Reconstruction of High-energy Muons in CMS

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The Physics of the Dimuons at the LHC WS'2022

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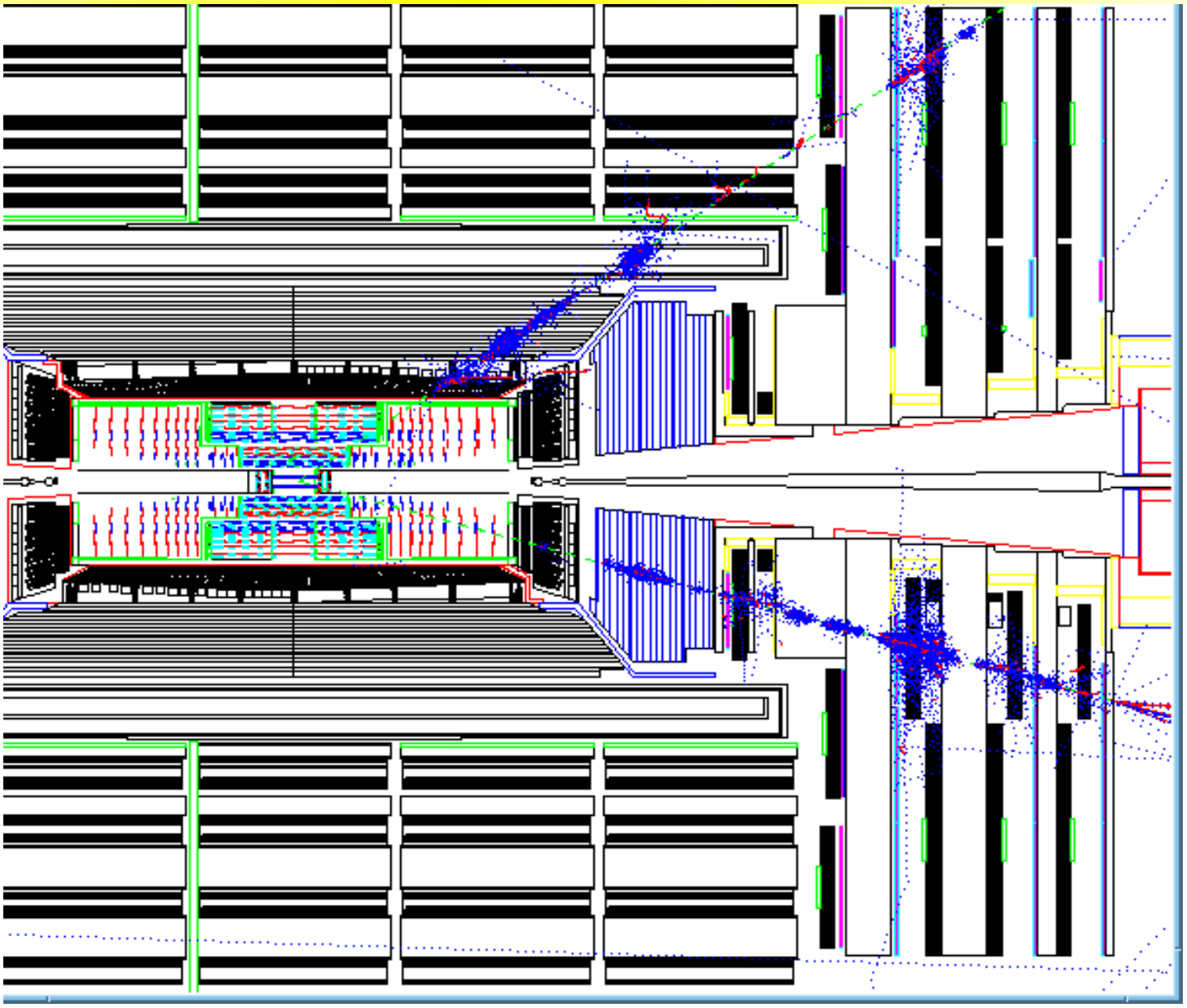
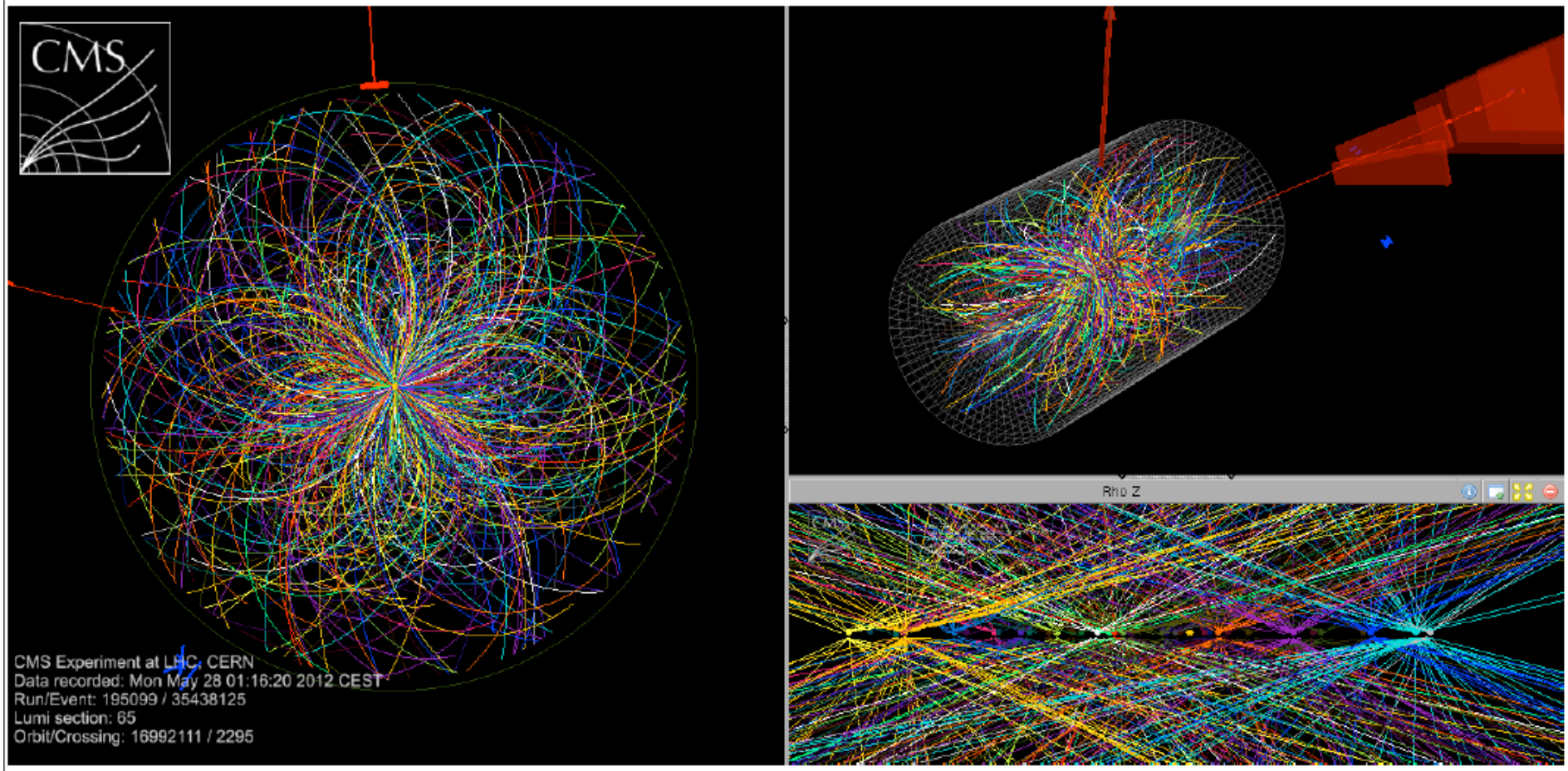
An example of heavy mass di-muon event simulation (Pt of muons ~ 1 TeV)



