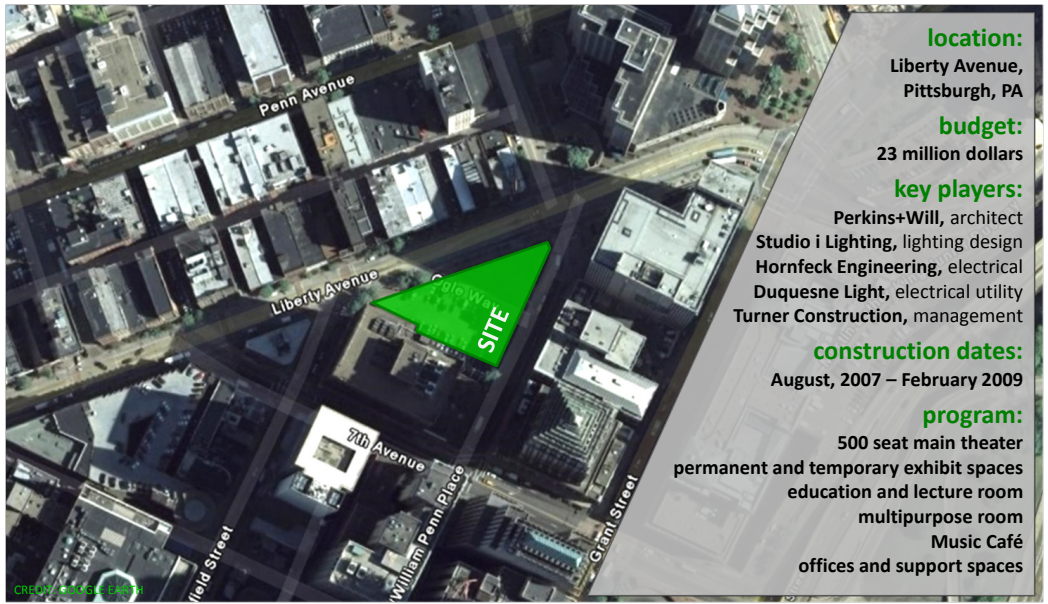
the august wilson center for african american culture

MICHAEL P. ROYER

LIGHTING AND ELECTRICAL | AE SENIOR THESIS | APRIL 15, 2008 | ADVISORS DR. RICHARD MISTRICK + TED DANNERTH

PROJECT OVERVIEW

true north ⇧



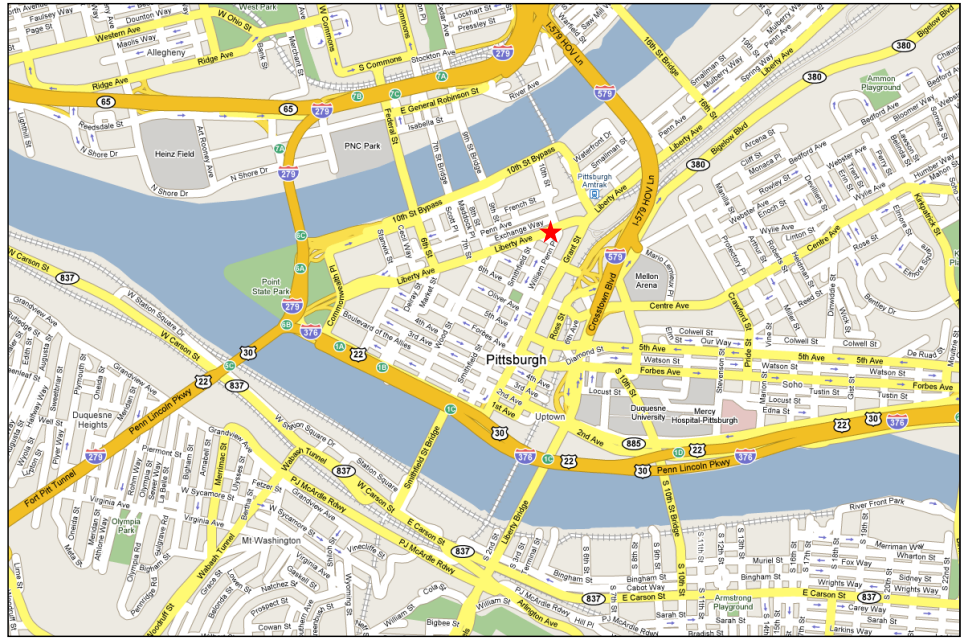
location:
Liberty Avenue, Pittsburgh, PA

budget:
23 million dollars

key players:
Perkins+Will, architect
Studio i Lighting, lighting design
Hornfeck Engineering, electrical
Duquesne Light, electrical utility
Turner Construction, management

construction dates:
August, 2007 – February 2009

program:
500 seat main theater
permanent and temporary exhibit spaces
education and lecture room
multipurpose room
Music Café
offices and support spaces



CREDIT: GOOGLE MAPS

PROJECT SITE

LIBERTY AVENUE STREETSCAPE

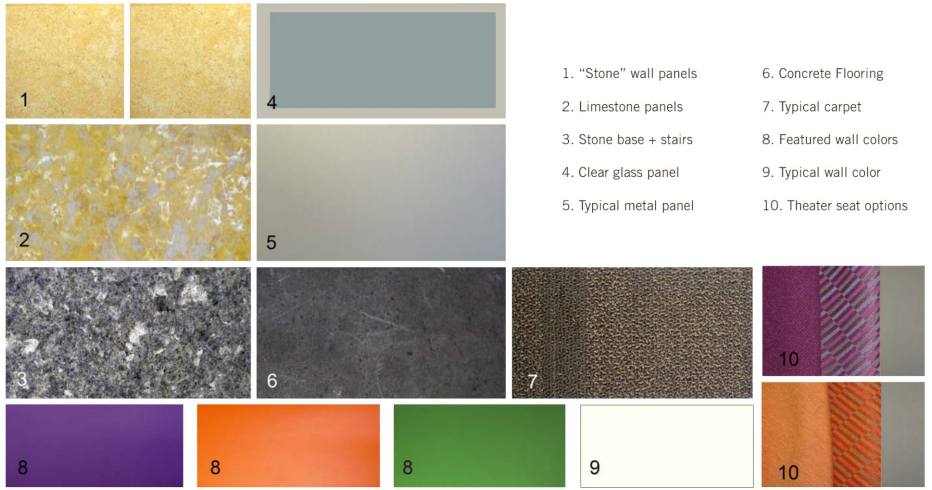
ADJACENT BUILDINGS

WILLIAM PENN PLACE

ARCHITECT'S VISION

"…a conceptually transparent, flexible container in which the accomplishments and artifacts, the activities and traditions of this culture can be proudly celebrated layered and displayed…. It is timeless, flexible and powerful in its simplicity."

Perkins+Will



1. "Stone" wall panels
2. Limestone panels
3. Stone base + stairs
4. Clear glass panel
5. Typical metal panel
6. Concrete Flooring
7. Typical carpet
8. Featured wall colors
9. Typical wall color
10. Theater seat options

CREDIT: PERKINS+WILL

BUILDING MATERIALS

SCOPE OF WORK

lighting : redesign of the Liberty Avenue façade, main lobby, education and lecture room, and meeting room

electrical : redesign of four lighting spaces, photovoltaic array analysis, voltage conversion analysis

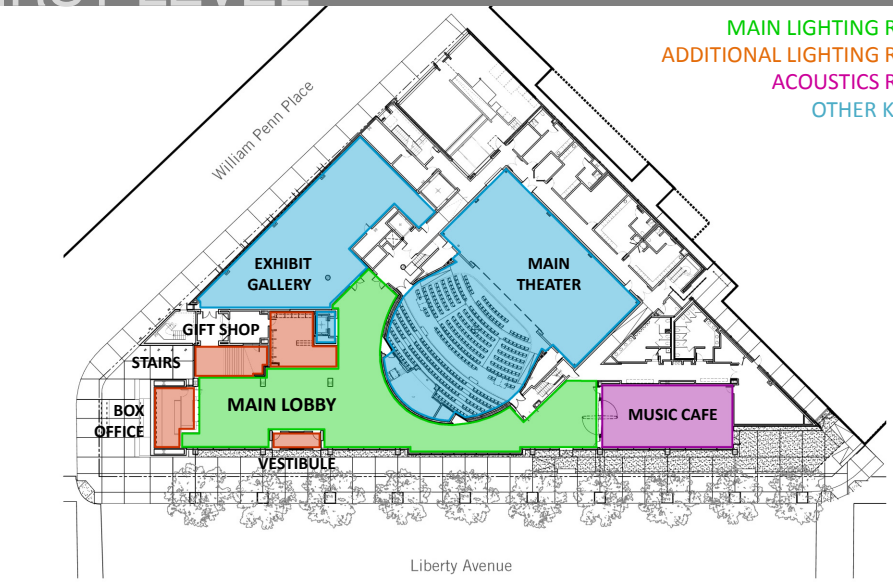
architecture : analysis and design of a roof terrace

acoustics : analysis and redesign of the Music Café and multipurpose room

CREDIT: PERKINS+WILL

FIRST LEVEL

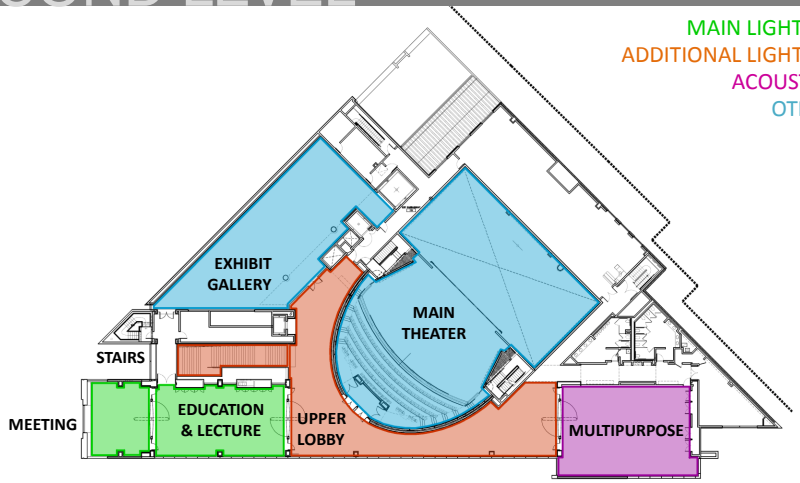
MAIN LIGHTING REDESIGN
ADDITIONAL LIGHTING REDESIGN
ACOUSTICS REDESIGN
OTHER KEY SPACE



