Fast Luminosity Monitoring with Diamond Sensors for Belle-II/SuperKEKB

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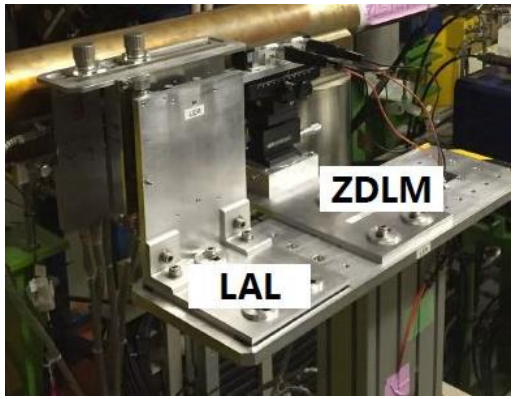
JENNIFER Meeting
22 -23 September 2016 , **Queen Mary Univ., London**

Fast Luminosity Monitoring

- **Goal: Realization of a fast lumi monitor based on radiative Bhabha scattering at low angle measurement with diamond sensors for SuperKEKB luminosity feedback and backgrounds study (BEAST).**
  - **Aimed precision: $\delta\mathcal{L}/\mathcal{L}$ ~ 10^{-2} to 10^{-3} in 1 to 10ms**
  - **Fast signal : Lumi monitoring for each bunch crossing: 2500 bunches/train, collisions every 4 ns**

- **Setup: 2 sets of 2 ~5x5 mm^2 diamond sensors coupled to fast charge amplifiers, positioned outside of the beam pipe**

  Collaboration with ZDLM group @ KEK (Cerenkov detector + scintillator)

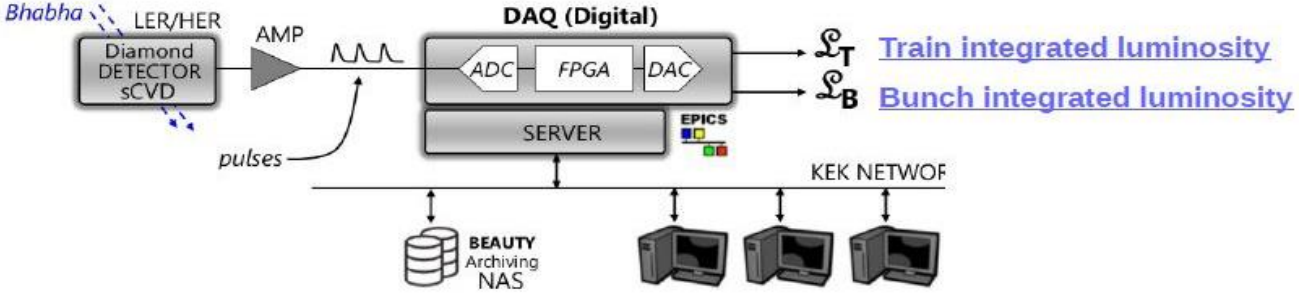


- **Locations :**

- In High Energy Electron Ring : 30m downstream the Interaction Point for Bhabha photon detection

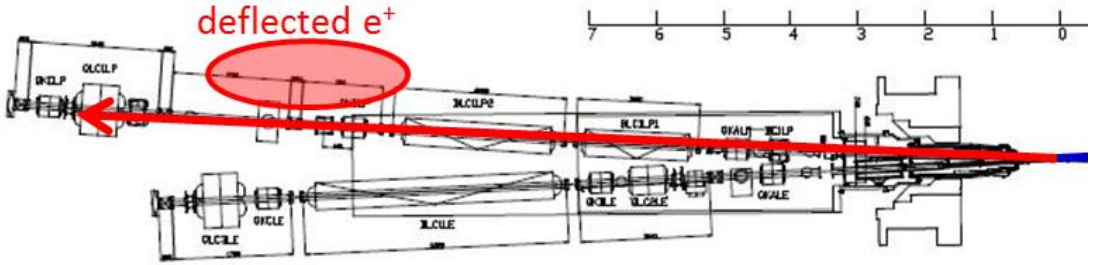
- In Low Energy Positron Ring : 11.9m from IP for Bhabha scattered positron detection

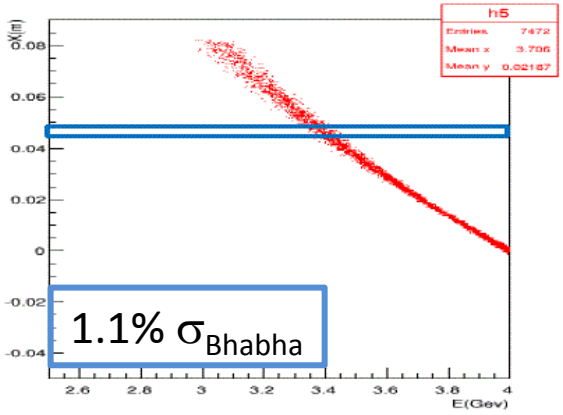
- **DAQ : ADC+FPGA+DAC synchronised to SuperKEKB RF**

