Goals of BEAST phase 2

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IN2P3-KEK collaboration on Belle II and BEAST meeting

2015/1/19-20

Introduction

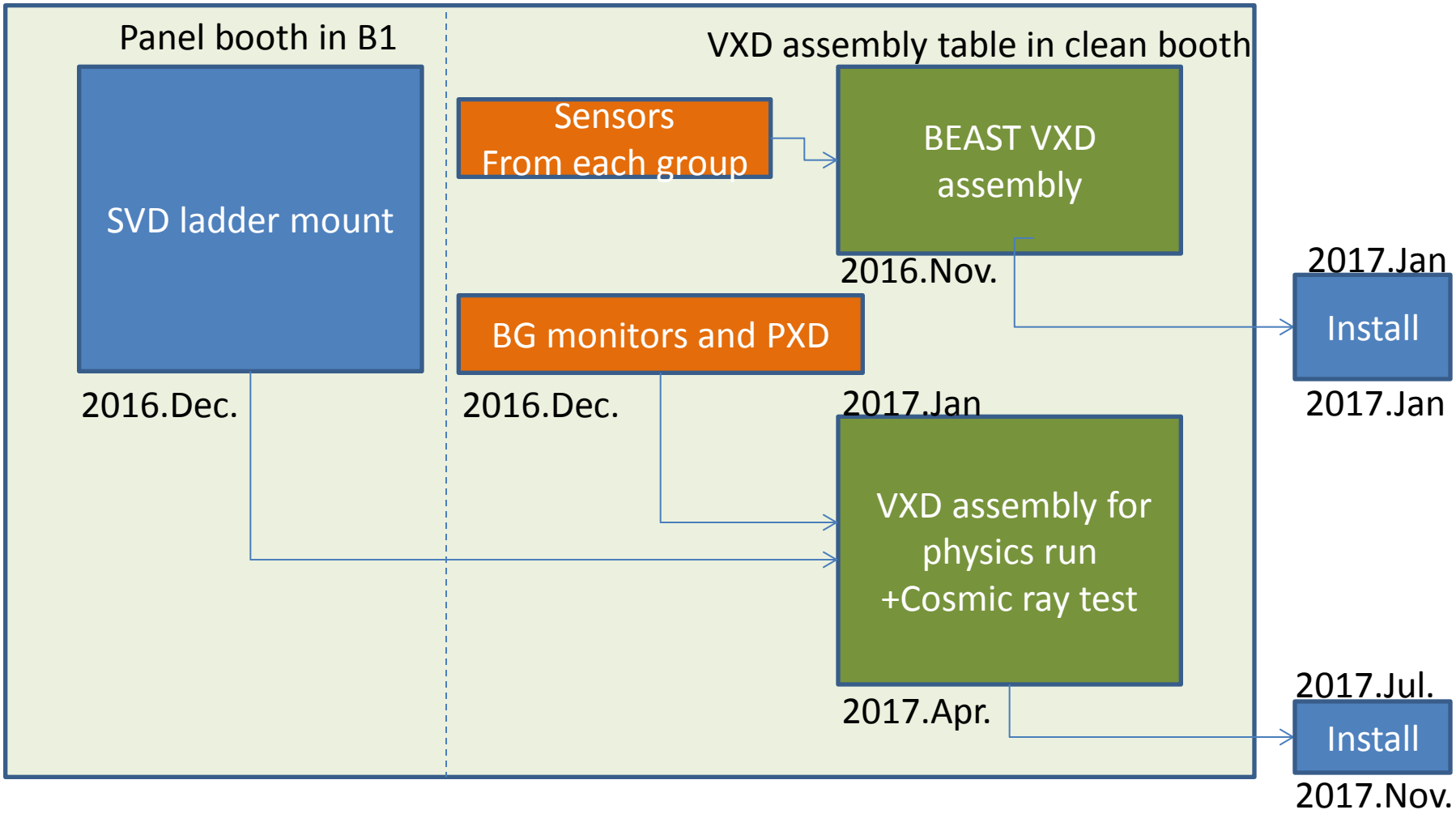
- There are many kind of parallel activities in the BEAST phase 2 period
  - Beam commissioning to start collision (machine group: KCG)
    - Forward luminosity monitors(ZDLM) for knob tuning
  - First try of BG control (mainly KEK belle group: BCG)
    - Beam collimators control study to achieve moderate BG
    - BG studies of each comportment to check consistency with simulation
    - Neutron measurement (fast and slow)
  - Belle II DAQ commissioning with partial VXD sensors (Belle II shift)
    - Full Belle II DAQ
    - Slow control (also communication with machine)
    - PXD RoI finding with CDC+SVD tracking data
  - Optimization of interlock system
    - Slow info. Some alarms or abort by environmental or rad. monitors
    - First info.: beam abort by hard wired signals
  - Calibration of BG monitors
    - Checking dependency of BG monitor with respect to SVD and PXD data

- Beam injection BG study
  - BG damping time measurement for Trigger veto gate
    - requiring storing veto gate width to condition database
    - With moderate update timing
- First try of operating CO2 cooling system for VXD sensors
  - Checking water vapor level by sucking air
  - cold and warm dry volume

Assembly work management

- We will assemble two sets of VXD system
  - VXD for BEAST phase II
  - VXD for physics run

https://belle2.cc.kek.jp/~twiki/bin/view/Detector/BelleIISchedule



BG sources and Radiation tolerance

- BG source
  - 4-fermion final state QED process (Lum.)
  - Touschek effect (Beam size and energy)
  - Beam-gas interactions (current, pressure)
  - Synchrotron radiation
  - Radiative Bhabha scattering (Lum.)
  - Injection BG
  - Unexpected noise BG?

