

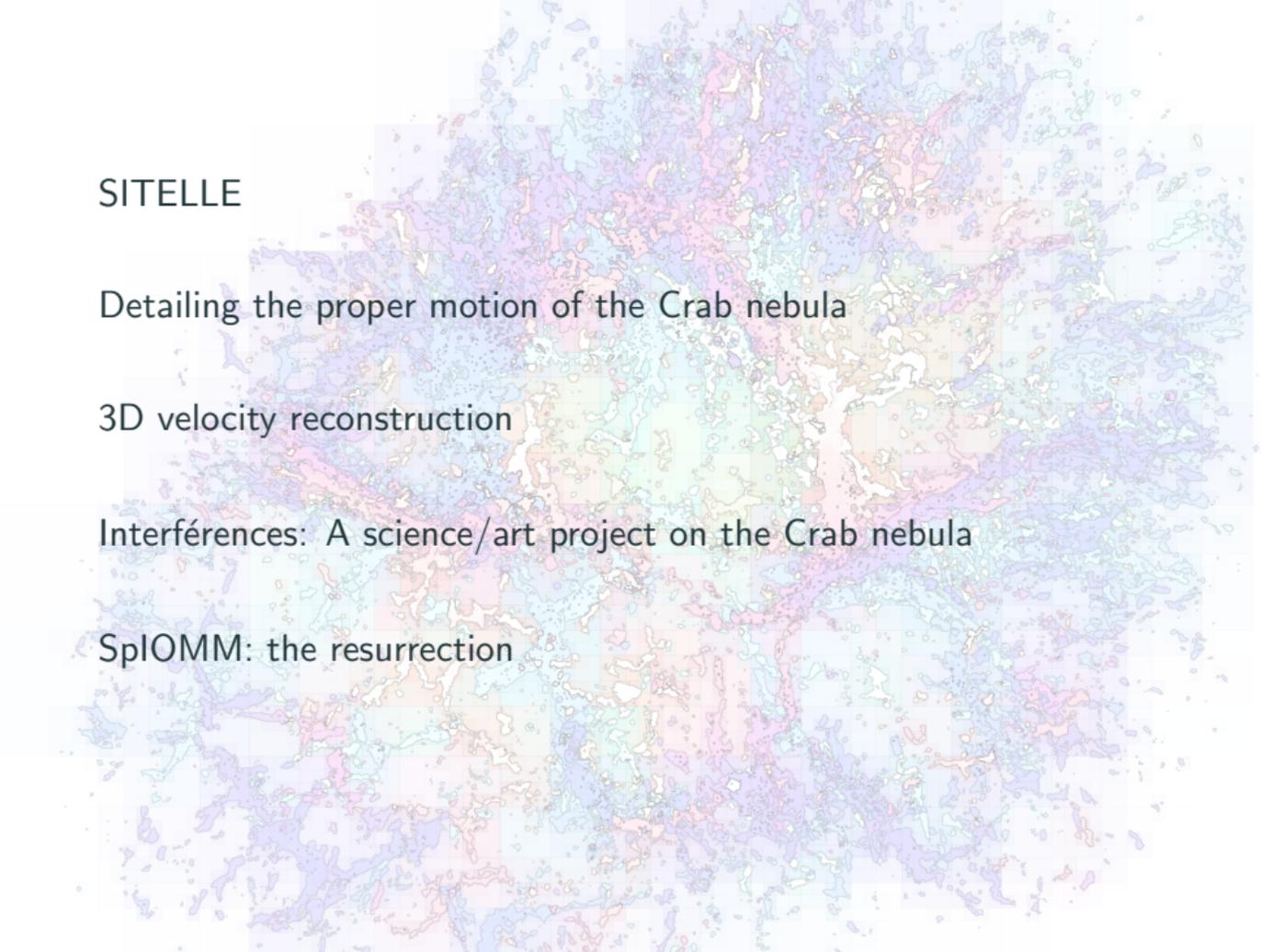
Towards a better 3D mapping of the Crab Nebula with SITELLE

May 10, 2023

+ Interférences
+ SPIOMM

Thomas Martin (Université Laval)
Laurent Drissen (Université Laval)





SITELLE

Detailing the proper motion of the Crab nebula

3D velocity reconstruction

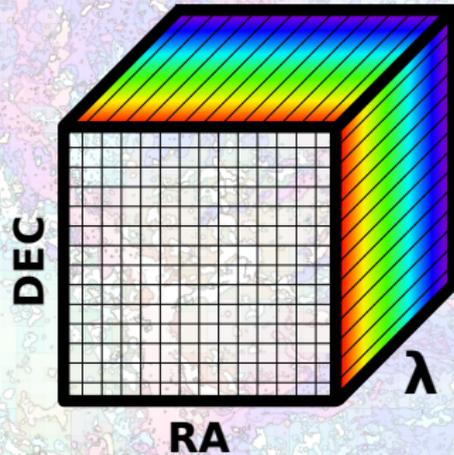
Interférences: A science/art project on the Crab nebula

SplOMM: the resurrection

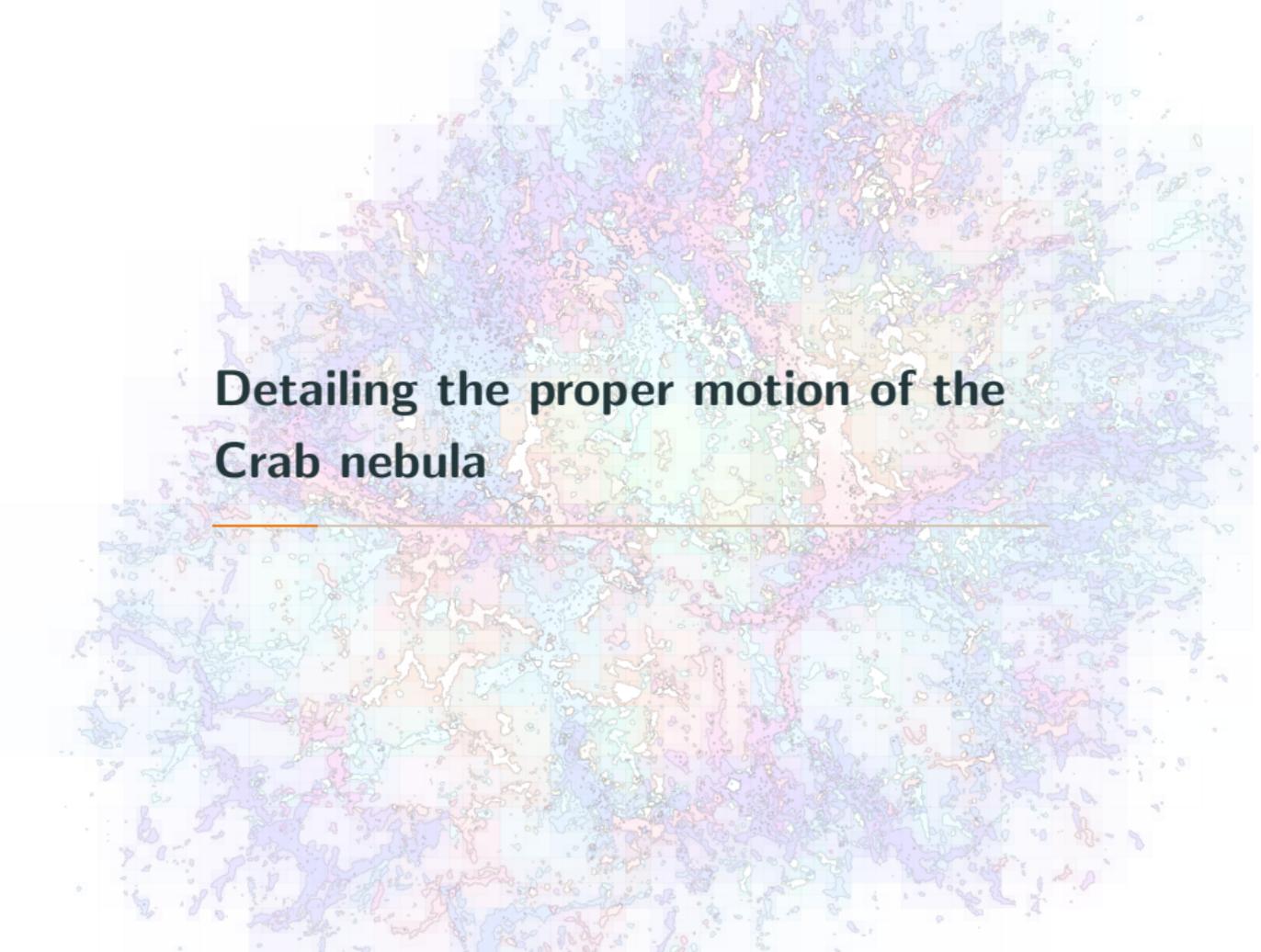
The image features a stylized, multi-colored map of Europe, where each country is filled with a different hue such as purple, blue, green, orange, and pink. A light gray grid is overlaid on the map. The word "SITELE" is printed in a bold, black, sans-serif font on the left side of the map. A thin orange horizontal line is positioned directly below the text.

