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APPLICATIONS

EuPRAXIA

HEP & Other Pilot Applications (WP7)

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HOPA beamlines

1. A positron source for low (positron spectroscopy for industrial applications) and high energy positrons (for example to study methods to accelerate positrons in plasma) **plus** a low charge beamline branch for HEP detector testing.
2. A betatron X-ray source for medical and industrial imaging.
3. A gamma-ray Compton source for industrial and medical applications and for studies of high-field QED.

These are representative, flag-ship applications. These beamlines will serve any application accepted by EuPRAXIA Selection Panel (see Access to Research Infrastructure presented by Maria Weikum and Franck Brottier). **There is no limit on the number of applications, all applications are considered. There is a limit on the number of beamlines EuPRAXIA can afford (money, space, personnel).**

HOPA beamlines

Another way of looking at it:

1. High charge beamline with a beam transport downstream plasma source.
2. High charge beamline without beam optics downstream plasma source; free space to accept any future configuration downstream plasma source.
3. High quality electron beam and an extra laser beam which might have high intensity. Both beams very well aligned and synchronized in time and 3D space.

HEP perspective:

Try to combine work on high charge and high quality electron beams as well as the work on 3D space and timing control; important considering the luminosity of a high energy particle accelerator.

Competitors

Positrons (or other secondary particles)

5 GeV RF electron accelerator would lead to higher positron charge but longer positron bunch length. As electrons are “lost” at the converter the cost of RF positron source would be significantly higher than the EuPRAXIA one.

X-rays

5 GeV synchrotron with 20-40 beamlines. It would be difficult for EuPRAXIA to produce cheaper X-ray photons but EuPRAXIA type betatron radiation X-ray source would have smaller footprint, eventually would be transportable and would have naturally short X-ray pulses naturally synchronized with a laser (easier pump-probe architecture).

Gammas

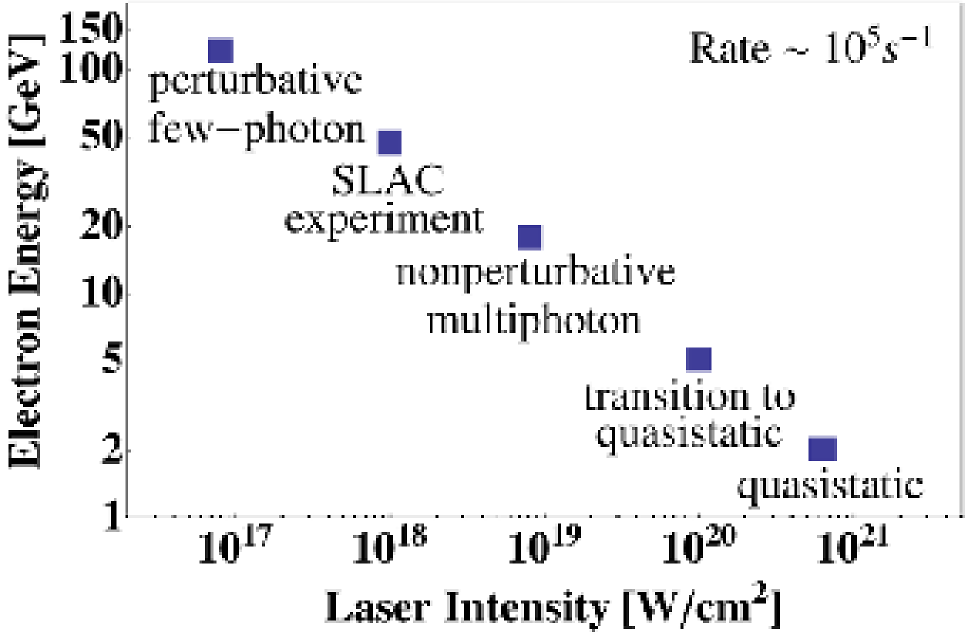
Many competitors: electrons with energies from 10s of MeV to few GeV, possibly in a storage ring of some design. At low electron beam energies EuPRAXIA probably can not compete but at GeV level electron energies this might be different and in addition, small footprint, transportability and short duration gamma pulses would be desired for some applications.

