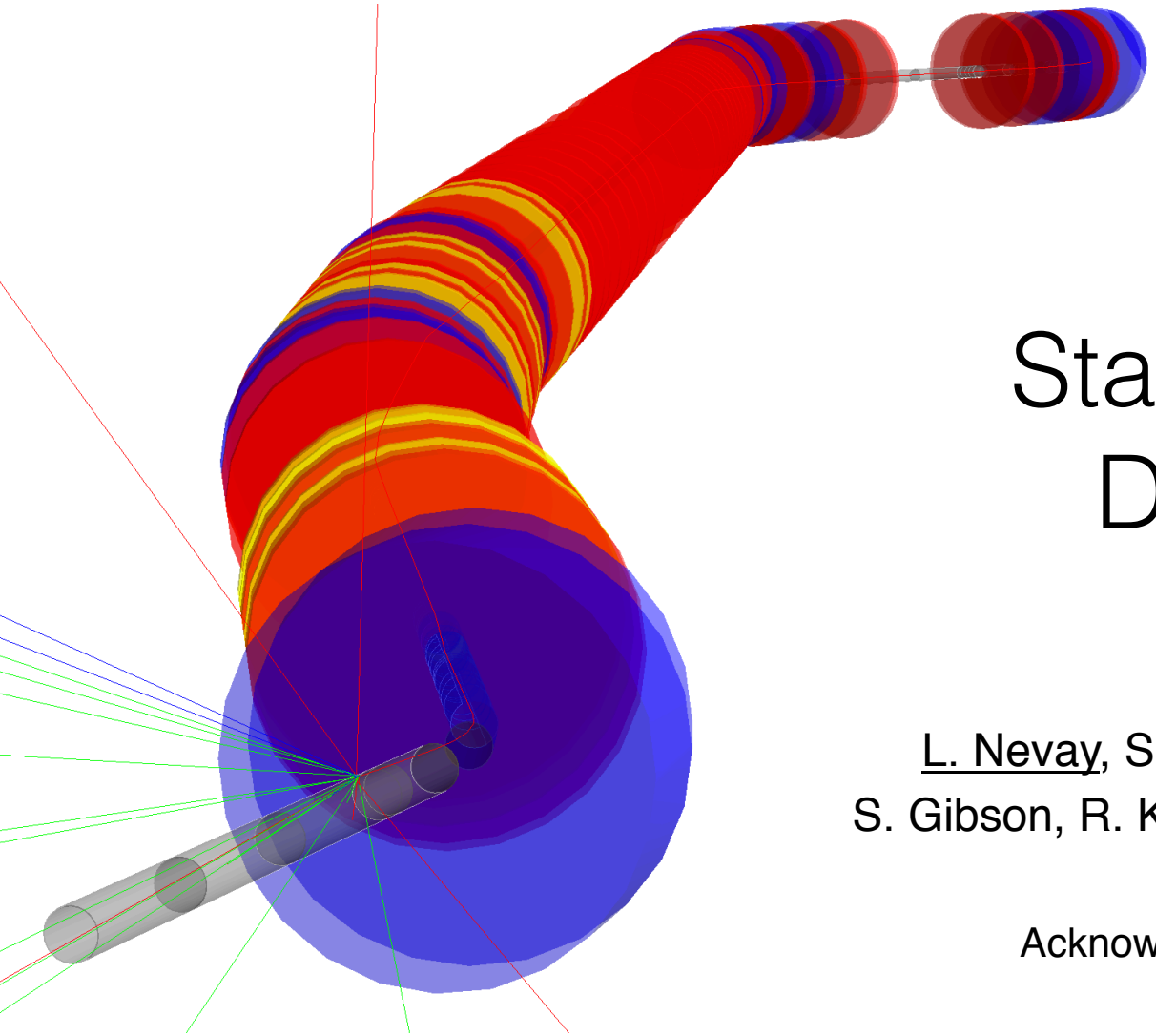


Status of BDSIM Developments at RHUL

L. Nevay, S. Boogert, H. Garcia-Morales, S. Gibson, R. Kwee-Hinzmann, J. Snuverink

Acknowledgments: R. Bruce, S. Redaelli

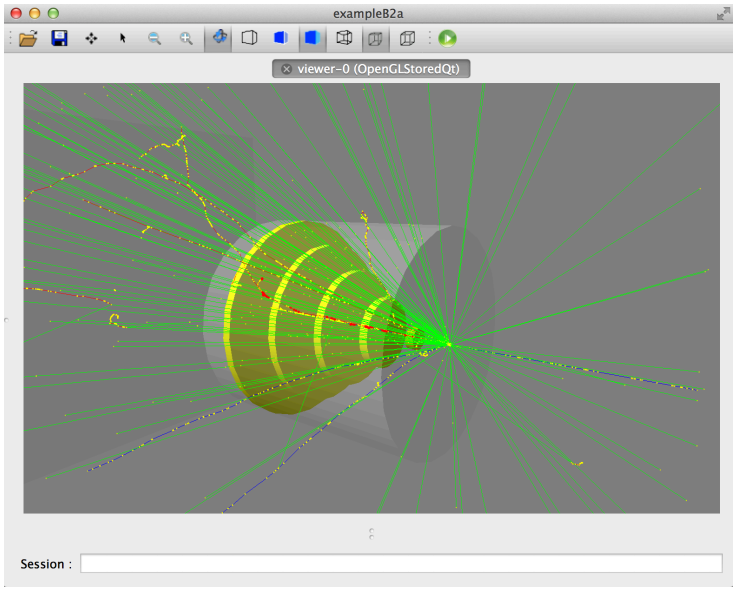
http://twiki.ph.rhul.ac.uk/twiki/bin/view/PP/JAI/BdSim

