Architectures for TPF-I/Darwin

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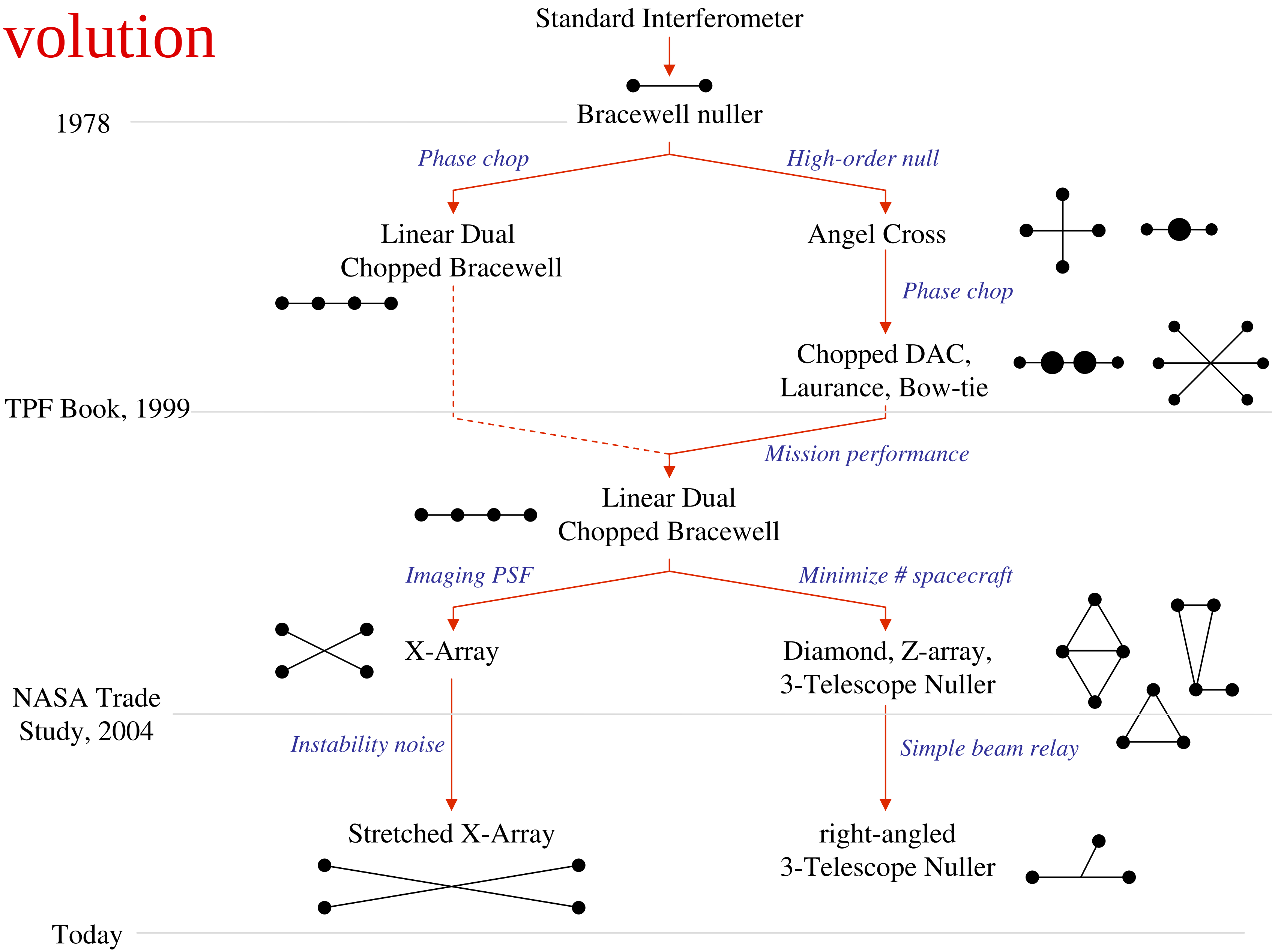
Jet Propulsion Laboratory
November 10, 2006

Evolution


Standard Interferometer
Bracewell nuller
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Phase chop
High-order null
Linear Dual
Chopped Bracewell
Angel Cross
Phase chop
Chopped DAC,
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Instability noise
Simple beam relay
Stretched X-Array
right-angled
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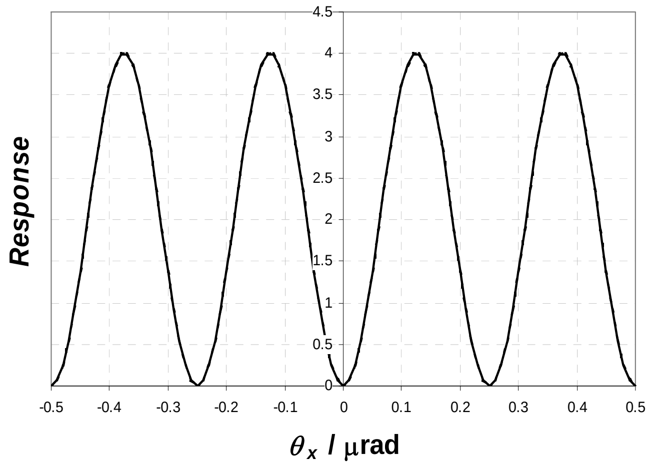
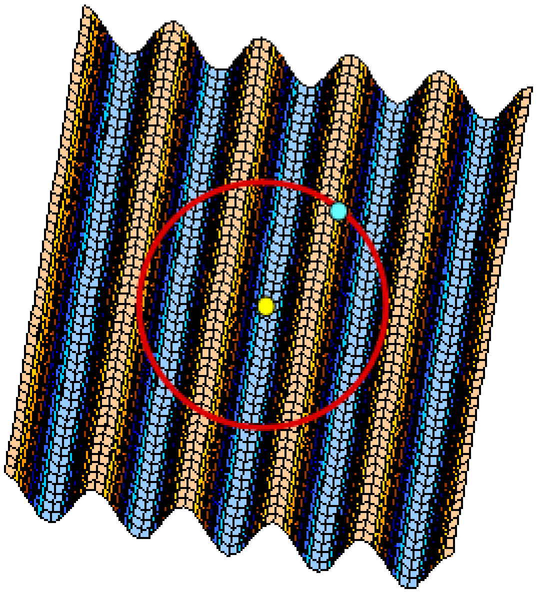
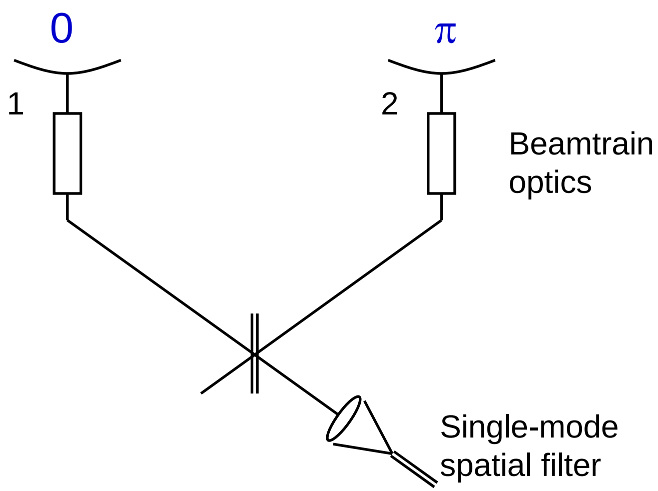
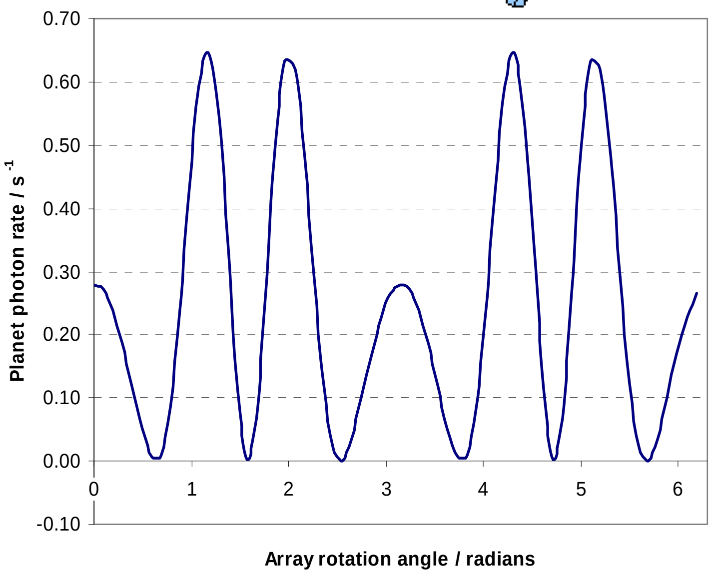
Today

