The background of the slide is a large, oval-shaped map of the X-ray sky. It is filled with numerous small, dark spots representing X-ray sources, with some larger and brighter than others. The map is overlaid with a grid of latitude and longitude lines, with labels for 60, 90, 120, 150, 180, 30, 60, 90, 120, 150, and 180 degrees. The overall color scheme is dark blue with yellow and white text.

A Library of the X-ray Universe: Generating the XMM-Newton Source Catalogues

Iris Traulsen

Axel Schwobe, Georg Lamer

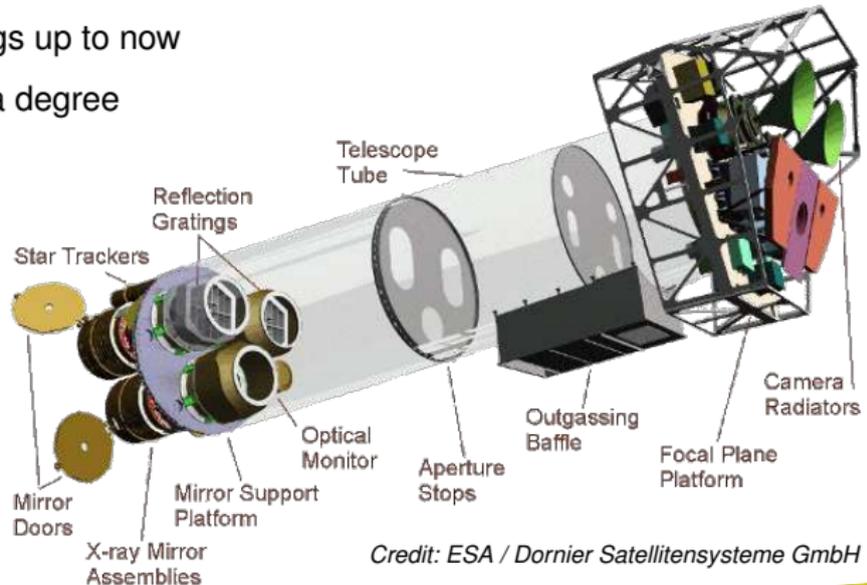
Leibniz-Institut für Astrophysik Potsdam (AIP)

on behalf of the XMM-Newton Survey Science Centre Collaboration

Berlin, June 2nd, 2016

XMM-Newton: ESA's large X-ray space telescope

- * built and operated by a consortium of 14 European countries
- * three X-ray (0.1–12 nm / 0.15–12 keV) and one UV/optical telescope(s)
- * observing the “hot” processes in the Universe since Dec. 1999
- * more than 12,400 pointings up to now
- * large field of view of half a degree



Credit: ESA / Dornier Satellitensysteme GmbH

The XMM-Newton Consortium

XMM-Newton

Mission Operations Centre (MOC)

ESOC (“Operations”),
Darmstadt, Germany:

flight control

XMM-Newton

Science Operations Centre (SOC)

ESAC (“Astronomy”),
Villafranca / Madrid, Spain:

data processing

XMM-Newton Survey Science Centre (SSC)

