Analysis of Hadron Data

- status report -

Outline:
- Simulation and Reconstruction Chain
- Simple Analysis of Pion Data in 2006
- Pions in 2007
- Particle Flow Studies: Shower Separation
- Outlook

Simulation and Reconstruction Chain
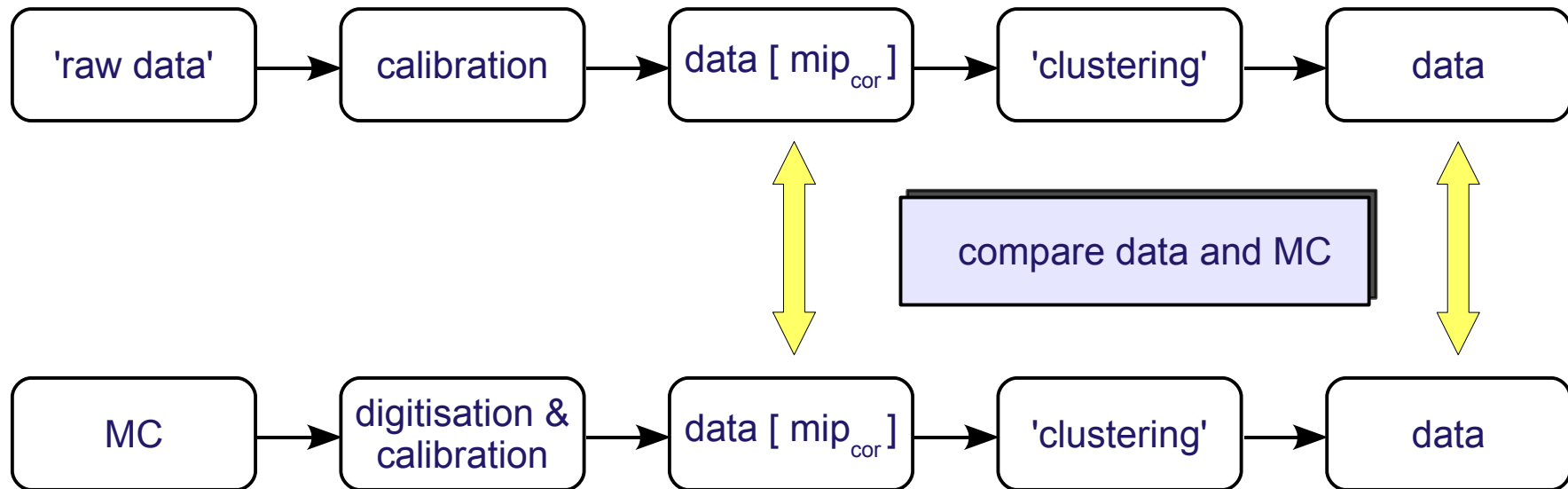
Study Hadron Data in 2006 and 2007:

- setup Marlin-Based reconstruction chain for data and MC

- use Mokka (GEANT4) as simulation input

- 'full' calibration for ECAL, HCAL and TCMT data

- introduce detector effects on MC (digitisation)

➜ compare data and MC (energy spectra, detector response, energy resolution, shower shapes, etc.)

- apply clustering procedures on both (e.g. deep analysis by V. Morgunov)

➜ compare data and MC on this level again

- study different physics models, particle flow, ...

Simulation and Reconstruction Chain

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we are somewhere here

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Simulation and Reconstruction Chain

```
┌───────────┐     ┌─────────────┐     ┌──────────────┐     ┌──────────────┐     ┌───────────┐
│ 'raw data'│ ──▶ │ calibration │ ──▶ │ data [ mip_cor ]│ ──▶ │ 'clustering' │ ──▶ │   data    │
└───────────┘     └─────────────┘     └──────────────┘     └──────────────┘     └───────────┘
                                              ▲                                        ▲
                                              │      ┌────────────────────────┐        │
                                              │      │   compare data and MC  │        │
                                              ▼      └────────────────────────┘        ▼
┌───────────┐     ┌─────────────┐     ┌──────────────┐     ┌──────────────┐     ┌───────────┐
│    MC     │ ──▶ │ digitisation &│ ─▶ │ data [ mip_cor ]│ ──▶ │ 'clustering' │ ──▶ │   data    │
│           │     │  calibration │     └──────────────┘     └──────────────┘     └───────────┘
└───────────┘     └─────────────┘
```

- implemented in 'official' framework (**hcal-v00-01-20** see talk by Sebastian)
- simple cut-based selection to find hadron showers fully contained in HCAL
- 'clustering' done by deep analysis processor

Simulation and Reconstruction Chain

'raw data' → calibration → data [mip_{cor}] → 'clustering' → data

MC → ... → ...ering' → data
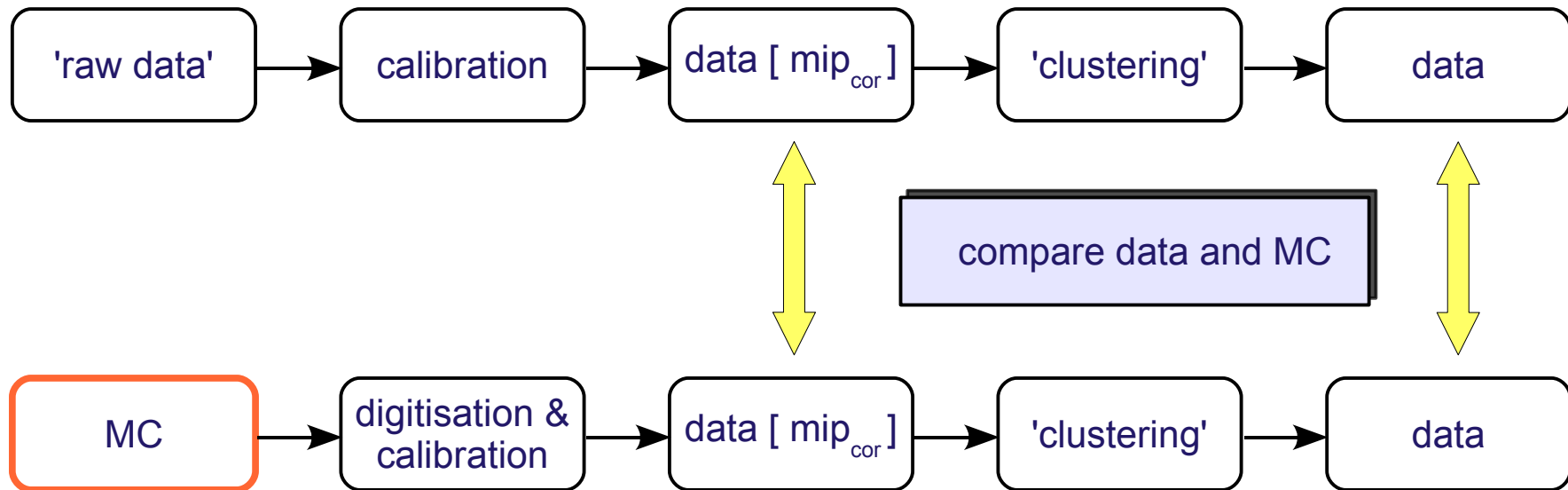
...ata and MC
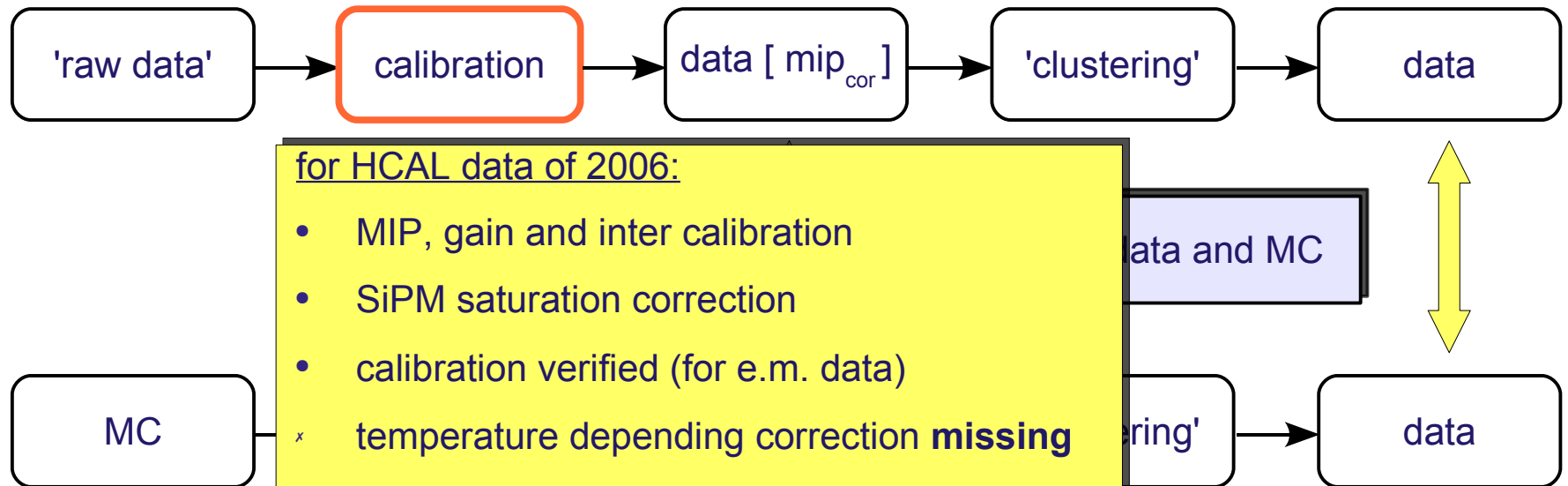
for HCAL data of 2006:
- MIP, gain and inter calibration
- SiPM saturation correction
- calibration verified (for e.m. data)
- temperature depending correction **missing**

for 2007 data:
- quite a few open issues concerning calibration (see talk by Beni Lutz)

- implemente... ...ee talk by Sebastian)
- simple cut-... ...ully contained in HCAL
- 'clustering' done by deep analysis processor

