# Required electron beam and/or radiation parameters for applications at the future European electron plasma accelerator research facility EuPRAXIA

## Preamble

One of the main goals of the workshop is a formulation of requirements that need to be met by the future EuPRAXIA accelerator test facility. We kindly request you to specify an application you have in mind and then, for this application, list as many required beam parameters as you can at this stage whatever the degree of uncertainty may be.

We are assuming that the baseline parameters listed below will be achievable by the plasma accelerator. As it is foreseen that the EuPRAXIA accelerator parameters will be evolving in time, for example reaching higher energies or repetition rates, please specify also desired parameters for longer-term goals, more ambitious, towards which we can work in future.

The beam that will be delivered by the plasma accelerator may not be suitable as is for many applications and might need some conditioning like: energy selection, intensity reduction, focussing or widening. Your parameters will influence the specifications for the required beam line and the necessary beam qualification diagnostics

In addition to specifying beam parameters, please list any other requirements such as field of view (e.g. for X-ray imaging), which would constrain beam line apertures, or needs for external magnets and other equipment, for example for HEP applications.

Please refer to the example at the end of the document. Feel free to adapt this document to express your requirements.

## Baseline electron beam parameters

| parameter | baseline value | considered upgrades |
|---|---:|---:|
| energy | 1–5 GeV | |
| bunch charge | 30pC | 100pC |
| number of electrons | $200.10^6$ | $600.10^6$ |
| bunch duration | 10fs | 3–30fs |
| repetition rate | 10Hz | 100Hz |
| total energy spread | 1% | |
| norm'd transvers emittance | 1 mm.mrad | |
| | | |

## Required electron beam parameters

The units are suggestions; feel free to use the adequate units for your application(s) and adapt the tables if necessary. Also you are welcome to add parameters or questions that are relevant to your application, and to propose different applications. Please copy/paste this page for each application.

| **Description of application**<br>**Design and investigation of narrow bandwidth (1-10 %) inverse Compton scattering (possibly multicolor) on 1-10 MeV level** | | | | |
|---|---|---|---|---|
| parameter | required value/range | | desirable in future | |
| | min | max | min | max |
| energy [GeV] | 0.5 | 1 | 0.5 | 5 |
| energy spread (after selection) [%] | 1% | 5% | 0.1 % | 1% |
| energy fluctuation (shot-to-shot) [%] | 1 % | 5 % | 0.1 % | 1% |
| number of delivered electrons | 30 pC | 100 | 100 | As much as possible |
| precision on n delivered electrons [%] | 10 % | | 1 % | |
| bunch duration [fs] | Few fs | | | |
| repetition rate [Hz] | 1 Hz | 5 Hz | 10 Hz | |
| number of del'd bunches per hour | | | | |
| beam diameter [m] | Few microns | | | |
| beam divergence [mrad] | 1 mrad | | 0.1 mrad or less | |
| electron flux density per shot [$m^{-2}$] | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## Other requirements (infrastructure, equipment, space, etc)

| parameter | required value/range | |
|---|---|---|
| | min | max |
| size of setup zone (length, width, height) | Given by required gamma-ray shielding | |
| size of user zone (length, width, height) | | |
| magnet (type, field strength, volume) | | |
| additional laser (energy, duration) | Scattering laser, ~1 ps, 0.5 J | 1-2 J |
| synchronisation signal (duration, jitter) | 100 fs level | |
| fiducial references | | |
| background monitoring | x-ray spectrometer (bremsstrahlung, betatron radiation) (high-res) gamma spectrometer to quantify produced signals | |
| radiation protection (sv/hour | To be evaluated | |
| photon flux density per shot [$m^{-2}$] | | |

| | | |
|---|---|---|
| | | |
| | | |

## Comments:

Narrow bandwidth inverse Compton scattering relies on small electron beam energy spread (1 % level) and small beam divergence. Thus, might involve implementation of high-quality electron beam injector (e.g. hybrid LWFA/PWFA, e.g. see WP 14 proposals).

Regardless of high demands regarding those injectors, the produced beams would strongly advance radiation sources in general and also boost FEL applications.

## Required photon beam parameters (THz, X-rays etc)

The units are suggestions; feel free to use the adequate units for your application(s) and adapt the tables if necessary. Also you are welcome to add parameters or questions that are relevant to your application, and to propose different applications. Please copy/paste this page for each application.

| **Description of application** | | | | |
|---|---|---|---|---|
| parameter | required value/range | | desirable in future | |
| | min | max | min | max |
| energy [MeV] | | | | |
| spectral width [MeV] | | | | |
| number of delivered photons | | | | |
| bunch duration [fs] | | | | |
| repetition rate [Hz] | | | | |
| number of del'd shots per hour | | | | |
| field of view or beam diameter [m] | | | | |
| beam divergence [mrad] | | | | |
| photon flux density per shot [$m^{-2}$] | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## Other requirements (infrastructure, equipment, space, etc)

| parameter | required value/range | |
|---|---|---|
| | min | max |
| size of setup zone (length, width, height) | | |
| size of user zone (length, width, height) | | |
| magnet (type, field strength, volume) | | |
| additional laser (energy, duration) | | |
| synchronisation signal (duration, jitter) | | |
| fiducial references | | |
| background monitoring | | |
| radiation protection (sv/hour | | |
| photon flux density per shot [$m^{-2}$] | | |
| | | |
| | | |
| | | |
| | | |

## Comments:

## Required electron beam parameters (example)

This is an example, the numbers bear no relation to what indeed may be required for each application.

| **Description of application**<br>Simultaneous calibration of large electro-magnetic detector modules with electrons. A wide, quasi-parallel beam sprays a granular calorimeter module. | | | | |
|---|---|---|---|---|
| parameter | required value/range | | desirable in future | |
| | min | max | min | max |
| energy [GeV] | 0.5 | 3 | 0.1 | 10 |
| energy spread (after selection) [%] | 0.5% | 1% | 0.1% | 0.3% |
| energy fluctuation (shot-to-shot) [%] | 1% | 2% | 0.1% | |
| number of delivered electrons | 10 | 100 | 10 | 100 |
| precision on n delivered electrons [%] | 10% | 50% | 1% | 10% |
| bunch duration [fs] | does not matter, if <10ps | | | |
| repetition rate [Hz] | 10 | 1000 | 100 | 1000 |
| number of del'd bunches per hour | 1000 | 4000 | 1000 | 10000 |
| beam diameter [m] | 0.3 | 0. | | |
| beam divergence [mrad] | 1 | 3 | 0.1 | 1 |
| electron flux density per shot [$m^{-2}$] | **not more than 0.1 electrons in a Moliere radius!** | | | |
| | | | | |
| | | | | |
| | | | | |

## Other requirements (infrastructure, equipment, space, etc)

| parameter | required value/range | |
|---|---|---|
| | min | max |
| size of setup zone (length, width, height) | 1m x 0.5m x 0.5m | 4m x 1m x1m |
| size of user zone (length, width, height) | 5m x 5m x 3m | 10m x 5m x 5m |
| magnet (type, field strength, volume) | no | solenoid, 1T, $1m^3$ |
| additional laser (energy, duration) | no | no |
| synchronisation signal (duration, jitter) | 1ms, jitter 100ps | 1ms, jitter 100ps |
| fiducial references | yes | yes |
| background monitoring | yes | yes |
| radiation protection (sv/hour) | to be evaluated | |
| moveable stage (range ) | 0.5m | 1m |
| cryogenics | no | no |
| cooling | no | yes |
| | | |
| | | |
| | | |

## Comments: