Planetarium presentation: scenario for planetarium operators

Black text basilar concepts and topics *(within the 60 min presentation)*

Green text additional concepts and topics *(extra the 60 min presentation)*

Italic direct references to research project activities (es. 3D models)

Underlined technical features to be adapted to each planetarium

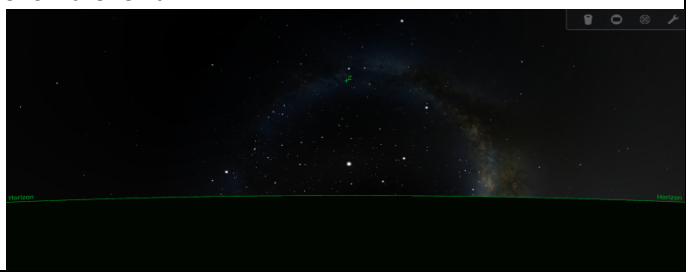
"with *pointer*" features to be shown by the operator by a laser pointer
"with **planetarium**" features to be shown by the planetarium

Timing indication (approximative)

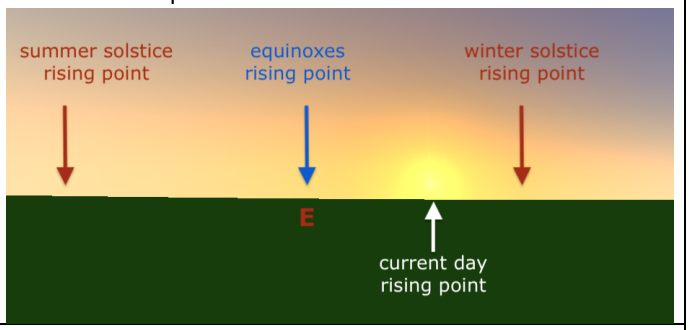
Topic	Duration (approx.)
Topic **ONE**: **what is a planetarium**. Why we should look at the sky. The horizon.	05 min
Topic **TWO**: **apparent diurnal motion** of Sun and stars: rotation of the Earth and its axis' orientation	18 min
Topic **THREE**: **constellations**	04 min
Topic **FOUR**: **apparent annual motion** of the Sun: revolution of the Earth	18 min
Topic **FIVE**: how to position and navigate on Earth looking at the sky: **the observer position**	15 min

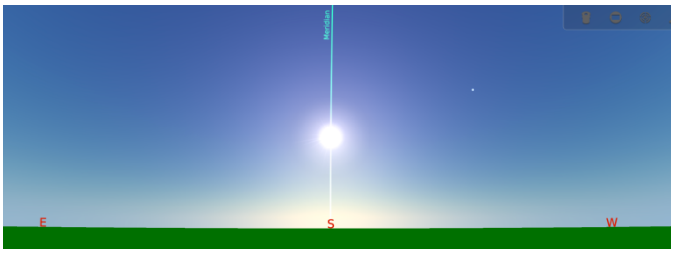
1. Topic **ONE**: **what is a planetarium**. Why we should look at the sky. The horizon.

What to say	What to show
1. Welcome under the dome. What is a planetarium. Why we need a planetarium: seeing celestial objects at any time, with every weather, seeing celestial motions at any rate, seeing skies from different locations of the Earth. 2. Why the planetarium is dark: eyes have to adapt to darkness. What we will see: stars and celestial objects visible to the naked eye. 3. Why observing the sky is important: keeping time, positioning and navigation, learning about geometrical and mechanical features of Earth and Solar System objects.	//
1. We are in a geocentric, i.e. "what we see from Earth", perspective. The celestial sphere model. *We "enter" the bottle globe, and in this way we pass from an allocentric point of view to a geocentric POV.*	//

