

Kinematic signatures of secular evolution

Francesca Iannuzzi

Context

P.I. **Johan Knapen**, IAC

Other node leaders:

Athanassoula, LAM - **Gil de Paz**, UCM

Salo, Uni Oulu - **Schinnerer**, MPIA

Verheijen, Uni Groningen



DETAILED
ANATOMY OF
GALAXIES



Aim

Continue the **S4G** effort in studying the properties of nearby galaxies

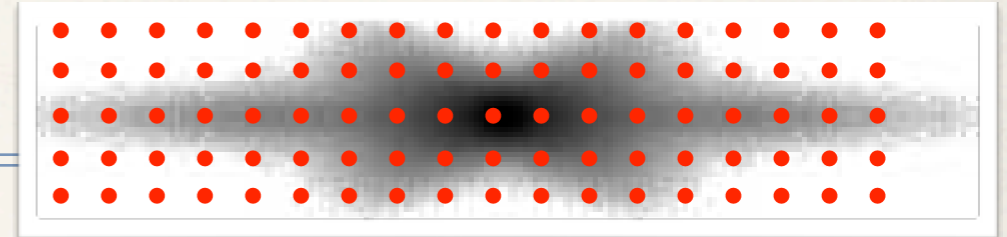


Marseille node



Input from simulations, especially as far as secular evolution is concerned

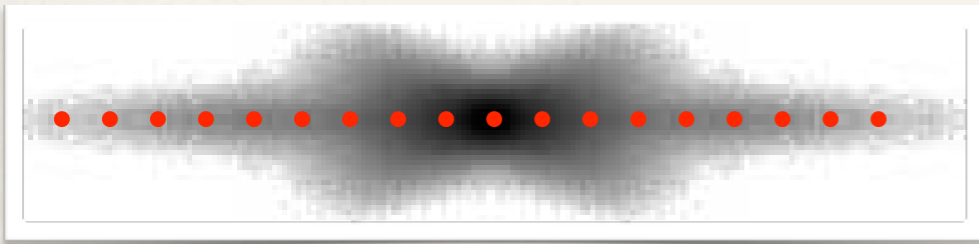
Purpose



Study the signatures of bar & peanut bulges on 2D kinematic maps



Bar and peanut diagnostics from 1D kinematics:



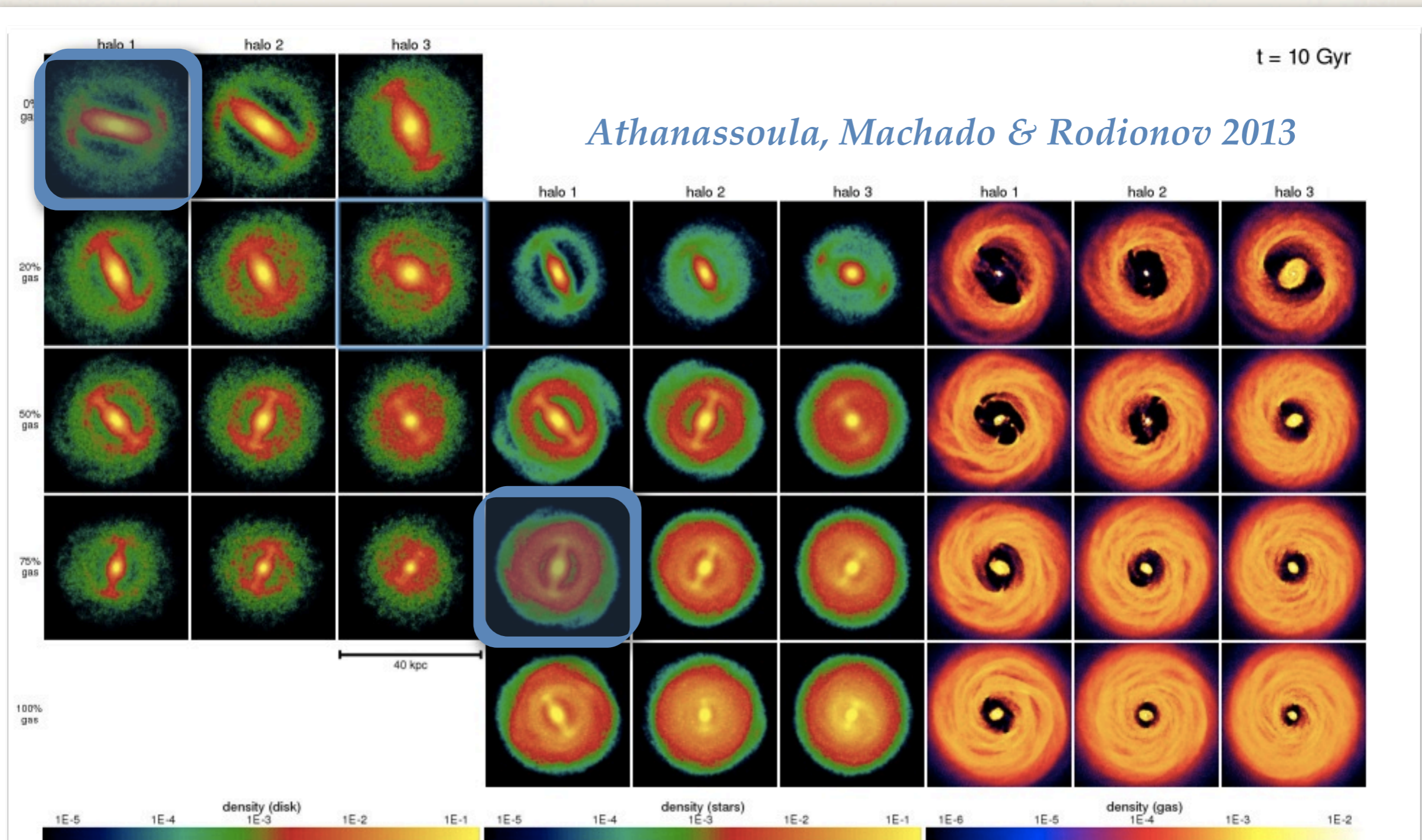
Chung & Bureau 2004 (observations)

Bureau & Athanassoula 2005 (simulations)

Their conclusion being:

- ❖ $V-h3$ correlation is the most telling feature
- ❖ Bar strength and position angle are degenerate quantities

Method I - Simulations



Method II - Kinematic maps

- ❖ Constructed with:

- ♦ Michele Cappellari's Voronoi-binning technique

Cappellari & Copin 2003

- ♦ A customised version of Jonathan Brown's routine

Brown, Valluri, Shen & Debattista 2013

Initial focus

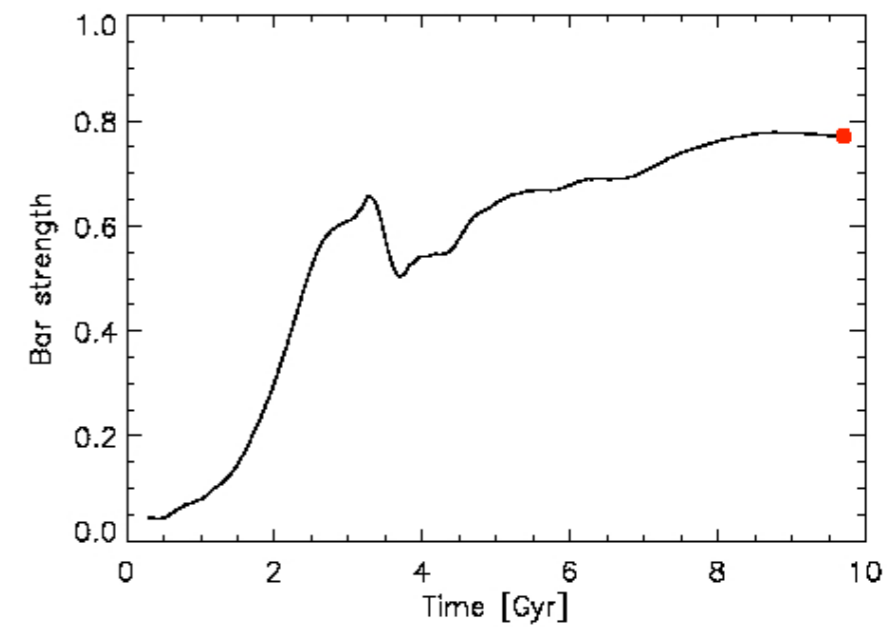
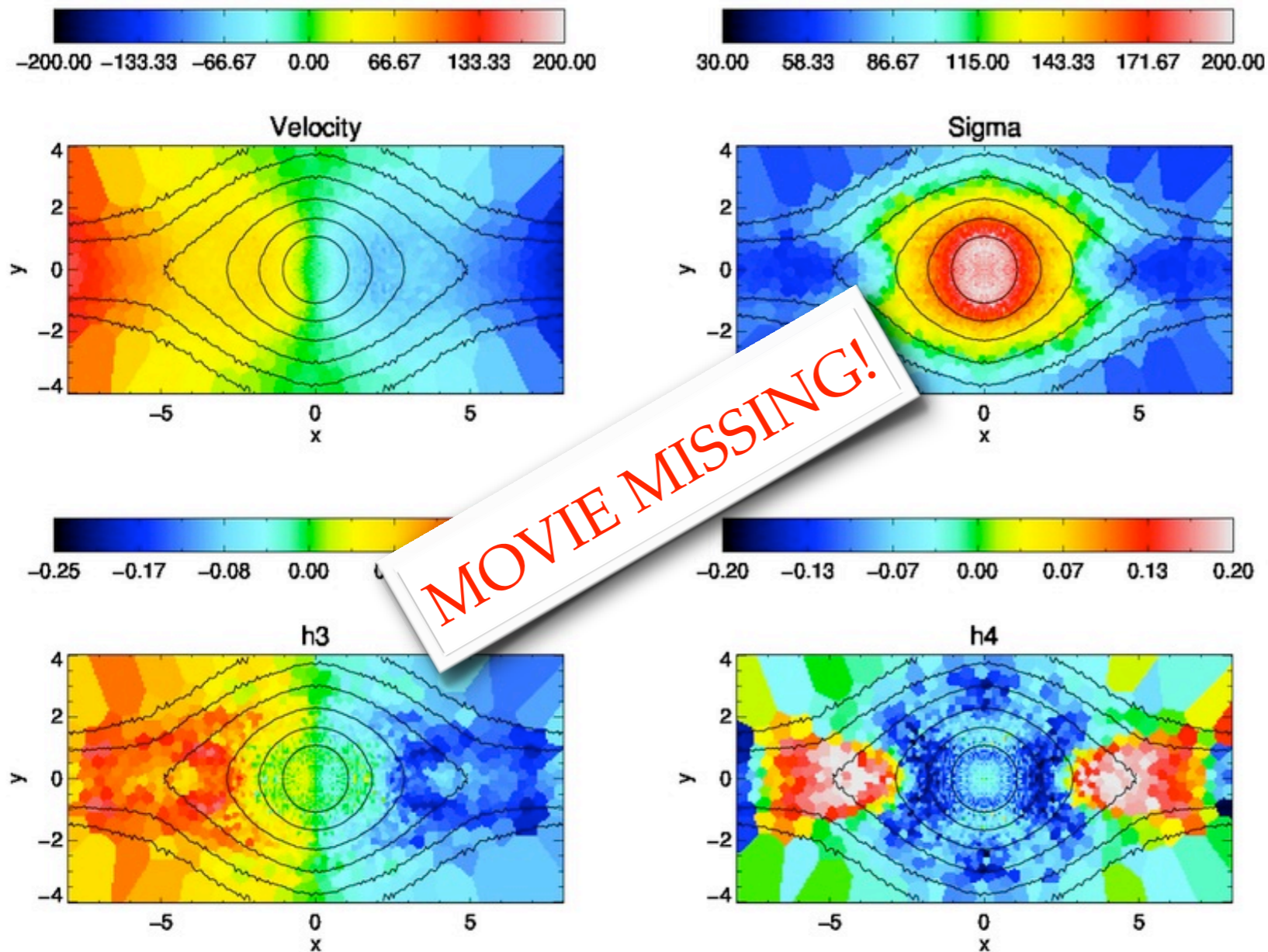
- ❖ Edge-on galaxies:
 - ◆ end-on case - peanut diagnostics
 - ◆ finding the position angle of the peanut
 - ◆ signatures of different stellar populations

