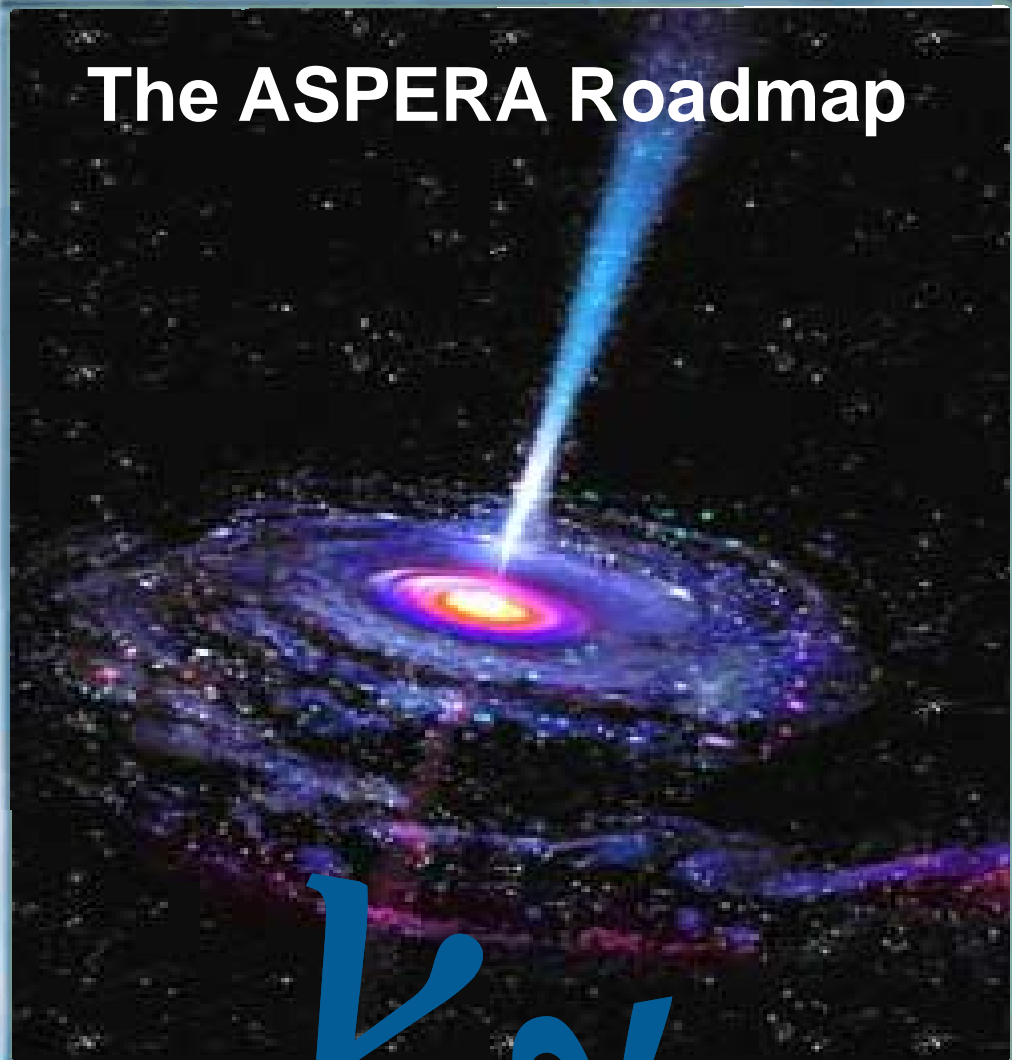


# The ASPERA Roadmap



Key  
n

## 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)

## 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:

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- Questionnaires from agencies
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- → 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

Present information is last-minute information:

Not 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
- ....

Not every experiment yet included in the Excel table

Sometimes not clear whether total cost or only European cost

No prioritization at all in the WGs !

## 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

„calendar of d

## – Clear definition of milestones and decisions points

- Roadmap Phase II (30 page paper for politicians) – August 2008

2009/10: Explicit recommendations

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 road

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 convergence (reduction factor ~2)
- **YES** – we see that from the phase-II questionnaires
- **NO:**  
Need factor 2 pressure! See positive examples next slide
- **NO:** Compare ratio #scientists/cost for LHC, FAIR, XFEL – it is similar:
  - APP 3000 scient./1.4 M€ 2011-
  - FAIR 2500 scientists/1.2 M€

# Funding





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 personnel

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

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

Prioritization mandatory:

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)

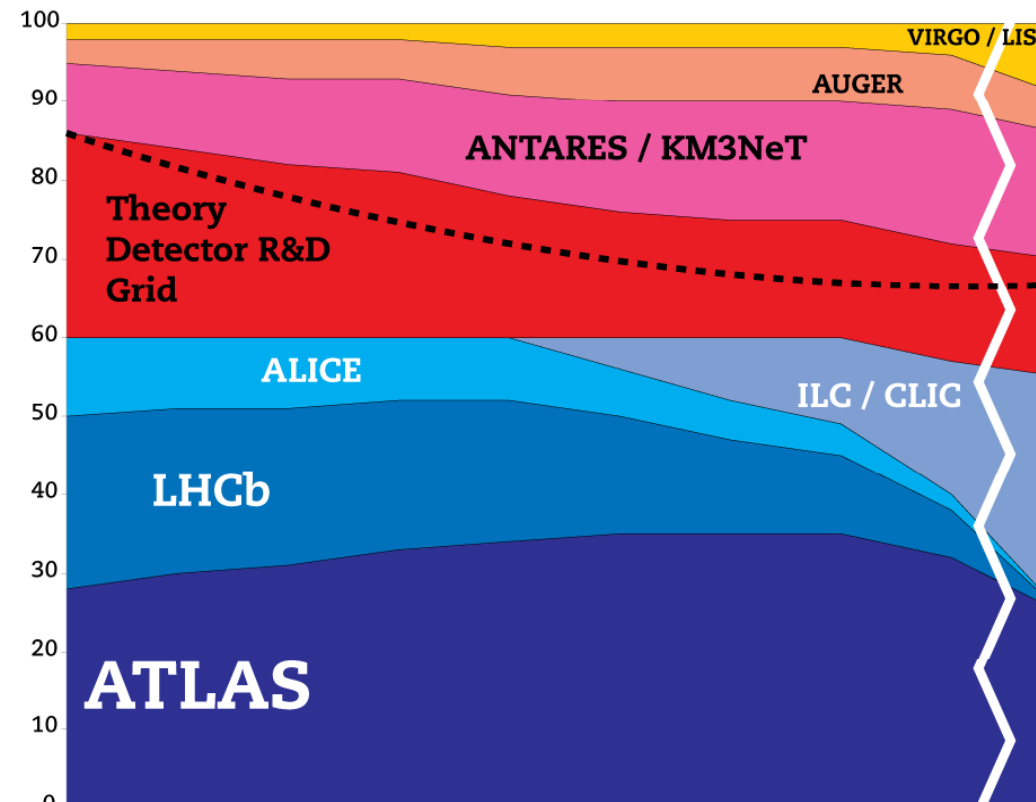
Increase will likely come in steps

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

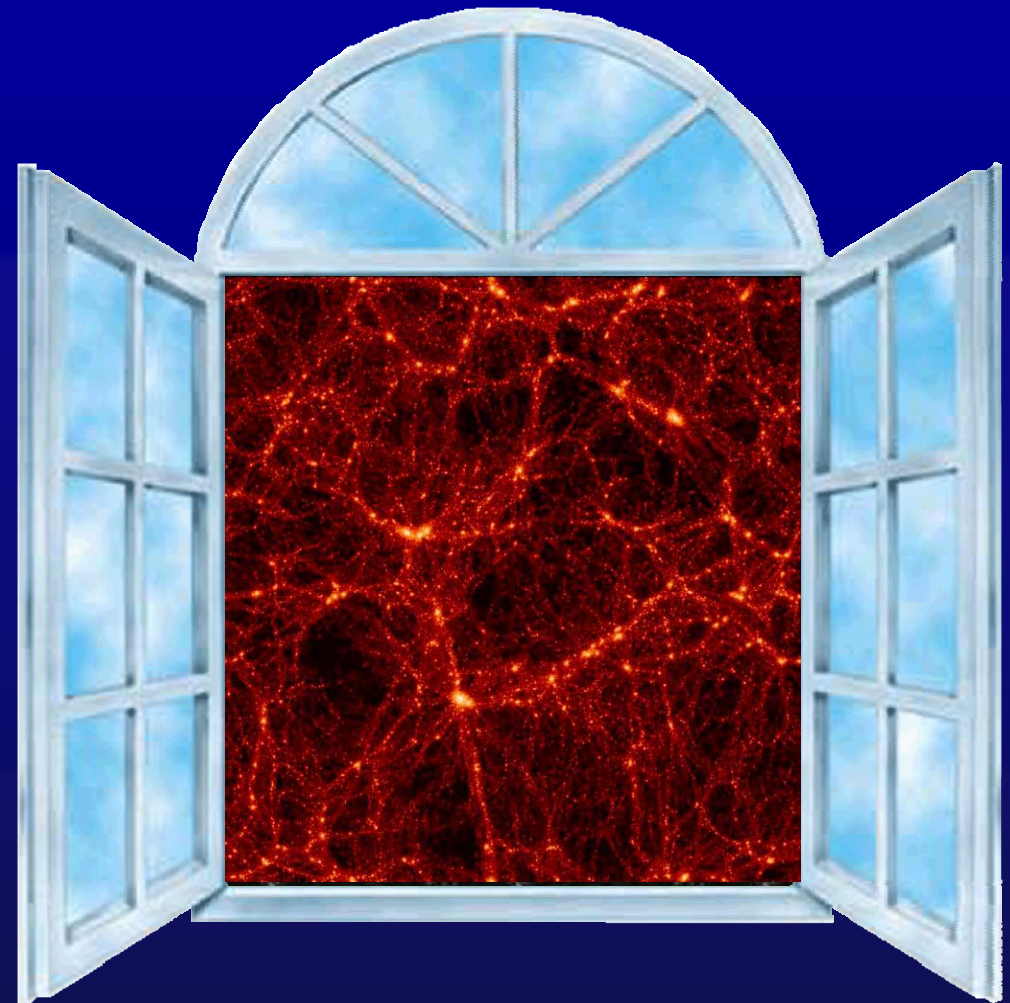
# Some examples of significant funding st

