

Towards the APPEC strategy



APPEC

AstroParticle Physics *European Consortium*

Frank Linde, TeV Particle Astrophysics, CERN, September 12-16

ASTROPHYSICS

APPEC

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dark energy

gravitational waves

CMB

HE neutrinos

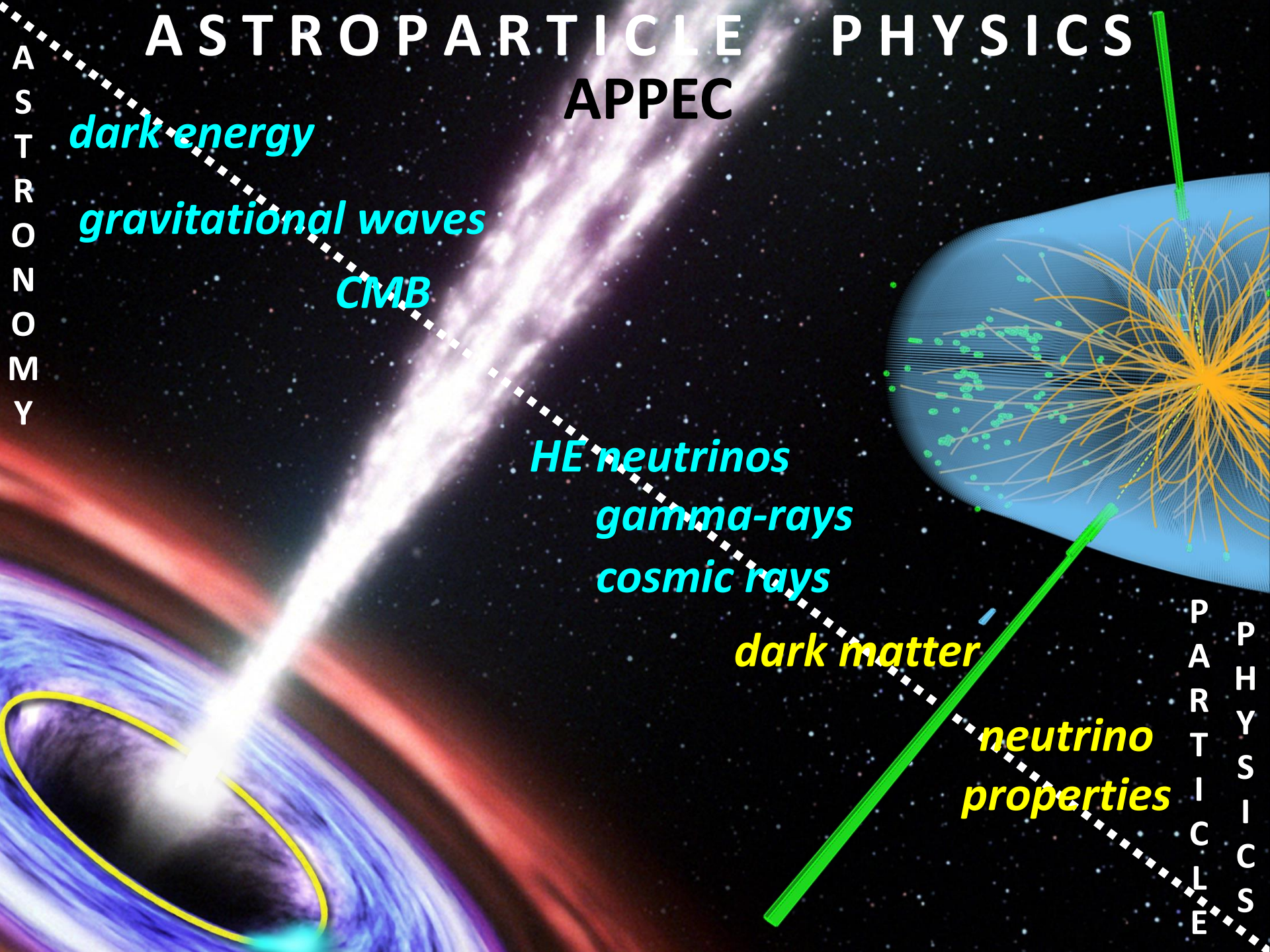
gamma-rays

cosmic rays

dark matter

*neutrino
properties*

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ASTROPHYSICS

APPEC

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dark energy

2011

gravitational waves

1993

CMB

1978

2006

HE neutrinos

gamma-rays

cosmic rays

1936

dark matter

neutrino

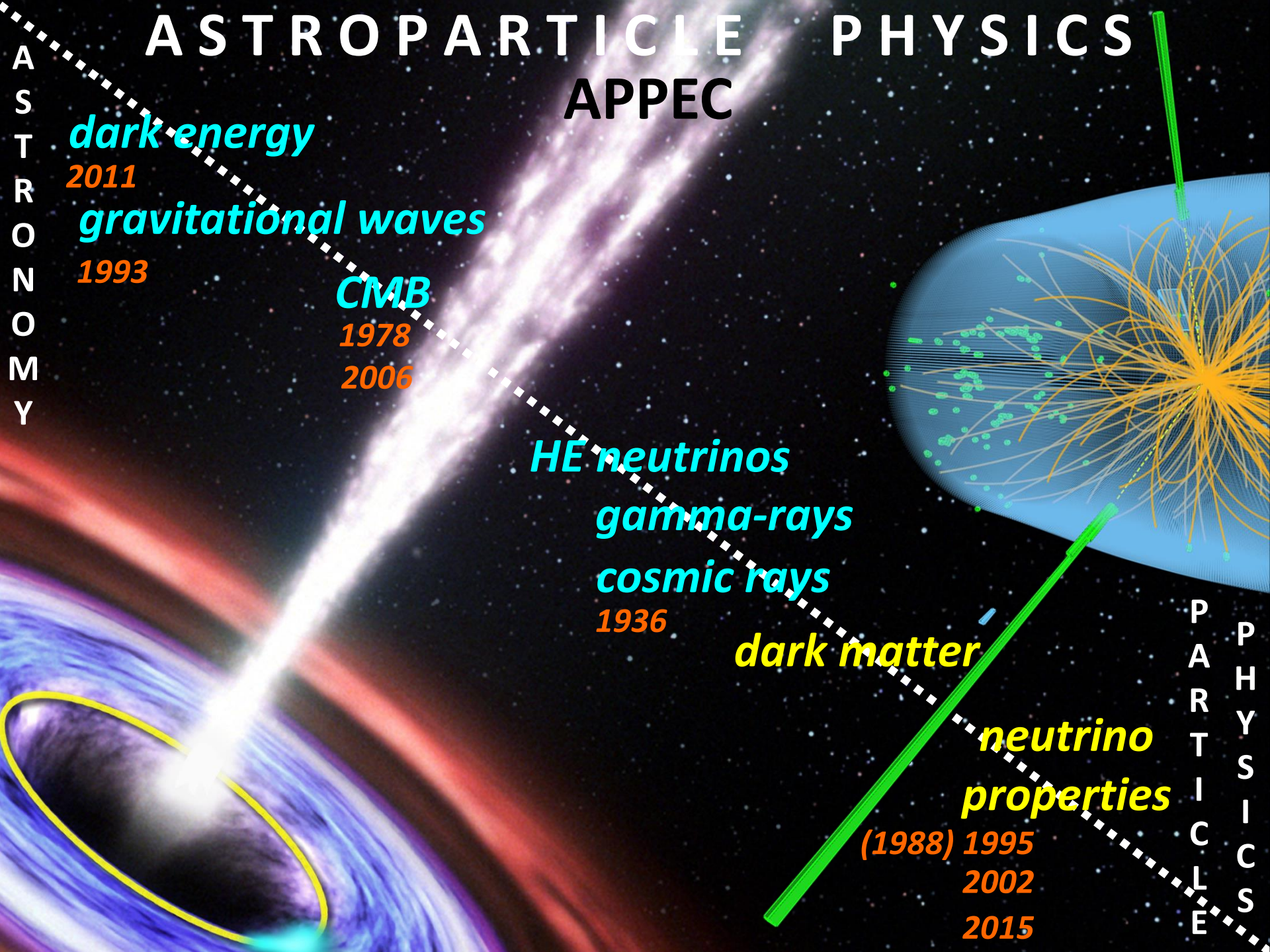
properties

(1988) 1995

2002

2015

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ASTROPARTICLE PHYSICS

APPEC

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dark energy

2015

LVC

gravitational waves

CMB

IceCube

2013

PeV neutrinos

gamma-rays

cosmic rays

dark matter

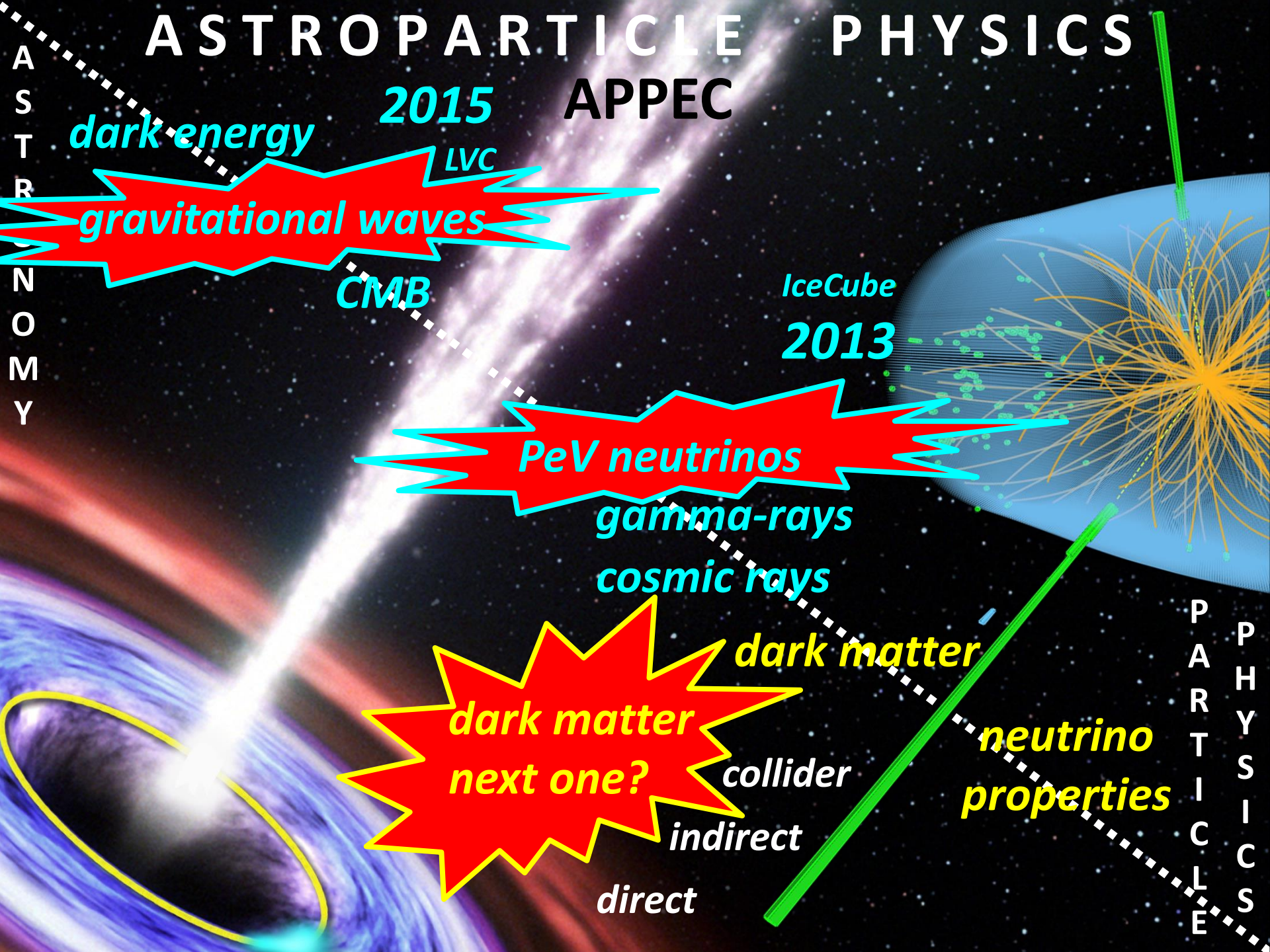
*dark matter
next one?*

collider

indirect

direct

*neutrino
properties*



Crucial ingredients

The image features three interlocking blue puzzle pieces arranged in a triangular pattern against a black background. Each piece contains text. The top piece is labeled 'community' with the subtext 'EU: few 1000 scientists'. The middle piece is labeled 'science' with the subtext 'excellent'. The bottom piece is labeled 'technology' with the subtext 'state-of-the-art'.

community

*EU: few 1000
scientists*

science

excellent

technology

state-of-the-art

APPEC: *(expanding)* organisation

AstroParticle Physics European Consortium

*cash budget: ~80 k€ /year ...
(members invest a lot more!)*

Scientific
A + CERN
Advisory
ESO
Committee

