



Trak 6.0

**Finite-element Charged-particle Optics,
Electron and Ion Gun Design**

Field Precision

Copyright 2002

PO Box 13595

Albuquerque, New Mexico 87192 U.S.A.

Telephone: 505-220-3975

FAX: 505-294-0222

E Mail: techinfo@fieldp.com

Internet: <http://www.fieldp.com>

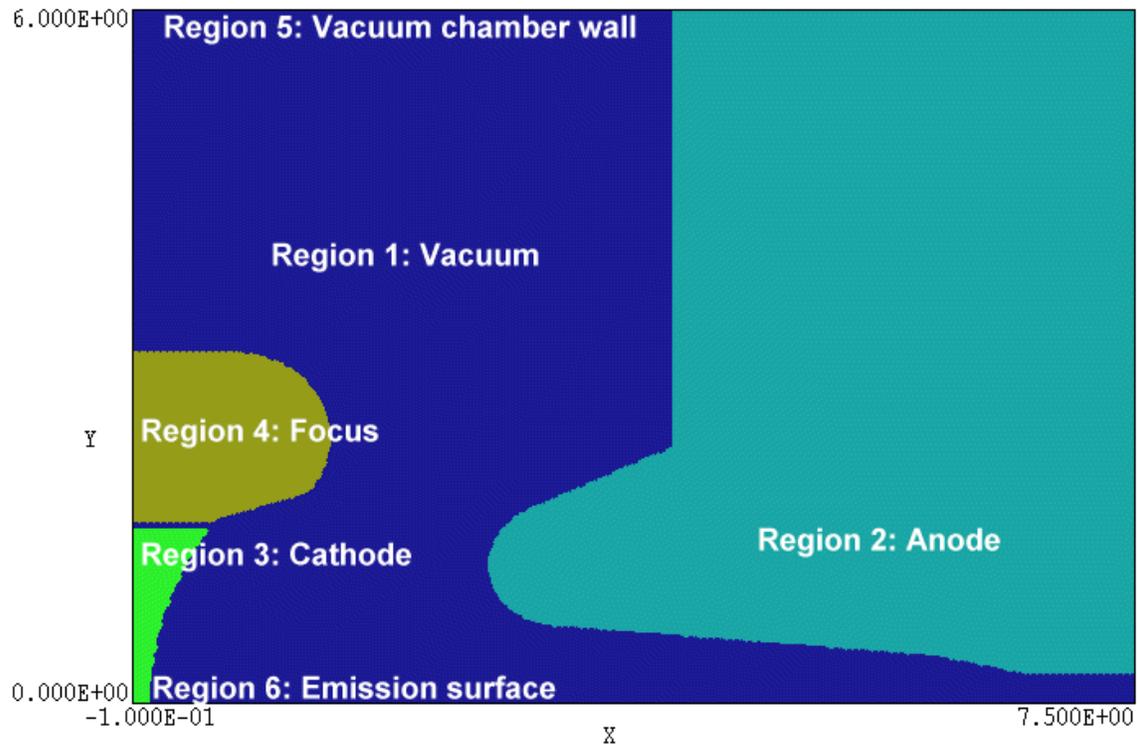


Figure 2.1. Region definitions for the KLYGUN example.

Chapter 2. Walkthrough example

2.1. Setup

In this chapter, we will follow an advanced **Trak** application step-by-step. The simulation determines the performance of a high-intensity, relativistic klystron gun. The gun is designed for a strong beam convergence and therefore represents a challenge to the accuracy of a numerical code. Figure 2.1 shows the geometry. An electron beam of current 460 A is extracted from a spherical-section cathode across a 660 kV acceleration gap. It is assumed that you have installed the programs `tc.exe`, `mesh.exe`, `estat.exe`, `vestat.exe`, `trak.exe` and `vtrak.exe` and have created a data directory such as `\tricom\buffer`. Ensure that **TC** has the correct settings for the program and data directory. Move the following files to the data directory: `klygun.min`, `klygun.ein` and `klygun.tin`.