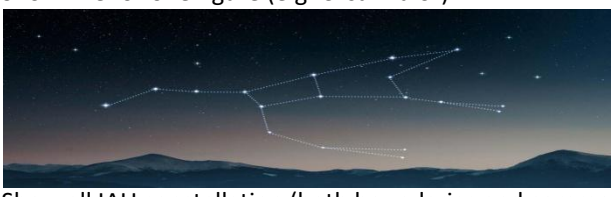
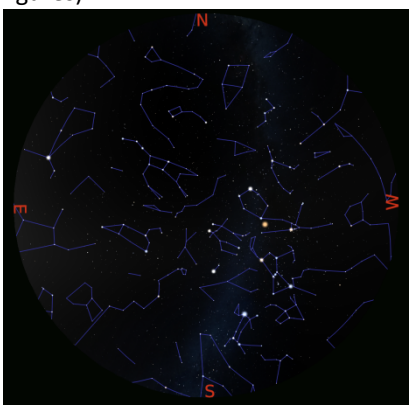
2. Apparent vs actual motions: we are on a moving object so it is difficult to discriminate between the two kinds of motion (we are not inertial observers) **QUESTION 1: What is "still" with respect to you in the two different systems?** **ANSWER 1: In the bottle globe (allocentric view) the Sun, stars and celestial bodies are still wrt to you** **In the planetarium (geocentric view) the Earth, i.e. you, is still.**	
1. First reference line: the horizon as the "visibility" line. Ideal vs real horizon. **QUESTION 2: What dome feature represents the horizon?** **ANSWER 2: The dome feature representing the horizon is its *edge*, because it is the line from which we see celestial bodies appear** 2. Another reference point: the *zenith*, our vertical direction	(with *pointer*/or **planetarium**) Rising Sun, half over the horizon. Show horizon in the dome: the horizon is the *edge* of the dome. Show the *zenith*. 

2. Topic **TWO**: **apparent diurnal motion** of Sun and stars: rotation of the Earth and its axis' orientation (15 min)

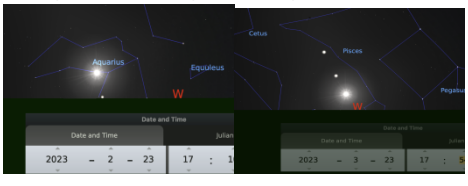
What to say	What to show
QUESTION 3: Where will the Sun rise tomorrow? Same point or not? **ANSWER 3: No, the Sun will not rise in the same point** 1. The Sun does not rise exactly in the same point each day but it rises in a well defined part of the horizon. The rising point of the Sun changes every day in a yearly pattern. 2. Solstices (= days "at the edge" of the rising zone of the horizon) and equinoxes (= days "in the middle" of the rising zone of the horizon).	(with **planetarium**) Sun laying over the horizon (one single image today). (with *pointer*) Show different point for sunrise, in particular points for solstices and equinoxes 
1. The Sun's path on the celestial sphere: Sun's path is a circle, starting from its rising point in the eastern horizon and ending in its setting point in the western horizon. Height of celestial object as an angle. Sun's path is not the same during the year (we will see it better later): how does it vary? **QUESTION 4: What stays constant in the Sun's paths throughout the days?** **ANSWER 4: What is constant is the direction of the culmination point**	(with **planetarium**) Sun moving in the sky along the current day's path (path is marked) (show an equatorial grid just for some seconds) Stop Sun at the culmination point. Movie showing the different Sun's path for 3 different days (for Greece and Germany) Show meridian (with *pointer*) Height of Sun at the culmination point

