

# Particle Physics at the Institute of High Energy Physics (HEPHY) of the Austrian Academy of Sciences

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RECFA site visit of Austria  
April 6th, 2018

Jochen Schieck  
HEPHY and TU Wien



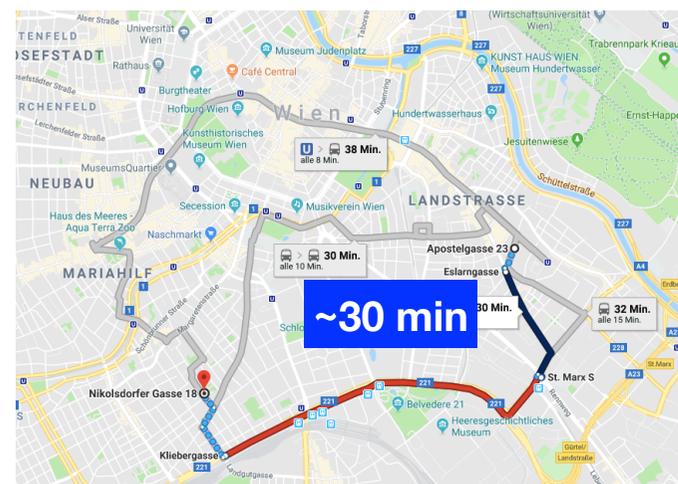
# Background Information about HEPHY

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- HEPHY was founded in 1966 to fully exploit the Austria's membership to CERN (Austria joined CERN in 1959)
- HEPHY is Austria's largest research institute focusing on experimental particle physics
  - Significant contribution to Austria's education and outreach in experimental particle physics
- Only one professorship for experimental particle physics in Austria (TU Wien - since 2014) which is held by Jochen Schieck, director of HEPHY
  - Close collaboration of HEPHY with TU Wien in education and research

# HEPHY - more Information

- HEPHY research institute funded by the Austrian Academy of Sciences
- Institute currently split in two locations; renovation or new location since several years under discussion
- Currently about 75 people working at the institute
  - ~ 25 junior and senior scientists
  - ~ 20 PhD students
  - ~ 20 technical personal
  - ~ 10 students and internships



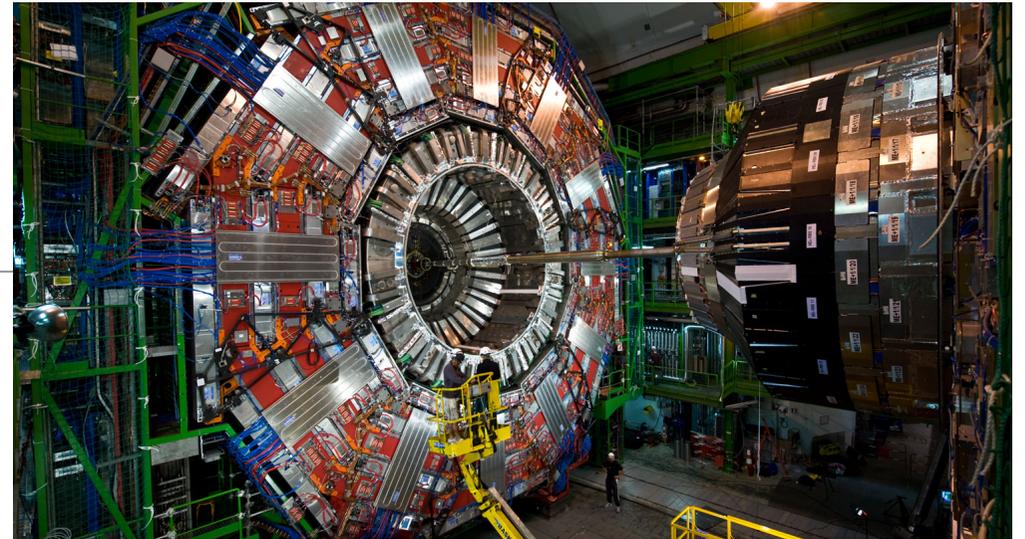
# HEPHY - Scientific Program

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- Contribution to experimental program in various leading international particle physics laboratories
  - CERN - **CMS**-experiment at the LHC
  - KEK - **Belle II**-experiment at the SuperKEKB
  - LNGS - **CRESST**- dark matter experiment
- Detector development with focus on **silicon based detectors**
- Theory group working on **dark matter**, **SUSY** and **QCD**

