

The PandaRoot code

How to run a full analysis chain

Stefano Spataro

Panda Computing Week
Torino, 23-27 July 2012



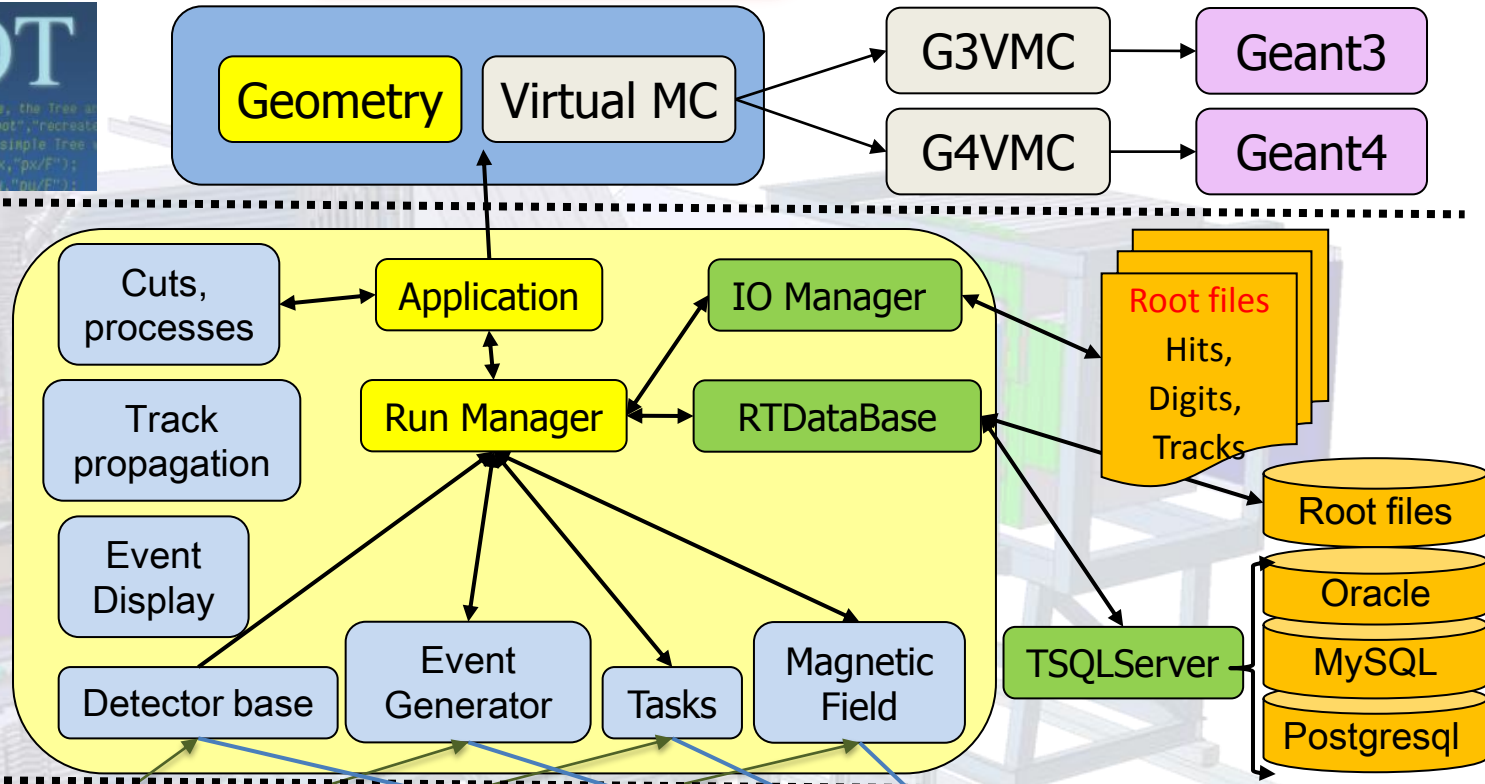
Overview

- General code structure
- Data Flow
- Tracking
- Pid
- Analysis
- How to run a full analysis chain

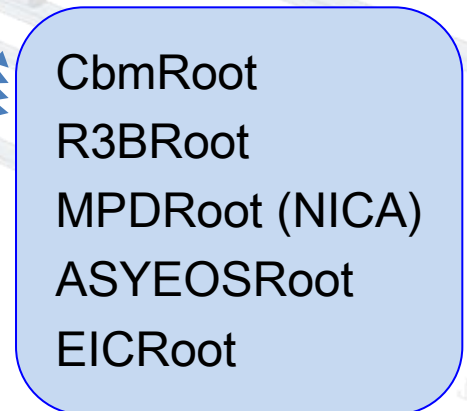
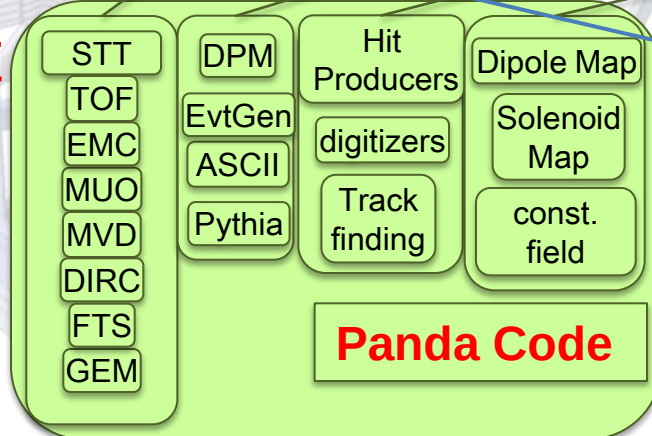


FairRoot

M.Al-Turany,
 D.Bertini,
 F.Uhlig,
 R.Karabowicz



PandaRoot



ROOT
(5.32)

based on

Virtual
Monte-Carlo (2.13)

dynamic data structure

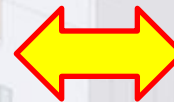
(based on ROOT Trees and Folders)

use of many ROOT application

(TGeo, EVE, TMVA, PROOF, TSQLServer)

same geometry/code for
Geant3 - Geant4 (9.5)

compiled and running on more
than 10 **Linux** platforms + **Mac OS X**



PANDAROOT Dashboard

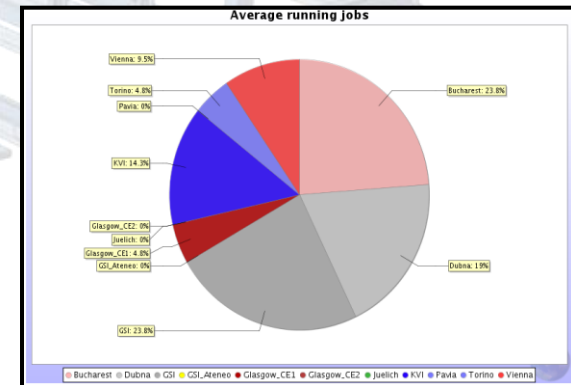
Information about stability and validity of the newest PandaRoot submission revision.

No fix changed as of Friday, May 18 2012 00:00:00 CEST

Site	Build Name	Version	Platform	Build	Test	Pass	Fail	Peak	Build Time
india.in	Ubuntu, Pandaroot-5.32, Geant4-9.5, ROOT-5.32, TGeo-9.5, TSQLServer-9.5, TMVA-9.5, PROOF-9.5, EVE-9.5, TGeo-9.5, TSQLServer-9.5, TMVA-9.5, PROOF-9.5, EVE-9.5	5.32	Linux	0	0	0	0	0	2012-05-18T00:00:00 CEST
india.in	Ubuntu, Pandaroot-5.32, Geant4-9.5, ROOT-5.32, TGeo-9.5, TSQLServer-9.5, TMVA-9.5, PROOF-9.5, EVE-9.5, TGeo-9.5, TSQLServer-9.5, TMVA-9.5, PROOF-9.5, EVE-9.5	5.32	Linux	0	0	0	0	0	2012-05-18T00:00:00 CEST
india.in	Ubuntu, Pandaroot-5.32, Geant4-9.5, ROOT-5.32, TGeo-9.5, TSQLServer-9.5, TMVA-9.5, PROOF-9.5, EVE-9.5, TGeo-9.5, TSQLServer-9.5, TMVA-9.5, PROOF-9.5, EVE-9.5	5.32	Linux	0	0	0	0	0	2012-05-18T00:00:00 CEST



collaboration with
external developers



CERN/ALICE
FAIR/HADES-CBM-R3B

Panda Data Flow

* Dual parton Model
** Ultra Relativistic Quantum
Molecular Dynamics

event
generation



transport



digitization



tracking



particle
identification



analysis

EvtGen

DPM*

Pythia6/8

Fluka

UrQMD**

GEANT3/GEANT4

MVD

STT

FTS

GEM

TOF

DIRC

MUON

EMC

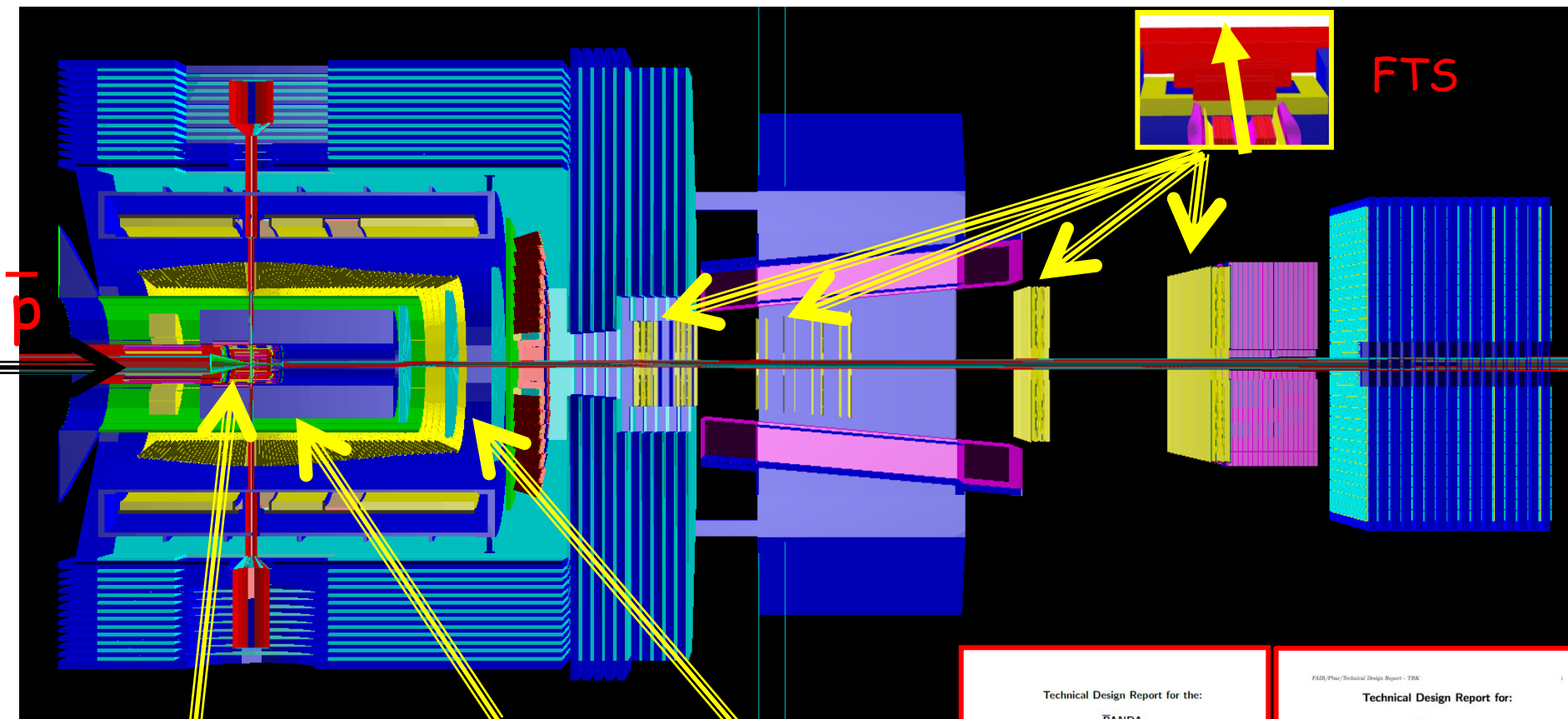
Charged Track

Charged Candidate

Neutral Candidate

PID Probability

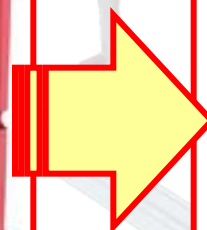
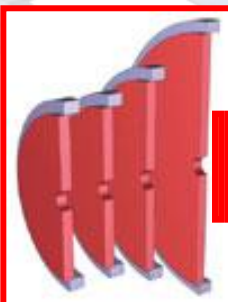
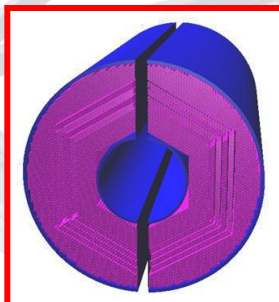
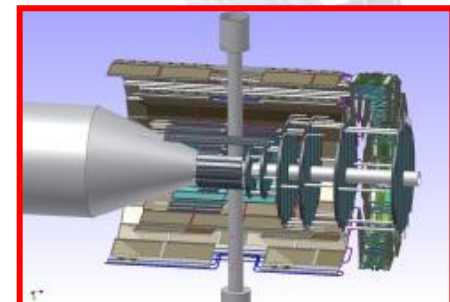
Analysis



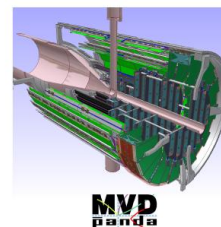
MVD

STT

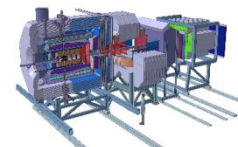
GEM

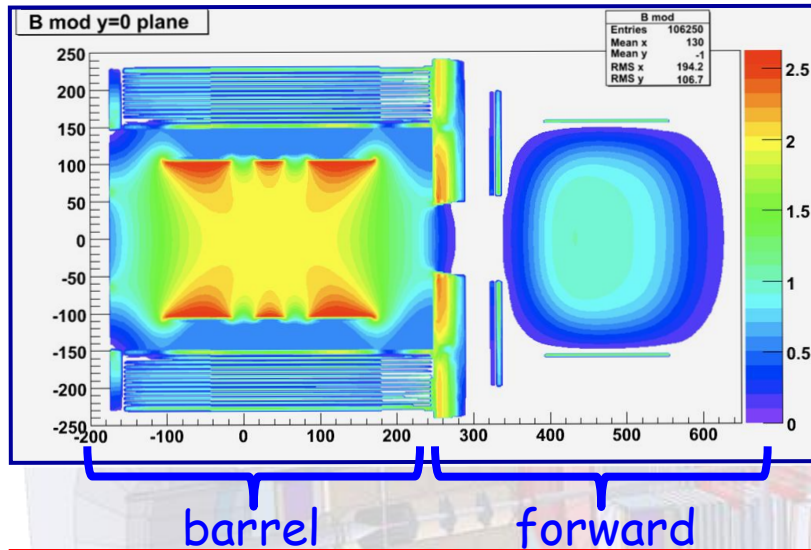


Technical Design Report for the:
PANDA
Micro Vertex Detector
(AntiProton Annihilations at Darmstadt)
Strong Interaction Studies with Antiprotons
PANDA Collaboration


MVD
panda

FAIR/Phas/Technical Design Report - TRK
Technical Design Report for:
PANDA
Tracking System
(AntiProton Annihilations at Darmstadt)
Strong Interaction Studies with Antiprotons
PANDA Collaboration
June 8, 2018





