Safety Underground

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Deep Underground Science and Engineering Laboratory (DUSEL)

2010 NSF Large Facility Workshop

May 4-7, 2010

All Facility Safety Session

1:30 TO 2:00 PM

Upper Big Branch Disaster (2010)

- Explosion pentagon *(requirements for a mine explosion)*

Fuel – methane and coal dust

Dispersion or mixing

Ignition source

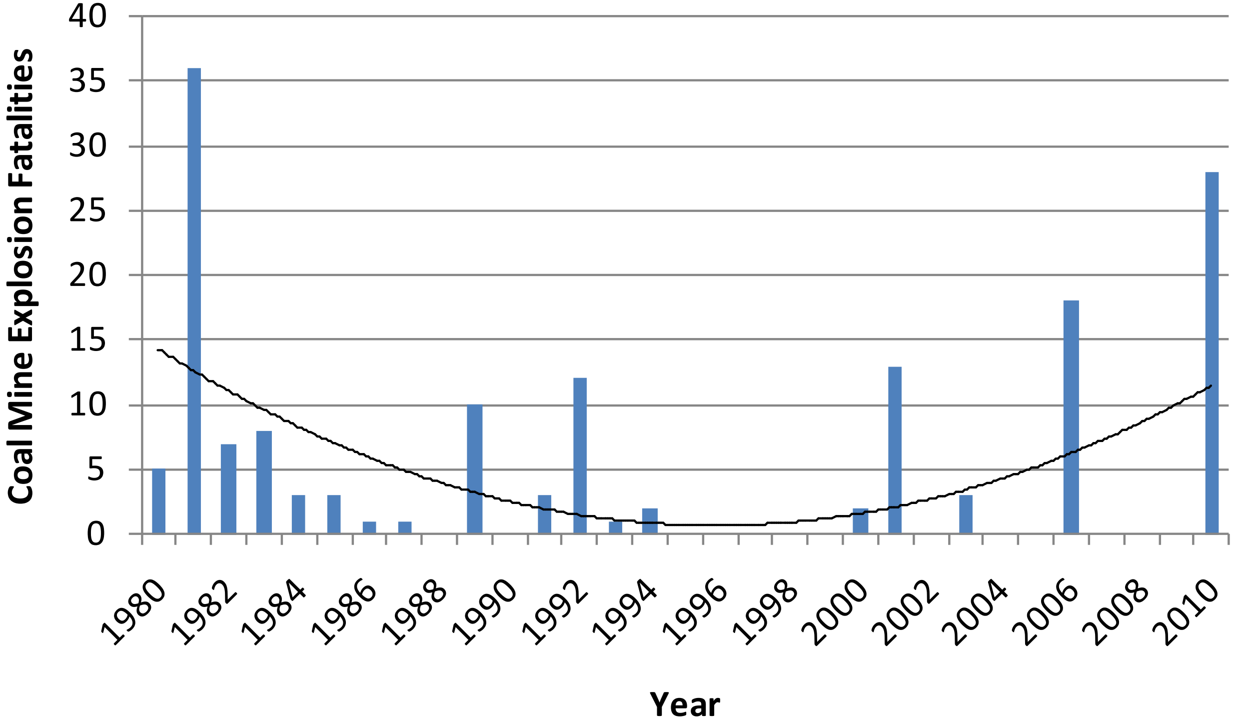
Oxygen

Confinement

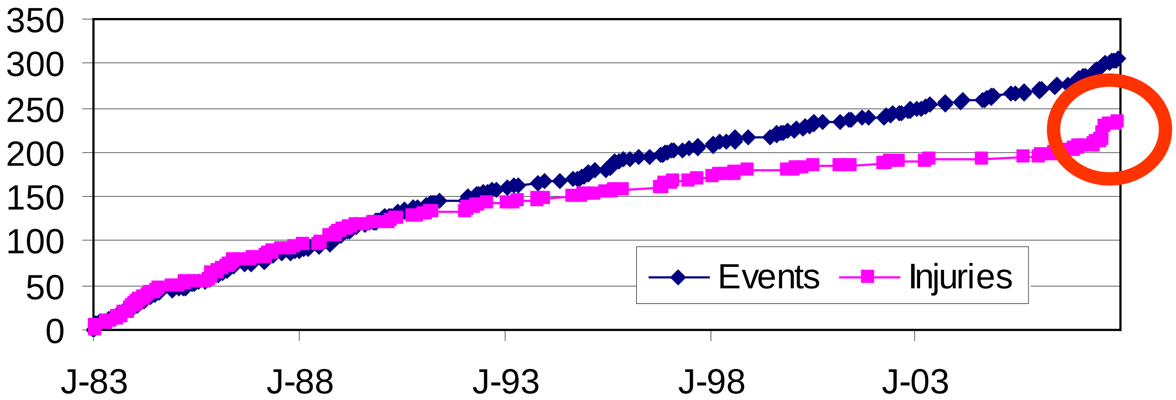
- Imagine yourself standing inside the barrel of a cannon!

Upper Big Branch Disaster (2010)

- UBB - 29 miners fatally injured in an explosion
- Explosion hazards are preventable
- Why are they still occurring



Crandall Canyon Disaster (2007)

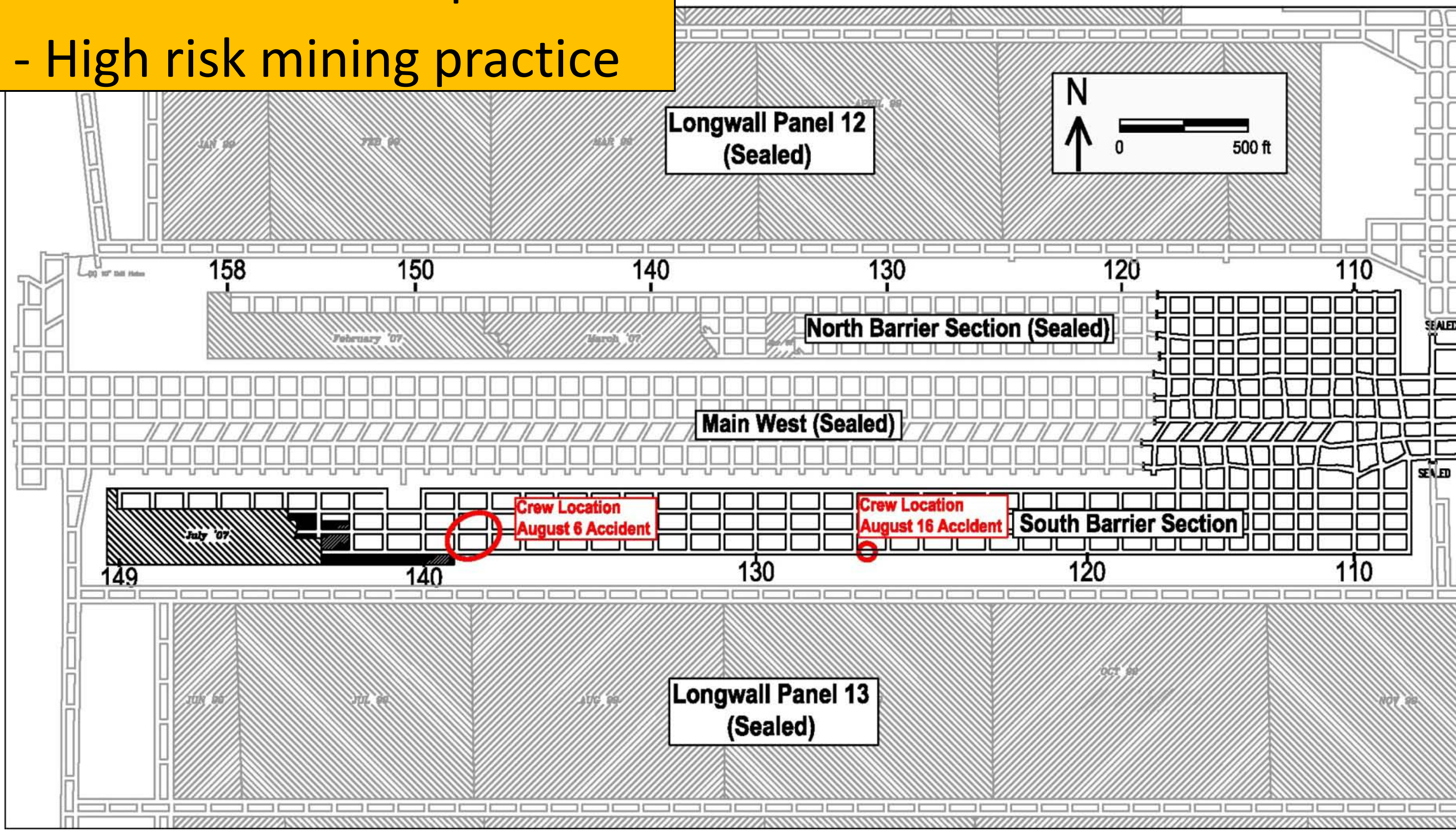


Crandall Canyon

Low likelihood of occurrence but high consequence events

Crandall Canyon Disaster (2007)