20th November 2014

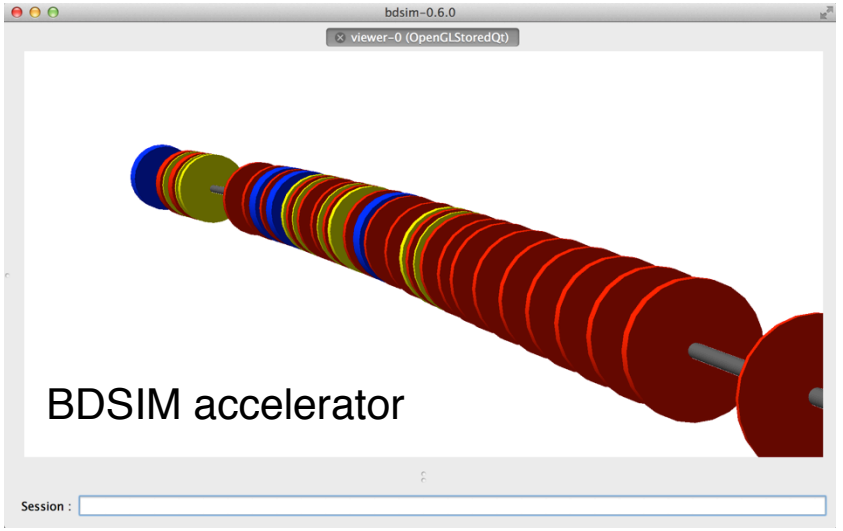
Beam Delivery Simulation - BDSIM

- Tracking code that uses Geant4
- Used to simulated beam loss and detector backgrounds
- Particles tracked through vacuum in normal way
  - thick lens tracking

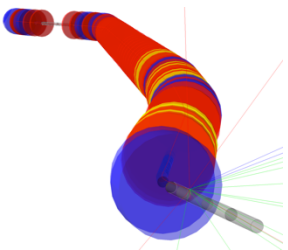
- Geant4 used for interaction with machine
- Full showers of secondaries created by Geant4 processes
- Secondaries tracked throughout the accelerator



Geant4 example detector

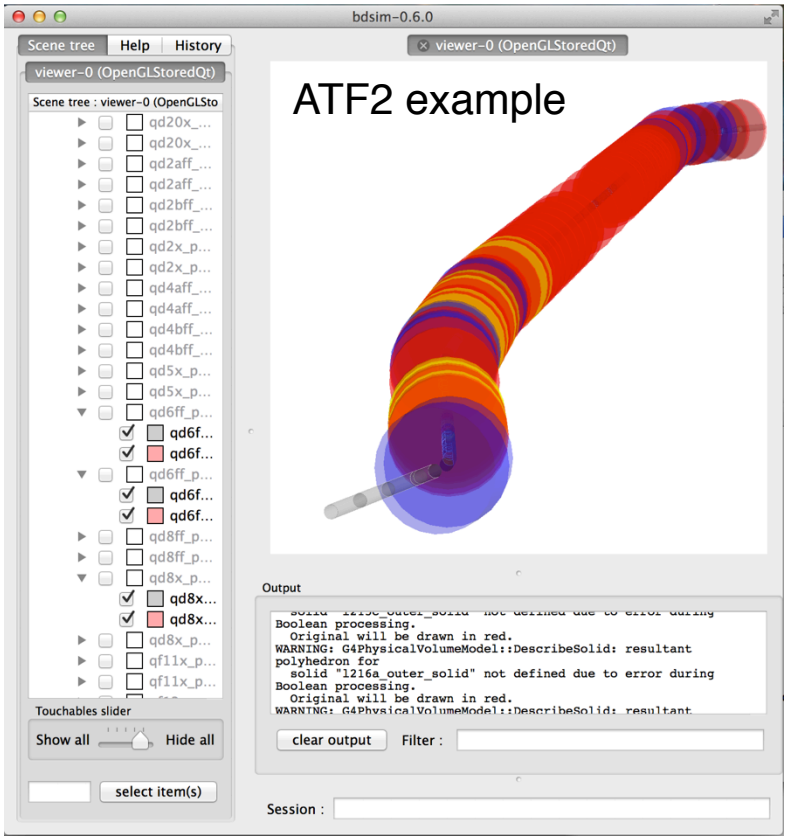


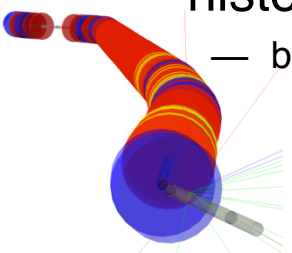
BDSIM accelerator



A BDSIM Accelerator Model

- Beamline built from ASCII input
- Geant4 model of accelerator automatically created
- Generic geometry created by default
  - typically cylinders of iron
  - more specific geometry can be specified or imported
- Normal Geant4 Runge-Kutta steppers are replaced
  - vacuum steppers replaced by maps for specific magnet types
  - much faster and more accurate for known fields – ie quadrupolar
- Hits on accelerator recorded
- Integrated analysis for energy loss histograms
  - both ASCII and ROOT output supported



