X-ray beam transport systems at the European XFEL

Harald Sinn, Antje Trapp, Raul Villanueva, Martin Dommach.

European XFEL, Albert-Einstein-Ring 19, 22761 Hamburg, Germany

Conceptual Design of X-ray Beam Transport Systems.

SASE1 and SASE2: A double mirror system at about 250 m distance from the FEL source point will offset the beam sideways by > 25 mm (Fig.1). To adjust to beam divergences at lower X-ray energies, incident angles at the offset mirrors are adjustable, leading to an increased offset (Fig.3) The very hard spontaneous radiation background (critical energy is around 200 keV) is not reflected by these mirrors and will be absorbed in the bremsstrahlung collimator at 273 m. Optionally, a double Laue diamond monochromator can be used to offset a narrow band pass of harder X-rays. A distribution mirror at 370 m can be used to reflect the beam to the side station. In order to adjust the footprint on this mirror, the beam will be pre-focused by the second offset mirror (Fig. 3, bottom). A convex adjustable curvature of the distribution mirror can be used to control the horizontal beam size in the experimental stations.

SASE3, Figure 2: The adjustable offset mirrors are similar to the hard X-ray beamlines. At 301m, a VLS grating monochromator setup (E/dE ≈10^4) is used in the vertical in-line geometry. A cylindrical pre-mirror and focuses the zero and first order from the VLS grating onto the exit slit at 400 m. Distribution mirrors can be used to branch-off the monochromatic or pink beam to more exit ports.

Focusing schemes based on ellipsoidal mirrors or KB-systems are currently under consideration. For the hard X-ray beamlines, beryllium or diamond based CRLs and diamond based zone plates are possible focusing elements as well. Delay lines are being discussed for soft and hard X-ray beamlines.

