

DAYLIGHT AND ARTIFICIAL LIGHTING STRATEGIES FOR A NICU REMODEL

Graduate Students:
Rachel Browne, Elham Masoomkhah,
Nada Maani & Karina Adams

Professors:
Sergio Paleroni & Huafen Hu
Advisor: Benjamin Deines

PORTLAND STATE UNIVERSITY
SCHOOL OF ARCHITECTURE

Firm Partners:
Mark Elliott, SRG Partnership, Inc.
Zach Suchara, Luma Lighting Design

RESEARCH OVERVIEW

SRG is proposing an NICU (Neonatal Intensive Care Unit) remodel for a major healthcare provider here in the Portland metro area. This is an intensive care unit for babies born prematurely and up to 6 months of age. The space is in an existing hospital and has previously been used as an NICU. However, it is currently being used as overflow office space and is now under consideration for being remodelled and re-commissioned as an NICU. The healthcare provider who owns the hospital has recently realized that this could be a value-added service for their business model.

Our research project focussed on two factors that affect the design of the NICU project. First, we researched any possible day-lighting strategies for the space along with any supplemental electric lighting as required. Second, we have researched circadian day/night cycle lighting for the spaces serving the infant patients, their families, and the hospital staff.

Unlike pediatric and adult patient care rooms which do require exterior windows for daylight and views, NICU rooms do not have the same requirement. Currently, there are no specific applicable codes requiring natural daylight within the NICU patient rooms other than a general reference of "access to natural light". However, in the last few years, codes have changed to recommend natural light as a way of speeding up recovery and creating a more inviting space for visitors as well as patients. We have been challenged to find out whether adding natural daylight will, in fact, help premature and young infants, or is darkness is actually preferable.

The existing NICU unit, has little available natural light to patient care areas and no natural light to staff work areas. Of the 15 existing NICU patient rooms only six have exterior windows.

METHODOLOGY

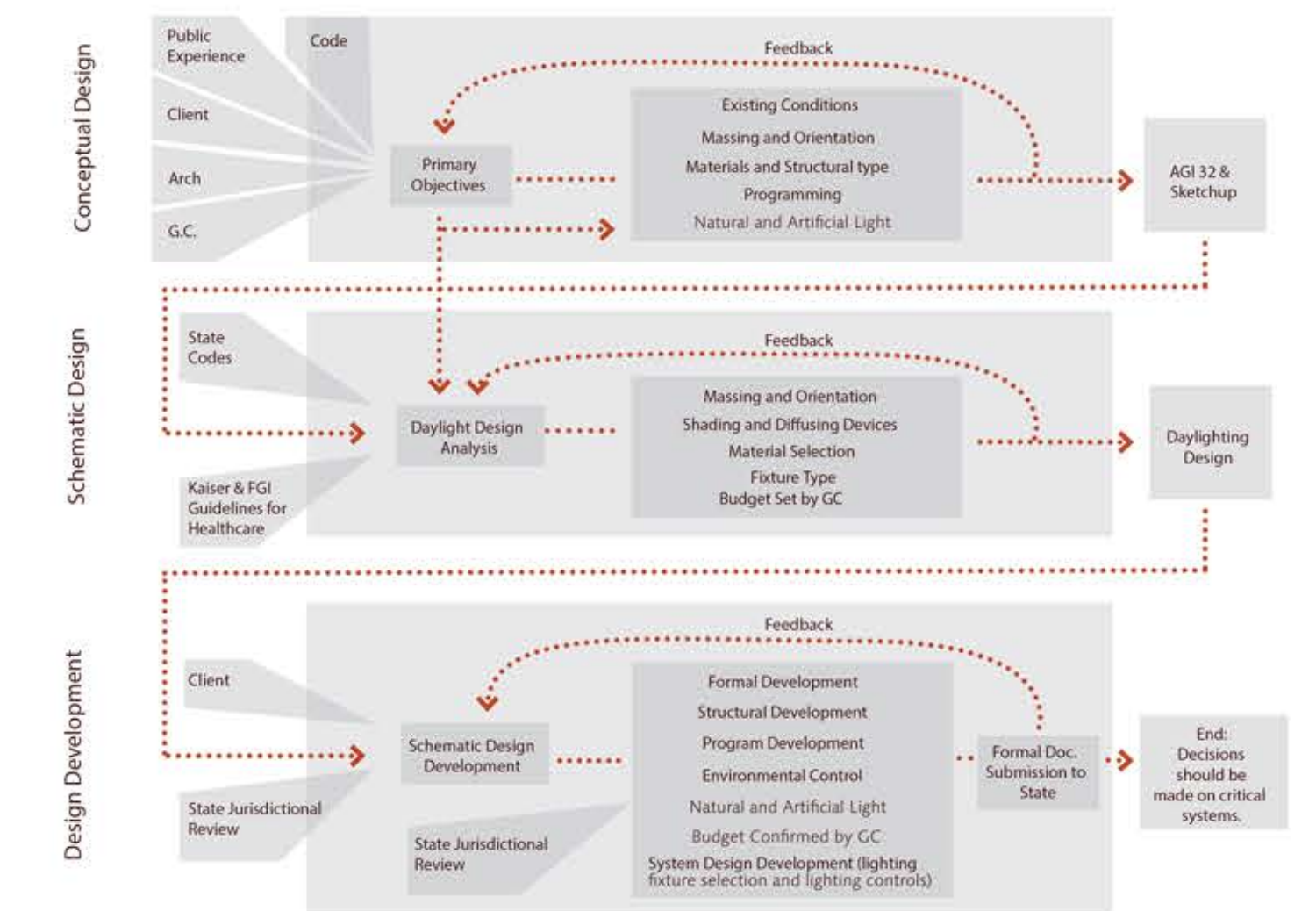
To address existing conditions, we propose the following three goals:

- The first is understanding what results natural day-lighting can have on the NICU patients' recovery and outcomes, the family members' experiences, and satisfaction/productivity of the staff.
- The second is to research any current NICU analyses and case studies by recognized experts, including any industry guidelines that might be applicable.
- The third is to research and develop available lighting systems and technologies that address daylighting needs and Circadian cycles, applicable to this specific project. We will be collaborating with Luma Design (lighting designer for the project).

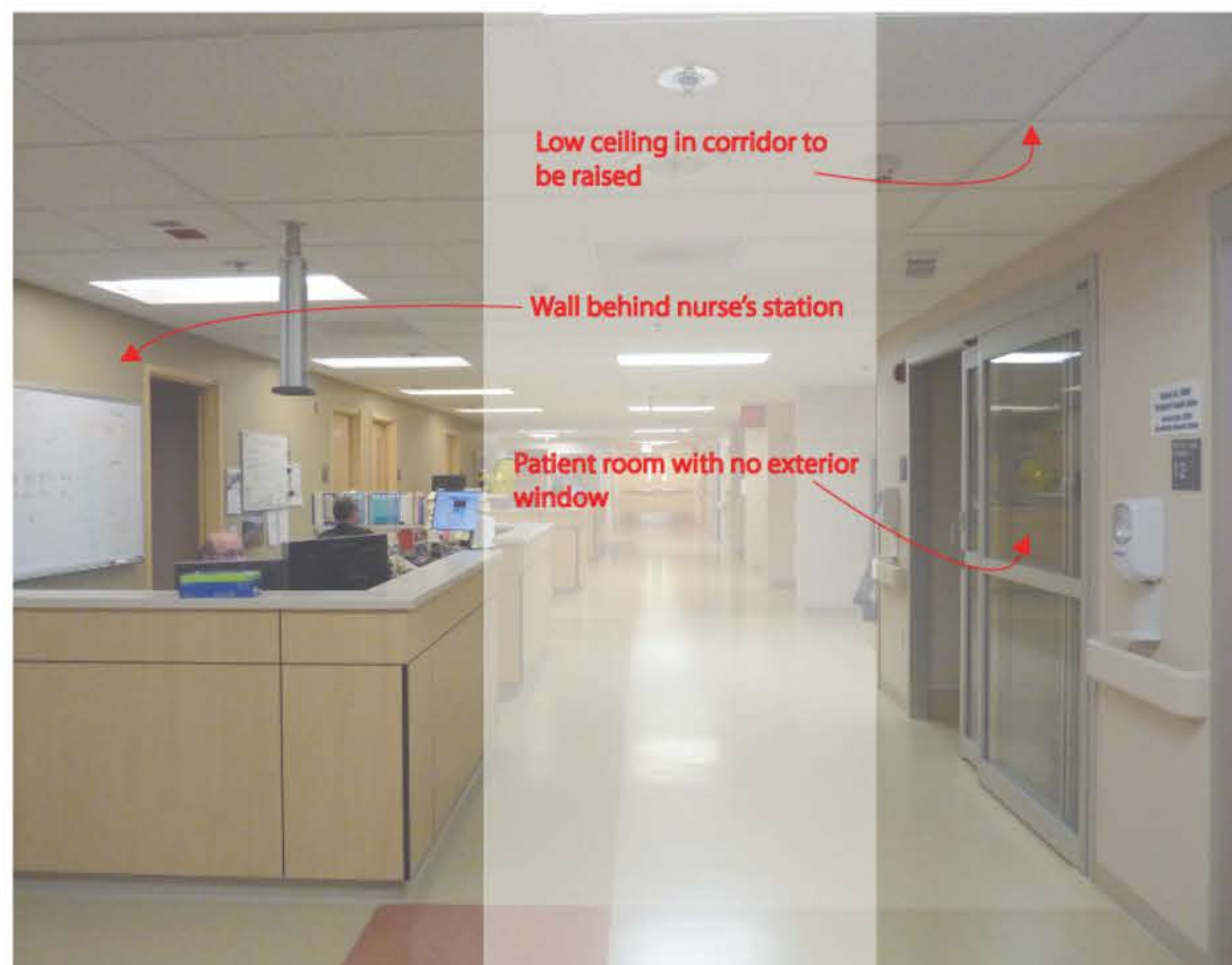
EQUIPMENT REQUIRED

AGi32 - Lighting Simulation Software
Google Sketchup

METHODOLOGY DIAGRAM:



