# Double stars in TGAS

## some validation results

**Institute for Space Studies of Catalonia**
**and**
**Institute of Cosmos Sciences - University of Barcelona**

Claus Fabricius

# HTPM → TMPM → TGAS

- The Hundred Thousand Proper Motions
  - Combining Hipparcos (~ 1 mas) and Gaia (~ 1 mas)
    - Very good proper motions
    - Little more than half a year of Gaia observations

- " How would you like a TMPM ? "
  - (Lindegren, July 2014)

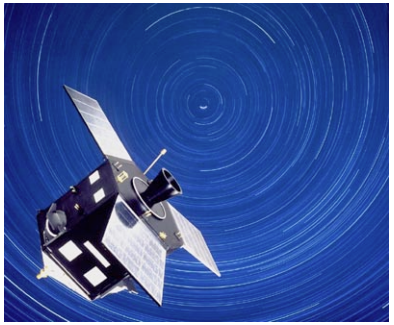
- Problem for HTPM
  - Cannot calibrate Gaia with 100 000 stars, 6–12 months of data

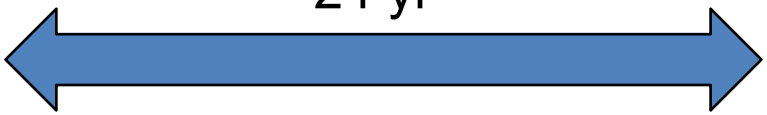
# TGAS

- **T**ycho – **G**aia **A**strometric **S**olution
- Concept devellopedat Lund
  - Michalik, Lindegren, Hobbs 2015, A&A, 574, A115

- NB: TGAS does not contain (close) binaries
  - Often the primary
  - Rarely the secondary
  - Sometimes neither component
  - Sometimes the other is in DR1

# TGAS

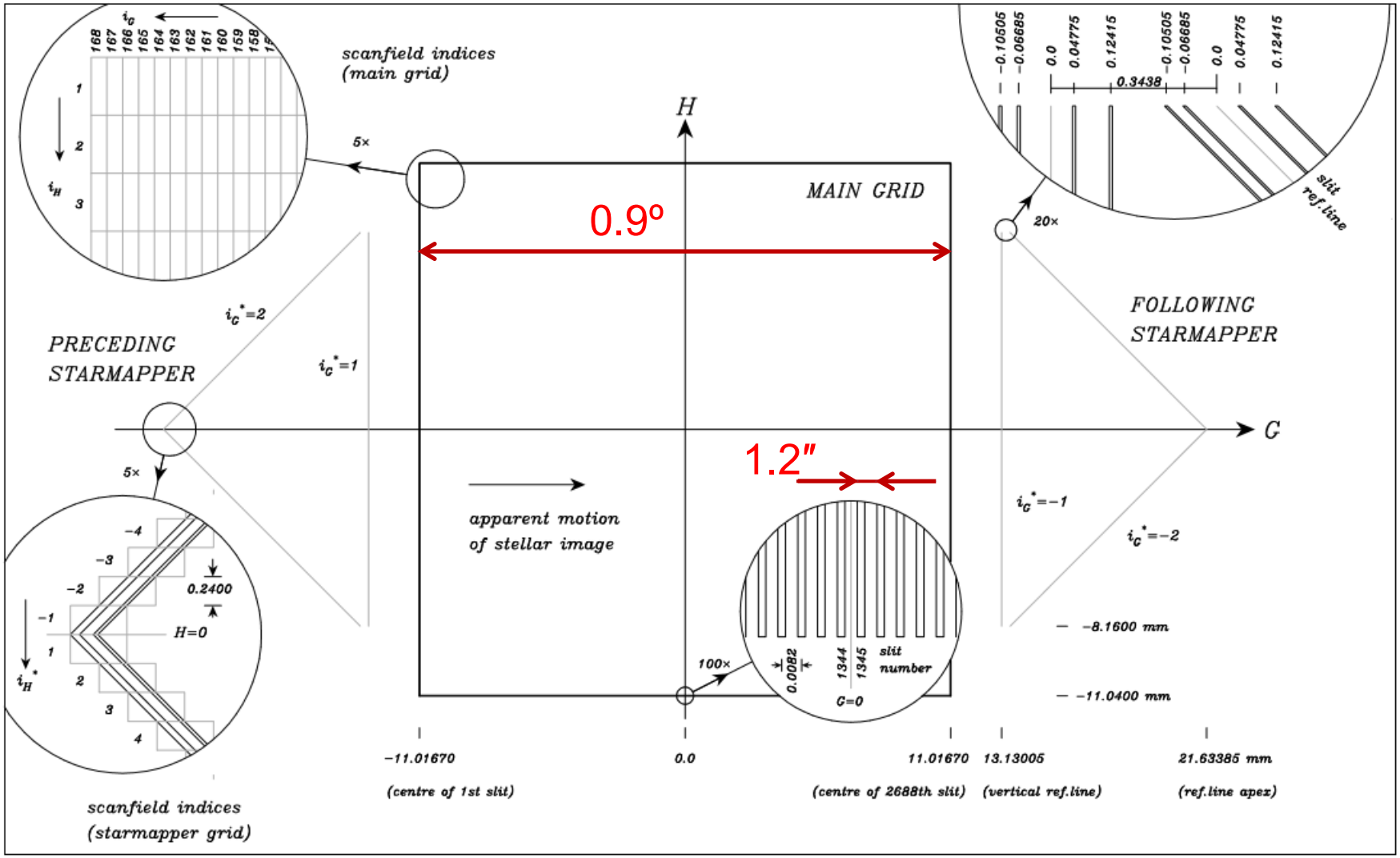






- TGAS: Combining HIPPARCOS/Tycho with Gaia
- Bootstrapping Gaia calibrations
  - Using HIP/Tycho-2 ***positions***
- Positions, parallaxes, proper motions for 2M+ stars
  - Only well behaved sources
  - Parallaxes to 0.3 mas
  - Proper motions for HIP stars to 70 μas/yr

# Hipparcos focal plane



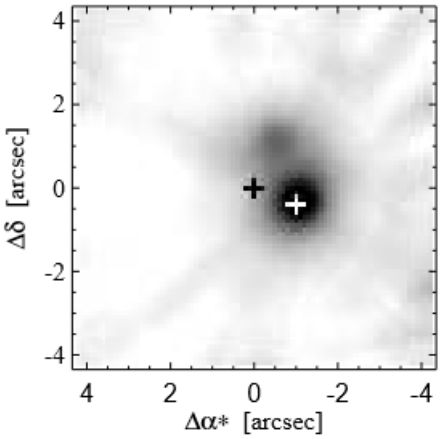



ESA-1200, Vol 2, Fig 2.10

# Hipparcos DMSA

- 12 000 double and multiple systems
  - Mostly successfully resolved
  - Some ambiguous or poor solutions

