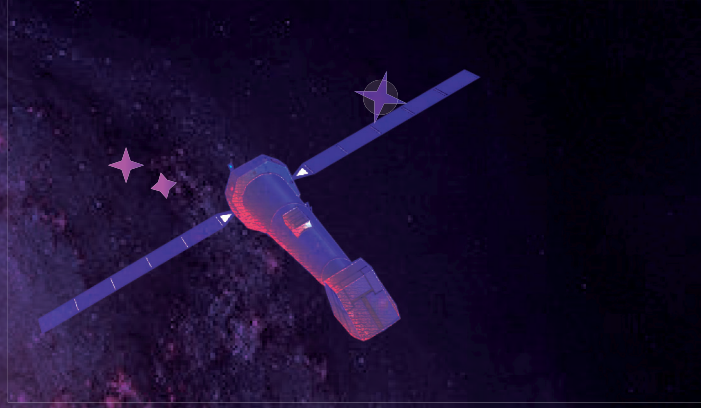

Athena Board Game

irap astrophysique & planétologie

IFU ATHENA X-ray Integral Field Unit

LIÈGE université

ATHENA

Conception: Yael Nazé

Graphical design: Paula Marques - www.studio-urbain.fr


ATHENA

The *Athena* board game: rules

Material: two pages with rules & information, 12 Instrument cards **(I)** with *Athena* instruments, 24 Object cards **(O)** with real astrophysical objects, 24 Action cards **(A)** with positive or negative events that may occur to any real project, 40 proposals of scientific projects, 6 pawns and a special dice.

Goal: getting data with the *Athena* observatory to solve a scientific riddle, and publish the results.

Players: from two to six players of age above 12.

Game outline:

1 - Shuffle all **IAO** cards (instruments, actions, objects) together and place them aside face down – this is the science deck.

2 - In astronomy, there are often many more projects submitted to an observatory's science board than available observing time. Your first challenge will be to face this "pressure factor". Shuffle the project proposal cards. Each player then picks up one of them at random: he/she can begin to play only if the proposal is accepted. You may decide to discard an accepted proposal, but must then wait for the next turn to draw a new proposal card.

3 - Your second challenge is to perform the selected project. Place it on your board, put your pawn on the zero of the time scale and picks up three cards from the top of the science deck. Each proposal card states the scientific objective, indicates the type of observation needed* , and the exposure time required to fulfil the project.

4 - For each turn of the normal phase of the game:

a. The player rolls the dice to get time for his/her project: the obtained value adds to the one previously gained, which can be indicated using the time scale.

b. The player also picks up the top card of the science deck, then he/she can either use one of the 4 cards (i.e. putting an instrument, object, or publication card to fill the individual board, or using one of the action cards).

- To place one instrument or object card on the individual board, it must be compatible with the proposal. To assess the match, one just needs to look at the cards: the instrument card indicates the type of observation that can be performed with it and the object card indicates the proposal numbers with which it is compatible.
- The publication card cannot be used before appropriate instrument and object cards have been placed on the board and the full amount of exposure time has been gathered.
- A player cannot have more than 3 cards in hand at the end of his/her turn (not counting the board's cards): additional ones must be discarded in an "archive pile".
- If there are no more cards in the science deck to continue the game, shuffle the archive pile, and make a new science deck from it.

5 - As in science, the winner is the first to publish…

** There are four types of observations : (1) IMA=imaging, (2) LC=lightcurve (i.e., registering the evolution of the target brightness with time), (3) LRS=low-resolution spectroscopy and (4) HRS=high-resolution spectroscopy.*

Athena (Advanced Telescope for High ENergy Astrophysics) is the next X-ray observatory mission selected by the European Space Agency (ESA), within its Cosmic Vision 2015-2025 programme. It is the first astrophysical large-class mission within that programme, and is due for launch in early 2030s.

Athena undertakes three key scientific objectives:

1) Determine how and when large-scale hot gas structures formed in the universe and track their evolution to the present day.
2) Perform a complete census of black hole growth in the universe, determine the physical processes responsible for that growth and its influence on larger scales, and trace these and other energetic and transient phenomena to the earliest cosmic epochs.
3) Explore high-energy phenomena in all astrophysical contexts, including those yet to be discovered, to significantly advance our understanding of the universe.

Athena will consist of a large telescope, with 12m focal length, utilizing a novel technology developed in Europe. It has two instruments: the Wide Field Imager (WFI) offers wide-field spectral imaging while the X-IFU instrument provides spatially resolved very high-resolution spectra.

Speak like an X-ray astronomer!

• **AGN (Active Galactic Nucleus):** it is a center of galaxy which is much brighter than usual because the supermassive black hole located there actively accretes material.

• **Black hole:** it is a region where the gravitation is so intense that not even light (the fastest thing in the Universe) can escape from it. Black holes with masses similar to those of stars form when a very massive star dies, but others are much heavier and reside in the centers of galaxies.

• **Galaxy:** it is a large collection of stars, dust, and gas, which is usually classified based on its shape (spiral, elliptical, irregular). The solar system resides in a galaxy called the Milky Way, which contains hundreds of billions of stars.

• **Grazing incidence and X-ray telescopes:** to reflect X-rays, the light must arrive at the mirror with a very low angle, i.e. at grazing incidence, similar to a pebble skipping on a lake.

• **GRB (Gamma-Ray Burst):** they are the brightest events in the Universe, thought to correspond to the birth of a black hole, either from the merging of two neutron stars or the death of a very massive star.