Simulation and Reconstruction Chain

'raw data' → calibration → data [mip$_{cor}$] → 'clustering' → data

compare data and MC

MC → digitisation & calibration → data [mip$_{cor}$] → 'clustering' → data

for 2006:
- Mokka 06-03-p02, GEANT4 8.1.p02
- TBCern1006_01
- physics list: QGSP_BERT_HP
- simple beam profile

for 2007:
- complete Mokka model **not** available yet (see talk by Fabrizio)

(**hcal-v00-01-20** see talk by Sebastian)

adron showers fully contained in HCAL

rocessor

Simulation and Reconstruction Chain

```
┌───────────┐     ┌───────────┐     ┌─────────────┐     ┌────────────┐     ┌──────┐
│'raw data' │ ──> │calibration│ ──> │data [ mip_cor ]│──>│'clustering'│ ──> │ data │
└───────────┘     └───────────┘     └─────────────┘     └────────────┘     └──────┘
                                           ↕                                    ↕
                              ┌─────────────────────────┐
                              │   compare data and MC   │
                              └─────────────────────────┘

┌───────────┐     ┌───────────┐     ┌─────────────┐     ┌────────────┐     ┌──────┐
│    MC     │ ──> │digitisation &│ ──>│data [ mip_cor ]│──>│'clustering'│──> │ data │
│           │     │ calibration │     └─────────────┘     └────────────┘     └──────┘
└───────────┘     └───────────┘
```

- impleme...   **1-20** see talk by Sebastian)
- simple c...   ...rs fully contained in HCAL
- 'clusterin...
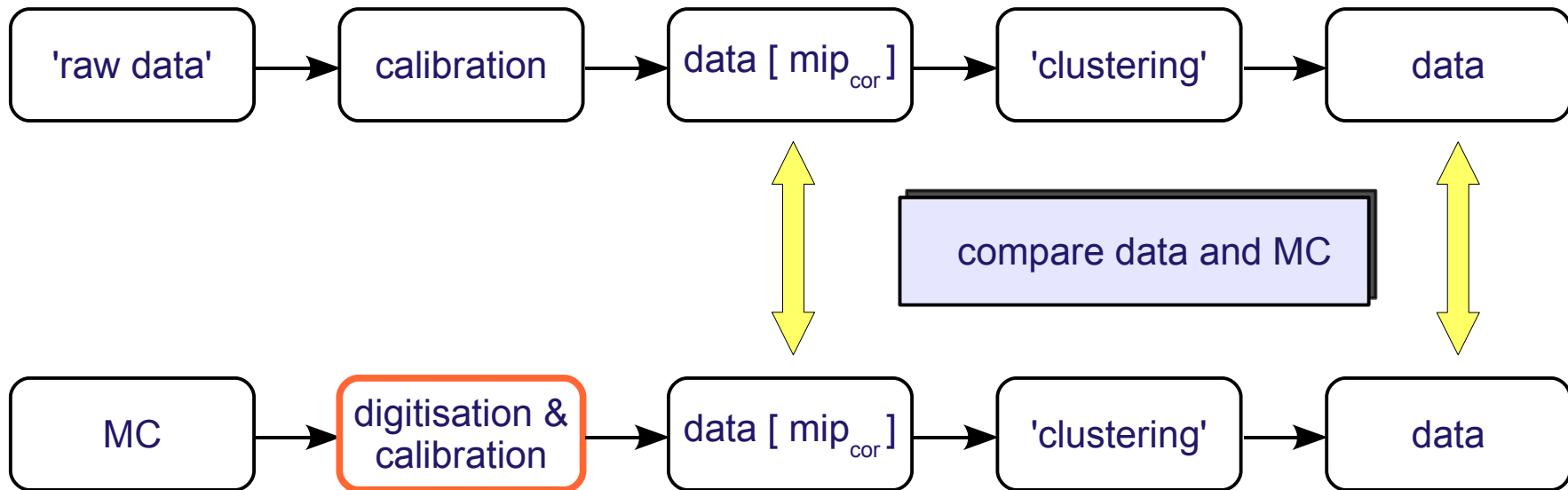
> **for 2006/2007:**
> - **inverse** MIP, gain and inter calibration
> - **inverse** SiPM saturation correction
> - light cross-talk correction
> - ✗ temperature dependency **missing**
> - ✗ **first version** of a digitisation, **cross-checks needed** (see anlysis of e.m. data)
> - ✗ digitisation for ECAL & TCMT **not** implemented in this chain yet

Simulation and Reconstruction Chain

'raw data' → calibration → data [mip_{cor}] → 'clustering' → data

simple, cut-based selection to compare data and MC

compare data and MC

MC → digitisation & calibration → data [mip_{cor}] → 'clustering' → data
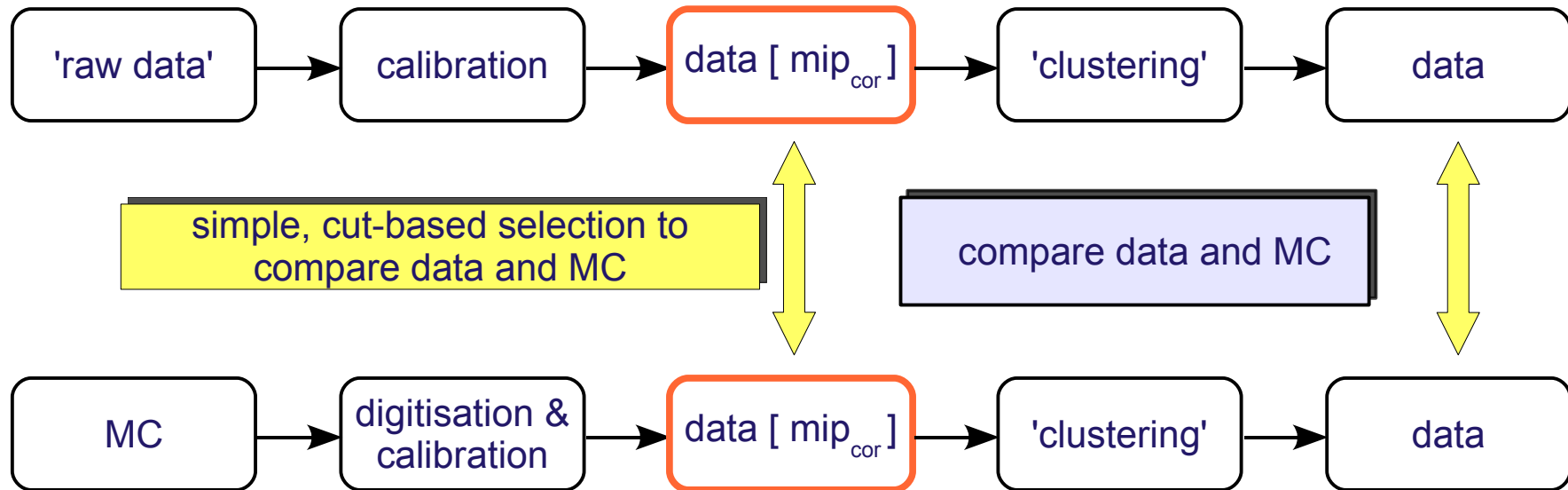
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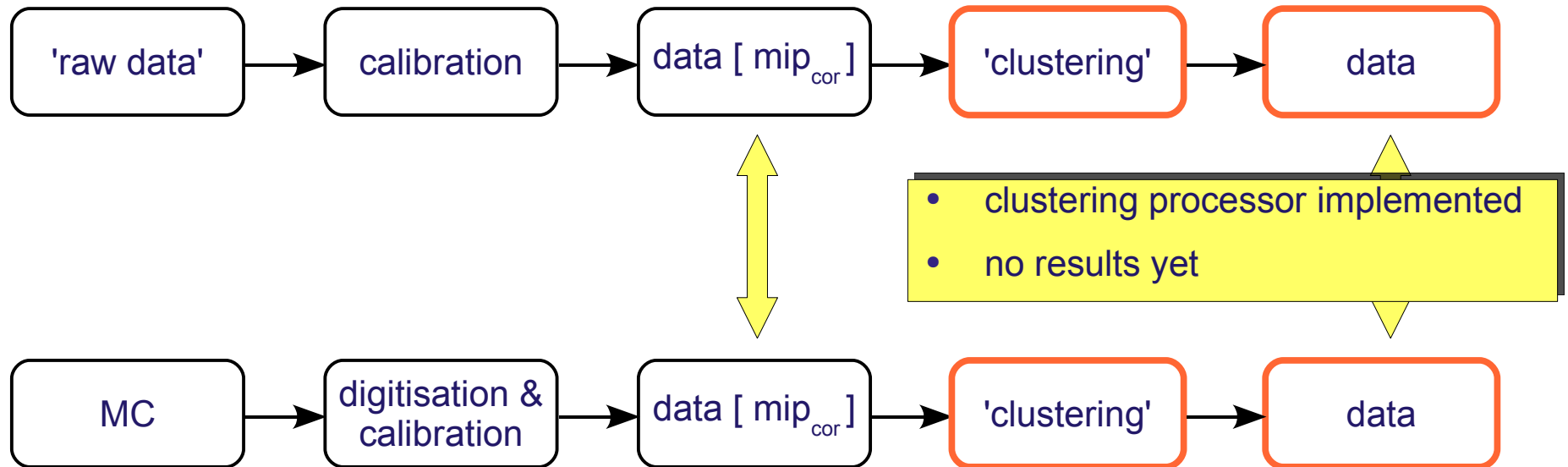
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Simple Analysis of Pion Data in 2006

- first approach: take data of Oct. 2006, find shower fully contained in HCAL

- following Marius studies from beginning of 2007 (GEANT3 $\leftrightarrow$ GEANT4)

- simple cut-based selection, muon data for comparison (run 300771):

  → NHitsECAL < 38　　(muon: approx. 32 hits in the ECAL)

  → EnergySumHitsECAL < 55 mips　　(muon: approx 48 mips)

  → NHitsHCAL > 40　　(muon: approx. 24 hits)

