

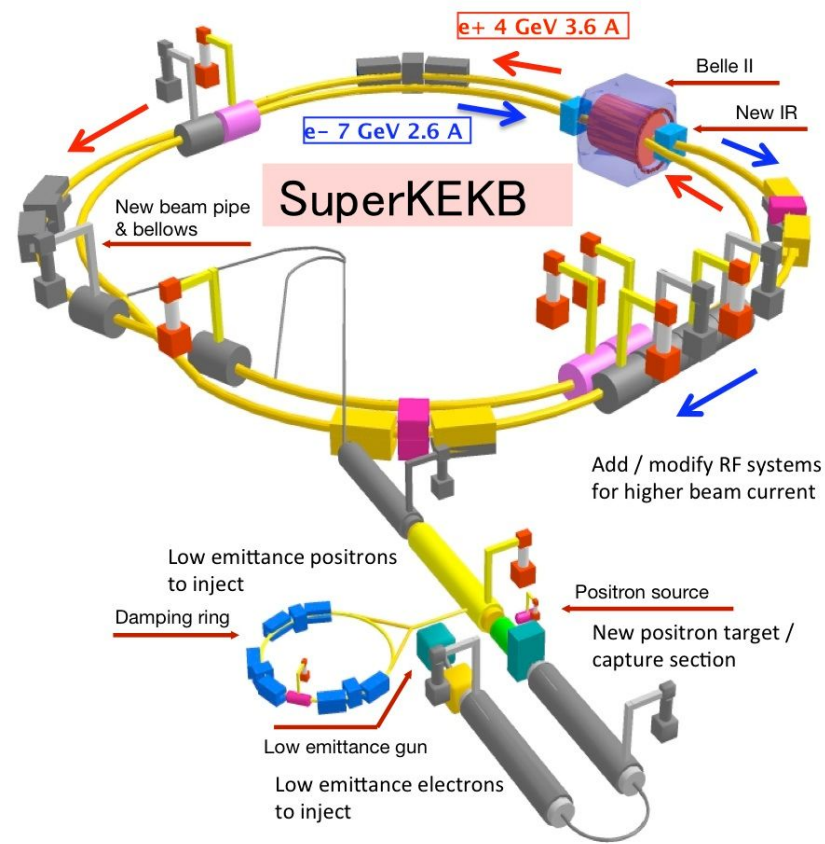
Belle & Belle II

(Fokus: deutsche Gruppen)

Martin Heck (KIT)

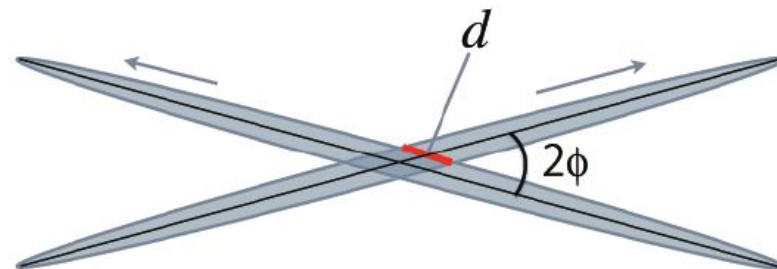
KET Meeting, Bad Honnef, 19.11.2016



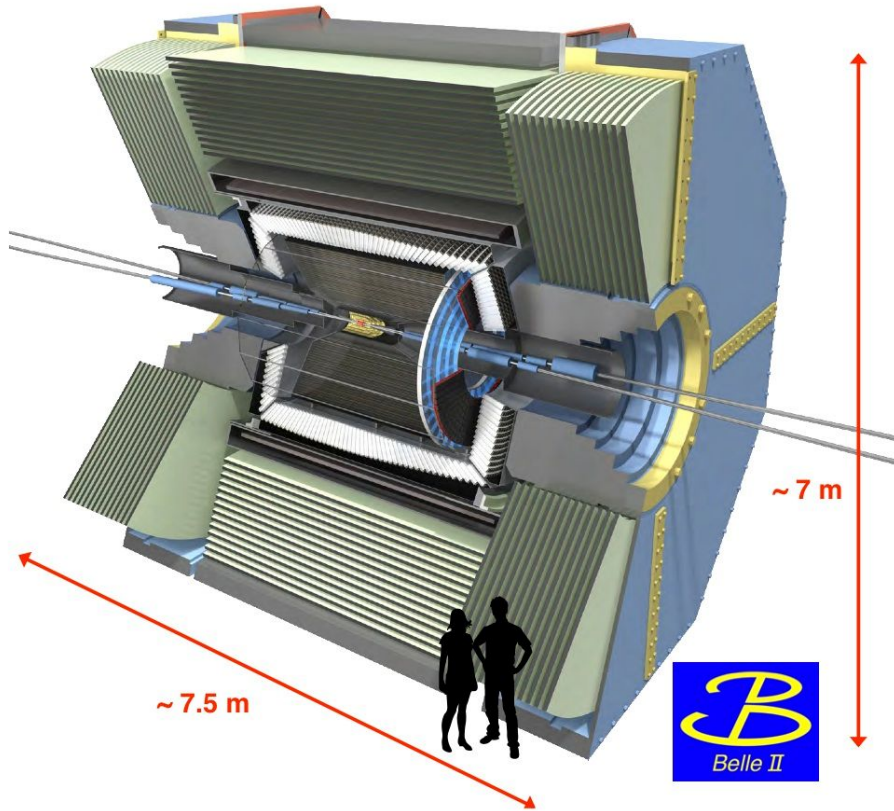


Die Maschine

- Nano-Beam Schema!



	KEKB Achieved	SuperKEKB
Energy (GeV) (LER/HER)	3.5/8.0	4.0/7.0
ξ_y	0.129/0.090	0.090/0.088
β_y^* (mm)	5.9/5.9	0.27/0.41
I (A)	1.64/1.19	3.60/2.62
Luminosity ($10^{34} \text{ cm}^{-2} \text{ s}^{-1}$)	2.11	80

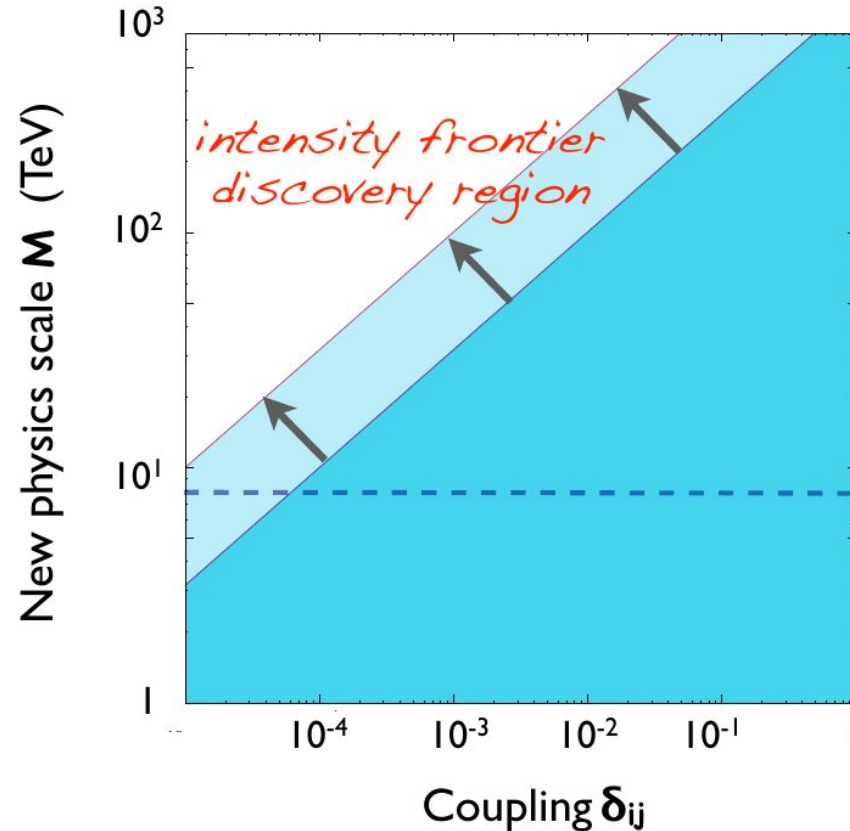
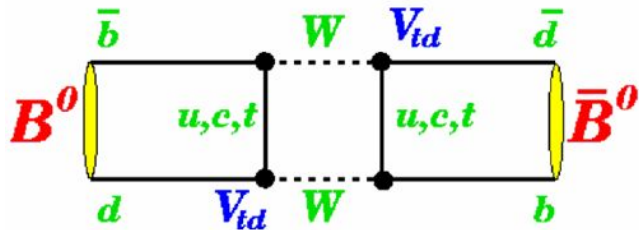


Der Detektor

- VXD: Vertex-Detektor
 - **PXD: Si-Pixel Detektor**
 - **SVD: Si-Streifen-Detektor**
- CDC: Driftkammer
- ARICH: Aerogel RICH
- TOP: Time of Propagation Counter
- ECL: Elektro-magnetisches Kalorimeter
- KLM: K_L - und Myon-Kammern

Die “Intensity-Frontier”

- Kopplungen oder Effekte, die im Standardmodell unterdrückt oder verboten sind;
- Z.B. bei Überprüfung der KM-Theorie über B-Mixing tauchen Faktoren $V_{td} \sim 1\%$ in den Amplituden auf;



Warum Belle II?

Am LHC:

- mehr B-Mesonen, da σ_B 10^6 x größer;
- Zerfallslänge der B-Mesonen im Laborsystem viel größer;

KEKB: $\sim 180 \mu\text{m}$ ($\beta\gamma = 0,4$)
SuperKEKB: $\sim 125 \mu\text{m}$ ($\beta\gamma = 0,28$)

Typisch für LHC-Experimente:

$\sim 10^4 \mu\text{m}$

Viel weniger Untergrund, kein Pile-Up
→ höhere Luminosität handhabbar;

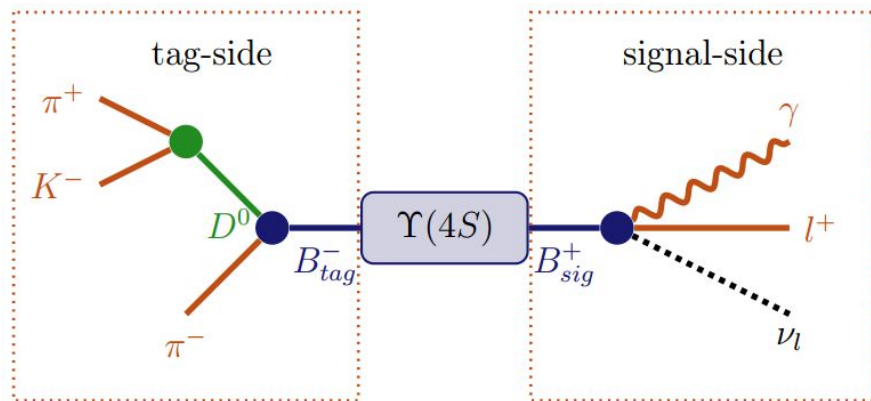
Anfangszustand $\Upsilon(4S)$ wohl definiert

→ 2 B-Mesonen *und sonst nichts*

→ mehrere π^0 , K_S -Mesonen im Endzustand;

→ 30-40% Flavour-Tagging-Effizienz;

→ Vollständigen Ereignisinterpretation für Zerfälle mit vs möglich.



