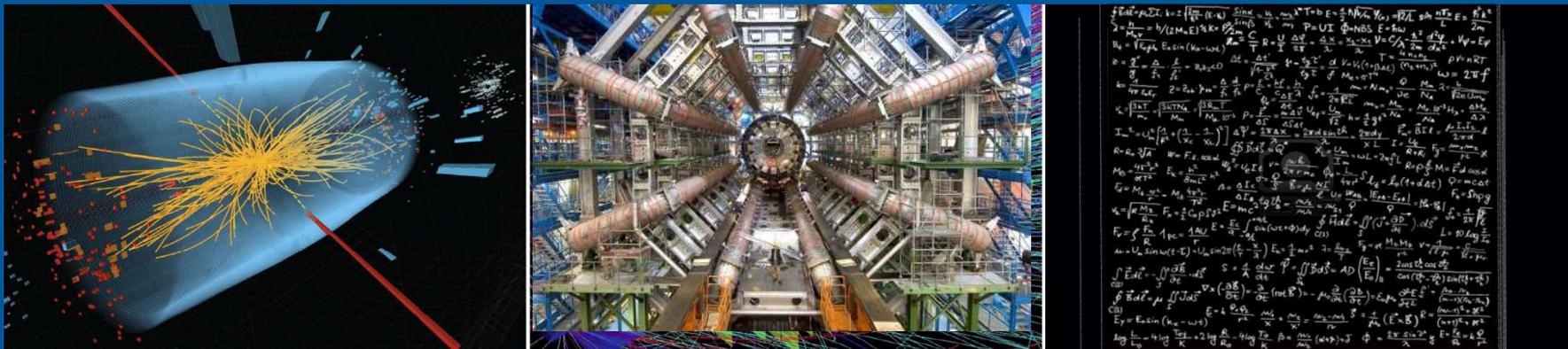
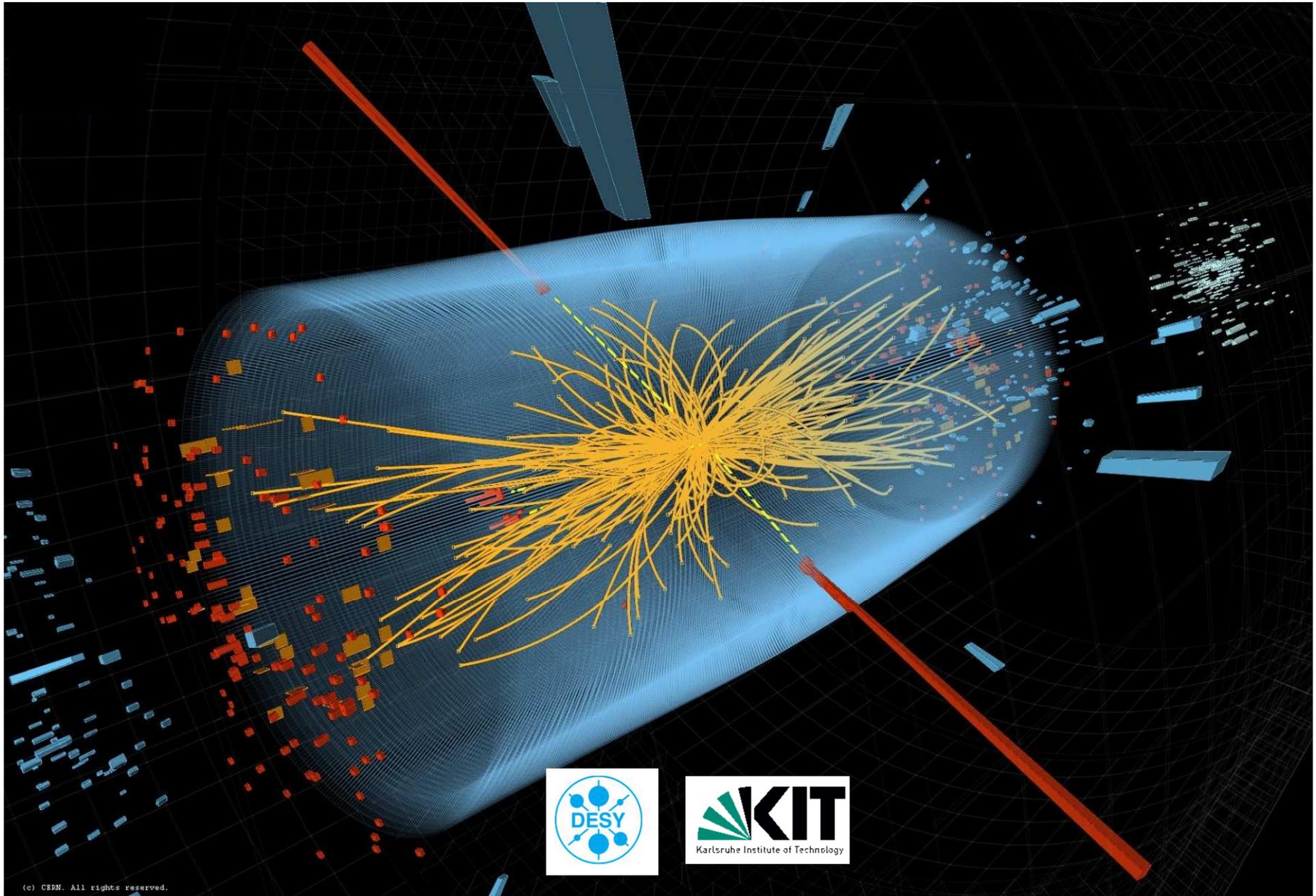


## Fundamental Particles and Forces



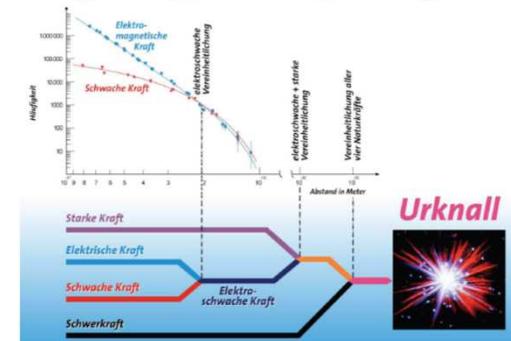
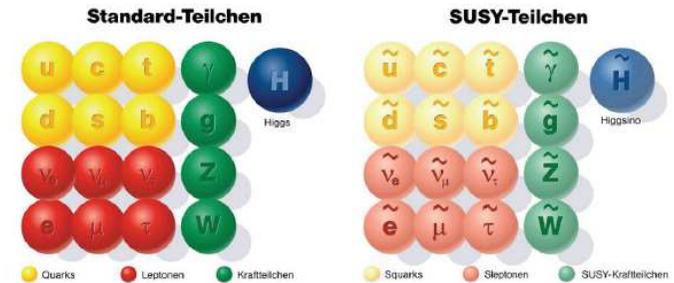
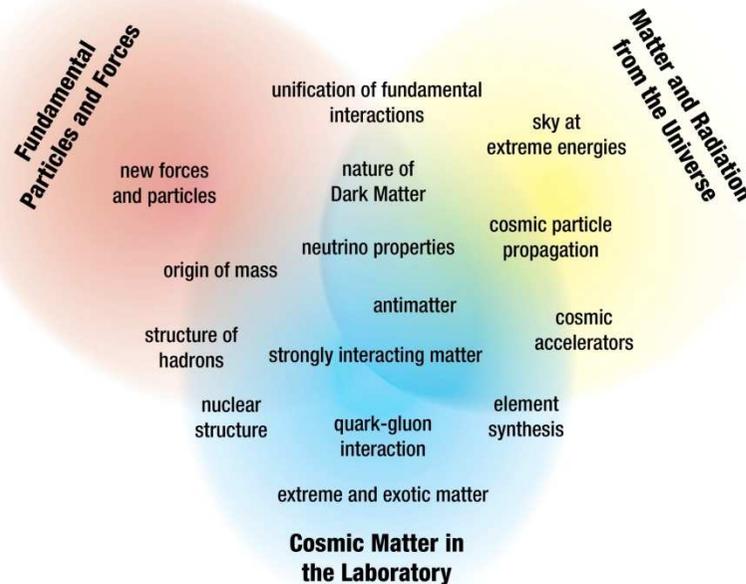
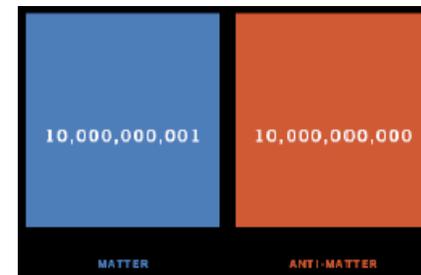
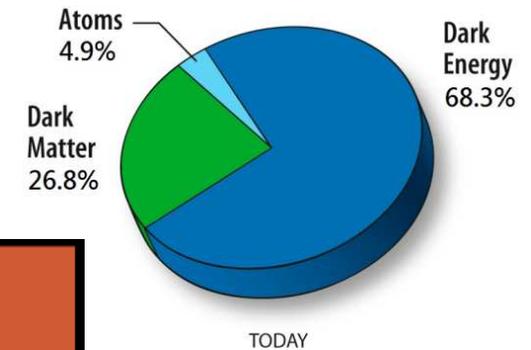
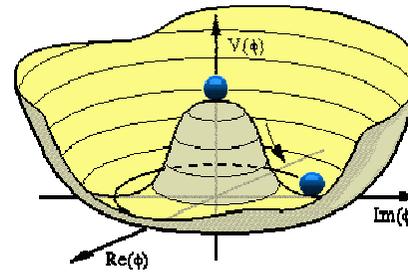
J. Mnich (DESY)

# Fundamental Particles and Forces



# Elementary Particle Physics

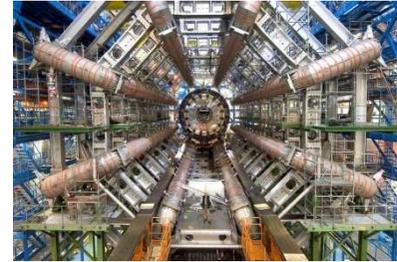
- **The Big Questions:**
  - **origin of mass**
  - **nature of Dark Matter**
  - **new forces and particles**
  - **matter-antimatter asymmetry**
  - **unification of fundamental forces**
  - ...
- **Particle Physics in the programme context:**



# Elementary Particle Physics

- 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

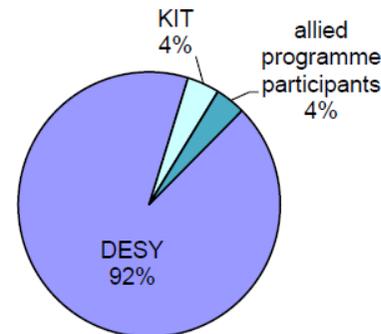


- Computing Infrastructure

- Tier-1 **GridKa**
- Tier-2 **DESY Grid Centre**



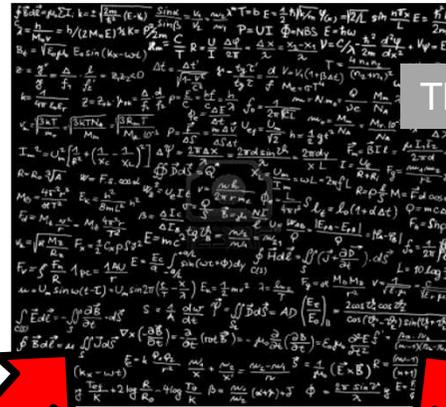
- Participating Helmholtz Centres



Personnel share financed  
by Helmholtz  
Total 138 scientists plus 60  
PhD students

# Particle Physics Strategy 2015-19

- **Maximum discovery potential**
- **Highest sensitivity**
- **Guidance and interpretation by theory**



Theory



HERA



LHC



ILC



KEK/BELLE



- **Computing: Tier 1 & Tier-2, LSDMA**
- **Detector & accelerator development (→ Matter and Technology)**
- **Testbeam**

# 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<sup>4)</sup> we strongly recommend to contribute actively to the realisation of this project.

