Requirements and Optimisation for the CTA SST sub-system

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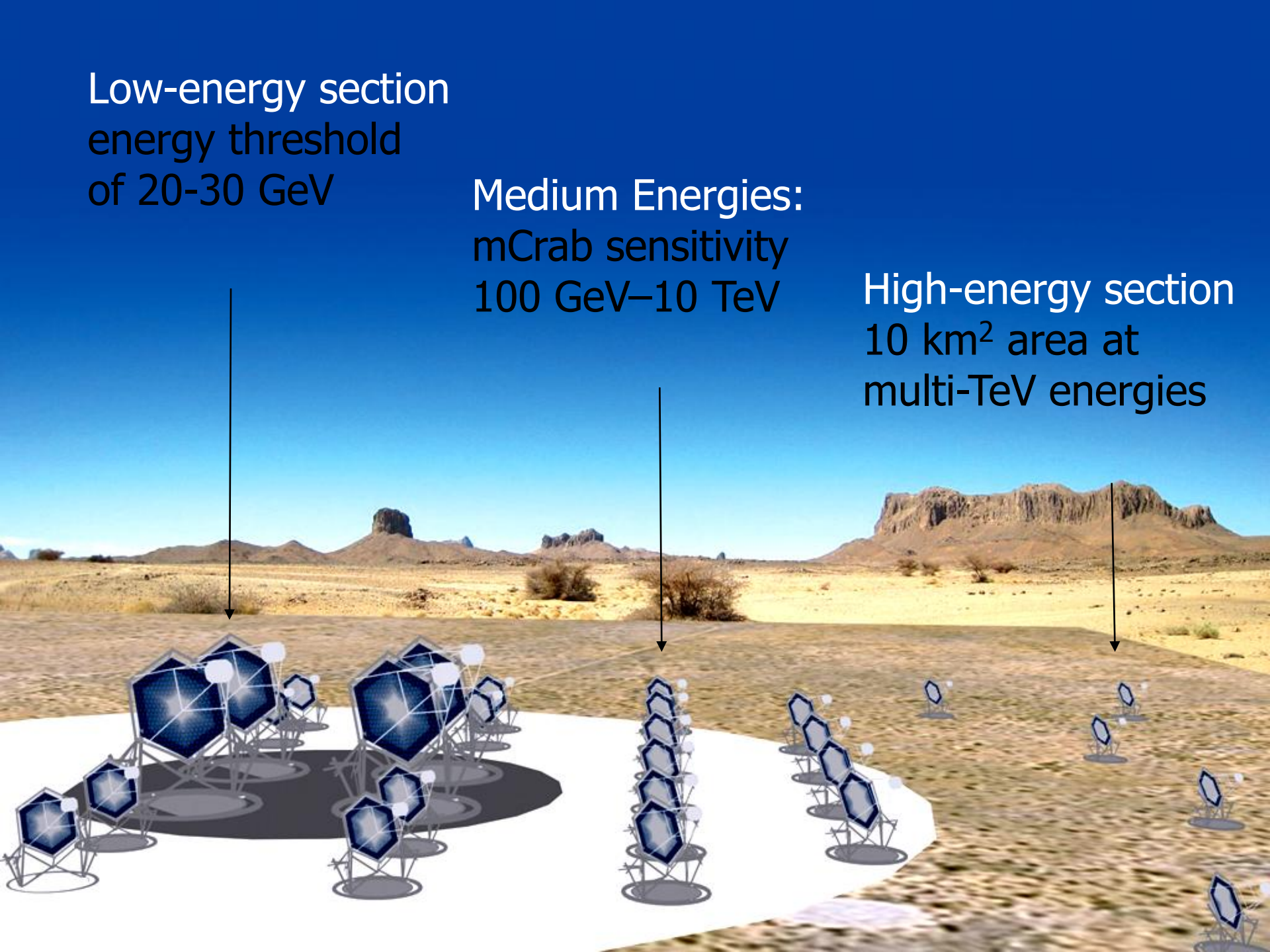
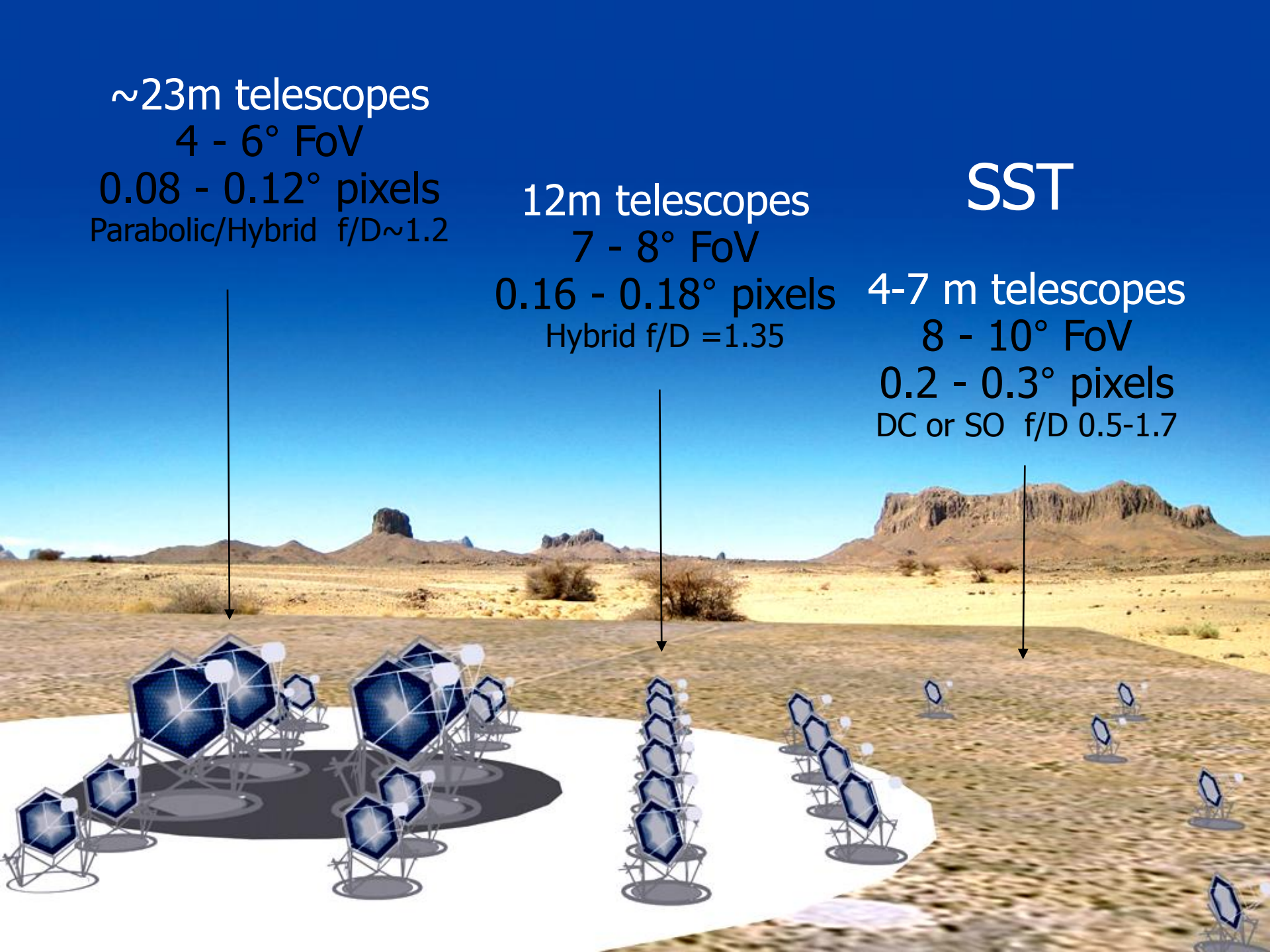
University of Leicester

Liverpool SST Meeting Sept. 2010


Low-energy section
energy threshold
of 20-30 GeV
Medium Energies:
mCrab sensitivity
100 GeV–10 TeV
High-energy section
10 km^2 area at
multi-TeV energies


~23m telescopes
4 - 6° FoV
0.08 - 0.12° pixels
Parabolic/Hybrid f/D~1.2
12m telescopes
7 - 8° FoV
0.16 - 0.18° pixels
Hybrid f/D =1.35
SST
4-7 m telescopes
8 - 10° FoV
0.2 - 0.3° pixels
DC or SO f/D 0.5-1.7

4 The Gamma-ray Horizon

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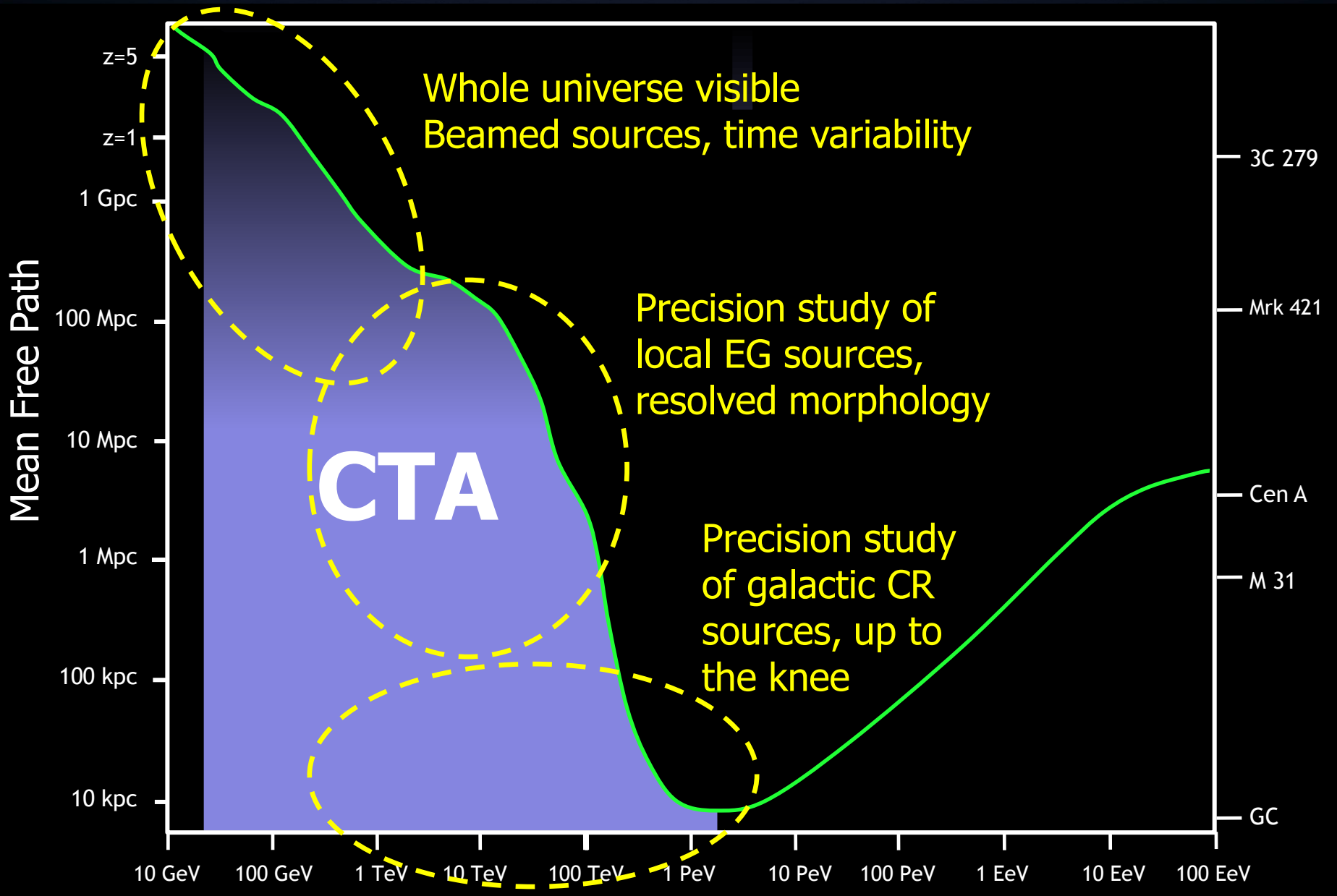