- 9 workers fatally injured
  - Six in initial bursts
  - Three in rescue attempt
- Cause - High risk mining practice



Why are these disasters occurring?

- *Reliance on prescriptive regulations for mine safety standards*
- *Hazard recognition is not a requirement (poorly defined in standards)*
- *As a result,*
  - *Hazards are not being adequately assessed*
  - *Risks are not being mitigated*
- *A reactive safety culture currently exist*
- *A proactive safety culture is needed (more on this later…)*

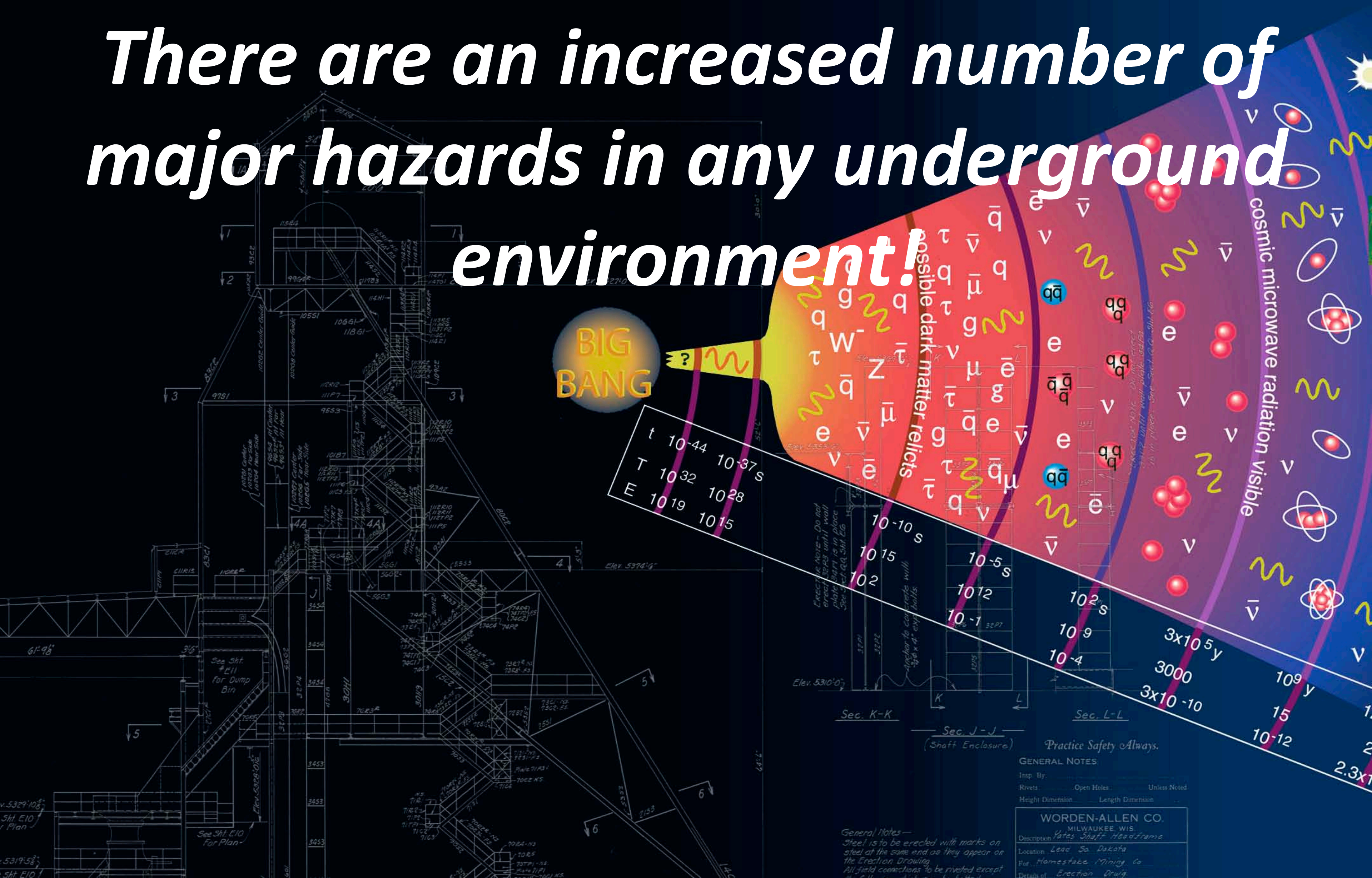
- *Sunshine Mine fire in 1972, 91 miners died in an Idaho hardrock silver mine*
- *Belle Isle explosion in 1979, 5 miners died in a Louisiana salt mine*

Hazards in the underground environment (Multiple Fatality Events over Last 12 Years)

- *Explosions*
- *Explosives*
- *Ground falls*
- *Mobile equipment collisions*
- *Fires*
- *Inundations*
- *Surface subsidence from strata collapse*
- *Slope or highwall failures*
- *Drowning*
- *Asphyxiation*

So what's this got to do with DUSEL?

There are an increased number of major hazards in any underground environment!



What is DUSEL (Deep Underground Science and Engineering Laboratory)?

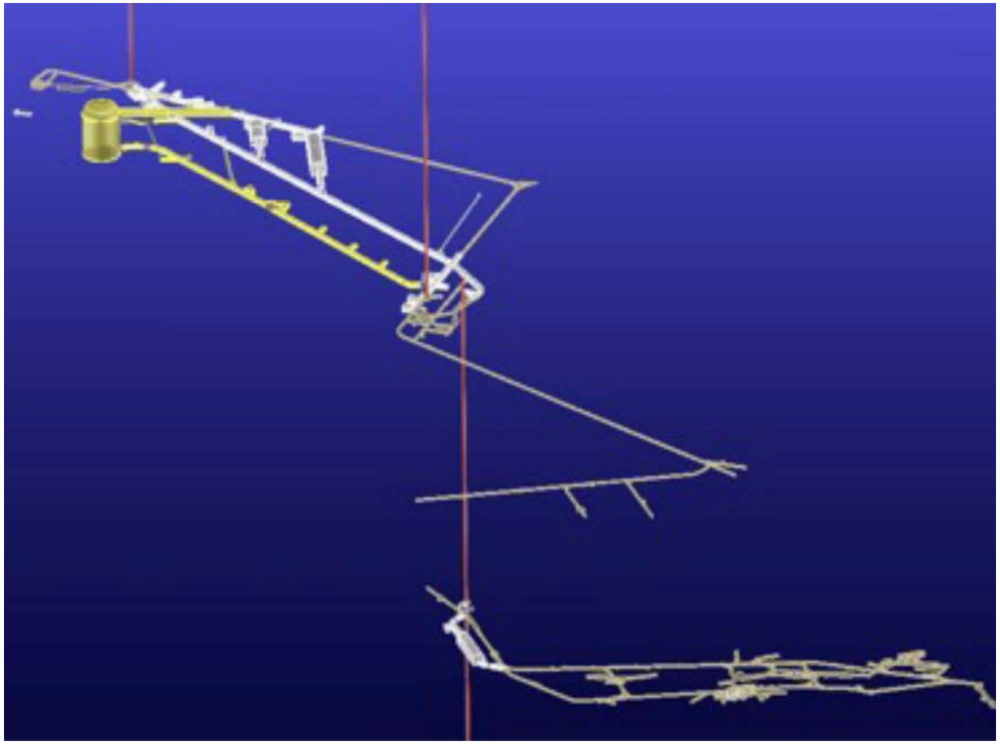
- *Currently in design with NSF funds*
- *Sanford Laboratory (SDSTA) currently operates the footprint of the future DUSEL*
- *Property*
  - *186 surface acres*
  - *7,700 underground acres*
  - *370 miles of drifts*
  - *14 shafts and winzes*

