Sites, Buildings, Infrastructure
(mostly buildings)

John Cooper

2nd NuMI Off-Axis Experiment Detector Workshop
at Argonne National Laboratory

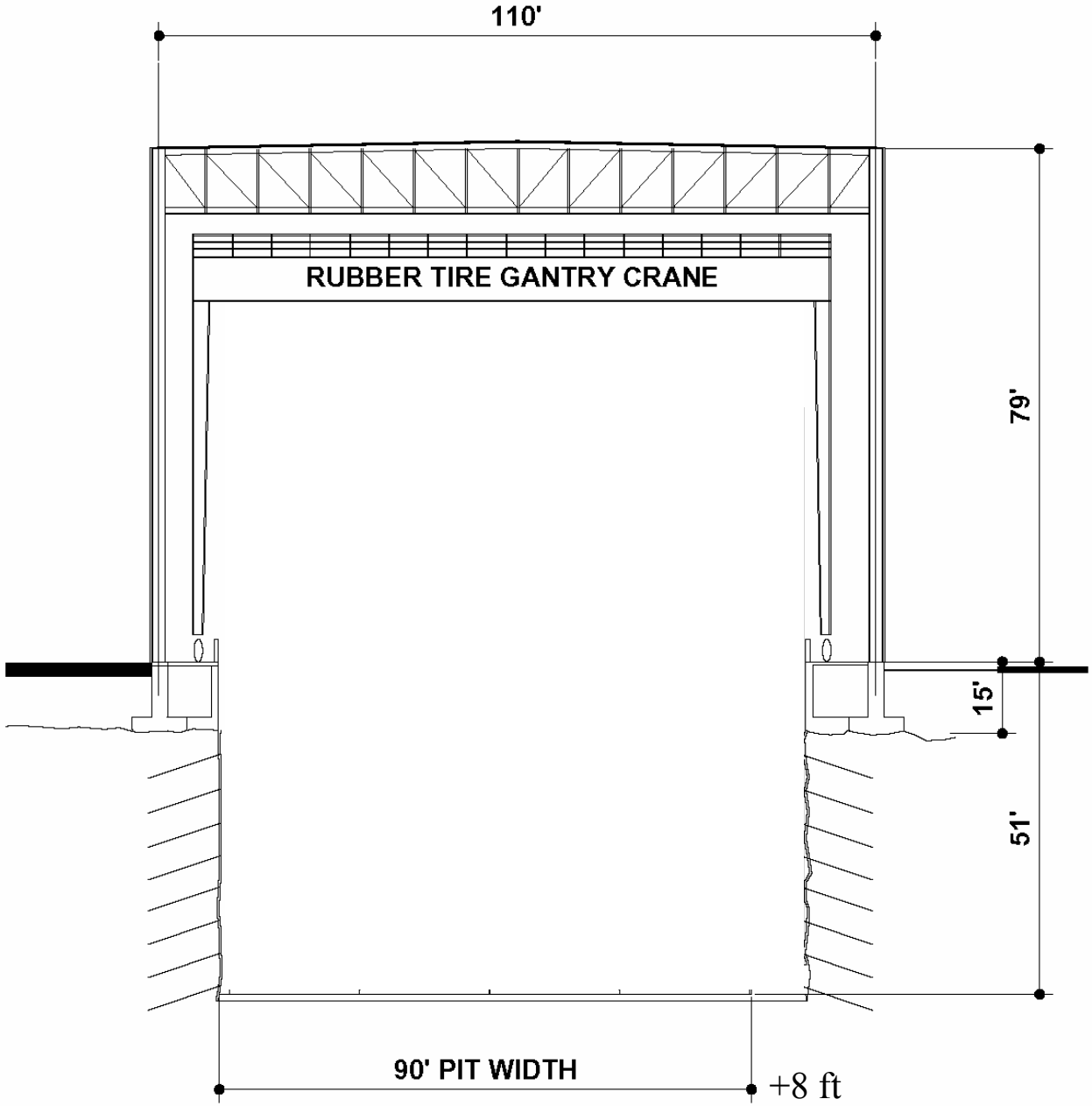
April 26, 2003

New building design

from Fermilab Facilities Engineering Services Section (FESS)

- Steve Dixon & Tom Lackowski did the estimate
- The design goal was to do an estimate for something simple, hopefully cheap
  - 50 kton detector
  - Based on containers, but scalable for other schemes
  - Partial excavation in bedrock, about half the detector below grade
  - No overburden,
    - Contrast with the 10 meter overburden CNA design shown at SLAC
  - No building crane, instead use a Rubber Tire Gantry (RTG)
  - Limited HVAC (keep above 32 F, ventilation)
- Will compare with the CNA design
  - requires scaling since that design is for a smaller building

