Optical cavity for high flux light sources

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The 12th FCPPL workshop, Shanghai

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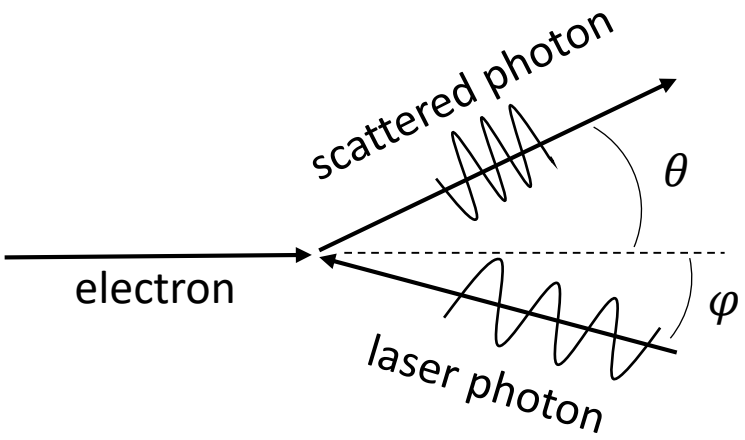
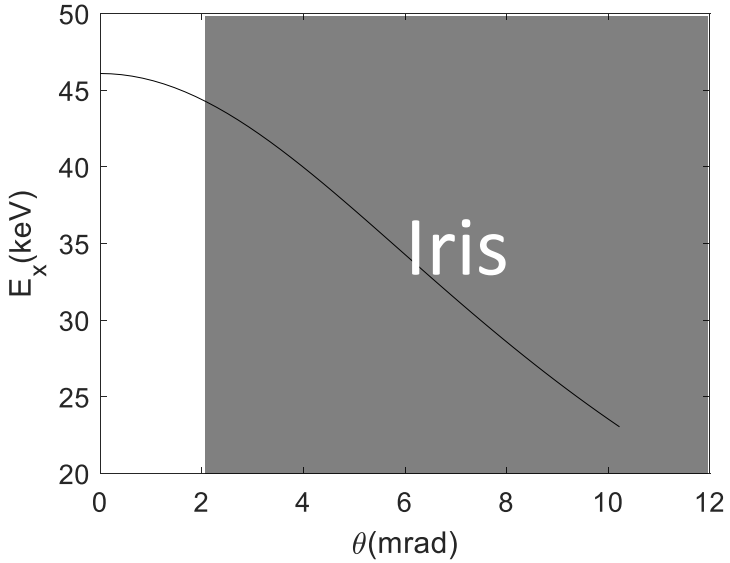
ICS (Inverse Compton Scattering)



- **Powerful mechanism to boost photon**

For back scattered photon ($\varphi = 0, \theta = 0$)

$$E^{bs} \approx 4\gamma^2 E_L$$



50MeV electron, $\lambda = 1\mu m$ laser

- **Compact Light Source**

40keV X-rays from *50MeV* electrons

While Sychrotron and FEL needs *GeV* electrons

- **Quasi-monochromatic**

ICS (Inverse Compton Scattering)

