The Need for 3D Visualization in Astronomy

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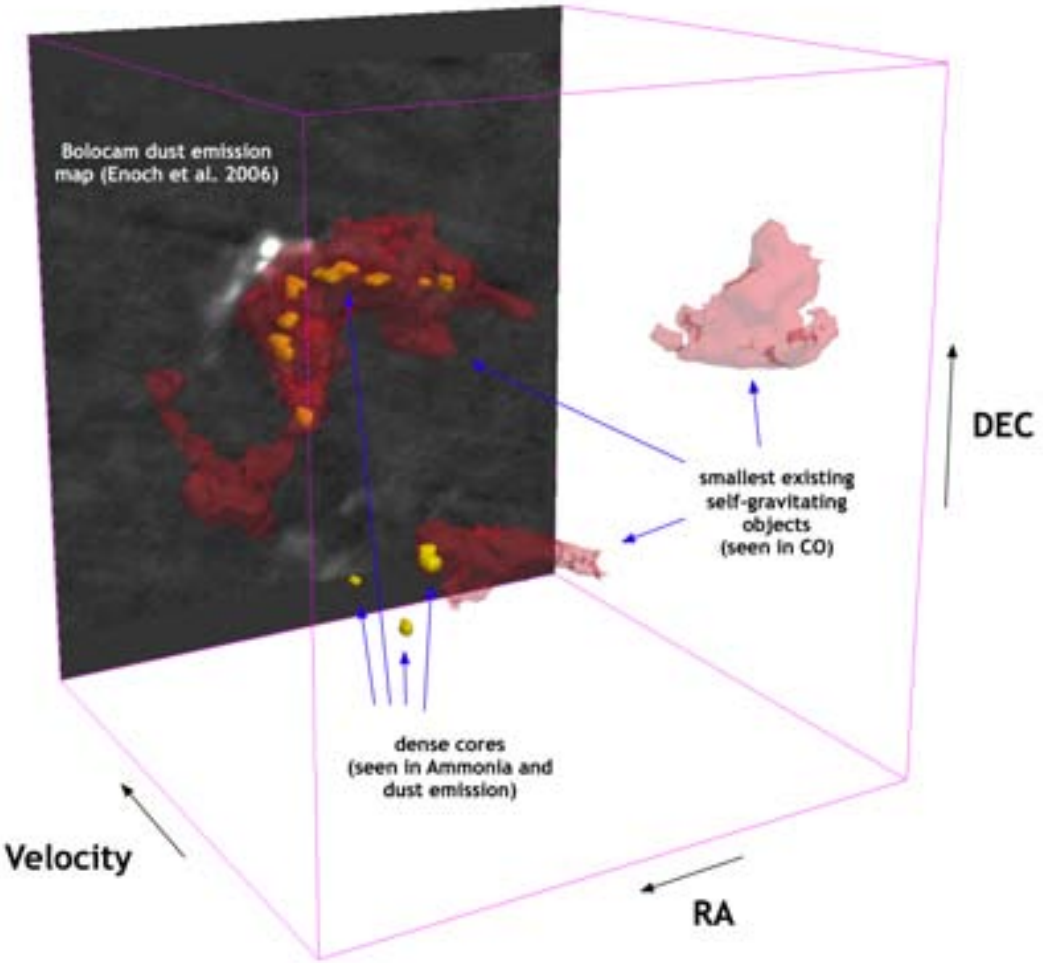
Cambridge, MA

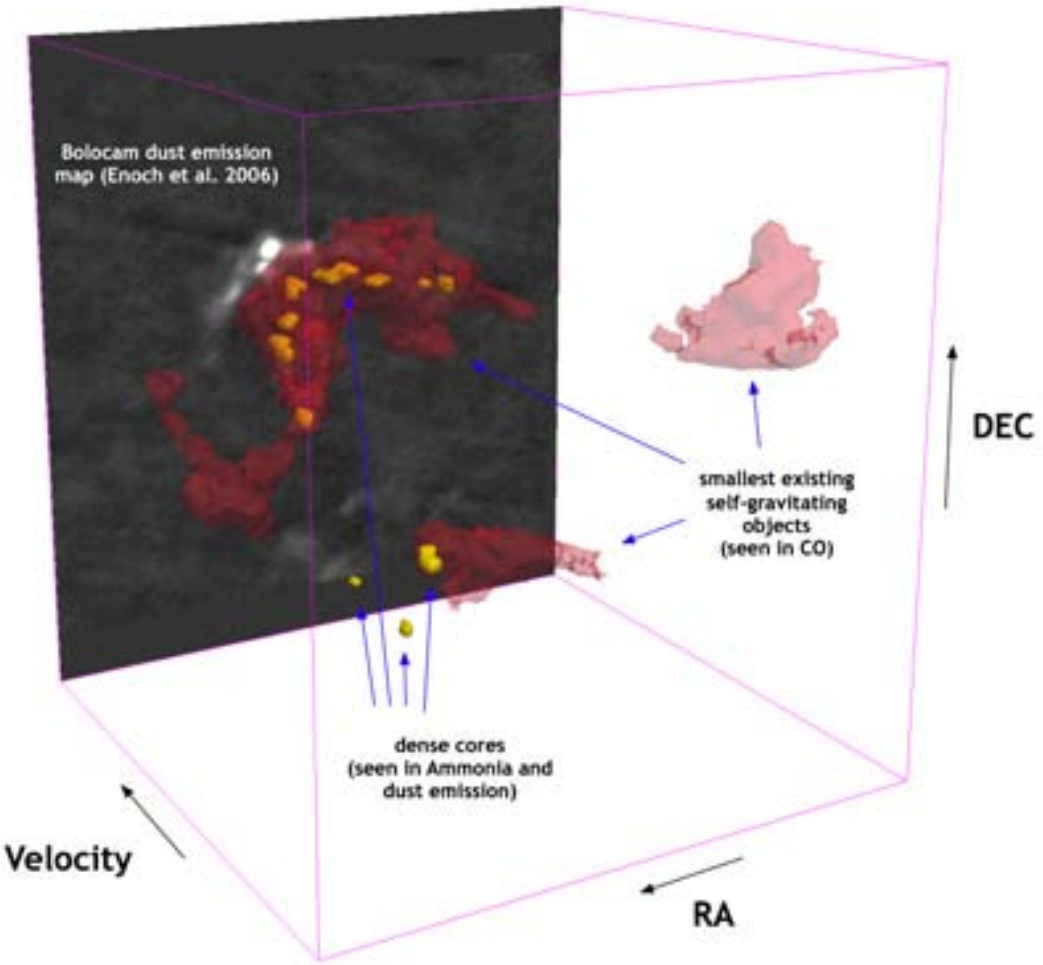
3D Visualization in Astronomy
Santa Barbara, 2007 November 8

3D Visualization of Astronomy Data



L1448 in diverse tracers (Kauffmann et al., in prep.)

