# OpenDreamKit

## Work Package 4: User Interfaces

# Overview

The general goals of WP4:

- Improve existing Jupyter tools (T4.2)
- Build new tools in the Jupyter ecosystem (T4.3, 4.8)
- Improve OpenDreamKit components, especially where they interact with each other (T4.1, 4.4, 4.5, 4.12)
- Demonstrate effectiveness in scientific applications (T4.9, 4.11, 4.13)
- Work on Active Documents (T4.6, 4.7)

# Overview

**Goal**: Provide unified interfaces for OpenDreamKit VREs

Broad categories of work:

- Connect with underlying computational software
- Notebook interfaces
  - Bring notebooks to more communities
  - Improve working with notebooks
  - Collaborative workspaces
- Interactive documents and documentation

# Milestone M6: Prototype VRE for mathematical researchers

User story: a group of mathematical researchers with access to common computational resources, such as a shared lab computer or cloud servers, shall be able to deploy a prototype VRE with JupyterHub, integrating OpenDreamKit components. The Jupyter kernels for mathematical software developed as part of OpenDreamKit make computational mathematical components accessible in a Jupyter environment, enabling a Jupyter-based deployment of the relevant tools for the researchers.

OpenDreamKit produces tools for researchers to use. **WP4 is about making those tools accessible to researchers and research results accessible to others.**

# OpenDreamKit bet on Jupyter notebooks

It has paid off!

- Millions of notebooks online (over 3M on GitHub alone)
- June 2018, Jupyter awarded prestigious 2017 ACM Software System Award
- Previous winners include: UNIX, TCP/IP, the Web, TeX, Java, GCC, LLVM

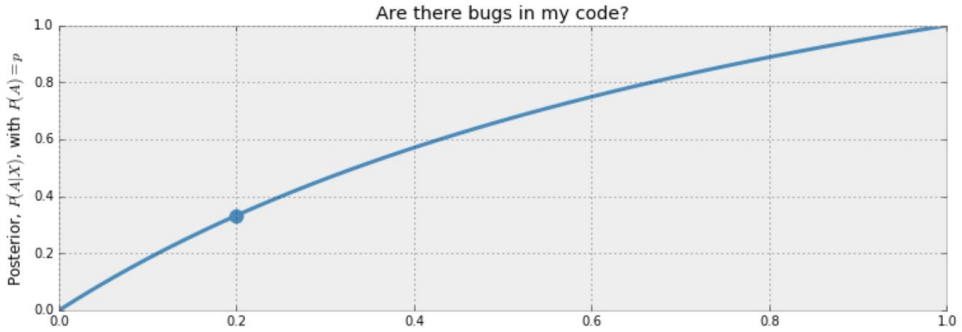
# Background: Jupyter notebooks

Document with code, prose, maths, visualization

$$= \frac{2p}{1+p} \tag{11}$$

This is the posterior probability. What does it look like as a function of our prior, $p \in [0, 1]$?

```
figsize(12.5, 4)
p = np.linspace(0, 1, 50)
plt.plot(p, 2*p/(1+p), color="#348ABD", lw=3)
plt.title("Are there bugs in my code?");
```



# Background: Jupyter notebooks

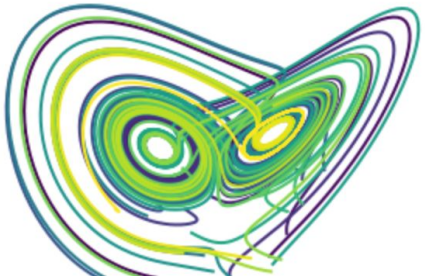
It also has support for rich, interactive UI components:

```
from notebooks.lorenz import solve_lorenz
w=interactive(solve_lorenz,sigma=(0.0,50.0),rho=(0.0,50.0))
w
```

