LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Belle II Computing

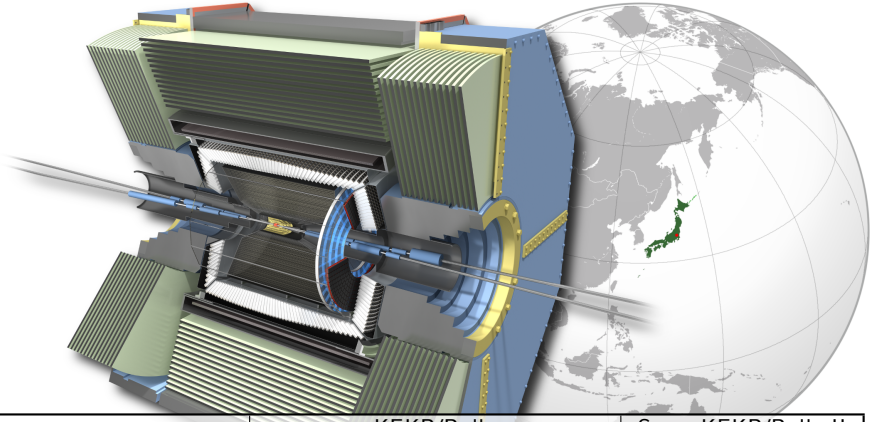
Martin Ritter for the Belle II Collaboration