3D Visualization of Astronomy Data



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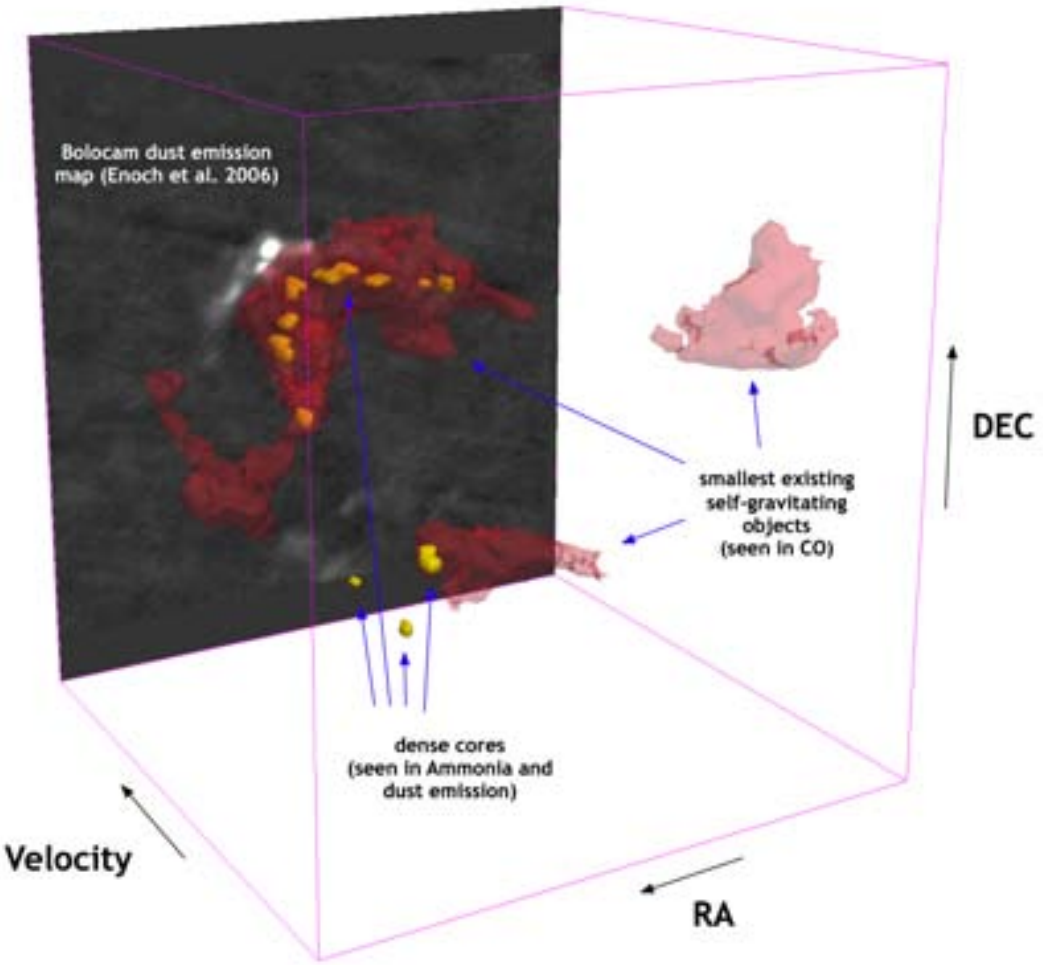
Negative Comments

- "Why not channel maps?"
- "Why not IDL?"
- "Why these pretty pictures?"

3D Visualization of Astronomy Data



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- "Can one identify objects?"
- "What data can one visualize?"

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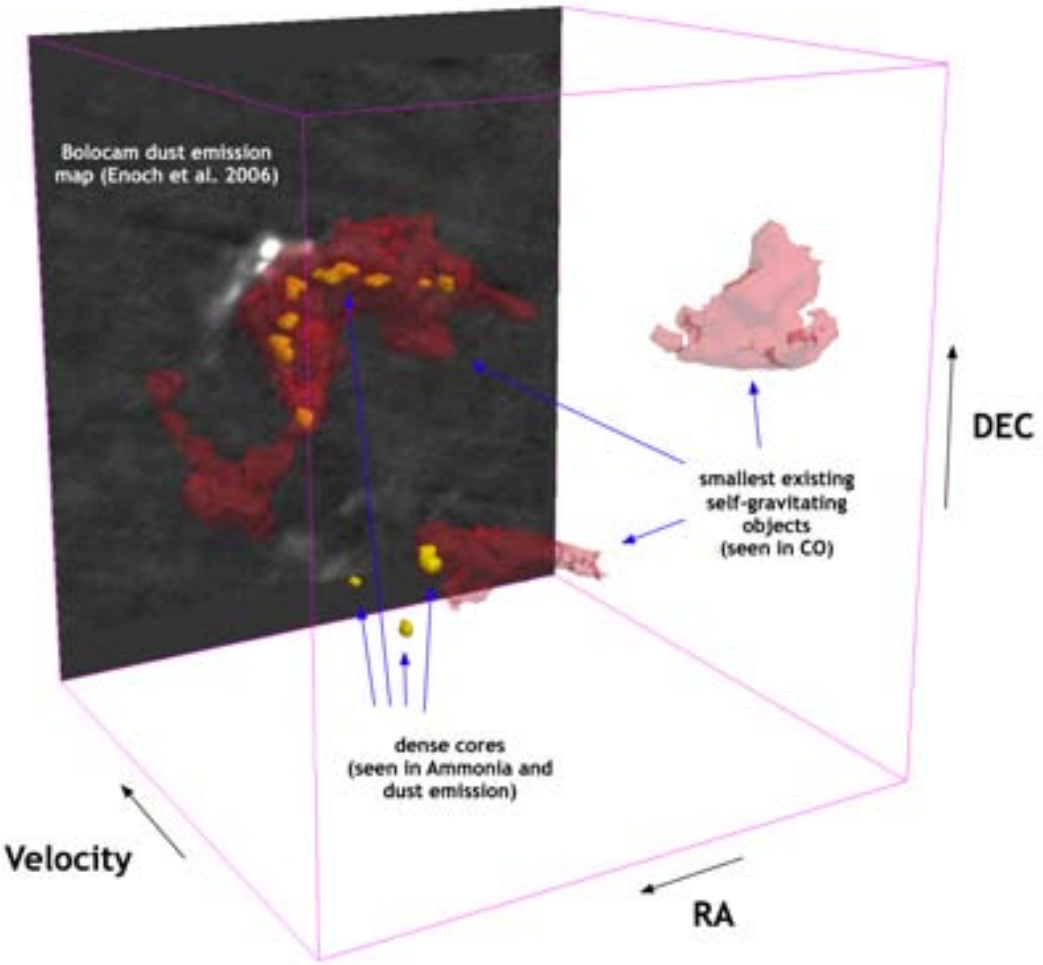

L1448 in diverse tracers (Kauffmann et al., in prep.)

This sets the agenda for today's tutorial...

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Outline

1. Research Situations with 3D Needs
   - Spatial 3D Data & Simulations
   - Observational Data Cubes
   - Tabulated Data
2. Software: Requirements & Available Packages
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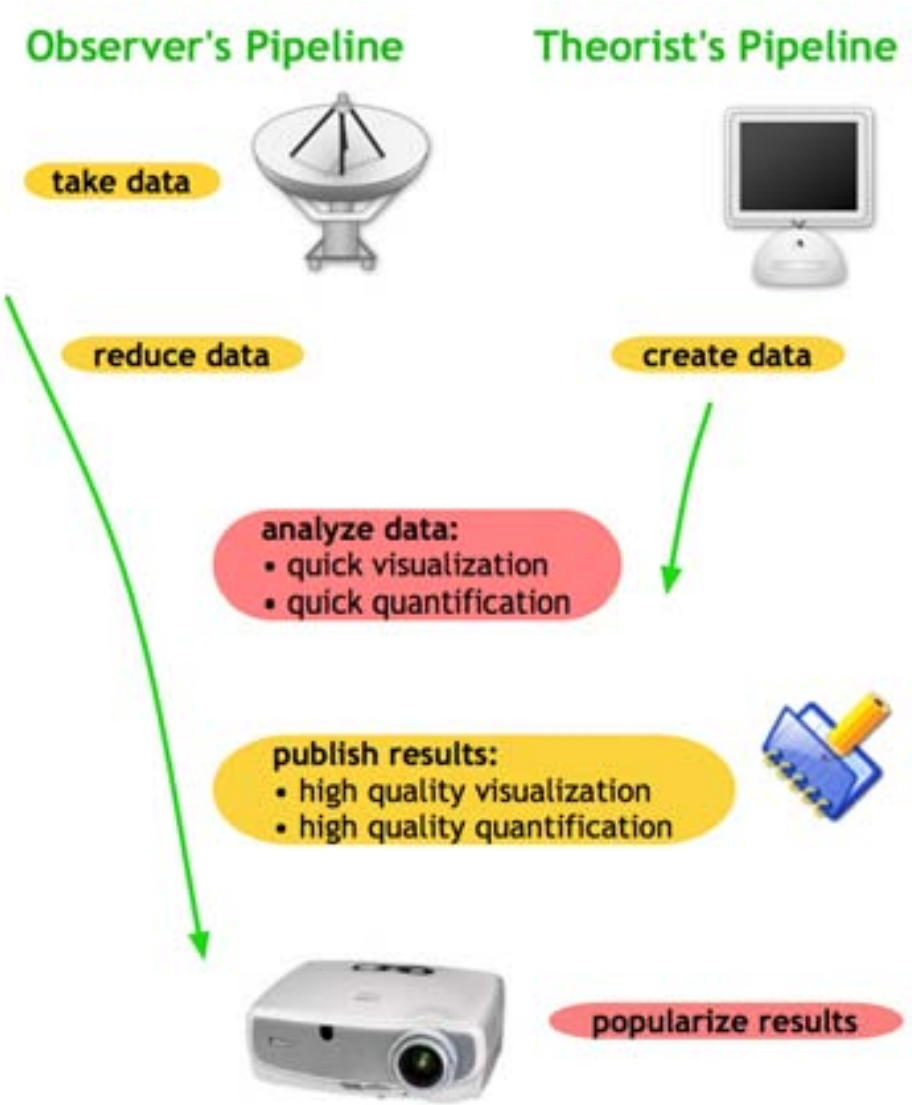
Astronomical Research Pipeline