# CMS @ LHC

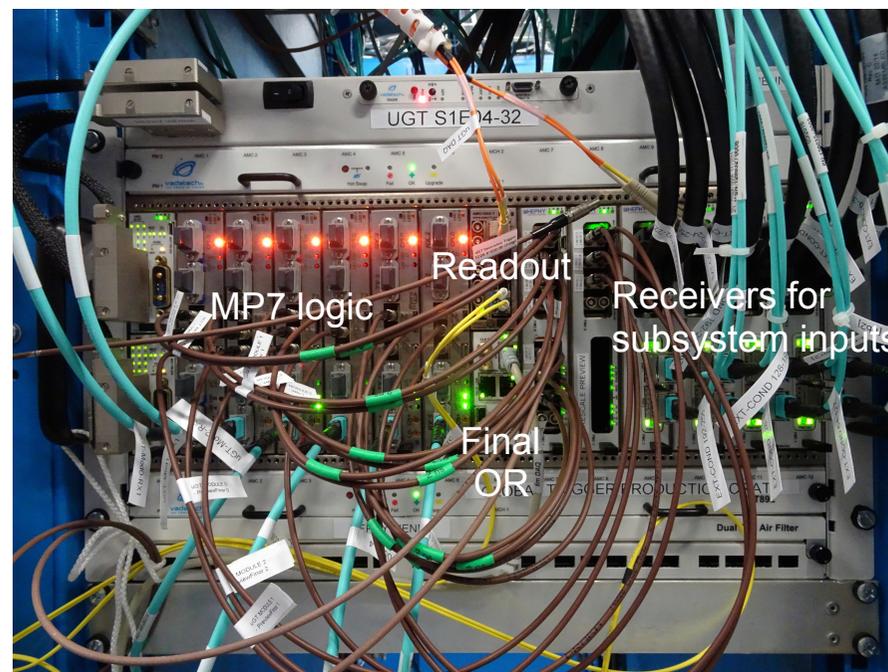
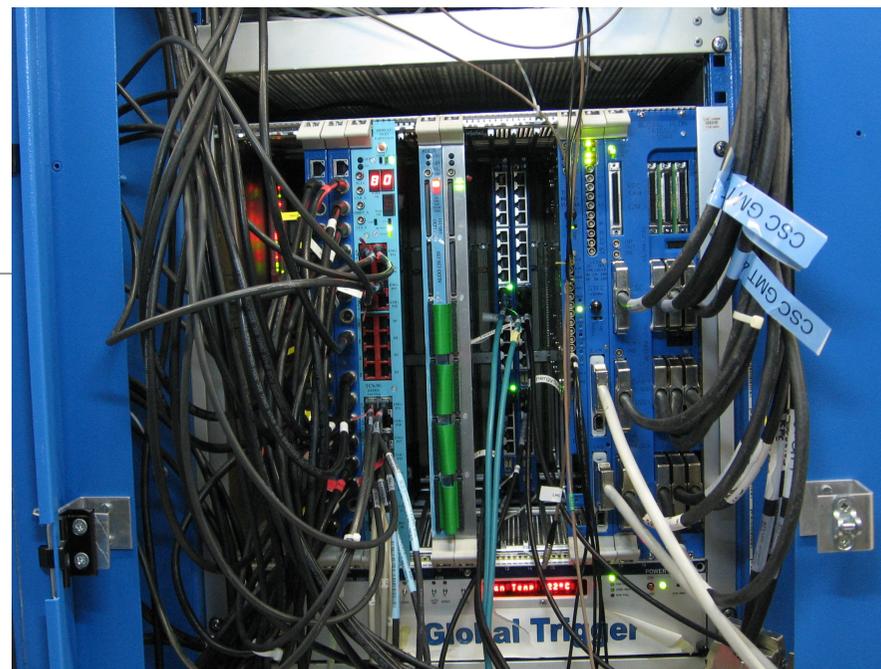
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- Founding member of the CMS collaboration
- **CMS construction:** contributions to trigger and tracker
- **Data analysis:** SUSY, Higgs and Quarkonia
- **Phase I upgrade:** trigger - barrel track finder, global muon trigger and global trigger
- **Phase II upgrade:** sensor development for outer tracker and high granularity calorimeter

# CMS Trigger Phase I upgrade

- HEPHY responsible for **global Trigger** and parts of **Muon Trigger during** construction of LHC
- Major upgrade during Phase I shutdown
  - Hardware change to  **$\mu$ TCA based system**
  - Software based system allows more flexibility
  - Constant upgrade of system



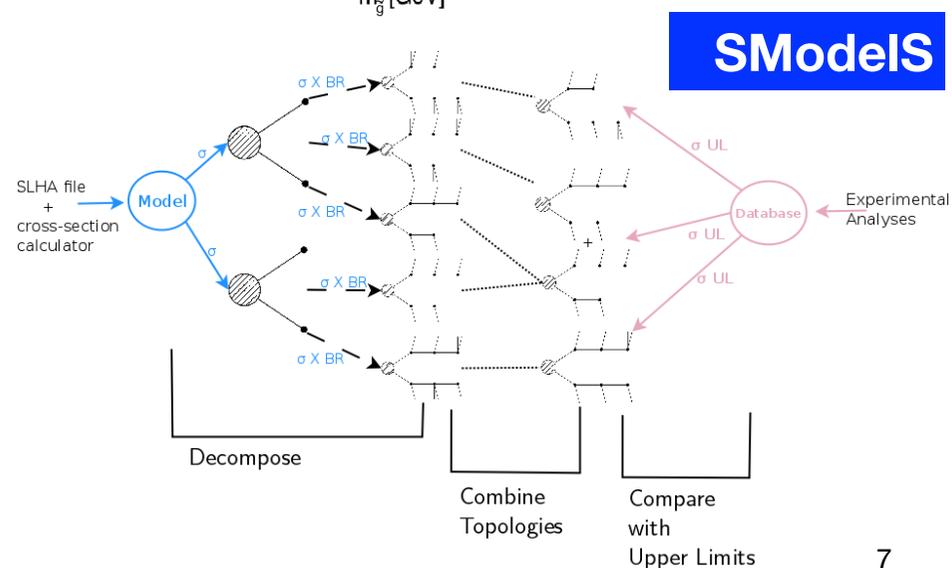
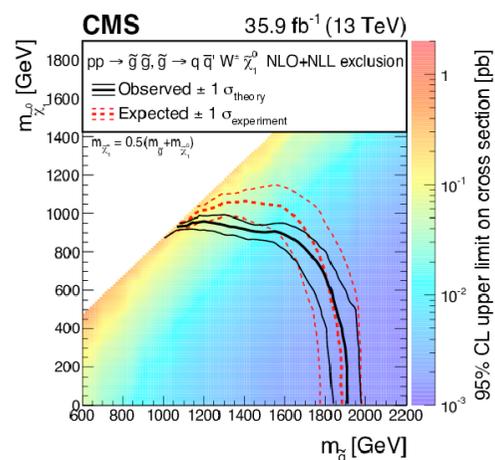
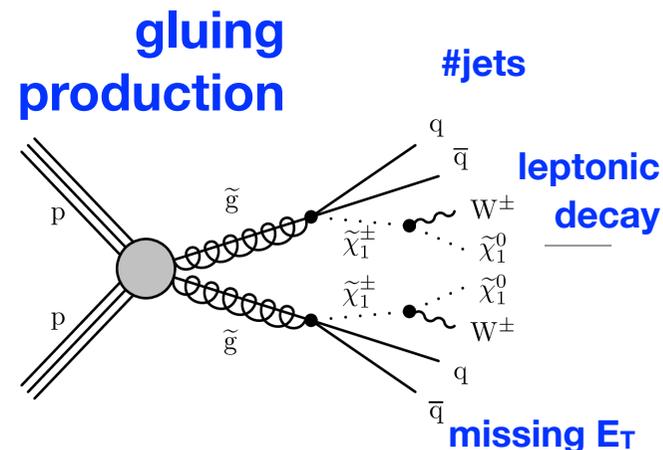
# CMS - Data Analysis

- SUSY, Higgs and Quarkonia HEPHY's CMS research topics

- Two co-convenors of major CMS physics groups (SUSY & exotica)