Physik bei Belle II

B-Physik

- CP-Verletzung;
- Seltene Zerfälle (FCNC, leptonische (auch mit ν s), LFV-Zerfälle);
- Präzisionsmessungen von SM-Parametern (CKM-Matrix, m_b, \dots);
- Zusammensetzung der B-Zerfälle;
- ...

τ -Physik ($\sigma_{\text{Prod}}(\tau\tau)$ ähnlich wie $Y(4S)$)

- Lepton-Flavourzahl-Verletzung;
- ...

Weitere Spektroskopie

- X, Y, Z, Bottomonium, Charmonium;

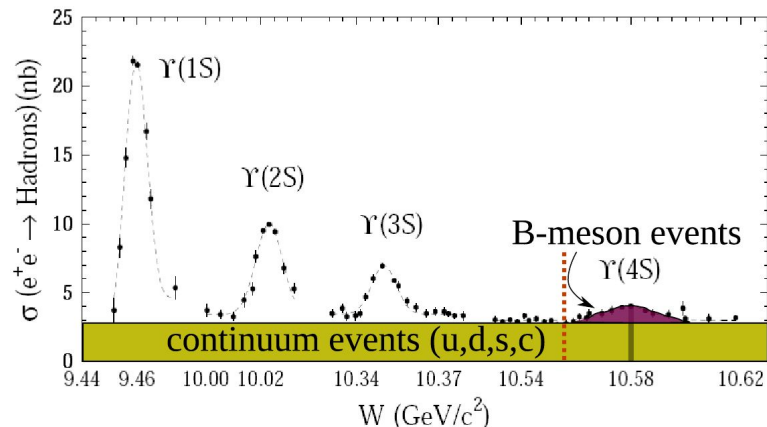
Charm-Physik

($\sigma_{\text{Prod}}(\text{cc})$ ähnlich wie $Y(4S)$)

- CP-Verletzung;
- Verzweigungsverhältnisse;
- Angeregte Zustände;
- ...

Andere Analysen

- Hadronisierung mit Hilfe von u/d/s-Paarproduktionsereignissen;
- Dark-Photon, Weinberg-Winkel;
- ...



Belle II Kollaboration

Deutschland mit 2. meisten Mitgliedern hinter Japan;
3 deutsche Institute in den Top 10 größten Instituten;



**Sprecherin für die
deutschen Gruppen:
Concettina Sfienti
(sfienti@uni-mainz.de)**

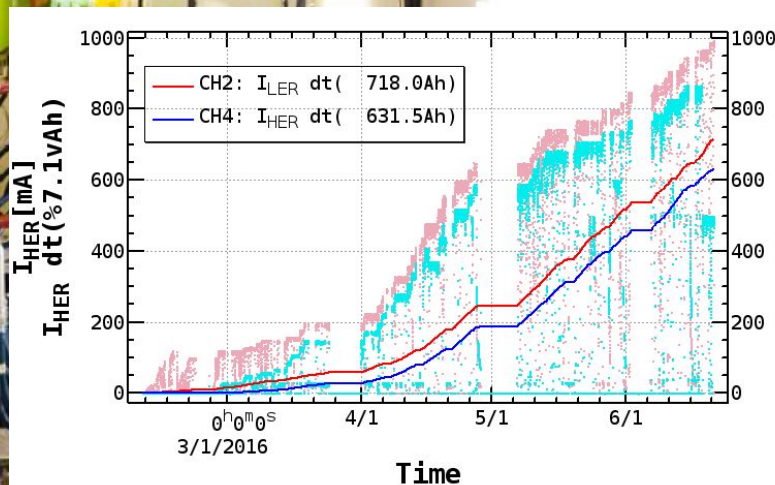
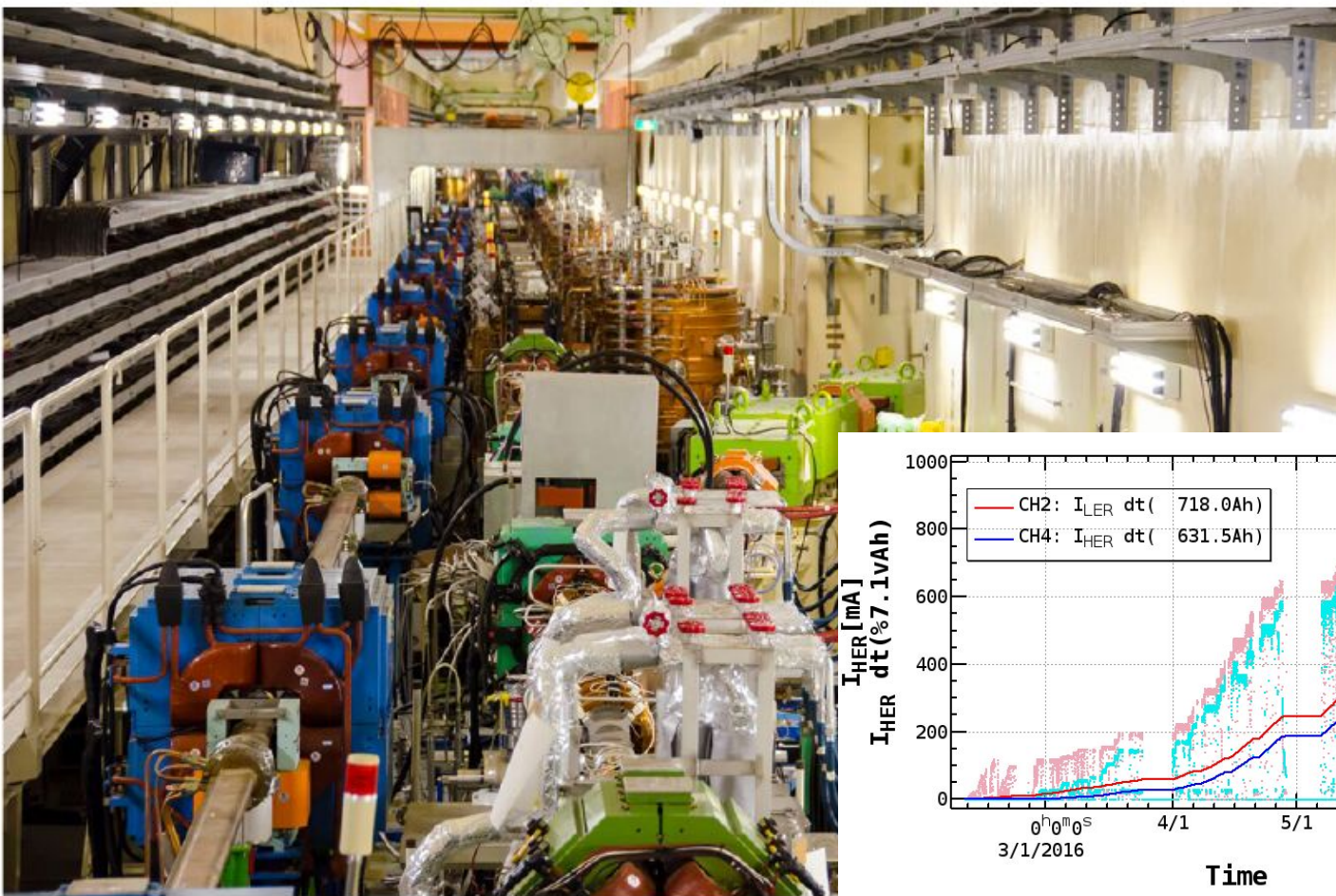
**Universitäten:
Göttingen, Gießen, Bonn,
Mainz, Heidelberg,
München (TUM + LMU);
KIT, DESY, FZ Jülich, MPI,
HLL;**

Personen mit Leitungsfunktionen in Deutschland

Software Coordinator	T. Kuhr	LMU
Tracking Convenor	M. Heck	KIT
Alignment/Calibration Coordinator	C. Kleinwort	DESY
Pixel Detector Coordinators	L. Andricek, C. Kiesling	HLL/MPI
VXD Commissioning Leader	C. Marinas	Bonn
EvtGen & (Semi-)Leptonic Decays	F. Bernlochner	Bonn
Time-dependent CPV	L. Li Gioi	MPI
Hadronic B decays	P. Goldenzweig	KIT
Charm Physics	G. Casarosa	Mainz
Institutional Board (Deputy Chair)	H.-G. Moser	MPI



Feb 2016: First Turns at SuperKEKB (4 GeV e^+ 's and 7 GeV e^- 's)



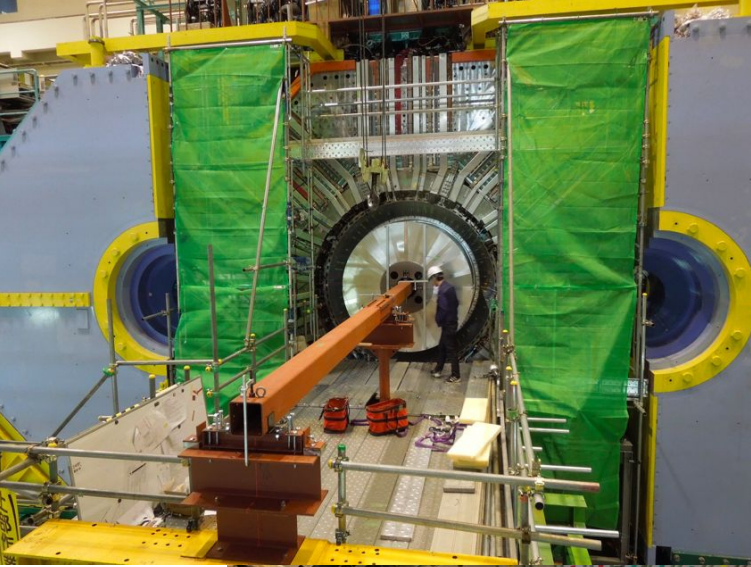
June 28, 2016 (LER beam current at 1000 mA, HER at 870 mA)

Messung des Untergrundes mit BEAST (Beam Exorcism for A Stable experiment)