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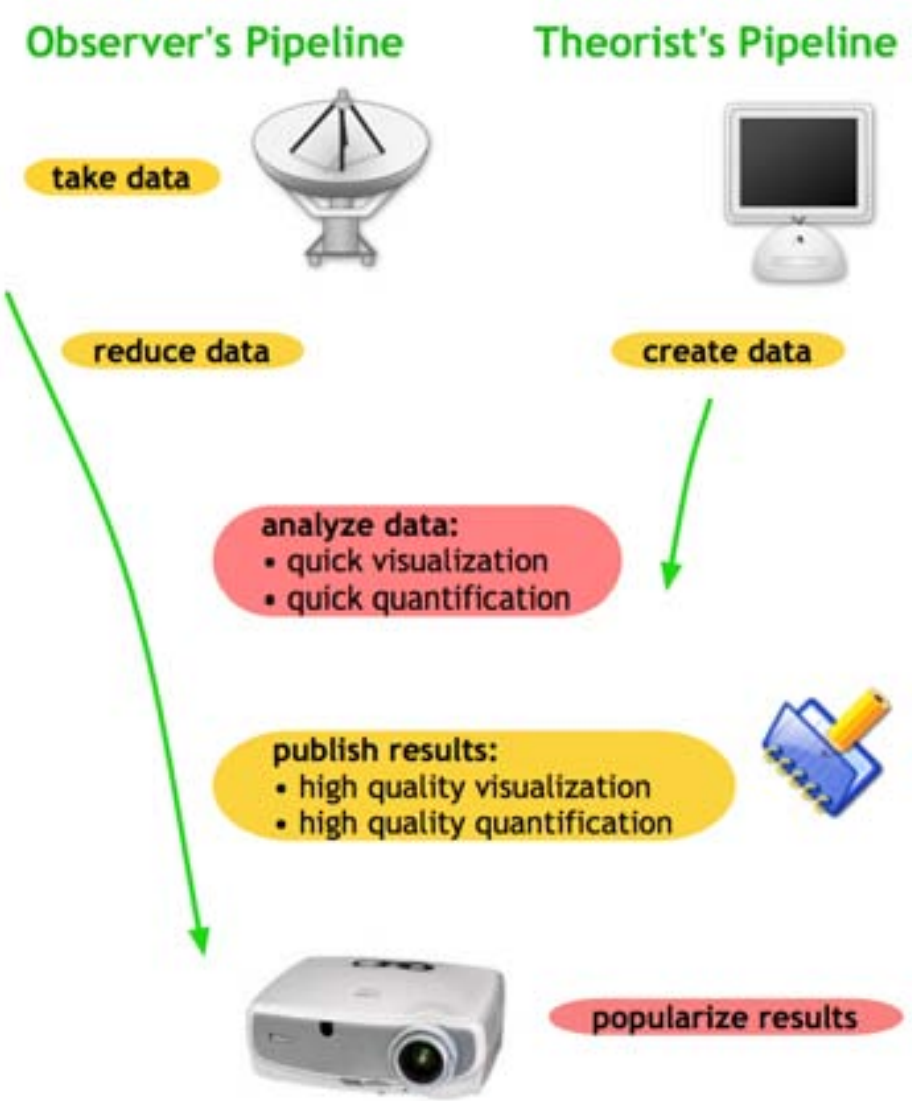
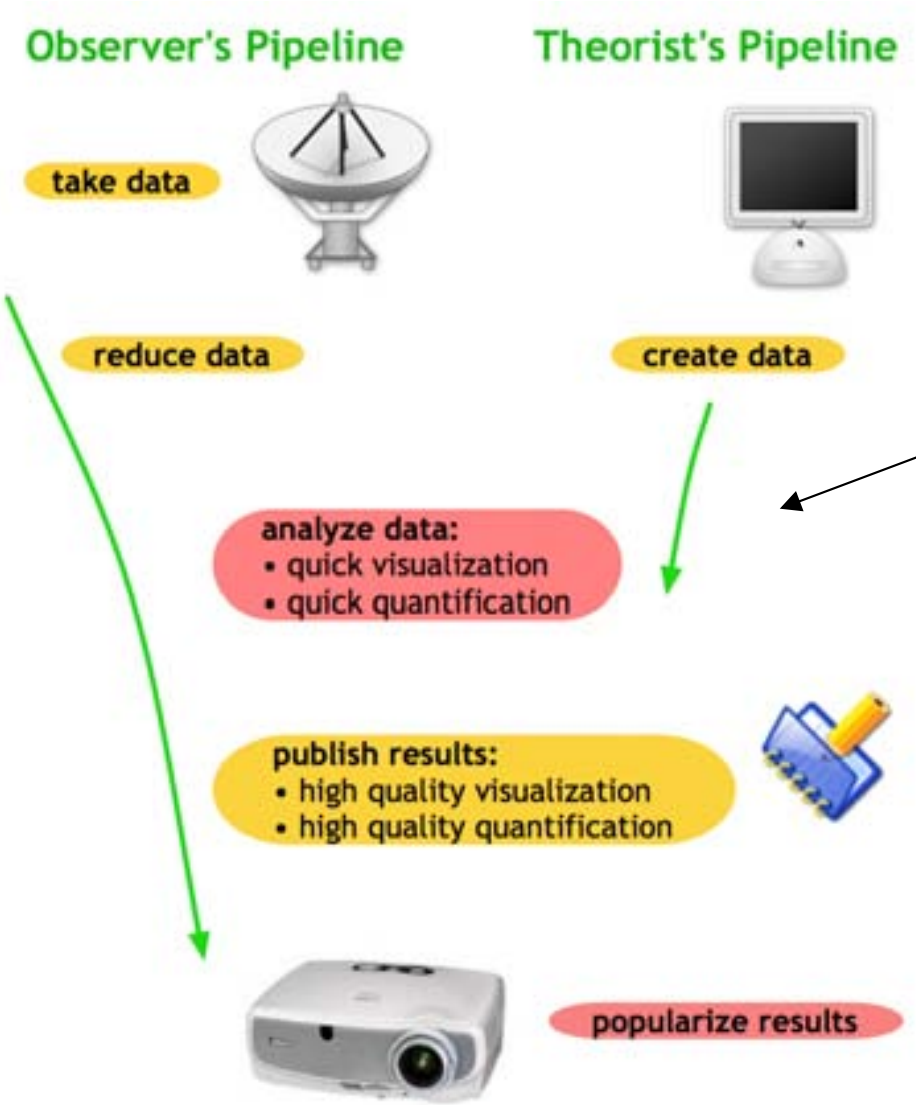


obvious use of 3D

Astronomical Research Pipeline



non-obvious use of 3D

this section's focus

obvious use of 3D

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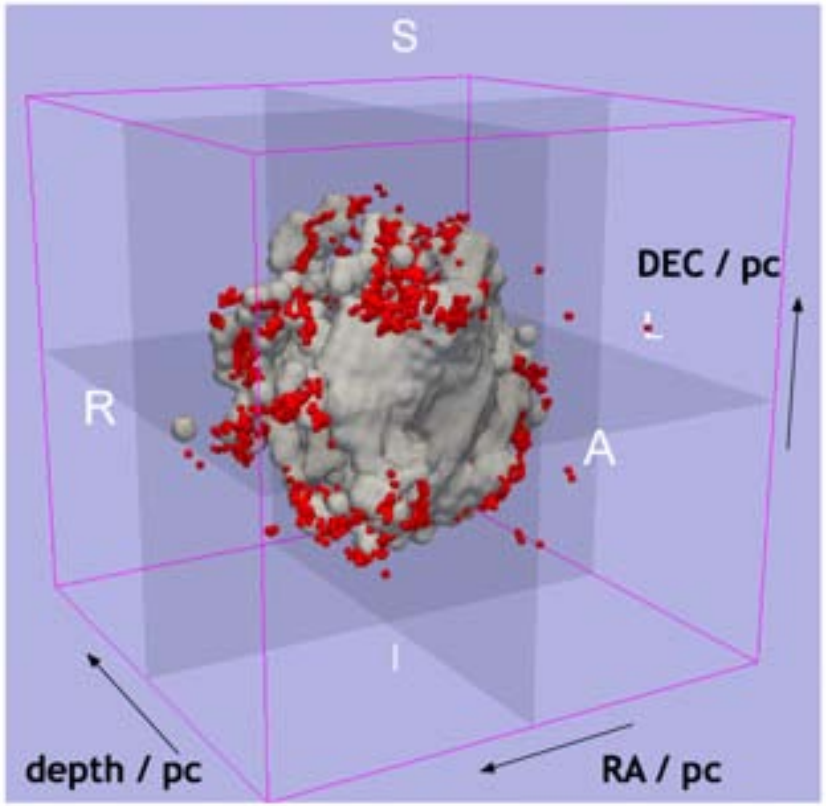
Data with three Spatial Dimensions

