

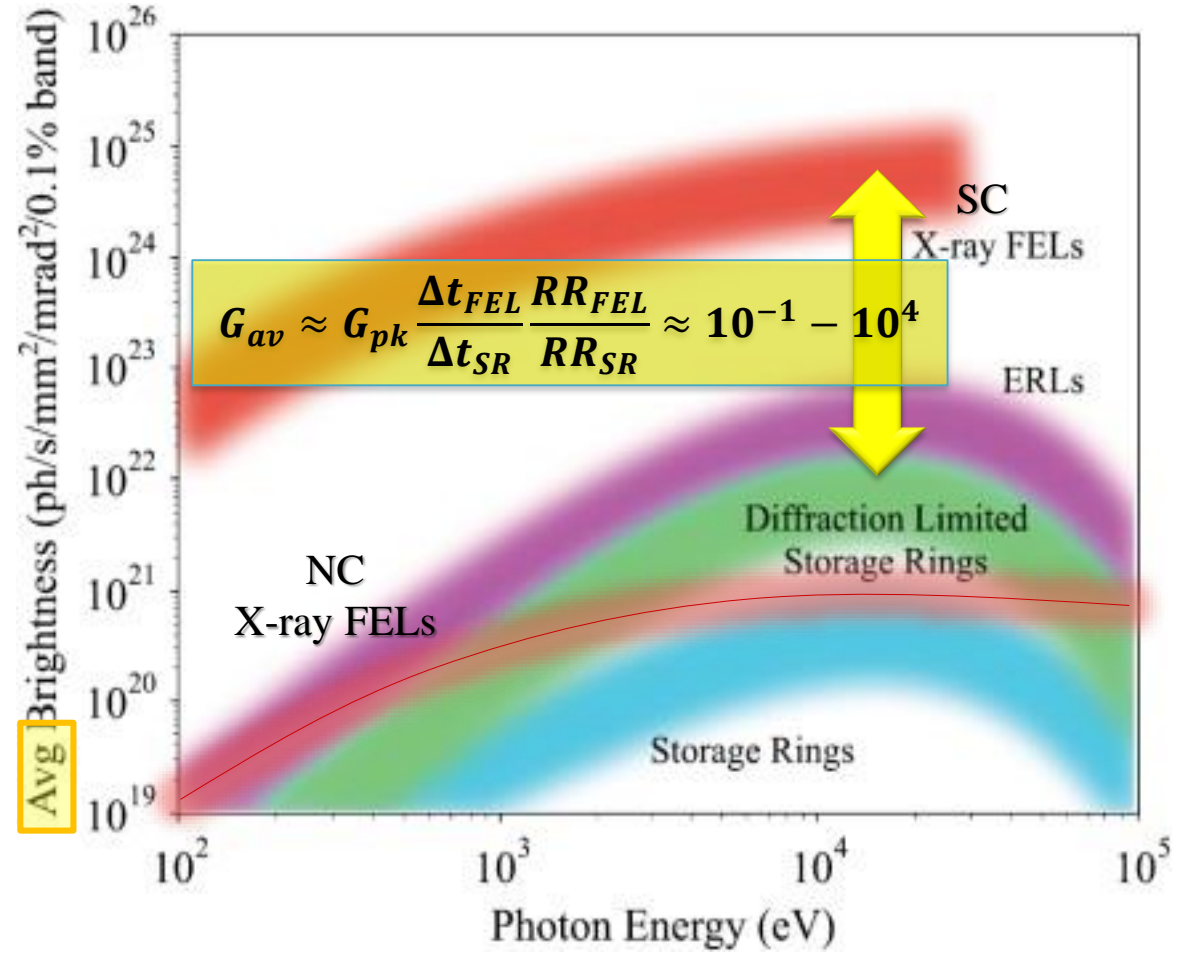
