LABM status
Large Angle Beamstrhalung Monitor

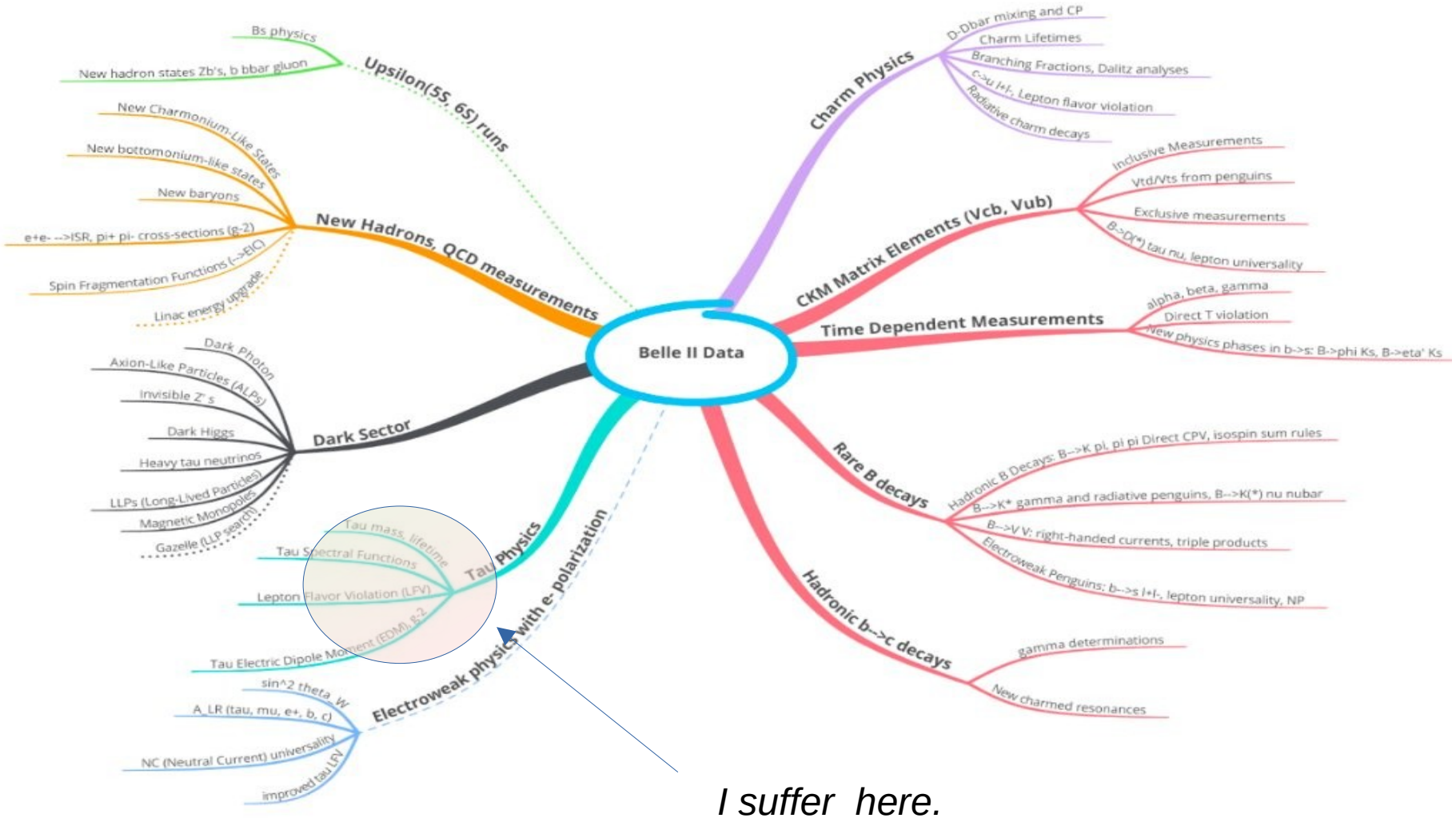
Pedro Luis Manuel Podesta Lerma
Universidad Autonoma de Sinaloa

Colaboración Belle II

26 paises and regions, 123 institutions, ~1100 collaborators

Armenia (1), Australia (3), Austria (1), Canada (5), China (12), Czechia (1), France (3), Germany (12), India (9), Israel (1), Italy (9), Japan (16),Malaysia (1), Mexico (3), Poland (1), Russia(6), Saudi Arabia(1), Slovenia(2), South Korea(9), Spain(1), Taiwan(3), Thailand(2), Turkey(1), USA (18), Ukraine (1), Viet Nam(1).

Las fisica en Belle II



I suffer here.

Plenty of New Physics

From KEKB to SuperKEKB

Instantaneous Target Luminosity: $L = 6 \times 10^{35}\, cm^{-2} s^{-1}$

Achieved Luminosity (world record): $L = 4.7 \times 10^{34}\, cm^{-2} s^{-1}$

Belle II

Target (Achieved)

e^+ 4GeV 3.6 A (~2.0 A)

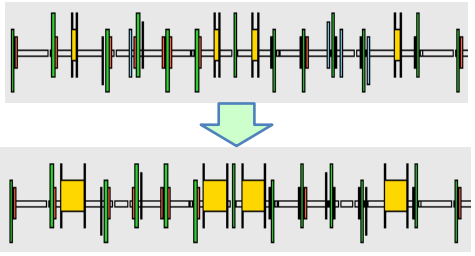
e^- 7GeV 2.6 A (~2.0 A)

New superconducting /permanent final focusing quads near the IP

New IR

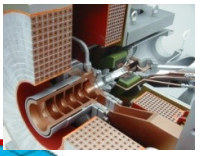
Colliding bunches

Replace short dipoles with longer ones (LER)



