

Preserving Reality: LiDAR + VR = Time Travel?



Ross Tredinnick

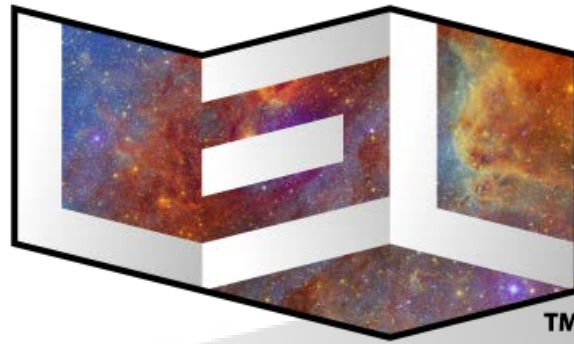
Living Environments Laboratory

WID Discovery Seminar Lunch Series

May 13th 2016

Outline

- **LEL Research**
- **LiDAR & VR + History**
- **Displaying LiDAR data with VR technology**
- **Other Applications**
- **Future Directions**
- **Questions**



Advance the field of Virtual Reality

**Collaboration through Immersive Scientific /
Information Visualization**

**Visualize any home to help in advancing home
health care & home health care technology**



- **AHRQ (Agency for Healthcare Research & Quality) Funded 5 Year Project - 2.5 million**
- **20 LiDAR scans of homes with people having self-reported diabetes: Fall 2014-Spring 2015**
- **Repeated study of the homes using the LiDAR data + VR CAVE.**
- **How does home context affect personal health information management (PHIM)?**

VR? LiDAR?

- **VR = Virtual Reality**
 - Interacting with technology that mimics your own senses towards the point that you can't distinguish between the two
- **LiDAR = Light Detection and Ranging**
 - Surveying laser technology to measure distances
 - Originally Light + Radar
 - Also referred to as “Laser Scanning”

VR - Sensorama

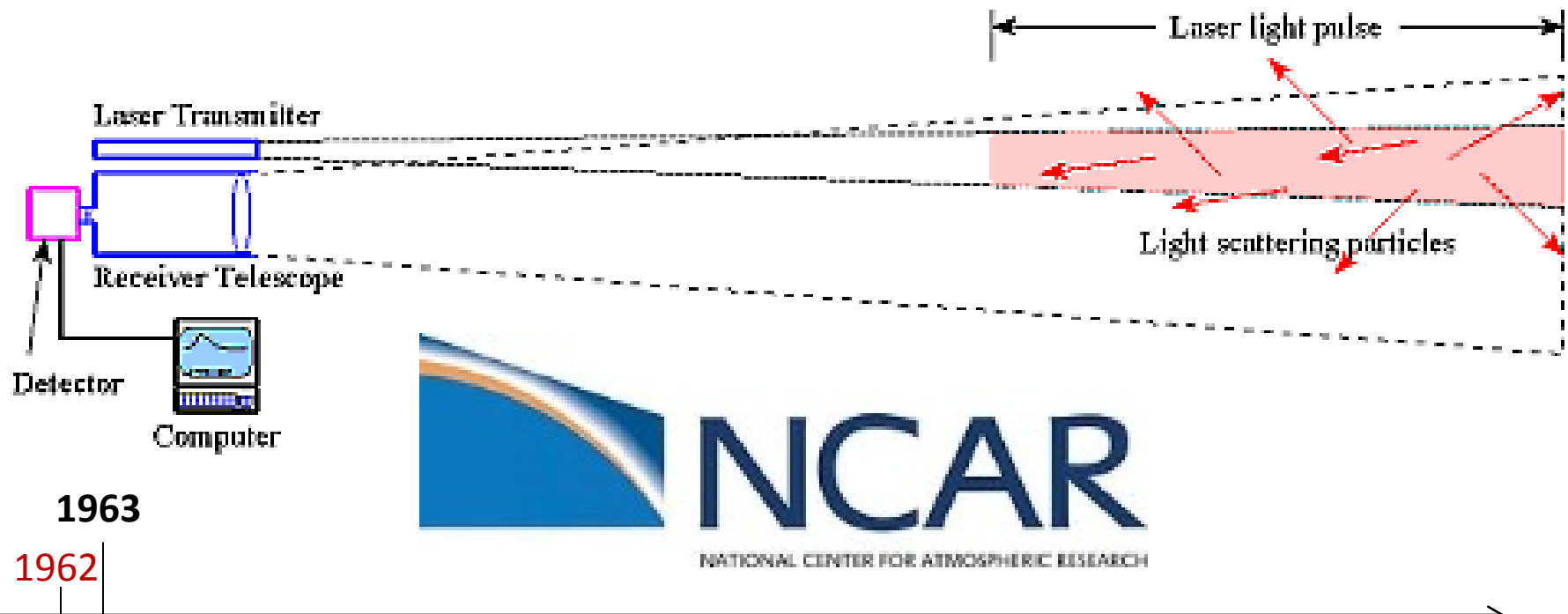


Heilig, M. (1998, January). Beginnings: sensorama and the telesphere mask.
In *Digital illusion* (pp. 343-351). ACM Press/Addison-Wesley Publishing Co..

1962

LiDAR – First Use Cases

- **Meteorology – measuring clouds and atmospheric gases.**



VR - First Research HMD



Sutherland, Ivan E. "The ultimate display."
Multimedia: From Wagner to virtual reality (1965).

- Ivan Sutherland's "Sword of Damocles" HMD

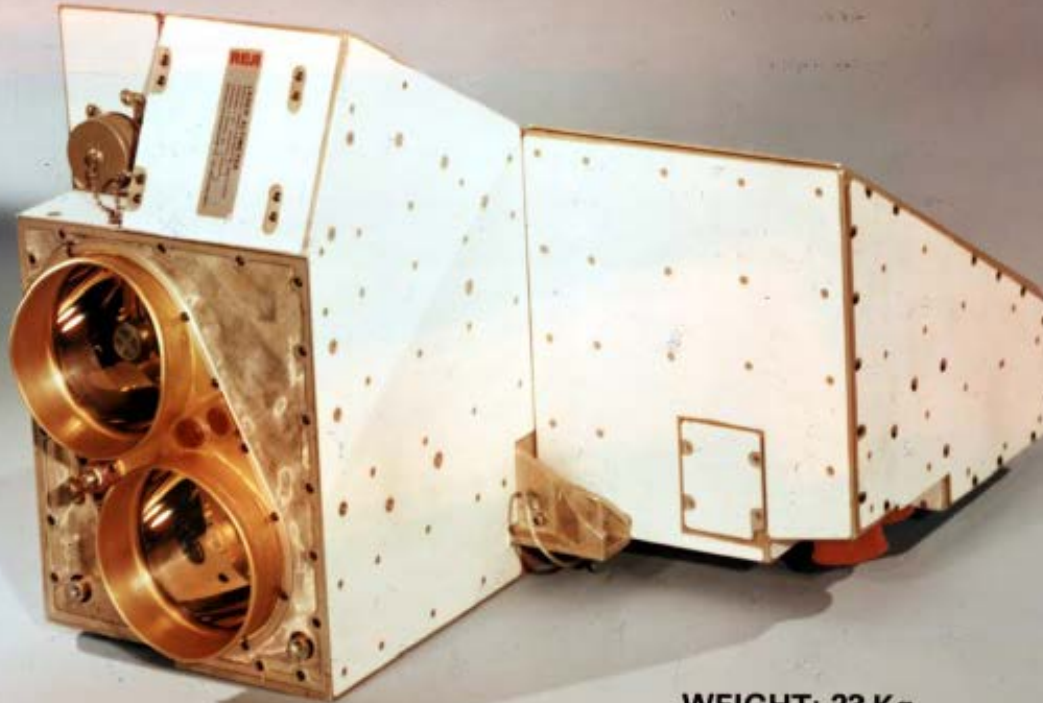




First Space Lidar: Apollo Laser Altimeter (1971)



FLIGHT QUALIFIED LIDAR SYSTEM



WEIGHT: 23 Kg
POWER DISSIPATION: 60 WATTS
TRANS/REC. APERTURES: 10 cm

Laser transmitter:

- Mechanically Q- switched ruby laser
- Flashlamp pumped
- Based on mil-qualified rangefinder for tank
- 0.05 Hz laser firing rate
- RCA Astronautics
- Flown on Apollo 15-17



1963

1968

1962

1971

Virtual Reality & First Consumer HMD



- **EyePhone 1 - \$9,400, EyePhone HRX = \$49,000, Gloves = \$9,000**

Teitel, Michael A. "The EyePhone: A head-mounted stereo display." *SC-DL tentative*. International Society for Optics and Photonics, 1990.



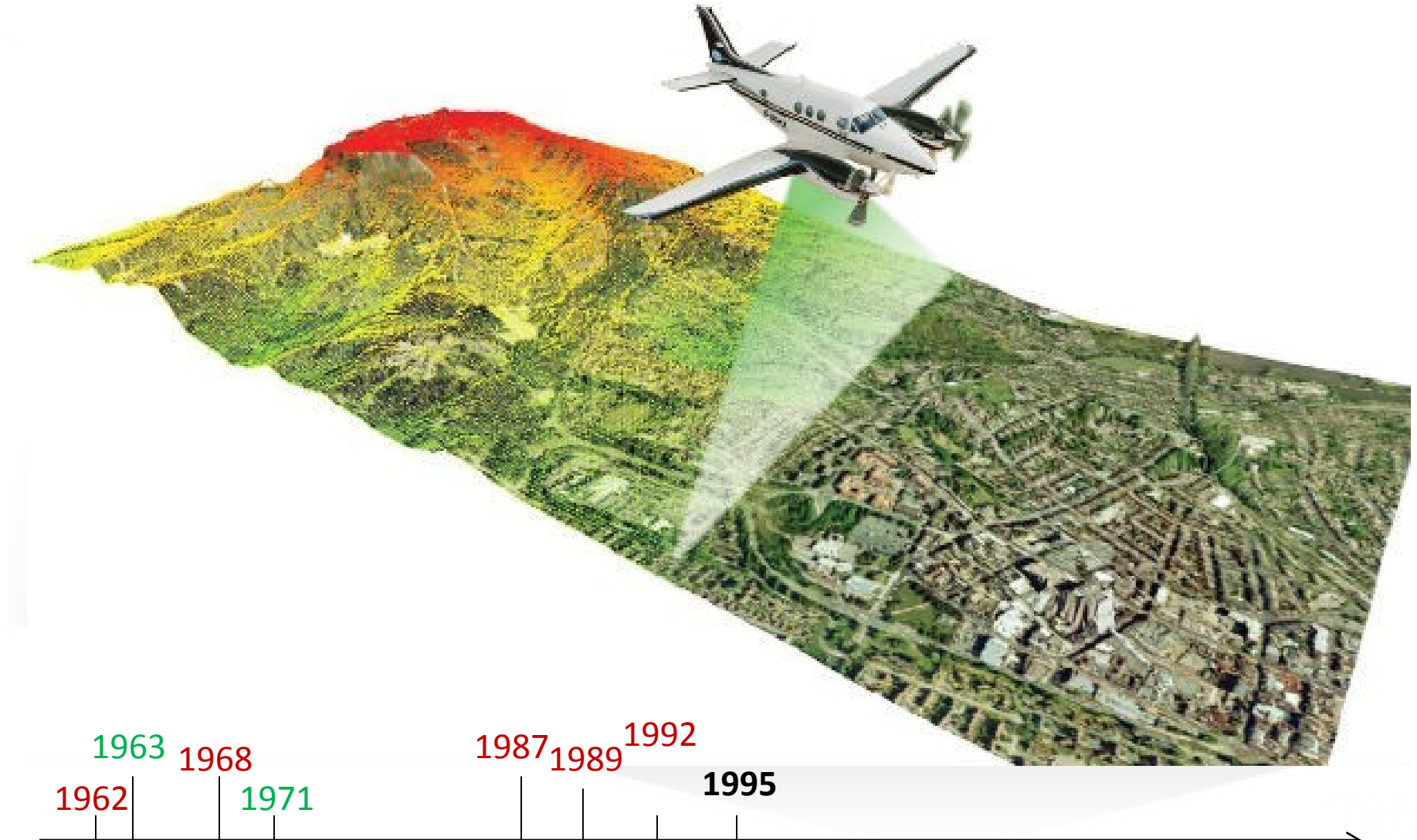
VR - First CAVE



Cruz-Neira, C., Sandin, D. J., DeFanti, T. A., Kenyon, R. V., & Hart, J. C. (1992).
The CAVE: audio visual experience automatic virtual environment.
Communications of the ACM, 35(6), 64-73.