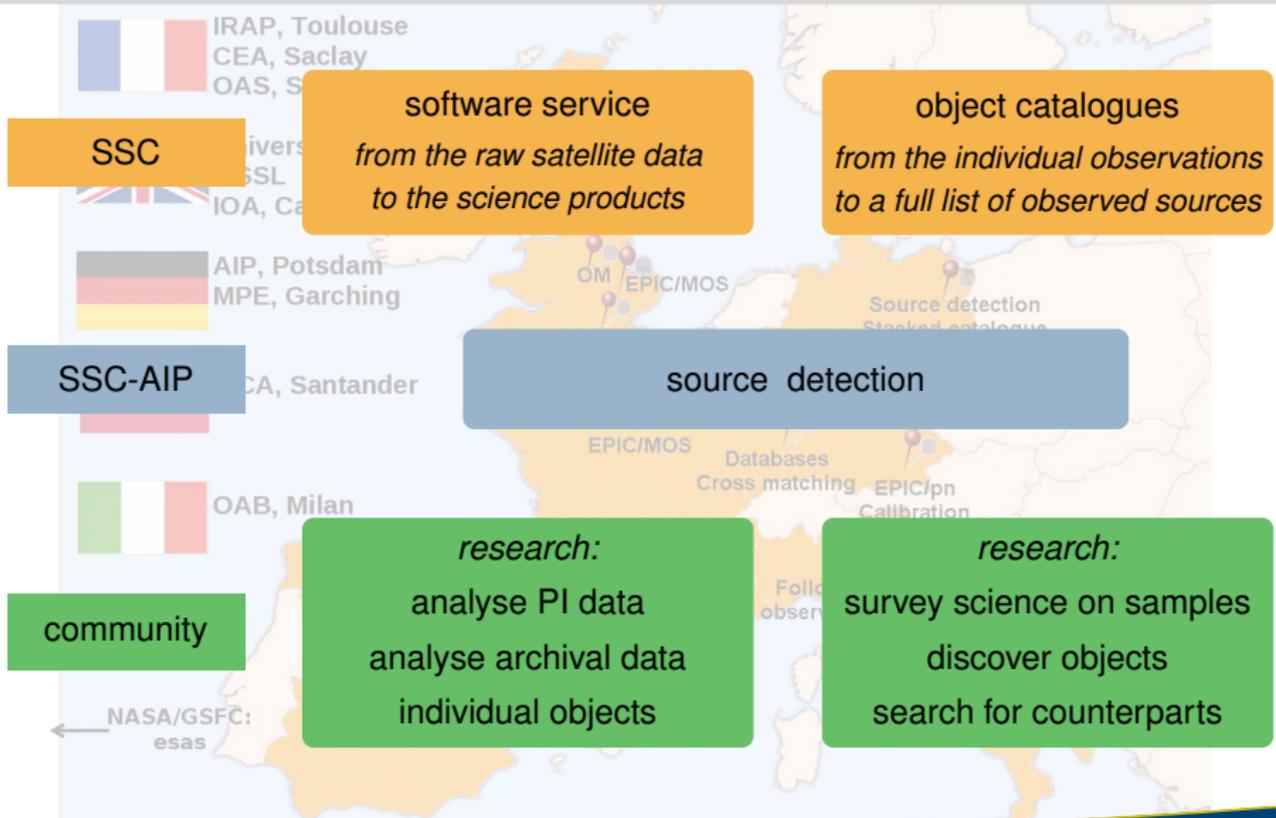
international consortium,
ten founding institutes (1995) in
UK – France – Spain – Germany – Italy:
science analysis software & catalogue creation

The XMM-Newton Survey Science Centre (SSC)



Map adapted from IRAP Toulouse & U. Leicester

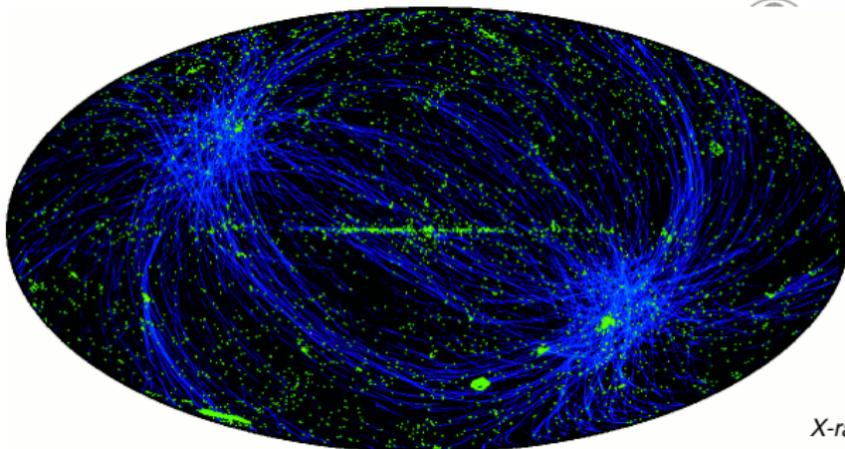
The XMM-Newton Survey Science Centre (SSC)



I. Catalogue creation



XMM-Newton
SCIENCE CENTRE



*Sky map:
X-ray group U. Leicester*

3XMM

&

XMMSL1

pointed observations:

almost 680 000 detections /

469 000 unique sources

more than 900 square degrees

slews:

about 40 000 detections

about 70% sky coverage

sensitivity similar to ROSAT

The 3XMM catalogues: some facts

- * standardized reduction pipeline
- * including e.g. thorough treatment of X-ray and instrumental background
- * variety of **source parameters** like coordinates, fluxes, hardness ratios, extent, detection likelihood, variability, ...
- * fluxes in five narrow and two broad energy bands
- * flagging of potentially spurious detections
- * **spectra and time series** of bright sources
- * matching of multiply observed detections into unique sources
- * **cross-correlation** with external catalogues
- * **full reprocessing** after substantial software upgrades, **increments** inbetween