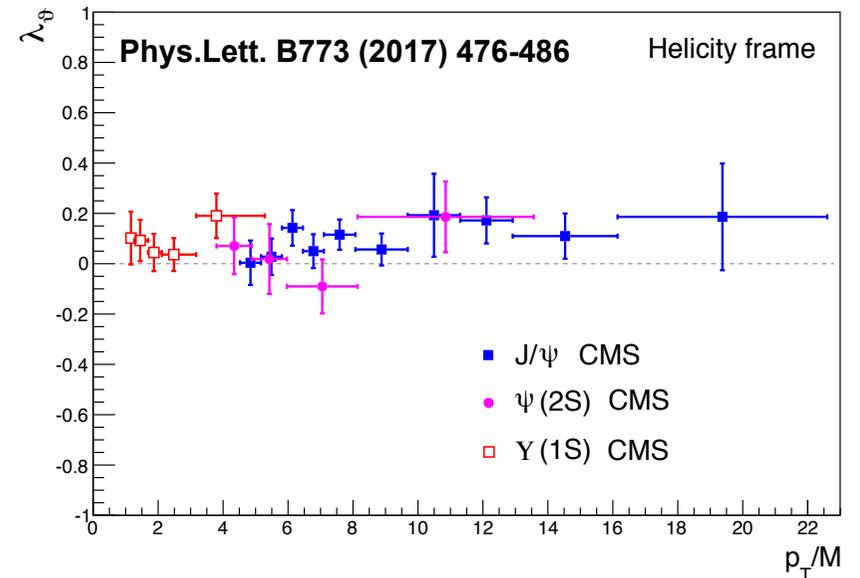
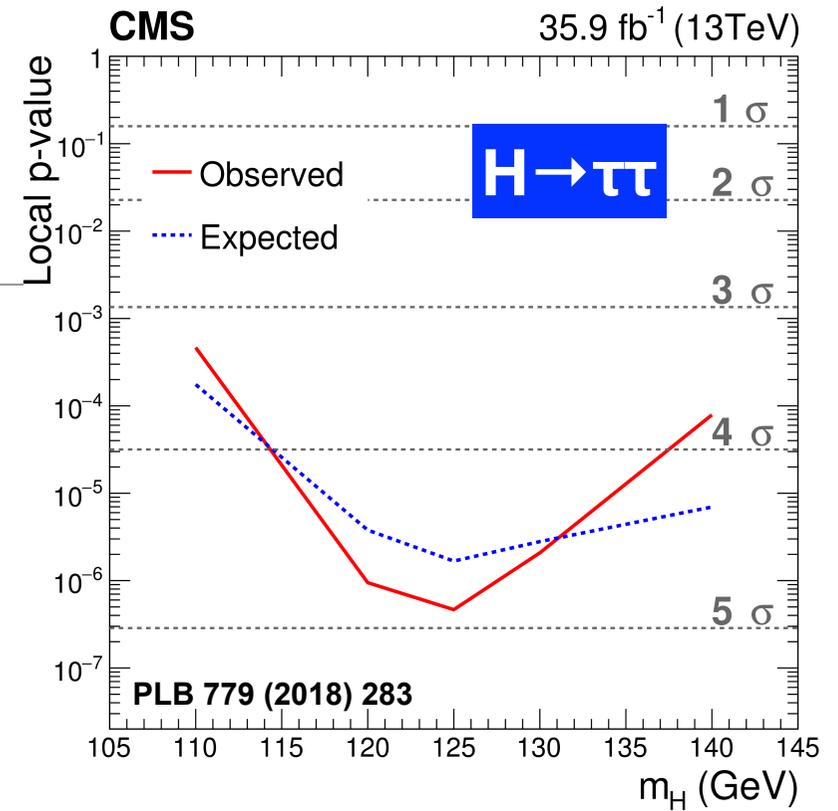
- Supersymmetry:

- Search for **gluinos**
- Search for **stop** - compressed mass spectra and di-lepton channel
- Interpretation for searches using simplified models: **SModels**



# CMS - Data Analysis

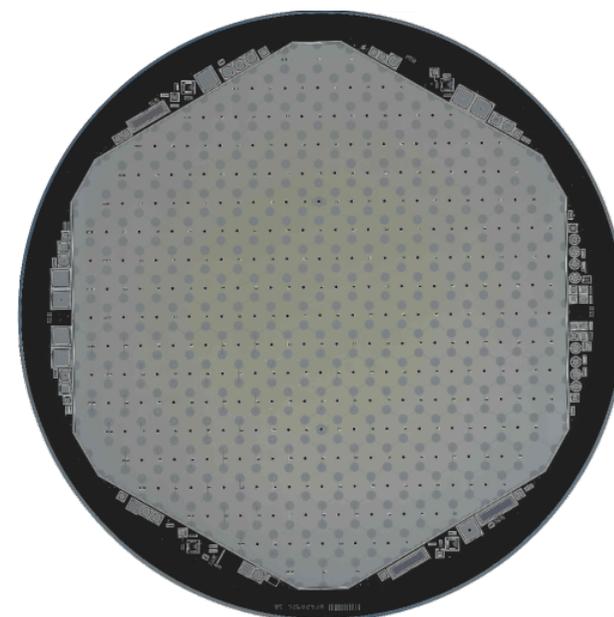
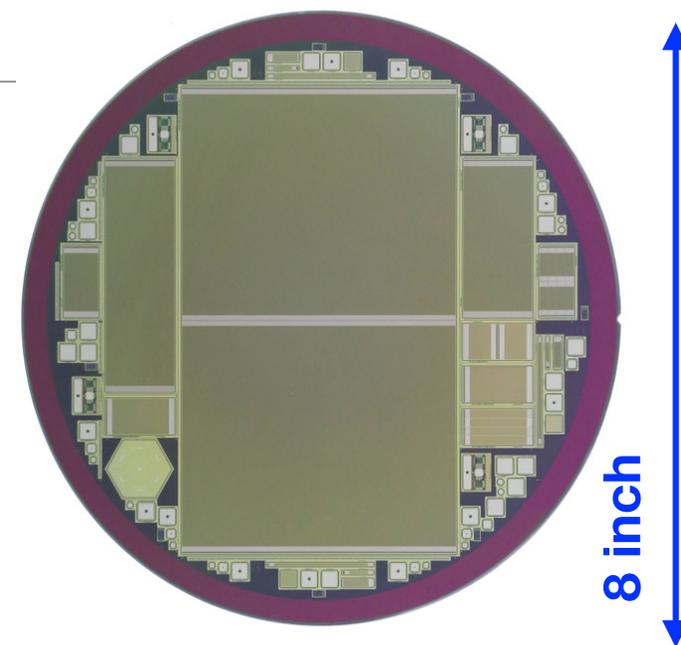
- Search and studies of Higgs boson decays to two  $\tau$ -leptons
  - Side product: measurement of  $Z \rightarrow \tau\tau$
- Measurement of quarkonia production and polarisation
  - Tool to study non-perturbative QCD
  - Studies of  $J/\psi, \Psi'$  and  $Y(nS)$  published so far



