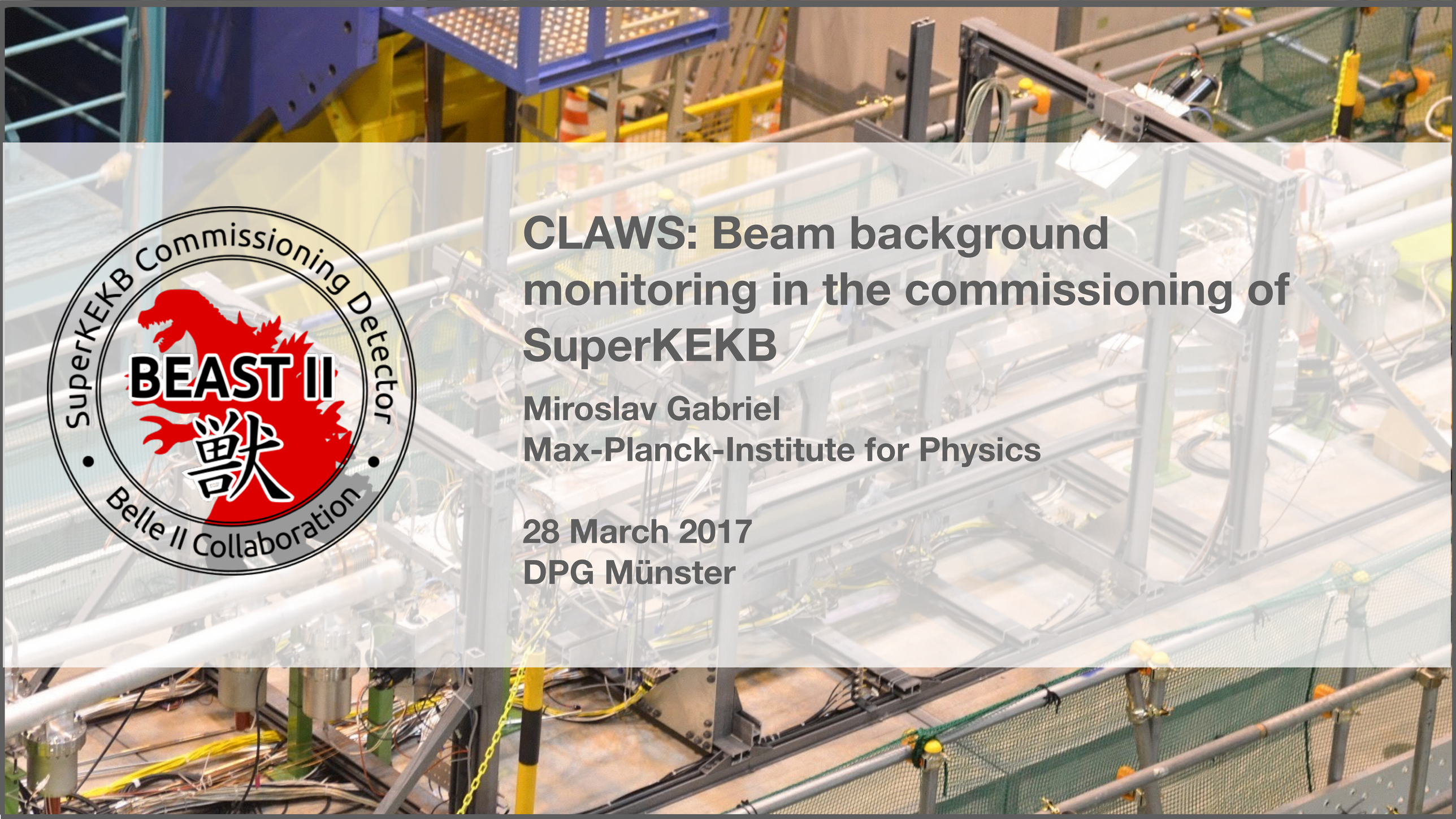

CLAWS: Beam background monitoring in the commissioning of SuperKEKB

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Outline:

- SuperKEKB & Beast Commissioning Campaign
- First Results from Beast Phase 1
  - Beam-gas & Touschek Results
  - Injection Background
  - Vacuum Scrubbing
- Summary & Outlook to Phase 2

Super KEKB:

