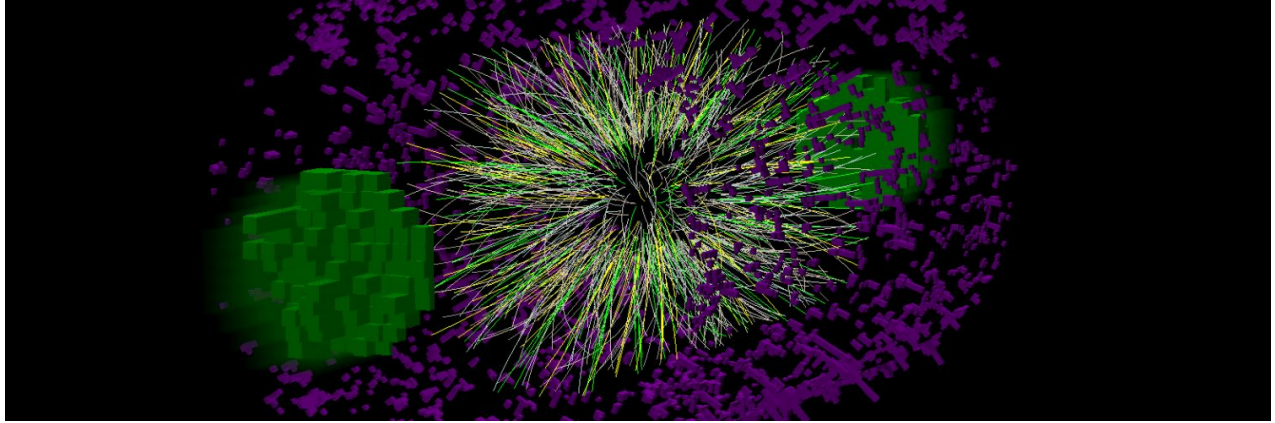

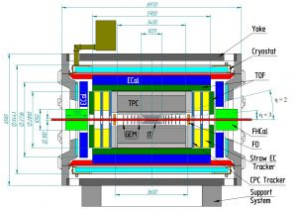

Software Developments for Femtoscopic Analysis and Data Storage

Grigory Nigmatkulov[1], Pavel Batyuk[2]

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[2] Joint Institute for Nuclear Research, Dubna, Russia
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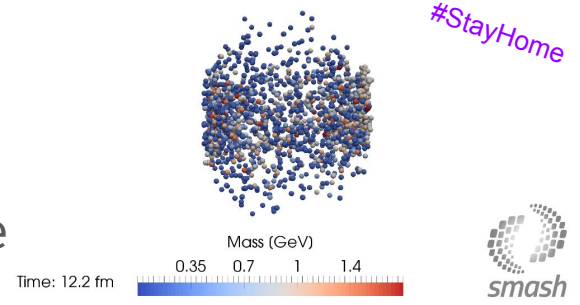
V-th Collaboration Meeting of the MPD Experiment at the NICA Facility
April 24, 2020

Femtoscopic measurements in MPD

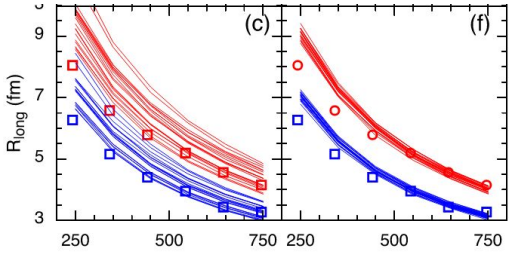
#StayHome



Animation by J. Mohs

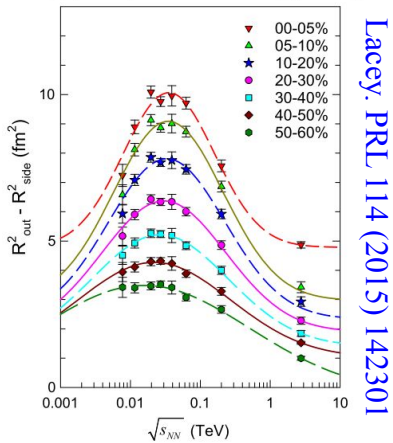
Will allow to study the dynamic properties of the medium produced in heavy-ion collisions looking at the two-particle momentum correlations

Pratt, Sangaline, Sorensen, Wang. PRL 114 (2015) 202301



Provide information about spatial and temporal properties of the particle emission process, final-state interaction between particles, allows one to put constraints on the Equation of State and various models, sensitive observable for the first-order phase transition