Competitors

QED, high field

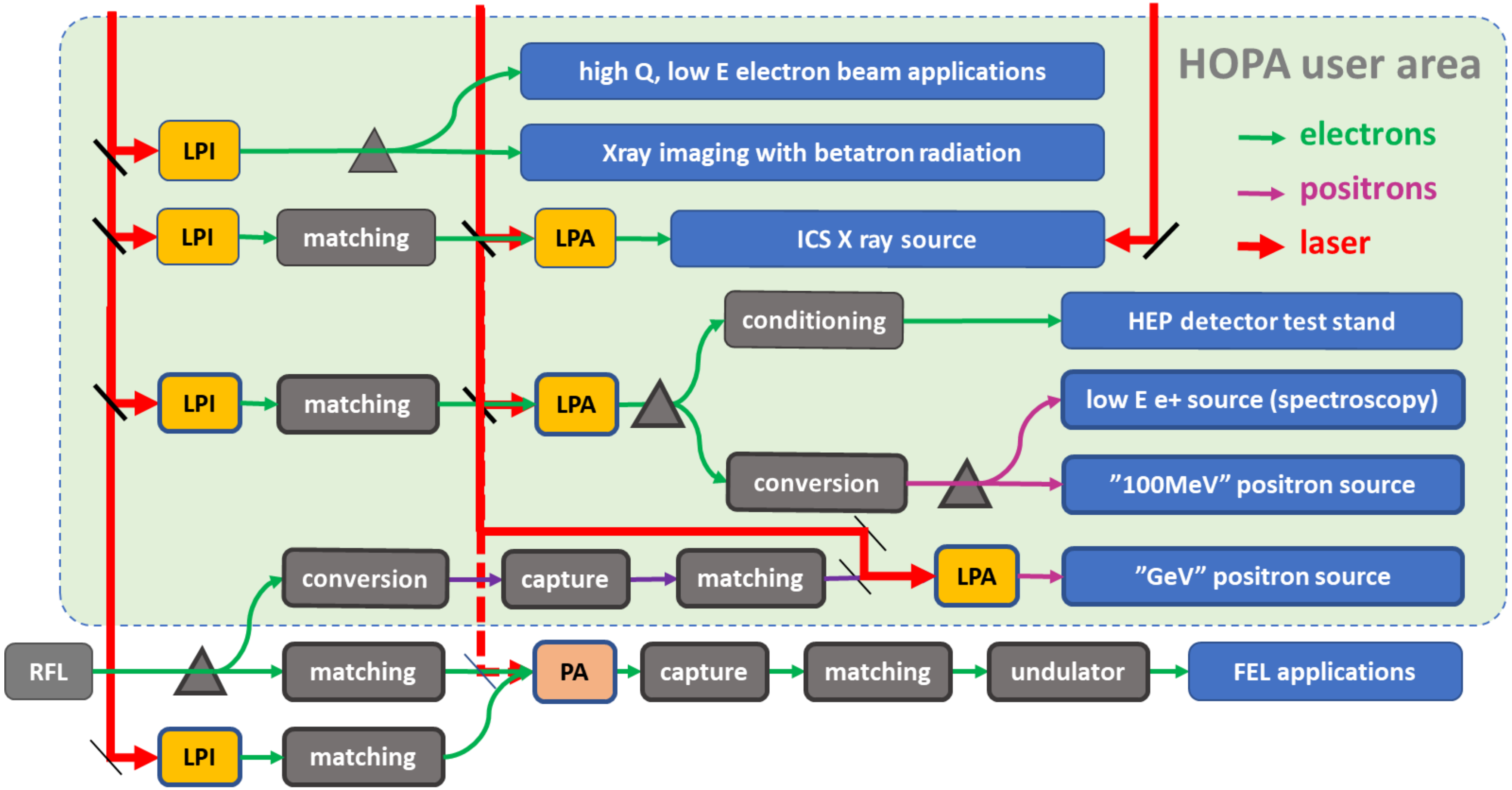
The main competitor is probably 0.1 to 1 PW laser - XFEL electron (17.5 GeV) collider planned at DESY.

As XFEL electron beam can't go below about 8 GeV, EuPRAXIA 5 GeV electron beam together with about 10^{20} W/ cm^2 laser intensity would bring complementary measurements providing stability and repeatability of the electron laser light interaction which is the key requirement.



H. Hu et al. PRL **105**, 080401 (2010)

One site conceptual diagram



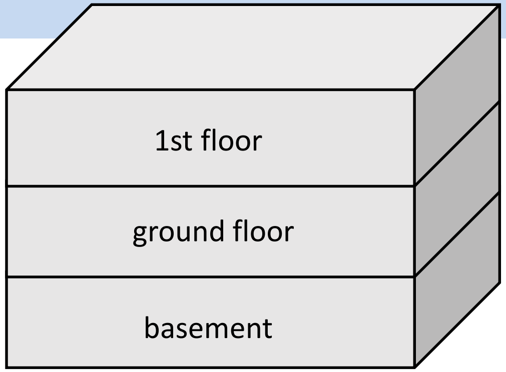
Proposal for EuPRAXIA Beamline Layout

Horizon 2020

- *Assuming DESY and INFN-LNF as **two main machine sites**, one focused on LWFA, the other focused on PWFA*
- *Taking into account: 1) previous discussions and proposals (e.g. WP7 presentation from Liverpool, WP7 reports, Walker et al. (2018)), 2) EuPRAXIA@SPARCLAB Layout*
- *Support labs, offices, etc. are not considered in detail yet; **footprint is not yet optimised***
- ***Phased implementation** of beamlines & user areas is foreseen*

