Monte Carlo Tools in ALICE

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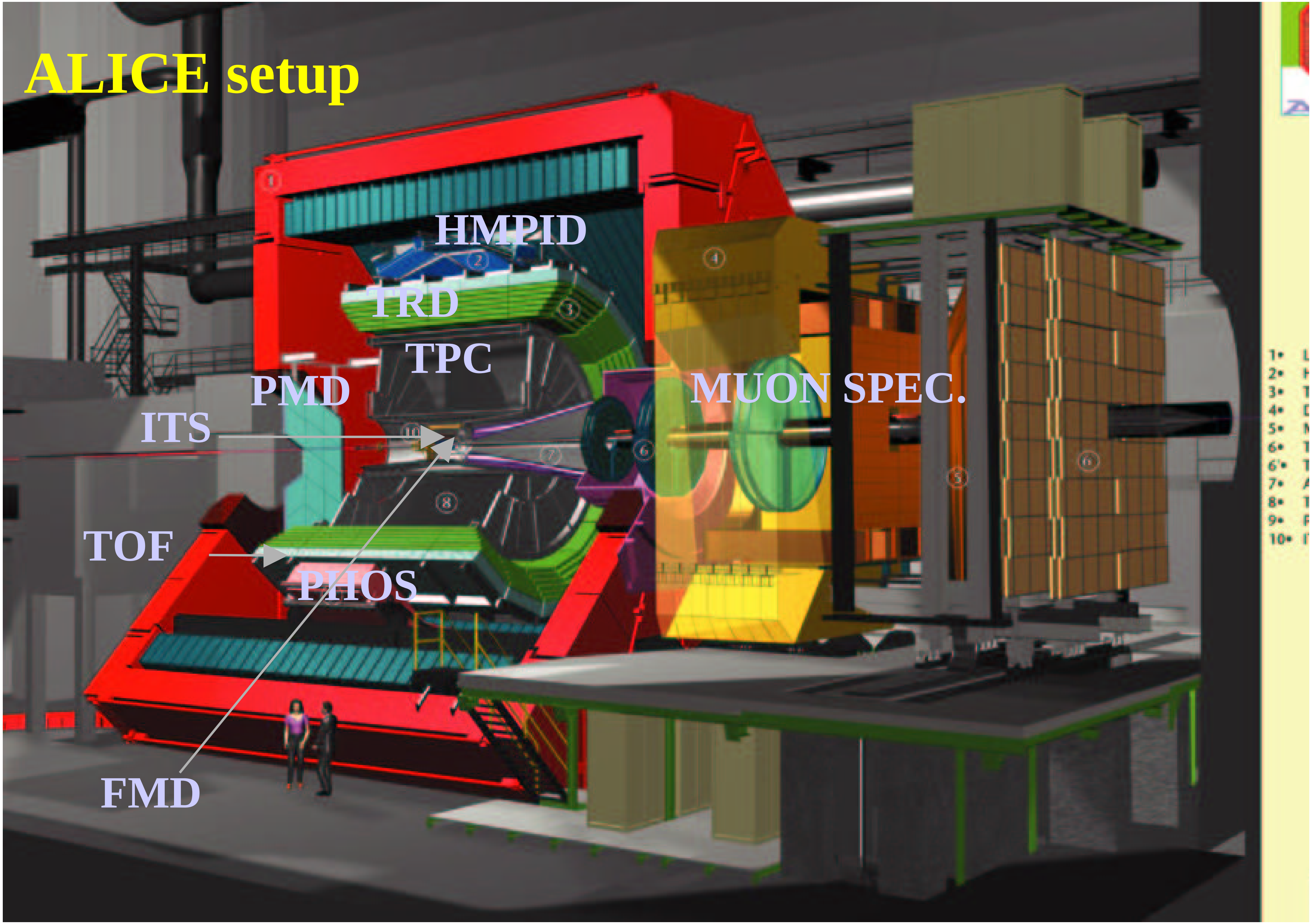
Outline