5 The Gamma-ray Horizon

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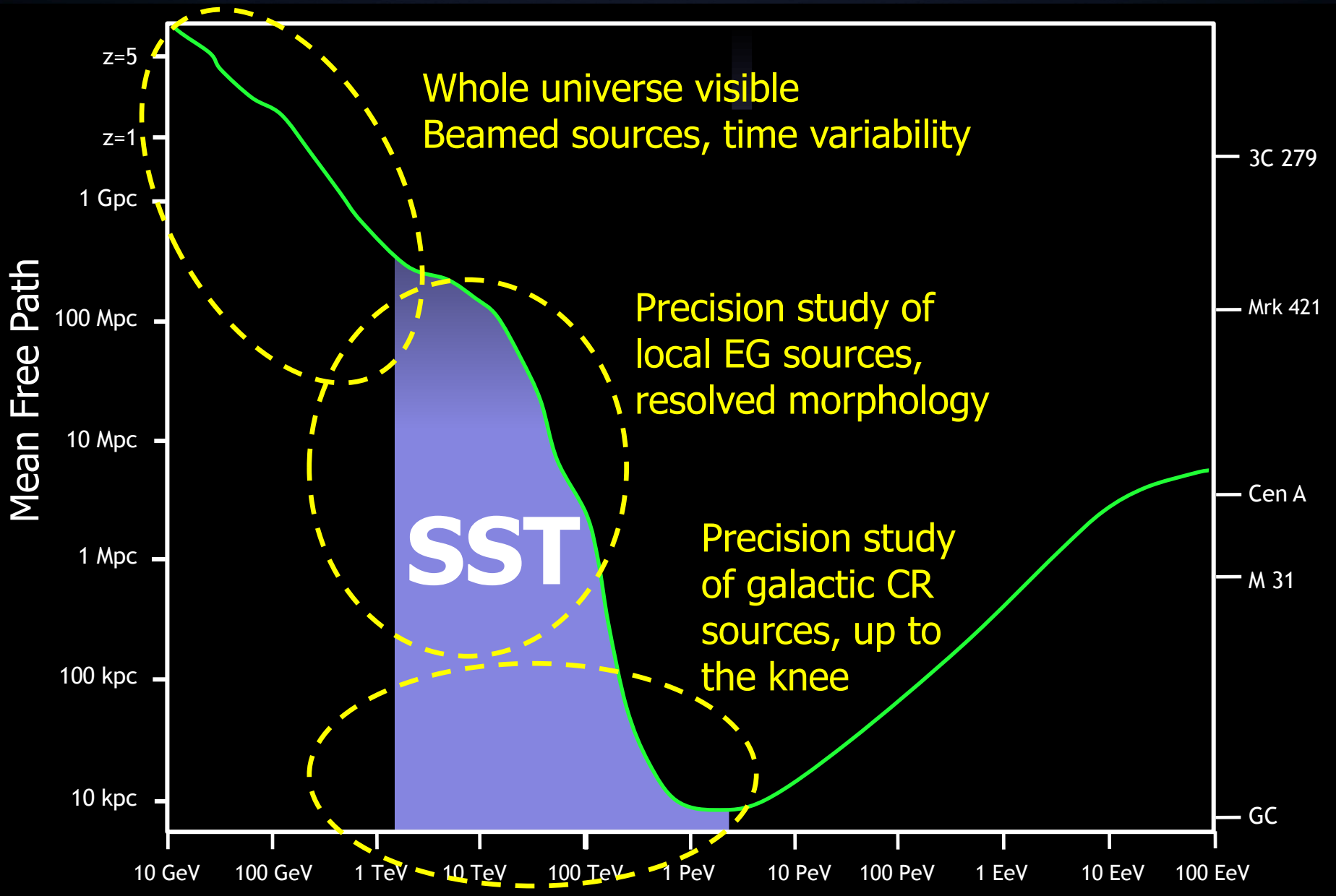

6 Photon Statistics

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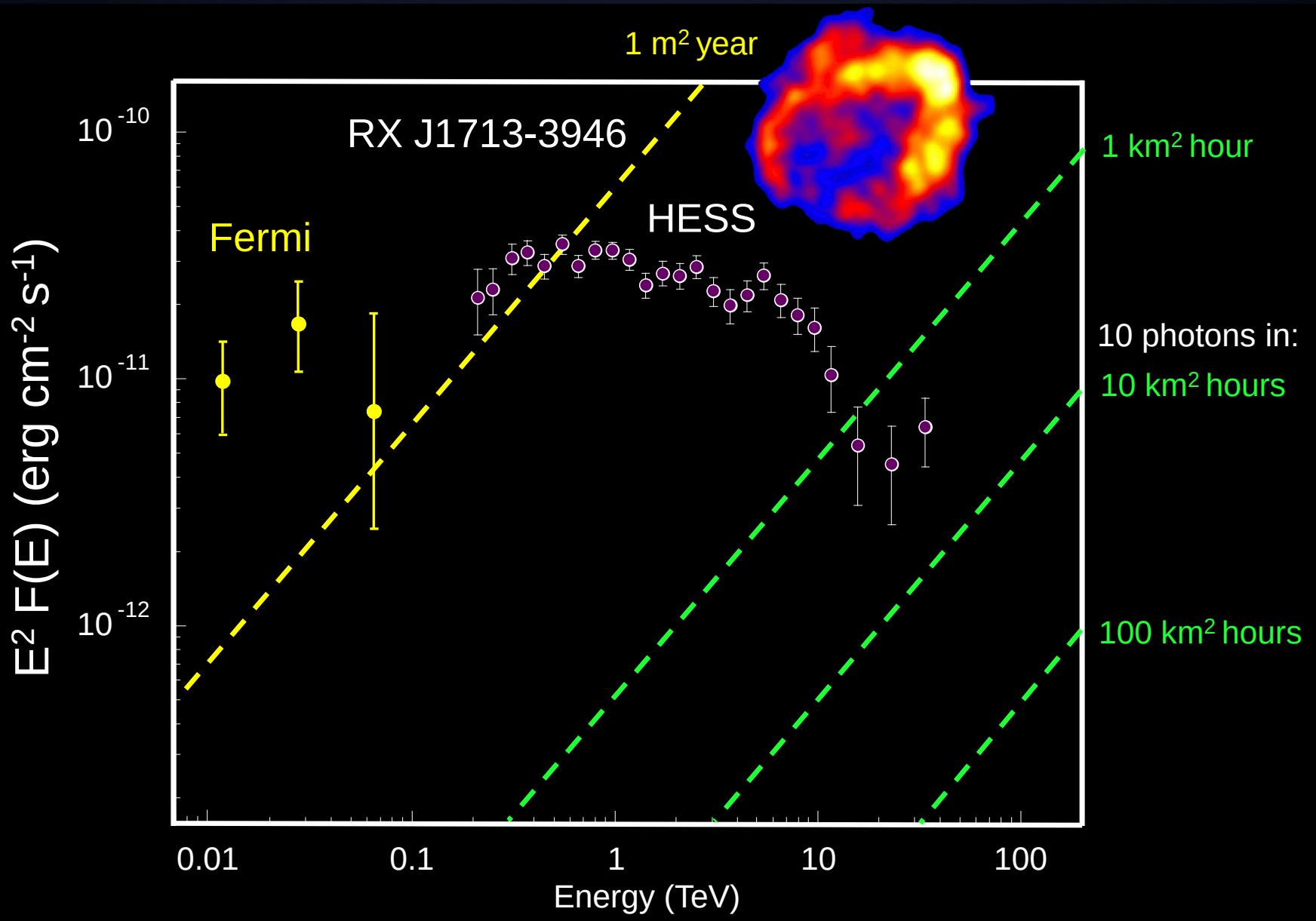

7 Photon Statistics

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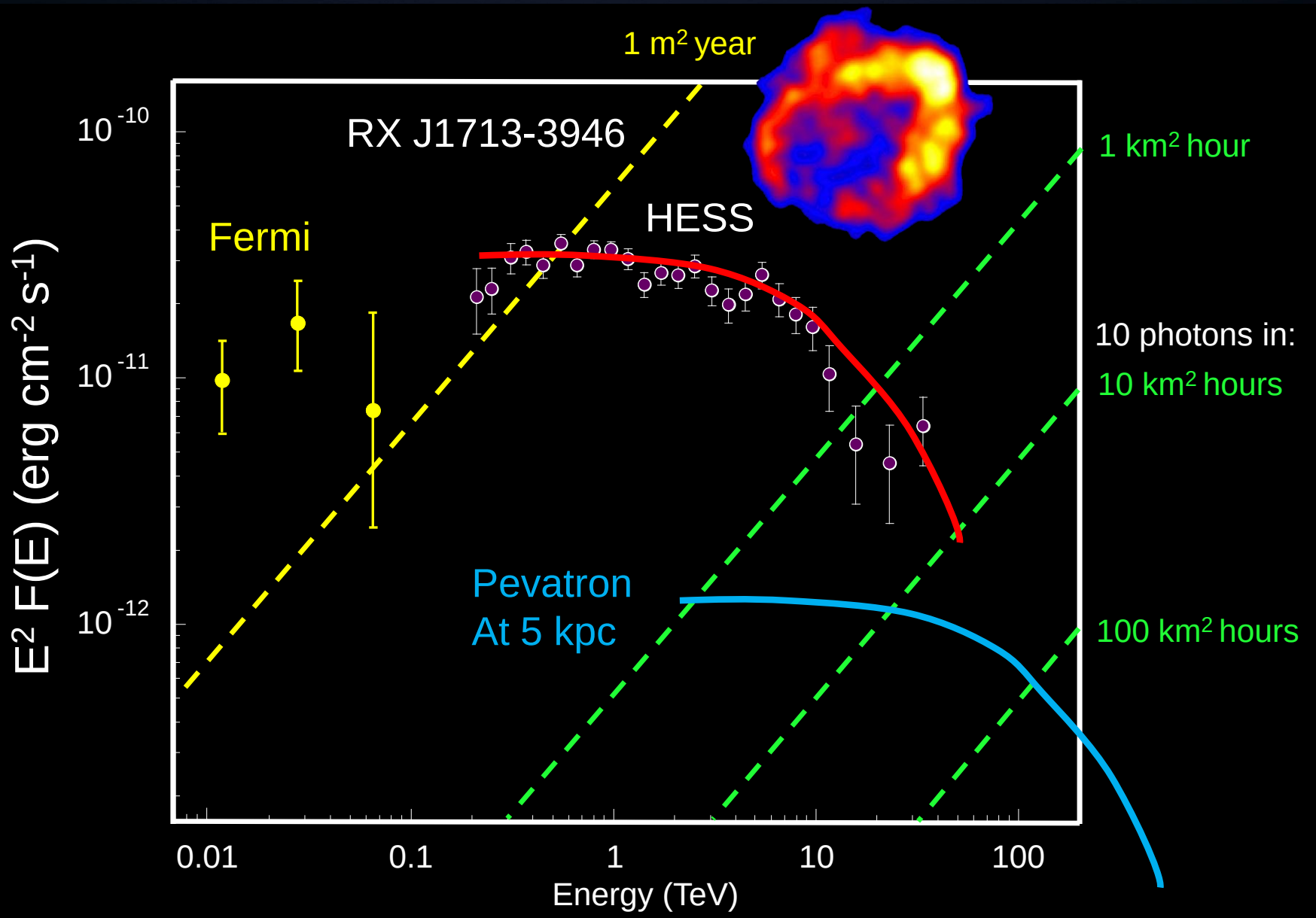

