ML for luminosity maximization

(IP8 optics tunning with crossing angle and short vertex)

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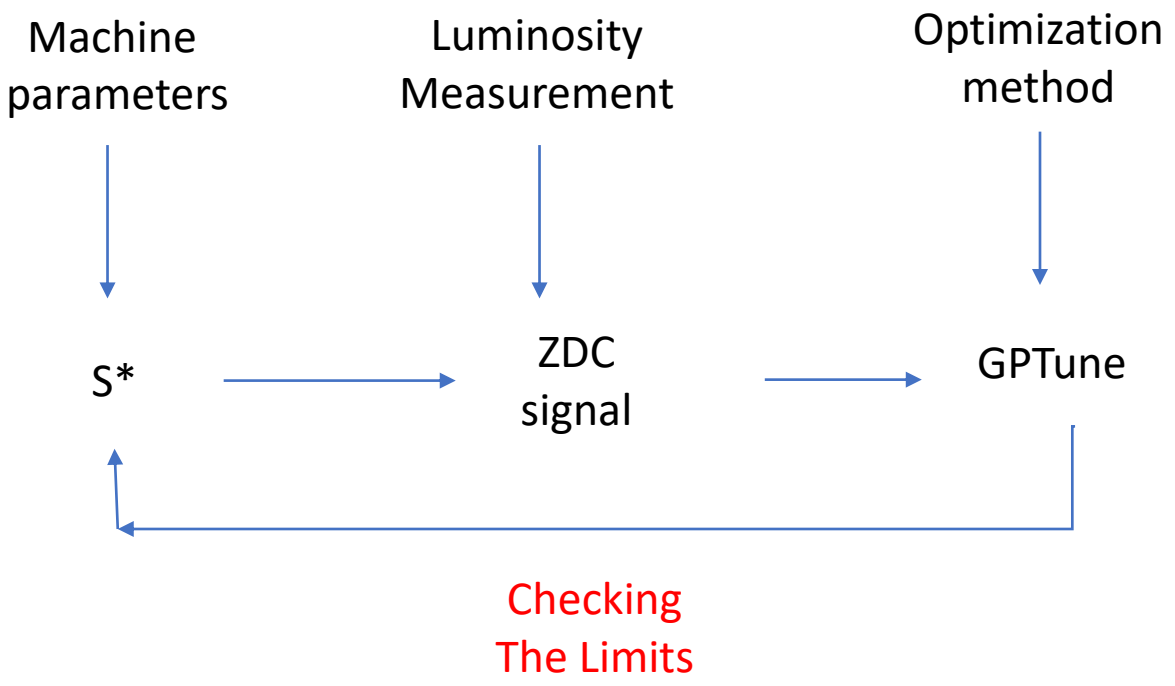
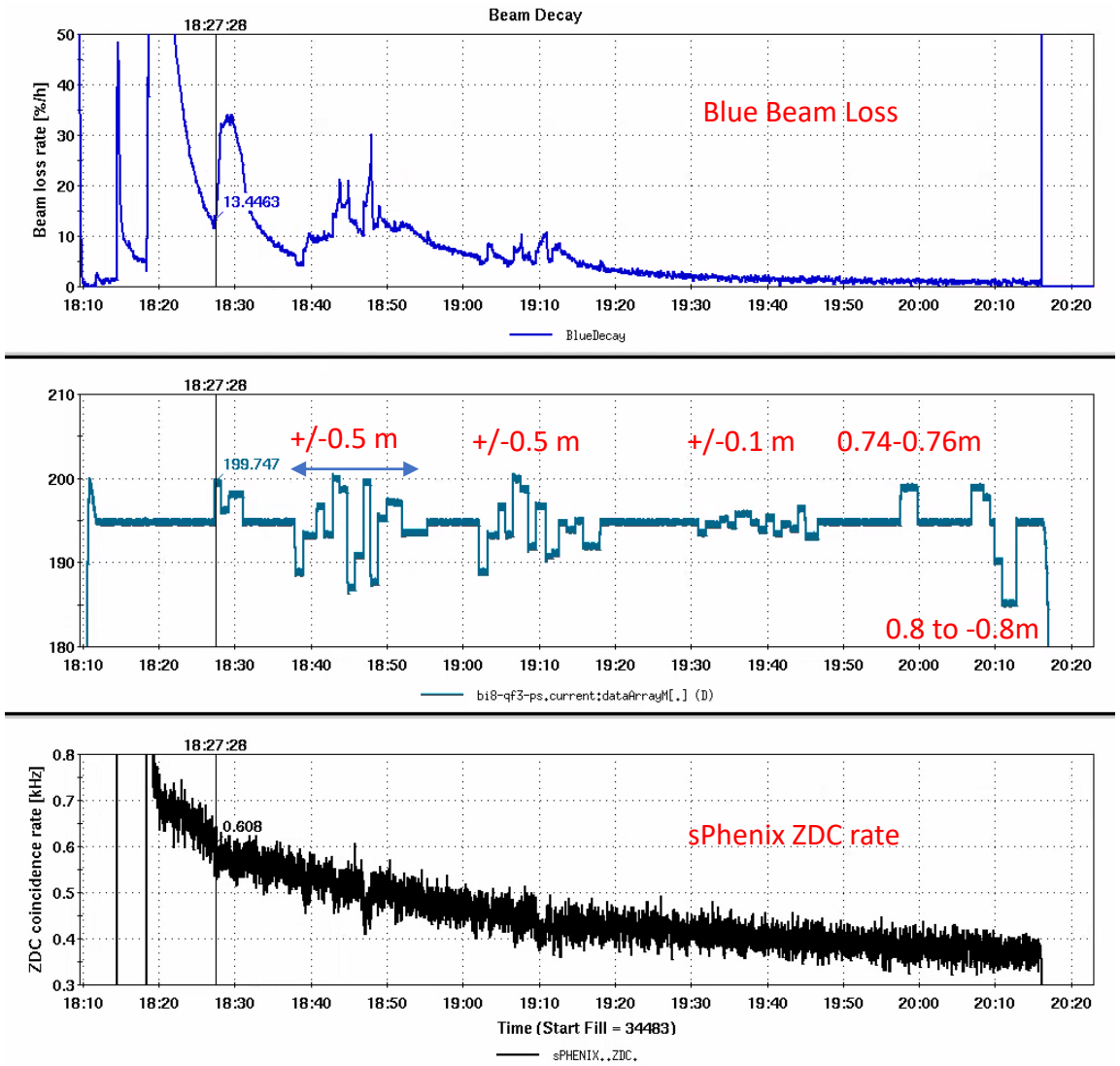
APEX 0516