Single Bracewell configuration



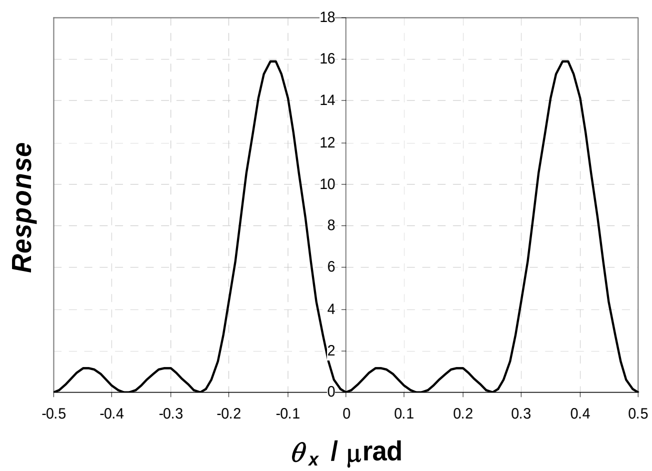


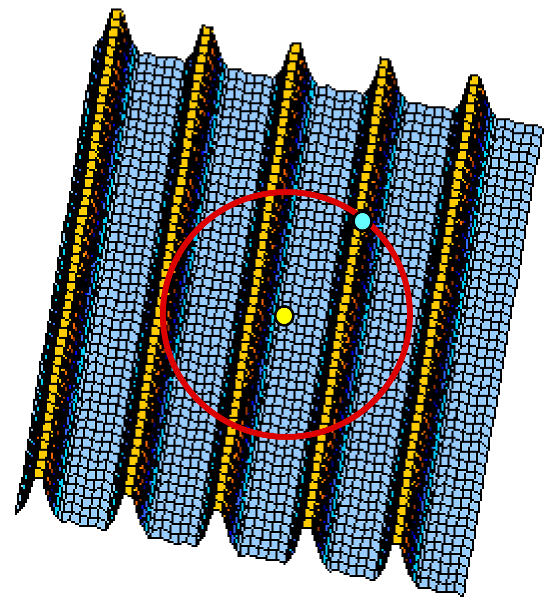


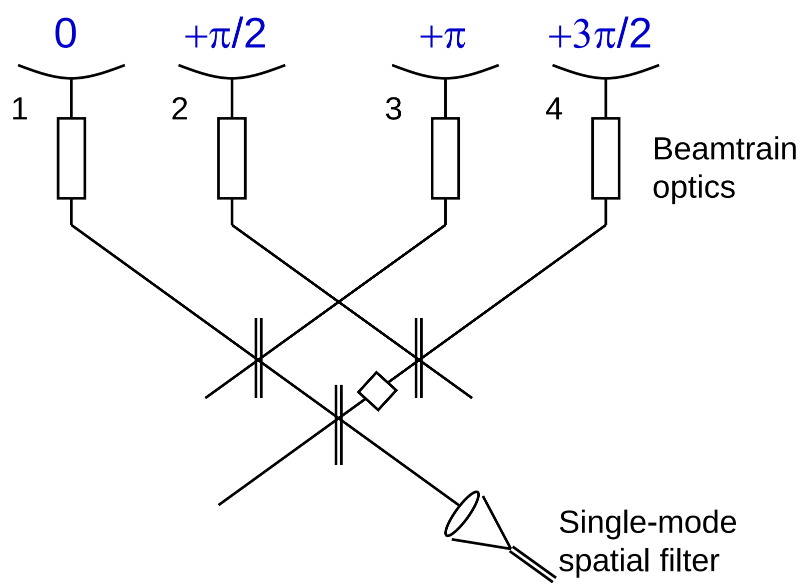


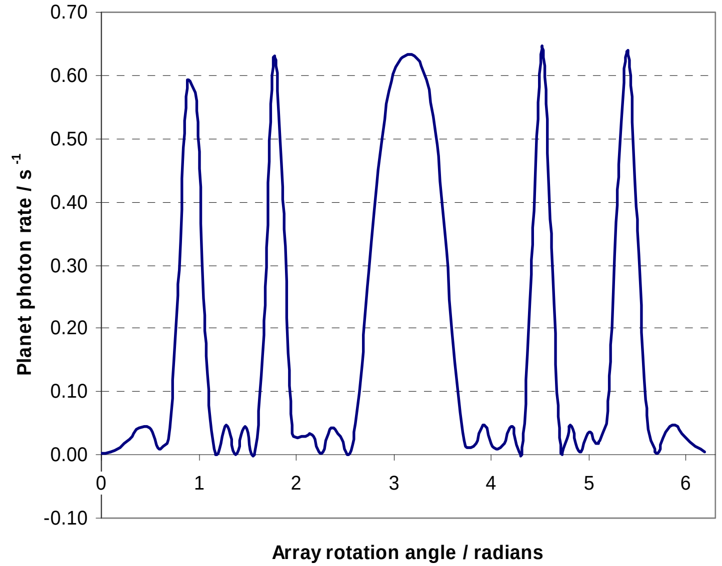
- Symmetric response => poor separation of planet from EZ
- Vulnerable to drifts

Dual Bracewell configuration



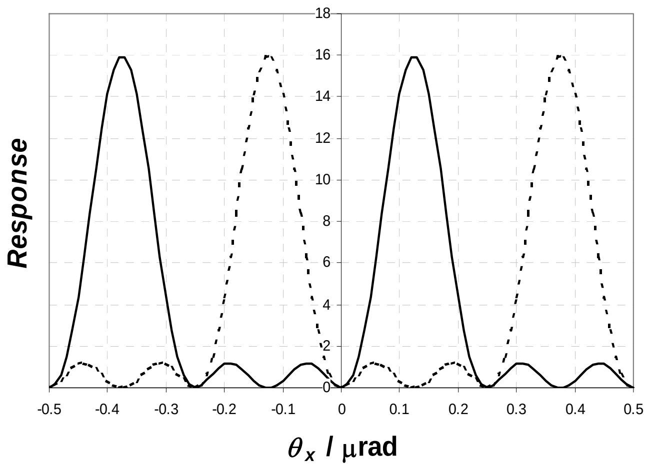


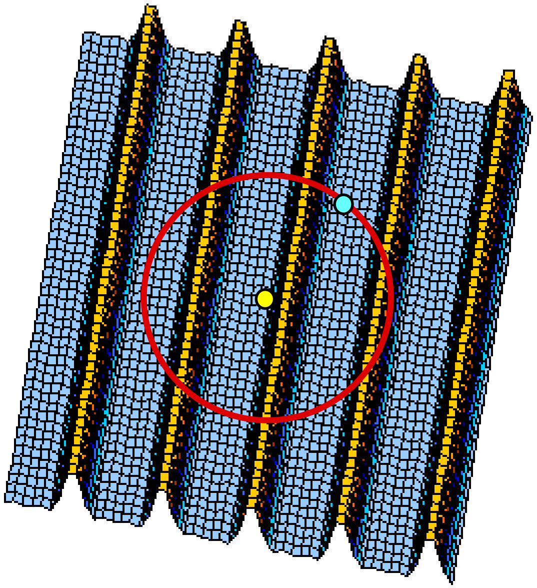


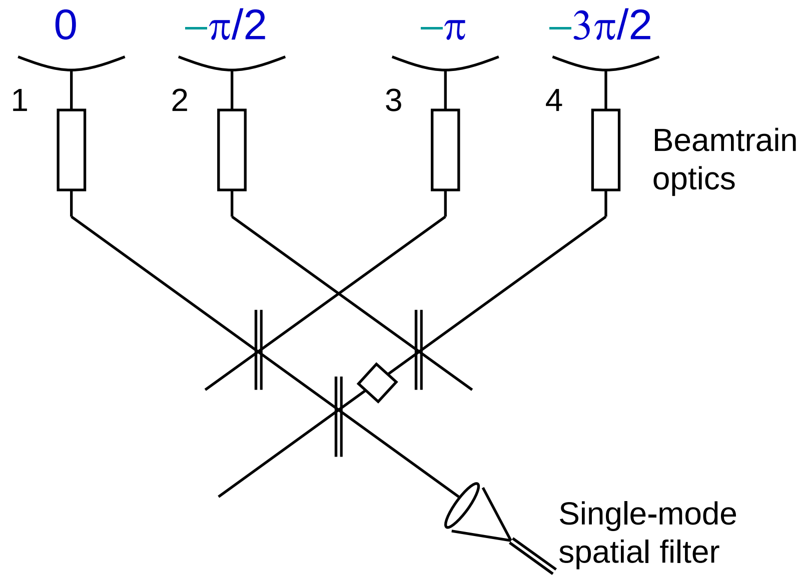


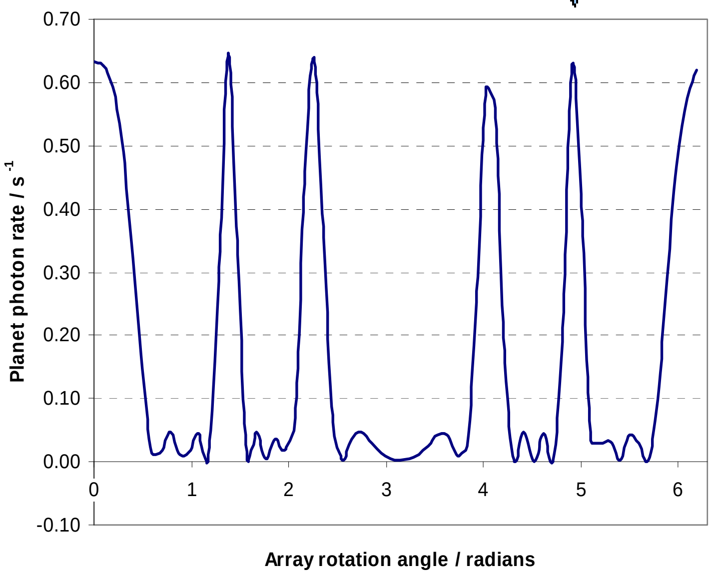
- Asymmetric response; 'left' chop state