Initial focus

- ❖ Edge-on galaxies:
 - ♦ **end-on case - peanut diagnostics**
 - ♦ finding the position angle of the peanut
 - ♦ signatures of different stellar populations

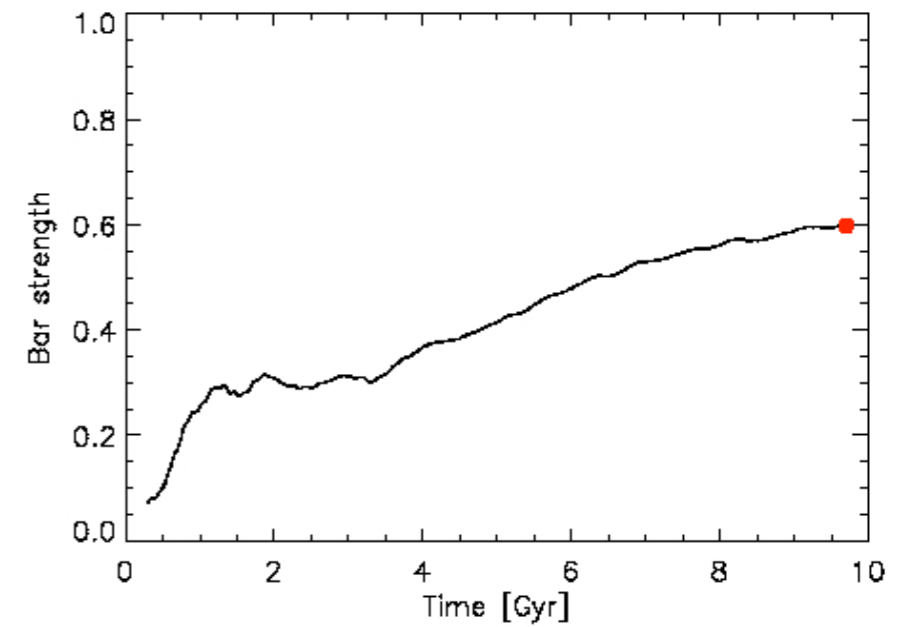
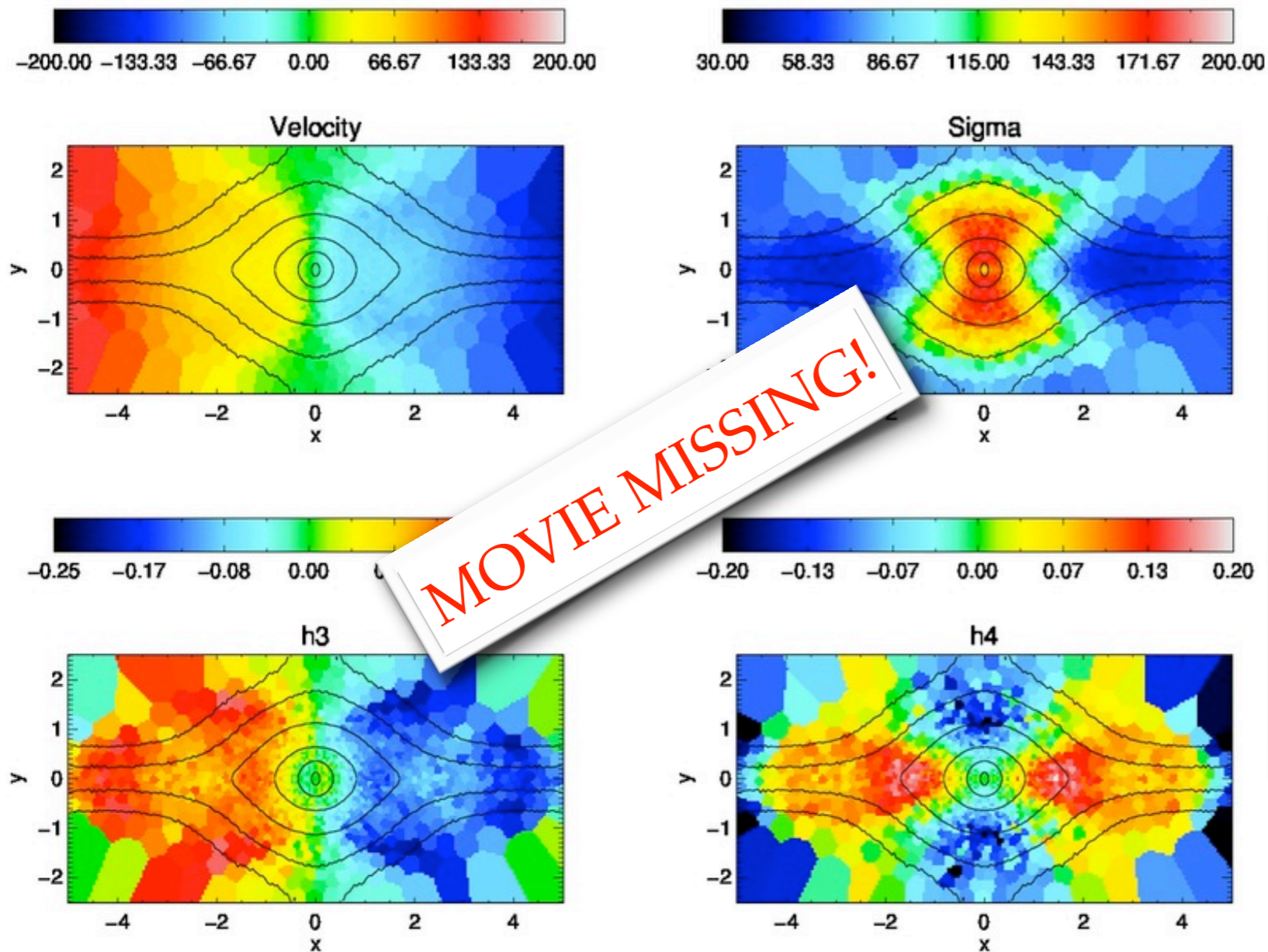
Peanut diagnostic

Simulation without gas - Strong bar / peanut



Peanut diagnostic

Simulation with gas - Moderate bar / peanut



Peanut diagnostic

- ❖ $h3/h4$ maps have potentially interesting features
- ❖ No evidence of similar features in simulations with classical bulge

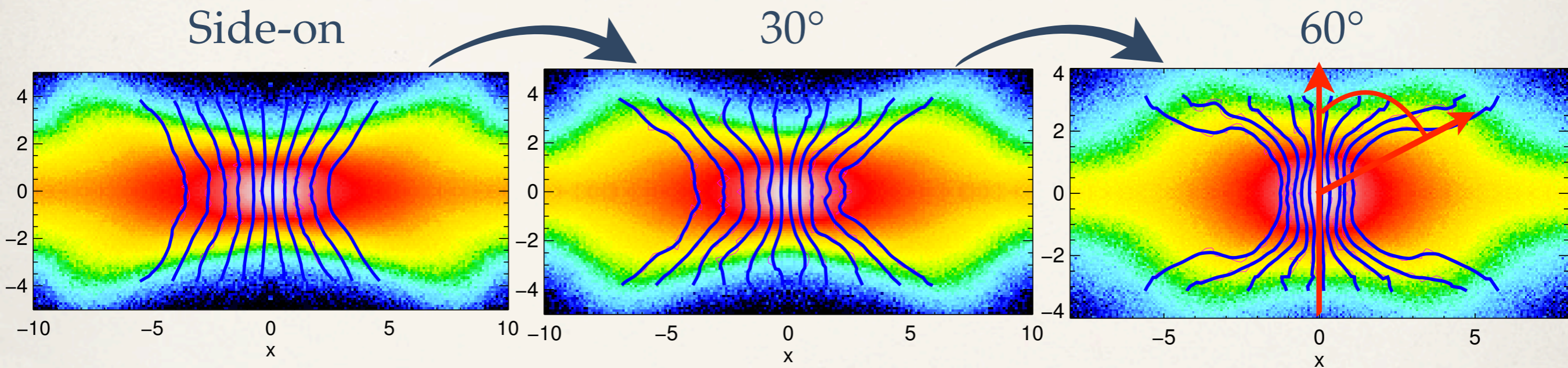
==== Next steps =====

- ❖ Check variations with bar strength and evolutionary history
- ❖ Systematic comparison with morphologically similar, peanut-less cases

Initial focus

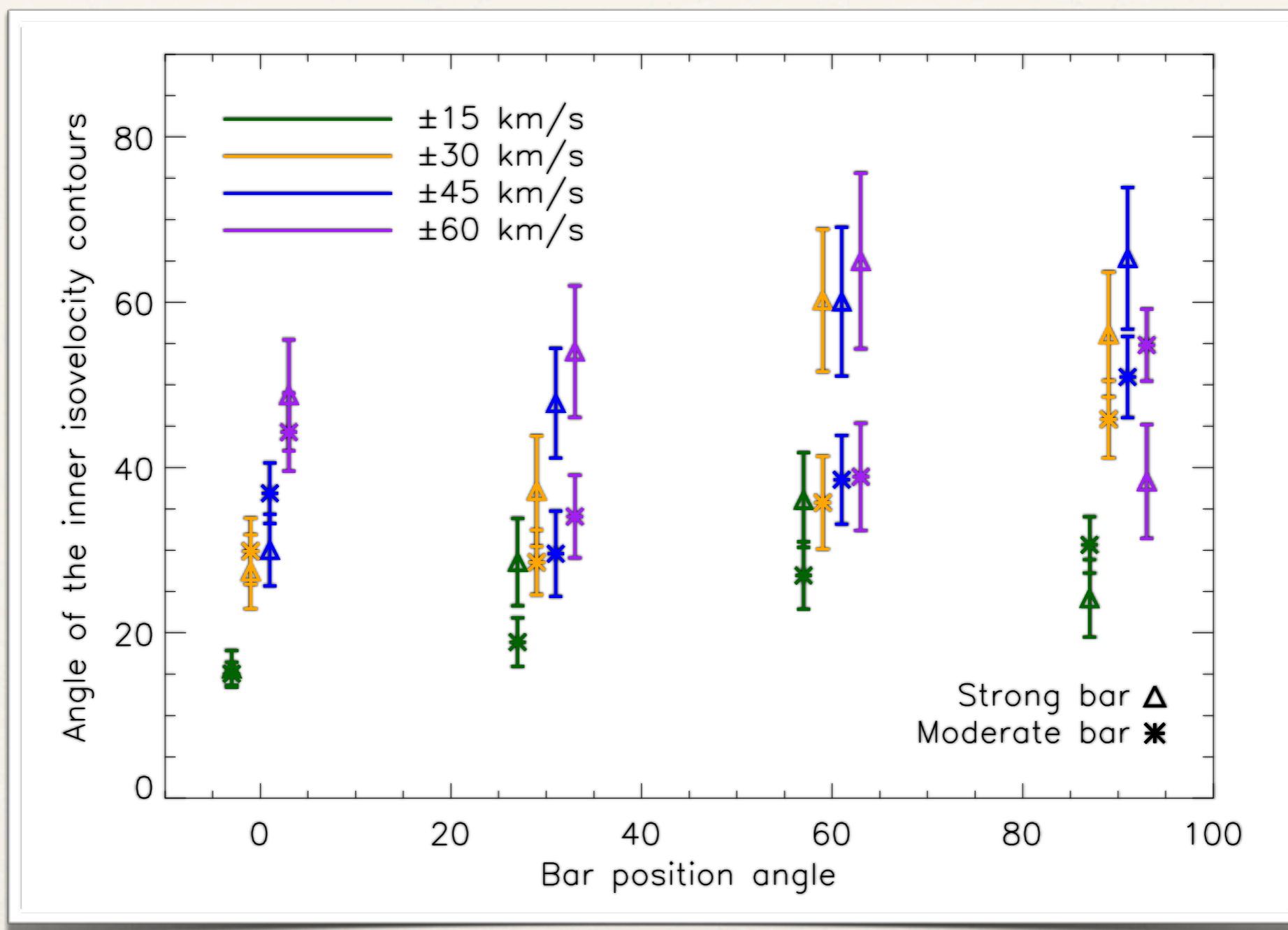
- ❖ Edge-on galaxies:
 - ♦ end-on case - peanut diagnostics
 - ♦ **finding the position angle of the peanut**
 - ♦ signatures of different stellar populations

