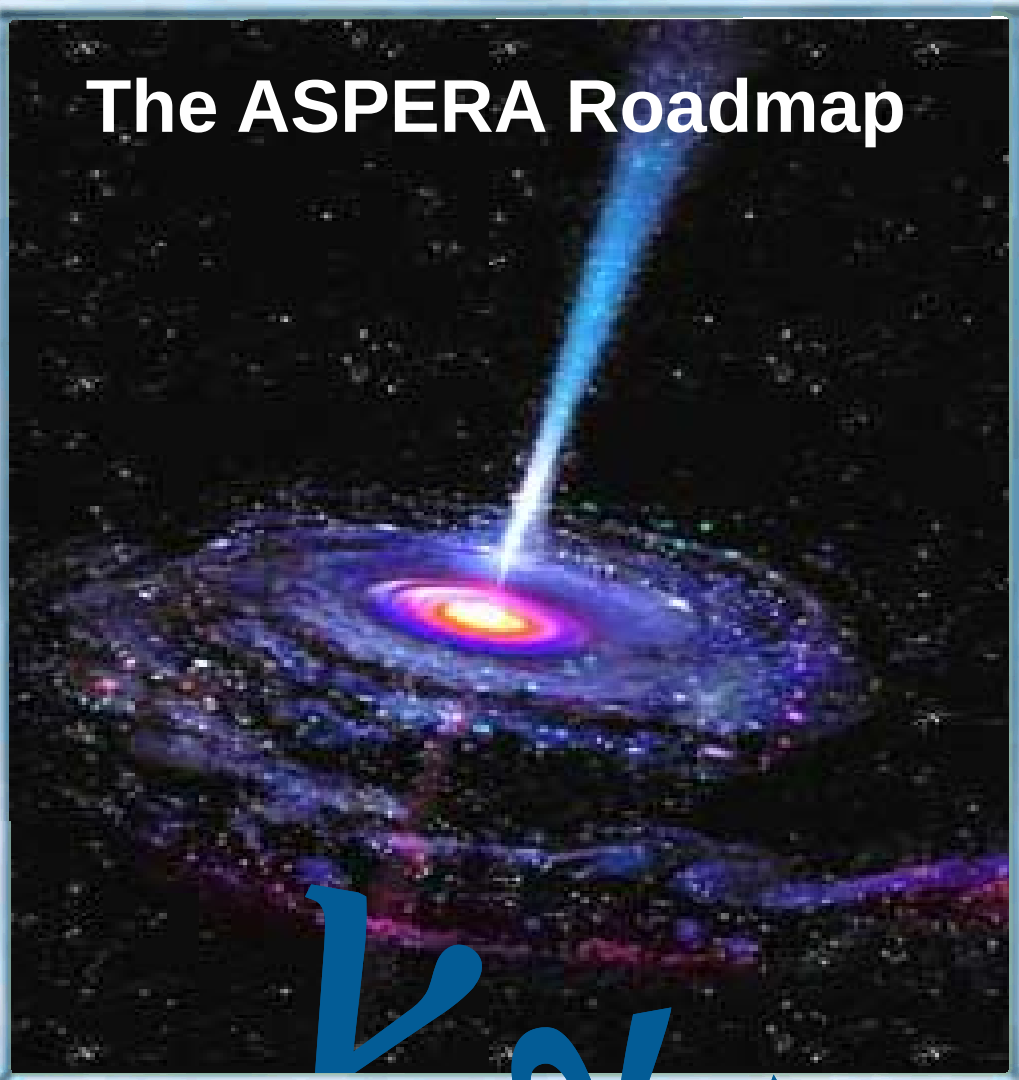
The ASPERA Roadmap



3 Pha

Prehistory:

- PRC extensively examines field 2003-2005, 7 themes one by one

Phase I:

- Questionnaires from subfields, PRC discussions, community discussions
- Roadmap Phase I
- Recommendations correspond to reduction of original projects by factor 2.
- But: required funding 2010-2015 still twice as high as present 5-year budget

Phase II+III:

- Questionnaires from subfields
- Questionnaires from agencies
- **Amsterdam Meeting 20/21 Sept 2007**
- Scrutinize information
- Explore further sources of funding and obvious cost reductions in projects
- Develop recommendations for 3 different funding scenarios (constant, moderate increase, strong increase)
- Approach Priorities
- Recommendations for Infrastructures
- Clear definition of milestones
- Roadmap Phase II (30 page paper for politicians)

3 Pha

Phase I:

- Questionnaires from subfields, PRC discussions, community discussions
- Roadmap Phase I
- Recommendations correspond to reduction of original projects by factor 2.
- But: required funding 2010-2015 still twice as high as present 5-year budget

Phase II+III:

- Questionnaires from subfields
- Questionnaires from agencies
- **Amsterdam Meeting 20/21 Sept 2007**
- → Scrutinize information
- Explore further sources of funding and obvious cost reductions in projects
- Develop recommendations for 3 different funding scenarios (constant, moderate increase, strong increase)
- Priorities step 1
- Recommendations for Infrastructures
- Clear definition of milestones
- Roadmap Phase II (30 page paper for politicians) – August 2008
- 2009/10: Explicit recommendations

esent information is last-minute information:

ot always on the same footing

- PhD students included/not included
- Private funding “ “
- Plans clear/less clear (sometimes just declare a claim)
- Level of discussion within the community
- ....

ot every experiment yet included in the Excel table

Sometimes not clear wether total cost or only European cost

No prioritization at all in the WGs !

3 Pha

Phase I:

- Questionnaires from subfields, PRC discussions, community discussions
- Roadmap Phase I
- Recommendations correspond to reduction of original projects by factor 2.
- But: required funding 2010-2015 still twice as high as present 5-year budget

Phase II+III:

- Questionnaires from subfields
- Questionnaires from agencies
- **Amsterdam Meeting 20/21 Sept 2007**
- Scrutinize information (post workshop PRC)
- Explore further sources of funding and obvious cost reductions in projects
- Develop recommendations for 3 different funding scenarios (constant, moderate increase, strong increase)
- **Priorities step 1**
- **Recommendations for Infrastructures**
- **Clear definition of milestones and decisions points**
- Roadmap Phase II (30 page paper for politicians) – August 2008

„calendar of d

Reactions to Phase I roadm

Many positive reactions
on Roadmap Phase I ,
but also critical questions

Main points of critique:

- „just a wish list“
- „cost estimate not realistic,
  will be more than factor 2“
- „factor 2 funding increase
  is an illusion“
- „an overall sum of 1.2-1.5
  M€ for Astroparticle in
  Europe is too ambitious

Reactions to Phase I roadm

Many positive reactions on Roadmap Phase II , but also critical questions

Main points of critique:

- „just a wish list“
- „cost estimate not realistic, will be more than factor 2“
- „factor 2 funding increase is an illusion“
- „an overall sum of 1.2-1.5 M€ for Astroparticle in Europe is too ambitious

- YES and NO.
  It is a result of previous con
  gence (reduction factor ~2)
- YES – we see that from the
  phase-II questionnaires
- NO:
  Need factor 2 pressure! Se
  positive examples next slid
- NO: Compare ratio
  #scientists/cost for LHC, FA
  XFEL – it is similar:
  - APP 3000 scient./1.4 M€ 2011-
  - FAIR 2500 scientists/1.2 M€

Funding

The fact

2006 expenses in Aspera countries:

- 70 M€ investment, about 150 M€ personnel

Roadmap-I estimate: 135 M€ per year

Roadmap-I request: 1200-1400 M€ in 5 years, 2011-2015, mostly investment, some personne

Now: WG requests including personnel sum up to ~2000 M€ in 2011-2015

This seems to be a factor 2, but w.r.t.investmen 3-3.5 (see later).

Prioritization mandatory:

Funding scena

Assume 3 scenarios:

1) Constant funding

2) Average increase 4% per year

   – → 50% after 10 years

3) Average increase 7% per year

   – → 100% after 10 years

Is anything above that realistic ?

Compare also P5 roadmap, USA (optimistic case factor 2 after 10 years)

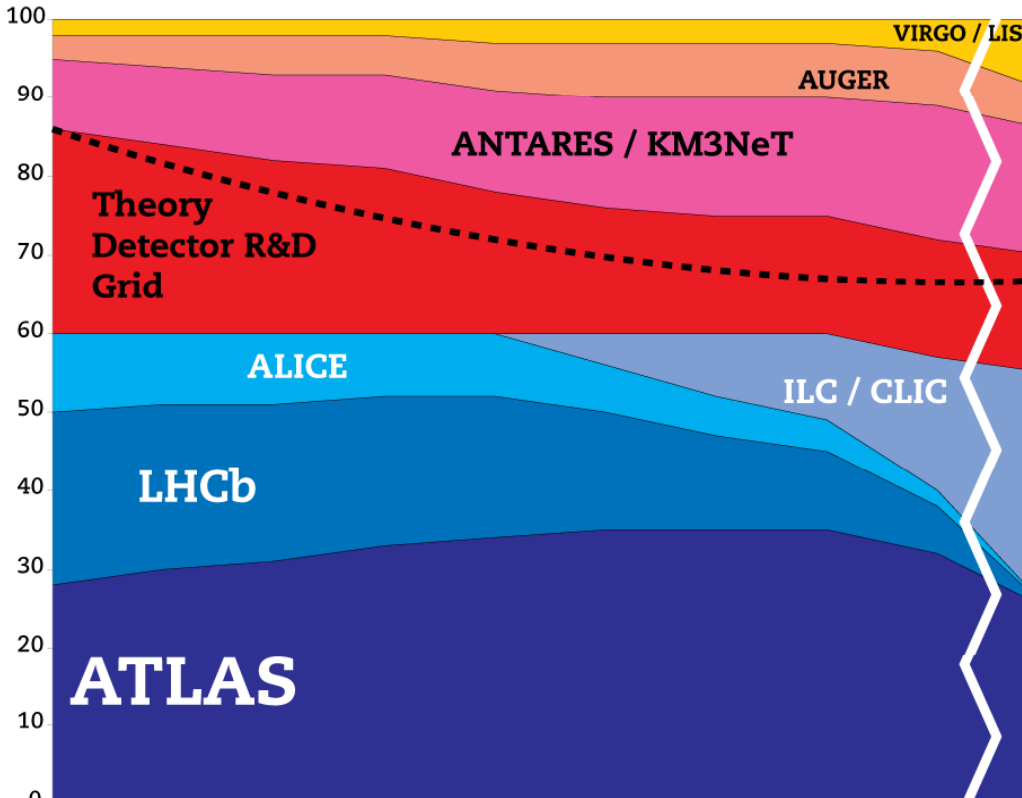
Increase will likely come in steps

There are examples of significant steps in funding (see next page)

