Insertion device for the hard x-ray nanoprobe

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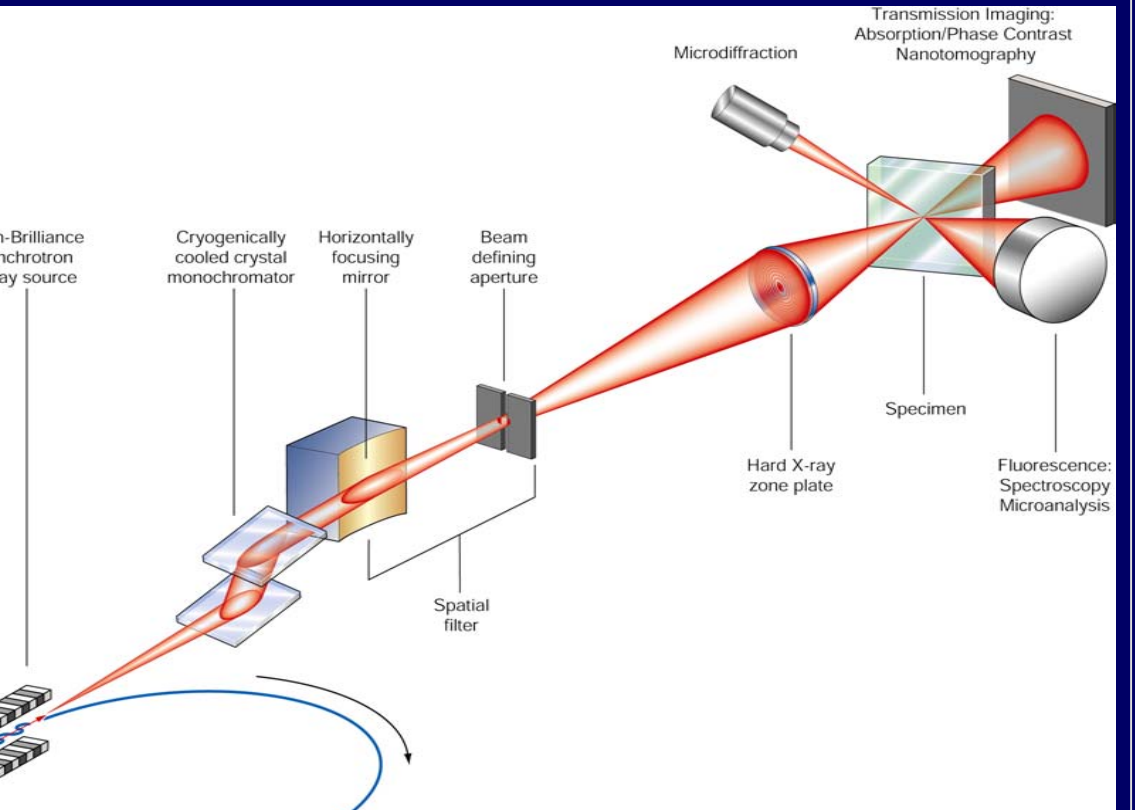
- Goal: Imaging and micro-analysis at highest spatial resolution

- Concept:
  - Use spatially coherent part of ID beam to achieve diffraction limited resolution.
    - σ_v = 50 μm, D_{ZP} = 90 μm @ 10 keV
    - Spatial Resolution: δ = 30 nm
    - Energy range: 3 – 30 keV

- Requirement: high 2D brilliance on specimen

Beamline layout NanoCAT, APS 26-ID



Technical Approach:

- Fresnel Zone Plates for focusing and imaging
- Match lateral coherence in ho and vert. using spatial filtering
- Twin collinear ID to maximiz brilliance.

