Helium-3 thermal neutron detectors the Belle II commissioning detector

for 2016 CAP congress

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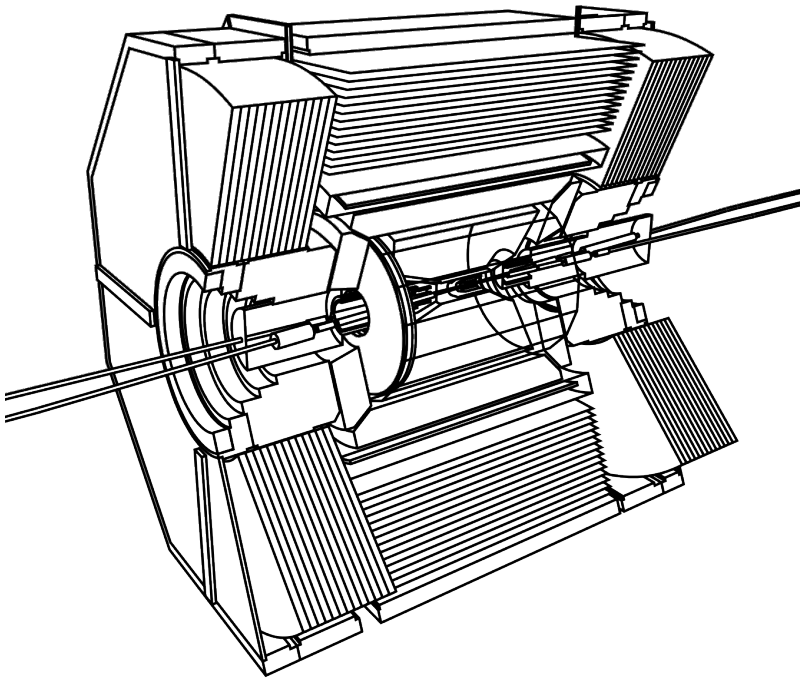
Department of Physics and Astronomy
University of Victoria

June 13, 2016



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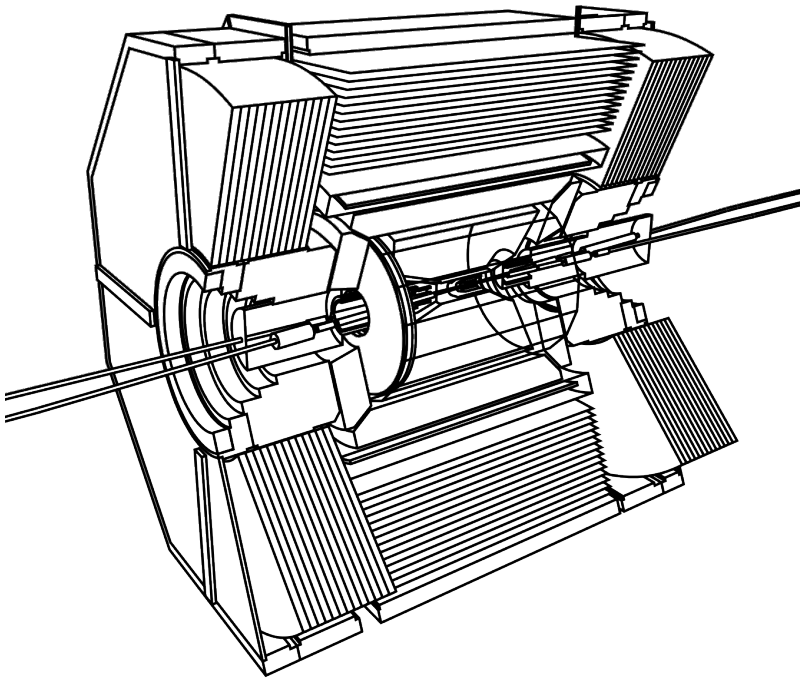

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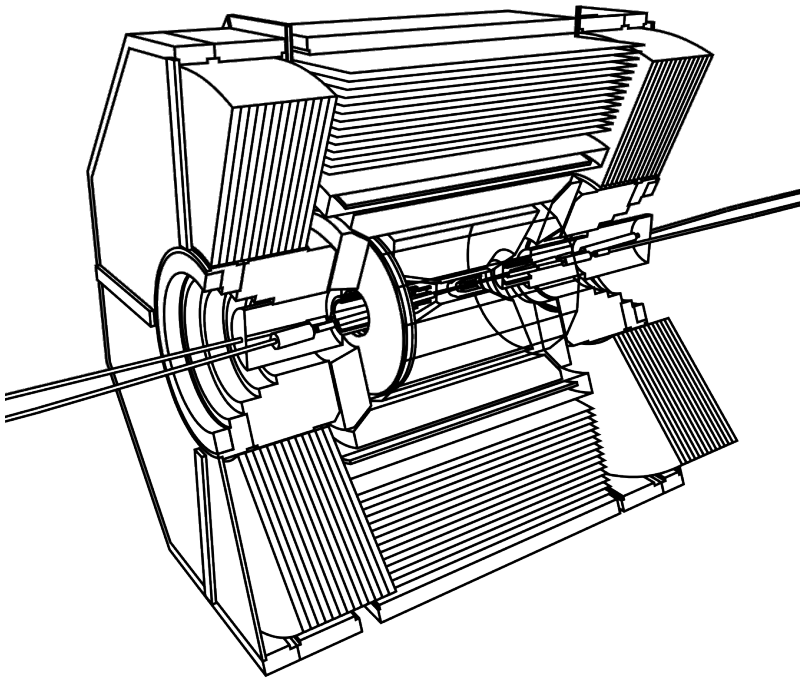

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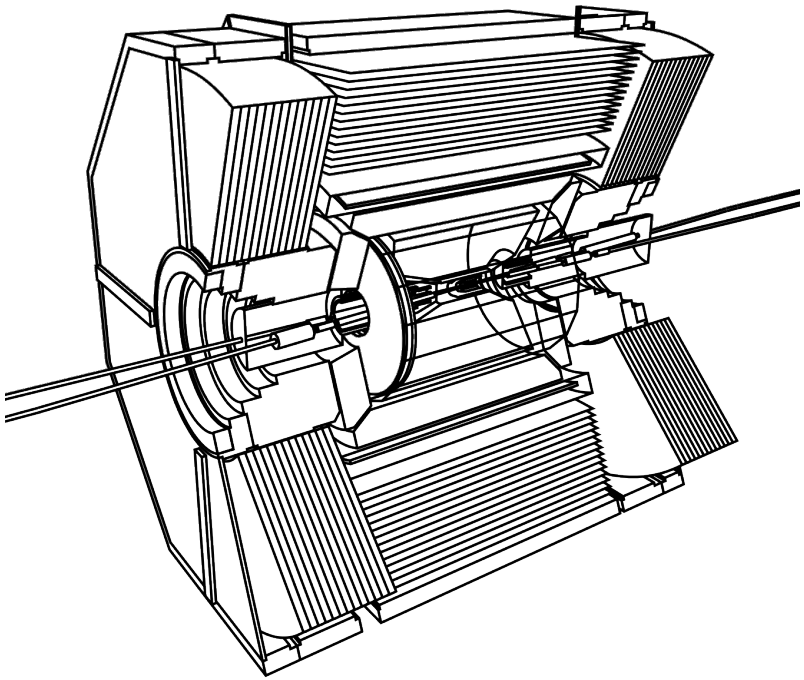

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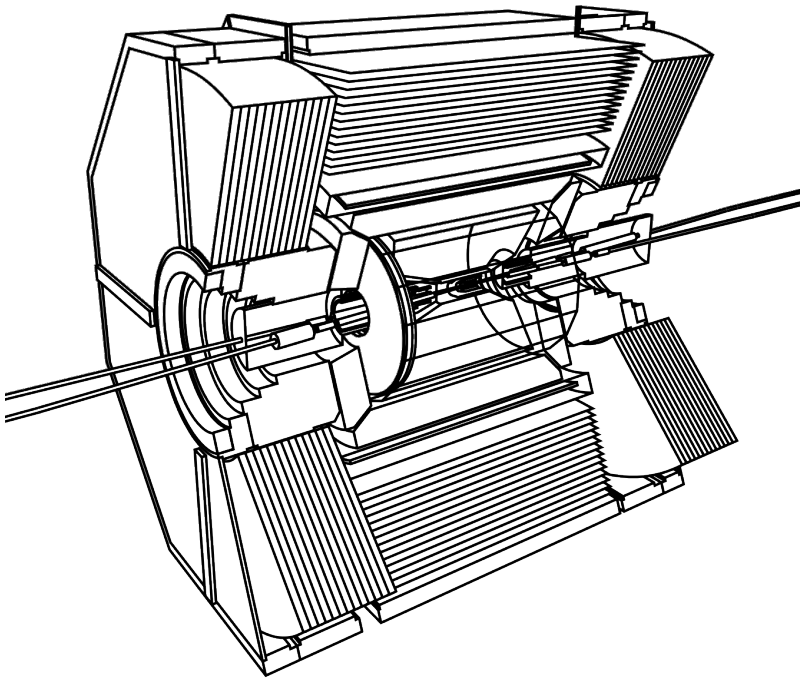

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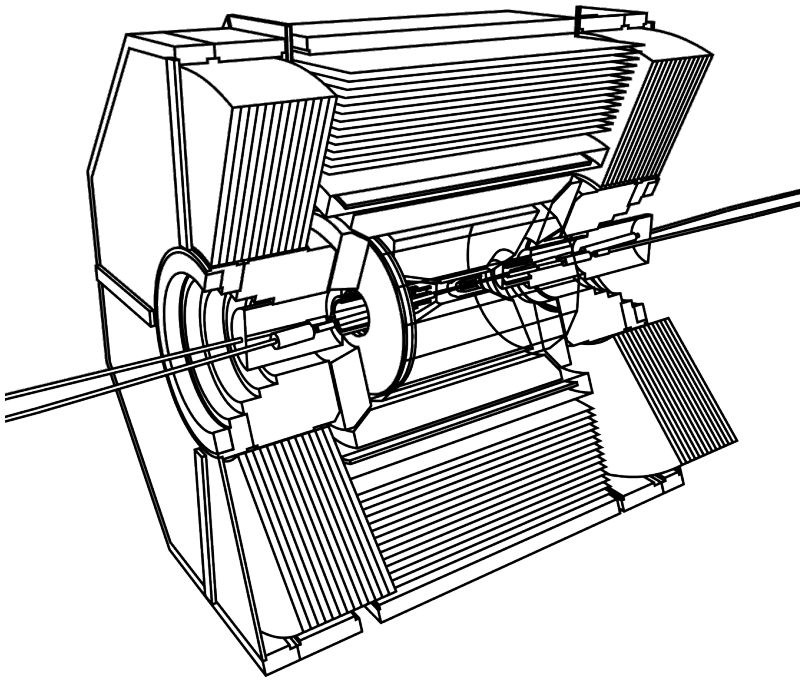

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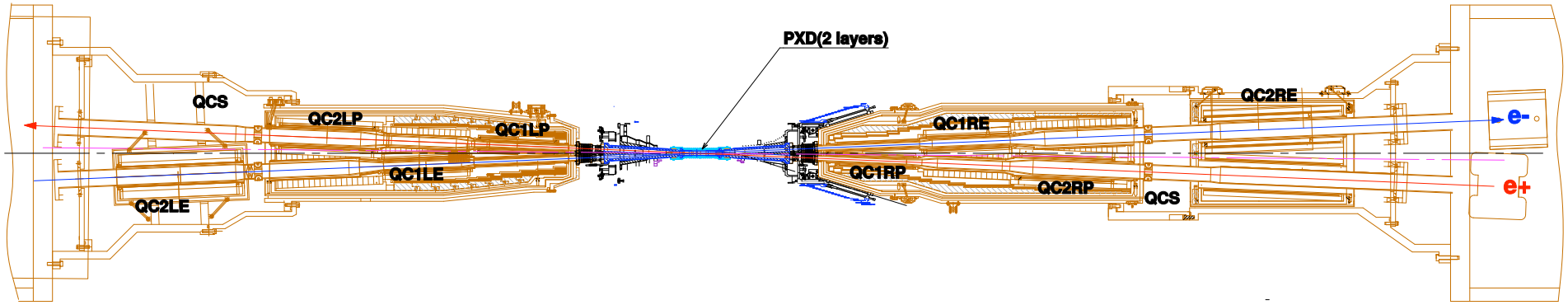
  - Precision measurements that may show deviations from the standard model.
  - Rare or forbidden (by the standard model) decays.

Belle II



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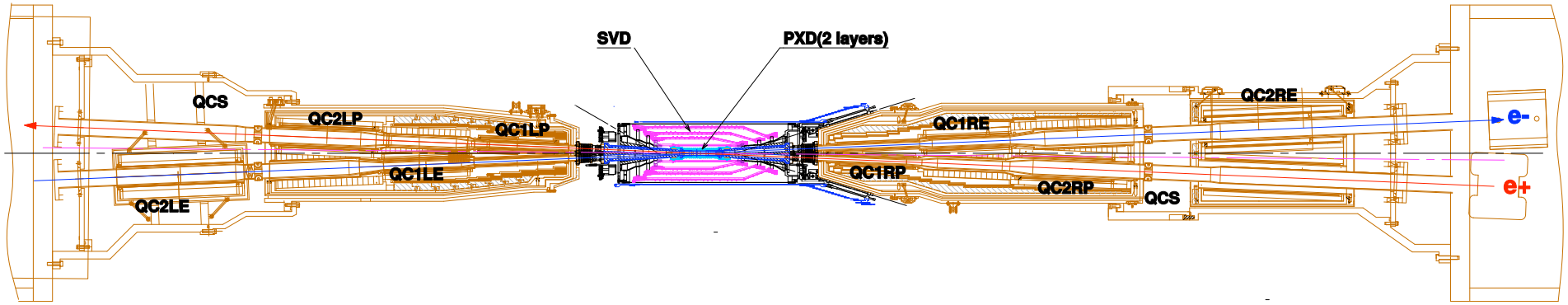
20110701 R5
20100808 R4
20100519 R3
20100330 R2
20100310 R1

DESIGNED	DRAWN	CHECKED		
Takashi Kohriki 20100215	Takashi Kohriki 20100215			
FINISH	ORIGINAL SCALE	SIZE	SHEET	REV.
CLEAN & DEGREASE REMOVE ALL BURRS	1/10	A1	of	R12
TITLE		DRAWING NO.		
Belle-II(Nano beam)				

Belle II



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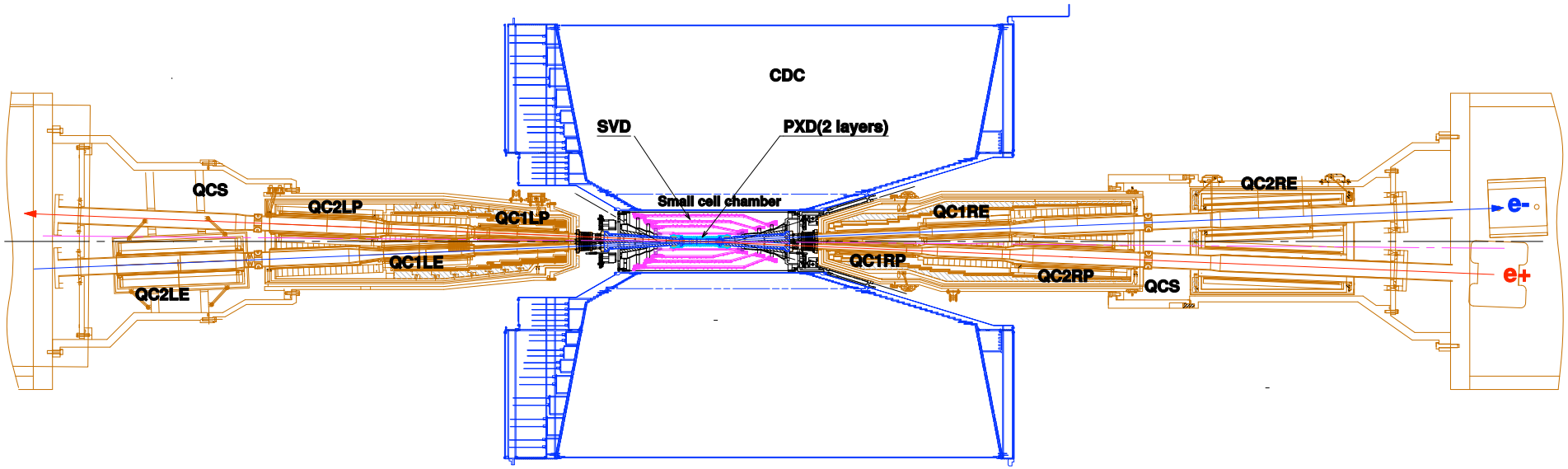
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SVD
PXD(2 layers)
Small cell chamber
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QC2LP
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QC1LE
QC2LE
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QC1RP
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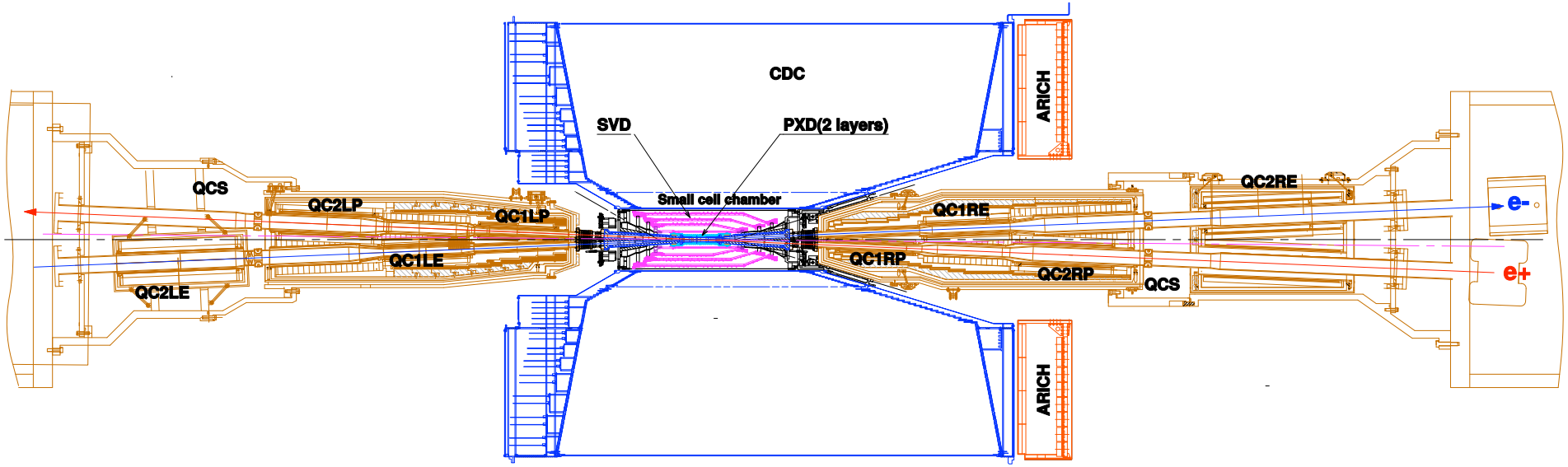
e+