Lednický et al. PLB 373 (1996) 30
Rischke, Gyulassy. NPA 608 (1996) 479
Lisa et al. Ann. Rev. Nucl. Part. Sci 55 (2005) 479
Shapoval et al. NPA 968 (2017) 391



Lacey. PRL 114 (2015) 142301

For more information see Konstantin Mikhaylov's talk on Fri. 24 at 13:50

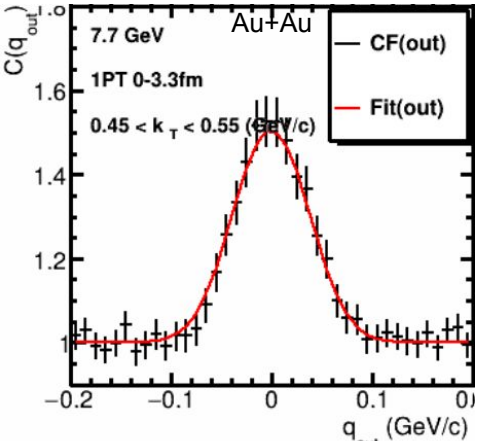
MpdFemtoMaker: what is it?

#StayHome

MpdFemtoMaker - a package to perform femtoscopic analysis (not only femto!)

Features:

- Inherited from STAR (StHbtMaker) and ALICE (AliFemto)
  - Incorporates best practices
- Works with ROOT 5 and 6 (may work standalone)
- Already implemented in the MpdRoot framework
  - One can work with the data right away
  - Flexible - analyst can use either existing OR add personal “Reader” to his/her favorite input data format, apply the whole variety of the event/track/pair/... cuts, fill and plot histograms, publish a Nature/PRL/PRC paper
  - Will be tuned to work with the miniDst



MpdFemtoMaker: how to start using?

Q: How to get?
A: Simply install MpdRoot on your machine:
http://mpd.jinr.ru/howto-install/
and that is it. MpdFemtoMaker is a part of MpdRoot.

Q: Is there any example that one can start with?
A: In MpdRoot in the directory:
macro/physical_analysis/femto/
(currently, it works with data format McDst)

Q: Whom should I contact to clarify things?
A: Developers of the package (mainly me) or other PWG3 members.

Main macro to define conditions of user's analysis

```
int main(int argc, char* argv[]) {
...
 // Create and set track cut
trackCut->setPdgId(particlePdg);
trackCut->setEta(-1., 1.);
trackCut->setPt(0.15, 1.55);
trackCut->setMass(particleMass);
...
// Set how many events to mix
hbtAnalysis->setNumEventsToMix(10);
...
// Lednicky weight generator
hbtWeight->setPairType(pairType);
hbtWeight->setCoulOn();
hbtWeight->setQuantumOn();
hbtWeight->setStrongOff();
hbtWeight->set3BodyOff();
...
// Create 1D correlation function
// integrated over kT
StHbtModelQinvCorrFctn *oneDim =
new StHbtModelQinvCorrFctn
("hTheorQinv", 40, 0., 0.4);
// Create 3D correlation function
// integrated with kT binning
StHbtModelBPLCMS3DCorrFctnKt *threeDim =
new StHbtModelBPLCMS3DCorrFctnKt
("hTheorBPLCMS", 80, -0.4, 0.4, 4,
0.15, 0.59);
}
```

DST *for reconstructed data*

The data formats may vary from an experiment to experiment, but a general (oversimplified) scheme of the experimental data flow:

Nuclear Instruments and Methods in Physics Research A 389 (1997) 81–86

ELSEVIER

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

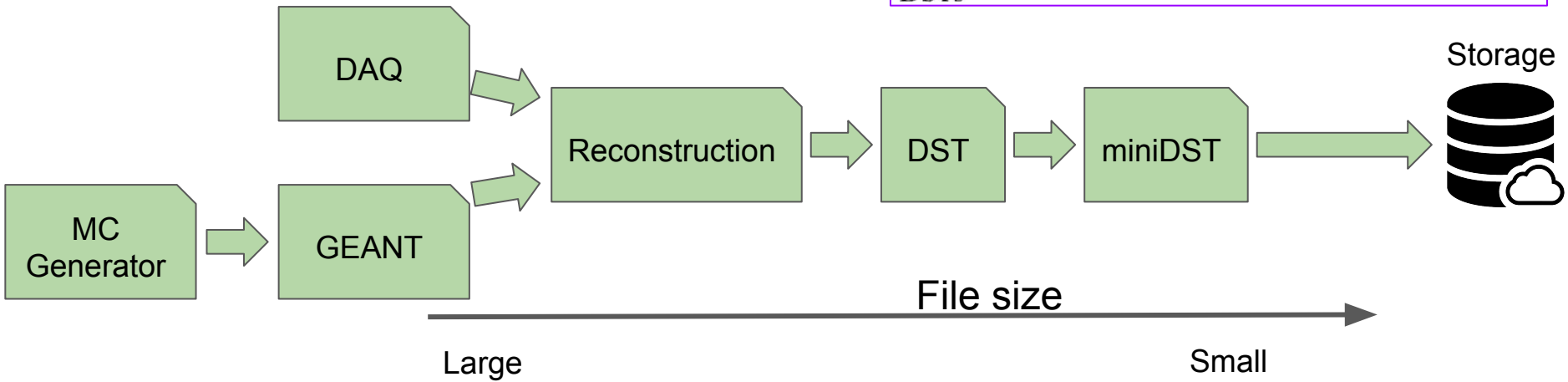
ROOT – An object oriented data analysis framework

Rene Brun[a,*], Fons Rademakers[b]

[a]CERN, Geneva, Switzerland
[b]NIKHEF & Hewlett-Packard, Geneva, Switzerland

5. The ROOT Trees

For many years, the data flow model in HEP has been: Raw Data Tapes → Data Summary Tapes → Mini/Micro DSTs



The file size of the current MpdDst is ~1.3 MB/event

MpdMiniDst: requirements

#StayHome

- ★ As small as possible
  - Small file size (✔)
  - Only vital variables for all analyses (discussions with PWGs are important)
- ★ MUST be implemented in MpdRoot
  - Done (✔)
- ★ Independent on the MPD software
  - Must work on any computer farm or laptop with vanilla ROOT 5 or 6 (✔)
  - Works on various OSs (Linux, MasOS, Windows) (✔)
  - Only simple (native) data types (int, float, ...) (✔)
  - Should be easily compiled with Makefile or CMake (✔)
- ★ Easy/fast to produce
  - During the whole production chain (DAQ->DST->miniDst) (✔)
  - Or reproduced for the larger format (DST->miniDst) (✔)

```
671M    /zfs/store6.hydra.local/mpddata/data/exp/dst-2020-01-10-mpg4-500ev/AuAu/11.0GeV-mb/UrQMD/mp01-2020-500ev-pf/urqmd-AuAu-11.0GeV-mb-eos0-500-998.reco.root
32M     urqmd-AuAu-11.0GeV-mb-eos0-500-998.reco.MiniDst.root
```

Compression ~ x20

```
Files passed: 300
Files total : 300
<seconds/file>: 44
Conversion has been finished.
```

MpdMiniDst: what is currently in?

#StayHome

List of currently implemented classes (MpdMini**ClassName**):

Event - information about general event properties

Track - reconstructed track parameters

TrackCovMatrix - convariance matrix of the *global* track

BTofHit - barrel Time-Of-Flight hit information

BTofPidTraits - information about TOF-matched track

BECalHit - hit in barrel ECal

BECalPidTraits - information about ECal-matched track

McEvent - generator-level event properties

McTrack - track information (from MC generator)

DstReader - does all routing job and allows one to read DST

Makefile - to compile in a standalone mode

minidst_env.sh - shell script to setup the environment for standalone mode

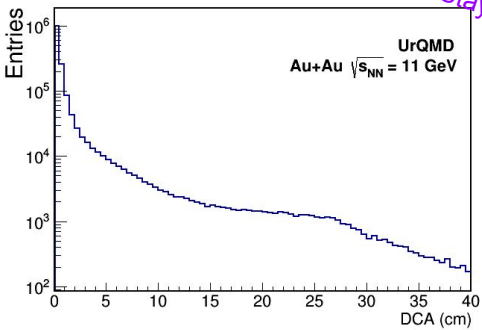
Simple usage example:

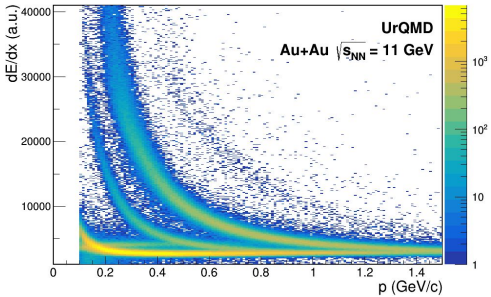
```
#include "Rtypes.h"
#include "TChain.h"
#include "TFile.h"
#include "TVector3.h"
#include "TH1F.h"
R__ADD_INCLUDE_PATH($VMCWORKDIR)
#include "macro/mpd/mpdloadlibs.C"
void miniExample(const Char_t* inFileName = "example.MiniDst.root") {
  // Instantiate reader
  MpdMiniDstReader* miniDstReader = new MpdMiniDstReader(inFileName);
  // Reader initialization
  miniDstReader->Init();
  // One can specify branches to read
  miniDstReader->SetStatus("*", 0);
  miniDstReader->SetStatus("Event*", 1);
  miniDstReader->SetStatus("Track*", 1);
  miniDstReader->SetStatus("BTofHit*", 1);
  miniDstReader->SetStatus("BTofPidTraits*", 0);
  miniDstReader->SetStatus("BECalHit*", 0);
  miniDstReader->SetStatus("BECalPidTraits*", 0);
  miniDstReader->SetStatus("TrackCovMatrix*", 0);
  miniDstReader->SetStatus("McEvent*", 0);
  miniDstReader->SetStatus("McTrack*", 0);
  // Retrieve events in tree
  Long64_t events2read = miniDstReader->chain()->GetEntries();
  // Loop over events
  for (Long64_t i = 0; i < events2read; i++) {
    // Retrieve current miniDst (from the given .MiniDst.root file)
    MpdMiniDst *dst = miniDstReader->miniDst();
    // Get MiniEvent
    MpdMiniEvent *event = dst->event();
    // Get primary vertex z-position
    Float_t z = event->primaryVertex().Z();
    // Define histogram(s) to fill
    TH1F *histo = new TH1F("histo","Global track momentum",200,0.,2.);
    // Track loop
    for (Int_t j = 0; j < dst->numberOfTracks(); j++) {
      // Retrieve j-th mini track
      MpdMiniTrack *miniTrack = dst->track(j);
      // Global track full momentum
      Float_t ptot = miniTrack->gMom().Mag();
      histo->Fill( ptot );
    }
    // Loop over barrel TOF hits
    for (Int_t j = 0; j < dst->numberOfBTofHits(); j++ ) {
      // Retrieve j-th hit information
      MpdMiniBTofHit *btofHit = dst->btofHit( j );
      // x position of hit
      Float_t xPosition = btofHit->btofHitPosX();
    }
  }
  // Finalize miniDst reader
  miniDstReader->Finish();
}
```

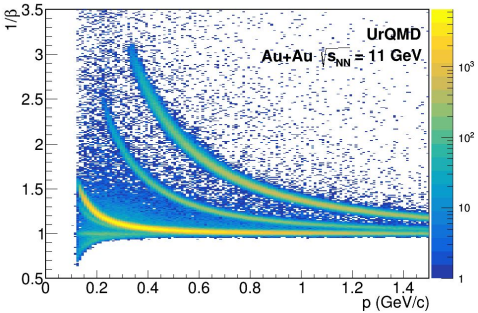
MpdMiniDst: features and performance

#StayHome

- Event information: primary vertex, multiplicity, …
- Information about primary tracks (tracks were refitted to the primary vertex)
- Correct DCA
- Possibility to look at MC generator level information
- Access to PID information
- Barrel ECal with track-matching info
- FHCal - possibility to reconstruct event plane and determine centrality
- TOF-matching information
- etc…







MpdDst ~1.3 MB/event

MpdMiniDst ~ 66 KB/event

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Summary

- MpdFemtoMaker
  - First version is implemented in the MpdRoot framework
  - Tested using MC generator data
- MpdMiniDst
  - First version has been released and implemented in MpdRoot
  - High compression compared to MpdDst

Outlook

- MpdFemtoMaker
  - Parameter tuning
  - Detector effects (e.g., track-merging and track-splitting)
- MpdMiniDst
  - Discussions with PWGs
  - Information from trigger detectors
  - PID info
  - Check track-matching procedures
  - Physics performance

Problems (need input from experts)

- Bad NCX/Hydra performance
- Absence of data set book keeping and scheduler
- Hybrilit may block users without reasons (no response for weeks)
- Absence of trigger information in data
- Absence of realistic PID