Belle and the BEAST

Belle II will eventually roll in on a pair of railroad tracks



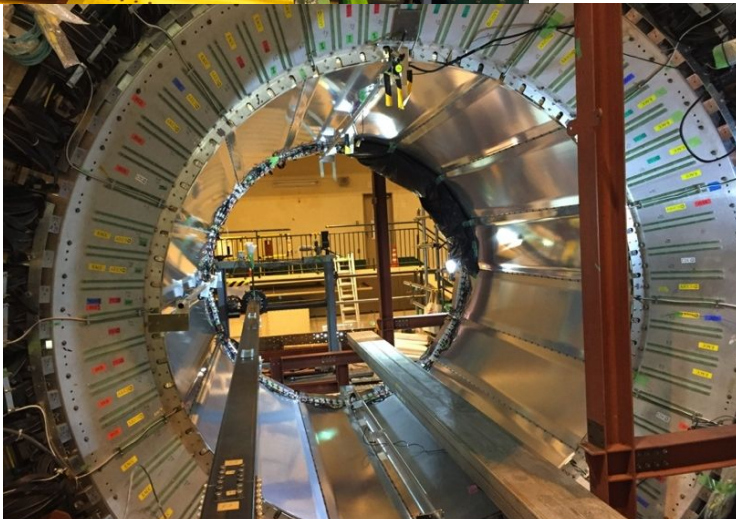


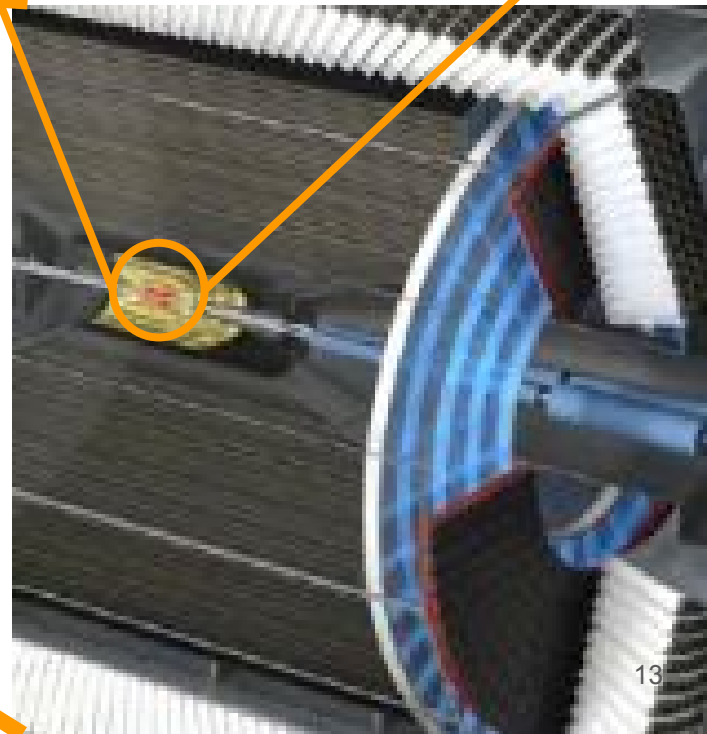
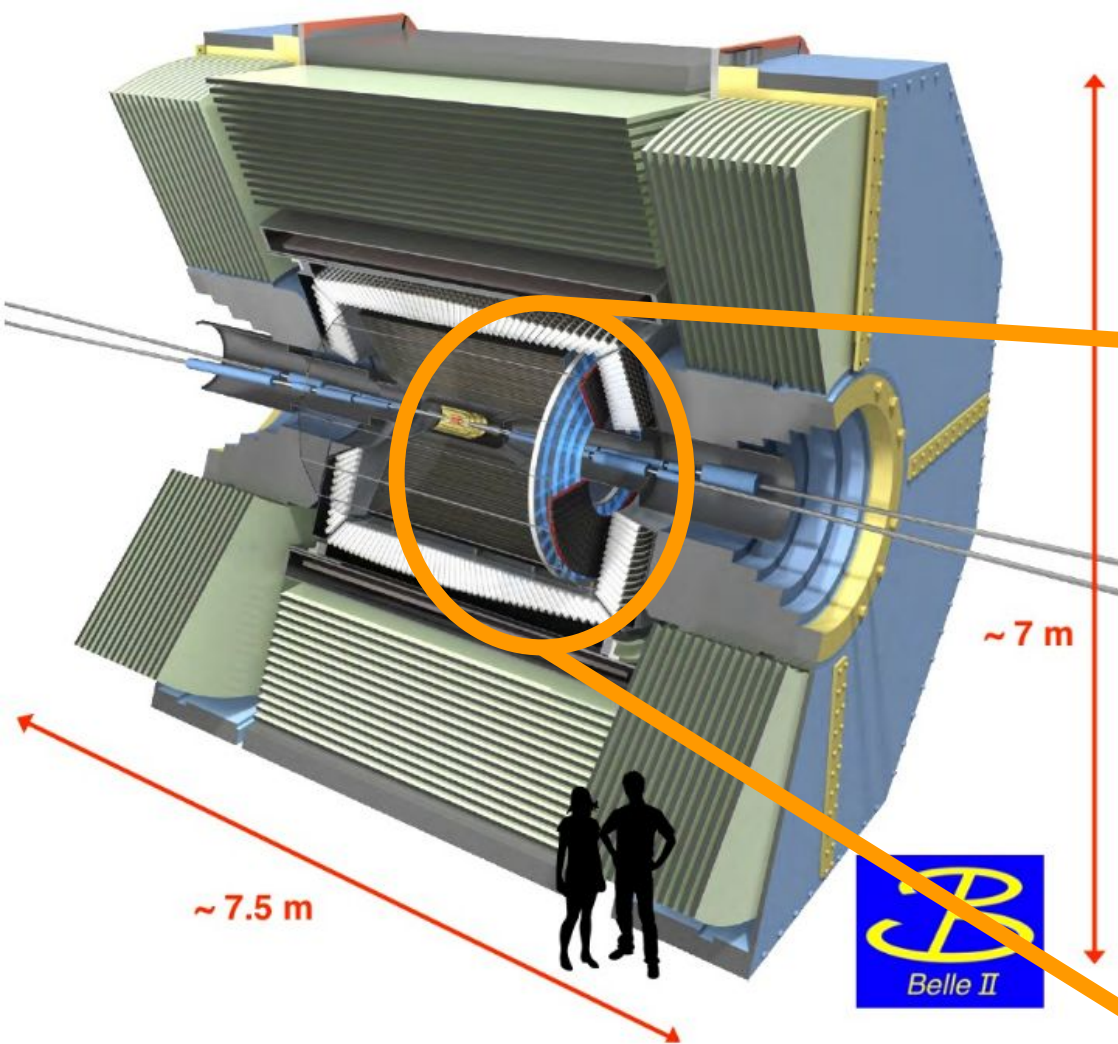
**Oktober:
CDC-
Instal-
lation**



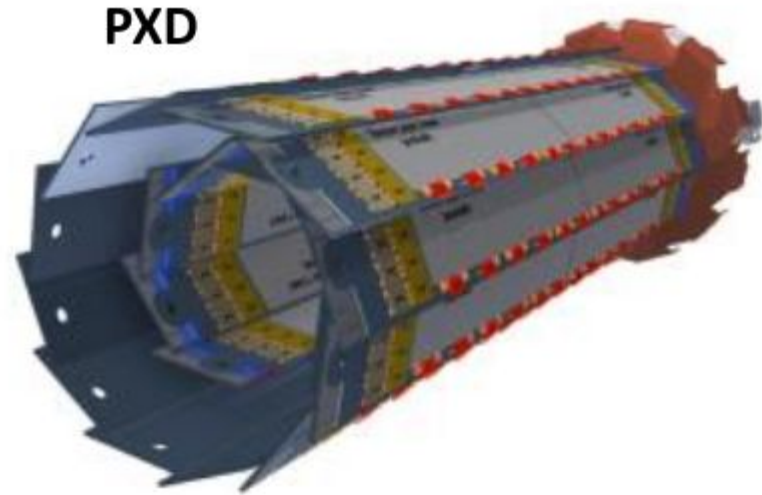
ARICH: Rings from cosmic ray

**Mai:
TOP-
Instal-
lation**



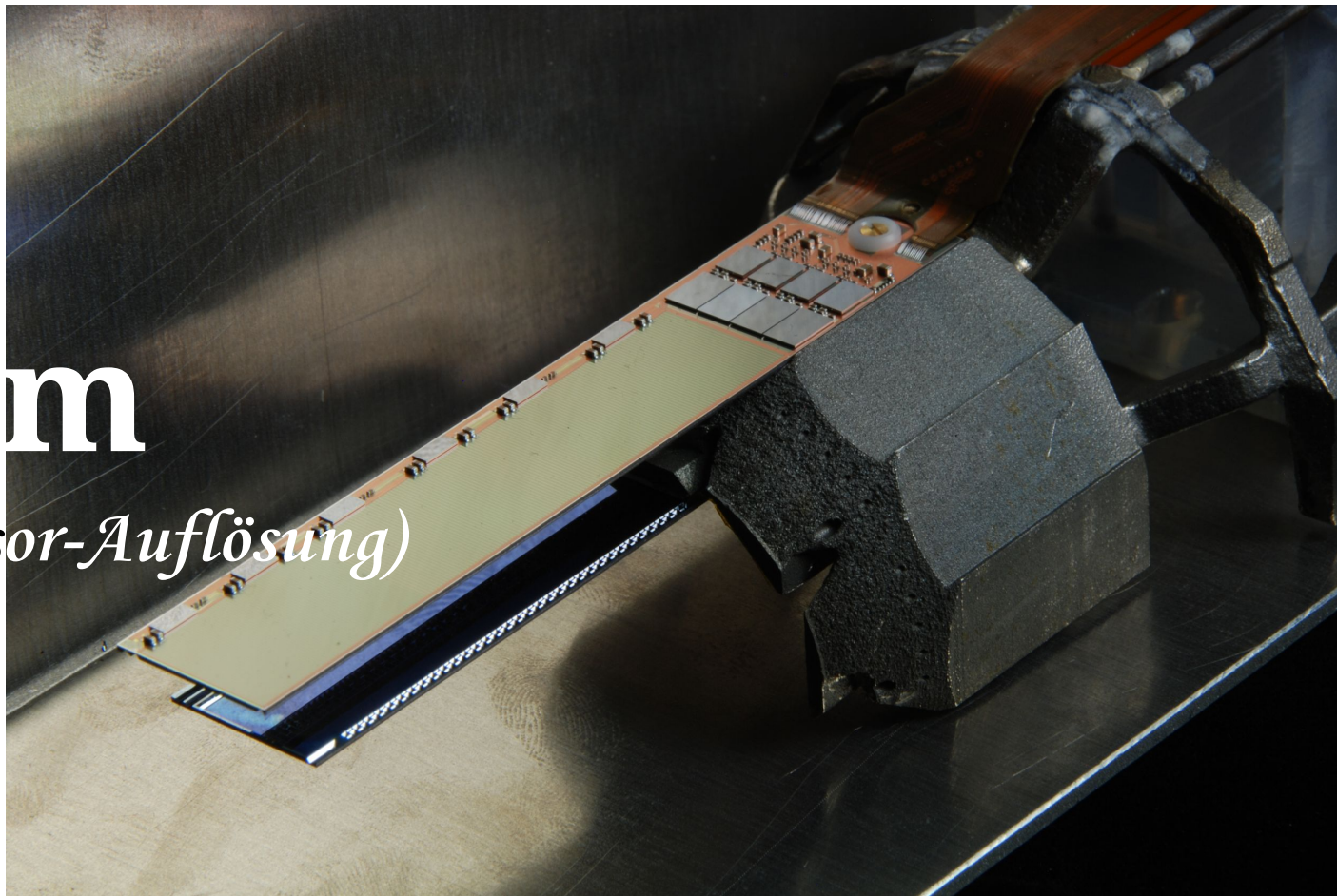
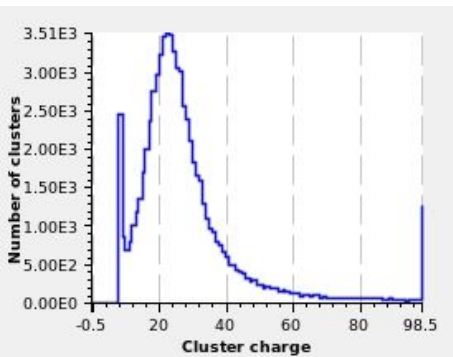


Warum DEPFET Pixel Detector (PXD)?