- **Small cross-section**

$$\sigma \cong 6.65 \times 10^{-29} m^2$$

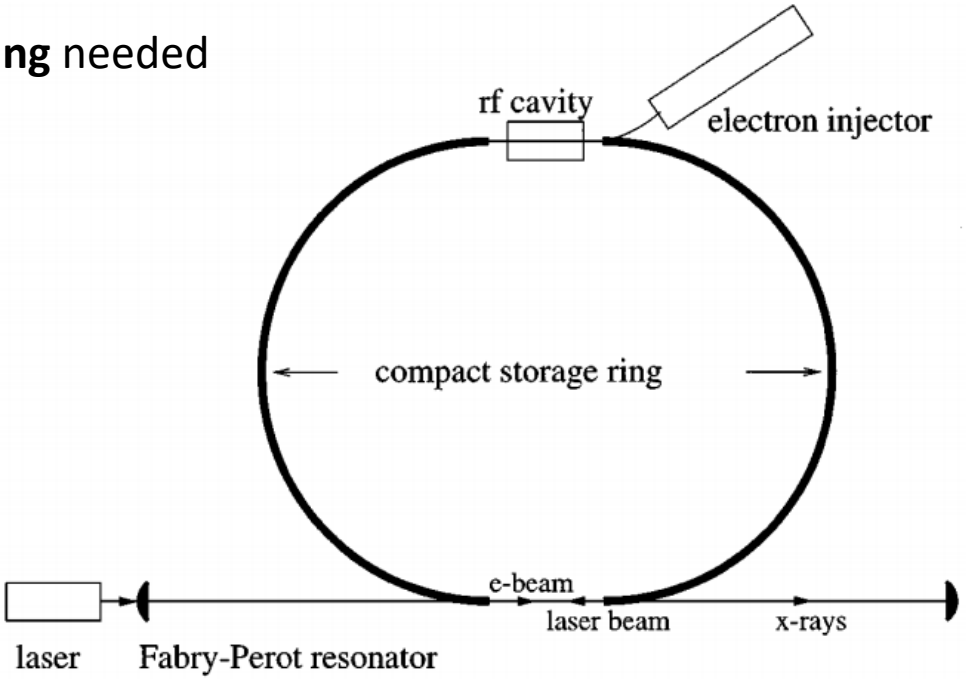
1nC electron, 500mJ laser → 10^6 /pulse X-ray

