

Belle II Virtual Reality & CAVE Implementation

Michael Bender, Thomas Kuhr

Excellence Cluster Universe

Ludwig-Maximilians-Universität München

CHEP 2018, Sofia, 12.07.2018

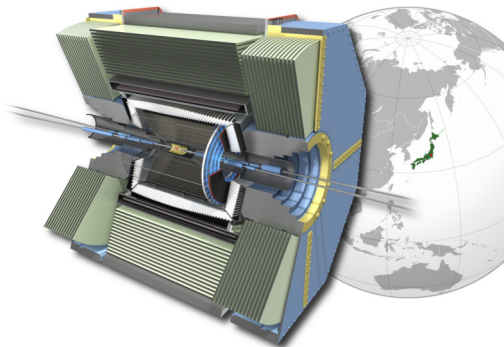
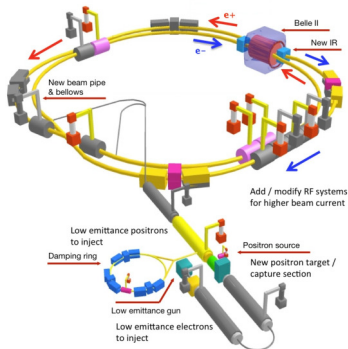


Federal Ministry
of Education
and Research



SuperKEKB

- $e^+ e^-$ collider at KEK, Japan
- (mainly) operates at $\Upsilon(4S)$ resonance
 ⇒ produces B meson pairs
- design luminosity of $8 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$
 (40x the current world record)
- data taking started this April

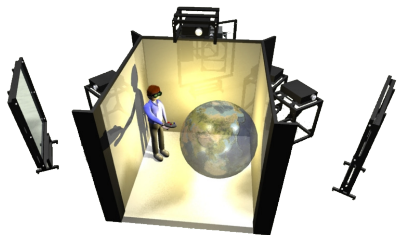
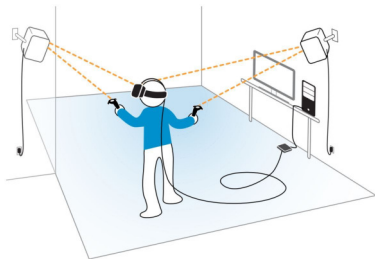


Belle II

- precise measurement of CP violation and indirect searches for new physics
- asymmetric detector design
- high particle identification efficiency
- precise momentum resolution



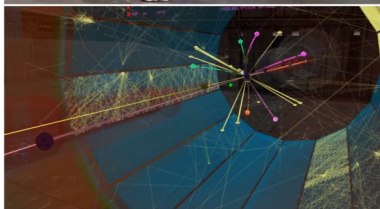
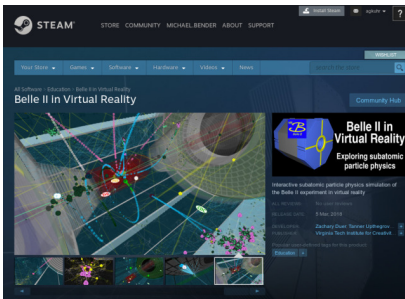
Virtual reality (VR) is a computer-generated scenario that simulates an immersive environment.



Belle2VR

(Leo Piilonen, Belle2VR - A VR Visualization of Subatomic Particle Physics)

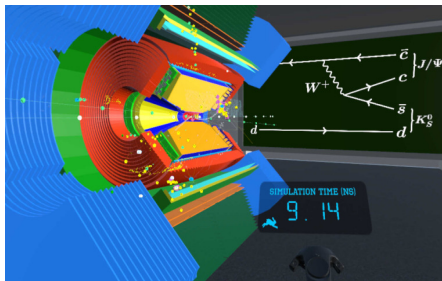
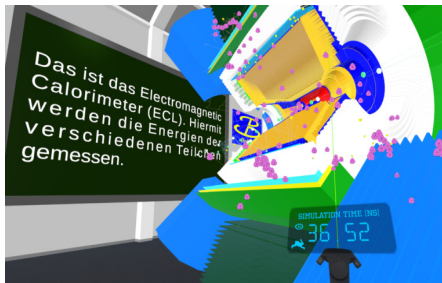
- by L. Piilonen and his team at Virginia Tech
- using **Unity** as software-development platform (free for non-commercial use)
- supports HTC Vive, Oculus Rift and there's also a browser version available 😊
- export geometry from GEANT4 detector description to .fbx format
- export the event history from GEANT4 simulation to .csv file
⇒ both can easily be imported to Unity



- users can:
 - > move around freely
 - > control detector and event
 - > examine particle properties
- ⇒ pedagogical tool in undergraduate & high school physics
- ⇒ app available on **STEAM**

Belle2VR "Munich edition"

- adapted original Belle2VR
 - ⇒ put emphasis on outreach
 - ⇒ focus on audience without prior knowledge
 - ⇒ removed some of the "higher level" mechanics
 - ⇒ added Feynman diagrams
 - ⇒ added detector description



