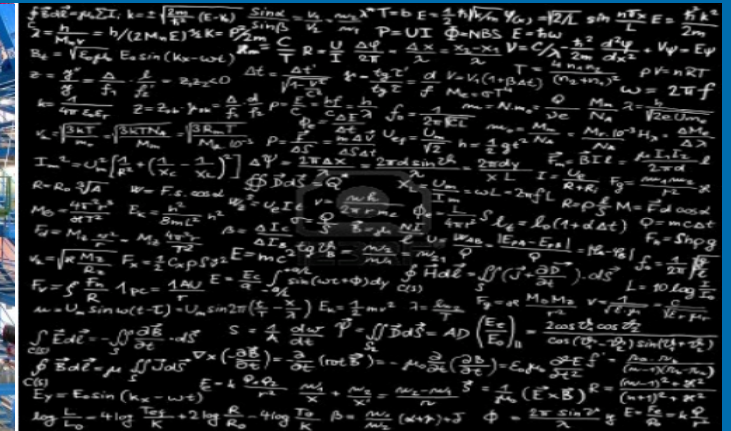
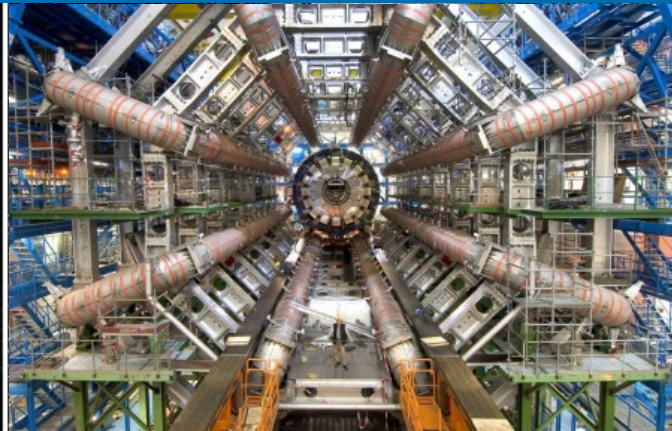
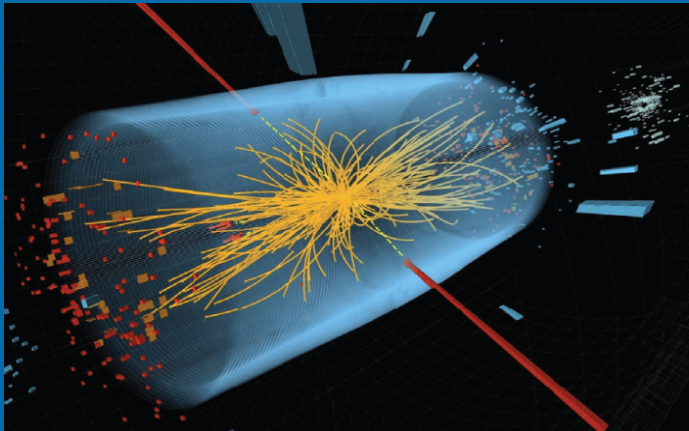


Fundamental Particles and Forces

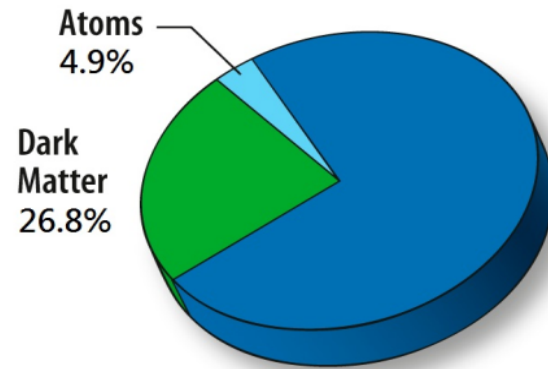


J. Mnich (DESY)

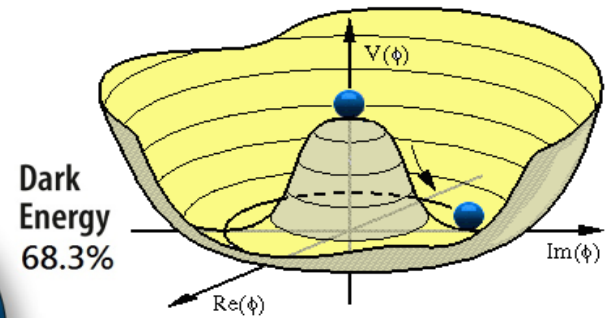
Elementary Particle Physics

The Big Questions:

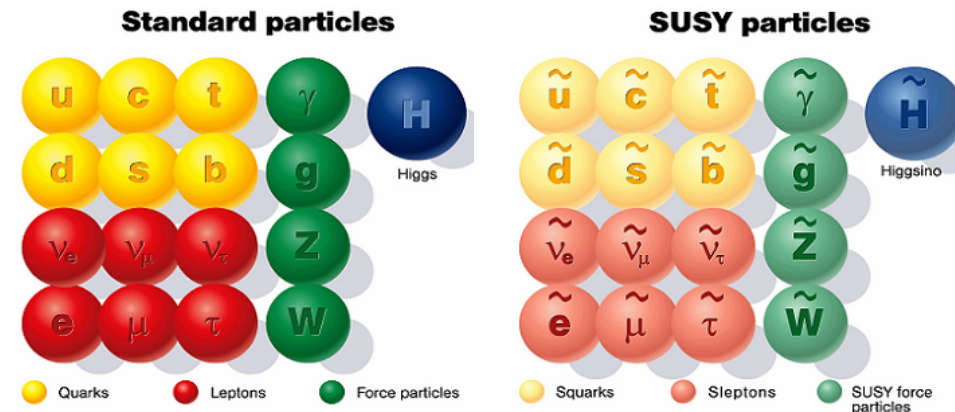
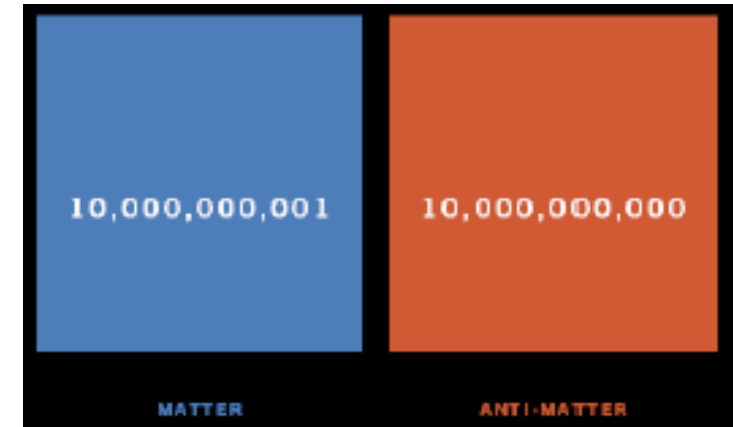
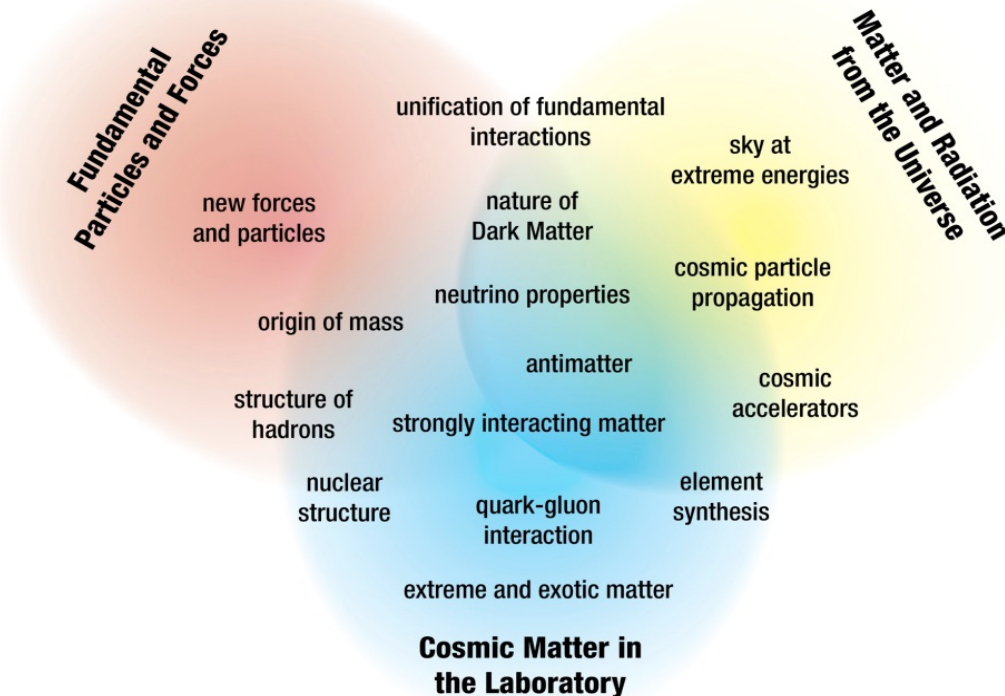
Origin of mass
Nature of Dark Matter
New forces and particles
Matter-antimatter asymmetry
Unification of fundamental forces



TODAY



Particle physics in Matter & Universe:



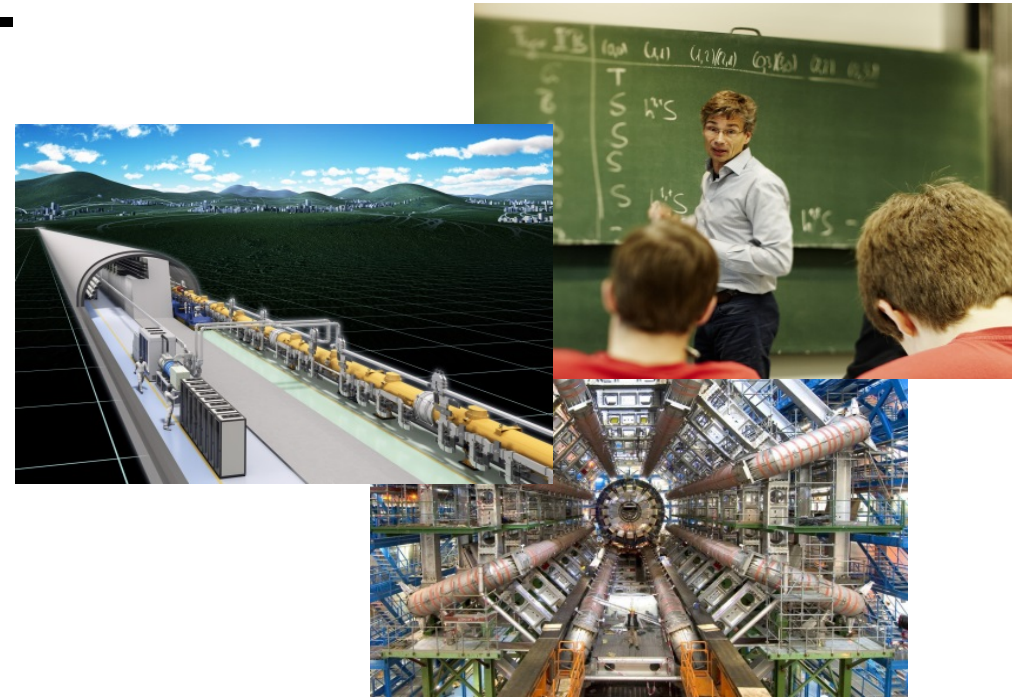
Fundamental Particles and Forces

The **Big Questions** require **cutting-edge research** in the triangle

- proton-proton physics
Large Hadron Collider (LHC)
- electron-positron Physics
Belle (II)
International Linear Collider (ILC)
- theoretical particle physics

Computing infrastructure

- Tier-1 GridKa
Tier-2 DESY Grid Centre



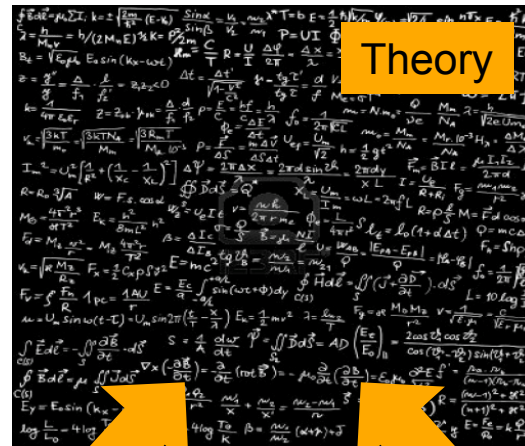
Participating Helmholtz centres



Total 138 scientists plus
60 Ph.D. students
financed by Helmholtz

Particle Physics Strategy 2015-19

Maximum discovery potential
Highest sensitivity
Guidance and interpretation
by theory



- + Computing: Tier 1 & Tier-2
- + Detector & accelerator development ($\rightarrow$ *Matter and Technology*)
- + Test beam

Particle Physics Roadmaps

Helmholtz strategy well aligned with national and international partners

Helmholtz shapes national and international roadmaps

CERN Council Update of the European Strategy for Particle Physics (May 2013)



- **LHC, incl. HL-LHC**
- **accelerator R&D**
- **strong support for ILC**
- **importance of theory**
- **role of national labs**

German Committee for Particle Physics (KET, Nov. 2012)



LHC

1. The successful running of the LHC and its experiments continues to be the recommendation with highest priority. This includes in particular the high luminosity upgrades of the LHC and the Phase-2 upgrades of the experiments, which currently constitute the only way to directly explore the multi-TeV energy regime.

ILC

2. The proposal of the Japanese community to host the ILC as an international project finds enthusiastic support in the German community. In view of the unique capabilities of such a facility for precision measurements of the newly discovered particle, the foreseen expandability to higher energies and the technical readiness of the project as documented in the Global Design Effort ⁴⁾ we strongly recommend to contribute actively to the realisation of this project.

Japan: Future Projects of High Energy Physics

ILC

- Should a new particle such as a Higgs boson with a mass below approximately 1 TeV be confirmed at LHC, Japan should take the leadership role in an early realization of an e^+e^- linear collider. In particular, if the particle is light, experiments at low collision energy should be started at the earliest possible time. In parallel, continuous studies on new physics should be pursued for both LHC and the upgraded LHC version. Should the energy scale of new particles/physics be higher, accelerator R&D should be strengthened in order to realize the necessary collision energy.

