Event Reconstruction in the PandaRoot Framework

Stefano Spataro

for the PANDA collaboration

UNIVERSITÀ DEGLI STUDI DI TORINO
ALMA UNIVERSITAS TAURINENSIS

ISTITUTO NAZIONALE DI FISICA NUCLEARE
Sezione di Torino

CHEP 2012

Tuesday, 22th May, 2012

Overview

- The Panda Experiment
- The FairRoot and PandaRoot frameworks
- Tracking
- Particle Identification
- Analysis
- Time Based Simulation

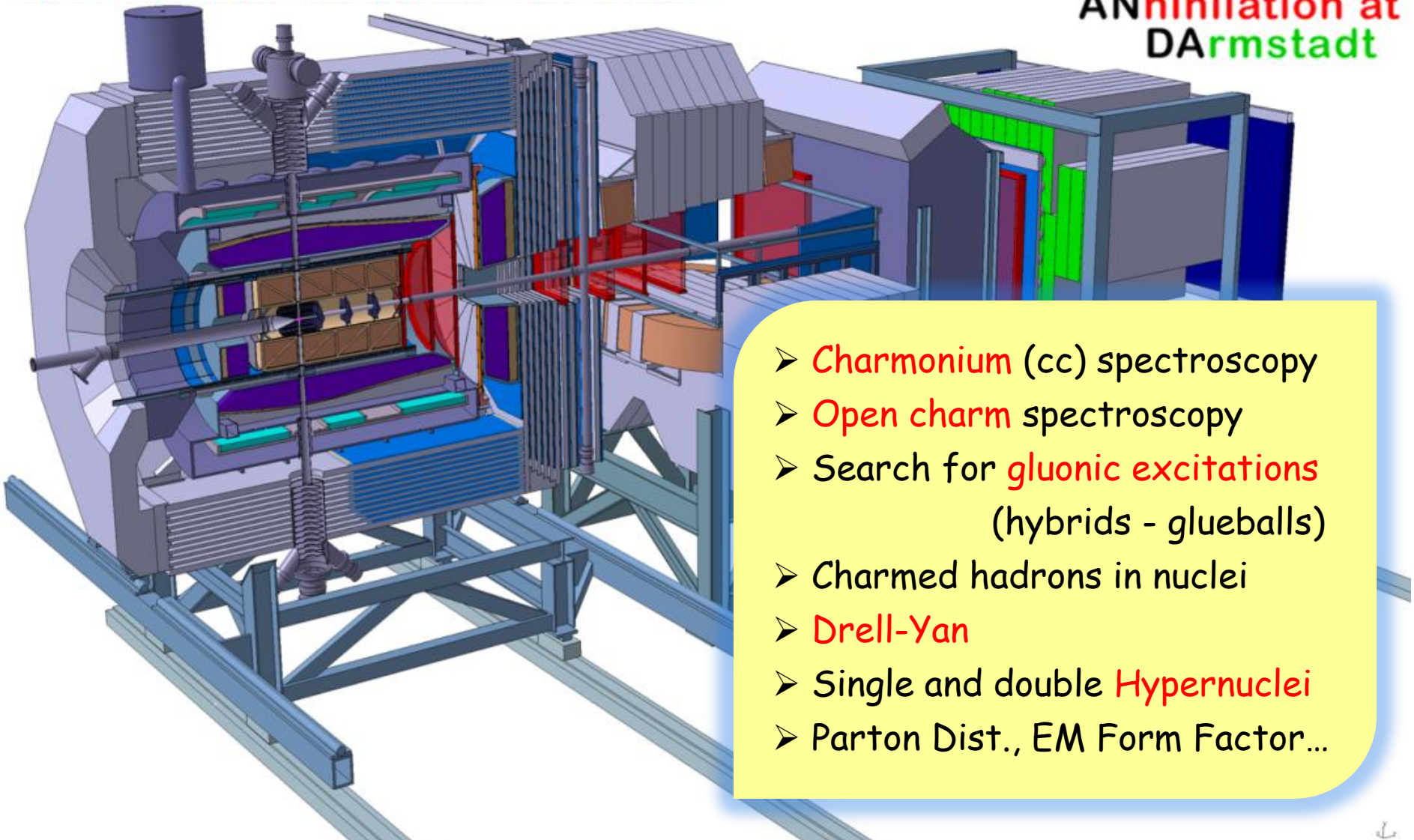
The Panda experiment

AntiProton Annihilations at Darmstadt

$\bar{p}p$, $\bar{p}A$ collisions

1.5⇒15 GeV/c ($\bar{p}$ momentum)

Anti-Proton
ANnihilation at
DArmstadt



- Charmonium (cc) spectroscopy
- Open charm spectroscopy
- Search for gluonic excitations (hybrids - glueballs)
- Charmed hadrons in nuclei
- Drell-Yan
- Single and double Hypernuclei
- Parton Dist., EM Form Factor…

Code Design

Geometry
Virtual MC
G3VMC
Geant3
G4VMC
Geant4

FairRoot

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

Cuts, processes
Application
IO Manager
Root files
Hits, Digits, Tracks
Track propagation
Run Manager
RTDataBase
Root files
Event Display
Oracle
MySQL
Postgresql
TSQLServer
Detector base
Event Generator
Tasks
Magnetic Field

PandaRoot

STT
TOF
EMC
MUO
MVD
DIRC
FTS
GEM
DPM
EvtGen
ASCII
Pythia
Hit Producers
digitizers
Track finding
Dipole Map
Solenoid Map
const. field
Panda Code

CbmRoot
R3BRoot
MPDRoot (NICA)
ASYEOSRoot
EICRoot

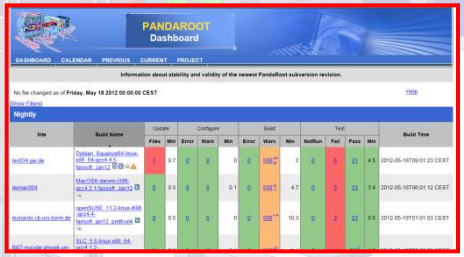
The PandaRoot framework

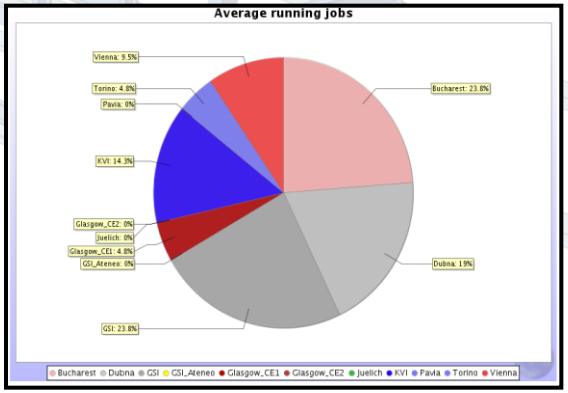
ROOT (5.32) based on **Virtual Monte-Carlo (2.13)**

