Visualization Tools

Meeting of HPC ACHs

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- Build visualization solutions for Plasma Physics

- Science communication (both external and internal) and scientific visualization

- For communication : building a tokamak digital twin to integrate different aspects in the same visualization

- For scientific visualization :

  Paraview modules

REAL-TIME DIGITAL TWIN

Outline of the workflow

- Stating the requirements and retrieve the related CPU numerical physics methods
  – *C. Sommariva*

- Design an implementation that can run efficiently on a GPU in a real-time rendering context
  – *F. Cabot*

- Port the design in a high level rendering engine (Unreal) and enhance the visuals
  – *S. Mannane, L. Serafin*

- Model TCV from technical CADs and render it in a photorealistic way
  – *B. Padernoz, M. Toussaint*

- Integrate both the particles and the tokamak model in an end-user application
  – *S. Mannane, L. Serafin*
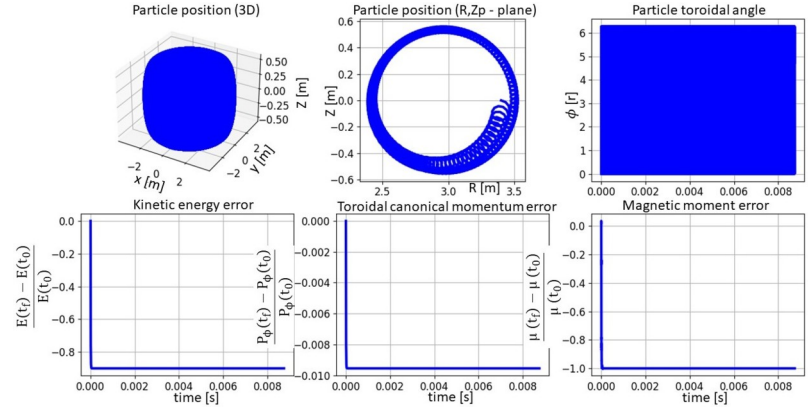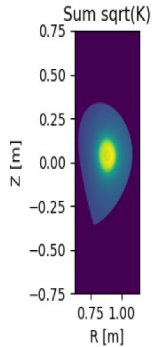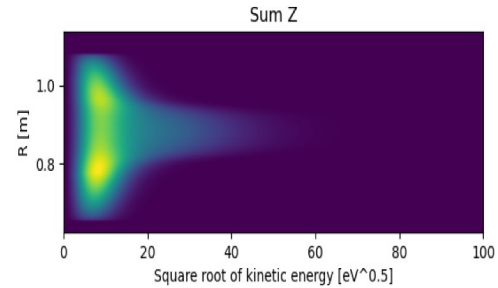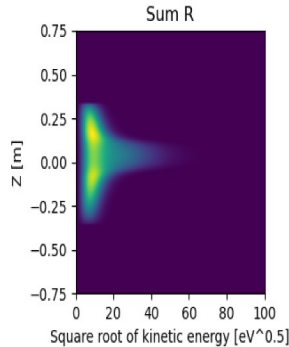
LIVE DEMO

REAL-TIME DIGITAL TWIN

Use Boris method for electro-magnetic force integration

Phase-space particles initialization through importance sampling (separate or combined position/velocity possible)

- Coulomb collisions of tracked particles with background plasma particles

    → *Takizuka, T., & Abe, H. (1977). A binary collision model for plasma simulation with a particle code. Journal of computational physics, 25(3), 205-219.*

- Requires a better way to visualize than pure realism (collisions are too infrequent and of small magnitude at those time scales → try Nanbu collision operator)

- NBI ionization using Suzuki method for reaction rates

    → *S Suzuki et al 1998 Plasma Phys. Control. Fusion 40 2097*

- Ported ASCOT5's BBNBI code to GPU/GLSL for real-time ionization in a rendering context

- NBI ionization requires dynamic particle types

- Implemented a particle dynamic allocator/deallocator on the GPU (Pool allocator)

- Useful for other types of reactions

- Needs balancing for continuous runs and anticipation for first allocation of the pool

PARAVIEW VISUALIZATION

PARAVIEW VISUALIZATION

- Started recently

- Performance issues still (probably not using the right ParaView API – any help would be appreciated)