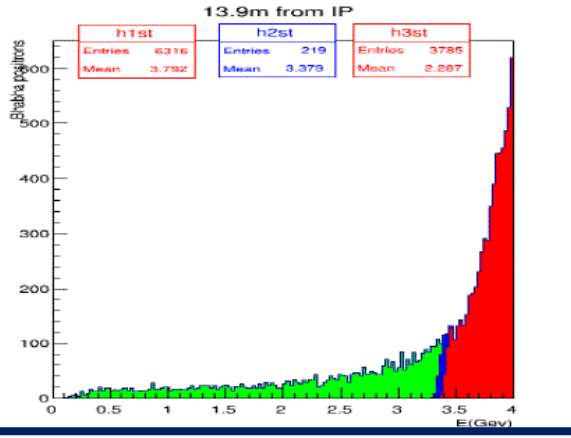


Sensor locations

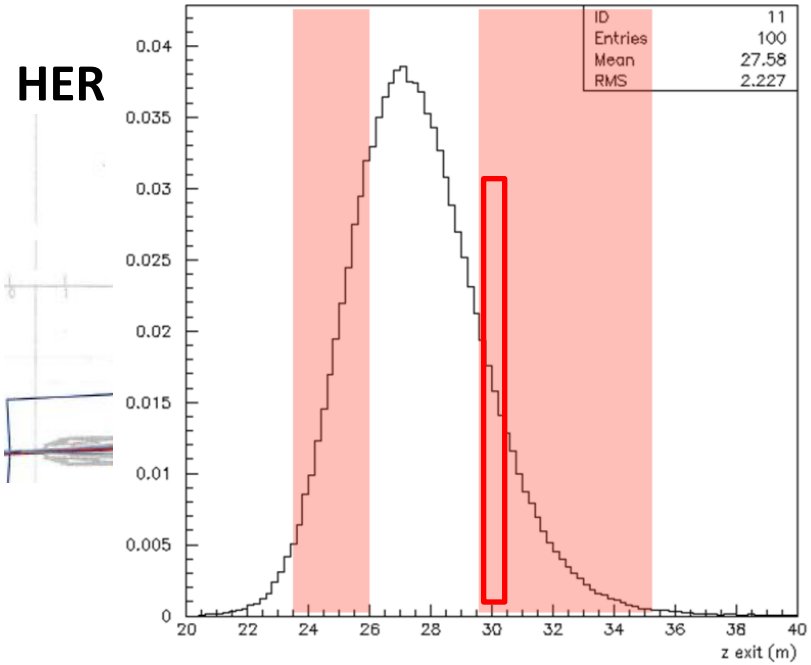
LER

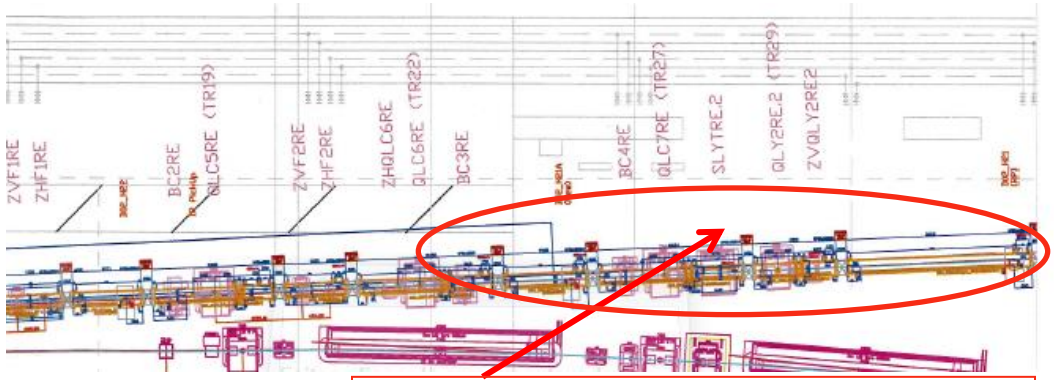






HER

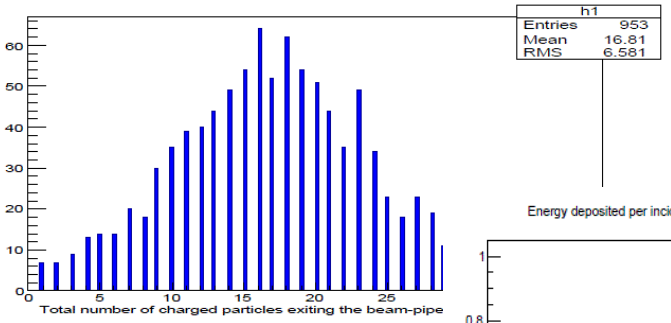


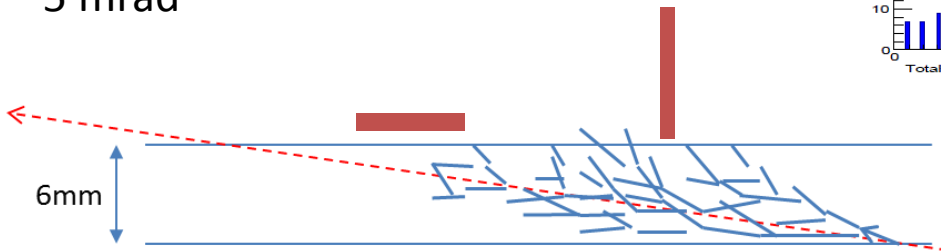


γ main spot hits ante-chamber edge at 27.4m downstream IP, with a mean angle of 5.9 mrad

