INVERSE COMPTON SCATTERING

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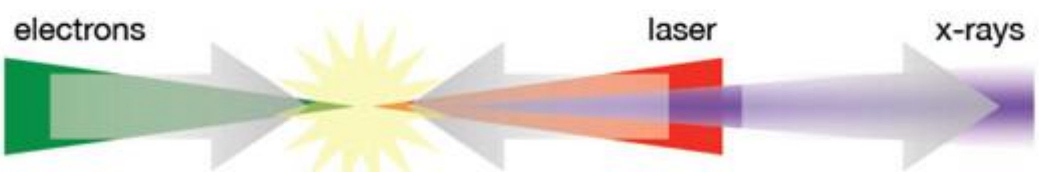
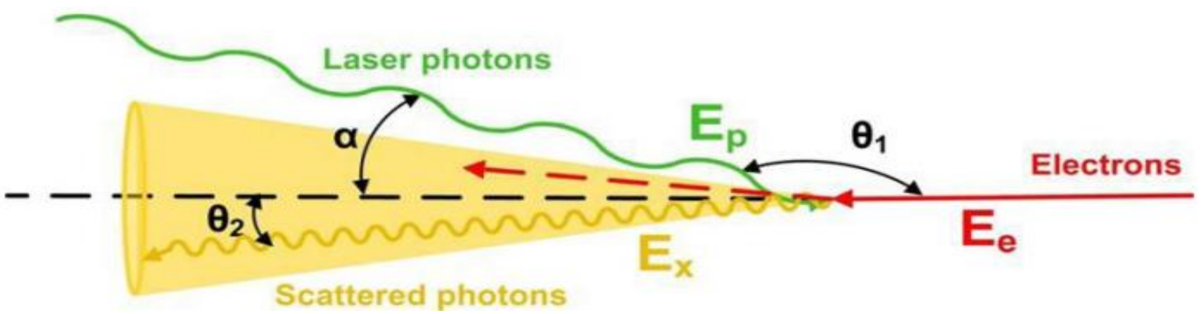


Inverse Compton Scattering

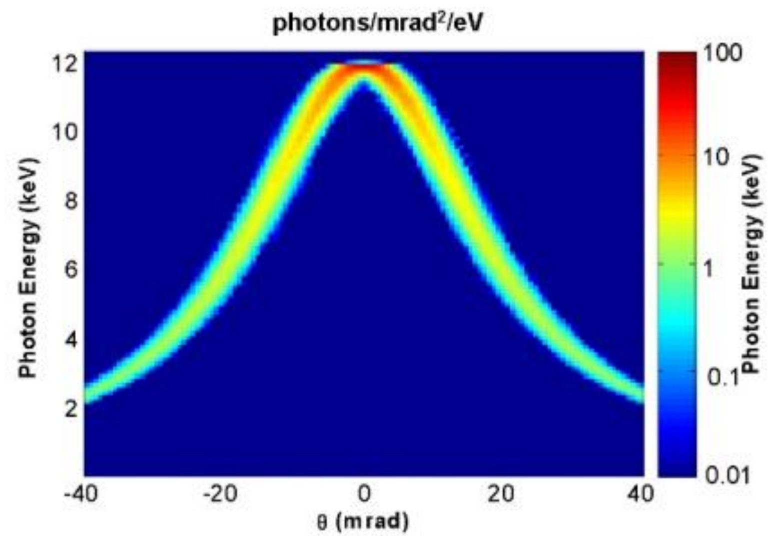


- Compton Scattering between pulsed laser and electron bunches
- Incoherent X-ray source of wave number:

$$k' = \frac{k(1 - \beta \cos\theta_1)}{1 - \beta\cos\theta_2 + \frac{k}{E_0}(1 + \cos\theta_1 \cos\theta_2)} \quad \rightarrow \quad k' \approx \frac{k(1 - \beta\cos\theta_1)}{1 - \beta\cos\theta_2}$$

Advantages

- Peak photon energy is tunable
  - Energy of electron bunch
  - Angle of intersection
- Select bandwidth by adjusting acceptance angle
- Low energy, high brightness
- Maximum energy from 180° scattering:

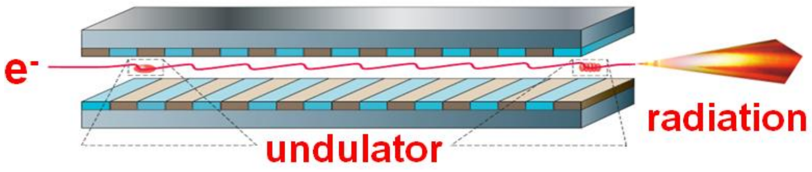


$$\lambda'_{max} = \lambda \frac{1-\beta}{1+\beta} = \lambda \frac{1-\beta^2}{1+2\beta+\beta^2} \approx \frac{\lambda}{4\gamma^2}$$

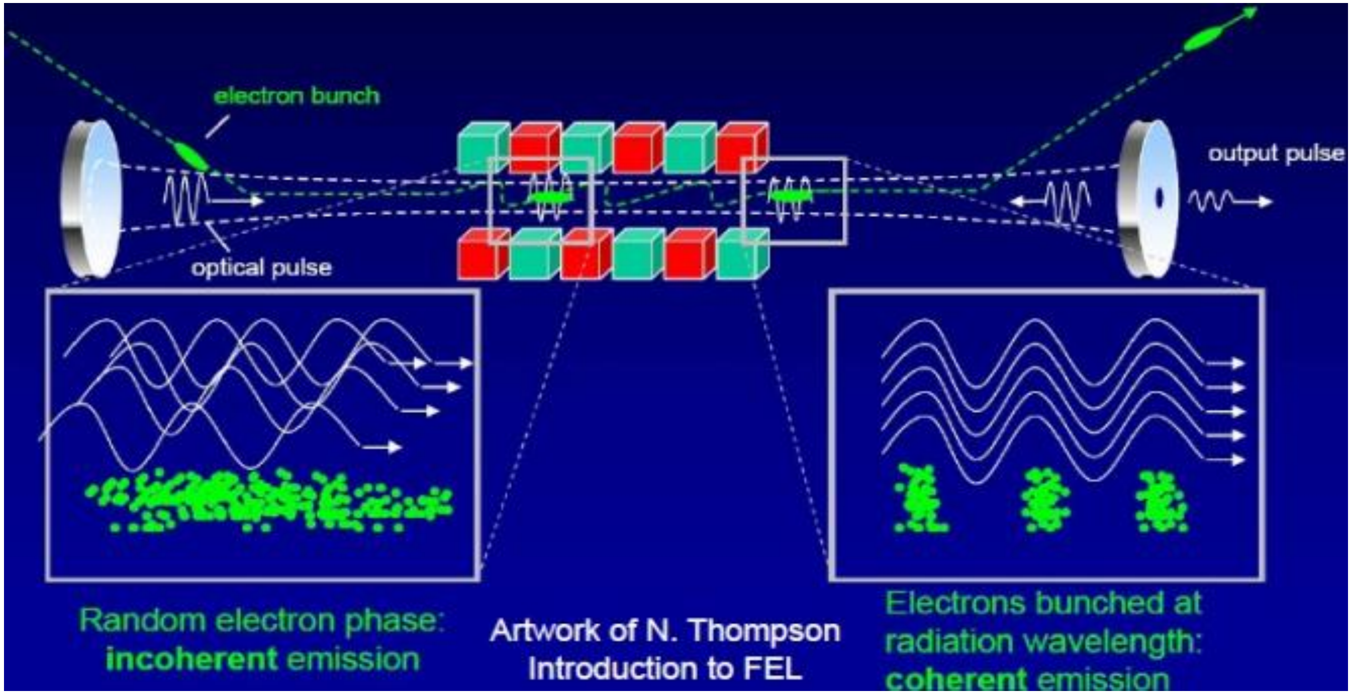
Undulator Model

- Field of laser replaces field from undulator magnets
- Model predicts same initial emission produced by an undulator with period: $\lambda_{und} = \lambda_{laser}/2$
- For conventional undulator, K ~ 3.5 (LCLS)
- For the laser, K is several orders of magnitude smaller
  - $K \propto \lambda_{laser} B/r$ (B = field amplitude, r = spot radius)