Redesign the lattices of HER & LER to squeeze the emittance

Add / modify RF systems for higher beam current



Positron source

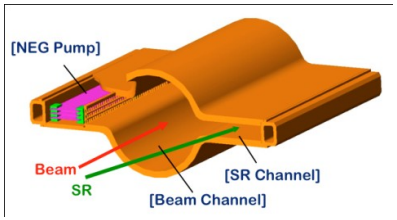
New positron target / capture section

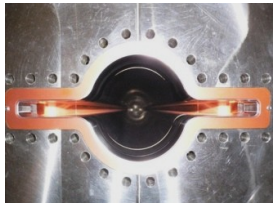
Damping ring

Low emittance positrons to inject

Low emittance gun

TiN-coated beam pipe with antechambers

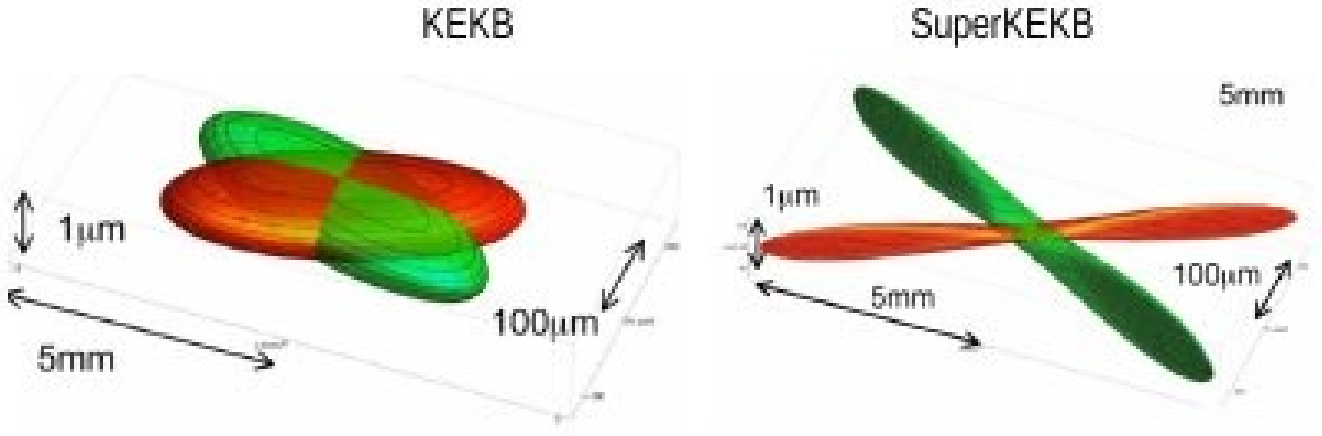




$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

Low emittance electrons to inject

Nanobeam is the key to increase luminosity



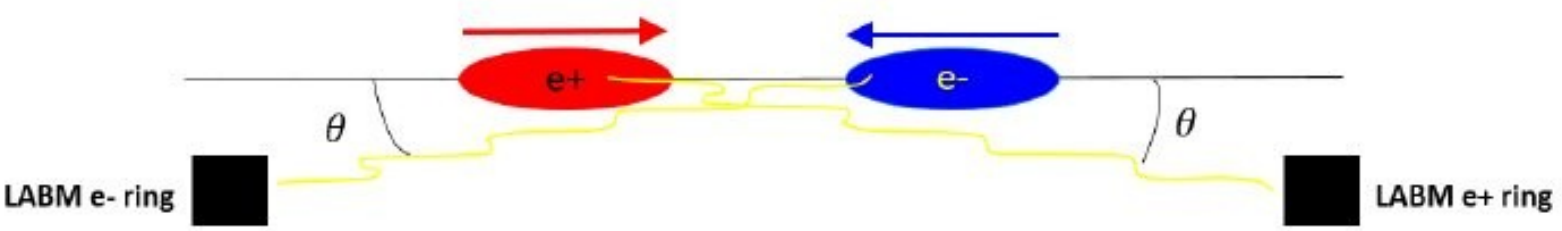
	E(GEV) HER/LER	β^*_y(mm) HER/LER	β^*_x(mm) HER/LER	2φ (mrad)	I(A) HER/LER	L ($cm^{-2}s^{-1}$)
KEKB	3.5/8.0	5.9/5.9	1200/1200	22	1.6/1.2	$2.1x10^{34}$
SuperKEKB	4.0/7.0	0.27/0.30	32/25	83	3.6/2.6	$80x10^{34}$

Large Angle Beamstrahlung Monitor (LABM)

- Beamstrahlung light produced by the interaction of one beam and the electromagnetic field of the other.

- At large angle, Beamstrahlung is strongly polarized and contamination from synchrotron radiation is small

- Visible ligh (350-650 nm)
  - Easy to work
  - Fraction 10^{-11} (e-) to 10^{-12} (e+) of total Beamstrahlung energy emitted but enough for LABM



