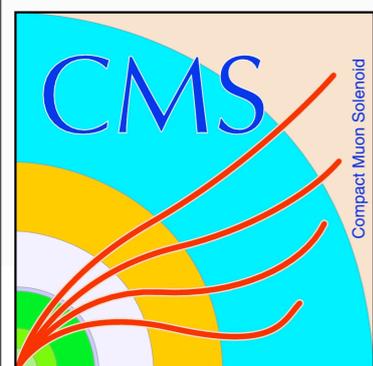


# **Validation of Software Releases for CMS**

**Computing in High Energy and Nuclear Physics,  
Prague, Czech Republic, 21 - 27 March 2009**

**Event Processing Parallel Track - 03/23/09**



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- ▶ Talk describes the central  
**CMS Release Validation Process**
- ▶ CMS software
- ▶ Releases
- ▶ Release Validation
  - ▶ Validation Samples
  - ▶ Performance
- ▶ 2008 Release Validation
- ▶ Summary & Outlook

- ▶ Consists of **more than 2 Million lines of CMS code**
- ▶ **Over 250 active developers** are maintaining and improving the code base continuously
- ▶ **Code is consolidated into releases**
- ▶ **Feature sets** are grouped into **release cycles**
  - ▶ E.g. Cosmics data taking in 2008, Summer/Fall 2008 MC production, Integration of a new ROOT version, etc.
- ▶ **Rapid development per cycle: new test release approximately every week**

▶ In 2008, CMS released **78 different releases** of the Software Stack in **4 different release cycles**:

▶ There are 3 types of releases:

▶ **Pre-Release:**

- ▶ consolidates the current state of the code
- ▶ Purpose: test interdependencies between different software components developed in parallel
- ▶ Not used for official production

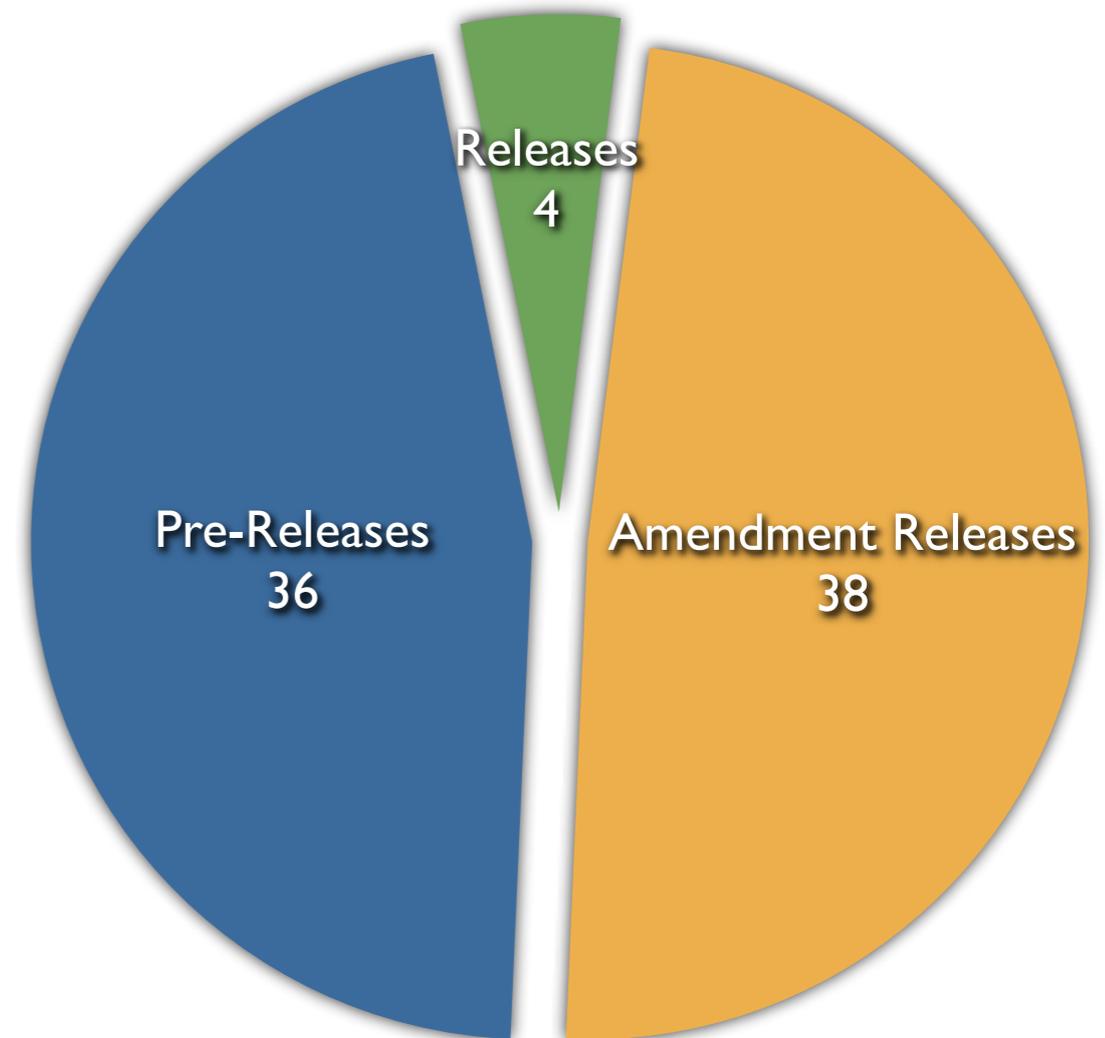
▶ **Release:**

- ▶ Closes the development cycle
- ▶ Final feature set, new features are not allowed to be added anymore
- ▶ Used for production of MC samples and central re-processing's as well as analysis
- ▶ Distributed and installed world-wide on all official levels of the CMS tiered computing infrastructure