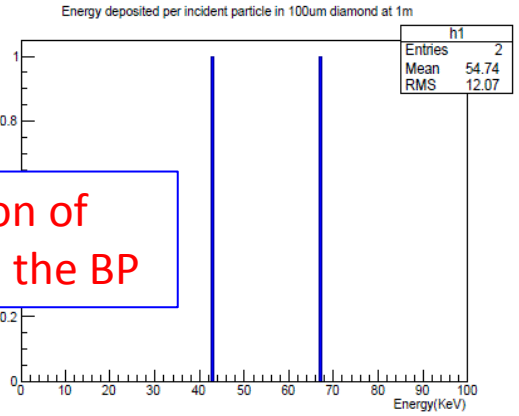
Geometry of LER beam pipe

- At 11 m dowstream the of IP, 3.3 GeV Bhabha positrons cross the BP material at 5 mrad

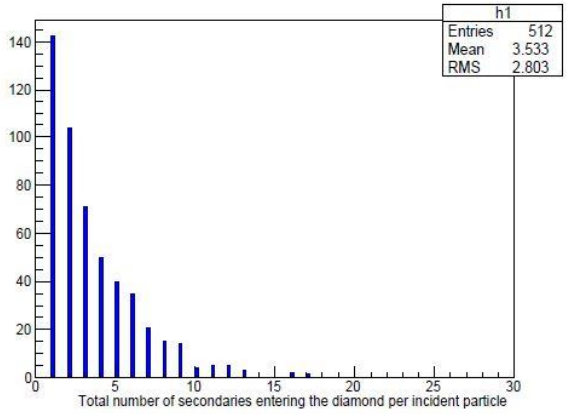




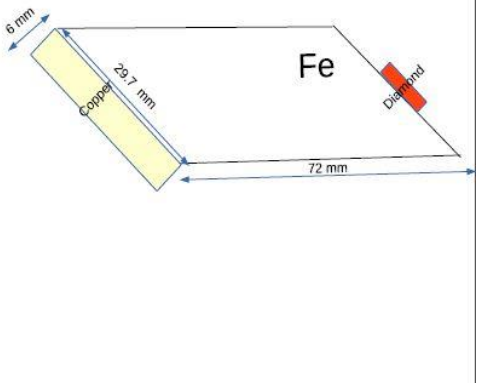
< 0.2% of fraction of Bhabhas exiting the BP



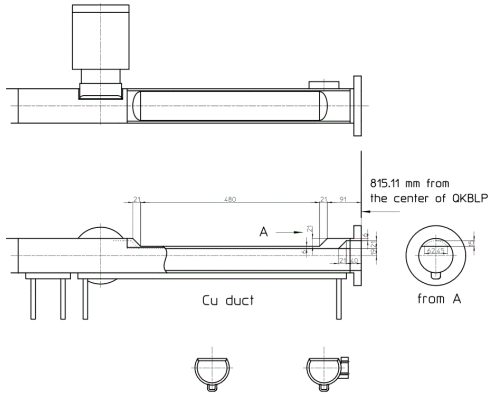
- A modification of the vacuum chamber may be required (window + radiator)



~50% of fraction of Bhabhas exiting the BP

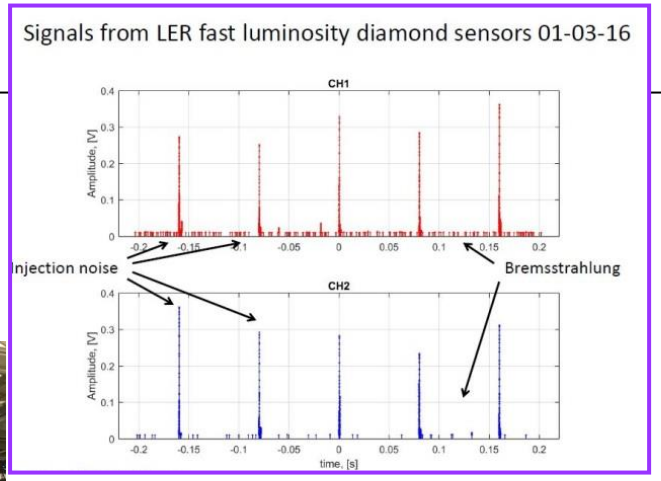


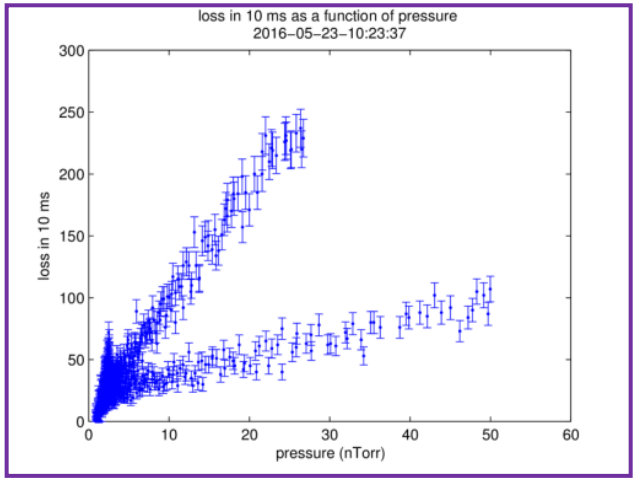
Window design proposed by Prof. Kanasawa-san, to be installed in 2017



