wakis

3D Electromagnetic Time-Domain wake and impedance solver

CSC on IT services – 08 October 2024 – Lightning Talk

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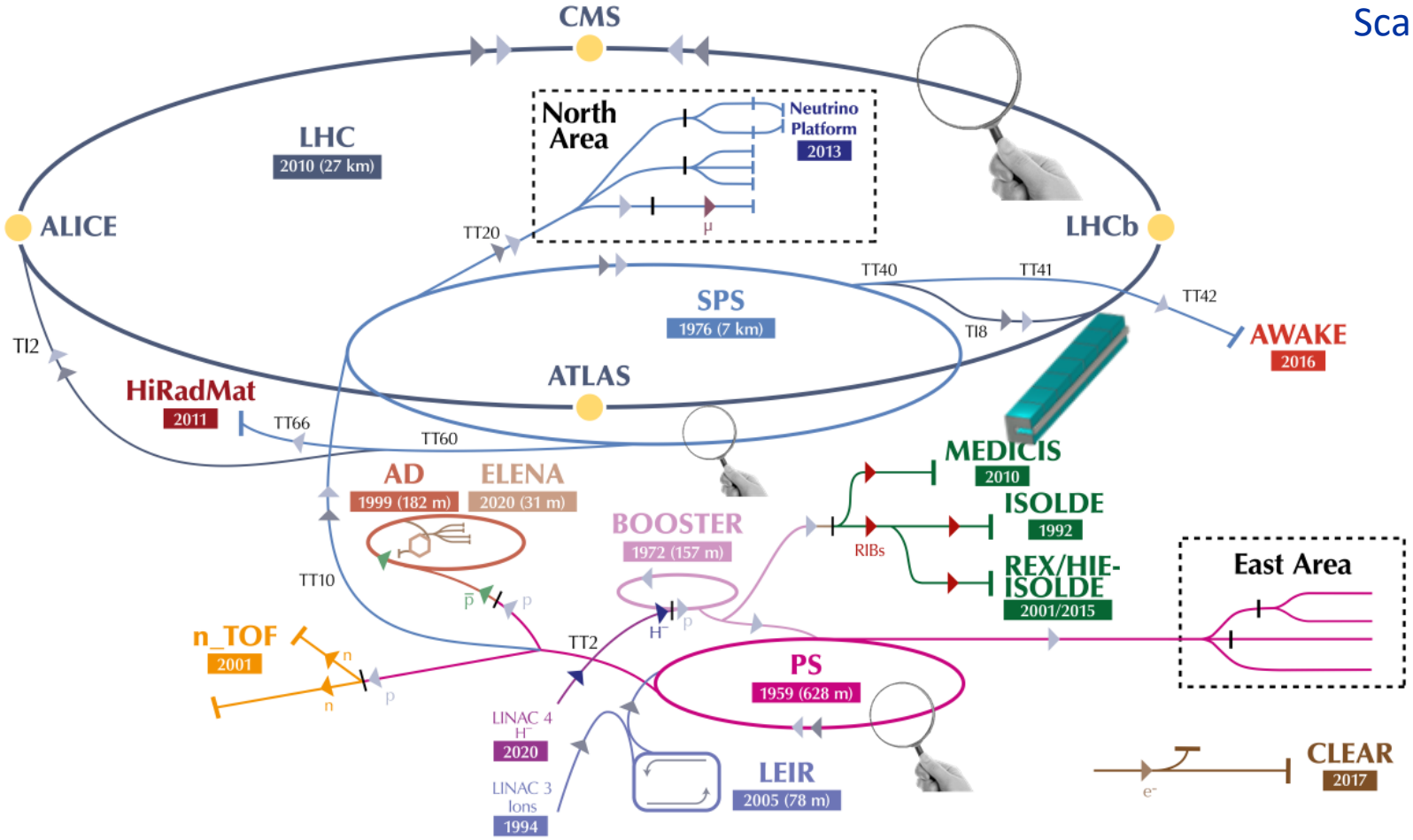
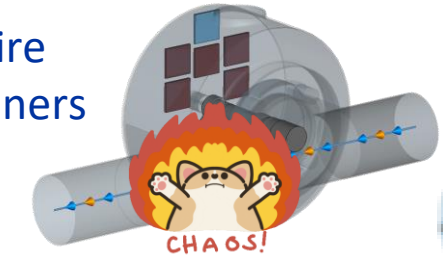
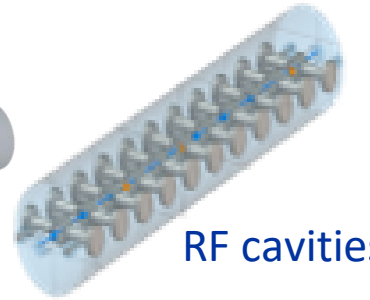
Accelerator components… can break