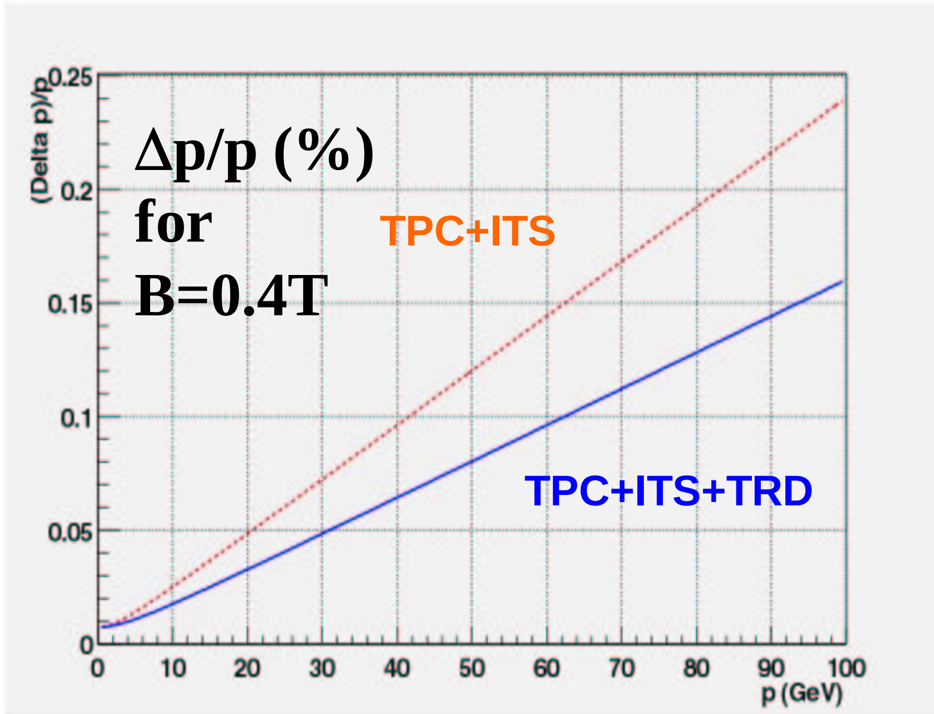
- ALICE in short
- General Remarks about simulations of Heavy Ion Collisions
- The ALICE approach
  - Interface to external generators
  - Parameterization libraries
  - Cocktail events
  - Afterburner
  - Generators for ultra-peripheral collisions
- Conclusions

