KATRIN‘s Open-Source Particle Tracking Package Kassiopeia

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Overview

- C++ framework for high quality **particle tracking simulations**
- **Well-established** software package written to meet the requirements of the KATRIN collaboration [1]
  → Used in many theses [2,3] as well as refereed publications [4,5,6]
- Open-source since 2013 github.com/KATRIN-Experiment/Kassiopeia
- **OpenCL-support** for GPU accelerated simulations
- Object-oriented design enables **extensibility** and **integration** into existing analysis frameworks

```
<geometry>

    <cylinder_space name="example_shape"
              z1="-0.1" z2="0.1" r="0.4"/>

    <space name="example_space" node="example_shape">
        <transformation rotation_euler="90 45 -10"/>
        <transformation displacement="0 0 2.5"/>
    </space>

</geometry>
```

Components

- **Kommon**
  - Collection of basic utilities, used by the other libraries
  - Basis for parsing of XML-elements in configuration files
- **KGeoBag**
  - Toolkit to handle geometric calculations
    → Defines boundary-element mesh algorithm, which is used by KEMField
  - Includes many pre-defined shapes and allows construction of complex geometries
- **KEMField**
  - Accurate calculation of static electromagnetic fields [7]
  - Accounts for symmetry arguments for short computation times [8,9]
- **Kassiopeia**
  - Combines all three libraries to perform particle tracking, visualization and more

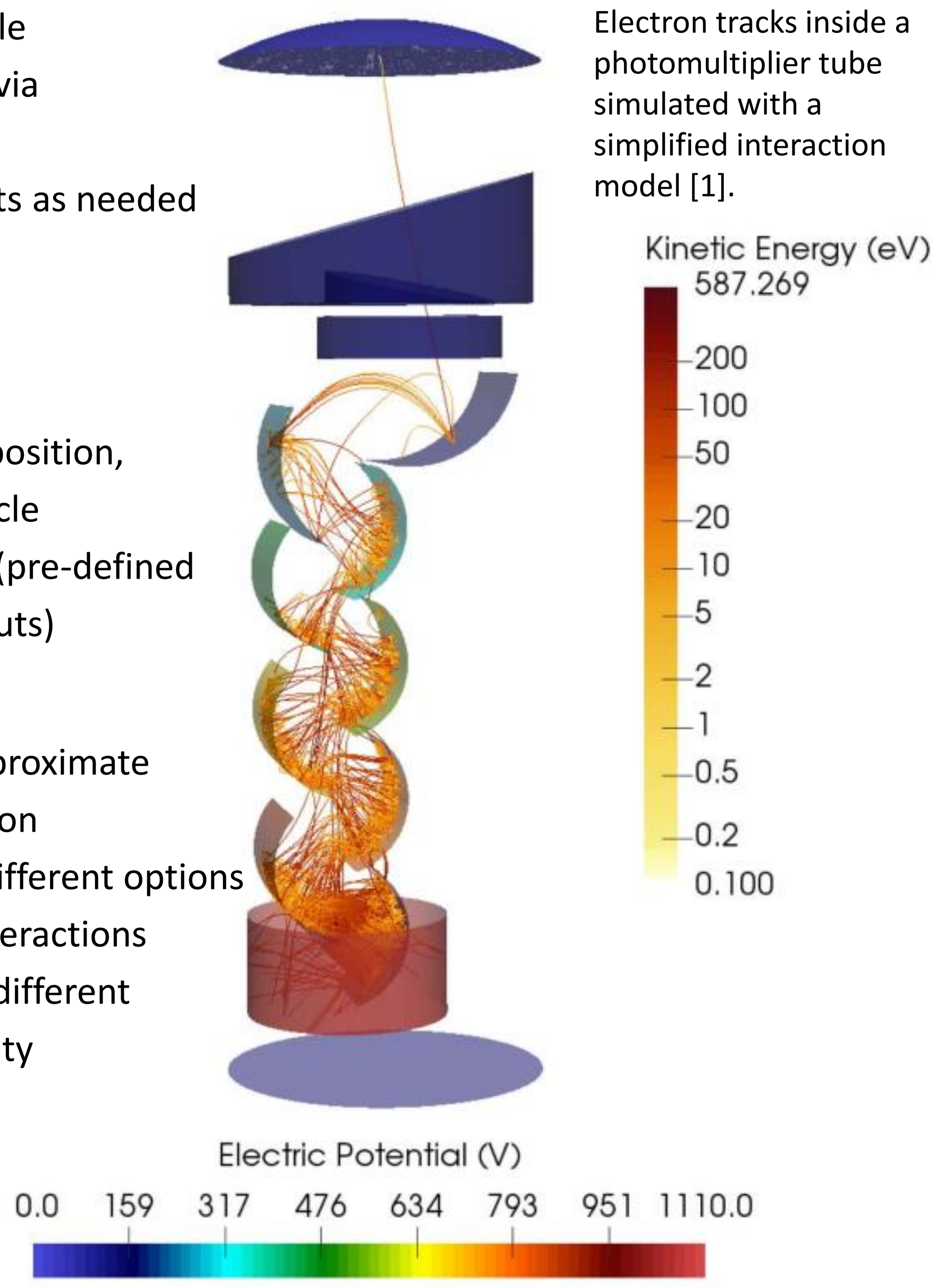
Simulation Step-by-Step

Geometry Design
- Many pre-defined shapes available
- Assembly of geometry elements via tree-like structure
- Apply rotations and displacements as needed
- Define level of discretization
- STL-File import possible

Particle generation
- Define start parameters such as position, direction, energy of desired particle
- Many options for randomization (pre-defined distributions, decays, custom inputs)

Particle navigation
- Solve full Lorentz equation or approximate trajectory via adiabatic propagation
- Control step-size precisely with different options
- Configure volume and surface interactions
- Divide simulation geometry into different navigation regions to gain flexibility
- Configure termination conditions

Output storage
- Customizable levels of detail
- Store as ROOT or VTP file for data analysis and visualization



Electron tracks inside a photomultiplier tube simulated with a simplified interaction model [1].

Kassiopeia‘s Future

Kassiopeia is already a strong tool in the field of particle physics. However, we believe that it has not yet reached its full potential. Two significant aspects shall make the software more accessible for both developers and users.

Regular User Call

- **Monthly online-meeting** for Kassiopeia users and developers.
- Participants from many different collaborations (including KATRIN, Project8, DARWIN)
- **Ask questions** concerning your special use case:
  Do you experience problems? Have you found a bug? What is the most efficient way to solve your problem?
- Beginners as well as experienced users → **Everyone is welcome**!

Improve accessibility for new and advanced users using collective intelligence

Simplified Open-Source Development

- Past workflow: Private development
  → KATRIN internal updates are pushed to the github repository irregularly
  Major updates include detailed changelog.
- New workflow: **Public development first!**
  → Main development for all libraries happens directly inside the github repository.
  Several **advantages** for developers and users **outside the KATRIN collaboration**:
  - Greater motivation to actively develop and to create pull requests
  - Be able to track changes through the commit history
  - Always get the latest version of the software
  - Initiate discussion between developers and users
  - Improve ability to integrate Kassiopeia into custom frameworks

Actively define the future and **unlock full potential of Kassiopeia**

References

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