Fast Luminosity Monitoring: Highlights and status

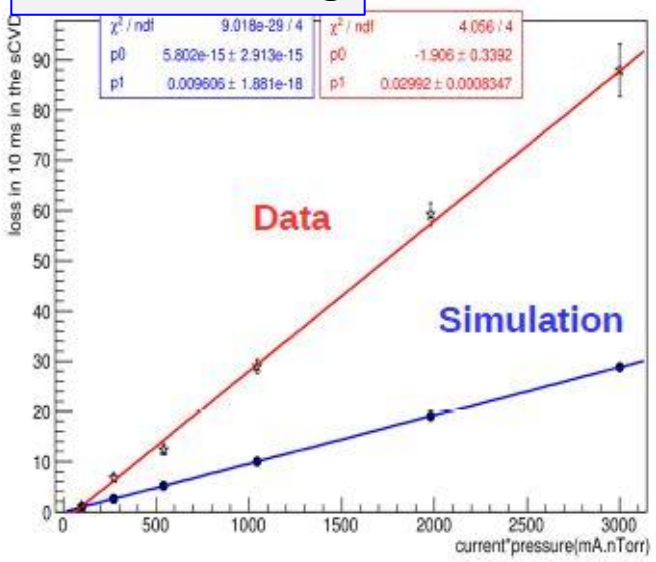
- **Automn 2015**: Installation of LAL made pillars and sCVD diamond sensors on SuperKEKB Rings
- **February 2016**: Installation of LAL Rack in Electronic Hut
- **02/2016➔06/2016: Phase 1 of SuperKEKB commissioning**
  - Single beam background measurements (bremsstrahlung + Touschek) with sCVD in HER & LER with oscillo
  - Developments of scripts and GUI for real time data taking and processing/post processing analysis
  - Tests and improvement of LAL Diamond sensors
  - LER background analysis / comparison with simulations