Belle II


CDC
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Small cell chamber
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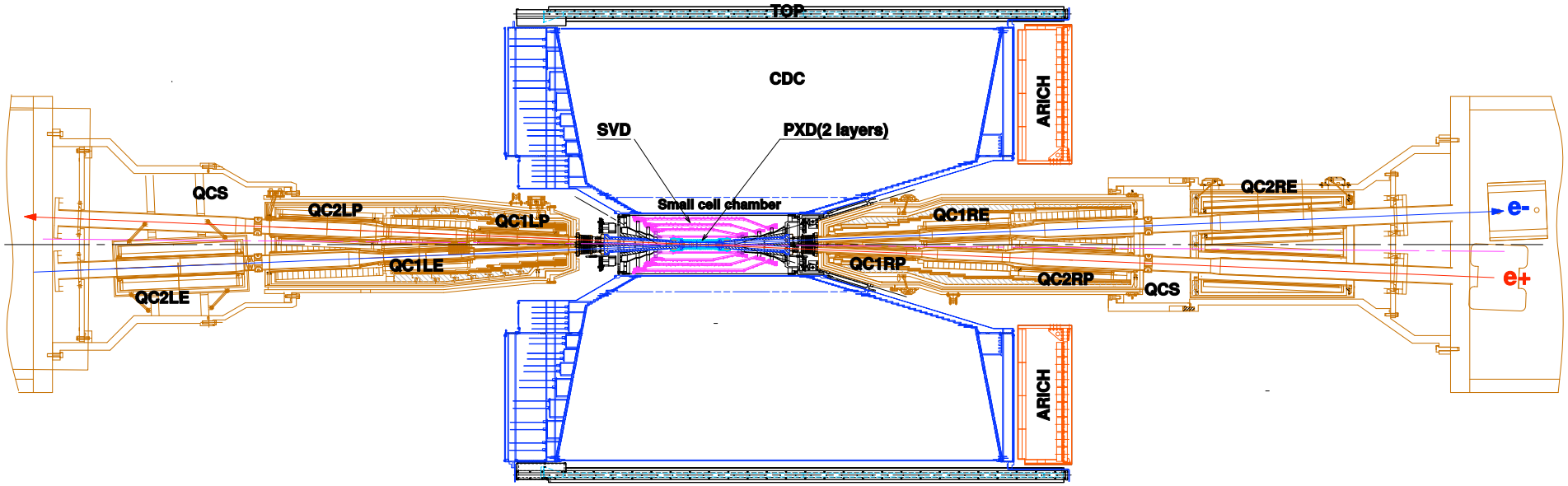

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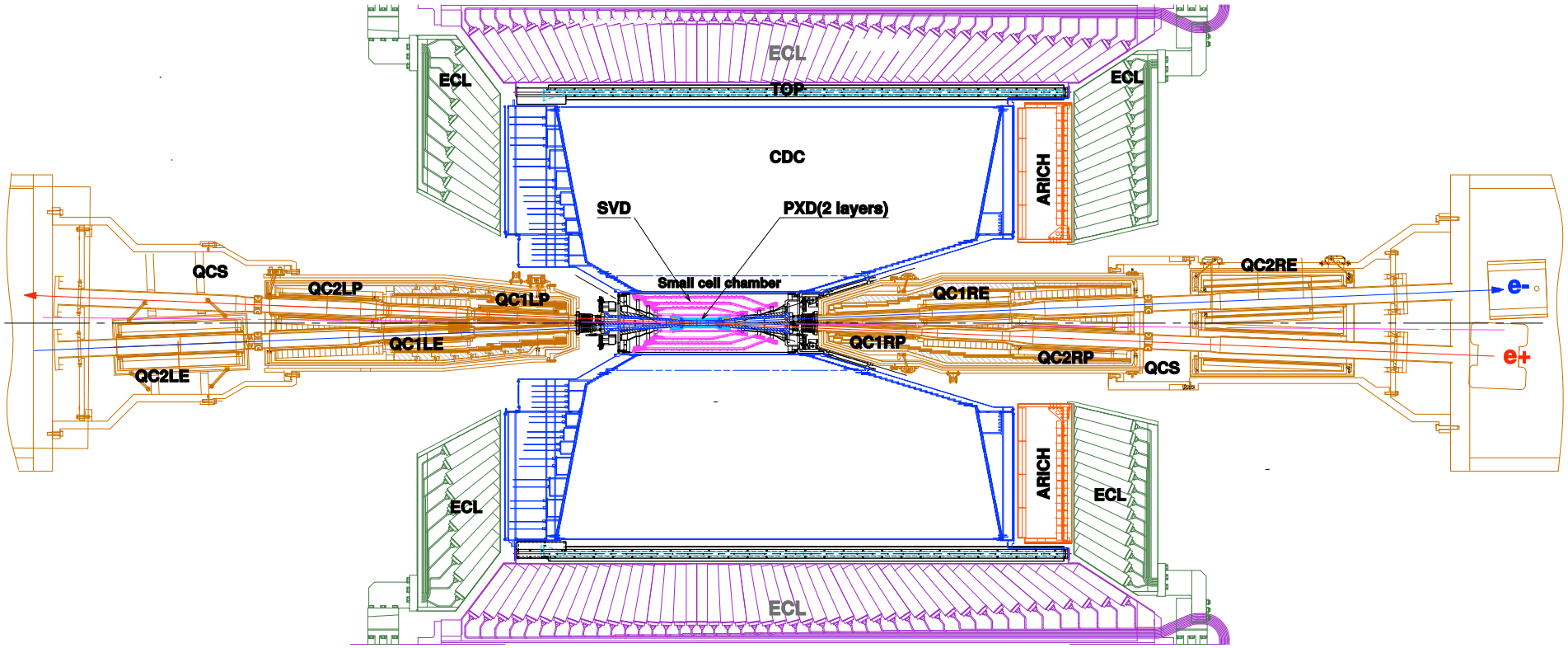
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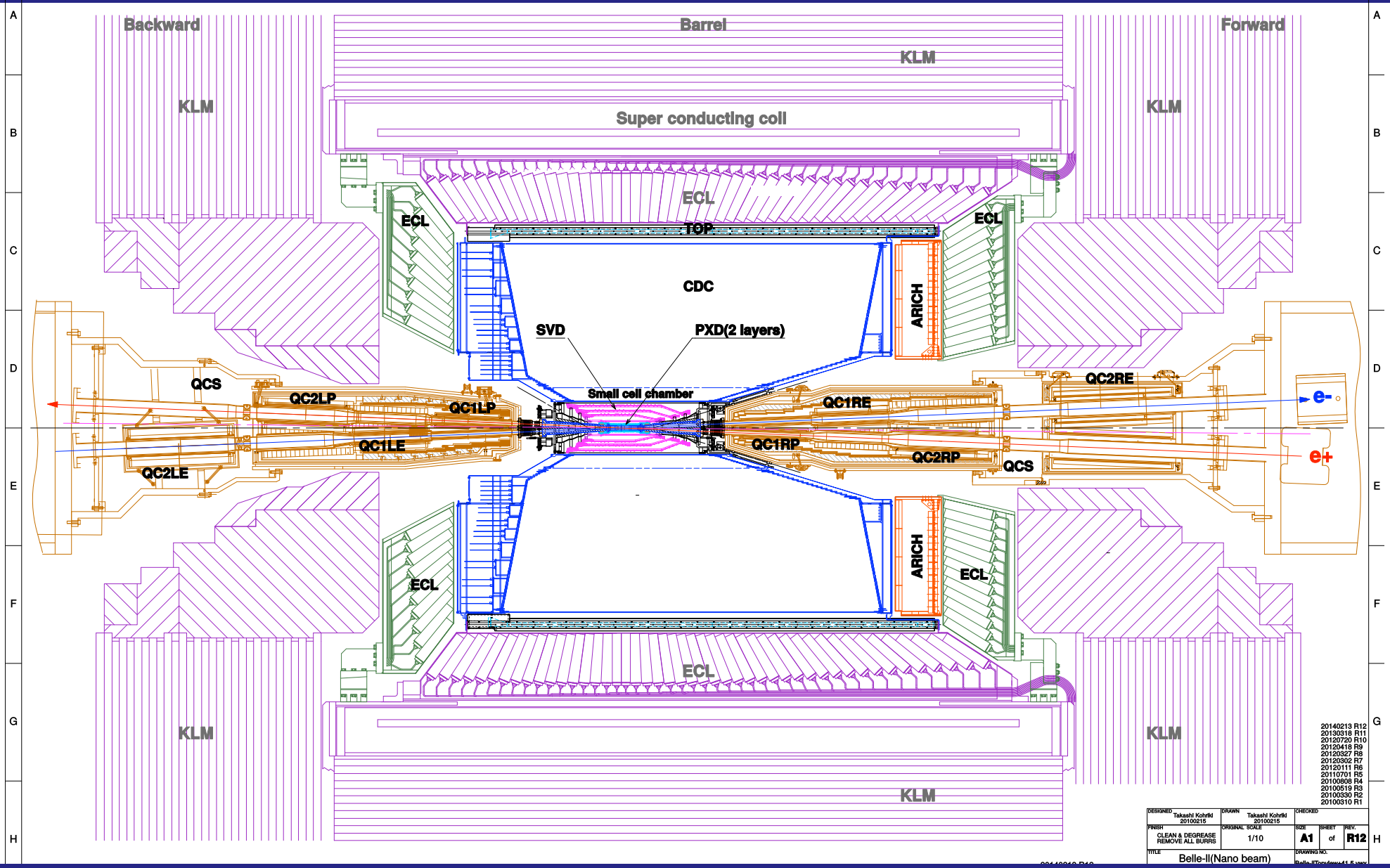
Backward
Barrel
Forward
KLM
KLM
KLM
Super conducting coil
ECL
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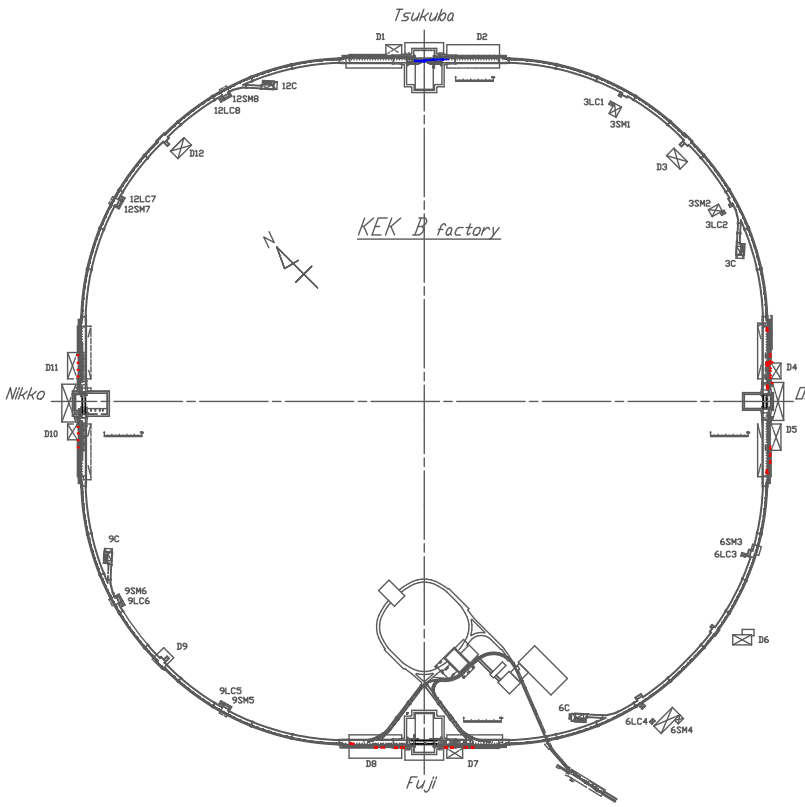

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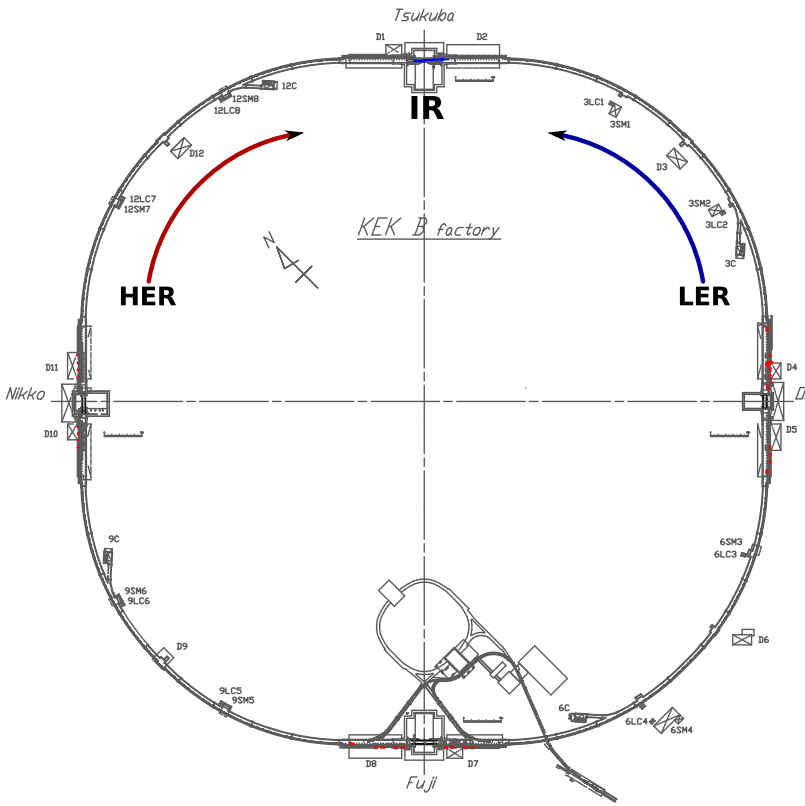

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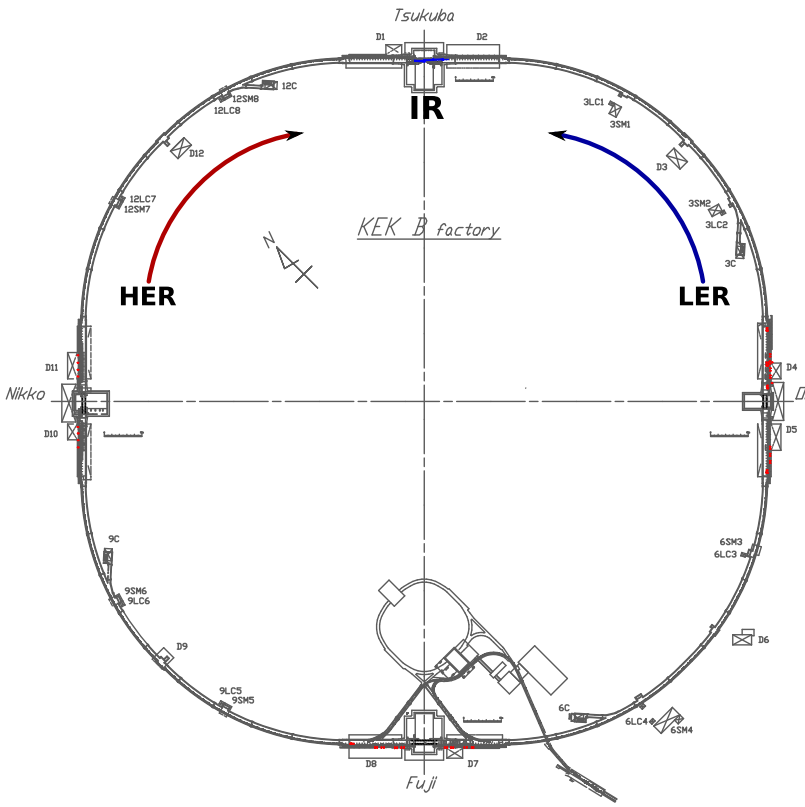
- SuperKEKB aims to achieve a luminosity of $80 \times 10^{34} cm^{-2} s^{-1}$, more than 40 times the luminosity of its predecessor, KEKB.



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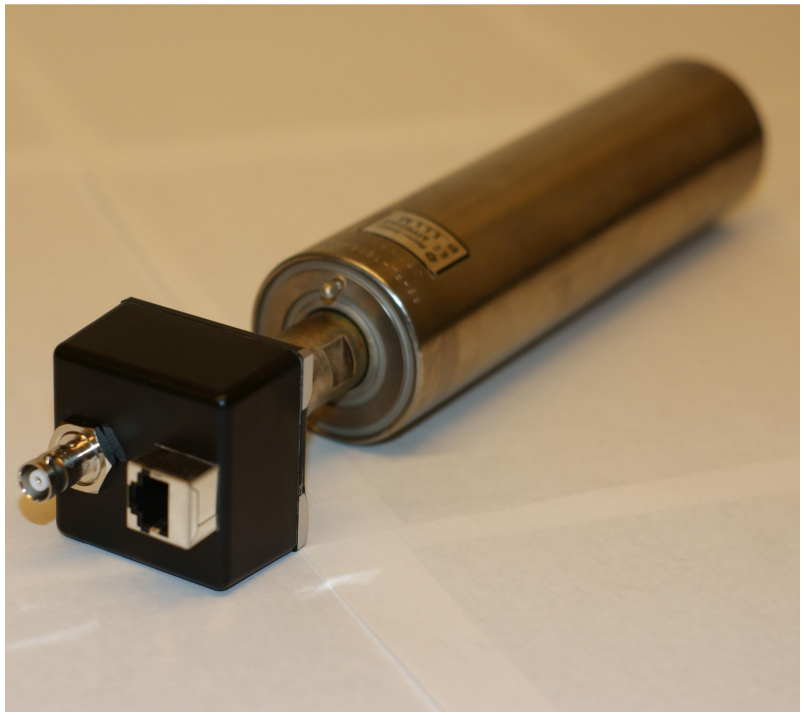
  - Beam-beam or Touschek - beam particles interact with other beam particles and are deflected out of the beam.

Helium-3 tubes

- One of UVic's contributions to BEAST II is the thermal neutron detectors.



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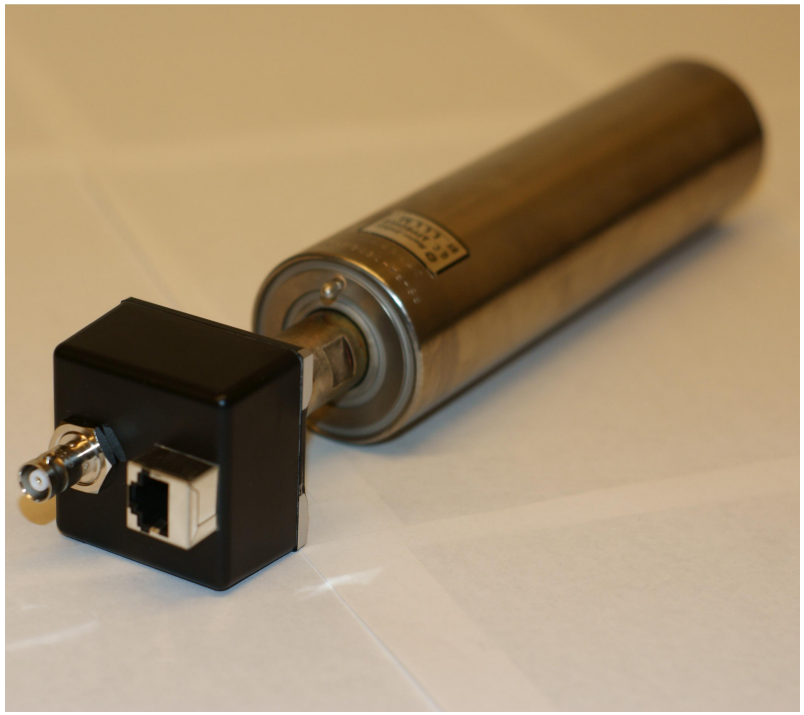

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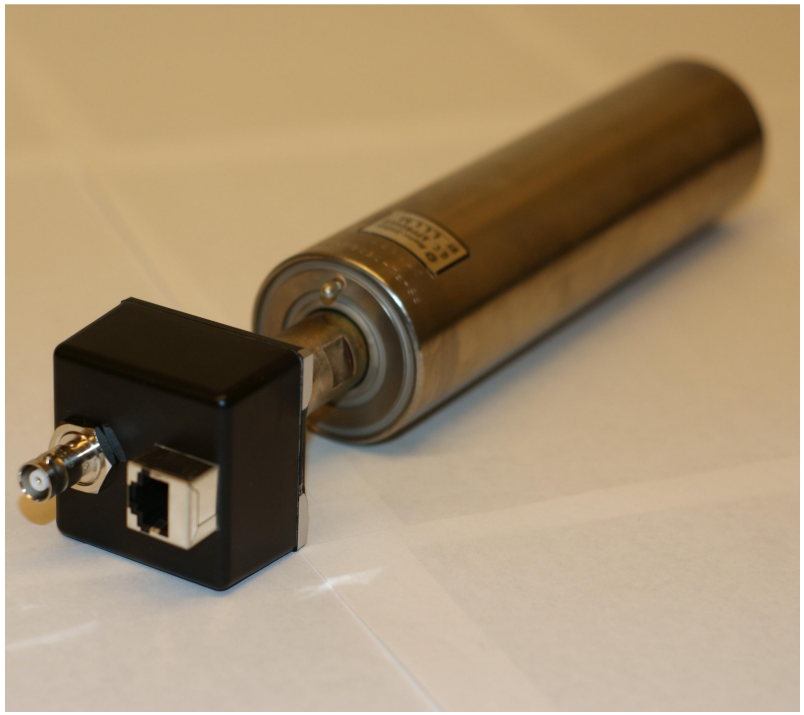

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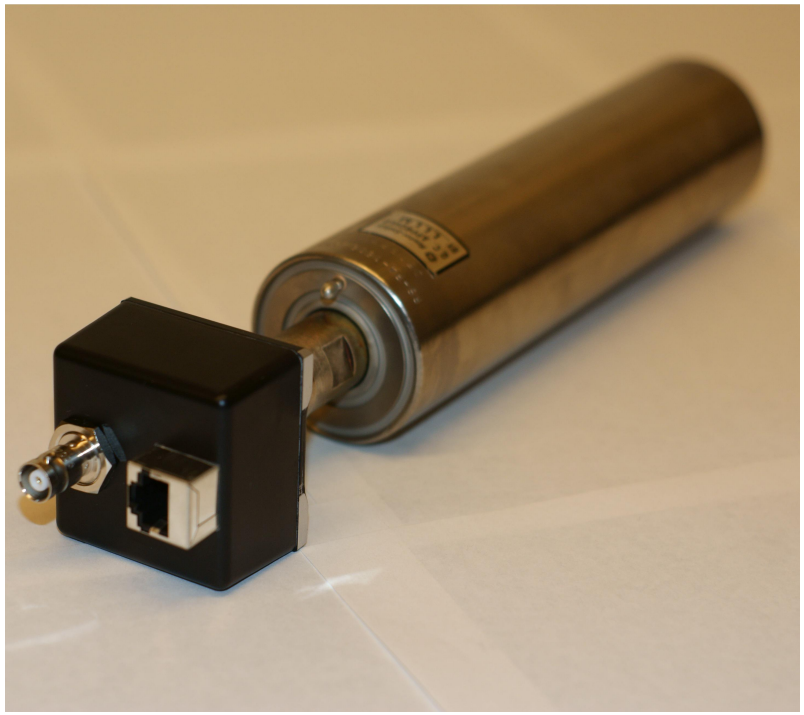
- The amplifier system was designed and built by UVic's electronics office.



