EIC Software Consortium: Monte Carlo Initiative

EIC Software Consortium

ESC initiatives for MC simulations

ESC – EICUG

Markus Diefenthaler

EIC Software Consortium

ESC members

ANL, BNL, FNAL,

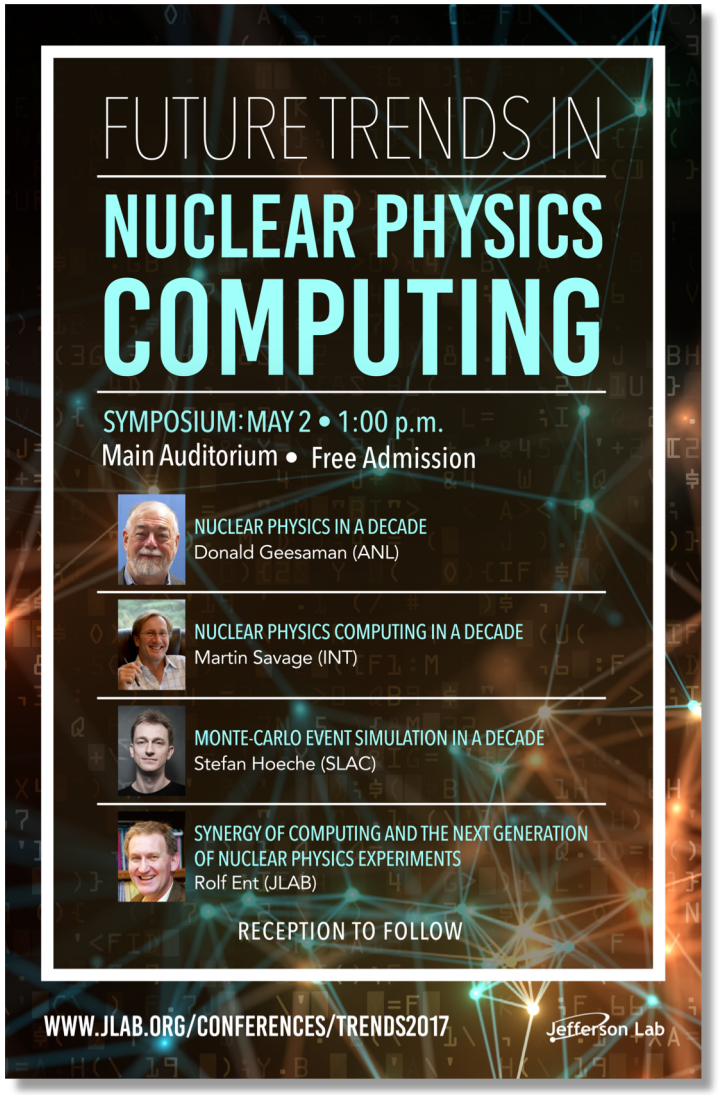
JLAB, SLAC, INFN

Trieste, W&M

ESC goals and focus (details)

- continue work on common interfaces (e.g., geometry, file formats, tracking)
- explore new avenues of software development (e.g., machine learning)
- **reach out to the EIC community**
  - communicate present status of EIC software
  - bring existing EIC software to the end users
  - produce publicly available consensus-based documents on critical subjects
  - provide vision for the future

Future Trends in Nuclear Physics Computing



Donald Geesaman (ANL, former NSAC Chair) "*It will be **joint progress of theory and experiment** that moves us forward, not in one side alone*"

Martin Savage (INT) *"The next decade will be looked back upon as a **truly astonishing period in NP** and in our understanding of fundamental aspects of nature. This will be **made possible by advances in scientific computing** and in how the NP community organizes and collaborates, and how DOE and NSF supports this, to take full advantage of these advances."*