Rosen et al. 2016, A&A 590, A1 (highlight)

The 3XMM catalogues: some interfaces

several web interfaces, in particular:

<http://xmm-catalog.irap.omp.eu>

<http://nxsa.esac.esa.int/nxsa-web>



XMM-NEWTON SURVEY SCIENCE CENTRE

Search XMM-Newton catalog objects

SEARCH

Search the XMM-Newton source catalog. Query can be any column name and constant or its values joined by AND/OR with another constraint. Column name can be: SC_RA, SC_DEC, SC_POSITION, SC_DET_ML, SC_EXTENT, SC_PVAR, SC_EP_3_FLUX and others.

Example: MQ2

Show query language

HOME CATALOG DIAGRAMS WEB SERVICES DOCS LINKS ABOUT

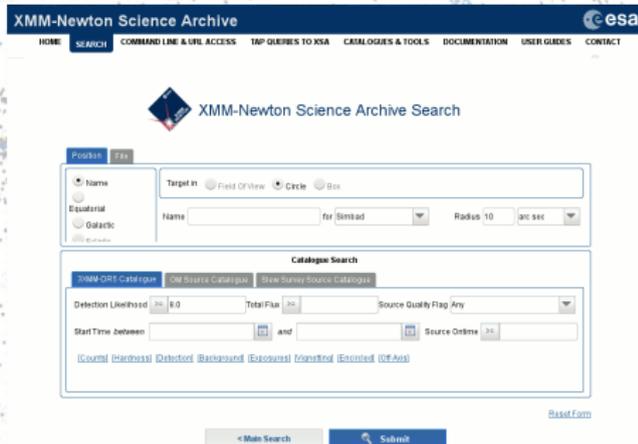
NEWS

21
NOV 2016

New features of the XMM-Newton photon database. The photon extraction from an observation of 1E 1407.0-6408, a well-known magnetar, and one of its preheats for yourself. 7500+ XMM-Newton observations and ~100 million calibrated and barycentered photons are accessible from this website.

WEBSITE OVERVIEW

This website provides experimental access to the XMM-Newton source catalog XMM-DR5 and some of its associated data products. Launched in 1999, the XMM-Newton satellite is the major European X-ray observatory class telescope that is operated by the European Space Agency (ESA). The XMM-Newton Survey Science Centre has run the pipeline that



XMM-Newton Science Archive 

HOME SEARCH COMMAND LINE & URL ACCESS TAP QUERIES TO XSA CATALOGUES & TOOLS DOCUMENTATION USER GUIDES CONTACT

XMM-Newton Science Archive Search

Position **+**

Target in Field Of View Circle Box

Equatorial Name for Simbad Radius 10 arc sec

Galactic

Catalogue Search

XMM-DR5 Catalogue DR Source Catalogue New Survey Source Catalogue

Detection Likelihood 8.0 Total Flux Source Quality Flag Any

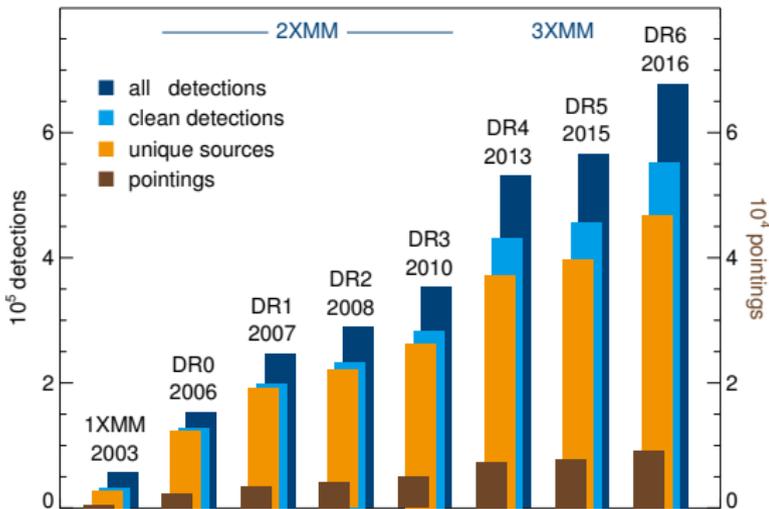
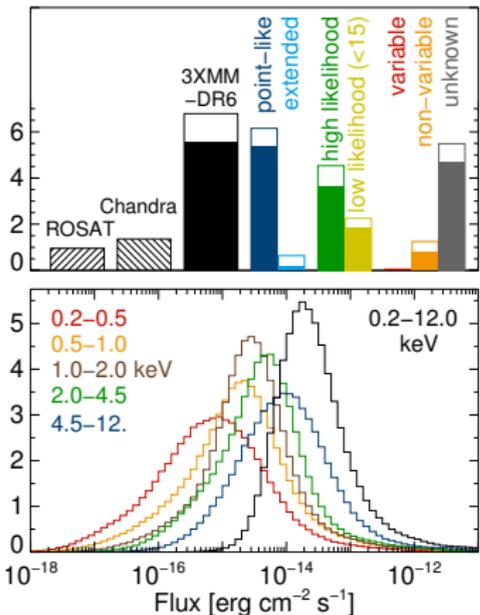
Start Time Between and Source Order

