

Time-based reconstruction of free-streaming data in the CBM experiment

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DPG Spring Meeting, Bochum
1 March 2018



FIAS Frankfurt Institute
for Advanced Studies

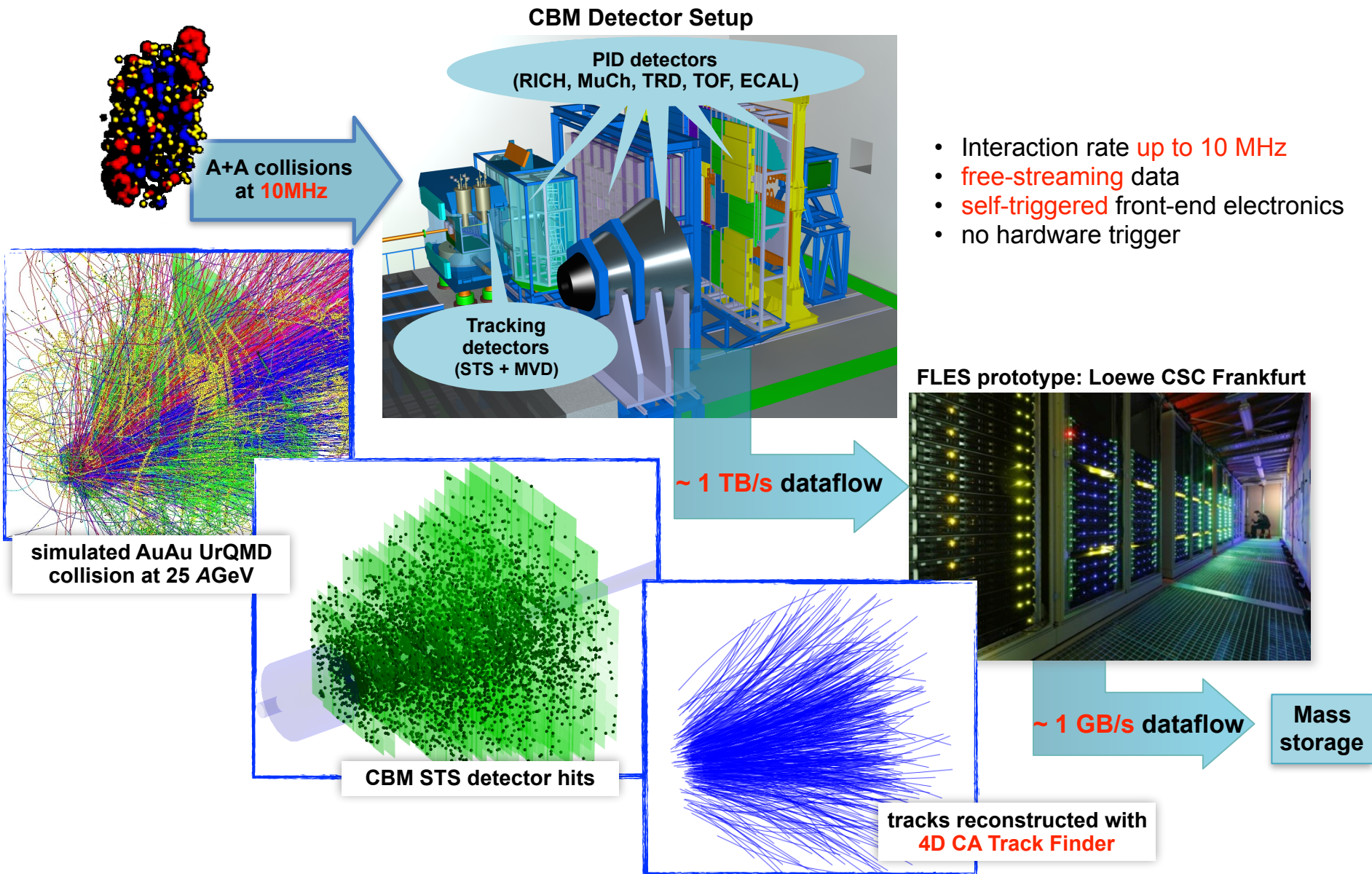


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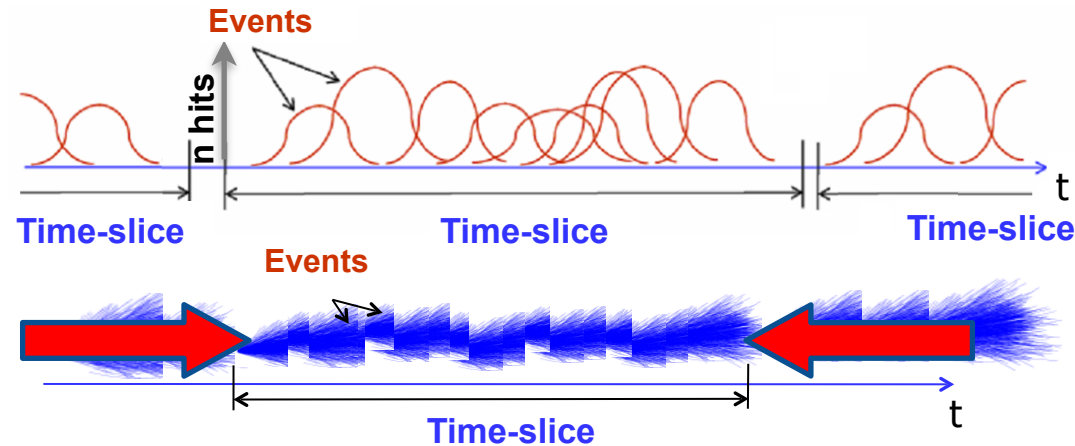
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Online Reconstruction in CBM



Limited bandwidth of data storing leads to
online event reconstruction and selection on a dedicated computer farm.