▶ **Amendment Release:**

- ▶ Bug fix release for specific problems found in a release
- ▶ Supersedes previous releases and used for central production and processing activities

Software Releases in 2008



- ▶ **Purpose of Release Validation:**
  - ▶ Guarantee that all components of a release **work together without interference or failures during execution**
  - ▶ Check that release **can be used by the global production infrastructure** of CMS
  - ▶ Validate the **correctness of produced physics output**
  - ▶ **Validate the performance** of a release in terms of
    - ▶ **Algorithmic performance**
    - ▶ **Stability at larger scales** (e.g. number of events)
    - ▶ **Memory and time consumption**

- ▶ **Produce** Monte Carlo (MC) simulation **samples** and reconstruction passes of detector data **once per release**
- ▶ Provide samples to software experts **promptly for validation and bug fixes**
- ▶ Use **dedicated resources** where software can be installed instantaneously after release announcement:
  - ▶ **CERN:**
    - ▶ **500 priority batch slots** co-shared with T0
  - ▶ **Fermilab:**
    - ▶ **opportunistic cycles of 5000 batch slots** of T1 center in parallel to central production

- ▶ All Release Validation Samples are grouped in **Validation Sets**:
  - ▶ **“Standard Set”**:
    - ▶ produced **within 24 hours** at CERN to enable rapid feedback before the next release (~1 week), primarily used for software validation
  - ▶ **“High Statistics Set”**:
    - ▶ produced **within 1 week** at Fermilab, primarily used for physics validation

	Full Simulation			Fast Simulation		
Generation	Particle Gun	Physics Process	# Events / Sample	Particle Gun	Physics Process	# Events / Sample
Standard Set	8	24	9k	6	1	27k
High Statistics Set	12	19	25k	0	8	100k

(detector data samples have been added only recently)

- ▶ Balance statistics and number of samples to stay within resource limits

## Validation group

Simulation

Fast Simulation

Trigger

ECAL lower level reconstruction

HCAL lower level reconstruction

Track reconstruction

Electron and Photon reconstruction

Muon reconstruction

Tau reconstruction

Jet and MET reconstruction

b tagging

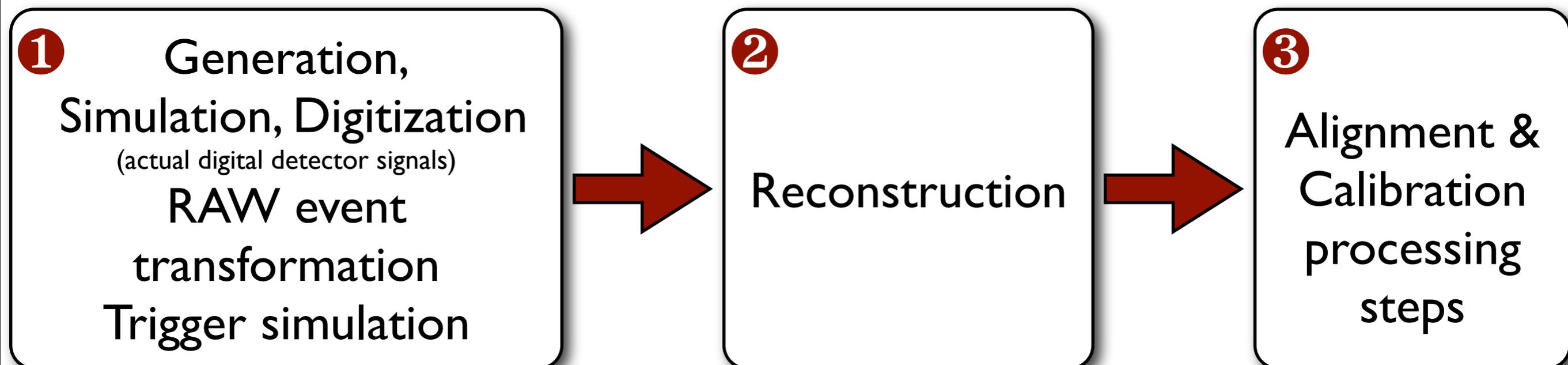
Particle Flow reconstruction

Alignment & Calibration

- ▶ **3 main groups** of validators:
  - ▶ **Reconstruction** software development
  - ▶ **Trigger** development
  - ▶ **Alignment & Calibration** development
- ▶ All groups define **benchmark samples** which **differ in their generator configuration**
  - ▶ Single particle samples vs. different physics processes like generic QCD to SUSY benchmark points

