Combinatorial background studies for D^0 reconstruction at ALICE

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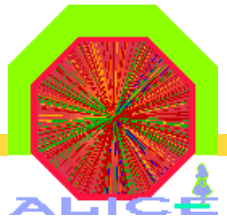
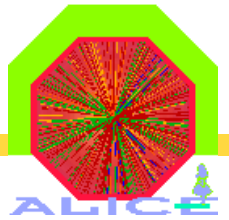
Overview



- Quark-Gluon Plasma and open charm production
- D^0 measurements at ALICE
- Combinatorial background reconstruction methods
  - Like-sign pairs
  - Rotational background
  - Event mixing
- Summary & conclusions

Quark-gluon plasma and open charm production



By colliding heavy nuclei (Pb-Pb at ALICE) a new state of matter can be formed, the quark-gluon plasma (QGP). A new state of matter where the quarks have become deconfined.

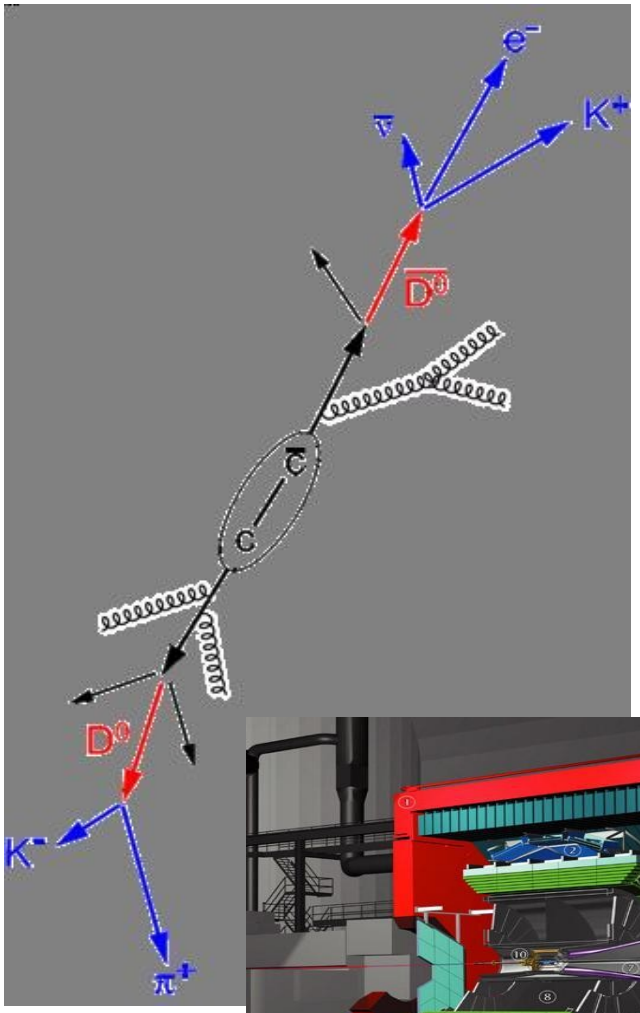
At the early stages of the collision, before the formation of the QGP, heavy quarks are created. These heavy quarks have the potential to travel through the QGP.

Heavy quarks can be used to study the properties of the QGP

- Charm quarks: 400 times heavier than light quarks ($m_c \approx 1.3$ GeV) and with short life times (100-150μm)
- Interaction with QGP causes energy loss, but charm quarks have higher penetrating power
- Probe of QGP properties: degree of thermalization, energy density, dissipation of quark energy and drag coefficient