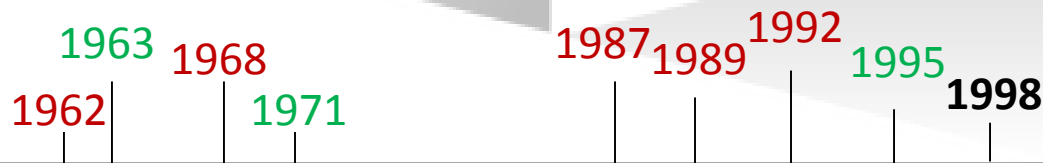
Aerial LiDAR



First Consumer Terrestrial LiDAR



Photo: RIEGL Timeline Pulsed Laser
Radar and Laser Scanning Since 1968

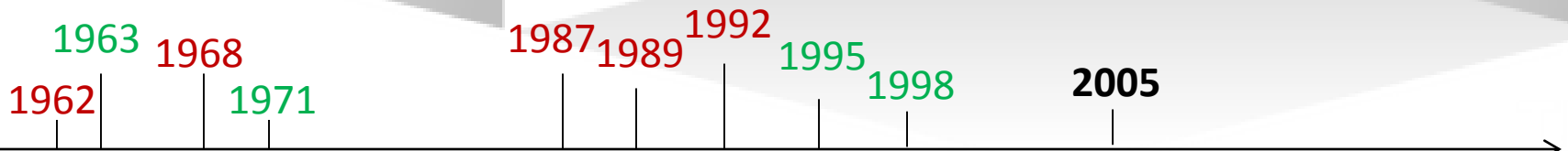


VR – For Comparison...

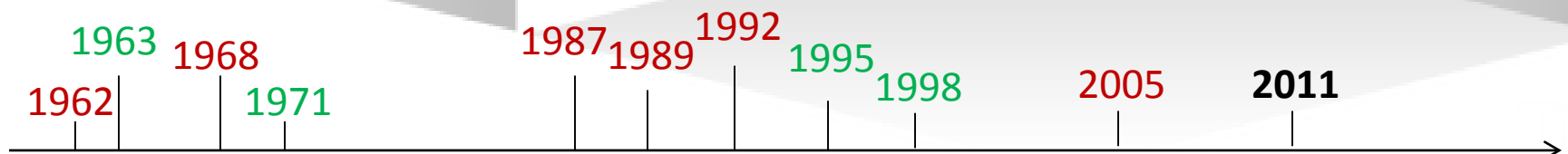
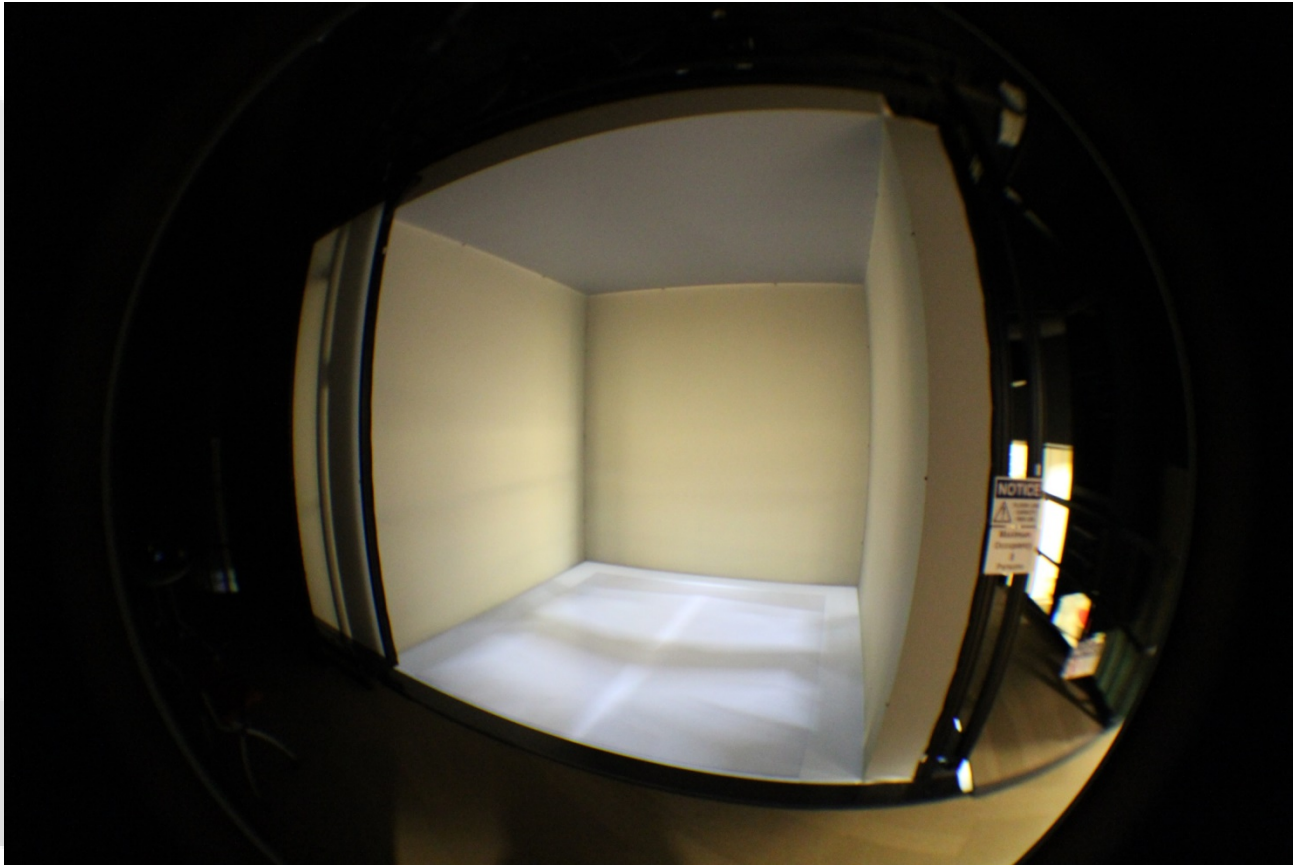


- nVis nVisor SX HMD - \$24,000
- + HiBall Tracking System - \$50,000

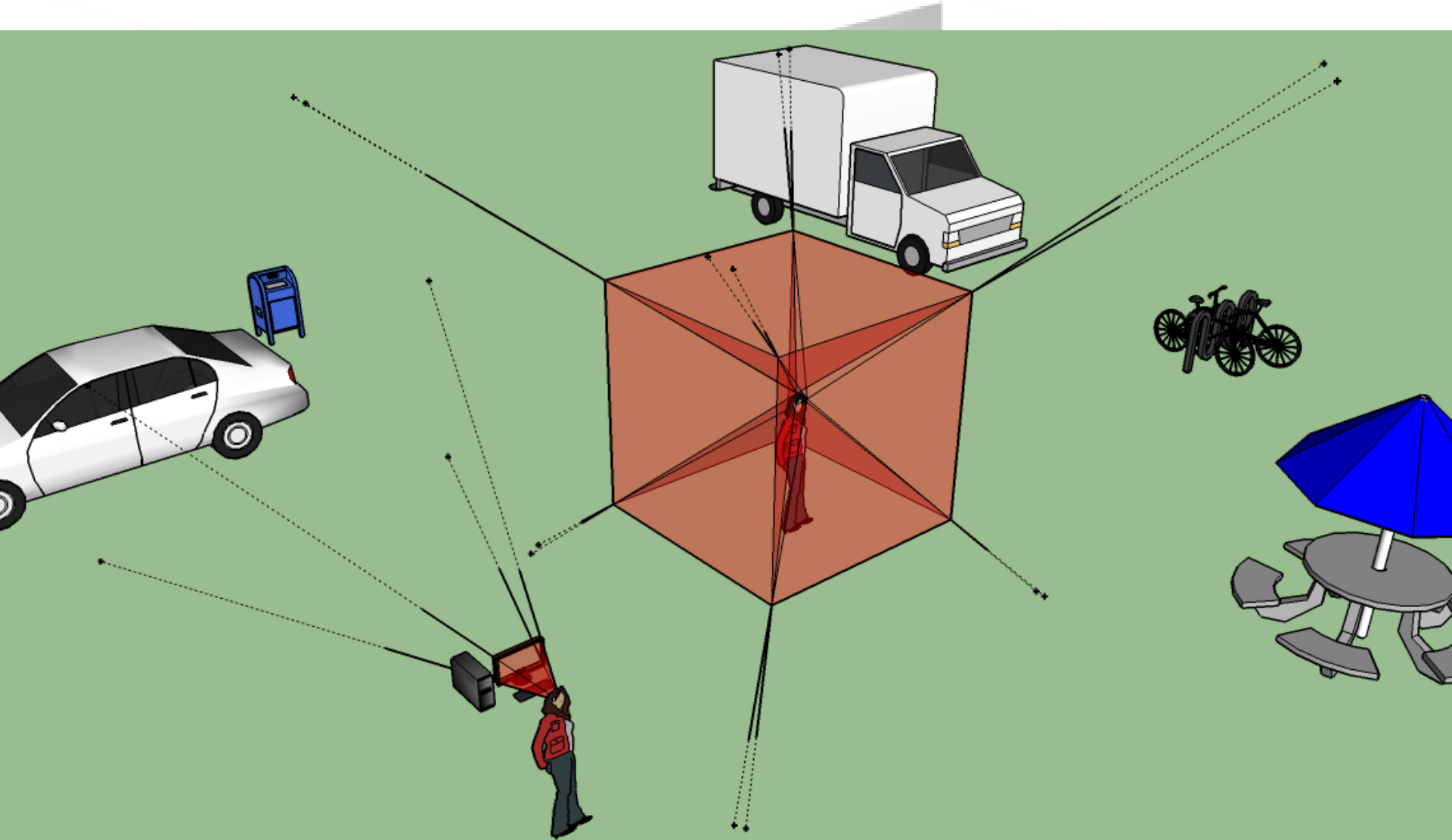
<http://www.slideshare.net/marknb00/2013-lecture3-ar-tracking>