- ▶ Due to **resource constraints**, need to find **synergy between different requested samples**, examples:
  - ▶ QCD for  $3000 \leq p_T^{\text{hat}} \leq 3500$  (very high energy background sample) is used by
    - ▶ b tagging group
    - ▶ Jet reconstruction group
    - ▶ Trigger group
- ▶ Also **different detector condition sets** are requested (ideal aligned detector vs. expected worse alignment at startup of data taking)
  - ▶ Example: **Top quark dataset**
    - ▶ Ideal conditions used by
      - ▶ b tagging group
      - ▶ HCAL lower level reconstruction group
      - ▶ Track reconstruction group
    - ▶ Startup conditions used by
      - ▶ b tagging group for comparison to ideal conditions
      - ▶ HCAL lower level reconstruction group for comparison to ideal condition
      - ▶ Trigger group

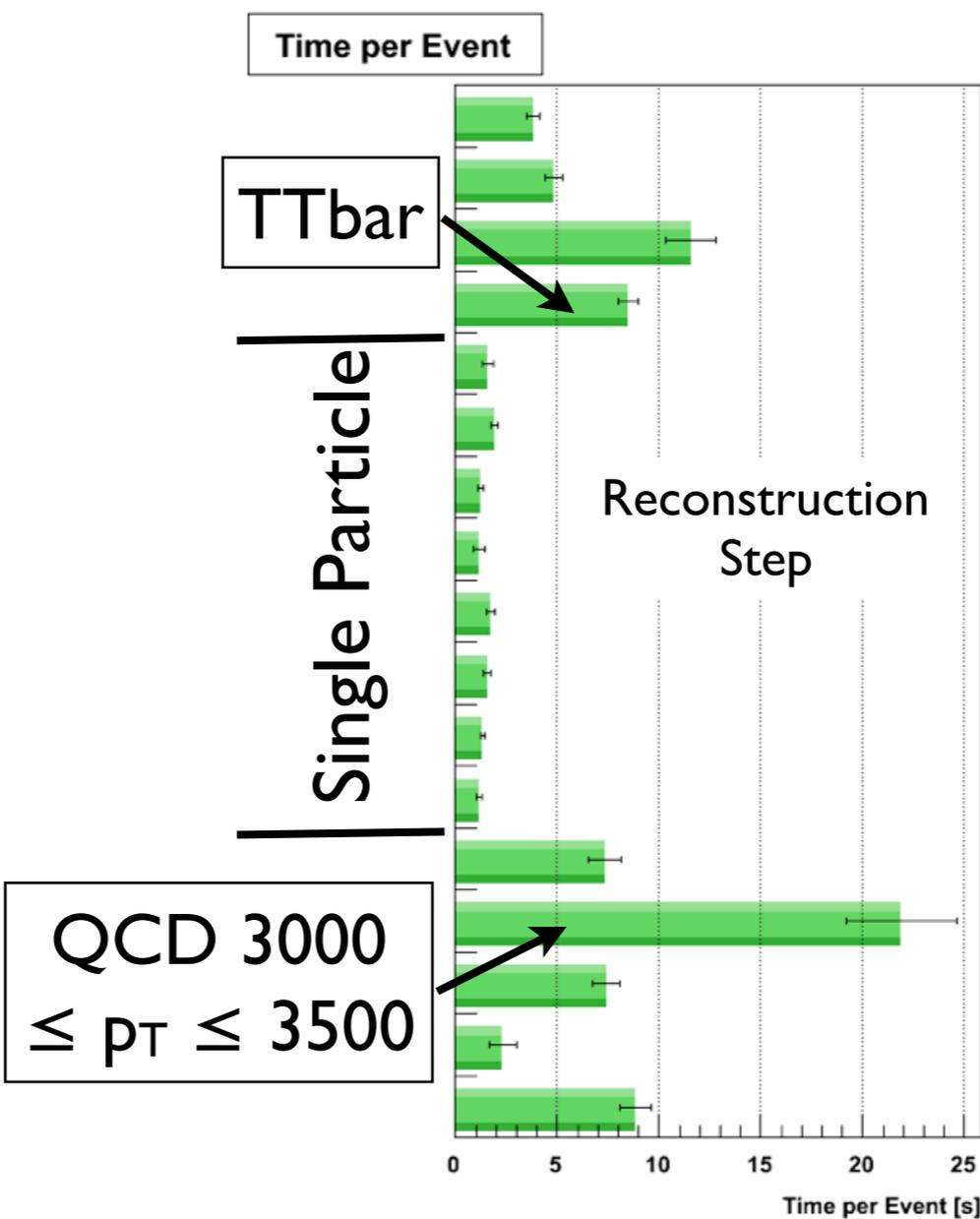
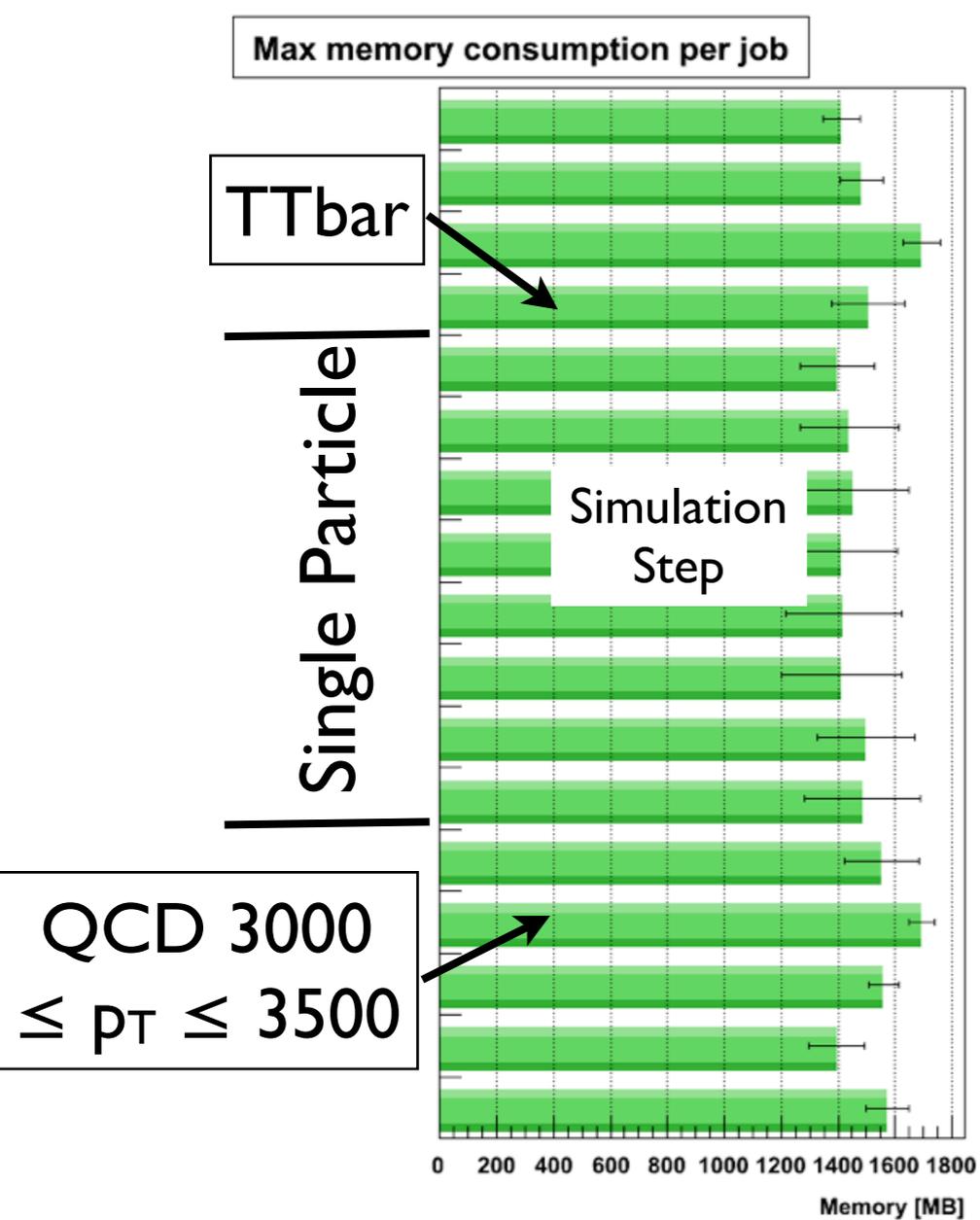
## ▶ Sample production requires multiple steps (feature)