8 Limitations

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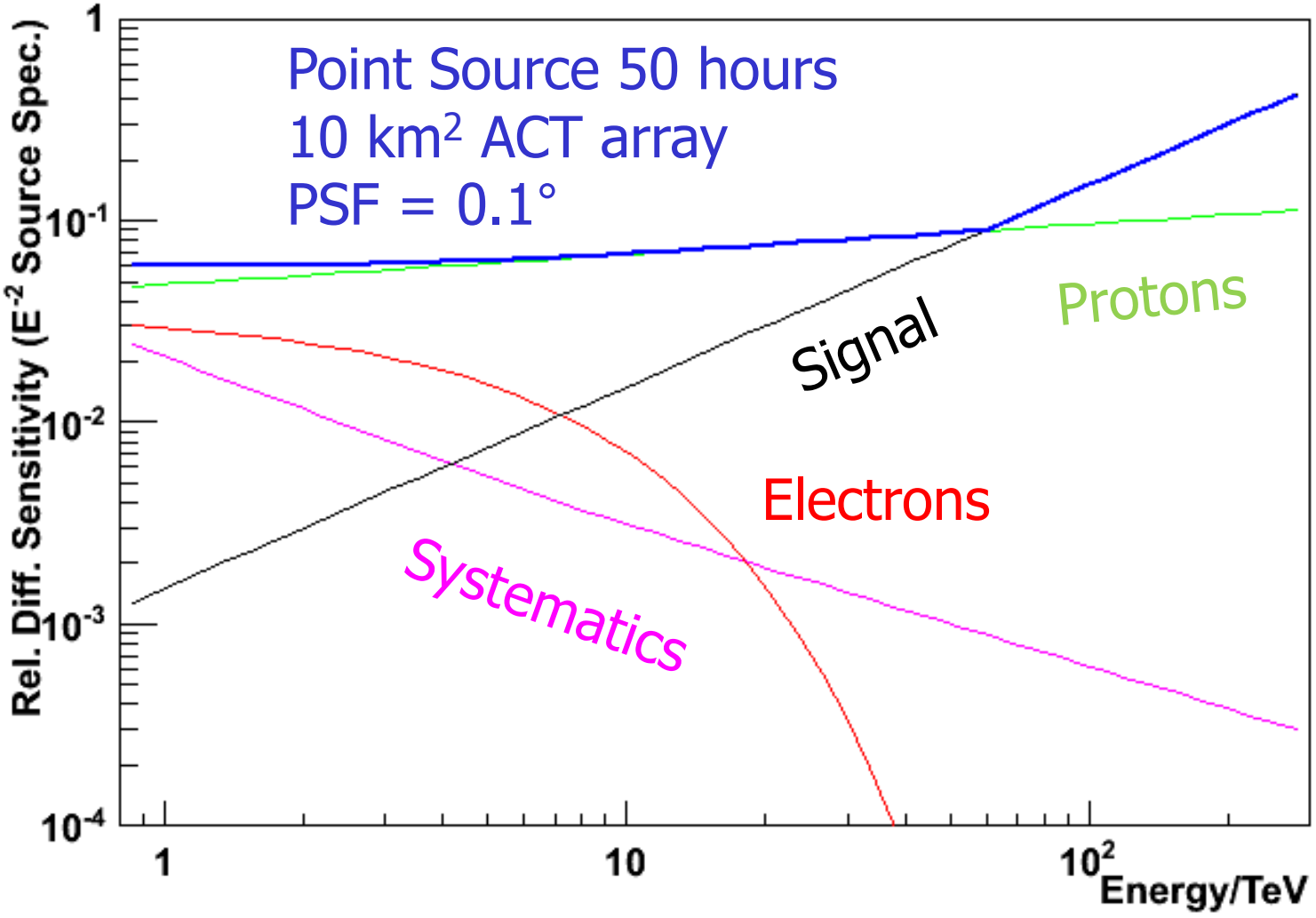

9 Limitations

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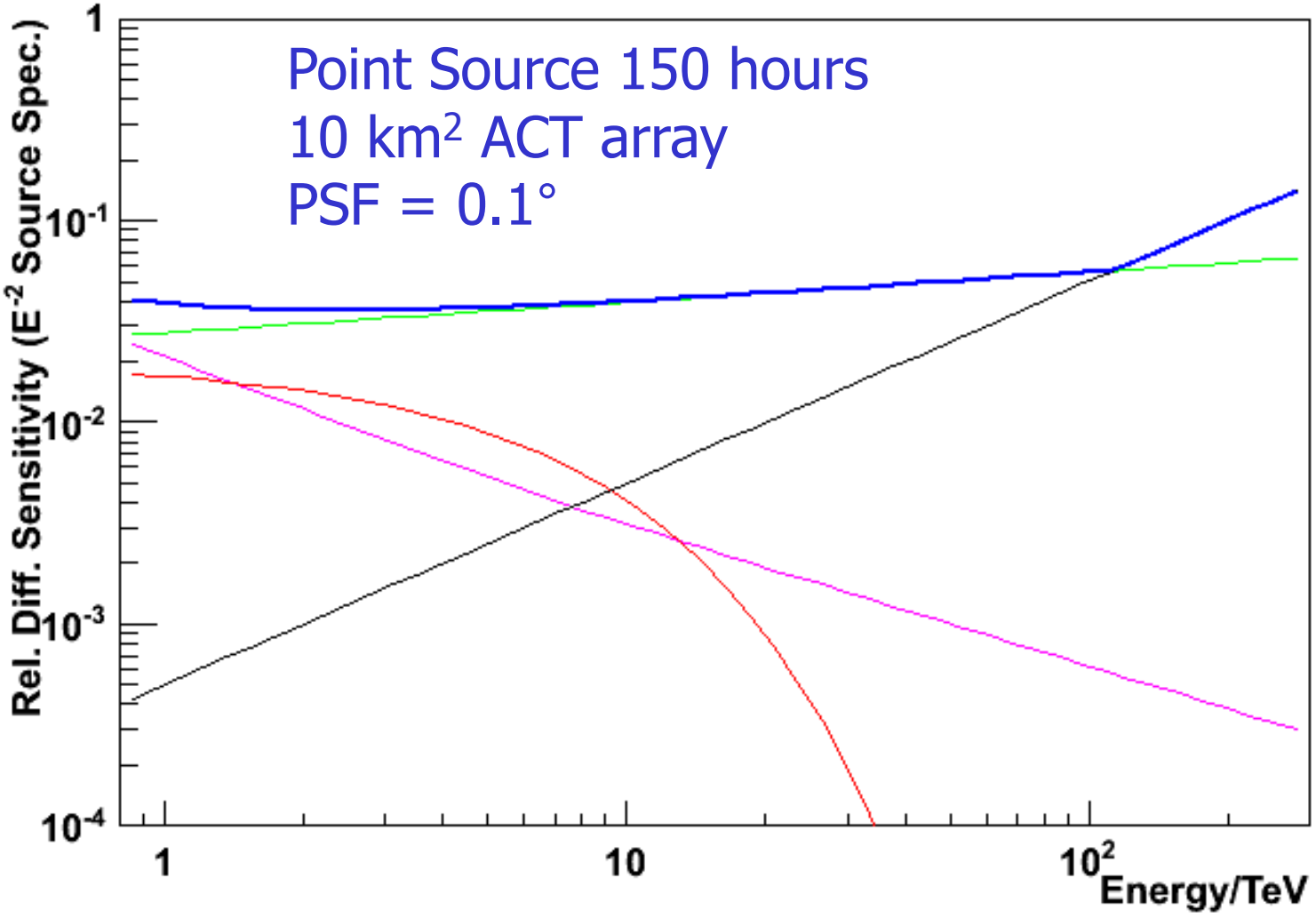

