



AGH UNIVERSITY OF SCIENCE
AND TECHNOLOGY

Heavy Flavours in Poland

Agnieszka Obłąkowska-Mucha (AGH-UST)

On behalf of Polish heavy flavour community

**Restricted Committee for Future Accelerators visit to Poland
Kraków, 11.05.2012**

Flavour physics experiments with Polish contribution

▶ Charm & Beauty

- LHCb
- Belle, Belle II
- SuperB



▶ Strangeness

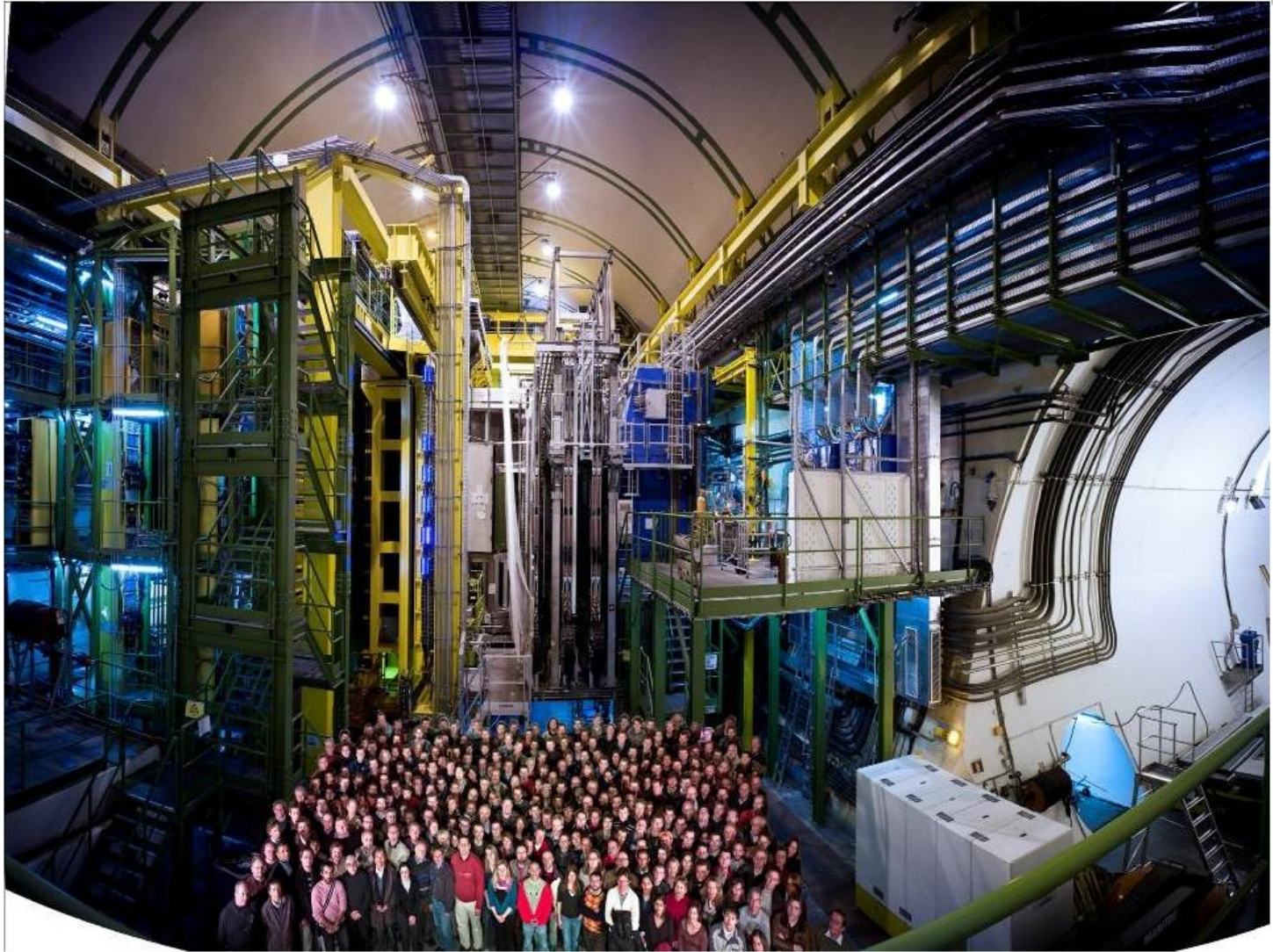
- KLOE/KLOE2

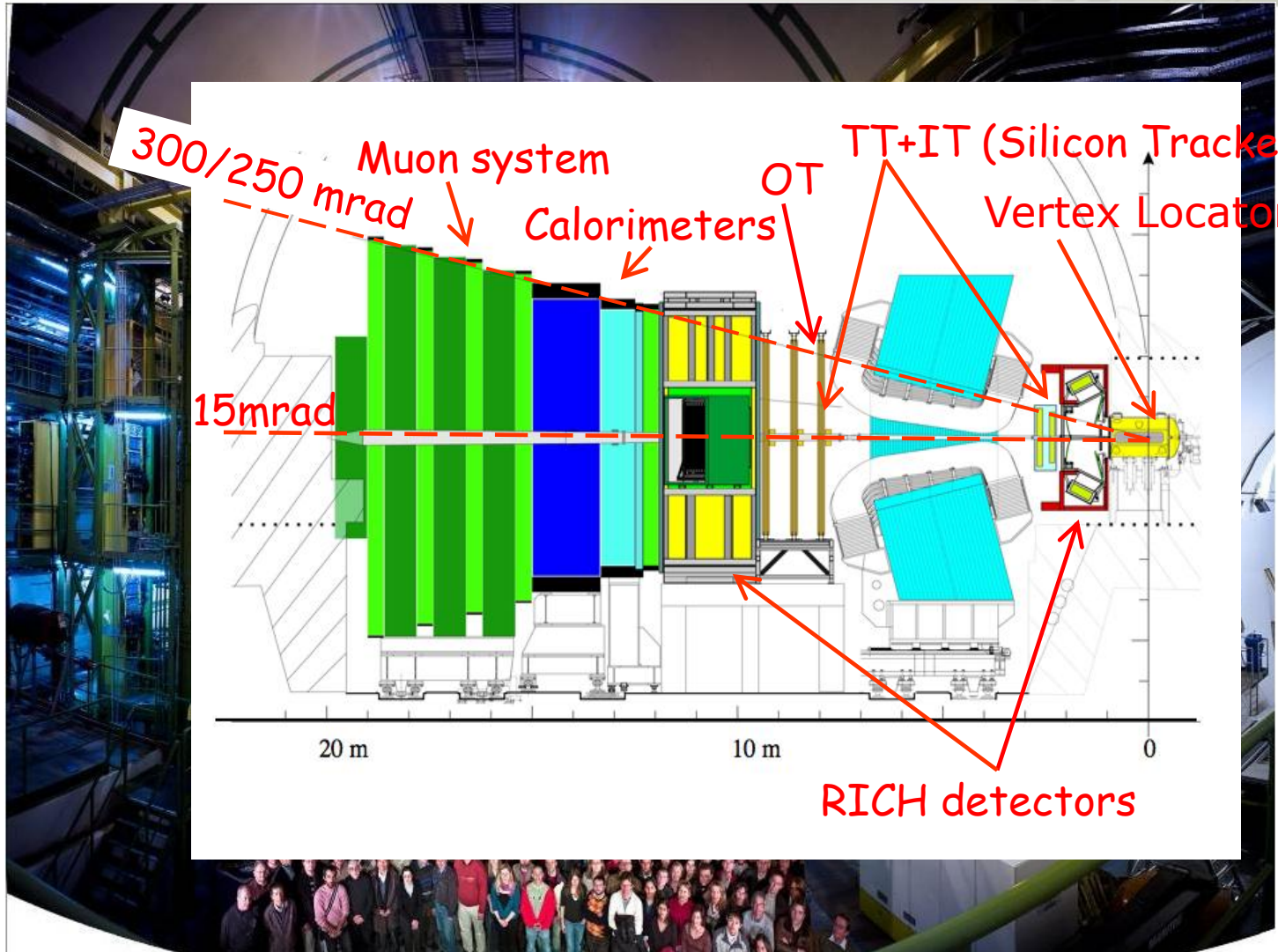
▶ Up & Down

- nEDM/n2EDM



JAGIELLONIAN UNIVERSITY
IN KRAKOW



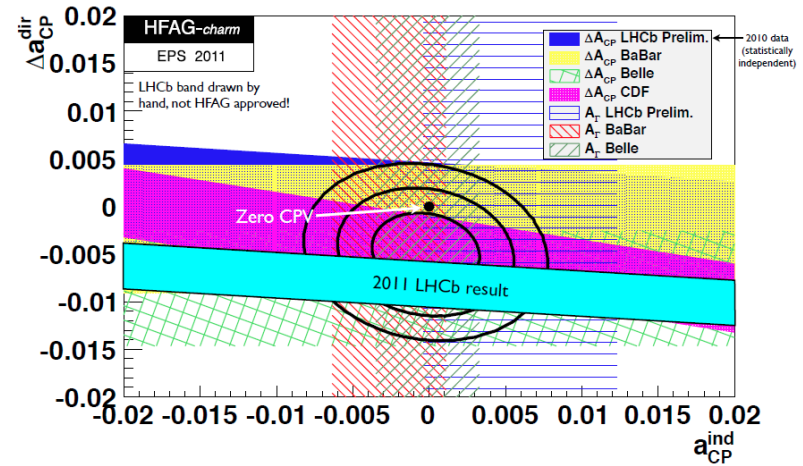
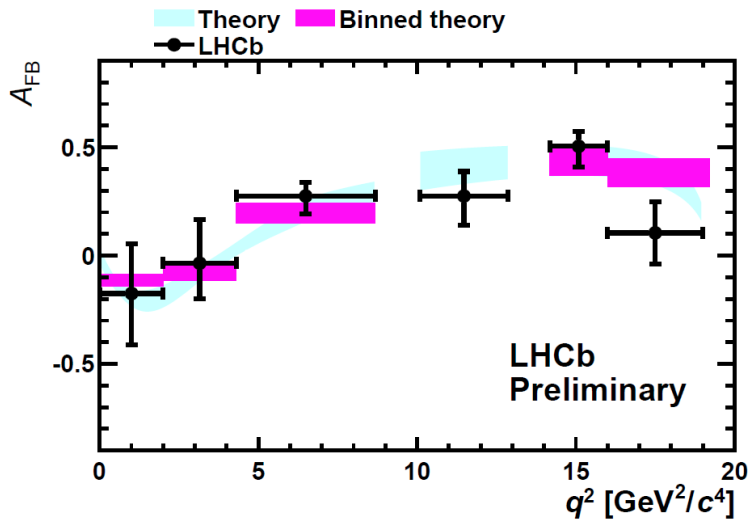


LHCb- current status

Very successful operation to date - indirect searches for NP

best spatial, IP and mass resolution in LHC

- the B_s mixing phase φ_s in time dependent angular analysis (world best)
- the $B_{s,d} \rightarrow \mu\mu$ branching ratio – constraining SUSY (world best)
- $B \rightarrow K^*\mu\mu$ decay
- exciting results in charm sector
 - first evidence of CP violation
 - direct CP asymmetry
 - measurement of y_{CP} and A_F



- Institutions in Poland:
 - Krakow: AGH-UST, IFJ PAN
 - Warsaw: NCBJ
- Participants:
 - 9.5 staff, 3.5 PhD students, 2 technical staff
- Main hardware contribution:
 - contribution to the Outer Tracker (800k CHF)
 - contribution to Fast Control System of DAQ
- Main responsibilities:
 - Co-responsibility for trigger system and central software
 - supervision of software and hardware for vertex detector
 - Data analysis involvement: CKM γ , T violation, ϕ_s , lepton nb violation
- Financing:
 - 2000-2013 (NCN) ~200 kCHF/year