to increace the average flux of X-ray

Fabry-Perot cavity and **electron storage ring** needed

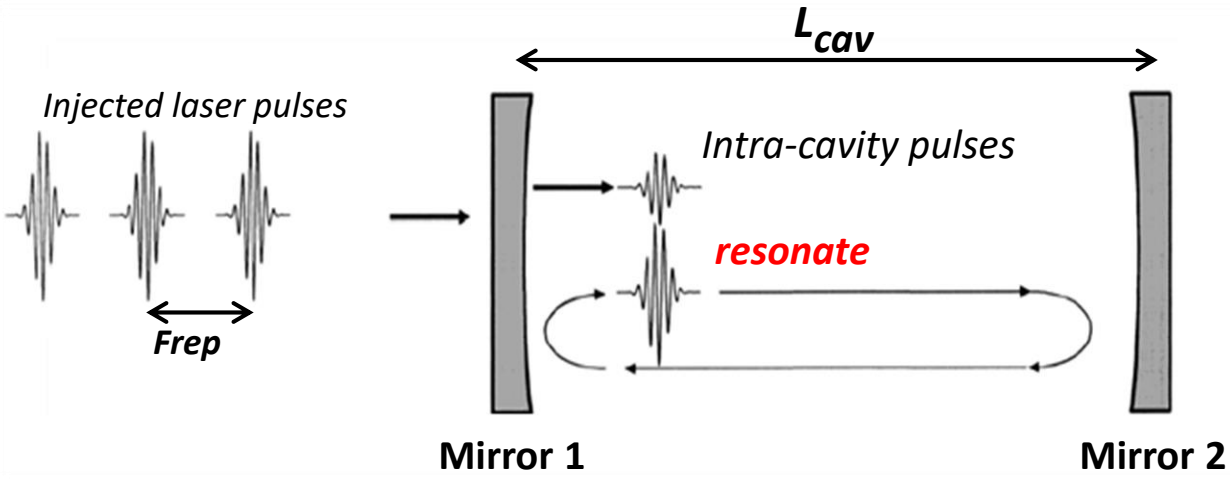
X-ray repetation rate $\sim 10MHz$

flux $\sim 10^{12} photons/second$

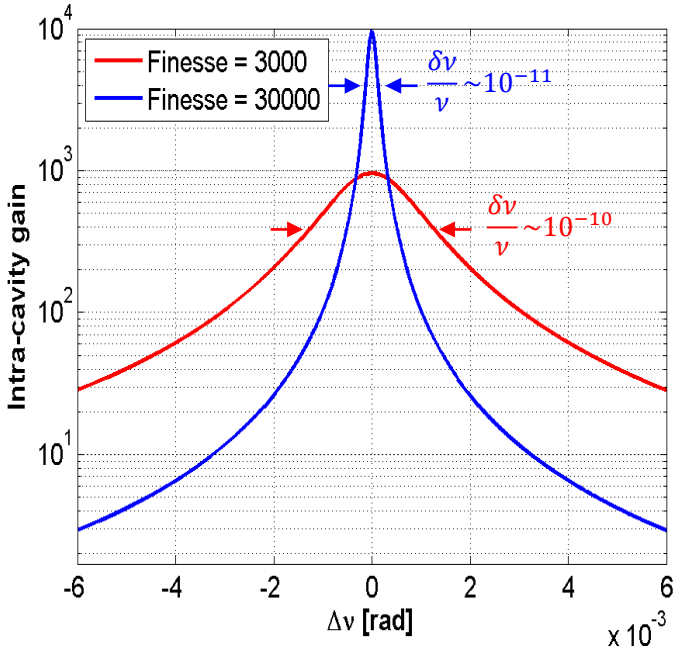


Physical review letters, *80*(5), 976.

Fabry-Perot cavity



- **resonator**, laser power stacked, $Gain \cong \frac{Finesse}{\pi}$
- **high repetition rate**, ~10MHz, cavity size ~few meters
- high demand for **feedback electronics**



TTX (Tsinghua Thomson X-ray source)

TTX

- 45MeV Linac
- 1nC
- 800nm laser
- pulse energy ~500mJ
- pulse length ~50fs
- flux ~10^6/pulse

