Missed Debris Disks in the HST archive

An insight of the ALICE project

Elodie Choquet

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The ALICE group at STScI:

R. Soummer (PI), M. Perrin, L. Pueyo, B. Hagan, E. Gofas-Salas, C. Chen, D. Golimowski, J. Debes, D.C. Hines, A. Sivaramakrishnan, C. Stark, A. Moro-Martin, S. Wolff, J. Mazoyer, M. N'Diaye, M. Ygouf, A. Greenbaum, B. Ren

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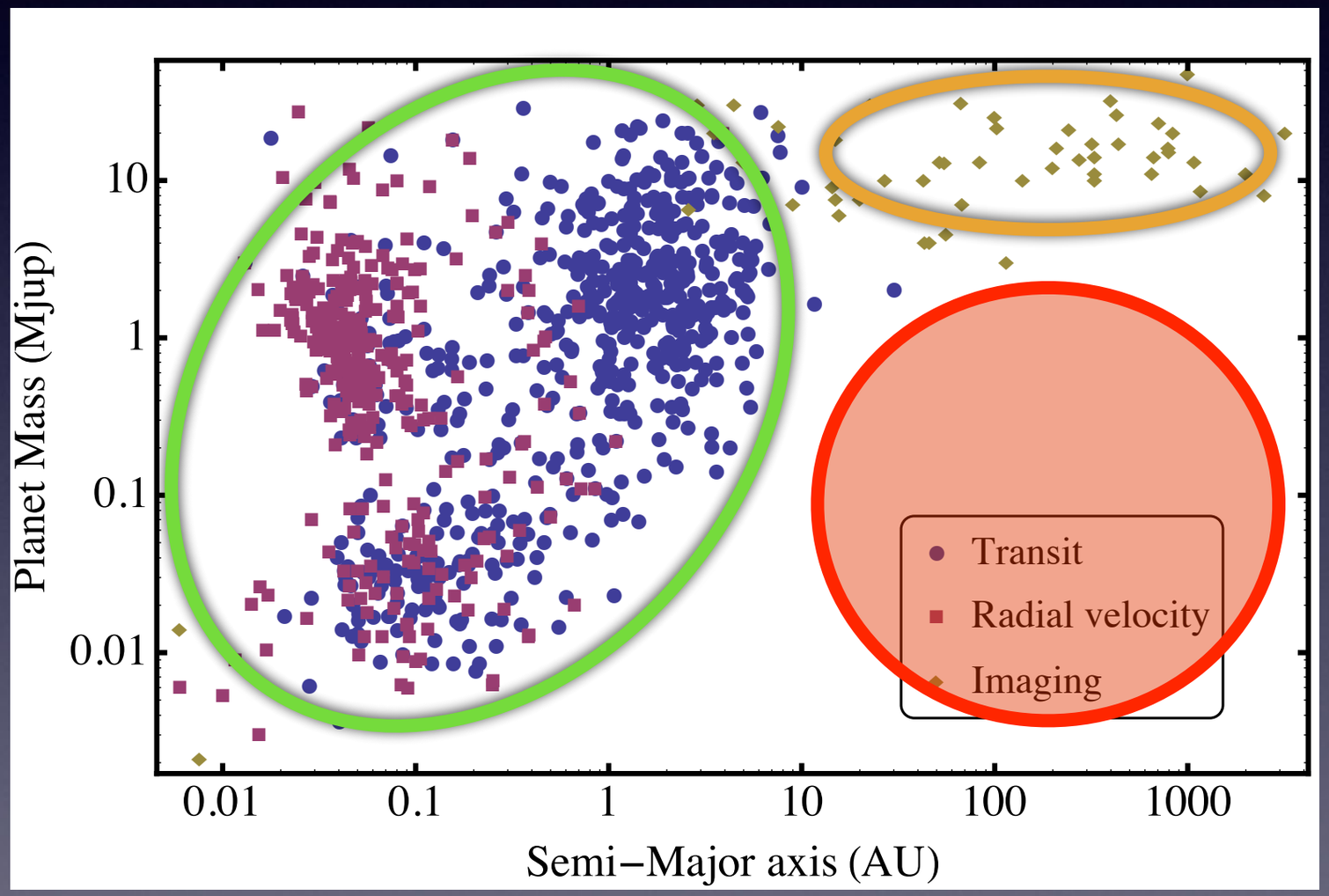
May 20th 2016, Santiago

Exoplanet Exploration:
Statistical census

Petigura et al. 2013
Dong & Zhu 2013
Batalha 2014
Burke et al. 2015
...

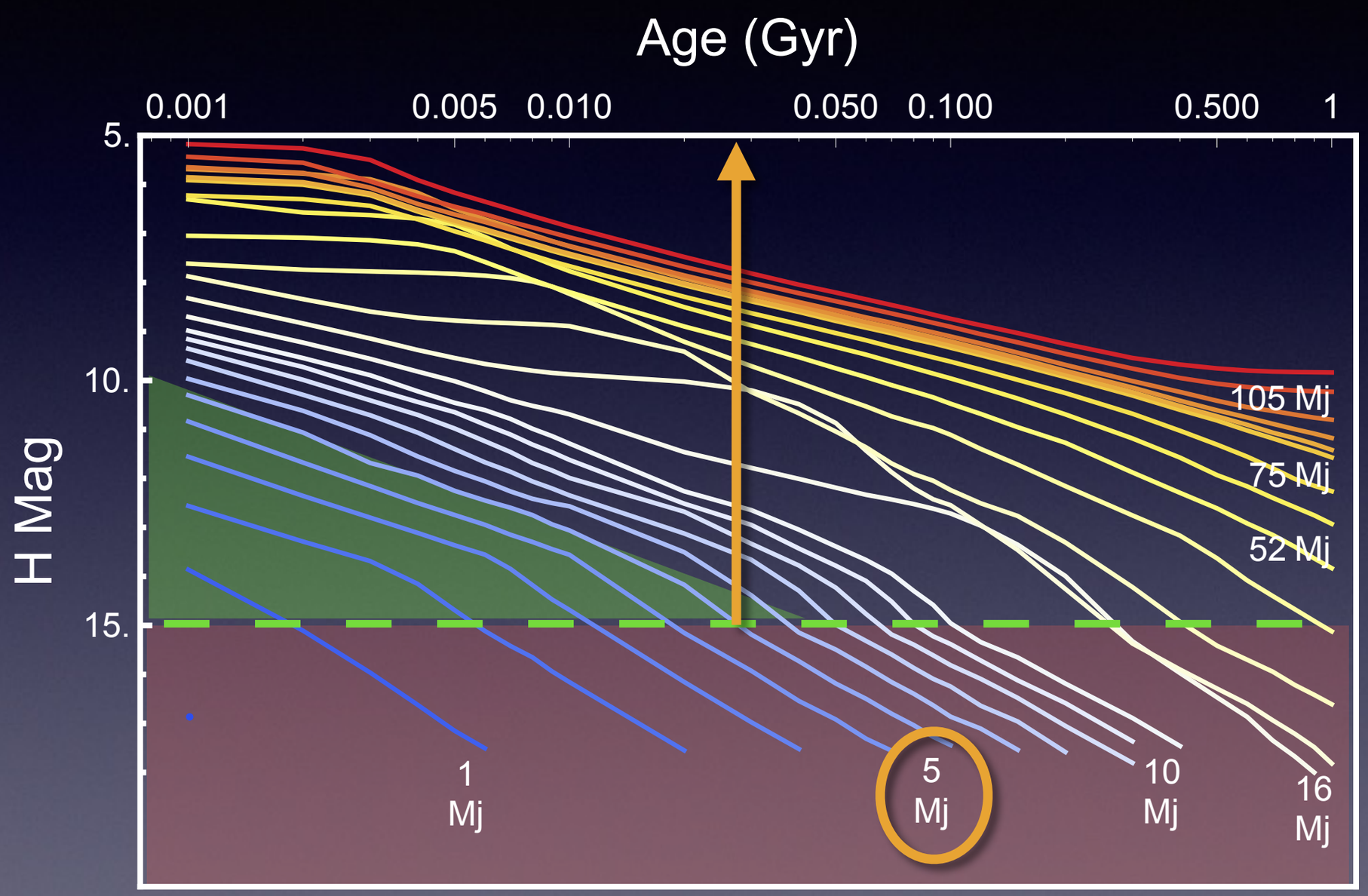


Rameau et al. 2013
Biller et al. 2013
Chauvin et al. 2015
...