APPEC *functional centers*



STFC – Swindon/UK
Outreach, Web pages



DESY - Hamburg/D
Management, Computing & Industry



APC - Paris/F
Roadmapping, Common Calls, Interdisciplinary



LSC - Canfranc/S
Web host



LNGS - L'Aquila/I
Networking, Theory, Graduate Schools

APPEC: website & newsletter

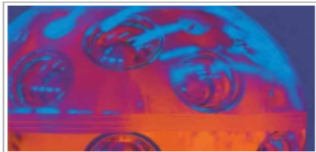


www.appec.org

Astroparticle Physics European Consortium

Home About Science Strategy Infrastructures Industry Computing Multidisciplinary Theory Communication Calls Documents

NEWS



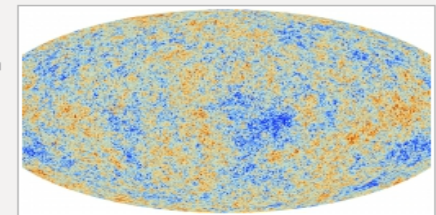
**APPEC MAKES SENSE:
INVITATION TO THE KICK-OFF
WORKSHOP 27 SEPTEMBER IN
MUNICH**

FEATURES

TOWARDS THE EUROPEAN COORDINATION OF THE CMB PROGRAMME 2016

APPEC invites you to attend a workshop on the next steps in cosmic microwave background research. "Towards the European coordination of the CMB programme" will look at the requirements of the next space mission, and what can be achieved with intermediate experiments including ground or balloon-based observations. The meeting will gather both principal investigators and agency re...

[Read more](#)



European Astroparticle Physics Newsletter May 2016

The latest astroparticle physics news. Trouble viewing this newsletter? [Click here.](#)



Astroparticle Physics European Consortium

May 2016

LIGO and Virgo receive Special Breakthrough Prize

More than 1000 scientists and engineers involved in the detection of gravitational waves [have been awarded a special Breakthrough Prize in Fundamental Physics](#). The award of \$3 million will be shared between LIGO founders Ronald WP Drever, Kip S Thorne, and Rainer Weiss, and 1005 others in the LIGO-Virgo Collaboration as well as seven additional scientists recognised for their contributions to the success of LIGO.