Building Cross section

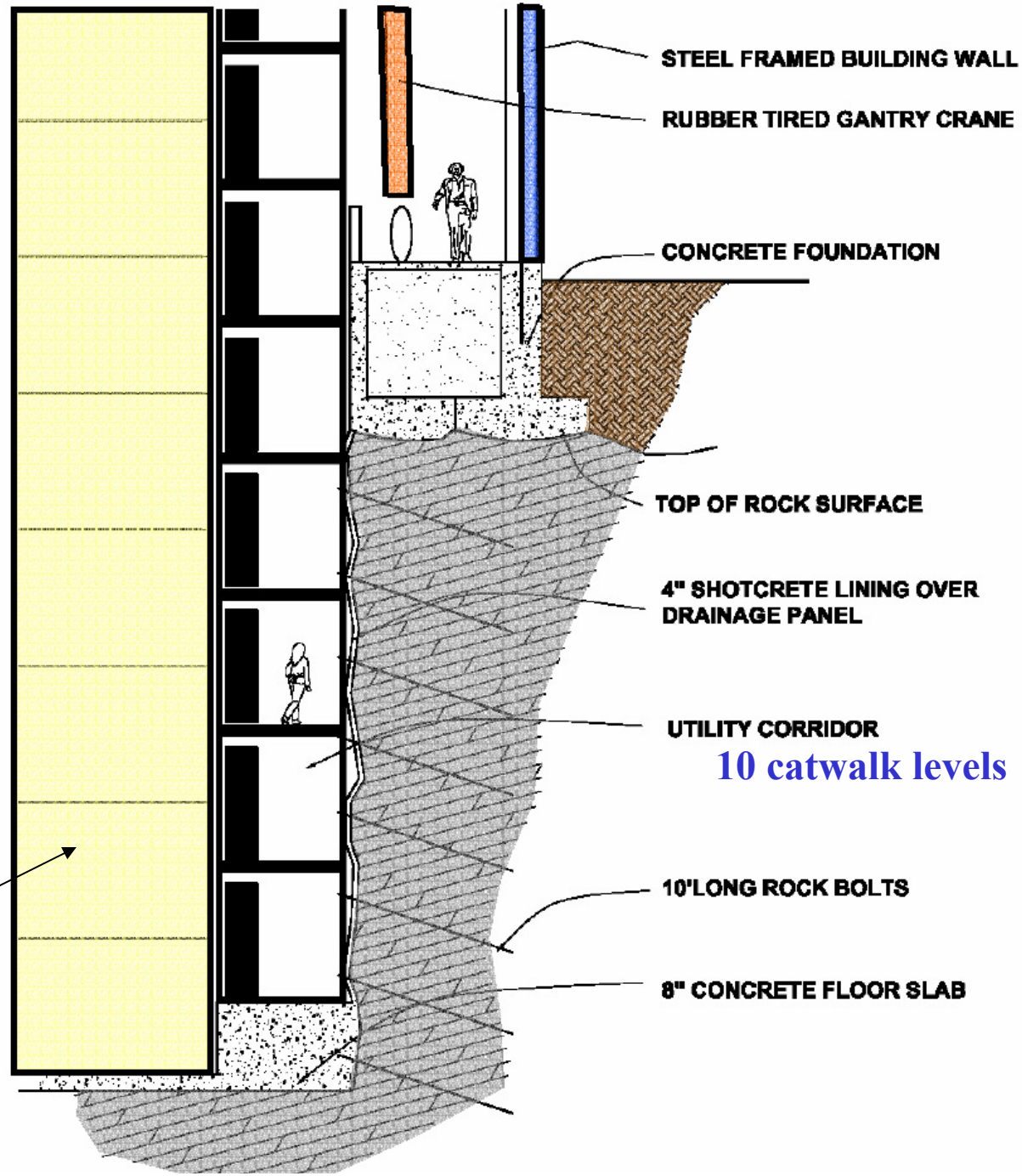


79 ft high building

15 ft of soil

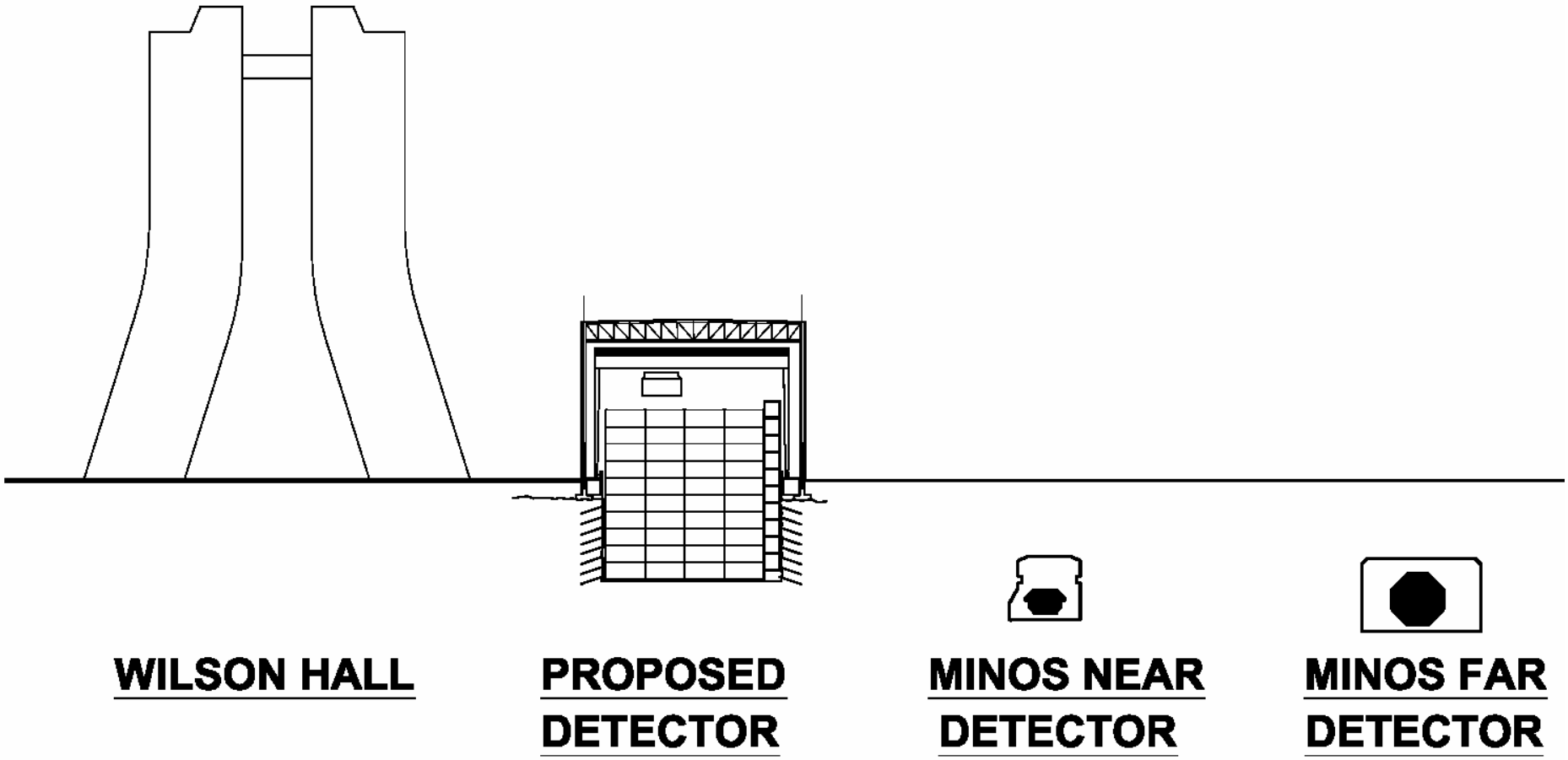
36 ft into bedrock

Zoom in

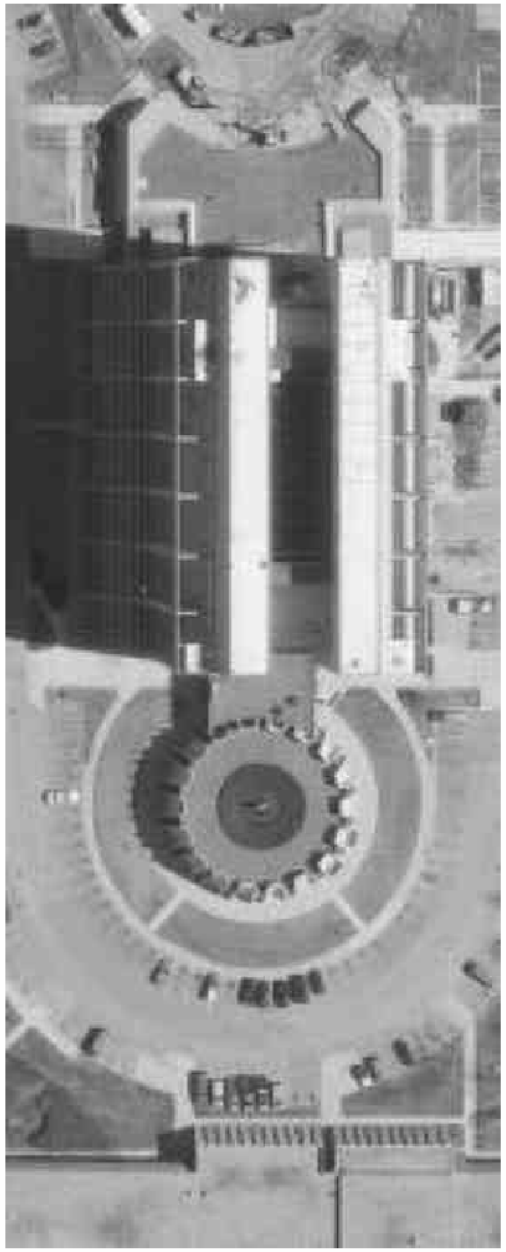


Container stack

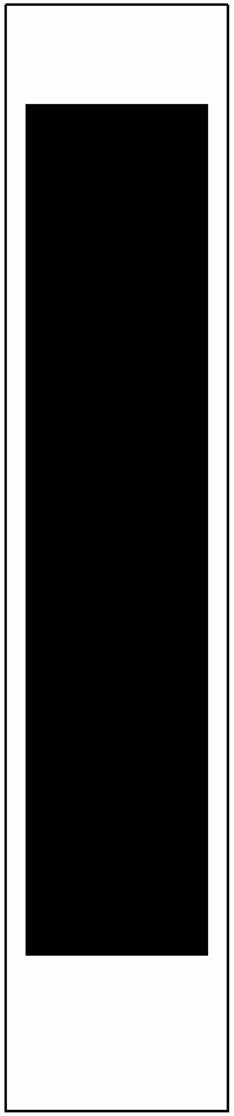
Zoom out


WILSON HALL
PROPOSED DETECTOR
MINOS NEAR DETECTOR
MINOS FAR DETECTOR

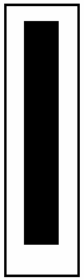
WILSON HALL



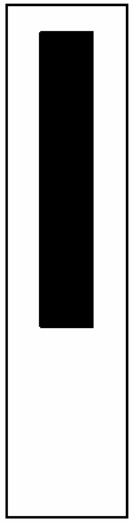
PROPOSED DETECTOR



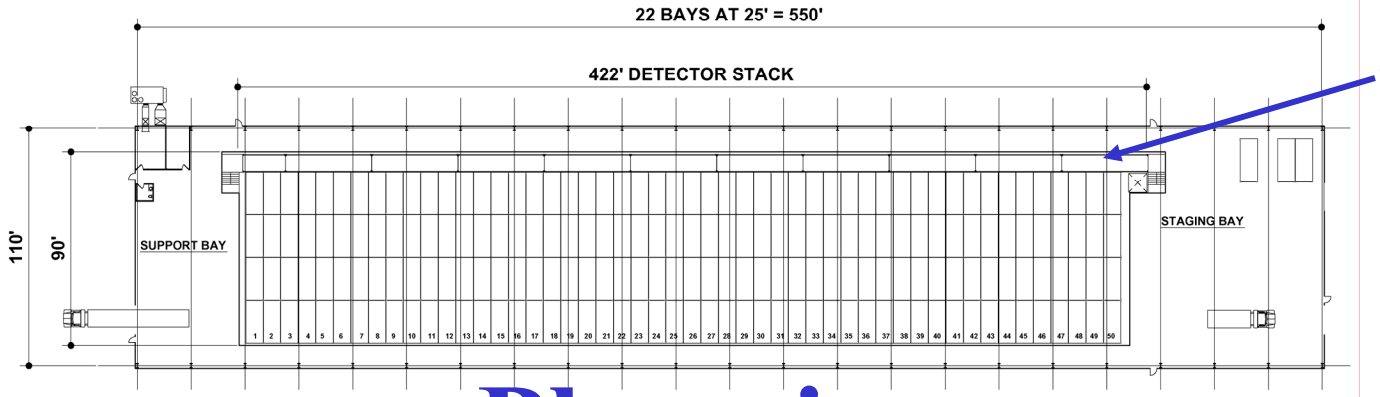
MINOS NEAR DETECTOR



MINOS FAR DETECTOR

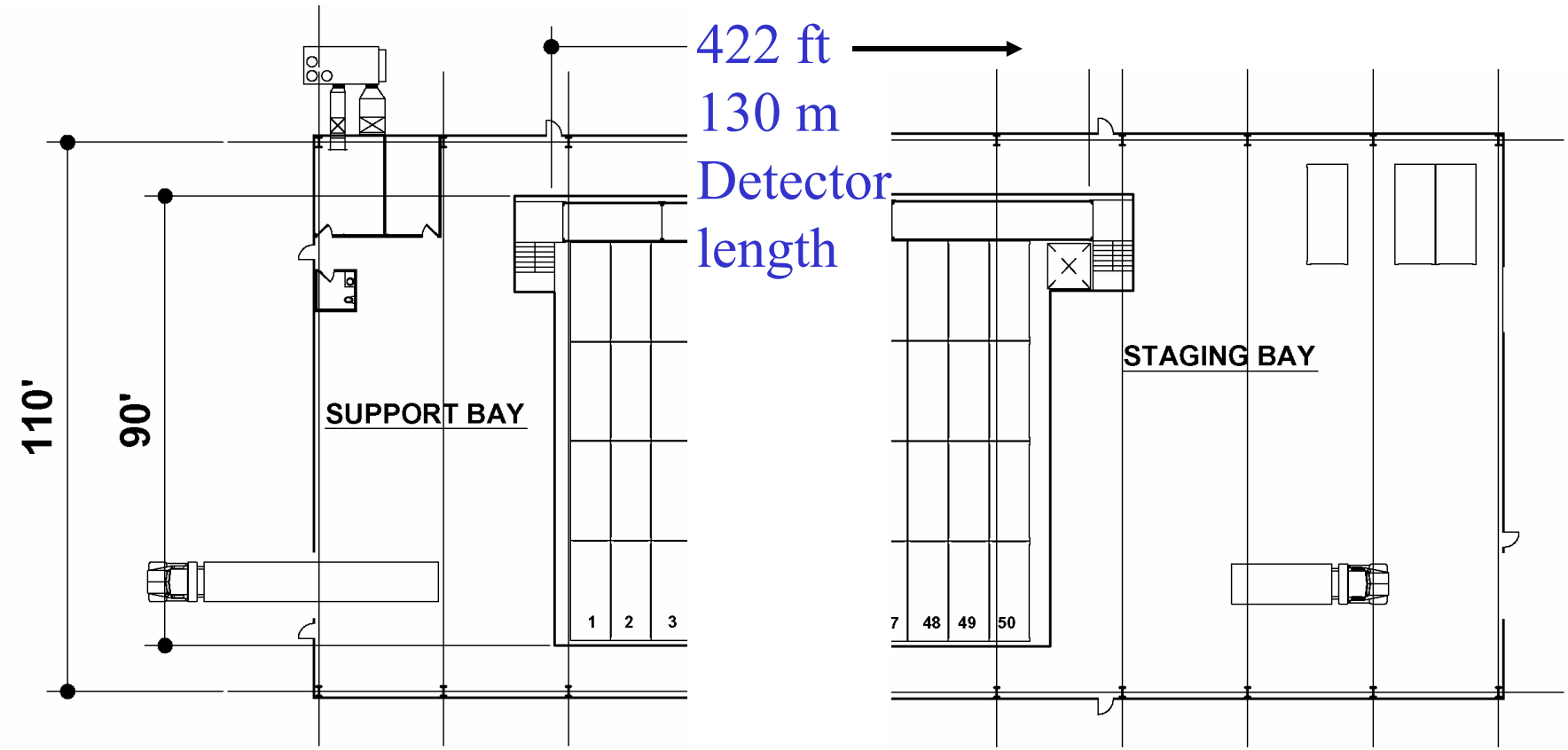


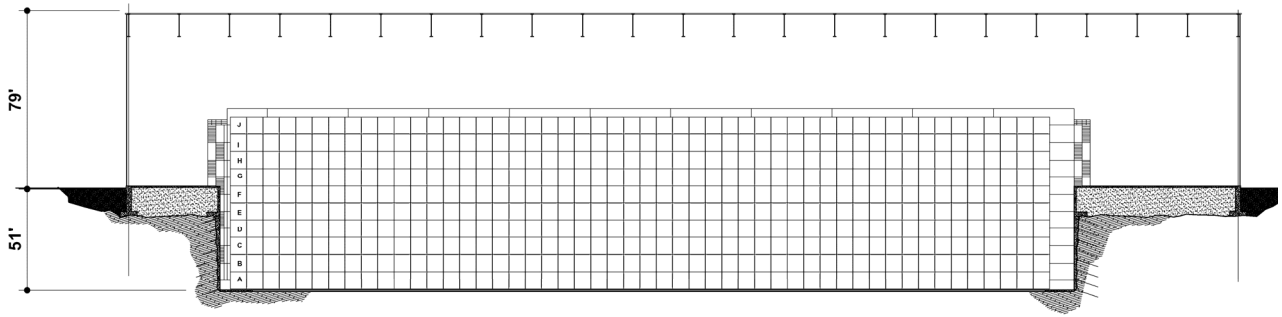
Zoom UP



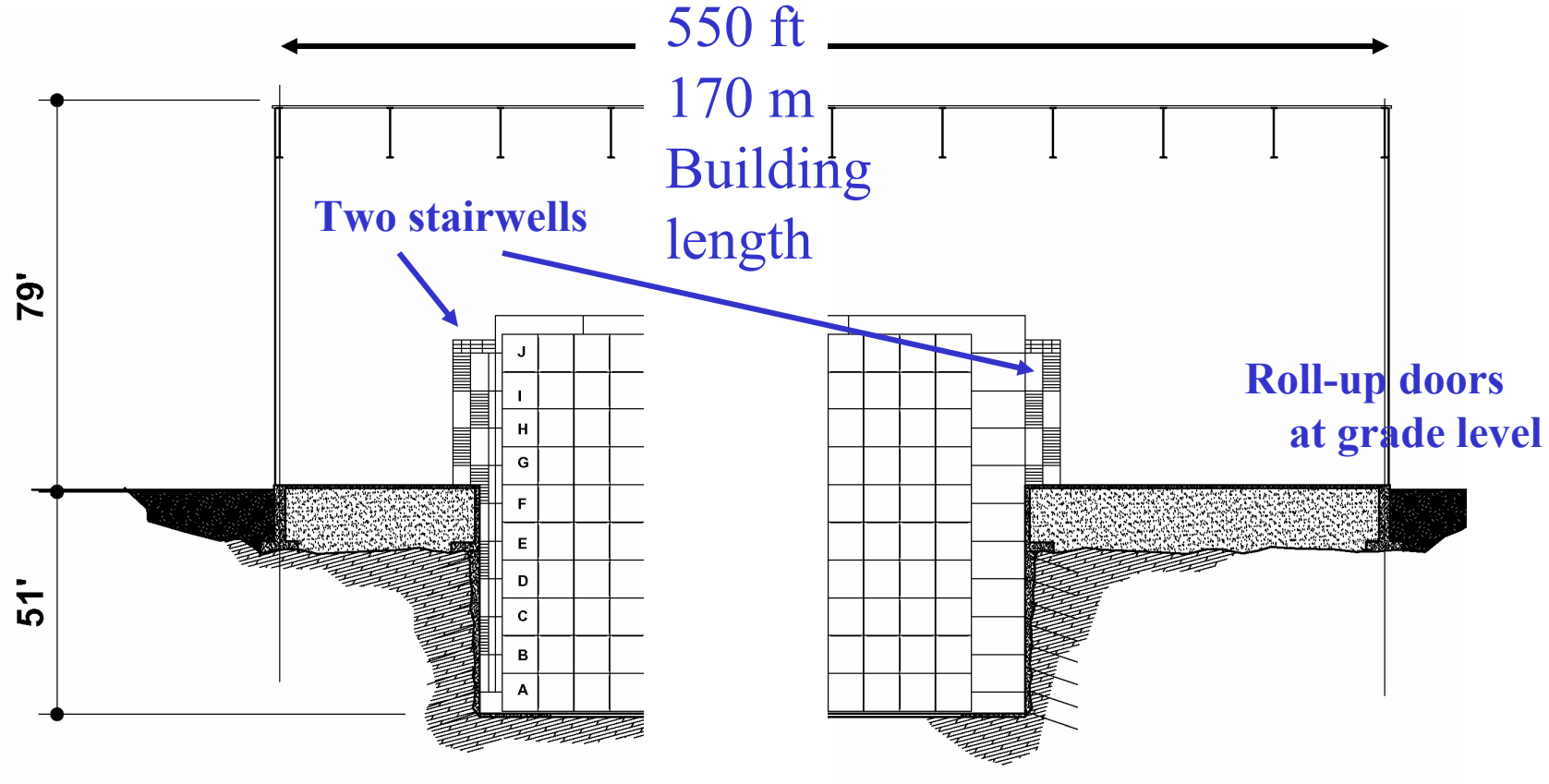
Catwalk on one side

Plan view





Long cross section



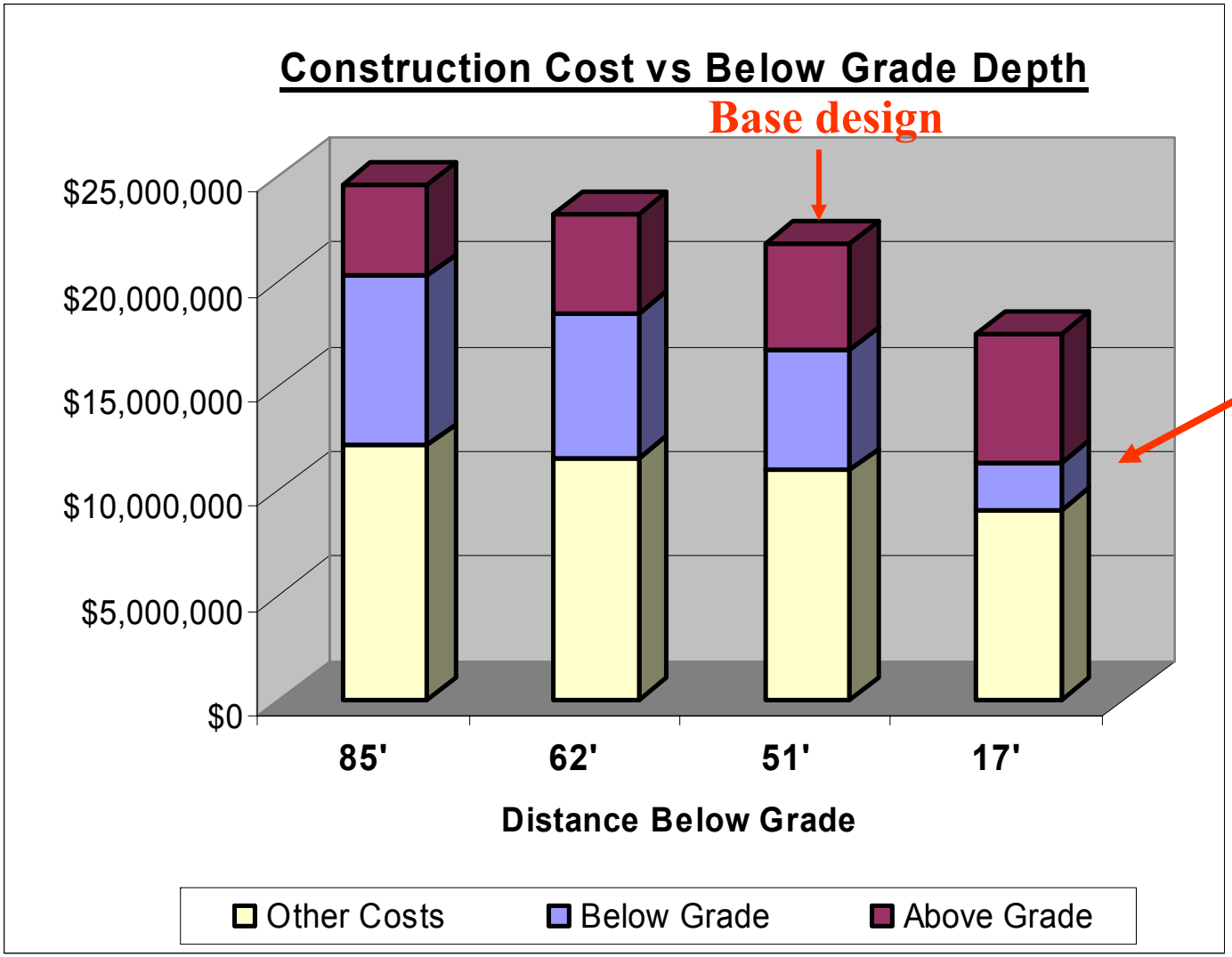
FESS Cost estimate

ITEM NO.							
01							
	01						
	02						
	03						
	04						
	05	Public/Private Road Fees					$0
02		GENERAL CONDITIONS	$2,476,800				
	01	Percentage of Construction Costs		20%	%	$12,384,000	$2,476,800
03		SITE WORK/INFRASTRUCTURE	$1,516,000				
		Includes Sub-tier contractor OH&P 15%	$198,000				
	01	Clear and Grub Entrance Road					
	02	Strip 1' of soil					
	03	Entrance Road Base 1 mile x 30' x 18"					
	04	Entrance Road Paving 1mile x 24' x 4"					
	05	Access Road					
	06	Site Power Pole Line					
	07	Communication Lines					
	08	Strip and grub					
	09	Site Grading					
	10	Gates and Fencing					
	11	Sidewalks					
	12	Construction Hardstands					
	13	Electrical Substation (2000 kVA Transformer)					
