Event Simulation Tools in ALICE

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Generator Mini-Workshop

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Outline

- General Remarks about simulations of Heavy Ion Collisions
- The ALICE approach
  - Interface to external generators
  - Parameterization libraries
  - Cocktail events
  - Afterburner
  - Generators for ultra-peripheral collisions
- Conclusions

Simulation of Heavy Ion Collisions

- Shortcomings of existing generators
  - None of the existing generators do give detailed account of the expected multiplicities, pt and rapidity dependence at LHC energies
  - Most of the hard probes (heavy flavor, jets ...) are not properly reproduced by existing generators.
  - Existing generators do not provide for event topologies like momentum correlations, azimuthal flow etc.
- The small cross-section of hard processes would demand prohibitively long runs to simulate a number of events that is commensurable with the expected number of detected events in the experiment

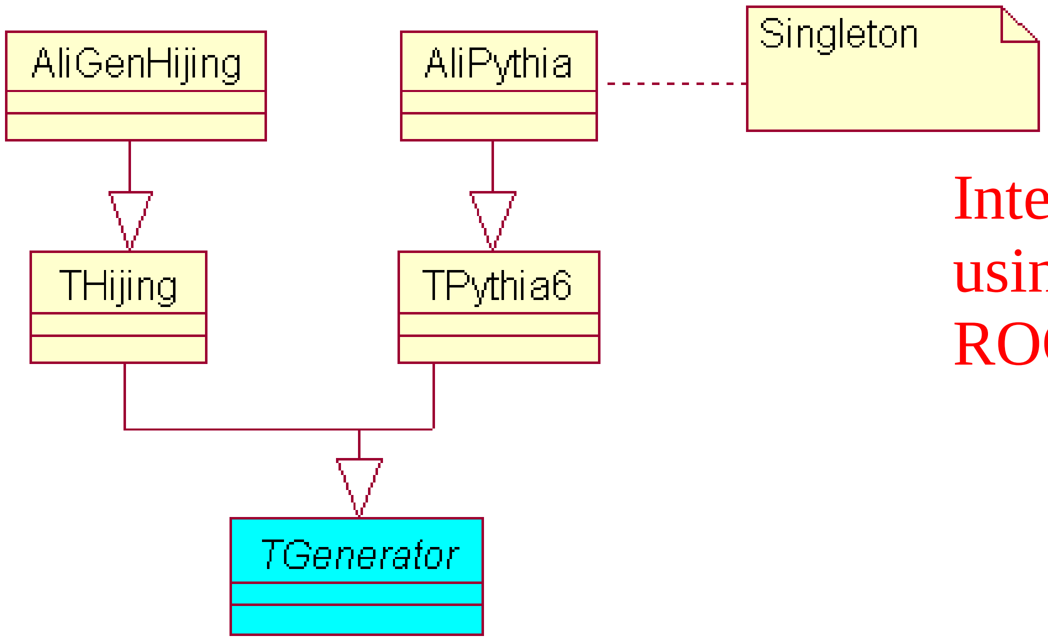
However, ...

- ... situation not as hopeless as it seems
  - secondary role of MC in data analysis
    - See RHIC
    - Compare PbPb to pp, pPb, light AA
    - Compare different centralities
    - Hard probes = signal + underlying event
  - Slightly different situation for jet quenching (energy loss of partons in deconfined medium)
    - Interplay of underlying event and observables
    - Could do more if model for fragmentation + quenching would be available in MC

The ALICE Approach

- ***The simulation framework provides an interface to external generators, like HIJING and DPMJET.***
- ***A parameterised "signal free" underlying event with multiplicity as a parameter is provided.***
- ***Rare signals can be generated using***
  - ***External generators like PYTHIA***
  - ***Libraries of parameterized p_t and rapidity distributions***
- ***The framework provides a tool to assemble events from different signal generators***
  - ***On the primary particle level (cocktail)***
  - ***On the digit level (merging)***
- ***After-Burners are used to introduce particle correlations.***

Event Generator Interfaces: External Generators



Interface to external generators using the TGenerator class from ROOT

External Generators: HIJING

- HIJING
  - HIJING (Heavy Ion Jet INteraction Generator) combines a QCD-inspired model of jet production with the Lund model for jet fragmentation. Hard or semi-hard parton scatterings with transverse momenta of a few GeV are expected to dominate high energy heavy ion collisions. The HIJING model has been developed with special emphasis on the role of mini jets in pp, pA and A A reactions at collider energies.