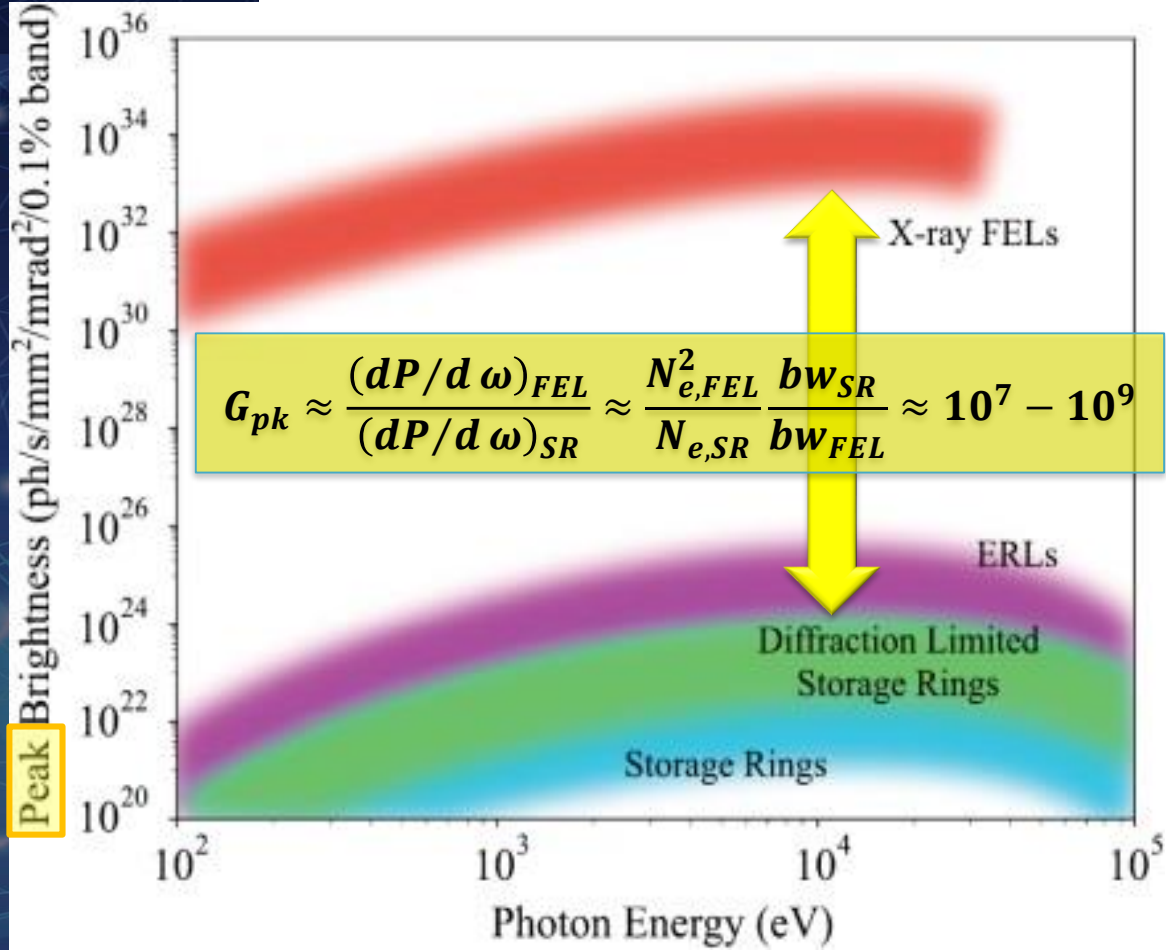


