Large- and Small-Scale Magnetic Fields in Cygnus-X North

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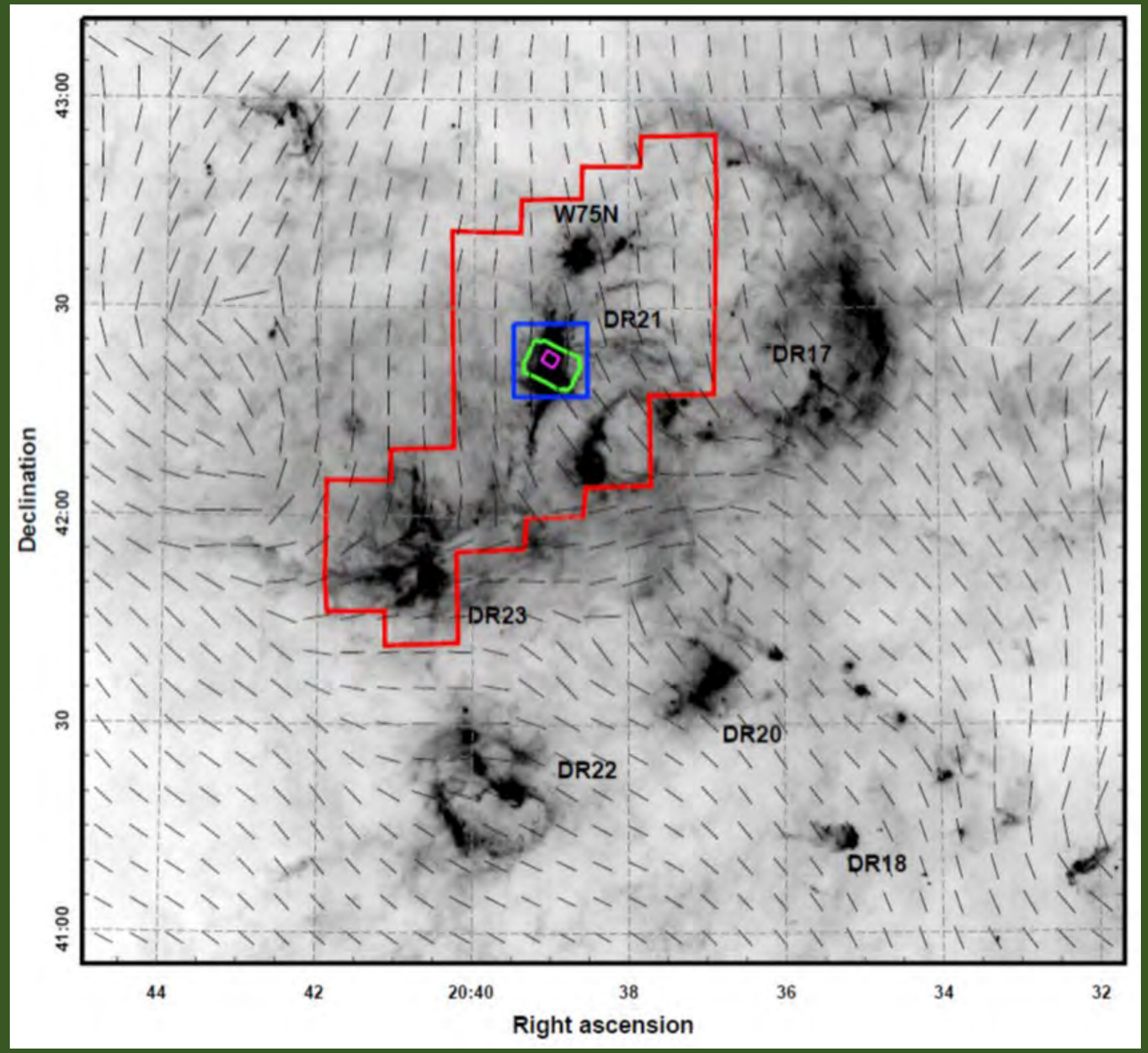

50 light years

Planck satellite submm magnetic field vectors over Herschel satellite far-infrared dust emission (at 160μm). Study region shown as red, blue, green, and magenta polygons.