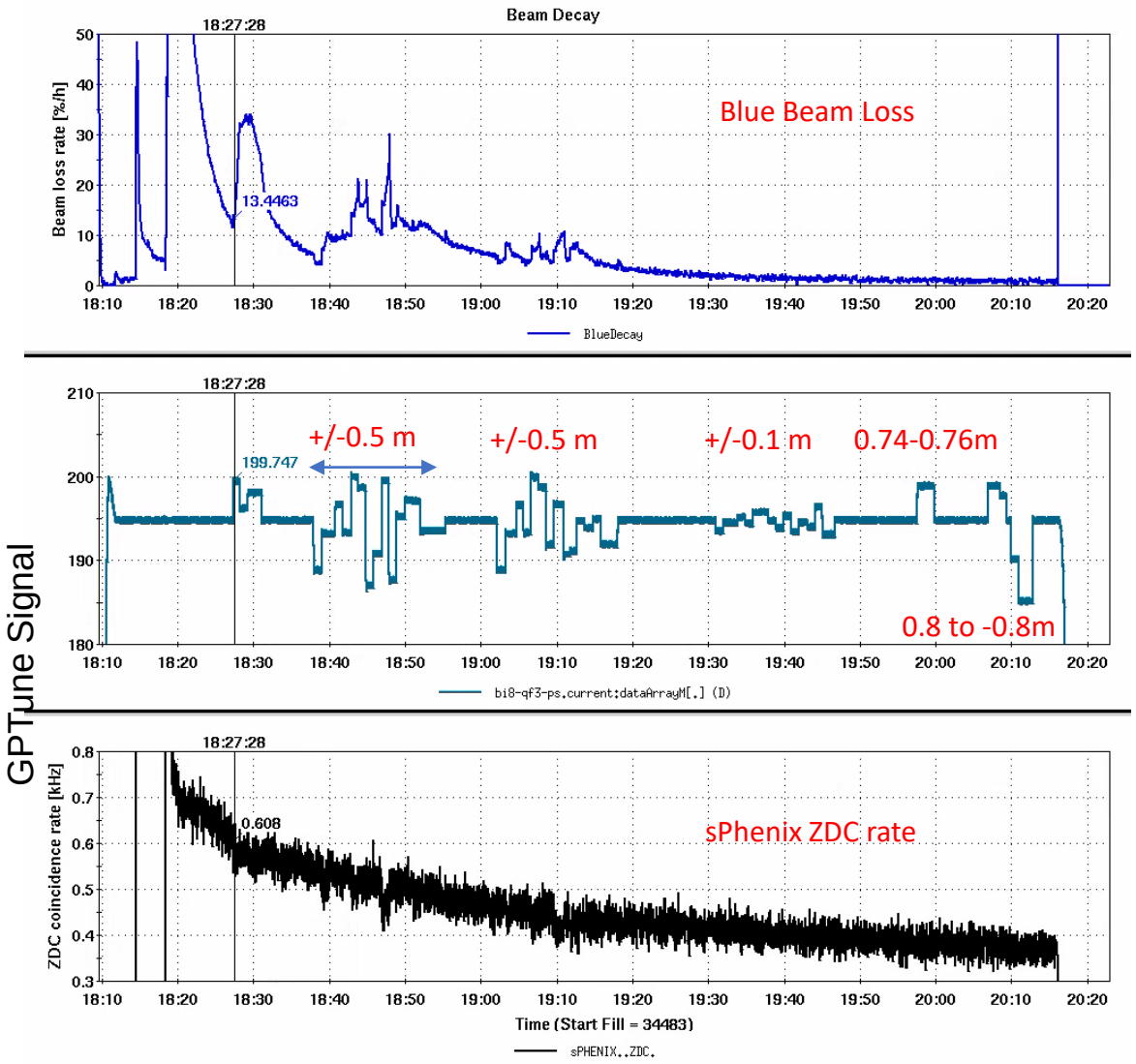
- The optimization loop was tested on 05/15 with 0 ZDC
- Used during APEX time, after changing store name.
- 17:30 PM – 18:25 PM
- 18:25 PM – 20:13 PM
- 28x28, 1.5E11 store, blue beam
- 15 iterations, IP8, 2mrad