Dual Bracewell right chop state



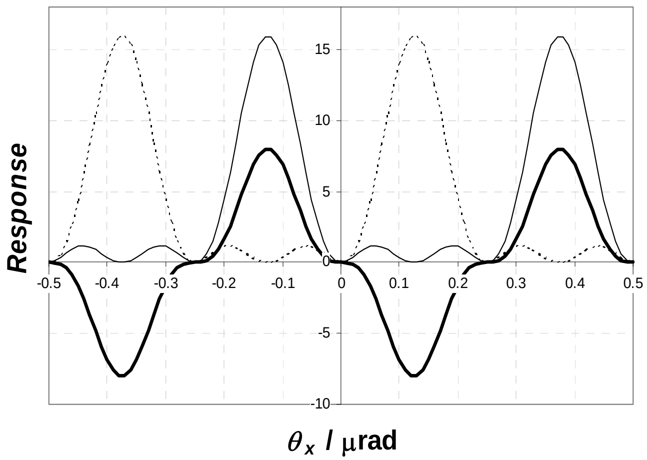


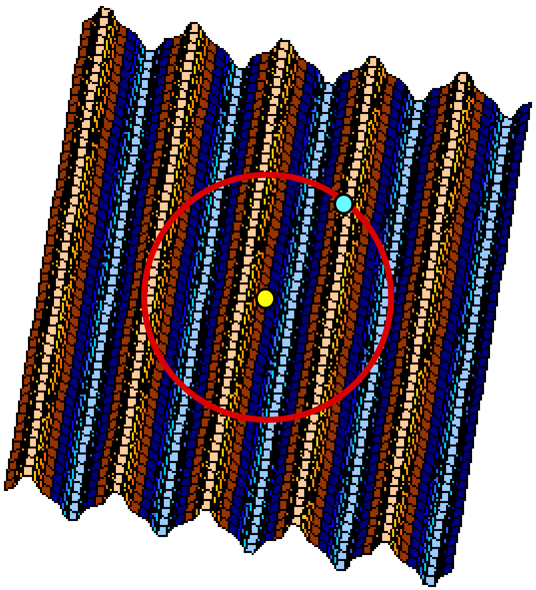


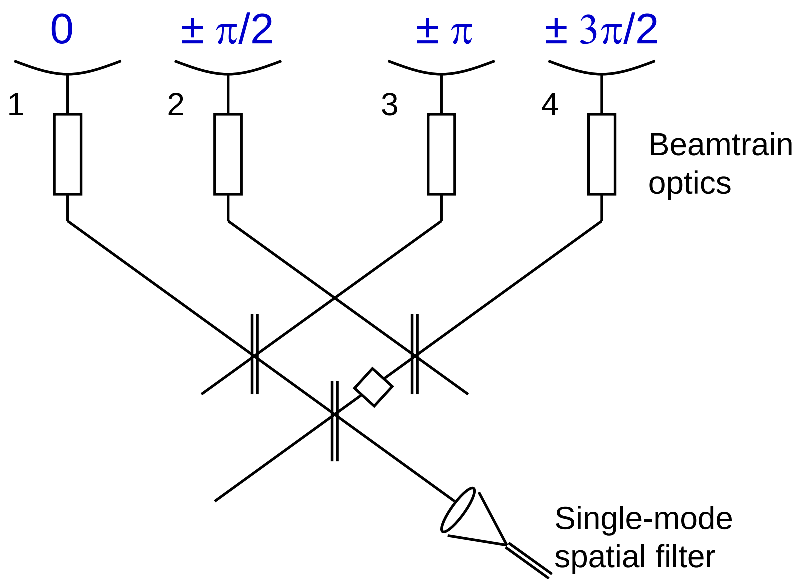


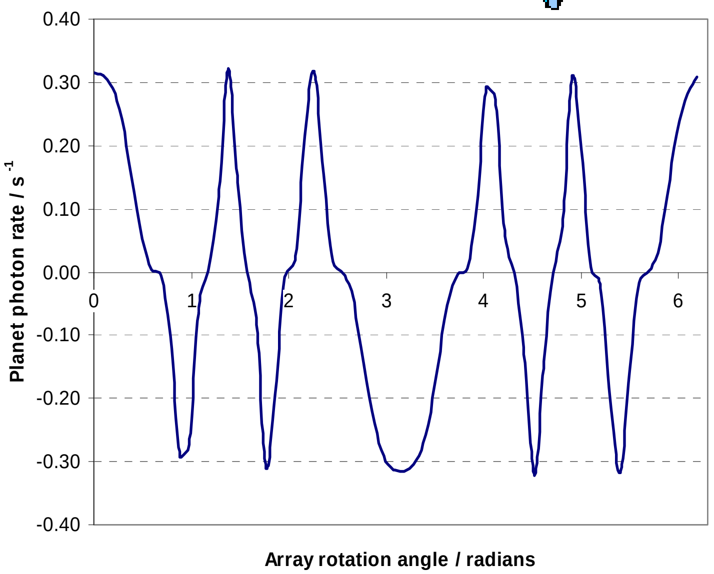
- Switch every 1 – 10 secs

Chopped Dual Bracewell



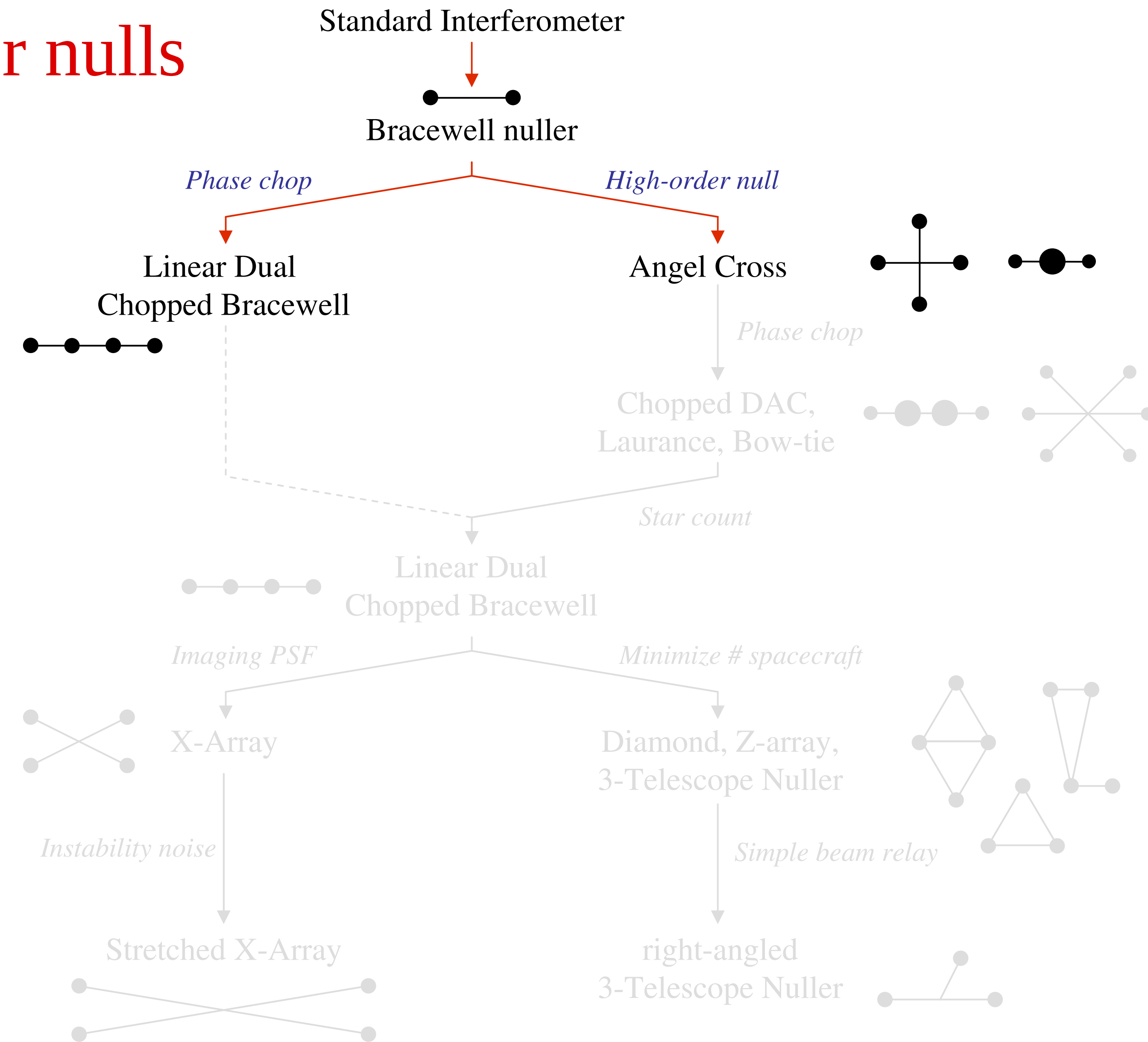






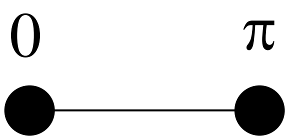
- Purely anti-symmetric response
  => only sensitive to planet
- Phase chop reduces drifts