CREDIT: PERKINS+WILL

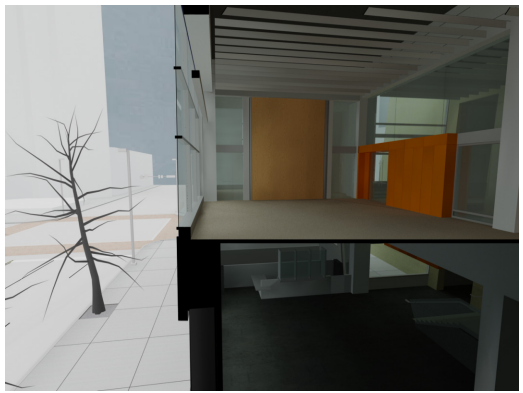
SECOND LEVEL

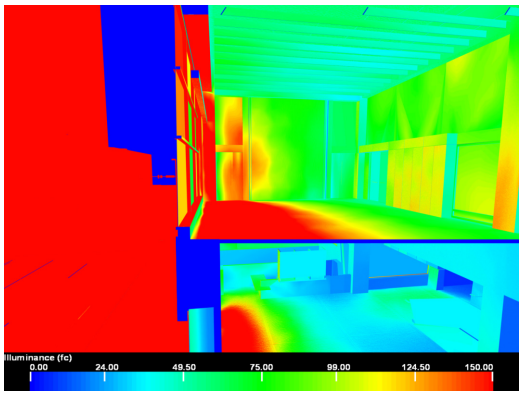
MAIN LIGHTING REDESIGN
ADDITIONAL LIGHTING REDESIGN
ACOUSTICS REDESIGN
OTHER KEY SPACE



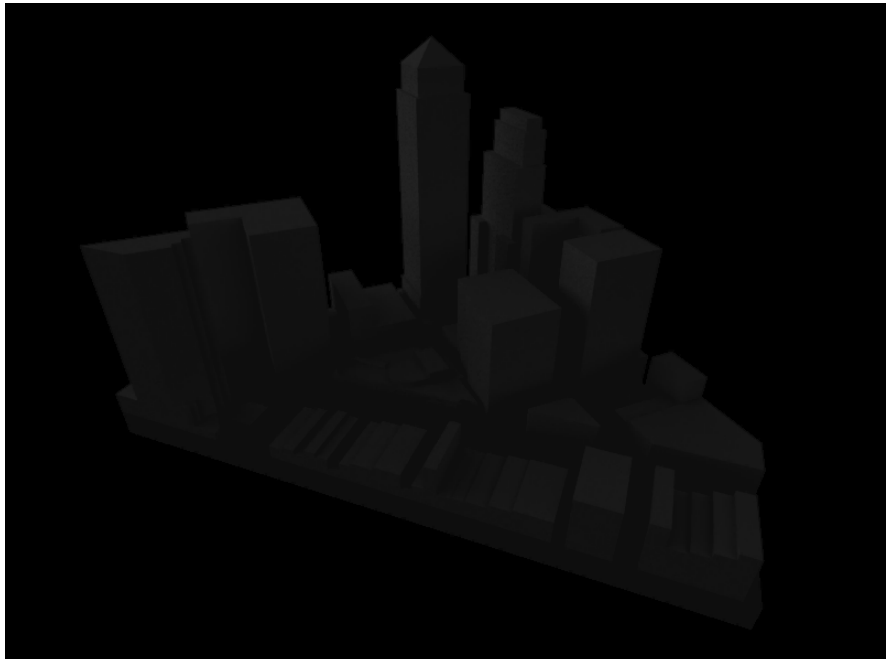
CREDIT: PERKINS+WILL

DAYLIGHT ANALYSIS





CONDITIONS: MIDDAY, MARCH 21, OVERCAST SKY



CONDITIONS: MARCH 21, CLEAR SKY

ARCHITECTURE

ROOF TERRACE DESIGN

design intent & concepts: create an alternative venue for gatherings, speakers, exhibits

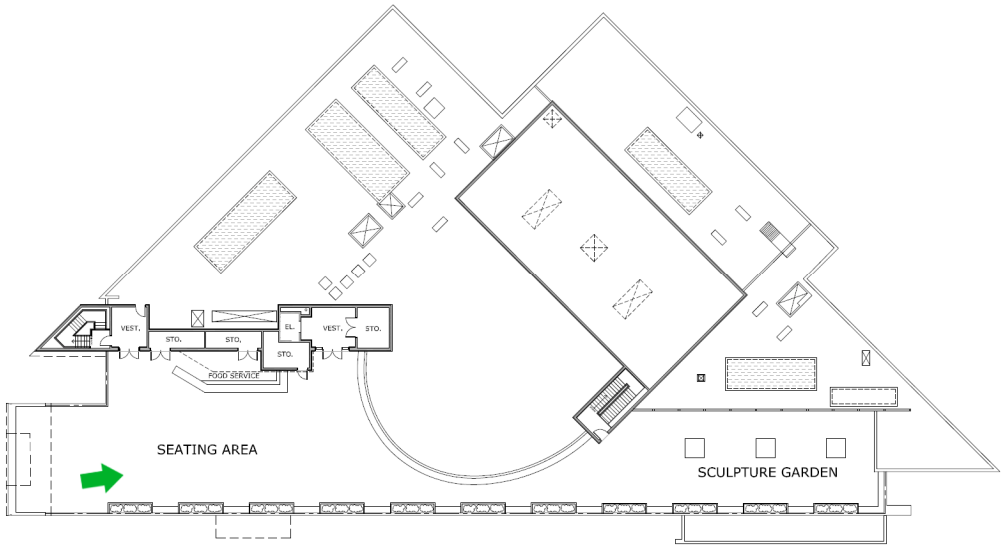
produce a sense of enclosure and feeling of integration with existing design

analyze feasibility based on construction sequence and effect on other building systems

consider volumes and planes that can be utilized for enhancement of lighting concepts

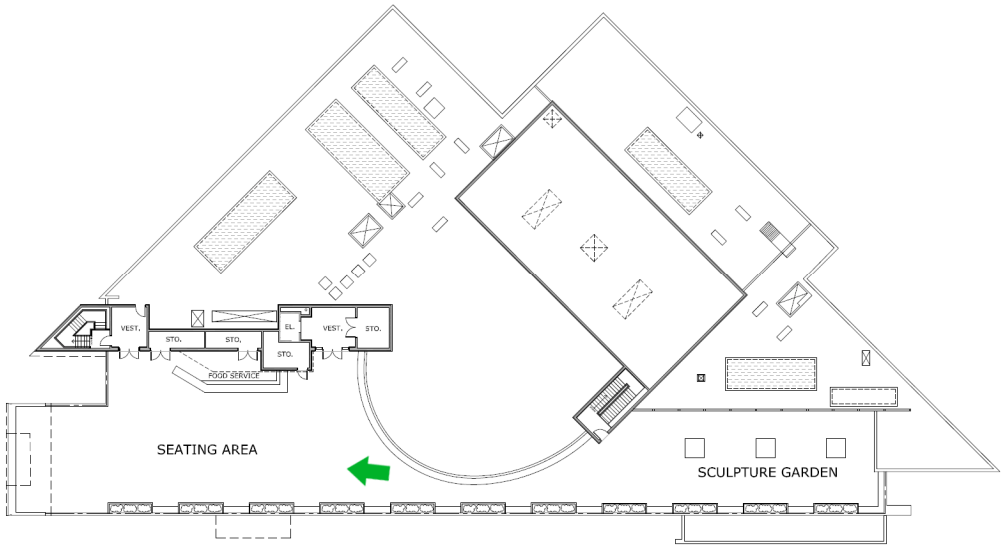
ARCHITECTURE

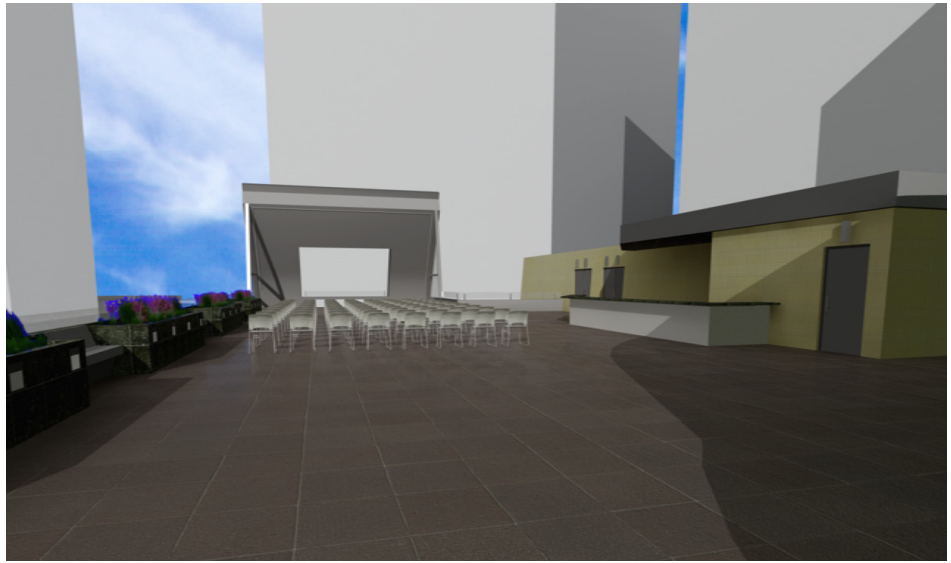
roof plan



ARCHITECTURE

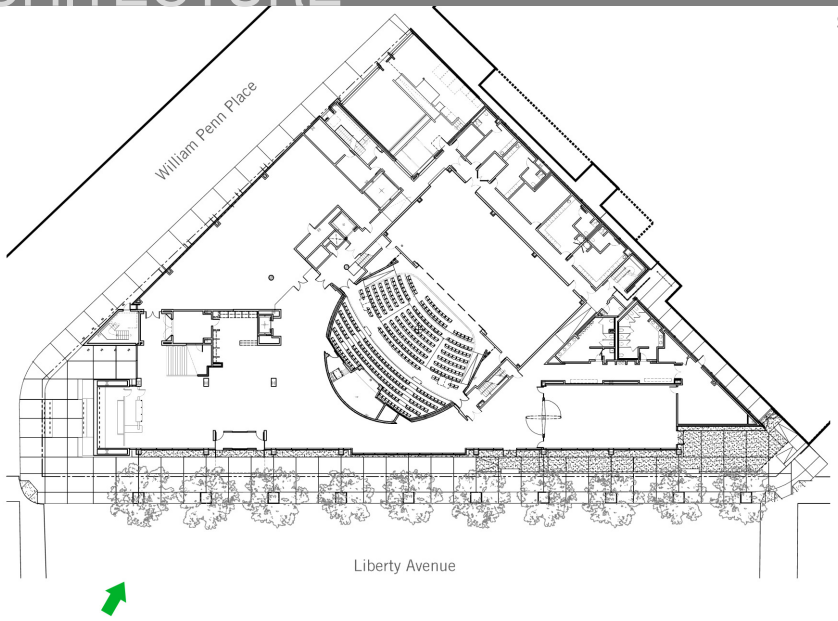
roof plan

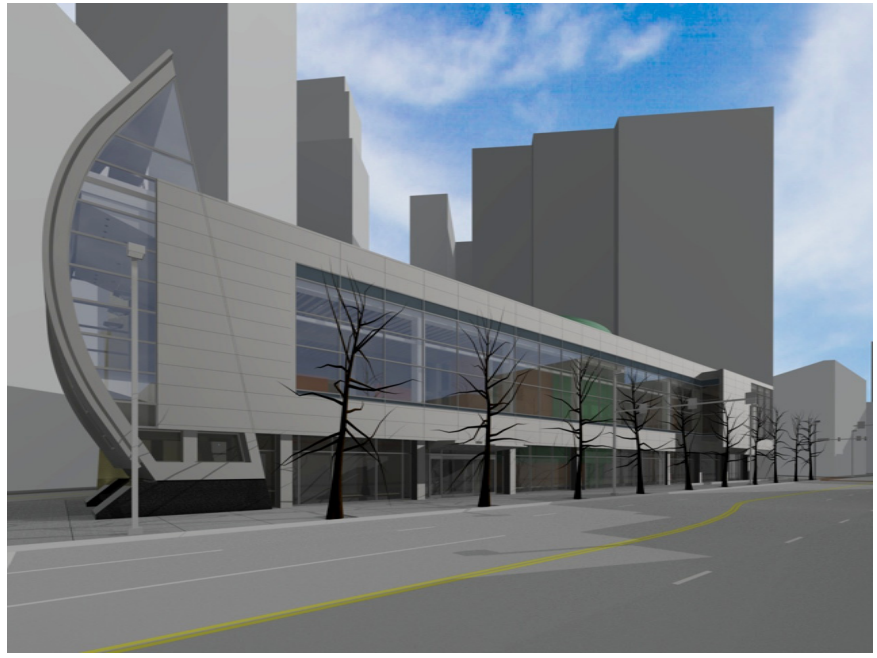




ARCHITECTURE

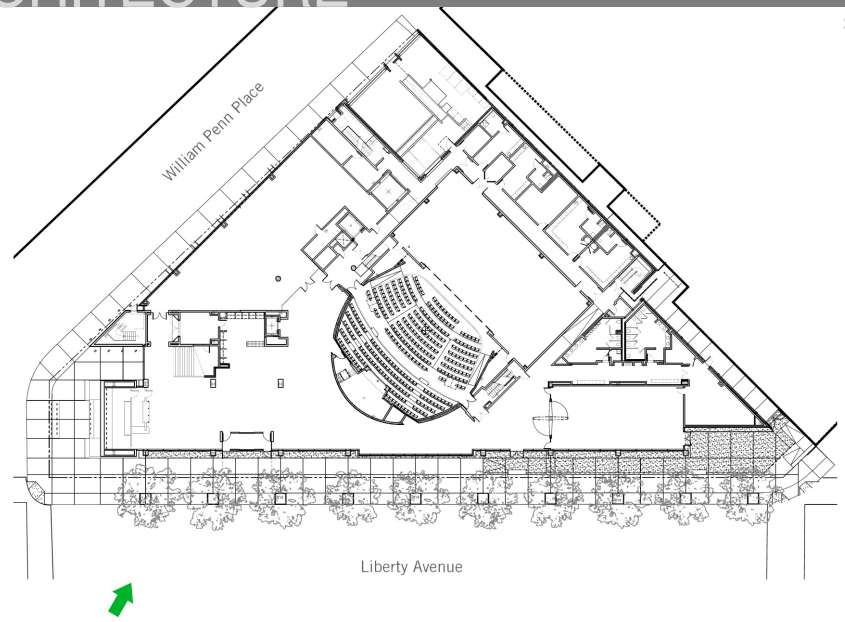
site plan

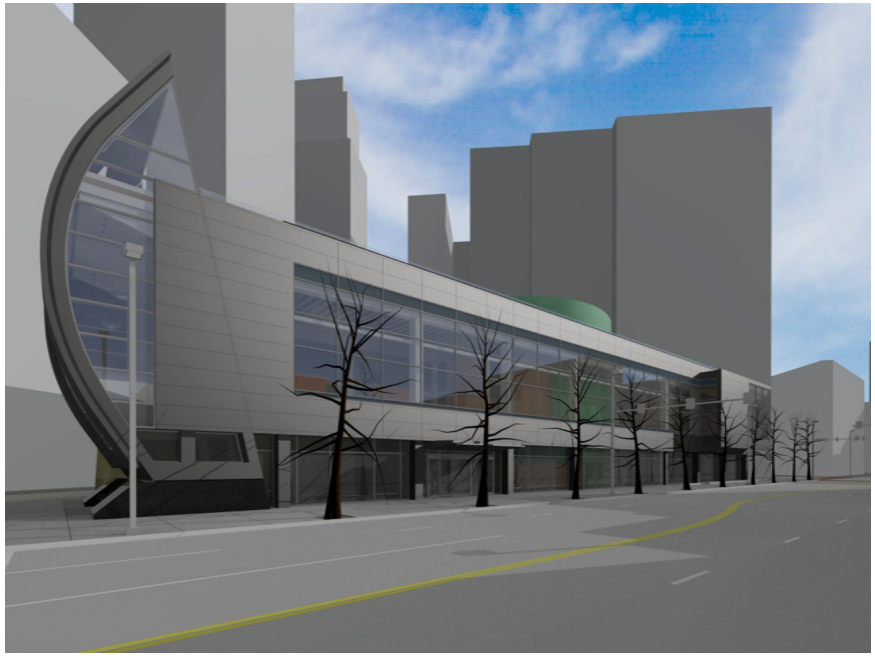




ARCHITECTURE

site plan





LIGHTING REDESIGN

LIBERTY AVENUE FAÇADE

design intent & concepts: develop the signature qualities of the building

create focal points to guide patrons and add visual interest

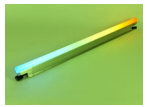
define a 'theater stage' theme that allows the building to interact with the streetscape