76566 C&D

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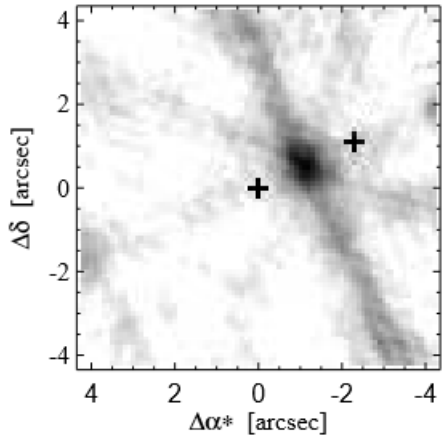


Fabricius & Makarov 2000

- DMSA positions (+) on stacked Tycho counts
  - Resolving problematic cases using **Hipparcos Transit Data**
    - HTD concept devellopped at Lund by Lindegren

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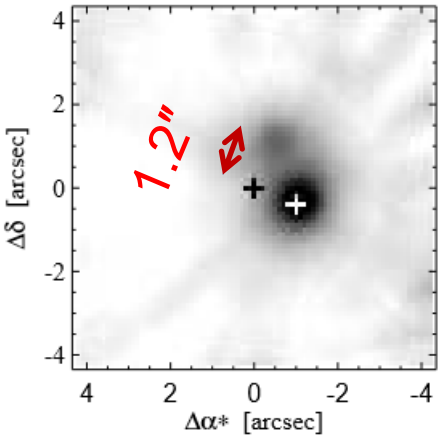


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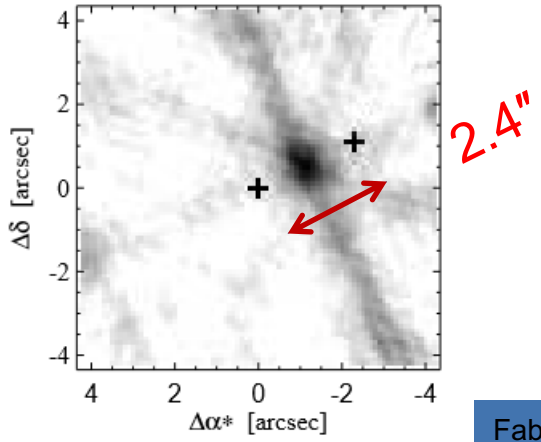


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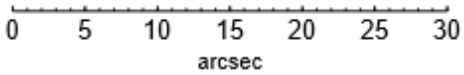
# Orbiting doubles suffer in Hipparcos

HIP @ 1706

FK5 @ 1706

- Problem:
  - Short mission duration compared to orbital period
- Example:
  - Castor

HIP @ 1991

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  - new possibilities
  - HIP transit data for 38000 stars

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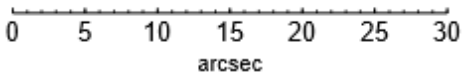


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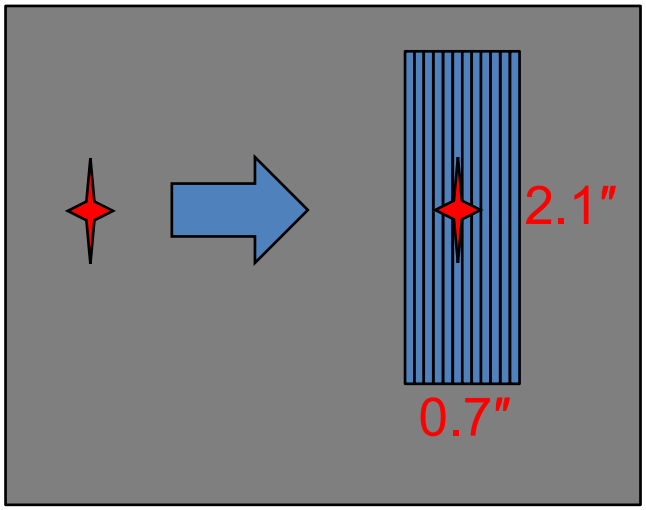
# Gaia observing strategy

- Gaia strategy
  - Only small “windows” are read from the CCDs



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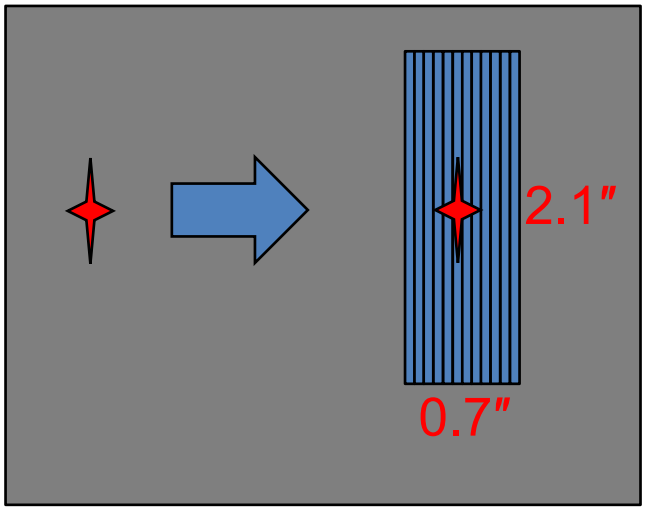
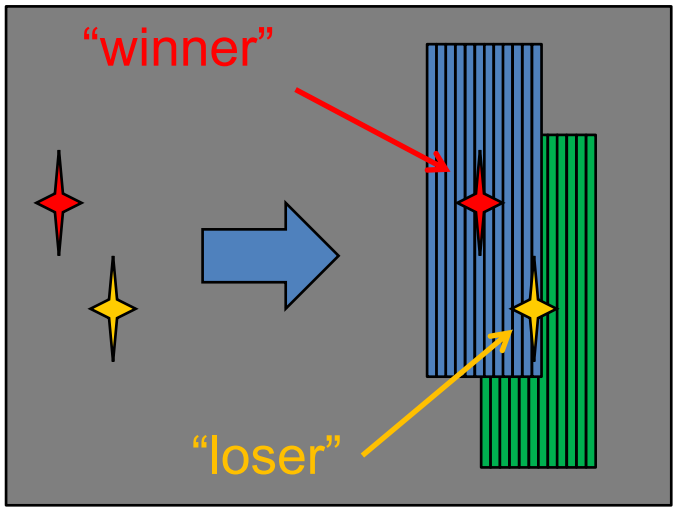
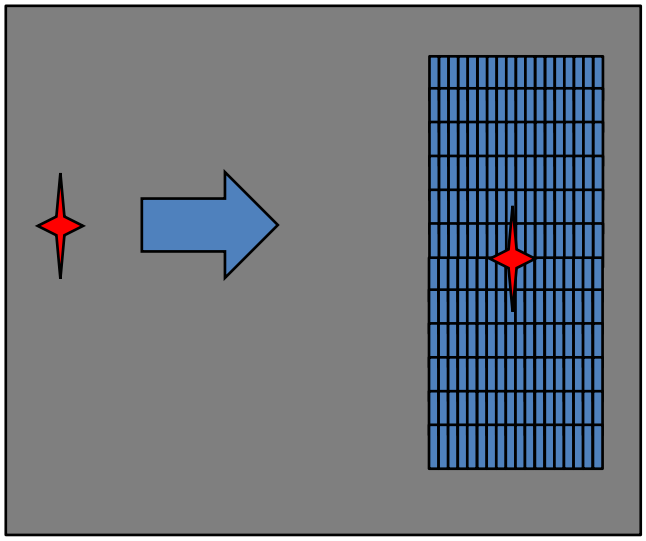
  - Only small “windows” are read from the CCDs
  - The fainter component of a binary gets a truncated window