SITELLE

SITELLE: an Imaging Fourier Transform Spectrometer



- Michelson interferometer
- **Hyperspectral data cubes**
 - large FOV: 11'x 11'
 - R up to 10,000
 - 4 million spectra per cube
 - from 350 (!) to 700 nm

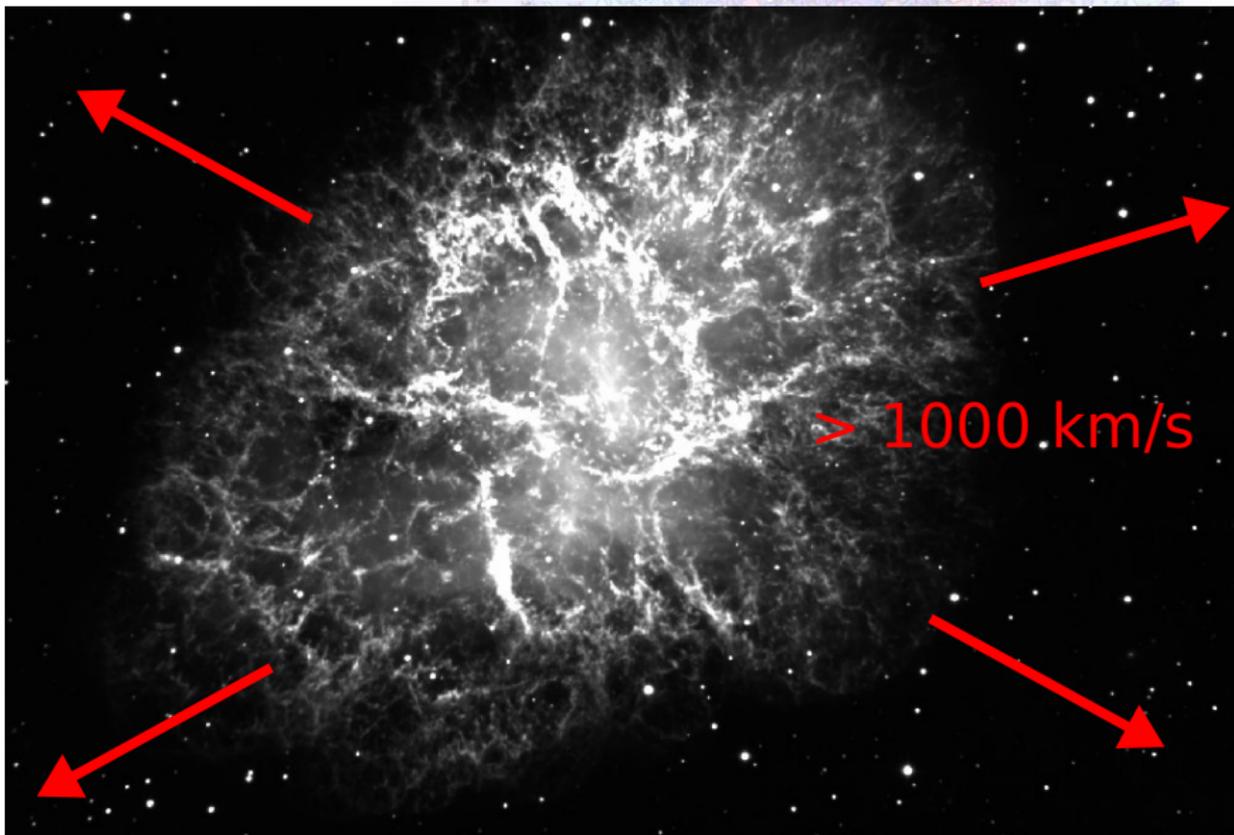


Detailing the proper motion of the Crab nebula

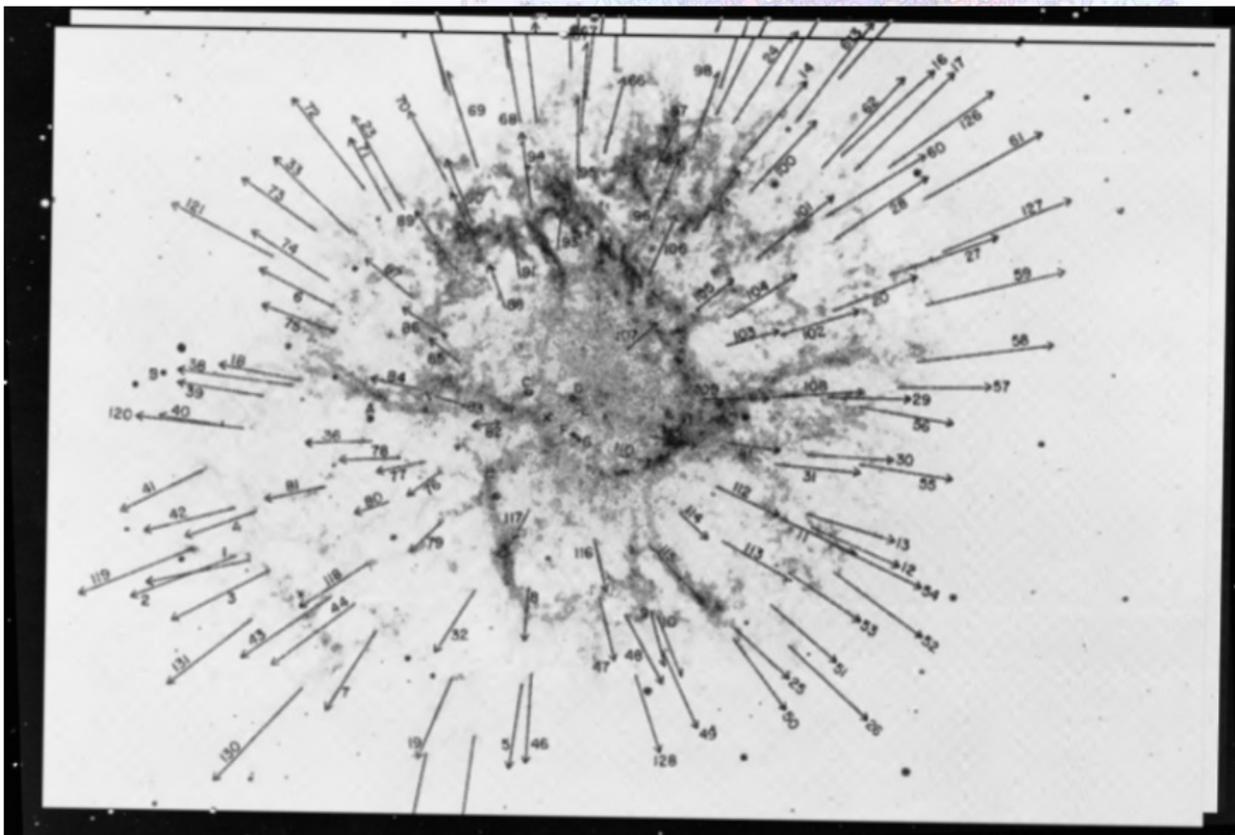
Baade 1950, Palomar







Virginia Trimble 1967



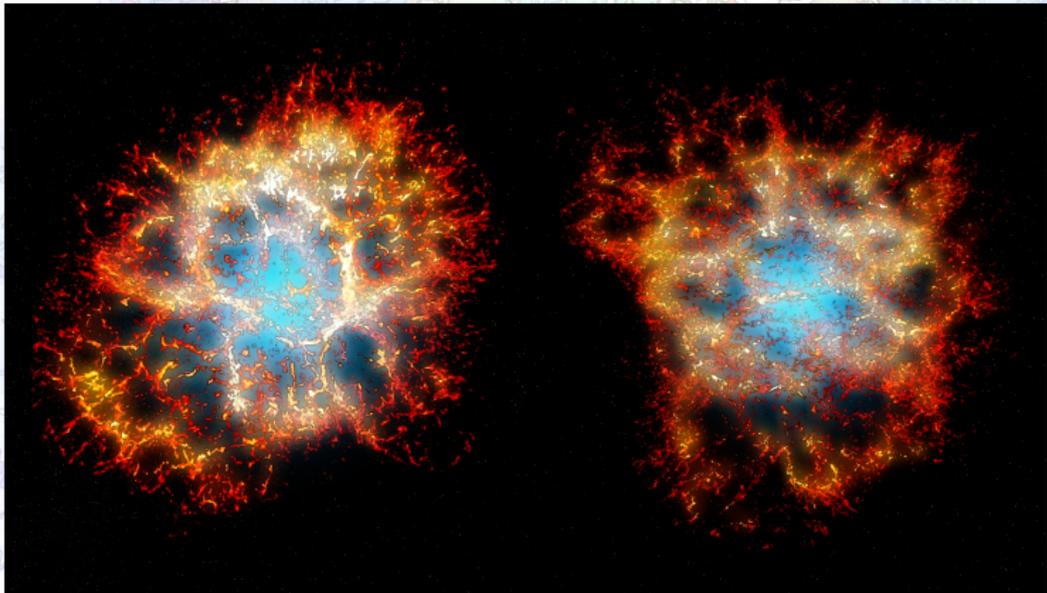