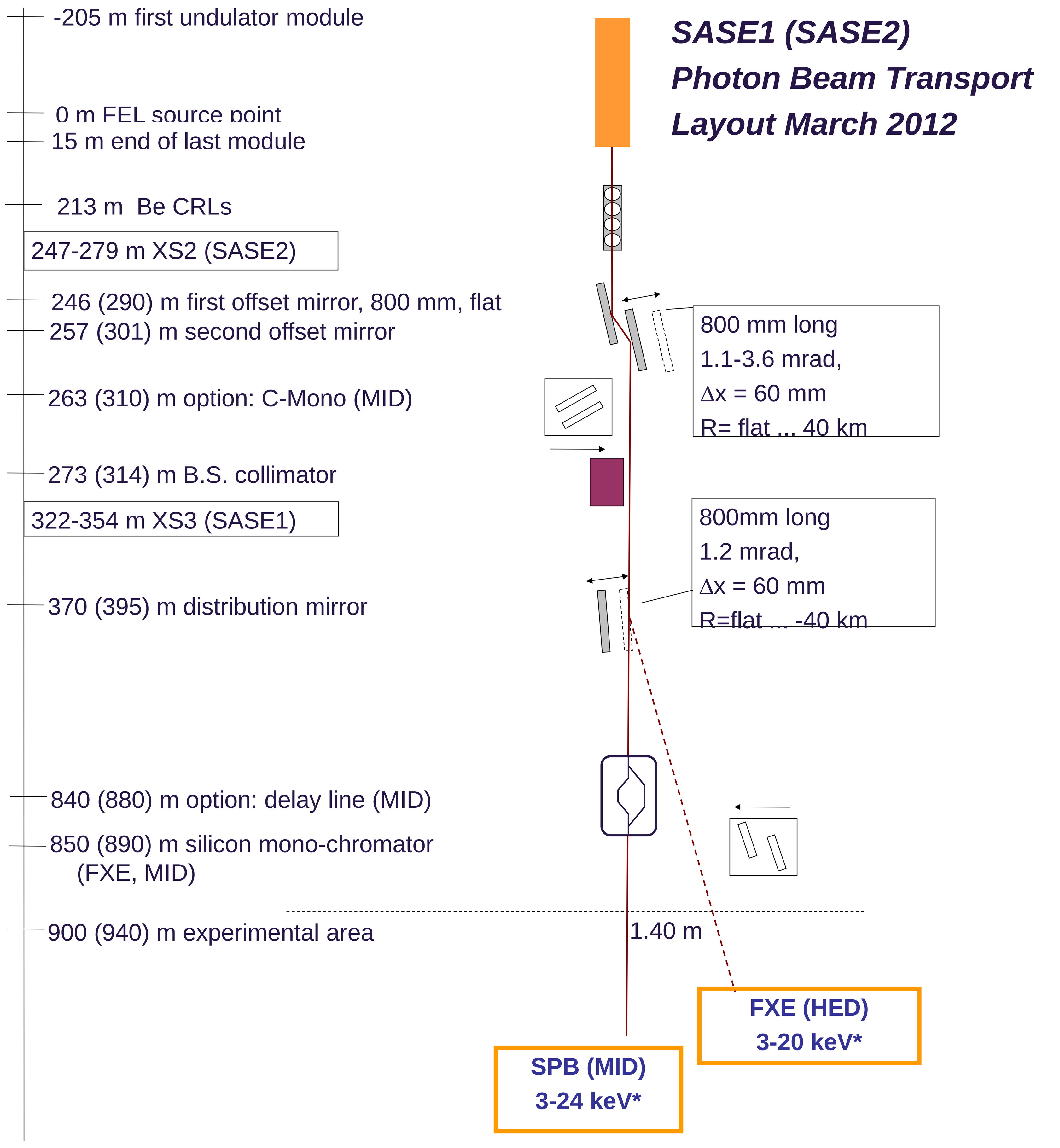

Figure 1: Conceptual Design of SASE1 and SASE2 beam transport systems. (*)From 3-5 keV limited performance: < 4 σ transmission, no CRL collimation.

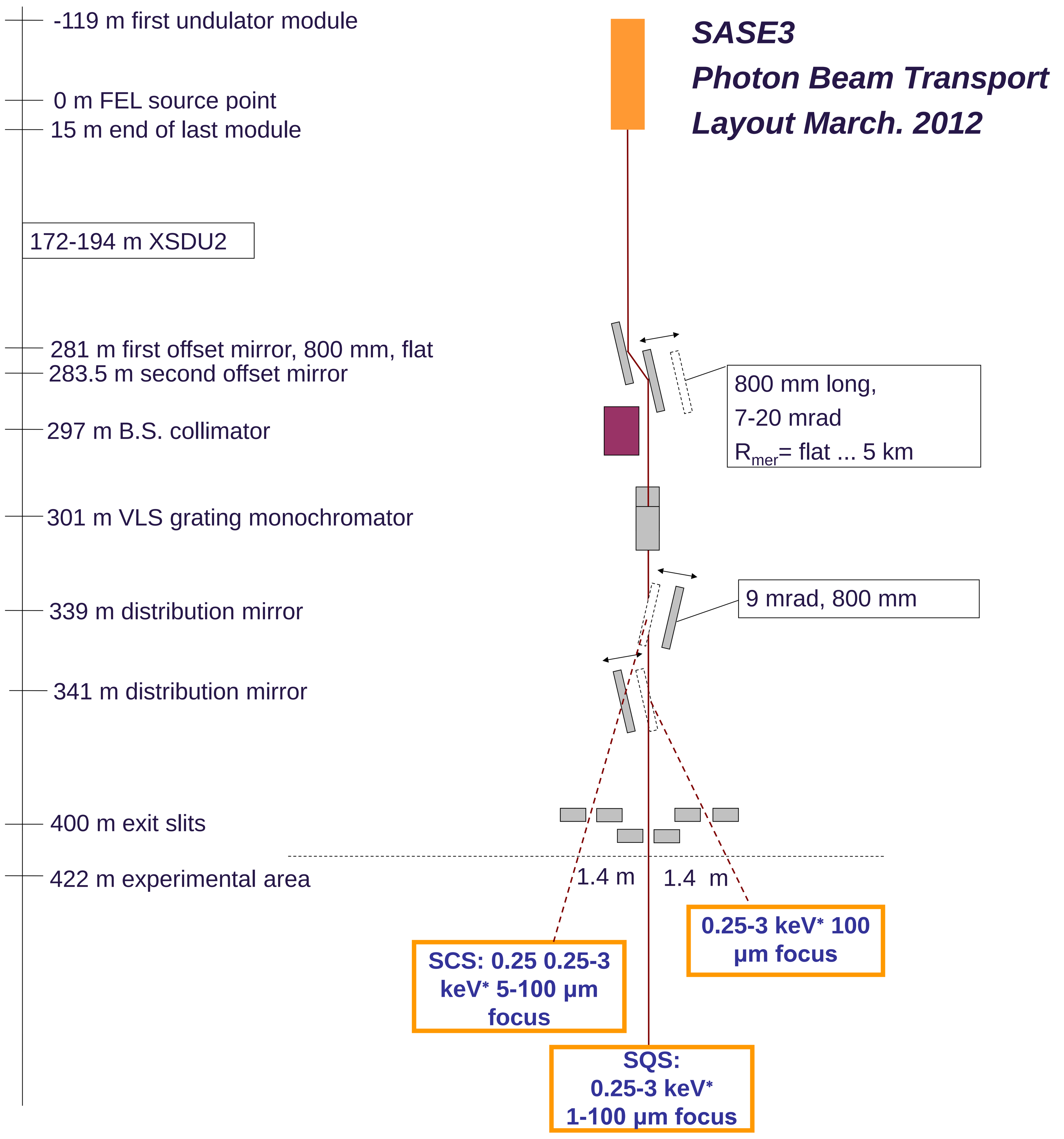

Figure 2: Conceptual Design of SASE3 beam transport system. (*) From 0.25-0.5 keV limited performance: < 4 σ transmission.