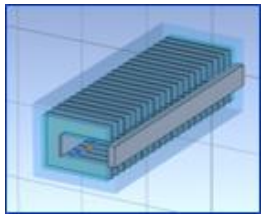


Wire Scanners



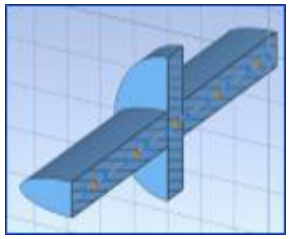


RF cavities

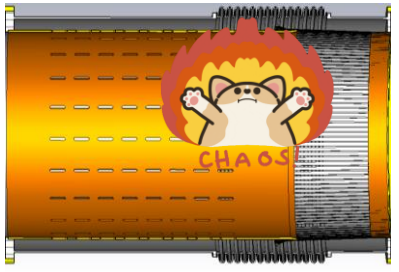


Kicker magnets

Beam Position Monitors



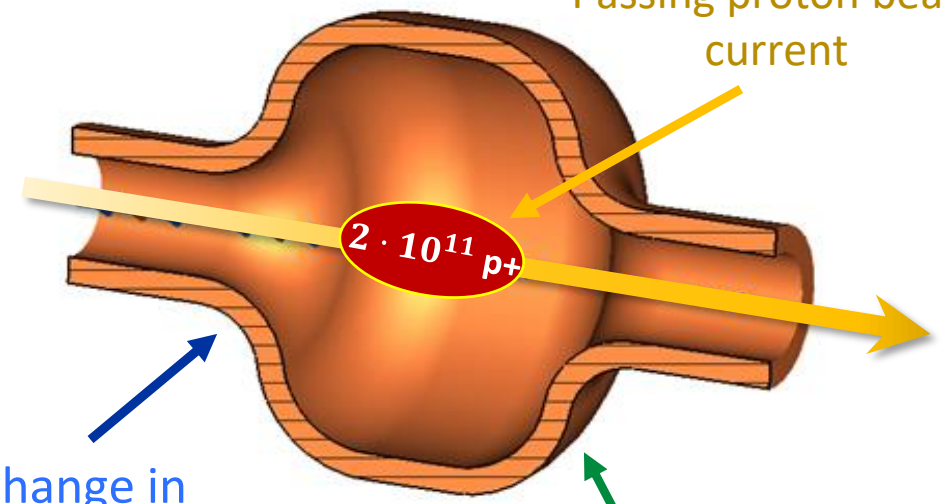
Step transitions



Warm Vacuum modules

One of the causes… wakefields & impedance

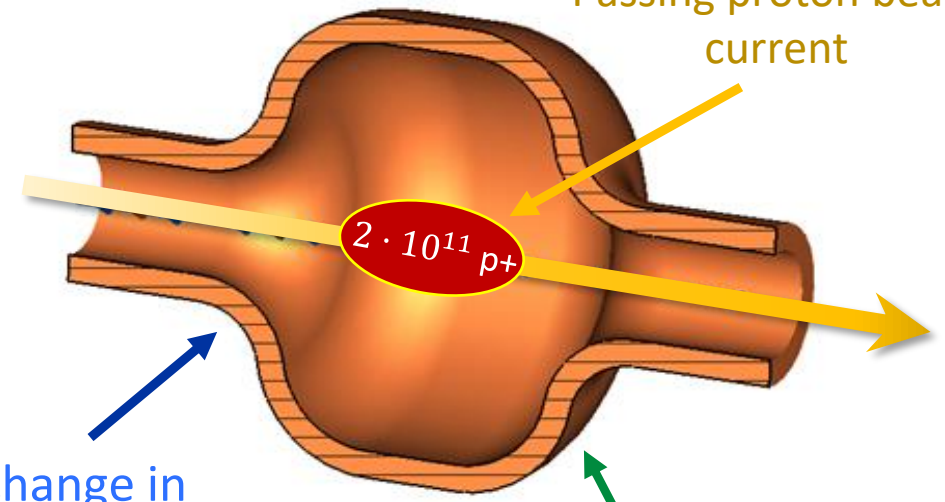
Simplified accelerator component



Excites over time

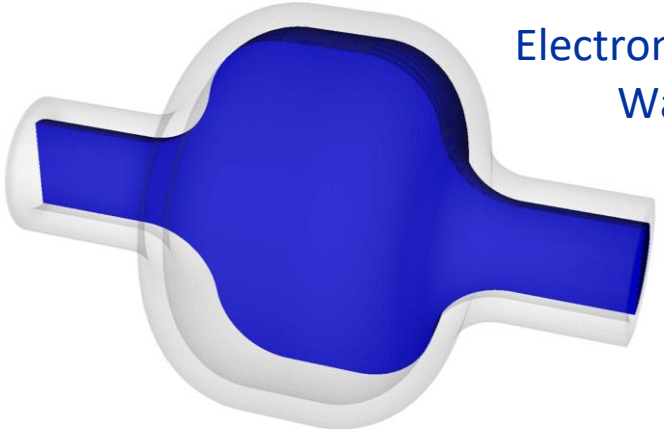
One of the causes… wakefields & impedance

Simplified accelerator component