exoplanet.eu

Exoplanet Exploration:

Limitations of HCI planet surveys



Allard et al. 2003
BT-Settl models

For a given abs. mag. limit, eg. H = 15 here:

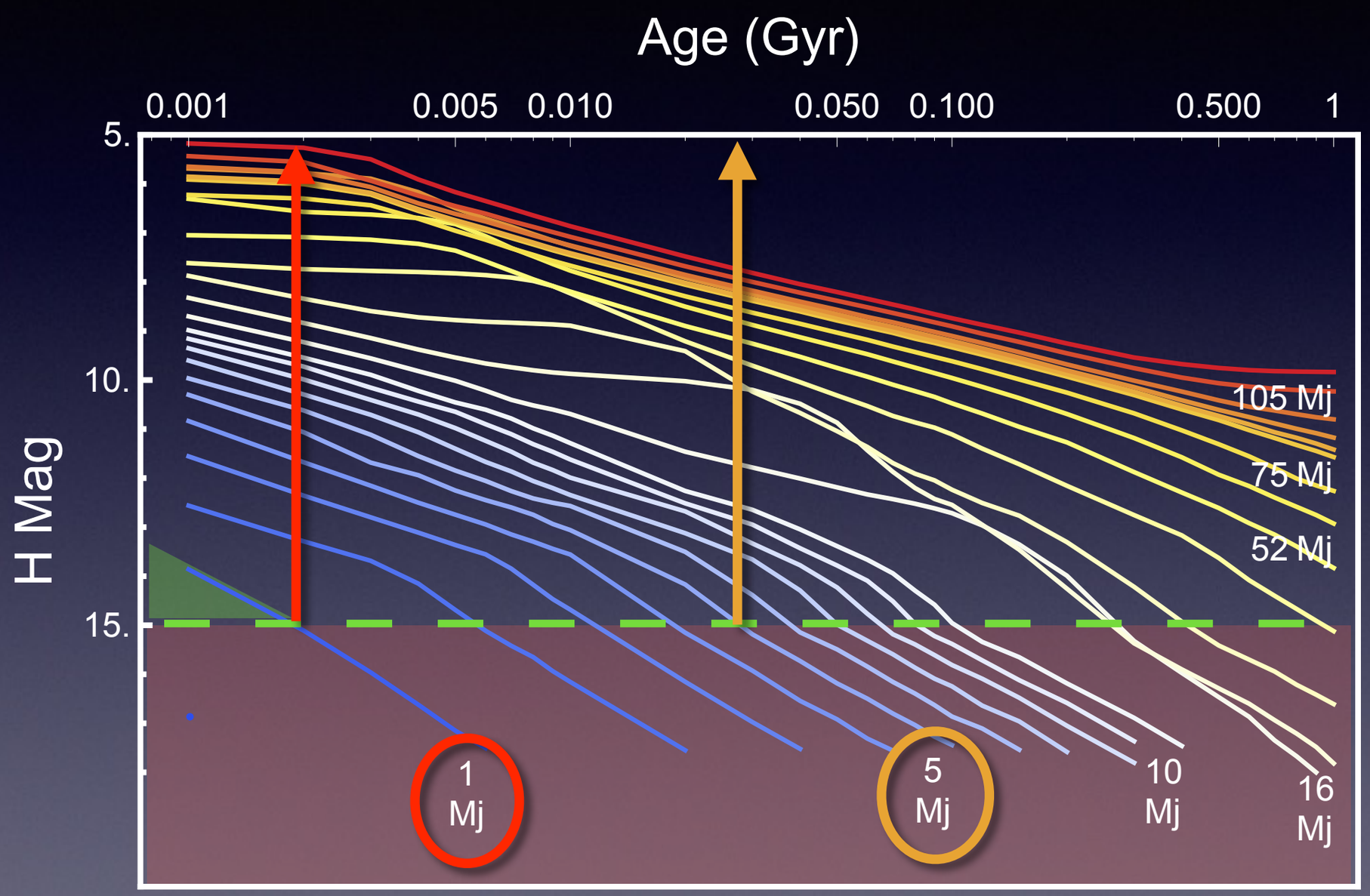
Planet apparent mag:

- h = 15 at 10pc
- h = 20 at 100pc

- **5 Mjup planets can be detected only if Age < ~30Myr**

Exoplanet Exploration:

Limitations of HCI planet surveys



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For a given abs. mag. limit, eg. H = 15 here:

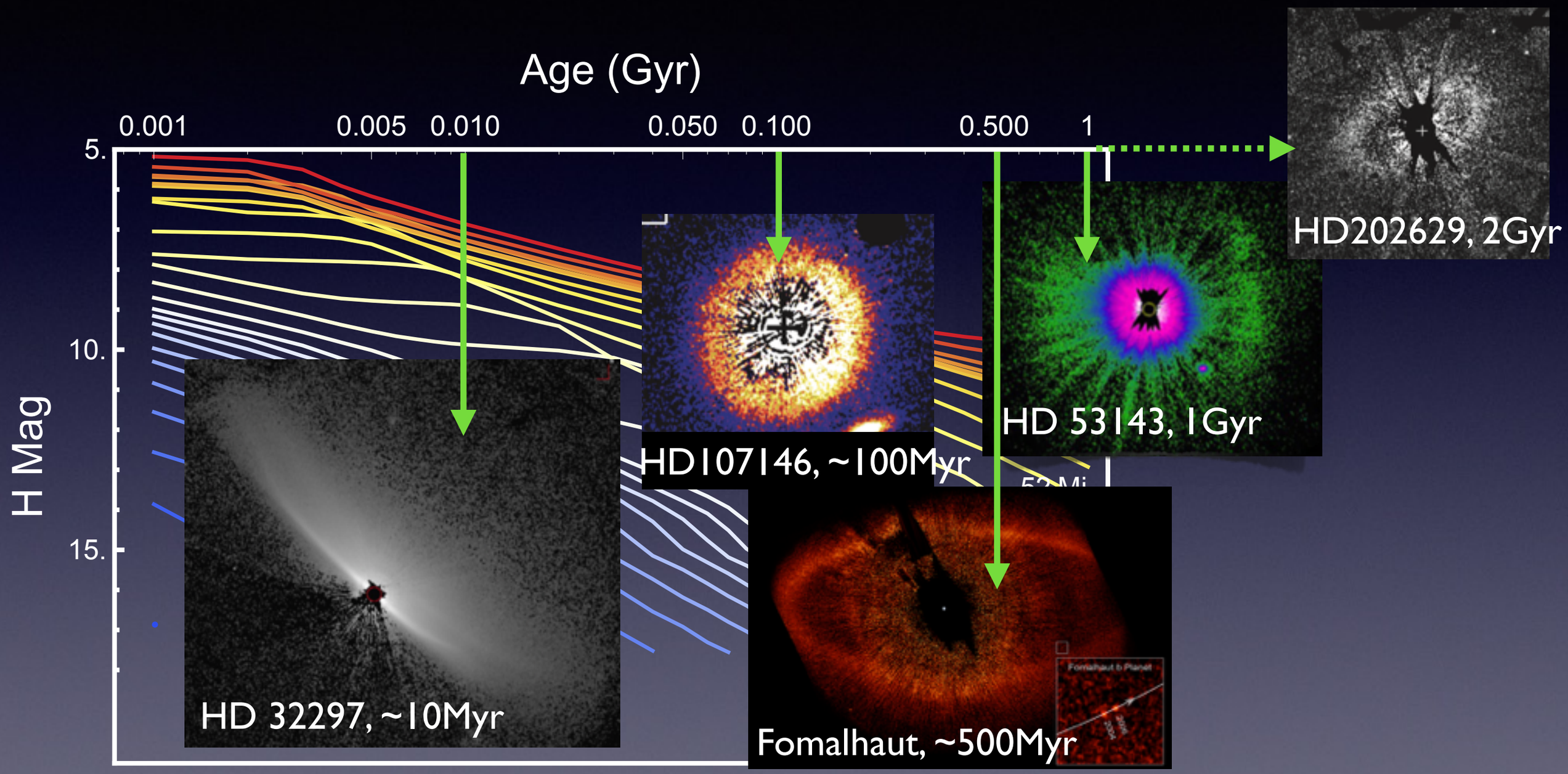
Planet apparent mag:

- h = 15 at 10pc
- h = 20 at 100pc

- **5 Mjup planets can be detected only if Age < ~30Myr**
- **1 Mjup planets: only if Age < ~2Myr**

Exoplanet Exploration:

Limitations of HCI planet surveys



Debris disk studies:
searching signposts of planets from ~5Myr to 1Gyr

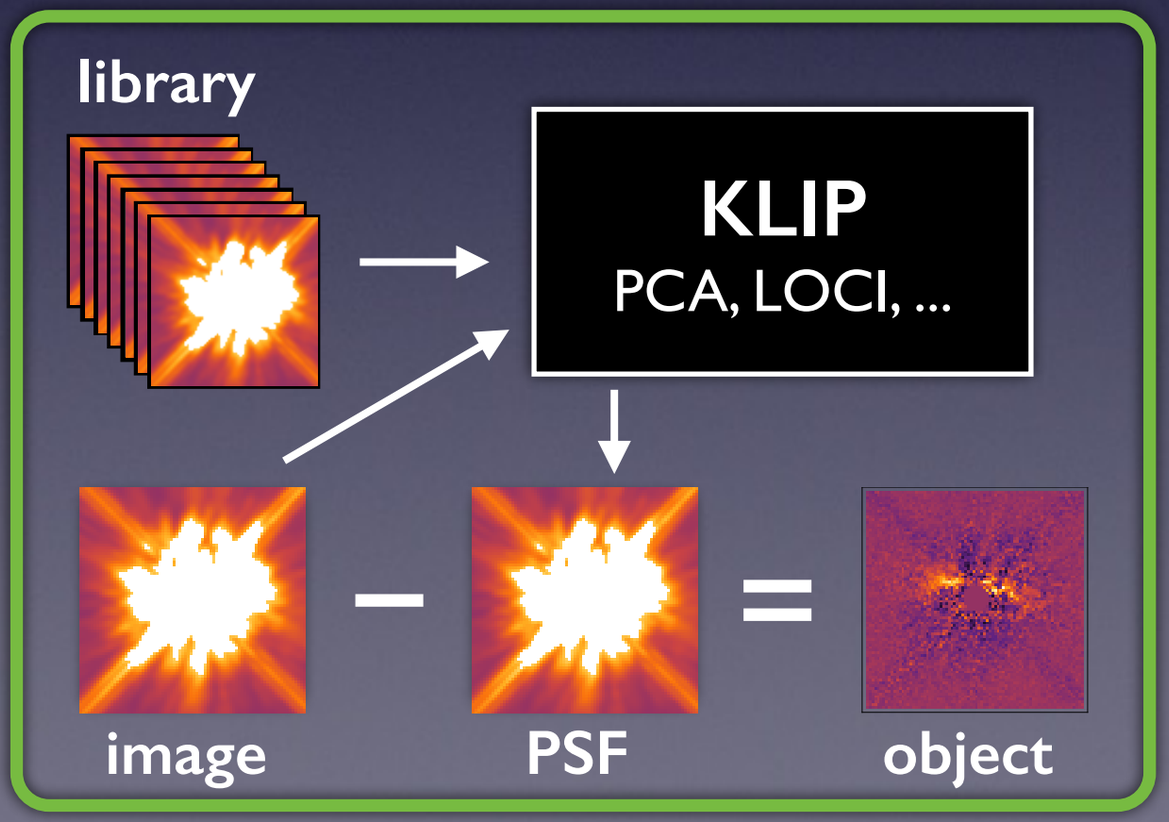
The ALICE project

Archival Legacy Investigations of Circumstellar Environments

PI: R. Soummer (STScI)

Re-analysis of the NICMOS coronagraphic archive using advanced post-processing methods

PSF-library-based algorithms



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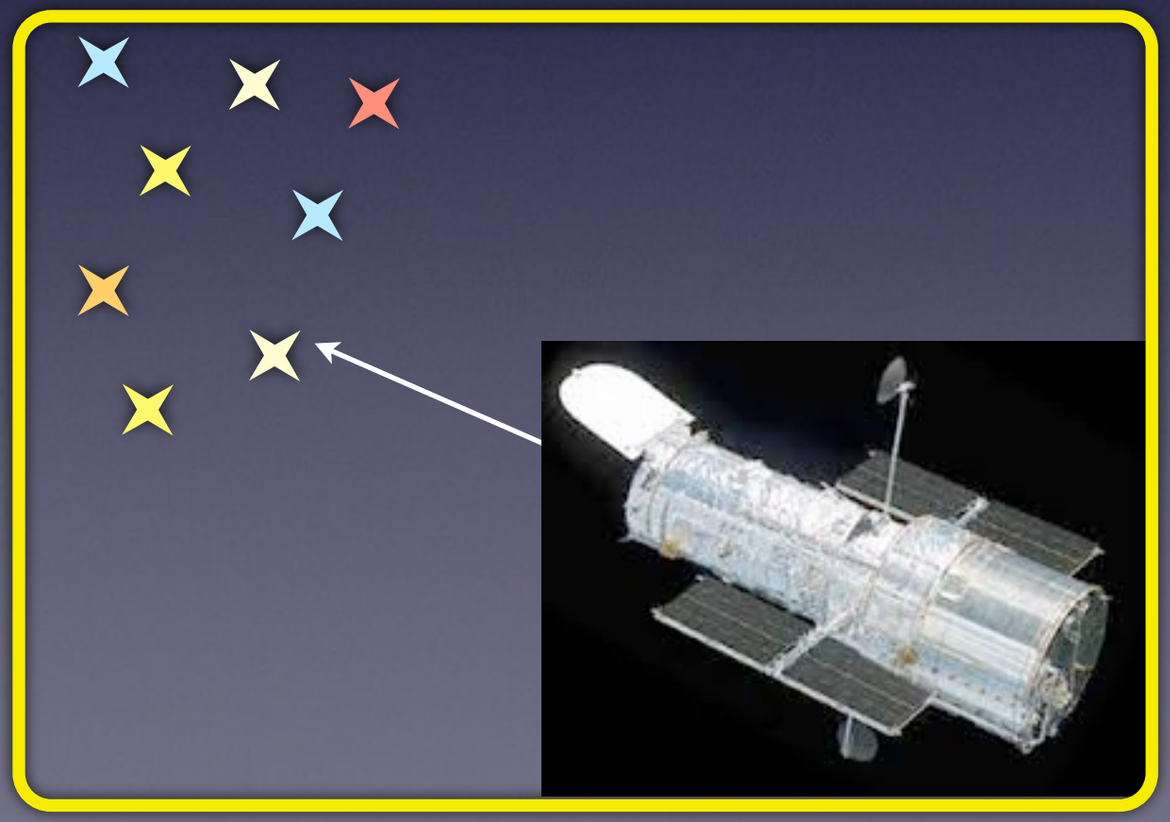
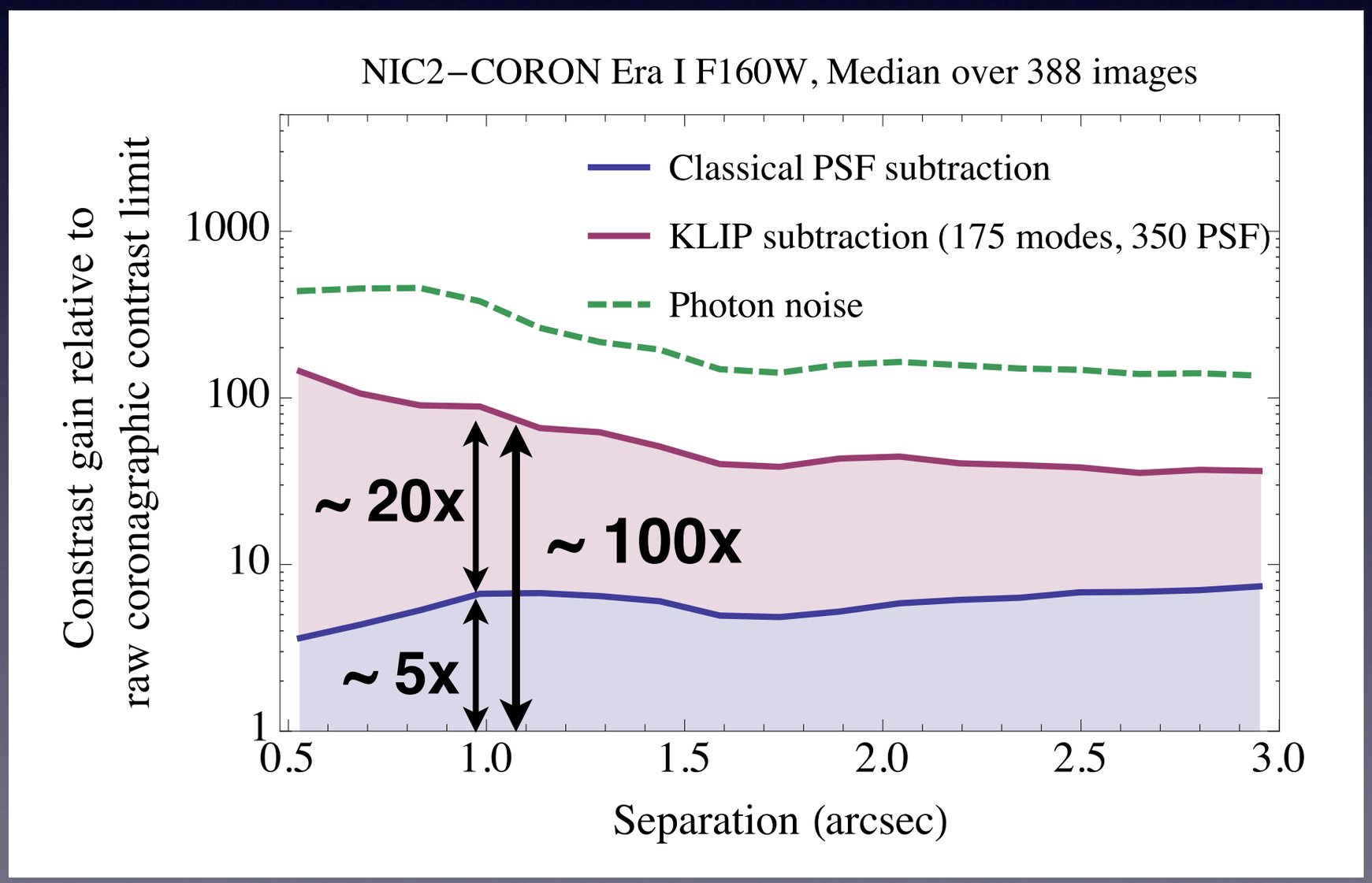
Multi References Differential Imaging