update to **TTX2**

- Optical cavity
- Electron storage ring

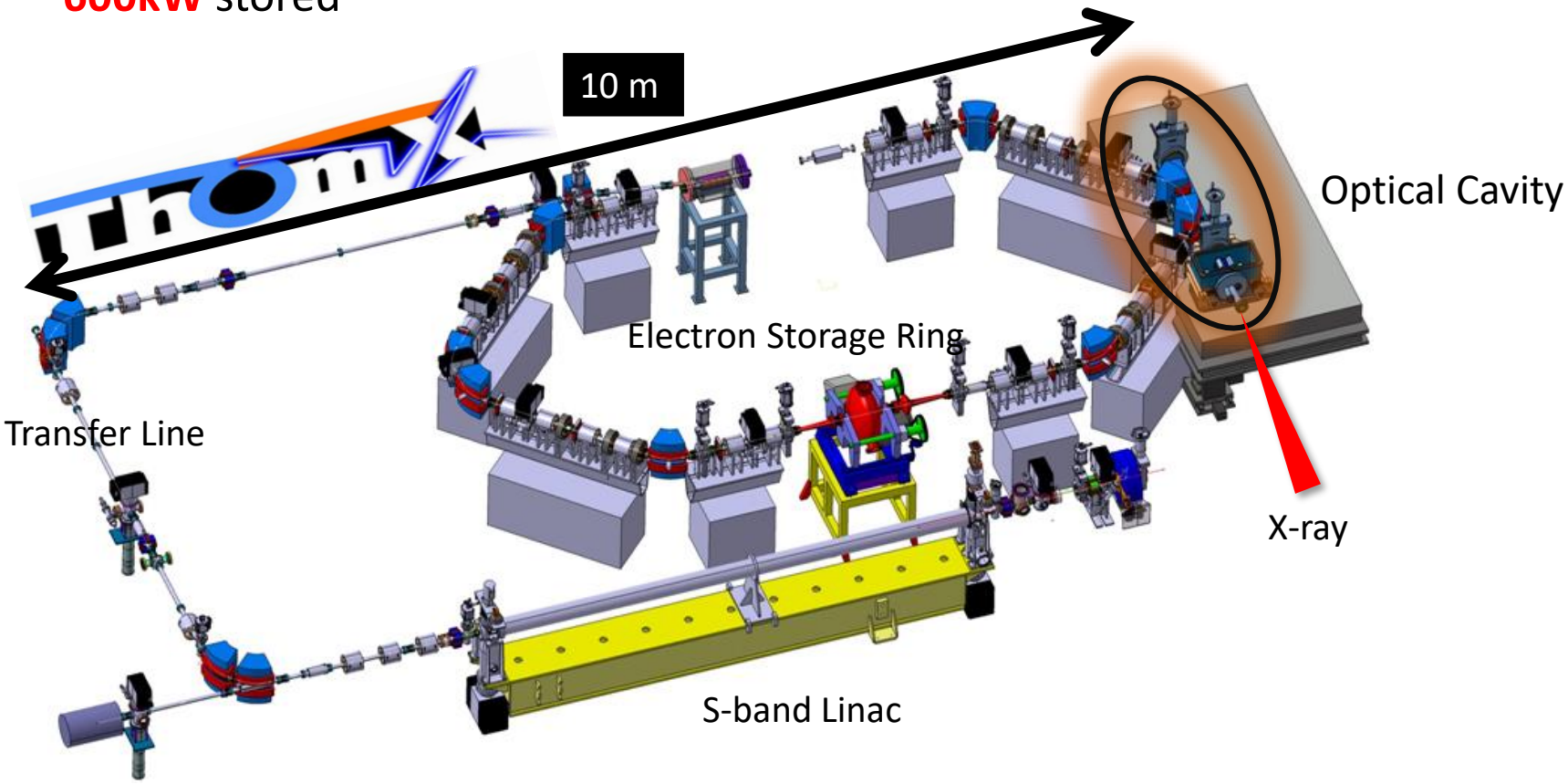
collaborating with LAL

ThomX project (at LAL)

- 50-70MeV
- 1 nC
- 1030nm laser
- 10k gain
- **600kW** stored

- flux **10^{11} – 10^{13}** ph/s
- 16.7 MHz
- energy cut-off **46-90keV**

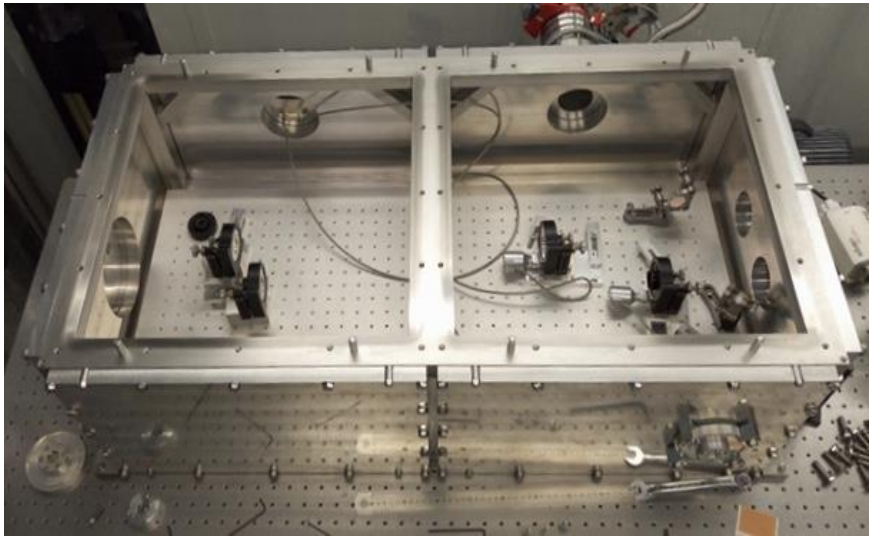
Applications:
- Radiography
- Radiotheraphy
- Crystallograhy



