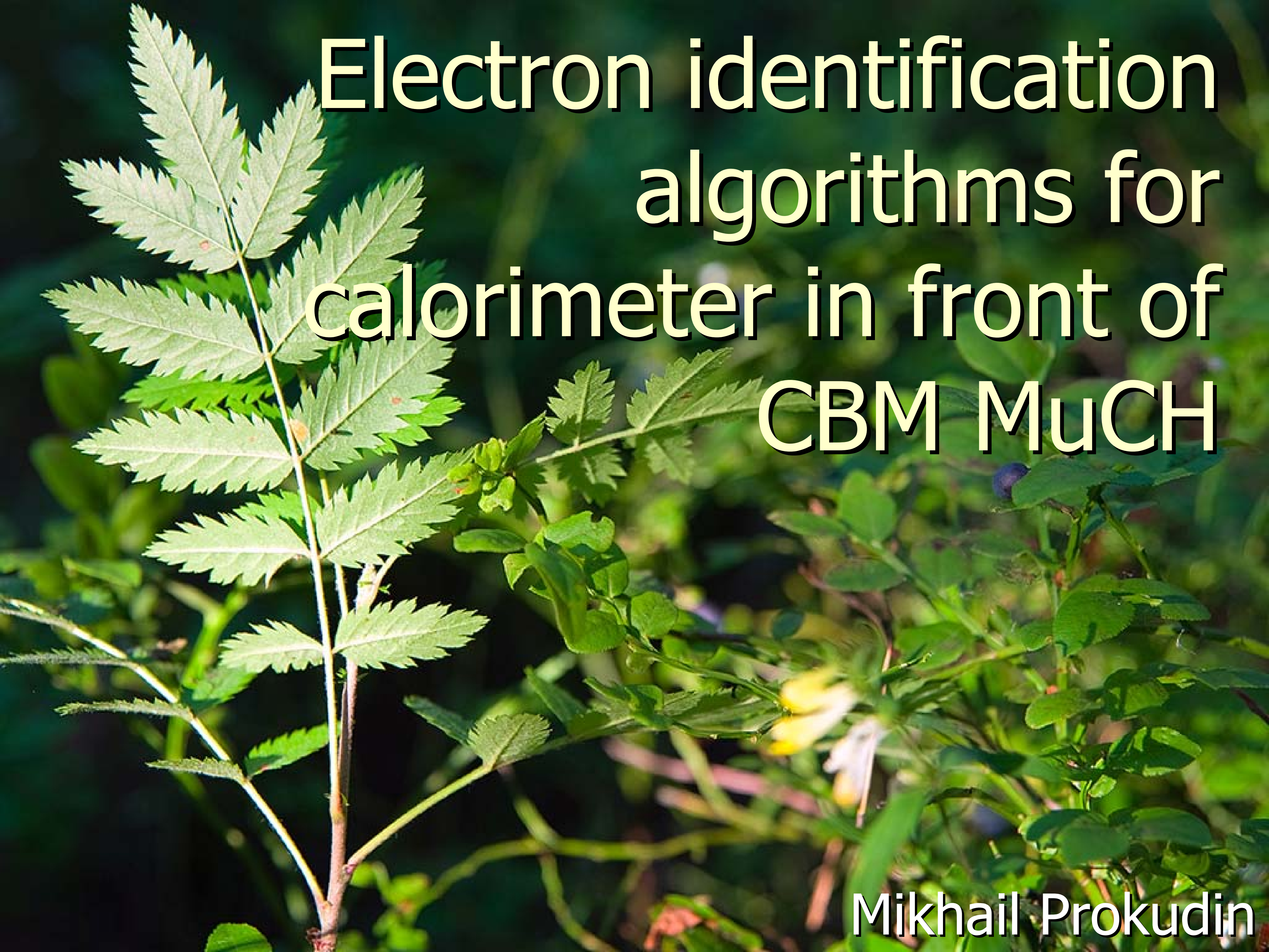


Electron identification algorithms for calorimeter in front of CBM MuCH

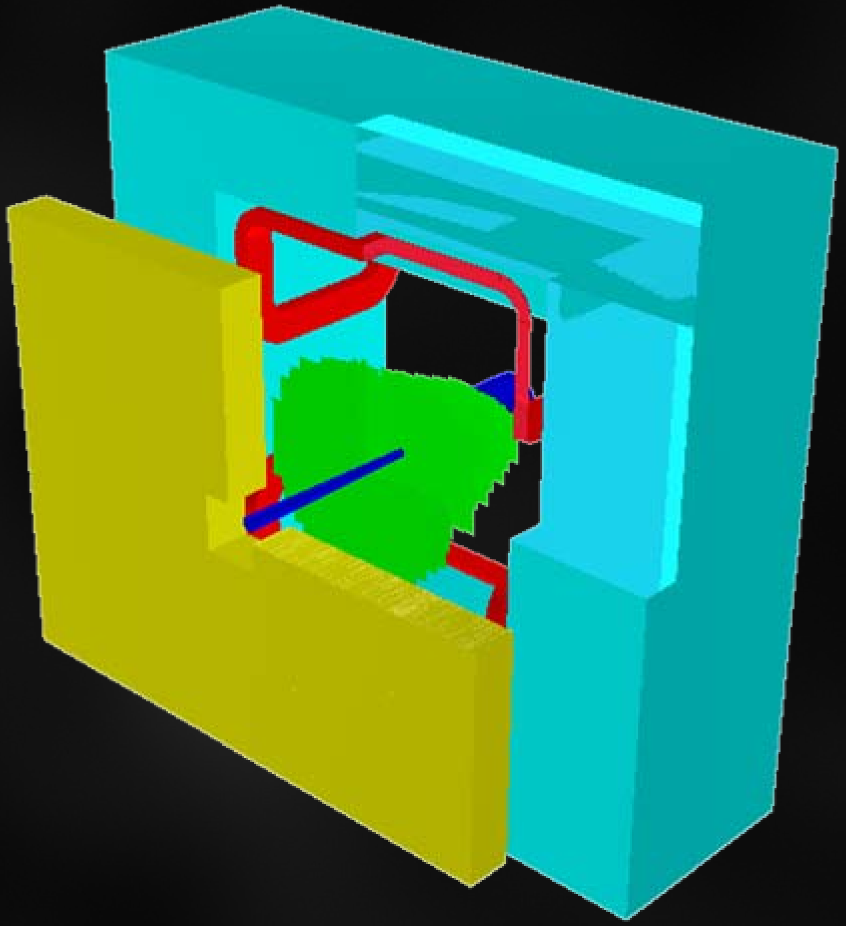
Mikhail Prokudin

Outline

- Electron identification
  - Calorimeter geometry
  - Methods
    - Cluster formation
    - E_{calo}/P_{track}
    - Impact point analysis
  - Results
    - $J/\psi \rightarrow e^+e^-$ as a test channel
- Lead/scintillator calorimeter
  - Geometry and photon reconstruction quality

Geometry

- Size: $2.5\times2.0\ m^2$
  - 20×16 modules
  - 25 readout channels per module
    - $2.5\times2.5\ cm^2$ cell size
  - 7900 channels total
- 1.5 m distance from target
  - 5–45° angular acceptance

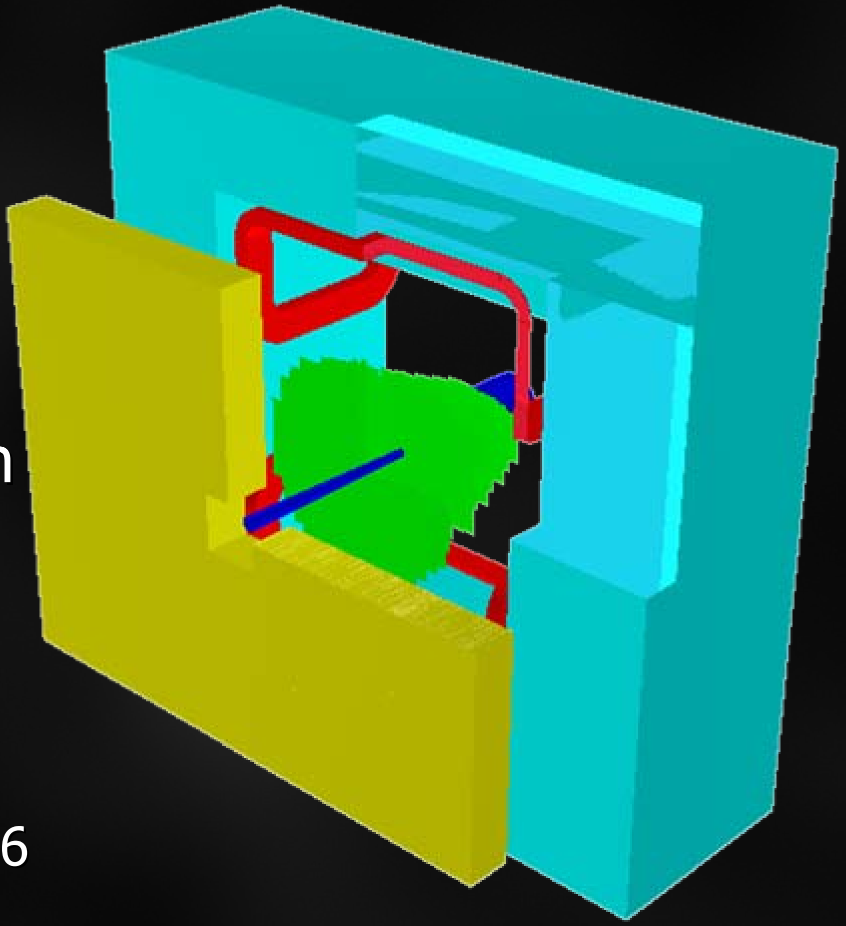


Geometry

- 70 layers
  - 1.0 mm tungsten
  - 1.5 mm plastic
    - 175 mm total thickness
    - Space for readout?
  - $20X_0$
  - 0.95 nuclear interaction length
  - Energy resolution

$$\frac{dE}{E} = \frac{7.6\%}{\sqrt{E}} \oplus 1.4\%$$

    - non zero constant term because calorimeter a little bit short for 16 GeV photons



Inputs and methods

- 30 GeV pC events for background
  - … and J/ψ→e+e- for signal
- Tracking system
  - position on calorimeter surface
  - momentum

For calorimeter in electron option

- Compare E_{calo} and P_{track}
  - new cluster formation procedure
- Preshower information
  - no preshower in calorimeter in front of MUCH
- Shape
  - energy deposition in 2×2 subcluster/energy deposition in 3×3 cluster
  - Impact angles very high