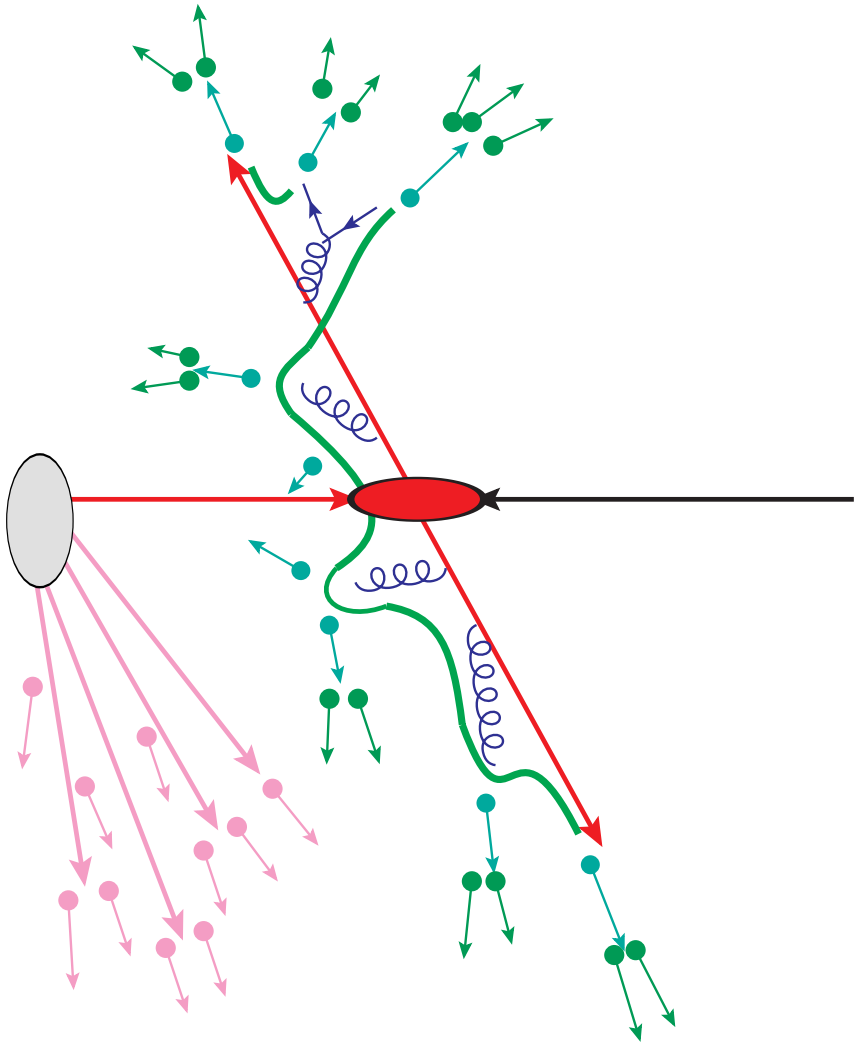
Monte Carlo Event Generator

MCEG

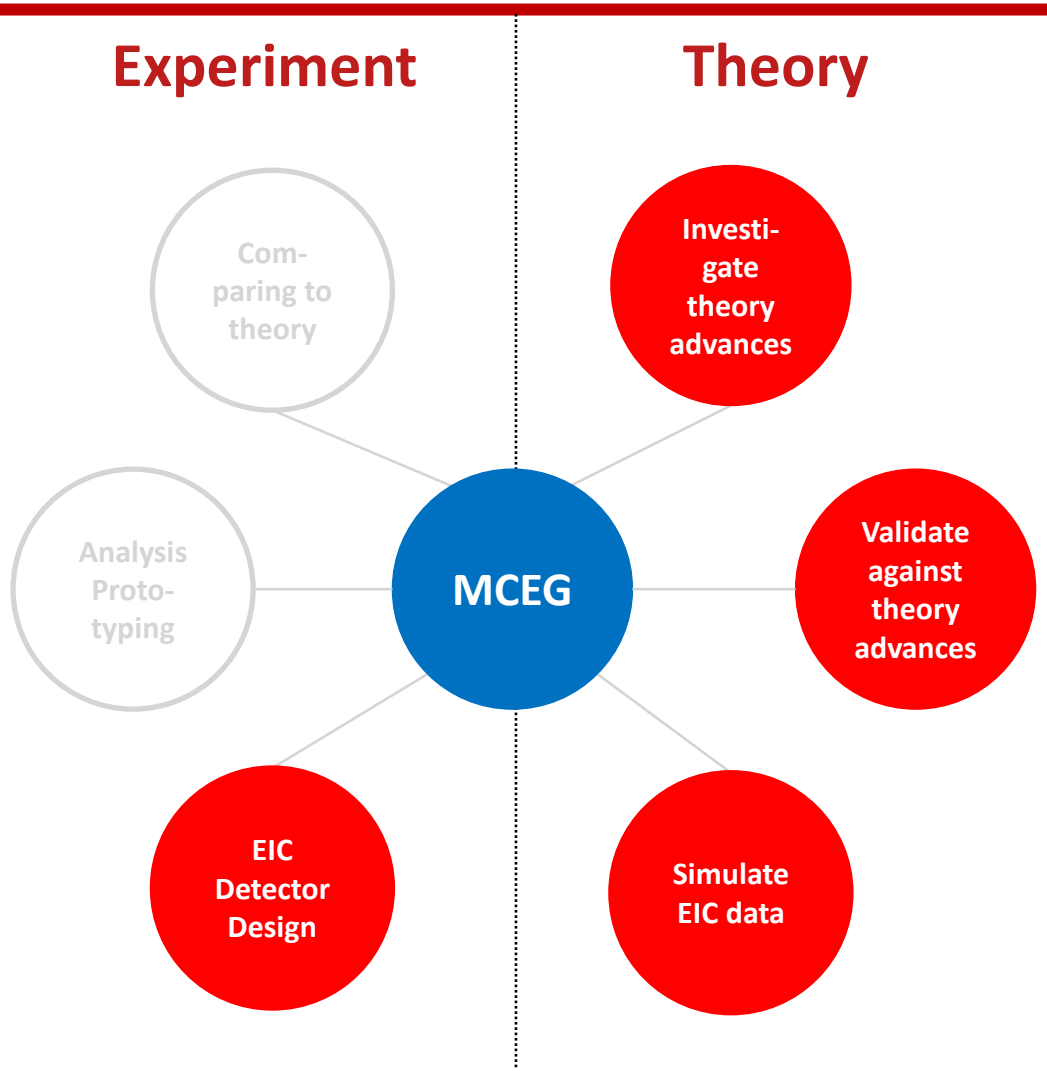
- faithful representation of QCD dynamics
- based on QCD factorization and evolution equations

Algorithm of general-purpose MCEG

1. Generate kinematics according to fixed-order matrix elements and a PDF.
2. QCD Evolution via parton shower model (resummation of soft gluons and parton-parton scatterings).
3. Hadronize all outgoing partons including the remnants according to a model.
4. Decay unstable hadrons.