ThomX Optical Cavity

ThomX cavity

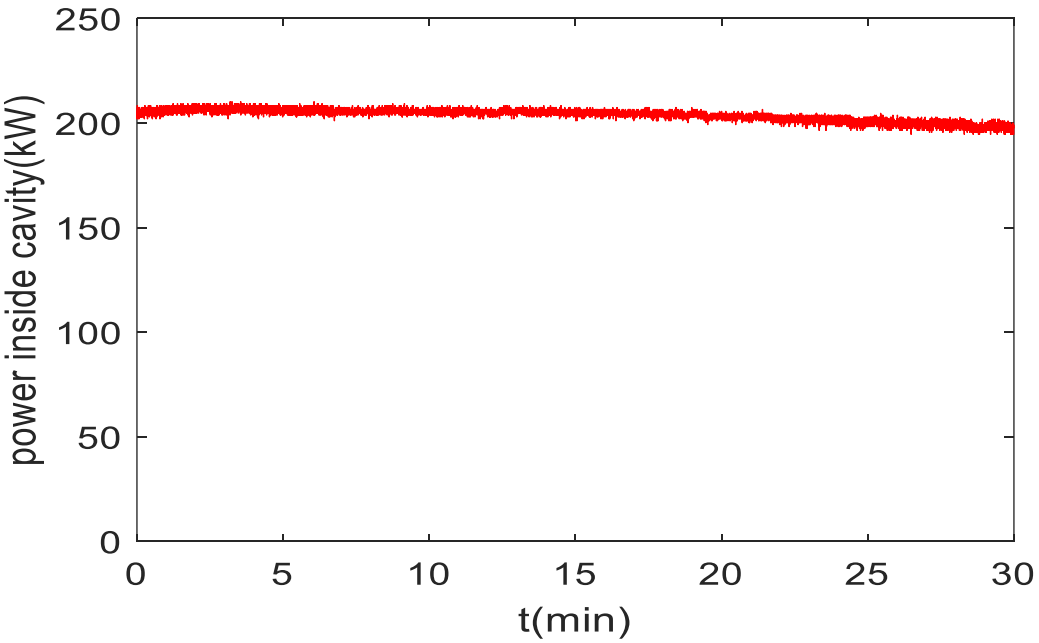
- Cavity length/ Freq = 9m/ 33.33MHz
- Finesse = 42000
- Laser wavelength = 1030nm
- Input laser power = 100W
- Goal of stored power = 600kW



ThomX R&D Cavity

- Cavity length/ Freq = 2.25m/ 133.33MHz
- Finesse ~ 25000
- laser wavelength = 1030nm
- Input laser power = 40W

