Ultra low beta* optics at ATF2: status and plans

CLIC Mini Week, December 11-13, 2023

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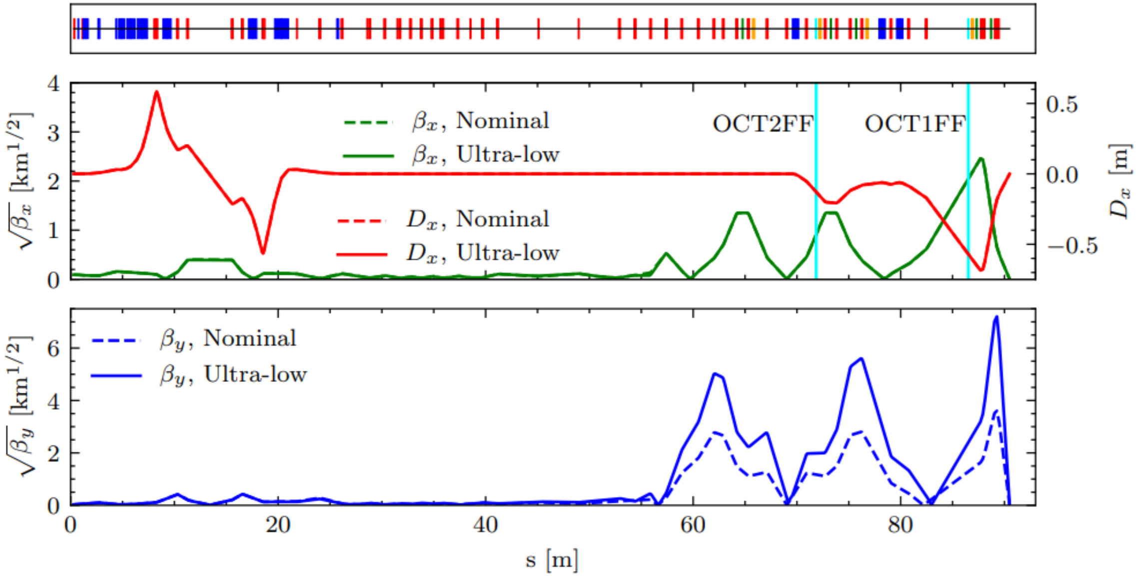
ATF2 Ultra-low β* optics



	ATF2 optics Nominal $10\beta_x^* \times \beta_y^*$	ATF2 optics Ultra-low $\beta_x^* \times 0.25\beta_y^*$	ILC	CLIC	CLIC
Beam energy [GeV]	1.3		250	380	3000
Vertical emittance [pm]	12		0.035	0.008	0.003
Horizontal emittance [nm]	1.2		5.0	2.55	0.2
Energy spread [%]	0.008		0.2	0.3	0.3
Beta-function β_x^*/β_y^* [mm]	40/0.1	4/0.025	13/0.4	8/0.07	4/0.12
Vertical chromaticity $\frac{L^*}{\beta_y^*}$	10000	40000	10000	86000	50000
Vertical beam size [nm]	37	27 (20[a])	7.7	2.4	1.0

[a]with octupoles.

- Ultra low β* (0.25 β^*_y) optics aims to test the FFS tunability at **higher chromaticity level**, approaching CLIC ones.
- To reduce the **impact of the multipolar errors**, the optics runs with larger ($25\beta_x^*$) horizontal beta-function.
- To tackle the **3rd order aberrations** a pair of octupoles was installed.