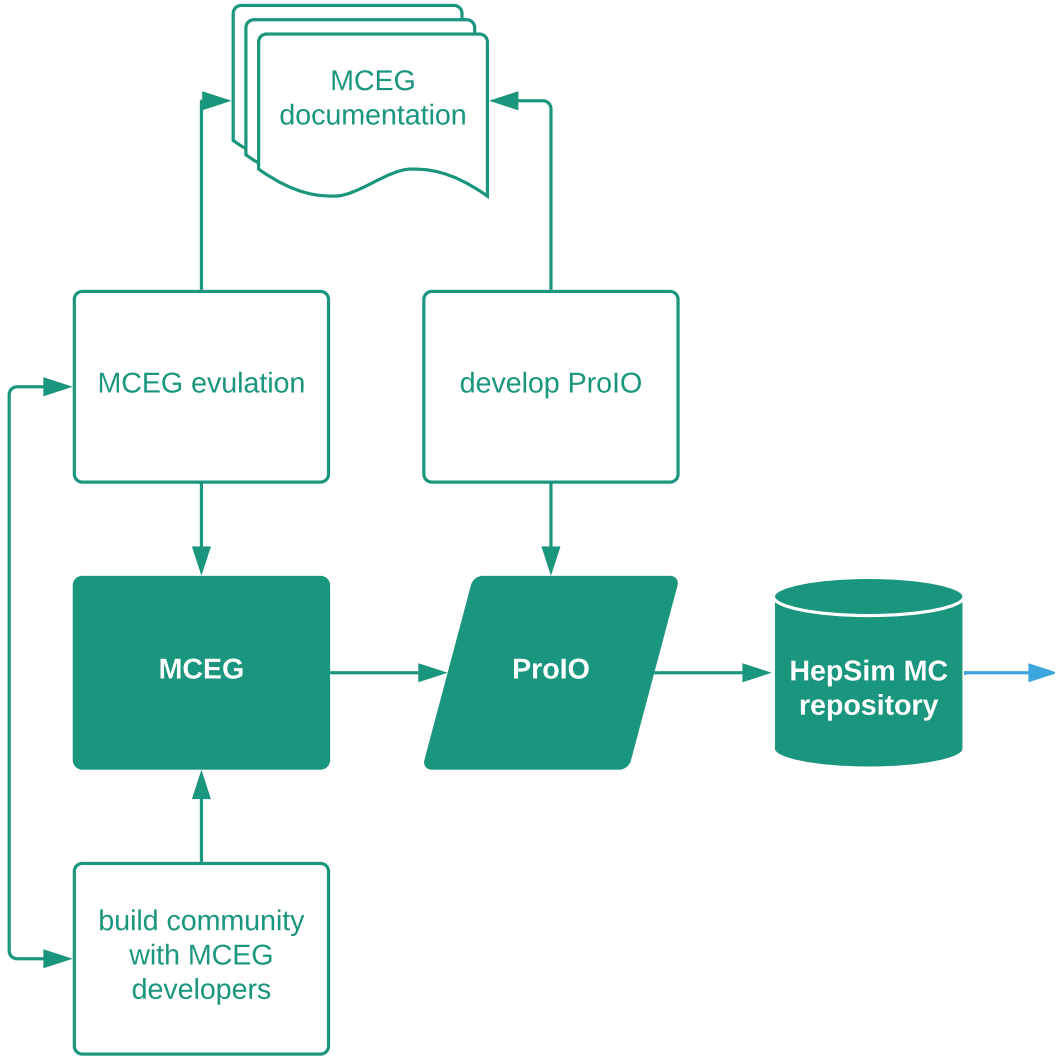


MCEG in Experiment and Theory

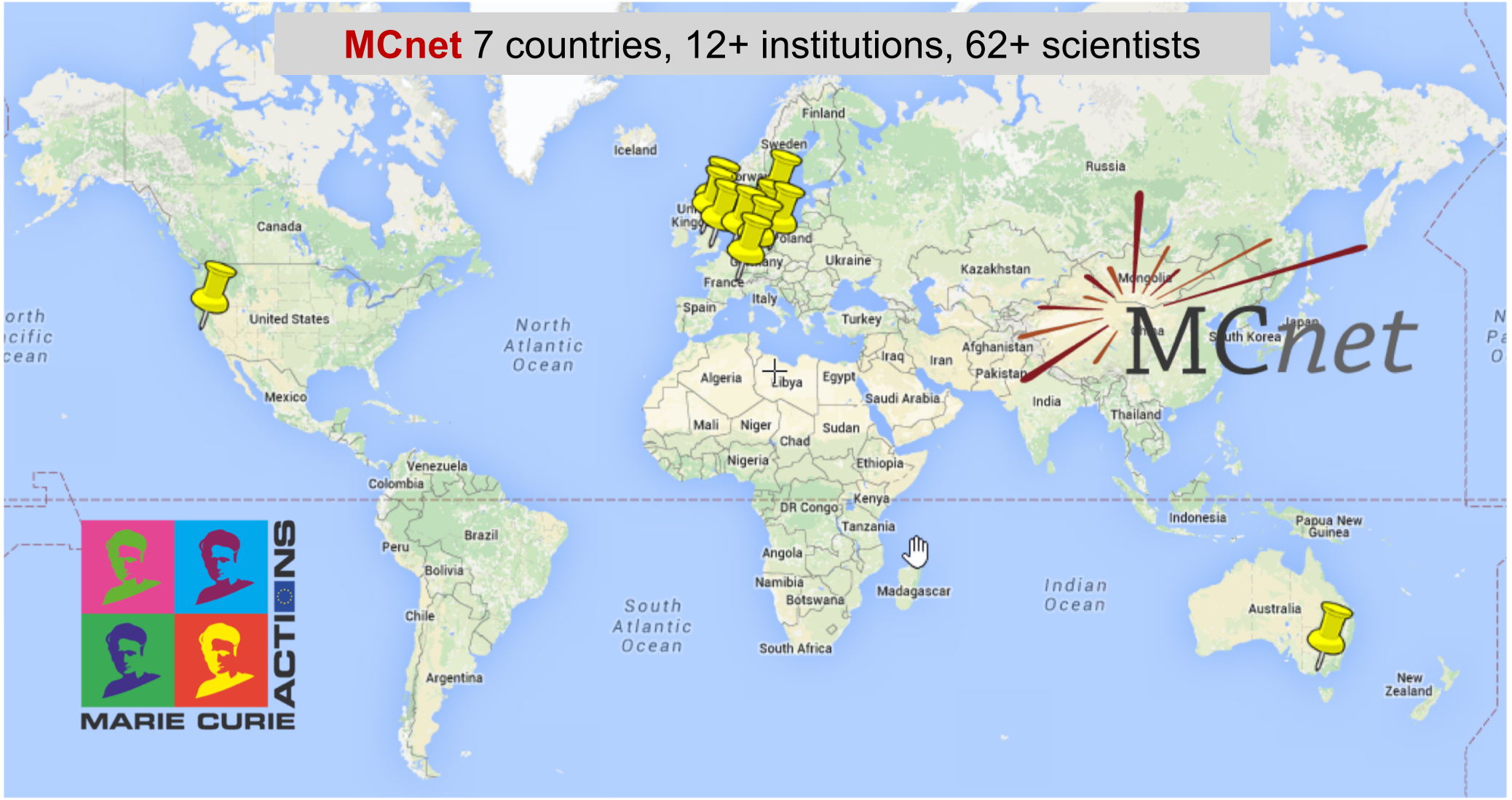


Lesson from HEP high-precision QCD measurements require high-precision MCEGs

ESC MC Initiative

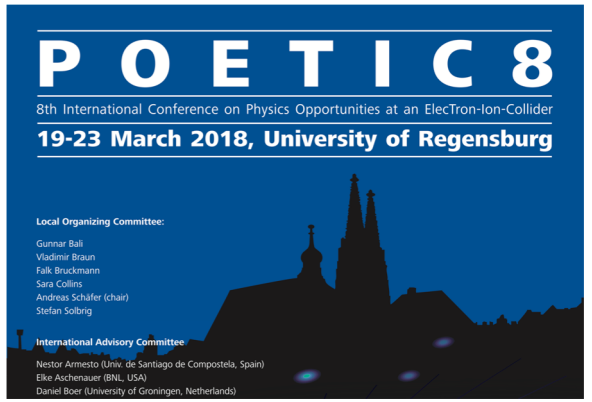


MCEG Developers



MCEGs for future ep and eA facilities

Satellite Workshop during POETIC 8, March 22-23 2018



Collaboration HEP - NP

Organizers

- **Elke-Caroline Aschenauer** (BNL; ESC)
- **Markus Diefenthaler** (Jlab; ESC)
- **Simon Plätzer** (University of Vienna; MCnet)
- **Stefan Prestel** (FNAL; ESC, MCnet)

MCnet

Goals

- MCEG requirements for upcoming ep and eA measurements
- Roadmap for MCEG developments for upcoming ep and eA measurements

MC Workshop – Introduction

UCL

Future *ep/eA* experiments