Edward Witten, the chair of the Selection Committee said: "This amazing achievement lets us observe for the first time some of the remarkable workings of Einstein's theory. Theoretical ideas about black holes which were close to being science fiction when I was a student are now reality."



APPEC: common calls



CTA

DARWIN

EURECA

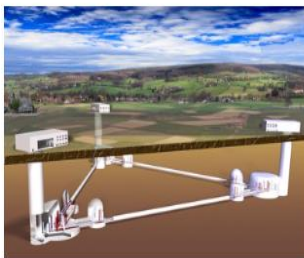
KM3NeT

LAGUNA-LBNO

EINSTEIN TELESCOPE

Underground labs

GRAVITATIONAL WAVES: A NEW WAY TO EXPLORE THE UNIVERSE



TOWARDS GRAVITATIONAL WAVE ASTRONOMY

ET will be a 3rd generation GW observatory. The conceptual design is being developed in a European-wide effort, supported by the European Commission under the Seventh Framework Programme. GWs, being

perturbations of the structure of space-time, produce minuscule changes in the relative distances of free masses. Each ET interferometer will monitor such distances shooting laser beams in two directions and studying the interference pattern after beam reflection on mirror test masses put at kilometeric distances.

ET constitutes a natural evolution with respect to first generation interferometers (Virgo, LIGO, GEO600) and with respect to the "advanced" ones (expected to be operative by around 2015). The sensitivity will be improved with an arm length of 10 km, instead of 3 km as in Virgo. Further improvements will come from cryogenic mirrors to fight against thermal noise and from being underground, to reduce seismic noise.

With a sensitivity 10 times better than advanced detectors, ET will be able to explore a Universe region with a radius of billions of light years, collecting thousands of events (GW bursts) per year of observation.

