

Particle and Astroparticle theory at Stockholm University

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Partikeldagarna, AlbaNova October 17, 2008



Lars Bergström,
Professor
Cosmology and Dark
Matter



Joakim Edsjö,
Associate Professor,
VR-position
Supersymmetry,
DarkSUSY



Ariel Goobar,
Professor
Supernova Cosmology
**Gruber Prize winner
2007**



Edvard Mörtzell,
Associate Professor
Cosmology, supernovae,
weak lensing



Bo Sundborg,
Associate Professor
String theory, string
cosmology



Fawad Hassan,
Associate Professor
String theory, string
cosmology



Markus Berg
VR Research Assistant
String cosmology &
phenomenology



Jan Conrad
Research Associate (KVA)
Fermi/HESS/CTA Dark
Matter searches

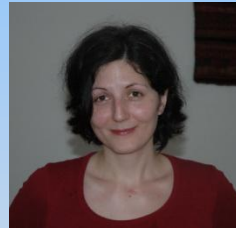
Kjell Rosquist
Professor
General relativity



H. Rubinstein
Guest Professor (emeritus)
Magnetic fields in the Universe
Chief Editor, JCAP and JHEP



Gabrijela Zaharijas
Postdoc



Pat



Alexander



Yashar



Mikael



Erik



Anders



Sara



Stefan

PhD students

Projects

L. Bergström: Dark matter, indirect detection through positrons and gammas (with J. Edsjö, T. Bringmann & G. Bertone); **Dark Matter in Fermi** (with J. Edsjö, J. Conrad & Fermi Collab.); **Cosmological signals of WIMPs** (with A. Sellerholm & J. Conrad); **CMB & Early Universe**; **SUSYfit** (with J. Edsjö, J. Conrad, Y. Akrami & P. Scott); **Hydrodynamical N-body simulations of cosmic gamma-rays** (with A. Pinzke & C. Pfrommer).

Leader of Linnaeus Project: Oskar Klein Centre (next talk).

J. Edsjö: **DarkStars - main sequence and population III stars** (with P. Scott, S. Sivertsson & M. Fairbairn); **Searches at Atlas and connections to dark matter: early searches using isolated leptons, meta-stable stops, more general missing E_T searches** (with E. Lundström, S. Rydbeck, A. Sellerholm, M. Johansen, D. Milstead); **BMSSM** (with M. Berg, E. Lundström & S. Sjörs), **SUSYfit** (with L. Bergström, J. Conrad, Y. Akrami & P. Scott); **Dark matter in Fermi** (with L. Bergström, J. Conrad & Fermi Collab.); **DarkSUSY** (with P. Gondolo, L. Bergström, P. Ullio, E.A. Baltz, M. Schelke, T. Bringmann and G. Duda).

F. Hassan: Consistent long distance modifications of gravity as a possible resolution of the Cosmological constant/dark energy problem (with S. Hofmann & M. von Strauss).

E. Mörtzell: Putting limits on models with inhomogeneous dark energy or matter (with M. Blomqvist); Fitting "exotic" models of cosmic acceleration; Using lensing to extract structure and substructure distribution (with T. Riehm).

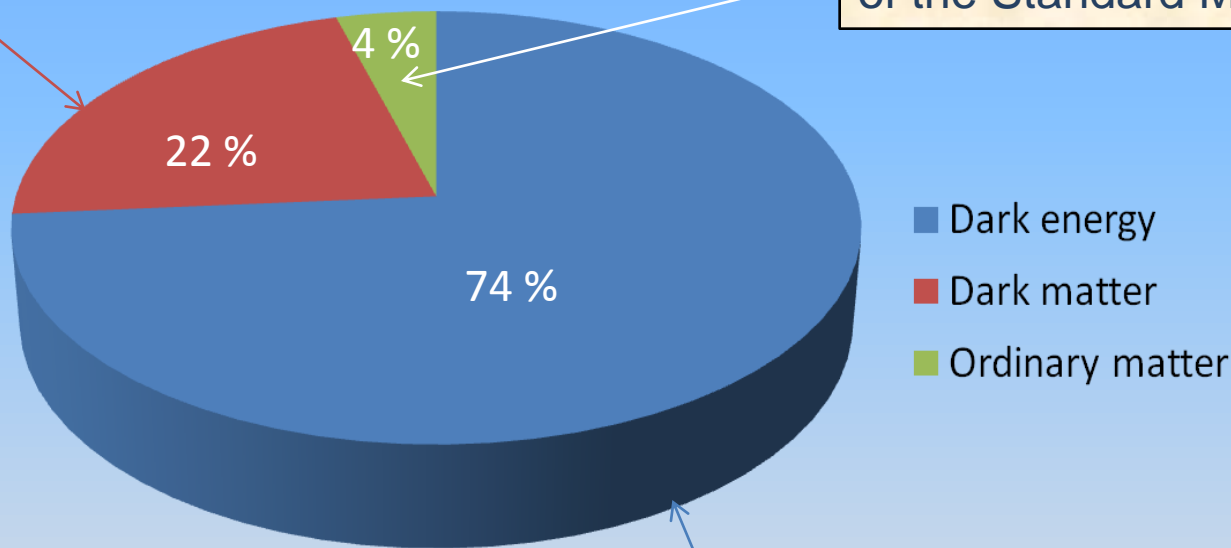
M. Berg: D-brane models in particle physics, D-brane loop corrections (with Haack, Kang, Samtleben); The very early universe in string theory, brane inflation, reheating (with McAllister, Pajer, Haack, Kans, Sjörs) Effective field theories of neutralino dark matter, $MSSM_5$ (with Edsjö, Lundström & Sjörs).