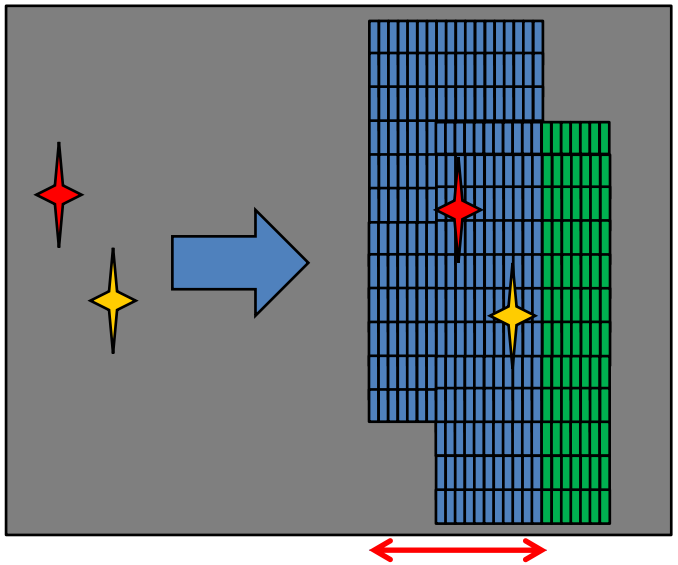


# Gaia observing strategy

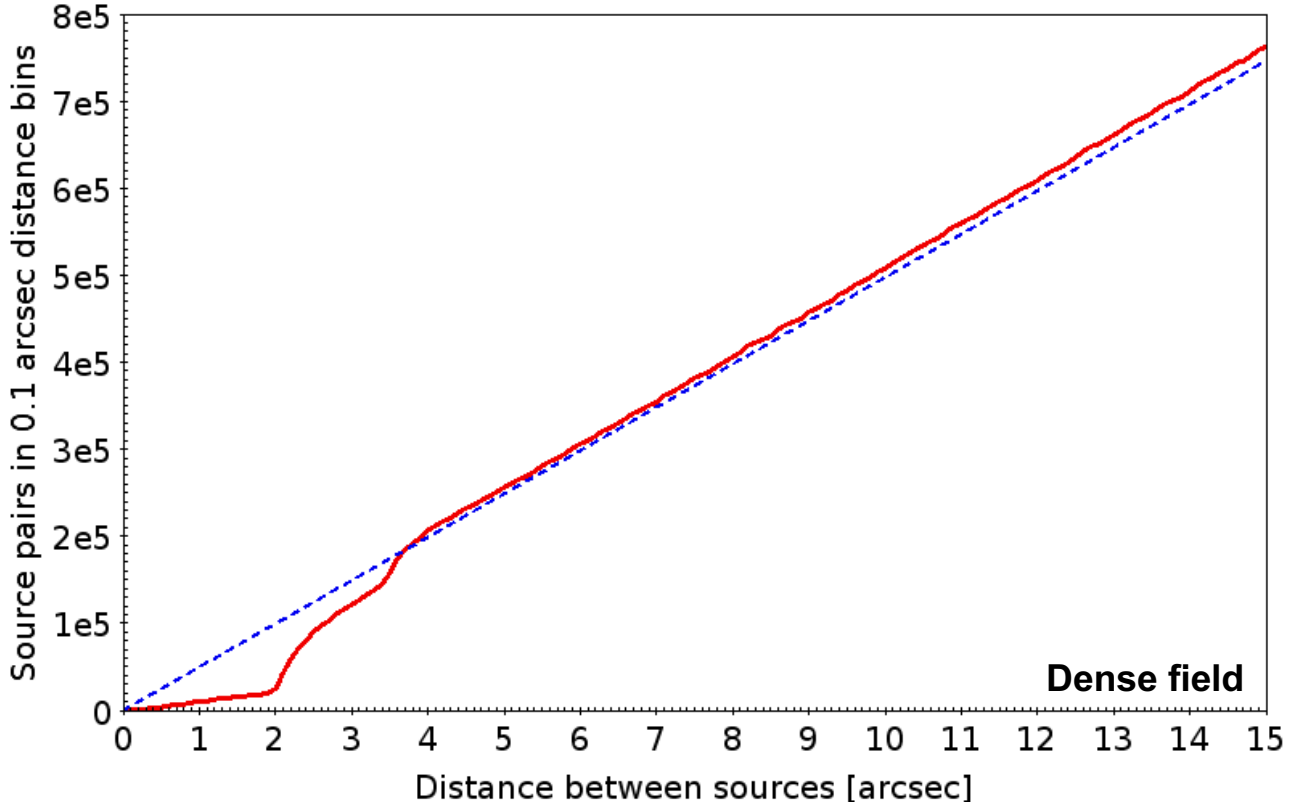
- Gaia DR1 & TGAS:
  - All sources treated as single
  - Bright sources observed with full pixel resolution
    - G < 13 mag
    - Applies to all TGAS