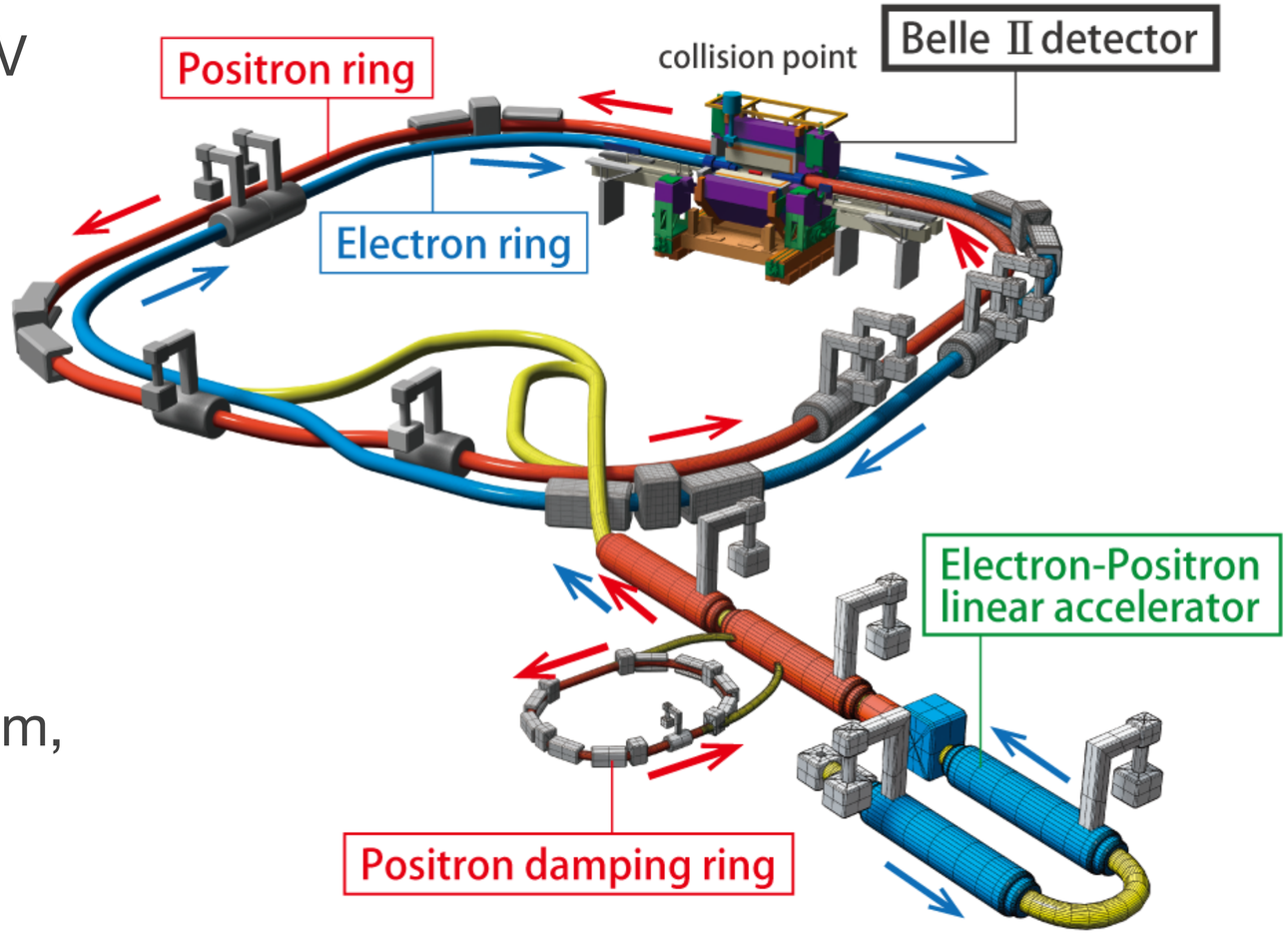
SuperKEKB accelerator at KEK, Tsukuba:

- asymmetric e^+e^- -collider (CMS =10.58 GeV Y(4s))
- high luminosity B-factory targeting CP-violation
- upgrade from KEKB

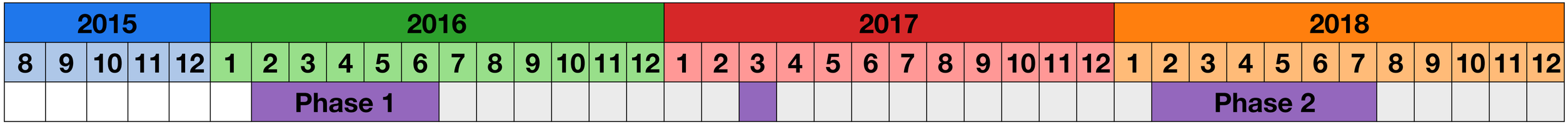
Increase in luminosity by factor of 40 ($8x10^{35}cm^{-2}s^{-1}$):