MUONS:
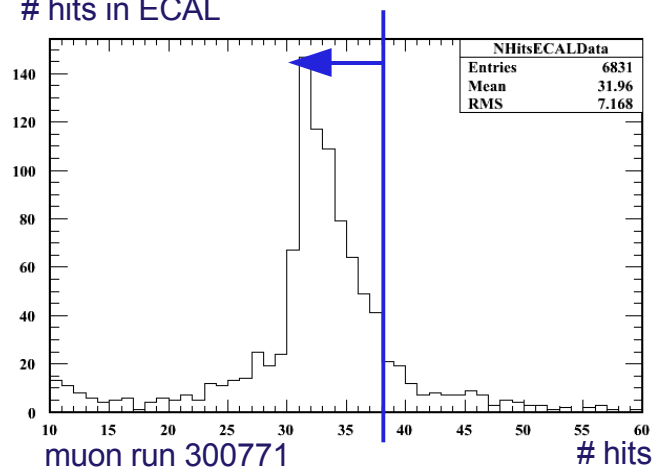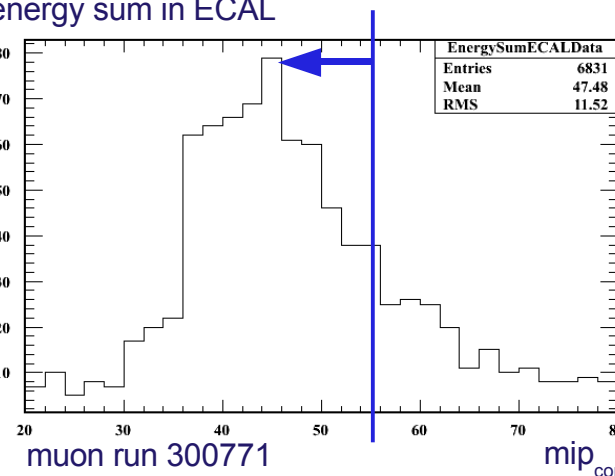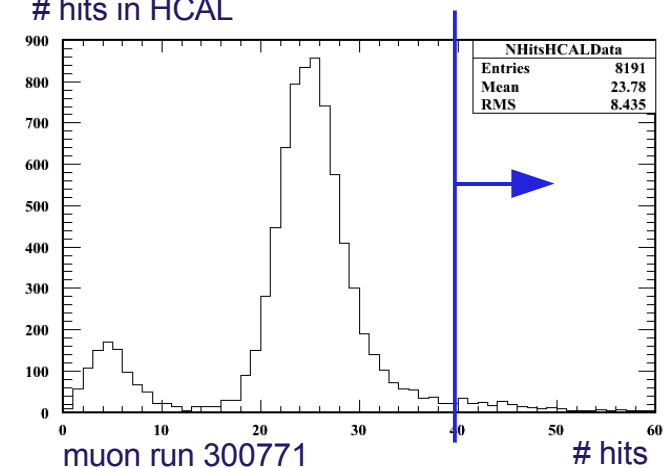
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  → NHitsHCAL > 40   (muon: approx. 24 hits)

  → NHitsTCMT < 10   (muon: approx. 22 hits)

  → EnergySumHitsTCMT < 15 mips   (muon: approx. 28 mips)

MUONS:

hits in TCMT
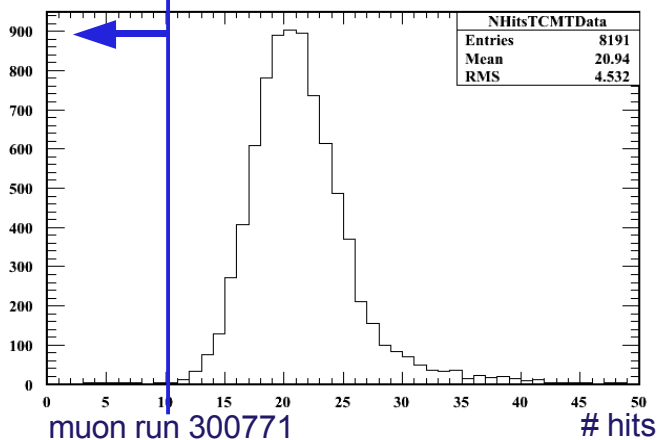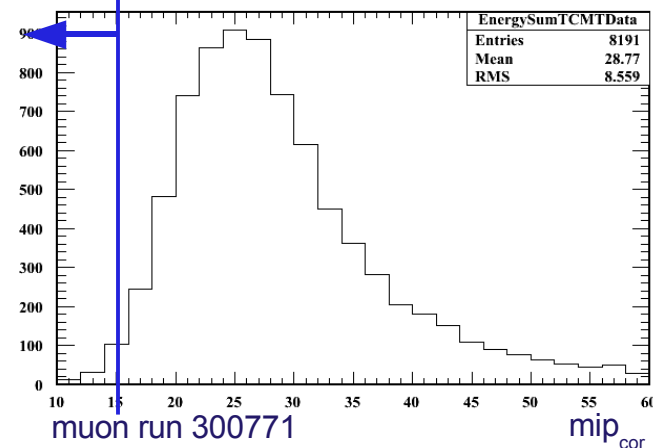
NHitsTCMTData	
Entries	8191
Mean	20.94
RMS	4.532

muon run 300771   # hits

energy sum in TCMT

EnergySumTCMTData	
Entries	8191
Mean	28.77
RMS	8.559

muon run 300771 mip_{cor}
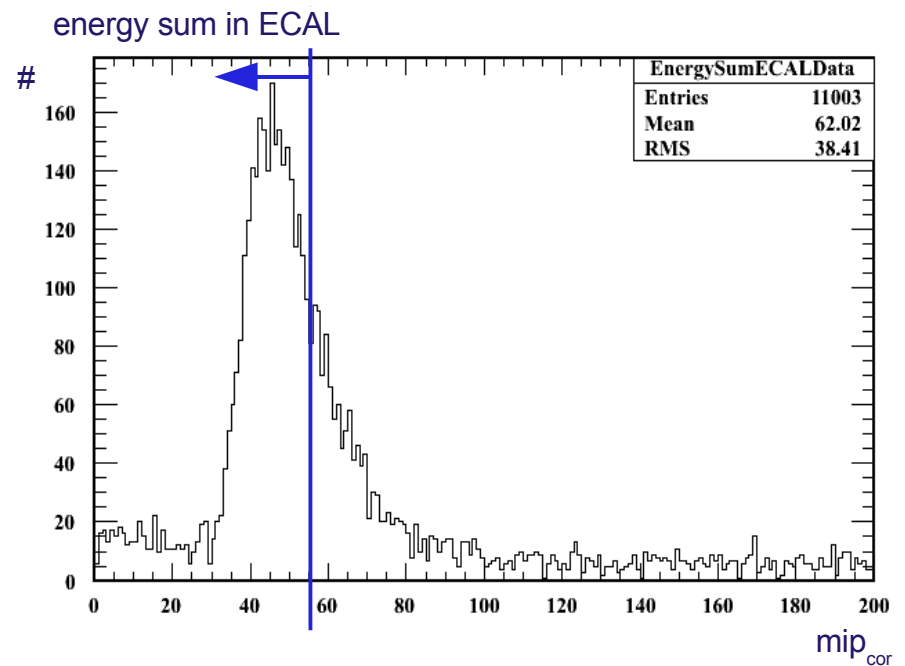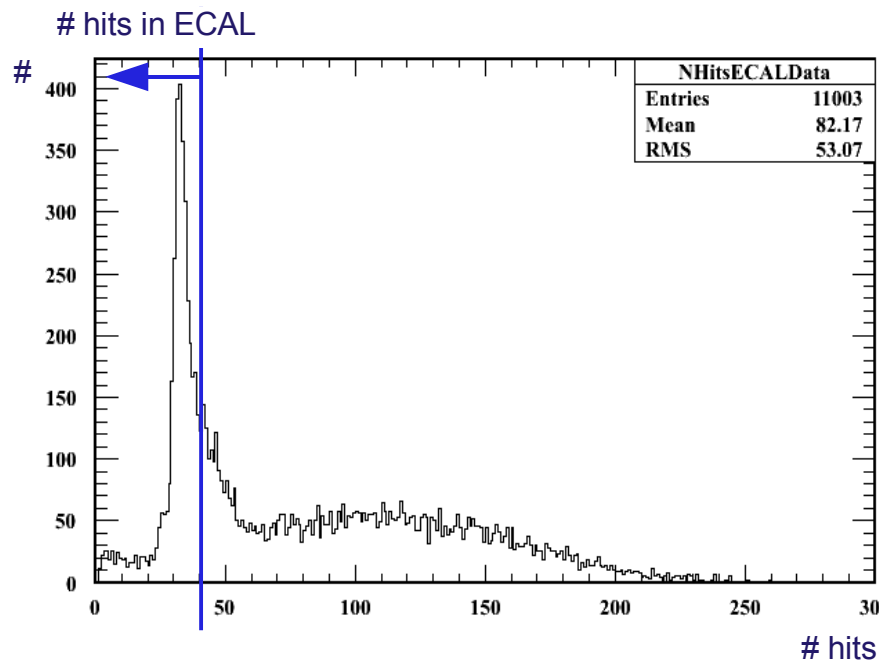
First Look into Data of 2006