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

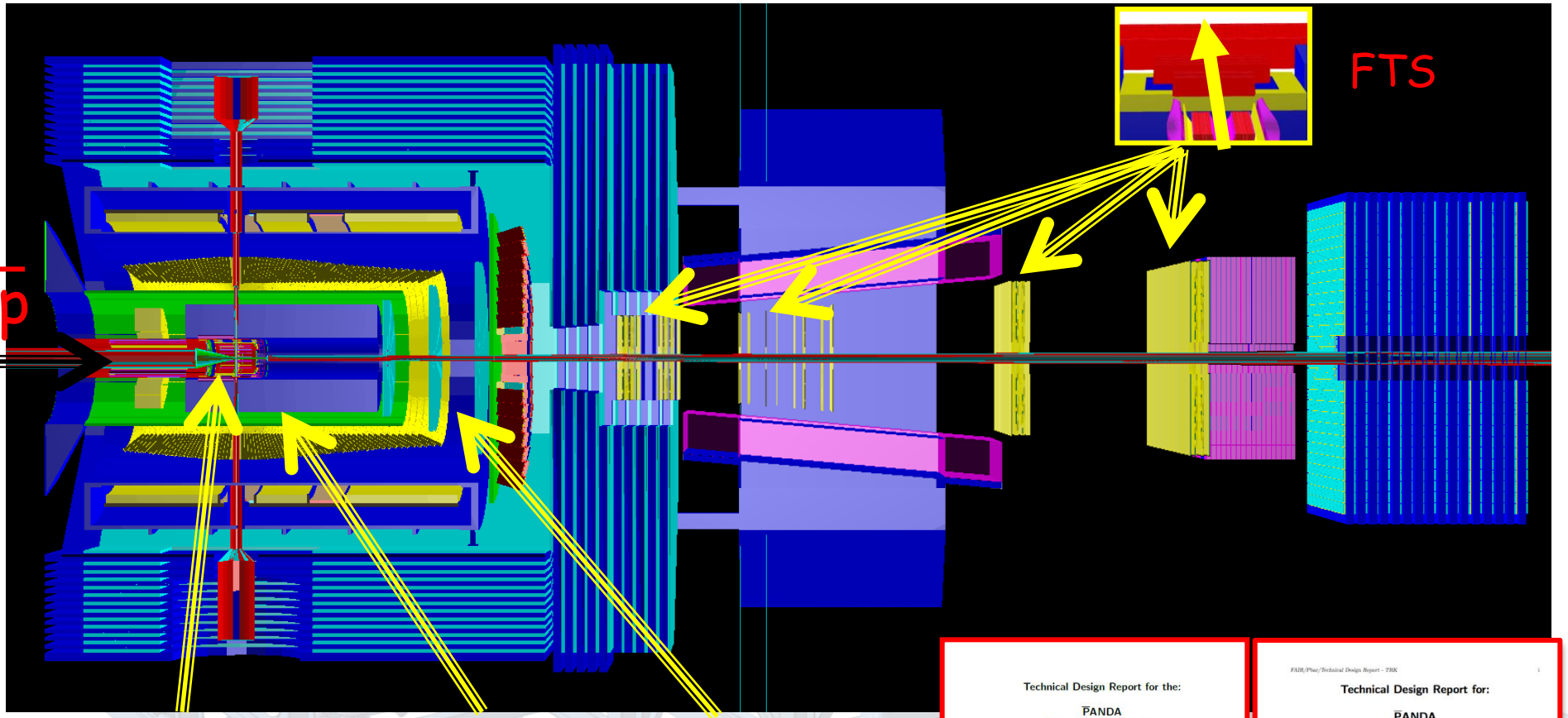




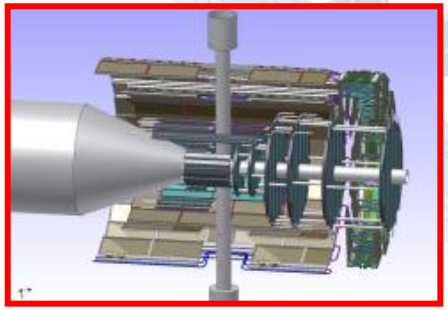
collaboration with
external developers

CERN/ALICE
FAIR/HADES-CBM-R3B

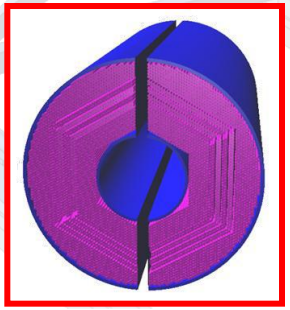
Global Tracking



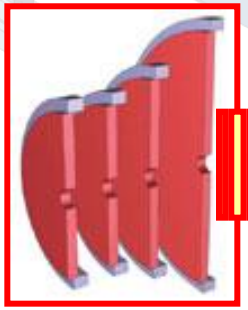
MVD

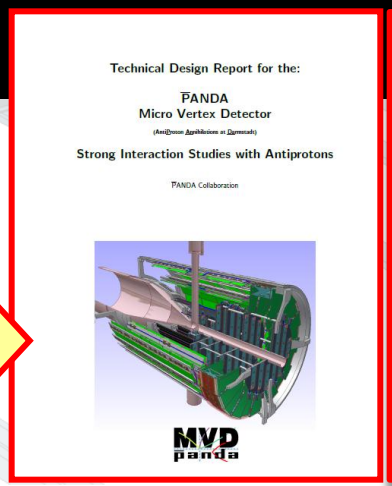


STT

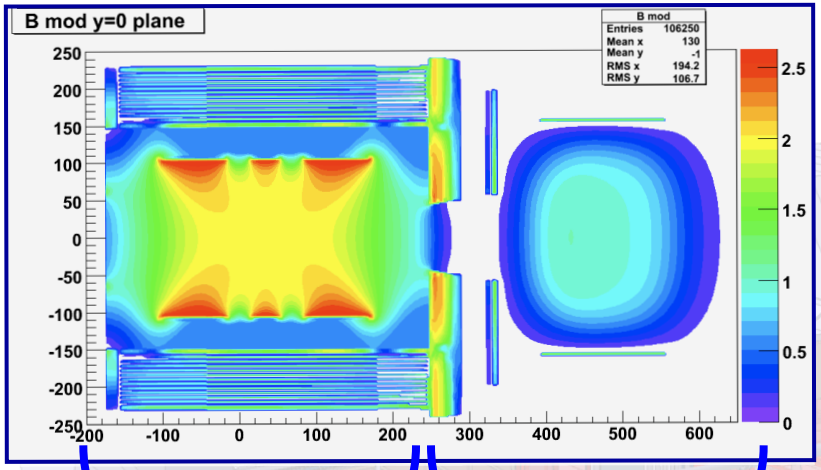


GEM





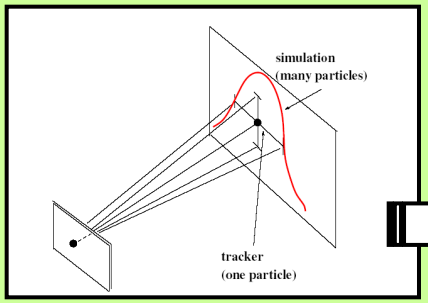
Tracking: Global Fit



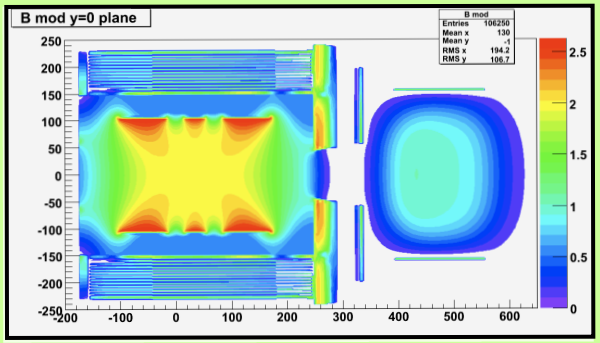
Energy loss
Not homogeneous magnetic field
Different detector hits

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

Prefit Track ⇒ Kalman Filter (GENFIT- Munich*) ⇐ Detector Hits



⇒ Track Follower (GEANE - Pavia**) ⇐



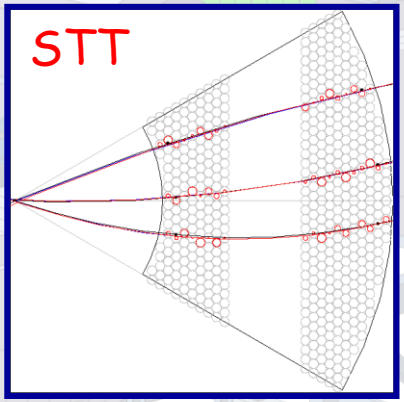
**A.Fontana, L.Lavezzi, A.Rotondi

same geometry for simulation and track following

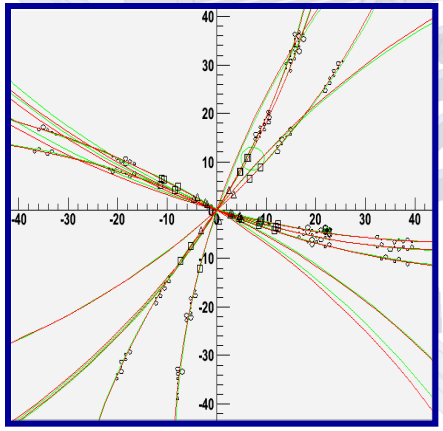
*F.Böhmer, C. Höppner, S.Neubert, J.Rauch → Poster: New Developments in the GENFIT track fitting framework

Barrel Tracking: Pattern Recognition

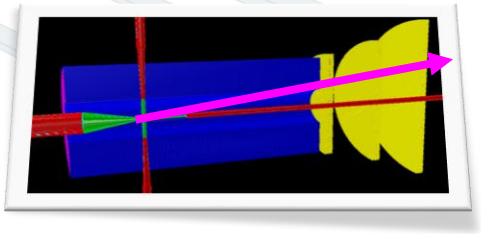
1° step – MVD/STT local pattern recognition



2° step – Correlation of STT & MVD tracklets
– Correlation with STT/MVD spurious hits



3° step – Extrapolation to GEM planes

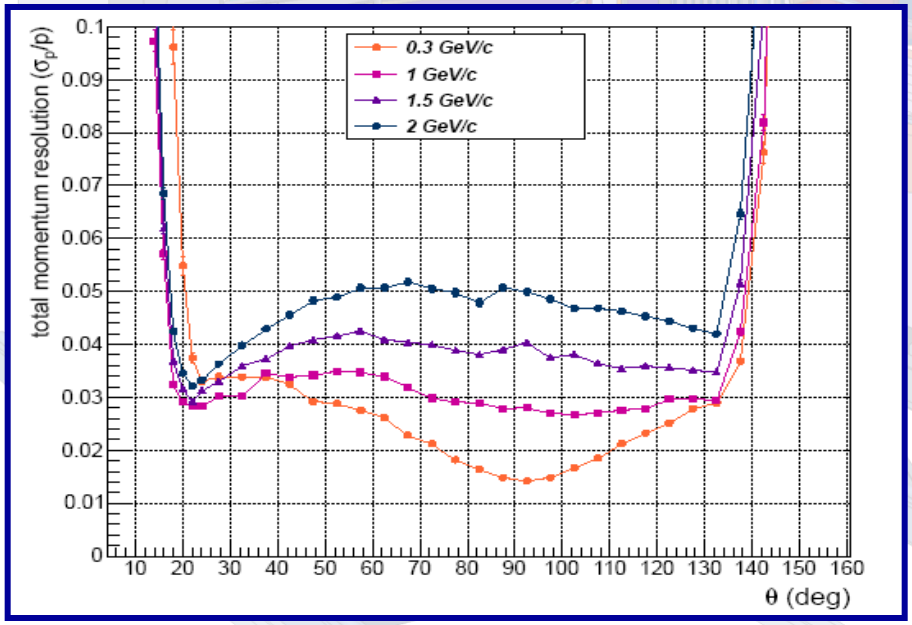


4° step – Kalman Filter

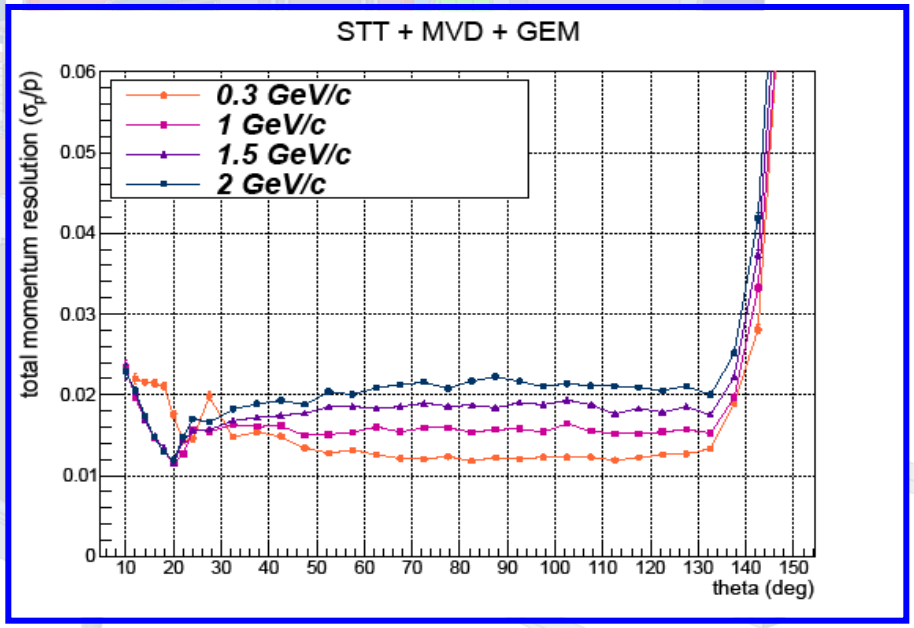
G.Boca, R. Karabowicz , L.Lavezzi, T.Stockmanns

