The European synchrotron (ESRF)

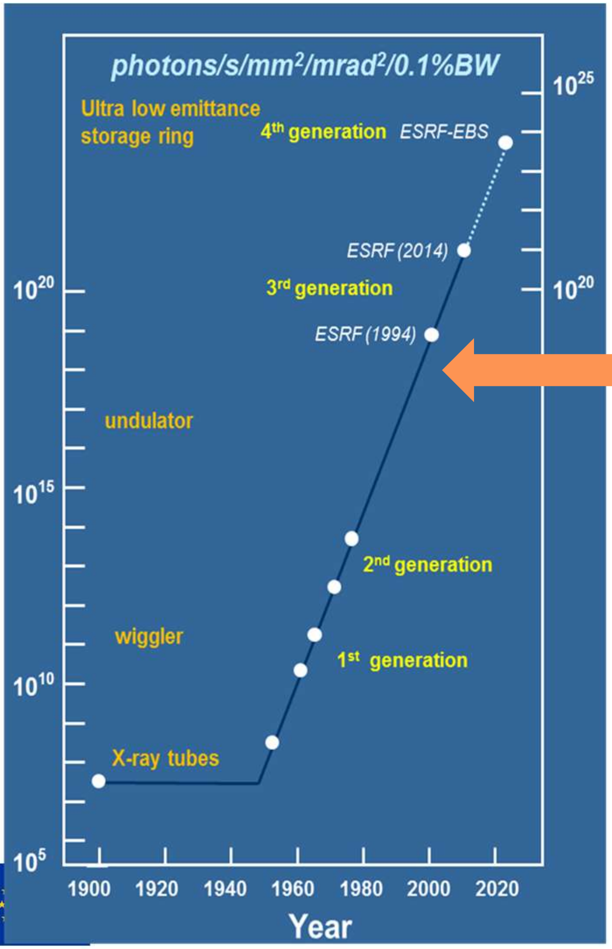
Ennio Capria (ESRF)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No **101008126**

Annual meeting

Introduction to the ESRF

Synchrotron light sources



An international cooperation

13 Member states:

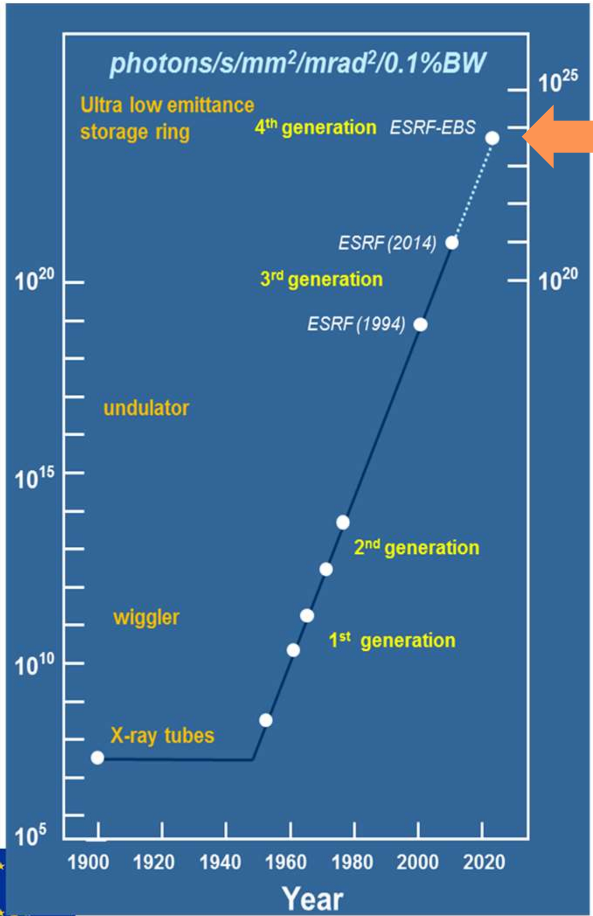
France	27.5 %
Germany	24 %
Italy	13.2 %
United Kingdom	10.5 %
Russia	6 %
Benesync (Belgium, The Netherlands)	5.8 %
Nordsync (Denmark, Finland, Norway, Sweden)	5 %
Spain	4 %
Switzerland	4 %

9 Associate countries:

Israel	1.75 %
Austria	1.75 %
Centralsync (Czech Republic, Hungary, Slovakia)	1.05 %
Poland	1 %
Portugal	1 %
India	0.66 %
South Africa	0.3 %

Contribution to the budget in %

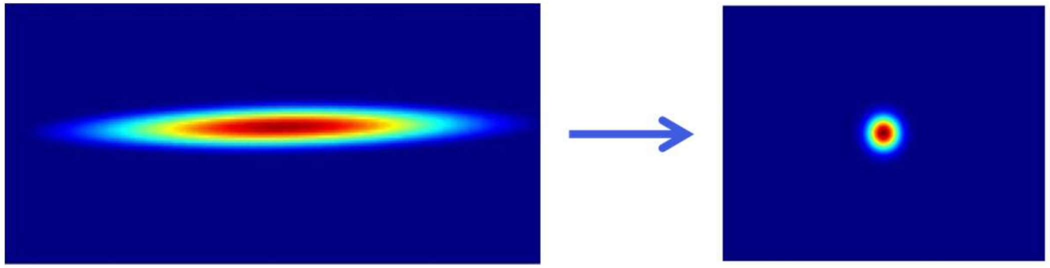
The ESRF, the first 4th generation synchrotron in the world