Cas A SNR in SiII (grey) and ArII (red)



Delaney et al. (in prep.; see also 2007 AAS 210, 1502)

there is a very limited number of observational datasets with three spatial dimensions

usual reasoning:
age, τ, and speed, v, known $\Rightarrow$
$s = v \cdot \tau$, scale along line of sight can be calculated

simulations are further obvious merely spatial datasets

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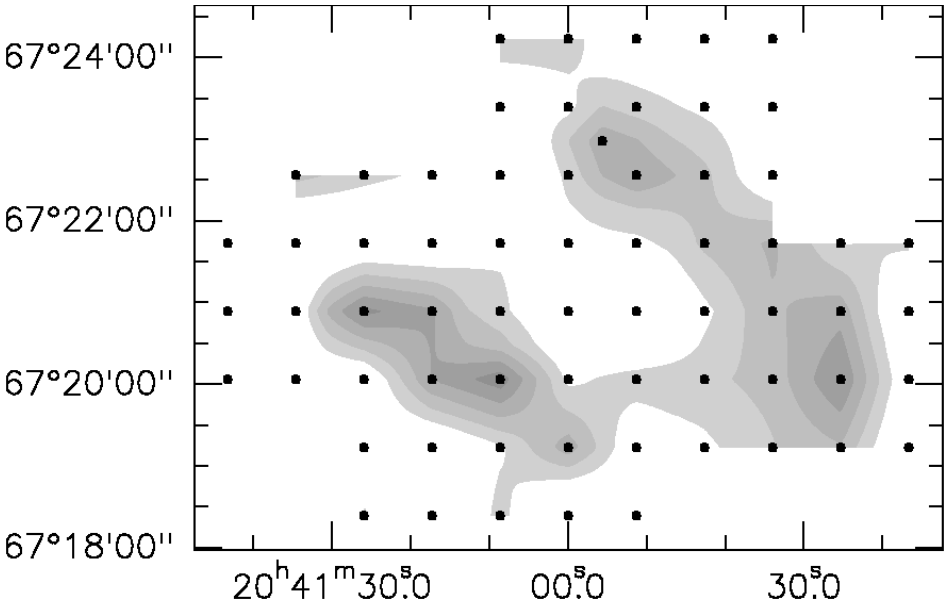
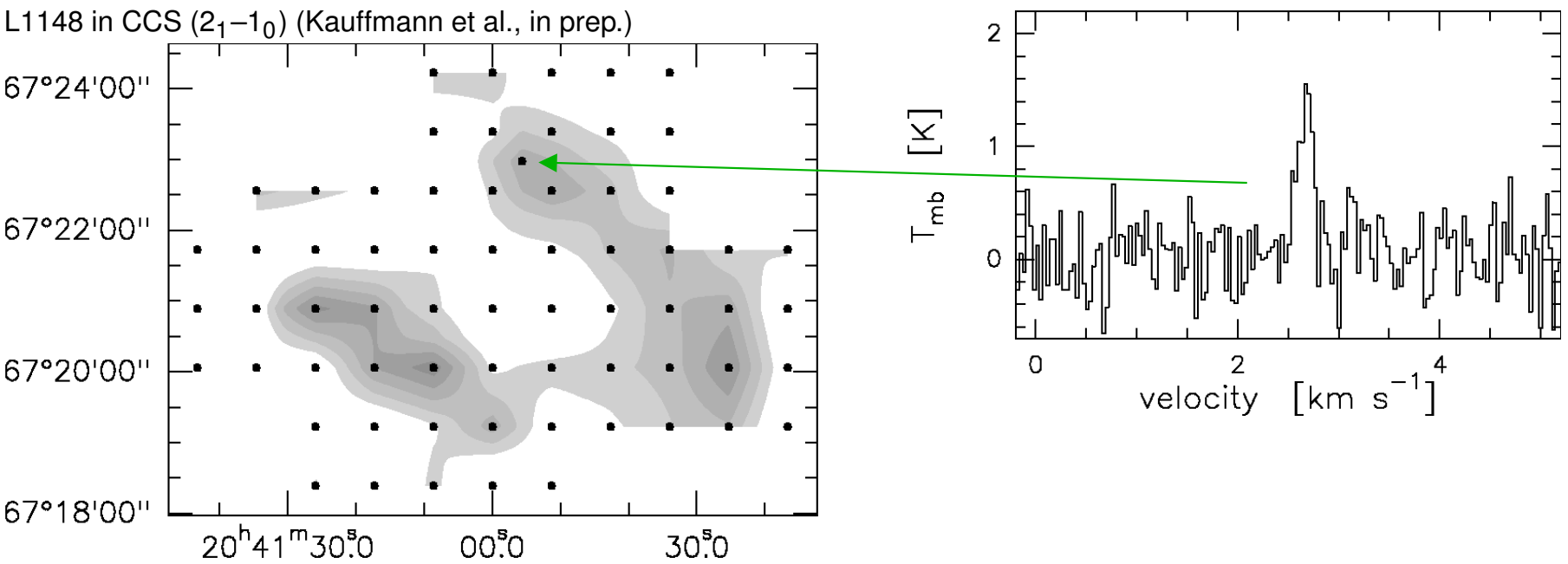
Spectra Across an Area

L1148 in CCS (2_1–1_0) (Kauffmann et al., in prep.)