Matthew Wing (UCL / DESY)

- Introduction
- Current *ep* and *eA* results
- Possible future colliders
  - Electron–ion collider (EIC)
  - Large hadron–electron collider (LHeC) and future circular collider hadron–electron (FCC-he) collider
  - Very high energy electron–proton (VHEeP) collider
  - Issues and needs for Monte Carlos
- Summary and outlook

POETIC-8, MCEG Workshop — 22–23 March 2018, University of Regensburg

LUND UNIVERSITY

General Purpose

Event Generators

Overview and Status

Leif Lönnblad

Department of Astronomy
and Theoretical Physics
Lund University

POETIC-8' 2018-03-22

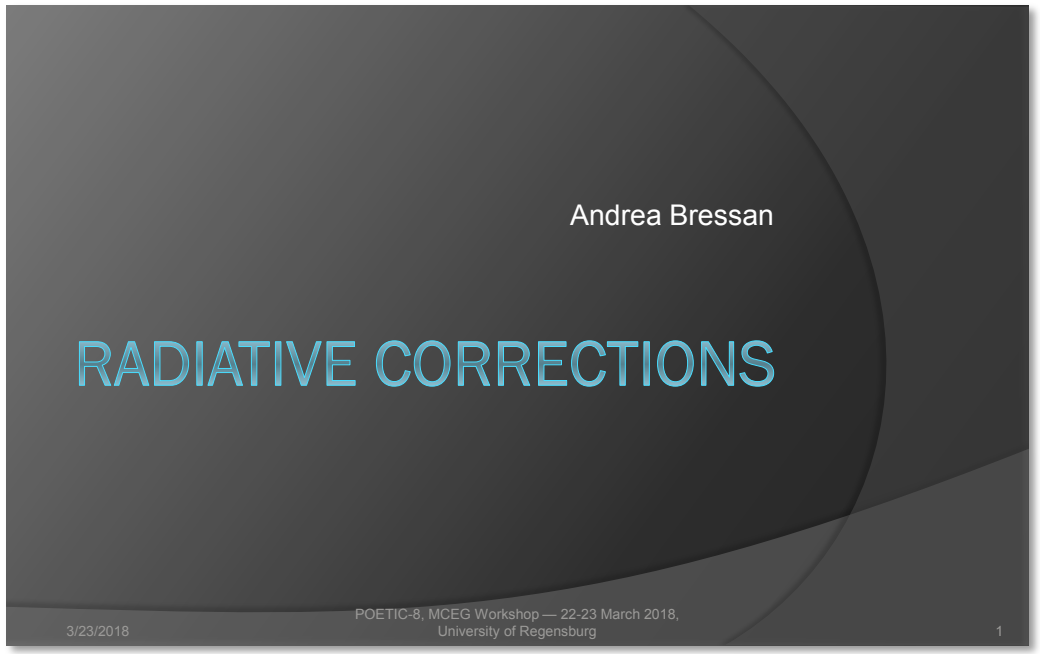
- MCEG not about tuning but about physics
- multi-leg NLO matching with parton showers
- ready to work on ep/eA