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

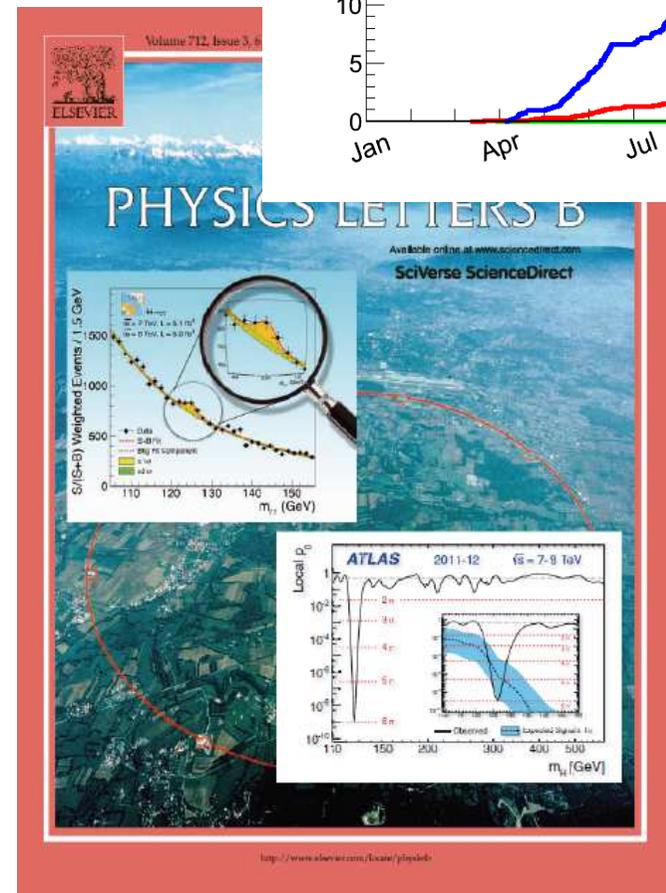
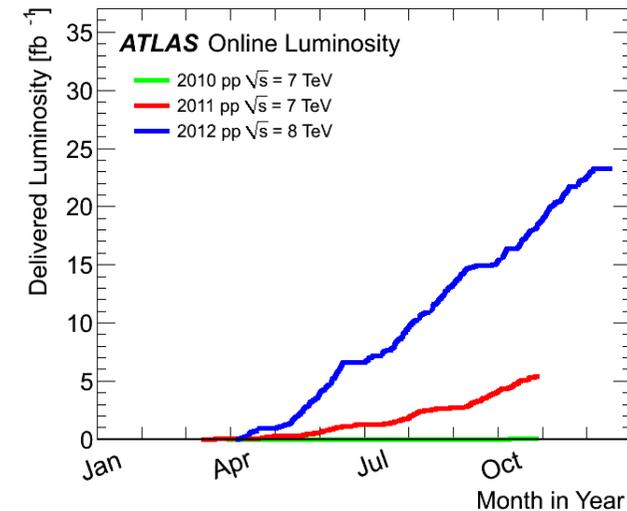
- **Japan: Future Projects of High Energy Physics**

**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.

# The Large Hadron Collider (LHC)

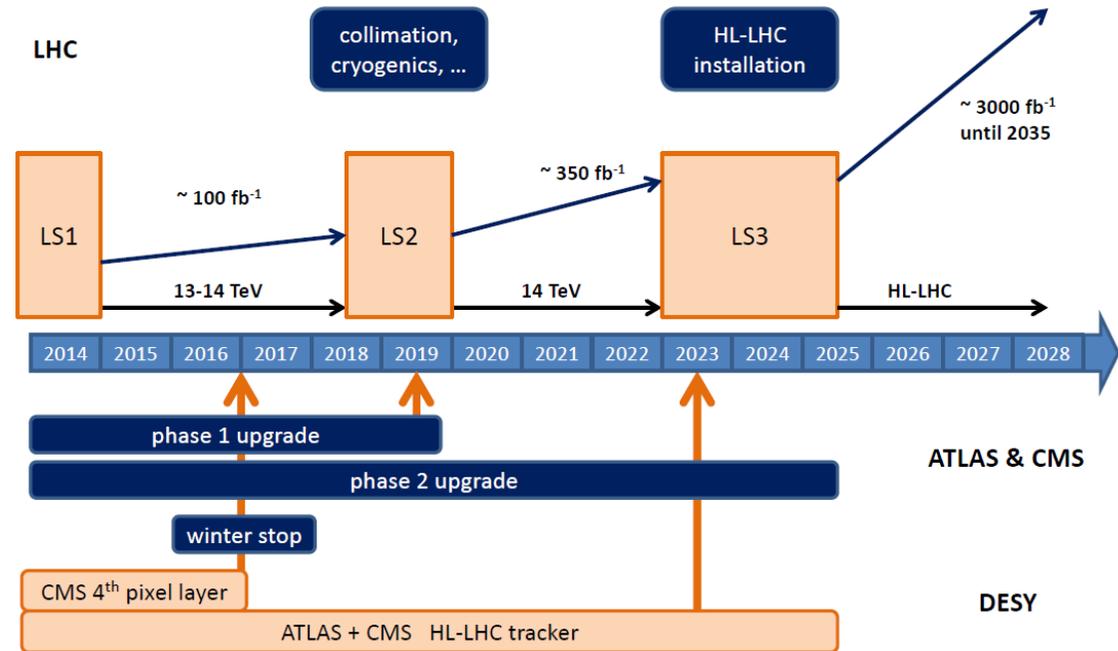
- Very successful run in 2012 at 8 TeV
- > 400 publications so far by each experiment (ATLAS & CMS)
  - Higgs discovery and properties
  - search for new physics
  - physics at  $10^{-19}$  m
- 2013/14 consolidation work
  - preparation of LHC and experiments for full energy (14 TeV) from 2015
  - work progressing on schedule
- Helmholtz centres play leading role in the LHC collaborations
  - physics, detector, computing, management



# LHC Future

- **Physics programme until 2035**  
LHC just started:

- so far just about half the maximum energy reached 8 TeV wrt. 14 TeV
- and 1% of the luminosity  $\approx 30 \text{ fb}^{-1}$  by end of 2012  $\approx 3000 \text{ fb}^{-1}$  expected by 2035



- **2015 ff LHC running at 13-14 TeV**
  - $\approx 100 \text{ fb}^{-1}$  by 2019
- **after 2022 High Luminosity LHC**
  - increase luminosity beyond  $10^{34}/\text{cm}^2/\text{s}$  by approx factor 5 to 10

## Major detector upgrades required

- Mainly tracking detectors
- Reach end of their lifetime with  $O(300 \text{ fb}^{-1})$
- Higher luminosity requires finer granularity and trigger capabilities

# LHC Detector Upgrades

- Proposal for Helmholtz Strategic Large Investments
  - **DESY: 20 M€ for investments into ATLAS & CMS tracker (phase II)**
  - **KIT: 3.8 M€ for CMS electronics**
  - **GSI: 4.2 M€ for ALICE TPC**
- Proposal in preparation
  - **to be considered in this evaluation for submission 2<sup>nd</sup> half 2014**
- Coherent approach with national and international partners
  - **e.g. plan for CMS tracker endcap**

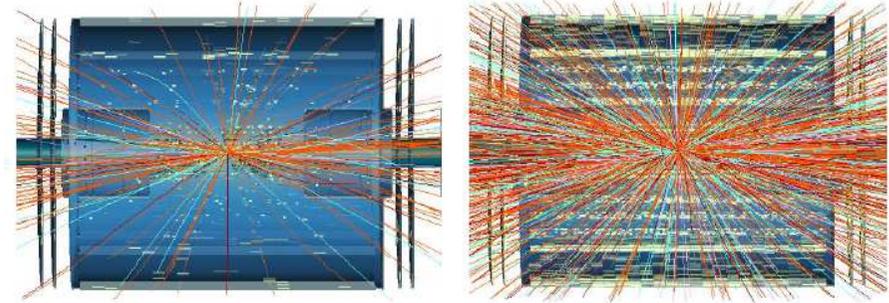
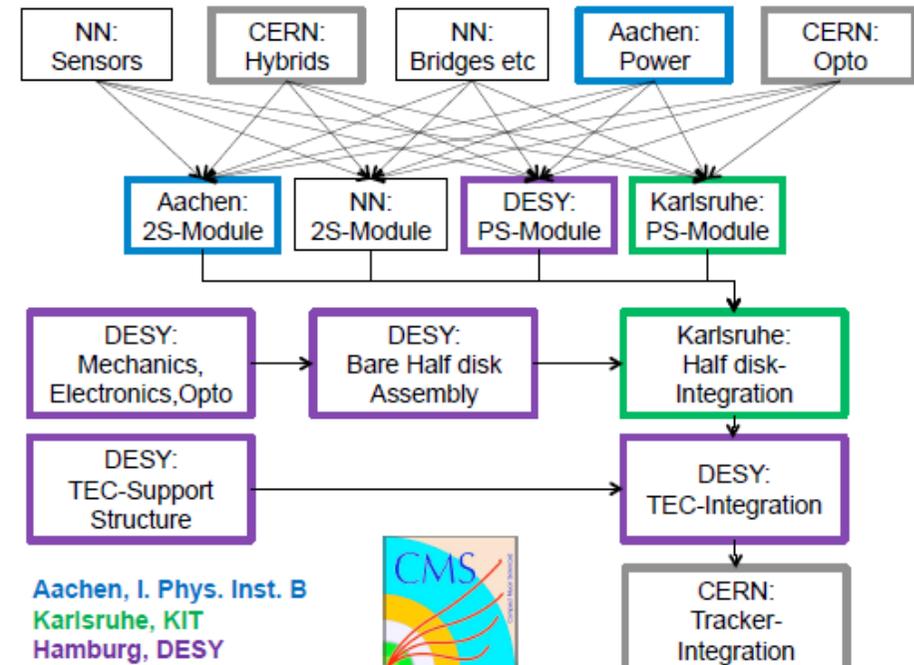


Figure 6: Simulated event in the ATLAS detector at the “low luminosity” ( $1 \cdot 10^{33}/\text{cm}^2\text{s}^{-1}$ ) phase of the LHC, and at the high luminosity ( $5 \cdot 10^{34}/\text{cm}^2\text{s}^{-1}$ ) phase. For the high luminosity phase, 200 pile-up events are simulated (see Table 1).