example: a cloud mapped in CCS

Spectra Across an Area

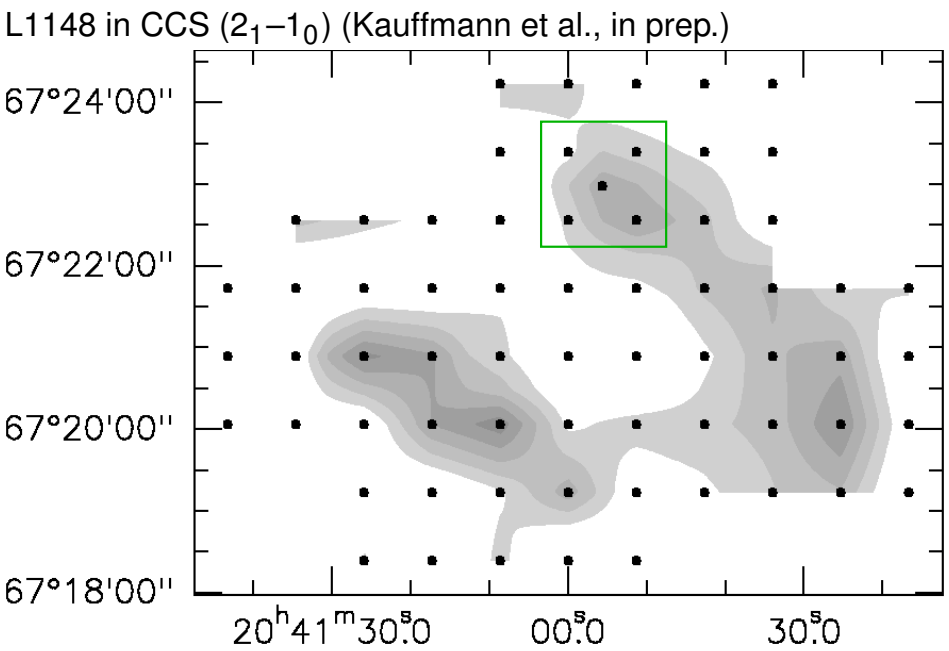


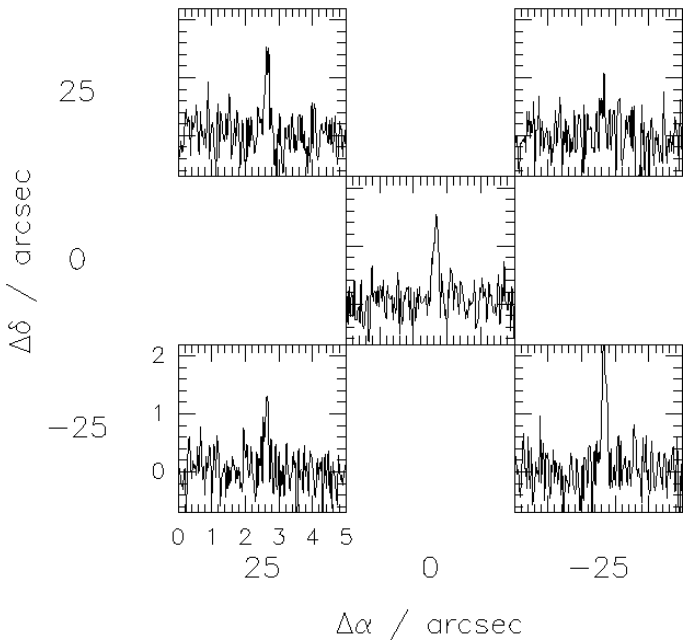
example: a cloud mapped in CCS

single observation: $I(\nu)$

conversion to velocity: $\nu \rightarrow v = c \cdot (\nu_0 - \nu)/\nu_0$, for given rest frequency, ν_0,
i.e., uses Doppler effect

Spectra Across an Area





example: a cloud mapped in CCS

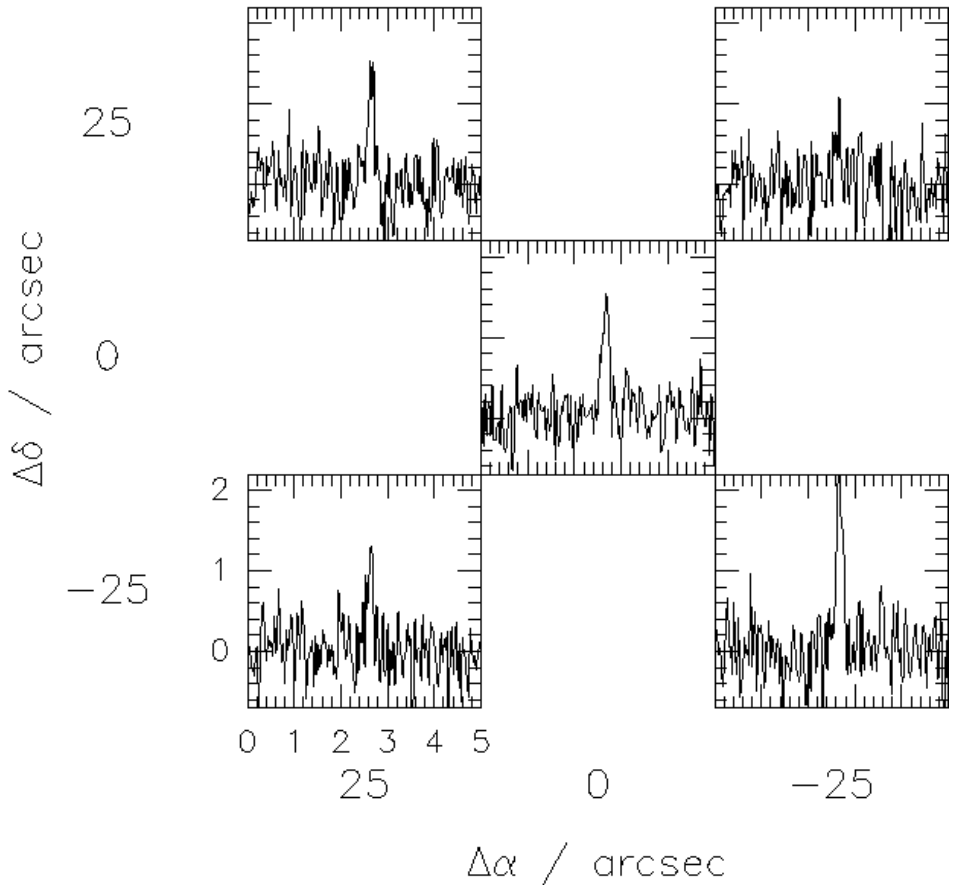
mapping observations: $I(\nu)$ at given (α, δ)

rewritten: $I(\nu, \alpha, \delta)$, i.e., 3D field

continuous cubes are called volumes

Visualization Approaches

array of spectra: i.e., plot *I*[*v*] at given [α, δ]



Visualization Approaches

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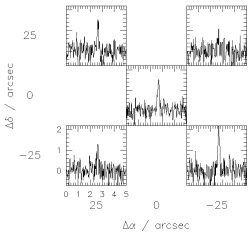
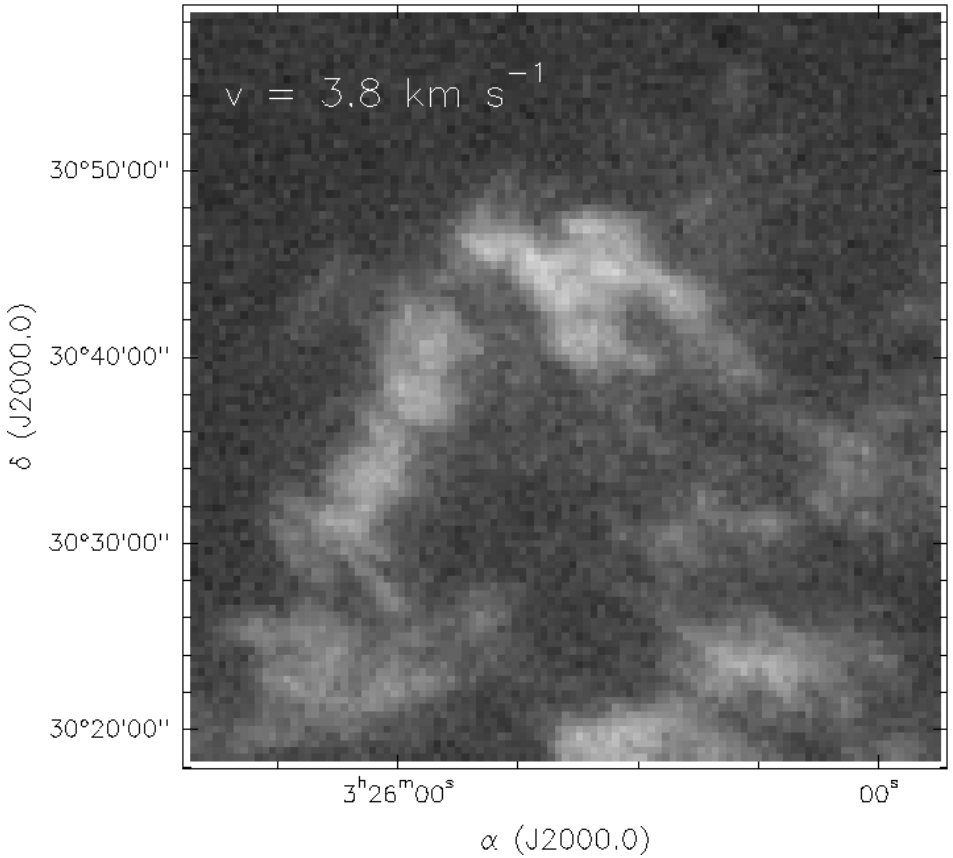


channel maps: i.e., plot $I[\alpha, \delta]$ at given v

L1448 in ^{13}CO (1–0)



all L1448 data: COMPLETE survey,

`http://www.cfa.harvard.edu/COMPLETE/`

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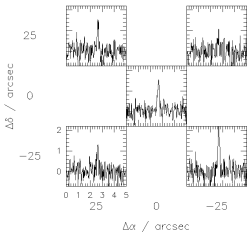

