ALPS-II
Resources, schedule & conclusions

Review of the ALPS-II TDR by the DESY PRC

7 November 2012

Axel Lindner, DESY

HELMHOLTZ ASSOCIATION

DESY

Outline

- Collaboration and personnel
- Investments
- Operation costs
- Cost summary
- Schedule
- Other WISP experiments
- Conclusions

Collaboration and personnel

ALPS-II is a joint effort of

- DESY:
  Babette Döbrich, Jan Dreyling-Eschweiler, Samvel Ghazaryan,
  Reza Hodajerdi, Friederike Januschek, Ernst-Axel Knabbe, Axel Lindner, Dieter Notz,
  Andreas Ringwald, Jan Eike von Seggern, Richard Stromhagen, Dieter Trines
- Hamburg university:
  Dieter Horns
- AEI Hannover:
  Robin Bähre, Benno Willke

with strong support from

- LZH Hannover / neoLASE:
  Maik Frede, Bastian Schulz

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ALPS

Theory **Exp. Particle physics** **Accelerator physics** **Surface physics**

Astronomy **Astroparticle physics** **Laser physics** **Engineer**

Collaboration and personnel

Institution	Physicist FTE	Postdoc FTE	Ph.D. student	Eng. FTE	Note
Albert-Einstein-Institute:					
R. Bähre			1.0		
B. Willke	0.2				
DESY:					
B. Döbrich		1.0			
J. Dreyling-Eschweiler			1.0		
S. Ghazaryan	0.2				
R. Hodajerdi			1.0		
F. Januschek		1.0			
E.-A. Knabbe	1.0				
A. Lindner	0.3				
D. Notz	0.1				
A. Ringwald	0.2				
R. Stromhagen				0.3	
D. Trines	0.5				
J. E. v. Seggern			1.0		
N. N.		0.5			laser / optics
University of Hamburg:					
D. Horns	0.2				
Sum	2.7	2.5	4.0	0.3	

Table 5.1: The ALPS collaboration as of August 2012.

Collaboration and personnel: summary

Present:

- One part time postdoc for laser/optics missing in Hamburg!
- Technical support will (likely) increase by 0.5 FTE from 2013 onwards.
- With these issues solved seems to be sufficient for the ALPS-II R&D:
  - 3.5 FTE senior scientists (including engineer),
  - 2.5 FTE postdocs,
  - 4 PhD students.
- Personnel not sufficient for cost-effective data taking (three shifts per day) with ALPS-IIc (cooled down magnet string).

Near Future:

- At least two new PhD students have to be hired in late 2013.

Expansion of the collaboration

- Research center Jülich (nuclear physics institute):
  applied for third party funds for a Ph.D. student at ALPS-II.

- CERN:
  first discussions on joining ALPS optics activities for further developments at OSQAR.

- Discussions with NeoLase / LZH Hannover on joining the collaboration to support the laser.

Crucial for further discussions: “Go ahead” for ALPS-II at DESY!

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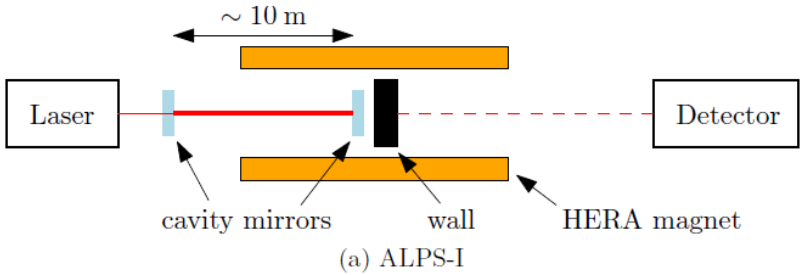
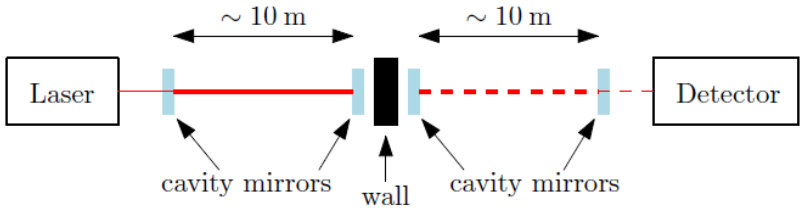
Reminder: the stages of ALPS-II