Position angle I: iso- v_{los} contours



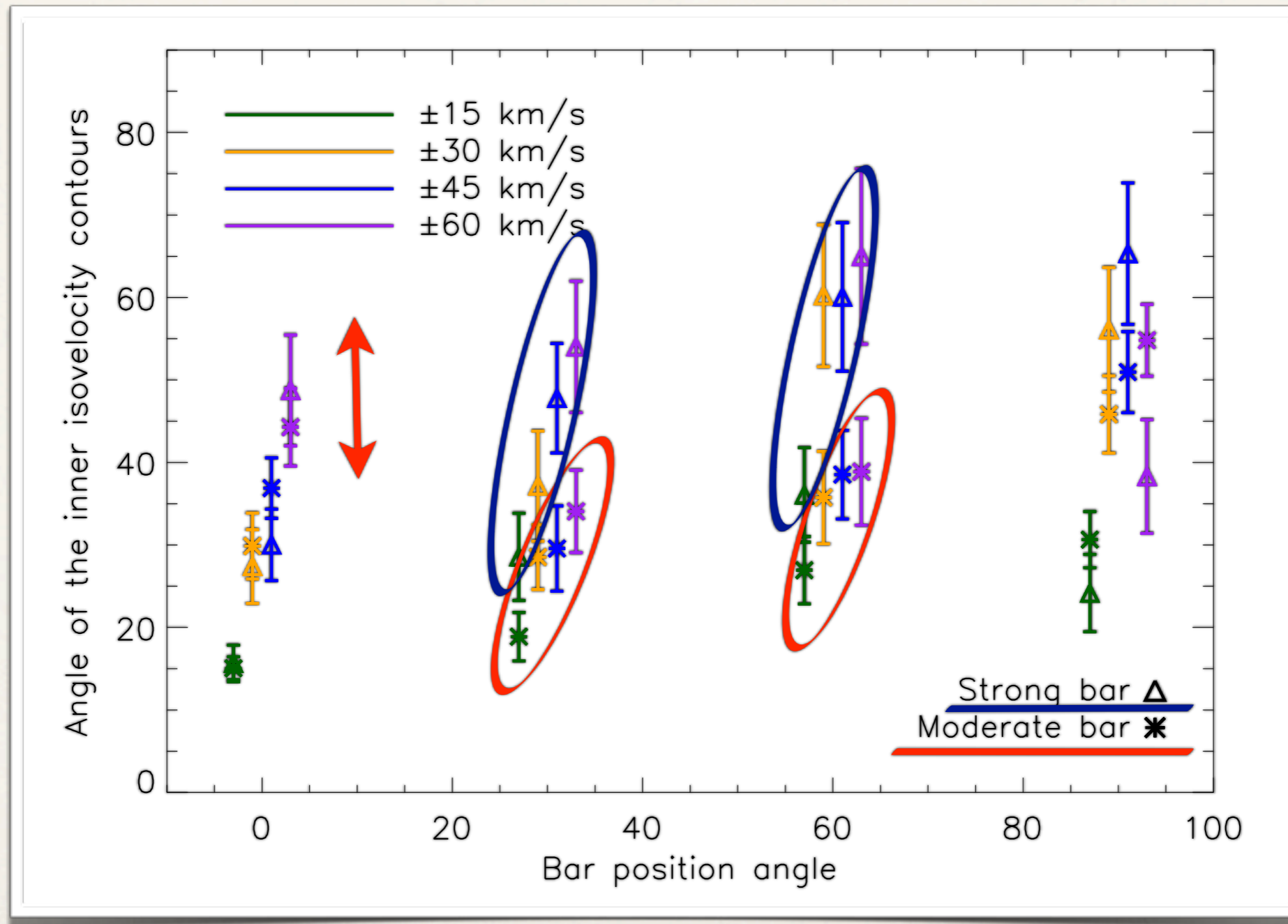
Could the opening of the inner contours point to the bar / peanut position angle?

Position angle I: iso- v_{los} contours



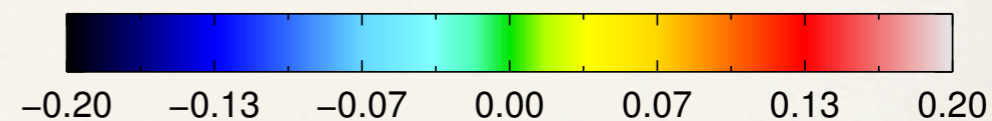
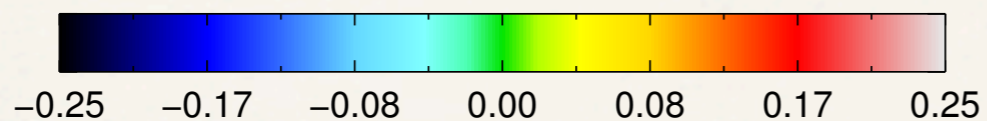
Not too conclusive, for the moment

Position angle I: iso- $v_{l_{os}}$ contours

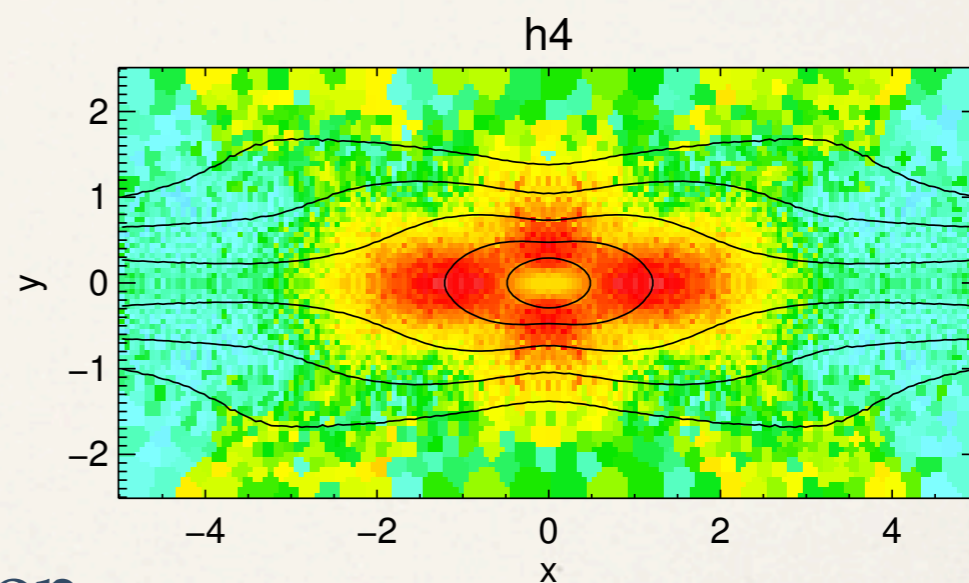
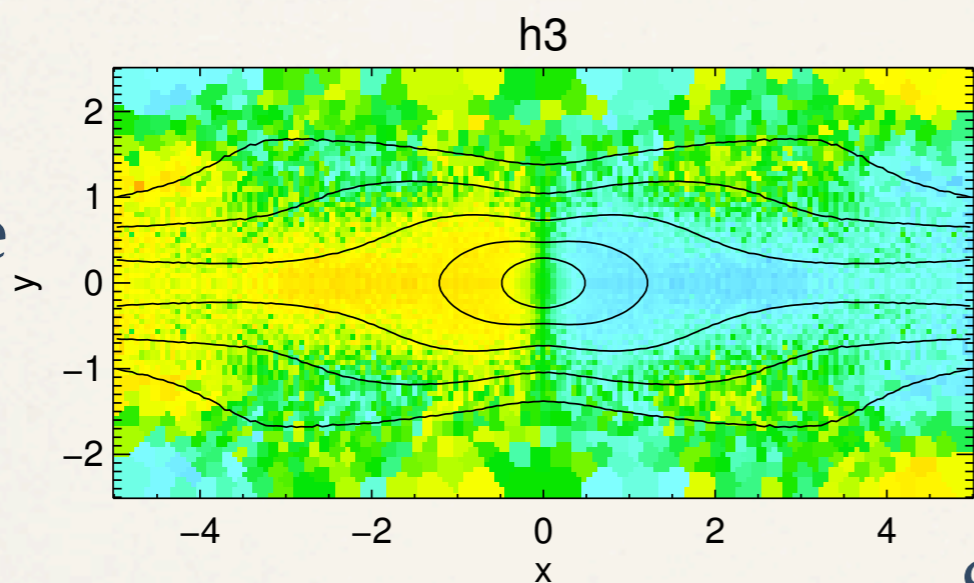


Not too conclusive, for the moment

Position angle II: h3/h4 maps

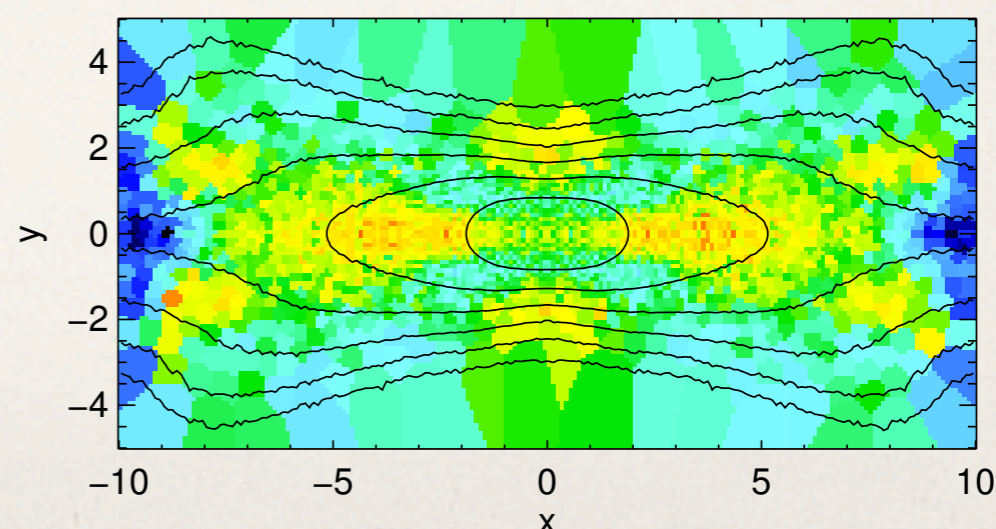
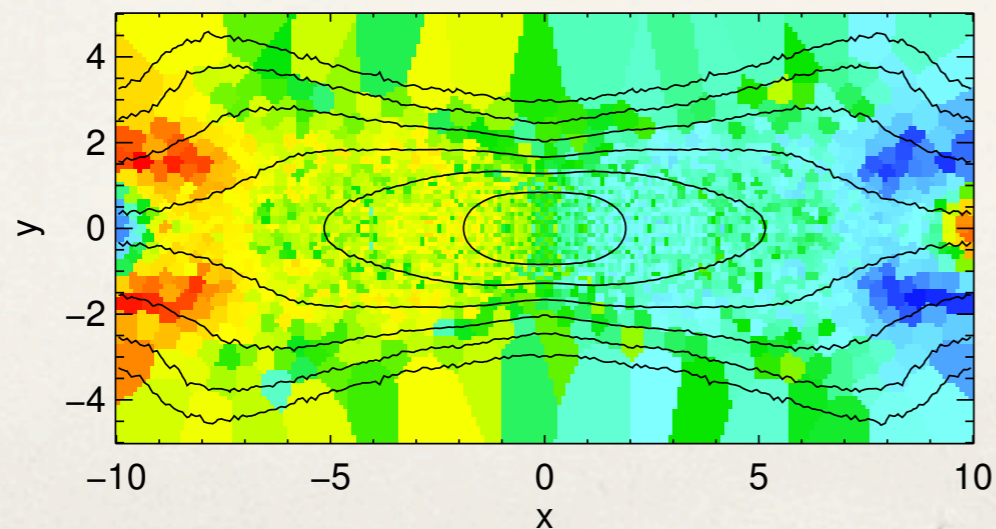


