MACHINE BACKGROUND STUDIES WITH BEPC II/BES III

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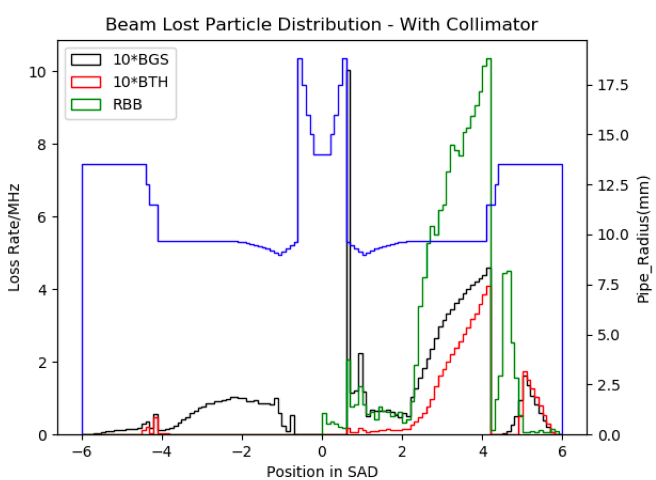
Motivation

- Important to validate the modellings and Monte Simulation programs for the CEPC background estimation with real data where they are applicable;
  - BEPC II/BES III, SuperKEKB/Belle II, LEP I/II ...
- Encountered extremely high backgrounds from the beam-gas interaction at the CEPC, which should be better understood and suppressed with improved design.



10^{-8} pa assumed

Background Type	Hit Density($cm^{-2}\cdot BX^{-1}$)	TID($krad\cdot yr^{-1}$)	1 MeV equivalent neutron fluence ($n_{eq}\cdot cm^{-2}\cdot yr^{-1}$)
Pair production	2.26	591.14	1.11e+12
Synchrotron Radiation	0.026	15.65	
Radiative Bhabha	0.34	592.66	1.44e+12
Beam Gas	36.8372	39901.139	9.65e+13
Beam Thermal Photon	2.31	2325.49	5.48e+12
Total	41.7732	43426.079	10.453e+13

I. Verification of Modelling & Simulation

What Can Be Learnt from B II/BES III

Basic Principles

Single beam mode: three dominant contributions from Touschek, beam-gas and electronics noise (+ cosmic rays)

$$O_{single\ beam} = O_{Touschek} + O_{beam-gas} + O_{e-noise,cosmic}$$

$$= S_t \cdot D(\sigma_{x'}) \frac{I_t \cdot I_b}{\sigma_x \sigma_y \sigma_z} + S_g \cdot I_t \cdot P(I_t) + S_e$$

Double beam mode: additional contributions from luminosity related backgrounds, e.g. radiative Bhabha scattering