run 300660, pi, -10GeV: plots for ECAL
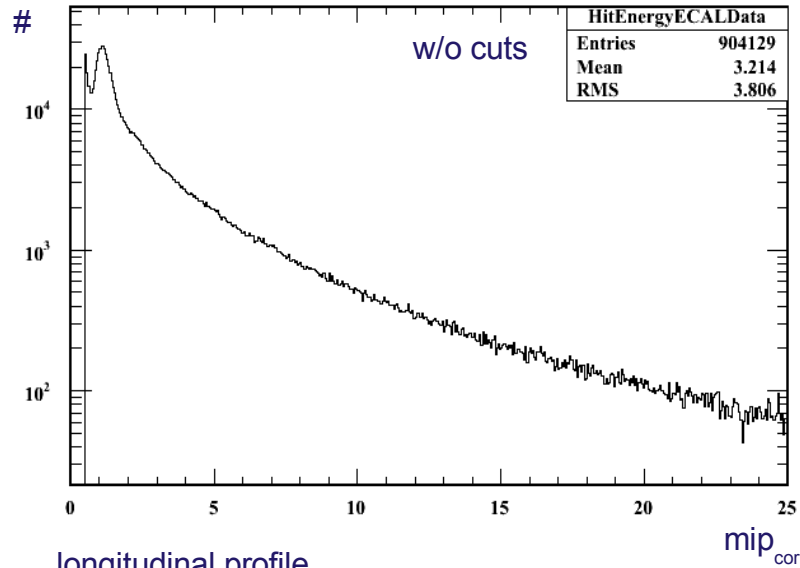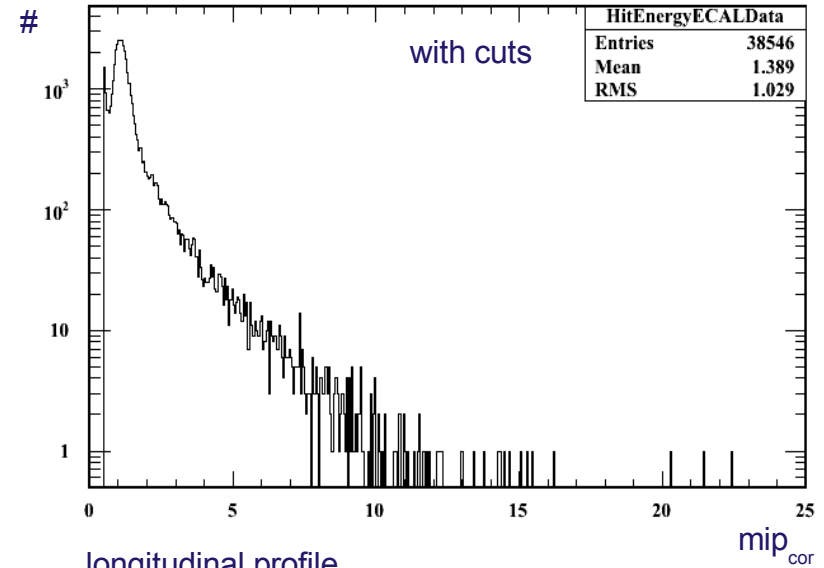
First Look into Data of 2006
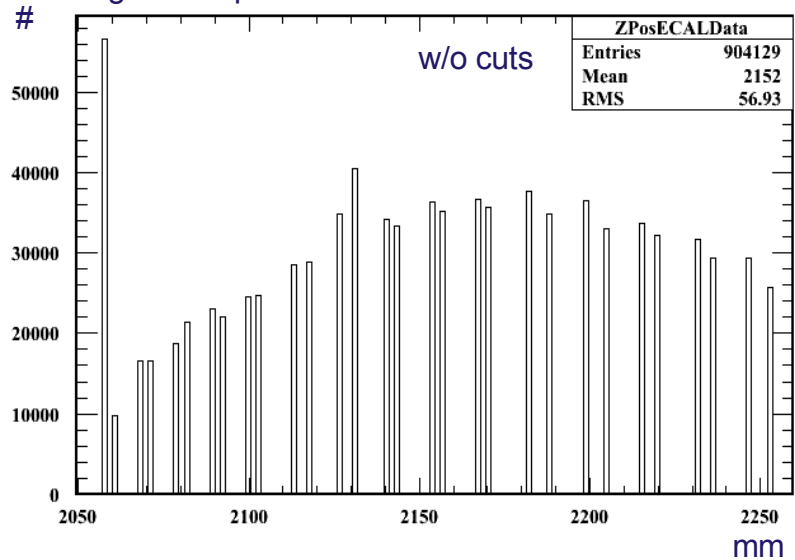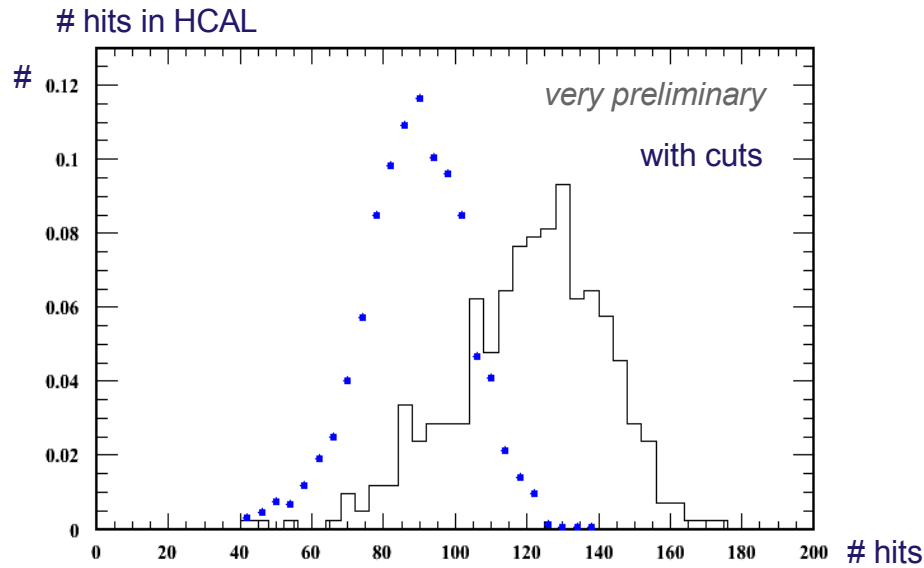
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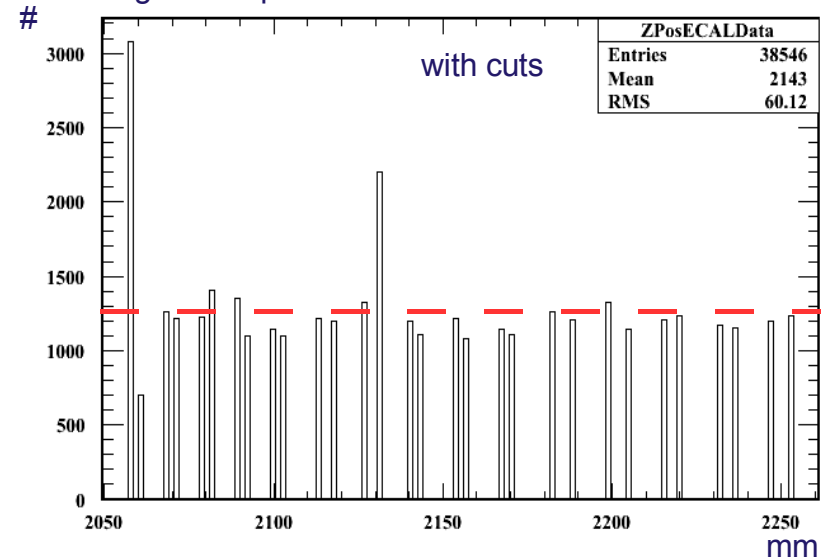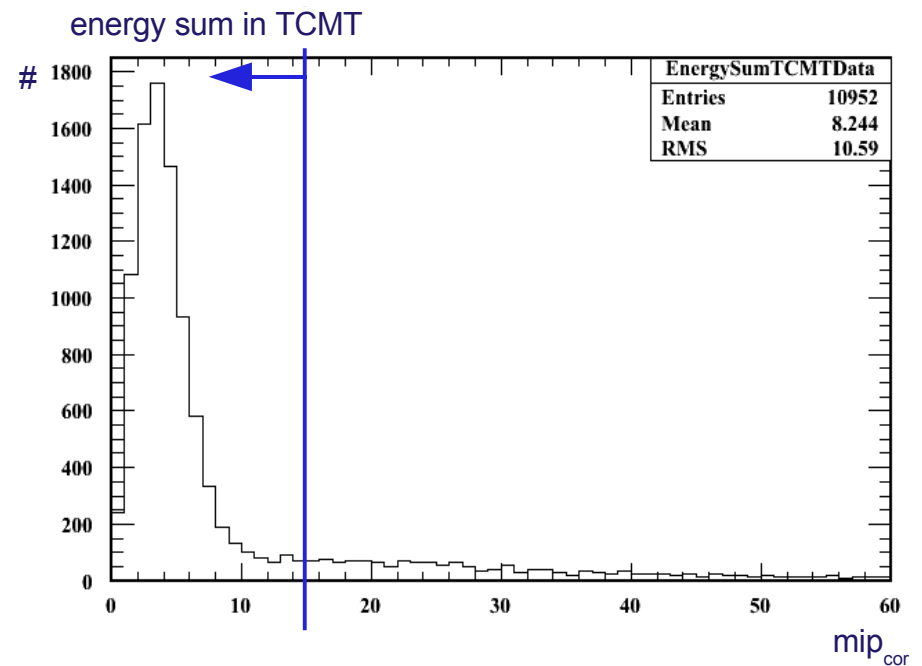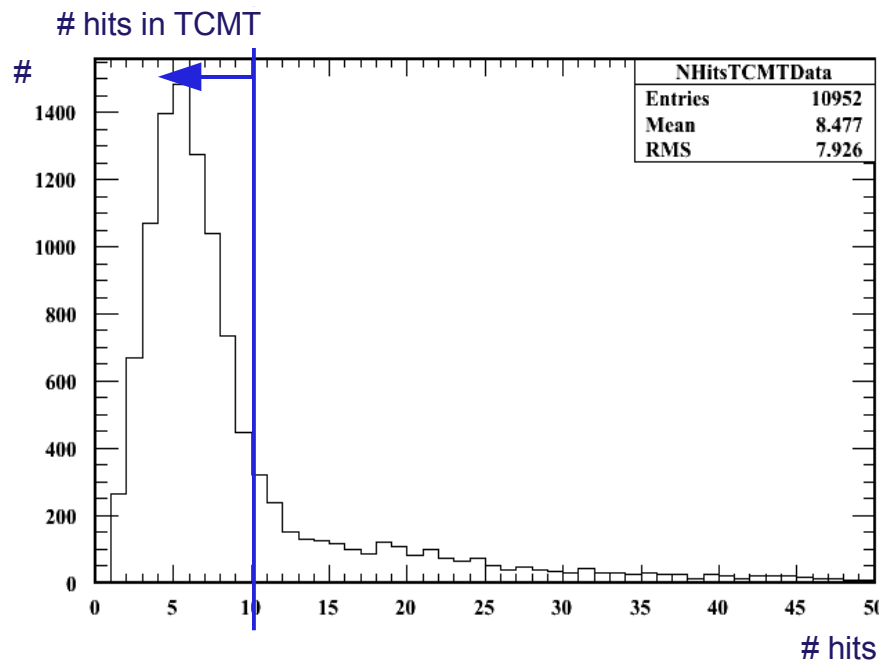
First Look into Data of 2006