# CMS - Phase II upgrade - Detector Development

## Outer Tracker and HGC

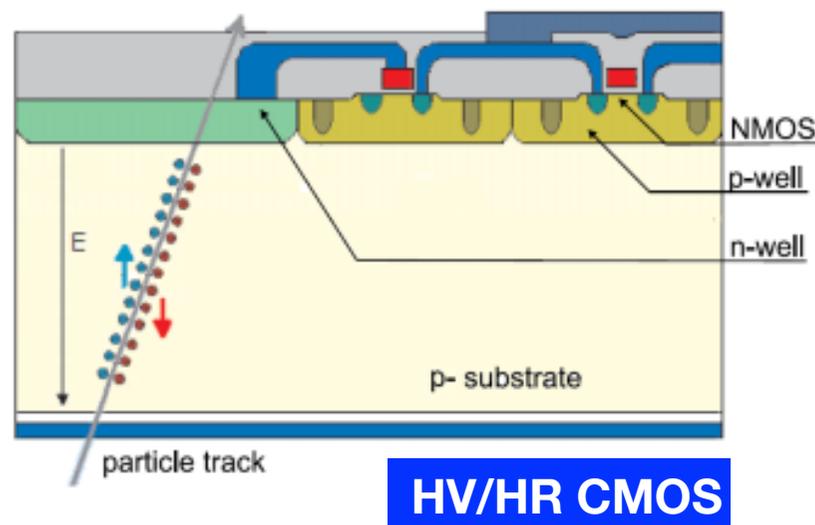
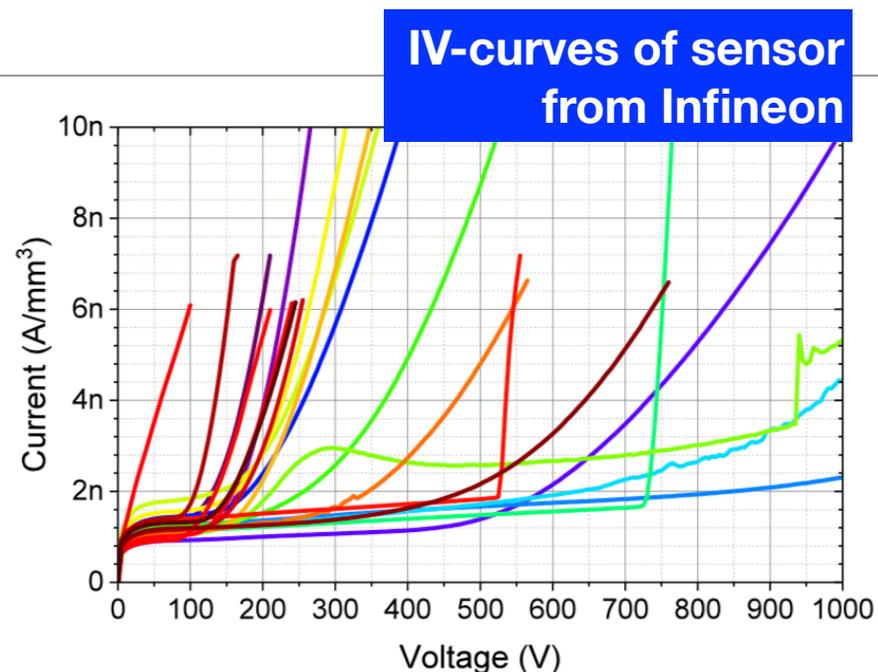
- HEPHY's focus on development of silicon sensors for **CMS outer tracker** and **HGC**
- Close collaboration with Austrian industry (Infineon)
- **First production of 8" sensors**  
→ impact on HGC design
- Qualification of Infineon as partner currently in important phase
- HGC and outer tracker co-convenor for sensors from HEPHY
- Significant contributions to **tracker and HGC TDR**



# CMS - Phase II upgrade - Detector Development

## Outer Tracker and HGC

- Detailed sensor tests including **irradiation** and **test beams**
- Outstanding issue to solve before qualification for production: early break down of IV-curves
- **Next generation** of silicon detectors
  - Increased need for silicon detectors → industrial production desirable
  - **HV/HR-CMOS** sensor as HEP silicon detector
  - Large area active sensors with integrated electronics
  - HEPHY develops HV/HR-CMOS within RD50 collaboration