sigma 11.50

beta 2.33

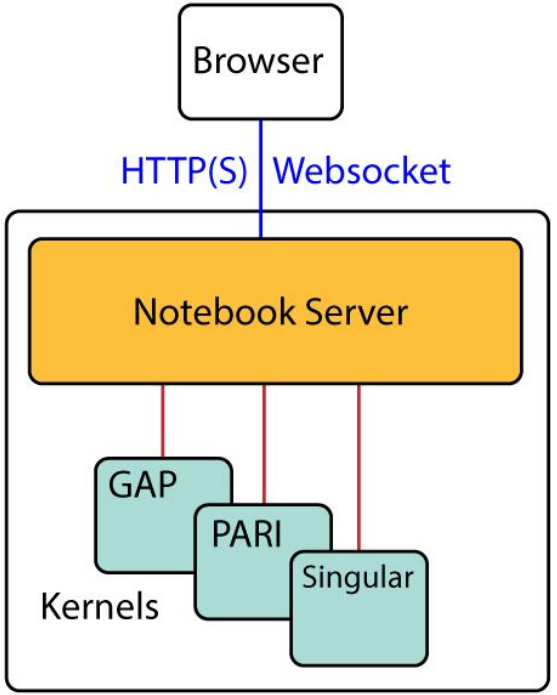
rho 21.80



# Background: Jupyter notebooks

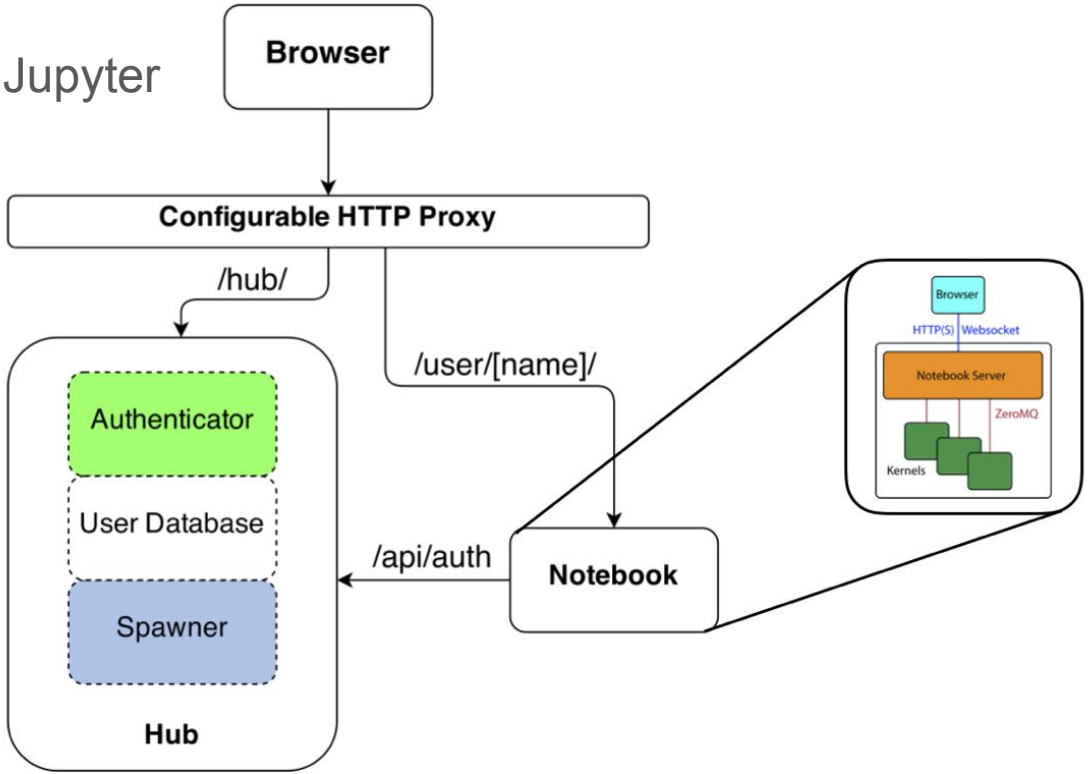
Web-based interactive computing environment