Hybrid 7 Bend Achromat lattice

P. Raimondi et al.

4nm.rad **100pm.rad**



Ultra low emittance high energy storage ring

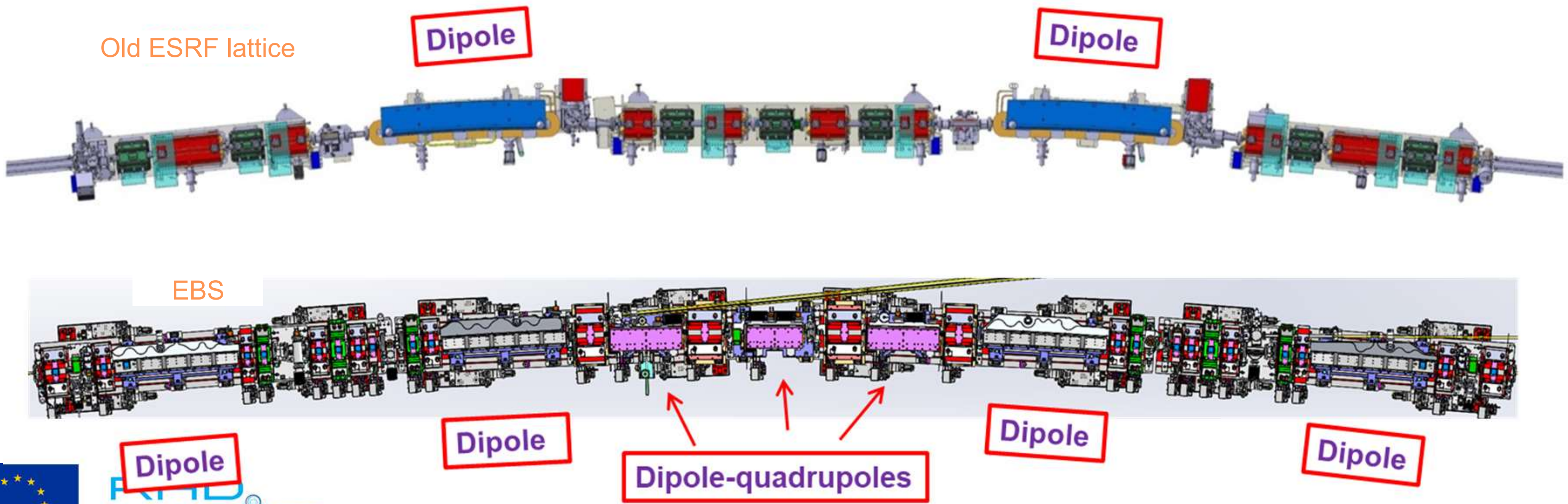
The ESRF, the first 4th generation synchrotron in the world

ESRF lattice (cell)

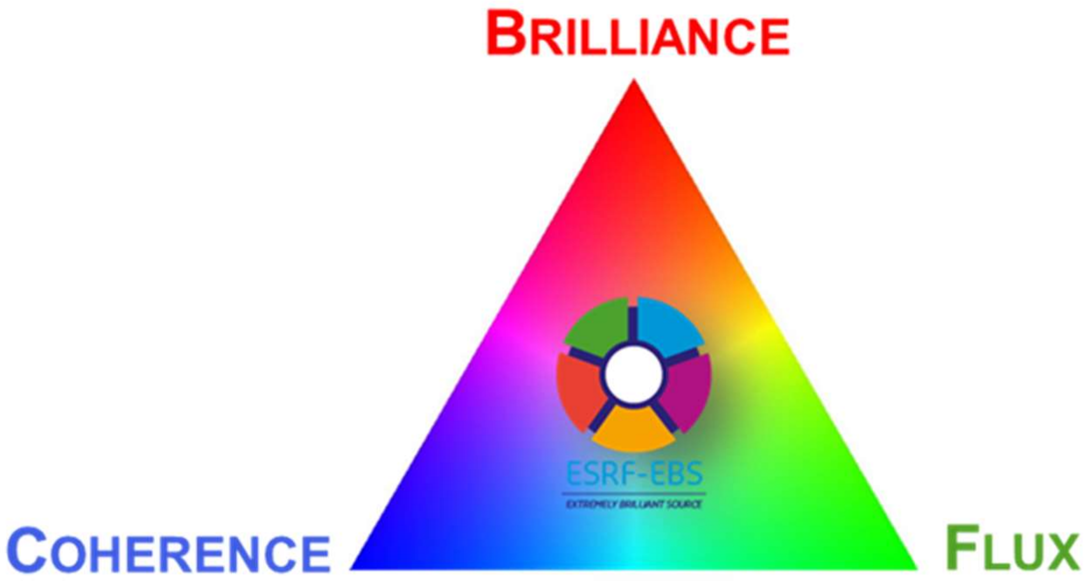
Double Bend Achromat = (2 dipoles + 15 quad. sext.) per cell
ID length = 5 m (standard) / 6m / 7m

EBS lattice (cell)

Hybrid 7 Bend Achromat = (4 dipoles + 3 dipole-quad + 24 quad., sext., oct.)
ID length = 5 m



What's the advantages with EBS?