Barrel Tracking: Performances

STT stand-alone

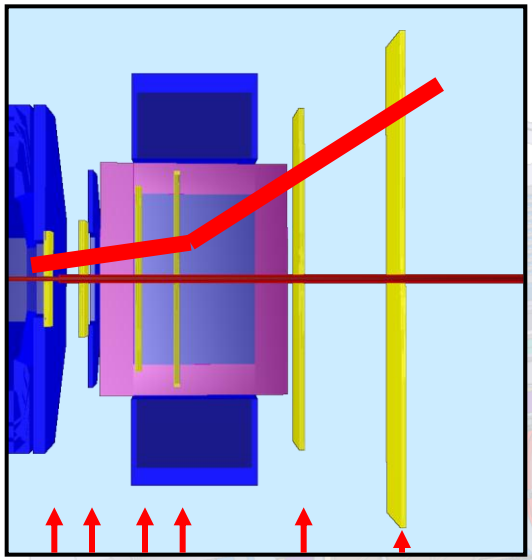


STT+MVD+GEM



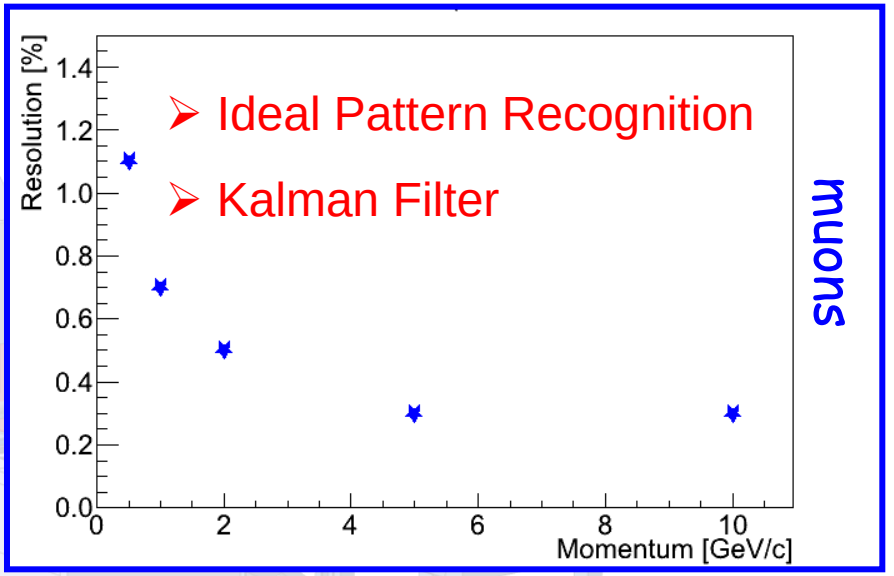
Large Improvement from MVD/GEM detectors