G. Zaharijas (starts Nov. 1): Phenomenology of a wimponium (a bound state of two wimps); Estimates of sensitivity for a low energy threshold dark matter experiment; Exclusion limits for various dm models.

New Physics **required** in cosmology: Dark Matter and Dark Energy, Matter-Antimatter Asymmetry.

Also in particle physics: Neutrino Masses, Hierarchy $m_W \ll m_{Pl}$

Composition of the Universe

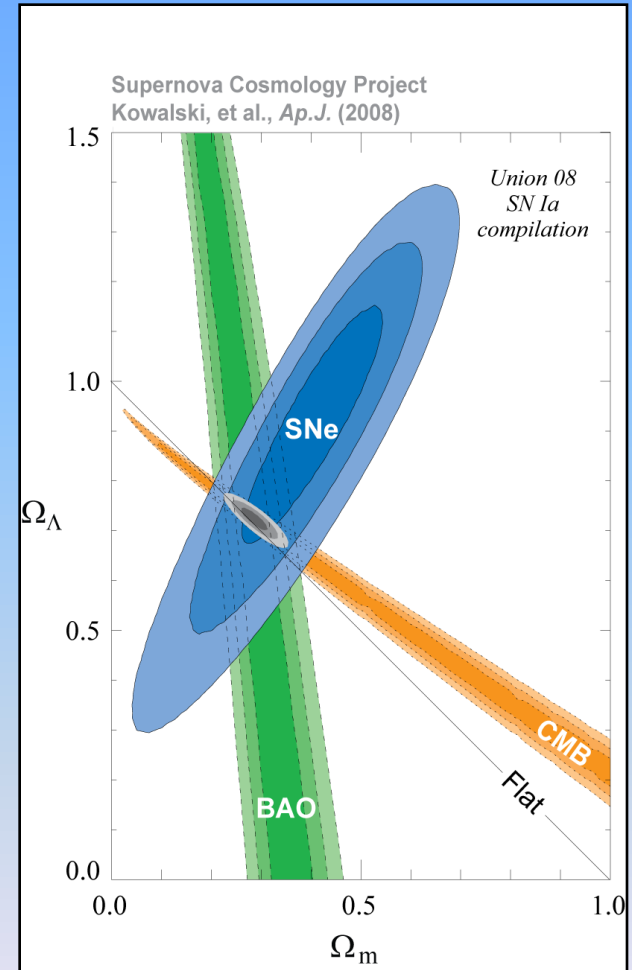
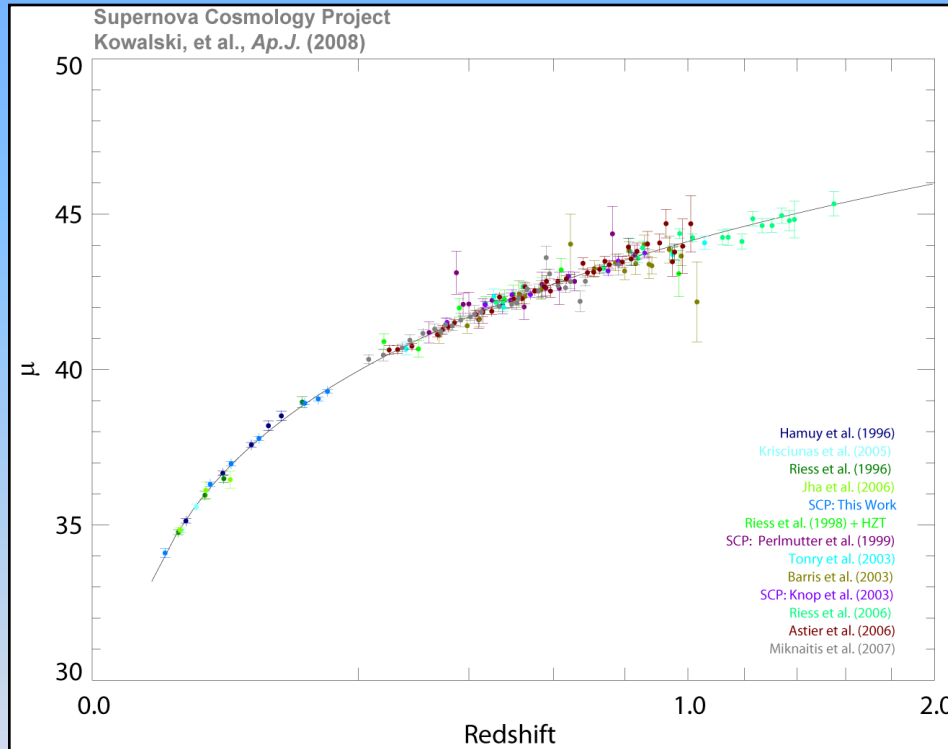


