4mMOSST : 4-meter Multi-Object Spectroscopic Survey Telescope

A proposal in response to the ESO call for a multi-object spectroscopic facility/instrument

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OVERVIEW

- Consortium
- Science drivers
- Instrument requirements
- Telescope options
- Wide-field correctors
- Positioner concepts
- Spectrographs
- Survey software & data

CONSORTIUM

- Leading Institutes
  - Astrophysikalisches Institut Potsdam (D)
  - Ludwig-Maximilian Universität, München (D)
  - Max Planck Institut für Extraterrestrische Physik, München (D)
- Supporting Institutes
  - Cambridge University (UK)
  - GEPI, Paris (F)
  - University of Oxford/RAL (UK)
  - NOVA, Dwingeloo (NL)
  - Zentrum für Astronomie, Univ. of Heidelberg (D)
- Science Institutes
  - University of Groningen (NL)
  - University of Lund & Uppsala (S)
- First telecon early Sept 2010

SCIENCE DRIVERS

- Follow-up of Space Missions of key European interest
  - Gaia follow-up:
    - Stellar radial velocities, parameters and abundances ($15 < m_G < 20$ mag)
    - Chemical tagging ($m_G < \sim 16$ mag)
  - eROSITA follow-up:
    - Cosmology with x-ray clusters of galaxies ($z < \sim 0.6$, $r < 21.5$ mag)
    - X-ray AGN evolution to z~5
    - Galactic x-ray sources, resolving the Galactic edge
  - Euclid (and other imaging surveys) follow-up:
    - Dark Energy from BAO
    - Galaxy evolution

GALACTIC ARCHEOLOGY

- Milky Way 3D potential from streams to ~100kpc
- Dark Matter halo substructure kinematic effects on cold streams
- Accretion history of the Milky Way halo/bulge/thick disk system
- Determine the potential of the bar and spiral arms (resonances)
- The importance of stellar radial migration for thin/thick disk
- Finding Extreme Metal Poor star candidates
- Formation history of thin disk (with R~20,000-30,000 mode)