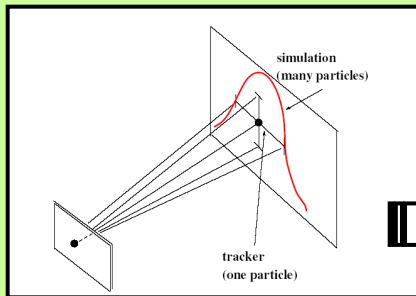
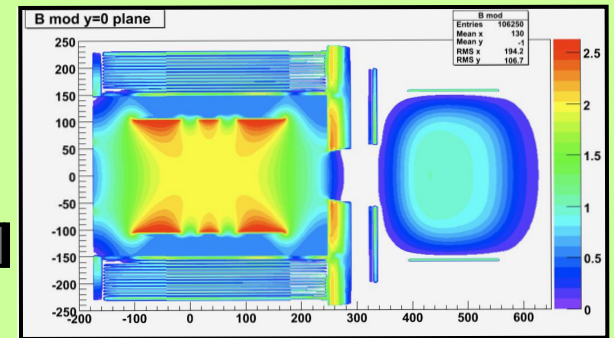
Energy loss
Not homogeneous magnetic field
Different detector hits

- 3D points - TPC
- planar hits - MVD/GEM
- tube + drift time - STT/FTS

Prefit Track

Kalman Filter
(GENFIT- Munich)

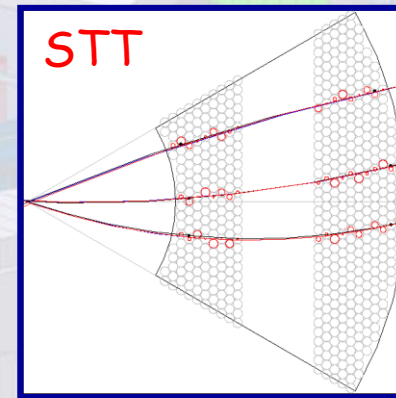
Detector Hits


Track Follower
(GEANE - Pavia)


same geometry for simulation and track following

Barrel Tracking: Pattern Recognition

1° step - MVD/STT **local** pattern recognition

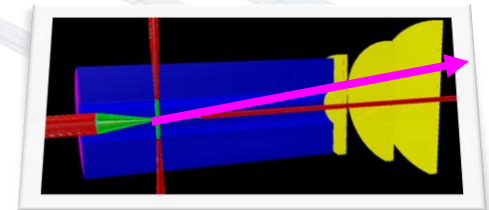
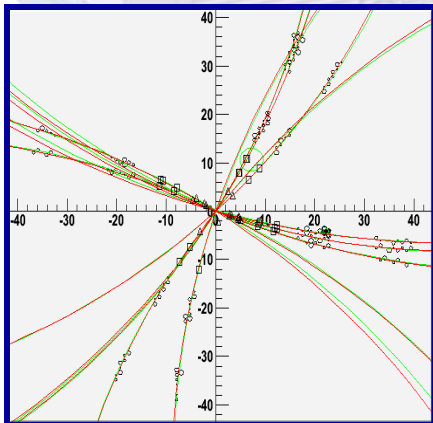


2° step - Correlation of **STT** & **MVD** tracklets

- Correlation with STT/MVD spurious hits

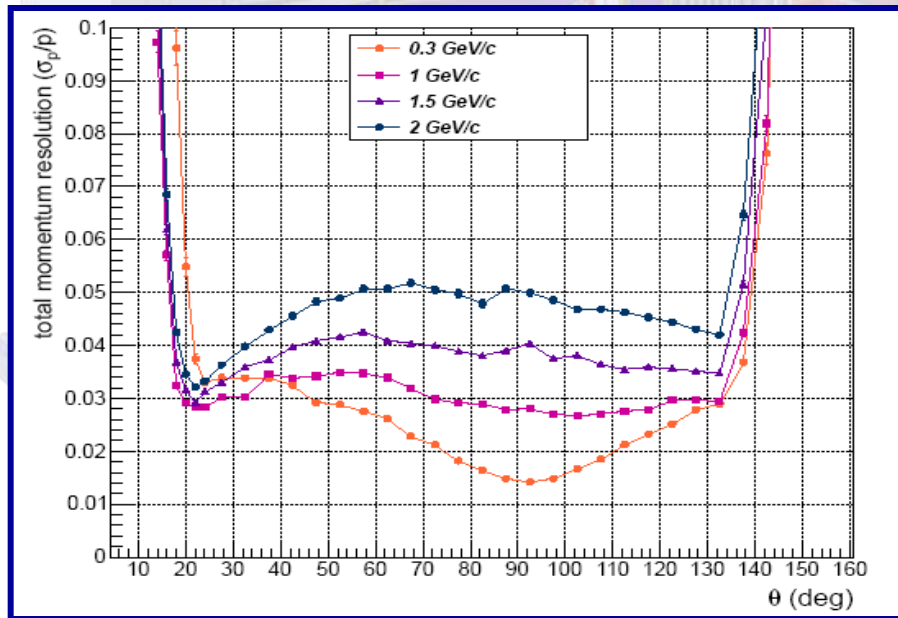
3° step - Extrapolation to **GEM** planes

4° step - Kalman Filter

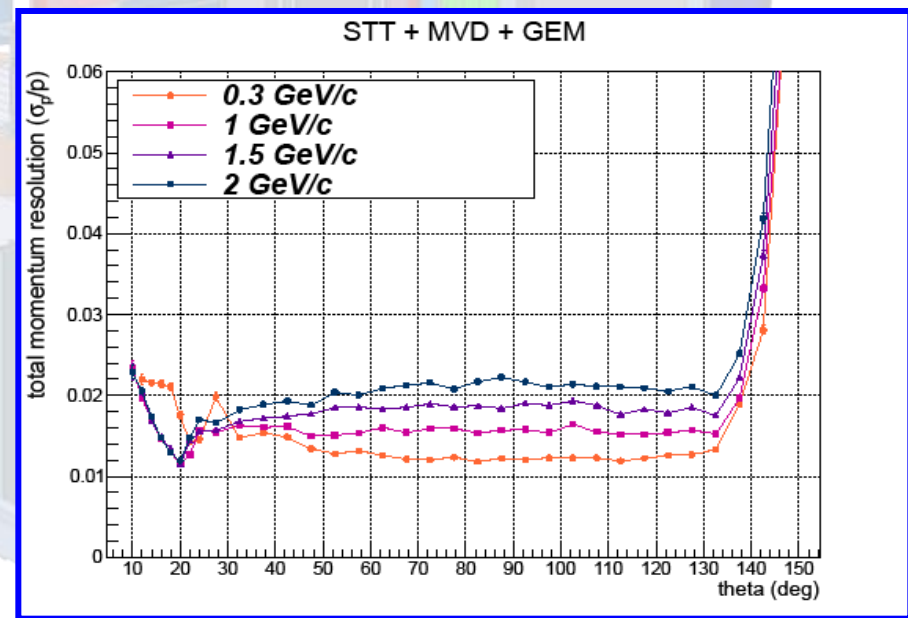


Barrel Tracking: Performances

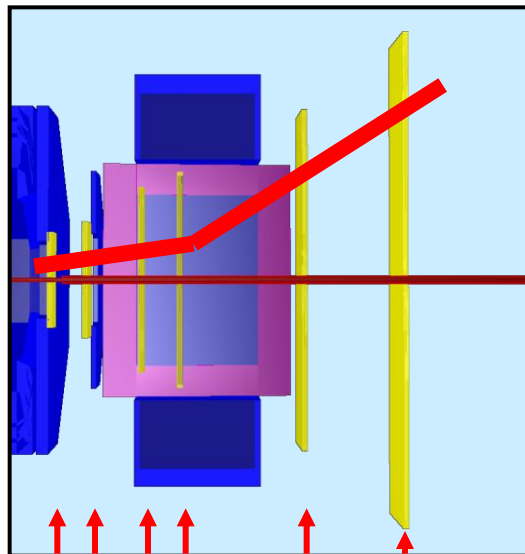
STT stand-alone



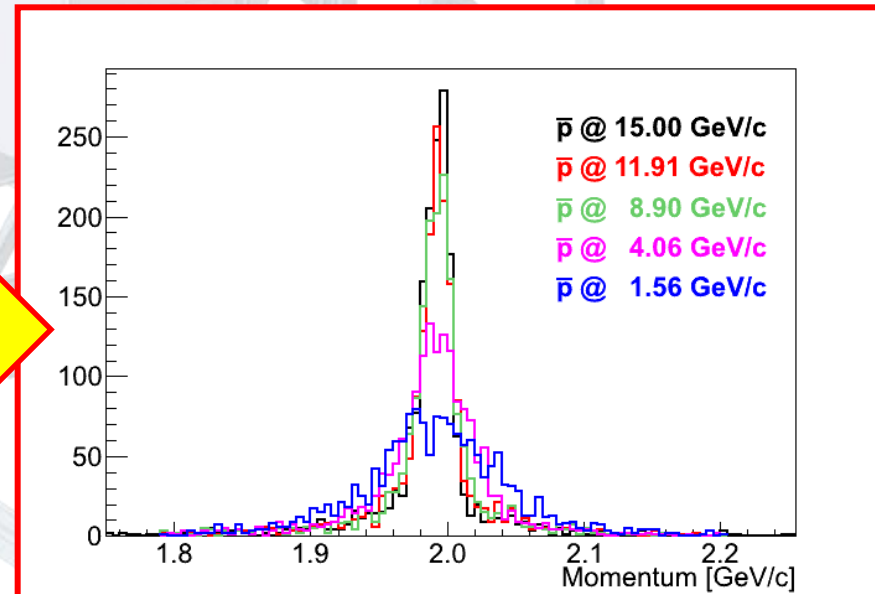
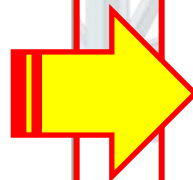
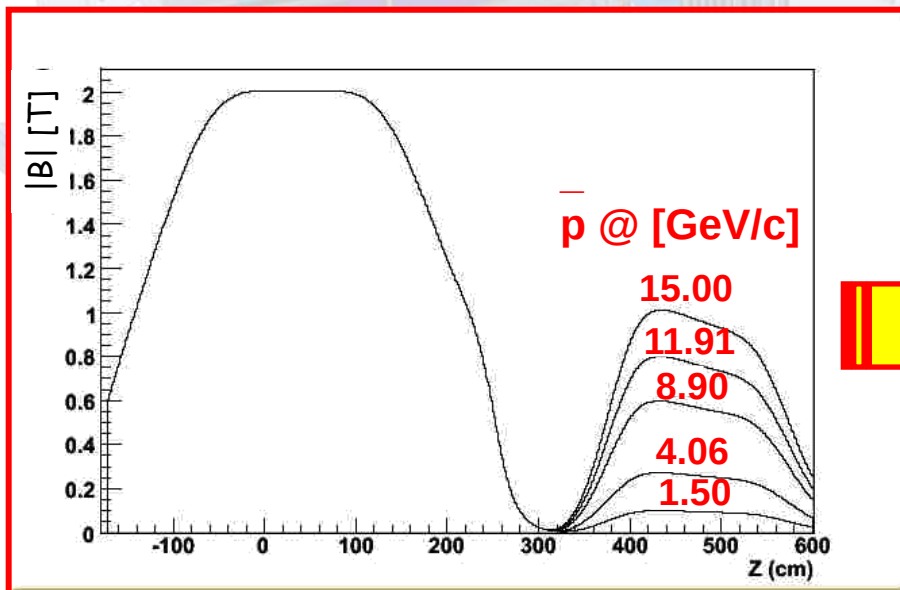
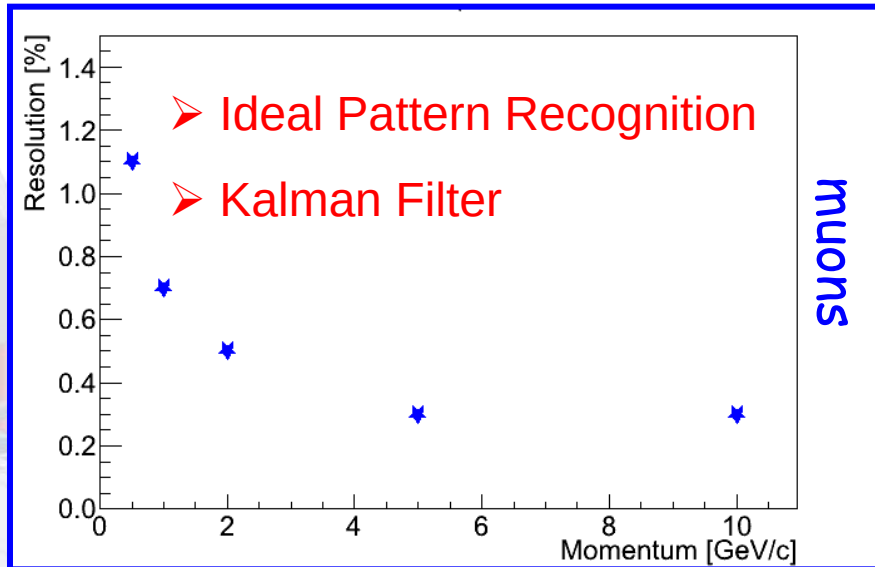
STT+MVD+GEM



Large Improvement from MVD/GEM detectors



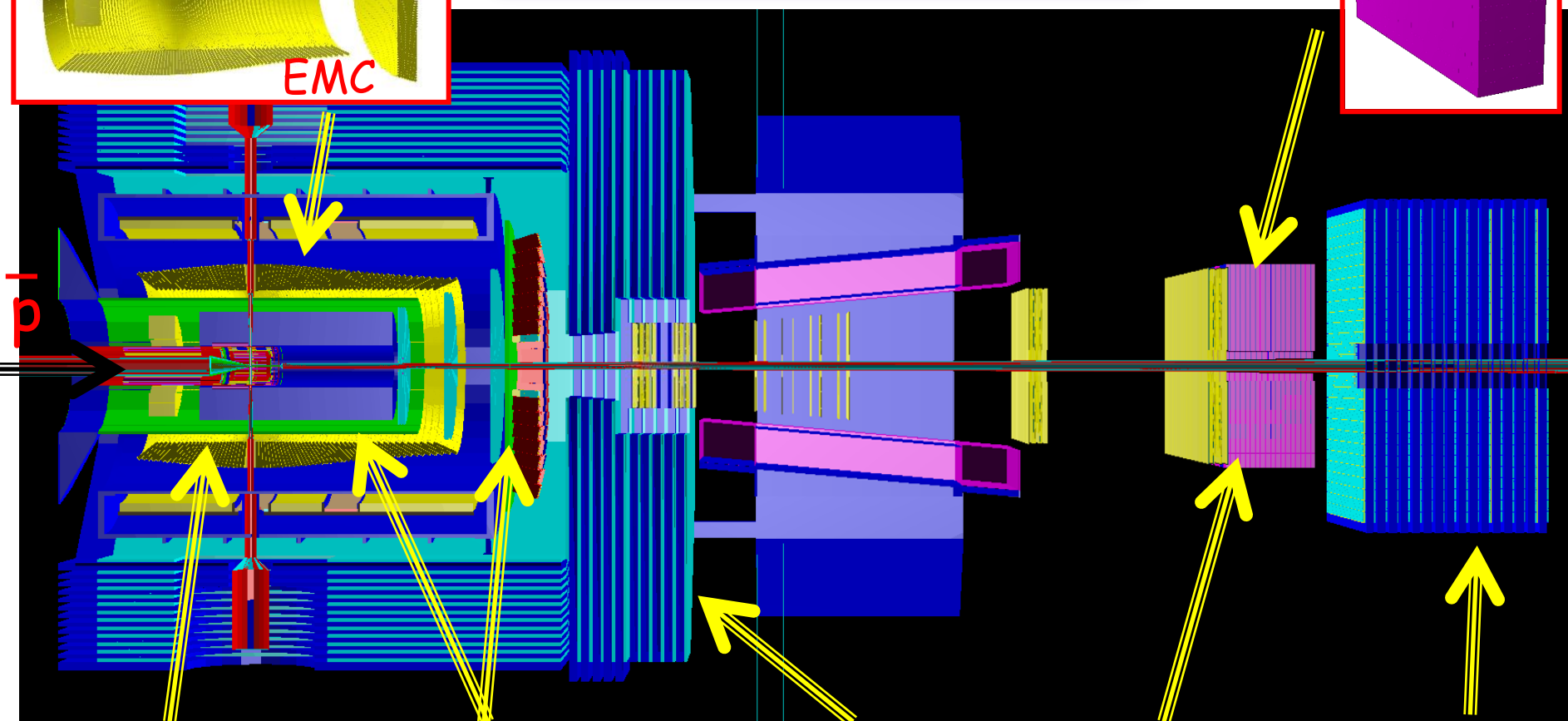
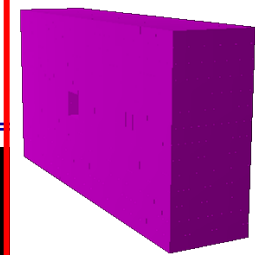
FTS
+
MVD
+
GEM