MC Workshop – General-Purpose Event Generators Herwig, Pythia, Sherpa

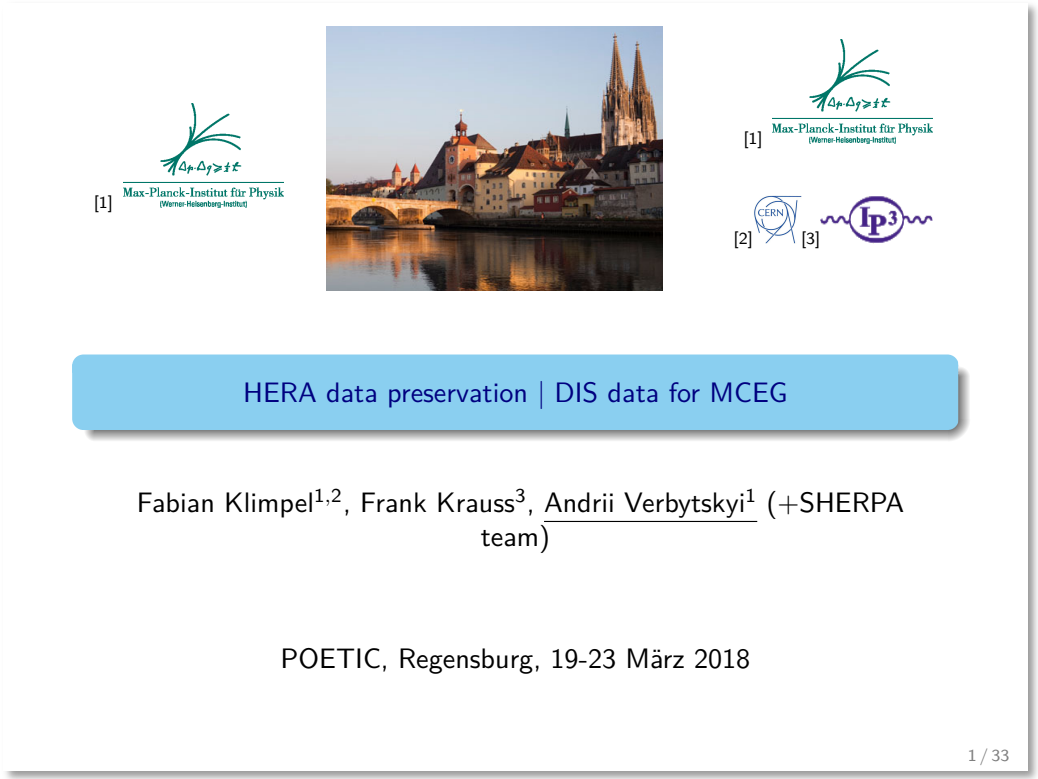
- huge potential for DIS simulations
- first DIS implementation

- DIS
- photoproduction
- hard diffractive photoproduction

MC Workshop – MC Tools

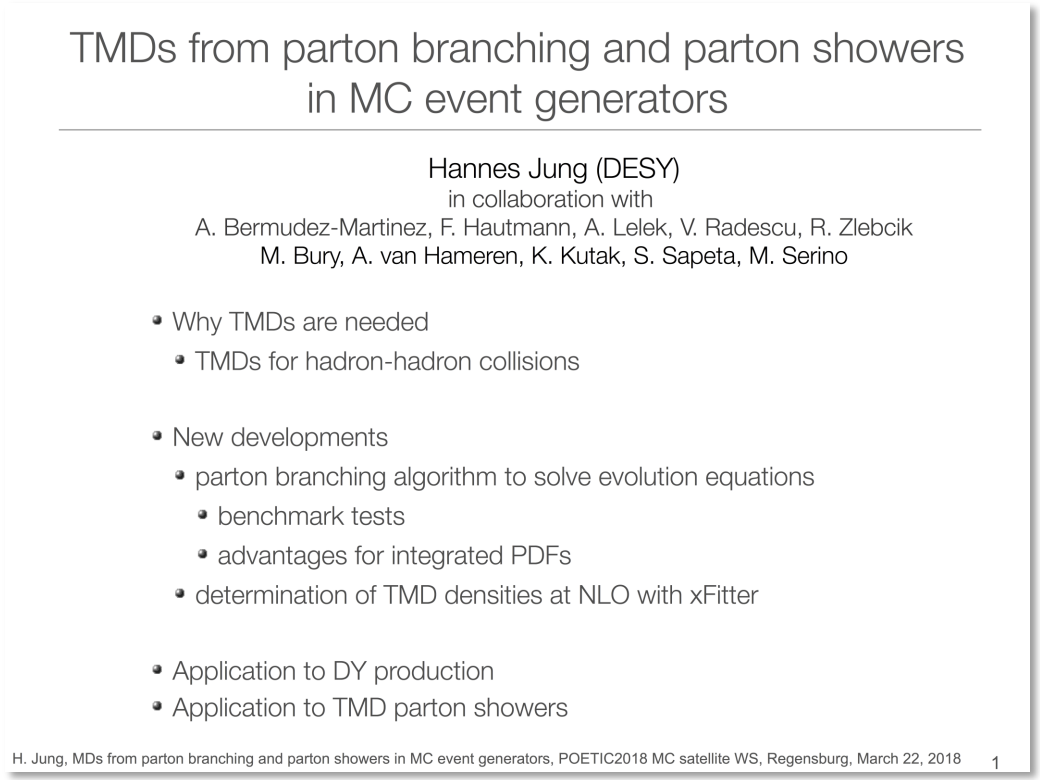


- ESC project on radiative corrections



- make DIS analysis available (RIVET)
- include DIS data in standard tunes
- Sherpa DIS comparisons