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



$10^{-4}$

**Stage 1:**  
Field in  
Infancy

**Stage 2:**  
Prepare the  
instruments

**Stage 3:**  
Maturity.  
Rapid  
progress

$10^{-6}$

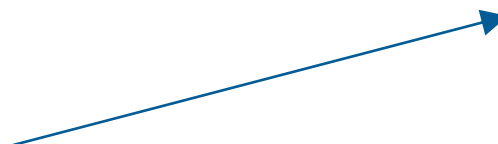
$10^{-8}$

**Stage 4:**  
- Understand remaining  
background. 100 kg scale  
- Determine best method  
for ton-scale detectors

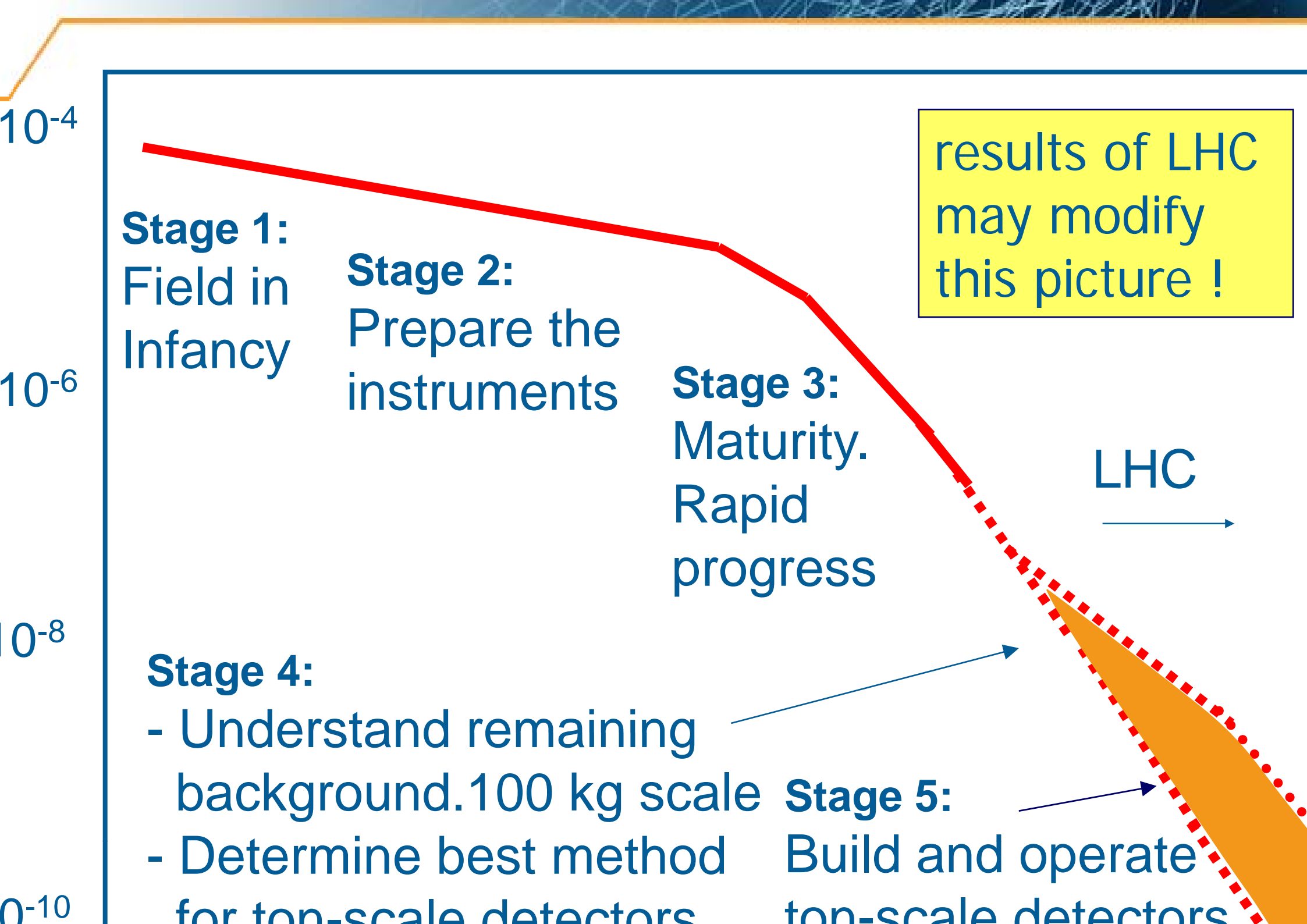
**Stage 5:**  
Build and operate  
ton-scale detectors

results of LHC  
may modify  
this picture !

LHC



$10^{-10}$



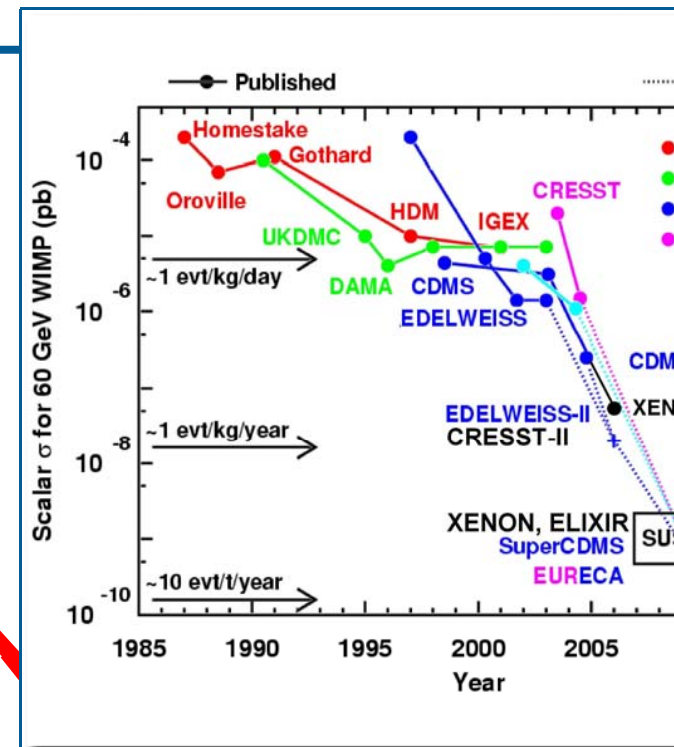
$10^{-4}$

$10^{-6}$

$10^{-8}$

$10^{-10}$

- Background
- Funding / Infrastructure



# Towards 2 ton-scale zero-background detectors

Now: 10 kg scale

2009/11: 100 kg scale

2011-17: constr. ton



modular expansion

LXe

LXe

LAr

LAr



XENON/LUX, WARP

Xe-100

Ar-100



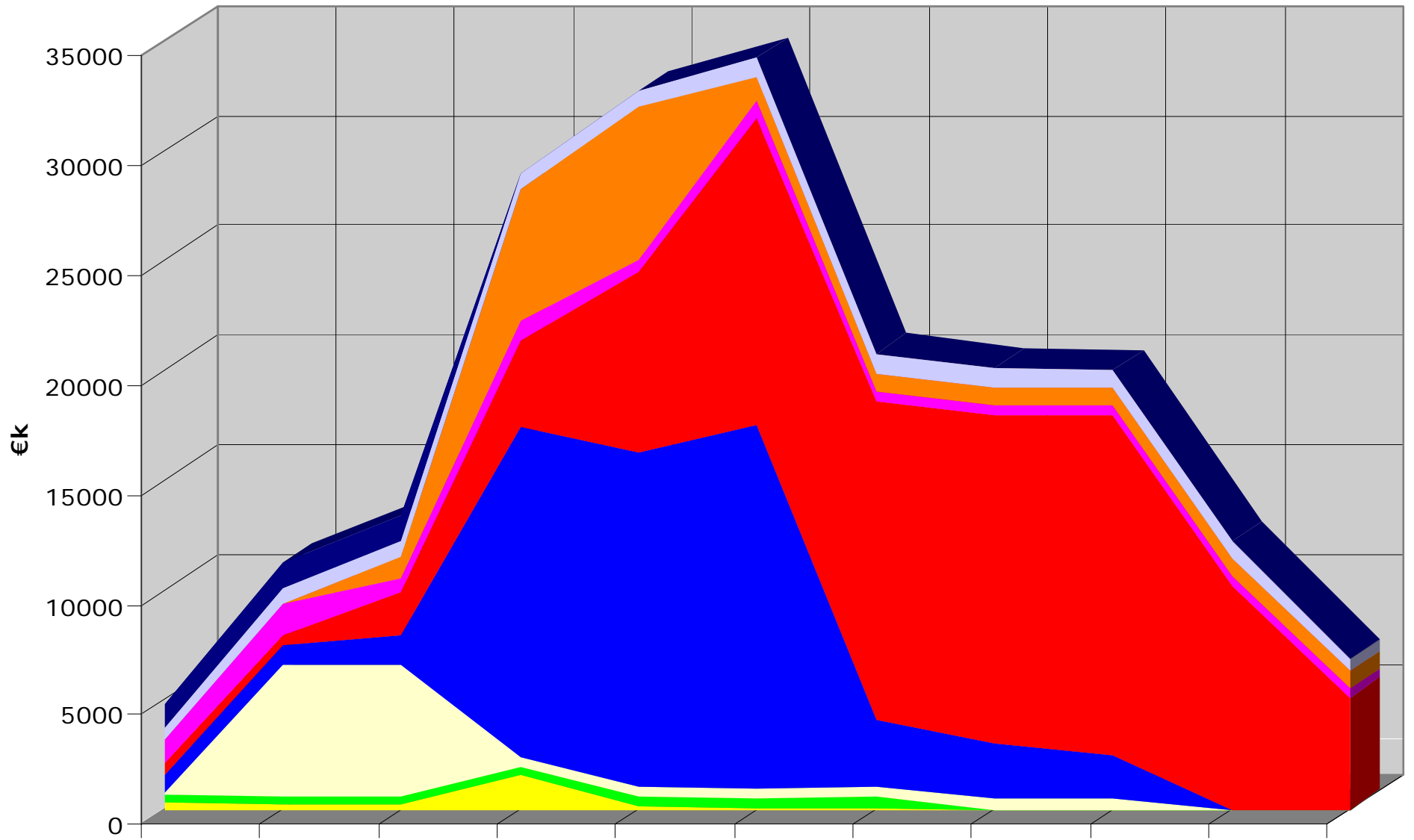
Noble liquid  
@ ton scale

ELIXIR, ..

a possible convergence scenario

# Investment - Total ASPERA

ArDM CYGNUS DAMA1ton ELIXIR EURECA SIMPLE Ulisse ULTIMA ZEPLIN





# Properties of Neutrinos



# Neutrino Prope

Experiment	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

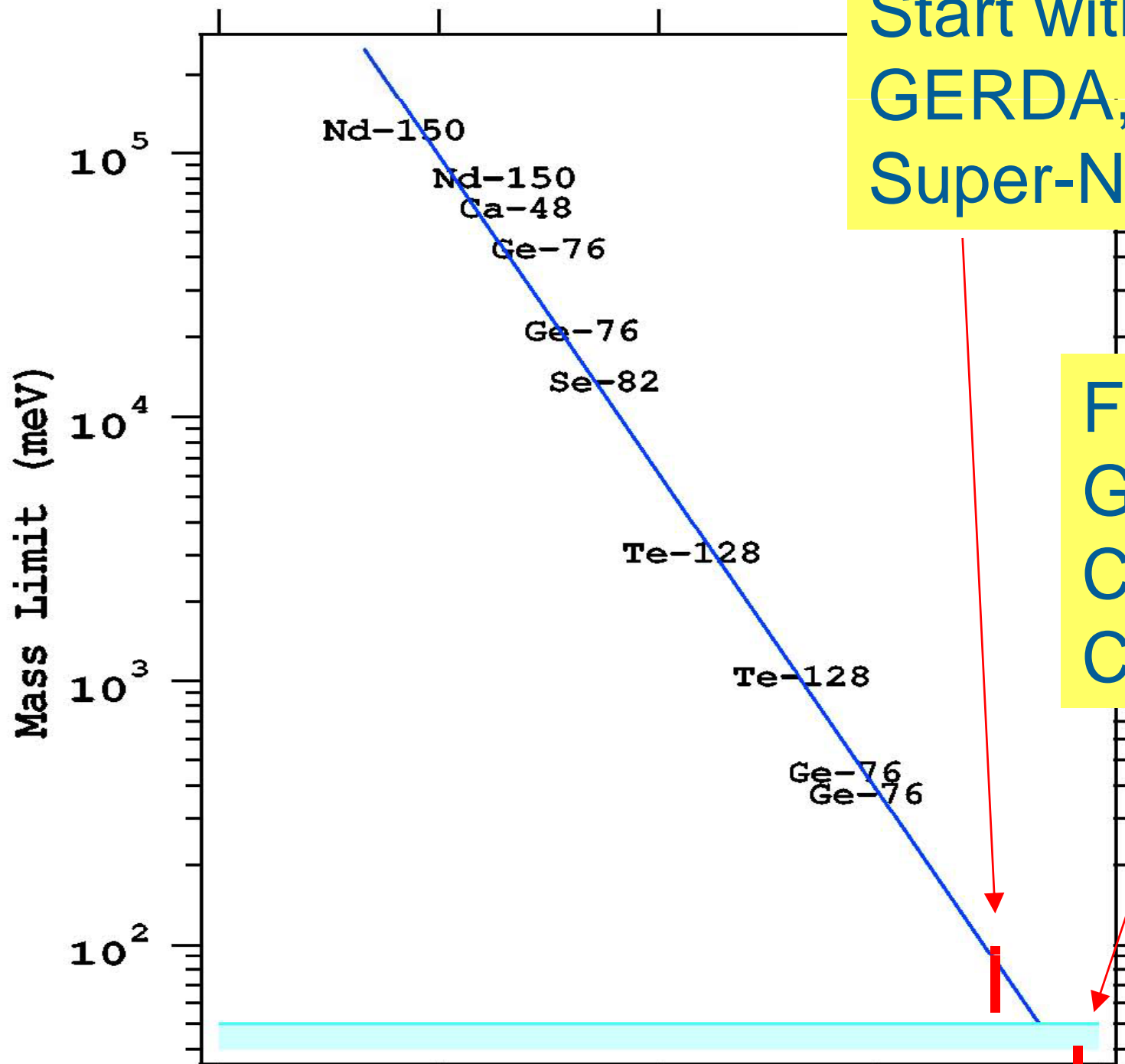
1-ton experiment not yet specified and included. Would it start

– in parallel ?