## ▶ **Special for Release Validation** compared to Production:

- ▶ **All created output of the simulation step is written out for validation** (incl. usually skipped output of digitization and special trigger debug information)
- ▶ **Higher level steps augmented with special validation** components storing histograms into the output file (following the CMS DQM infrastructure)
- ▶ **Consequence:** distorts performance figures but enables all groups to efficiently perform validation

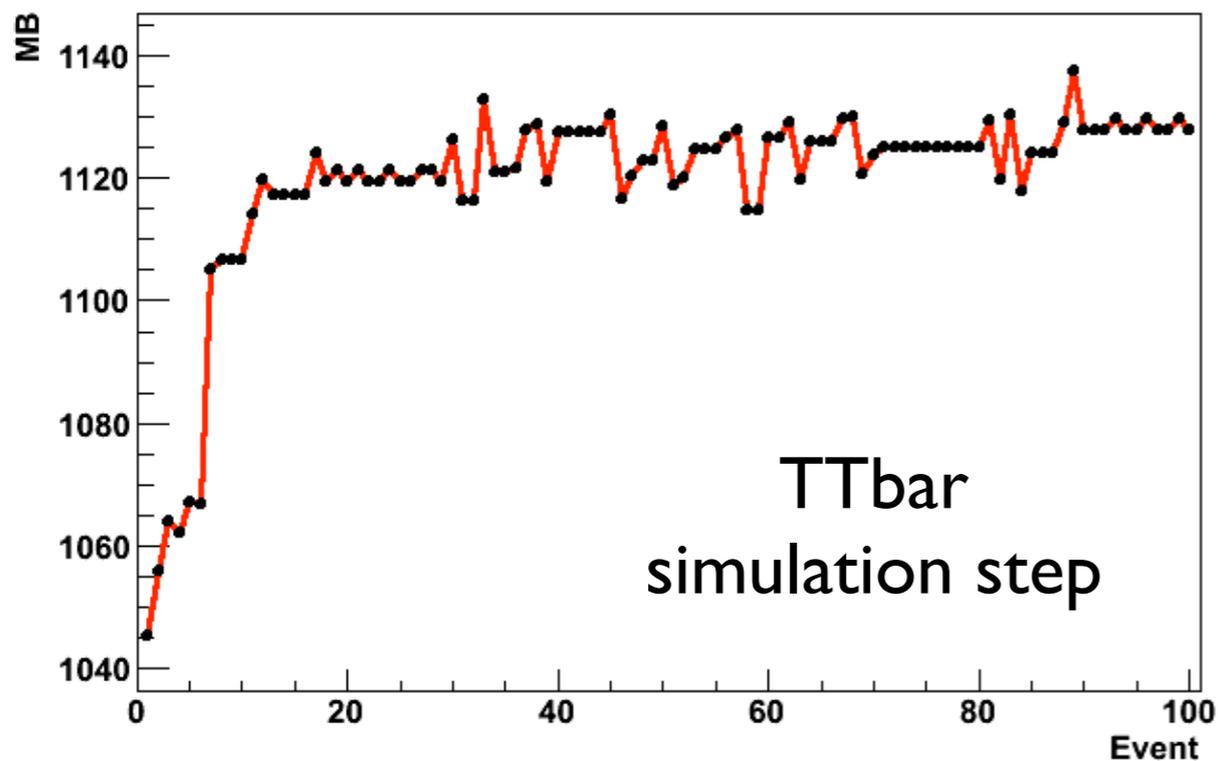
- ▶ In addition to individual validations performed by software experts:
  - ▶ **Extract for every release: Overall Performance Overview** like **average memory and time consumption from all Release Validation production jobs, averaged per sample**
  - ▶ Possibility to compare different samples in one release and between releases



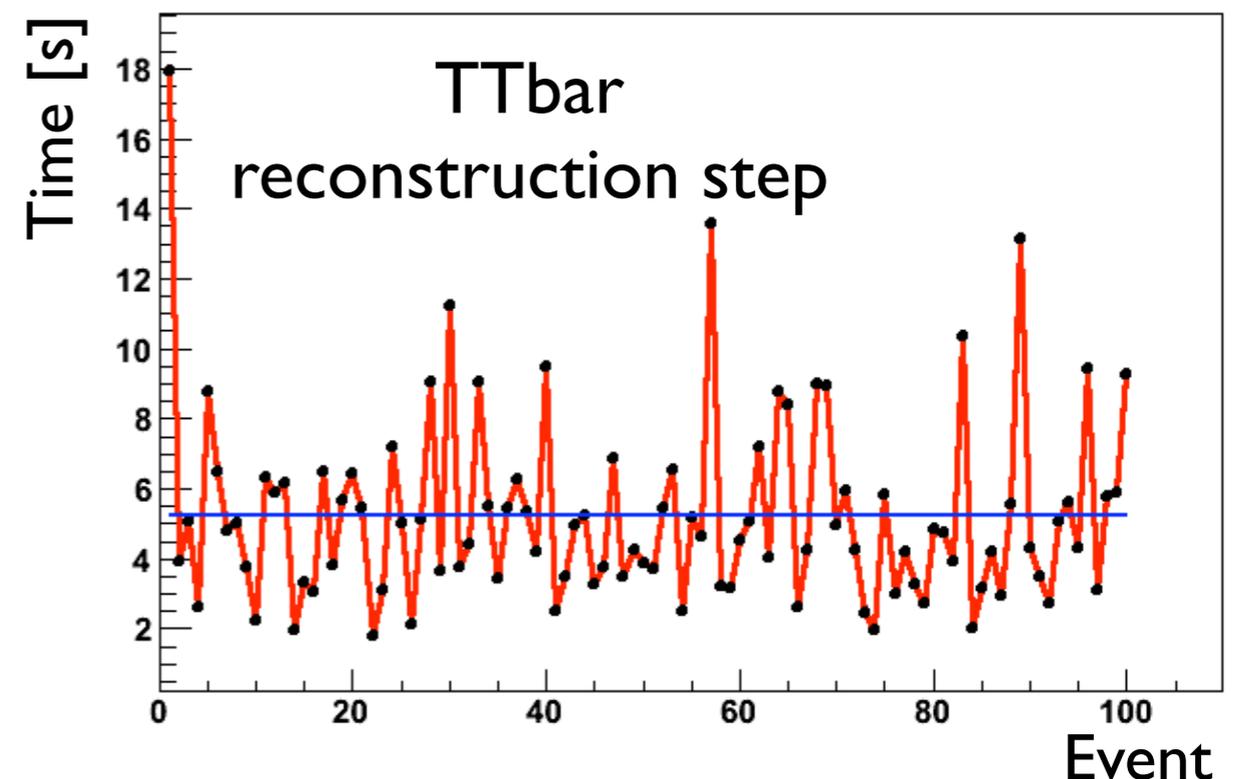
**Warning:**  
Performance distorted because of special validation workflows