Moderate
bar/P

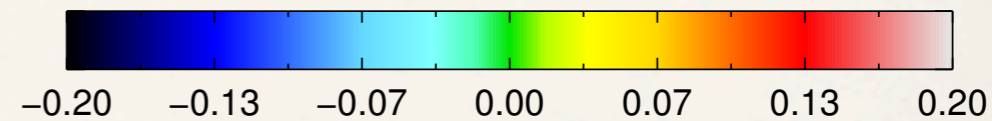
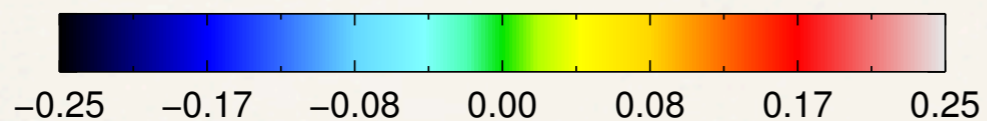


Side-on

Strong
bar/P



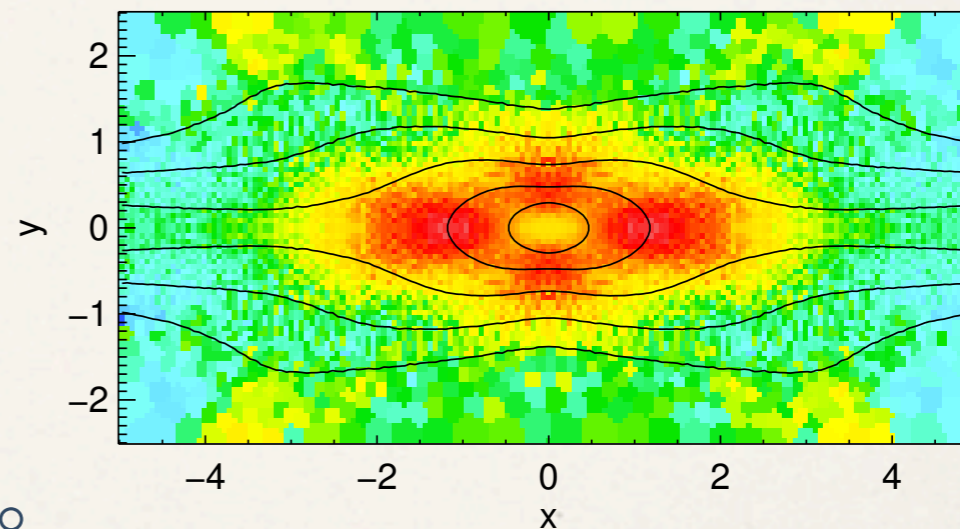
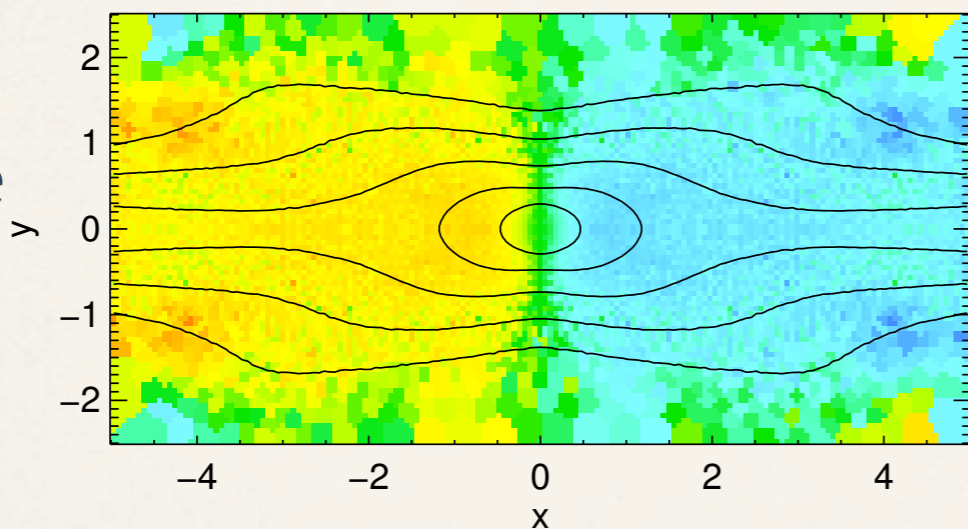
Position angle II: h3/h4 maps



h3

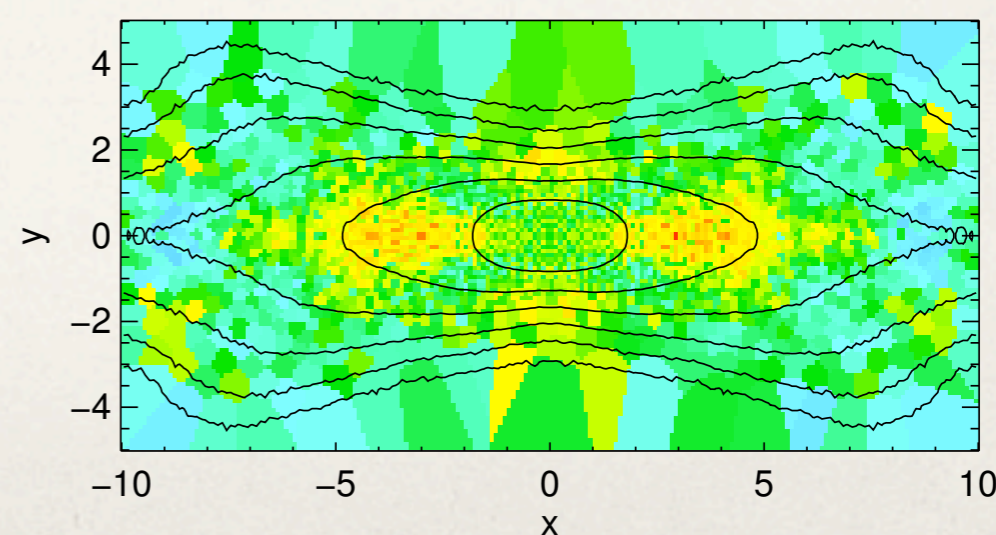
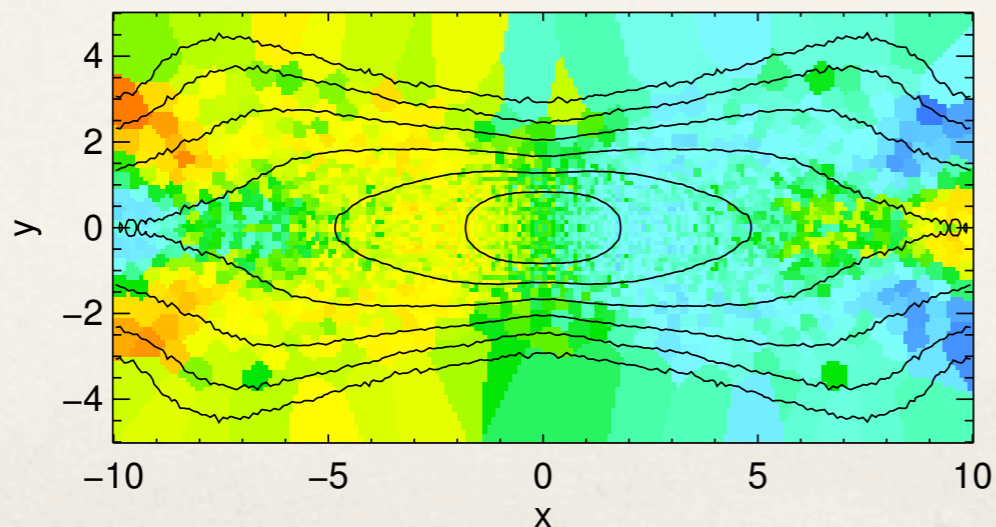
h4

Moderate
bar/P

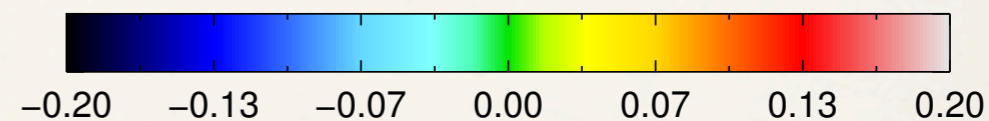
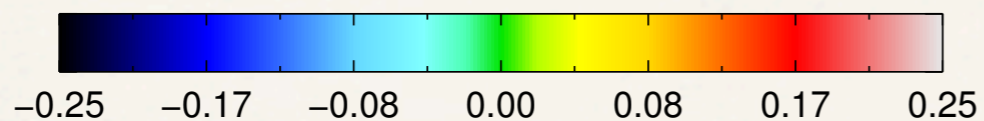


15°

Strong
bar/P

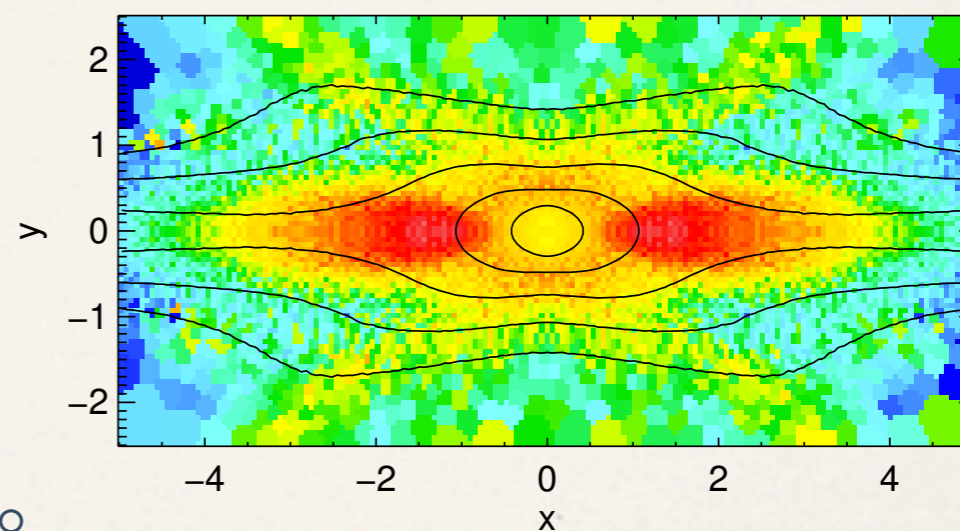
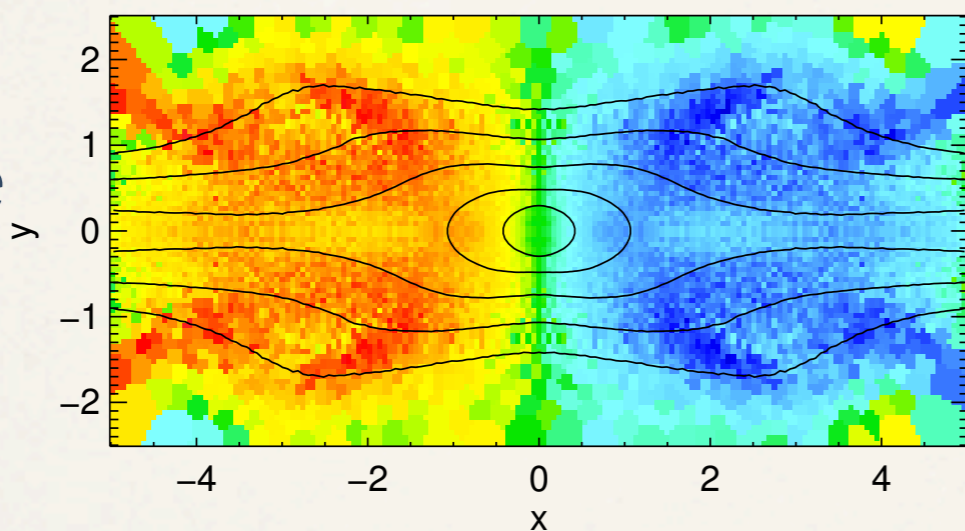


