT DELIVERABLES

- 2 PhD thesis
- Membership in astroparticle physics experiments
- Specialised analysis software and analysis methods
- Detector/application prototypes

Why do we want to research Dark Matter?

- **Dark matter is one of the biggest unsolved mysteries of the Universe**
- It may be one of the major physics discoveries of our time !
- Even if not found the research will be ground-breaking
- LHC is currently on the verge of important discoveries of dark matter
- Crucial astroparticle physics experiments are or will soon deliver new unique data
- There is a huge research potential in combining results from LHC with the results from astroparticle and astrophysics
- Norwegian scientists are in a very good position to contribute significantly to dark matter research
- University of Bergen has a unique chance to take a leadership position in this research field in Norway

DISCOVERIES ARE JUST AROUND THE CORNER
EXITING TIMES FOR DARK MATTER RESEARCH!

Something old, something new and something blue ...

About the grant

- High level of scientific quality by international standards
- Team work is important and are looking for team players
- Opportunity for the team to work towards international excellence
- Long term investment



PL recipe for getting the grant (here it is !)

- Build the foundation of the group in research which we are familiar with and where we have good chances to succeed internationally → **ATLAS, LHC**
- Make something new to try to become excellent. Providing new research or combining research in new ways → **Combining astroparticle physics and particle physics in Norway**
- The future potential in Bergen is particularly high on the detector side, where synergies between the groups can give positive long term outcome → **Detector development**
- Take a bit of risk !

= A NORWEGIAN DARK MATTER CENTRE!

Project work

Work-package 1:

LHC study of Dark Matter candidates (ATLAS)
(1 PhD + 1/2 postdoctor)

Work-package 2:

Astroparticle study of Dark Matter candidates (CTA)
(1 PhD + 1/2 postdoctor)

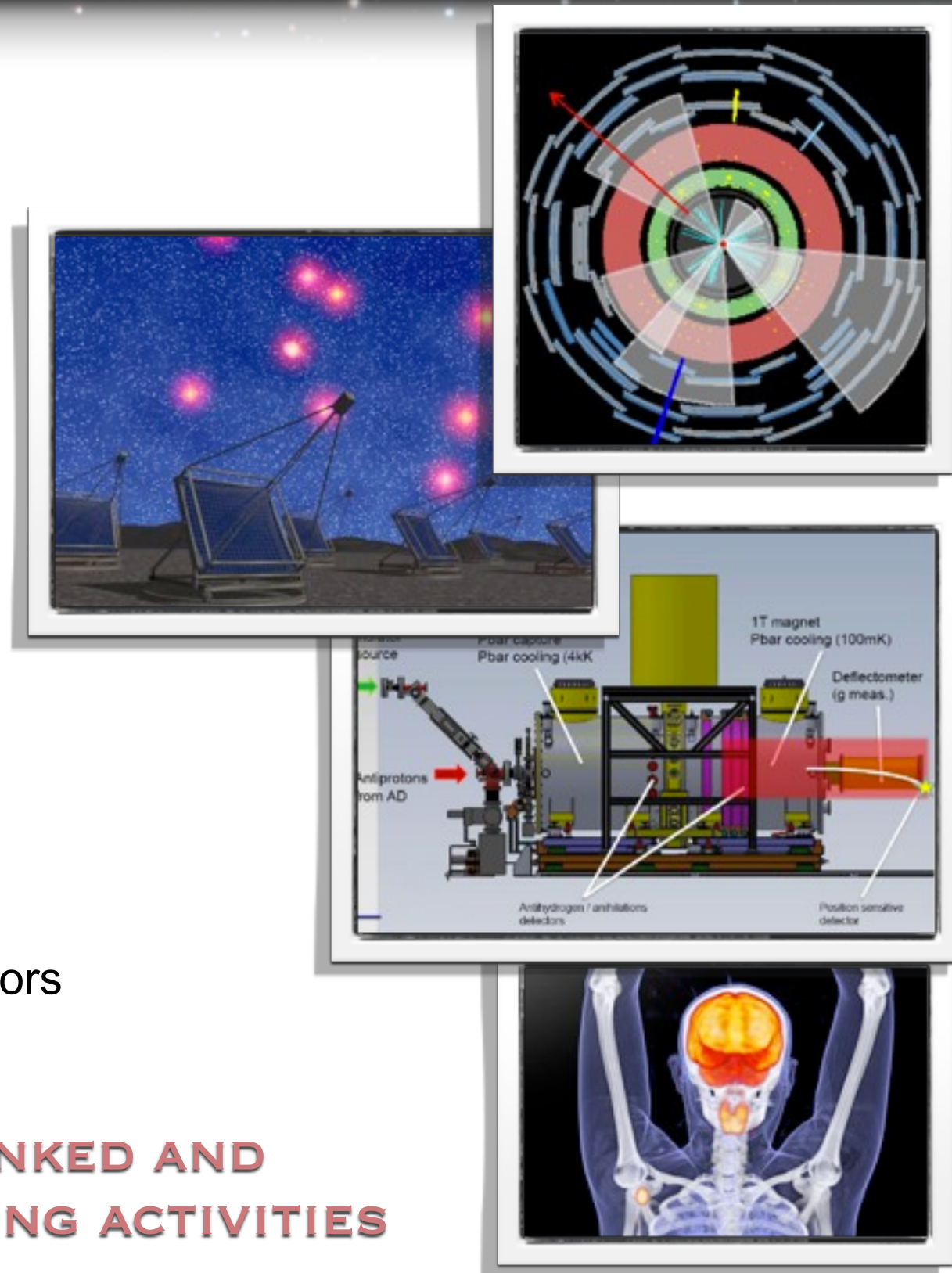
Work-package 3:

Particle detector upgrade for dark matter detection
(ATLAS upgrade, AEgIS and CTA)
(1 PhD + 1 postdoctor)

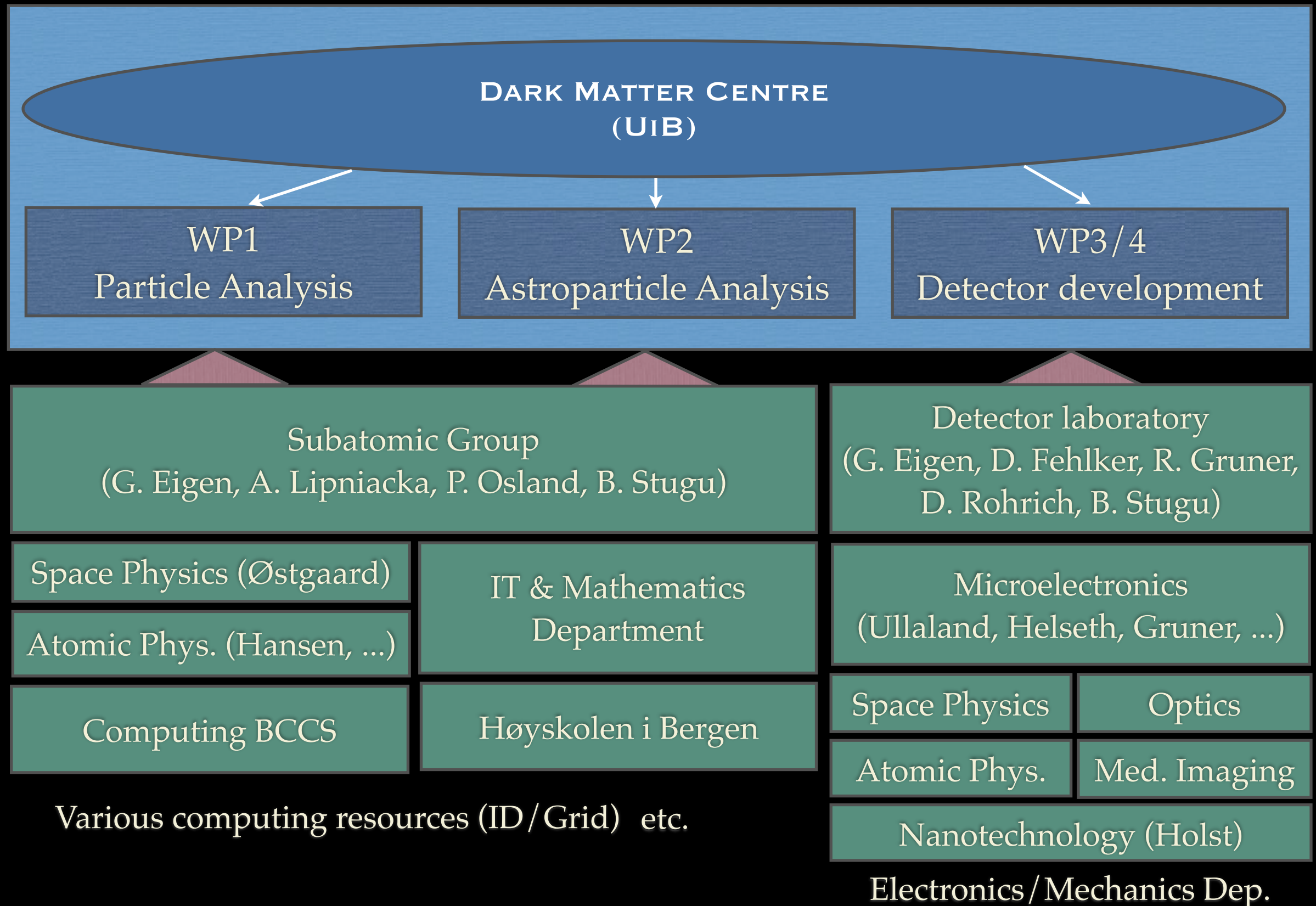
Work-package 4:

New applications for particle and astroparticle detectors
(Masters)