HIJING

- Hijing used as
  - Underlying event
    - Realistic fluctuations (N,E) from jets
    - Pessimistic multiplicity (dN/dy ~ 6000)
  - Particle Correlation studies
    - Inclusive
    - Reconstructed jets
  - Nuclear effects
    - Shadowing
    - Quenching (parton energy loss)

External Generators: DPMJET

- DPMJET
  - DPMJET is an implementation of the two-component Dual Parton Model for the description of interactions involving nuclei based on the Glauber-Gribov approach. DPMJET treats soft and hard scattering processes in an unified way. Soft processes are parameterised according to Regge-phenomenology while lowest order perturbative QCD is used to simulate the hard component. Multiple parton interactions in each individual hadron/nucleon/photon-nucleon interaction are described by the PHOJET event generator. The fragmentation of parton configurations is treated by the Lund model PYTHIA.

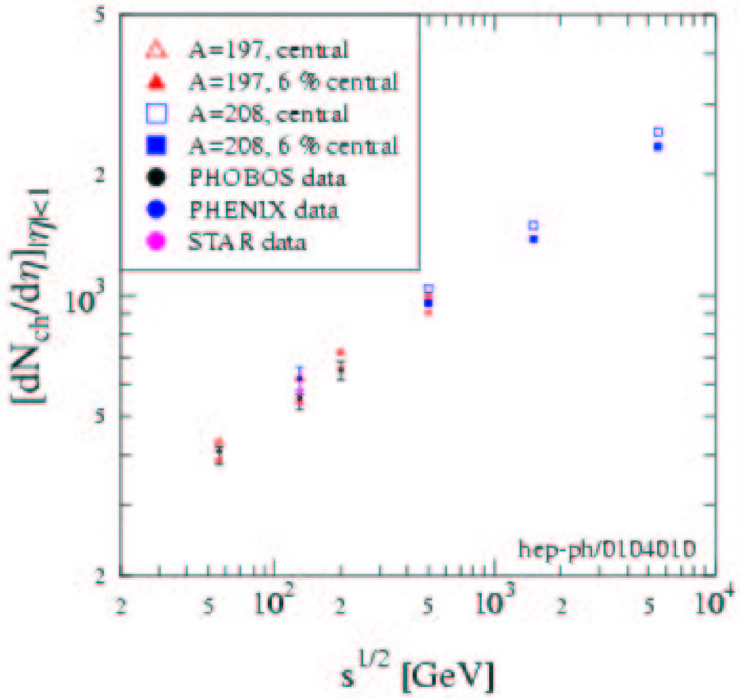
External Generators: SFM

- SFM (String Fusion Model)
  - The soft interactions are described by the Gribov-Regge theory of multipomeron exchange. The hard part of the interactions, included as a new component of the eikonal model, begins to be significant above 50GeV. The hard part of the interaction is simulated by PYTHIA and the strings formed by gluon splitting are fragmented with JETSET. Fusion of soft strings is included. Fragmentation is through the Artru-Mennessier string decay algorithm.

Multiplicities
PbPb @ 5.5 TeV

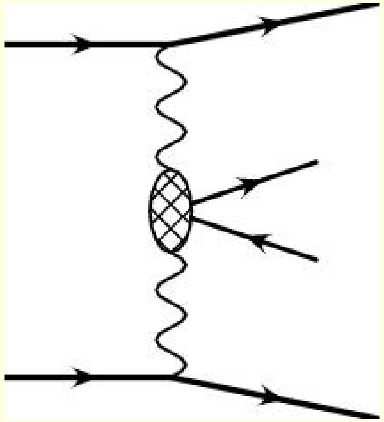
Table 1.1: Charged particle multiplicity for different generators

generator	comments	$dN_{ch}/d\eta$ at $\eta = 0$	N_{ch} in $\|\theta - 90\| < 45$
HIJING 1.36	with quenching	$\simeq 6200$	$\simeq 10800$
	without quenching	$\simeq 2900$	$\simeq 5200$
DPMJET-II.5	with baryon stopping	$\simeq 2300$	$\simeq 4000$
	without baryon stopping	$\simeq 2000$	$\simeq 3500$
SFM	with fusion	$\simeq 2700$	$\simeq 4700$
	without fusion	$\simeq 3100$	$\simeq 5500$