Ordinary matter: Physics of the Standard Model

Dark Matter: What is it? Is it related to new particle physics beyond the SM? Does it have a signature at LHC or in direct and indirect detection experiments?

Dark energy: cosmological constant or time-evolving field (quintessence or k-essence?)

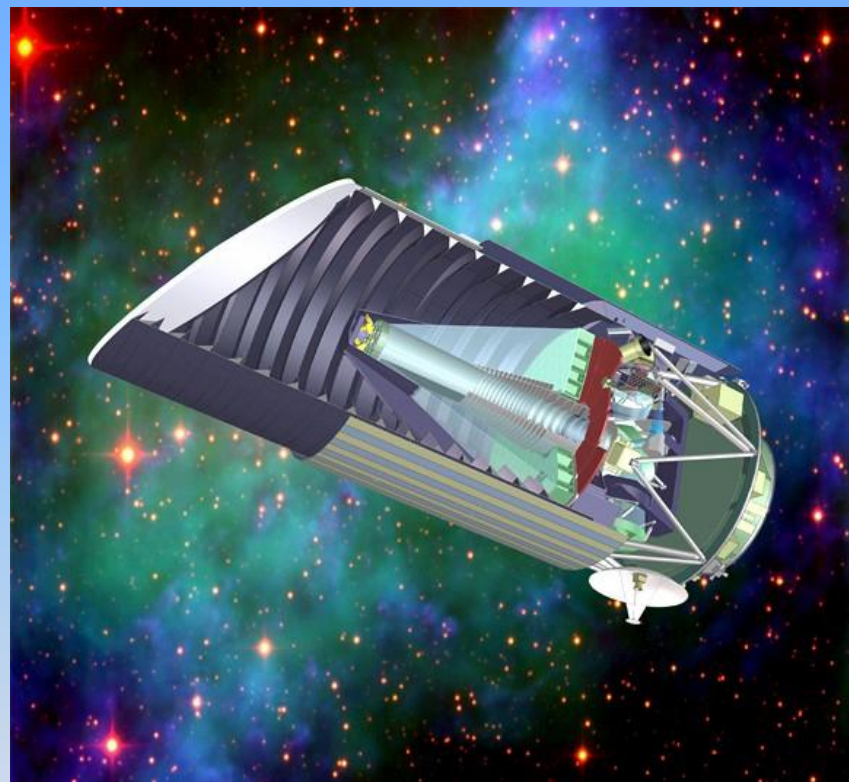
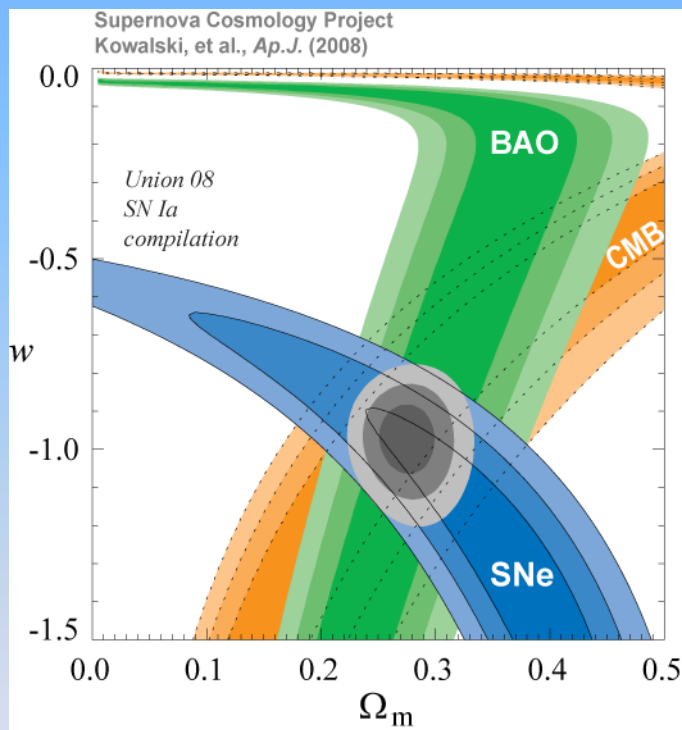
Latest results from the Supernova Cosmology Project