– after ?

– instead of ?

} Super-NEMO ?

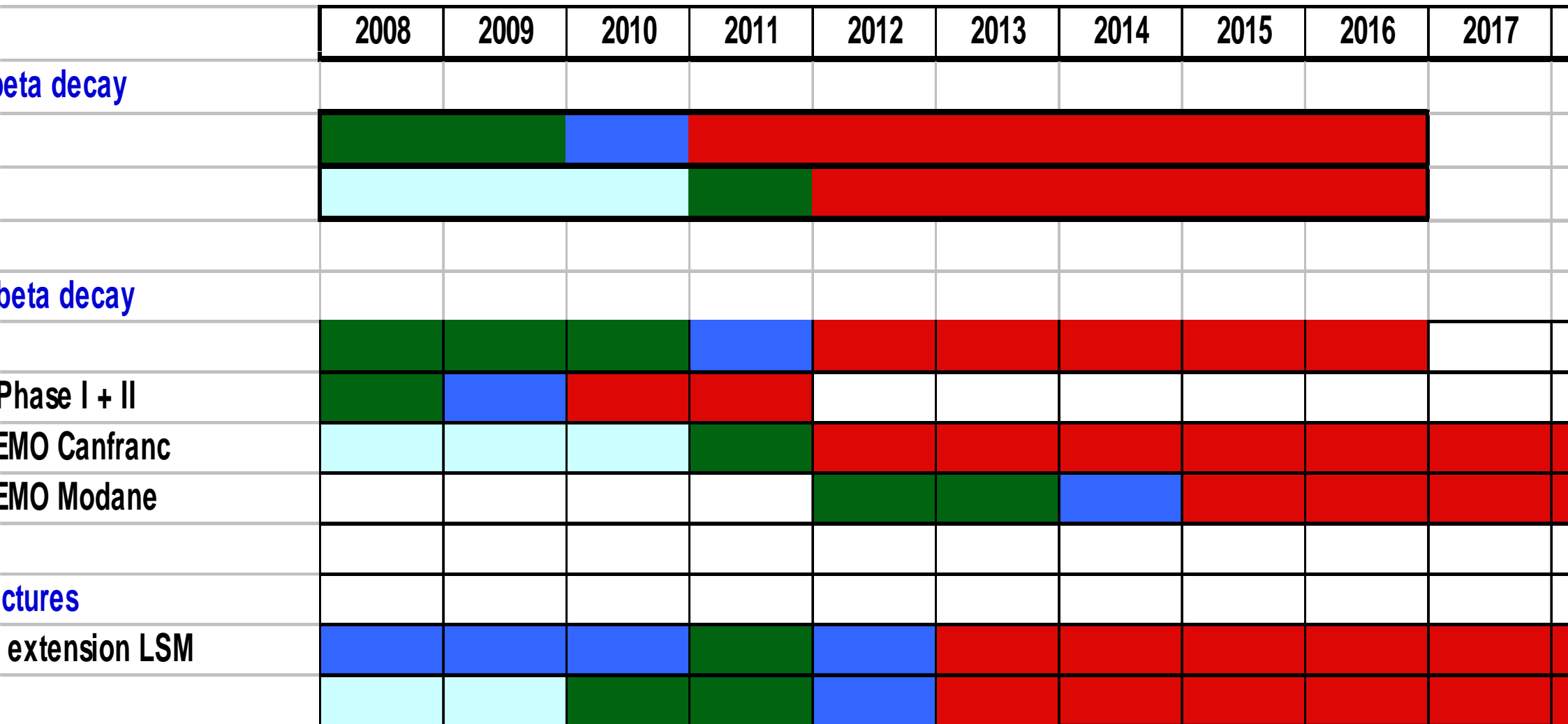


Start within next 5 years:  
 GERDA, Cuore,  
 Super-NEMO, EXO-200, .

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

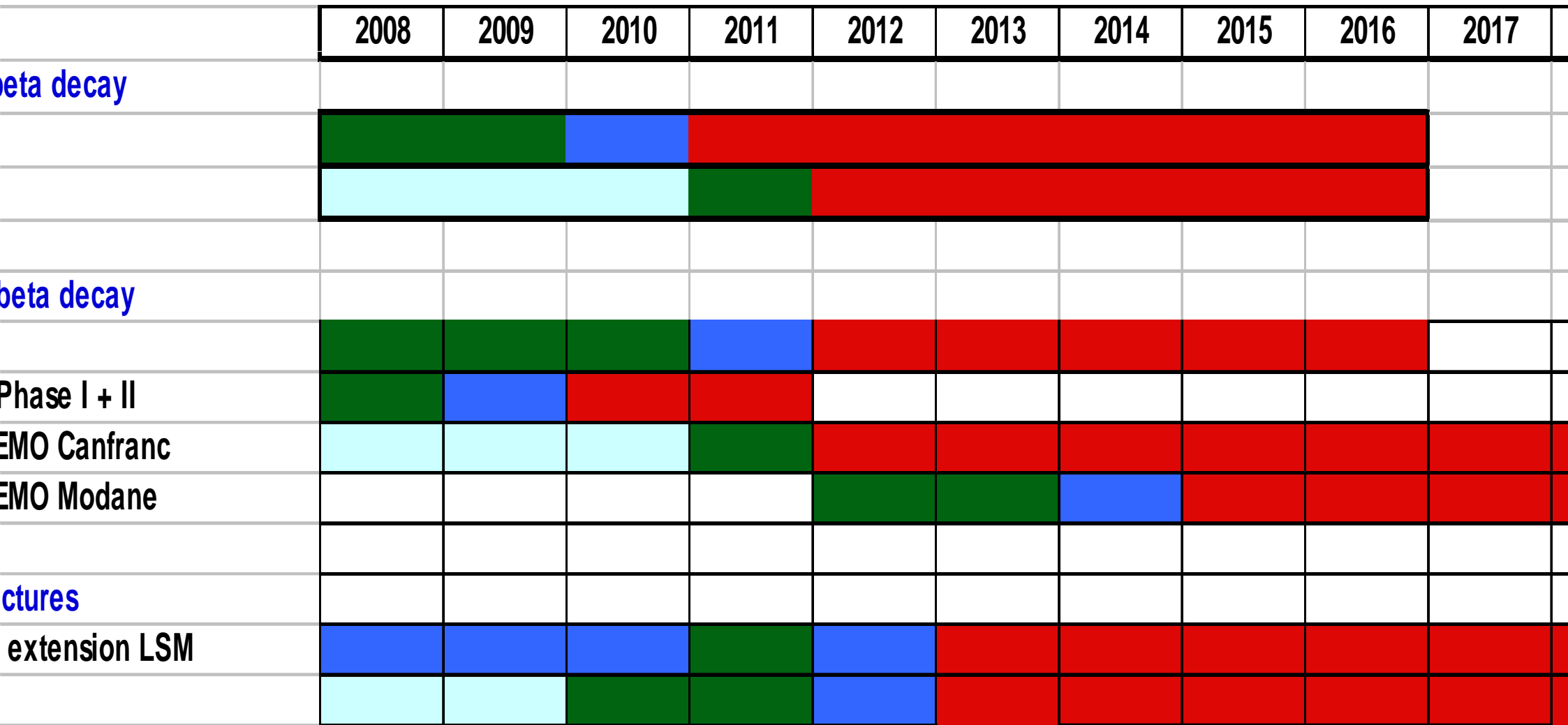
20-50 meV range req  
 active mass of order c  
 ton, good resolution  
 BG. Price tag 50-200

# Neutrino Prope



Phases	
1. R&D	Dark Green
2. Construction	Blue
3. Commissioning	Red
4. Operation	Dark Red

# Neutrino Prope



Decision points:

13:

MARE-II ?

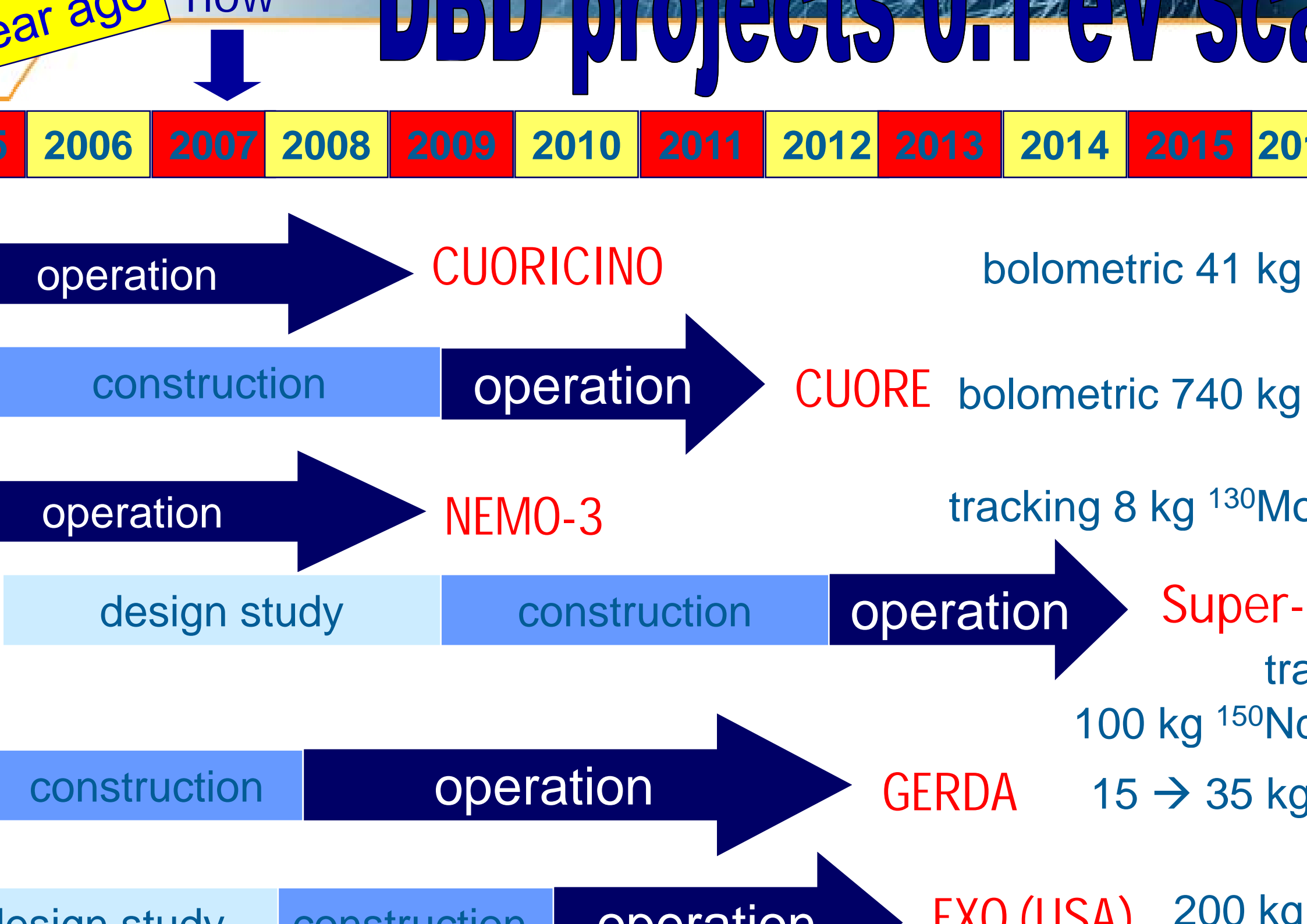
13:

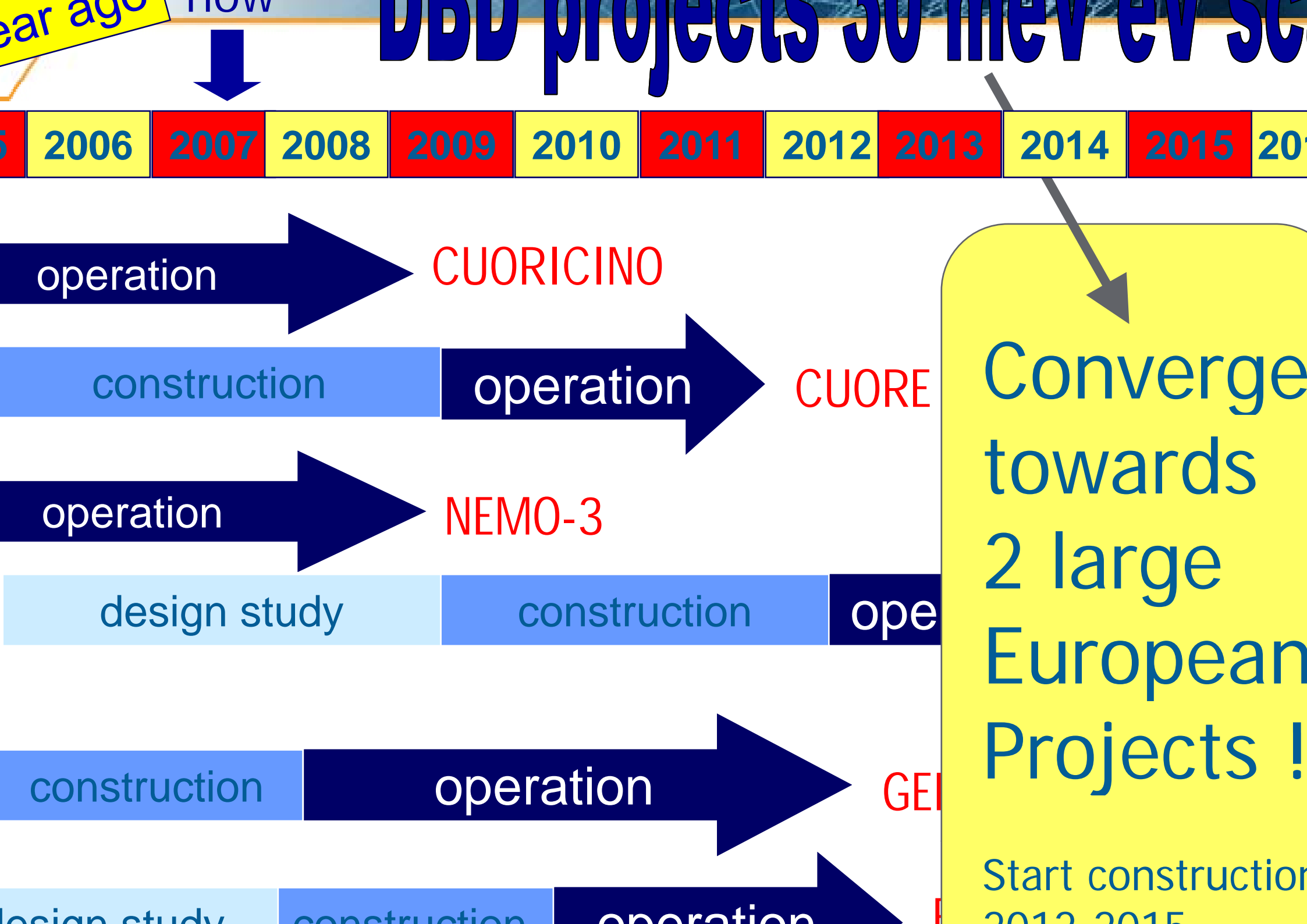
Inverted hierarchy

test KKGH

## Phases

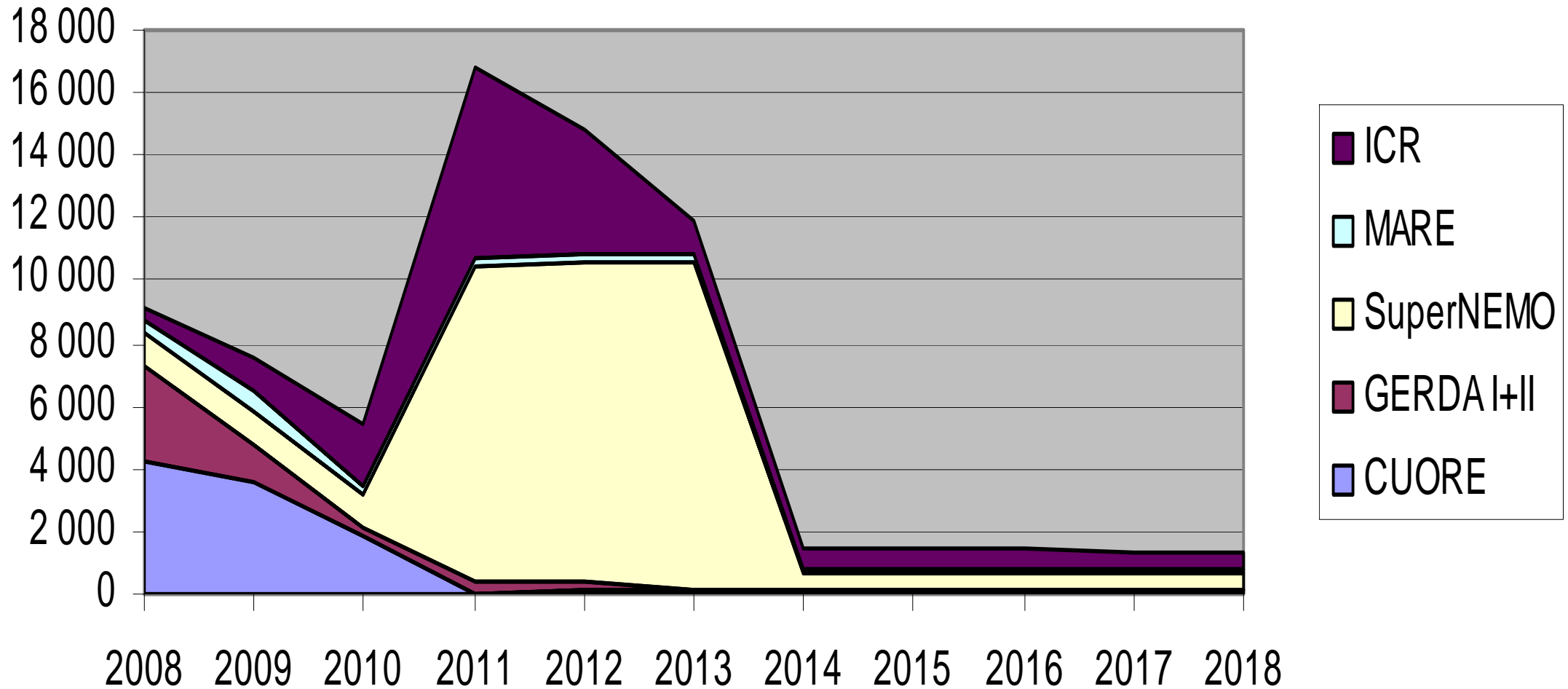
1. R&D
2. Construction
3. Commissioning
4. Operation



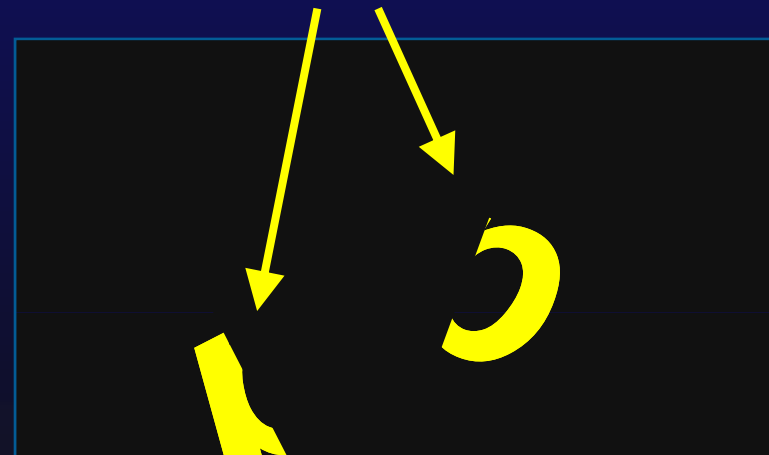
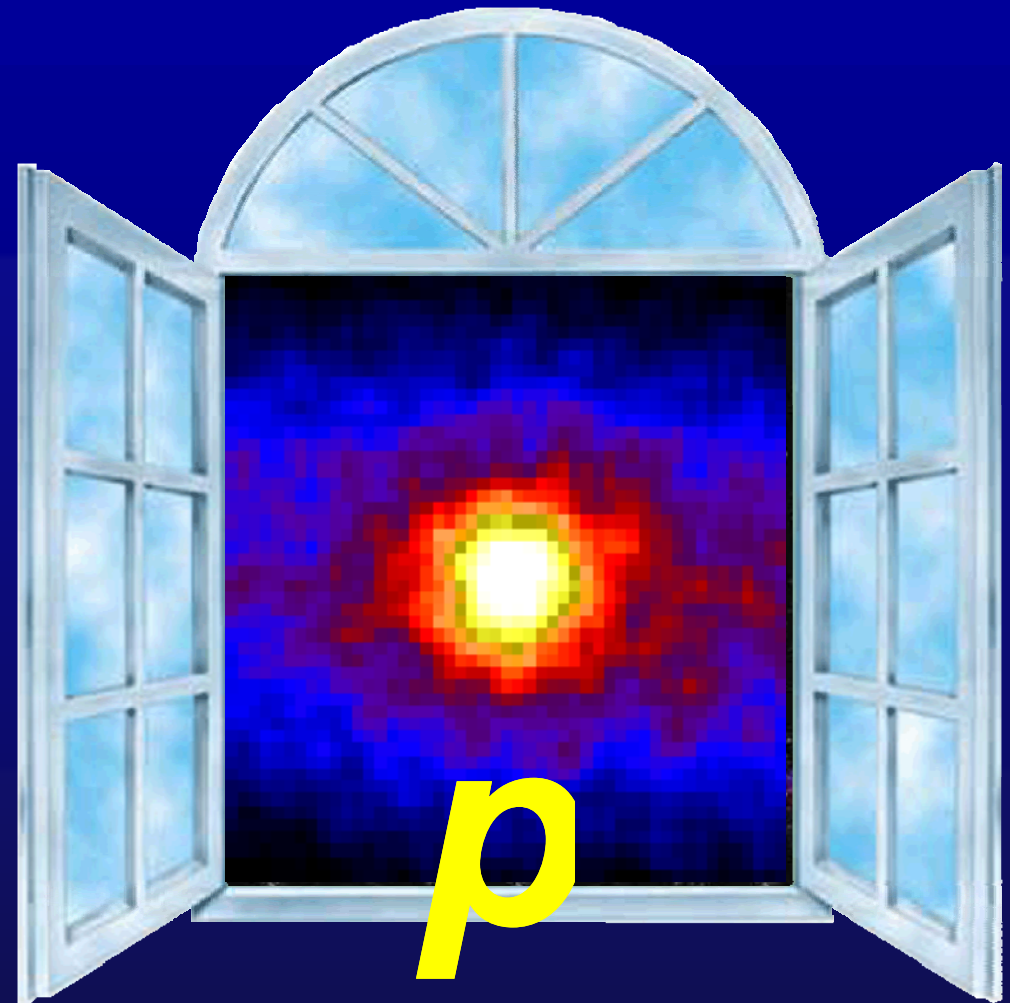




