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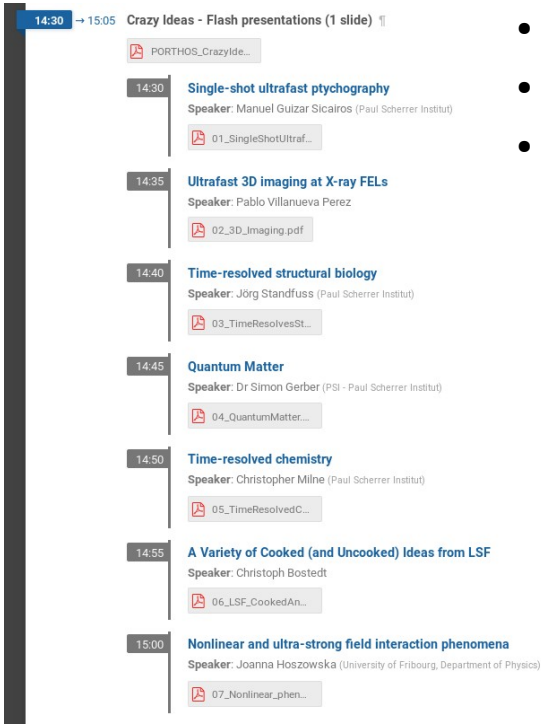
Summary of Photon Science Workshop and Design Implications

Porthos Machine Working Group Meeting, 22 September 2020

Photon Science Workshop on Porthos



- 11 September (on Zoom)
- Material on INDICO (https://indico.psi.ch/event/9145)
- Fields covered:
  - Single-shot ultrafast ptychography
  - Ultrafast 3D imaging
  - Time-resolved structural biology
  - Quantum matter
  - Time-resolved chemistry
  - Chemical imaging with incoherently scattered light
  - Stimulated spectroscopy for operando studies
  - Gas-phase scattering of molecular systems
  - From thermal to non-thermal processes
  - Nonlinear and ultra-strong field interaction phenomena

LSF "cooked & uncooked" ideas

Photon requirements (Marco's summary)

Imaging (3D + SingleShotPtycho)
- Energy: 12.4-30 keV
- 5 fs
- 100 Hz repetition rate
- Linear Polarisation
- Self-seeding, one color

Time-resolved structural biology
- 3-35 keV
- 5 fs
- 100 Hz
- No polarization needed
- Broad (0.5-1%) bandwidth

Time-resolved chemistry
- 12-35 keV
- 5 fs
- 100 Hz repetition rate (50 Hz useable)
- Linear polarisation
- Photon energy scanning, two-color, spectral control

Quantum Matter
- 2-12.4 keV and $\gtrsim$ 20 keV
- sub-fs (less critical for pulsed magnet)
- 100 Hz (less critical for pulsed magnet)
- Full polarization control
- CHIC and seeding

Non-linear phenomena
- 5-30 keV
- 0.1 fs FWHM (≤ core hole lifetimes)
- 100 Hz
- Linear polarisation
- Tunable photon energy, pump-probe, focus

Cooked and uncooked from LSF
- 5-20 keV
- Atto- to femto-seconds
- 100 Hz (?)
- Linear polarization (?)
- Two-color, “intense pulses”

SwissFEL PORTHOS – Wishlist for Machine

- Energy: up to 35 keV , definitely above 20 keV
- Pulse length: < 5 fs (ideally down to atto-seconds)
- Rep. rate: 100 Hz
- Polarization: Linear polarisation (full control)
- Features: Photon energy scanning
  one and two-colour
  spectral control
  CHIC, seeding
  broad bandwidth

Machine wish list (my summary)

Property	Absolute must	Desirable
Photon energy	**up to 20 keV**	**up to 30–35 keV** *(not so clear how important the gain is compared to 20 keV)*
Pulse length	**≤ 5 fs**	**down to 0.1 fs**
Polarization	**linear**	**full polarization control** *(only requested by quantum matter)*
Repetition rate	**100 Hz 12/24 h**	**100 Hz always**
Special features	• tunable photon energy • high-power pulses • spectral control (incl. large bandwidth 1%) • self-seeding • two colors	

Design implications

- **Photon energy:** depending on the upper limit we agree on, the maximum energy will require SC undulators or may be reached with conventional undulators or with a combination. In any case a linac upgrade will most likely be required to reach the requested photon energy range (details see Sven's slides).
- **Intra-undulator chicanes (CHIC design):** essential to realize short pulses with high intensity as requested.
- **Polarization:** linear (combined requirements of high photon energy and polarization control seem exceedingly rare)
- **Repetition rate:** it may be possible to forego true three-bunch operation by applying "smart scheduling" 100/50/50 Hz or 100/90/10 Hz scenarios with 12 h alternation?
  → *Save the cost of RF energy loss and additional gun laser?*
- **Special features:** most (if note all) of them can be covered in all scenarios with the planned hardware.

How to proceed? (Proposal to be discussed)

- **Objective:** deliver to the management a set of options with rough price tags.
- Sketch out (optimize) **three options** based on different technology and covering different photon energy ranges (considering the combined Aramis-Porthos potential):
  1) All conventional undulators (lowest cost and risk)
  2) All SC undulators for highest energy reach (with fundamental)
  3) Mixed conventional and SC undulators
- Determine the **price difference** between two-bunch operation and three-bunch operation.
- This will result in a **total of six options** covering different needs in terms of photon energy and repetition rates.
- Leave it to the management to **decide what price we are willing to pay for which features!**

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Thank you…