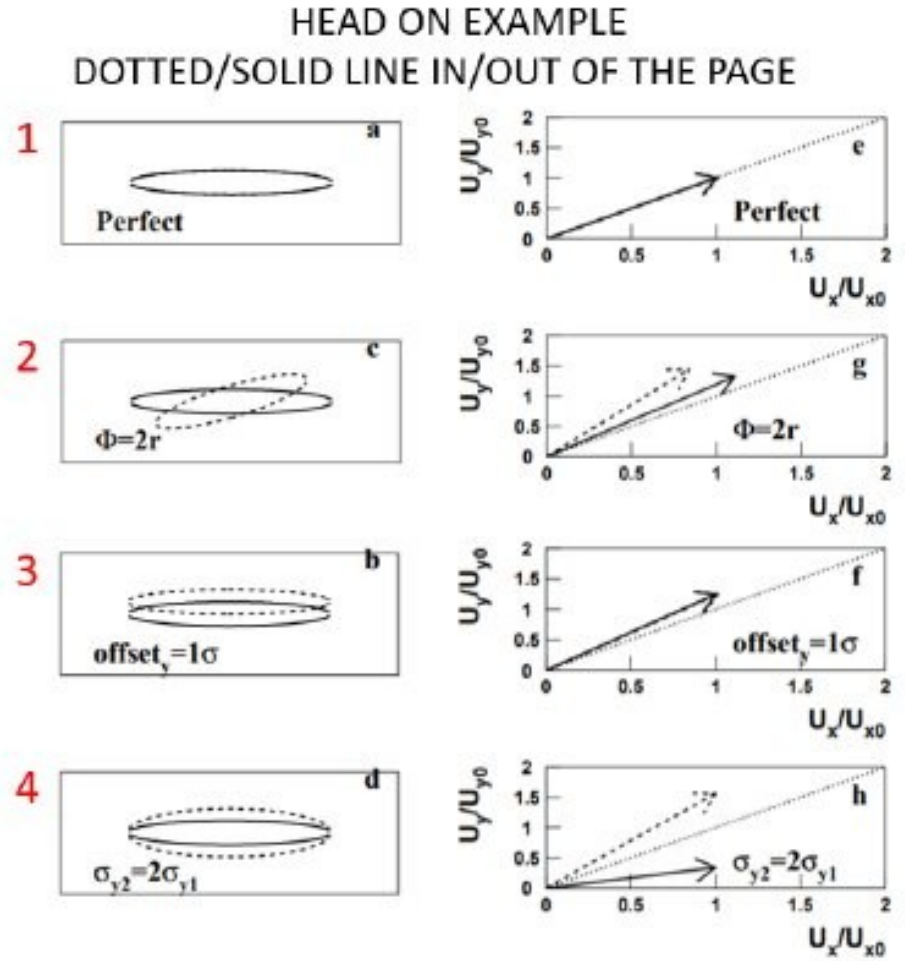
Luminosity and Beamstrahlung

- Highest luminosity is for perfect Overlap beams at interaction point

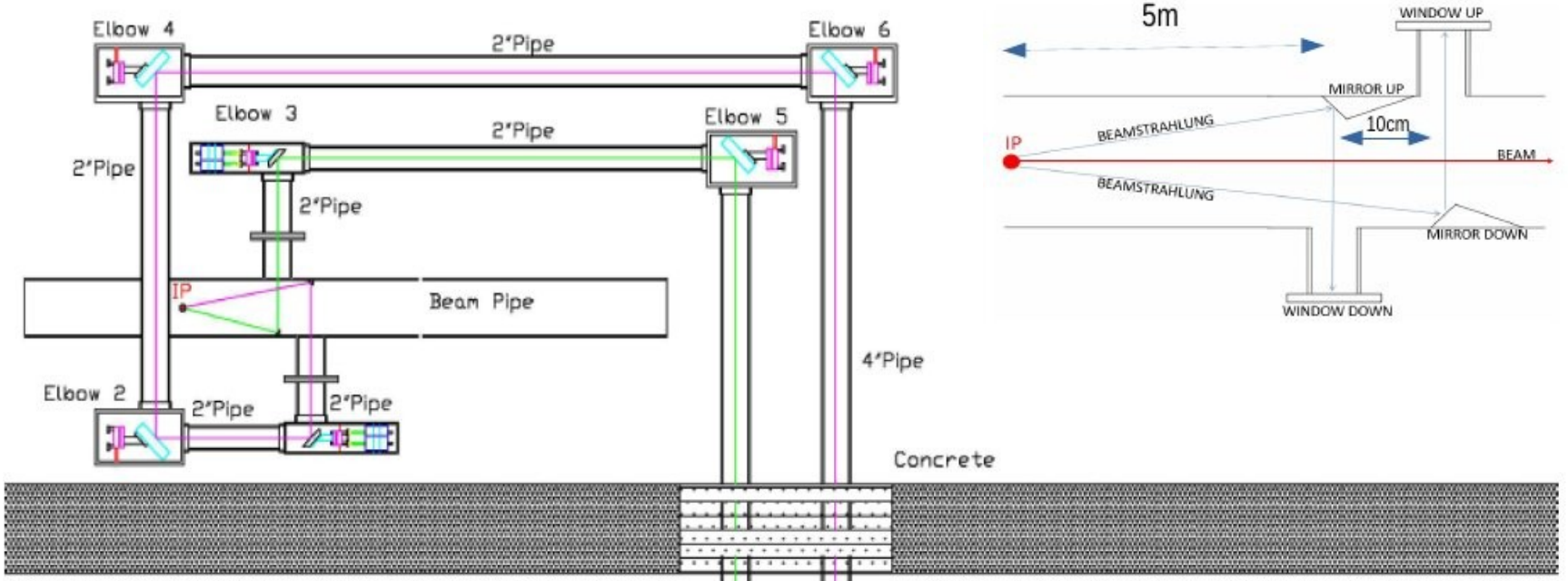
- The pathologies are rotation, offset and bloating.

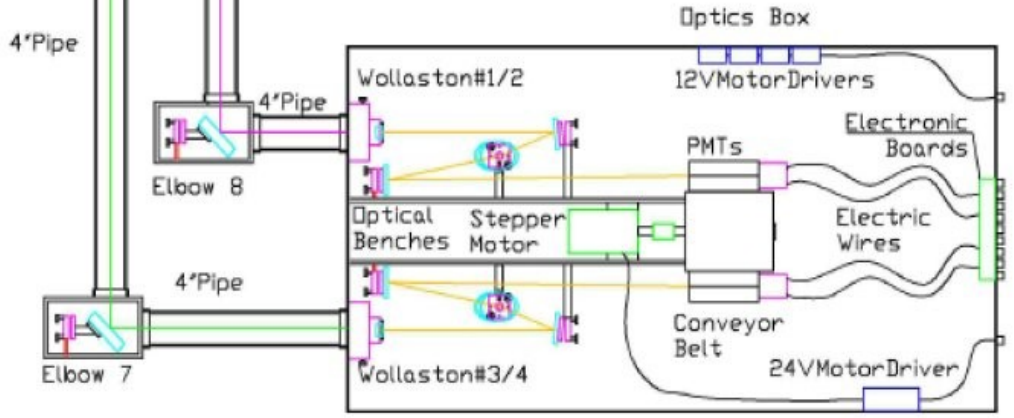
- Ratio of x to y polarization show Characteristic pattern fro mismatch