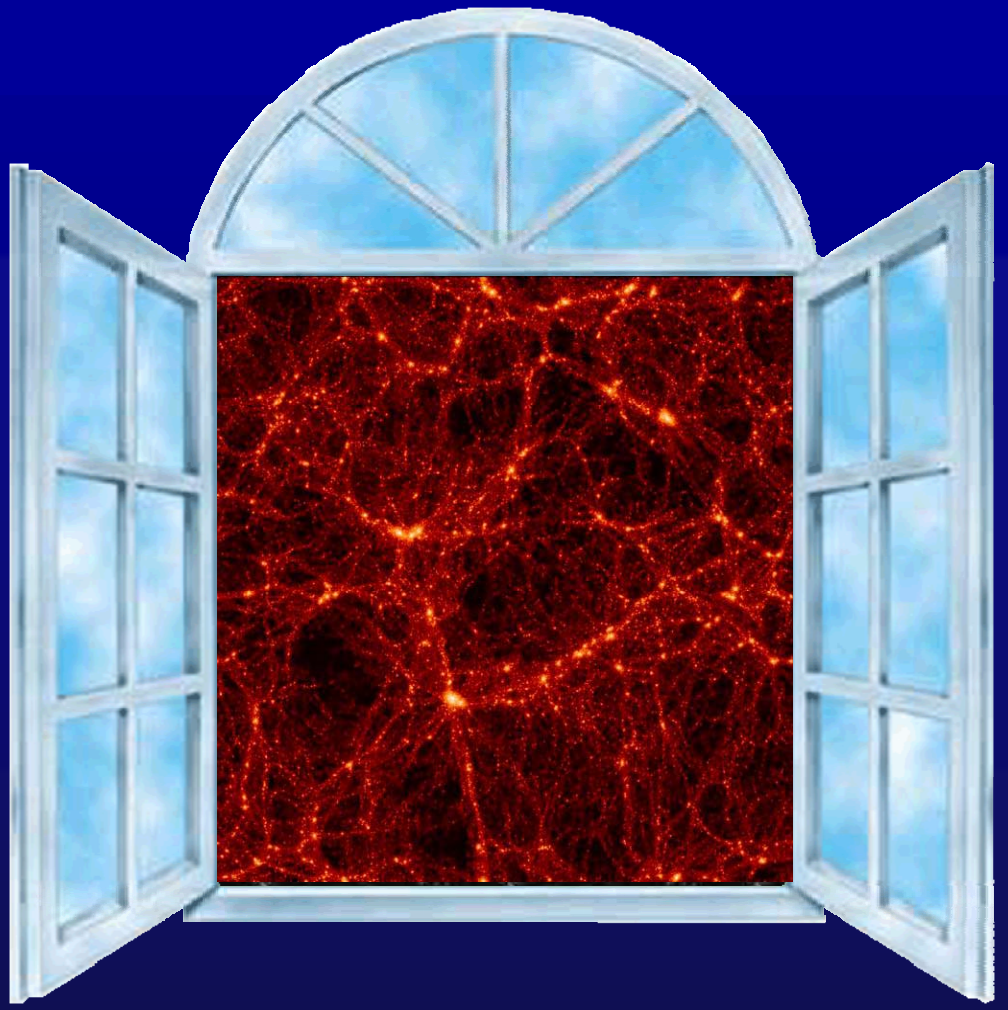
Some examples of significant funding st

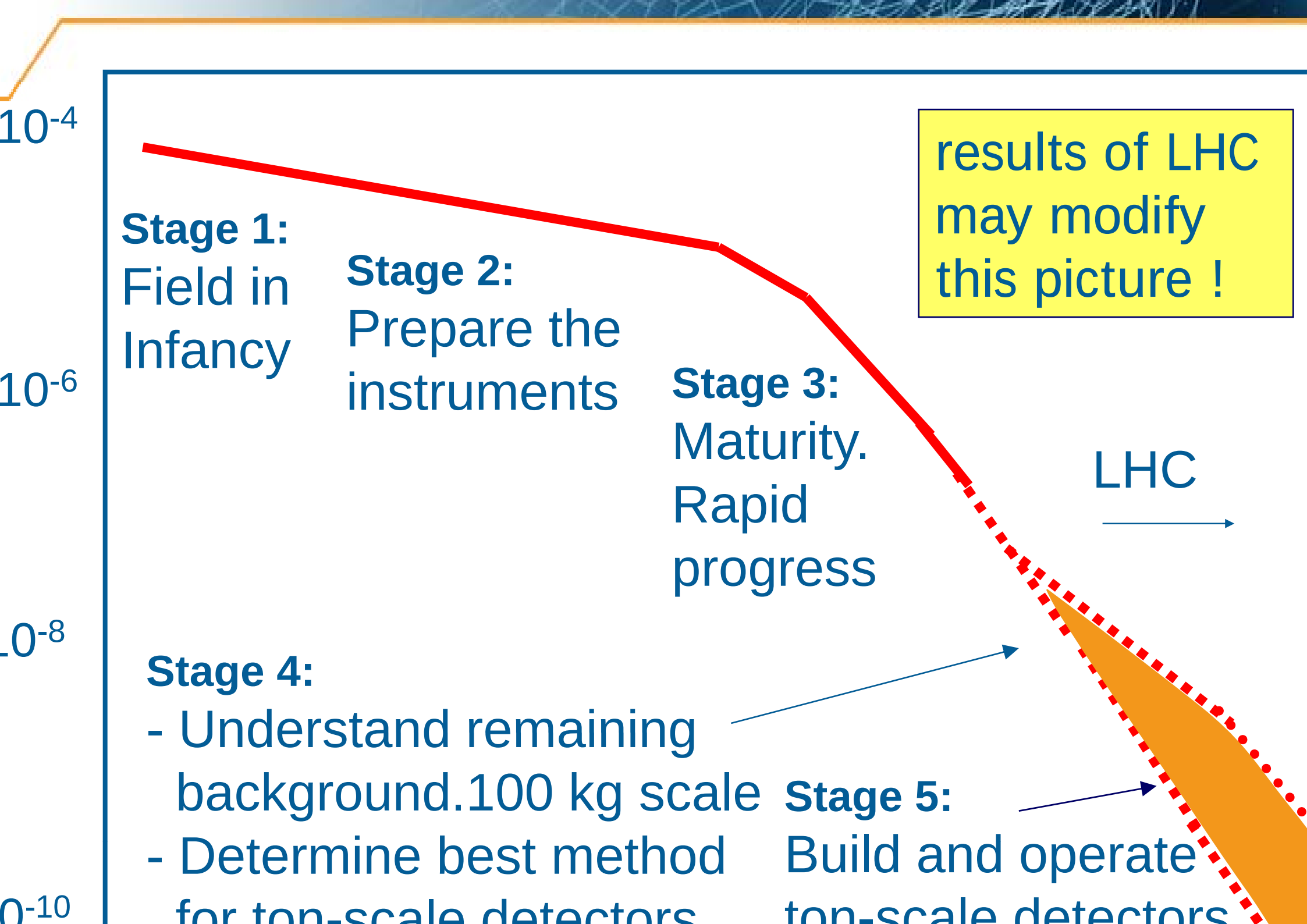
German Verbundforschung (federal support for Universities): factor 2 increase end of the nineties (now 3.5 M€/y)

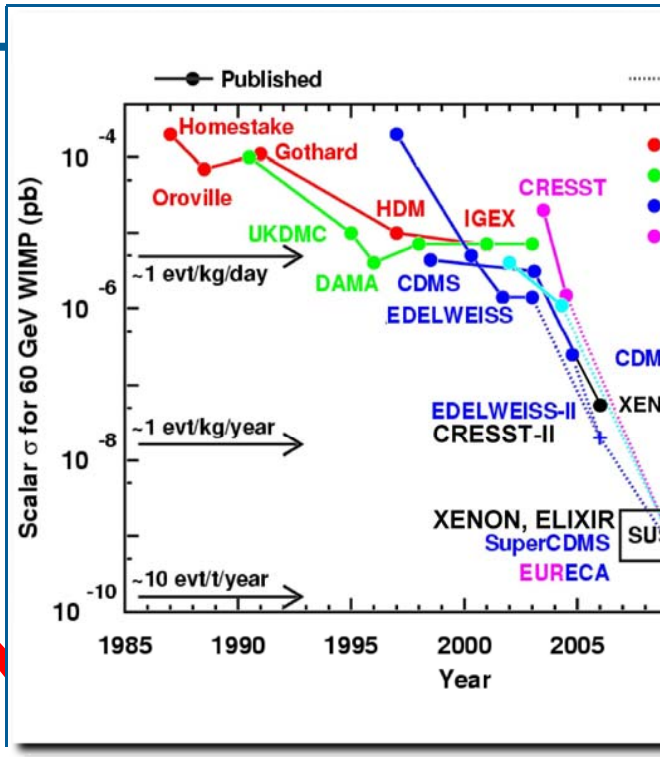
NIKHEF strategic plan: factor 2 increase from 2007 to 2012



Dark Matter Searches




10-4
10-6
10-8
10-10
Stage 1:
Field in
Infancy
Stage 2:
Prepare the
instruments
Stage 3:
Maturity.
Rapid
progress
results of LHC
may modify
this picture !
LHC
Stage 4:
- Understand remaining
background.100 kg scale
- Determine best method
for ton-scale detectors
Stage 5:
Build and operate
ton-scale detectors



10^-4

10^-6

10^-8

10^-10

- Background
- Funding / Infrastructure

Towards 2 ton-scale zero-background dete

Now: 10 kg scale 2009/11: 100 kg scale 2011-17: constr. ton

CRESST

Edelweiss

EURECA-100 → EURECA @ ton scale

modular expansion

LXe

LXe

LAr

LAr

XENON/LUX, WARP

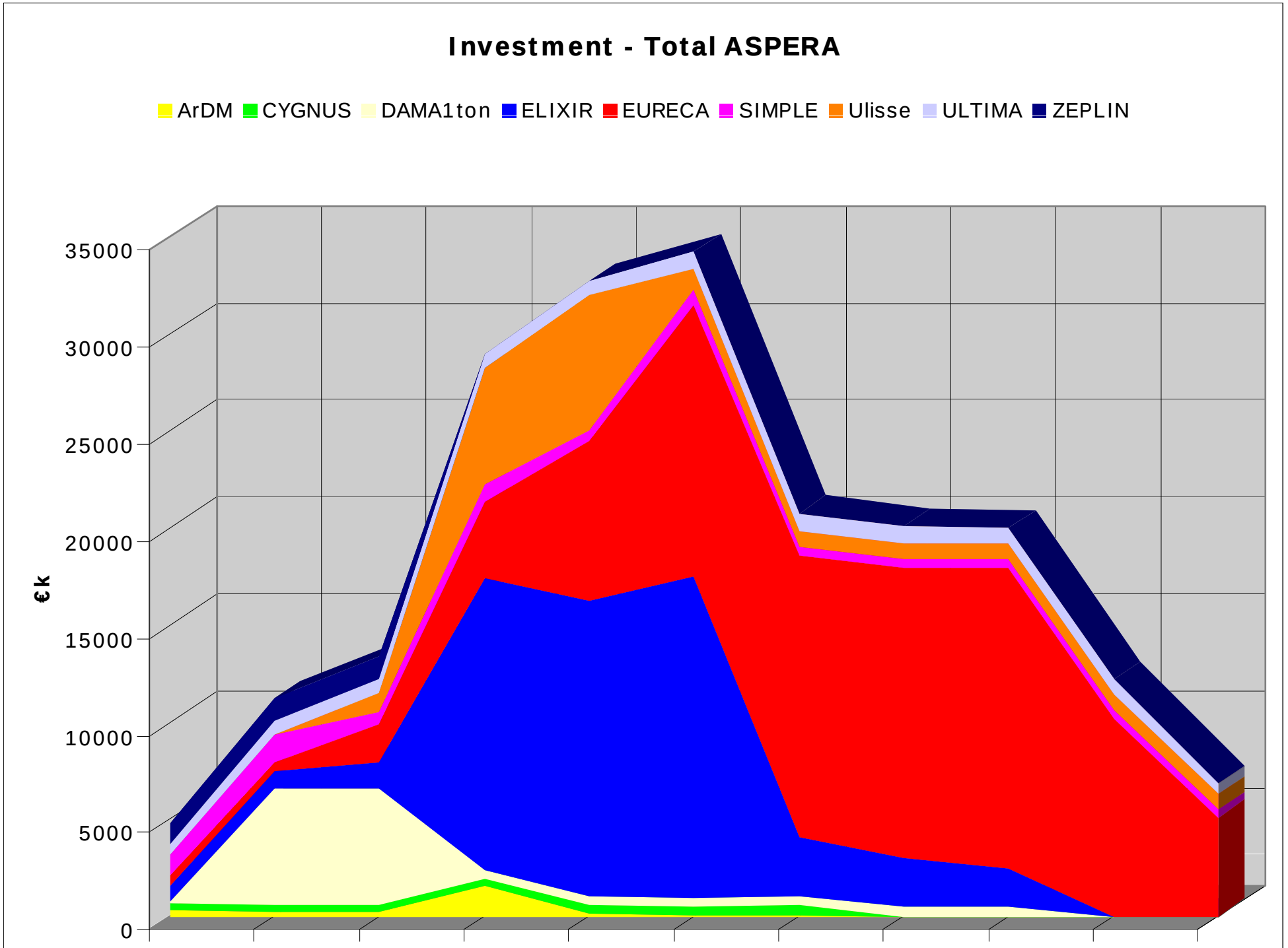
Xe-100

Ar-100

→ Noble liquid @ ton scale

ELIXIR, ..

a possible convergence scenario


Investment - Total ASPERA
ArDM
CYGNUS
DAMA1ton
ELIXIR
EURECA
SIMPLE
Ulisse
ULTIMA
ZEPLIN
€k
35000
30000
25000
20000
15000
10000
5000
0

Properties of Neutrinos

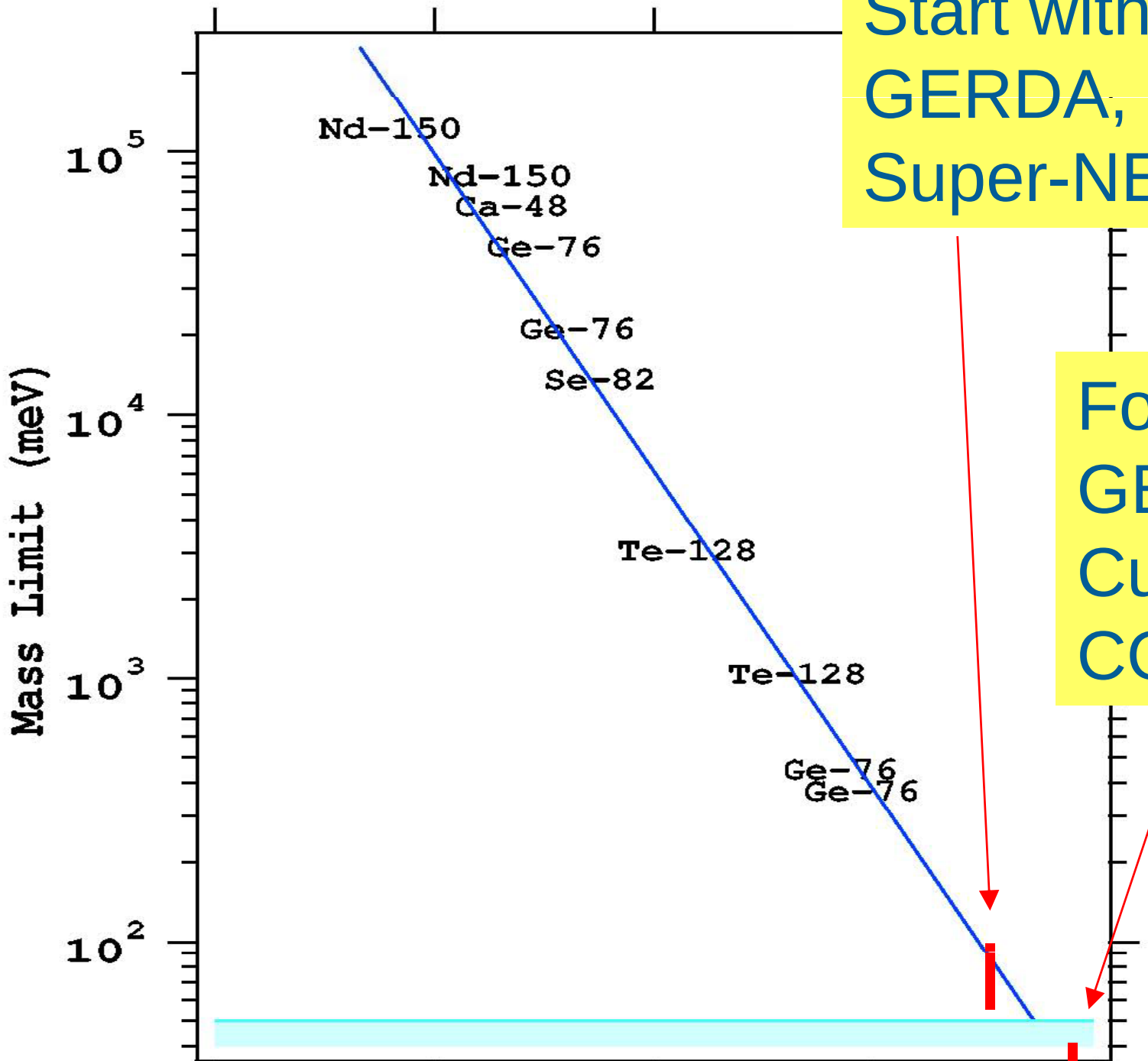
Neutrino Prope

xperiment	k€	
main source		milestones
KATRIN:	40.000	-
Astrop.Phys.		operation 2010
MARE I:	5.450	
Astrop.Phys.		R&D<2011; construction=2011; operation 2016
CUORE:	13.900	
Astrop. Phys		construction + commissioning<2012; operation 2017
GERDA I+II:	5.250	
Astrop. Phys		contruction + commissioning<2009; operation 2009
SuperNEMO:	104.000	
Astrop. Phys		R&D <2009 construction <2013

1-ton experiment not yet specified and included. Would it start

- in parallel ?
- after ?
- instead of ?

} Super-NEMO ?