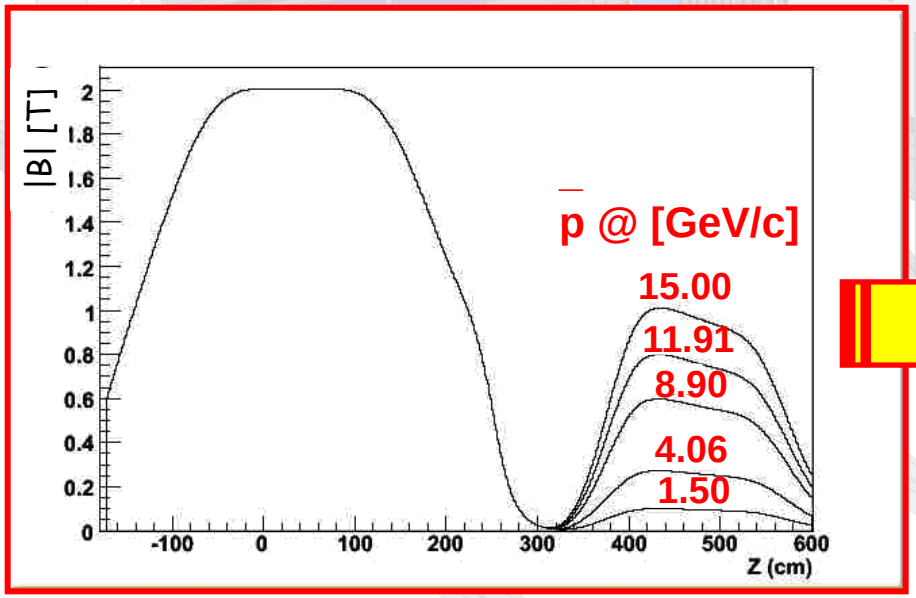
Forward Tracking

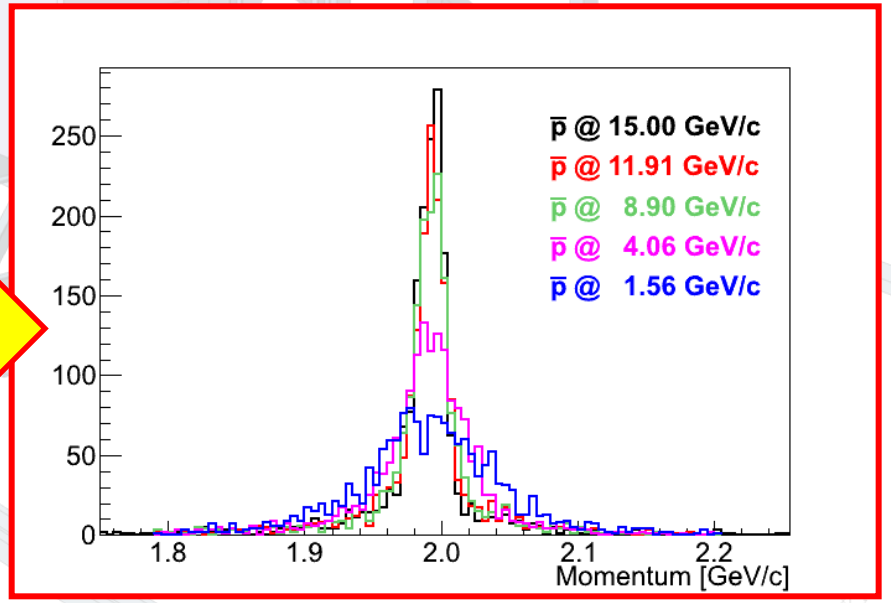


FTS
+
MVD
+
GEM

- Ideal Pattern Recognition
- Kalman Filter

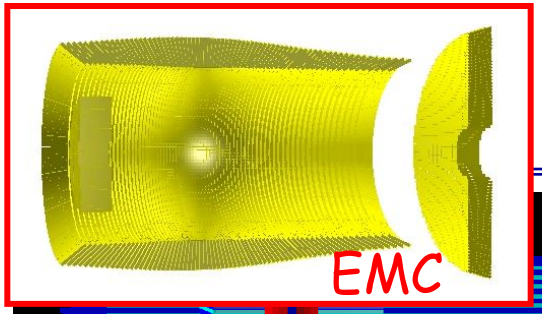




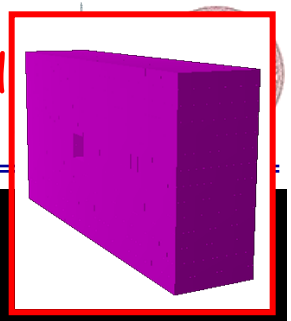


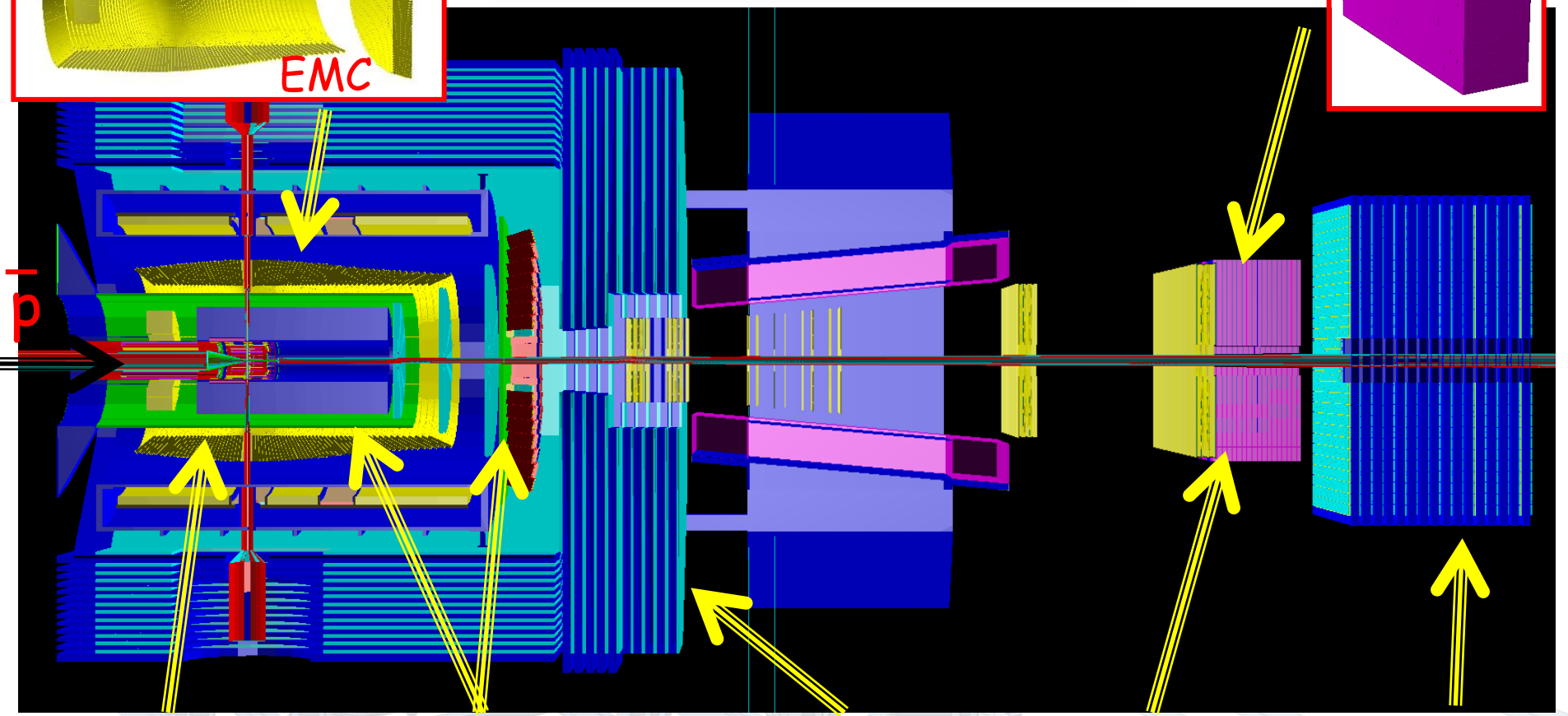
E.Fioravanti, I.Garzia, R.Kliemt

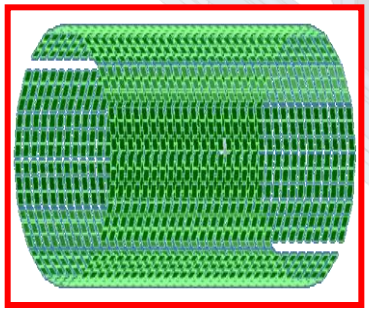
Particle Identification

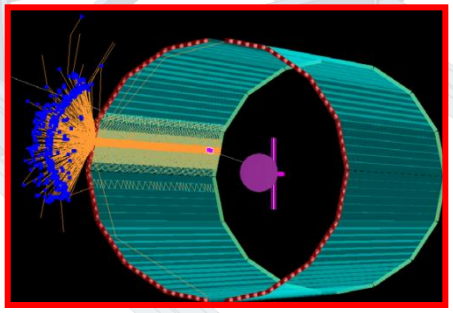


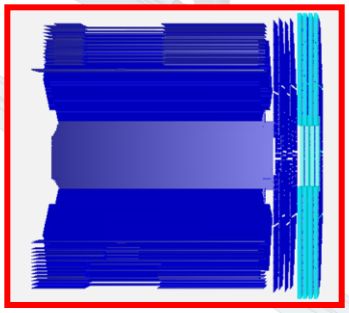
Forward EMC

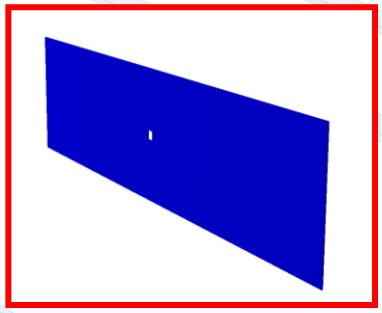


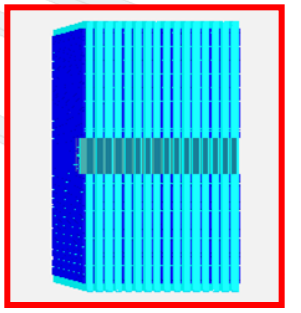






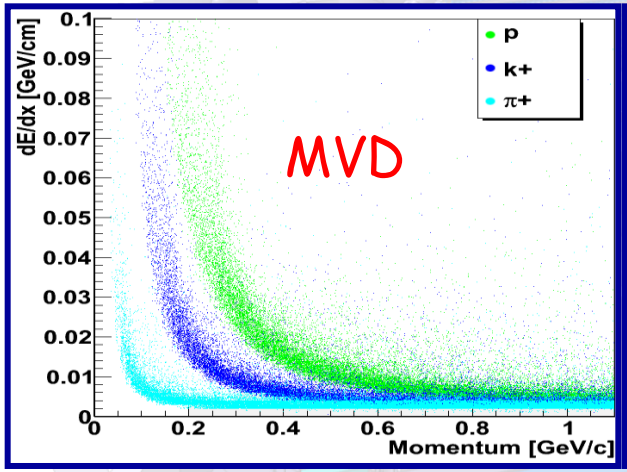


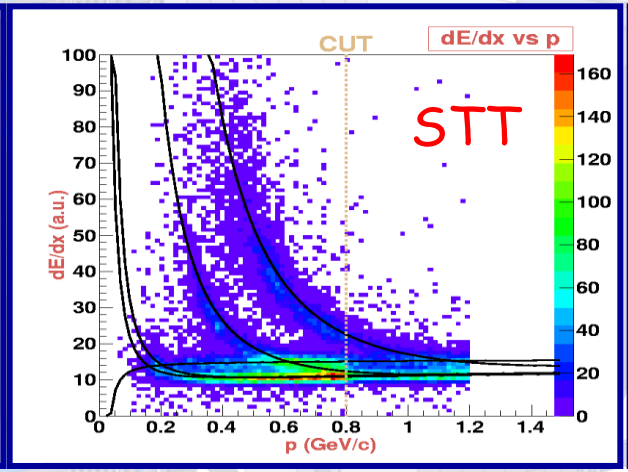


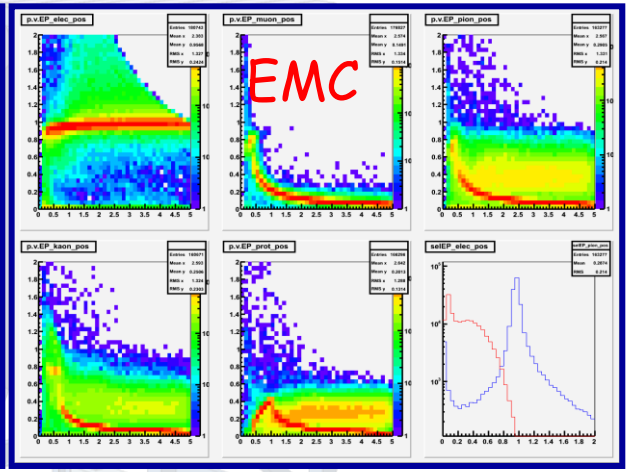


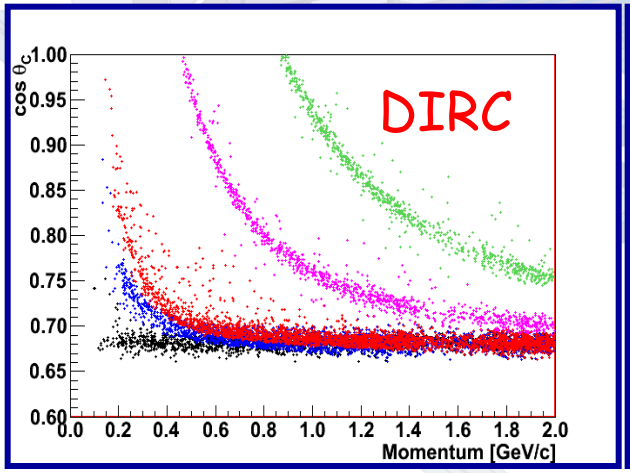
Particle Identification

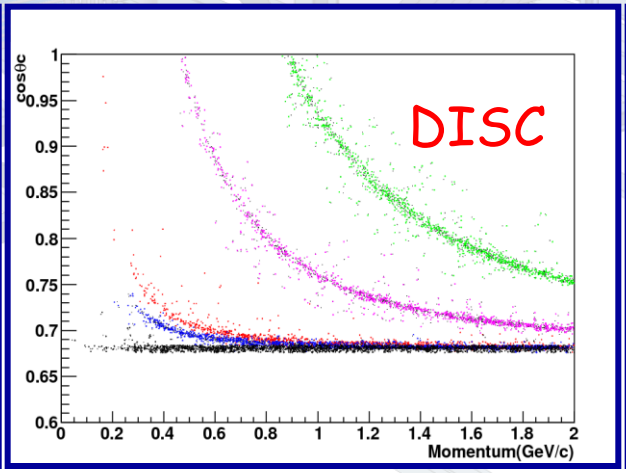
Implemented PDFs for many detectors (Bayes)

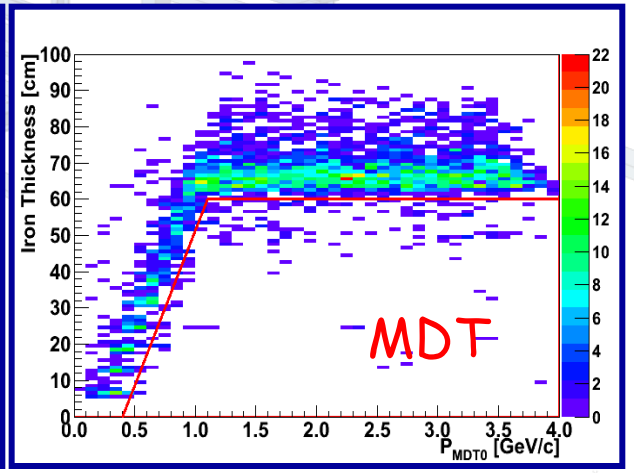












A.Cecchi, L.Lavezzi, R.Kunne, Y.Lang, L.Zotti

Interface to Analysis

Flexible way to switch between different algorythms

PndPidCandidate

PidChargedCand
- Momentum
- STT dE/dx
- EMC energy
- EMC shower shape
- Cherenkov angle
- MVD dE/dx
- # Muon Layers
- …

PidNeutralCand
- Momentum
- STT dE/dx
- EMC energy
- EMC shower shape
- Cherenkov angle
- MVD dE/dx
- # Muon Layers
- …

PndPidProbability

EMC SS
- P(e)
- P(π)
- P(μ)
- P(K)
- P(p)
- …

DIRC
- P(e)
- P(π)
- P(μ)
- P(K)
- P(p)
- …

MVD
- P(e)
- P(π)
- P(μ)
- P(K)
- P(p)
- …

…
- P(e)
- P(π)
- P(μ)
- P(K)
- P(p)
- …

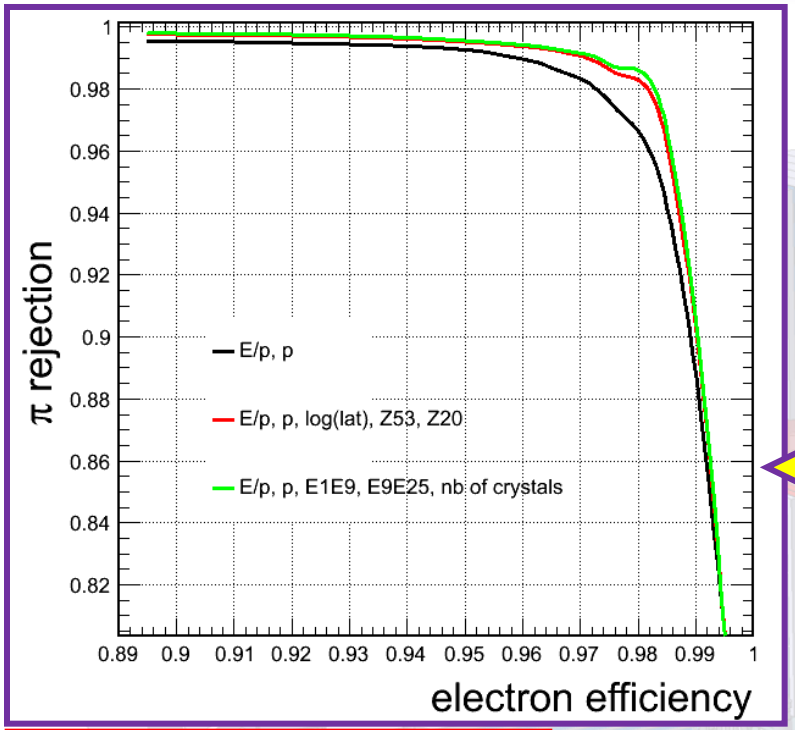
PndAnaPidCombiner

```
analysis->FillList(pip, "PionLoose","BEMC;BMVD;BDIRC")
```