Additional methods

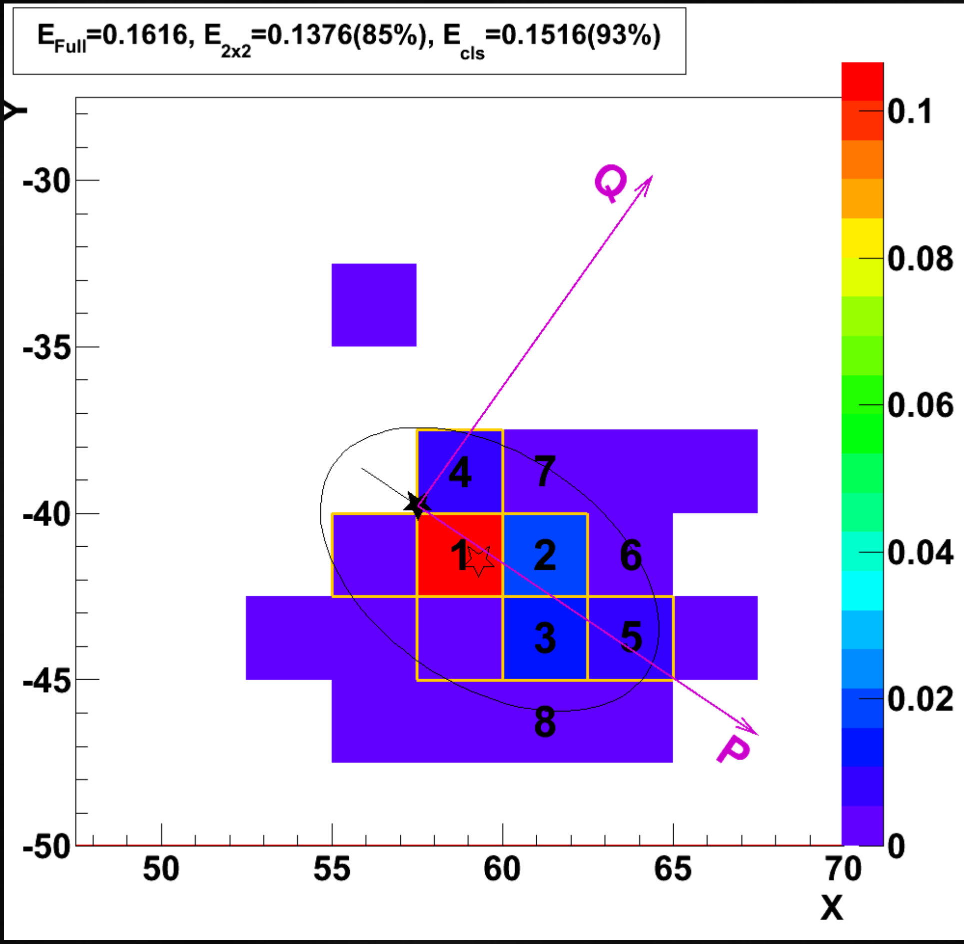
- Reconstruction of impact point by calorimeter
  - (not very) advanced shower shape analysis
- Analysis of MUCH hits on track trajectory after the calorimeter
  - Require integration of calorimeter with MUCH system
- For large (25° and more) impact angles a cell hit by the track can be used as a preshower
  - not implemented

- All presented analysis is preliminary and can be improved

Cluster formation

Electrons. E=2 GeV, Angle=25°

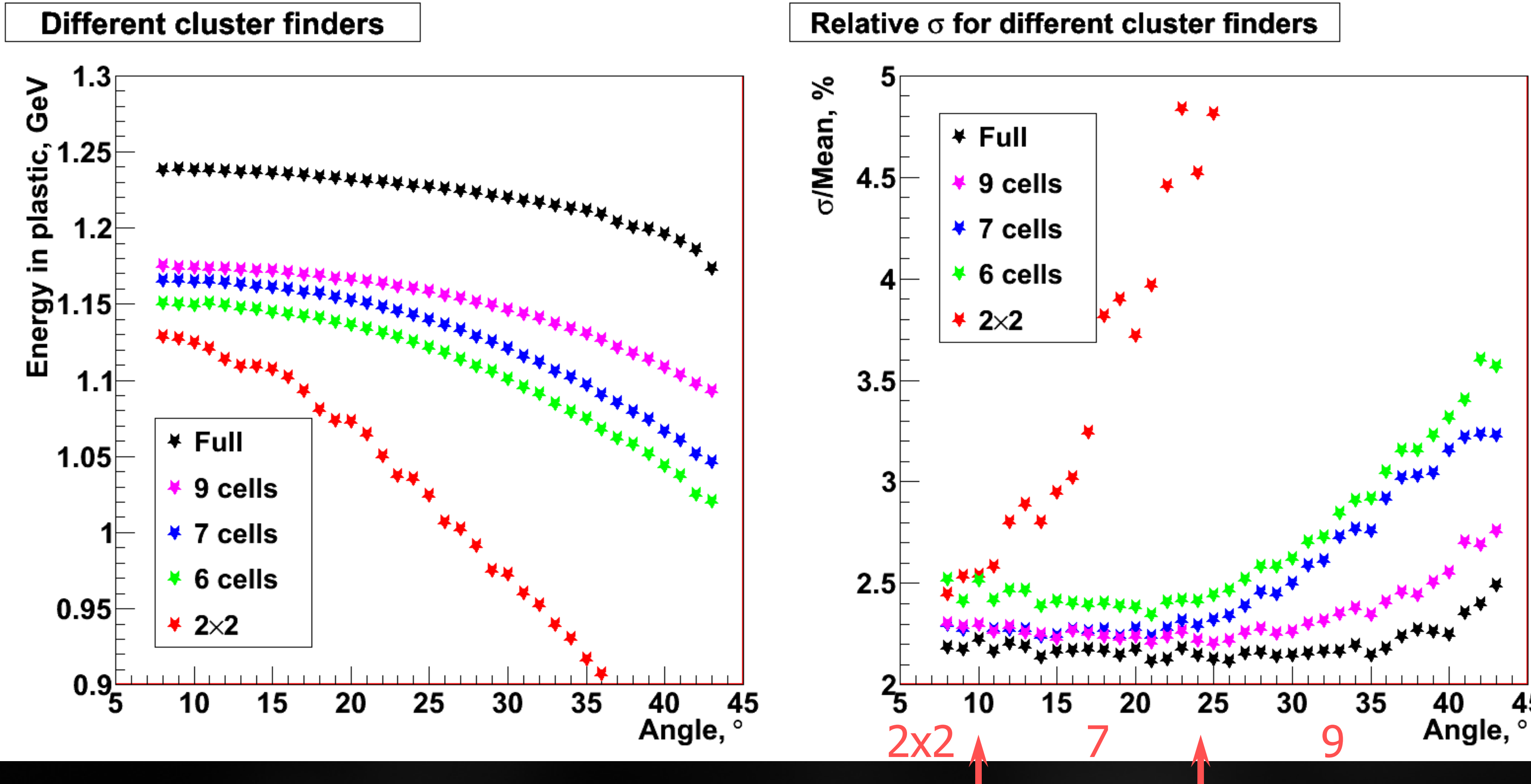
- Procedure
  - local maximum
  - 2x2 maximum matrix
  - center of gravity of 2x2 maximum matrix (☆)
  - ellipse
    - center of ellipse located on line from center of calorimeter to found center of gravity
  - sort all cells depending on area intersect with ellipse
  - cluster
    n cells with maximum intersection area