Stockholm Supernova Cosmology Group led by
A.Goobar, CoPS

Is the dark energy density constant or not?

Current data compatible with Λ
($w=-1$)

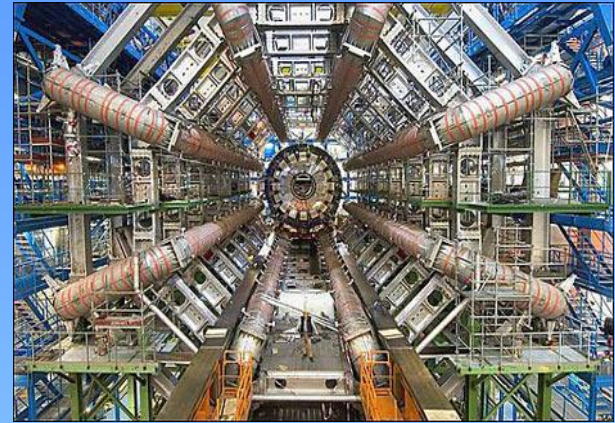


SNAP: contender for the next
generation of experiments (JDEM)

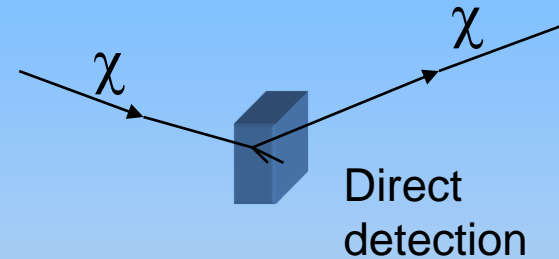
SNe + weak lensing

Methods of WIMP Dark Matter detection:

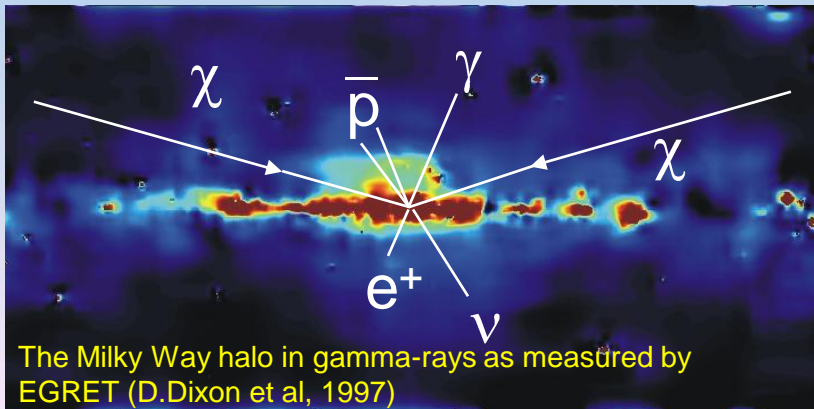
- Discovery at **accelerators** (Fermilab, **LHC**, ILC...).
- **Direct detection** of halo particles in terrestrial detectors.
- **Indirect detection** of neutrinos, gamma rays & other e.m. waves, antiprotons, positrons in balloon- or space-based experiments.
- For a **convincing** determination of the identity of dark matter, plausibly need detection by at least two different methods.