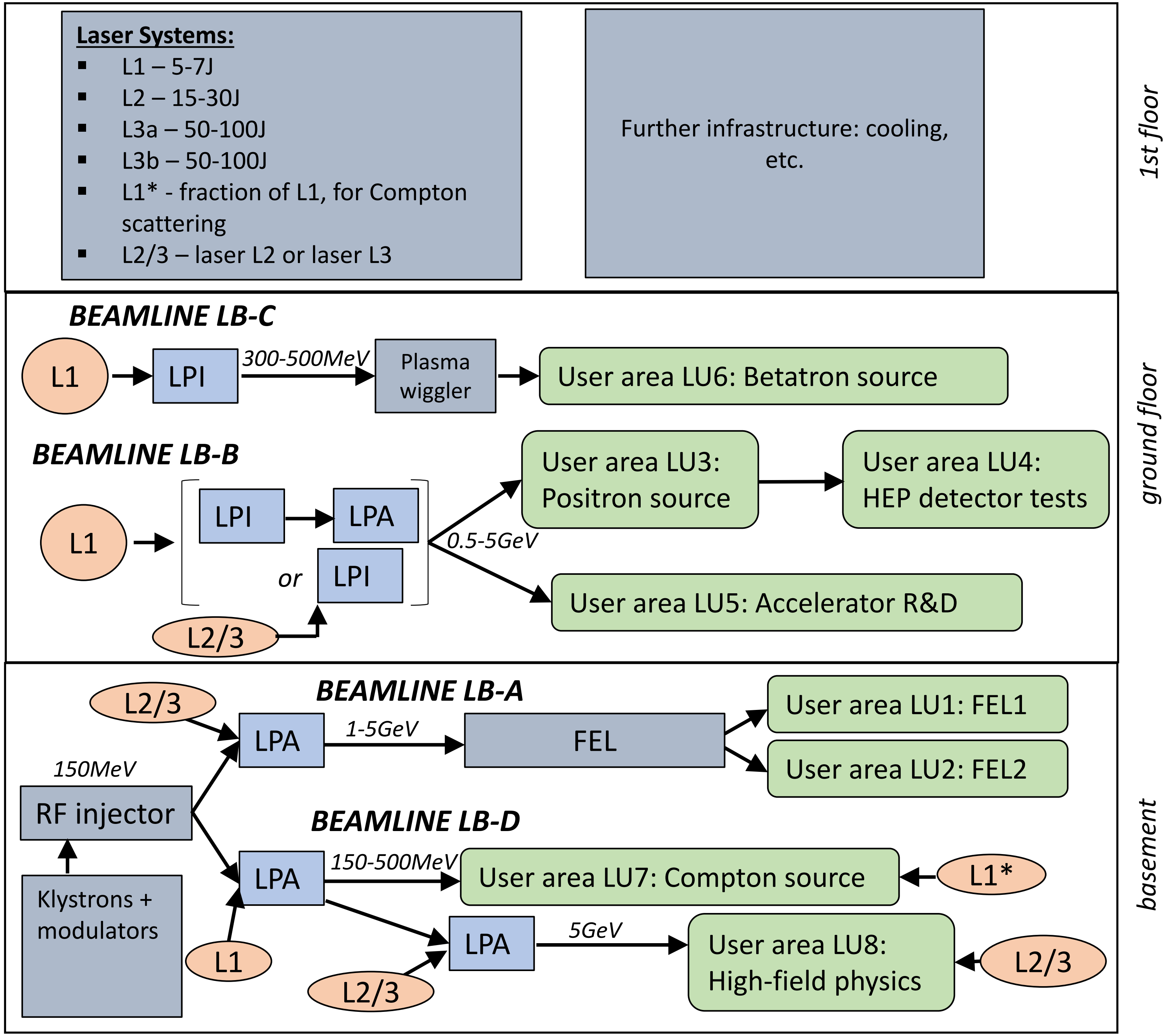
DESY site

- ➢ ***4 beamlines***
- ➢ ***8 user areas***



LB-A: FEL – high energy, low charge, high quality
LB-B: HEP + Materials – medium-high energy, high charge, medium-high quality
LB-C: Medical + Materials – low energy, high charge, medium quality
LB-D: Materials – low-high energy, medium charge, high quality