	14	Four Way Air Switch					
	15	750 KW Diesel Generator					
	16	Oil Containment					
	17	(2)-5" Electrical Ductbank in Concrete					
	18	3-1/C 750 MCM Conductors					
	13	Water Well (200' deep)					
	14	Water Storage (& Fire) Tank					
	15	Fire Protection Panel (in Building Estimate)					
	16	Sanitary Sewage Holding Tank					
	17	Fire Underground Main					
	18	Envir. Protection - silt fence					
	19	Mine Water Treatment w chemicals					
	20	Settling basin 1/2 acre					
	21	Hydrant + PIV's					
	22	DWS 3"					
	23	Storm Sewer					
	24	Exterior Lighting					
04		BELOW GRADE	$5,739,000				
		Includes Sub-tier contractor OH&P 15%	$749,000				
	01	Excavate Overburden		3			
	02	Haul Overburden Spoils		36500	CY	$3.00	$109,500
	03	Excavate Rock		58175	CY	$38.00	$2,210,650
	04	Haul Muck		87260	CY	$3.00	$261,780
	05	Rock Bolts 5'x5' pattern 10'LG		17000	LF	$6.75	$114,750
	06	Drainage Strips		5600	LF	$8.00	$44,800
	07	Shot Crete W/ WWF 4"		41984	SF	$8.00	$335,872
	08	CIP Slab on Grade		397	CY	$250.00	$99,250
	09	CIP Retaining Wall		1250	CY	$450.00	$562,500
	10	CIP Grade Beam		155	CY	$450.00	$69,750
	11	CIP Piers and Footings		135	CY	$500.00	$67,500

						$350.00	$496,300
						2,000.00	$88,000
						$12.00	$18,000
						$2.00	$73,800
	01	Metal Deck 18 Ga		60500	SF	$1.60	$96,800
	02	Purlins		144	Tons	$2,200.00	$316,800
	03	Trusses		155	Tons	$2,200.00	$341,000
	04	Truss Bracing		3.7	Tons	$2,200.00	$8,140
	05	High Bay Columns		105	Tons	$2,200.00	$231,000
	06	Grits		56	Tons	$2,200.00	$123,200
					Ea	$49,000.00	$98,000