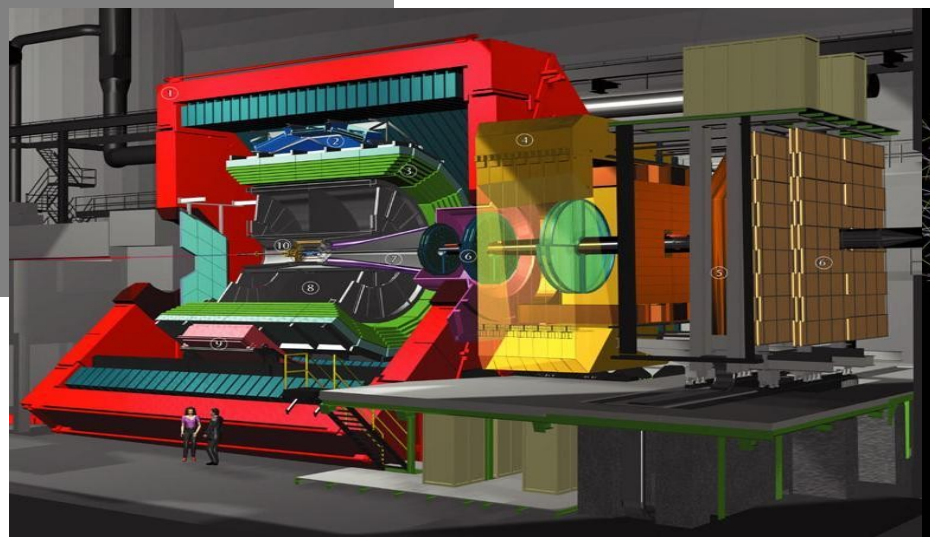
But you have to detect them first!

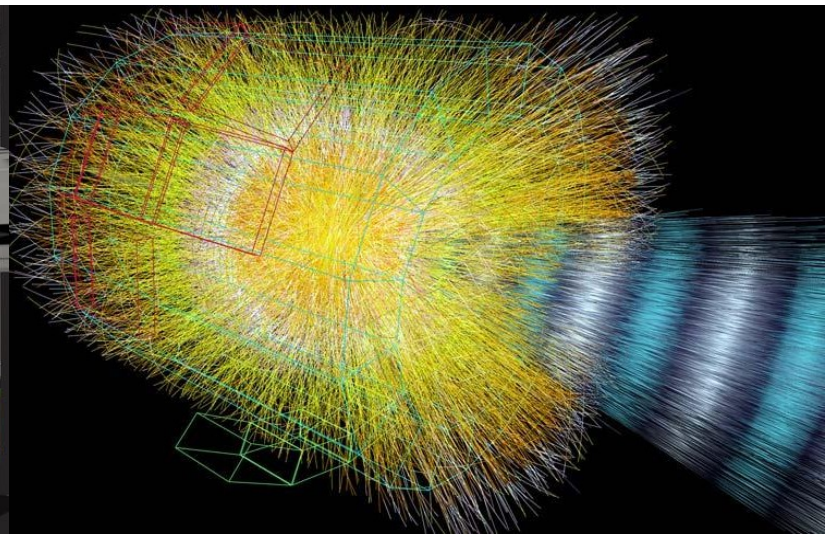
D^0 measurements at ALICE



Goal: full reconstruction of open charmed mesons, in particular the D^0

- $c \rightarrow D^0 + X$ (BR = 56.5%)
- 'Probe' of the QGP: signal in invariant mass distribution
- Large combinatorial background (especially in a high multiplicity environment) obscures D^0 signal: background reduction necessary
- ITS and TPC most important detectors for vertexing and tracking



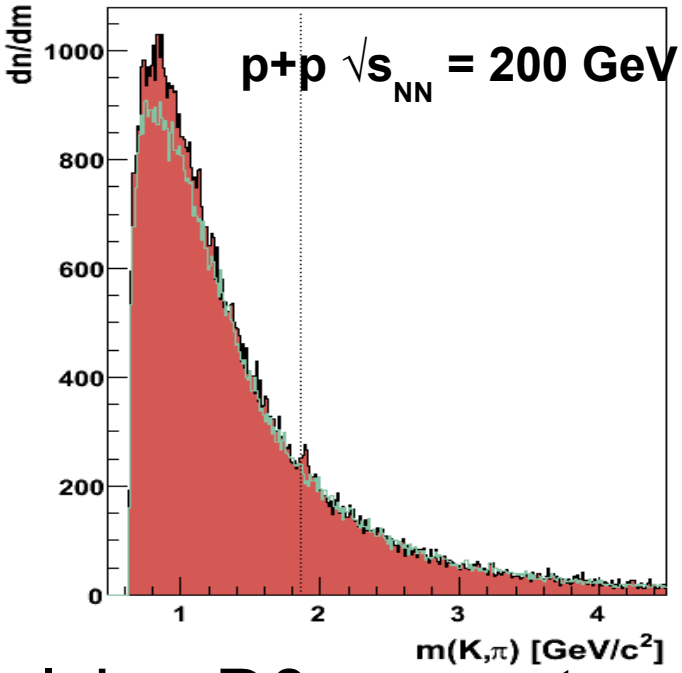


Combinatorial background reconstruction Methods (1)