3D mapping of the Crab Nebula with SITELLE – I. Deconvolution and kinematic reconstruction

T. Martin ,  ^{1,2}★ D. Milisavljevic³ and L. Drissen^{1,2}

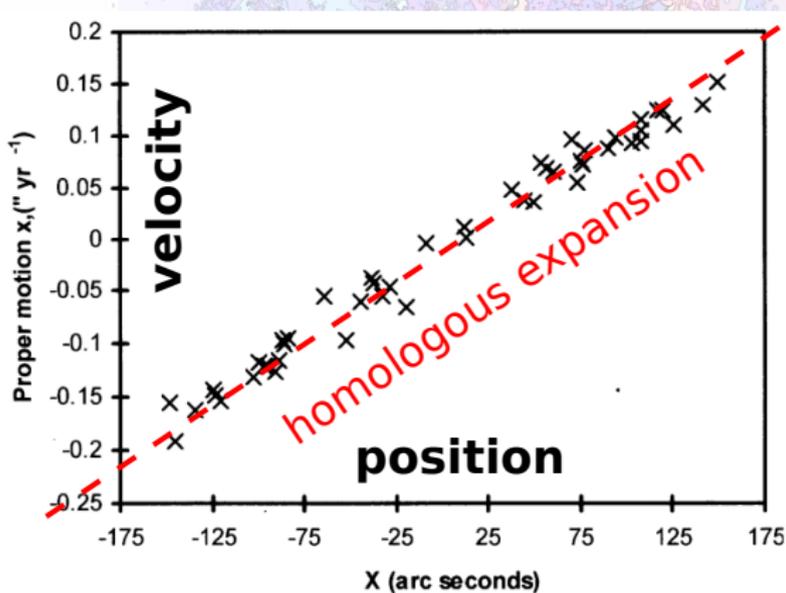
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²Centre de Recherche en Astrophysique du Québec, Département de physique, Université de Montréal C.P. 6128, Succ. Centre-Ville, Montréal (Québec) H3C 3J7, Canada

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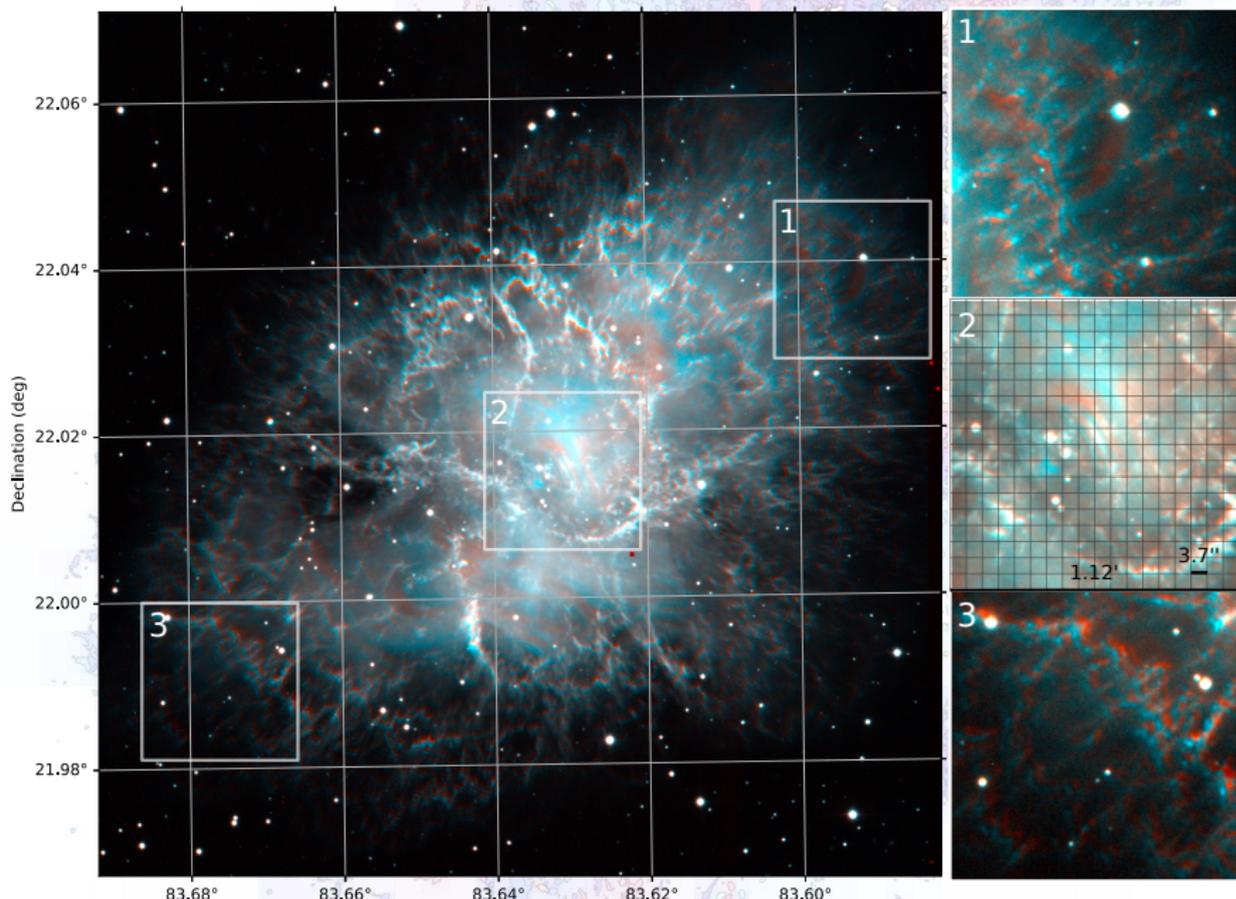