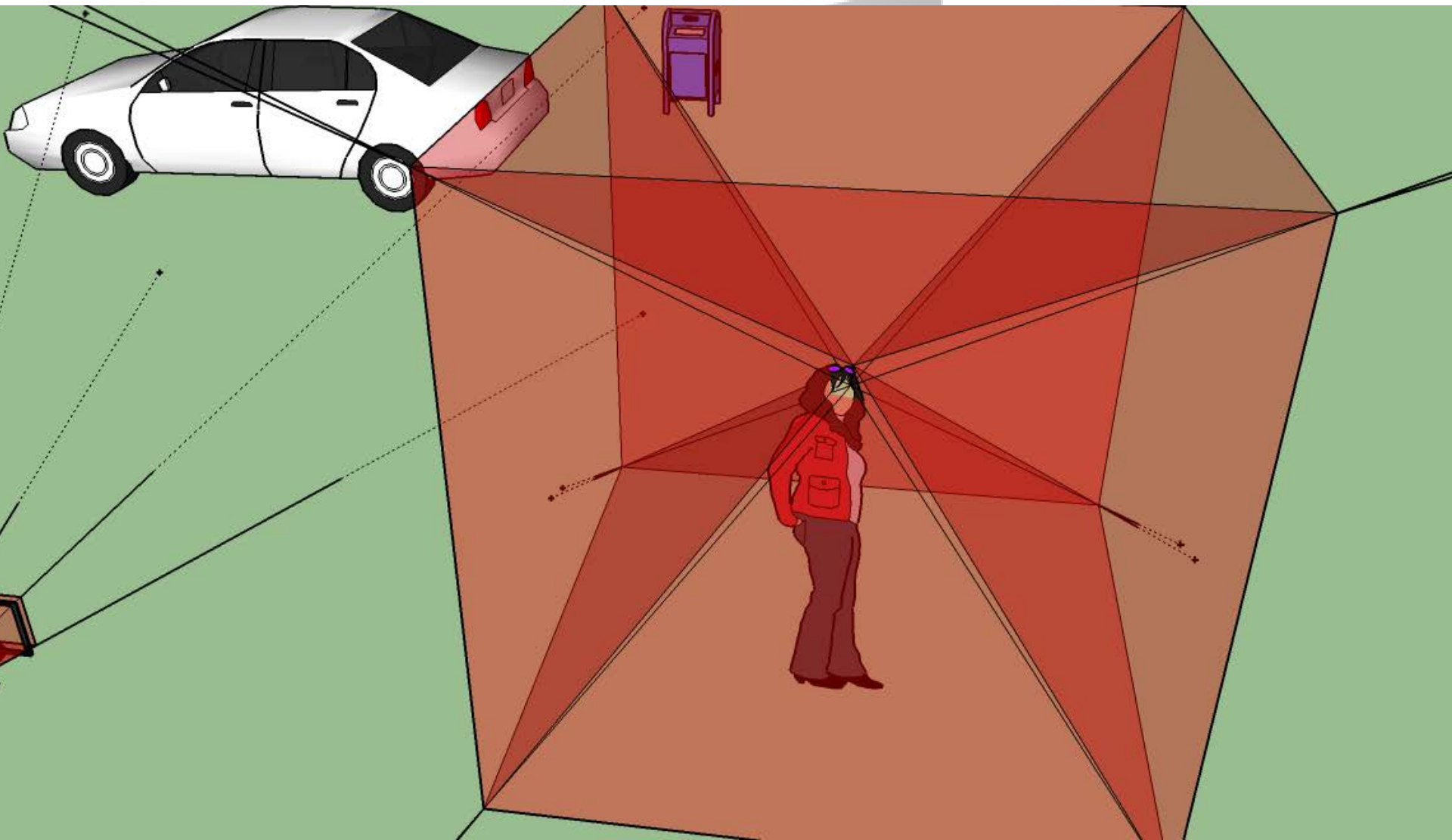
LEL CAVE



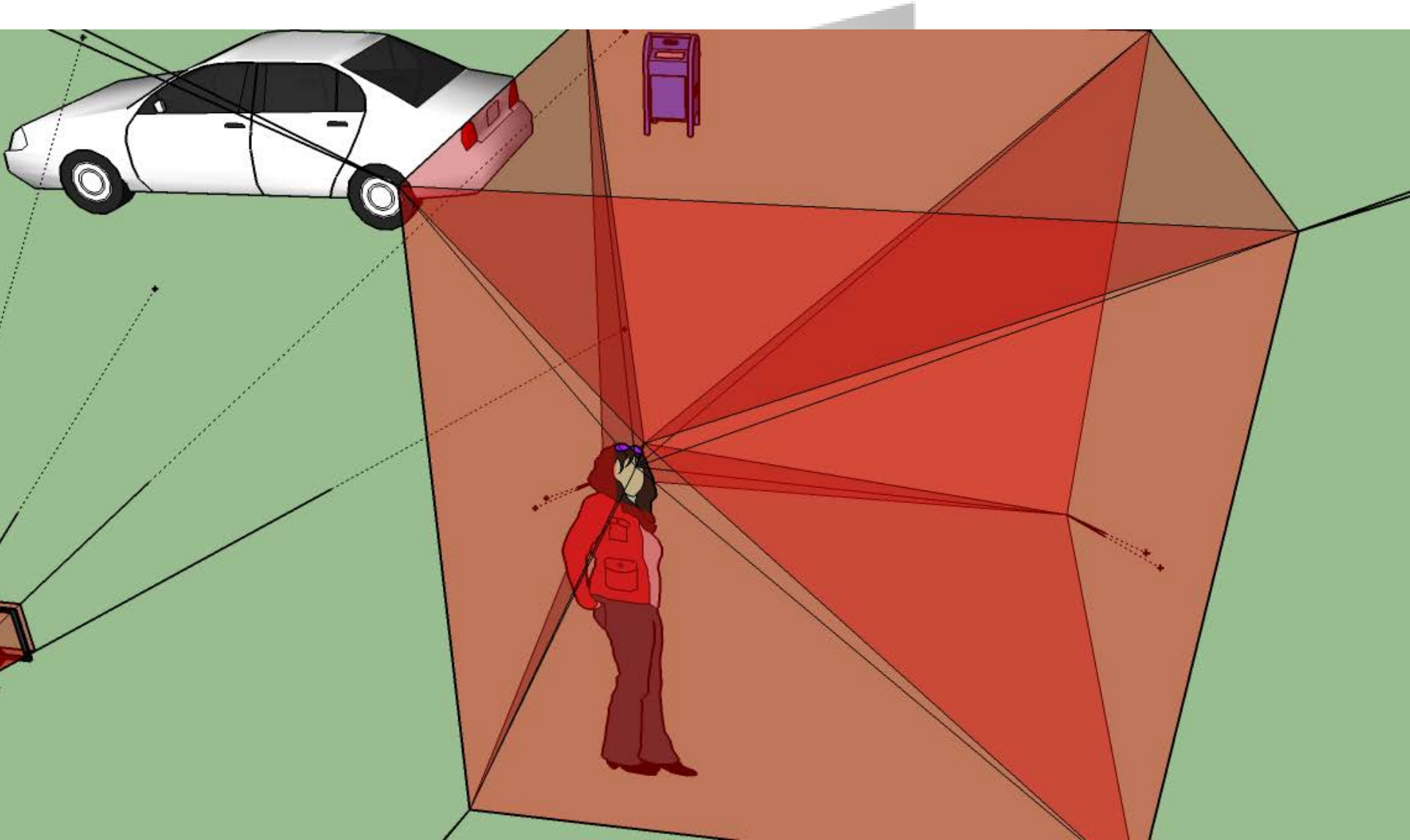
Cave Explanation



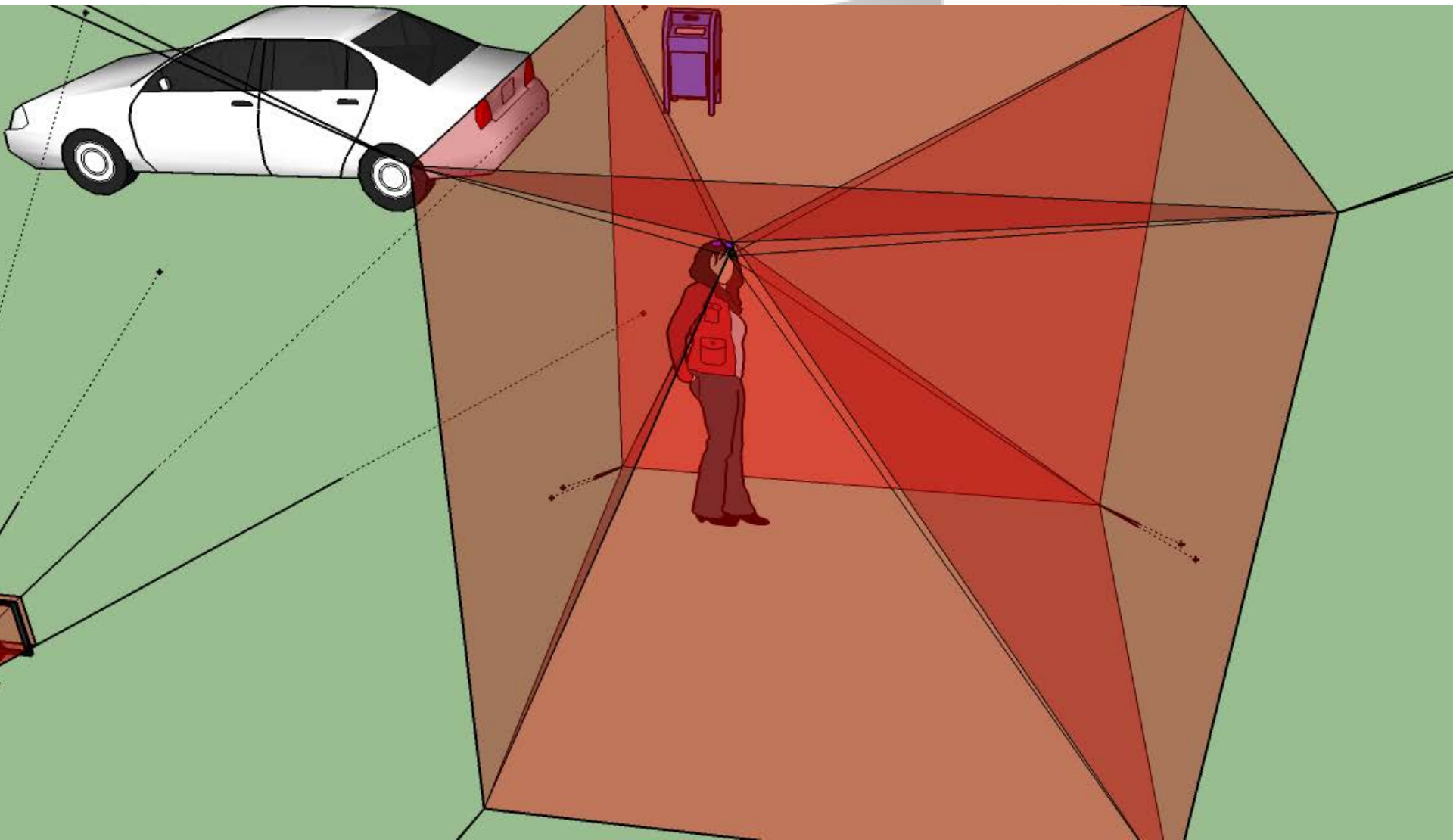
Cave Explanation



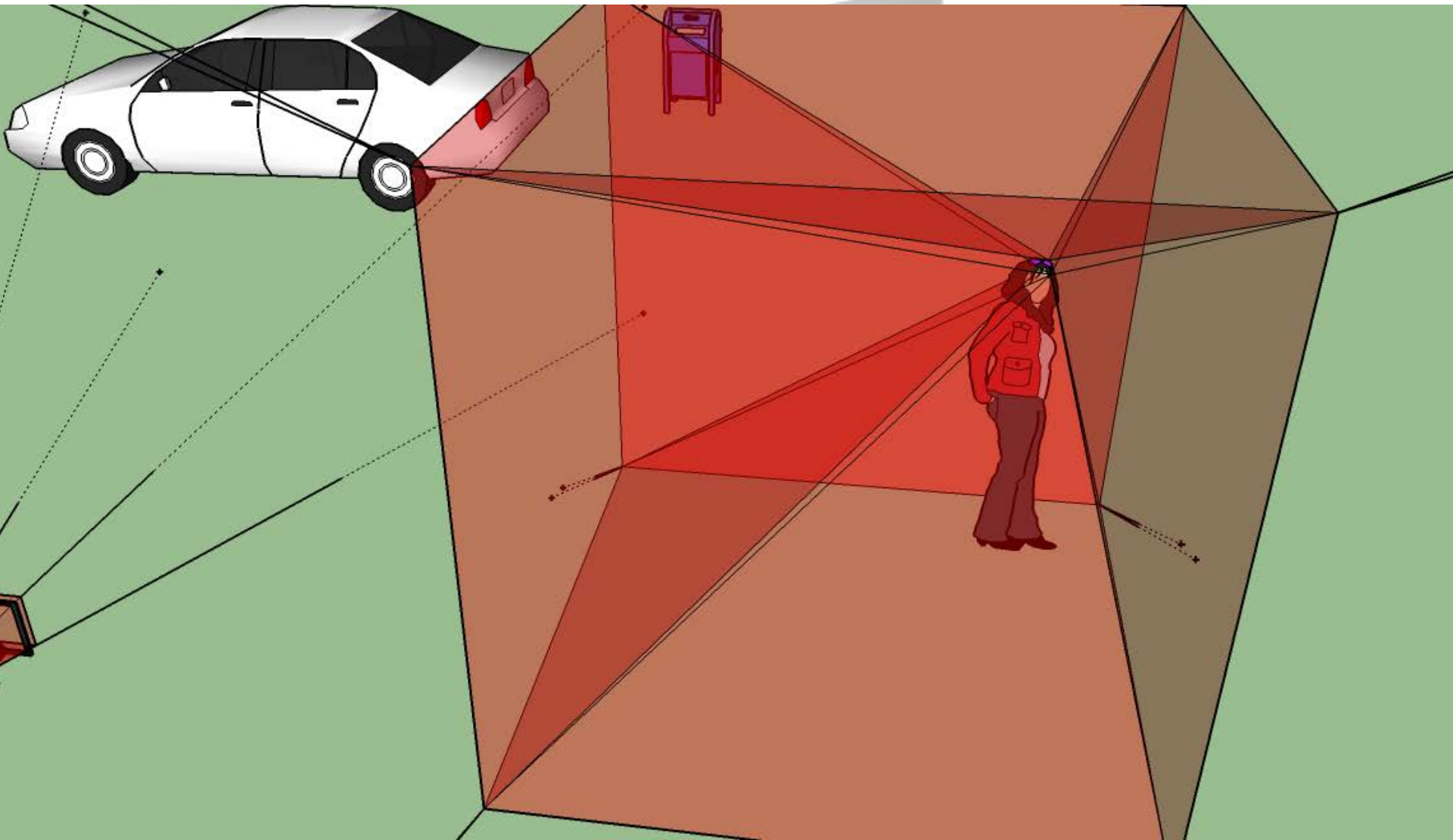
Cave Explanation



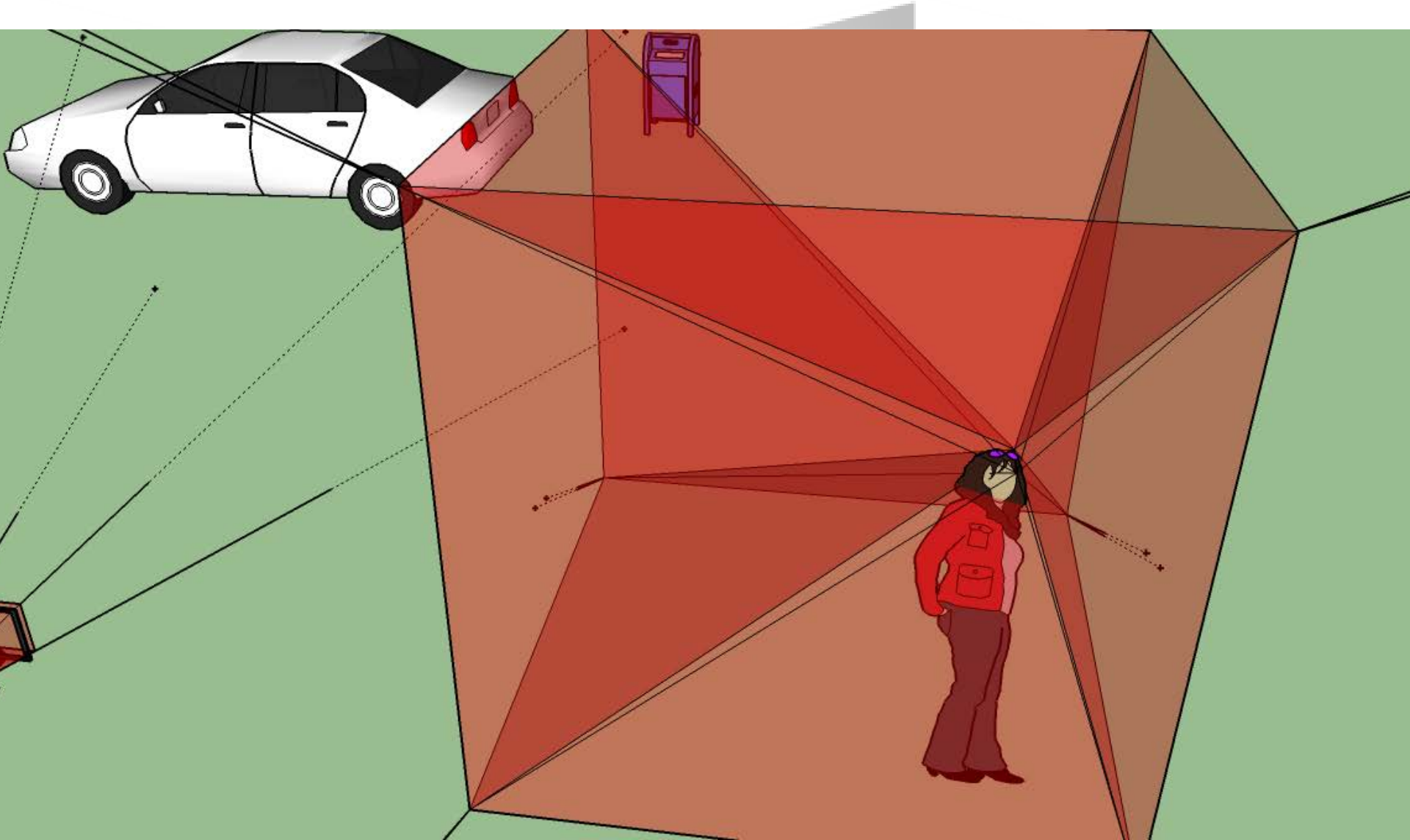
Cave Explanation