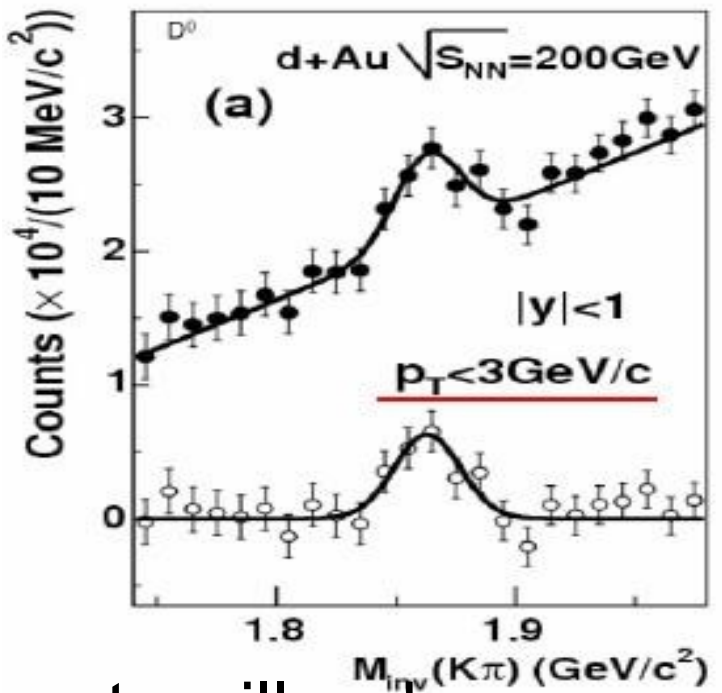
- General: D^0 invariant mass reconstructed by combining positive and negative tracks (unlike-sign pairs).
- Correlations between certain tracks create resonances; e.g. two daughters of same D0 cause peak at 1.865 GeV/c^2.
- Uncorrelated tracks create combinatorial background, which may drown out signal; Subtraction of combinatorial background required.

Figures of RHIC data. p+p at ALICE will be done at 10 TeV.

→ Even more combinatorics!



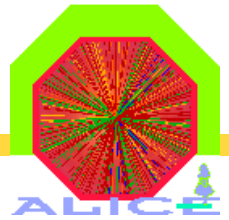
STAR Collaboration, A. Mischke et al., J. Phys. G35, 104117 (2008)



STAR Collaboration, J. Adams et al., Phys. Rev. Lett. 94, 062301 (2005)

Note: Applying D0 reconstruction cuts will reduce the background significantly! *Not shown in presentation*

Combinatorial background reconstruction Methods (2)



(1) Polynomial fit:

- good signal necessary

(2) Same charge-sign (like-sign) pair combinations:

- Straightforward, reasonable statistics, possible problems in the low mass region.

(3) Rotational background (Multiple rotations):

- Rotation of one track in x-y plane

- Pro: Increasing the number of rotations sizable reduction of the fluctuations .

• Cons: Rotating changes event topology.

(4) Event mixing:

- Very good statistic. Mixed events need to be of similar topology.