> <http://www.et-gw.eu>



CTA

DARWIN

EURECA

KM3NeT

LAGUNA-LBNO

EINSTEIN TELESCOPE

Underground labs

DARWIN: TOWARDS THE MULTI-TON SCALE DARK MATTER NOBLE LIQUIDS DETECTOR



SOLVING THE DARK MATTER MYSTERY

In recent years, many experiments have attempted to face the dark matter challenge. In this race, the XENON experiment located at the INFN's Gran Sasso underground laboratory in Italy recently proved to be the most sensitive, setting the best limits for dark matter. Other experiments such as COUPP, super CDMS and

LUX (North America) or Edelweiss at the French underground laboratory in Modane are at the stage of waiting for new results, and ArDM at the Canfranc underground laboratory in Spain and DarkSide at Gran Saso are both starting.

But given current results, it is clear that we will need at least a ton-scale detector to discover dark matter particles. The idea of DARWIN is to use both argon (LAr) and xenon (LXe) as WIMP targets. Results from noble liquid detectors have recently shown that they are among the most promising technology to push the sensitivity of direct WIMP searches into unexplored regimes of the parameter space. Thus, such a detector would not only have a realistic chance of discovering the nature of dark matter, but also be able to study its properties, such as its mass, its interaction strength and its local distribution in our galaxy.



APPEC: *technology fora*

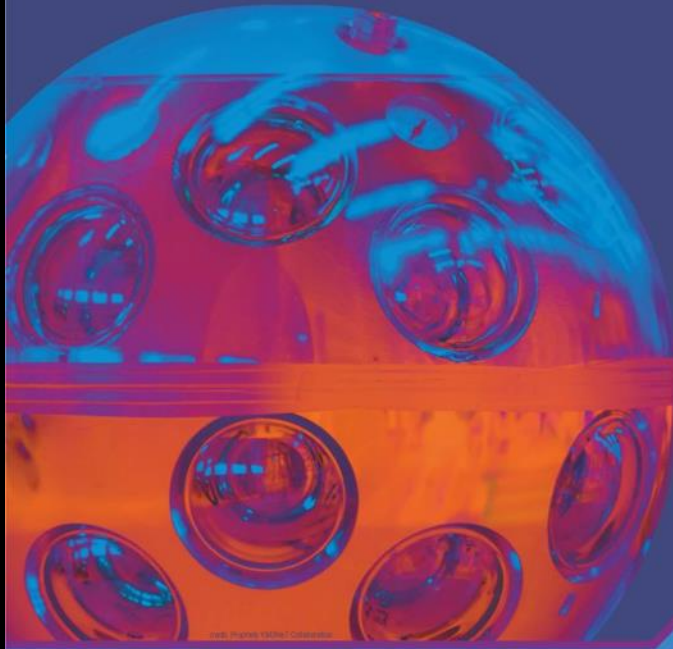
APPEC

Technology Forum 2015



LOW LIGHT-LEVEL DETECTION

in astroparticle physics and in medical application



22 - 23 April 2015
München Nymphenburg Castle

APPEC - Astroparticle Physics European Consortium - appec.org

Kick-off Meeting SENSE

SENSE

27 September 2016 *Munich*
Europe/Berlin timezone

Search

Overview

Timetable

Registration

└ Registration Form

List of registrants

The SENSE project will be funded by the European Commission as a Coordination and Support Action in the domain of Future Emerging Technologies (FET-Open) with the aim of coordinating the research and development efforts in academia and industry in low light level sensing.

This initiative has emerged from the series of Technology Forums organized within the frame of ASPERA and APPEC. SENSE is a three-year project. Starting in September 2016, R&D experts will be invited to prepare an R&D roadmap towards the ultimate low light level sensors. SENSE will then coordinate, monitor, and evaluate the R&D efforts of research groups and industry in advancing low light level sensors and liaise with strategically important European initiatives and research groups and companies worldwide. The SENSE Project shall

- setup an experts group and conduct the development of a European R&D roadmap towards the ultimate low light-level (LLL) sensors,
- monitor and evaluate the progress of the developments with respect to the roadmap,
- coordinate the R&D efforts of research groups and industry in advancing LLL sensors,
- prepare a database of light sensor specifications and lab equipment, test stands and expertise available in the different institutions,
- liaise with strategically important European initiatives and research groups and companies world-wide,
- create the Technology Exchange Platform to enable an efficient exchange between researchers and developers being involved in SENSE,
- prepare training events and material to attract and teach especially young researchers,
- work out a technology training session that can implemented in any existing summer school.

EU FET-Open: low-level light sensing

APPEC: workshops

**International meeting
for large ν -infrastructures**

**Florence
CMB workshop**



APPEC
International
Meeting for
Large
Neutrino
Infrastructures

23-24 June 2014
Ecole d'Architecture Paris
3 Quai Panhard et Levassor
Paris, 75013

Speakers
E. Lisi, J. Strait,
M. Nessi, T. Kobayashi,
S.K. Agarwalla, M. Diwan,
M. Shiozawa, A. Rubbia,
T. Ekelof, K. Long,
S. Ritz, J. Lesgourgues,
A. Smirnov, A. McDonald,
P. Huber, T. Laserre,
Y. Wang, SB Kim,
N. Mondal, M. Kowalski

<http://appec.org/9-features/78-gnm.html>



Towards the European
Coordination
of the CMB program

JL. Puget, A. Challinor,
R. Sunyaev, L. Verde,
N. Aghanim, F. Bouchet,
JP. Leahy, JC. Hamilton,
A. Monfardini, JA. Rubiño-Martín,
E. Battistelli, S. Masi, J. Delabrouille,
P. de Bernardis, J. Carlström, M. Devlin,
S. Hanany, A. Kogut, M. Hazumi,
PG. Tizien, M. Bersanelli, E. Martínez,
M. Griffin, J. Baselmans, K. Irwin