$$O_{double\ beam} = O_{e^+} + O_{e^-} + O_{\mathcal{L}}$$

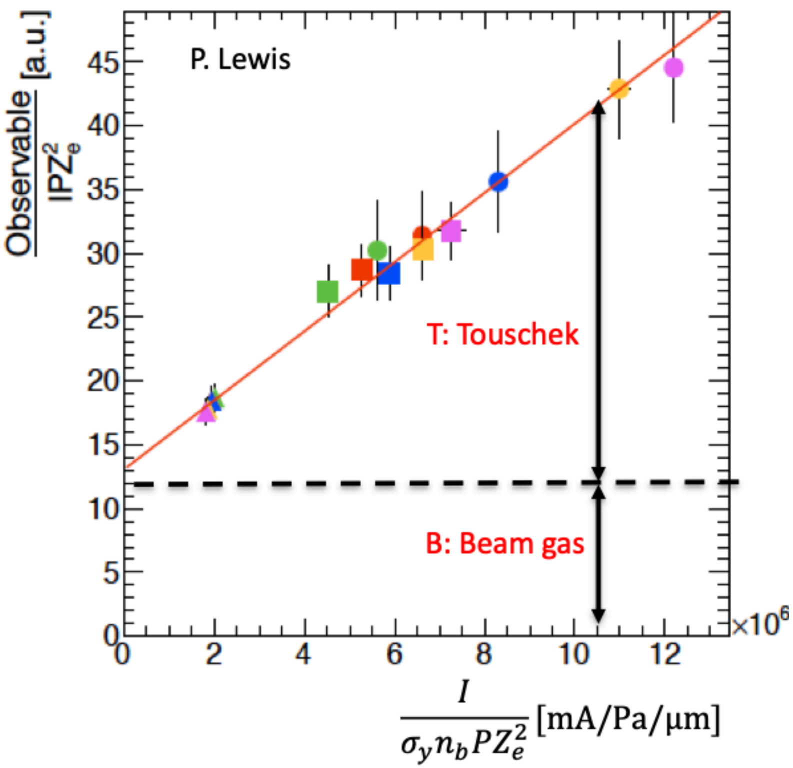
WHAT CAN BE LEARNT FROM B II/BES III

SINGLE BEAM MODE

$$S_t \cdot D(\sigma_{x'}) \frac{I_t \cdot I_b}{\sigma_x \sigma_y \sigma_z} + S_g \cdot I_t \cdot P(I_t) + S_e$$

- No Beam, detector with high voltage on to measure the backgrounds in MDC and EMC → $\boldsymbol{S_e}$
- Touschek backgrounds: with fixed beam energy and total current (I_t), varying bunch number (changing I_b), bunch size (σ_y, σ_z) → $\boldsymbol{S_t}$
- Beam-gas backgrounds: with $\boldsymbol{I_b}$ and bunch size fixed, increasing the bunch number (increasing $\boldsymbol{I_t}$) → $\boldsymbol{S_g}$

Example plot from SuperKEKB



What Can Be Learnt from B II/BES III

Double Beam Mode

$$O_{double\ beam} = O_{e^+} + O_{e^-} + O_{\mathcal{L}}$$

- Fixed beam energy & current, bunch parameters, operating
  - Single e^+/e^-beam
  - Separate e^+ and e^- beams
  - Colliding e^+ and e^- beams
- Thorough understanding of the radiative Bhabha scattering backgrounds would be vital for optimizing the collimators.

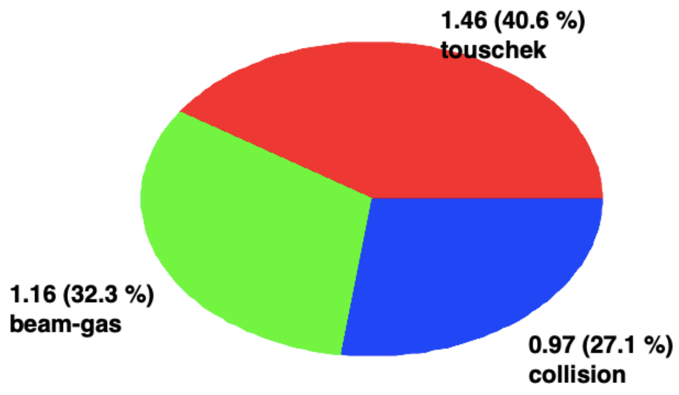
The number of collimators is shown at around 2-4. Taking into account the necessary freedom required for tuning, the number of the collimators is extremely insufficient. According to experience in other colliders such as LEP, KEKB, PEP-II, SuperKEKB, 10-20 of them may be needed per IP.