LHCb - construction of Outer Tracker



Production of panels



Production of modules



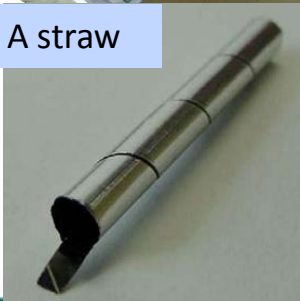
Tests



A module

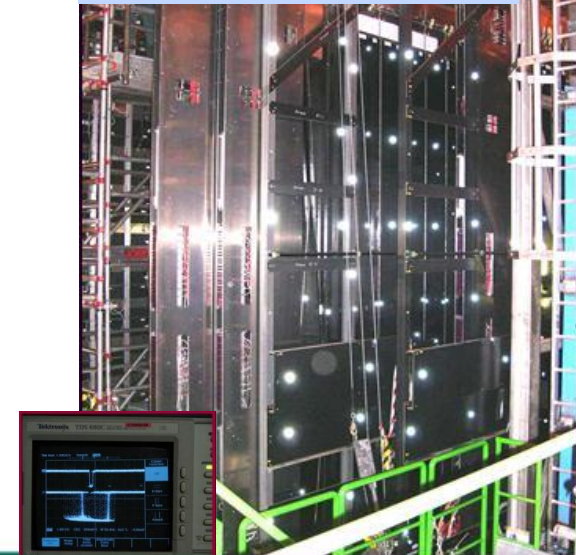


A straw

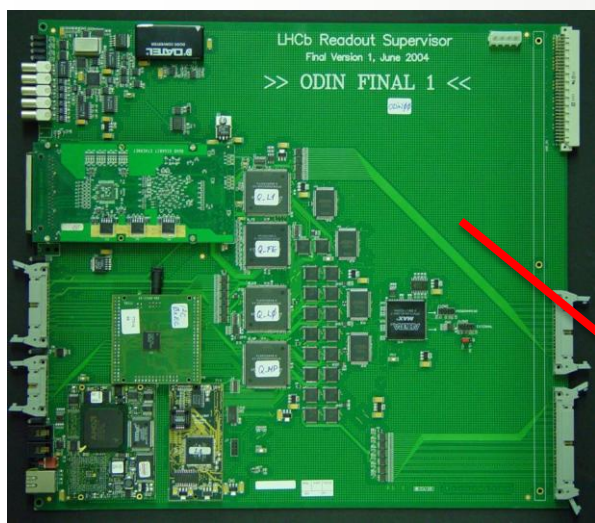


- **Polish contribution**
 - Prototypes of OT module
 - Technology of production
 - Production of panels (1000 m²)
 - Production of modules
 - Design of readout electronics
 - Design of OT mechanical support
 - Position monitoring system

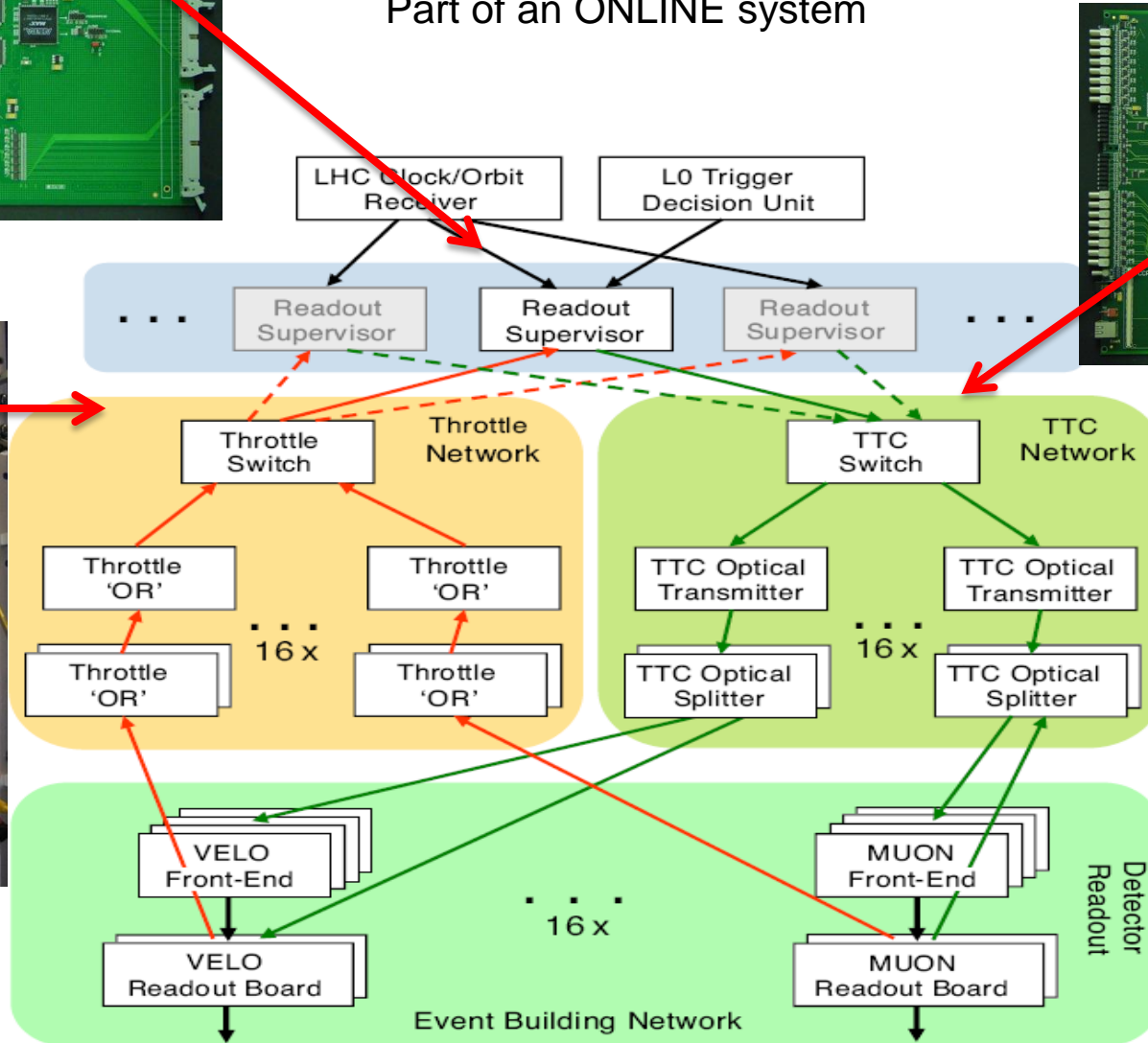
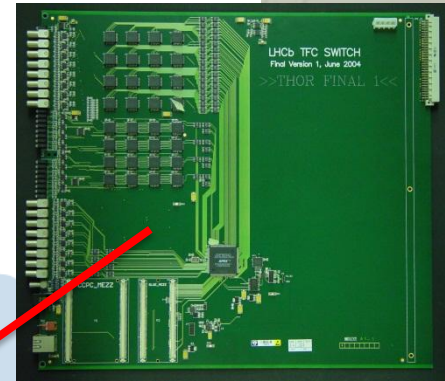
Outer Tracker in experimental cavern