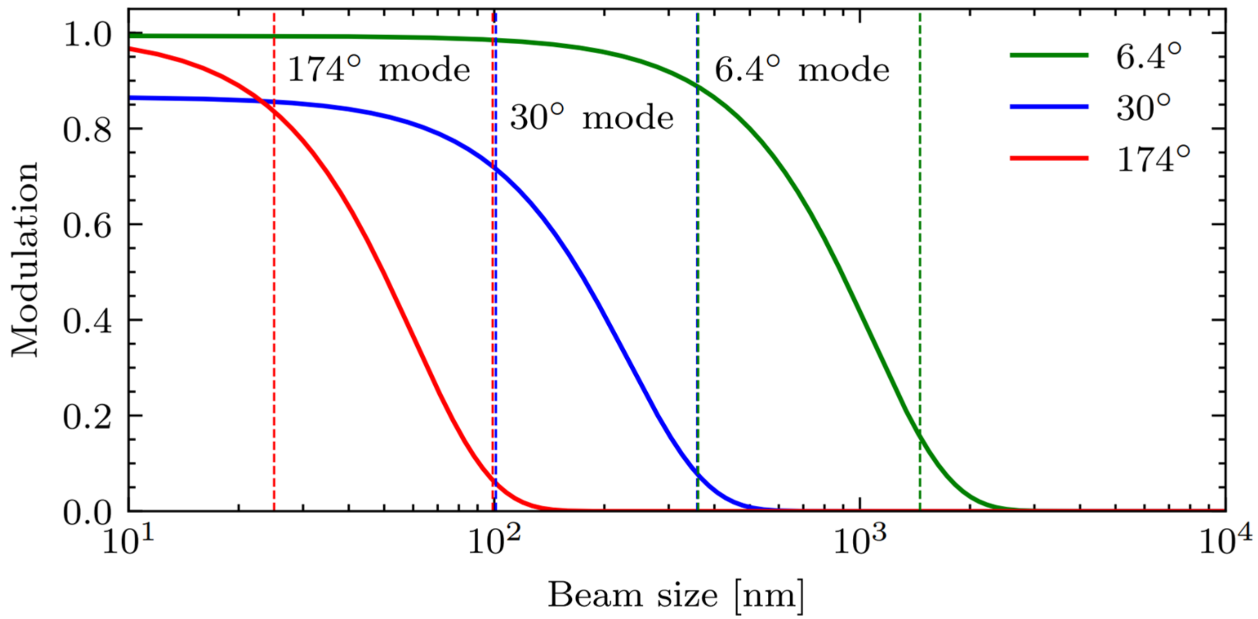
ATF2 tuning procedure

Typical tuning routine (~1 week):

i. **Machine preparation:**
Start up, DR tuning, BPM calibrations, etc.