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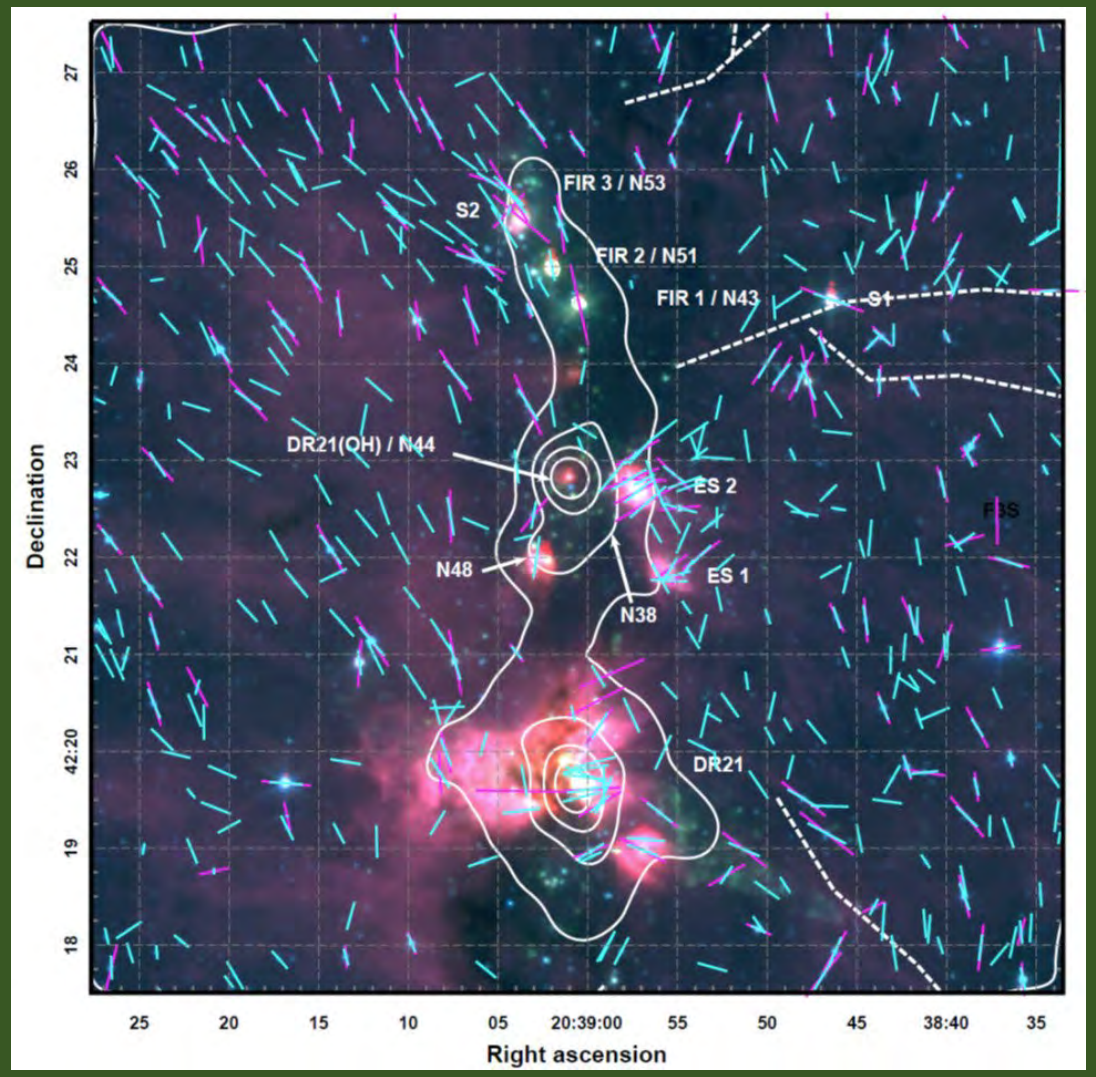
Magnetic Fields: A Friend or Foe of Star Formation?