Bremsstrahlung and e-m showering close to hard muons lead to the problems with reconstruction in the muon system

CSC APPEARED IN HIGH PU EVENT DISPLAY



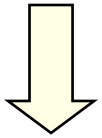
Approved for public display (May 2012)
https://indico.cern.ch/conferenceDisplay.py?confId=169297

Motivation

✓ ***studies with hard*) muons at CMS can lead to new physical phenomena discoveries and also be a tool for testing of reconstruction algorithms on their efficiency and a precision of measurements***

✓ ***precision of measurements in the muon system plays a leading role in achieving of the required resolution on transverse momentum and mass reconstruction for the processes with hard muons***

✓ ***Dubna group is responsible for ME1/1 production***
ME1/1 is the most precise station
in the muon endcap system:
$\sigma(ME1/1) : \sigma(ME2 \div 4) \sim 1 : 2$



a special interest to high-p_T muons (~ 1 TeV),
where a role of the muon system increases

**) hard muons – the muons with high transverse momenta from several hundred GeV up to TeV region*

Endcap Muon Reconstruction

Local (individ.detectors)

Regional (Muon system)

Global (Muon & Tracker system)

Local reconstruction:

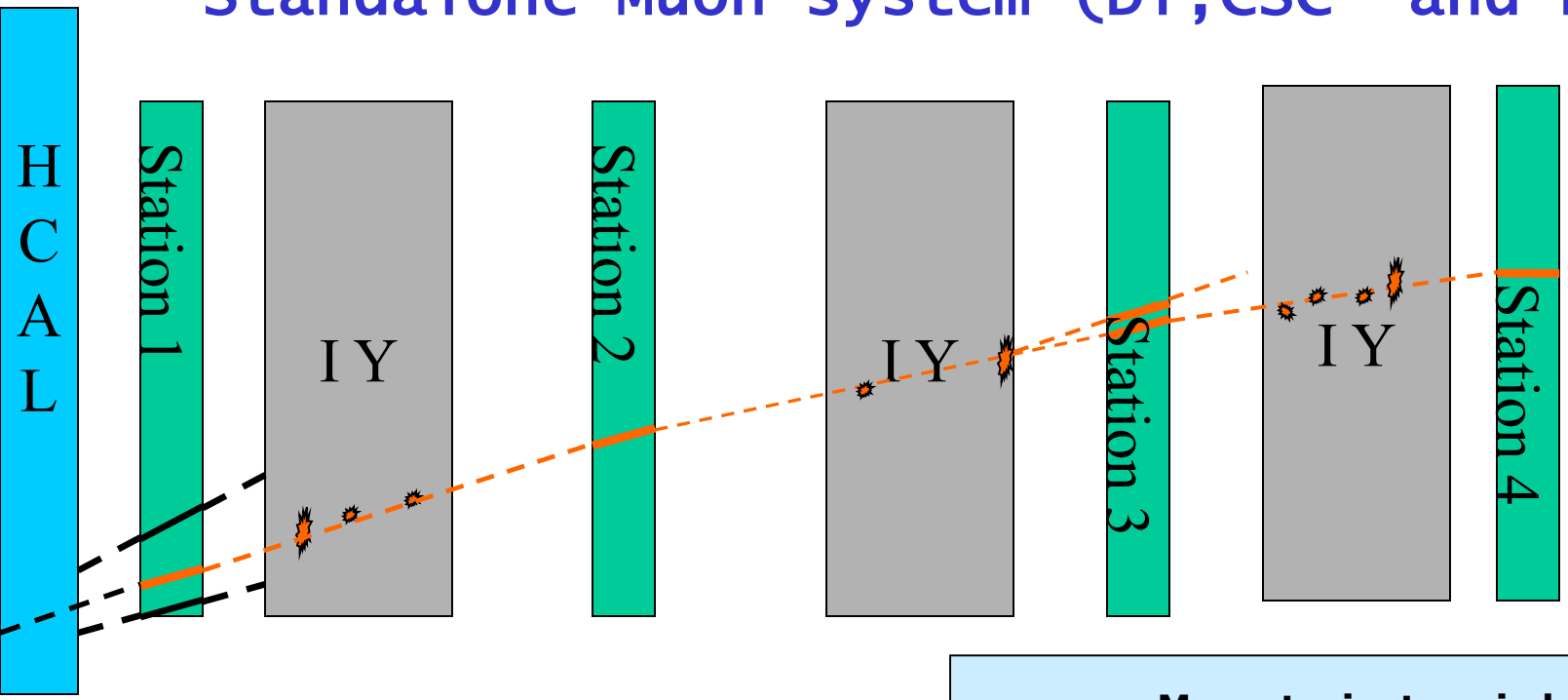
1. **Drift Tubes in the Barrel**
2. **CSCs in the Endcap**: clusters of Digis fitted into RecHits, i.e. position of hits in the detector layers.
3. Track-segment building (track following & track road methods) with the compatible RecHits in muon chambers.