LHCb - Time And Fast Control system



Part of an ONLINE system





- Central shifts (data manager and HLT piquet duty)
- Expert shifts/run chief duty (VELO and OT piquets)

High Level Trigger (HLT)

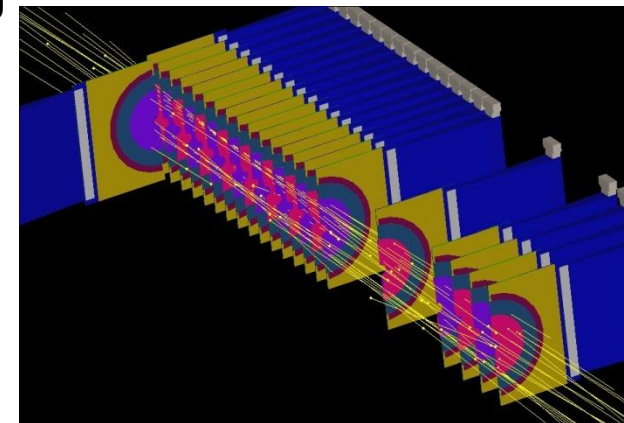
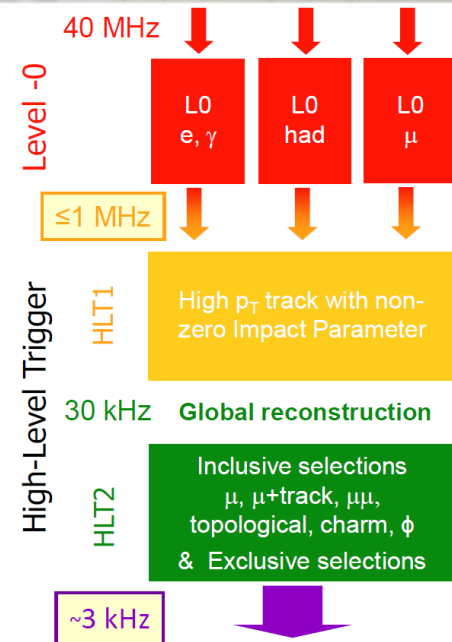
- Development and implementation of the electromagnetic alley
- Contribution to the stripping

Vertex Locator (VELO)

- Silicon simulation and reconstruction (**coordination**)
- Software off-line calibration platform (**coordination**)
- Detector performance monitoring during the data taking
- Radiation damage monitoring and study

Outer Tracker

- Monitoring and alignment software



- Engagement in **CKM parameters** determination:
 - γ from time dependent and amplitude analyses,
 - β_s from $B_s \rightarrow$ (pseudo) Scalar-Vector,
- T violation** in $B \rightarrow K\phi\phi$
- Lepton number violation** in $\tau \rightarrow \mu\mu\mu$,
- CPV** in charm decays
- Rare decays**: $B \rightarrow K^* \mu\mu$ – golden channel for NP searches

$$B_s^0 \rightarrow J / \Psi \eta^{(0)}$$

$$B_s^0 \rightarrow \eta_c \phi$$

$$B_s^0 \rightarrow \chi_c \phi$$

$$B_s^0 \rightarrow J / \Psi f^0$$

$$B \rightarrow D\pi$$

$$B \rightarrow D^* \pi$$

$$B \rightarrow D^* a_1$$

$$B \rightarrow DK$$

Strong interest of the Krakow groups:

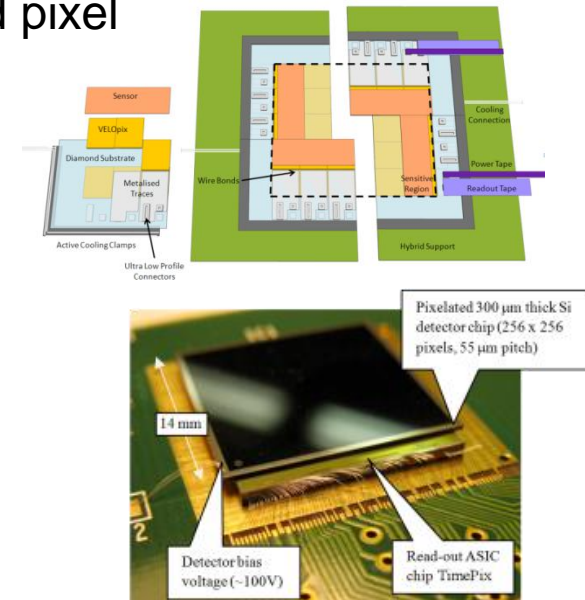
AGH-UST

- **design of the new front-end read-out chip** (TT, VELO, IT)
part of the **Collaboration Upgrade Resource Board**
- software for the upgraded Vertex Locator
silicon simulation
monitoring and calibration
hardware emulation
- TELL40 electronic DAQ board firmware (strip and pixel option)

IFJ PAN

- HLT software trigger development
- PV reconstruction algorithms

For more details see Marek Idzik's talk!