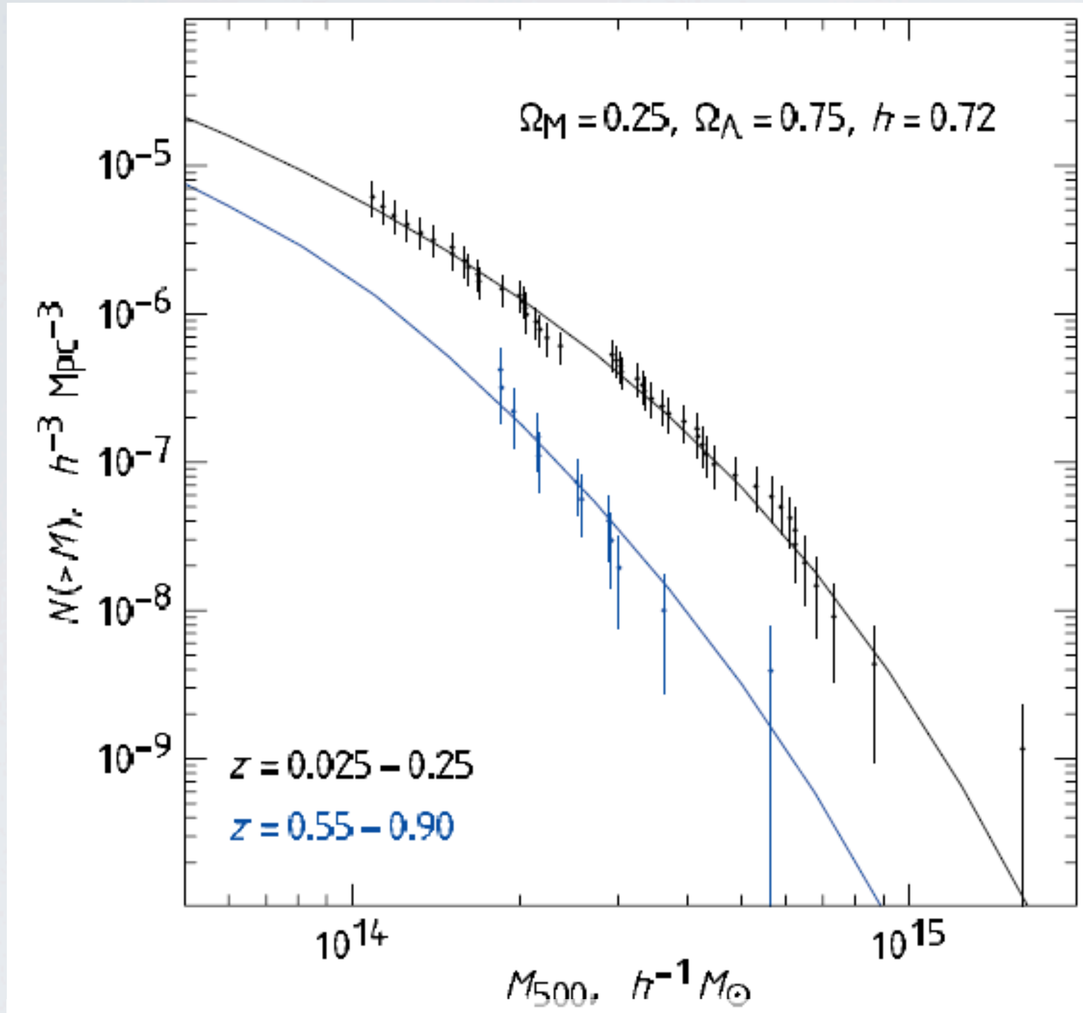
eROSITA

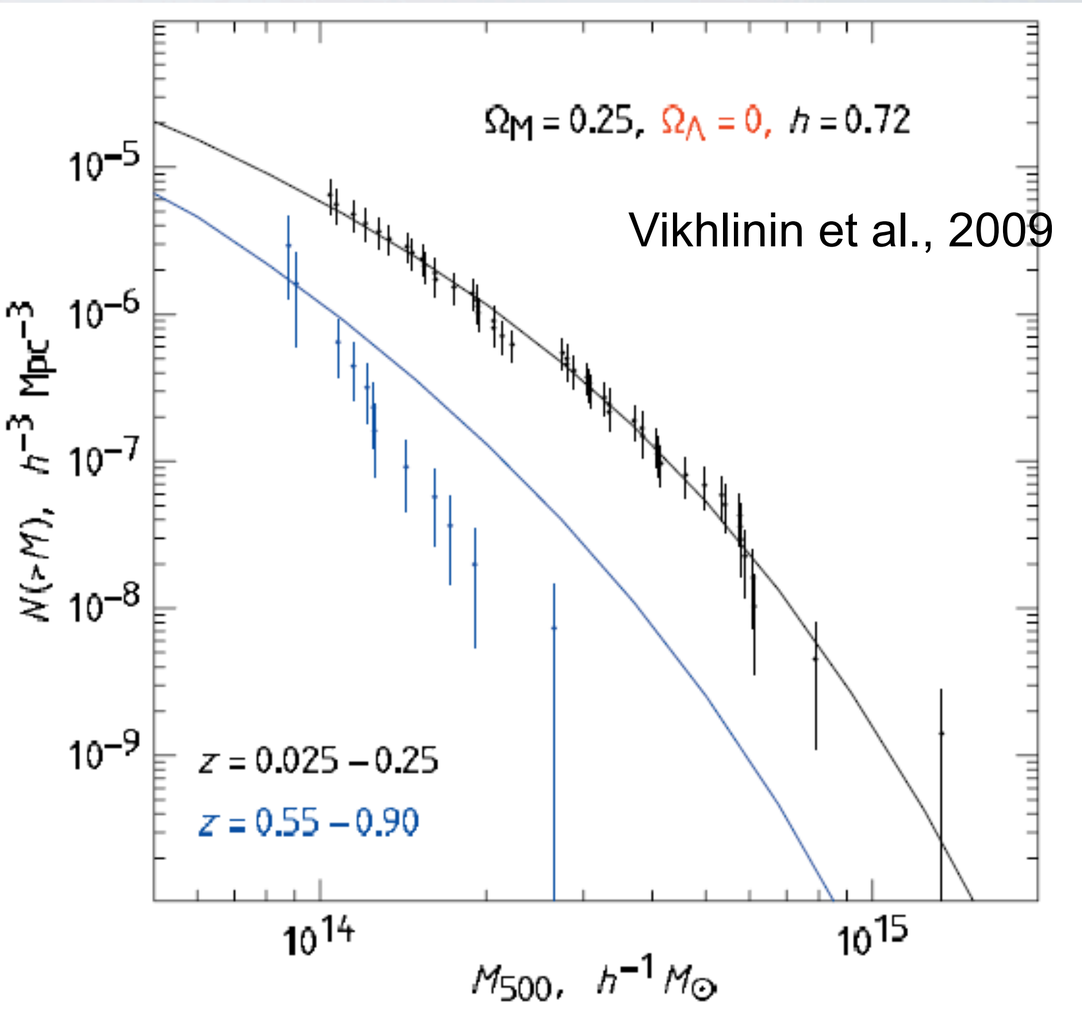
- German - Russian mission
- 0.3-4.5 keV, beam ~25''
- 8x all sky survey (4 year) + 3 years pointed observations
- Sky divided in 2 between Germany and Russia (no decision yet)
- Launch end 2012
- Mission goals:
  - Dark Matter and Energy, growth of structure
  - X-ray detection of 100000 galaxy clusters
  - X-ray detection of 3 Mio point sources

GALAXY CLUSTERS COSMOLOGY

- Cluster mass function N(M,z) depends mainly on the matter density Ω_m and the amplitude of the primordial power spectrum σ_8 (Reiprich & Böhringer 03)
- Evolution N(M,z) gives sensitive constraints on DE (Vikklinin+09)
- Cluster power spectrum (spatial distribution) amplitude and shape depends on DM and DE
- Cluster baryon fraction as function of z gives constraints on DM and DE (Allen+07)
- Baryonic wiggles due to acoustic oscillations at recombination give (tight) constraints on space curvature (Angulo+05, Wagner09)
- Clusters provide direct distance measurements due to combined X-ray and SZ-measurements