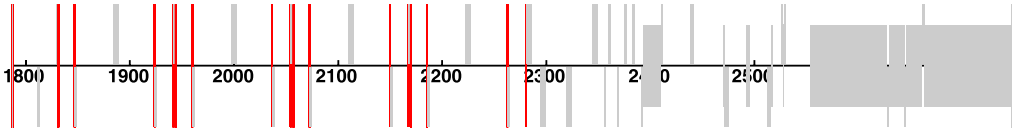


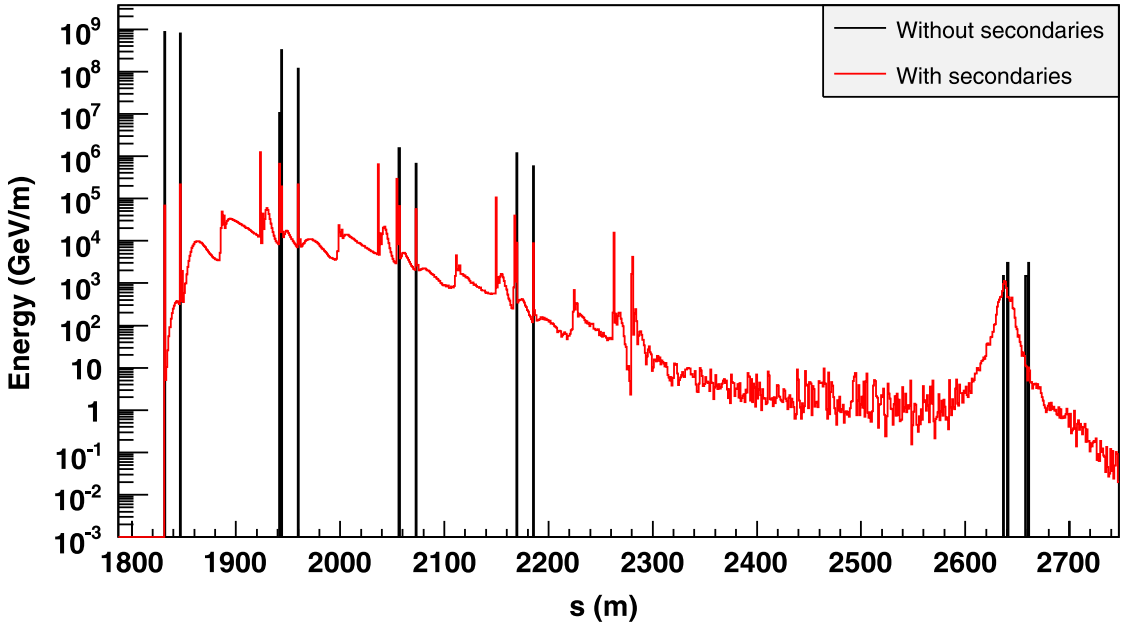
In the Past…

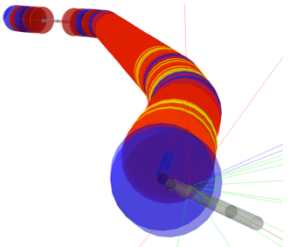
- BDSIM was originally started by G. Blair at Royal Holloway
- Created to simulated the final focus of future linear colliders
- Used to simulated beam loss and backgrounds for:
  - International Linear Collider (ILC)
  - Compact Linear Collider (CLIC)

- Also for laserwires
  - Signal to noise
  - Accuracy
  - Detector placement

CLIC beam delivery system



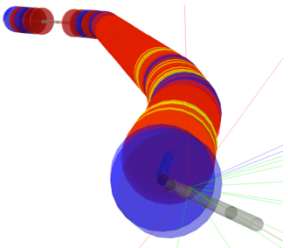




Phys. Rev. ST Accel. Beams 12, 081001 (2009)

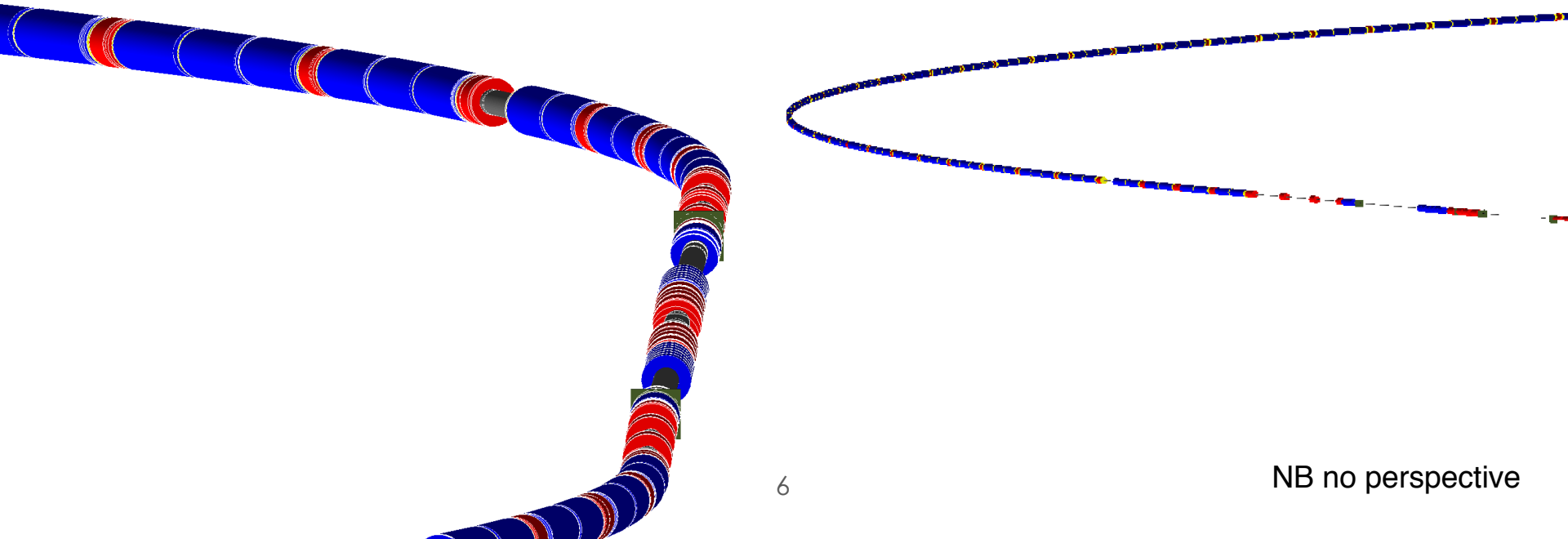
Recent Developments

- Previously used for linear accelerators
  - ie single pass
- Currently being developed to simulate the LHC & HL-LHC
- Various extra features for rings
  - control the number of turns in the machine
  - much improved efficiency
  - new input distributions
  - curvilinear output coordinates
- New input preparation and output analysis tools
  - python packages as well as sample root scripts
- Significant code refactorisation and modernisation
- Cmake build system for easier deployment
- Move to GIT repository for software versioning
- Open source GPLv3 licence