APPEC
ASTRONET

Villa Finaly, Florence
31st August-1st September, 2015

<https://indico.cern.ch/event/376392/overview>

1. June 2014 (Paris) → **LBNF/DUNE**
2. April 2015 (Chicago)
3. May 2016 (Tokyo)

1. September 2015 (Florence)
2. September 2016 (Florence)
→ **EU ground-based CMB experiment?** + **CORE (ESA)**

APPEC: *unique infrastructure*

*deep-underground
low-background
laboratories*

*dark matter
 $0\nu\beta\beta$ decay*

*BUL – Boulby/UK
LNGS – Gran-Sasso/I
LSC – Canfranc/ES
LSM – Modane/F
CallioLab – Pyhäjärvi/SF
LSBB – Rustrel/F*



APPEC: *roadmapping*

2008

2011

'Magnificent 7'

ASTROPARTICLE PHYSICS
the European strategy

Astroparticle physics

The European Roadmap

HE gammas
HE neutrinos
HE cosmic rays
Gravitational waves
Dark matter
 ν -mass
 ν -mixing & p -decay



<http://www.aspera-eu.org>

www.aspera-eu.org



APPEC: *roadmapping*

2008

2011

Magnificent 7

ASTROPARTICLE PHYSICS
the European strategy

Astroparticle physics

The European Roadmap

HE gammas

HE neutrinos

HE cosmic rays

Gravitational waves

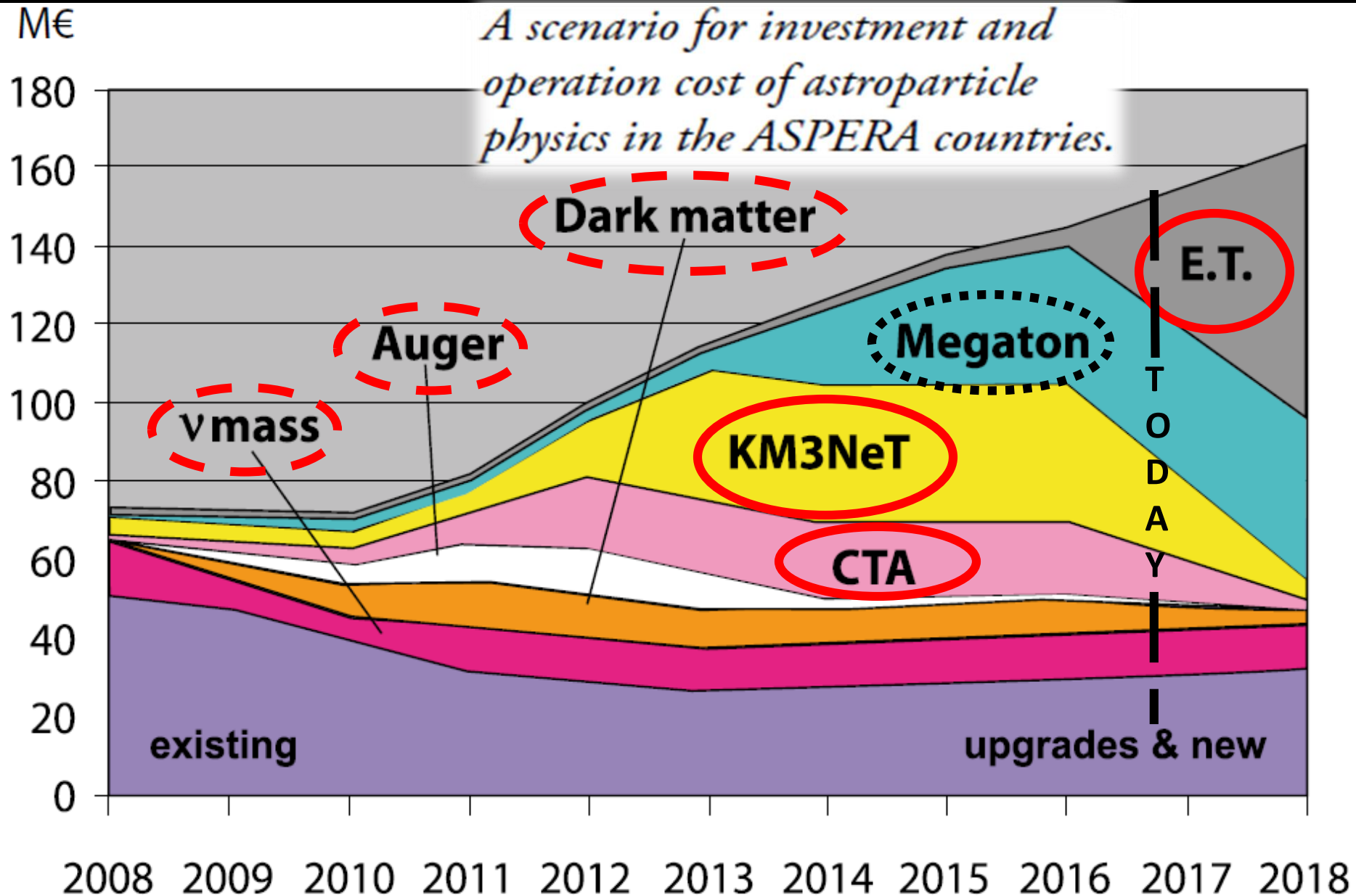
Dark matter

ν -mass

ν -mixing & p -decay

In 2008: still lots of speculation ...

Ambitions APPEC's 2008 roadmap ...