Position angle II: h3/h4 maps



h3

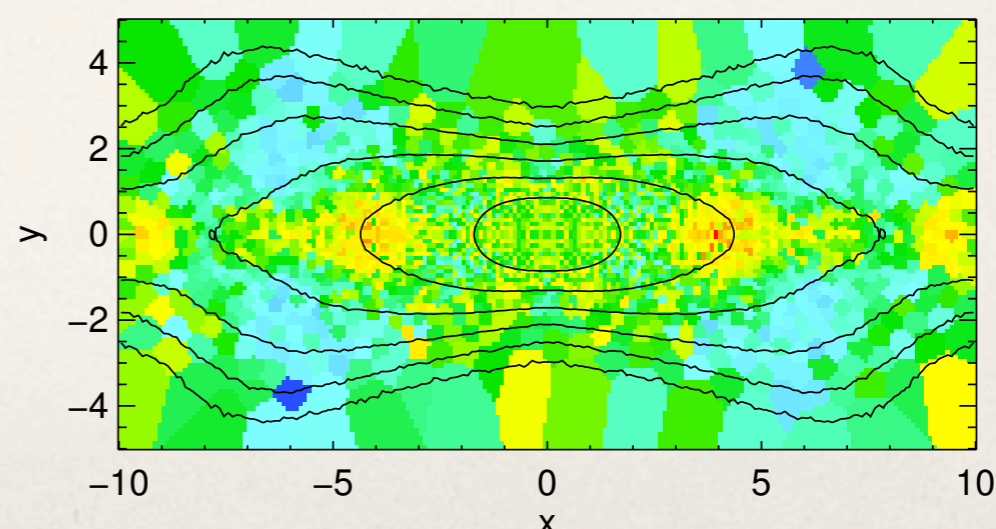
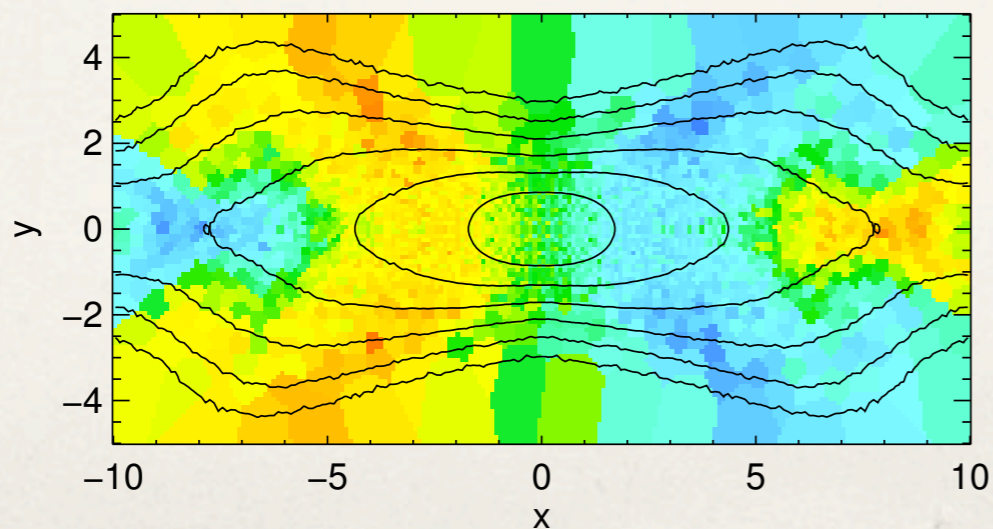
h4



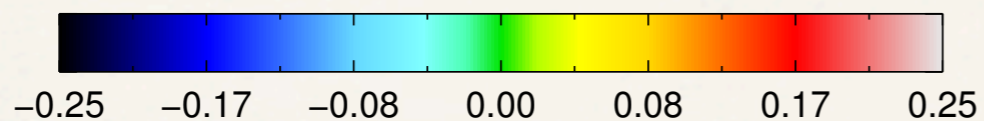
Moderate
bar/P

30°

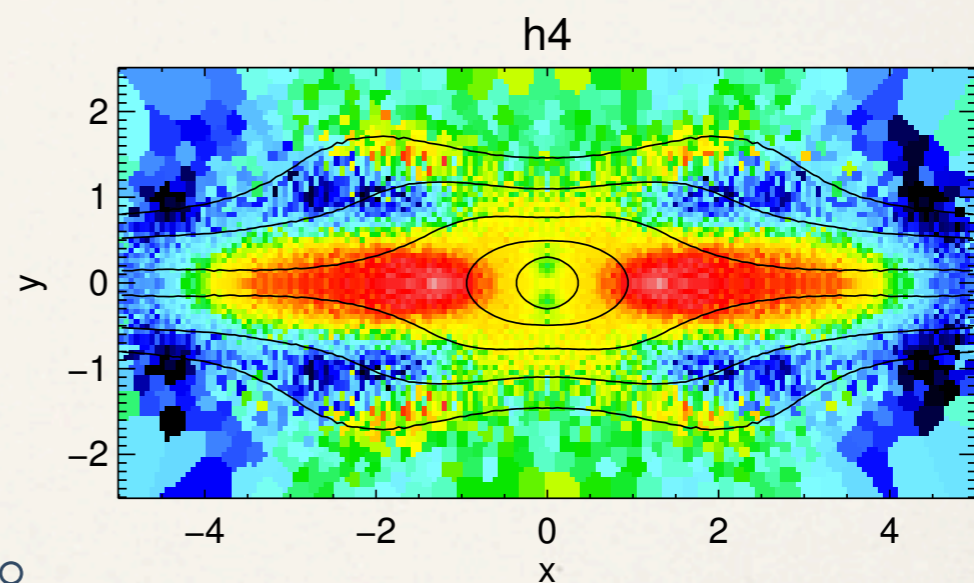
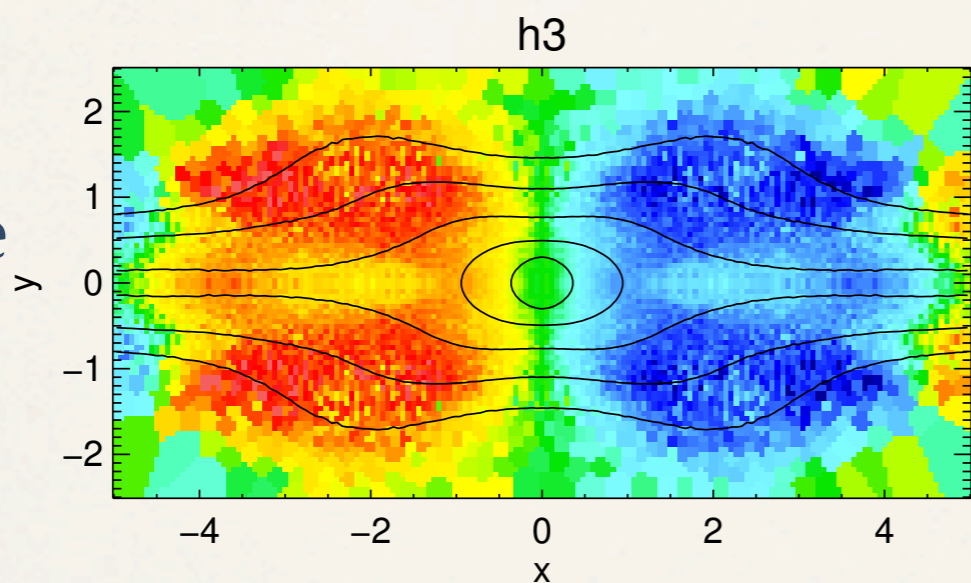
Strong
bar/P



Position angle II: h3/h4 maps

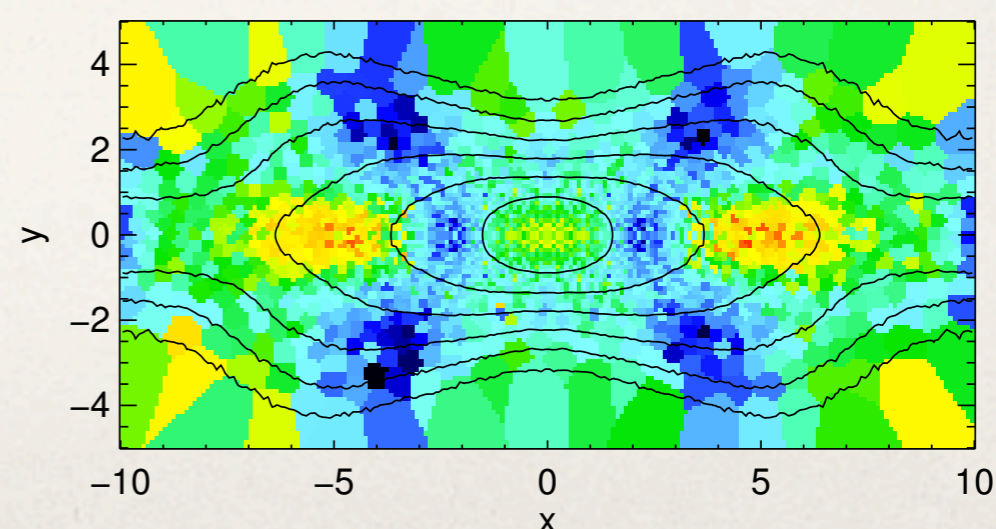
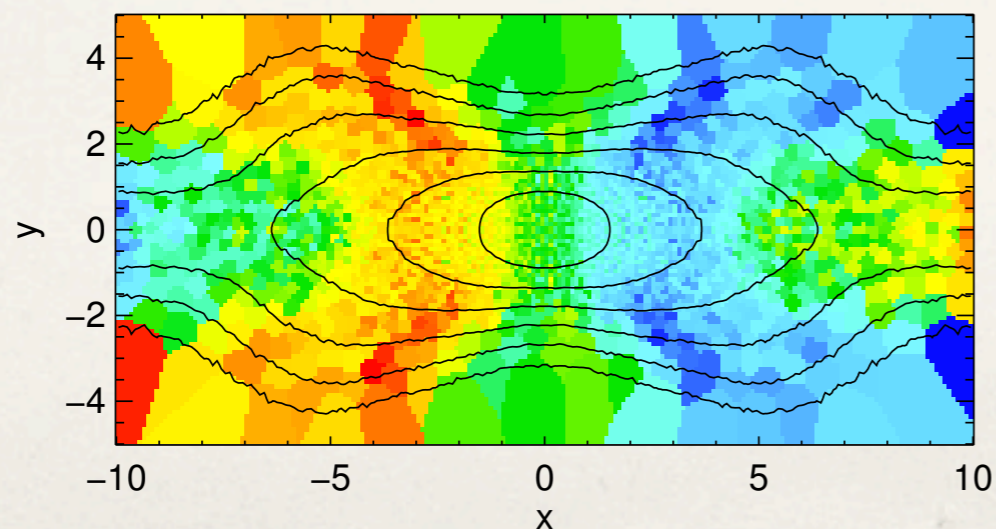