Background picture

Nakayama

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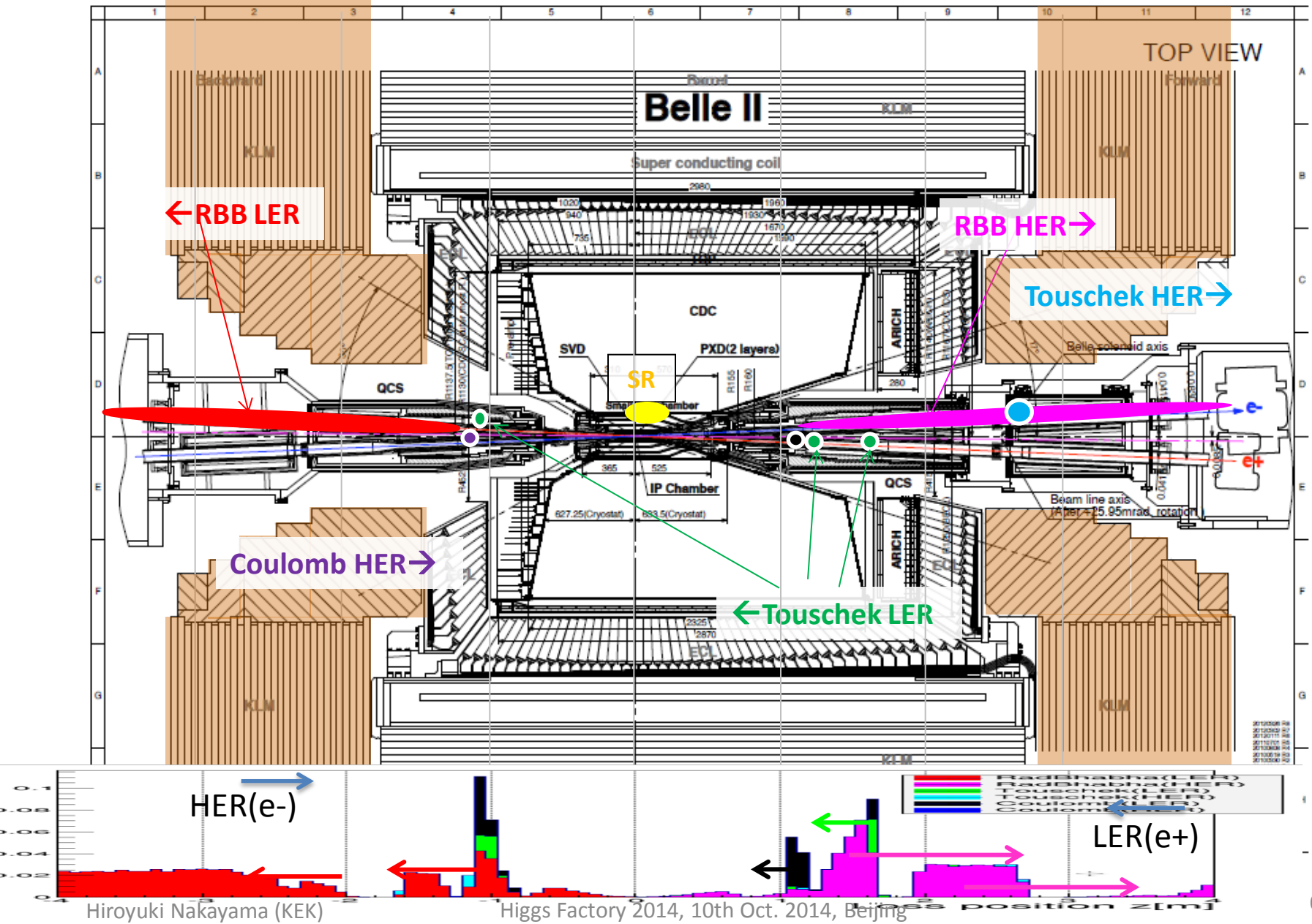


Key point!