ALPS-I



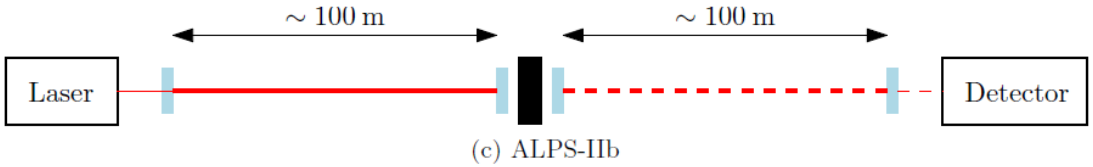
(a) ALPS-I

> **ALPS-IIa**



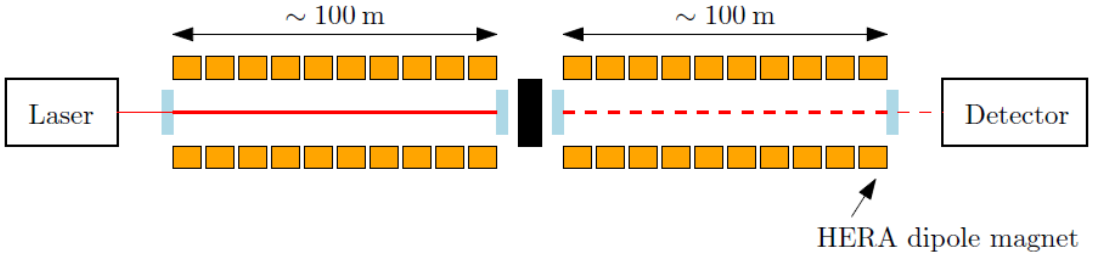
(b) ALPS-IIa

> **ALPS-IIb**



(c) ALPS-IIb

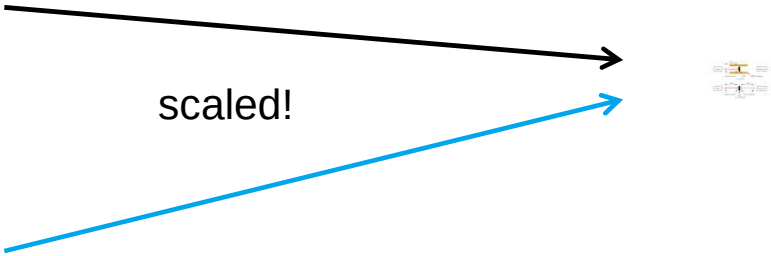
> **ALPS-IIc**



(d) ALPS-IIc

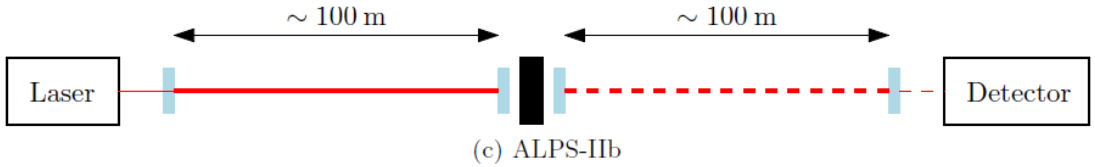
Reminder: the stages of ALPS-II

ALPS-I



> **ALPS-IIa**

> **ALPS-IIb**



(c) ALPS-IIb

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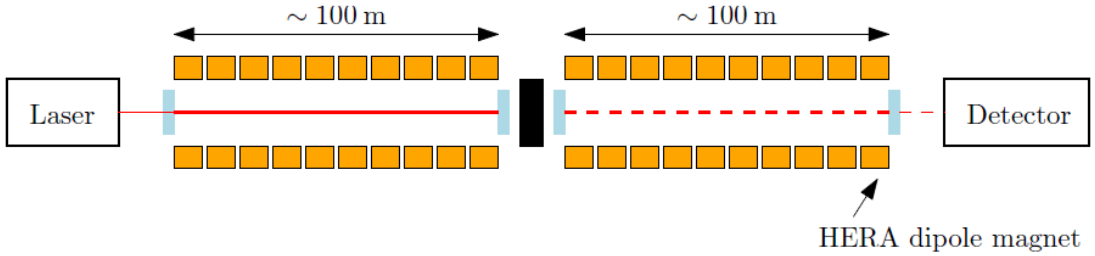

(d) ALPS-IIc

Investments

Workpackage	ALPS-I re-used	ALPS-IIa	ALPS-IIb	ALPS-IIc	Total
Laser & optics	300 k€	155 k€	141 k€	10 k€	606 k€
to be spent		54 k€	141 k€	10 k€	205 k€
Cleanr. & infra.		80 k€	160 k€	105 k€	345 k€
to be spent		5 k€	160 k€	105 k€	270 k€
Detection systems	30 k€	243 k€			273 k€
to be spent		26 k€			26 k€
Magnets modif.				302 k€	302 k€
to be spent				292 k€	292 k€
Magnet setup				192 k€	192 k€
to be spent				192 k€	192 k€
Vacuum system	10 k€	40 k€	120 k€	10 k€	180 k€
to be spent		40 k€	120 k€	10 k€	170 k€
DAQ & elect.		7 k€			7 k€
to be spent		7 k€			7 k€
Sum	340 k€	525 k€	421 k€	620 k€	1905 k€
to be spent		132 k€	421 k€	610 k€	**1162** k€

Table 5.2: Investments of the ALPS-II experiment. The second column lists items which will be re-used from ALPS-I.

In total:

> 1.91 M€.

Already done:

> 0.74 M€ (incl. 0.27 M€ 3rd party funds).

Investments: done

Workpackage	ALPS-I re-used	ALPS-IIa	ALPS-IIb	ALPS-IIc	Total
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340 k€ re-used from ALPS-I.

(laser & optics)

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403 k€ already invested by

- AEI (73 k€)
- DESY (85 k€)
- U. HH (245 k€)

Investments: min. DESY matters

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Essential DESY matters to be spent:

- Infrastr. (270 k€)
- Magnets (484 k€)
- Vacuum (170 k€)

In total: 924 k€.

Summary on to-date contributions

	AEI	DESY	HH Univ.
FTE (since ≈ 2011)	1.2	7.6	0.2
Investments	73 k€	85 k€	245 k€

Remarks:

- The Ph.D. students are jointly supervised with AEI or HH Univ.
- Equipment worth 340 k€ is reused from ALPS-I.

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Operation costs

Workpackage	ALPS-IIa	ALPS-IIb	ALPS-IIc	Note
Laser & optics maint.	2 k€	2 k€	2 k€	yearly costs
Vacuum maint.	2 k€	4 k€	6 k€	yearly costs
Cleanrooms (incl. consumables, TES)	10 k€	10 k€	10 k€	yearly costs
Operation time	1.6 years	1.8 years	1.2 years	
Magnet tests			100 k€	2014/2015
Magnets & cryog.			253 k€	in HERA North
Sum	22 k€	29 k€	375 k€	

Table 5.3: Operation costs of the ALPS-II experiment for 2013 to 2017. It is assumed that the ALPS-IIa laboratory will be available for further optical and laser R&D after finalizing the ALPS-IIa stage with yearly 20% of the operation costs for full usage.

- In total 426 k€ (2013-2017), thereof
- 353 k€ for cryogenics.