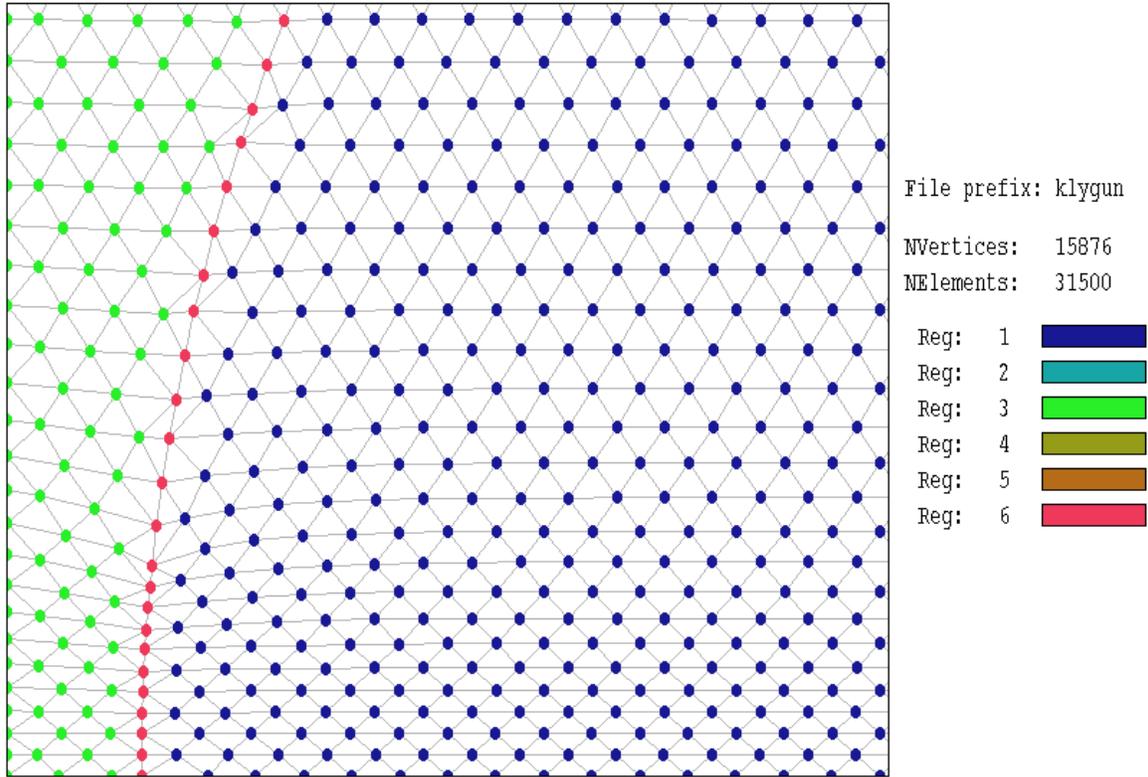


Figure 2.2. Detail of the mesh on the axis near the cathode for the KLYGUN example showing node identities

2.2. Defining the geometry

Table 2.1 lists the input file for **Mesh**. The file was prepared from the drawing file `KLYGUN.DXF` using the drawing editor of **Mesh**. Resolutions in the `XMesh` and `YMesh` commands were set manually. Note the fine resolution near the axis for a good representation of electric fields within the converged beam. Figure 2.2 shows a detail of the mesh at the axis near the cathode. Also note that the focus electrode (Region 4) is displaced axially a distance 0.030" to ensure that the beam was completely focused into the transport tube. The displacement was determined from previous runs. The main difference from a standard input mesh for **EStat** is the presence of Region 6, an open region that covers the surface of the cathode (nodes marked in red in Fig. 2.2). The associated nodes have the same potential as those of the cathode (Region 3), so they do not affect the electrostatic solution. The marked vertices are used in **Trak** to identify surface segments that will act as emission sites for electrons.