Language-agnostic protocol for computation



# Background: JupyterHub

Extensible VRE built around Jupyter



# Notebook Interfaces

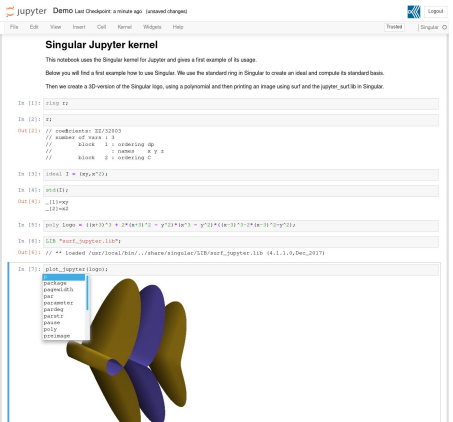
Key areas:

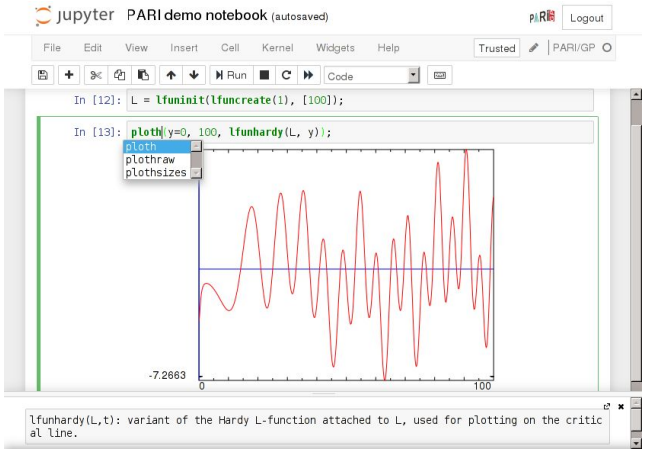
- Improve working in notebooks
- Improve working with notebooks

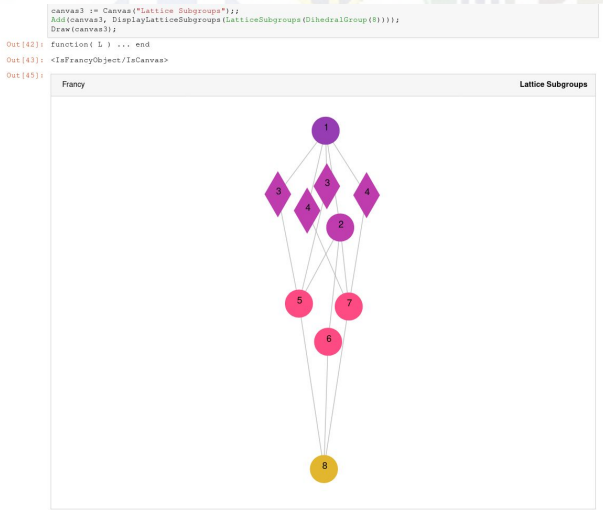
https://opendreamkit.org/try/try/

# Highlight: OpenDreamKit kernels

- Now 117 Jupyter kernels (49 when ODK started), 6 contributed to by ODK.
- Further improved kernels from first reporting period (GAP, PARI, Singular). Delivered as D4.7, and MMT as part of WP6
- Also contributed to kernels: cling (C++), SageMath