Cave Explanation



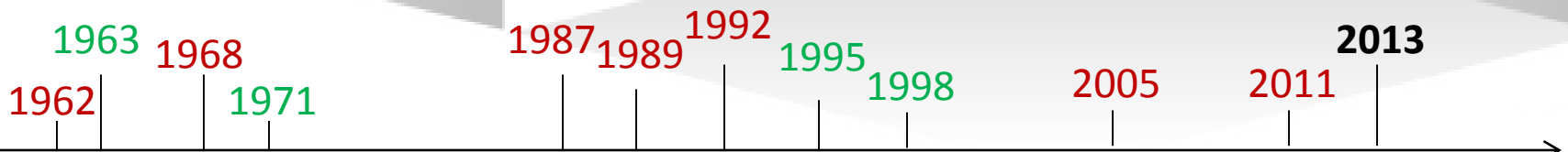
Cave Explanation



Terrestrial LiDAR



Photo: John Hart, Wisconsin State Journal

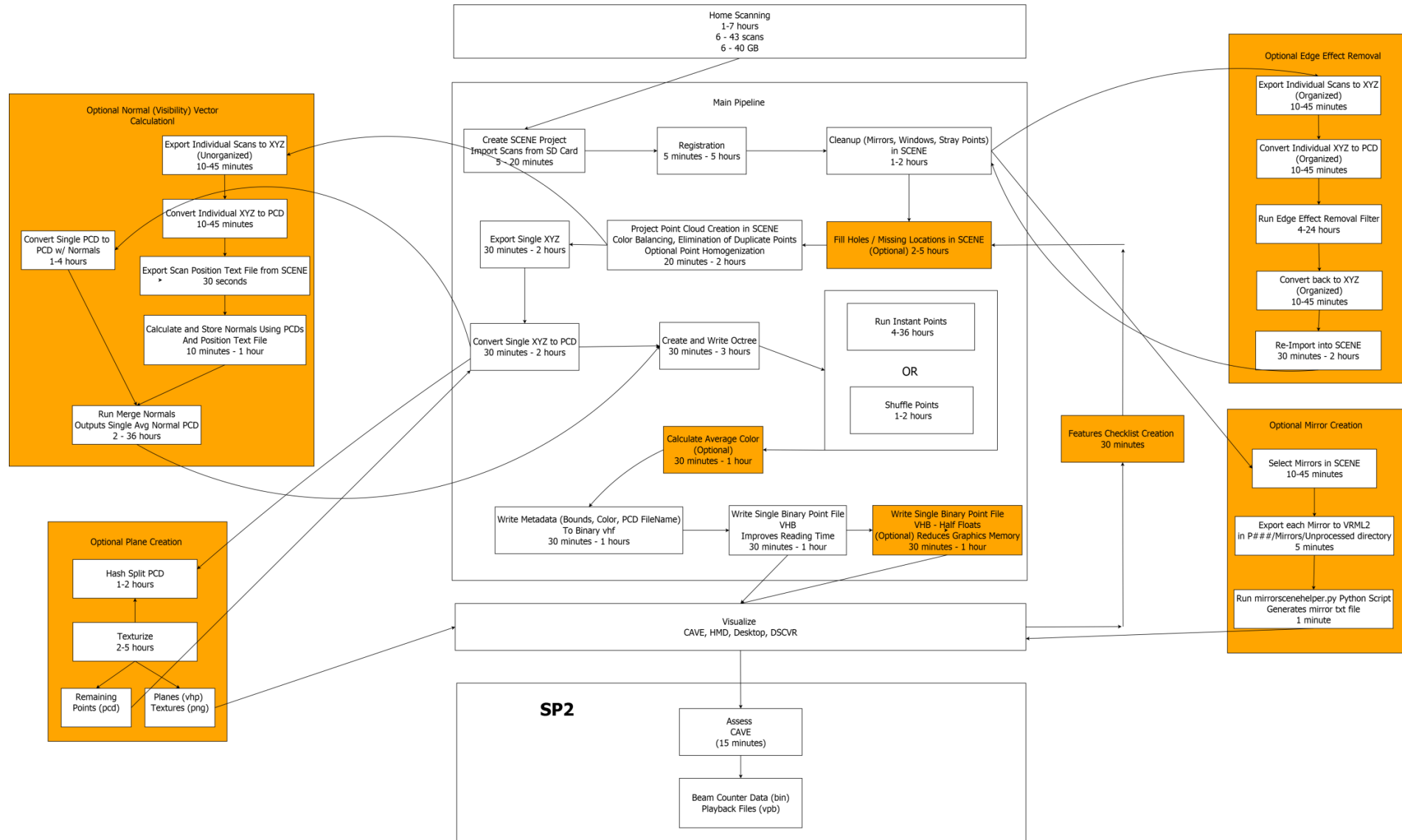


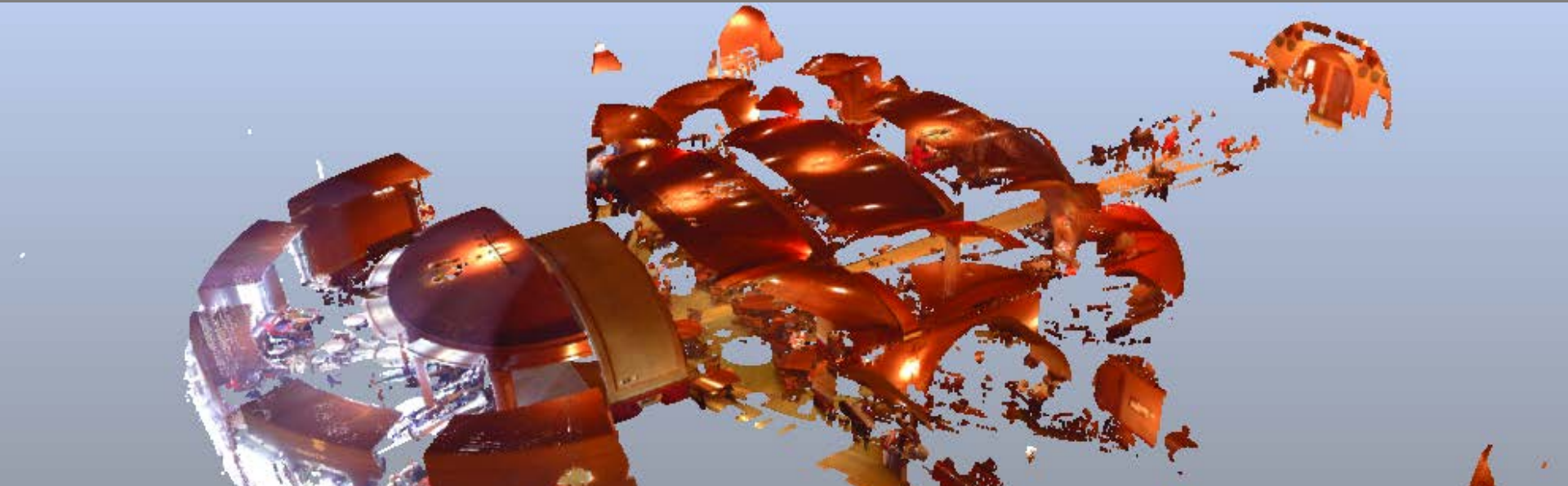
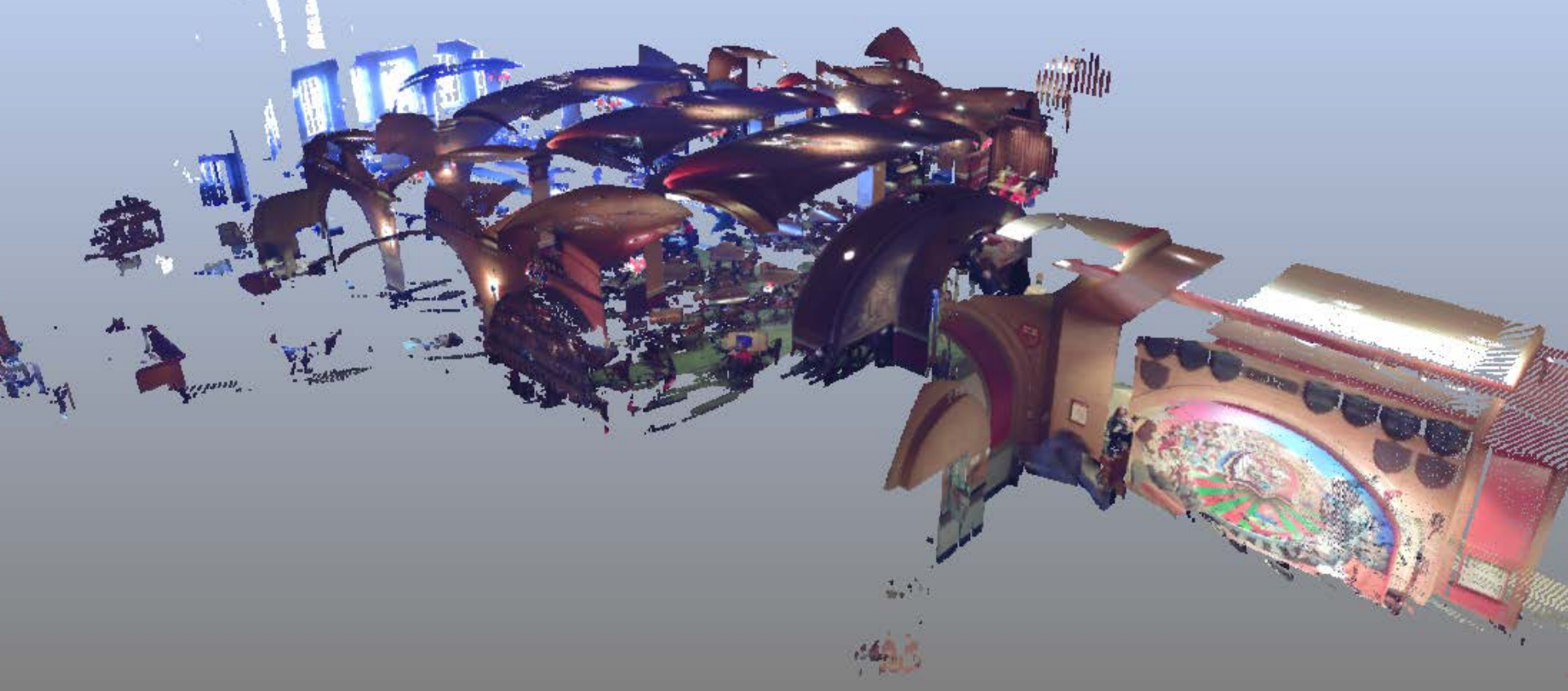
LiDAR Video