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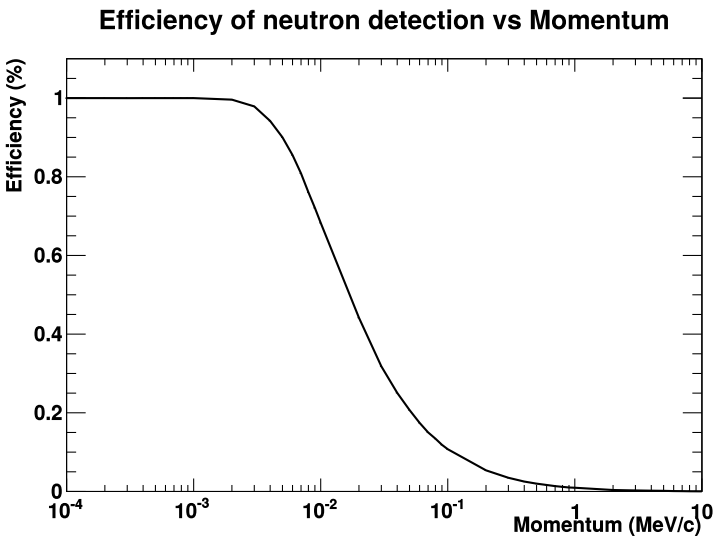

From GEANT4. Neutron starts at center of tube.

- When a thermal neutron interacts with an atom of ^{3}He, a proton and a tritium are created:
  - ${}^3_2He + {}^1_0 n \rightarrow {}^3_1 H + {}^1_1 H + 760 MeV$

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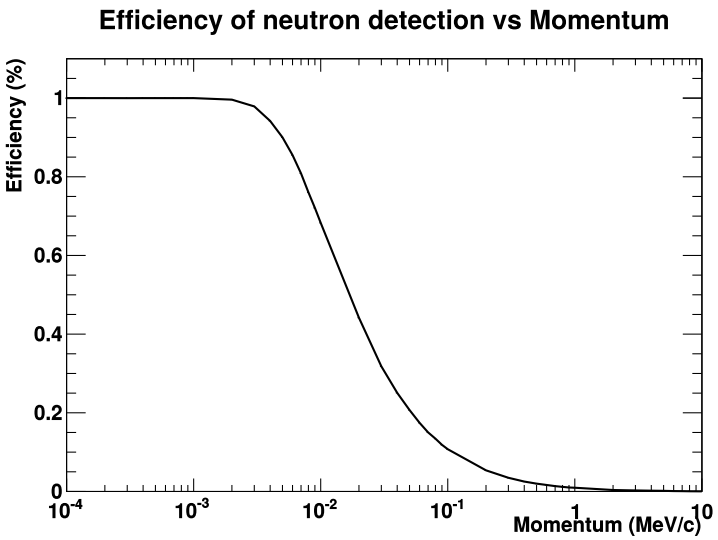

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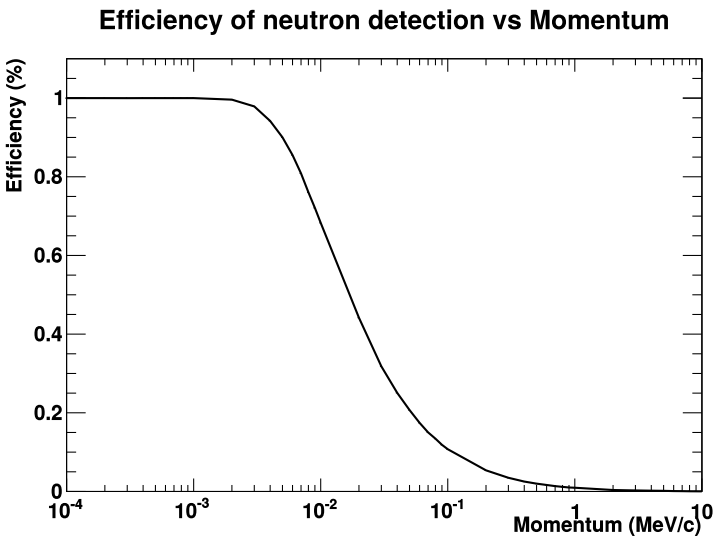

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- The cross section of this reaction falls rapidly as a function of the neutron's momentum.

Helium-3 tubes

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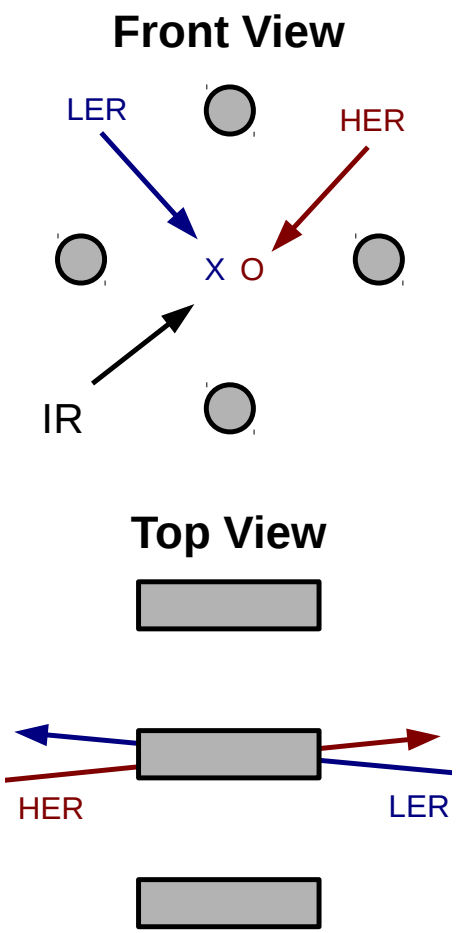

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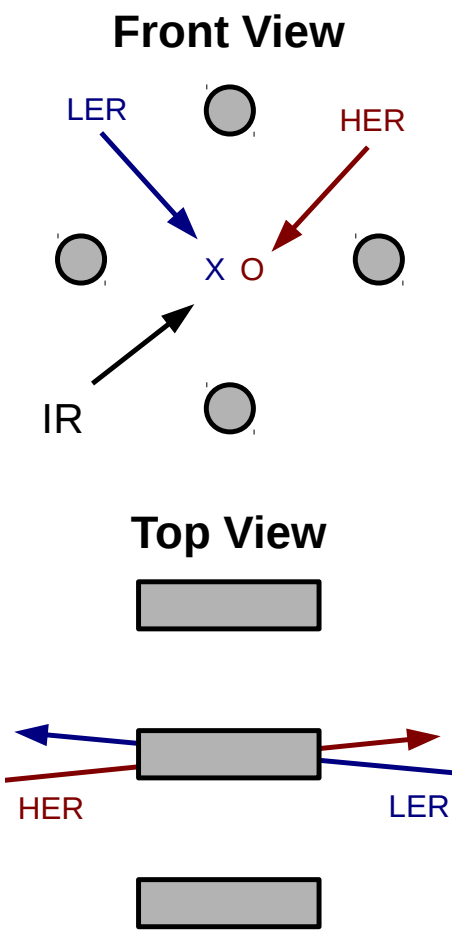

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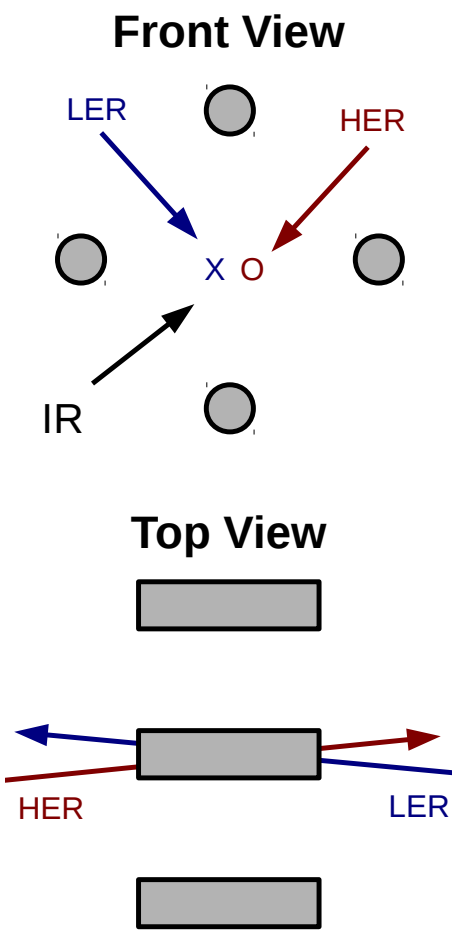

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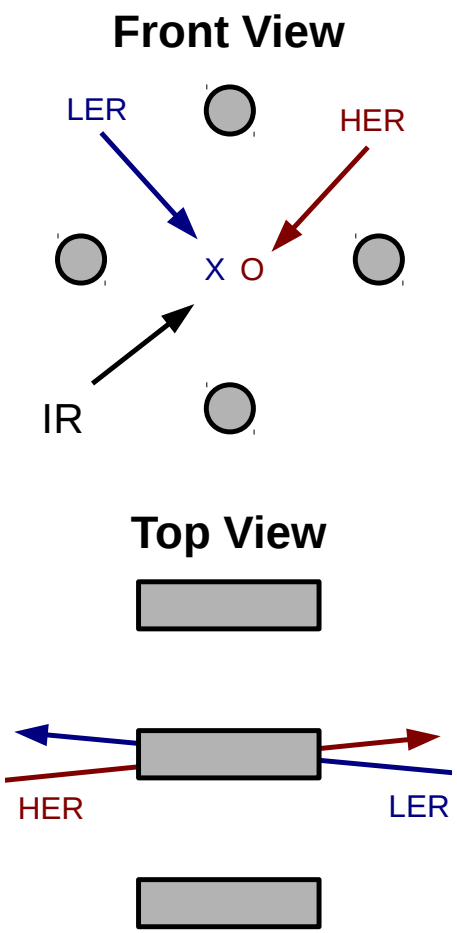

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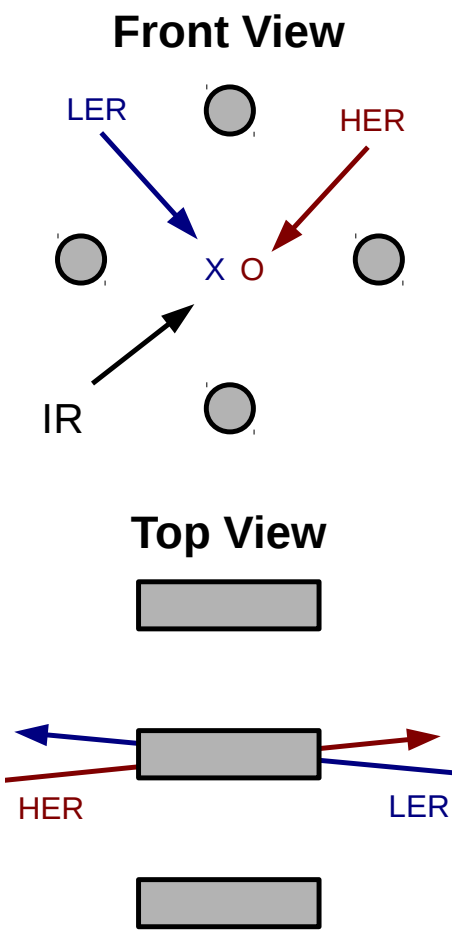

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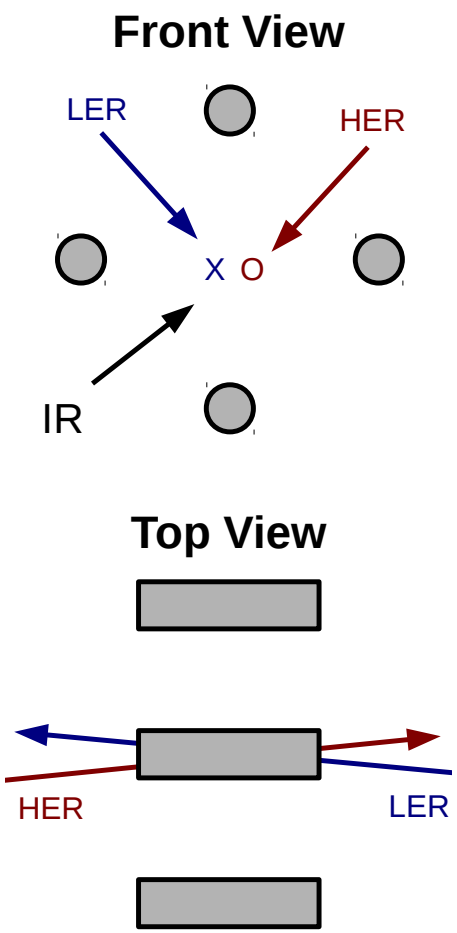
  - ϕ=180 (to the left)
  - ϕ=270 (below the beam pipe)



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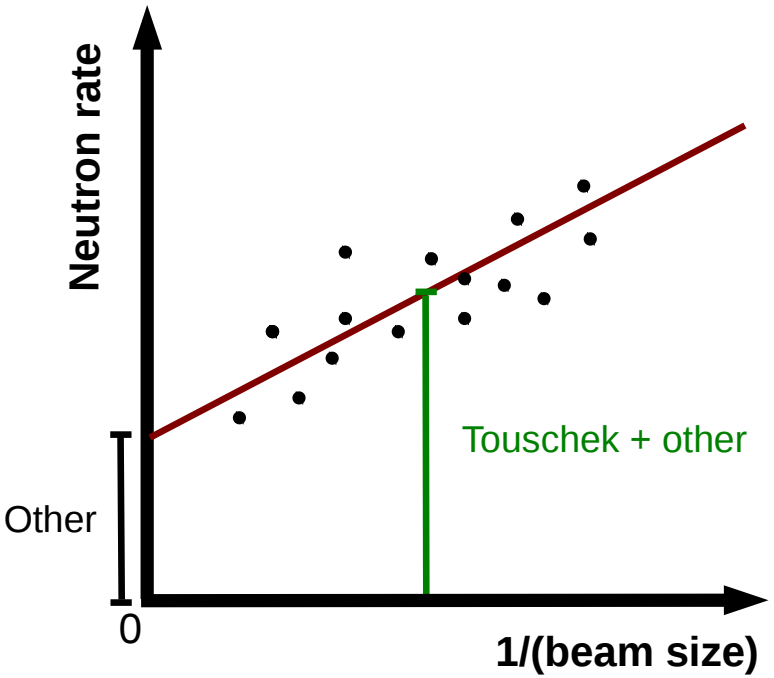
- The goal of these studies was to seek evidence of Touschek and beam gas beam backgrounds, and determine how large an effect they had.
- The ultimate goal is to compare these results with simulation in order to verify the accuracy of the simulation.

Beam size studies



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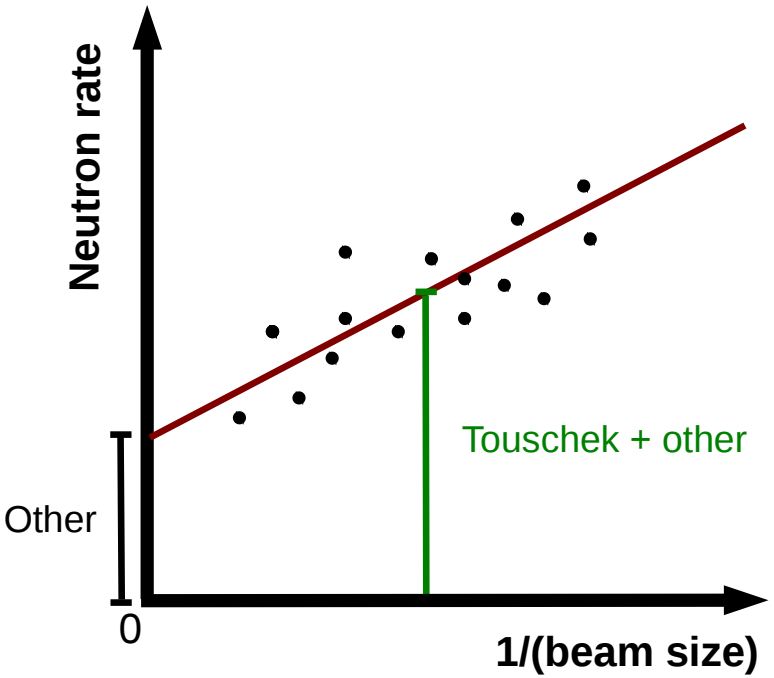

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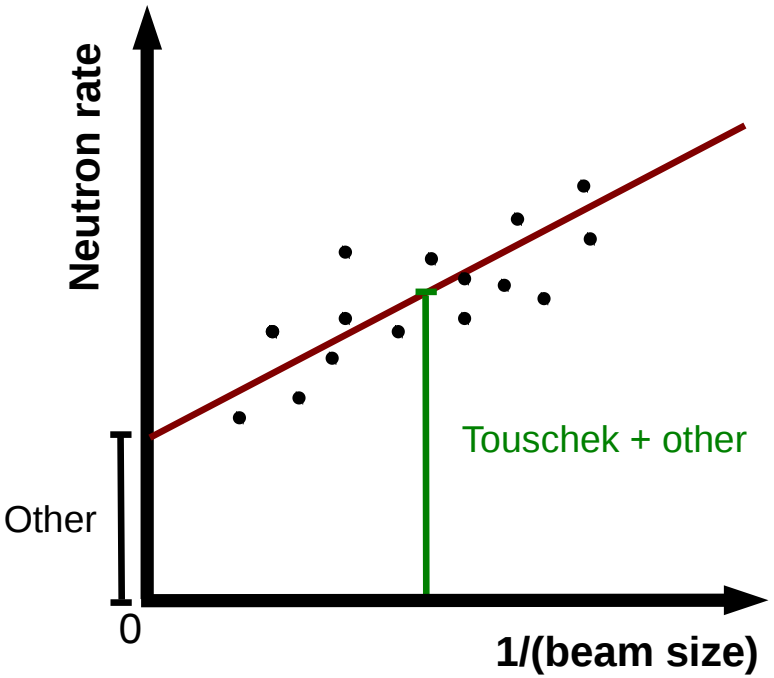
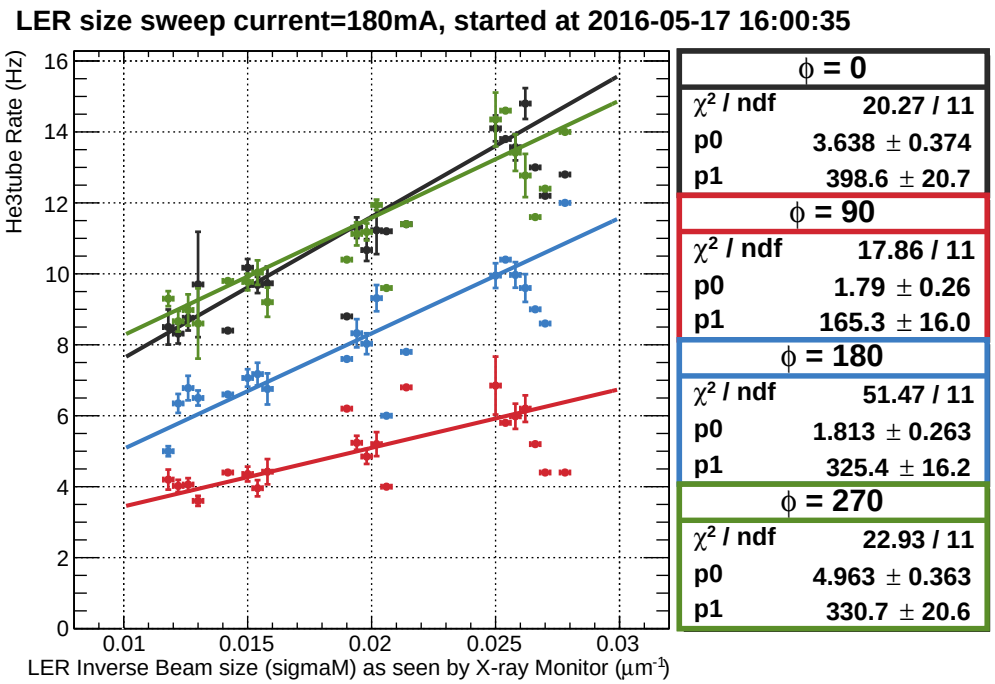
- When the beam size is infinite, there is no Touschek contribution.