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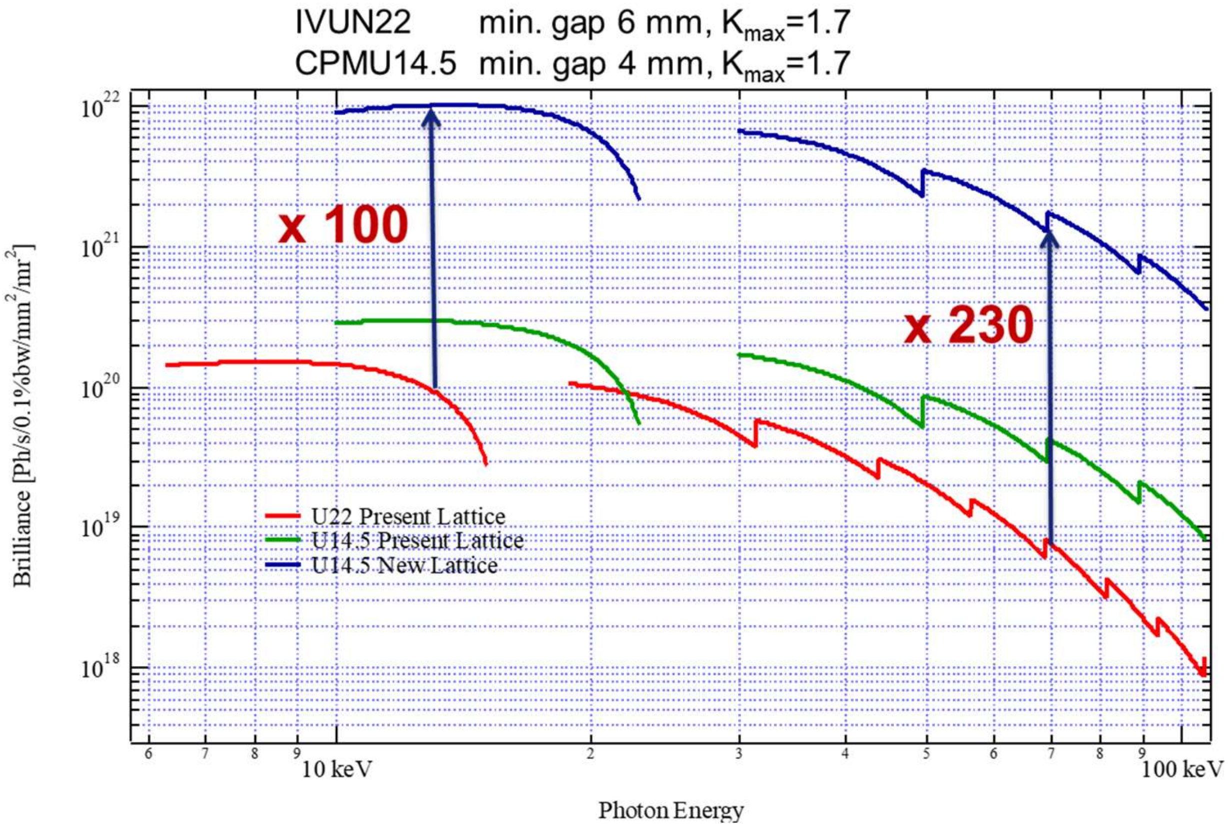
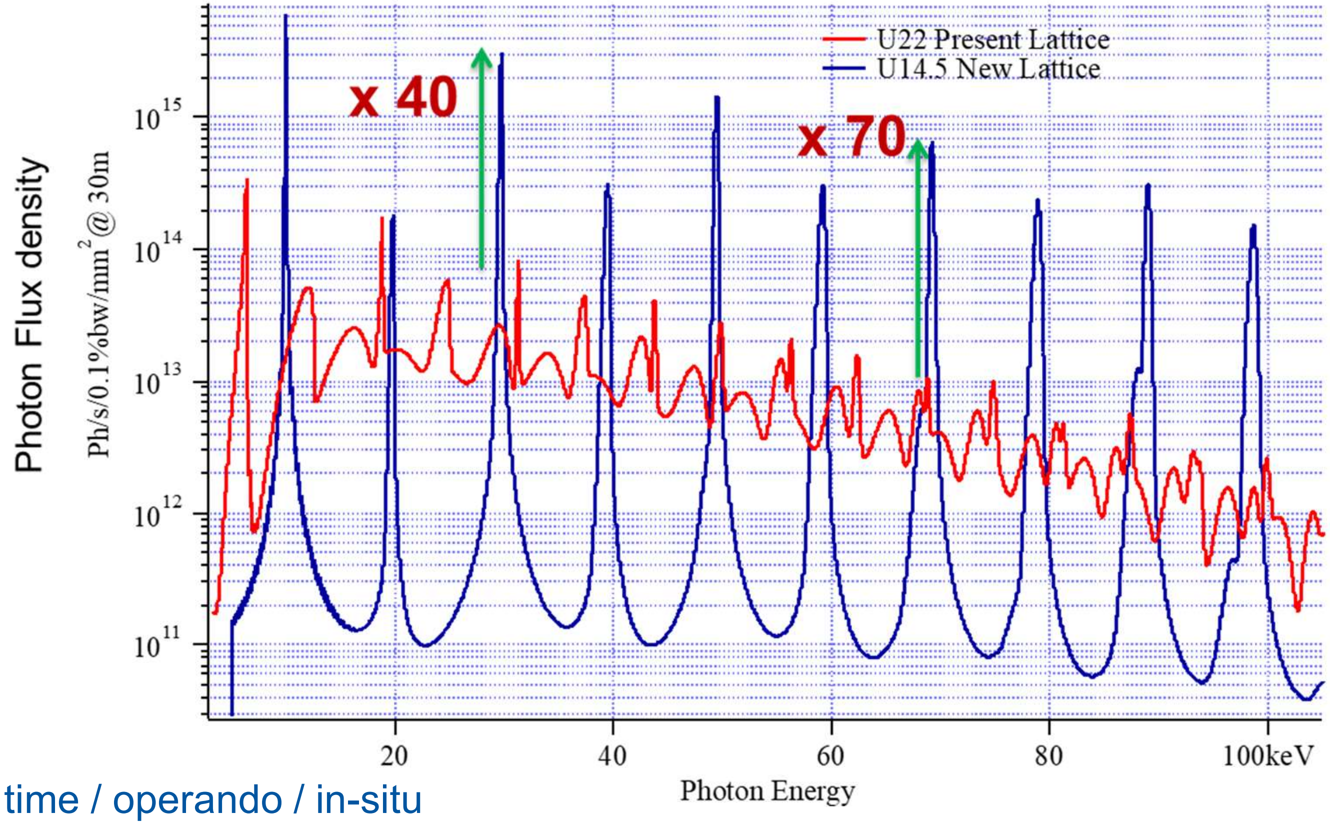


Smaller beams -> higher spatial resolution for multimodal mapping analysis.

What’s the advantages with EBS?



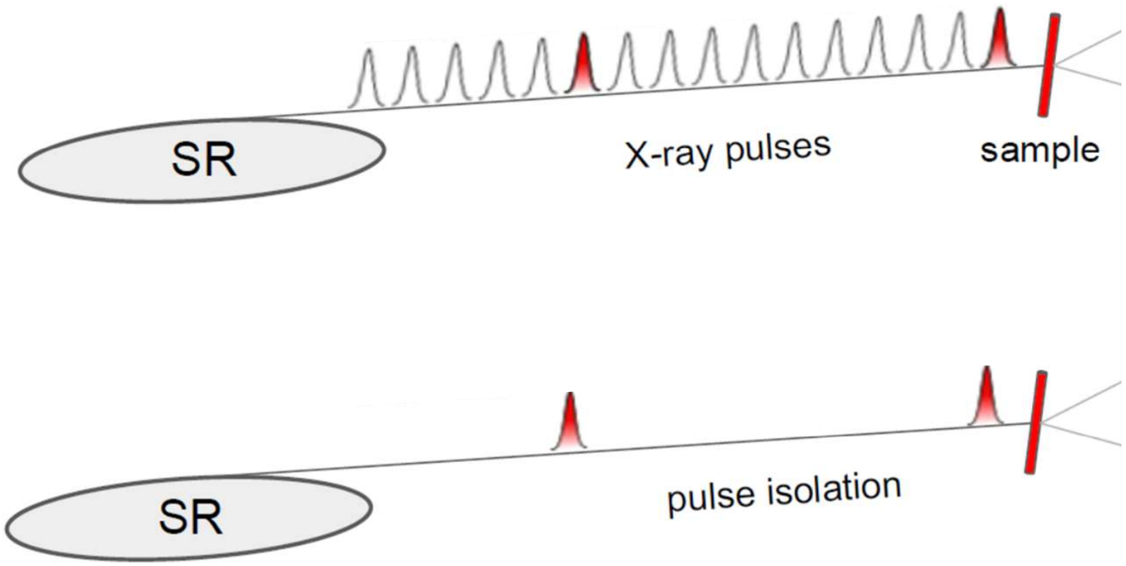
Faster acquisitions-> real time / operando / in-situ