- Begin with ORB5 data, aims to be more generic

PARAVIEW VISUALIZATION
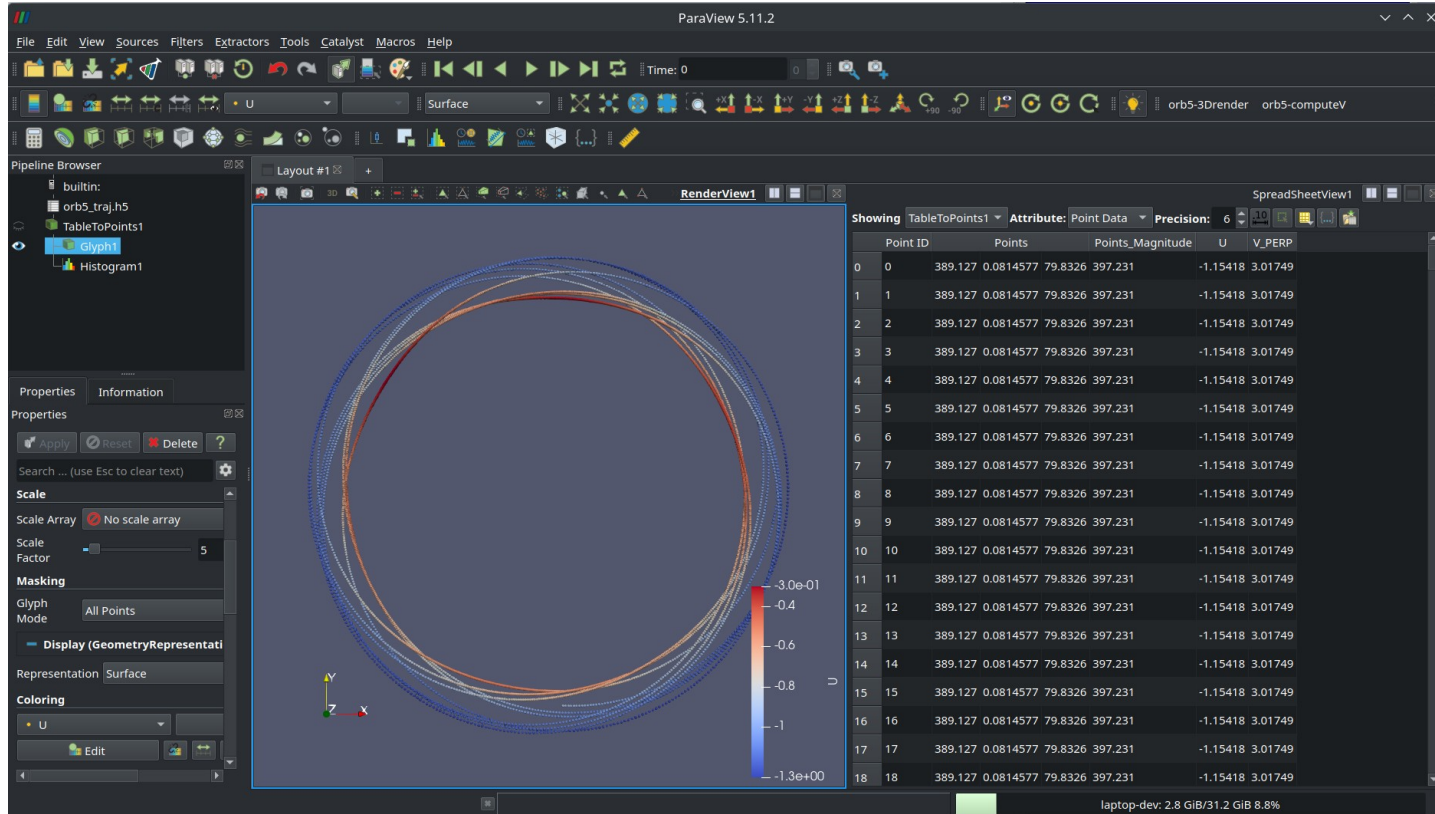
FUTURE WORK

- More reaction types (being implemented : charge exchange, nuclear reactions, ...)