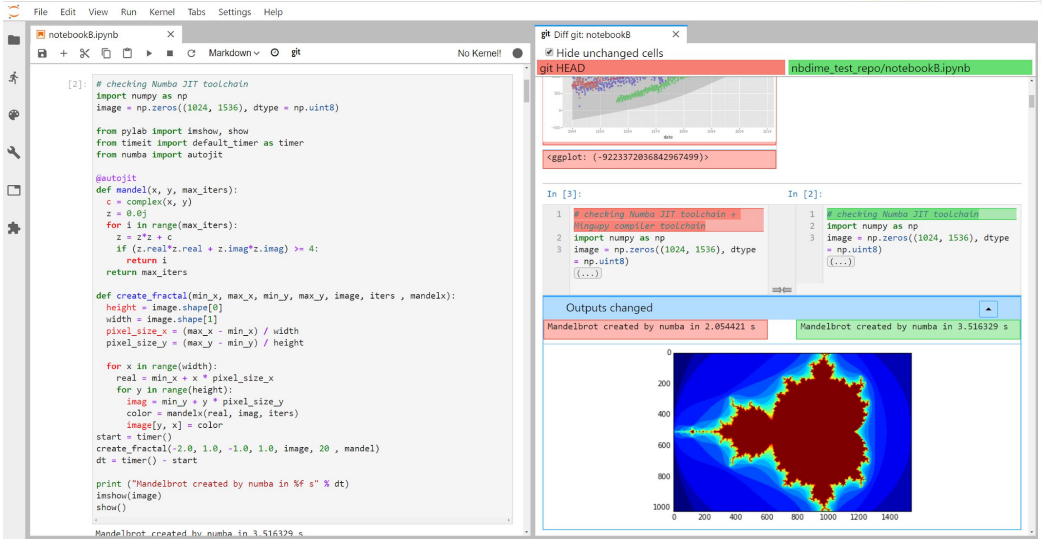
# KPI: ODK Kernels on GitHub

Notebooks found on GitHub using each kernel (code):

- SageMath: 6199
- Xeus-cling: 684
- GAP: 63
- Singular: 8
- PARI/GP: 3
- MMT: 1

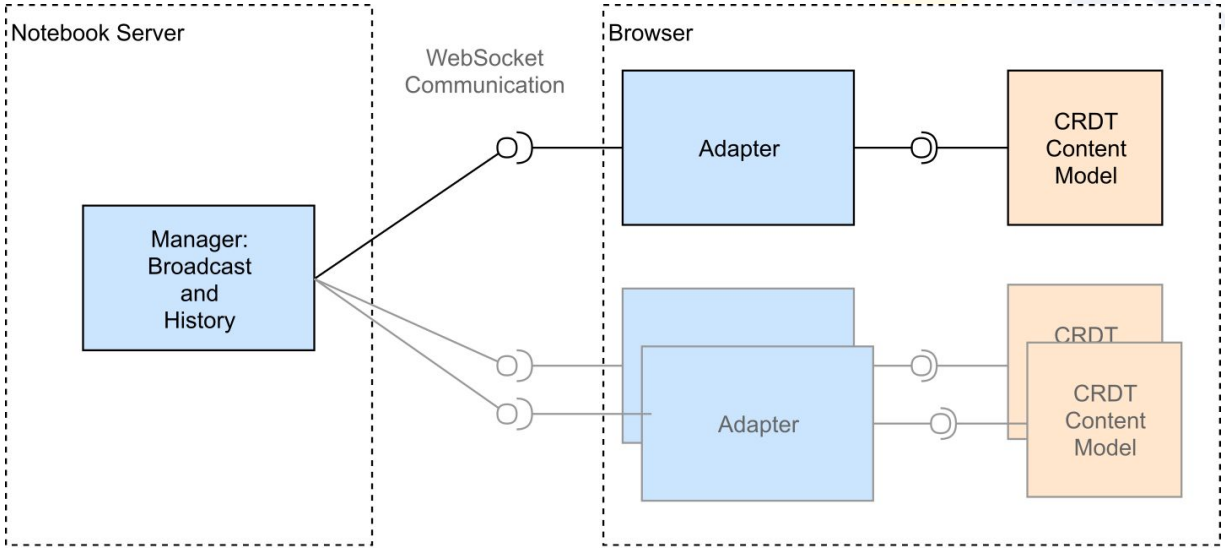
# Highlight: nbdime

- Further development on the nbdime project, delivered in the first period (D4.6). Has been met with enthusiasm, adoption in the community.
- Jupyter Notebook and Jupyter Lab extensions, git integration.



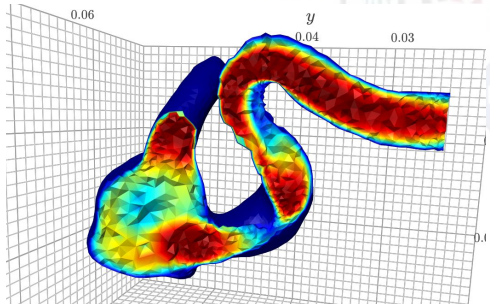
# Highlight: real-time collaboration

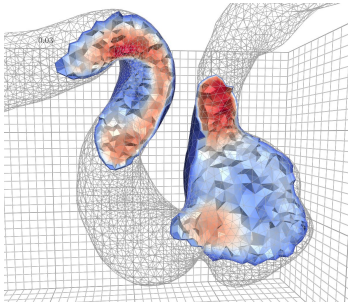
- D4.15 prototype and plan for live collaboration in JupyterLab. Optimistic about good integration during the final year of ODK.