high throughput

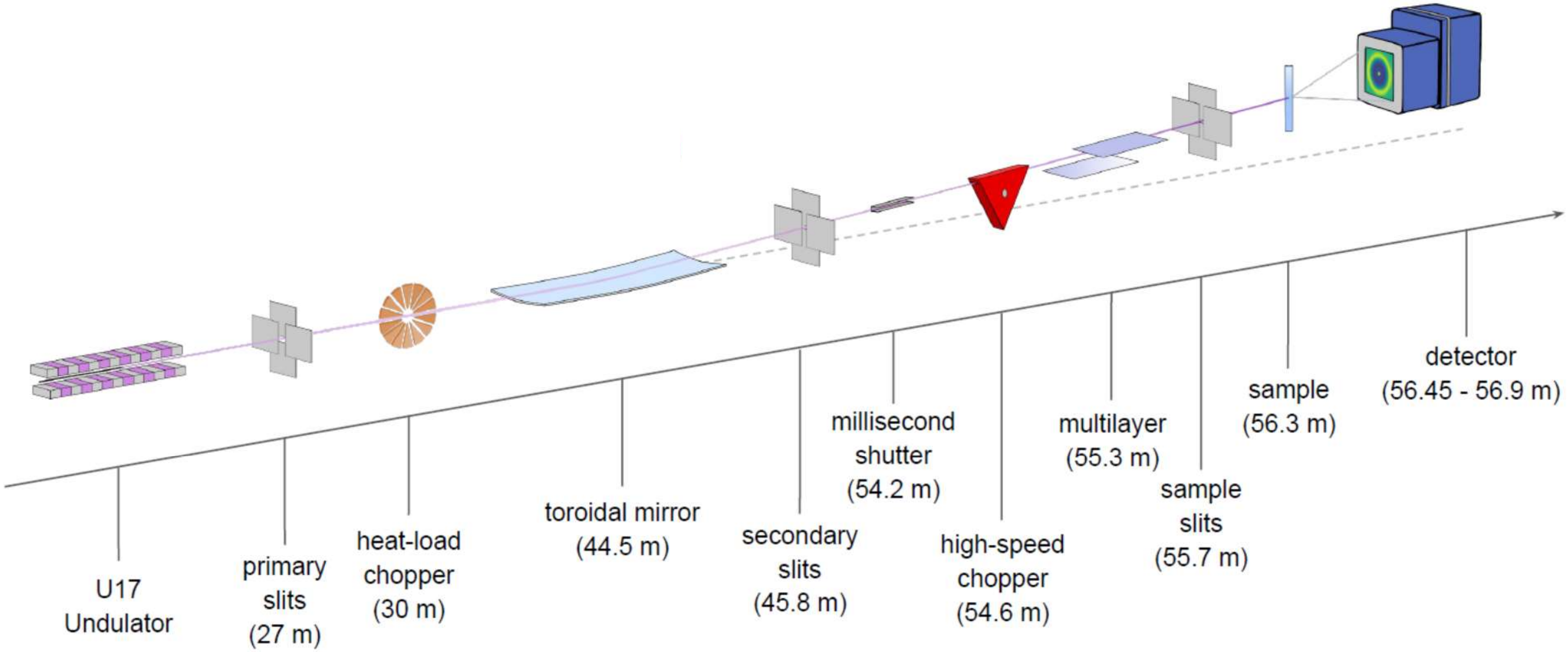
Better detection limit (signal/noise ratio)

X-ray focused pulsed beams: the beamline ID09

Time structure in a synchrotron



ID09 beamline layout

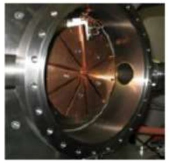


M. Levantino

ID09 synchronisation

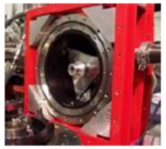
Incoming X-ray beam
(100 ps pulses at 352 MHz)