Particle Identification

Forward
EMC 1

EMC



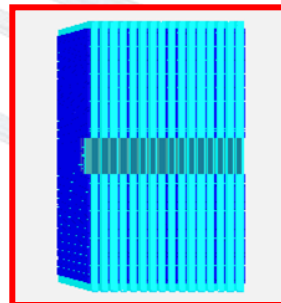
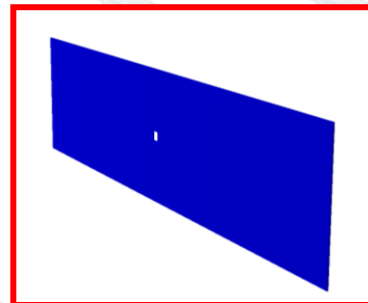
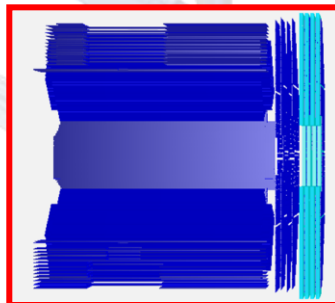
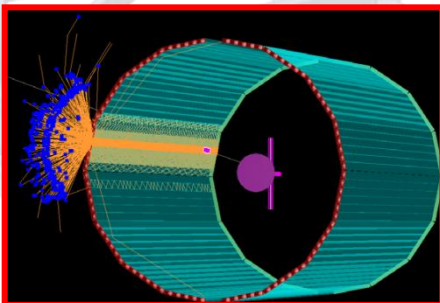
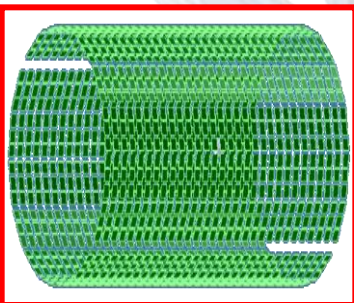
TOF

DIRC

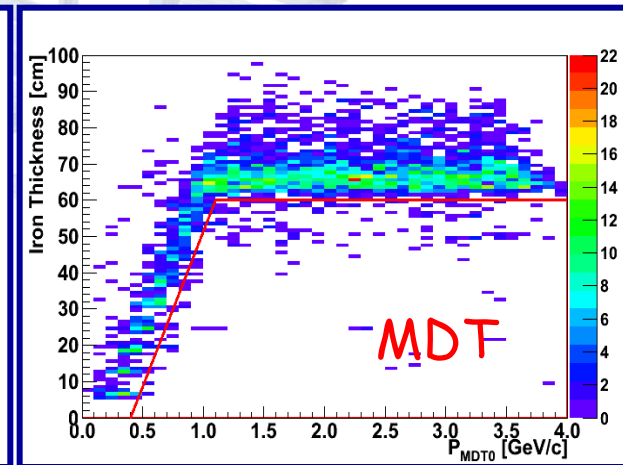
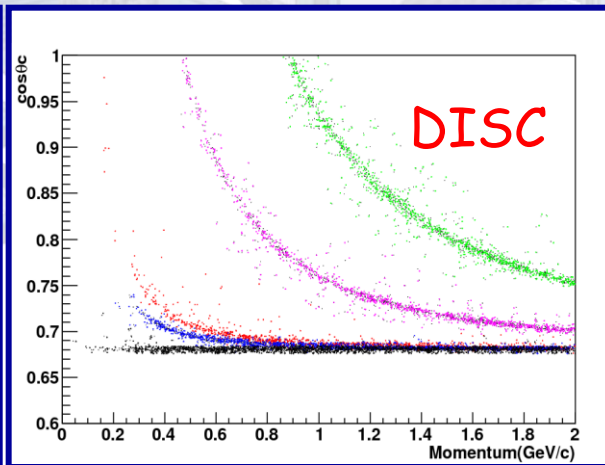
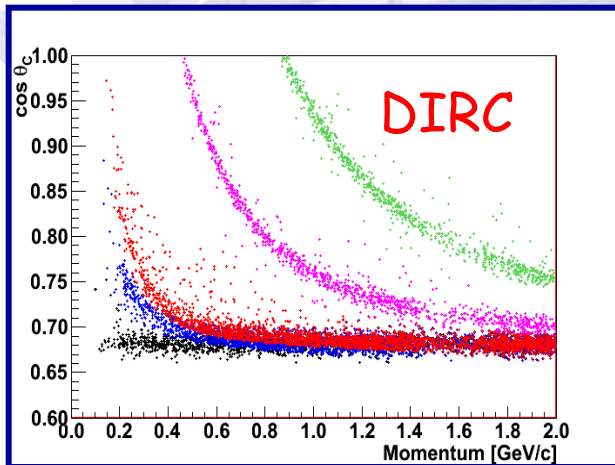
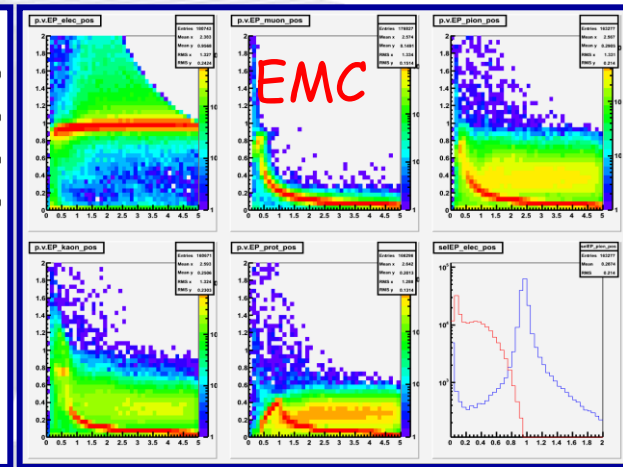
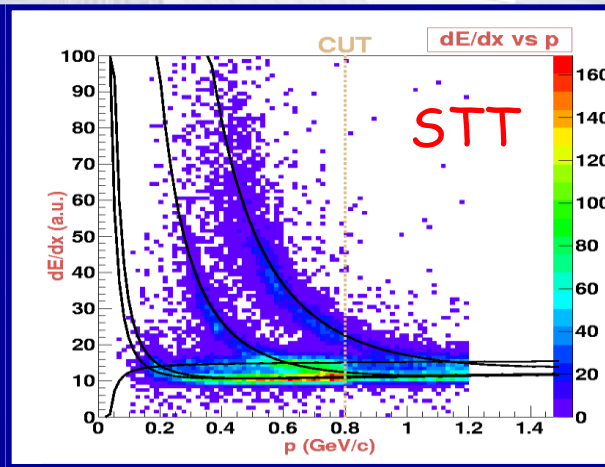
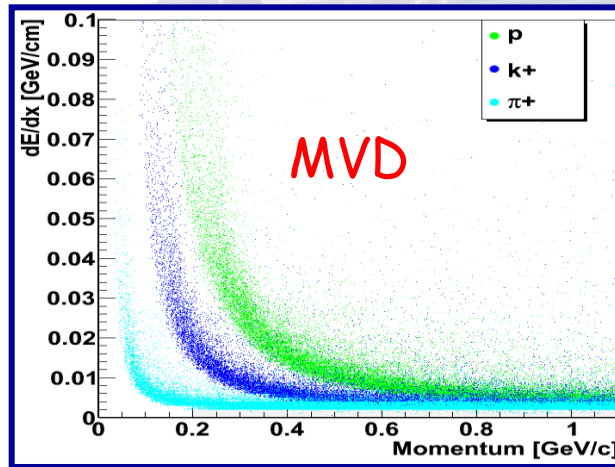
MDT

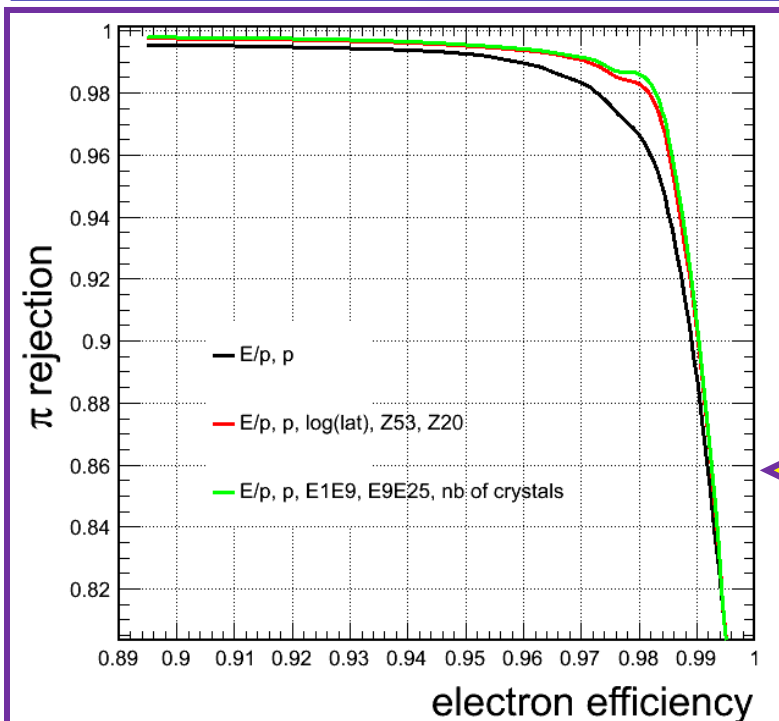
FTOF

FWDMDT



Implemented PDFs for many detectors (Bayes)





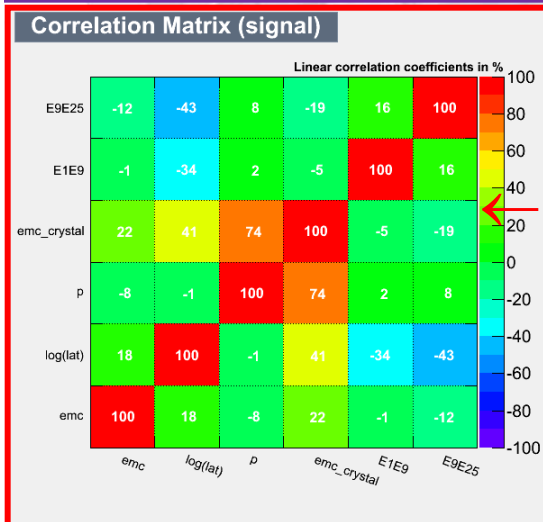
implementation of **TMVA** methods

➤ **EMC** shower shape analysis

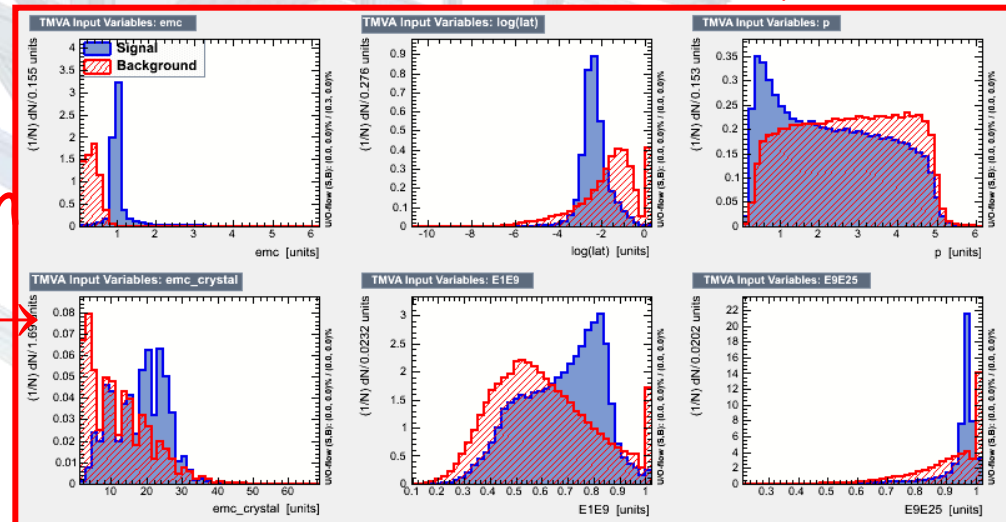
e/π
separation
in EMC

preliminary tests for muons (MDT)

M.Babai, M.Gumberidze, D.Melnichuk



Correlation
Variables

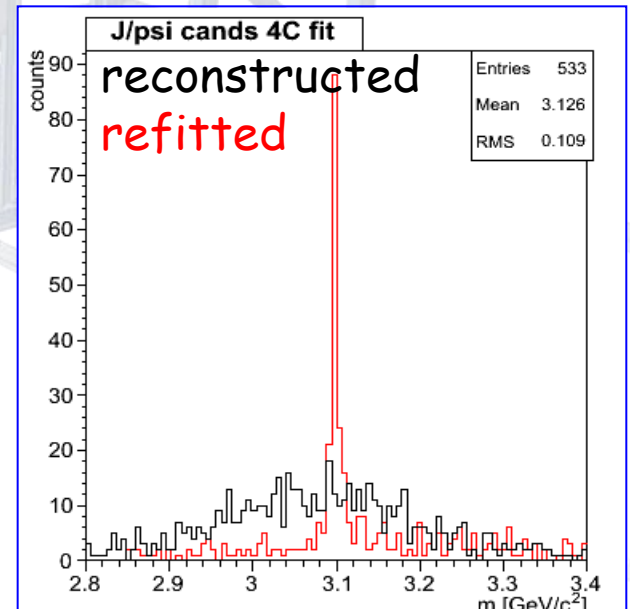
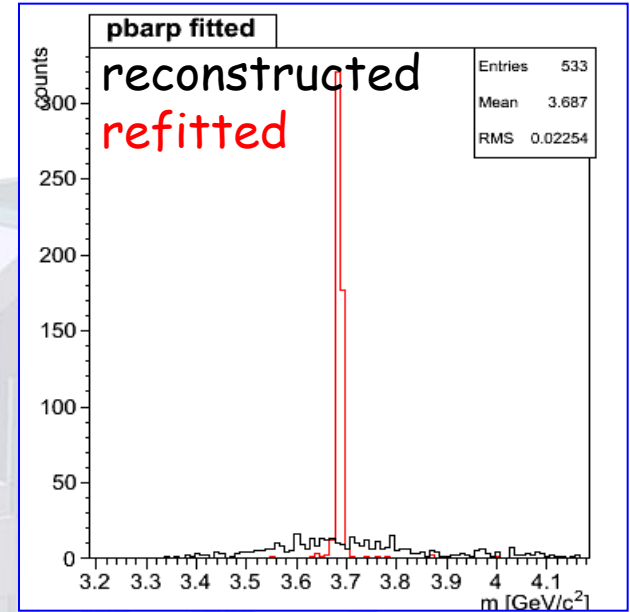
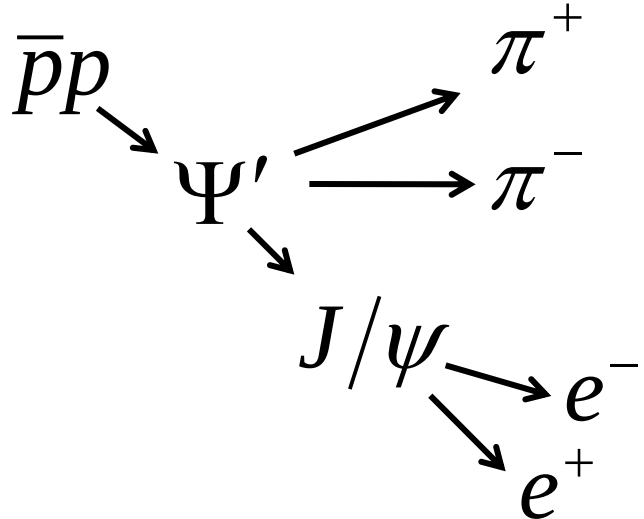