Beam size studies



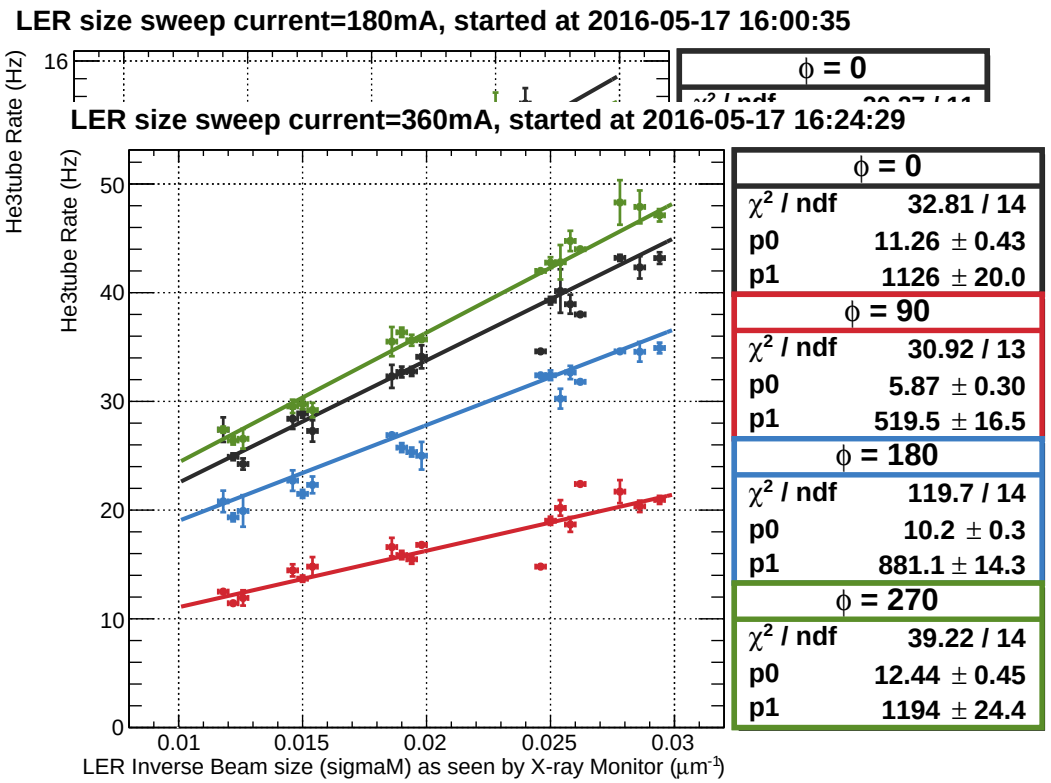
- Touschek beam losses are proportional to the inverse of the beam size.
- When the beam size is infinite, there is no Touschek contribution.
- By plotting the rate in the helium-3 tubes vs the inverse of the beam size, it is possible to calculate the Touschek contribution for a given beam size and beam current.

LER beam size study



- There is clear evidence of the Touschek effect.
- As the beam size decreases, the rate clearly increases.

LER beam size study



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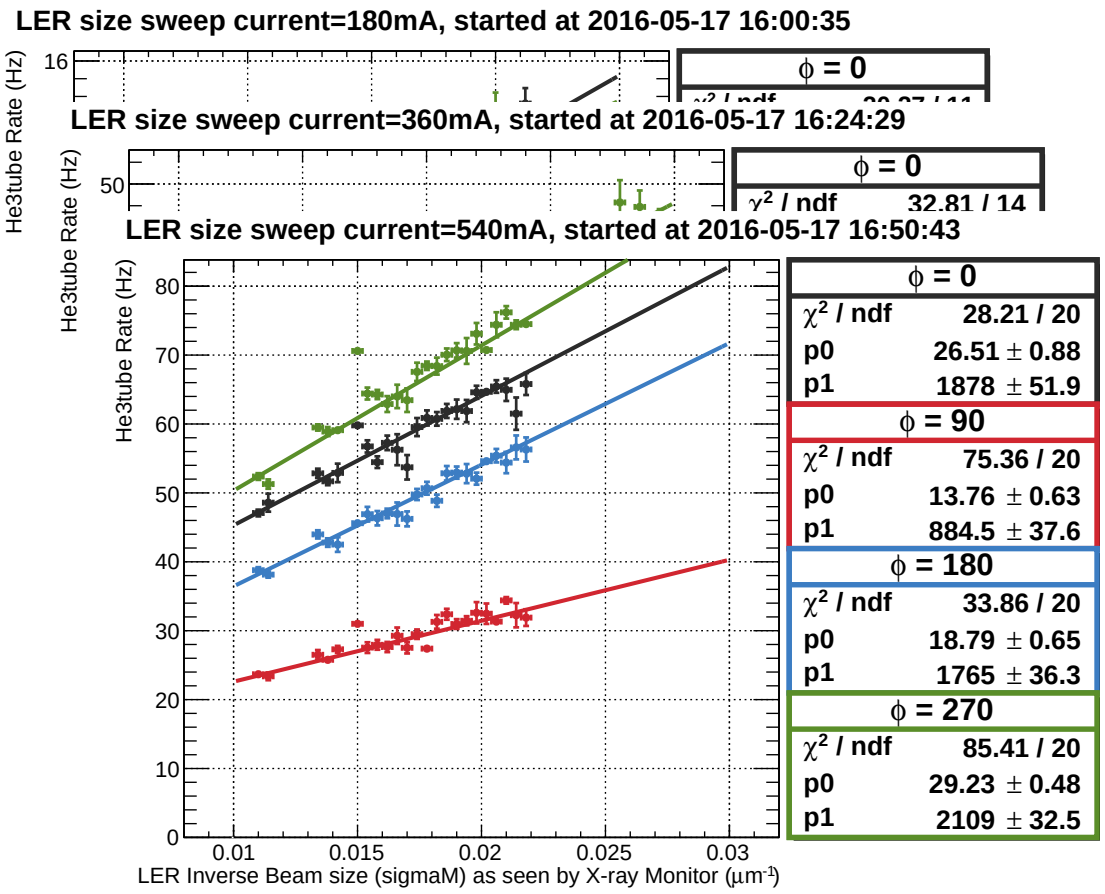
LER beam size study



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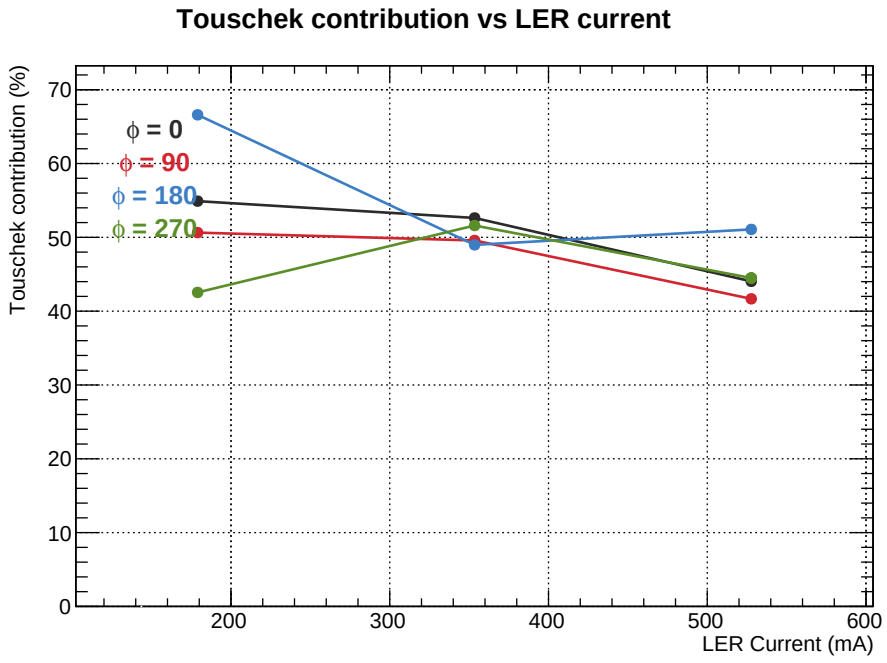
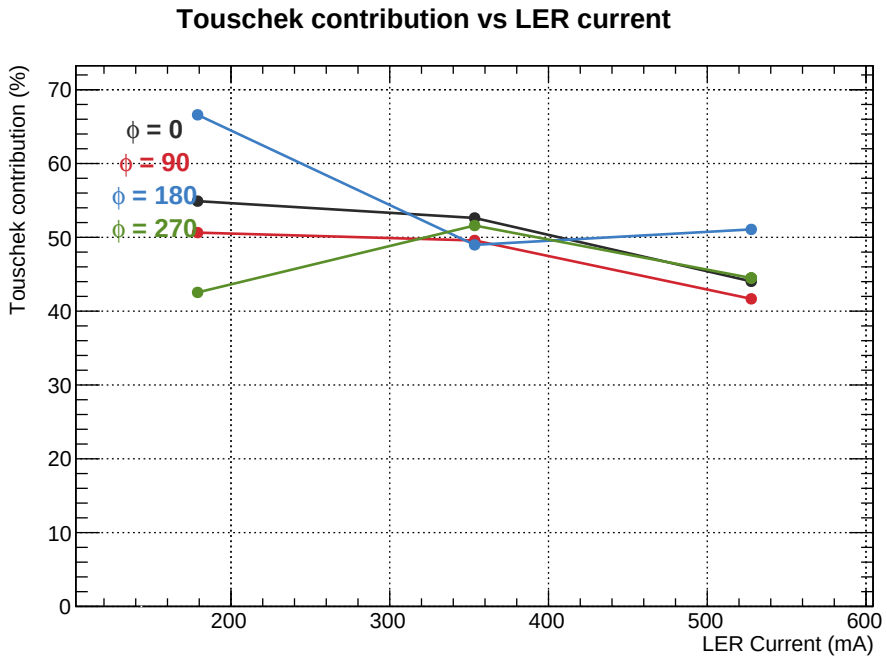
LER beam size study - conclusions



- Plotted here is Touschek/(Touschek+Other) at a beam size of 90μm calculated using fit information.

LER beam size study - conclusions



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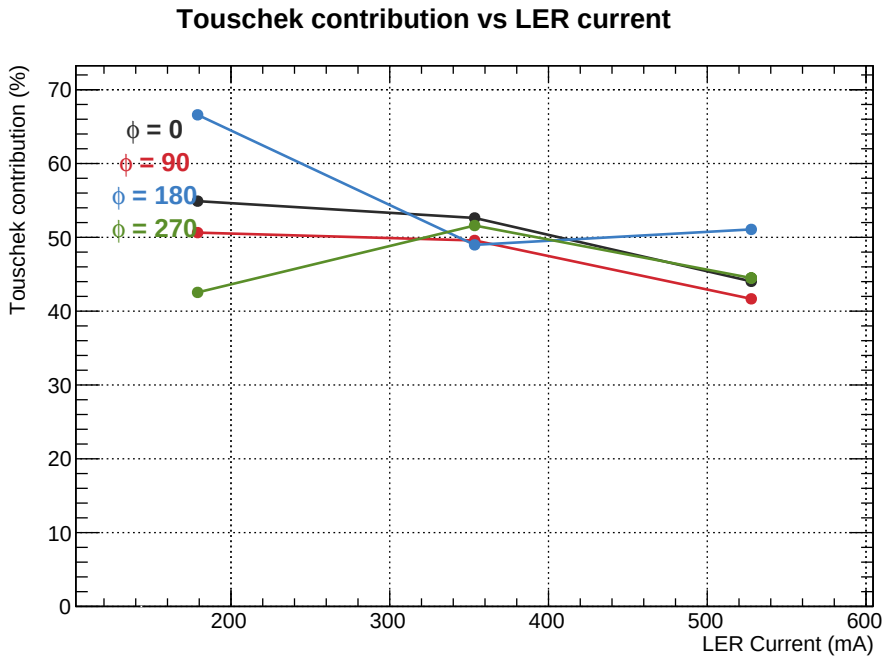
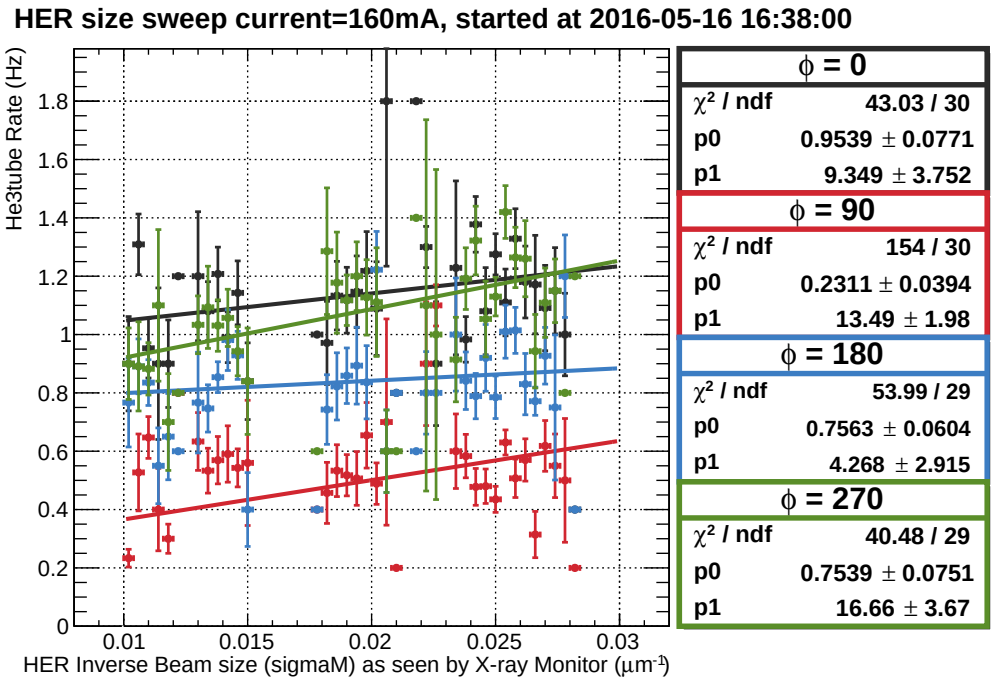
LER beam size study - conclusions



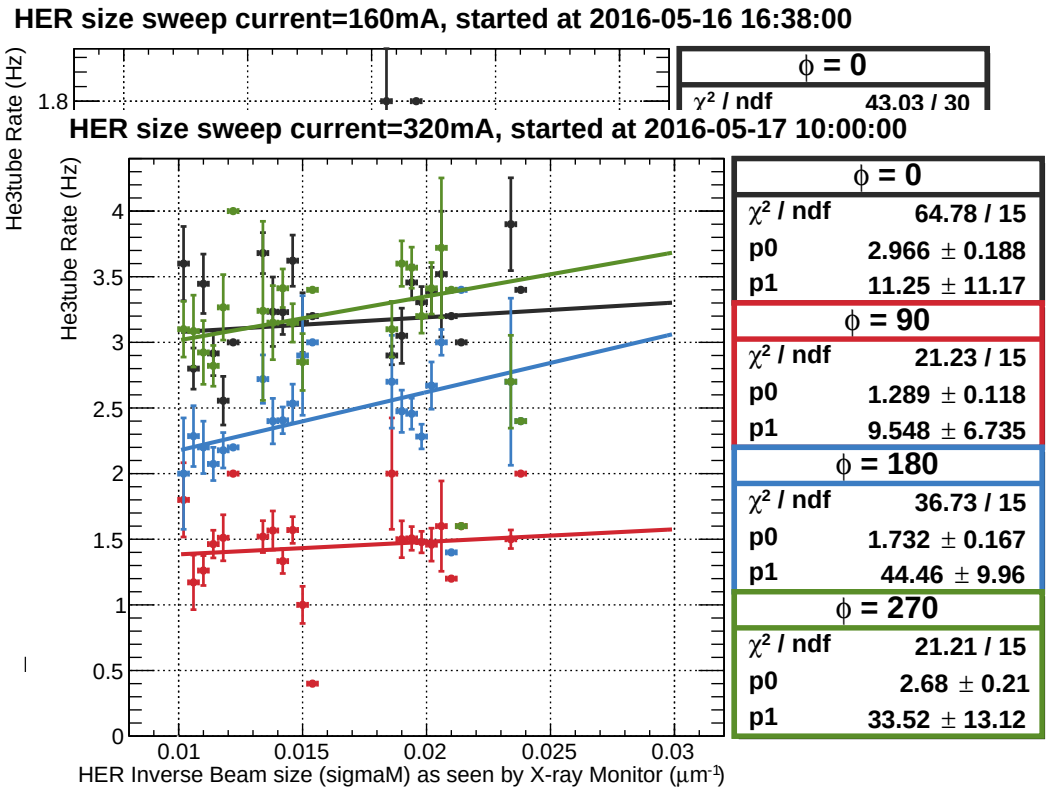
- Plotted here is Touschek/(Touschek+Other) at a beam size of 90μm calculated using fit information.
- Touschek contribution in LER appears to be constant at about 60%.