Very similar to precluster formation for photons

Cluster size

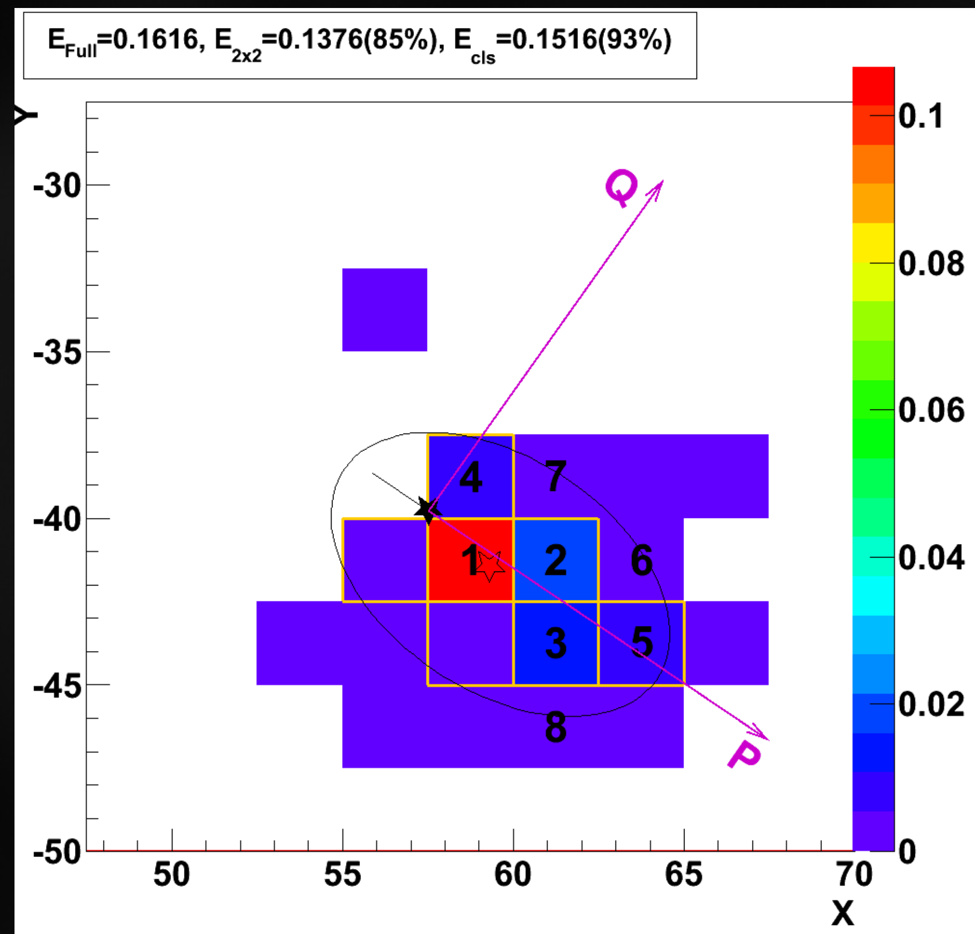
16 GeV photons



Maximum and track matching

- Vector V: ★→☆
  - ★: track impact point
  - ☆: calorimeter cluster's center of gravity
- use P and Q reference system
  - Coordinates of the vector: (V_P, V_Q)
- The V_Q should be [-1.2cm, +1.2cm]
- The boundaries for V_P are tabulated as a function of
  - impact angle
  - momentum