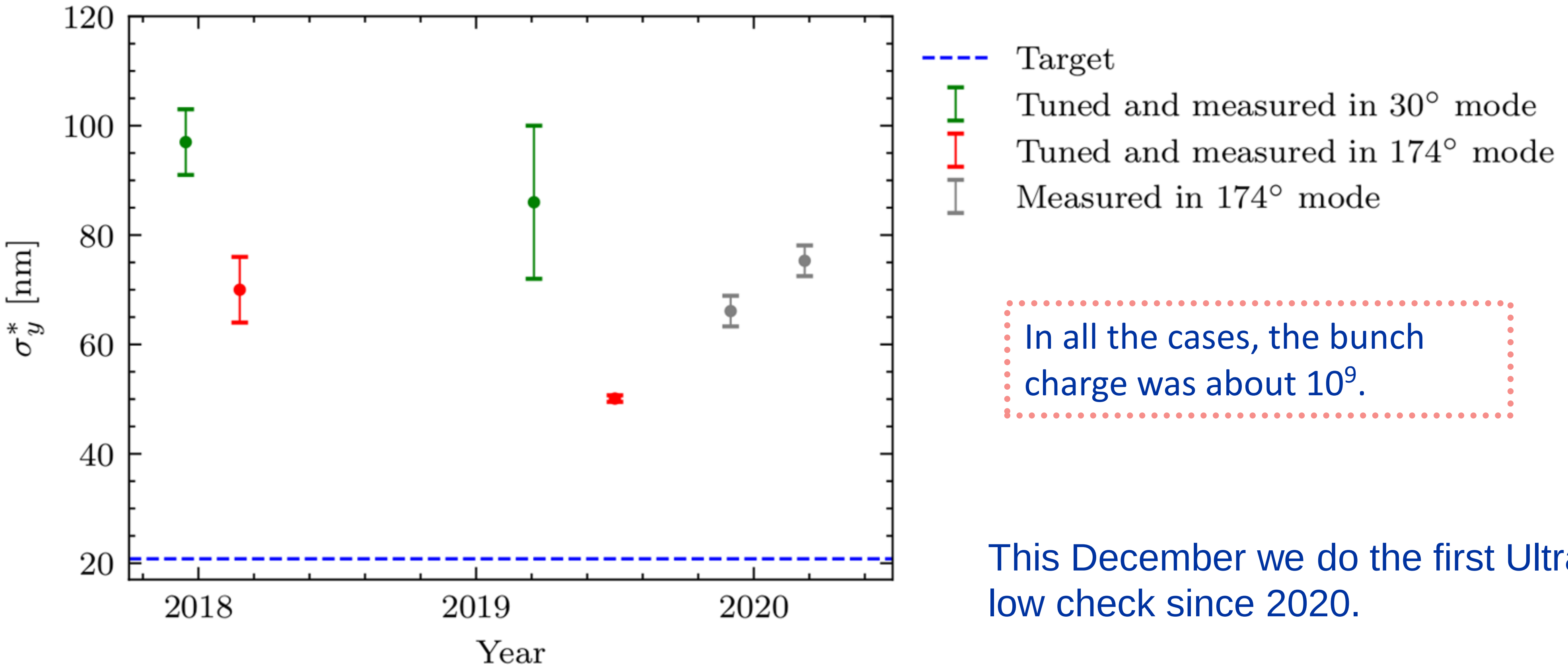
ii. **FFS and extraction tuning**
Orbit + dispersion corrections →Multi-OTR → optics matching → sextupoles BBA → IPBSM setup

iii. **Beam size tuning with IPBSM**
Linear knobs → non-linear knobs → octupoles (?)



! The bunch charge has to stay low to reduce the impact of the intensity dependence.

Tuning history (25 x 0.25 optics)