- candidate list
- selection criterium
- algorithms to merge

K. Götzen, R.Kliemt

MultiVariate Particle Identification



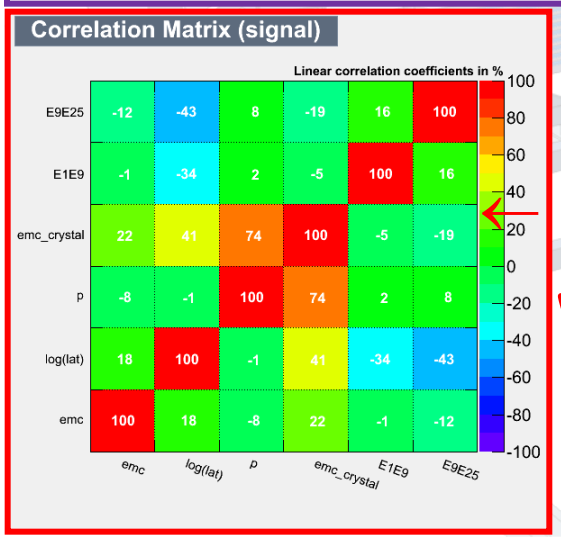
implementation of TMVA methods

- EMC shower shape analysis

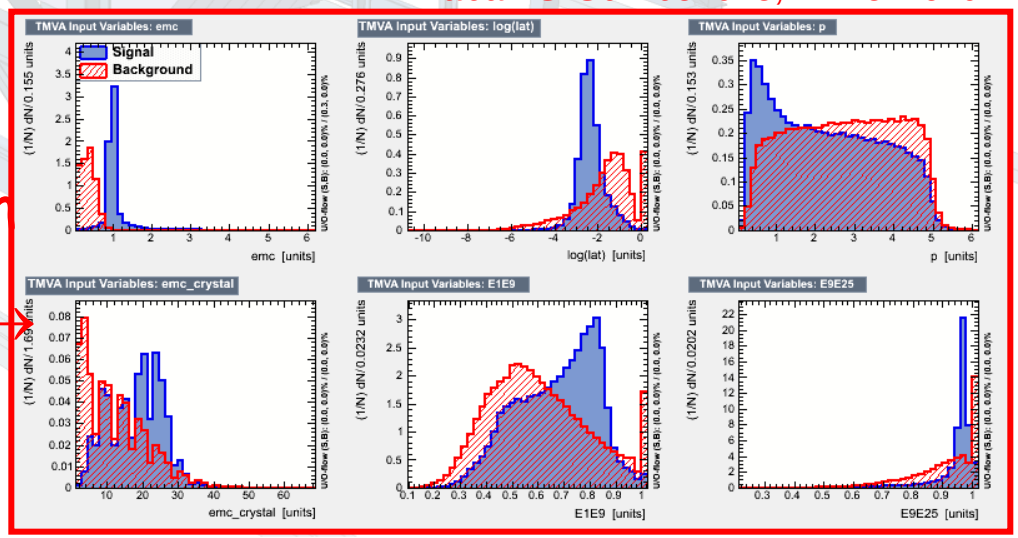
e/π separation in EMC

preliminary tests for muons (MDT)

M.Babai. G.Gumberidze, D.Melnichuk



Correlation Variables

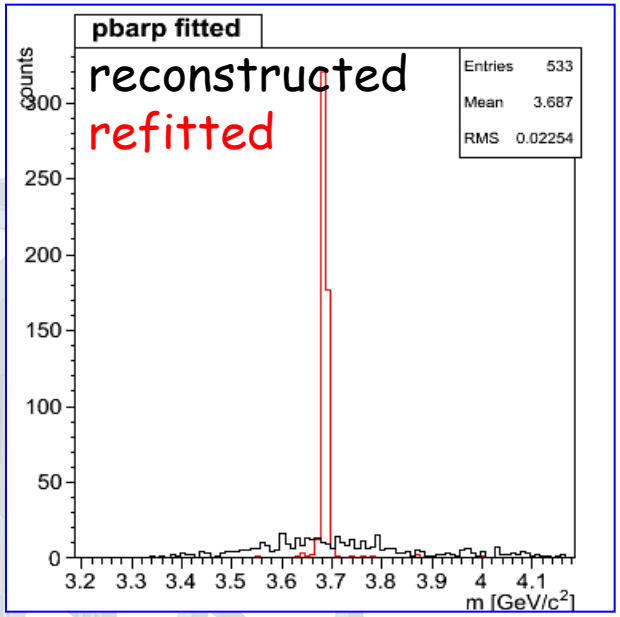


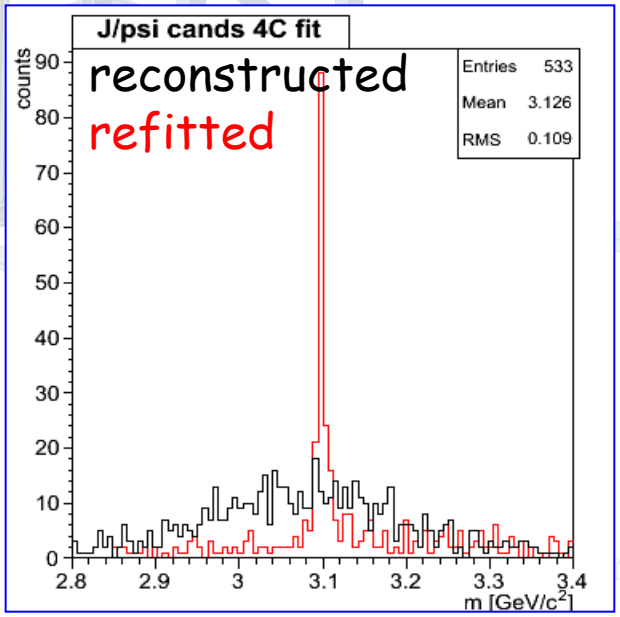
Analysis ⇨ Rho Toolkit

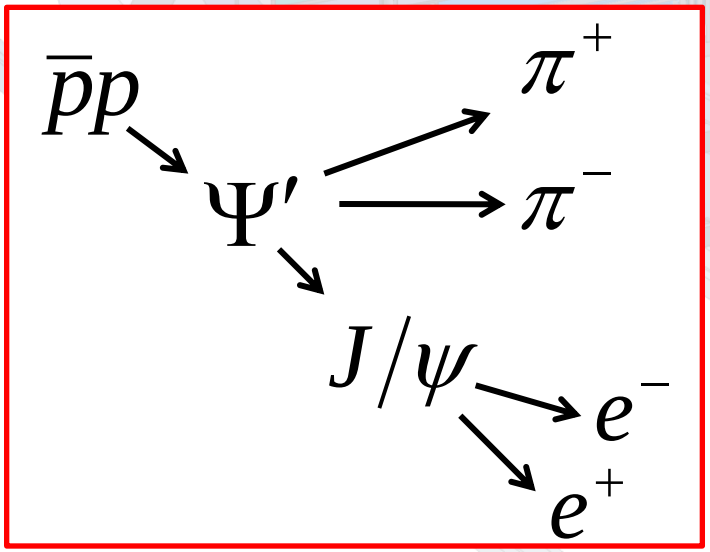
Implementation of

- kinematic fitters
- vertex fitters
- fast simulation

Ψ' 4C constraints



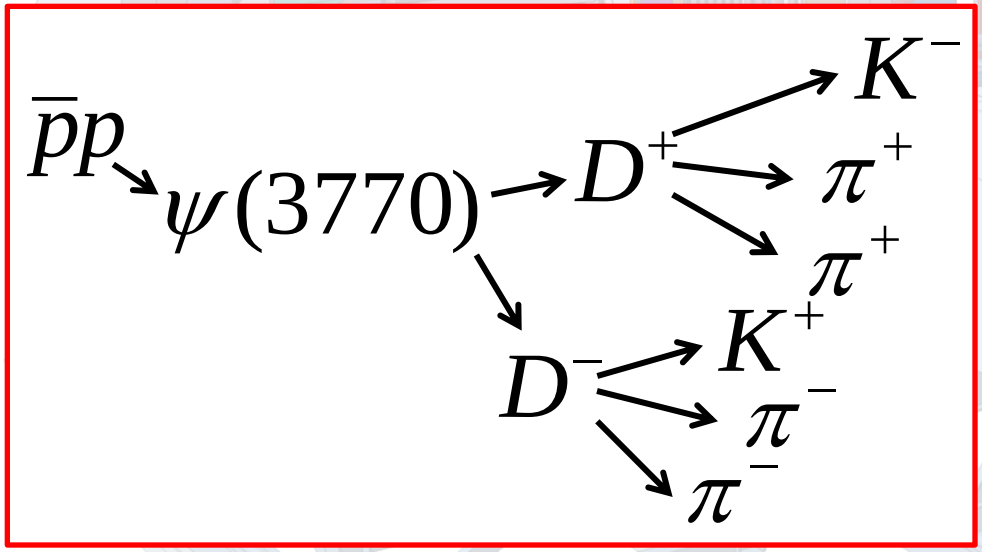


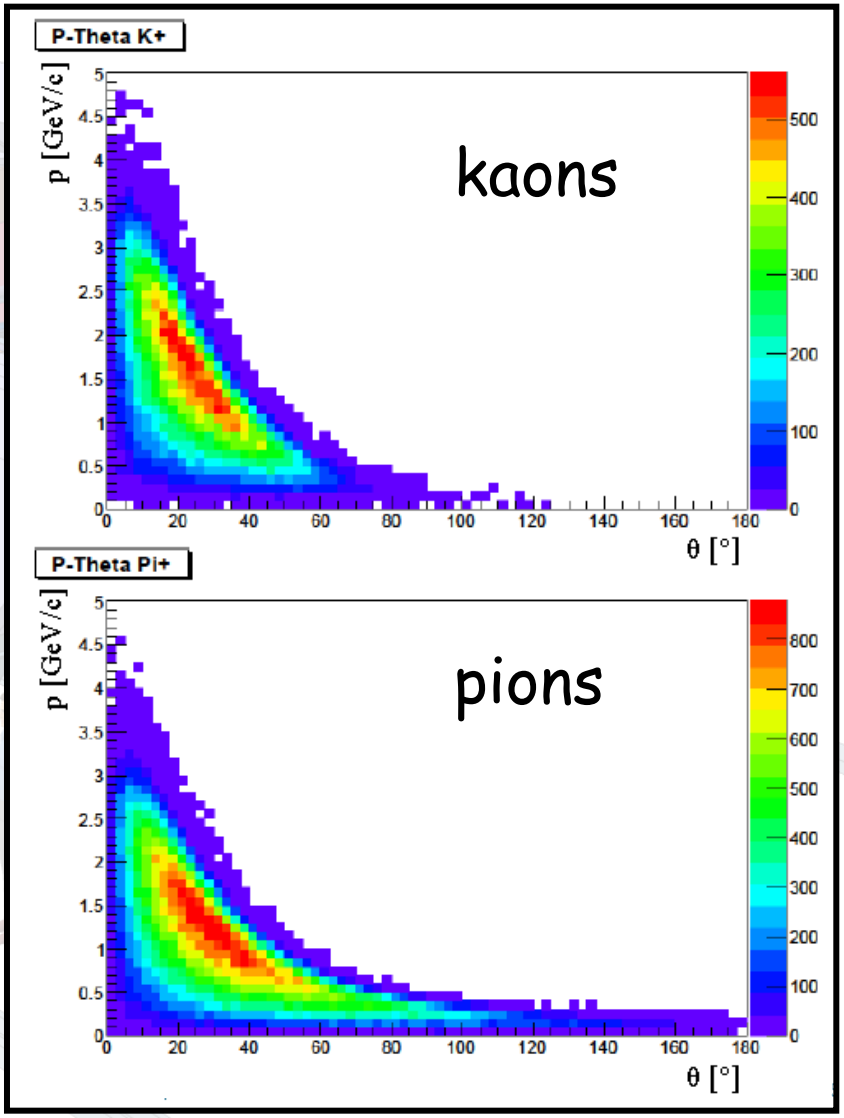


K.Götzen, R.Kliemt, V.Jha

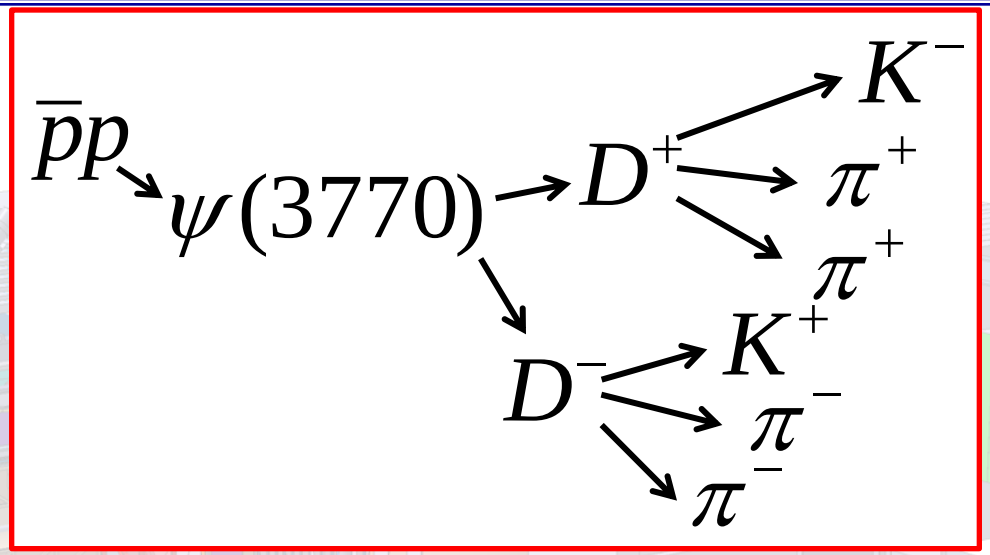
Reconstruction of Physics Channels – D^+D^-