Electrons. E=2 GeV, Angle=25°

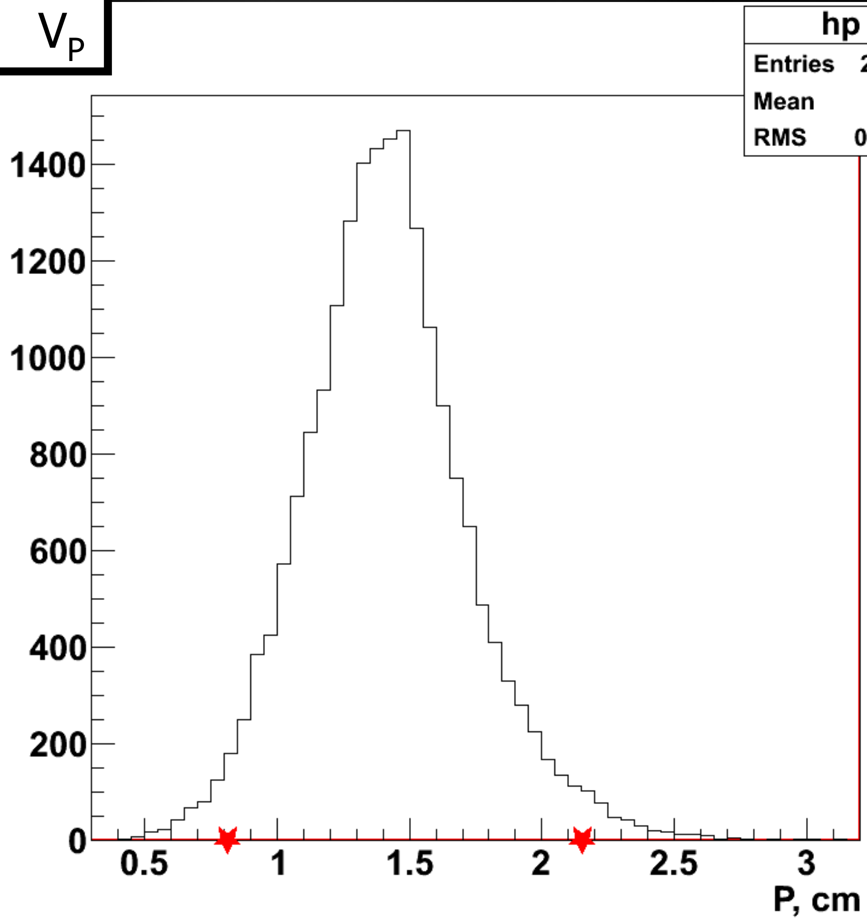


P axis coincide with direction of particle momentum

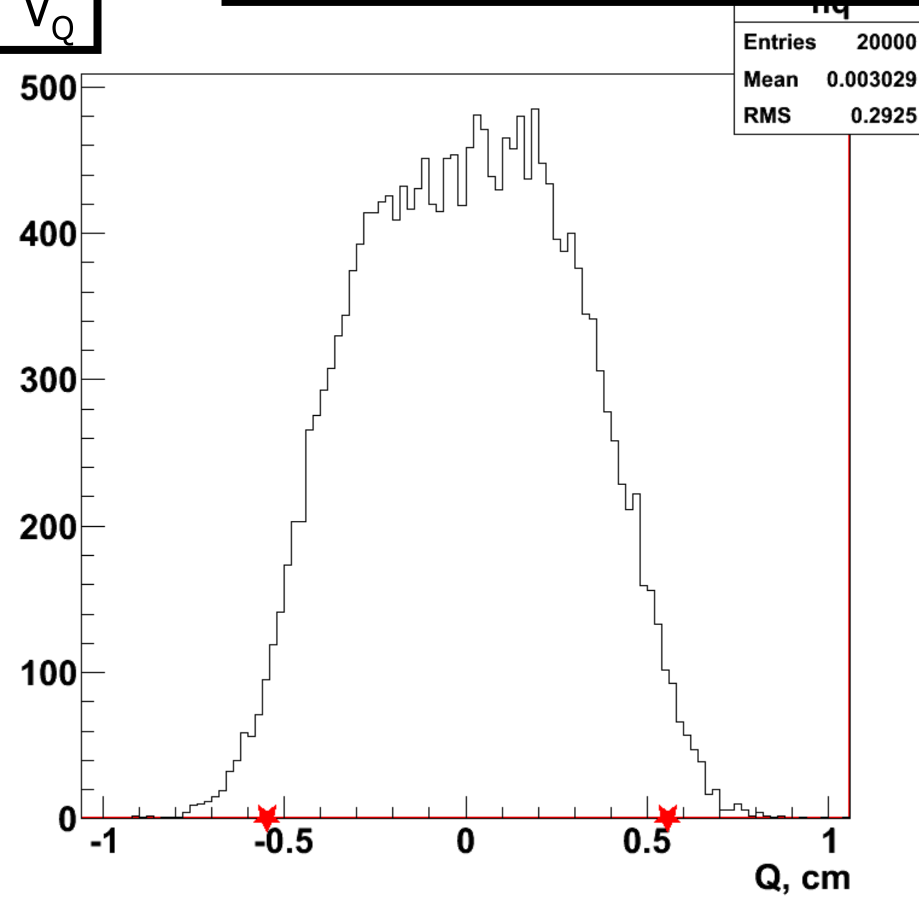
Examples of V_P and V_Q

Electrons. E=2 GeV, Angle=15°

V_P



V_Q



[-2%,+2%] of the distribution outside the region marked by red ★ stars.

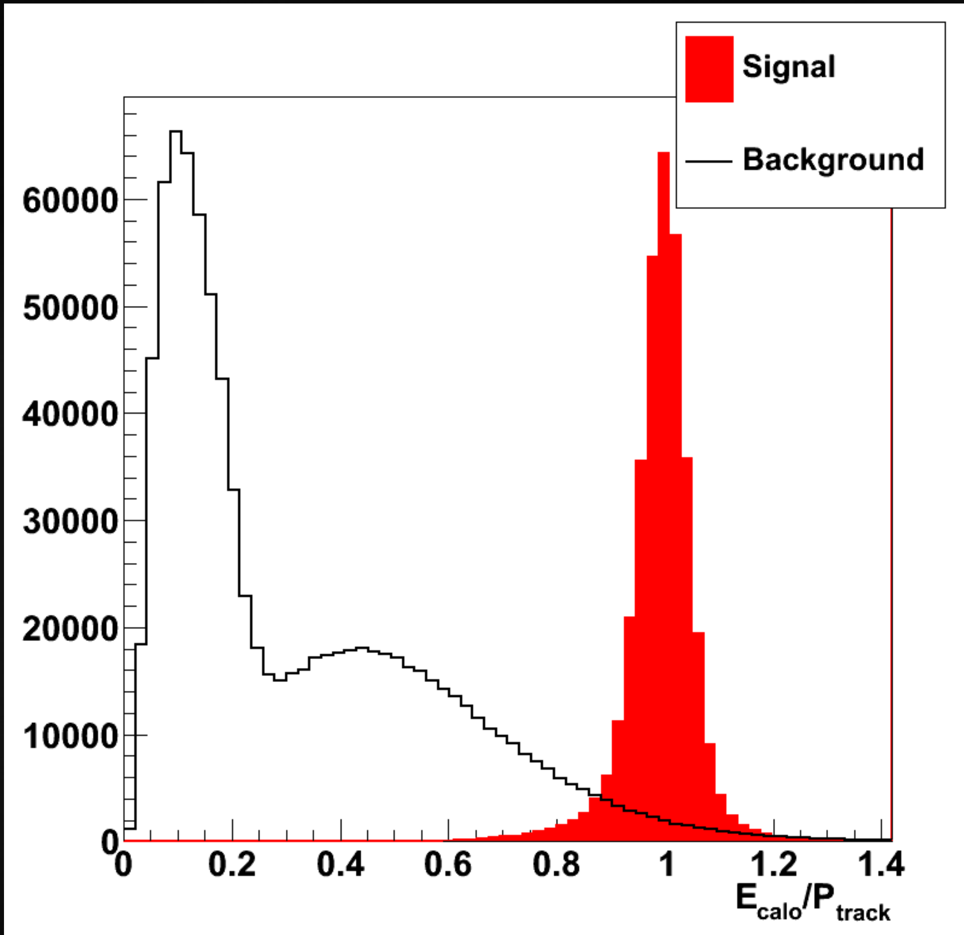
[-1.2cm, +1.2 cm] boundaries used for V_Q

