

ML for luminosity maximization

(IP8 optics tuning with **crossing angle** and **short** vertex)

X. Gu, G. Robert-Demolaize, V. Schoefer, Y. Hao, W. Fung, J. Qiang,
S. Li, Y. Kan

May 5, 2023

Outline:

1) Motivation

2) GPTune for optimization

3) Preliminary Plan

4) Others

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:

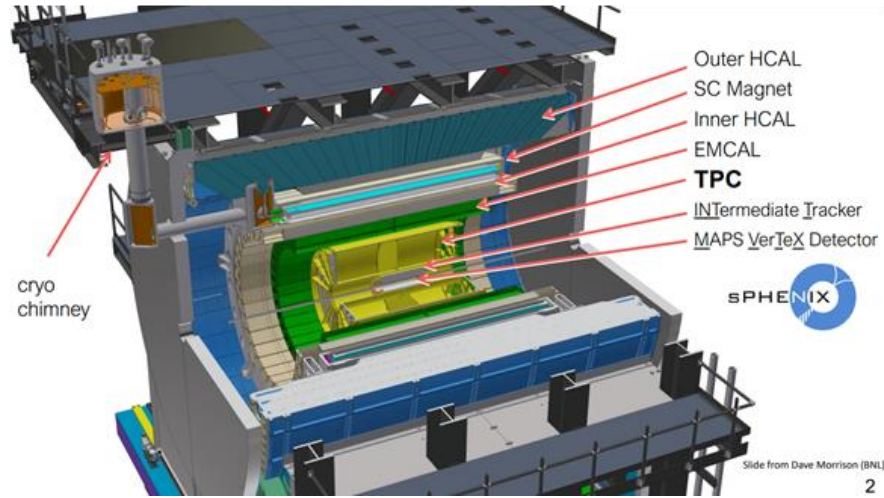
1. Orbit (Dipole)
2. Tune (Quadrupole),
3. Chromaticity (Sextuple)
4. Octupole

- Local (IR8) Parameters:

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

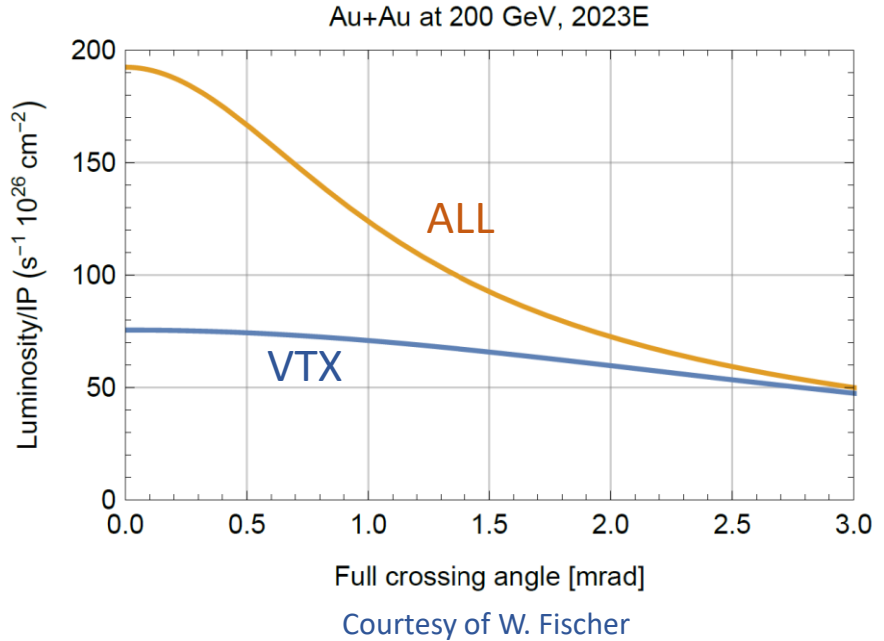
- Other Parameters:

1. RF Voltage
2. Collimator Position



- sPHENIX:

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



2) Bayesian optimization at LBNL GPTune

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

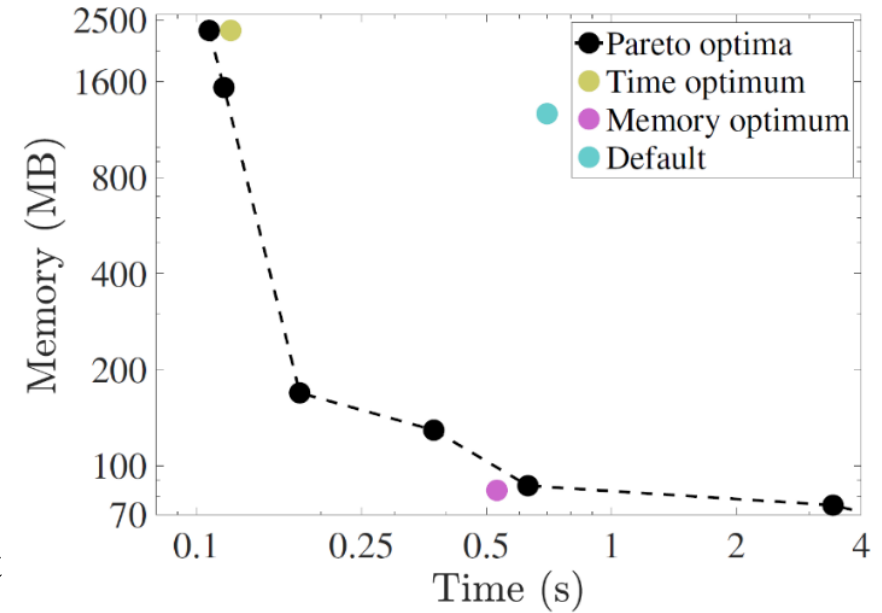
- (1) relies on dynamic process management for running applications with varying core counts and GPUs
- (2) can incorporate coarse performance models to improve the surrogate model
- (3) allows multi-objective tuning such as tuning a hybrid of computation, memory and communication
- (4) allows multi-fidelity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

Application:

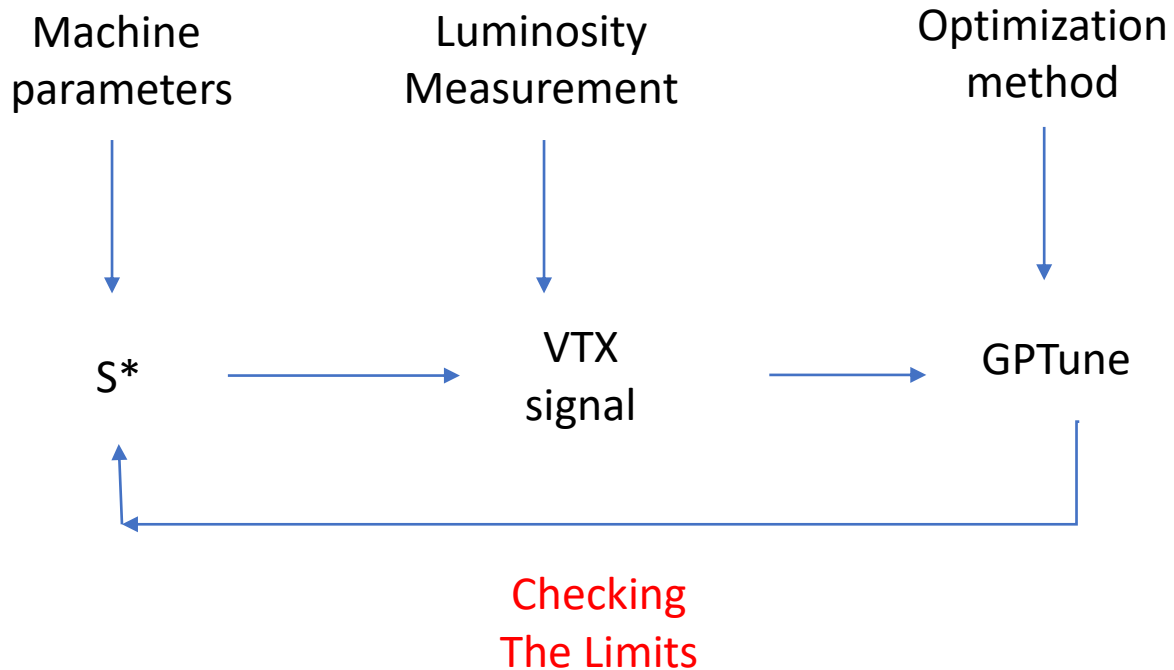
Conduct parameter optimization for several HPC codes. The most notable result is for the multiscale production-level full-blown simulation codes, M3D-C1 and NIMROD that are used in the fusion Tokamak design.