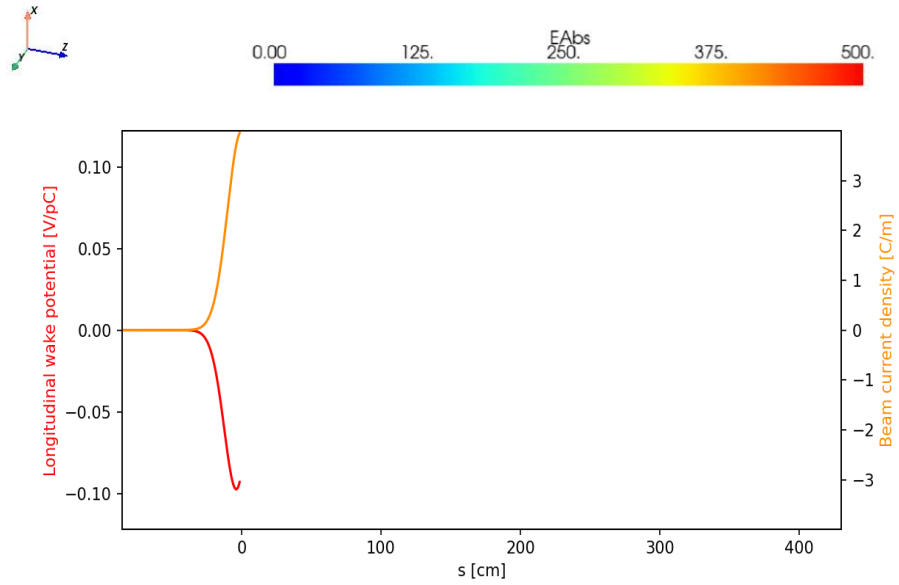


Excites over time

EAbs field, timestep=35000



Electromagnetic (EM) Wakefields



To calculate wakefields… Numerical solver

Maxwell Equations (Integral form)

$$\oint_{\partial A} \boldsymbol{E} \cdot d\boldsymbol{s} = -\iint_{A} \frac{\partial \boldsymbol{B}}{\partial t} \cdot d\boldsymbol{A}$$

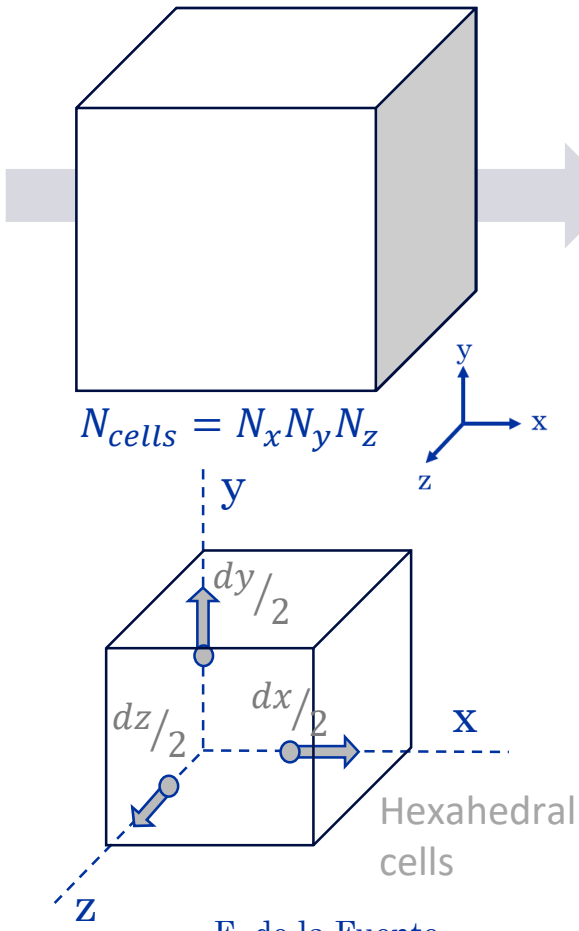
$$\oint_{\partial A} \boldsymbol{H} \cdot d\boldsymbol{s} = -\iint_{A} \left(\frac{\partial \boldsymbol{D}}{\partial t} + \boldsymbol{J}\right) \cdot d\boldsymbol{A}$$