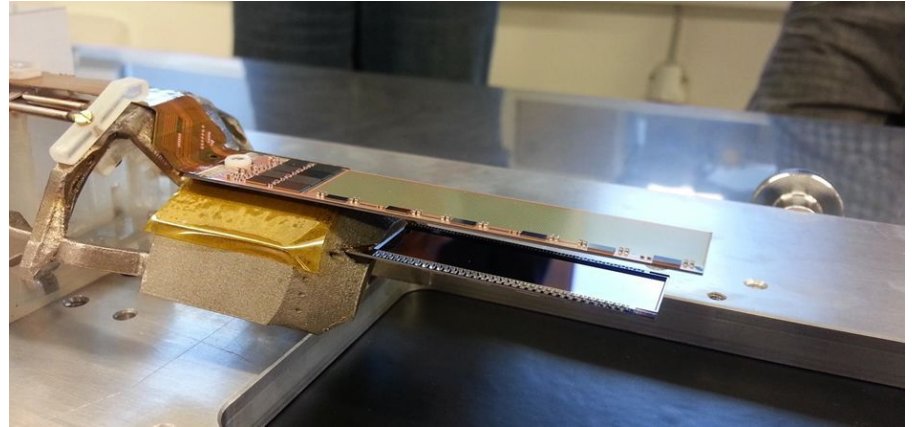


< 10 μm

(In-Plane Sensor-Auflösung)



$< 0,2\% X_0$
(all inclusive)



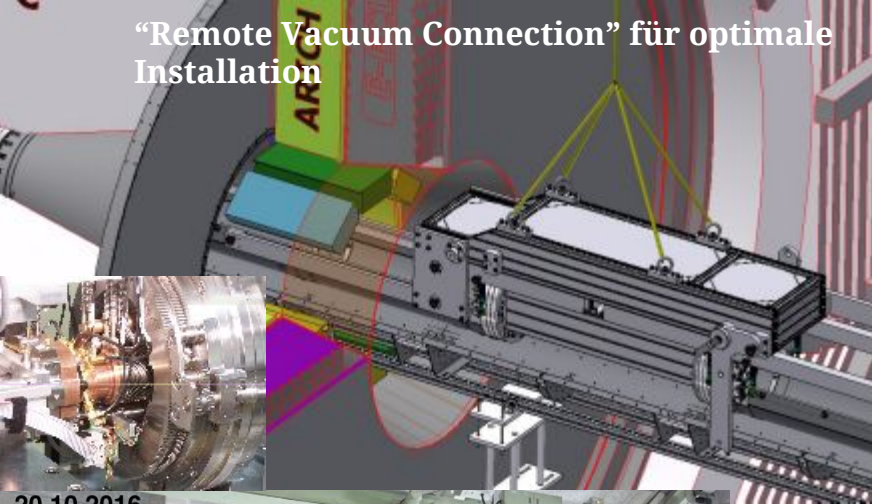
Hohe Untergrundrate bei
diesem Abstand erfordert
Zwischenspeicherung
und Online-Selektion

@ 1,4 cm

*(Abstand vom
Wechselwirkungspunkt)*



“Remote Vacuum Connection” für optimale Installation



20.10.2016

CO₂ VXD-Kühlung erreicht KEK



Verantwortung für Systeme, die für PXD
und SVD gebraucht werden

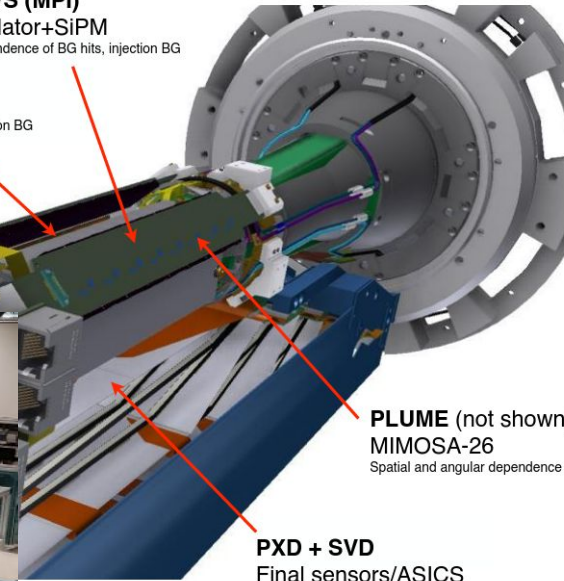
BEAST II System Integration at DESY



PERSY: PERmanently Running System
Integration will start in Dec 2016

CLAWS (MPI)
Scintillator+SiPM
time dependence of BG hits, injection BG

FANGS (BN)
ATLAS FE-I4 Pixels
Spatial dependence of BG hits, injection BG
Energy spectrum of BG hits



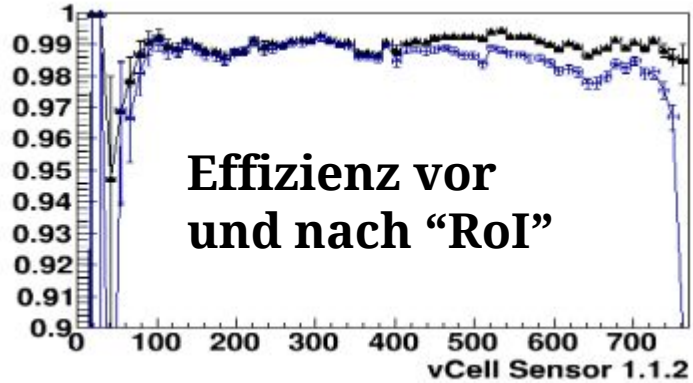
PLUME (not shown)
MIMOSA-26
Spatial and angular dependence of BG