Annual Terascale Alliance Workshop, November 18, 2015

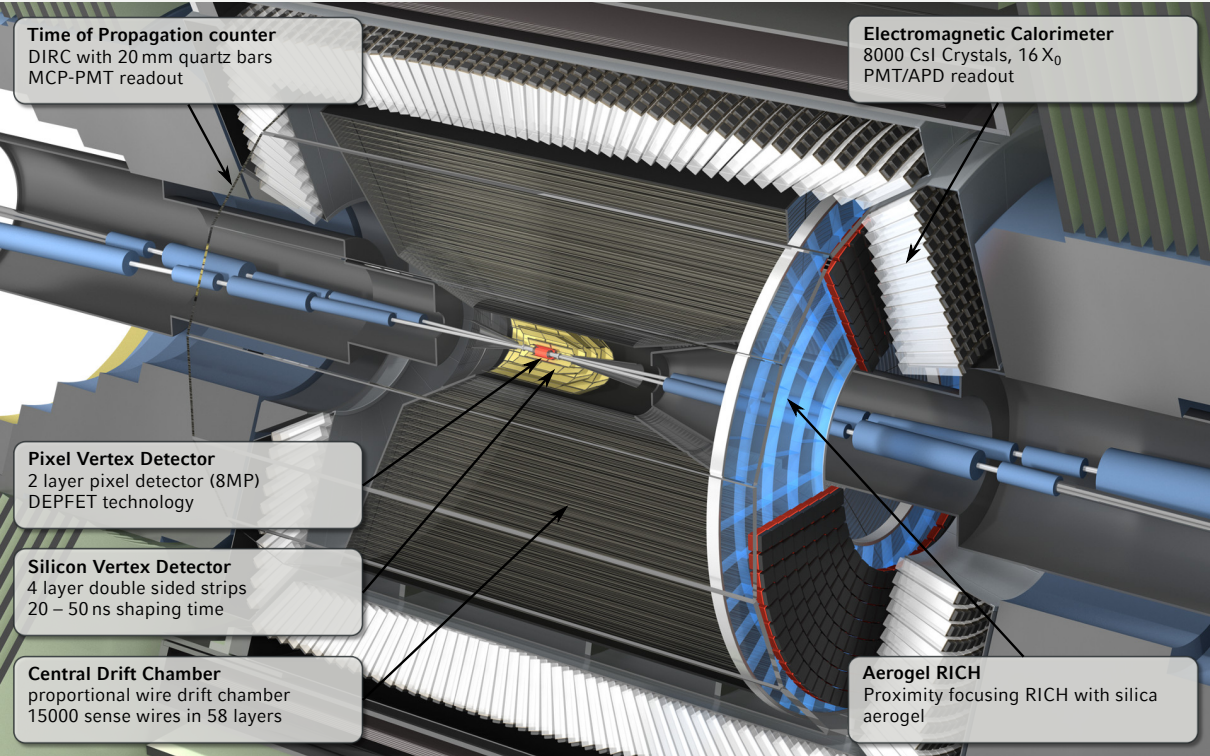
TUM LMU Excellence Cluster Universe

Belle/Belle II Experiment

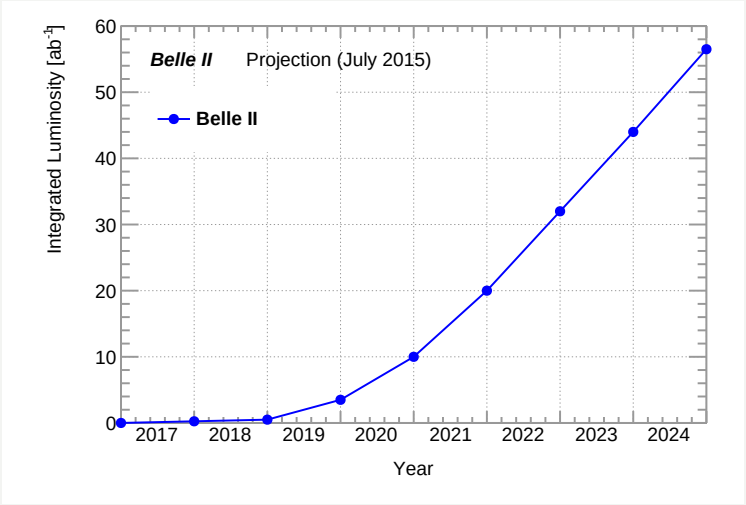
Asymmetric e^+e^- experiment mainly at the $\Upsilon(4S)$ resonance (10.58 GeV)



	KEKB/Belle	SuperKEKB/Belle II
operation	1999 – 2010	2018 –
peak luminosity	$2.11 \times 10^{34}\,\mathrm{cm^{-2}s^{-1}}$	$8 \times 10^{35}\,\mathrm{cm^{-2}s^{-1}}$
integrated luminosity	$1023\,\mathrm{fb^{-1}}$ (772 million $B\overline{B}$ pairs)	$50\,\mathrm{ab^{-1}}$


Time of Propagation counter
DIRC with 20 mm quartz bars
MCP-PMT readout
Electromagnetic Calorimeter
8000 CsI Crystals, 16 X_0
PMT/APD readout
Pixel Vertex Detector
2 layer pixel detector (8MP)
DEPFET technology
Silicon Vertex Detector
4 layer double sided strips
20 – 50 ns shaping time
Central Drift Chamber
proportional wire drift chamber
15000 sense wires in 58 layers
Aerogel RICH
Proximity focusing RICH with silica aerogel

Luminosity projection

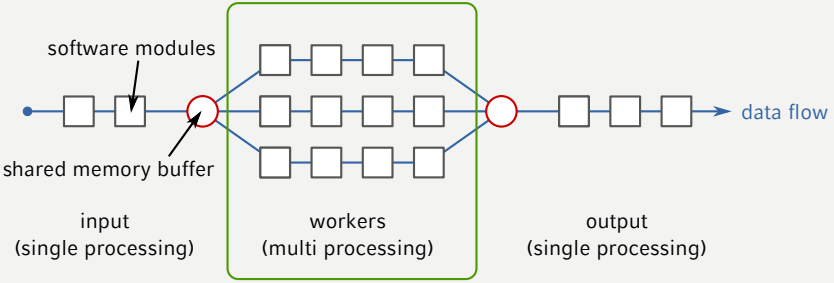


- beamline completed
- commissioning will start next year
- first data with full detector in 2018