# DR1 angular resolution

- Few resolved pairs in DR1
  - Window conflicts set in around 2 – 3 arcsec



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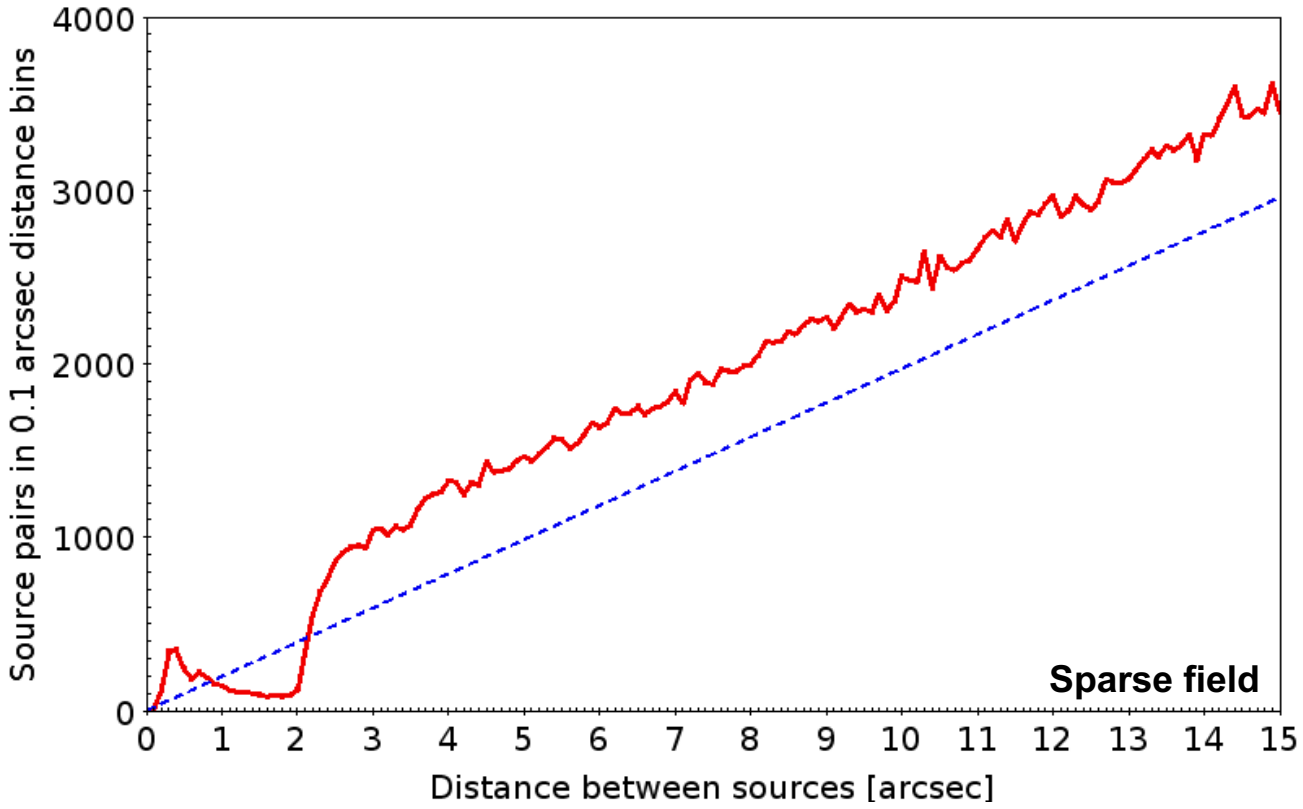
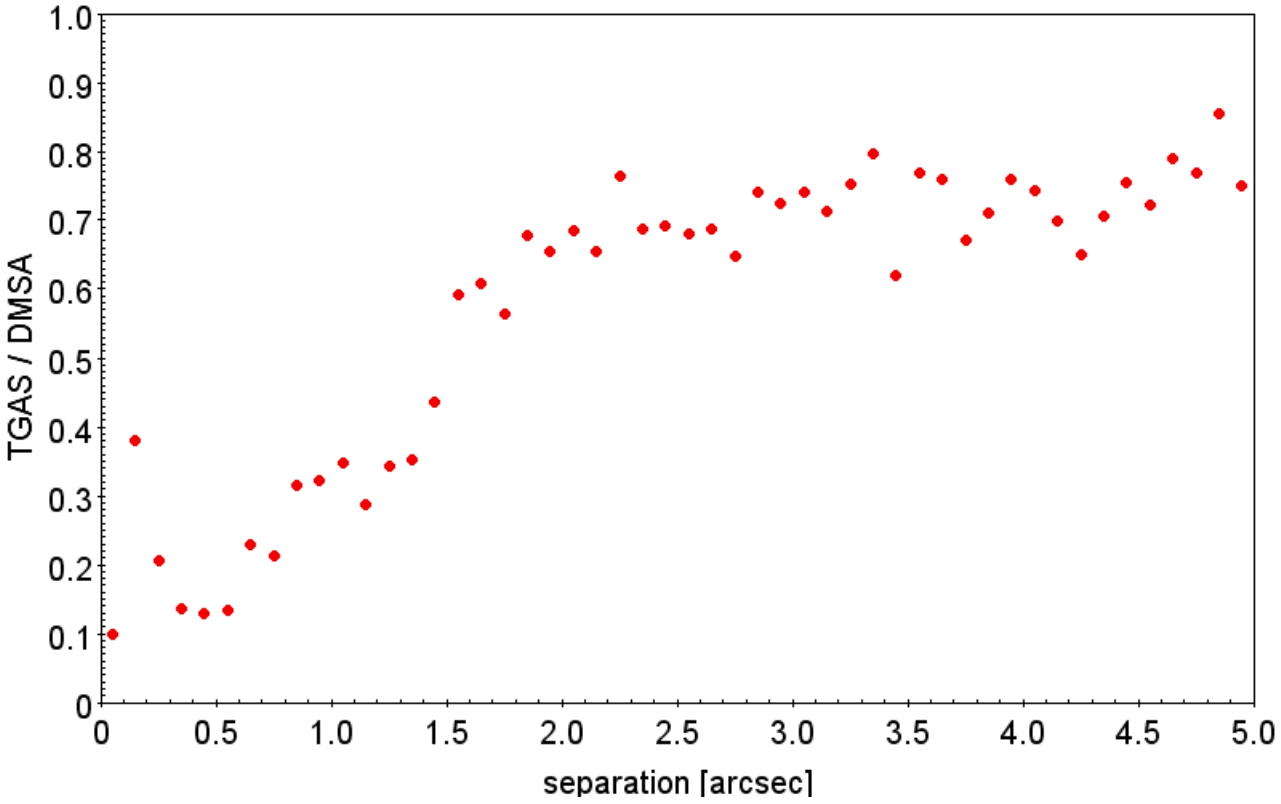
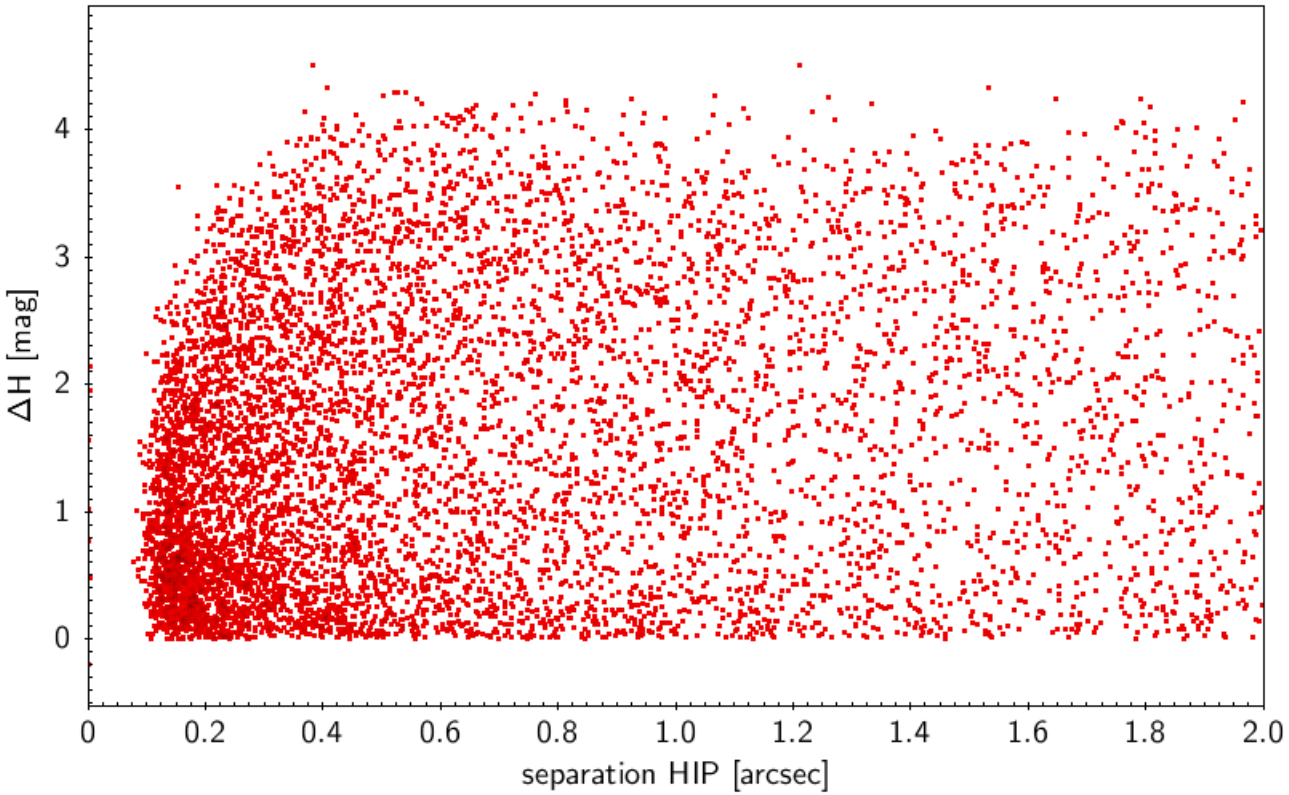