Hypothesis 1: homologous expansion

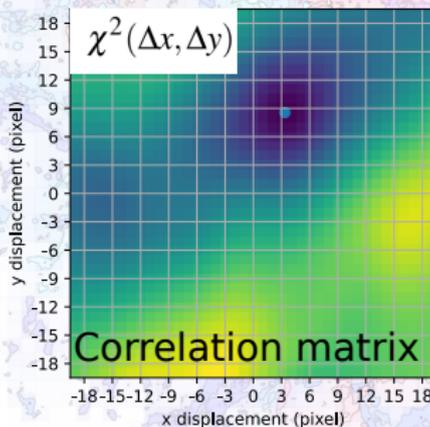
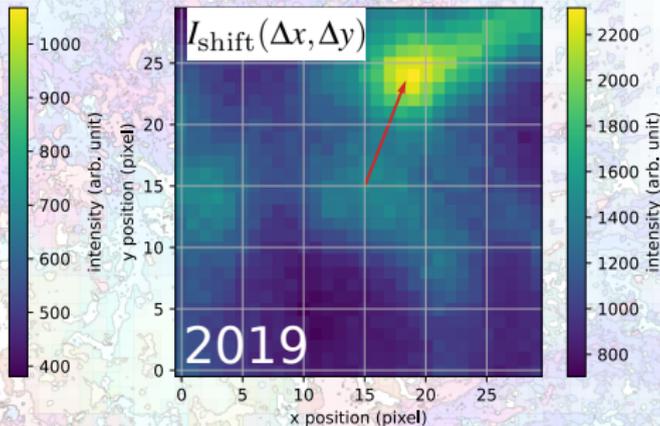
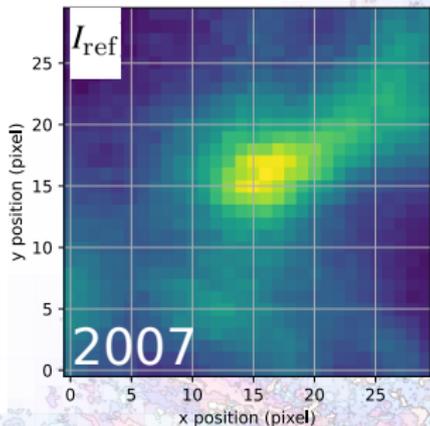


- homologous expansion: $\mu \propto r$

Paper II - MEGACAM images comparison (2007-2016-2019)



Algorithm (~Particle Image Velocimetry - fluid mechanics)



Brute force minimization

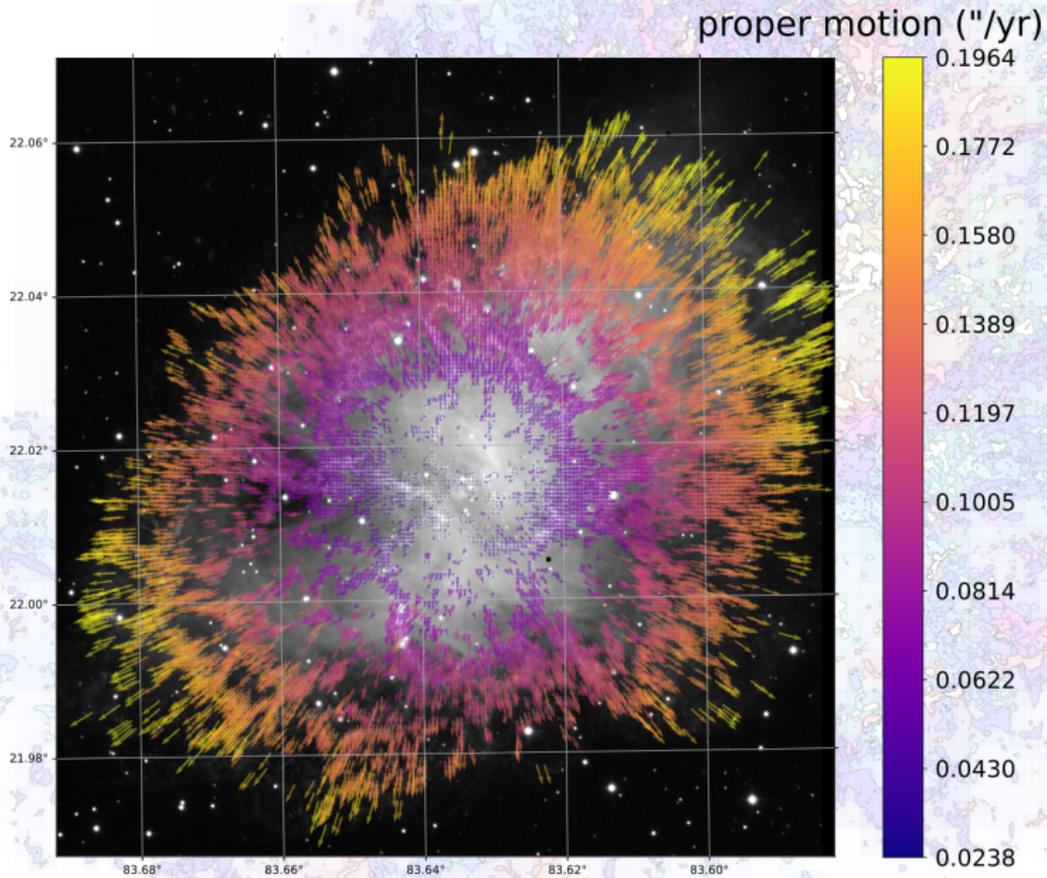
$$\chi^2(\Delta x, \Delta y) = \sum (I_{shift}(\Delta x, \Delta y) - I_{ref})^2$$

2019 tile is shifted in x,y
and the distance squared (χ^2)
is computed => χ^2 matrix.

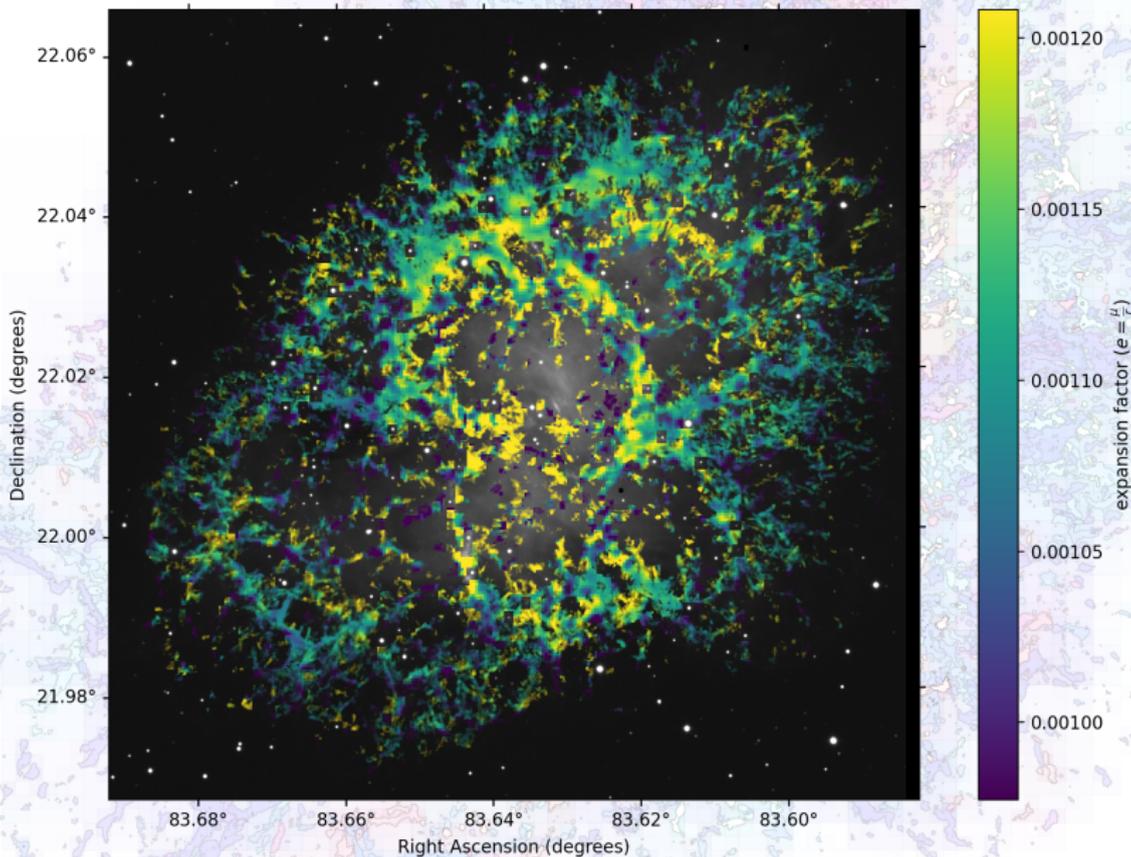
noise limited algorithm.