APEX 0516

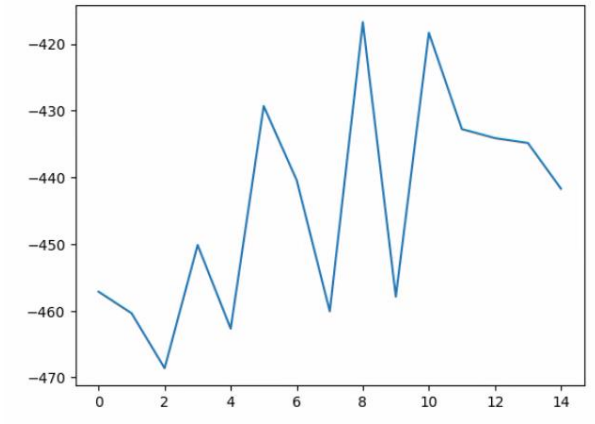


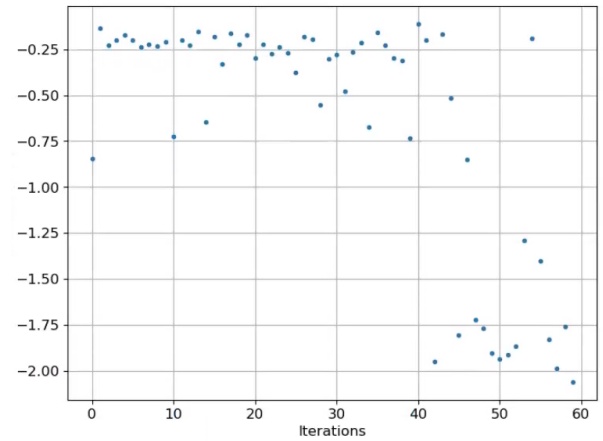
- S*: +/-0.5 m without decay compensation
- S*: +/-0.5 m.
- S*: +/-0.1 m.
- S*(x plane): 0.74-0.76m.
- S* (x plane): 0.8m->0.4m->0m->-0.4m->-0.8m.
- S* > 0.8 m, MADX didn't find solutions.

APEX 0516



- Beam loss is acceptable.
- ZDC rate was changed. Didn't see any visible improvement.
- 20% SN, with +/- 0.8m, it is expected 17% change for ZDC rate.
- GPTune works with std ±10% (pp) noisy signals! ±15%





1) Preliminary Plan

1. Check beam loss at IP6: changing s* within +/-0.5 m, at store; manually.

2. Check optimization script at IP6: with GPTune and ZDC signal, detector OFF

3. Optimization at IP6: Vertex signal, 30 s and +/- 1.5 meter (can be changed to any). Currently "cdevCommand starVertex.Z get mean"

4. Repeat above for IP8.

2) Machine setup

1) Beam Type (proton, Au, …): Proton
2) Beam Energy (100 GeV): Store
3) RHIC Rings to Be Used: Blue
4) Ramp Name : pp24-100GeV-s0::store
5) Buch Filling Pattern: 28 bunches
6) Bunch Intensity: 1.0e10