- “Nano-beam” scheme
- doubled beam current
- numerous upgrades to RF, magnets, vacuum, new positron ring

Schematic overview of SuperKEKB layout



How to commission a Particle Accelerator: Beast



Setup Instal-lation

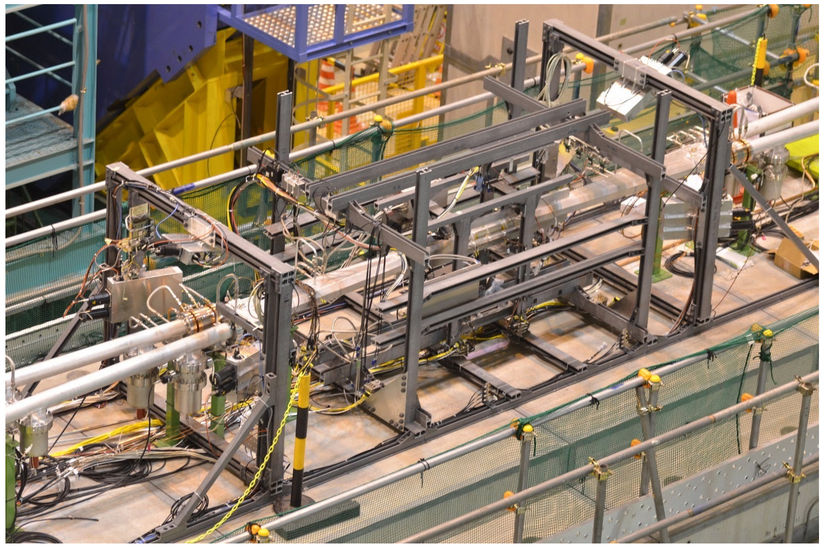
First turns

Beam studies

Now

Belle 2 roll in

First collisions



Beast Phase1: Key Points

- without Belle 2 detector
- tuning of beam optics & accelerator
- vacuum scrubbing

Beast Phase1: Goals

- successfully circulate both beams
- determine beam loss effects & rates
- quantify tuning effects in dedicated beam studies