Analysis $\Rightarrow$ Rho Toolkit

Implementation of

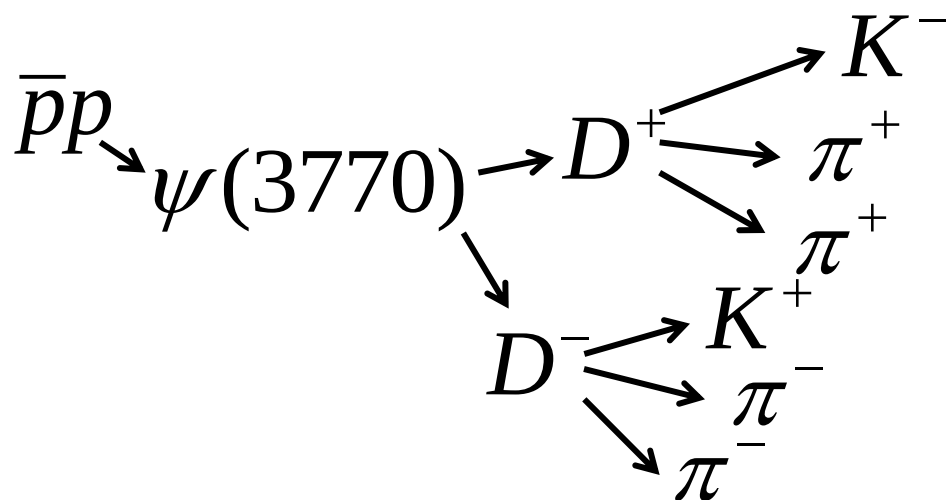
- kinematic fitters
- vertex fitters
- fast simulation

Ψ' 4C constraints

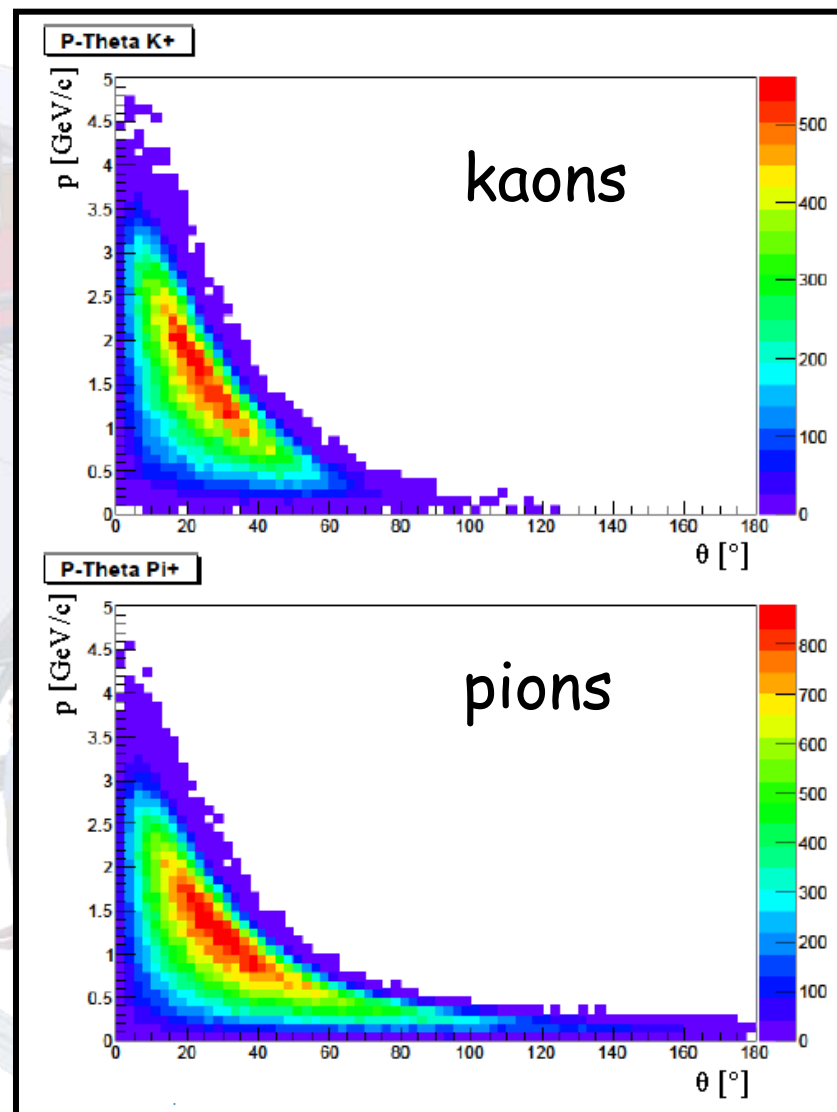


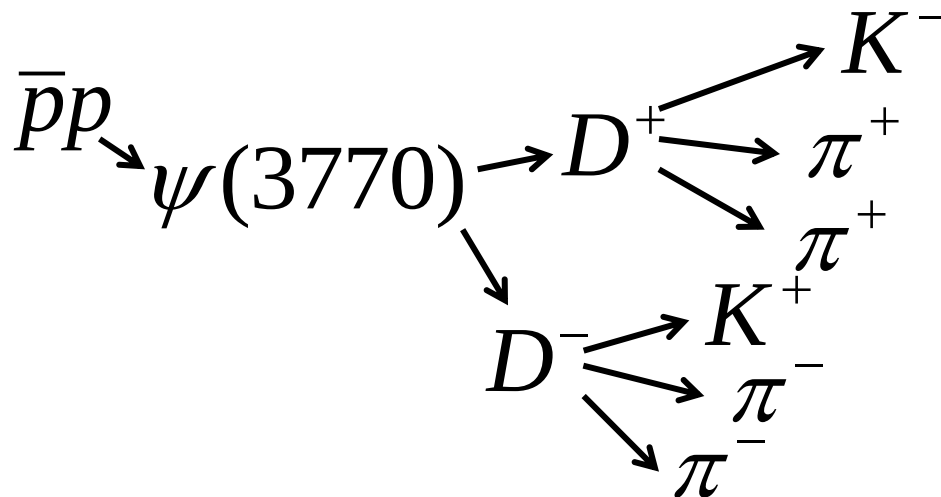
Reconstruction of Physics Channels - D^+D^-

Heavy-Light Systems

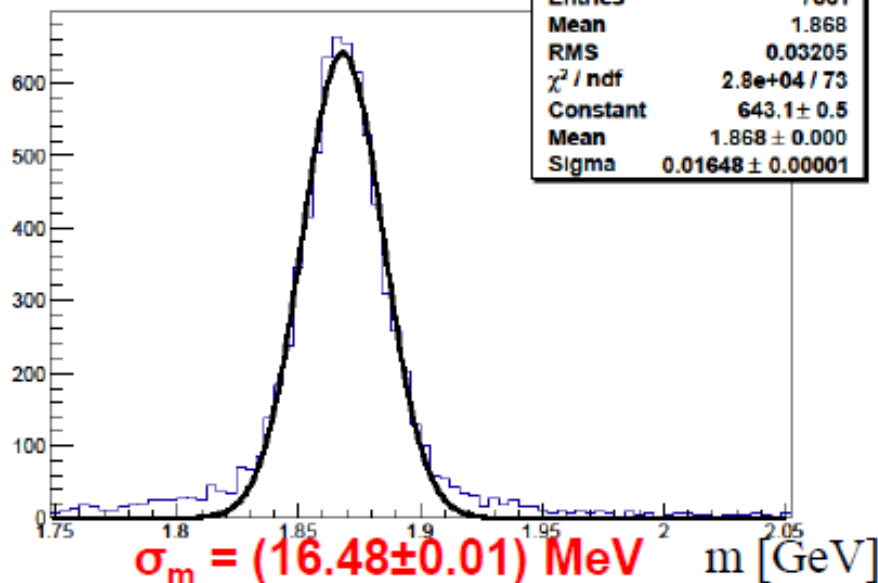


- ❑ 6 charged tracks in the final state
- ❑ Secondary vertexing

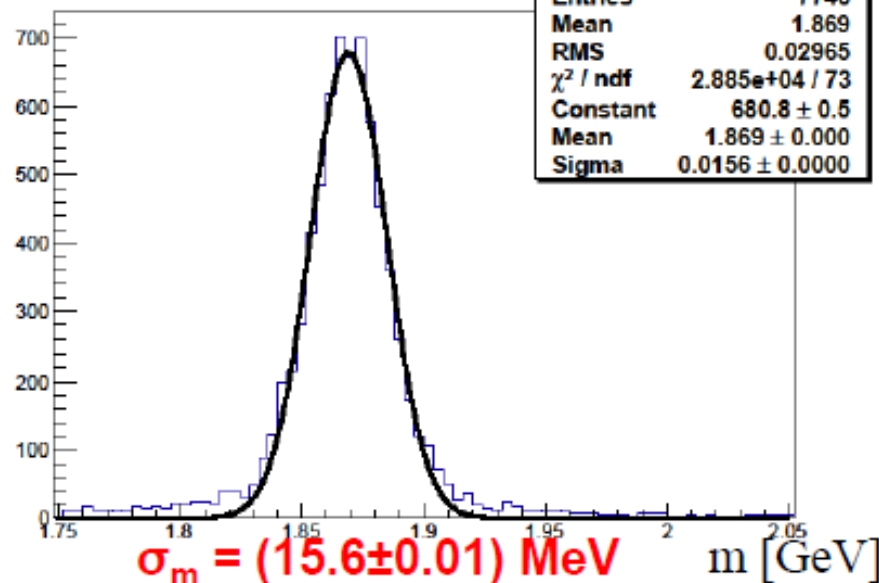




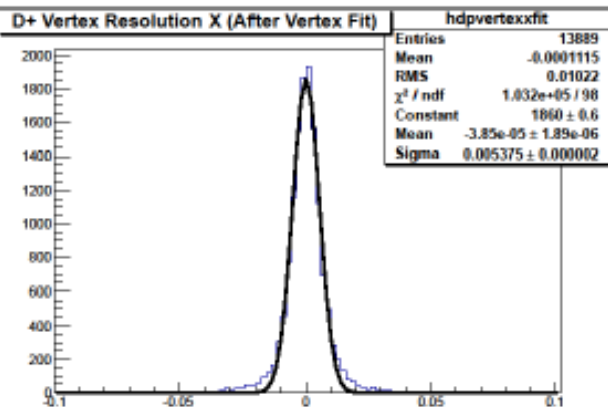
D+ Vertex Fit Accepted Mass



D- Vertex Fit Accepted Mass

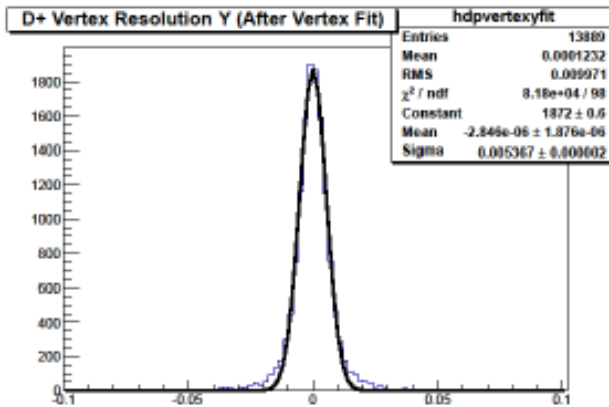


D-Meson Vertex Resolution



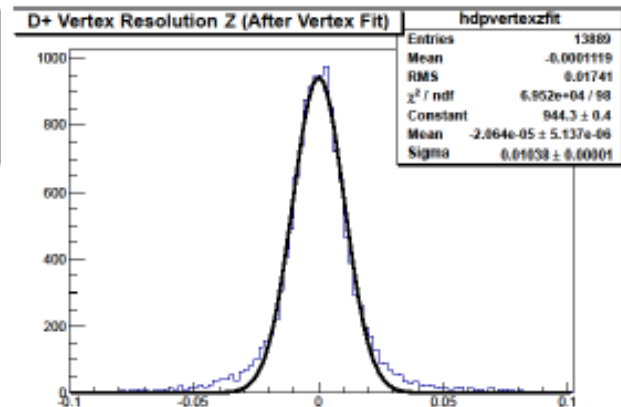
x (Reco - MC) [cm]

$$\sigma_x = (53.75 \pm 0.02) \mu\text{m}$$



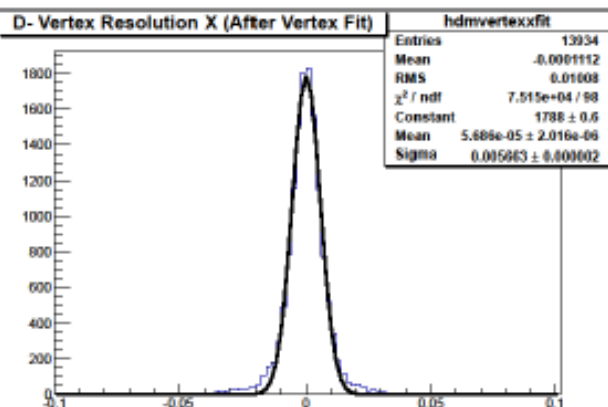
y (Reco - MC) [cm]

$$\sigma_y = (53.67 \pm 0.02) \mu\text{m}$$



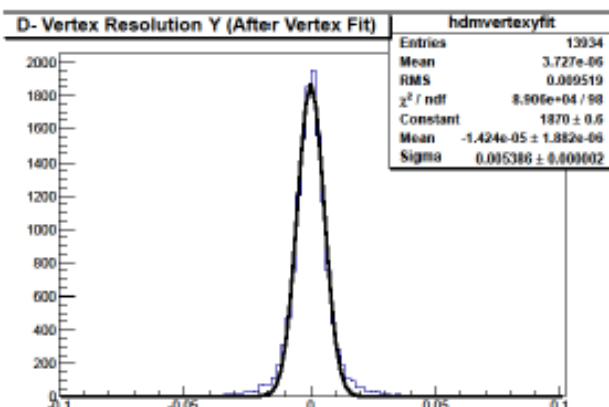
z (Reco - MC) [cm]

$$\sigma_z = (103.8 \pm 0.1) \mu\text{m}$$



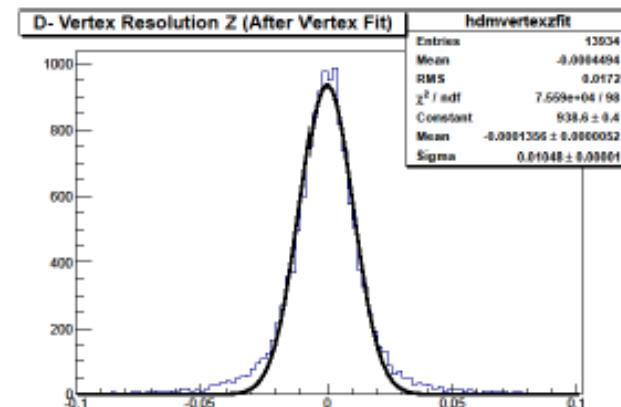
x (Reco - MC) [cm]

$$\sigma_x = (56.63 \pm 0.02) \mu\text{m}$$



y (Reco - MC) [cm]