help to define and highlight the volumes of space that the architecture creates

select IESNA criteria: appearance, shadows, glare, surfaces

3 fc vertical, 5 fc horizontal illuminance

LIGHTING REDESIGN

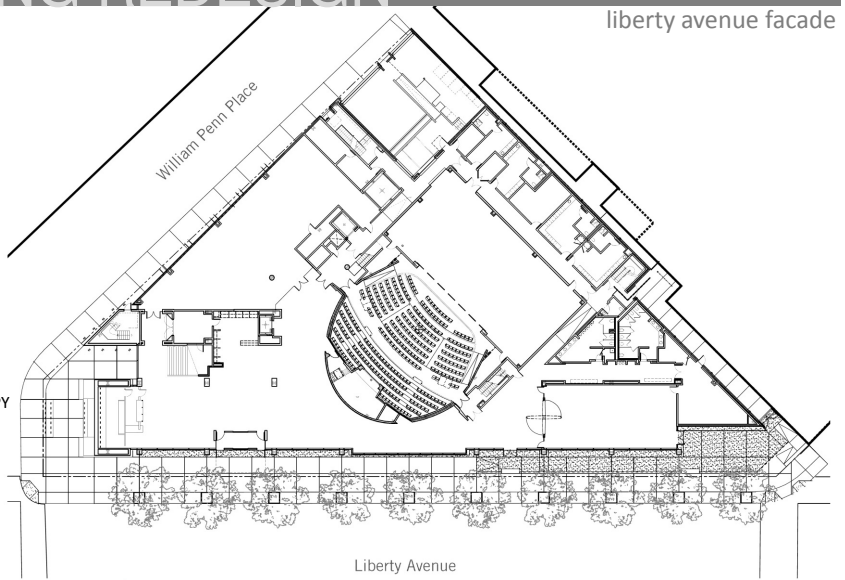


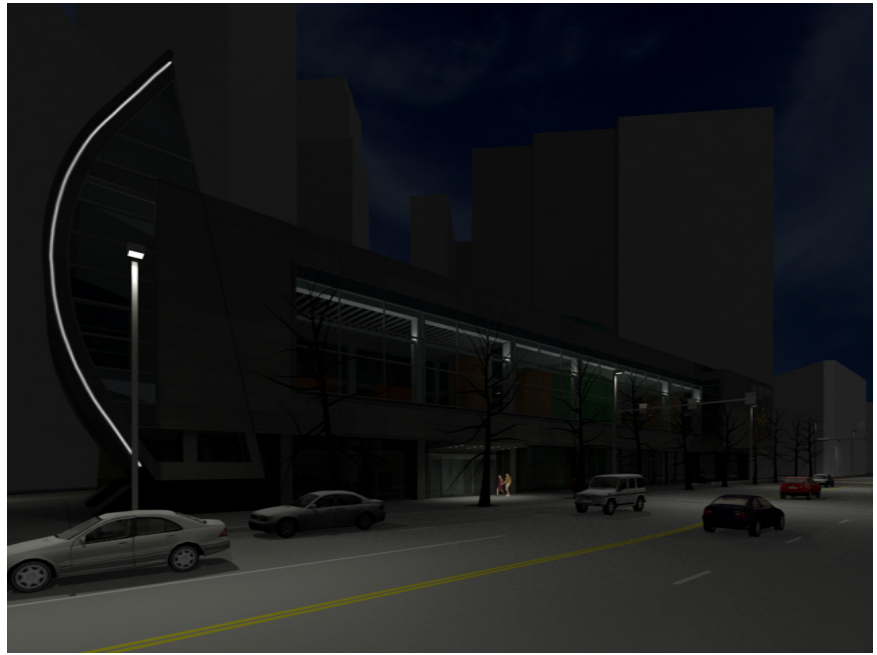
SOFFIT LIGHTING

SAIL OUTLINES

MAIN ENTRANCE CANOPY

liberty avenue facade





LIGHTING REDESIGN

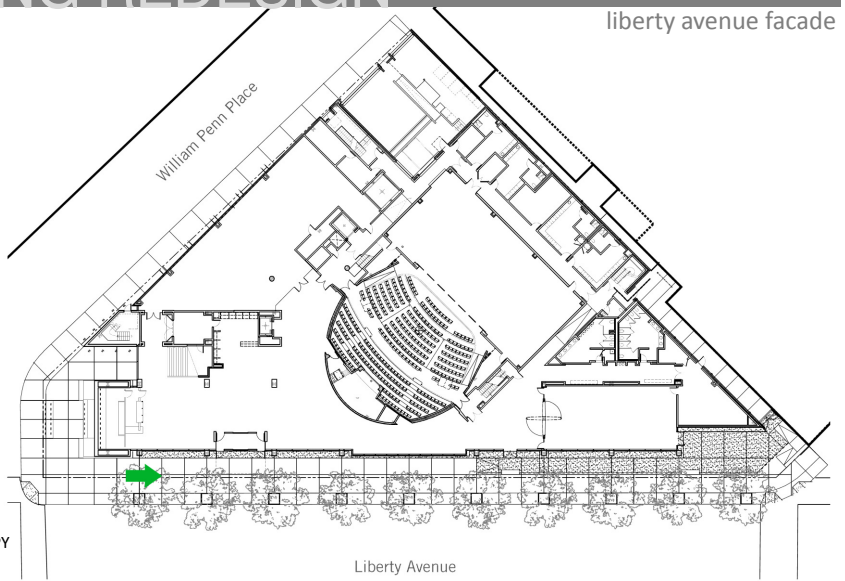
THEATER EXTENSION

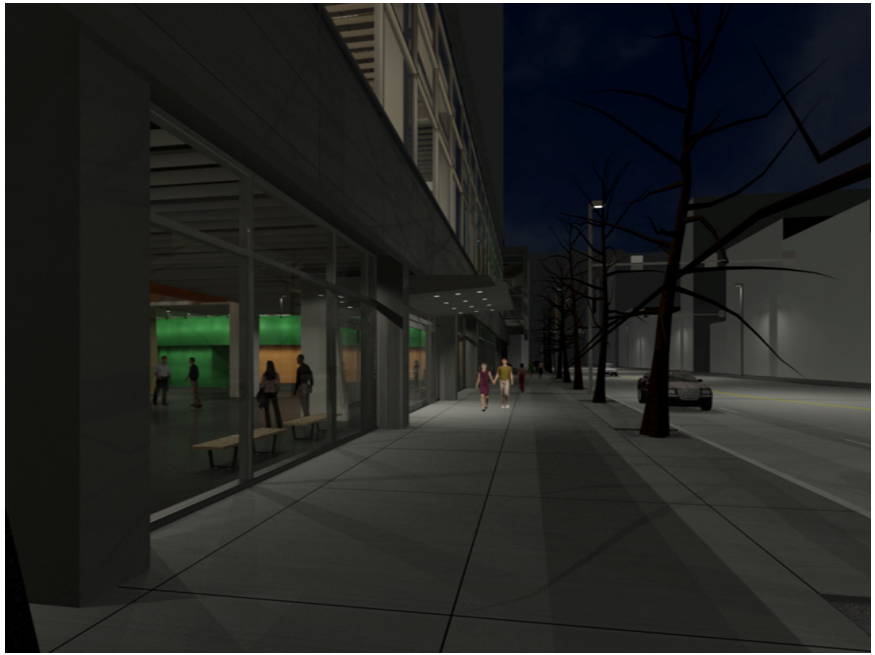
SAIL OUTLINES

STONE WALL WASH

MAIN ENTRANCE CANOPY

liberty avenue facade





LIGHTING REDESIGN

liberty avenue facade

by the numbers:

THEATER DRUM ILLUMINANCE, EXTERIOR: **30 FC**

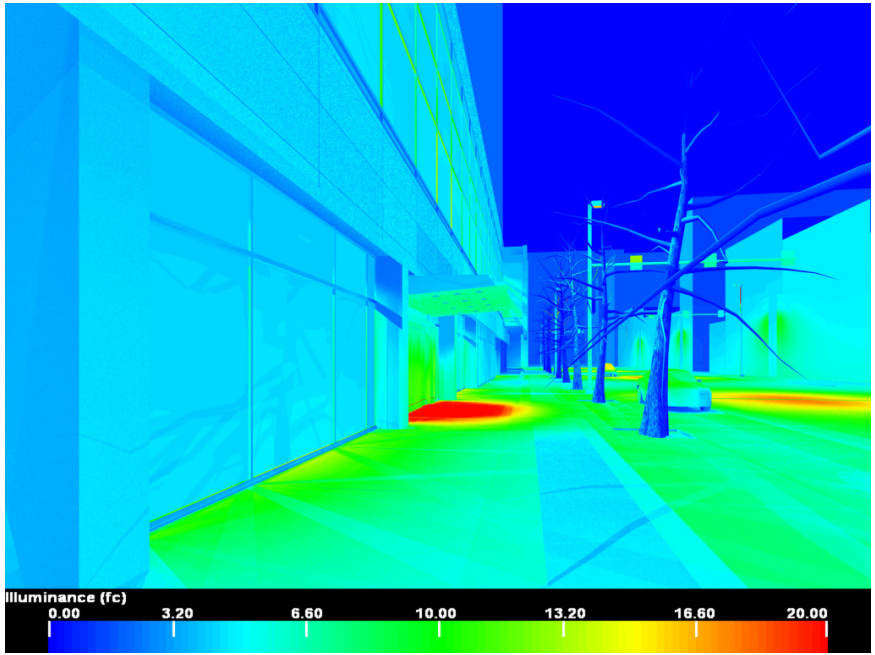
THEATER DRUM ILLUMINANCE, SECOND LEVEL: **30-40 FC** (at 100% light output)

THEATER DRUM ILLUMINANCE, LOWER LEVEL: **30 FC** (at 100% light output)

HORIZONTAL ILLUMINANCE LEVEL - TARGET | PROVIDED: **5** FC | **6 FC**

ILLUMINANCE RATIO - TARGET | PROVIDED: **3:1** | **4:1** (entrance to surround)