PXD + SVD
Final sensors/ASICs



Testbeam mit komplettem VXD System-Test

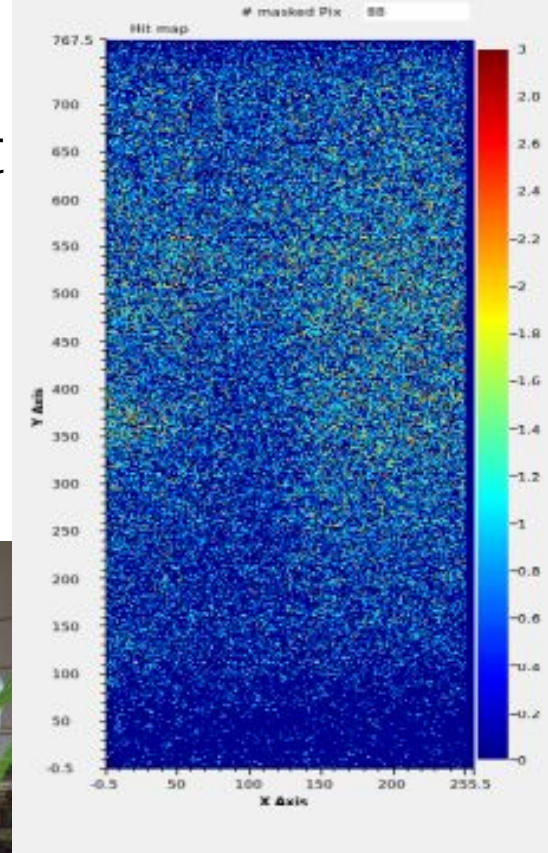
efficiency



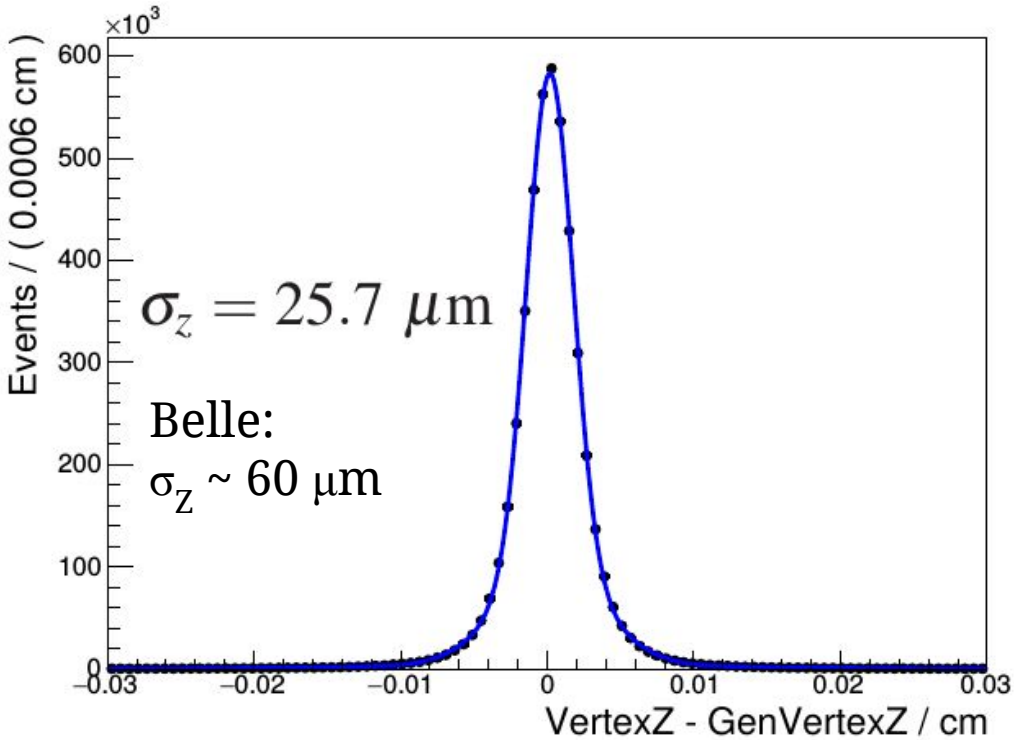
**Effizienz vor
und nach “RoI”**

DESY Testbeam

Copyright: DESY PR



$$B \rightarrow J/\psi K_s, \quad J/\psi \rightarrow \mu^+ \mu^-$$



Nicht-PXD Aktivitäten

- Magnetfeld-Messung
- Computing
- Web-Umzug
- Algorithmen-Entwicklung
- Trigger

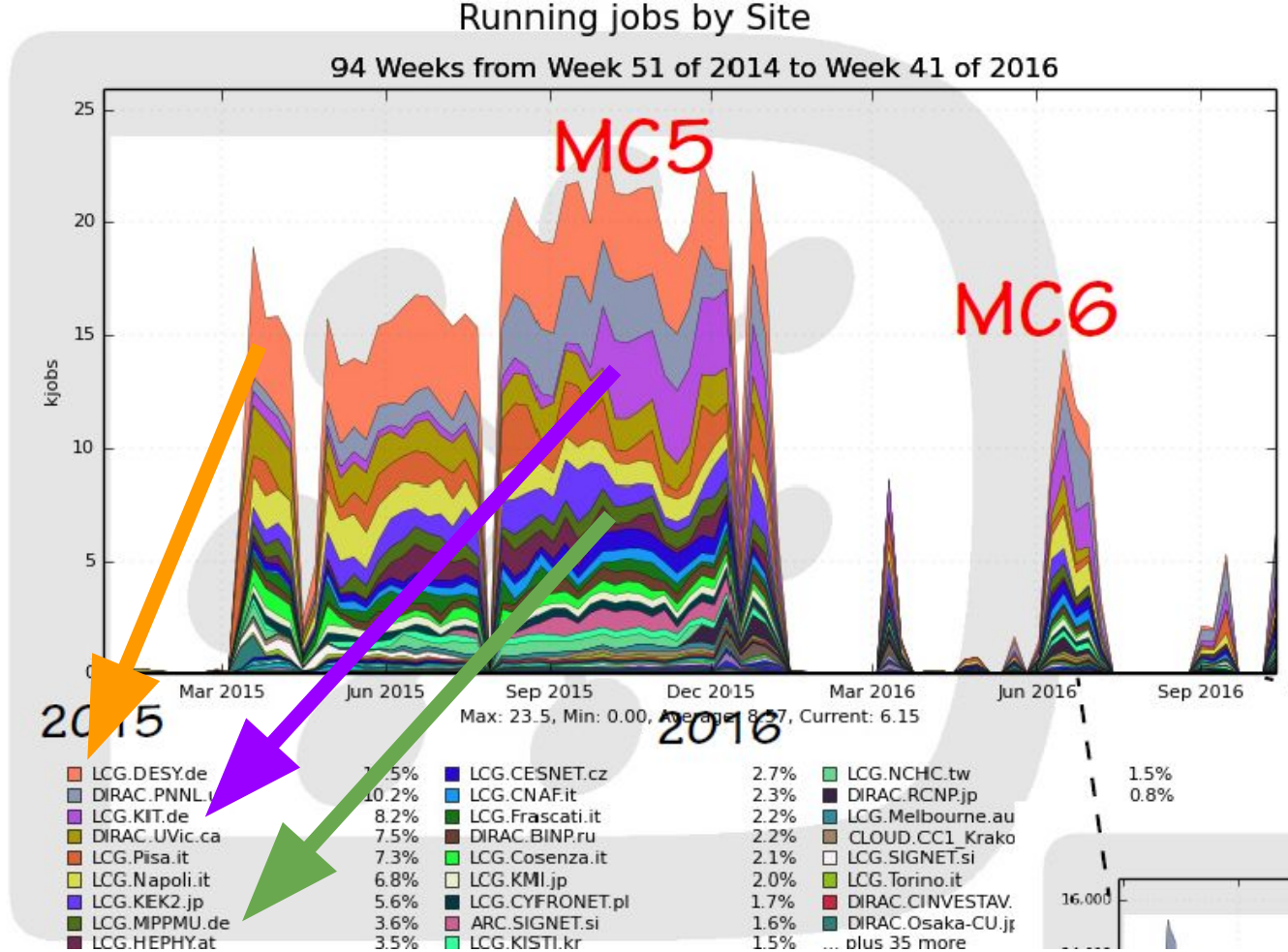
B-Field scan in CDC volume in Jun/Jul















Computing

+

Belle II Network Workshop
organized by Bruno Hoefft
(KIT)



“Collaborative Tools”-Umzug ans DESY

Web Pages	Wiki	Issue Tracking	Mailing Lists	Code Repository Build Services	Agenda Service	Document Service
 belle2.org <ul style="list-style-type: none"> Public / internal pages  <ul style="list-style-type: none"> Modern design CMS based Maintainable from outside 	 <ul style="list-style-type: none"> ATLASSIAN tool State-of-the art wiki Connection to jira & stash Powerful GUI Many plug-ins available Thorough documentation Migration from Twiki By far the most work 4000 pages migrated No automatic migration Some effort to compare content 4 FTEmonth manual work Workflows need adoption Archived twiki available 	 <ul style="list-style-type: none"> ATLASSIAN tool Connected to confluence Migration from redmine ATLASSIAN plug-in 	 <ul style="list-style-type: none"> sympa list@belle2.org Migration from sympa Cleanup and reordering 	 <ul style="list-style-type: none"> ATLASSIAN tools Connected to confluence Migration from SVN to GIT Hooks plug-in  <ul style="list-style-type: none"> Virtual machines in Xen Buildbot on VMs Build slaves for OS'   	 <ul style="list-style-type: none"> Indico Commonly used Copy from KEK indico Selected categories only Not yet done! 	 <ul style="list-style-type: none"> Invenio Migration from Invenio Copy from KEK Invenio Straight forward

Algorithmen- und Software-Entwicklung

~Arbeit von $\frac{1}{4}$ der Belle II-Mitglieder an deutschen Instituten

- Framework

Modul-, Prozess-Kommunikation, Test- und Validierungs-Framework, Geometrie-, DB-Interface, persistentes Datenformat, Support ...

KIT, LMU

- Tracking

Driftkammer-, SVD-Track-Finding, Fitting, Merging, High-Level-Trigger, Alignment, Kalibration, ...

**DESY, KIT,
Mainz**

- Analysewerkzeuge

- Vollständige Ereignisinterpretation
- Kontinuumsunterdrückung
- Flavour-Tagging
- Vertexing
- ...

**KIT
KIT
KIT, MPI
MPI**

} 100%

- Generator Tuning

DESY

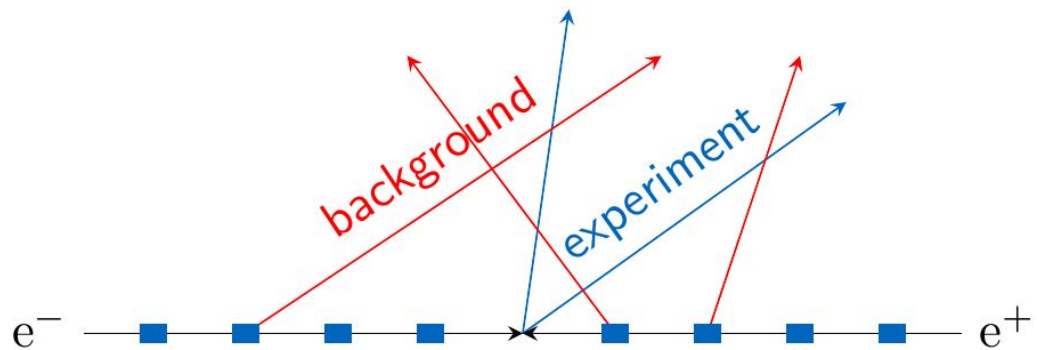
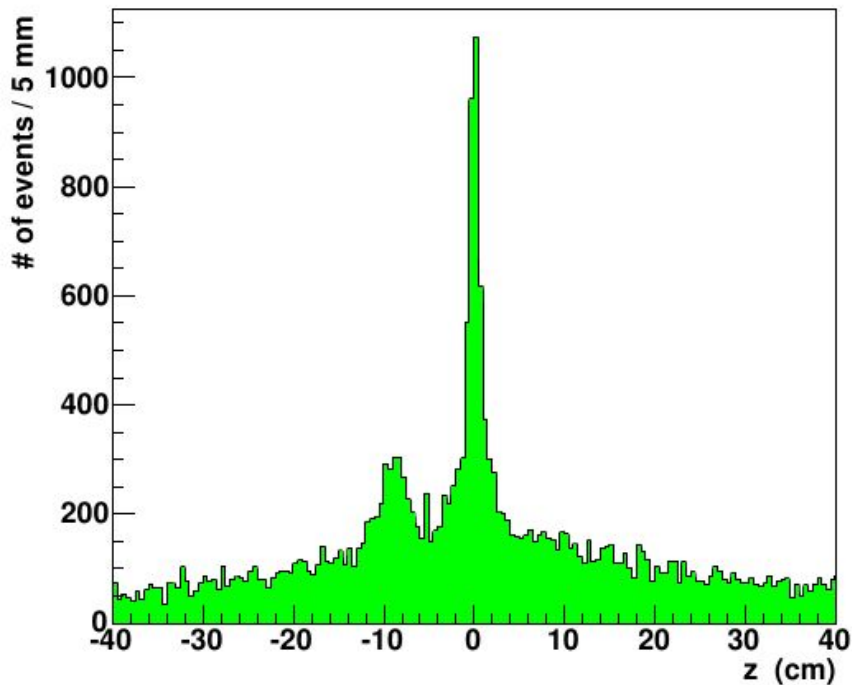
Belle Physik-Papers von deutschen Instituten seit 2015

- V. Chobanova, J. Dalseno, C. Kiesling, *et al.*, "First Observation of the Decay $B^0 \rightarrow \psi(2S) \pi^0$ ", PRD 93, 031101 (2016). MPI
- P. Vanhoefer, J. Dalseno, C. Kiesling, *et al.*, "Study of $B^0 \rightarrow \rho^+ \rho^-$ decays and implications for the CKM angle ϕ_2 ", PRD 93, 032010 (2016). MPI
- P. Hamer, A. Frey, *et al.*, "Search for $B^0 \rightarrow \pi \tau \nu$ with hadronic tagging at Belle", PRD 92, 072013 (2015). GÖ
- M. Huschle, T. Kuhr, M. Heck, P. Goldenzweig, *et al.*, "Measurement of the branching ratio of $B \rightarrow D^{(*)} \tau \nu$ relative to $B \rightarrow D^{(*)} l \nu$ decays with hadronic tagging at Belle", PRD 92, 072014 (2015). KIT/
LMU
- A. Heller, P. Goldenzweig, M. Heck, T. Kuhr, A. Zupanc, *et al.*, "Search for $B^+ \rightarrow l^+ \nu \gamma$ decays with hadronic tagging using the full Belle data sample", PRD 91, 112009(R) (2015). KIT
- C. Oswald, P. Urquijo, J. Dingfelder, *et al.*, "Semi-inclusive studies of semileptonic B_s decays at Belle", PRD 92, 072013 (2015). BN
- B. Kronenbitter, M. Heck, P. Goldenzweig, T. Kuhr, *et al.*, "Measurement of the branching fraction of $B^+ \rightarrow \tau^+ \nu$ decays with the semileptonic tagging method", PRD 92, 051102 (2015). KIT
- L. Pesantez, P. Urquijo, J. Dingfelder, *et al.*, "Measurement of the direct CP asymmetry in $B \rightarrow X_{\{s+d\}} \gamma$ decays with a lepton tag", PRL 114, 151601 (2015). BN