7) Other Beam Conditions: nominal operation store
   with 1 mrad crossing angle at IP6 and 2 mrad at IP8
8) Regular Machine Settings to Be Altered:

4) Beam Loss Check IP6

1) 28 bunches and ramp to store
2) Orbit feedback OFF
3) change s* = 0.5 m at IP6 in the file, X plane then Y
3) run madx file to create IP6 trim strength
5) sent the strength to the rampeditor
6) activate it
7) check beam loss/optics measurement
8) Repeat above for -0.5 m or others
9) Check 0.6 ->0.8 m check loss

S* and beta* changing scripts: Tested

1. change the target s*, beta* within ‘deltas.dat’ file;
2. run ‘madx job.madx_Au16-e0::store’ command, will get ‘IP8knob.dat’ file;
3. run ‘CreateSend.IP8’ command, will get ‘SendTrim.IP8’ file;
4. run ‘SendTrim.IP8’ command.

5) Check optimization script

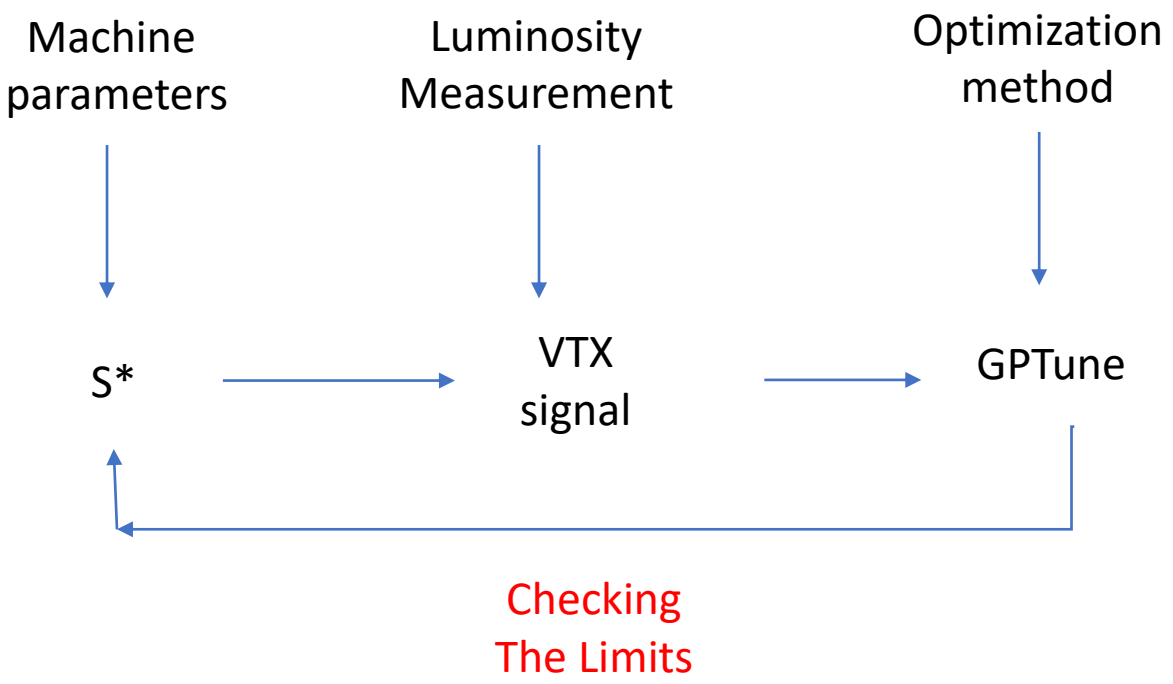
1) Copy all madx file to the GPTune folder (before APEX)
2) run the script for 10~20 iterations
3) Monitoring the RampEditor and activate it for each iteration
4) Wait activate RampEditor (30 s)
5) ZDC signal (10 s)