$$\oiint_{\partial V} \boldsymbol{B} \cdot d\boldsymbol{A} = 0$$

$$\oiint_{\partial V} \boldsymbol{D} \cdot d\boldsymbol{A} = \iiint_{V} \boldsymbol{\rho}\, dV$$

$$\boldsymbol{D} = \varepsilon \boldsymbol{E}, \quad \boldsymbol{B} = \mu \boldsymbol{H}, \quad \mathbf{J} = \sigma \boldsymbol{E} + \boldsymbol{\rho v}$$

1st approximation
Domain discretization
dx, dy, dz



Maxwell Grid Equations

$$\boldsymbol{C D_s e} = -\boldsymbol{D_A} \frac{\partial \boldsymbol{b}}{\partial t}$$

$$\tilde{\boldsymbol{C}} \tilde{\boldsymbol{D}}_{\boldsymbol{s}} \boldsymbol{h} = \tilde{\boldsymbol{D}}_{\boldsymbol{A}} \left(\frac{\partial \boldsymbol{d}}{\partial t} + \boldsymbol{j}\right)$$

$$\boldsymbol{S D_A b} = \mathbf{0}$$

$$\tilde{\boldsymbol{S}} \tilde{\boldsymbol{D}}_{\boldsymbol{A}} \left(\frac{\partial \boldsymbol{d}}{\partial t} + \boldsymbol{j}\right) = \mathbf{0}$$

Computer friendly!

$$\boldsymbol{d} = \tilde{\boldsymbol{D}}_{\boldsymbol{\varepsilon}} \boldsymbol{e}, \quad \mathbf{b} = \boldsymbol{D}_{\boldsymbol{\mu}} \boldsymbol{h}, \quad \mathbf{j} = \tilde{\boldsymbol{D}}_{\boldsymbol{\sigma}} \boldsymbol{e} + \boldsymbol{j}_{\boldsymbol{src}}$$

Integrals to matrices:

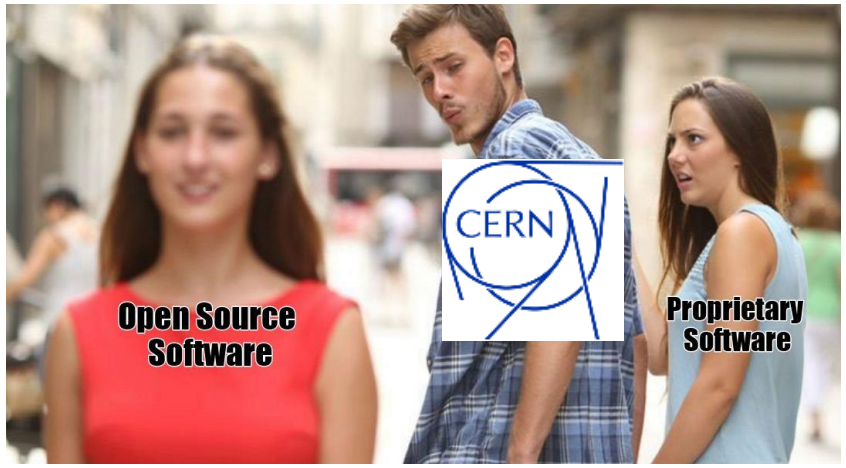
- Operators
- Grid areas and lengths
- Materials