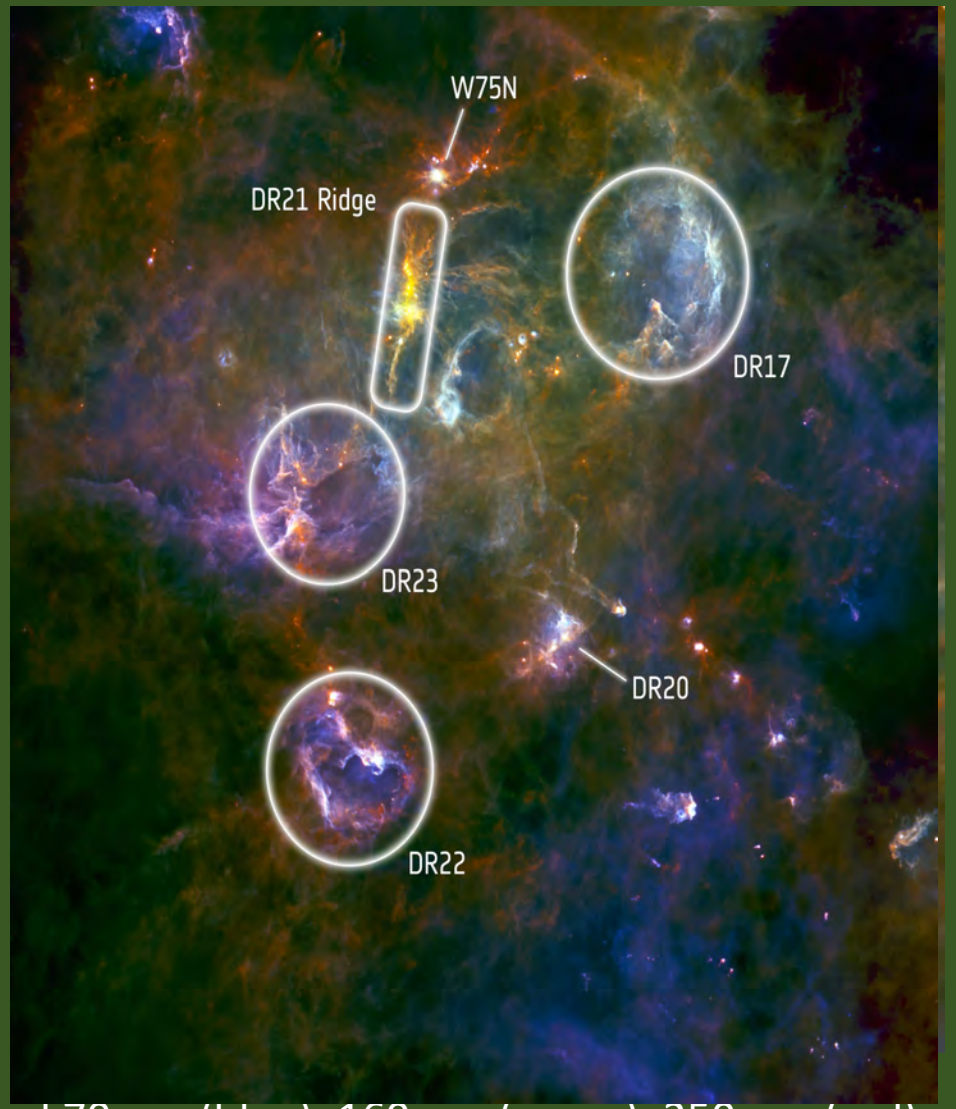
- Magnetic fields may direct gas flow to high-density regions, helping stars to form
- Magnetic fields may resist gas flow, hindering star formation
- Sensing magnetic fields is now fairly easy using near-infrared and/or far-infrared (FIR) polarimetry (SOFIA HAWC+)
- Magnetic field vectors at right are from the Mimir near-infrared (NIR) instrument on the Perkins Telescope in AZ



Spitzer IRAC 8 μm (red), 4.5 μm (green), and 3.6 μm (blue). Vectors show Mimir NIR polarizations. Contours are *Herschel* PACS 160 μm emission.

Lasagna or Spaghetti? Disentangling Cygnus-X Clouds

- Cygnus-X is the closest, richest star-forming region of galaxy-scale significance (e.g., cloud mass $\gg 10^6\ M_\odot$, ~100 massive stars)
- It has multiple constituent clouds.
- Are the clouds located in distinct layers, like flat noodles in lasagna?
- Or are the clouds composed of filaments that tangle up, like spaghetti?