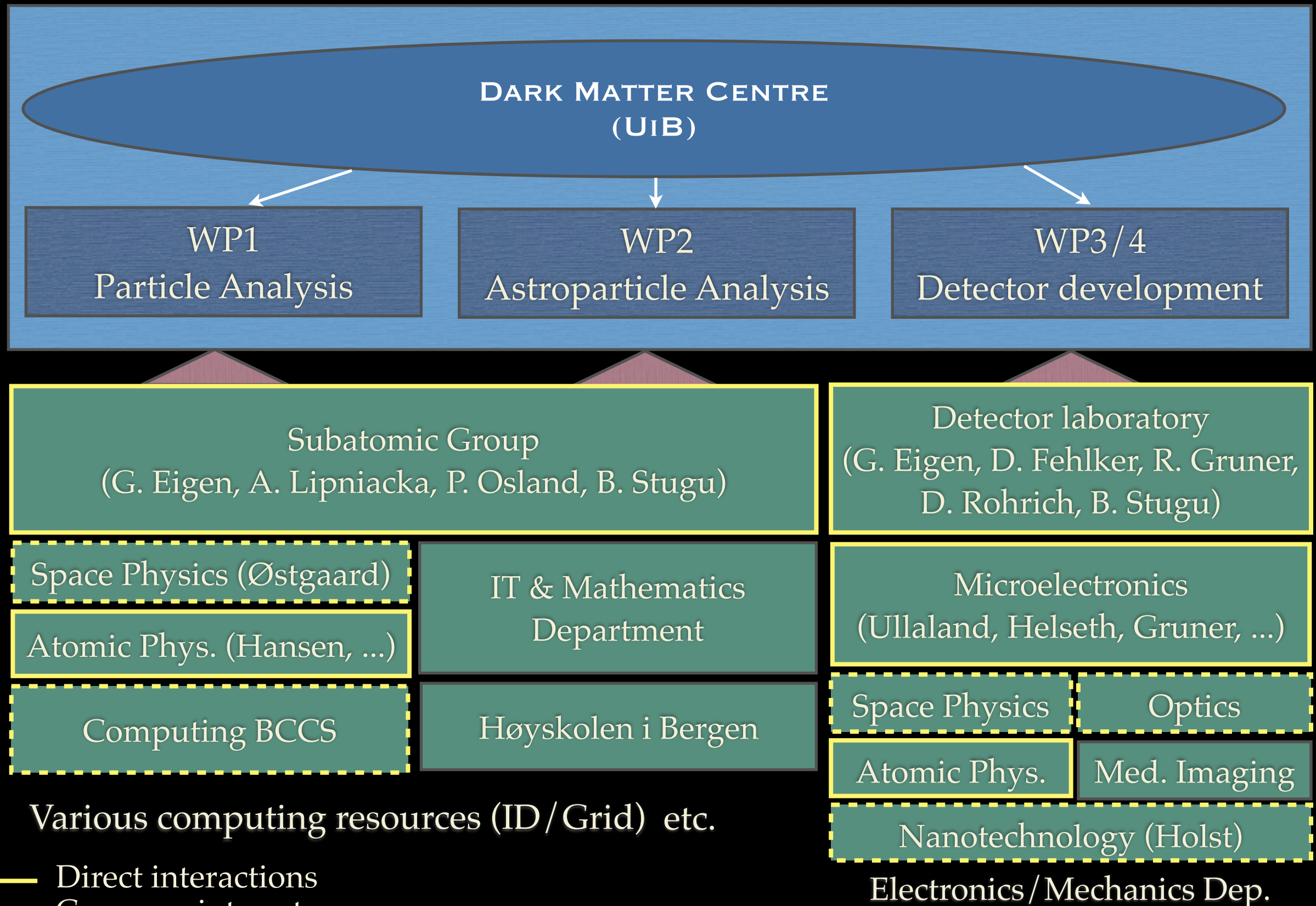
**ALL WORK-PACKAGES ARE INTERLINKED AND
STRENGTHEN AND COMPLEMENT EXISTING ACTIVITIES**



Integration at UiB

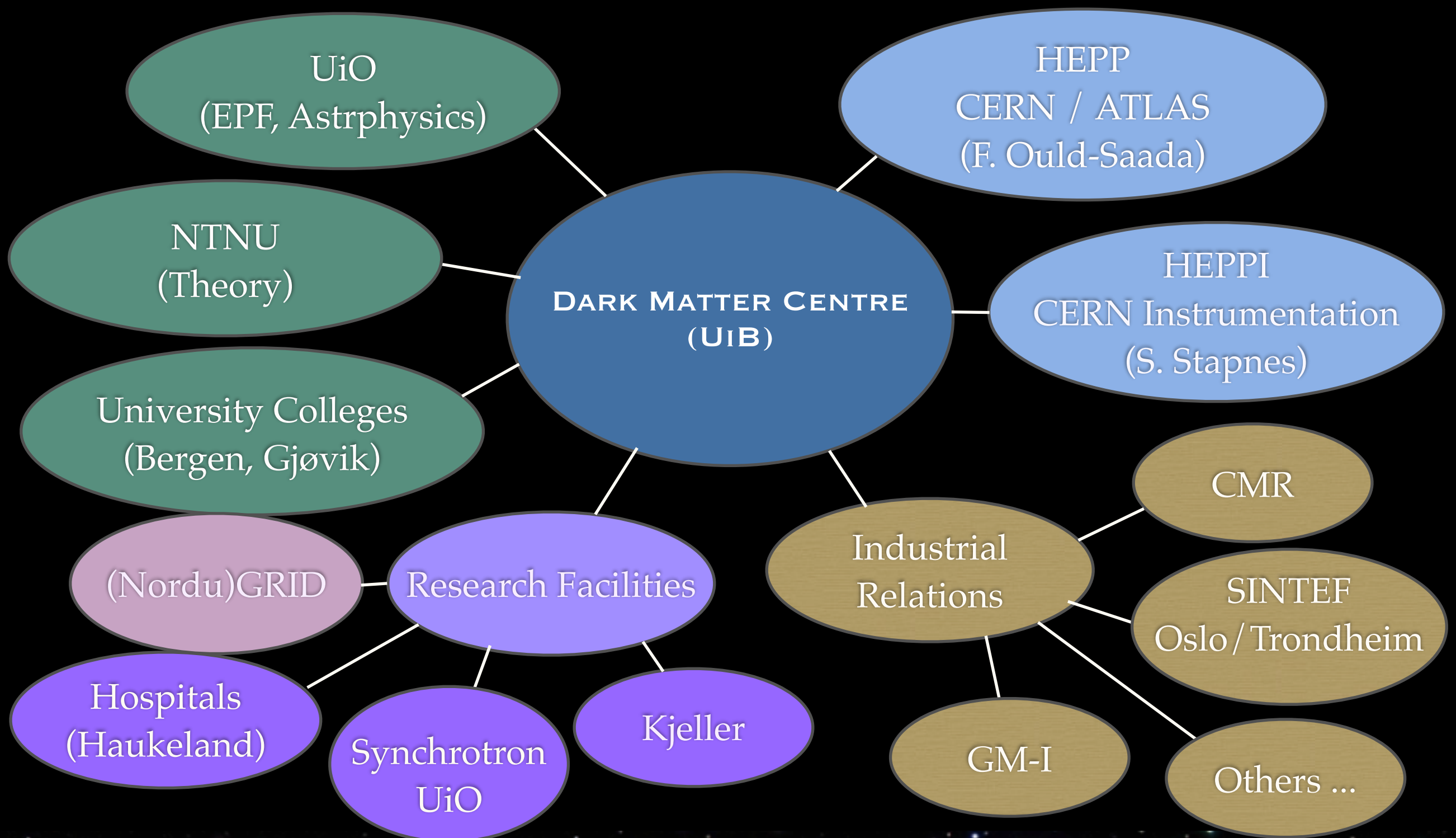


Integration at UiB



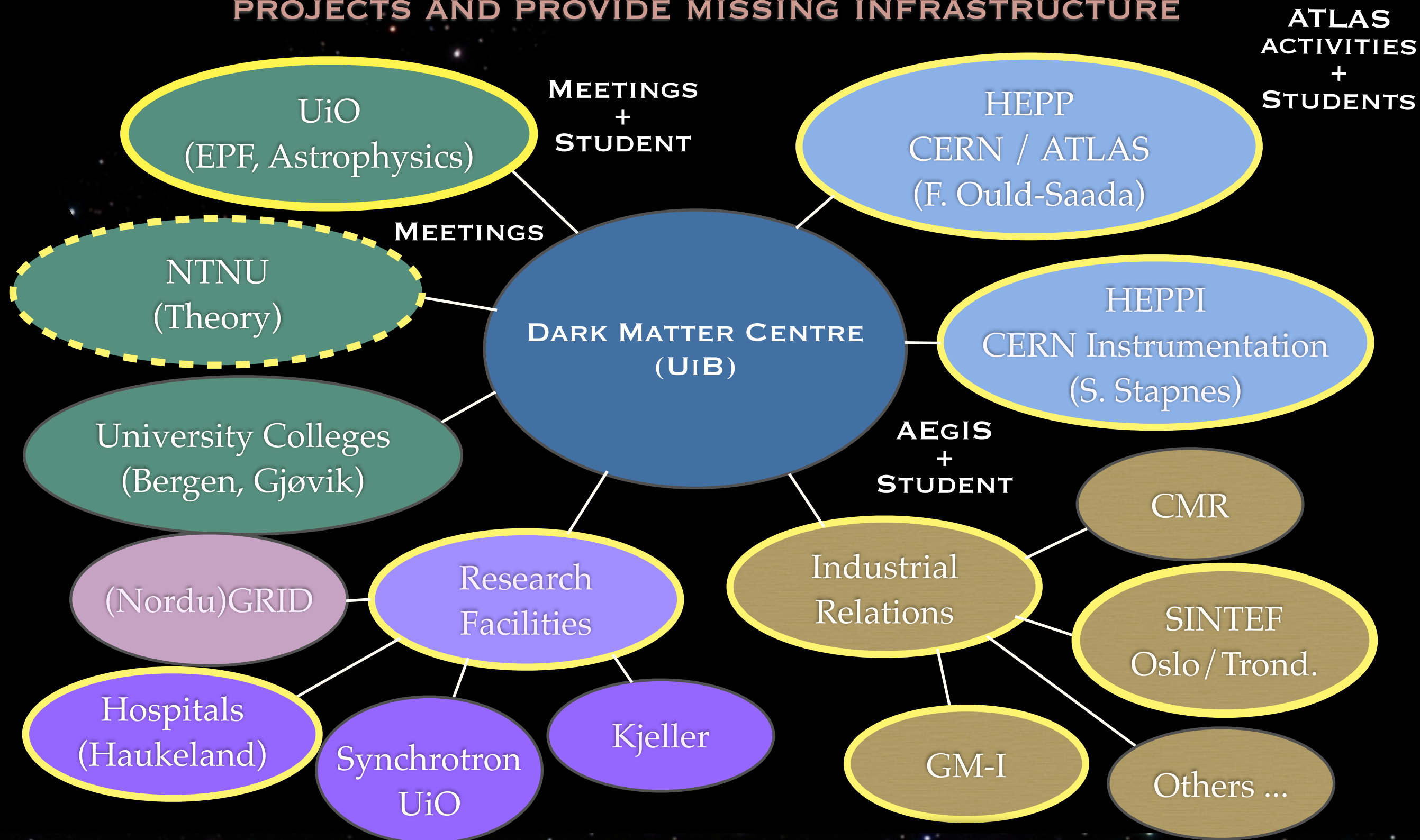
Integration in Norway (from proposal)

THIS GROUP WILL BE NEW IN NORWAY, BUT WILL LINK EXISTING PROJECTS AND PROVIDE MISSING INFRASTRUCTURE



Established direct links (after ~12 months)