Moderate
bar/P



45°

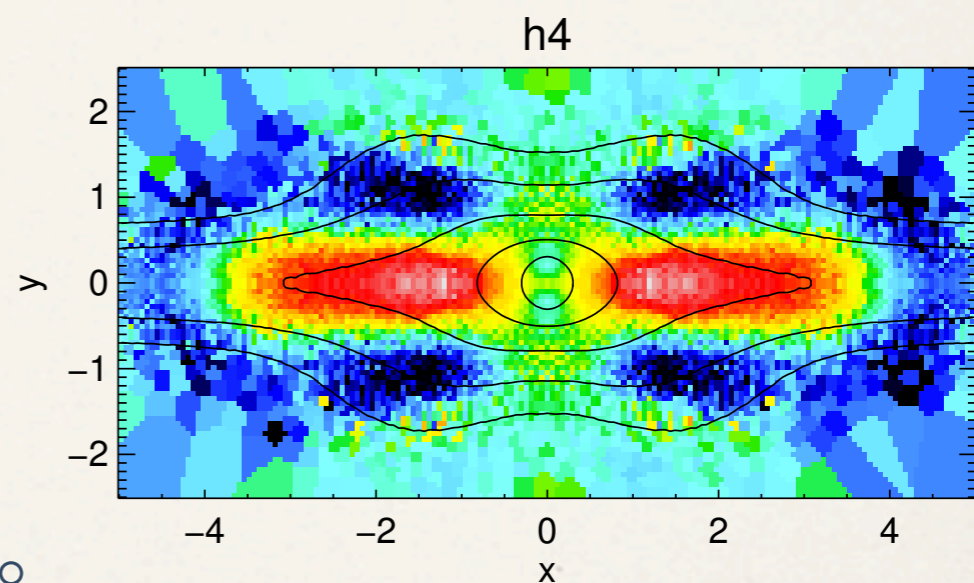
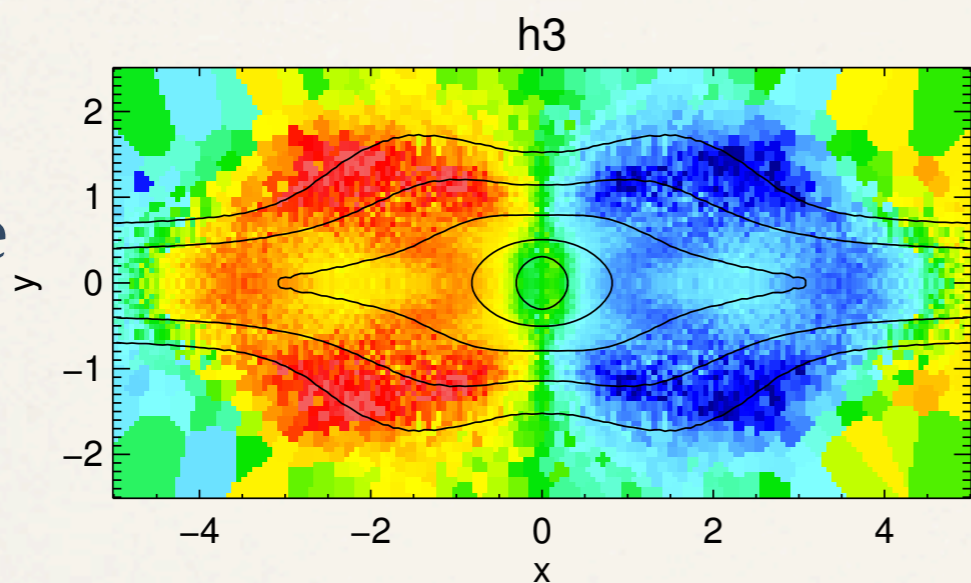
Strong
bar/P



Position angle II: h3/h4 maps

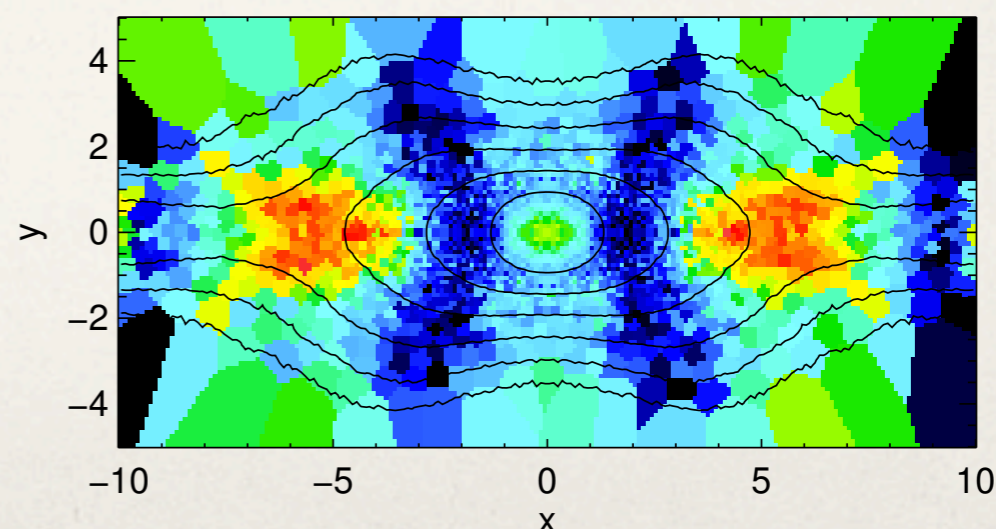
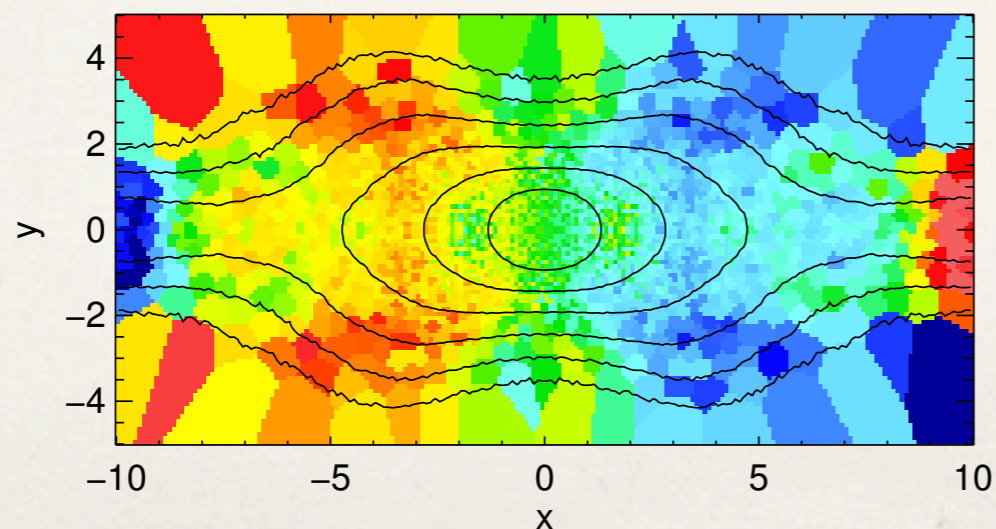


Moderate
bar/P

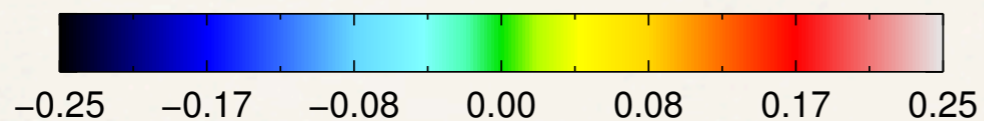


60°

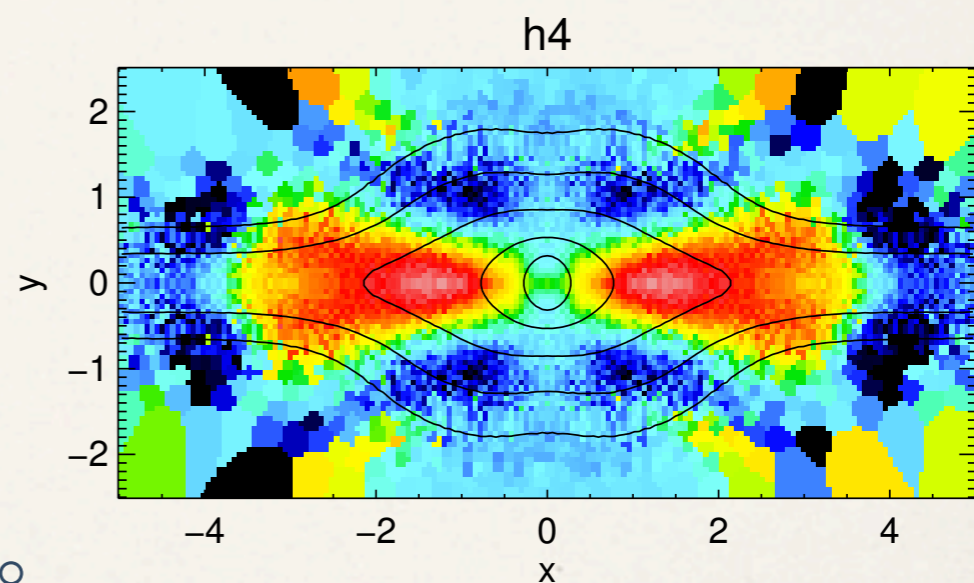
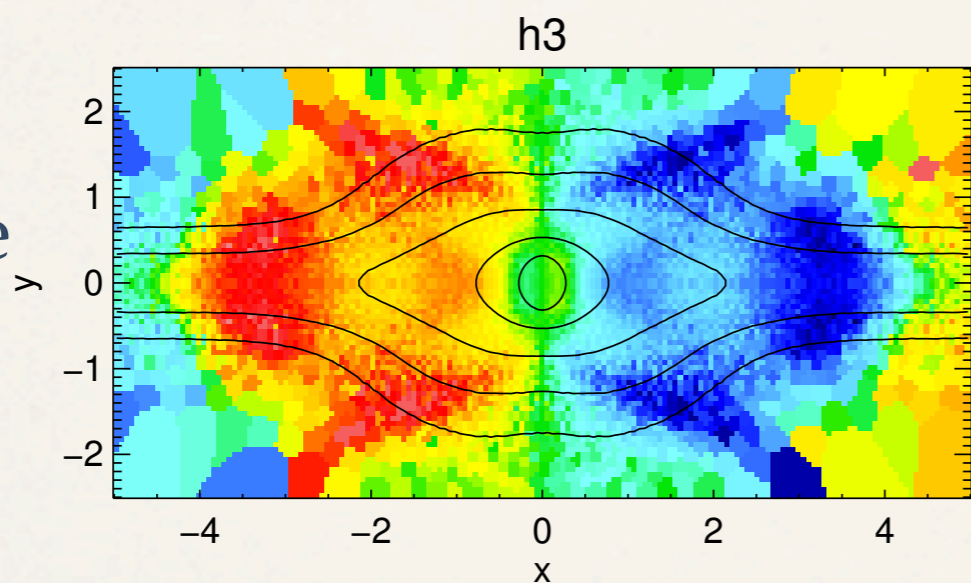
Strong
bar/P



Position angle II: h3/h4 maps

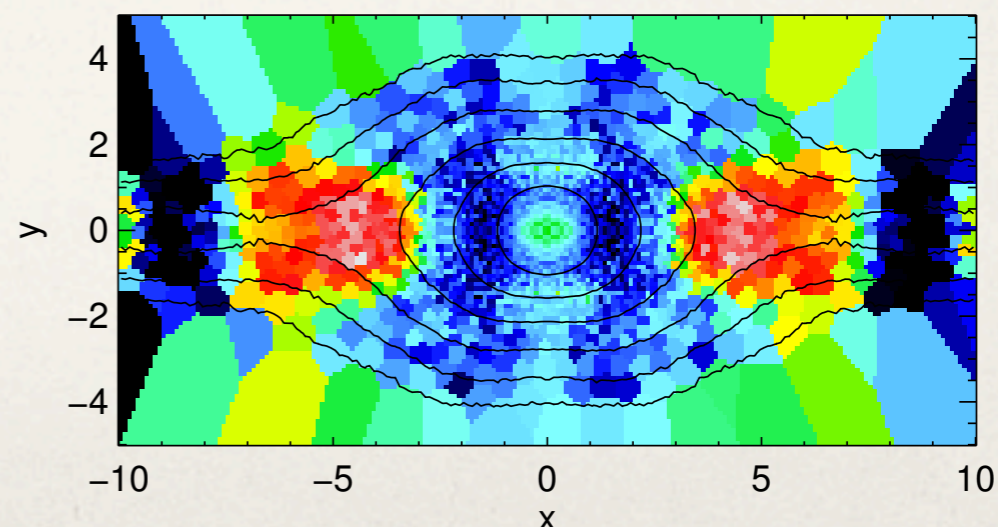
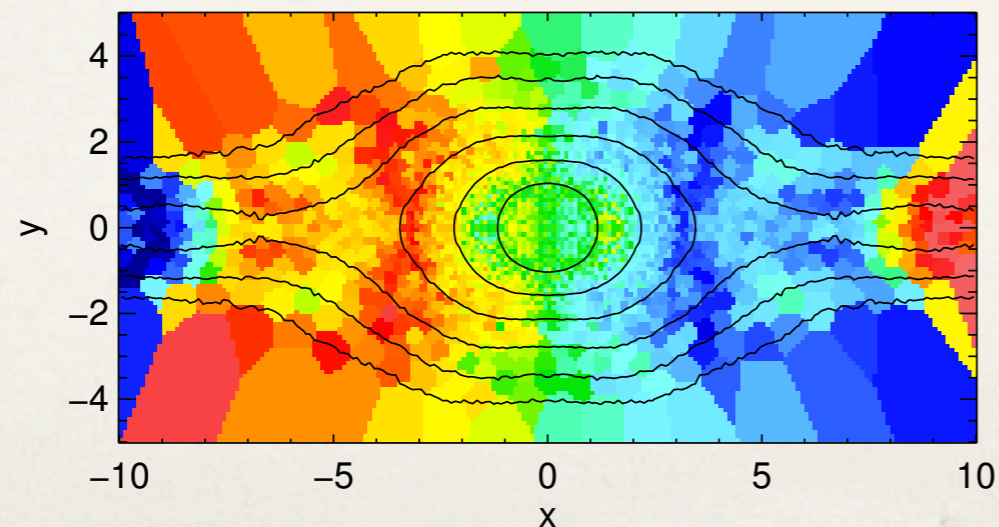