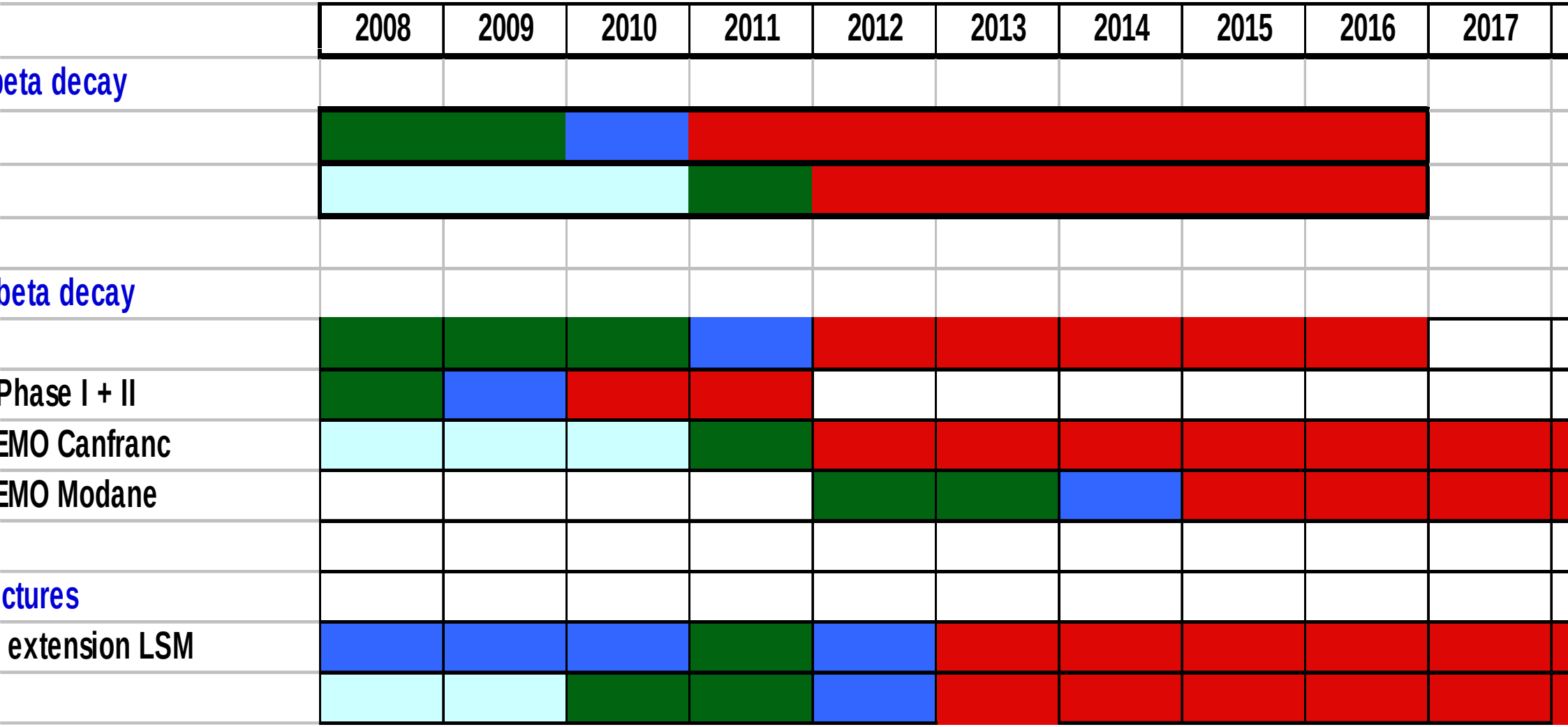


Start within next 5 years:
GERDA, Cuore,
Super-NEMO, EXO-200, ..

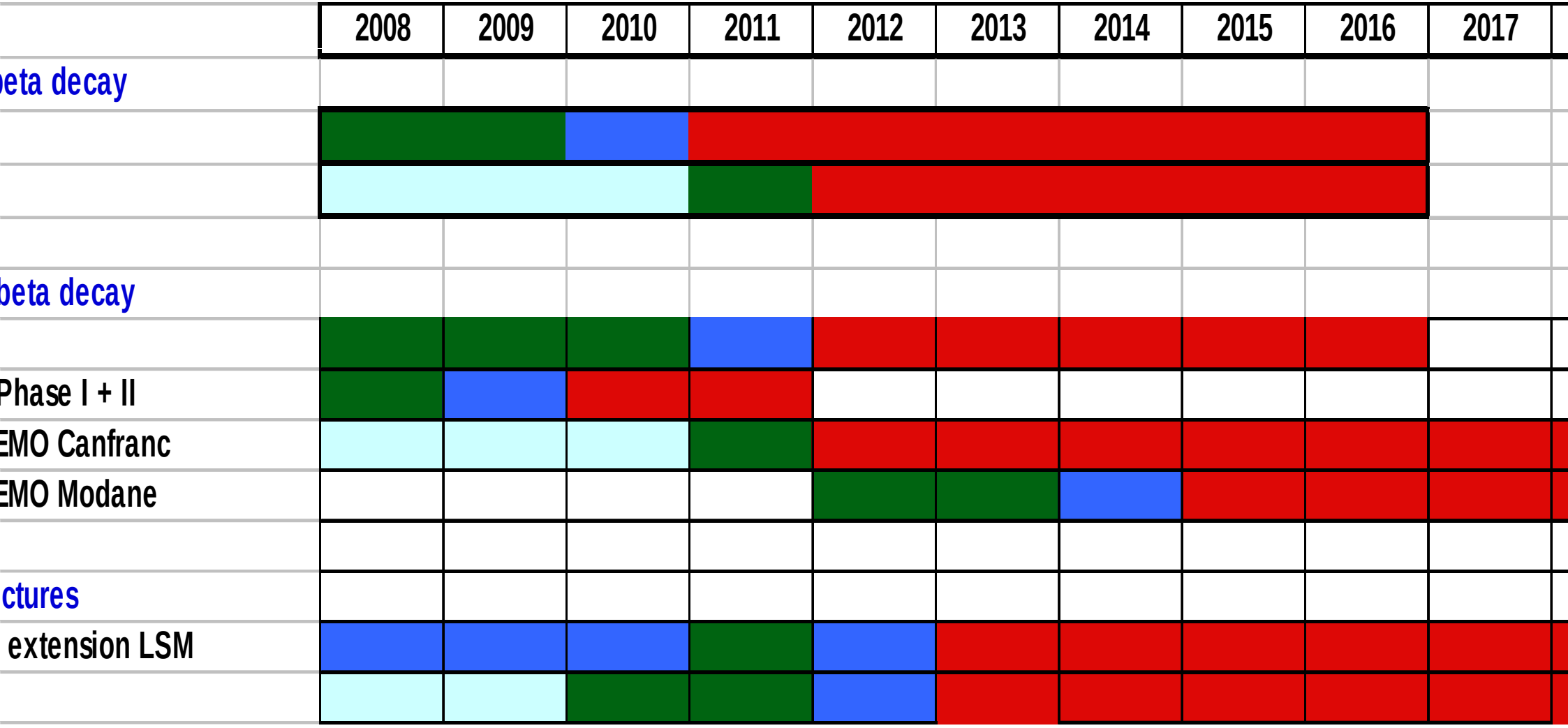
Following generatio
GERDA+Majorana
Cuore-enr., EXO-1
COBRA,. ..

20-50 meV range req
active mass of order **
**ton, good resolution
BG. Price tag 50-200

Neutrino Prope



Neutrino Prope

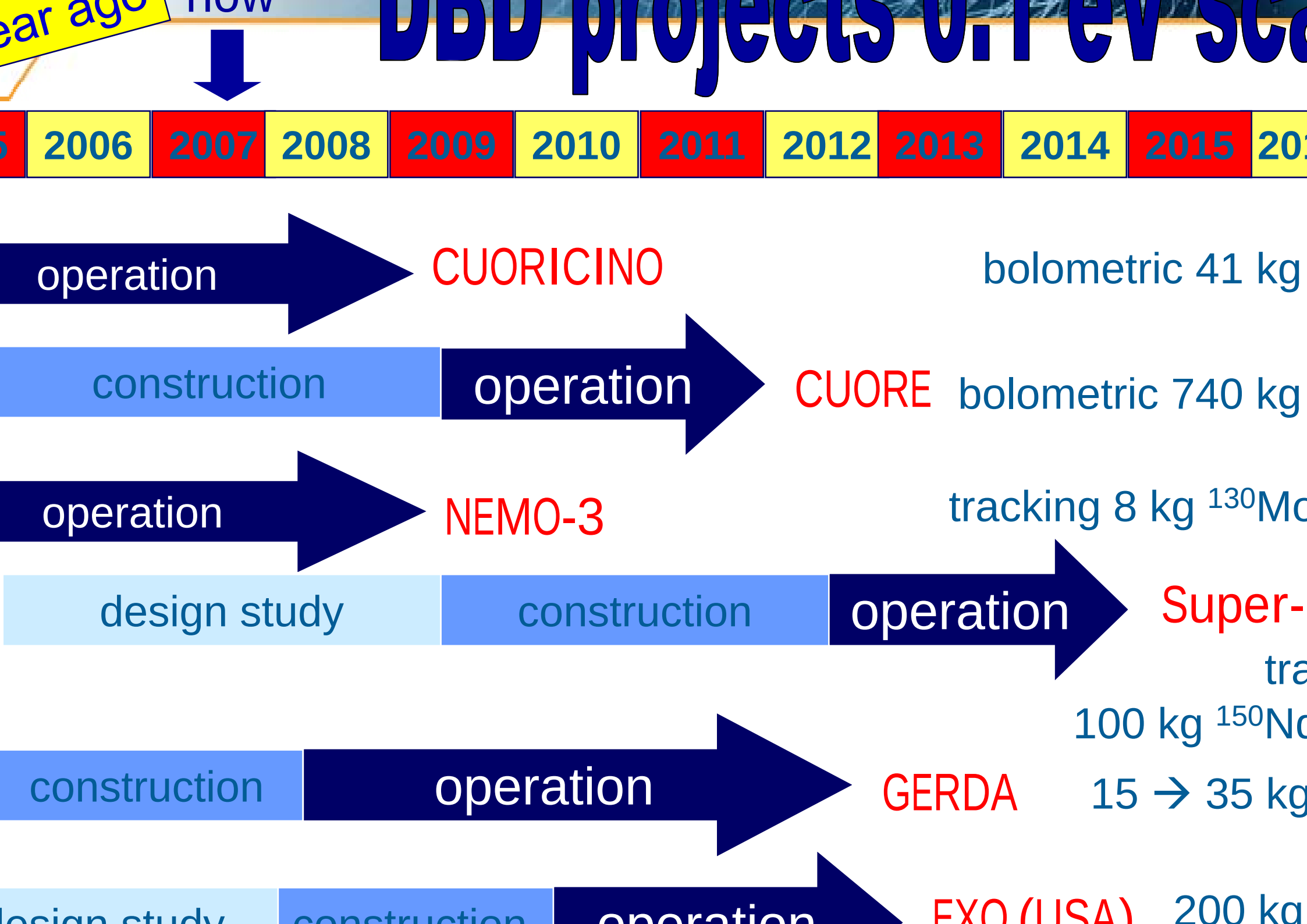


sion points:
13:
MARE-II ?
13:

Inverted hierarchy

test KKGH

Phases
1. R&D
2. Construction
3. Commissioning
4. Operation


ear ago
now
0νββ projects 0.1 ev sca
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
operation
CUORICINO
bolometric 41 kg
construction
operation
CUORE
bolometric 740 kg
operation
NEMO-3
tracking 8 kg 130Mo
design study
construction
operation
Super-
tra
100 kg 150Nd
construction
operation
GERDA
15 → 35 kg
operation
EXO (USA)
200 kg