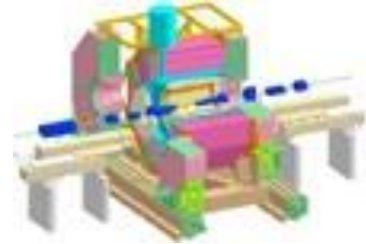




Belle @ KEKB/ Belle II @SuperKEKB



- Institutions in Poland:
Krakow: IFJ PAN
- Participants:
4 staff, 1 PhD student, 3.5 support
- Main hardware contribution:



Belle: contribution to the silicon vertex detector (SVD) readout electronics and calibrations;

BelleII: contribution to power supply for pixel detector, SVD readout electronics and cooling, distributed computing;

- Main (current) responsibilities:

Belle – dedicated data analyses and coordination of the Belle charm physics group;

BelleII - integration of the SVD read-out with the central DAQ system, coordination of the SVD software group, GRID middleware.

- Financing:

Belle: (NCN) 2011-2013 ~24 kEUR/year

BelleII: (NCN) 2011-2015 ~95 kEUR/year

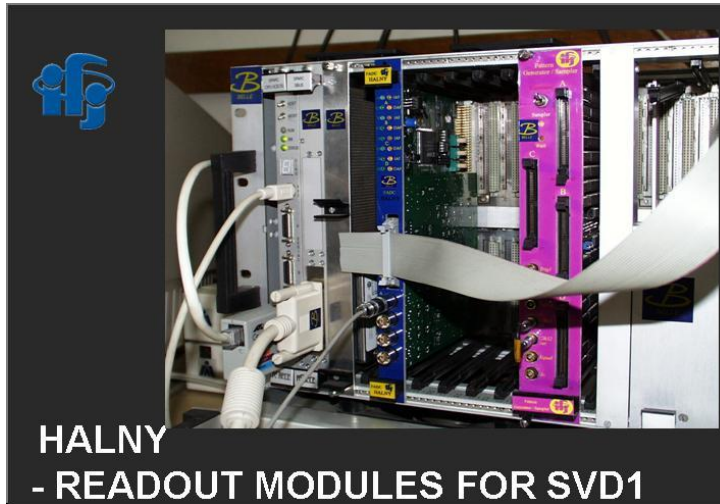


Belle / Belle II – current status

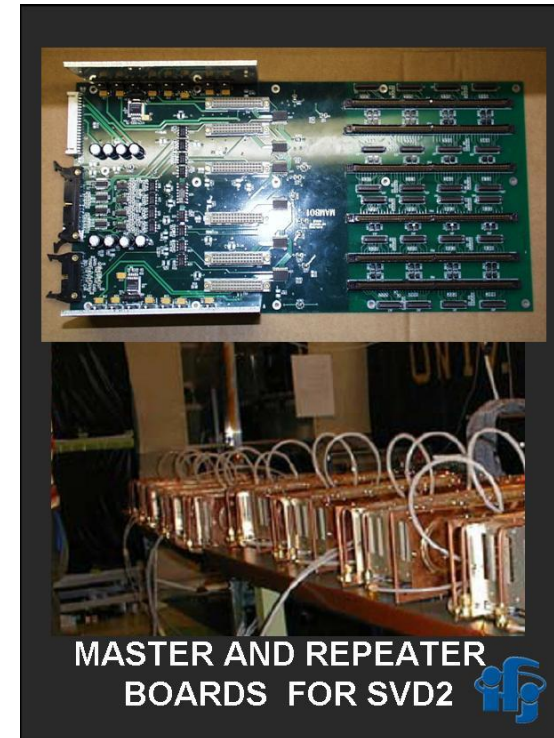


Belle stopped data taking in 2010. After more than a decade of the very successful operation, having collected largest data samples ($L_{int} > 1 \text{ ab}^{-1}$) @ $\Upsilon(nS)$ ($n=1,2,4,5$) that provided many exciting results, Belle entered the intense analysis phase.

– **Polish group contributed for >15 years!**



HALNY
- READOUT MODULES FOR SVD1



MASTER AND REPEATER
BOARDS FOR SVD2

Belle II & SuperKEKB ($L_{\text{peak}} \sim 8 \times 10^{35} / \text{cm}^2 / \text{s}$) - construction started; start of data taking in 2015

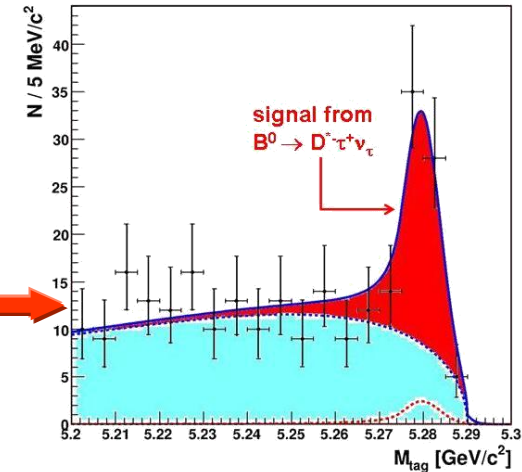
Belle II – CERN recognized experiment (RE20),
large European contribution (1/3 of the collaboration)



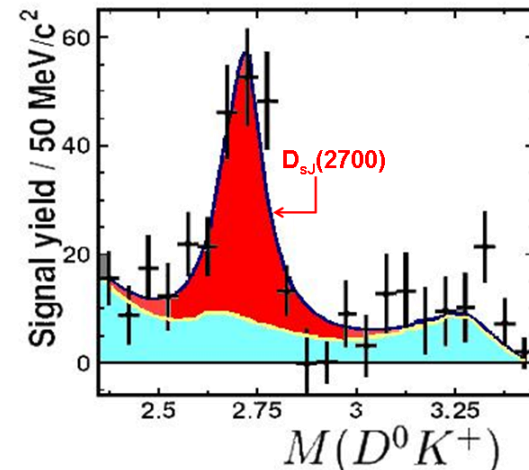
BELLE – Polish contribution to physics analyses



- Hadronic B decays with $b \rightarrow s$ transition - polarization studies in $B \rightarrow \phi K^*$ (first polarization measurement in FCNC B decay);
- B decays with $b \rightarrow c \tau \nu_\tau$ transition - first observation of the exclusive semitauonic B decay in the $B^0 \rightarrow D^{*-} \tau^+ \nu_\tau$ mode;
 - Tools for reconstruction of the tagging B;
- Hadronic and semileptonic B decays with $\bar{s}s$ -pair production;
- Charmed-strange meson spectroscopy - observation of $D_{sJ}(2710)$;