CLUSTER MASS FUNCTION VS. COSMOLOGICAL MODEL



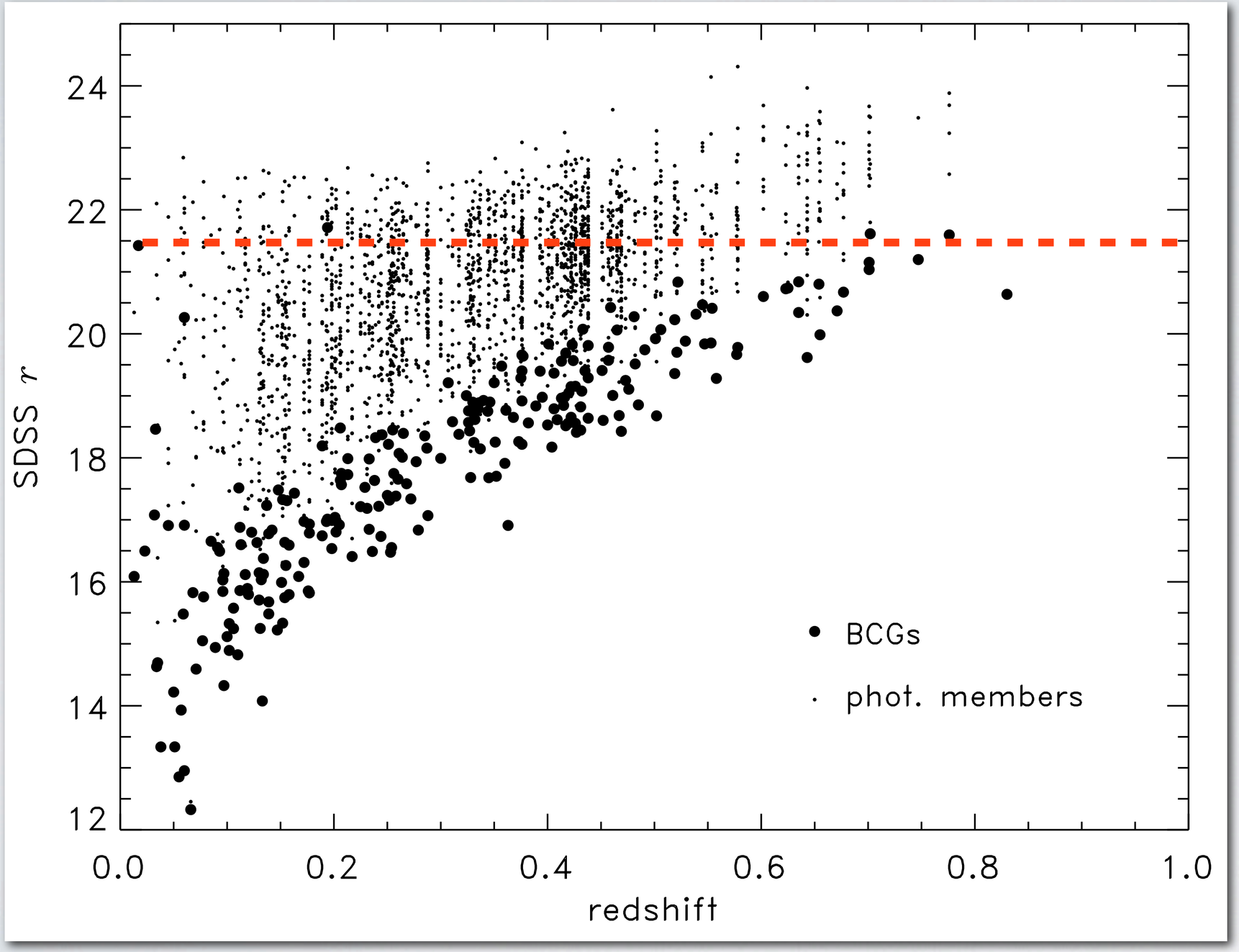


Vikhlinin et al., 2009

ROSAT discoveries, Chandra follow-up, 88 objects

With eROSITA & 4mMOSST: ~4×10^4 clusters, 10 redshift bins → Ω_Λ = f(time)