MC Workshop – Novel QCD Phenomena



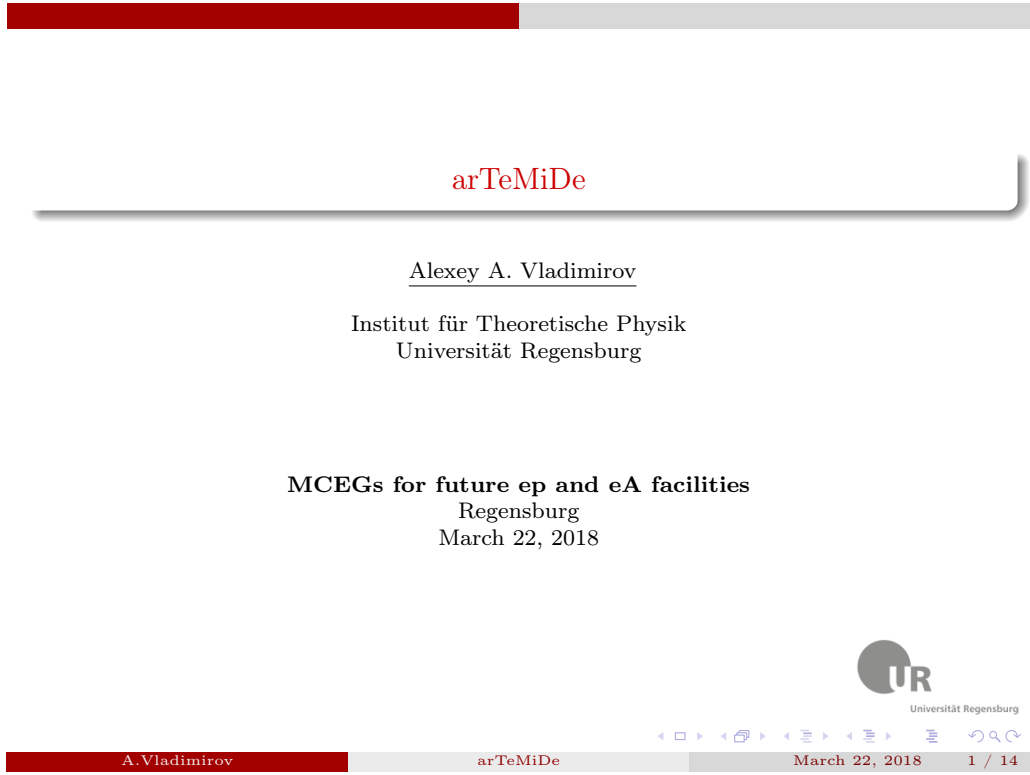
TMDs from parton branching and parton showers in MC event generators

Hannes Jung (DESY)
in collaboration with
A. Bermudez-Martinez, F. Hautmann, A. Lelek, V. Radescu, R. Zlebcik
M. Bury, A. van Hameren, K. Kutak, S. Sapeta, M. Serino

- Why TMDs are needed
  - TMDs for hadron-hadron collisions
- New developments
  - parton branching algorithm to solve evolution equations
    - benchmark tests
    - advantages for integrated PDFs
  - determination of TMD densities at NLO with xFitter
- Application to DY production
- Application to TMD parton showers

H. Jung, MDs from parton branching and parton showers in MC event generators, POETIC2018 MC satellite WS, Regensburg, March 22, 2018 1

- unintegrated PDFs
- include TMD factorization and evolution



arTeMiDe

Alexey A. Vladimirov

Institut für Theoretische Physik
Universität Regensburg

MCEGs for future ep and eA facilities
Regensburg
March 22, 2018

Universität Regensburg

A.Vladimirov arTeMiDe March 22, 2018 1 / 14

- TMD distributions
- TMD evolution
- TMD cross-sections

MC Workshop – eA

eA: interesting prospect

γ*A pA, AA

DIPSY and Angantyr: Towards *e*A exclusive final states

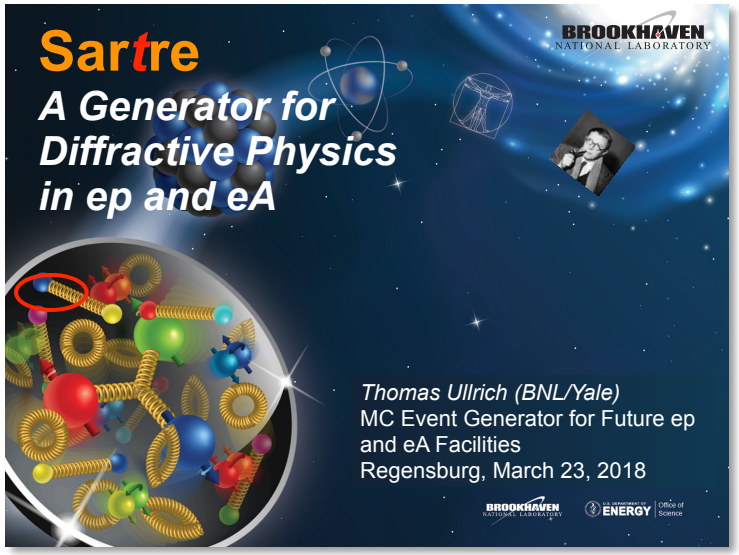
Christian Bierlich
bierlich@thep.lu.se

Lund University / University of Copenhagen

Mar 22, 2018
MCEG for *e*A Workshop

MCnet Vetenskapsrådet LUND UNIVERSITY Discovery

Christian Bierlich (Lund/NBI) DIPSY and Angantyr Mar 22, Regensburg 1 / 19



collaborate with BeAGLE

BeAGLE:
Benchmark eA Generator for LEptoproduction

hard interaction + nuclear response

Mark D. Baker*
MDBPADS Consulting

E.C. Aschenauer, J.H. Lee
Brookhaven National Laboratory

L. Zheng
China Univ. Of Geosciences (Wuhan)

22 March 2018

* Contact: mdbaker@mdbpads.com (@bnl.gov, @jlab.org)

