

SCIENTIFIC IT AND APPLICATION SUPPORT



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### INTRODUCTION

- Build visualization solutions for Plasma Physics
- Science communication (both external and internal) and scientific visualization



### INTRODUCTION

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

Paraview modules

EPFL

# **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 realtime 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





Use Boris method for electromagnetic force integration

Phase-space particles initialization through importance sampling (separate or combined position/velocity possible) 0.75 0.50 -

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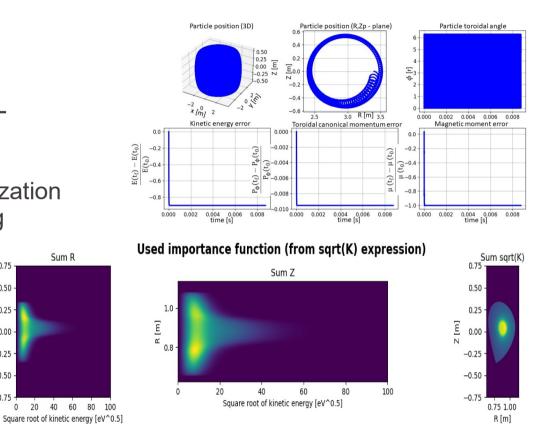
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Z [m]





 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

 $\rightarrow$  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

EPFL

# 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

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# FUTURE WORK



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

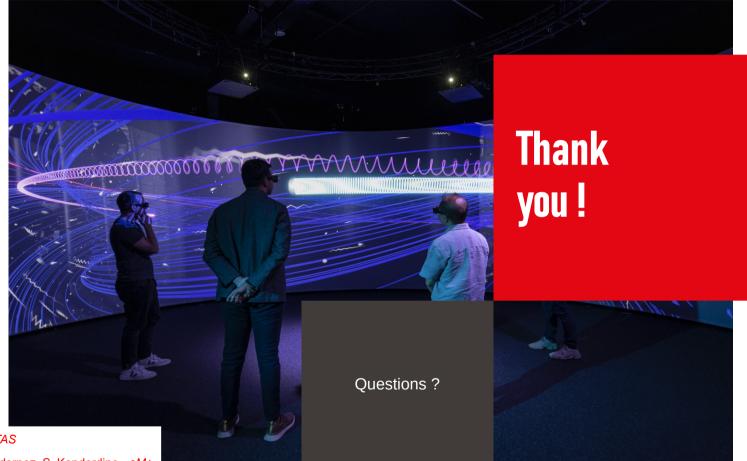


CONCLUSION

- 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



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