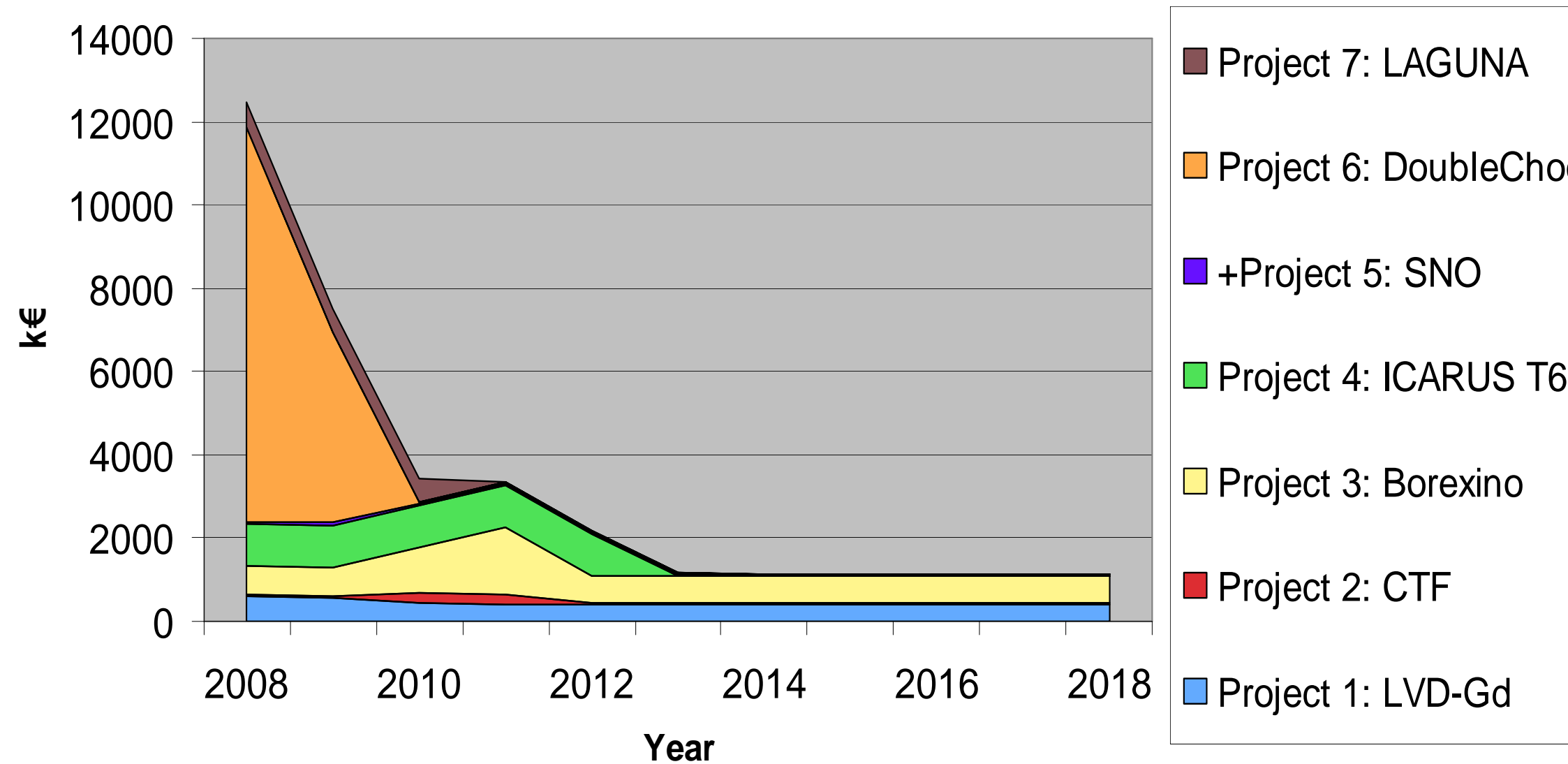
## Investments k€



# Low Energy Neutrino Astronomy and Proton Decay



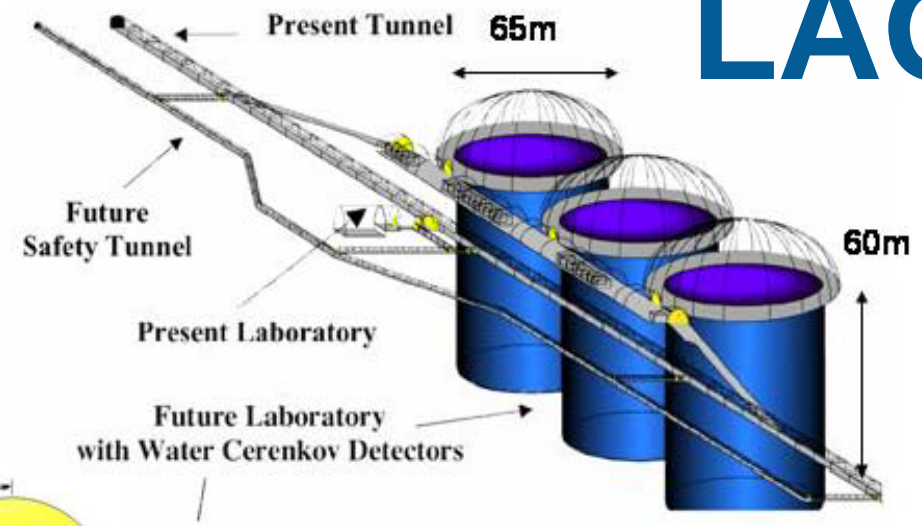
## Indicative investment needs (without megaton-scale-physics)



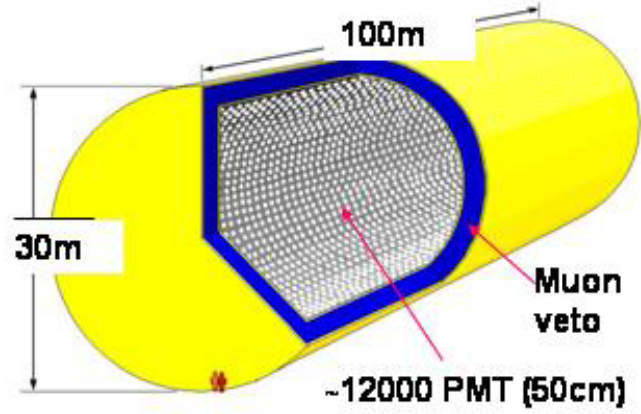
# LAGUNA

30-1000 ktons

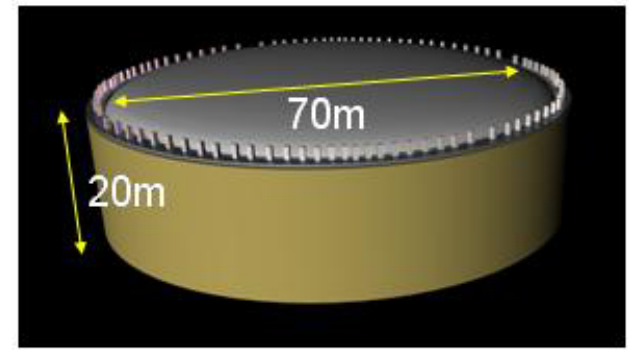
MEMPHYS:  
Water Cherenkov,  
(420 kton - 1 Mton)



LENA:  
Liquid Scintillator  
(30-70 kton)



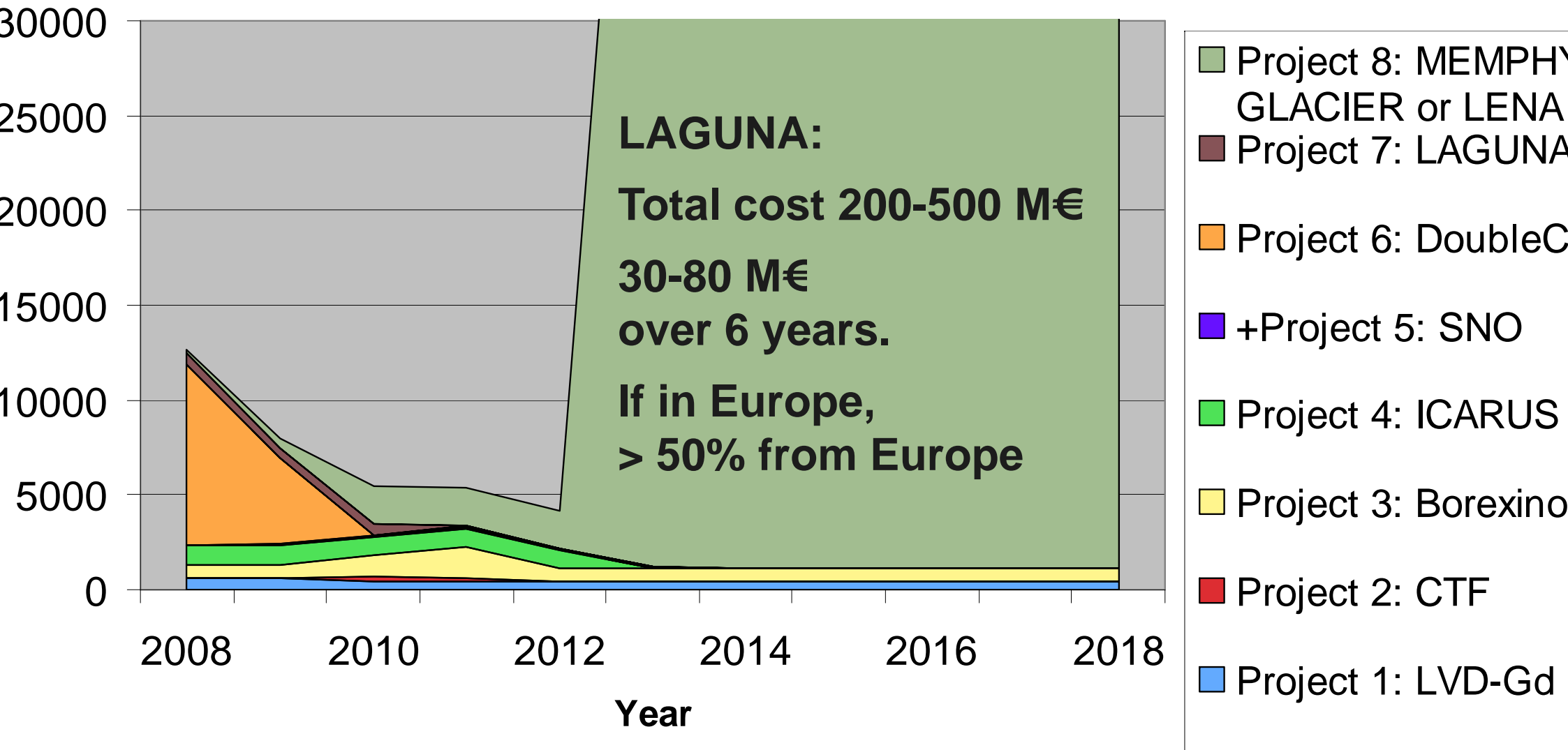
GLACIER: Liquid Argon (50 -100 kton)



Modular  
(Gran Sasso)

20 ktons

## Indicative investment needs (total)



# The High Energy Universe



## European priorities, new projects next dec

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

# Charged Cosmic R

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

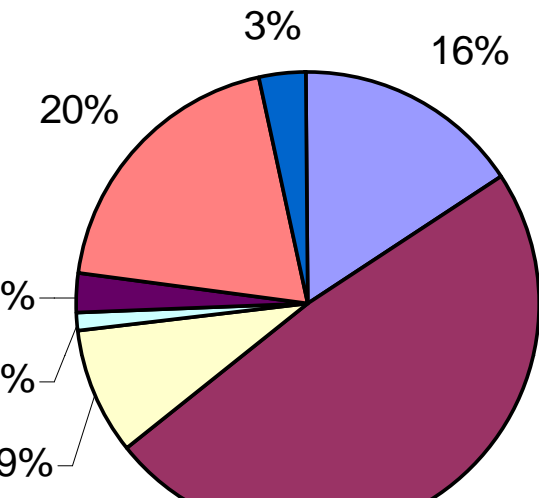
*Cost worldwide*



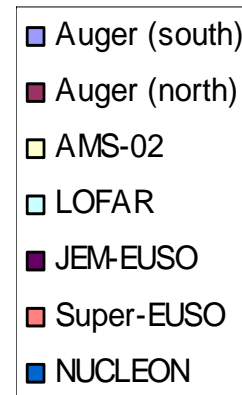
# Charged Cosmic R

Experiment	k€	FTE (additional 2008-2018)
Auger (south):	15.000	-
Auger (north):	45.700	655
AMS-02:	8.500	335
JEM-EUSO:	2.600	50
Super-EUSO:	18.600	50
LOFAR(CR):	1.000	77
NUCLEON:	3.212	151