[-10%,+30%] boundaries used for V_P

Maximums exclusion for Photon reconstruction

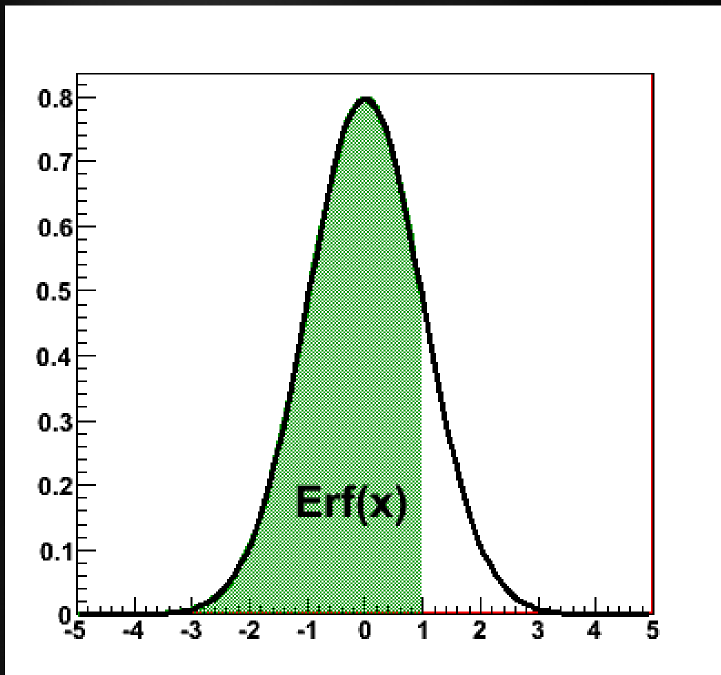
Cluster energy vs. track momentum

- Cluster energy ≠ particle energy
  - only energy in scintillator is seen
  - calibration needed
    - technical issue identical to one for photons
- Use e^+e^- from J/ψ decay as a signal