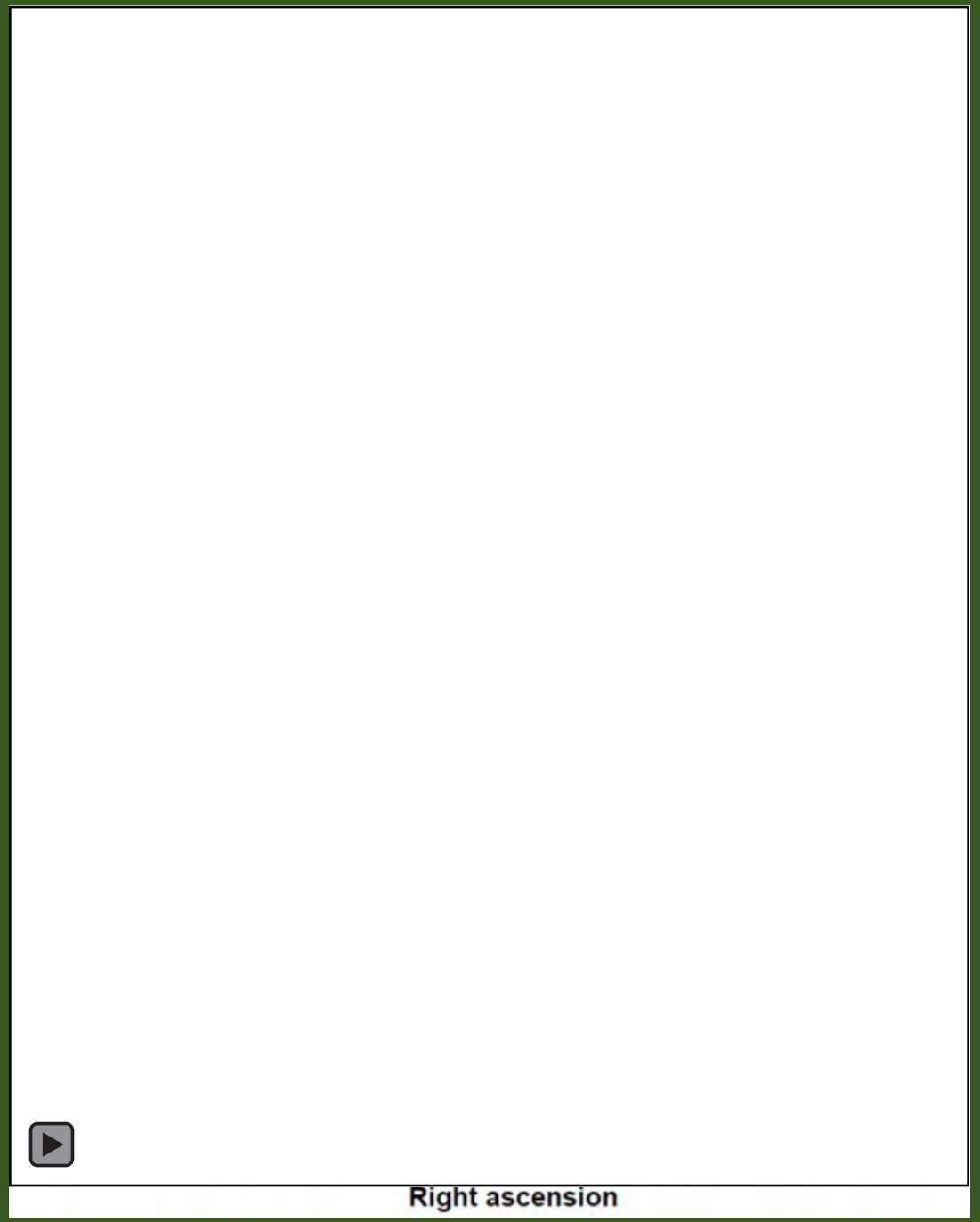


Herschel 70 μm (blue), 160 μm (green), 250 μm (red)
Credit: ESA/Herschel/SPIRE/PACS/HOBYS

