Thermal emittance - Solenoid Specifications

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Abstract

To define the location of YAG1, simulations of solenoid scans were done using PARMELA used as an optical properties tracker. Analytical computations are difficult to perform when one wants to take into account the focusing properties of the RF cavity with that of the solenoid on a realistic beam. The required range of solenoid currents and the screen position of YAG1 are justified.

The thermal emittance measurement is performed by measuring the beam size evolution as a function of solenoid current.

.1 Simulations

Simulations of the thermal emittance measurement for the LCLS photoinjector beamline were done to determine

- YAG1 screen location
- solenoid current range
- beam size on that screen

Those simulations were run with PARMELA, used as a an optics tracking code, with the space charge off.

The distribution was typical for the LCLS as described in the following table, but only 2k particles were used.

Several injection phases were studied as it changes strongly the focusing properties of the beam at the exit of the gun.

.2 Solenoid specifications

The solenoid current range has been specified to reach a maximum of 260A. This corresponds to a field of 3.8kG. The nominal field is 2.7kG for a beam with 6MeV total energy (kinetic energy of 5.5 MeV). The maximum field has been specified to ne 3.75 kG giving 20% overhead for a 7 MeV beam. A similar solenoid was characterized at the GTF showing good linearity at least up to 3.33kG.

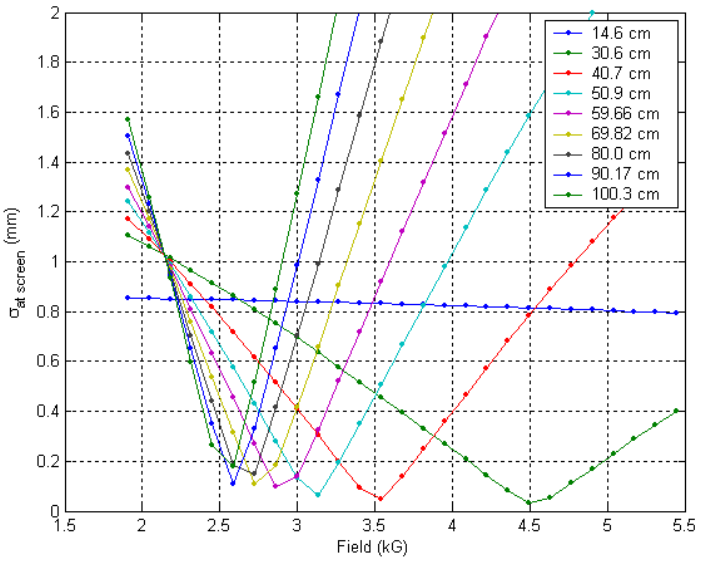
For out thermal emittance measurements, we would like not to exceed 3.3kG.

.3 Standard injection phase

The standard operating phase is 27 degrees.

The waist is clearly detectable when the beam size measured is at least 4 times that of the waist.

In figure 1, we see that the waist can only be reached for fields smaller than 3.3kG for positions of the screen larger than 50cm.



1. Beam size vs solenoid current typical for thermal emittance measurement; Standard injection phase of 27 degrees

In figure 2, a better resolution on the region of interest is given. Positioning the screen at 55 cm or 60 cm would be safer.

.4 Other injection phases

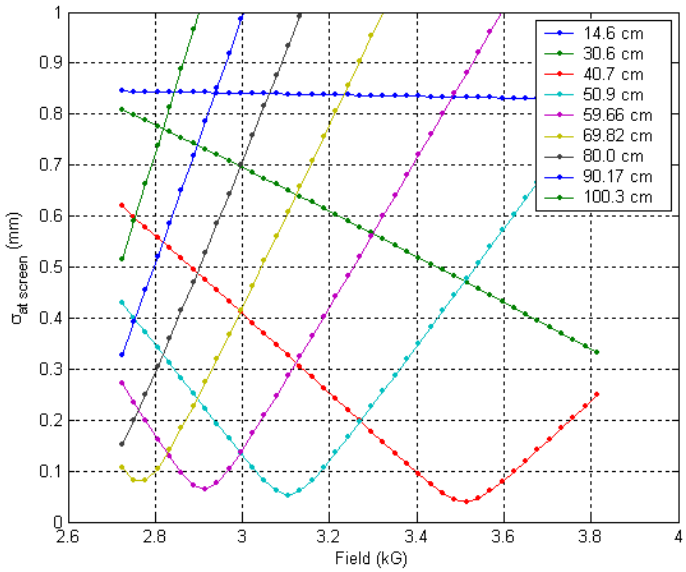
Other tunings might require different operating injection phases. At this stage of the design we are also considering longer pulses than thew 10ps nominal case.

