Background noise characterization and simulation on the LABM

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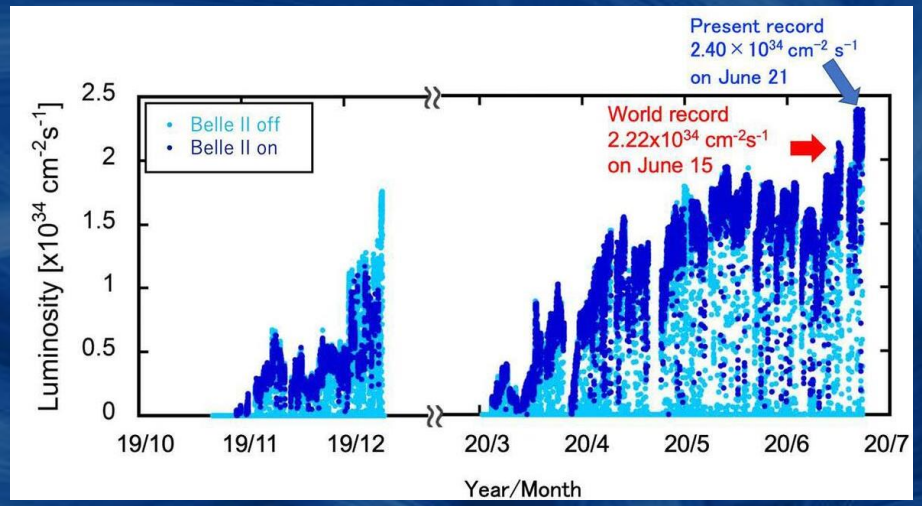
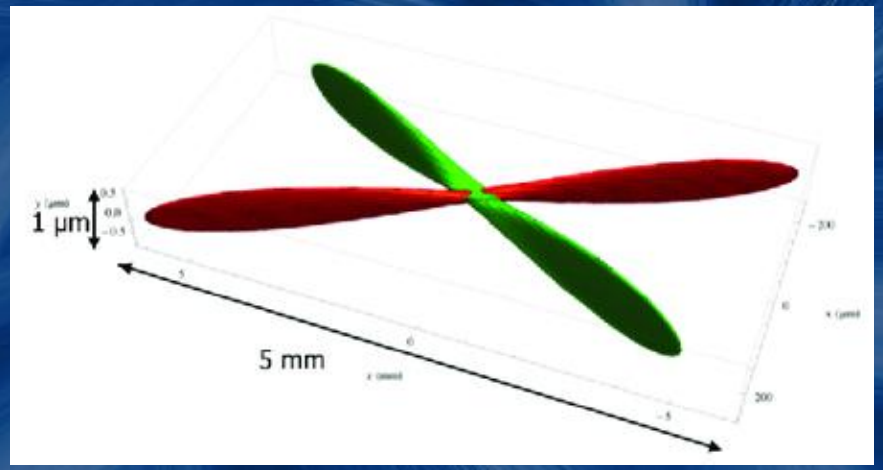
Introduction



[1]



[2]

High luminosity, but still missing.

There are different beam monitors in the accelerator, but none of them measure the beam parameters in the interaction region.

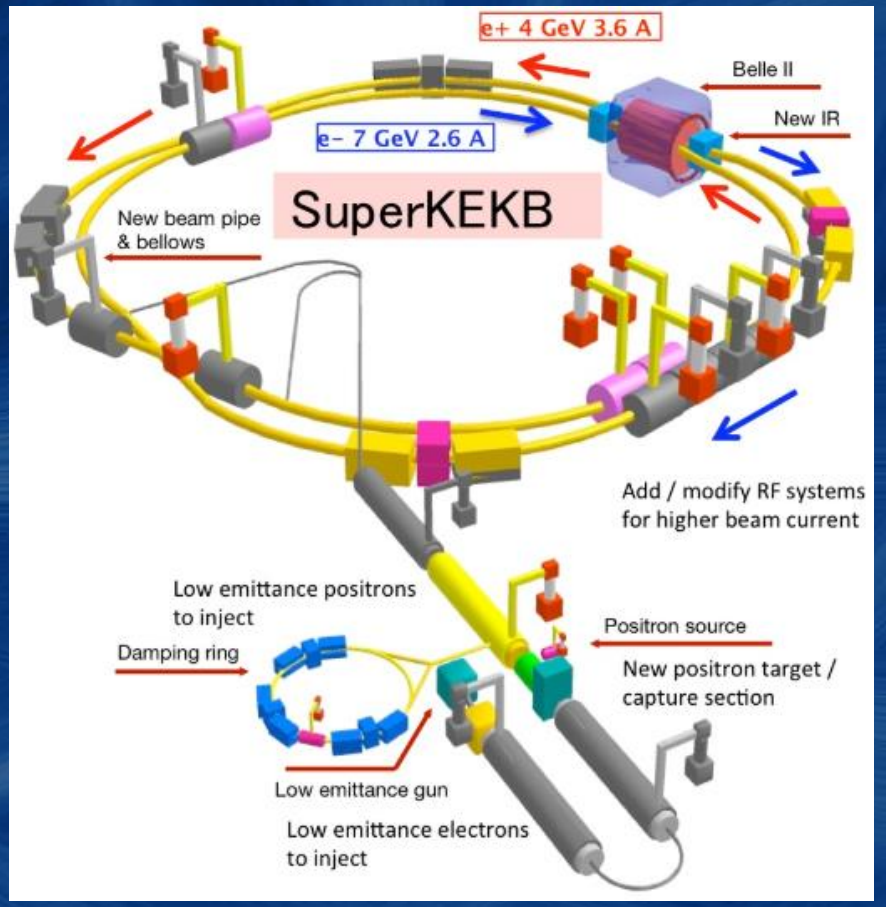
[1] KEK. (2020). SuperKEKB collider achieves the world's highest luminosity. KEK. URL: https://www.kek.jp/en/newsroom/2020/06/26/1400/

[2] Martini, Alberto. (2018). The Belle II experiment: Status and prospects. EPJ Web of Conferences. 192. 00028. 10.1051/epjconf/201819200028.

Belle II

Meson factory that searches for new physics. [3]

The LABM detector is instaled in the “SuperKEKB” particle accelerator, to work along the Belle II experiment.



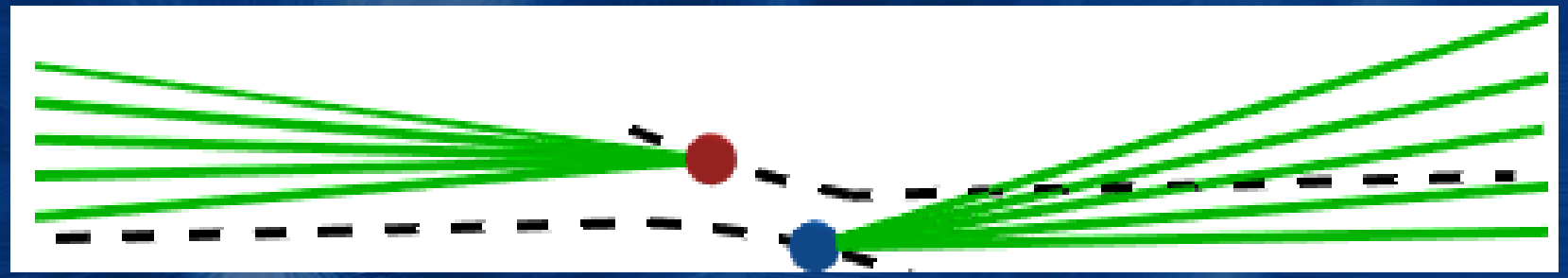
[4]

[3] Deutsches Elektronen-Synchrotron DESY. Super KEKB and Belle II. 2018. URL https://www.belle2.org/project/super_kekb_and_belle_ii/.

[4] Deutsches Elektronen-Synchrotron DESY. Super KEKB and Belle II. 2018. URL https://www.belle2.org/project/super_kekb_and_belle_ii/.