0.5 pixel < uncertainty < 1 pixel
seeing ~ 3.5 pixels

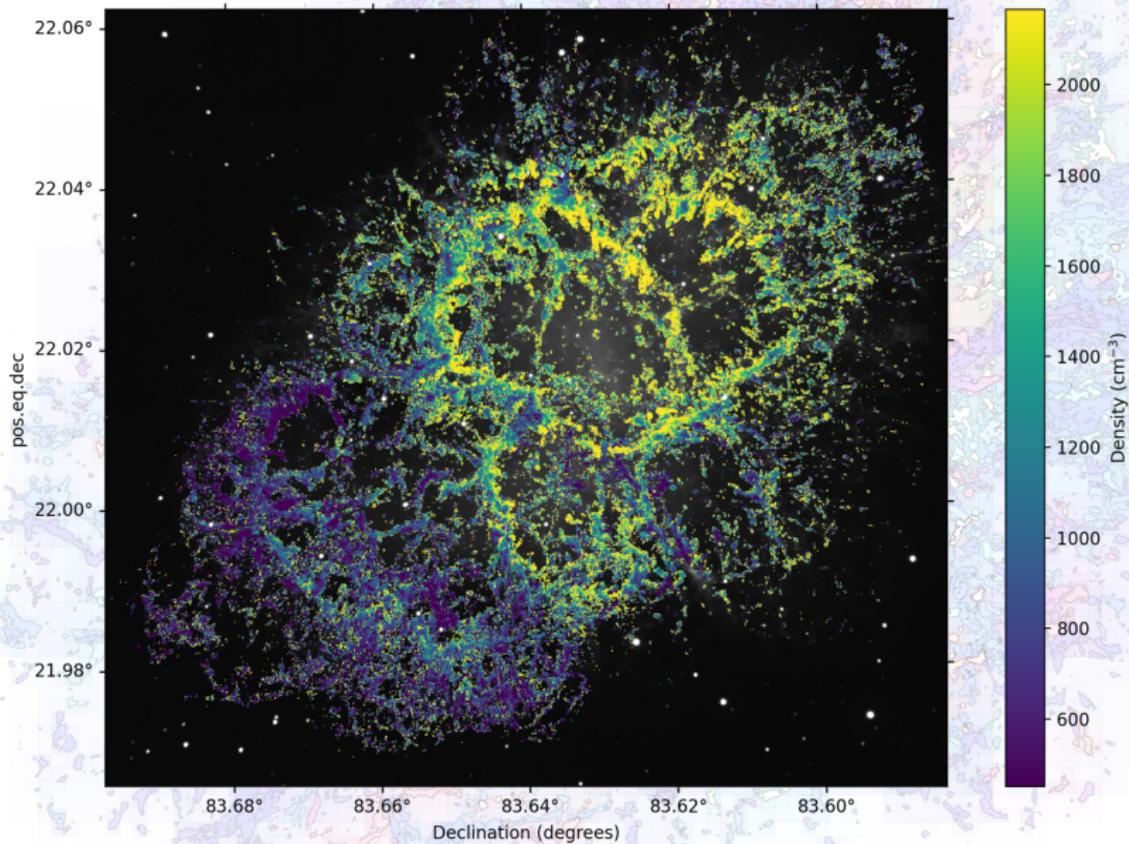
Proper motion map



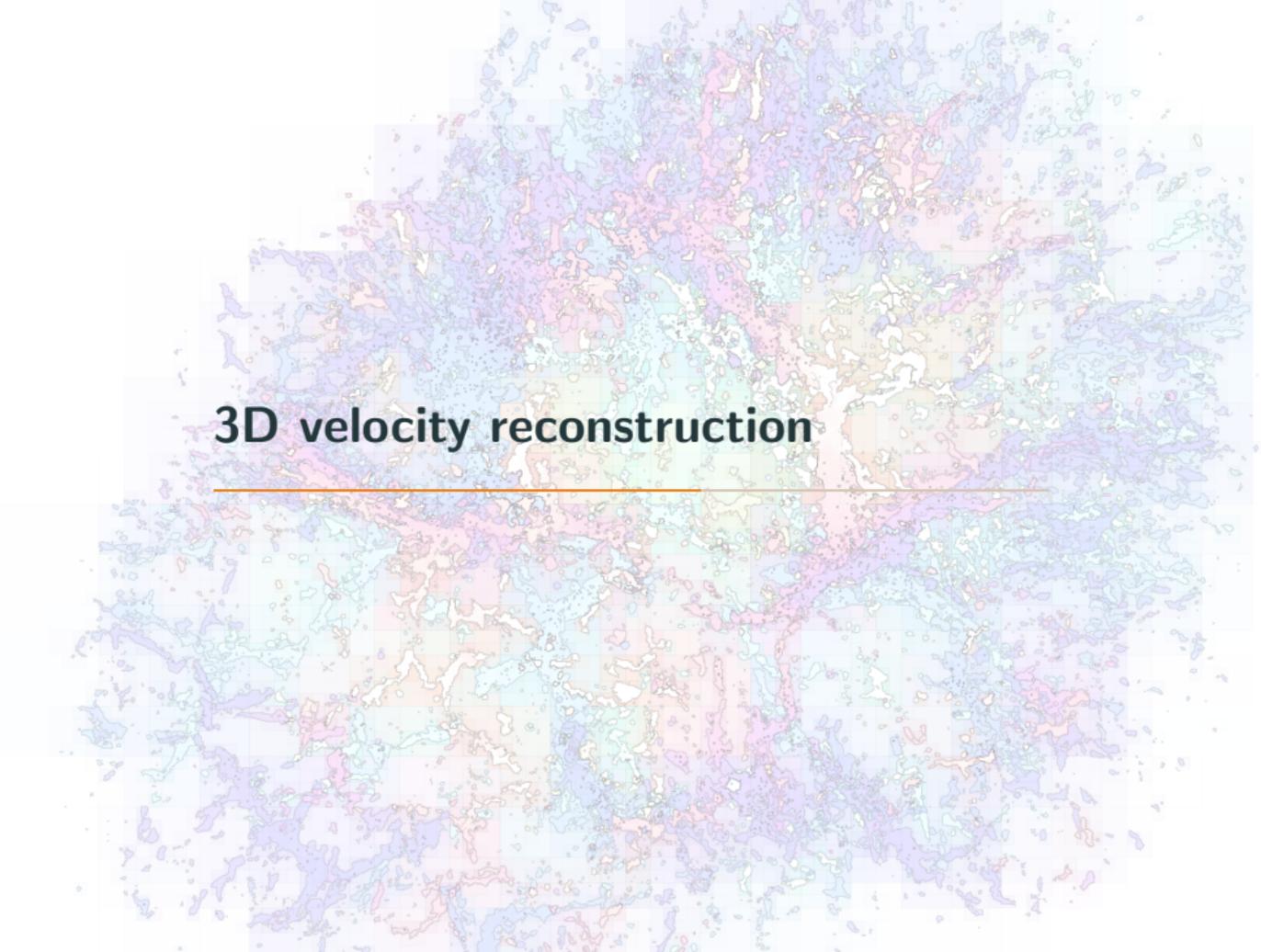
Expansion factor ($= \mu/r$)(should be flat if $\mu \propto r$)



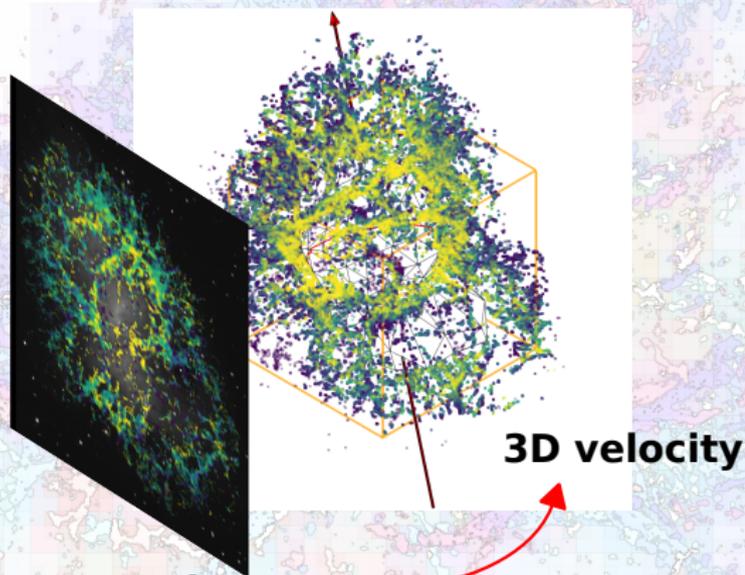
Comparison with density (obtained with SITELLE in dec 2022)