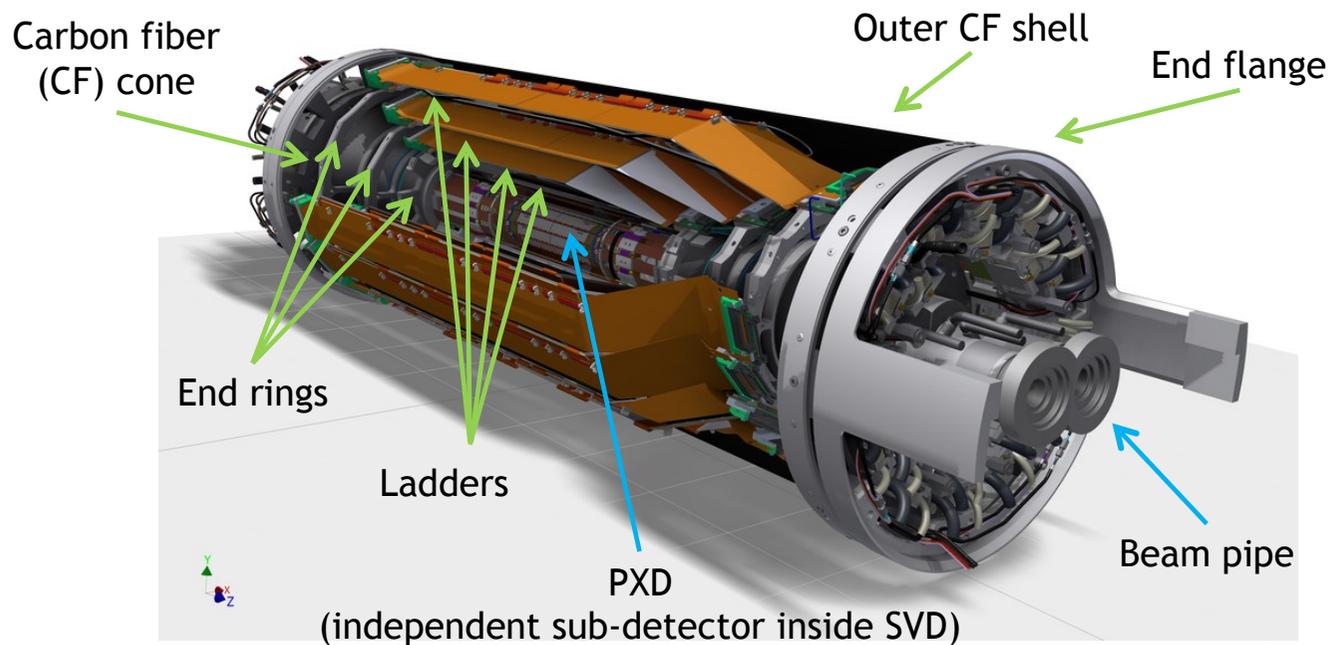


# Belle II - Construction of SVD

- HEPHY designed **silicon vertex detector** (SVD) and manages SVD detector group
- Construction of layer 5 at HEPHY
- HEPHY also responsible for readout system

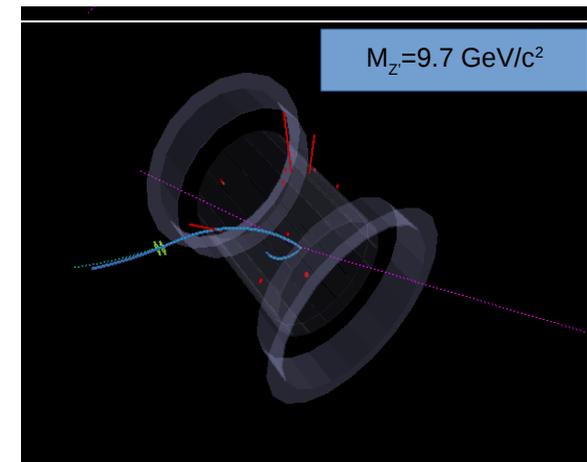
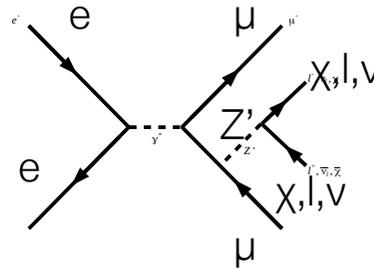
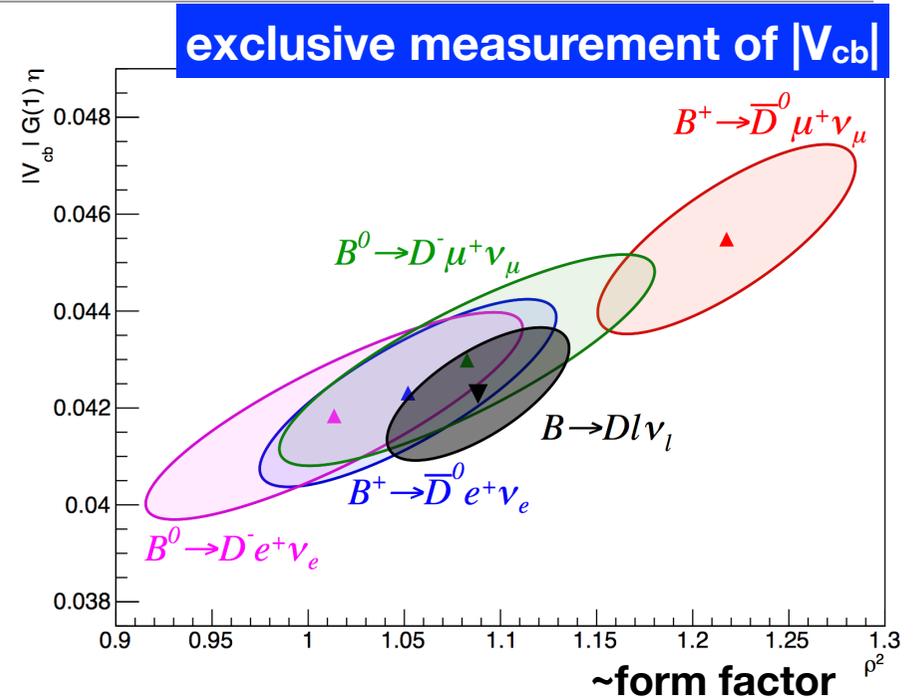


**SVD L5 Ladder**



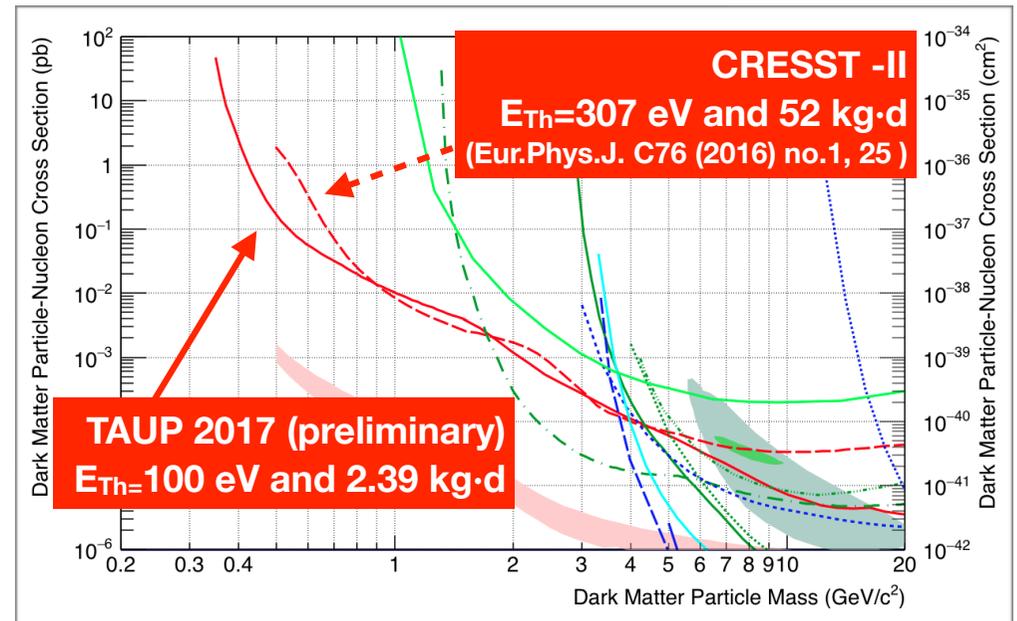
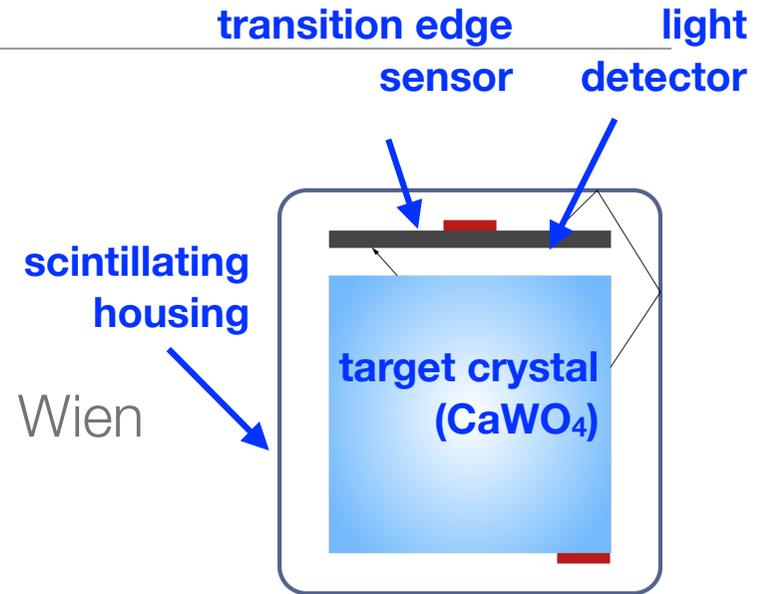
# Belle I & II - Data Analysis