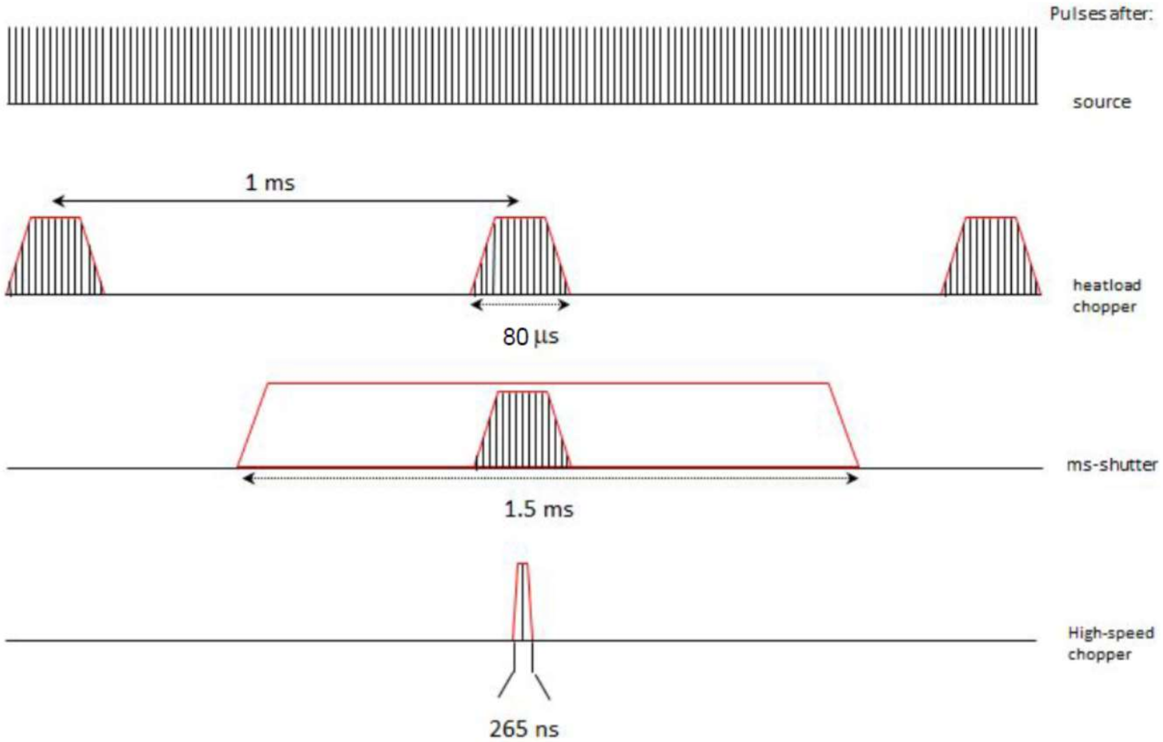
heat-load
chopper



millisecond
chopper

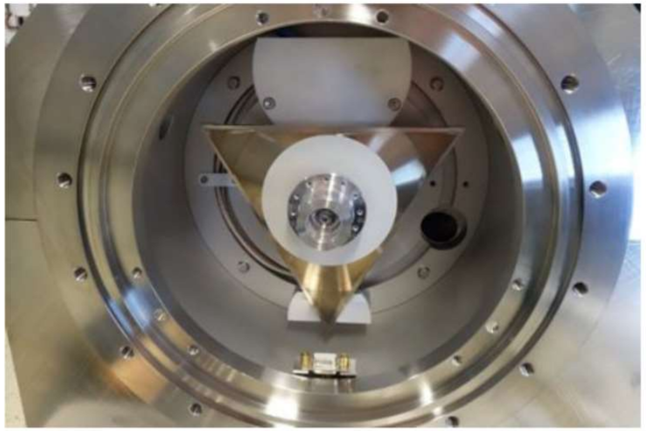
high-speed
chopper

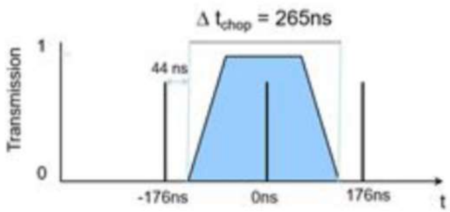


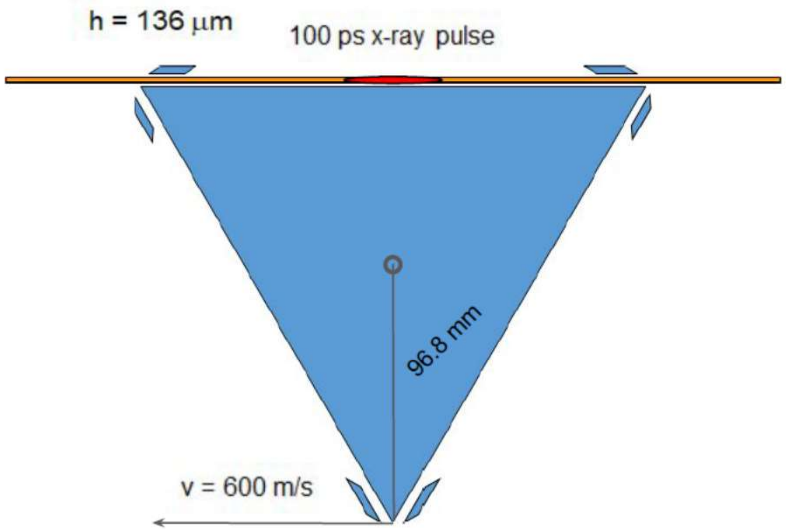


M. Levantino

High speed chopper

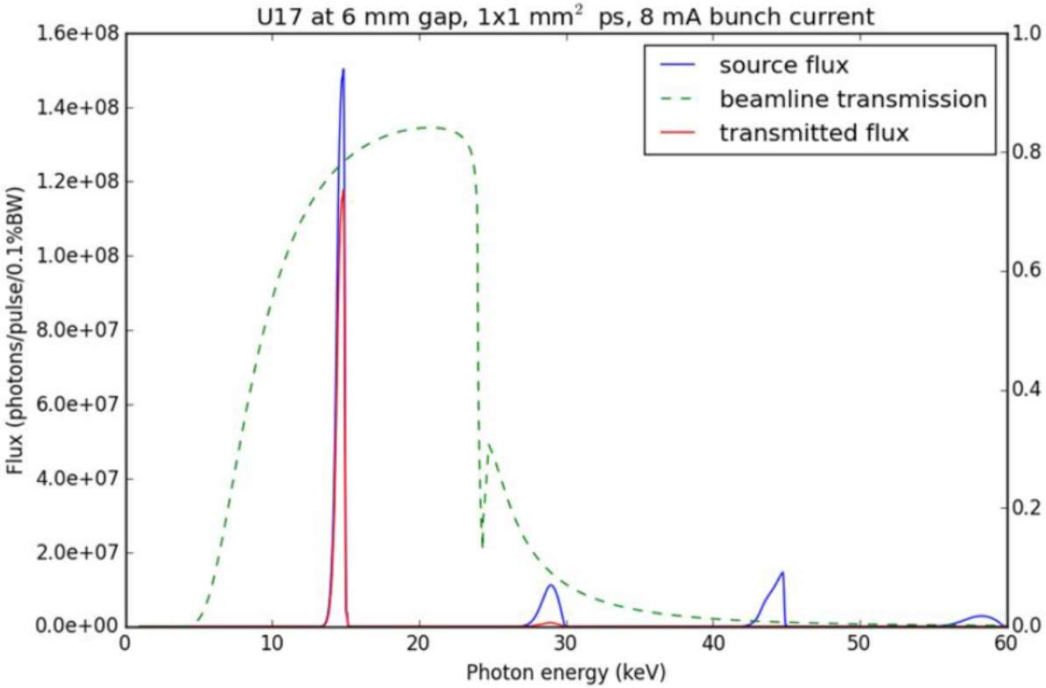






M. Levantino

Pink beam



PINK BEAM: 15-20keV

Brilliance 1.8×10^{22} ph/s/0.1%bw/mm^2/mrad^2

Beam spot size: 30um