Overall performances

- Mean gain over raw coronagraphic PSF: **~ 100x at 1”**
- Mean gain over classical PSF subtraction: **~ 20x at 1”**



The NICMOS archive:

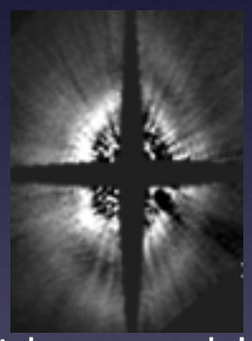
Debris disk detections in its lifetime

of targets / program

HR 4796A

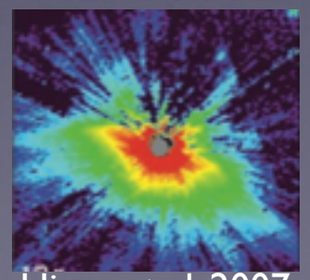
Schneider et al. 1999

HD 141569A

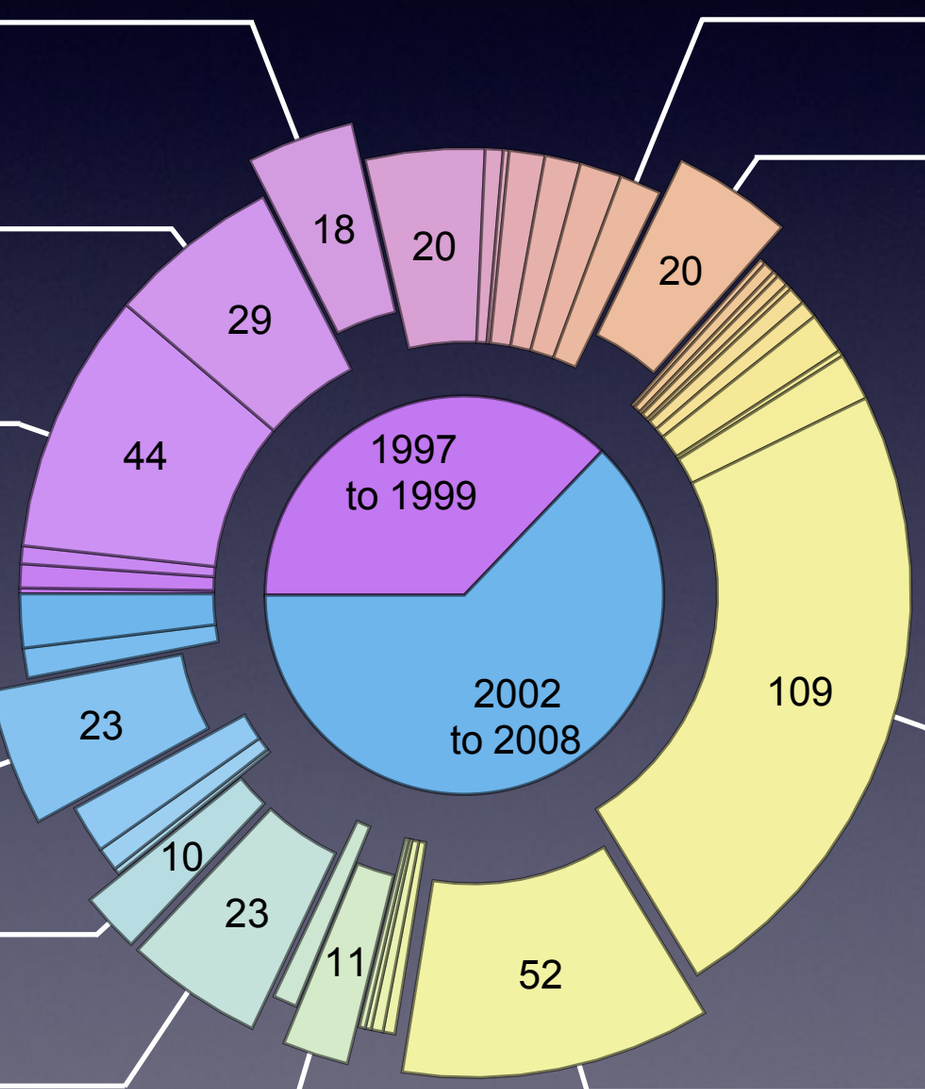


Weinberger et al. 1999

HD 61005



Hines et al. 2007



Debris disk survey
(Smith, 1999)
1 detection

Planet survey
(Schneider, 1999)

Planet survey
(Becklin, 1999)
1 detection

Debris disk survey
(Metchev, 2007)

Debris disk survey
(Weinberger, 2006)

Debris disk survey
(Hines, 2006)
1 detection

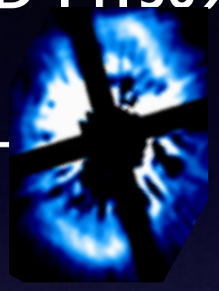
Debris disk survey
(Ardila, 2006)

Debris disk survey
(Clampin, 1999)

Planet survey
(Song, 2005)