- Focus on determination of **CKM matrix elements  $|V_{cb}|$**  with Belle data using inclusive and exclusive measurements
- Preparation for data analysis with Belle II data ongoing
- Determination of  $|V_{cb}|$
- Search for **light dark matter**  
→ missing energy



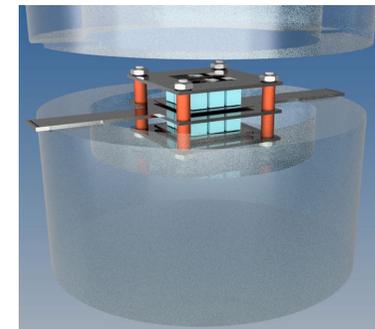
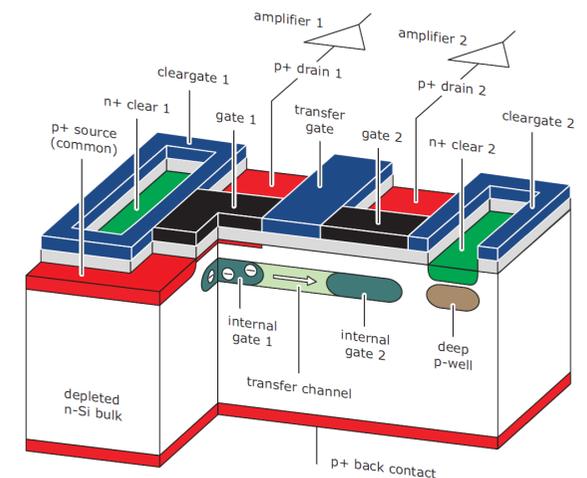
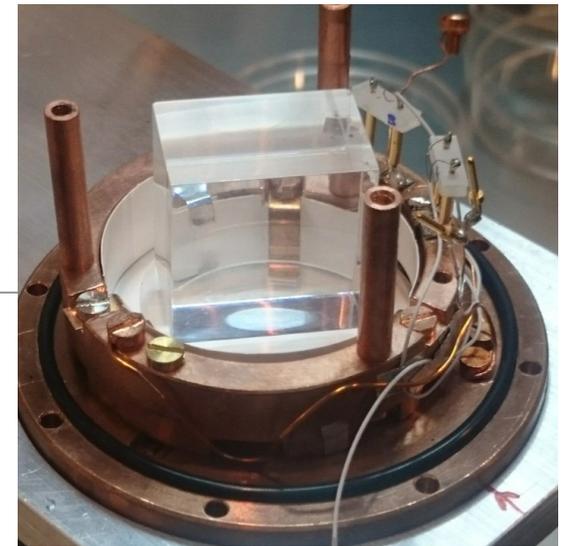
# CRESST - search for Dark Matter

- New group at HEPHY since 2014  
→ extension of HEPHY's research profile towards non-accelerator physics
- Joined research group between HEPHY and TU Wien
- Member of the CRESST collaboration  
→ leading sensitivity in low mass region
- HEPHY responsible for electronics, simulation and data analysis