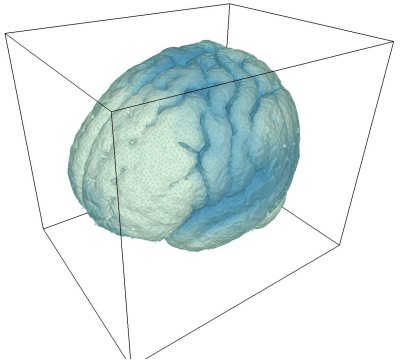


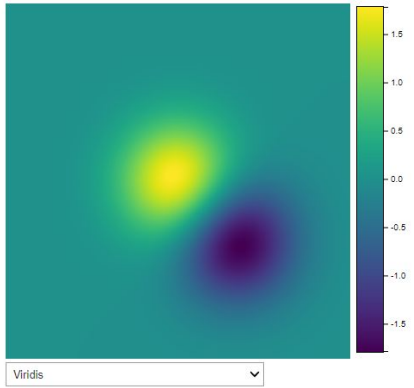
# Highlight: 3D visualization in Jupyter notebooks

- D4.12: Jupyter extension for 3D vis, demonstrated with fluid-dynamics
- Packages:
  - k3d-jupyter
  - ipydatawidgets
  - ipyscales
  - unray
- Improved distribution



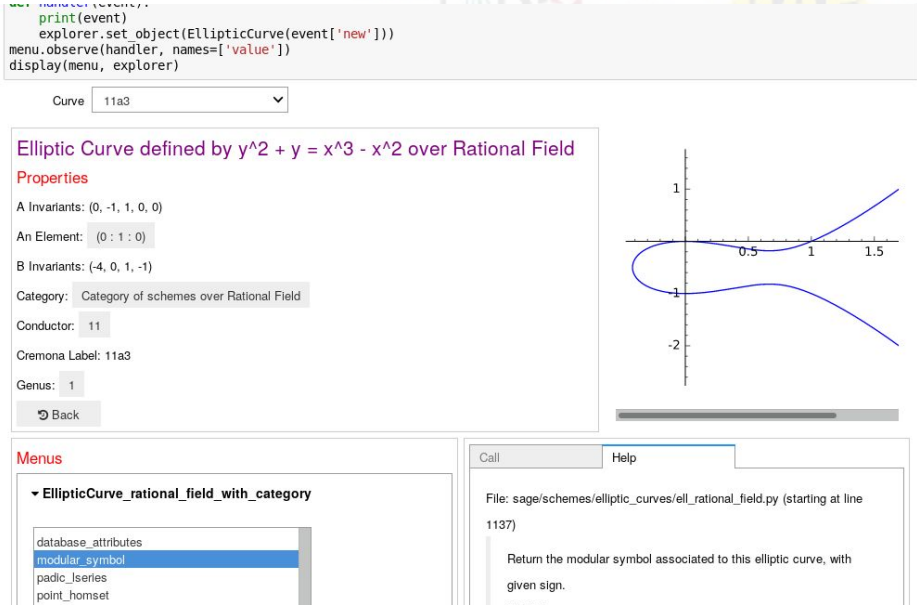







# Highlight: Dynamic documentation and exploration system

- Delivered D4.16 as two new packages, built on Jupyter widgets for interactively exploring objects in Sage
  - Sage Combinat Widgets
  - Sage Explorer