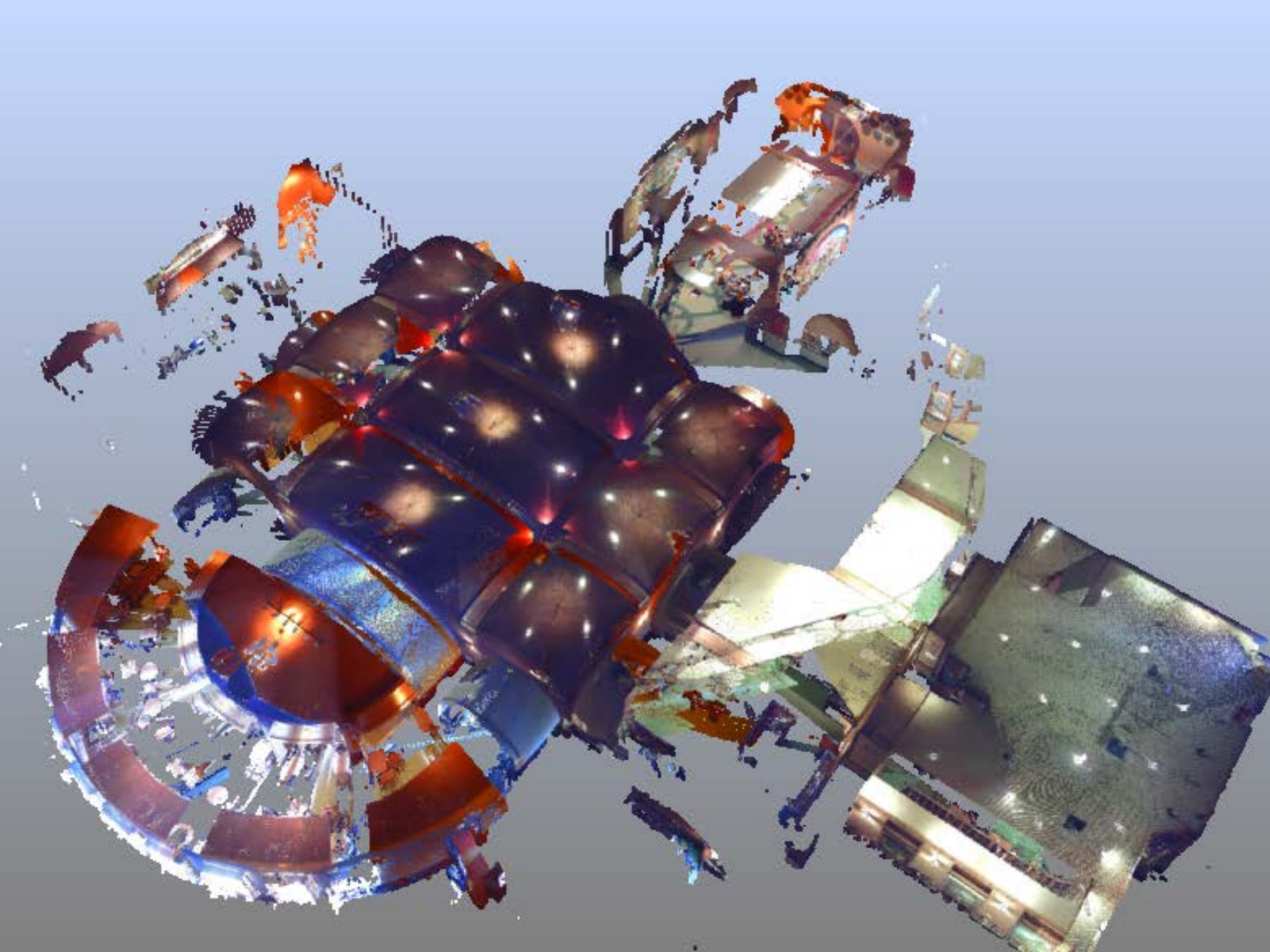
Terrestrial LiDAR & Point Clouds

- Generates *point clouds* – a list of 3D points (3 floating point values) with associated RGB color values for each point.
- Sub-millimeter precision
- Lighting inherently present in data
- 500 million – 1 billion points in hours
- Scanner medium setting: 10-12 minutes = 45 million points
- **BIG DATA!**

Pipeline

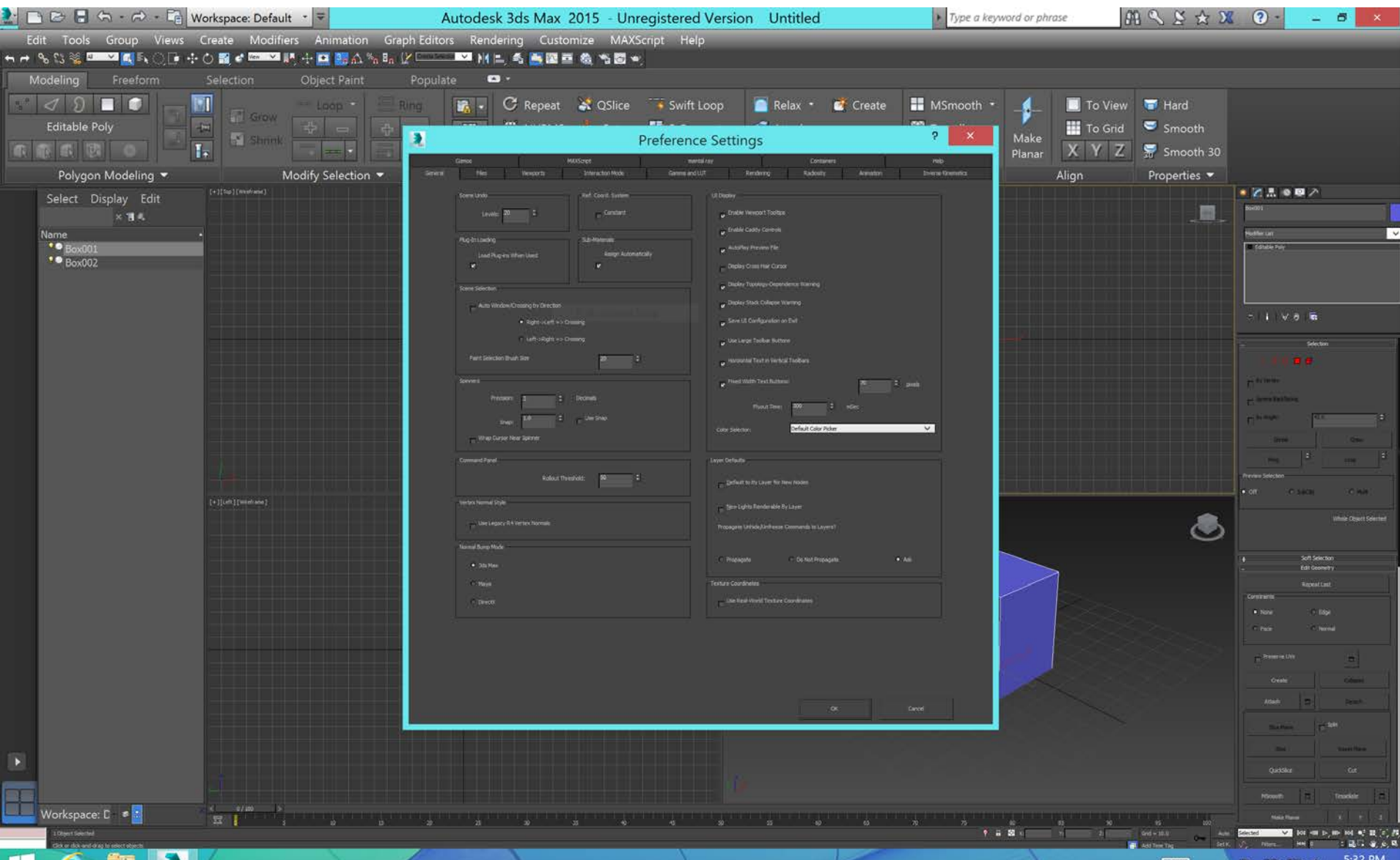






Registered Walkthrough

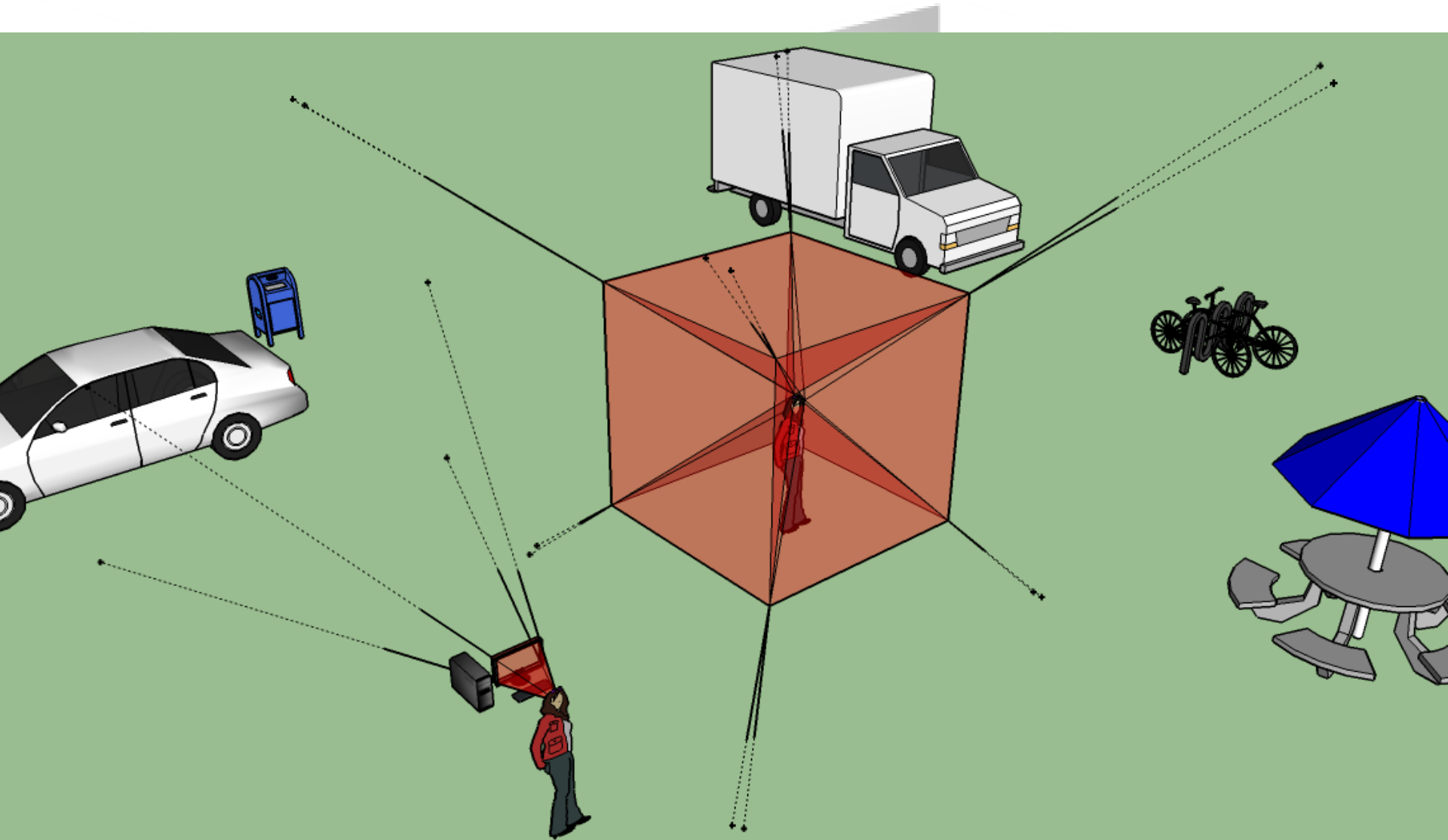
Why LiDAR?



Why LiDAR?