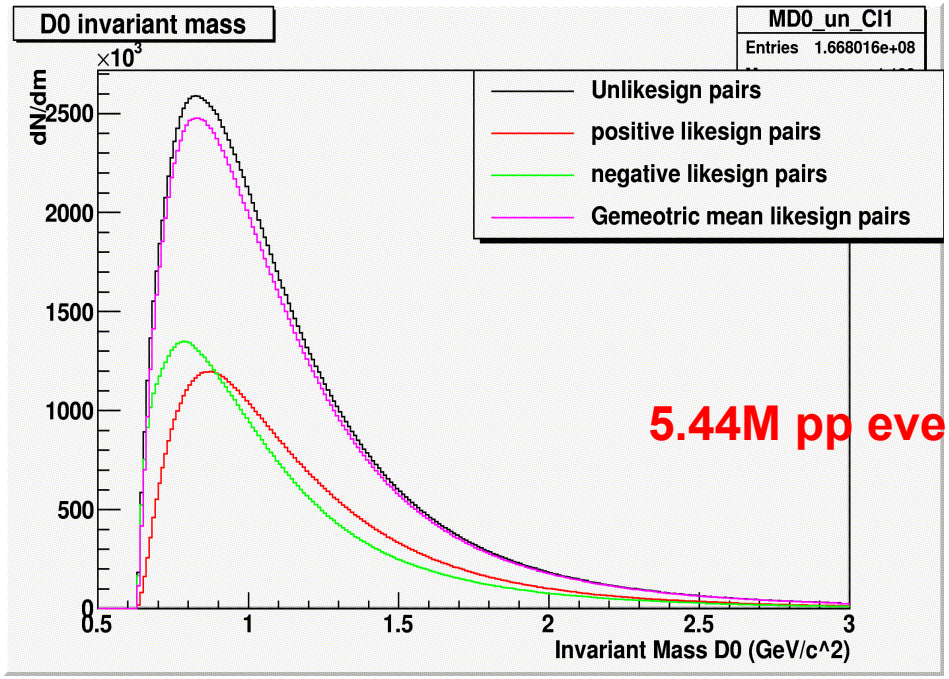
Like-sign pairs

Method: Only combine two positive or two negative tracks (like-sign pairs) instead of a negative and positive track.

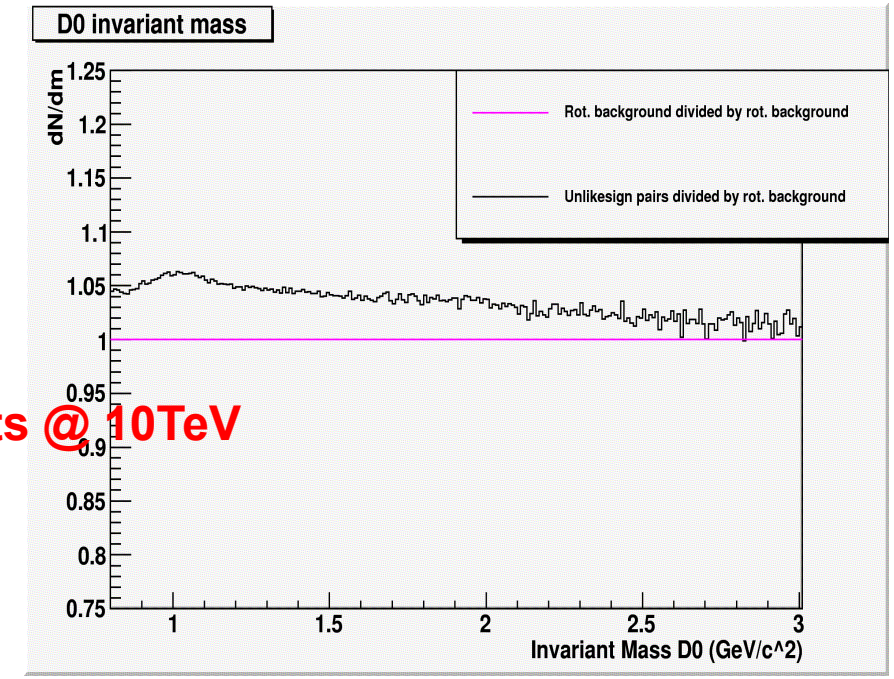
No correlations between combined tracks: result is background

Use geometric mean of positive and negative like-sign pairs to calculate background spectrum ($N_{GM}=2\sqrt{N_p N_n}$).