BG simulation is assuming effective BG reduction by optimized beam collimators

In other word, we have to optimize beam collimator condition before comparing with simulation

Opening/closing collimator is operated by

Belle Commissioning Group(BCG)

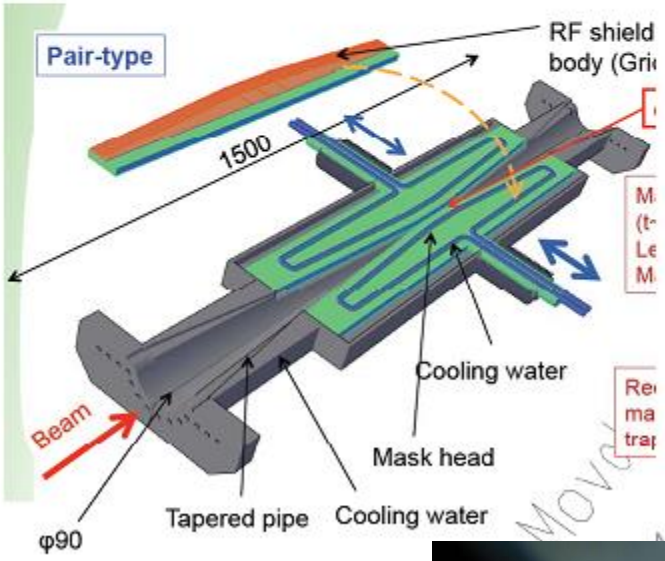
BG reduction

Collimators in the ring

- Horizontal collimation from both inner/outer sides
- Stop off-momentum e+/e- before reaching interaction region

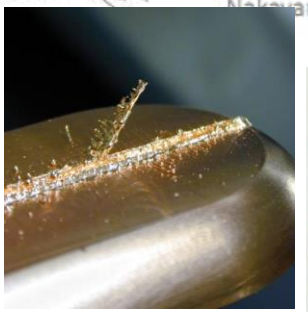
Heavy-metal shield

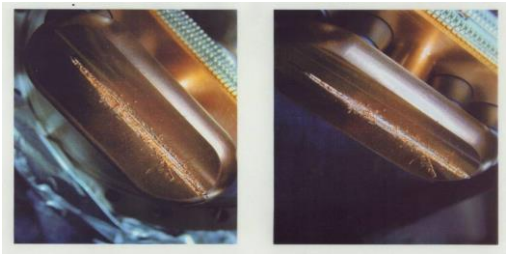
- Placed outside IR beam pipe
- Protect inner detector from EM shower created by loss particle