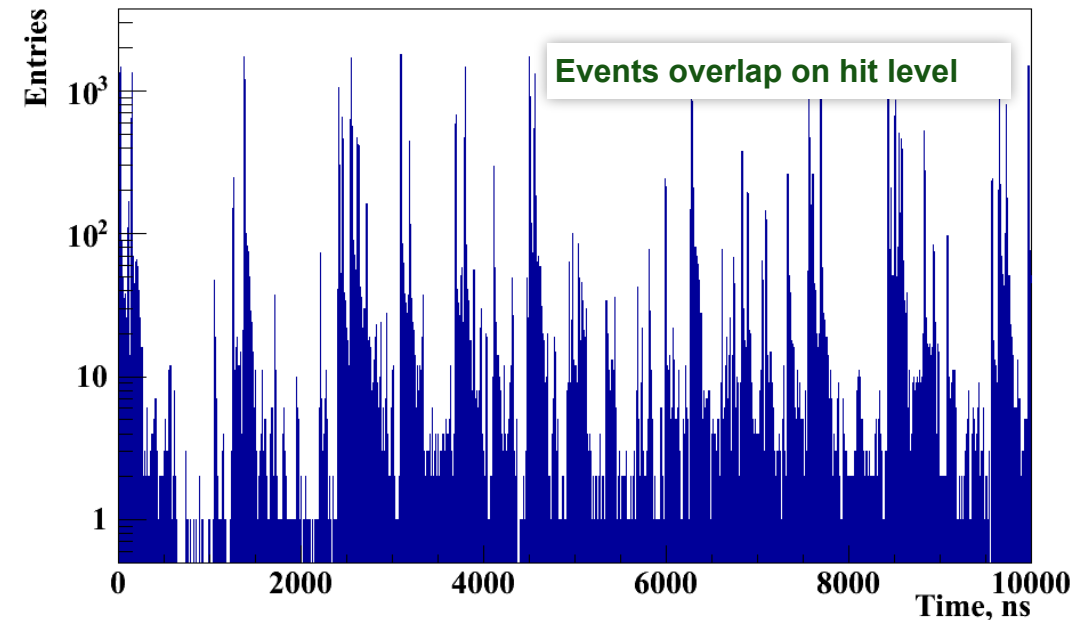
Time-based Reconstruction in CBM



- Interaction rate up to 10 MHz
- free-streaming data
- self-triggered front-end electronics
- no simple hardware trigger

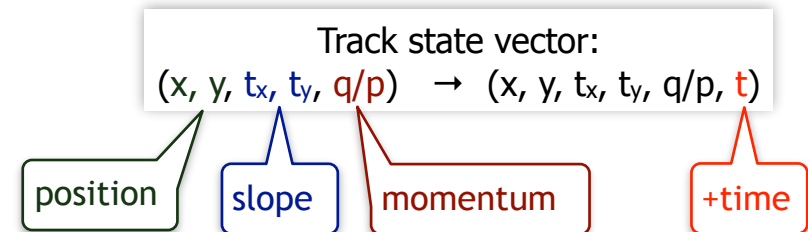
Events overlap

Hit time measurement in STS at interaction rate 10 MHz



- Time-slice rather than event-based reconstruction
- Time-based tracking: 4D measurements (x, y, z, t)

4D tracking



No a-priori association of signals to physical events!
Correct procedure of event building from time-slices is crucial for correct physics interpretation.