# Interactive Documents

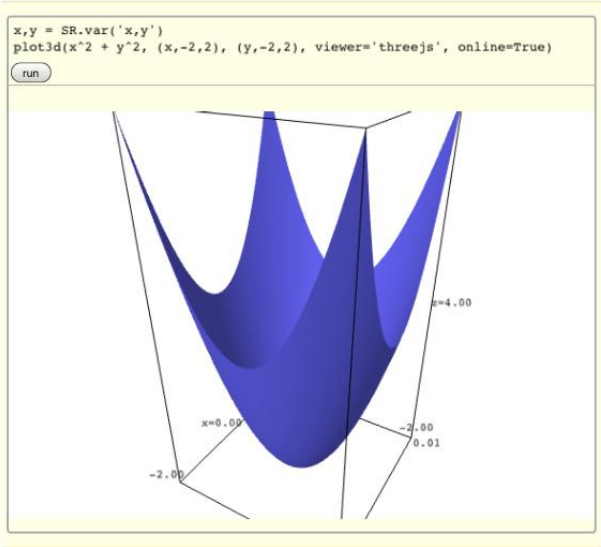
Key areas:

- Active Documents
- Interactive Documentation

# Highlight: Active Documents Workshop

Workshop on live documents hosted in Oslo. Resulted in new package: thebelab, for embedding execution on any page, integrating tools from JupyterLab and MyBinder.org, demonstrating value of coordination.

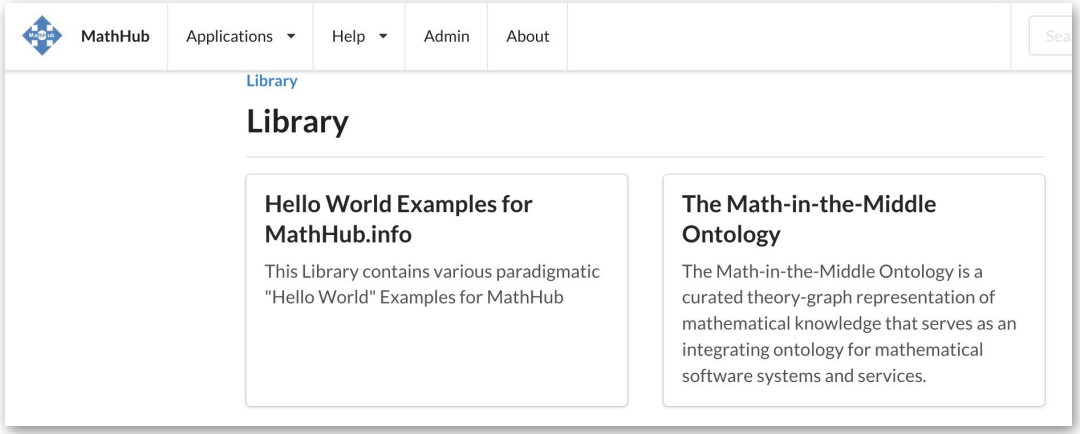
3D plots are functional with the `threejs` backend:



# Highlight: MathHub notebook integration

MathHub.info is a portal for active mathematical documents. As part of D4.11, a notebook integration with MathHub was added. This allows:

- Authoring MathHub documents as a Notebook
- Interactively exploring existing MathHub documents as a Notebook.



# Highlight: Sage documentation

- Refactorisation of SageMath's Sphinx documentation system as part of D4.13
- Improve Sphinx support for Cython projects.
  - Enabled building proper documentation for fpylll, CyPari2, CySignals.
- To completely enable Cython documentation out of the box, Python needs to be fixed. For this, we submitted PEP (Python Enhancement Proposal) 580.

# Highlight: PARI bindings

- Improved PARI/GP bindings delivered as D4.10
- CyPari2 used to be part of SageMath, but it was made a separate package in D4.10 (see also D4.1). This ties into WP3.