Point Clouds + CAVE

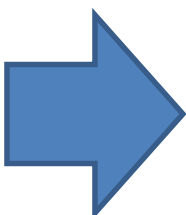
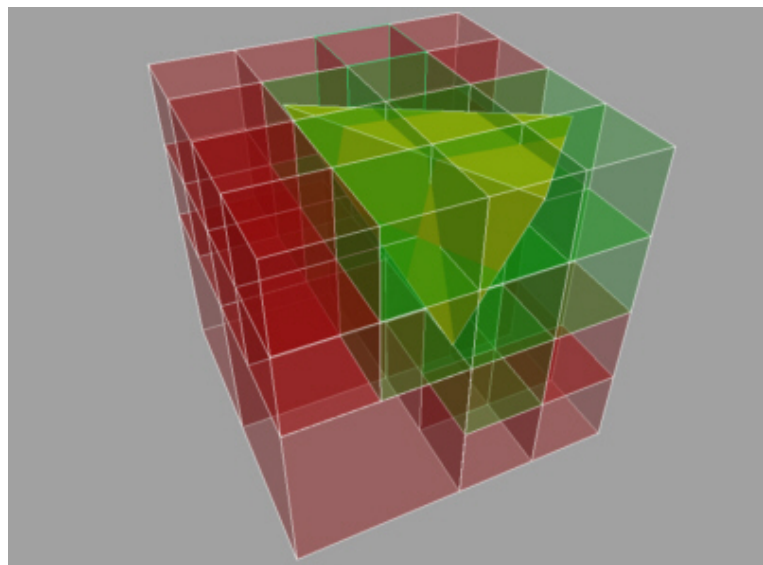
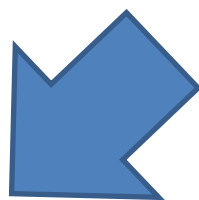
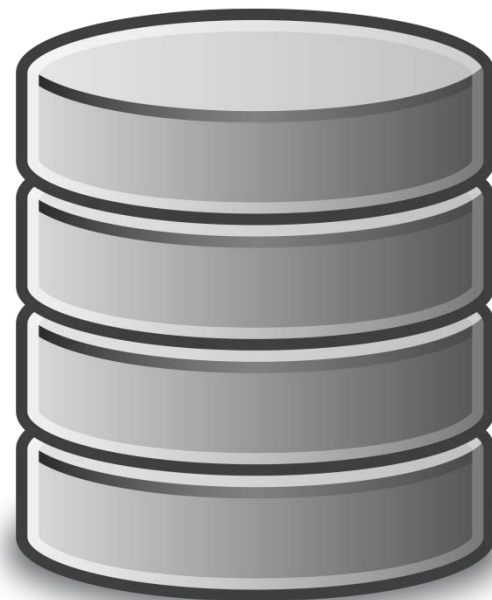
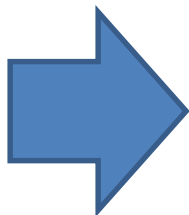
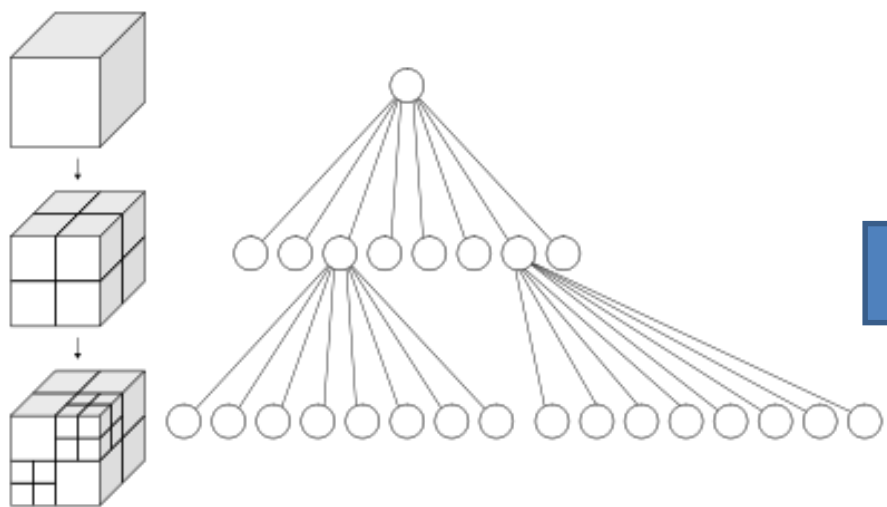


Point Clouds + CAVE



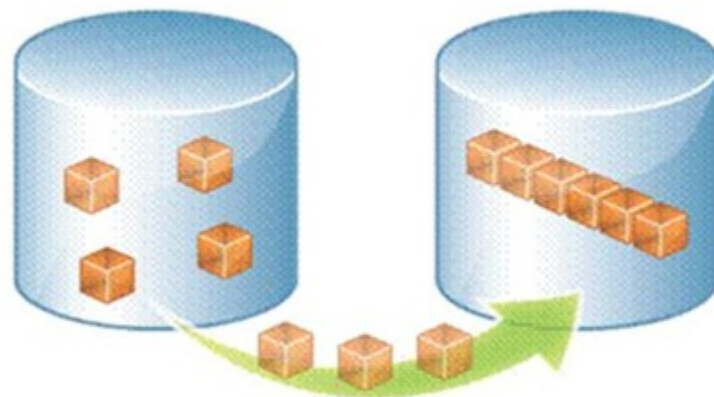
Visualizing BIG DATA

- **5 – 35+ GB single binary files**
 - Exceeds GPU memory
- **Plus – draw points all twice for stereo viewing with VR hardware...**
 - Geometry Limited – exceeds GPU bandwidth
- ***How to display massive point clouds with quality visuals at interactive rates using VR hardware?***



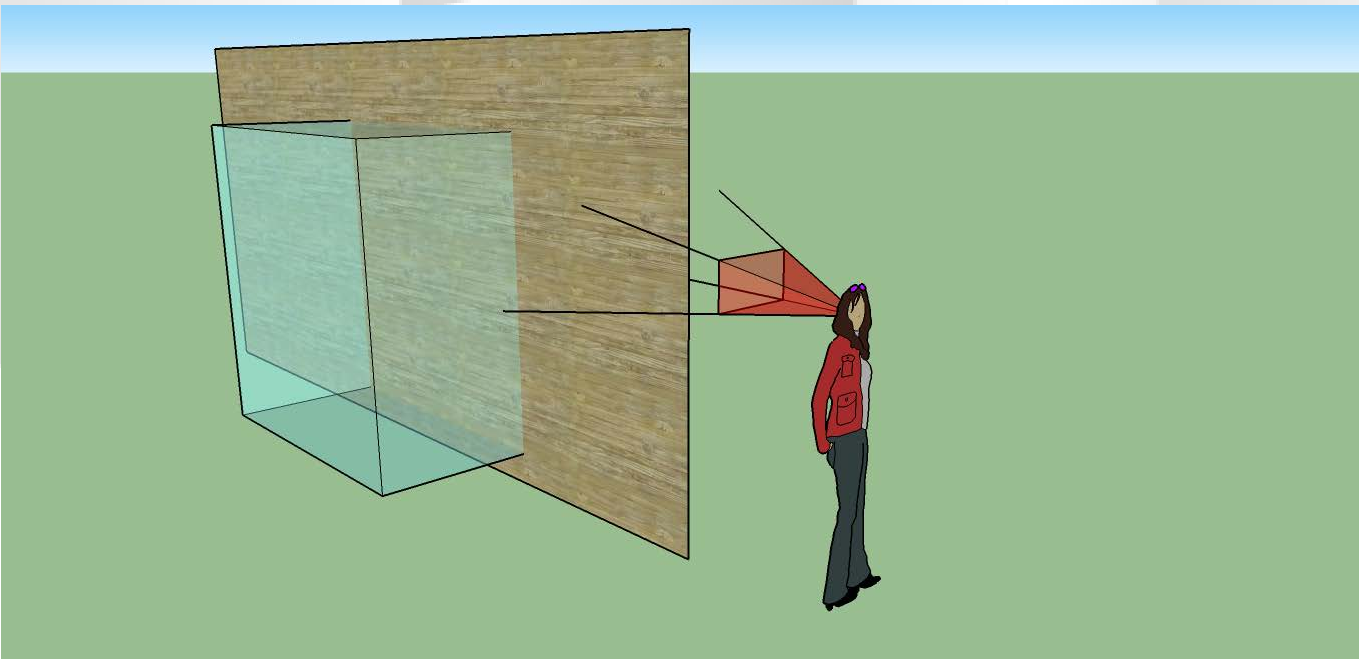
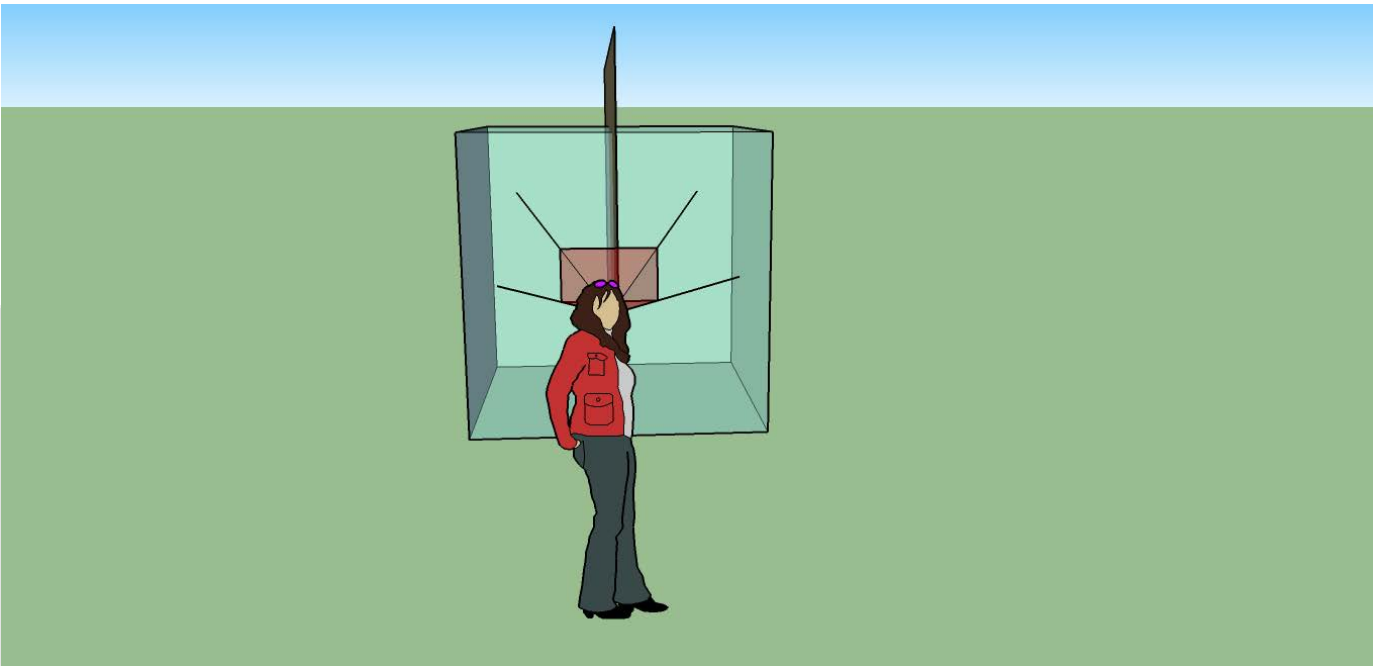
Static Data

Streamed Data



Approach 1

- **Try to always draw the “most visible points” in the octants per frame by some metric (Level of Detail)**
 - Can still be a huge # of points.
 - Vertex Buffer Object per octant
 - Octant bounds projected area = max number of points to draw per frame.
 - Not the best measurement – over-estimation.
 - **Point limit based on GPU memory limit.**