The Beast Systems

^{3}He Tubes:
- thermal neutron rate

Crystals:
- 6 CsI(Ti) + 6 CsI+LYSO crystals
- em energy spectrum & injection bg

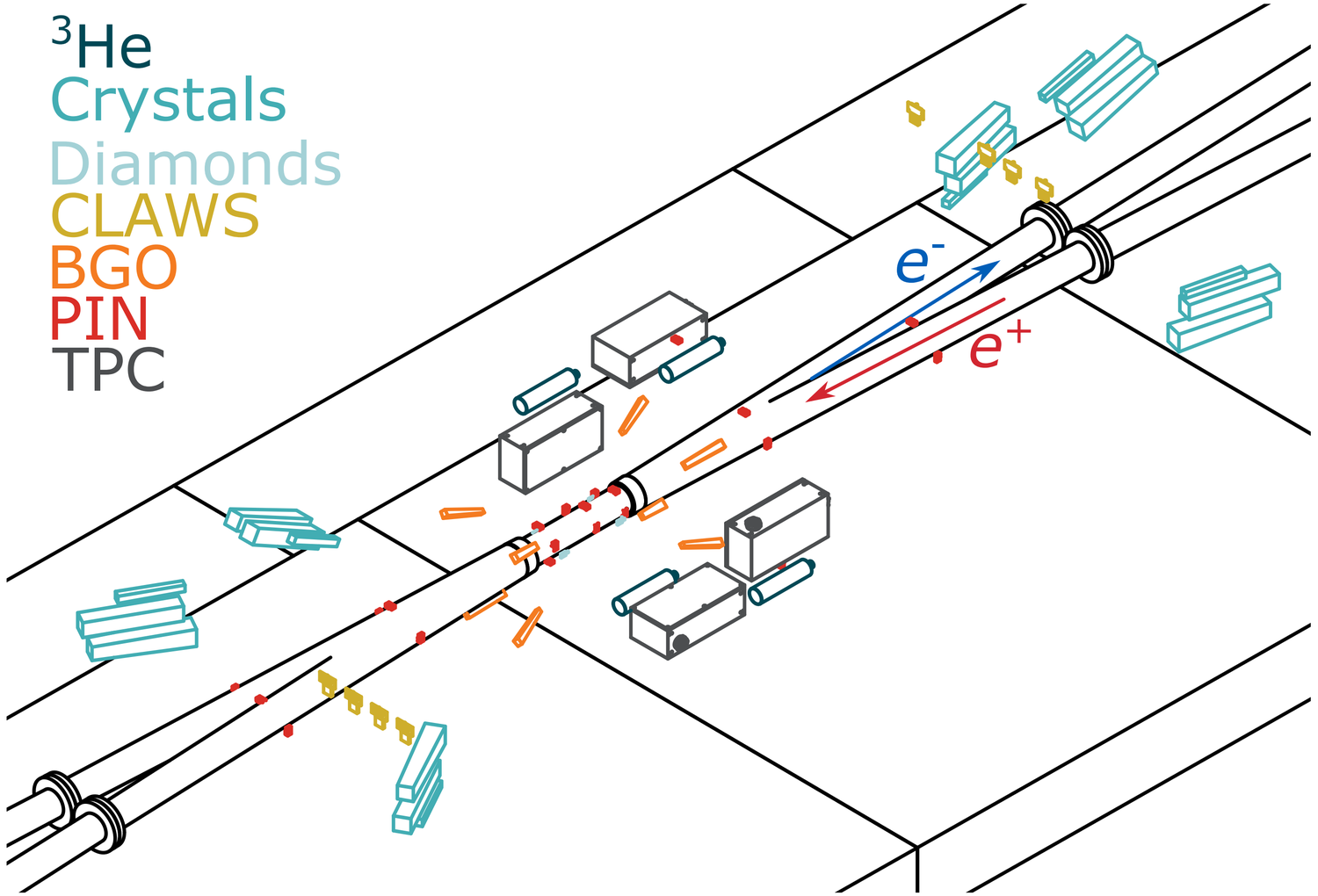
Diamonds:
- 4 diamond diodes for

CLAWS:
- 8 plastic scintillators with SiPM readout
- injection background

BGO:
- BGO crystals
- luminosity & em rate measurement

PIN Diodes:
- 64 diodes
- neutral & charged dose rate

TPC:
- 4 micro time projection chambers
- fast neutron flux & direction info



Beast Phase 1

Preliminary Results

Regular Beam Background Processes: Model for BG

Beam-gas interactions with residual gas atoms/molecules:

- **Bremsstrahlung**
- **Coulomb** scattering
- depending on current ***I***, pressure ***P***, effective atomic number ***Z*** and **beam-gas sensitivity *B***:

$$BG_{beam-gas} = B \times IPZ_e^2$$

Touschek intra-beam interactions:

- intra-beam Coulomb-scattering
- dominant in high density beams: major concern for SuperKEKB & nano-beam scheme
- depending on current ***I***, vertical beam size **σ** and **touschek sensitivity T:**

$$BG_{touschek} = T \times \frac{I^2}{\sigma_y}$$

Results for BG Model:

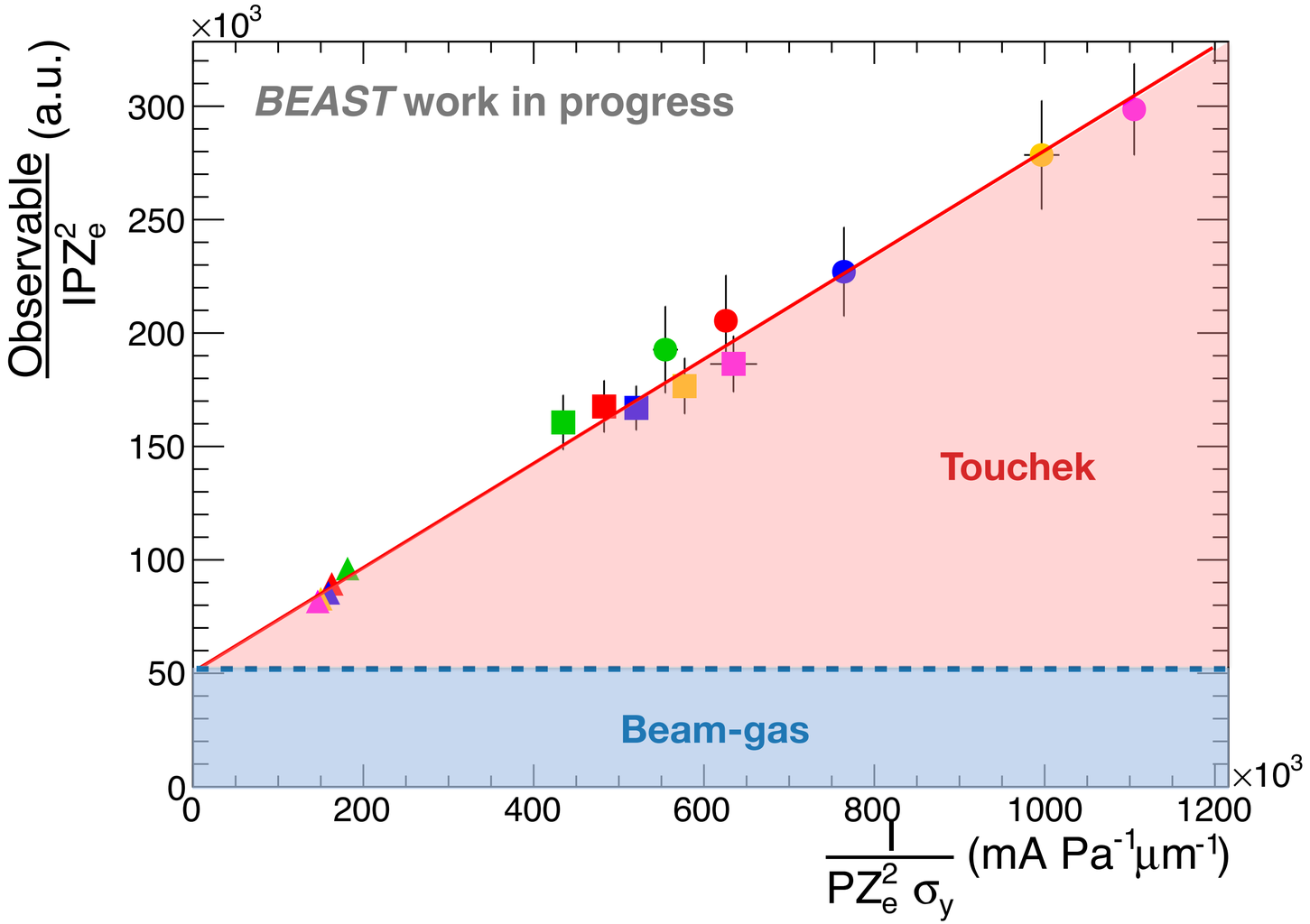
Size-sweep Scans:

- 15 dedicated runs for 5 different beam sizes & 3 currents
- data from BGO crystals

Combined Model:

$$\frac{BG}{IPZ^2} = B + T \times \frac{I^2}{\sigma_y}$$

- fit linearity **validates** the **model**
- sensitivities ***B*** (offset) & ***T*** (slope) extracted from fit