10 Limitations

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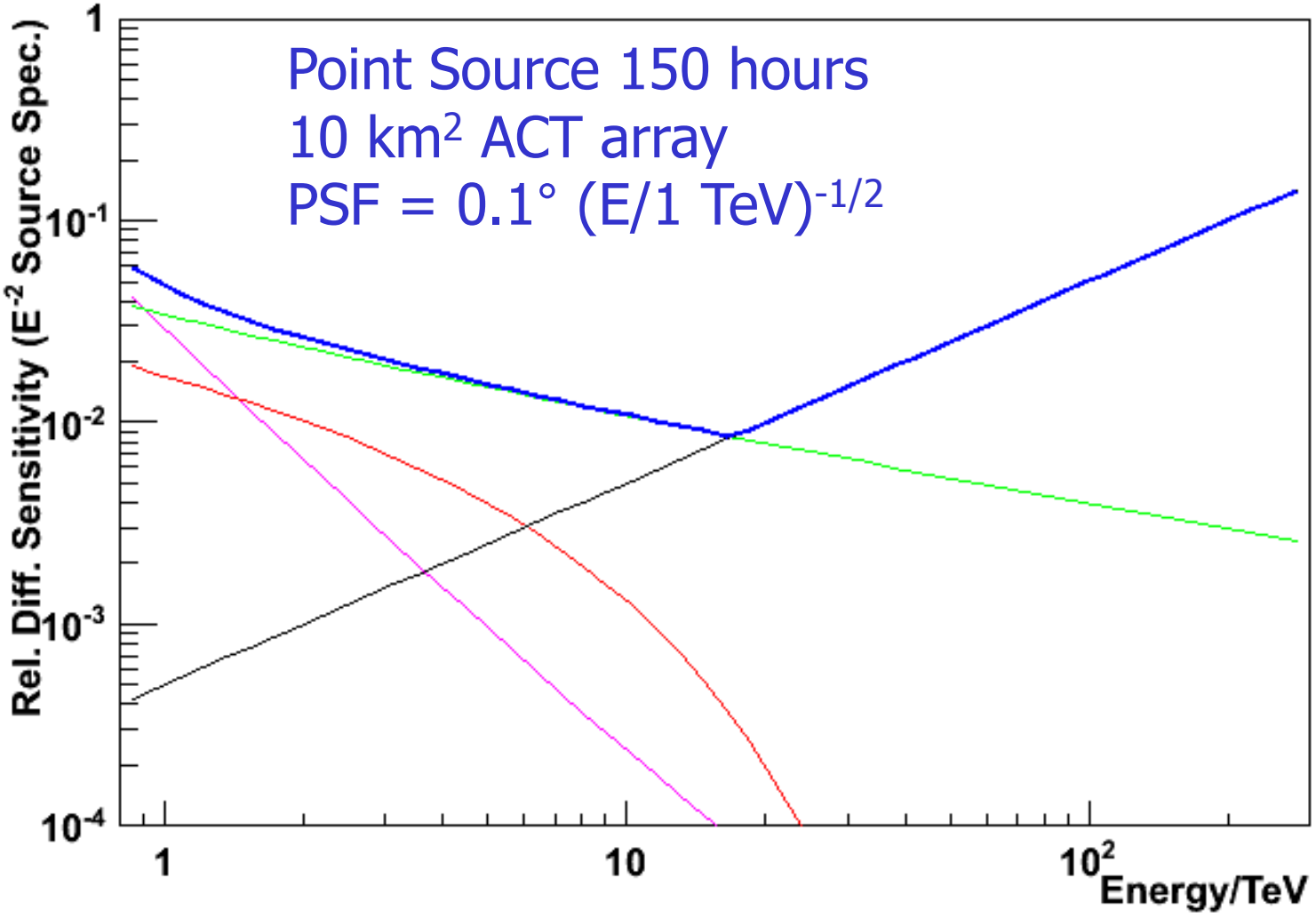

11 Angular resolution

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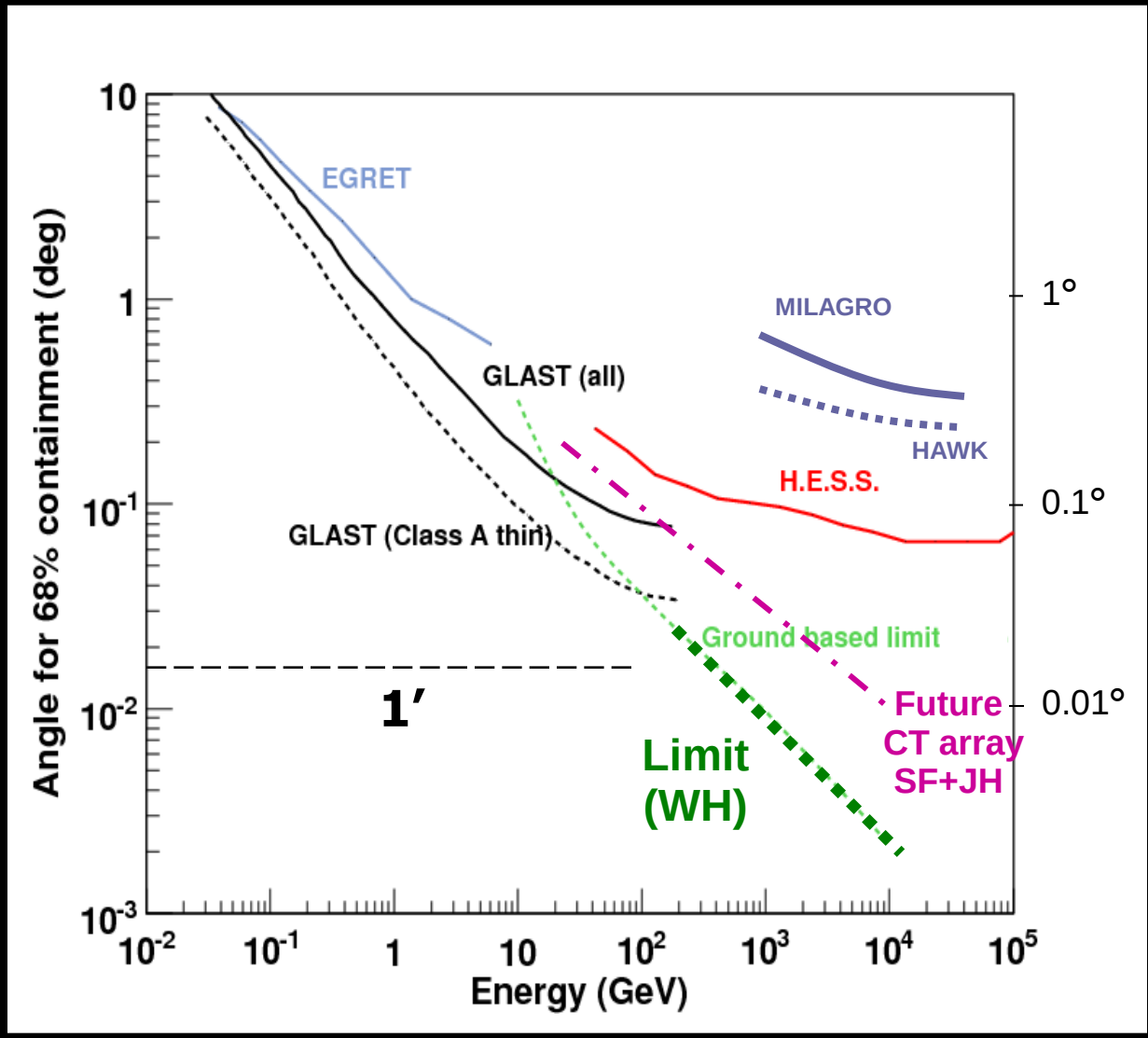
- ~1’ resolution achievable with next generation IACT arrays
- Fundamental limit is ~10” above a few TeV



12 Resolution

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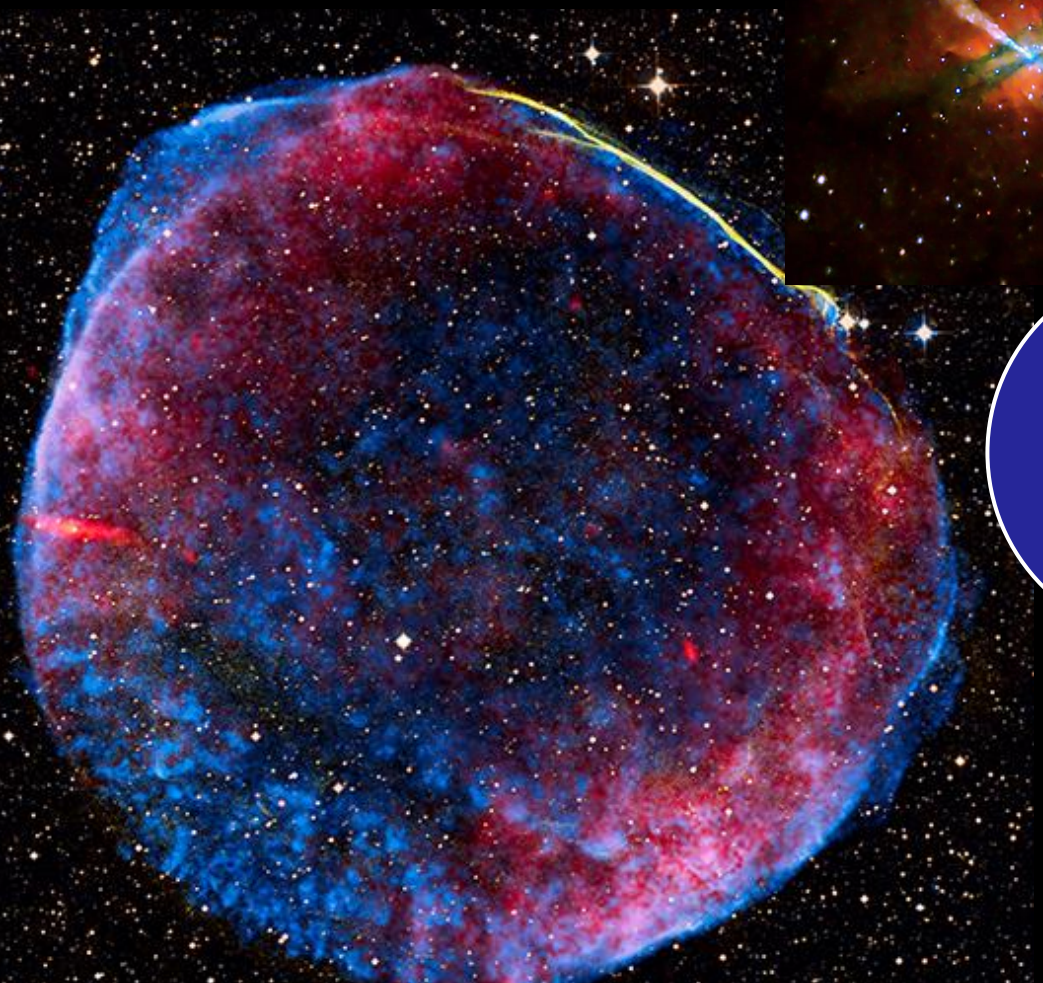
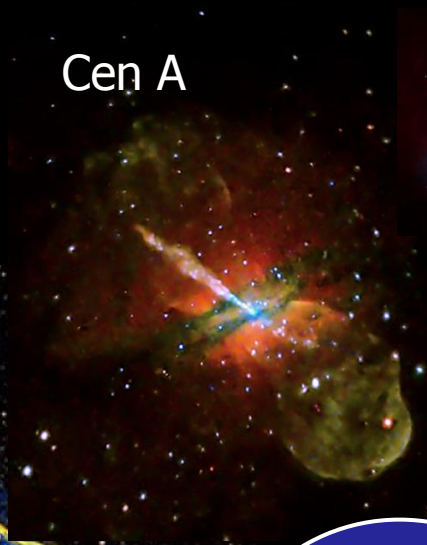
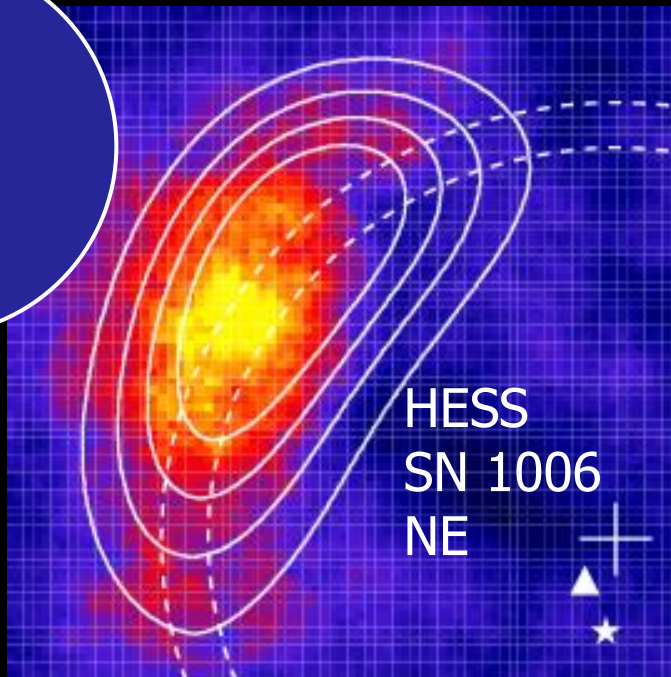




