# Status of SixTrack with collimation

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on behalf of the collimation team

# Outline

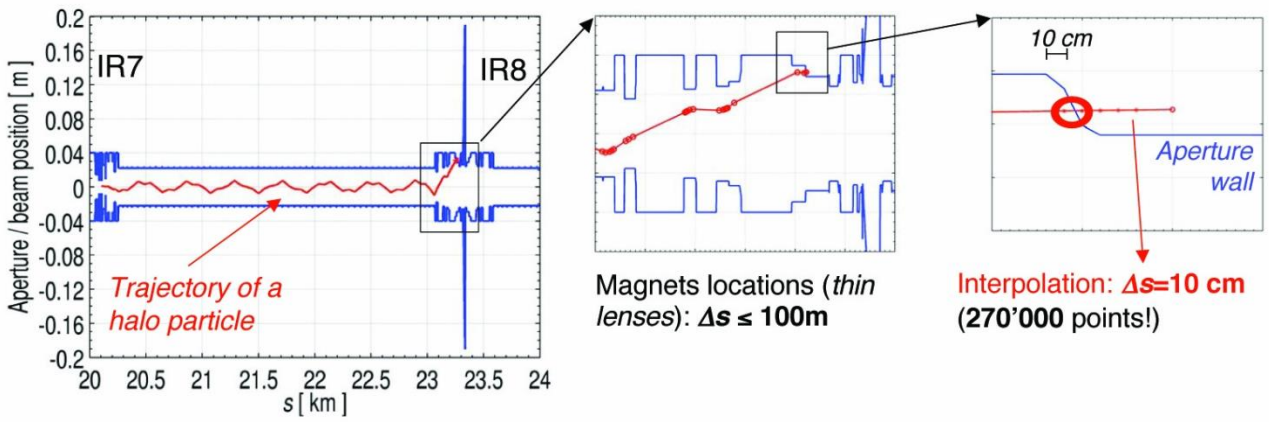
- Overview of SixTrack
- Recent developments
- Future plans

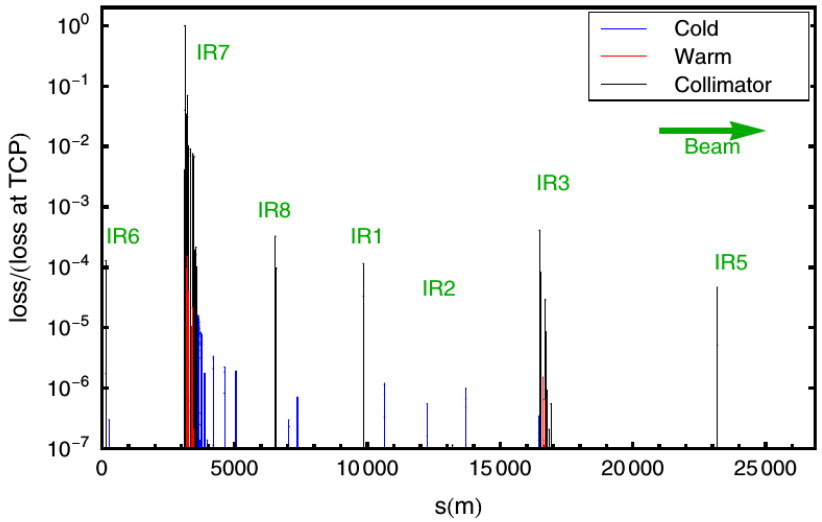
# SixTrack introduction

- SixTrack: 6D thin-lens symplectic element-by-element tracking developed by F. Schmidt for long term tracking in high energy rings.
  - Includes imperfections and field errors, linear and non-linear fields, beam-beam kicks, fully chromatic and coupled tracking
- Used initially for dynamic aperture studies.
- SixTrack extended for collimation studies (thesis G. Robert-Demolaize 2003)
  - used to design the present LHC collimation system. Excellent performance in the machine so far during Run I and Run II