Table 2.1. File klygun.min

```

* TRICOMP for Windows MESH input file
* Created with XLate
* Date: 01/10/01
* Time: 08:39:30
*
* Field Precision
* PO Box 13595, Albuquerque, New Mexico 87192
* Telephone: 505-220-3975 FAX: 505-294-0222
* E Mail: techinfo@fieldp.com
* -----
GLOBAL
XMESSH
-1.00000E-01 7.50000E+00 0.05
END
YMESH
0.00000E+00 2.50000E-01 0.025
2.50000E-01 6.00000E+00 0.05
End
END
* -----
REGION FILL SolVolume
L -1.00000E-01 0.00000E+00 7.50000E+00 0.00000E+00
L 7.50000E+00 0.00000E+00 7.50000E+00 6.00000E+00
L 7.50000E+00 6.00000E+00 -1.00000E-01 6.00000E+00
L -1.00000E-01 6.00000E+00 -1.00000E-01 0.00000E+00
END
* -----
REGION FILL Anode
L 7.50000E+00 2.50000E-01 6.66700E+00 2.50000E-01
L 6.66700E+00 2.50000E-01 6.00000E+00 4.08000E-01
L 6.00000E+00 4.08000E-01 3.08544E+00 6.69126E-01
A 3.08544E+00 6.69127E-01 2.60001E+00 1.20235E+00 3.13300E+00 1.20000E+00
A 2.60001E+00 1.20235E+00 2.89721E+00 1.67801E+00 3.13300E+00 1.20000E+00
L 2.89721E+00 1.67801E+00 4.00000E+00 2.22200E+00
L 4.00000E+00 2.22200E+00 4.00000E+00 6.00000E+00
L 4.00000E+00 6.00000E+00 7.50000E+00 6.00000E+00
L 7.50000E+00 6.00000E+00 7.50000E+00 2.50000E-01
END
* -----
REGION FILL CathSupport
L -1.00000E-01 0.00000E+00 4.06420E-02 0.00000E+00
A 4.06420E-02 0.00000E+00 4.76324E-01 1.50000E+00 2.84064E+00 0.00000E+00
L 4.76324E-01 1.50000E+00 -1.00000E-01 1.50000E+00
L -1.00000E-01 1.50000E+00 -1.00000E-01 0.00000E+00
END
* -----
REGION FILL FocusElect
XShift 0.030
L -1.30000E-01 1.56500E+00 4.80000E-01 1.56500E+00
L 4.80000E-01 1.56500E+00 1.23063E+00 1.81616E+00
A 1.23063E+00 1.81616E+00 6.69000E-01 3.03800E+00 6.69000E-01 2.29800E+00
L 6.69000E-01 3.03800E+00 -1.30000E-01 3.03800E+00
L -1.30000E-01 3.03800E+00 -1.30000E-01 1.56500E+00
END
* -----
REGION GroundedWall
L 4.00000E+00 6.00000E+00 -1.00000E-01 6.00000E+00
END
* -----
REGION EmissSurface
A 4.76324E-01 1.50000E+00 4.06420E-02 0.00000E+00 2.84064E+00 0.00000E+00
END
* -----
ENDFILE