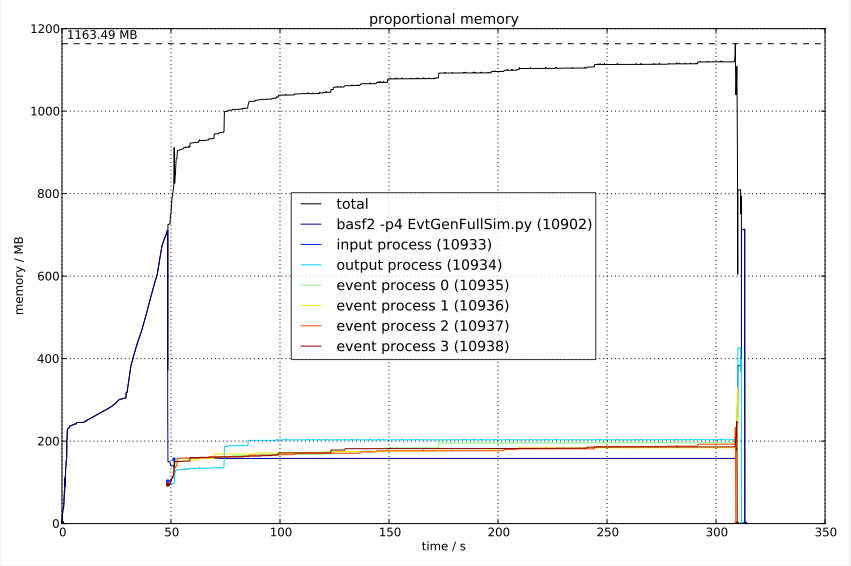
Software

Mainly written from scratch using experiences from Belle and other experiments

- modular approach
- utilize new technologies: C++11 (gcc 5.2), ROOT 6, Geant 4.10, Python 3.5
- python as steering/scripting language
- ROOT for input/output (also raw data)
- parallel processing support using `fork`



Multiprocessing Memory Consumption



- static memory pages shared between processes
- no need for locking, no race conditions
- communication between processes limited

Resource Estimation

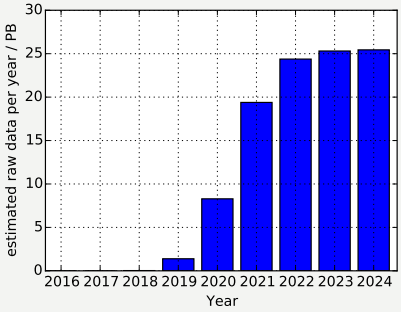
Current Performance

- raw data ~ 300 kB per event
- simulation & reconstruction ~ 90 HepSPEC06/s per event
- reconstructed data (mdst) ~ 40 kB per event

estimation of required disk space/processing power from luminosity projection

- by 2024, total number of events 3.75×10^{11} events
- ~ 100 PB raw data, ~ 25 PB/year with full luminosity
- plan to keep 2 copies, one at KEK, one distributed

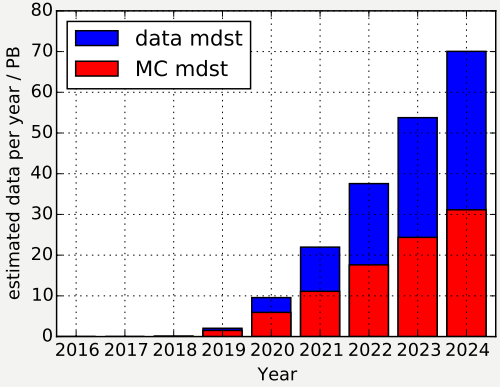
process	cross section
$B\overline{B}$	~ 1 nb
u, d, s, c pair	~ 3 nb
τ	~ 1 nb
background	~ 2.5 nb