- Publication of the Digital Twin project for other institutes to use with their own data

- Particle-wall collisions

- Advance on ParaView visualization (6D data, volumetric data)

- Continuous work : verification

- Real-time GPU simulation of particle interactions with background plasma in a TCV digital twin, soon released for other tokamaks

- Building blocks of Paraview visualization
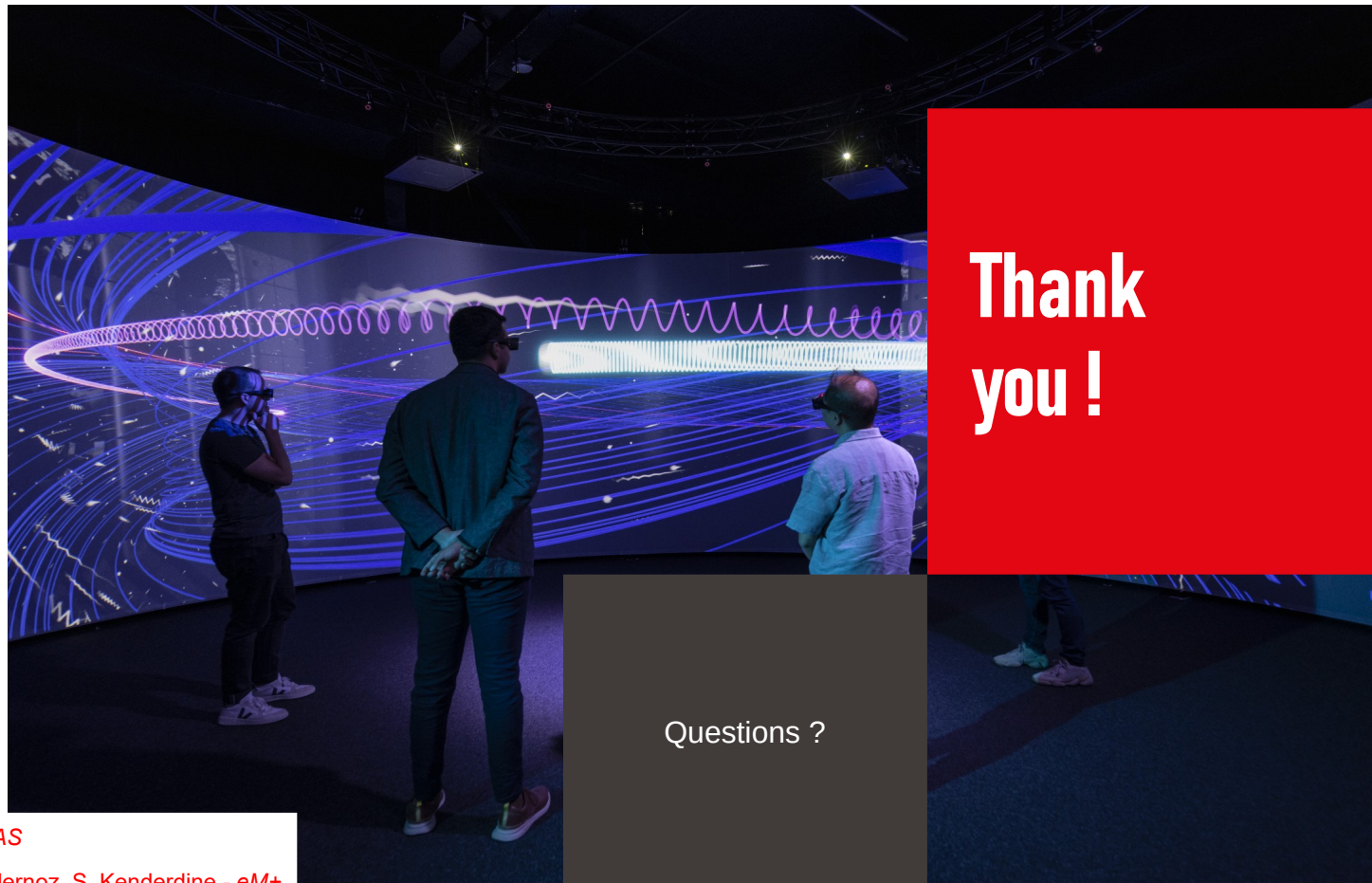
Thank you !

Questions ?

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