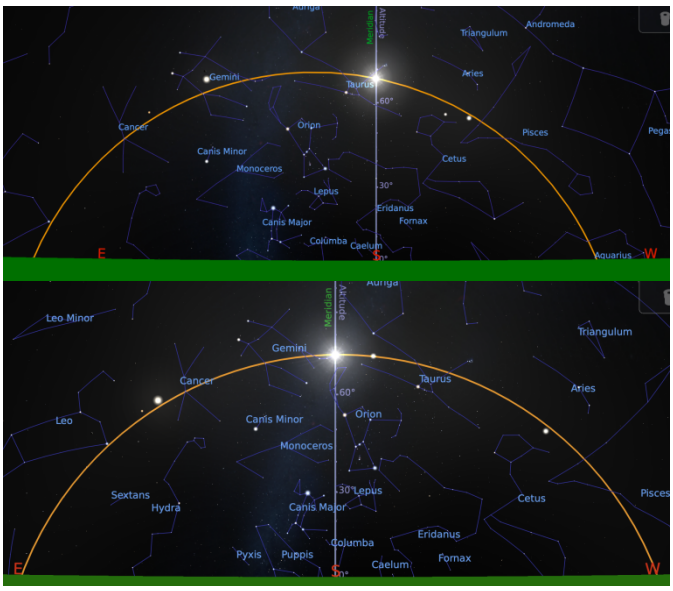
2. The culmination point of the Sun: different height during the year but same direction. The cardinal direction South. The other cardinal points are defined from the South. 3. The culmination point divides daylight time in two halves: midday. 4. The shortest shadow identifies N-S direction and midday: solar clocks. 5. Rising and setting points are opposite with respect to the North-South line. Since also the culmination point varies day by day the Sun's path changes in length during the year (the Sun's path has to pass through all these three points). 6. Apparent speed of the Sun is almost constant so paths of different lengths are covered in different amounts of time: we have different daylight time during the year (seasons). 7. Culmination height, daylight duration and insolation: causes of the seasons (geocentric reference system).	Different Sun's paths for different days (in particular for solstices), identifying rising and setting point for each path Correspondence between culmination point and cardinal direction South . (with **planetarium**) Mark cardinal direction South and other cardinal direction Local meridian as the "midday line" and as a reference line. Show local meridian. 
1. The motion of the stars: the stars move all together, with no noticeable motion with respect to one another: we see the whole sphere rotating with everything in it, *just as we rotated the bottle globe.* **QUESTION 5: Which other celestial body does the same motion?** **ANSWER 5: the Sun: it rises in the eastern horizon, culminates towards the South, sets in the western horizon** 2. The motion of the stars is like the Sun's one both spatially (rise in the eastern horizon, culmination toward South, set in the western horizon) and temporally (it takes about 24 hours): **QUESTION 6: Why do different objects make the same movement?** **ANSWER 6: Because it's not them who rotate, it's us, so that we see our motion, not theirs.** 3. Earth's rotation: we see Earth moving, not stars or Sun (merry-go-round analogy: relativity of motion). **Apparent diurnal motion = Earth's rotation** 4. Apparent diurnal motion is not a definitive proof of Earth's rotation but it is a strong hint: we need other proofs.	(with **planetarium**) Sunset Daily motion of stars at noticeable rate (more than one turn) (with *pointer*) Point one star and follow its trail
QUESTION 7: Which is the only fixed point (or line) in Earth's rotational motion? **ANSWER 7: It's the axis of rotation** 1. We are able to identify throughout the stars the axis of rotation: circumpolar stars toward the northern horizon. 2. Polaris is "almost fixed". Celestial North Pole. Importance of Polaris as a benchmark of CNP (unlike CSP)	(with **planetarium**) Daily motion of stars at noticeable rate (more than one turn) (with *pointer*) Circumpolar stars and their closed trails Smaller circles for stars nearer Polaris

3. Topic **THREE**: **figures in the sky and constellations.**

What to say	What to show
1. It is not easy to navigate the sky (e.g. to find a precise star) without any reference point: we have to find a simple method to rapidly find given stars and objects. 2. We observe that stars do not have any detectable (for a brief amount of time) motion with respect to one another, so we use stars to "draw" figures in the sky and more easily remember their reciprocal position.	(with *pointer*) Draw lines for one constellation (with **planetarium**) Show line for one figure (e.g. Ursa Maior)  Show all IAU constellation (both boundaries and common figures) 
1. There are no actual lines in the sky: it is possible to draw different figures with the same stars. 2. Asterisms are typical of each culture.	(with planetarium) Show different figures for one asterism
1. Constellations are used to identify precise areas in the sky. 2. IAU selected 88 constellations to cover all the celestial sphere and to be used without ambiguities in international context. 3. Each constellation defines an area of the celestial sphere: IAU officialized *boundaries* of the constellations, not lines or figures, hence called "asterisms"	(with planetarium) Show boundaries of IAU constellations
1. Main constellation of the current season	(with planetarium and pointer) Various constellations and their figures, their mythology

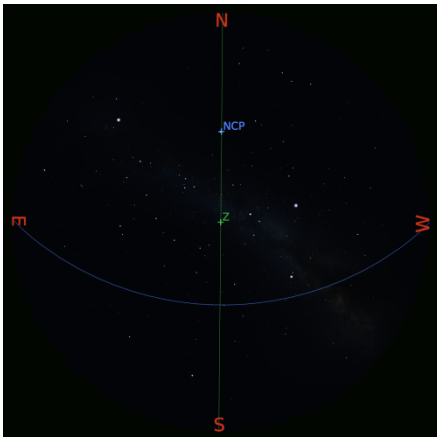
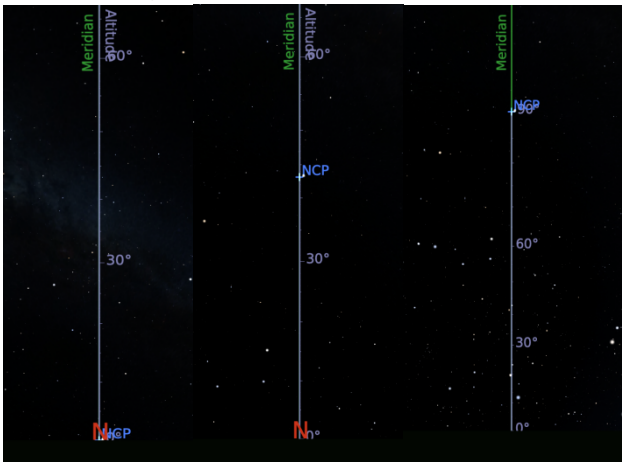
4. Topic **FOUR**: **apparent annual motion** of the Sun: revolution of the Earth