- Bloating (4) limits superKEKB



LABM diagram





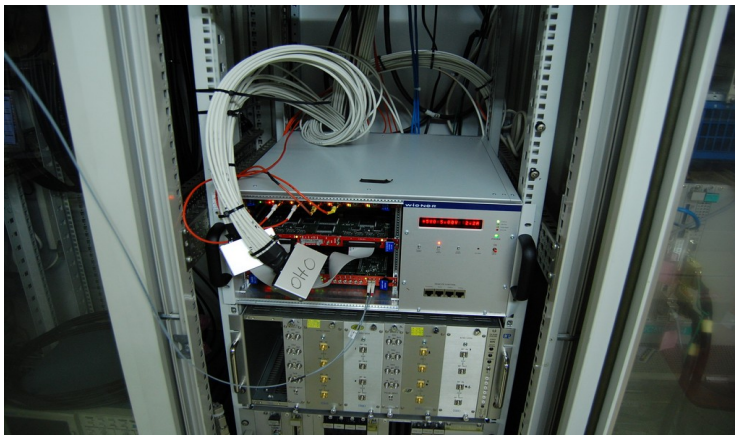
Four telescopes

Two for High Energy Ring e-
Two for Low Energy Ring e+

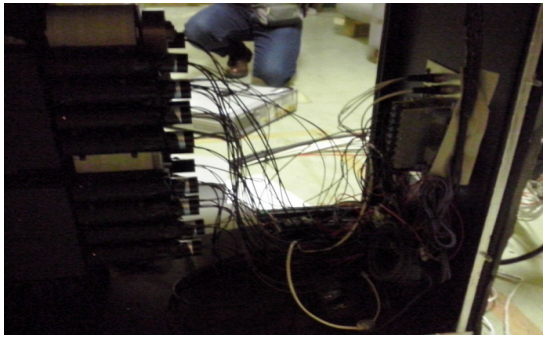
32 PMT

Connection to beam line

Optical line (4)



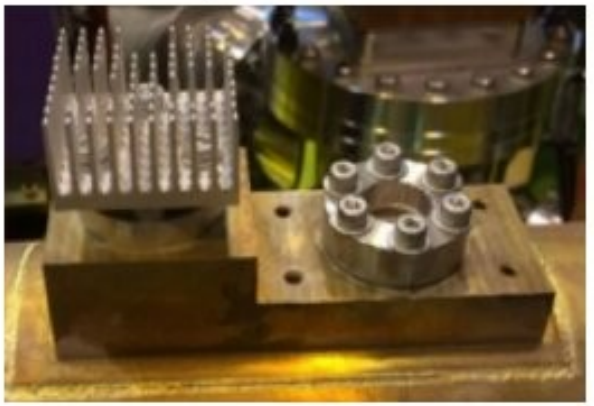
Scaler, power supply (16)



Photomultipliers (32)

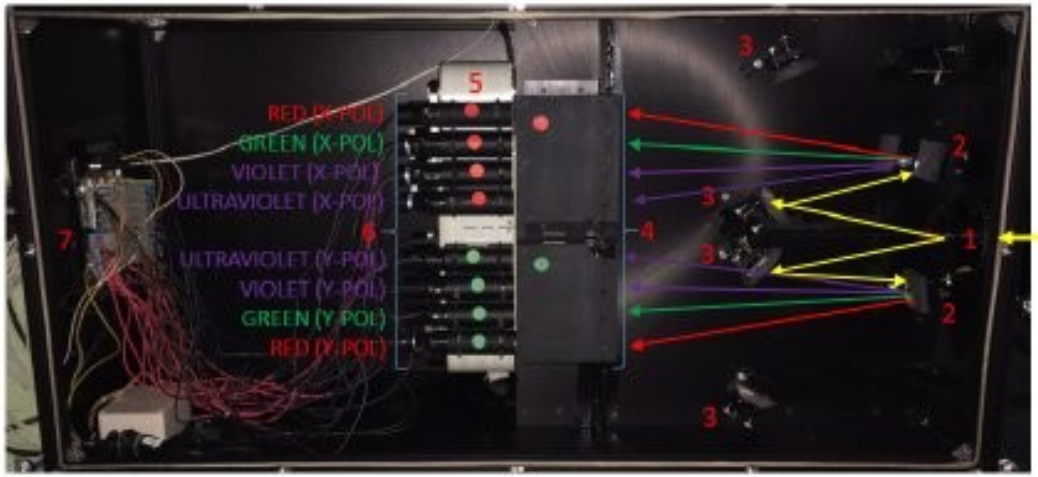
Vacuum mirror

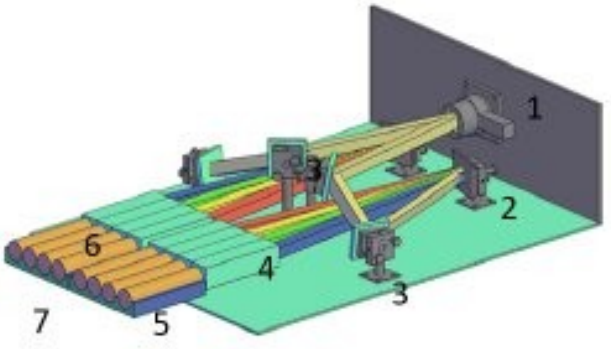
Window in beam line



Optic Box setting 2015 -2023

- Wollanston prism
- Gratings
- Mirrors
- Focusing lens
- Conveyor belt
- PMT
- Electronics