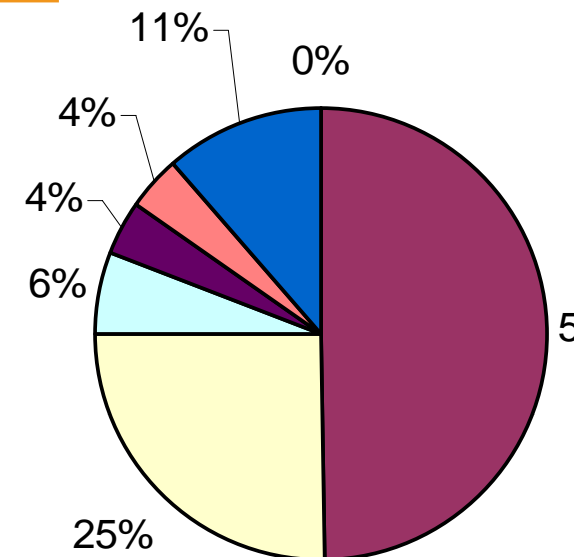
cost Europe



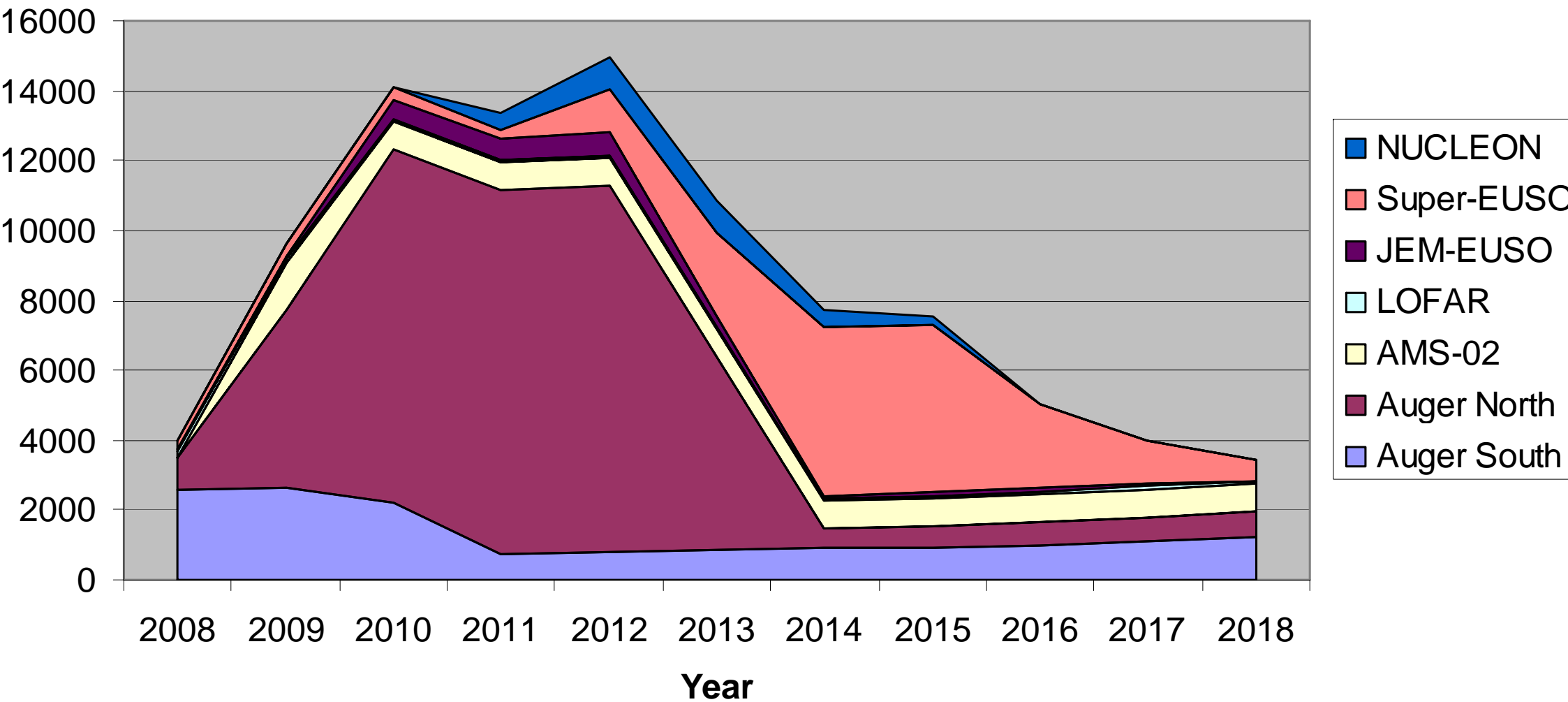
Investments k€



FTE



## Investments (ASPERA part)

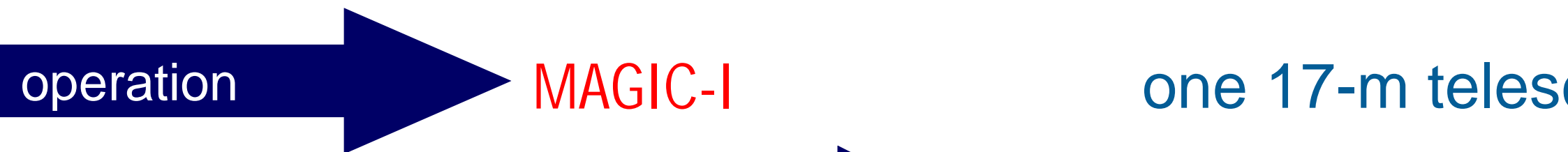
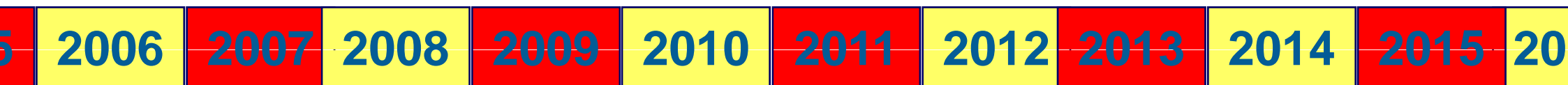
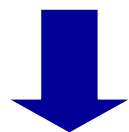


# High Energy Gamma

Experiment	k€	FTE (additional 2008-18)
main source	milestones	
<b>HESS:</b>	<b>9.050</b>	<b>235</b>
Astrop.Phys.	HESS II commissioning in 2009	
<b>MAGIC:</b>	<b>9.700</b>	<b>260</b>
Astrop.Phys.	MAGIC 2 commissioning in 2008	
<b>VERITAS:</b>	<b>11.051</b>	<b>115</b>
Astrop.Phys.	Started full operation spring 2007.	
<b>VERGO-YBJ</b>	<b>2.500</b>	<b>150</b>
Astrop.Phys.	Completion with lead layer in 2008	
<b>SWGO:</b>	<b>985</b>	<b>103.5</b>
Astrop.Phys.	First telescope by end 2007	
<b>GLAST:</b>	<b>177.500</b>	<b>990</b>
Astrop.Phys.	Design Study until 2011; Start construction 2011	
<b>GLAST</b>	<b>198.200</b>	<b>150.5</b>
Space agencies	Launch in 2008; 5 years warranted operation	

# Gamma Rays: IACTs

now



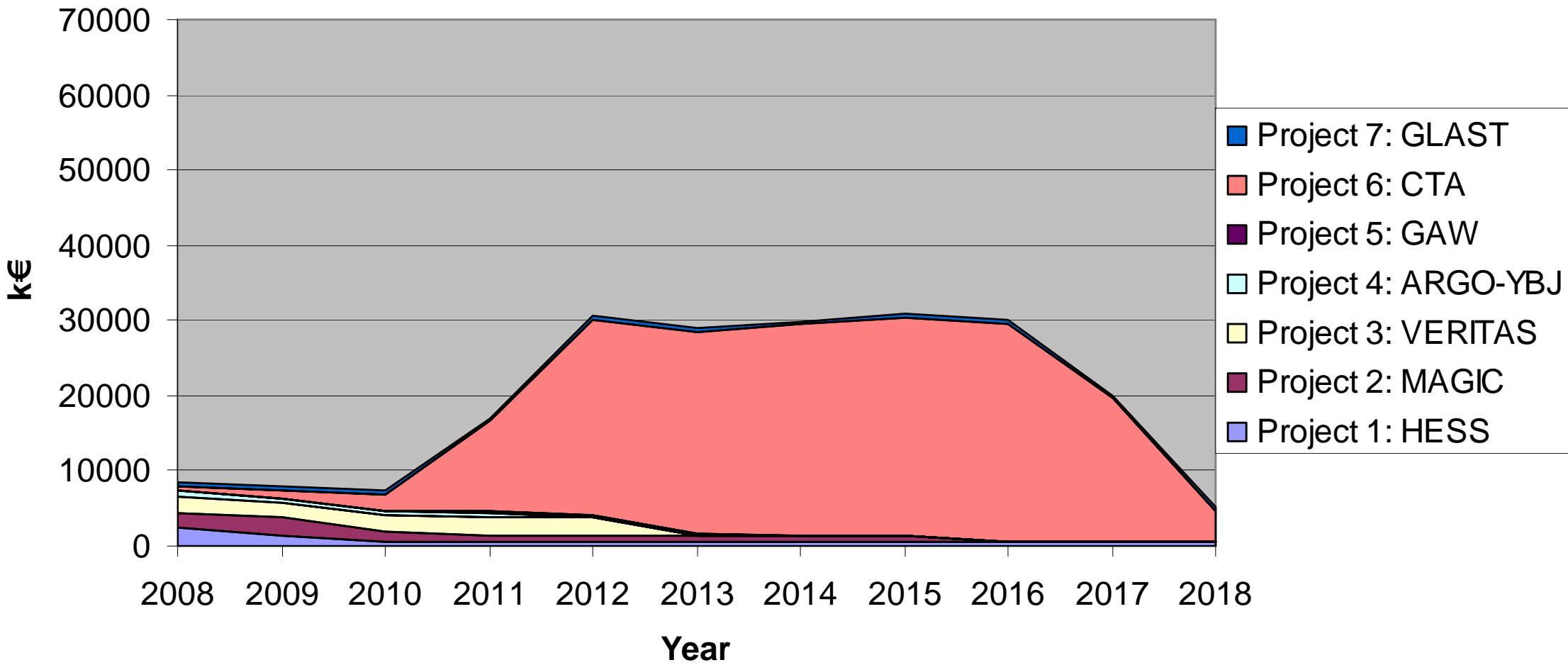
**Coordination with USA, Japan, Australia**