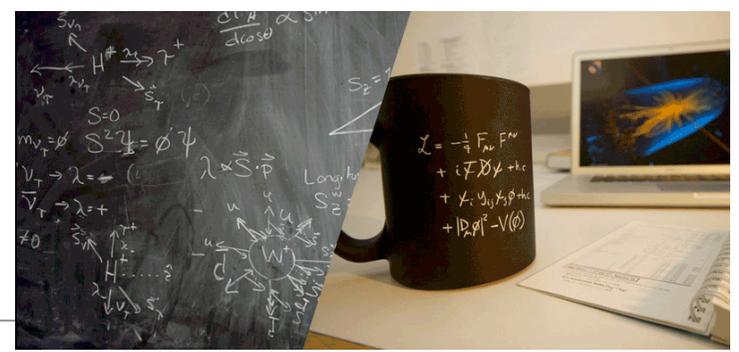


# Dark Matter & Neutrino studies

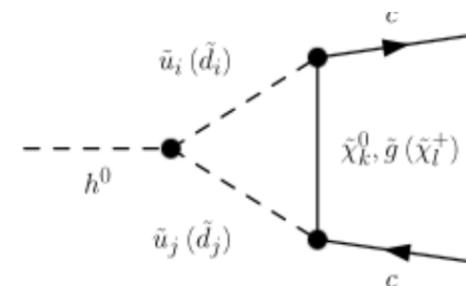
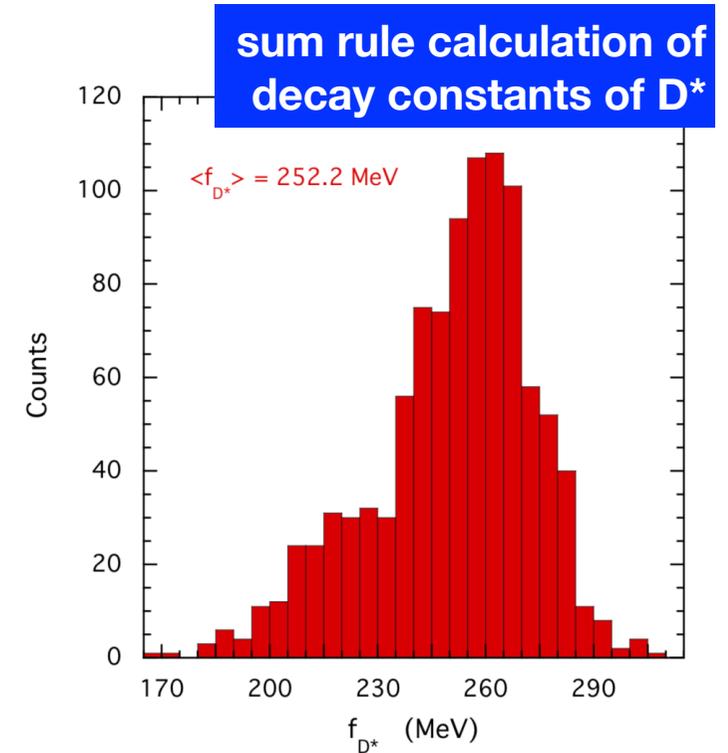
- Several R&D projects for future dark matter experiments
- **COSINUS:** dark matter searches with cryogenic operation of NaI crystals
- **RNDR-DEPFET:** search for MeV dark matter with dark matter-electron scattering
- **v-cleus:** studies of coherent neutrino scattering



# Theory Activities at HEPHY



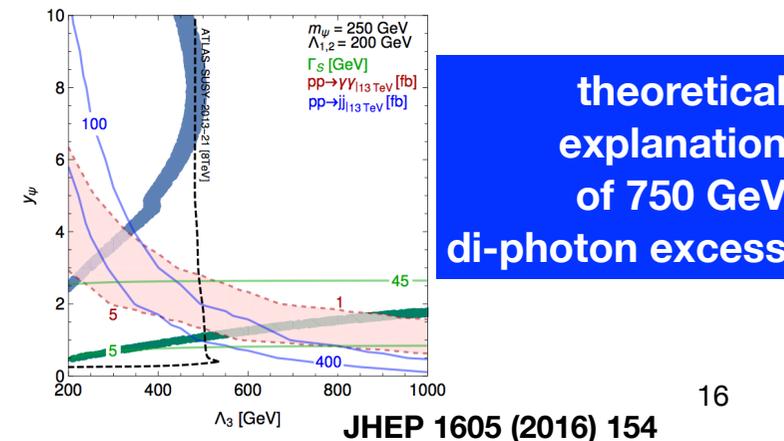
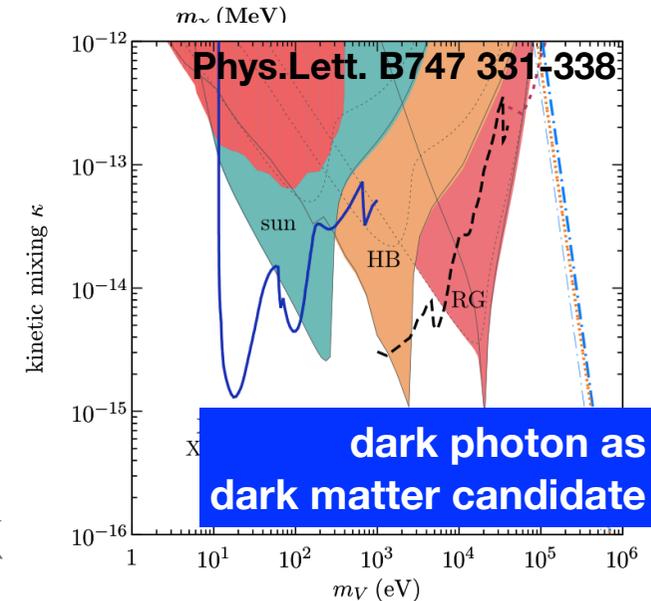
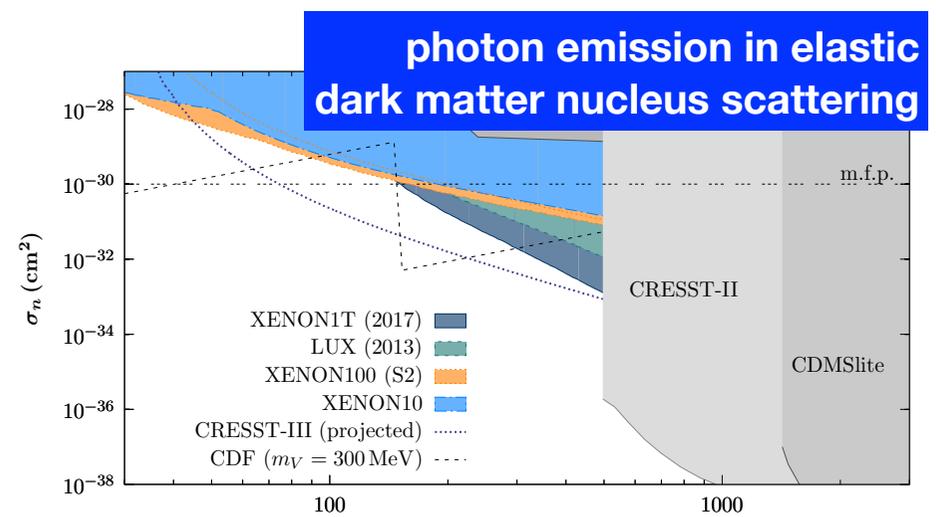
- Quantum Chromodynamics (QCD)
  - Analysis and description of bound states using non-perturbative approaches
- Beyond the standard model / Supersymmetry
  - Phenomenological exploration of supersymmetric SM



**H → cc - flavour violation in MSSM**

# Theory Activities at HEPHY

- Dark matter
  - Research group on dark matter established in summer 2014 third-party funded “New frontiers group”
  - Dark matter studies using direct detection, indirect detection and dark matter production



## other HEPHY Activities

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- Operation of **GRID infrastructure**  
→ covered by D. Liko's presentation
- **Outreach activities**  
→ covered by B. DeMonte's / Marko Dragicevic's presentation
- **Algorithm and software development**  
with focus on tracking  
→ department closed by the end of 2017 due to retirement

# Conference and Workshops organised by HEPHY

- Organisation of international conferences and workshops
  - CKM 2014 with about 200 participants
  - EPS-HEP 2015 with more than 700 participants - largest international particle physics conference of the year with large media coverage
  - VCI 2016 with about 300 participants - part of a conference series and every third year in Vienna
  - LHCSki2016, ALPS2017 and ALPS2018: new conference series initiated by HEPHY for "post-Moriond" discussions - well received by the community
  - CTD 2016 - Connecting the Dots - workshop on tracking and pattern recognition February 2016.
  - ISQTDQAQ 2018 - international school of trigger & data acquisition - together with CERN, February 2018
- Organisation of several internal collaboration meetings (SUSY-CMS)



Welcome to the EPS-HEP 2015 conference!