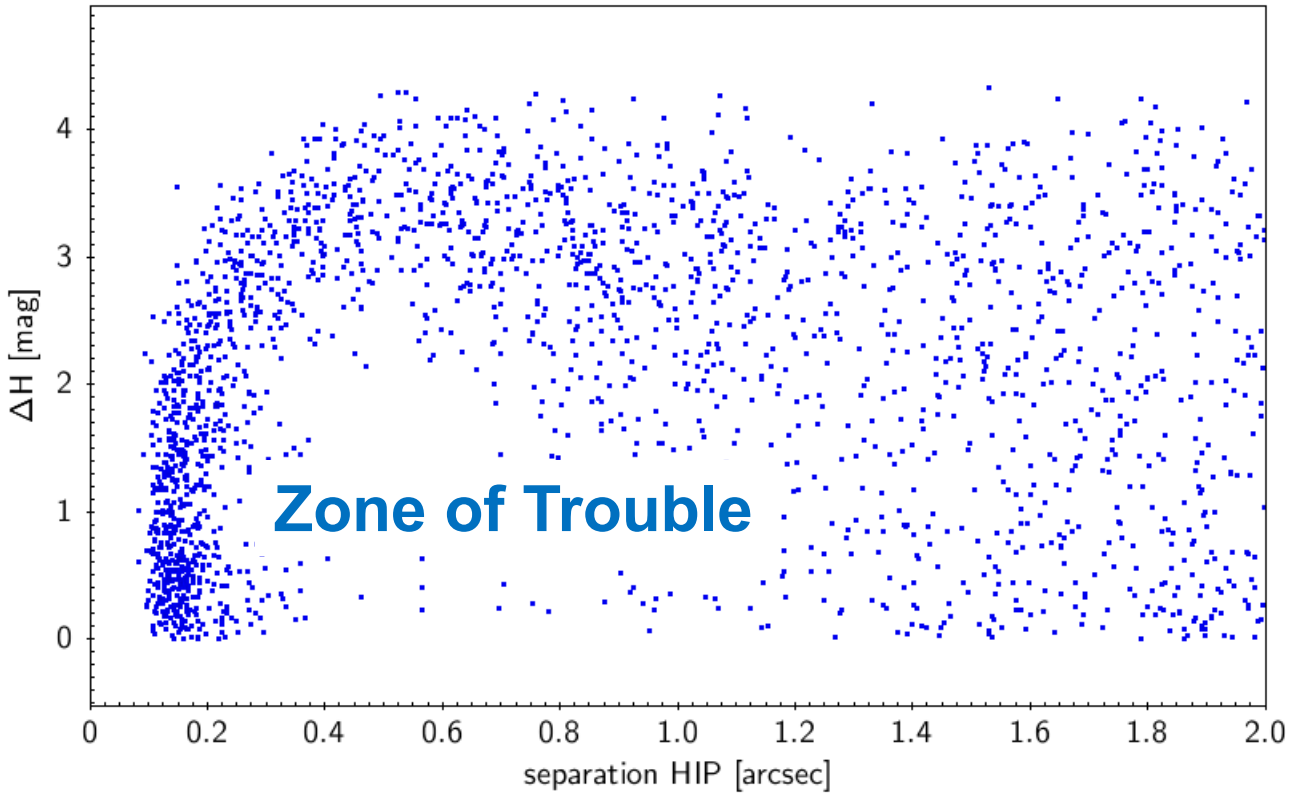
# Fraction of HIP-DMSA in TGAS



# HIP-DMSA, ρ < 2″


ΔH [mag]
0
1
2
3
4
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
separation HIP [arcsec]

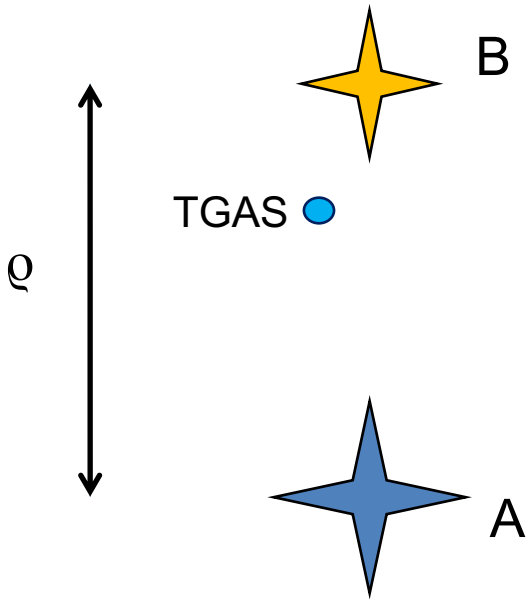
# TGAS, ρ < 2″




- ZoT: secondary disturbs primary too much

# TGAS offset from Hipparcos

- Hipparcos double propagated to Gaia epoch
  - TGAS will normally fall in between the two components