MACHINE STUDIES LAST SUMMER

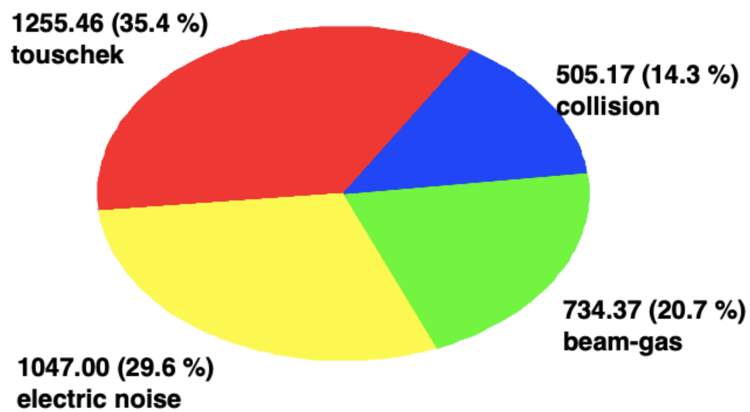
- Two hours of machine time allocated to background studies last summer, with the starting machine parameters:

$$I_t = 450\ \mathrm{mA}, E_{beam} = 2.22\ \mathrm{GeV}, N_{bunch} = 75$$

- Recorded parameters: bunch size, beam current, beam life-time, vacuum pressure, MDC (current through the 5th layer of wires)/EMC cluster counts



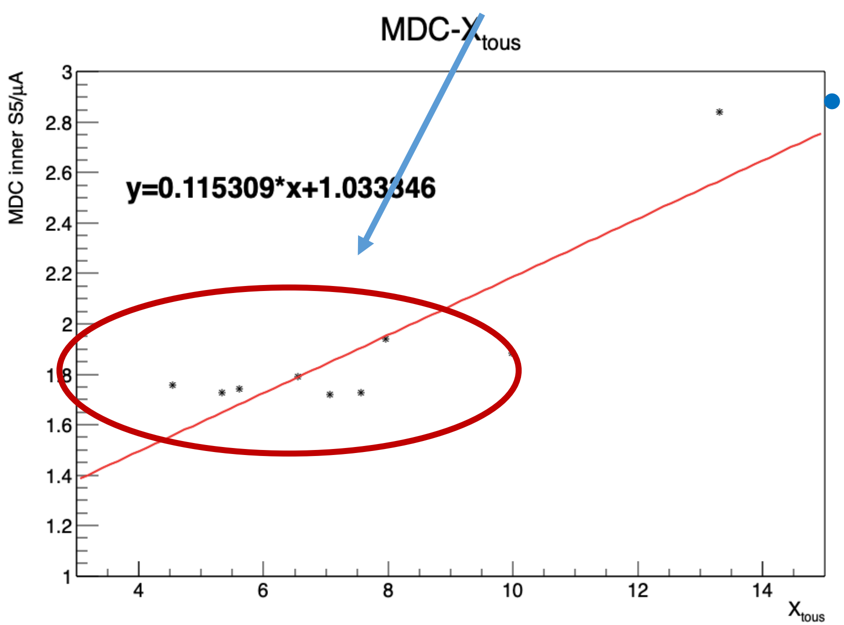
MDC



EMC

WHY ANOTHER ROUND?

