ELENA LNS (SOURCE) LINE:

FIRST STUDY FOR DIFFERENTIAL PUMPING APERTURES

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INTRODUCTORY COMMENTS

- The first doublet is incorporated into the source:

  a. Effective length = 70 mm
  b. Electrode gap (aperture diameter) = 50 mm
  c. Maximum voltage (latest information) = ±6.5 kV

- In order to make this preliminary study some BIG assumptions had to be made because the extraction electrodes are not defined. In principle, the acceleration will also affect the beam transversely. To be done: solve Laplace equation inside the source extraction region and integrate equation of motion in the realistic fields up until the internal doublet.

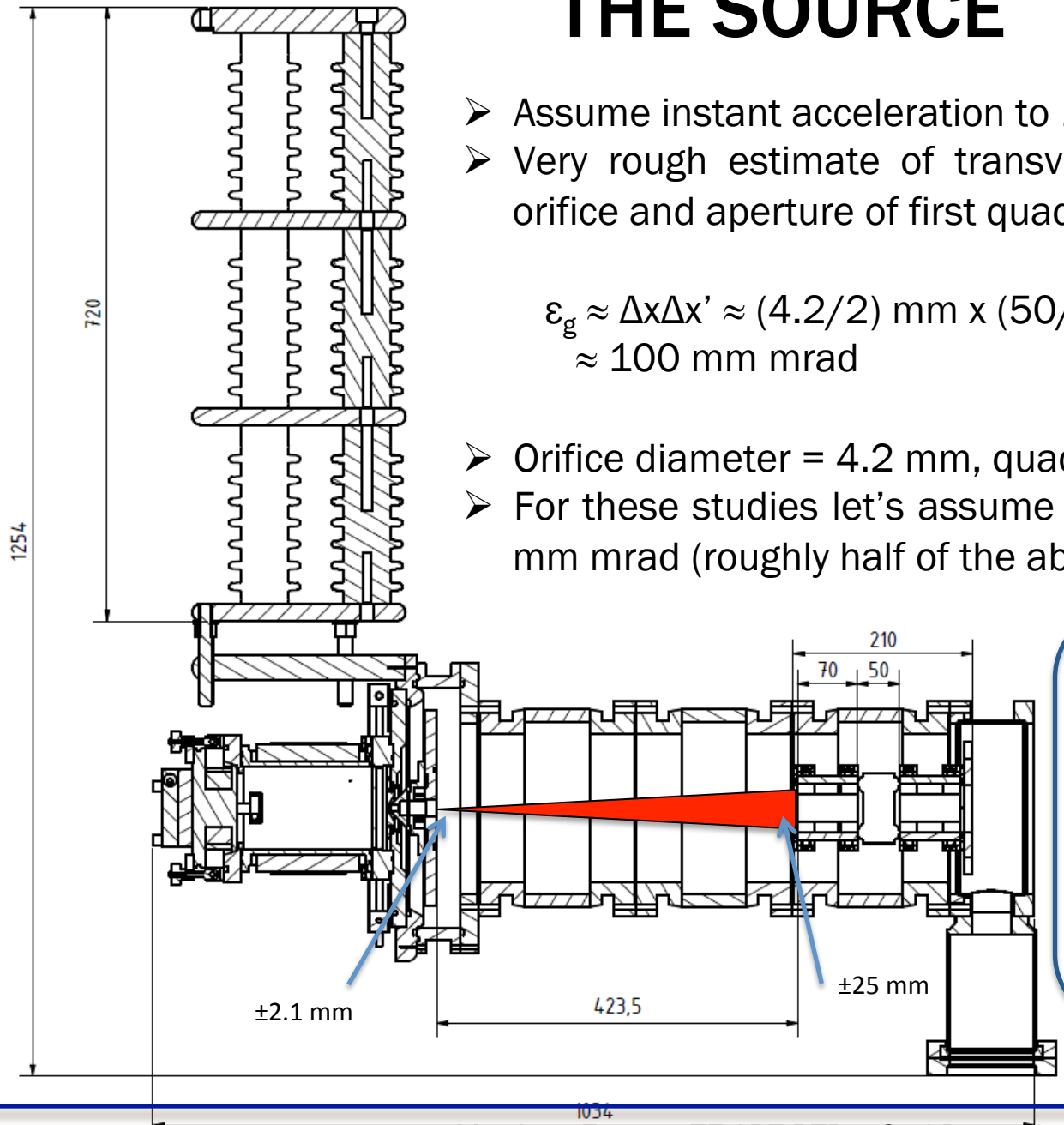
- Assumptions:
  a. Instantaneous acceleration at extraction from orifice, with no transverse effects.
  b. Orifice acts as a source of particles which defines the beam emittance and hence initial beta function: $\beta = \sigma^2/\varepsilon$, assuming $\alpha = 0$.
  c. Selected an emittance of 50 mm mrad according to old measurement data and a factor of two lower than the approximate acceptance.
  d. No steering/error studies, only nominal beam dynamics.
  e. Space-charge neglected.