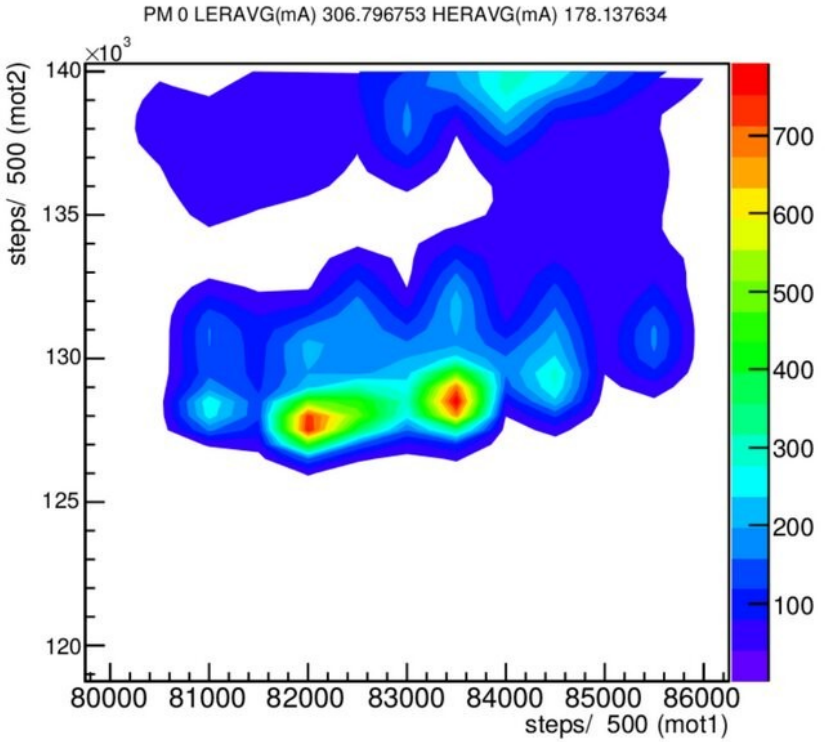


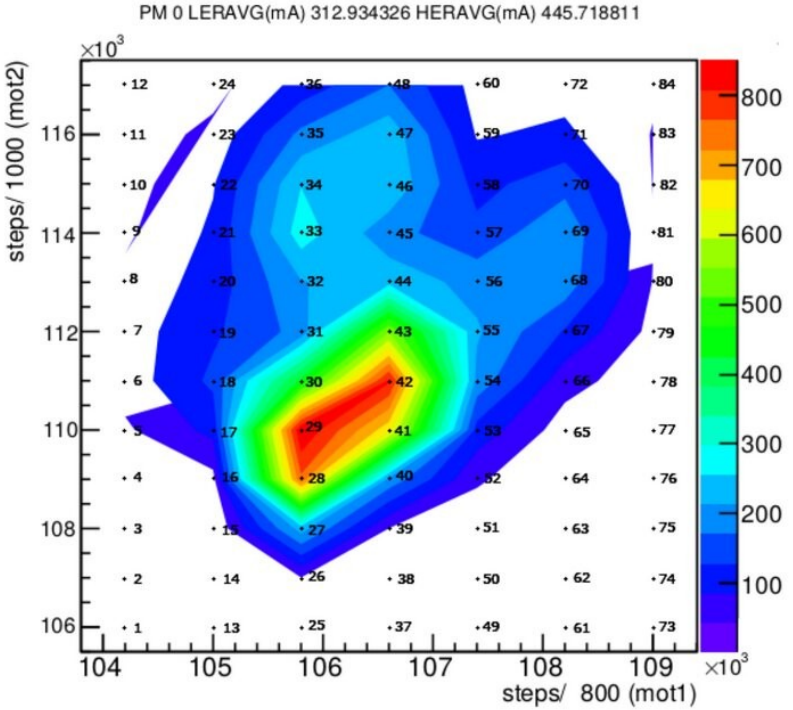


LABM scans

- Scanning means move the mirrors to get coven a mirror area of 2x2 mm²

- Red zone is Beamstrahlung, Green is Coulumb and Touscheck tails with quadrupole blue are reflections (This redundancy is welcome)





Heat map for signal (parallell vs vertical position of the primary mirror) Blue C. and T. radiation, Red Beamstrahlung radiation .

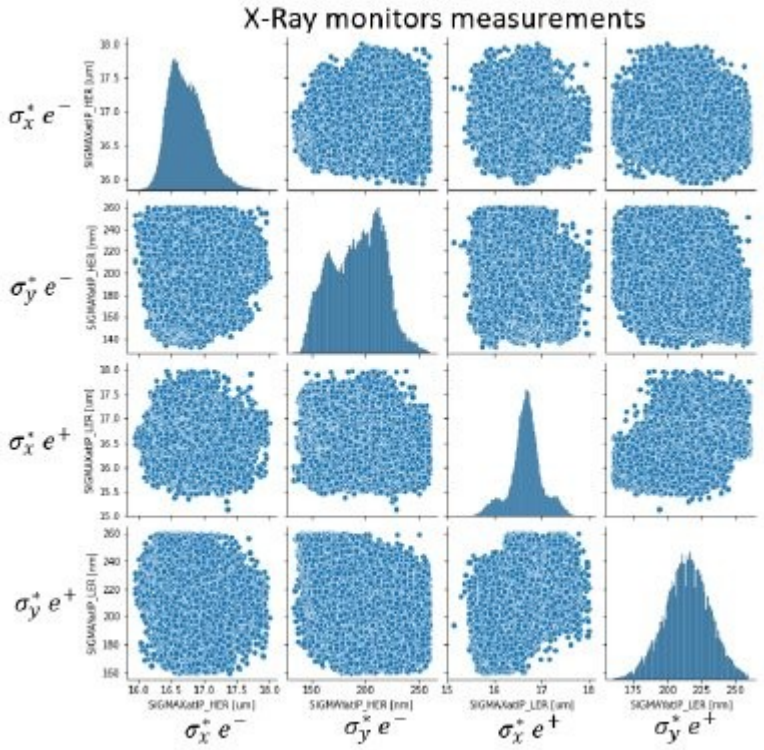
Data analysis

- We use data from X ray Monitors (XRM)