Nakayama (KEK) 5

Production: machine
Operation: Belle-KEK





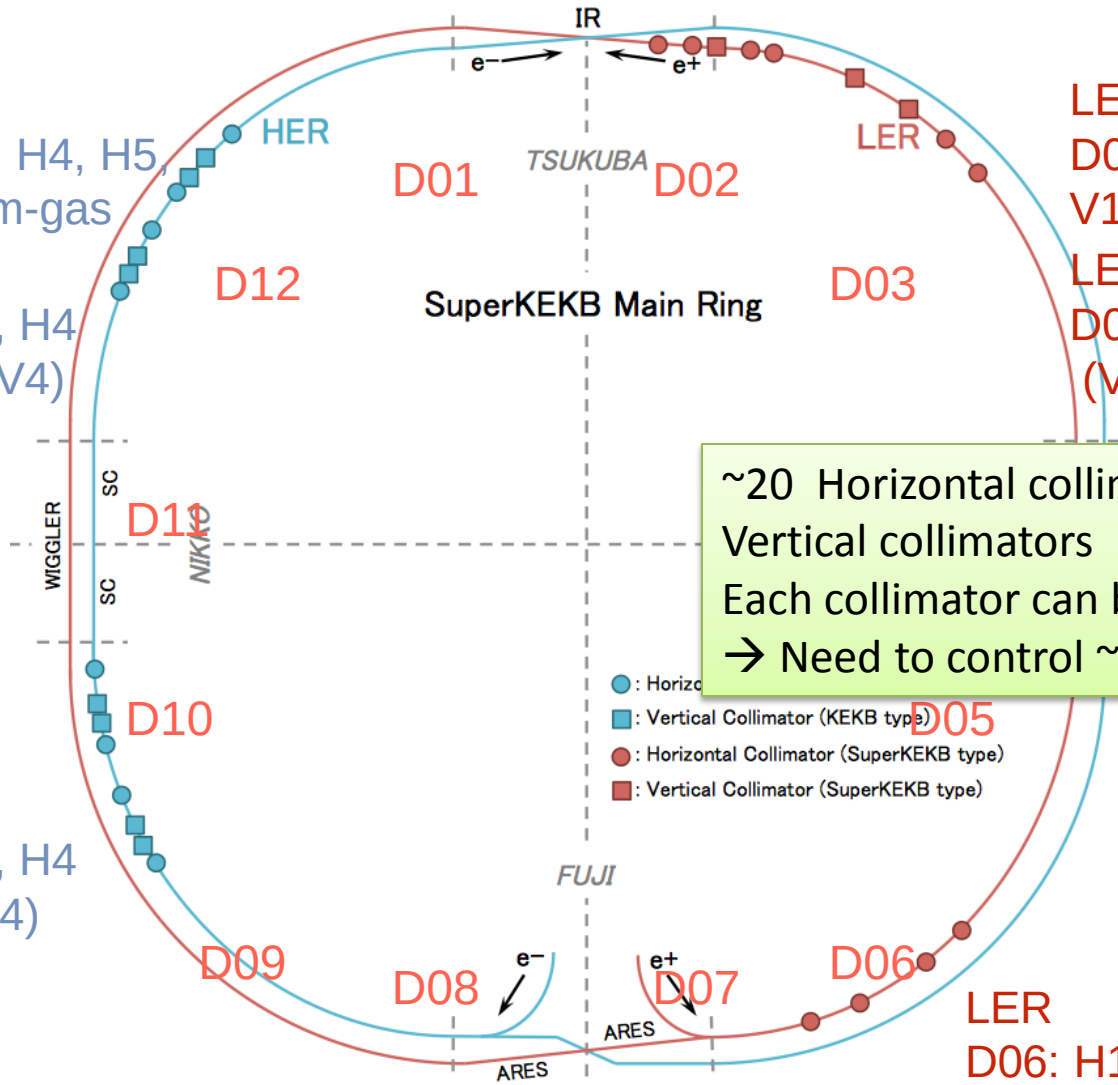
SuperKEKB Collimators Location

HER
D01: H1, H2, H3, H4, H5,
V1 for Beam-gas
HER
D12: H1, H2, H3, H4
(V1, V2, V3, V4)

HER
D09: H1, H2, H3, H4
(V1, V2, V3, V4)

LER
D02: H1, H2, H3, H4,
V1 for Beam-gas
LER
D03: H1, H2
(V1, V2)

LER
D06: H1, H2, H3, H4



~20 Horizontal collimators and 2 Vertical collimators
Each collimator can be asymmetric
→ Need to control ~50 parameters!

Vertical collimator width vs. Coulomb loss rate, Coulomb life time

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ler1604, V1=LLB3R downstream

V1 width[mm]	IR loss [GHz]	Total loss[GHz]	Coulomb life[sec]
2.40	**0.04**	153.9	1469.8
2.50	**0.05**	141.8	1594.8
2.60	**0.09**	131.0	1724.9
2.70	**0.24**	121.4	1860.2
2.80	**1.65**	111.4	2000.5
2.90	**11.48**	100.8	2014.3
3.00	**21.98**	90.3	2014.3

her5365,V1=LTLB2 downstream

V1 width[mm]	IR loss [GHz]	Total loss[GHz]	Coulomb life[sec]
2.10	**0.0007**	49.6	3294.0
2.20	**0.001**	45.2	3615.2
2.30	**0.357**	41.0	3951.3
2.40	**7.99**	33.0	3985.9
2.50	**13.1**	27.9	3985.9

Based on element-by-element simulation considering causality the phase difference (by Nakayama)

Up to 100turns

Relative position to the beam

IR loss rate is VERY sensitive to the vertical collimator width.
(Once V1 aperture>QC1 aperture, all beam loss goes from V1 to IR

Typical orbit deviation at V1 : +-0.12mm (by iBump V-angle: +-0.5mrad@IP)

In order to optimize collimator settings to reach reasonable BG condition

- There are 20 horizontal collimators and 2 vertical collimators.
- Collimator operation is affects not to only BG reduction but also to beam life time.
  - On the KEKB case, beam lifetime was around a few hours
  - On the superKEKB case, it will be only 600 second
  - This optimization work on KEKB was took around one year(Haba, Uno) to take over as a shifter work, but updating it until end of the beam.
- We need some kind of semi-automated collimator control system.
  - Set limit for each collimator position to avoid unexpected huge BG
  - Collimator control panel is prepared by Vacuum group but not automatic
- Input information is
  - beam loss monitors sitting around the KEKB ring
  - BG sensor hit rate and dose information in Belle II
    - Scintillator around QCS
    - Diamond sensors?
    - Pin diode?
  - Beam lifetime by machine group

We should prepare some design documents
How to deliver the data?
How much time constant?
What kind of information can be prepared?
Optimizing algorithm ideas