Vacuum Scrubbing: How to clean a beam pipe

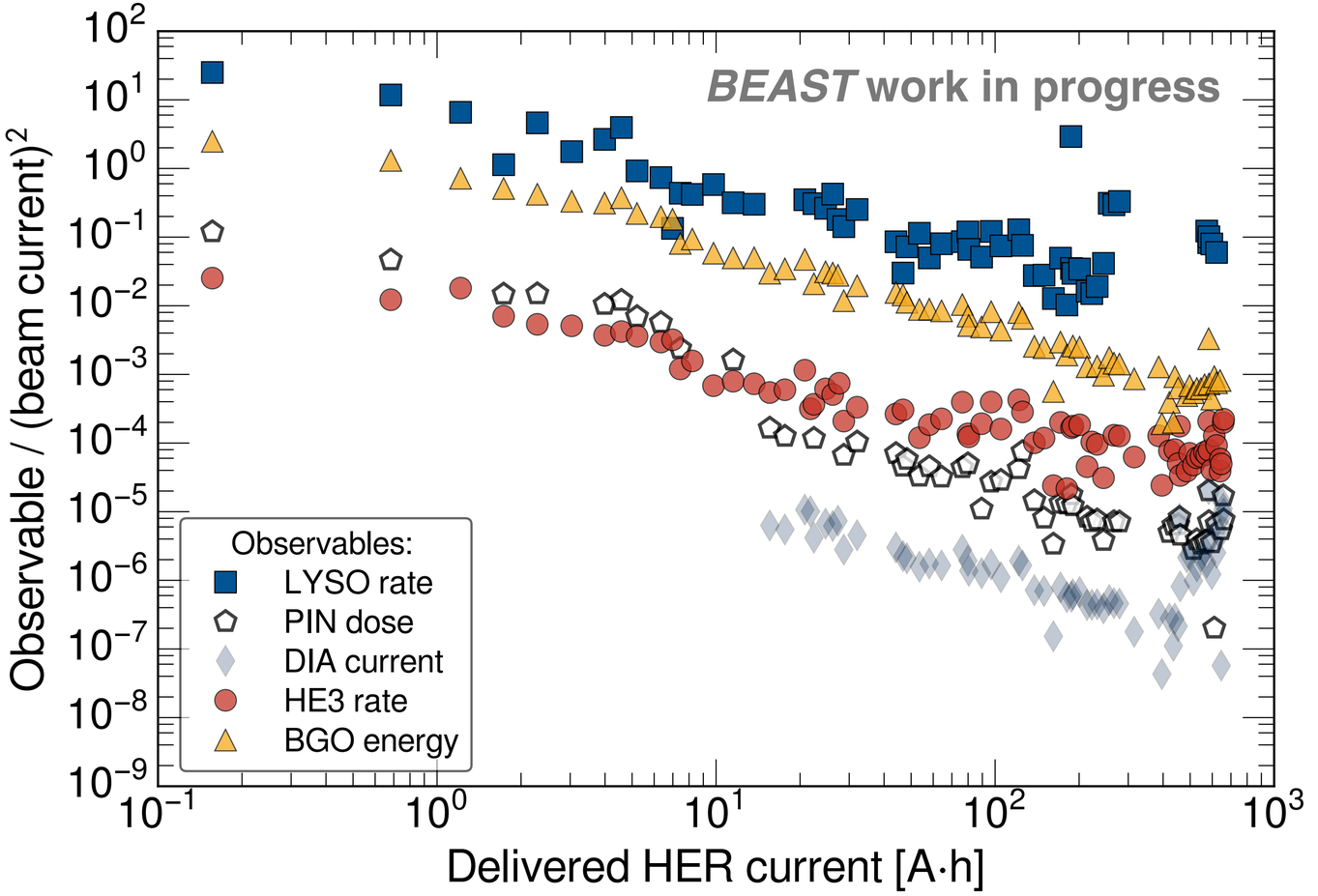
Technique of Vacuum Scrubbing:

- desorption of impurities on beam pipe walls stimulated by **high currents** and **wide beams**

Quantified results show improvement in beam-gas background:

- vacuum improves over time reducing gas induced backgrounds
- final “physics quality” not yet reached

Background rate at the IP, normalised to current^2 over total delivered current x time