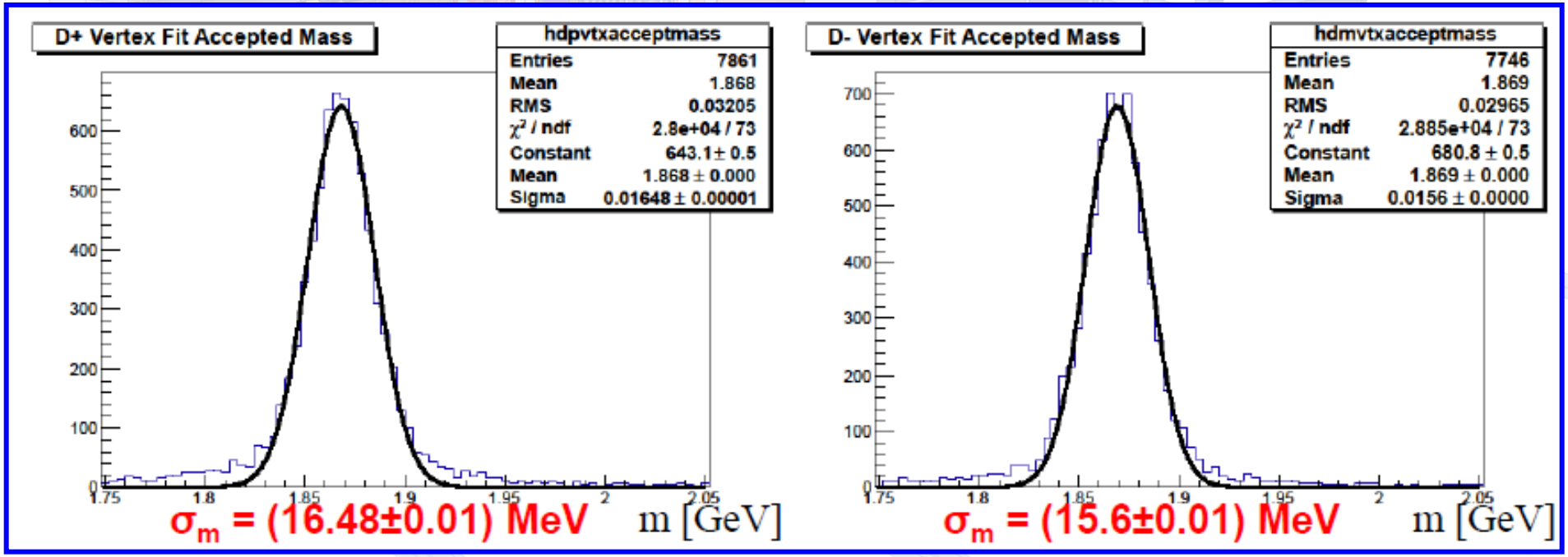
Heavy-Light Systems





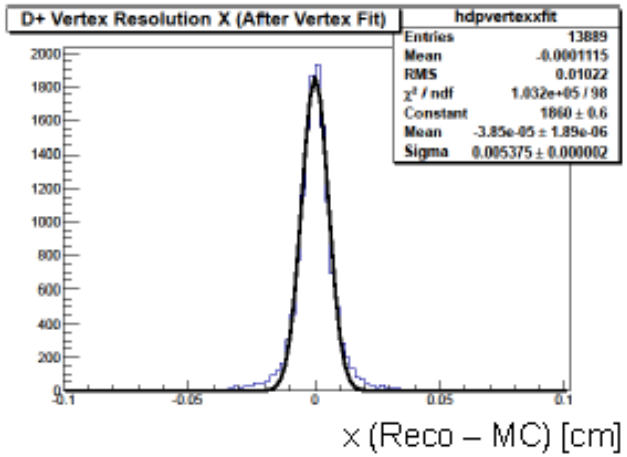
- 6 charged tracks in the final state
- Secondary vertexing


$\bar{p}p \to \psi(3770) \to D^+ \to K^-\pi^+\pi^+$
$\psi(3770) \to D^- \to K^+\pi^-\pi^-$

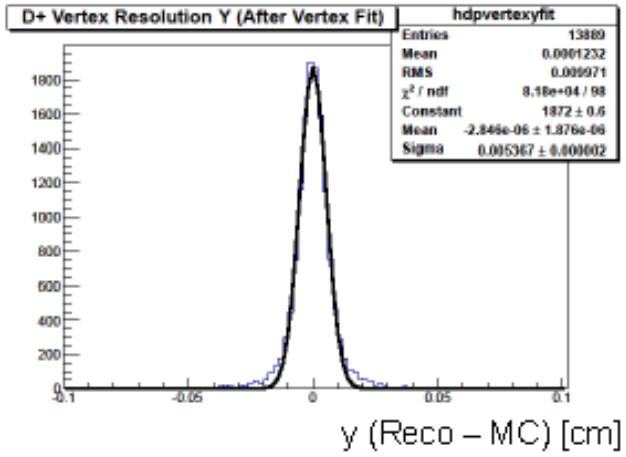

D+ Vertex Fit Accepted Mass
hdpvtxacceptmass
Entries 7861
Mean 1.868
RMS 0.03205
χ² / ndf 2.8e+04 / 73
Constant 643.1 ± 0.5
Mean 1.868 ± 0.000
Sigma 0.01648 ± 0.00001
σm = (16.48±0.01) MeV
m [GeV]
D- Vertex Fit Accepted Mass
hdmvtxacceptmass
Entries 7746
Mean 1.869
RMS 0.02965
χ² / ndf 2.885e+04 / 73
Constant 680.8 ± 0.5
Mean 1.869 ± 0.000
Sigma 0.0156 ± 0.0000
σm = (15.6±0.01) MeV
m [GeV]