DUSEL's physics mission - WIMPs (weakly-interacting massive particles)

- *What is the Universe made of?*
- *What is Dark Matter?*
- *What is the origin of the elements in the cosmos?*
- *What can neutrinos tell us about the matter/antimatter asymmetry?*
- *Is ordinary matter inherently (un)stable?*
- *What is the spectrum of neutrinos from supernovae?*
- *And much more…..*

DUSEL's safety goal

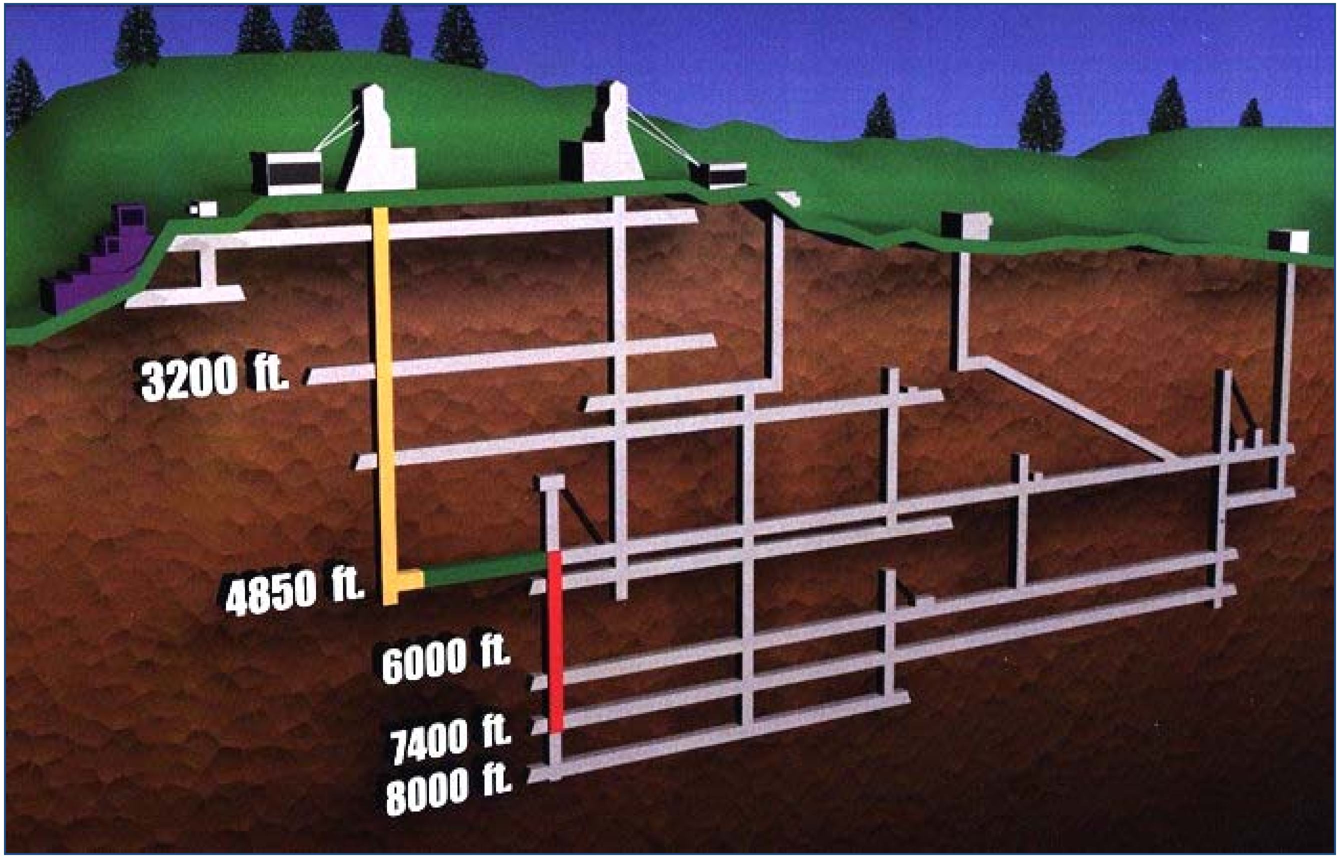
To develop an enduring international underground laboratory with a best-in-world class scientific program of research, education and outreach and do so as quickly and as cost efficiently as is consistent with the highest level of safety



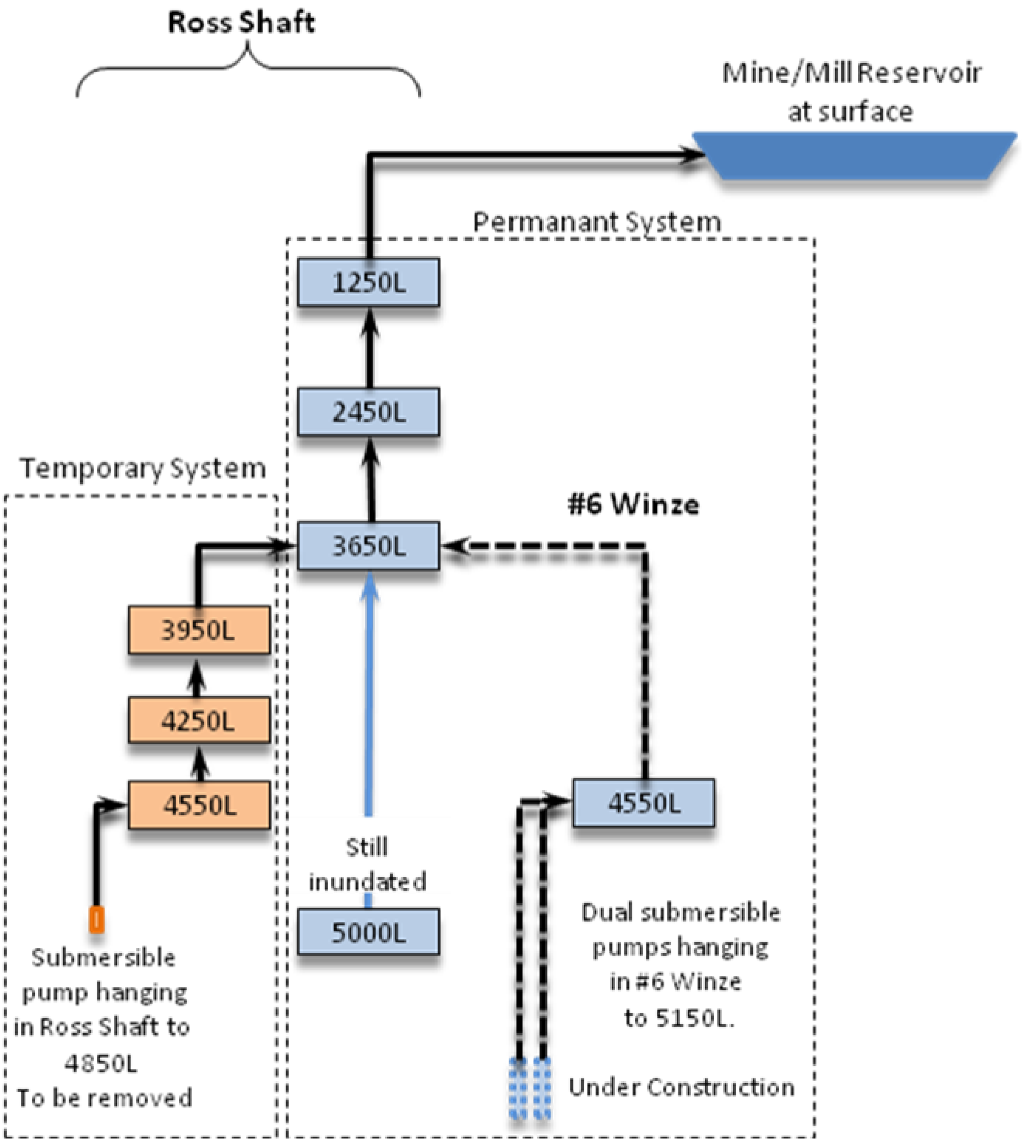
- *EH&S functions have been developing over the last 2-years*
- *Rely on the Integrated Safety Management (ISM) approach*

What are the construction plans for DUSEL?