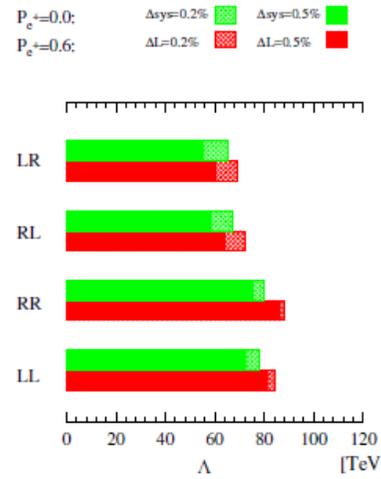
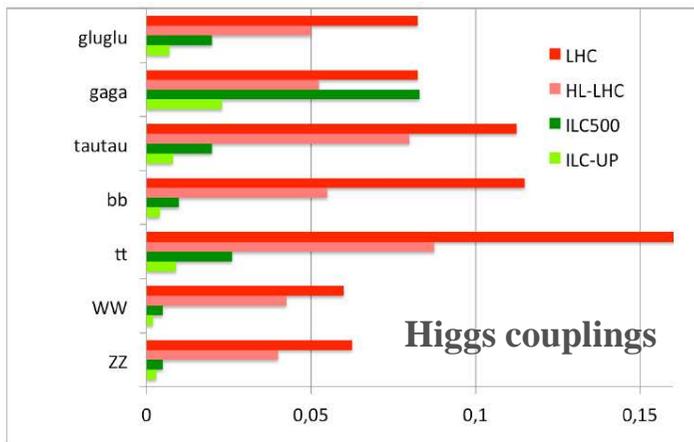
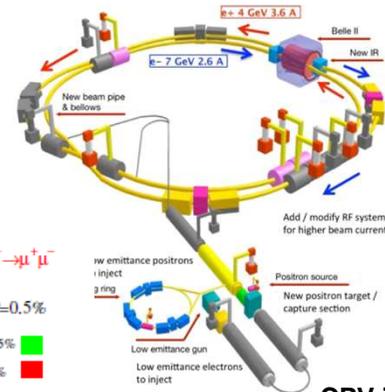
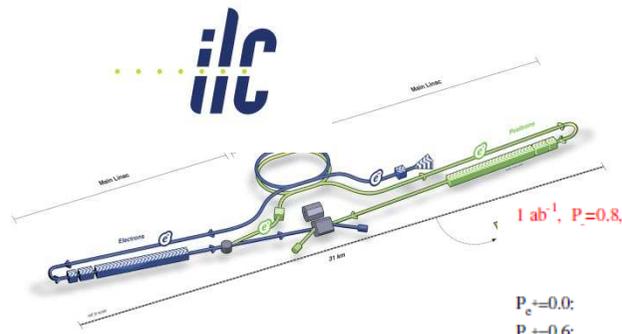
# Electron-Positron Physics

- Precision physics through collisions of fundamental particles:

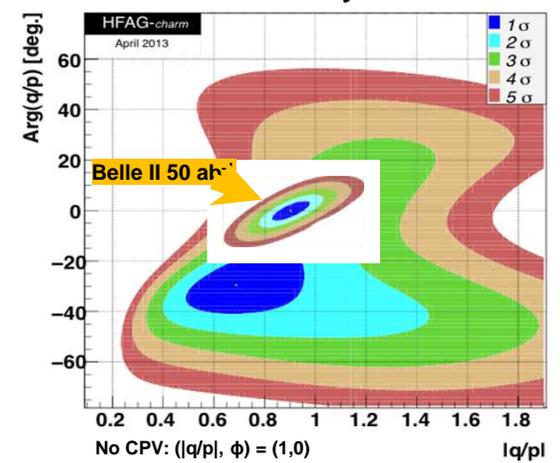
Model-independent studies of the Higgs

Indirect signals of New Physics at high mass scales

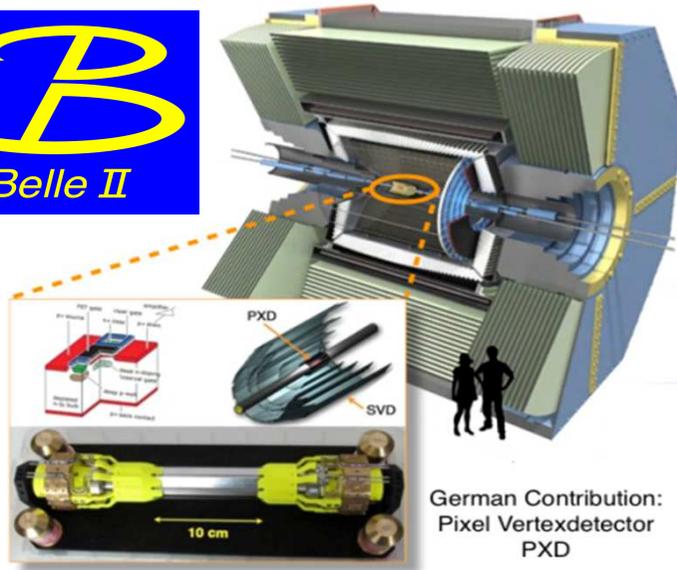
Matter-Antimatter Asymmetry



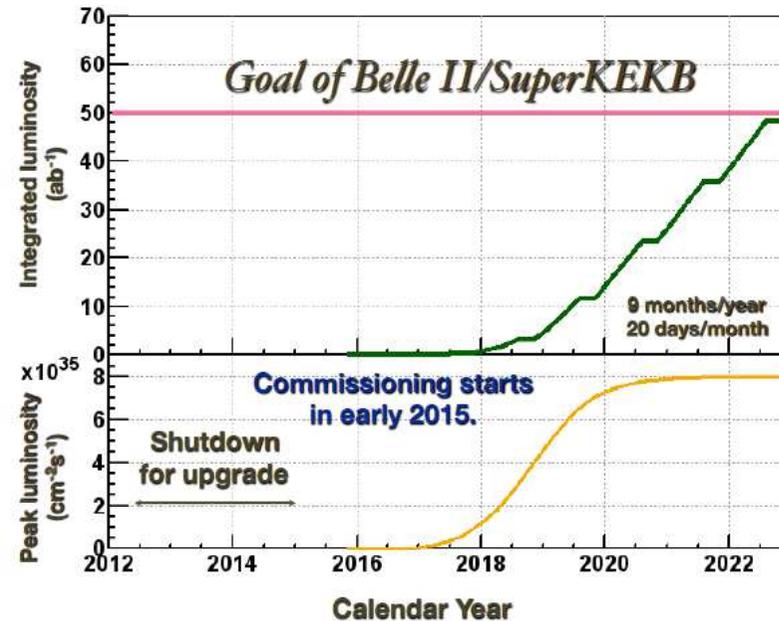
CPV in the  $D^0-\bar{D}^0$  System



# BELLE II at SuperKEKB



German Contribution:  
Pixel Vertexdetector  
PXD



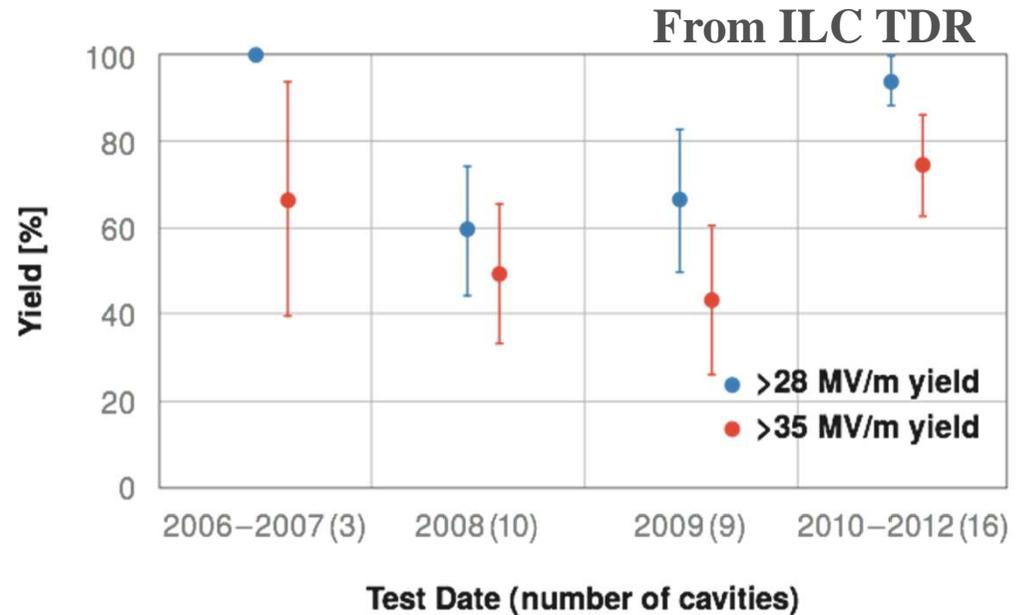
- German contribution: pixel vertex detector in DEPFET technology
  - Germany 2<sup>nd</sup> largest contribution in BELLE II
  - one of the largest HEP projects in D
- Helmholtz: support German Belle II groups by exploiting specific infrastructure and expertise available
  - cooling, mechanics, alignment, testbeam, ...
- Computing
  - Tier-1 at GridKa
  - Tier-2 at DESY



- Install & commission vertex detector in 2016
- Accumulate  $\approx 10 \text{ ab}^{-1}$  by 2019

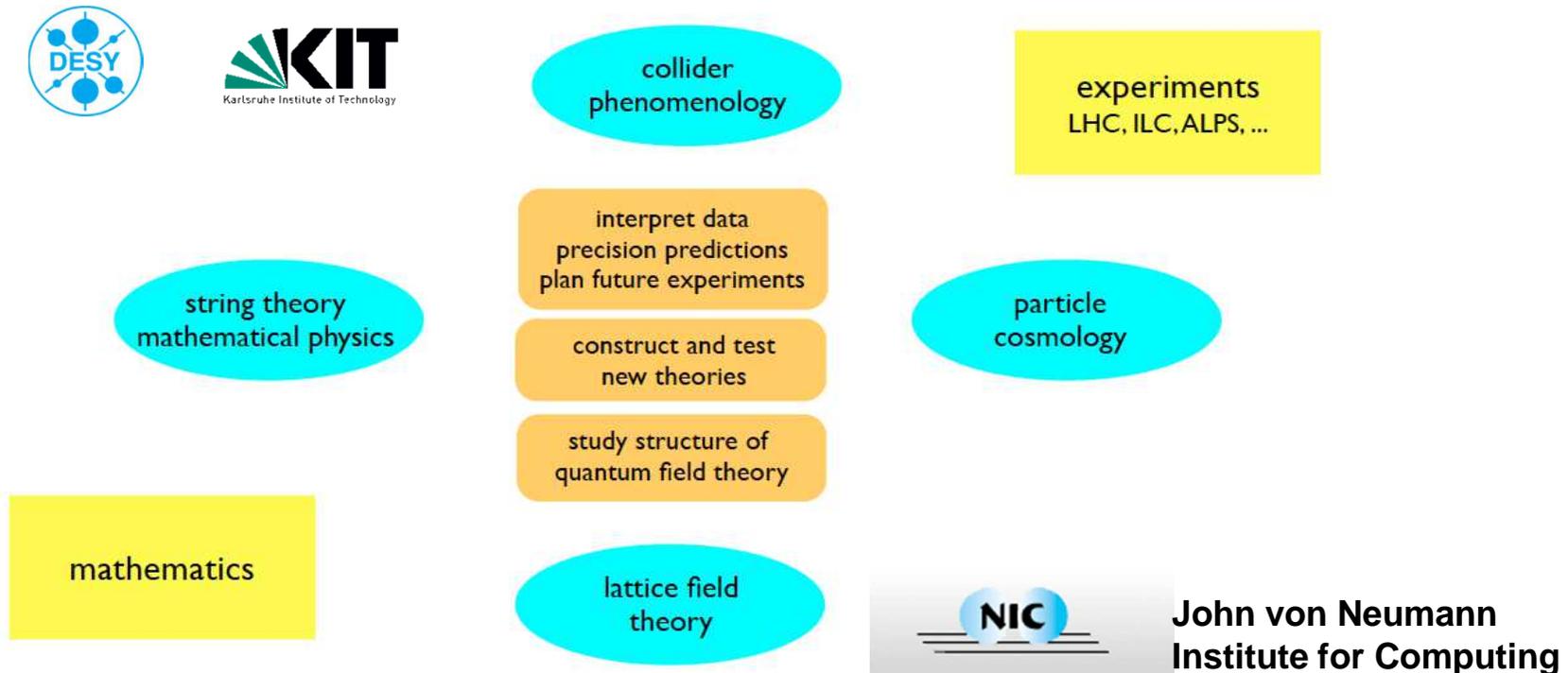
# International Linear Collider (ILC)

- 2013: Technical Design Report submitted and evaluated
  - R&D goals reached
  - synergy with XFEL construction
- Strong interest by Japanese scientists and politics to host the ILC
  - selection of a site in northern Japan
- R&D for accelerator & detector
  - strong synergy with Matter & Technology
- Unique role of DESY



# Particle Physics Theory

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



- **Collaboration between different HGF centres: DESY, **KIT (new)**, 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:**



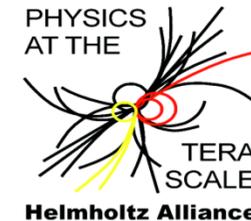
Particles, Strings,  
and the Early Universe  
Collaborative Research Center SFB 676



