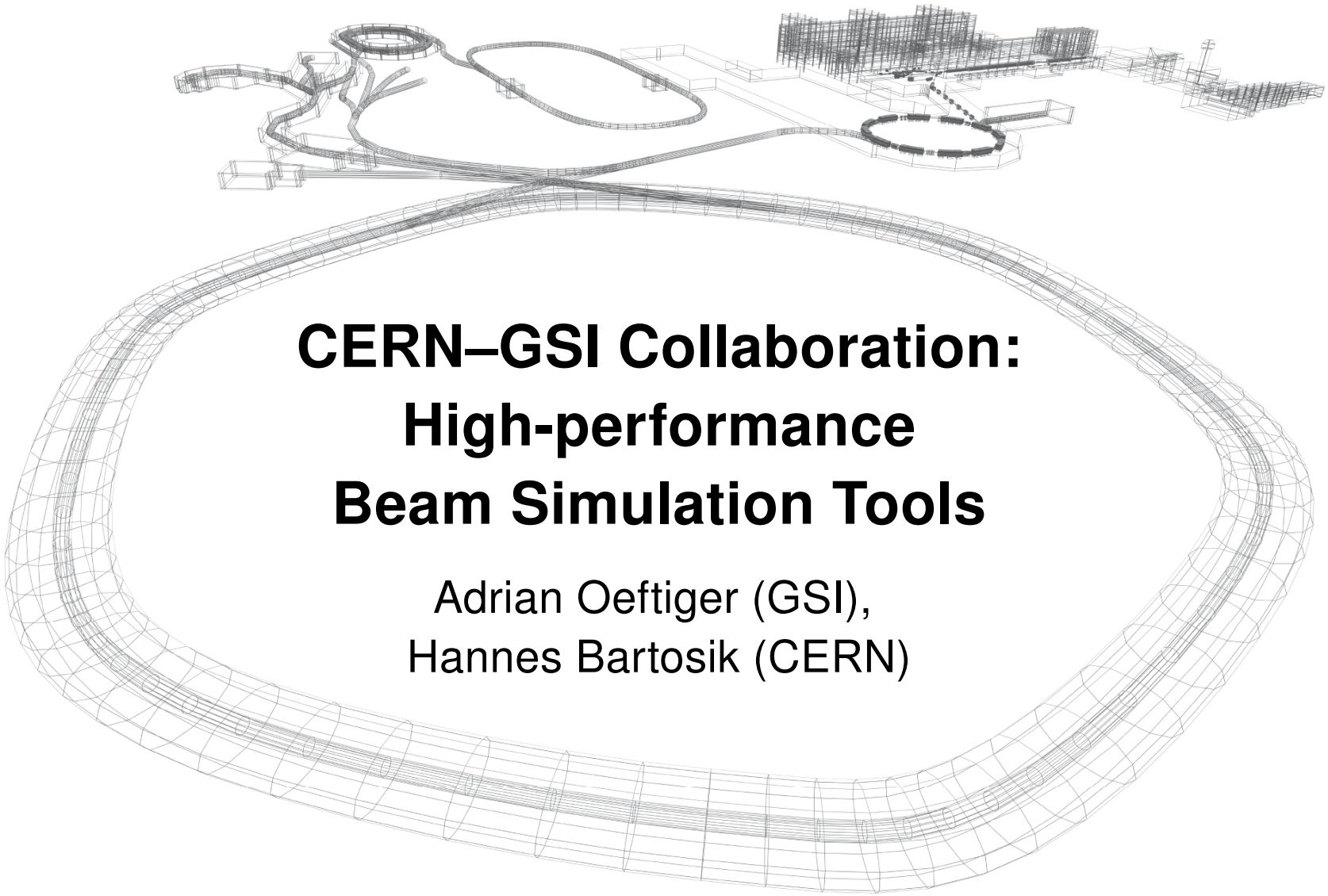


CERN–GSI Collaboration: High-performance Beam Simulation Tools

Adrian Oeftiger (GSI),
Hannes Bartosik (CERN)