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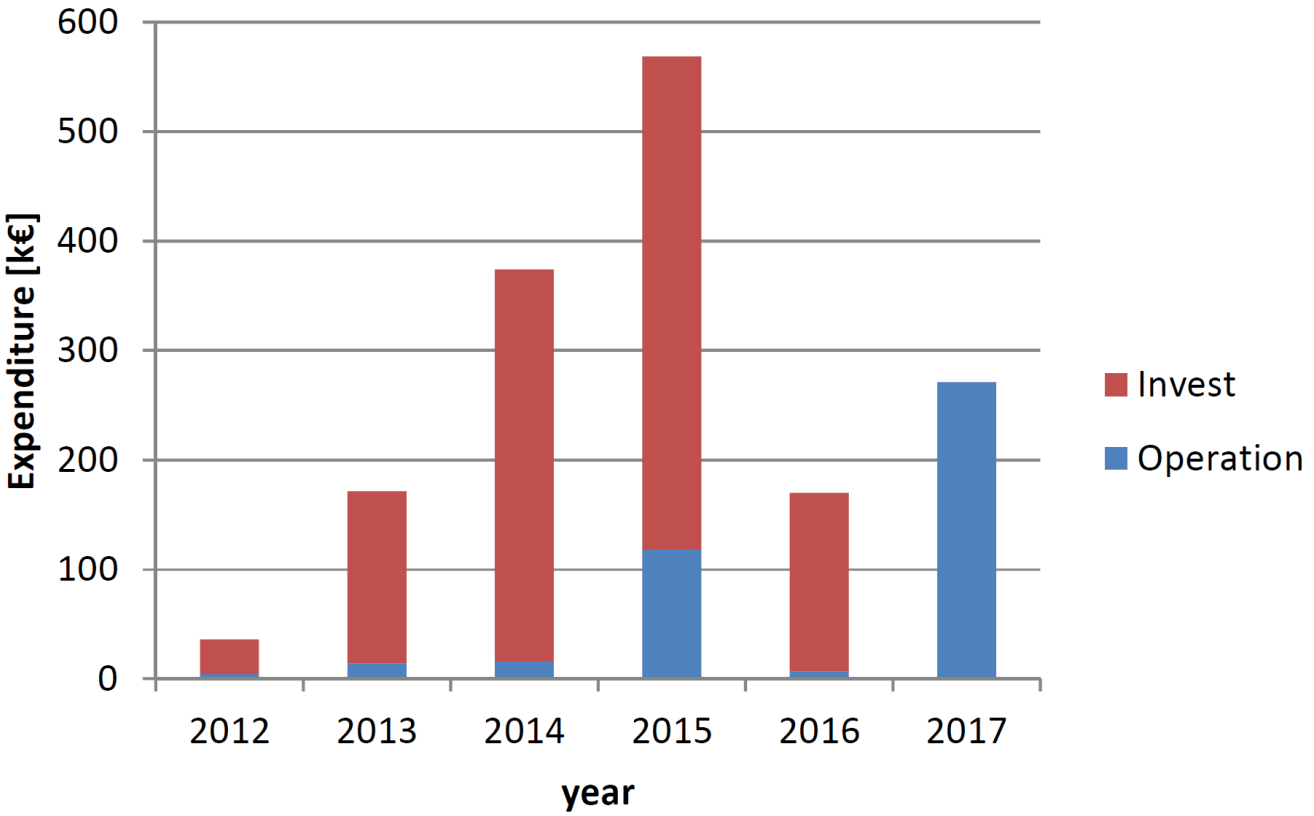
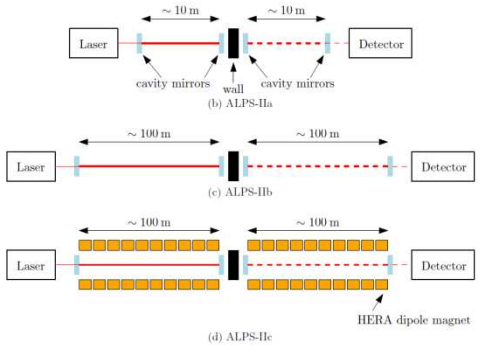
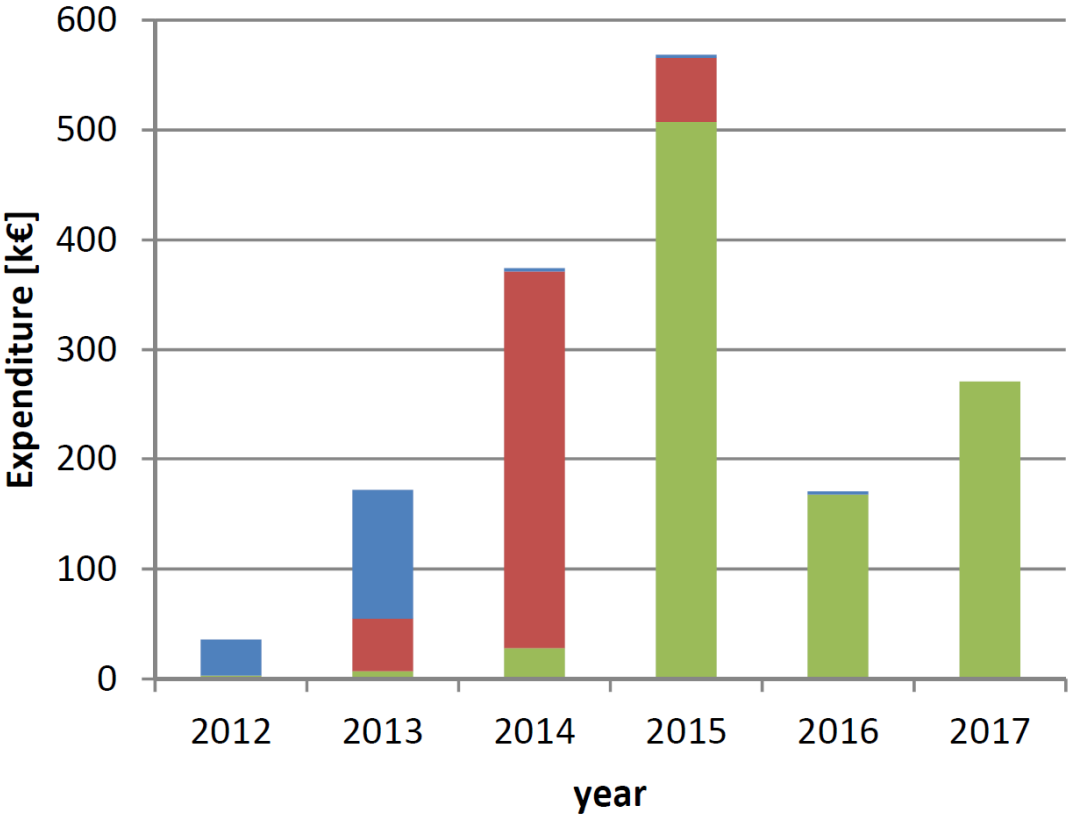
Cost summary: ALPS-IIa to IIc

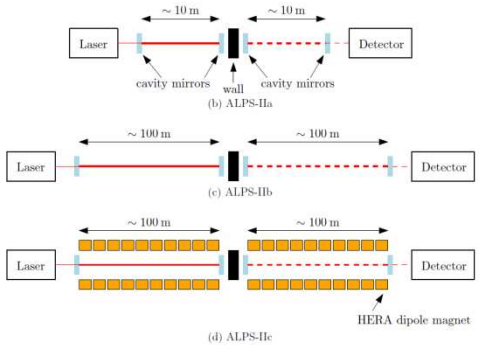




- In total: 1.59 M€ to be spent.
  - 1.16 M€ investments,
  - 0.43 M€ operation costs.