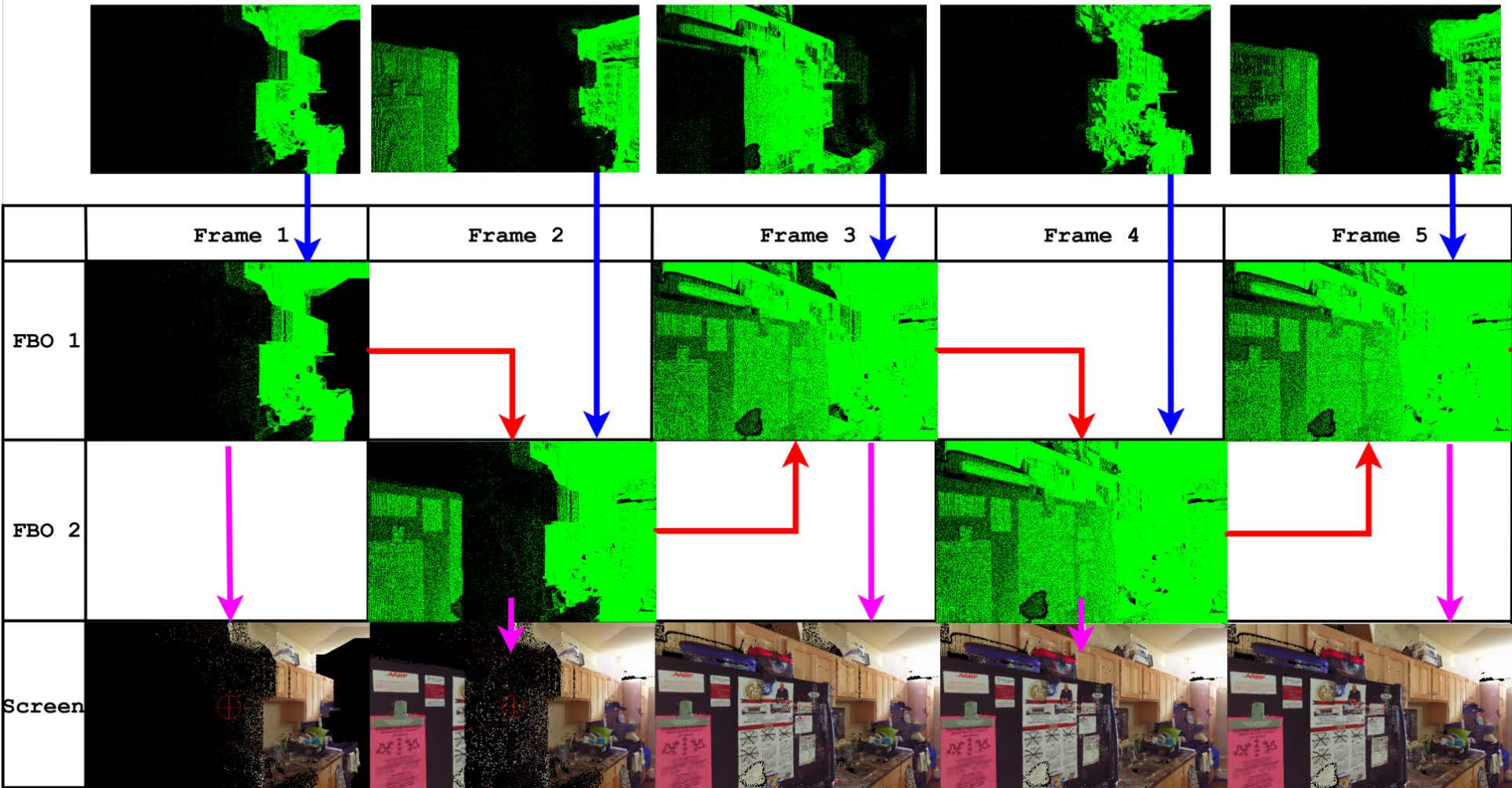


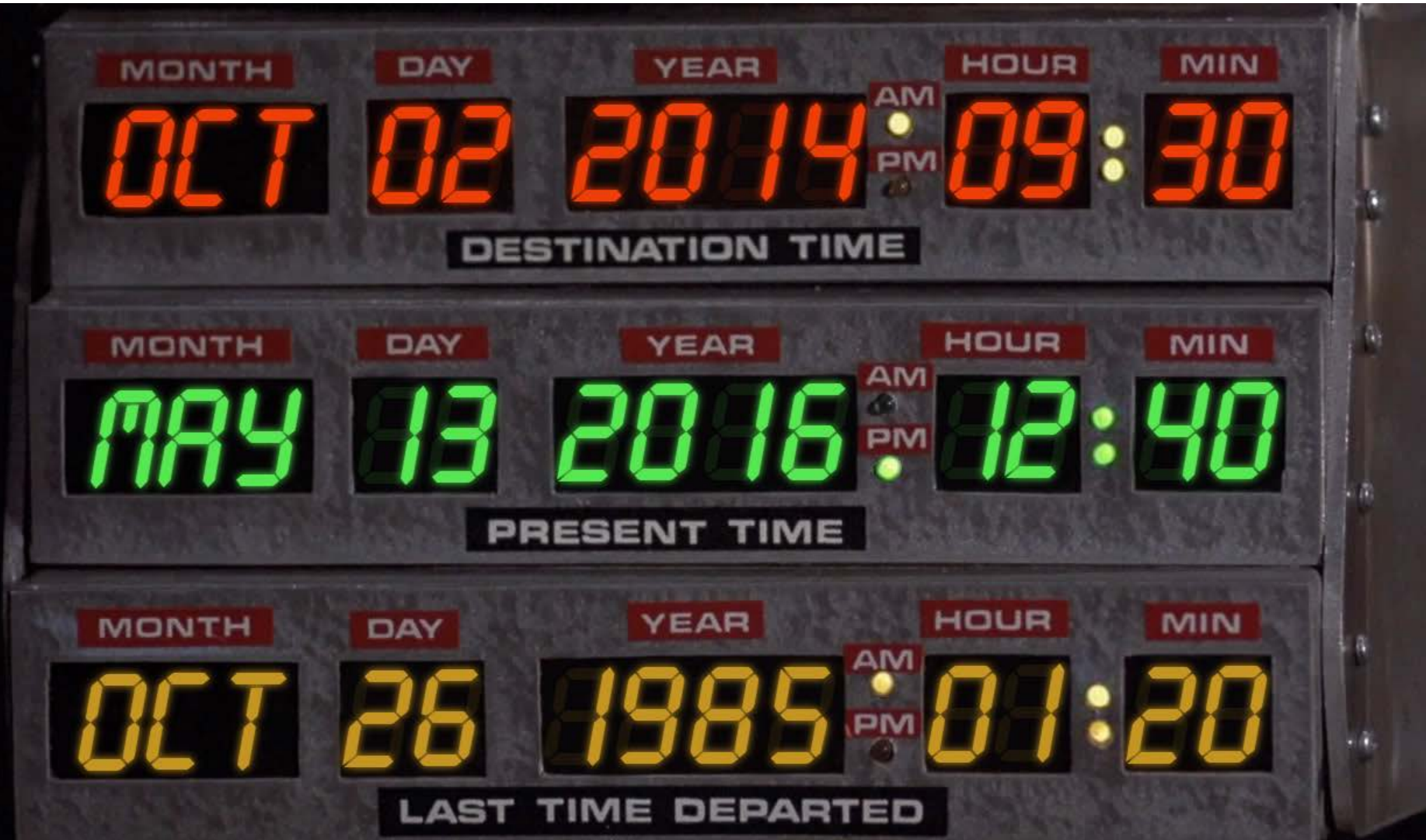
Approach 2

- **Choose a set number of points we draw each frame.**
 - Allows frame-rate control in lieu of brief artifacts
 - Single vertex buffer object updated each frame
- **Re-draw the previous frame's visible points.**
 - Frame-to-frame coherence
- **Draw all of the points in each octant over consecutive frames**
 - So that all points are actually drawn

Approach 2

→ = Source Point Cloud Data: Streamcount S per frame, point size 1 → = FBO Grid Projection R →





Walkthrough Example

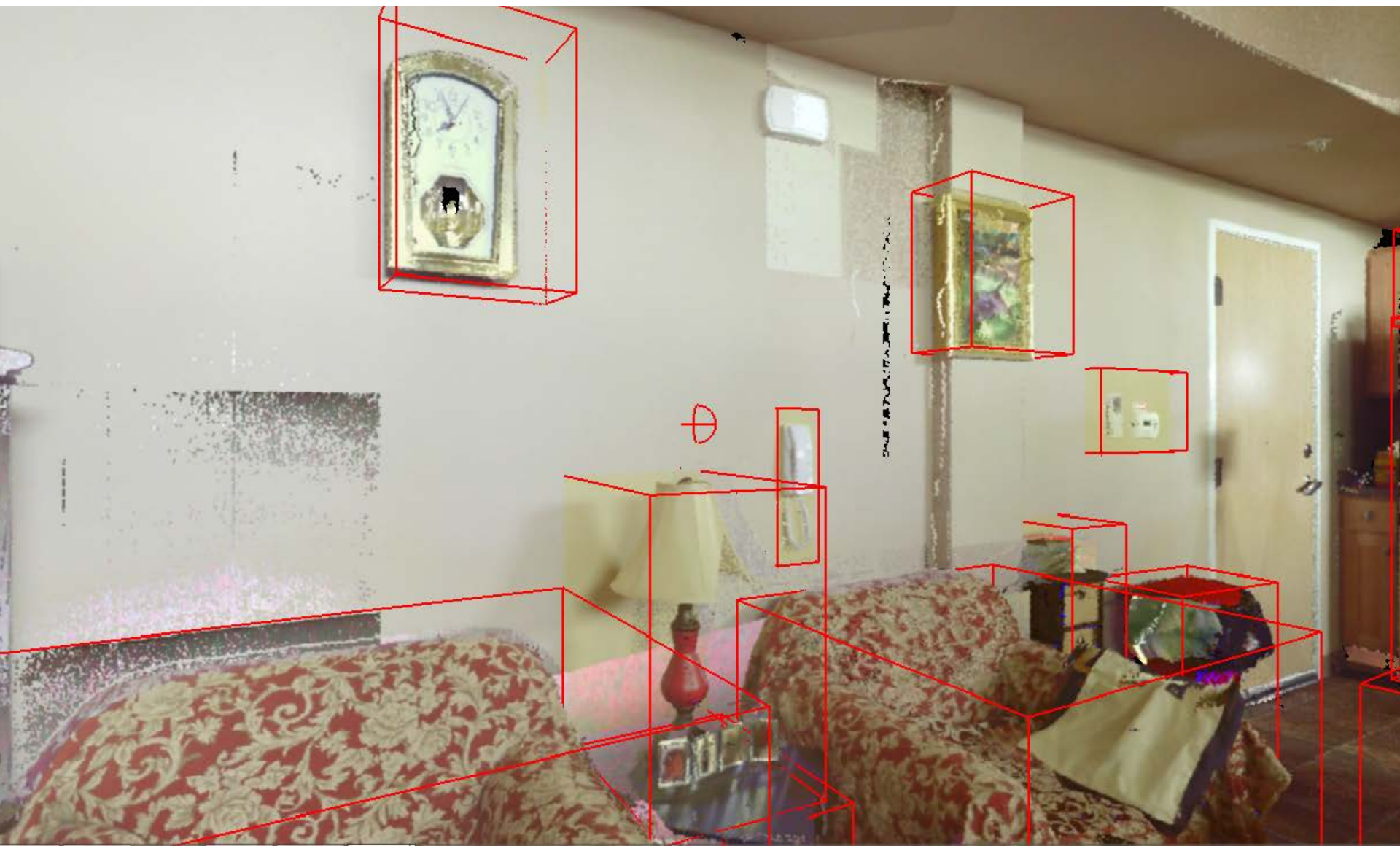


Selection “Beam Counter”

- Separate CPU thread for intersecting wand with scene for point selection



Segmentation



Early vizHOME Findings

- 20 homes scanned, processed and viewable with ability to select points in CAVE
- Consensus amongst lay-persons and experts – but fewer items selected by lay-persons
- Health happens all over the house
- Home care often has intricate setups – equipment in cramped and cluttered spaces.
- Majority of lay-persons not experiencing simulator sickness

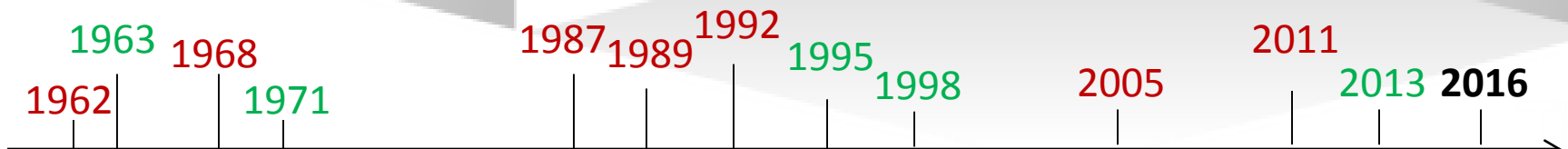
vizHOME Recruitment

- **Know someone who has been told they have diabetes?**
- **Think they would like to participate in a Fall or Spring semester study?**
- **Contact Gail Casper**
 - gcasper@wisc.edu
 - 608-316-4340