$$\lambda' = \lambda_{und} \frac{1 + 0.5K^2 + \gamma^2\theta^2}{2\gamma^2}$$



Goal: Coherence



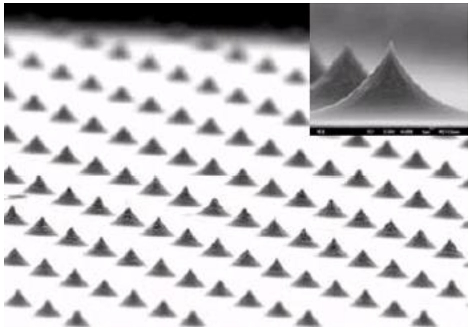
- **Step1**: Initial X-ray radiation from ICS
- **Step2**: X-rays interact with electron bunch to produce microbunching
- **Challenge:** Sustain microbunching to produce coherent X-rays

Obstacles and Options

- Short undulator period requires low energy electron beam to produce same x-ray frequency

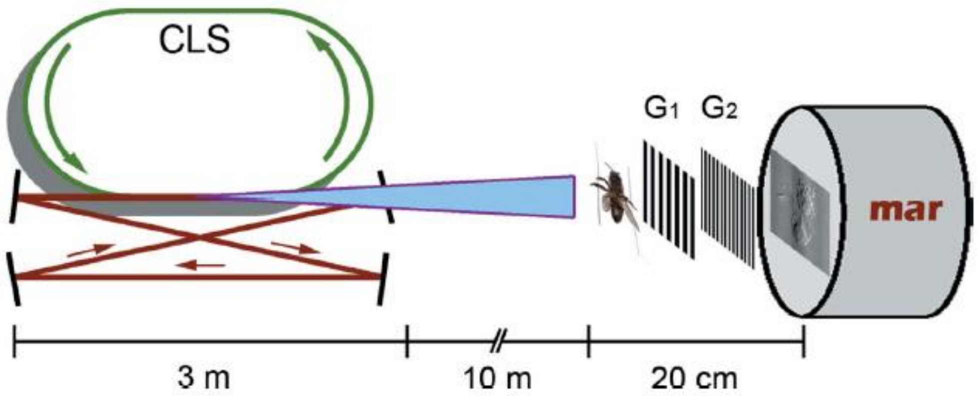
  $$\lambda' \approx \lambda_{Laser}/(4\gamma^2)$$
- Corresponding emittance of electron bunch is too large
  - Need $\gamma\varepsilon < \gamma\lambda/4\pi$
  - Electron bunches smear

- Improve emittance
- Beam Conditioning
- Longer laser wavelength (THz)
- Pre-bunching (emittance exchange)