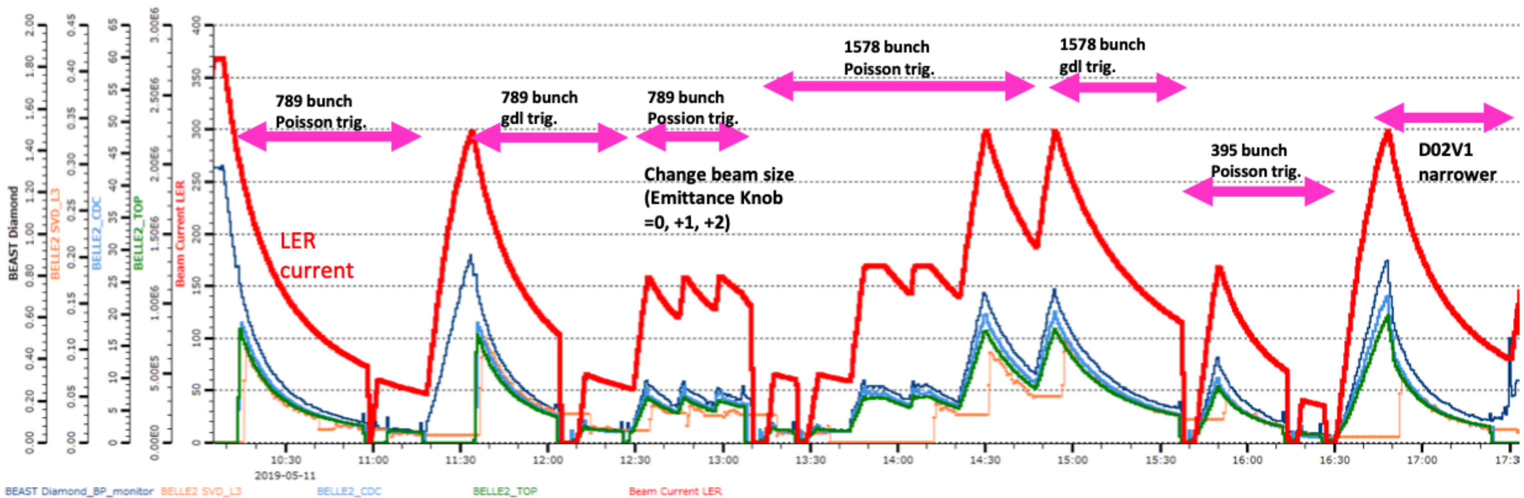
- Not easy to extract correct coefficients with the limited machine/beam parameter points (even worse if encountered with unstable machine status);
- Detector information not fully extracted; more concerned if the detector status was not configured properly;



- Simulation results DO NOT match the measurements;
  - *Try to re-build the lattice based on the extracted magnet configurations from the database rather than using the default one*

PROPOSED EXPERIMENTAL STEPS

SuperKEKB background runs



- Propose to repeat the summer studies with longer machine time (extending to 12 hours) to take background with more machine/beam parameter points (details attached)
- Important to improve the communication between the machine and detector operation

II. Vacuum Pressure Degradation

IMPACTS OF SR ON VACUUM PRESSURE

- Beam-gas backgrounds depending significantly by the vacuum pressure, which can be affected by the synchrotron radiation during operation;

- To collect initial data of SR impacts on Vacuum, with different design parameters (energy, flux, angle, material…) for CEPC.

Proposed by H. Shi & M. Sullivan

LEP MEASUREMENTS

- LEP studies back in 1982 with very low photon energy (critical energy ~2 keV);

- Relevant parameters for CEPC:
  - Higgs: ~360 keV on arc, ~25 keV on last bending;
  - Z: ~23keV on arc.

- To find an end station at the SR facility with the beam energy of 25 keV, e.g. BSRF