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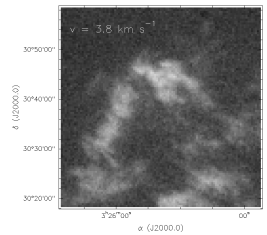

position-velocity-diagrams: e.g., plot $I[v, \alpha]$ at given δ

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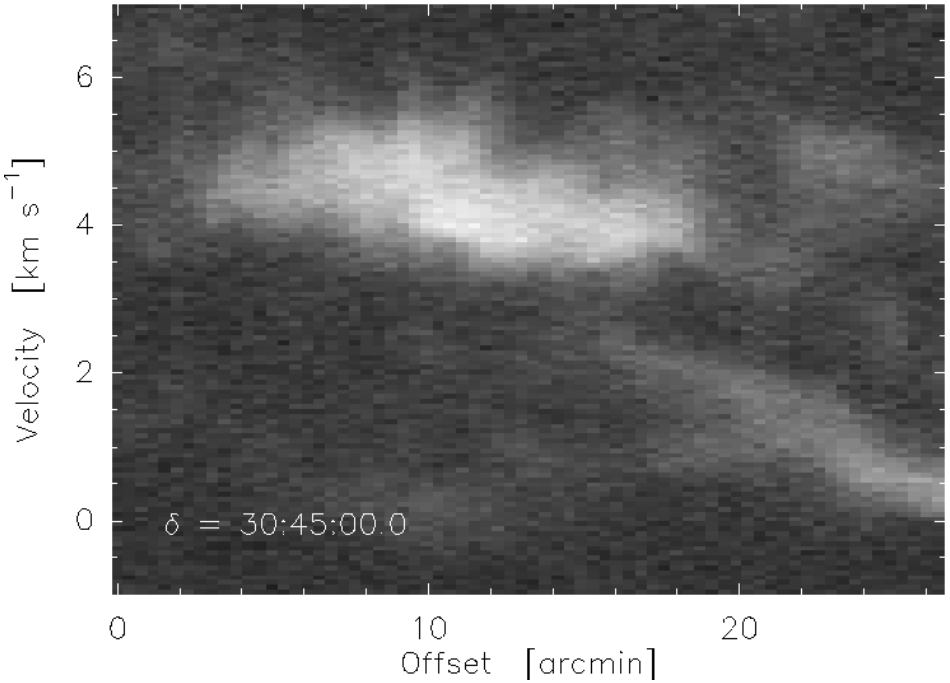

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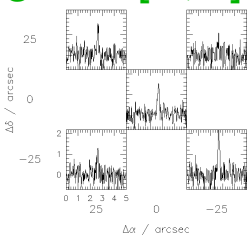

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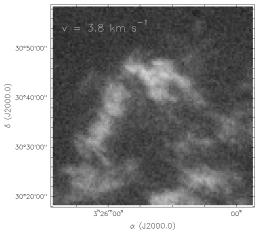

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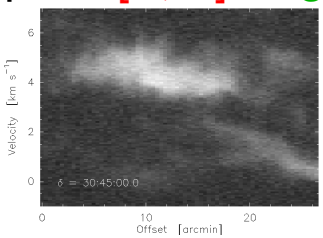

3D visualization: i.e., plot $I[v, \alpha, \delta]$ — without further constraints

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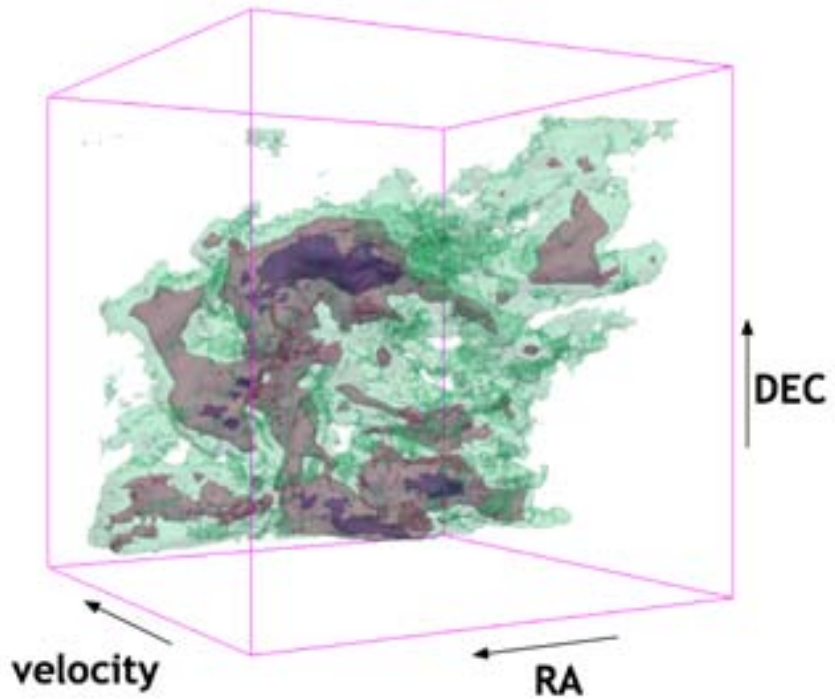

approach closest to data structure

Visualization Approaches

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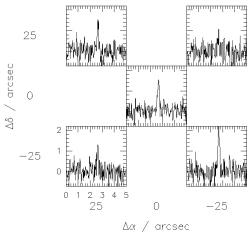

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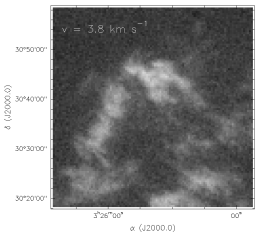

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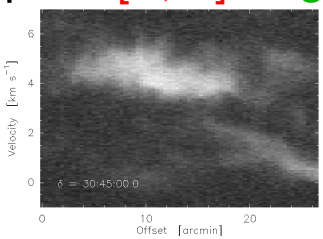

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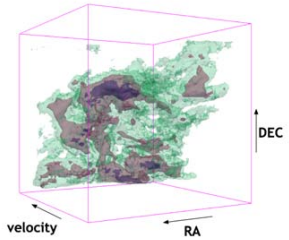
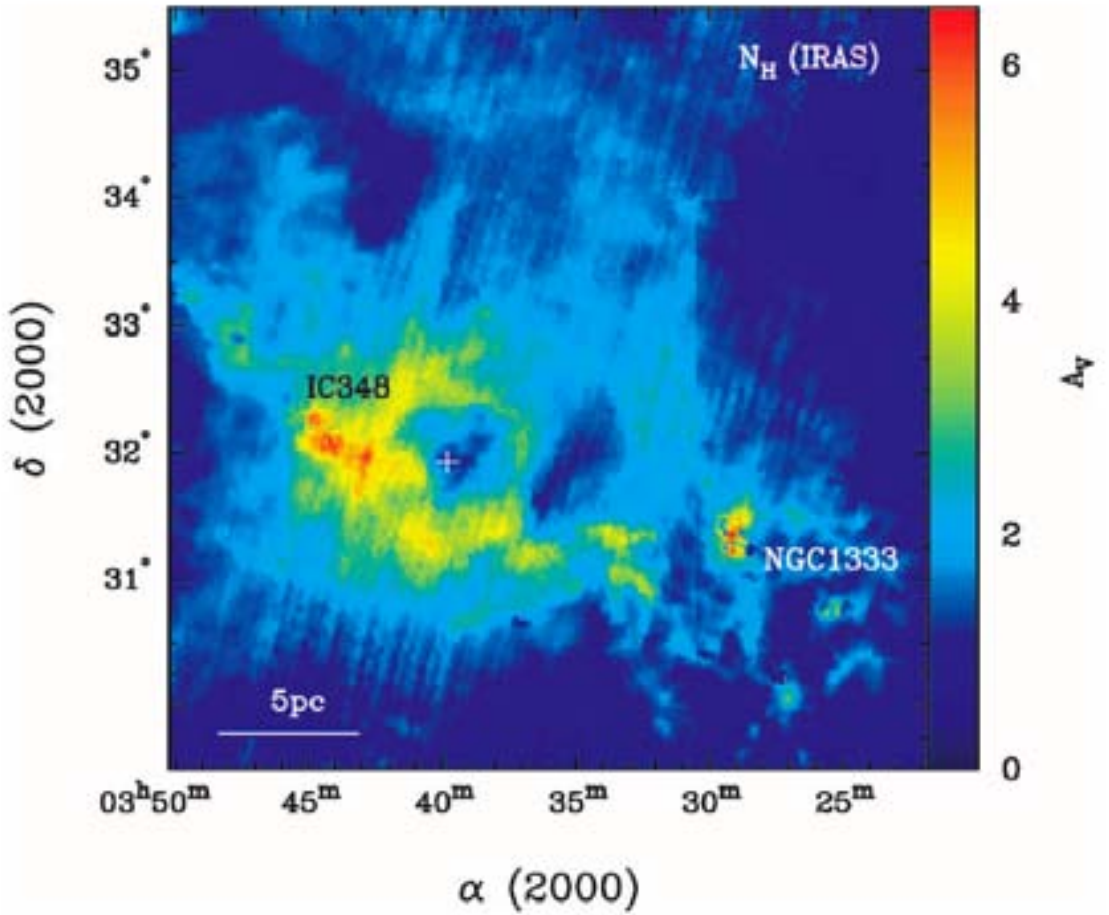


choice of visualization approach is based on scientific problem, personal preferances, and data size

all approaches except for 3D require memorizing during data analysis

3D visualization is thus particularly interesting for the analysis of large datasets