					Tons	$2,200.00	$8,800
					Tons	$2,200.00	$11,000
					SF	$2.10	$127,050
					SF	$0.75	$45,375
					SF	$12.00	$1,190,400
					EA	$14,000.00	$28,000
					EA	$8,000.00	$8,000
					EA	$800.00	$4,800
					Lot	$80,000.00	$80,000
					EA	$7,250.00	$14,500
					EA	$3,500.00	$28,000
					EA	$3,250.00	$3,250
					EA	$650.00	$5,200
					EA	$250.00	$1,000
					Lot	$110,000.00	$110,000
					EA	$35,000.00	$70,000
					Lot	$27,000.00	$27,000
					EA	$12,000.00	$24,000
					Lot	$130,000.00	$130,000
					Lot	$24,000.00	$24,000
					EA	$20,000.00	$80,000
					Lot	$12,000.00	$12,000
					Lot	$17,000.00	$17,000
					Lot	$8,000.00	$8,000
					Ea	$80,000.00	$80,000
					Lot	$4,000.00	$4,000
					Ea	$800.00	$800
					Lot	$75,000.00	$75,000
					Lot	$15,000.00	$15,000
					SF	$6.25	$143,750
					SF	$3.00	$181,500
					EA	$2,400.00	$9,600
					EA	$15,400.00	$30,800
					EA	$3,800.00	$15,200
					EA	$3,200.00	$12,800
					EA	$2,900.00	$11,600
					EA	$2,100.00	$8,400
					LF	$23.00	$4,600
					EA	$420.00	$3,360
	47	Power Distribution		60500	SF	$5.00	$302,500
	48	Unit Heaters		36	EA	$2,000.00	$72,000
	49	Lighting		60500	SF	$1.33	$80,465
	50	Fire Detection		60500	SF	$2.25	$136,125
06		PERMITS, FEES, PS	$6,942,000				
		Bare Construction Costs	$12,384,000				
	01	Environmental Impact Studies & Mitigation		$12,384,000	%	1%	$124,000
	02	Engineering Design, Inspection and Administration		$12,508,000	%	20%	$2,502,000
	03	Management Reserve		$15,010,000	%	25%	$3,753,000
	04	Indirect Costs		$18,763,000	%	3%	$563,000