Beam Simulation Tools

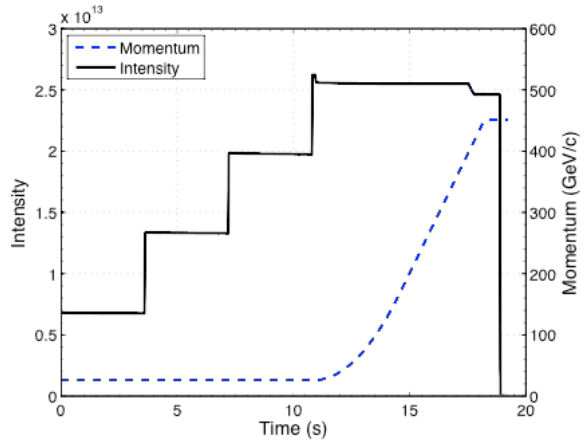
Context

CERN and GSI synchrotrons:

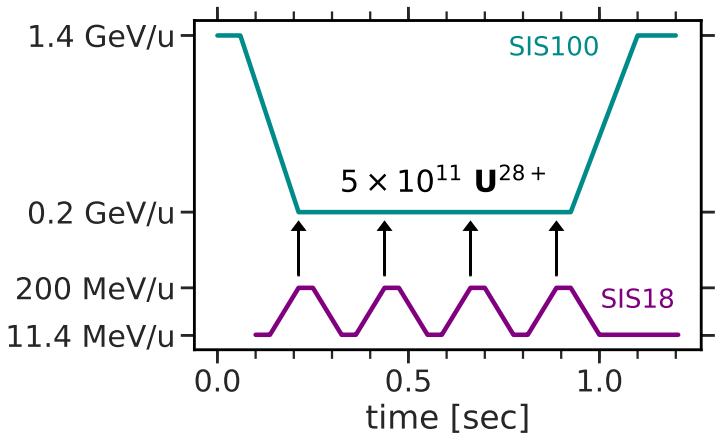
- long storage times during accumulation at injection energy

$\longrightarrow$ slow beam quality degradation due to resonances with space charge

$\Longrightarrow$ push for high-brightness / high-intensity beams requires detailed studies of beam dynamical mechanisms and mitigation approaches



(a) CERN SPS: 10.8 s injection plateau



(b) GSI SIS100: 1 s injection plateau

Beam Simulation Tools

Context

CERN and GSI synchrotrons:

- long storage times during accumulation at injection energy

$\longrightarrow$ slow beam quality degradation due to resonances with space charge

$\Longrightarrow$ push for high-brightness / high-intensity beams requires detailed studies of beam dynamical mechanisms and mitigation approaches

Goals of Collaboration

1. develop reliable simulation tools for long-term collective beam dynamics (space charge)
2. target high-performance architectures (GPU)
3. establish machine models enabling *fast and accurate* predictions for long-term emittance growth and beam losses

Joint Achievements

- 2019 – 2020: development / testing of SixTrackLib and PySixTrack
  - → complementary access to GPU hardware (AMD, NVIDIA)
  - → joint notebook talks on PyHEP ’19/’20 workshops