European research infrastructures roadmap: ESFRI

European Strategy Forum
on Research Infrastructures

ESFRI

STRATEGY REPORT ON RESEARCH INFRASTRUCTURES

1

ESFRI PROJECTS

	NAME	FULL NAME	FORWARD PLAN (YEAR)	OPERATION (YEAR)	LEGAL STATUS (AGREEMENT/ACCORD)	CONSTRUCTION COST (€M)	OPERATIONAL BUDGET (€M/AN)
ENERGY	ECCSEL	European Carbon Dioxide Capture and Storage Laboratory Infrastructure	2008	2016	ERIC under preparation	80-120	1**
	EU-SOLARIS	European SOLAR Research Infrastructure for Concentrated Solar Power	2010	2020*	ERIC under preparation	120	3-4
	MYRRHA	Multi-purpose Hybrid Reactor for High-tech Applications	2010	2024*		NA	100
	WindScanner	European WindScanner Facility	2010	2018*		45-60	8
ENVIRONMENT	ACTRIS	Aerosols, Clouds and Trace gases Research Infrastructure	2016	2025*		190	30
	DAHURIUS-RI	International Centre for Advanced Studies on River-Ses Systems	2016	2022*		222	28
	ESCAT_3D	Next generation European Incoherent scatter radar system	2008	2021*		74	6
SPACE	EPOS	European Plate Observing System	2008	2020*	ERIC under preparation	52	15
	SIOS	Svalbard Integrated Arctic Earth Observing System	2008	2020*		80	3-2

CTA

Cherenkov Telescope Array

2023*

297

20

EST

European Solar Telescope

2026*

200

9

KM3NeT 2.0

KM3 Neutrino Telescope 2.0:
Astroparticle & Oscillations Research with Cosmics
in the Abyss

2020*

92

3



ROADMAP 2016

INITIAL SCIENCE CASES

SCIENCE CASES

ERIC

European Research Infrastructure for Heritage Science

2016

2022*

4

5

*expected

**for controlled works

NA: Not Available

European research infrastructures roadmap: ESFRI

European Strategy Forum
on Research Infrastructures

ESFRI

STRATEGY REPORT ON RESEARCH INFRASTRUCTURES

1

ESFRI PROJECTS

	NAME	FULL NAME	EU COMP. YEAR (YMR)	OPERATION (YMR)	LEGAL STATUS (AS OF 1 JANUARY 2014)	CONSTRUCTION COST (€ M)	OPERATIONAL BUDGET (€ M) PA
BIOT	ECCSEL	European Carbon Dioxide Capture and Storage Laboratory Infrastructure	2008	2016	ERIC under preparation	80-120	1**
	EU-SOLARIS	European SOLAR Research Infrastructure for Concentrated Solar Power	2010	2020*	ERIC under preparation	120	3-4
	MYRRHA	Multi-purpose Hybrid Reactor for High-tech Applications	2010	2024*		NA	100
	WindScanner	European WindScanner Facility	2010	2018*		45-60	8
ENVIRONMENT	ACTRIS	Aerosols, Clouds and Trace gases Research Infrastructure	2016	2015*		190	30
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ENVIRONMENT	EPOS	European Plate Observing System	2008	2020*	ERIC under preparation	52	15
	SIOS	Svalbard Integrated Arctic Earth Observing System	2008	2020*		80	2-2
	ArArE	Infrastructure for Analysis and Experimentation on Ecosystems	2010	2018*		200	2-2**
ENVIRONMENT	EMBRIC	European Marine Biological Resource Centre	2008	2016	ERIC under preparation	4.5	6
	EMPHASIS	European Infrastructure for multi-scale Plant Phenomics and Simulation for food security in a changing climate	2016	2020*		72	16
	ERHHA	European research infrastructure on highly pathogenic agents	2008	2018*		NA	NA

ESFRI Projects

The ESFRI Projects have been selected for scientific excellence and maturity and are included in the Roadmap in order to underline their strategic importance for the European Research Infrastructure system and support their timely implementation. The ESFRI Projects can be at different stages of their preparation according to the date of inclusion in the ESFRI Roadmap.

* expected

** for controlled delivery

NA: Not Available

National roadmaps: *APP well represented*



Next steps:
*funding alignment,
cost savings, staging, ...*

APPEC: *roadmapping*

2008



2011



HE universe

gammas

neutrinos

cosmic rays

gravitational waves

Dark universe

dark matter

dark energy

Early universe

CMB

ν -properties

mass, mixing, ...

APPEC: *roadmapping*

2008

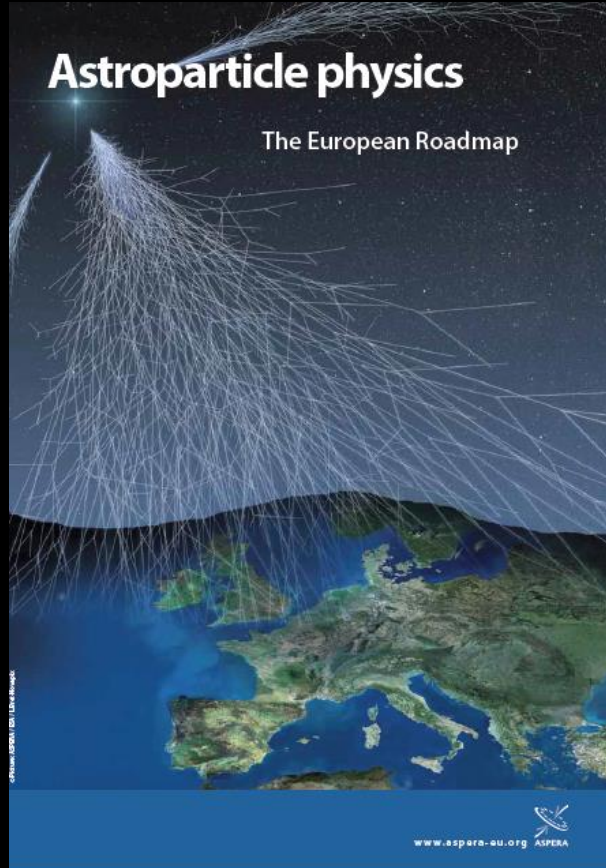
ASTROPARTICLE PHYSICS
the European strategy