Beamstrahlung Radiation

The bremsstrahlung radiation is a type of light emitted by charged particles that turn their direction because an interaction with the electromagnetic field generated by a particle beam [5].



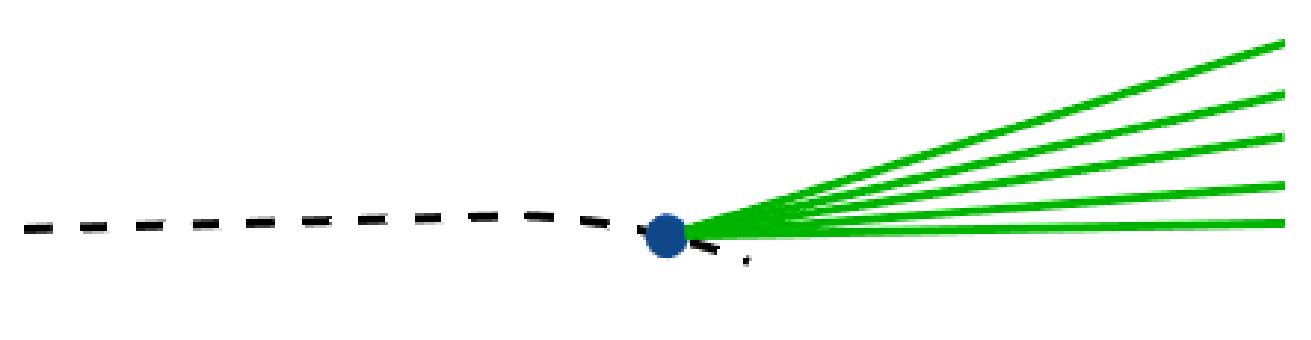
The first approximation of the beamstrahlung radiation power is as follow.

$$P_{bs} = C_1 I_1 {I_2}^2$$

[5] Daniel V. Schroeder. A posible design of large angle beamstrahlung detector for cesr. 1990. doi:10.2172/6078574. URL https://www.osti.gov/servlets/purl/6078574.

Synchrotron Radiation

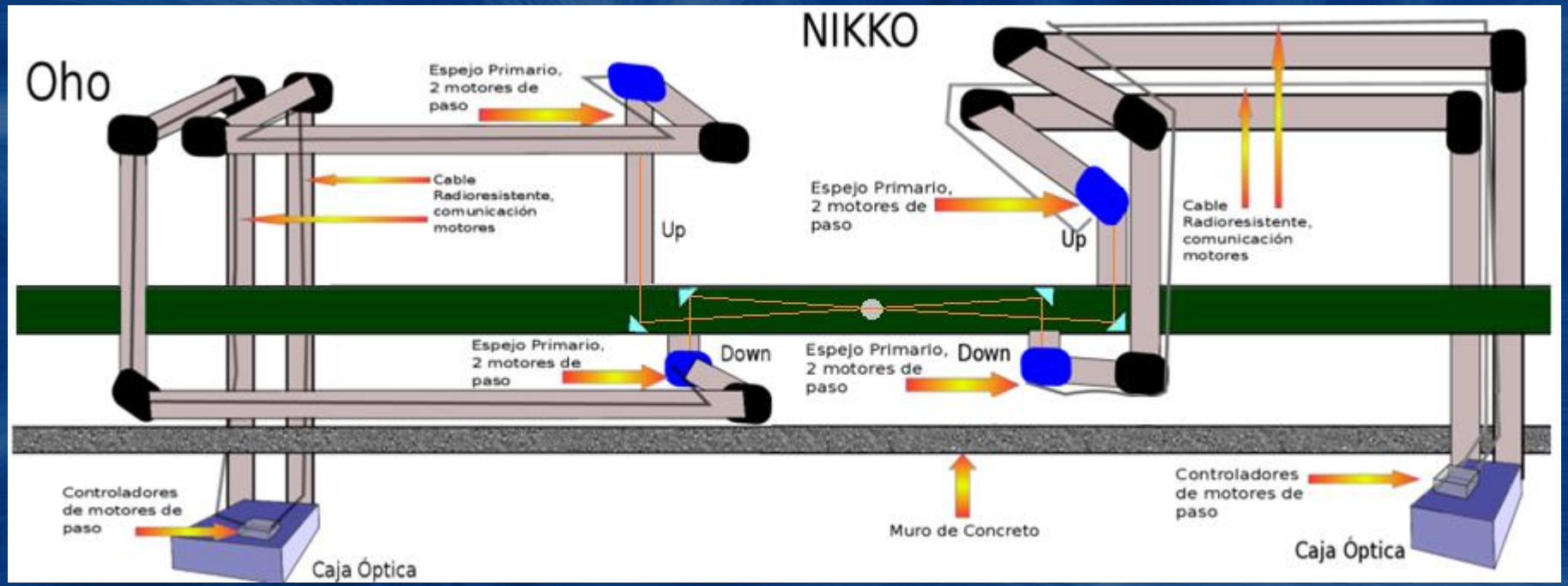
The synchrotron radiation is a type of light emitted by energetic relativistic particles that turn their direction because an interaction with an external magnetic field.



The first approximation of the synchrotron radiation power is as follow.