ear ago

now

DBD projects 30 nev ev sc

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	20

operation — CUORICINO

construction → operation — CUORE

operation — NEMO-3

design study → construction → ope

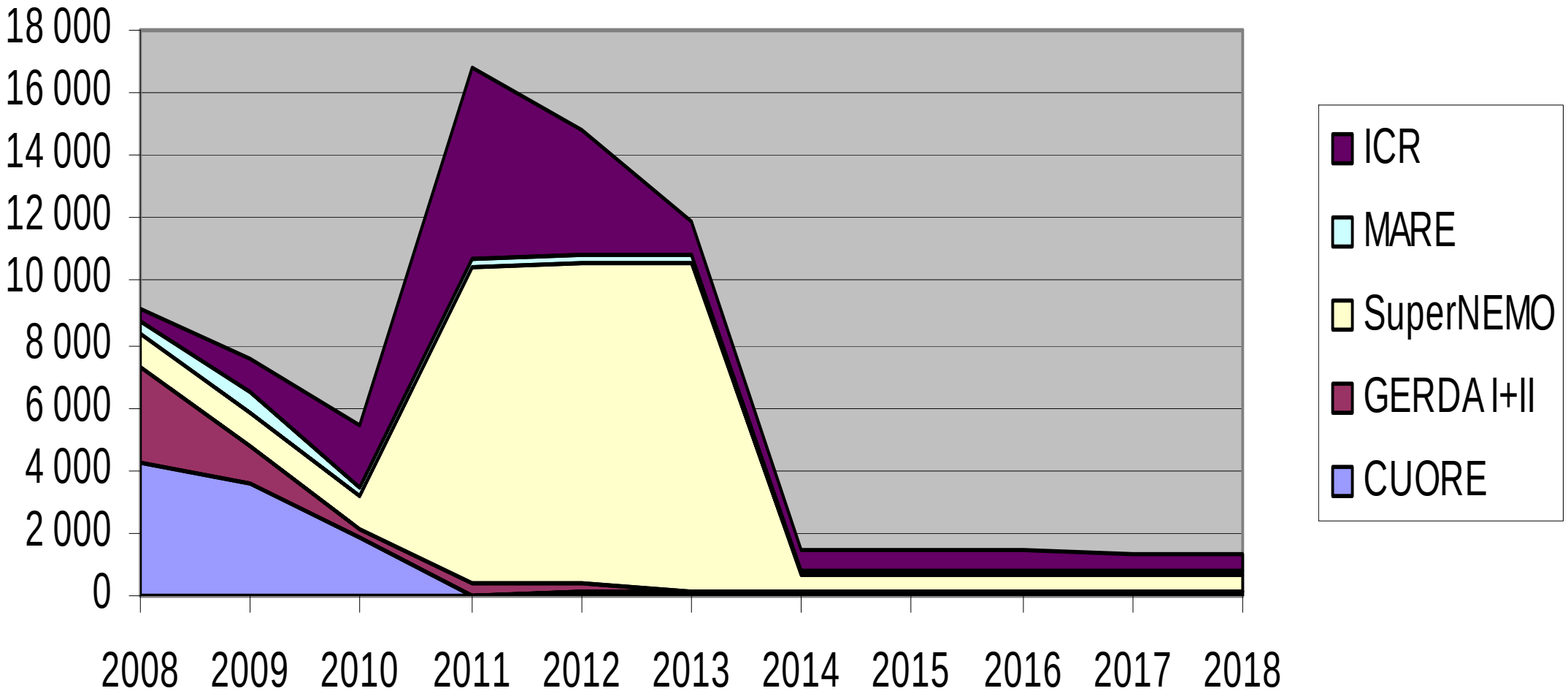
construction → operation — GE

design study → construction → operation — E

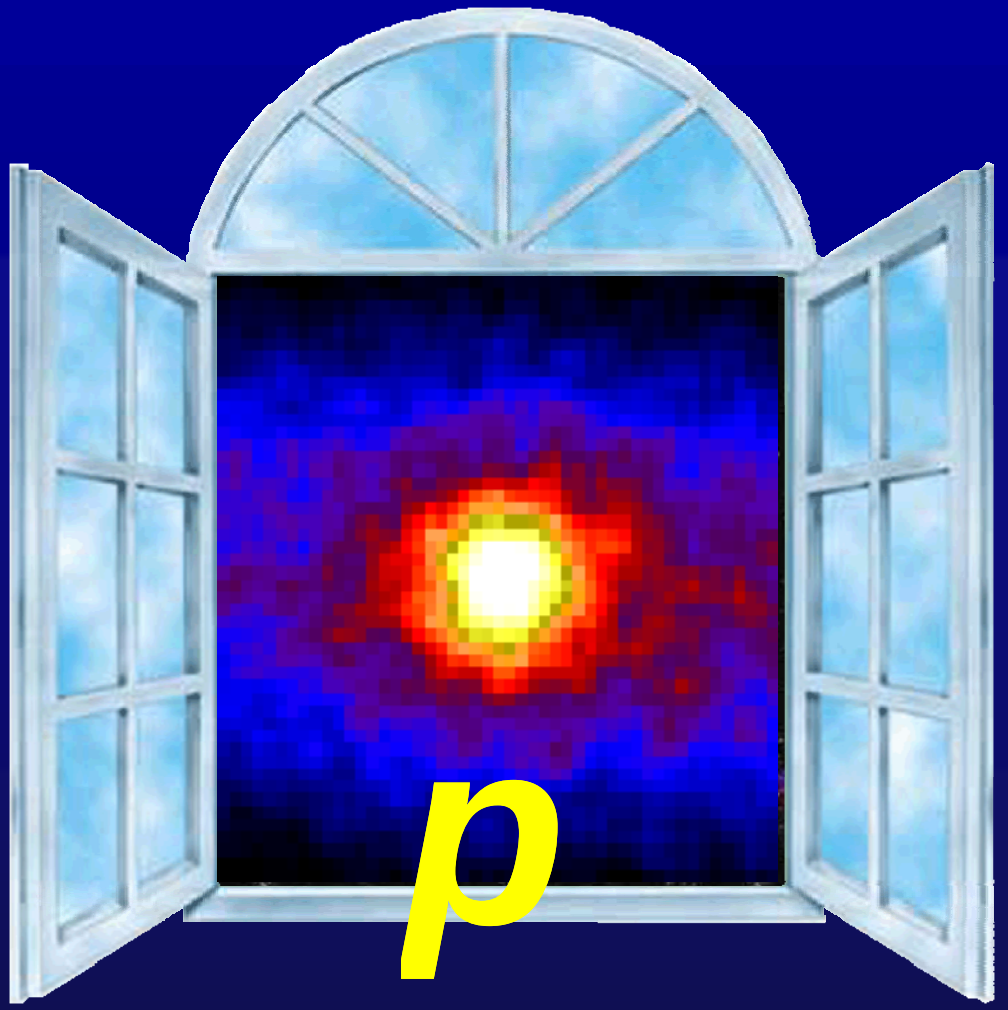
Converge towards 2 large European Projects !

Start construction 2012-2015

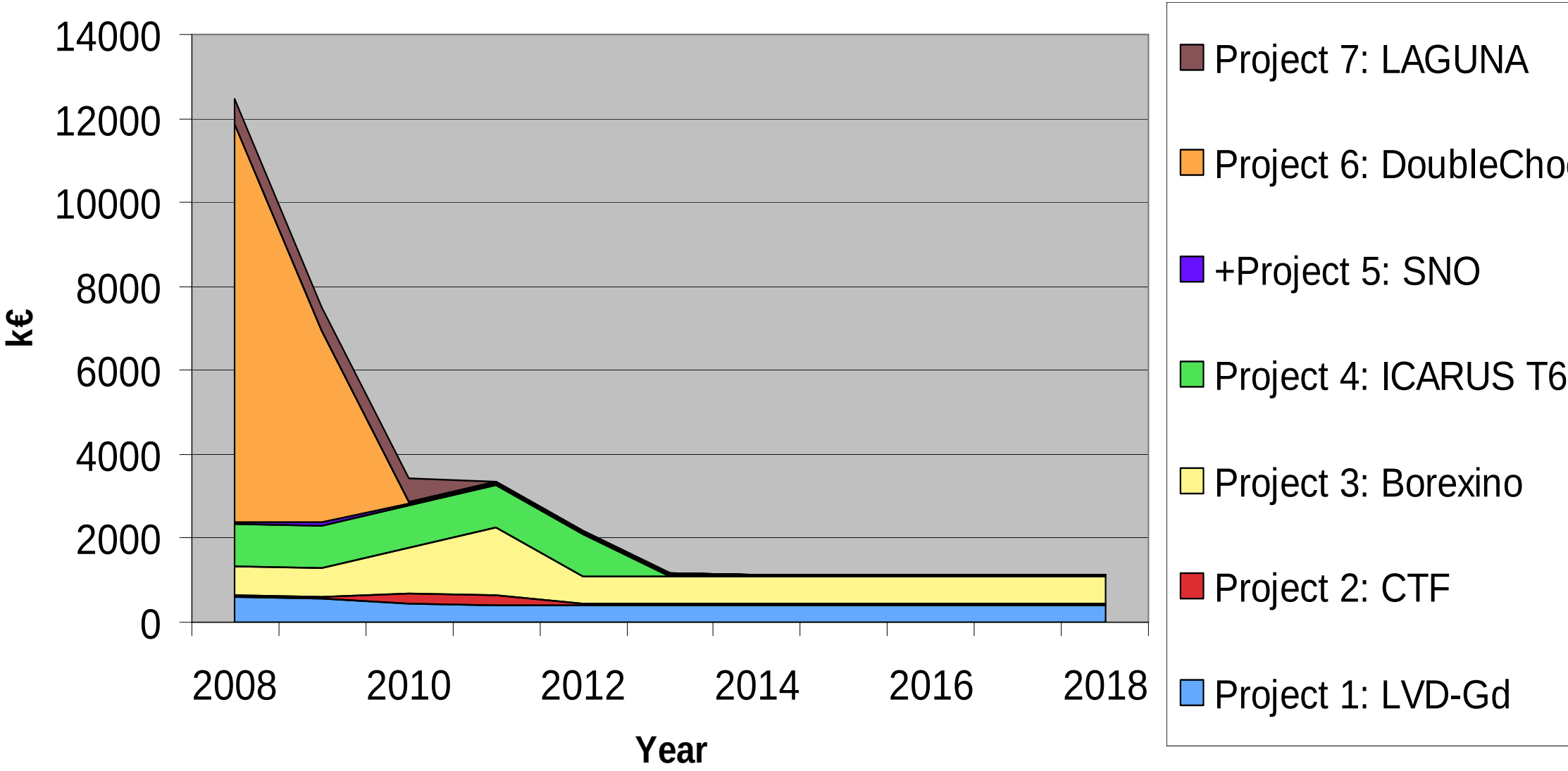
Neutrino I


Investments k€
18 000
16 000
14 000
12 000
10 000
8 000
6 000
4 000
2 000
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
ICR
MARE
SuperNEMO
GERDA I+II
CUORE

Low Energy Neutrino Astronomy and Proton Decay



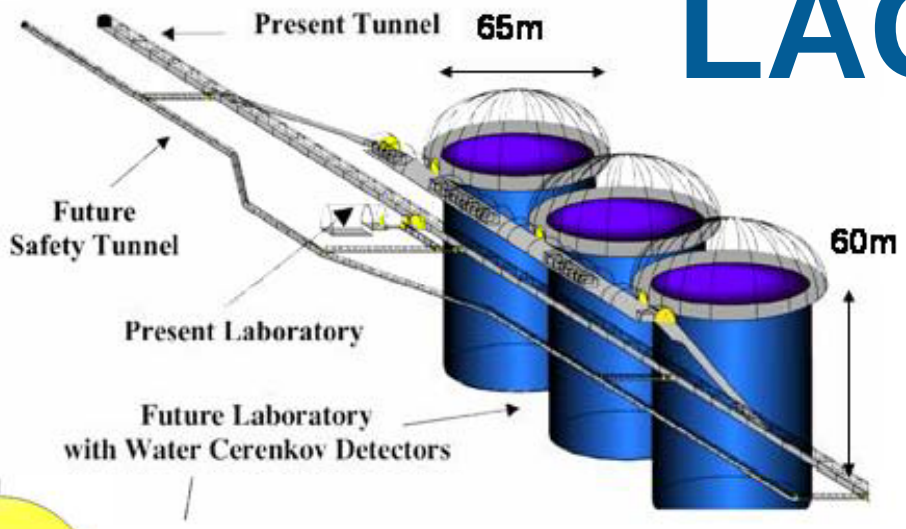
Indicative investment needs (without megaton-scale-physics)



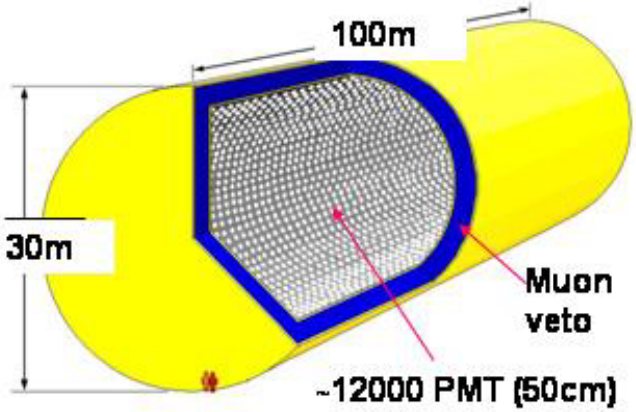
LAGUN

30-1000 ktons

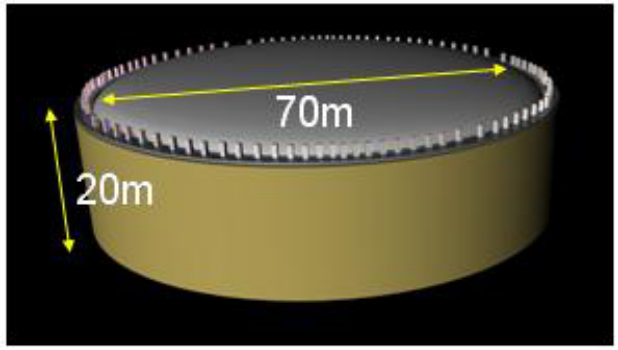
MEMPHYS:
Water Cherenkov,
(420 kton -1 Mton)



LENA:
Liquid Scintillator
(30-70 kton)



GLACIER: Liquid Argon (50 -100 kton)

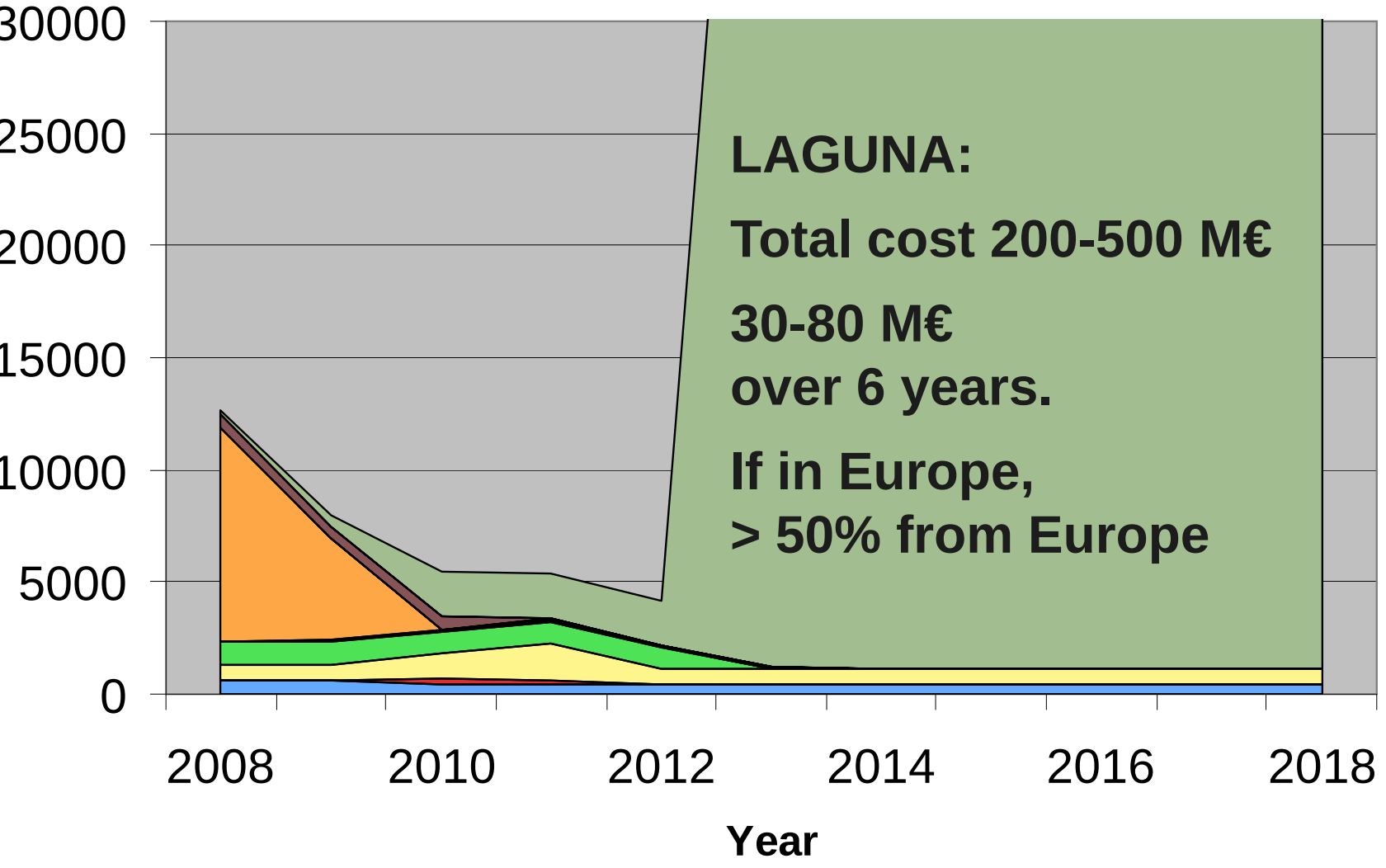


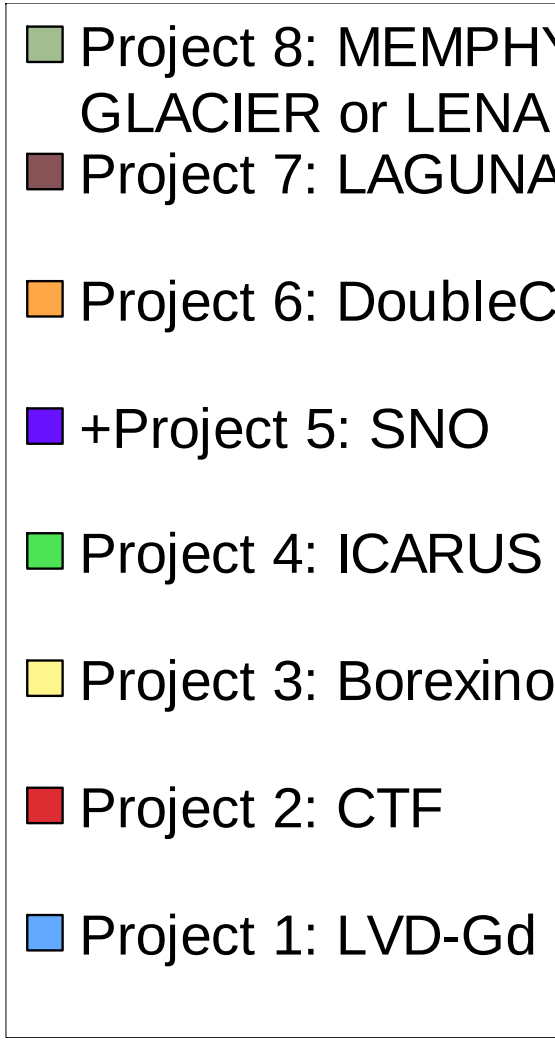
odulAr

20 ktons

ran Sasso)

