MACE

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Mach-Cones-Evolution

Part of my Diploma thesis
Collaborators:
Horst Stöcker (Frankfurt),
Laszlo Csernai (Bergen)

Workshop: “Heavy Ion Collisions at the LHC – Last Call for Predictions”, CERN-TH, 2007-05-31.

Outline

- Brief introduction to Mach cones
- MACE-model:
  - How we model the jet
  - How we model sound waves
  - How we see the cone in the model
  - How we get correlation signals
- Calculations for static medium
- Results:
  - Static medium (test case)
  - Central LHC-Collisions
- Summary

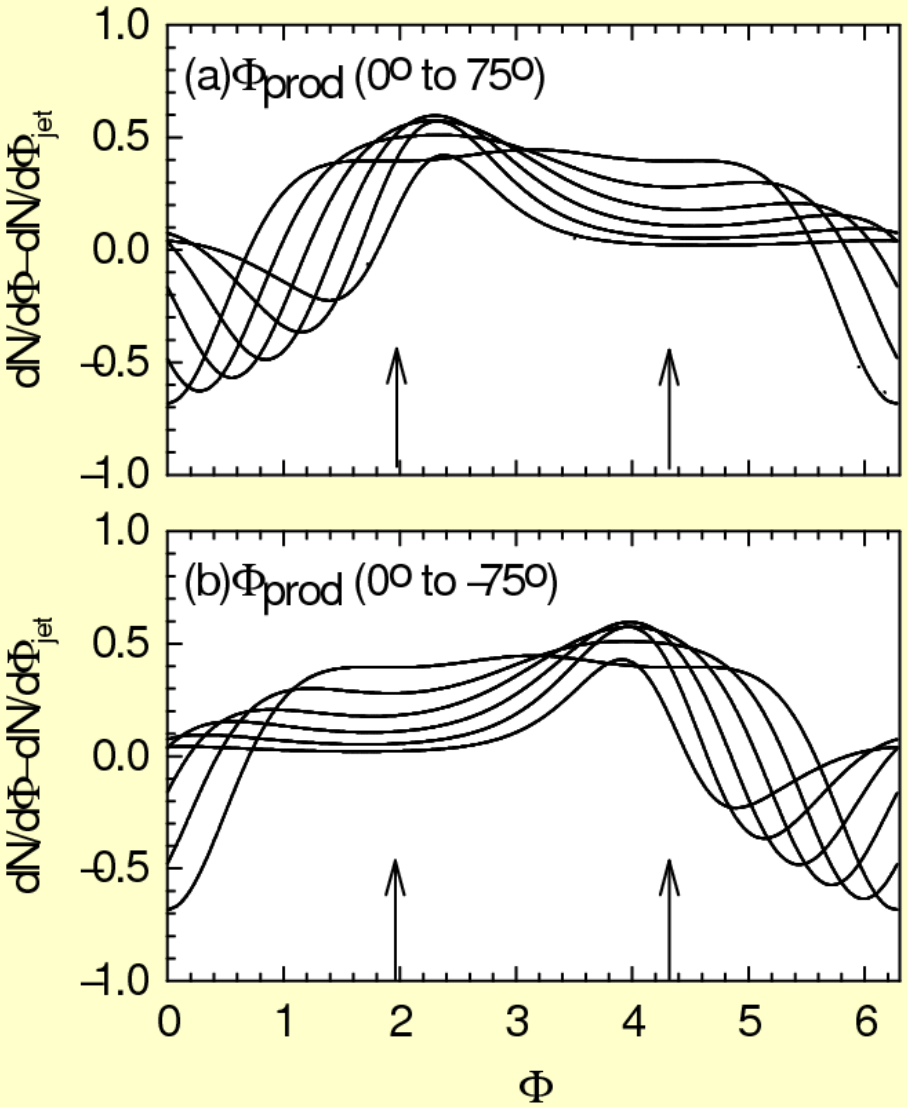
Introduction

Mach-Cones in nuclear matter

- First predicted by Stöcker (1975)
- Developed further by Shuryak
- More works by Stöcker and Satarov, Stöcker & Mishustin (2005), Chaudhuri (2006) and many more
- Claimed to be seen at RHIC!

Introduction

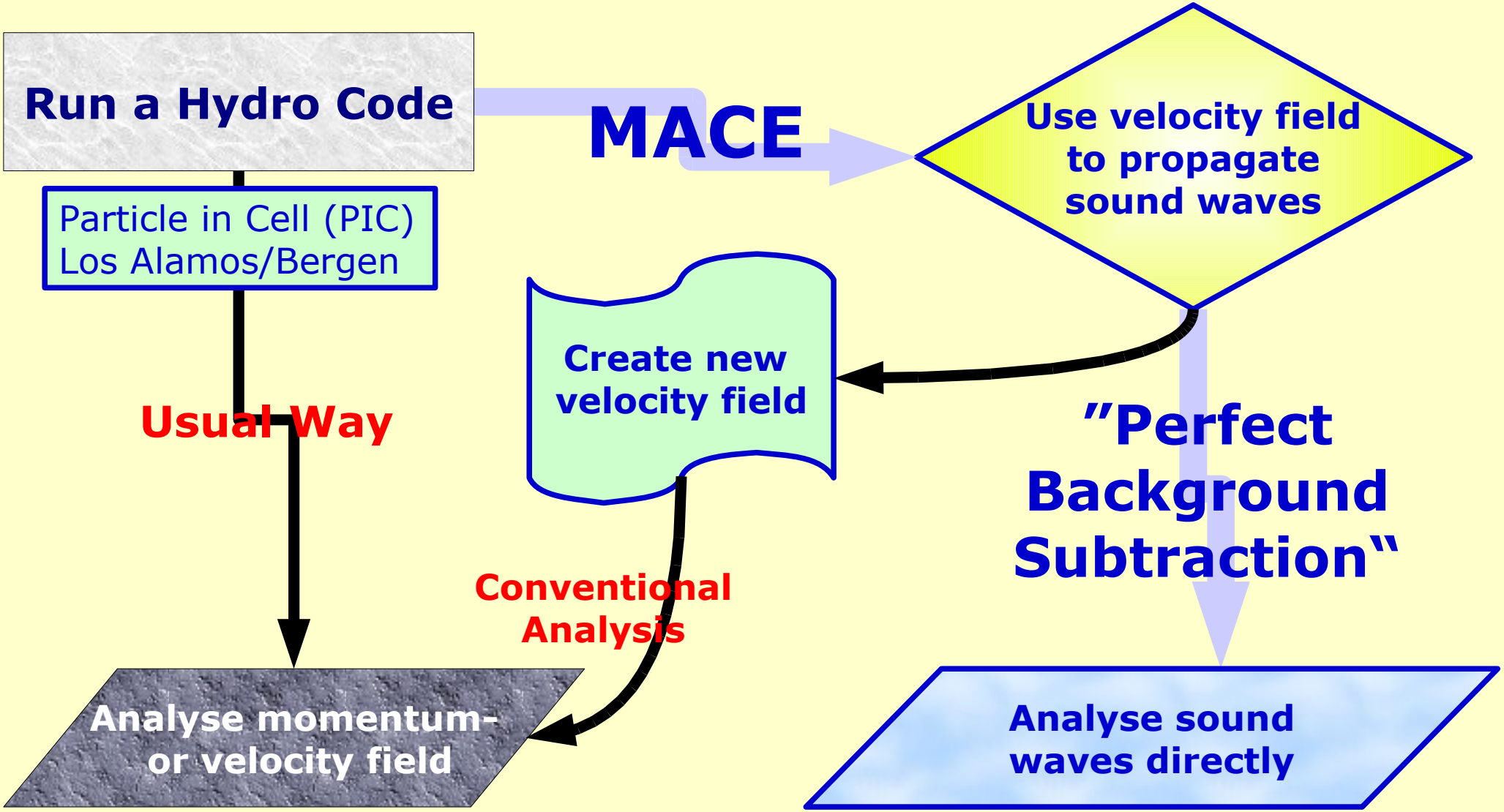
Satarov (2005) and Chaudhuri (2006) predict a broadening of mach angle for jets from peripheral regions



Satarov: Phys. Lett. B **627** (2005) 64
Chaudhuri: nucl-th/0610121

MACE in short

The basic structure of MACE



MACE

Jet

- Only backward jet is considered
- Jet moves straight with speed of light
- Only used for creation of sound waves and correlation

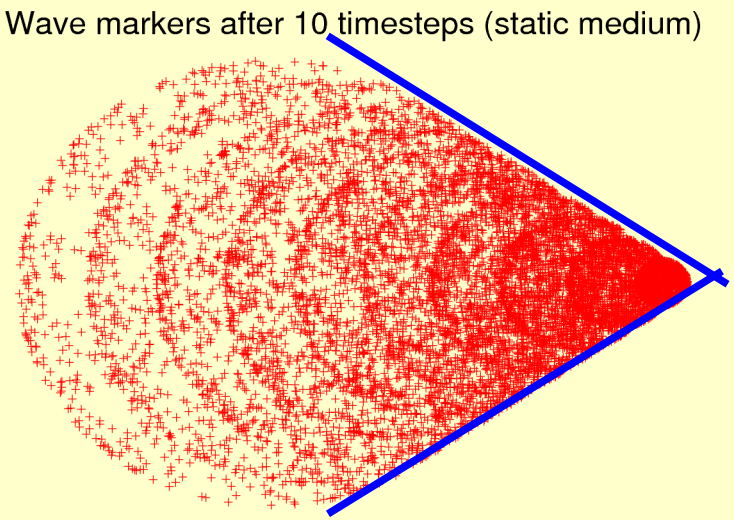
Sound waves

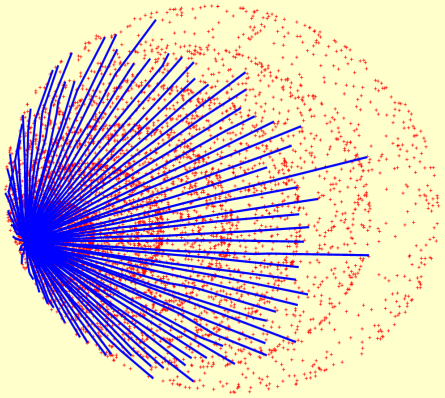
- Sound waves represented by discrete logical ”wave markers“
- Constant speed w.r.t. the medium ($1/\sqrt{3}$)
- No sound propagation outside the medium
- No reflection on the border of the medium

Mach-Cones!?

So, how do we get Mach-Cones?

- Soundwaves are spherical (if not, then only through hydro flow)
- We take the shape, i.e. the surface, of the affected region.
- Surface is found by taking a number of lines that go along the outside.
- Lines finally represent the surface.

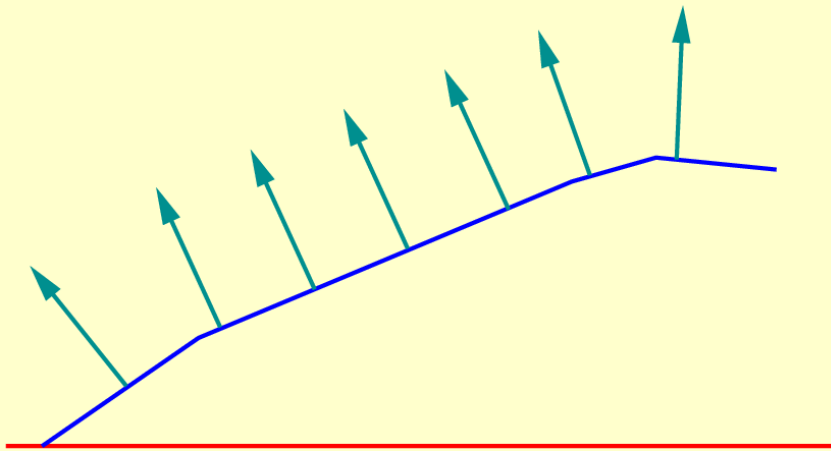




Particle flow

How do we get the signal?

- Perpendicular to wave lines
- Signal created at regular intervals along the lines
- Correlation calculated only from this signal, without Hydro-background (”perfect“ background subtraction)



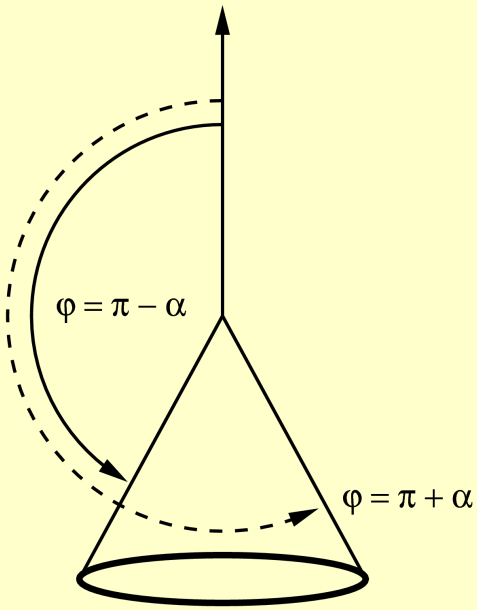
Expectations in static medium

Expected Correlations in static medium

Rotation of coordinate system leads to alteration of correlation functions

For mid-rapidity-jet:

$$\frac{dN}{d(\Delta\phi)} = \frac{1+\tan^2(\Delta\phi)}{\sqrt{\tan^2\alpha - \tan^2\Delta\phi}}$$



For arbitrary jet:

$$\frac{dN}{d(\Delta\phi)} = \frac{1+\tan^2(\Delta\phi)}{1+\tan^2(\Delta\phi)\sin^2\tau}\left\{\frac{\cos\tau}{\sqrt{\tan^2\alpha+\tan^2\Delta\phi\,[\tan^2\alpha\sin^2\tau-\cos^2\tau]}} - \sin\tau\right\}$$

α: Mach angle ($\cos^{-1}(\sqrt{c_s})$)
τ: Jet deviation from midrapidity

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Expected Correlations in static medium

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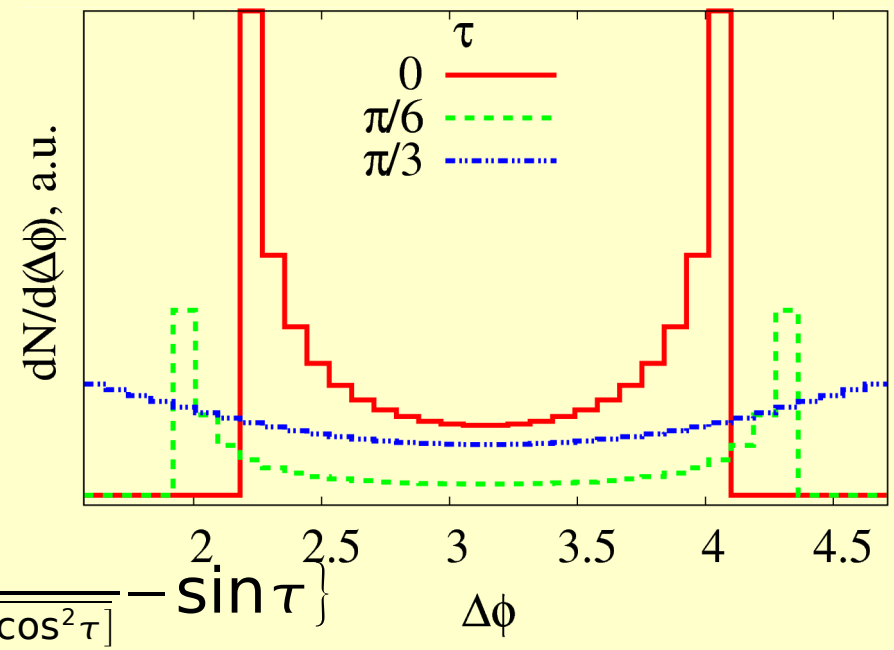

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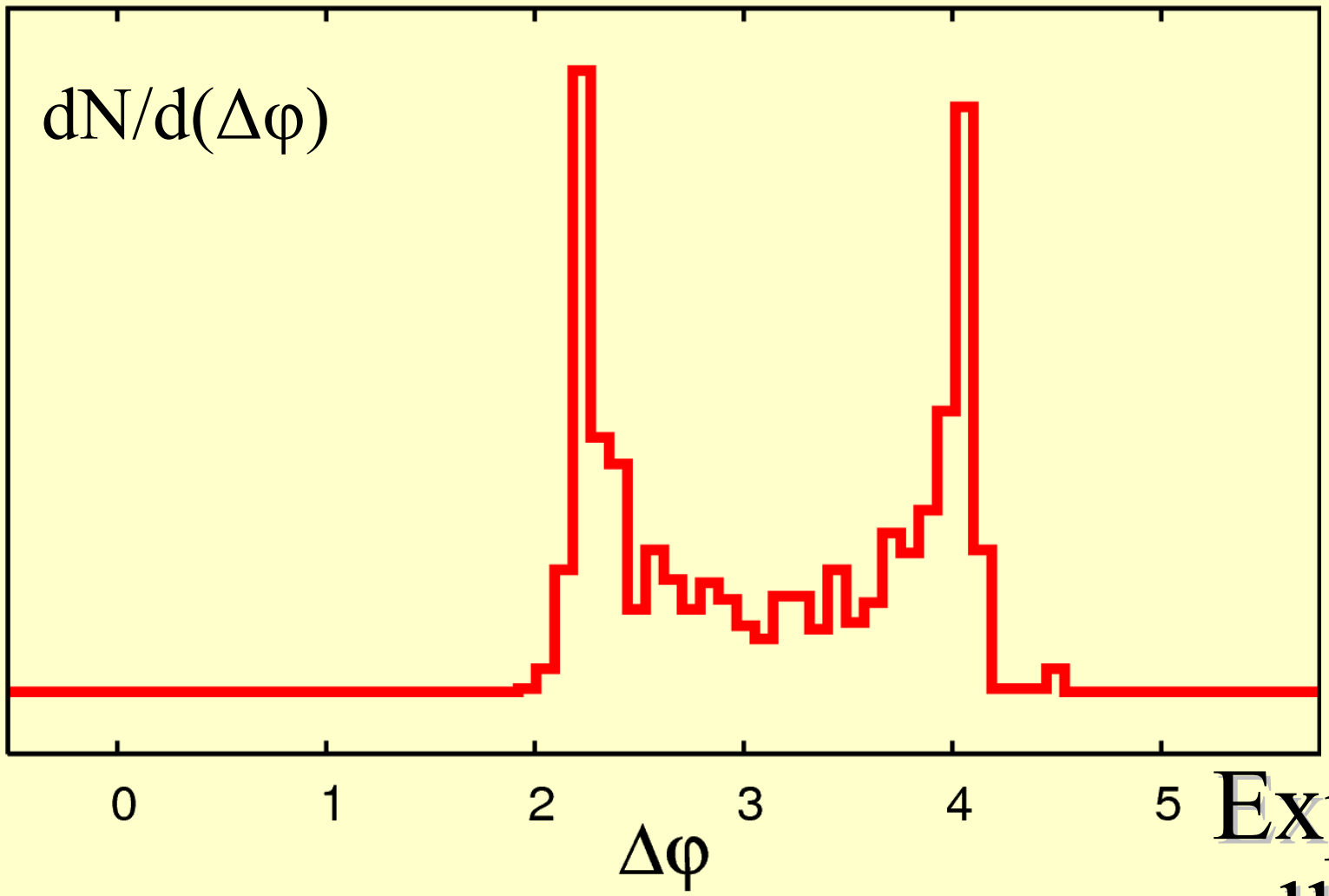
Results

Static medium, midrapidity

Jet in midrapidity

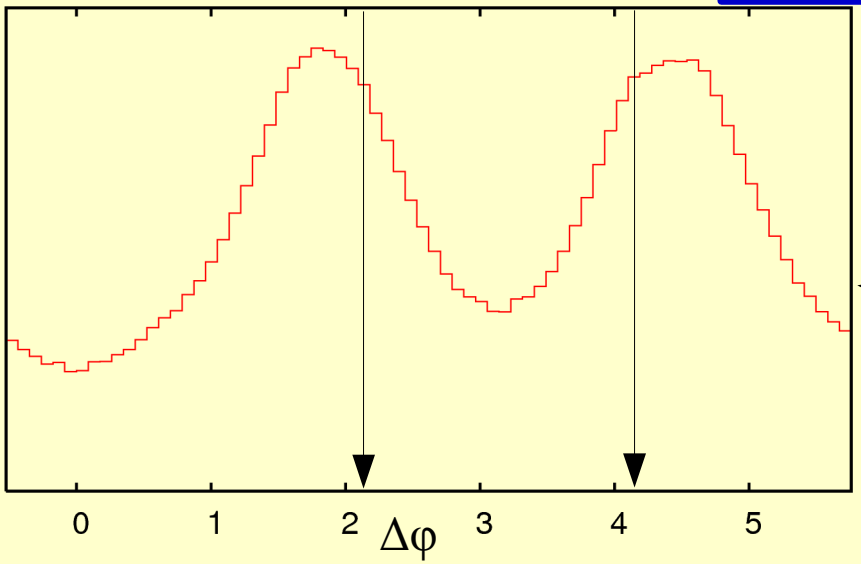


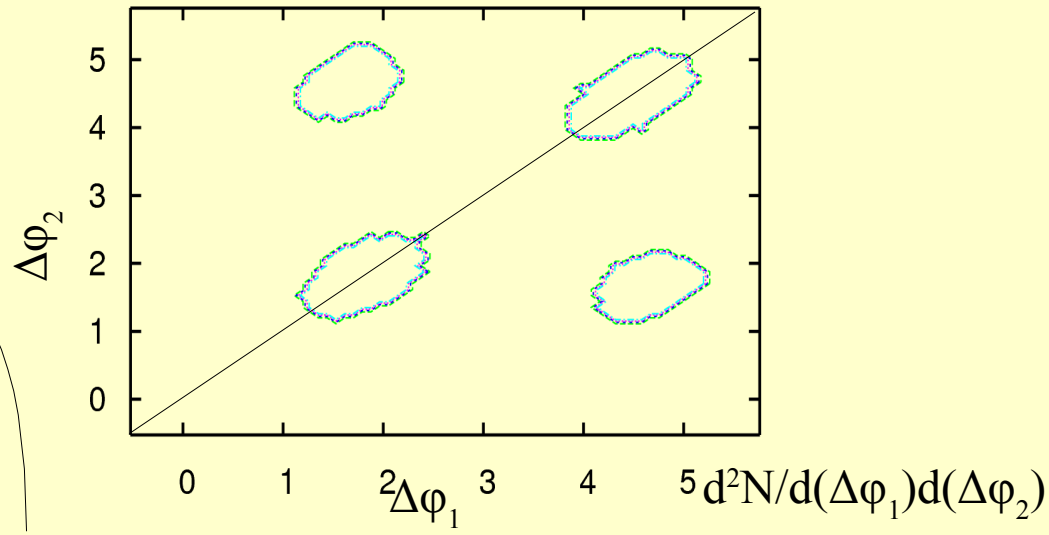
Expectations well matched!

Results

LHC 5.5 ATeV central

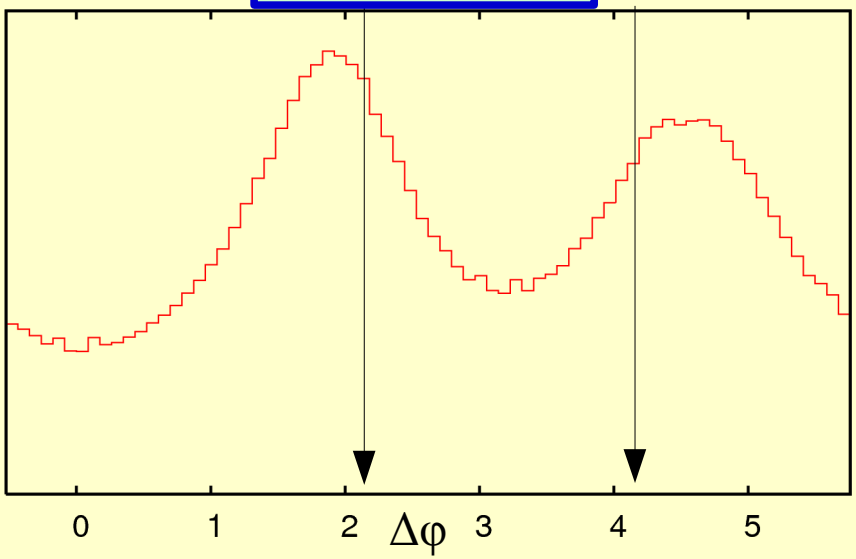
Minimum jet bias



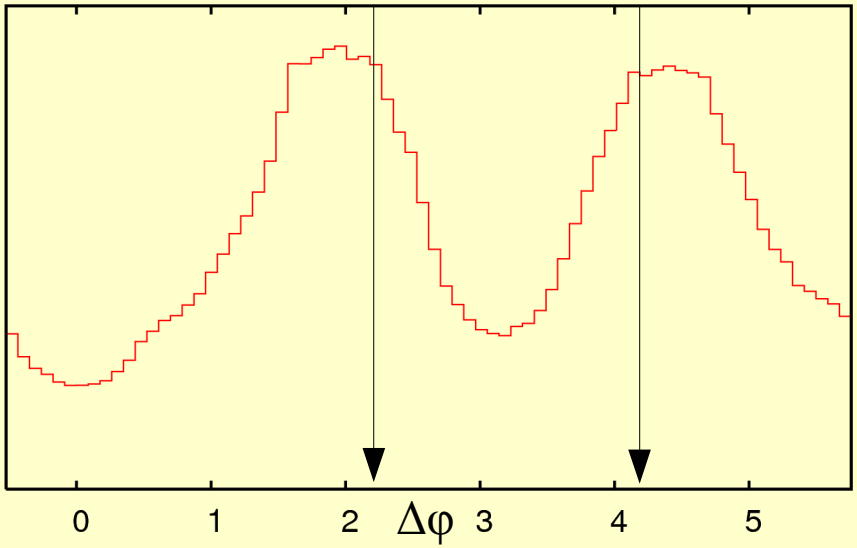


dN/d(Δφ)

Forward jets



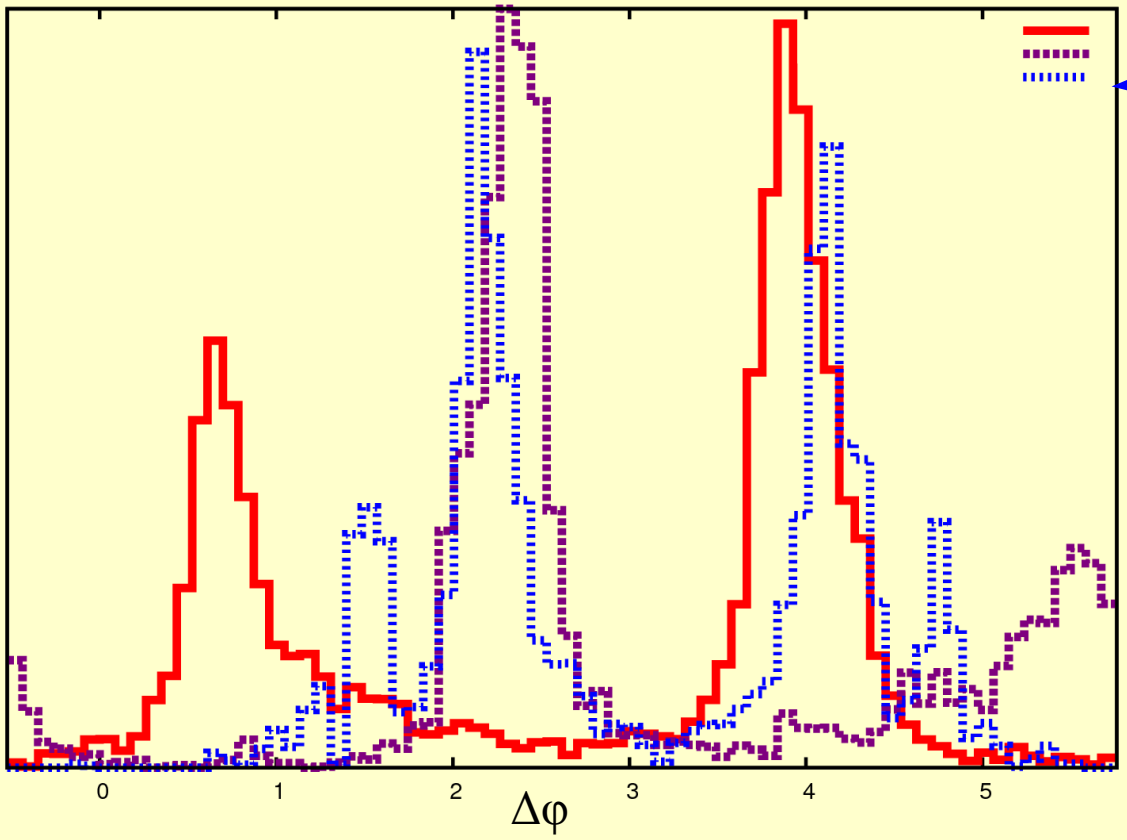
Midrapidity jets

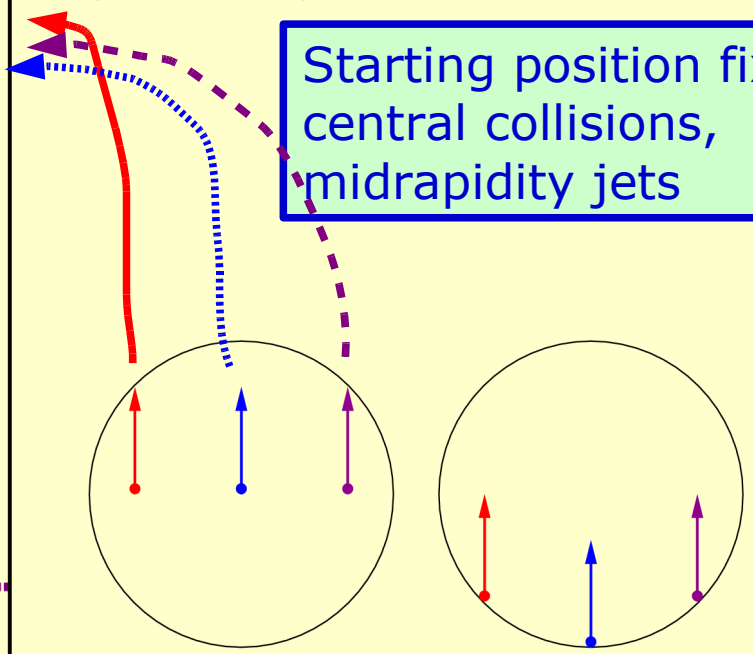


Results

LHC 5.5 ATeV central

- Cones too far apart ($c_s^{2,\ \mathrm{apparent}} \approx 0.17$)
- Reason: no constraints on origin of jet.





Starting position fixed; central collisions, midrapidity jets

My startpoints

Chaudhuris startpoints

- With centrally started jets, the ”real“ speed of sound can be seen.

Conclusions

- Mach cones can be modelled by MACE superimposed to a Hydro(?) velocity field
- No need for jet quenching estimates etc.
- Correlations show systematically lower sound velocities than used
- Only in event-by-event analysis true speed of sound may be revealed
  - look out for symmetric correlation events!

Thank you very much

for your attention