Cost summary: ALPS-IIa to IIc





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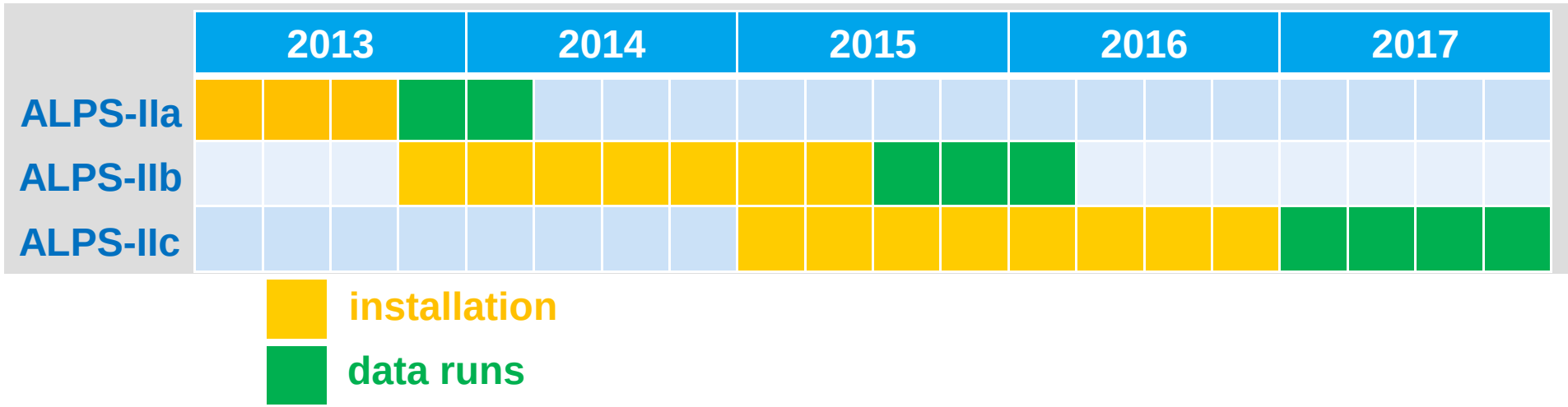
Schedule (rough)

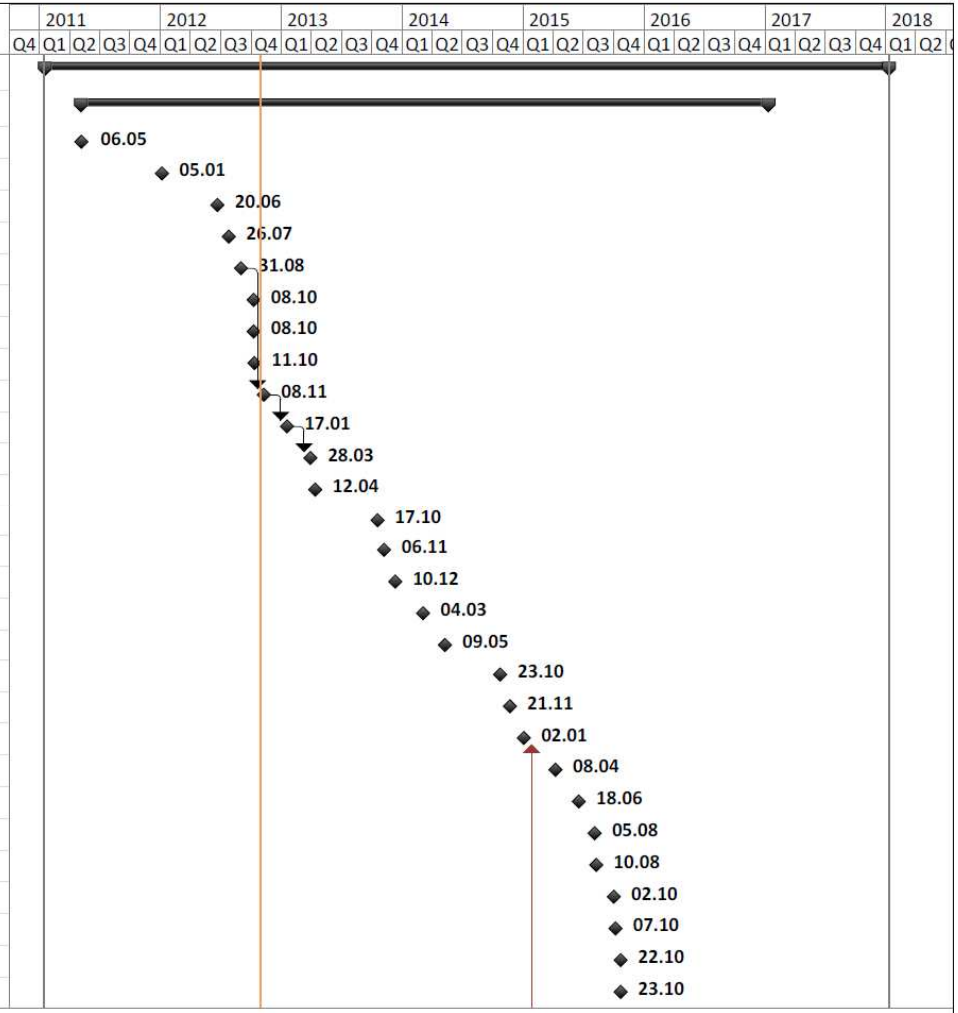


Please keep in mind:

The sensitivity of ALPS-II to the WISP coupling strength
increases with time$^{1/4}$ only (time$^{1/8}$ if background limited).
Hence the experiment is quickly done once the systematics are under control.

Schedule (detailed)