M.Mertens

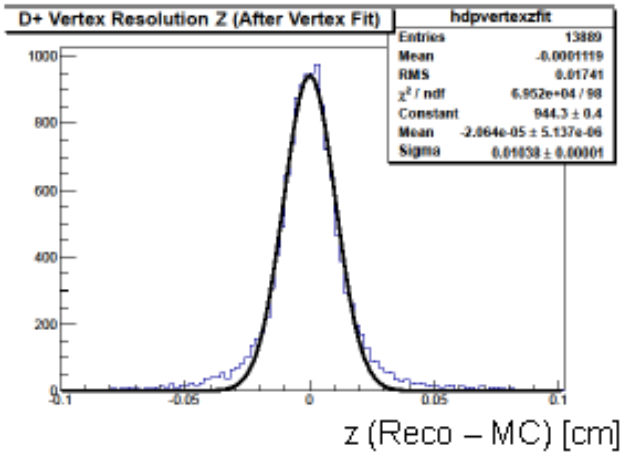
D-Meson Vertex Resolution



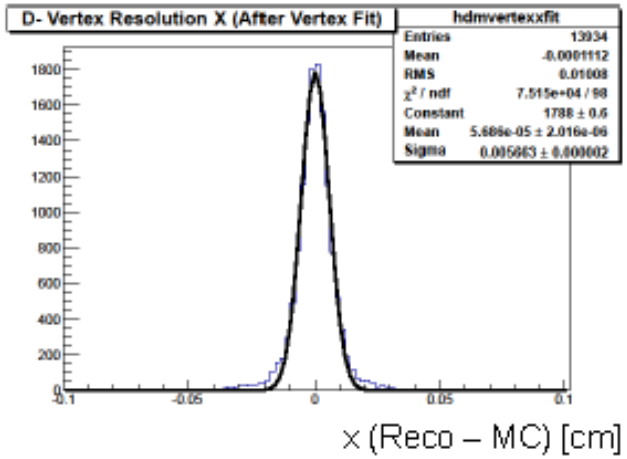
$\sigma_x = (53.75 \pm 0.02)\ \mu m$



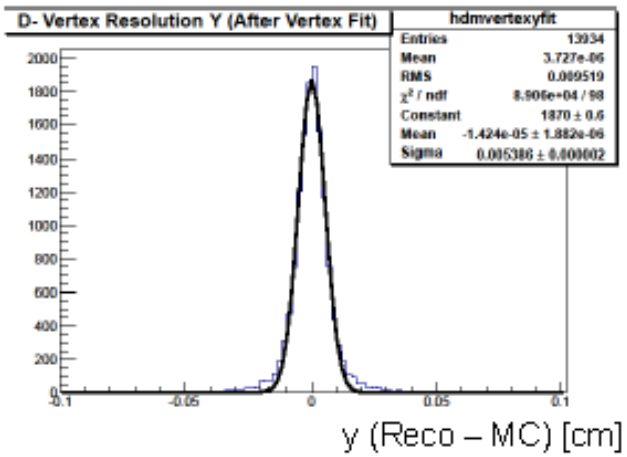
$\sigma_y = (53.67 \pm 0.02)\ \mu m$



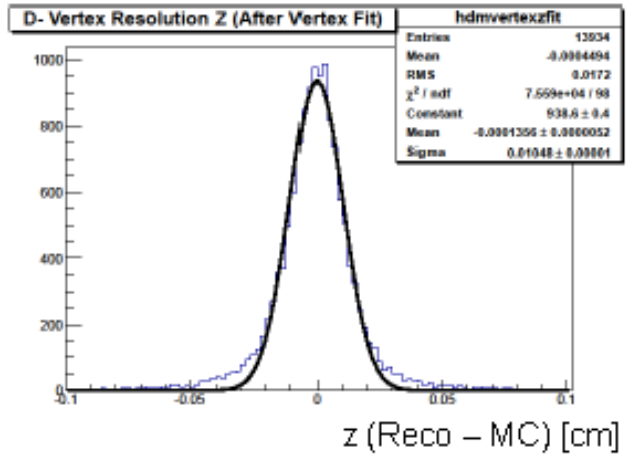
$\sigma_z = (103.8 \pm 0.1)\ \mu m$



$\sigma_x = (56.63 \pm 0.02)\ \mu m$

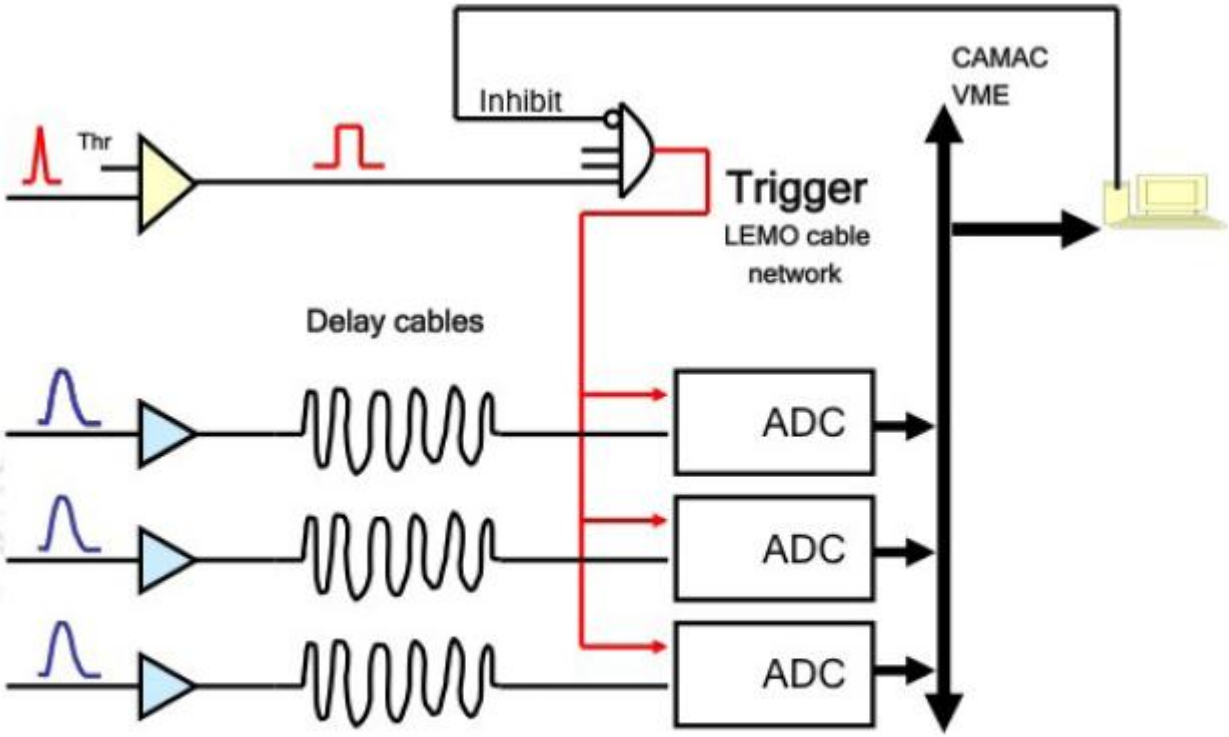


$\sigma_y = (53.86 \pm 0.02)\ \mu m$

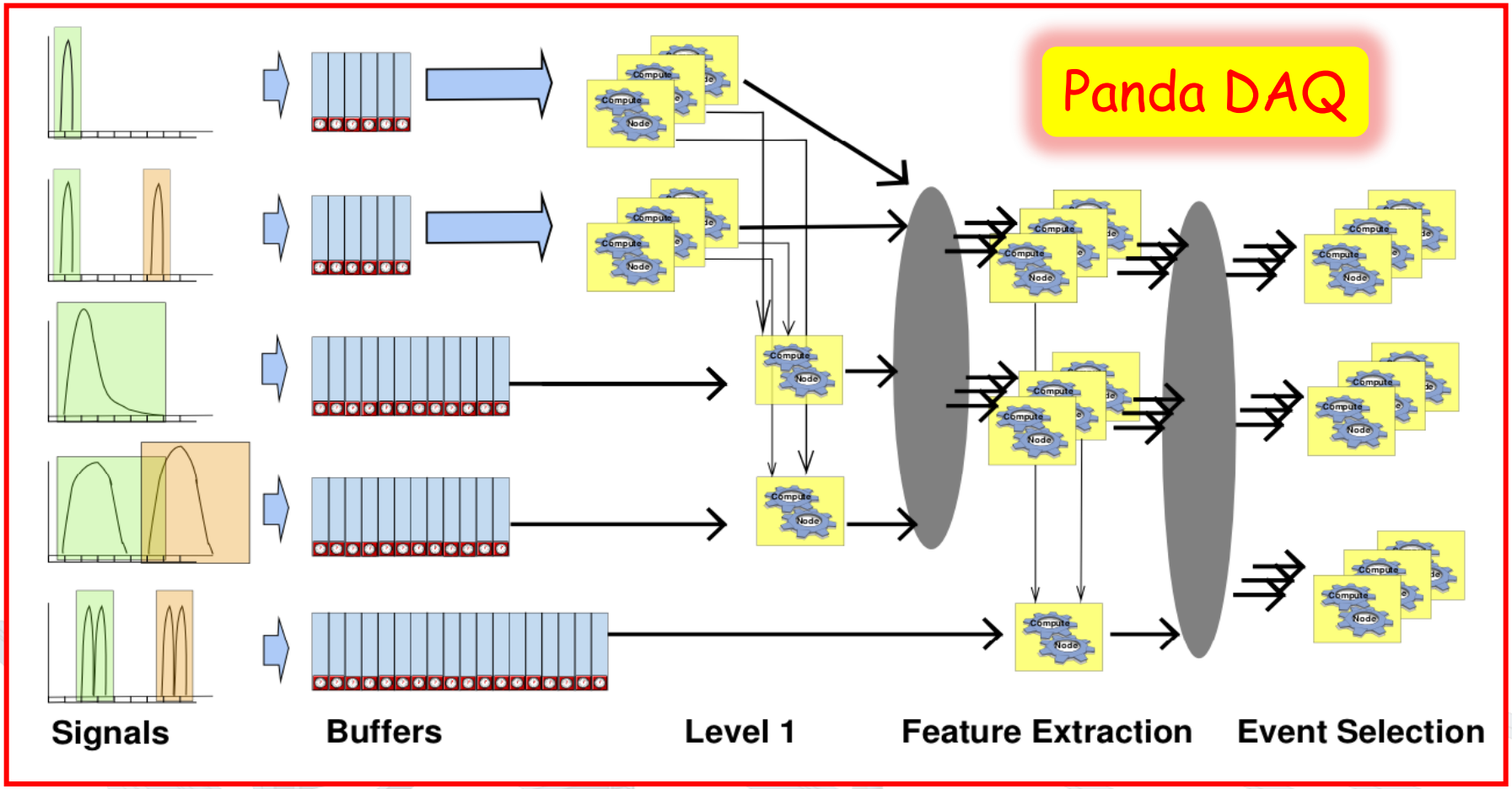


$\sigma_z = (104.8 \pm 0.1)\ \mu m$

Traditional DAQ



Trigger latency about 100 - 500 ns (40-130 m)