$$P_s = C_0 I_1$$

Experimental Setup of the LABM

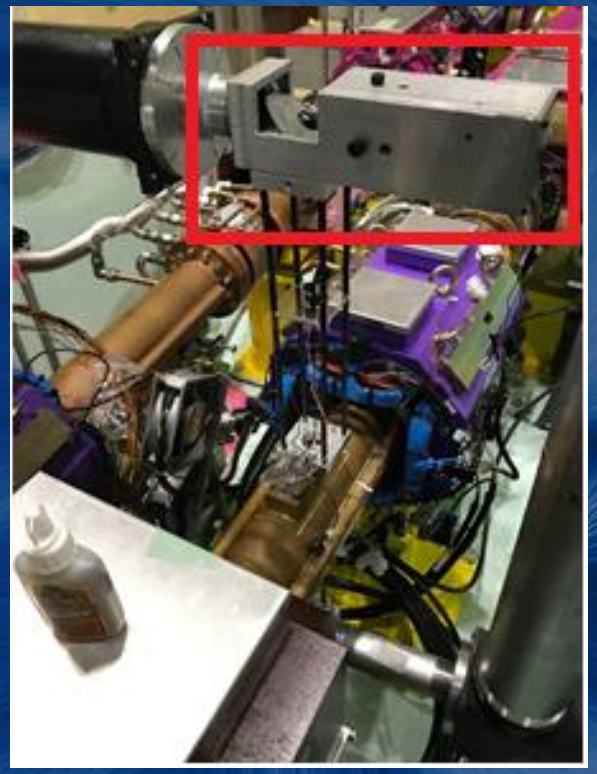


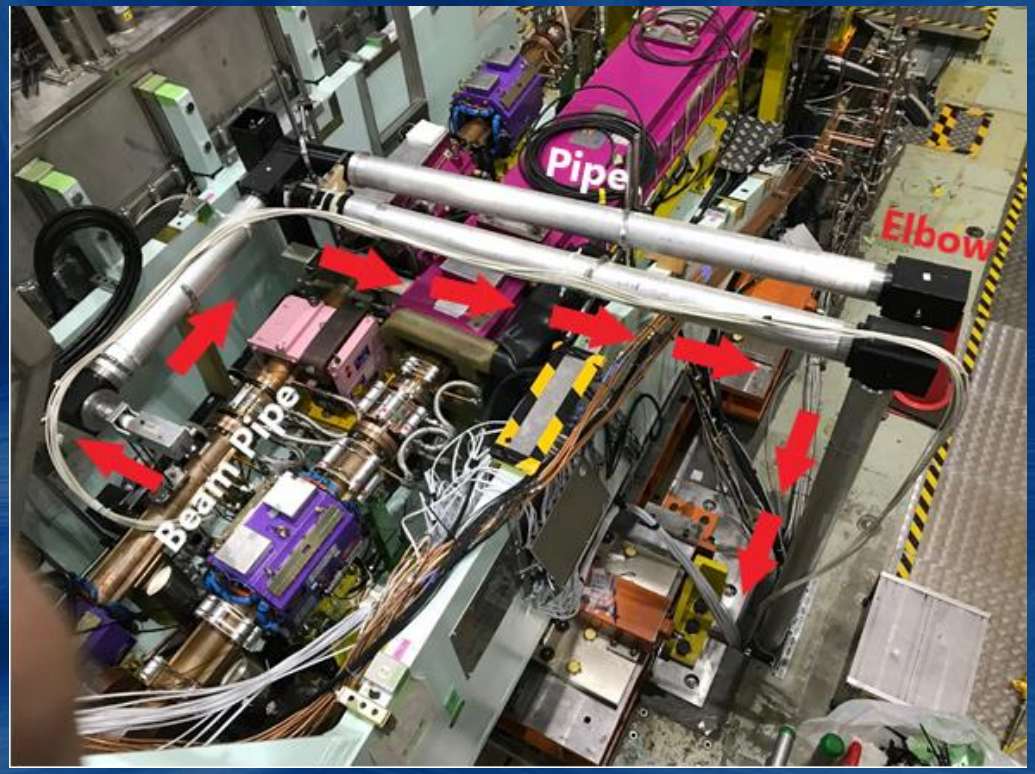
[6]

General scheme of the “Large Angle Beamstrahlung Monitor” (LABM). This is a scheme that shows the different components of the LABM.

[6] S. Doeg. Monitor de haz (e+ e-) labm en belle ii. 2016.

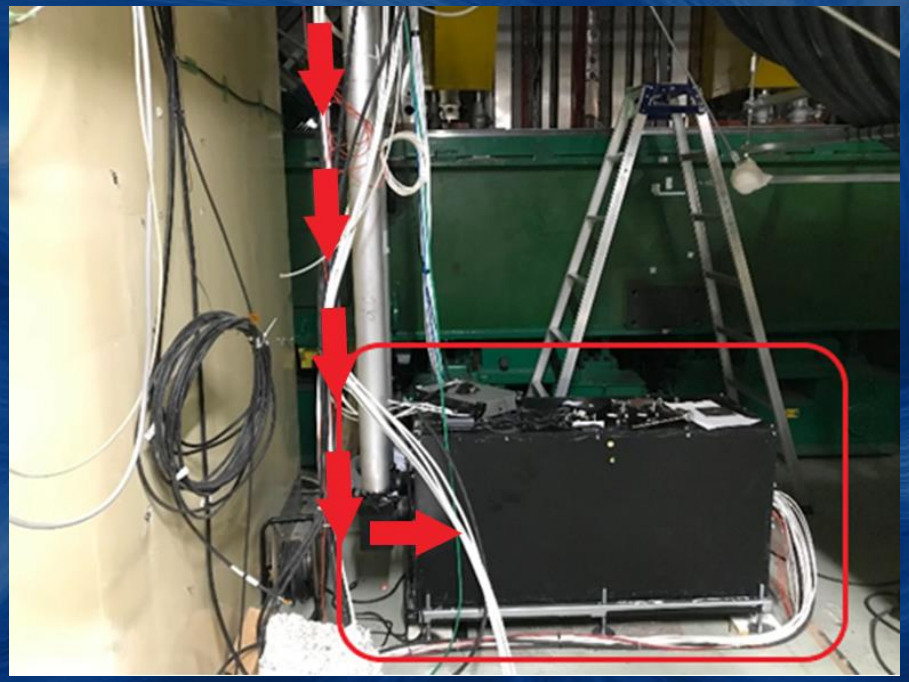
Components of the LABM

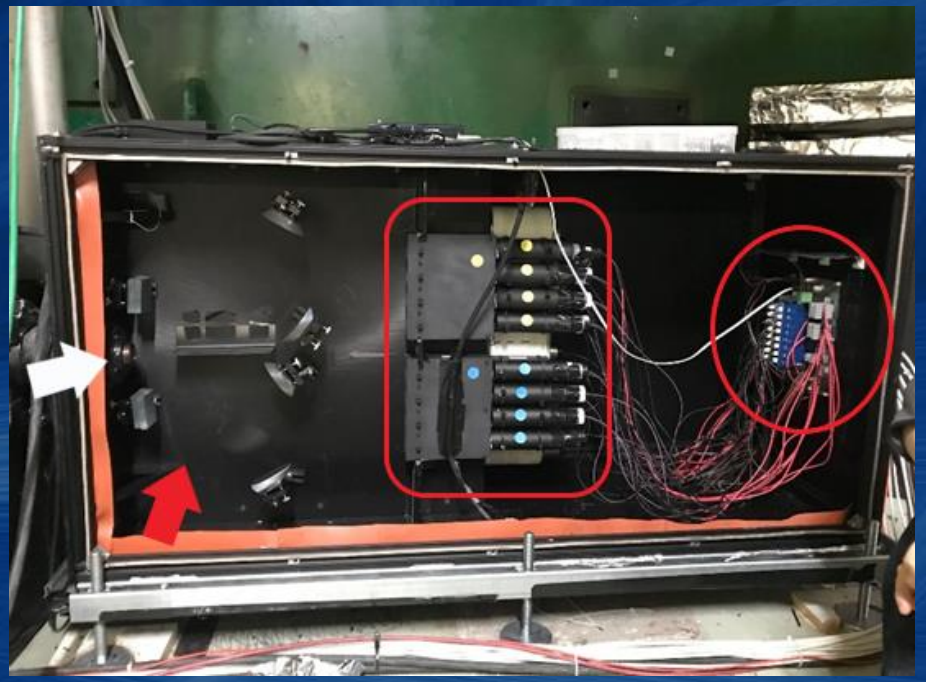




LABM components. In the left image there is the beam pipe windows, the primary elbow and the primary mirror. On the right image the optical path is shown.