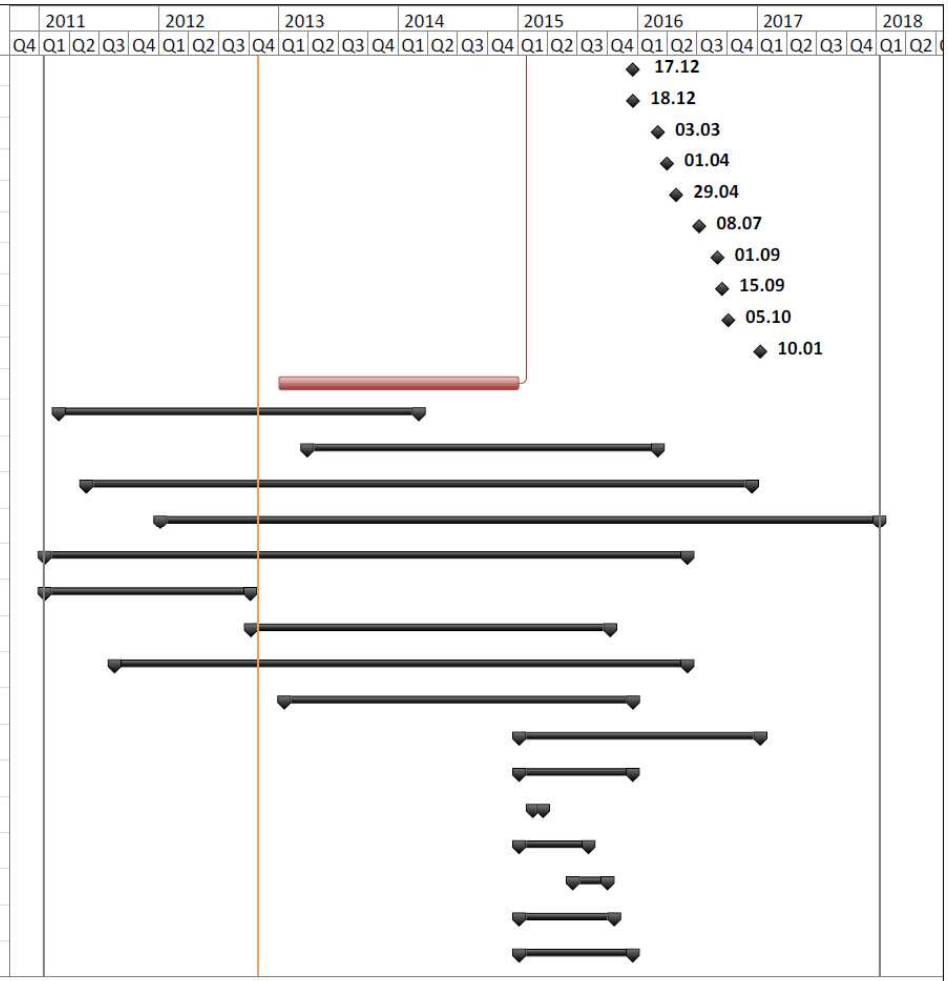
ID	Task Name
0	**Schedule ALPS II**
1	**Milestones**
2	verification deformation method
3	test pressure prop
4	demonstration down conversion
5	ADR cryostat available
6	completion of TDR
7	completed magnet test
8	CCD detector ready
9	first operation PC in air
10	PRC meeting
11	recommendation of PRC
12	approval of directorate
13	physics run ALPS-IIa with CCD PC 5000
14	start Installation ALPS-IIb
15	physics run ALPS-IIa with CCD RC 40000
16	TES ready for ALPS-IIa
17	end ALPS-IIa
18	DAQ system available
19	definition of string length
20	magnets ready for measurements
21	start installation ALPS-IIc
22	order series quench protection
23	completion disassembly e-ring left
24	completion disassembly e-ring right
25	completion disassembly p-ring left
26	completion disassembly p-ring right
27	physics run ALPS-IIb
28	ready for work on cryogenics
29	supports out



Page 1

Schedule (detailed)

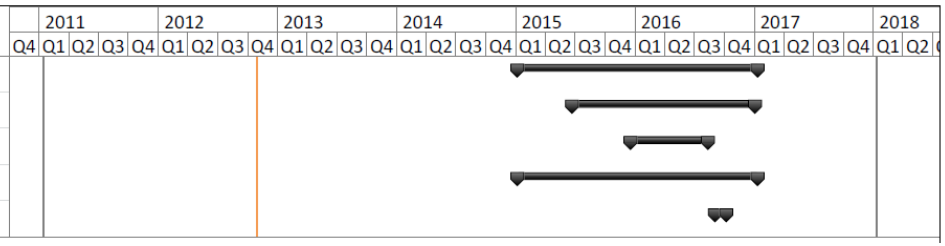
ID	Task Name
30	boxes moved
31	magnets ready for installation
32	end of ALPS-IIb
33	supports in
34	boxes ready
35	magnets installed
36	strings completed
37	final pressure test
38	laser huts installed
39	ready for ALPS-IIc
40	cryogenics and labor tied to XFEL
41	**ALPS-IIa general tasks**
59	**ALPS-IIb general tasks**
68	**Laser and optics**
85	**Detection system**
99	**Magnets and cryogenics**
100	**Prototype dipoles**
116	**Magnets for ALPS-IIc**
128	**Quench protection +power supply**
133	**Vacuum system**
137	**Installation**
138	**Disassembly**
139	**Kicker bypass WL**
142	**Electron machine**
155	**Proton machine**
164	**Infrastructure**
168	**Cryogenics work**



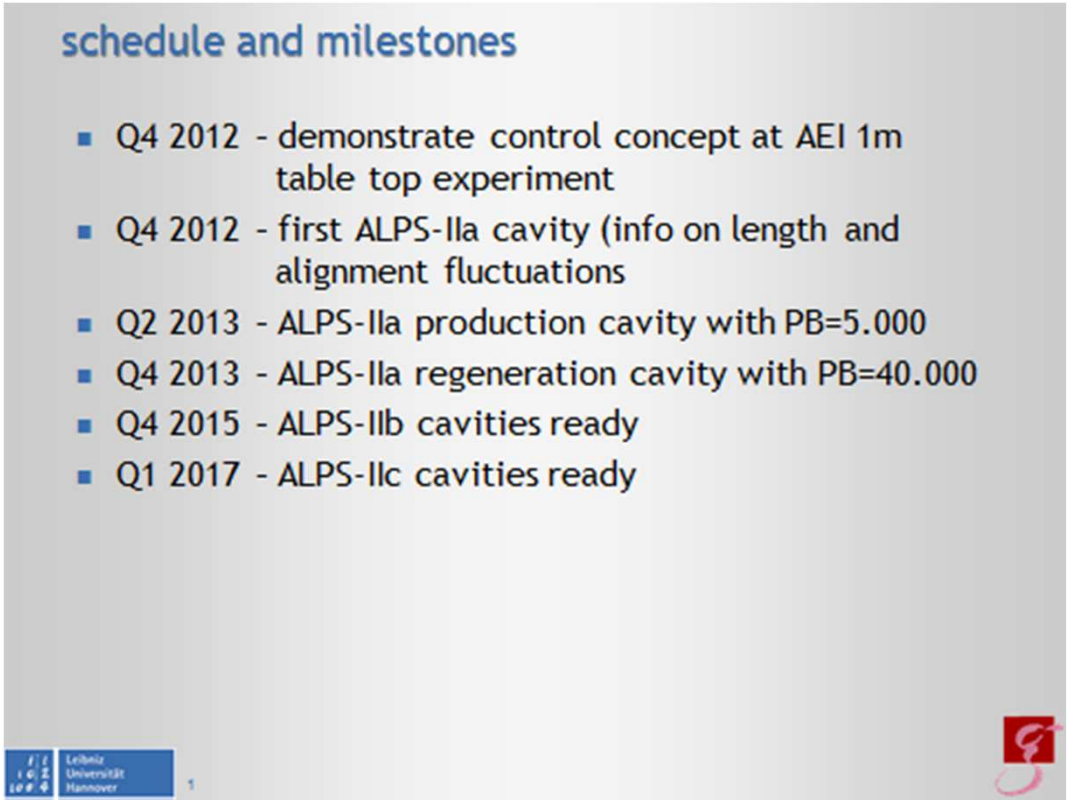
Page 2

Schedule (detailed)

ID	Task Name
172	**Assembly**
173	**Cryogenics work**
180	**Laser huts**
184	**Strings**
196	**Interlock**