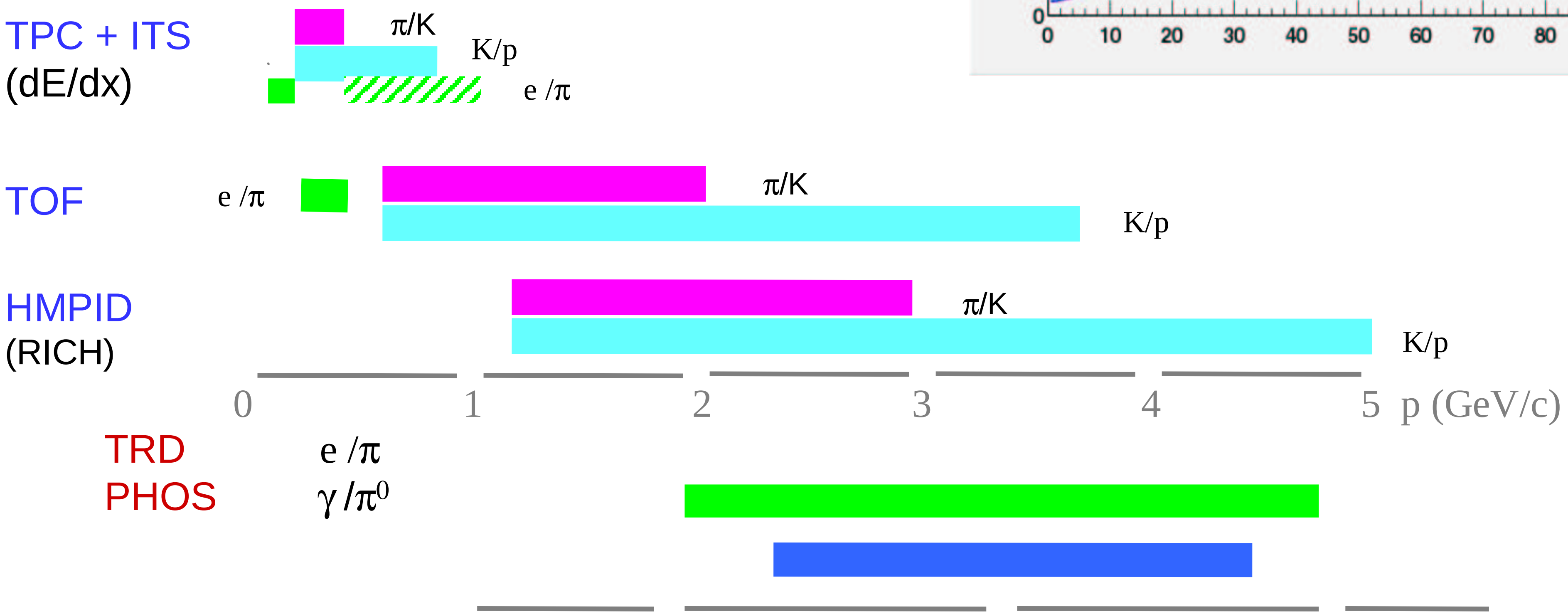
ALICE setup



ALICE in short

- ALICE is the LHC experiment dedicated to the study of heavy ion collisions.
- A multipurpose experiment, with excellent tracking and secondary vertex capability, electron and muon detection and high resolution γ spectrometer. Unique Particle Identification complex.





Simulation of Heavy Ion Collisions

- Shortcomings of existing generators at LHC energy
  - None of the existing generators 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

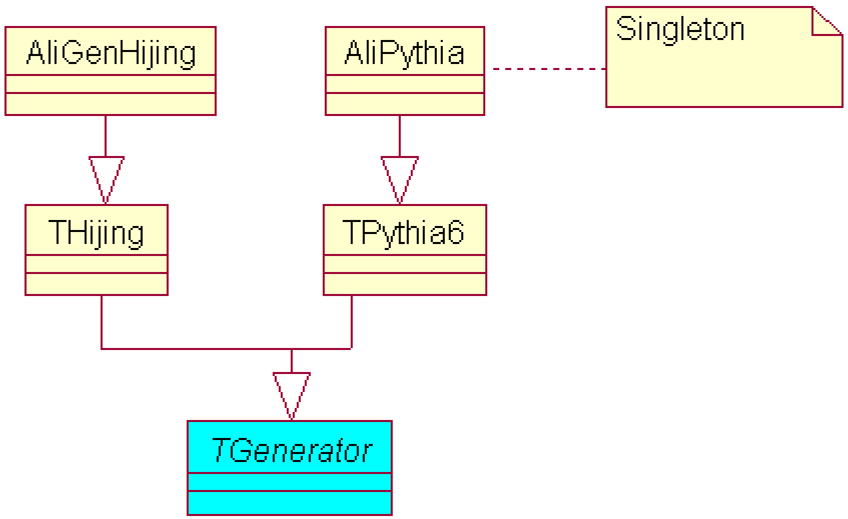
However, ...

- ... 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/continuum
- Slightly different situation for jet quenching (energy loss of partons in deconfined medium)
  - Interplay of underlying event and observables
  - Could obtain more information from data analysis if 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. 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

- So far the only generators used in production
- Hijing used in ALICE for
  - Underlying event simulation
    - 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. The fragmentation of parton configurations is treated by the Lund model PYTHIA. (see talk by J. Ranft during HI session)

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 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.