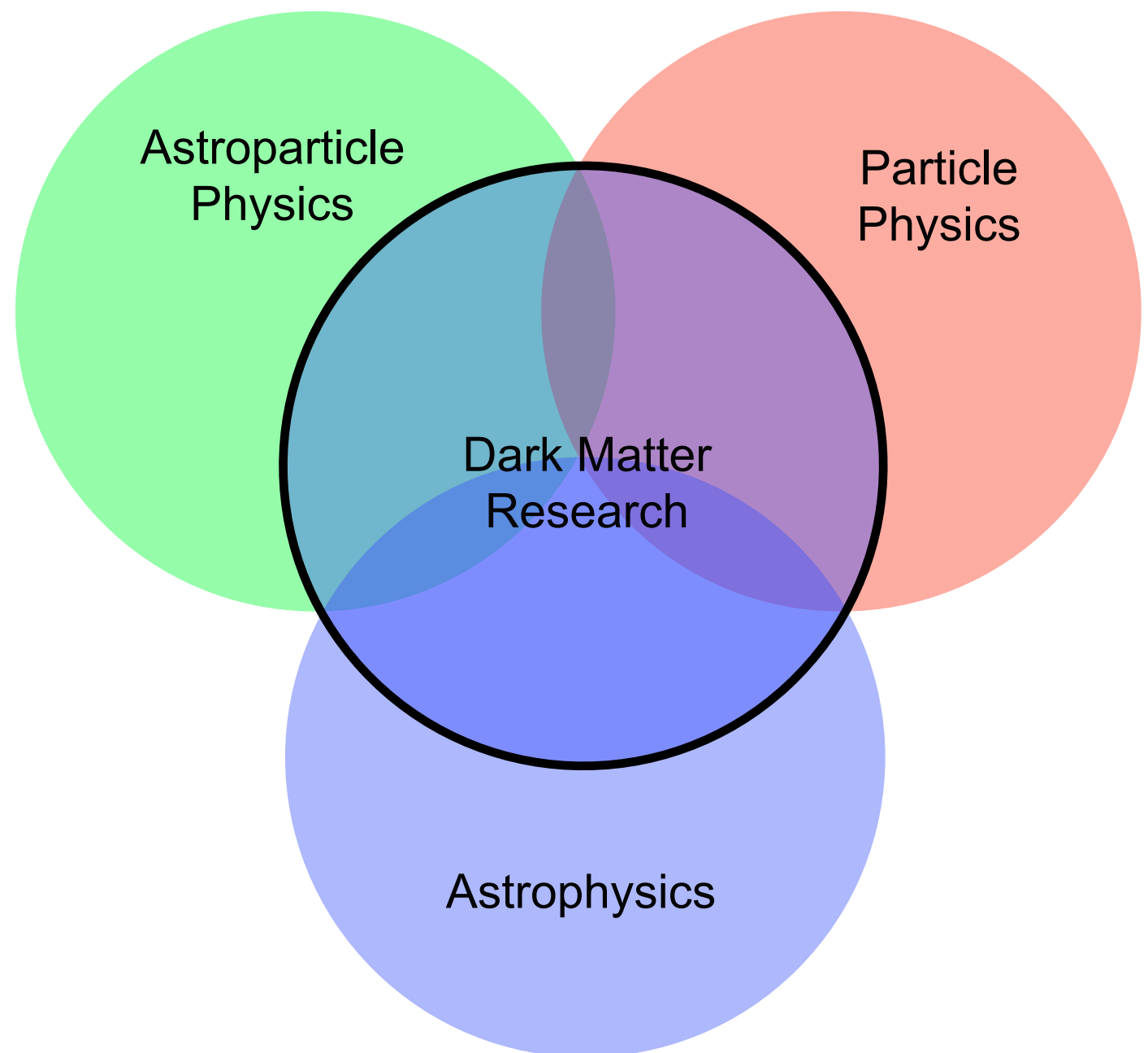
THIS GROUP WILL BE NEW IN NORWAY, BUT WILL LINK EXISTING PROJECTS AND PROVIDE MISSING INFRASTRUCTURE



Project work

DAMARA WORK TO PROVIDE A CURRENTLY MISSING LINK BETWEEN THEORETICAL AND EXPERIMENTAL RESEARCH IN THIS FIELD IN NORWAY

- To be successful we need to combine research from the three core areas:
 - Particle physics
 - Astroparticle physics
 - Astrophysics
- Expertise in all these fields are present in Norway



A deep space photograph of a star field, likely the Orion constellation, with the title 'Project Team and Organisation' overlaid in white text. The background is a dense field of stars of various colors (white, blue, orange) against a black sky. A prominent bright orange star is visible near the bottom center, and a bright blue star is near the top center. The text is centered horizontally and vertically.

Project Team and Organisation

The Team



Heidi Sandaker

Project leader

Background in particle physics and detector development



Trygve Buanes

Postdoctor, deputy

Background in particle physics and detector development



Nicola Pacifico

Postdoctor

Background silicon sensor development and characterisation



Jan Lindroos

Doctoral student

Master in theoretical astrophysics

WP1



Angela Gligorova

Doctoral student

Master in physics
WP3



Ørjan Dale

Doctoral student

Master in particle physics

WP1/2



Knut Dundas Morå

Master student

Bachelor from NTNU

WP1/2



Thomas Burgess

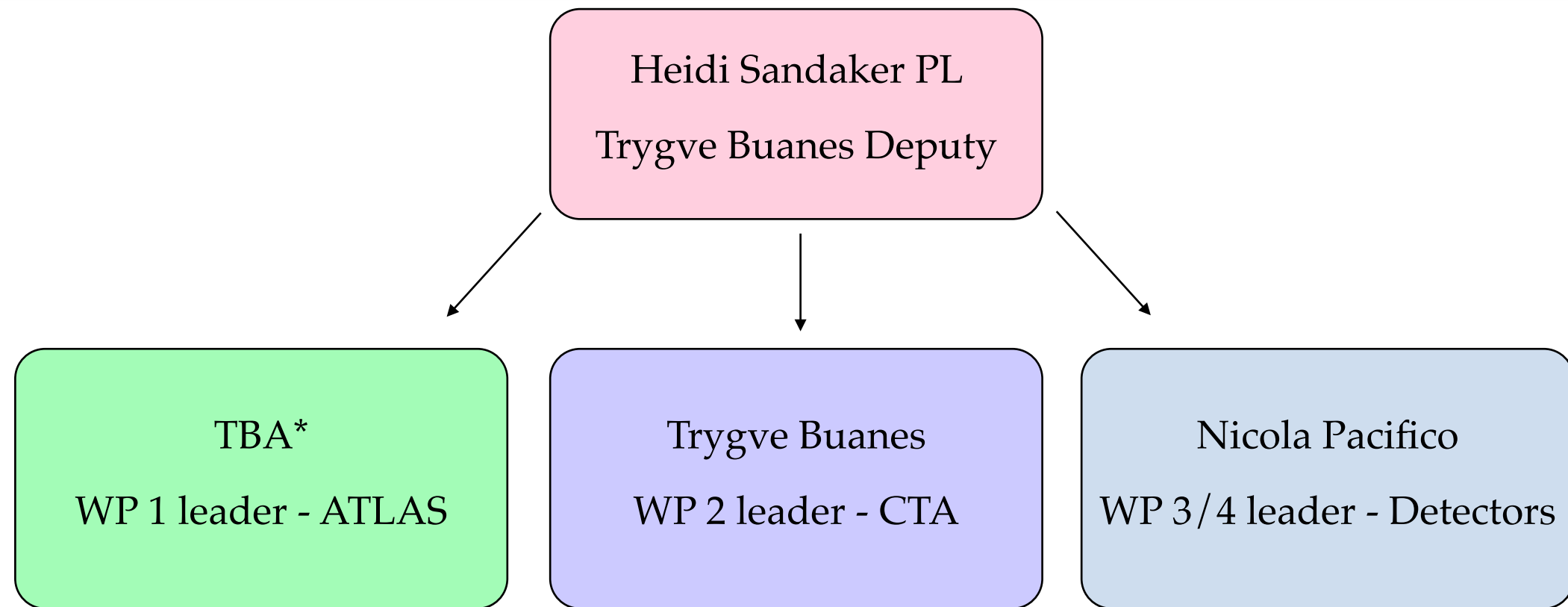
Postdoctor

Working with us during 2012, now left

ONE MORE PERSON IS EXPECTED TO JOIN IN 2012

TWO MASTER STUDENTS FROM PAUL SABATIER, FRANCE, FINISHED THEIR STAGE FOR THEIR MASTER STUDIES (WP4)

The Team




WP1: Jan Lindroos, Ørjan Dale (1 / 2), Trygve Buanes (1 / 2), Heidi Sandaker

WP2: Knut D. Morå, Ørjan Dale (1 / 2), Trygve Buanes (1 / 2), Heidi Sandaker

WP3: Angela Gligorova, Nicola Pacifico, Heidi Sandaker

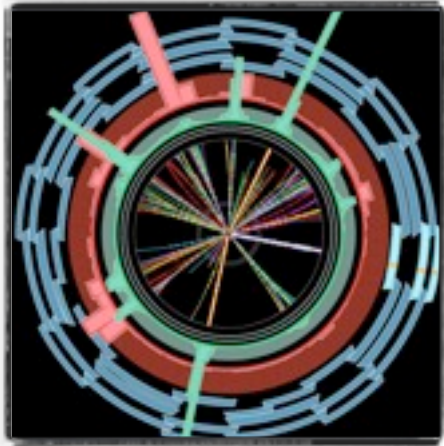
WP4: Exchange students, Heidi Sandaker

* This workpackage is lead together with the rest of the SUSY with taus group in Bergen

A deep space photograph showing a vast field of stars against a black background. A prominent, bright yellow star is located in the lower center, surrounded by a faint, reddish-orange nebula. Numerous other stars of various colors (white, blue, red) and sizes are scattered across the frame. The text "How far have we come ? Since start in January 2011..." is overlaid in white, centered in the upper half of the image.

How far have we come ?
Since start in January 2011...

Achievements since 2011

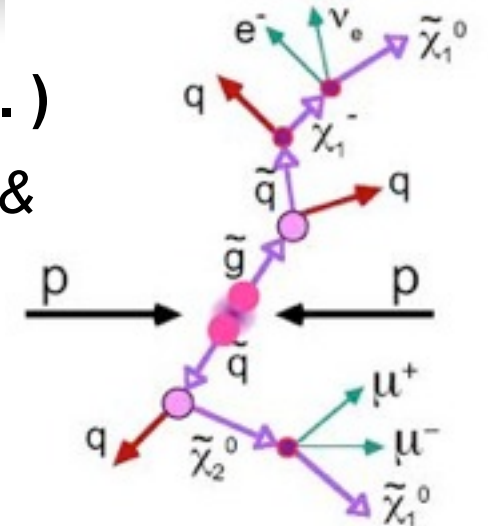


WP 1: Particle Physics Analysis (with Anna et al.)

Analysis of possible dark matter signals in LHC data & Standard Model background

Comparing with the newest astrophysics results

Jan, Ørjan, Trygve, Knut, Heidi



TASK 1:

- Software and analysis for ATLAS searches for supersymmetry with taus
- We are internationally active within the ATLAS group “Informal SUSY with taus”
- The first analysis we made (2011/2012) is currently being published :

ATLAS Internal note: <http://cdsweb.cern.ch/record/1449784>

Conference note approved: <https://cdsweb.cern.ch/record/1472054>

Paper ready for submission: <https://cdsweb.cern.ch/record/1459116>

→ Ørjan will
present this work

TASK 2:

- Work on phenomenology performing SUSY with tau searches to look for not yet excluded areas of mSugra - linking particle physics and astroparticle physics
- Publication almost ready to be submitted to arXiv

→ Jan will
present this work

MAIN GOAL FOR 2012 - FIRST PUBLICATIONS ✓

Achievements since 2011



WP 2: Astroparticle physics analysis

Analysis of astrophysics and astroparticle physics data

Study of the dark matter characteristics and background signals

Ørjan, Jan, Trygve, Knut, Heidi

Task 1:

- Software and analysis for CTA Dark Matter searches, focussing on CTA sensitivity to gamma line-emission searches - first version and plots ready
- We focus internationally on the CTA group for Dark Matter
- New collaboration with the Oscar Klein centre for Cosmoparticle Physics in Stockholm
- We joined in time to contribute some small part to the CTA special issue of ApJ :

Arxive link: https://dl.dropbox.com/u/14048479/CTA/cta_dm_v3.pdf

→ *Trygve will present CTA*

Task 2:

- The CTA dark matter group is interested in interpretations of high $\tan \beta$ results from LHC - We have the tools to make a first small analysis for this within the ATLAS Astro forum

COMPLETELY NEW ACTIVITY FOR US
GOAL IS TO HAVE FIRST RESULTS IN 2012 ✓

→ *Knut presents high $\tan \beta$*

Achievements since 2011



WP 3/4: Detector Development and Applications

Develop new detectors for dark matter detection

Research applications of these detectors (medical imaging)

Angela, Nicola, Trygve, Heidi (Laura, Ben)