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

LHCphenonet

HiggsTools



WOLFGANG-PAULI-CENTRE  
A COMPETENCE FIELD OF PIER



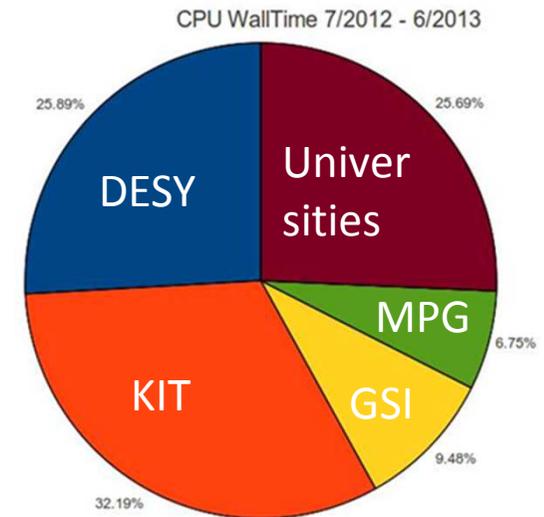
- **Industry cooperations: Wolfram Research, MapleSoft, RISC Software GmbH**

# 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

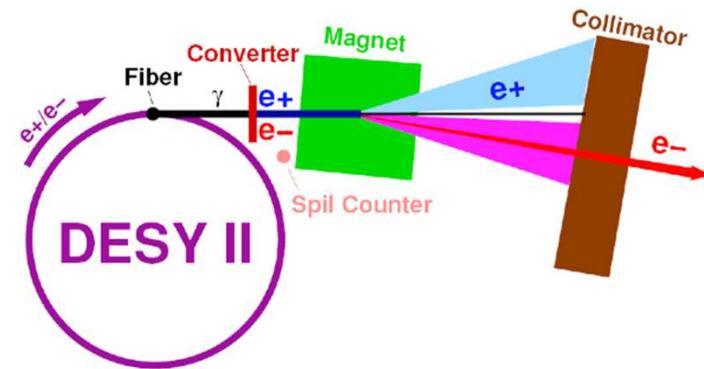
**Helmholtz provides > 2/3 of the German LHC computing share!**

- DESY testbeam (→ next slide)
- Laboratory for large detectors
  - intended as detector development hub for particle physics (LHC) in Germany  
→ **LHC Detector Upgrade**
- Alliance “*Physics at the Terascale*“
  - platform for exchange in German HEP community physics, detectors, computing
  - Analysis Centre at DESY as central hub
  - education:  $\approx 15$  schools & workshops per year attracting many young people
  - common events of the 3 Alliances (→ MUTLINK)

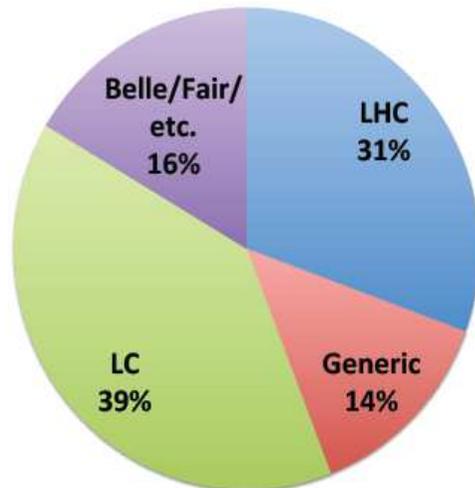


# DESY Testbeam

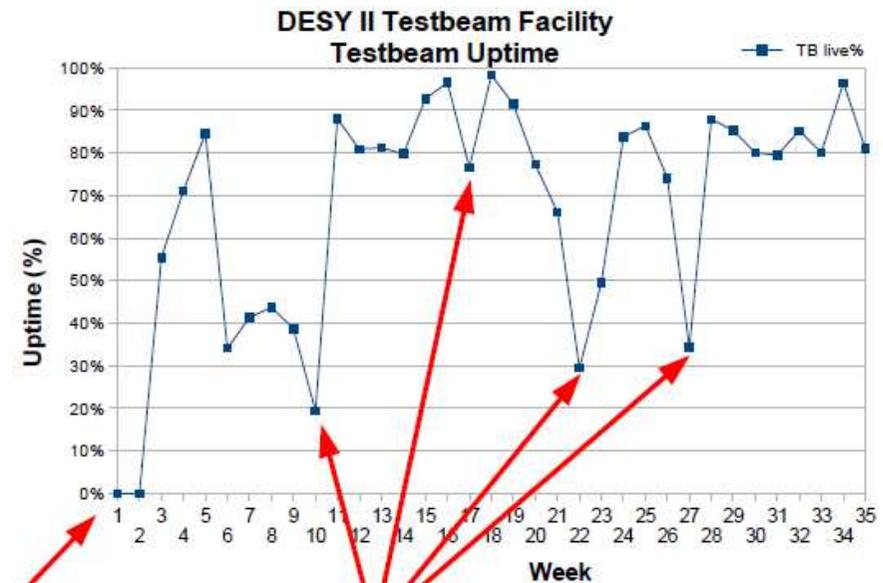
- Increasingly important facility for detector R&D  
→ **Matter & Technology**
- Used by many projects  
– ≈ 400 users in 2013



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



User groups represent all HEP communities.



Ramp-Up

Wartungswoche

# 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
- **LK II Computing facilities**
  - essential for the physics programme
- **Helmholtz Particle Physics programme 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 Isabel 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**

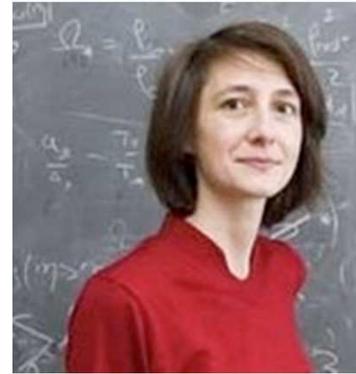


**2014 María Aldaya Martín**  
**CMS top physics**



# Helmholtz Recruitment Initiative

- Successes in Helmholtz-wide competition
- Appointment procedures with universities ongoing
- **Geraldine Servant (Barcelona)**
  - international leading theorist at the interface between cosmology and collider physics
  - offer from Hamburg University
- **Christophe Grojean (Barcelona)**
  - international 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



# Backup Slides

# Young People

- **Career development of Helmholtz Young Investigator Group Leaders since 2009**
- **Many are now university professors:**



**Laura Covi**  
**W3 professor at**  
**U Göttingen**



**Erika Garutti**  
**W2 professor at**  
**U Hamburg**



**Sven Moch**  
**W2 professor at U**  
**Hamburg**



**Ulrich Husemann**  
**W3 professor at KIT**  
**Karlsruhe**

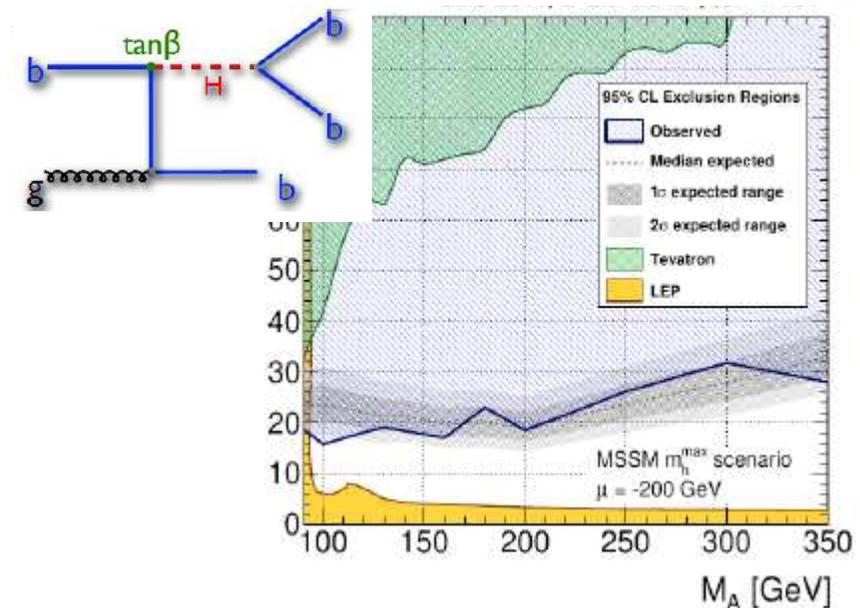
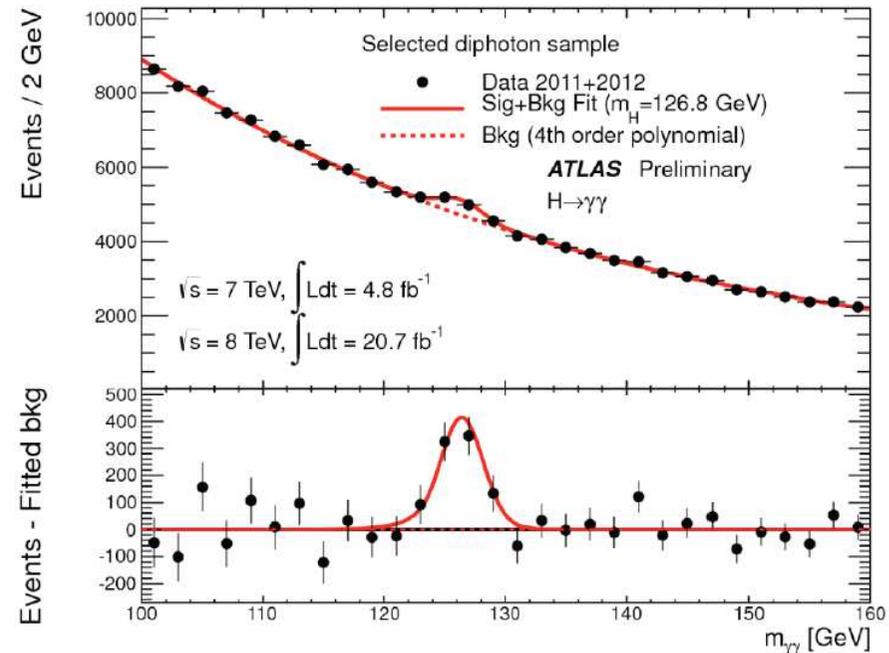
# Helmholtz Alliance „Physics at the Terascale“

- **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
- **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 beyond 2014 only a limited Alliance program will be possible!**
  - schools & workshops
  - hopefully keeping the structure in Germany
  - no support for common projects

Money is tied  
to specific positions

# 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  $\Phi \rightarrow 3b$
  - with KIT
- In both examples analysis performed by YIGs