4D Cellular Automaton (CA) Track Finder

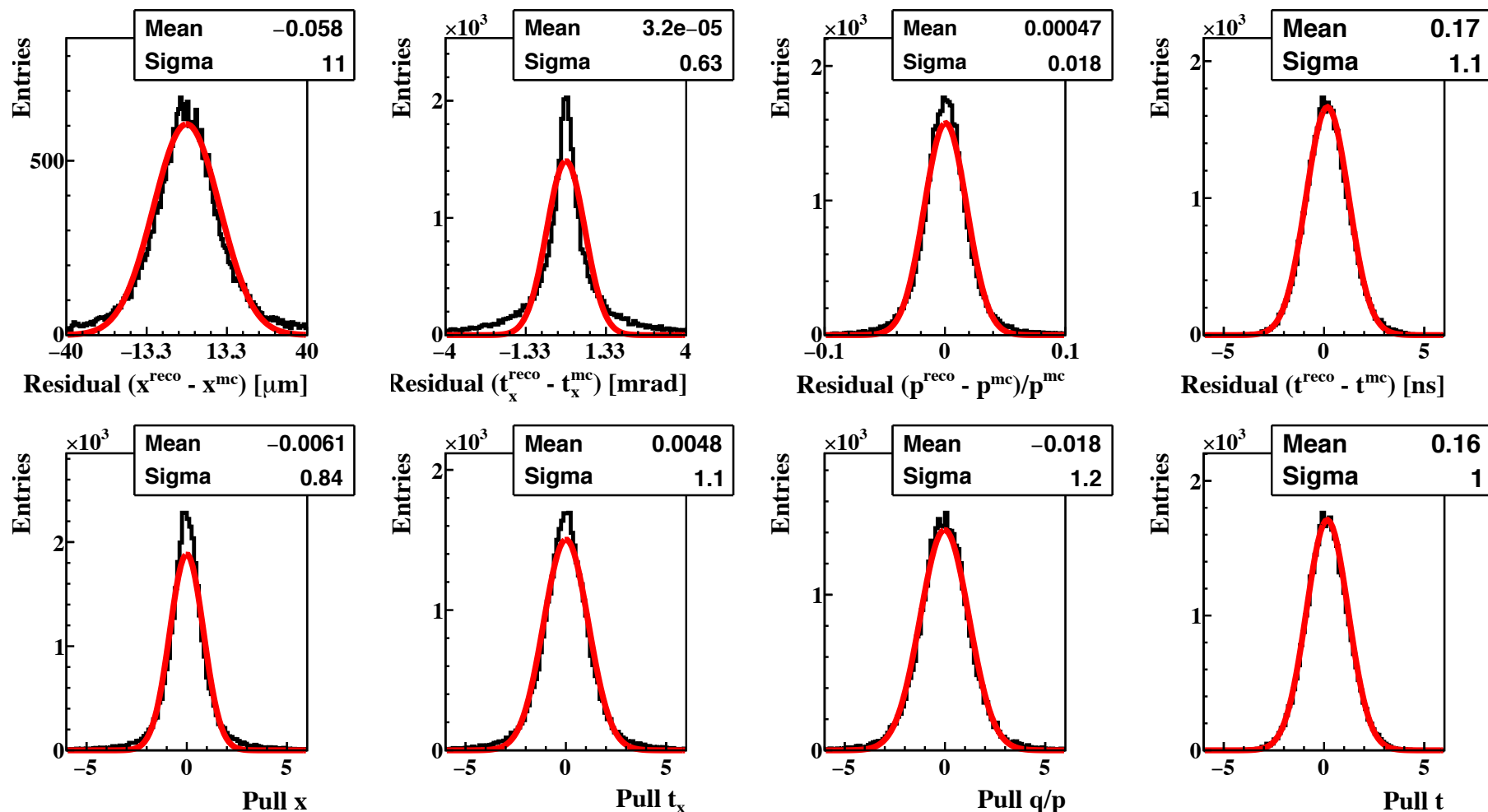
100 AuAu minimum bias events at 10 AGeV

Efficiency, %	3D	4D 0.1MHz	4D 1MHz	4D 10MHz
All tracks	92.5 %	93.8 %	93.5 %	91.7 %
Primary high-p	98.3 %	98.1 %	97.9 %	96.2 %
Primary low-p	93.9 %	95.4 %	95.5 %	94.3 %
Secondary high-p	90.8 %	94.6 %	93.5 %	90.2 %
Secondary low-p	62.2 %	68.5 %	67.6 %	64.3 %
Clone level	0.6 %	0.6 %	0.6 %	0.6 %
Ghost level	1.8 %	0.6 %	0.6 %	0.6 %
True hits per track	92%	93 %	93 %	93%
Hits per MC track	7.0	7.0	6.97	6.70