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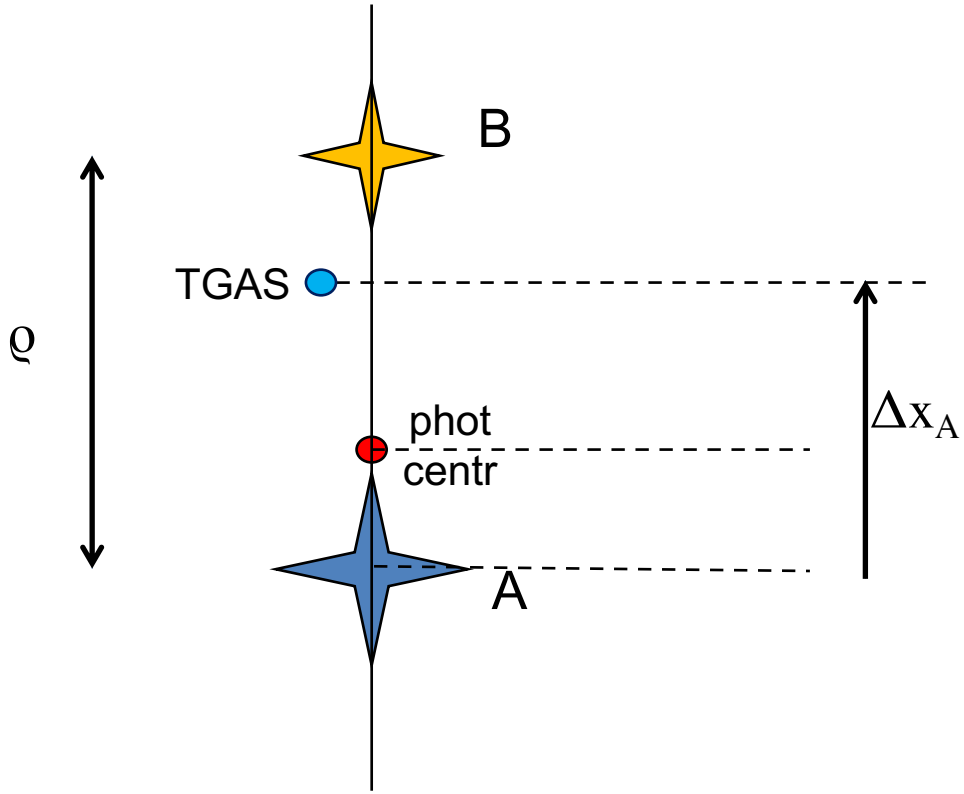
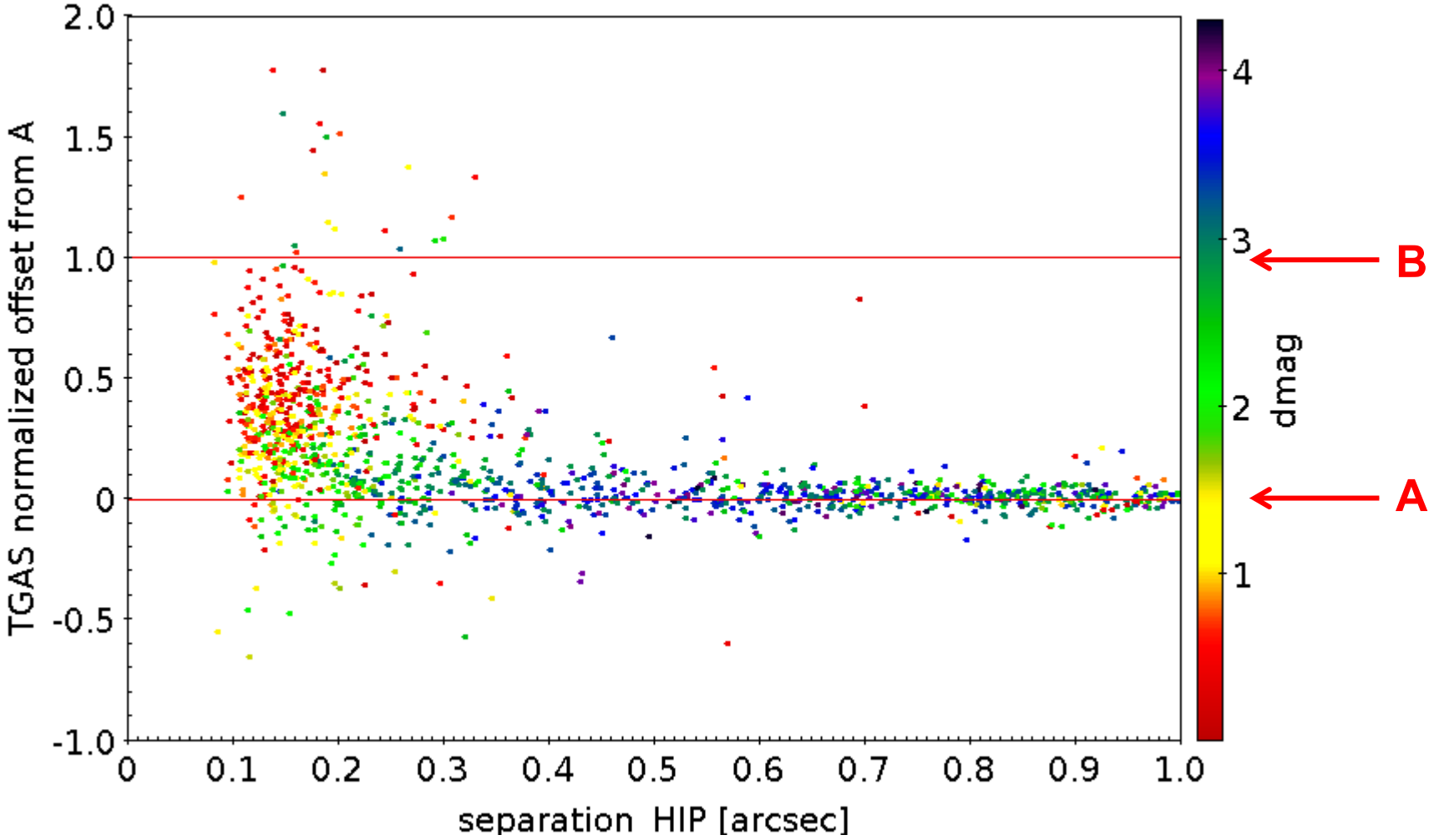
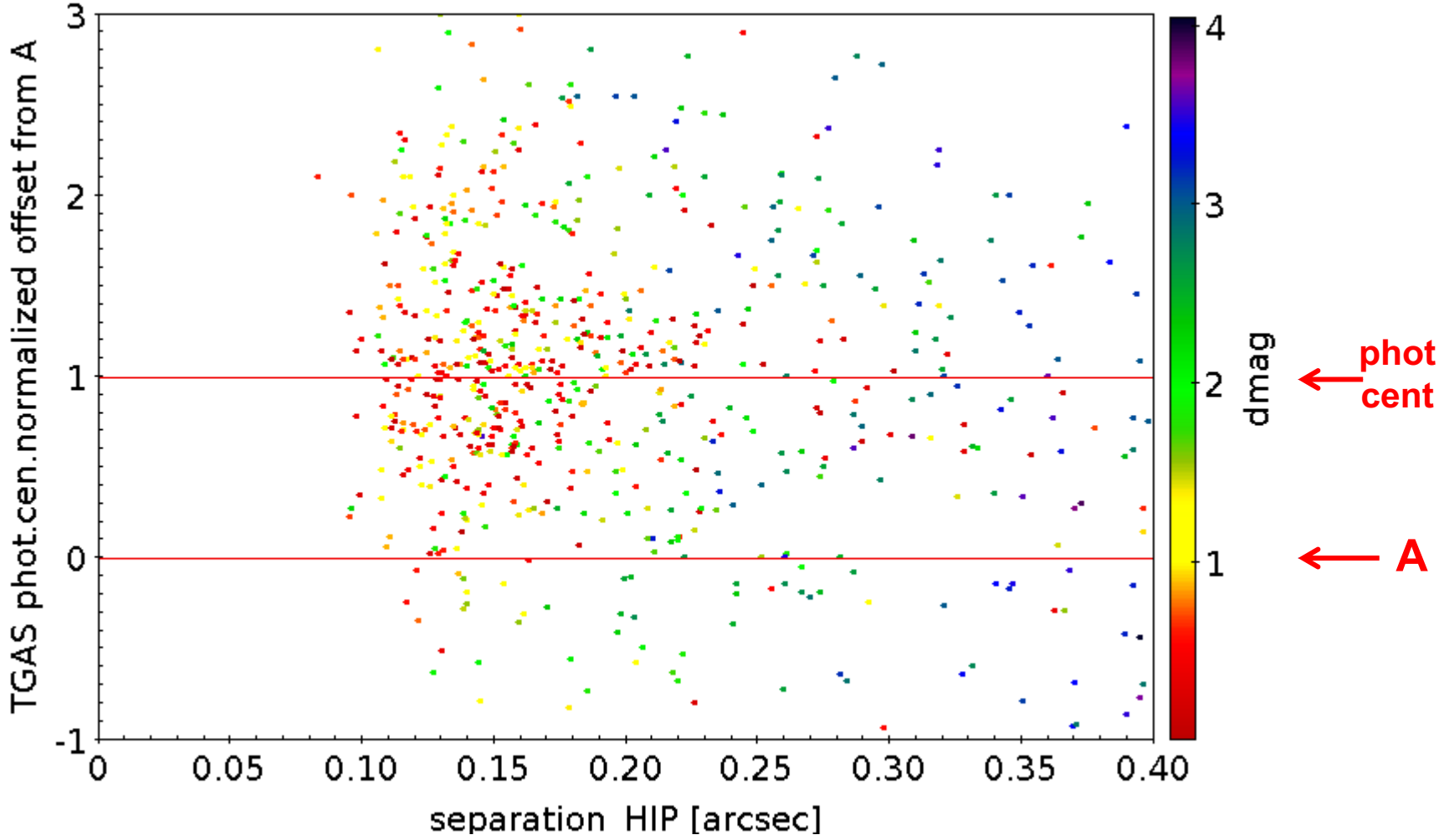