- 94 line estimate
  - 12,384 K $ construction costs
  - 134 K $ Environmental
  - 2,477 K $ General Conditions
  - 2,502 K $ EDIA
  - 563 K $ indirect costs
- 18,050 K $ Subtotal
  - 3,753 K $ contingency (25%)
- 21,803 K $ TOTAL

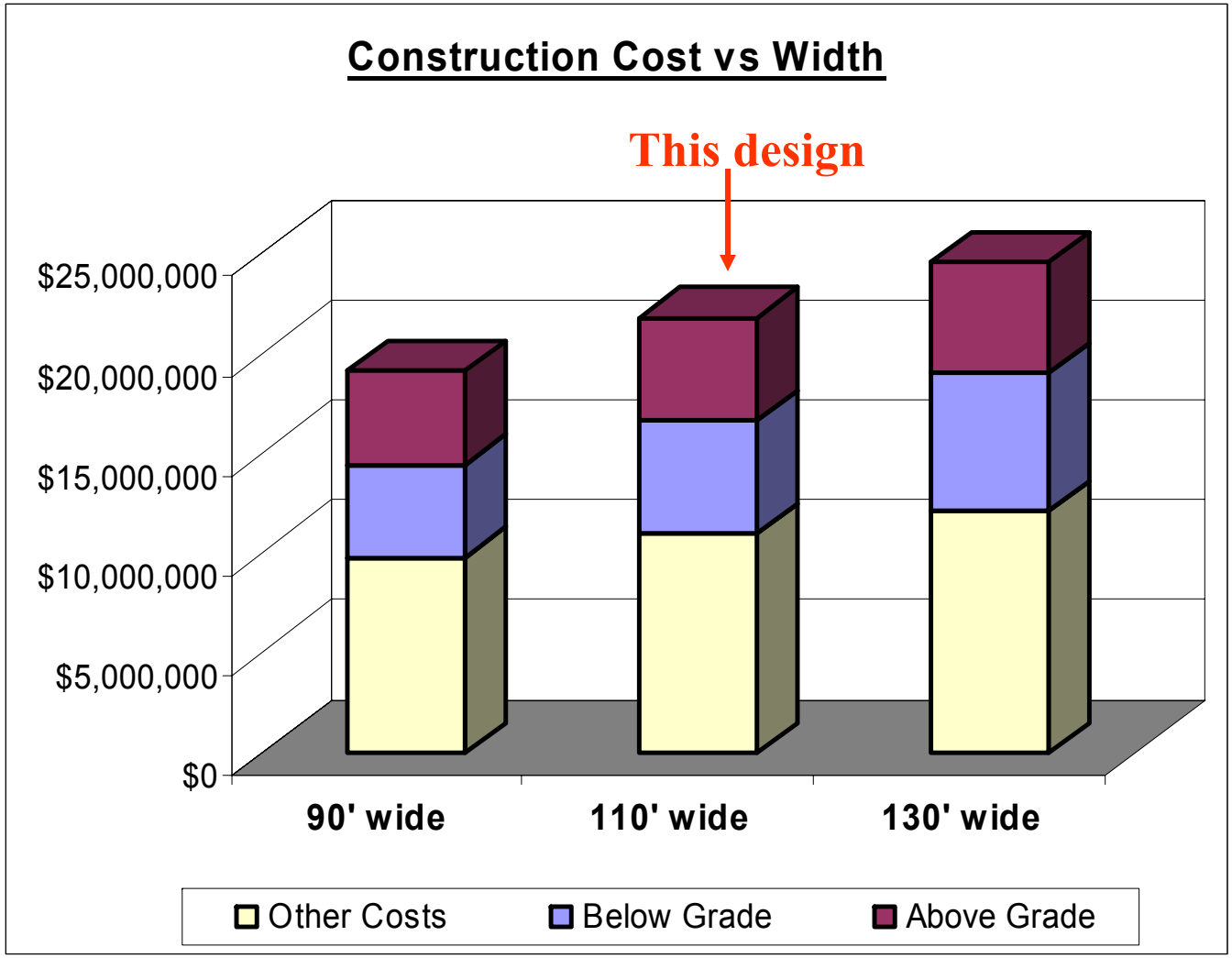
Our prejudice was 50/50 (above/below grade) would be most cost effective. **Not true**



Excavate just to bedrock is cheapest

Scaling with width

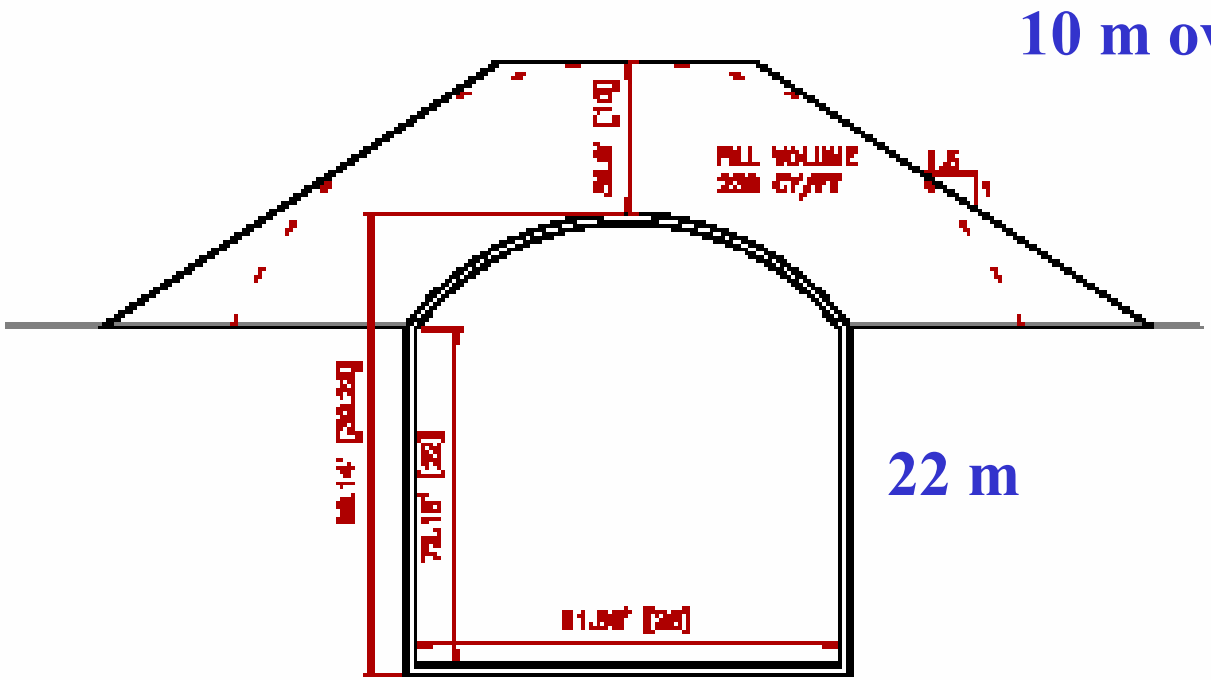
for schemes needing more width to load detectors
or just for a wider detector