USA: Snowmass conclusions and recommendations to P5 in line with worldwide strategy statements

The Large Hadron Collider (LHC)

Very successful run in 2012 at 8 TeV

> 200 publications so far by each experiment (ATLAS & CMS)

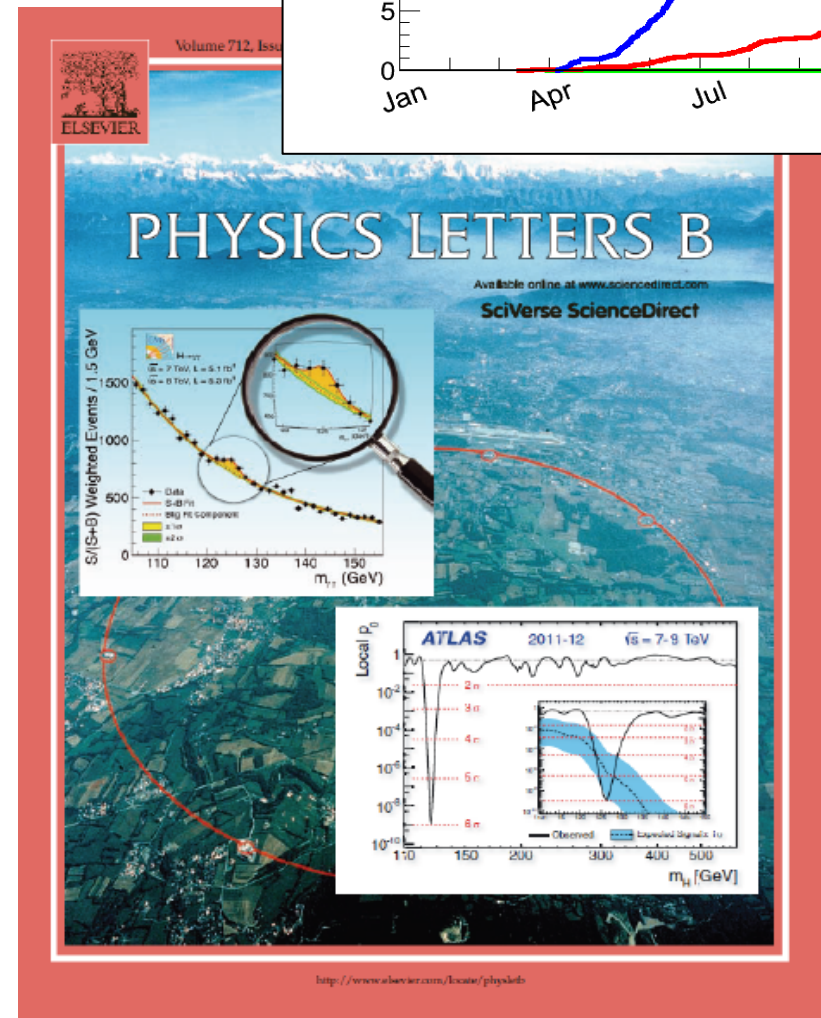
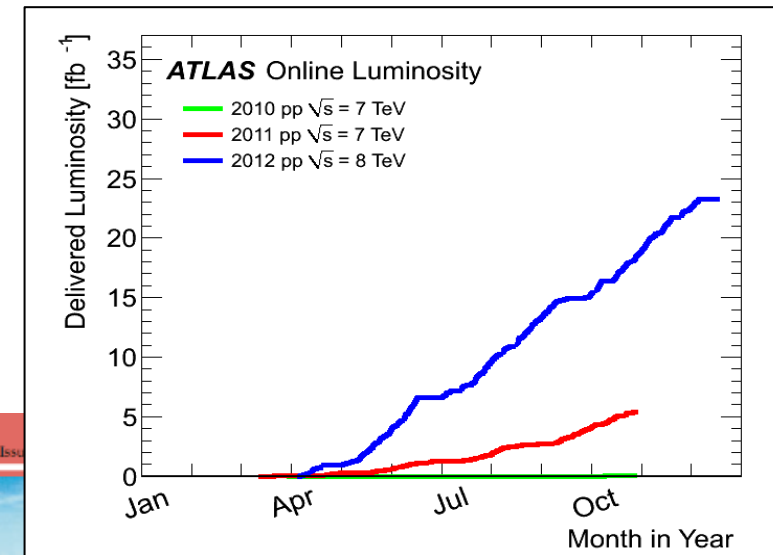
- Higgs discovery + properties
- search for new physics
- physics at 10^{-19} m

2013/14: Consolidation work

- preparation of LHC and experiments for full energy (14 TeV) from 2015 on
- work progressing according to schedule

Helmholtz centres play leading role in LHC collaborations

physics, detector,
computing, management



German Participation at the LHC

Germany is largest CERN member state

- contribution approx. 20%

German contribution to the LHC experiments (ALICE, ATLAS, CMS, LHCb)

- 3 Helmholtz centres
- 2 Max Planck institutes
- 25 universities

More than 1000 scientists in the experiments

- plus theorists

Helmholtz constitutes about 20% of German participation
(in terms of # of scientists)

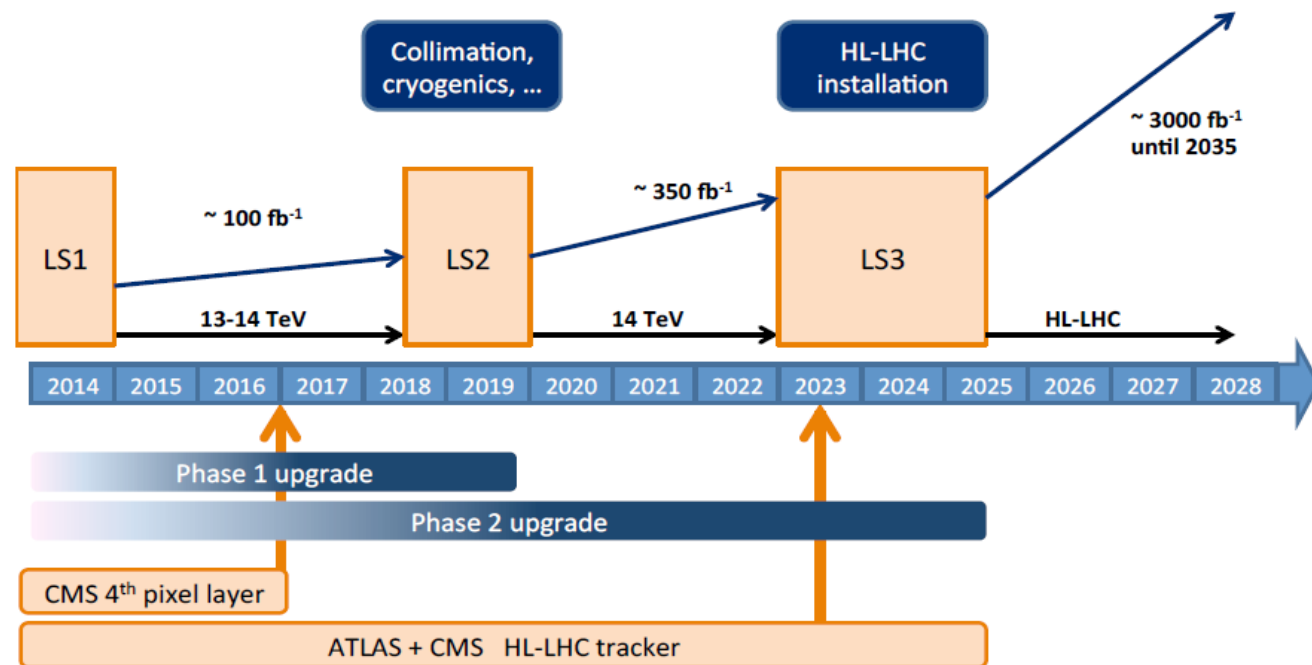


LHC Future

Physics programme until 2035 – LHC just started:

so far approx. half the max. energy reached (8 instead of 14 TeV)

1% of the intended luminosity $\approx 30 \text{ fb}^{-1}$ by end of 2012
 $\approx 3000 \text{ fb}^{-1}$ expected by 2035



2015ff: LHC running at 13-14 TeV
 $\approx 100 \text{ fb}^{-1}$ by 2019

2023-35: High-Luminosity LHC
increase luminosity beyond $10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ by approx. factor 5 to 10

- Major detector upgrades required.
- Tracking detectors reach end of their lifetime with $O(300 \text{ fb}^{-1})$
- Higher luminosity requires finer granularity and better trigger capabilities

Must establish the basis now!

LHC Detector Upgrades

Proposal for Helmholtz Strategic Large Investments

DESY: 20 M€ for investments into ATLAS & CMS tracker (Phase 2)

KIT: 3.8 M€ for CMS electronics

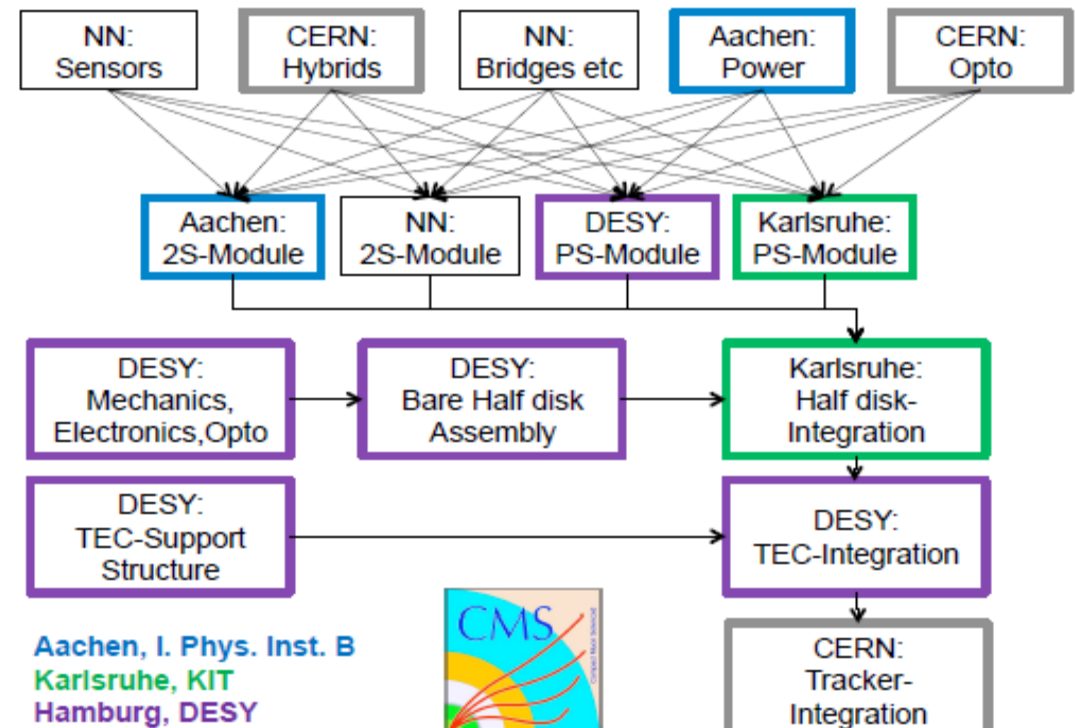
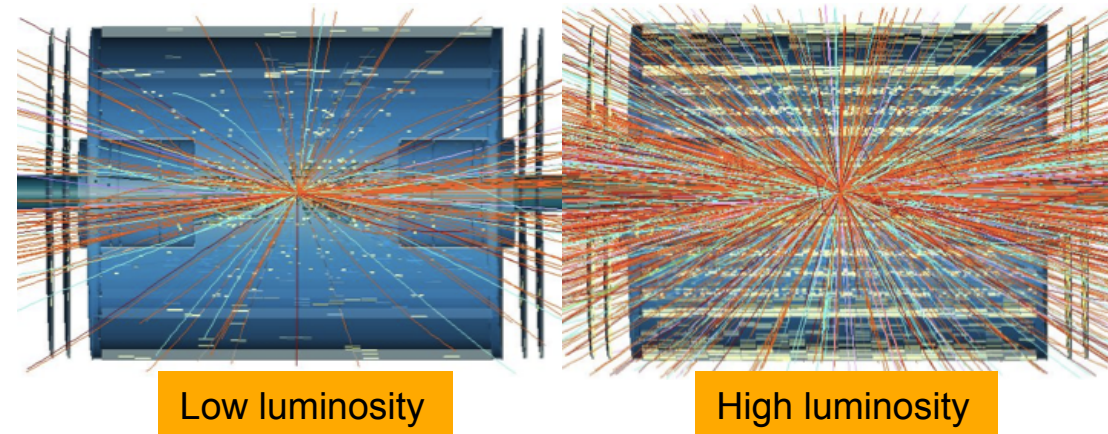
GSI: 4.2 M€ for ALICE TPC
(→ topic 2)

Proposal in preparation

to be considered in this
evaluation for submission
2nd half 2014

Coherent approach with national and international partners

e.g. plan for CMS tracker endcap



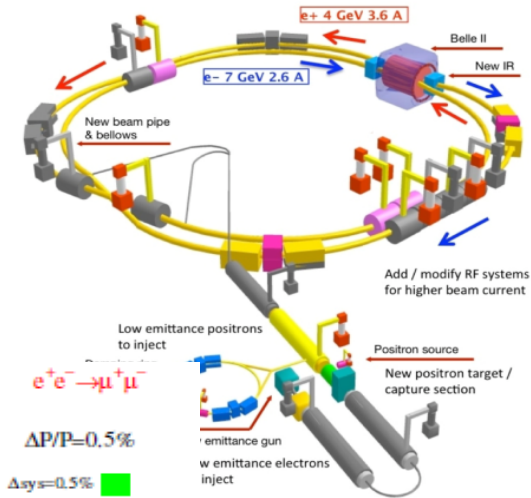
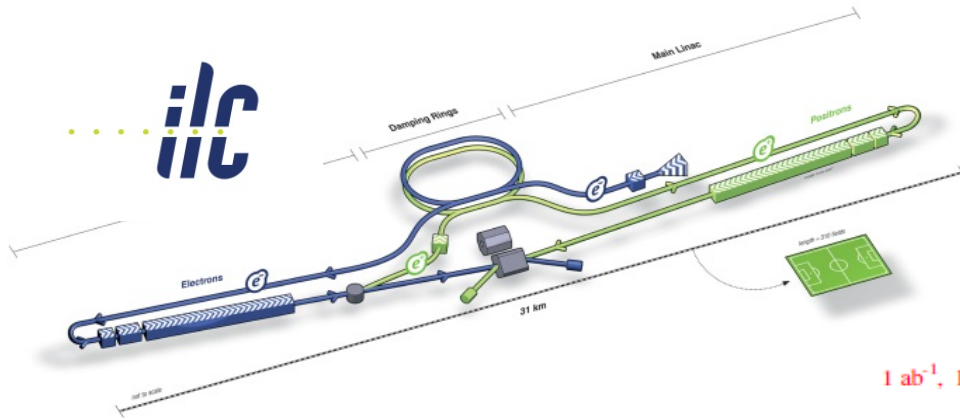
Electron-Positron Physics

Precision physics through collisions of fundamental particles:

Model-independent studies of the Higgs

Indirect signals of new physics at high mass scales

Matter-Antimatter Asymmetry



1 ab^{-1} , $P_e=0.8$,

$e^+e^- \rightarrow \mu^+\mu^-$

$\Delta P/P=0.5\%$

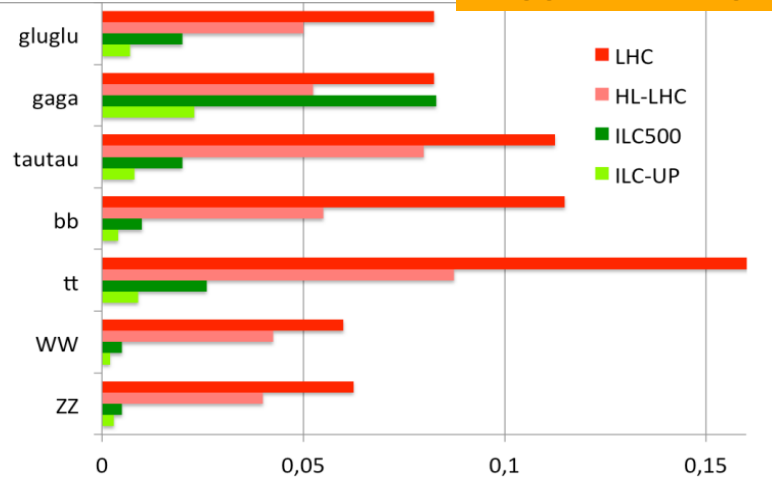
$P_e=0.0$;