1. What to say	What to show
1. We observe that in each month we see different constellations setting immediately after the Sun in the same point of the horizon. 2. We reconstruct, via star maps, the starred background of the Sun: **we see that the Sun moves with respect to the "fixed" stars.** 3. Relationship between visibilities of Sun and stars: why we do not see stars by day. Atmospheric scattering. Sun and stars both move on the celestial sphere. Only in a planetarium can we see the Sun and stars at the same time.	(with **planetarium**) Show diurnal motion with Sun and stars at the same time. Stop (or maintain) Sun at the sunset and show how starred background changes during time  (if possible: show first the alternating and daylight and darkness with the Sun, then remove the atmospheric scattering and show Sun and stars at the same time)

	(with **planetarium**) Show daily motion at a noticeable rate with Sun and stars at the same time
1. Sun always remains on a line wrt to fixed stars: the ecliptic. The Sun returns on the same starred background after a certain amount of time: the sidereal year. After a sidereal year, we are in the same position with respect to the Sun and stars: Earth has completed an orbit around the Sun. **Apparent annual motion = Earth's revolution.** 2. The ecliptic is the intersection between the celestial sphere and the ecliptic plane. 3. Direct annual motion: from West to East. Reverse annual motion: from East to West	(with **planetarium**) Show the ecliptic and the apparent annual motion (one year turn) 
1. We follow the annual motion of the Sun by the constellations crossed by the ecliptic (which are thirteen): the zodiacal constellations.	(with **planetarium**) Show the zodiacal constellations figures along the ecliptic
1. Earth's motions are not separate: they occur at the same time 2. Culmination height, daylight duration and insolation as a function of the Sun's position along the ecliptic: the seasons (geocentric perspective)	(with **planetarium**) Show the ecliptic. Put the Sun in a precise point of the ecliptic and show daily motion (focusing on rising, culmination, setting point for that given day) with both ecliptic and Sun's path. Move the Sun in a different point of the ecliptic and repeat to see the difference. 

5. Topic **FIVE**: how to position and navigate on Earth looking at the sky: **the observer position**

What to say	What to show

1. We can put each point of the Earth' surface in univocal correspondence with points on the celestial sphere: we can navigate on Earth by looking at the sky. 2. We project reference points and lines on Earth of the geographical grid on the celestial sphere: **QUESTION 8: Where are the *position of the observer, NP, meridian and Equator* projected in the celestial sphere?** **ANSWER 8: *as below*** a. Position of the observer = zenith b. North Pole = celestial North Pole c. Main meridian = local meridian d. Equator = celestial Equator	(with **planetarium**) Show CNP, celestial Equator, local meridian, zenith 
QUESTION 9: Can latitude be read on the celestial sphere (without reference circles?) **ANSWER 9: Not directly: we need to find a proxy for it** 1. Latitude can be directly seen on the celestial sphere: it equals the height of Polaris (in the northern hemisphere) because both angles are complementary to the same angle (angle between Polaris and zenith, called co-latitude).	(with *pointer*) Show latitude as the angular distance between celestial Equator and zenith Show colatitude as angle btw zenith and CNP Show latitude as height of Polaris
1. Traveling south we see new stars (never seen before) appear on the southern horizon, all having apparent diurnal motion: traveling north we see visible stars disappear. 2. Height of Polaris increases traveling north and diminishes traveling south: at the Equator Polaris is laid on the horizon, and it is not visible in the southern hemisphere. At the north Pole Polaris coincides with zenith.	(with *pointer*) Show Polaris positions at different latitudes Show stars with higher southern declinations appear and disappear on the dome Show some figures in southern constellations  (with planetarium) Show sky at different latitudes, first towards Equator, then towards North Pole
1. The star trails inclinations (i.e. the angle they form with the horizon at the star rise) changes with latitude. 2. Sun's path changes inclination with latitude too, but it also changes in length, as previously described, at each latitude 3. We thus see that through stars we can always find our position on Earth and, guided by stars, be certain to come back home (closing sentence).	(with **planetarium**) Show startrails at - local latitude; - Equator - North Pole Show Sun's path at the NP for December and June

	Go back to local latitude

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