3D velocity reconstruction



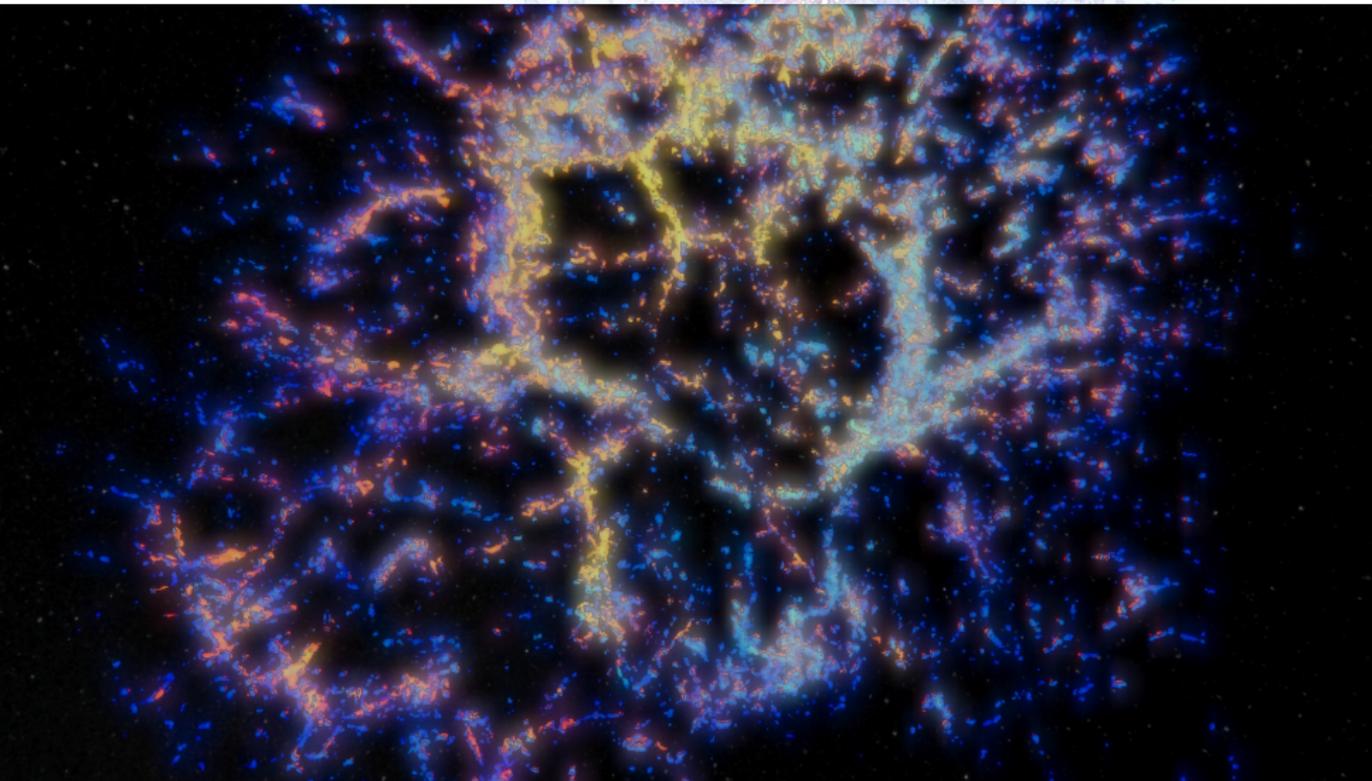
Paper III - From 2D proper motion to exact 3D velocity



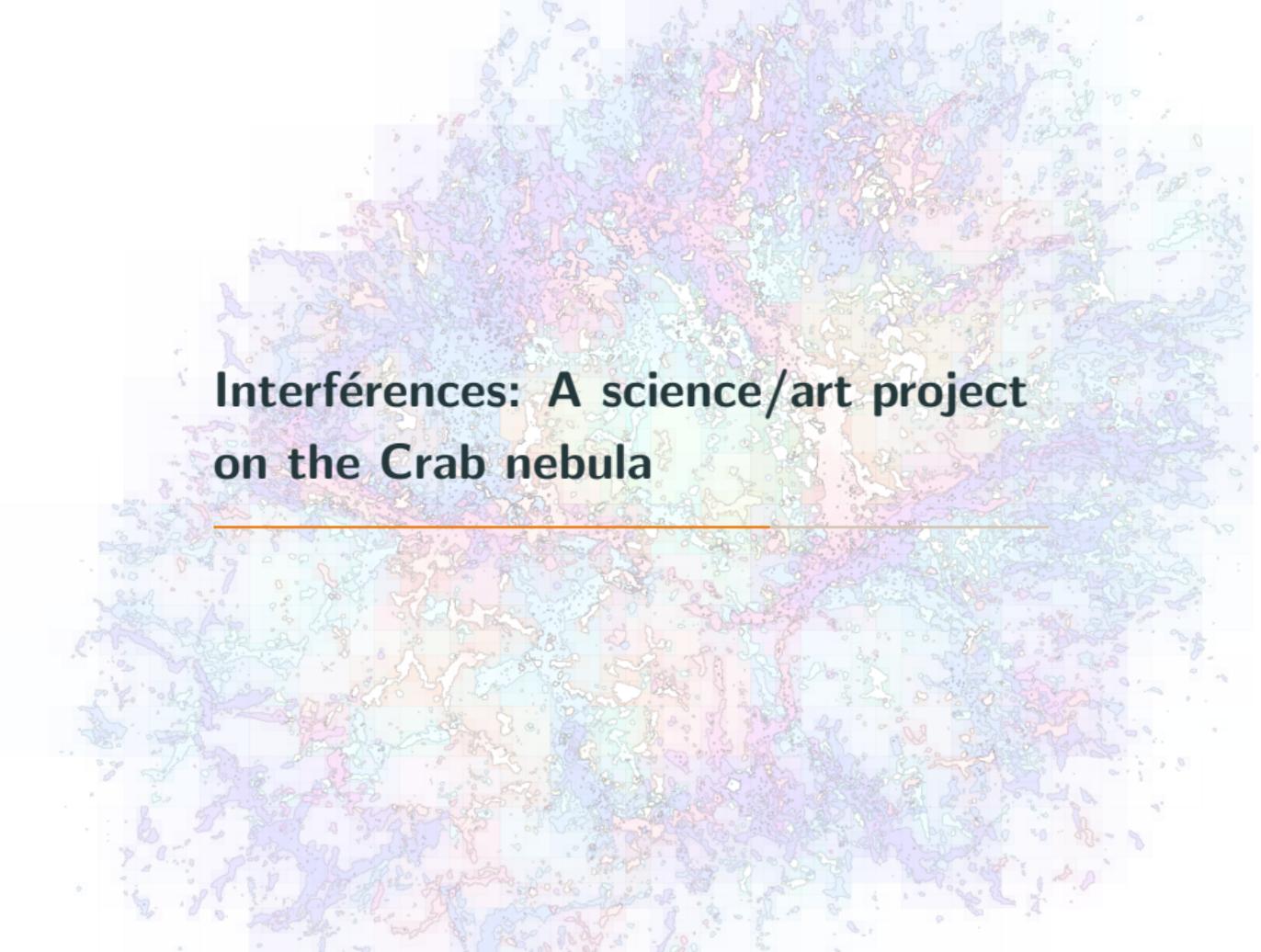
2D proper motion
= mix of multiple components
along the line of sight

?