• **ks:** in X-ray astronomy the duration of an observation is typically measured in kiloseconds, 1ks = 1000 s.

• **Neutron star:** this is the dead core of a massive star. It is very compact as it weighs about the mass of the Sun but enclosed in a radius of only 10km. When it emits beamed light, it behaves like a lighthouse and is called a pulsar.

• **Planet:** it is a ball of gas and/or rocks which orbits around a star. Our planet is the Earth.

• **Planetary nebulae:** when a star similar to the Sun dies, its core becomes a white dwarf and its external layers are violently ejected. They interact with the surroundings, forming a planetary nebula.

• **Spectroscopy:** it is the study of the distribution of brightness as a function of energy.

• **Star:** it is a large ball of gas whose center is so hot that nuclear fusion takes place. This process releases energy, making the star shine. The closest star from Earth is the Sun.

• **Supernova:** suddenly, a very bright source appears which slowly fades – this event is called a supernova. It occurs when the most massive stars reach the end of their lives or when white dwarfs become too heavy. This titanic event ejects material at high speed, creating a shockwave into the surroundings, and this interaction will finally form a supernova remnant which can be observed for a long time after the initial explosion.

• **X-rays:** the light exists with different "colors", some being invisible to the eyes, like X-rays. This high-energy light is emitted by very hot (multimillion degree) material or by high-speed particles in a magnetic or electric field.

• **XRB (X-ray binary):** it is a peculiar couple composed of a compact object (neutron star or black hole) and a normal star whose matter is partly "sucked" by its companion. This accretion process makes the system shine very brightly in X-rays.

• **White dwarf:** this is the endpoint of stars such as the Sun. This compact object weighs as much as the Sun but with a radius 100 times smaller.

For more information: **http://www.the-athena-x-ray-observatory.eu**

Thanks to Didier Barret, Edoardo Cucchetti, Arne Rau, Gregor Rauw, and the ACO team for their help.


ks
5 10 15 20 25 30 35 40 45 50
100 95 90 85 80 75 70 65 60 55
105 110 115 120 125 130 135 140 145 150
200 195 190 185 180 175 170 165 160 155
205 210 215 220 225 230 235 240 245 250


ATHENA

Print for each player

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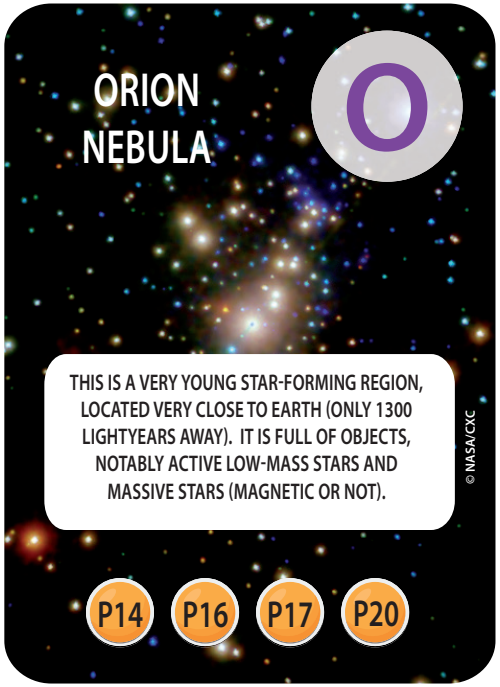
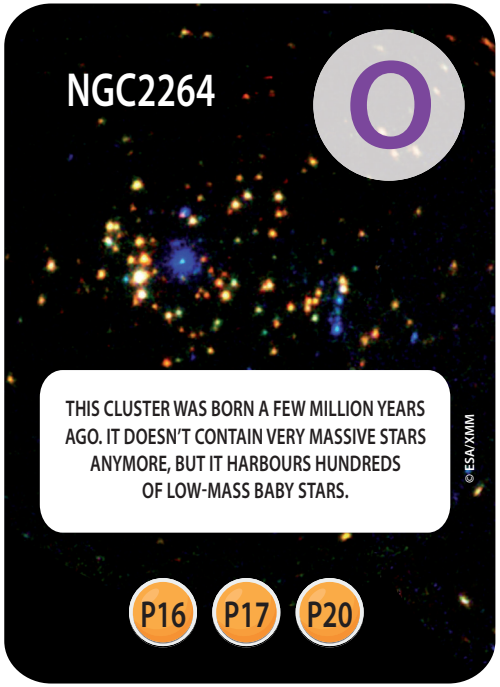
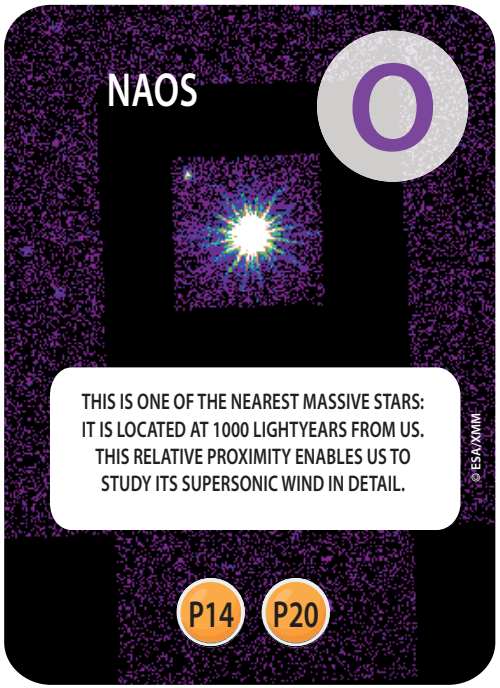
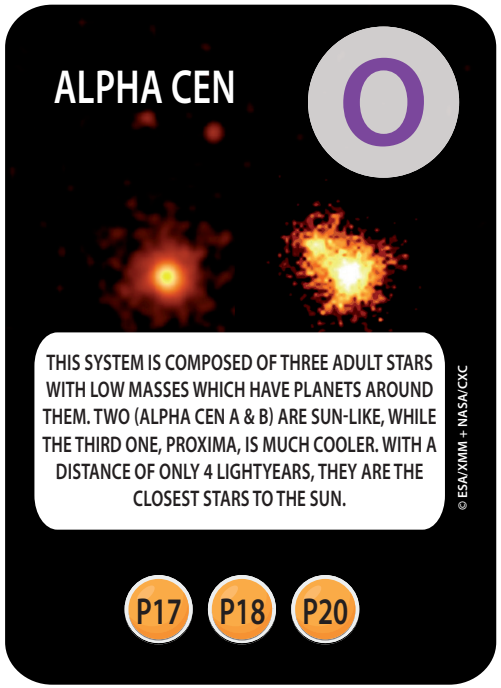
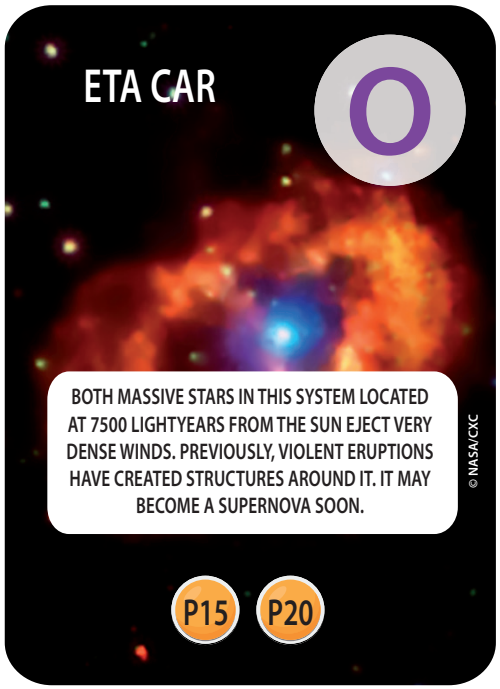
ATHENA

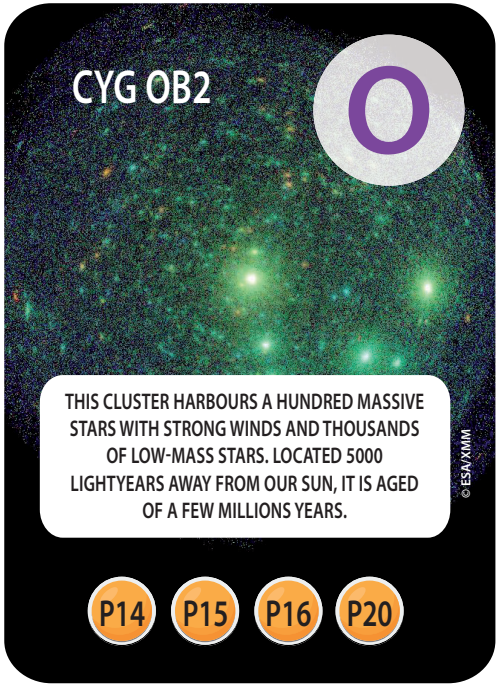

ORION NEBULA
O
THIS IS A VERY YOUNG STAR-FORMING REGION, LOCATED VERY CLOSE TO EARTH (ONLY 1300 LIGHTYEARS AWAY). IT IS FULL OF OBJECTS, NOTABLY ACTIVE LOW-MASS STARS AND MASSIVE STARS (MAGNETIC OR NOT).
© NASA/CXC
P14 P16 P17 P20

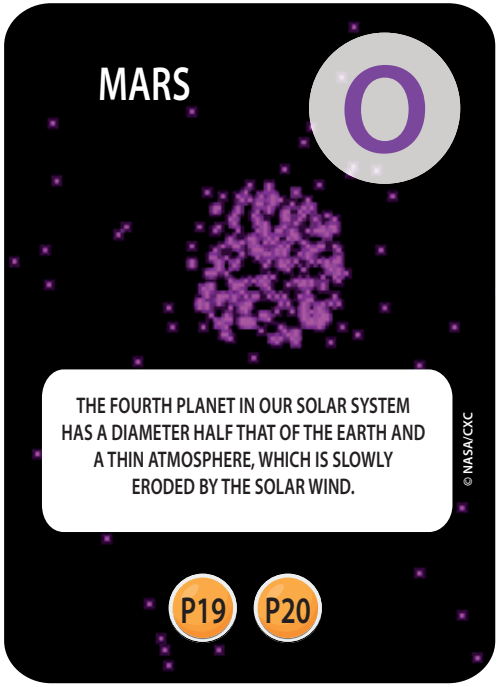

NGC2264
O
THIS CLUSTER WAS BORN A FEW MILLION YEARS AGO. IT DOESN'T CONTAIN VERY MASSIVE STARS ANYMORE, BUT IT HARBOURS HUNDREDS OF LOW-MASS BABY STARS.
© ESA/XMM
P16 P17 P20