# Basic functionalities

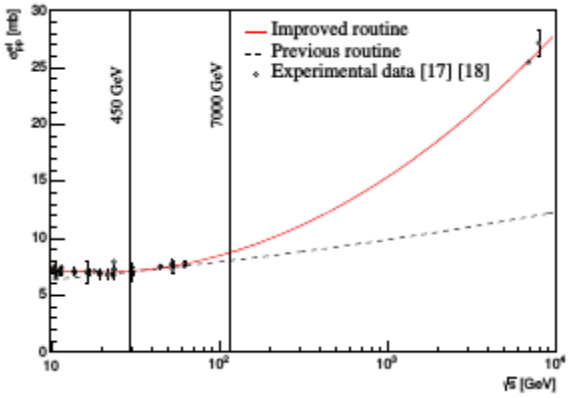
- Tracking of an initial beam halo with amplitudes large enough to hit collimators
  - Diffusion by default not included
- Magnetic tracking overridden by dedicated Monte Carlo in collimators
  - Including K2 scattering routine (Jeanneret and Trenkler) in collimators
  - With collimator imperfections
- Aperture check with 10 cm precision
- Output: losses around the ring



# Recent additions and improvements

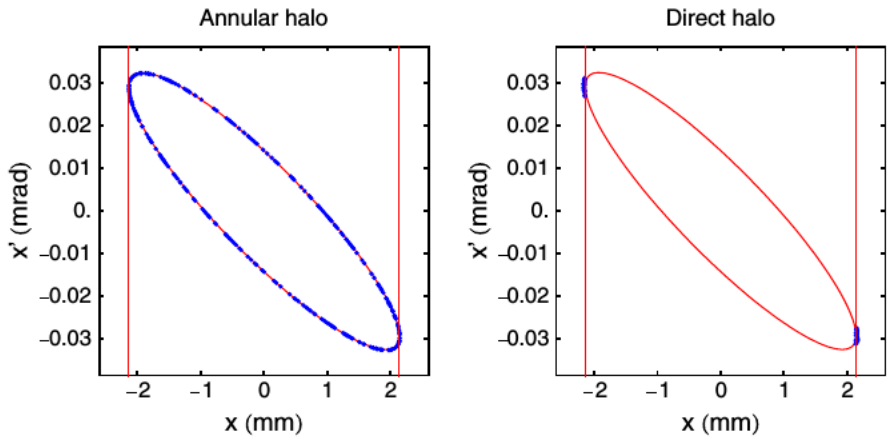
- Several recent improvements to the original version
  - Not all the ones listed are included in the standard release yet
- Improved scattering routine *(C. Tambasco, B. Salvachua et al.)*
  - Updated cross sections for single diffractive, elastic pp, ….




- Online aperture check *(P. Hermes, A. Mereghetti, J. Ortega et al.)*
  - Previously, aperture checks performed using post-processing on dumped tracks.
  - Online checks provides improvements in speed and required disk space
  - Synergy with FLUKA coupling
- HDF5 binary tracks *(R. Kwee, Y. Levinsen)*

# Recent additions and improvements

- Improved halo modeling for speed and parametric studies
  - "Direct" halo with particles sampled at the face of the collimator




*PRSTAB 17, 081004 (2014)*

- Improved outputs
  - New dedicated files to e.g. track the full history of collimator impacts and interaction types
- DYNK module *(K. Sjobak, A. Santamaria et al.)*
  - Dynamically changing properties of accelerator elements such as magnetic fields, RF parameters … See talk by Kyrre
- Asynchronous beam dump *(R. Bruce, E. Quaranta et al.)*
  - Using DYNK and measured waveform to dynamically change kickers