HER beam size study



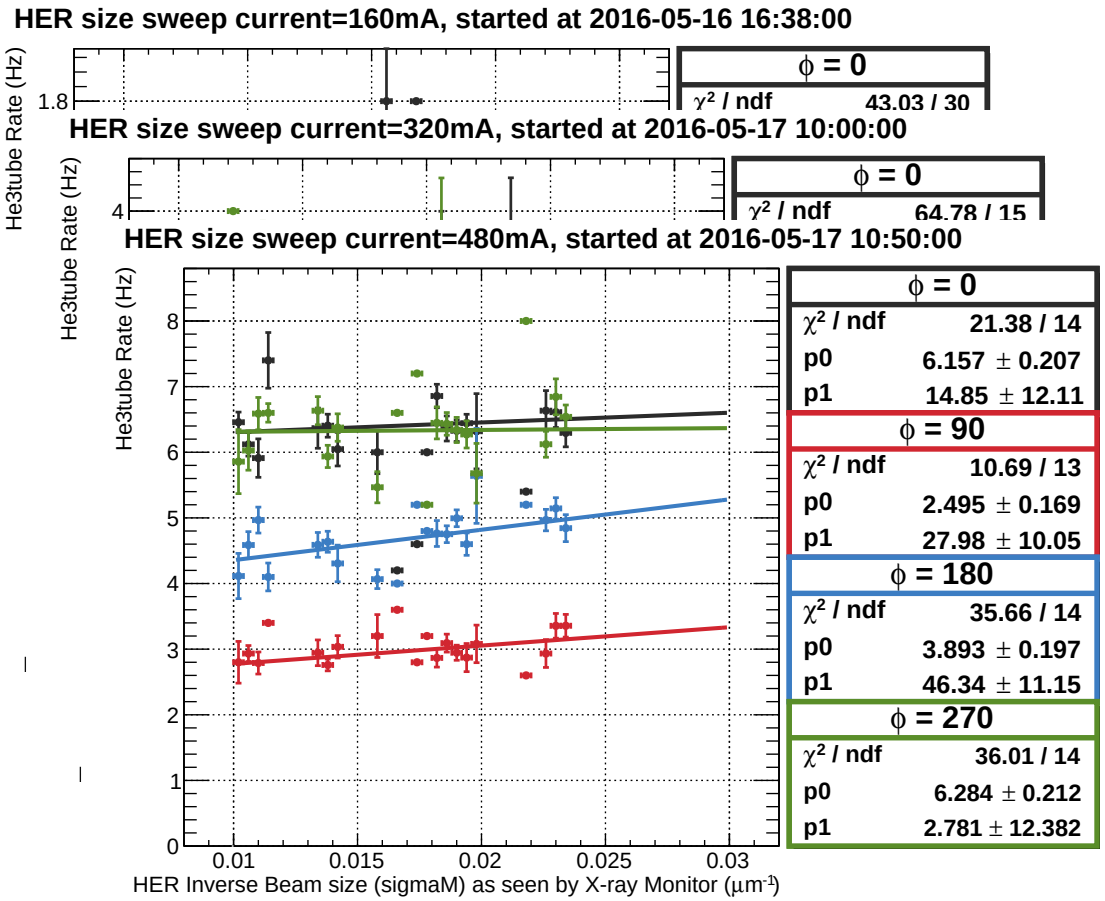
- The HER beam is older, and better vacuum scrubbed, and produces a lower rate in the tubes.

HER beam size study



- The HER beam is older, and better vacuum scrubbed, and produces a lower rate in the tubes.
- Thus, the statistics are poor for the HER runs.

HER beam size study



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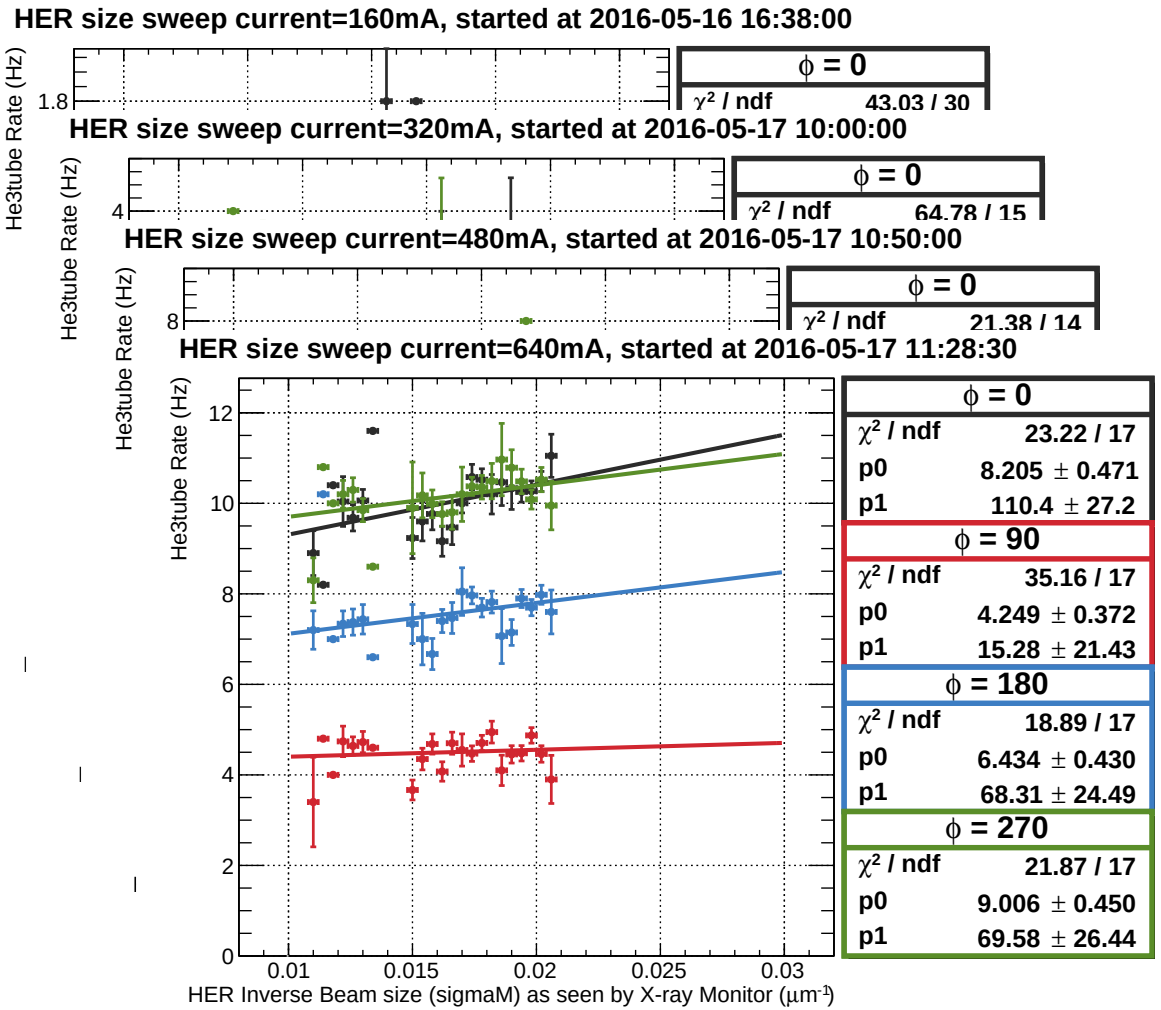
- This is reflected in the quality of the fits.

HER beam size study



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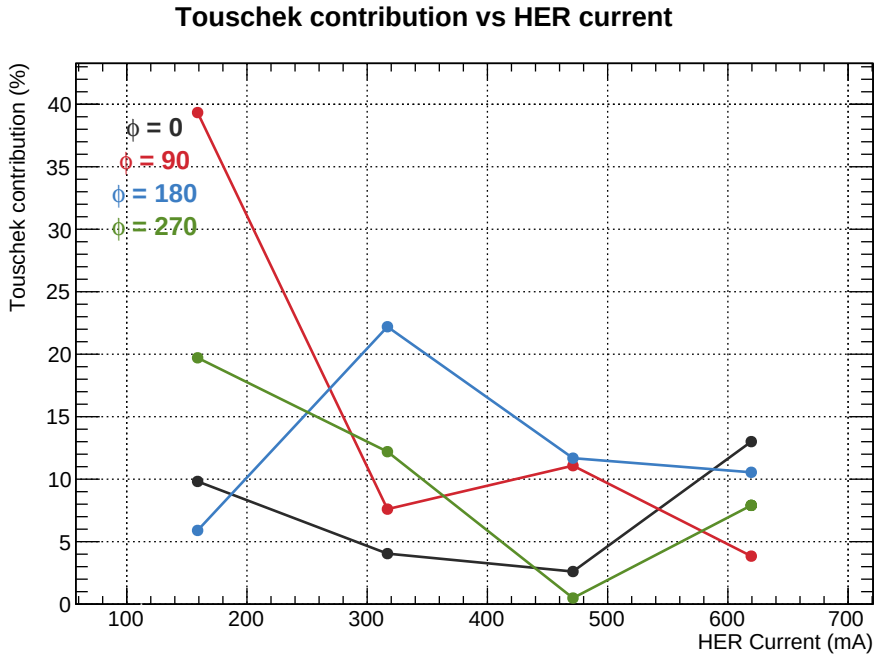
HER beam size study - conclusions



- If we believe the fit data, there is clear evidence of Touschek.
- The Touschek contribution is about 5-20%

- During the vacuum bump studies, the pressure was in the beam pipe was increased at several locations.

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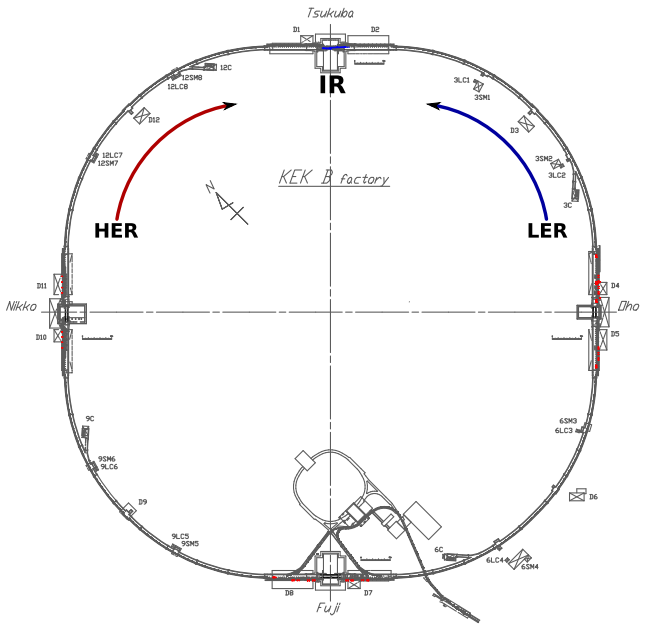
  - Coulomb scattering: beam particles deflect off atoms of gas in the beam pipe have no angular dependence.
  - Bremsstrahlung: beam particles are slowed down by gas atoms has an angular dependence.
- To make any angular effect more pronounced, the rate in each tube was divided by the average rate in that tube for that run.

- Vacuum bump occurred at several different locations along the LER beam:



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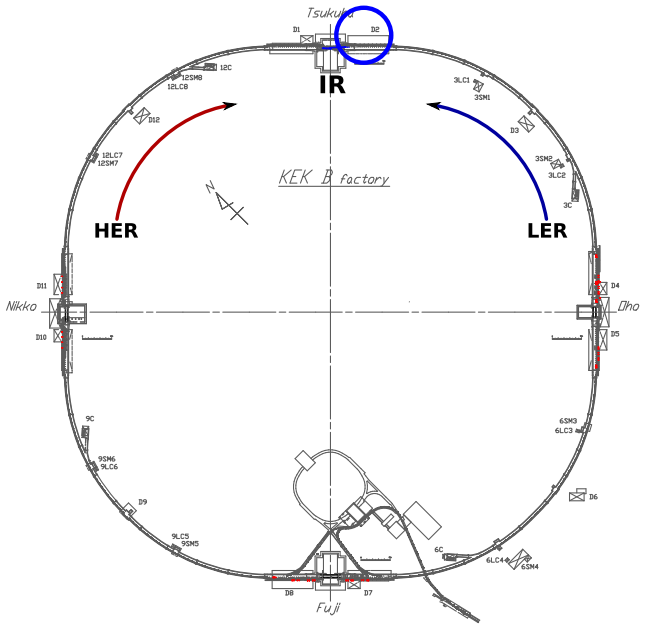
  - D02: L25, L26



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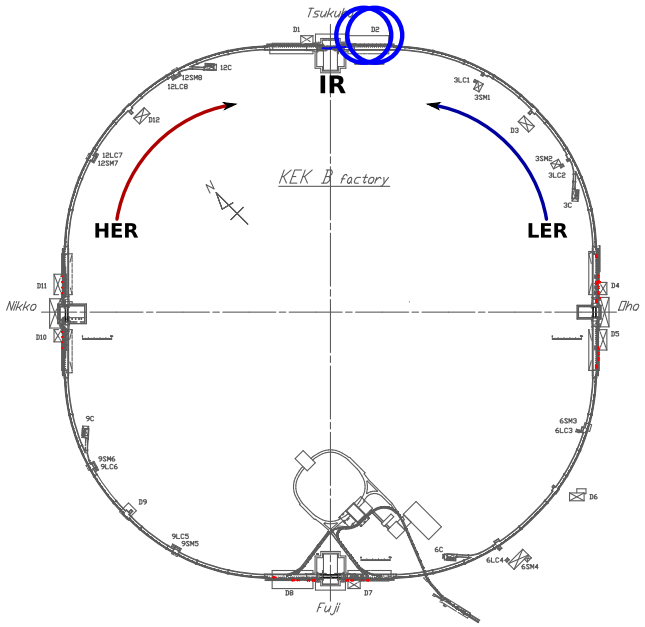

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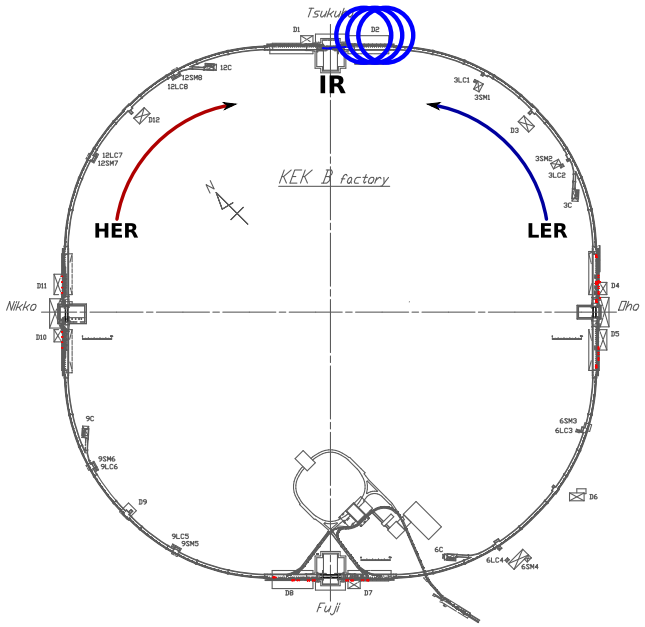

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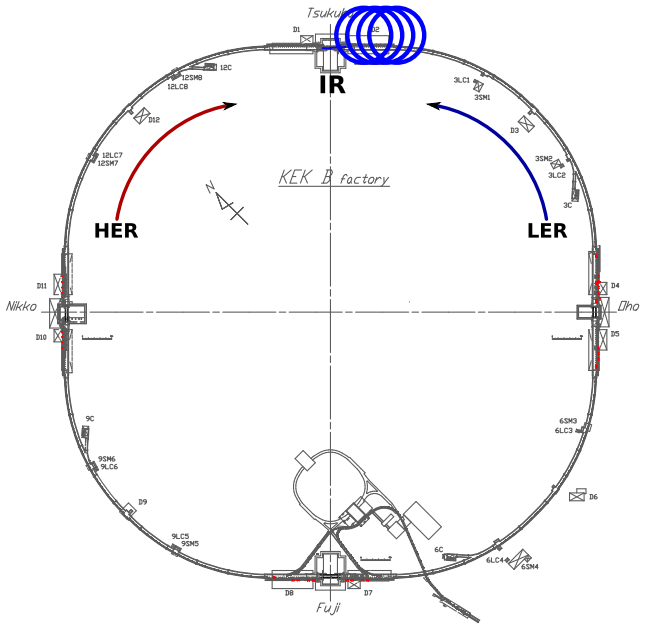

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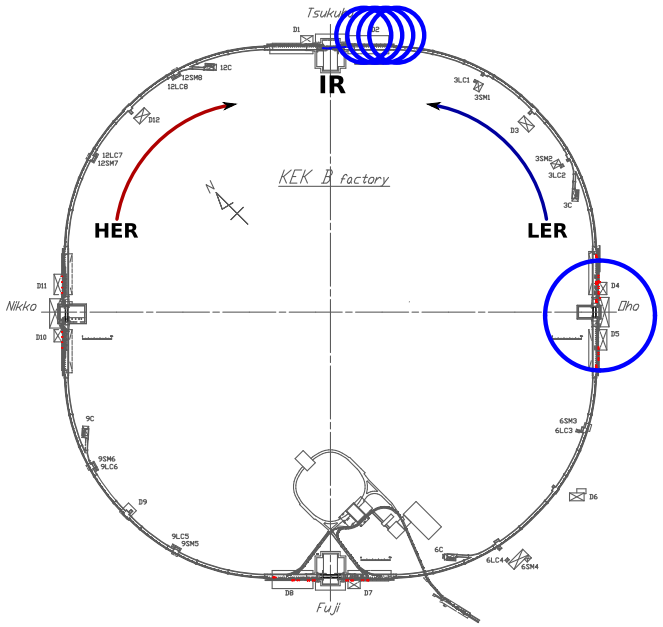
  - D02: L18, L19, L20
  - D04, D05



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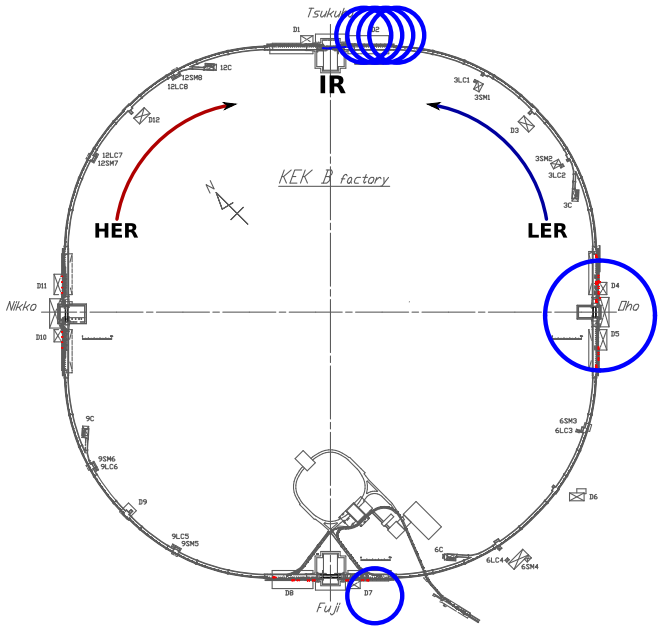
  - D07



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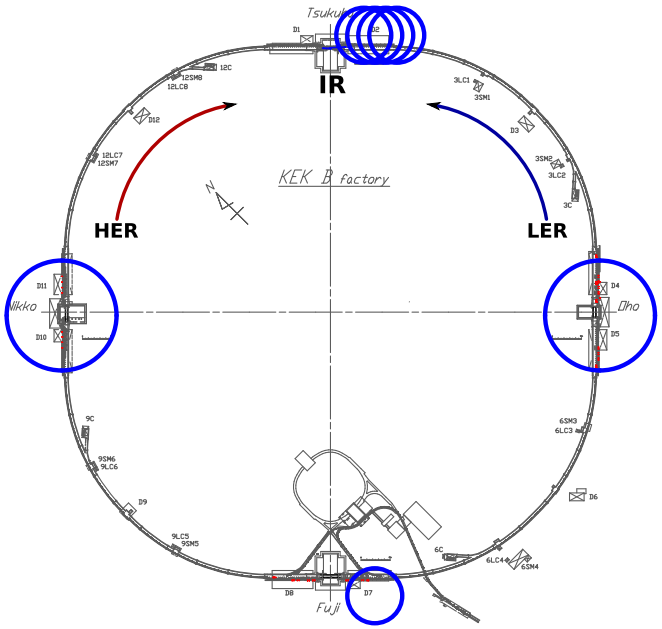
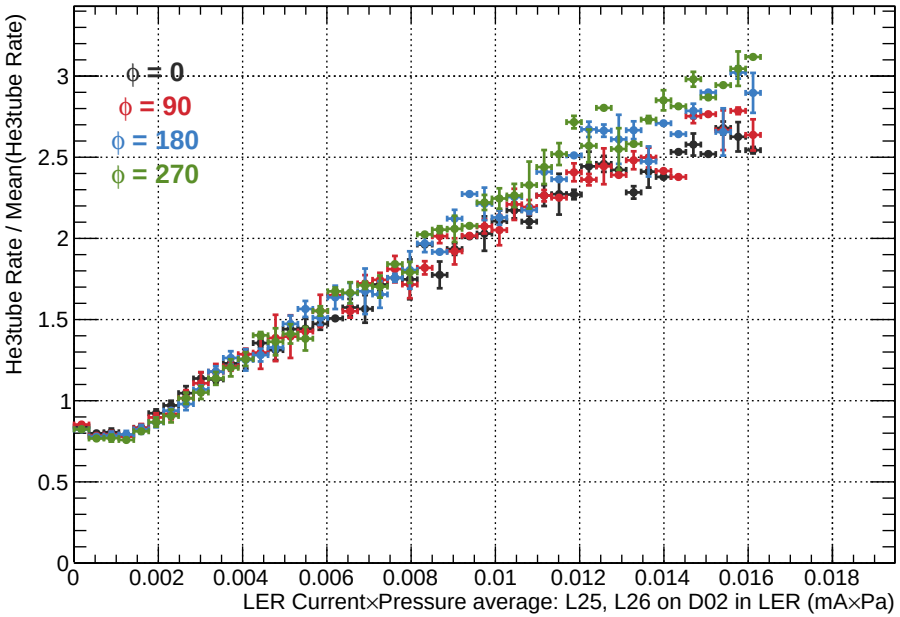
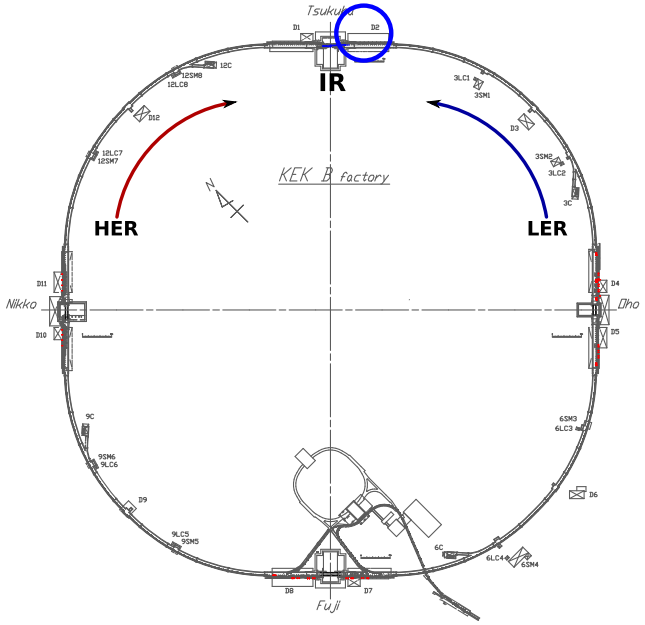
  - D10, D11



