Electron rings have been investigated in a different works. The results of such researches are presented in the table:

<table>
<thead>
<tr>
<th>R (cm)</th>
<th>( \zeta_2 ) (kA)</th>
<th>( \zeta_1 ) (kA)</th>
<th>( E ) (kG)</th>
<th>( E_mV )</th>
<th>( T_{\text{repeat}} ) (ns)</th>
<th>( T_{\text{pulse}} ) (ns)</th>
<th>( N_0 ) (pp.225-246, 2005).</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>Cornell</td>
<td>3.5</td>
<td>10 - 20</td>
<td>0.5</td>
<td>3 - 10</td>
<td>0.5</td>
<td>50</td>
</tr>
<tr>
<td>1979</td>
<td>Cornell</td>
<td>6</td>
<td>4 - 20</td>
<td>1 - 10</td>
<td>1 - 3</td>
<td>2 - 3</td>
<td>20</td>
</tr>
<tr>
<td>1979</td>
<td>Maryland</td>
<td>6</td>
<td>2 - 20</td>
<td>1.5</td>
<td>2 - 3</td>
<td>2</td>
<td>5 - 10</td>
</tr>
<tr>
<td>1979</td>
<td>Maryland</td>
<td>6</td>
<td>1.5</td>
<td>1.5</td>
<td>2.5</td>
<td>3 - 5</td>
<td>5 - 10</td>
</tr>
</tbody>
</table>

The main parameters of the experimental setups for the forming of tubular rings are:
- Cathode radius \( R \), Diode current \( I_1 \), Beam current after cusp \( I_b \), Magnetic field in the homogeneity region \( U \), Diode voltage \( E_1 \), Injected electron energy \( E_m \), Pulse duration of diode voltage at half maximum of the signal \( T_{\text{pulse}} \), Beam duration after cusp \( T_{\text{pulse}} \), Number of trapped electrons \( N_0 \). 

In this paper we investigated a forming of a tubular electron beam by the particle-in-cell method with the one-particle approximation without the space charge effects. We are calculating the electron beam dynamics in a static magnetic field in a cylindrical coordinate system using a Runge-Kutta or modified Euler methods.

The equations of motion in axial symmetrical magnetic field are:

\[
\dot{r} = \frac{1}{m} \frac{\partial}{\partial z} \left( m \frac{d^2 r}{dt^2} - e \phi \right), \\
\dot{z} = \frac{1}{m} \frac{d}{dt} \left( m \frac{d^2 z}{dt^2} + e \phi \right),
\]

where

\[
\phi = \frac{\gamma}{\gamma_0} \left( \frac{1}{\gamma_0} - \frac{1}{\gamma} \right) \frac{1}{m} \left( m \frac{d^2 \gamma}{dt^2} + e \frac{d \phi}{dz} \right).
\]

The magnetic field is calculated using "Poisson Superfish" application package. It allows to calculate the necessary magnetic fields in axial symmetrical coordinate system with the consideration of the saturation effects.

Error in magnetic field calculations is average \(-10^{-3}\) %, and for beam dynamics is \(-0.12\) % in homogeneous field region and \(-1.4\) % in the cusp region.

The results of the magnetic field calculations are shown on the fig.2 and fig.3.

Based on simulations results, we can await that on a distance \(>10\) cm from the cusp it’s formed a dense ring of a relativistic electrons. At the injection current \(~2\) kA number of the trapped particles is \(~10^{10}\). Longitudinal velocity of the electron ring is \(~0.2\) c with the small size of the ring \(~2\) mm. Such parameters of the ring are allowed to consider it for different applications. For using the ring for collective ion acceleration it’s necessary to decelerating of axial velocity of the ring to \(~0.1\) c, ensure the focusing of the electrons with consideration of the space-charge forces with the loading of ions in the ring. Rely on the experience of the previous experiments, their problems can be solved by the using of resistive walls or using a low vacuum mode (fluid jets) for electron ring decelerating by the trapped ions, which are moreover produced the focusing of electrons in the ring.

Future plans: development of the methods of simulations including the calculating the self electrical and magnetic fields of the ring; simulations with the resistive walls, modeling of loading the ions in the ring.