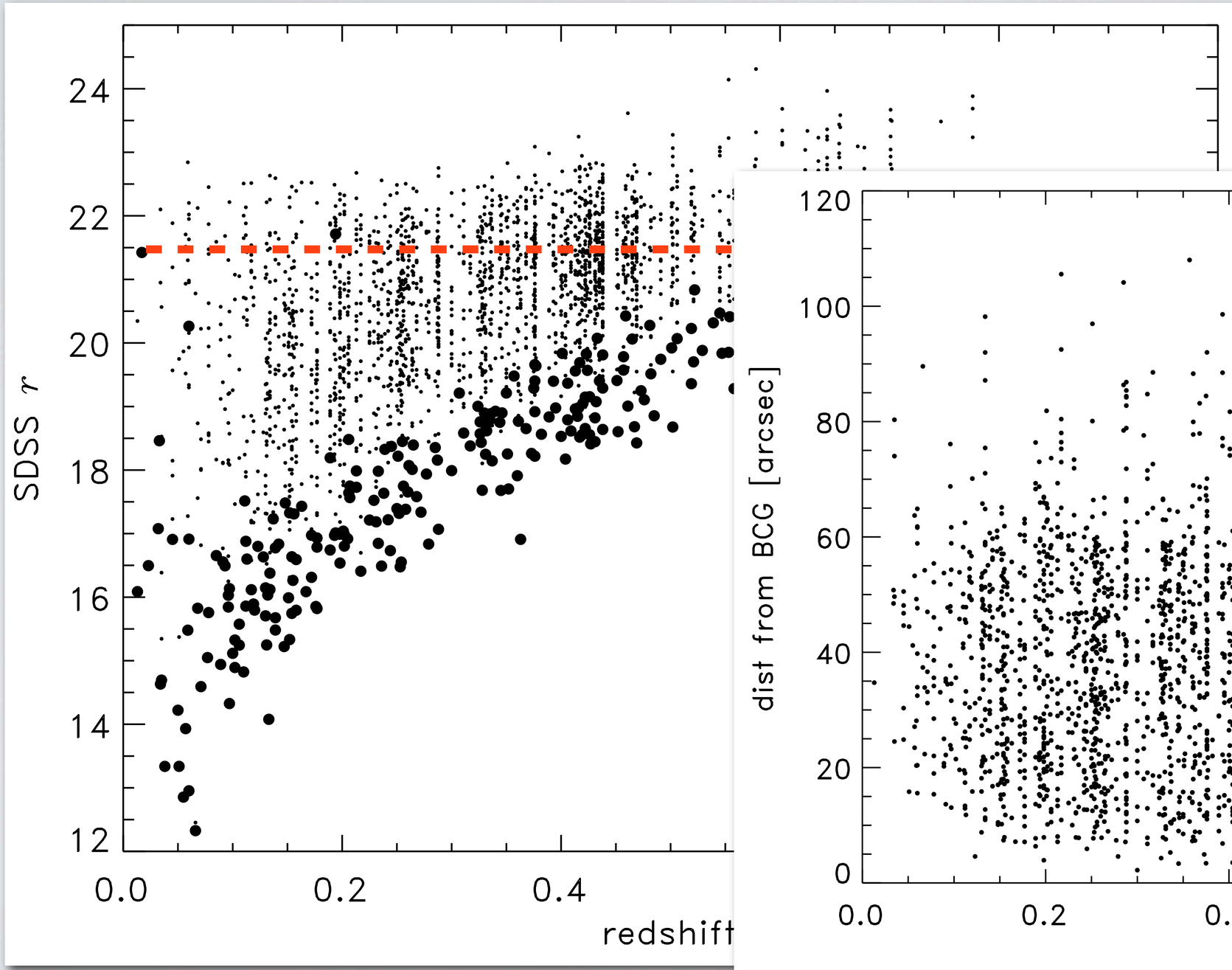
4mMOSST LIMITS ON CLUSTER GALAXIES

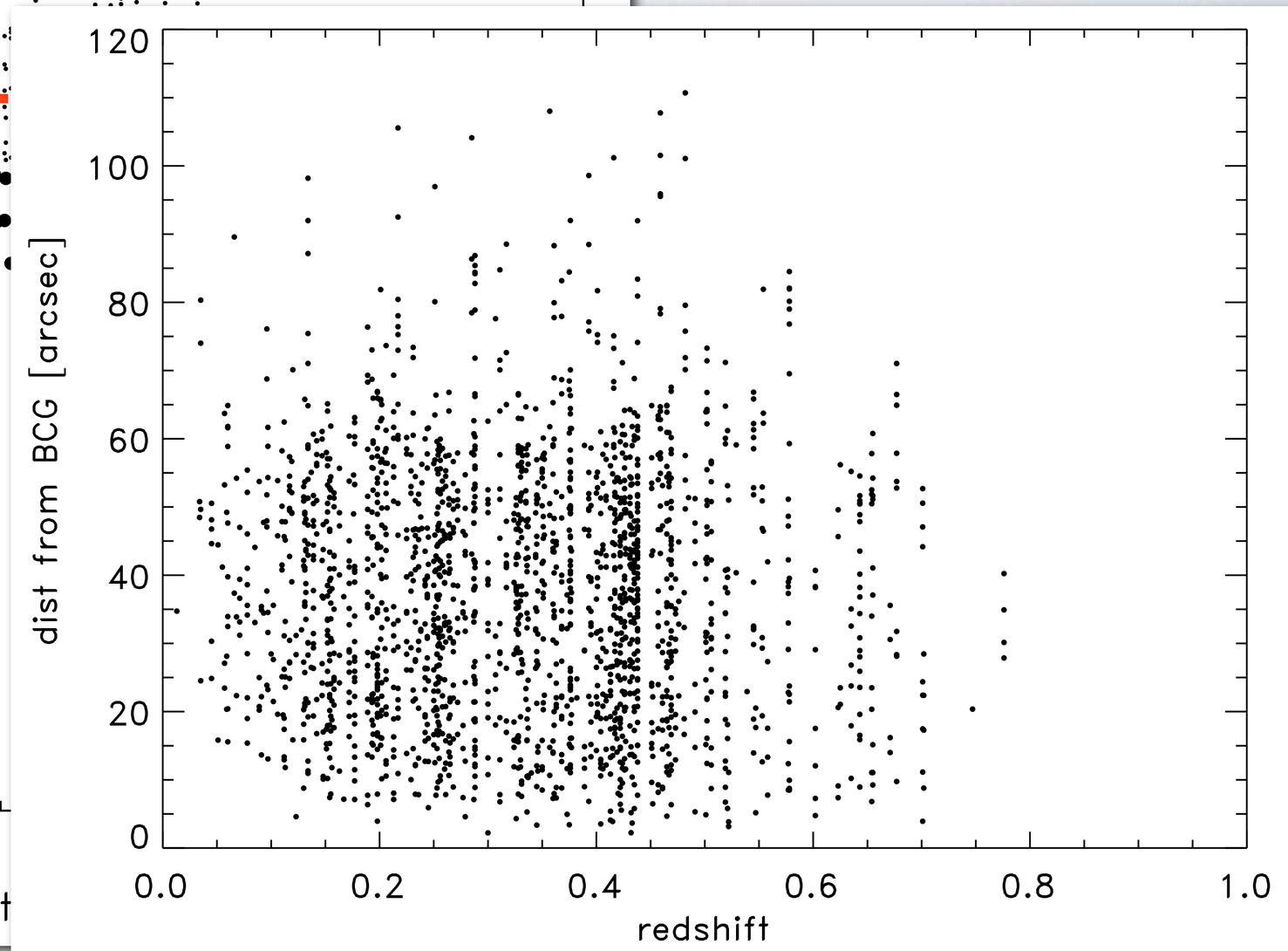


Based on x-match
XMM fields & SDSS

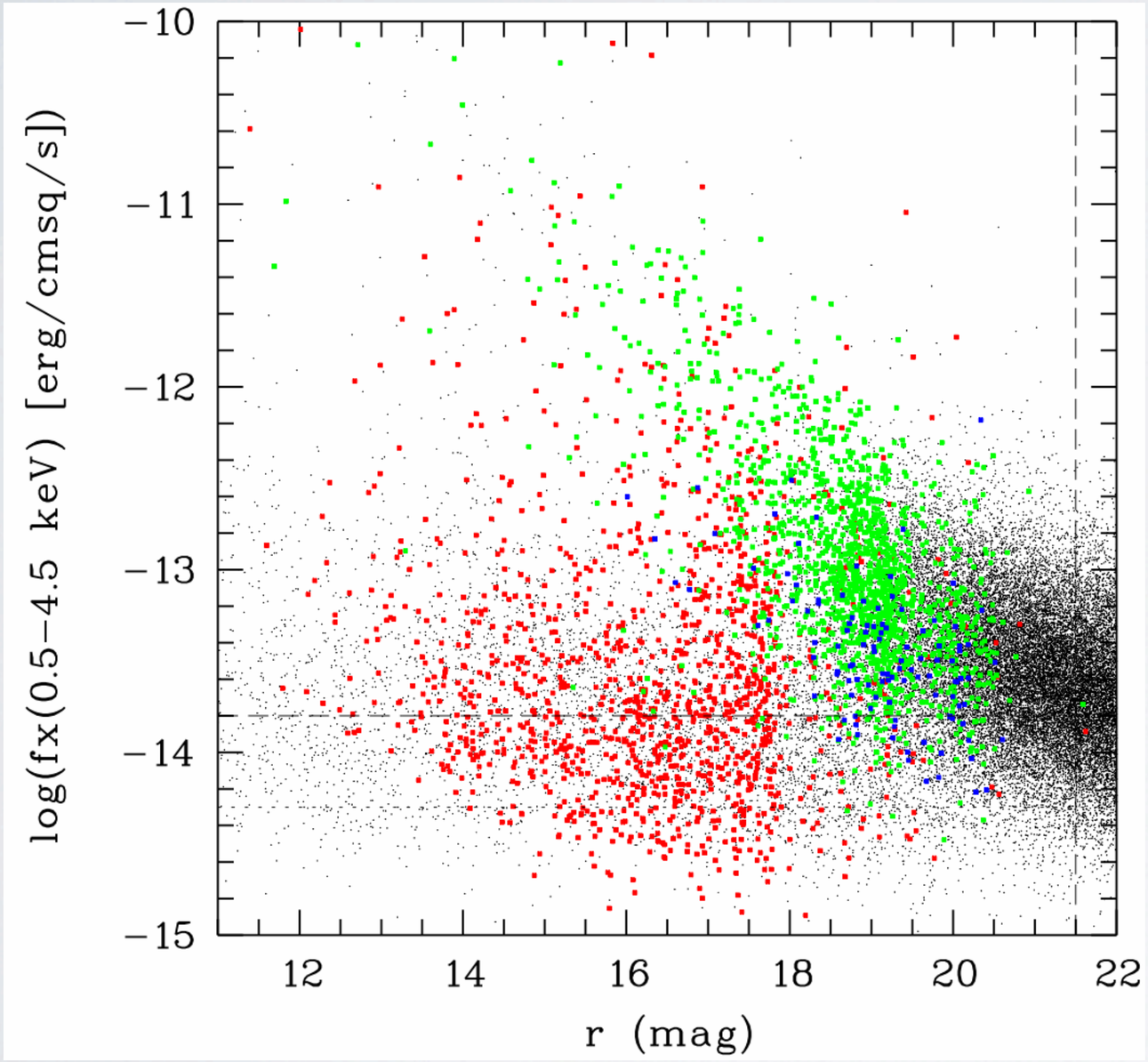
4mMOSST LIMITS ON CLUSTER GALAXIES

- Need to reach high fiber densities



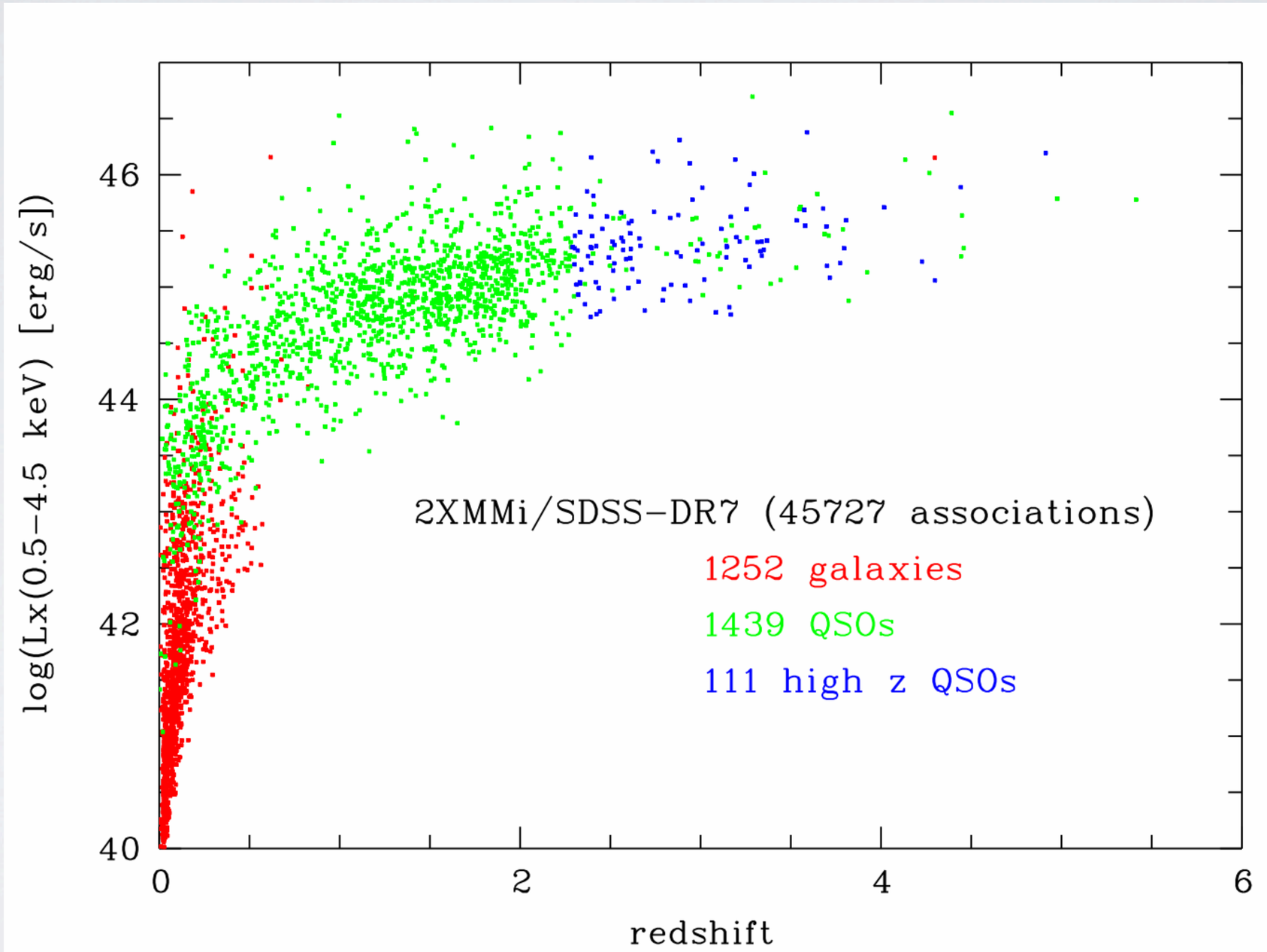


Extra-galactic discovery space



- Based on x-match XMM fields & SDSS
- Galaxies
- QSOs
- High-z QSOs
- unidentified
- About 300 objects/degree^2

AGNs to z=5


log(Lx(0.5-4.5 keV) [erg/s])
redshift
2XMMi/SDSS-DR7 (45727 associations)
1252 galaxies
1439 QSOs
111 high z QSOs
40
42
44
46
0
2
4
6

GALACTIC X-RAY SOURCES

- Expect 1–2 million Galactic point source
- Constraining evolutionary channels
  - coronal X-ray emitters
  - X-ray binaries of all sorts (magnetic cataclysmic variables, colliding winds massive stars, etc.)
- More exotic objects:
  - isolated accreting NS
  - isolated BH
  - extragalactic Magnetars...