Timeslices from CBMROOT, time-based digitisation, cluster and hit finder in STS

4D Kalman Filter Track Fitter

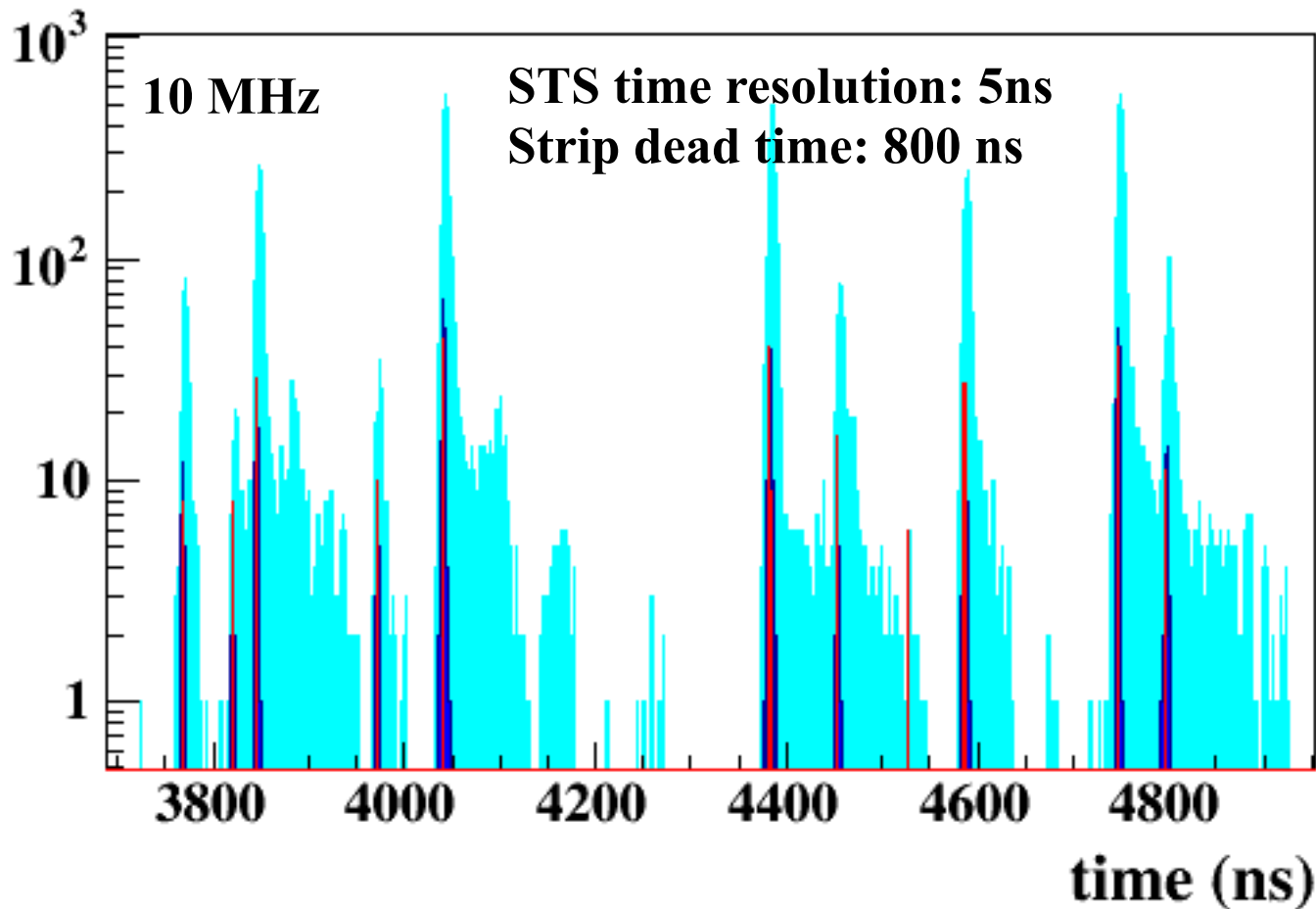
100 AuAu UrQMD minimum bias events at 10 AGeV, 8 STS stations



Track fit quality is high: parameters are unbiased, errors are correctly estimated.

Track based Event Builder

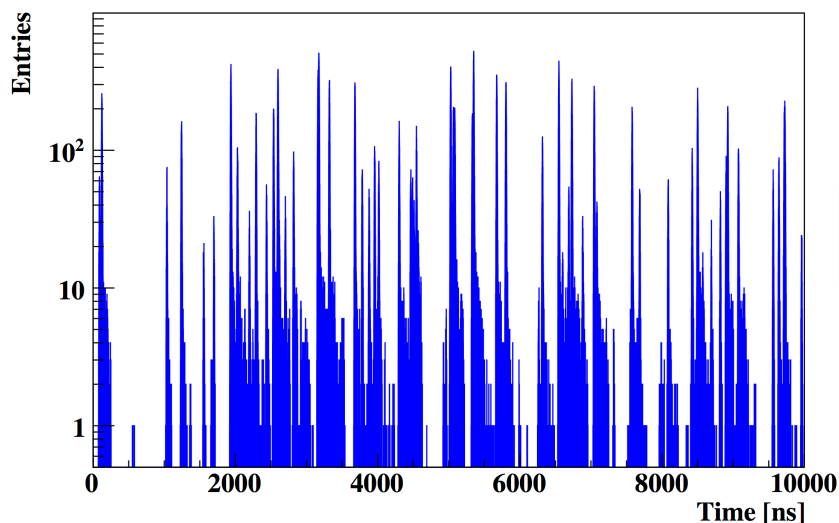
High rate scenario: STS hits+tracks+ mcEvent vs time



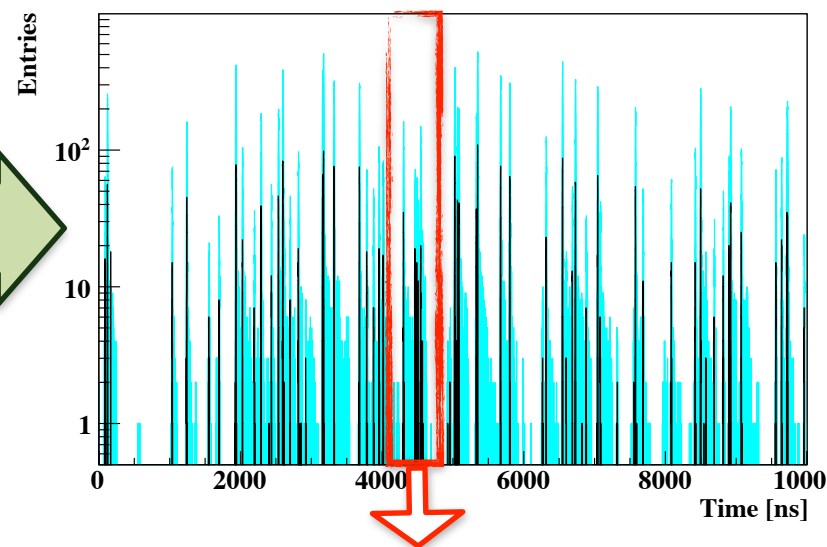
Build events with isolated collisions from continuous time-stamped data.