Details: optics

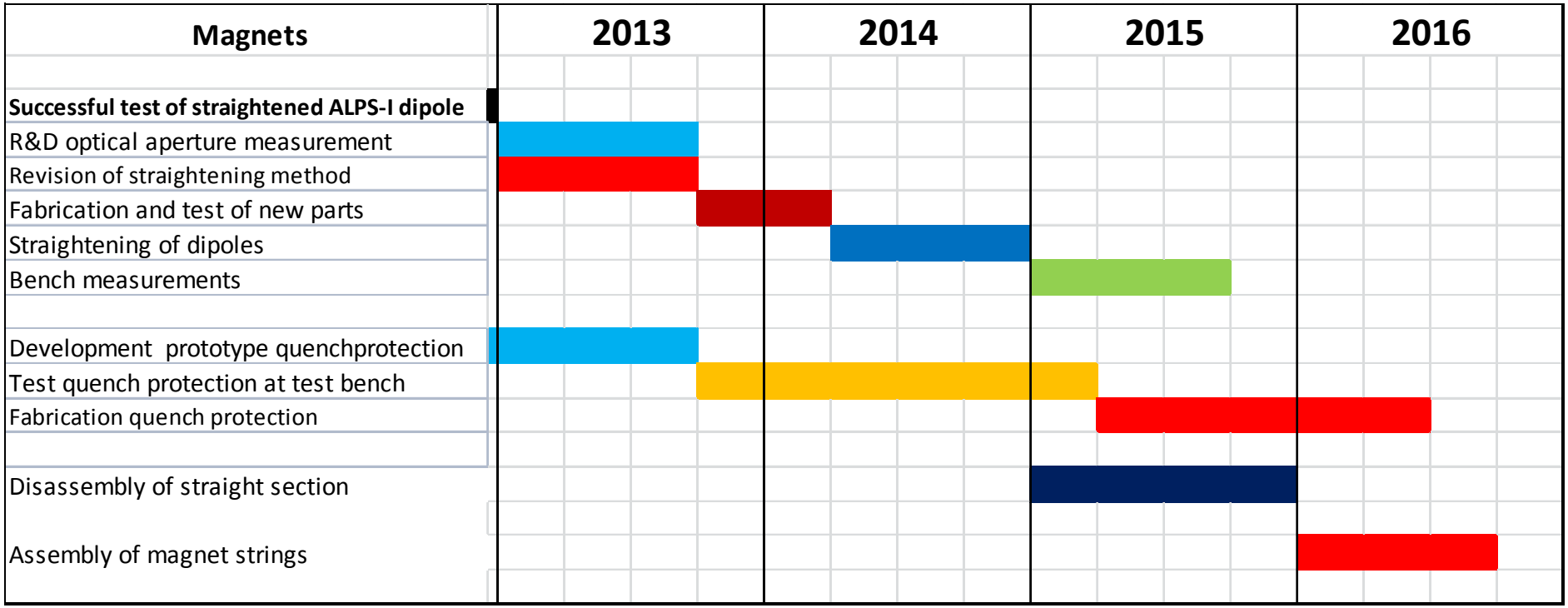


- Total investments: 606 k€.
- To be spent: 205 k€.
  - 54 k€ in 2012 / 2013 for ALPS-IIa.
  - If ALPS-IIa is a success: 141 k€ for ALPS-IIb.
  - 10 k€ for ALPS-IIc.

Details: detector

- Total investments: 273 k€.
- To be spent: 26 k€.
  - The same system will be used for all stages of ALPS-II.

Details: magnets



- Total investments: 302 k€.
- To be spent: 292 k€.
  - 38 k€ in 2013 / 2014 for straightening.
  - 254 k€ in 2015, thereof 226 k€ for the new quench protection.

Schedule & decisions

- 2013
  - General: Physics runs: ALPS-IIa
  - Optics: Proof of concept for 10 m optical setup (40000 power build up in RC)
  - Detector: Data taking first with CCD, transport of TES to Hamburg, and integration of TES in the optical system
  - Magnet: Review of the straightening procedure
  - Infrastructure: Preparation for ALPS-IIb setup
- 2014
  - Optics: Analyze and optimize ALPS-IIa setup, redesign control loops for application in ALPS-IIb
  - Magnet: Straightening of the spare magnets
  - Infrastructure: Begin ALPS-IIb setup in HERA tunnel
- 2015
  - General: Commission and data taking ALPS-IIb
  - Optics and Detector: Physics run ALPS-IIb
  - Magnet: Disassembly of HERA section, cryogenic magnet tests
- 2016
  - General: Preparation for ALPS-IIc
  - Optics: Setup and commission of cavities in magnet bore
  - Magnet: Assembly of straightened magnets in HERA tunnel
- 2017
  - General: ALPS-IIc data taking

"Go-ahead" required in:

- ALPS-IIa:
  (already active)
- ALPS-IIb:
  autumn of 2013
- ALPS-IIc:
  early 2014

DESY

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Other selected WISP experiments

A number of (mostly) small-scale experiments:

Experiment	Type	Location	Status
ALPS-II	Laboratory experiments, light-shining-through-a-wall	DESY in HH	proposed
CERN microwave cavity experiment		CERN	running
OSQAR		CERN	running
REAPR		UF / FNAL	proposed
BMV	Polarization studies	Toulouse	running
PVLAS		Ferrara	started
CAST	Helioscopes	CERN	running
IAXO			proposed
TSHIPS		Hamburg	started
ADMX / ADMX-HF	Haloscopes	Seattle / Yale	preparation
WISPDMX		DESY in HH	first thoughts

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ADMX / ADMX-HF	Haloscopes	Seattle / Yale	preparation
WISPDMX		DESY in HH	first thoughts

Other selected WISP experiments

BMV (Toulouse):

BMV experiment

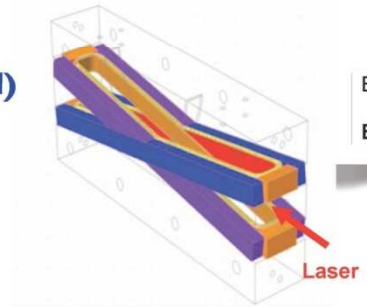
Biréfringence Magnétique du Vide

LNCMI

- **ellipticity measurement**

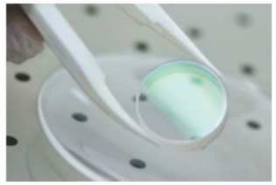
Battesti et al, *Eur. Phys. J. D*, **46**, 323-333, 2008

- **high transverse magnetic field (XCoil)**



B = 14,3 T	8300 A
B^2L = 28 T^2m	t ~ 5 ms

- **high reflectivity mirrors**



finesse : 450 000
cavity linewidth : 130 Hz

lundi 28 novembre 2011

DESY

Other selected WISP experiments

BMV (Toulouse):

- Aims to measure the magnetic vacuum birefringence with the help of pulsed 30 T magnets (1000 pulses needed). Magnet prototypes are working already.
- With the BMV setup, the QED effect sensitivity corresponds roughly to an ALP-photon coupling of less than 10^{-8} GeV^{-1}
  (improving ALPS-I by a factor of ≈ 6,
  being still a factor of 500 worse than the ALPS-II goal).
- The QED sensitivity could be reached in 2013/2014 (?).