- *Rehabilitate a small portion of the underground to a depth of approximately 8,000-ft below the surface*
- *Control the hazards throughout the underground*



Current activities (dewatering)



Current activities (exploration)

- *Diamond core drilling*
- *In-situ stress measurements*
- *Re-entering associated drifts for inspection*

Current activities (ventilation)

- *Installing barriers*
- *Maintaining and installing high capacity fans*
- *Modeling*
- *Monitoring conditions*

Current activities (preparing for early science)

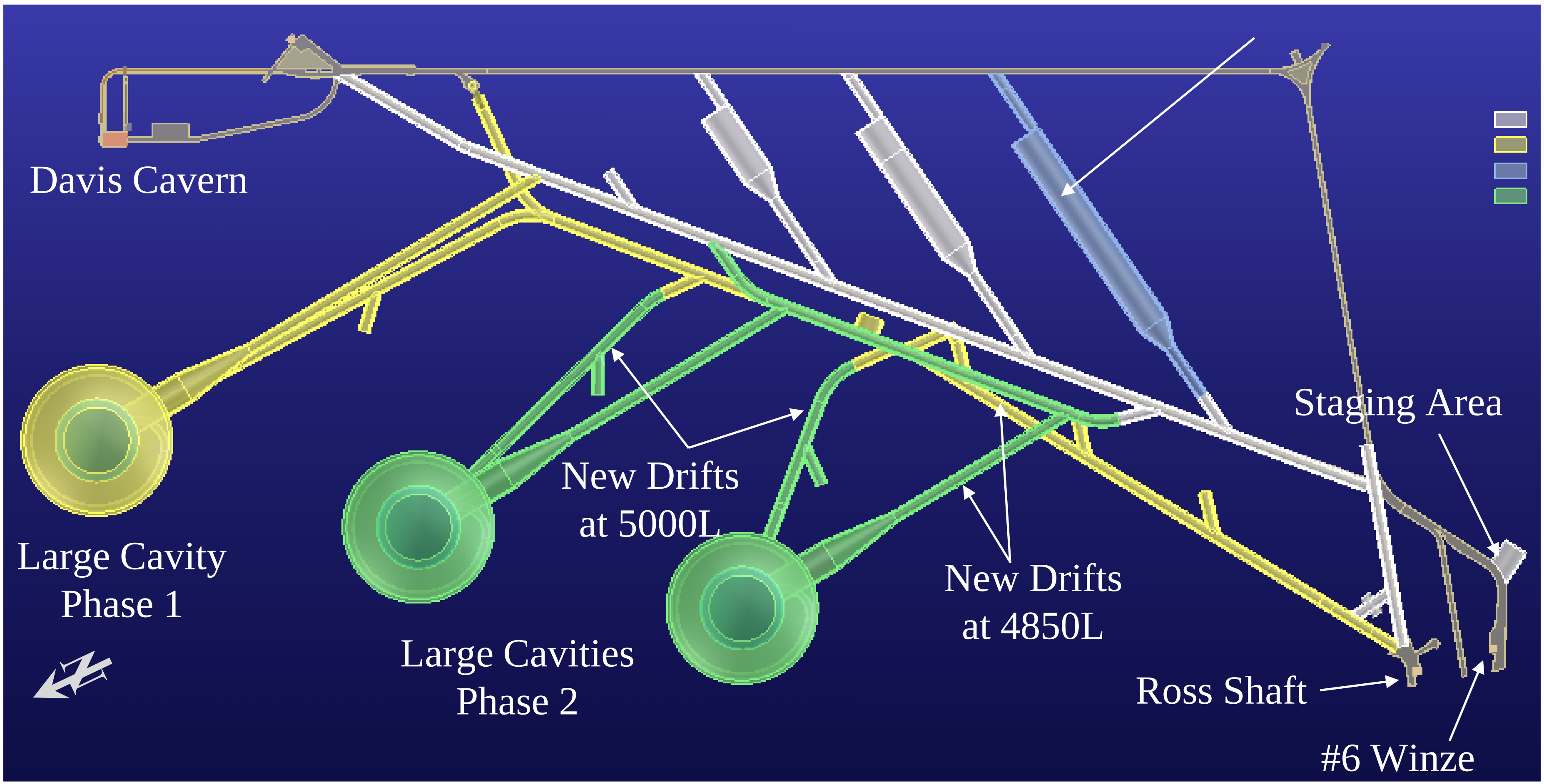
- *LUX surface (complete)*
- *LUX underground*
- *Majorana underground*
- *BGE's (on-going)*

Current activities (new developments)

- *Excavating transitional space*
- *Rehabilitating shafts*
- *Adding additional ground support*

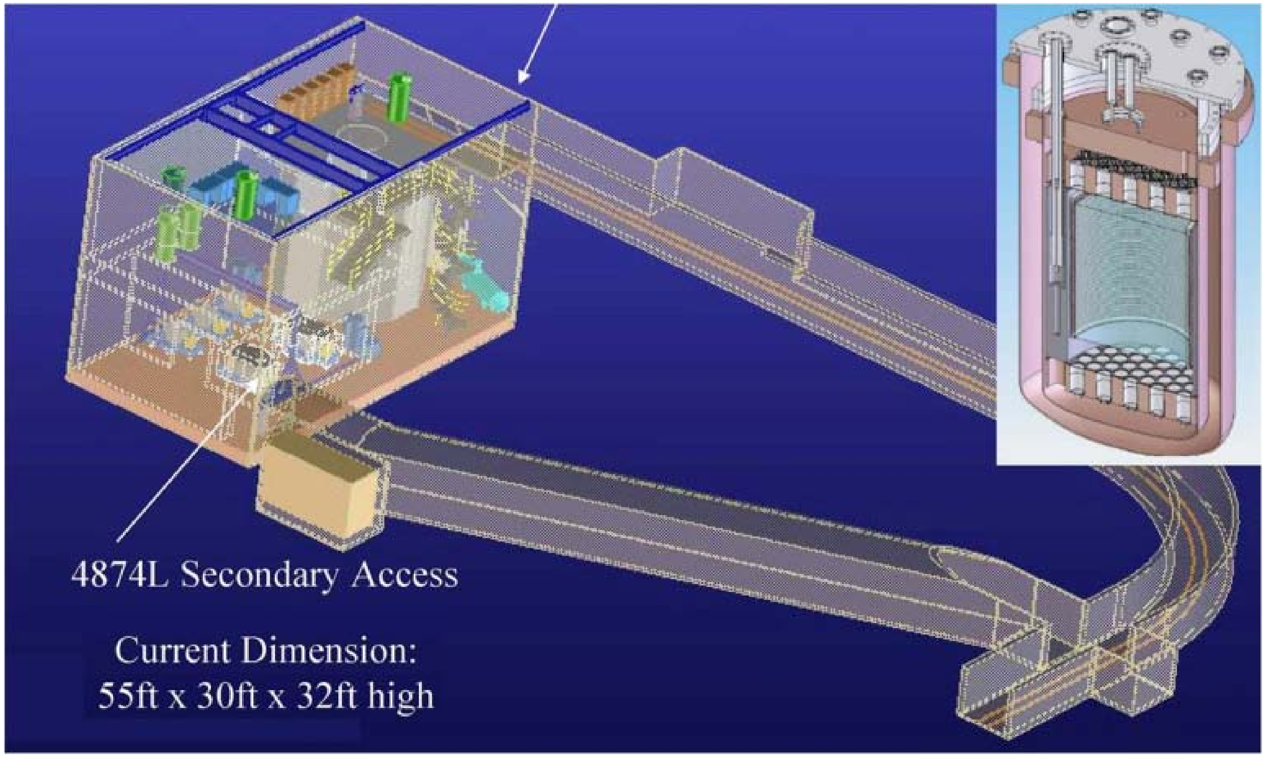
Future activities underground

- *Excavate new drifts*
- *Excavate at least one large cavity (160-ft wide)*
- *Rehabilitate shafts*