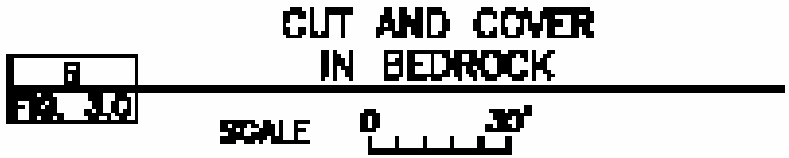


Very linear

CNA building

described by Marvin Marshak at SLAC





CNA building

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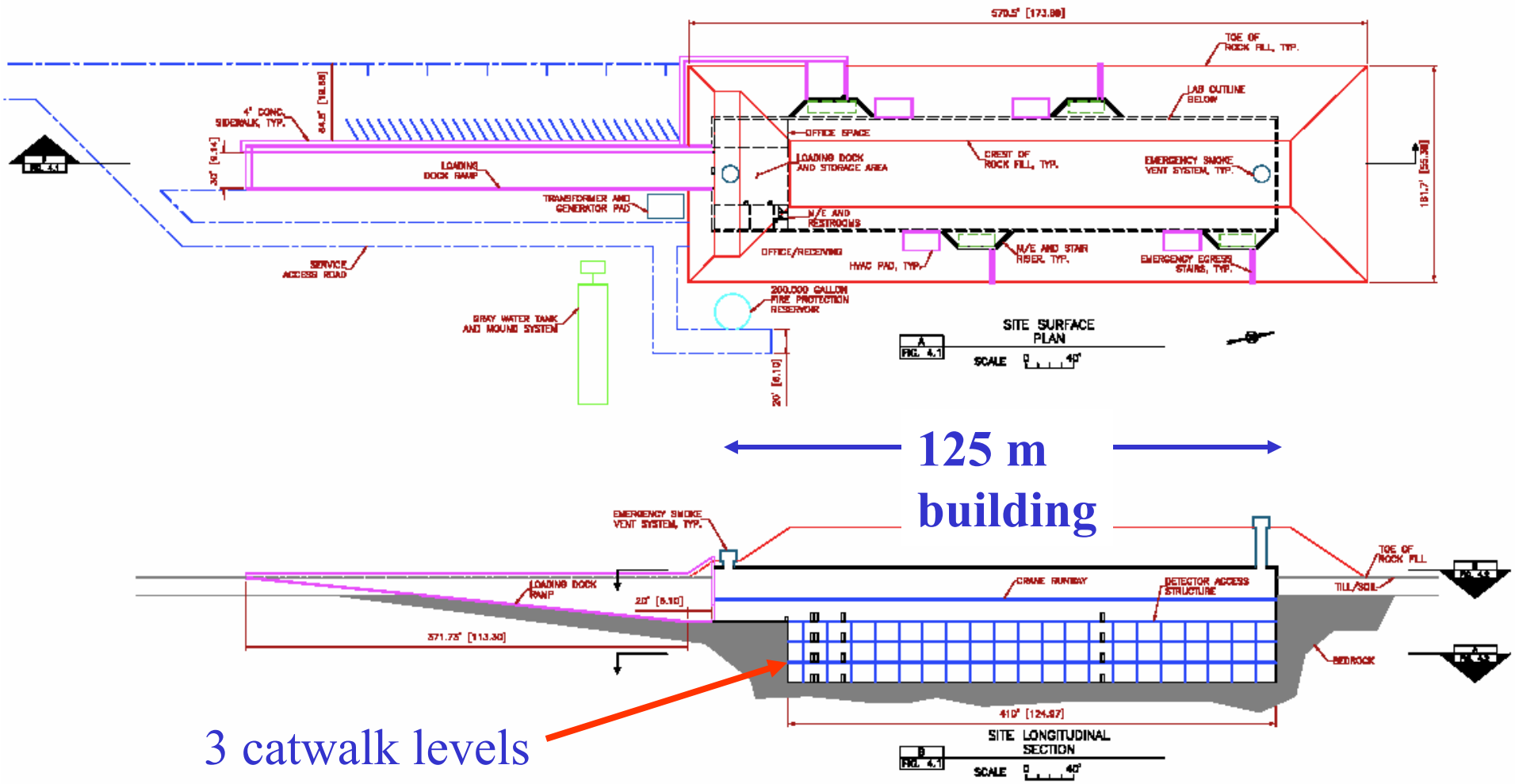
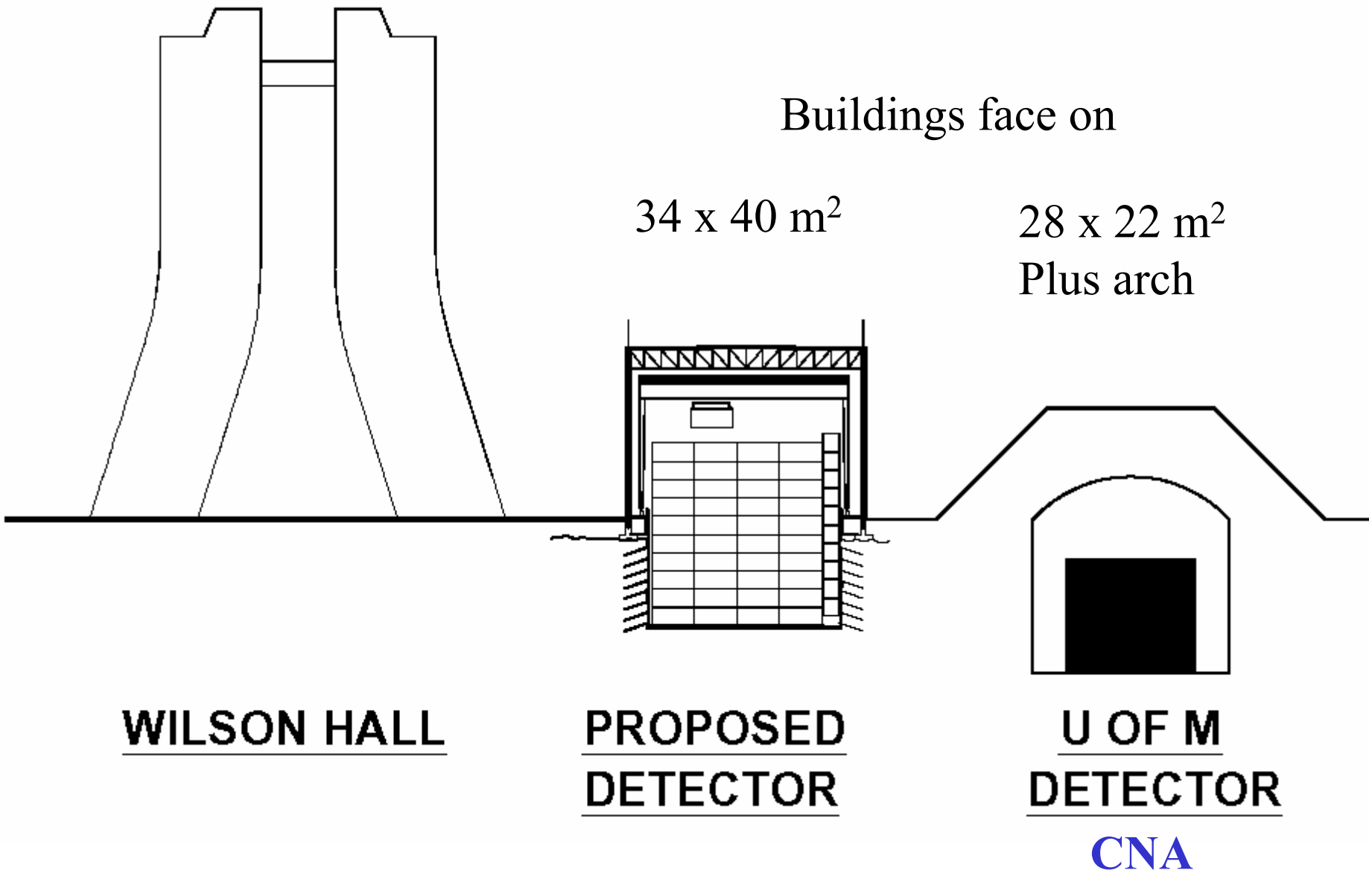