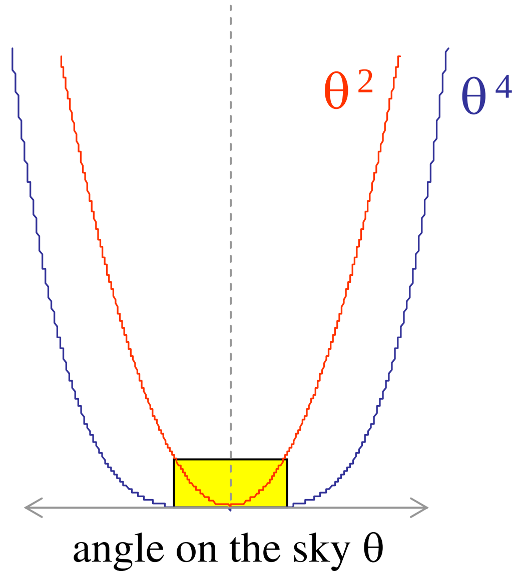
High-order nulls



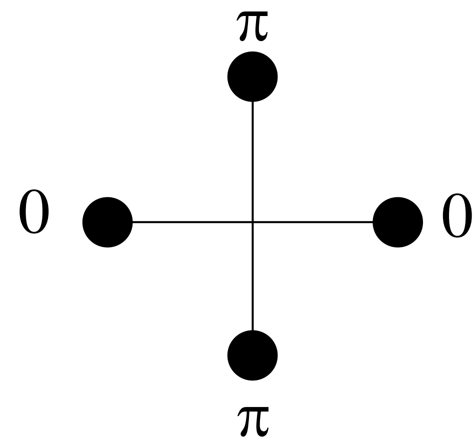
High-order nulls reduce stellar leakage

Bracewell

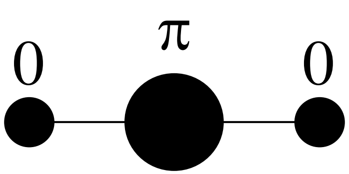




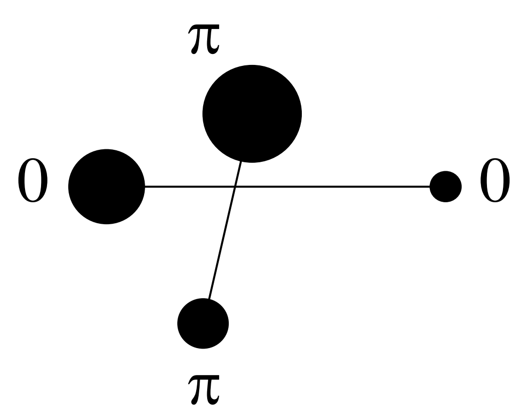
Angel Cross



Degenerate Angel Cross

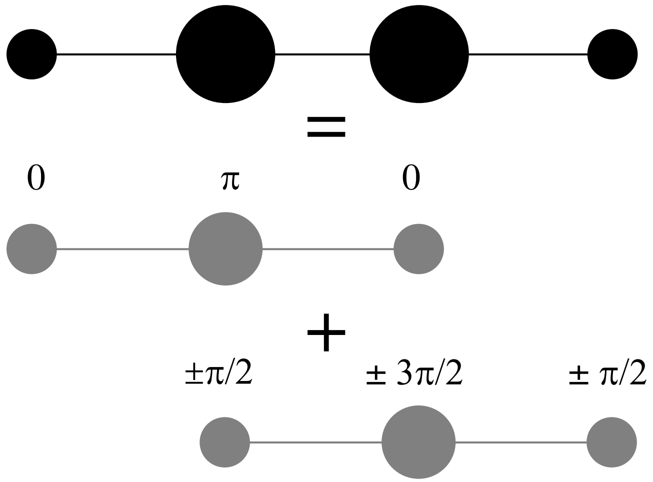


Generalized Angel Cross

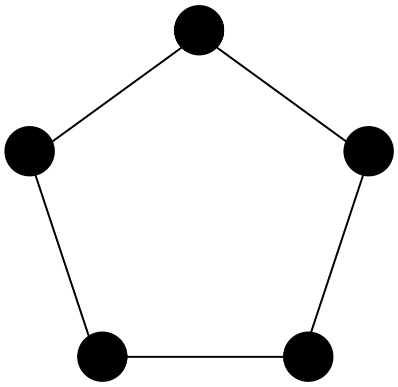


High-order nulls with phase chopping

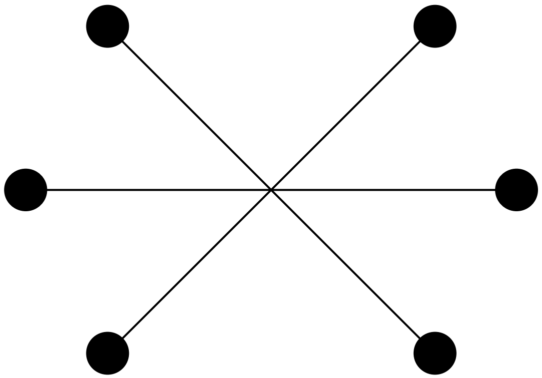
Chopped Degenerate Angel Cross

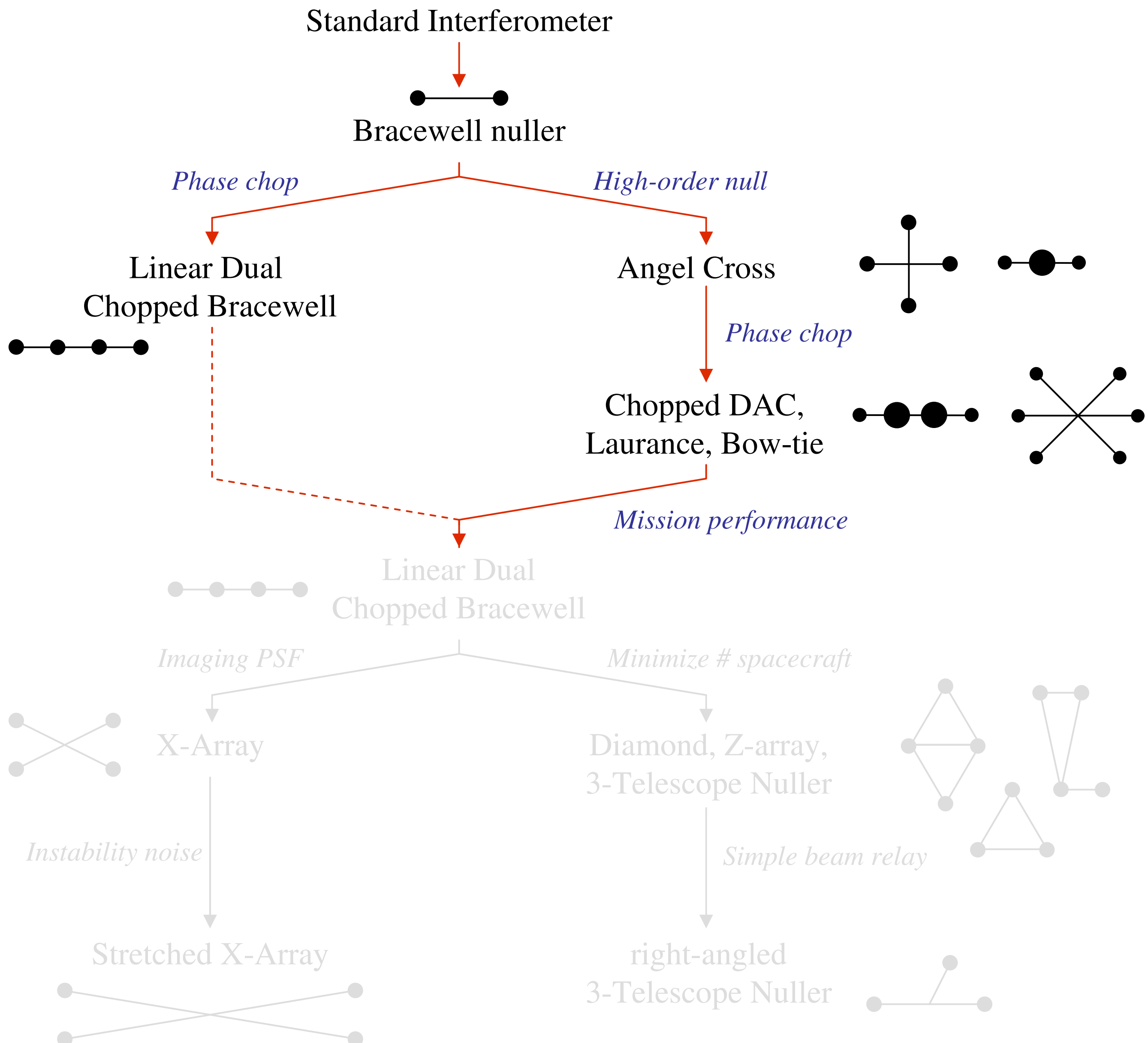


Robin Laurance family