LEAPS League of European
Accelerator-based
Photon Sources

LEAPS – WG2 Photon Sources
Status of FEL Activities and Outlook
Simone Di Mitri, Elettra Sincrotrone Trieste

LEAPS WG2 meeting
Remote, 08.09.2020

Brilliance.....



.....and much more

Femtosecond-resolved RIXS:

probe the evolution of low energy electronic excitations in **correlated materials**.

Peak Flux

Average Power

Nonlinear X-ray optics:

measure **disordered systems** with higher **sensitivity** than in conventional linear spectroscopy.

Transverse and Longitudinal Coherence

Time Resolution

Compactness

Fine spectroscopy:

Time-resolved photoelectric effect and photon scattering for analysis of **matter in linear response regime**.

X-ray attosecond science:

coherent phase control to build attosecond pulse trains

Overview

- SX & HX, SASE & SS

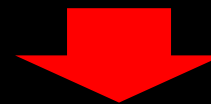


- MHz CW (SASE)
- XFELO, RAFEL
- Attosecond
- IR-FEL
- D/L/PWFA



- SASE > 20 keV
- EEHG > 500 eV
- MHz CW (SASE)
- MHz EUV (seed)
- Femtosecond
- L/PWFA

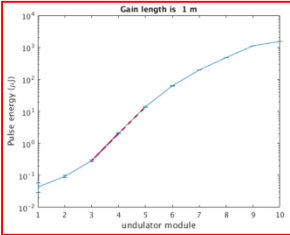
- IR-EUV, HGHG
- HX, SASE & SS



- Soft x-rays SS
- EEHG-PEHG
- MHz CW



Examples of FEL R&D in WG2

Lab	Recent / <i>Near</i> term achievements	Long term R&D	Collaborations
PSI SwissFEL, 100Hz HX (Aramis), SX (Athos)	<ul style="list-style-type: none"> • 2-bunches@28ns delay • SX to internal users • CHICs (1.5 mJ@540eV, $L_g=1m$) 	<ul style="list-style-type: none"> • Athos upgrade to ESASE (2021?) • EEHG (2022?) • 3rd beamline, HX (Porthos) 	
MAX-IV 3 GeV short pulse facility	<ul style="list-style-type: none"> • High brightness photo-injector • Passively linearized magnetic compressors • Femtosecond bunches and diagnostics • Low noise RF amplifiers. Solid state modulators. Timing. 	<ul style="list-style-type: none"> • SX (1-5nm), fs FEL • HX beamline 	<ul style="list-style-type: none"> • S-TCAV • Dog-leg compressors •
EU-XFEL 17.5 GeV SC linac	<ul style="list-style-type: none"> • 0.5-20 keV, 3 (HX) – 10 (SX) mJ • 3 FEL lines, 3 instruments in place, + 3 instruments planned. • Lasing at 30 keV fund. • 5 fs rms e-beam jitter • 3 – 6 instruments in simultaneous operation (complex pulse distribution system) 	<ul style="list-style-type: none"> • CW operation • Ultra-bright injector • Larger beamlines fan-out • >15 keV / >40 keV, > mJ • ESASE • Variable pulse length 	<ul style="list-style-type: none"> • Passive linearizer • X-TCAV • IBFB • Machine learning •

Examples of FEL R&D in WG2 (con't)

Lab	Recent / <i>Near</i> term achievements	Long term R&D	Collaborations
Elettra FERMI, 10-50 Hz EUV HGHG, 4-100 nm 5+1 beamlines	<ul style="list-style-type: none"> • < mJ pulse energy, 3 -6 fs seed-electron t-jitter, 0.01% relative bw (FL) • 2-pulses, 2-colors, tuneable time/spectral separation. Full polarization control • Coherent phase control (as-train) • Superradiance (5 fs fwhm) • EEHG@7nm fund., h=101 observed 	<ul style="list-style-type: none"> • 1.8 GeV@50 Hz (35 MV/m S-band) • FEL-1 EEHG • FEL-2 EEHG+HG HG (?) 	<ul style="list-style-type: none"> • High gradient S-band • MBI characterization & control • EEHG to 2 nm
SOLARIS Synchrotron light source	<ul style="list-style-type: none"> • POLFEL, S- & C-band technology 	<ul style="list-style-type: none"> • SOLARIS full energy injection @1.5 GeV, FEL energy upgrade 	<ul style="list-style-type: none"> • NCNR, HZDR, DESY • THz & VUV beamline • Compressors
CLS Synchrotron light source	<ul style="list-style-type: none"> • TRIUMF, 30 MeV SC-RF linac 	<ul style="list-style-type: none"> • IR FEL, 0.2 – 10 um, sub-ps pulses, 35 MeV 	<ul style="list-style-type: none"> • Univ. Waterloo, Univ. Saskatchewan • TRIUMF et al.