Time-based Reconstruction Chain

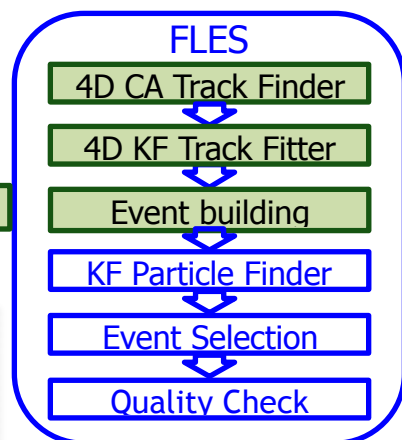
STS hits 10MHz



STS hits + reco tracks 10MHz



Track
Finder



Ideal
Event
Builder

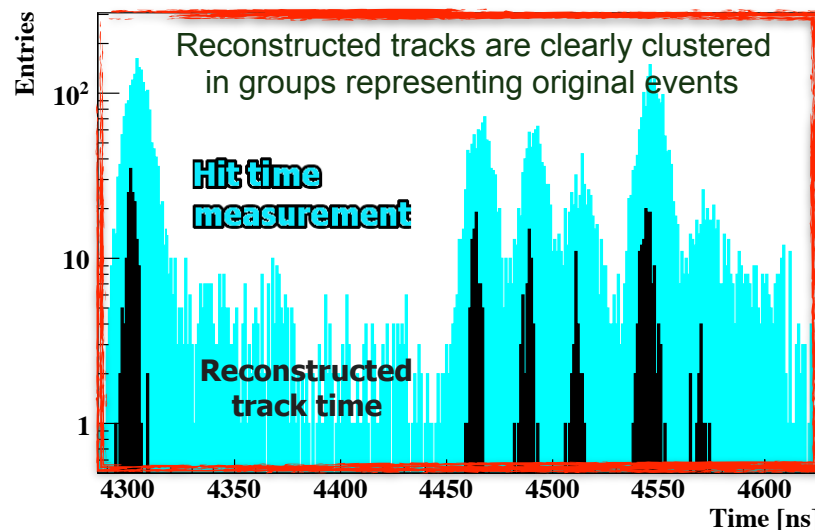
4D tracks + MC
event number

physical events

Realistic
Event
Builder

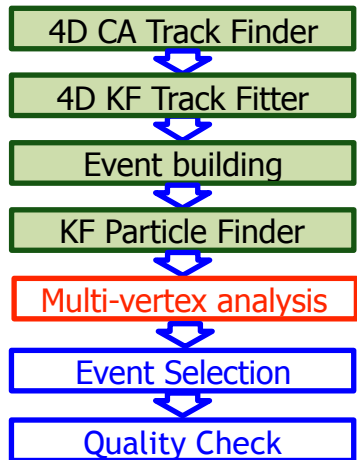
4D fitted tracks:
time + error

physical events



Short-lived Particle Reconstruction

FLES

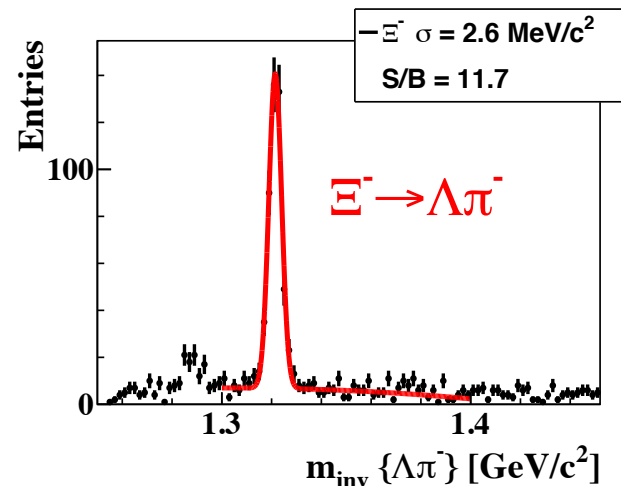
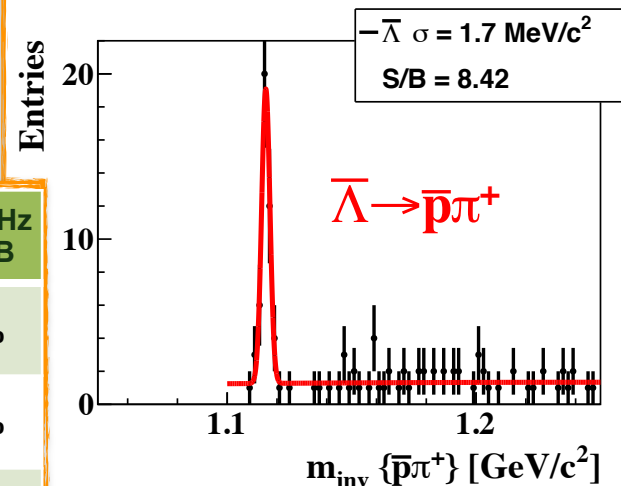
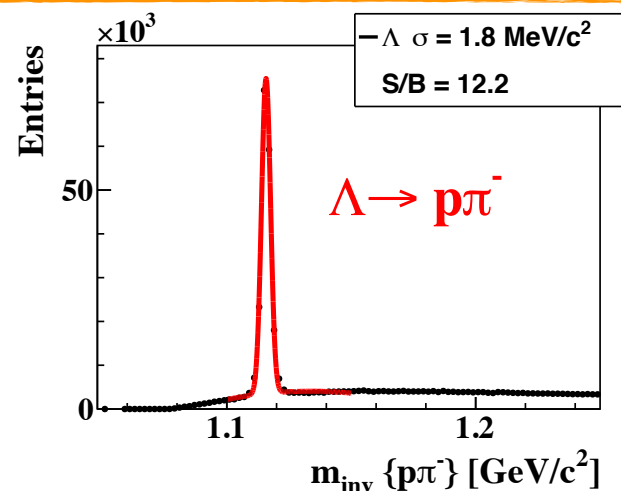
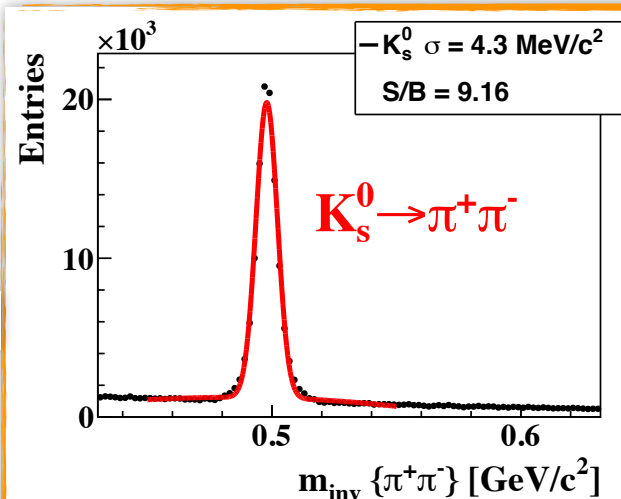