# Plans 2015-19

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

- Physics
- Operation
- Detector upgrades

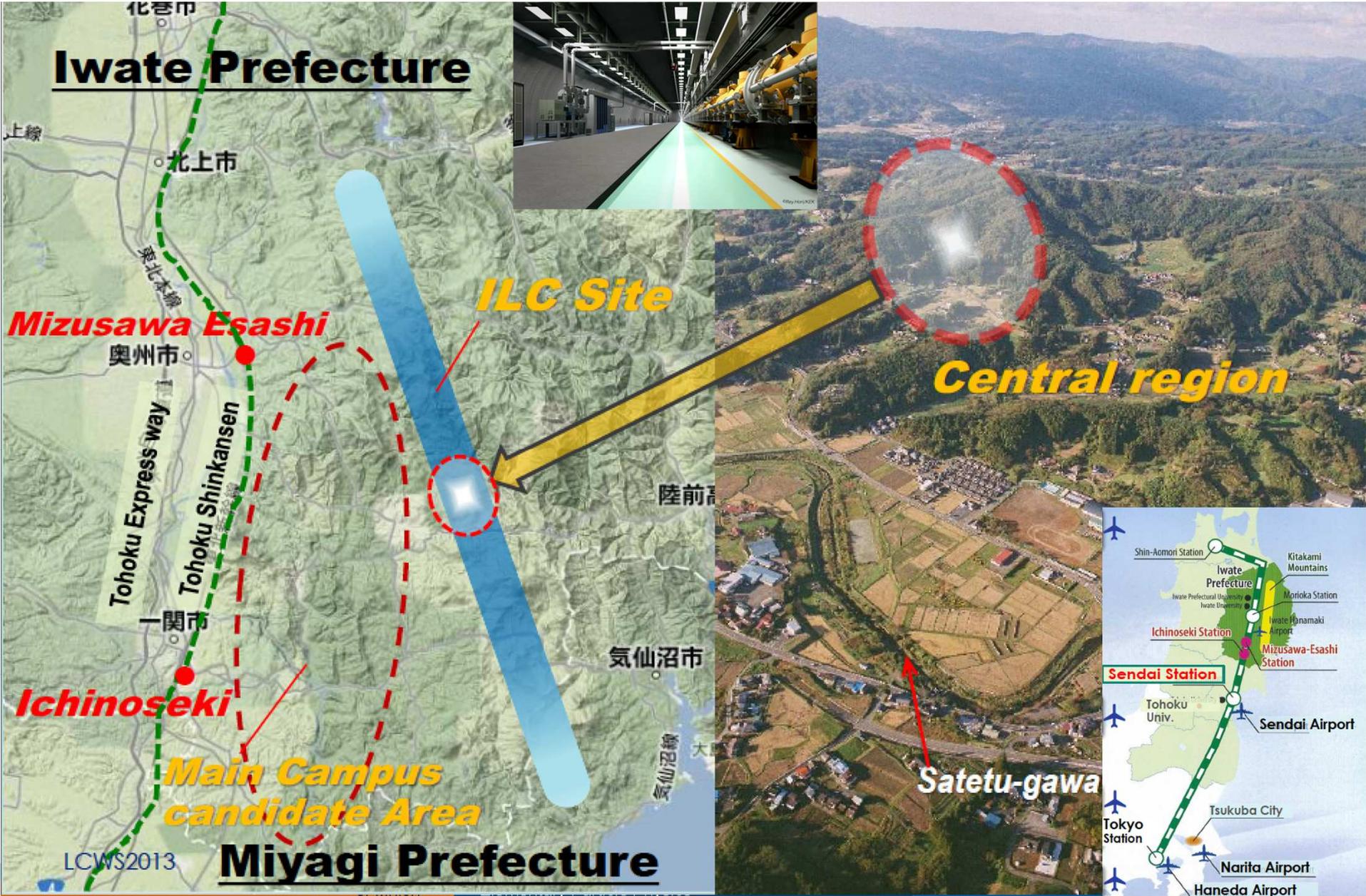
- > Performing physics analyses & preparatory studies for upgrade
    - physics topics: Higgs, SUSY, top-quark, QCD, electro-weak
  - > Operation and maintenance of detectors
    - Fulfill long-term commitments and prepare for future role as integration centre
  - > Short term & long term detector upgrades
    - 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

# LHC Schedule

F. Bordry, 02.12.2013



# ILC Site Selection

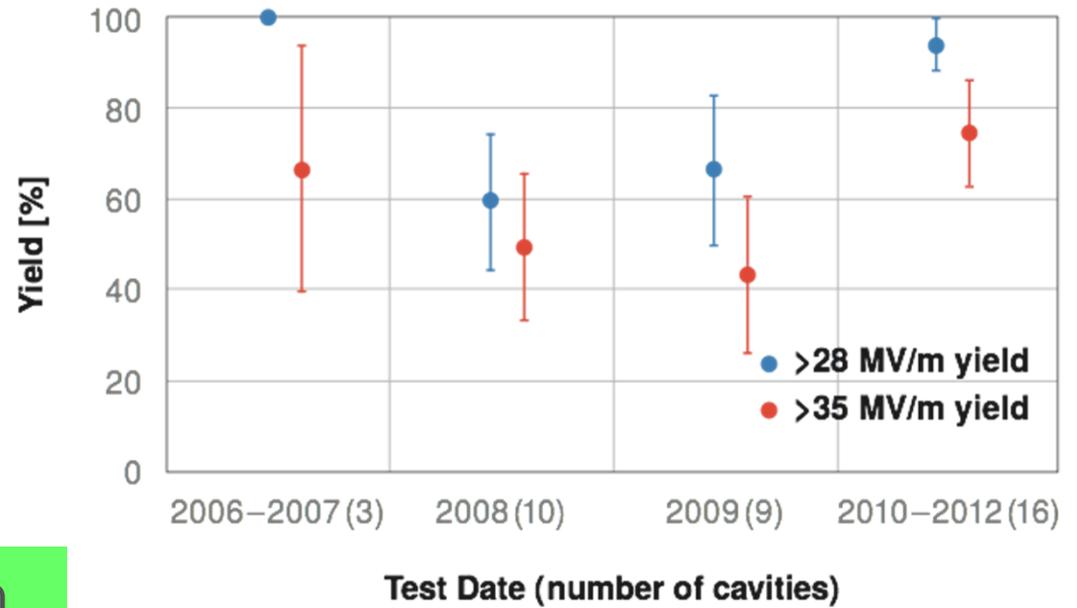


# ILC

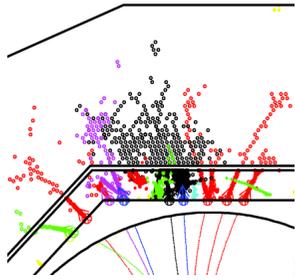
- **ILC in short**
  - ~18000 SCRF cavities
  - 31.5 MV/m
  - 1750 cryomodules

- **European XFEL**
  - based on same technology
  - 840 cavities
  - 24 MV/m req.
  - 100 cryomodules

main goal

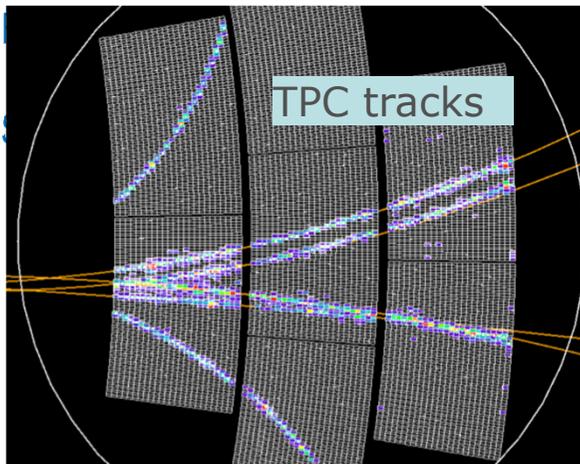


# ILC Detector



→ Programme Matter and technology

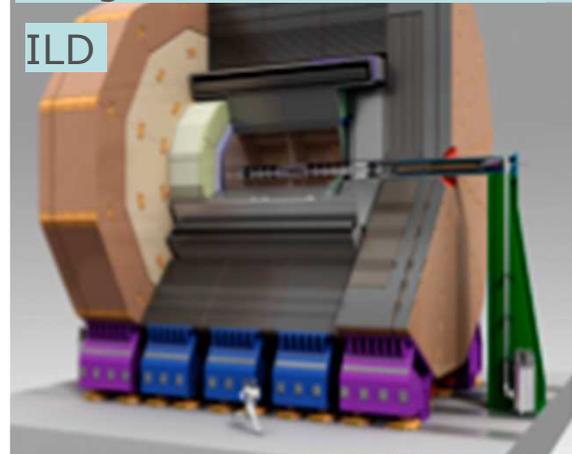
- DESY leading center effort
- Physics studies (with theory)
- Detector concept ILD
- Time projection chamber
- Hadron calorimeter