THE SOURCE

- Assume instant acceleration to 100 keV.
- Very rough estimate of transverse acceptance defined by orifice and aperture of first quadrupole:

$$\varepsilon_g \approx \Delta x \Delta x' \approx (4.2/2)\ \text{mm} \times (50/2/423.5)*1000\ \text{mrad}$$
$$\approx 100\ \text{mm mrad}$$

- Orifice diameter = 4.2 mm, quadrupole aperture = 50 mm.
- For these studies let's assume a geometric emittance of 50 mm mrad (roughly half of the above estimated acceptance):



Input MAD-X parameters:

W_k = 100 keV
ε_g = 50 mm mrad
$\beta = \sigma^2/\varepsilon = 2.1^2/50$
$= 0.09$ mm/mrad
$\alpha = 0$

LAYOUT AND CONSTRAINTS

- Using the latest straight-line LNS layout (presented at IIC in September) and LNI/LNE00 as held by integration team.

- Matching to ELENA ring through LNI and LNE00 using parameters provided by Pavel (cross-checks on these parameters still to be done). Polarity of quads wasn't checked.

- Firstly, I use the quadrupole doublet inside the source to match through the aperture constraint introduced by the differential pumping apertures in the LNS line.

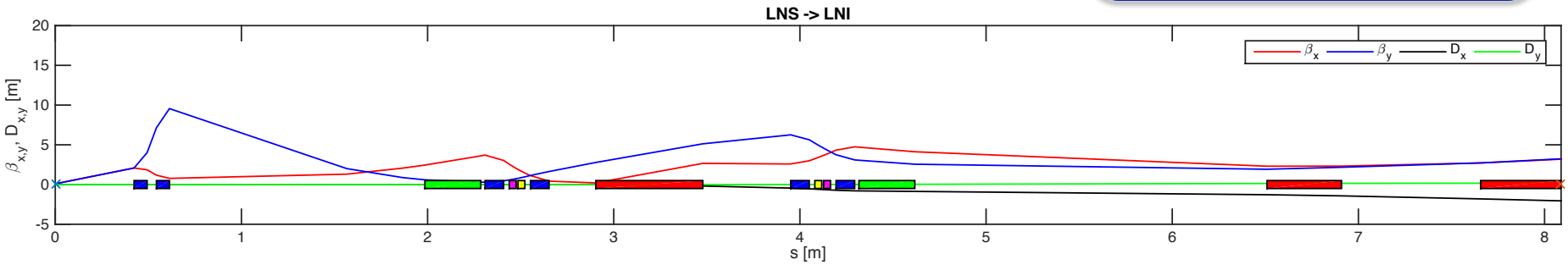
- Secondly, I match to the ring using the available quadrupoles, in the LNS line and either the LNI or LNE00 lines. In both cases I don't match the dispersion. Needs to be looked into in more detail…

- Even though dispersion is mismatched, the energy spread from the source is expected at the level of some eV in 100 keV! This means that dispersive effects can (I think) be neglected. In the following studies I assume $\Delta p/p = 10^{-4}$.