# Recent additions and improvements

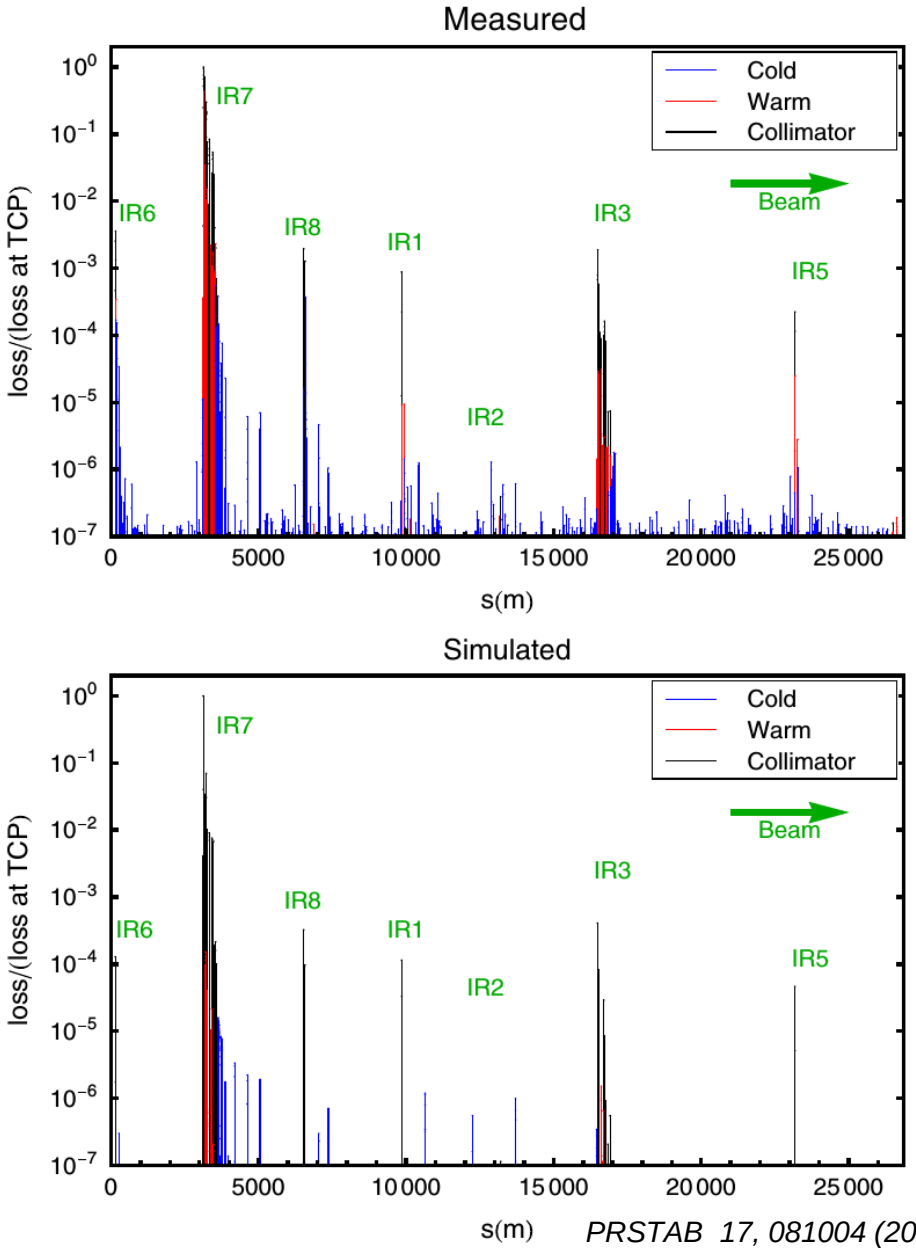
- Coupling to FLUKA *(FLUKA team, collimation team)*
  - Take advantage of the FLUKA scattering models online.
  - See later talk
- Tracking for heavy ions *(P. Hermes)*
  - Needed update of SixTrack core routines for magnetic tracking to treat heavy ions with various masses and charges
  - SixTrack built-in scattering cannot handle heavy ions – need e.g. FLUKA
  - See later talk

# Recent additions and improvements

- New materials *(E. Quaranta)*
  - Updated material database to include new materials considered for upgrades.
  - See later talk
- Crystal routines *(D. Mirarchi)*
  - Improved crystal physics. See later talk
- Hollow electron lens *(V. Previtali)*
  - Included new element for electron lens

# SixTrack results

- Present status: many updates have improved the original version
- Recent comparison of updated SixTrack (integrated scattering) to Run I LHC measurements (PRSTAB 17, 081004 2014)
- Qualitatively good agreement of loss pattern