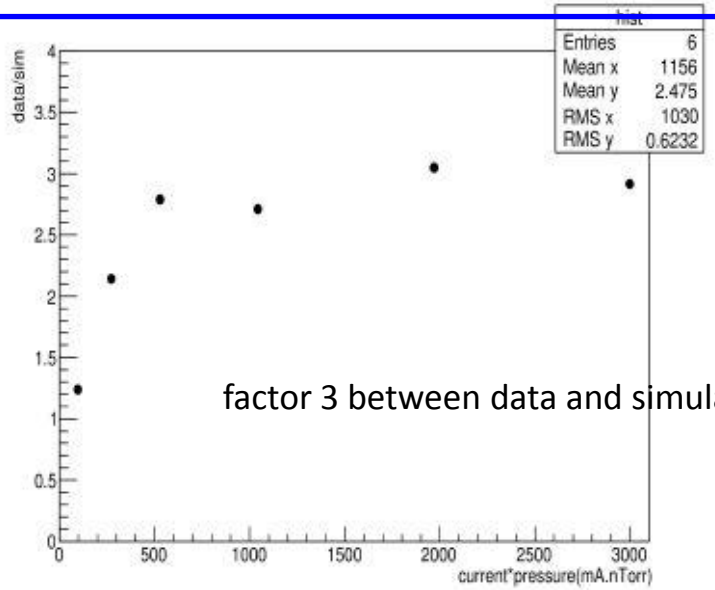




LER Background studies during phase 1

Bremsstrahlung

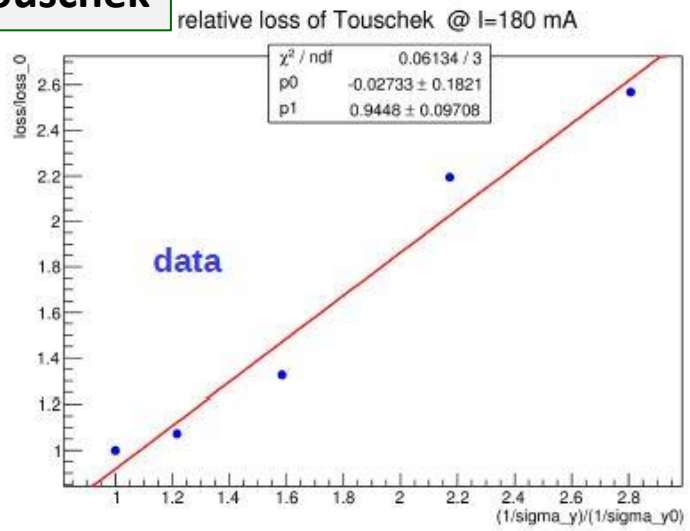


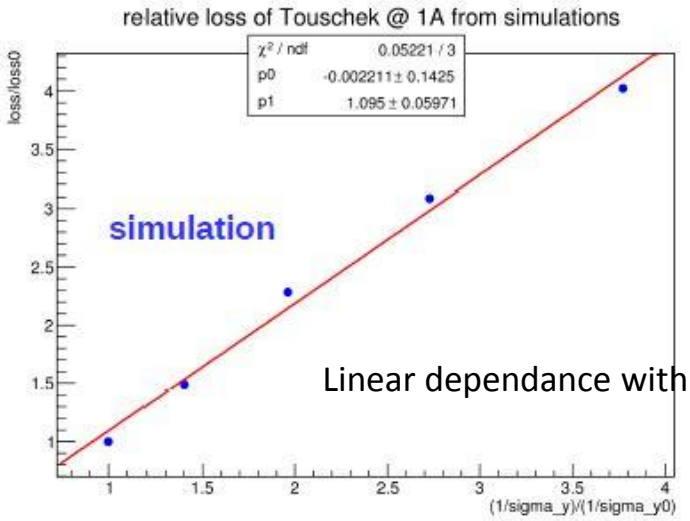


factor 3 between data and simulation is understood

D. El Khechen analysis

Touschek





Linear dependance with $1/\sigma_y$

Fast Luminosity Monitoring - Schedule for next years

07/2016-10/2017:

- Finalization LER background phase1 data analysis
- DAQ for the phase II of SuperKEKB commissioning (11/2017):
  2 choices are studied, choice will be fixed at end of fall 2016
- HER phase 1 data analysis.
- R&D Diamond sensors miniaturized packaging @ LAL
- adaptation of existing pillar in LER for phase-II (to fit with vacuum chamber modification)

11/2017-03/2018: tests during phase II of SuperKEKB commissioning

- Bhabha acquisition and first luminosity measurement tests
- Single beam background characterization
- Integration CVD DAQ to the SuperKEKB feedback system

- optimization of choice for final sensors (500um/140um sCVD) and ampli (Charge/current) (TIL/BIL)

10/2018: Phase III = first Belle-II runs

- Operating fast lumi monitoring system for SuperKEKB feedback
- New single beam and beam-beam background characterization
- Non linear phenomena measurements occurring with small beam size beam-beam interaction

Used Secondments

Number of asked secondments: 15

Used secondments: 11

Dima El Khechen – PhD student : +5 months

background simulation, phase 1 data acquisition, participation to SuperKEKB phase 1 commissioning, collaboration with BEAST-II on background study

Didier Jehanno – elec. Eng., DAQ : +5 months

installation, readout synchronisation, phase1 data acquisition…

Viacheslav Kubytskyi – Post-doc: 1 month

Started secondments: 3

Yann Peinaud – mech. eng.