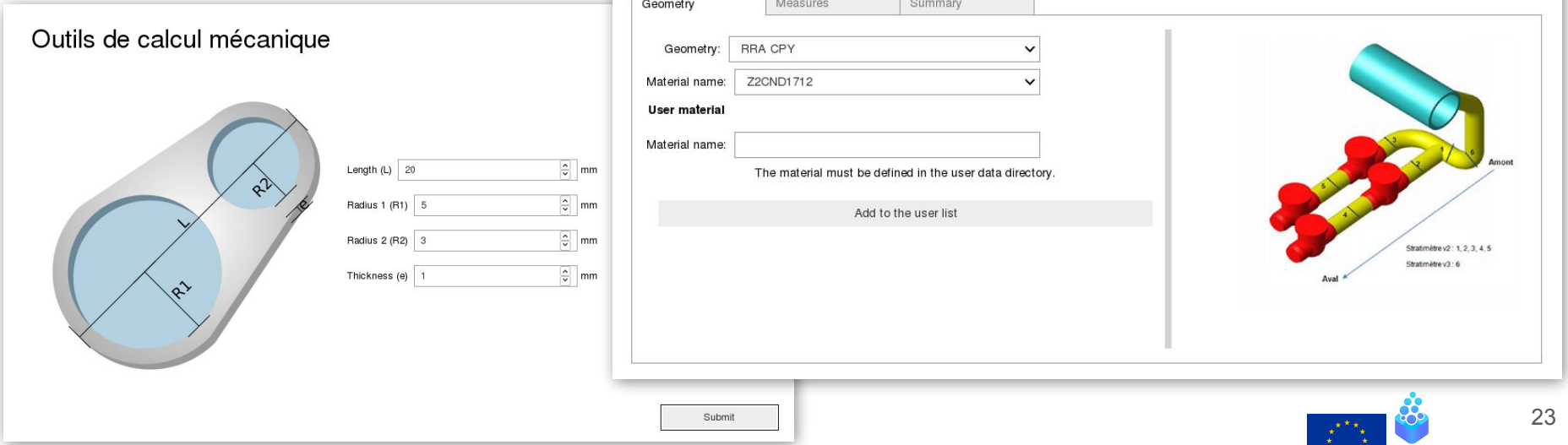
```
In [1]: from cypari2 import Pari
        pari = Pari()

In [2]: E = pari.ellinit([-82, 0]); E

Out[2]: [0, 0, 0, -82, 0, 0, -164, 0, -6724, 3936, 0, 35287552, 1728, Vecsmall([1]
        ), [Vecsmall([64, 1])], [0, 0, 0, 0, 0, 0, 0, 0]]

In [3]: E.ellanalyticrank()

Out[3]: [3, 106.734807462587]
```

# KPI: JupyterHub deployments

- Local CoCalc instance at Universität Zürich.
  - Deployed September 2015 - February 2016.
  - People involved: @pdehaye, @williamstein
- Instance of JupyterHub deployed by the Mathrice group
  - Host Infrastructure: France Grille's LAL cloud
  - Users: members of math labs in France
  - Main use case: casual use
- Local JupyterHub instance at Université Paris Sud / Paris Saclay
  - Host Infrastructure: France Grille's LAL cloud
  - Users: personnel and students of UPSud / Paris Saclay
  - Main use case: use in classroom (Python, Sage, C++), casual use
  - People involved: @VivianePons, @nthiery, @gouarin
- JupyterHub instance deployed on USheffield's HPC system
  - People involved: @mikecroucher
- JupyterHub instance(s) deployed at UVSQ
  - Main use case: use in classroom (Sage, Python, C, Apache Spark), casual use
  - People involved: @defeo
- JupyterHub and Binder instances deployed on EGI infrastructure
- Easy deployment of live GAP/SageMath/... notebooks with mybinder, thanks to the Docker containers (#58); potential alternatives: Debian packaging and Conda packaging.
  - People involved: @nthiery, ...
- Local instance of CoCalc (using the Docker container) at the University of Gent
  - Main use case: teaching for mathematics students
- Deployed at jupyter.mathhub.info
  - With MMT kernel
  - People involved: @tkw1536

# Highlight: Simulagora

- Logilab VRE deployment for application development and deployment.
- Can use JupyterLab for application development, which can then be deployed with a simplified parameters form input.



# KPI: Usage/impact statistics (since last reporting period)

- Nbdime: 855 stars on github, 64 contributors (36 in 12 months prior), 611 comments, 239 new issues (241 closed).
- Thebelab: 44 stars, 15 contributors, 151 new issues (118 closed), 323 comments.
- K3D-Jupyter: 48 stars, 14 contributors, 140 new issues (129 closed), 303 comments.