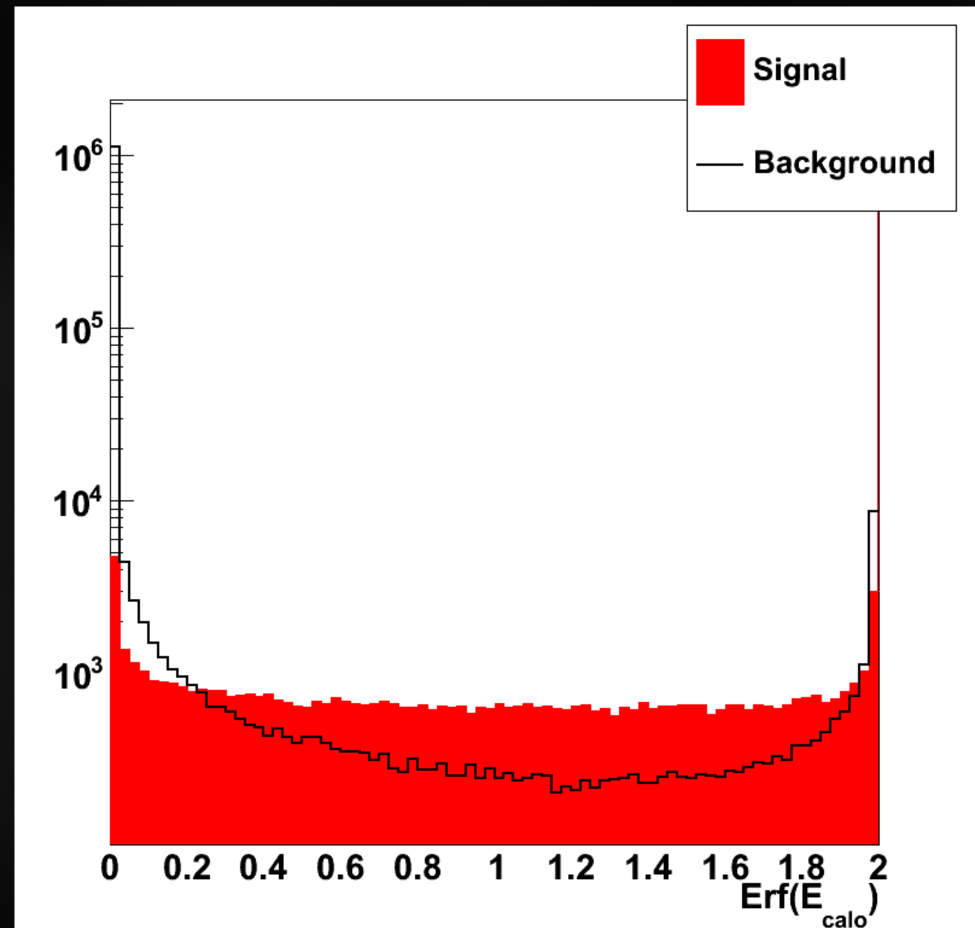


- (very) simple approach
  - not care about calorimeter energy resolution

Cluster energy vs. track momentum. Another variables



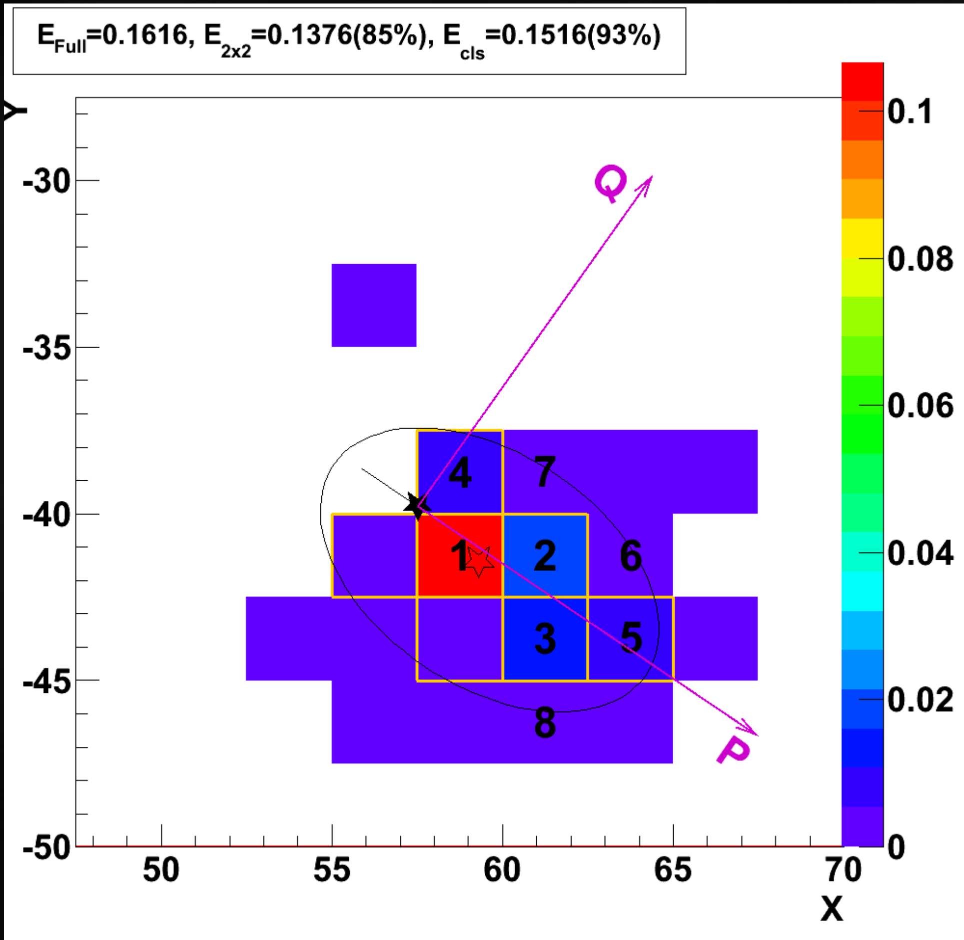
- Center: momentum measured by tracker
- Sigma: Energy resolution for given energy (momentum)
- Integrate $[-\infty, E_{calo}]$



- Log scale!
- Cut at 0.05

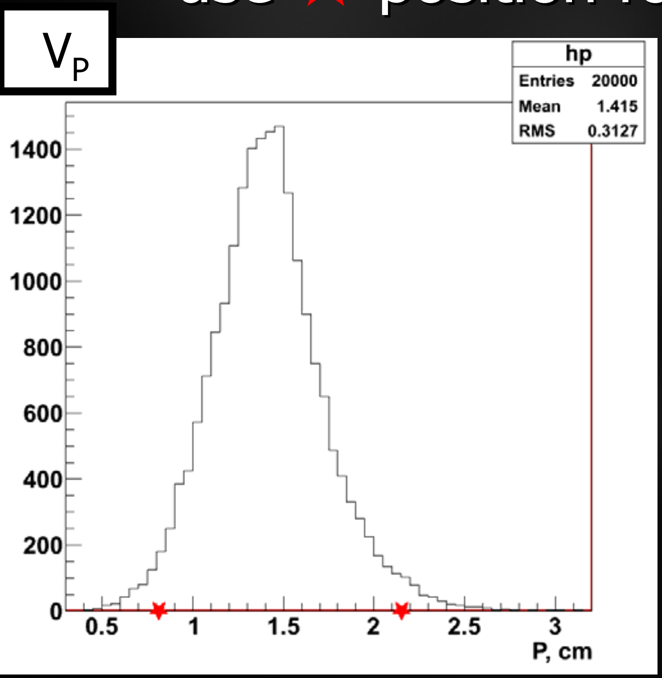
Reconstruction of impact point by calorimeter

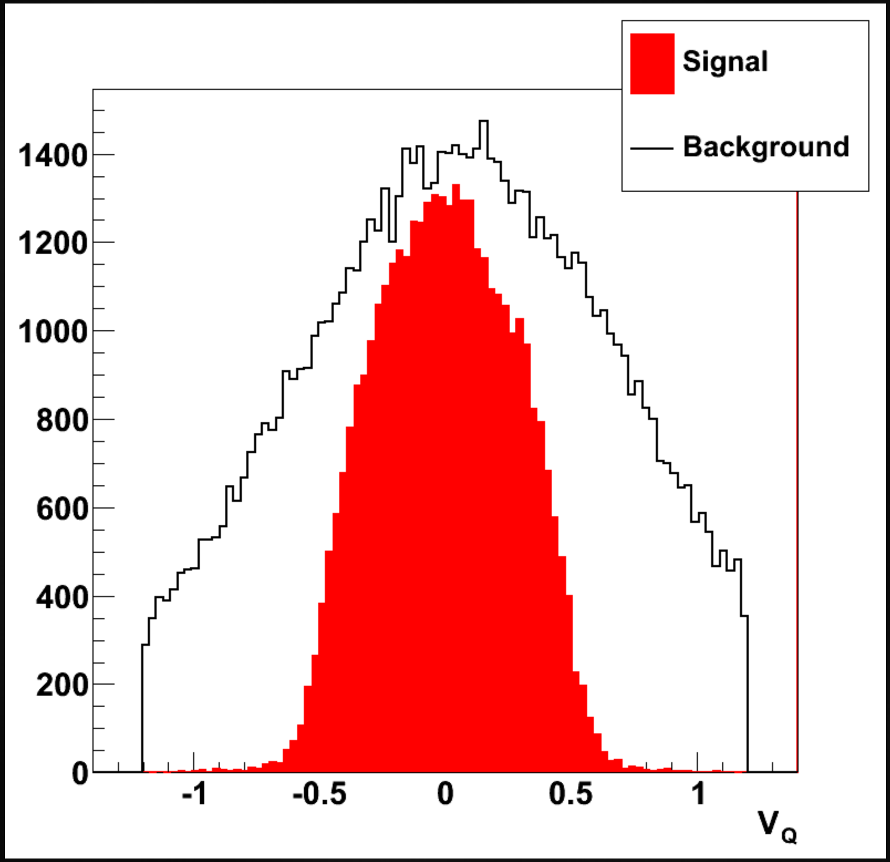
- Same vector V (V_P, V_Q) as for matching between track and calorimeter cluster
- Slick boundaries for matching
  - tight for identification
  - very simple approach