**CTA**

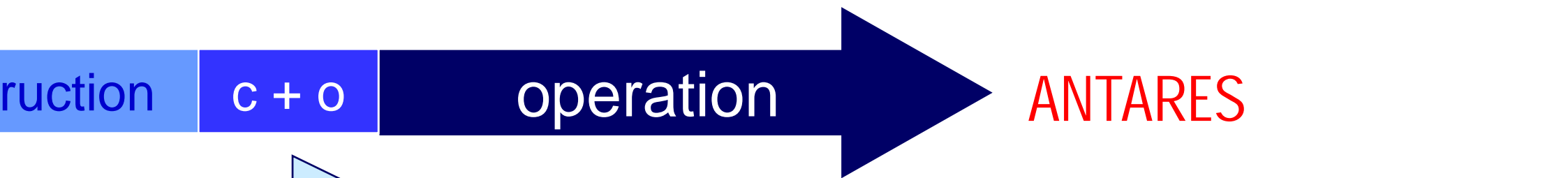
construction + operation operation

# High Energy Gamma

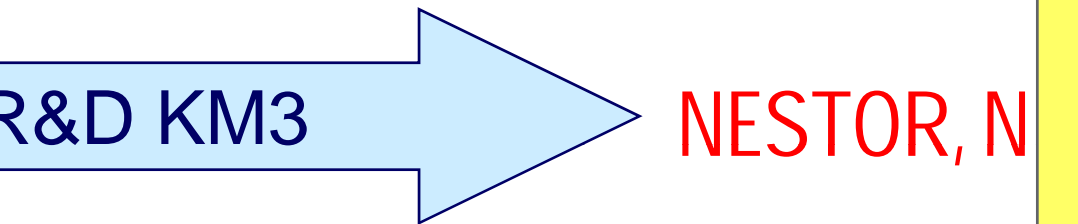
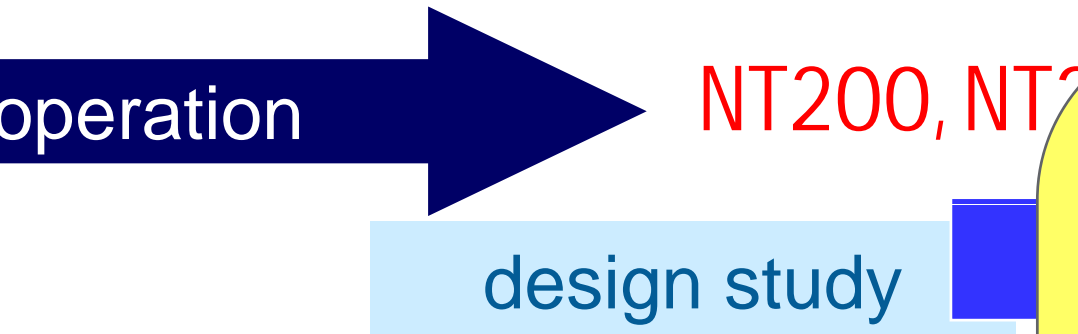
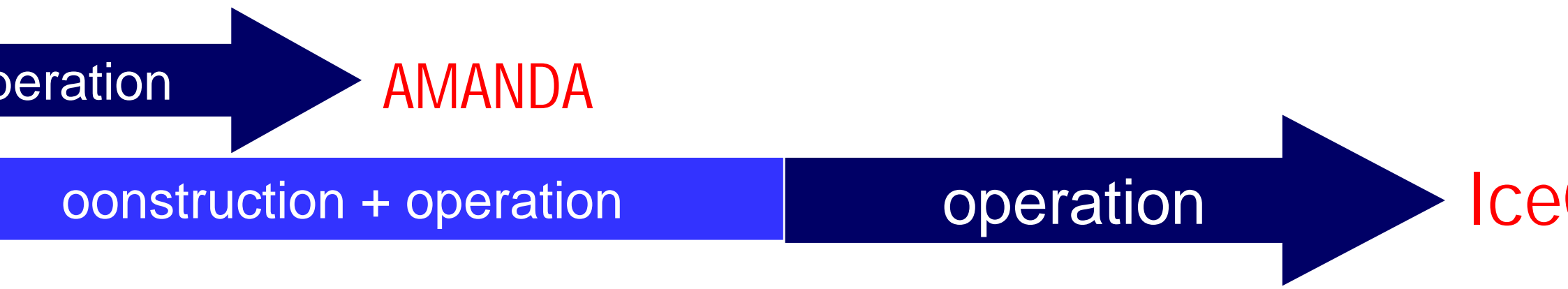
## Investments



# THE NEUTRINO TELESCOPE

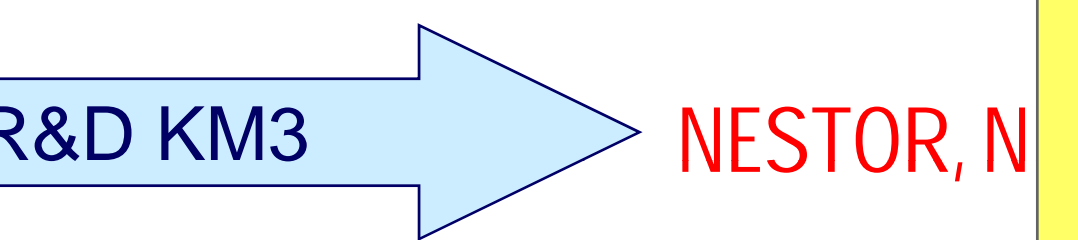
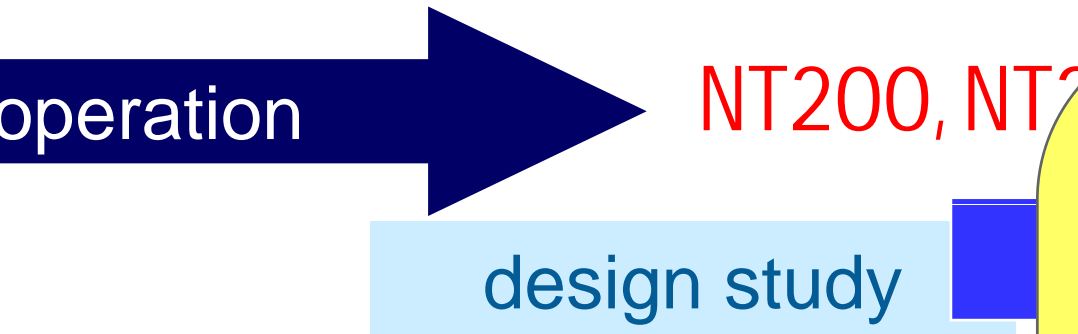


# THE NEUTRINO TELESCOPE



Recommendation: only ONE large detector on the Northern hemisphere. Expect consolidation of physics case from IceCube and H.E.S.S.

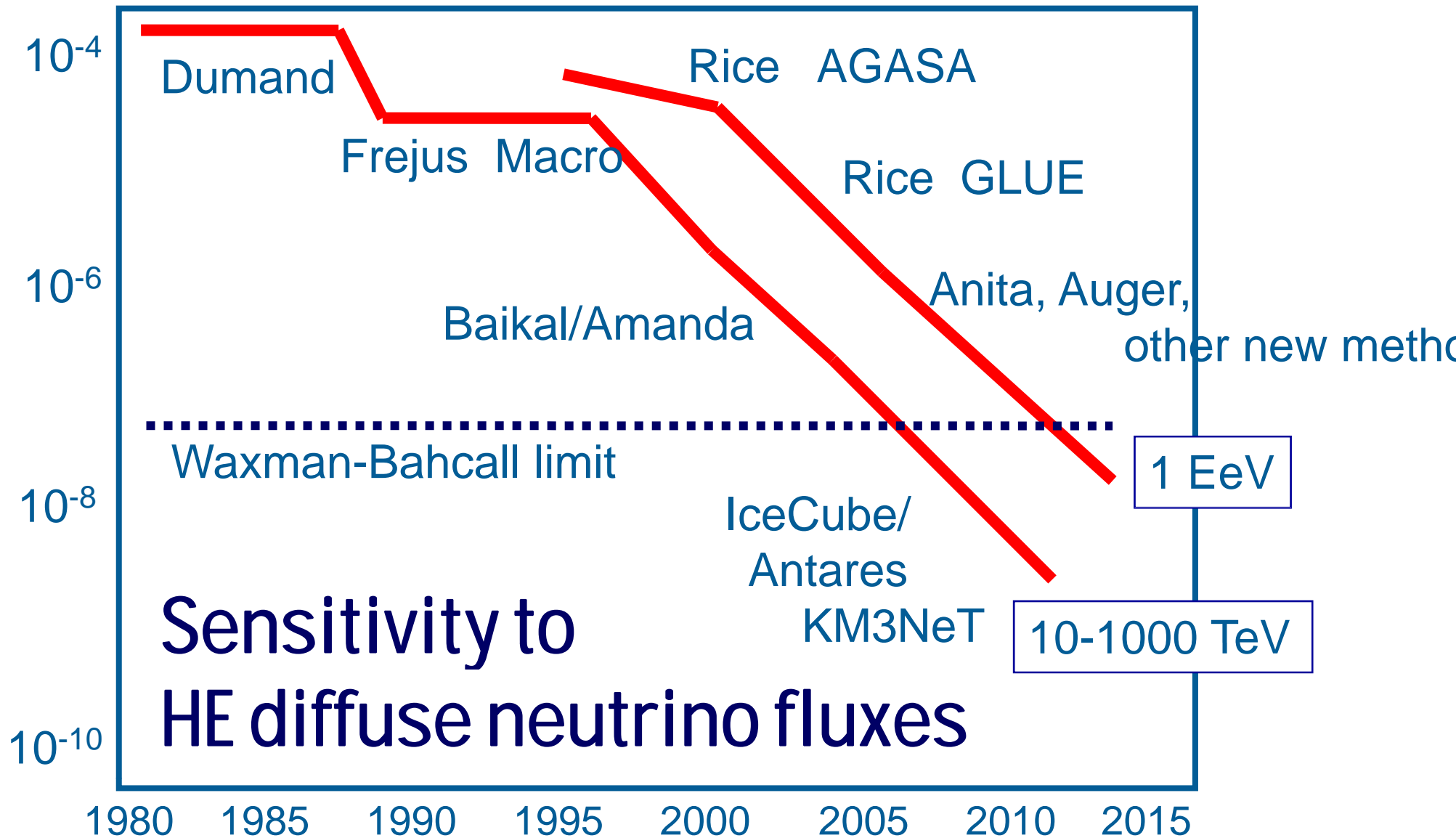
# THE NEUTRINO TELESCOPE



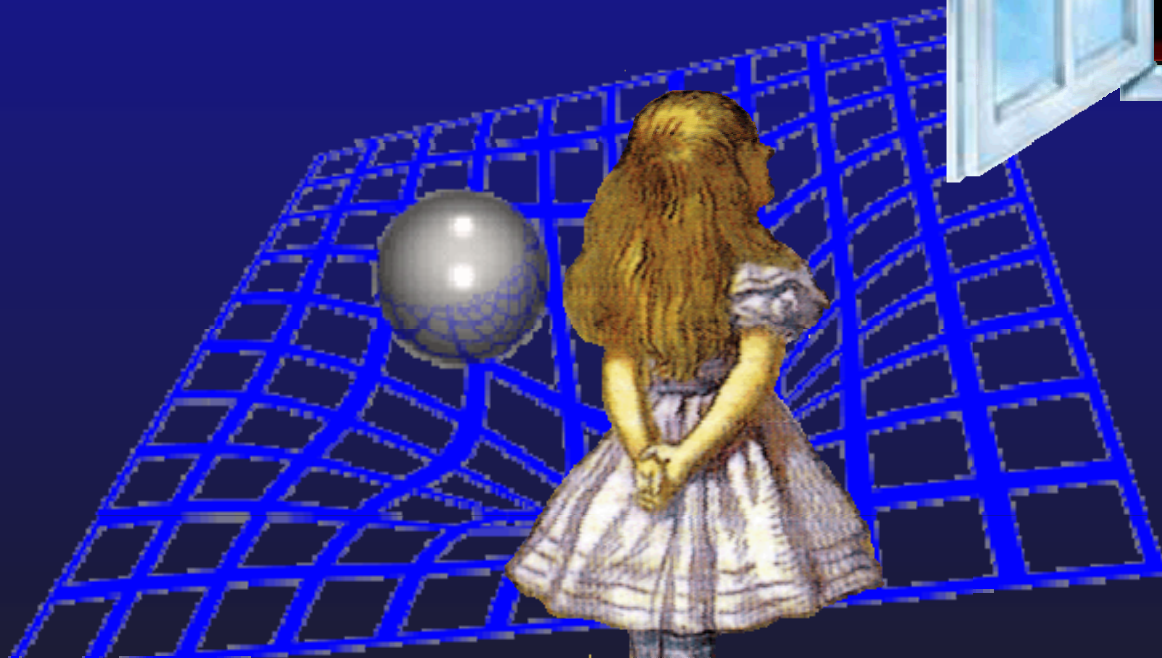
Need detector with  $>1 \text{ km}^3$ , if IceCube does not discover sources until 2009 (IceCube has  $1 \text{ km}^3 \times \text{year}$  early 2009). Challenge to stay below 200 MC/L.