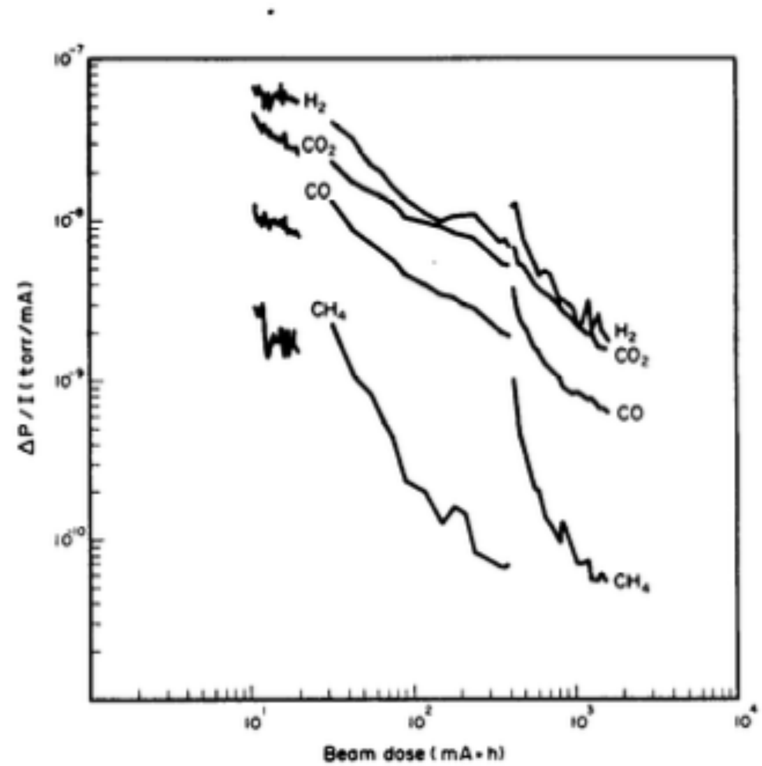
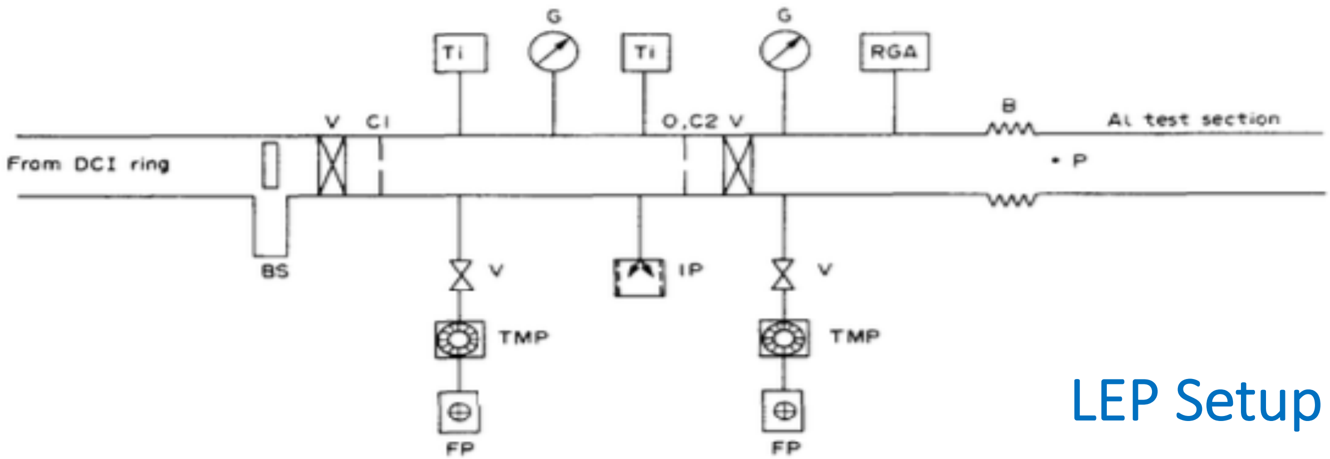


Figure 4. The specific partial pressure rise $\Delta P/I$ as a function of the beam dose for H_2, CH_4, CO and CO_2 for the first series of measurements—unbaked.

EXPERIMENTAL SETUP



LEP Setup

At one BSRF end station

- CEPC vacuum chamber prototypes (Cu/Al, 2 meters long preferred but depending on the space)
- Gas pressure monitors and gas composition analysis tools; Connecting chambers …

STEPS (IDEAS)

- Pump the Cu chamber and set the incident angle and energy;
- Record data (pressure, gas type, pump speed) with photon exposure;
- Stop when reach the stopping condition(accumulate current or pressure). Exposure the chamber on air;
- Repump and repeat, with different conditions(energy, angle, hitting side…).

- Repeat the same tests with the Al vacuum chamber

- *(Draft plan attached)*