Task 1 - Silicon development

- AEgIS aim to measure the effect of gravitation on anti-Hydrogen.
 - Design of the first prototype AEgIS silicon strip detector
 - Testbeam results from May 2012 with the Mimotera detector
- 3D silicon development in preparation of ATLAS upgrade activities

→ *Nicola will present AEgIS*

→ *Angela will present testbeam*

Task 2 - Photomultiplier development

- Building a small pilot test-bench for characterisation of CTA cameras

→ *Trygve will present CTA work*

WP 4 - Applications

- Preparation to build a PET test-bench for tests of SiPMs for medical applications

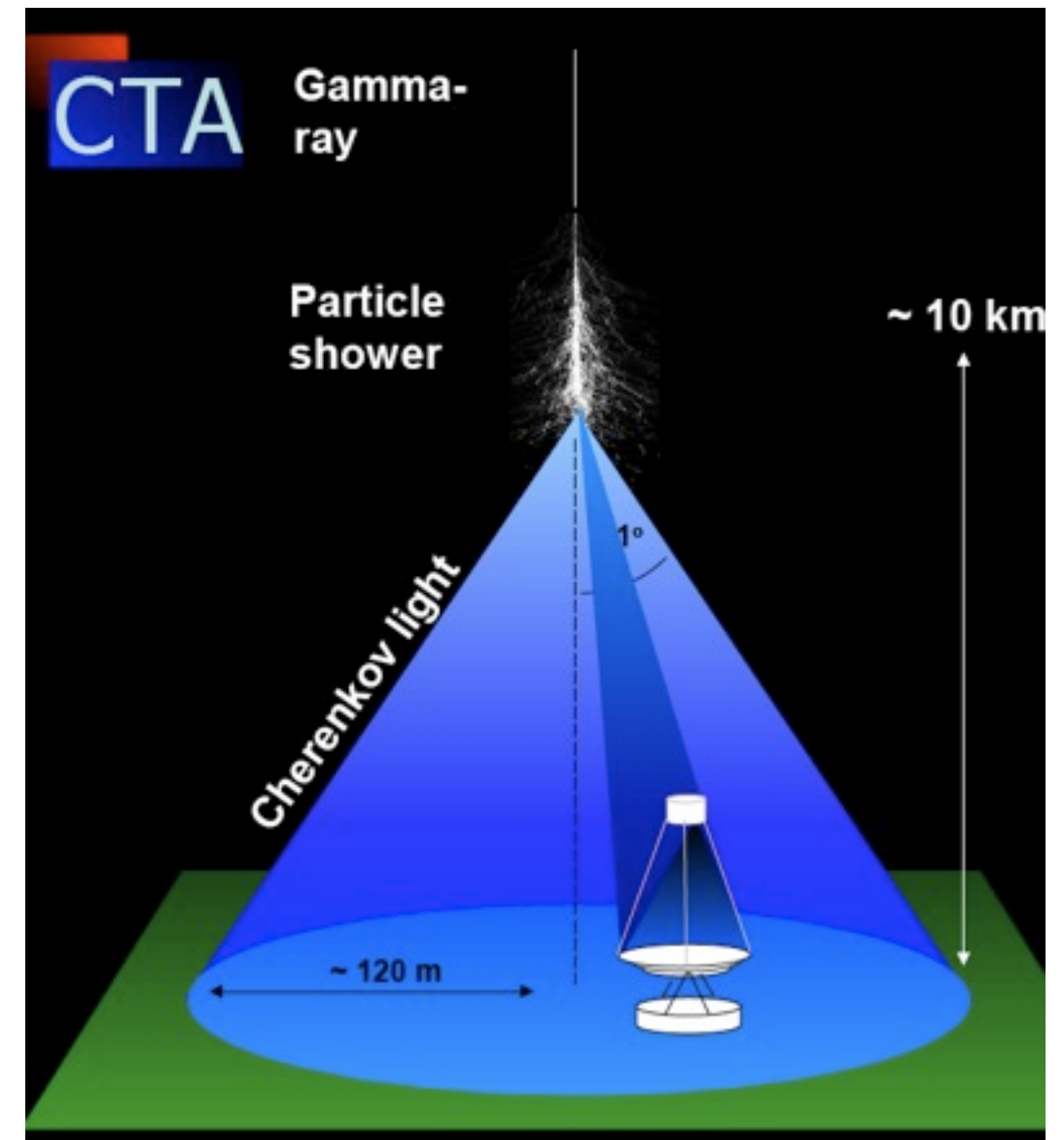
→ *Heidi will present the others*

STRENGTHENING THE CORE ACTIVITIES OF OUR DETECTOR LABORATORY

Achievements since 2011

SINCE BEG. 2012 NORWAY IS MEMBER OF CTA

- The next generation ground-based gamma ray instrument
- Observes the Cherenkov light from high energy cosmic radiation
- Two observatories operating as one covering both hemispheres and a large energy range
- Construction phase 2014-2018
- CTA is included in ESFRI road map and is one of the “Magnificent Seven” from the ASPERA roadmap
- We are members of the preparatory phase



NEW COLLABORATION WITH THE OSCAR KLEIN CENTRE IN STOCKHOLM

SINCE SUMMER 2012 ATLAS HAS A NEW ASTRO FORUM

- ★ Open forum for discussion of astroparticle physics related issues
- ★ Channel for communication to the astrophysics and cosmology communities
- ★ Supporting existing physics groups in their analyses related to astroparticle physics

→ *Conveners David Berge and Heidi*

First list of analyses this group will focus on to start with

- A. Monojets / Monophotons
- B. Top-philic Dark Matter searches

→ *See Knut's talk*



C. High $\tan \beta$ analysis

- Motivation: High $\tan \beta$ studies are very interesting to the astroparticle physics community, both in terms of ATLAS reach but also to show overlap or complementarity between the particle and astroparticle experiments. See references and arguments in this talk: <https://indico.cern.ch/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=184874>



D. Searches for interesting regions in SUSY parameter space

- Motivation: Often ATLAS experiments present models/results which are already partially excluded by astroparticle physics data or other experiments. This work aim to improve this situation where possible, see the following talk: <https://indico.cern.ch/getFile.py/access?contribId=2&resId=1&materialId=slides&confId=184874>

OUR GROUP AIMS TO BE ACTIVE IN THIS FORUM

→ *See Jan's talk*

Meetings, workshops and seminars

Meetings arranged in 2011 / 2012:

- Group meetings. Takes place mostly once a week, normally on Thursday morning at 10:00.
- Meetings with collaborators take place when needed.

Workshops arranged in 2011 / 2012:

- 9.3.2011 - Start of project symposium
- 25.2.2011 - Medical imaging workshop (participants from Bergen, Oslo and CERN)
- 22-23.2.2011 - Anti-matter workshop (~ 20 participants from all over the world, mostly members of the AEGIS collaboration)
- 21.10.2011 - 1st. Norwegian Dark Matter Meeting, arranged by the DAMARA project together with the Institute of Astrophysics at the University of Oslo.



Invited speakers to our seminar series in 2011 / 2012:

- Subir Sarkar, Theory, Oxford University
- Cinzia da Via, Project Leader 3D silicon, Manchester University
- Gemma Testera, INFN (Istituto Nazionale Fisica Nucleare)
- Michael Doser, Project Leader AEGIS, CERN
- (Gian Giudice, Theory, CERN (as part of the IFT seminar series))
- Jan Conrad, Oscar Klein Centre for Cosmoparticle Physics, Stockholm University
- Peter Jenni, ATLAS, CERN



1st Norwegian Dark Matter workshop

- More than 30 participants !
- In collaboration with the Insitute of Theoretical Astrophysics in Oslo
- Participants from theory and experiments
- Participants from Oslo, Trondheim, Bergen and Stockholm !

**QUITE SOME INTEREST
FOR OUR ACTIVITIES !**

Home UIO > The Faculty of Mathematics and Natural Sciences > Institute of Theoretical Astrophysics

For employees Norwegian website

Search in Institute of Theoretical Search

UiO : Institute of Theoretical Astrophysics
The Faculty of Mathematics and Natural Sciences

Home Research Studies Student life Services and tools About the institute People

Research

Research groups from A to Z

Cosmology

Events

• Seminars


Dark Matter Meeting

The Institute of Theoretical Astrophysics will host an informal Dark Matter meeting on Oct 21st, 2011. This meeting is on the initiative of the [Norwegian Centre for Dark Matter Analysis, Research and Applications \(DAMARA\)](#) at the [Department of Physics and Technology](#) in Bergen and organised together with the Institute of Theoretical Astrophysics in Oslo.

Time and place:
Oct 21, 2011 09:00 AM - 04:00 PM, Institute of Theoretical Astrophysics, Main Auditorium

Overview:

The main objective of the meeting is for young people in Norway working on Dark Matter related topics to meet and get to know each other. Secondly, the meeting presents the new collaboration between the [Oskar Klein Center for Cosmoparticle Physics \(OKC\)](#) in Stockholm, Sweden and the [DAMARA](#) project on CTA as well as the new collaboration with the Institute of Theoretical Astrophysics in Oslo.



Timetable:

When	What	Who
09:45	Welcome	David F. Mota and Heidi Sandaker: Dark Matter research in Norway
10:00	Coffee and cake	
10:15 - 11:00	Colloquium	Jan Conrad: Searches for Dark Matter with astrophysical gamma rays - status and perspectives
11:15	Part 1	Reports from students and postdocs
11:00		
10:15 - 11:00	Colloquium	Jan Conrad: Searches for Dark Matter with astrophysical gamma rays - status and perspectives
10:00	Coffee and cake	
09:45	Welcome	David F. Mota and Heidi Sandaker: Dark Matter research in Norway

Talks in 2011/2012 (not at IFT)

Conferences/Reviews :

- *Unified Dark Sector*, [Fysikermøtet 2011](#) (22. juni 2011), Jan Lindroos
- Presentation at the CTA workshop in Toulouse, May 2011, Heidi Sandaker
- Norwegian CERN evaluation, spring 2011, Heidi Sandaker

Seminars and workshops:

- Norway HEPP workshop Geilo, (April 2012), Trygve Buanes
- Norway HEPP workshop Geilo, (April 2012) Thomas Burgess, Jan Lindroos
- Stockholm workshop, (23.3.2012) Knut D. Morå
- Stockholm workshop, (23.3.2012) Thomas Burgess
- *Raskere en lyset?*, [Fellesseminar, IFT, UiB](#) (30. sep. 2011), Trygve Buanes
- *The Phantom of the OPERA*, [Fredagskollokvium, NTNU](#) (14. sep. 2011), Trygve Buanes

1st Norwegian Dark Matter meeting (organised by DAMARA) :

http://www.mn.uio.no/astro/english/research/groups/cosmology/events/dm_meeting.html

- *Study of CTA sensitivity for gamma line-emission searches*, (21. October 2011), Trygve Buanes
- "mSUGRA high $\tan(\beta)$ grid" (21. October 2011), Jan Lindroos
- Plans for CTA membership, (21. October 2011), Heidi Sandaker

1st ATLAS Astro meeting (co-chaired by Heidi Sandaker)

- *High $\tan \beta$ region and models of interest for astroparticle experiments*, (19.4.2012), Heidi Sandaker

Meetings at CERN :