BDSIM LHC Model

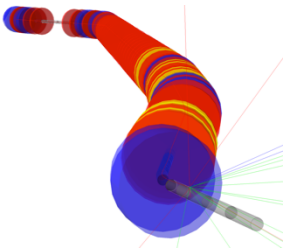
- Created model of existing LHC for comparison
  - before using for HL-LHC simulations
- 3.5TeV 2011 & 4TeV 2012 physics run lattices
- pybdsim – python tools used to prepare inputs
  - supplied with BDSIM
  - allows easy conversion of inputs
  - can easily aggregate input information from various sources



NB no perspective

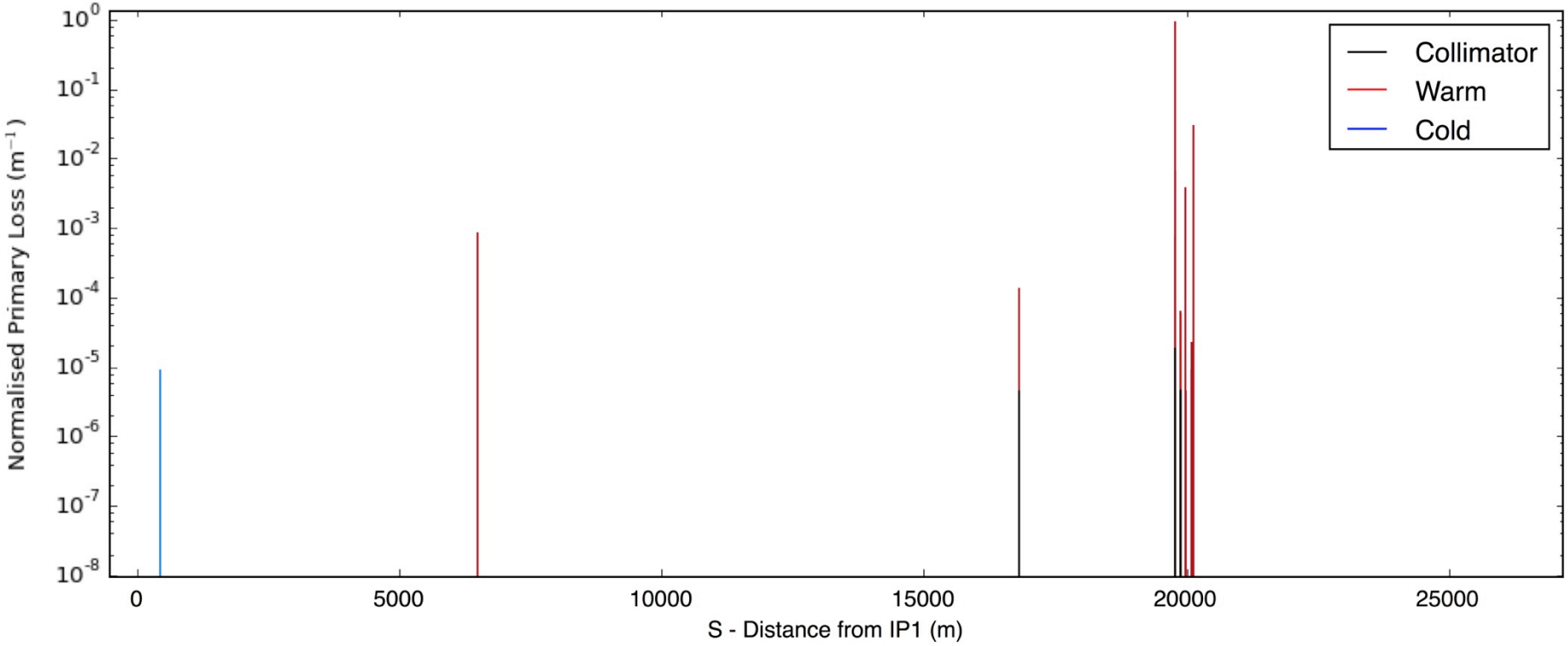
LHC Simulation Details

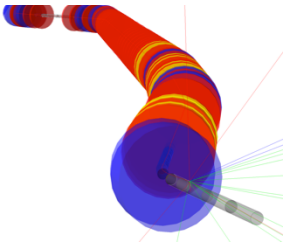
- 3.5TeV 2011 B1 lattice presented here
  - Both SixTrack loss maps as well as processed BLM data available for this lattice
- Model created from MadX twiss & aperture output
- Collimator DB + collgaps files for collimator materials and apertures
- Generic geometry used for now – iron cylinder magnets
- Run twice with different input distributions
  - vertical halo - ellipse at *n* σ in *y,y'* phase space, Gaussian in *x,x'*
  - horizontal halo - ellipse at *n* σ in *x,x'* phase space, Gaussian in *y,y'*
- Embarrassingly parallelised
  - *n* jobs each with different random number generator seed
  - simulates *m* particles
- Typically 100k primary particles in 1k jobs
- ~ 1 day on 150 node farm
  - duration depends on tracking cuts