Mask dependence

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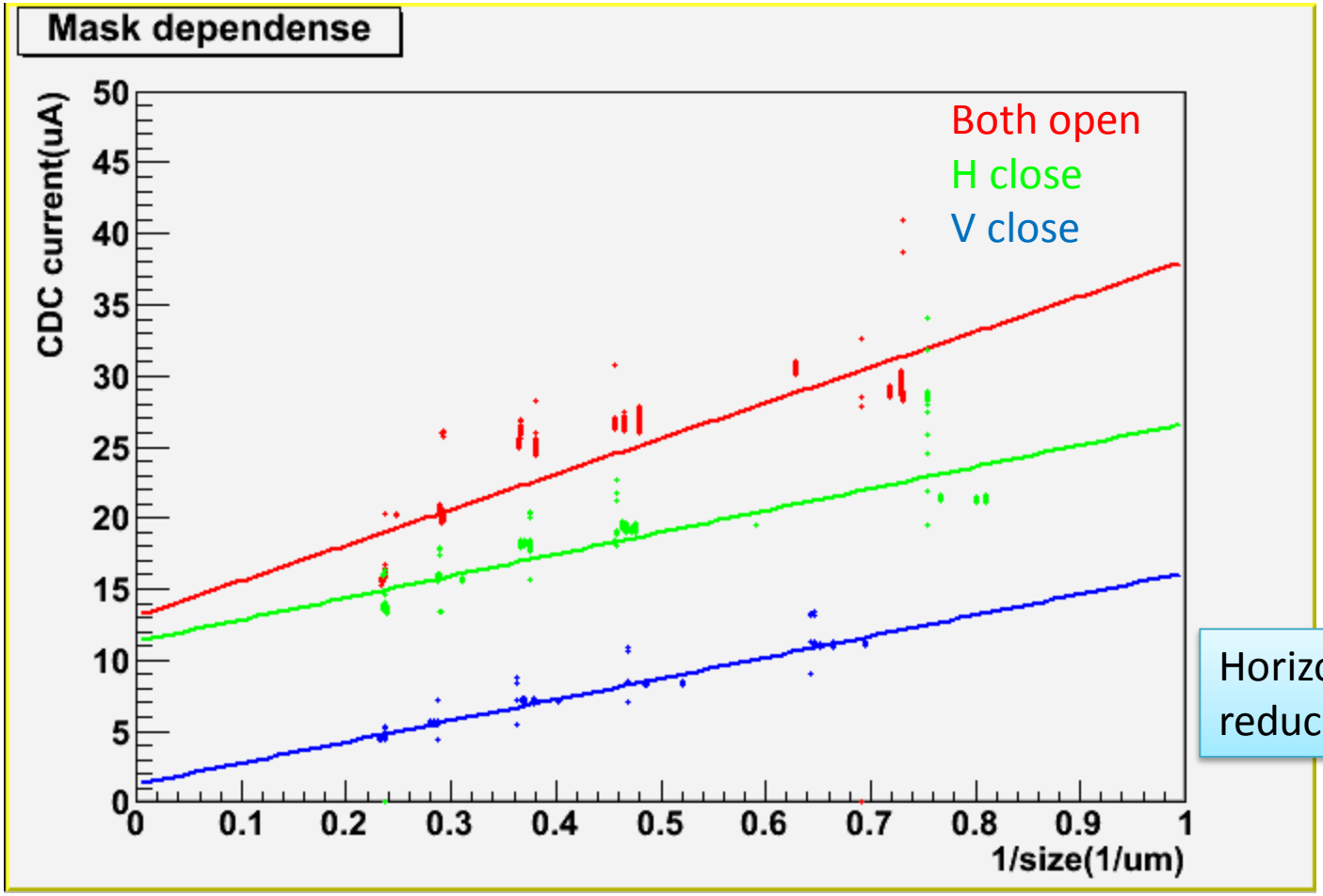
CDC current ~ BG hit rate