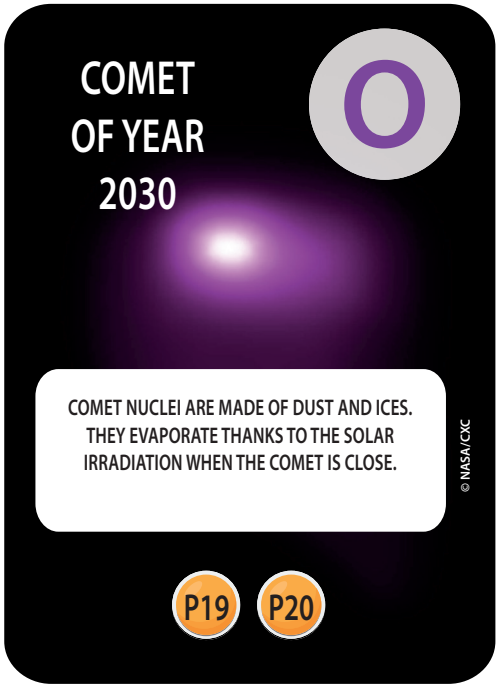

NAOS
O
THIS IS ONE OF THE NEAREST MASSIVE STARS: IT IS LOCATED AT 1000 LIGHTYEARS FROM US. THIS RELATIVE PROXIMITY ENABLES US TO STUDY ITS SUPERSONIC WIND IN DETAIL.
© ESA/XMM
P14 P20


ALPHA CEN
O
THIS SYSTEM IS COMPOSED OF THREE ADULT STARS WITH LOW MASSES WHICH HAVE PLANETS AROUND THEM. TWO (ALPHA CEN A & B) ARE SUN-LIKE, WHILE THE THIRD ONE, PROXIMA, IS MUCH COOLER. WITH A DISTANCE OF ONLY 4 LIGHTYEARS, THEY ARE THE CLOSEST STARS TO THE SUN.
© ESA/XMM + NASA/CXC
P17 P18 P20


ETA CAR
O
BOTH MASSIVE STARS IN THIS SYSTEM LOCATED AT 7500 LIGHTYEARS FROM THE SUN EJECT VERY DENSE WINDS. PREVIOUSLY, VIOLENT ERUPTIONS HAVE CREATED STRUCTURES AROUND IT. IT MAY BECOME A SUPERNOVA SOON.
© NASA/CXC
P15 P20


CYG OB2
O
THIS CLUSTER HARBOURS A HUNDRED MASSIVE STARS WITH STRONG WINDS AND THOUSANDS OF LOW-MASS STARS. LOCATED 5000 LIGHTYEARS AWAY FROM OUR SUN, IT IS AGED OF A FEW MILLIONS YEARS.
© ESA/XMM
P14 P15 P16 P20


MARS
O
THE FOURTH PLANET IN OUR SOLAR SYSTEM HAS A DIAMETER HALF THAT OF THE EARTH AND A THIN ATMOSPHERE, WHICH IS SLOWLY ERODED BY THE SOLAR WIND.
© NASA/CXC
P19 P20


COMET OF YEAR 2030
O
COMET NUCLEI ARE MADE OF DUST AND ICES. THEY EVAPORATE THANKS TO THE SOLAR IRRADIATION WHEN THE COMET IS CLOSE.
© NASA/CXC
P19 P20

ATHENA

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HD189733

O

IN THIS NEARBY SYSTEM (LOCATED AT ONLY 63 LIGHTYEARS), A PLANET AS BIG AS JUPITER ORBITS A SUN-LIKE STAR IN ONLY 2.2 DAYS. IT IS SO CLOSE THAT THE PLANET'S ATMOSPHERE IS EVAPORATING.

© NASA/CXC

P18 P20

CAT'S EYE NEBULA

O

A SUN-LIKE STAR DIED, LEAVING BEHIND A COMPACT CORPSE (CALLED WHITE DWARF). THE OUTER STELLAR LAYERS WERE VIOLENTLY EJECTED, GIVING RISE TO THIS PLANETARY NEBULA.

© NASA/CXC

P11 P20

CRAB NEBULA

O

IN 1054, A NEW "STAR" APPEARED IN THE TAURUS CONSTELLATION. AT THIS POSITION, WE OBSERVE TODAY A SUPERNOVA REMNANT SURROUNDING THE DEAD STELLAR CORE WHICH IS A PULSAR.

© NASA/CXC

P11 P13 P20

GRB 301206

O

FAR AWAY, A VERY MASSIVE STAR DIED IN A SUPER EXPLOSION, GENERATING A GAMMA-RAY BURST.

© ESA/XMM

P6 P10 P20

GRB 300401

O

FAR AWAY, A VERY MASSIVE STAR DIED IN A SUPER EXPLOSION, GENERATING A GAMMA-RAY BURST.

© NASA/CXC

P6 P10 P20

SGR A

O

THE CENTRE OF OUR GALAXY HARBOURS A SUPERMASSIVE BLACK HOLE WHICH SOMETIMES ENGULFS SOME NEARBY MATERIAL. IN ITS SURROUNDINGS ONE CAN FIND SEVERAL X-RAY BINARIES AND CLUSTERS OF MASSIVE STARS.

© ESA/XMM

P9 P12 P14 P15 P20

M82 X-2

O

THIS OBJECT LOCATED IN A NEARBY GALAXY BELONGS TO THE CLASS OF ULTRALUMINOUS X-RAY SOURCES WHOSE NATURE REMAINS MYSTERIOUS THOUGH THEY CERTAINLY CONTAIN A COMPACT OBJECT ACTIVELY ACCRETING MATTER.

© NASA/Nustar

P10 P12 P14 P20

CYG X-1

O

LOCATED 6000 LIGHTYEARS AWAY, THIS X-RAY BINARY COMPRISES A BLACK HOLE AND A MASSIVE STAR.