run 300660, pi, -10GeV: plots for TCMT

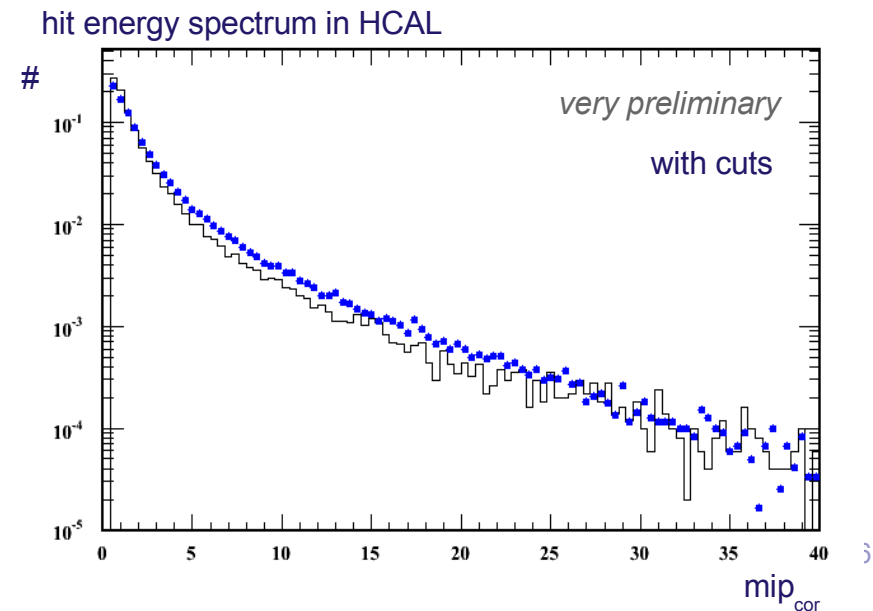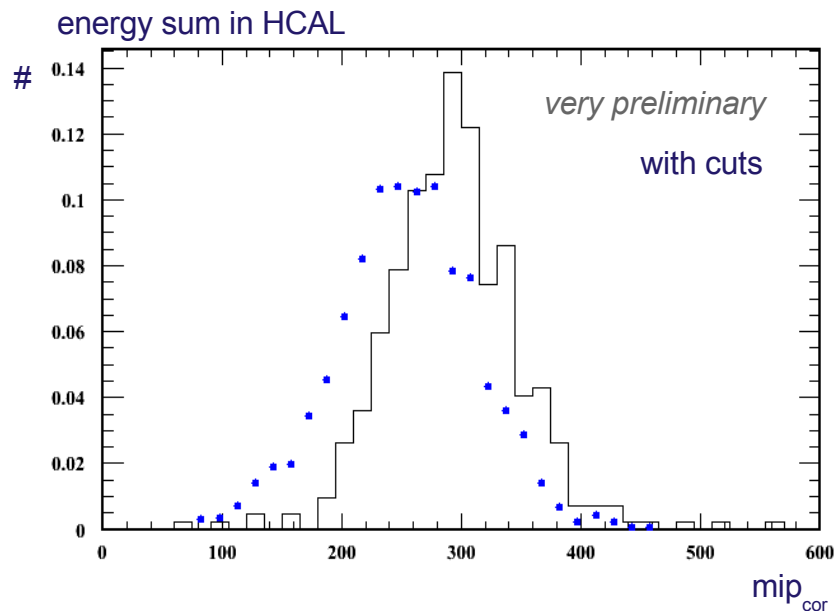# First Look into Data of 2006

run 300660, pi, -10GeV: plots for TCMT

hit energy spectrum in TCMT

w/o cuts

HitEnergyTCMTData	
Entries	96289
Mean	1.328
RMS	1.414

hit energy spectrum in TCMT

with cuts

HitEnergyTCMTData	
Entries	7251
Mean	0.8569
RMS	0.7237
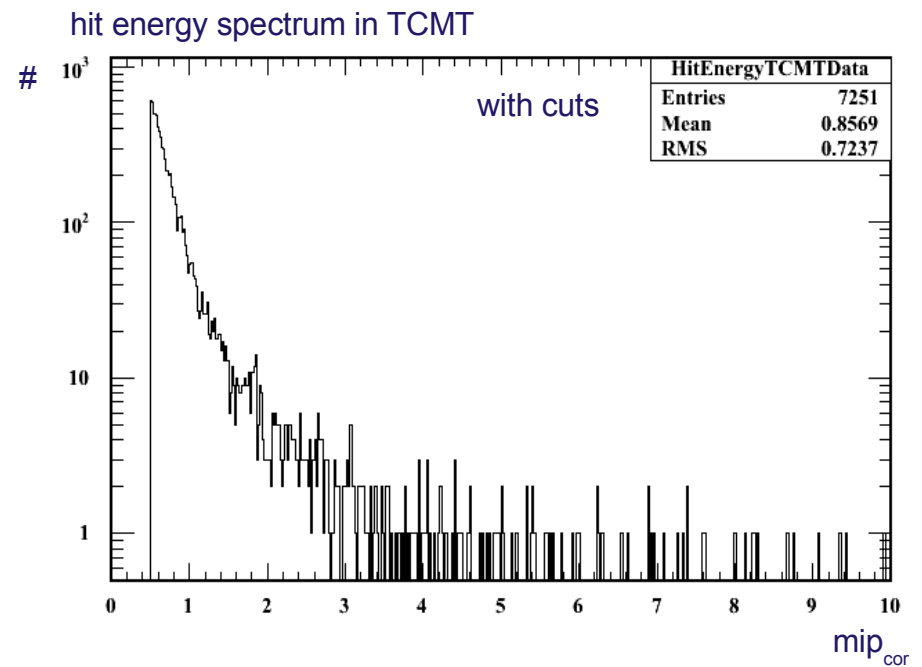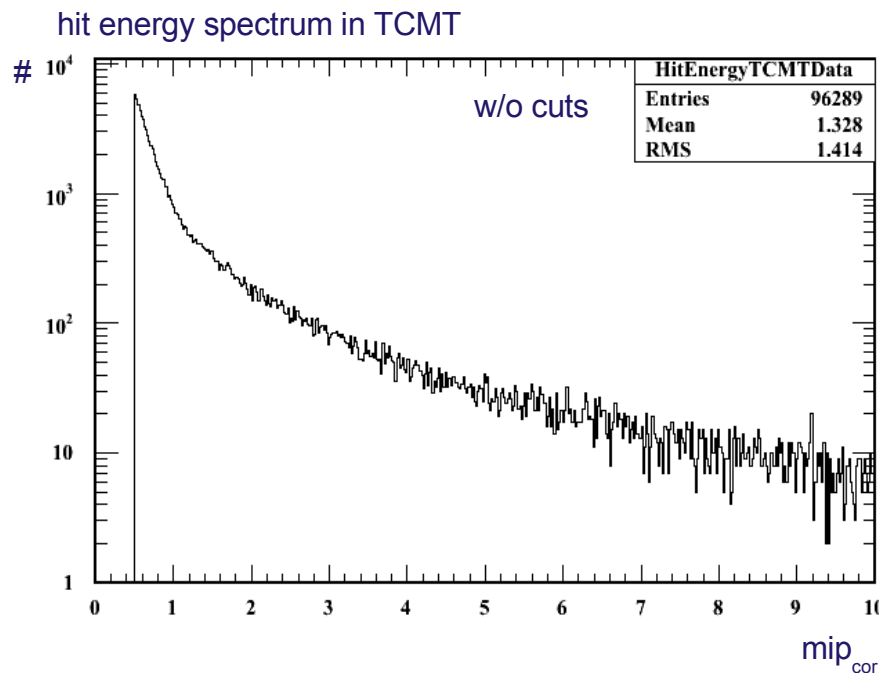
First Look into Data of 2006

run 300660, pi, -10GeV: plots for HCAL, comparison with MC

- **blue**: data, **black**: MC
- → calibration verified (for e.m. showers)
- → digitisation **not** verified yet