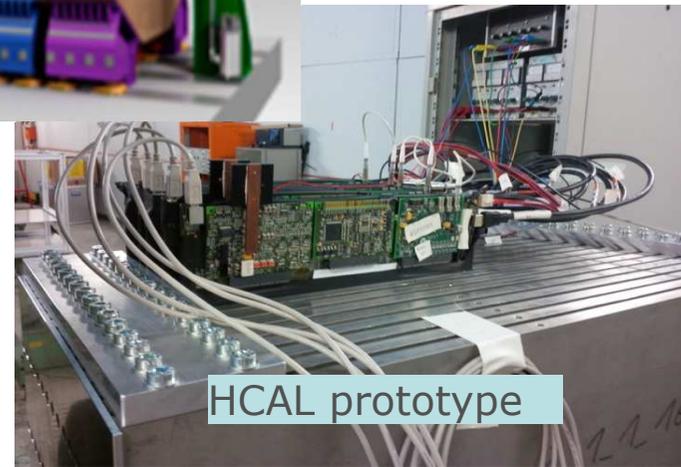
TPC tracks

Integration and software

ILD

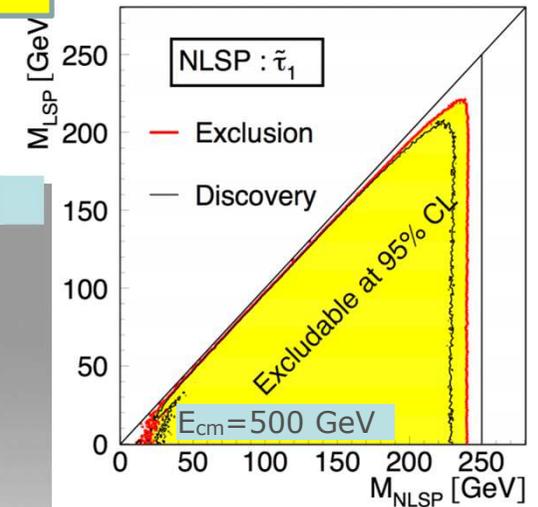


DESY test beam



HCAL prototype

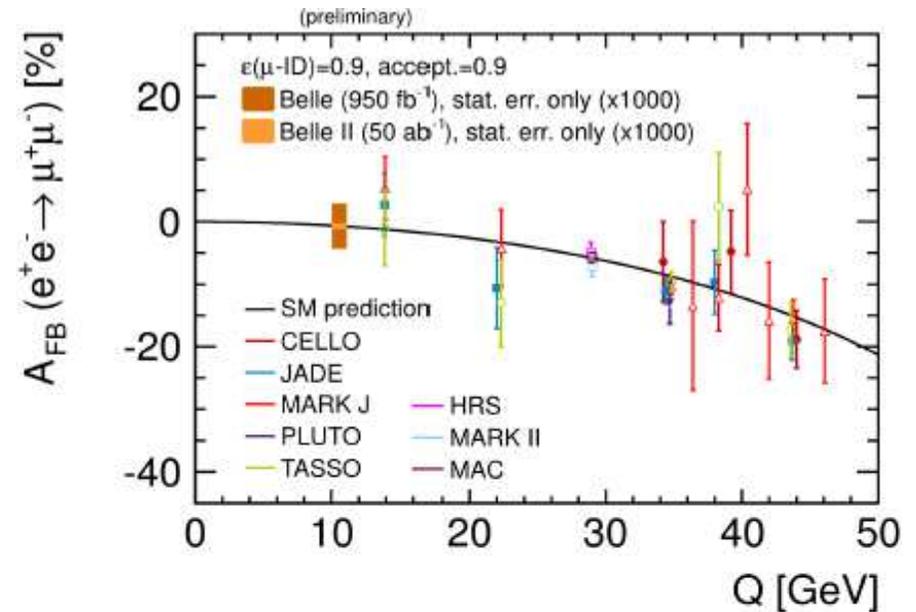
stau discovery reach



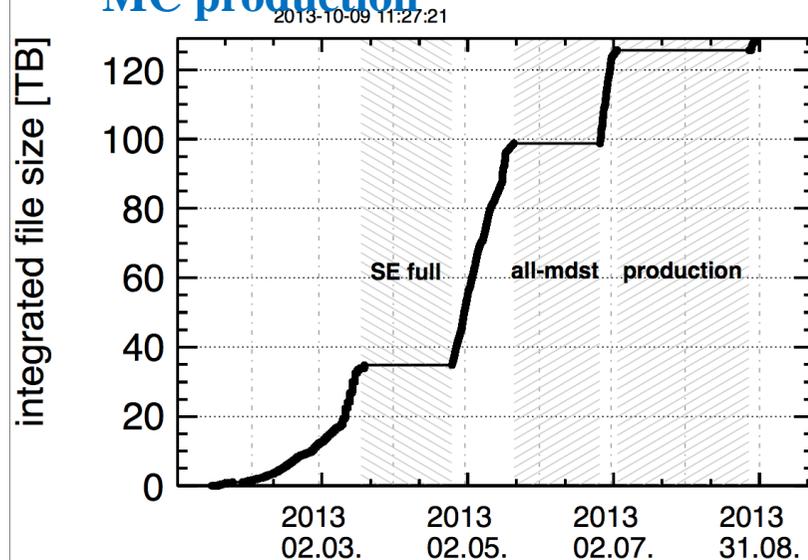


# DESY in BELLE I

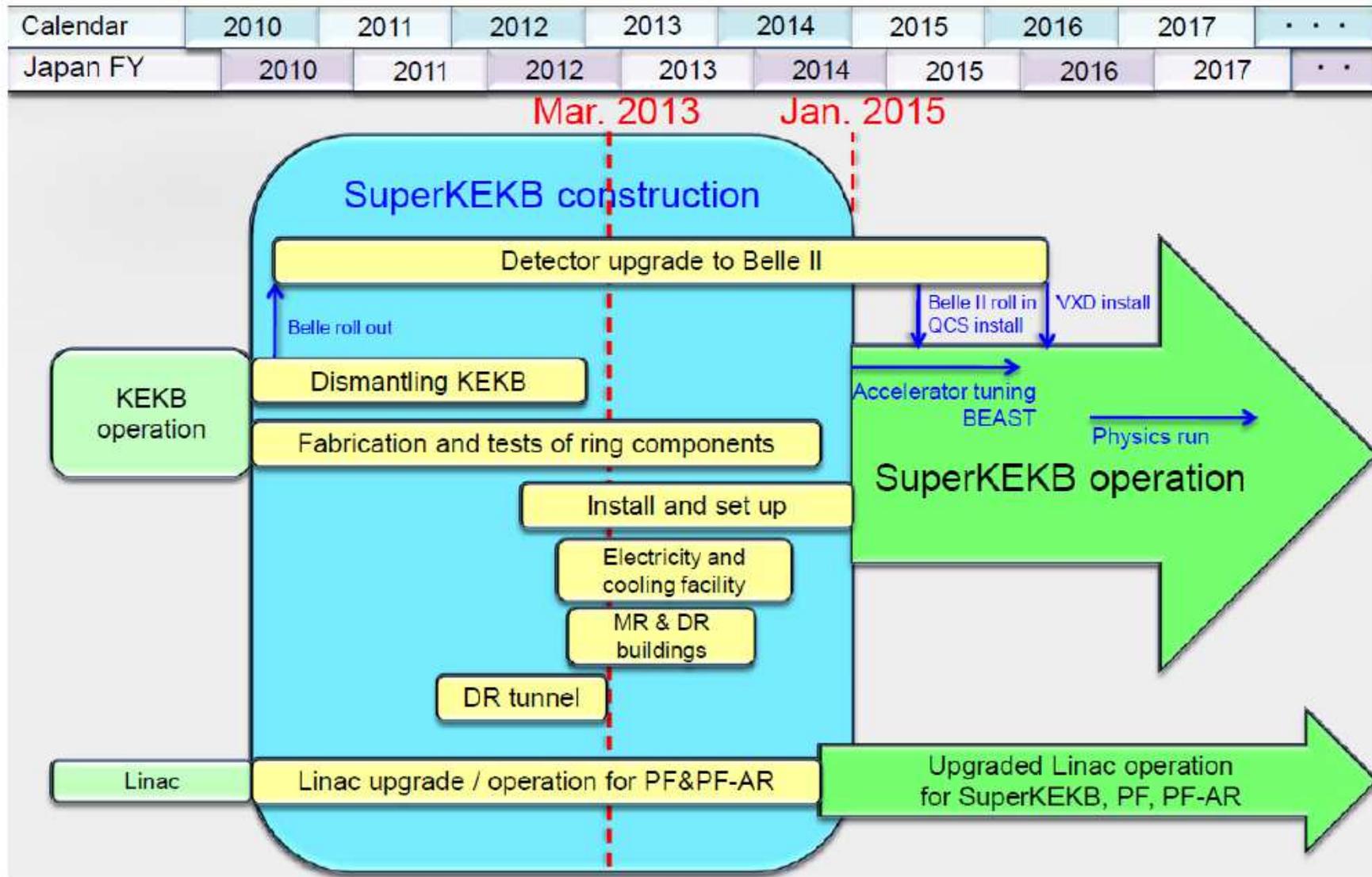
- Access to the world largest data sample at the Y(4S)
  - about  $1000 \text{ fb}^{-1}$  collected between 1999 and 2010
- Start analysis of  $A_{\text{FB}} e^+e^- \rightarrow \mu^+\mu^- (\gamma)$ 
  - replicate full Belle I data set at DESY
  - one of the leading centres for Belle II