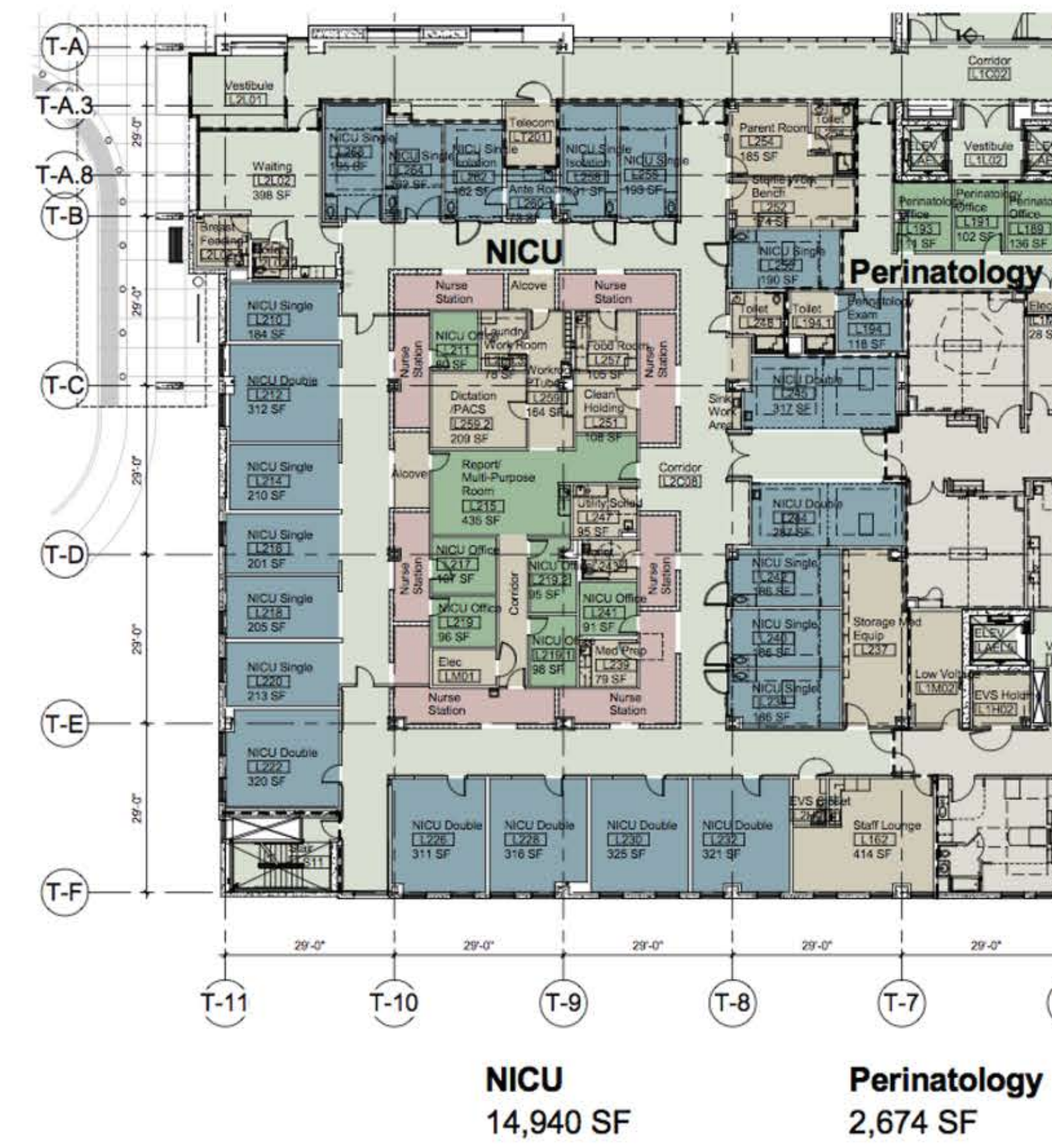
EXISTING CONDITIONS:



PROPOSED PATIENT ROOM:



EXISTING FLOORPLAN :



SRG PROPOSED FLOORPLAN:



ADULT EYES/CIRCADIAN RHYTHM

When humans are indoors for long periods of time and without access to the sunlight of the outside world, we start to suffer. This is because our bodies are in-tune to sunlight in a cycle called the circadian rhythm. Our body (particularly eyes) are clued into the sun (or lack of sun) and creates Melatonin which triggers various biological processes based on what time of day it is (morning, afternoon, evening, or night). One of the more obvious and easily felt processes that gets disrupted if we are not following the 24 hours cycle of the sun is our sleep. Jet-lag is a common example of how our sleep gets disrupted when we tamper with the cycle our body is used to. Research is starting to tell us that not only is sleep disrupted, but that we are also putting stress on other body processes and thus setting us up for diseases such as Seasonal Affective Disorder (SAD), Diabetes, Hypertension, Obesity, and Cancer. The following is an example of a study on breast cancer and Melatonin release:

"Life in industrialized societies is primarily life inside buildings. Illumination from electric lighting in the built environment is quite different from solar radiation in intensity, spectral content, and timing during the 24 hour daily period. Humans evolved over millions of years with the day-night pattern of solar radiation as the primary circadian cue. This pattern maintained a 24-hour rhythm of melatonin release, as well as a host of other physiological rhythms including the sleep-wake cycle. Electric lighting in the built environment is generally more than sufficient for visual performance, but may be inappropriate for the maintenance of normal neuroendocrine rhythms in humans; e.g., insufficient during the day and too much at night. Lighting standards and engineering stress visual performance, whereas circadian function is not currently emphasized. The molecular biological research on the circadian clock and on mechanisms of phototransduction makes it clear that light for vision and light for circadian function are not identical systems. In particular, if electric lighting as currently employed contributes to 'circadian disruption' it may be an important cause of 'endocrine disruption' and thereby contribute to a high risk of breast cancer in industrialized societies" Richard G. Stevens, Mark S. Rea, *Cancer Causes & Control*, Vol. 12, No. 3 (Apr, 2001), pp. 279-287