$P_e=0.8$

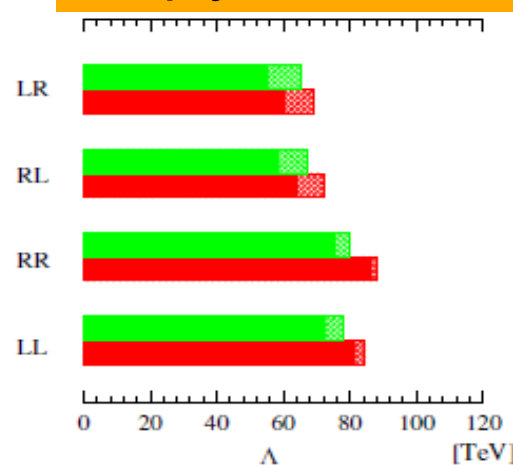
$\Delta \text{sys}=0.2\%$

$\Delta \text{sys}=0.5\%$

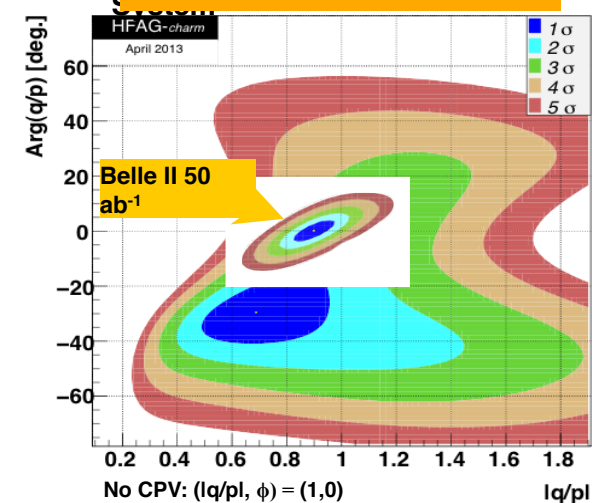
Higgs couplings



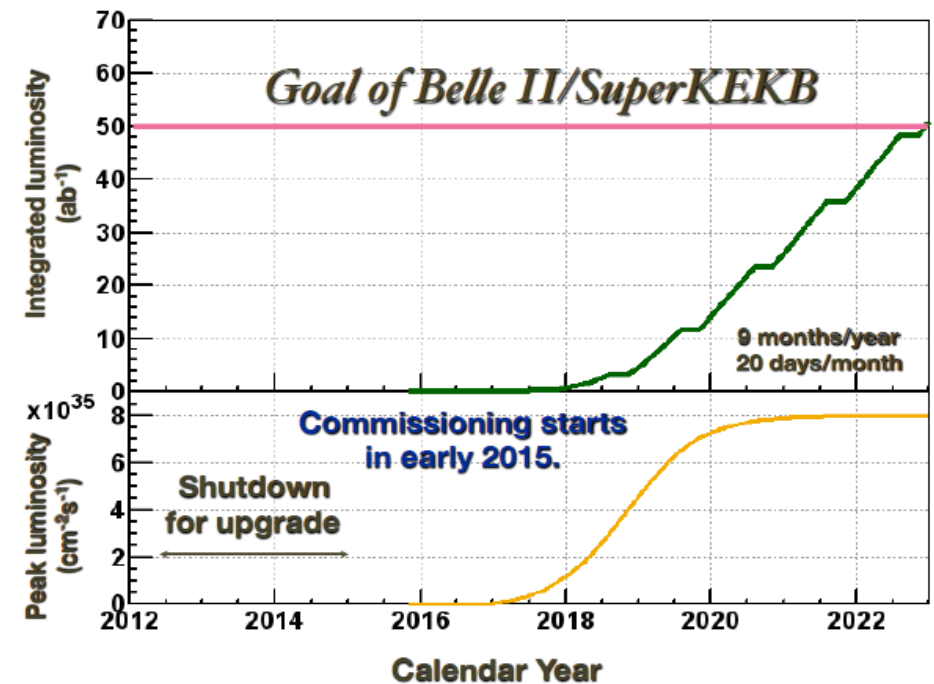
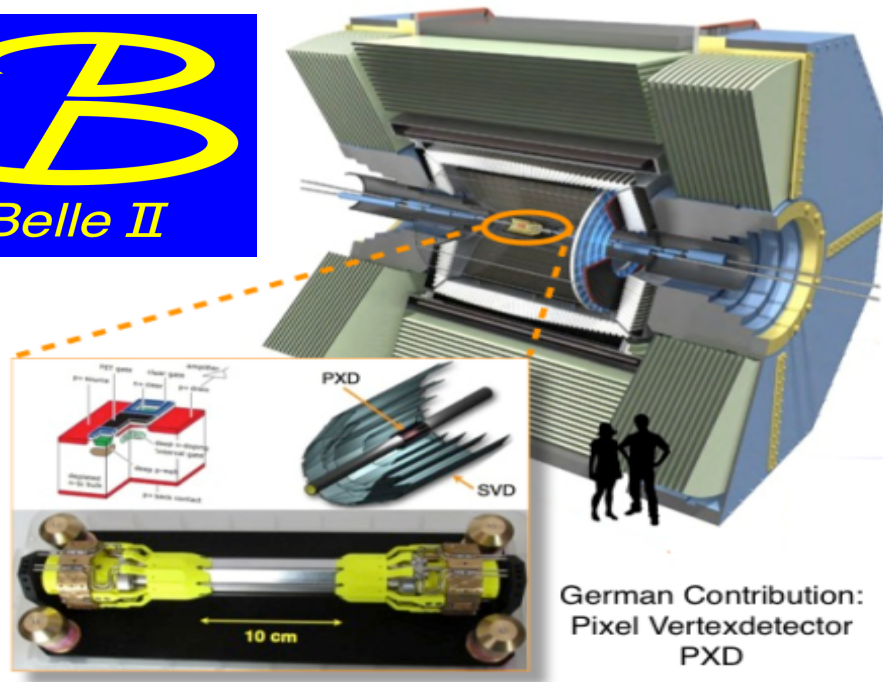
New physics scale Λ



CPV in the D^0 system



BELLE II at SuperKEKB



German contribution: pixel vertex detector in DEPFET technology

- Germany 2nd largest contribution in BELLE II
- one of the largest HEP projects in Germany

Helmholtz: support German Belle II groups by exploiting specific infrastructure and expertise available

- cooling, mechanics, alignment, test beam

Computing – Tier-1 at GridKa
– Tier-2 at DESY

Install & commission vertex detector in 2016

Accumulate $\approx 10 \text{ ab}^{-1}$ by 2019

International Linear Collider (ILC)

2013: Technical Design Report submitted and evaluated

R&D goals reached.

Synergy with XFEL construction!

Strong interest by Japanese scientists and politics to host ILC

Selection of a site in northern Japan.

R&D for accelerator & detector

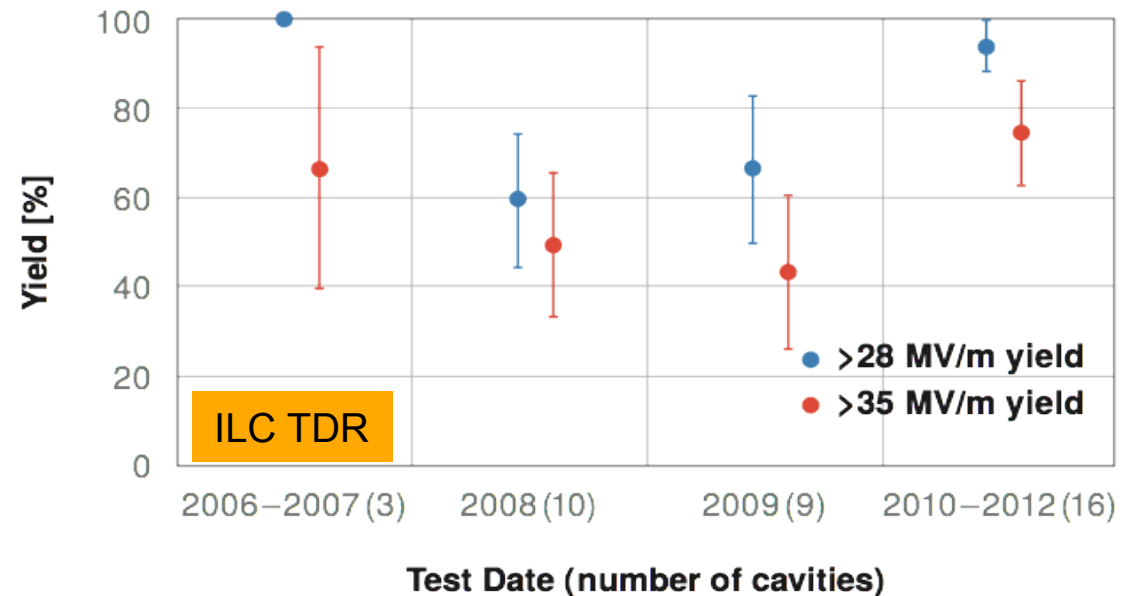
Strong synergy with Matter & Technology

Linear Collider Collaboration (LCC)

Synergy with CLIC, e.g. detector R&D

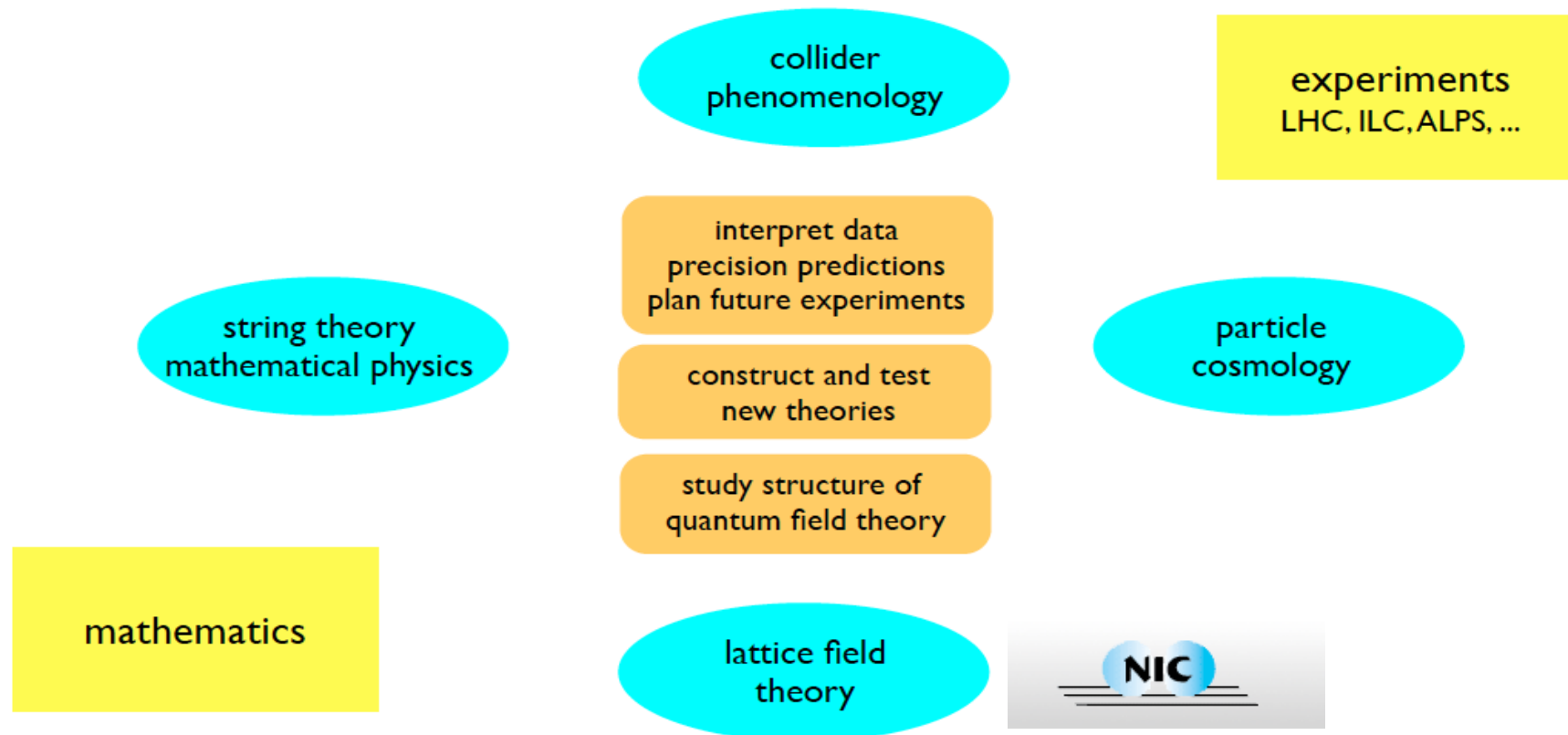
Unique role of DESY!

(cf. evaluation in 2009)



Particle Physics Theory

Particle physics theory in Helmholtz: broad spectrum, firmly connected to the experimental programme



Collaboration between different HGF centres: DESY, KIT, Jülich, GSI

Closely integrated with local universities

(Hamburg, Berlin, Karlsruhe, theory & experimental groups)

Particle Physics Theory

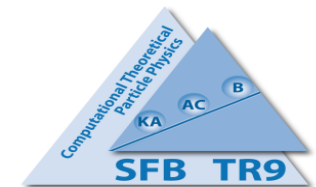
Shapes theoretical particle physics in Germany & beyond

- lectures, schools, conferences, workshops
- fellowship programme (each year >300 applications from around the globe)
- large fraction of theory staff in Germany have a DESY history

Networks and grants:



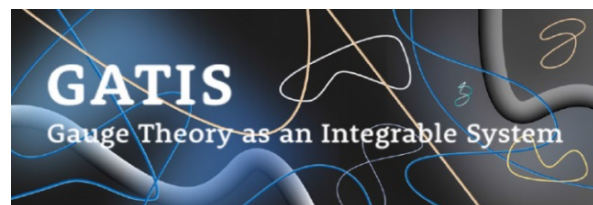
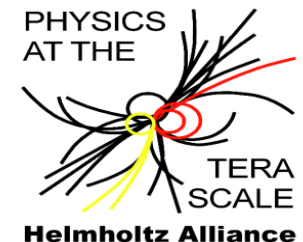
Particles, Strings,
and the Early Universe
Collaborative Research Center SFB 676



Research Training Group 1670
MATHEMATICS INSPIRED BY STRING THEORY AND QUANTUM FIELD THEORY

LHCphenOnet

HiggsTools



WOLFGANG-PAULI-CENTRE
A COMPETENCE FIELD OF PIER



Studienstiftung
des deutschen Volkes



Industry cooperations: Wolfram Research, Maplesoft, RISC Software GmbH

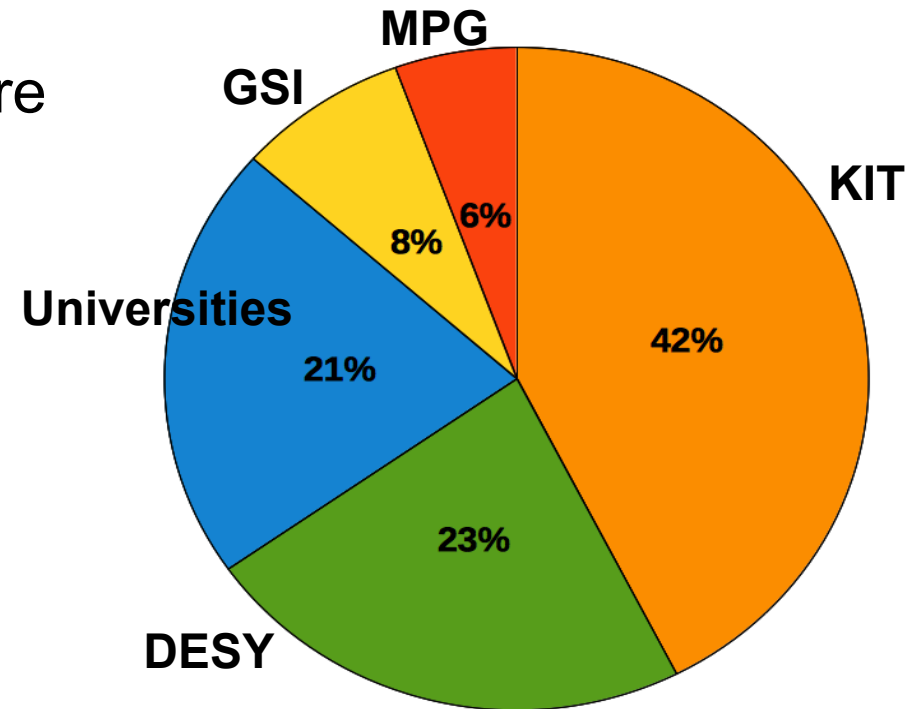
Infrastructure

LK II topics: GridKa and DESY Grid Centre

- German Tier-1 centre at KIT (GridKa) for all 4 LHC experiments and more
- DESY operates Tier-2 centres for ATLAS, CMS, LHCb and more NAF as crucial element for LHC analyses in Germany
- Helmholtz provides > 2/3 of the German LHC computing share!