NIGHT SCENE ILLUMINANCE ON SOFFIT: **9 FC**



LIGHTING REDESIGN

MAIN LOBBY

design intent & concepts: create relaxing and welcoming environment

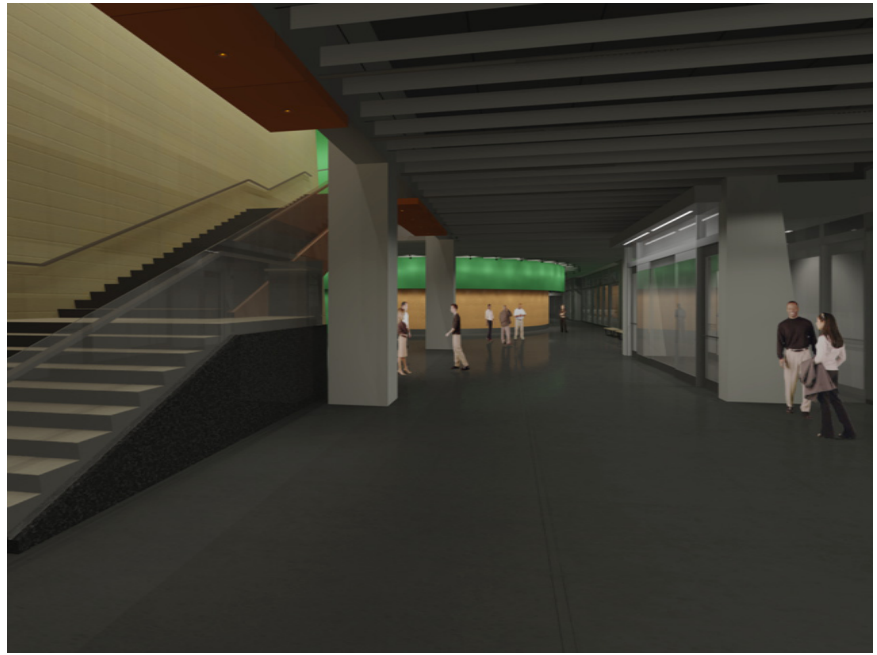
draw patrons to points of interest

flexibility to respond to various use conditions and daylight conditions

smooth transitions to surrounding spaces

select IESNA criteria: appearance of space and luminaires

3 fc vertical, 20 fc horizontal illuminance (theater lobby)



LIGHTING REDESIGN

LINEAR FL. DOWNLIGHT

CFL DOWNLIGHT

CFL. PENDANT

MR16 HAL. DOWNLIGHT

HALOGEN TRACKHEAD

main lobby

LIGHTING REDESIGN

main lobby

by the numbers:

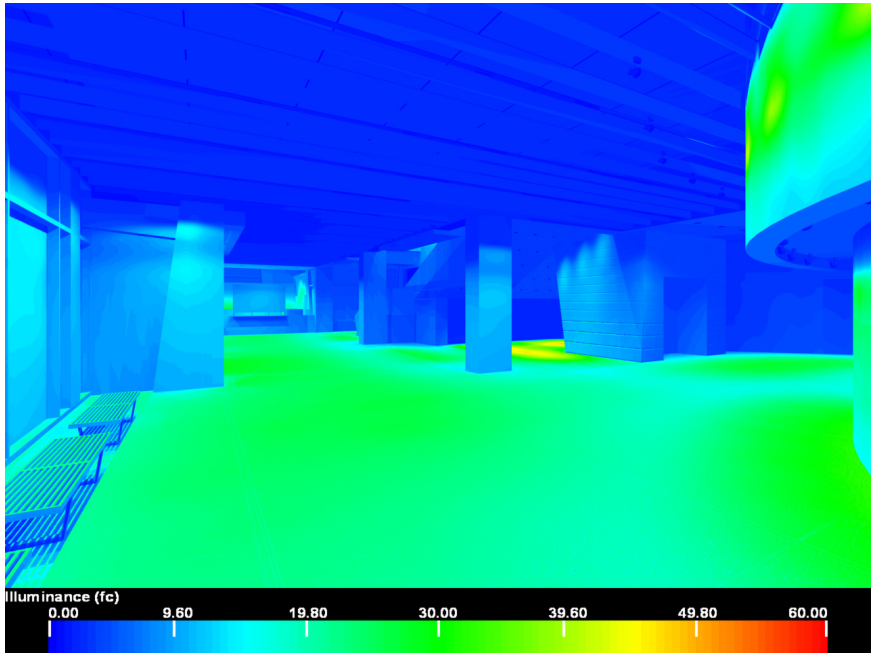
ILLUMINANCE LEVEL - TARGET | PROVIDED: 20 FC | **22 FC** (at 100% light output)

LUMINANCE RATIO, THEATER DRUM: **3:1**

LUMINANCE RATIO, BOX OFFICE: **3:1**

LUMINANCE RATIO, GIFT SHOP: **2:1**

POWER DENSITY - ALLOWABLE | ACTUAL: 3.3 W/SF | **1.07 W/SF**



LIGHTING REDESIGN

main lobby

by the numbers:

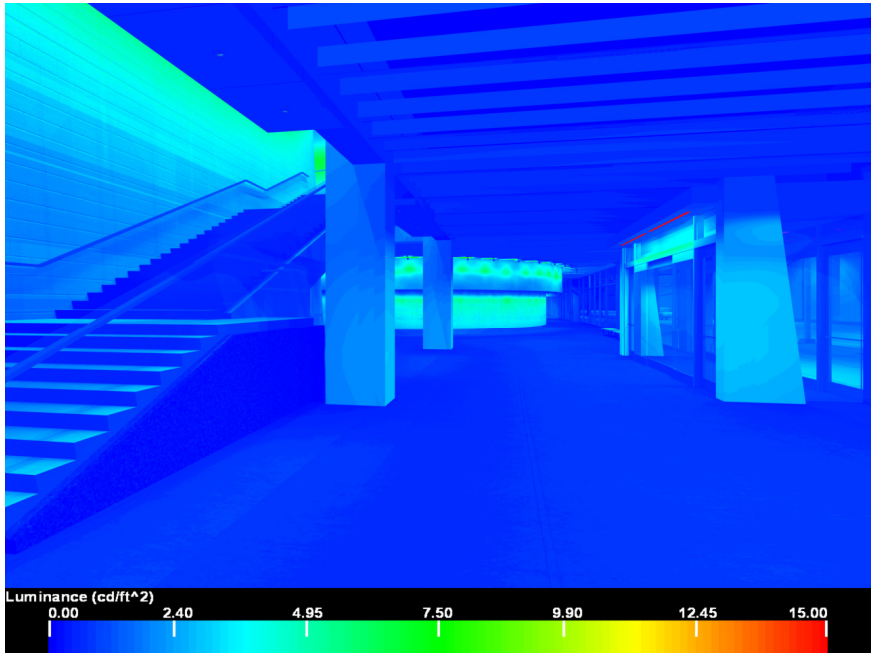
ILLUMINANCE LEVEL - TARGET | PROVIDED: 20 FC | **22 FC** (at 100% light output)

LUMINANCE RATIO, THEATER DRUM: **3:1**

LUMINANCE RATIO, BOX OFFICE: **3:1**

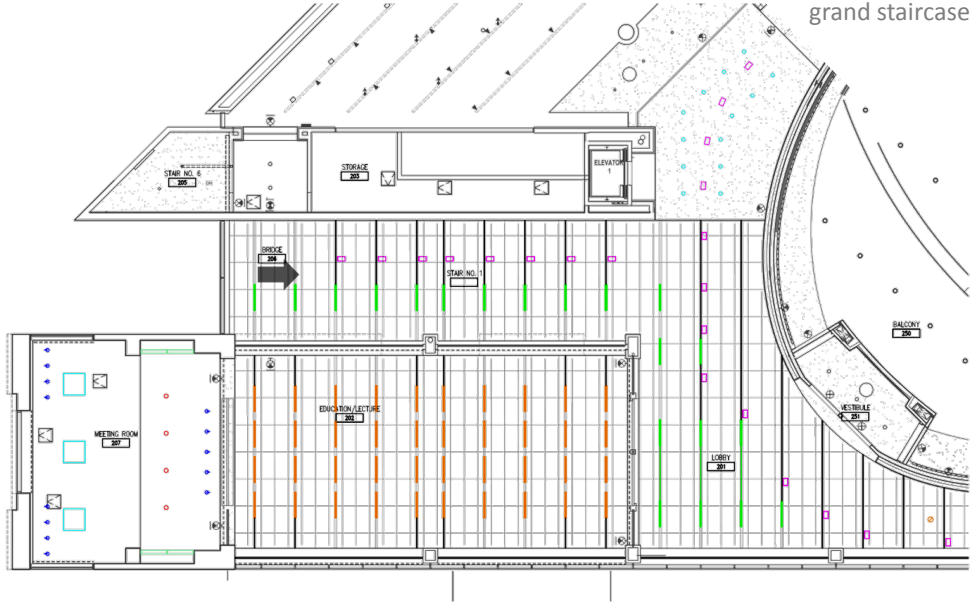
LUMINANCE RATIO, GIFT SHOP: **2:1**

POWER DENSITY - ALLOWABLE | ACTUAL: 3.3 W/SF | **1.07 W/SF**



LIGHTING REDESIGN

grand staircase



LIGHTING REDESIGN

upper level lobby

LIGHTING REDESIGN

EDUCATION AND LECTURE ROOM

design intent & concepts: design for strong visual clarity

provide even and adequate light on the work plane

design a flexible system for varied presentations and activities which considers daylighting issues