© NASA/CXC

P10 P12 P13 P14 P20

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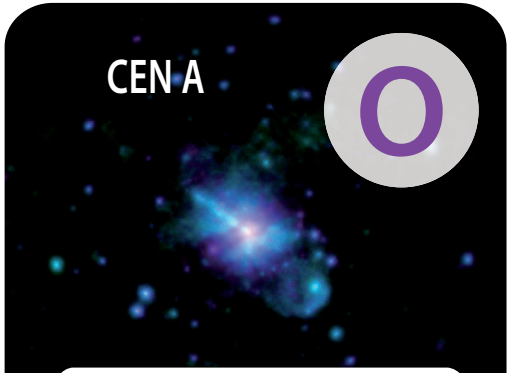
CEN A

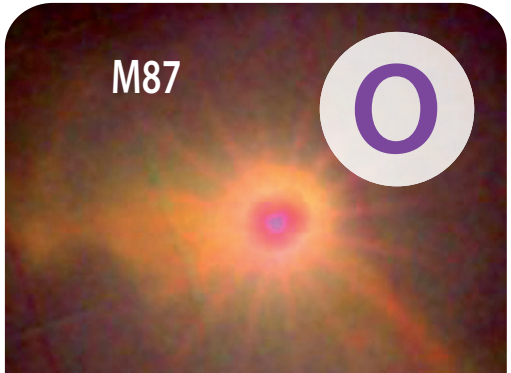


THIS STRUCTURE WAS BORN FROM A COLLISION BETWEEN TWO GALAXIES. AT ITS CENTRE CAN BE FOUND AN AGN WITH A SUPERMASSIVE BLACK HOLE OF 55 MILLION SOLAR MASSES ENGULFING MATERIAL SURROUNDING IT, GIVING RISE TO JETS.

© ESA/XMM

P5 P7 P8 P9 P10 P20

M87

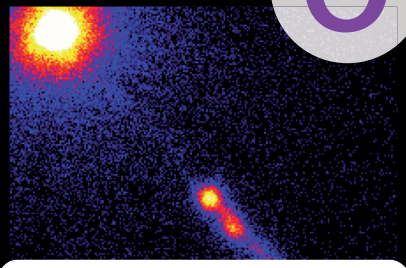


THIS ELLIPTICAL GALAXY HARBOURS AN AGN – ITS SUPERMASSIVE BLACK HOLE LAUNCHES A JET MOVING AT VELOCITIES CLOSE TO THE SPEED OF LIGHT.

© ESA/XMM

P5 P7 P8 P9 P10 P20

3C 273

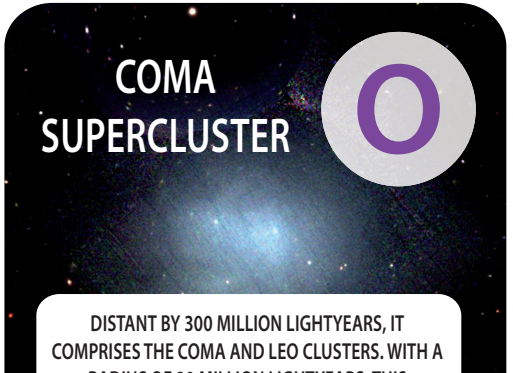


THIS OBJECT WAS THE FIRST QUASAR (A TYPE OF AGN) IDENTIFIED. LOCATED MORE THAN 2 BILLION LIGHTYEARS AWAY, ITS SUPERMASSIVE BLACK HOLE LAUNCHES JETS AS BIG AS OUR OWN MILKY WAY.

© NASA/CXC

P5 P7 P8 P9 P10 P20

COMA SUPERCLUSTER



DISTANT BY 300 MILLION LIGHTYEARS, IT COMPRISES THE COMA AND LEO CLUSTERS. WITH A RADIUS OF 20 MILLION LIGHTYEARS, THIS LARGE-SCALE STRUCTURE CONTAINS MORE THAN 3000 GALAXIES, INCLUDING SOME AGNS AND SUPERGIANT ELLIPTICAL GALAXIES.

© ESA/XMM

P3 P4 P5 P6 P7
P8 P9 P10 P20

PERSEUS CLUSTER

THIS CLUSTER, SITUATED AT ABOUT 240 MILLION LIGHTYEARS FROM EARTH, CONTAINS MORE THAN A THOUSAND GALAXIES, INCLUDING SOME AGNS, IN A GIGANTIC CLOUD OF MULTIMILLION DEGREE GAS.

© ESA/XMM

P3 P4 P5 P6 P7
P8 P9 P10 P20

VIRGO CLUSTER

THIS NEARBY CLUSTER IS LOCATED AT LESS THAN 60 MILLION LIGHTYEARS AWAY. IT CONTAINS A LITTLE MORE THAN A THOUSAND GALAXIES, INCLUDING SOME AGNS.

© NASA/CXC

P3 P4 P5 P6 P7
P8 P9 P10 P20

DEEP FIELD #1

THIS SMALL AREA OF THE SKY PROVIDES THE OPPORTUNITY TO OBSERVE THE DISTANT UNIVERSE: GALAXY CLUSTERS OR AGNS ARE THEN SEEN WHEN THE UNIVERSE WAS VERY YOUNG.

© ESA/XMM

P1 P2 P4 P6 P20

DEEP FIELD #2

THIS SMALL AREA OF THE SKY PROVIDES THE OPPORTUNITY TO OBSERVE THE DISTANT UNIVERSE: GALAXY CLUSTERS OR AGNS ARE THEN SEEN WHEN THE UNIVERSE WAS VERY YOUNG.