DESY test beam (→ next slide)
Laboratory for large detectors
intended as detector development
hub for particle physics (LHC) in
Germany → LHC Detector Upgrade

Tier 1+2 CPU Walltime 7/12 – 6/13



Alliance “*Physics at the Terascale*”
platform for exchange in German HEP
Physics, detectors, computing

- Analysis Centre at DESY as central hub:
- education and networking
 - ≈ 15 schools & workshops per year
 - attracting many young people
 - common events of the 3 Alliances
(→ MUTLINK)

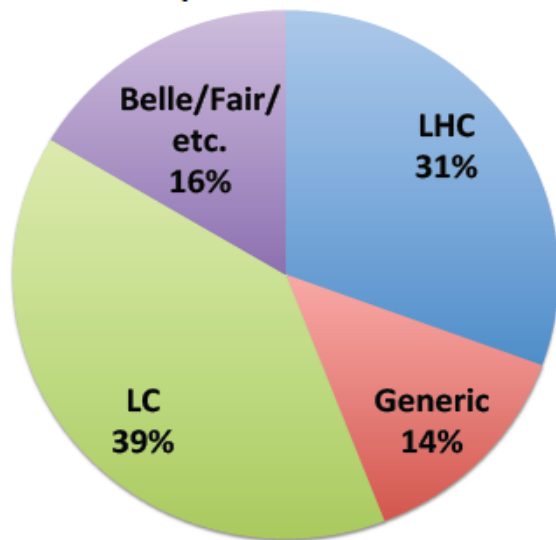
DESY Test Beam

Increasingly important facility for detector R&D

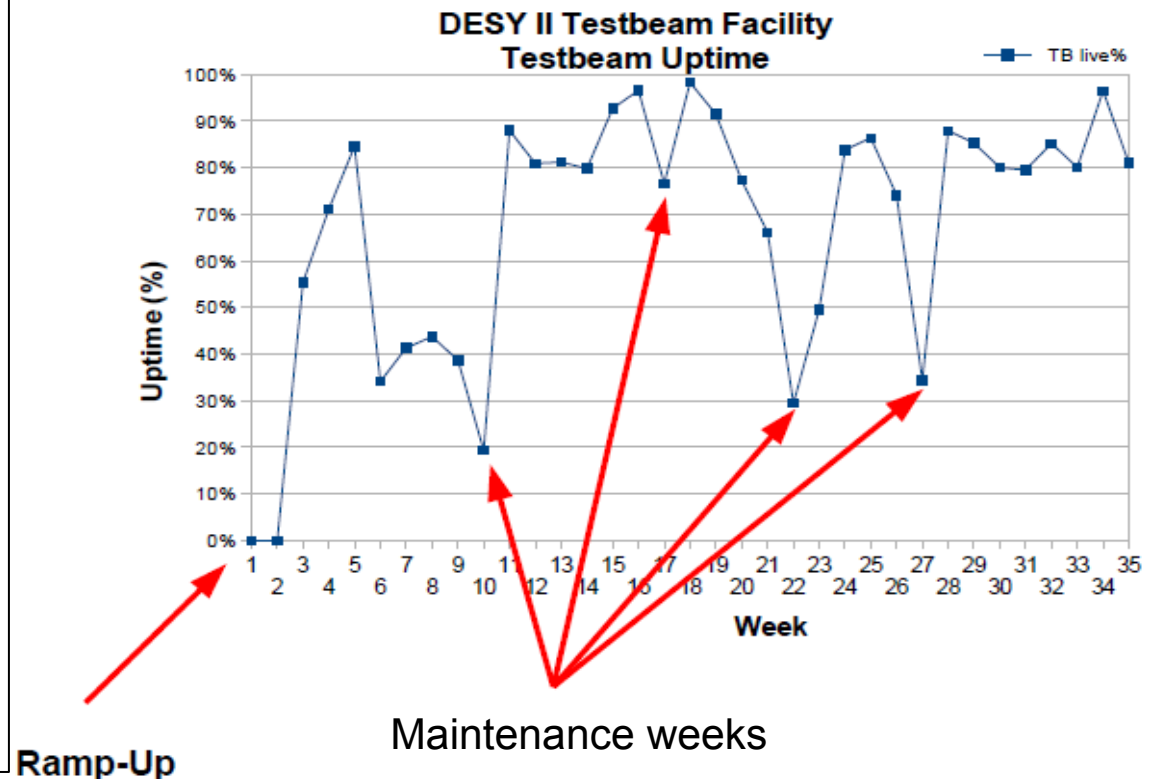
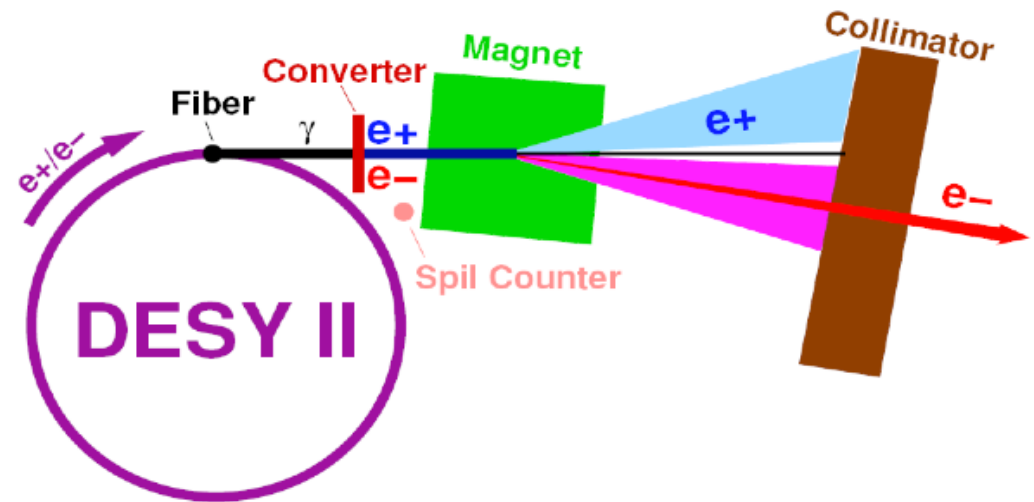
→ *Matter and Technology*

Used by many projects
approx. 400 users in 2013

- German groups : 24.7 %
- European groups : 50.2 %
- Extra-European users : 25.1 %



User groups represent all HEP communities.



Summary & Conclusion

Exciting times for particle physics

Proton-proton physics at the LHC:

- spectacular discovery of a Higgs boson
- just started and 20 years more to come

Electron-positron physics:

- BELLE II: complementary physics to LHC (precision)
- ILC: strong physics case, encouraging developments in Japan

Theory

- crucial for the success of the experimental programme:
 - predictions, interpretations, tools
- development of new methods and concepts

LK II computing facilities

- essential for physics analysis

Helmholtz particle physics 2015-19

- addresses the big challenges
- shapes - and is aligned with - national and international roadmaps

The Guarantors of the Future:

Leaders of Young Investigator Groups

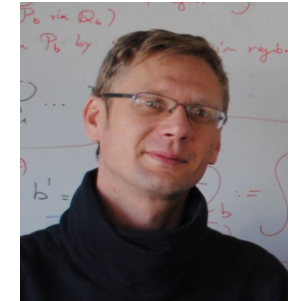
2009 Isabell Melzer-Pellmann

CMS SUSY



2009 Alexei Rasperezza

CMS Higgs



2010 Alexander Westphal
Theory / Cosmology



2011 Kerstin Tackmann
ATLAS Higgs



2012 Frank Tackmann
Theory / Phenomenology (Emmy Noether)



2012 Yvonne Peters
ATLAS top physics



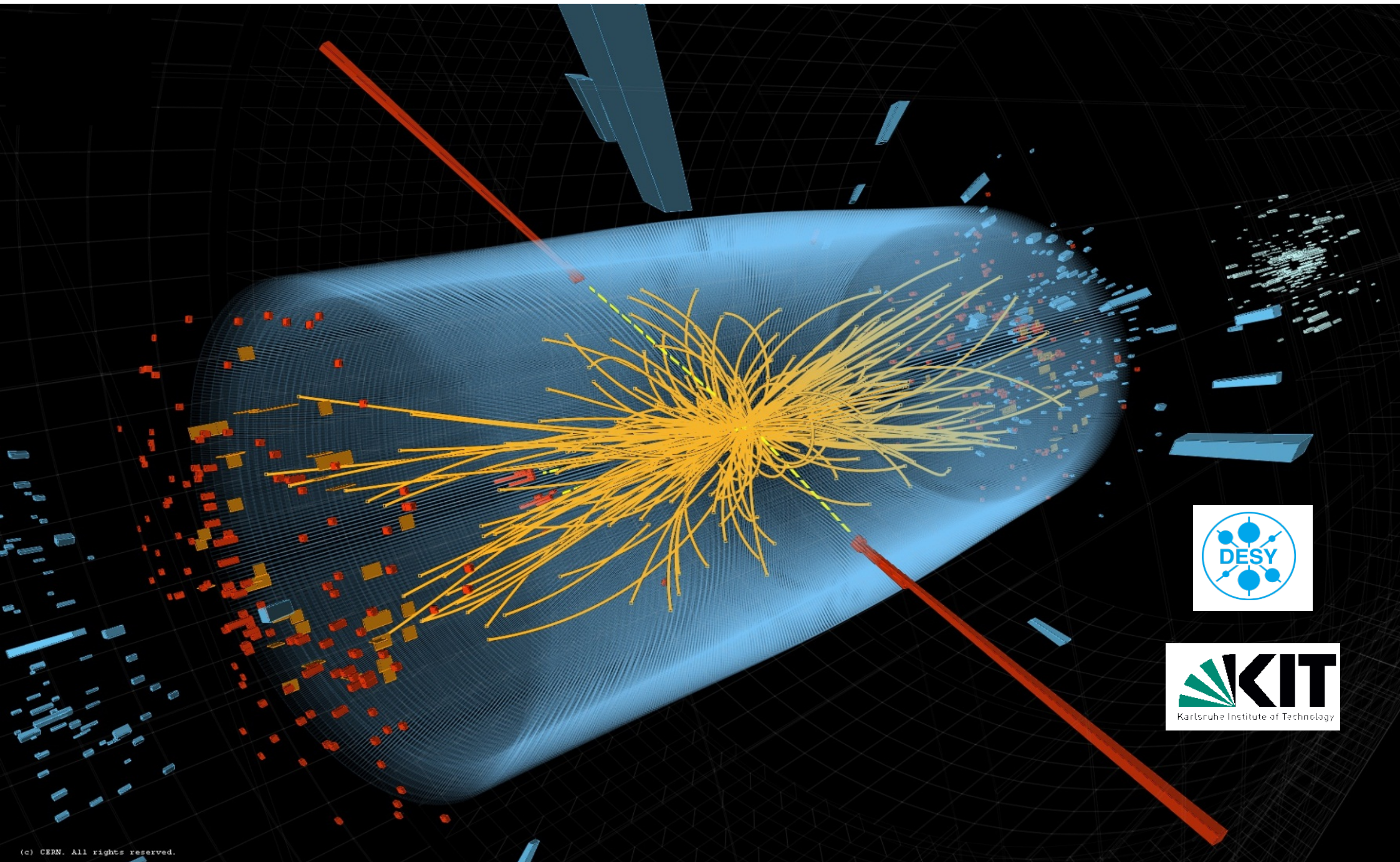
2012 Ralf Ulrich
CMS forward physics for
cosmic ray analysis



2014 María Aldaya Martín
CMS top physics



Backup Slides



Helmholtz Recruitment Initiative

Successes in Helmholtz-wide competition

Appointment procedures with universities ongoing

Geraldine Servant (Barcelona)

leading theorist at the interface between cosmology
and collider physics

offer from Hamburg University



Christophe Grojean (Barcelona)

internationally leading LHC phenomenologist

common appointment with Humboldt University Berlin
envisaged



Elisabetta Gallo (Florenz)

ex-spokesperson ZEUS, now CMS

common appointment with Hamburg University



Kerstin Borras (DESY)

W2/W3 Initiative

Common appointment with RWTH Aachen

2014/15: CMS Deputy Spokesperson



Young People

Career development of Helmholtz Young Investigator
Group Leaders since 2009:

Many are now university professors!



Laura Covi
W3 professor,
U Göttingen



Erika Garutti
W2 professor,
U Hamburg



Sven Moch
W2 professor,
U Hamburg



Ulrich Husemann
W3 professor,
KIT Karlsruhe

Helmholtz Alliance „Physics at the Terascale“

Additional funding for the Alliance ended December 2012

Confirmed funding for 2013 and beyond:

approx. 1 Mio €/year from DESY

approx. 1 Mio €/year from Universities

Money is tied
to specific positions!

Extra support from Helmholtz: 500 k€/year for 2013/2014

support for (limited) continuation of structures

support for workshop and schools programme (needs significant engagement by DESY to maintain the current level)

support for a small number of projects with clear and central contribution to the Alliance goals

With the current funding, only a limited Alliance programme possible after 2014!

schools and workshops

hopefully maintaining the structure in Germany

no support for common projects!

Plans 2015-19

Fulfill DESY's role as a national lab for the LHC:

Physics

Operation

Detector upgrades

Performing physics analyses & preparatory studies for upgrade

physics topics: Higgs, SUSY, top-quark, QCD, electro-weak

Operation and maintenance of detectors

fulfill long-term commitments and prepare for future role as integration centre

Short term & long term detector upgrades

construction of new CMS pixel & contributions to ATLAS IBL

R&D for tracker upgrade $\Rightarrow$ annual research field budget increment

prepare infrastructure for future upgrade

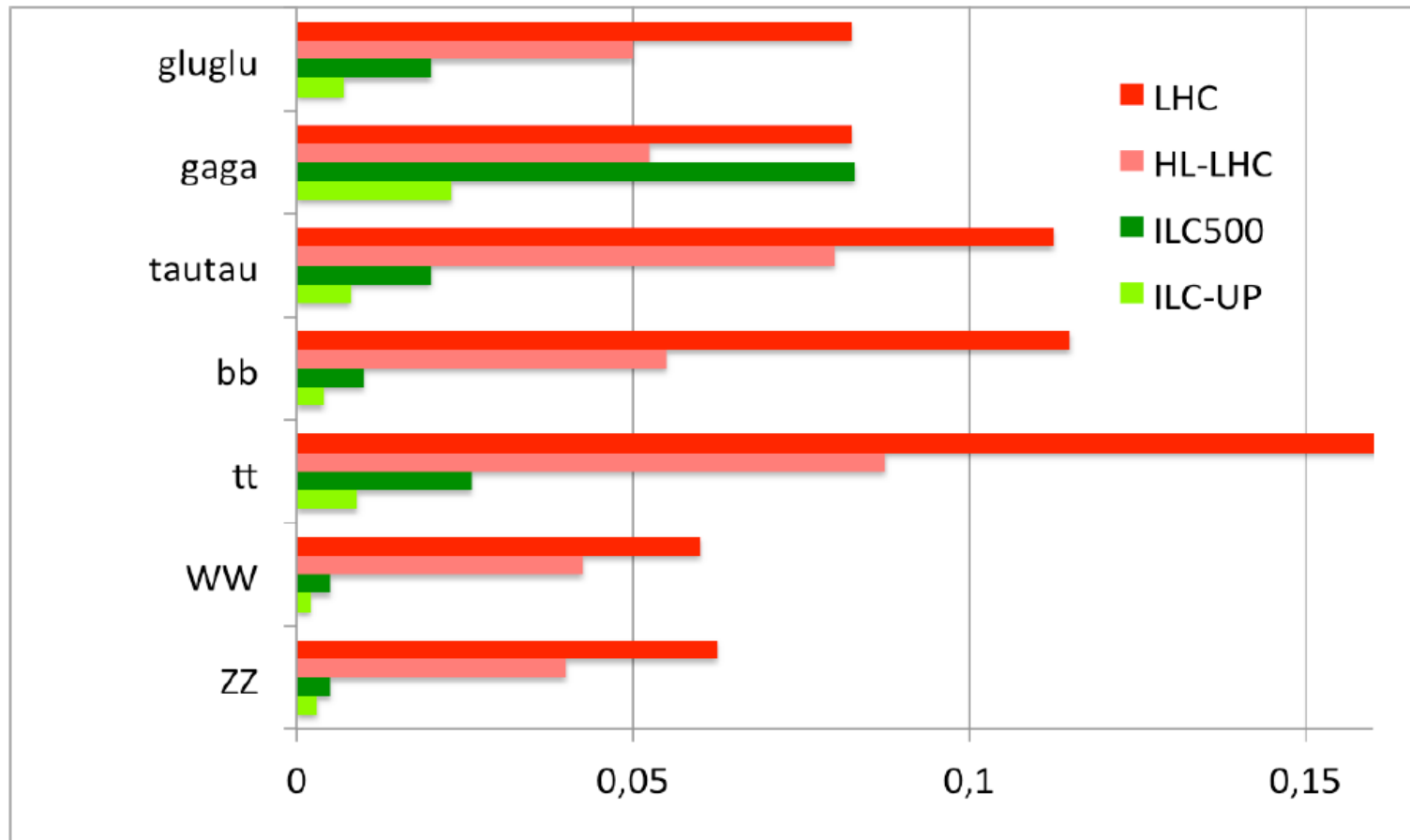
construction of new tracker end-caps for ATLAS and CMS

$\Rightarrow$ application for a capital investment

Higgs Couplings: Comparison LHC & ILC

[K. Desch '13]

Snapshot 10/2013



Fineprint:

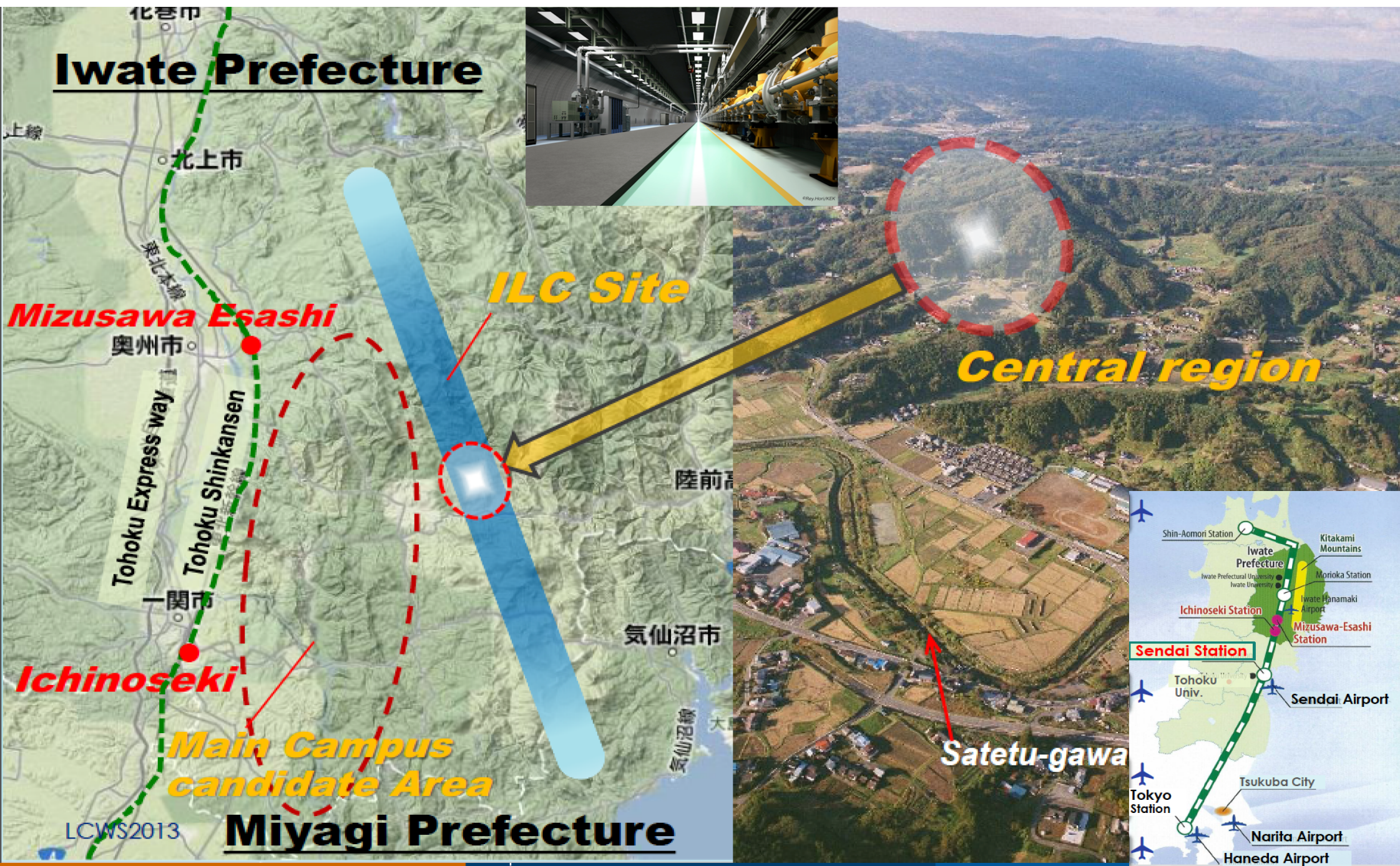
LHC: based on
W.Murray, HL-LHC workshop
Aix-les-bains, slide 24
averaged ATLAS+CMS
average upper+lower range
(ATLAS+CMS differ considerably
for some parameters,
discussion on syst. errors
ongoing)

ILC: based on ILC white paper
arxiv:1310.0763

ILC-500 =
250 fb⁻¹ @ 250 GeV +
500 fb⁻¹ @ 500 GeV

ILC-UP =
1150 fb⁻¹ @ 250 GeV +
1600 fb⁻¹ @ 500 GeV +
2500 fb⁻¹ @ 1000 GeV

ILC Site Selection



International Linear Collider ILC

ILC in short

~18000 SCRF cavities

31.5 MV/m

1750 cryomodules

European XFEL

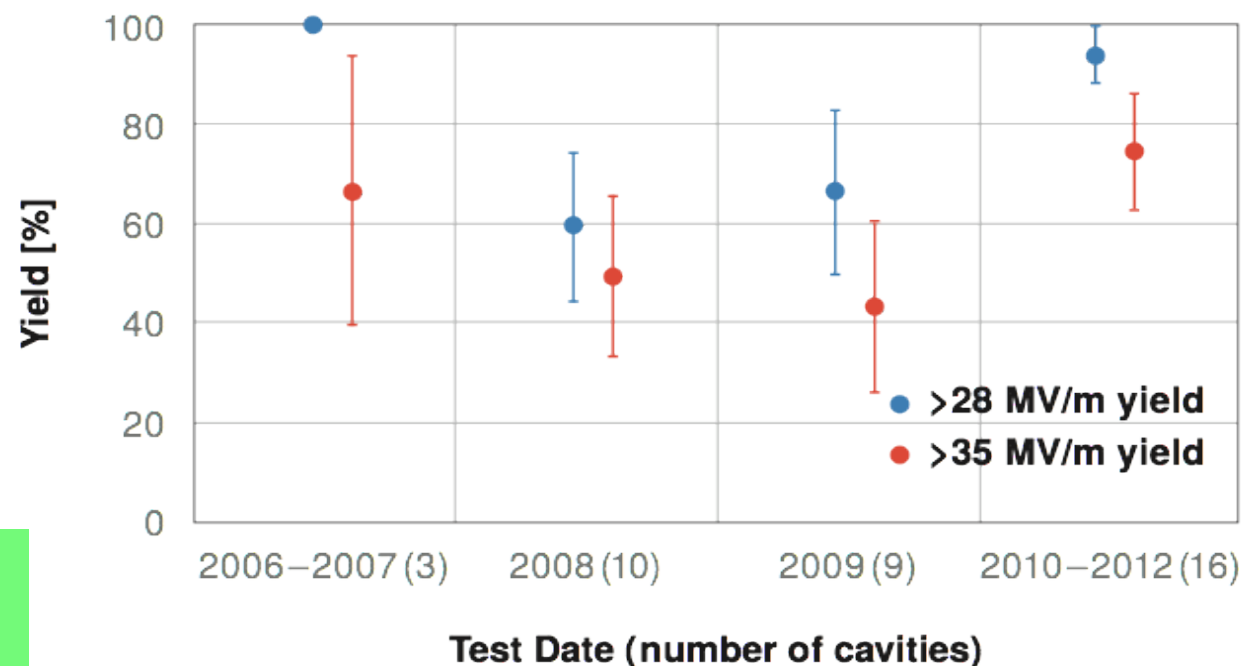
based on same technology

840 cavities

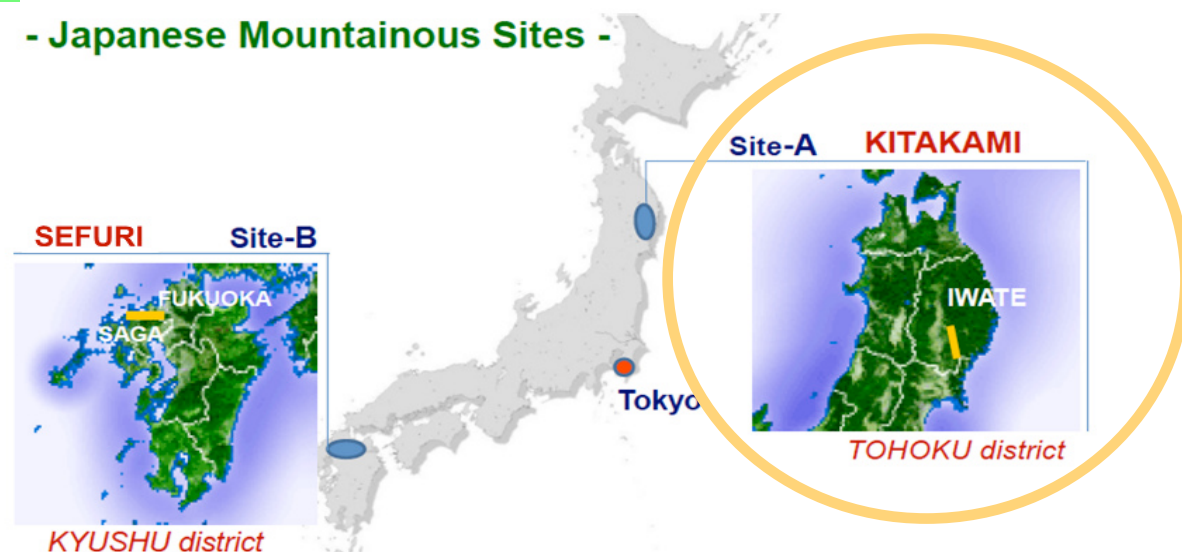
24 MV/m req.

100 cryomodules

main
goal



- Japanese Mountainous Sites -



ILC Detector

DESY leading centre in the LC detector effort

Physics studies (with theory)

Detector concept ILD

Time projection chamber

Hadron calorimeter

Forward calorimeter, vertex detector

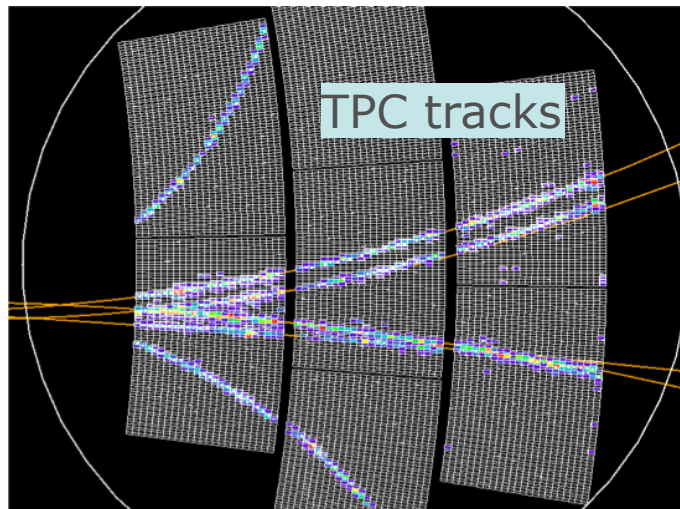
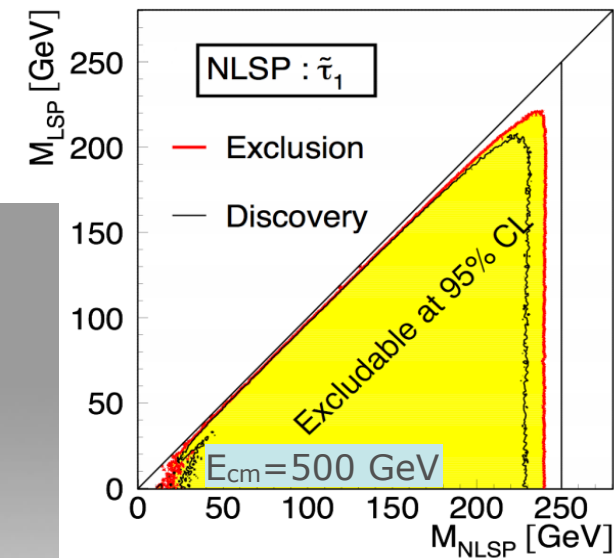
Strategic asset: test beam

→ *Matter and technology*

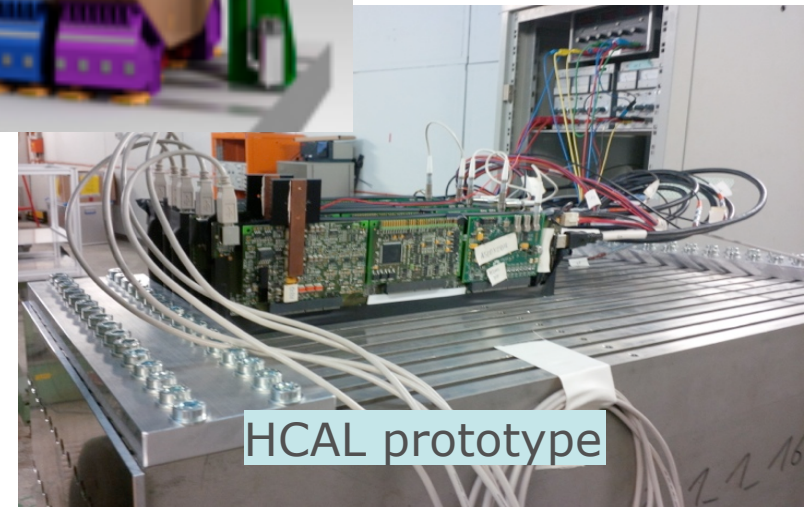
Integration and software

ILD

stau discovery reach



DESY test beam



DESY in BELLE I

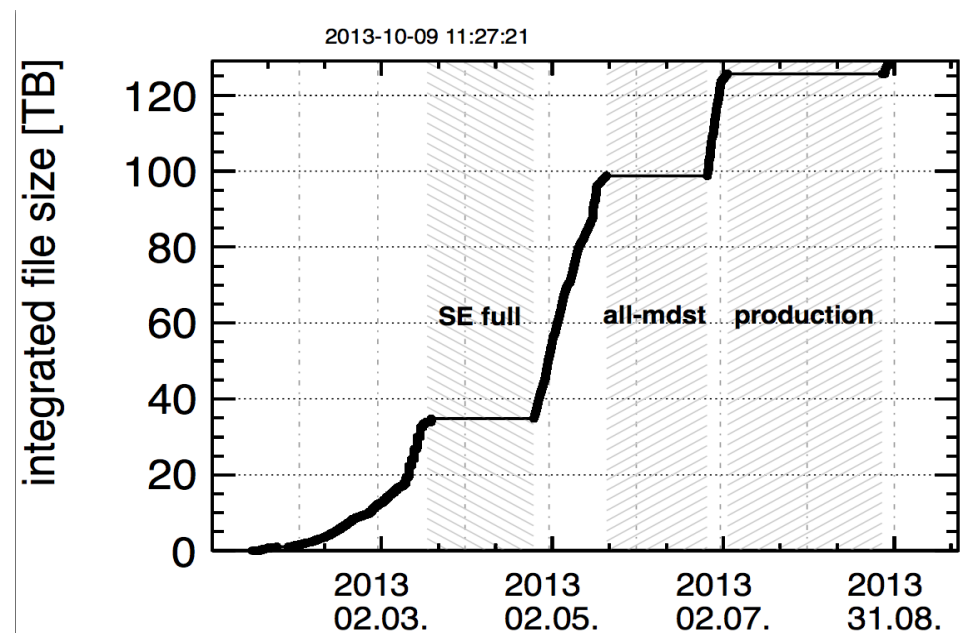
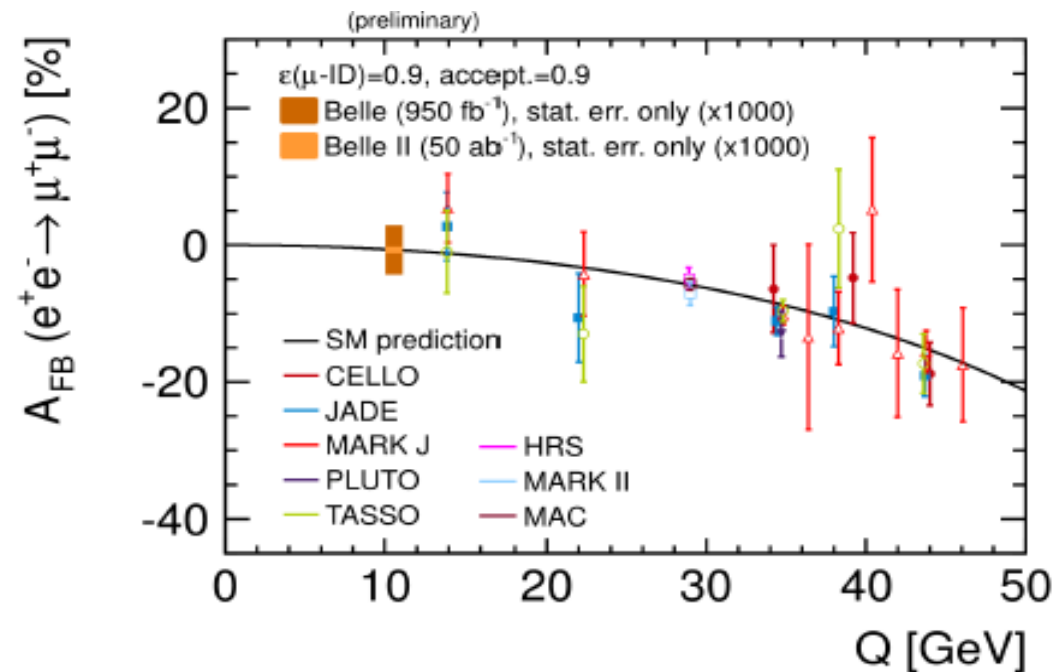
Access to the world largest data sample at the Y(4S)

about 1000 fb⁻¹ collected between
1999 and 2010

Start analysis of $A_{\text{FB}}(e^+e^- \rightarrow \mu^+\mu^- (\gamma))$

replicate full Belle I data set at DESY

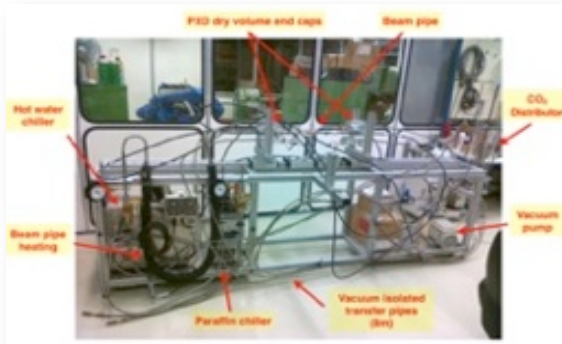
one of the leading centres for
Belle II MC production