[Count](#) [Bandpass](#) [Colorful](#) [Background](#) [Exposure](#) [Normalized](#) [Rejected](#) [Off-Axis](#)

[Reset Form](#)

< Main Search Submit

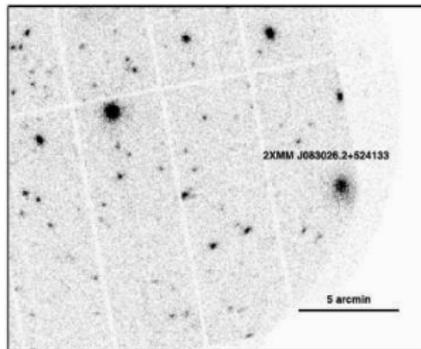
The 3XMM catalogues: some numbers



3XMM-DR6: release planned for June 2016

Scientific impact of the 3XMM catalogues: some examples

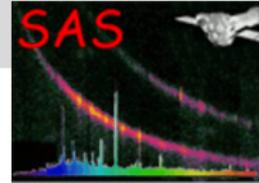
- * **discoveries** (“serendipitous” detections) of new objects
 - galaxy clusters, active galactic nuclei, ultraluminous X-ray sources, interacting binaries, ...
 - example*: discovery of an isolated neutron star candidate, Pires et al.
 - example*: discovery of the most X-ray luminous galaxy cluster at redshift 1, Lamer et al.
- * comprehensive database for
 - ▶ **statistical studies** of object classes
 - ▶ finding **counterparts** of IR – GeV sources
 - ▶ **timing and variability** studies
- * basis of **international projects** like
 - ▶ The XMM-Newton spectral-fit database
 - ▶ EXTraS: Exploring the X-ray Transient and variable Sky
 - ▶ ARCHES: Astronomical Resource Cross-matching for High Energy Studies



Lamer et al. (2008)

(→ hundreds of citations to the 2XMM/3XMM papers)

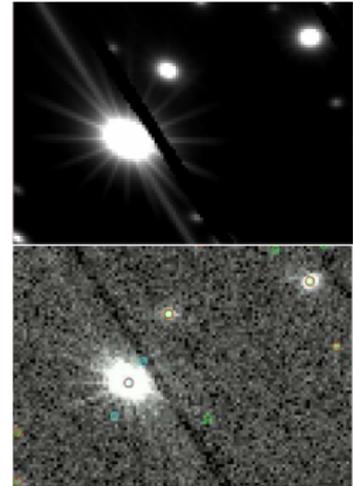
II. Science Analysis Software



- * suite of more than 250 extraction & analysis tasks
- * used by every observer to process the data
thousands of users, more than 4500 refereed XMM-Newton papers
- * development & maintenance: Spain, Germany, France;
online HelpDesk offered by SOC/ESAC in Spain
- * 12 packages under AIP responsibility⁺:

maximum-likelihood source detection

- ▶ highest possible detection sensitivity &
lowest possible number of false (“spurious”) detections
- ▶ part of many individual proposals
- ▶ central part of the catalogue pipeline