5) Resource and Collaboration

- BNL: CAD support, Run coordinator, control, operator, RF and AP group
- MSU: Yue Hao, Will Fung
- LBNL: Ji Qiang, Sherry Li, Yi-Kai Kan

Backup Slides

4) Online Luminosity Optimization



S* and beta* changing scripts: ready for testing:

1. change the target s*, beta* within ‘deltas.dat’ file;
2. run ‘madx job.madx_Au16-e0::store’ command, will get ‘IP8knob.dat’ file;
3. run ‘CreateSend.IP8’ command, will get ‘SendTrim.IP8’ file;
4. run ‘SendTrim.IP8’ command.

Guillaume Robert-Demolaize.

GPTune is ready for test with scripts:

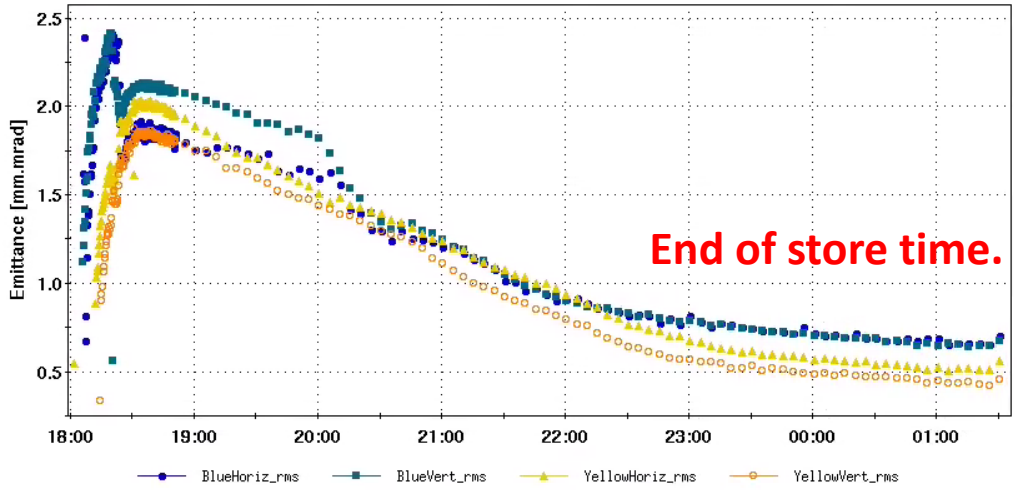
1. Installed and tested
2. Did optimization with Eq. as an input