- ~ 25-30 reports about the 1 tau analysis [Informal SUSY with taus and Editorial Board](#), (2012) Trygve Buanes, Thomas Burgess, Ørjan Dale, H. Sandaker together with the rest of the Bergen group
- ATLAS Astro - high $\tan \beta$ analysis, [Etmis subgroup meeting](#), 21.6.2012), Heidi Sandaker
- Signal optimisation studies, [Rare b decays workshop](#) (14. April 2011), Trygve Buanes
- Selection Optimization Studies, [Rare b decays subgroup meeting](#) (13. May 2011), T. Buanes
- Selection Optimization Studies, [Rare b decays subgroup meeting](#) (16. May 2011), T. Buanes
- Separation of $t\bar{t}b\bar{a}$ and SUSY with kinematic fitting, [Informal SUSY with taus](#) (8. June 2011), Trygve Buanes
- Update on KLfitter, [Informal SUSY with taus](#) (15. June 2011), Trygve Buanes
- Separation of $t\bar{t}b\bar{a}$ and SUSY with kinematic fitting, [Informal SUSY with taus](#) (6. Aug. 2011), Trygve Buanes
- Cut flow check from Bergen, high $\tan \beta$ and some analysis ideas, [Informal SUSY with taus](#) (3. Sep. 2011), Ørjan Dale
- Update on 1tau analysis on rel17, [Informal SUSY with taus](#) (1. Nov. 2011), Trygve Buanes
- mSUGRA model in high $\tan \beta$ region, [Informal SUSY with taus](#) (8. Nov. 2011), Jan Lindroos
- Comparison of fast and full simulations, [Informal SUSY with taus](#) (15. Nov. 2011), T. Buanes
- Update on 1tau analysis on rel17, [Informal SUSY with taus](#) (29. Nov. 2011), Trygve Buanes
- Rel17 1tau update, [Informal SUSY with taus](#) (6. Dec. 2011), Ørjan Dale
- Update on 1tau analysis on rel17, [Informal SUSY with taus](#) (13. Dec. 2011), Trygve Buanes

**Shows the excellent
performance of our team
members !**

- ★ Presenting our research results in Norway and abroad !
- ★ Initiative to create a research environment for our group
- ★ Building contacts outside of IFT

Outreach activities in 2011/2012

Popular talks :

- *Verdens største mikroskop – om ATLAS-eksperimentet på CERN, Norske fysikkstudenters konferanse 2011 (13. mars 2011), Trygve Buanes*
- *Masterprogrammer i partikkelfysikk, Fellesseminar/infomøte (18. mars 2011), Trygve Buanes*
- *Norwegian teachers program [2] (13-18.03.2011), Heidi Sandaker*
- *Norwegian mini-winterschool (2-4.11.2011), Trygve Buanes og Heidi Sandaker*
- *Universets mørke sider, Bergen astronomiske forening (9. 11.2011), Trygve Buanes*
- *Researcher's corner, Researchers' night (23. september 2011), Trygve Buanes*
- *LHC physics and ATLAS detector, Swedish High School students at CERN (december 2011), Heidi Sandaker*
- *Higgs mekanismen, Katedralskolen, autumn, Knut Dundas Morå*

Interviews (newspaper, tv) :

- *Vitenskapens usanne "sannheter", nrk.no, (24. september 2011), Trygve Buanes*
- *Interview with NTB, Norwegian news agency (15.6.2011), two articles, Heidi Sandaker*
- *Forskere - til datamaskinene, [1], Forskning.no, (8.4.2011), Heidi Sandaker*
- *Skyter med antistråler, På høyden og Forskning.no, [3] (24.2.2011), Heidi Sandaker*
- *Brutt lyshastigheten. Hva så?, Forskning.no (24.9.2011), Heidi Sandaker*
- *Hektisk blant verdens fysikere, Forskning.no (10.10.2011), Heidi Sandaker*
- *Ser hint av svaret, På høyden (14.12.2011), Heidi Sandaker*

Newspaper articles :

- *Inn i det ukjente, Morgenbladet (16.12.2011) written by Anna Lipniacka and Heidi Sandaker*
- *Kaster nytt lys på universets mørke hemmelighet (9.8.2012) written by Anna Lipniacka and Heidi Sandaker*

Visits :

- *Universets mørke sider, Besøk fra Danielsen videregående skole (15. september), Trygve Buanes*
- *CERN committee meeting, visit to ATLAS (1.11.2011), Trygve Buanes, Ørjan Dale, Heidi Sandaker,*
- *Norwegian mini-winterschool (2-4.11.2011), Trygve Buanes og Heidi Sandaker*
- *Several guided tours for visitors at ATLAS and at CERN (2010 - 2011), Heidi Sandaker*

A deep space photograph showing a vast field of stars against a black background. The stars vary in brightness and color, with some appearing as distinct points of light and others as soft, glowing clouds. A prominent, bright orange-yellow star is located near the center, while a cluster of blue-white stars is visible in the upper right. The text "Research results" is centered in a white, sans-serif font.

Research results

Research results 2011-2012

- Special issue of ApJ about CTA

Accepted for publication: https://dl.dropbox.com/u/14048479/CTA/cta_dm_v3.pdf

Publication on ATLAS results on Supersymmetric models with taus (first half of 2012)

ATLAS Internal note: <http://cdsweb.cern.ch/record/1449784> signed off by the Editorial Board

Conference note approved: <https://cdsweb.cern.ch/record/1472054> in time for SUSY12

Paper ready for submission: <https://cdsweb.cern.ch/record/1459116>

Publication on SUSY model space (first half of 2012)

Submission imminent

Publication of AEGIS results from testbeam starting June 2012 (second half of 2012)

Ongoing analysis, data is ready - working title: "Low energy anti-proton annihilations in silicon"

Publication about CTA gamma line-emission searches (second half of 2012)

Ongoing analysis - First results are good but need modifications

Publication about ATLAS results relevant for astroparticle physics (end of 2012)

Probably 2013 ...

Publication(s) from ATLAS 3D and/or IBL development

3D prototype should be available for pbar testbeam autumn 2012 - publication late 2012 or early 2013 ...

A deep space photograph showing a vast field of stars against a black background. The stars vary in color, including white, blue, and orange, and some have prominent diffraction spikes. A faint, dark, nebula-like structure is visible in the lower center. The text "Future prospects and Conclusion" is centered in white.

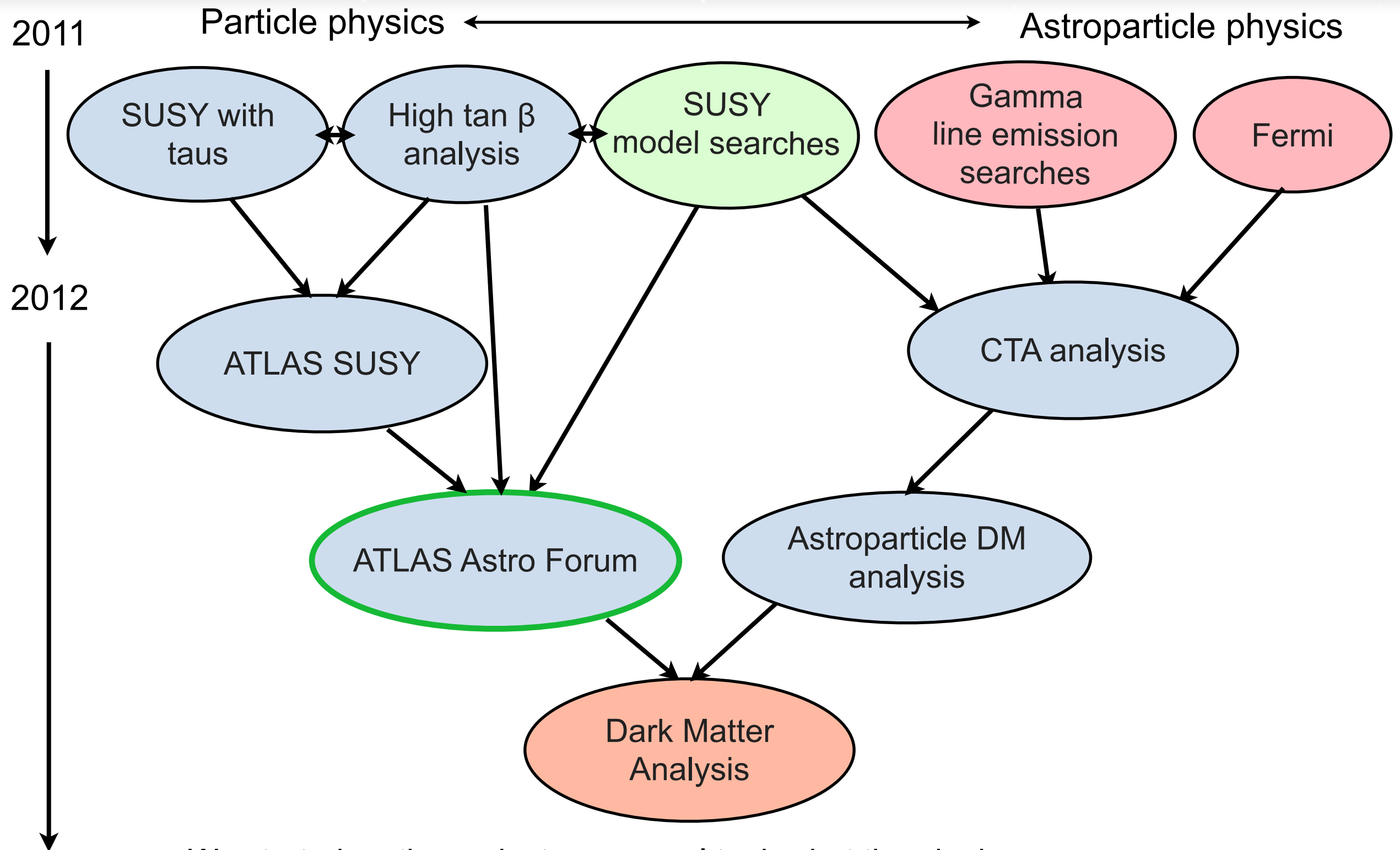
Future prospects and Conclusion

Longterm project plans

YEAR	MAIN ACTIVITIES	MAIN DELIVERABLES
2011	Centre establishment -employment -building network -experiment membership (access data) -analysis projects and software -writing project proposals	A team ✓ A centre ✓ Experiment memberships ✓ Software & analysis tools ✓
2012	Focus on ATLAS work (LHC stop in 2013) Publications EU application (PL)	First publications ✓ Detector design ✓ Calibration prototype
2013	Focus on CTA work Publications EU application (PL) BFS application (PL deputy)	Publications Detector prototype(s) Calibration test-bench
2014	Focus on Team & Detectors -PhD students finishing -PhD and Postdoctor careers -First measurements for AEgIS Centre survival -funding	Publications Defense of 3 PhD theses Final detector in AEgIS

