



# Work Group II

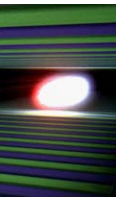
## Measurement of **spectral** properties

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- 10 participants
  - attending specialists for these techniques :  
PES, prism spectrometer, crystal spectrometer,  
(online) grating spectrometer,...
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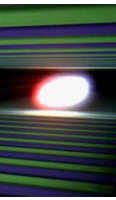
## What are the purposes of spectral measurements ?



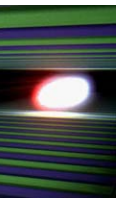
- A. Monitor central photon energy (center-of-mass)
- B. Determine pulse duration – spike width
- C. Beam position (center-of-mass of profile)
- D. Bandwidth
- E. Undulator commissioning
- F. Spatial / transverse distribution of spectral modes
- G. Higher harmonics content (intensity ratios)
- H. Polarization (accuracy of linear pol., degree of helical pol.)
- I. Calibration of monochromator
- J. Compare against other spectral techniques
- K. Transverse coherence

single-shot  
integrated

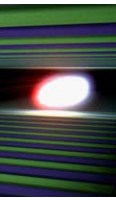
# Which technique for which purpose ?



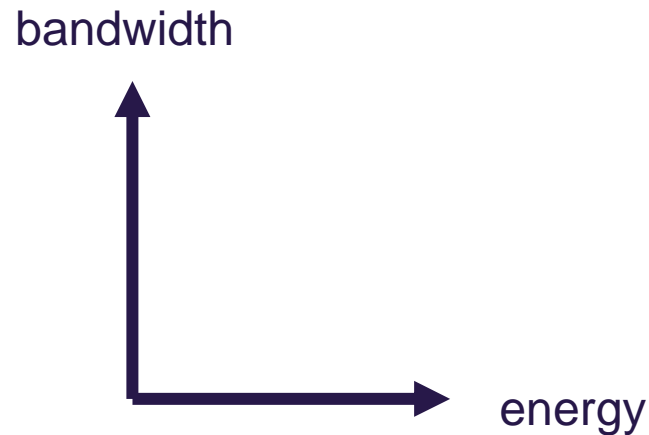
- destructive methods
  1. crystal spectrometer
    - a) dispersive (A,B,D,I,K)
    - b) non-dispersive = monochromator (E/F, G)
  2. grating spectrometer (A,B,D,E/F)
  3. refraction with prism (A,D,G)
  4. dispersive XRRS (A,B,D,I)
  5. Energy calibration by absorption edge (foil/wedge in beam+scan electron energy) (A,G)
- online measurements
  6. gas based – photoionization (A,B,C,D,G,H,I)
  7. beamsplitter + destructive
  8. for soft x-rays: grating in first order (A,B,D,E/F)

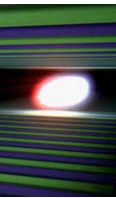


- Technical issues
  - Charge buildup
  - Feedback system to machine
  - sensitivity of prism spectrometer to beam position jitter ?
  - limits to the retarding potential ? today 3 kV standard
  - difficulty for online grating spectrometer: production of gratings large enough for footprint, quality
  - spectrometer angular acceptance ?
  - measurement of full spectrum and spikes with single device ? detector channel number must be considered
- Monochromator vs. Spectrometer
  - limited bandwidth of mono → increased intensity fluctuations behind exit slit
  - crystal monochromator not good for single-shot center-of-mass, neither the spikes
  - online spectrometer upstream calibrated against downstream monochromator (main contribution to spectrum)
  - monochromator can assess pulse stretching
- Recommendations
  - use spikes at higher harmonics to measure pulse duration (if very high resolution is needed)
  - use integral over dispersed beam transverse profile as intensity normalization + intensity measurement behind spectrometer
  - use prism as selective (mirror) element for higher harmonics



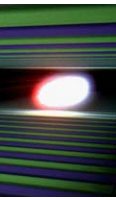
- for single shot measurements:
  - required intensity ?
  - max. 220ns
    - electron ToF: ok,
    - ion ToF: difficult - spectra overlap,
      - spread < 200ns for Xe
      - worst case 0.9 $\mu$ s for C60
      - for Xe<sup>+</sup>/Xe<sup>2+</sup> flight time 1 $\mu$ s, spread 500ns





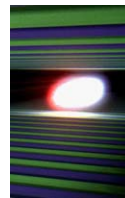
- soft x-ray undulator commissioning:
  - K adjustment not so critical like in hard x-ray case
  - requirement  $\Delta K = 1E-3$
- resolution of the grating spectrometer for pulse duration / spikes
  - for 100eV / 30fs pulses : >100meV spikes det. ok (resolution 1000)
  - at 10keV (crystal): 100fs pulses = 10meV resolution needed: 1E-6 !
  - at 1keV (grating): 100fs pulses: 1E-4 - 1E-5 res. needed
- resolution of prism spect. : scales with distance to detector, several 10m enough for 10E-4 resolution (scales linear with energy, range 5 – 100keV)
- spikes determination by PES:
  - ex. Ne 90eV  $\rightarrow$  1E6 events  $\rightarrow$  100 electrons detected
  - 10000 ToF electrons detected per shot needed

# Topics to study after workshop



- Repulsive effects in PES due to large electron cloud → distortion of ToF  
→ loss of resolution ?
- search for other than rare gases with edges in the range 8-12keV
- list of accuracies per device:  
beam property – relevant energy range and resolution
  - is it feasible ?
  - what is needed to realize this accuracy ?
    - e.g. gas pressure

# What are the purposes of spectral measurements ?



- A. **Monitor central photon energy (center-of-mass)**
  - a) resolution  $10E-4$  for 6-12keV
  - b) resolution  $3*10E-4$  for 1-3keV
- B. Determine pulse duration – spike width
  - a) resolution  $10E-6$  for 6-12keV (10meV)
  - b) resolution  $1E-4 - 1E-5$  for 1-3keV
- C. **Beam position (center-of-mass of profile)**
  - a) 10% of beam diameter = 1mm @  $z=1000m$  for 6-12keV
  - b) 10% of beam diameter = 1-3mm @  $z=300m$  for 1-3keV
- D. Bandwidth (like A)
  - a) resolution  $10E-4$  for 6-12keV
  - b) resolution  $3*10E-4$  for 1-3keV
- E. **Undulator commissioning**
- F. **Spatial / transverse distribution of spectral modes**
- G. **Higher harmonics content (intensity ratios)**
- H. **Polarization (accuracy of linear pol., degree of helical pol.)**
- I. **Calibration of monochromator**
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