© ESA/XMM

P1 P2 P4 P6 P20

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P1

DETECT THE VERY FIRST GROUPS OF GALAXIES OF THE UNIVERSE, TO DETERMINE HOW THE LARGE-SCALE STRUCTURES OF THE COSMOS FORMED.

100 KS

IMA

P2

INVESTIGATE THE INFLUENCE OF SUPERMASSIVE BLACK HOLES ON THE FORMATION OF GALAXIES IN THE VERY EARLY UNIVERSE BY STUDYING DISTANT AGNS.

50 KS

IMA

P3

CONSTRAIN THE DETAILED PROPERTIES OF THE HOT GAS FILLING CLUSTERS OF GALAXIES TO BETTER UNDERSTAND ITS ORIGIN.

100 KS

HRS

P4

DETERMINE HOW THE CHEMICAL CONTENT OF THE UNIVERSE EVOLVED WITH TIME BY COMPARING THE X-RAY EMISSION OF CLOSE AND DISTANT CLUSTERS OF GALAXIES.

200 KS

HRS
LRS

P5

IMAGE THE ENVIRONMENT OF SUPERMASSIVE BLACK HOLES IN AGNS TO STUDY THE IMPACT OF THEIR JETS ON THEIR GALACTIC OR INTERGALACTIC NEIGHBOURHOOD.

50 KS

IMA

P6

DETECT FILAMENTS OF HOT GAS LOCATED BETWEEN GALAXY CLUSTERS AND DERIVE THEIR PROPERTIES BY OBSERVING THEIR SIGNATURE IMPRINTED IN THE X-RAY EMISSION OF DISTANT AGNS OR GRBS.

250 KS

HRS


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ATHENA

ATHENA

P7

MONITOR THE VARIATIONS OF ULTRA-FAST OUTFLOWS LAUNCHED BY THE ACTION OF SUPERMASSIVE BLACK HOLES IN AGNS, TO BETTER UNDERSTAND THEIR ORIGIN.

50 KS

LC

P8

CHARACTERIZE THE MATTER FALLING INTO SUPERMASSIVE BLACK HOLES IN AGNS TO DERIVE THE BLACK HOLES' SPINS, WHICH HELP UNDERSTAND THEIR GROWTH AND FATE.

100 KS

HRS

P9

STUDY THE DISRUPTION OF STARS AS THEY PLUNGE INTO SUPERMASSIVE BLACK HOLES BY MONITORING THEIR X-RAY EMISSION.

75 KS

LC

P10

STUDY DUST IN OUR GALAXY THANKS TO THE HALO IT PRODUCES AROUND A DISTANT BRIGHT SOURCE (GRB, AGN, OR XRB).

70 KS

IMA

P11

MAP THE MATTER EJECTED BY DYING STARS TO BETTER UNDERSTAND HOW STELLAR DEATH OCCURS AND HOW THIS EJECTION SHAPES THE STAR'S ENVIRONMENT.

50 KS

LRS
IMA

P12

MONITOR THE VARIATIONS OF THE X-RAY EMISSION FROM MATERIAL FALLING TOWARDS DEAD STARS TO DETERMINE THEIR PHYSICAL PROPERTIES.

50 KS

LC


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ATHENA

P13

ESTABLISH HOW THE X-RAY SIGNATURES OF MATERIAL CLOSELY SURROUNDING DEAD STARS ARE SHAPED TO DERIVE THEIR MASS AND RADIUS, WHICH HELPS BETTER UNDERSTANDING THEIR PHYSICAL STATE.

200 KS

HRS

P14

MONITOR THE X-RAY EMISSION OF MASSIVE STARS (EITHER ALONE OR IN COUPLE WITH A COMPACT OBJECT) TO DETERMINE THE STRUCTURE OF THEIR WINDS.

150 KS

HRS
LC

P15

STUDY IN DETAIL THE HOT GAS CREATED BY THE COLLISION BETWEEN THE SUPERSONIC WINDS OF TWO MASSIVE STARS FORMING A PHYSICAL PAIR.

150 KS

HRS

P16

CONSTRAIN EXACTLY HOW BABY STARS GROW BY CLOSELY FOLLOWING THEIR ERUPTIONS.

50 KS

HRS
LC

P17

DETERMINE THE LEVEL OF MAGNETIC ACTIVITY OF VERY COOL STARS, IN ORDER TO SEE WHETHER THEIR PLANETS COULD BE HOSPITABLE.

80 KS

LC

P18

MEASURE THE MAGNETIC INTERPLAY BETWEEN A STAR AND ITS PLANETS BY MONITORING THE X-RAY EMISSION OF THE SYSTEM.

200 KS

LC


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ATHENA

ATHENA

P19

MAP THE X-RAY EMISSION ASSOCIATED TO THE INTERACTION BETWEEN THE SOLAR WIND AND THE ATMOSPHERE OF SOLAR SYSTEM TARGETS (COMETS OR PLANETS).

50 KS

IMA

SORRY, YOUR PROPOSAL WAS NOT SELECTED

P20

JOKER

STUDY WHAT YOU WANT!