The track-segments are selected by a goodness of fit criteria (χ^2).

See more detailed report about local reconstruction by N. Voytishin tomorrow

Regional Muon Reconstruction

Standalone Muon system (DT,CSC and RPC):



e.m.showers& punchthrough

Multiple scattering, energy losses, bremsstrahlung, e^+ e^- pair production etc.

from Hadron Calorimeter (HCAL)

in Iron Yokes (I Y)

Muon trajectory is built on a base of CSC and DT track-segments

→ **Recursive track fitting (from hit to hit in endcap; with use segments in barrel) by the least squares method (Kalman filter propagation & parameter estimation)**

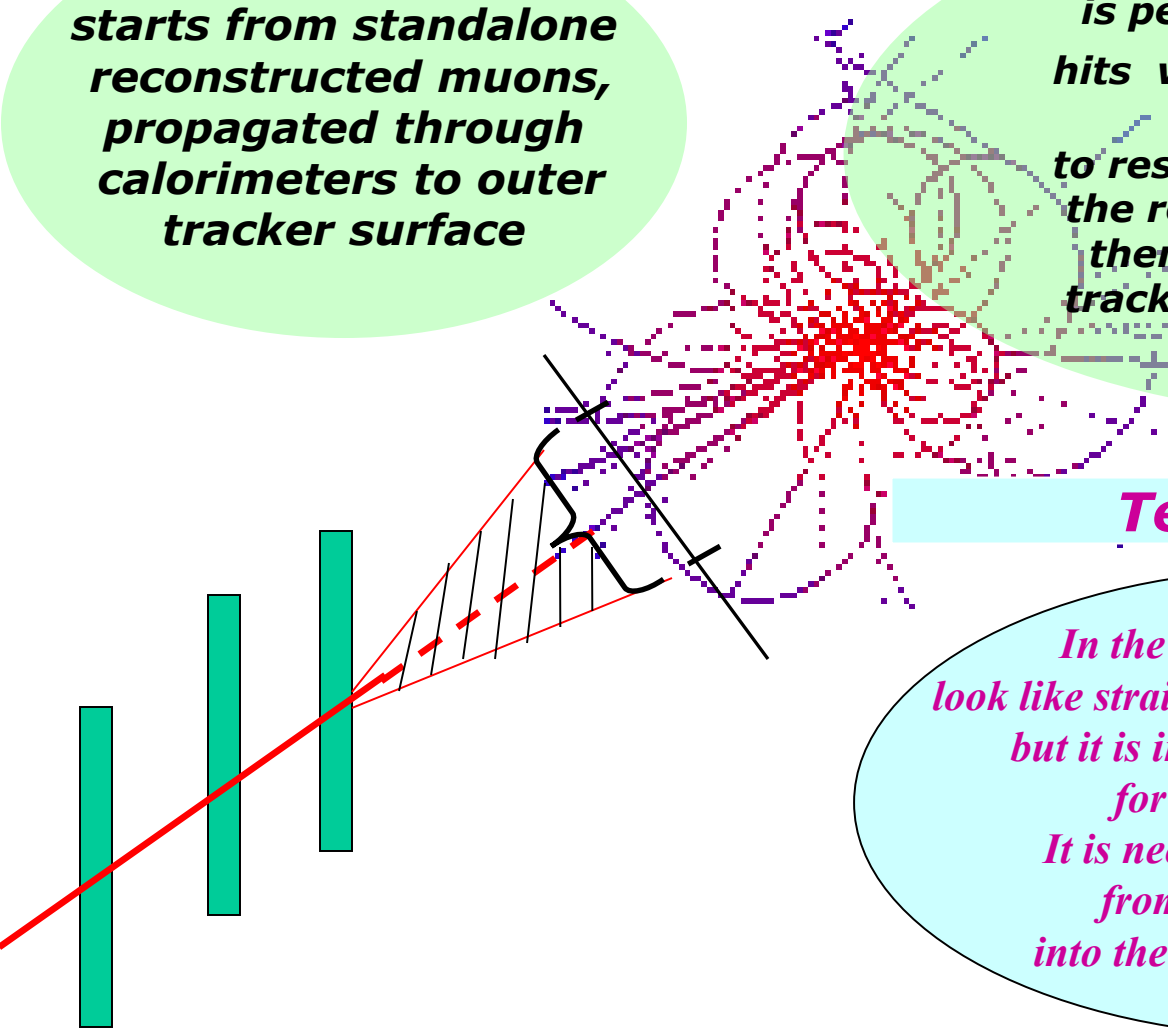
Global Muon Reconstruction

inclusion of tracker hits

starts from standalone reconstructed muons, propagated through calorimeters to outer tracker surface

regional track reconstruction is performed using Tracker hits within this (η,φ)-region;

to resolve the ambiguities, all the reconstructed tracks are then refitted including the tracks in the muon chambers



TeV Muons:

In the Tracker hard muons look like straight lines easy to reconstruct but it is impossible to estimate Pt for the straight lines. It is necessary to include hits from the Muon system into the Global reconstruction.

Modification of local reconstruction algorithm for muons in CSCs