2011

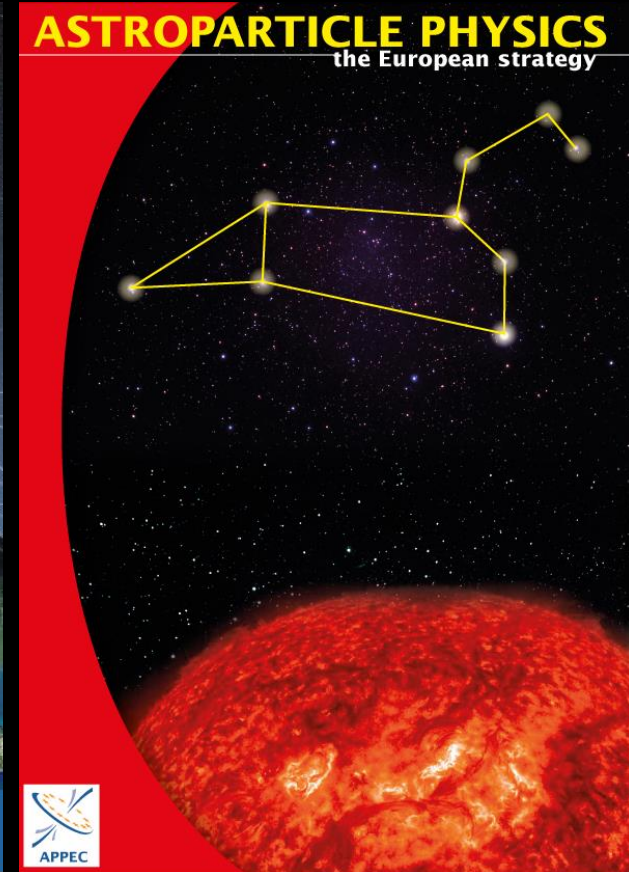
Astroparticle physics

The European Roadmap



2016

ASTROPARTICLE PHYSICS
the European strategy



resource aware

APPEC: *Town Meeting* → *roadmap*

Wednesday 6 April

09:00-10:00 Registration - Welcome coffee

	Speaker	Moderator
10:00-10:15	Antonio Masiero <i>APPEC SAC Chair</i>	Antonio Masiero <i>APPEC SAC Chair</i>
10:15-11:00	Felix Aharonian	Christian Spiering
11:00-11:45	Gisela Anton	Stanislaus Bentvelsen
11:45-12:30	Andreas Haungs	Johannes Bluemer

12:30-14:00 Lunch - Buffet

14:00-14:30	Multimessenger study of the Universe - Theory	Roger Blandford	Antonio Masiero
14:30-15:00	Current problems in cosmology - Theory	Subir Sarkar	Lars Bergstroem
15:00-15:30	Current problems in neutrino - Theory	Eligio Lisi	Janet Seed

15:30-16:15 Coffee

16:15-17:00	Neutrino parameters with large experiments (CP violation, mass hierarchy,...)	Mauro Mezzetto	Fernando Ferroni
17:00-17:45	Lepton number violation and basic neutrino properties	Andrea Giuliani	Stefano Ragazzi
17:45-18:30	Cosmology - Dark Matter	Jocelyn Monroe	Mario Martinez

18:30-18:45 Break

18:45-19:30	T. Kajita public lecture	Takaaki Kajita	Stavros Katsanevas
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19:15-20:15 Cocktail

Thursday 7 April

09:30-10:15	Cosmology - CMB	Francois Bouchet	Stavros Katsanevas
10:15-11:00	Cosmology - Dark Energy	Ramon Miquel	Reynald Pain

11:00-11:45 Coffee

11:45-12:30	HE-Univers - Gravitational Waves	Patrick Sutton	Federico Ferrini
12:30-13:00	APP Computing	Volker Beckmann	Katharina Henjes-Kunst

13:00-14:30 Lunch - Buffet

14:30-15:00	APP - Detector R&D, Industry	Jo v/d Brand	Teresa Montaruli
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15:00-17:00	Round table with international agencies (CERN, ASTRONET, ESO, DOE, NSF, CANADA, CHINA, JAPAN)	F.Giannotti (CERN), R. Gilmozzi (ESO), K. Turner (DOE), J. Whitmore (NSF), T. Kajita (Japan), SN Zhang (China), N. Smith (Canada), C. Vincent (Astronet), M. Carena (Fermilab)	Stavros Katsanevas
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17:00-17:45 Coffee

17:45-18:15	Conclusions, APPEC, community, roadmap, funding alignment, international coordination	Frank Linde <i>APPEC Chair</i>	Frank Linde <i>APPEC Chair</i>
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Paris, April 6-7

Executive summary

Science

Extreme universe

Mysterious neutrinos

Dark universe

Early universe

Fundamentals

Theory

Detector R&D

Computing

Organisation

Recommendations

- **with community**
- **APPEC GA & SAC**



Status: <http://app2016.in2p3.fr/>



APPEC Town Meeting 2016

6-7 April, 2016

Amphitheatre Paris-Sorbonne, France

[Home](#)

[Programme](#)

[Registration](#)

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[Venue](#)

[Accommodation](#)

[Committees](#)

[Draft Considerations](#)

[Draft Recommendations](#)

The Astroparticle Physics European Consortium (APPEC) invites you to a town meeting at the [Grand Amphithéâtre de Sorbonne](#) in Paris on the 6th and 7th April 2016 to discuss an update of the 2011 APPEC Astroparticle Physics roadmap, to be published in September 2016.