```

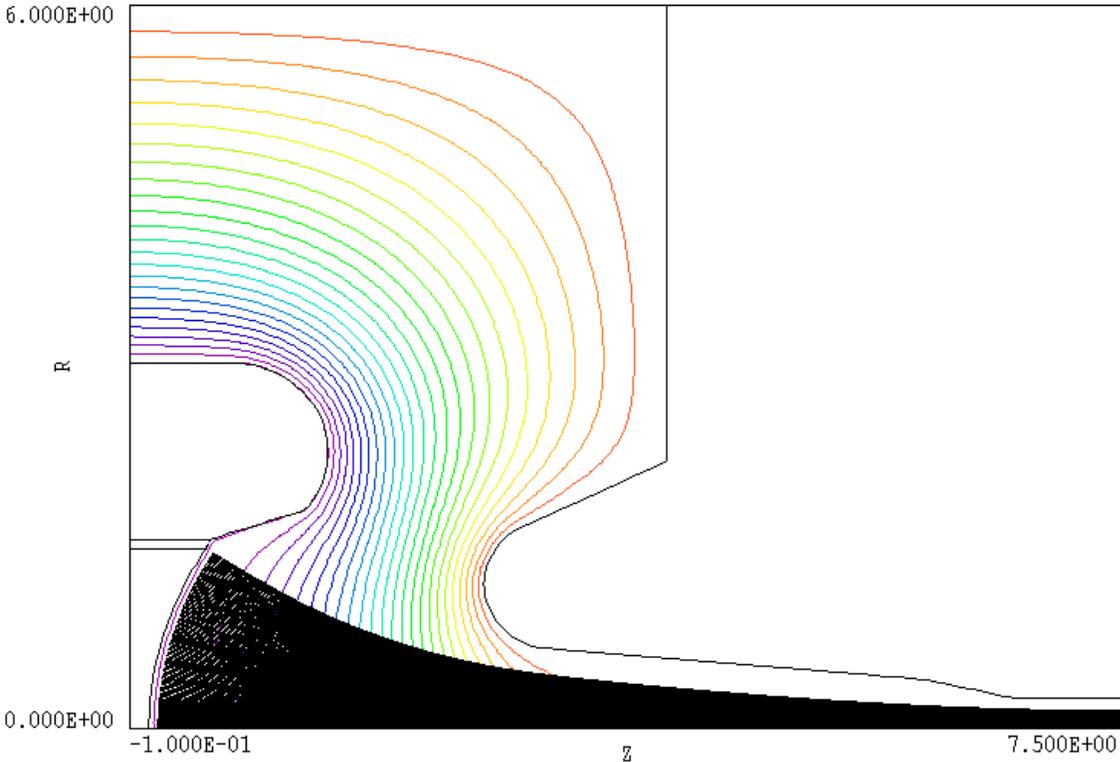


Figure 2.3. KLYGUN example: electrodes, equipotential lines and orbit traces

2.3. Creating the applied field solution

From **TC**, run **Mesh** and click on the command *Load script (MIN)*. If the programs and data files are in the correct locations, the file `klygun.min` should be available in the dialog. Pick the file, process the mesh, and save the output file. At this point, you can experiment with different plot functions in **Mesh** to check the geometry. Next, run **EStat** from **TC**. Click on the command *Start run* and pick the file `klygun.ein`. This file assigns the dielectric property of vacuum to Region 1 and sets the potentials of the cathode, emission surface and focusing electrode to -660.0 kV. All other electrodes are set to 0.0 kV. The solution is complete in a few seconds. The program creates an electrostatic solution file `klygun.eou` that can be inspected with the **VEStat** program. This file is one of the required inputs for the **Trak** run. The other input is the **Trak** command script listed in Table 2.2. Preparation of this file is the main subject of this manual.

Table 2.2. File klygun.tin

```
* File KLYGUN.TIN
*
FIELDS
  EFile = KLYGUN.EOU
  DUnit = 39.37
END
*
PARTICLES RELBEAM
  NCycle = 20
  Emit(6) 0.0 -1.0 0.070
  EmitParam(6) 1
  NSearch(E) = 3
  Avg = 0.20
  Dt = 1.0E-12
END
*
DIAGNOSTICS
  EDump = KLYGUNP
  BBScan 0.00 0.00 2.00 1.50 0.00 2.00
  PartList
END
ENDFILE
```

2.4. Contents of the Trak control script

The commands in the file `KLYGUN.TIN` are divided into three sections that must appear in the order shown: *FIELDS*, *PARTICLES* and *DIAGNOSTICS*. In the *FIELDS* section the *EFIELD* command loads the solution file that we prepared with **EStat**. Note that the *DUnit* command does not affect mesh coordinates loaded from `KLYGUN.EOU`. These quantities have already been converted to meters in **EStat**. The *DUnit* command signifies that the dimensions in script commands that involve spatial quantities (like *BBScan*) are given in inches and **Trak** will convert them to meters. The commands of the *PARTICLES* section control the orbit integration and the Child-law emission algorithm. The command *Emit(6) 0.0 -1.0 0.070* specifies that nodes associated with Region 6 define emission segments. The additional parameters signify that the emitted particles are electrons and that the computational emission surface is 0.07" from the physical surface of the cathode. The *BBScan* command of the *DIAGNOSTICS* section specifies that calculations of the beam magnetic field and current density should be included in the run listing file (`KLYGUN.TLS`). The command *PartList* calls for a record of initial and final particle parameters in the listing file. In response to the command *EDump = KlygunP*, the program creates a file `KLYGUN.EOU` that contains information on the modified electrostatic solution including effects of beam space-charge. The file is in standard **EStat** format and can be analyzed with **VEStat**.

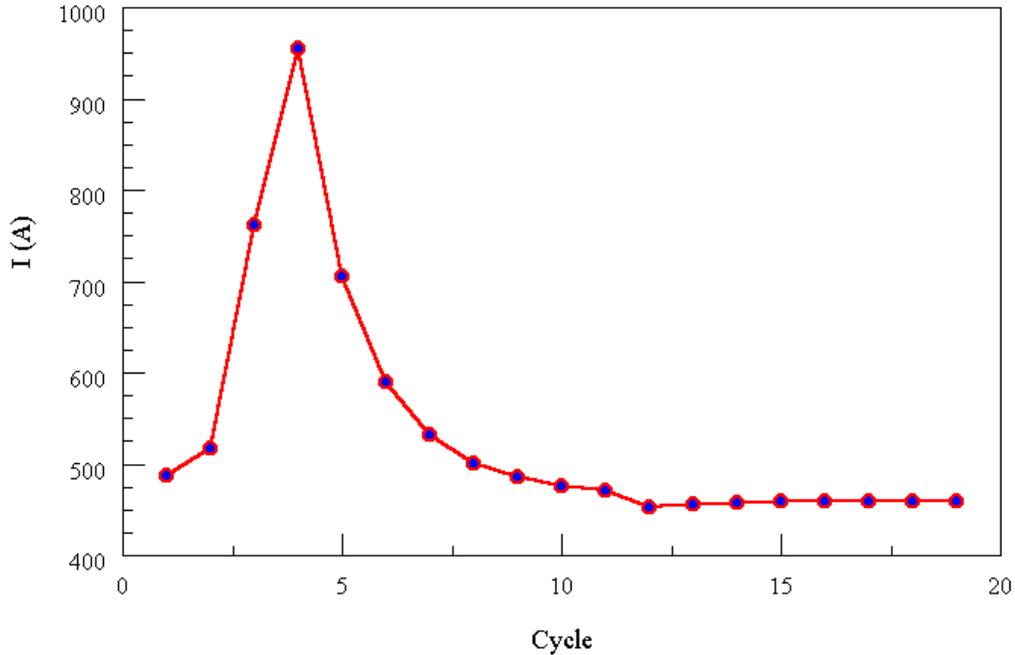


Figure 2.4. KLYGUN example - convergence of emitted current.