100 KS

IMA - LC
HRS - LRS

SORRY, YOUR PROPOSAL WAS NOT SELECTED

SORRY, YOUR PROPOSAL WAS NOT SELECTED

SORRY, YOUR PROPOSAL WAS NOT SELECTED


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Print twice


SORRY, YOUR PROPOSAL WAS NOT SELECTED


SORRY, YOUR PROPOSAL WAS NOT SELECTED


SORRY, YOUR PROPOSAL WAS NOT SELECTED


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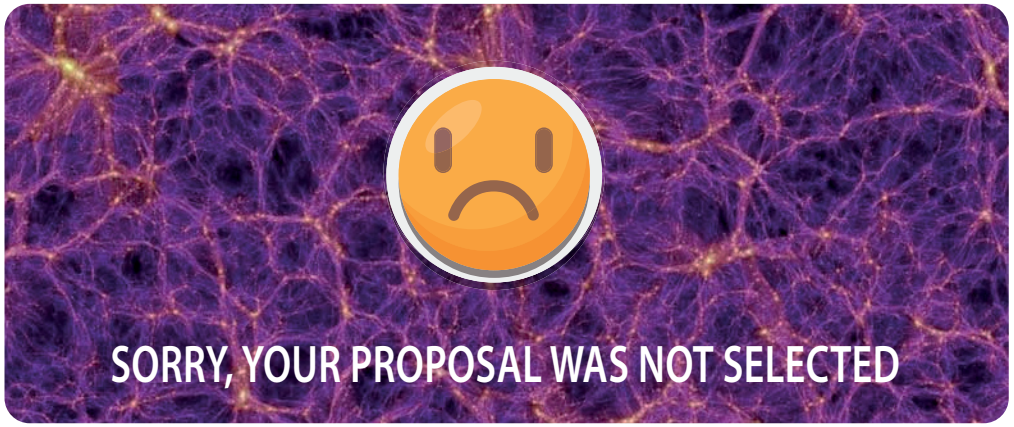
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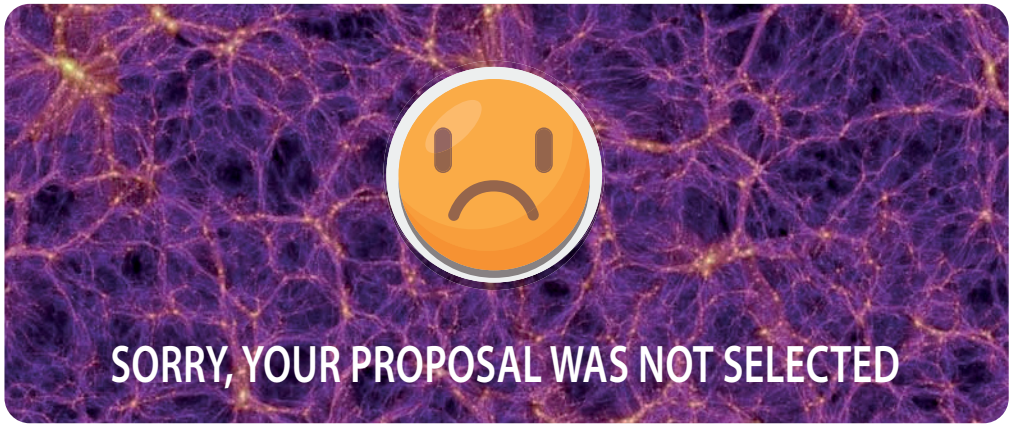
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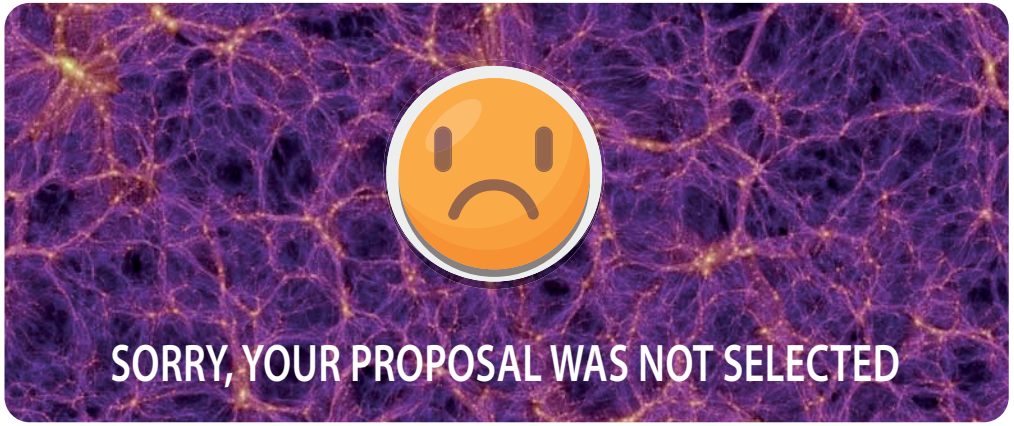
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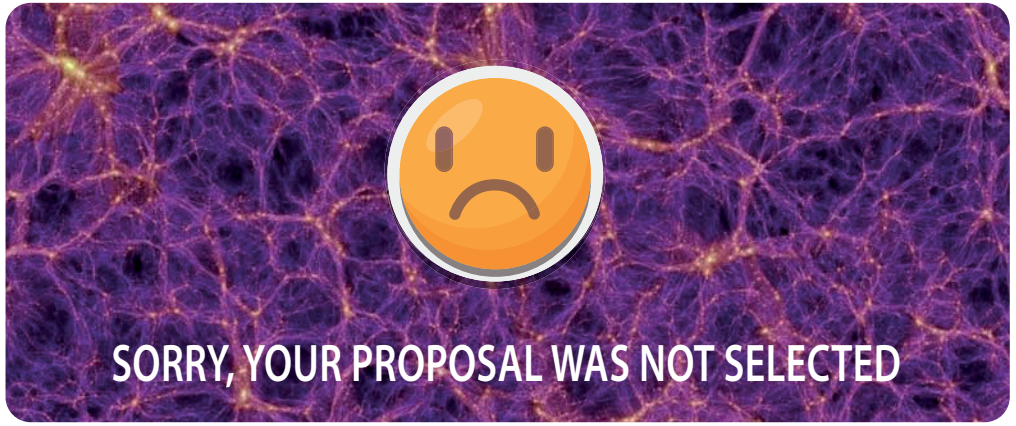
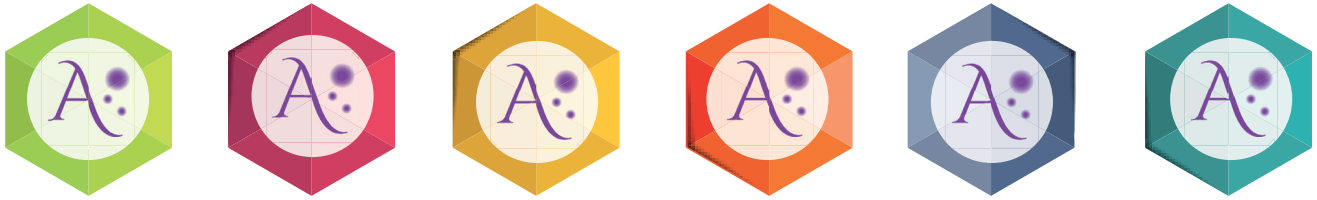