CERN/Atlas



Indirect detection

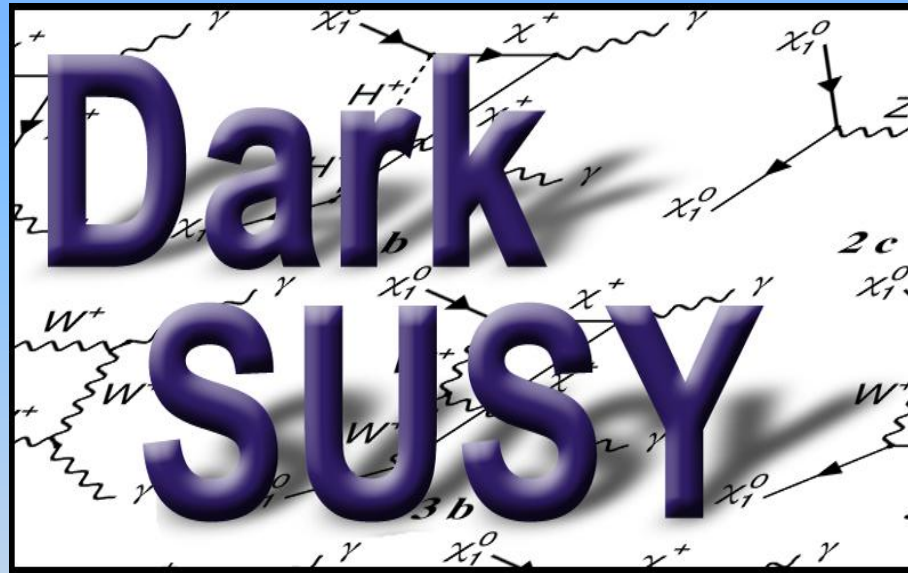


$$\frac{d\sigma_{si}}{dq} = \frac{1}{\pi v^2} (Zf_p + (A-Z)f_n)^2 F_A(q) \propto A^2$$

$$\Gamma_{ann} \propto n_{\chi}^2 \sigma v$$

Annihilation rate enhanced for clumpy halo; near galactic centre and in subhalos

Tool for computing cosmological relic density, masses, branching ratios, direct and indirect detection cross sections for general WIMPs, especially super-symmetric ones:



P. Gondolo, J. Edsjö, L.B., P. Ullio, Mia Schelke and E. A. Baltz, JCAP 2004

(with additions by T. Bringmann and G. Dudas)

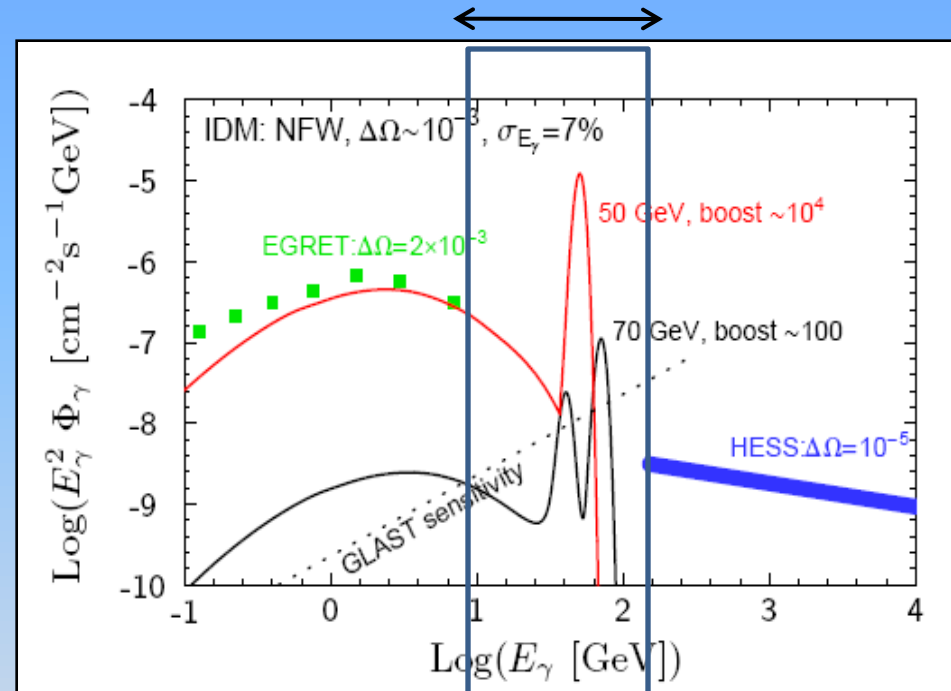
Example of more "conventional" Dark Matter model: One extra, Inert, Higgs Doublet

⇒ Ordinary Higgs can be as heavy as 300 GeV without violation of electroweak precision tests

⇒ 40 – 70 GeV inert Higgs gives correct Dark Matter density

⇒ The perfect candidate for detection in Fermi/GLAST!

No data exists in this range!
Fermi/GLAST will get it!



M. Gustafsson, L.B., J. Edsjö, E. Lundström, PRL 2007

Can be searched for at LHC through

$$pp \rightarrow W^* \rightarrow HA \text{ or } HS$$

$$pp \rightarrow Z^*(\gamma^*) \rightarrow SA \text{ or } H^+H^-$$

VR, June 2008:

Linnaeus grant, 70 MSEK over
10 years granted for the project
"Cosmo Particle Collaboration"
at Stockholm University

A field with great tradition in Stockholm...