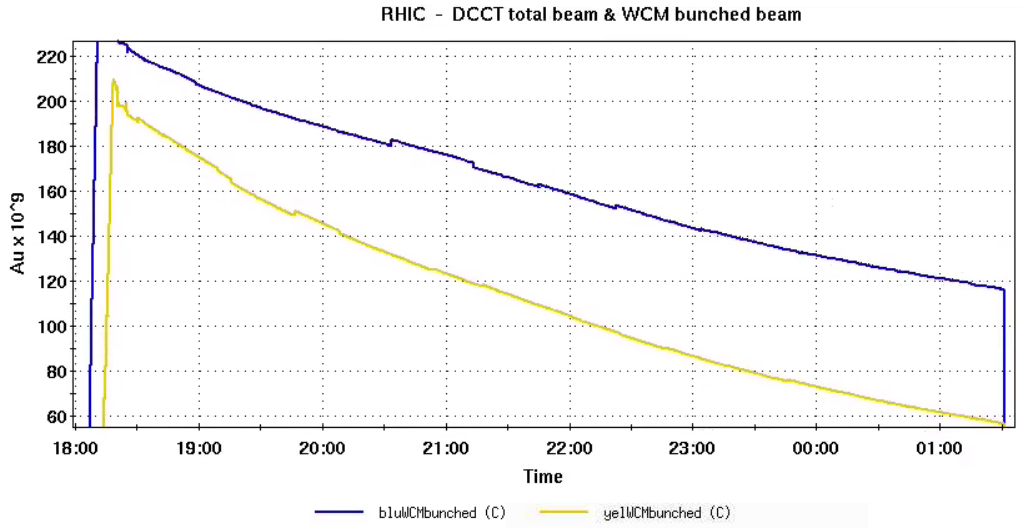
Vertex: contacted with sPHINEX people:

1. Did it with PHENIX before
2. Send the vertex data several ways.

5) Challenges

- Changing the Dispersion at IP
- Changing the optics around the ring
- The beam emittance is changing during the store

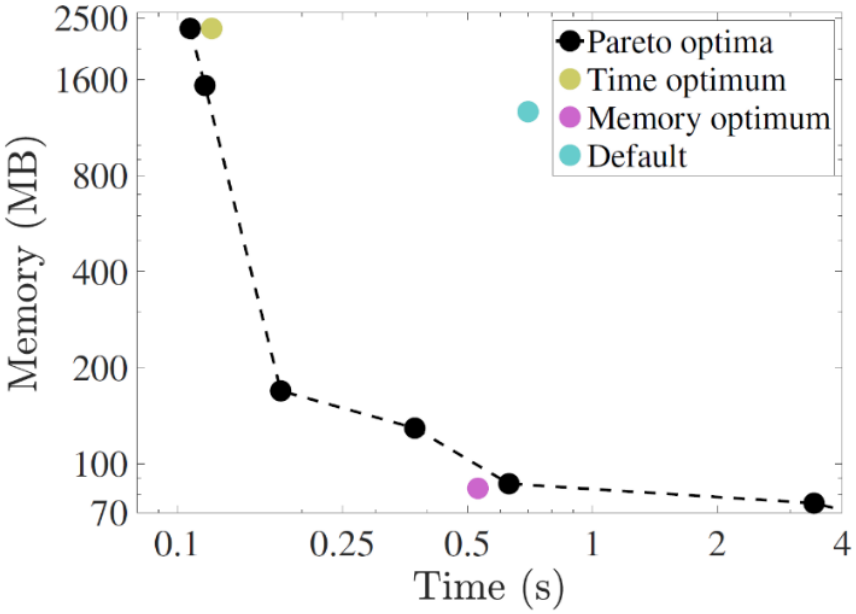




2) Bayesian optimization at LBNL GPTune

Several features of GPTune (BLNL) are very useful for HPC simulation codes, including:

(1) relies on dynamic process management for running applications with varying core counts and GPUs
(2) can incorporate coarse performance models to improve the surrogate model
(3) allows multi-objective tuning such as tuning a hybrid of computation, memory and communication
(4) allows multi-fidelity tuning to better utilize the limited resource budget
(5) supports checkpoints and reuse of historical performance database.