- Weak correlation between parameters

- Select stable physics run more than 100 mA

- A lot of variability even in stable runs



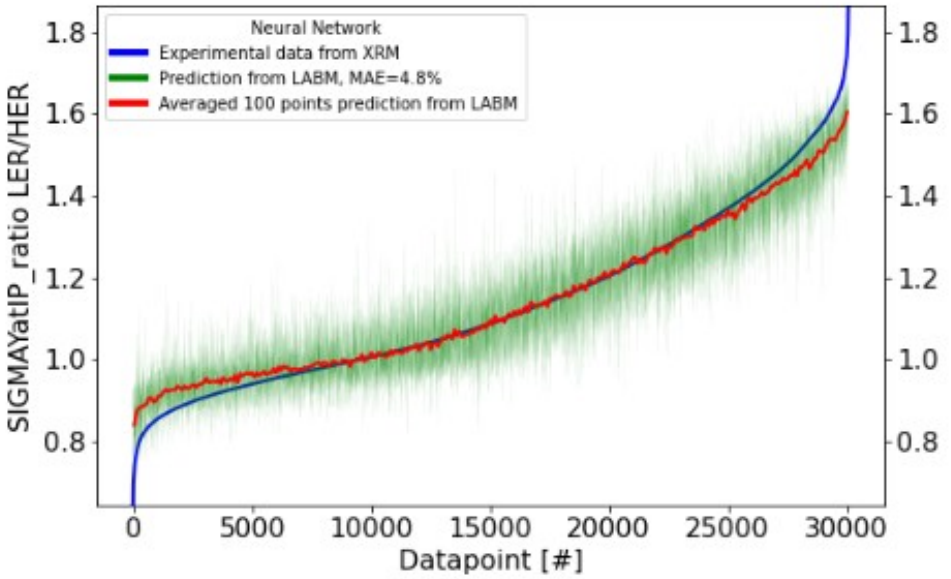
Neural network to get beam parameters

- Result can be calculated analytically but quite difficult

- Neural network is good but need Training

- Measurements from 16 PMT , offset Transverse sizes, bunch length vertical Angles.

-NN reproduced superKEKB at IP at a few percent



https://arxiv.org/abs/2206.11709

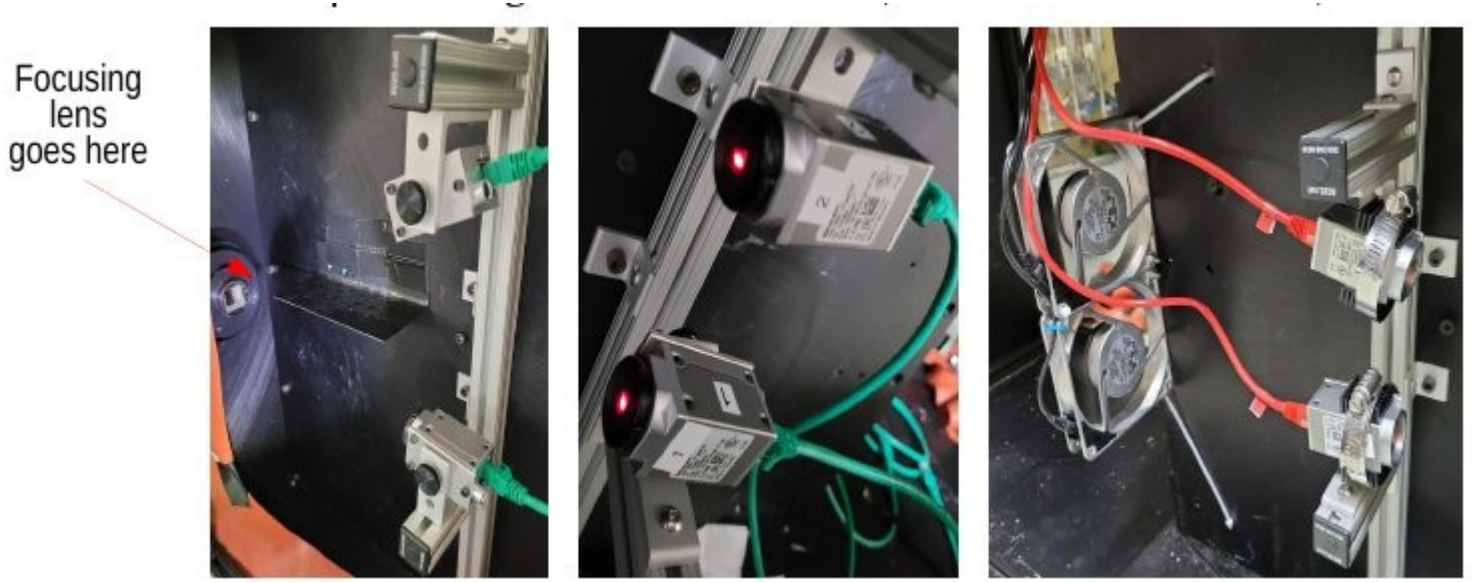
Upgrade 2023

- Replace PMT with basler CMOS cameras in the optic box

- Remove PMT, lens, conveyor belt, electronics card.