2.5. Running Trak and analyzing the results

Run **Trak** from **TC** and click on the *Start run* command. Pick the input file KLYGUN . TIN. The program identifies emission segments and starts one electron from each segment at an emission surface a short distance from the cathode. **Trak** performs twenty iteration cycles consisting of orbit tracking with space-charge assignment and electrical field recalculation. The run time is less than one minute on a fast computer. When the run is complete, start **VTrak** and click on the *Load orbit file* command. Pick the file KLYGUN . TOU, the output plot file created during the **Trak** run. Then click on the *Load electric field file* command and pick the file KLYGUNP . EOU. You should see a plot similar to Figure 2.3 showing self-consistent orbit traces superimposed on equipotential lines of the modified field solution.

Trak can record a wide variety of useful data in the listing file. Figures 2.4 and 2.5 illustrate the type of information that can be extracted. Figure 2.4 shows the total current emission from the cathode as a function of the iteration cycle. With proper averaging, the code converges to an equilibrium where the particle orbits and consequent space-charge density are consistent with the total electric fields. Figure 2.5 shows radial current density profiles at different distances (in inches) from the cathode. Because of over-focusing on the outer edge, the compressed beam has a hollow profile.

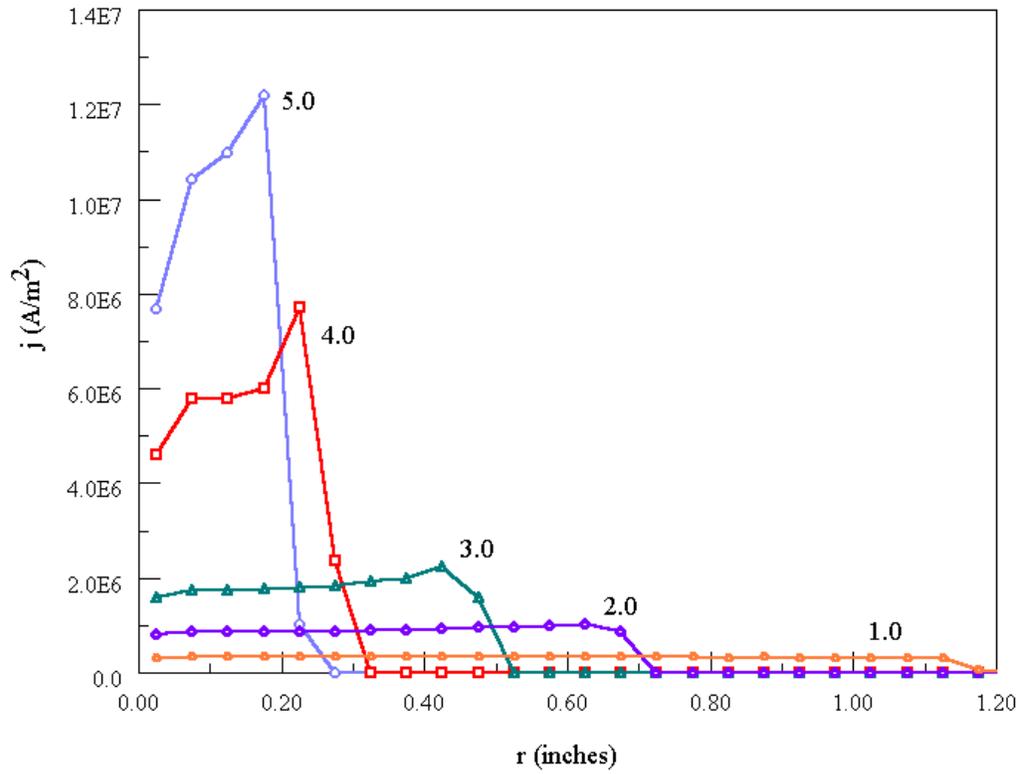


Figure 2.5. KLYGUN example - current density profiles at different distances from the cathode (dimensions in inches)