Application:
Conduct parameter optimization for several HPC codes. The most notable result is for the multiscale production-level full-blown simulation codes, M3D-C1 and NIMROD that are used in the fusion Tokamak design.

https://github.com/mkturkcan/GPTune
https://nimrodteam.org/meetings/team_mtg_5_21/nimrod_meeting_YangLiu.pdf

1) Motivation--RHIC luminosity Optimization

$$L = \frac{N_1 N_2 f H}{2\pi \sqrt{\sigma_{x1}^2 + \sigma_{x2}^2}\sqrt{\sigma_{y2}^2 + \sigma_{y2}^2}}$$

- Global Parameters:

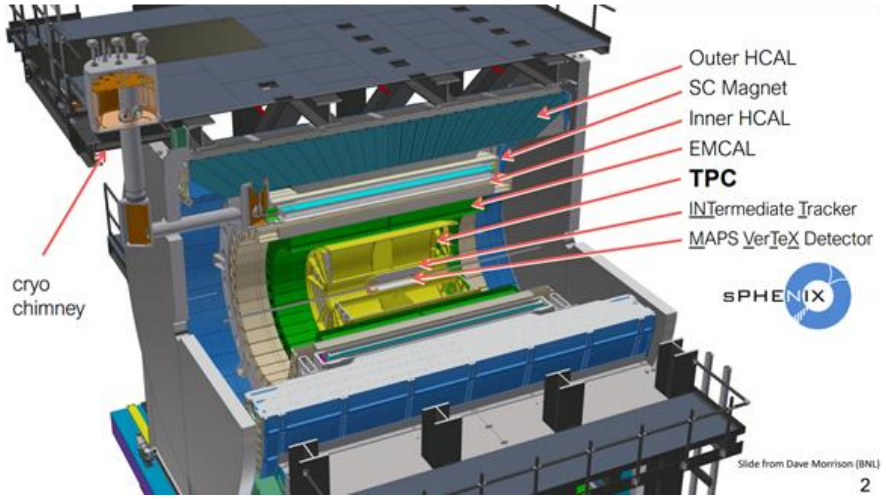
1. Orbit (Dipole)
2. Tune (Quadrupole),
3. Chromaticity (Sextuple)
4. Octupole

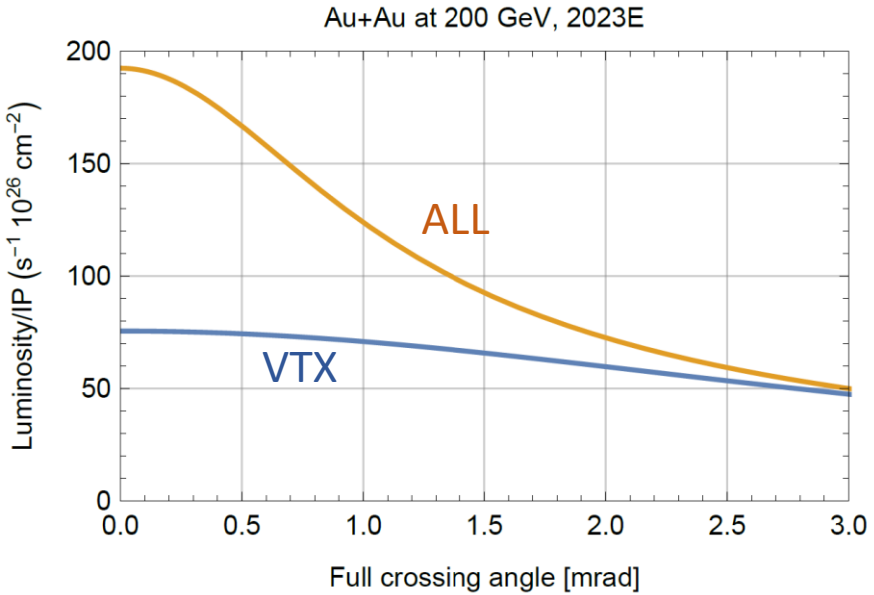
- Local (IR8) Parameters:

1. Beta*
2. S* (more sensitive than head on)
3. Transverse offset

- Other Parameters:

1. RF Voltage
2. Collimator Position





Courtesy of W. Fischer

- sPHENIX:

1. VTX (+/-10 cm)
2. Crossing angle (2mrad)
3. S/N - Background