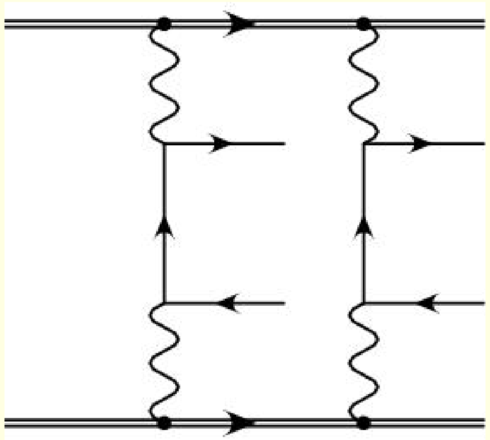


Ultra-peripheral Collisions

$AA \rightarrow AA\ \gamma\gamma \rightarrow AA\ X$



$AA \rightarrow AA\ e^+e^-$



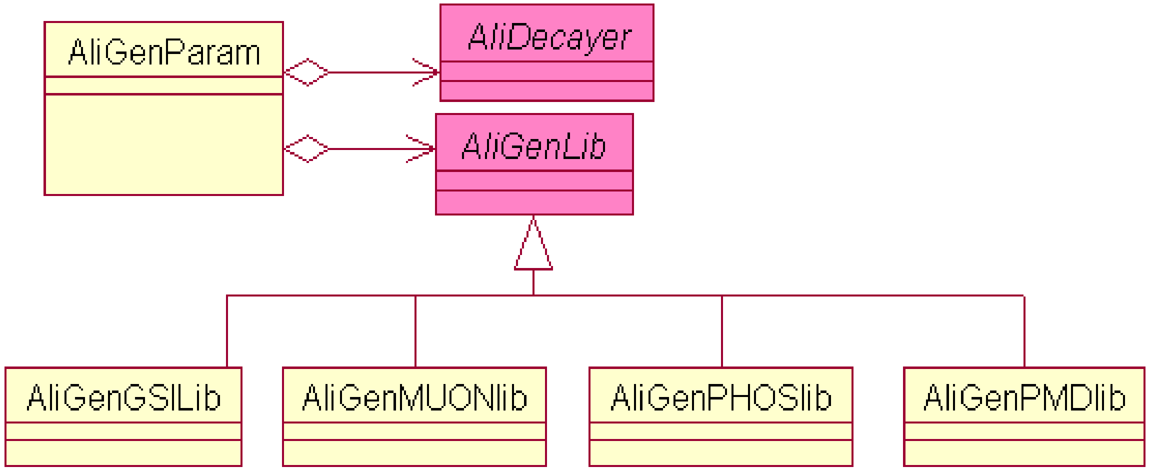
- K. Hencken et al.
- TPHIC
  - Massive particle production described in Equivalent Photon Approximation
- TEPEM
  - Electron positron pair production in UPC

pp

- Minimum Bias
  - Pythia, Herwig
- Hard Probes
  - Pythia tuned to NLO (MNR)
  - NLO topology
  - Modification of nuclear structure functions via EKS in PDFlib

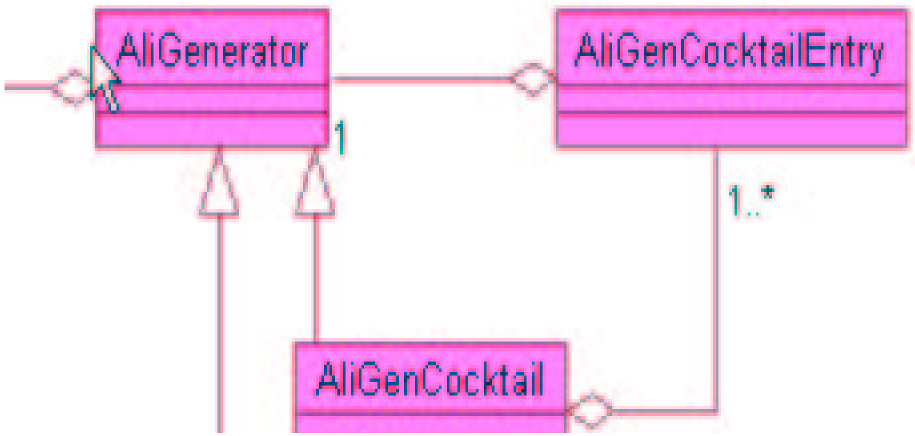
Event Generator Interfaces: Parameteriations