  i) Brilliance/power ratio: ~ 2.5 x brilliance at 2 x PD

  ii) Option: use of single ID at high K to reduce PD

Design considerations

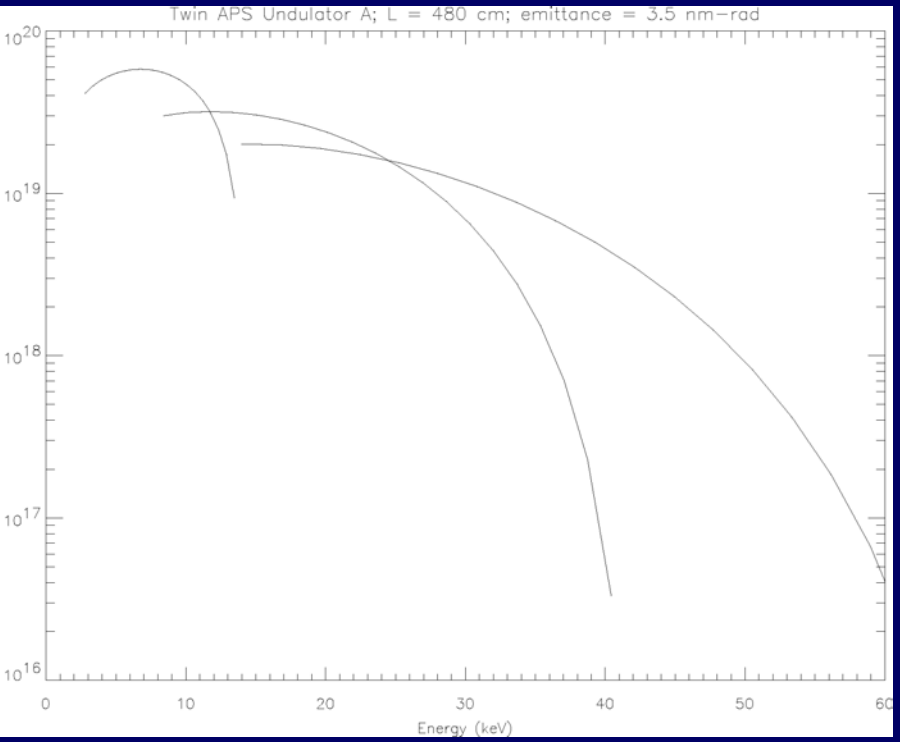
- High source brilliance ⇒ twin U-A, L = 4.8 m
- Small source aspect ratio σ_v/σ_h ⇒ spatial filtering

- Challenge: preserve brilliance in beamline!
  - High total power: P_{tot} = 12 kW @ 3 keV (K=2.72), 100 mA
    ⇒ Custom front end (160 mA feasible)
  - High on-axis heatload: Twin collinear U-A at 3 keV (K = 2.72), 100 mA:
    - 340 kW/mrad^2
    - PD = 370 W/mm^2 @ 30 m
    - HHL Crystal mono: Power absorbed in first 10 μm 14 W/mm^2/10μm
    - HHL mirror (illuminated at full length): 1 W/mm^2 @ θ = 2.6 mrad

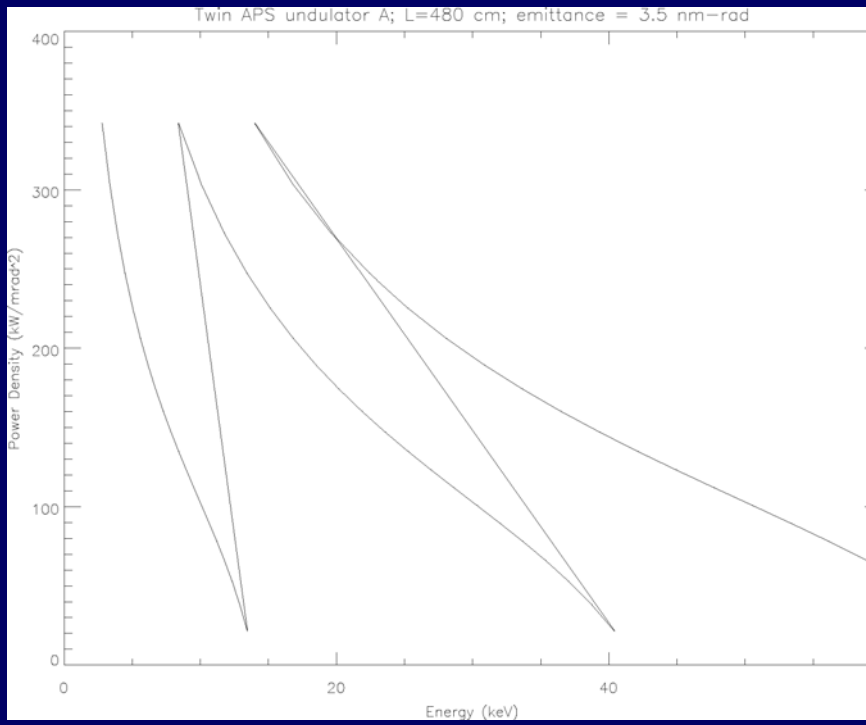
- Future: I = 160 - 200 mA! 10 m straight sections?