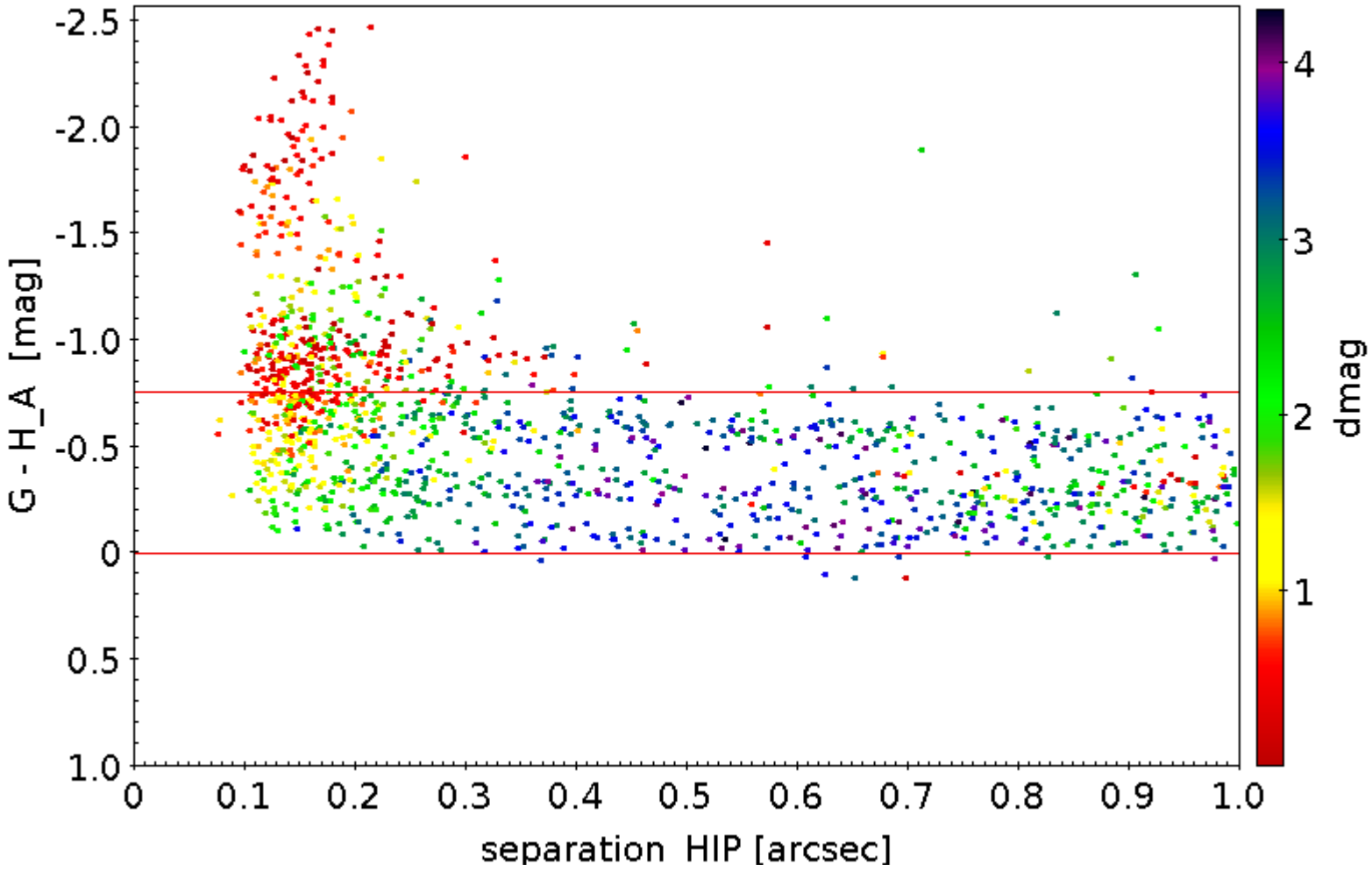
# TGAS pos offset from A → B



# TGAS pos offset from A → phot cent



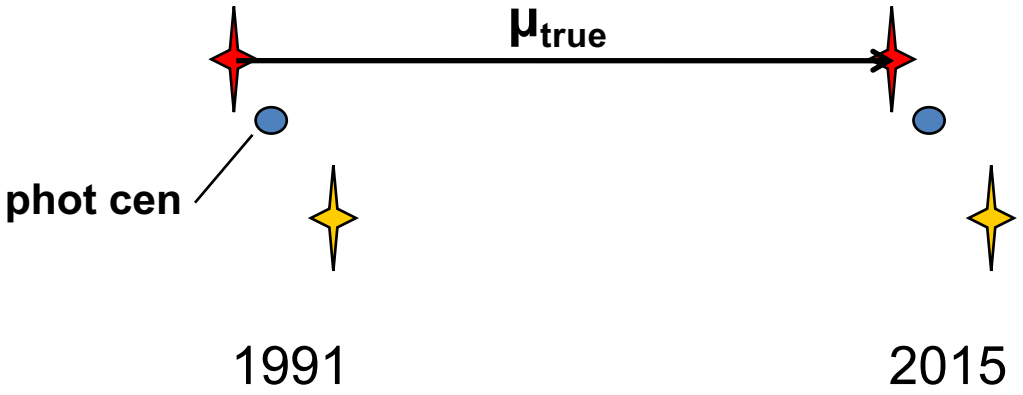
# TGAS magnitude offset from A



# Close Hipparcos doubles

- Separation < 0.25 arcsec
  - Small ΔH dominate
    - already in DMSA
  - Astrometry: Photo centre
  - G photometry: biased
- Separation 0.3 – 0.5 arcsec
  - Large ΔH dominate
    - contrary to DMSA
    - Small ΔH give poor images
  - Astrometry: Photocentre → comp A
  - G photometry: biased