3.5 TeV B1 Primary Loss Map

- Record position of first scattering of primary
- **Preliminary!** This is actually a recent feature of BDSIM



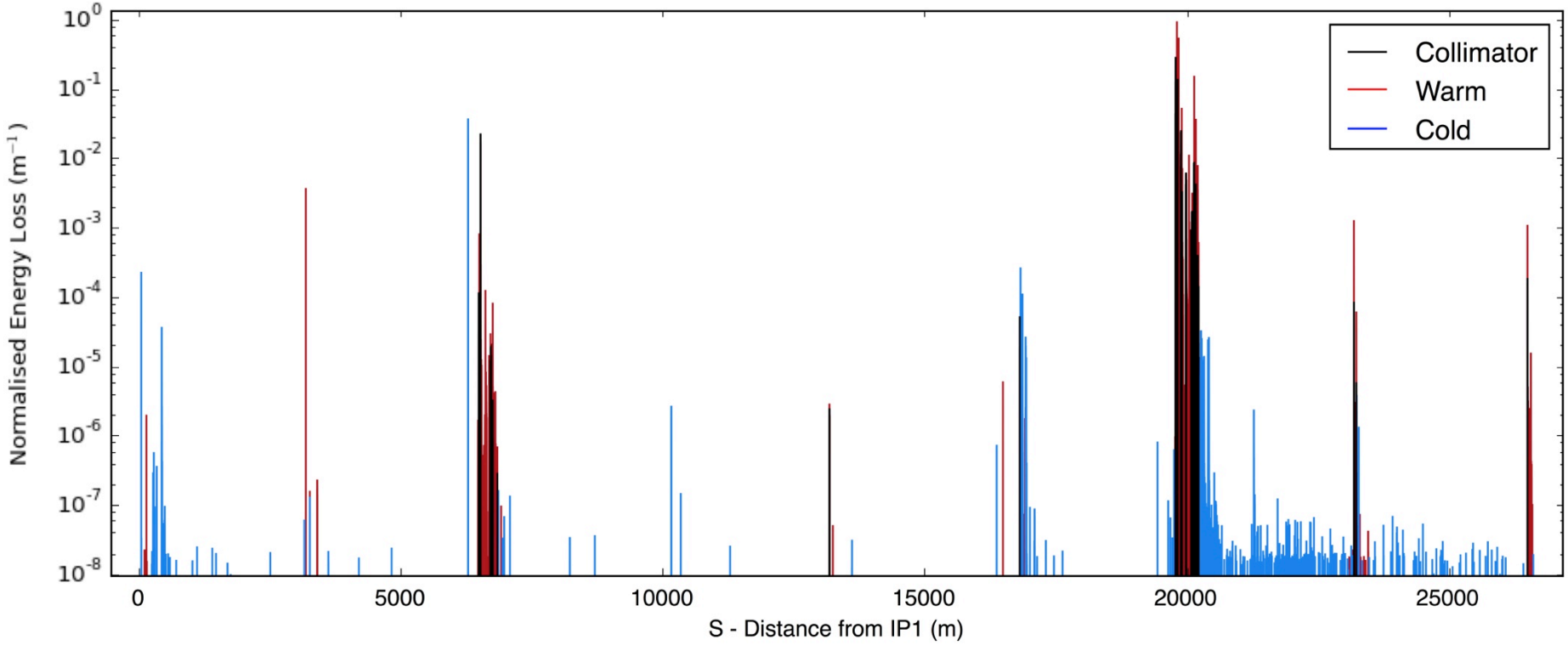


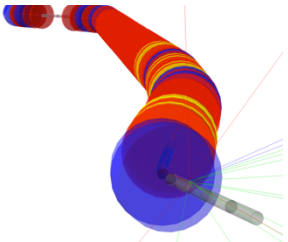
334400 primaries simulated

215984 primary hits

Energy Deposition Map

- BDSIM ➔ the full energy deposition from secondaries
- Here, normalised to maximum loss