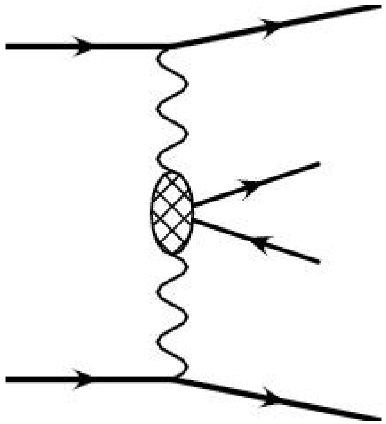
Multiplicities
PbPb @ 5.5 TeV

Table 1.1: Charged particle multiplicity for different generators

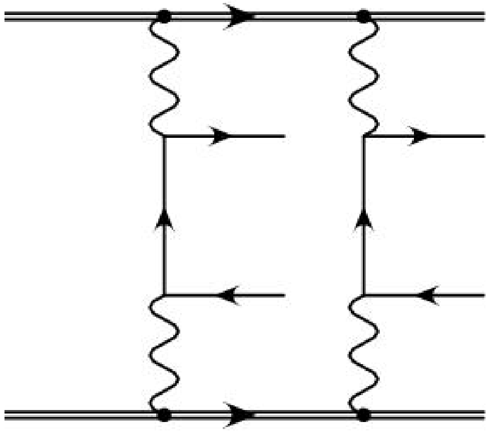
generator	comments	$dN_{ch}/d\eta$ at $\eta = 0$	N_{ch} in $|\theta - 90| < 45$
HIJING 1.36	with quenching	$\simeq 6200$	$\simeq 10800$
	without quenching	$\simeq 2900$	$\simeq 5200$
DPMJET-II.5	with baryon stopping	$\simeq 2300$	$\simeq 4000$
	without baryon stopping	$\simeq 2000$	$\simeq 3500$
SFM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

Ultra-peripheral Collisions

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



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

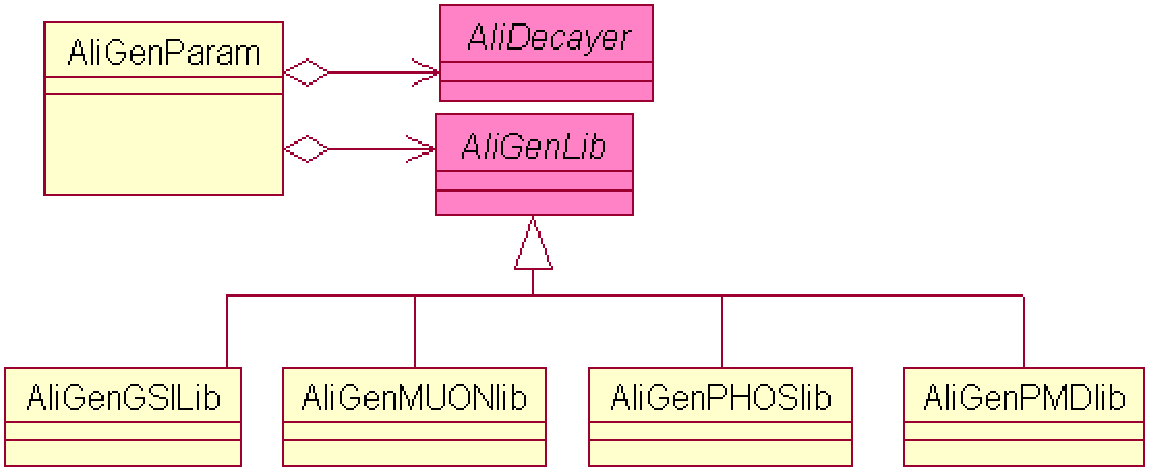


- K. Hencken et al.
- TPHIC
  - Massive particle production described in Equivalent Photon Approximation
- TEPEM
  - Electron positron pair production in UPC

pp

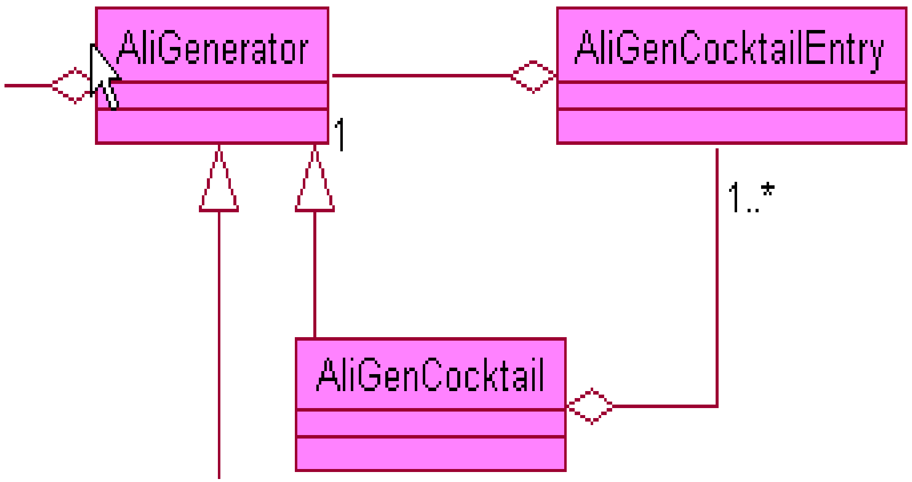
- Minimum Bias
  - Pythia, Herwig
- Hard Probes (see talk by A. Dainese during HI session)
  - Pythia tuned to NLO (MNR)
  - NLO topology
  - Modification of nuclear structure functions via EKS in PDFlib