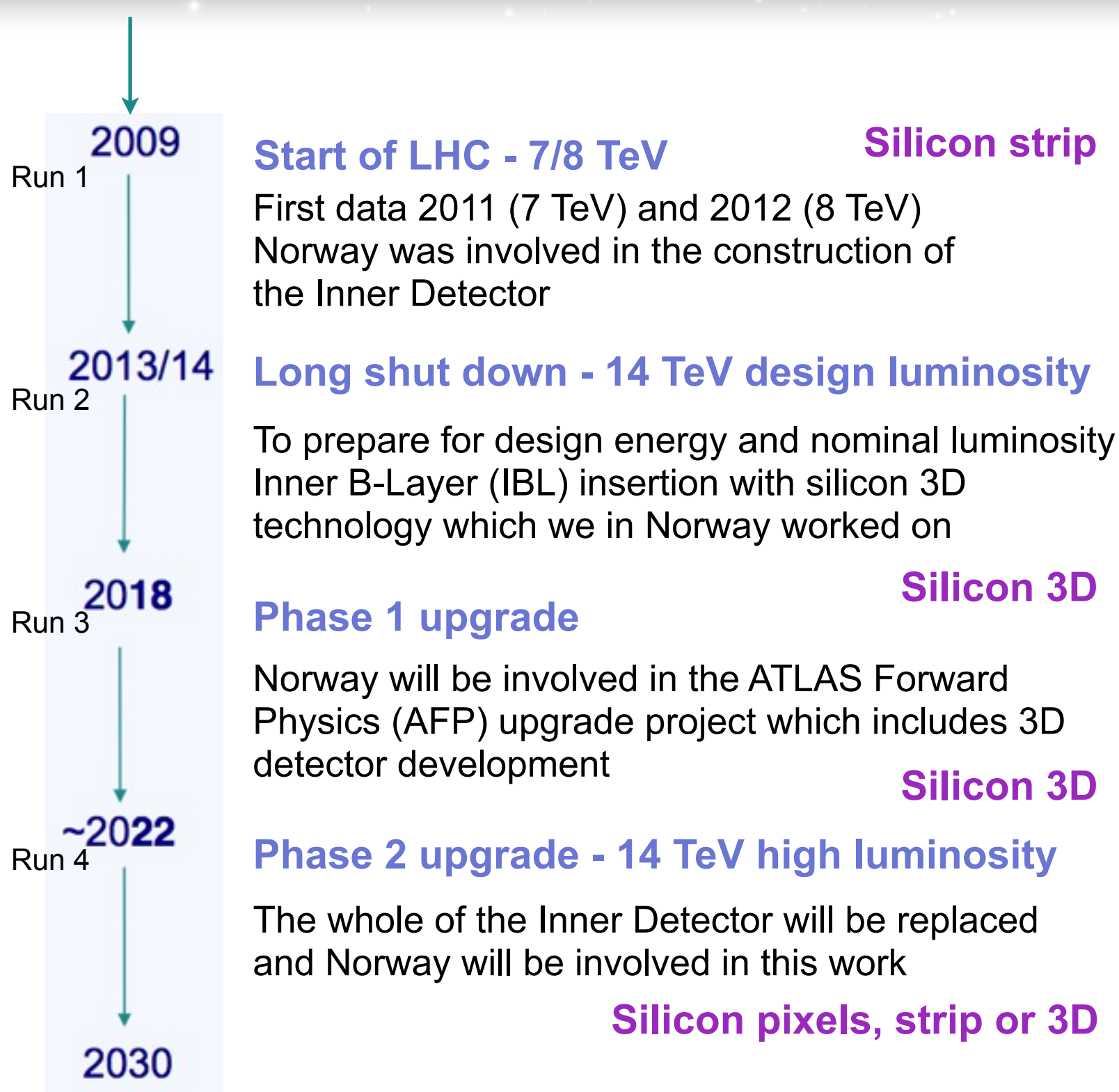
Within the scope of the 4 years of this project

Longterm research plans - WP1 & 2



We started up the project on several topics but the aim is convergence

Longterm research plans - WP3 & 4



ATLAS
Silicon
Strips

Activities at
a minimum
in Bergen

~ 2015

ATLAS
Silicon
?

Problem of continuity over time to
keep state-of-the-art in our lab
WITHOUT DAMARA

Longterm research plans - WP3 & 4

ATLAS/LHC schedule

Start of LHC - 7/8 TeV

First data 2011 (7 TeV) and 2012 (8 TeV)
Norway was involved in the construction of the Inner Detector

Silicon strip

Long shut down - 14 TeV design luminosity

To prepare for design energy and nominal luminosity
Inner B-Layer (IBL) insertion with silicon 3D technology which we in Norway worked on

Silicon 3D

Phase 1 upgrade

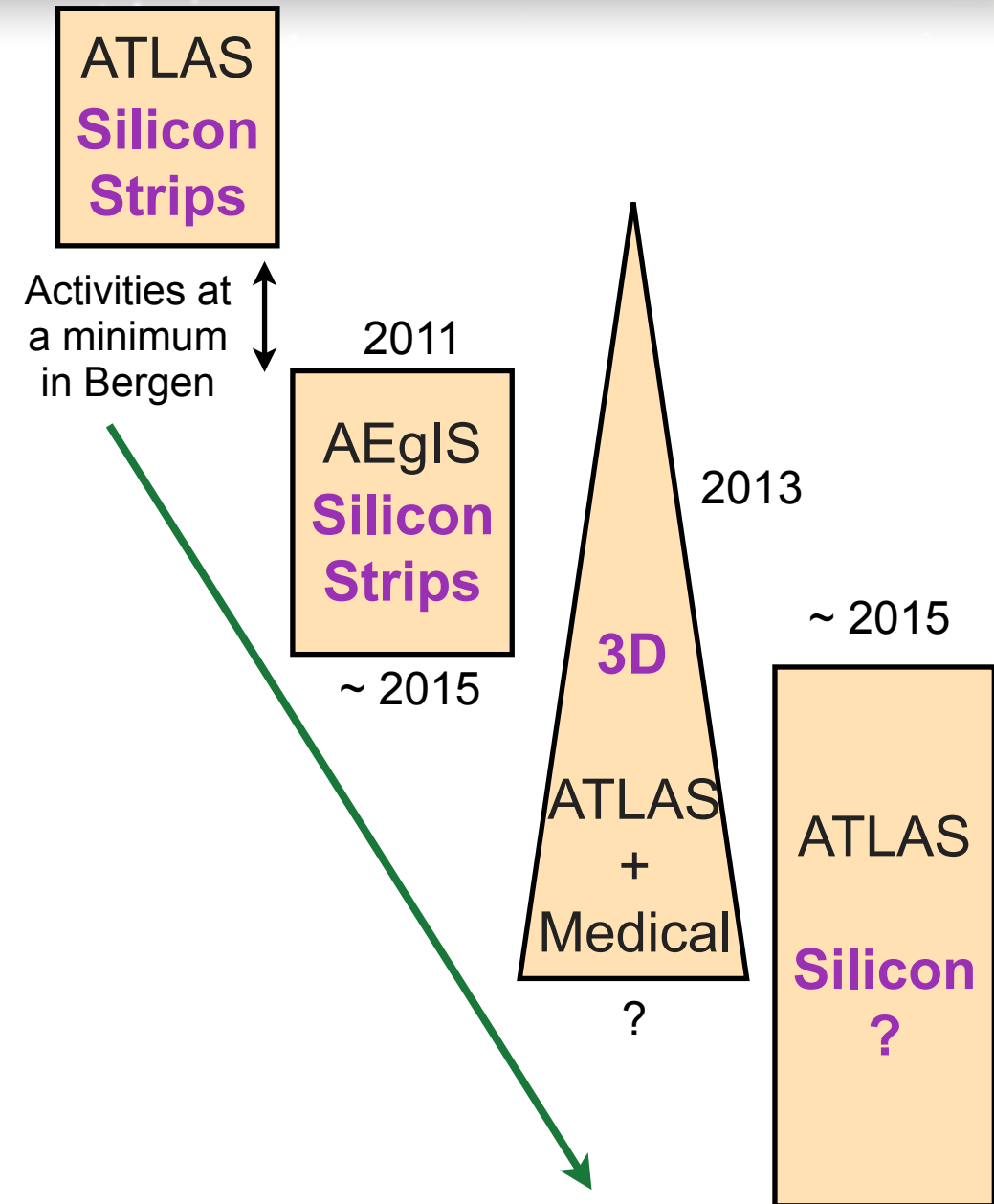
Norway will be involved in the ATLAS Forward Physics (AFP) upgrade project which includes 3D detector development

Silicon 3D

Phase 2 upgrade - 14 TeV high luminosity

The whole of the Inner Detector will be replaced and Norway will be involved in this work

Silicon pixels, strip or 3D



Support detector development with additional funding sources

WITH DAMARA


Summary and conclusions

SUMMARY OF ACHIEVEMENTS IN 2011/2012

- Hiring of all members of personell in the original grant completed **Yes**
- All PhD students started their work **Yes**
- Activities in all core areas of the project, all work-packages well on their way **Yes**
- First publications **Yes**
- Additional grants (AEglS and 3D) **Yes**

STATUS OF PROJECT DELIVERABLES

- 2 PhD thesis **3 PhDs started/1 Master**
- Membership in astroparticle physics experiments **Members in CTA !**
- Specialised analysis software and analysis methods **First version**
- Detector/application prototypes **ongoing**

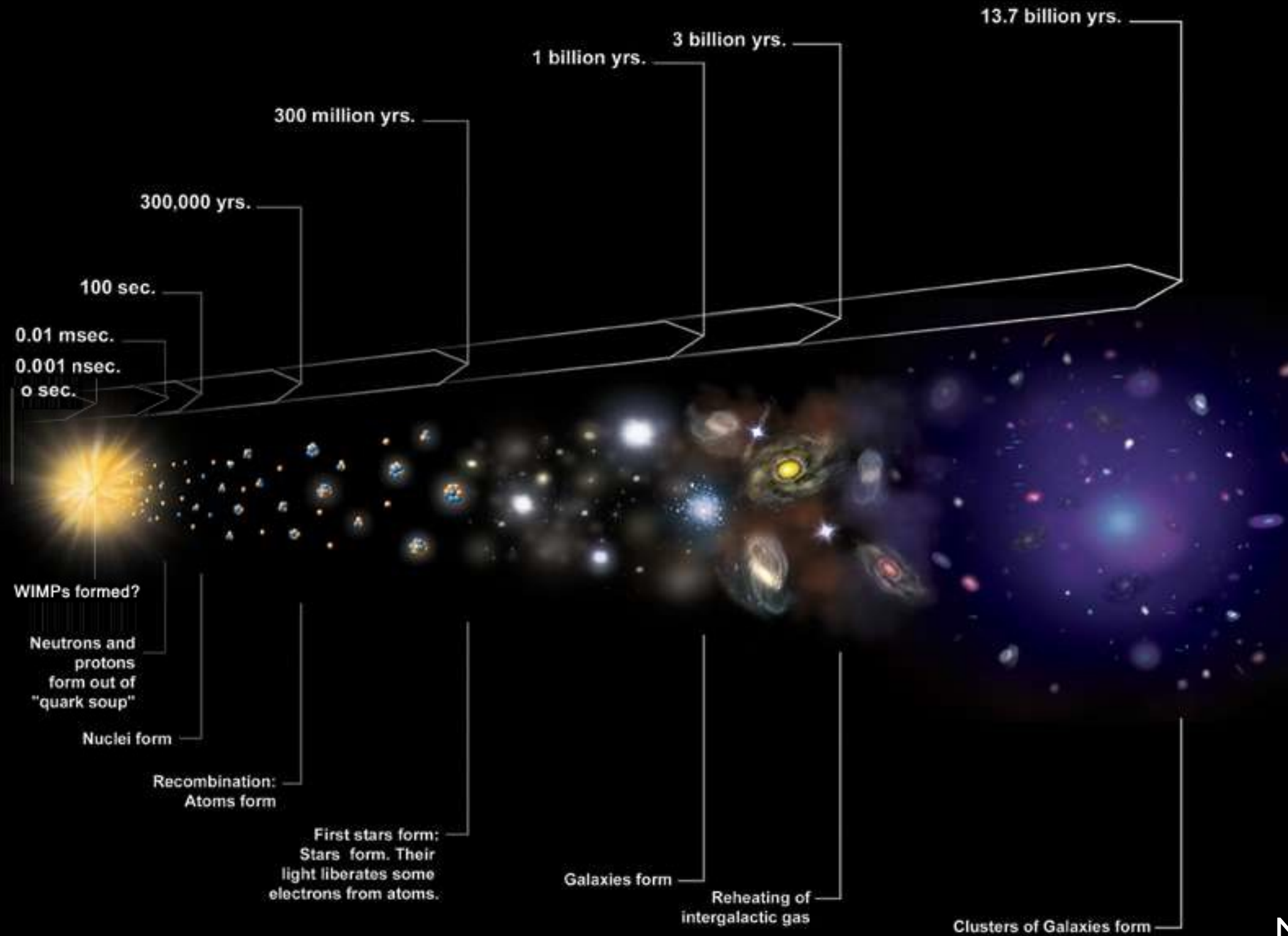
A deep space photograph showing a vast field of stars against a black background. A bright yellow star is the central focus, surrounded by numerous smaller stars of various colors (blue, white, red). The text is overlaid in the center of the image.