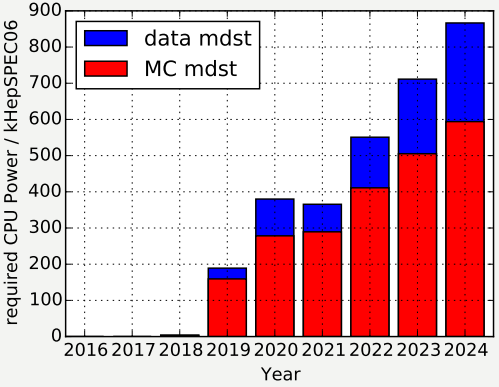


Reconstructed Data and MC

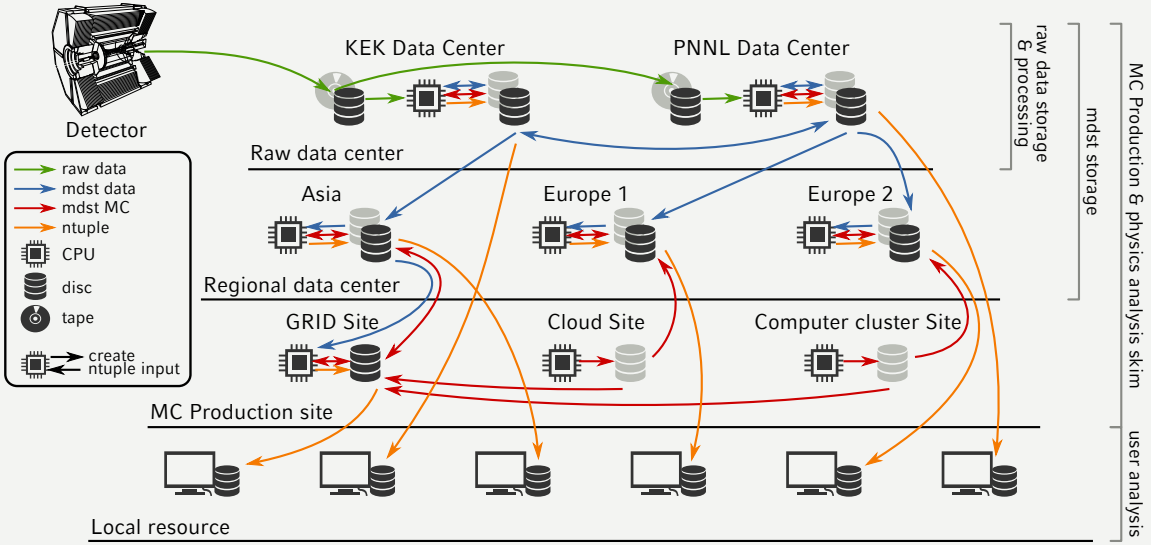
Reconstructed data is factor 10 smaller

- needs to be replicated for different regions (Asia, Europe, North America)
- keep two versions (reprocessing)
- MC: data $\times 4$ till 2019, reduce to data $\times 1$
- reprocessing: assume data has to be reprocessed
  (4 times / year in the beginning, once per two years after 2020)