Components of the LABM

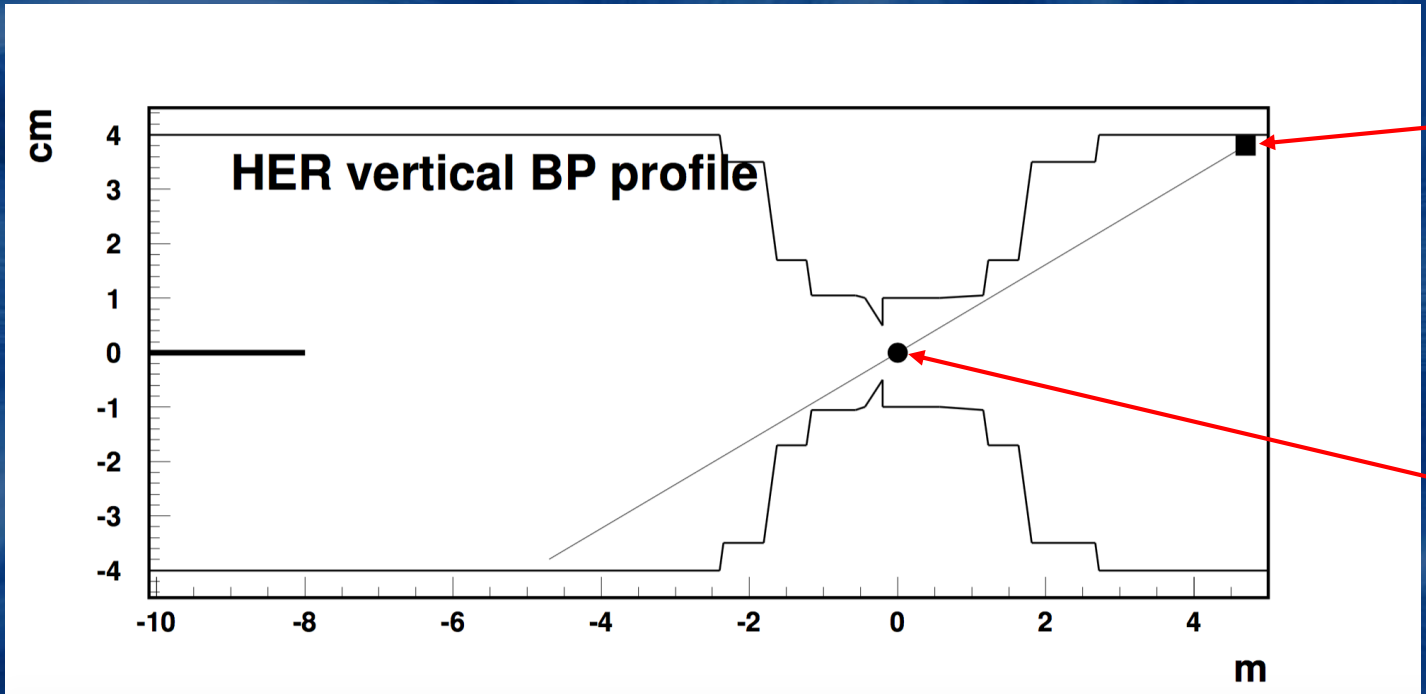




LABM components. On the left image is the final part of the optical path where it connects to the optical box. On the right image the internal components of the optical box are shown.

LABM Simulation

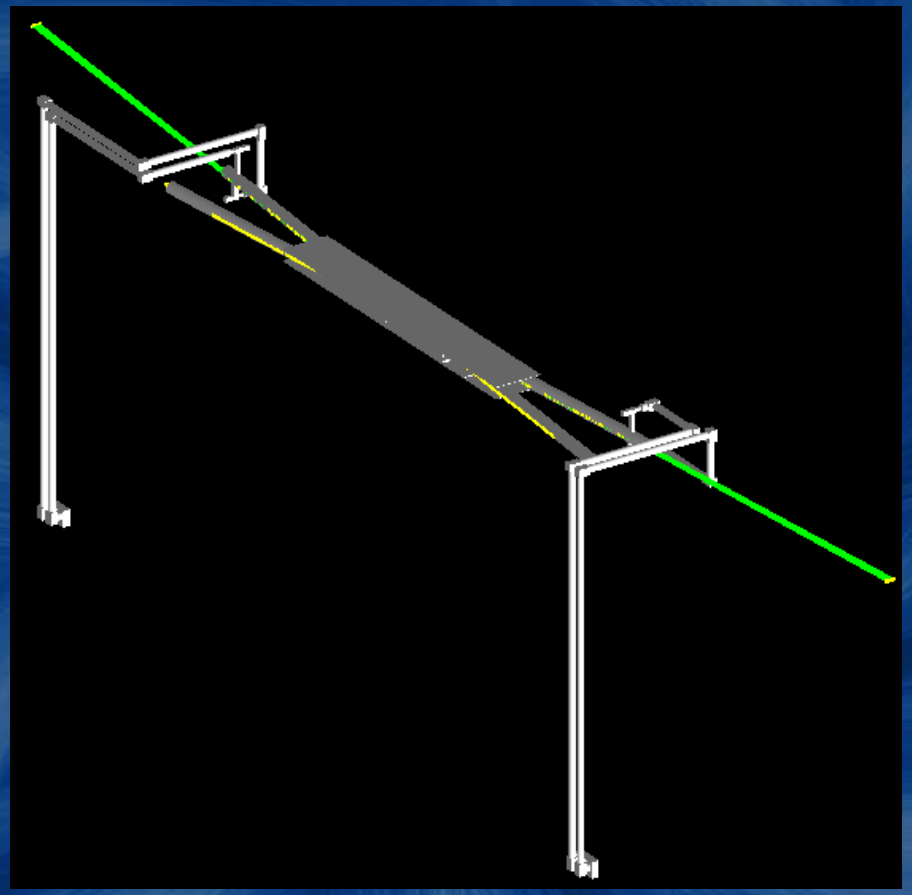
The LABM simulation was developed on Geant4.



Beryllium mirror

Interaction Region

Simulation Configuration



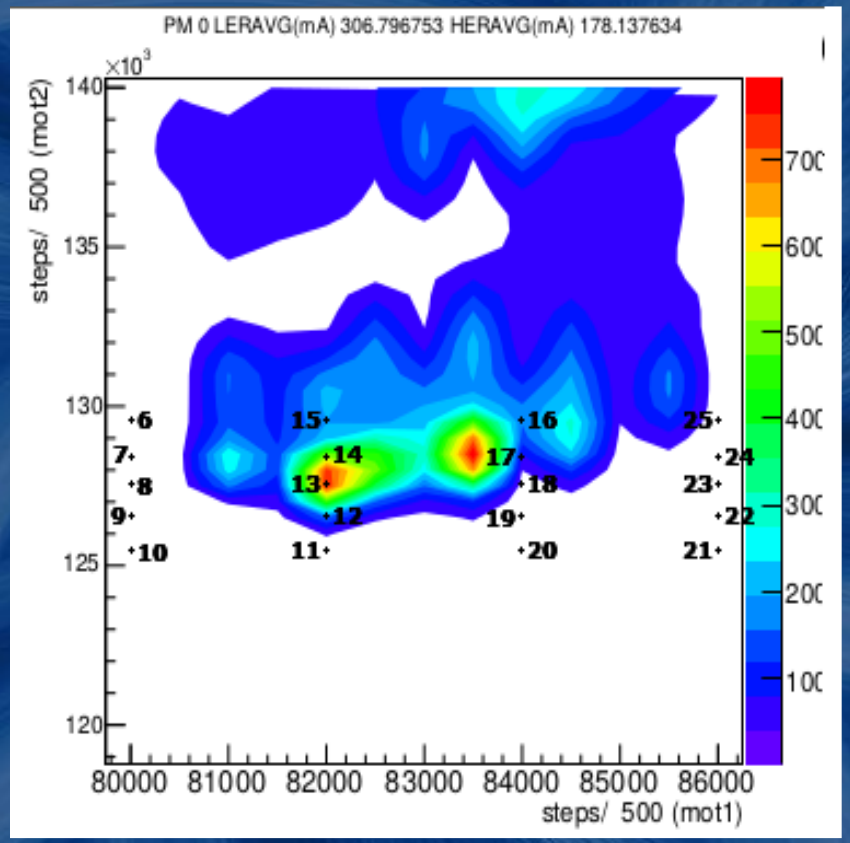
Simulation of the four optical paths of the LABM.