A. Matyja *et al.* (Belle Collab.) Phys. Rev. Lett. **99**: 191807 (2007)



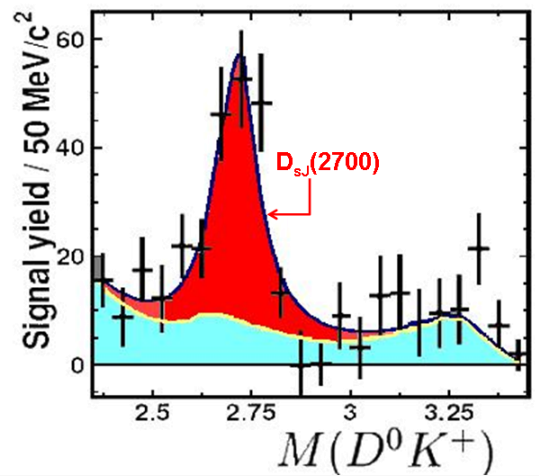
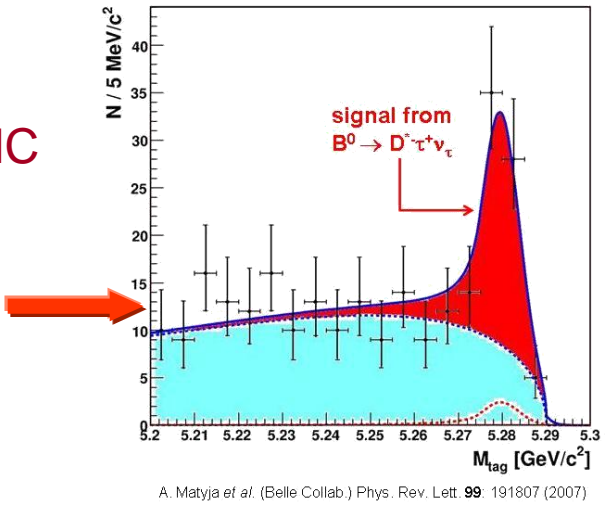
J. Brodzicka *et al.* (Belle Collab.) Phys. Rev. Lett. **100**: 092001 (2008)



BELLE – Polish car

Another Breakthrough in "Missing Energy" Decays.
 Belle Reports the First Observation of $B^0 \rightarrow D^{*+} \tau^- \nu_\tau$
 A. Matyja et al., PRL 99, 191807 (2007) (arXiv:0706.4429)

- Hadronic B decays with $b \rightarrow s$ transition - polarization studies in $B \rightarrow \phi K^*$ (first polarization measurement in FCNC B decay);
- B decays with $b \rightarrow c \tau \nu_\tau$ transition - first observation of the exclusive semitauonic B decay in the $B^0 \rightarrow D^{*+} \tau^- \nu_\tau$ mode;
 - Tools for reconstruction of the tagging B;
- Hadronic and semileptonic B decays with $\bar{s}s$ -pair production;
- Charmed-strange meson spectroscopy - observation of $D_{sJ}(2710)$;



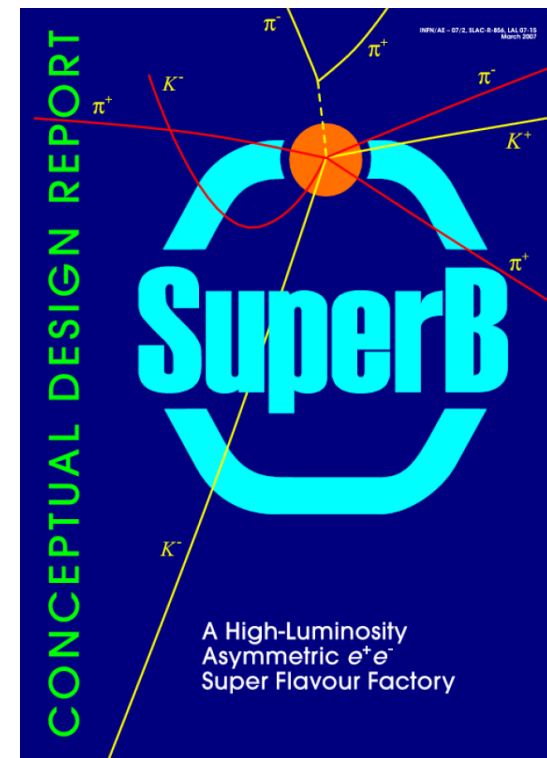
- Institutions in Poland (Krakow only):

ACK CYFRONET,
AGH-UST,
CUT,
IFJ PAN.

The above entities formed
the [National SuperB Consortium](#)
(16. May 2011)

- Participants:

7.1 staff,
2.5 PhD students,
1 technical staff





- Main hardware contribution:

- contribution to the [Instrumented Flux Return \(IFR\)](#) detector

- ✓ current R&D work on SiPMs, electronics, mechanical construction and software;
 - ✓ application for funds after TDR– autumn 2012).

- Substantial participation in the [accelerator construction](#) (2015).

- Participation in the overall [computing system](#).

- Main responsibilities:

- Co-responsibility for the IFR detector,

- Co-responsibility for the computing system,

- Physics studies: CP and T violation in B meson and tau lepton decays

- Financing:

- Application to NCN (Dec. 2012),

- Very limited resources at home institutions,

- One individual „diamond” grant.