Examples of Q distributions

- $-0.5<V_Q<0.5$
- V_P depends on energy
  - use ★ position for a cut





- TODO:
  - Need a better criteria

Results

	Hadron rejection	Efficiency
E_{calo}/P_{track}	25.8	90.2%
+impact point	62.4	82.5%

Momentum	Hadron rejection
<5GeV	55.6
5-8 GeV	673
>8 GeV	>1000

- First version of identification for calorimeter in front of MUCH
  - Still could be optimized
  - At least 2 more methods for electrons identification
    - hits in MUCH on track trajectory
    - preshower-like information for large angles
  - Longitudinal segmentation?

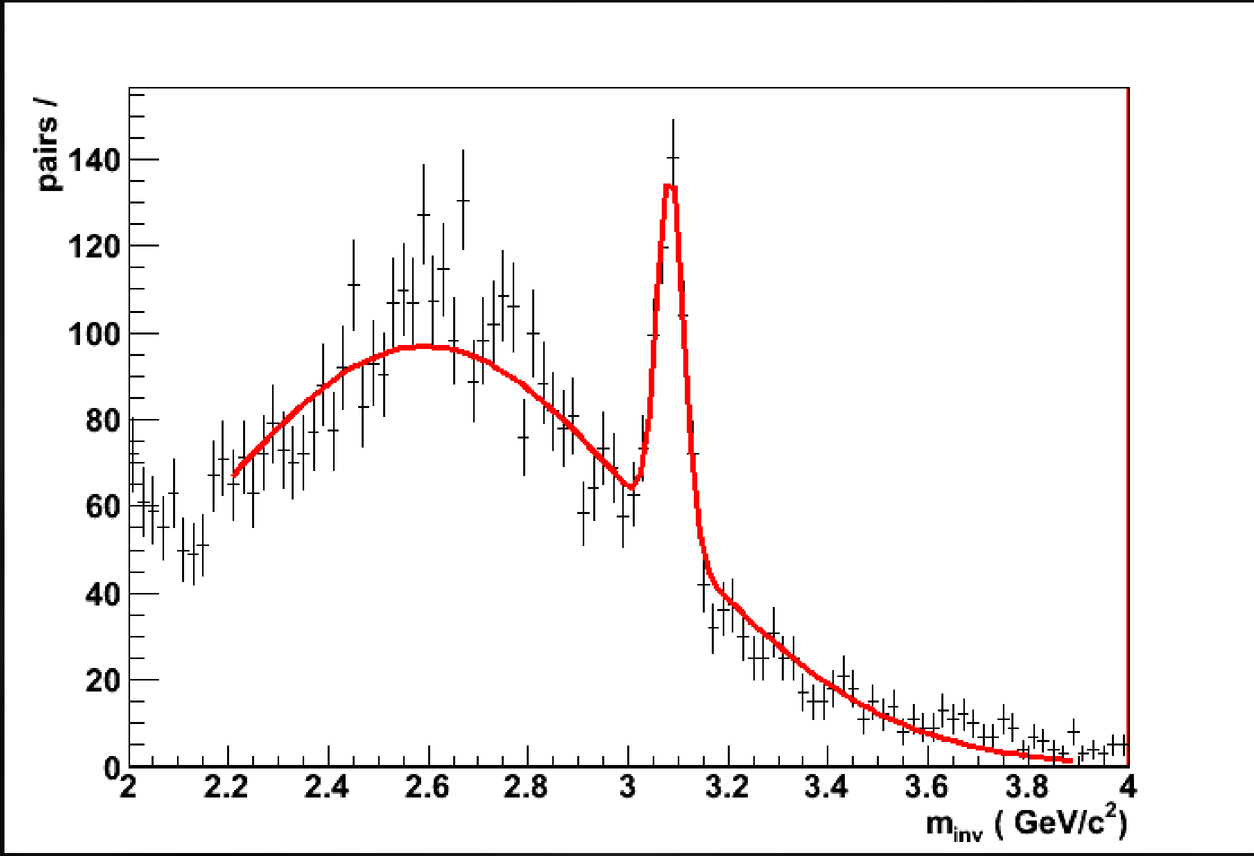
J/ψ generation

- Background
  - 1000000 events
  - 30 GeV pC UrQMD
- No events after cuts
  - see multiplicity
- Superevent
  - Equivalent of 10^{12} events

- Signal
    - 40000 events
  - J/ψ from HSD
  - UrQMD pC
  - Energy/Momentum badly violated!
- Multiplicity: 5.12e-8

J/ψ signal

- Efficiency: 15%
- S/B: 0.99
- Cuts
  - P_T>1.2 GeV
  - Id with calorimeter only



Conclusions

- First version for calorimeter in front of MUCH presented
- 2 methods reviewed
  - E_{calo}/P_{track}
  - Reconstruction of impact point by calorimeter
    - parameters depend on energy

TODO

- 2 more methods can be used
- shower shape analysis
  - like for photons

Methods

- Compare E_{calo} and P_{track}
  - new cluster formation procedure
- Preshower information
  - no preshower in calorimeter before MUCH
    - …for large (25° and more) impact angles a cell hit by the track can be used as a preshower
- Shape
  - energy deposition in 2×2 subcluster/energy deposition in 3×3 cluster
  - Impact angles very high
- Reconstruction of impact point by calorimeter
  - (not very) advanced shower shape analysis
- Analysis of MUCH clusters after calorimeter