- Only one scan to find the spot

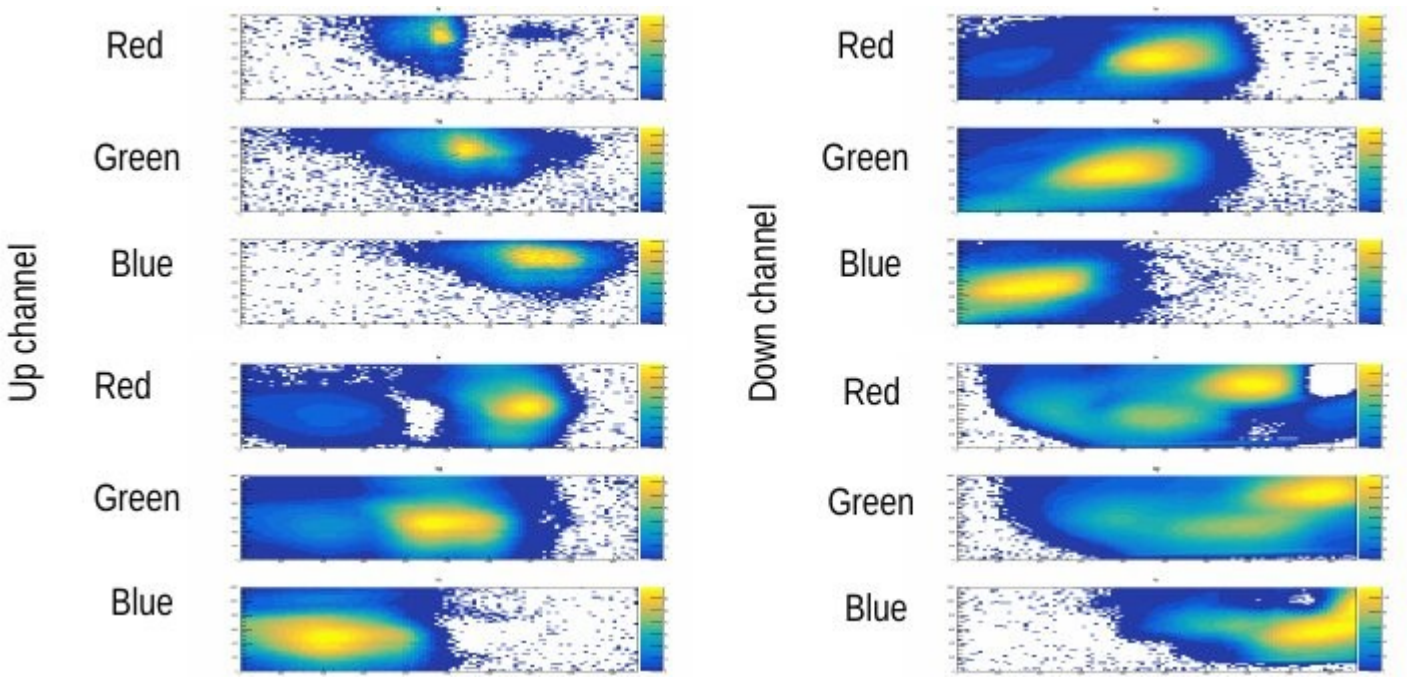
- Accurate position of cameras needed since sensor size is 6.68 x 4.20 mm



Results

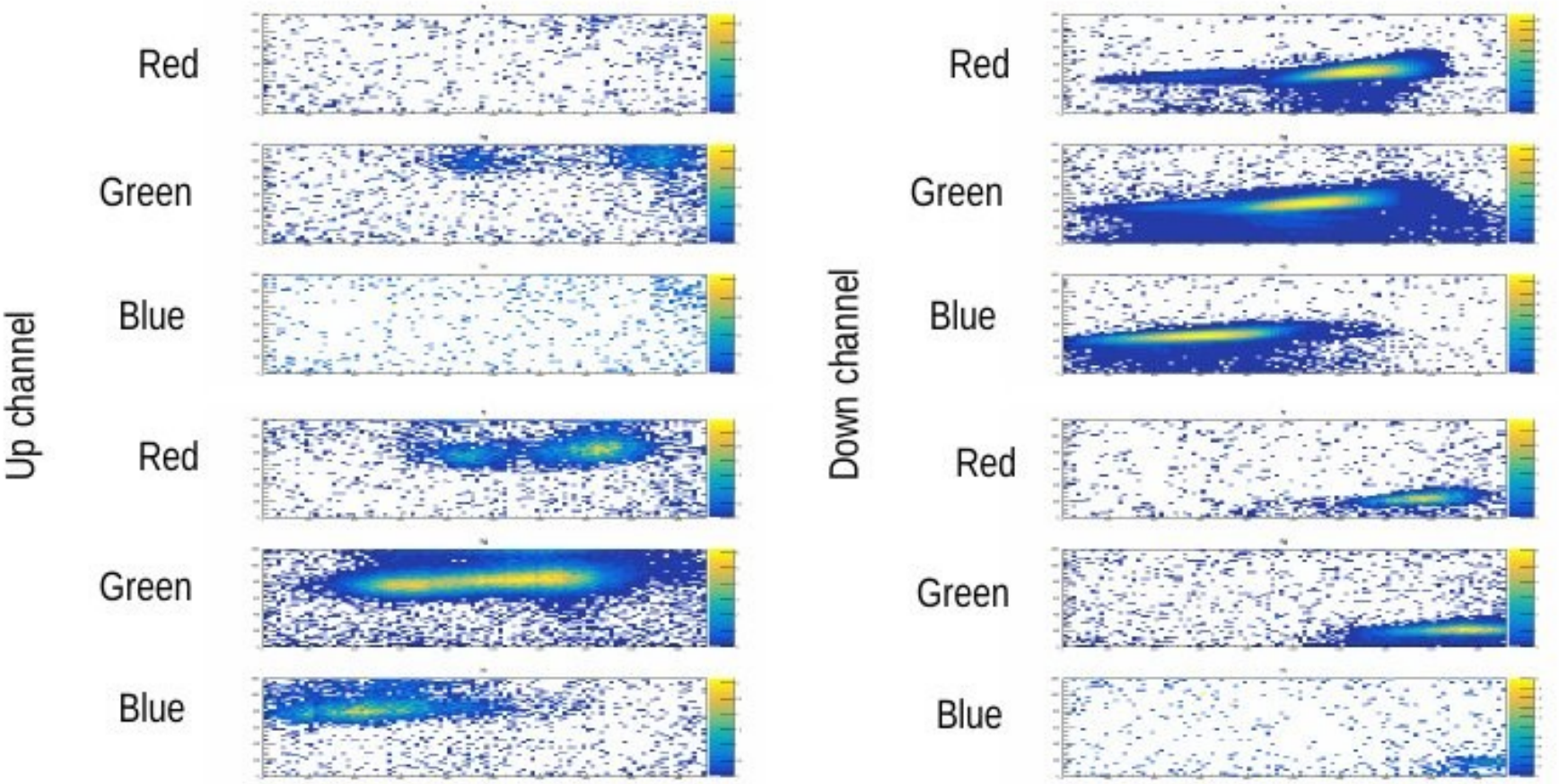
- Positron Beam (LER) optic channel, with 4 polarization