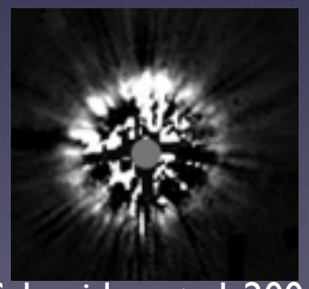
YSO Debris disk survey
(Schneider, 2005)
2 debris disk detections

HD 141569A



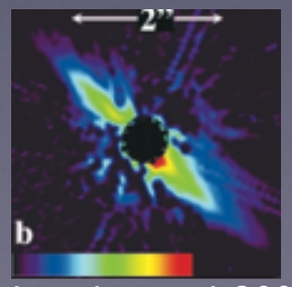
Augereau et al. 1999

HD 181327



Schneider et al. 2006

HD 32297



Schneider et al. 2005

The NICMOS archive:

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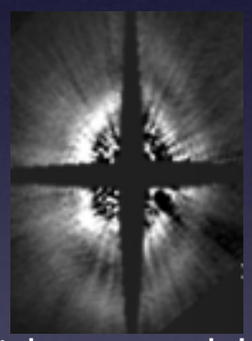
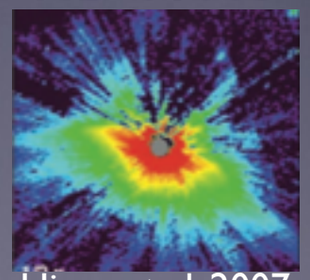


Weinberger et al. 1999

HD 61005



Hines et al. 2007

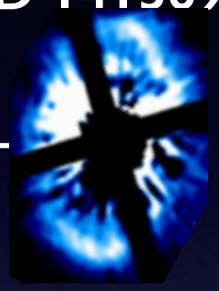
Debris disk survey
(Smith, 1999)
1 detection

Debris disk survey
(Hines, 2006)
1 detection

Debris disk survey
(Ardila, 2006)

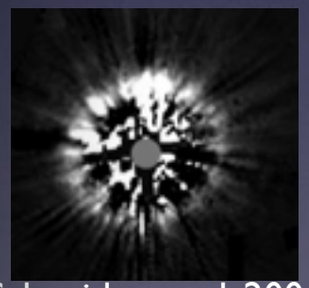
Debris disk survey
(Schneider, 2005)
2 debris disk detections