Offset Mirror Contamination.

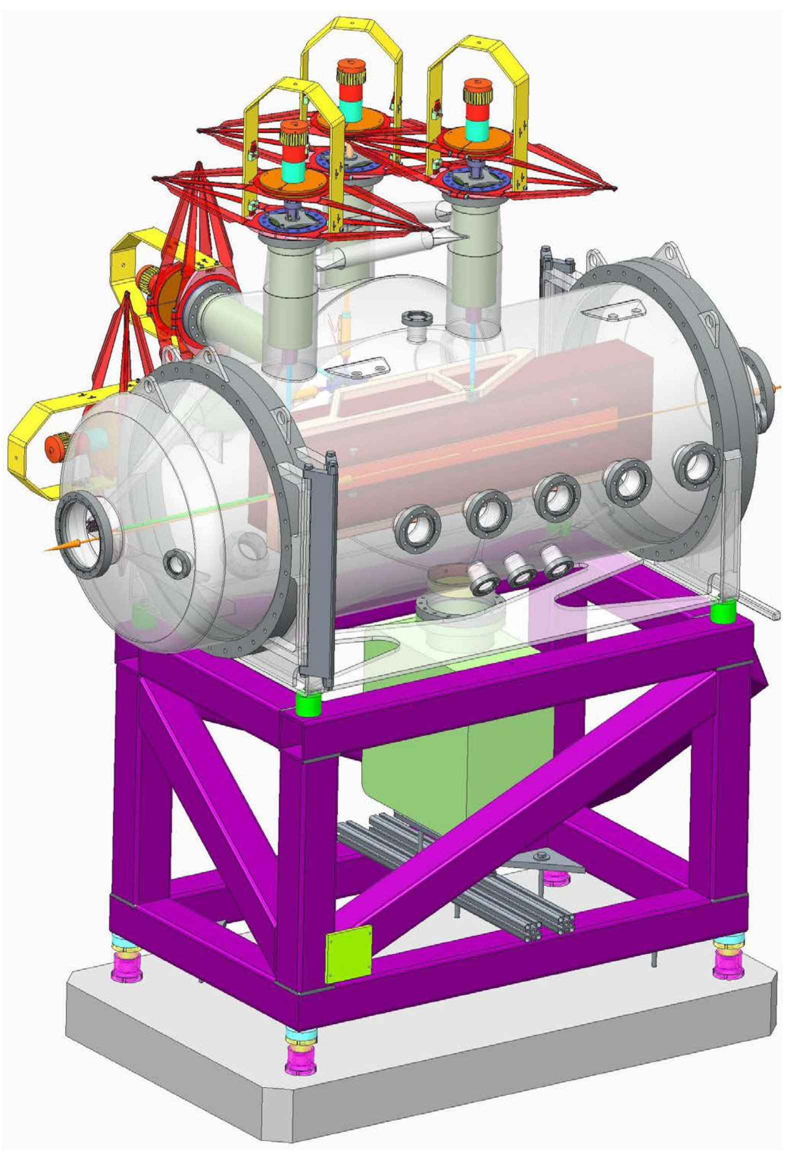

Figure 3: Mirror chamber based on parallel kinematics

The European XFEL facility will require long and ultra-flat X-ray mirrors for the beam offset and distribution system . This will consist on a super-polished 800 mm long mirror substrate in horizontal reflection geometry with a maximum peak-to-valley shape error of less than 2 nanometers over the entire aperture length. The main task of the horizontal offset mirrors is to separate the FEL beam from spontaneous background radiation (critical energy 100-200 keV) by offsetting the beam by 25mm.

Furthermore, the incidence angle on the mirror has to be adjusted to adapt to different beam energies (1.1mrad…20mrad). This results in offset variations from 25mm…115mm for different beamlines and photon energies. Therefore the mirror angle and the horizontal position of the mirrors have to be adjustable over a wide range (+-40mm). Similarly, large motions are required in the vertical to accommodate different beam conditions and the selection of different stripes on the active mirror surface.