Event Generator Interfaces: Parameteriations



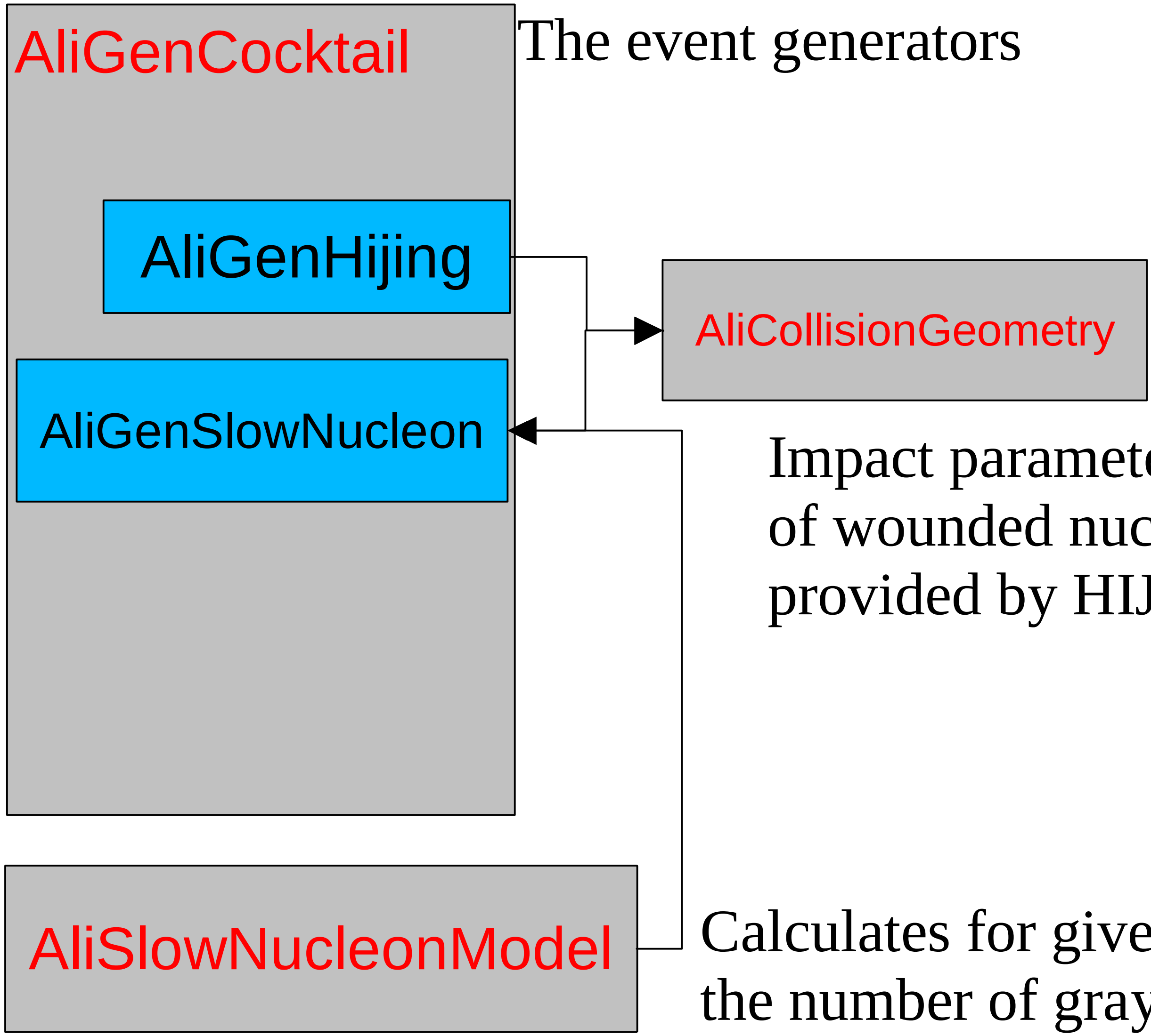
Interface to parametrisations and decayer

Event Generator Interfaces



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

pA Collisions



The event generators

Impact parameter, number
of wounded nucleon, participants
provided by HIJING or other model

Calculates for given Collision Geometry
the number of gray protons and neutrons

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

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 a collaborating classes tailored to these needs