The algorithm for Endcap track segment building has been improved taking into account the contamination of muon measurements by a secondary electromagnetic accompaniment:

1) **the more narrow rdϕ (dRPhiMax=1cm-> 3mm) and χ^2 criteria (100->20);**

2) **additional dϕ-checking (0.6 - 0.8 mrad);**

3) **rdf and df checkings for ME1/1 and others CSCs differ in the accordance with their accuracy;**

4) **if a number of RecHits is not so big (low contaminated chamber) then a required minimal number of hits in track segment is changed from 4 to 3.**

implemented in ORCA (December, 2003)

Modification of regional reconstruction algorithm in ORCA for TeV muons

Improved high Pt trajectory seed Generator in CSCs for Standalone Muon reconstruction:

(The first variant of the algorithm for ORCA_7 has been created in cooperation with Ivan Belotelov)

1) finding the track-segment pairs and select according to quality (priority of ME station pairs, hit multiplicity and number of track segments in chamber, number of points in track segment) in L1 (η, ϕ)-region

priority	*ME stations*
1	1 – (3,4)
2	1 – 2
3	2 – (3,4)

2) estimation of Pt by dϕ [Pt= $(C_1 + C_2\,\eta)/\,d\phi$] for a segment pair selected (the parameters C1 and C2 have been chosen with assistance of Gleb Mescherjakov)

