Darkcurrent Transport in the FLASH Injector

... with the new apertures library

- **Motivation:** Why a library for apertures?
- **Library:** Functions and tools
- **Implementation:** Rough overview
- **Aperture model:** File format

- **FLASH injector:** Darkcurrent transport GUN-DBC2

Motivation

Why a library for apertures?

- Astra, elegant, MAD-*, ... have their own aperture definitions embedded in the accelerator model.

  ... which makes it hard to share an aperture model between the codes.

  ... which are quite limited in complexity.

  ... and are missing a detailed output suited for the analysis of beam losses.

  particle losses vs. z,

  coordinates of lost particles,

  graphical representation of the aperture model

Library: Functions+Tools

Only two basic library functions:

- Read an aperture model from an XML file
- Check whether a given point (x,y,z) is within the aperture model

Tools:

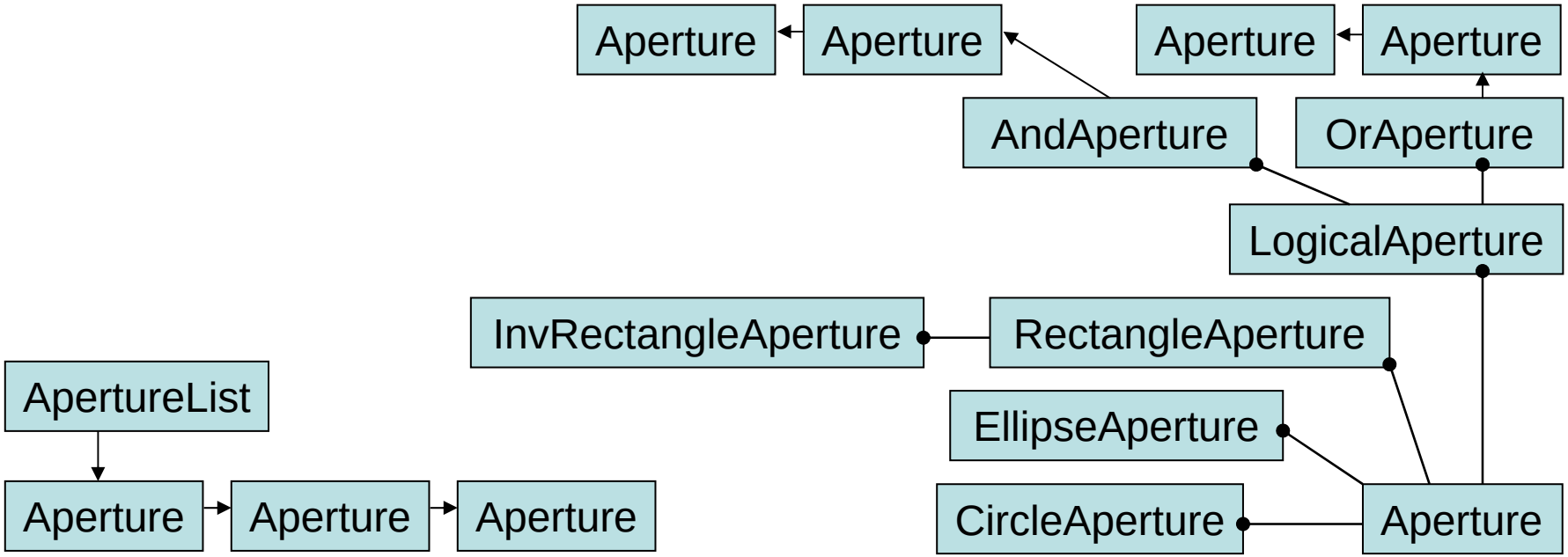
- **aperture-view** generates sections through the geometry which can be plotted
- **aperture-check** reads multiple phase space files and performs a collision test against an aperture model

Implementation

Programming language:

- Need high performance and OOP, ergo: **C++**
- Can provide wrappers for C, Fortran, ...

Small class overview:



File Format

Aperture model in XML format:

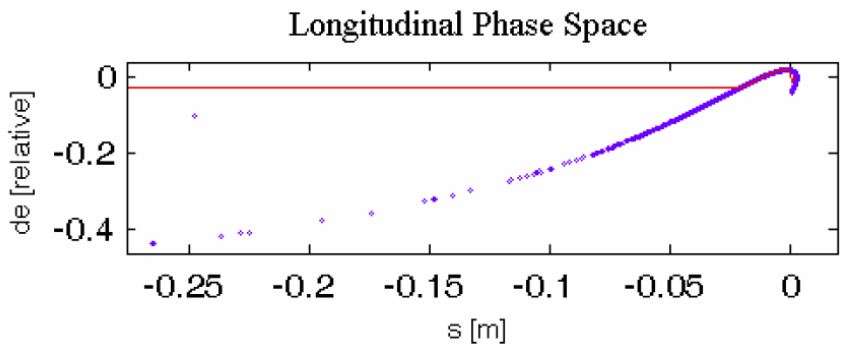
```
<?xml version="1.0" encoding="UTF-8" ?>
<aperture-list>
   <circle z="0.0" name="vacuum pipe">
      <x>0.0</x>
      <y>0.0</y>
      <r>0.0025</r>
   </circle>

   <and z="0.5" name="vacuum pipe with small square screen">
      <aperture-list>
         <circle z="0.0" name="vacuum pipe 2.5 mm">
            <x>0.0</x>
            <y>0.0</y>
            <r>0.0025</r>
         </circle>
         <circle z="0.2" name="vacuum pipe 3 mm">
            <x>0.0</x>
            <y>0.0</y>
            <r>0.003</r>
         </circle>
      </aperture-list>
      <aperture-list>
         <null z="0" />
         <inv_rectangle z="0.1" name="square">
            <x1>-0.0005</x1>
            <x2> 0.0005</x2>
            <y1>-0.0005</y1>
            <y2> 0.0005</y2>
         </inv_rectangle>
         <null z="0.11" />
      </aperture-list>
   </and>
```

```
   <ellipse z="1.0" name="ellipsoidal vacuum pipe">
      <x>0</x>
      <y>0.0</y>
      <wx>0.006</wx>
      <wy>0.004</wy>
   </ellipse>
   <include z="1.2" name="pinhole section">
      <filename>include.xml</filename>
   </include>
   <circle z="2.0">
      <x>0</x>
      <y>0.0</y>
      <r>0.01</r>
   </circle>
   <rectangle z="3.0" name="rectangular aperture">
      <x1>-0.004</x1>
      <x2>+0.004</x2>
      <y1>-0.002</y1>
      <y2>+0.002</y2>
   </rectangle>
</aperture-list>
```