We have established and is now operating the first
Centre for Dark Matter research in Norway



Extras

Particle physicists view of the Big Bang



NASA

Integration internationally

VARIOUS ROAD MAPS, COLLABORATION WITH EXISTING RESEARCH GROUPS, PARTICIPATION IN NEW AND EXISTING EXPERIMENTS

Some examples of interesting experiments



**NEW ASTROPARTICLE
PHYSICS GROUP**



etc.

*Well established, existing
collaborations*

Organisations/European strategy

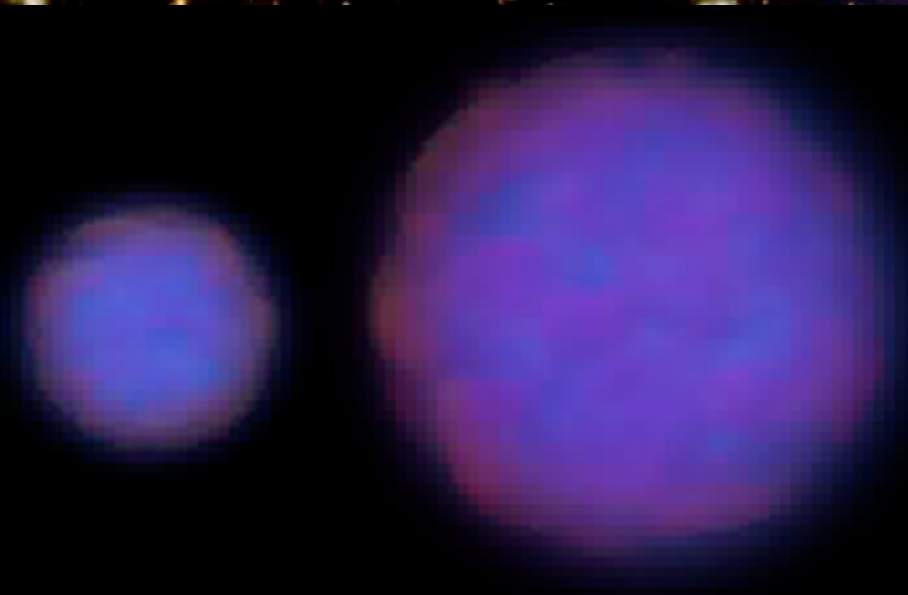


DEMANDING RESEARCH - VERY COMPETITIVE FIELD !

Observational evidence for dark matter



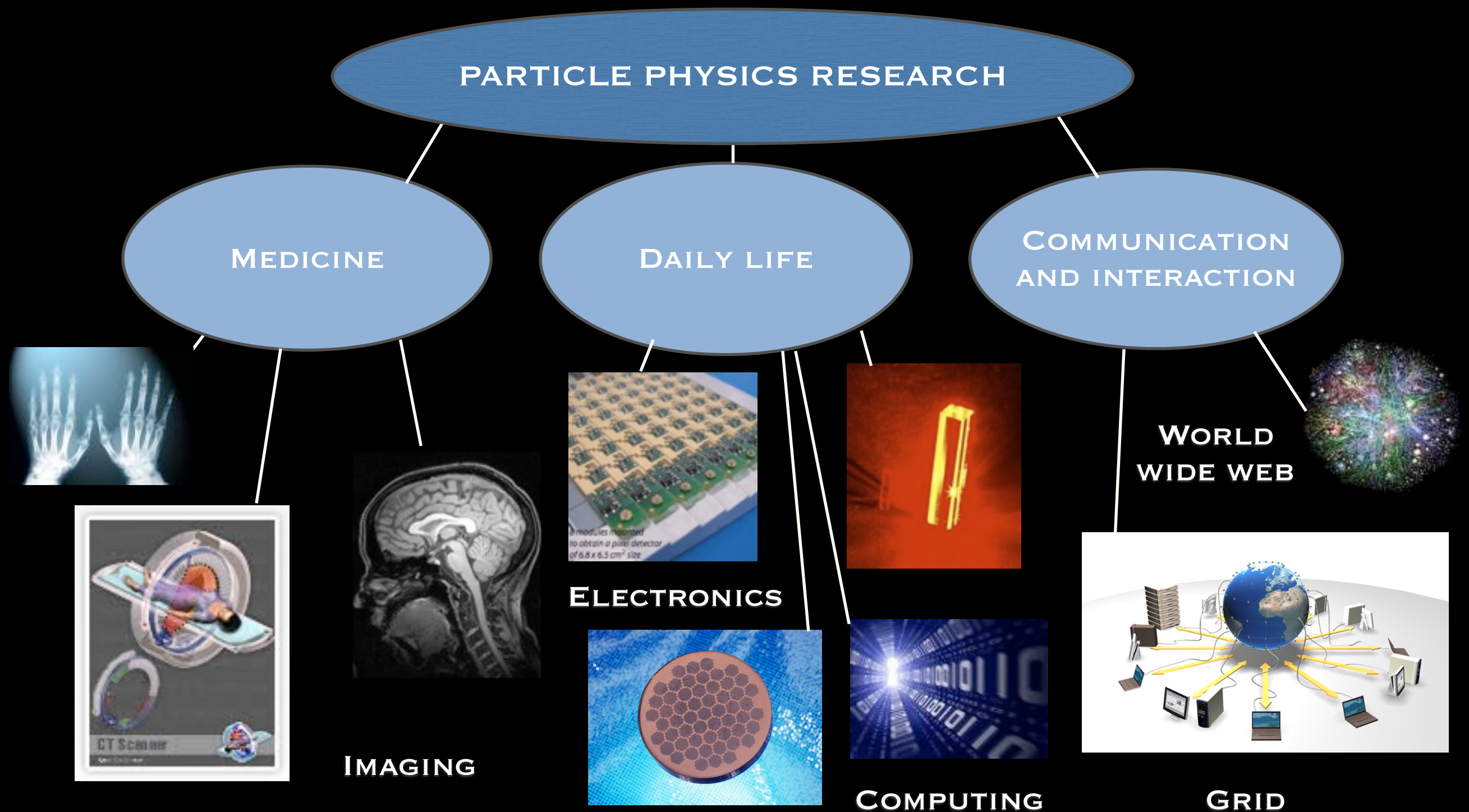
Hot gas (pink) detected in two galaxy clusters, one with a particular bullet shape. Other telescopes detected the bulk matter in the clusters which turns out to be dark matter (blue)



CREDIT: X-ray: NASA/CXC/CfA/M.Markevitch et al.;
Optical: NASA/STScI;
Magellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al.

Impact & benefits for society

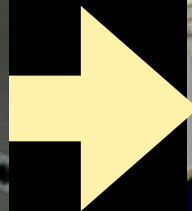
TRADITIONALLY, PHYSICS DISCOVERIES HAVE
LARGE IMPACT AND MANY BENEFITS FOR SOCIETY



Eye to the world ..

FOR THOSE NOT COMING TO BERGEN - WE COME TO THEM

- Bergen Control Room
 - Permits students in Bergen to participate in shifts, testbeams, workshops, meetings,
 - Will be accessible to all groups at the IFT
- Prototype ready - we will now ready to make the next step, upgrade to a full control room



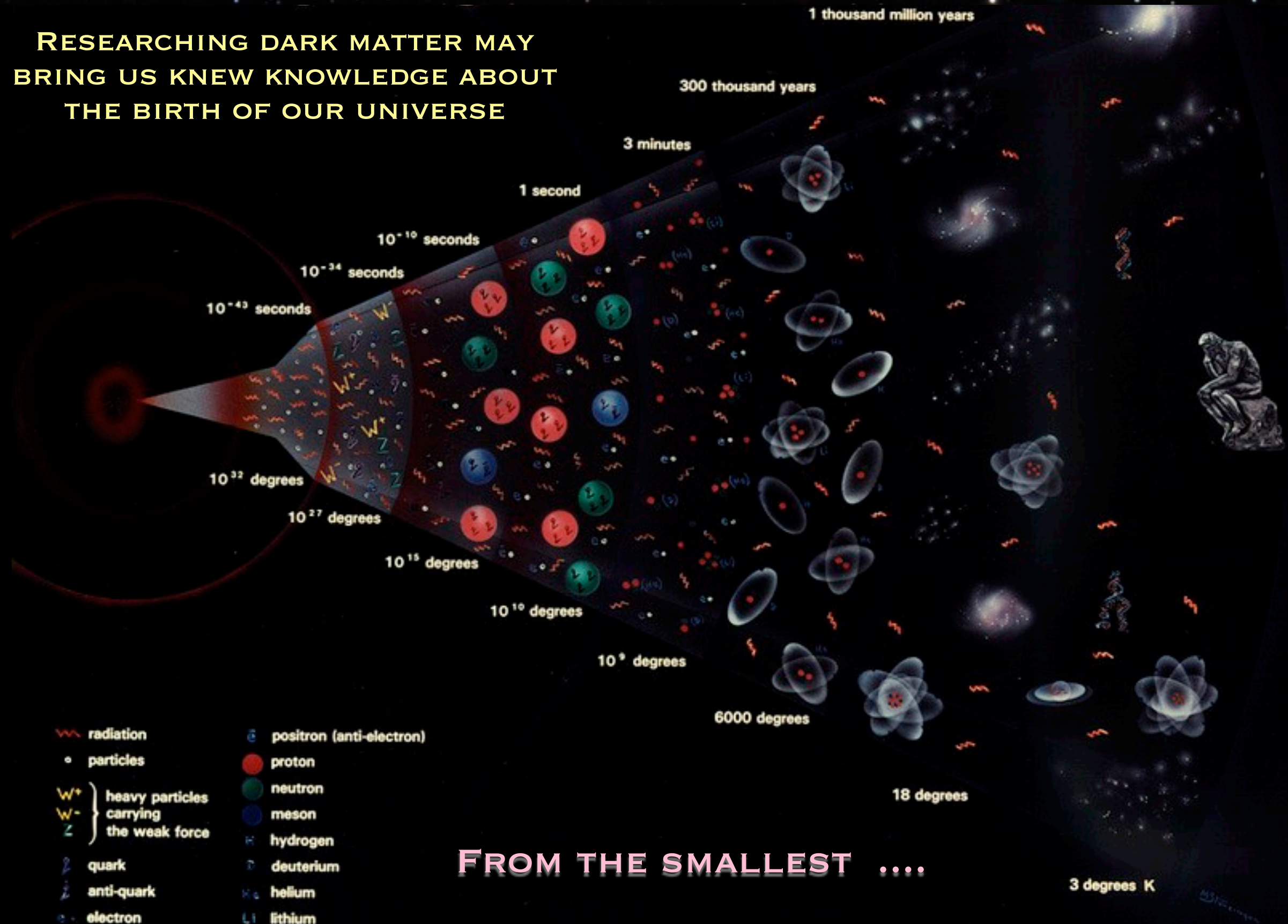
One of the hottest research topics of today

Publications, news articles, conferences, ...