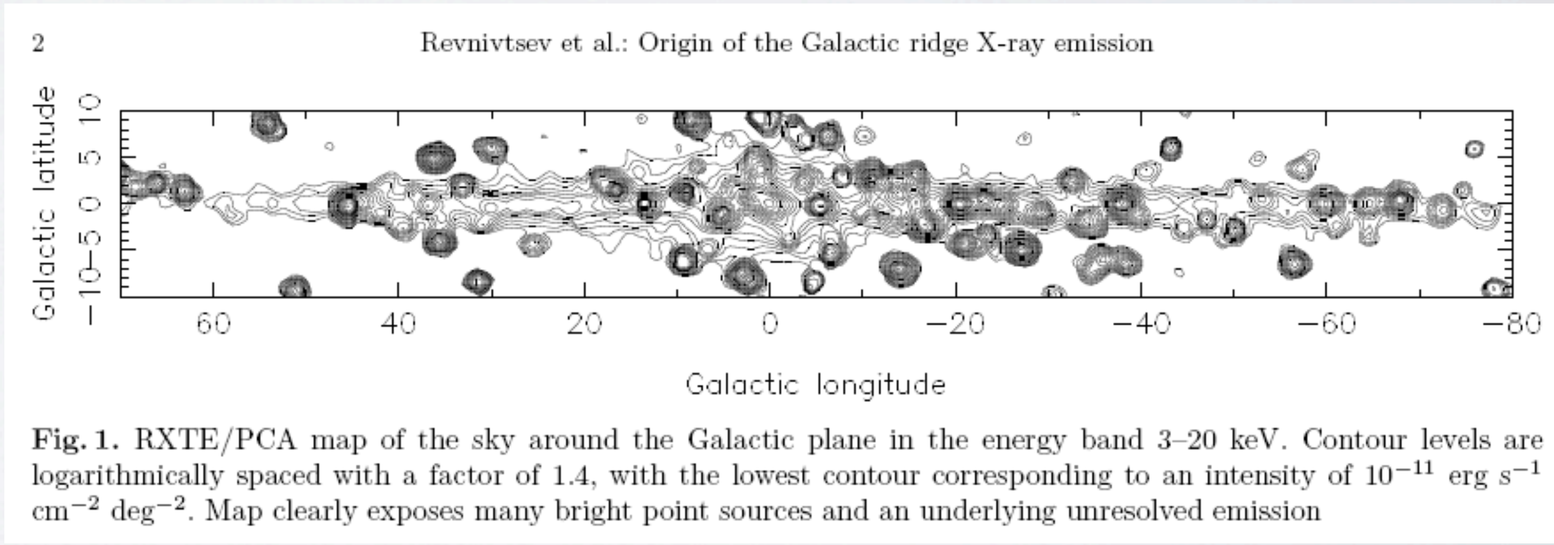
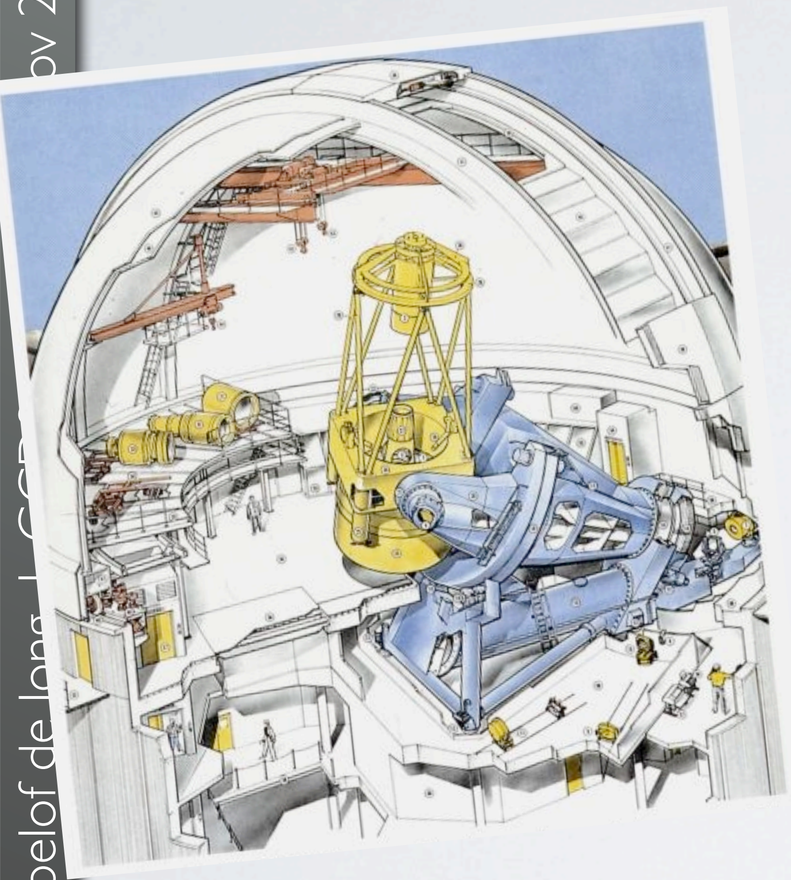


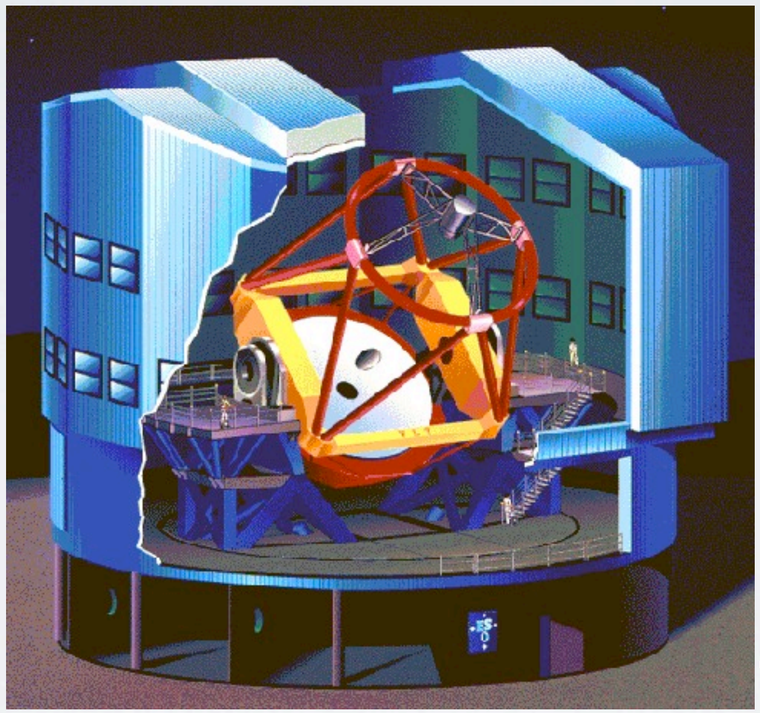
Fig. 1. RXTE/PCA map of the sky around the Galactic plane in the energy band 3–20 keV. Contour levels are logarithmically spaced with a factor of 1.4, with the lowest contour corresponding to an intensity of 10^{-11} erg s^{-1} cm^{-2} deg^{-2}. Map clearly exposes many bright point sources and an underlying unresolved emission