Step 1: Sift through the gas velocity structure

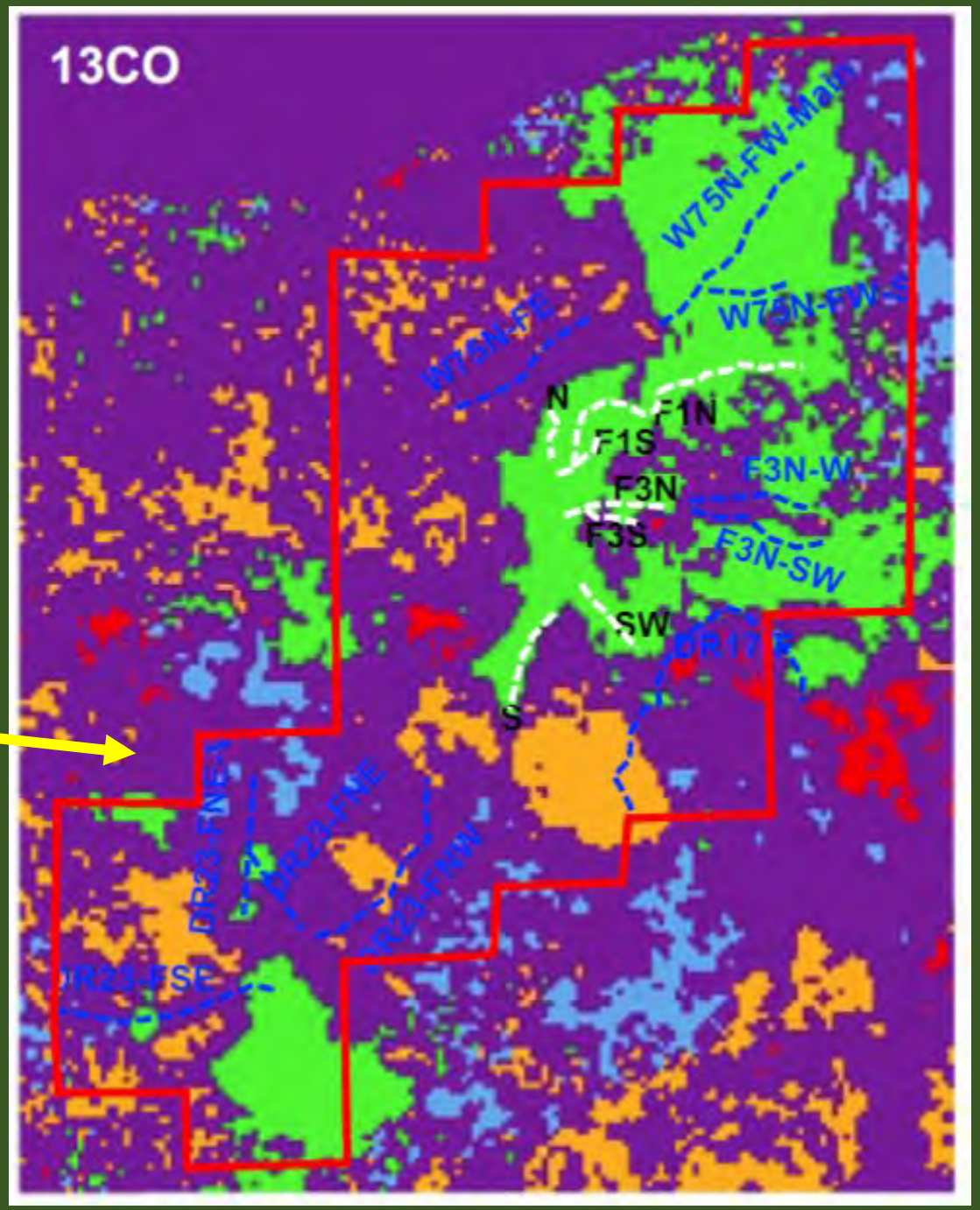
Movie of gas strength, stepping through velocities