- If BMV reaches the QED effect, this would provide an irreducible background in WISP searches with the BMV apparatus.

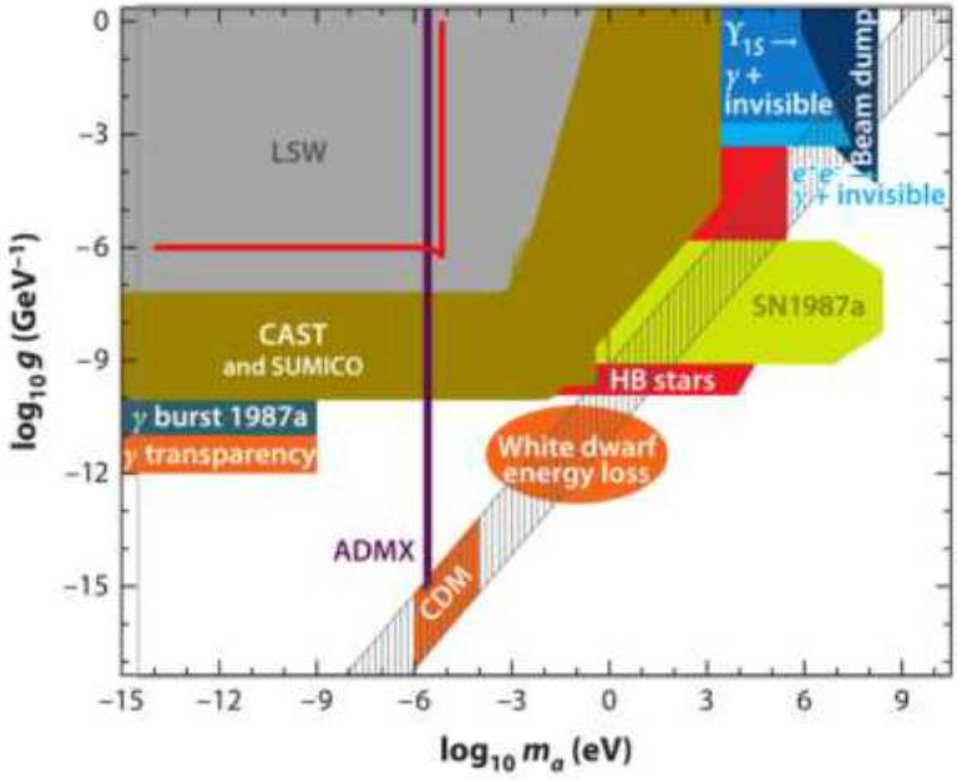
Other selected WISP experiments

CERN microwave cavity experiment (M. Betz, F. Caspers):

Other selected WISP experiments

CERN microwave cavity experiment (M. Betz, F. Caspers):

- Preliminary result slightly worse than ALPS-I.



- At present unclear how to increase the sensitivity significantly.

Other selected WISP experiments

OSQAR (CERN):

Other selected WISP experiments

OSQAR (CERN):

- OSQAR uses two LHC dipole magnets (9 T, 14.3 m).
  The magnetic length is 28% of the ALPS-II target.
- OSQAR had a LSW data run with a 3 W laser in 2012 and
  reached an ALP sensitivity slightly worse than at ALPS-I.
- Unfortunately the OSQAR laser failed recently.
- The collaboration aims for purchasing a new laser and setting up an optical cavity in 2013/2014 allowing to reach 1 kW of effective laser power (the ALPS-I achievement).
- This would allow to improve the ALPS-I sensitivity for the ALP-photon coupling by about a factor of 6
  (being still a factor of 500 worse than the ALPS-II goal).

Other selected WISP experiments

REAPR in the US:

- Information by D. Tanner?

Outline

- Collaboration and personnel
- Investments
- Operation costs
- Cost summary
- Schedule
- Conclusions

1: There is physics beyond the SM

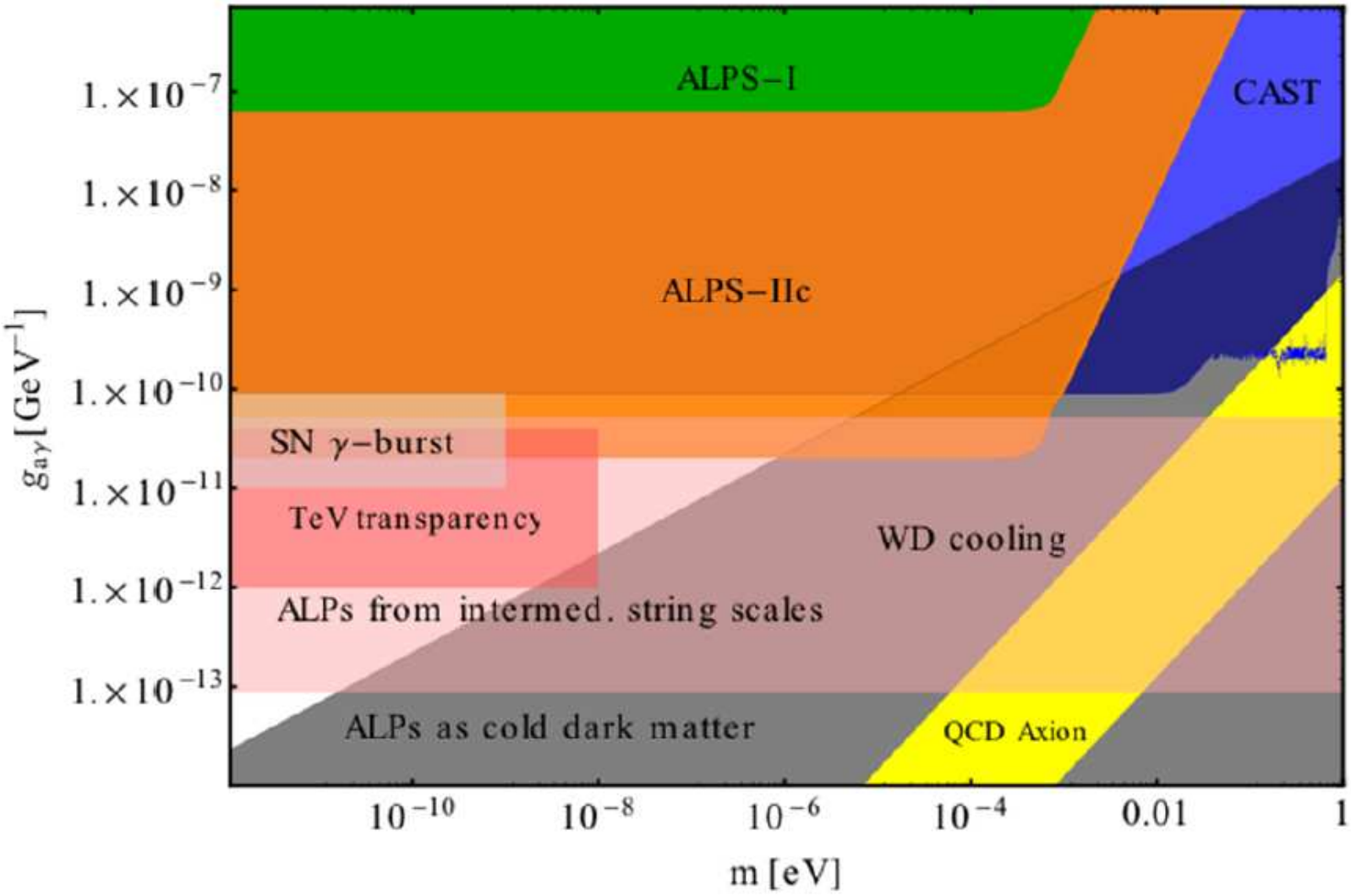
which might hint at Weakly Interacting Slim Particles (WISPs).