HD 141569A



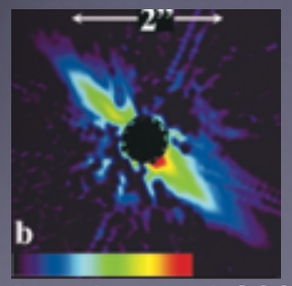
Augereau et al. 1999

HD 181327



Schneider et al. 2006

HD 32297

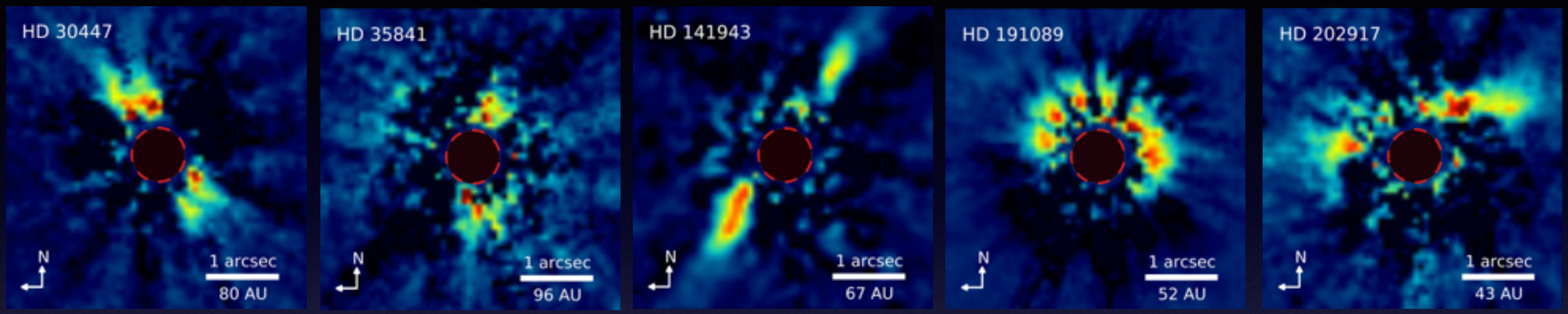


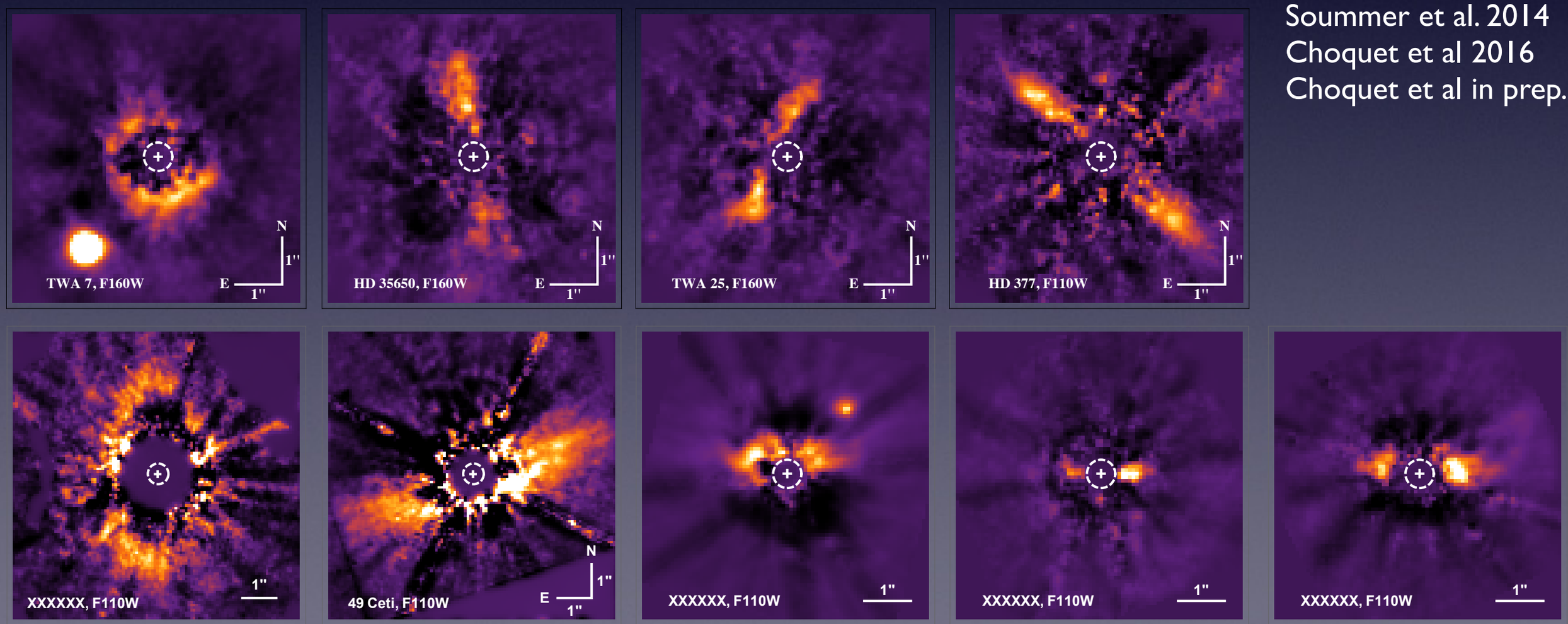
Schneider et al. 2005

~400 targets observed
~100 in debris disks surveys

5 debris disk detections
+ 3 known debris disks characterized

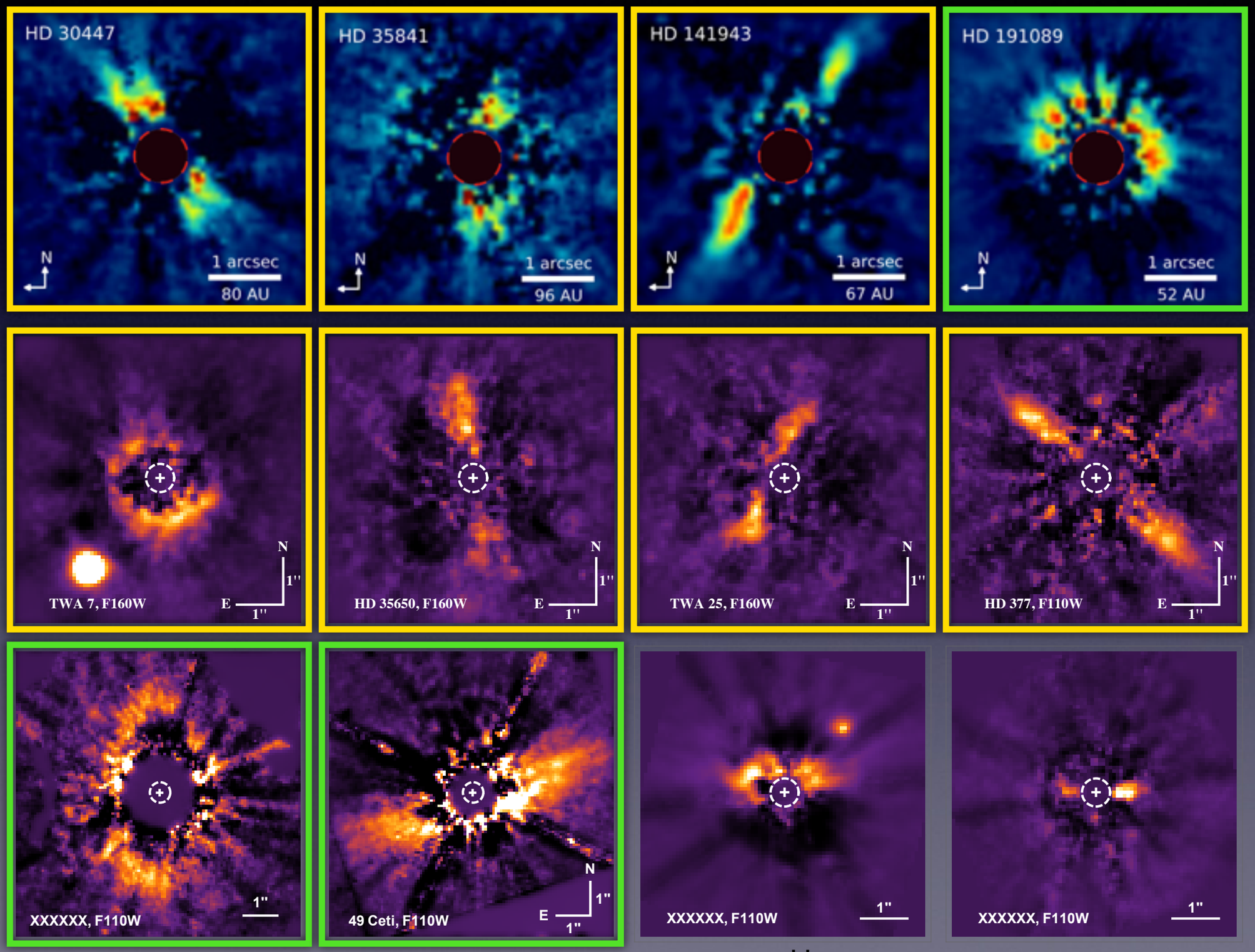
ALICE debris disk detections





Soummer et al. 2014
Choquet et al 2016
Choquet et al in prep.

ALICE debris disk detections



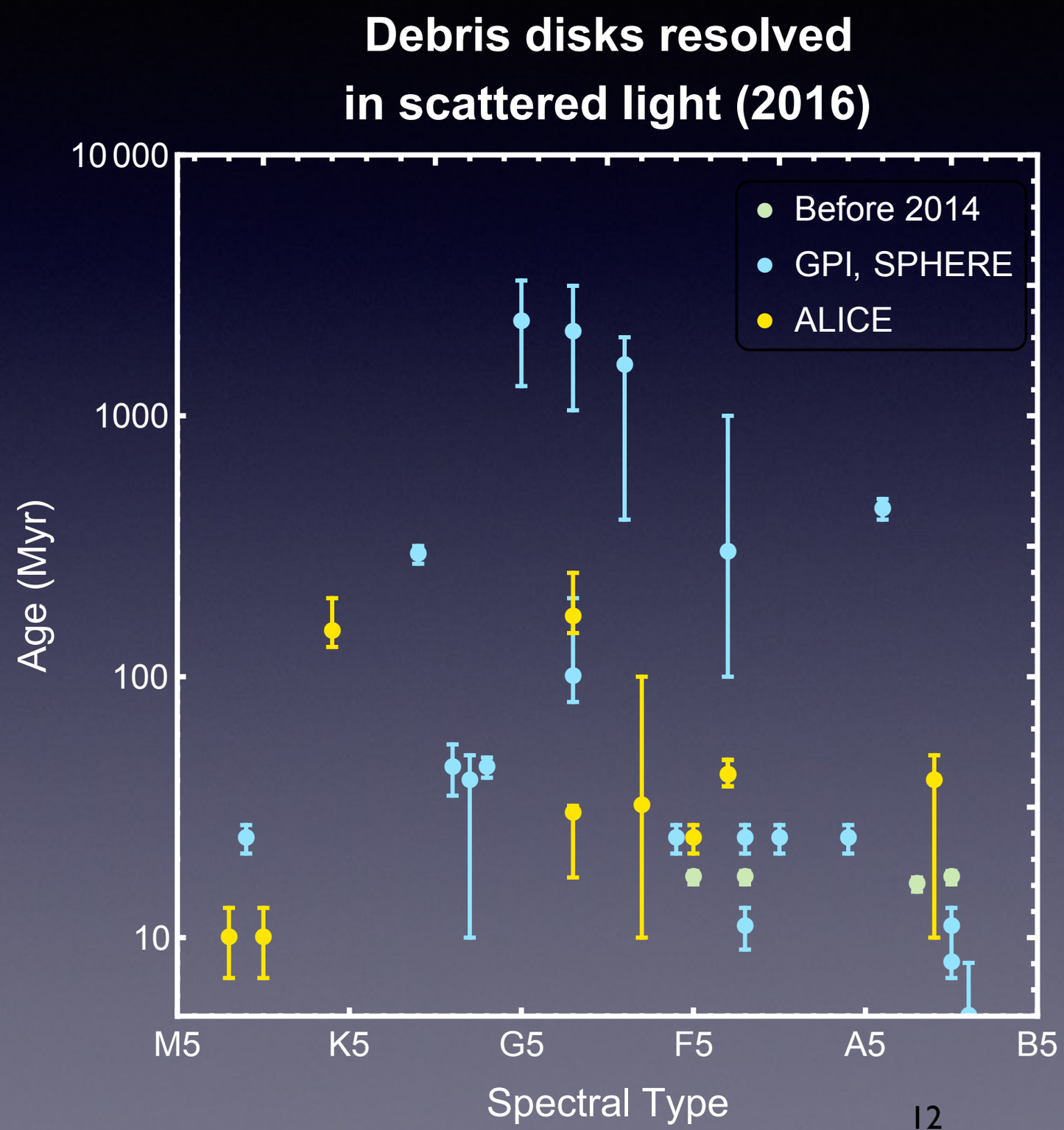
Soummer et al. 2014
Choquet et al 2016
Choquet et al in prep.