Current design: Twin U3.3, L=480 cm

Brilliance, e = 3.5 nm-rad



Power density



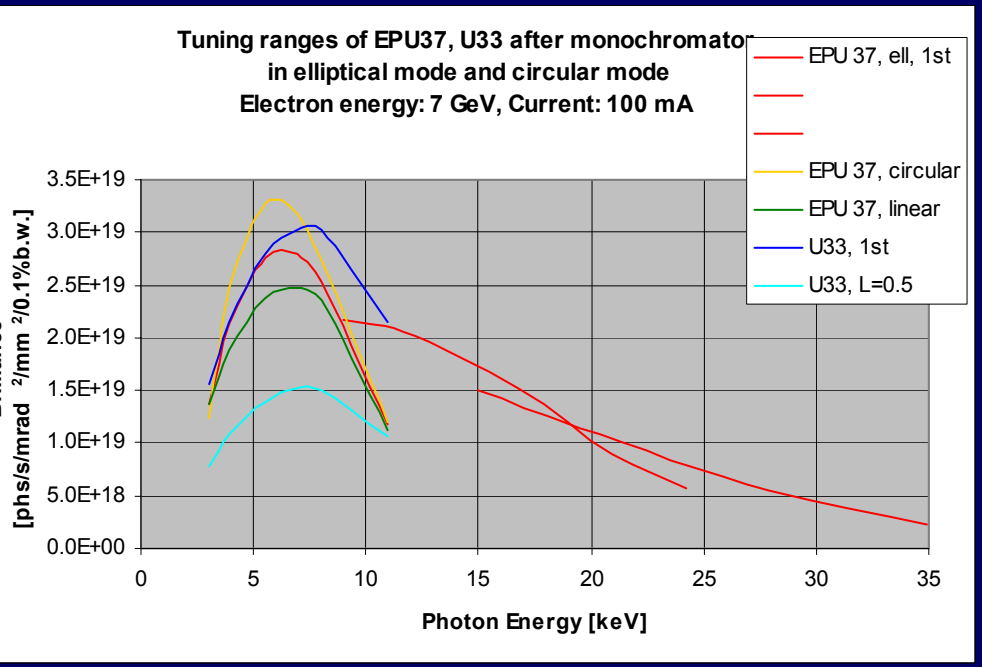
Consideration of APPLE device for Nano-CAT

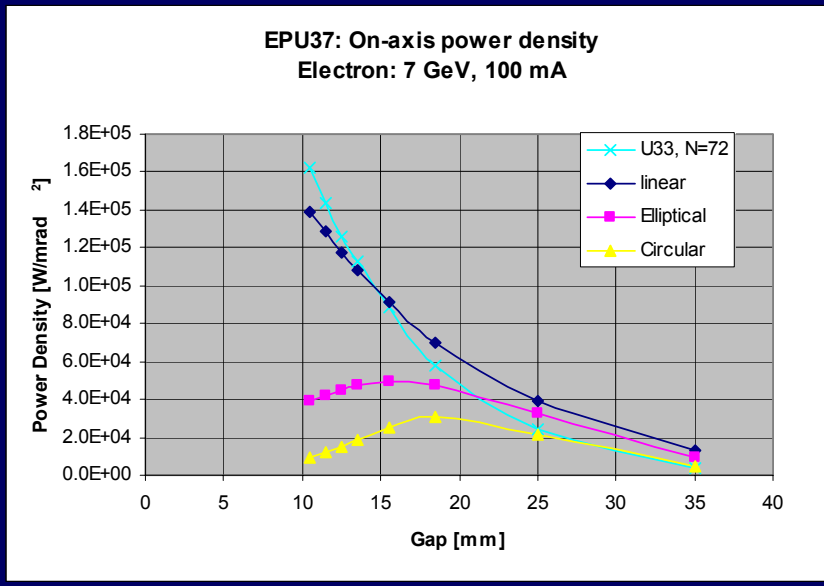
Horizontal and vertical parts of magnetic structure can be phase shifted by $\lambda_u/4$

$\Rightarrow$ - low on-axis PD in elliptical mode (large K)

- high harmonics achieved in linear mode

Disadvantage: significanty reduced reflectivity of π mode in monochromator





U33, U37 AFTER monochromator. Monochromator reflectivity (Si<111>) on σ and π modes considered

Summary

NanoCAT conceptual design:

- Twin collinear U3.3:
  - Desired energy range: 3 – 30 keV
  - Maximize source brilliance: N=144
  - Flexibility: use one or two devices depending on K
  - Operational reliability: non-unique device

Challenge: on-axis power density!

Other options:

- larger λ_u (e.g. U3.6) to reach 3 keV at reduced K (specialized device)
- ID configurations that reduce on-axis PD, but still provide higher harmonics
  - Example: APPLE II.
  - Are there other possible configurations?
  - What is impact of different ID configurations on ring?