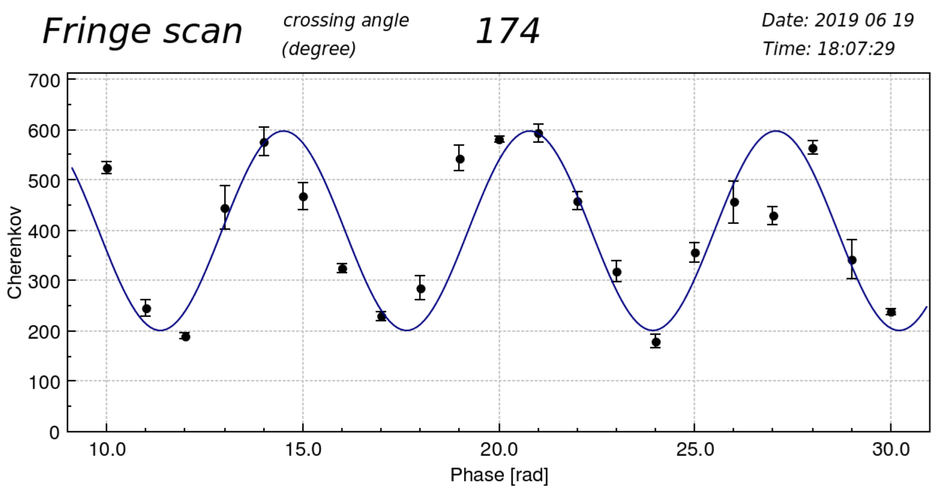


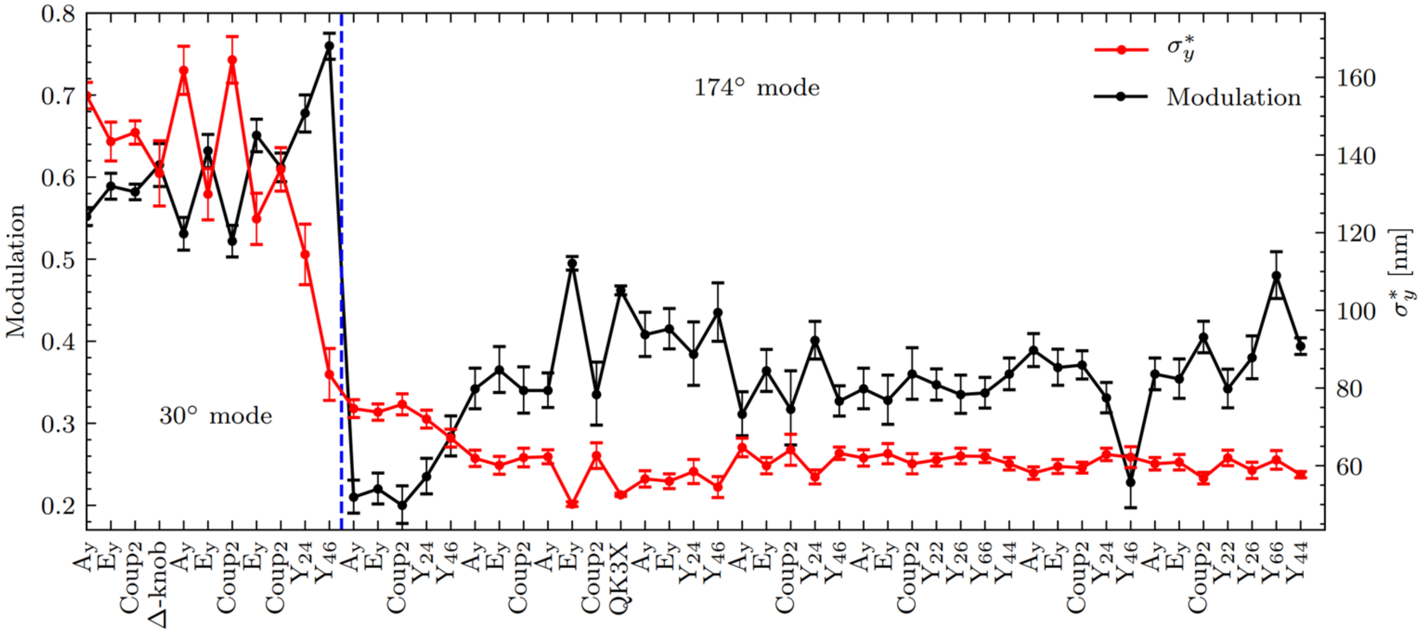
In all the cases, the bunch charge was about 10^9.

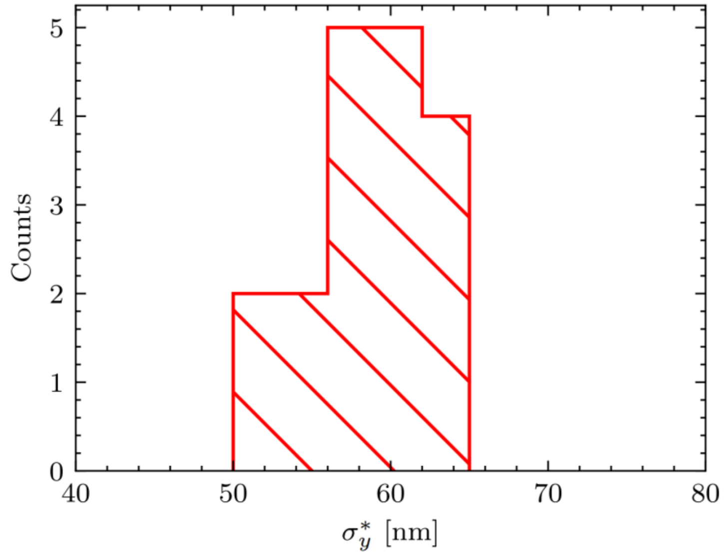
This December we do the first Ultra-low check since 2020.