Illustration: Feature-Discovery in Large Datasets



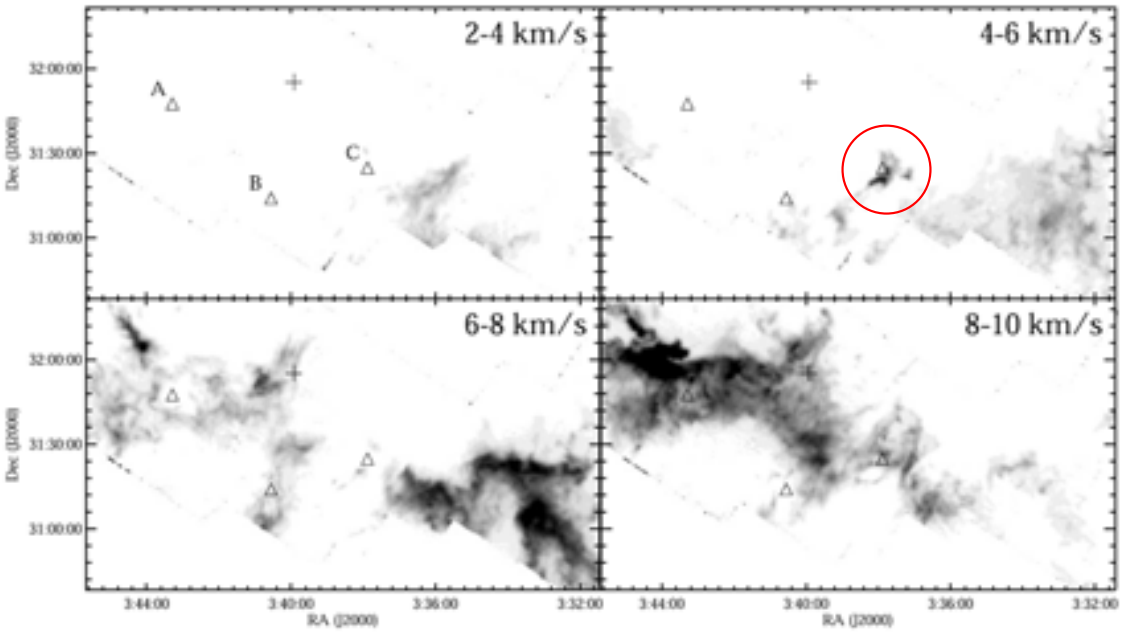
Ridge et al. (2006):

a 10 pc shell of warm (29 K) dust in Perseus

probably driven by expanding HII-region

relation to molecular cloud?

Illustration: Feature-Discovery in Large Datasets



^{13}CO channel maps:
no obvious features

map has 250 000 pixels. . .

8 μm emission knots:

one out of three shows
unusual ^{13}CO velocities

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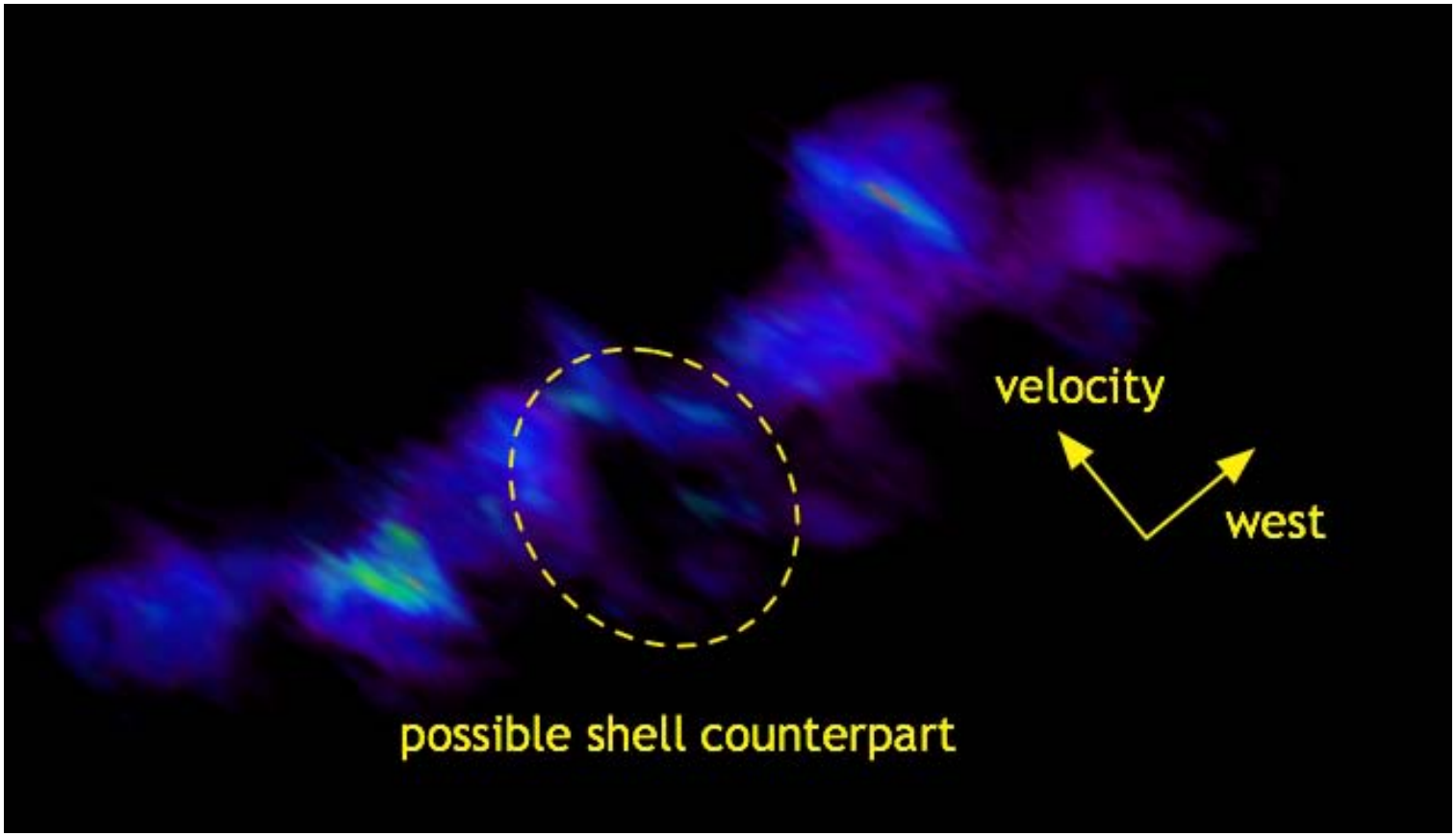

^{13}CO 3D visualization:

clear indication for extended emission from the shell

(Borkin & Arce, in prep.)