- intend to cooperate with "Netzwerk Teilchenwelt"
 - German outreach organization for particle physics
 - intend to acquire several VR headsets
 - can be used by schools or at events
- ⇒ Belle2VR (original or Munich edition) can be used by them

- annual event on the Garching campus
- with > 10,000 visitors in 2017
- different research areas present their work
- attracted many people with our VR setup 😊



Das Belle II Experiment

Das Belle II Kollaboration

- 100 Mitglieder aus 16 Ländern in 13 Institutionen
- Nachfolge der Belle-Kollaboration
- Internationaler Zusammenschluss von Physikern, Ingenieuren und Informatikern

Das Belle II Beschleuniger

- Beschleunigung Elektronen und Positronen auf 10 GeV-Energie
- Zwei Lager-Ringbeschleuniger mit Abstrahlungen von 100 Tera- und 100 Femtoampere
- 400 km lange Kollaborator aus 10 Nationen
- Super-KBK (Super-Kamiokande) als Neutrino-Messstation
- Super-KBK (Super-Kamiokande) als Neutrino-Messstation

Das Belle II Detektor

- 400 km langer Beschleuniger mit 100 GeV-Energie
- Beschleunigung Elektronen und Positronen auf 10 GeV-Energie
- Zwei Lager-Ringbeschleuniger mit Abstrahlungen von 100 Tera- und 100 Femtoampere
- 400 km langer Beschleuniger mit 100 GeV-Energie
- Beschleunigung Elektronen und Positronen auf 10 GeV-Energie

Was werden wir damit produzieren?

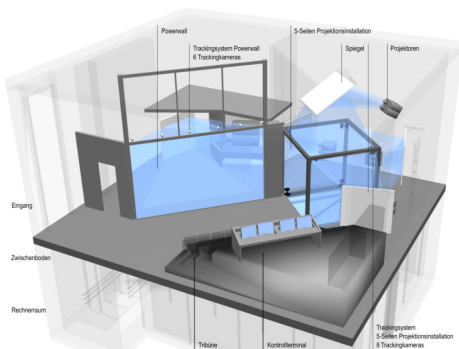
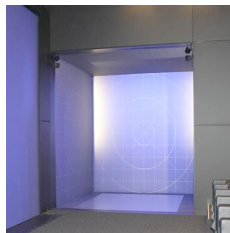
- Erzeugung des Standardmodells
- Prüfung der Vorhersagen des Standardmodells
- Suche nach Physik jenseits des Standardmodells
- Neutrinomessung
- Erzeugung von Neutrinos



BYOPD



- **CAVE** is the acronym for **Cave Automatic Virtual Environment**
- immersive VR environment where projectors are directed to up to six walls of a room-sized cube
- (often) made up of rear-projection screens
- 3D (shutter) glasses create impression of stereoscopic depth



Leibniz Supercomputing Centre
of the Bavarian Academy of Sciences and Humanities

The **CAVE** at LRZ:

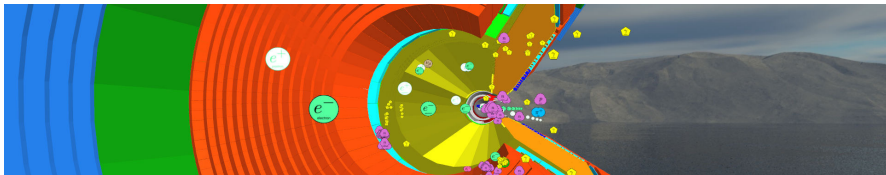
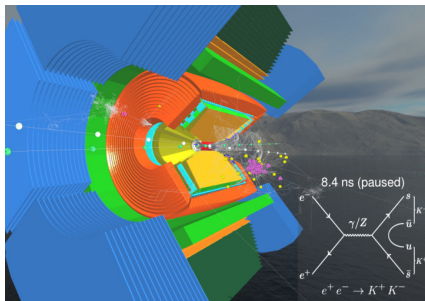
- five 2.7m x 2.7m walls with two 1080p active stereo projectors each
- cluster of 12 nodes (10 render & 2 server)
- each equipped with:
 - > 2 Intel Xeon (8core) CPU
 - > 256 GB RAM
 - > Nvidia Quadro P6000
- ART TrackPack4 with 4 cameras



GRETCHEN

(Graphical Education Tool (for) Cave (h) Environments)

- simple event display for educational purposes in CAVE environments
- written in OpenGL (version 3.3)
- custom made library to synchronize nodes
- reuses resources from Belle2VR (event files, detector model, particle sprites)
- particles translate according to simulation
- control detector and event





GRETCHEN



Conclusion & Outlook

- ⇒ multiple VR activities at Belle II
- ⇒ Belle2VR for head-mounted displays & GRETCHEN for CAVE installations
- ⇒ GRETCHEN can easily be adapted for other experiments



GRETCHEN

Thank you for your attention!