- answer: We obtained **2 cubes** of the same object (2016, 2022)



- RED: nov. 2016
- BLUE: dec. 2022



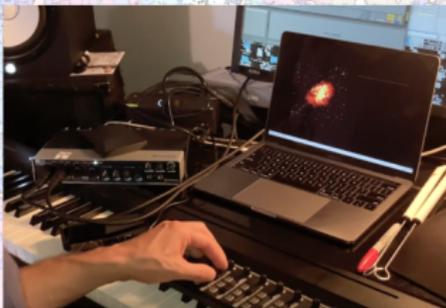
**Interférences: A science/art project
on the Crab nebula**

Origins

Pulsart Trio (Québec)

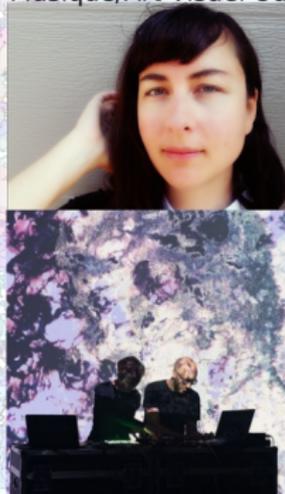


sound synthesis
from SITELLE data



+ **3D data** of the Crab

Myriam Boucher
(Pr. Musique/Art Visuel UdeM)



+ Program **PRISME-ART** - FRQNT/FRQSC (pilot project)

The project: A story of the Space/Humanity relationship through the Crab

Musique

Rafael Zaldivar (co-PI, Pr. ULaval)

Pulsart Trio (composition audio + narratif)

Jérémie Carrier (Dr. musique, vibraphone)

Simon Beauséjour (batterie, percussion)

Olivier Madore-Millette (orgue, piano, synthé)

Andrée Lévesque-Sioui (chant)

Serges Samson (prise de son, mix, mastering @LARC ULaval)

Mathieu David-Gagnon (tutoriel Arp, Moog, Synthi)

Science

Laurent Drissen (co-PI, Pr. ULaval)

Thomas Martin (synthé SITELLE, données 3D, coordination, narratif)

Jean-François Robitaille (Université Grenoble-Alpes)

Mitchell Mickaliger (Radio data, Manchester university)

Laurie Rousseau-Nepton (CFHT, consulting on indigeneous cosmogony)

Paul Charbonneau (New Mexico pictures, UdeM)

Fidèle Robichaud (Professionnel de recherche à l'OMM)

Comm

Carolanne Charette (documentation du processus)

Mathieu Arseneault (coordination, UdeM)

Video

Myriam Boucher (co-chercheuse, Pr. UdeM composition visuelle, VJ)

Marc-André Yonkers-Vidal (artiste visuel)

Eruoma Awashish (artiste visuel)

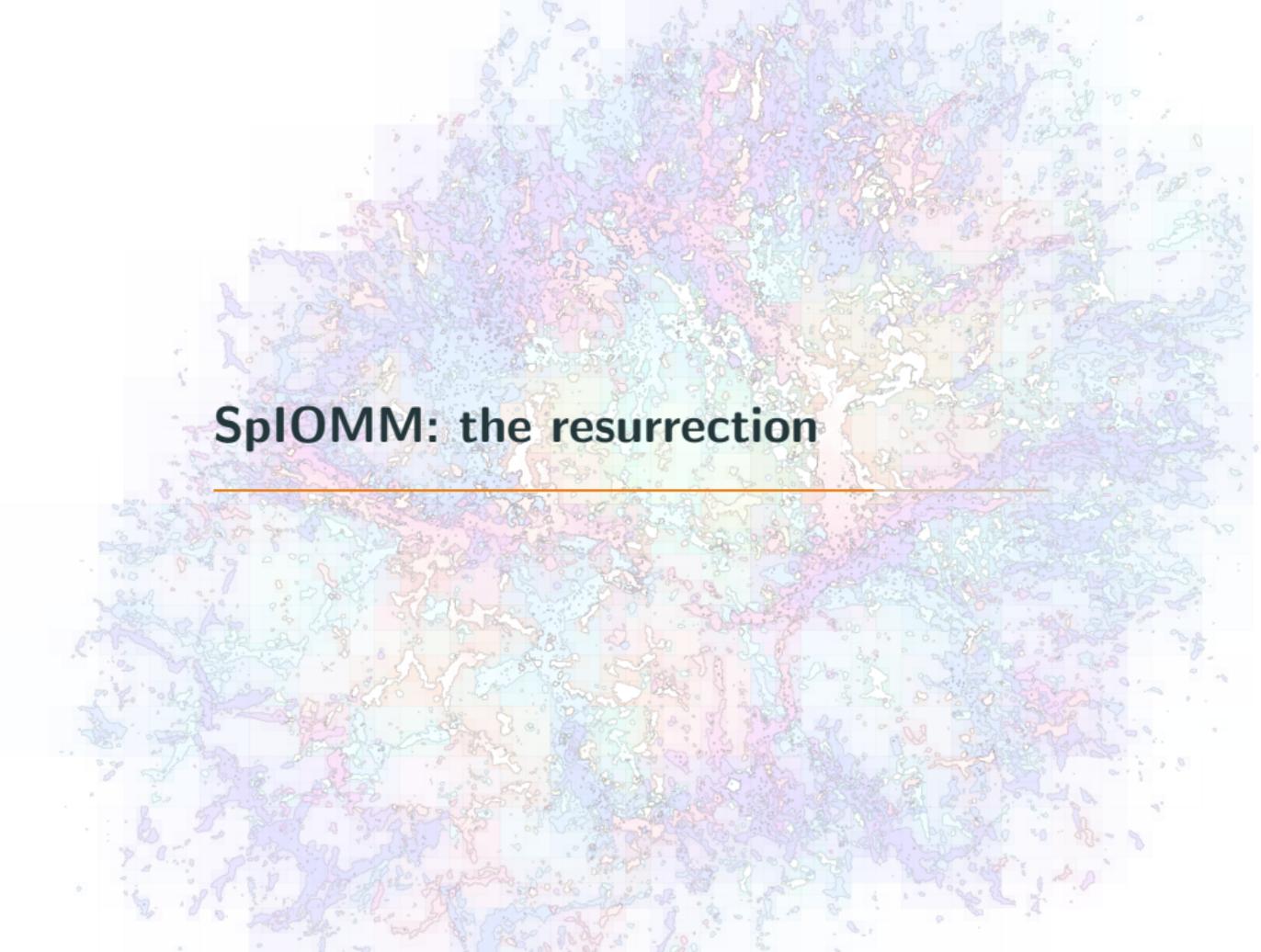
Jérémie Martineau (visuel, prises vidéo 360, UdeM)

Jean-Sébastien Shnubb (rendu 3D, UdeM)



360 Live performance @ Planétarium de Montréal (end of 2023)
+ 2D performances in festivals
+ Studio recorded soundtrack + 2D video