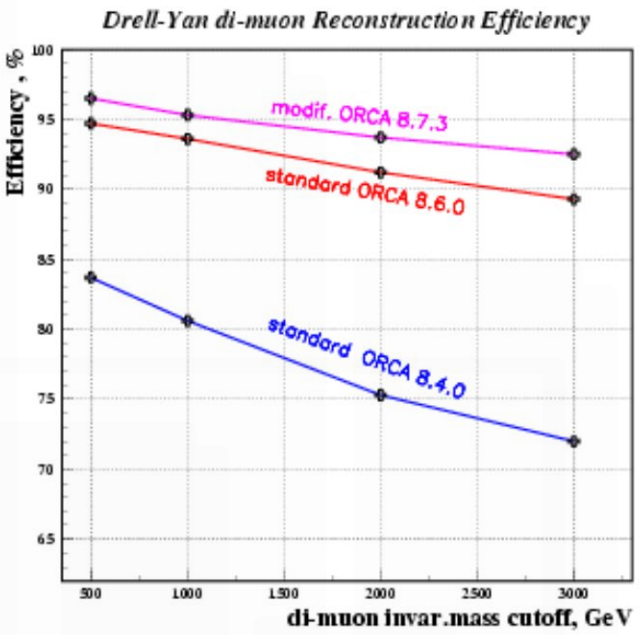
3) use these seeds to start standard muon reconstruction

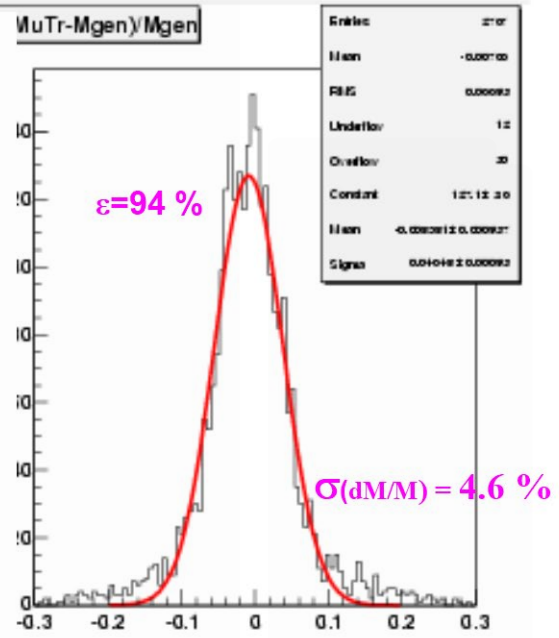
4) the code is implemented in the MuonReconstruction package of the MuonReco subsystem

Drell-Yan di-muon Mass Reconstruction in modified ORCA_8_7_3

off-line muon reconstruction

Mon Sep 5 23:36:32 2005



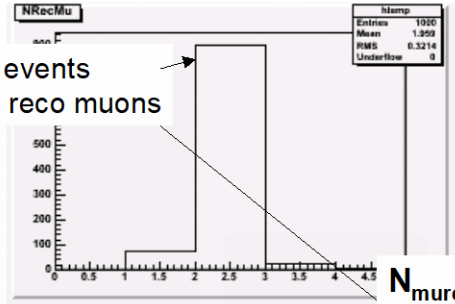


sample with di-muon invariant mass cut-off 2000 GeV

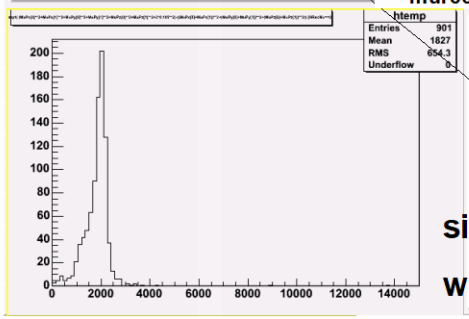
Muons (III)