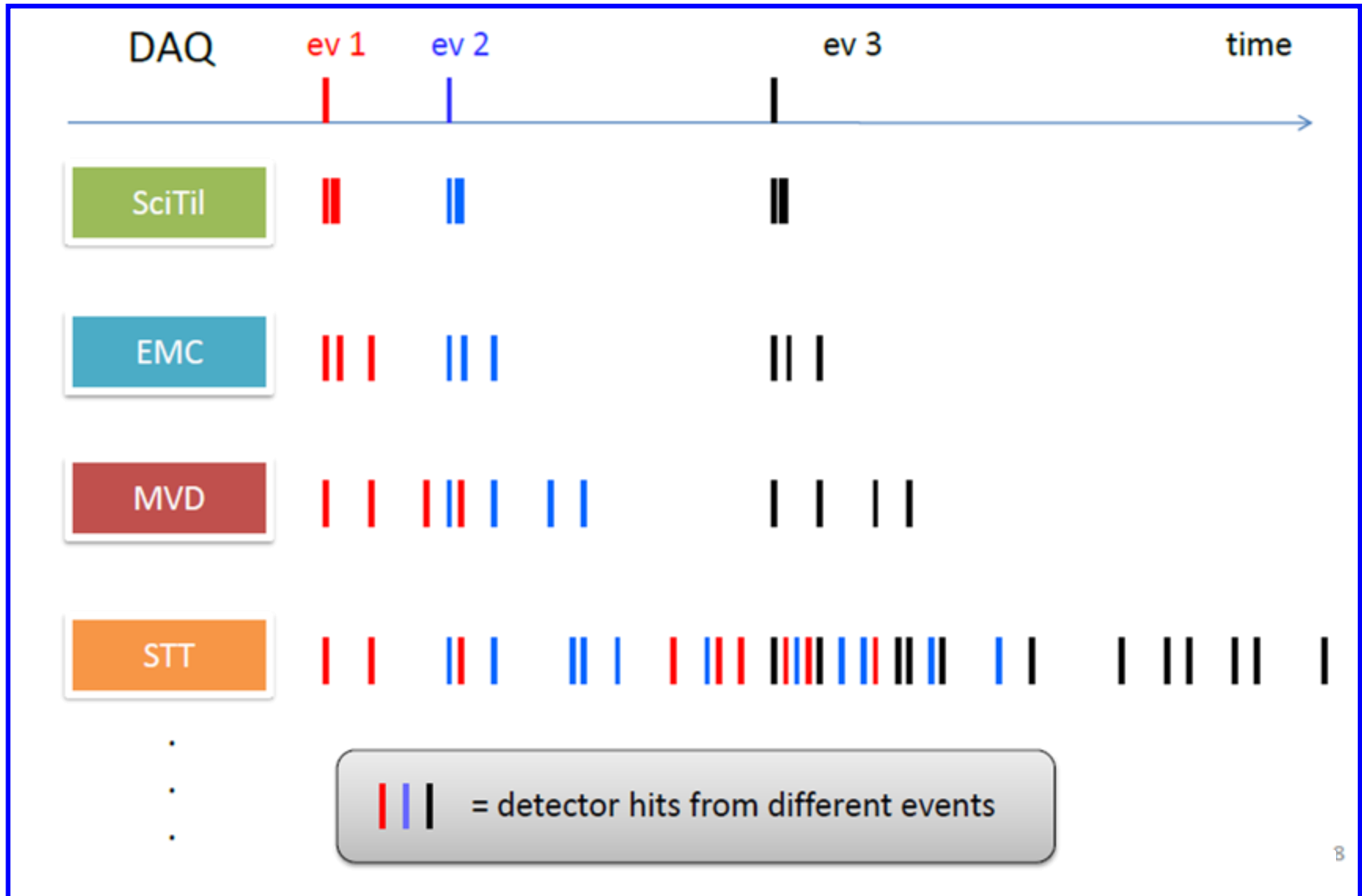
$$\sigma_y = (53.86 \pm 0.02) \mu\text{m}$$

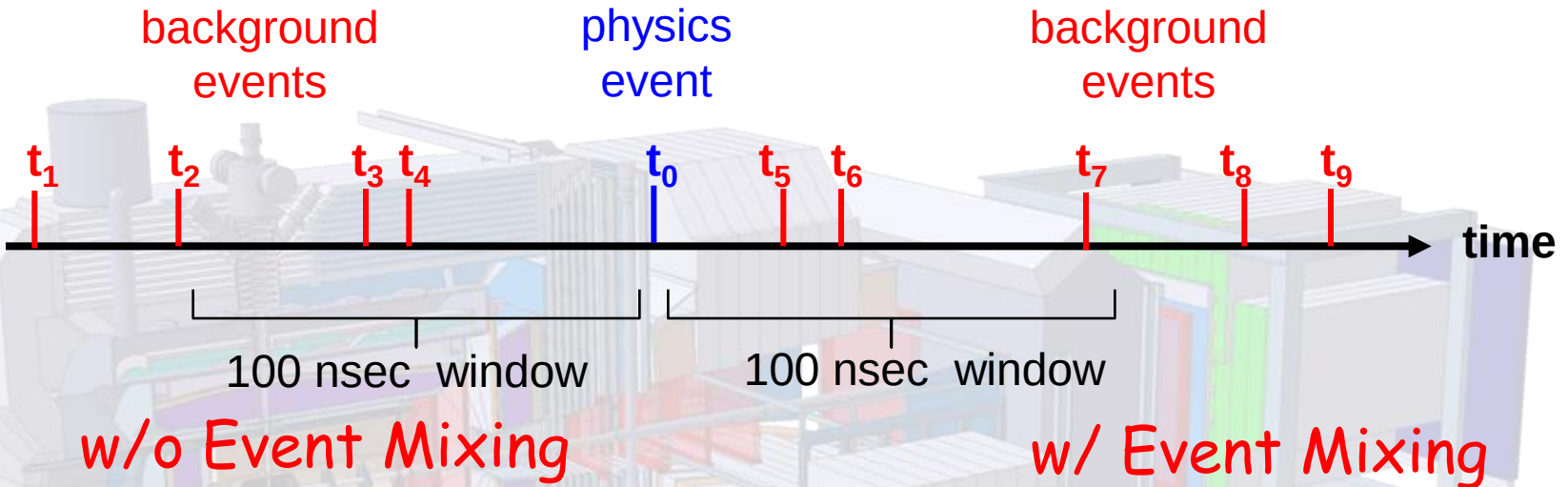


z (Reco - MC) [cm]

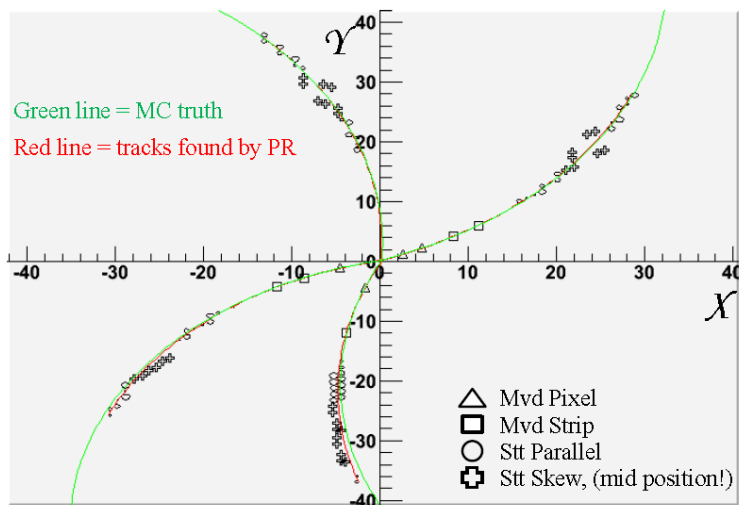
$$\sigma_z = (104.8 \pm 0.1) \mu\text{m}$$

slow transition from **event based** to **time ordered** simulation





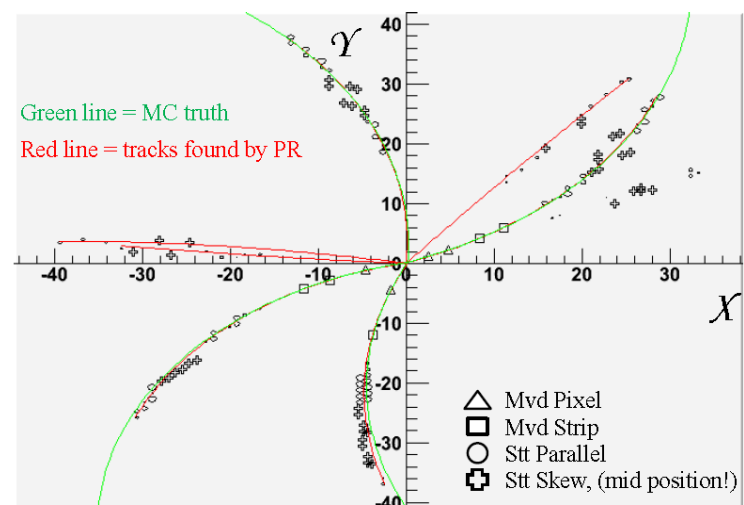
Example : 4 tracks evt mixed with previous bkg evt with $\delta t = -100$ nsec



Unmixed 4 track event

4

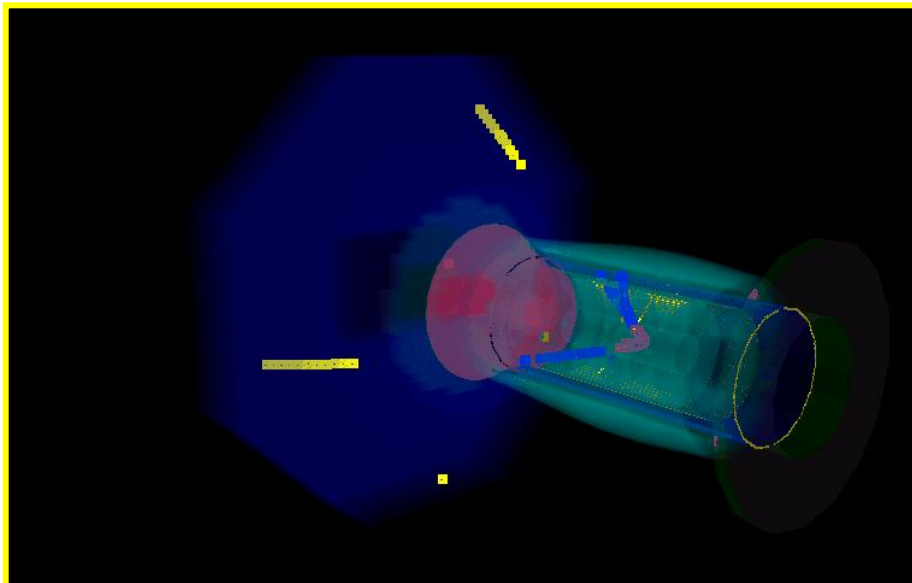
Example : 4 tracks evt mixed with previous bkg evt with $\delta t = -100$ nsec



Resulting mixed event

5

@ 20 MHz interaction rate

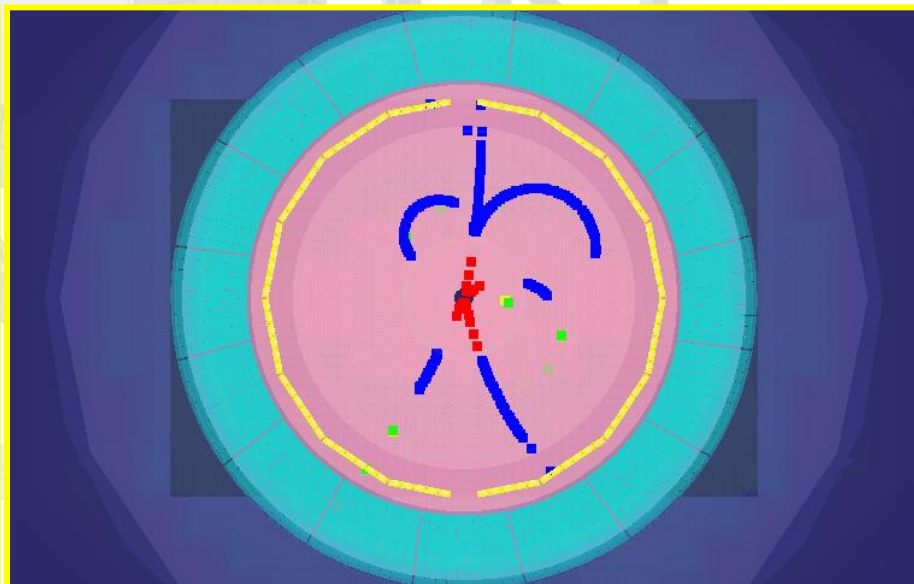
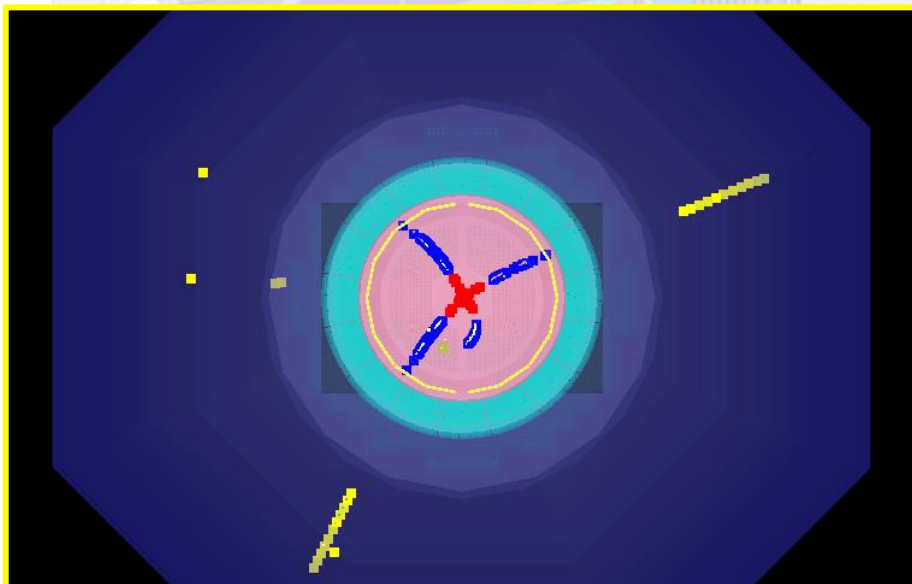