Indicative investment needs (total)





he High Energy Universe

European priorities, new projects next dec

- Charged Cosmic Rays
  - Auger North
- Gammas
  - CTA
- Neutrinos
  - KM3NeT

Charged Cosmic R

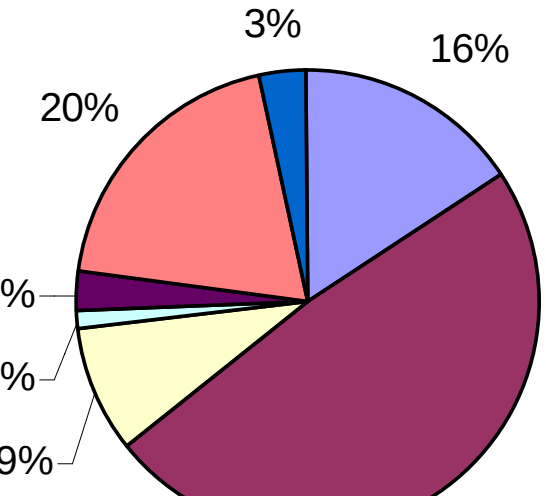
periment	k€	FTE (additional 2008-18)
main source	milestones	
uger (south):	30.000	-
Astrop.Phys.	operation 2018++; construction<2011	
uger (north):	91.400	1400
Astrop.Phys.	R&D<2012; construction<2015; operation 2018++	
EM-EUSO:	90.000	150
space agencies	2009 A+B report JAXA, launch 2013	
UPER-EUSO:	155.000	335
space agencies	R&D<2012, constr.<2016 commis.<2019	
OFAR:	104.000	77 (only CR)
astronomy	R&D+construction CR-KSP <2012 (1M€)	
UCLEON:	40.150	600
space agencies	operation >2014	construction<2011
MS-02:	20.000	4000
space agencies	operation >2008	end 2015

cost worldw

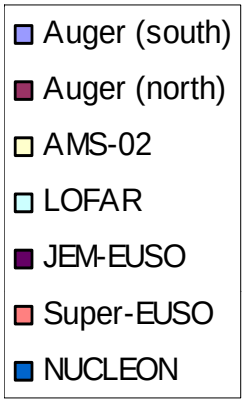
Charged Cosmic R

periment	k€	FTE (additional 2008-2018)
uger (south):	15.000	-
uger (north):	45.700	655
MS-02:	8.500	335
M-EUSO:	2.600	50
UPER-EUSO:	18.600	50
OFAR(CR):	1.000	77
UCLEON:	3.212	151

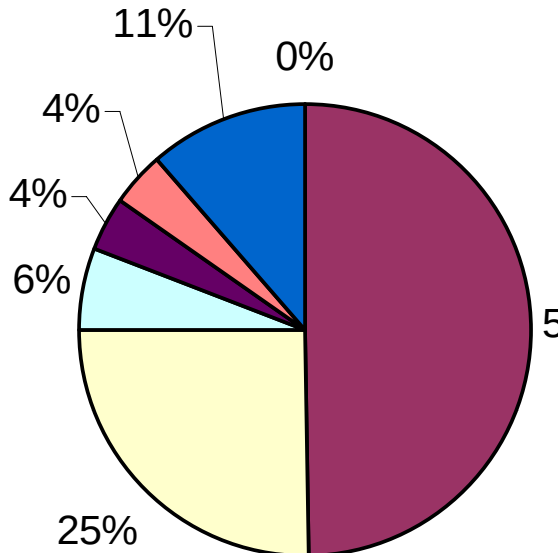
cost Europe



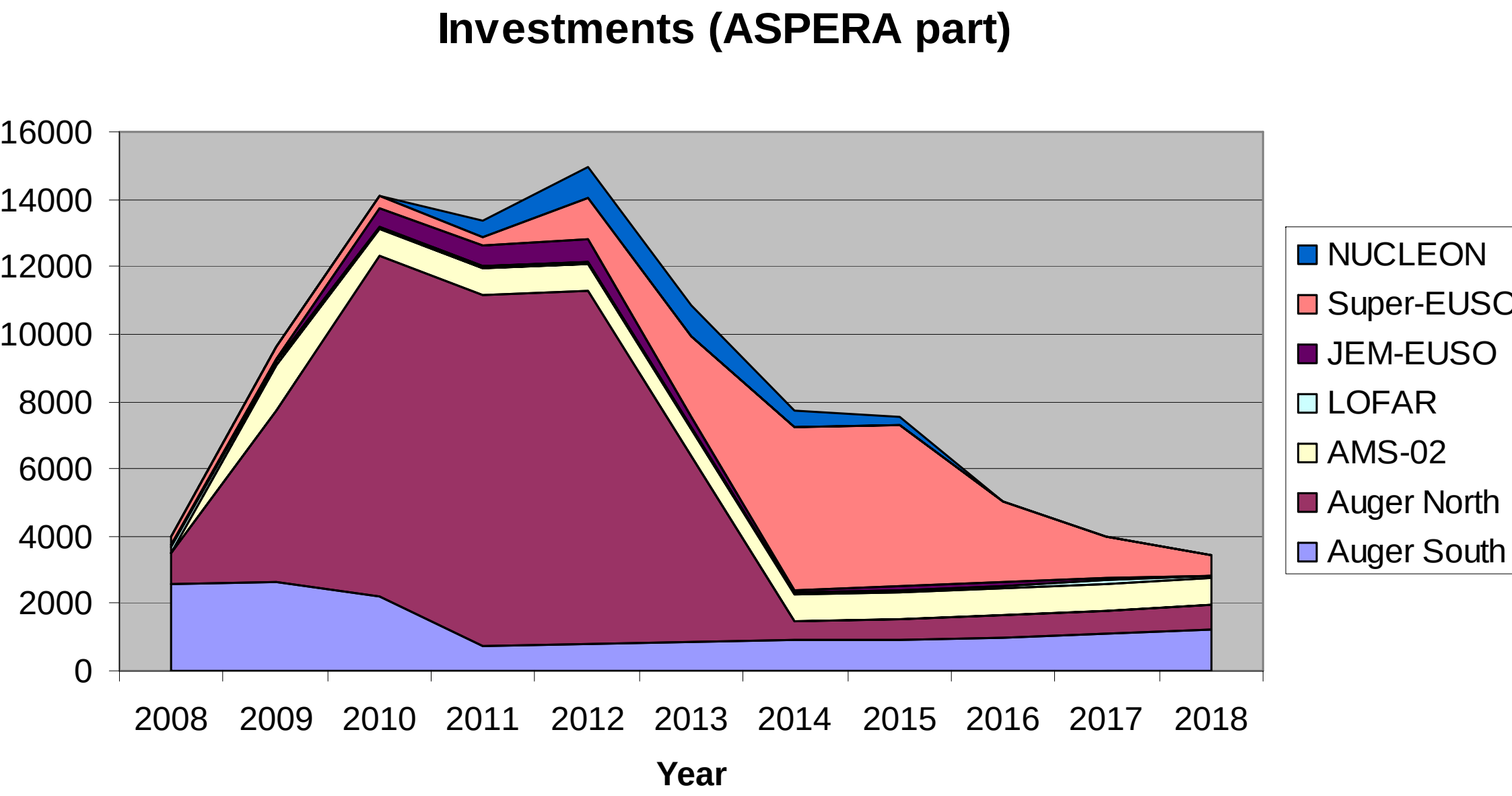
Investments k€



FTE



Charged Cosmic R



High Energy Gamma

periment	k€	FTE (additional 2008-18)
main source	milestones	
.E.S.S.:	**9.050**	**235**
Astrop.Phys.	HESS II commissioning in 2009	
AGIC:	**9.700**	**260**
Astrop.Phys.	MAGIC 2 commissioning in 2008	
ERITAS:	**11.051**	**115**
Astrop.Phys.	Started full operation spring 2007.	
RGO-YBJ	**2.500**	**150**
Astrop.Phys.	Completion with lead layer in 2008	
AW:	985	103.5
Astrop.Phys.	First telescope by end 2007	
TA:	**177.500**	**990**
Astrop.Phys.	Design Study until 2011; Start construction 2011	
LAST	**198.200**	**150.5**
Space agencies	Launch in 2008; 5 years warranted operation	

now

Gamma Rays: IA

5	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	20

operation — H.E.S.S. — four 11-m telesc

construction — operation — H.E.S.S.- II — + one 2 teles

operation — MAGIC-I — one 17-m teles

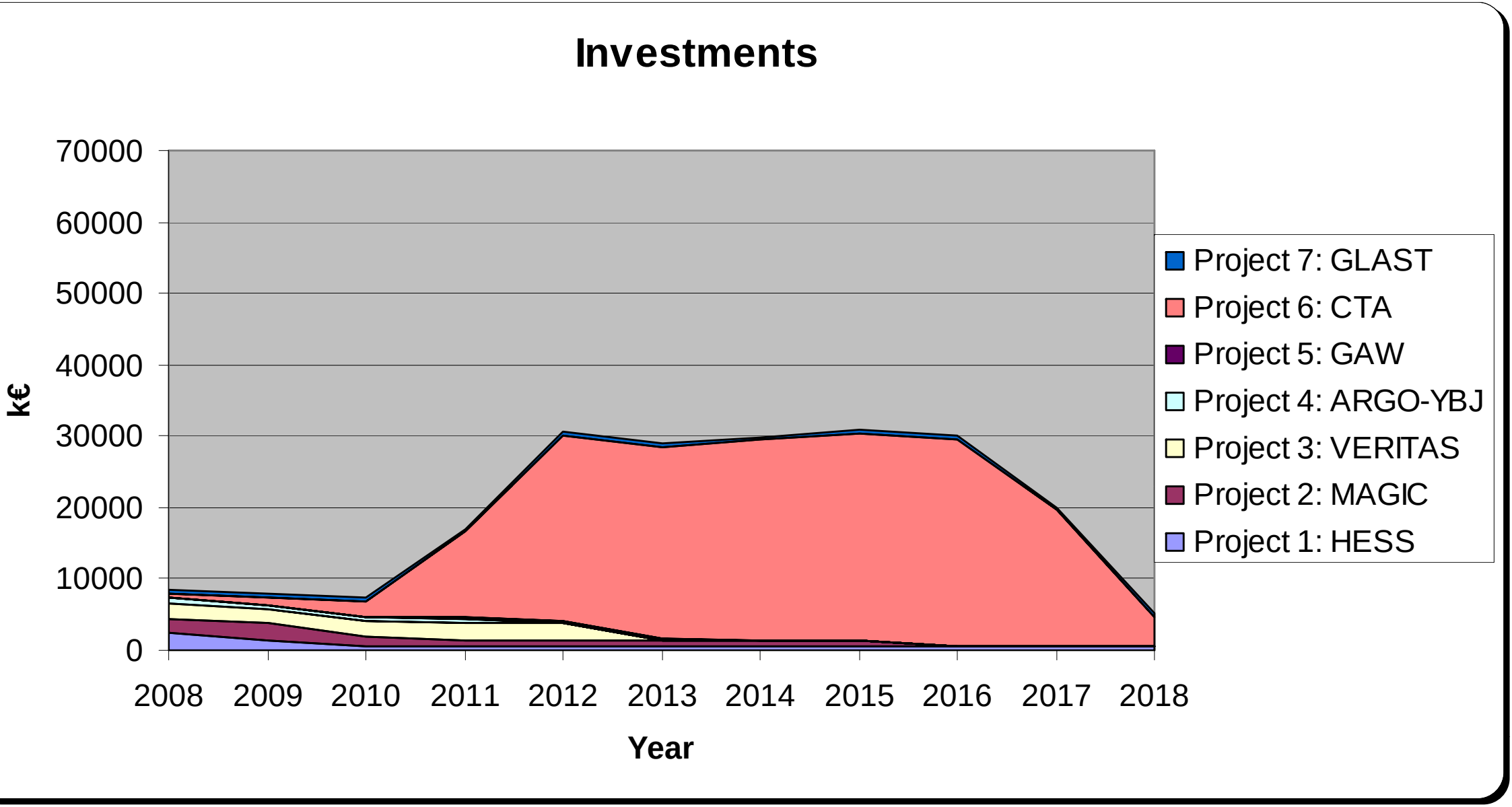
construction — operation — MAGIC- II — 2nd 1 teles