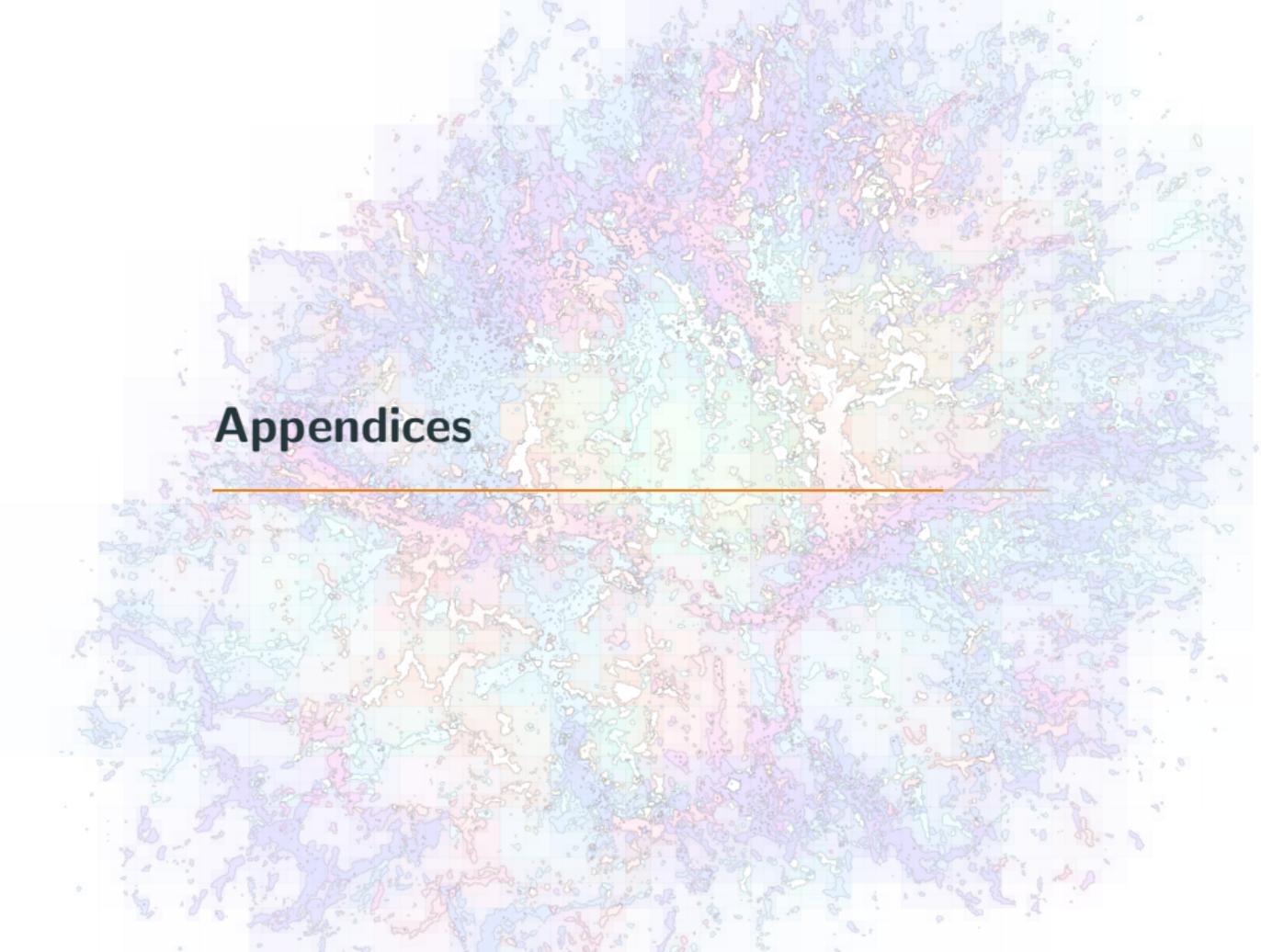
SpIOMM: the resurrection



- SplOMM (SITELE prototype) died in August, **2015**
- We start to rebuild in October **2019**.
 - Rewrite servo code from scratch
 - **Vanessa Livernoche** (Cégep La Pocatière)
 - Nexline replacement
 - white light replacement
 - "Jupette" replacement
 - **Fidèle Robichaud**: Telescope debugging + maintenance

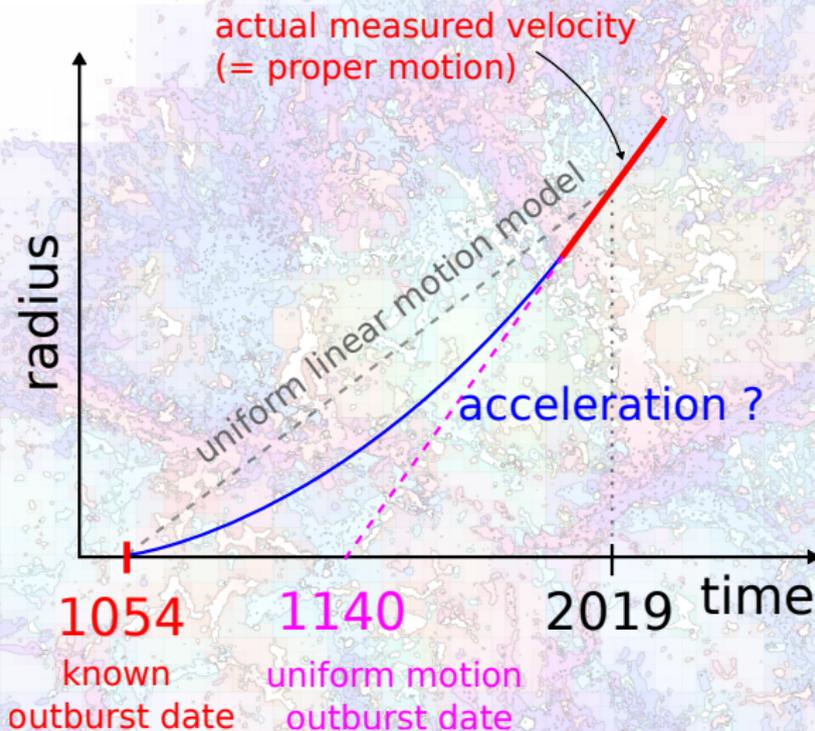


- June 25th, **2021, Commissioning** (+ Vanessa Livernoche, Gabriel Savard): SplOMM OK but **telescope was shaking at some places.**
- December **2022, Telescope testing** (+ Billy Gamache): **OK**
- March, 11th **2023, Science Verification** (+ Damien Beaulieu): **OK**
- SplOMM is now ready for the great adventure!



Appendices

Hypothesis 1b: uniform motion

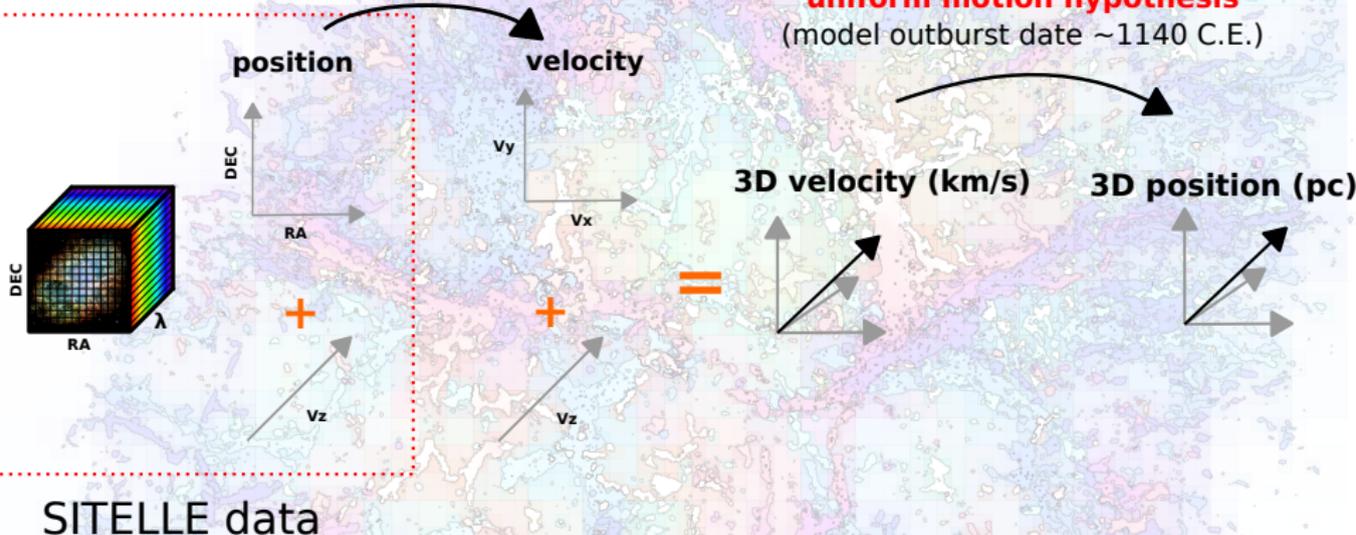


- uniform motion: $r = vt$

3D reconstruction model

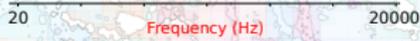
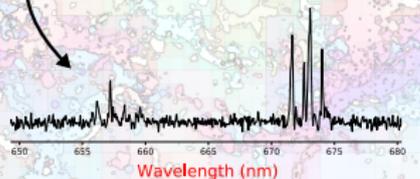
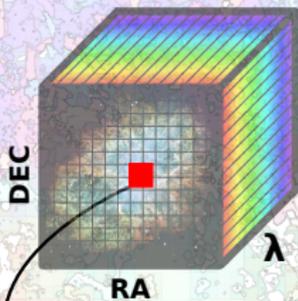
homologous expansion hypothesis

uniform motion hypothesis
(model outburst date ~ 1140 C.E.)



- Up to now: no precise measurement of the proper motion everywhere to try and obtain a more robust model.

Sound synthesis with SITELE



MIDI controlled parameters

frequency range, brightness, distortion pitch, envelope, velocity ...