- ▶ CMS also **validates releases interactively** in a controlled environment using the CMSSW performance suite
- ▶ The **exact central production workflows** are used to avoid distortions due to special Release Validation components in the workflows
- ▶ A set of **standardized machine** is used instead of batch processing to avoid machine architecture dependencies
- ▶ More information in poster: [\[69\] The CMSSW benchmarking suite: using HEP code to measure cpu performance](#)
- ▶ Examples for top dataset, performance significantly improved compared to overall performance overview by removing the validation parts of the workflows:

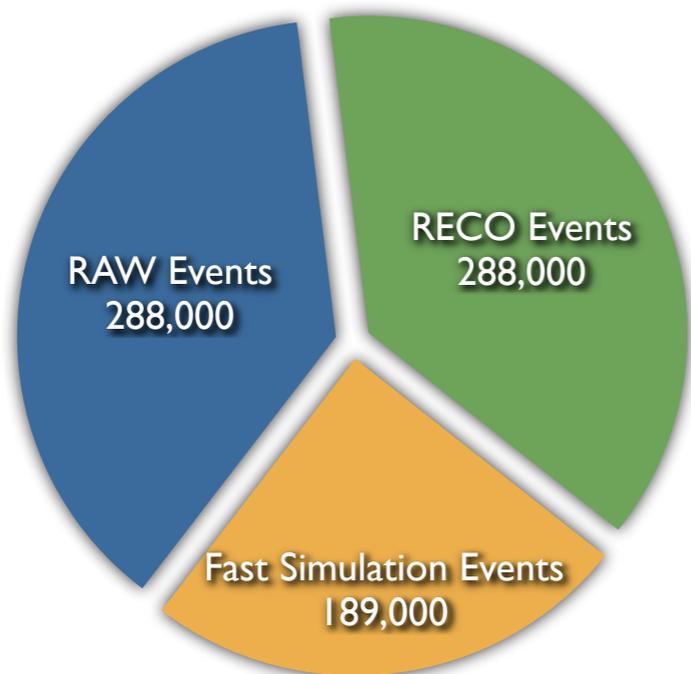
## Memory consumption



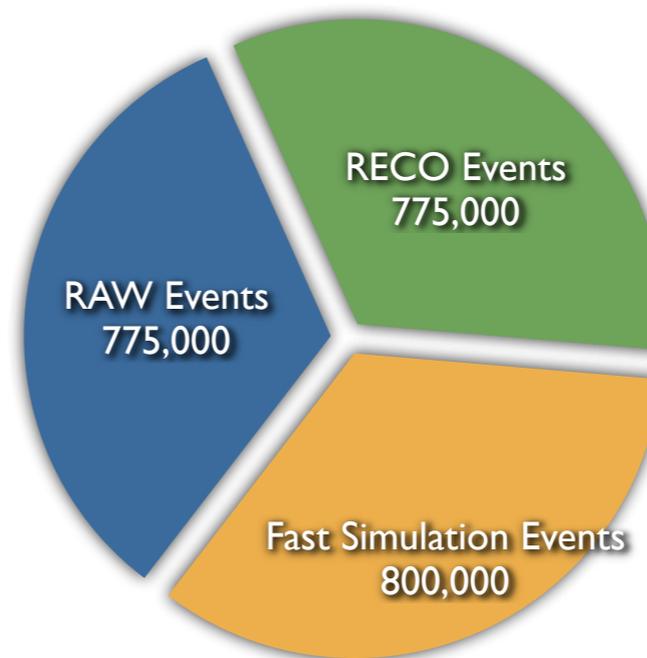
## Time per event



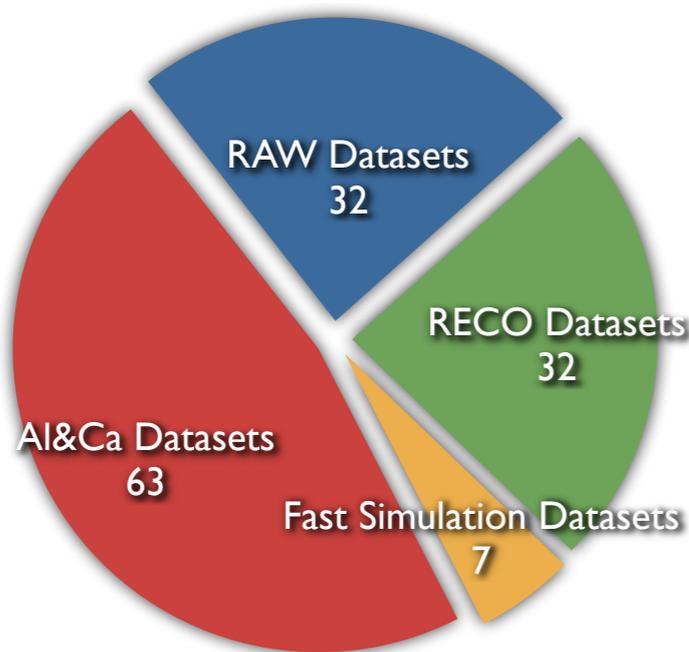
Events per Standard Set



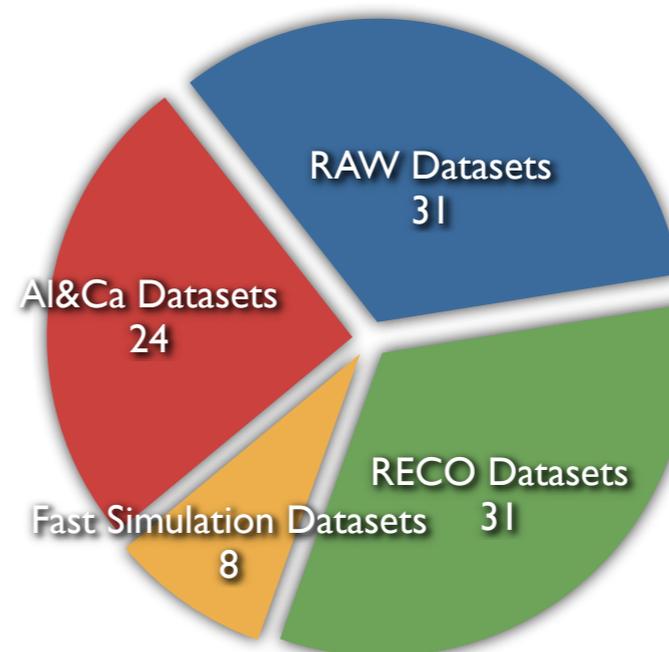
Events per High Statistics Set



Datasets per Standard Set