match existing room aesthetics and compliment the baffle ceiling system

select IESNA criteria: glare, shadows, light distribution on task plane

30 fc horizontal illuminance

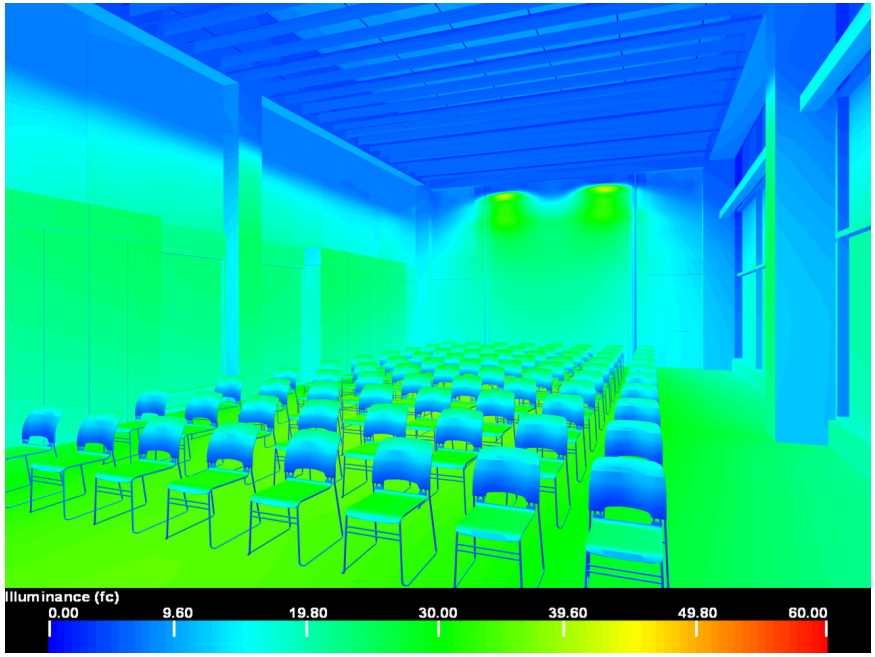
LIGHTING REDESIGN

education and lecture room

by the numbers:

ILLUMINANCE LEVEL - TARGET | PROVIDED: 30 FC | **38 FC** (at 100% light output)

POWER DENSITY - ALLOWABLE | ACTUAL: 1.4 W/SF | **1.24 W/SF**



LIGHTING REDESIGN

MEETING ROOM / DONOR LOUNGE

design intent & concepts: create a warm and relaxing ambiance

design for an upscale appearance

be conscious of appearance from exterior and light the ceiling

help make the space a signature room in a signature building

select IESNA criteria: appearance of space and luminaires, glare, facial rendering

5 fc vertical, 30 fc horizontal illuminance

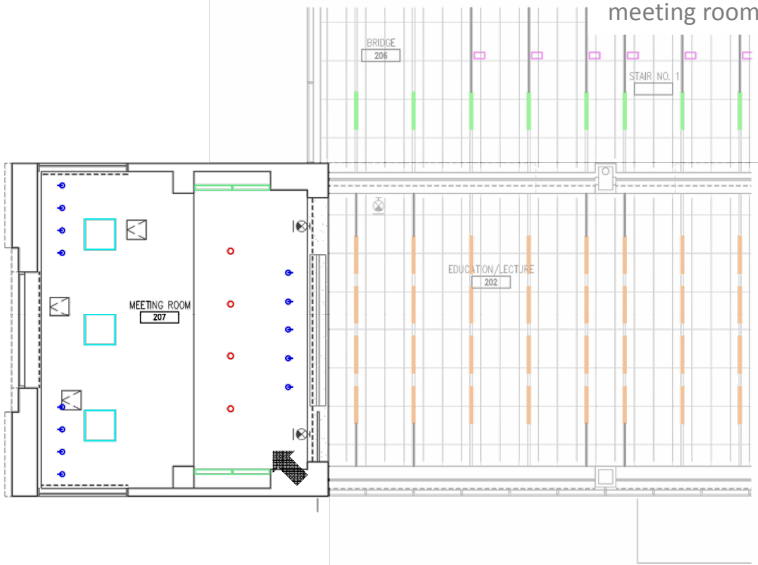
LIGHTING REDESIGN

CFL DECORATIVE PENDANT

HALOGEN GIMBAL DOWNLIGHT

LINEAR FL. WALLWASHER

CFL DOWNLIGHT



LIGHTING REDESIGN

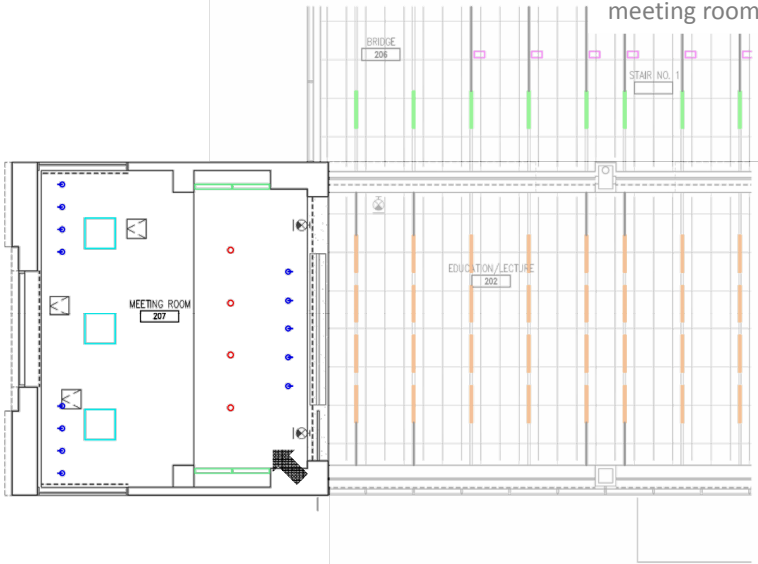
CFL DECORATIVE PENDANT

HALOGEN GIMBAL DOWNLIGHT

LINEAR FL. WALLWASHER

CFL DOWNLIGHT

meeting room



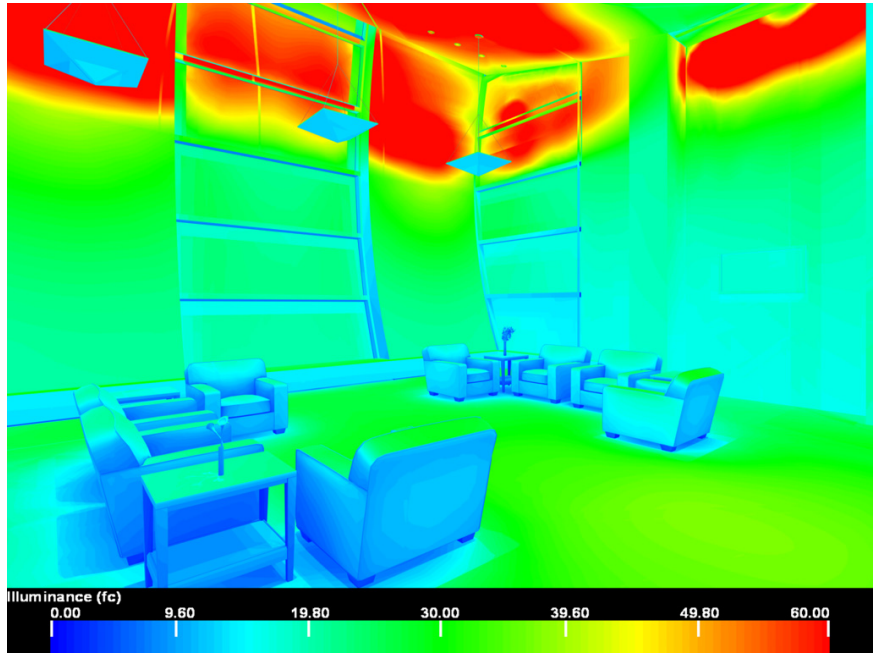
LIGHTING REDESIGN

meeting room

by the numbers:

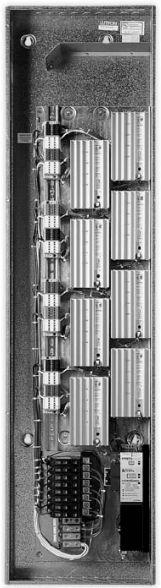
ILLUMINANCE LEVEL - TARGET | PROVIDED: 30 FC | **35 FC** (at 100% light output)

POWER DENSITY: 1.3 W/SF | **1.61 W/SF**



LIGHTING CONTROLS

DIMMER RACK 101/201



design intent & concepts: one dimming panel for all lighting in public spaces (lobbies, box office, gift shop, exterior)

architectural preset controls allow maximum flexibility and provides ability to send signals necessary for a theater lobby