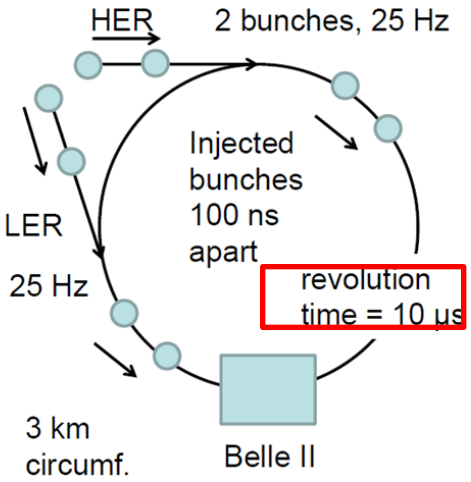


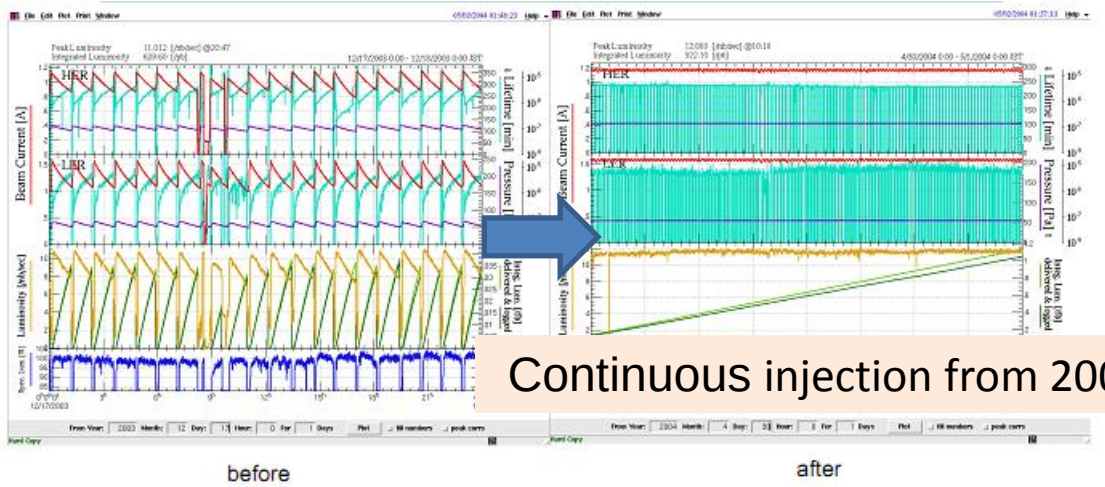
Horizontal masks reduce Touschek BG

Current=1450mA

Injection BG

50 Hz beam injection





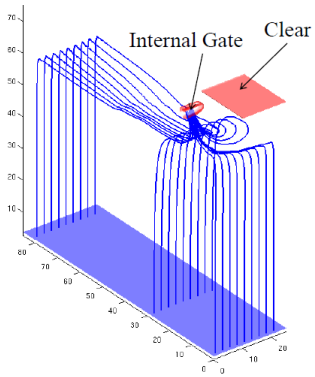
Continuous injection from 2004

The injection BG is vetoed by revolution signal from machine.
(The beam life time is ~600s for LER by Touschek effect)

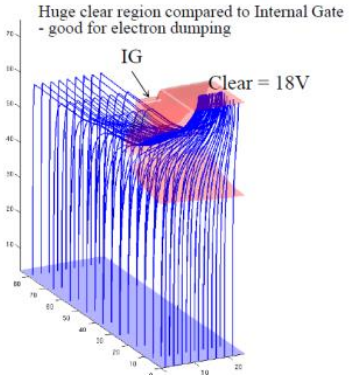
PXD gated mode is requiring Veto Gate timing and their width

PXD case : to avoid injection hits

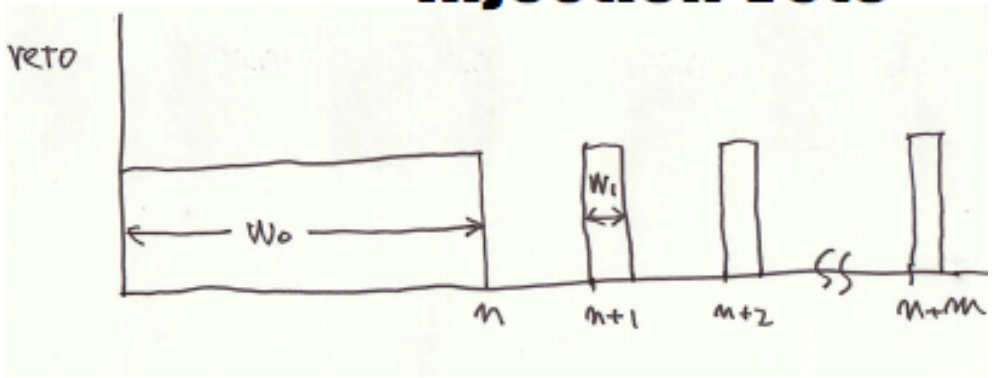
Normal operation:
Signal charge drifts into internal gate