VR – Present Day



- Gear VR - \$99
- Oculus Rift - \$599
- HTC Vive - \$799



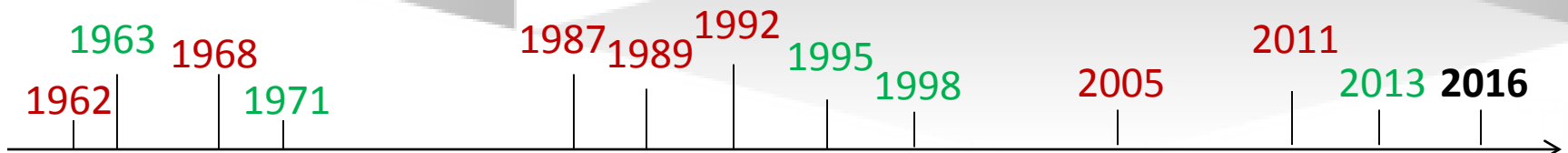
LiDAR – Present Day

- **Velodyne LiDAR**

- \$8,000

- <http://grindgis.com/data/lidar-data-50-applications>

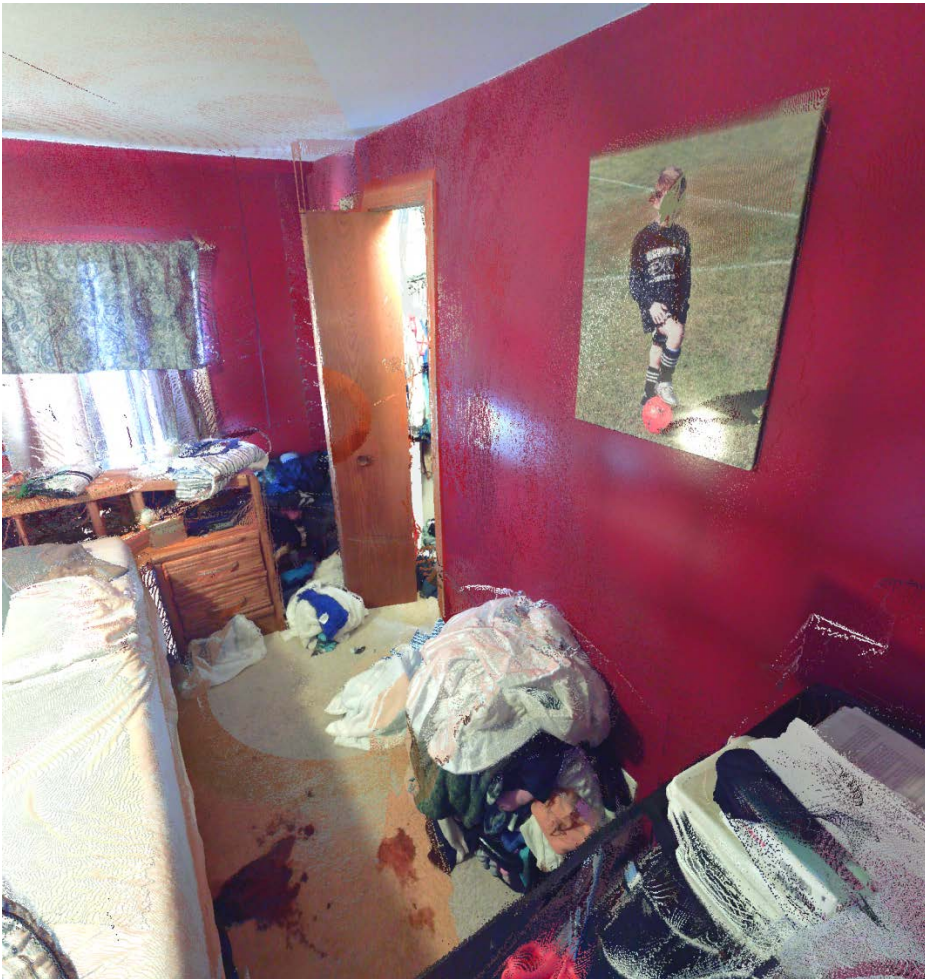
- <http://blogs.dlt.com/government-agencies-lidar-cut-costs-hundreds-cases/>



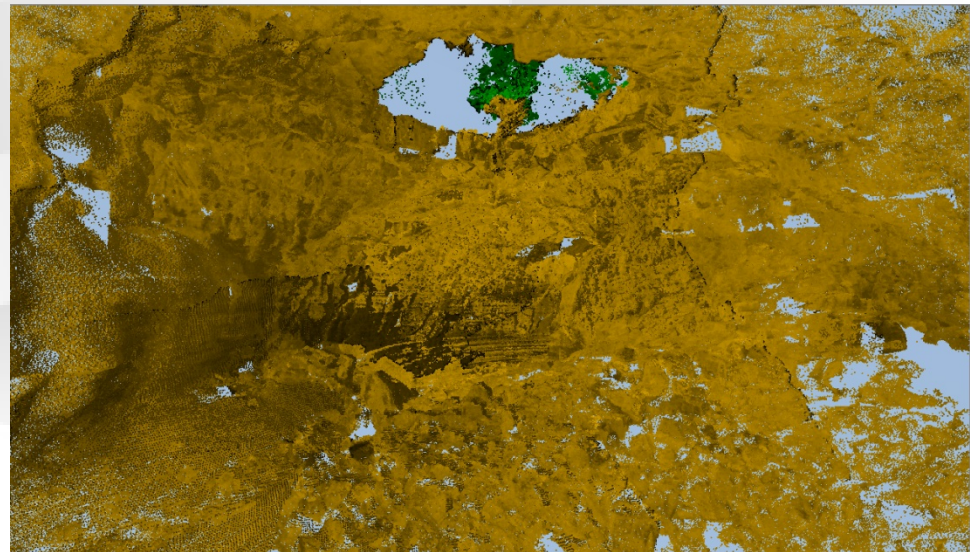
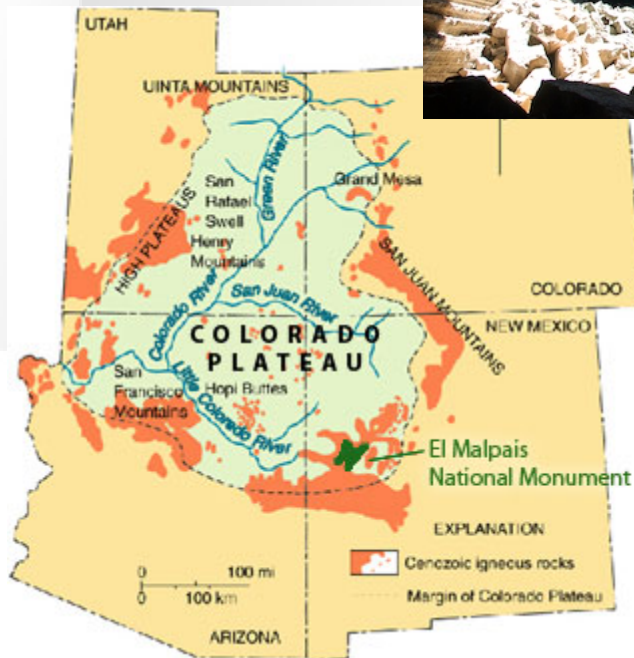
Cultural Heritage



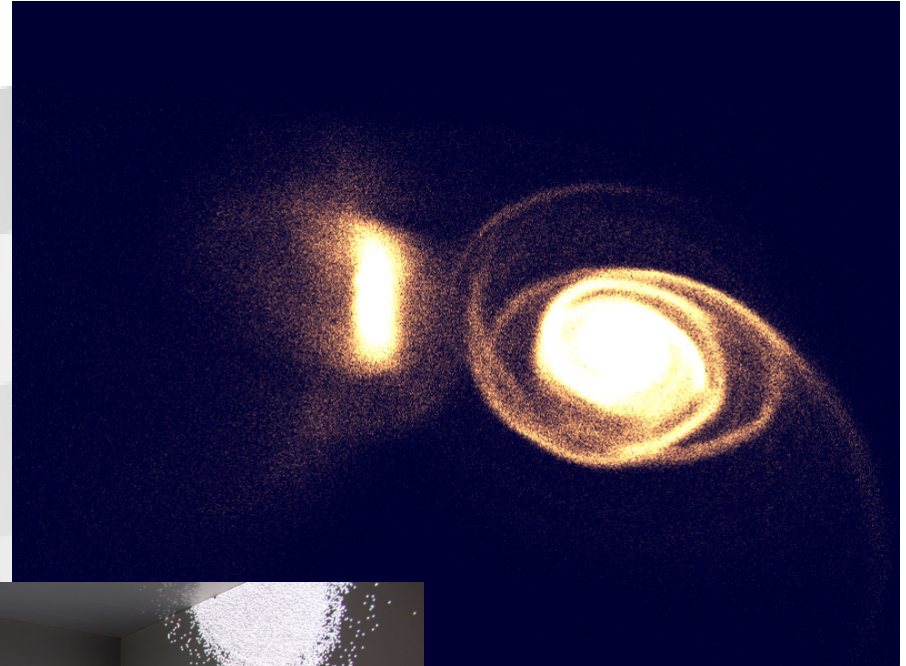
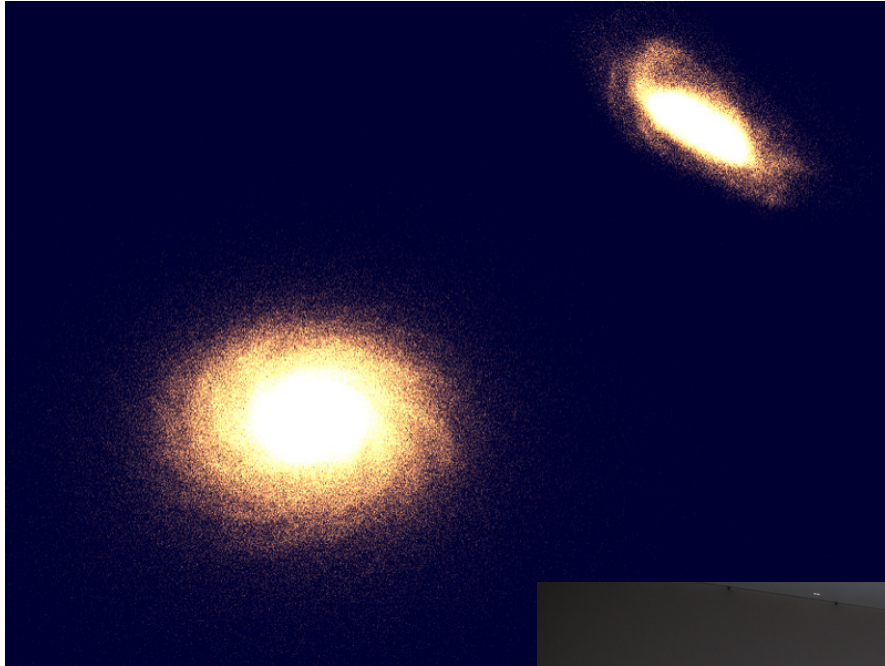
CSI - WID



Cave in a CAVE



Astronomy



Future Directions

- **Combining other imaging with LiDAR**
 - Thermal?
 - Harmful chemical detection?
- **Wireless HMD / Full Body Tracking – AVS**
- **Time-Varying**
- **Screen Space Normals and Radii of Points**
- **Lighting Simulation?**
- **Photogrammetry Combination**
- **Hospital Outpatient Training – SafeHOME**

Collaboration @ LEL

Research Interest / Projects with UW:

- Astronomy
- Art / Art History
- Athletics
- Biology
- Biomedical Engineering
- Botany
- Chemistry
- Dance
- Industrial and Systems Engineering
- Library and Information Sciences
- Mechanical Engineering
- Physics
- Virology . . . And more

Industry Partnerships with:

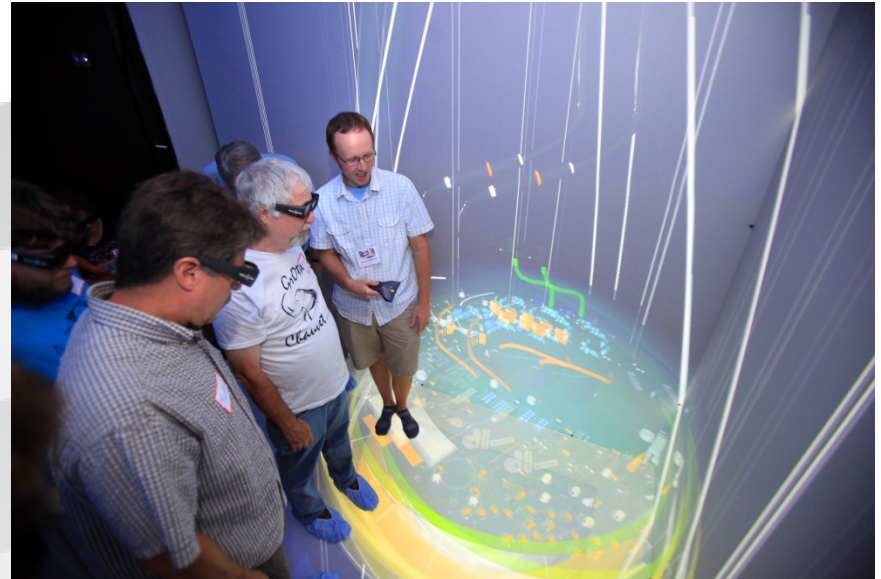
Biotech
Construction / BIM
Design
Entomology
Software Development
Zoology

Through Immersive Visualization

3D Visualization @ LEL

- **Bio-Molecular 3D Models (Protein Data Bank, etc.) (VMD)**
- **Volumetric Imaging (Voreen)**
- **Game Engine Environments / Polygonal 3D Models (Unity3D)**
- **New! - 360 Video**
- **Sequential 3D Text over Time (WordCAKE)**
- **3D Spatial Stereo Sound in any application**

Outreach @ LEL



Thanks for listening!

- The LEL is always seeking building and campus collaborations.
- All data can be visualized – come to us to discuss.
- Researchers Open House – 4th Wednesday of each month: 1:30 pm to 2:30 pm
 - May 25th – 1:30 pm.
- Special thanks to Patti Brennan, Kevin Ponto, Erica Gill, Markus Broecker, Gail Casper
- All past and present students & vizHOME team
- Special Thanks to Allison and Weston Tredinnick
- rdtredinnick@wisc.edu, 316-4672

Questions?