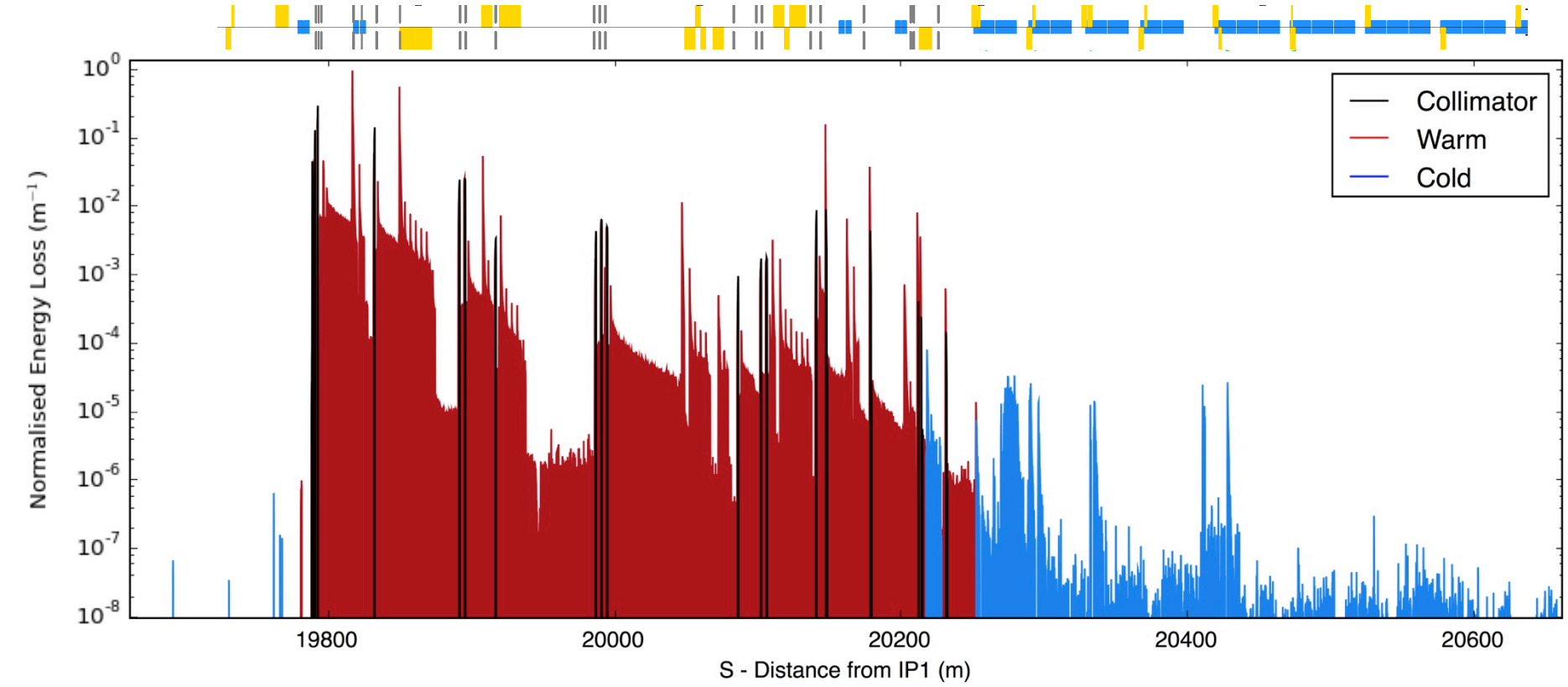


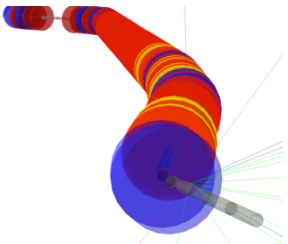
334400 primaries simulated
215984 primary hits

➔ 9.467 x 10^{9} energy loss ‘hits’

IR 7 Close Up

- IR7 dominates losses – most interesting region
- Continuous distribution of losses

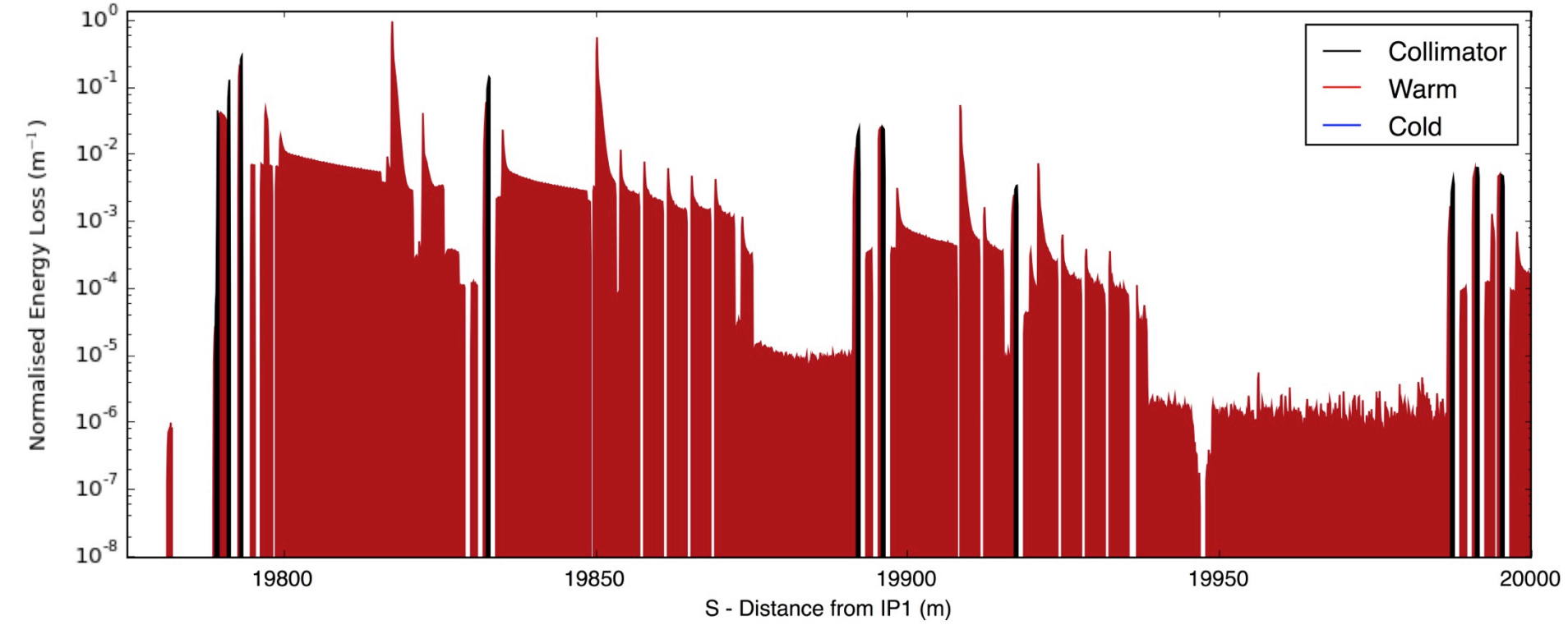


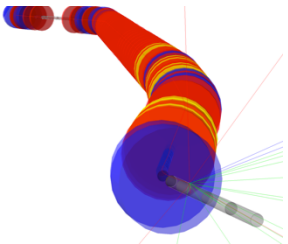


Beam line schematic from R. Bruce et al,
Phys. Rev. ST Accel. Beams 17, 081004 (2014)