Sample: mu03_Zprime_LRM_2000_mum

90%of events have 2 reco muons



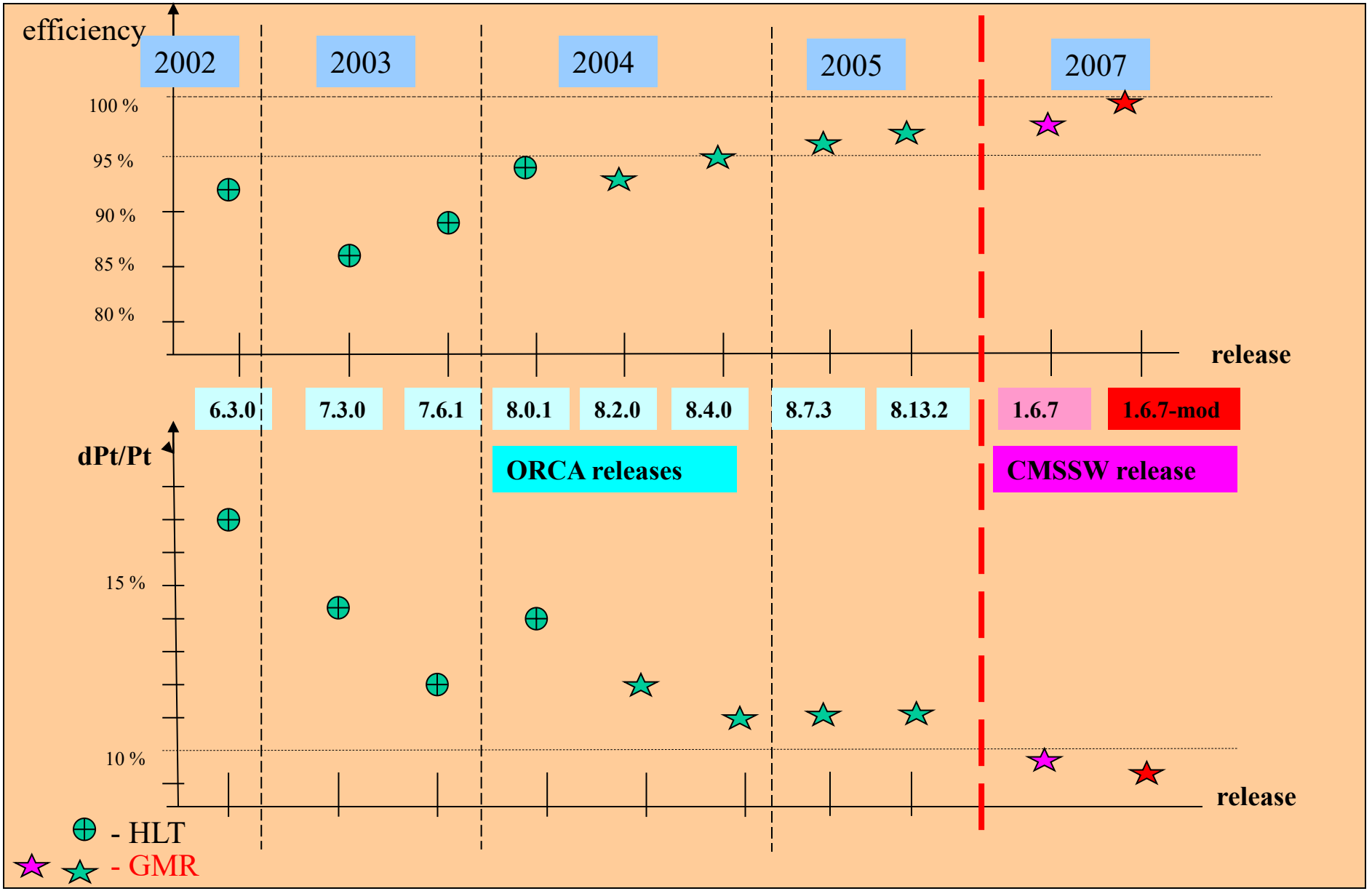
N_{murec}



significant (~15%) improvement w.r.t. previous ORCA - fix by V.Palichick

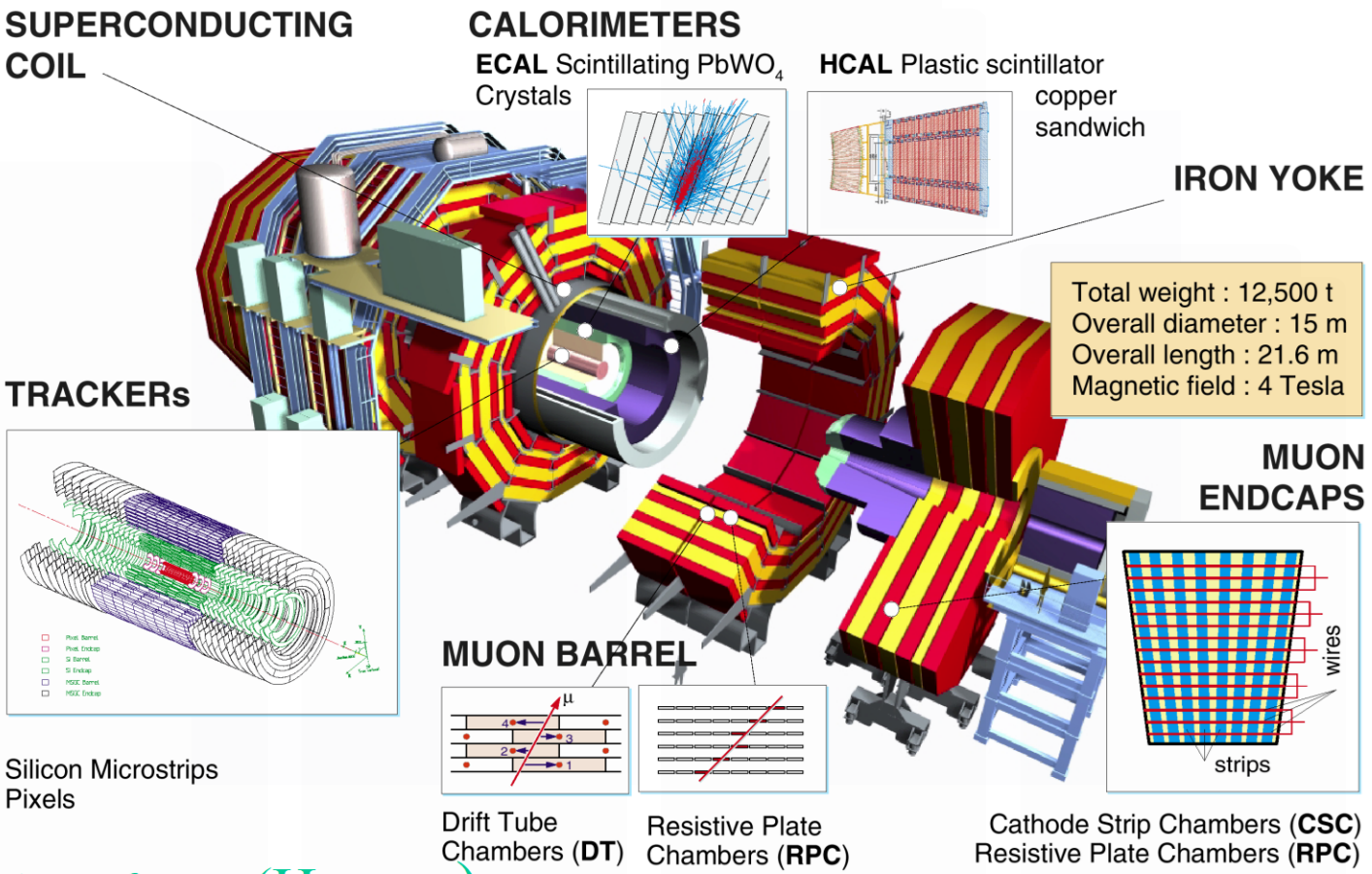
M(μ+μ-)

Progress with Single Pt = 1 TeV Muon Reconstruction in endcap ($1.2 < \eta < 2.1$) region



Back up

Compact Muon Solenoid Detector



ECAL - for γ $(H \rightarrow \gamma\gamma)$

Tracker & Calo system - for e^+, e^-, γ, hadrons, jets and $\nu(E_T$ miss)

Tracker & Muon system – for muons