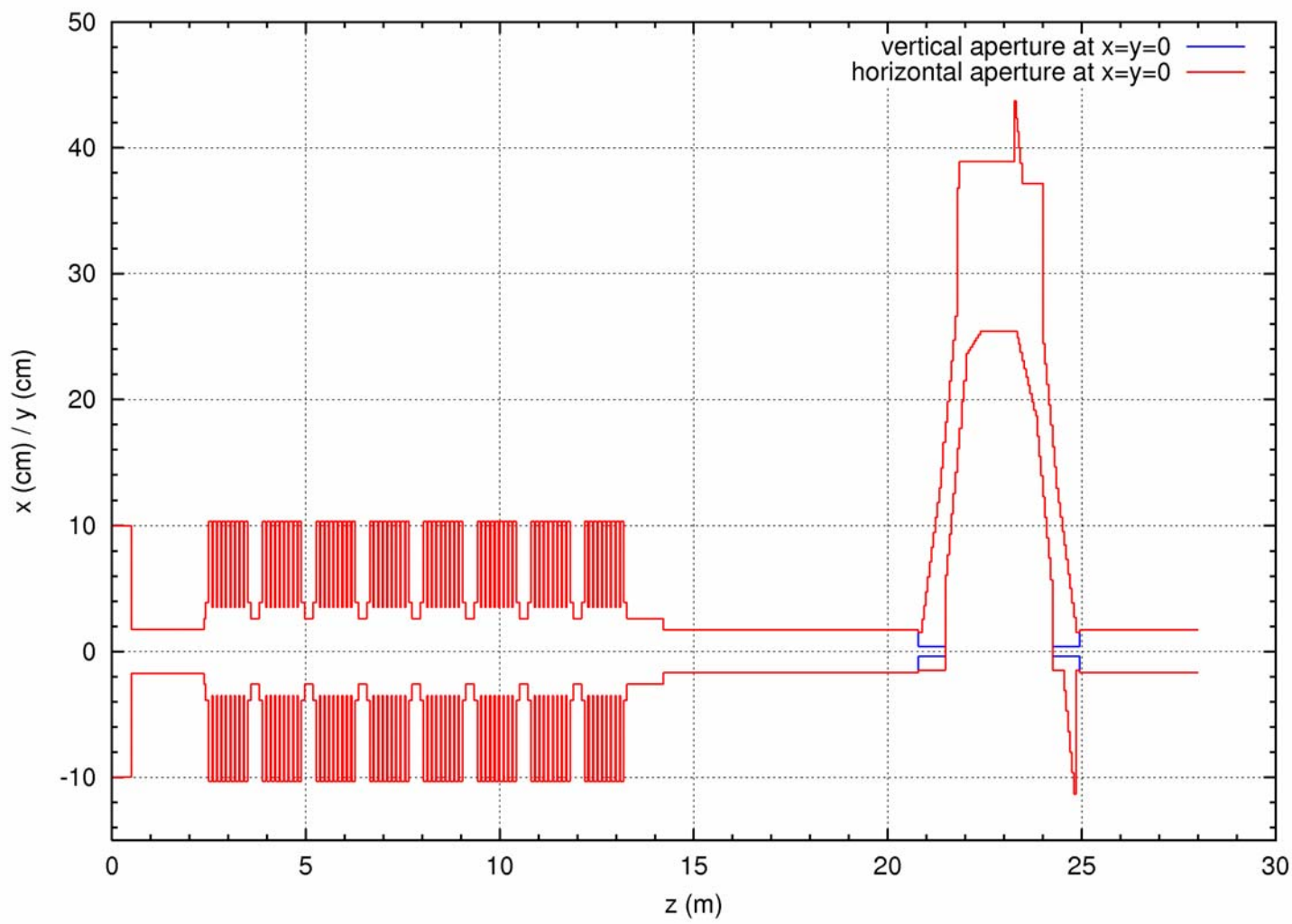
Darkcurrent in FLASH

Simple field emission model (Fowler-Nordheim equation):
Corresponds to Gaussian around RF gun phase 0° with σ=16°.

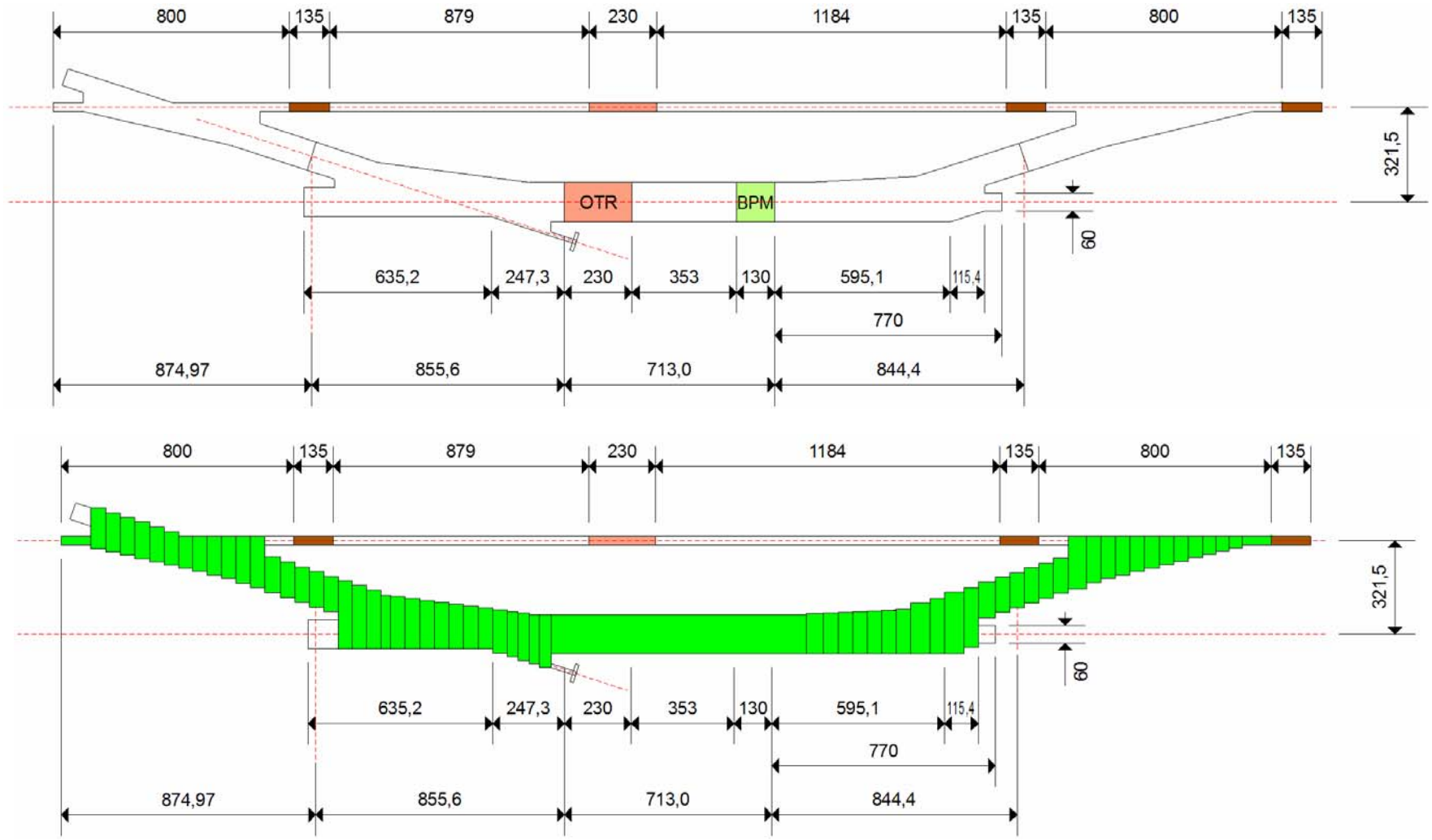
- Astra distribution with 200 000 particles
- Tracking without space charge
  - RF gun aperture handled by Astra
  - Saving 340 phase space files (~11 GB)
- Checking against aperture model with **aperture-check**