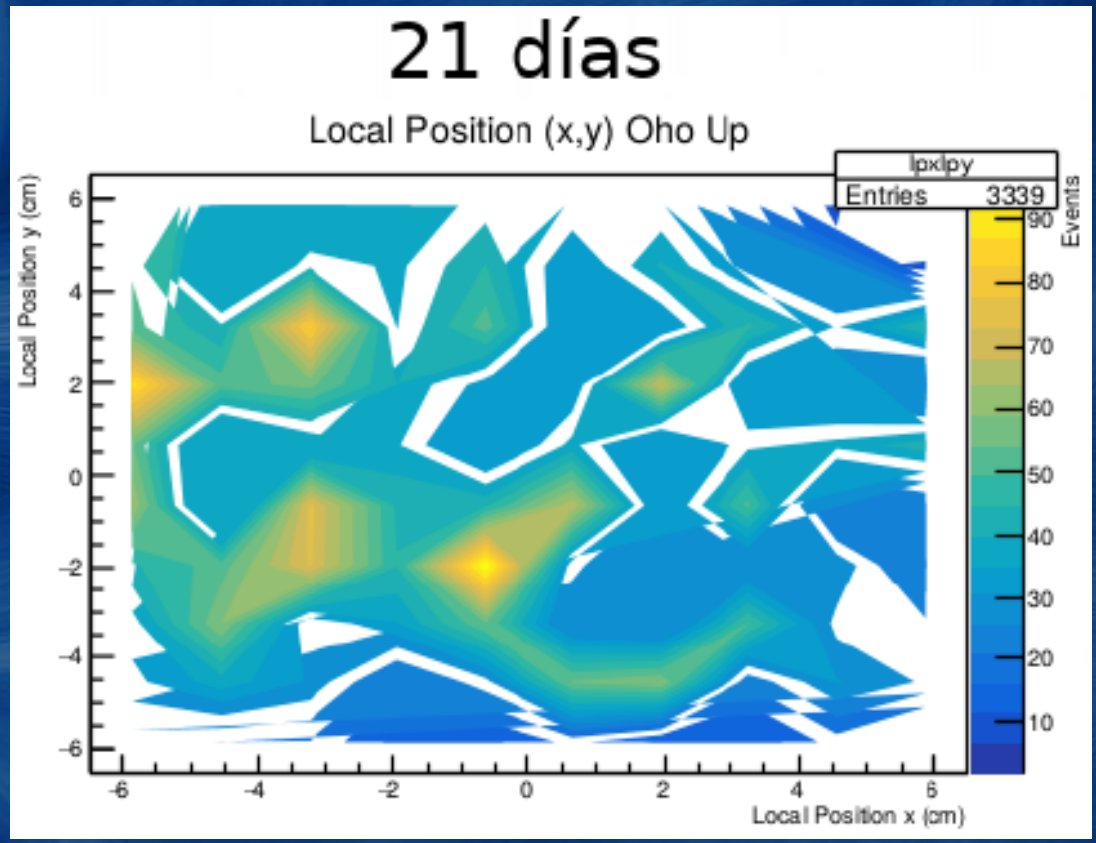
The intention of the simulation is to understand the background noise of the LABM, in particular the synchrotron radiation.

The real measures of the detector where used for the simulation

Simulation Results

Peaks of synchrotron radiation were found on the simulation, showing similar structures as in the LABM results.





Pedestal Analysis

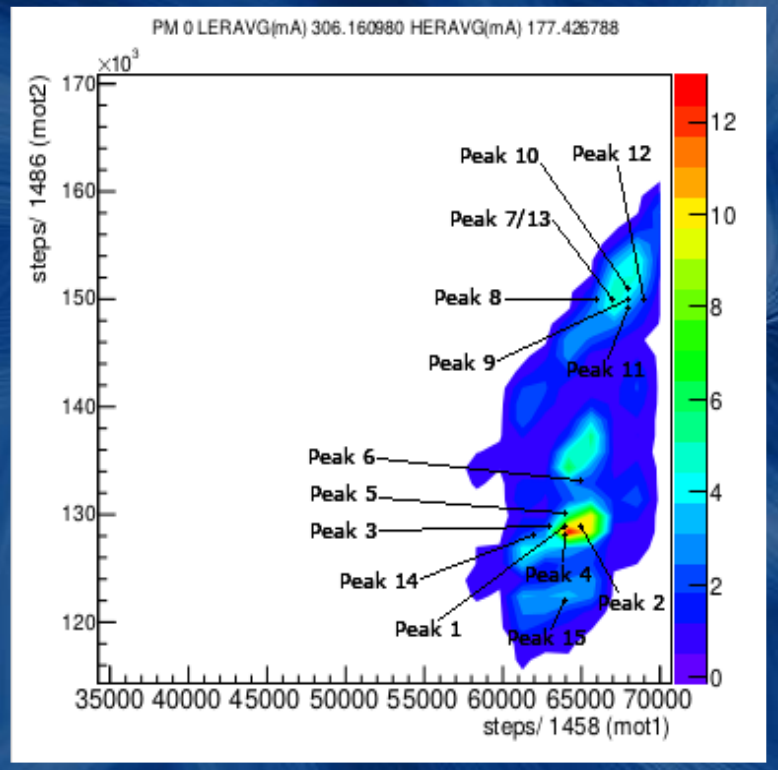
During the pedestal data taking the beam current was not zero, it was oscillating around zero.

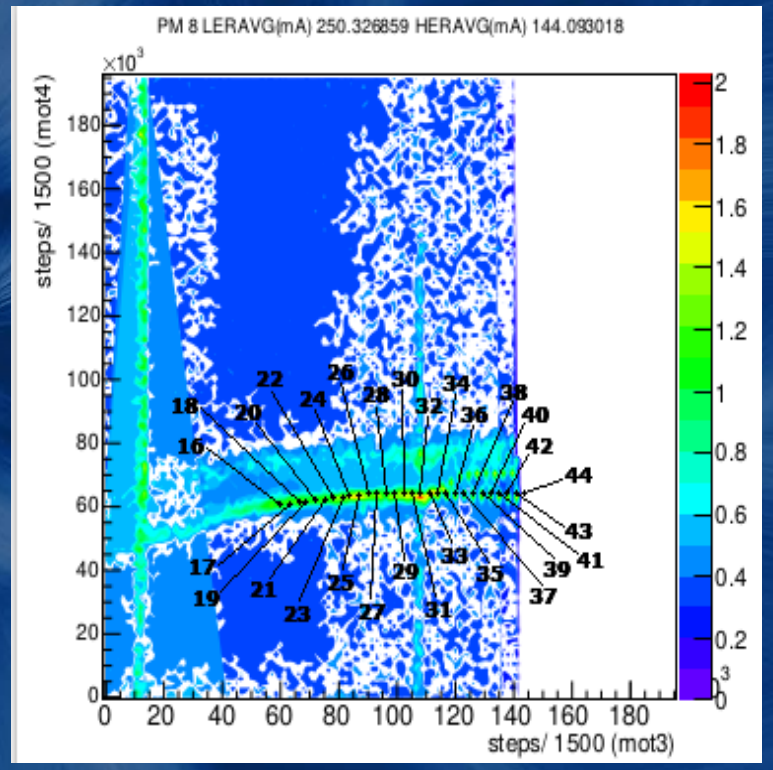
A cut in the current on the pedestal data was determined.

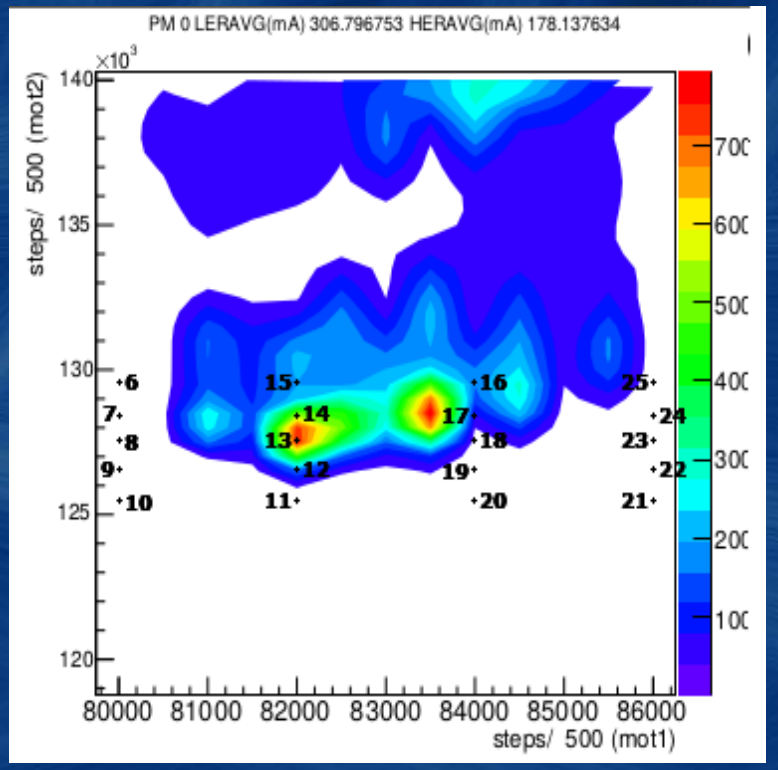
Haz	Media (mA)	Sigma (mA)	Limite inferior (mA)	Limite superior (mA)
LER	-0.005	0.0096	-0.0338	0.0238
HER	-0.055	0.0179	-0.1087	-0.0013

Scans 2019

All the different peaks of high power must be studied to determine if its synchrotron or beamstrahlung radiation.