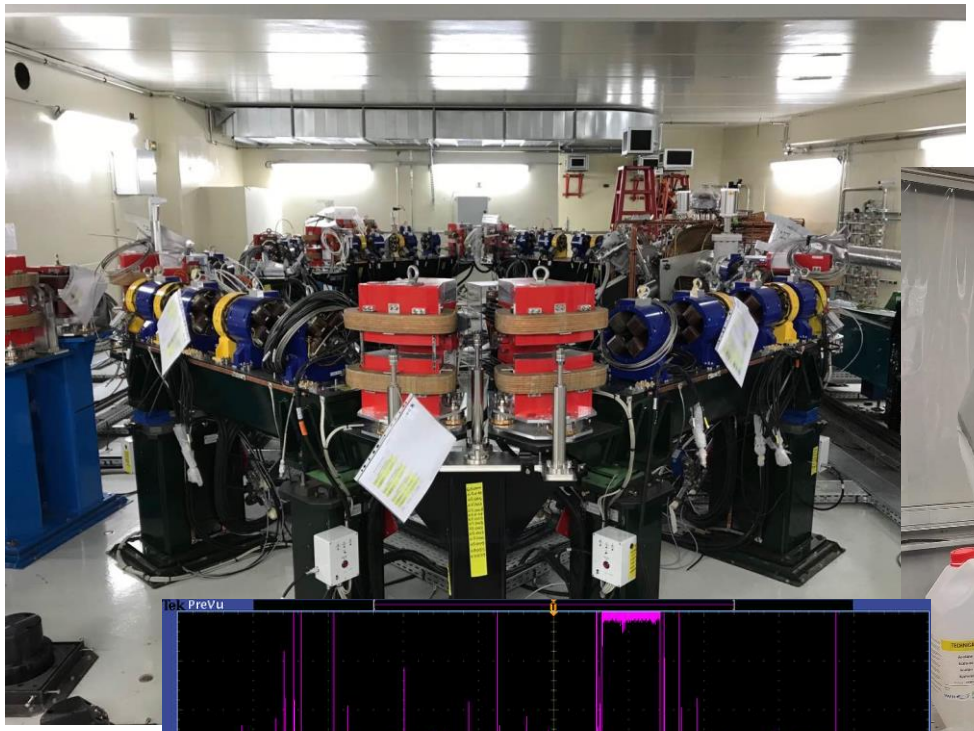
ThomX R&D Cavity

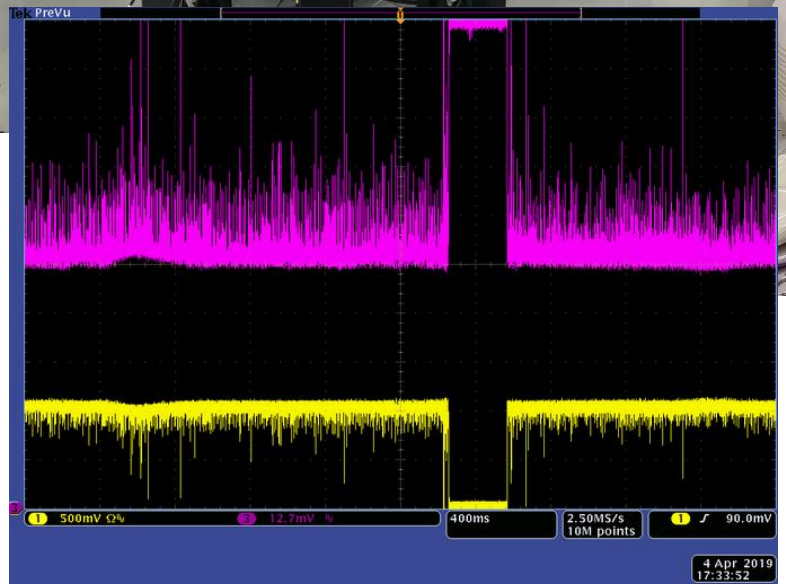


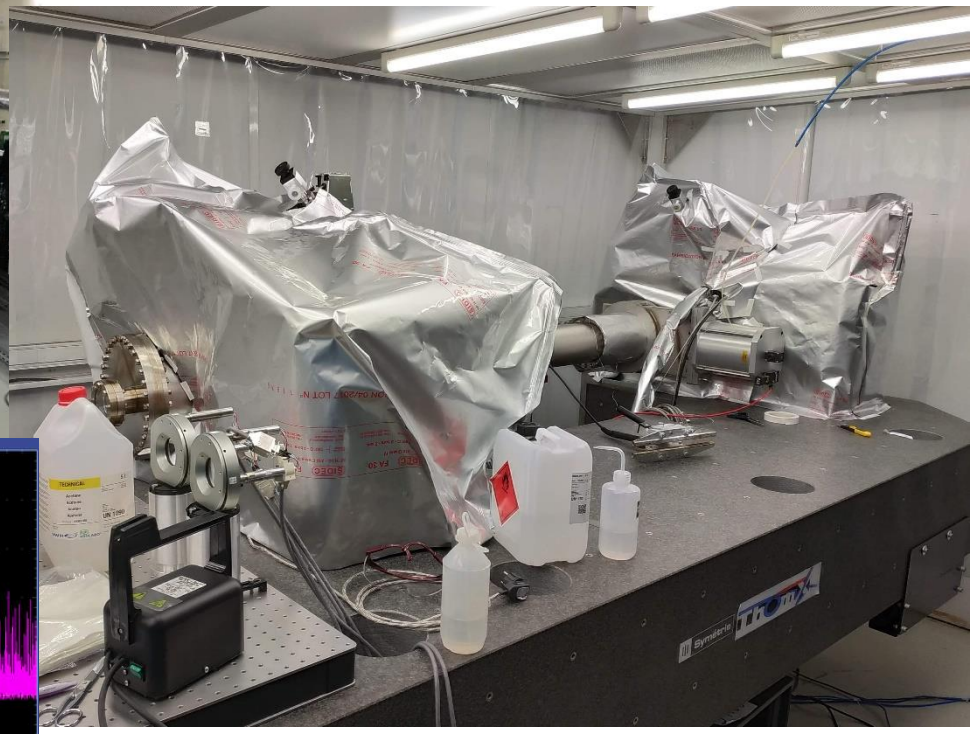
realized **200kW** stable running for 30min

- power inside cavity dropped from **205kW** to **197kW**
- no unlock
- without alignment
- injecting laser power ~40W, gain ~5000

ThomX progressing