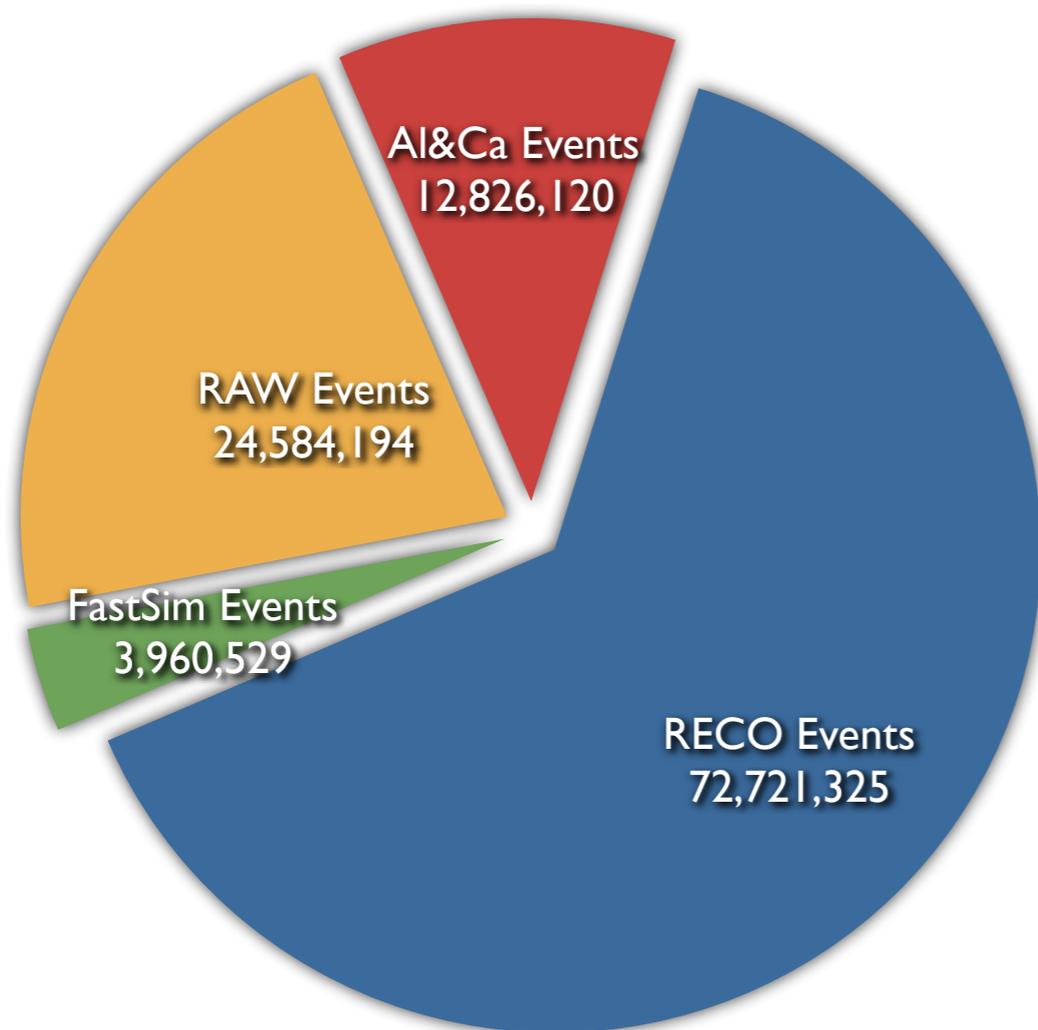
Datasets per High Statistics Set



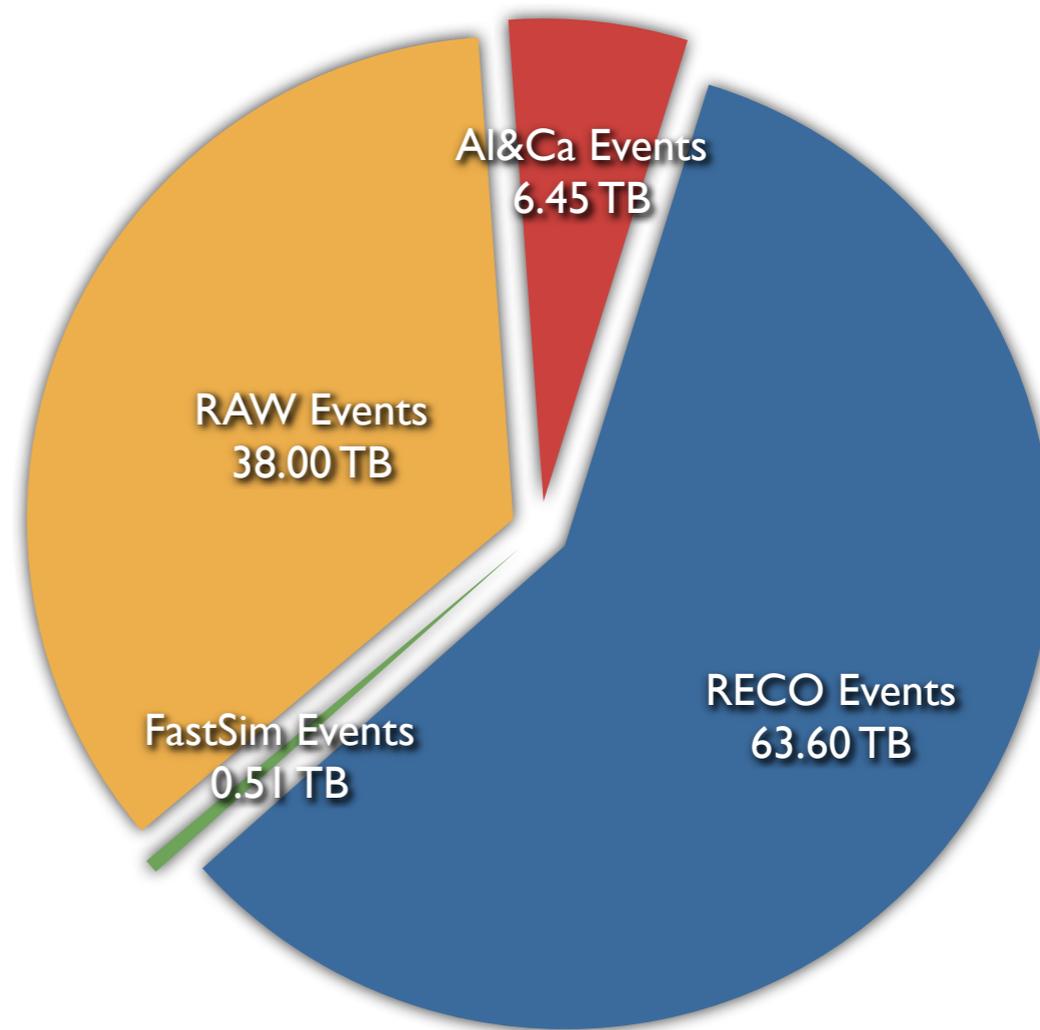
- ▶ Optimized production infrastructure is **able to produce significant numbers of events and different datasets** in 24 hours / 1 week

- ▶ In 2008, CMS produced for Validation alone:
  - ▶ **More than 5100 Datasets** consisting of:
    - ▶ **More than 114 Million events**
    - ▶ **Almost 110 TB of MC and data samples**

Events produced in 2008 for Validation



Terabyte produced in 2008 for Validation



- ▶ Release Validation is an **integral part of the CMS software development process**
- ▶ **Developers rely on timely provision of reference samples** to validate their software components:
  - ▶  **$\frac{2}{3}$  of the samples have been validated within 2 days**
  - ▶  **$\frac{1}{3}$  within 6-10 days**
- ▶ **Demand exceeds production capabilities many times**
  - ▶ Working on improving synergy between requests

- ▶ **CMS release validation contributes significantly to ensure stable production and analysis**
- ▶ By providing reference MC and data samples for each pre-release and release:
  - ▶ **Developers are able to validate** their software components for performance and stability
  - ▶ **Check interference effects** between different components developed in parallel
- ▶ CMS was able to **investigate stability and performance of each release within the very rapid development cycle** of almost one pre-release per week
- ▶ **In 2008**, the release validation **production was sizable** and resulted in **over 114 million events** and **110 terabyte of MC and data samples** produced
  - ▶ Represents an extra month of MC production capacity for CMS beyond the experiment goals
- ▶ **In the future**, the release validation sample sets will **use detector data samples as input** rather than MC generations