Lessons from MCEG at small-x for p+p/A, A+A : sampling nuclei for EIC

Prithwish Tribedy
BROOKHAVEN NATIONAL LABORATORY

Monte Carlo Satellite workshop of the POETIC-8

March 22-23, 2018, University of Regensburg, Germany

U.S. DEPARTMENT OF ENERGY | Office of Science

CGC + Pythia6

MC Workshop – MCEG R&D

- **MCEG R&D** requires *easy* access to *data*
- data := detailed analysis description / analysis + analysis results

- **HEP** existing workflow for MCEG R&D using tools such as Rivet and Professor

- **Workshop discussion**
  - What would be needed from HEP analysis tools to leverage them for NP as well?
  - How could we make the HERA data available?

ESC MC Data

Requirements for MC data

- HPC compatible, persistent, self-descriptive (MCEG settings, event description)

ESC project

- work on Google protocol buffer (flexible, portable, no external dependencies) based file format
- utilize **ProIO** for MC data
- work on community document on MC event model

Development history within ESC

ProMC (Sergei Chekanov) idea & original version for HepSim repository
- limited functionality MC application

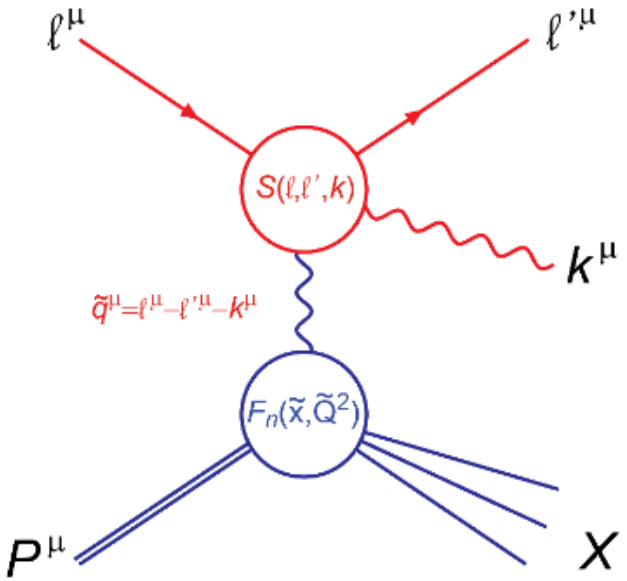
EicMC (Alexander Kiselev) second version
- MC application with several advanced features

ProIO (David Blyth) present development, close to the first official release
- general-purpose format with multi-language support

Radiative Effects and MCEG

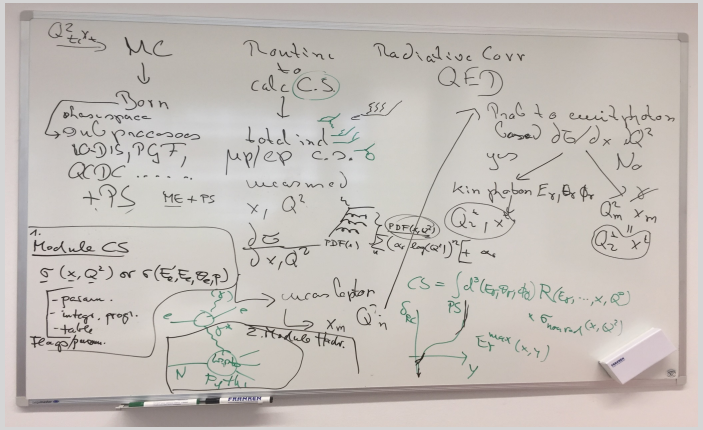
Radiative effects

- change kinematics on an event by event basis:
  - smearing of kinematic distributions
- change of virtual-photon direction:
  - false asymmetries in the azimuthal distribution of hadrons
- correction:
  - unfolding procedure, requires MCEG including radiative corrections / effects



Radiative effects library

- Elke-Caroline Aschenauer, Andrea Bressan
- essential for high-precision measurements at the EIC
- collaboration with Hubert Spiesberger:
  - start back from HERACLES part of Djangoh
  - work on interface to PYTHIA6/8



ESC Containers

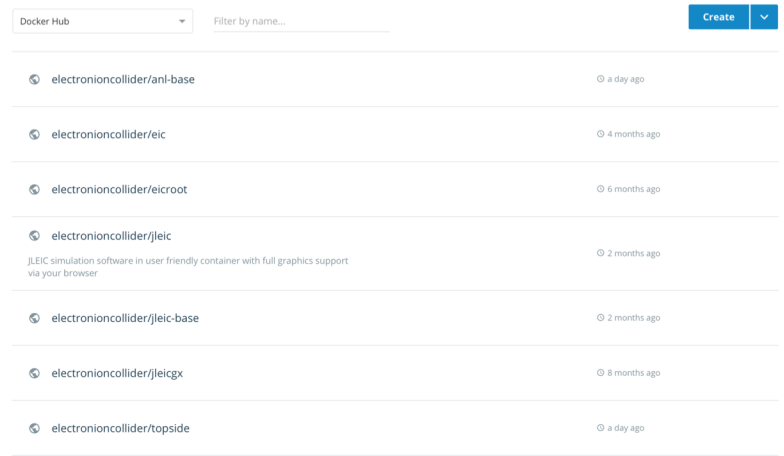
Benefits for EIC user community

- allow EIC users to run the same software under standardized environment on any Linux, Mac OS or Windows machine, eventually including GRID sites, commercial cloud systems, and HPC resources
- provide consistency between software generated at different facilities
- make it easier for new users to start working on the physics program and detector design for the EIC, by minimizing the pain of “installation overhead”