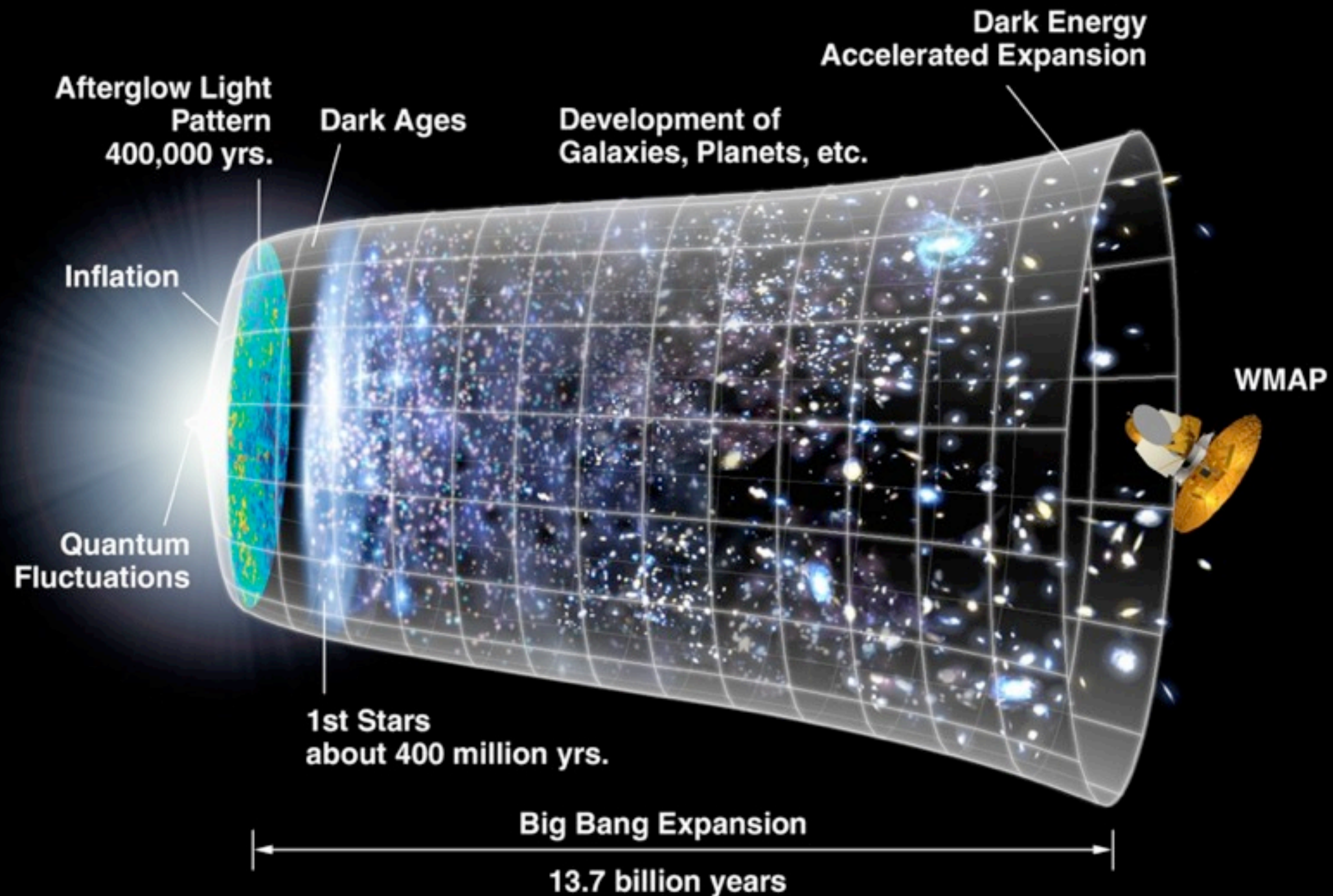
Particle physicists view of the Big Bang

RESEARCHING DARK MATTER MAY
BRING US NEW KNOWLEDGE ABOUT
THE BIRTH OF OUR UNIVERSE



Astrophysicist view of the Big Bang

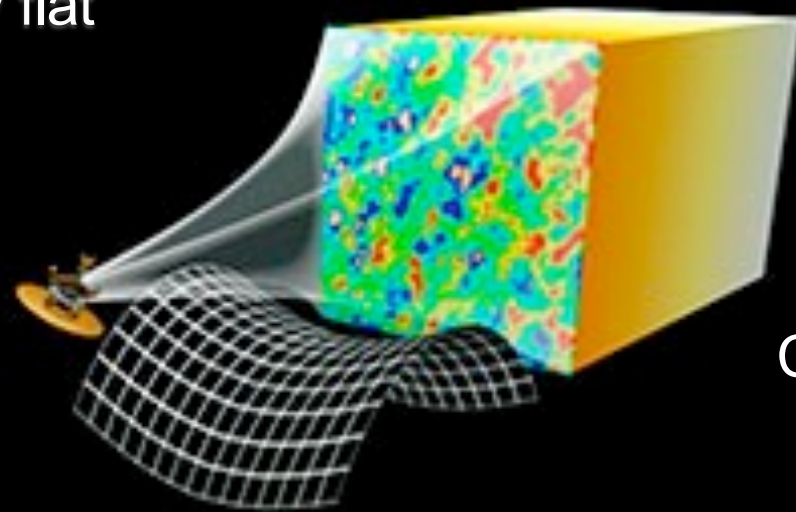
.... TO THE BIGGEST !



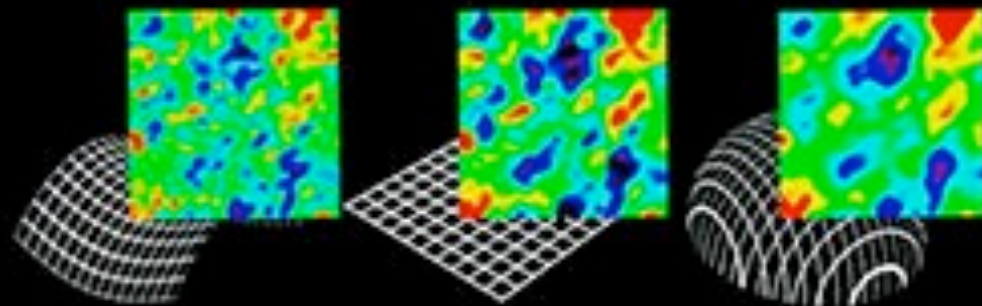
**DARK MATTER PLAYS A CENTRAL ROLE IN THE MODELING OF
STRUCTURE FORMATION AND THE EVOLUTION OF GALAXIES**

New information of the geometry of the universe

- The amount of dark matter and dark energy in the universe is crucial to determine the geometry of space
 - Open : density less than critical density
 - Flat : density equal to critical density
 - Closed: density more than the critical density
- Gives information on the evolution of the universe (eternal expansion, in equilibrium, or stop and collapse)
- The spacial geometry have been measured by WMAP to be nearly flat



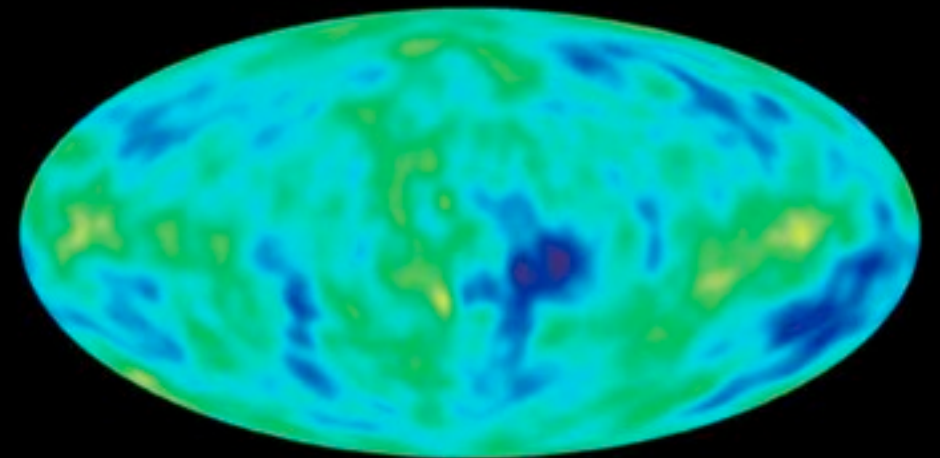
Cosmic microwave background



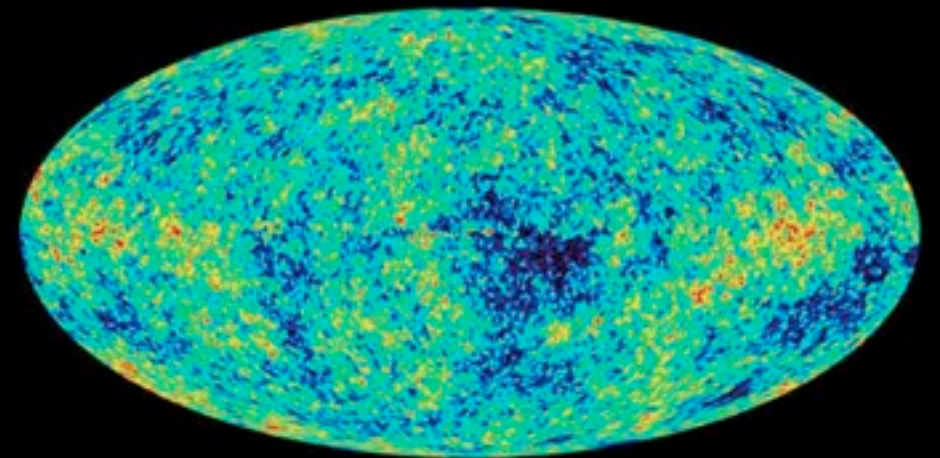
Open

Flat

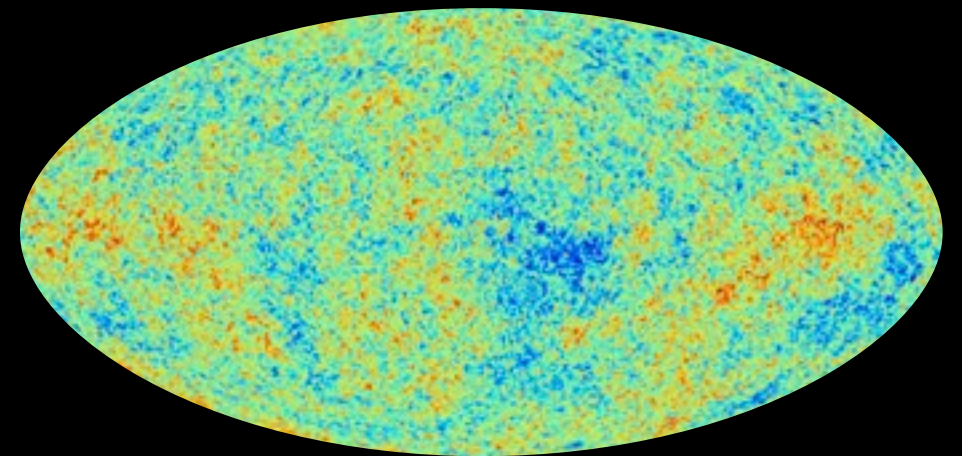
Closed



COBE



MAP



PLANCK (simulated)