Because of the findings and ongoing proof that humans need direct access to sunlight, it comes to reason that we need to design our hospitals so that the workers, patients, and their visitors have adequate access to sunlight at the appropriate times of day. In our project we are looking at an existing NICU (Neonatal Intensive Care Unit) hospital facility in the Pacific Northwest that has several patient rooms without windows and practically no window access to the the nursing staff areas. We are proposing adding solar fiber-optics to these various spaces that are lacking window access. We would also be providing electrical lighting that will be timed based on the circadian rhythm cycle.

BABY'S EYES/CIRCADIAN RHYTHMS

As with any human intervention, good intentions sometimes create new issues. Because we are actually dealing with spaces that are for the preterm infant, we need to delve further into the physiology of this age group. So the question is - how would daylight effect a prematurely born baby? We have found from several interviews and readings the following:

"The eye develops in near total darkness - requires it. Further, the immature eye of even 36-or-so week infants has an underdeveloped ability to accommodate to light. An analogy for our appreciation would be one of us being made to walk outside on a bright day with no sunglasses with our eyes dilated.A reasonable rule of thumb when designing a space that has to work for many infants is to make near darkness possible for the infant at any time with an ability to add light of variable levels for observation and care. It is easy to add light but difficult to take it away." M. Kathleen Philbin, RN, PhD

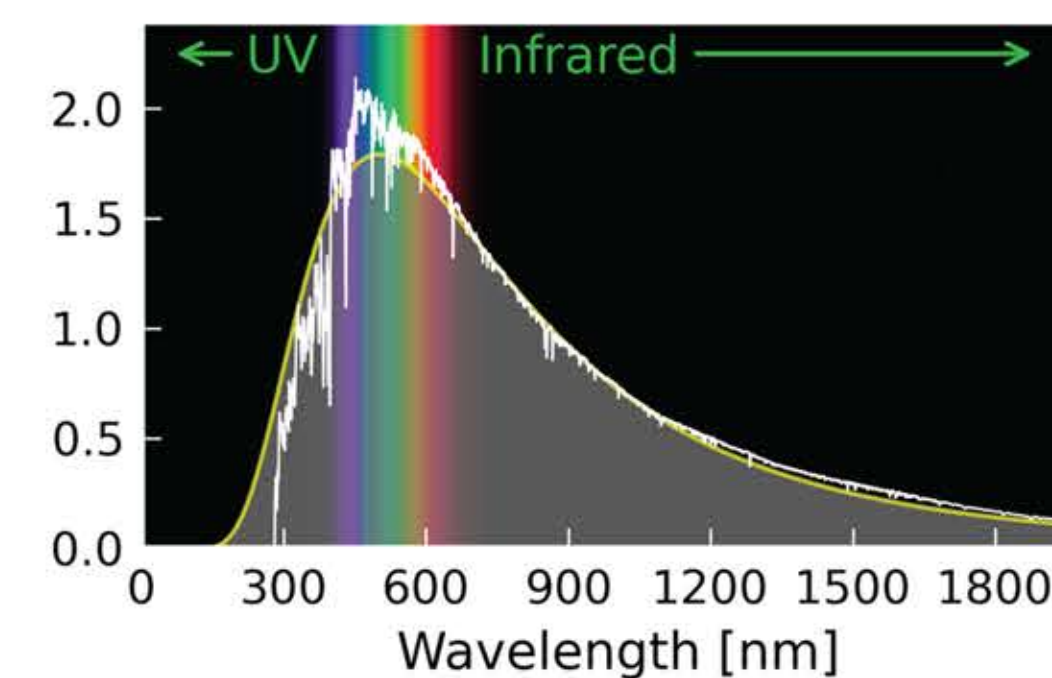
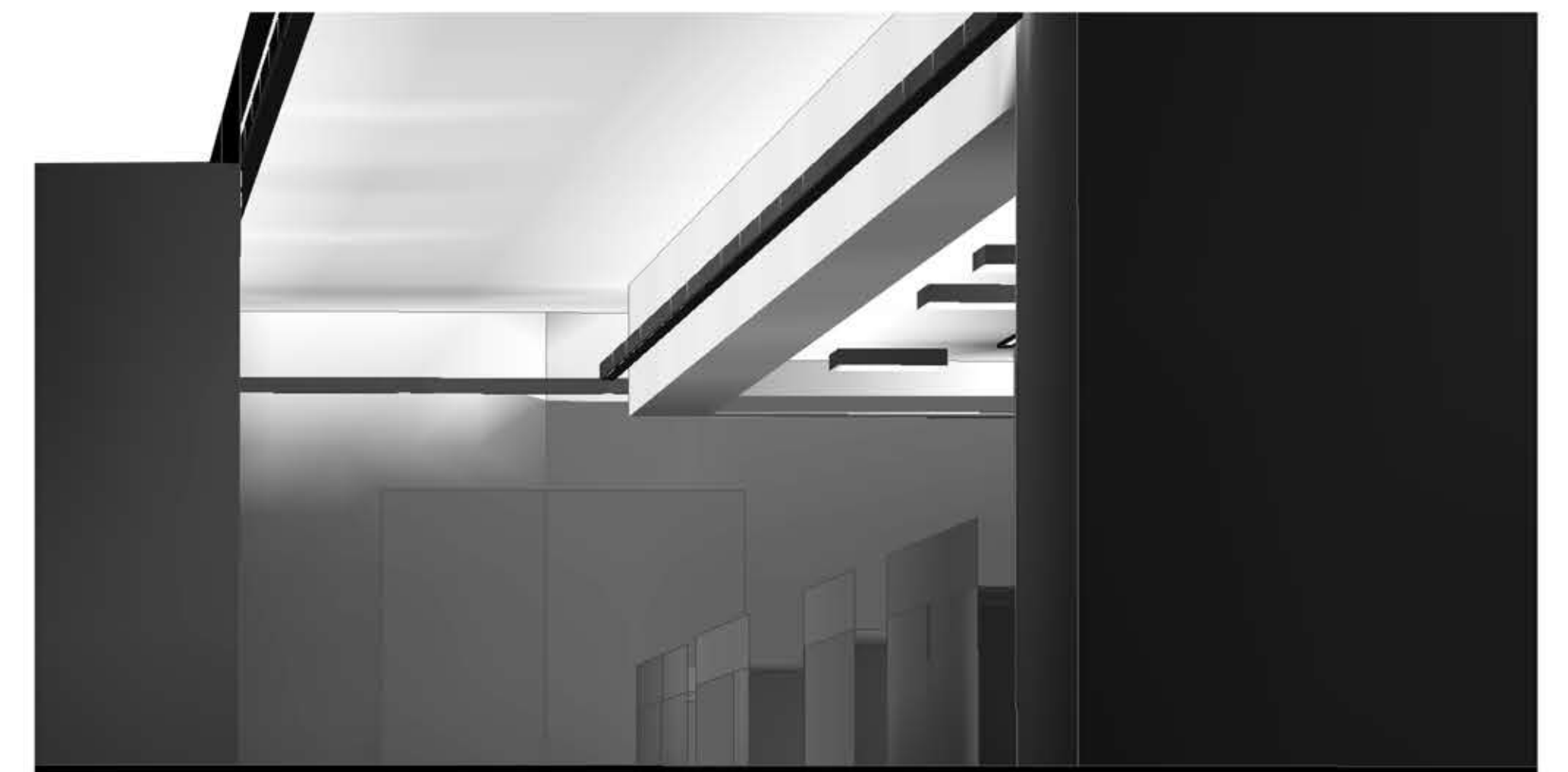
"...Circadian rhythms are present in the womb and affected by the maternal melatonin but outside the womb the brain can established them not before 3 months of age and for preterms it means corrected age. This is a validated confirmation to Heidi's recommendation on dimming of lighting in NICUs rather than establishing circadian rhythms of lighting before the brain is ready to collect the environmental input." Dr. Sari Goldstein