1′

2′

5′



13 Requirements

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- Area
  - O(10 km^2) at 100 TeV
- Energy Range
  - ~1 TeV to >> 100 TeV
    - Inefficient for the SST to compete with the MST in the core energy range - aim for SST dominance of sensitivity between 5 and 10 TeV (trigger 1-3 TeV)
    - Maximum energy?
      - Aim to run out of stats. for ~1 Crab source before saturation
- Angular resolution / Background rejection
  - As good as possible, BG free at lowest achievable energy (i.e. best sensitivity)

- Implies minimum dish diameter ~3 m (for <150 m spacing)

14 Special Considerations

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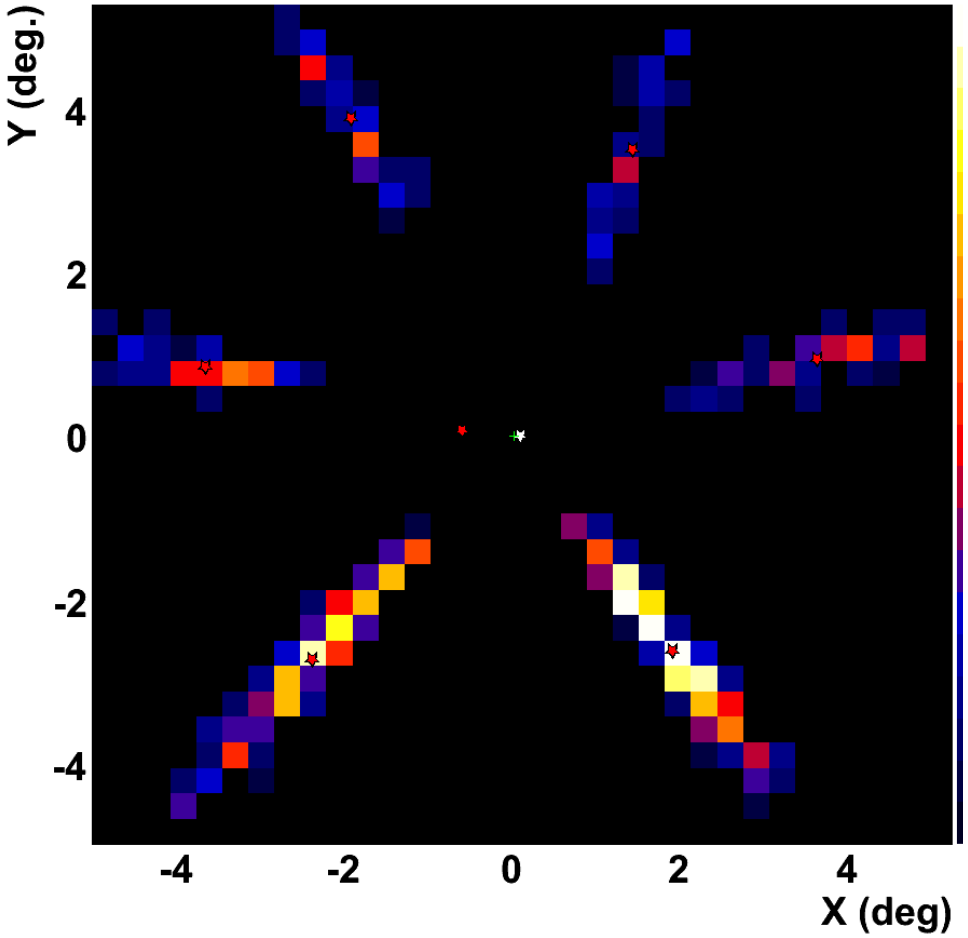

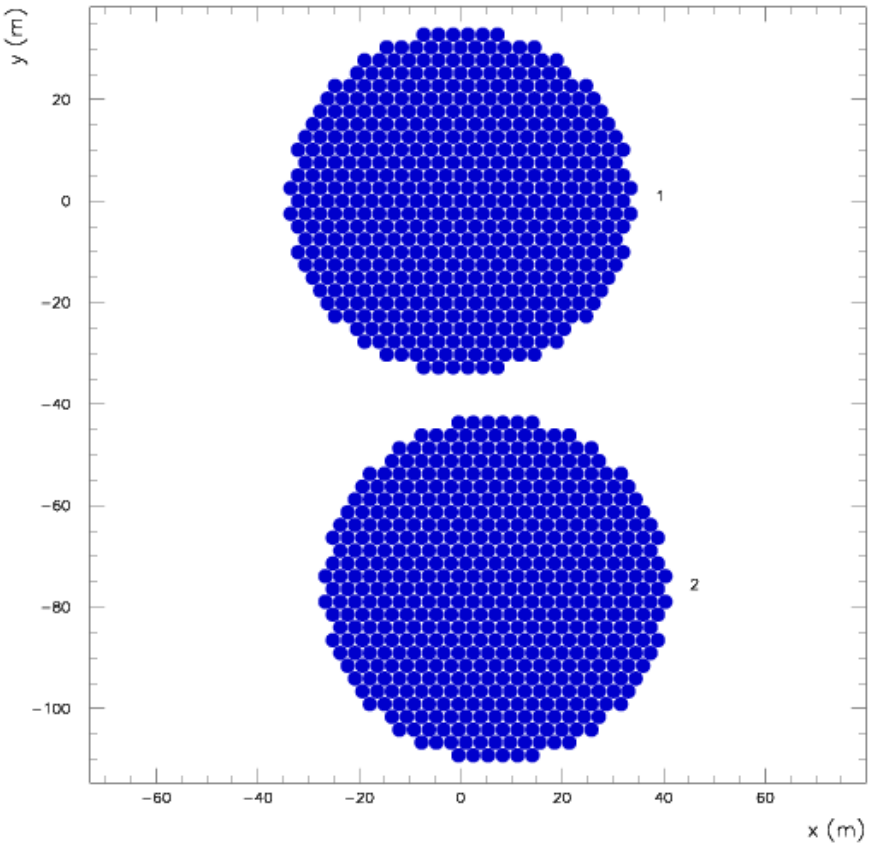

Long, wide, offset, large time-spread images

Examples: Images in six 10° FoV (0.25° pixel) cameras (30 m^2 tels.) ~500 m from the core of 14 TeV shower + VERITAS movie

15 Special Considerations

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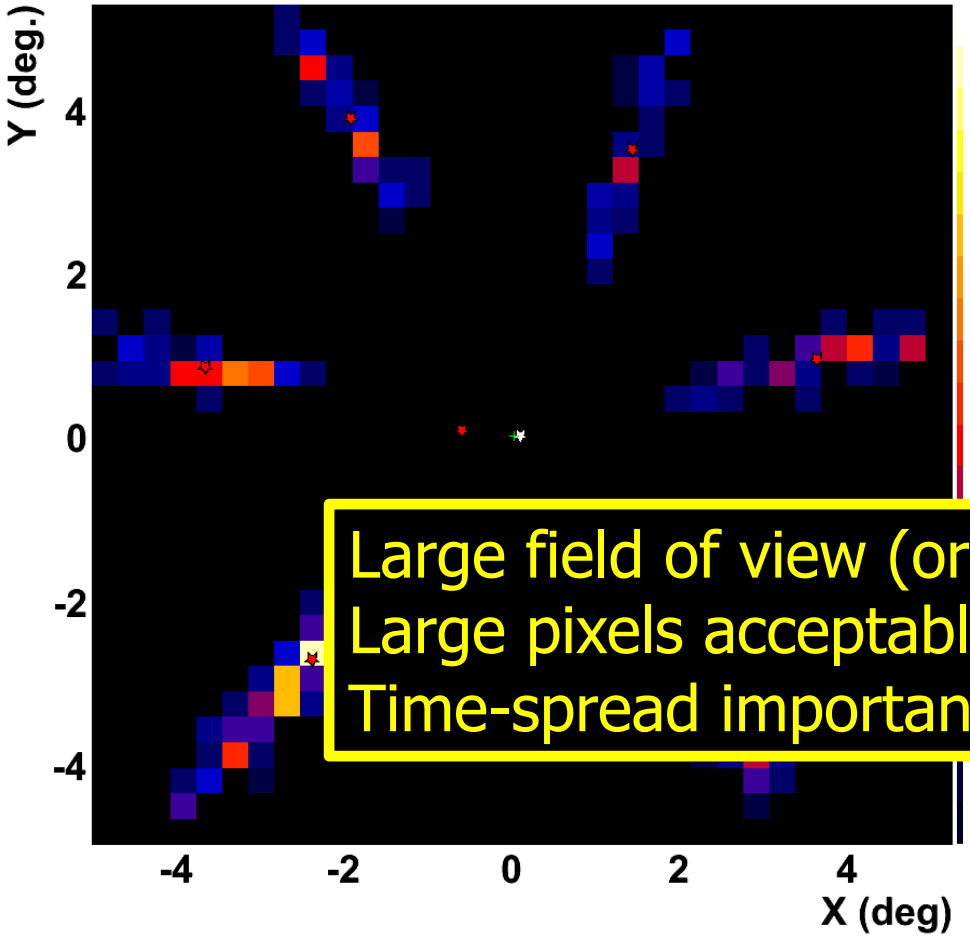

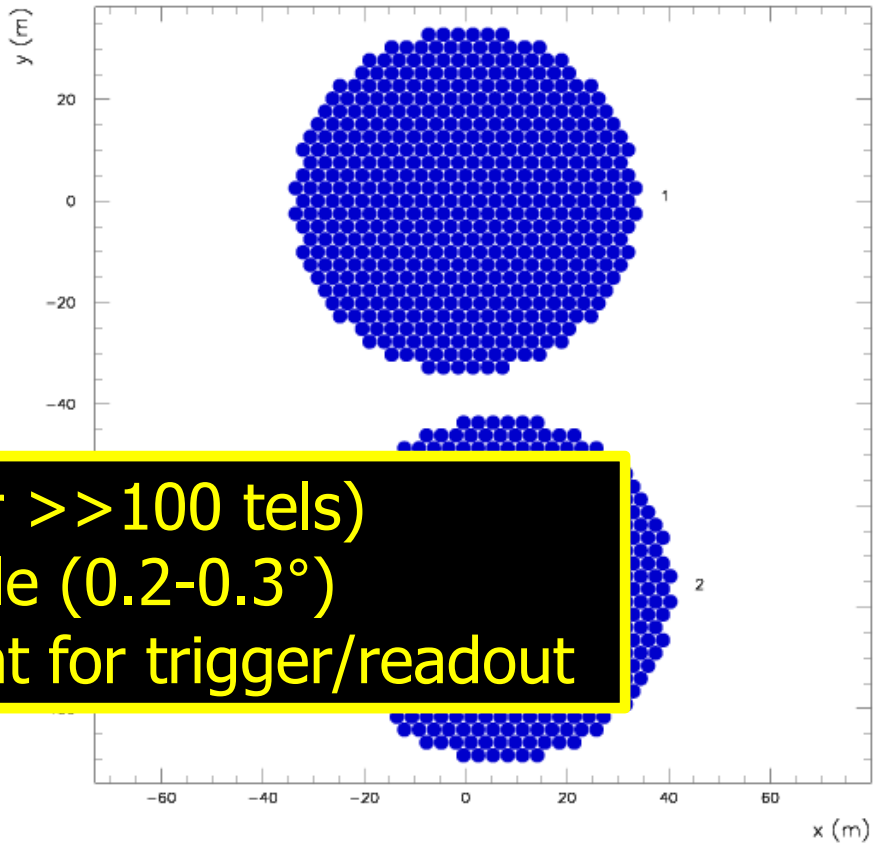

Large field of view (or >>100 tels)
Large pixels acceptable (0.2-0.3°)
Time-spread important for trigger/readout