DMX interface for LED applications

DIMMER RACK LAYOUT: DR101/201

AREA	CONTROL CHANNEL	CIRCUIT / DIMMER	DESCRIPTION	FIXT. TAG	NO. OF FIXT.	WATTS/ FIXTURE	MULT.	TOTAL WATTS	PHOTO CELL?	EMER. CRCT?
LOWER LOBBY	1	1	Theater Drum Upper	D	25	50	1.0	1250		
	2	2	Theater Drum Lower	D	25	50	1.0	1250		
	3	3	Downlights - Linear - 101	A	11	63	1.25	866	■	■
		4	Downlights - Linear - 101	A	17	63	1.25	1339		■
	4	5	Downlights - Linear - 106	A	4	63	1.25	315		■
		6	Downlights - Linear 106 + P	A/F	8/4	63/32	1.25	790	■	
	5	7	Downlights - Round	E	15	49	1.25	919		
	6	8	Downlights - Cabinets	E1/H	7/4	50/49	1.25	683		
GIFT SHOP	7	9	Downlights	H	20	50	1.25	1250		
		10	Downlights	H	17	50	1.25	1063		■
Box Office	8	11	Downlights	E1/I	15/3	49/38	1.25	1061		
SPARE	9	12								
VESTIBULE	10	13	Downlights	I	6	38	1.25	285	■	■
STAIRCASE	11	14	Wallwash	C	4	300	1.0	1200		
		15	Wallwash	C	4	300	1.0	1200	`	
	12	16	Downlights	B	10	64	1.25	800		■
UPPER LOBBY	13	17	Theater Drum + Track	C	5	300	1.0	1800		
		18	Theater Drum + Track	C	5	300	1.0	1800		
		19	Theater Drum + Track	C	5	300	1.0	1800		
		20	Theater Drum + Track	C	4	300	1.0	1800		
UPPER LOBBY	14	21	Downlights - Linear	A	10	63	1.25	788	■	■
		21	Downlights - Linear	A	10	63	1.25	788		■
	15	22	Downlights - Round	E	13	49	1.25	796		■
	16	23	Downlights - Pendant	F	6	32	1.25	240		
EXTERIOR	17	25	Inside	R	85	10	1.25	1063		
		26	Inside	R	85	10	1.25	1063		
	18	27	Sail LED	S	120	3	1.25	450		
	19	28	Downlights - Exterior	M	15	22	1.25	413		
SPARE		29								
SPARE		30								
SPARE		31								
SPARE		32								

Panel Type: Lutron LP8/16-1204ML-20
Distribution Panel Power Supply: 1NDP1
Emergency Panel Power Supply: BE1
Location: Control Booth (151)

LOAD = 27.07 kW
(125% GROWTH FACTOR) DEMAND LOAD = 93.99 A
FEEDER SIZE = (4) #3 in 1.25" Conduit
PROTECTION = 100 A

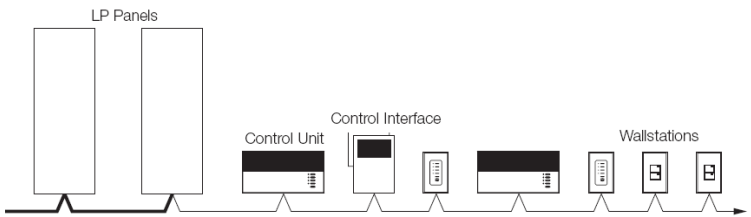
LIGHTING CONTROLS

DIMMER RACK 202/207

design intent & concepts: architectural preset controls allow maximum flexibility for scene control in meeting room and varied levels in education and lecture room

ability to control shades with the same interface

cost effective incorporation of photosensor dimming



SCHEMATIC REPRESENTATION: NOT ACTUAL SYSTEM

DIMMER RACK LAYOUT: DR202/207

AREA	CONTROL CHANNEL	CIRCUIT / DIMMER	DESCRIPTION	FIXT. TAG	NO. OF FIXT.	WATTS/ FIXTURE	MULT.	TOTAL WATTS	PHOTO CELL?	EMER. CRCT?
EDUCATION	1	1	Northwest Downlights + Track	A	5	125	1.25	1141.25	■	
	2	2	Northeast Downlights + Track	A	5	125	1.25	1141.25	■	
	3	3	Southwest Downlights + Track	A	5	125	1.25	1141.25		■
	4	4	Southeast Downlights + Track	A	5	125	1.25	1141.25		■
MEETING	5	5	Pendants	L	3	116	1.25	435		
	6	6	Downlights	E1	8	49	1.25	490		■
	7	7	Accent - Wood/Sail	J	13	50	1.25	812.5		
	8	8	Linear Wallwasher	K	4	35	1.25	175		
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										
SPARE										

Panel Type: Lutron LP4/16-1204ML-20
Distribution Panel: 1NDP1
Emergency Panel: BE1
Location: 202 Closet

LOAD = 6.48 kW
(200% GROWTH FACTOR) DEMAND LOAD = 26.99 A
FEEDER SIZE = (3) #10 in .5" Conduit
PROTECTION = 30 A

ELECTRICAL

PHOTOVOLTAIC ARRAY ANALYSIS

Roof Area available for PV array: Approximately 12,000 ft^2 (1115 m^2)

Product: BP Solar 5170S

Energy Produced: 192KWh

Physical Size: 1.26 m^2

Efficiency: 13.5%

Total System Efficiency (Combined Panel and System): 3%

Unit Cost: $5,750

Maintenance Costs: $10,000/10 Years

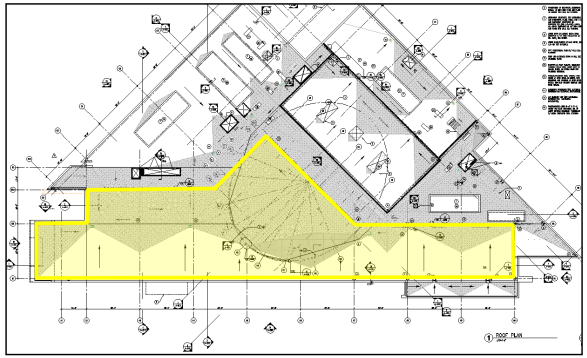
Design Costs: $15,000

Other Equipment Costs (inverter and power equipment): $100,000

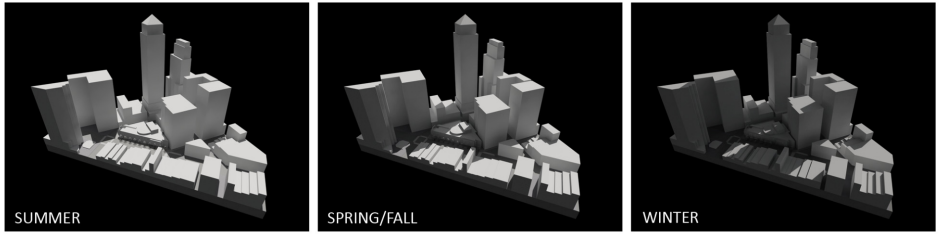
Energy Rate: .1236 cents/KWh

Financial Incentives: None (Non-Profit)

Energy Savings/Year/Panel: $28



AVAILABLE ROOF AREA



SHADOW CONDITIONS AT MIDDAY

ELECTRICAL

VOLTAGE SYSTEM CONVERSION

description:

Covert MSB1 and associated loads (primarily equipment) from 208/120V to 480/277V

motivation:

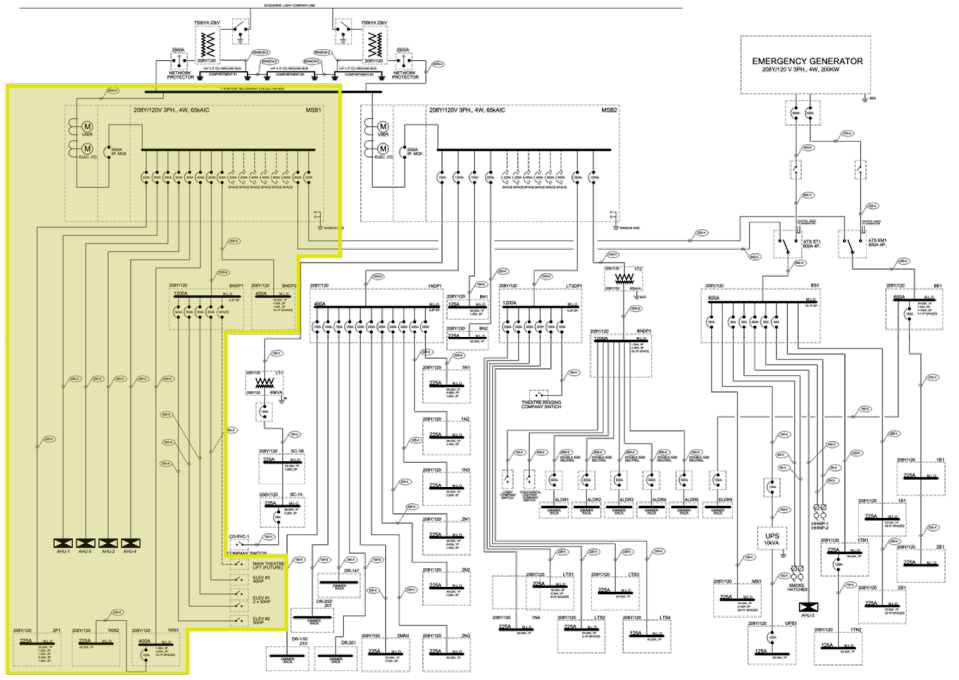
Equipment size reduction can reduce cost for a project that is over budget

potential side effects:

Redundancy provided by collector bus eliminated

limitations:

Cost analysis considers only major equipment and feeders



SECTION TO BE REDESIGNED

ELECTRICAL

VOLTAGE SYSTEM CONVERSION

VOLTAGE CONVERSION COST ANALYSIS			
Type	**Existing Cost**	**New Cost**	**Difference**
PANELS	$48,800	$30,350	**$18,450**
FEEDERS	$68,900	$24,600	**$44,300**
OTHER	$0	$5,625	**$5,625**
TOTAL			**$57,125**

conclusion:

For a project trying to reduce cost, this is an option that provides limited disruption. Actual cost savings will be greater when individual breakers are considered.