DESY Activities around BELLE II PXD

Support German Belle II groups by exploiting specific expertise available

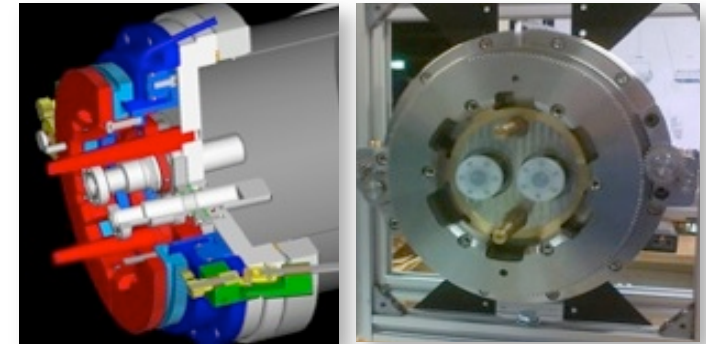
Thermal Mock-up & Shield for VXD



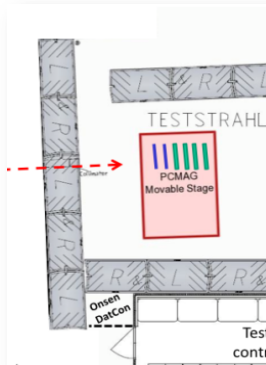
CO₂ Cooling System



Remote Vacuum Connection



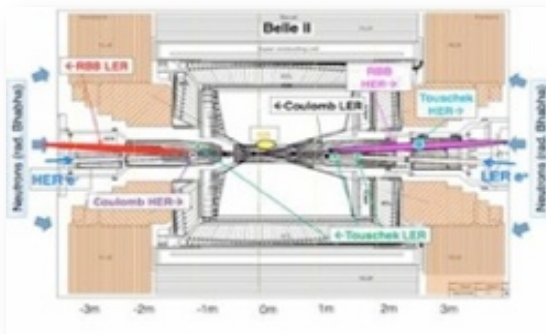
DESY Test Beam



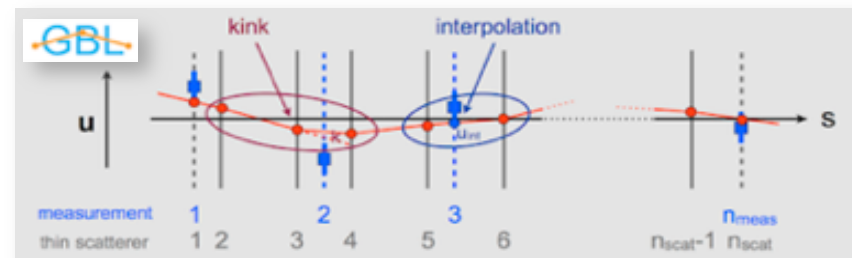
Milestones 2015-19:

- Install & commission PXD in 2016
- Align detector & start physics programme
- Ramp up SuperKEKB and accumulate $\approx 10 \text{ ab}^{-1}$

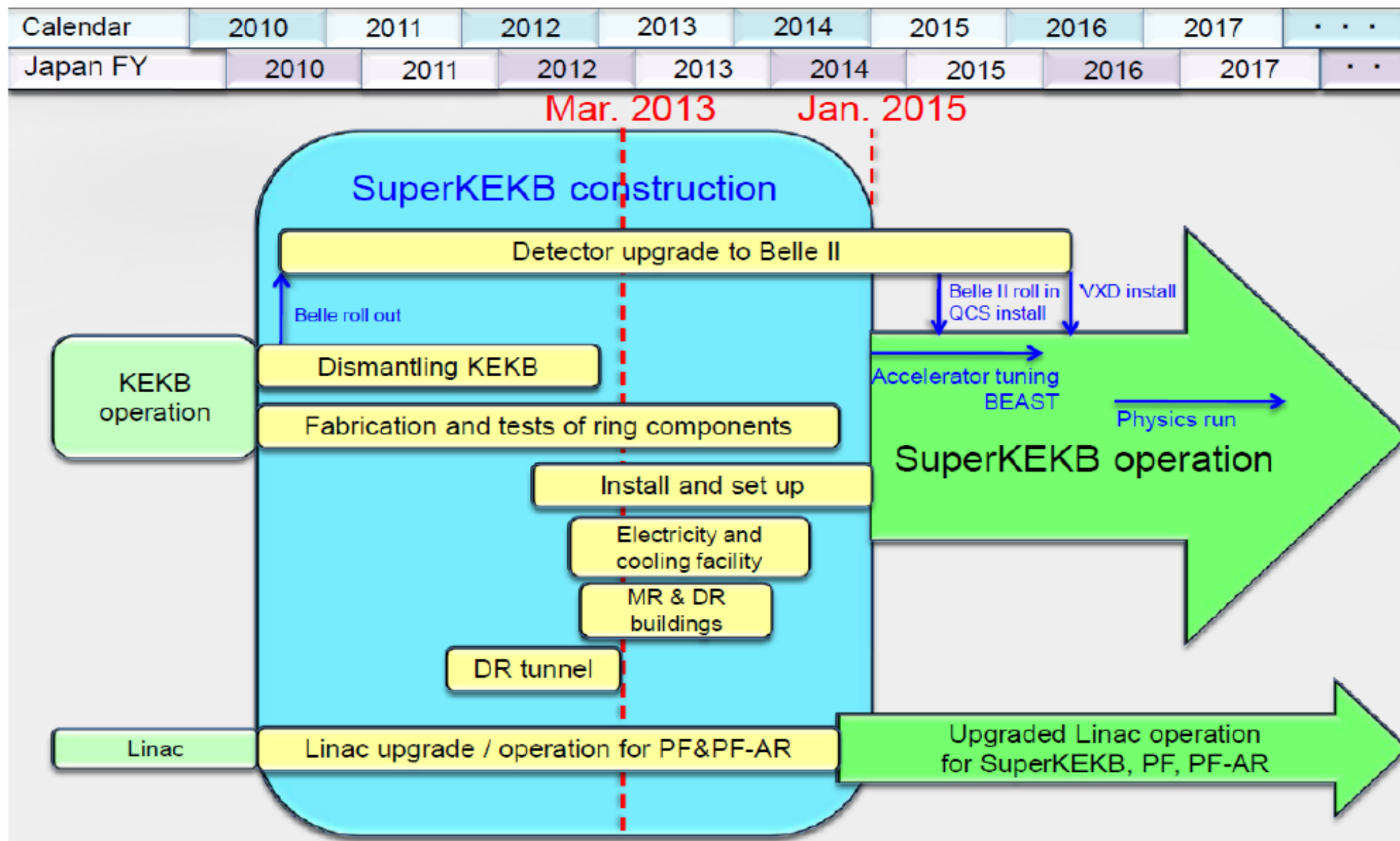
SynRad Background MC



Tracker Alignment and Calibration



Belle II Schedule



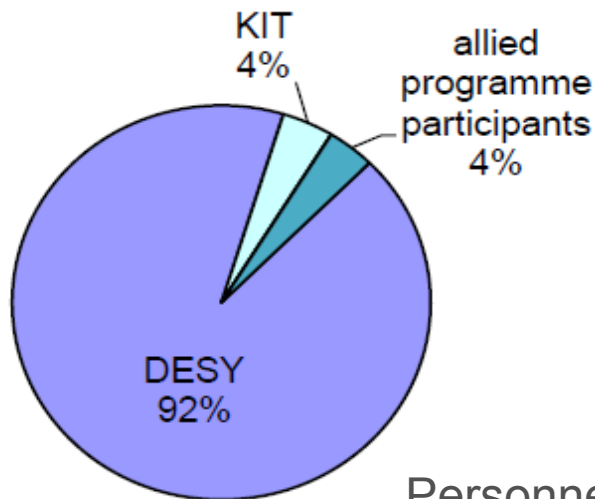
Fundamental Particles and Forces

Participating Helmholtz Centres

Matter and the Universe, Topic Fundamental Particles and Forces

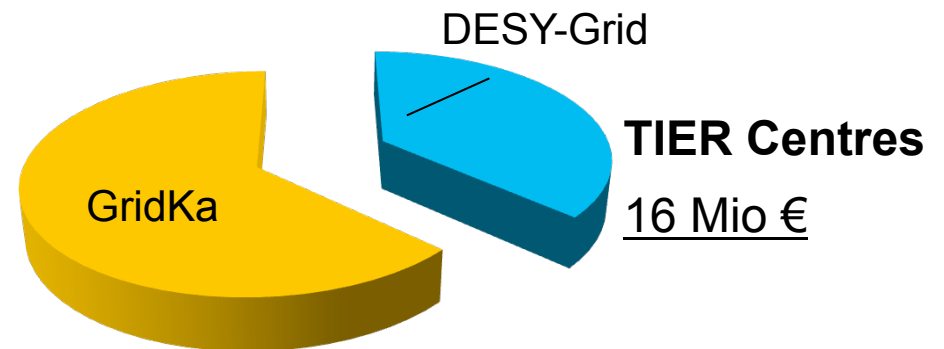


Research personnel (LK I)

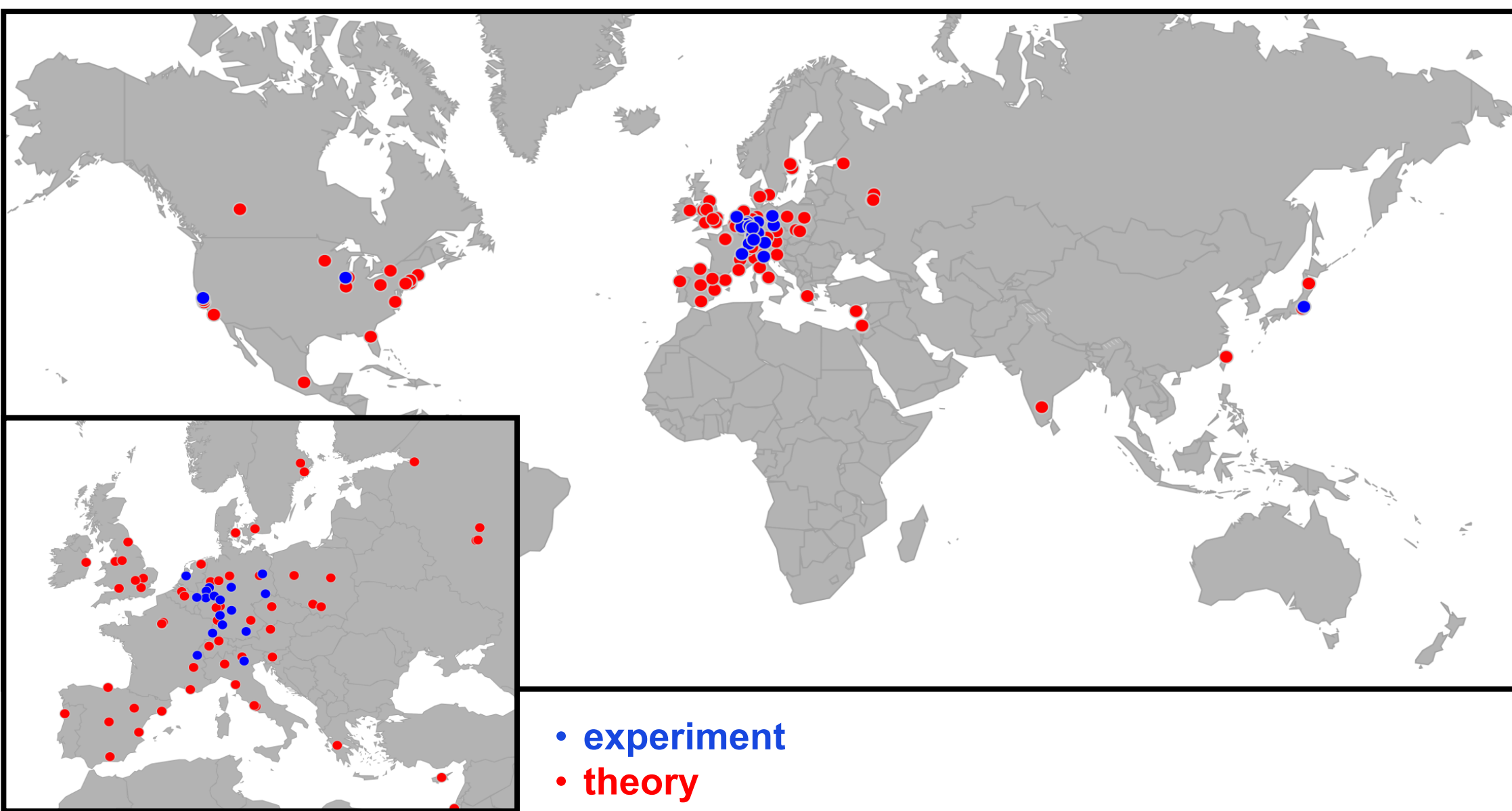


Personnel share financed
by Helmholtz:
Total 138 scientists plus 60
Ph.D. students.

Budget large infrastructure (LK II)



DESY Cooperations in Particle Physics



Not for referee handout

Facts

DESY Fraction in D-HEP

From RECFA Study 2012/13

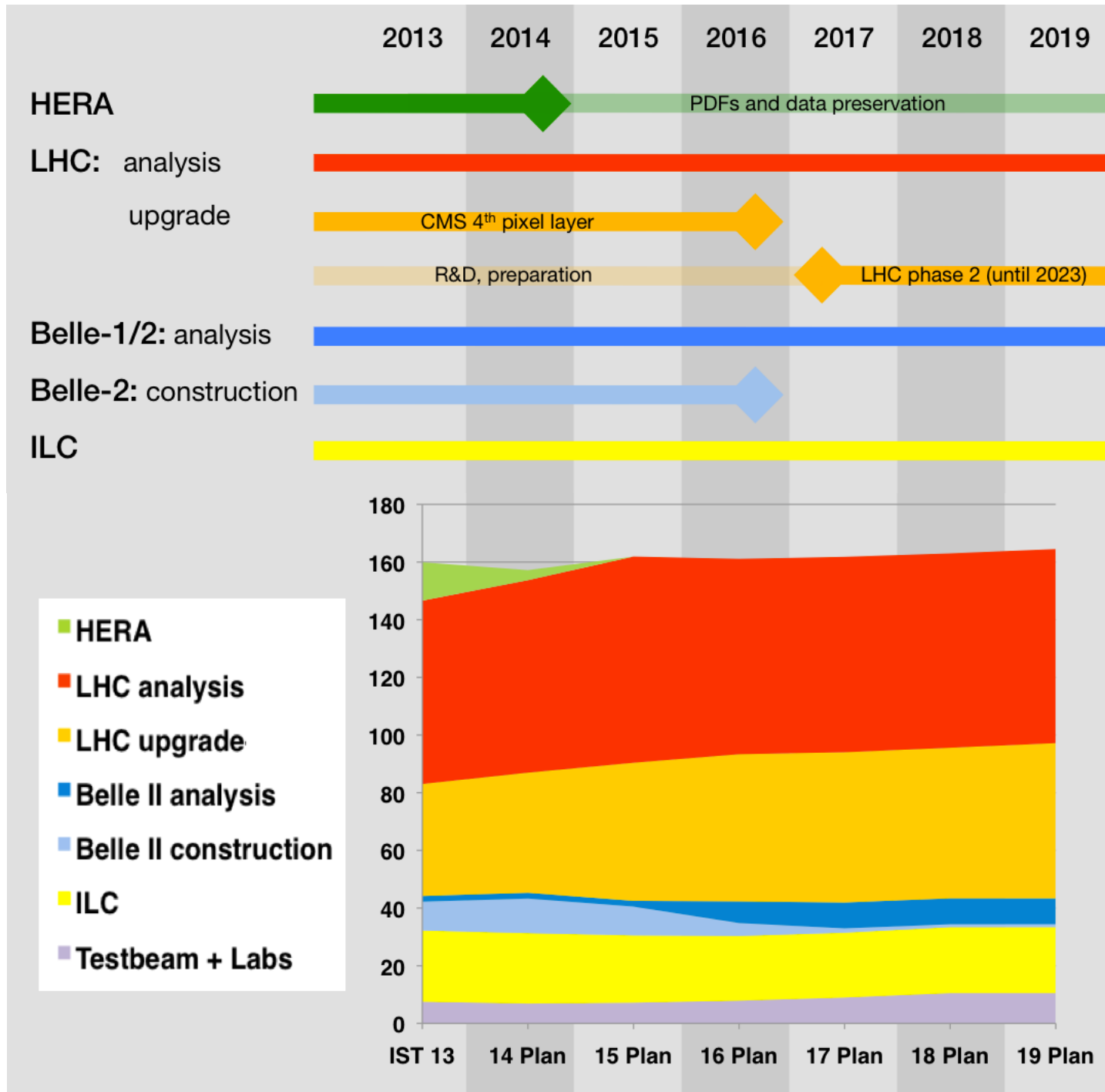
		Germany	DESY*	DESY Fraction [%]
Professors		129	12	9
	females [%]	6	0**	
permanent scientists		192	92	48
	females [%]	12	15	
YIGs etc.		40	11	28
	females [%]	33	27	
temporary staff	Postdocs	463	110	24
	Ph.D. students	695	95	14
	females [%]	17	22	