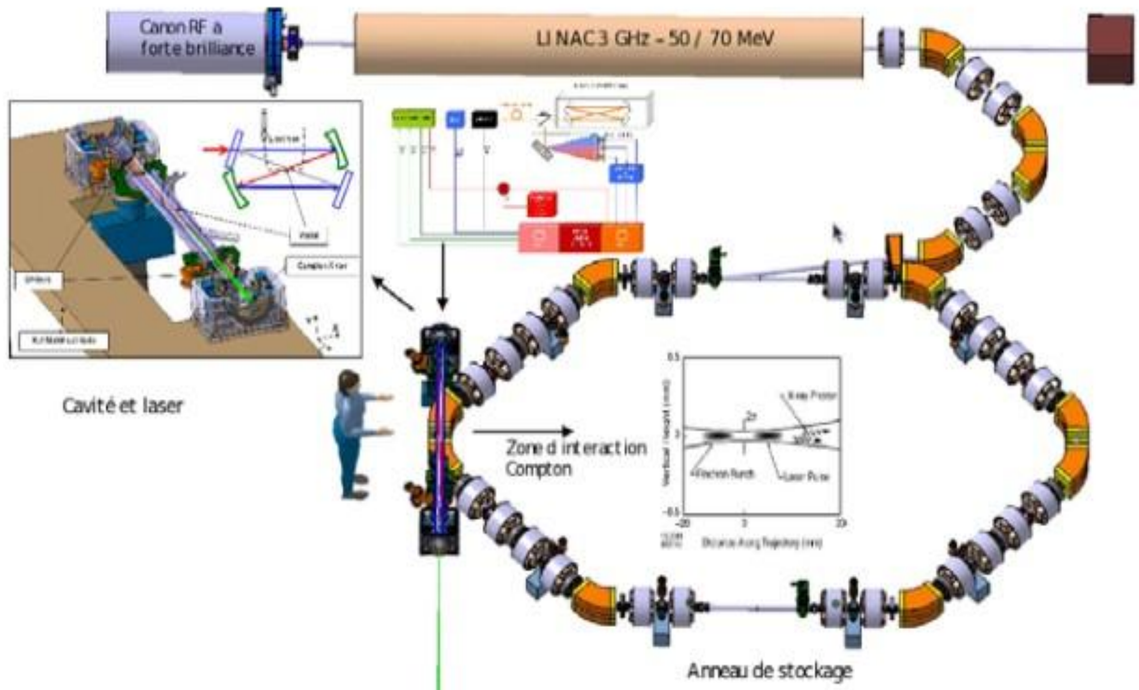
Current Capabilities

- More easily attainable goal: increase # of photons/sec
- Increase repetition rate and/or increase brightness of electron pulses
- Beamline design:
  - Storage ring
  - Superconducting RF linac



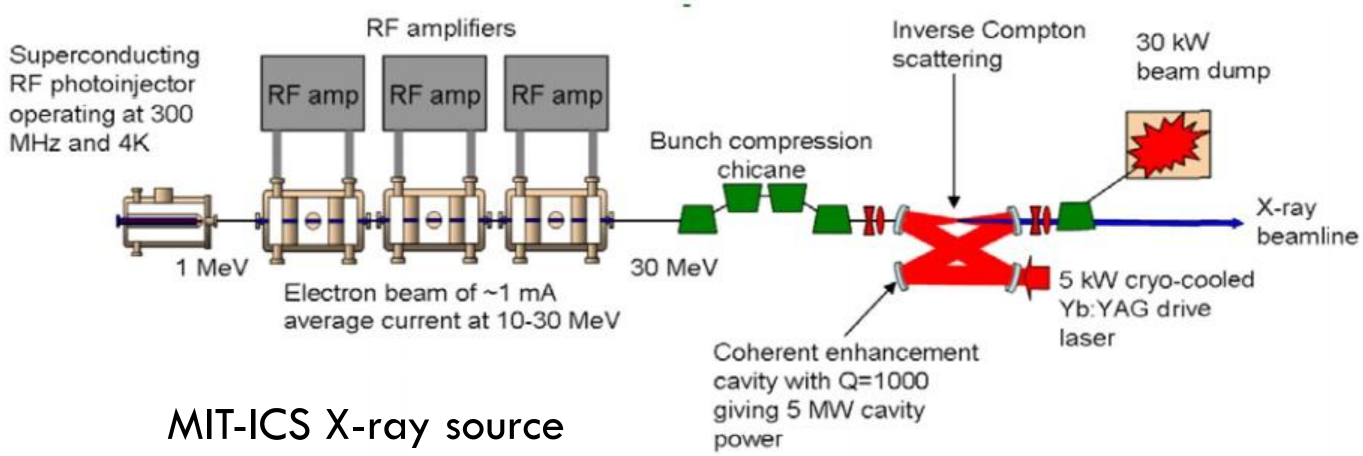
ICS Storage Ring

- Small storage ring recirculates the electron bunch
- MHz repetition
- Beam emittance and energy spread gradually grow due to intrabeam scattering



Layout of the THomX concept

Linac Set-Up



MIT-ICS X-ray source

- High brightness, short pulse duration
  - good for study of dynamical systems of matter
- Superconducting linacs need low temperature
  - Expensive cryogenic system
  - Poor Stability

References

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