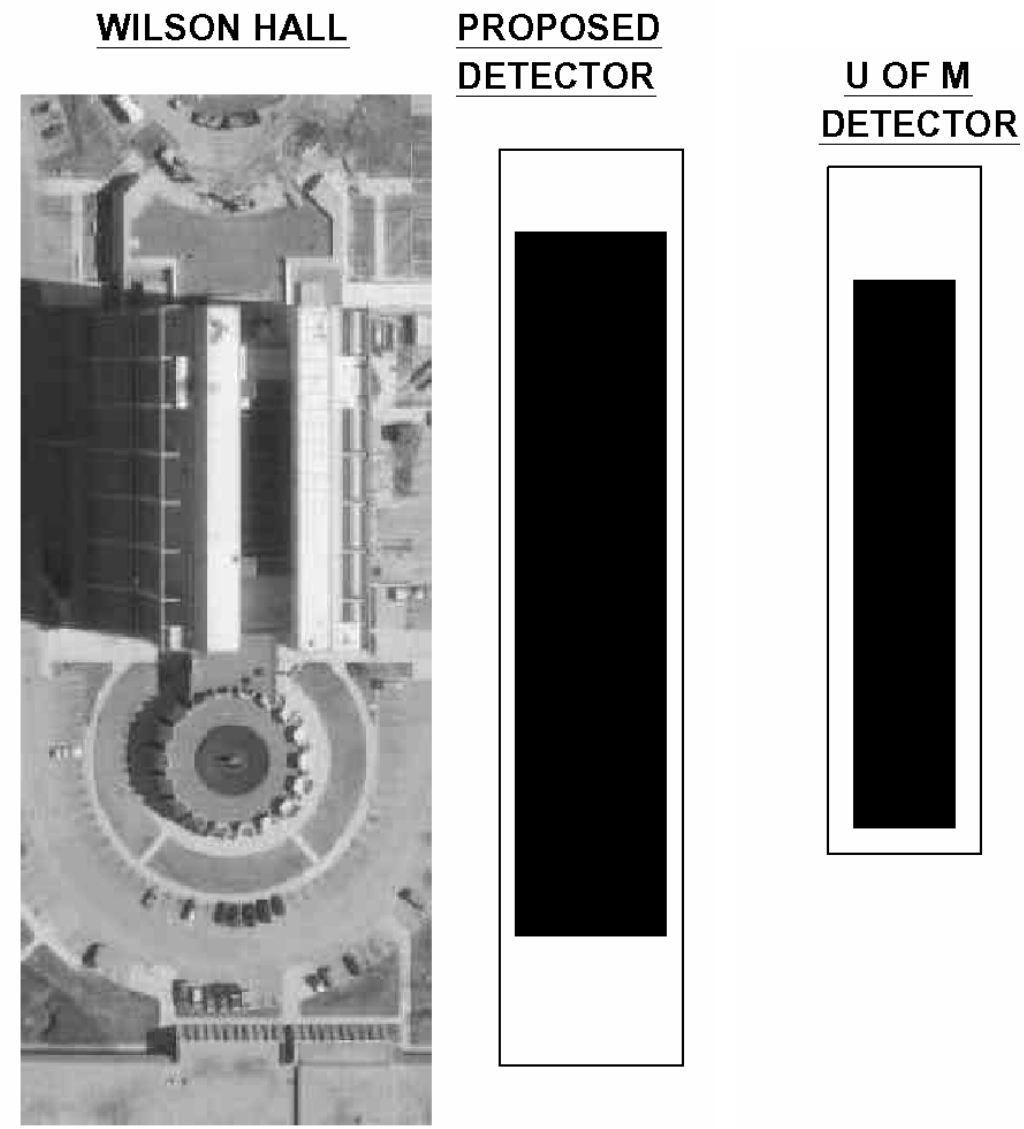
Compare Fermilab to CNA

- First, just compare a **"surface" building**
- CNA got a surface design
  from Miller-Dunwiddie Architects
  - 13,474 K $
  - For a 28 m by 22 m by 100 m building
  - Subtract 1,670 K$ for catwalks not in Fermilab design
  - Subtract about 1,000 K$ for office space, HVAC (72+-5 F)
  - To get 10,804 K$ + 25% contingency = **13,505 K$**
- The Fermilab building is 34 m by 40 m by 170 m
  - Scale to surface, scale width, scale length
  - 9,984 K $ + 25% contingency = **12,060 K$**
- **12% difference – I declare this to be a success**
- **So try to get the overburden / no overburden difference**

Beam View


Buildings face on
34 x 40 m²
28 x 22 m²
Plus arch
WILSON HALL
PROPOSED DETECTOR
U OF M DETECTOR
CNA

Plan View



Building surface areas

Fermilab 34 x 170 m^2

CNA 28 x 125 m^2

Compare CNA & Fermilab Buildings

- **CNA / Minnesota**
- Detector width 20 m
- Structure width 28
- Detector height 20 m
- Structure height 22 m,
  22 m in bedrock
- Detector length 100 m
- Structure length 130 m
- Overburden 10 m

- Structure footprint area 3,500 m^2
- Detector volume 40,000 m^3
  - (about 20 Kton)
- Structure volume 79,400 m^3
- **Cost 27.0 M$**
  - Scale by detector volume? (* 2.4)
  - **To get 64.8 M$??** **Not quite**

- **Fermilab**
- Detector width 28 m
- Structure width 34 m
- Detector height 26 m
- Structure height 40 m,
  15.6 m in bedrock
- Detector length 130 m
- Structure length 170 m
- No Overburden, but also deep

- Structure footprint area = 5,780 m^2 (*1.65)
- Detector volume 94,640 m^3 (* 2.37)
  - (50 Kton) (*2.50)
- Structure volume 231,200 m^3 (* 2.91)
- **Cost 21.8 M$**

Adjustments to both

- Fermilab used $38 /cubic yard for excavation of 58,175 CY

UNIT PRICE ANALYSIS FOR ROCK EXCAVATION

Cost Data from Cost Works program by RS Means, copyright 2003
(1st Quarter 2003 update)

Total cost used in estimate for rock excavation,
not including hauling = $38.00

Drill and Blast only, Deep hole method over 1500 cy =	$29.50 / cy
Excavate and load blasted rock into muck bucket =	$1.33 / cy
Clamshell at 20 cy/hr (plus 15% if loading into trucks) =	$7.13 / cy
Total =	**$37.83 use $38.00 / cy**

The excavation section did not have a listing for a crane and a muck bucket, so it was reasoned that a clamshell would approximate the cost for a crane and muck bucket.

- CNA used $ 10 /CY
- Makes a big difference, so must adjust one or the other

More adjustments

- **Subtract**
  - 1.67 M$ from CNA for catwalks not in Fermilab estimate
  - 0.25 M$ for crane in CNA.
    - Different detectors need very different cranes anyway?
    - CNA 10 T, Fermilab needs 30 T
  - 0.36 M$ for Office space not in Fermilab estimate
    - » And multiply by 1.25 cont., 1.2 conditions, 1.2 EDIA
- **Add** to CNA estimate for the excavation
  - First scale up by detector volume since all underground, factor of 2.37
  - Then add increased cost per unit volume of ($38- $10) for 94,640 m^3 = about 119,000 CY = 3.33 M$
    - » And multiply by 1.25 cont., 1.2 conditions, 1.2 EDIA
    - » Net of 6.0 M$

“Final” comparison

- CNA at 27 M$
  - - 4.1 M$ for items not in Fermilab estimate
  - Then (27.0 - 4.1)*2.37 = 54.3 M$
  - Then add excavation cost differential of 6.0 M$
- **Net is**

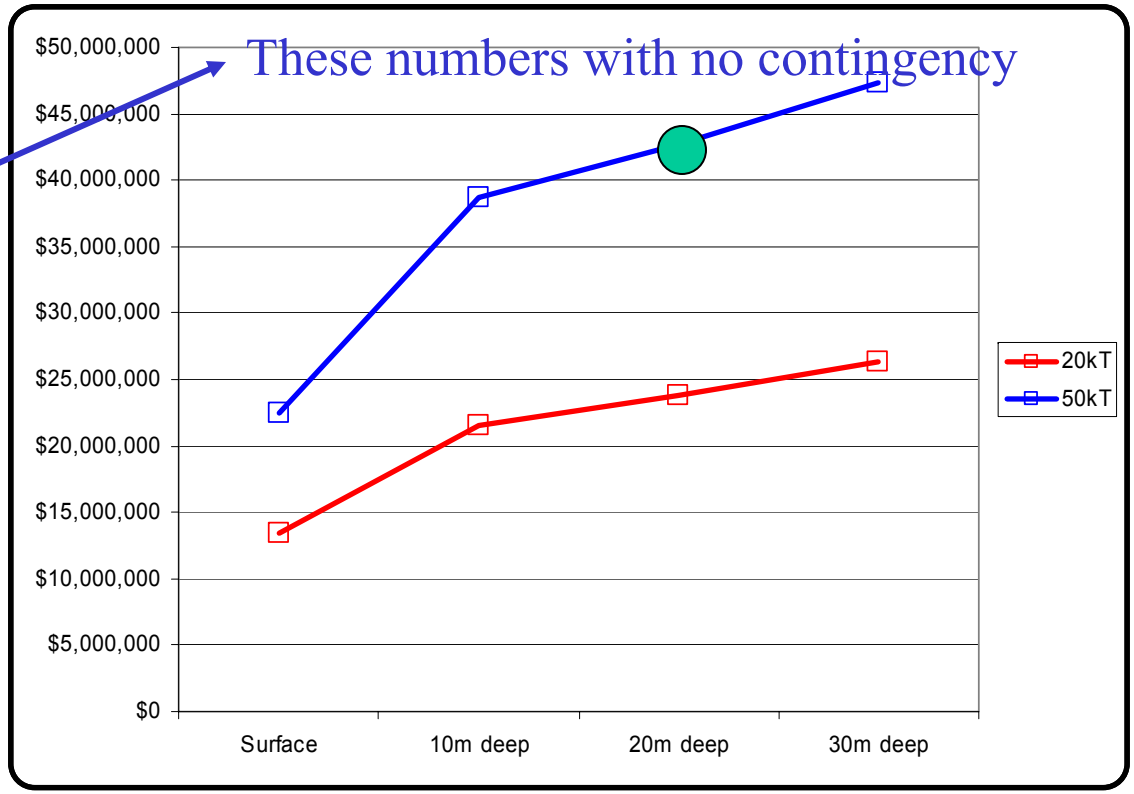
  CNA at 60 M$

  vs.

  Fermilab at 22 M$
  - **Ratio is 2.7**
- **The extra $ gets TWO things**
  - **10 m overburden**
  - **HVAC with 72 +- 5 deg F**

Cross check from Earl Peterson

- Earl scaled the CNA estimate from 20 kton to 50 kton
- At 20 m deep he gets about 42 M$ * 1.25 = 53 M$
- But this would compare to Fermilab with the <u>cheaper</u> excavation cost, 22 M$ → 19



- Ratio is 2.8, so again I declare victory (for both of us) !