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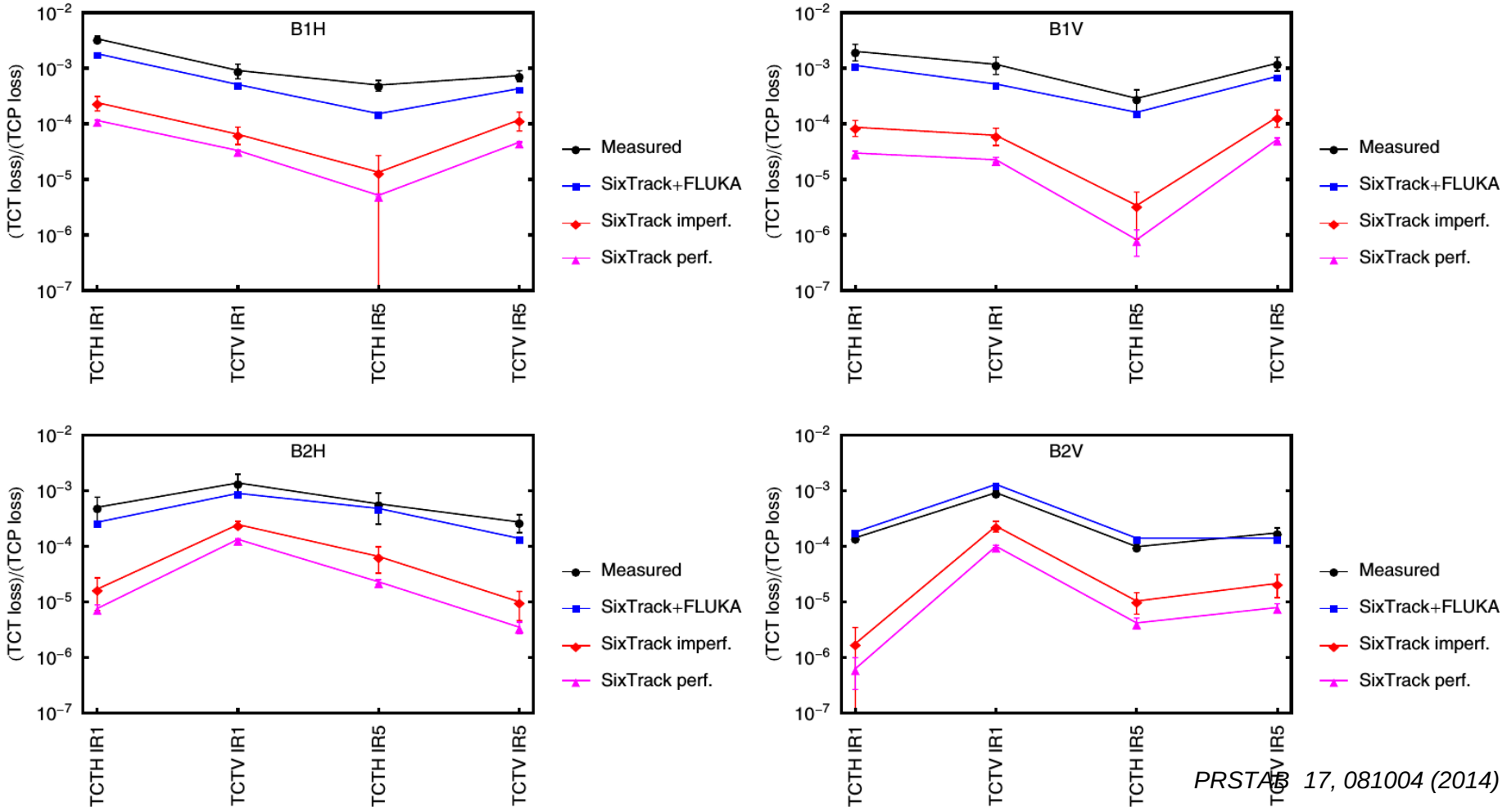
# Comparison of TCT losses

- For quantitative comparison, need to include shower
  - Second simulation step with FLUKA (E Skordis et al.). Agreement within factor ~3. More recent benchmarks in talk E. Skordis

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# Future plans

- Present SixTrack does a good job in predicting loss patterns. Improvements still possible!
- BOINC / LHC at home *(A. Mereghetti et al.)*
  - Access to thousands of CPUs from volunteers can considerably speed up simulation times
  - Only small files can be transferred to and from clients. Needs online aperture check in release version
- Better halo modeling *(H. Garcia et al.)*
  - Want to have a general model that can be used to generate halo for any cleaning loss, including also off-momentum
  - See later talk

# Future improvements

- General usability improvement and cleanup
  - Would be useful to clean up code structure, collimation block in fort.3, output files …
  - Lower priority. No dedicated resources

- Core SixTrack *(R. de Maria et al.)*
  - Crab cavities, etc…
  - Profit from improvements and additions in main realease. Now on Github

# Summary

- SixTrack with collimation used to design the present LHC collimation system
- Output agrees well with observed loss patterns at the LHC
- Actively developed and maintained
  - Several improvements and additions in the last few years
  - Further development in the pipeline