First Look into Data of 2006

run 300660, pi, -10GeV: plots for HCAL, comparison with MC

longitudinal profile — *very preliminary* — w/o cuts

longitudinal profile — *very preliminary* — with cuts
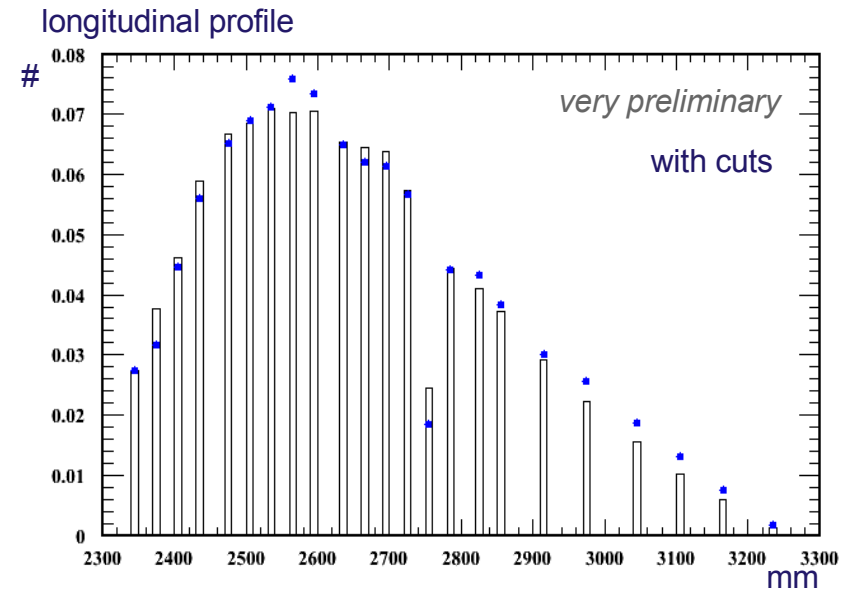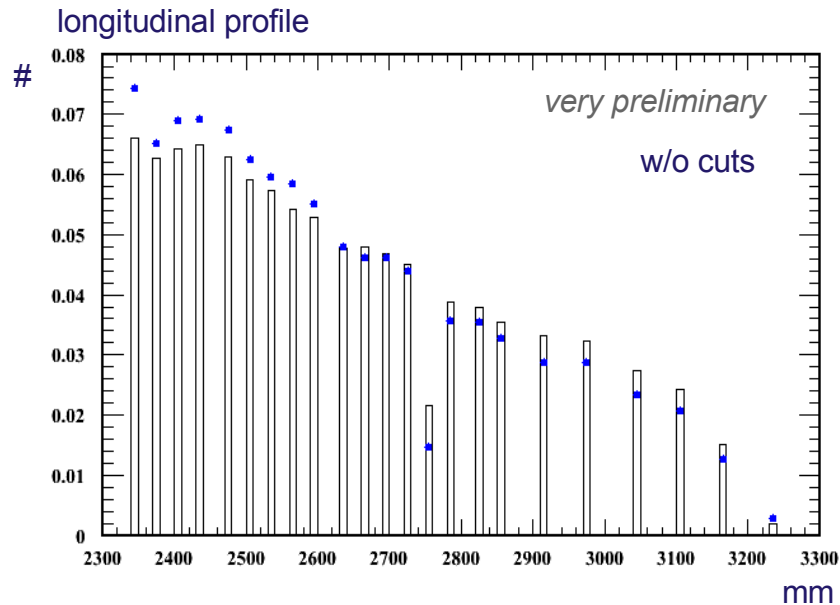
- **blue**: data, **black**: MC
- 'some' **large** discrepancy between data and MC → understand them
- **first** try using Mokka/GEANT4 with digitasation
- more statistics for data and MC available
- ➜ not a limiting factor
- high purity, hadron shower contained in HCAL

Pions in 2007

Longitudinal Profiles:
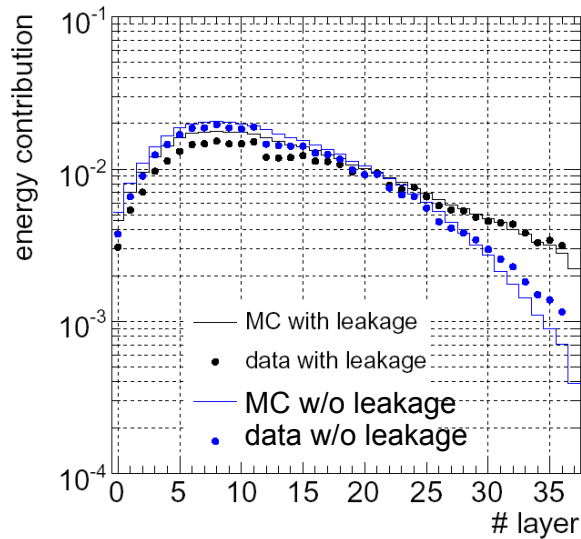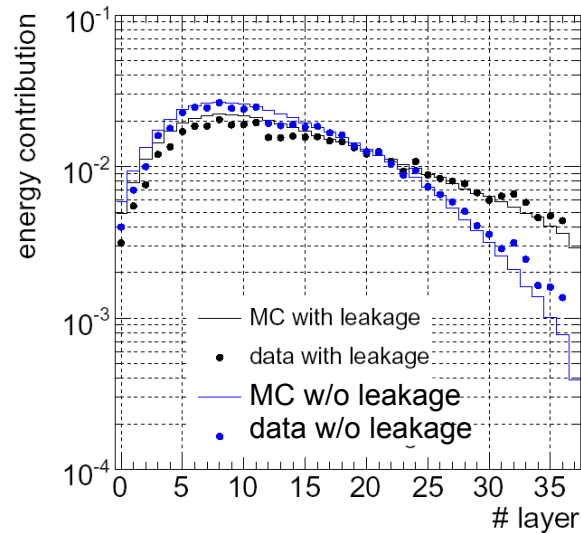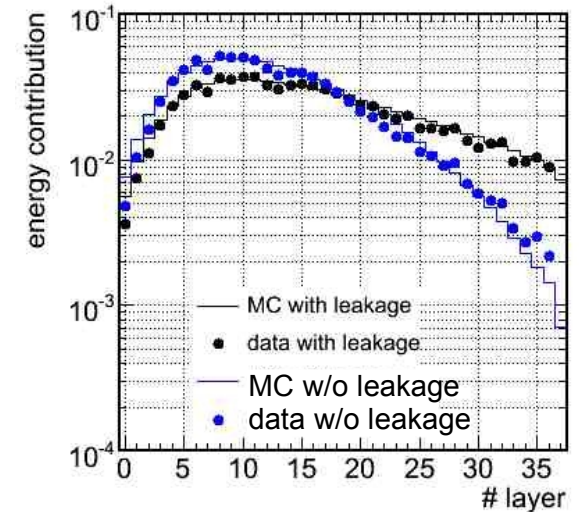
Marius Groll

- **not** (yet) done within the Marlin-Based simulation and reconstruction chain → 'stand-alone'

- preliminary calibration factors

- for 2007: neither digitisation nor calibration verified yet

- GEANT3 Gheisha

- pions contained in AHCAL have still quite different profile

Oliver V

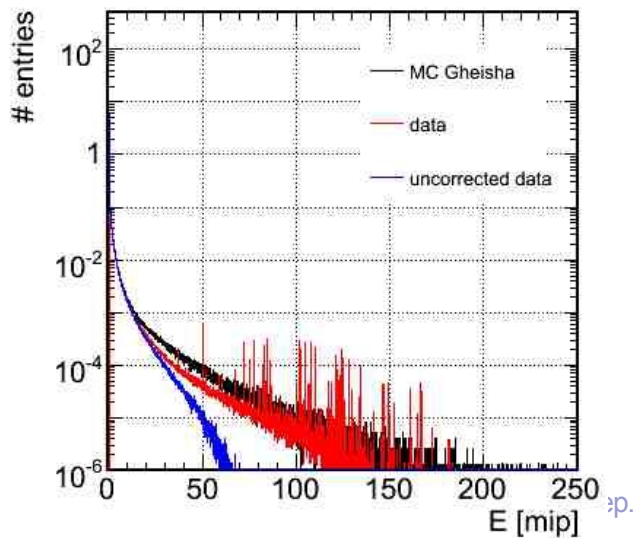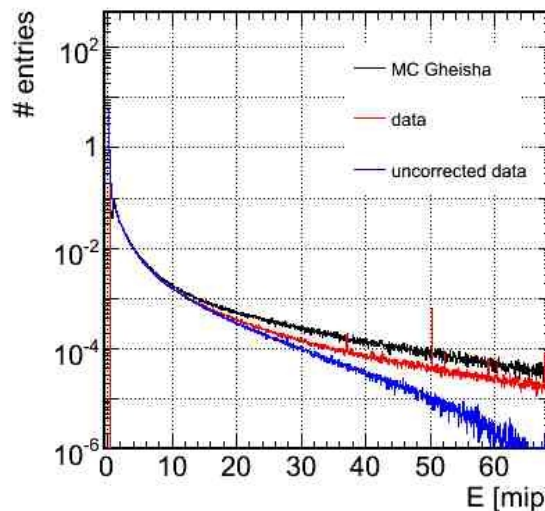# Pions in 2007

Hit Energy Spectrum:

Energy 20 GeV
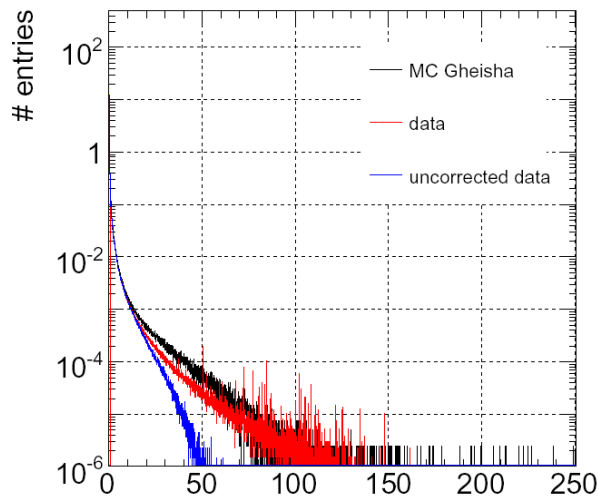
- SiPM response correction needed (non-linearity correction)

- more and more important for energies above 20 GeV

- spikes due to calibration issues (not visible in uncorrected spectrum)
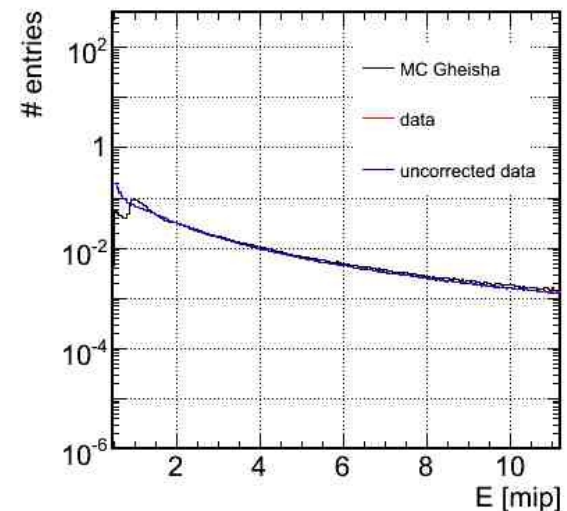
Marius Groll
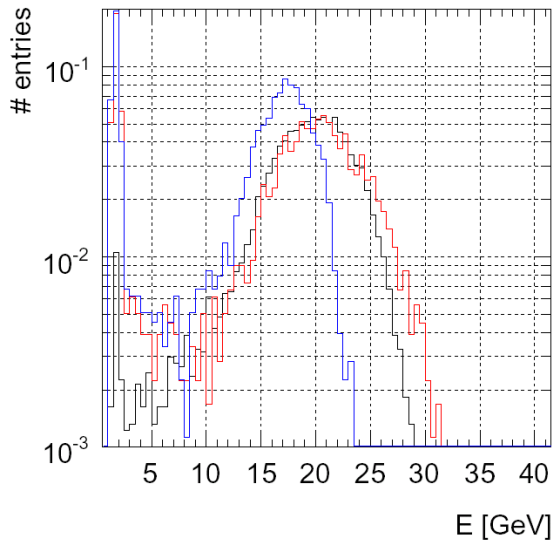
Energy 45 GeV