By now you probably forgot the totals

- **Our best attempt at apples to apples estimates on Building costs are:**

  – 20 m down with 10 m overburden @ **53 – 60 M$**
  – 16 m down with no overburden @ **19 – 22 M$**
  – On the surface, no overburden @ **12 – 13.5 M$**

  – **All with 25% contingency**

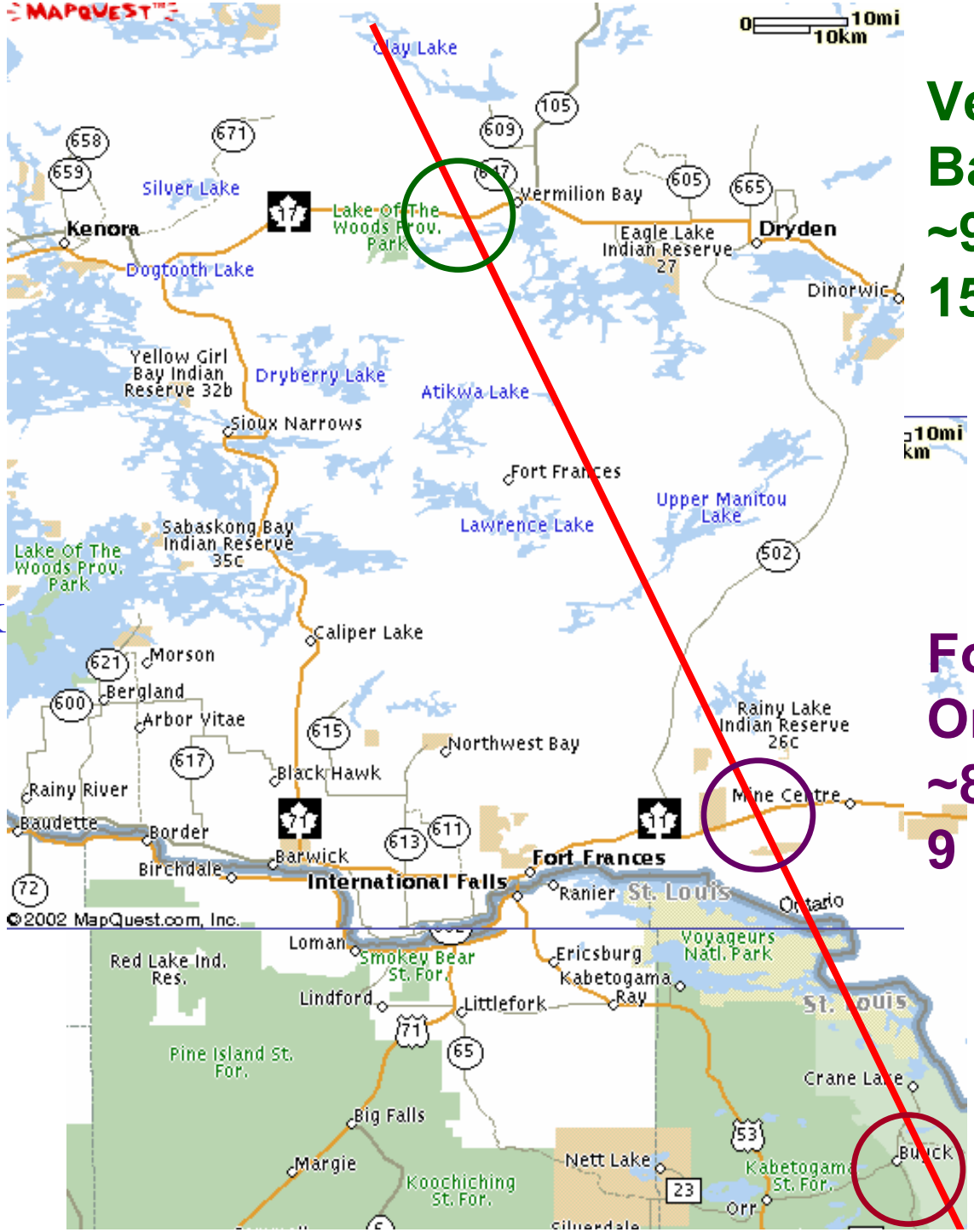
Enough of that, what about Infrastructure?

- The building estimates include
  - Fire protection, including water storage
  - Restrooms, potable water
  - Modest (short) access roads
- But nothing on
  - Power, except a substation
  - Land costs
  - …..
  - And we will have to work these things out eventually, but they are site dependent
- **So let's remind ourselves of the sites studied so far**

5 sites have been looked at:

	Distance (km)	**Off-Axis** (km)
Vermilion Bay, Ontario	**950**	**15.6**
Fort Frances, Ontario	**875**	**9**
Ash River, Minnesota	**812**	**11.8**
Buyck, Minnesota	**774**	**9.3**
Cliffs-Erie, Minnesota (LTV)	**712**	**10.5**

Many more map details in J. Urheim's London talk and Marvin Marshak's SLAC talk



Vermilion Bay, Ontario ~950 km, 15.6 km up

Fort Frances, Ontario ~875 km, 9 km up

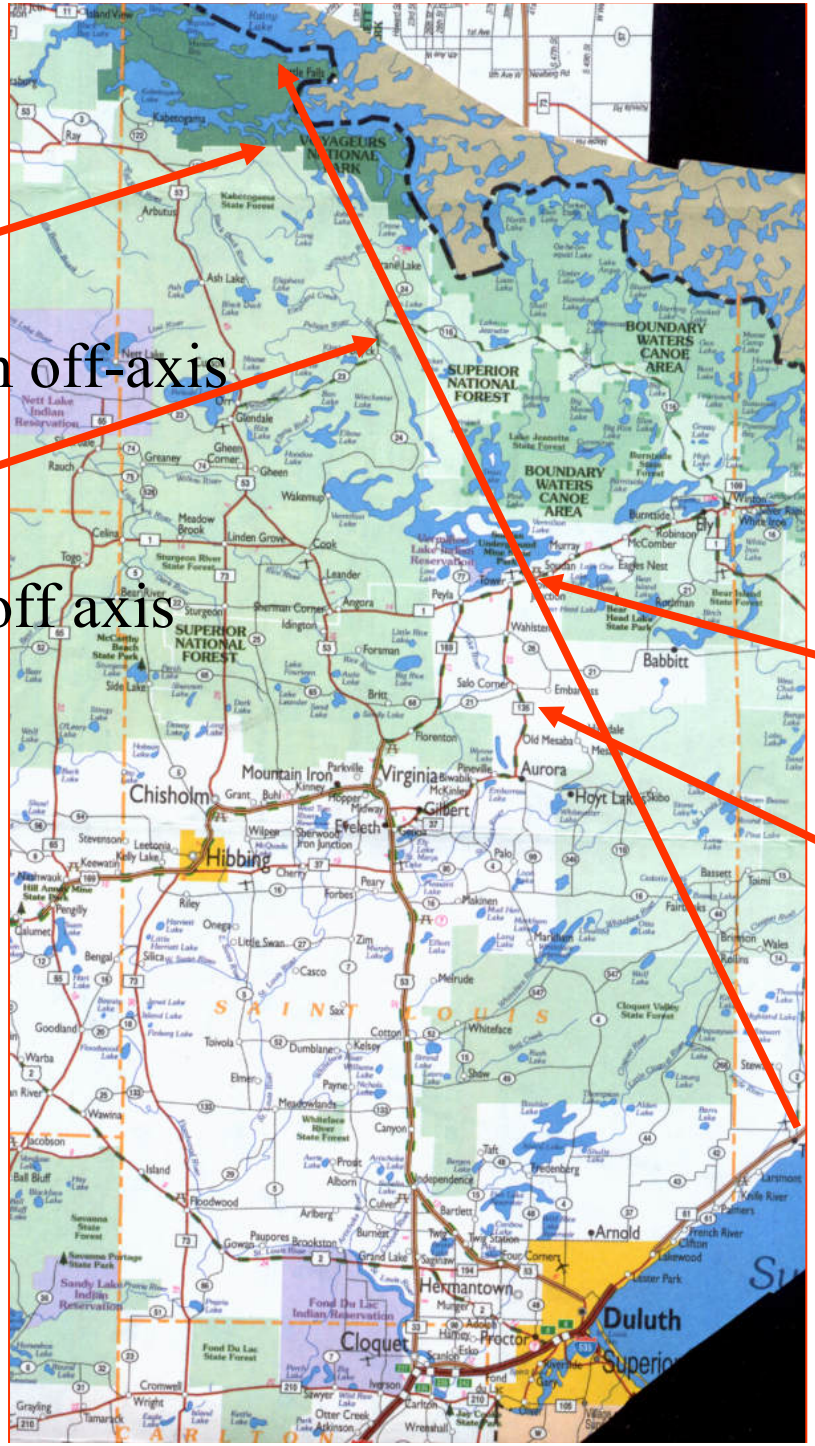
Buyck, MN 775 km, 2 km up

Ash River

812 km, 11.8 km off-axis

Buyck

774 km, 9.3 km off axis



Soudan

Cliffs-Erie

712 km,
10.5 km off-axis

To provoke Site Discussion:

- **Politics**
  - Cliffs-Erie is easiest, but shortest baseline
  - If in Canada, maybe Canadian funds, otherwise…

- **Next step(s)**
  - Based on discussion here concentrate on only two?
  - Most northern US, most northern Canada?