IR 7 – A Closer Look

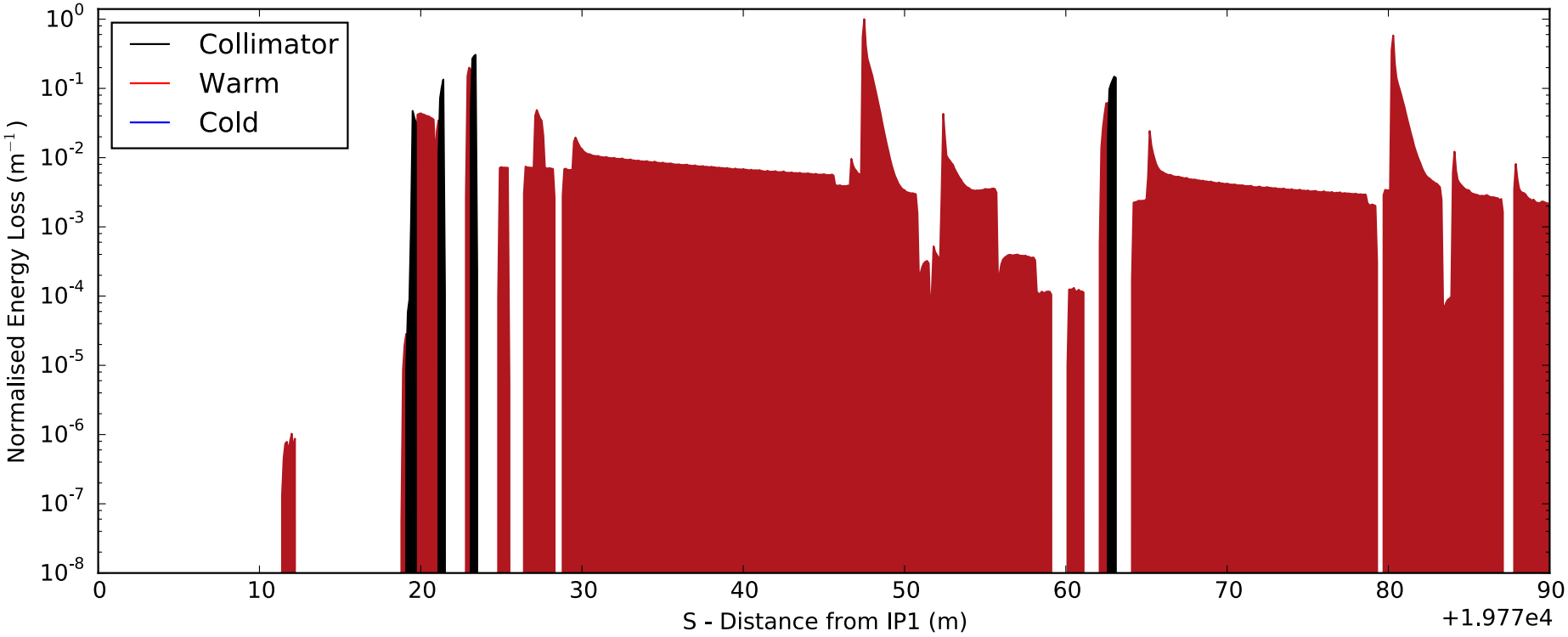
- Collimator shadows and optical effects evident

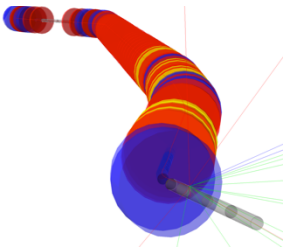




Backward Scattering

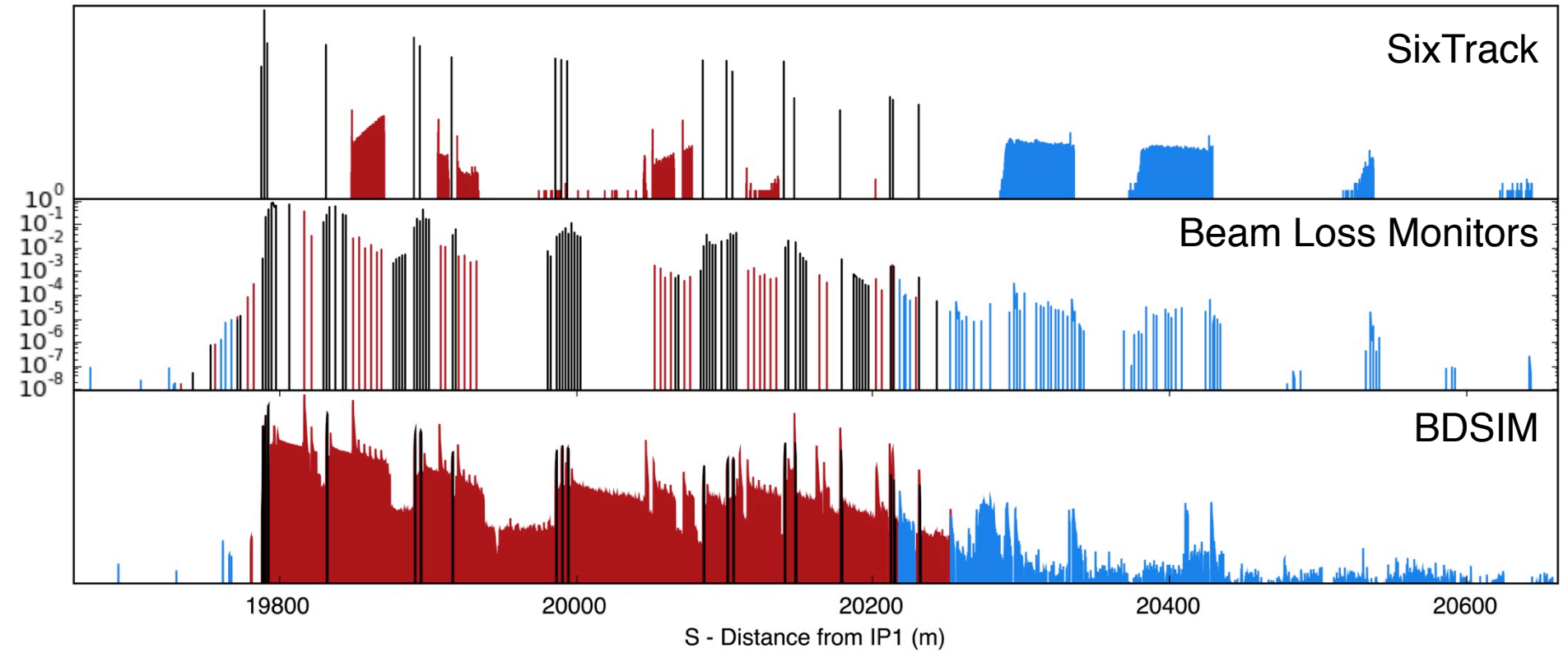
- BDSIM propagates secondaries backwards as well
- Strong rise in warm losses just before each collimator