Oskar Klein (1894 - 1977)
Professor at Stockholm University

Klein's paradox, Klein-Nishina formula, Kaluza-Klein extra dimensions, Alfvén-Klein matter-antimatter cosmology,...

... so we have proposed to create a centre under the Faculty with the name

The Oskar Klein Centre for Cosmo Particle Physics

See web page, okc.albanova.se



VR Linneaus grant: 70 MSEK/10 years

The Oskar Klein Centre

for Cosmo Particle Physics

at Stockholm University

L. Bergström (Project leader) CoPS, Fysikum, SU

C. Fransson (Co-leader), Astronomy, SU

J. Edsjö, CoPS, Fysikum, SU

A. Goobar, CoPS, Fysikum, SU

J. Sollerman, Astronomy, SU

G. Östlin, Astronomy, SU

S. Hellman, Particle Physics, SU (Atlas)

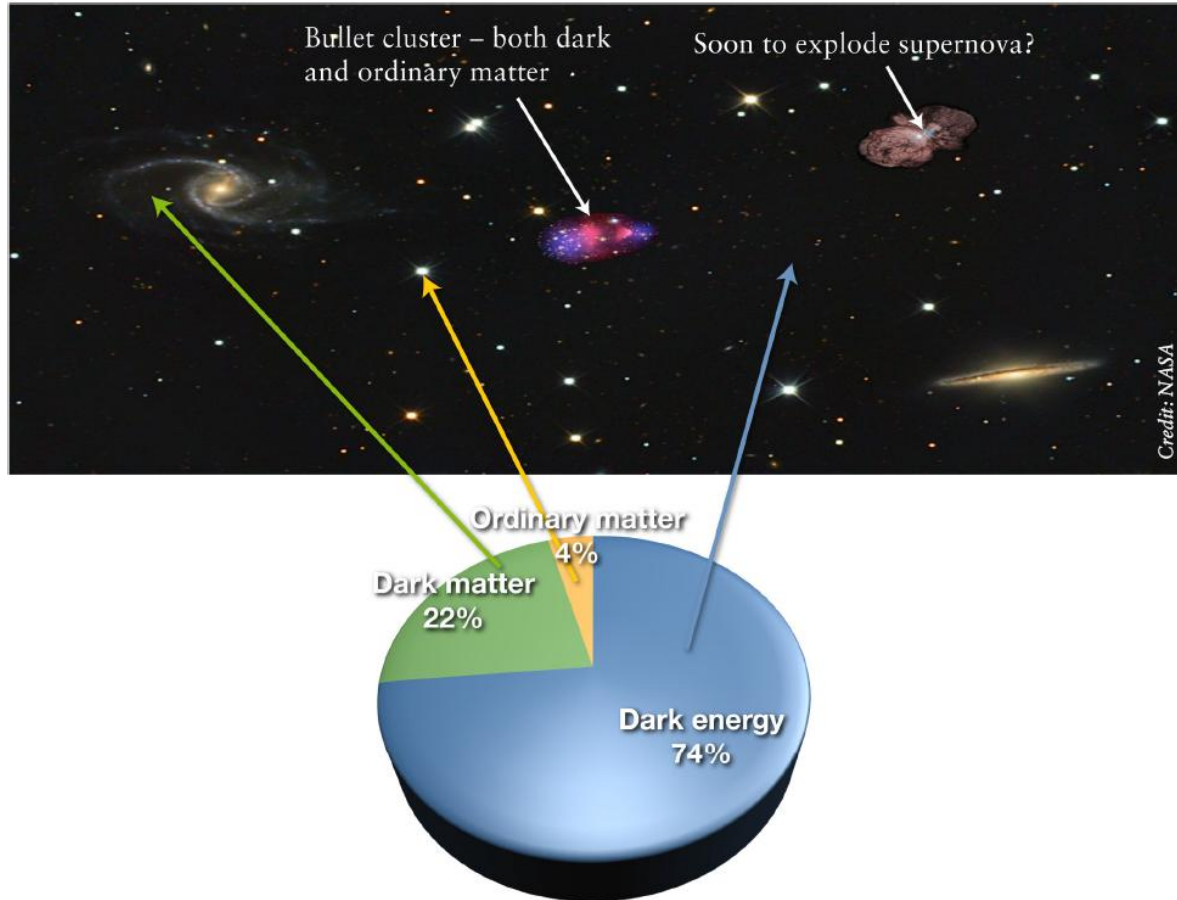
K. Jon-And, Particle Physics, SU (Atlas)