Long, wide, offset, large time-spread images

Examples: Images in six 10° FoV (0.25° pixel) cameras (30 m^2 tels.) ~500 m from the core of 14 TeV shower + VERITAS movie

16 Array Options

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- Huge phase-space available – start with some attractive solutions:

1) Share MST photosensor/mechanics and (possibly) readout electronics
   - Scale down primary mirror 12m→7m to get from 0.18° → 0.25° with reasonable f/D

2) Take plate-scale of cheaper photosensors (5-7mm) and adapt optics to get primary as large as possible (e.g. f/D → 0.5)
   - Two-mirror solution or light-cones+SiPMs: ~4m ∅

NB: Decision point for 1 versus 2 reflectors – Oct 2011

17 Telescope Cost

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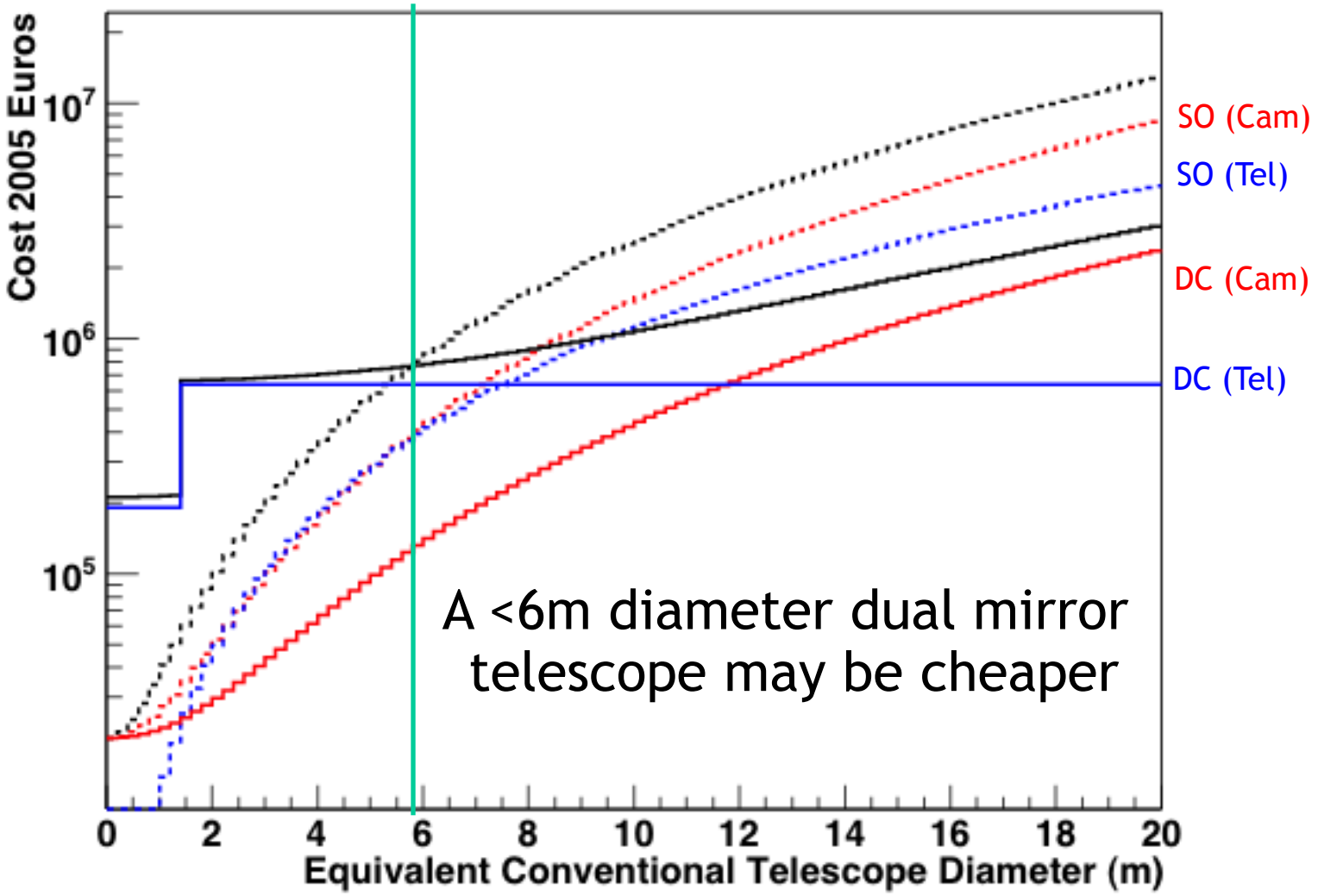
Assumes: SO Cam Pixel Cost = 1/3× DC, SO Tel/Mir = 3× DC



18 Telescope Cost

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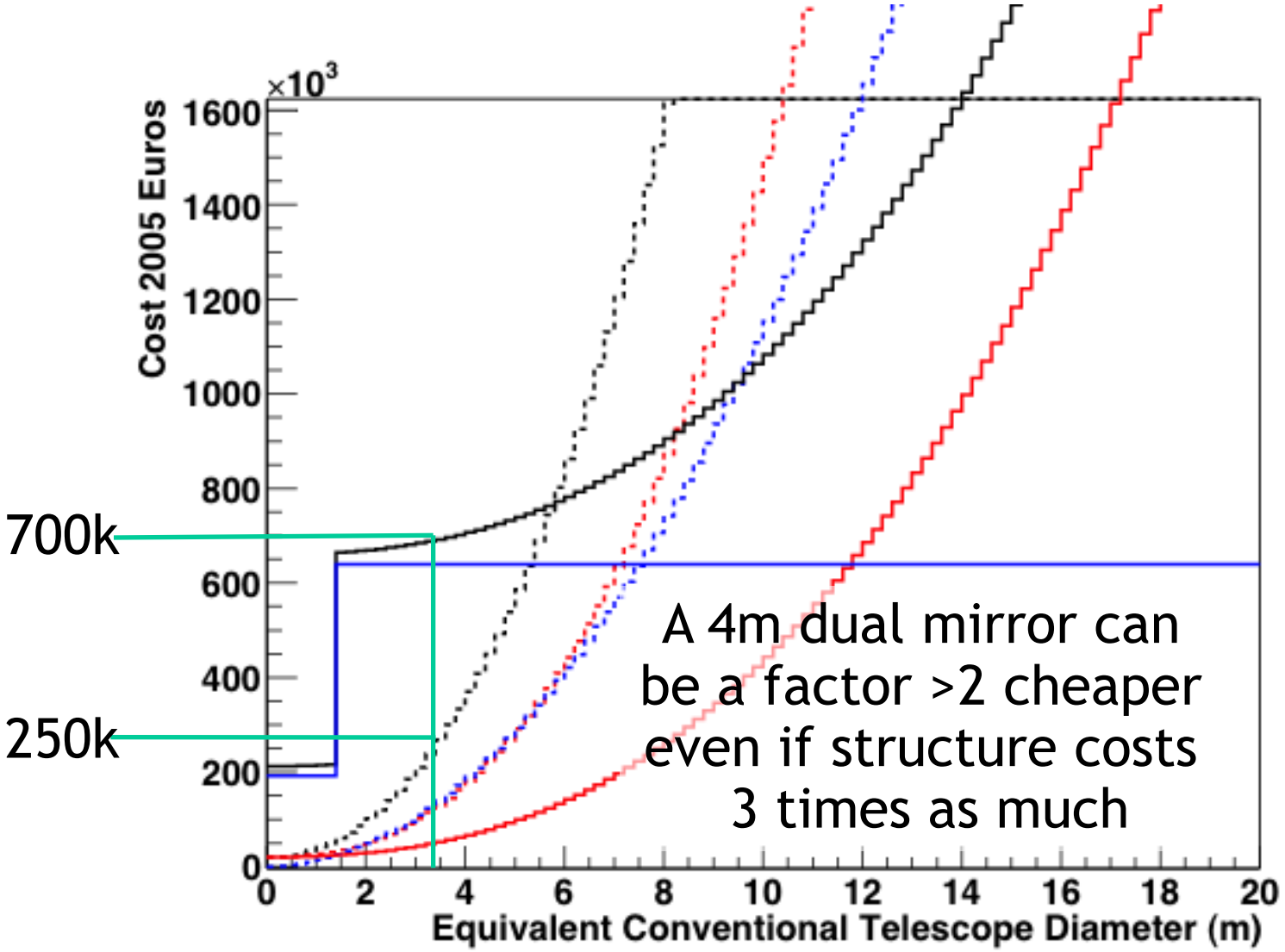