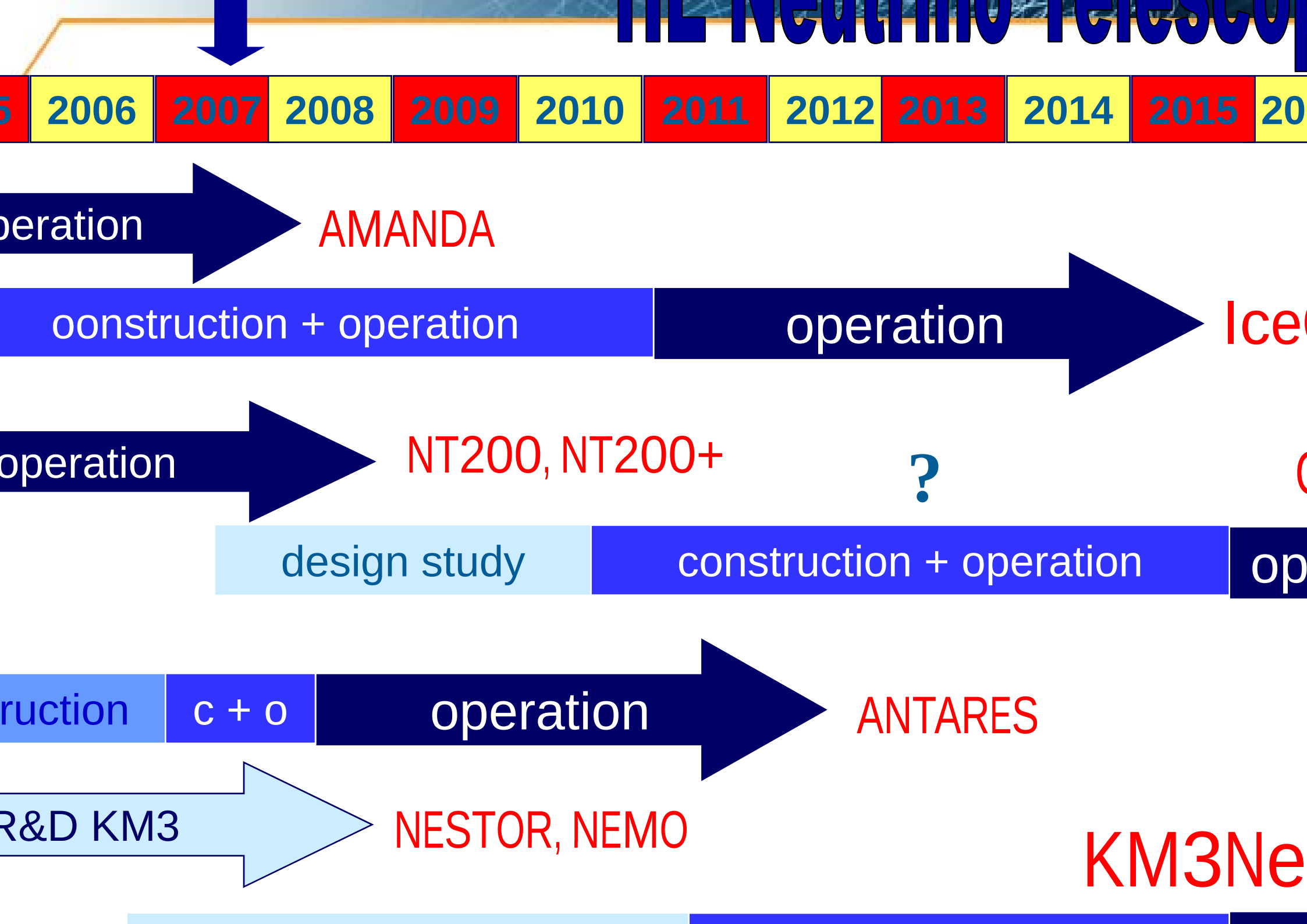
Coordination with USA, Japan, Australia

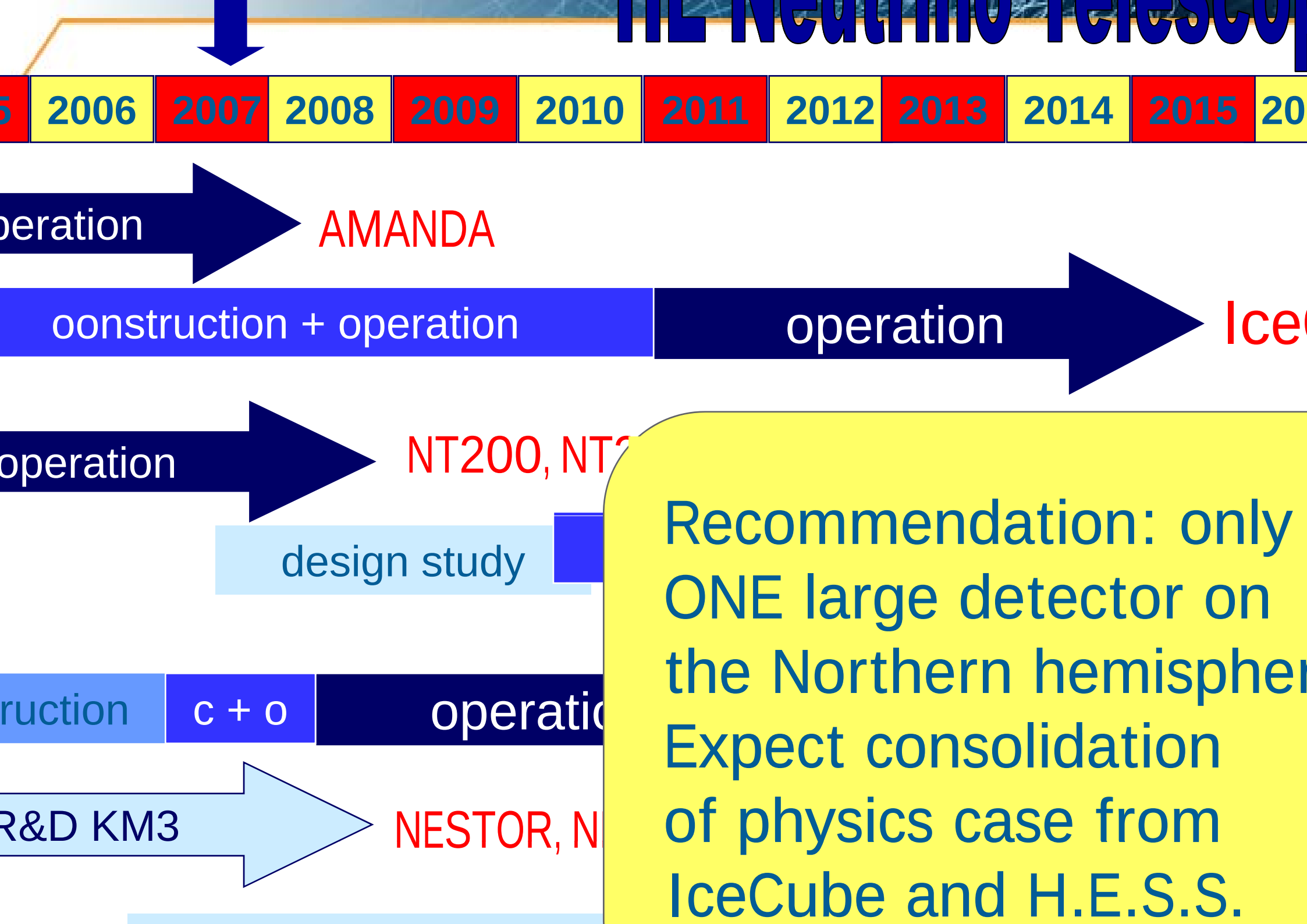
CTA

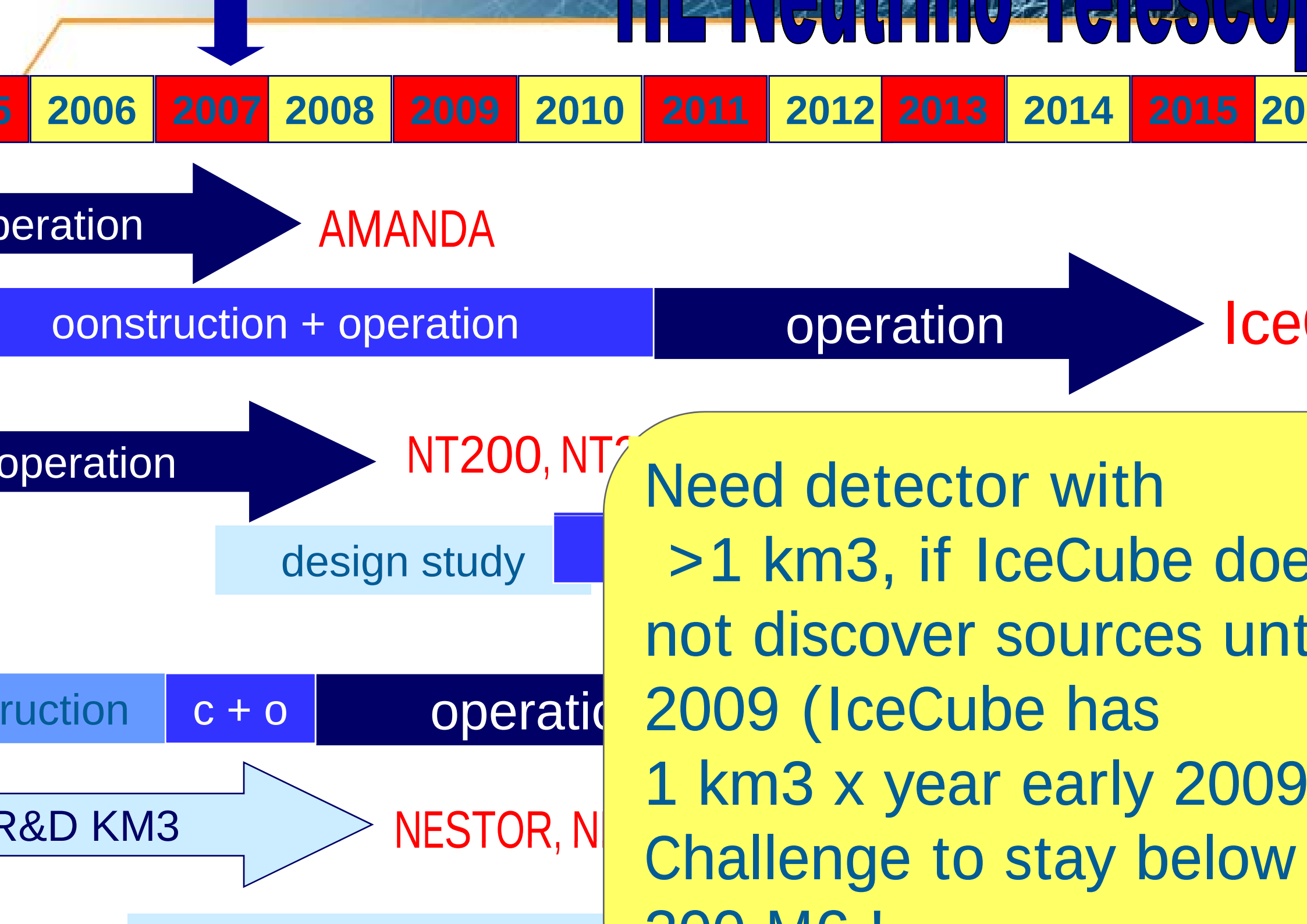
ction + operation — opera

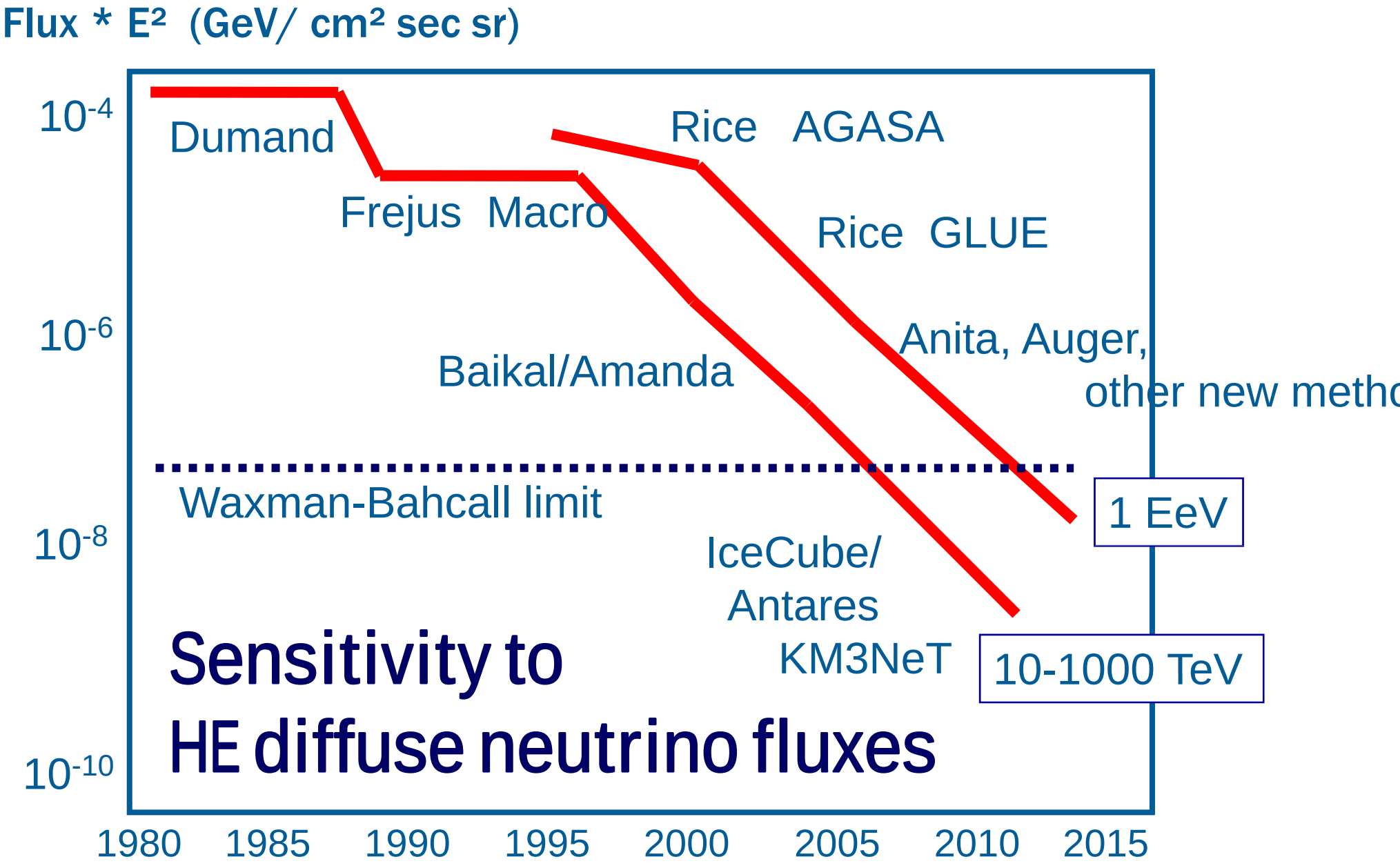
High Energy Gamma




2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
operation
AMANDA
oonstruction + operation
operation
operation
NT200, NT200+
?
design study
construction + operation
operation
ANTARES
R&D KM3
NESTOR, NEMO
KM3Ne