Moderate
bar/P



75°

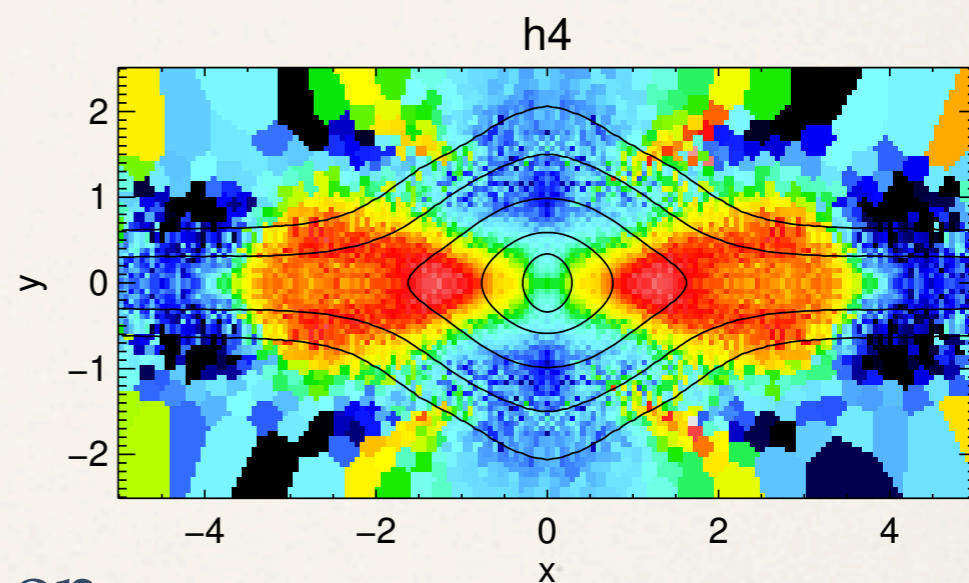
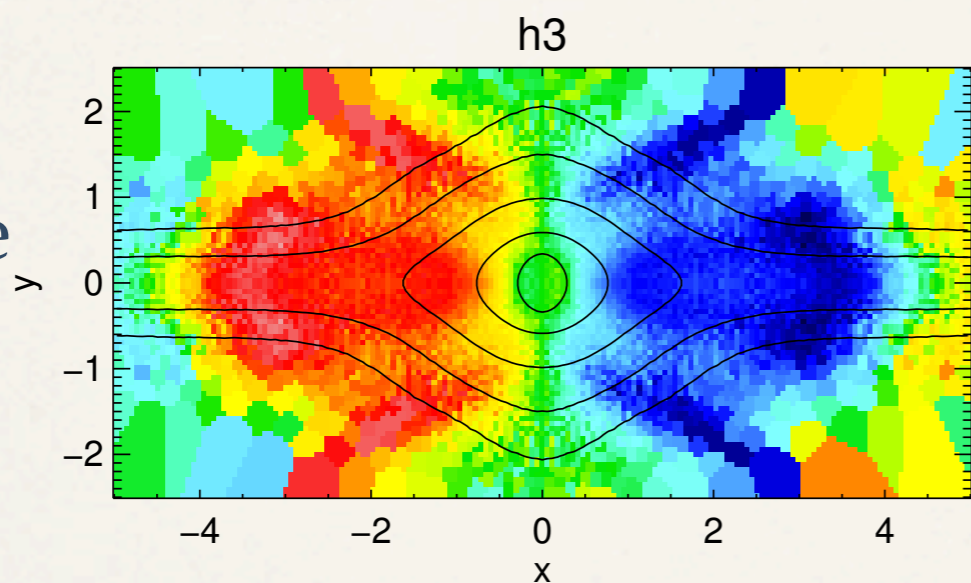
Strong
bar/P



Position angle II: h3/h4 maps

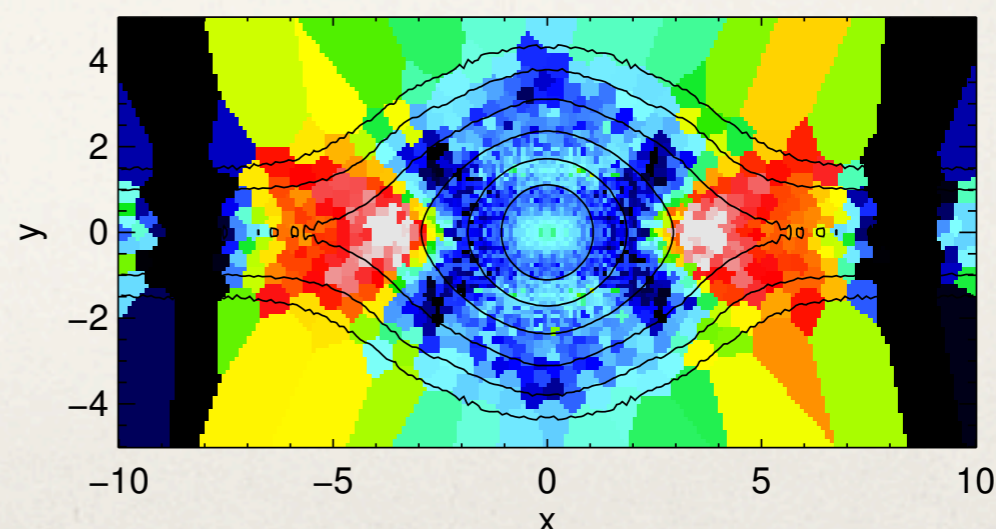
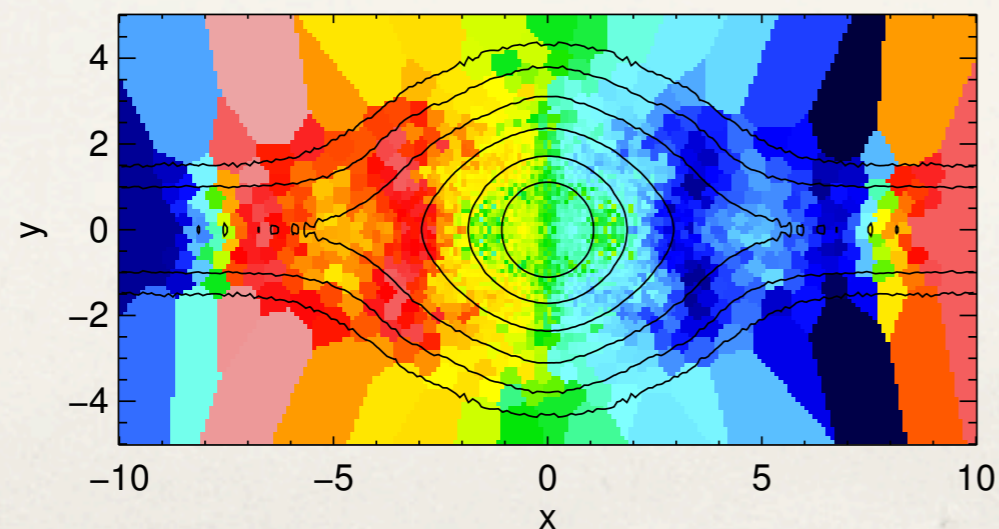


Moderate
bar/P



End-on

Strong
bar/P



Position angle

- ❖ Possibly some hints from the iso-velocity contours, but there exist some degeneracy with the strength of the bar / peanut
- ❖ Morphology and magnitude of h_3 / h_4 vary with position angle, with possibly a smaller dependence on the strength of the bar / peanut

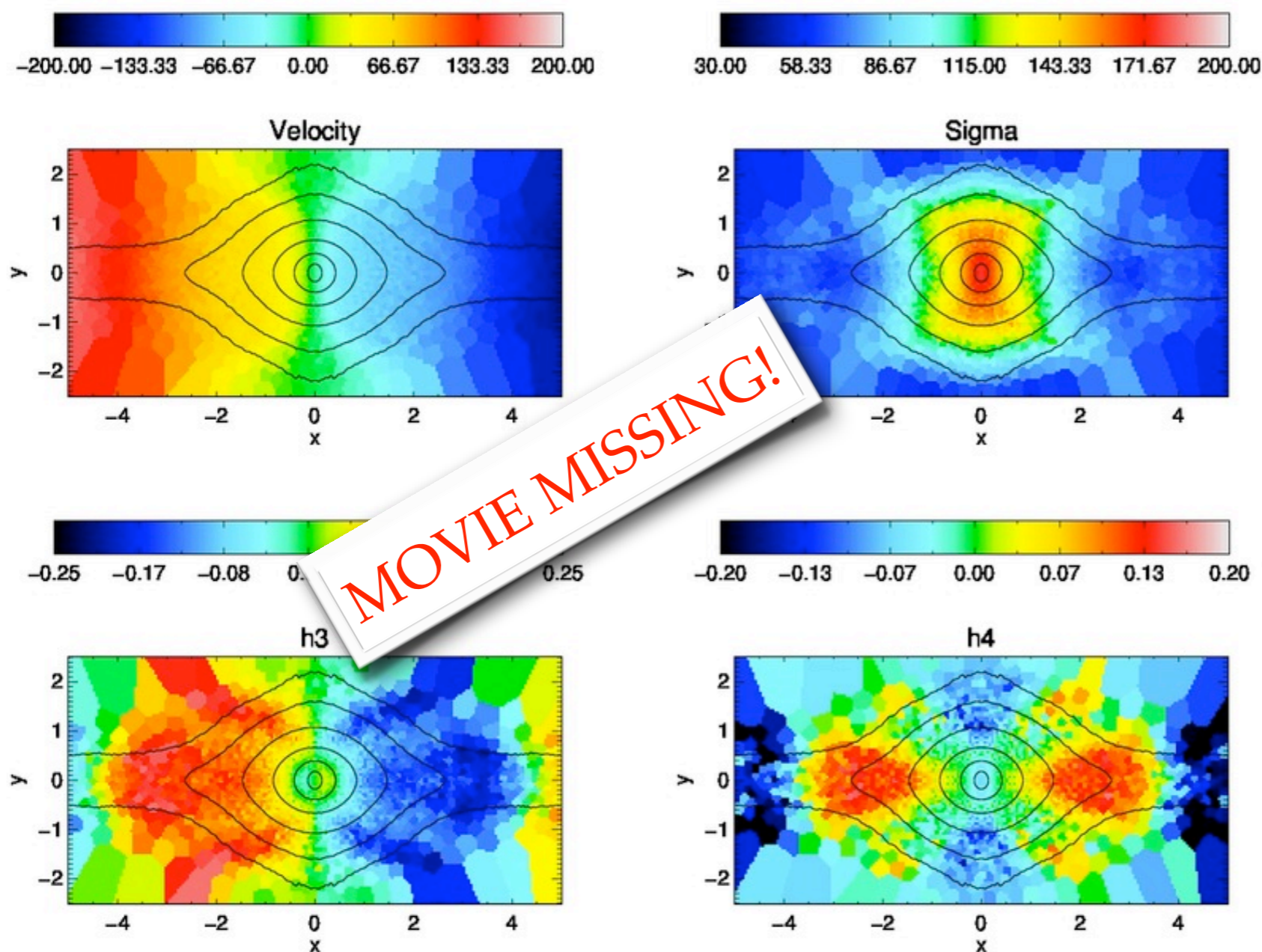
==== Next steps =====

- ❖ Make this quantitative: extract the position angle from the map
 - ◆ study the dependence on the strength of the bar / peanut
 - ◆ study the variations induced by different stellar components