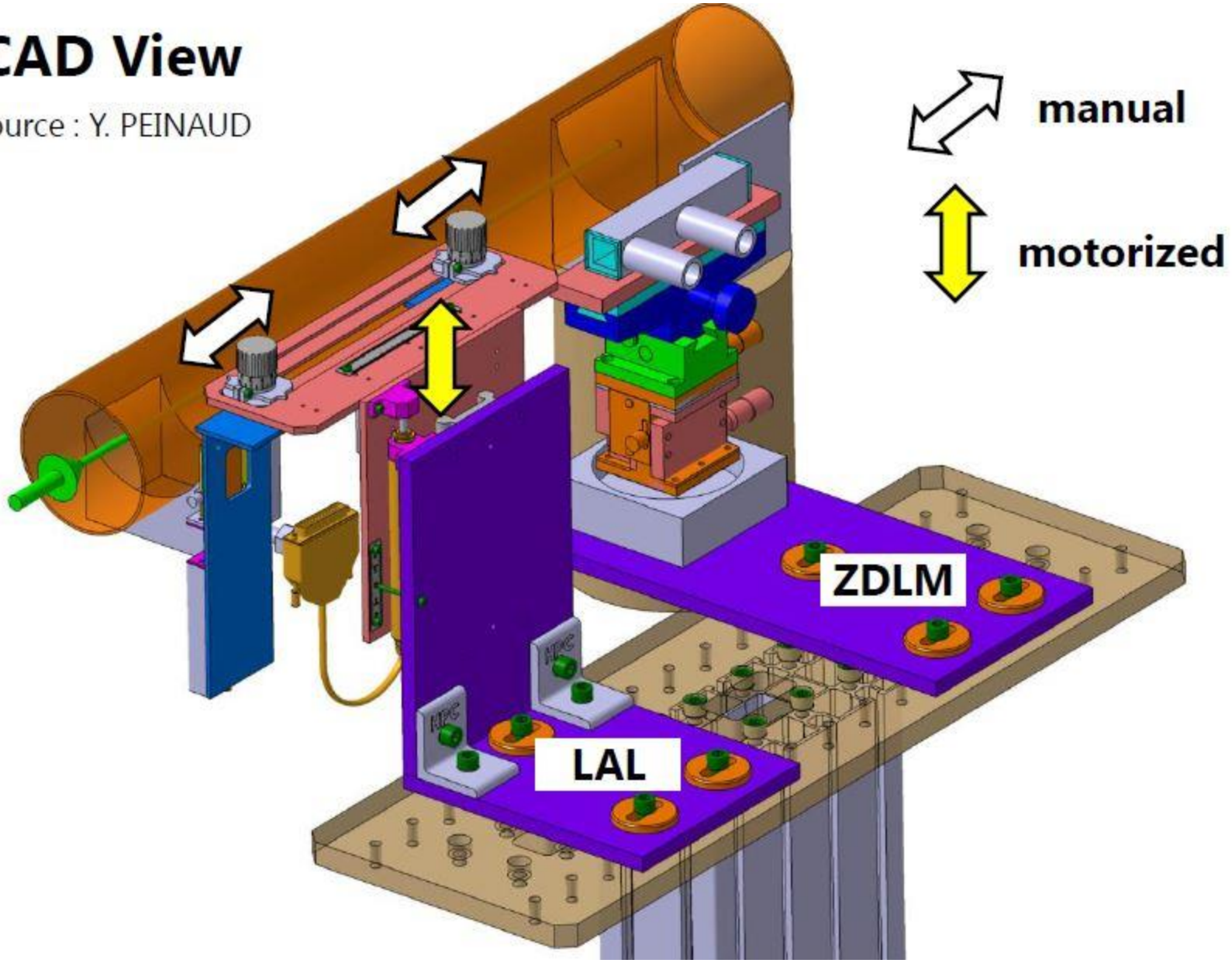
Philip Bambade- researcher

Cécile Rimbault-researcher

Back-up

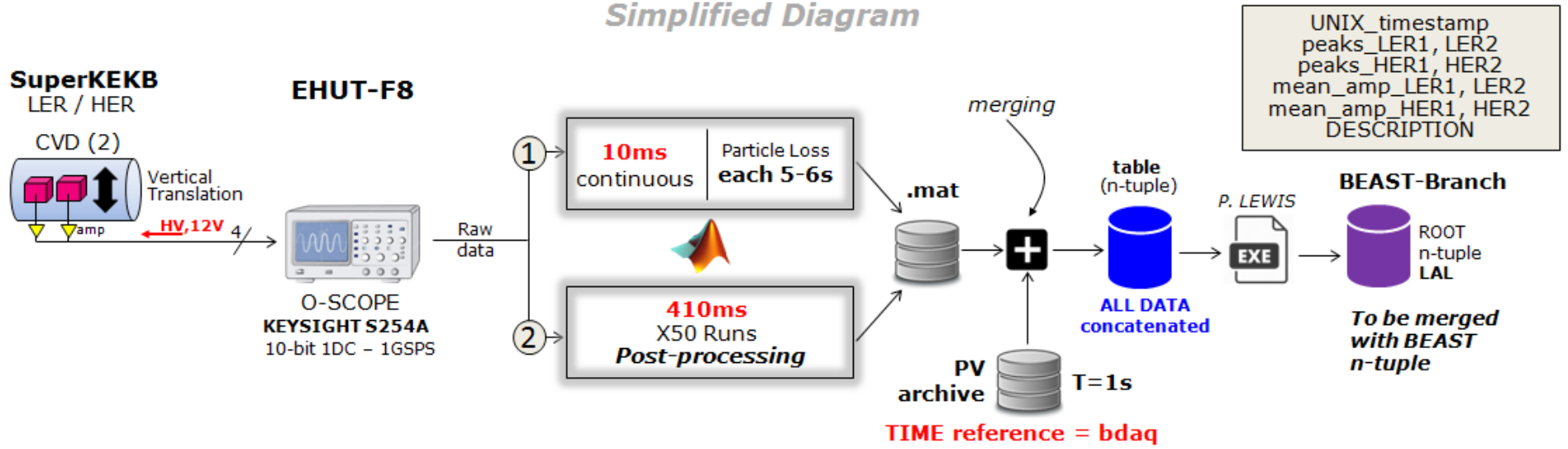
CAD View

Source : Y. PEINAUD

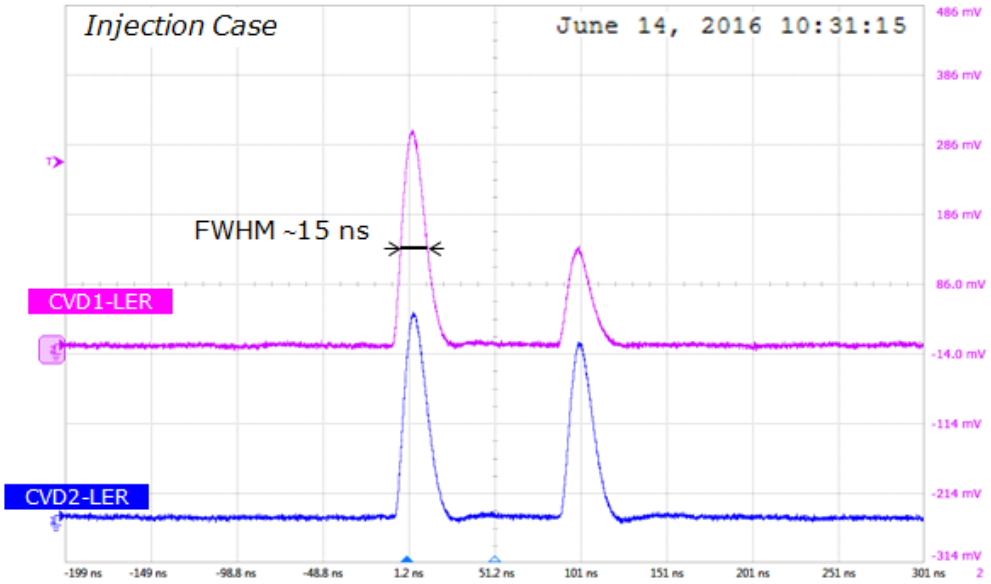


DATA ACQUISITION SETUP

Simplified Diagram



CVD Signal example (LER)