First image

First image in scattered light

ALICE results

Resolved debris disks overview



2013:

19 disks resolved in scattered light

2016:

- 10 new ALICE disks
- 4 new SPHERE/GPI disks

33 disks resolved in scattered light
(~ 30% by ALICE project)

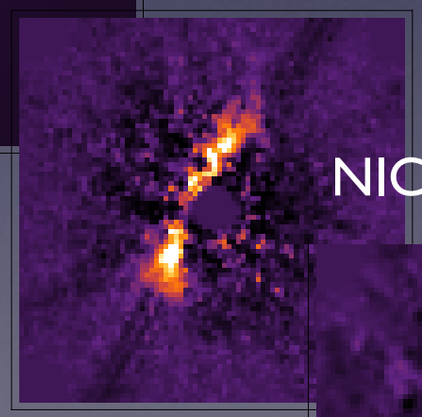
Disk characterization

Critical steps for debris disk comparative studies:

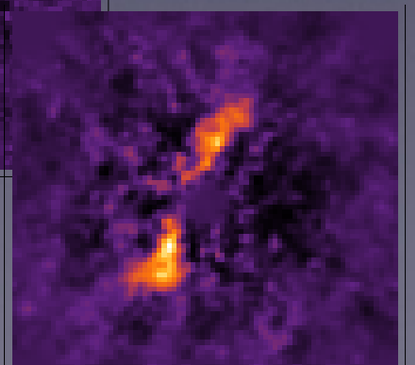
- Morphologic and photometric characterization
- Dust color measurement with new observations

Disk model

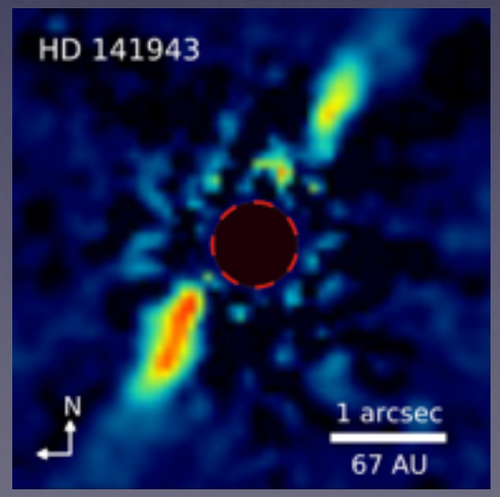
Forward model

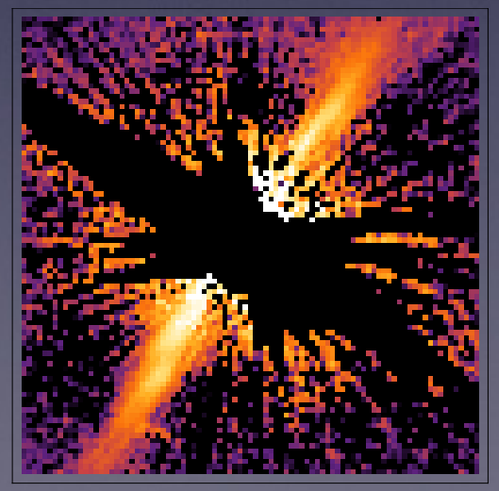


NICMOS image



Near IR + Visible images





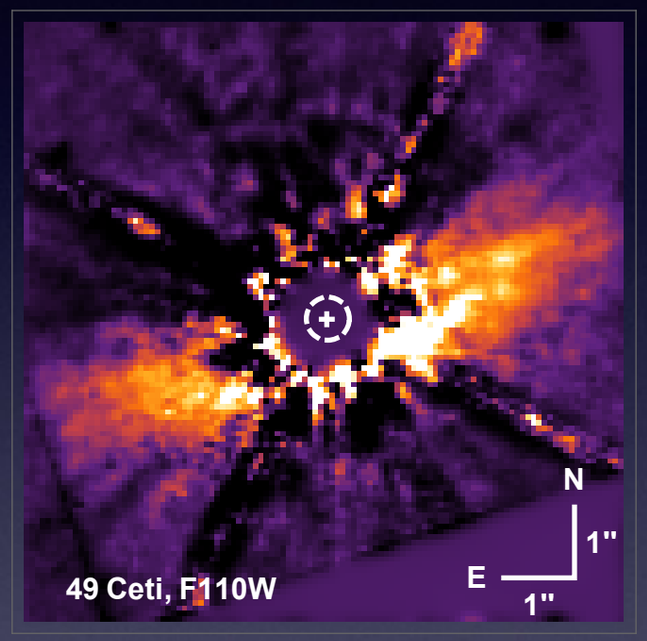
49 Ceti

First scattered-light images

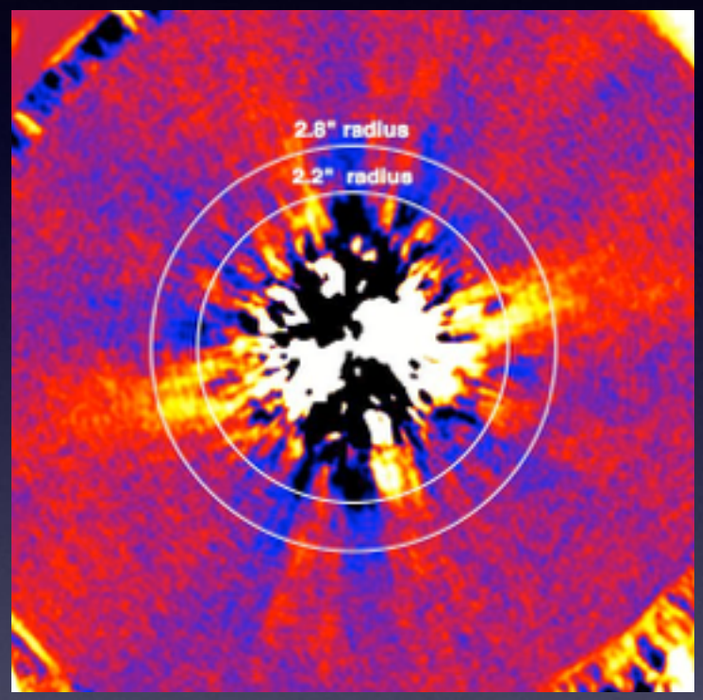
On-going characterization

ALICE program

HST-NICMOS F110W

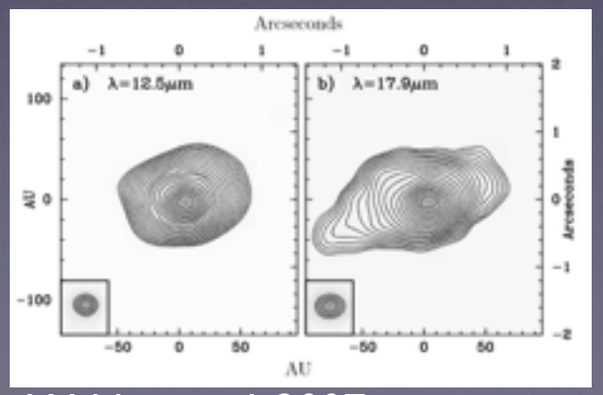


VLT-SPHERE H band



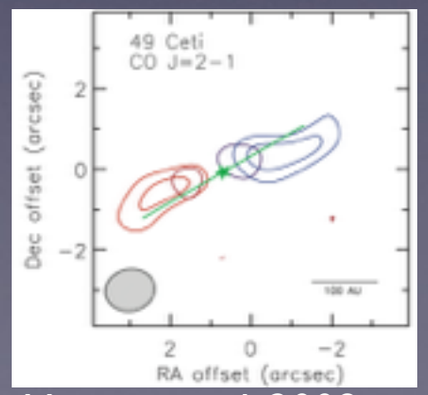
SHARDDS survey
(PI: J. Milli)