source image and fitted PSF

⁺SSC-AIP is funded via the DLR

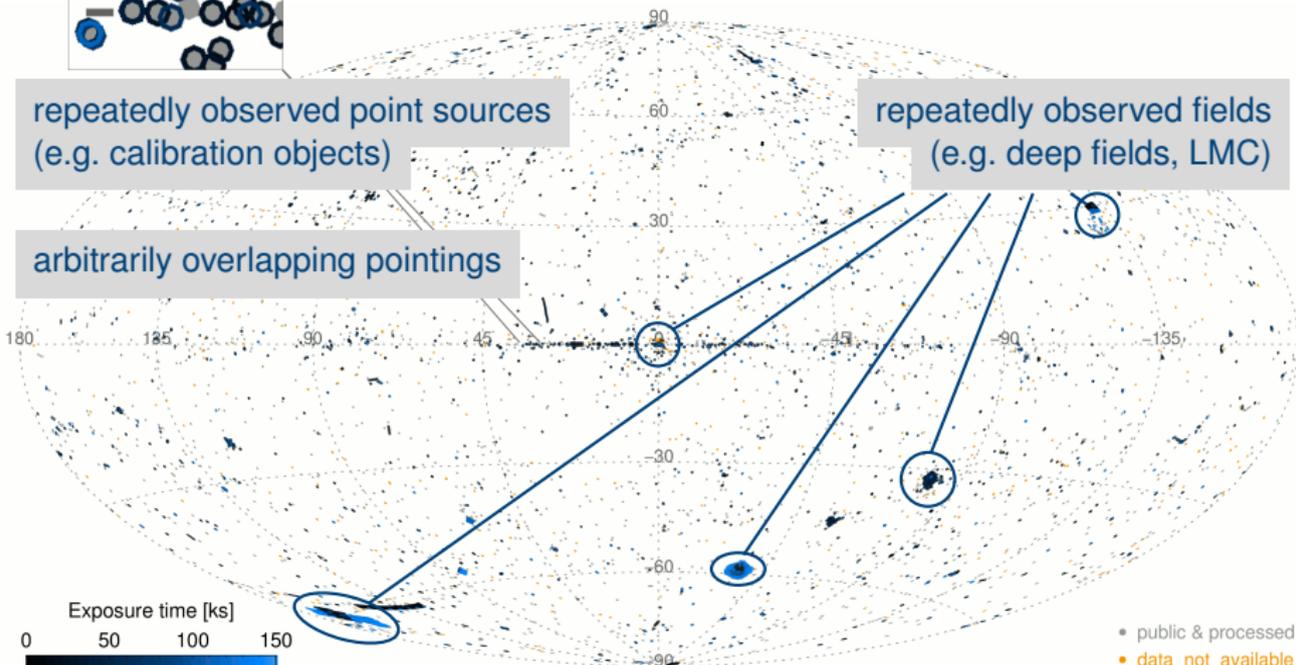
My current project: Source detection in overlapping observations



repeatedly observed point sources
(e.g. calibration objects)

repeatedly observed fields
(e.g. deep fields, LMC)

arbitrarily overlapping pointings

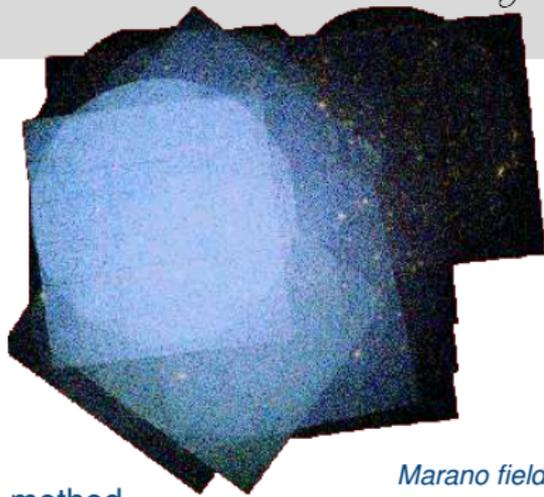


repeatedly observed fields in the XMM-Newton sky (*blue*)

Aims of stacked source detection

Overlapping observations,
intentionally or arbitrarily:

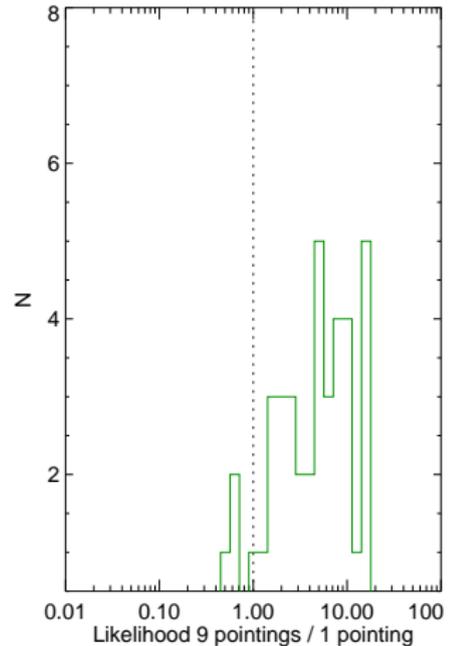
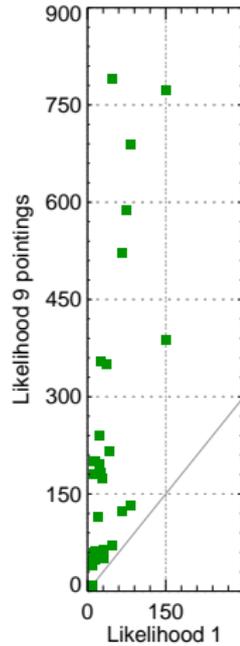
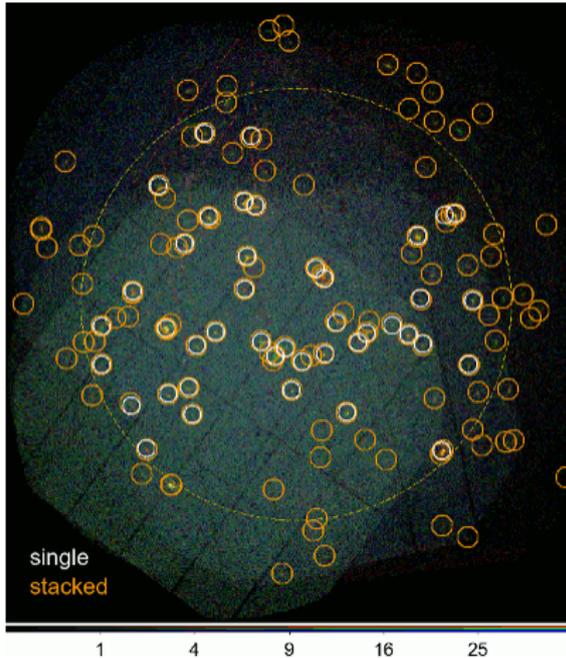
- * in 3XMM: processed individually
- * stacked processing:
longer effective exposure time



Marano field

- Aims:
- ▶ provide a **standardized source-detection method** for overlapping observations
 - ▶ more convenient handling of multiple pointings for the users
 - ▶ optimize stacked **source parameters**
 - ▶ basis of a future “**stacked catalogue**” of repeatedly observed sources
 - ▶ cf. other surveys

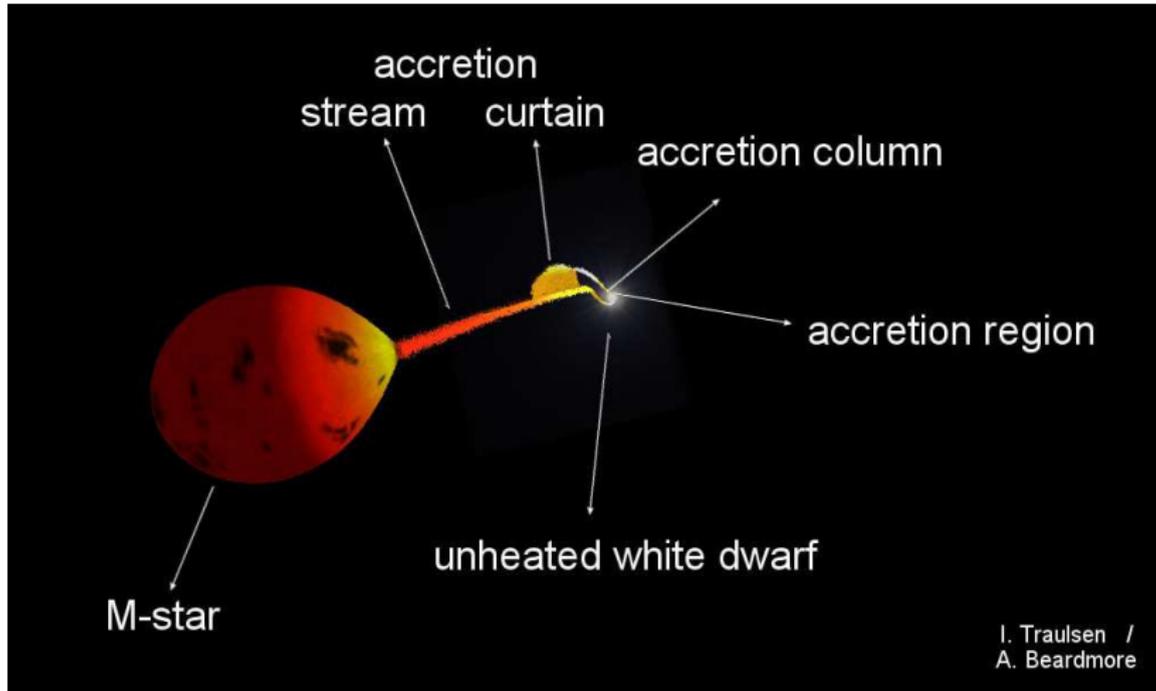
Example Marano field – single vs nine observations