19 Optimisation

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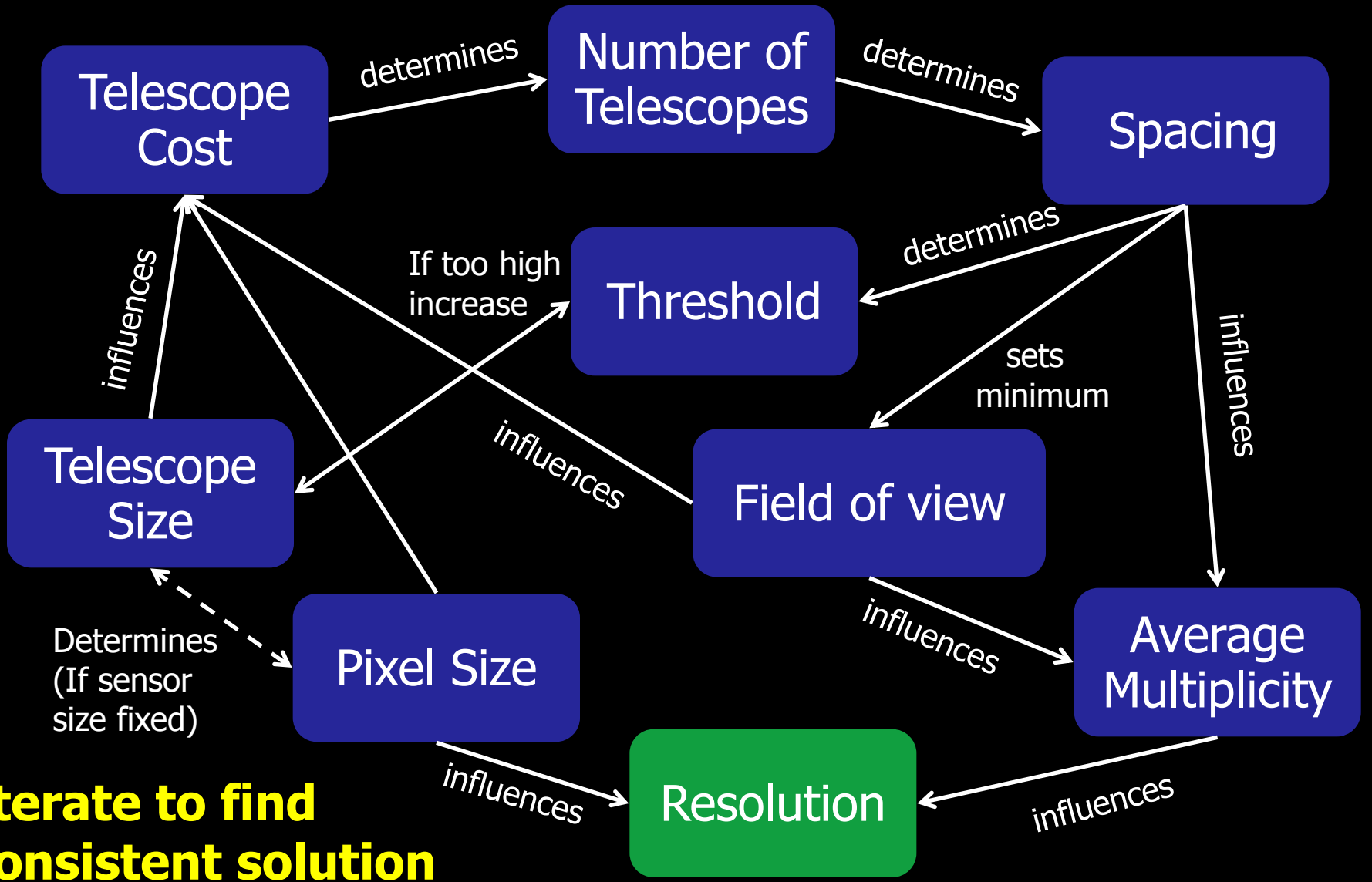
For fixed area & array cost



Iterate to find consistent solution

20 Optimisation Attempt

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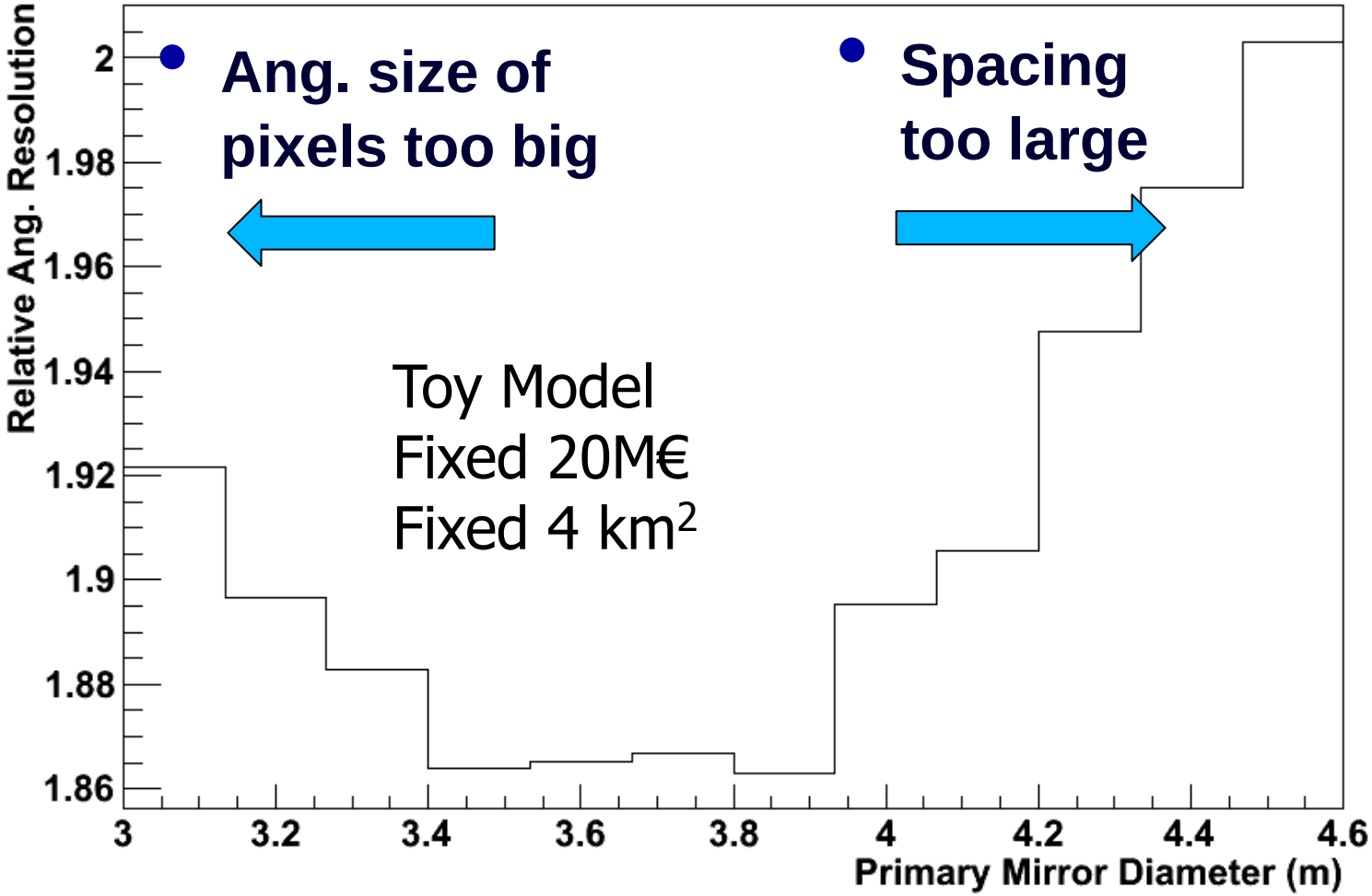

21 Optimisation Attempt

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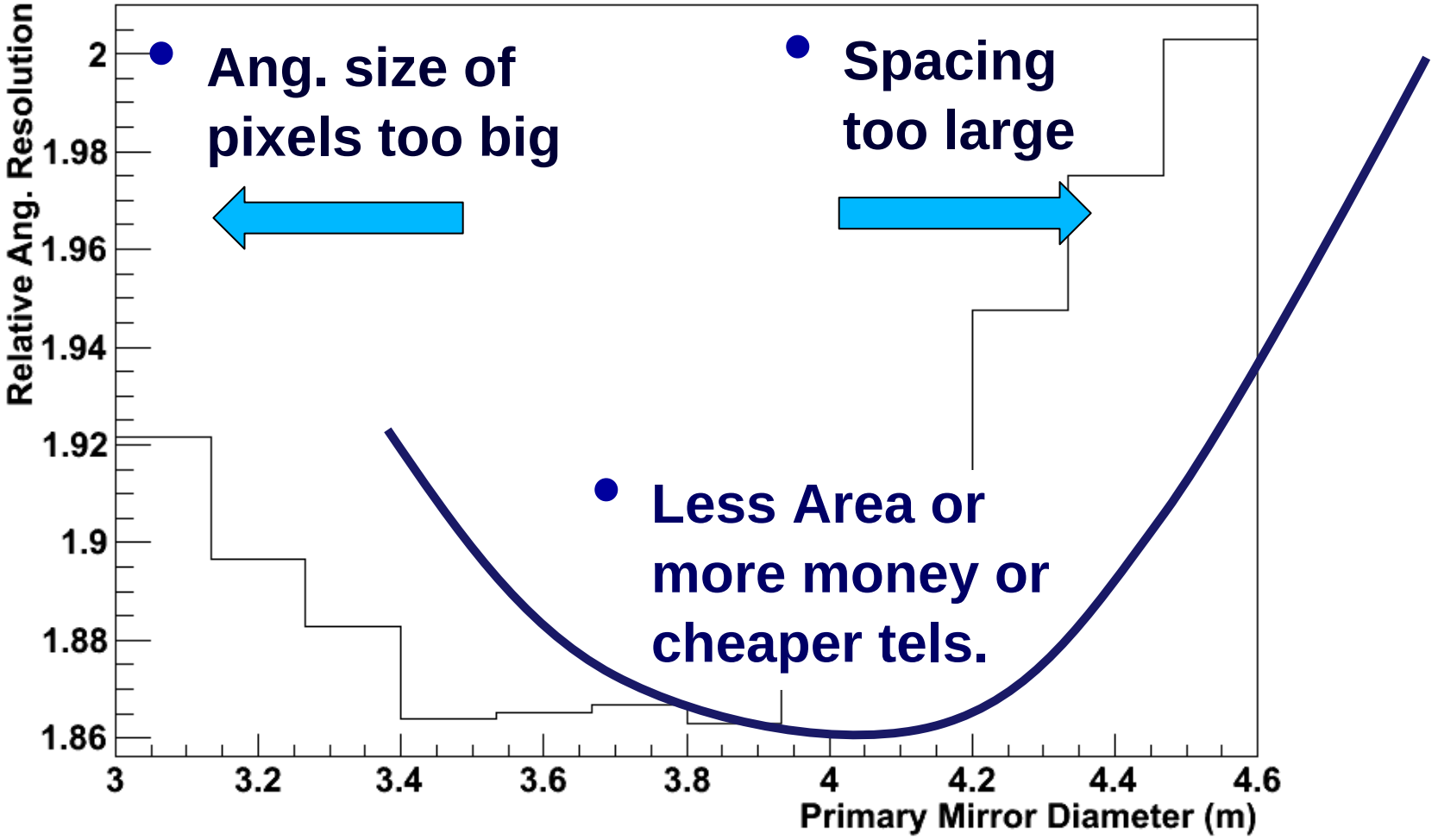
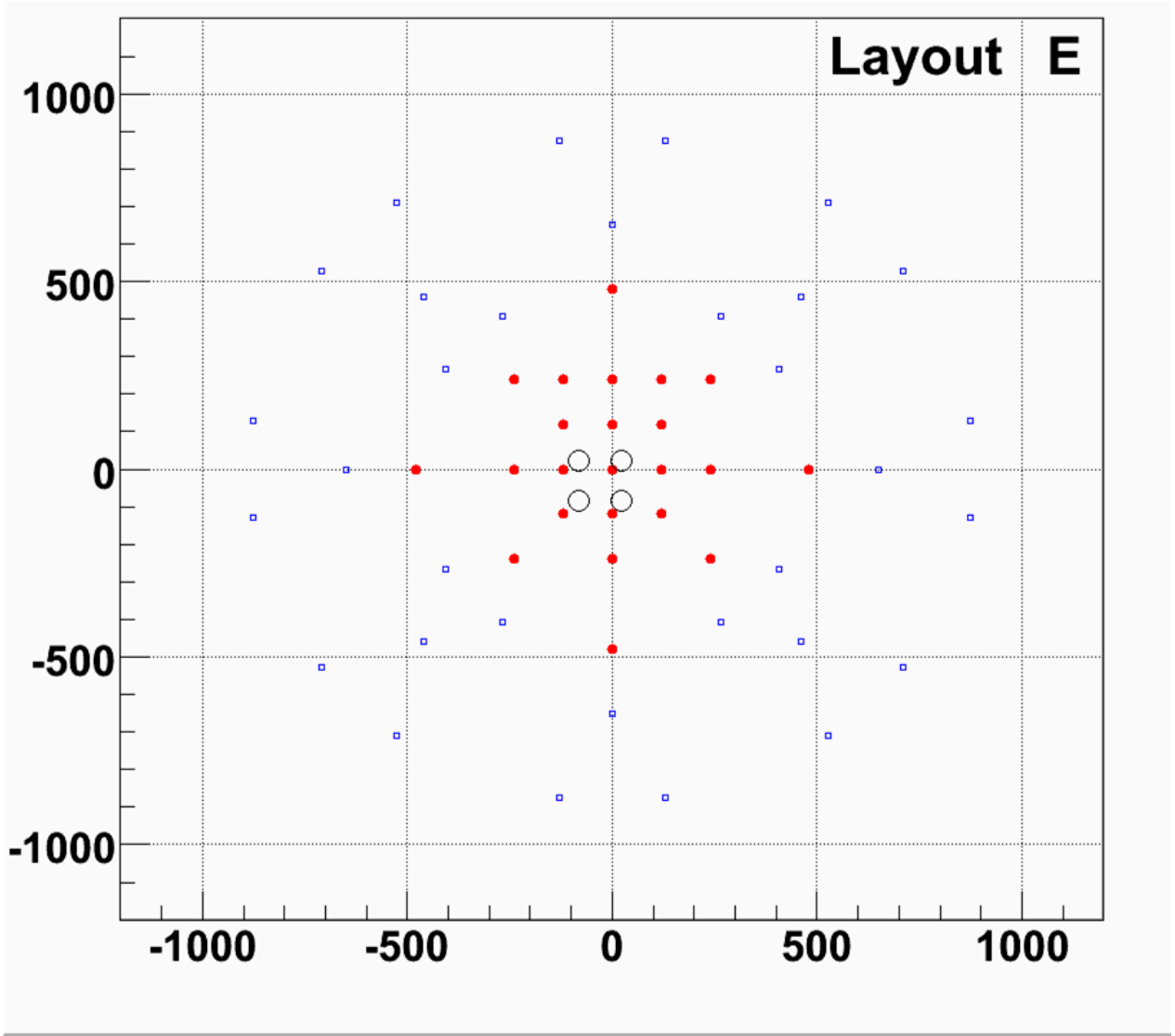