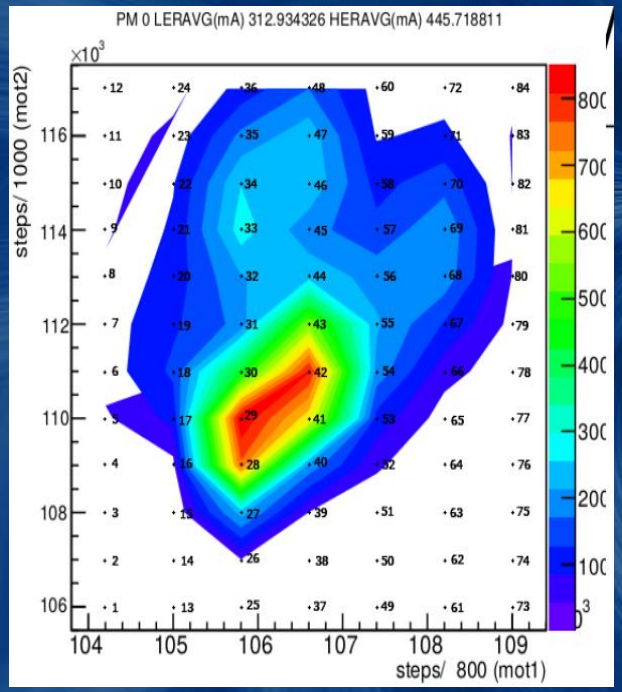


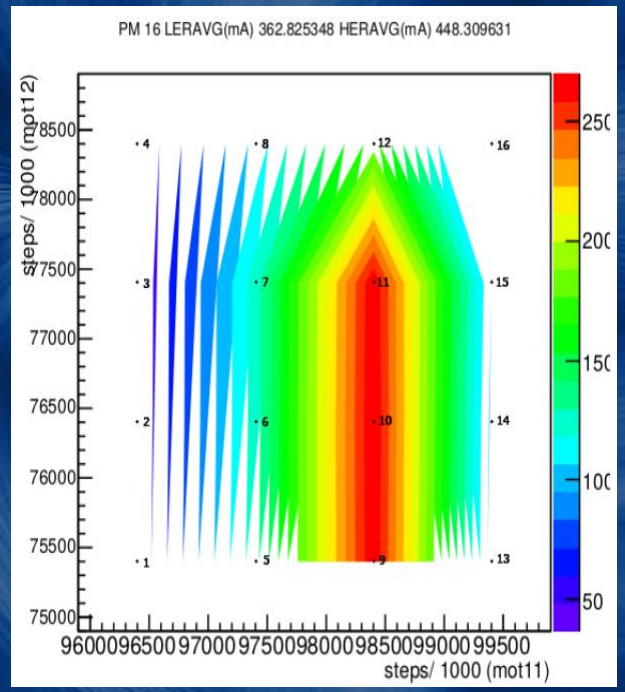


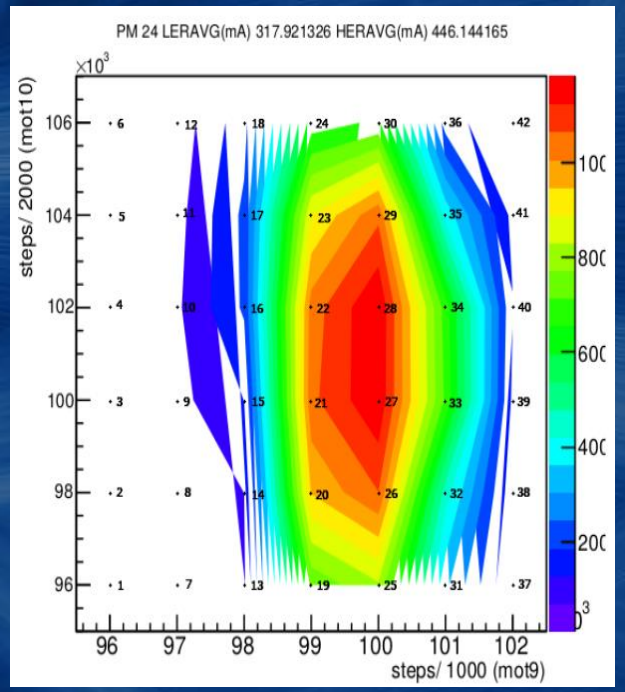


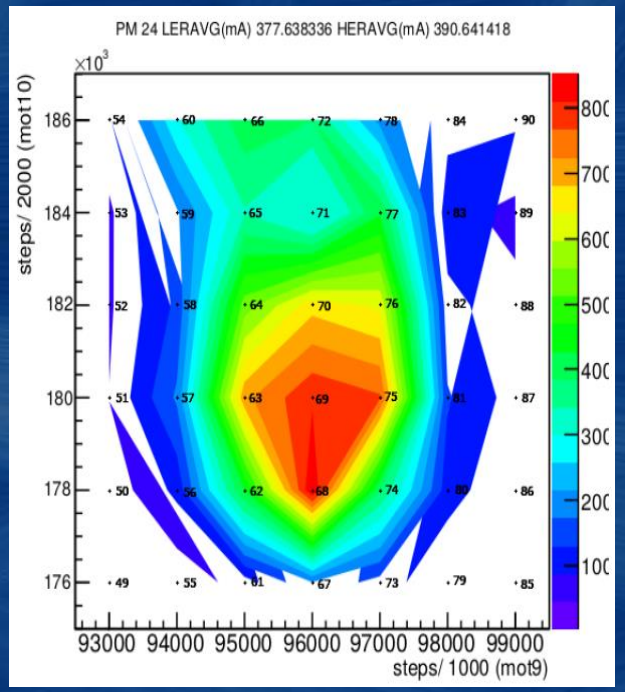
Scans 2020

For 2020 data, a point mesh around the high power peaks was implemented to observe the difference between high and low power points. Two different regions of the Nikko Up channel were studied.









Analysis Results

Using the first approximation of the synchrotron and Beamstrahlung radiation the next function is obtained

$$P = P_s + P_{bs} = C_0 I_1 + C_1 I_1 {I_2}^2$$

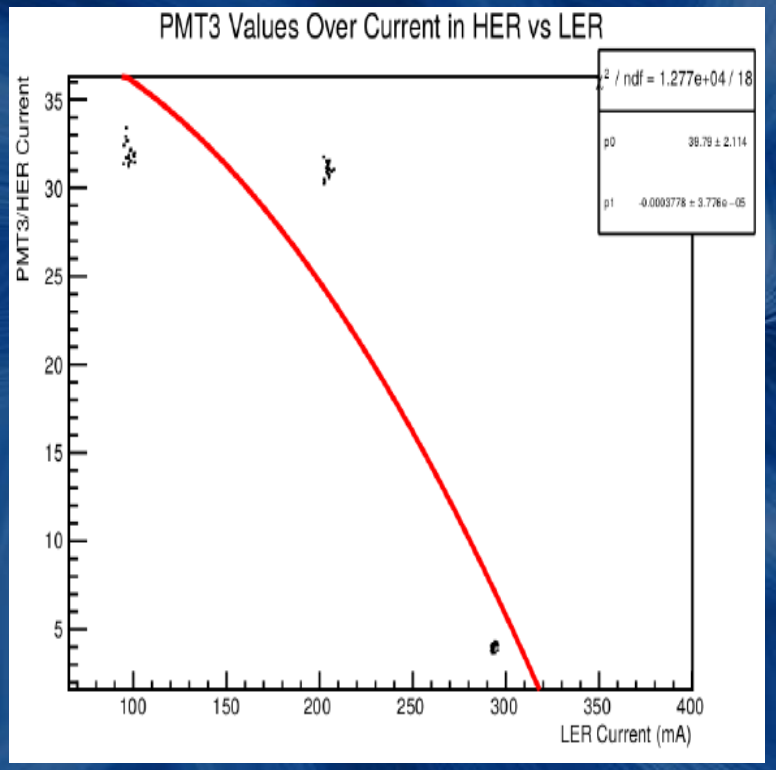
Normalizing this function with respect to I_1