Low energy ring

LER Vacuum bump in D02 L25 & L26, started at 2016-05-23 10:28:00

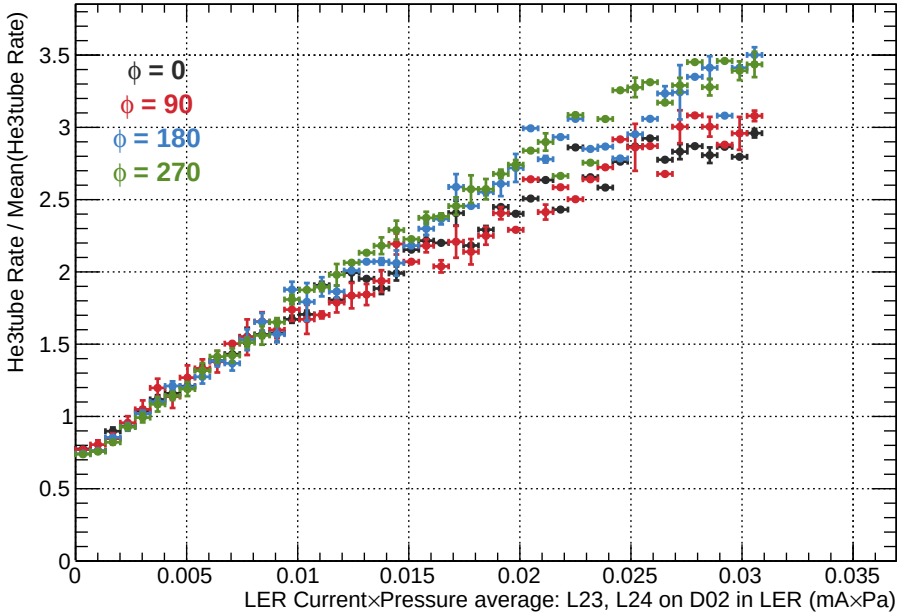


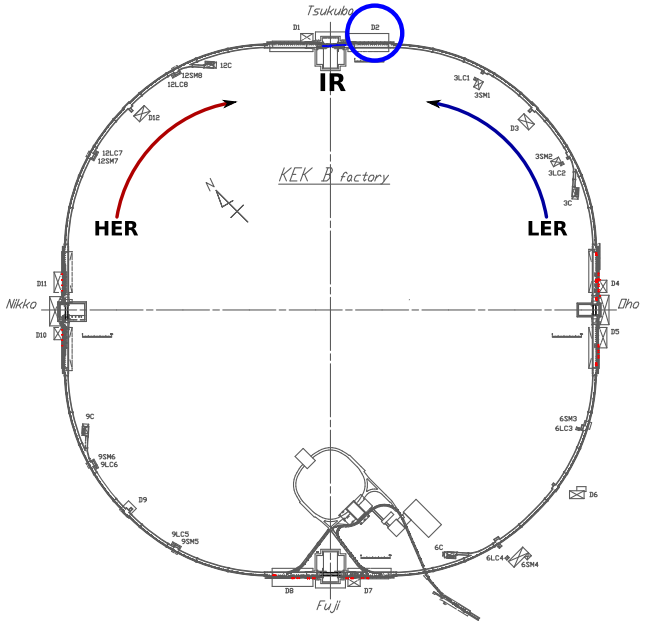


Low energy ring

LER Vacuum bump in D02 L25 & L26, started at 2016-05-23 10:28:00

LER Vacuum bump in D02 L23 & L24, started at 2016-05-23 11:30:00





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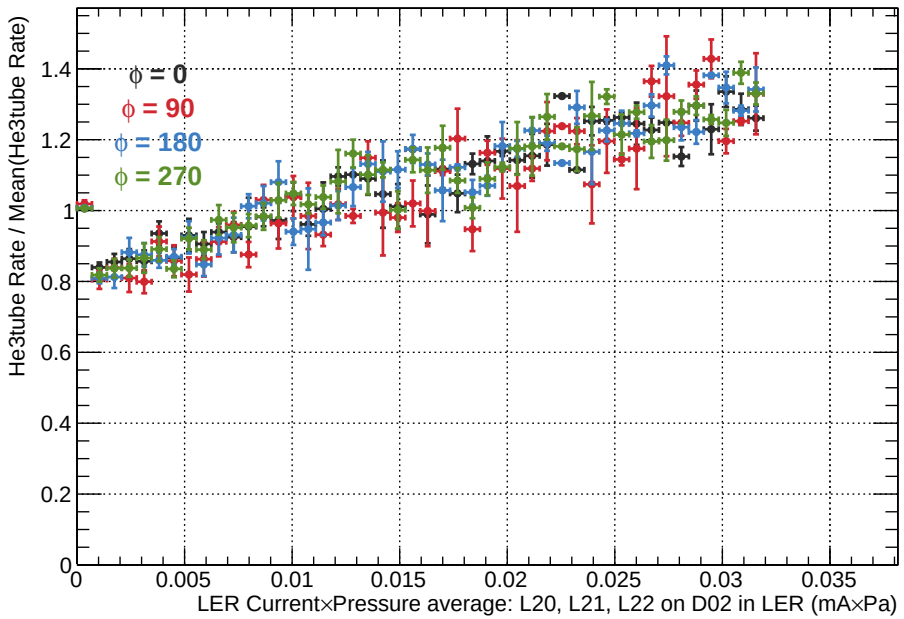
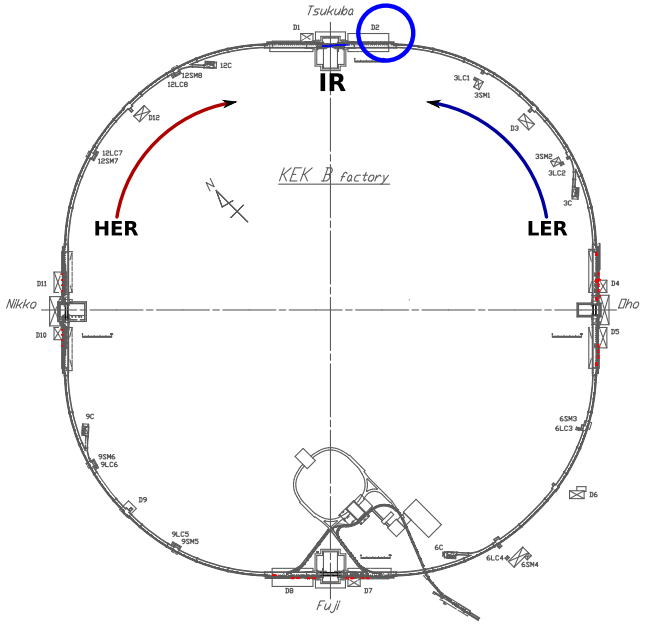
LER Vacuum bump in D02 L23 & L24, started at 2016-05-23 11:30:00

LER Vacuum bump in D02 L20, L21 & L22, started at 2016-05-23 12:36:00





Low energy ring

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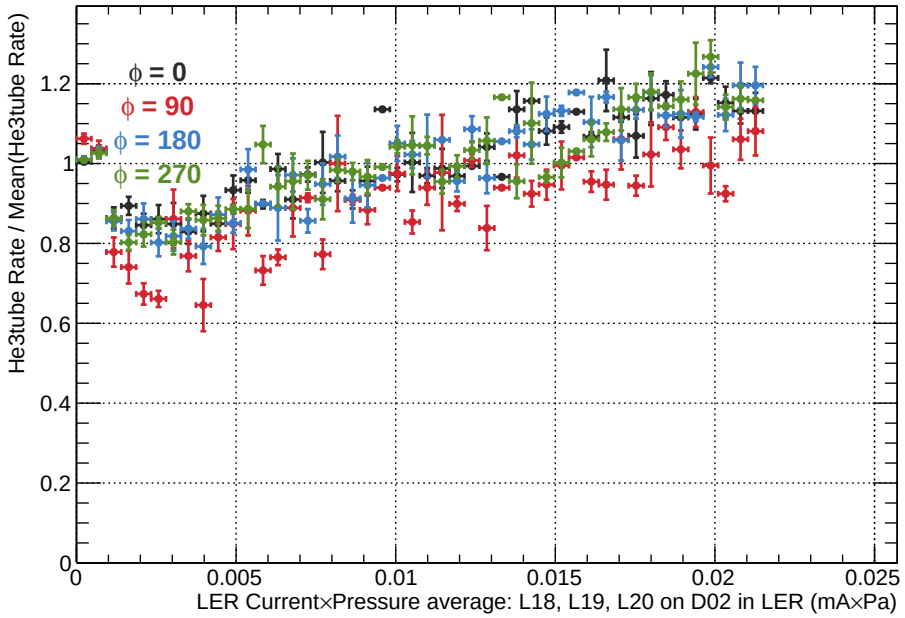
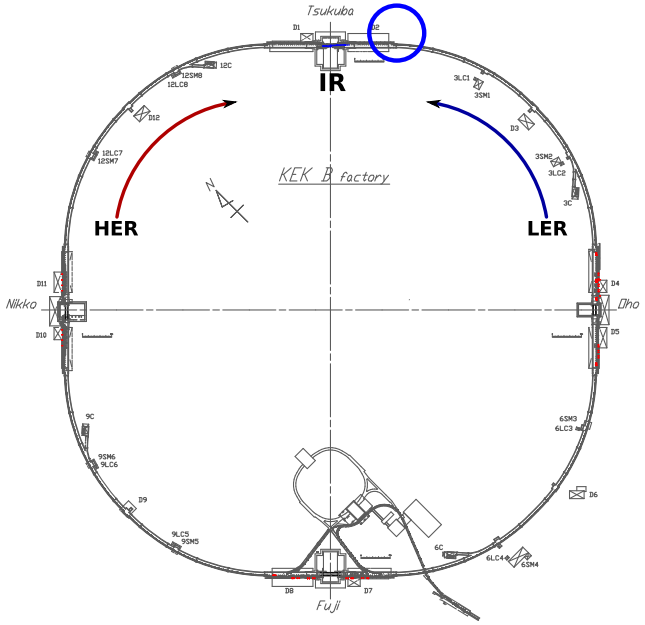
LER Vacuum bump in D02 L20, L21 & L22, started at 2016-05-23 12:36:00

LER Vacuum bump in D02 L18, L19 & L20, started at 2016-05-23 13:55:00





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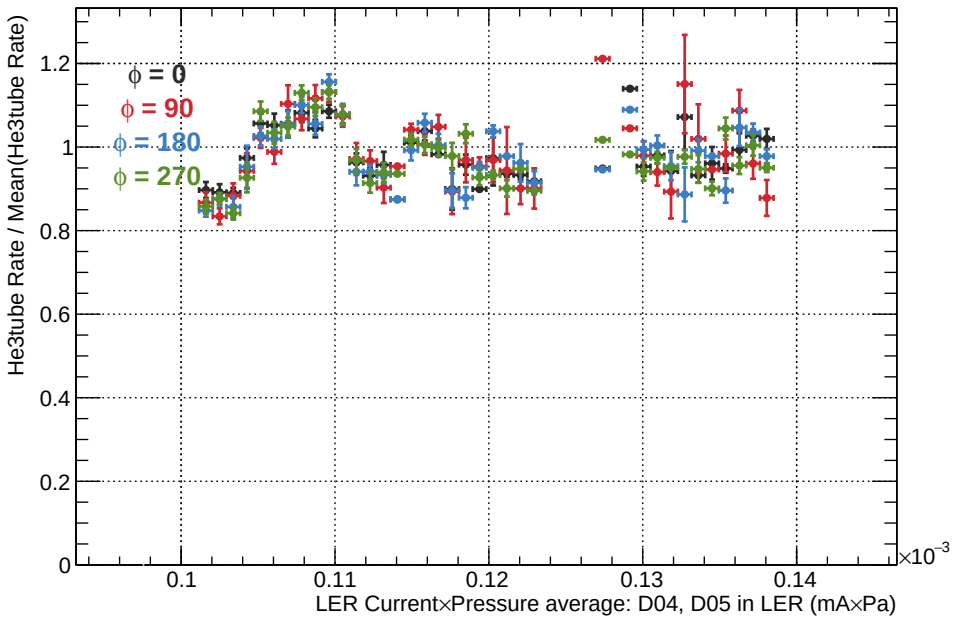
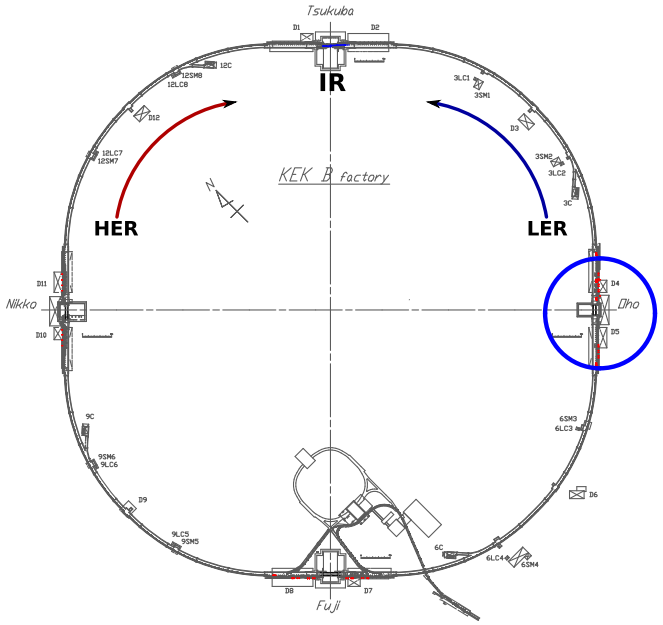
LER Vacuum bump in D02 L18, L19 & L20, started at 2016-05-23 13:55:00

LER Vacuum bump in D04 & D05, started at 2016-05-23 15:25:00





Low energy ring

LER Vacuum bump in D02 L25 & L26, started at 2016-05-23 10:28:00

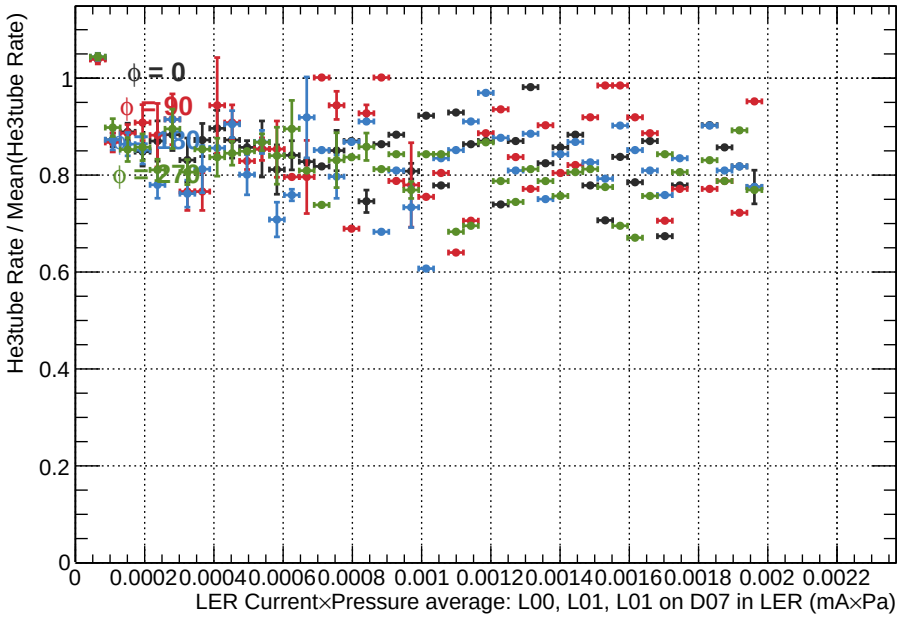
LER Vacuum bump in D02 L23 & L24, started at 2016-05-23 11:30:00

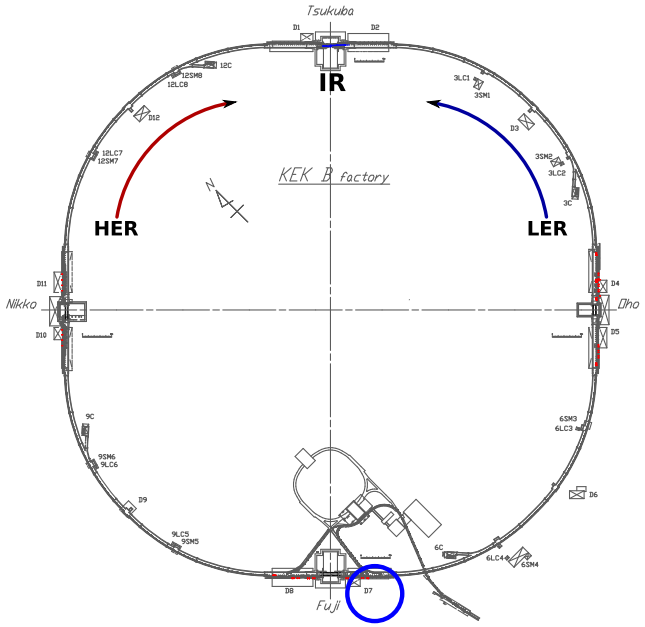
LER Vacuum bump in D02 L20, L21 & L22, started at 2016-05-23 12:36:00