continuous sampling DAQ
flash ADC

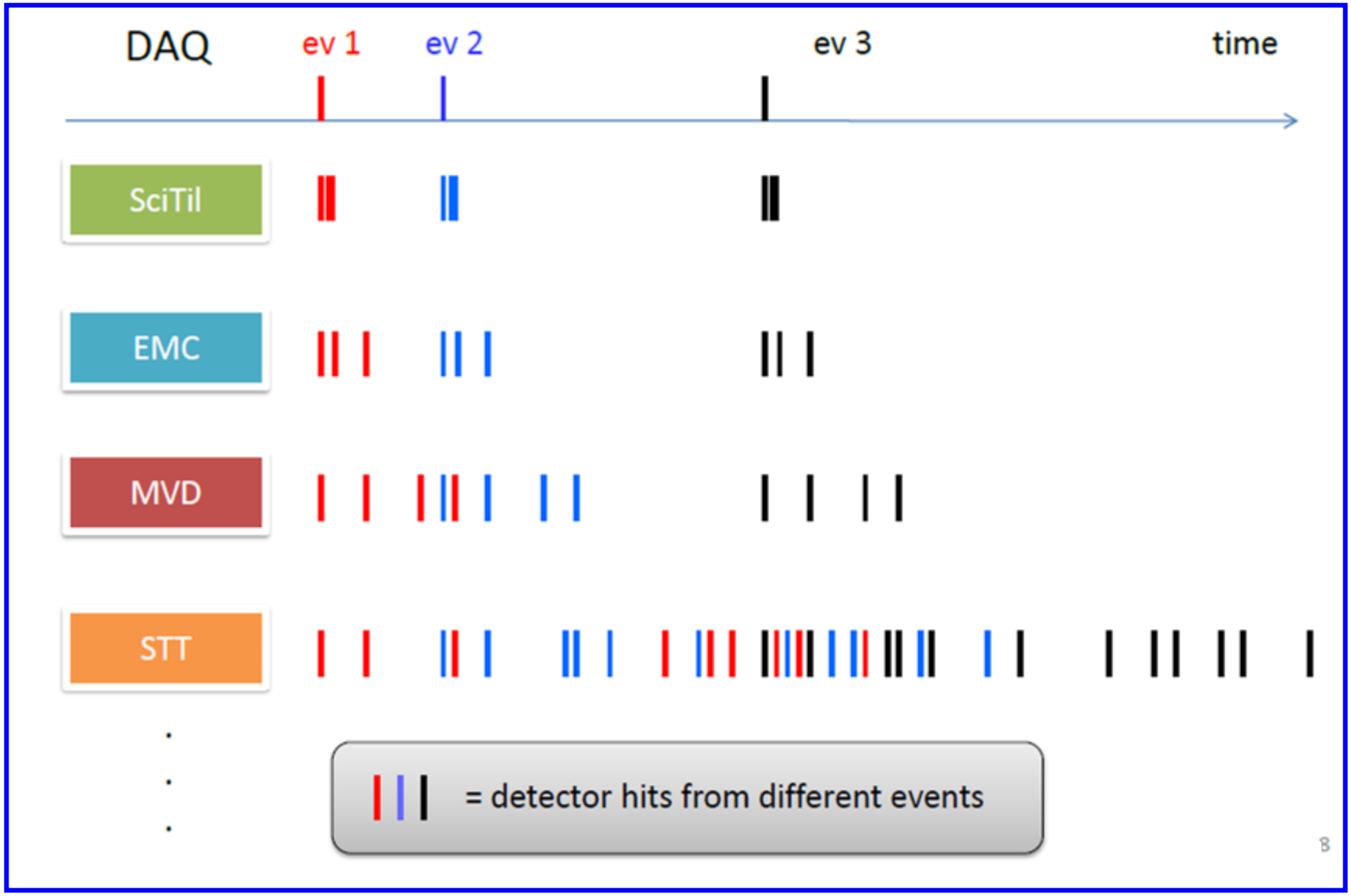
self-triggered
detector front-end

each signal get a time stamp (155.52 MHz)
high quality clock distributed

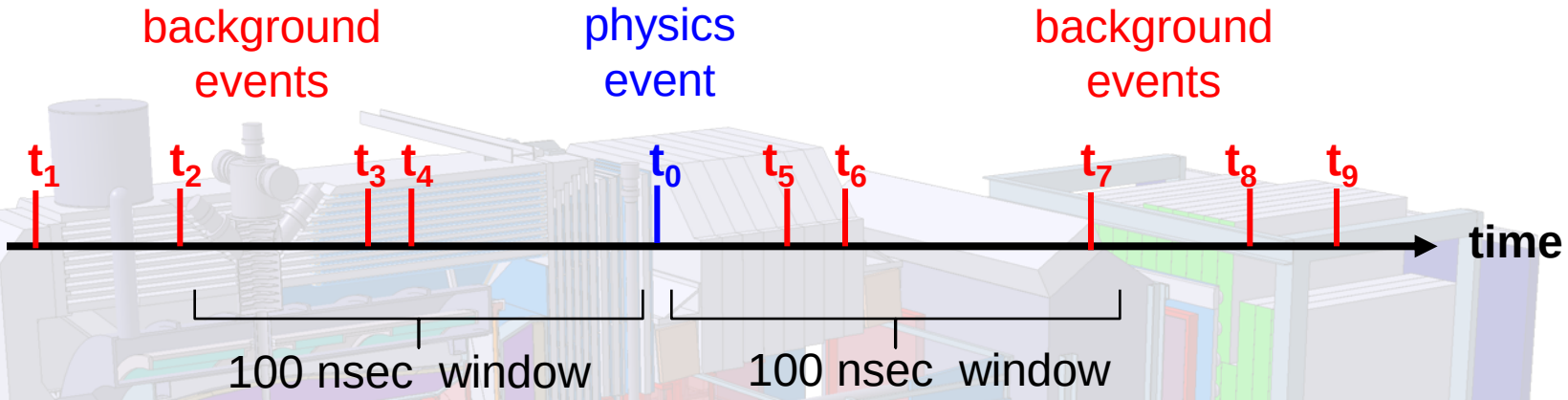
front-end feature extraction
(signal amplitude, shape, …)

Time Dependent Simulation

slow transition from event based to time ordered simulation

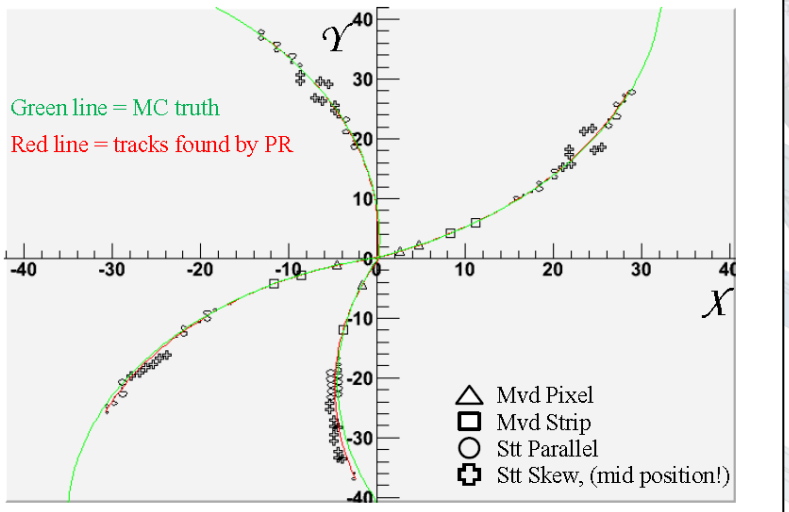


STT MIXING



w/o Event Mixing

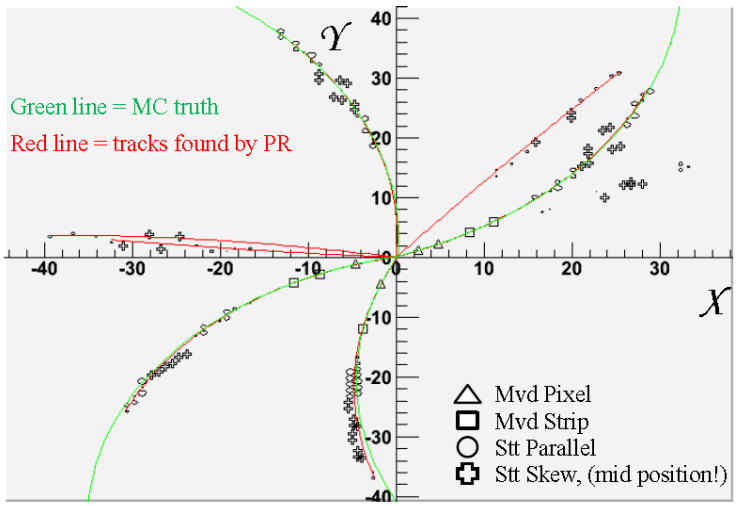
Example : 4 tracks evt mixed with previous bkg evt with $\delta t = -100$ nsec



Unmixed 4 track event

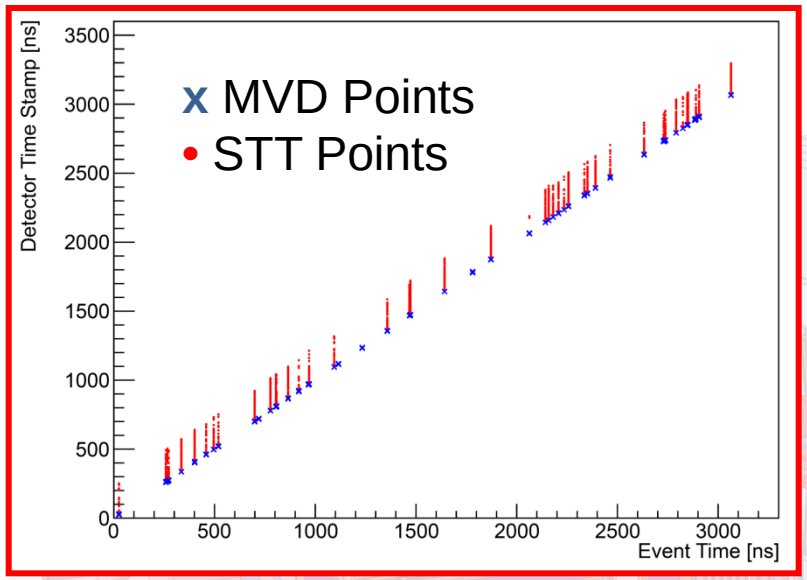
w/ Event Mixing

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



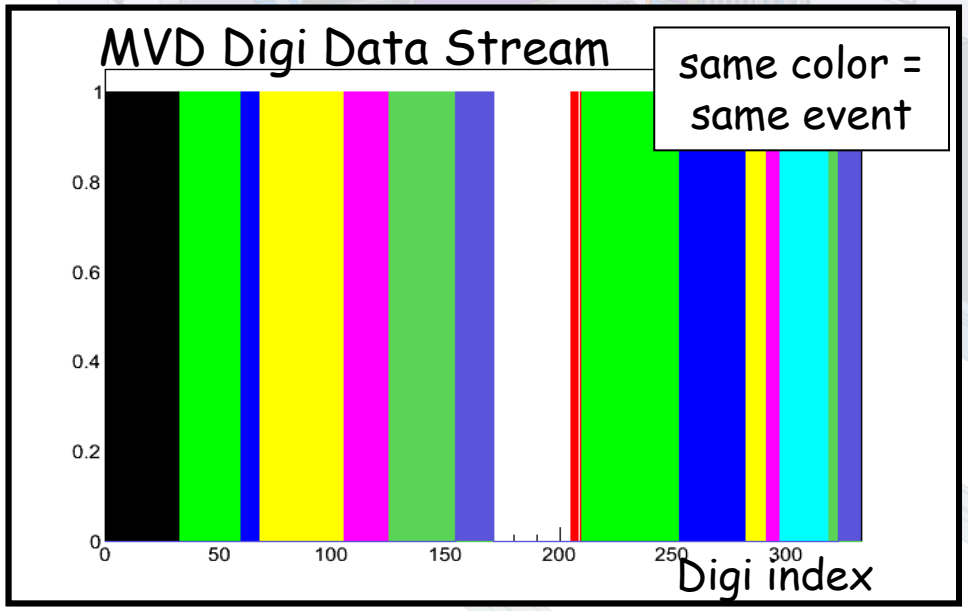
Resulting mixed event

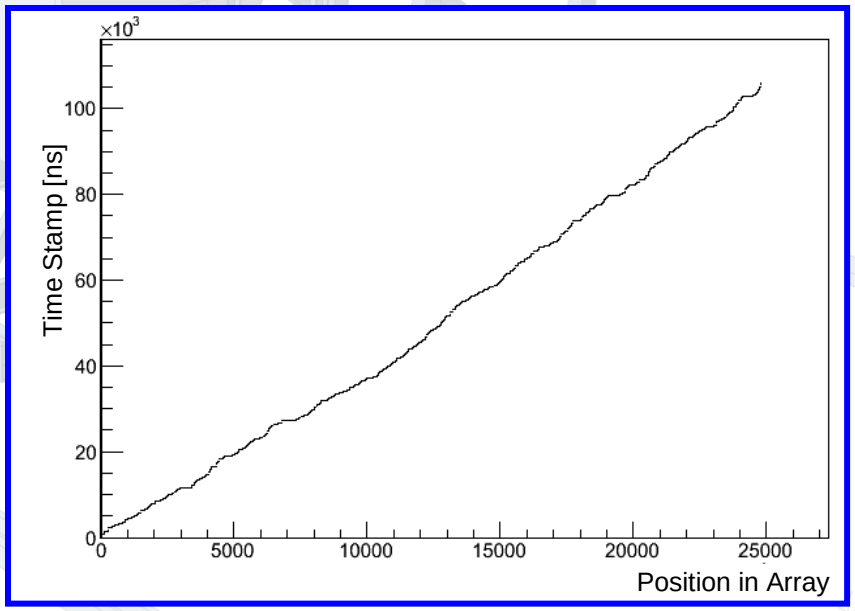
@ 20 MHz interaction rate



Time Based Simulation

- Randomized Digi Data
- Sorting Digi Data using Time Stamps + Drift Time, ToT…





M.Al-Turany, T.Stockmanns

Summary

✓ PandaRoot is the framework for the Panda full simulation
✓ Used successfully for massive data production on PandaGrid

Reconstruction

- Central Tracking in the Barrel ⇒ complete (submitted TDRs for STT&MVD)
- Forward Tracking ⇒ just started, promising results
- Bayesian Particle Identification ⇒ available, flexibility at the analysis stage
- Investigation on TMVA methods for PID
- Analysis of physics benchmark channels ⇒ ready !

Time Based Simulation

- New concept, challenging online and offline reconstruction
- Basic Event Mixing algorithms and cleaning code ready
- Time Based structure implemented in the framework and in some detectors
- Redesign reconstruction code…