# Summary

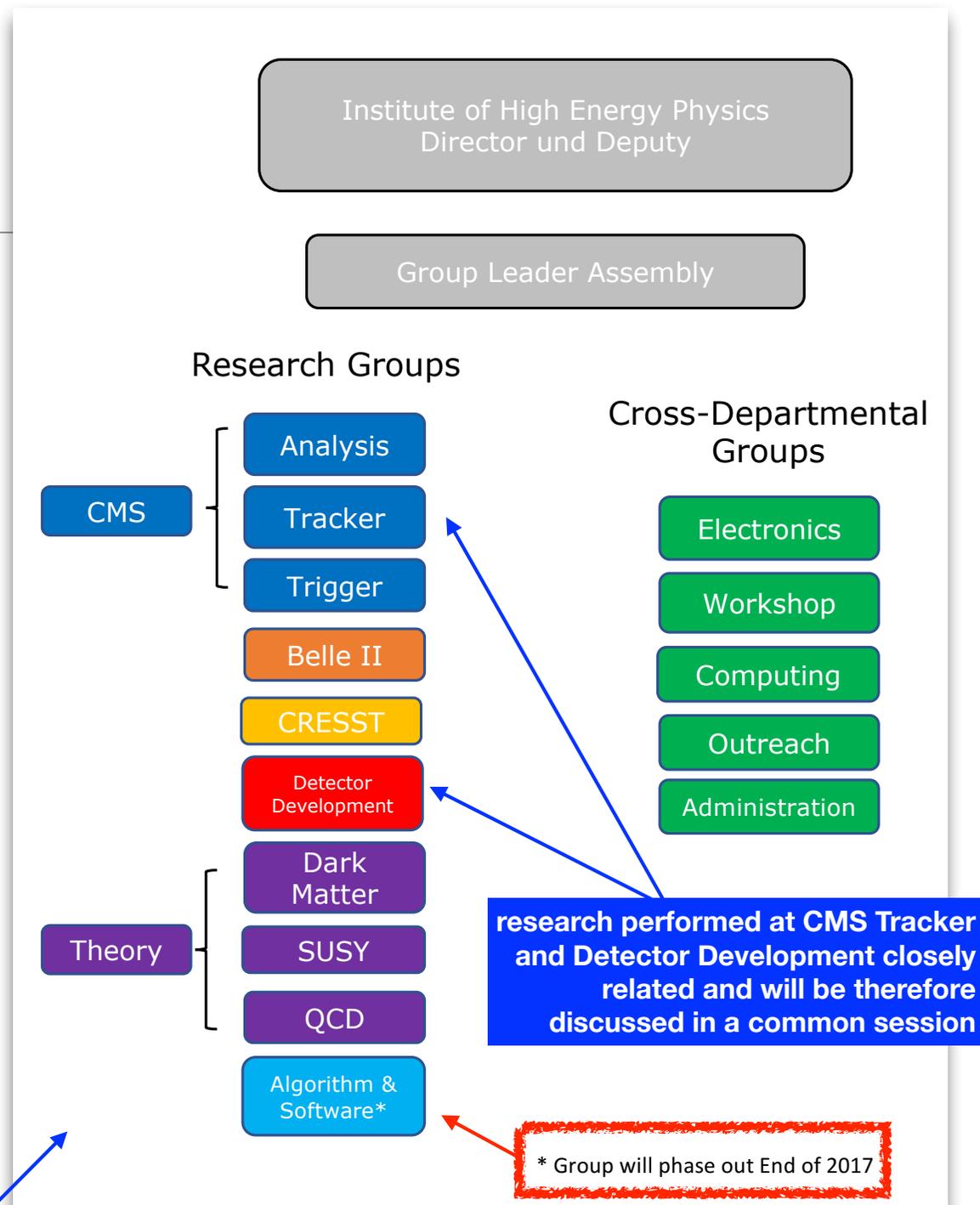
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- HEPHY research institute of the Austrian Academy of Sciences
- Experimental program covers research at CMS@LHC, Belle@KEK and CRESST@LNGS
- Detector development for future experiments with focus on silicon based techniques
- Theory studies on QCD, SUSY and dark matter

additional information

# Organisation

- HEPHY is subdivided in research groups and cross-departmental groups
- Research groups follow independent research program
- Cross-departmental groups work closely together with research groups (project based)



outline of this meeting

retirement of group leader R. Frühwirth<sup>21</sup>

# Cooperation with Universities

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- Long-standing collaboration of HEPHY with Technische Universität Wien (TU Wien)
  - Jochen Schieck full professor at TU Wien since 2014 (new position)
  - Joined research group on experimental dark matter searches
  - Five senior scientists with *venia legendi* at TU Wien
    - Lecturer from HEPHY cover significant part of particle physics education at TU Wien
    - Starting from Summer 2017 J. Schieck will teach mandatory particle physics course for master students
- Cooperation agreement ÖAW-TU Wien initiated by HEPHY allows junior HEPHY scientist without *venia legendi* to teach at the TU Wien (also with University)
- One senior scientist with *venia legendi* at the University of Vienna

# Cooperation with Universities

HEPHY is member of the 2014 FWF funded graduate school “Particles and Interactions” ([www.dkpi.at](http://www.dkpi.at))

$\int dk \Pi$  Doktoratskolleg  
Particles and Interactions

Joined initiative of TU Wien, University of Vienna, Stefan Meyer Institute (SMI) and HEPHY



Four scientists of HEPHY are members of the DKPI-faculty

Renewal of DKPI approved by FWF with four senior scientists from HEPHY