1.2×10^{11} ph/pulse

<150ps pulse duration

The energy of the pulse is 300 uJ

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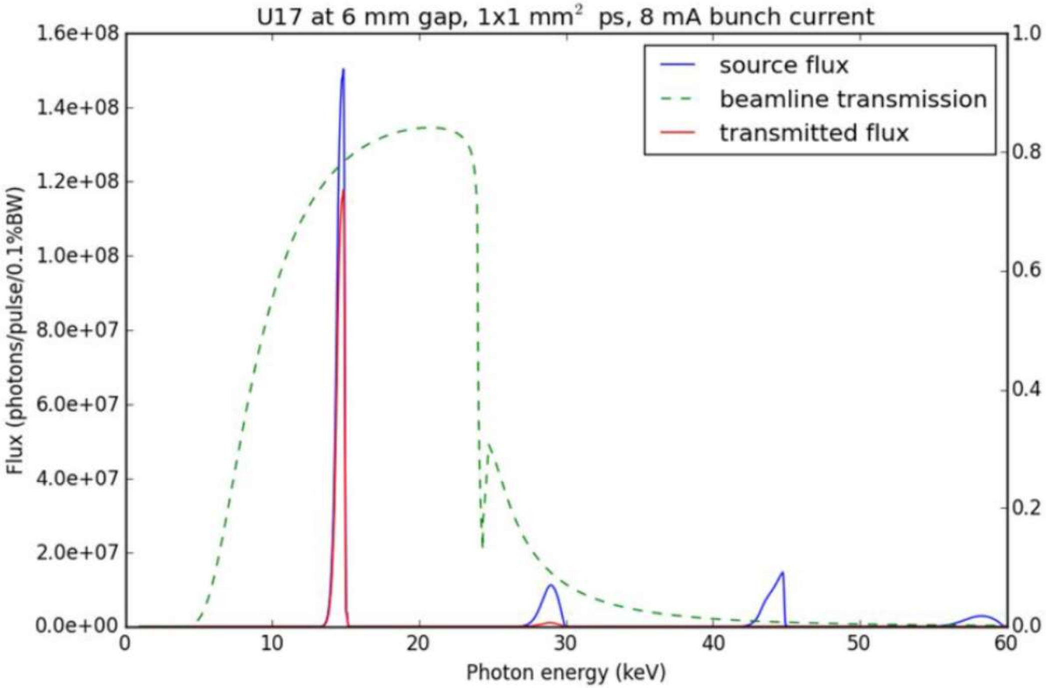
Pink beam



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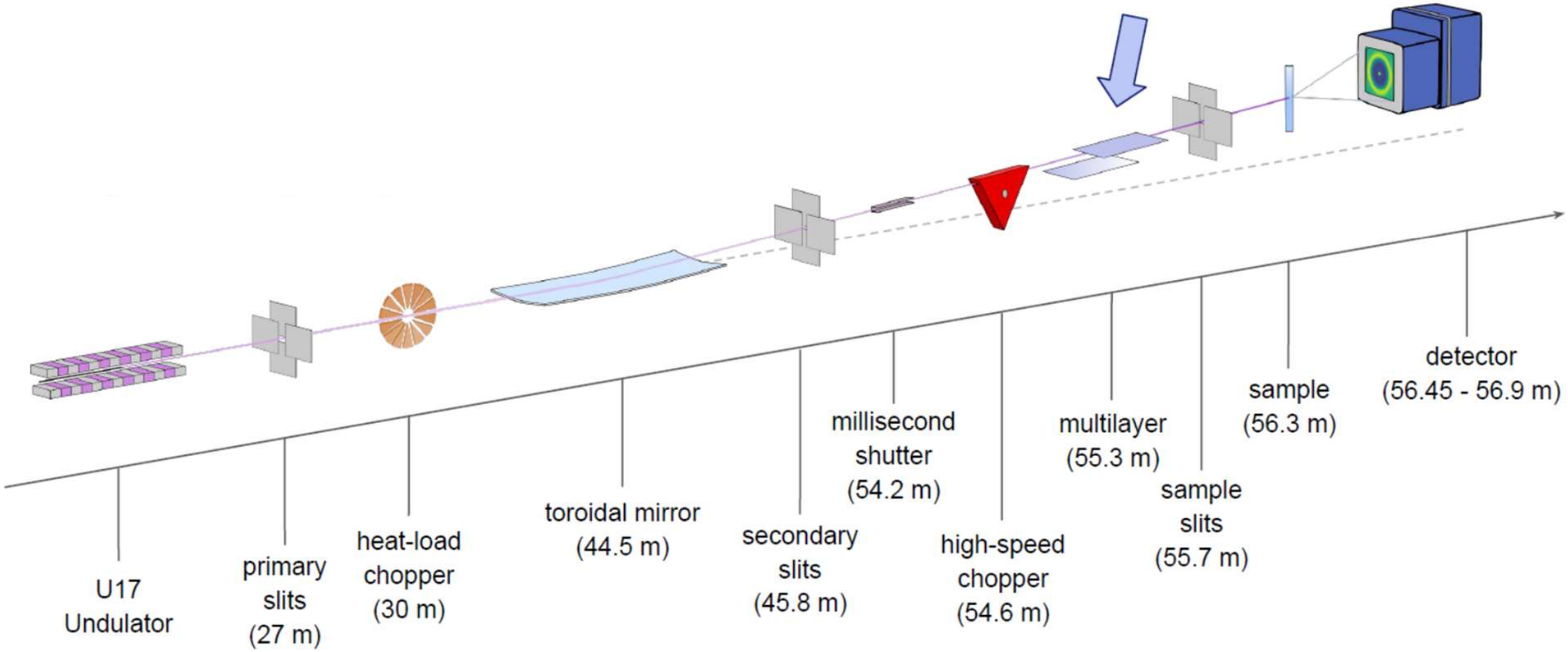
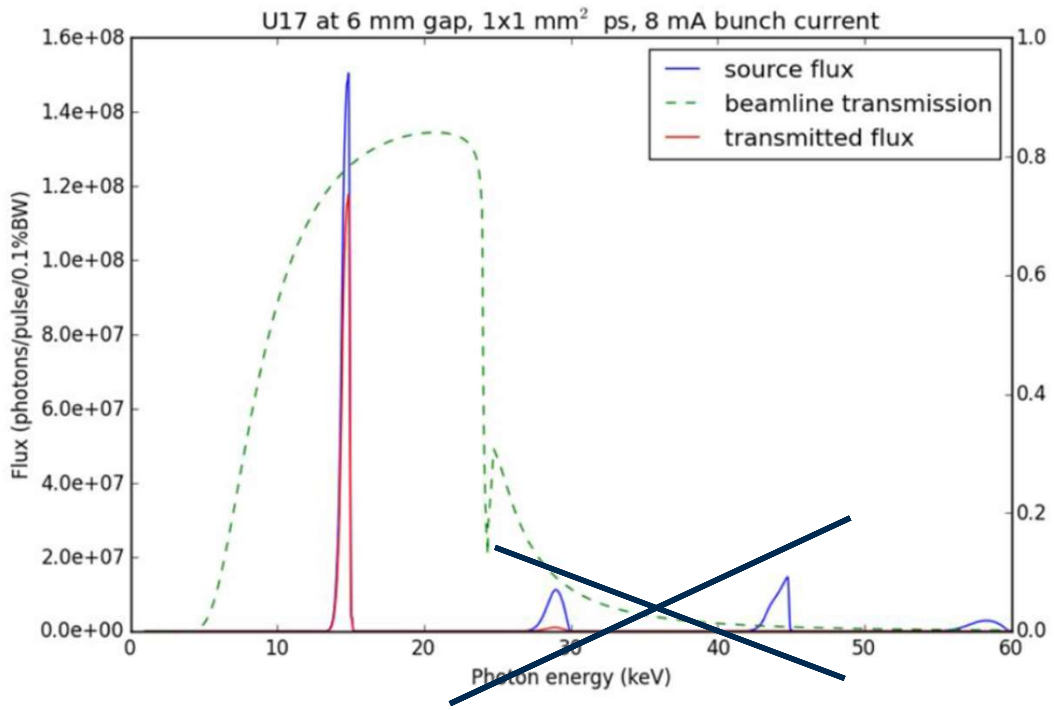
To improve spatial resolution
Pinhole 5um already commissioned
Pinhole 1um under commissioning