Note: *Perhaps unsuited for pp collisions due to charge asymmetry*



5.44M pp events @ 10TeV



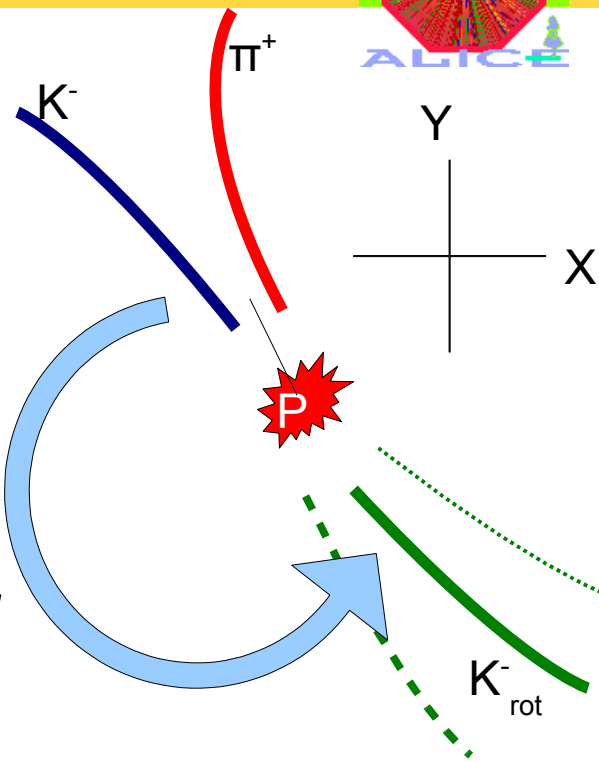
Rotational background

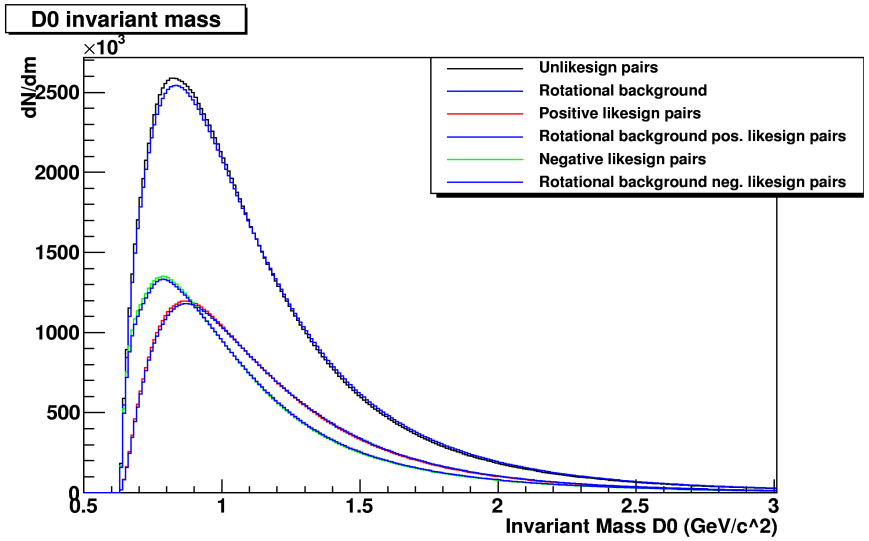
Method: Combine a positive and negative track, then rotate the negative one around the primary vertex in the x-y plane of the detector

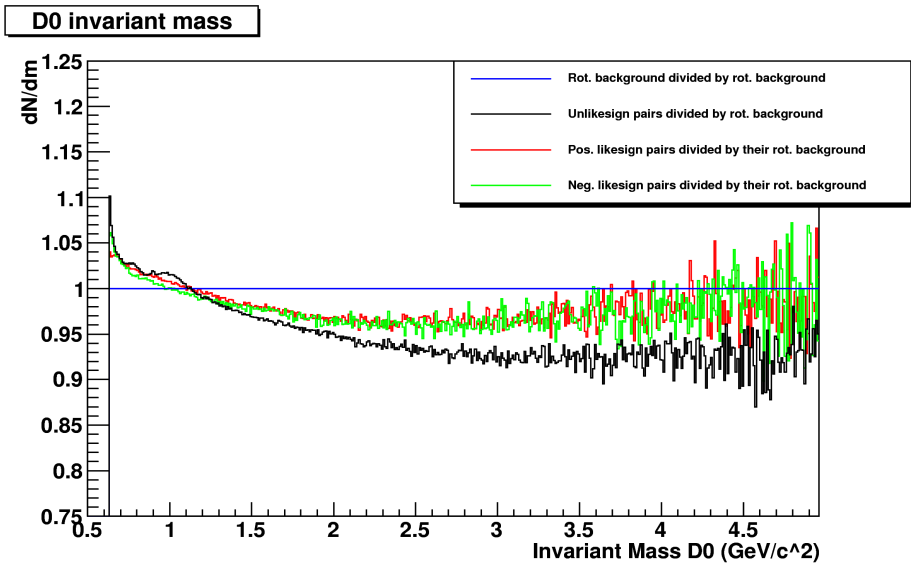
Rotations break correlations, resulting in background

By applying multiple rotations, the statistics can be increased significantly

Note: *Rotating will change the event topology and invariant mass spectrum*







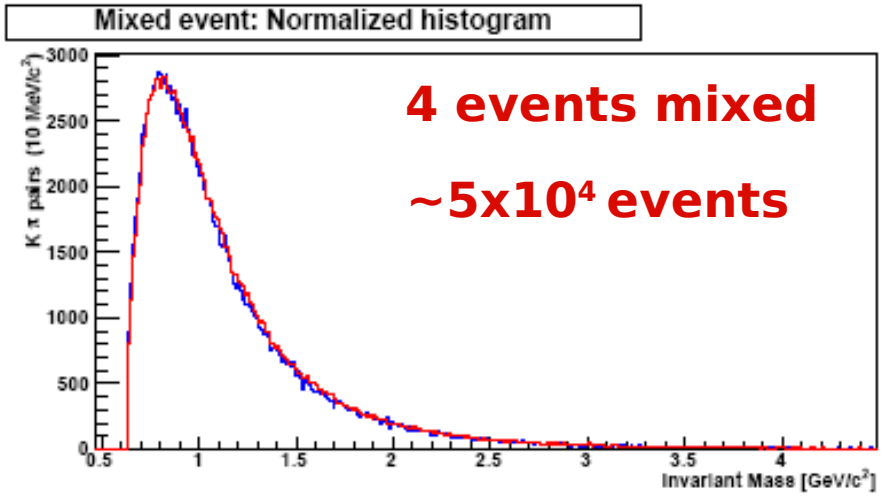
Event mixing

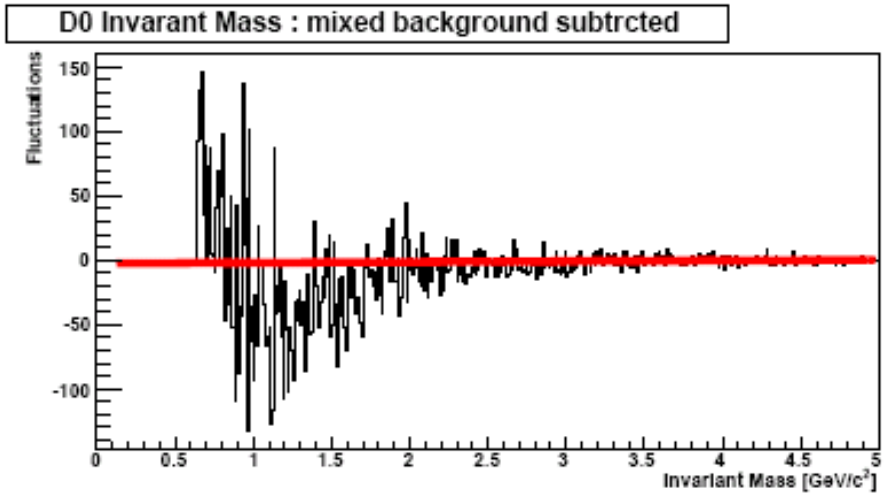
Method: Mix tracks from different events to break track to track correlation and increase the statistic.

Strongly dependent on the event topology. Mix ONLY similar events (*i.e. primary vertex Z, multiplicity, η leading particle …*)

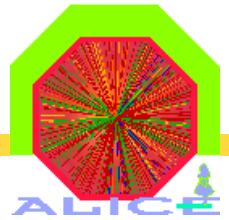
Topological cuts on tracks require to shift each primary vertex of the mixed events to a common primary vertex and to recompute the secondary vertices after the shift of each single track according to the primary vertex transformation.

Note: *Very good agreement but requires careful treatment in terms of memory usage and cuts implementation*





Summary & conclusions



- The ALICE experiment will study the properties of the quark gluon plasma
- The D^0 meson can be used as a probe for this medium
- High particle multiplicity and resulting large combinatorial background obscure D^0 signal; background reduction necessary
- Various methods available: like-sign pairs, rotational background & event mixing
- All techniques approximate combinatorial background to reasonable degree for region around D^0 peak (~1.865 GeV/c^2)
- More statistics required (for reconstruction cuts)!