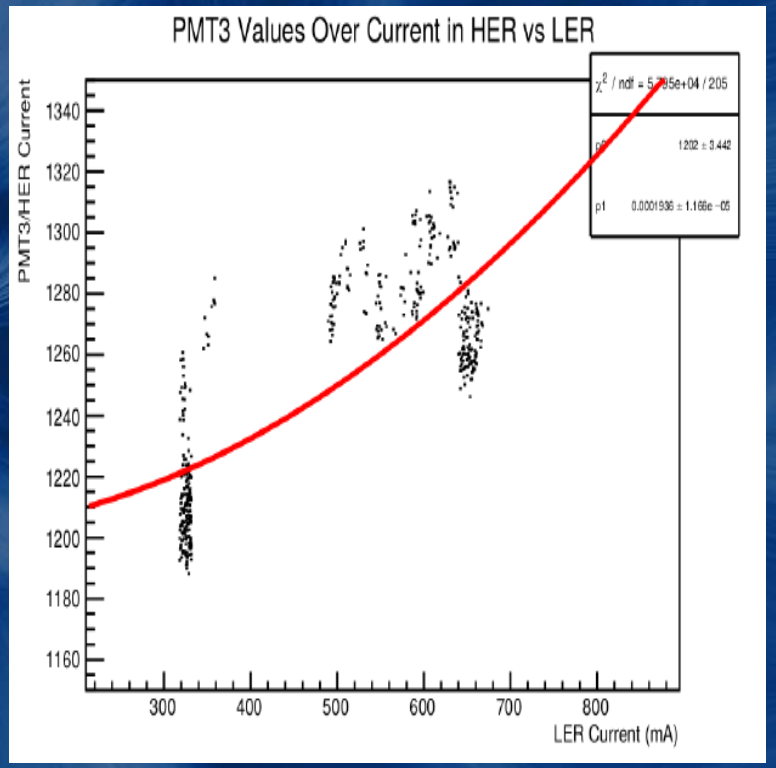
$$\frac{p}{I_1} = C_0 + C_1 {I_2}^2$$

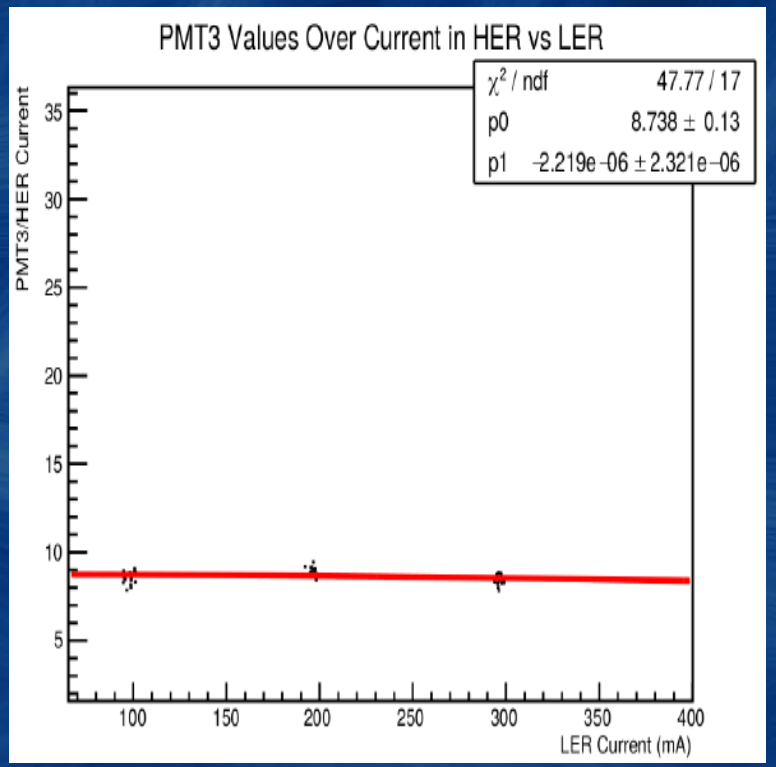
Where C_0 is associated to synchrotron radiation and the $C_1 {I_2}^2$ term to the beamstrahlung radiation.

Analysis Results 2019

Three results were obtained using this adjustment to the 2019 data, where most of the results have a constant adjustment and a few of them gave a quadratic adjustment.