SORRY, YOUR PROPOSAL WAS NOT SELECTED

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Print twice

A

THE MISSION DIRECTOR HAS GRANTED YOU SOME OF HIS DISCRETIONARY TIME: ADD 20KS TO YOUR OBSERVING TIME BUDGET.

A

SINCE YOU HAVE PARTICIPATED TO THE MISSION DESIGN, YOU HAVE ACCESS TO GUARANTEED TIME: ADD 40KS TO YOUR OBSERVING TIME BUDGET.

A

A SOLAR FLARE INTERRUPTS THE OBSERVATION OF ONE OF YOUR OPPONENTS. IT WILL BE RESCHEDULED LATER, BUT HIS/HER PROJECT HAS TO RESTART GATHERING OBSERVING TIME (TIME BUDGET BACK TO ZERO).

A

YOUR TARGET MAKES AN UNEXPECTED EVENT AND YOUR PROGRAM THEN GAINS PRIORITY: YOU GET ANOTHER TURN (SO TAKE A NEW CARD AND ROLL THE DICE ONCE AGAIN).

A

THE PROPRIETARY PERIOD ENDED, BUT ONE OF YOUR OPPONENTS DIDN'T FINISH WORKING ON HIS/HER DATA. ANOTHER TEAM HAS DOWNLOADED THE DATA WHICH ARE NOW PUBLIC AND HAVE PUBLISHED THEM. HE/SHE MUST START ALL OVER AGAIN, DISCARDING ALL HIS/HER CARDS AND DRAWING A NEW PROPOSAL.

A

THE GROUND ANTENNA IS TAKEN OVER BY ANOTHER SPACE MISSION: THE DATA TRANSMISSION WAS ABRUPTLY ENDED AND EVERYTHING WAS LOST. THE PROJECT OF ONE OF YOUR OPPONENTS WILL BE RESCHEDULED LATER, BUT HAS TO RESTART GATHERING OBSERVING TIME (TIME BUDGET BACK TO ZERO).

I

WFI ATHENA

THIS INSTRUMENT TAKES IMAGES OF X-RAY SOURCES OVER LARGE SKY AREAS. IT MEASURES THEIR POSITION AND EXTENT; MONITORS THEIR BRIGTHNESS; AND PROVIDES A FIRST IDEA OF THE DISTRIBUTION IN ENERGY OF THE INCOMING X-RAY EMISSION.

IMA LC LRS

I

IFU ATHENA X-ray Integral Field Unit

THIS INSTRUMENT RECORDS VERY PRECISELY THE ARRIVAL TIME AND ENERGY OF ANY INCOMING X-RAY, HENCE IT CAN DETECT SUBTLE VARIATIONS OF A SOURCE FLUX AS WELL AS PINPOINTING THE PHYSICAL PROPERTIERS (VELOCITY, COMPOSITION, ...) OF A TARGET.

LC HRS

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CONGRATULATIONS, YOU HAVE PUBLISHED YOUR RESULS!

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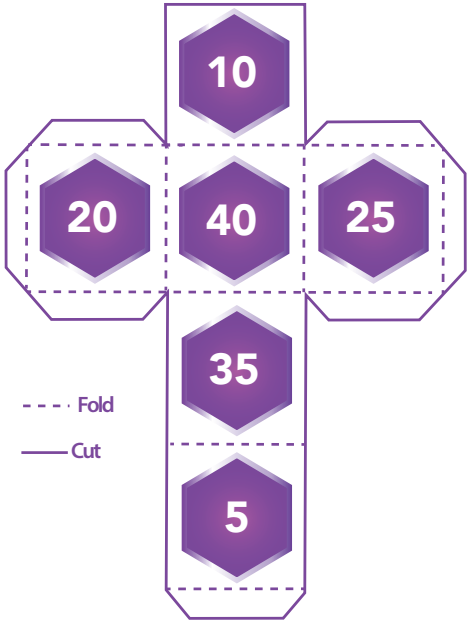

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