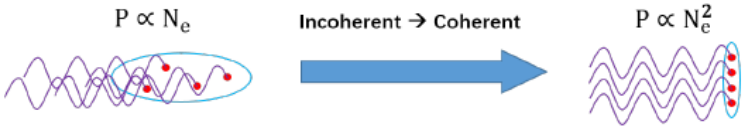


- cavity-laser **locking** has been realized
- high power experiments in progress

TTX progressing

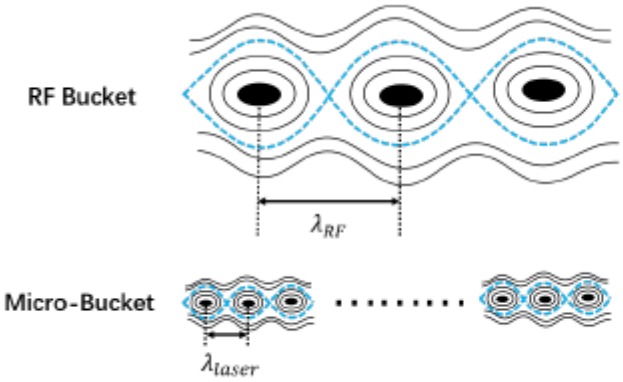
- optical, electronic, mechanical components ready
- experiments start in July 2019

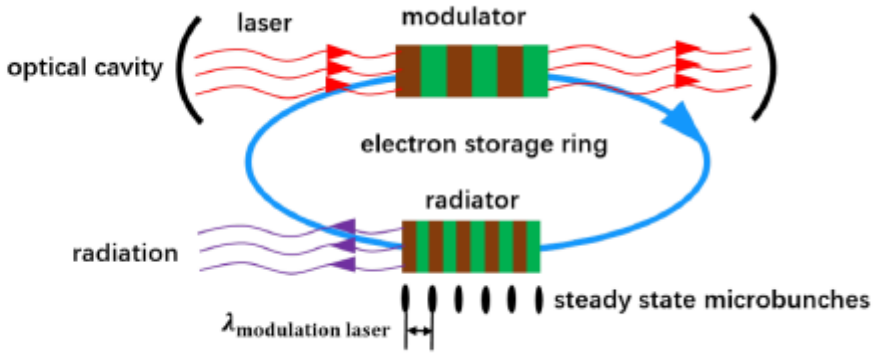
SSMB (Steady-State Microbunching)