* including third-party funding, M&T, LK-2

** 3 appointment procedures ongoing

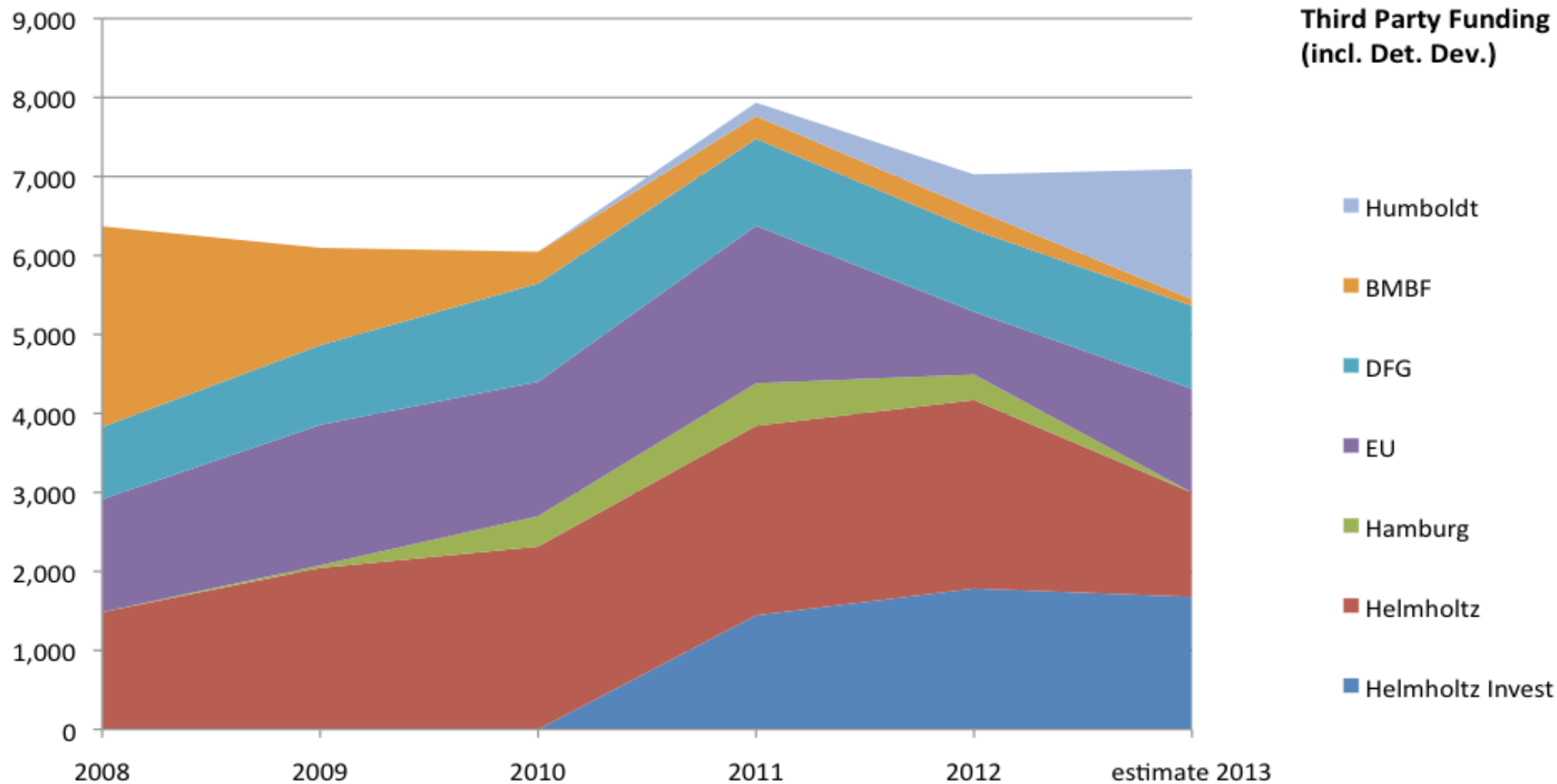
Ph.D. physicists		825	225	27
all physicists		1520	320	21