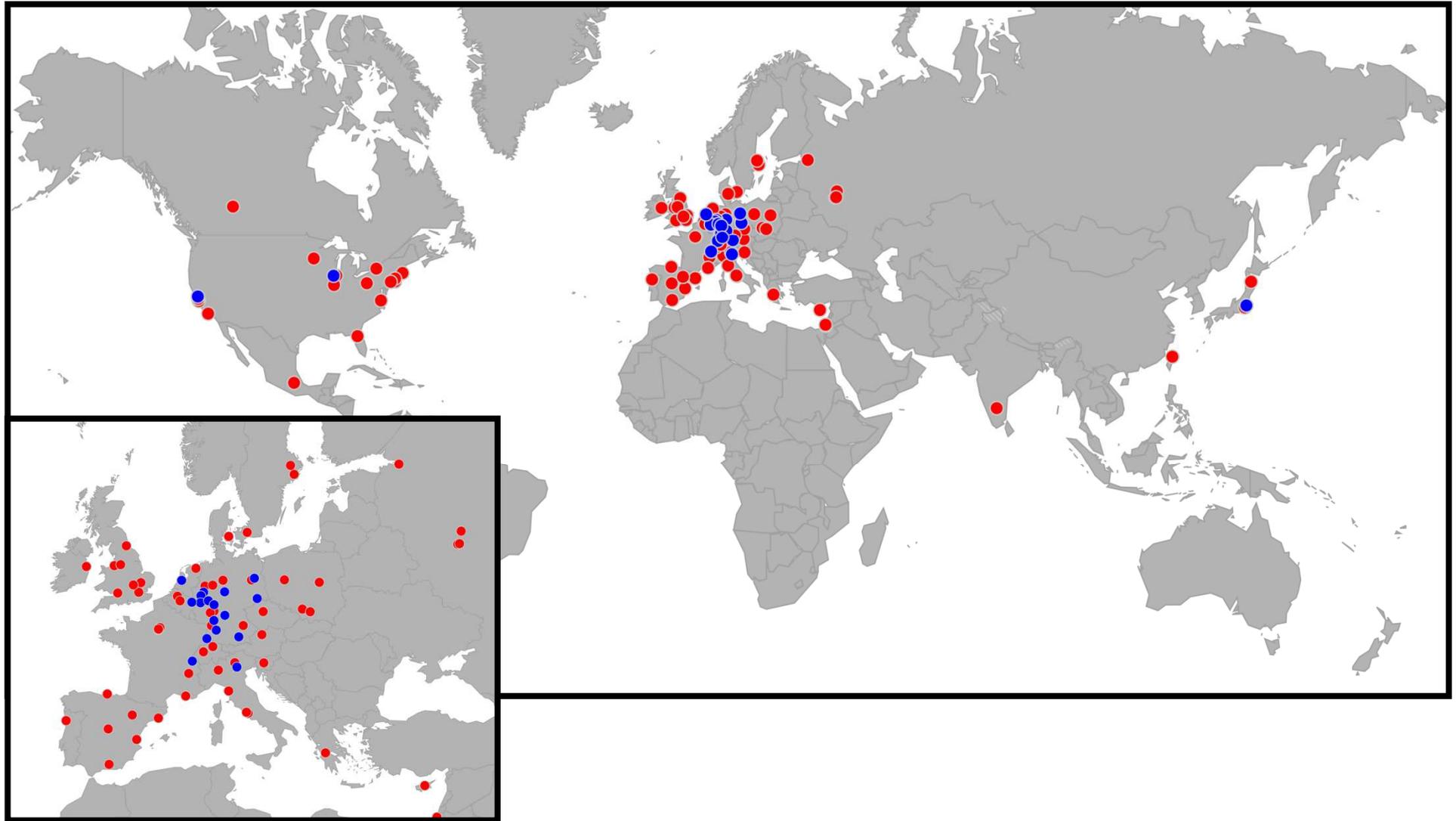
## MC production



# Belle II Schedule



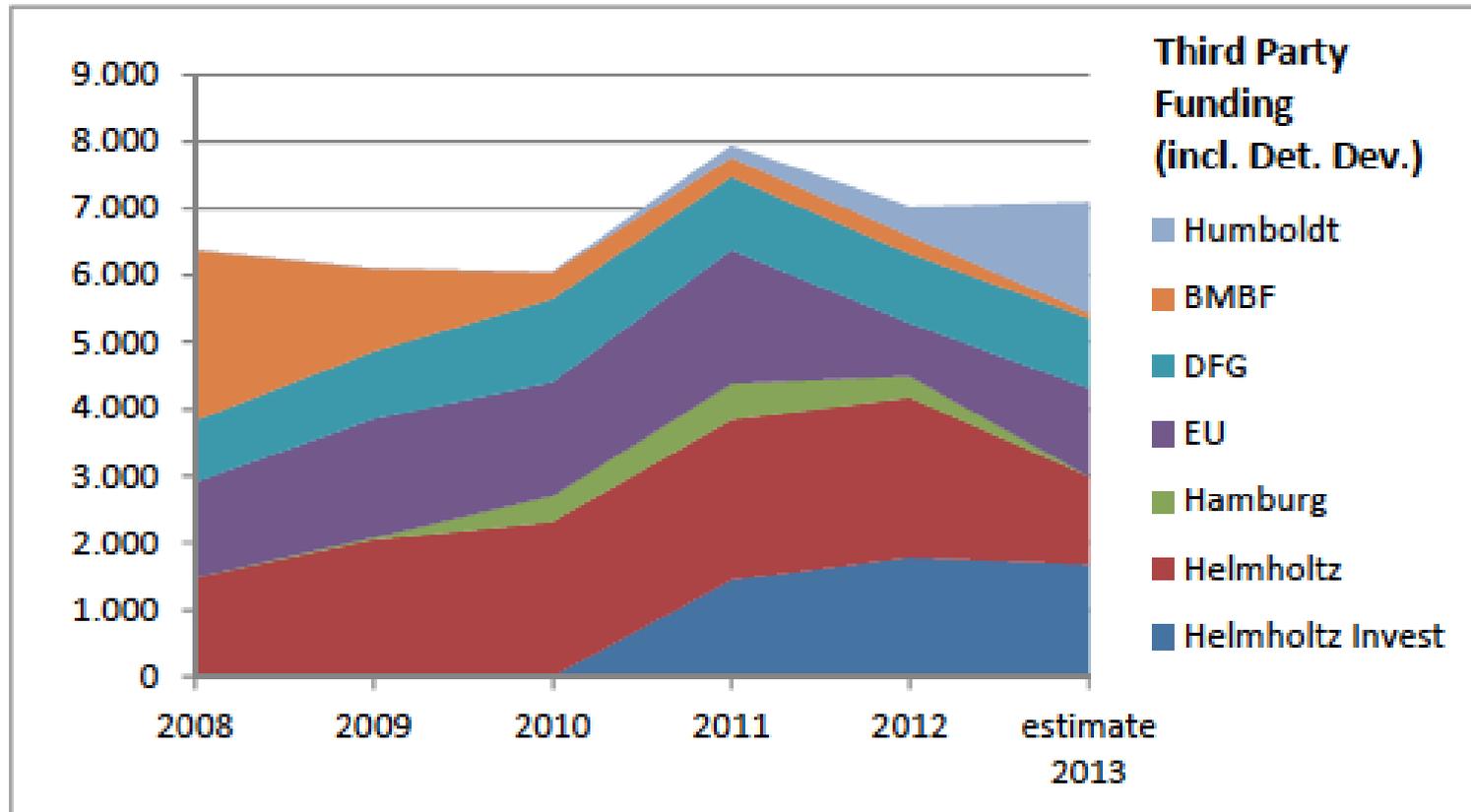
# DESY Cooperations in Particle Physics



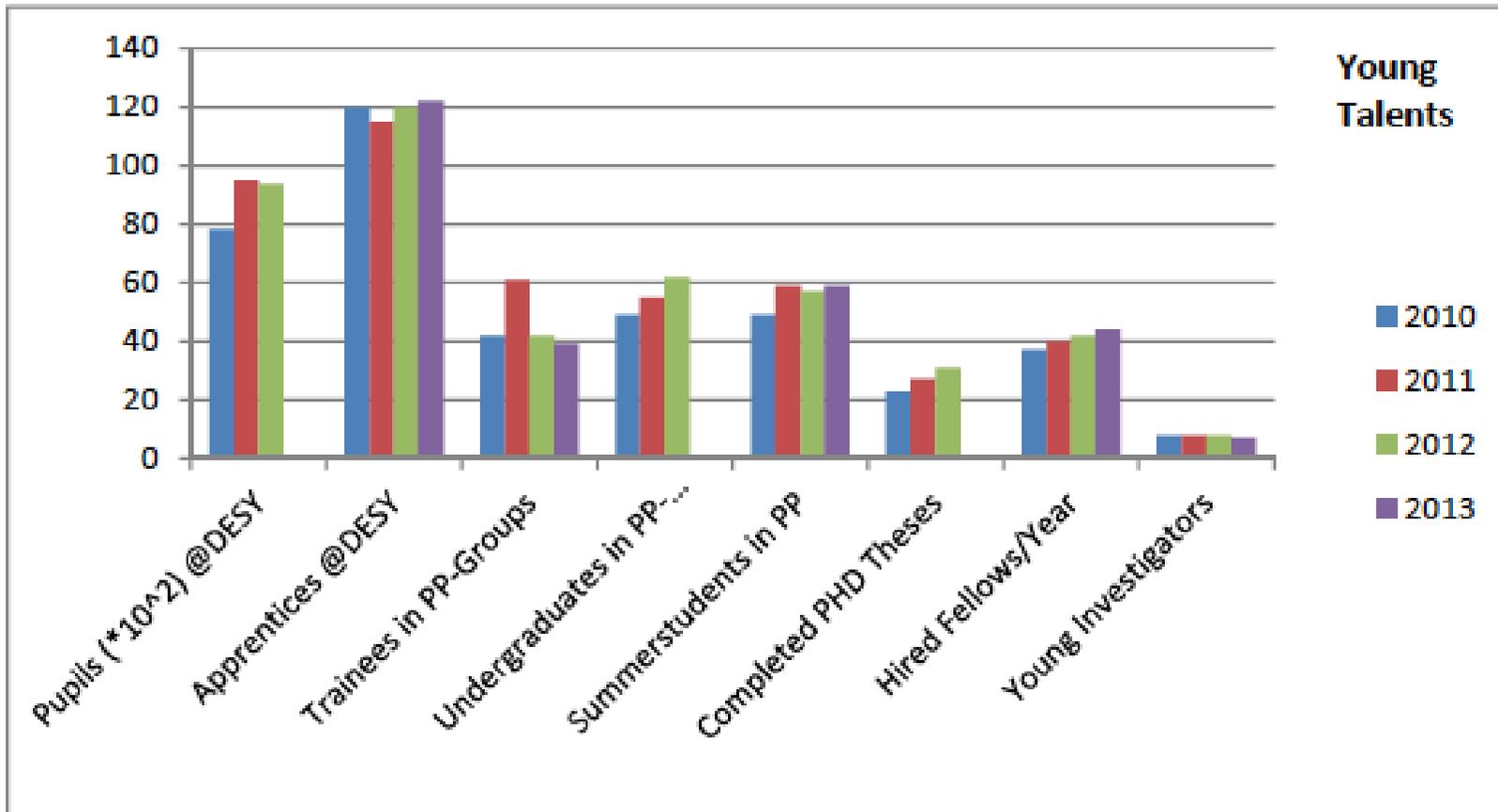
# DESY Particle Physics

# Facts

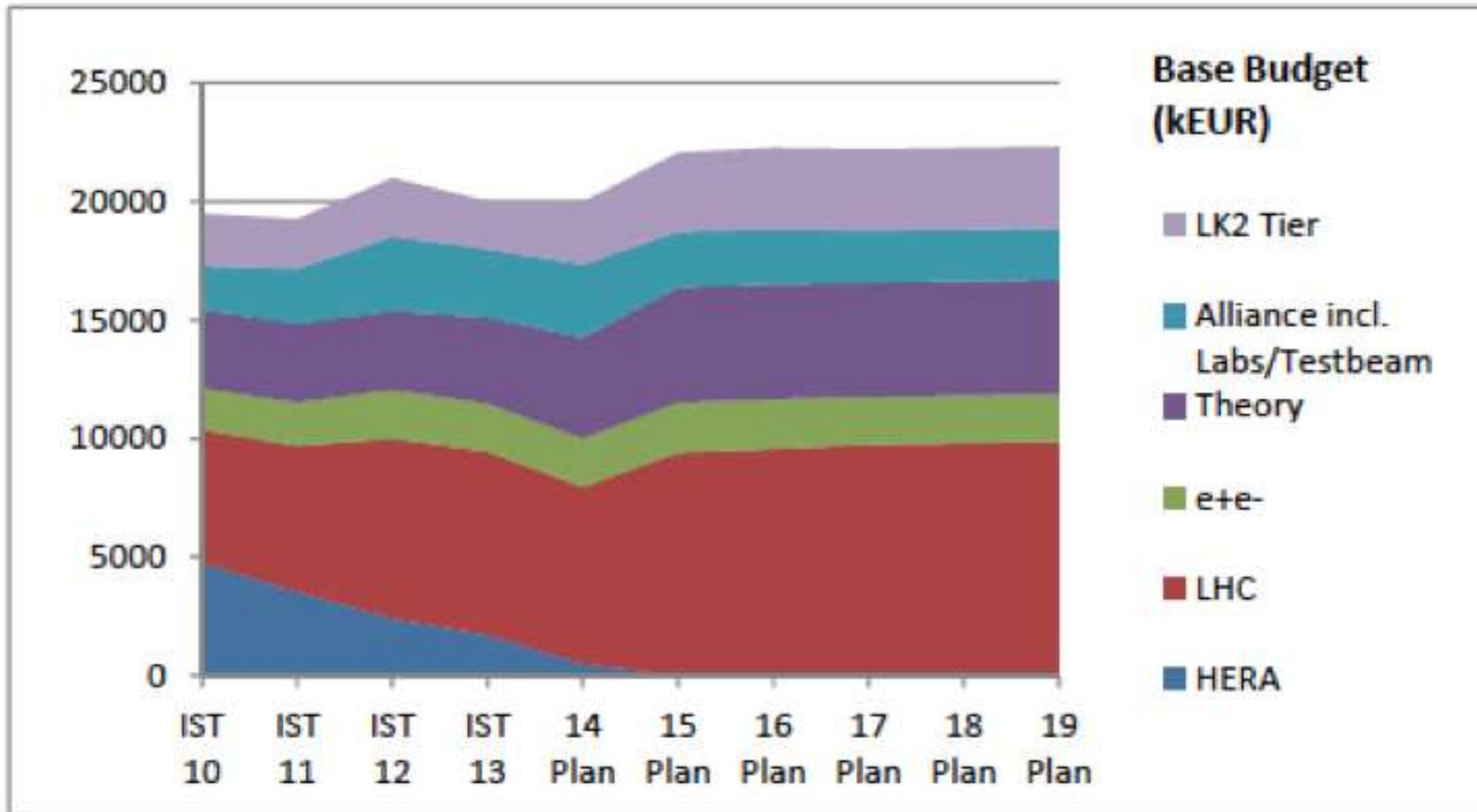
# THIRD-PARTY FUNDING



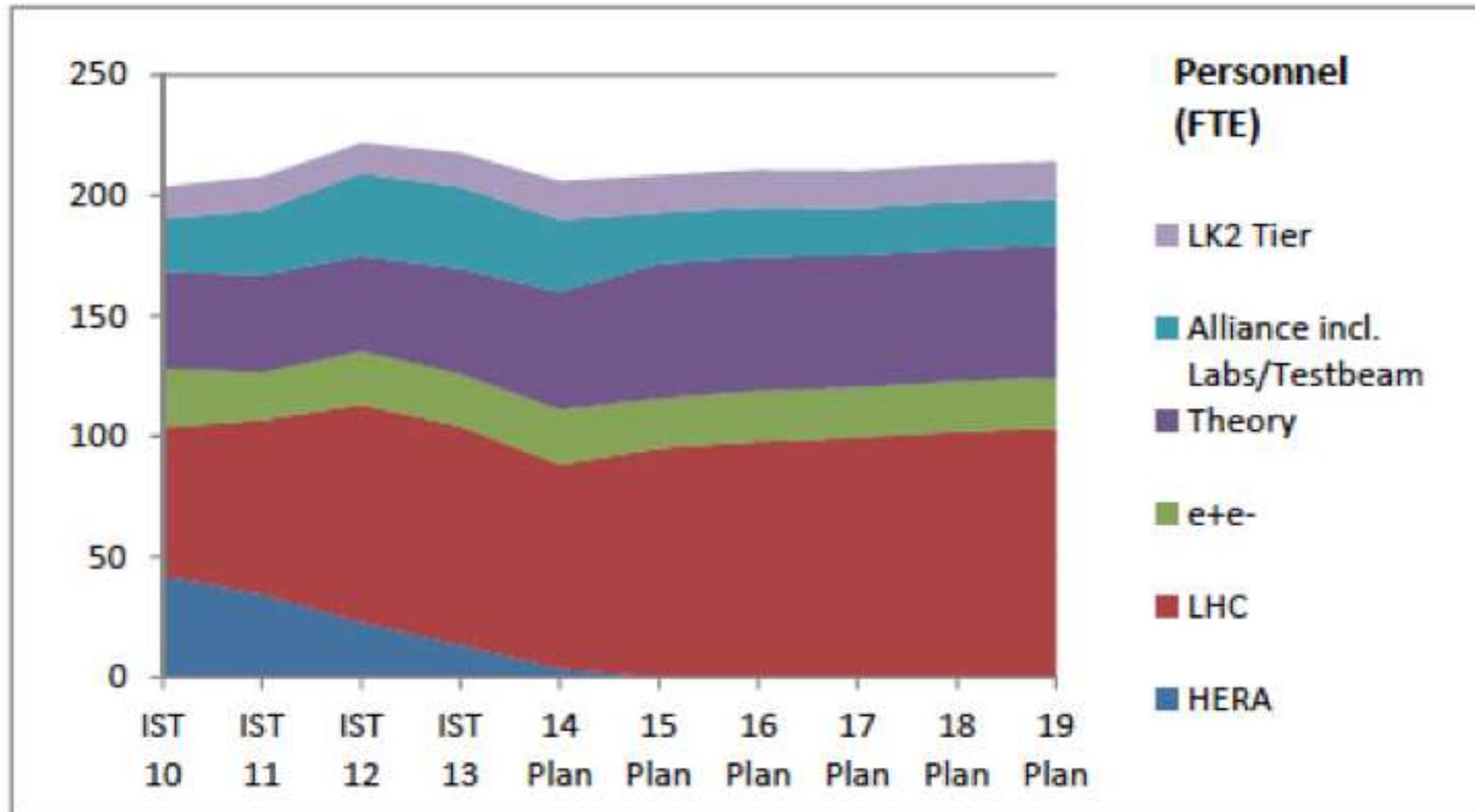