We must be very careful when introducing the sunlight to the patient rooms in our project. We, therefore, are only placing any new solar fiber-optic units over the area where the parent/visitor would sleep and not directly over the baby's bed. It is now the practice in NICU's that the baby's beds are covered with a thick blanket, which should be expected in this facility as well. Thus, we minimize the impact on the baby's eyes, and help with the visitor and hospital worker:

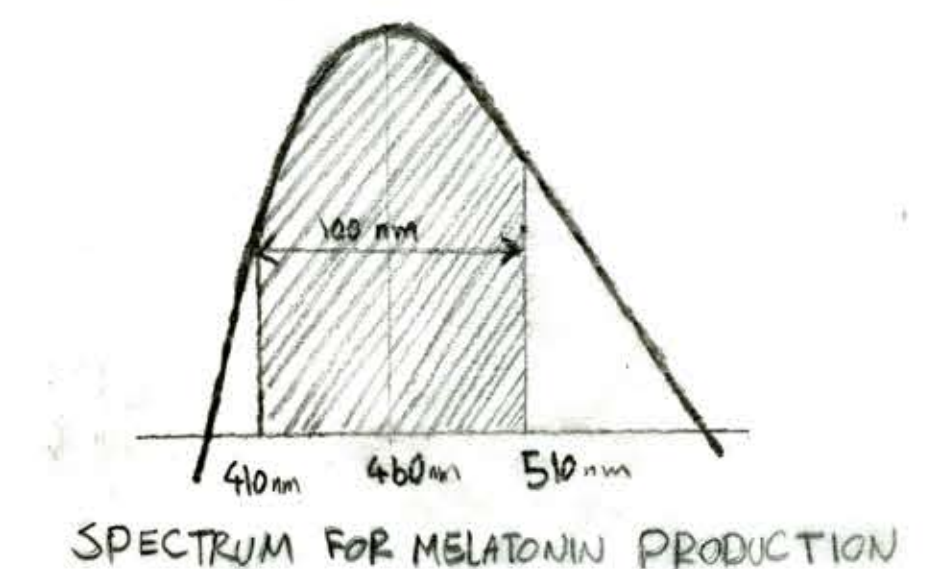
References:

- Bartholomew, Edward, *Integrated Lighting Analysis* - UMI Art and Architecture Miller Hull Ann Arbor; MI University of Washington Department of Architecture - Seattle, Integrated Design Lab, 2008.
- DiLaura, David and others, *The Lighting Handbook* (10th Edition, New York, Illuminating Engineering Society, 2011).
- Foley, Maximilian, *Daylighting Analysis* - UMI Art and Architecture Miller Hull Ann Arbor; MI University of Washington Department of Architecture - Seattle, Integrated Design Lab, 2007.
- Goldstein, Dr. Sari, "Re: Help on Lighting for NICU Project" NIDCAP (Newborn Individualized Developmental Care and Assessment Program) Federation International Google Group and Email to K.Adams, November 25, 2013
- Guenther, Robin and Gail Vittori, *Sustainable Healthcare Architecture*, New Jersey, John Wiley & Sons, Inc., 2013
- "Heschong Mahone Group, Inc. - Daylighting and Productivity," Heschong Mahone Group, Inc. - Daylighting and Productivity, N.p., n.d. Web 09 Oct. 2013.
- IES Guidelines for Upgrading Lighting Systems in Commercial and Institutional Spaces IES LEM-3-13, Illuminating Engineering Society
- "LBNL Lighting Research Group," LBNL Lighting Research Group, N.p., n.d. Web 09 Oct. 2013.
- Lighting Controls for Energy Management IES LEM-7-13, New York, Illuminating Engineering Society
- Recommended Practices for Daylighting Buildings IES RP-5-13, New York, Illuminating Engineering Society
- Pechacek, Christopher S., Marilyn Anderson, PhD and Steven W. Lockley, PhD, *Prospective Evaluation of the Circadian Efficacy of (Day)Light in Rooms*, US Airforce, MIT and Harvard, MA.
- *Perinatol*, 33:51, April 2013 doi:10.1038/jp.2013.9
- "Pen-Pixel Lighting Data Analysis," Ernest Orlando Lawrence Berkeley National Laboratory - Environmental Energy Technologies Division - Department of Building Technologies - Lighting Research Group Berkeley, 2005.
- Philbin RN, PhD , M. Kathleen, "Re: Help on Lighting for NICU Project" NIDCAP (Newborn Individualized Developmental Care and Assessment Program) Federation International Google Group and Email to K.Adams, November 25, 2013
- "Special Notices," Lighting Research Center, N.p., n.d. Web 09 Oct. 2013.
- Stevens, Richard G. and Mark S. Rea, *Cancer Causes & Control*, Vol. 12, No. 3 (Apr, 2001), pp. 279-287
- White, RD, "Chair and The Committee to Establish Recommended Standards for Newborn ICU Design," Report of the eighth consensus conference on Newborn ICU Design.

AGI32 RENDERINGS:



SUNLIGHT SPECTRUM

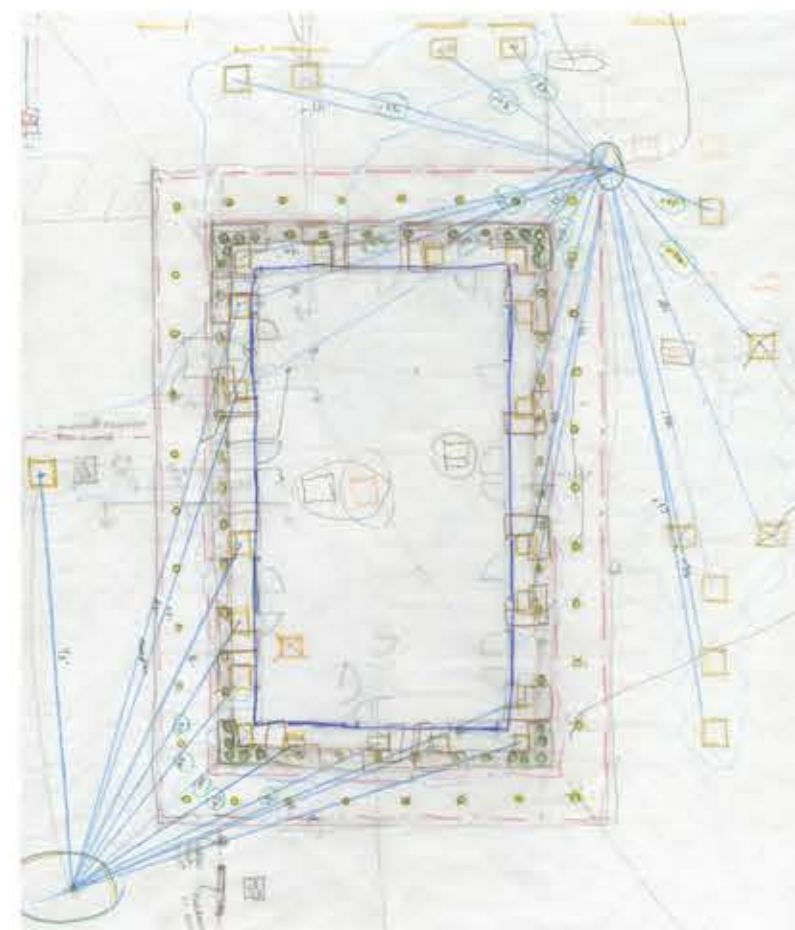
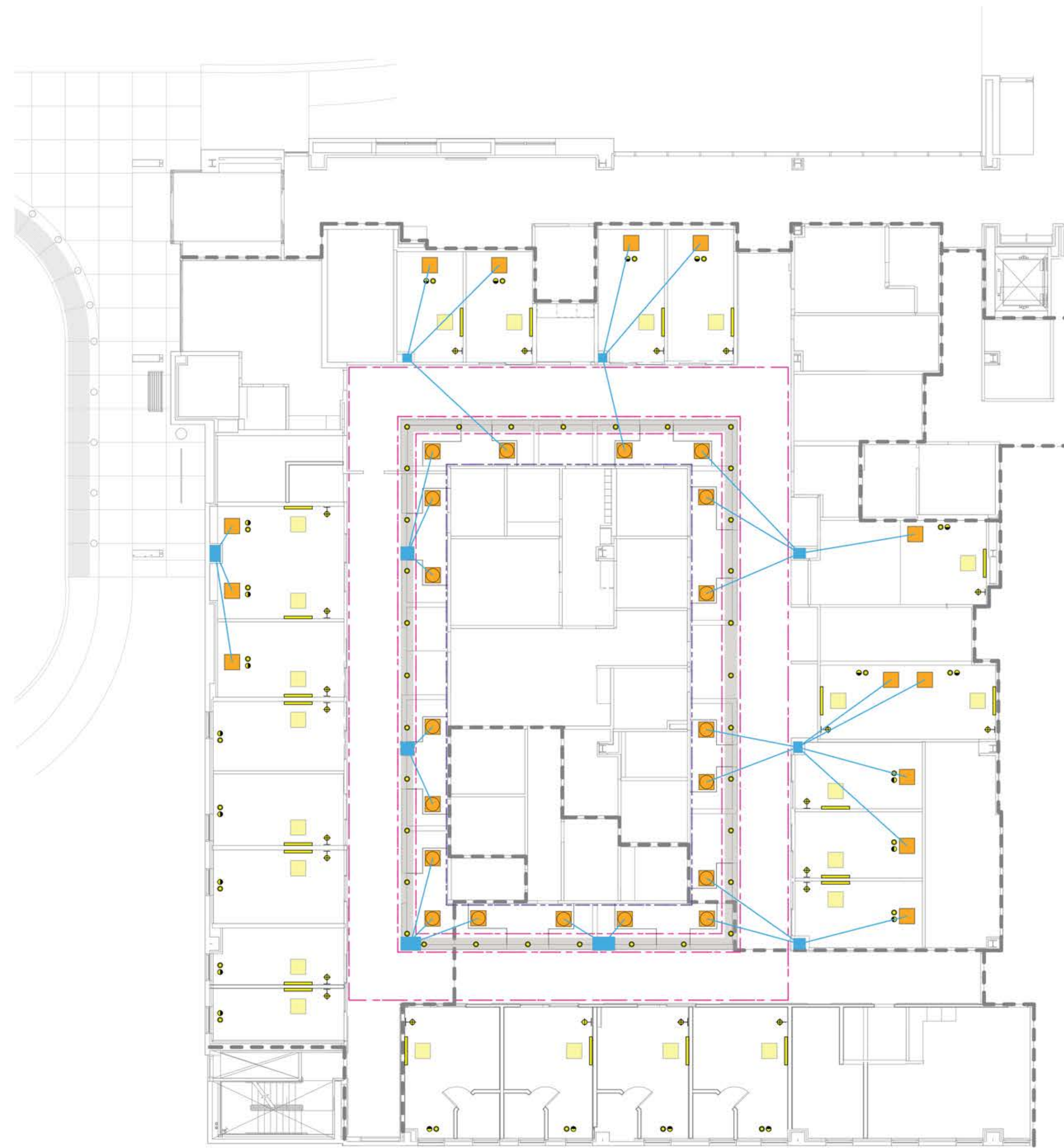