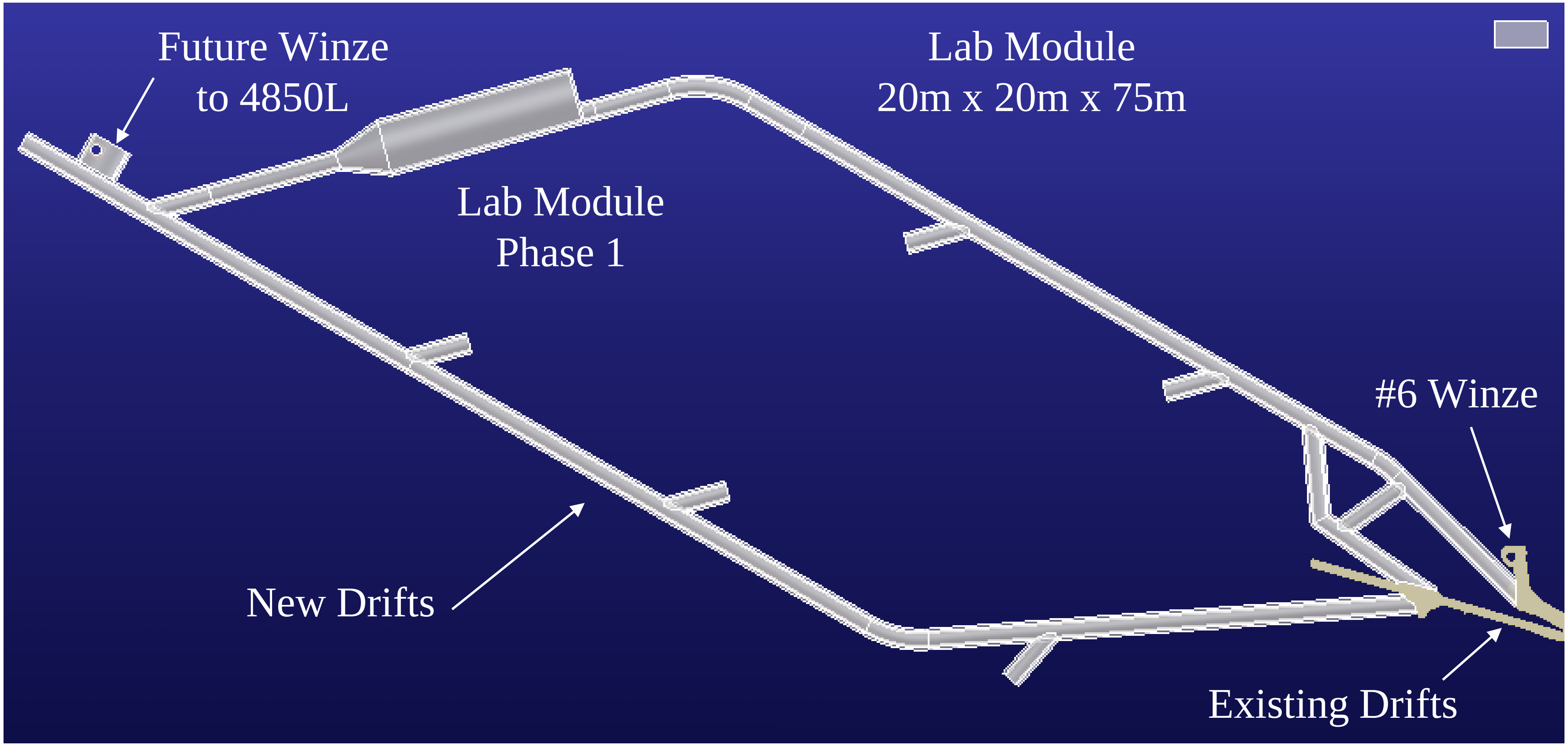


Future activities (science)

- *LUX, Majorana, BGE's*
- *Large experiments with Cryogens*



Future activities (Construction of the deep-level campus at the 7,400-ft Level)



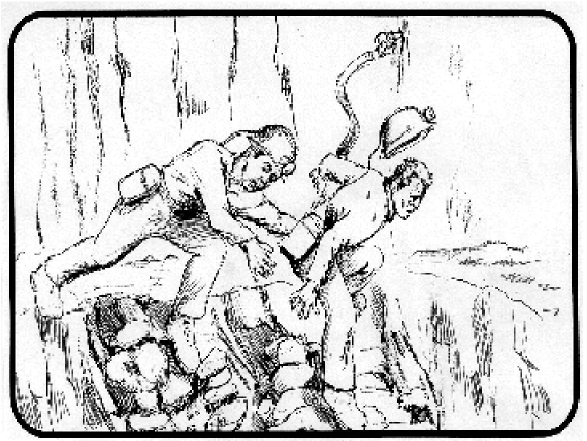
- *This is a very complex and complicated project!*
- *We should all be excited about the prospects for conducting “deep science and engineering research”*

Lets talk about major hazards

- *A <u>hazard</u> is a source of potential harm*
- *Identify hazards by looking at energies*

What are the "Major" Hazards at DUSEL?

- *Strata (collapse)*
- *Gases (explosions)*
- *Water (inundation & drowning)*
- *Gravity (falls-from or falling objects)*
- *Spontaneous combustion (combustible materials)*
- *Struck-by (mobile equipment)*
- *Poisonous gases (hydrogen sulfide)*
- *Electricity (electrocution)*
- *Fire (Diesel, electrical equipment, etc)*
- ***Cryogens (rapid expansion > asphyxiation)***

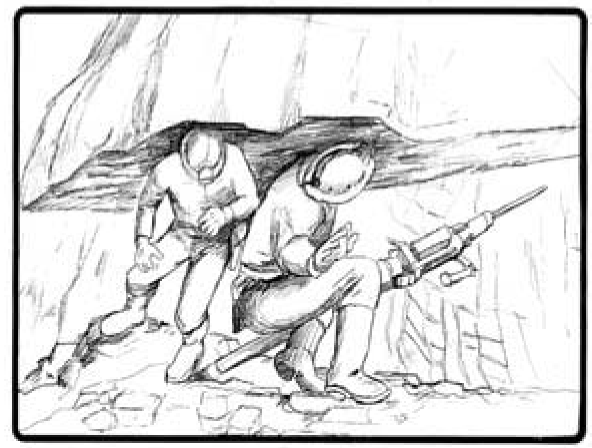


Assess hazards (Look for big energies)

- *Chemical – coal, sulfide minerals, gases, fuels, lubricants, degreasers, solvents, paints, etc.*
- *Electrical – high voltage, batteries, etc.*
- *Gravitational (objects) – falling rock, tools, machinery, structures, etc.*
- *Gravitational (people) – falling from or into equipment, structures, ladders, shafts, etc.*
- *Machine (fixed) – powered by electrical, hydraulic, pneumatic, combustion, etc.*
- *Machine (mobile) – haulage trucks, LHDs, locos, tools, etc.*

Looking backward at Homestake Mine for answers
(from Steve Mitchell's book)