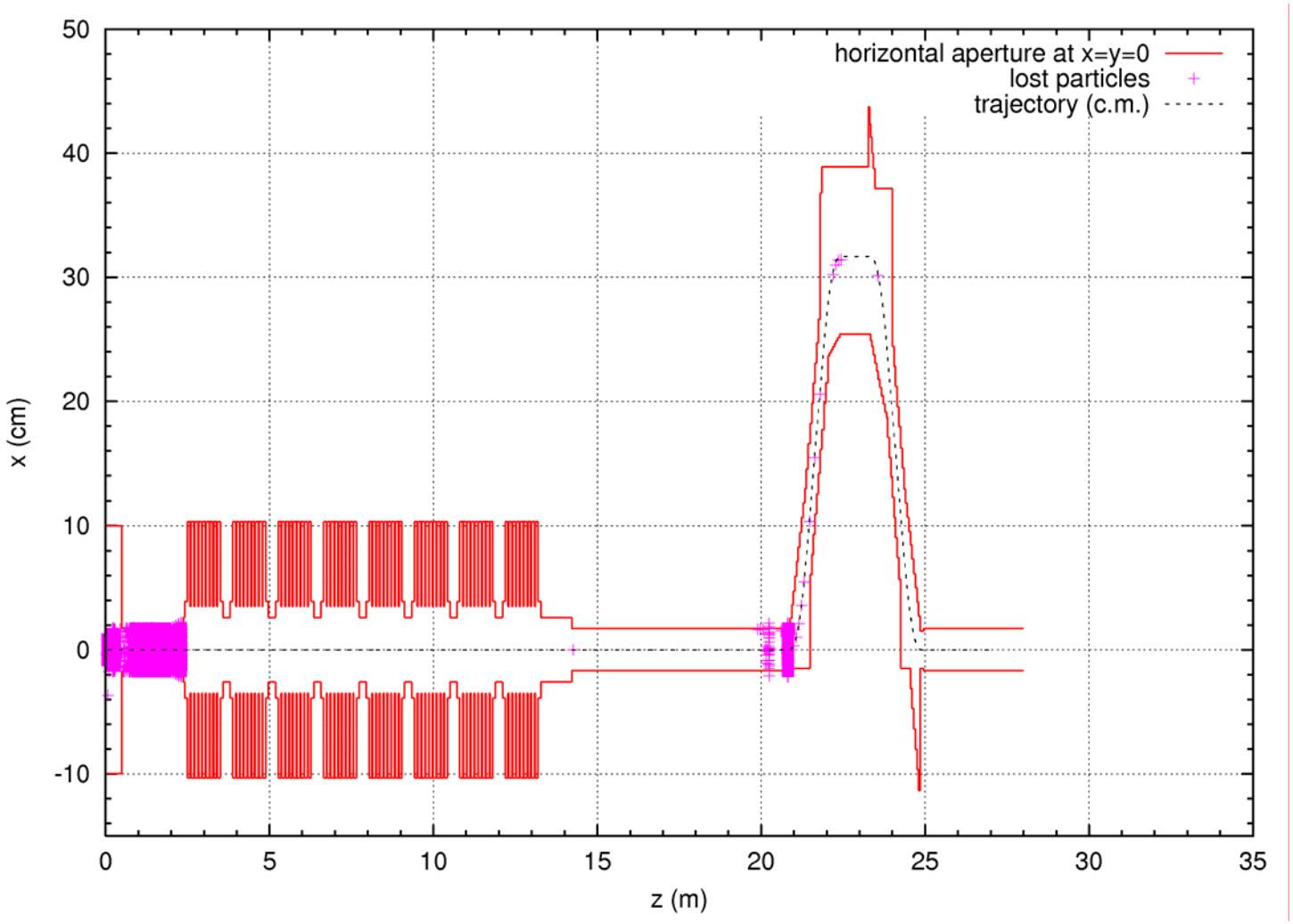
FLASH Injector Aperture



BC2 Vacuum Chamber



Darkcurrent Losses



Losses Along the Injector