Container technology

- **Container** := very lightweight Virtual Machine
- **Main players**
  - **Docker** industry standard, requires admin privilege on host
  - **Singularity** standard on OSG, can run entirely in unprivileged mode
  - **Shifter** (NERSC only)

Containers for EIC software tools by ANL, BNL, JLAB



Community document on container guidelines released

Inspiration for MCEG Container

Container for Pythia8+DIRE by Nadine Fischer (Pythia)

jupyter README✔ 8 minutes ago

Logout

File Edit View Language Plain Text

```
Welcome to the Jupyter notebooks for Pythia 8 and DIRE!


You have the choice to run the following notebooks:

pythiaPI.ipynb
  Gives a basic idea of the Pythia 8 event generator, by using the Python
  interface of Pythia 8. You can adjust a set of parameters and choose
  from different different histograms to be plotted.

pythiaRivetPI.ipynb
  Shows how to use the Pythia 8 event generator, together with Rivet,
  by using the Python interface of Pythia 8.

pythiaRivet.ipynb
  Shows how to use Pythia 8, together with Rivet, by using an already
  compiled executable called pythiaHepMC. You can adjust a set of parameters
  and a settings file is created.

pythiaRivetUS.ipynb
  As pythiaRivet.ipynb, but uses a prepared settings file, to be provided
  by the user.

direRivet.ipynb
  Shows how to use Pythia 8 with the DIRE parton shower, together with
  Rivet, by using the default DIRE executable. You can adjust a set of
  parameters and a settings file is created.

direRivetUS.ipynb
  As direRivet.ipynb, but uses a prepared settings file, to be provided
  by the user.

direEvent.ipynb
  Pythia 8 with the DIRE parton shower, graphical output of one event
  with the default DIRE exectuable.
  The process can be choosen as well as a few basic parameters.

tuning.ipynb
  Tuning with Professor, Rivet, and Pythia 8 / DIRE.
```

Jupyter notebook interface

Pythia 8 standalone

This notebook gives a basic idea of the Pythia 8 event generator, by using the Python interface of Pythia 8. You can adjust a set of parameters and choose from different different histograms to be plotted.

First, lets import all neccessary modules.

In [1]:
```
import os, sys, pythia8
from plotting import MULTHIST
import py8settings as py8s
```

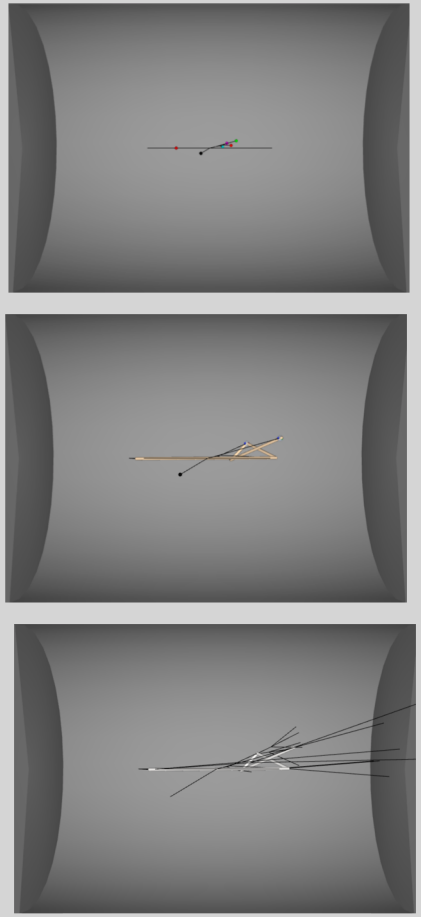
Now we create a Pythia 8 object and apply the settings to define the incoming beams. More settings can be adjusted later.

In [2]:
```
# Setup pythia, apply beam settings.
pythia = pythia8.Pythia()
py8s.beam_settings(pythia)
```

You can now set the parameters for the incoming beams:

beam A id [Beams:idA]	e-
beam B id [Beams:idB]	p
beam frame type [Beams:frameType]	2: back-to-back beams with different energies, set Beams:eA and Beams:eB
CMS energy for Beams:frameType = 1 [Beams:eCM]	65.7
beam A energy for Beams:frameType = 2 [Beams:eA]	10.8
beam B energy for Beams:frameType = 2 [Beams:eB]	100

Visualization of ep collision



ESC and EICUG

June 4 2018 Announcement of EICUG Software Working Group

Charge

The EICUG Software working group's initial focus will be on simulations of physics processes and detector response to enable quantitative assessment of measurement capabilities and their physics impact. This will be pursued in a manner that is accessible, consistent, and reproducible to the EICUG as a whole. It will embody simulations of all processes that make up the EIC science case as articulated in the White-paper. The Software working group is to engage with new major initiatives that aim to further develop the EIC science case, including for example the upcoming INT program(s), and is anticipated to play key roles also in the preparations for the EIC project(s) and its critical decisions. **The working group will build on the considerable progress made within the EIC Software Consortium (ESC) and other efforts.** The evaluation or development of experiment-specific technologies, e.g. mass storage, clusters or other, are outside the initial scope of this working group until the actual experiment collaborations are formed. The working group will be open to all members of the EICUG to work on EICUG related software tasks. It will communicate via a new mailing list and organize regular online and in-person meetings that enable broad and active participation from within the EICUG as a whole.

Conveners

David Blyth, Markus Diefenthaler

Markus Diefenthaler

mdiefent@jlab.org

Summary

ESC initiatives for MC simulations

- collaboration with MCnet
- containers and tutorials for EIC MCEGs
- MCEG workshop
  - write-up on requirements
  - next workshop after DIS 2019
- ProIO MC format
- radiative effects library

MCEG R&D required for EIC