Event Display $\Rightarrow$ TEve

$X(3872) \rightarrow J/\psi \pi^+ \pi^-$

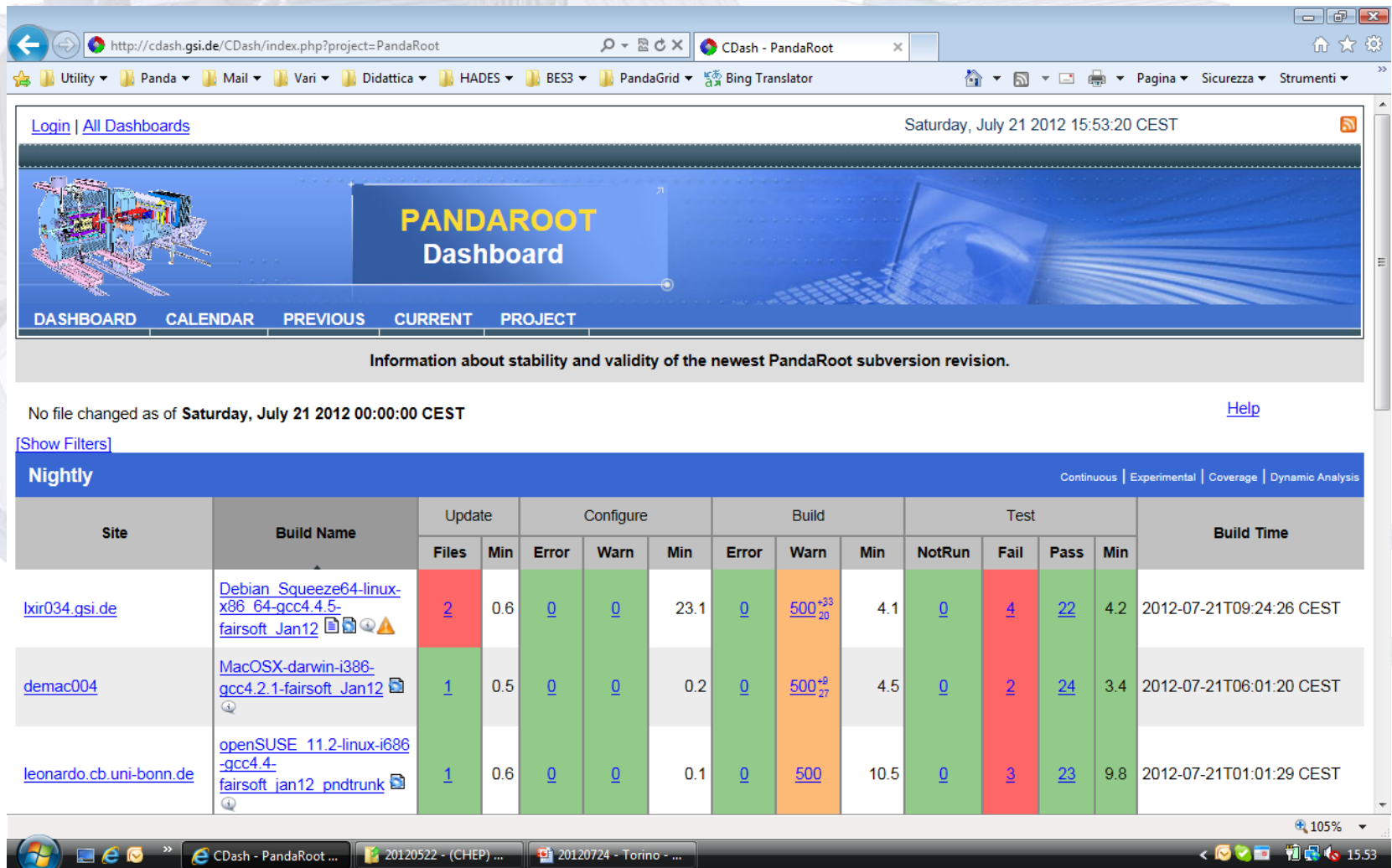
$J/\psi \rightarrow \mu^+ \mu^-$

$J/\psi \rightarrow e^+ e^-$



Is today a good day to update the trunk?

<http://cdash.gsi.de/CDash/index.php?project=PandaRoot>



The screenshot shows the CDash PandaRoot dashboard. The top navigation bar includes links for Login, All Dashboards, and a timestamp of Saturday, July 21 2012 15:53:20 CEST. The main header displays 'PANDAROOT Dashboard' with tabs for DASHBOARD, CALENDAR, PREVIOUS, CURRENT, and PROJECT. Below the header, a message states 'Information about stability and validity of the newest PandaRoot subversion revision.' and 'No file changed as of Saturday, July 21 2012 00:00:00 CEST'. A 'Show Filters' link is present. The main content area is titled 'Nightly' and includes a table with build status for three sites: lxir034.gsi.de, demac004, and leonardo.cb.uni-bonn.de. The table columns include Site, Build Name, Update (Files, Min), Configure (Error, Warn, Min), Build (Error, Warn, Min), Test (NotRun, Fail, Pass, Min), and Build Time.

Site	Build Name	Update		Configure			Build			Test				Build Time
		Files	Min	Error	Warn	Min	Error	Warn	Min	NotRun	Fail	Pass	Min	
lxir034.gsi.de	Debian_Squeeze64-linux-x86_64-gcc4.4.5-fairsoft_Jan12	2	0.6	0	0	23.1	0	500 ⁺³³ ₂₀	4.1	0	4	22	4.2	2012-07-21T09:24:26 CEST
demac004	MacOSX-darwin-i386-gcc4.2.1-fairsoft_Jan12	1	0.5	0	0	0.2	0	500 ⁺⁸ ₂₇	4.5	0	2	24	3.4	2012-07-21T06:01:20 CEST
leonardo.cb.uni-bonn.de	openSUSE_11.2-linux-i686-gcc4.4-fairsoft_jan12_pndtrunk	1	0.6	0	0	0.1	0	500	10.5	0	3	23	9.8	2012-07-21T01:01:29 CEST

This code is a mess!

Site	Build Name	Update		Configure			Build			Test				Build Time
		Files	Min	Error	Warn	Min	Error	Warn	Min	NotRun	Fail	Pass	Min	
lxir034.gsi.de	Debian_Squeeze64-linux-x86_64-gcc4.4.5-fairsoft_Jan12  	2	0.6	0	0	23.1	0	500 ⁺³³ ₂₀	4.1	0	4	22	4.2	2012-07-21T09:24:26 CEST
demac004	MacOSX-darwin-i386-gcc4.2.1-fairsoft_Jan12 	1	0.5	0	0	0.2	0	500 ⁺⁹ ₂₇	4.5	0	2	24	3.4	2012-07-21T06:01:20 CEST
leonardo.cb.uni-bonn.de	openSUSE_11.2-linux-i686-gcc4.4-fairsoft_jan12_pndtrunk 	1	0.6	0	0	0.1	0	500	10.5	0	3	23	9.8	2012-07-21T01:01:29 CEST
fb07-nuclear.physik.uni-giessen.de	SLC_5.5-linux-x86_64-gcc4.1.2-fairsoft_install_2012_01_27  	1	0.3	0	0	0	0	500 ⁺⁶⁵ ₈₈	1.4	0	2 ⁺² ₂	24 ₂	4.8	2012-07-21T02:00:59 CEST
briareos	Ubuntu12.04-linux-x86_64-gcc4.6-fairsoft_jan12  	0	0.8	0	0	0	0	500 ⁺¹⁸ ₁₆	2.7	0	4	22	2.2	2012-07-21T02:31:34 CEST
p Chad8.physik.uni-giessen.de	Ubuntu_11.10-linux-x86_64-gcc4.6-fairsoft_install  	2	0.6	0	0	0	0	500 ⁺⁹ ₈₀	1.9	0	0	26	2.3	2012-07-21T02:01:10 CEST
Totals	6 Builds	7	3.4	0	0	23.4	0	3000	25.1	0	15	141	26.7	
Continuous														
		Update		Configure			Build			Test				

Dashboard script are screwed

Macros do not work

It does not compile, no chance

Analysis Chain

```
> cd $VMCWORKDIR/macro/pid  
> root -l run_sim_sttcombi_pgun.C  
> root -l run_digi_sttcombi.C  
> root -l run_reco_sttcombi.C  
> root -l run_pid.C
```

Simulation
Digitization
Reconstruction
Pid

* Dual parton Model
** Ultra Relativistic Quantum Molecular Dynamics

event
generation



transport



digitization



tracking



particle
identification



analysis

EvtGen

DPM*

Pythia6/8

Fluka

UrQMD**

GEANT3/GEANT4

MVD

STT

FTS

GEM

TOF

DIRC

MUON

EMC

Charged Track

Charged Candidate

Neutral Candidate

PID Probability

Analysis

What "simulation" does

- Produce physical events (event generators)
- Propagate particles inside the detector (transport models)
- ... interactions with materials and with magnetic field

What "simulation" stores

- MonteCarlo information of all/some of the particles
- MC position, energy loss, time, inside detectors
- Geometry parameter file

macro/pid/run_sim_sttcombi_pgun.C

```
run_sim_sttcombi_pgun(Int_t nEvents=10, Int_t pid=13, Float_t p1=1.0, Float_t p2=-1, UInt_t seed=0)
```

Parameters for the macro

```
{
```

```
gRandom->SetSeed(seed);
```

Set the seed, if 0 -> random seed

```
TStopwatch timer;
```

```
timer.Start();
```

```
gDebug=0;
```

```
// Load basic libraries
```

```
// If it does not work, please check the path of the libs and put it by hands
```

```
gROOT->LoadMacro("$VMCWORKDIR/gconfig/rootlogon.C");
```

load the environment

```
rootlogon();
```

```
TString digiFile = "all.par";
```

```
TString parFile = "params_sttcombi.root";
```

```
FairRunSim *fRun = new FairRunSim();
```

```
// set the MC version used
```

```
// -----
```

```
fRun->SetName("TGeant3");
```

geant3 or geant4

```
//fRun->SetName("TGeant4");
```

```
fRun->SetOutputFile("points_sttcombi.root");
```

Passive elements

no data, only interaction with materials

```
fRun->SetMaterials("media_pnd.geo");
```

file with all the media definitions

```
// Create and add detectors
```

```
//-----
```

```
FairModule *Cave= new PndCave("CAVE");
```

```
Cave->SetGeometryFileName("pndcave.geo");
```

```
fRun->AddModule(Cave);
```

```
FairModule *Magnet= new PndMagnet("MAGNET");
```

```
// Magnet->SetGeometryFileName("FullSolenoid_V842.root");
```

// full solenoid geometry

```
Magnet->SetGeometryFileName("FullSuperconductingSolenoid_v831.root");
```

only coils

```
fRun->AddModule(Magnet);
```

```
FairModule *Dipole= new PndMagnet("MAGNET");
```

```
Dipole->SetGeometryFileName("dipole.geo");
```

dipole geometry

```
fRun->AddModule(Dipole);
```

```
FairModule *Pipe= new PndPipe("PIPE");
```

```
//Pipe->SetGeometryFileName("beampipe_201112.root");
```

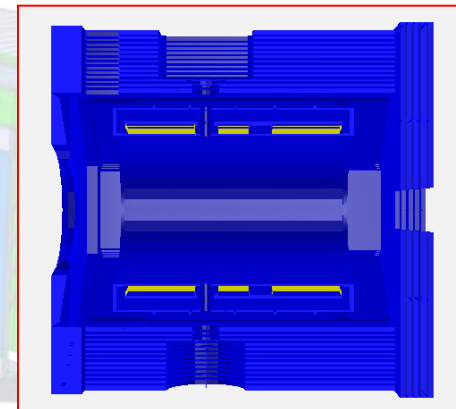
// curved pipe in forward region

```
fRun->AddModule(Pipe);
```

Magnet Design

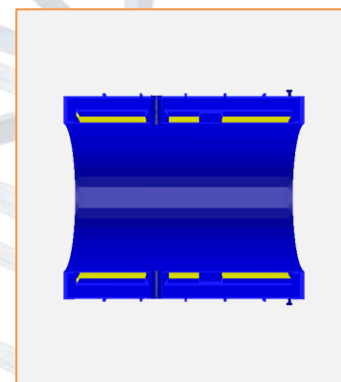
Full CAD conversion (Tobias Stockmanns)

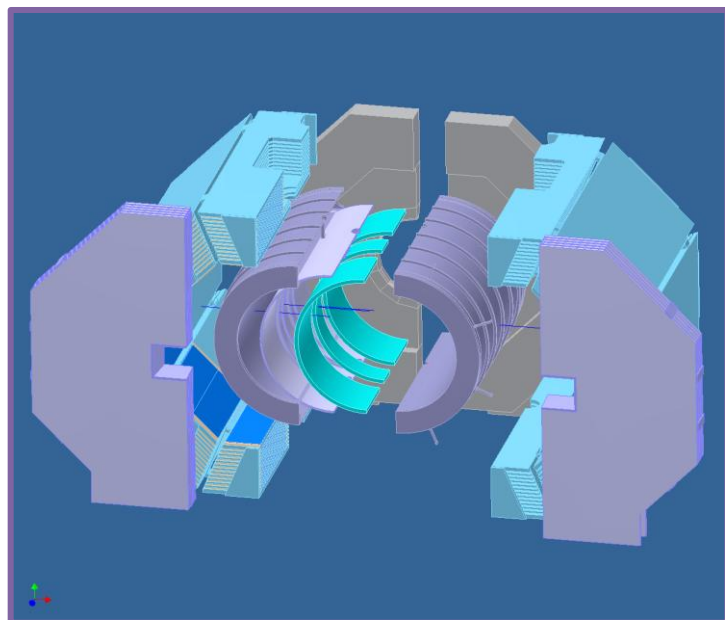
```
FairModule *Magnet= new PndMagnet("MAGNET");
Magnet->SetGeometryFileName
    ("FullSolenoid_V842.root");
fRun->AddModule(Magnet);
```



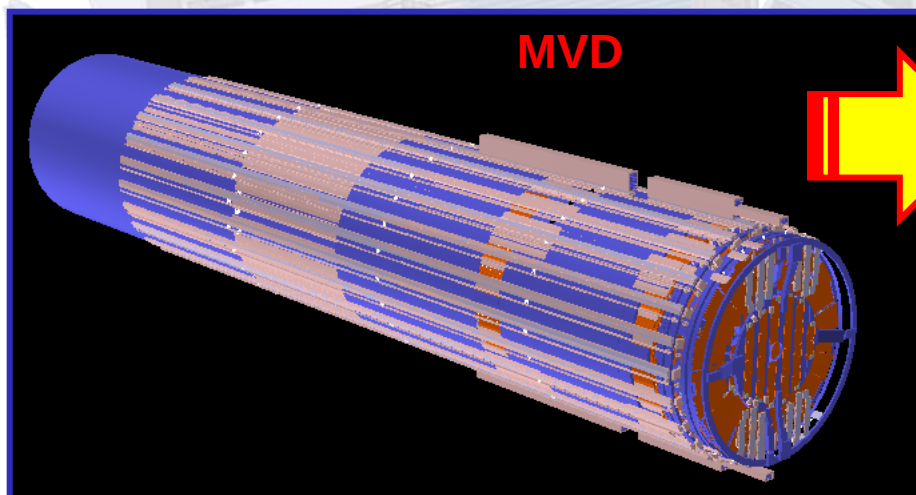
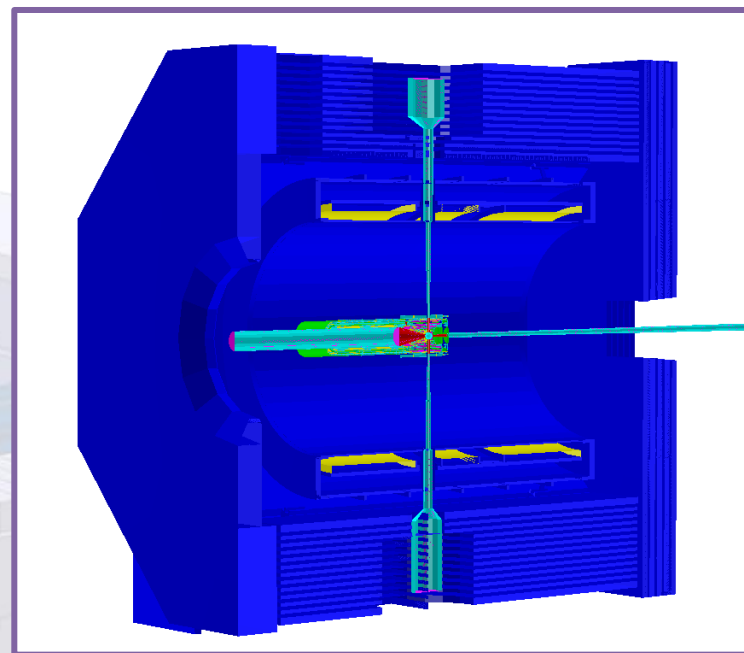
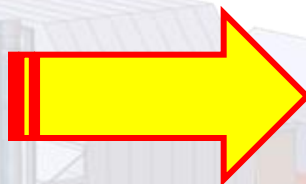
Coils CAD conversion (Tobias Stockmanns)

```
FairModule *Magnet= new PndMagnet("MAGNET");
Magnet->SetGeometryFileName
    ("FullSuperconductingSolenoid_V831.root");
fRun->AddModule(Magnet);
```