Use of a multilayer mirror

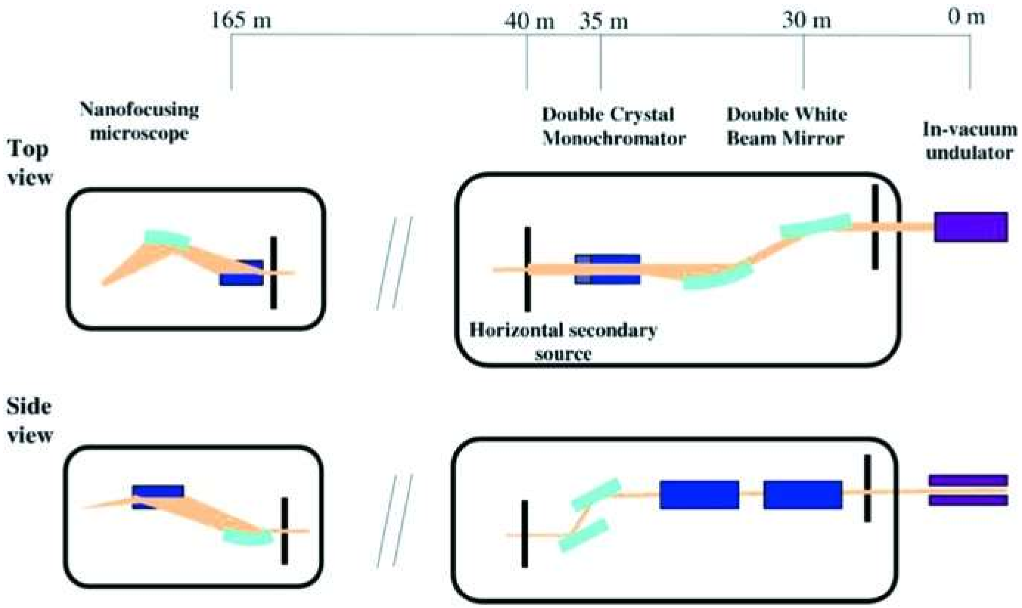


Use of a multilayer mirror



Looking for higher spatial resolution

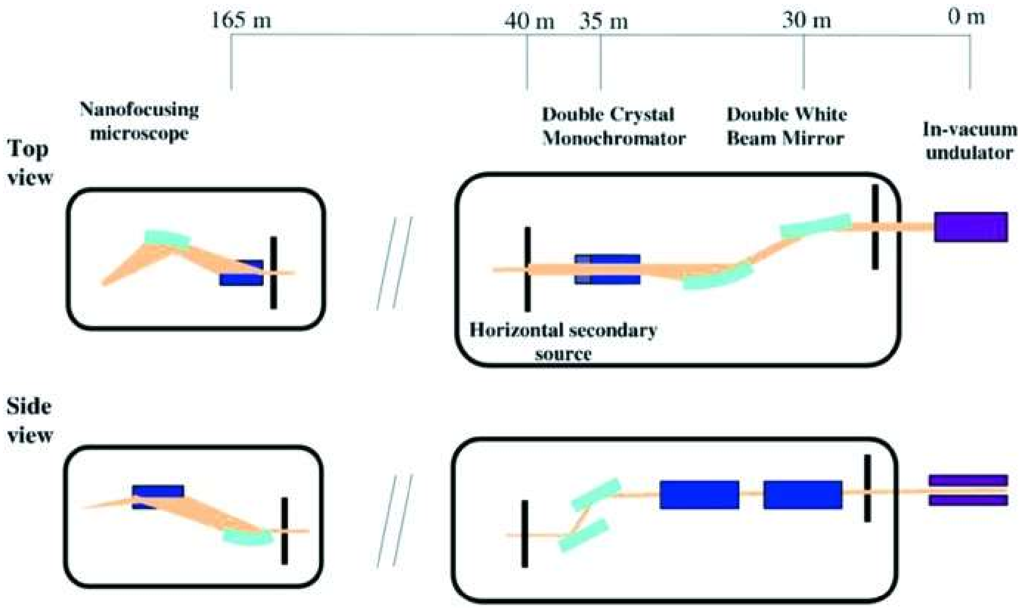
The beamline ID16B



Energy range
6.0 - 65.0 keV

Beam size
Minimum (H x V) : 50.0 x 50.0 nm²
Maximum (H x V) : 1.0 x 0.1 μm²

The beamline ID16B

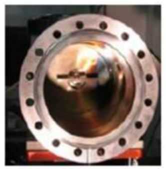


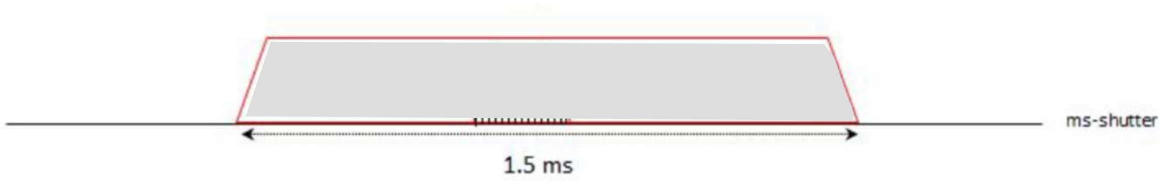
Energy range
•6.0 - 65.0 keV

Beam size
•Minimum (H x V) : 50.0 x 50.0 nm²
•Maximum (H x V) : 1.0 x 0.1 µm²

No possibility to select a single pulse

millisecond chopper

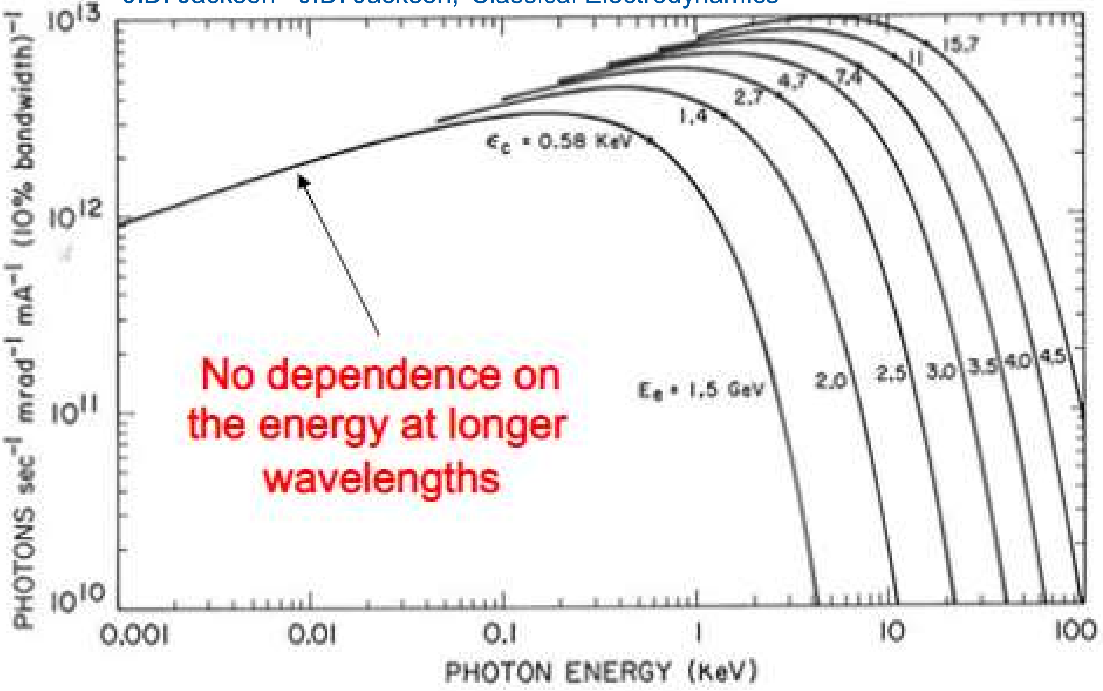




Some photons > 1MeV

Flux from standard sources

J.D. Jackson - J.D. Jackson, 'Classical Electrodynamics



Exchanging with Thomas Buslaps

“After EBS, on ID15 we will have a wiggler source which typically can provide useful photon flux up to energies of 500keV. The spectrum does not stop here but at high energies **you loose ~factor 10 in flux going to a higher energy E+100keV.**

The estimated spectral flux at 500 keV would be in the order of 1* 10^8 photons / s / mm^2 / 0.1%BW at 60m from the source:

this corresponds to a beam in EH2 (~60 m from source) using a beam size 1 x 1mm^2 after a monochromator with resolution of 0.1%BW (--> dE/E= 10^-3).

Going to 1MeV would mean reducing this number by ~10^5.
If you remove the mono you would gain a factor 1/10^-3= 1000: **at 500keV** ~ 1* 10^11 ph/s/mm^2 at 60 m from the source;

at 1MeV ~ 10^6 ph/s/mm^2

Any interest to go beyond?

Opportunities offered by synchrotron x-rays for irradiation of electronics

How we can synchrotron help?

The pulsed X-ray focused beam demonstrated effective for the following application:

- SPACE - Emulate the effect of heavy ions:
    - quantitative SEE evaluation has been demonstrated
    - pre-qualification of components for screening of components before qualification

- ATHMOSFERIC and TERRESTRIAL – localised fault injection