? 10 MHz

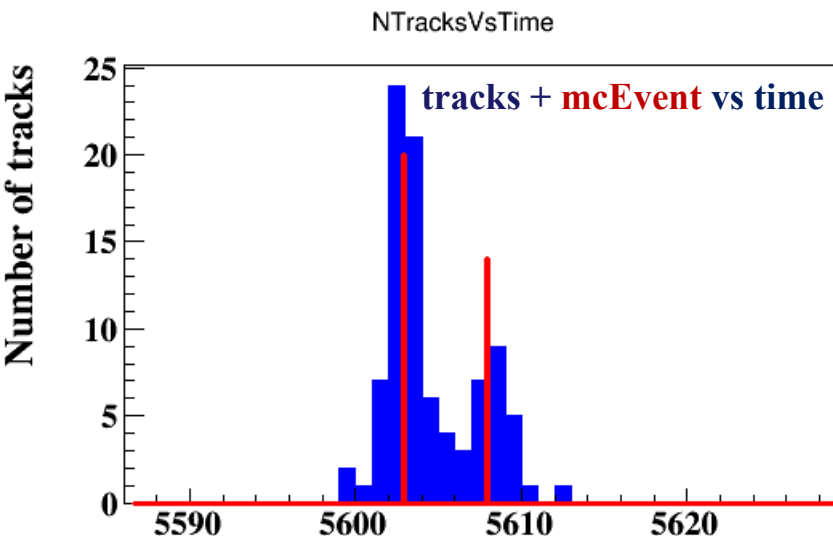
Extreme case of 10 MHz interaction rate requires further input from fast detectors (**ToF**) and **multi-primary vertex analysis**

Particle /Case	3D	4D 10 MHz Ideal EB	4D 10 MHz Real EB
K_s^0	22.9%	21.2%	21.2%
Λ	21.9%	19.8%	19.6%
Ξ^-	7.8%	6.3%	6.3%

300k mbias AuAu 10 AGeV events at 10 MHz, KF Particle Finder, ideal PID, realistic event builder