- Axion and axion-like particles (ALPs, pseudoscalar or scalar bosons)
- Hidden photons (neutral vector bosons)
- Mini-charged particles
- Scalars (gravity)

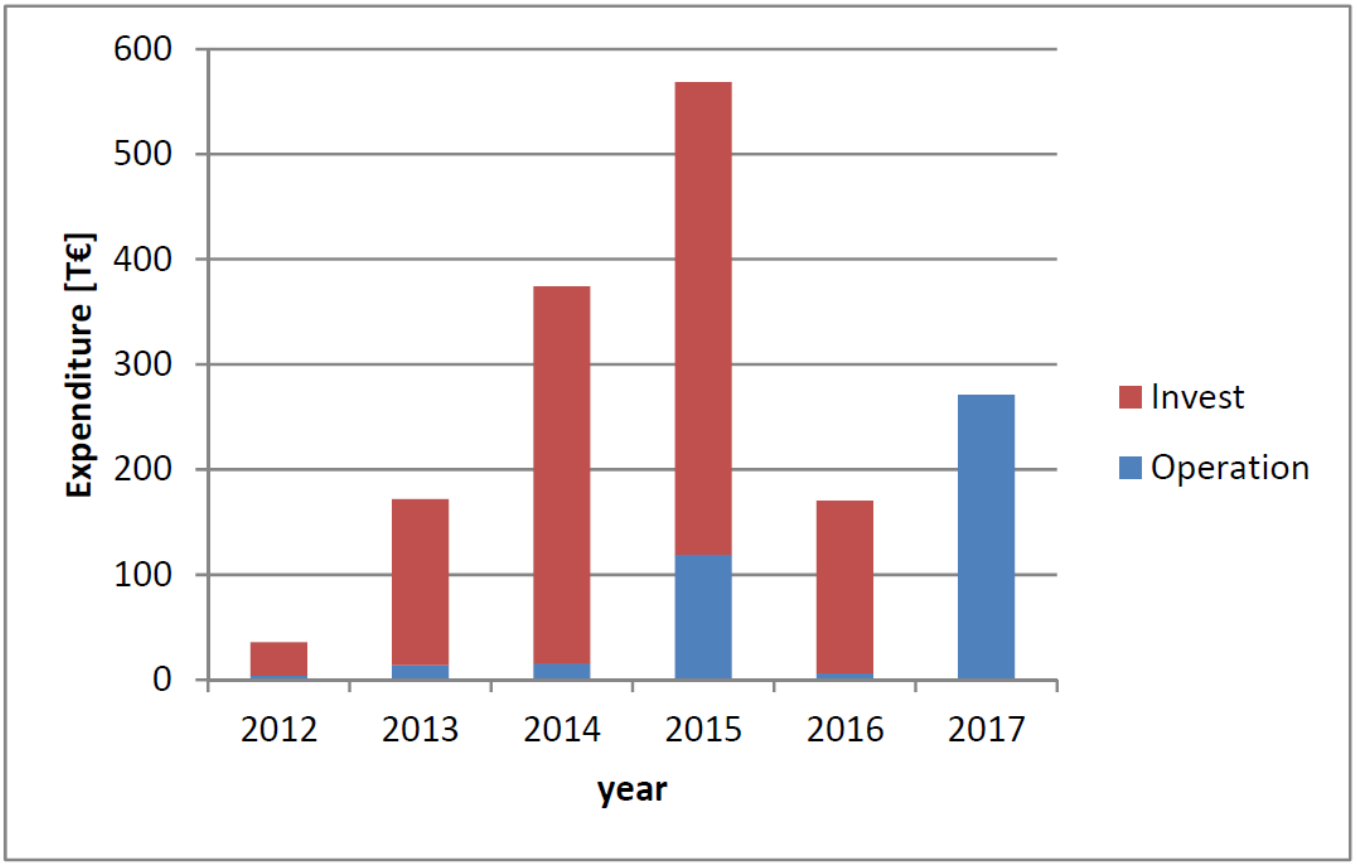
Phenomenon	WISPy explanation	WIMPy explanation
White dwarf cooling ★	Axion, ALP	
TeV transparency ★	ALP	
CMBR neutrino number ★	HP	
Dark matter	Axion, ALP, HP	yes
Dark energy ★	Scalars (gravity)	

★ to be confirmed!

2: ALPS-II has a unique potential …



3: … at moderate costs …

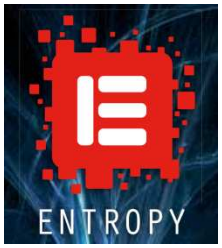


4: ... based on competent partners ...

Albert Einstein Institute
Hannover

Leibniz
Universität
Hannover

Universität Hamburg



5: ... and on the DESY infrastructure.

- Optics requirements
  allow for strings of up to
  2·10 straightened HERA dipoles.
- The straight sections of the HERA tunnel
  allow for strings of up to
  2·10 straightened HERA dipoles.
- There exist 24 spare HERA dipole magnets.

Conclusions

- There is physics beyond the standard model.
- ALPS-II has a unique discovery potential at moderate costs
  based on competent partners
  and on the DESY infrastructure.

That‘s why we propose to do it!