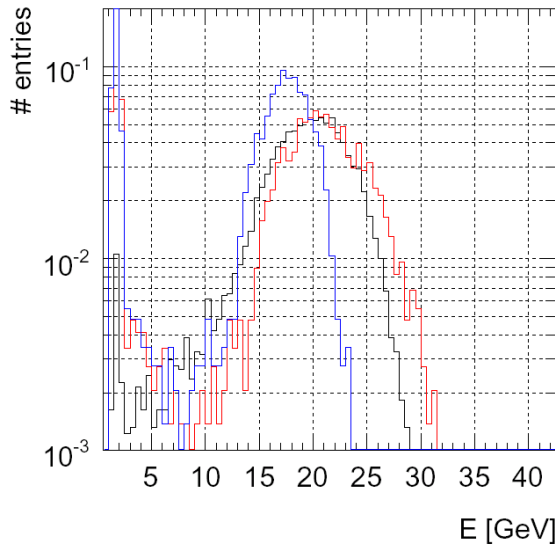**Energy 45 GeV**

Energy 45 GeV
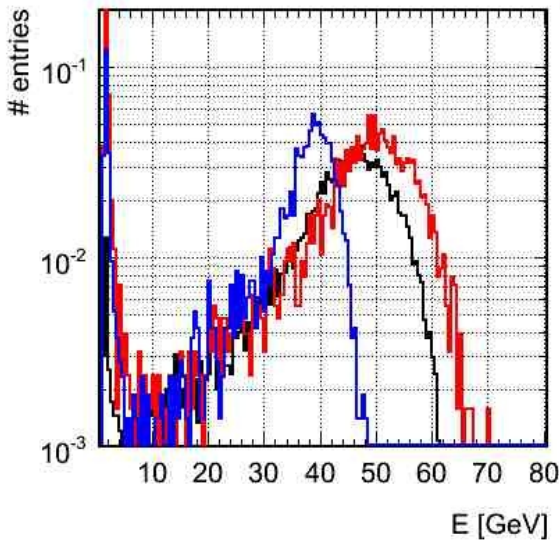
Pions in 2007

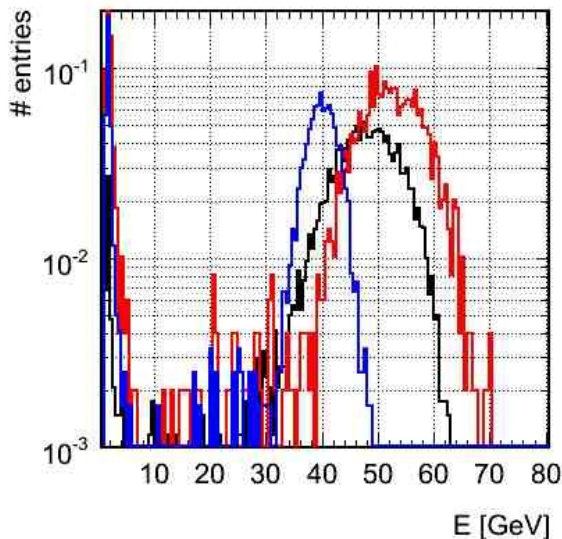Energy Sum:

Energy 20 GeV

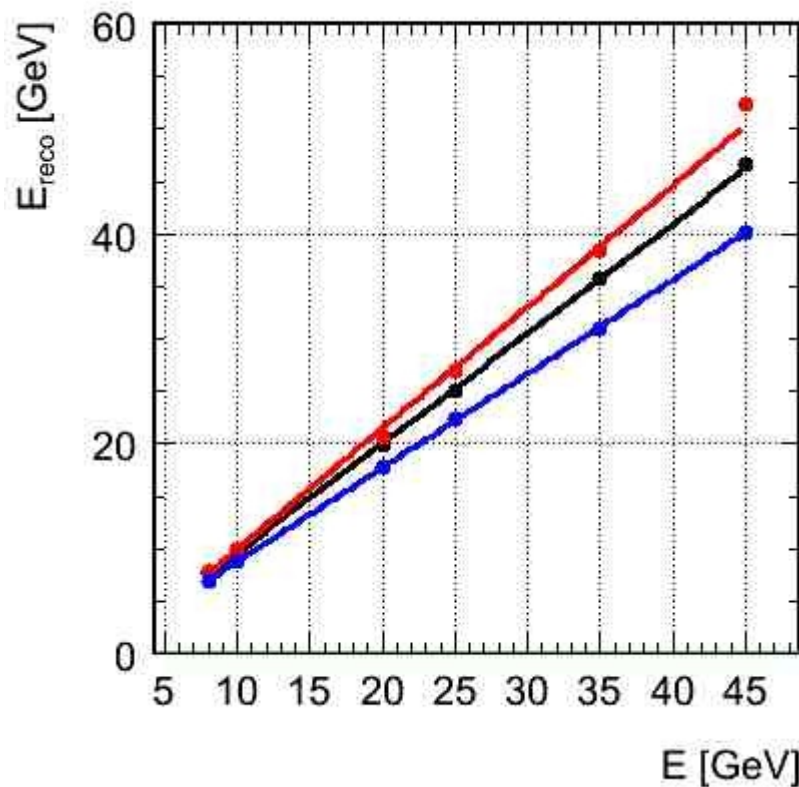Energy 20 GeV

Energy 45 GeV
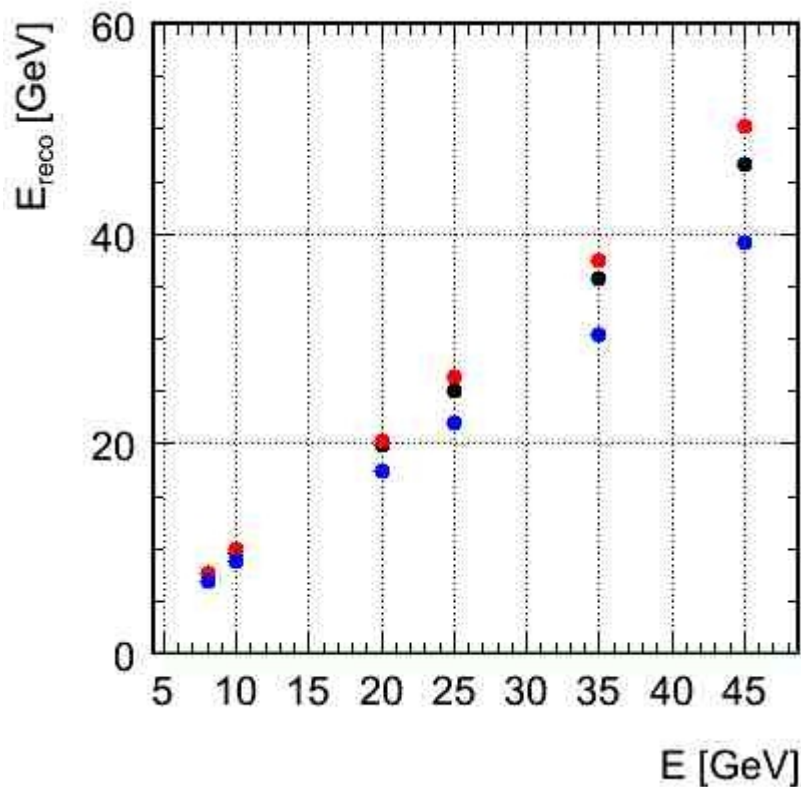

Energy 45 GeV

- effect of non-linearity visible
  black = MC
  blue = uncorrected data
  red = corrected data

- for 20 GeV:
  MC scaling: 1.33
  data scaling: 1.25

- too much reconstructed energy
  at higher beam momentum

Marius Groll

20

Pions in 2007

Linearity:

black = MC, blue = uncorrected data, red = corrected data


Marius Groll

Slopes: all/contained
MC: 1.04 / 1.05
data corrected: 1.12 / 1.15
data uncorrected: 0.87 / 0.90

