Comparison of OSIRIS/LCODE/QV3D simulations with the measurements of the proton beam in AWAKE experiment

**PROTON BEAM DIAGNOSTICS IN AWAKE**

- Streak camera collects the light from the OTR screen and measures a time resolved beam profile. One image gives the information about the size of proton beam micro-bunches and unmodulated beam head after SSM.

- Imaging stations measure time integrated transverse profile of the protons being defocused during the SSM. Radii of the outmost protons on these screens depend on the maximum fields excited in plasma.

**CODE BENCHMARKING**

Three different codes showed perfect agreement in 120 ps time window (15 plasma periods).

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<tr>
<th>Code</th>
<th>Geometry</th>
<th>Model</th>
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<tbody>
<tr>
<td>LCODE</td>
<td>2D cylindrical</td>
<td>Quasistatic</td>
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<tr>
<td>OSIRIS</td>
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<tr>
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</tbody>
</table>

Simulations were performed by Alexey Petrenko (Novosibirsk State University) and Alexander Gorn (Budker Institute of Nuclear Physics, Novosibirsk, Russia).

**PARAMETRIC SCANS**

We compare radii of outmost electrons at two Imaging Stations and in LCODE simulations. For quantitative agreement, the simulation window must be wide. This is necessary for correct simulation of high-energy plasma electrons that escape from the plasma as a result of wavebreaking. The electrons then create charge-separation field, return back and destroy the plasma wave.

**COMPARISON WITH STREAK CAMERA**

Comparison with streak camera images required accurate measurements of the initial proton beam parameters.

We took into account the effects of the finite streak camera slit. In order to get the best agreement we also assumed that the slit had an offset with respect to the beam axis.

For input parameters corresponding to the measured initial proton beam state, simulations showed the agreement in the longitudinal beam density profile and transverse size of the micro bunches and the beam head.