    - for functional safety testing
    - for well calibrated attacks for cyber-security applications

How we can synchrotron help?

The pulsed X-ray focused beam demonstrated effective for the following application:

Collaboration on modelling?

- SPACE - Emulate the effect of heavy ions:
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  - pre-qualification of components for screening of components before qualification

- ATHMOSFERIC and TERRESTRIAL – localised fault injection
  - for functional safety testing
  - for well calibrated attacks for cyber-security applications

How we can synchrotron help?

Presenting the following main advantages:

- High penetration depth, possibility to go through metallisations, 3D structures and packages
  - -> reduced sample preparation
- Spacial resolution (50nm to few um, depending from the instrument)
  - -> possibility for mapping techniques and simplified debut
- Possibility for time resolution with different time strucutures synchronized with your instrumentation
  - -> well controlled kinetic of charge deposition for SEE and minimised dose deposition

Support to TID testing:

- Tunable photon energy, spanning across several order of magnitude -> possibility to emulate Co60 sources at different dose rate?
- Beam intensity several orders of magnitude higher than laboratory X-ray benches -> possibility to speed up the testing?

ESRF in radnext

Necessity for a double review:

- The ESRF is not allowed to provide TA. It is necessary to operate the TA within the frame of the official public programme.
- The proposals submitted by RADNEXT needs to be also reviewed by the ESRF BTAP. The acceptance of the RADNEXT proposal is a critical factor
- This would introduce an additional delay, with the access that can occur up to 1y after the RADNEXT proposal.

First irradiation proposal in the history of the ESRF granted:

- 9 shifts has been allocated on ID09