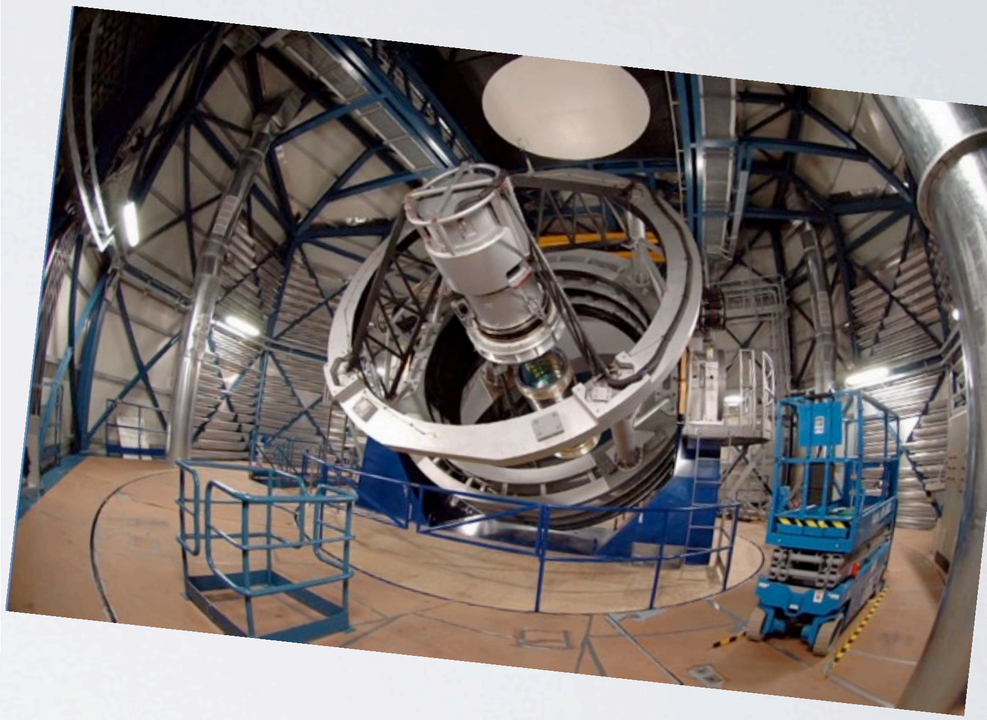
INSTRUMENT SPECIFICATION

Specification	Baseline	Goal
Field-of-View (FoV)	2 degree^2	>3 degree^2
Multiplex fiber positioner	1500	>3000
Number of fibers in ⌀=2' circle	>3	>7
Spectrographs – blue arm		
resolution @ 500 nm	R~3000	R~5000
passband	420-650 nm	370-650 nm
Spectrographs – red arm		
resolution @ 850 nm	R~5000	R~8000
passband	650-900 nm	650-950 nm
Reconfigure time between 1h exposures	5 min	3 min
Fields per night	5	10
Efficiency full system (M1-to-detection)	>15%	>20%
IFU mode		>1 arcmin^2 FoV
High resolution mode		R>20,000
Survey area (75% of time, 5 year)	10,000 degree^2	2x15,000 degree^2
Objects (75% of time, 5 year)	$6x10^6$	$25x10^6$