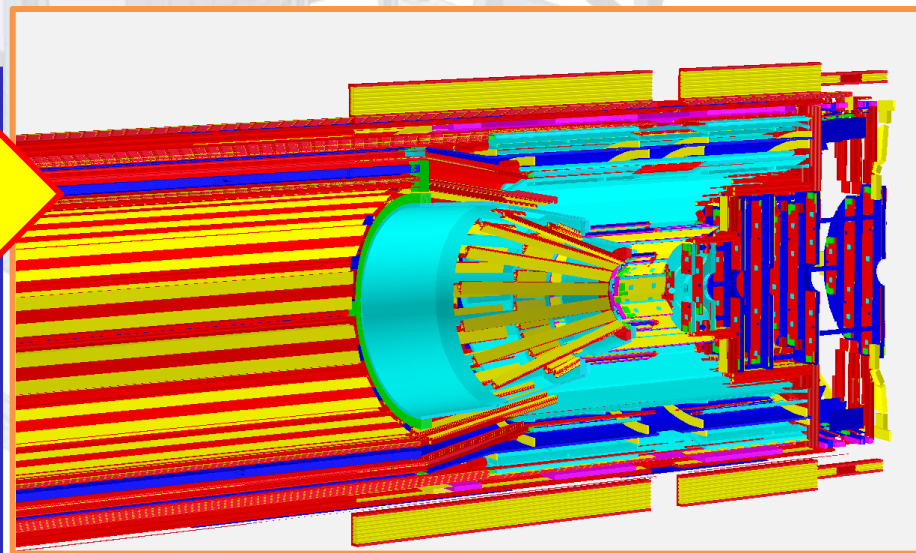
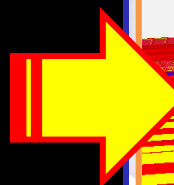




Solenoid
Yoke



MVD





24th July 2012

Stefano Spataro

The PandaRoot Code

How to run a full analysis chain



```
FairDetector *Stt= new PndStt("STT", kTRUE);  
Stt->SetGeometryFileName("straws_skewed_blocks_35cm_pipe.geo");  
fRun->AddModule(Stt);
```

kTRUE:

data stored

kFALSE:

no data stored

```
FairDetector *Mvd = new PndMvdDetector("MVD", kTRUE);  
Mvd->SetGeometryFileName("Mvd-2.1_FullVersion.root");  
fRun->AddModule(Mvd);
```

```
PndEmc *Emc = new PndEmc("EMC", kTRUE);  
Emc->SetGeometryVersion(1);  
Emc->SetStorageOfData(kFALSE);  
fRun->AddModule(Emc);
```

```
PndDrc *Drc = new PndDrc("DIRC", kTRUE);  
Drc->SetGeometryFileName("dirc_l0_p0_updated.root");  
Drc->SetRunCherenkov(kFALSE); // for fast sim Cherenkov -> kFALSE  
fRun->AddModule(Drc);
```

```
FairDetector *SciT = new PndSciT("SCIT", kTRUE);  
SciT->SetGeometryFileName("SciTil_Barrel_woPCB.root");  
fRun->AddModule(SciT);
```

```
FairDetector *Fts= new PndFts("FTS", kTRUE);  
Fts->SetGeometryFileName("fts.geo");  
fRun->AddModule(Fts);
```

```
PndMdt *Muo = new PndMdt("MDT", kTRUE);  
Muo->SetBarrel("fast");  
Muo->SetEndcap("fast");  
Muo->SetMuonFilter("fast");  
Muo->SetMdtMagnet(kTRUE);  
Muo->SetMdtMFIron(kTRUE);  
fRun->AddModule(Muo);
```

```
FairDetector *FTof = new PndFtof("FTOF", kTRUE);  
FTof->SetGeometryFileName("ftofwall.root");  
fRun->AddModule(FTof);
```

```
FairDetector *Gem = new PndGemDetector("GEM", kTRUE);  
Gem->SetGeometryFileName("gem_3Stations.root");  
fRun->AddModule(Gem);
```

```
PndDsk* Dsk = new PndDsk("DSK", kTRUE);  
Dsk->SetGeometryFileName("dsk.root");  
Dsk->SetStoreCerenkovs(kFALSE);  
Dsk->SetStoreTrackPoints(kFALSE);  
fRun->AddModule(Dsk);
```

```
FairPrimaryGenerator* primGen = new FairPrimaryGenerator();  
fRun->SetGenerator(primGen);
```

// Box Generator

```
FairBoxGenerator* boxGen = new FairBoxGenerator(pid, 1); // 13 = muon; 1 = multipl.  
if (p2<0.) p2 = p1;  
boxGen->SetPRange(p1, p 2); // GeV/c  
boxGen->SetPhiRange(0., 360.); // Azimuth angle range [degree]  
boxGen->SetThetaRange(0.5, 140.); // Polar angle in lab system range [degree]  
boxGen->SetXYZ(0., 0., 0.); // cm  
// boxGen->SetCosTheta (kTRUE); // uniform in solid angle  
primGen->AddGenerator(boxGen);
```

by default
uniform in p, theta, angle
NOT in solid angle

Other infos on Thursday morning

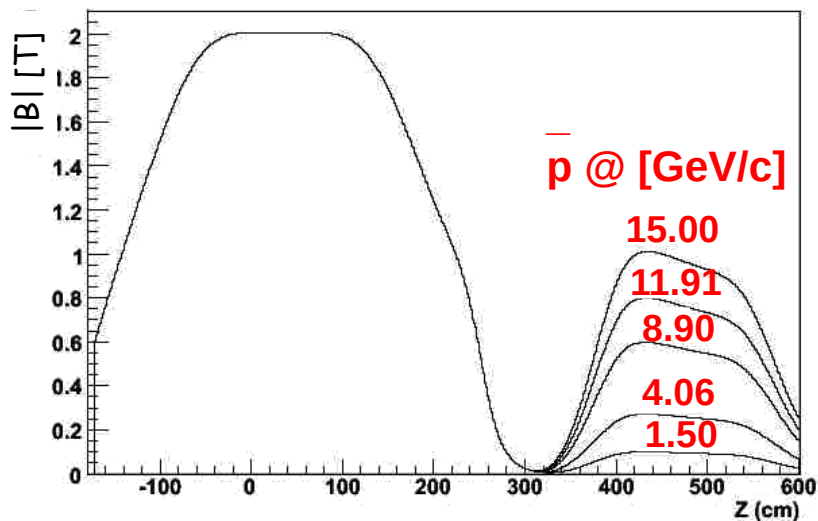
```
// Create and Set Magnetic Field
```

```
//-----
```

```
fRun->SetBeamMom(15);
```

```
PndMultiField *fField= new PndMultiField("FULL");
```

```
fRun->SetField(fField);
```



Run XXX events

```
// Transport nEvents  
// -----  
fRun->Run(nEvents);
```

What if I want to run from event 100 to event 120?

Not possible in simulation, events start always from 0

!!!!

```
~/jan12/pandaroot/macro/pid$ root -l run_sim_sttcombi_pgun.C"(100,13,1,2,34)"
```

```
spataro@briareos:~/jan12/pandaroot/macro/pid$ ls -ltr
```

```
...
```

```
-rw-rw-r-- 1 spataro spataro 4547      lug 23   15:43 gphysi.dat
```

```
-rw-r--r-- 1 spataro spataro 6687      lug 23   15:43 FairRunInfo_points_sttcombi.root
```

```
-rw-r--r-- 1 spataro spataro 447605    lug 23   15:43 points_sttcombi.root
```

```
-rw-r--r-- 1 spataro spataro 5264080    lug 23   15:43 params_sttcombi.root
```

```
spataro@briareos:~/jan12/pandaroot/macro/pid$
```

~~FairRunInfo_points_sttcombi.root~~

points_sttcombi.root

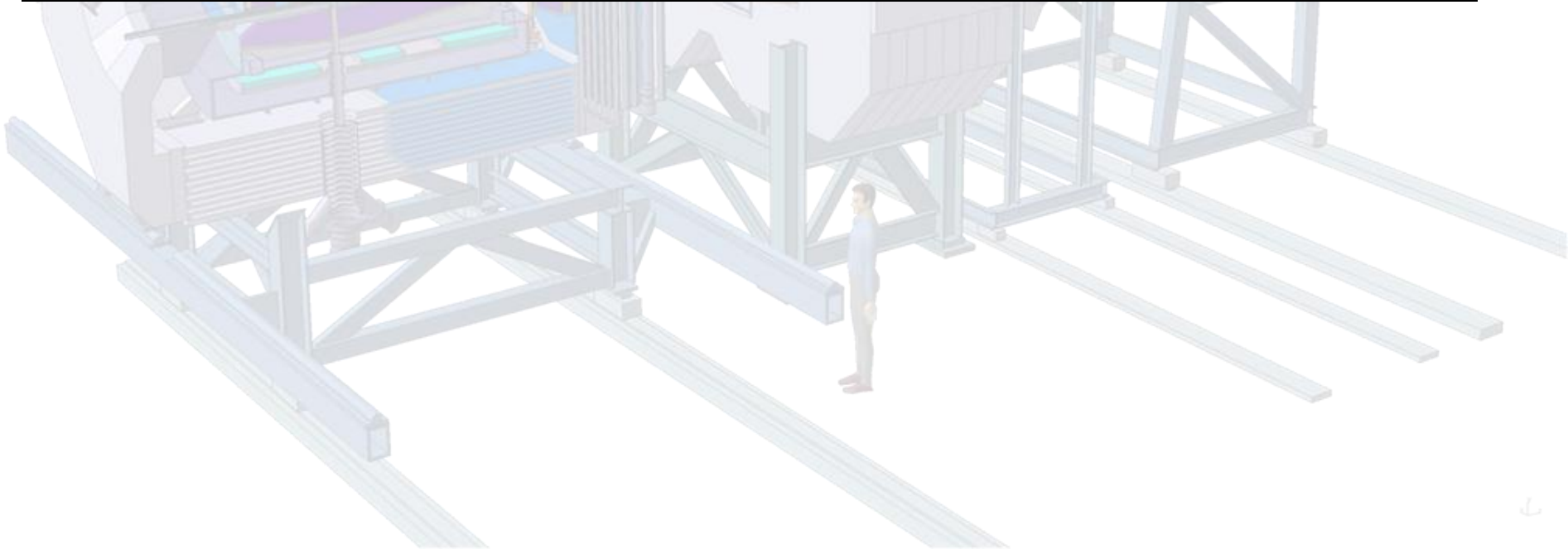
params_sttcombi.root

Log file

Output from sim

Parameter file


```
spataro@briareos:~/jan12/pandaroot/macro/pid$ root -l points_sttcombi.root
root [0]
Attaching file points_sttcombi.root as _file0...
Warning in <TClass::TClass>: no dictionary for class PndMCTrack is available
Warning in <TClass::TClass>: no dictionary for class PndSttPoint is available
Warning in <TClass::TClass>: no dictionary for class FairMCPoint is available
Warning in <TClass::TClass>: no dictionary for class FairMultiLinkedData is avai
...
root [1] TBrowser d
```





24th July 2012
Stefano Spataro

The PandaRoot Code

How to run a full analysis chain



ROOT Object Browser

Browser File Edit View Options Tools Help

Files

Draw Option: [v]

- root
 - PROOF Sessions
 - ROOT Files
 - points_sttcombi.root
 - cbmroot;1
 - BranchList;1
 - FileHeader;1
 - cbmsim;1
 - MCTrack
 - MCTrack.fUniqueID
 - MCTrack.fBits
 - MCTrack.fPdgCode**
 - MCTrack.fPx
 - MCTrack.fPy
 - MCTrack.fPz
 - MCTrack.fE
 - MCTrack.fMotherID
 - MCTrack.fSecondMotherID
 - MCTrack.fGeneratorFlags
 - MCTrack.fStartX
 - MCTrack.fStartY
 - MCTrack.fStartZ
 - MCTrack.fStartT
 - MCTrack.fPoints
 - @size
 - STTPoint
 - MVDPoint
 - SciTPoint
 - MdtPoint
 - GEMPoint
 - DskParticle
 - PndDskFLGHit
 - DrcBarPoint

Filter: All Files (*.*)