1 MIP = 3fC (18000 pairs e-/hole)

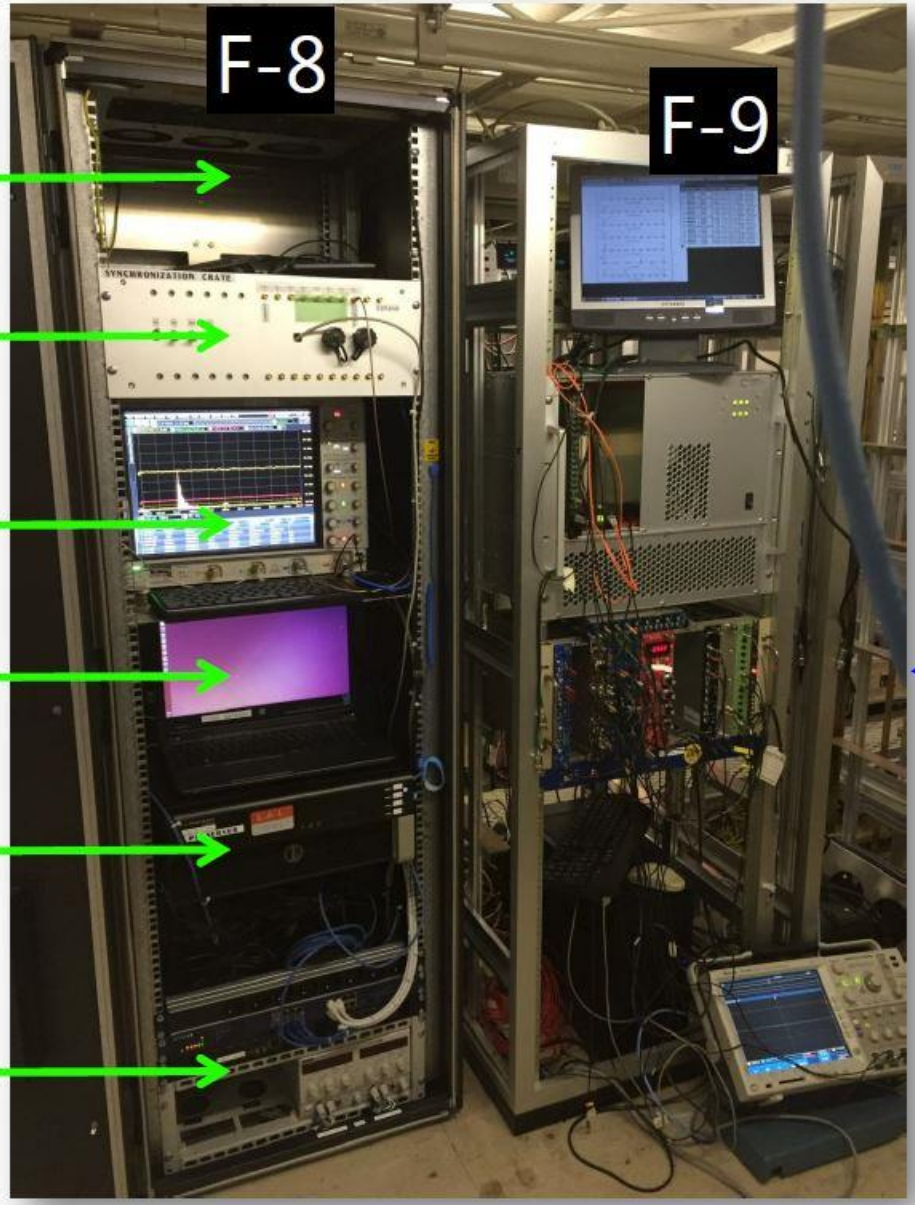
G → 1 MIP = **12mV**

4mV/fC

V_{Noise} = 0.73mVrms

SNR = 24 dB @1MIP

LAL RACK IN EHUT



DAQ (2017, PHASE2)