Gas quantities, colored by component

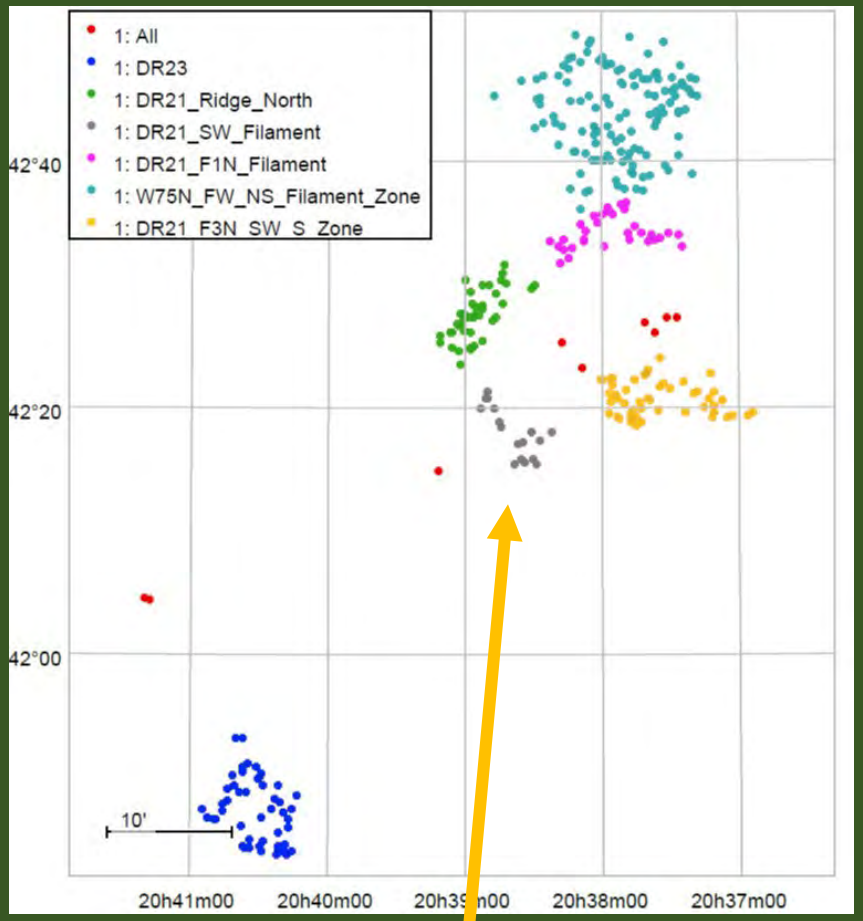


Step 2: Identify Zones with a Single Velocity Component

- Radio data can show where only ONE component is present
- Map of where each of the four components dominates over all the others
  - Green = “DR21 Component”
  - Orange = “W75N Component”
- But still no distance information!

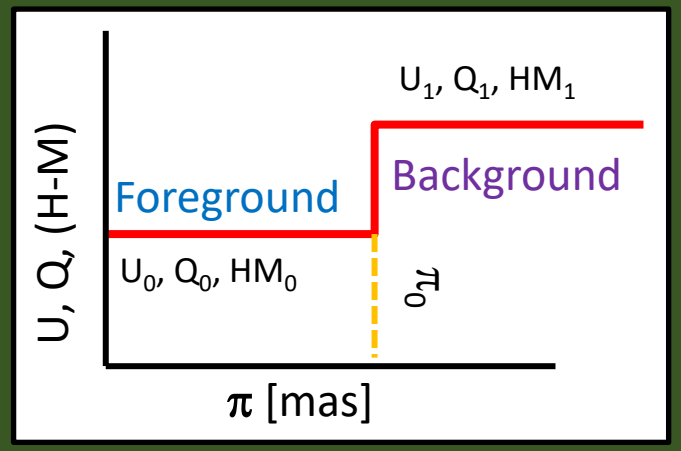


Step 3: Use Gaia to help determine Cloud Distances



Here, stars in the "DR21 Component" – sliced into 6 smaller zones

- Select stars within the one-component sky zones
- Gaia -> stellar distances from parallaxes (π). Some stars in foreground, some in background.



- Multi-wavelength photometry -> find jumps in stellar color (HM_0 -> HM_1)
- Near-infrared polarimetry -> find jumps in magnetic field properties (U_0,Q_0 -> U_1,Q_1)

Findings – Lasagna Wins!

- Find distinct, well-separated distances to the clouds and zones (-> the lasagna model)
- Clouds likely not colliding to trigger stars to form
- Can proceed to interpret SOFIA polarization maps for magnetic field properties of **single** cloud
- Can also proceed to full interpretation of the NIR polarization map across the larger field
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