Full MC – Configuration E



- 23m (x4)
  4.6° FoV,
  0.09° pixels
- 12m (x23)
  8° FoV
  0.18° pixels
- 7m (x32)
  10° FoV
  0.25° pixels

Nominal cost
80Me

23 Production 1 Config Sens.

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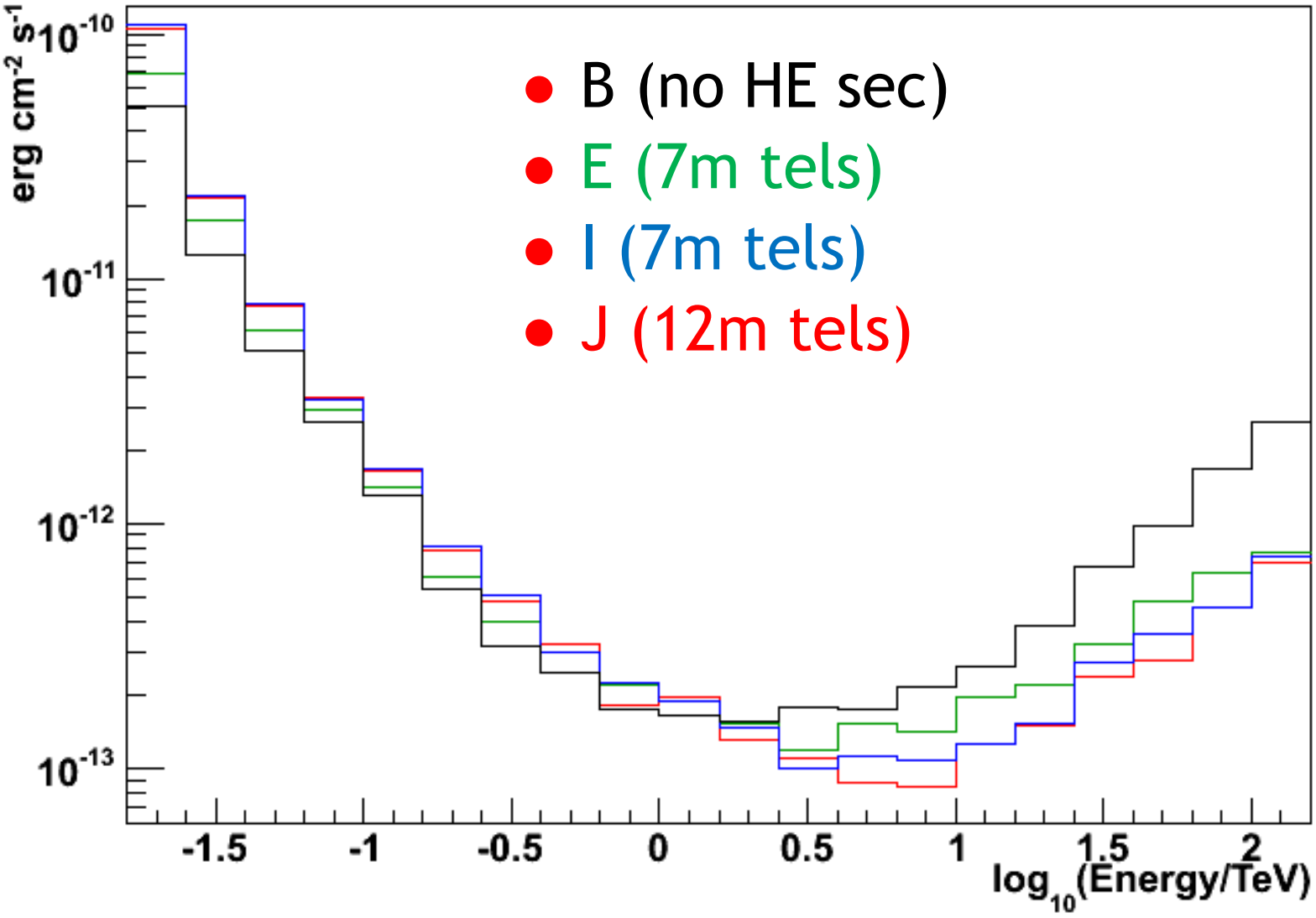

24 Point-source Sensitivity

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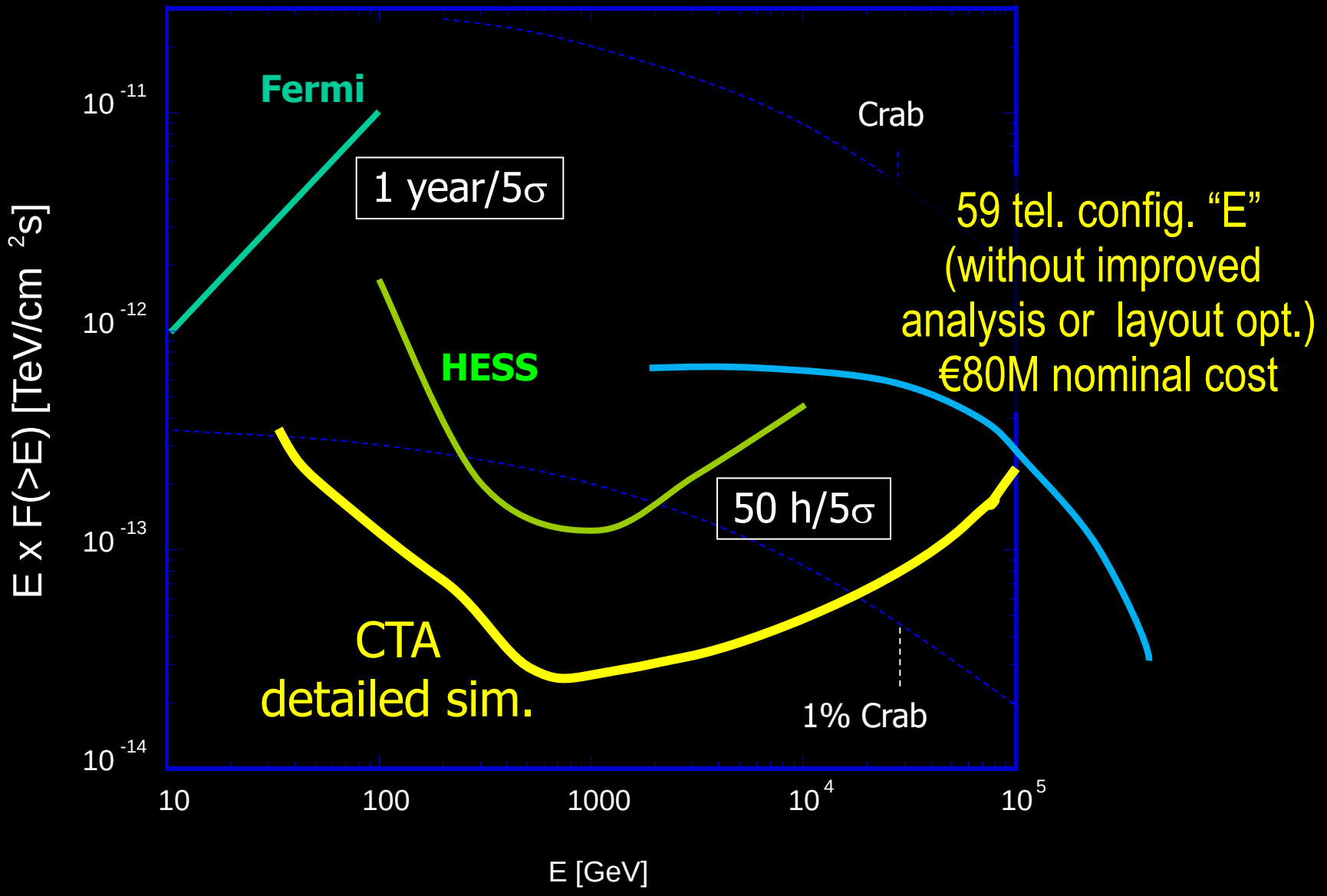

Conclusions

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- Unavoidable features of the SST
  - Many telescopes
  - >6° FoV
  - Long event/integration times
- Optimisation
  - Requires performance and cost information for individual components
    - Detailed design work needed
  - Can be done iteratively using Toy+Real MC once we have costed designs for different options
- Organisation...