SPECTRUM FOR MELATONIN PRODUCTION

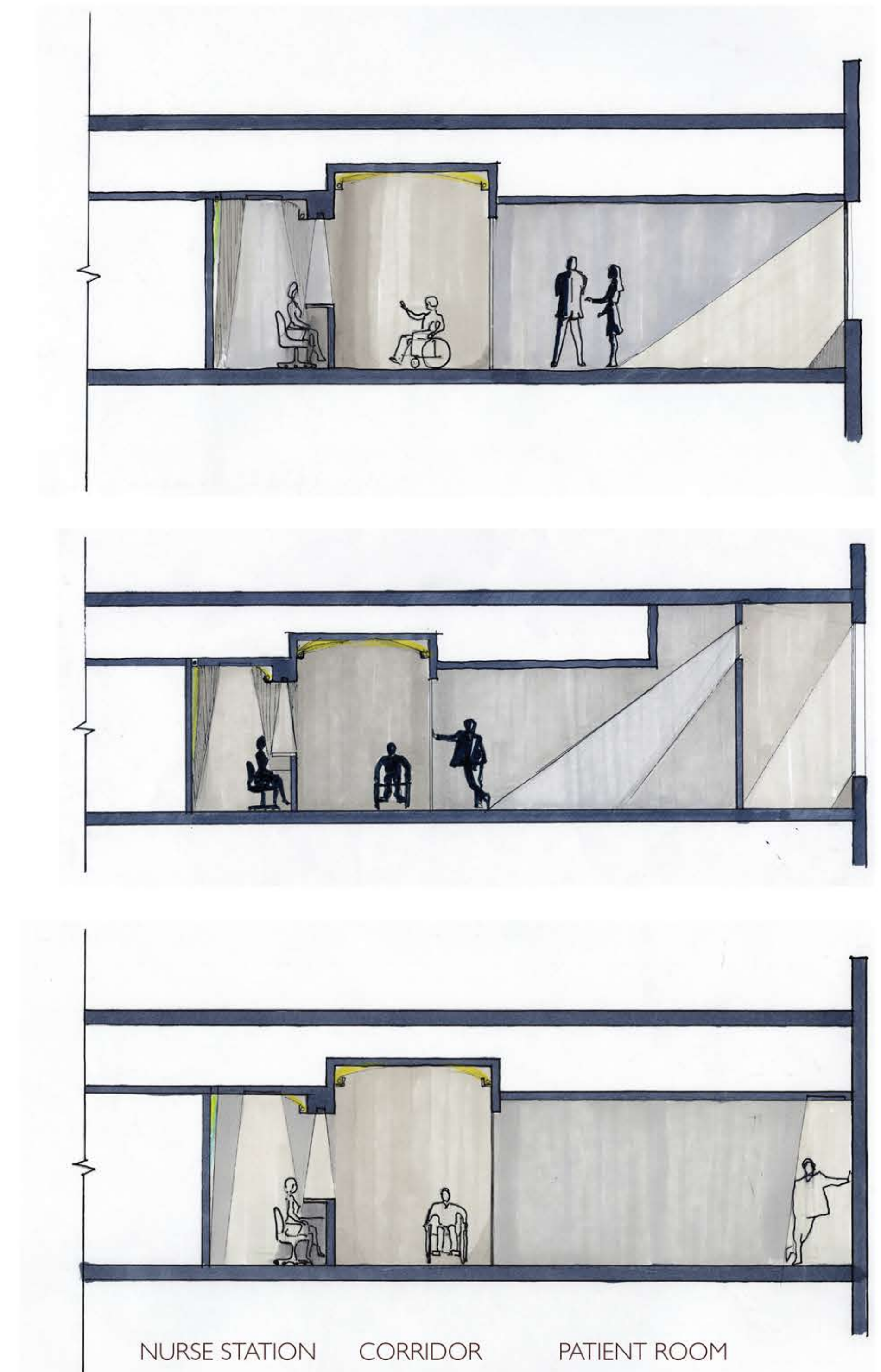
DESIGN DECISIONS:

The major lighting design changes based on our research are as follows:

- In order to help differentiate between circulation and the nurse's stations, we propose that the ceilings be raised at the circulation. We will introduce LED cove lighting to these "corridors" that will be programmed to the human circadian cycle.
- We will introduce the solar fiber-optic fixtures at the nurse's stations that have LED lighting which can be turned on as needed for additional lighting.
- At the nurse's stations we will also provide a cove light and wall wash light on the back wall - both of which will be programmed to the circadian cycle.
- At patient rooms without any windows, we will introduce solar fiber-optic fixtures over the visitor sleeping/waiting area.
- At patient rooms on the north side of the space, we have chosen to pop-up the ceiling at the ends of the rooms and add clerestory windows that can take advantage of the well day-lit hallway to the North.
- In the original design charrette (see 3rd board sketch), you will note that we were planning on running all of the solar fiber-optics to two main shafts. However, if we were to do that, many of the fiber-optics cables would have to reach over 90 ft. At 90 ft we are only gaining 200 lumens, so we decided that we had to come up with a way for shorter cable runs. We decided to bring the cables up by multiple columns. The structural/cost impact would be minimal since the cables are not very large.



- LEGEND
- NEW CLERESTORY WINDOW IN PATIENT ROOMS
 - 2X2 SOLAR FIBER-OPTIC FIXTURE
 - 2X2 SOLAR FIBER-OPTIC FIXTURE WITH LED
 - CHASE FOR FIBER-OPTIC CABLES
 - - - LED COVE LIGHTING WITH PROGRAMMABLE DIMMABLE CIRCADIAN LIGHTING*
 - - - LED WALL WASH LIGHTING WITH PROGRAMMABLE DIMMABLE CIRCADIAN LIGHTING*
 - LED RECESSED DIMMABLE CAN LIGHT FIXTURE
 - LED INDIRECT LINEAR LIGHT FIXTURE AT PATIENT HEADWALL
 - ⊙ TASK LIGHT AT SINK AREA
 - ⊙ DOWNLIGHT AND TASK LIGHT AT VISITOR AREA
 - EXAM LIGHT
- * WARM AND COOL WHITE LED'S THAT ARE MIXED TO COLOR TEMPERATURE OF SUN AT THE CORRESPONDING TIME OF DAY



The Parans L1 Luminaire spreads part of the light and creates a square light beam, resembling the light falling through a window.



The Parans L2 Hybrid luminaire combining sunlight and LED light.