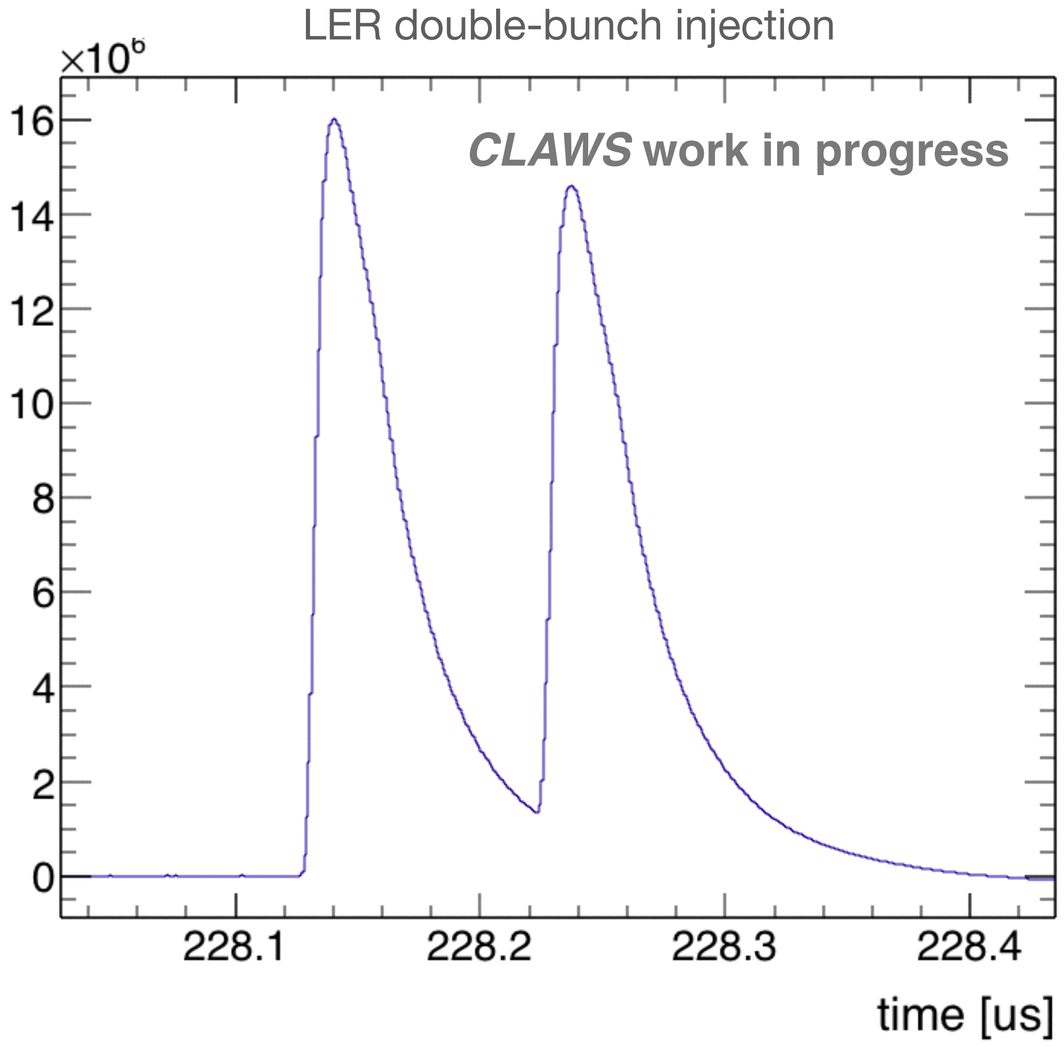
Beam Background from Top-Up Injections:

The Top-Up Injection Scheme:

- to achieve unmatched luminosities, beams in SuperKEKB will be continuously circulated
- to compensate for beam loss and collisions **new particles will be injected directly into circulating bunches**
- injected bunches result in considerable backgrounds for first turns
- single & double bunch injection

Impact on the Belle 2 Vertex Detector:

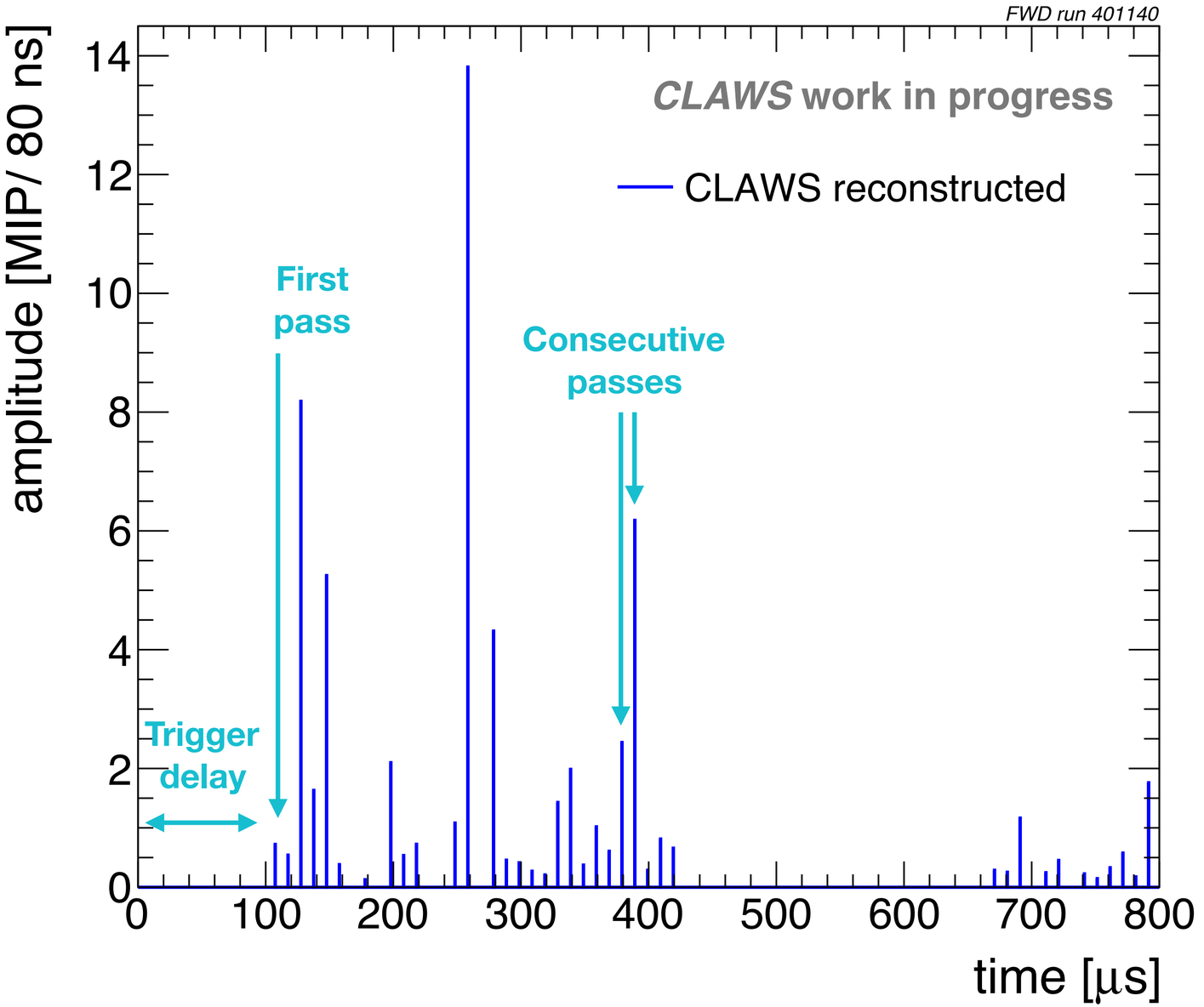
- injection background saturates Belle 2 vertex detector(PXD)
- precise knowledge vital for gating of PXD



Injection Measurements: CLAWS plastic scintillators

Sub-nano-second resolution continuously **sampled over ms** for resolving **bunch-by-bunch structure:**

- bunch spacing: 6.3 ns
- revolution time: 10 µs
- trigger delay: ~ 106 µs
- short (~ns), medium (~µs) and long (~ms) time structures



Summary & Outlook

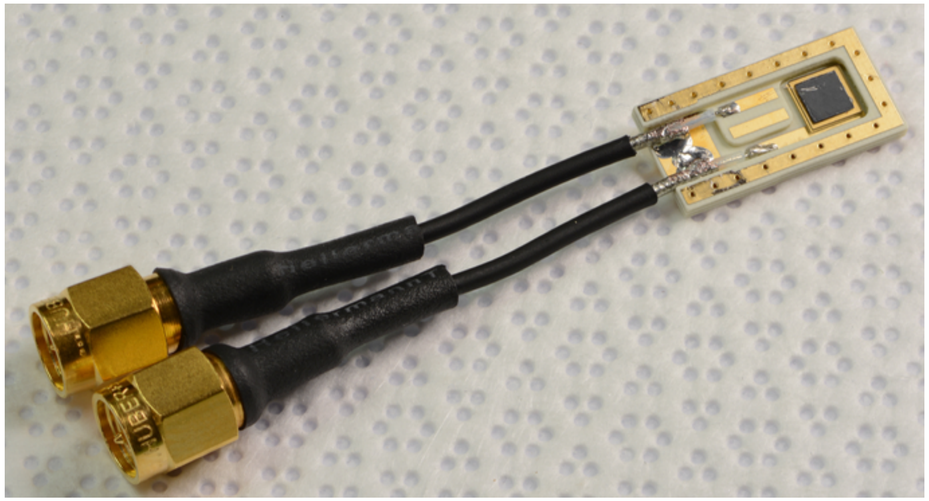
Beast Phase 1 (2016):

- first part of extensive SuperKEKB commissioning campaign
- Feb - June 2016
- first circulated beams
- heuristic model for beam backgrounds
- bunch-by-bunch structure from injections determined

Beast Phase 2 (2018):

- Feb - Juli 2018
- first collisions at the IP
- includes Belle 2 & final focusing (inner detector replaced by dedicated phase 2 system)

Backup

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CLAWS Ch 8