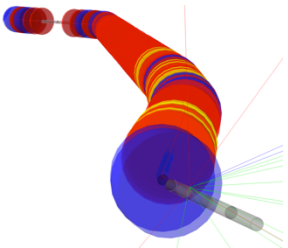




Comparison with BLM Data

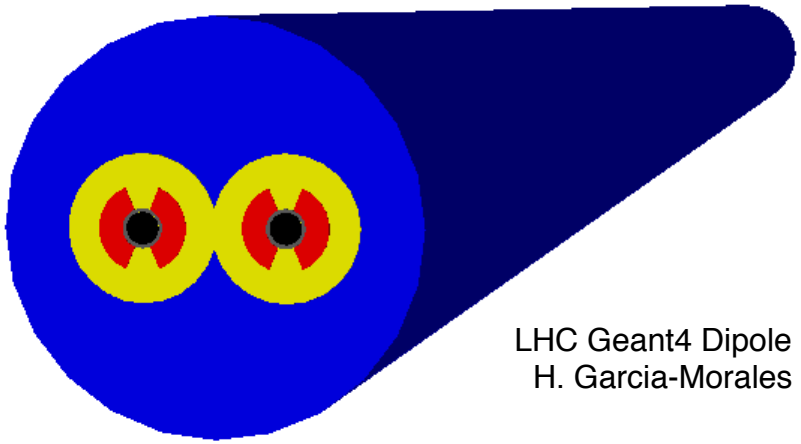
- Data from R. Bruce et al, Phys. Rev. ST Accel. Beams 17, 081004 (2014)



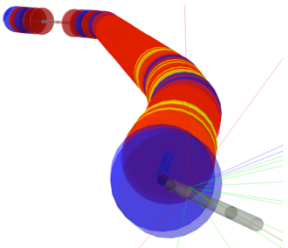


Looking Towards the Future…

- Perform quantitative comparison for B2, 4 TeV lattice
- Preparation of Hi Lumi lattice and comparison
- Compare to BLM data in upcoming operations for new higher energy
- Introduction of more realistic geometry
  - very simplified Geant4 model of generic LHC dipole & quadrupole
- 1st order geometry approximation
- Example dipole
  - under development
  - broad features
  - asymmetric, other beam pipe
- More tailored aperture
- Improved collimator geometry
  - again simplified version

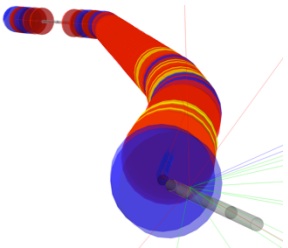


LHC Geant4 Dipole
H. Garcia-Morales



Future Technical Developments

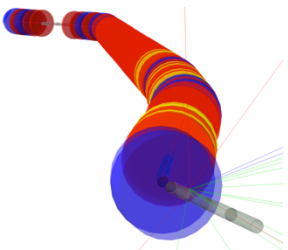
- Factorisation of tracking routines
  - for increased speed / simulation efficiency
  - too much time spent by Geant4 tracking management
  - can improve geometry hierarchy
  - also track only in C++ tracker until close to aperture
  - then pass to BDSIM Geant4 model
- Introduces ability to use other tracking codes
- Also introduces possibility of collective effects
  - Of particular interest for work on ILC
  - Existing interface with PLACET being actively developed
- Include HDF5 output format
- Introduce stronger geometry hierarchy for improved efficiency
- Factorise aperture classes to allow more flexible aperture definition
- Under active development at Royal Holloway and UCL
  - team of 5 people



Conclusion & Next Steps

- First Geant4 based loss maps generated using BDSIM
- Loss maps have full energy deposition from primaries and secondaries
- Quantitative comparison to existing simulations underway
- Access to full particle physics simulation of interactions
  - Full history of particles available

- Continue quantitative comparison with existing tools
- Validation of routines to extract primary impacts
- Tracking factorisation and extensions
- Improved efficiency
- Increased tracking accuracy



Thank you

http://twiki.ph.rhul.ac.uk/twiki/bin/view/PP/JAI/BdSim

Backup – Comparison Overlaid

- Green – Sixtrack
- Solid lines – BLMs
- Light area – BDSIM