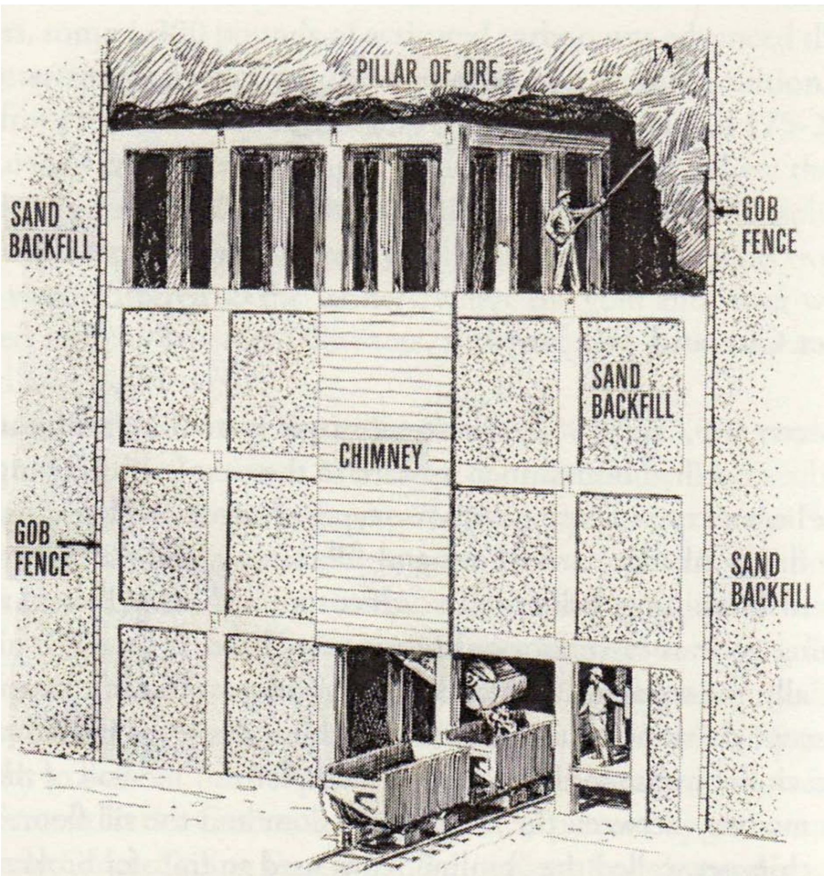
- *270 fatalities from 1876 to 2003 (mine + timber)*
- *Prior to 1918 ~ 7 to 8 per year*
- *After 1918 ~ 1 or 2 per year*

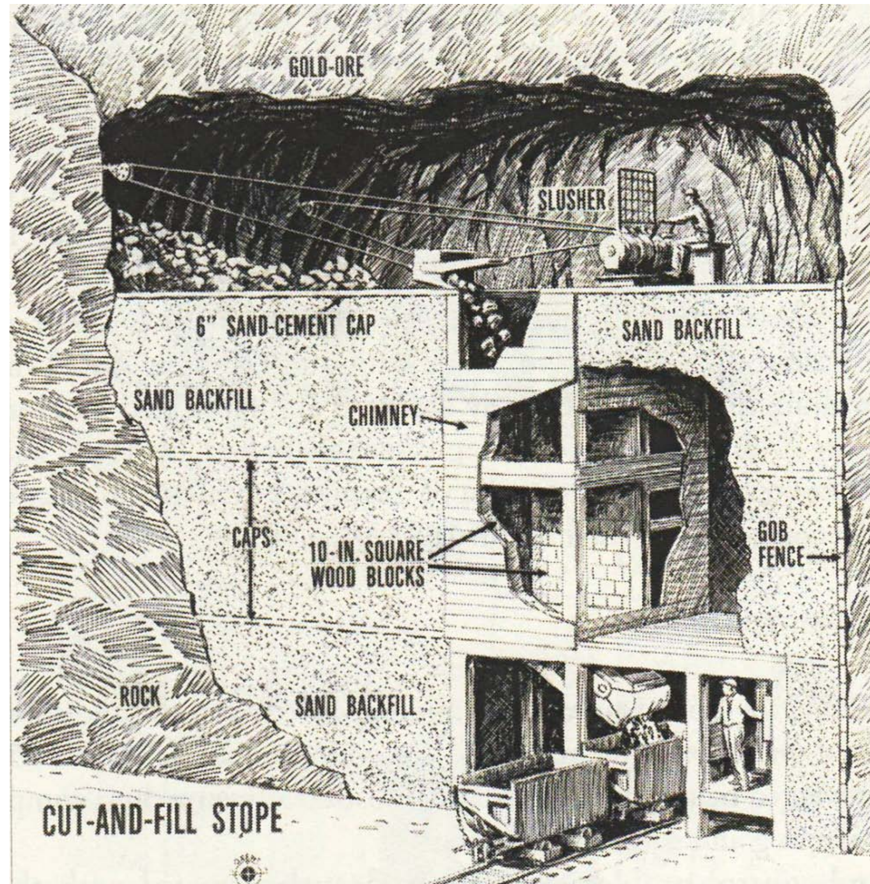


- ***41-pct falls of ground***
- *20-pct falls of person*
- *14-pct explosives*
- *8-pct powered haulage*
- *5-pct falling object (other than rock)*
- *4-pct struck by (cage, skip, cable, etc)*
- *8-pct other (electrocution, asphyxiation, drowning, etc.)*

Mining methods (many accidents related to unique work practices)

- *Square-set stopes*
- *Cut-and-fill stopes*



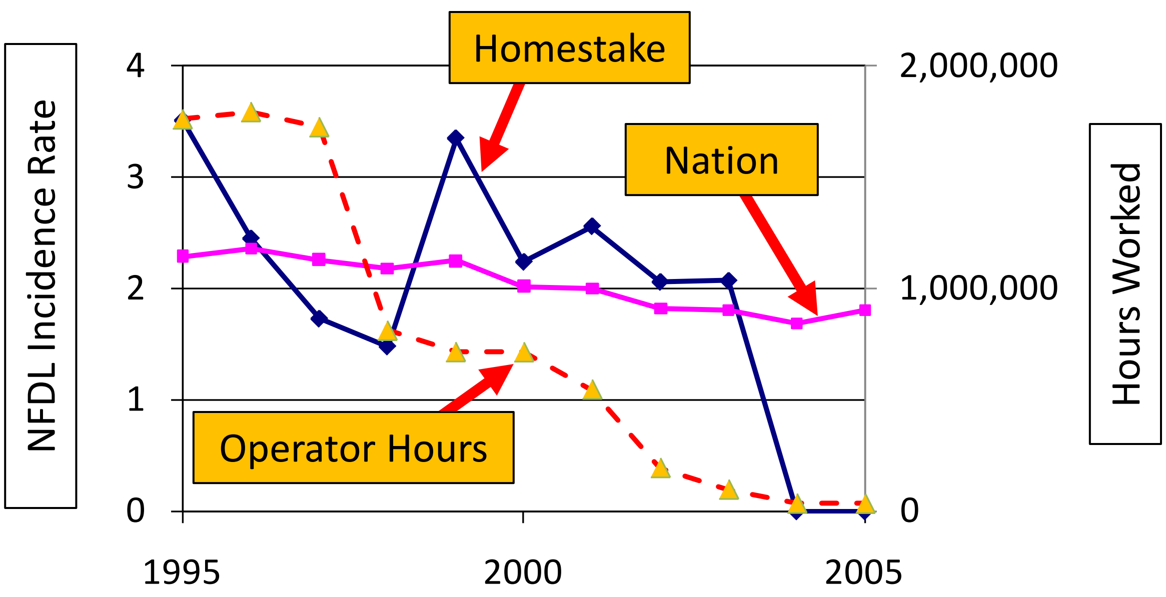


Mine safety (a 125-year history of innovation)

- *1911 – mine rescue team*
- *1916 – full-time safety engineer*
- *1923 – safety bonus system (300 shift accident free-$10)*
- *1931 – mine rescue team equipped with McCaa self-contained breathing apparatus*
- *1953 – USBM training, stench warning system, Central Safety Committee and Workmen's Safety Committee*
- *1954 – safety glasses mandatory*