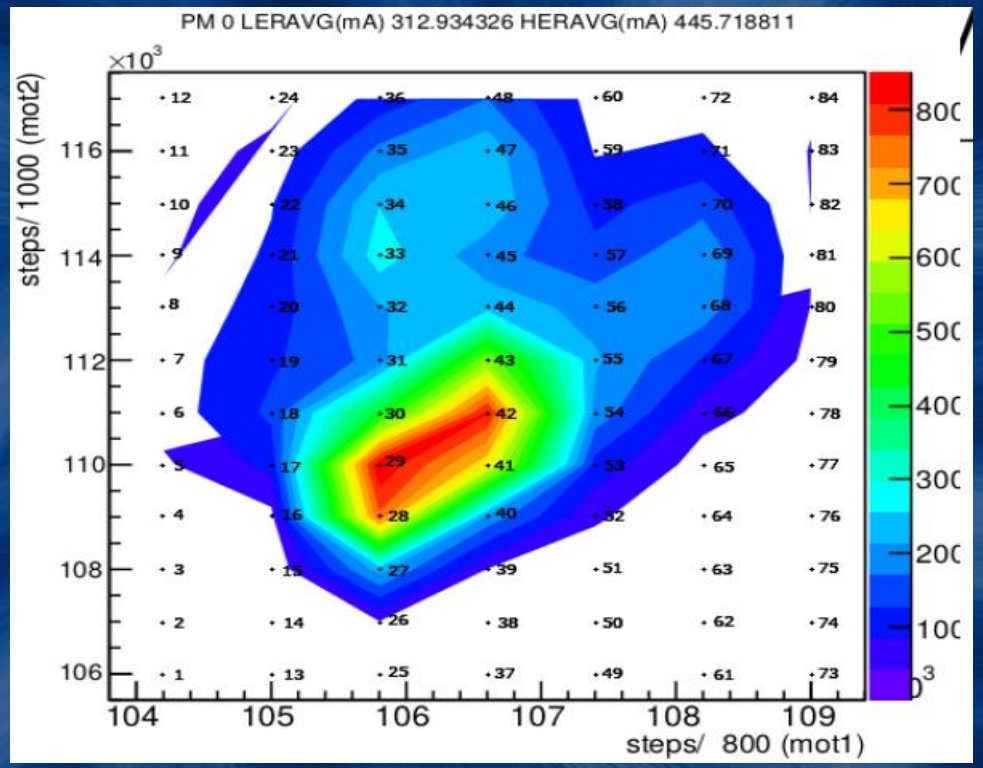


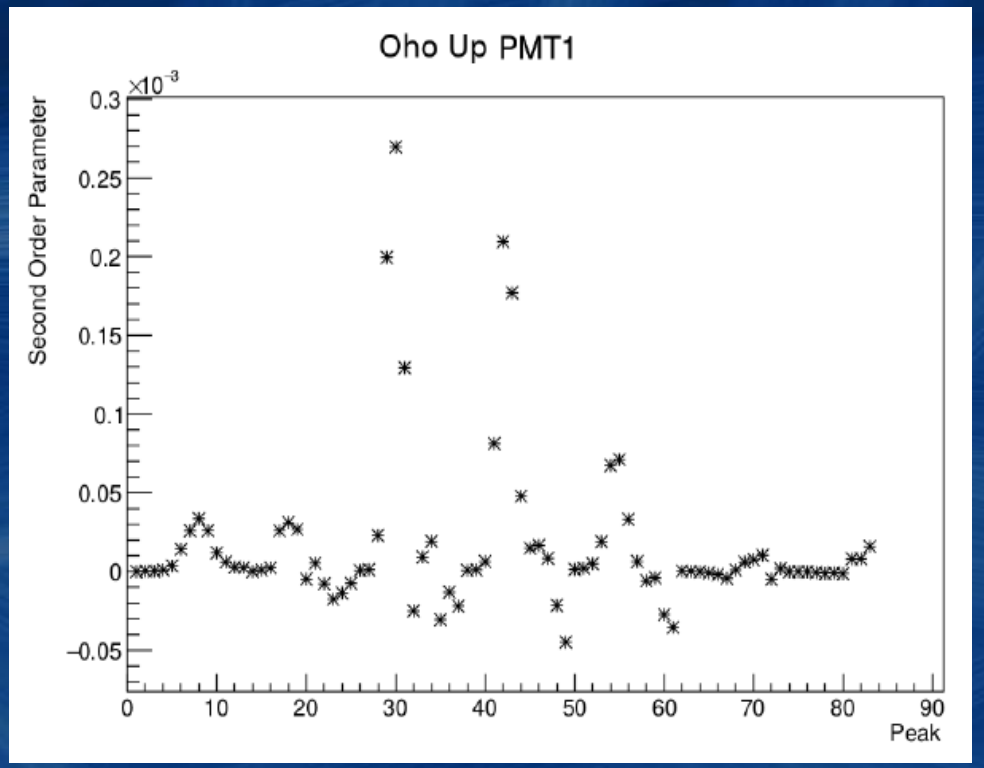




Analysis Results 2020

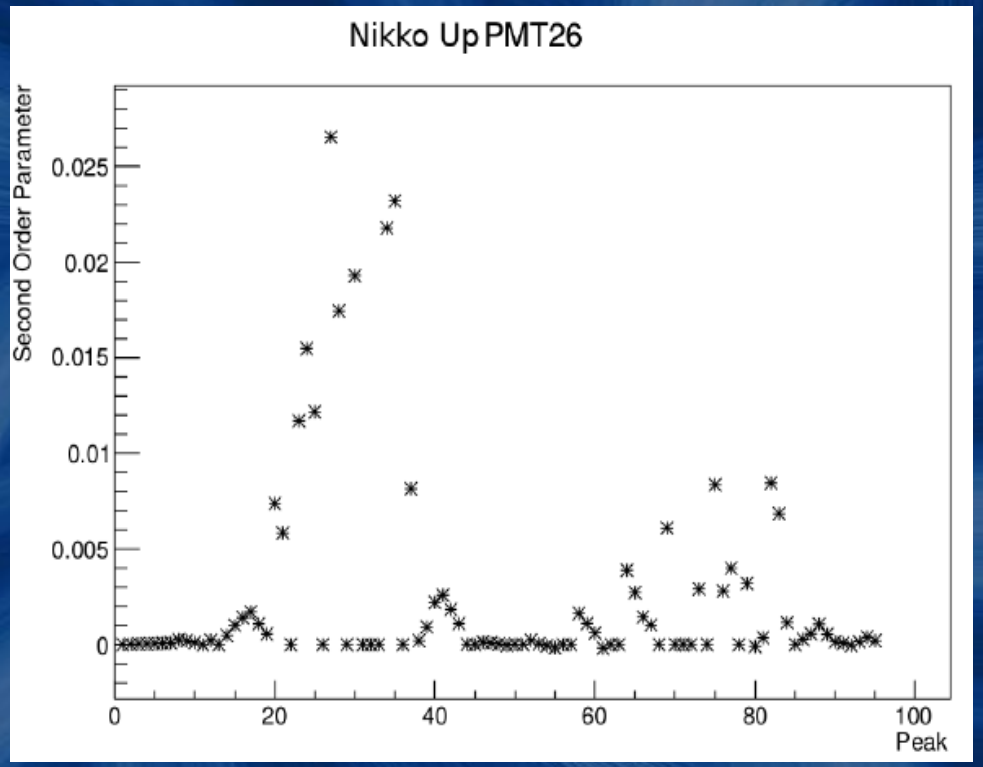
The second order parameter of the adjustment shows a difference of two orders of magnitude between the high power points and the low power points.

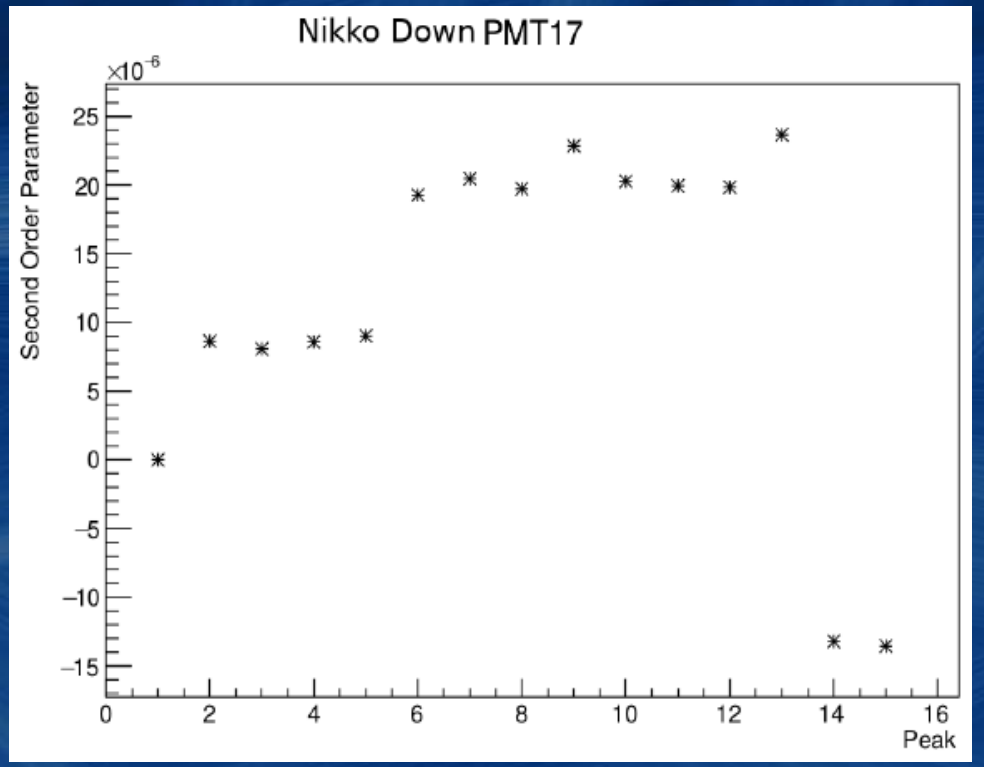




Analysis Results 2020

The same behavior can be seen on the Nikko Up channel, but not in the Nikko Down channel. This is because the Nikko Down channel is a “false peak”.





Conclusions

The simulation allowed us to understand how the synchrotron radiation behave in the LABM experiment.

The data analysis from 2019 allowed us to understand the behavior that data should follow.

The data analysis from 2020 allowed us to stablish a methodology to differentiate synchrotron radiation peaks from beamstrahlung peaks by looking to the different values of the second order parameter of the adjustment.

Conclusions

In summary

- Thanks to the simulation we now know that the “false peaks” are from synchrotron radiation.

- A methodology to determine if the radiation peaks are from synchrotron or beamstrahlung radiation was developed.

Work Perspective

- Change of the design of the LABM components for an easier installation and manipulation of the detector.

- Add the beamstrahlung effect to the simulation.

- Correlate other parameters of the beam monitors with the LABM data