- Different position due to chromaticity of Wollanston prism



- Electron Beam (HER) optic channel, with 4 polarization

- Results look not good mainly due to long optics.

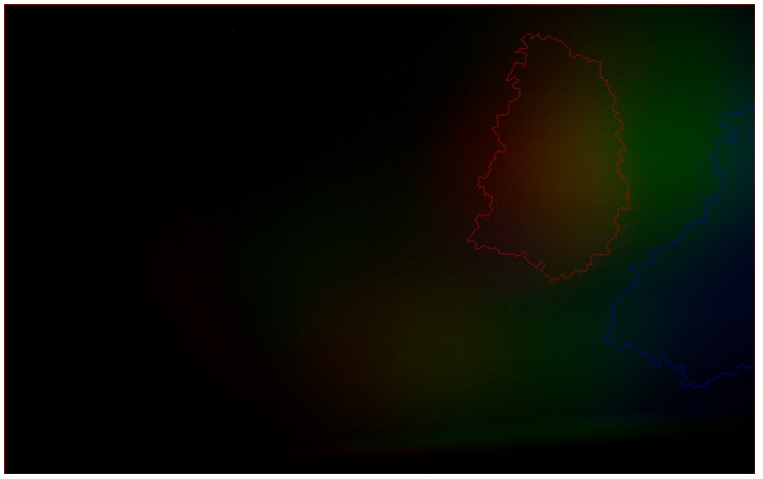


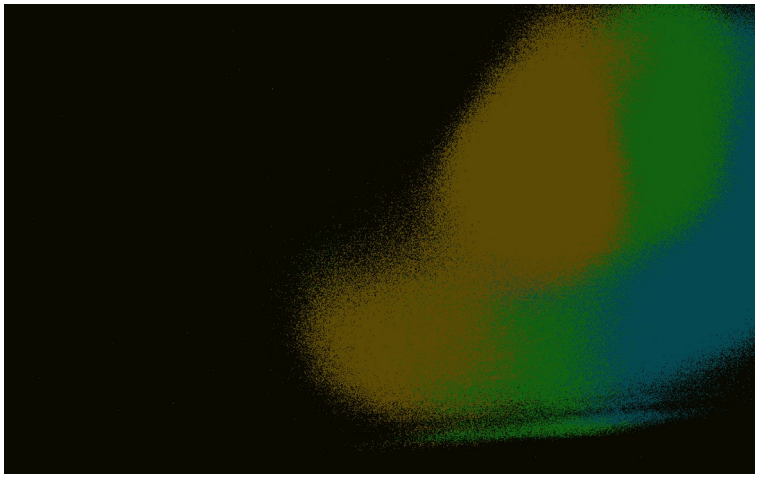
Analysis

We are testing different algorithm it is an interesting computer science problem by itself

- Watersheet, kmeans to get the best parameters (Raymundo Bueno UAS)

- We are also working with a simulation Xsuite developed at CERN, but with some SuperKEKB version.



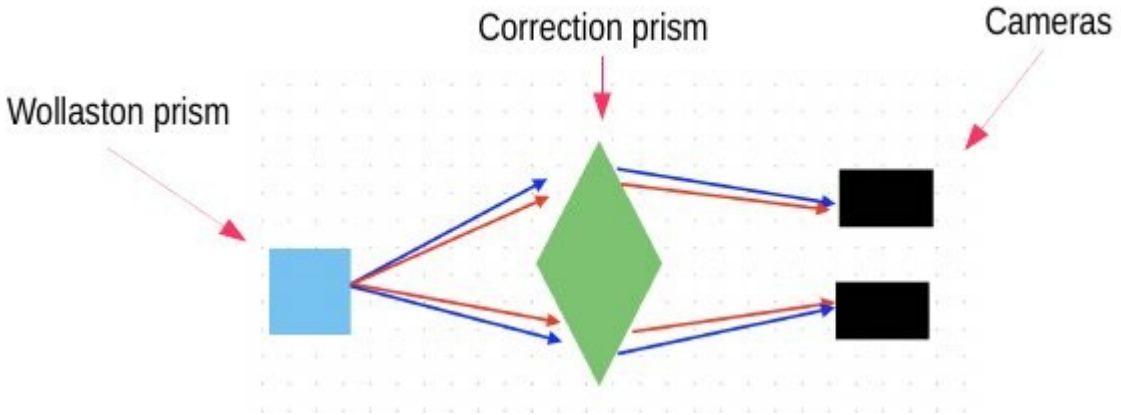


Upgrade 2025

- The main problem for alignment is the long optical channel. So we plan to move cameras closer to primary mirrors

  - Radiation damage to cameras could be an issue !!!

- One side HER up is already in place and the other will be installed fall 2025



Summary

- Beamstrahlung can be used to monitor beam parameters and beams relative positions

-Implementation of LABM in superKEK went a long way and many improvement were made over the original design, more to come

-Analysis is under way

- One side option is enough to determine both beam parameters

- Neural network and other computing techniques allows ti extract beam parameters

- LABM can be installed in EIC, superLHC