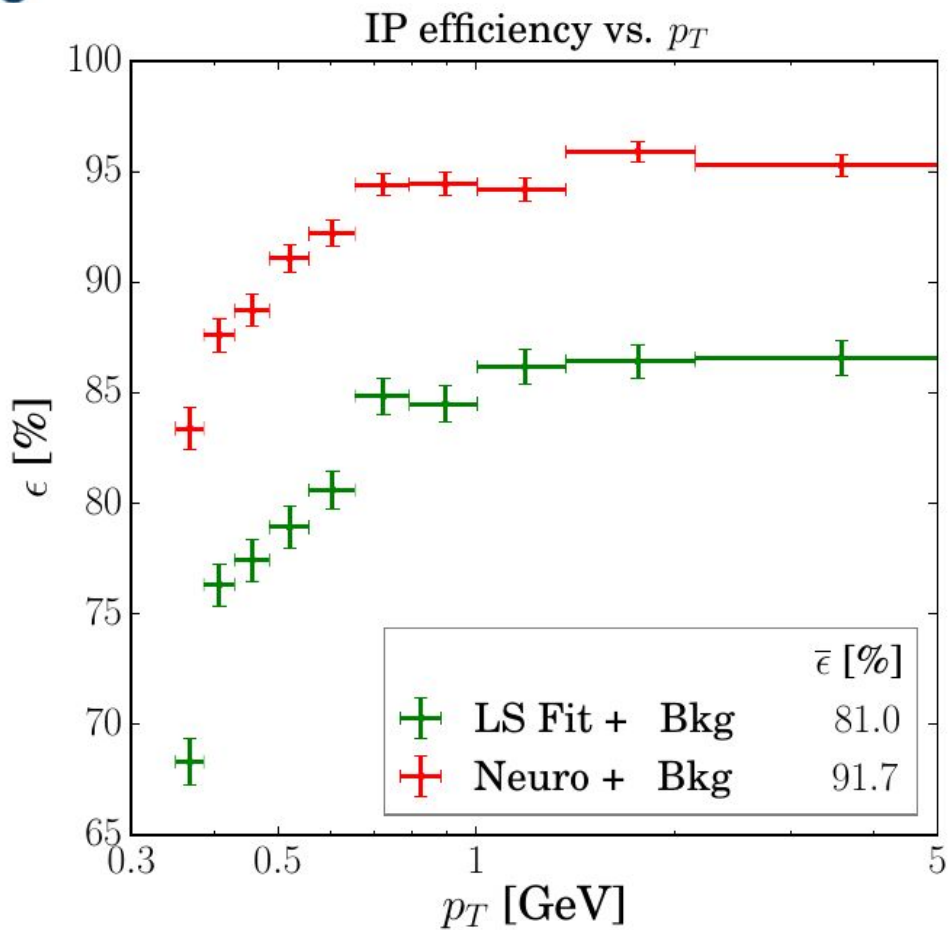
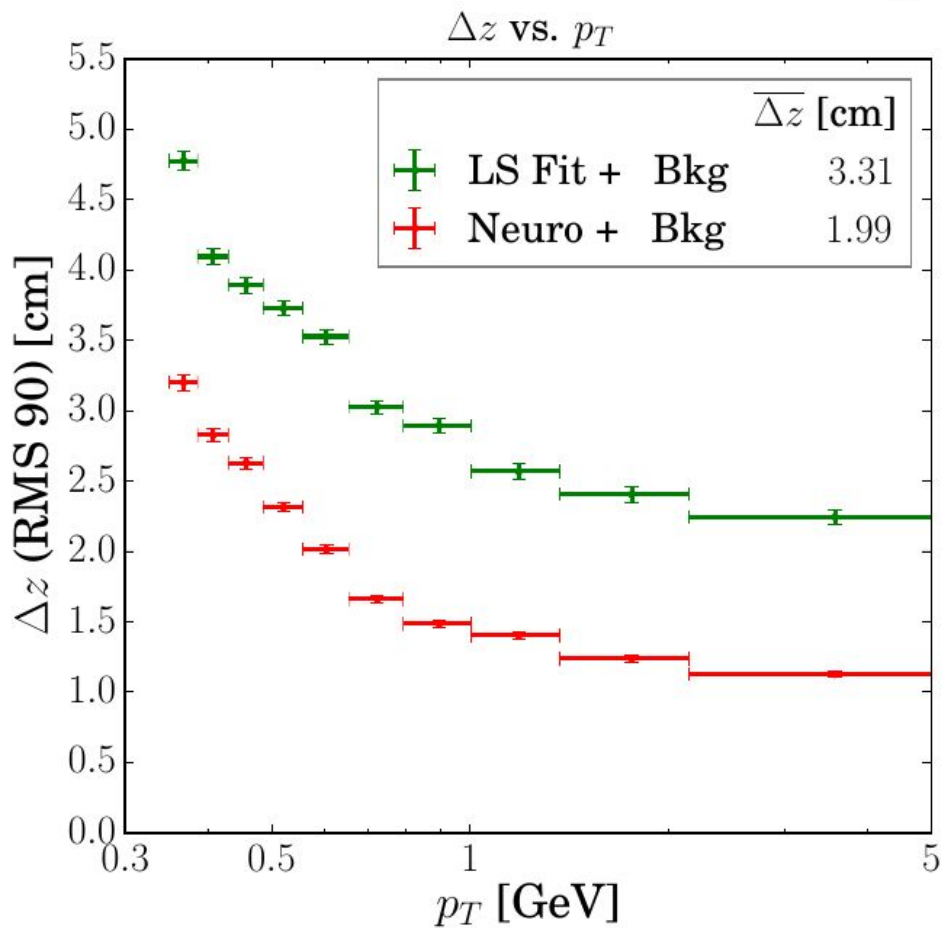
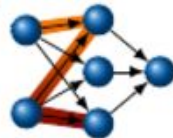
Weitere Analysen bereits submittiert oder kurz vor der Fertigstellung...

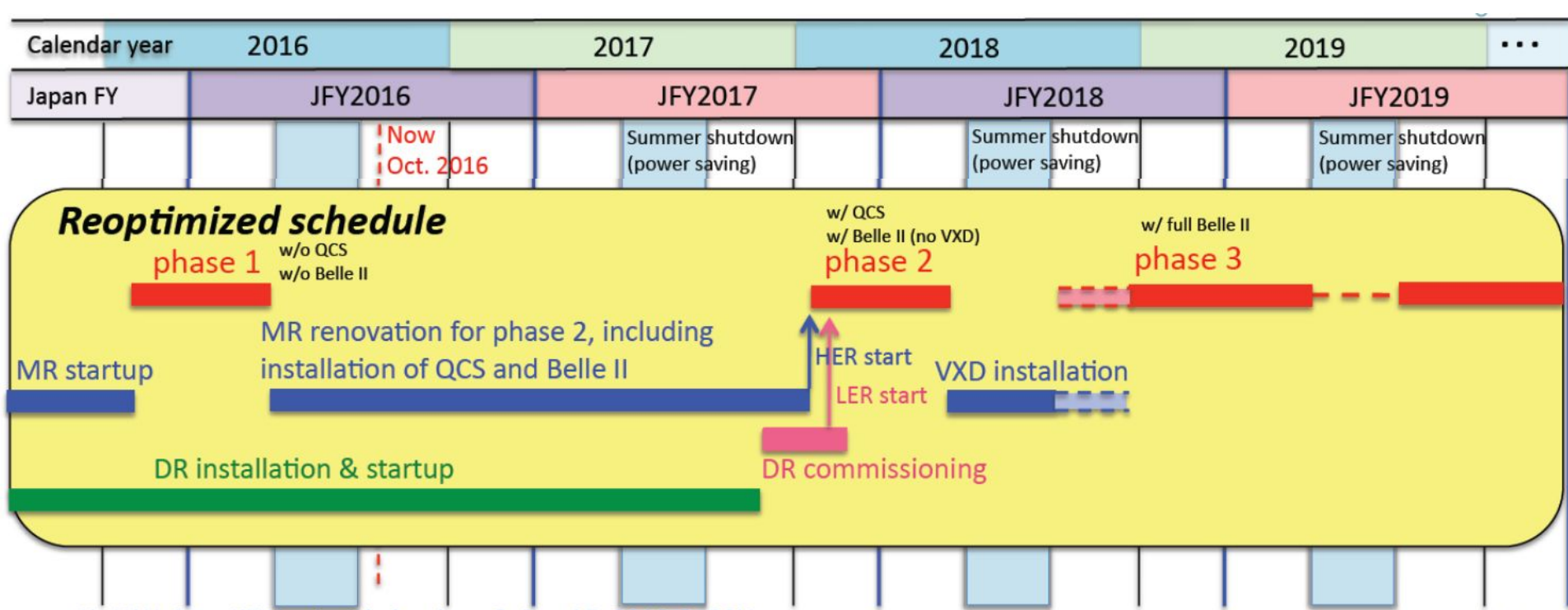
Motivation für “Neuro-z-Vertex Trigger” TUM, MPI, KIT (ITIV)

Z distribution



z-vertex distribution in Belle





Keine Fokus-Magnete,
Belle II in "Park-Position"

QCS-L (one of two final
focusing magnets) installed
this week! on Aug 1!