Initial focus

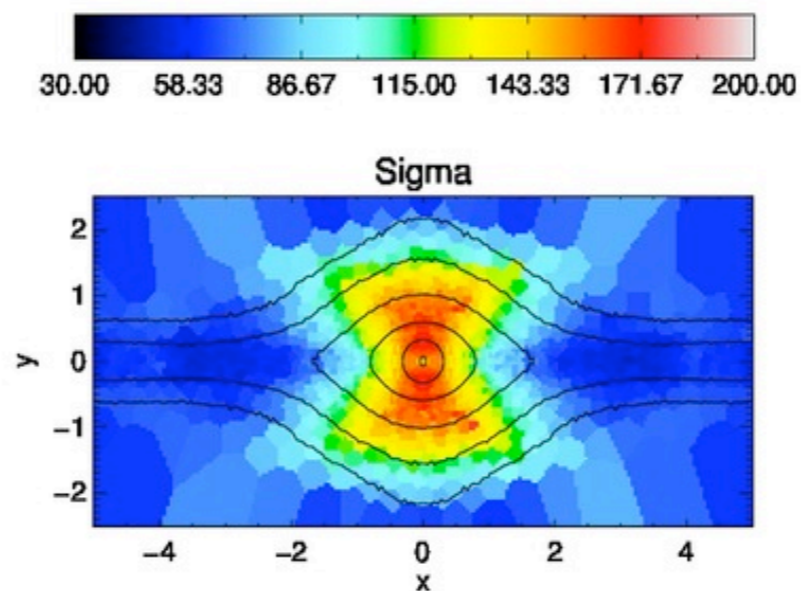
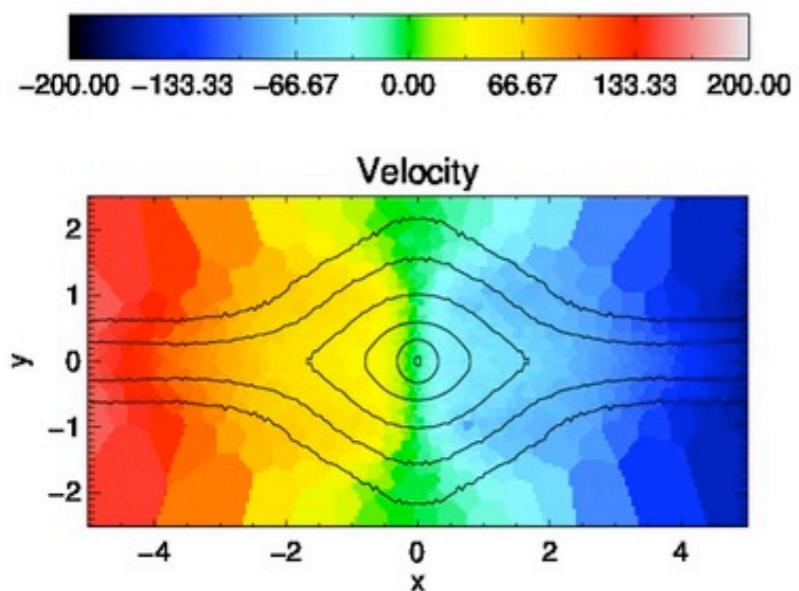
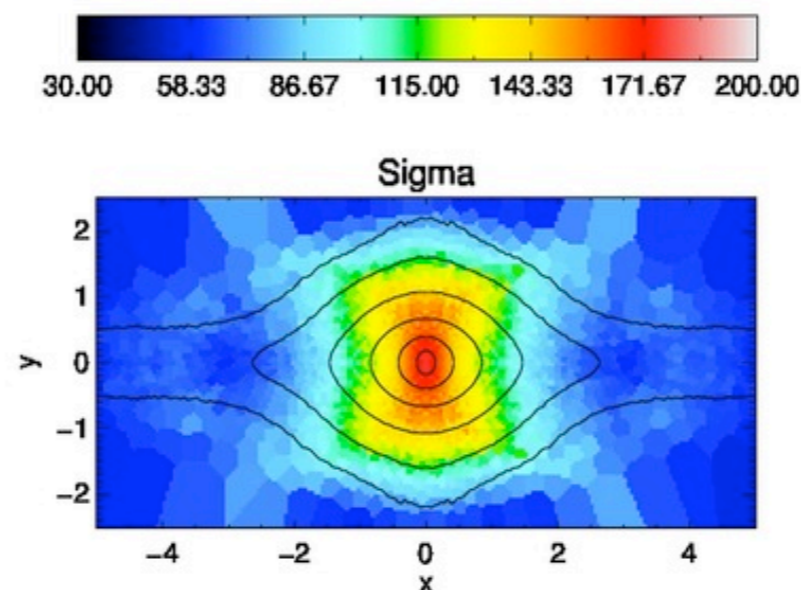
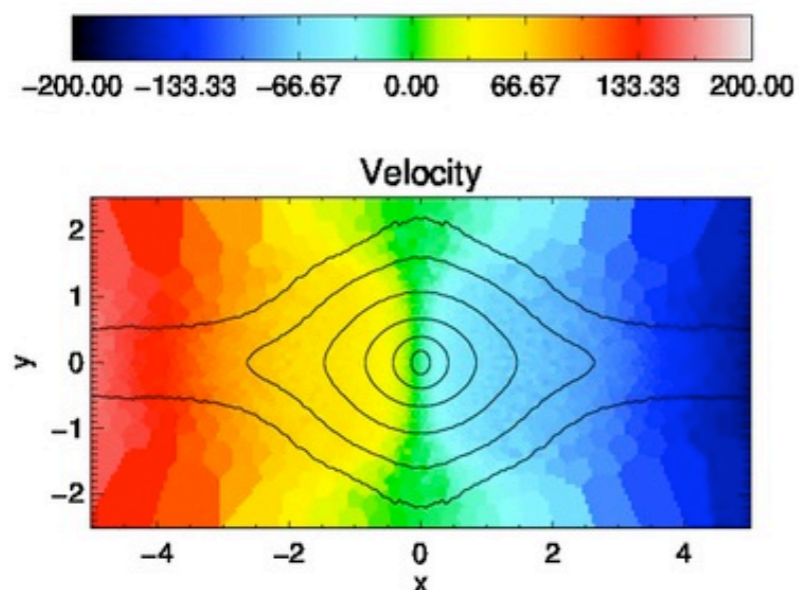
- ❖ Edge-on galaxies:
 - ◆ end-on case - peanut diagnostics
 - ◆ finding the position angle of the peanut
 - ◆ **signatures of different stellar populations**

Different stellar populations



Stars born within
200 Myr from the
beginning of
the simulation
-
no bar / peanut yet

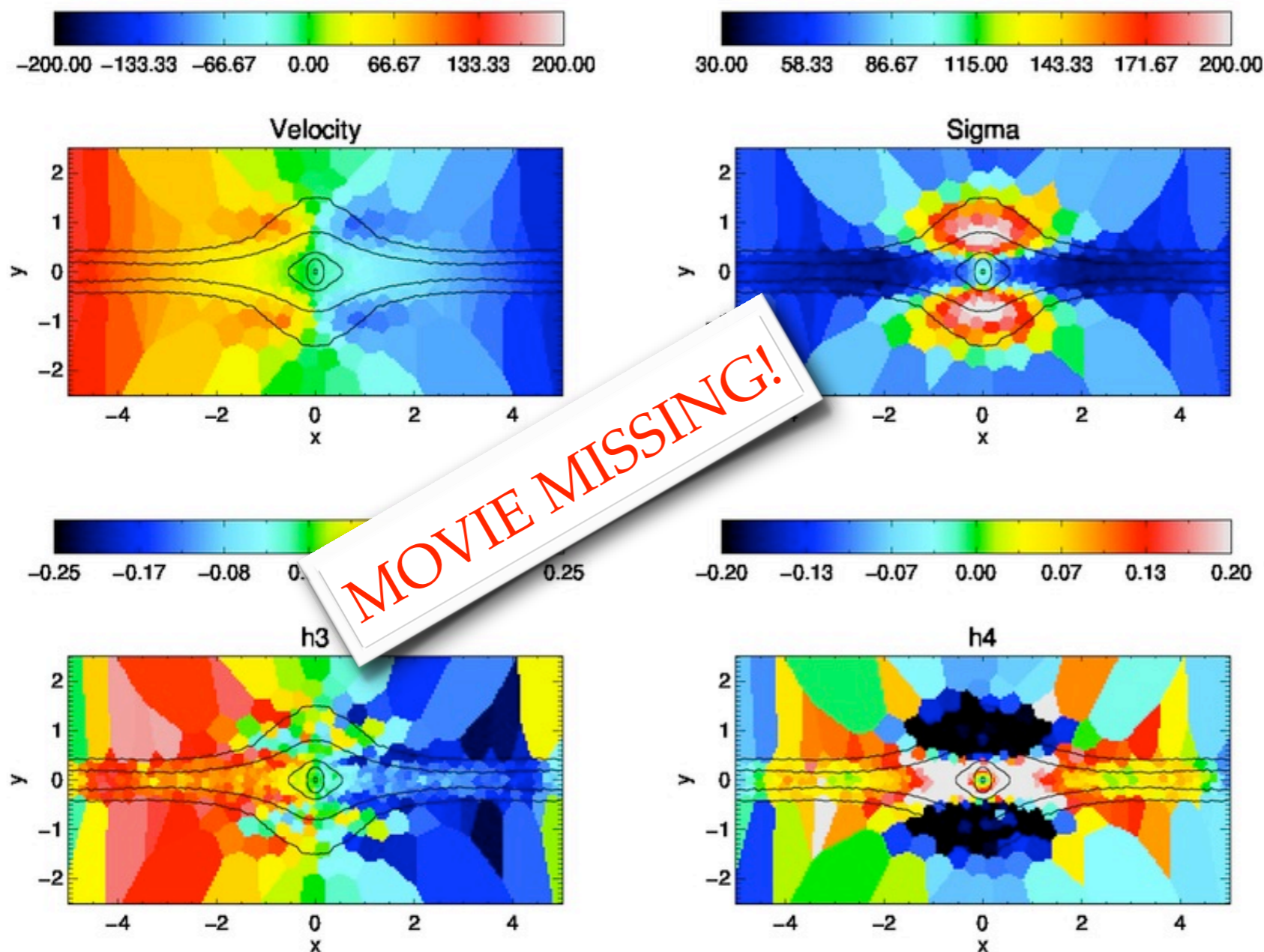
Different stellar populations



Stars born within
200 Myr from the
beginning of
the simulation
-
no bar / peanut yet

All stars

Different stellar populations



Stars born during
peanut formation

Summary

- ❖ We are extracting 2D kinematic maps from simulations of isolated disk galaxies
- ❖ Our purpose is to extend and improve bar / peanut diagnostics
- ❖ We started from the study of edge-on systems, with interest in peanut signatures in the end-on case and indicators for the position angle
- ❖ Our preliminary analysis suggests that:
 - ◆ $h3/h4$ maps may contain valuable information both for spotting a peanut seen end-on and for guessing its position angle
 - ◆ signatures left by different stellar populations are worth exploring

Summary

- ❖ Our next steps are:
 - ◆ extract quantitative information
 - check h3 / h4 features against a wider range of peanut and bar strengths
 - check the end-on maps against morphologically-similar, peanut-less cases
 - ◆ study the effect of inclination
 - ◆ produce realistic maps to assess the observability of the results

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To Be Continued...

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