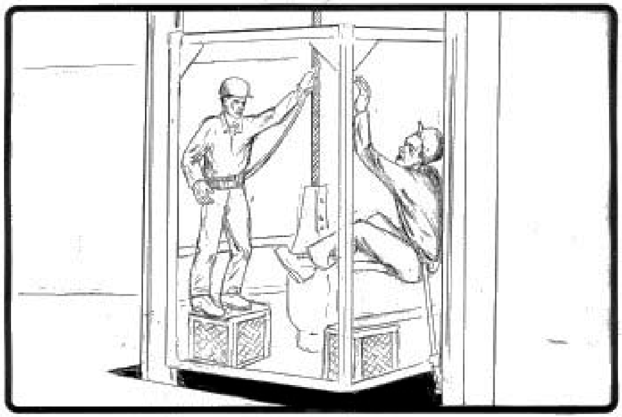
Major hazards were not being adequately addressed

- Some past work processes represent a significant risk for the project (17 fatalities at Homestake Mine between 1977 and 1994)
  - Hoist conveyance issues
  - Shaft rehabilitation issues
  - Drilling, blasting, mucking and installation of support issues



Risk and potential unwanted events

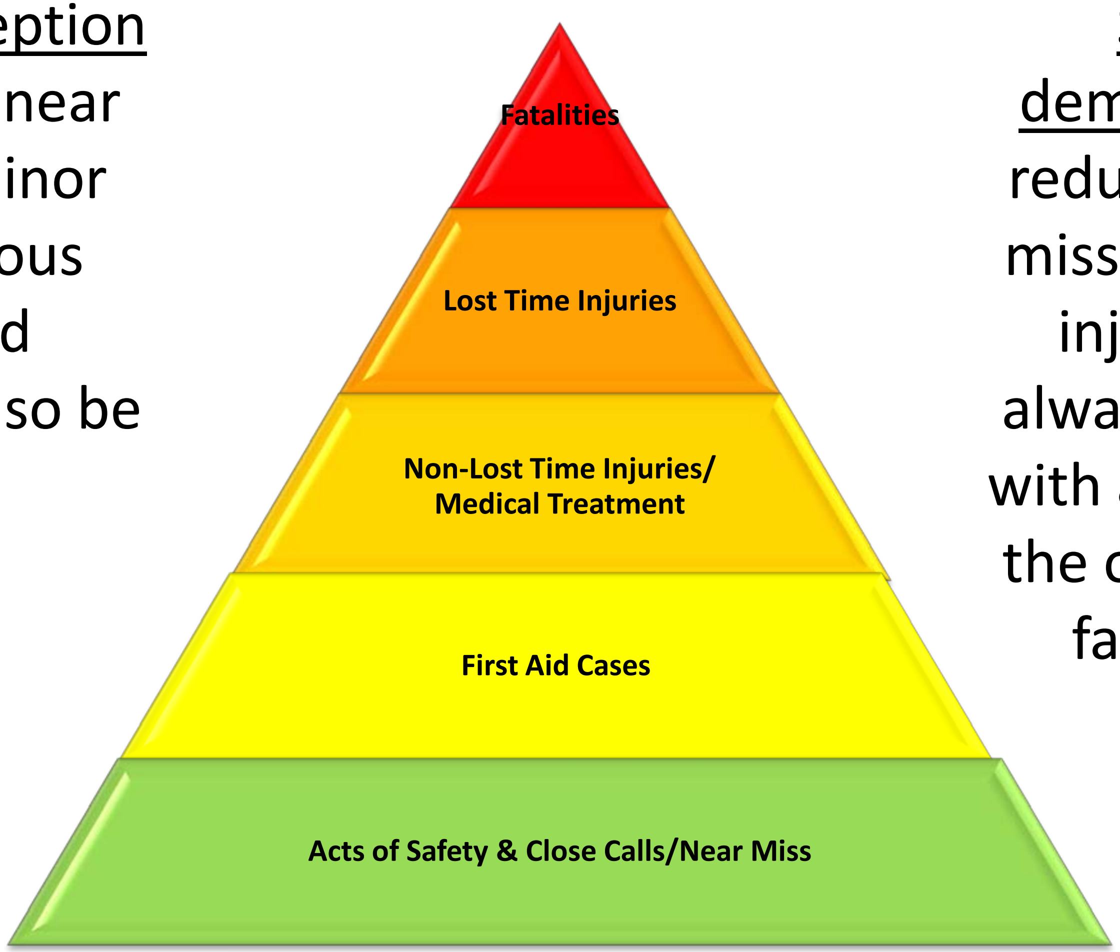
- *A risk is the chance of something happening that will have a negative impact on objectives*
  - *A situation or condition releases a hazard*
  - *This unwanted energy release causes an incident, or worse, an accident*
- *Look for potential unwanted events*



Risk = Probability of occurrence X Consequence of outcome

Need to focus on major hazards

<u>Common perception</u> – by reducing near misses and minor injuries, serious injuries and fatalities will also be reduced



<u>Statistics demonstrate</u> – a reduction in near misses and minor injuries is not always associated with a reduction in the occurrence of fatal injuries

Implication – major hazards need to be addressed directly

Major hazard risk assessment is a fundamental requirement for DUSEL?

- *Understand Potential Loss – what consequence types?*
- *Examine Potential Energies – what sources of harm?*
- *Review Existing Controls and Investigate New Ideas for Control (additional ways to reduce risk?)*