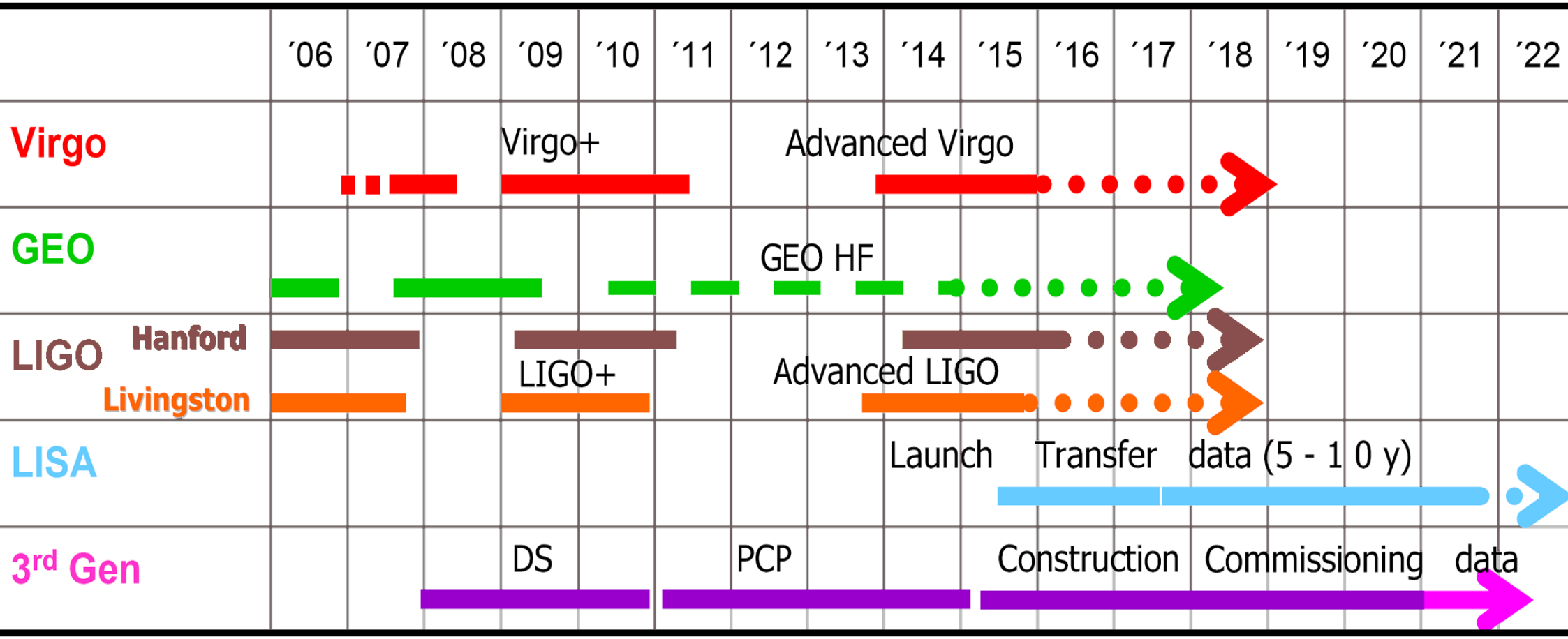

TE Neutrino Telescop
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
peration
AMANDA
oonstruction + operation
operation
Ice
operation
NT200, NT
design study
ruction
c + o
operati
R&D KM3
NESTOR, N
Recommendation: only
ONE large detector on
the Northern hemispher
Expect consolidation
of physics case from
IceCube and H.E.S.S.


2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
peration
AMANDA
oonstruction + operation
operation
Ice
operation
NT200, NT
design study
ruction
c + o
operatio
R&D KM3
NESTOR, N
Need detector with
>1 km3, if IceCube doe
not discover sources unt
2009 (IceCube has
1 km3 x year early 2009
Challenge to stay below


Flux * E² (GeV/ cm² sec sr)
10-4
10-6
10-8
10-10
Dumand
Frejus
Macro
Rice
AGASA
Rice GLUE
Anita, Auger,
other new metho
Baikal/Amanda
Waxman-Bahcall limit
1 EeV
IceCube/
Antares
KM3NeT
10-1000 TeV
Sensitivity to
HE diffuse neutrino fluxes
1980
1985
1990
1995
2000
2005
2010
2015

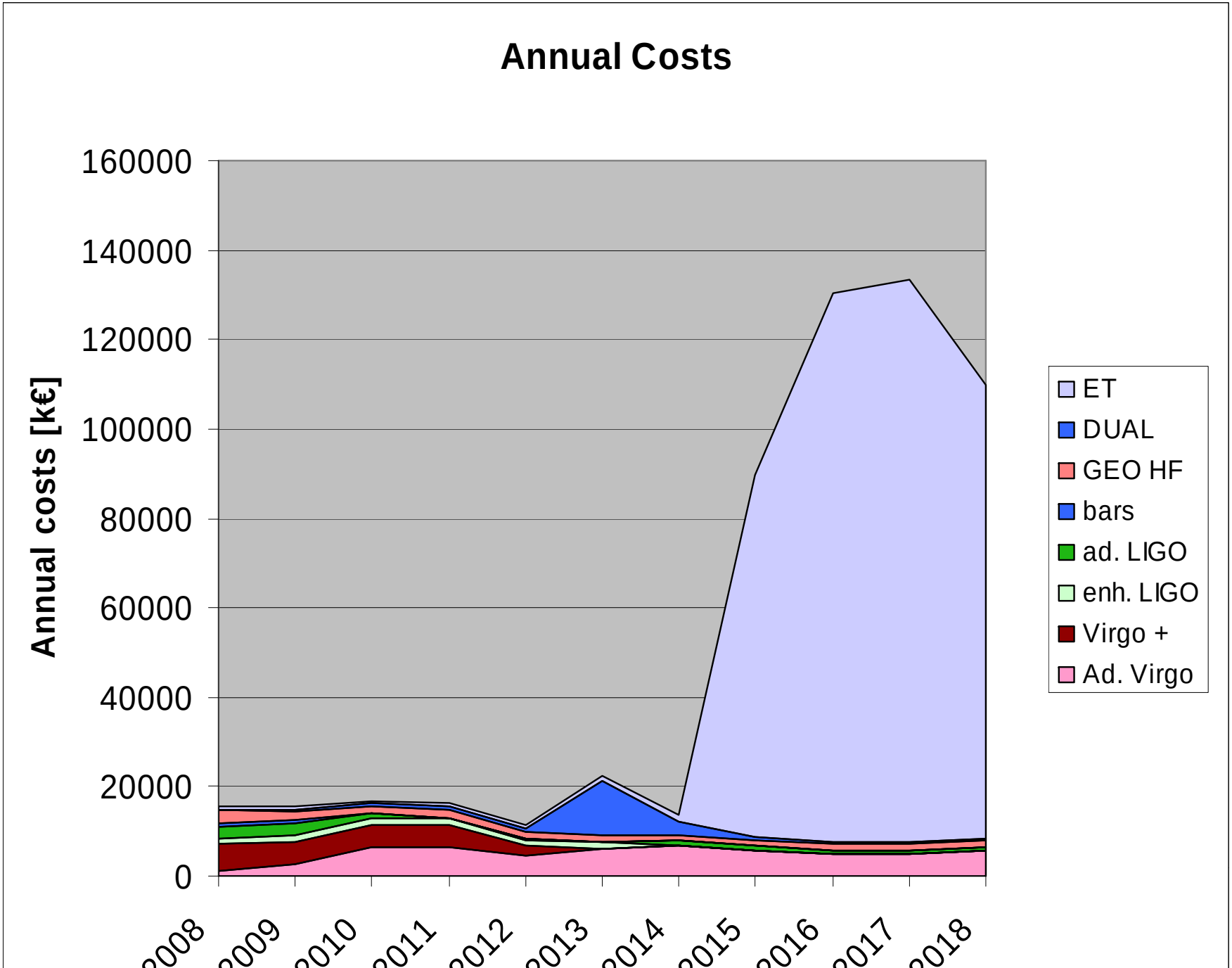
Gravitational Waves

Time C

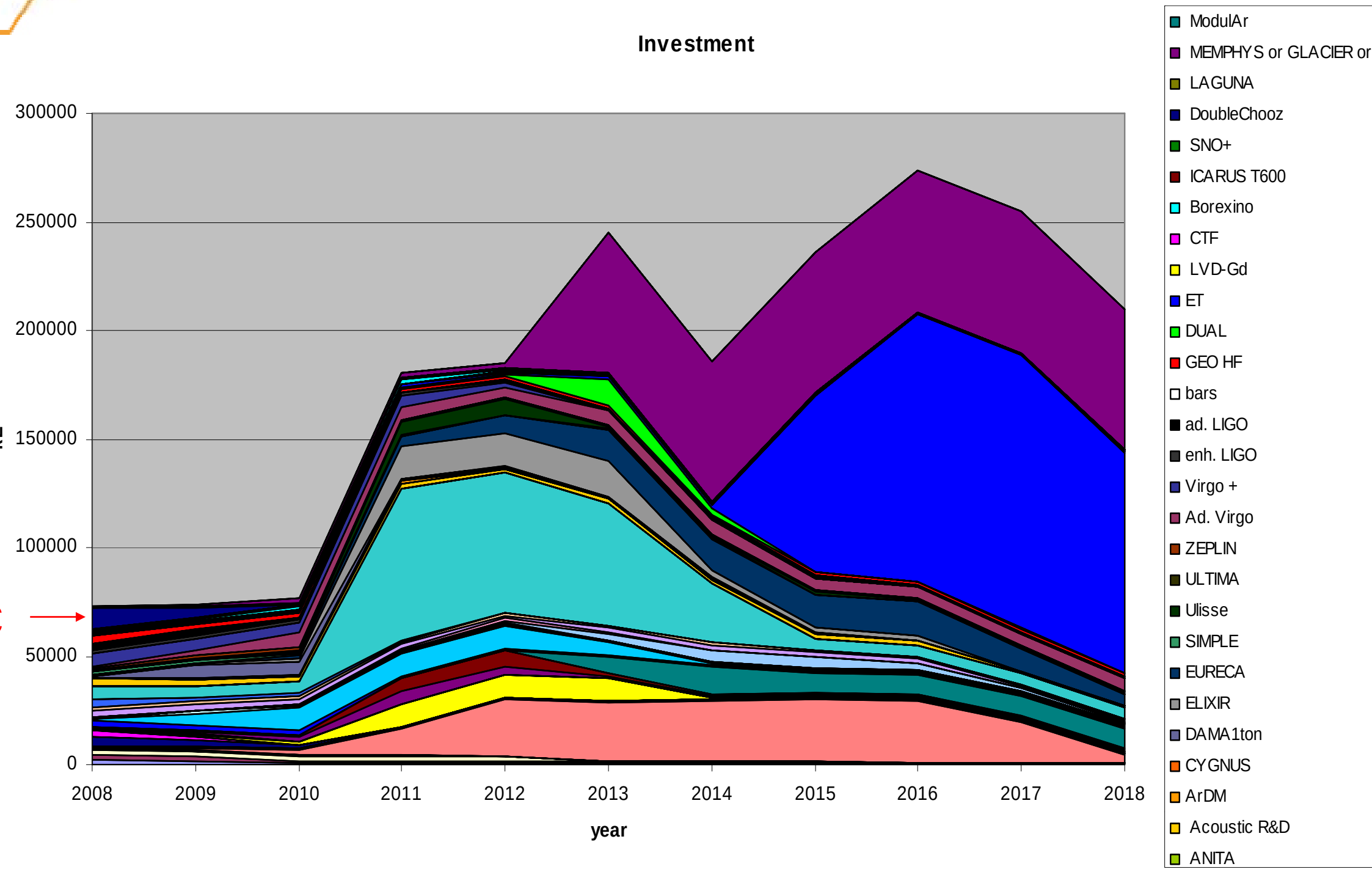

´06
´07
´08
´09
´10
´11
´12
´13
´14
´15
´16
´17
´18
´19
´20
´21
´22
Virgo
Virgo+
Advanced Virgo
GEO
GEO HF
LIGO
Hanford
Livingston
LIGO+
Advanced LIGO
LISA
Launch
Transfer
data (5 - 1 0 y)
3rd Gen
DS
PCP
Construction
Commissioning
data

