4-stage single-shot spectrometer.

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Motivation.

Goal:

Diagnose longitudinal properties of electron bunch for better FEL performance!

One possible way is spectroscopy of coherent radiation:

\[
\frac{dU}{d\omega d\Omega}_{\text{bunch}} \approx \left| \frac{dU}{d\omega d\Omega}_{\text{e}} \cdot N^2 \cdot |F(\omega, \vec{k}_\perp)|^2 \right|
\]

- not intrinsically limited in resolution
- not apriori a destructive method
- not a direct measurement of current profile

Examples of applications:
- Bunch compression monitor
- Substructures (e.g. Microbunching Instability)
- Profile reconstruction (?)

Request:

Record spectra with wide wavelength coverage for each bunch in macropulse!
Principle*.  

* developed by Hossein Delsim-Hashemi

I. dispersive device — reflective blazed gratings
   - high reflectance in 1st order at certain configuration
   - act like a mirror for a specific $\lambda$ – grating period ratio
   - staging dispersive elements (large spectral coverage)

II. focusing — special ring mirror
   - single mirror per stage (large dispersive angle of 60 deg)
   - focusing without geometric distortion

III. detector — pyro electric elements
   - wavelength range from 1 $\mu$m up to several 100 $\mu$m’s
   - 30 single elements per stage
   - see Bernhard’s talk

IV. readout electronics
   - amplifier chain (up to 1 MHz readout rate)
   - ADC for each detector element (sampling rate 9 MHz)
4 Stage Spectrometer I.

schematic view of CTR generation

spectrometer vessel in laboratory
4 Stage Spectrometer II.

grating plane

detector plane
4 Stage Spectrometer III.

signal feedthrough

electronic rack
Test Spectrum.

- test spectra under FEL condition
- spectra with 3 stages - uncorrected data
- errorbars show shot-to-shot fluctuation bandwidth
- 4\textsuperscript{th} stage equipped with transmission grating (not in operation)
Two installations at FLASH.

After last acceleration module:
  a. TR station off/on-axis screens
  b. spectrometer outside tunnel
→ good accessibility (for testing)
→ measure spectra of mostly full compressed bunch (dogleg missing)

In front of SASE undulators:
  a. TR screen off-axis / DR screen
  b. spectrometer inside tunnel
→ monitor capability
→ measure spectra of ’undulator’ bunches (after collimator, ORS and sFLASH)

Correlation of both spectrometers:
  i. bunch spectra evolution
  ii. ’cross check’ of spectrometer behavior
Thank you for your attention!
bunch current profiles

more realistic bunch

$\sigma_{\text{FWHM}} = 25.5 \mu\text{m}$

gaussian bunch

bunch profile with 3rd harmonic cavity

longitudinal formfactors $F$

long. formfactor for 3rd harmonic bunch