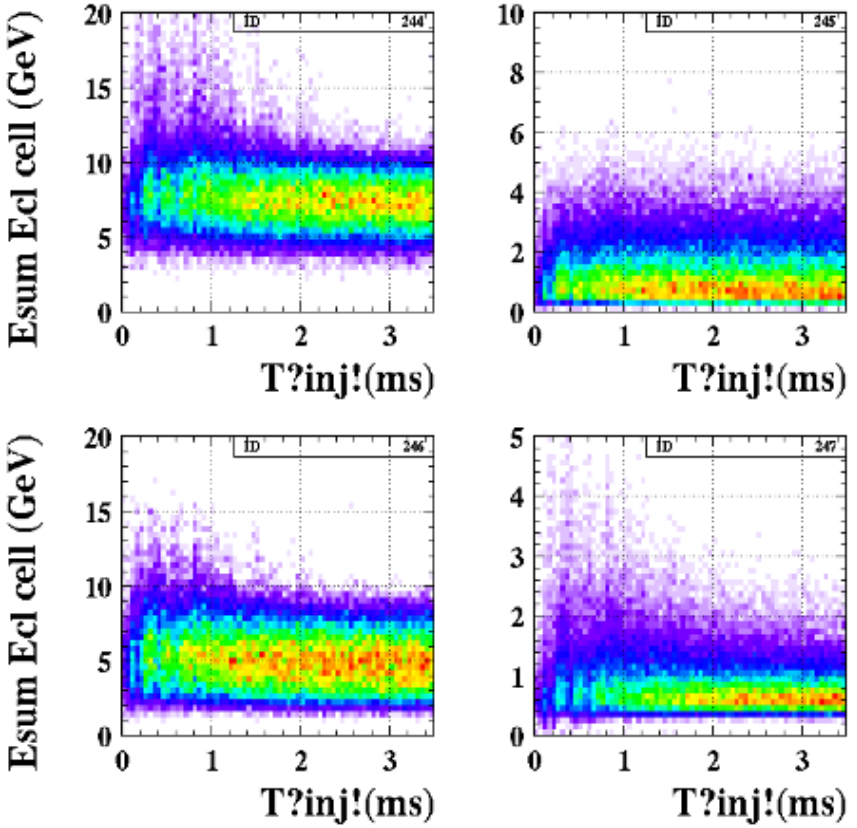


Gated operation
Charges from background drift directly to clear gate



Injection Veto





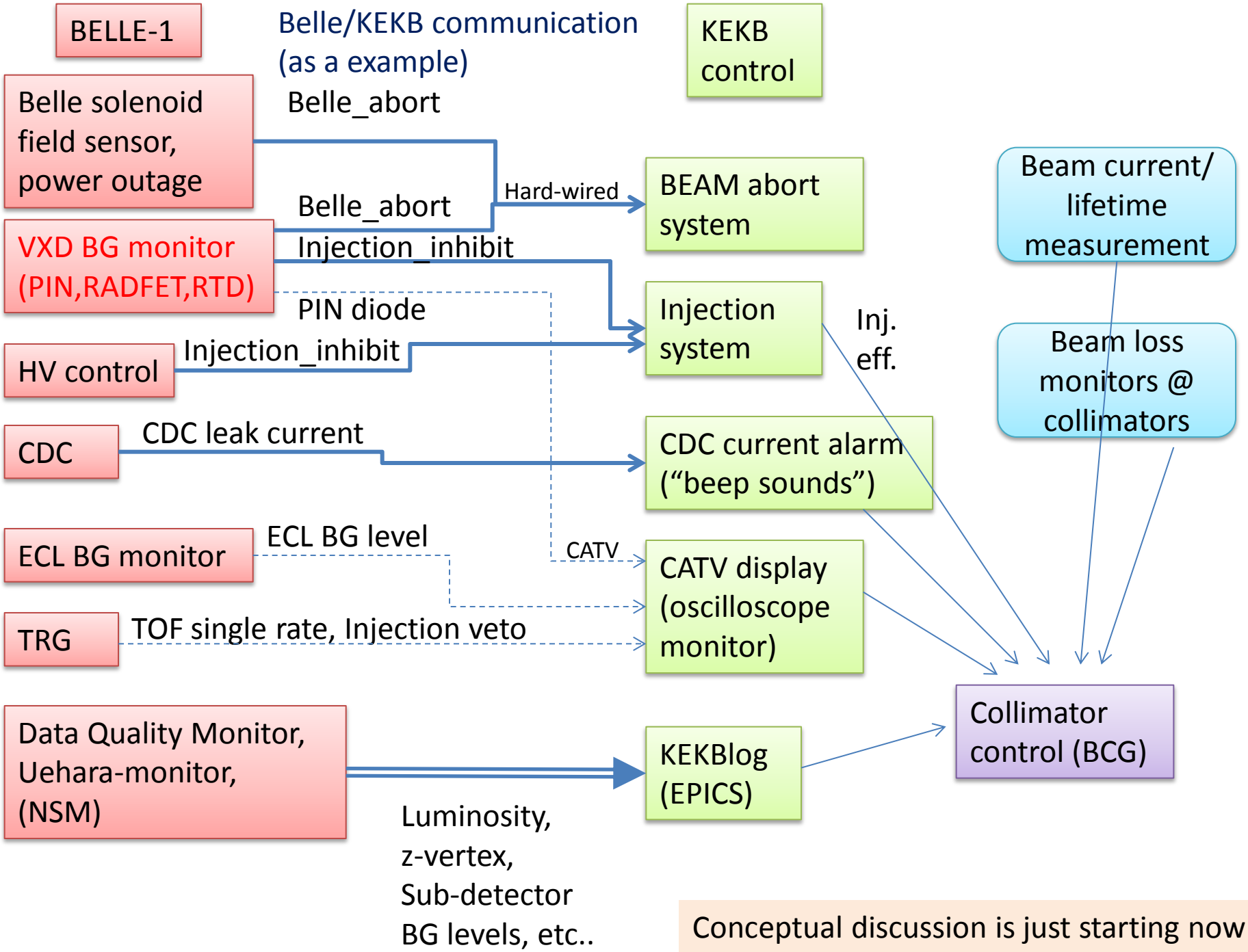
- **Two phases**
  - First phase : veto n turns completely
    W0 = n * 10 usec
    n = 10～100
  - Second phase : veto periodically
    W1 = ～1 usec
    m ～ 300
  - Three parameters (n, m, W1) are adjusted depending on SKEKB
- **Veto pattern is generated in GDL**
- **The first phase only in Belle case (n=350)**
- **Veto signal is sent to SEQ to calculate dead-time**

Injection timing: by DAQ , Trigger veto by Trigger group
Veto gate is directly affected to detector efficiency!

Gated mode optimization for Injection noise

- BEAST phase II is first chance to measure injection noise.
- Beam injection timing is provided by the Linac group
- Belle II Trigger veto gate(in GDL) for injection noise will be set by trigger group.
- PXD group may need to request change of veto gate width or gate timing to trigger group for PXD acceptable occupancy level.