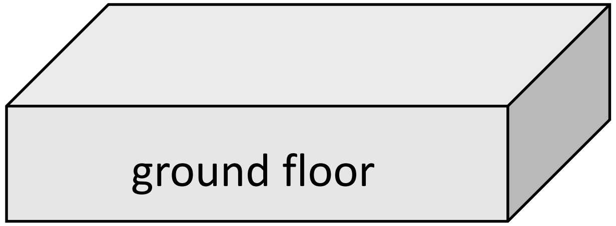
- *Very rough size estimate: 127m x 40m x 3 floors ~12,000m² footprint (excluding 5GeV FEL beamline)*
- *Length is limited by FEL beamline, width is limited by required user area space, esp. for HEP detector testing*
- *Reduction possible if building is not shaped rectangularly (as beamlines need less width)*
- *Varying lengths of beamlines should allow to fit some storage space and small preparation labs in basement and ground floor*



LPI = laser plasma injector, LPA = laser plasma accelerator

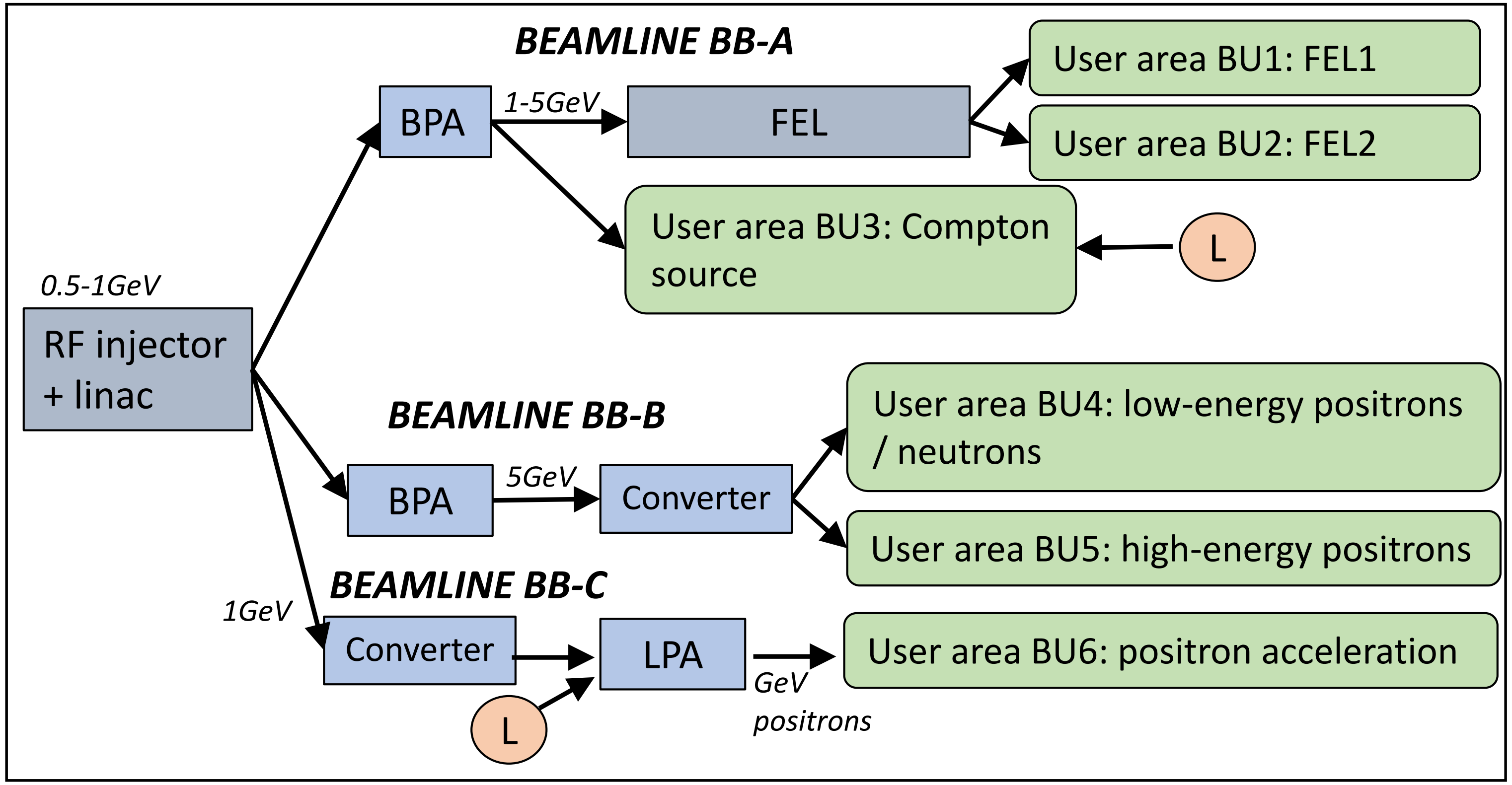
EuPRAXIA Frascati site

- ***3 beamlines***
- ***6 user areas***



BB-A: FEL – high energy, low charge, high quality
BB-B: Secondary particles – low-high energy, high charge, medium quality
BB-C: Positron acceleration (+ possible hybrid electron acceleration)

ground floor



- *Further infrastructure on first floor and in adjacent building*
- *Very rough size estimate: 134m x 35m x 1 floor ~4,690m^2 footprint (excluding 5GeV FEL beamline)*
- *Length is limited by FEL beamline, estimates based on EuPRAXIA@SPARCLAB CDR*
- *Building design also contains klystrons, modulators, laser labs within this estimate (see p. 26 EuPRAXIA@SPARCLAB CDR)*
- *Existing FLAME laser could be upgraded to PW-scale (L) and used for 1) Compton source, 2) positron acceleration, 3) electron acceleration beyond 5GeV*

Phased Implementation

DESY	INFN-LNF
Phase 1: LB-A (to 1GeV, one user area) + LB-B (one user area, LU3 or LU5)	Phase 1: BB-A (to 1GeV, one user area) + BB-B (BU4+BU5)
Gradual set up of further features: ▪ LB-B second user area (LU3 or LU5, respectively) ▪ LB-A energy increase to 5GeV (tbd) ▪ LB-A second user area U2 ▪ LB-C: LU6 ▪ LB-B third user area (LU4) ▪ LB-D: LU7+LU8 ▪ Possibly upgrade to hybrid acceleration scheme	Gradual set up of further features: ▪ BB-C ▪ BB-A energy increase to 5GeV (tbd) ▪ BB-A second user area U2 ▪ Possibly upgrade to hybrid acceleration scheme ▪ Possibly upgrade to higher energies through an extra LWFA stage

Predicted interdependencies:

- Parallel use of user areas and beamlines is limited by 1) multiple user areas feeding into one beamline, 2) number of available lasers
- At DESY: up to three user areas can run simultaneously and largely independently