Bow-Tie

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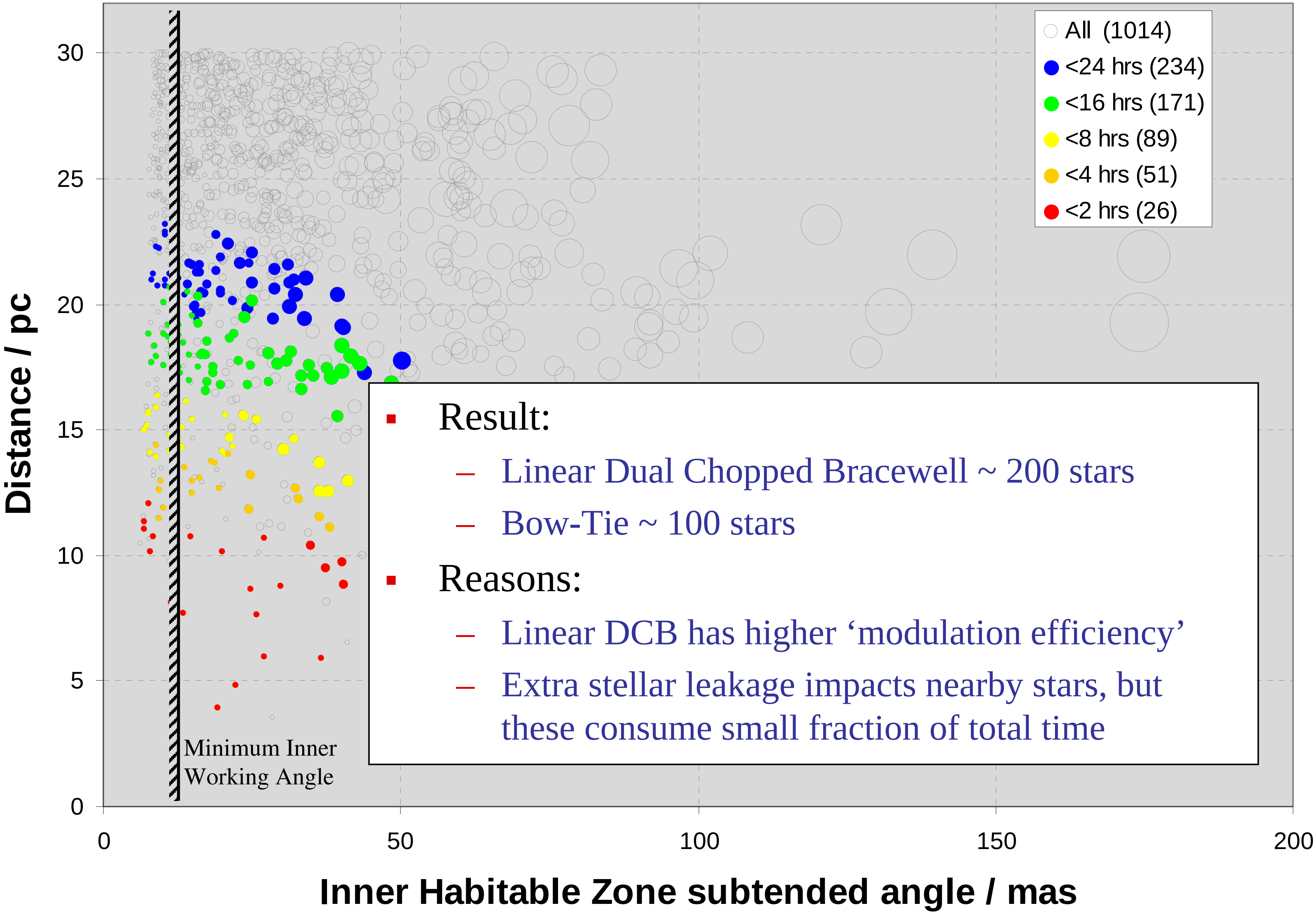
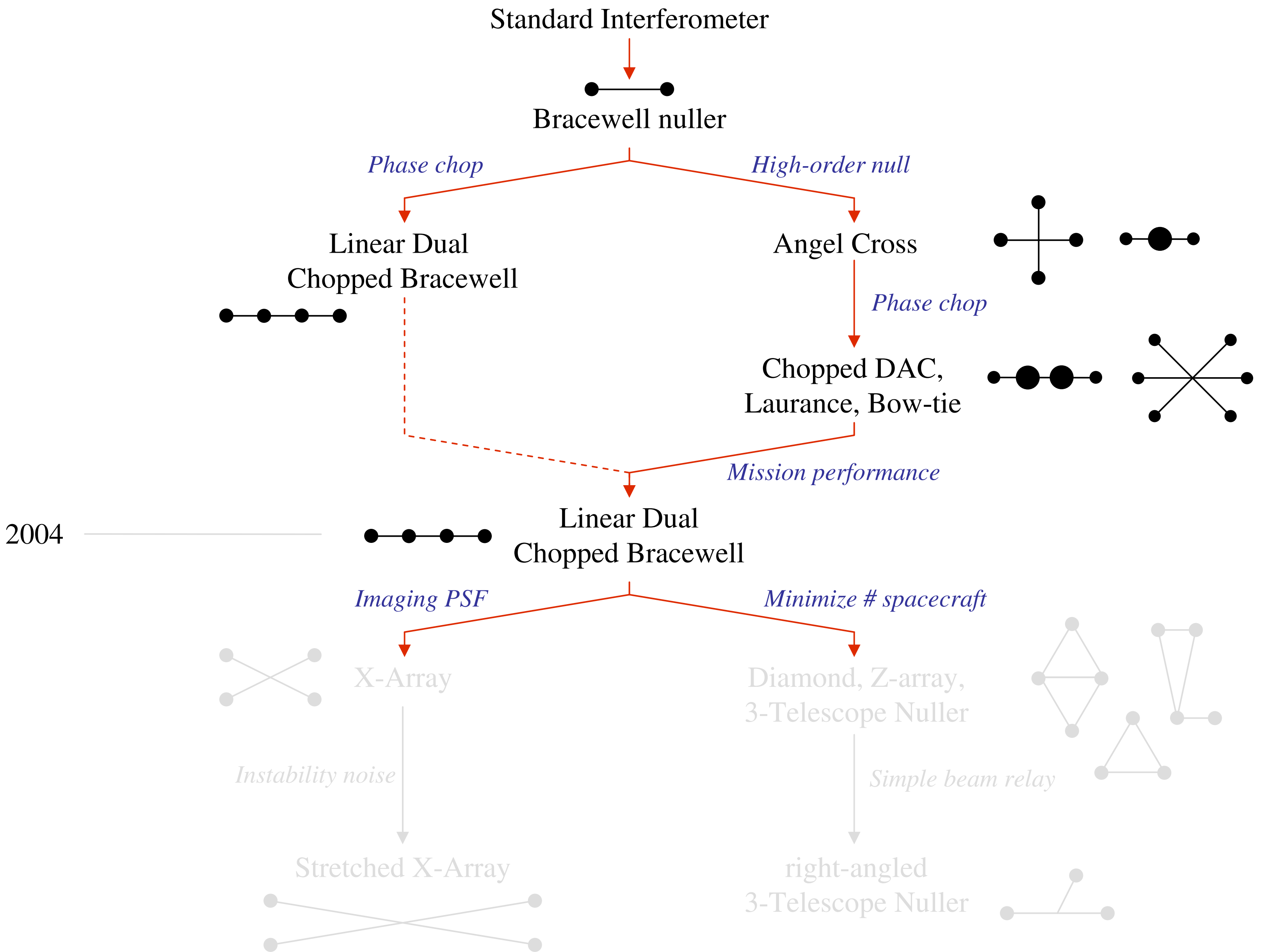
Mission performance model



- Result:
  - Linear Dual Chopped Bracewell ~ 200 stars
  - Bow-Tie ~ 100 stars
- Reasons:
  - Linear DCB has higher ‘modulation efficiency’
  - Extra stellar leakage impacts nearby stars, but these consume small fraction of total time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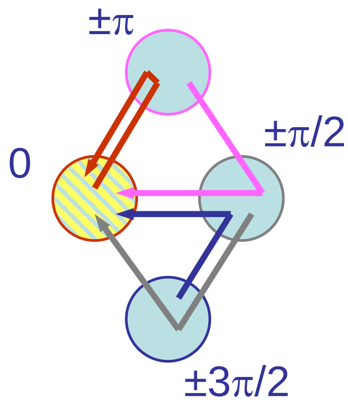
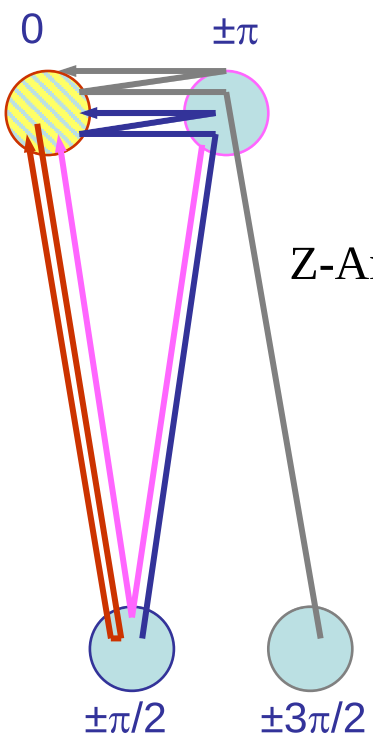
Minimizing # spacecraft