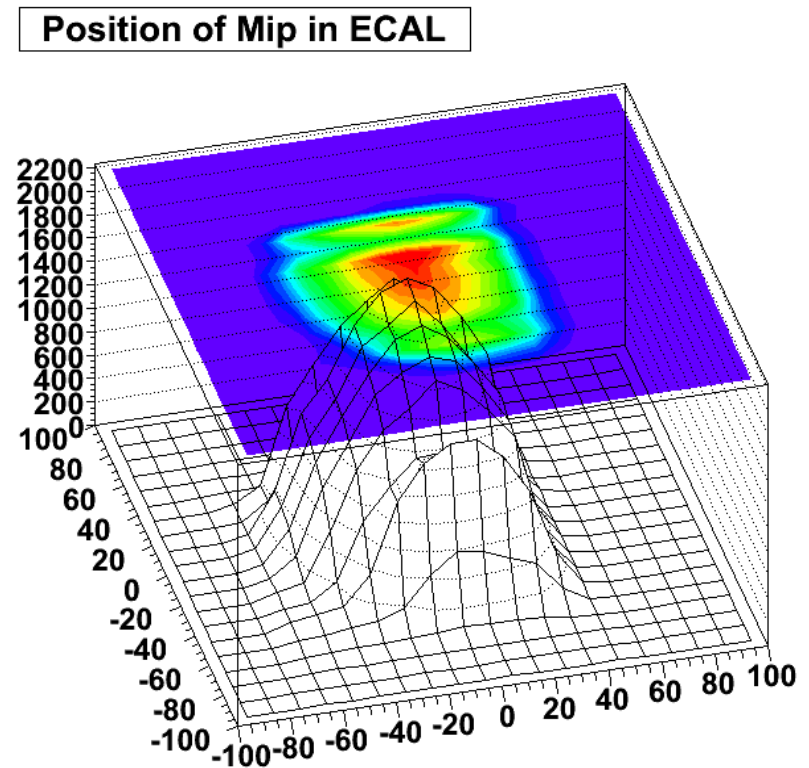# Particle Flow: Shower Separation

- A. Raspereza, 2004: MC study of shower separation in A-Hcal prototype

- dedicated clustering algorithm

- one charged and one neutral hadron close-by in calorimeter
  quality: fraction of events, where E_{reco} of neutral hadron within 3 σ of
  resolution for neutral hadron only
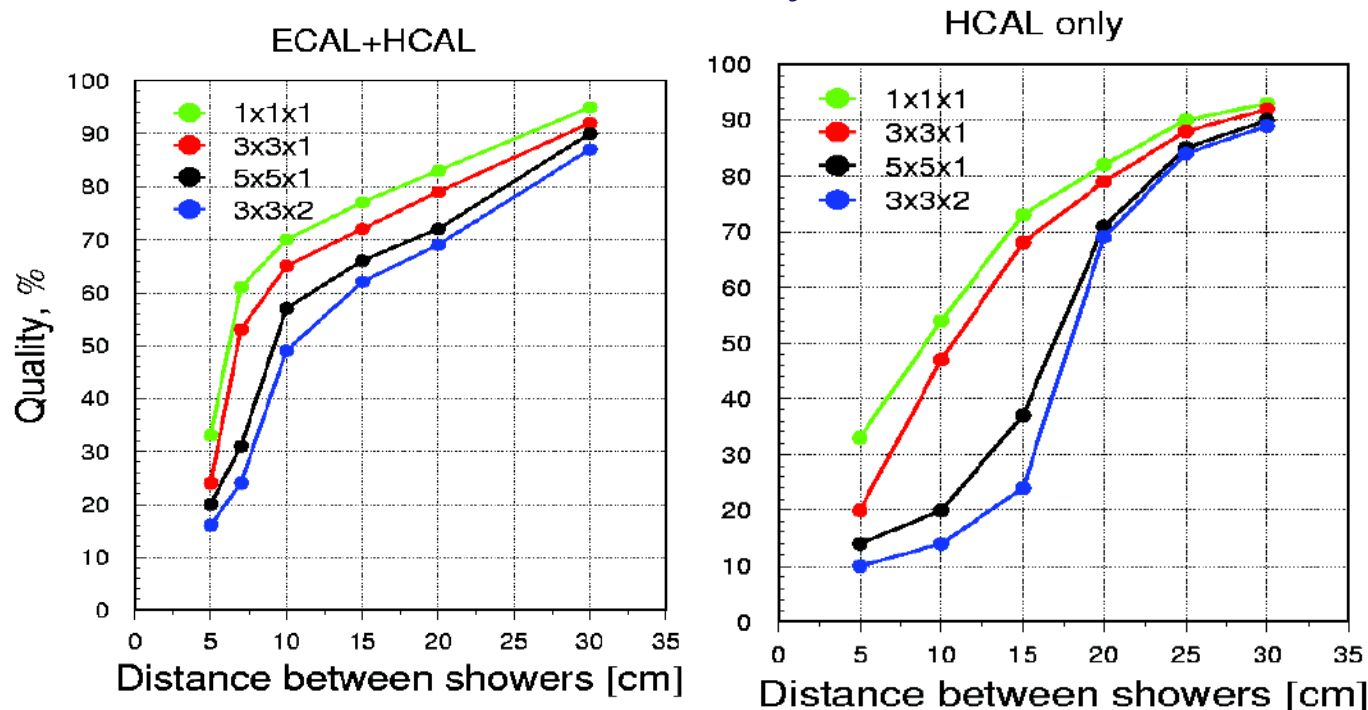
Jörgen Samson

Particle Flow: Shower Separation

- create 'two particle' events by overlaying two real data events

➔ 'OverlayProcessor'

- stick to events where shower is contained in HCAL (MIP track in ECAL, no/low leakage in TCMT)

- 10cm x 10cm coincidence trigger

- can get some statistics with distance of MIP tracks in ECAL of 10cm (up to a few thousand pairs per pion run)

- no need to shift events for this (->different tile sizes)

Position of Mip in ECAL

Jörgen Samson

Particle Flow: Shower Separation

- overlay of two events: overlay at hit level
    - sum hit energy after zero suppression
    - saturation correction applied before summation
    - apply cutoff after sum to emulate saturation
- apply (up to geometry) unmodified "TrackwiseClustering" algorithm by A. Raspereza
- small occupancy
- few cells have merged information
- repeat study on data and MC
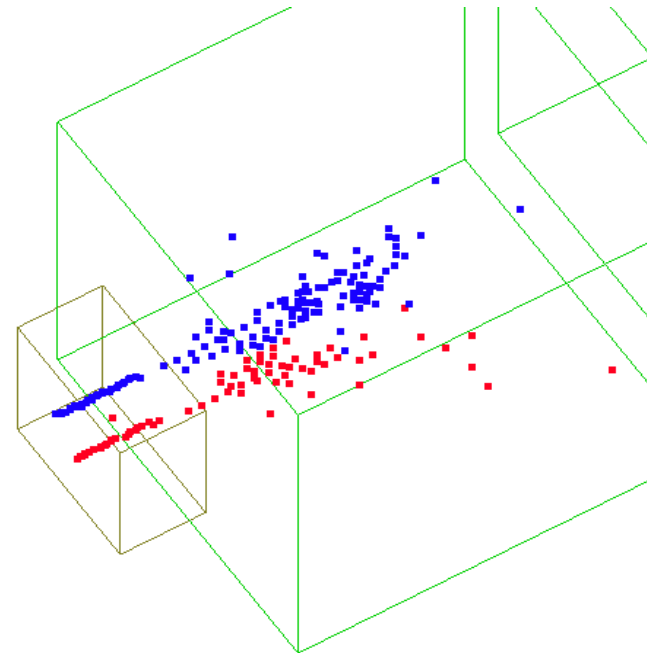
Jörgen Samson

TWO TESTBEAM EVENTS

Outlook

Simple Analysis of 2006 Hadron Data:

- implement digitisation of ECAL and TCMT, enhance statistics (MC)
- understand discrepancies between data and MC, validate digitisation
- run on different energies → detector response, linearity, energy resolution
- study different physics lists, run clustering and compare energy resolution
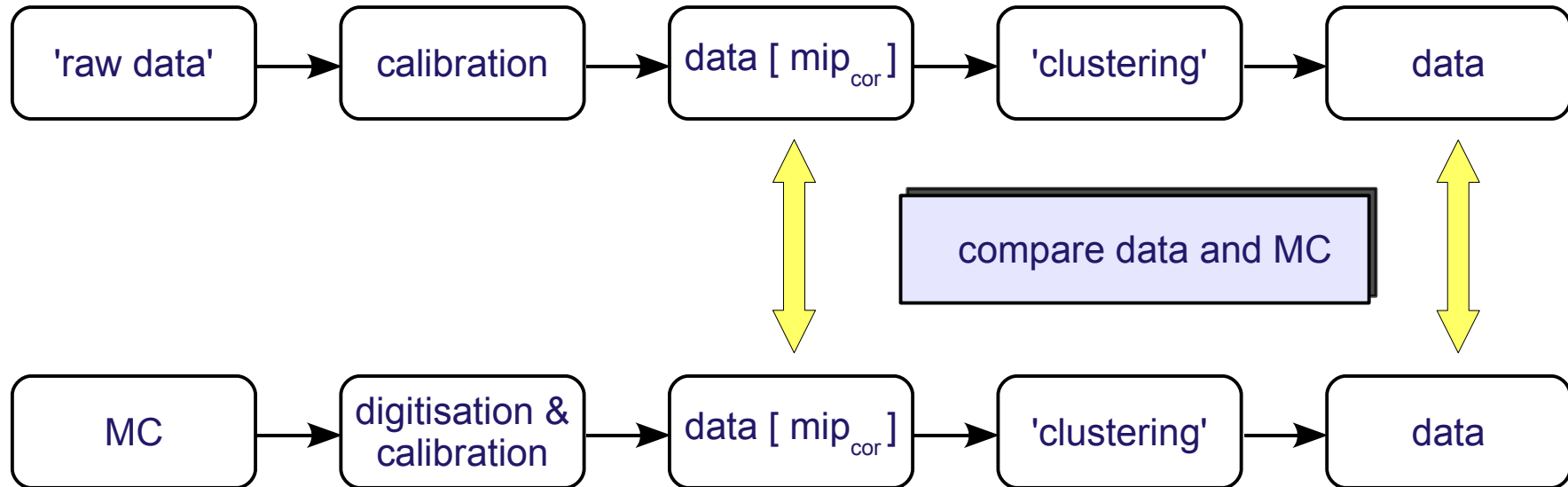- apply analysis on 2007 data

Hadron Data of 2007:

- complete set of calibrations and linearity corrections needed
- understanding of temperature corrections, study detector effects

and additionally:

- Particle Flow Studies, Shower Separation etc.
- interface GEANT3 to Mokka database, implement lcio output
- compare physics models in GEANT3 and GEANT4 with data

backup slides ...

Simulation and Reconstruction Chain

'raw data' → calibration → data [mip_{cor}] → 'clustering' → data

MC → digitisation & calibration → data [mip_{cor}] → 'clustering' → data

compare data and MC

- implemented in 'official' framework (**hcal-v00-01-20** see talk by Sebastian)
- simple cut-based selection to find hadron showers fully contained in HCAL
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First Look into Data of 2006

run 300660, pi, -10GeV: plots for HCAL, comparison with MC