<https://github.com/mkturkcan/GPTune>

https://nimrodteam.org/meetings/team_mtg_5_21/nimrod_meeting_YangLiu.pdf



4) Online Luminosity Optimization



S^* and β^* changing scripts: ready for testing:

1. change the target s^* , β^* 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:

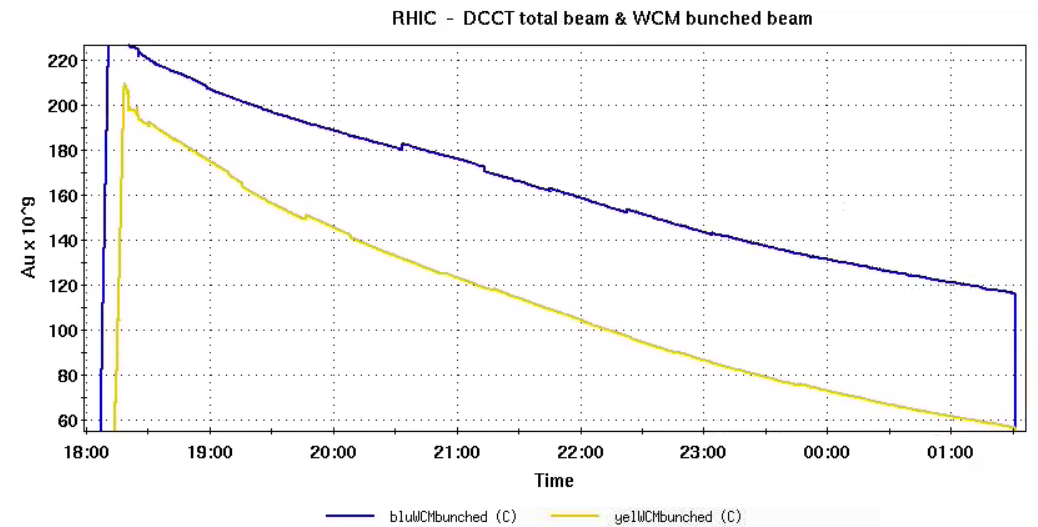
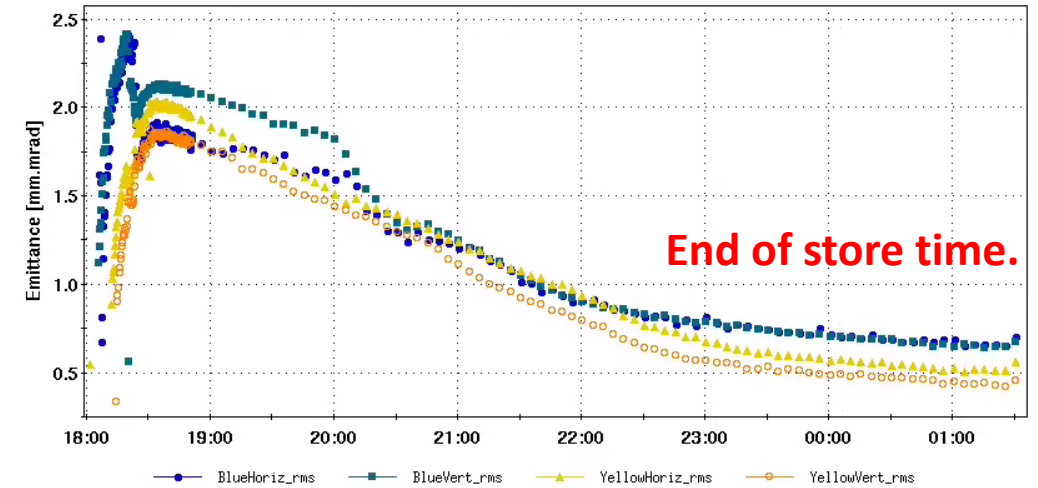
1. Did it with PHENIX before
2. Send the vertex data several ways.

4) Preliminary Plan

1. First, we will test the scripts without beam (with magnet?, injection)
2. Then, we can test them at other IP (10, or 6) with one or 6 bunches, head on and then with 2mrad angle. And find the s^* operation limit manually. (injection)
3. Then, repeat above procedure for IP8 without detector, 1 or 6 bunches. Will ask the permission for this.
4. Test the scripts and GPTune with detector ON;
5. Finally, we can optimize the Vertx signal.

5) Challenges

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



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