KLOE, KLOE-2



Institutions in Poland:

- Krakow: Jagiellonian University
- Warsaw: NCBJ

Participants:

- **3** staff, **4** PhD students, **0.5** technical staff

Main contribution:

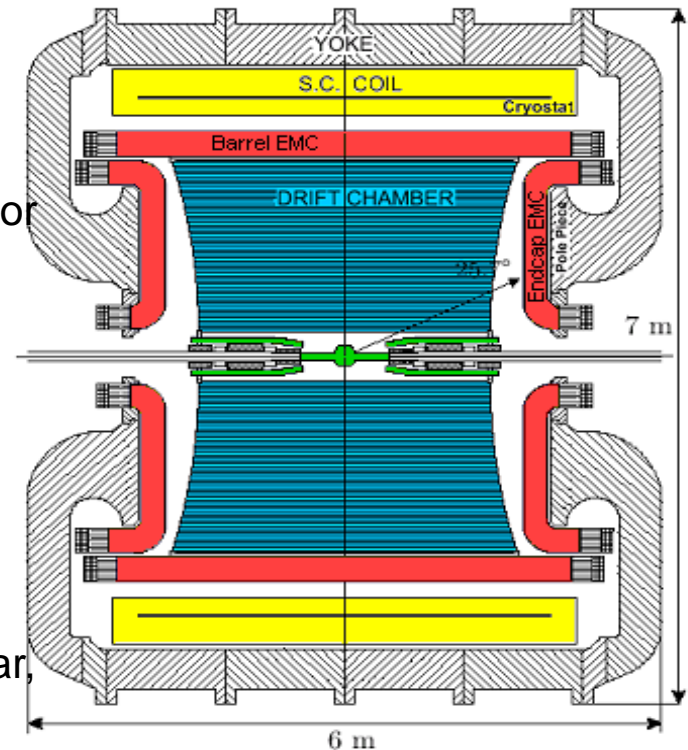
- Short- and long-term Phd students work in detector upgrade R&D and construction and data analysis.

Main responsibilities:

- Participation in low- and high energy taggers instalation
- Analysis of $\varphi \rightarrow \eta e^+ e^-$, $K_L \rightarrow 3\pi^0$, and other..

Financing:

- International PhD program 2011-14: 12kEUR/year,
- Polish Research Grants 2009-12: 45kEUR/year





KLOE-2: plans for physics



A few examples of new analyses planned for next years:

- Tests of discrete symmetries (CP, CPT, ...)
- Tests of quantum mechanics
 - time-evolution of the entangled pairs of neutral

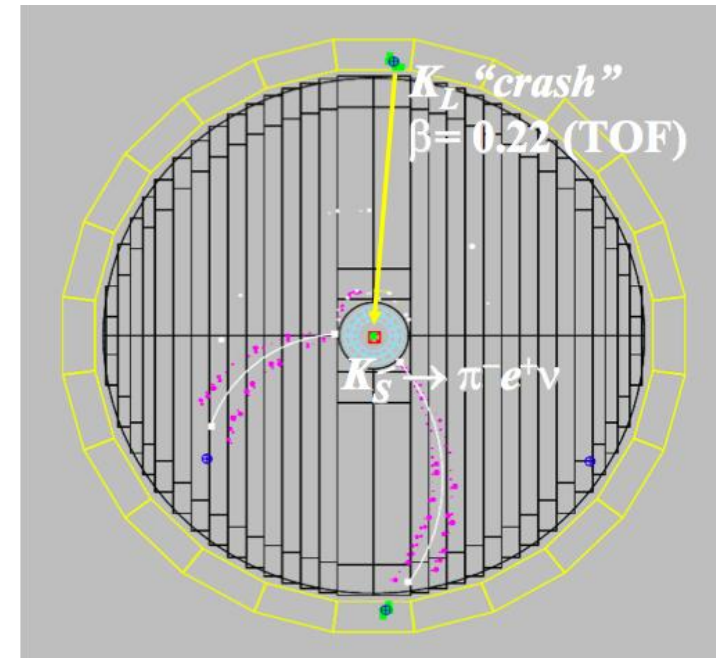
kaons

- Universality of the weak interaction of leptons and quarks
- Lepton universality
 - Search for possible deviations from SM