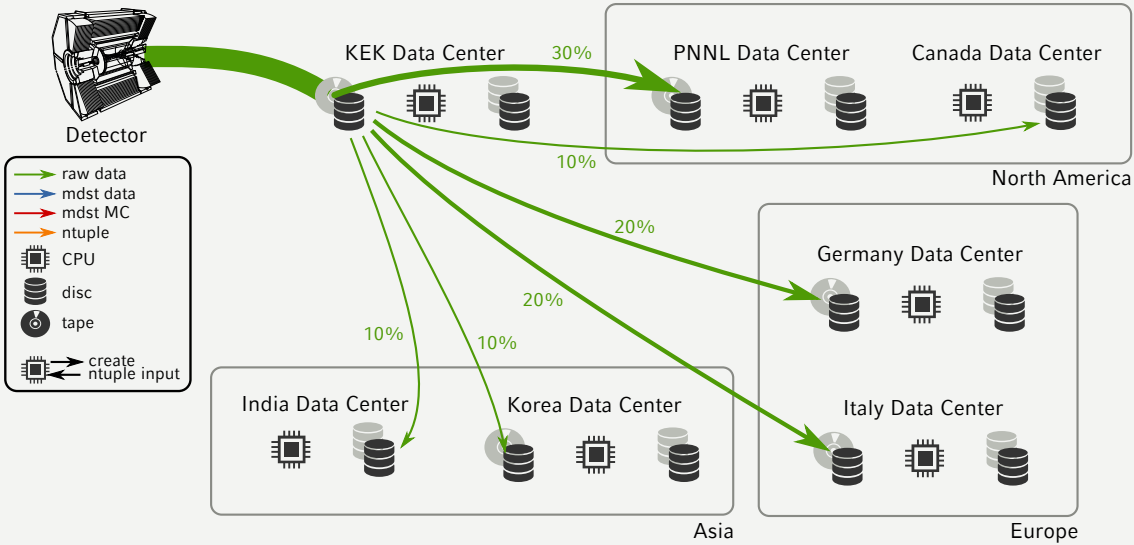




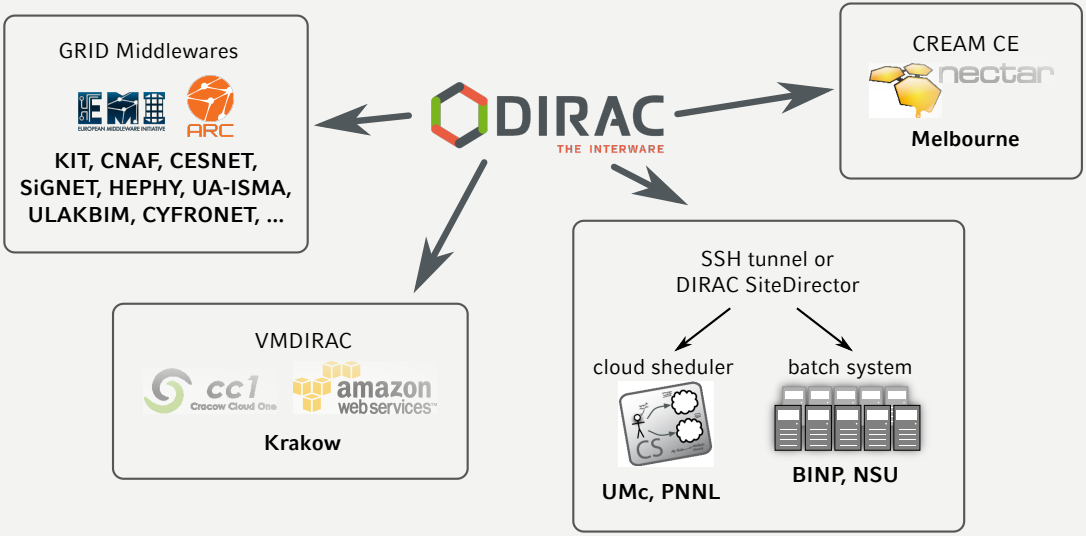
Computing Model



Raw Data After 3 Years



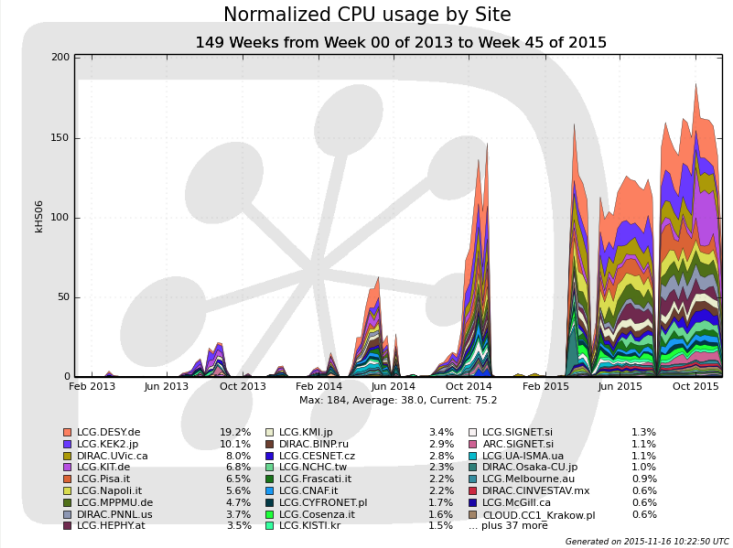
Computing System



MC Production Challenges

Belle II started first MC Production run in 2013

- this year first run with automated production system
- target: 2 PB in 200 days
- ~ 50 sites from 17 countries
- around 2 PB reserved storage
- average of ~ 150 kHS
- very strong German contribution: 31 %:
  - DESY 19 %
  - KIT 9 %
  - MPP/RZG 3 %



Data Challenge

ongoing investigations into network

	2019 Inbound Network bandwidth requirement (c.f. slide 3)	2024 Inbound Network bandwidth requirement (c.f. slide 3)	2015 Data Challenge Result	Comment
KEK → PNNL	5 Gbps	8 Gbps	~ 4 Gbps Spikes at 9 Gbps	Result from gsiftp:// Network tuning required
KEK → SIGNET	0.4 Gbps	0.6 Gbps	0.8 Gbps (high success rate) 2.4 Gbps (low success rate)	
KEK → NAPOLI	1.2 Gbps / 2*	4.5 Gbps / 2*	3 Gbps	3 Gbps with appropriate load. Higher bandwidths may be possible
KEK → KIT	1.5 Gbps / 2*	4.5 Gbps / 2*	3.5 Gbps	
KEK → DESY	1.5 Gbps / 2*	4.5 Gbps / 2*	3.0 Gbps	

* equal site splitting in country

Conclusions

Belle II will start physics in 2018

- target: 50 ab^{-1} till 2024
- 25 PB raw data per year with full luminosity
- expected total of roughly 300 TB of data (raw, mdst, MC)
- user analysis not included here

Computing System

- hierarchical structure similar to LHC experiments
- heterogeneous system using Grid, Cloud, Clusters
- using DIRAC

Current MC Production Challenge

- started first tests in 2013
- ongoing campaign with around 50 grid sites (150 kHS avg.)

Thank you
for your attention