Canvas_1 Editor 1

MCTrack.fPdgCode

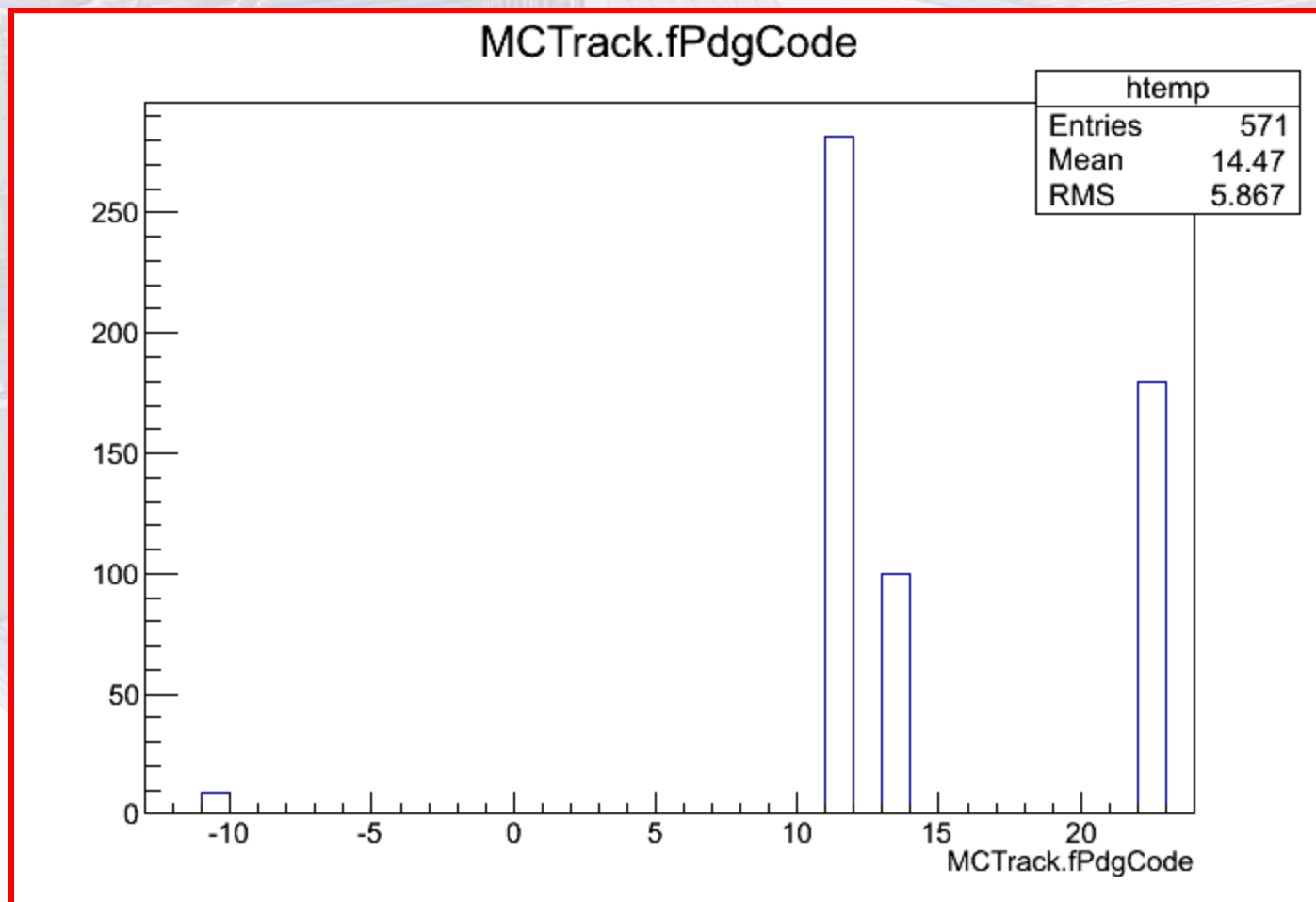
htemp	
Entries	571
Mean	14.47
RMS	5.867

Command

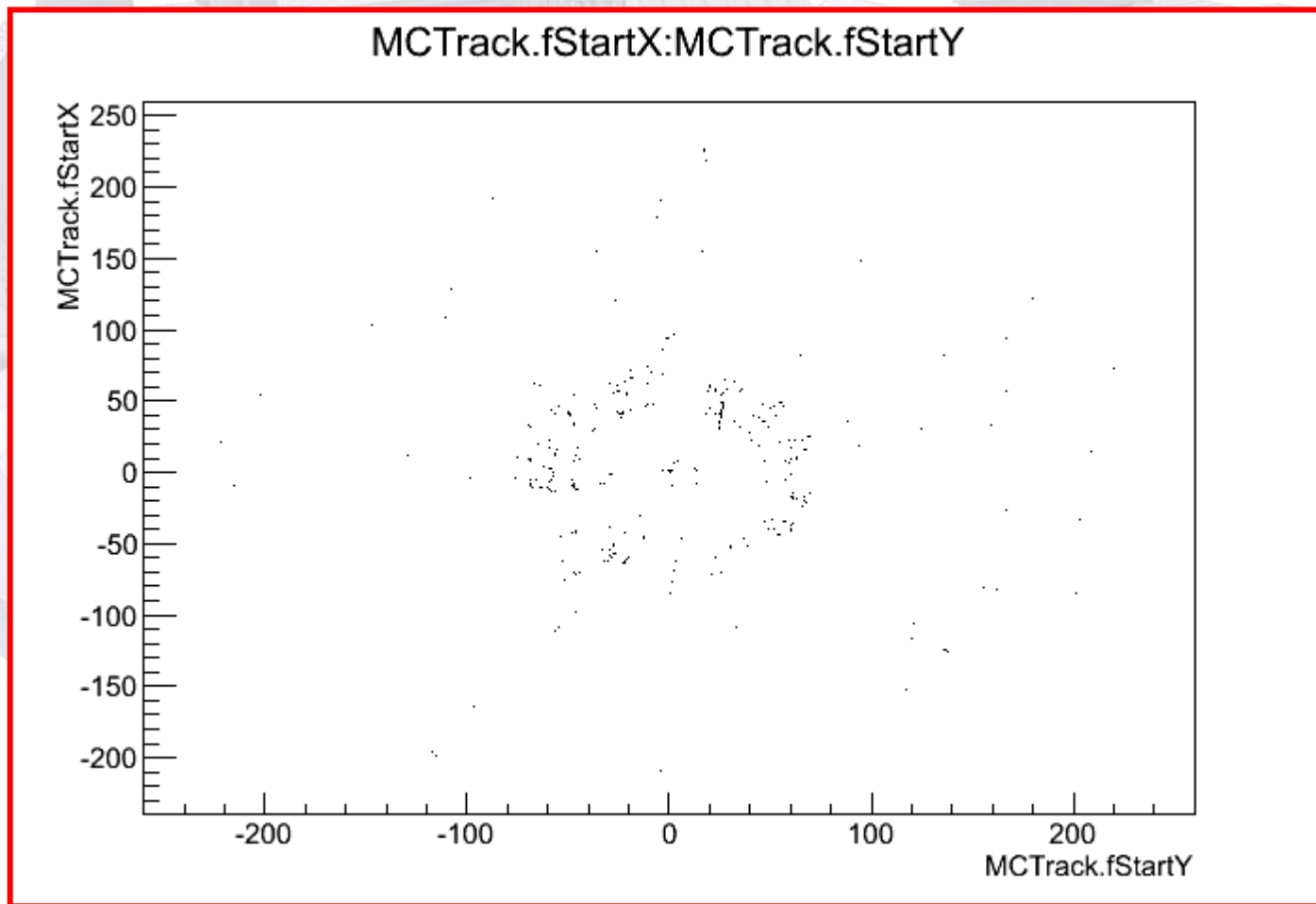
Command (local):

Taskbar: 20120724 - Torino ... Panda Computing ... 20101019 - (CHEP) ... spatara@briareos: ... ROOT Object Brow... Inbox in spatara@t... 15.50

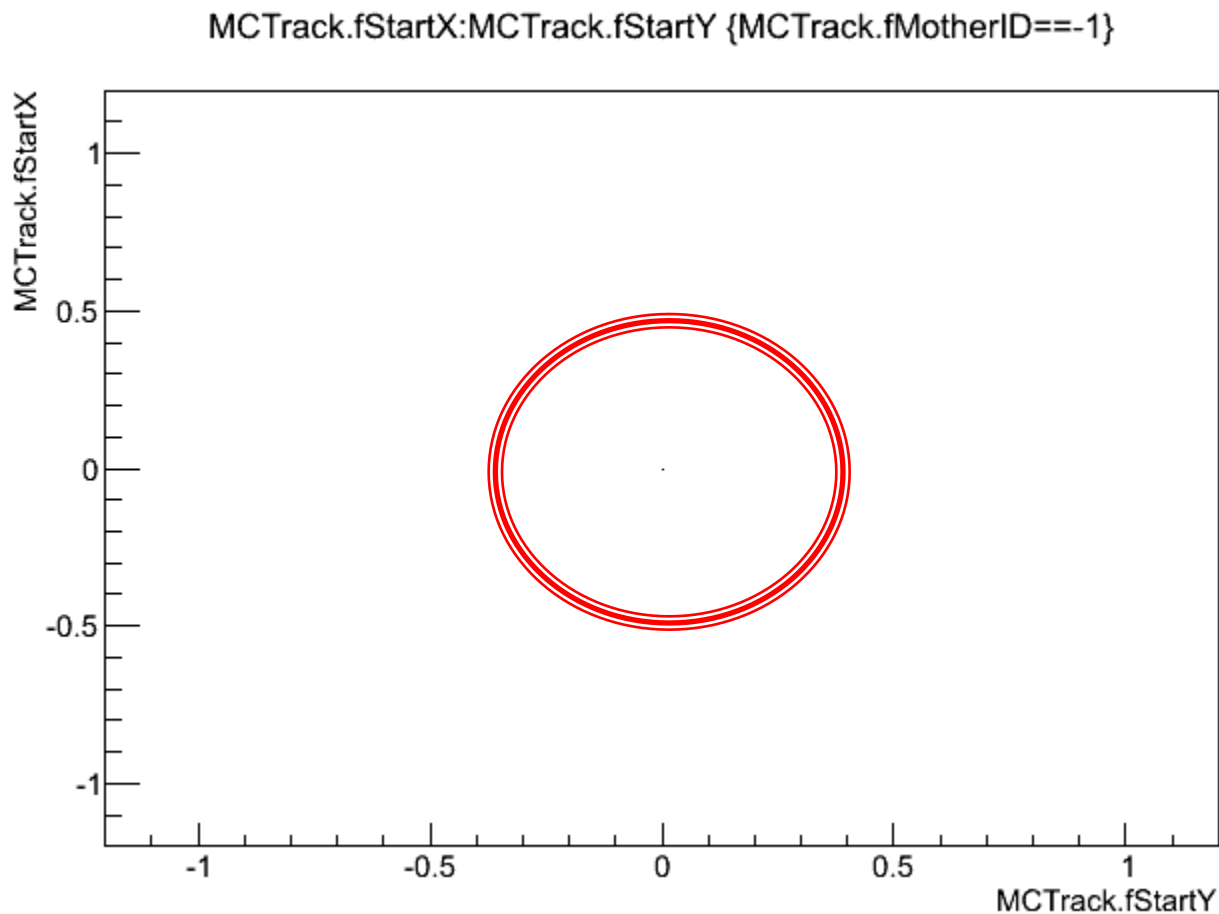
```
root [4] cbmsim.Draw("MCTrack.fPdgCode")
```



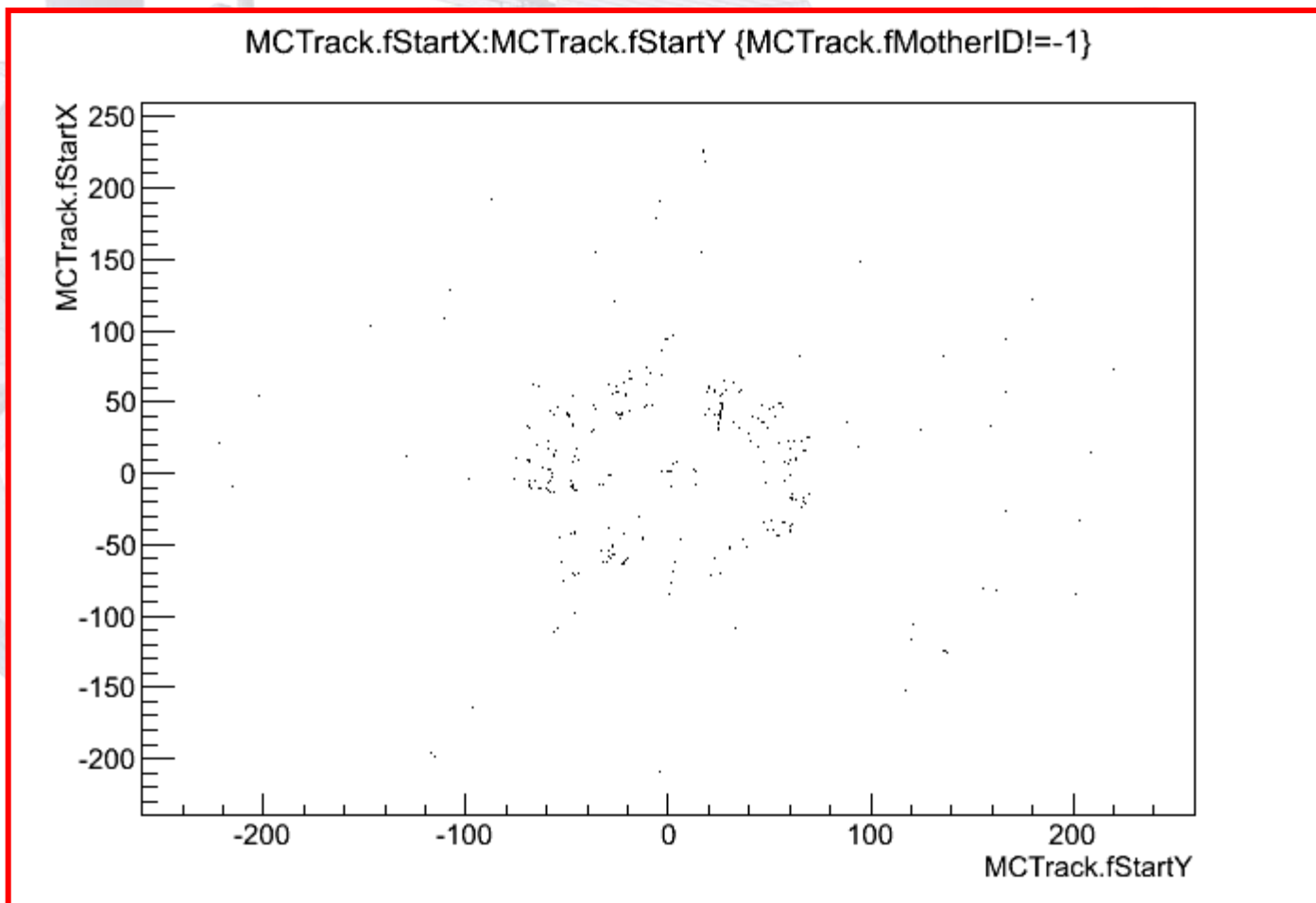
```
root [5] cbmsim.Draw("MCTrack.fStartX:MCTrack.fStartY")
```



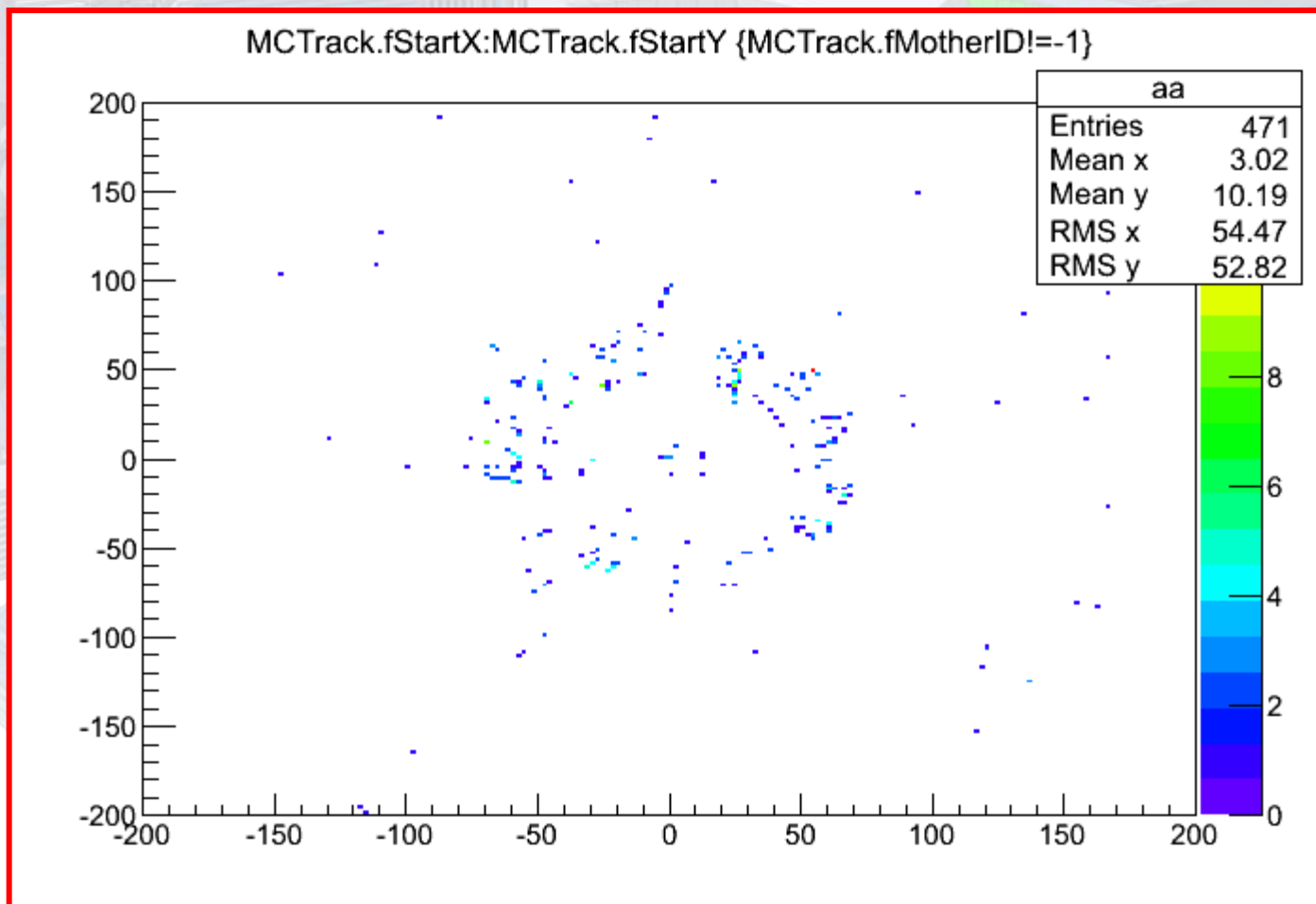
```
root [6] cbmsim.Draw("MCTrack.fStartX:MCTrack.fStartY","MCTrack.fMotherID== -1")
```




```
root [6] cbmsim.Draw("MCTrack.fStartX:MCTrack.fStartY","MCTrack.fMotherID!=-1")
```



```
cbmsim.Draw("MCTrack.fStartX:MCTrack.fStartY>>aa(200,-200,200,200,-200,200)",
            "MCTrack.fMotherID!=-1","colz")
```



```
root [11] cbmsim.Draw("MCTrack.fPdgCode","MCTrack.fMotherID!=-1","")
```