So far… only commercial software

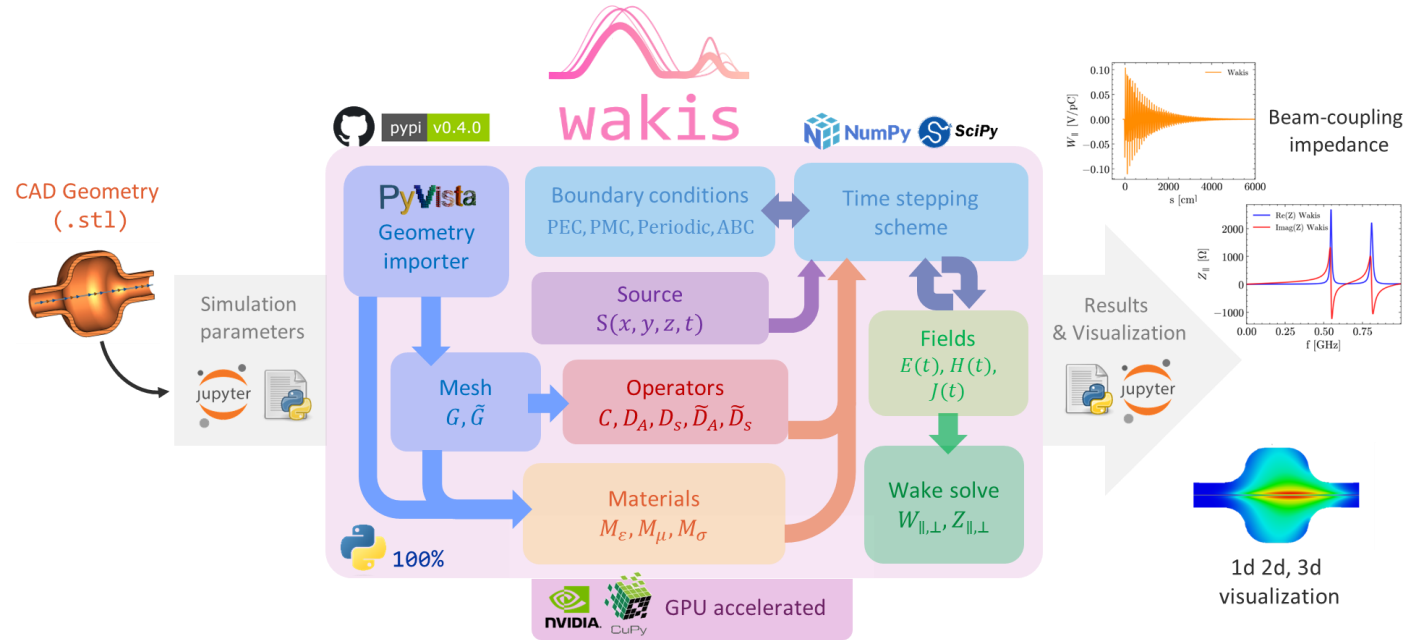
https://xkcd.com/

DASSAULT SYSTEMES

SIMULIA CST STUDIO SUITE



My PhD project

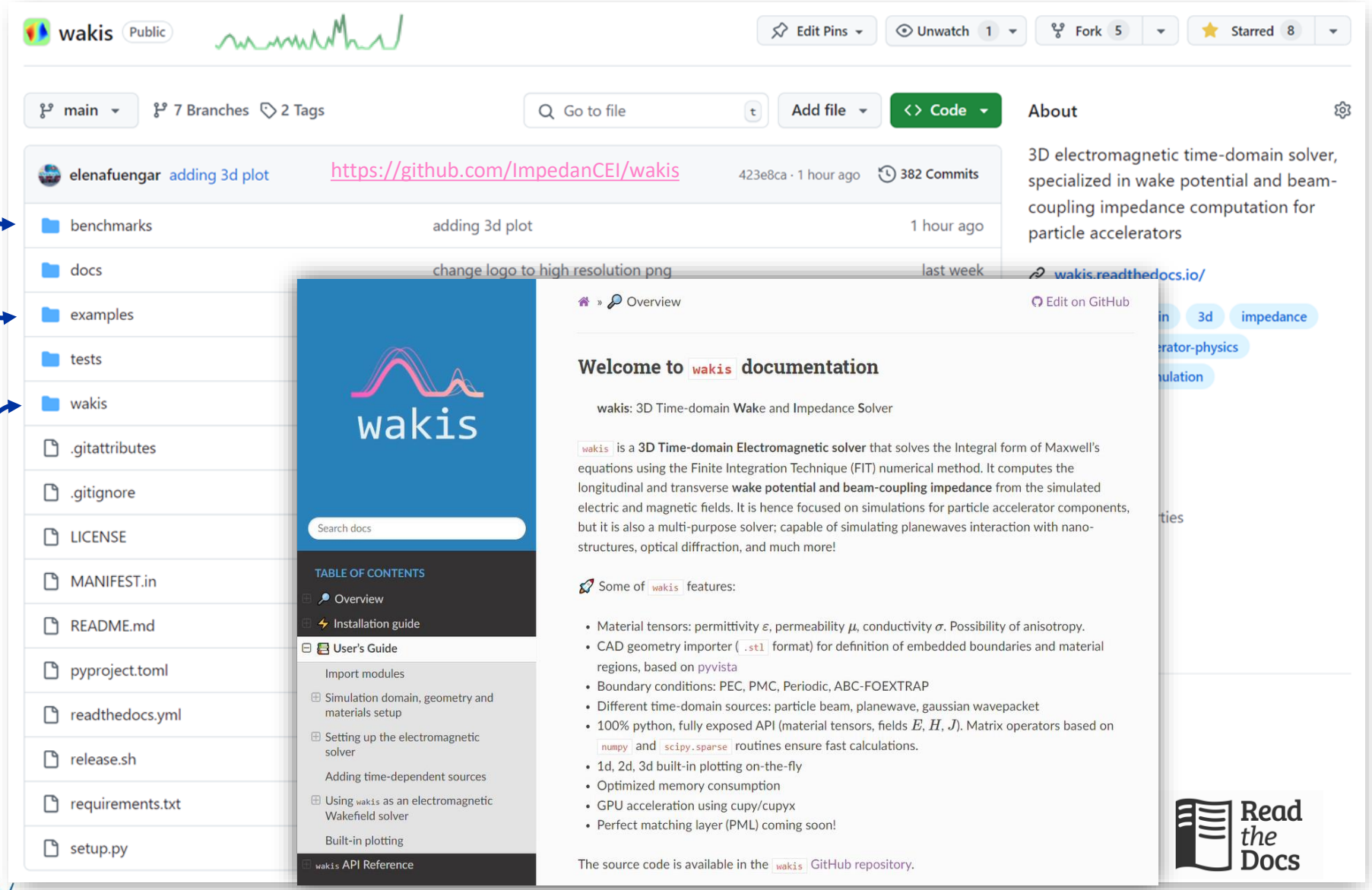


Open-source !

Benchmarks against CST studio®

Simulation examples ~2' to 20'

Source code



ATS sector ♡ IT group

Improve how we write code & exploit IT resources

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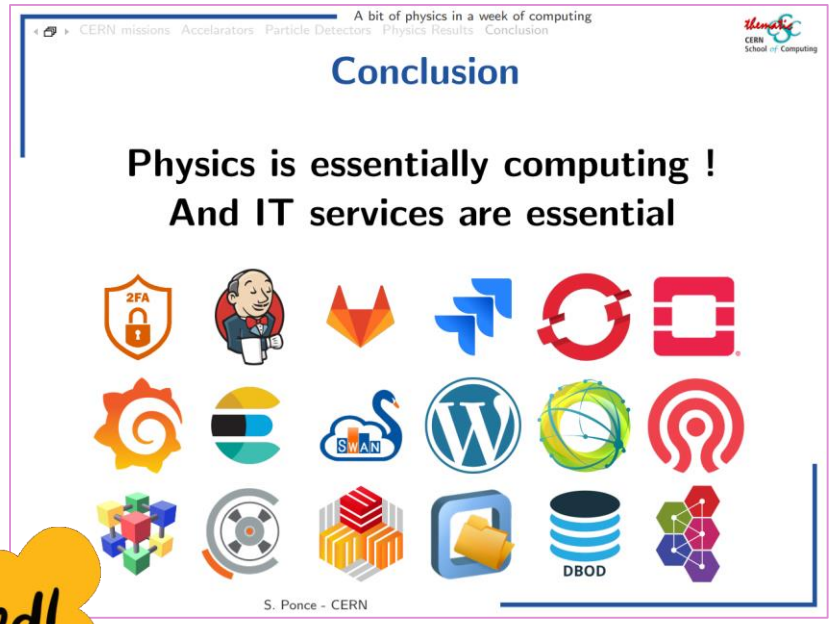

reana

Reproducible research data analysis platform

inspired!

Flexible

Run many computational workflow engines.

COMMON WORKFLOW LANGUAGE

Scalable

Support for remote compute clouds.

kubernetes HTCondor slurm workload manager

Reusable

Containerise once, reuse elsewhere. Cloud-native.

Free

Free Software. MIT licence. Made with ❤ at CERN.

CERN

Thank you for the attention ☺

Wakis:

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