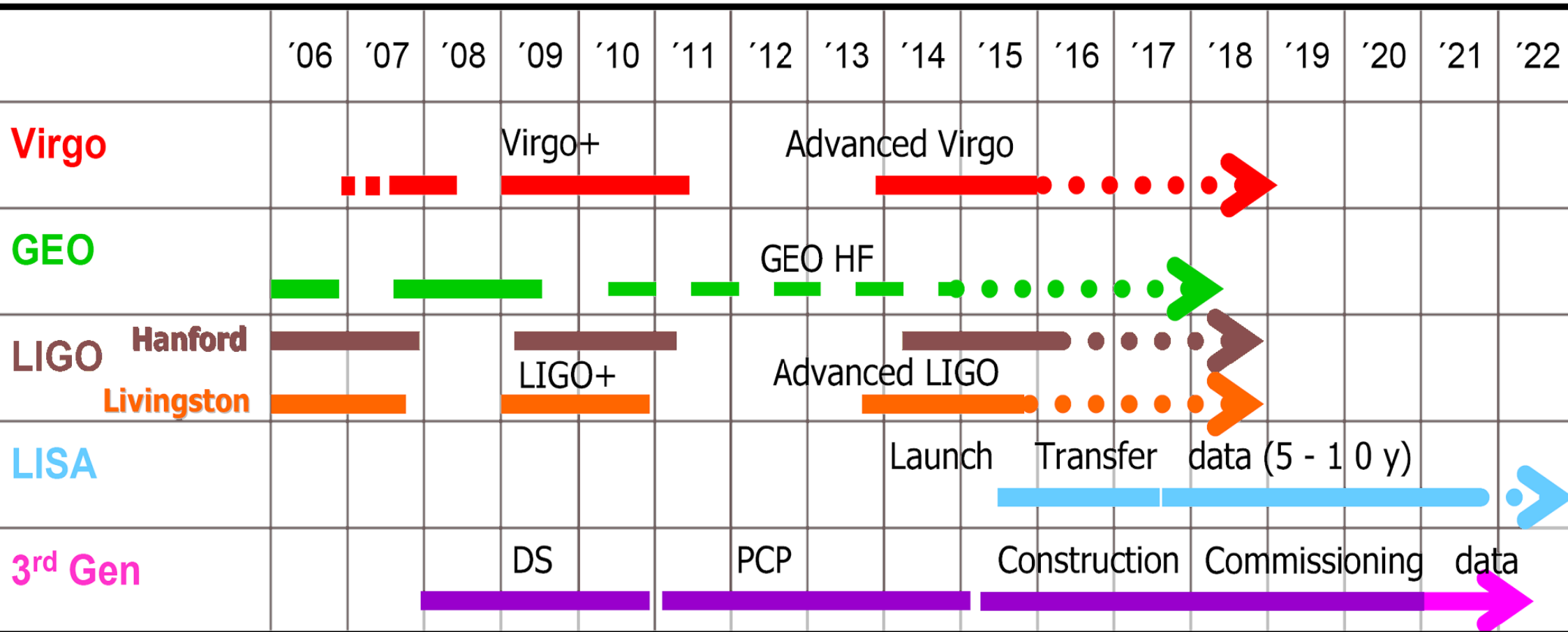


Flux \* E<sup>2</sup> (GeV/ cm<sup>2</sup> sec sr)



# Gravitational Waves



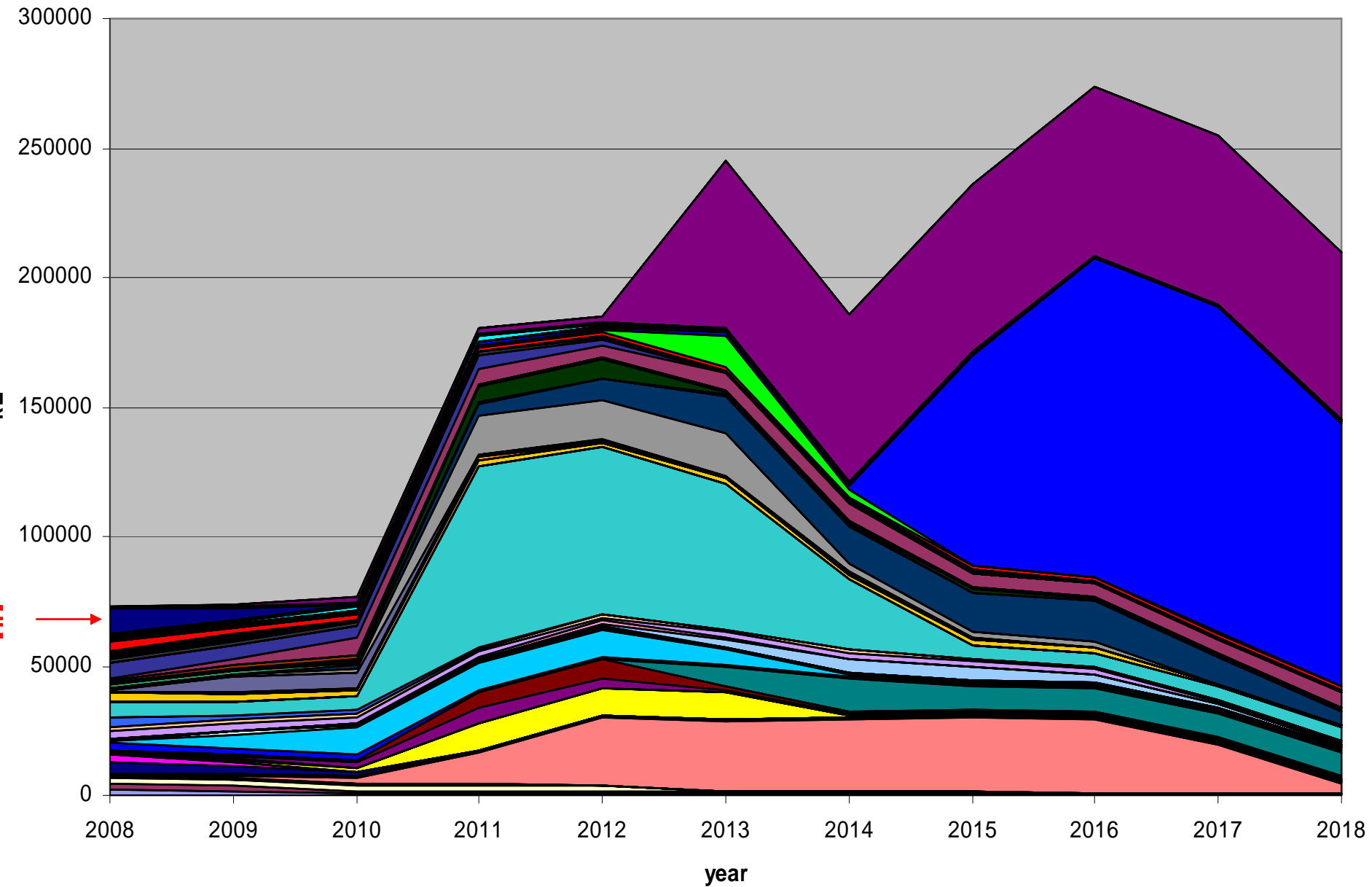




**Total cost**

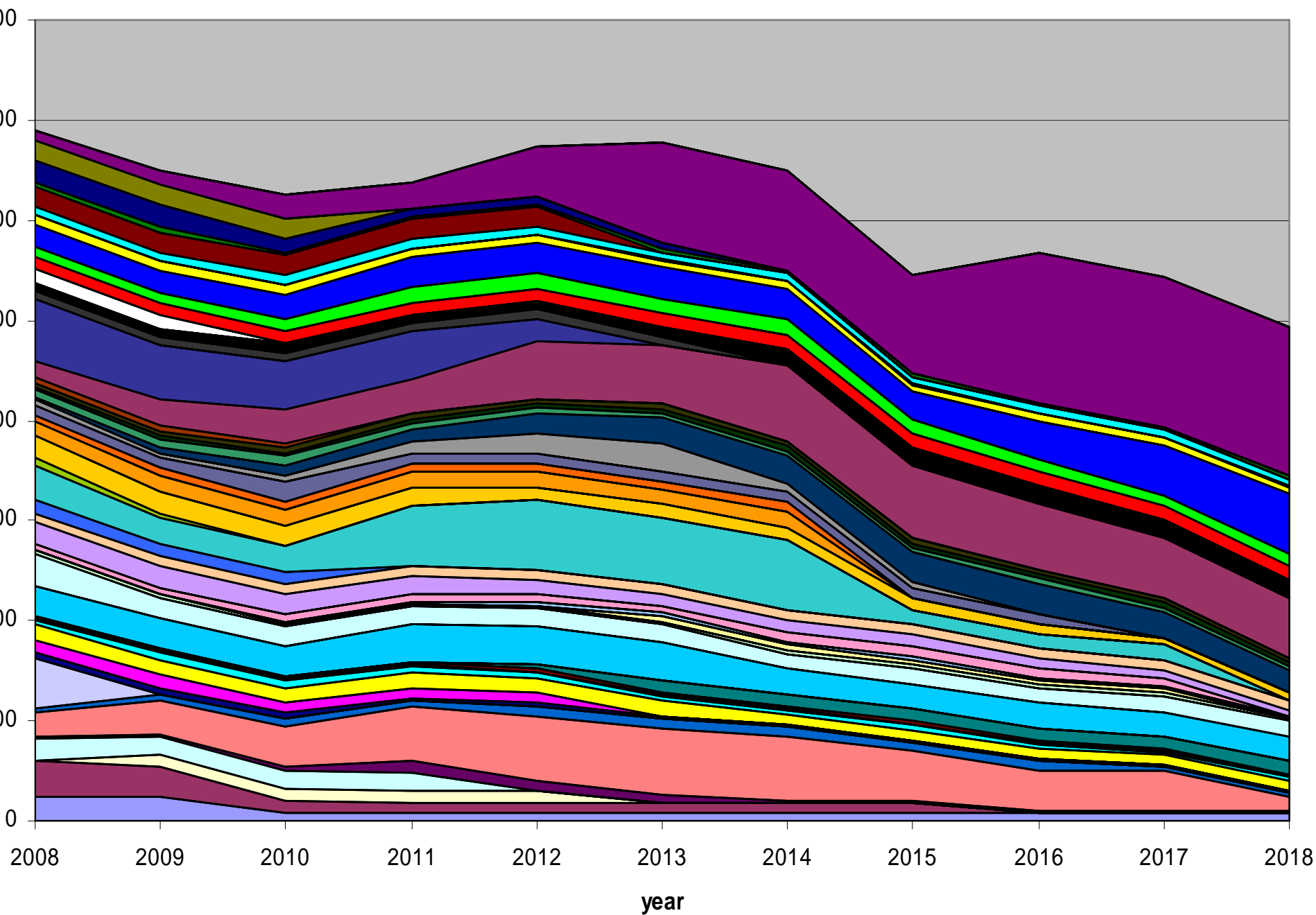


# Investment



- 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
- DAMA 1ton
- CYGNUS
- ArDM
- Acoustic R&D
- ANITA

# FTE



- 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
- DAMA 1ton
- CYGNUS
- ArDM
- Acoustic R&D
- ANITA

- Convergence
- Priority Definition
- Increased funding

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



# Visions



2013



## 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  $\Theta_{13}$
- 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 price
- 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 methods“ (e.g. acoustics, COUPP-like) are being implemented
- Still, we have kept **new methods and approaches** reserves for new „new methods“

# Visions



$\mu$



$\nu$

$\rho$

$\nu^p$

$m$

$\gamma$

### 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: flourishing 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

$\chi$



$p$

$\gamma$

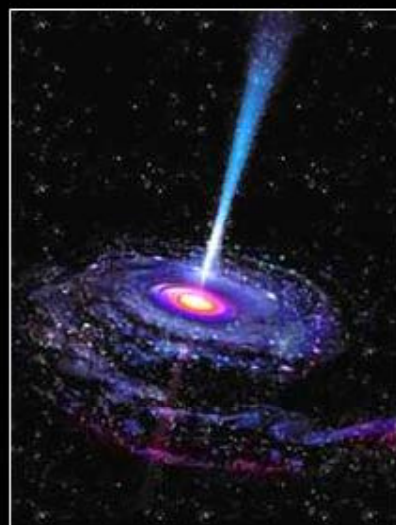
$\nu$

$0\nu\beta\beta$     $m_\nu^2$



# Perspectives of Astroparticle Physics in Europe

$\chi$



$p$

$\gamma$

$\nu$

$0\nu\beta\beta$   $m_\nu^2$



ASPERA Roadmap Phase-I

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

$\chi$

$p$

$\gamma$

$\nu$

*Cosmologie*

*Messagers de haute énergie*

*Ondes Gravitationnelles*



**Inscriptions:**

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

- Backups

Larger 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€

nger 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€