Dual Bracewell variants

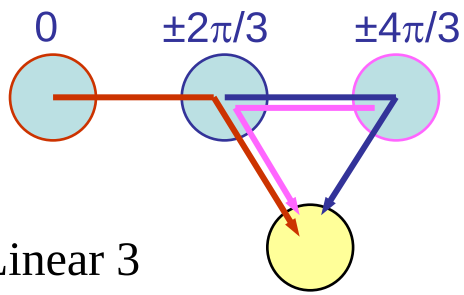
Diamond DCB





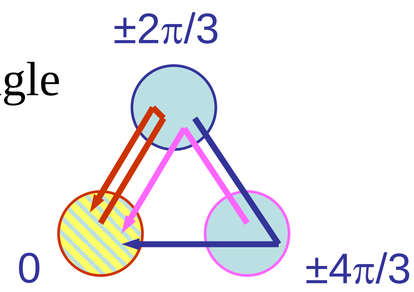
Z-Array

Three Telescope Nuller

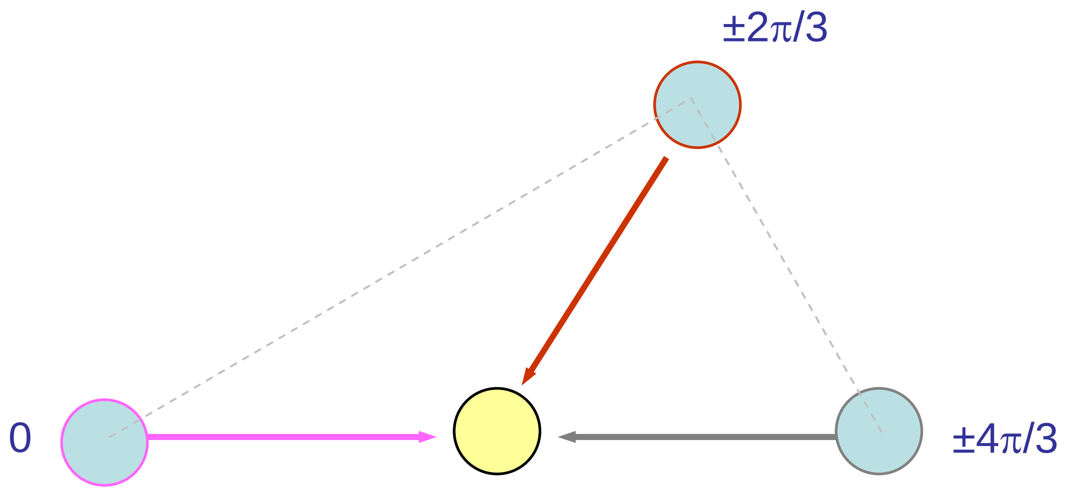


Linear 3

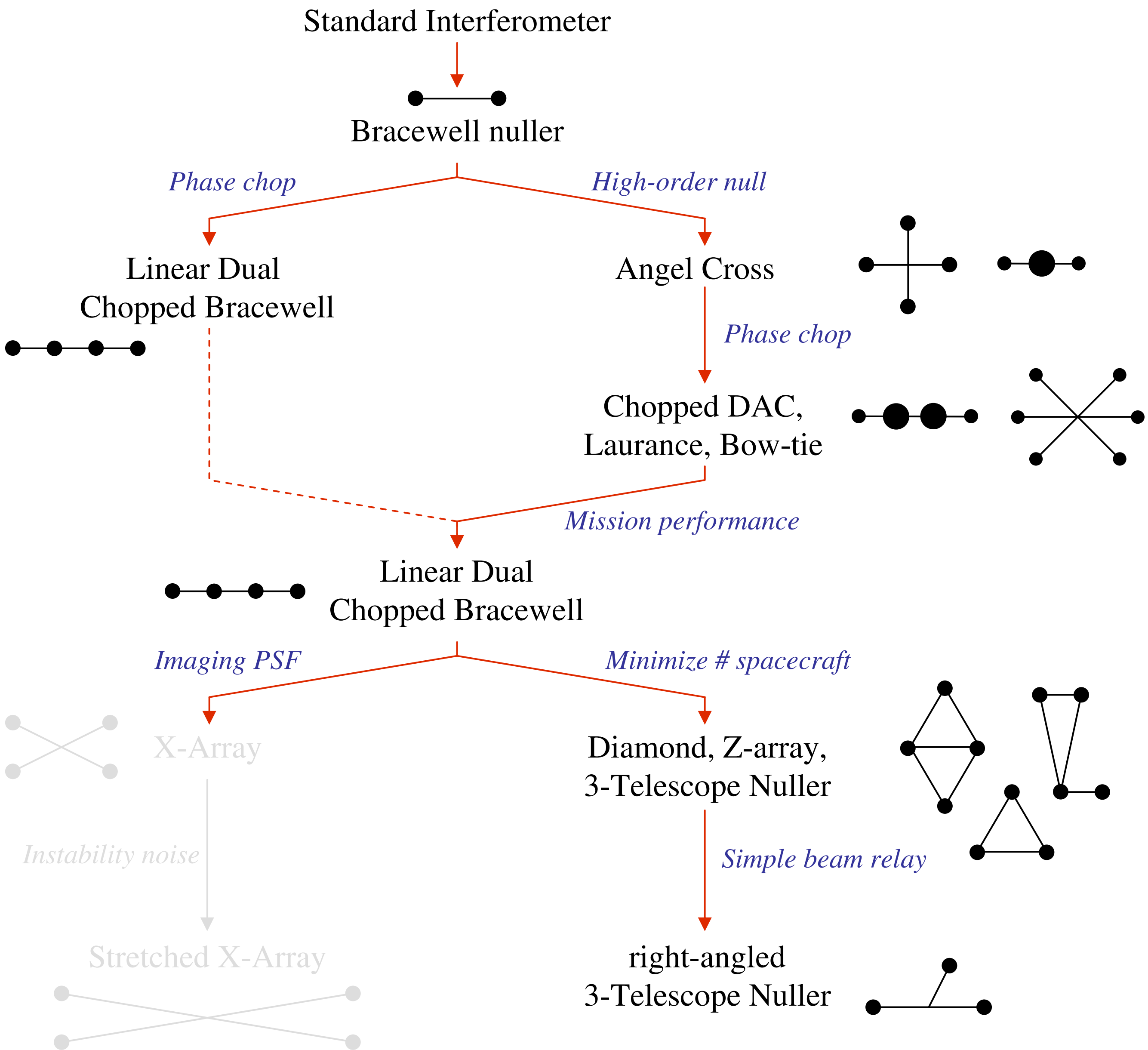
Triangle



Right-angled Three Telescope Nuller rTTN



- Breaks symmetry of the equilateral triangle
- Simple one-hop beam relay
- More in Philippe Gondoin's talk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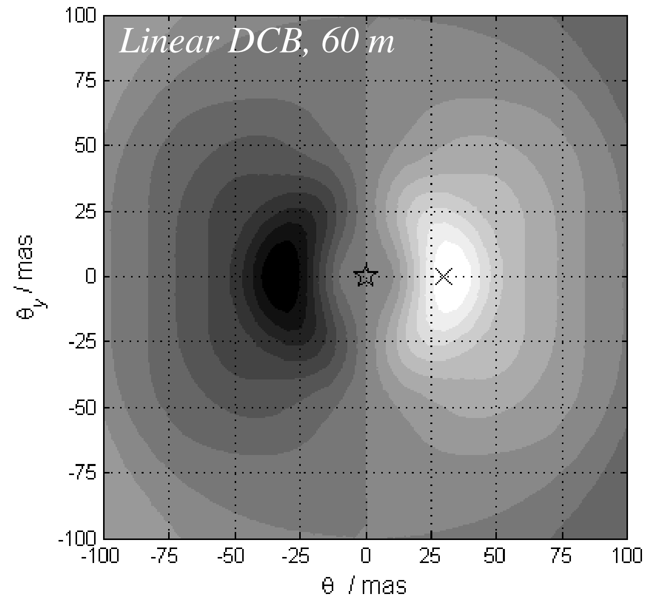
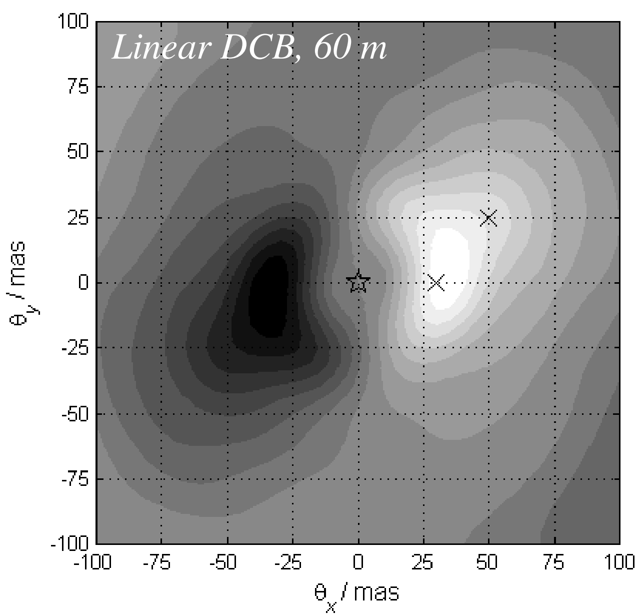
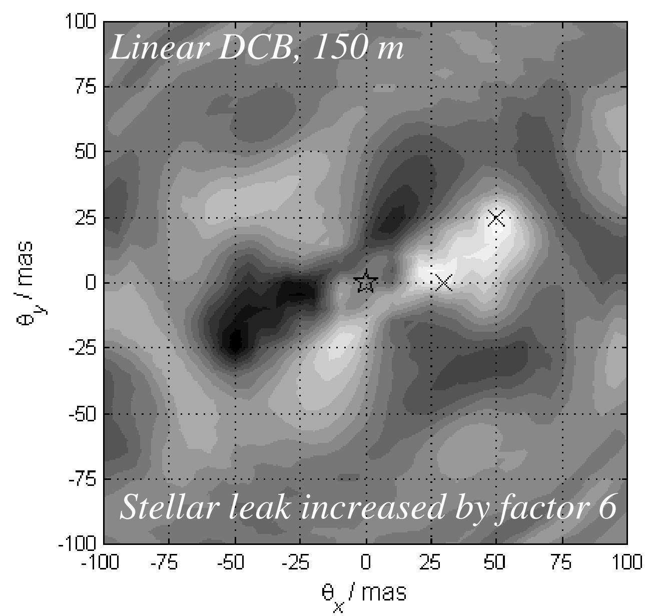
Imaging & the Point Spread Function