Small beam size achievements (June 2019)

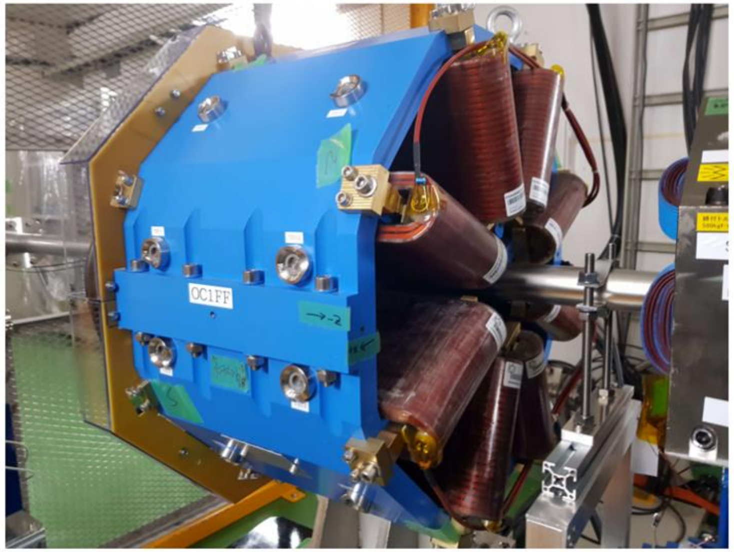
- The beam size achieved was **50 ± 0.6 nm**.
- The beam size was stable at the level of ~ **60 nm** for a long period of time.



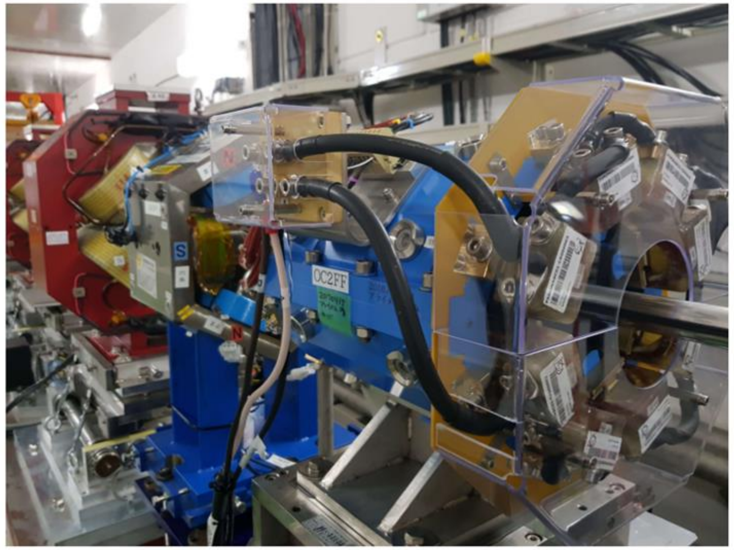




Octupoles



OCT1FF



OCT2FF

- Installed in 2017
- Repositioned in 2019

The octupoles impact starts to be visible once we reach the beam size **~ 40 nm**.

- Octupoles BBA was performed multiple times in the past.
  - Using dipole component (with IPBPMs). ~ 2017/2018
  - Using quadrupole component (with IPBSM). ~ 2019/2020
- No beam size reduction observed with octupoles yet.

Summary

- **In the past the small beam size of ~ 50 nm was achieved with Ultra-low β^* optics.**

- **Several techniques to align the octupoles were tested.**

Main concerns based on the past experience:

- Orbit stability
- Wakefields
- IPBSM performance

Prospects

- Tune 25x0.25 optics
- Verify the octupoles importance
- Switch to 10x0.25, 1x0.25 optics and **longer L* optics design**
- New tuning approaches (ML..)
- Automatization of the routine tasks.

Thank you for your attention!

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