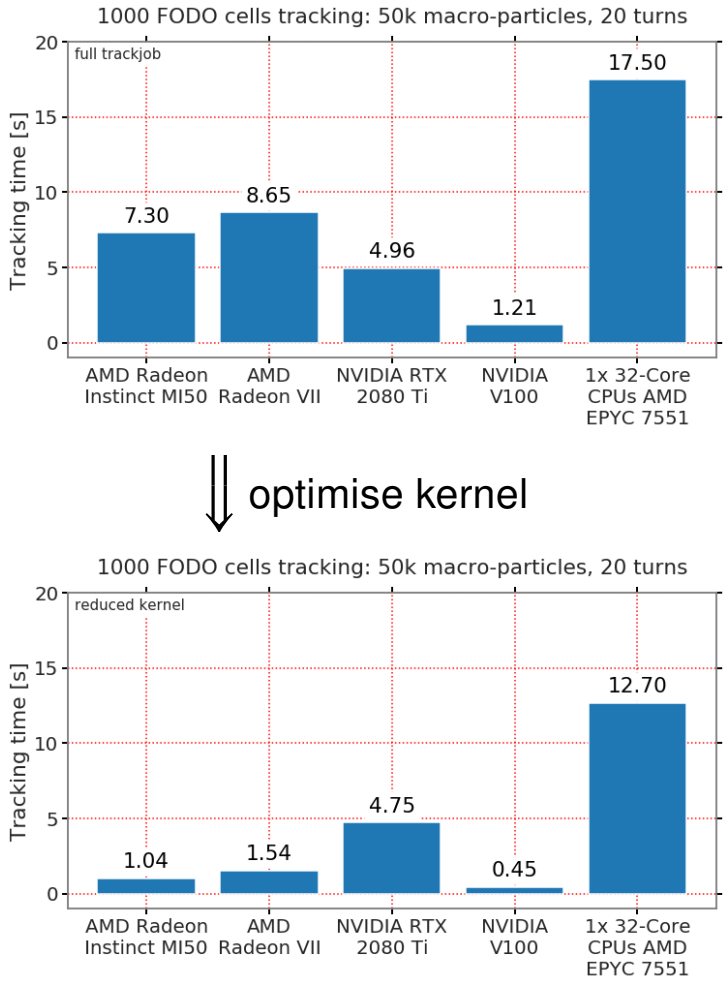


Figure: SixTrackLib improvement

Joint Achievements

- 2019 – 2020: development / testing of SixTrackLib and PySixTrack
  - ⟶ complementary access to GPU hardware (AMD, NVIDIA)
  - ⟶ joint notebook talks on PyHEP ’19/’20 workshops
- 2019: SixTrackLib + PyHEADTAIL
  - ⟶ united 2 GPU-enabled codes
  - ⟶ full non-linear tracking, detailed space charge models (frozen, self-consistent PIC in 2.5D/3D)
  - ⟹ speed-up of $\approx 10x$ to $\approx 100x$ compared to previous tools
- 2020: resonance dynamics for SIS100

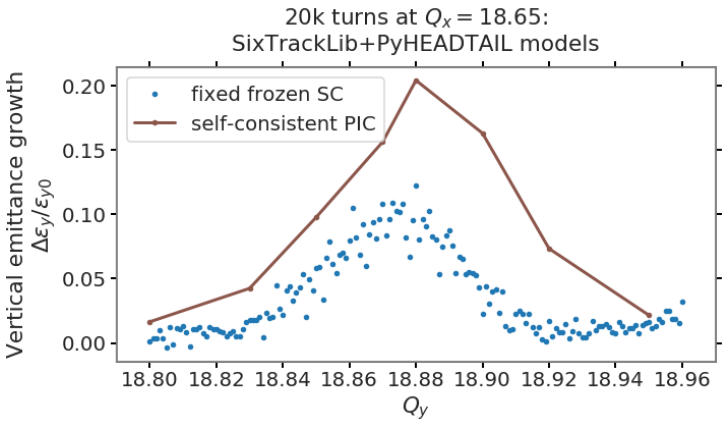


Figure: PIC vs. frozen SC (GSI)

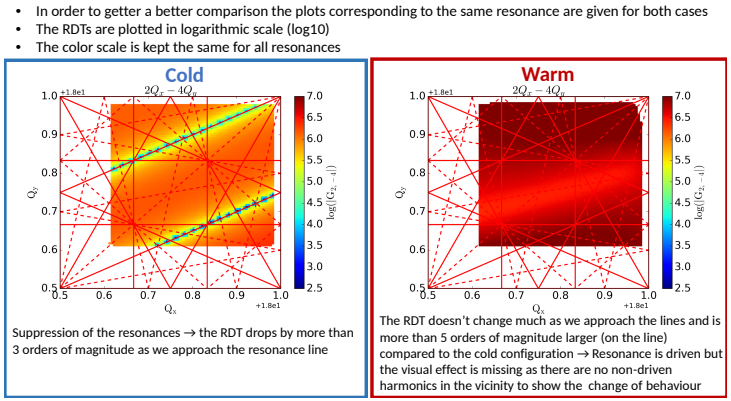


Figure: semi-analytic resonance driving term computation (CERN)

The Future

Plans

- establish detailed PIC model of SPS
- include advanced indirect space charge models in simulation suite
- joint measurement campaign of long-term space charge effects

$\Longrightarrow$ depends on boundary conditions (resources, public health situation)

Collaborators

Code development:

- *CERN ABP-HSS*: Riccardo de Maria, Martin Schwinzerl (Uni Graz)
- *CERN ABP-HSI*: Hannes Bartosik
- *GSI AP*: Adrian Oeftiger

Beam dynamics studies:

- *CERN ABP-HSI*: Hannes Bartosik, Foteini Asvesta
- *GSI AP*: Adrian Oeftiger, Dmitrii Rabusov (TU Darmstadt)