expectation to 0.4% precision

- Investigations of the structure of the scalar mesons
- Gamma gamma interaction

Asymmetry of $K_{S,L} \rightarrow \pi e \nu$ signals a CP violation

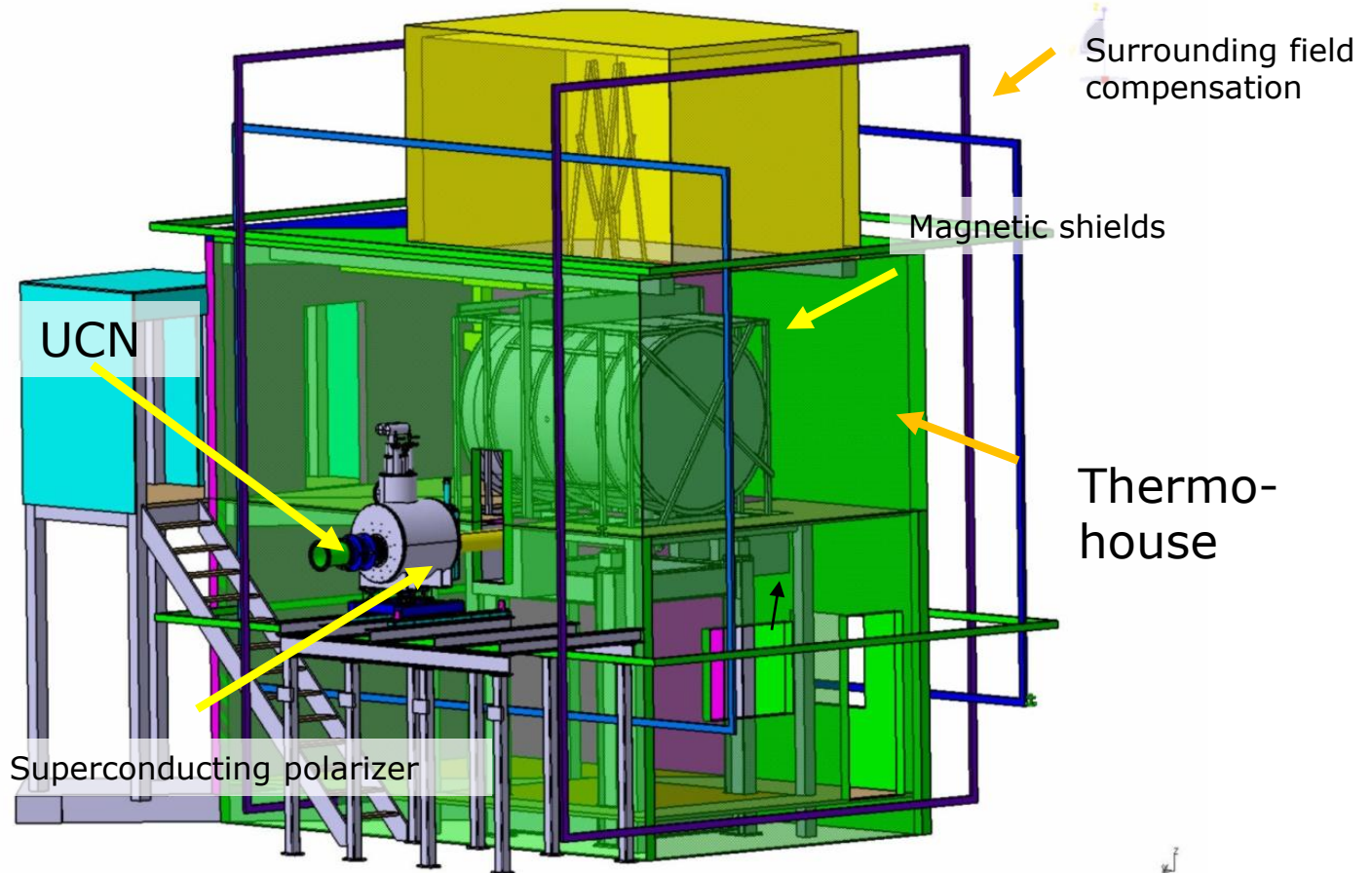




nEDM, n2EDM



Experiment is dedicated to measure the neutron electric dipole moment





nEDM, n2EDM



Institutions in Poland:

- Krakow: JU, IFJ PAN

Participants:

- 4 staff, 2 PhD students, 1 technical staff

Main contribution:

- Hardware, M&O

Main responsibilities:

- DAQ concept, integration, maintainace, on-line data analysis

Financing:

- Polish Research Grants 2009-13: 20kEUR/year

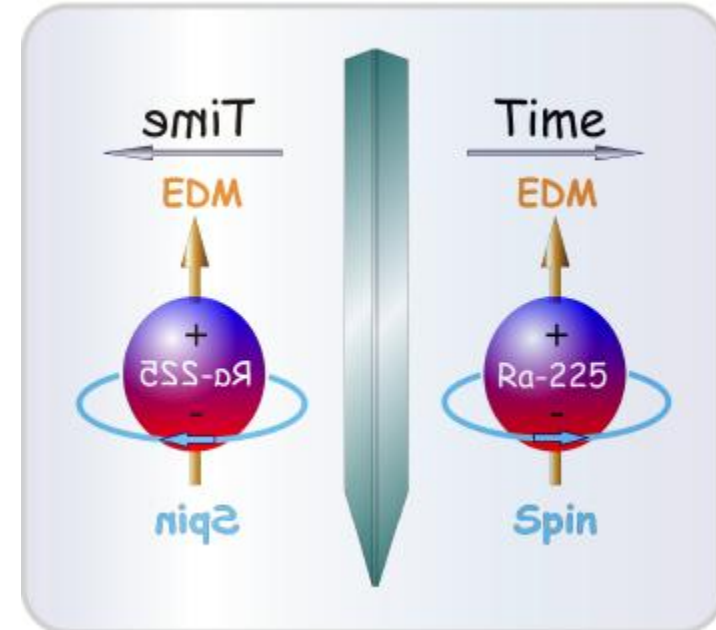
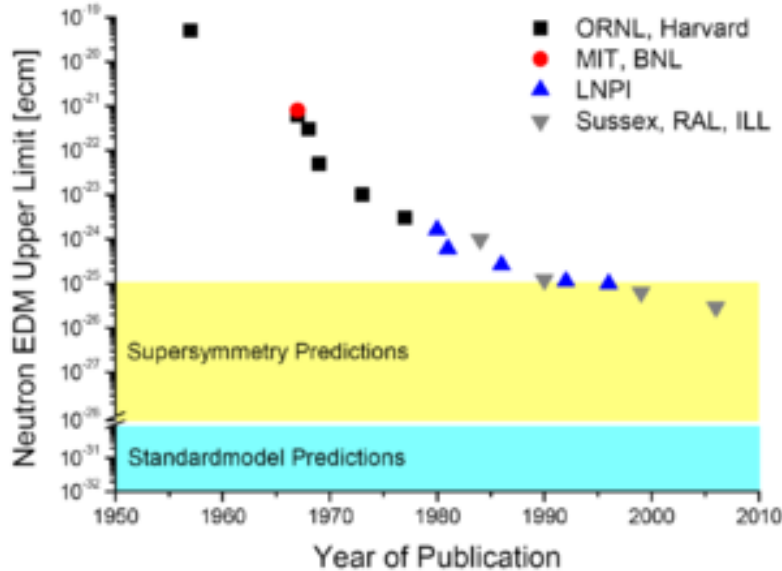


nEDM, n2EDM – physics



MS: $nEDM < 10^{-32} \text{ e} \cdot \text{cm}$,

Sensitivity to T (and CP) violation:



the goal is the sensitivity of $d_n < 5 \times 10^{-28} \text{ e} \cdot \text{cm}$

SUMMARY

- ▶ The subject of b- and c- quark sector in Poland is well represented by more than **27** scientists gathered in two groups: **LHCb** and **BELLE**.
- ▶ Poland has a well established and recognized contribution to the fundamental **neutron physics** research (neutron EDM, and correlations in neutron β decay).
- ▶ Krakow and Warsaw are **unique places to hunt for researchers** in Jagiellonian and Warsaw Universities, University of Science and Technology (AGH) and Technical University.
- ▶ The **comprehensive and multidisciplinary education** is the main advantage of our staff.
- ▶ Scientists are specialist in **experimental physics, electronics and computer sciences**.
- ▶ Obtained results and contributions are valuable outcomes in **former and present experiments**.
- ▶ Mainly due to the Polish funding authorities we have substantial financial support for the nearest future.
- ▶ Nevertheless some **problems** with funding might appear in the **next** couple of **years**.