→ more detections, higher likelihoods, consistent fluxes

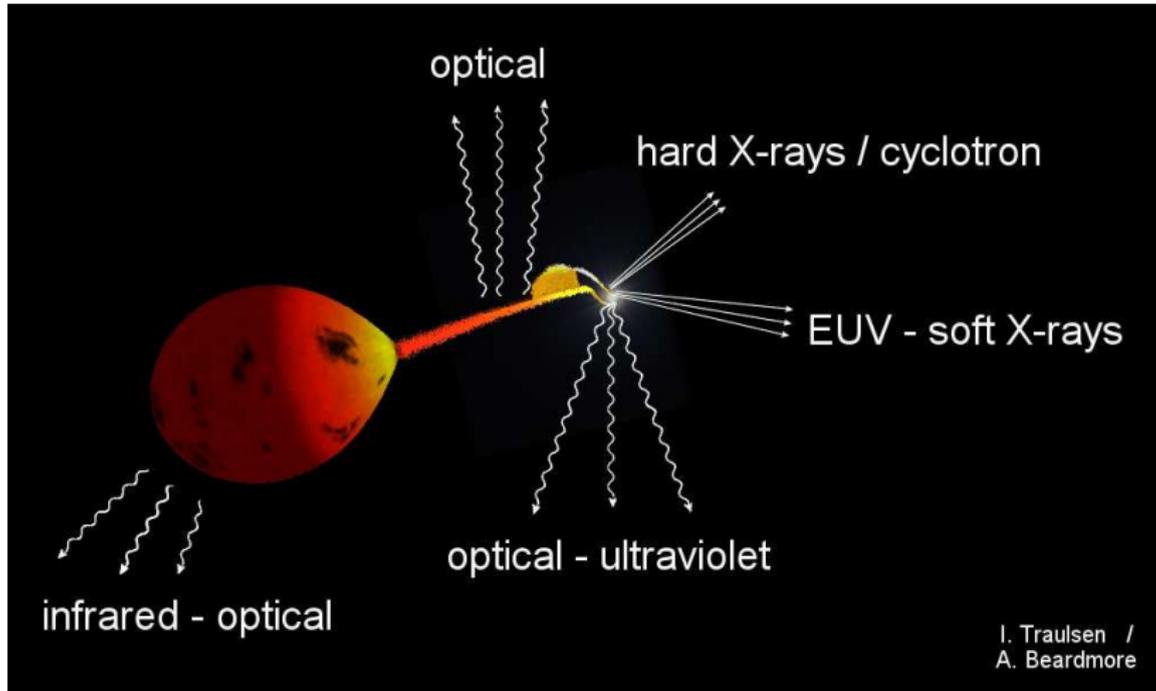
My scientific interest in XMM-Newton: Interacting binaries

Spectral energy distribution of magnetic cataclysmic variables:



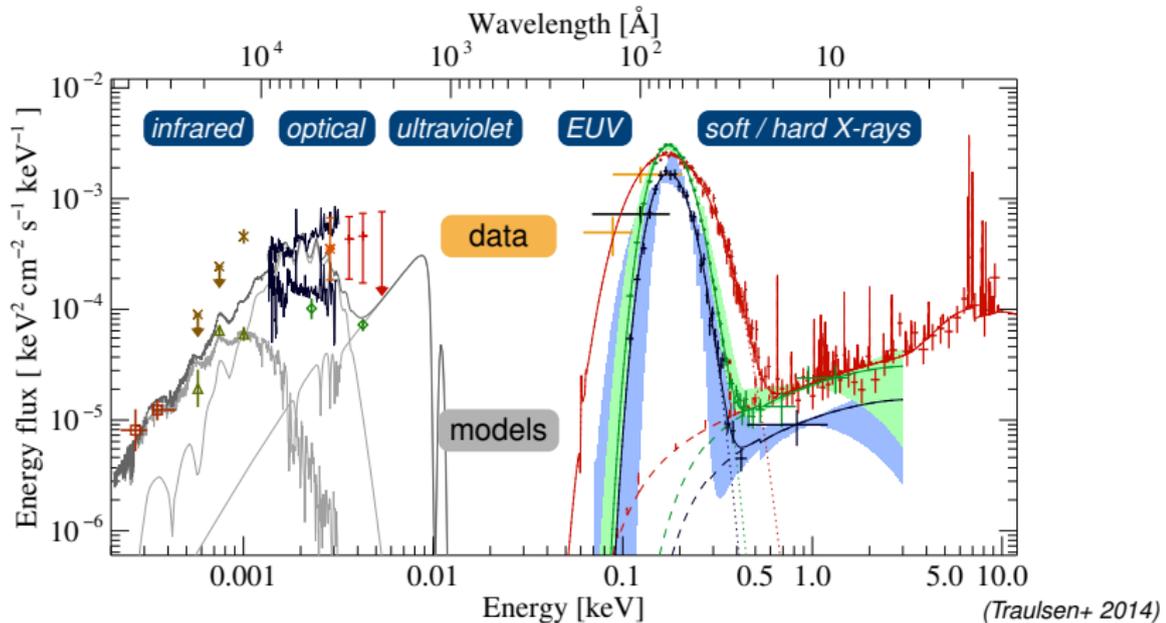
My scientific interest in XMM-Newton: Interacting binaries