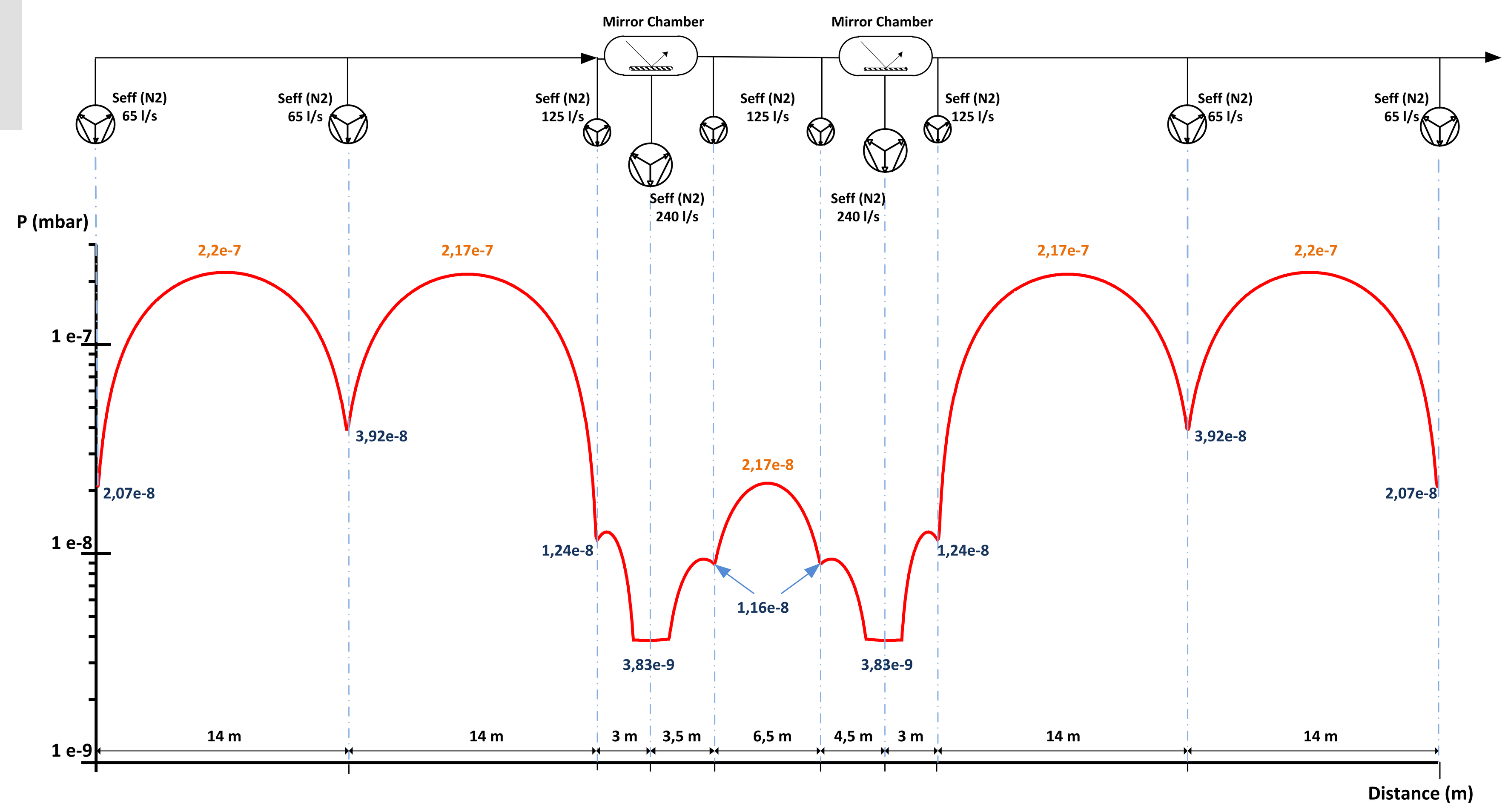

Figure 4: Total pressure distribution. Results from VAC-?? Sofware

Regarding to sustain the UHV condition in the mirror chambers, the pumping scheme shown in the Figure 4 has been foreseen. It contains a sequence of Ion Pumps with nominal pumping speed of 75, 150 and 300 l/s respectively. The estimated pressure profiles results from the following assumptions: S_{eff} = 85 % of S_N for all the pumps; 304 L Stainless Steel, mechanically polished; also a mild bake-out of the mirror chambers has been included (Outgassing rates of 1e-10 and 5e-13 mbar·l/s, respectively for the unbaked and baked surfaces).

When using this scenario, it can be appreciated that a UHV pressure of 3,83 e-9 mbar can be achieved in the mirror chambers. Obviously, these results are consistent with the expected least performance of the vacuum system for the Particle Free Area where the Offset Mirrors are.