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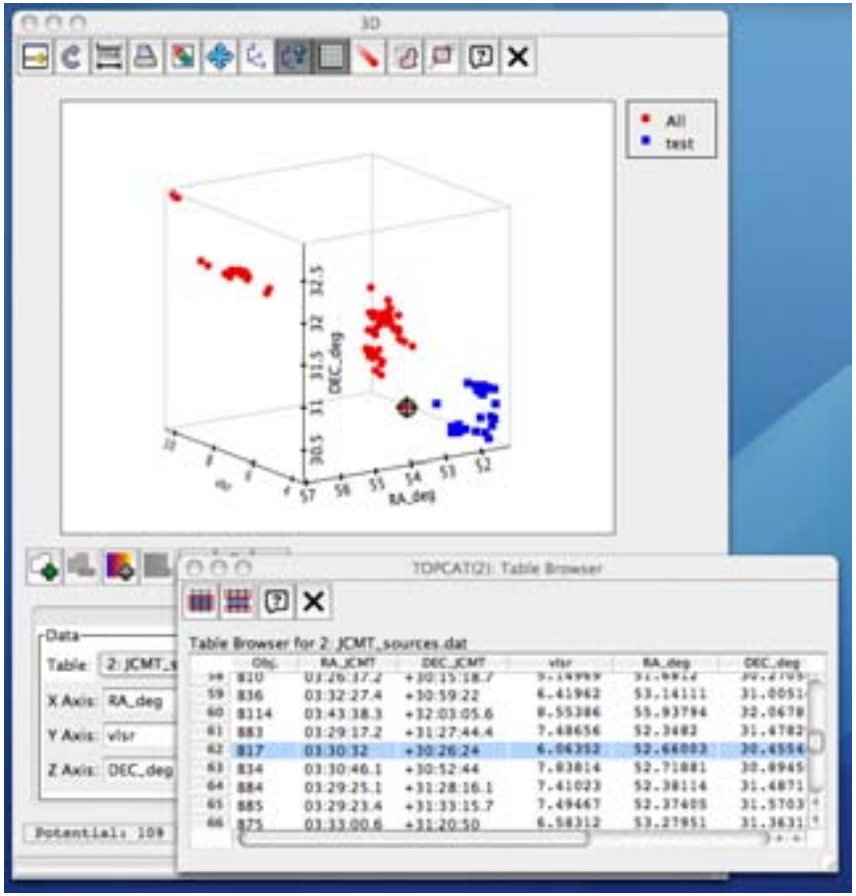
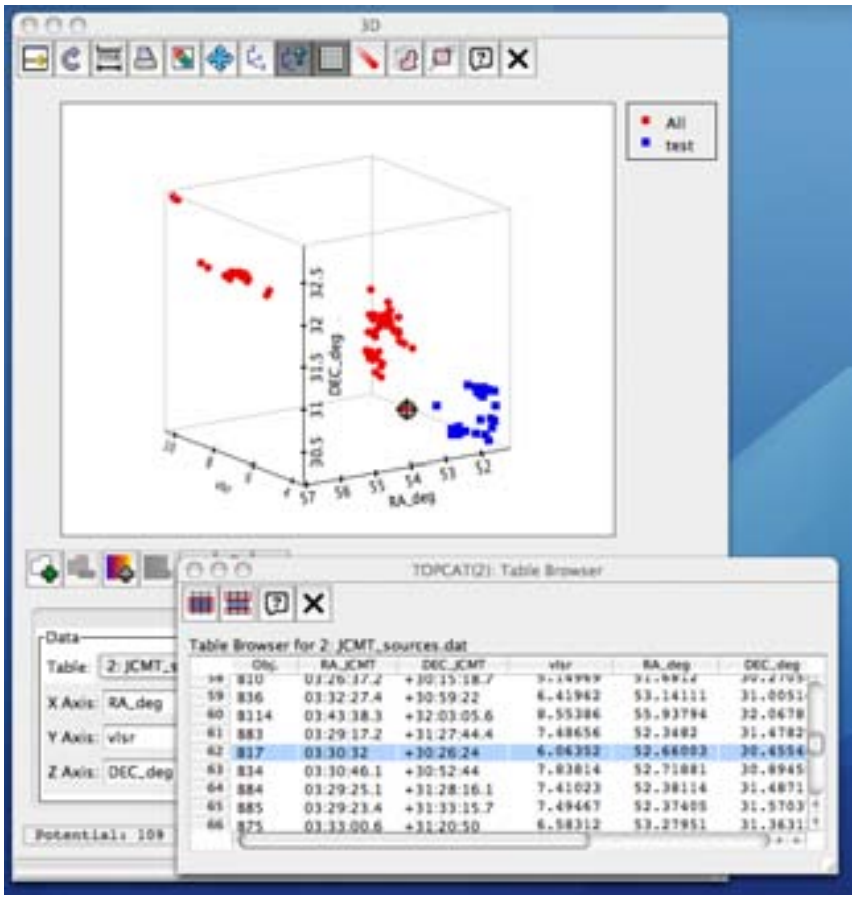


dense cores in Perseus seen in Topcat

non-volumentric data:

- data towards specific positions
- interesting for archival research

Tabulated Data



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interactive selection of objects crucial for archival work

generally: tools are important features of viewing software

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Ranges in Software Requirements

obvious variations in requirements:

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- availability of tools
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Figure Quality & Complexity

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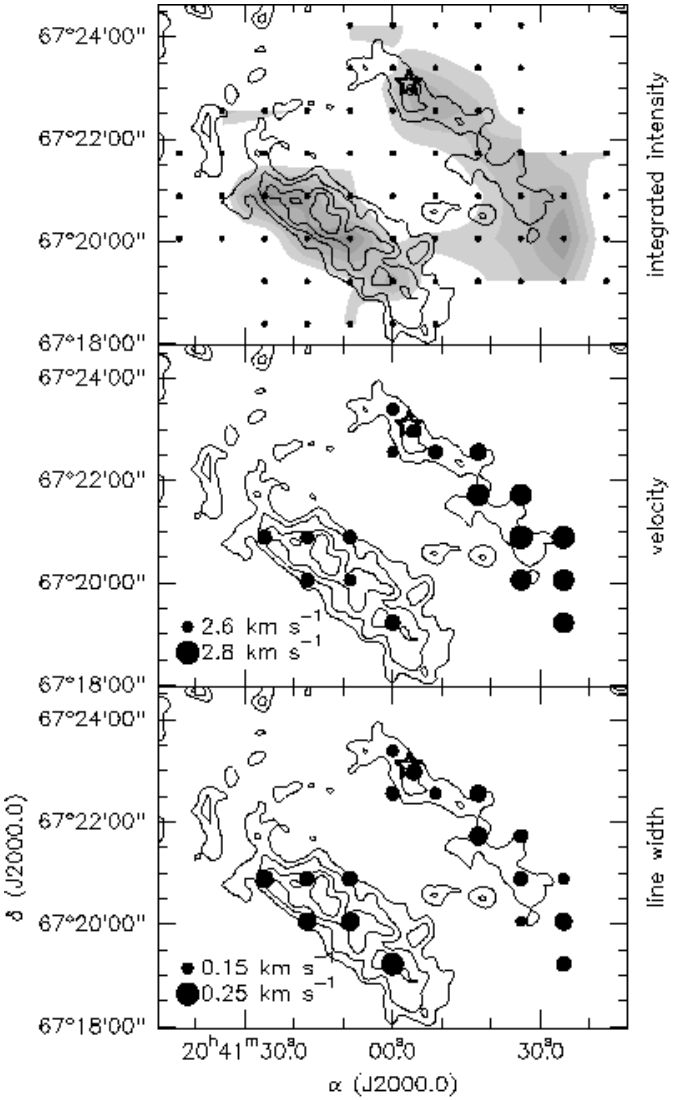

publication-quality plots have other requirements than data analysis plots

skript-driven 3D software with high resolution output is needed here

Ranges in Software Requirements

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- level of specialization

not so obvious variations:

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- figure quality & complexity

there is no standard application that meets all requirements at the same time

different users will need different packages

Available Software: Presented at ADASS 07

3D visualization tools: also come Tuesday, 1:30 pm

Name	Presentation	Aim
3D Slicer	O7.1, O7.2, D4	spectral data cubes (+ anything else)
OsiriX	this tutorial	spectral data cubes (+ any volume)
VisIVO	this tutorial	anything
S2PLOT	O7.3, P2.4	anything
Gaia 3D	P2.7	spectral data cubes
TopCat	D14	any tabulated data

colored packages are demo'ed in this tutorial

packages related to 3D:

Name	Presentation
HEALPix	P2.2
MUSE tools	P2.9
Euro3D	P1.20

packages are complementary because of different aims

program list: join us at
http://am.iic.harvard.edu/RelatedProjects

many of them used also in further posters and demos

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3D astronomy software:

- not only for pretty pictures
- also for non-spatial data
- different for different users

Come and try out!