Spectral energy distribution of magnetic cataclysmic variables:



My scientific interest in XMM-Newton: Interacting binaries

Spectral energy distribution of magnetic cataclysmic variables:



multi-wavelength observations + spectral models = first physically consistent SED model

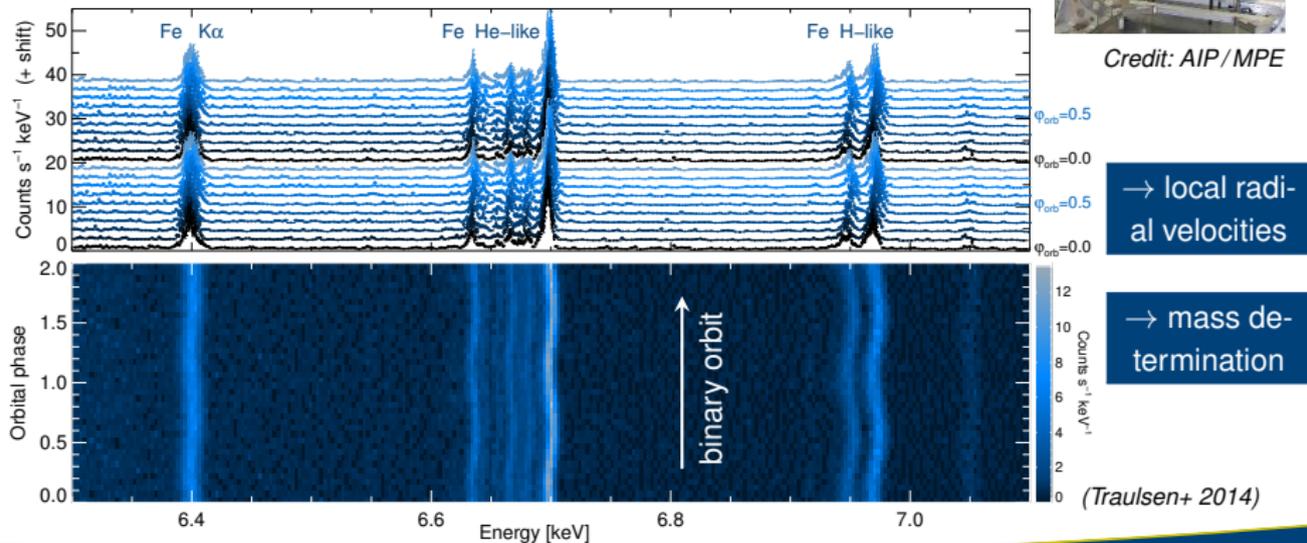
The future of space-based X-ray astronomy

Spektr-RG (Russia – Germany) planned launch in 2017:
era of object statistics

Athena (ESA large mission) proposed launch in 2028–2032:
carrying a calorimeter era of X-ray line diagnostics



Credit: AIP / MPE



3XMM – The largest library of the X-ray universe

- * currently the largest catalogue of X-ray sources
- * fund of new detections and counterparts to other observations
- * built by the international XMM-Newton Survey Science Centre Consortium
 - * example for the potential of future multi-national efforts
 - * yearly increments, next one to be released soon
- * new: stacked source detection in multiply observed fields
 - * looking forward to the upcoming opportunities like Spektr-RG carrying ART-XC & eROSITA