Projects



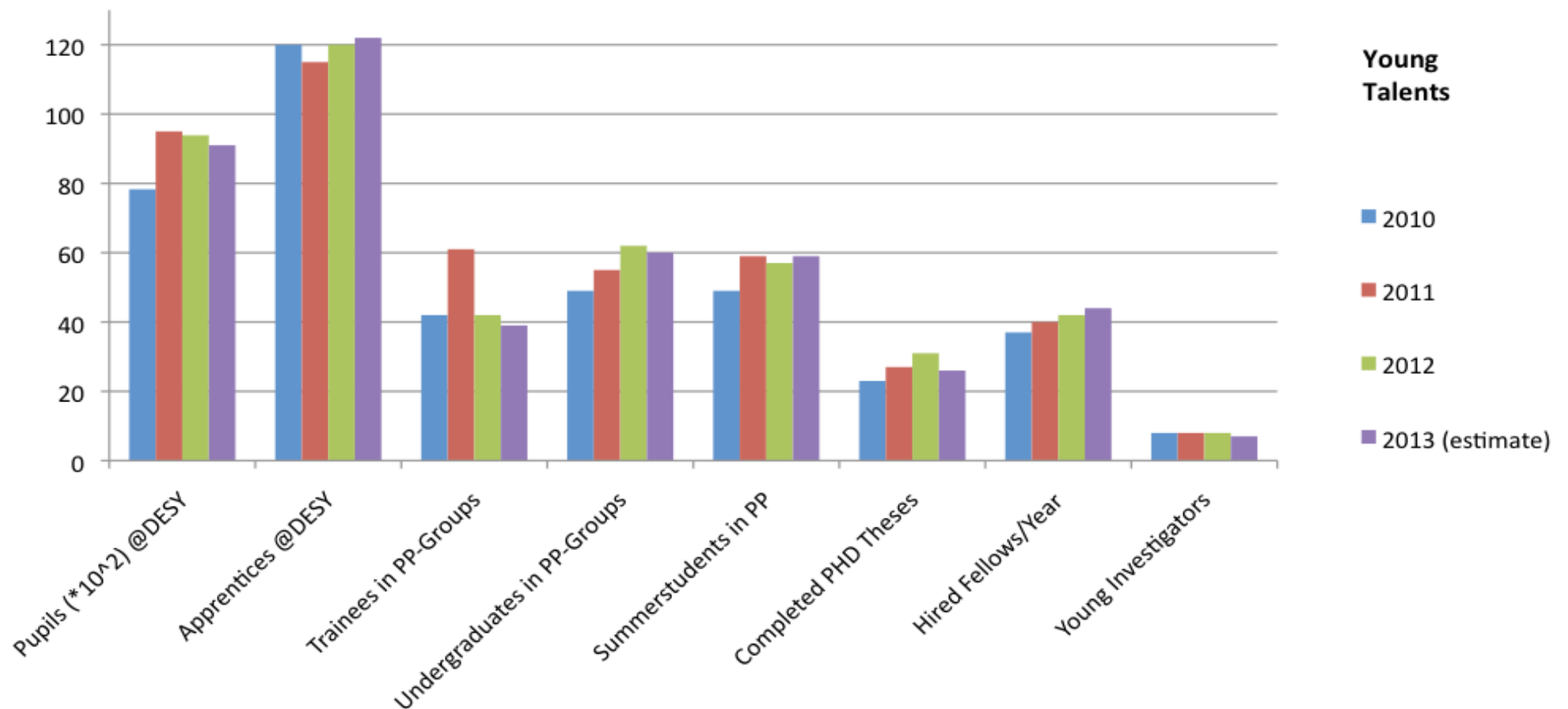
Third-Party Funding

DESY, incl. detector development



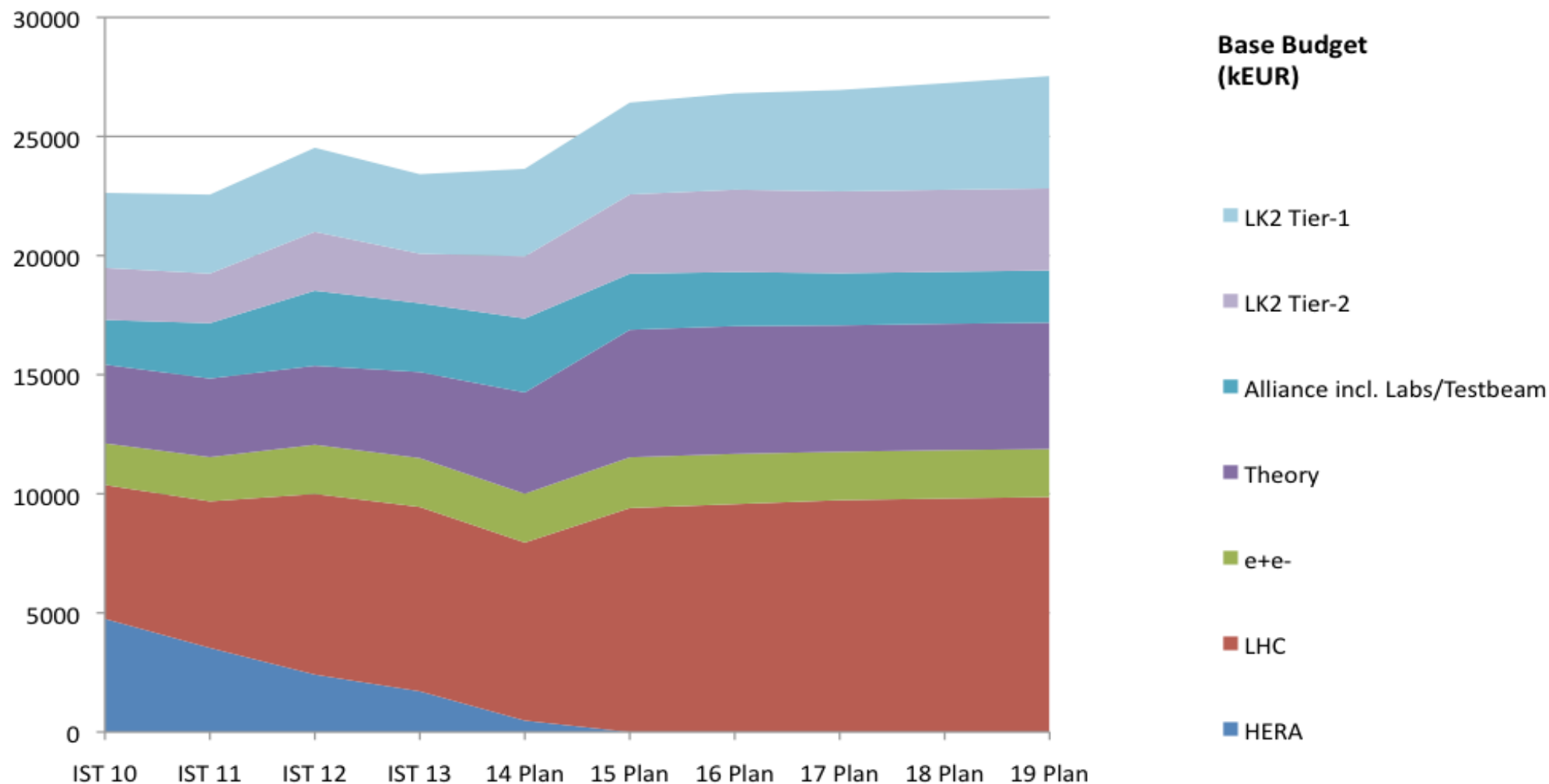
Young Talents

at DESY



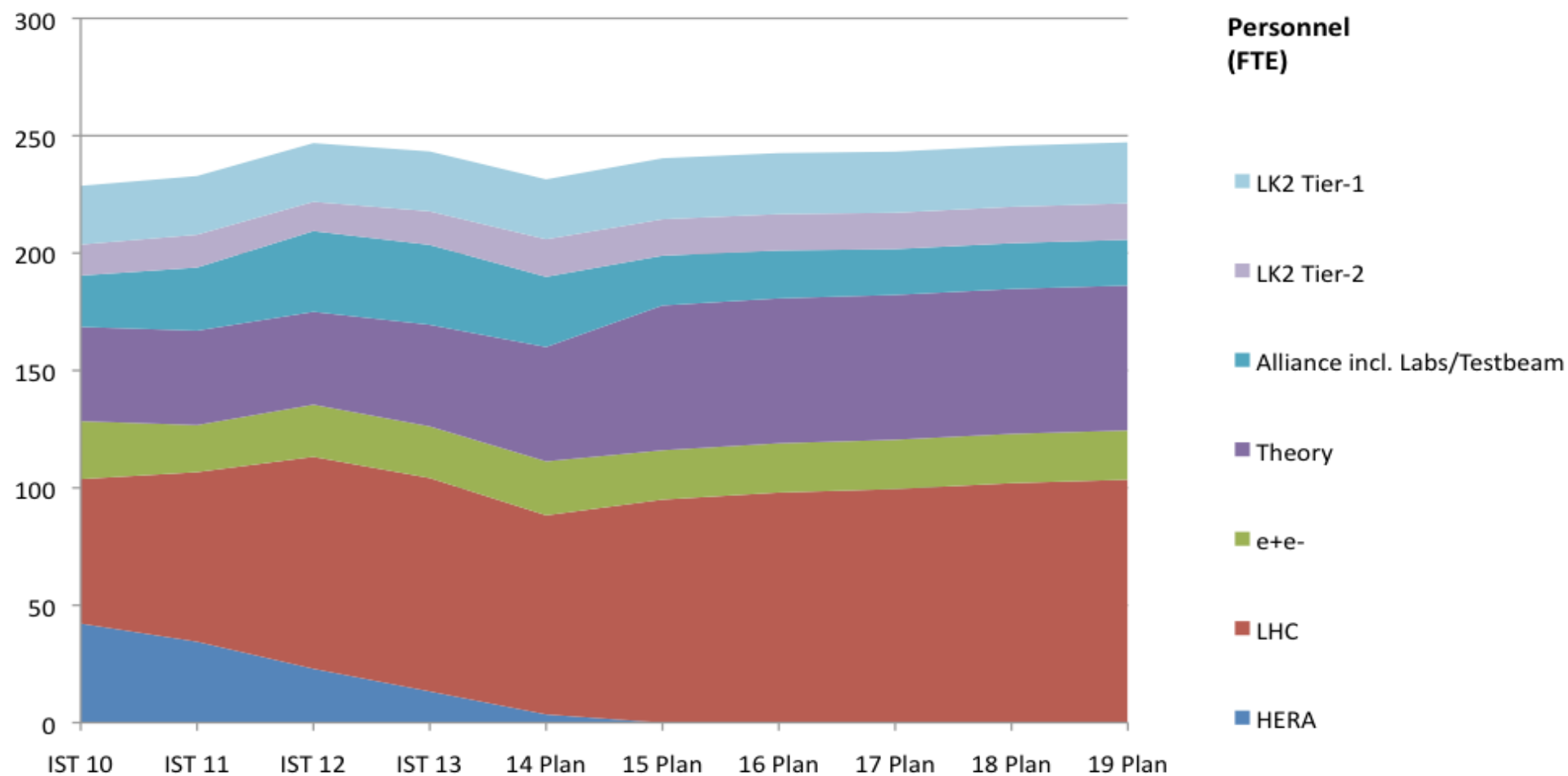
Funding – Base Budget

Direct expenses for DESY+KIT



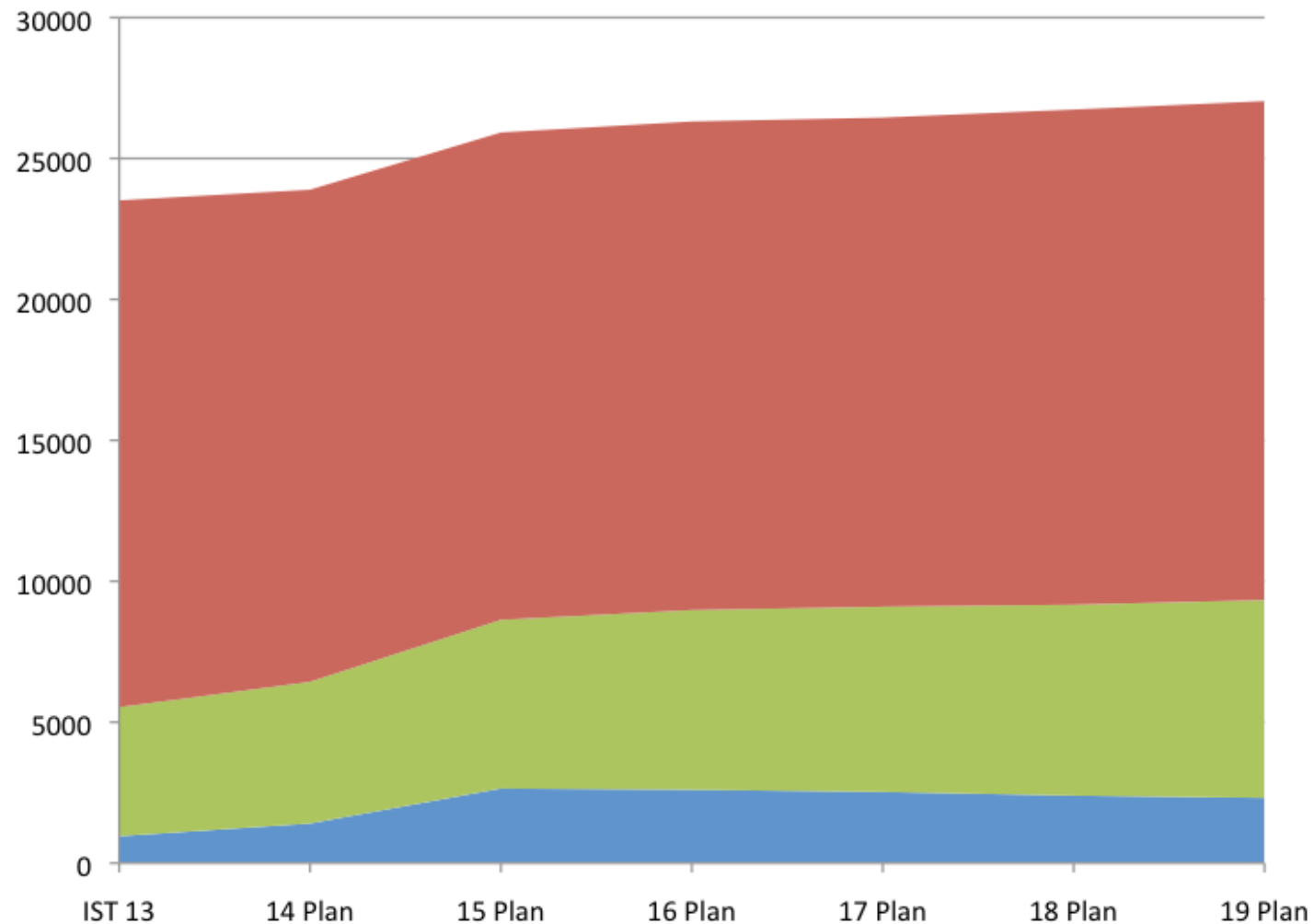
Personnel

DESY+KIT



Funding Structure

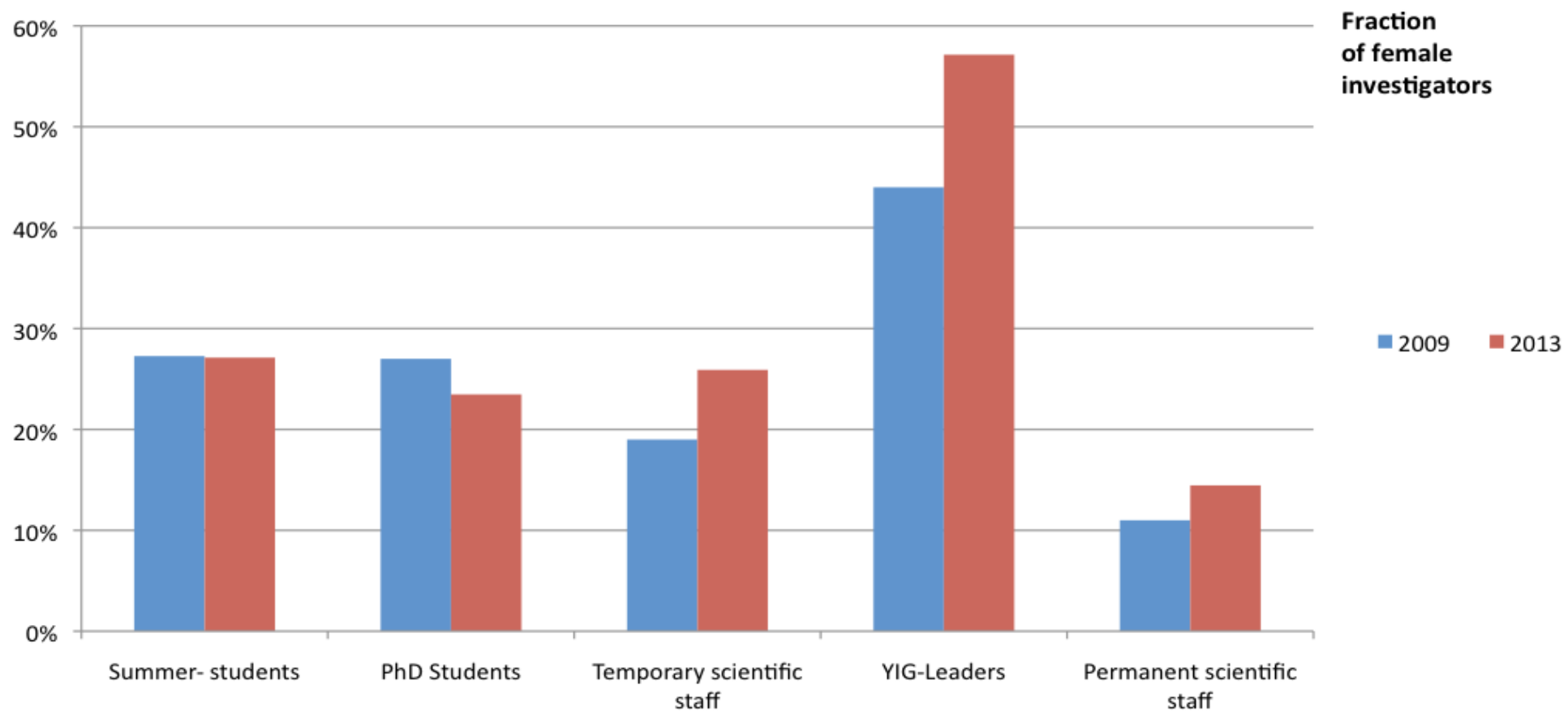
DESY+KIT



Particle Physics Funding Structure (kEUR)

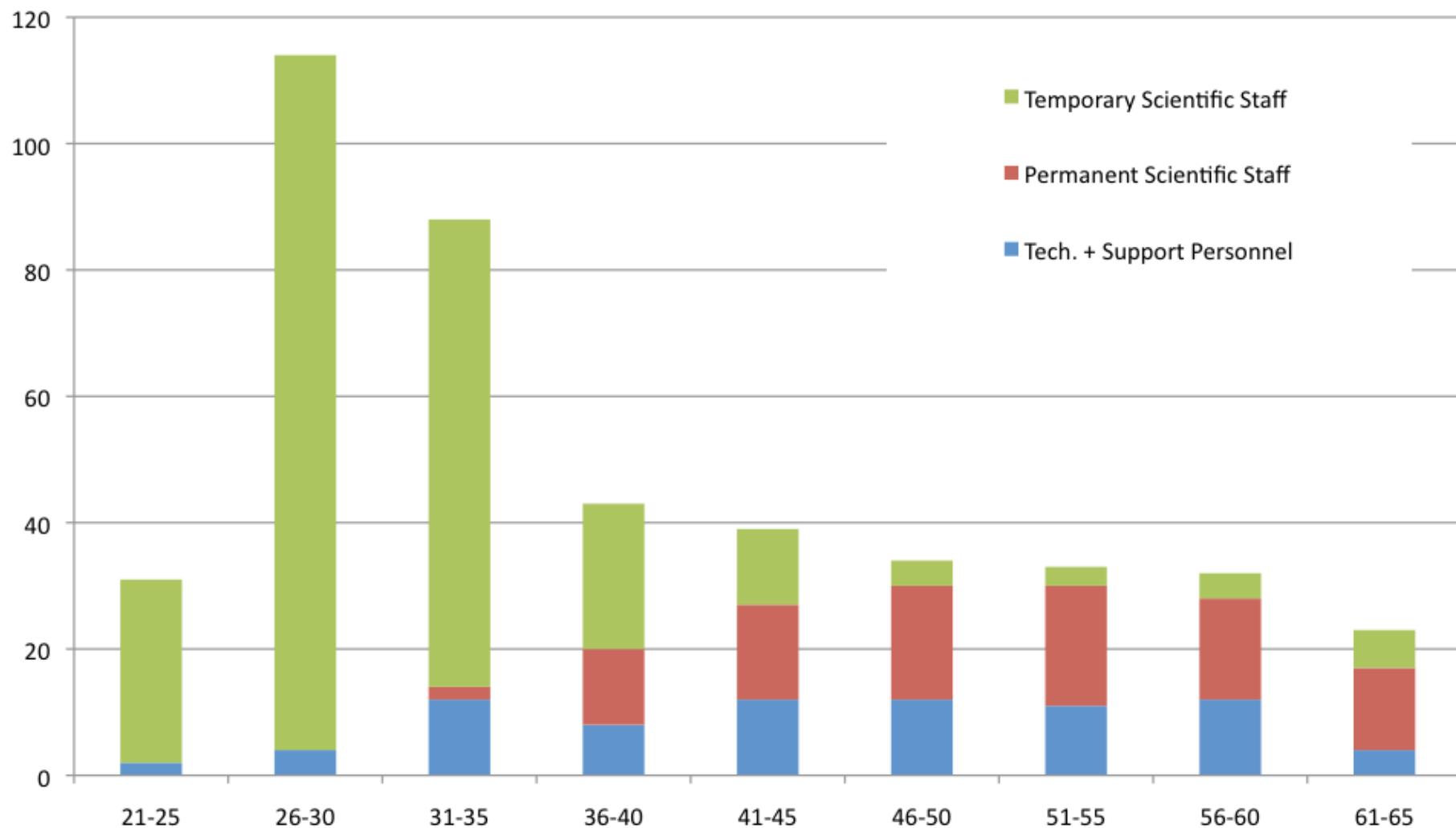
- Personnel Costs
- Non-Personnel Costs
- Invest

Gender Distribution at DESY



Age Distribution

at DESY in LK-1 and LK-2

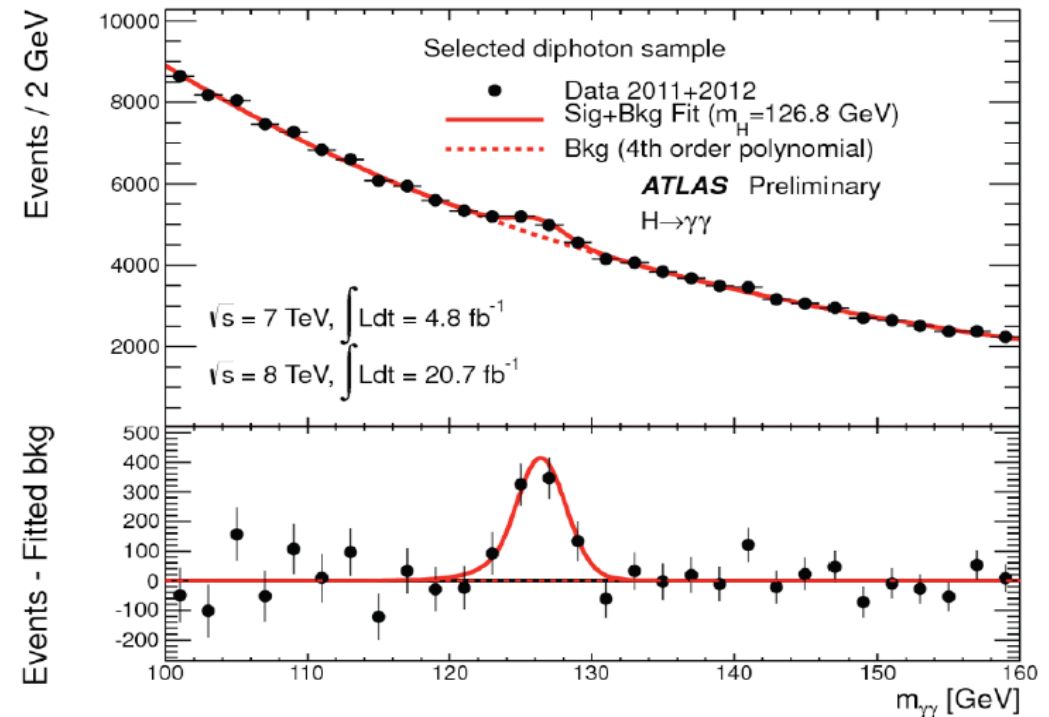


Physics at the LHC

Highlights 2010-14

Example ATLAS:

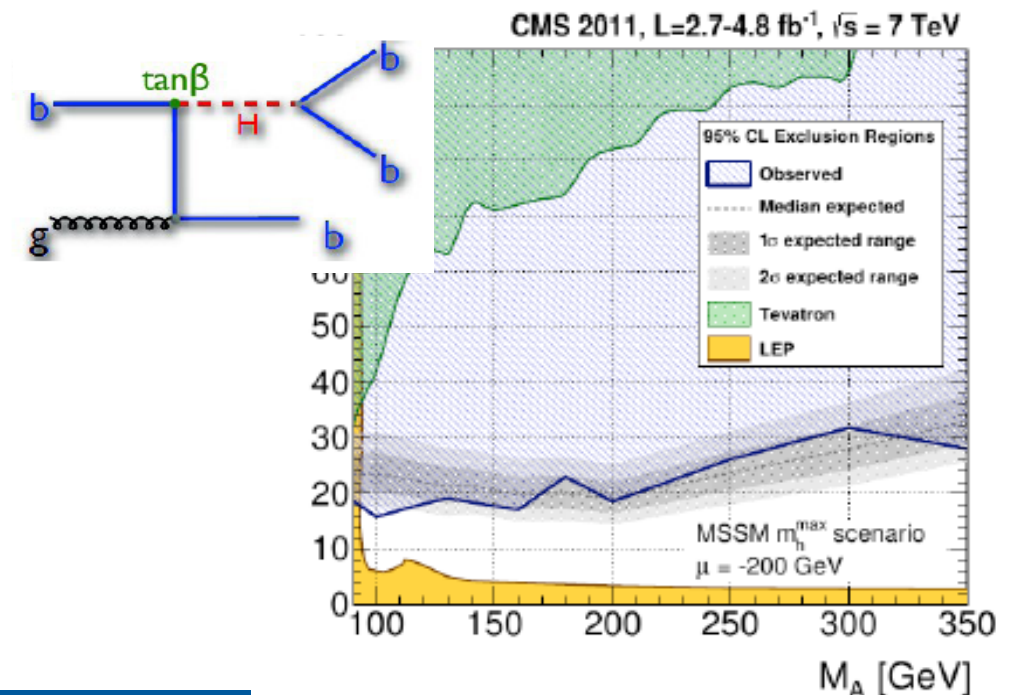
Higgs detection in $\gamma\gamma$
coordination of $H \rightarrow \gamma\gamma$ subgroup



Example CMS:

MSSM Higgs search $\Phi \rightarrow 3 b$
with KIT

In both examples analysis
performed by YIGs



LHC Schedule

F. Bordry, 02.12.2013