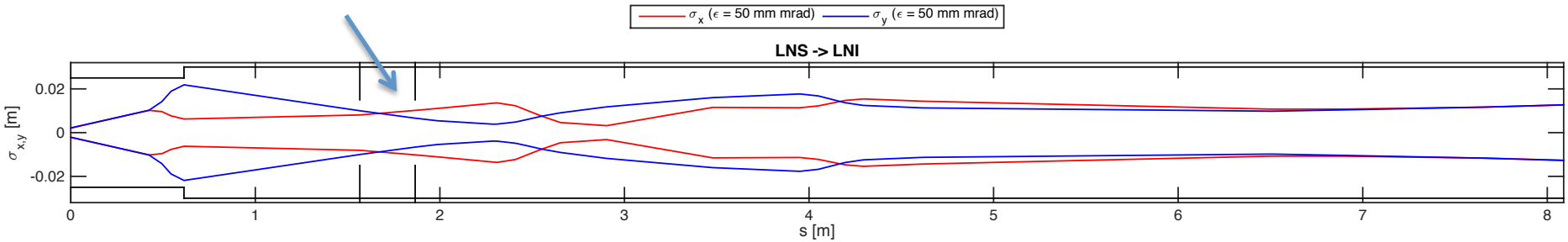
- Differential pumping apertures of 30 mm (diameter) are plotted, which appears to accept a 50 mm mrad emittance, BUT quadrupole voltages inside the source are on the large side… To be discussed…

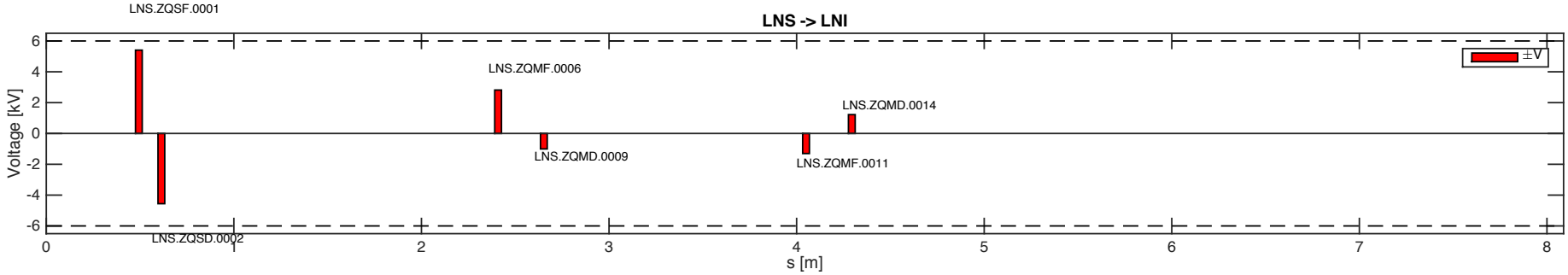
LNS TO LNI INJECTION

MAD-X input:
β = 0.09 mm/mrad
α = 0, ε = 50 mm mrad



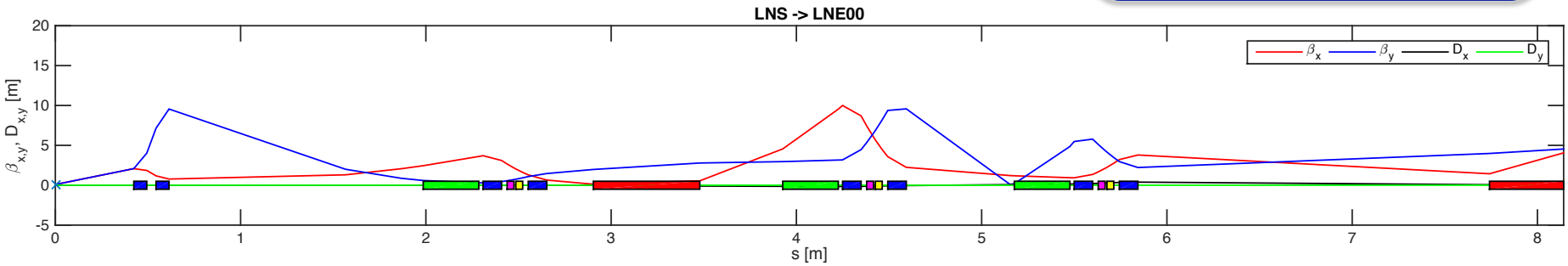
±15 mm apertures





LNS TO LNE00 INJECTION

MAD-X input:
β = 0.09 mm/mrad
α = 0, ε = 50 mm mrad



±15 mm apertures