Understand the hazards

↓

Identify the risks

↓

Analyse & Evaluate risks

↓

Consider the controls

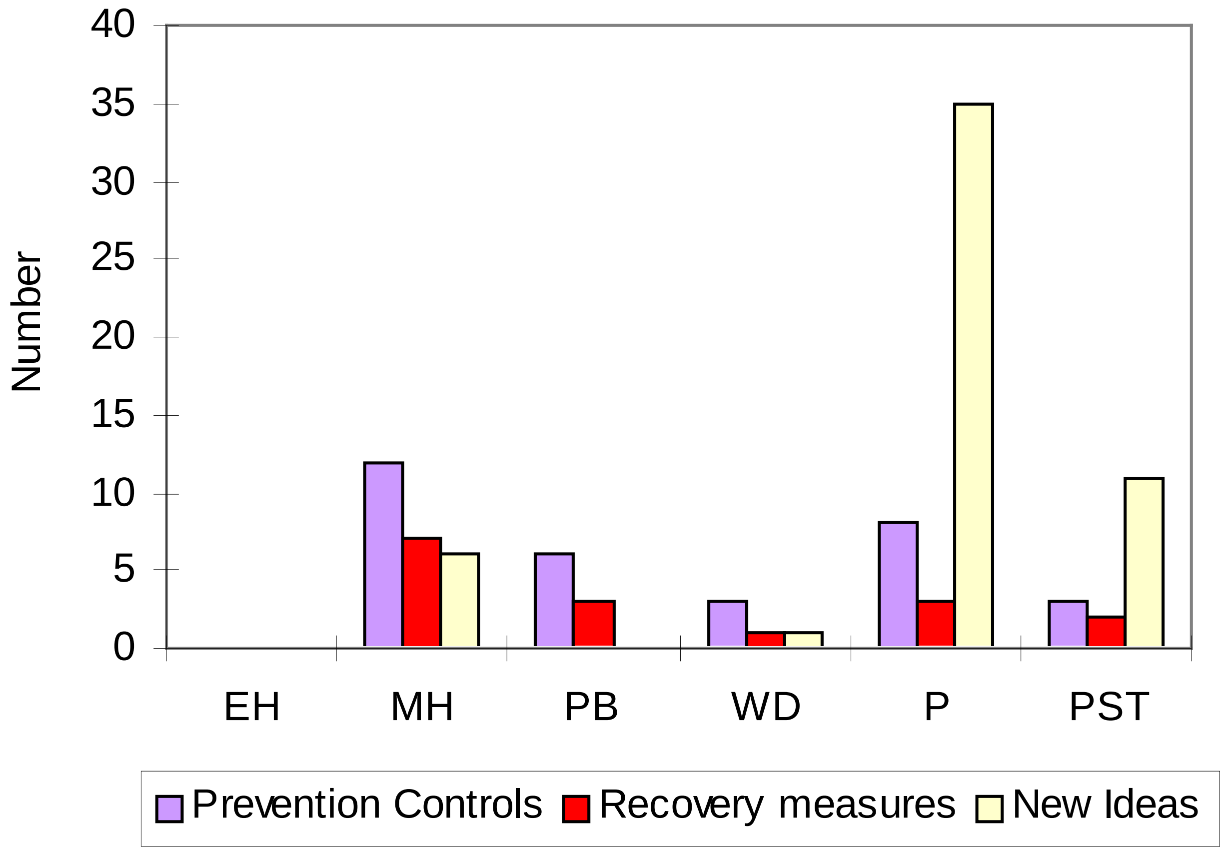
Remember -- Not all controls are equal

Risk reduction effectiveness

Control Category	Major Control Issue	Risk Reduction Effectiveness	Potential for Human Error
Eliminate Hazard	Organizational	Complete	Doesn't exist
Minimize Hazard	Engineering	High	Human error plays a minor role
Physical Barriers			
Warning Devices	Assessing	Medium	Human error is possible
Procedures	Work process	Low	Human error can play an important role
Personnel Skills and Training			

Potential for human error

In reality most organizations use controls with reduced effectiveness (from NIOSH field data)



Control Category
EH - Eliminate Hazard
MH - Minimize Hazard
PB - Physical Barriers
WD - Warning Devices
P- Procedures
PST - Personnel Skills and Training

Risk reduction effectiveness

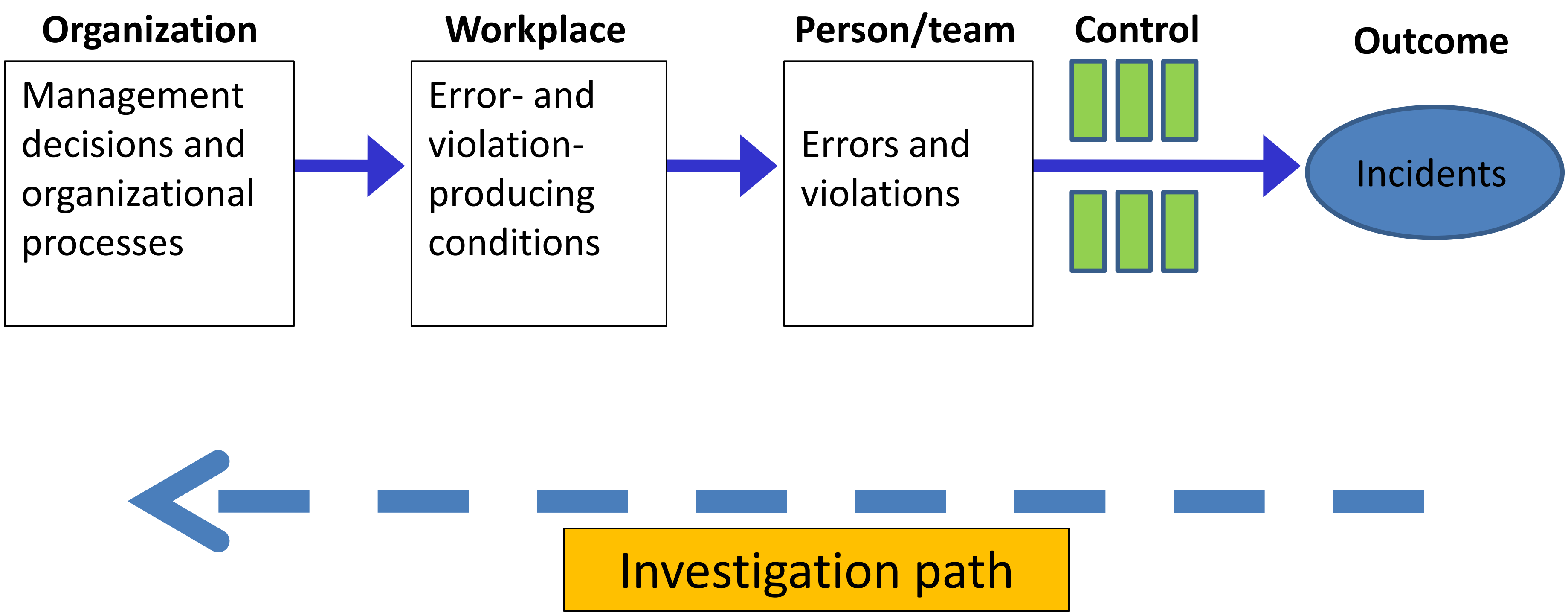
Questions to answer

- Was the threat or hazards identified and understood?
- What were the controls that were supposed to prevent the incident?
- Why didn’t they work as intended?

Only if threats and hazards are understood can controls be properly determined and their effectiveness evaluated

Utilize incident investigations

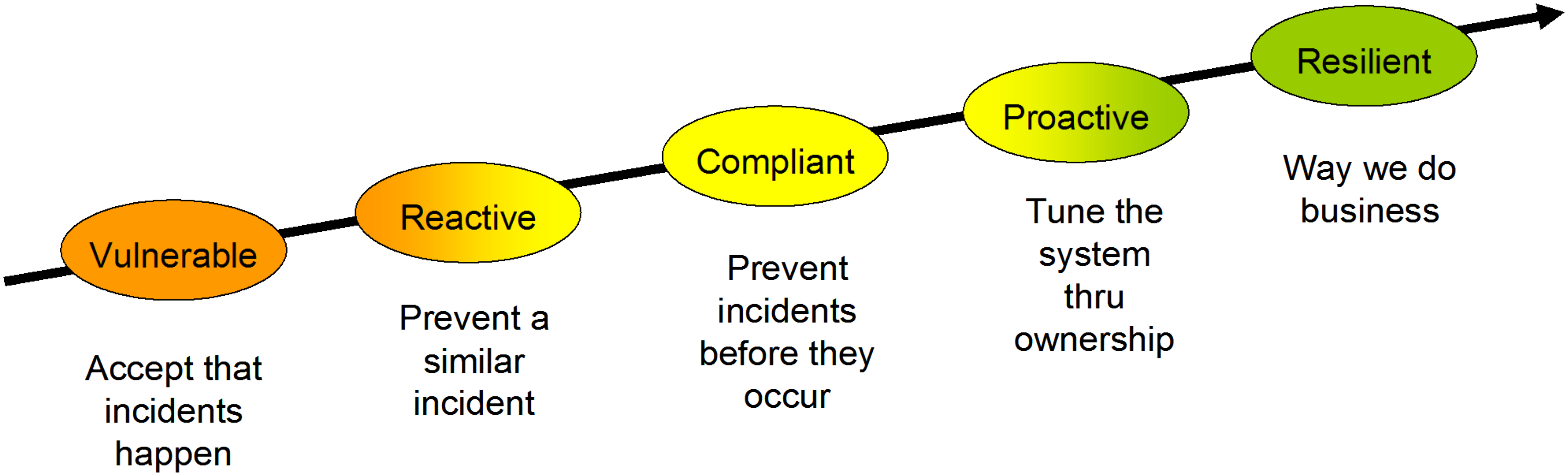
- Identify root cause
- Determine why controls didn't work
- Determine actionable outcomes that correct organizational issues



"Focus on the Right Things"

- *Set clear direction to solve specific high risk problems*
- *Focuses on priority concerns and conditions undergoing change*
- *Gets involvement and commitment from a wide cross-section of the operation's work force*
- *Decrease potential losses associated with risky work processes*
- *Build teams to mitigate major hazards*
- *Audits and review to provide assurances to management that the controls are being applied to some operational standard*
- *<u>Go beyond simply complying with existing standards and regulations</u>*

The Hudson Model – *It's a Journey*



- Develop a <u>proactive safety culture</u>
- Integrate safety programs into all aspects of the organization
- Develop a self-regulating philosophy where work processes utilize <u>leading</u> practices