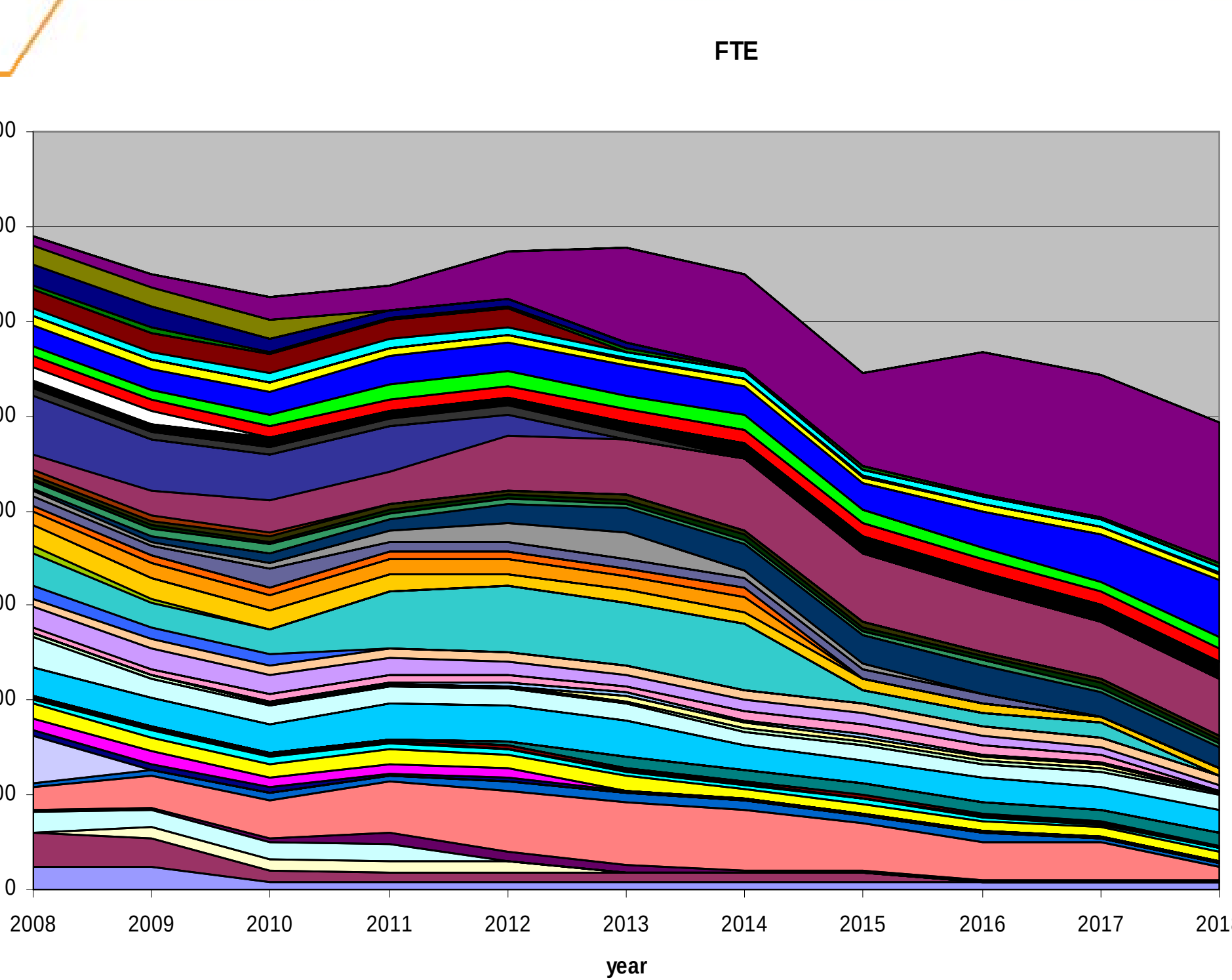
Gravitational Waves: Investr

Without LIS



Total cost


Investment
300000
250000
200000
150000
100000
50000
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
year
ModulAr
MEMPHYS or GLACIER or
LAGUNA
DoubleChooz
SNO+
ICARUS T600
Borexino
CTF
LVD-Gd
ET
DUAL
GEO HF
bars
ad. LIGO
enh. LIGO
Virgo +
Ad. Virgo
ZEPLIN
ULTIMA
Ulisse
SIMPLE
EURECA
ELIXIR
DAMA1ton
CYGNUS
ArDM
Acoustic R&D
ANITA


FTE
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
year
ModulAr
MEMPHYS or GLACIER
LAGUNA
DoubleChooz
SNO+
ICARUS T600
Borexino
CTF
LVD-Gd
ET
DUAL
GEO HF
bars
ad. LIGO
enh. LIGO
Virgo +
Ad. Virgo
ZEPLIN
ULTIMA
Ulisse
SIMPLE
EURECA
ELIXIR
DAMA1ton
CYGNUS
ArDM
Acoustic R&D
ANITA

- Convergence
- Priority Definition
- Increased funding

Our field is highly dynamic.
Keep room for new developments !

Visions

Dark Matter:

- LHC has discovered SUSY.
- First direct searches with sensitivity $<10^{-9}$ pb discover DM.

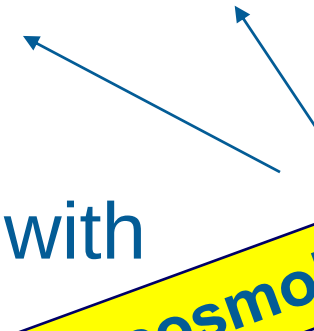
  → dramatically accelerated speed with other nuclei and methods for confirmation. Push directional methods.
- *If DM not yet discovered:*

  → move on with 2 experiments to 10^{-10} pb or below

Neutrino Properties

- Double-CHOOZ, T2K and others have measured finite Θ_{13}
- KATRIN measures neutrino mass > 0.2 eV
- and/or: Gerda/Cuore measure mass > 0.1 eV
- *If no sign for mass:*

  → move further on towards 1-2 DBD experiments with sensitivity 0.03 eV , see what MARE could do



Megaton-Detector

- Technology ready, worldwide consensus, construction started

High Energy Universe

- >200 gamma sources from HESS-II and MAGIC-II
- CTA under construction, first results from prototypes
- Rich sky-map from Auger-South, also chemical composition
- Auger-North under construction, first results
- IceCube has discovered neutrino sources
- KM3NeT is well under construction
  - *If no neutrino sources in IceCube until 2011:*
    → consequent re-design towards > 5 cubic kilometers for affordable pr
- Exciting multimessenger astronomy, including satellites (GLAST)

Gravitational Waves

- LIGO+, VIRGO+ and GEO have seen their very first event
- Adv LIGO, adv VIRGO, GEO-HF have started operation
- E.T. in preparatory phase
- Lisa-Pathfinder successful, clear way towards LISA

New Methods

- Variety of methods called „new m
  acoustics, COUPP-lik
  being implement
- Still, we have kep

We have to keep reserves for
new methods and approache

Visions

Dark Matter:

- Several experiments are below 10^{-10} pb and have seen DM
- Move from DM searches to DM studies

Neutrino mass:

- DBD measures neutrino mass 30-70 meV and proves inverted hierarchy
- *If not: hm …. There is no idea how to reach < 20 meV*

Megaton detectors:

- First subdetectors operate
- **>10000 neutrinos from SN2018A** (Feb 22, 2018)
  (IceCube measure precise early time profile)
- New precision results on solar physics

High Energy Universe:

- CTA full operation, > 500 sources, full astronomy mode
- Auger South/North, IceCube/KM3NeT + gammas: florishing multi-messenger astronomy
- GZK neutrino physics with reasonable statistics has started

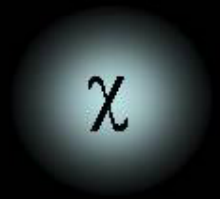
Gravitational Waves:

- Advanced LIGO/VIRGO, GeoHF, Dual have recorded a dozen GW events
- LISA launched, E.T. under construction. GW close to full astronomy mode

- Something totally different

Alice disclosing the Astroparticle Un

Perspectives of Astroparticle Physics in Europe



p

γ

ν

$0\nu\beta\beta$ m_ν^2

ASPERA Roadmap Phase-I

Perspectives of Astroparticle Physics in Europe

χ

p

γ

ν

$0\nu\beta\beta$ m_ν^2

ASPERA Roadmap Phase-I

Journée des Astroparticules
7 Septembre 2007
Auditorium CNRS
3 rue Michel Ange , 75016

χ

p

γ

ν

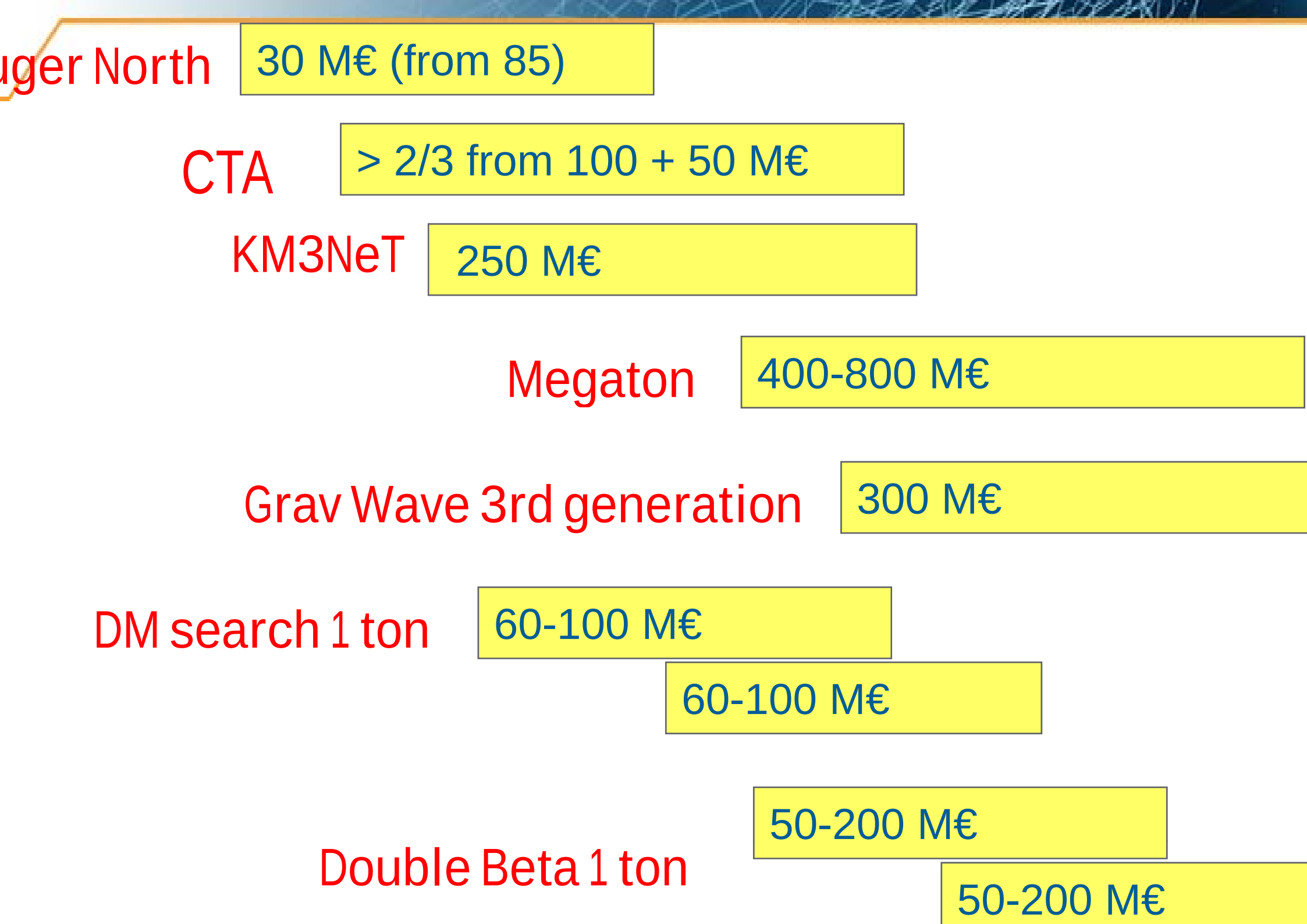
Cosmologie

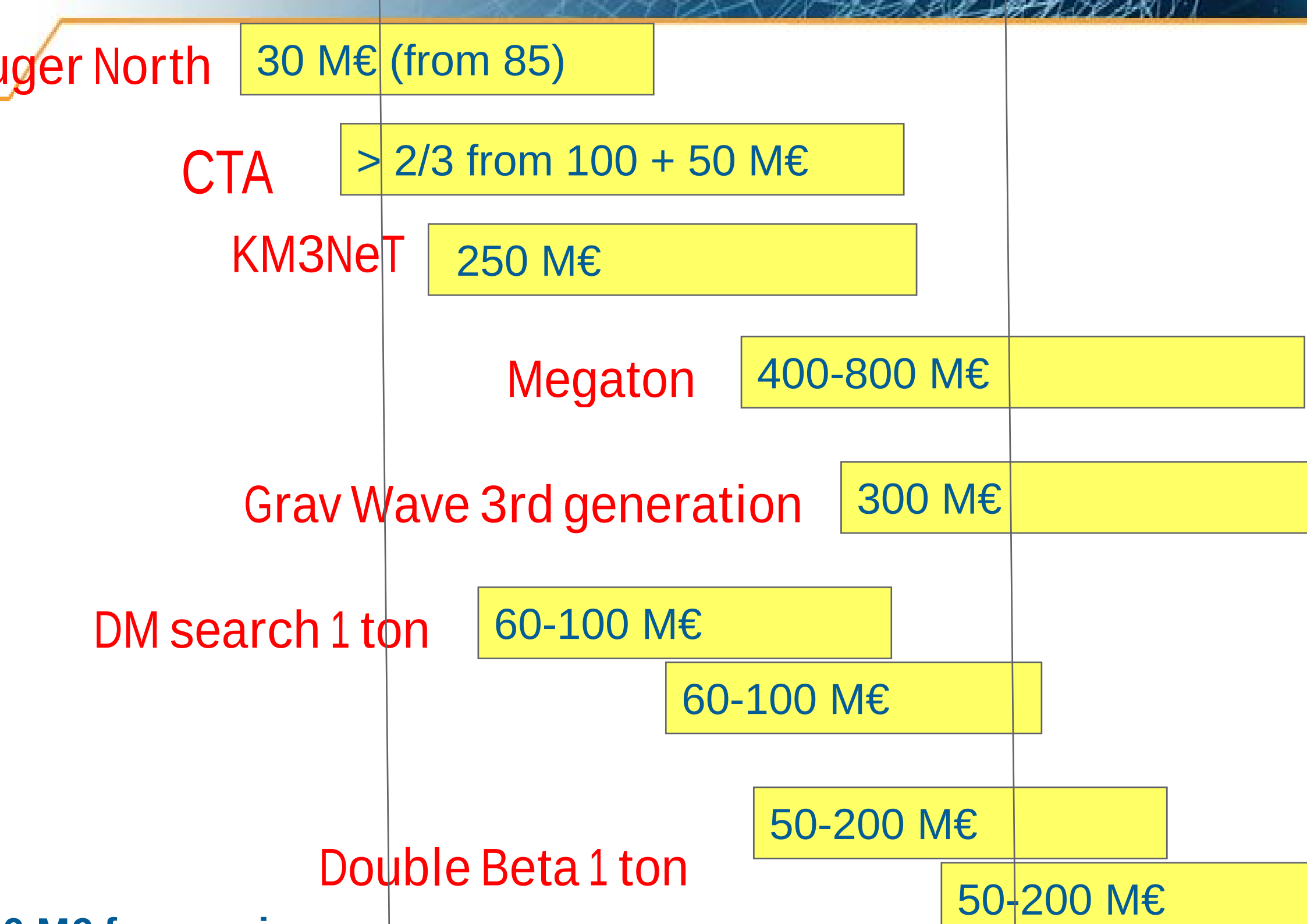
Messagers de haute énergie

Ondes Gravitationnelles

Inscriptions:
http://indico.in2p3.fr/conferenceDisplay.py?confId=361

- Backups


uger North
30 M€ (from 85)
CTA
> 2/3 from 100 + 50 M€
KM3NeT
250 M€
Megaton
400-800 M€
Grav Wave 3rd generation
300 M€
DM search 1 ton
60-100 M€
60-100 M€
Double Beta 1 ton
50-200 M€
50-200 M€


uger North
30 M€ (from 85)
CTA
> 2/3 from 100 + 50 M€
KM3NeT
250 M€
Megaton
400-800 M€
Grav Wave 3rd generation
300 M€
DM search 1 ton
60-100 M€
60-100 M€
50-200 M€
Double Beta 1 ton
50-200 M€