Interface to parametrisations and decayer

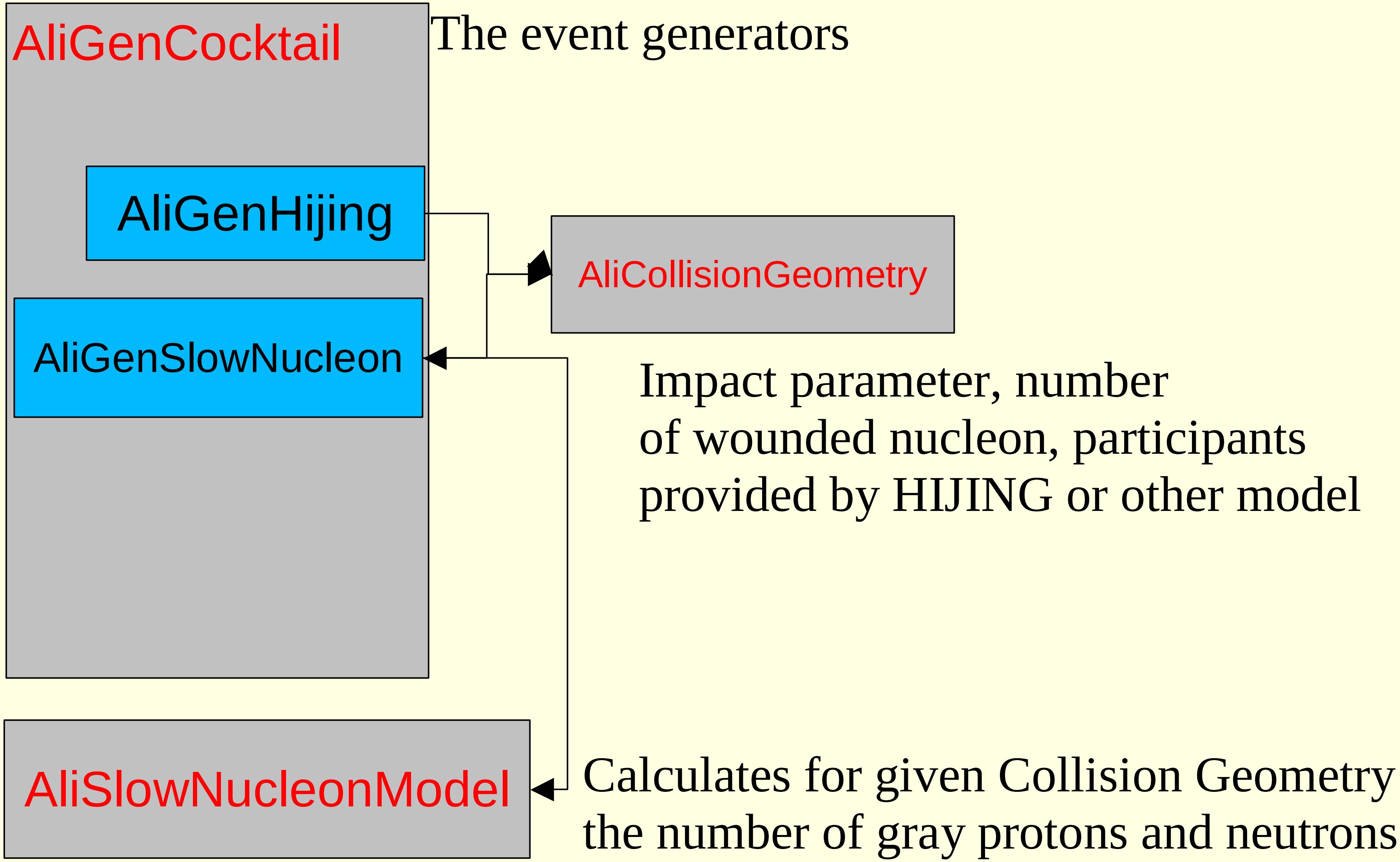


Event Generator Interfaces

- Cocktail class to assemble events, for example:
  - Underlying event + hard process
  - Different muon sources
  - pA + slow nucleons



pA Collisions



Afterburner Processors

- Introduction of correlations in otherwise uncorrelated events
  - 2 particle correlations
  - Flow
  - Assembling of new events
- Design of classes involved in event generation (*AliRun*, *AliStack*, *AliGenerator*) supports requirements for Afterburner
  - Example: Several objects of type *AliStack* containing the input events can be connected to the Afterburner (of type *AliGenerator*) to fill a stack connected to *AliRun* (output event)

Conclusions

- Shortcomings of present generators for Heavy Ion Collisions
  - Most interesting observables are nor simulated
- Solution
  - Hard probes: Assemble events as signal + underlying event
  - Soft probes: Afterburners, parameterisations, ...
  - Jet quenching ?
- The ALICE simulation framework provides collaborating classes tailored to these needs.