- Situation:
  - PXD occupancy can be measured in BEAST phase II through BelleII DAQ
  - On SVD case, some trigger related to injection gate can be used
  - Veto gate width might be changed by Beam settings
- Question
  - How to optimize acceptable veto gate width for PXD safer operation?
  - Veto gate width on second phase is expecting ~1us(see slide 6) level,
  - Do we have some injection BG sensors with high frequency readout to see the injection BG profile? (or optimizing only by PXD occupancy?)


BELLE-1
Belle/KEKB communication
(as a example)
Belle_abort
KEKB
control
Belle solenoid
field sensor,
power outage
Belle_abort
Hard-wired
BEAM abort
system
Beam current/
lifetime
measurement
VXD BG monitor
(PIN,RADFET,RTD)
Injection_inhibit
PIN diode
Injection
system
Inj.
eff.
Beam loss
monitors @
collimators
HV control
Injection_inhibit
CDC
CDC leak current
CDC current alarm
("beep sounds")
ECL BG monitor
ECL BG level
CATV
CATV display
(oscilloscope
monitor)
TRG
TOF single rate, Injection veto
Collimator
control (BCG)
Data Quality Monitor,
Uehara-monitor,
(NSM)
KEKBlog
(EPICS)
Luminosity,
z-vertex,
Sub-detector
BG levels, etc..
Conceptual discussion is just starting now

Operation condition

- There are three operation categories on BEAST phase II
  - @superKEKB machine control room(online data feedback)
    - ZDML (bunch by bunch luminosity info. for knob tuning)
    - Scintillator hit info.(for collimator optimization)
    - VXD environmental and radiation sensor info.
    - Abort signal (slow and fast)
    - …..
  - @BelleII control room
    - Data from each sub-detector
    - Environmental sensor
    - ….
  - BEAST DAQ
    - Data from each sensor (for offline analysis)
    - …..

This is by simply my understanding
These categorization should be finalized by BEAST group

Before operating VXD sensors

- Before start operation of VXD sensors, we have to validate, understand and setting moderate condition of some parameters:
  - Temp. and Hum. should be within operation condition
    - Some interlock study may be needed before starting beam
  - Checking hit rate of outer detectors
  - Optimizing Injection gate timing and their width roughly with redundancy
  - SR hit rate and energy dependence (acceptable level or not)
  - Beam collimator position settings to avoid huge BG by unexpected beam operation
    - Some information by BG sensors and beam loss monitors
      - Calibration as a first step
      - Setting acceptable condition of each sensor output as a interlock
    - How to synchronize data for offline analysis?
      - PXD/SVD data -> Belle II DAQ
      - BG monitor data-> EPICS?

How to analyze those Data on offline analysis?

Belle abort settings(what information, how to optimize?)

- What is critical situation on VXD operation?
  - Radiation damage of sub-component
    - What is acceptable range for PXD/SVD sensors on short term high radiation?
    - 4 level of abort signal will be prepared (Lorenzo's talk on last VXD workshop)
  - Out of Temp. range -> abort OR logic (not issue)
  - Out of Hum. range -> abort OR logic (not issue)
  - PXD high occupancy by BG hits(if we can measure only by data set through HLT , is the latency of read out chain acceptable?)
  - Be careful about latency of VXD abort decision logic
    - (FPGA based test system is now on preparation by Lorenzo)
    - On belle SVD2 case, simply NIM logic was used (by Tsuboyama-san)
  - Should BG sensor for Beam abort distinguish the injection noise from nominal BG (please refer time dependence of ECL energy deposit related to injection on slide 7 : Belle continuous injection case)?

Target of BEAST phase II

- BG condition control toward to Physics run
  - Up to L~ 10^34
  - Collimator operation
    - it is depending on beam condition, we should keep always updating
    - We should set the position limit for each masks.
  - Trigger Veto gate control management
    - it is depending on beam condition, we should keep always updating
  - Comparison of BG simulation with data for each component

- BG monitor optimization
  - Abort setting
  - Interlock system
  - Online monitors

Bkup

Draft

Carte for each sensor to know each status

Belle II sub-detectors have already defined everything below items

- Sensor name:
- Contact person on the commissioning:
- Purpose of the sensor on the BEAST:
- Number of sensor channels and sensor design:
  - Defined or on discussion
- Space allocation for sensor and services and bracket design:
  - fixed or on discussion
- Data output to:
  - KEKB operation room (EPICS or other special)
  - Belle II control room(database or other format)
  - BEAST DAQ (individual readout chain)
  - Using to create Belle abort signal or interlock
- Requiring input for analysis?
  - Injection timing (i.e. injection BG study)
  - Some other component (i.e. timestamp)

- Sensor will use which period?
  - BEAST phase I
  - BEAST phase II
  - Physics run
- Data format:
  - defined or on discussion
- Online monitor software:
  - finished, designed or on discussion