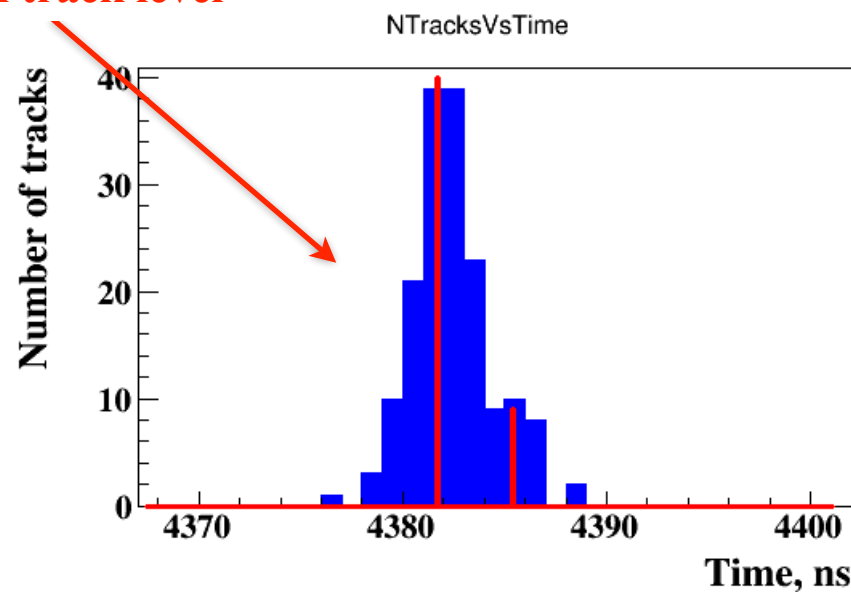
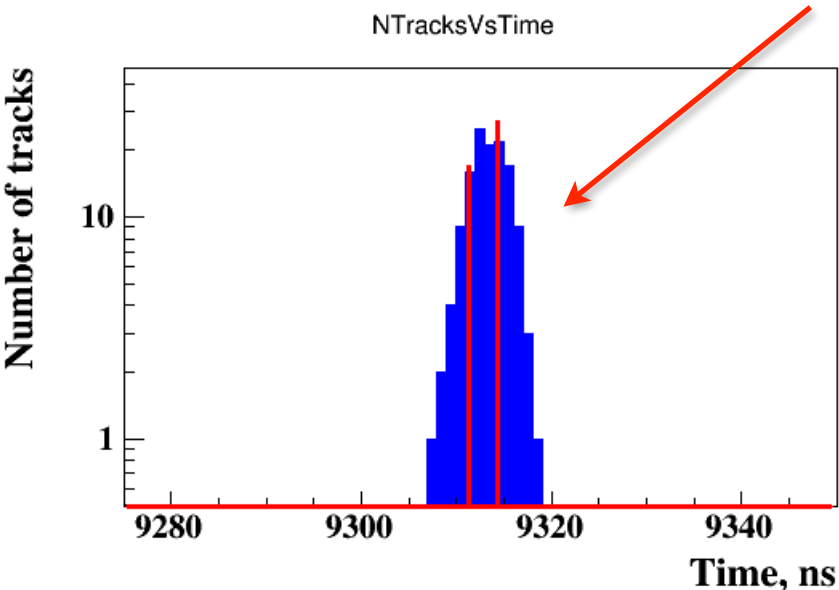


Multi-primary-vertex Analysis



- Track based EB with STS allows to resolve ~80% of collisions at 10MHz
- MPV analysis idea - examine track space topology and search for multiple primary vertices
- The first implementation of MPV analysis increases event separation efficiency from 80% to 89.5%

Events overlap on track level



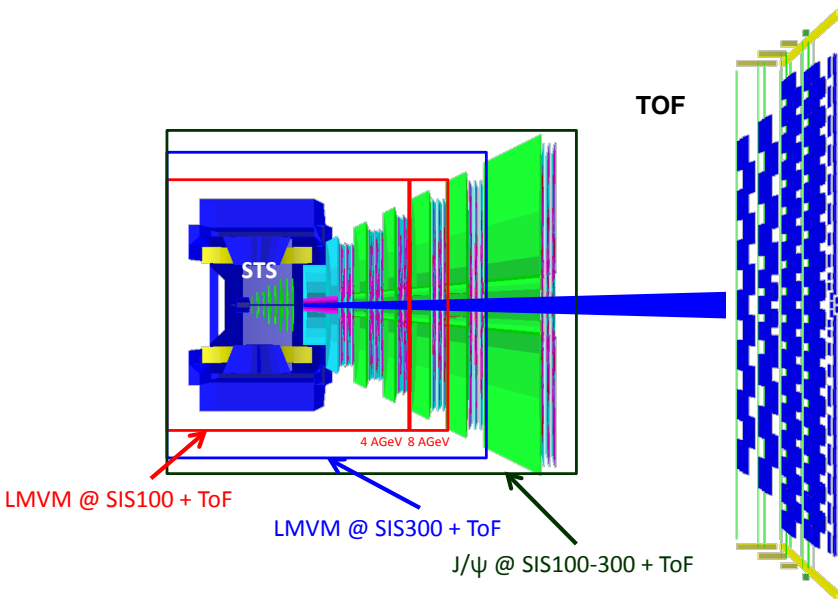
100 % collision resolution requires TOF + multi-vertex analysis.

Extend CA and KF Fit reconstruction in STS+MuCh

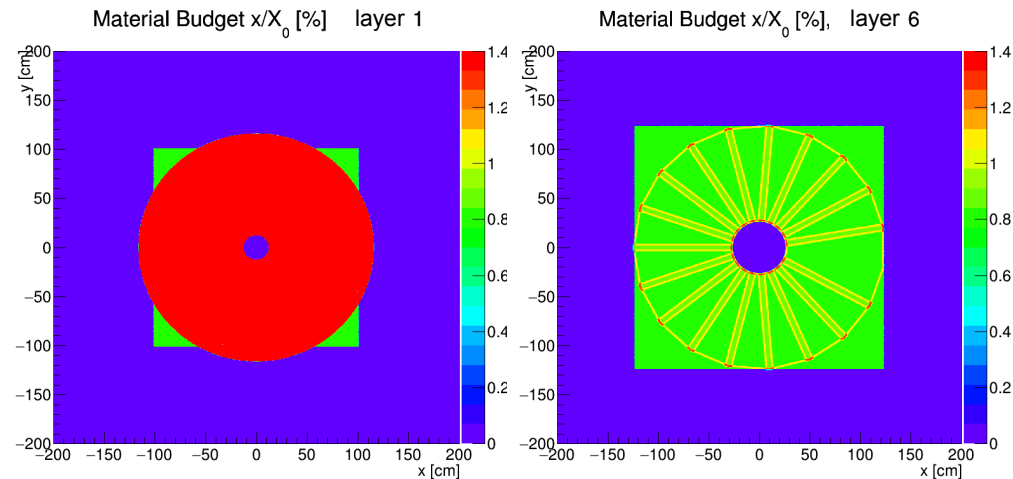
Motivation:

- Extend existing fast and parallel CA track finder to MuCh for online reconstruction
- mCBM needs tracking algorithm for complete mCBM detector system
- Easier alignment procedure due to independent reconstruction in STS and MuCh

Muon Detector Setup



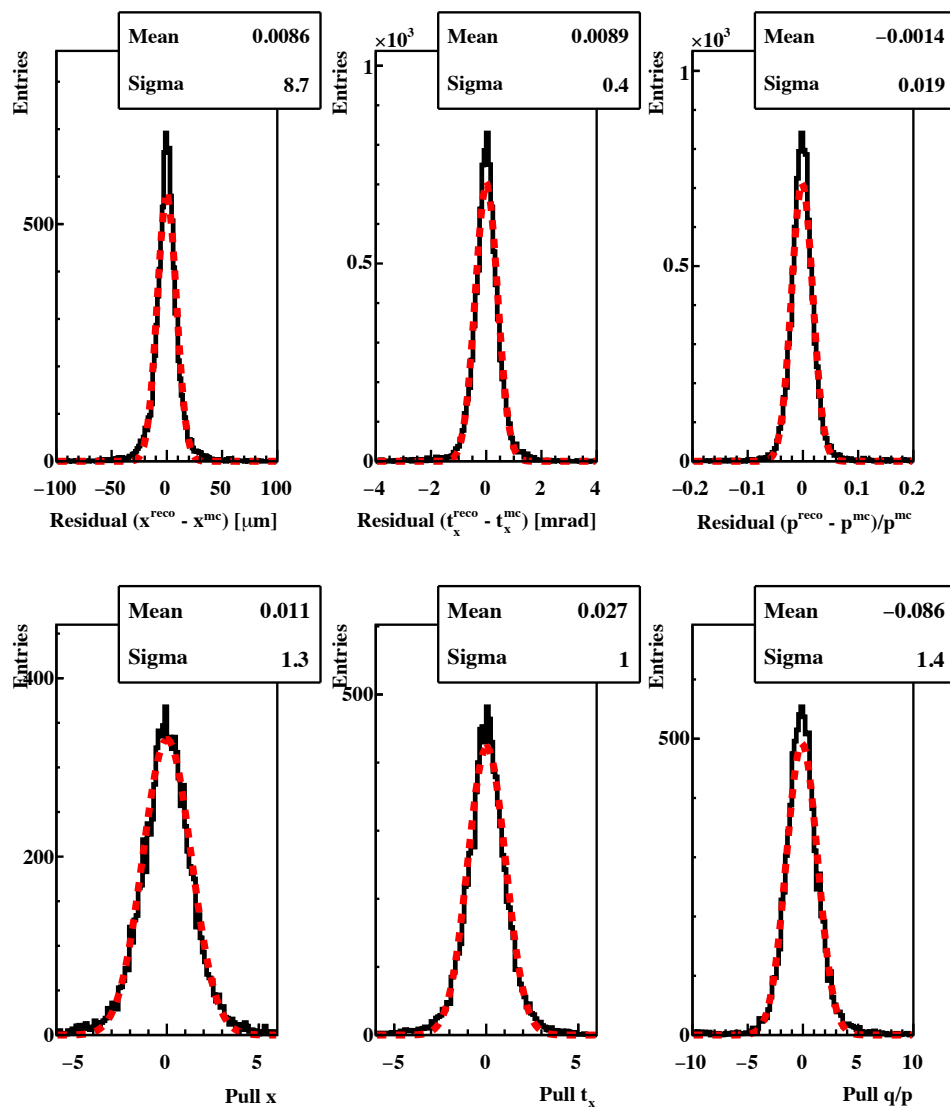
MuCh Material Budget Map



On the way to include MuCh and ToF detectors to 4D track reconstruction

Simultaneous reconstruction: STS+MuCh

Kalman Filter Track fit quality
in the 1st hit position (STS + MuCh)



CA Track Finder Performance (STS + MuCh):

10 muons per event (FairBoxGenerator)

Efficiency, %	4D 10MHz
All tracks	96.0 %
Clone level	1.4 %
Ghost level	17 %
True hits per track	82%
mcPoints per mcTrack	15.82
Hits per mcTrack	15.50

Reconstructable track: ≥ 4 consecutive mcPoints

All set: $p \geq 0.1 \text{ GeV/c}$

Ghost: purity < 70%

Clone: tracks reconstructed more than once

On the way to include MuCh and ToF detectors to 4D track reconstruction

Summary and Outlook

- Time-based reconstruction chain for CBM has been developed
- It includes CA track finder, KF track fit, event builder and KF Particle Finder
- Adding of time information from other detector systems to 4D analysis is in progress

Outlook:

- Include ToF information
- Multi-primary vertex analysis
- Include realistic PID