Search for New Physics

- There must be so far unobserved particles or forces
  - **Direct search**: Production of new particles → ATLAS, CMS @ LHC
  - **Indirect search**: Contribution of virtual new particles to observed processed → Flavor physics
$B \rightarrow D^{(*)} \tau \nu$

$R_{D^{(*)}} = \frac{\text{Br}(B \rightarrow D^{(*)} \tau \nu_{\tau})}{\text{Br}(B \rightarrow D^{(*)} \ell \nu_{\ell})}$

- World average of $R(D)$, $R(D^*)$ 4.1$\sigma$ away from SM prediction

$\Delta \chi^2 = 1.0$ contours

- $R(D) = 0.300(8)$ HPQCD (2015)
- $R(D) = 0.299(11)$ FNAL/MILC (2015)
- $R(D^*) = 0.252(3)$ S. Fajfer et al. (2012)
Belle II @ SuperKEKB: 50 ab$^{-1}$

SuperKEKB ➔ $8 \times 10^{35}$ cm$^{-2}$ s$^{-1}$

Belle: 1 ab$^{-1}$
LHC Run 3: 0.3 ab$^{-1}$
Belle II Detector

**EM Calorimeter:**
CsI(Tl), waveform sampling (barrel)
Pure CsI + waveform sampling (end-caps)

**Beryllium beam pipe**
2cm diameter

**Vertex Detector**
2 layers DEPFET + 4 layers DSSD

**Central Drift Chamber**
He(50%):C$_2$H$_6$(50%), small cells, long lever arm, fast electronics

**Electrons (7GeV)**

**K$
alemma_L$ and muon detector:**
Resistive Plate Counter (barrel)
Scintillator + WLSF + MPPC (end-caps)

**Particle Identification**
Time-of-Propagation counter (barrel)
Prox. focusing Aerogel RICH (fwd)

** positrons (4GeV) **
$B \rightarrow D^{(*)}\tau\nu @ Belle II$

- **Challenge:** Reconstruction of decays with neutrinos

$$R_{D^{(*)}} = \frac{Br(B \rightarrow D^{(*)}\tau\nu_\tau)}{Br(B \rightarrow D^{(*)}\ell\nu_\ell)}$$
Time Line

- SINET4 → SINET5
  - Japan-US: 100Gbps
  - Japan-EU: 200Gbps
- New KEKCC operation started
  - Start using LHCONE
- First official real data
  - w/ CDC+TOP+ECL+KLM
- LER/HER single beam circulation
  - Successfully finished
  - Beam background study was done
- TOP installation was completed
- CDC installation was completed
- ARICH + Fwd ECL installation was completed
- FWD/BWD QCS was connected with VXN system
- Phase 3 operation
  - 9 months / year


Phase 2 (MR)

Phase 3

Start in Feb. 2019

Global Cosmic run
- w/ B-field

Summer shutdown
- (power saving)

Power saving after mid July 2018

w/ full Belle II

w/ QCS
- w/ Belle II (no VXN)
First Collisions on April 26
Data Flow

**Beam data**

Data on Online storage (in SROOT)

SROOT - ROOT conversion @ KEKCC Frontend servers

RAW data (in ROOT)

RAW data (re)process @ RAW data centers

**uDST** (in ROOT)

Skim production @ sites where mDST are stored

User analysis @ sites where uDST are stored

N-tuple

**mDST** (in ROOT)

Skim production @ sites where mDST are stored

**MC**

MC production @ MC production sites

Event generation

Detector simulation

Digitization

Reconstruction are done in one step

User final-step analysis @ local resource

*: uDST = mDST of skimmed events with additional data objects for physics analysis
Resource Estimates

- **Tape (PB)**
  - Two RAW data replicas (on the globe)

- **Disk (PB)**
  - uDST (=skimmed mDST)

- **CPU (kHSOG)**
  - MC prod.
  - Data reprocess
  - Data process

**Updates**
- Detailed requests from physics
- Concrete analysis framework
- Updated data distribution strategy

**Uncertainties**
- Luminosity profile
- Background level
  - etc...

Looks similar to LHC experiments in Run 1
Belle II Collaboration

France joined in June 2017 (LAL, IPHC)
Israel joined in Oct. 2017 (Tel Aviv)

25 countries/region
108 institutes
741 colleagues

BNL joined in Oct. 2017
Computing Model

Belle II Computing Model

Detector

KEK Data Center

BNL Data Center

Raw Data Center

Regional Data Center

Asia

GRID sites

Europe site B

MC production and analysis

MC production sites

Cloud sites

Computer cluster sites

HPC sites

Raw data

mdst Data

mdst MC

dashed inputs for

udst

Ntuple

CPU

Disk

Tape

Storage for original + copy

Storage for copy

Temporary storage

Local resource
Expected Network Traffic

Data Replication - Total Inbound Traffic per Site per Year

- KEK 1 Gbps
- Germany 1.7 Gbps
- Italy 1.7 Gbps
- BNL Max 3.4 Gbps

Data Replication - Total Outbound Traffic per Site per Year

- KEK Max 7 Gbps
Computing System

**Human**

**Software interface**
- Interware extention
- Analysis user interface

**Interware**
- Management system

**Cyberinfrastructure**
- GRID services for Belle II

**Platform**
- GRID Middleware
- OS
- Hardware
- Network

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2017-Dec-13. Computing in HEP - Ueda I.
Production System

Different types of production
- MC production (w/ or w/o BG)
- Skim production
- RAW data process

Huge variety of modes
- BB, udsc, signal, background
- many physics skims

Complicated data management
- over world-distributed sites

Reduce human error and
- perform effective operation
Monitoring

Used/Free disk space for destination storages

Total Space by usage

Free
(*PNNL-SE not included)

Used

HappyFace → DIRAC

Data Transfer Map

Production progress

Storage access check from computing node

4. Completed

3. Transfer

Submitted

2. Job
MC Production Campaigns

Job workflow
- Manual
- Prototype
- Fabrication

Data transfer
- Job based
- FTS based
- DDM

Production workflow
- Manual
- Automatic issue detector

Monitoring

Shifter

Production Manager

Computing group

Belle II wide

Computing group

Data Prod. group

MC production
with heavy Disk I/O

MC production
with less Disk I/O

Keep stable production

Provide qualified data

20 kjobs

Running jobs (k jobs)

Increase scalability

4th

3rd

2nd

1st

3rd

2013

2014

2015

2016

2017

2018

Skim production w/ PS

User analysis
Summary

➢ Exciting physics potential with 50 ab$^{-1}$ at Belle II
➢ Two orders of magnitude higher data volume than at Belle
➢ Distributed computing system based on
   ➢ Existing technologies: DIRAC, LFC, CVMFS, ...
   ➢ Own development: DIRAC extensions, gbasf2 client, ...
➢ DIRAC provides interface to ARC-CES
Belle II Virtual Reality