RF SYNCHRO
Synchronizes DAQ sampling clock to RF clock

SCOPE (=DAQ, PHASE1)
2.5GHz BW – 20GSPS
800MSamples

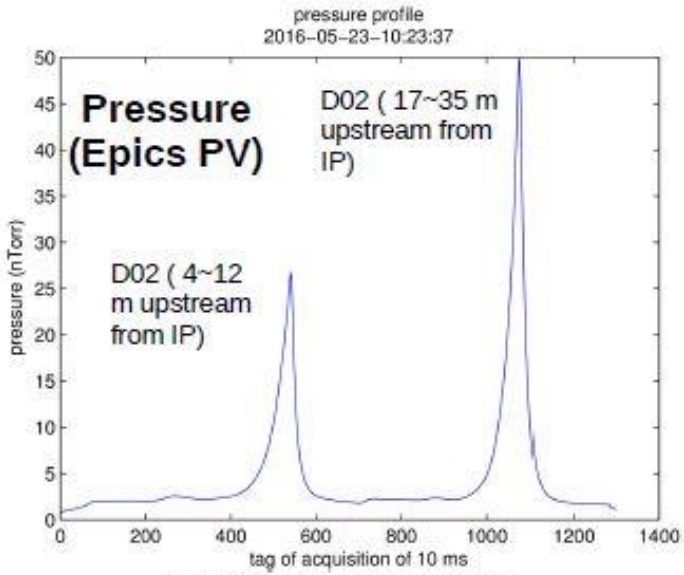
LINUX GATEWAY
PHASE1 only

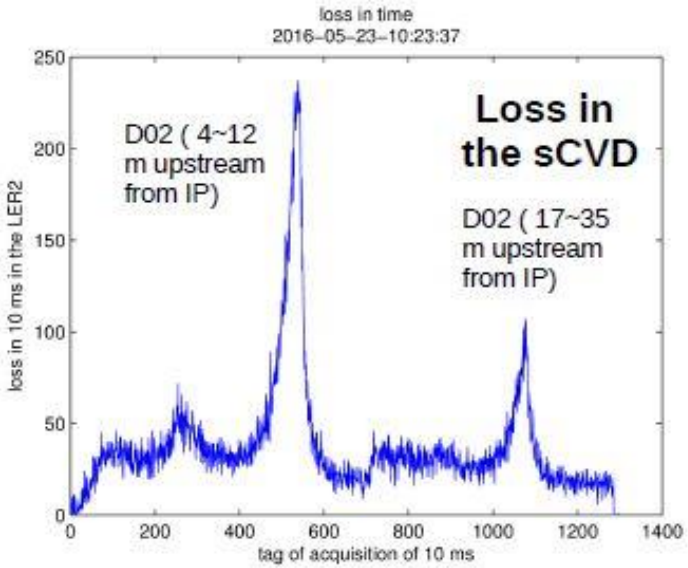
LAL SERVER
Windows, PHASE1
Linux SL6, PHASE2

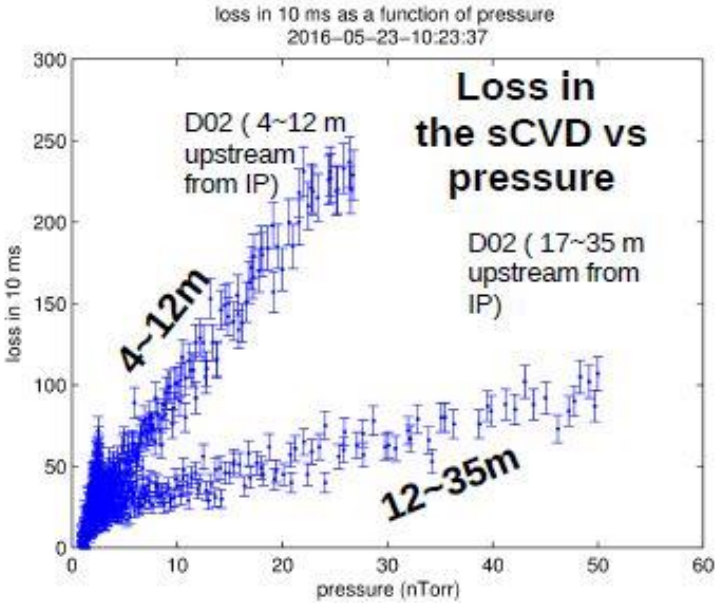
POWER SUPPLIES
Diamonds, amplifiers

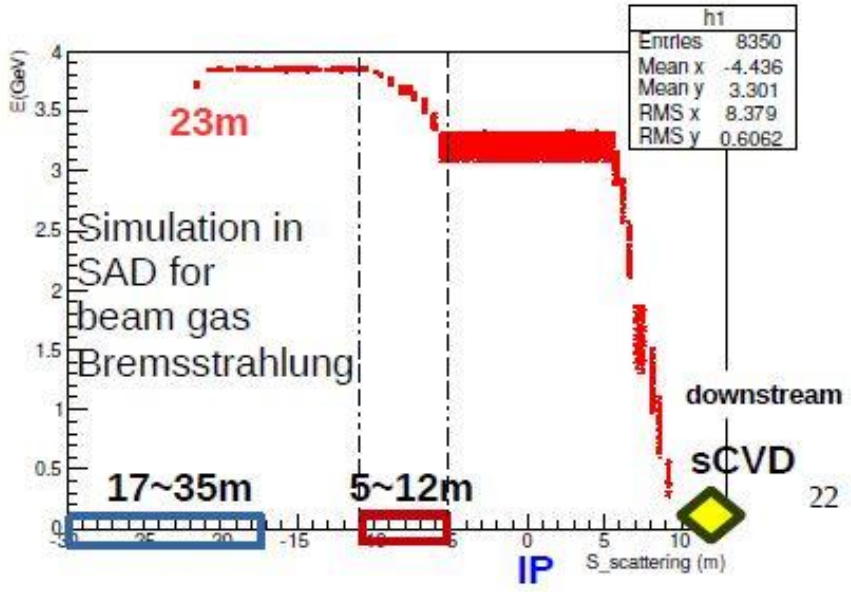
UEHARA-san's ZDLM

Losses in the sCVD during vacuum bumps in LER









Slide D. El Khechen