K. Hultqvist, Particle Physics, SU (IceCube)

M. Pearce, Physics, KTH

Representing ~ 70 Faculty, Research assistants,
Postdocs and Graduate Students

The CosmoParticle Collaboration (CPC)

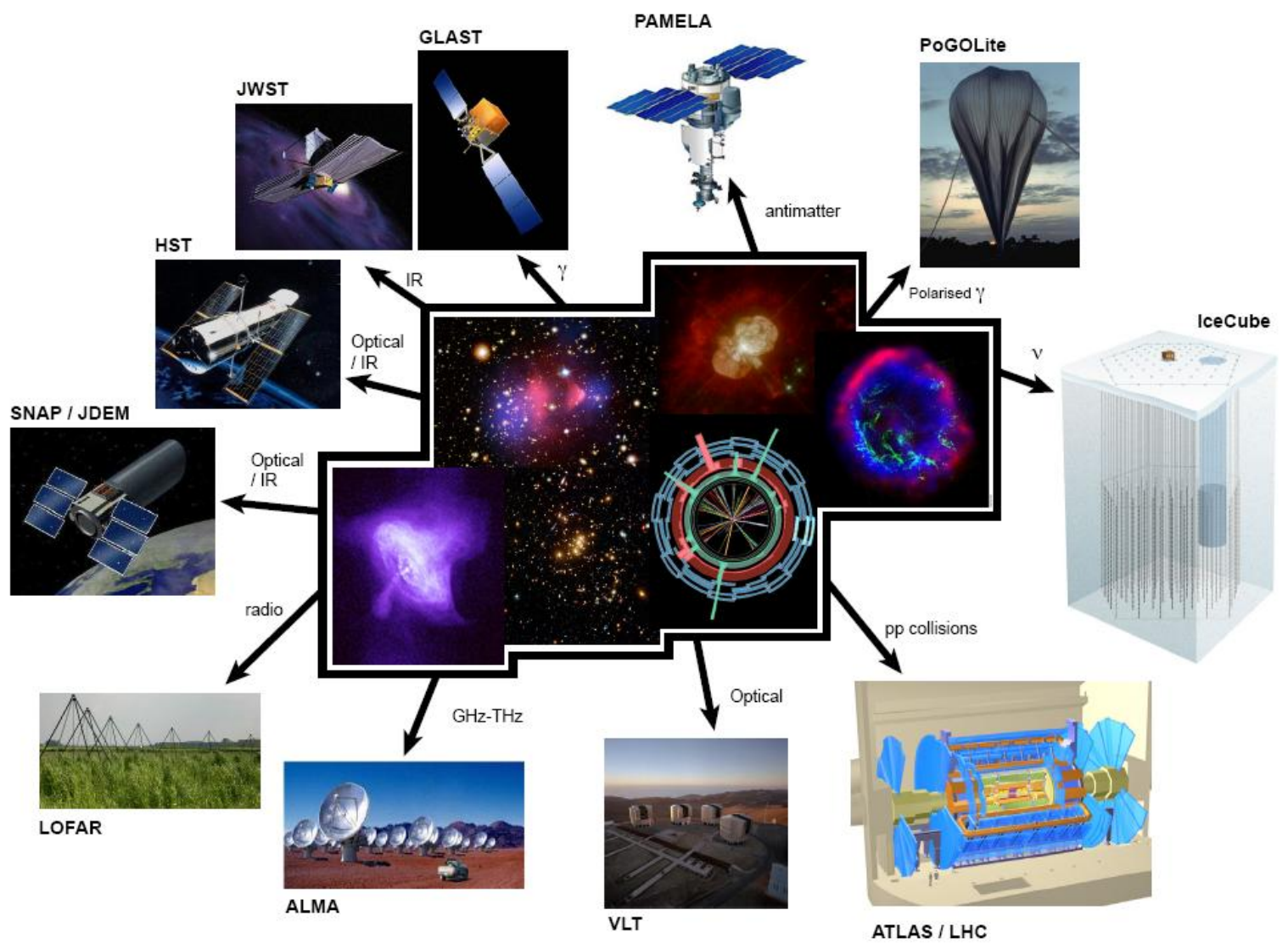


Themes

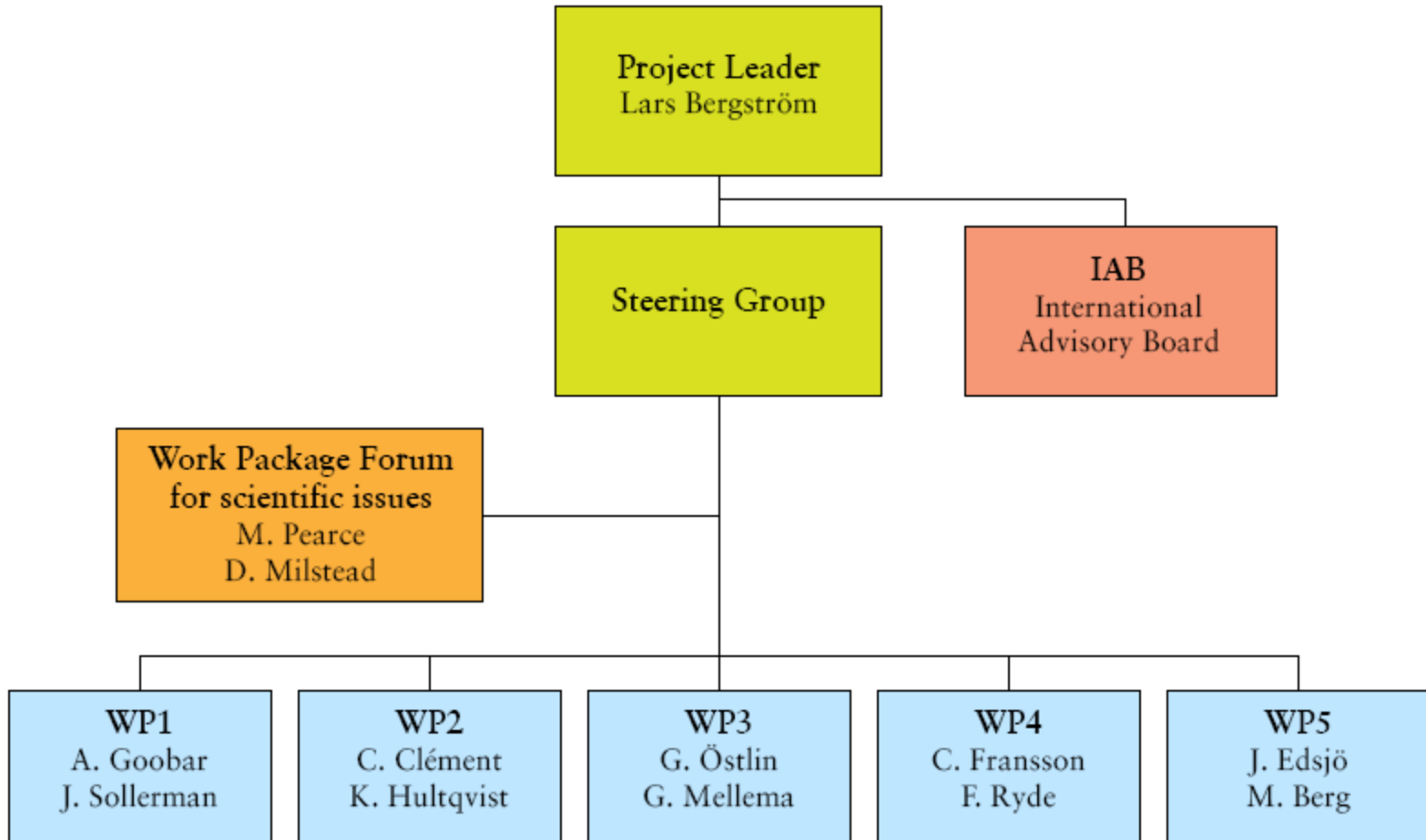
The proposed research is focused on three central themes in modern astrophysics, elementary particle physics and cosmology:

- A. Identifying theoretically, and probing observationally, measurable quantities of **dark energy** which can clarify the nature of this mysterious component of the energy density of the Universe.
- B. Searching experimentally for particle candidates of **dark matter**, which naturally means going beyond the standard model of particle physics, and if found, determining their properties and elucidating the underlying theoretical framework.
- C. Investigating the physics of extreme objects, such as **supernovae, neutron stars, and black holes**.

How will we do it?



How will we organize it?



We will announce within the next 10 days, up to **seven postdoctoral positions** in four areas:

- **The high-redshift Universe**
- **Supernovae, Gamma-ray bursts and Observational Cosmology**
- **Dark Matter, GRBs, and AGNs**
- **Particle physics phenomenology and/or cosmology**

The Oskar Klein Centre (OKC) has received funding from the Swedish Research Council (VR) for a ten-year programme in dark matter, dark energy, extreme objects in the universe, and related LHC-based studies. The aim is to create a productive and stimulating research environment emphasizing common goals and benefitting from the wide range of international research programs in physics and astronomy at Stockholm University and the Royal Institute of Technology. This announcement is part of the first round of recruitments for OKC, aiming to fill up to seven postdoc positions.

Deadline for applications: December 1, 2008