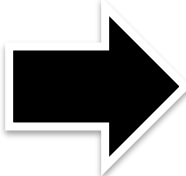
2017

Short period insertion devices	M.E. Couprie (SOLEIL) T. Schmidt (PSI)	SOLEIL, PSI, DESY, ELETTRA, ESRF, HZB, Diamond, Maxlab, ALBA, ANKA	S,F,C
Seed laser systems	M. Danailov (ELETTRA)	DESY, ELETTRA, EU-XFEL, HZDR, LNF, PSI	F
Electron bunch control (advanced bunch compressor, Laser heater, collimation)	S. Di Mitri (ELETTRA)	DESY, ELETTRA, EU-XFEL, MAXLAB, PSI	F,C
Advanced schemes for tailoring FEL pulses	S. Werin (MAXLAB) E. Allaria (ELETTRA)	ELETTRA, PSI, DESY, SOLEIL, MAXLAB, Eu-XFEL, DESY	F, C
Low emittance Photo-injectors (cw/sc and pulsed/nc)	T. Kamps (HZB)	HZB, DESY, HZDR, PSI, ELETTRA, LNF, MAXLAB	F,C
LEAPS accelerating techniques cwRF	H. Weise (DESY)	DESY, EUuXFEL, NCNR (Poland)	F
FEL tests stand (either stand-alone or attached to existing FEL)	M.E. Couprie (SOLEIL) B. Faatz (DESY) J. Clarke (ASTeC)	SOLEIL, DESY, ELETTRA, PSI	F
Tunable high power THz source for Eu-XFEL	Frank Stephan (DESY Zeuthen)	DESY, EU-XFEL (+ large number of potentially collaborating universities)	F
Very small aperture vacuum chamber	T. Schmidt (PSI) C. Herbeoux (SOLEIL)	ALBA, DESY, PSI, ANKA, SOLEIL, DIAMOND, MAXLAB	S,F
sc / nc cavities for bunch length control + RF systems	Jens Knobloch, Andreas Jankowiak (HZB)	ALBA, DESY, HZB, MAX IV, SOLEIL	S,F
Diagnostics and Feedback for advanced photon beam stability	G. Rehm (DIAMOND) R. De Monte (ELETTRA)	DIAMOND, Elettra, HZB, MAX IV, ESRF, PSI, SOLEIL	S,F
Sub femtosecond timing and synchronization	S. Hunziker (PSI)	PSI, DESY, ELETTRA	F,C

2017

WG2 Long-term Technology Roadmap

	ALBA	DESY	DIAMOND	ELETTRA	ESRF	EUROPEAN XFEL	FELIX	HZB	HZDR	INFN	ISA	MAX IV	PSI	PTB	SOLARIS	SOLEIL
High field, small aperture magnet - and related vacuum technology for beam guiding and as radiation source																
High brilliance Electron Beam production and control																
Specialized laser systems for Electron beam production, FEL seeding and plasma acceleration																
RF acceleration systems																
Advanced instrumentation for beam control and beam diagnostic																
Joint R&D on compact plasma accelerator for photon science (context EU design study EuPRAXIA)																



Pilot Project Cat-A: "LEAPS R&D Topic Insertion Devices" (LIDs)

WG2 FEL – What's next?

□ Worldwide efforts for:

- > mJ pulse energy @ > 10 keV (SASE)
- Full longitudinal coherence @ SX
- Femtosecond pulses and below
- MHZ CW time structure
- Simultaneous operation of multiple beamlines/instruments

□ Opportunity in EU for a synergic R&D action:

- Well-established FELs with aggressive R&D programs
- FEL projects emerging at labs hosting SRLS
- Complementarity of know-how in machine design and control

e-beam & FEL physics, hardware, controls, ...

Thank you for Your attention

***Questions and comments are
welcome***