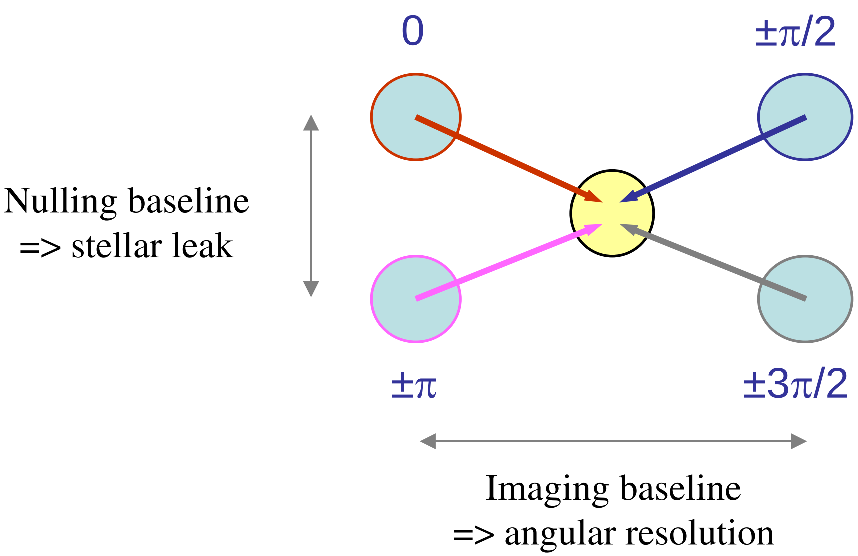
- Equivalent to synthesized beam of imaging interferometry
- Extra structure due to phased array



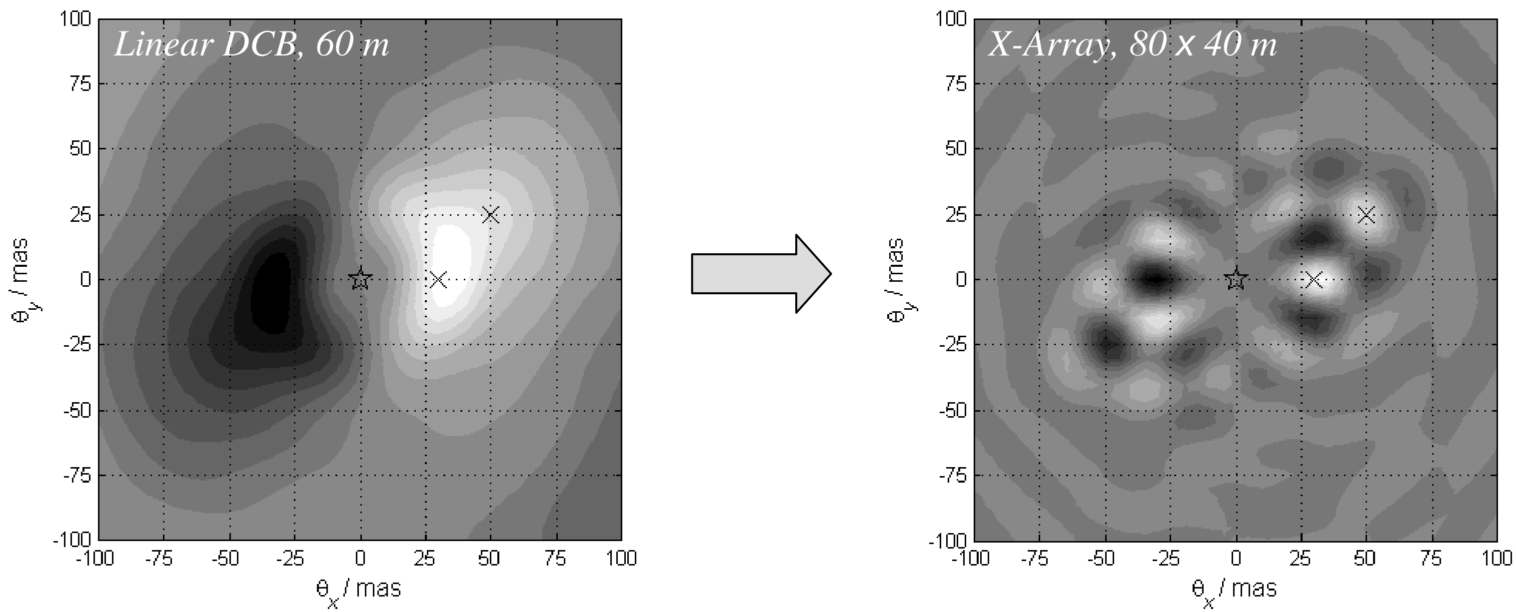


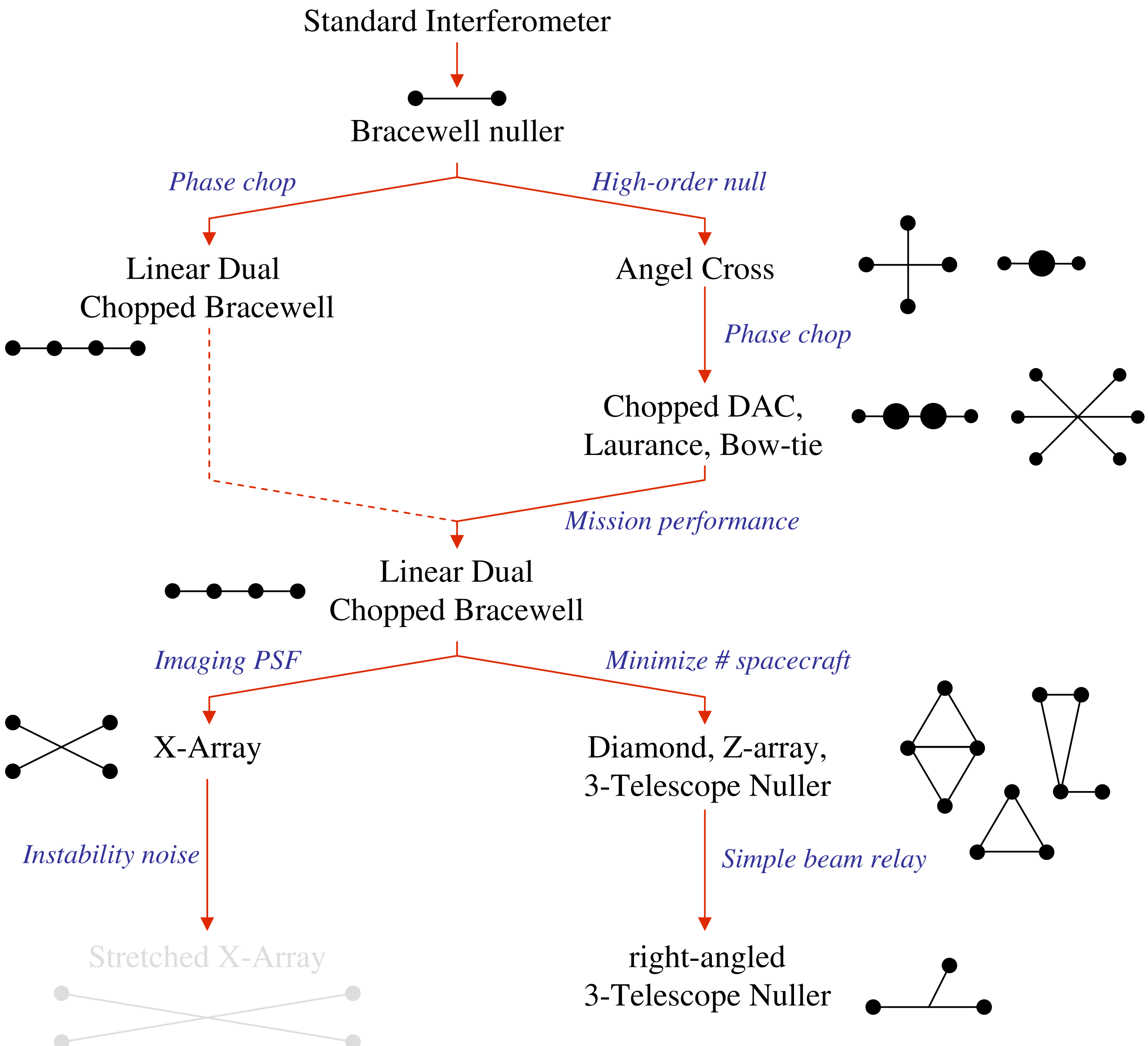


X-Array



- Independent control of stellar leak and imaging resolution
- Simple one-hop beam relay