Fokus-Magnete,
Belle II ohne VXD,
mit BEAST II

Finale Experiment-Konfiguration

Zusammenfassung

Deutsche Gruppen

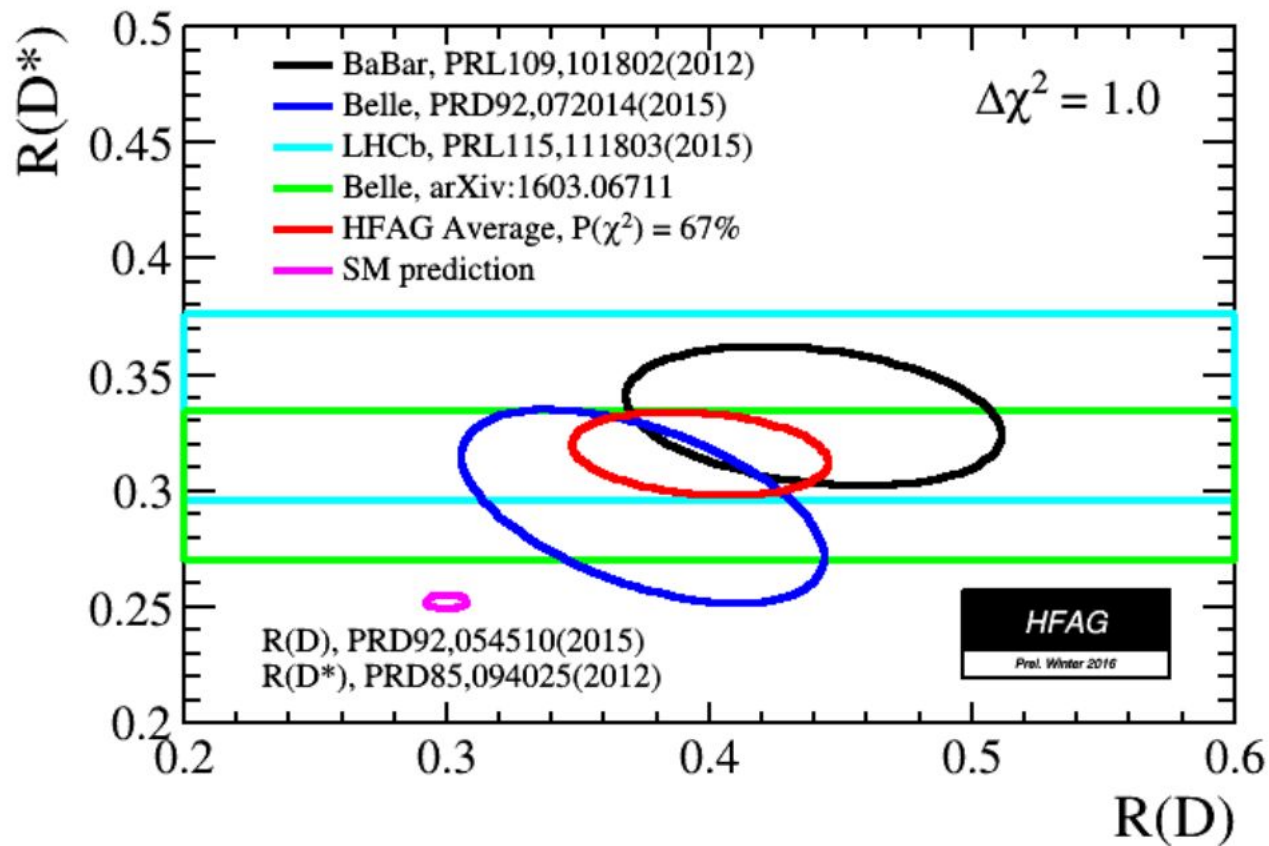
- bauen den Pixel Detektor und haben zentrale Verantwortung bei gesamter VXD Integration,
- dominieren die Software-Entwicklung,
- tragen signifikant zum Computing bei,
- analysieren Belle Daten mit präziseren Ergebnissen als je zuvor,
- engagieren sich beim Trigger, was noch von großer Wichtigkeit sein kann.

Erste Datennahme mit vollständigem Detektor: H2 JFY* 2018

* Das japanische Fiskaljahr geht bis März 2019.

BackUp

$B \rightarrow D^* \tau \nu$

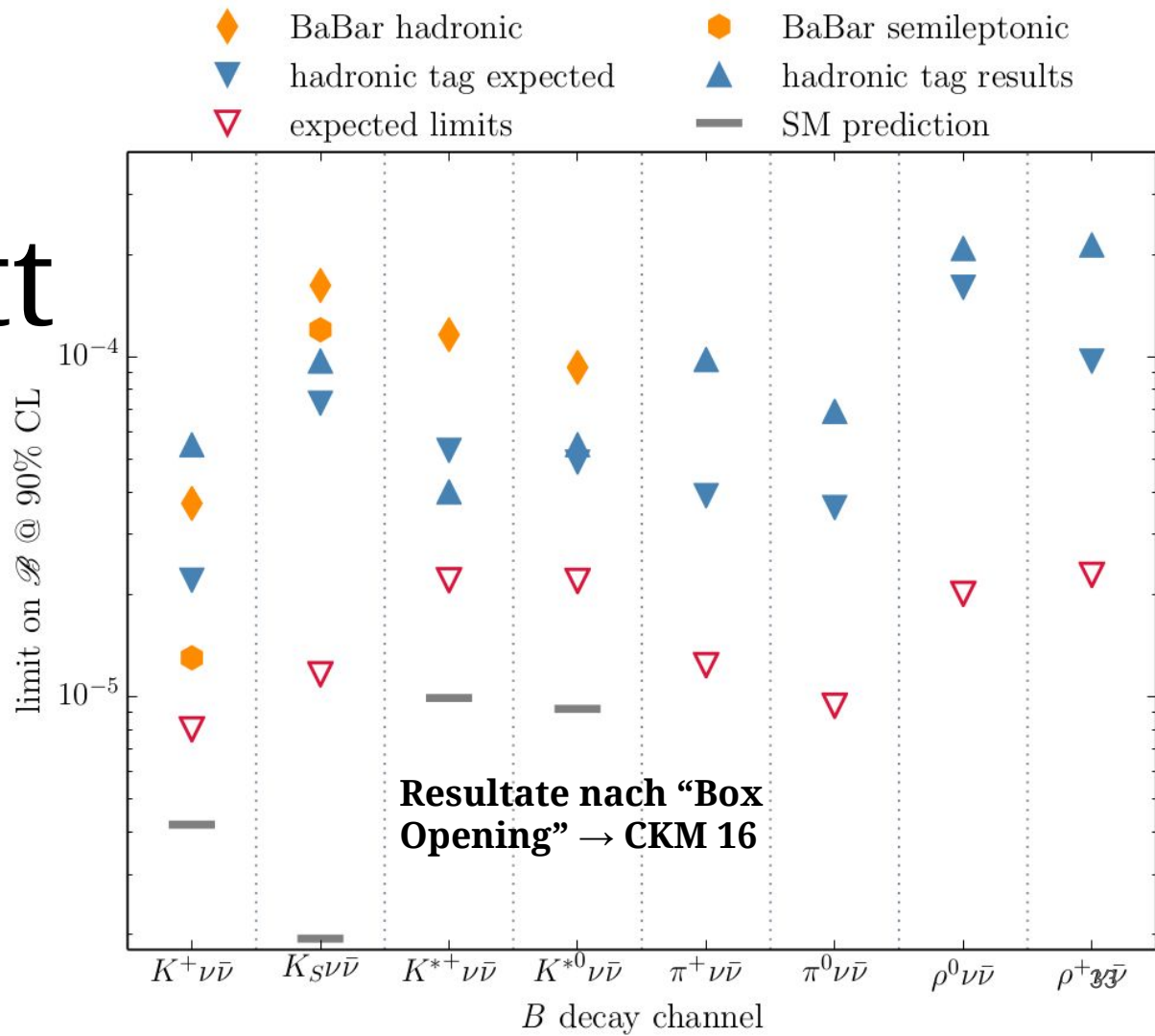


From “Physics at Super B Factory”

The Belle II(!) physics motivation book, p. 128 ff

Considering the amount of the expected background in $B^0 \rightarrow K^{*0} \nu \bar{\nu}$ (Tab. 5.10), the expected signal with the SM branching fraction $Br(B \rightarrow K^* \nu \bar{\nu}) = 1.3 \times 10^{-5}$ [95], and no improvements in the measurement method and detector performance, the required luminosity to observe the decay with a 3σ significance is above 100 ab^{-1} . However, the value changes drastically if beside the above mentioned hadronic tagging also the semileptonic tagging, mentioned in Sect. 5.1.3 is used. By examination of the results on the $B \rightarrow \tau \nu$ decays obtained by hadronic [87] and semileptonic [96] tagging we estimate the efficiency of the latter to be around 4-5 times better than for the hadronic tagging, at the deterioration of the signal to noise ratio by a factor of two. Taking into account also the planned upgrade of the detector, specifically the improved particle identification capabilities and the electromagnetic calorimeter performance, one can expect the improvement in the reconstruction efficiency for $B^0 \rightarrow K^{*0} \nu \bar{\nu}$ by around 70%. By these a 3σ significant signal of $B^0 \rightarrow K^{*0} \nu \bar{\nu}$ can be observed with around 30 ab^{-1} .

Fortschritt ohne neuen Detektor!



Warum Belle II?

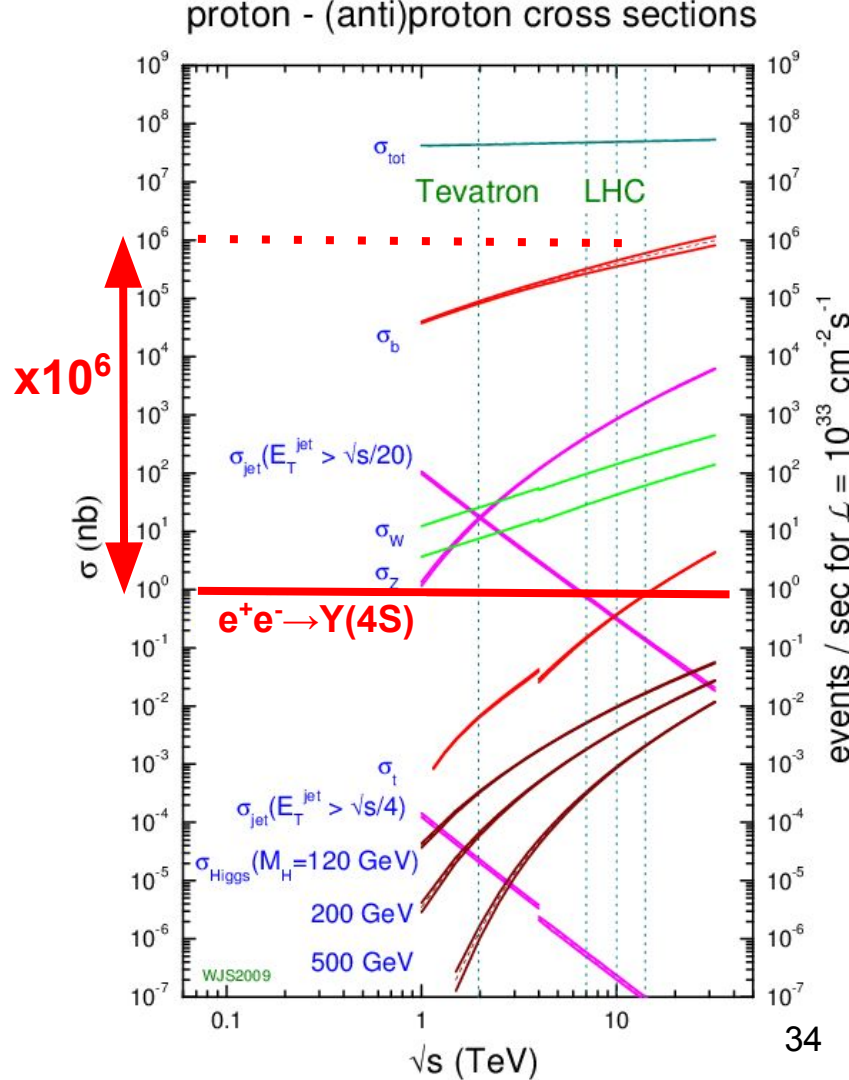
Am LHC:

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Typisch für LHC-Experimente:

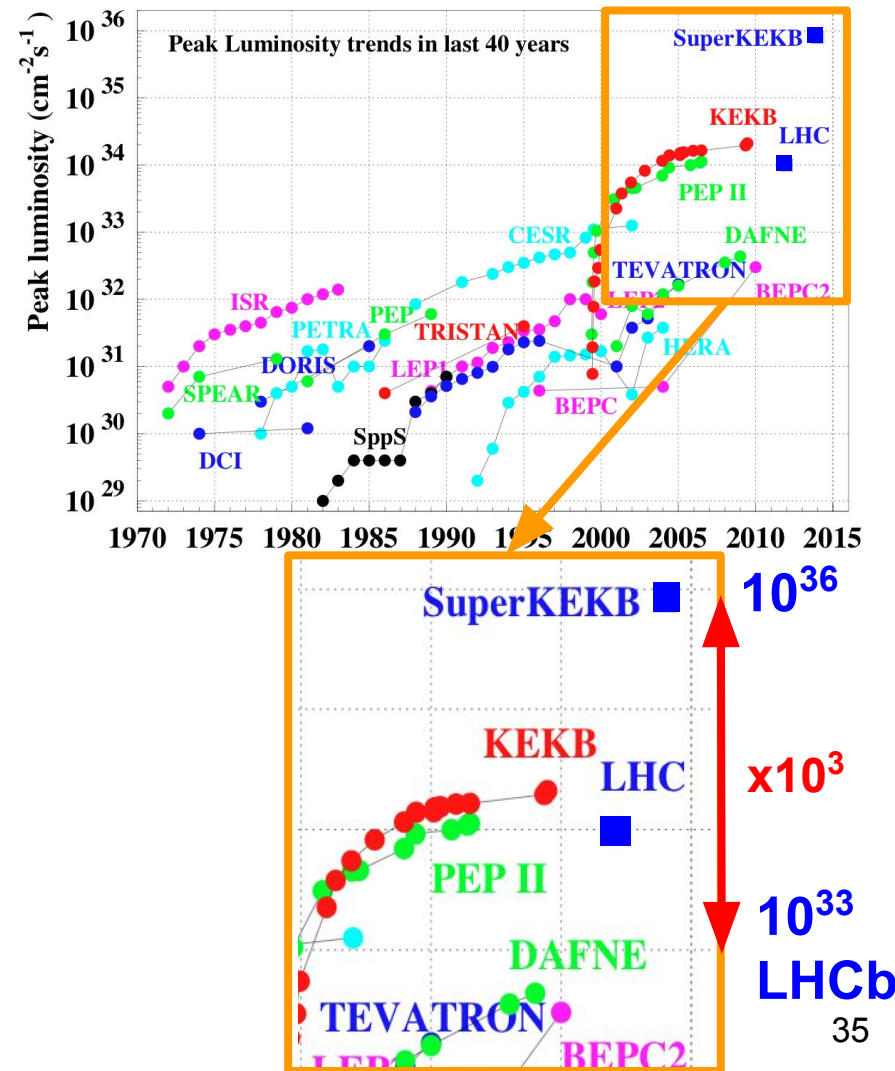
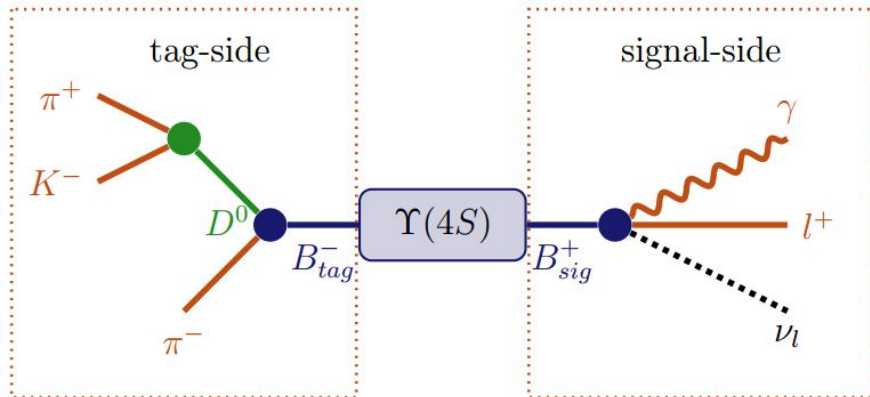
$\sim 10^4 \mu\text{m}$



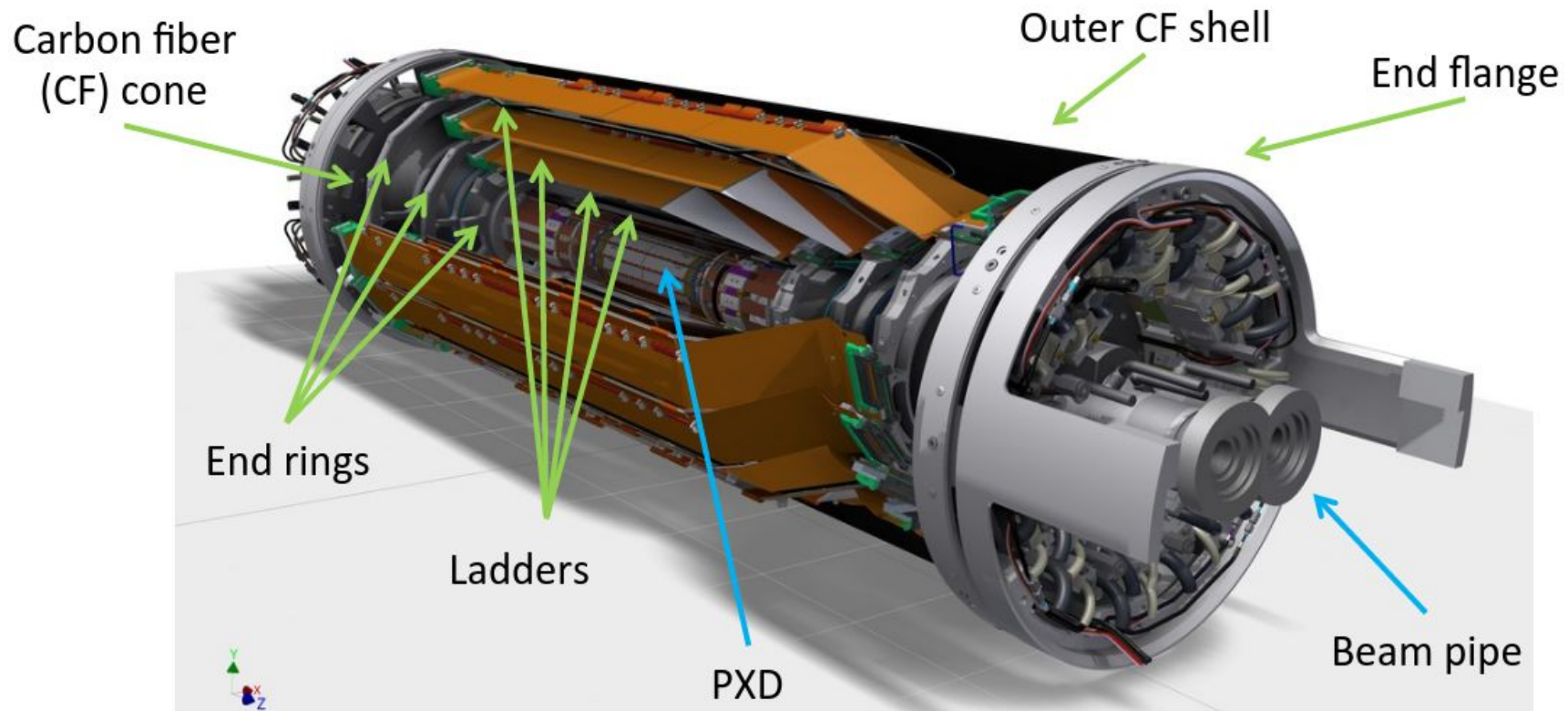
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- mehrere π^0, K_S -Mesonen im Endzustand;
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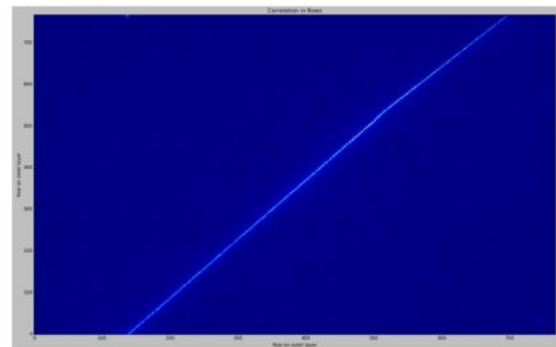


Belle II VXD

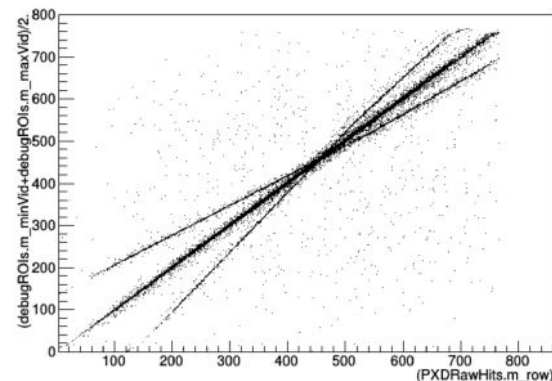


VXD Test at DESY in April 2016: Results

- ▶ **Rate:** up to 3 kHz with full DAQ chain
 - ▶ 30 times higher than 2014
- ▶ **“Golden” run #279:**
 - ▶ 1.15 M events with data reduction
 - ▶ No errors (“large-ROIs” workaround)
- ▶ **Correlations:**
 - ▶ Between all sensor layers
 - ▶ Between PXD hits and ROI coordinates on both layers
- ▶ **Secondary target:**
 - ▶ Multiple ROIs per 1 layer ($\sim 5\%$)
- ▶ **High-quality events:**
 - ▶ 18.9 M events (of total 101.1 M)
 - ▶ Still required certain workarounds



PXD rows layers 1 vs. layer 2



PXD rows vs. ROI coordinates

Pixel Vertex Detector for Belle II @ SuperKEKB

Precise Measurement
of particle origin