LER Vacuum bump in D02 L18, L19 & L20, started at 2016-05-23 13:55:00

LER Vacuum bump in D04 & D05, started at 2016-05-23 15:25:00

LER Vacuum bump in in D07 L00, L01 & L02, started at 2016-05-23 16:50:00





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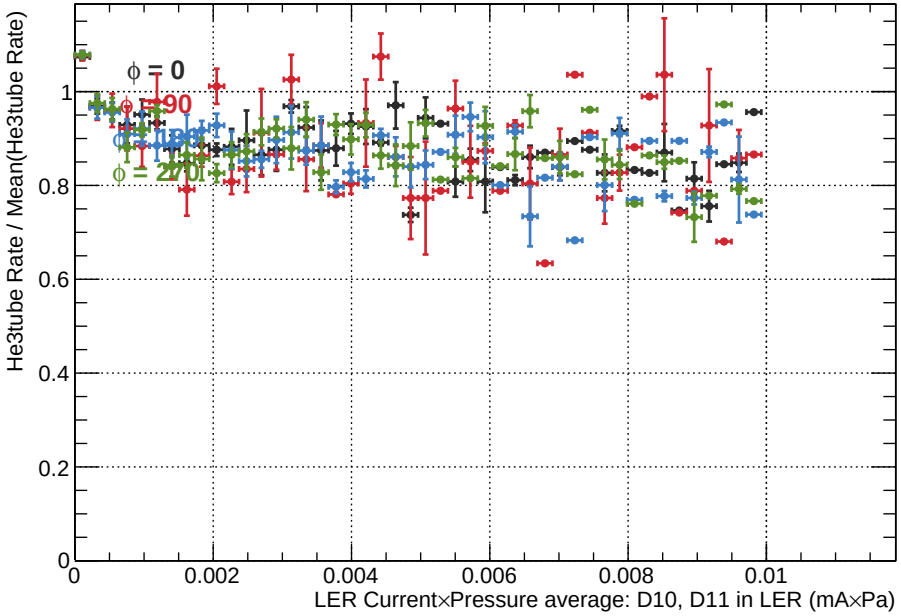
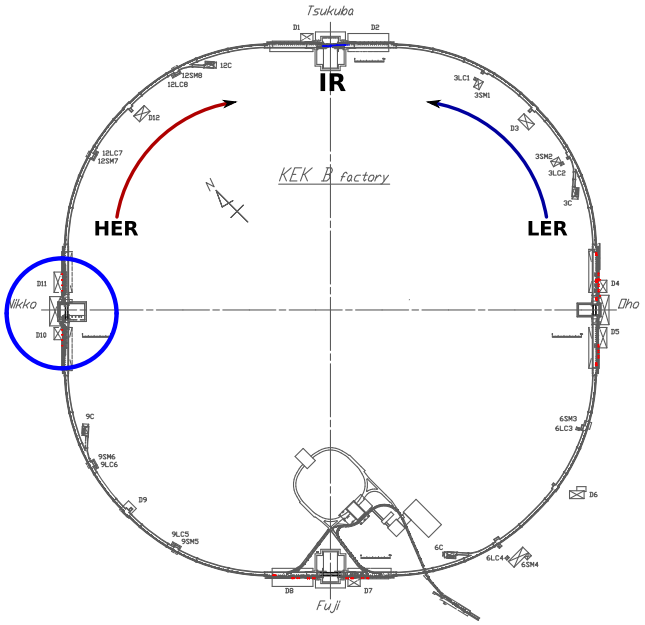
LER Vacuum bump in D02 L18, L19 & L20, started at 2016-05-23 13:55:00

LER Vacuum bump in D04 & D05, started at 2016-05-23 15:25:00

LER Vacuum bump in in D07 L00, L01 & L02, started at 2016-05-23 16:50:00

LER Vacuum bump in D10 & D11, started at 2016-05-23 17:40:00



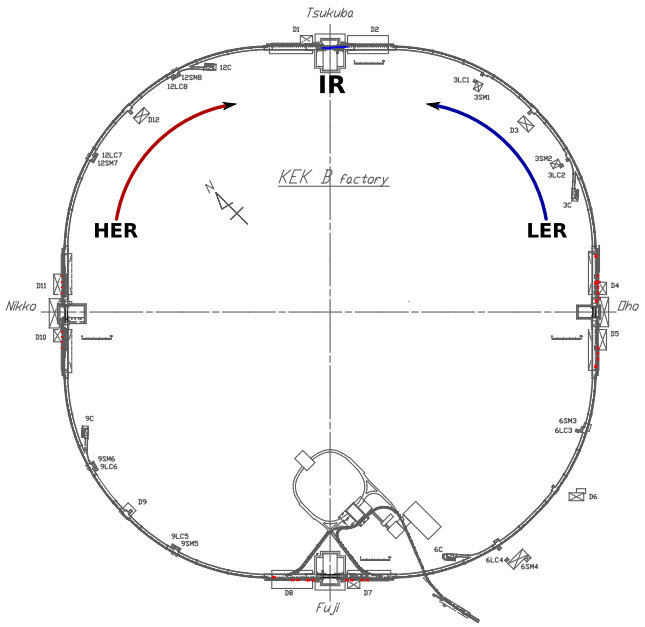


LER vacuum bump - Conclusions

- Pressure increases in D02 have a large impact on the helium-3 tube rate.
- The impact decreases as the pressure bump was moved along D02 away from the IR.
- Pressure bumps at locations further down the beam pipe have little to no effect on the helium-3 tube rate.
- No obvious dependence on ϕ observed in the LER.

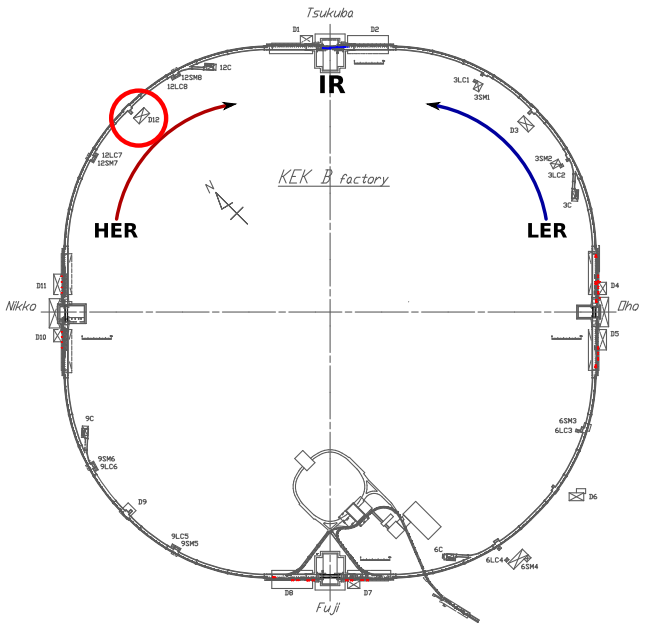
HER vacuum bump

- Vacuum bump occurred at several different locations along the HER beam:



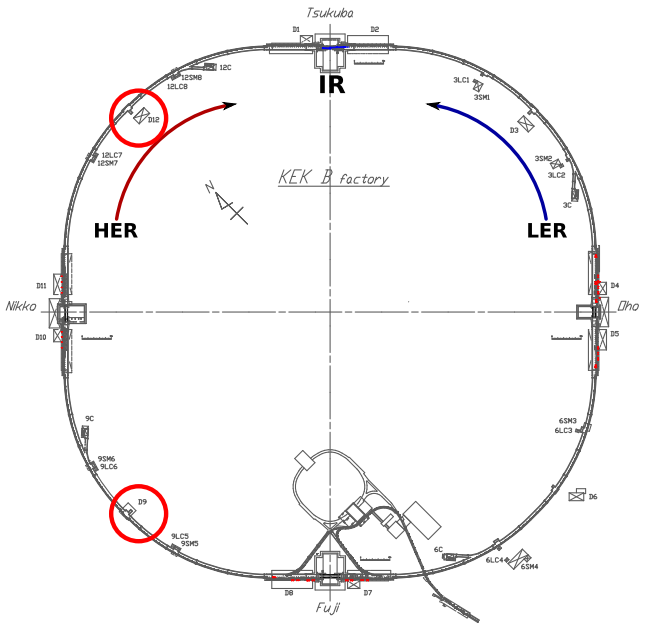
HER vacuum bump

- Vacuum bump occurred at several different locations along the HER beam:
  - D12



HER vacuum bump

- Vacuum bump occurred at several different locations along the HER beam:
  - D12
  - D09



HER vacuum bump

- Vacuum bump occurred at several different locations along the HER beam:
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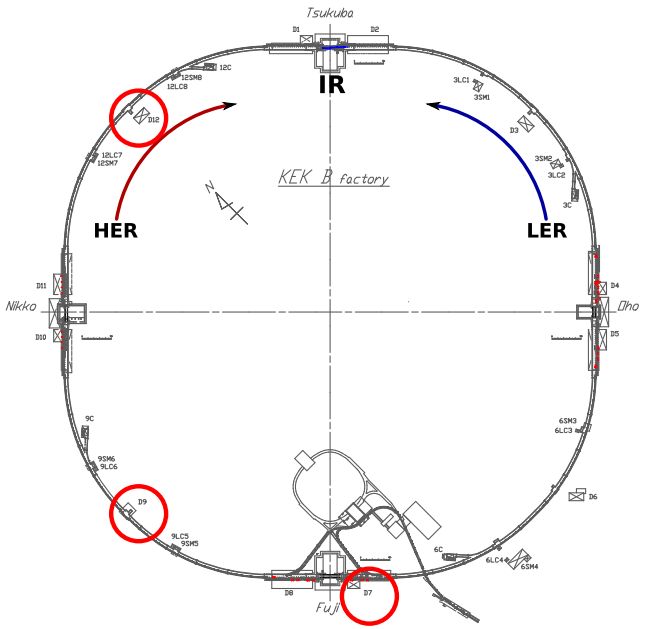
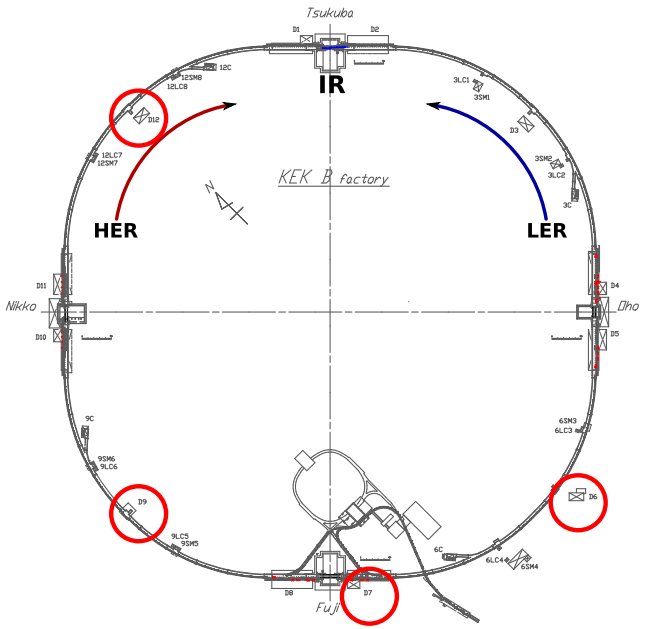
  - D09
  - D07



HER vacuum bump

- Vacuum bump occurred at several different locations along the HER beam:
  - D12
  - D09
  - D07
  - D06



HER vacuum bump

- Vacuum bump occurred at several different locations along the HER beam:
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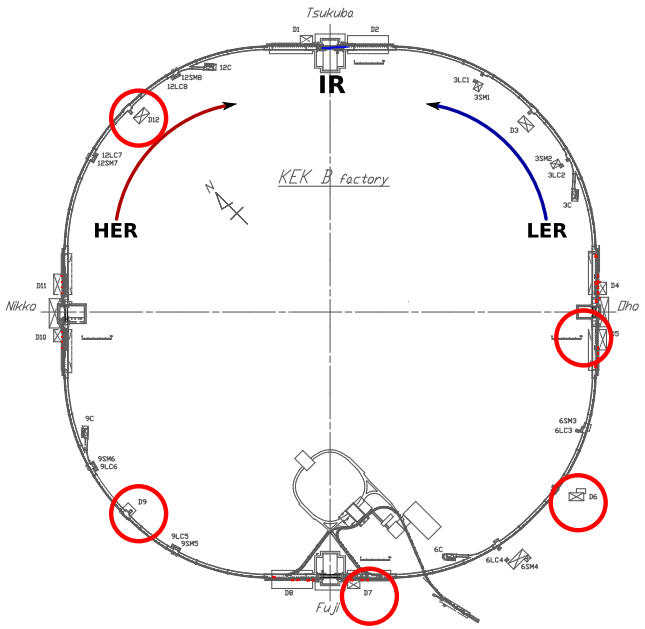
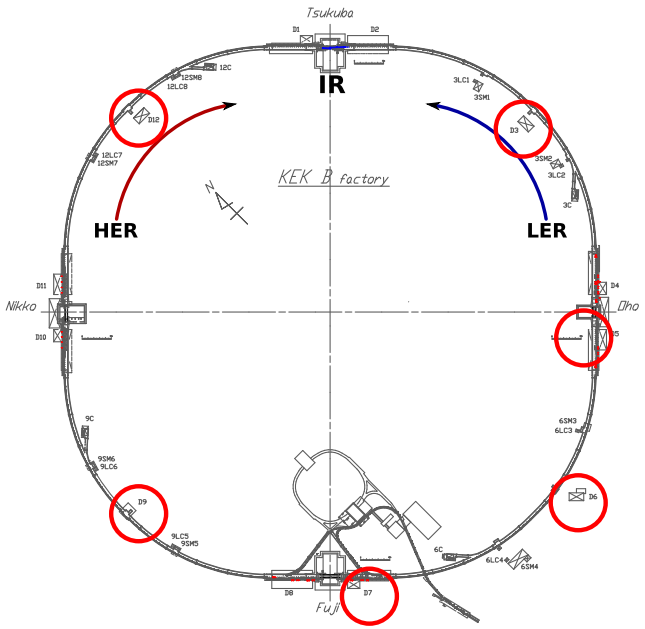
  - D09
  - D07
  - D06
  - D05

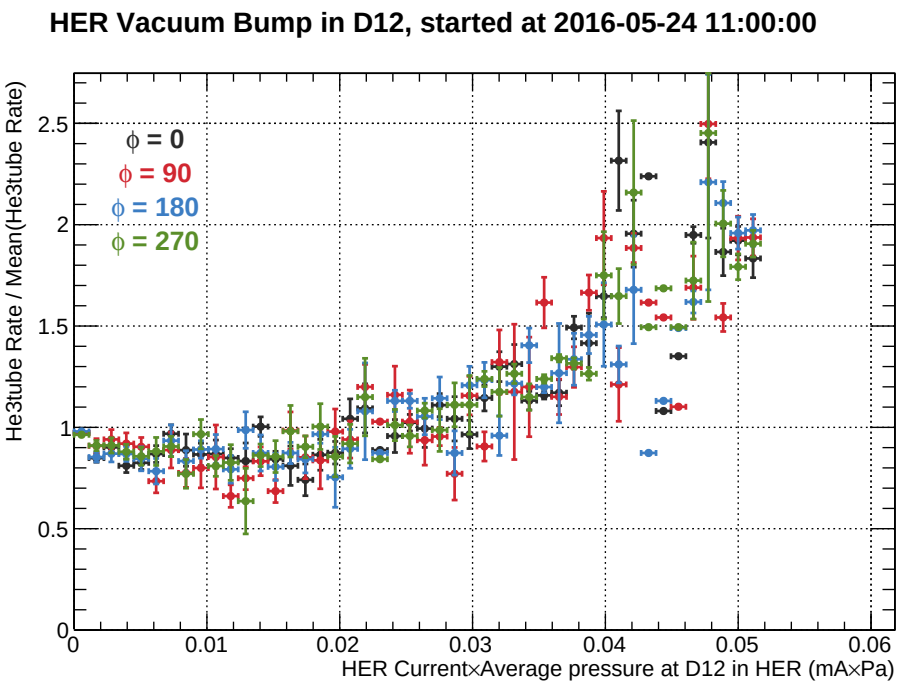


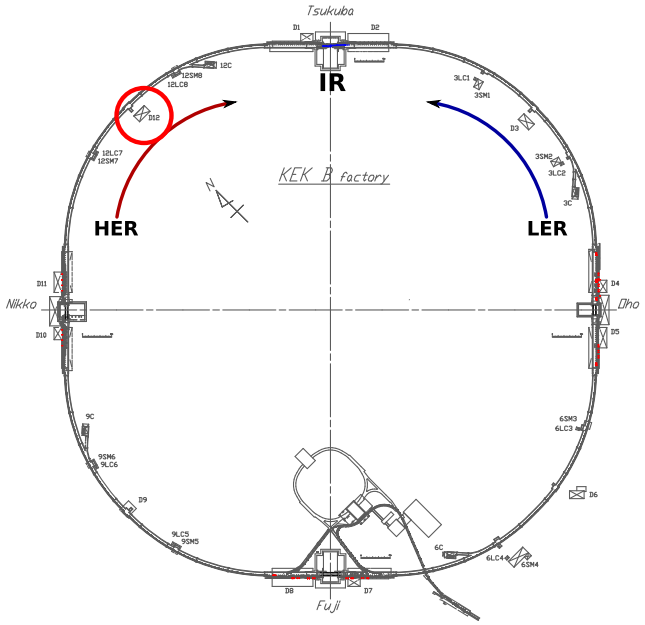
HER vacuum bump

- Vacuum bump occurred at several different locations along the HER beam:
  - D12
  - D09
  - D07
  - D06
  - D05
  - D03