Keck-MIRLIN, 12.5 and 17.9μm



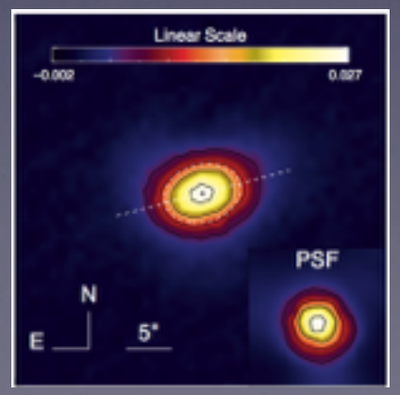
Wahhaj et al. 2007

SMA CO J=2-1 transition

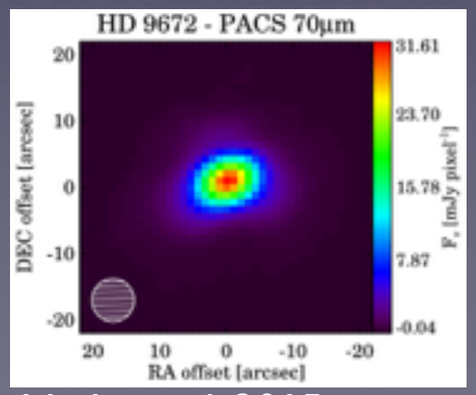


Hugues et al. 2008

Herschel-PACS 70μm



Roberge et al. 2013



Moór et al. 2015

49 Ceti

First scattered-light images

On-going characterization

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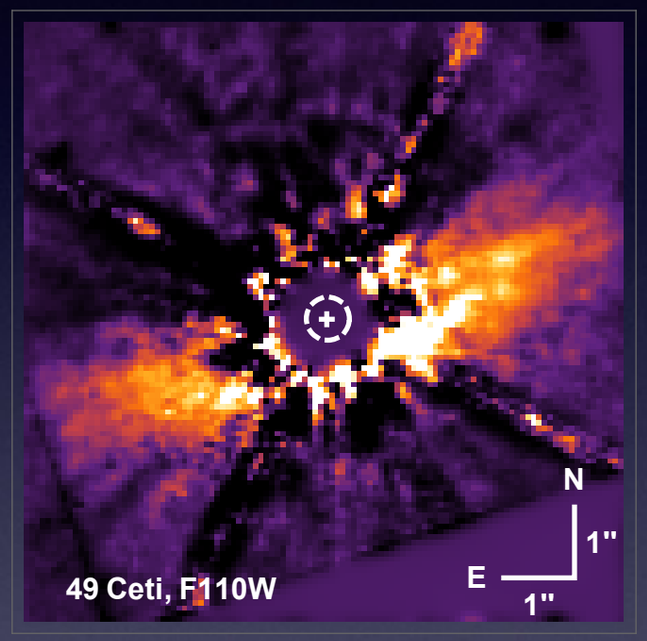
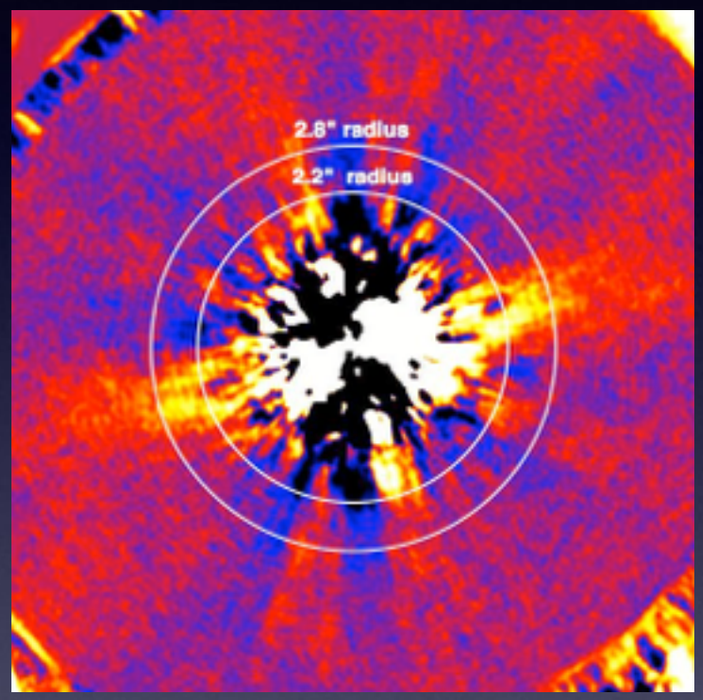


VLT-SPHERE H band



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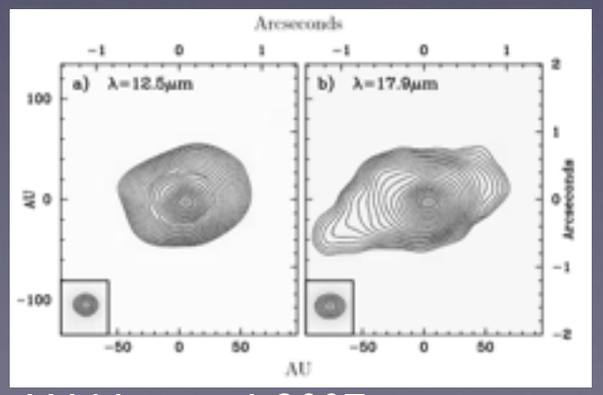
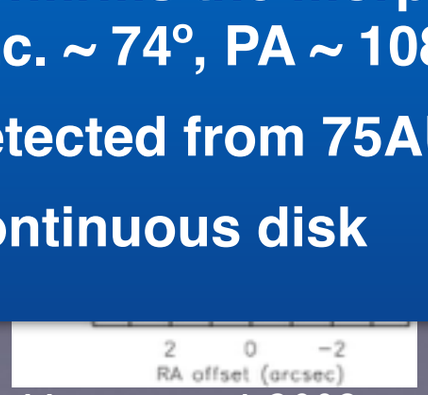
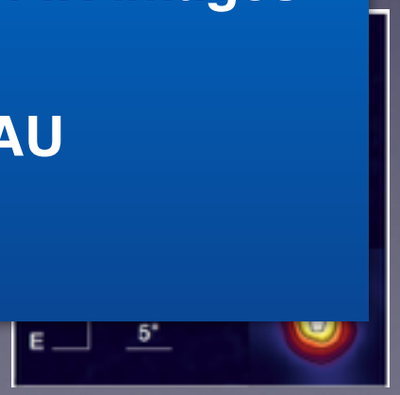


Wahhaj et al. 2007

- **Confirms the morphology of IR images (inc. ~ 74°, PA ~ 108°)**
- **Detected from 75AU to 250AU**
- **Continuous disk**

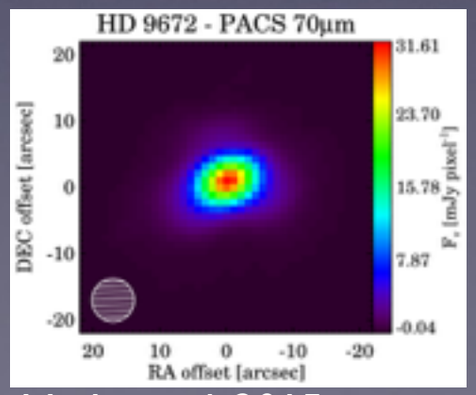


Hugues et al. 2008



Roberge et al. 2013

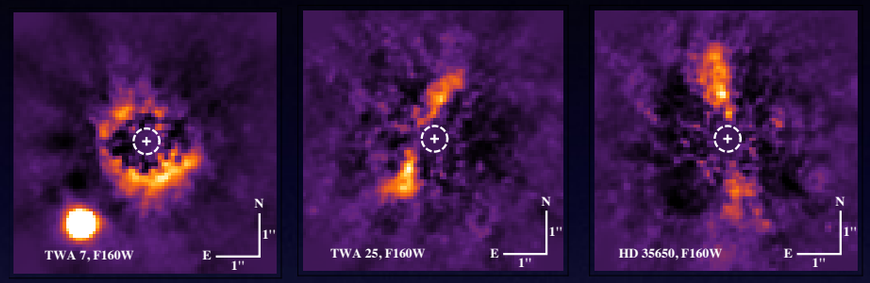
chel-PACS 70μm

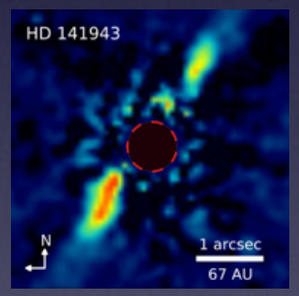


Moór et al. 2015

Conclusion

- **Take-home messages**
  - Archive reprocessing **complete**
  - **14** debris disks newly imaged





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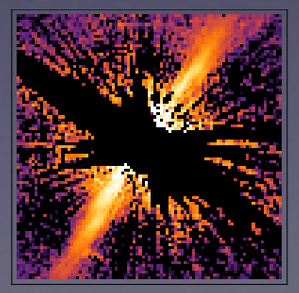

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color information

- **On-going and future work**
  - Disk characterization
  - NEED visible images !
  - Disk comparative studies

That’s it!