# YOUNG TALENTS @ DESY



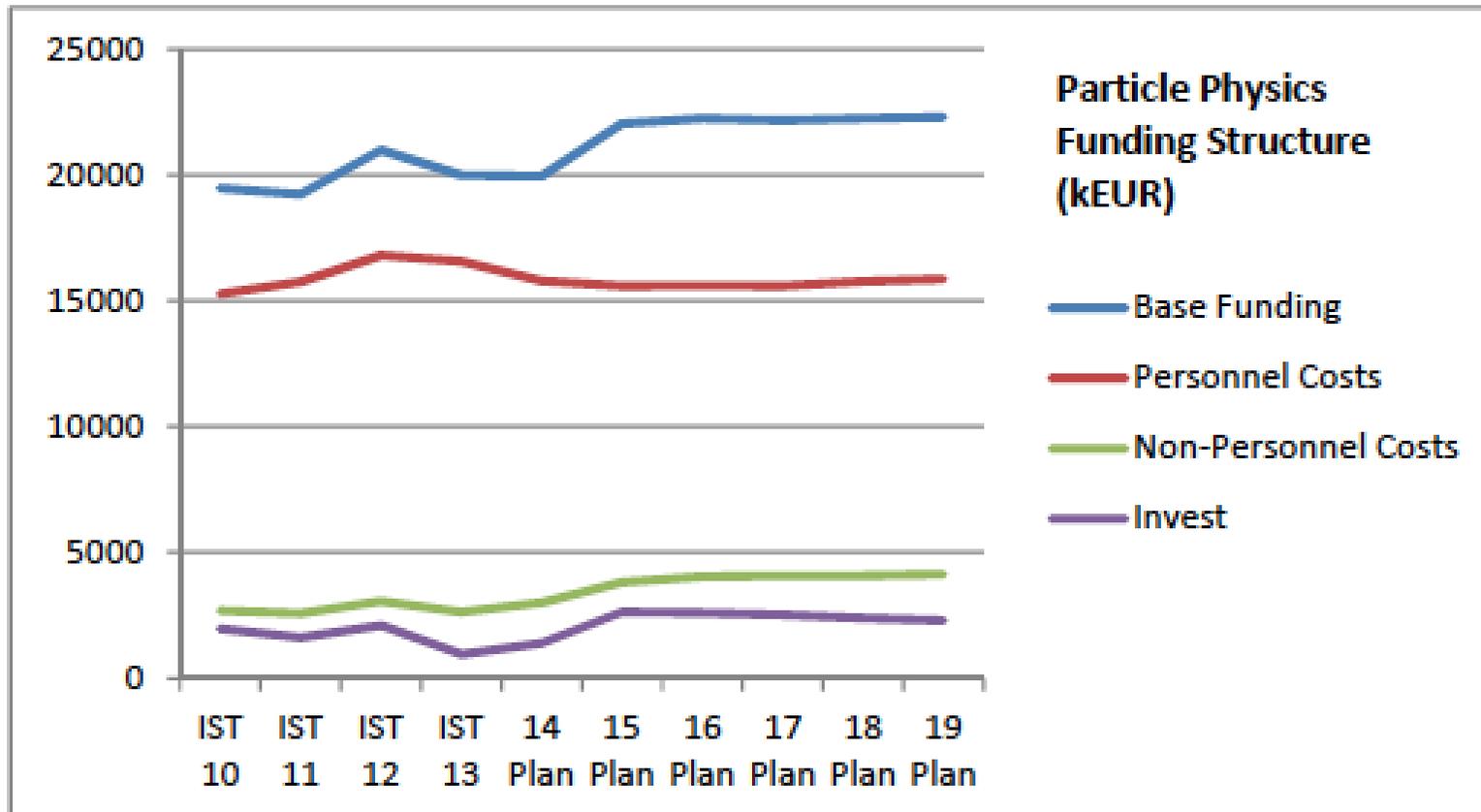
# FUNDING



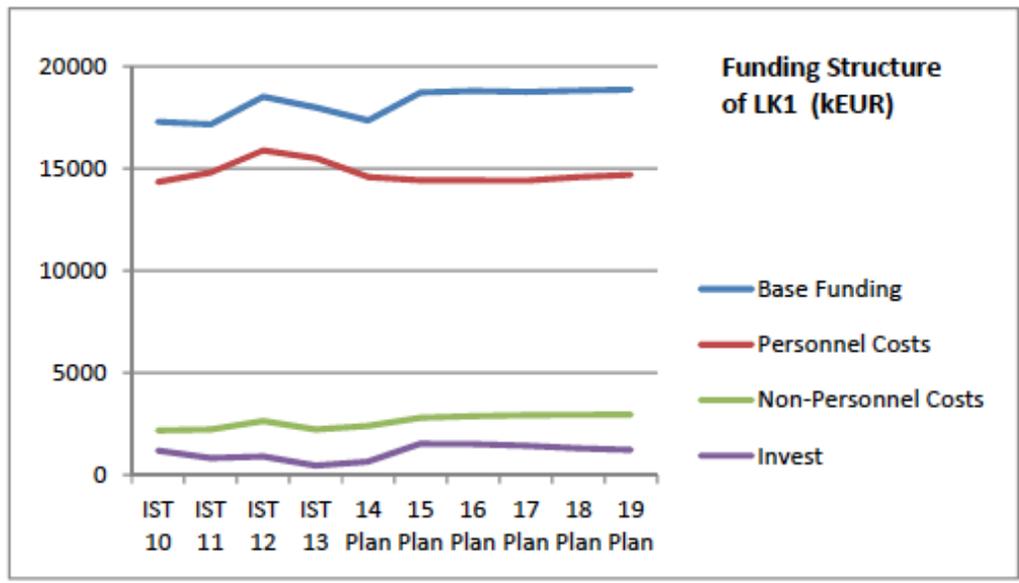
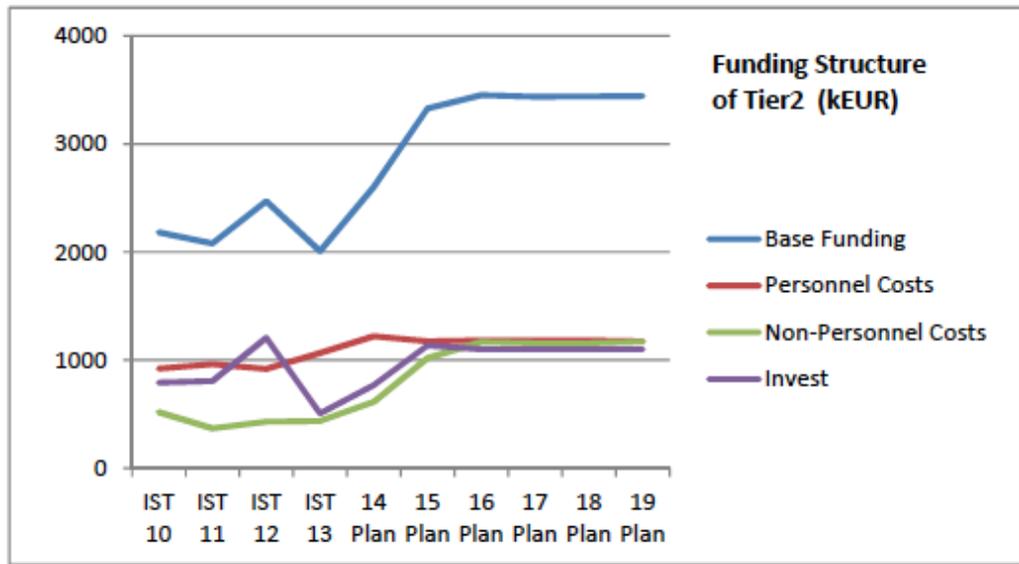
# PERSONNEL



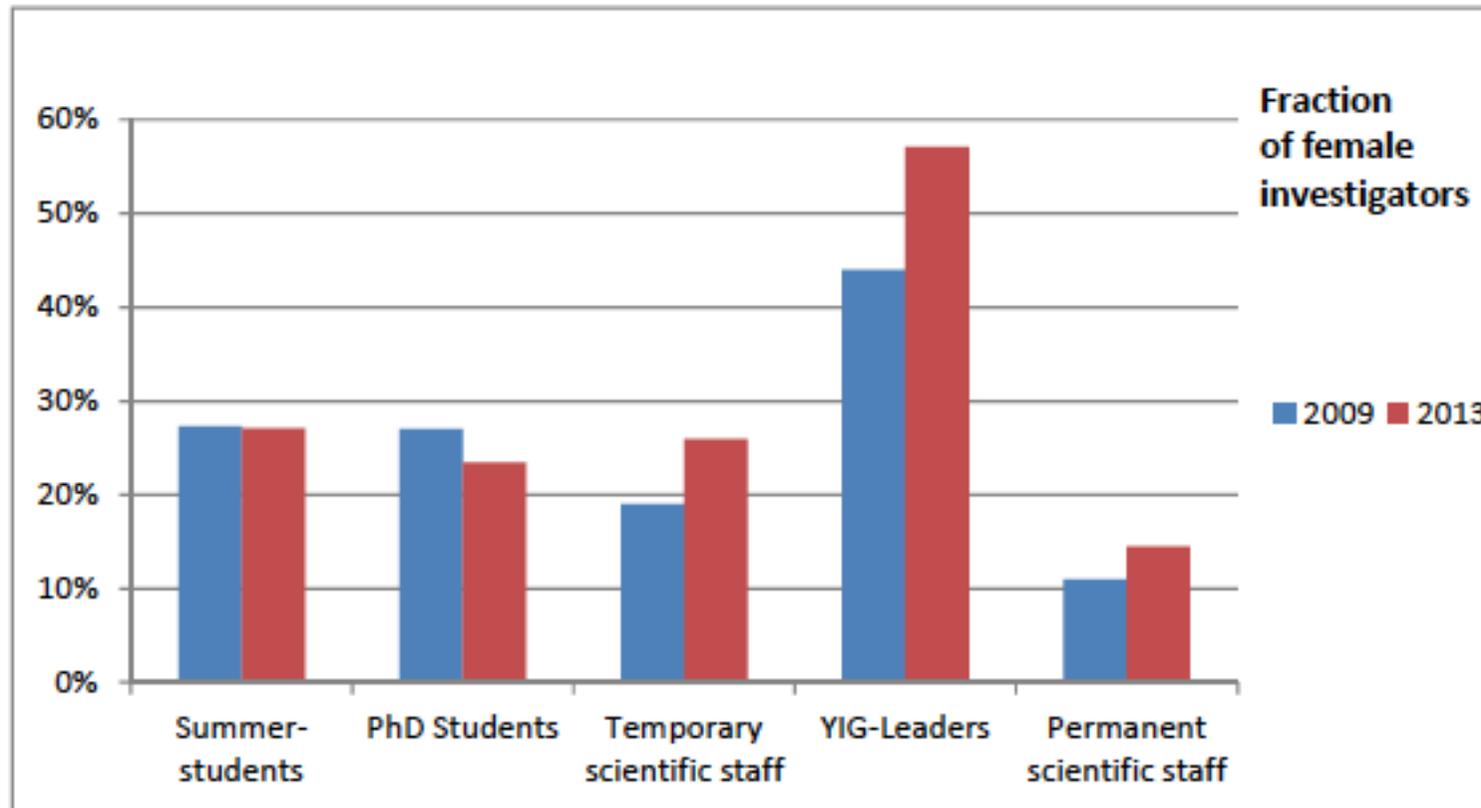
# FUNDING STRUCTURE



# FUNDING STRUCTURE – LK1/2



# GENDER DISTRIBUTION



# AGE DISTRIBUTION