In 2014 APPEC decided to launch an update of the 2011 Roadmap, transforming it to a “resource aware” roadmap. The intention was to gauge the financial impact of the beginnings of operation of the large global scale observatories put forward in the previous roadmap and to examine the possibilities of international coordination of future global initiatives. The APPEC Scientific Advisory Committee examined the field and prepared a set of recommendations. Based on these recommendations, the APPEC General Assembly drafted a set of “considerations” to be published by end of February 2016 and be debated in an open dialogue with the community, through the web page but primarily at the town meeting of 6-7 April. Based on this debate the final recommendations of APPEC will appear by September 2016.

Status: <http://app2016.in2p3.fr/>

Scientific issues (13)

*large-scale (CTA, ν -telescopes, Auger, GW)
medium scale (dark matter, ν -mass, $0\nu\beta\beta$)
synergies with PP, ASTRO & COSMO
foundations:*

*theory, R&D, computing, DU-labs
+ data policy*

Organisational issues (5)

*EU-Commission
collaboration: EU & global
collaboration: PP, ASTRO & COSMO
Inter-disciplinary aspects*

Societal issues (3)

*gender
education & outreach
industry*

European Strategy for Astroparticle Physics

APPEC—Astroparticle Physics European Consortium



Introduction

Astroparticle physics is the rapidly evolving field of research at the intersection of astronomy, particle physics and cosmology. Experimentally, it combines the advanced instrumentation of particle-physicists with the highest standard of imaging the cosmos by astronomers. Theoretically, it connects the Big Bang model of cosmologists to the standard model of particle physicists. The former gives a detailed description of the evolution of the macro-cosmos while the latter describes with stunning precision the micro-cosmos. Scientifically, astroparticle physics aims to gain insight into long-standing enigmas at the heart of our understanding of the universe such as:

- HE** **High-energy universe:** What can we learn about the cataclysmic events in our universe by combining all messengers – high-energy gamma-rays, neutrinos, cosmic-rays and gravitational waves – that we have at our disposal?
- D** **Dark universe:** What is the nature of Dark Matter and Dark Energy?
- V** **Mysterious neutrinos:** What are the intricate properties of neutrinos and what can they tell us?
- BB** **Early universe:** What else can we learn about the Big Bang – for example from the cosmic microwave background?

Given the increasing complexity, extensive running time and high capital investment of the experiments operated and planned by the European astroparticle physics community, the field organized itself in 2001 with APPEC as its coordinating body. The illustration shows the 2016 APPEC member countries. APPEC published a science vision, coined European Strategy for Astroparticle Physics, in 2008 and its first prioritized roadmap in 2011. The field made revolutionary progress since, with as a highlight the recent discovery of gravitational waves tracing back to one of the most energetic events in our universe ever witnessed by humanity: the merging of two black holes. The coming decade promises to be equally successful with an impressive arsenal of cutting-edge experiments expected to come into operation probing deep into the above scientific questions.

Competitive European participation in this dynamic and exhilarating field of research requires careful prioritization – notably regarding the larger infrastructures – and in most cases consultation and collaboration with our global partners and colleagues working in astronomy, particle physics and cosmology. The construction and, most importantly, also the running costs of projects must be scrutinized.

The new APPEC 2016 roadmap takes into account the collective funding level expected to be available at the national agencies and the EU and as such is not only a science vision but aims to be a resource-aware roadmap. The attribution of resources across the various activities is indicated in the attached graphic and summarizes APPEC's funding priorities in the context of global scientific ambitions. Its realization will allow for European researchers to successfully capitalize on past efforts and investments and promises to shed bright light on the composition and the mindboggling dynamics of our universe.

Resources & spending (in progress)

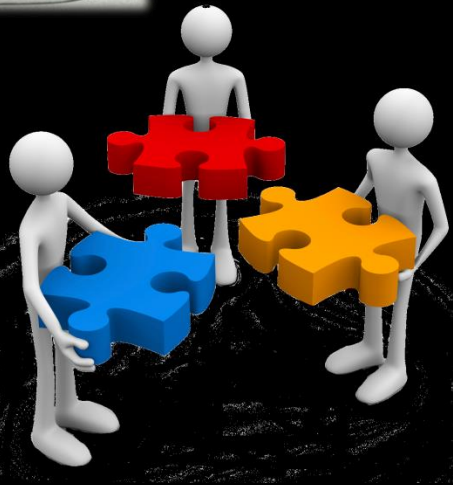


Concerns

*coherent program
connected community*



*Technical readiness /convergence
(notably in view of costs)
Realistic time schedules*



*Alignment of EU national funding ...
(harder in EU than in USA, Japan, China)*

Exploitation costs?

Astro-particle physics = astronomy + particle physics

***Bottom line: in EU we need stronger organisation ...
(& more €'s would help as well)***

Links to CERN, ESO/ESA, ...

Both ESO & CERN represented in APPEC General Assembly

European Particle Physics Strategy 2006:

7. A range of very important non-accelerator experiments take place at the overlap between particle & astroparticle physics ...

Council will seek to work with APPEC to develop a coordinated strategy in these areas of mutual interest.

European Particle Physics Strategy update 2013:

j. A range of very important non-accelerator experiments ... particle & astroparticle physics, such as searches for proton decay, $0\nu\beta\beta$ decay and dark matter and study of high energy cosmic-rays ...

In the coming years CERN should seek a closer collaboration with APPEC on detector R&D with a view to maintaining the community's capability for unique projects in this field.

ESA: Euclid & hopefully LISA, CORE, ...

ESO: negotiating with CTA for Southern hemisphere site

Promising – *very bright* – future ahead