# Proper motion bias in TGAS




- Bias for close Hipparcos doubles
  - Much larger than formal uncertainty
- Tycho-2: no resolved pairs closer than 0.8″
  - No TGAS proper motion bias expected

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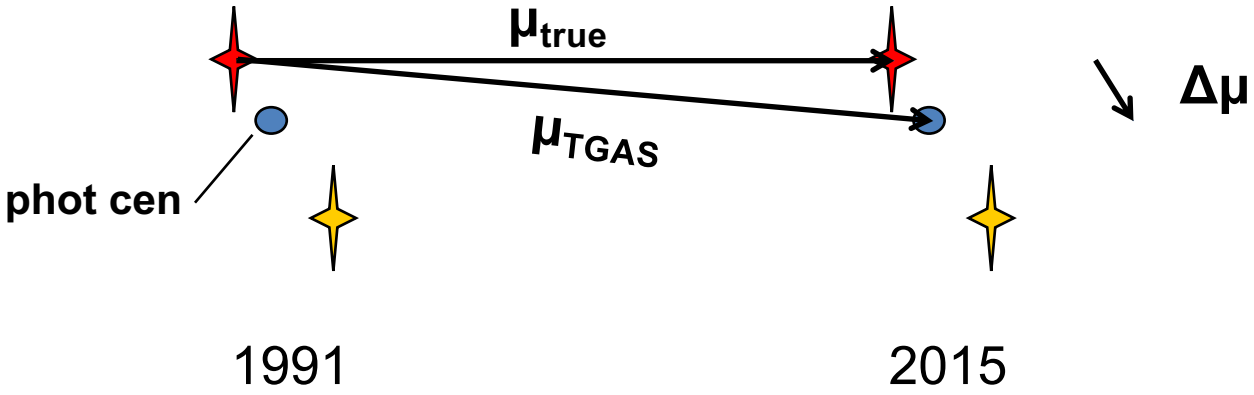


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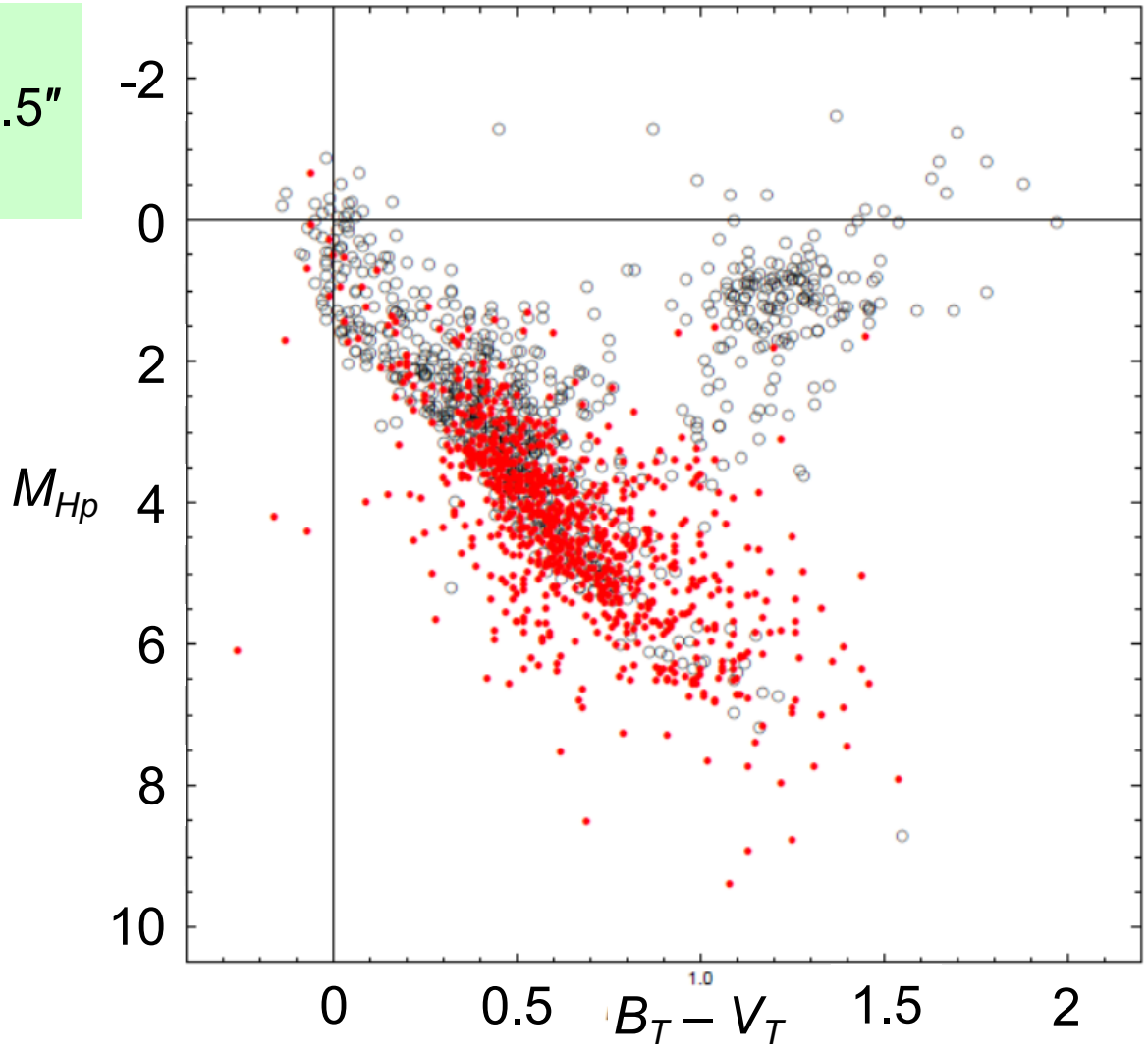
# TGAS – HIP/Tycho HR diagram

838 pairs
ρ: 0.3 – 2.5″
$\varpi/\sigma_\varpi > 7$




o: primaries
•: secondaries

Makarov, Fabricius, Frouard 2017

# Near future: Gaia DR2

- Sources are still treated as single
- No TGAS2
- Close binaries
  - Positional bias remains
  - No proper motion bias

# Unresolved binaries

- May go undetected if the companion is
  - Too close
  - Too faint
- Gaia has several ways it can detect close companions
  - Scan direction dependence of
    - Image shape
    - Astrometric residuals
    - Photometric residuals
  - Image reconstruction

Thank you!
Tack så mycket!