High energy ring

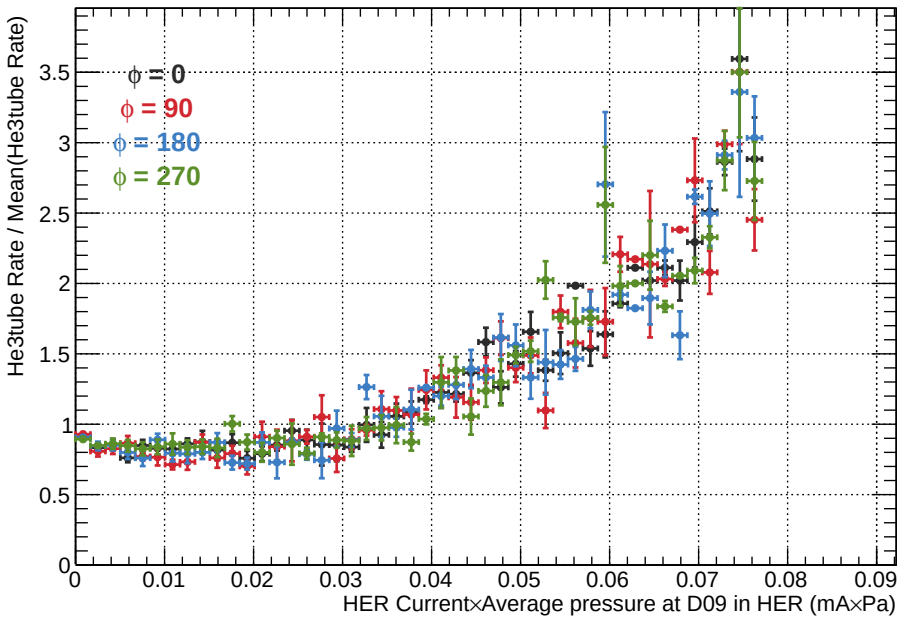


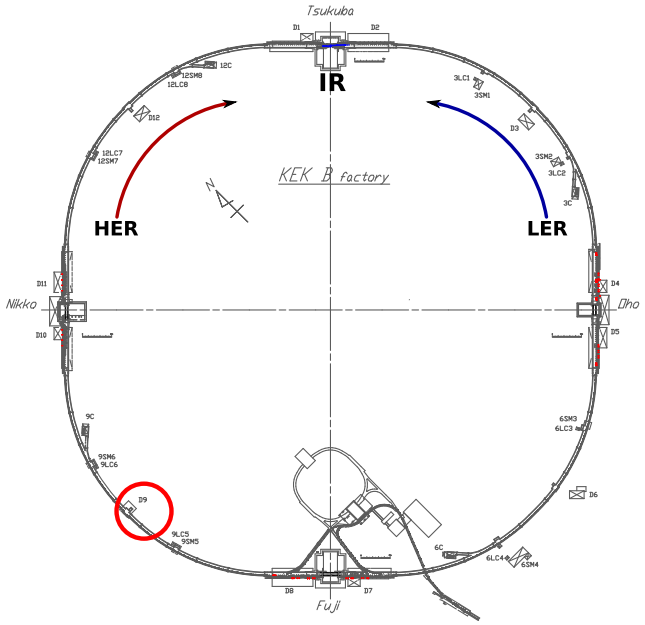


High energy ring

HER Vacuum Bump in D12, started at 2016-05-24 11:00:00

HER Vacuum Bump in D09, started at 2016-05-24 12:10:00



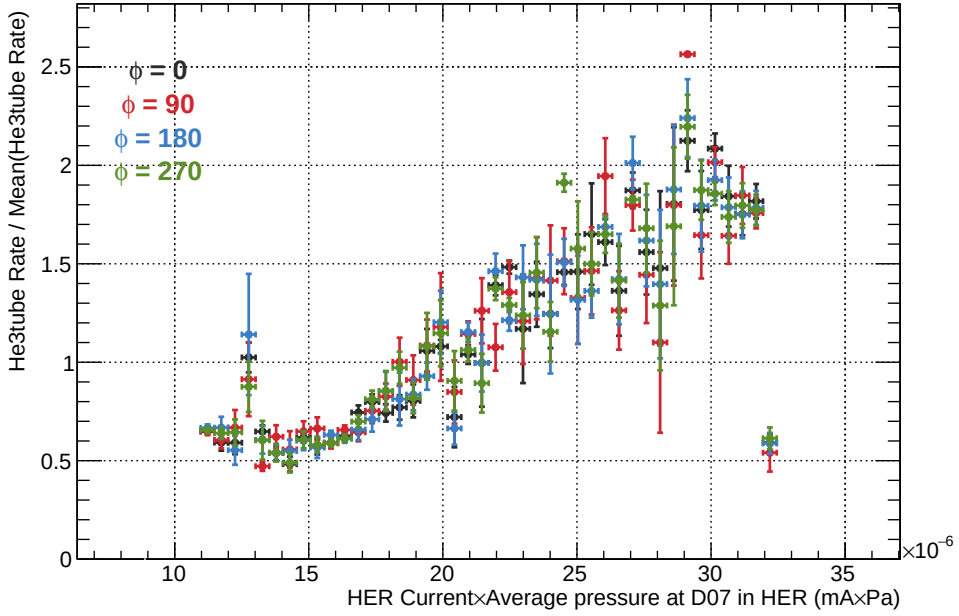


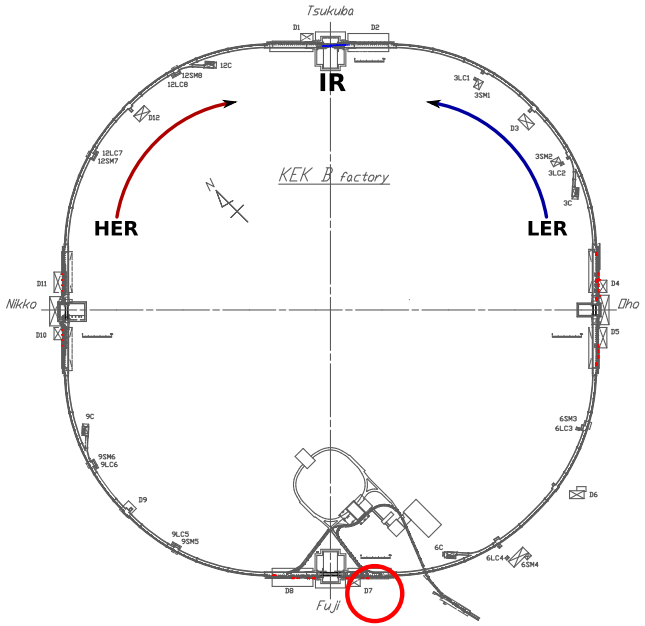
High energy ring

HER Vacuum Bump in D12, started at 2016-05-24 11:00:00

HER Vacuum Bump in D09, started at 2016-05-24 12:10:00

HER Vacuum Bump in D07, started at 2016-05-24 13:00:00





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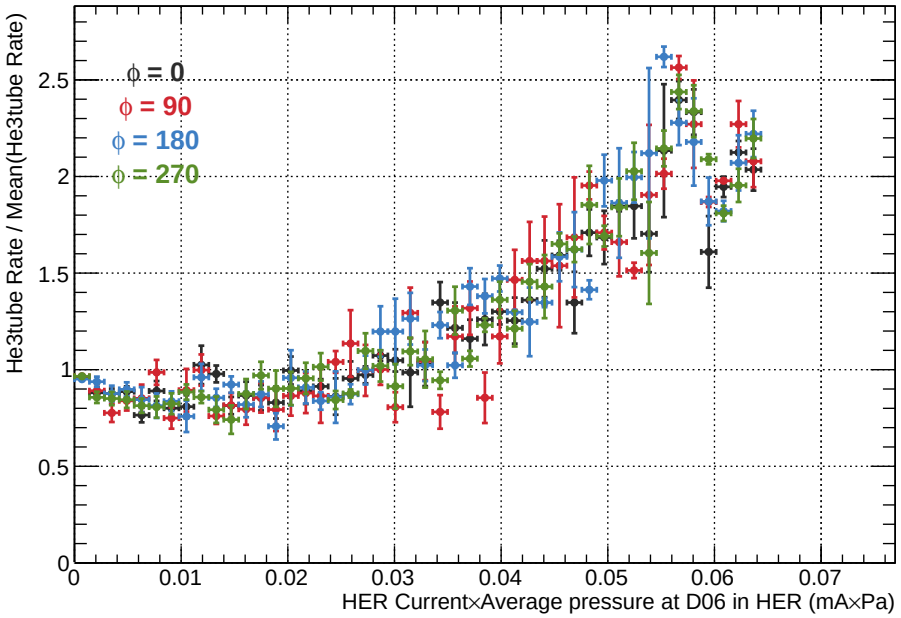
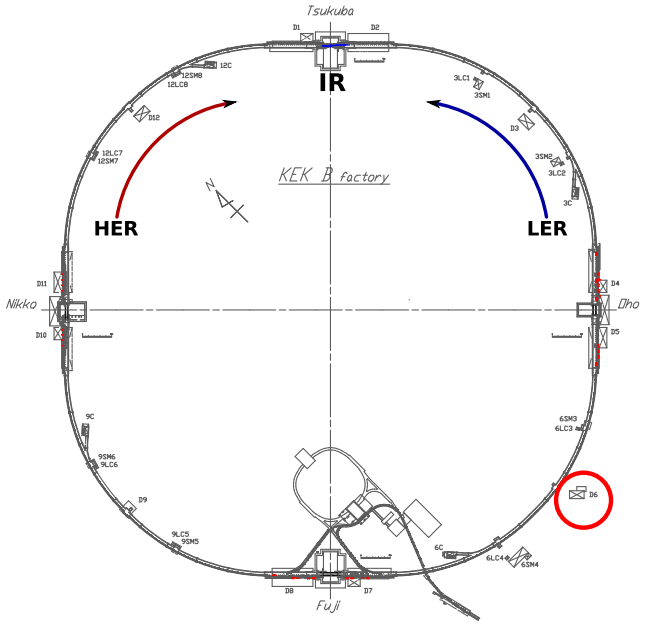
HER Vacuum Bump in D12, started at 2016-05-24 11:00:00

HER Vacuum Bump in D09, started at 2016-05-24 12:10:00

HER Vacuum Bump in D07, started at 2016-05-24 13:00:00

HER Vacuum Bump in D06, started at 2016-05-24 15:35:00





High energy ring

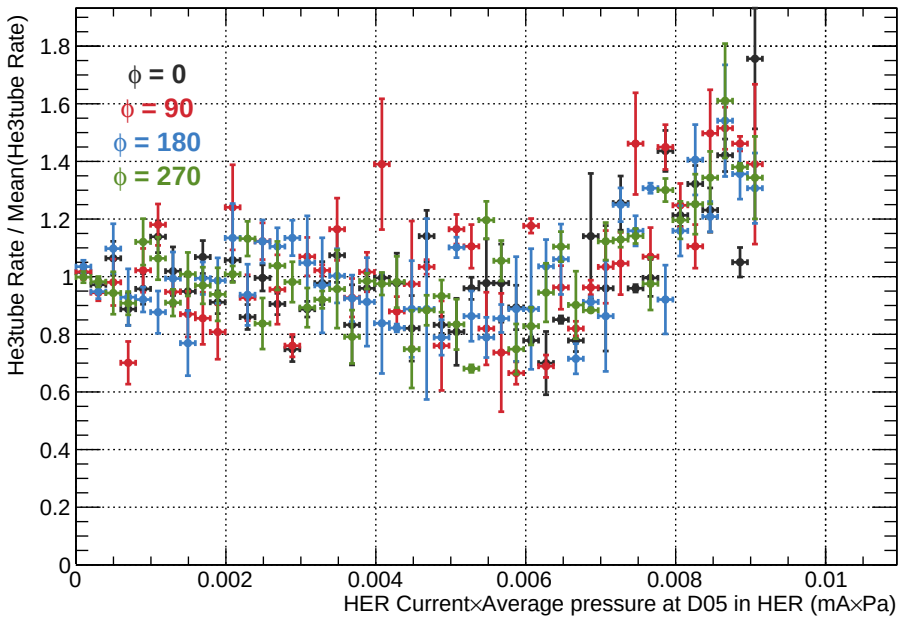
HER Vacuum Bump in D12, started at 2016-05-24 11:00:00

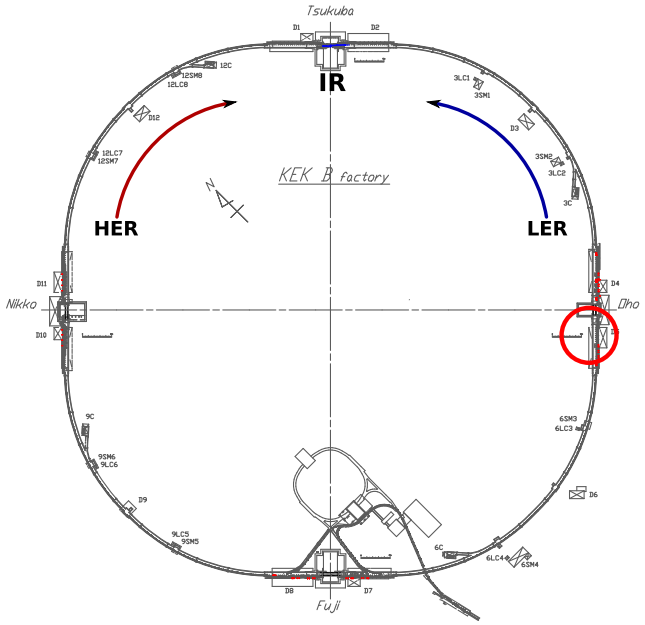
HER Vacuum Bump in D09, started at 2016-05-24 12:10:00

HER Vacuum Bump in D07, started at 2016-05-24 13:00:00

HER Vacuum Bump in D06, started at 2016-05-24 15:35:00

HER Vacuum Bump in D05, started at 2016-05-24 17:05:00





High energy ring

HER Vacuum Bump in D12, started at 2016-05-24 11:00:00

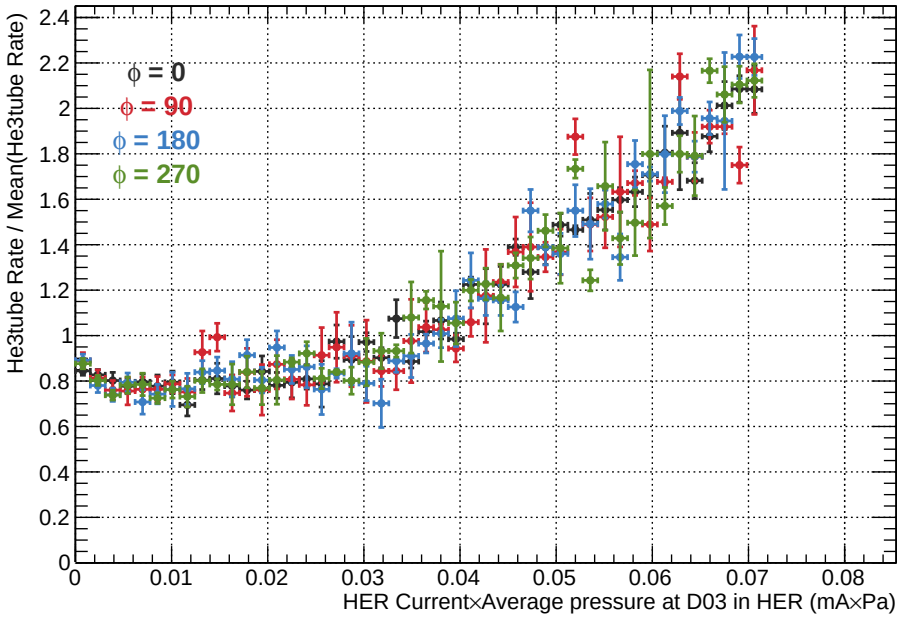
HER Vacuum Bump in D09, started at 2016-05-24 12:10:00

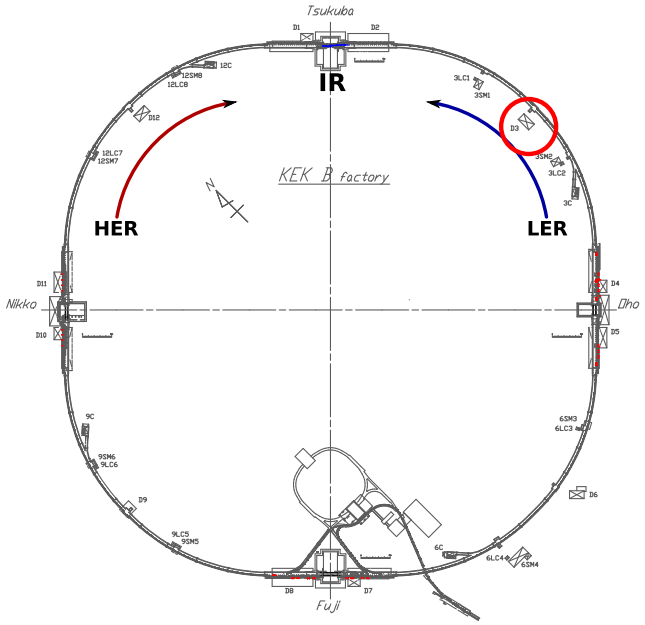
HER Vacuum Bump in D07, started at 2016-05-24 13:00:00

HER Vacuum Bump in D06, started at 2016-05-24 15:35:00

HER Vacuum Bump in D05, started at 2016-05-24 17:05:00

HER Vacuum Bump in D03, started at 2016-05-24 17:35:00

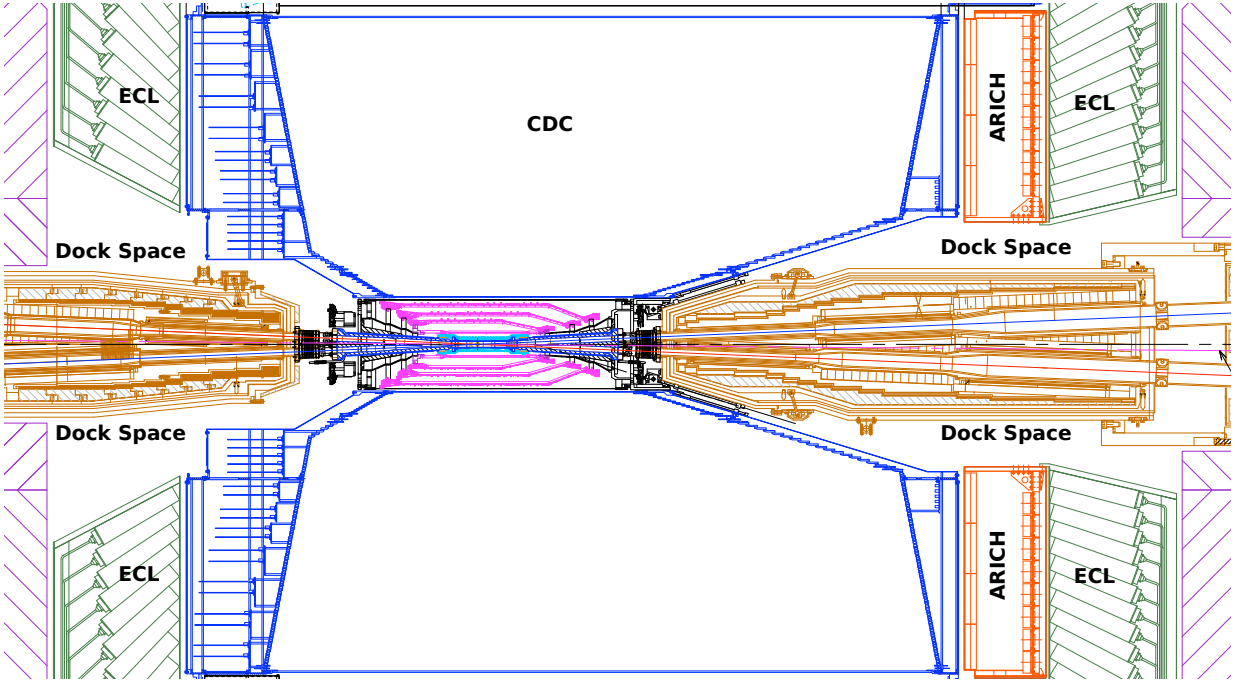




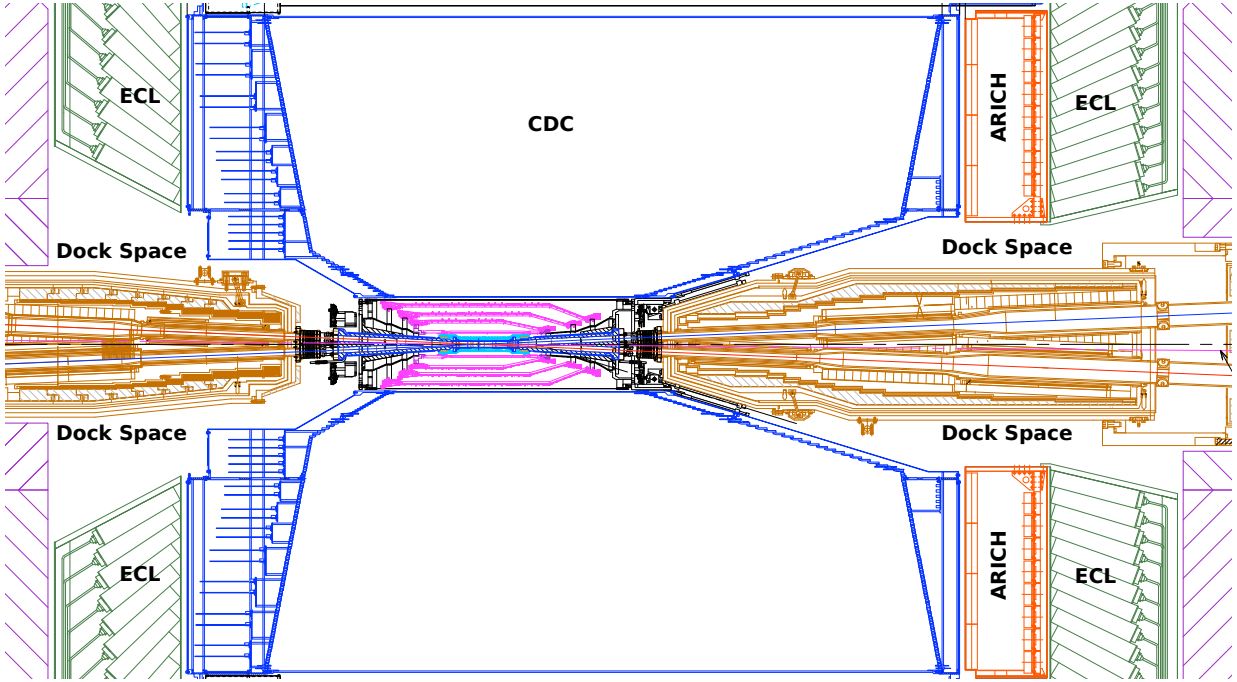
HER vacuum bump - Conclusion

- Unlike the LER, pressure increases at any location cause an increase in the helium-3 tube rate.
- As stated before, the HER beam is ‘cleaner’, and has a lower nominal pressure, so it is more sensitive to pressure increases.
- Not dependence on ϕ observed.

- Compare these results with simulation in order to assess the accuracy of the simulation.



- Compare these results with simulation in order to assess the accuracy of the simulation.
- Prepare Helium-3 tubes for phase 2 of BEAST.



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Conclusion

- Clear evidence of Touschek effect seen in the LER beam.
- Weaker evidence in the HER beam.
- Coulomb beam gas seen in both beams.
- No evidence of bremsstrahlung radiation.

Acknowledgements

- Special thanks to:
  - Paul Poffenburger at UVic for is advice on DAQ.
  - Neil Honkanen at UVic's machine shop for designing and building the amplifier system.
  - Peter Lewis at the University of Hawaii for coordinating the BEAST II DAQ work.
  - Hiroyuki Nakayama at KEK for coordinating with the accelerator folks.
  - The accelerator control group at KEK for the nice, stable beams.