- **microbunching** for high peak power
- **steady-state** for high repetition rate

- replacing **RF** modulation with **laser** modulation



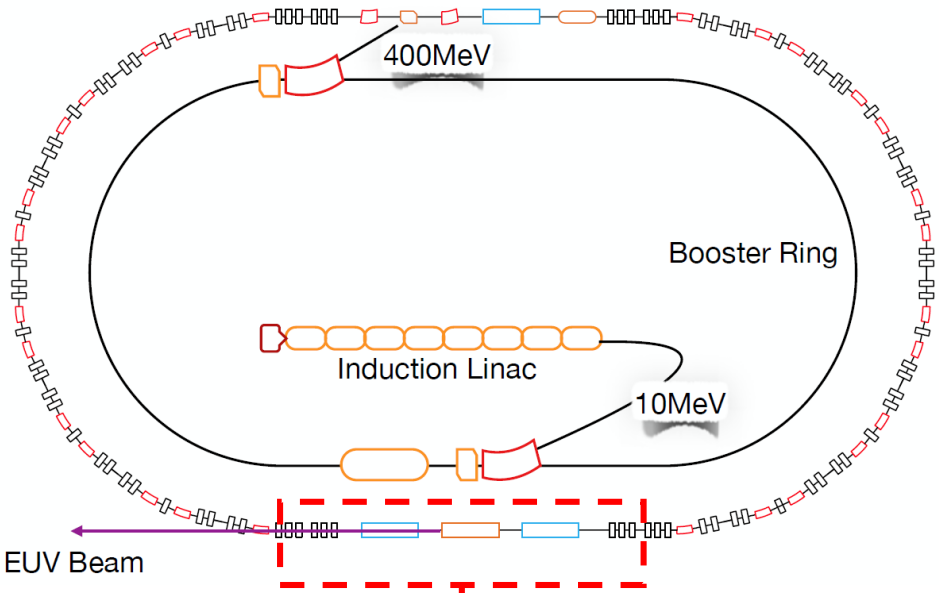


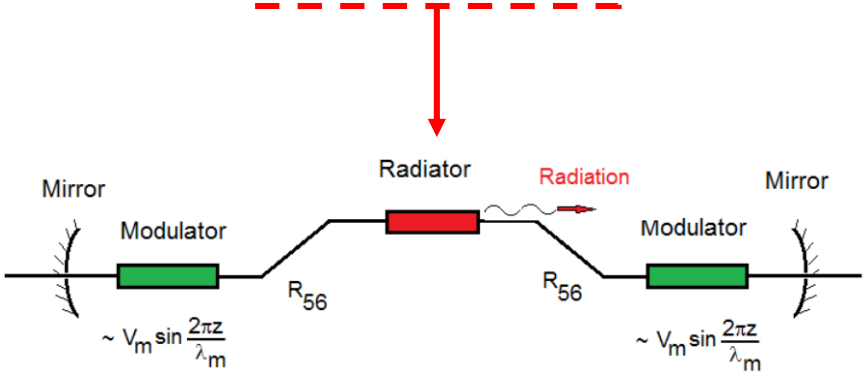
- **high power coherent radiation** with wavelength ranging from THz to EUV

Physical review letters, *105*(15), 154801.

SSMB (Steady-State Microbunching)

example layout of SSMB storage ring lattice





optical cavity with insertions

- demande for **optical cavity**
  - laser stored power 1 MW
  - laser linewidth $\leq 10\ kHz$
- **SSMB radition** ~1 kW
- for example, **EUV** radiation can be used for industrial **lithography** of chip production

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Summary

- optical cavity for inverse Compton scattering
  - ThomX R&D cavity realized 200kW stable run for 30min
  - ThomX cavity realized locking with laser
  - TTX cavity ready for experiments

- optical cavity for SSMB under design


清華大學
Tsinghua University


LABORATOIRE
DE L'ACCÉLÉRATEUR
LINÉAIRE

Thank you