Existing Design Equipment Schedule			
TYPE	TAG	LOCATION	DESCRIPTION
Transformer	*NA*	Transformer Vault	Duquesne Light Transformer
Main Switchboard	MSB1	Basement (013)	208Y/120, 3000A MCB
Distribution Panel	BNDP1	Basement (013)	208Y/120, 1200A MLO
Distribution Panel	BNDP2	Basement (013)	208Y/120, 400A MLO
Branch Circuit Panel	2P1	Electrical Room (212)	208Y/120, 225A MLO
Branch Circuit Panel	1KN1	Kitchen (140)	208Y/120, 400A MLO
Branch Circuit Panel	1KN2	Kitchen (140)	208Y/120, 225A MLO

Redesign Equipment Schedule			
TYPE	TAG	LOCATION	DESCRIPTION
Transformer	*NA*	*Trans. Vault*	*Duquesne Light Transformer*
Transformer	2T1	Electrical Room (212)	9 KVA, 480V to 108Y/120V
Transformer	1T3	Kitchen (140)	30 KVA, 480V to 108Y/120V
Main Switchboard	MSB1	Basement (013)	480/277, 1600A MCB
Distribution Panel	BNDP1	Basement (013)	480/277, 400A MLO
Distribution Panel	BNDP2	Basement (013)	480/277, 100A MLO
Branch Circuit Panel	2P1	Electrical Room (212)	480/277, 100A MLO
Branch Circuit Panel	2P1A	Electrical Room (212)	480/277, 60A MLO
Branch Circuit Panel	1KN1	Kitchen (140)	208Y/120, 400A MCB
Branch Circuit Panel	*1KN2*	*Kitchen (140)*	*208Y/120, 225A MLO (Unchanged)*

ACOUSTICS

MUSIC CAFÉ

goal:

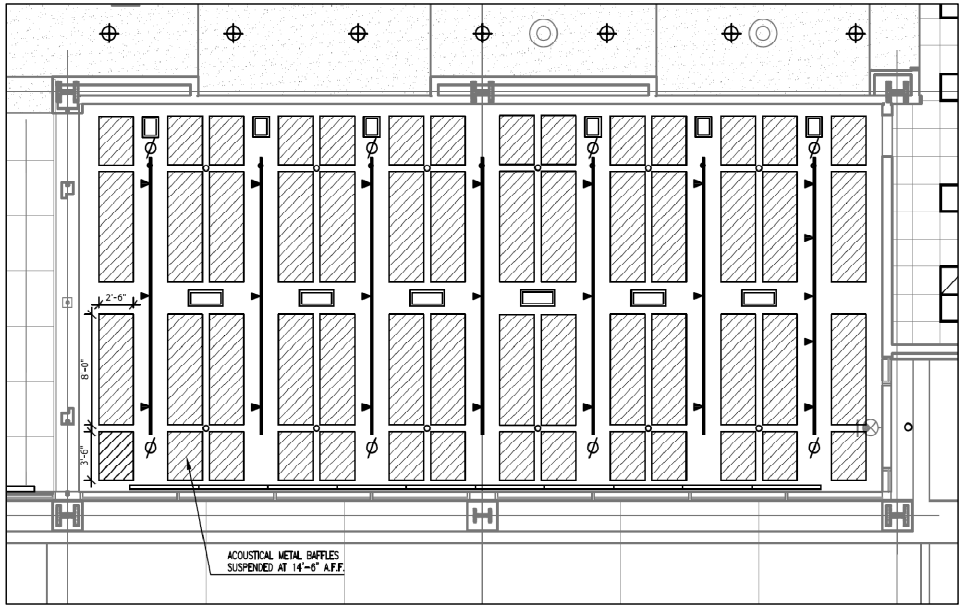
Redesign room to reach an optimal reverberation time of 1.0 to 1.1 seconds

motivation:

Room to be used for spoken word and music performances

REVERBERATION TIME SUMMARY: MUSIC CAFÉ (EXISTING)						
Freq. (Hz.)	125	250	500	1000	2000	4000
T_{60} =	1.677	2.596	0.801	0.798	0.807	0.752

REVERBERATION TIME SUMMARY: MUSIC CAFÉ (NEW)						
Freq. (Hz.)	125	250	500	1000	2000	4000
T_{60} =	**1.620**	**1.243**	**0.984**	**1.054**	**1.077**	**1.065**



MUSIC CAFÉ | NEW REFLECTED CEILING PLAN

ACOUSTICS

MULTIPURPOSE ROOM REDESIGN

goal:

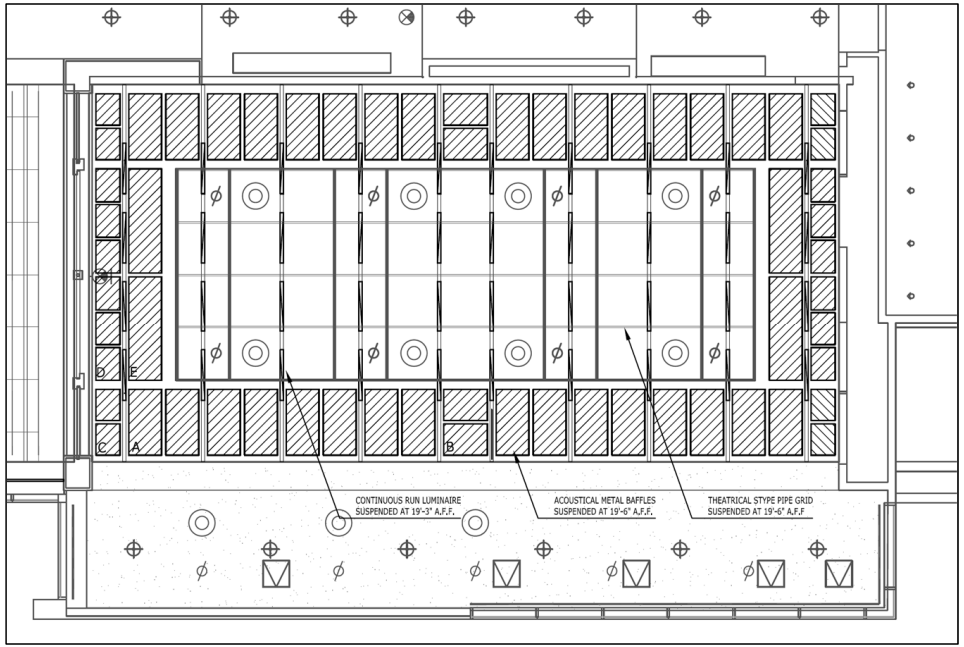
Redesign room to reach an optimal reverberation time of 1.1 to 1.2 seconds

motivation:

Room to be used for large gatherings, rehearsals and small performances

REVERBERATION TIME SUMMARY: MULTIPURPOSE (EXISTING)						
Freq. (Hz.)	125	250	500	1000	2000	4000
T_{60} =	1.372	2.471	1.011	1.036	1.042	0.941

REVERBERATION TIME SUMMARY: MULTIPURPOSE (NEW)						
Freq. (Hz.)	125	250	500	1000	2000	4000
T_{60} =	**1.741**	**1.723**	**1.112**	**1.200**	**1.213**	**1.120**



MUSIC CAFÉ | NEW REFLECTED CEILING PLAN

RESULTS SUMMARY

lighting : reinforce “transparent, flexible container” concept with a user-friendly, adaptive, and energy efficient design

Consistency of fixtures from space to space provides continuity when viewed from exterior. Control systems and dimming ballasts allow maximum flexibility. Redesigned spaces use 65% of ASHRAE 90.1 allowance.

electrical: allow for simplified lighting control with simplified system and reduced cost

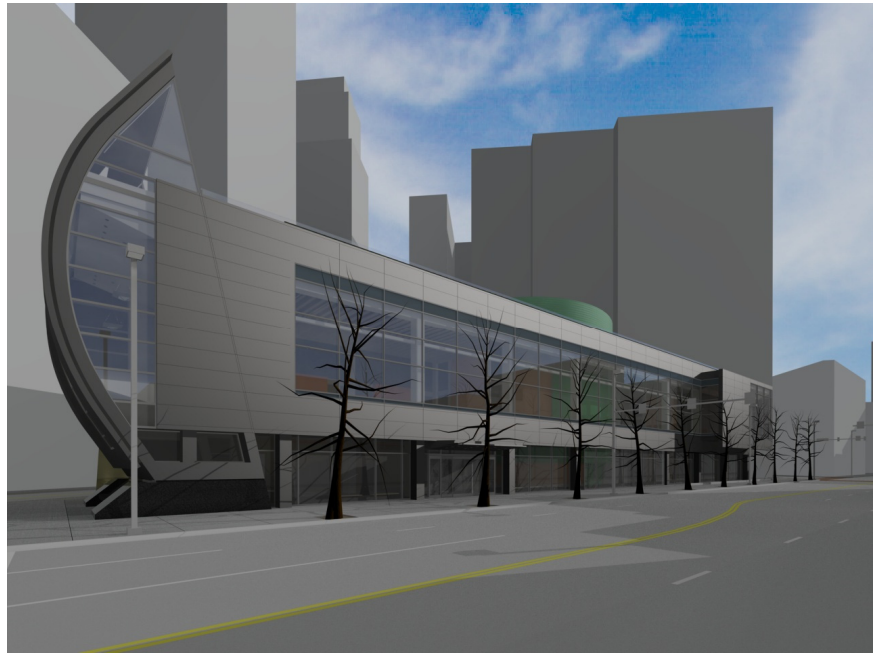
Dimming panels combine loads and allow for simplified control. Photovoltaic array will not provide cost savings. Converting to a 480/277V system will provide significant cost savings.

architecture: create an additional, alternate venue while helping to achieve lighting goals

A comfortable new space is designed with minimal impact on the existing design. The raised theatre drum fence aids in achieving lighting goals.

acoustics: provide improved acoustical properties with minimal impact on architecture

Intended reverberation times are reached by changing materials. STC will be difficult to improve without significantly altering the architecture.



FINAL REMARKS

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