We checked that the solenoid operating range was sufficient for a large span of injection phases.

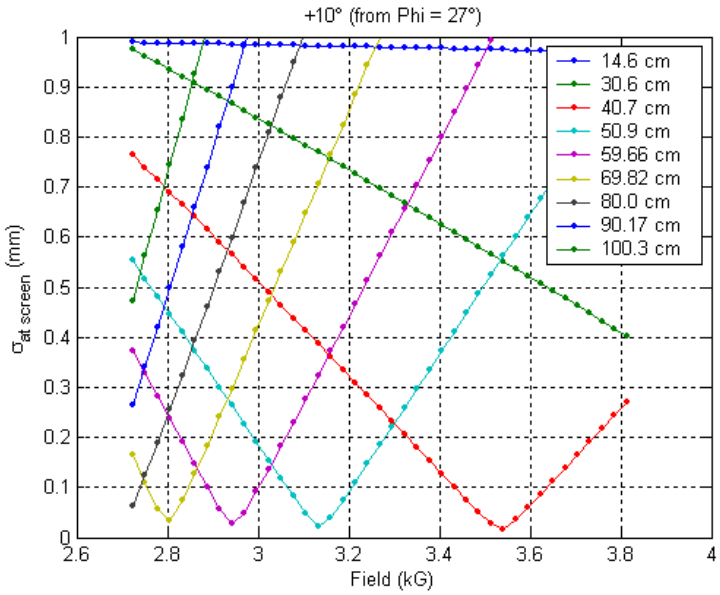
In figure3 , we show that for +10° offset in injection phase (or 37°), the range of solenoid currents required for performing a good thermal emittance measurement is even narrower than for the standard phase. In figure 4, we show that for -10° offset in injection phase (or 17°), the range of solenoid currents required for performing a good thermal emittance measurement is slightly larger than for the two pervious cases. For that reason, we would prefer to have the YAG1 screen positioned at least at 55cm

.5 Conclusion

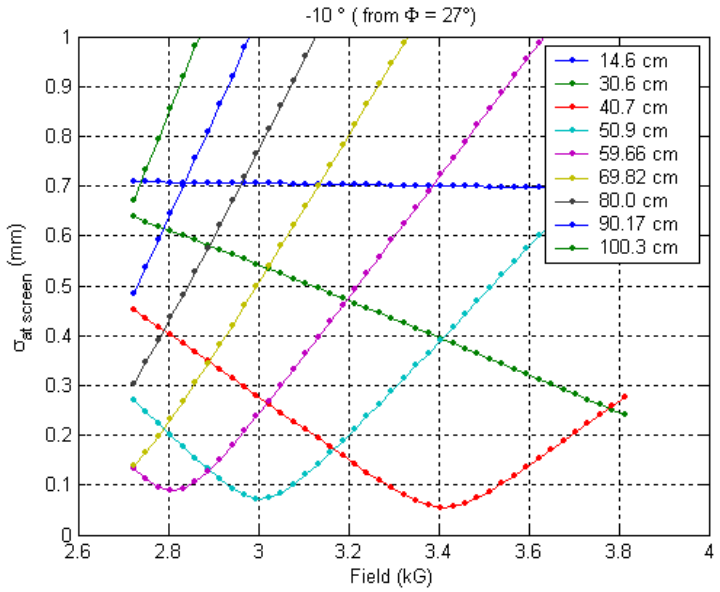
We have justified the need for having the first imaging screen YAG1 at least at 50cm from the cathode. A z = 55cm or 60cm will be even better as far as thermal emittance measurements are considered. The space constraint to fit a valve, corrector, BPM and a quadupole before entrance to the spcetrometer, will however impose the final position.



2. Zoom on figure 1



3. Beam size vs solenoid current for an injection phase offset by +10 degrees from standard operating conditions



4. Beam size vs solenoid current for an injection phase offset by -10 degrees from standard operating conditions