TELESCOPE SELECTION





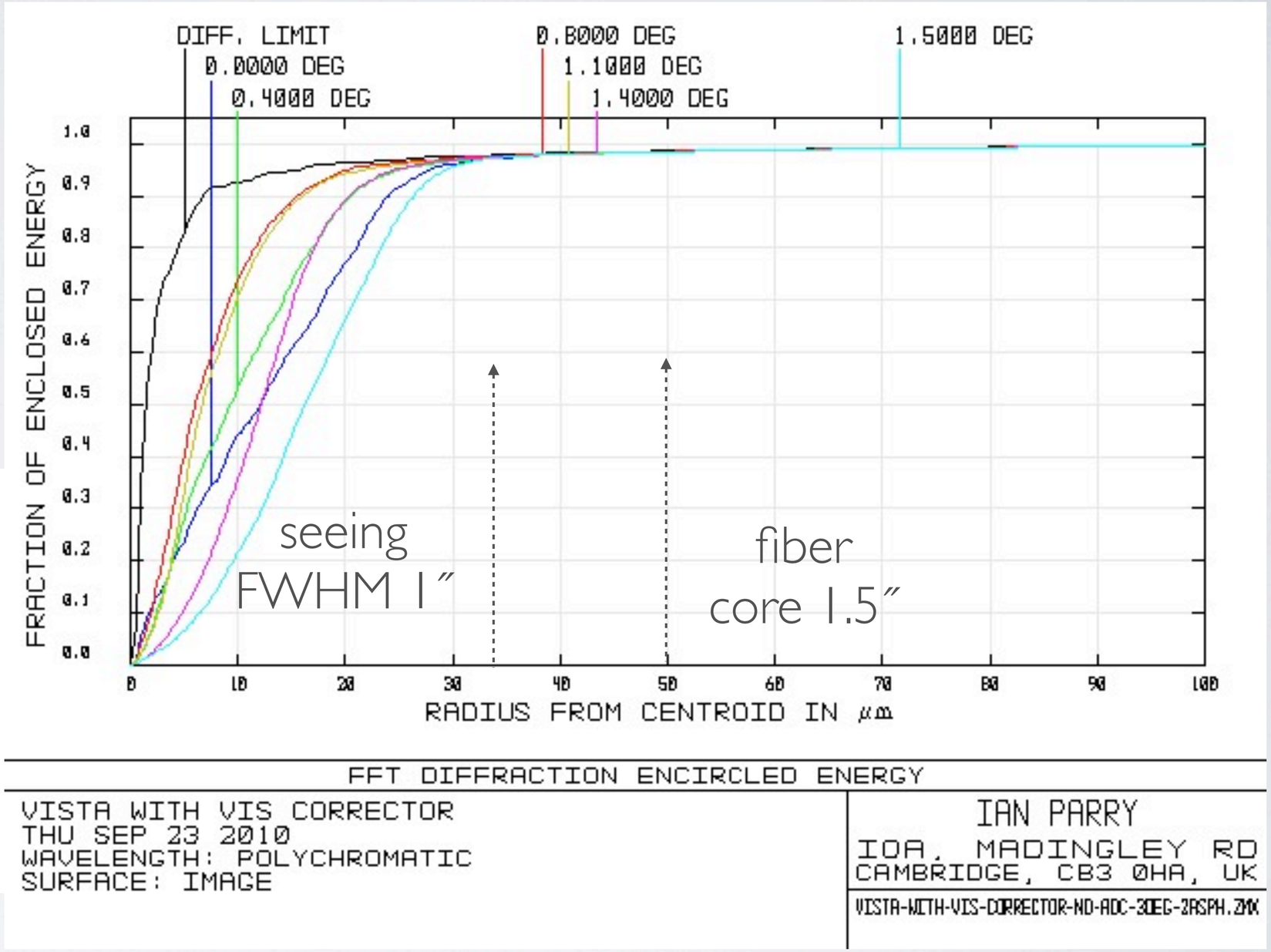


- Choice between 3.6m, NTT, VISTA
- 3.6m and NTT have 50cm Cassegrain hole ⇒ new secondary, "floating" focal plane

TELESCOPE PROS AND CONS

	VISTA	NTT	3.6m
Modern survey telescope	++	+	-
FoV corrector designed	⌀=2°	-	-
Preliminary corrector FoV	⌀=3°	⌀=2°	-
Rotator	+	-	NA
Easy access focus	++	--	-
Available space	-	-	++
Community reluctance	--	+	-
Total costs to create large FoV	++	--	-

VISTA CORRECTOR DESIGN

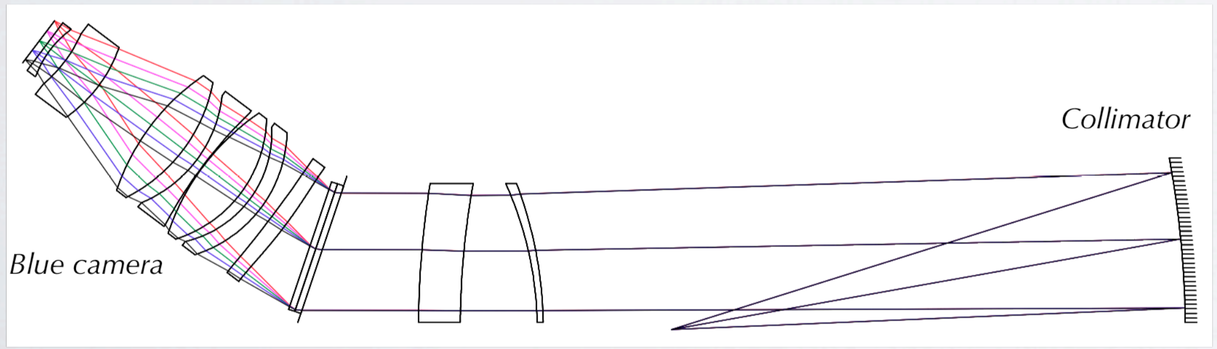


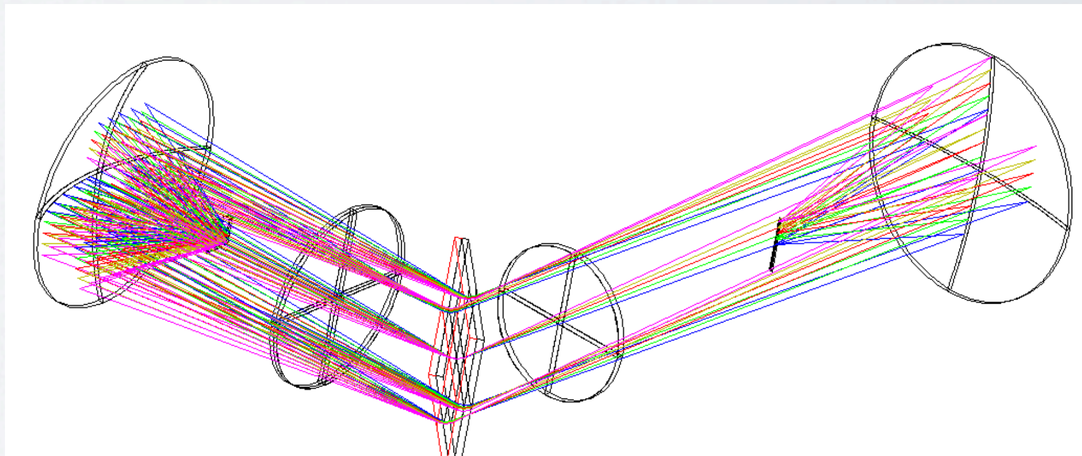
FIBER POSITIONER CONCEPTS

Concept	Advantages	Disadvantages
Plug plates	High density, low complexity, low build cost, close target proximity, curved focal surfaces	Handling, offline machinery requirements, labor intensive – high operations cost
Pick and place	Flexible, close target proximity	Single point failure mode, limit to multiplex
Locally sampling	Scalable, robust, high density, uniform areal sampling, curved focal surfaces acceptable	Complexity, high cost, impact of clustering

SPECTROGRAPHS

- Single configuration spectrographs
- Replicate R~5000 spectrographs till fiber count of positioner is reached
- Dedicated R~20,000 spectrograph for ~200 fibers if positioner allows it
- Minimize cross-talk between fibers as we have large dynamic range in science goals
  - If FoV >3 degree^2 we can repeat sky in different magnitude ranges
- Multiple designs currently being considered, building on earlier developments: WEAVE, WFMOS, GYES





SOFTWARE & DATA

- Software & data management significant fraction of effort
  - Selection, scheduling & simulations
  - Full optical modeling
  - Instrument control
  - Pipeline reduction
  - Galactic sources characterization
  - Extra-galactic sources characterization
  - Community access database
- Public data releases according to RAVE/SDSS model

QUESTIONS

- What is the Galactic *survey science* case for going down to 370nm versus 420nm?
- What particular *science niche* is left for the high resolution mode when HERMES has already surveyed much of the Southern sky

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