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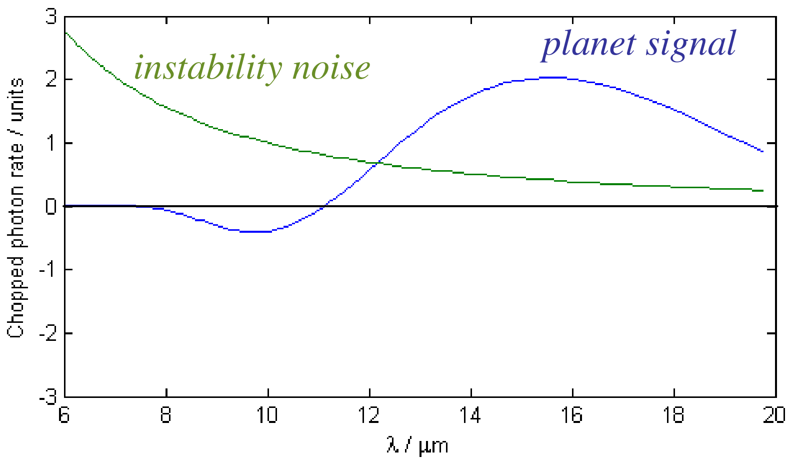
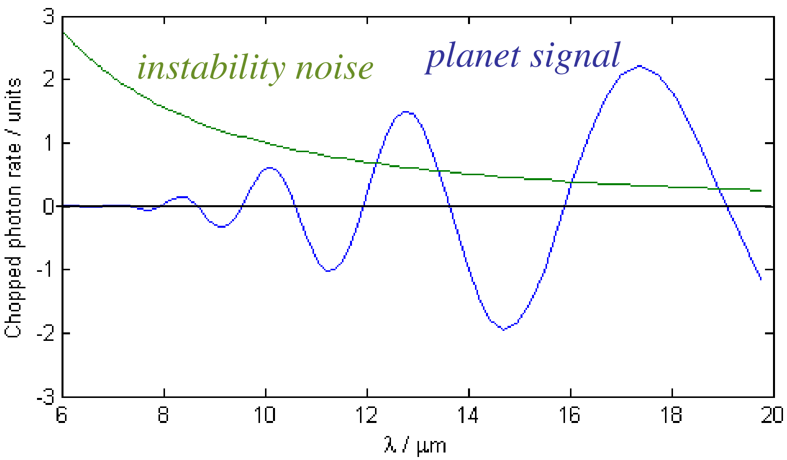
Instability Noise

- Instrument instability (path lengths, pointing, etc.) modulates the null depth => time-variable stellar leakage
- Drives the instrument performance
- Distinctive spectral signature:

Standard array size

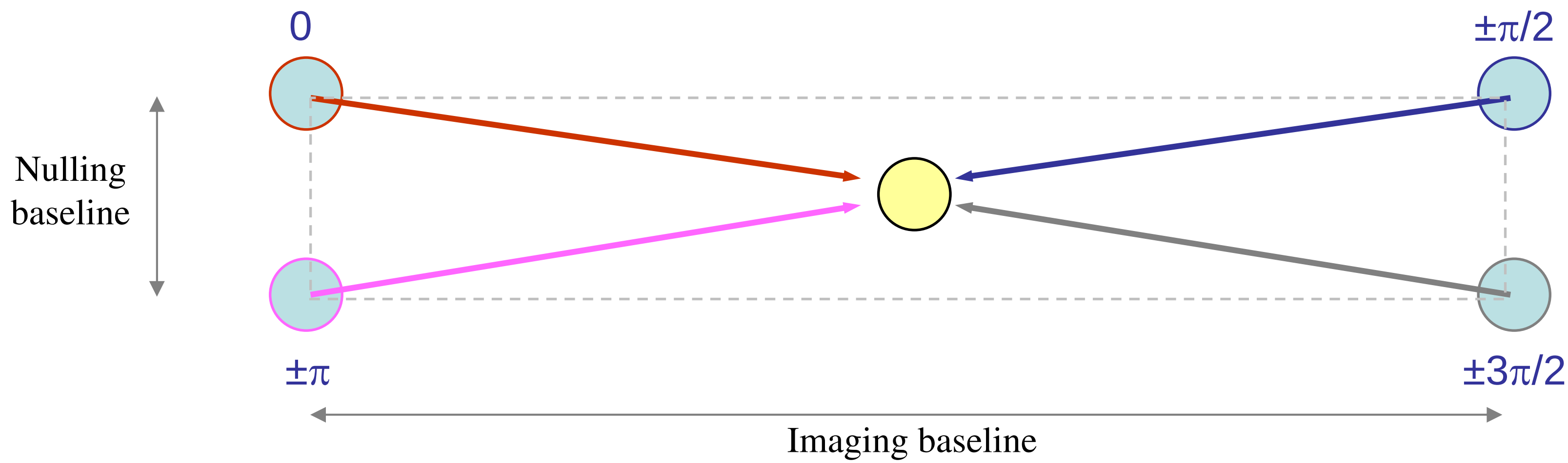


Stretched array size

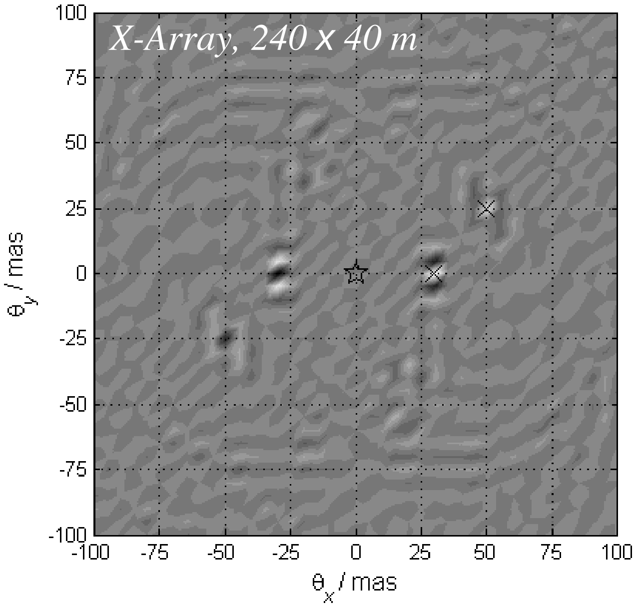


- By stretching the array we can effectively remove the instability noise
- Can relax null requirement from 10^{-6} to 10^{-5}

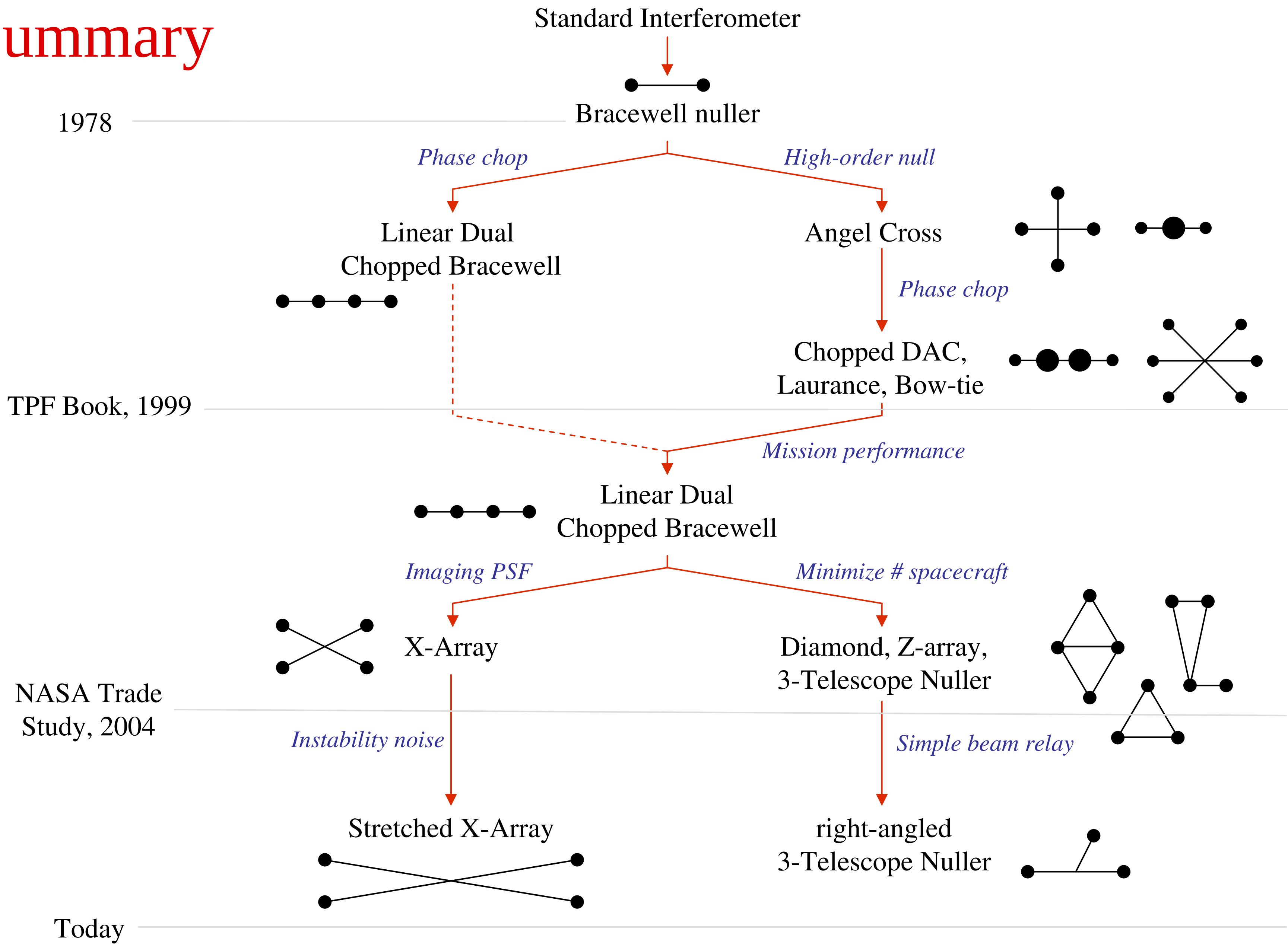
Stretched X-Array



- Only X-Array can be stretched without introducing extra stellar leakage
- 6:1 aspect ratio
- Excellent imaging properties
- Current configuration for TPF-I



Summary



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