- At Frascati: up to two user areas can run simultaneously and largely independently
- A possible upgrade option could include parallel operation of more beamlines through additional lasers or higher laser rep rate (so that one laser can be split between beamlines)

Open questions:

- Should any or both FEL-beamlines be upgraded to 5GeV? This would come with a significant beamline length increase.
- Should both FEL-beamlines have two user areas? If yes, for which types of experiments?

DESY site:

- Is there a case for including a user area for using the electron beam from Beamline LB-C (after or instead of radiation generation)?
- Can one laser (L2 or L3) be used as driver and for QED interactions at beamline LB-B simultaneously?
- Is there a case for building from ground floor to 2nd floor at DESY to reduce construction costs?
- Will the laser systems be stable enough being located on the first floor?
- Should both L3a and L3b run simultaneously or one only as backup?
- Can we include positron generation for material analysis in the medical + materials beamline (LB-C)? As two experimental areas (otherwise cannot switch quickly between them)?
- Does it make sense (with regard to beam parameters) to combine beamlines LB-C and LB-D to save beamline components and space?

Frascati site:

- At the INFN-LNF site, does it make more sense to split the beamlines after the RF accelerator or after the plasma stages?
- Where could acceleration beyond 5GeV (BPA+LPA) fit into at the INFN-LNF site?

Questions

1. If not all beamlines are installed at the same time, what is the time order of their installation?
2. Keeping possible upgrade of EuPRAXIA in mind, should we have shielding design for higher rates (kHz?), have extra space reserved for future development?

Summary

- All applications are considered but the number of beamlines is limited.
- There will be a discussion on HOPA beamlines layout (assuming Frascati and DESY sites) starting at 16:30 on Wednesday in Salvini Room.
- There is a proposal by a consortium of UK Labs and Universities to deliver to EuPRAXIA HOPA beamlines (subject to funding and details); related plenary talks by J. Clarke (Tuesday), G. Sarri, Z. Najmudin, R. Pattathil and M. Wiggins (Wednesday).

EuPRAXIA Research Infrastructure