Particle Accelerator Conference 07

22nd PAC Conference • June 25 - 29, 2007 • USA

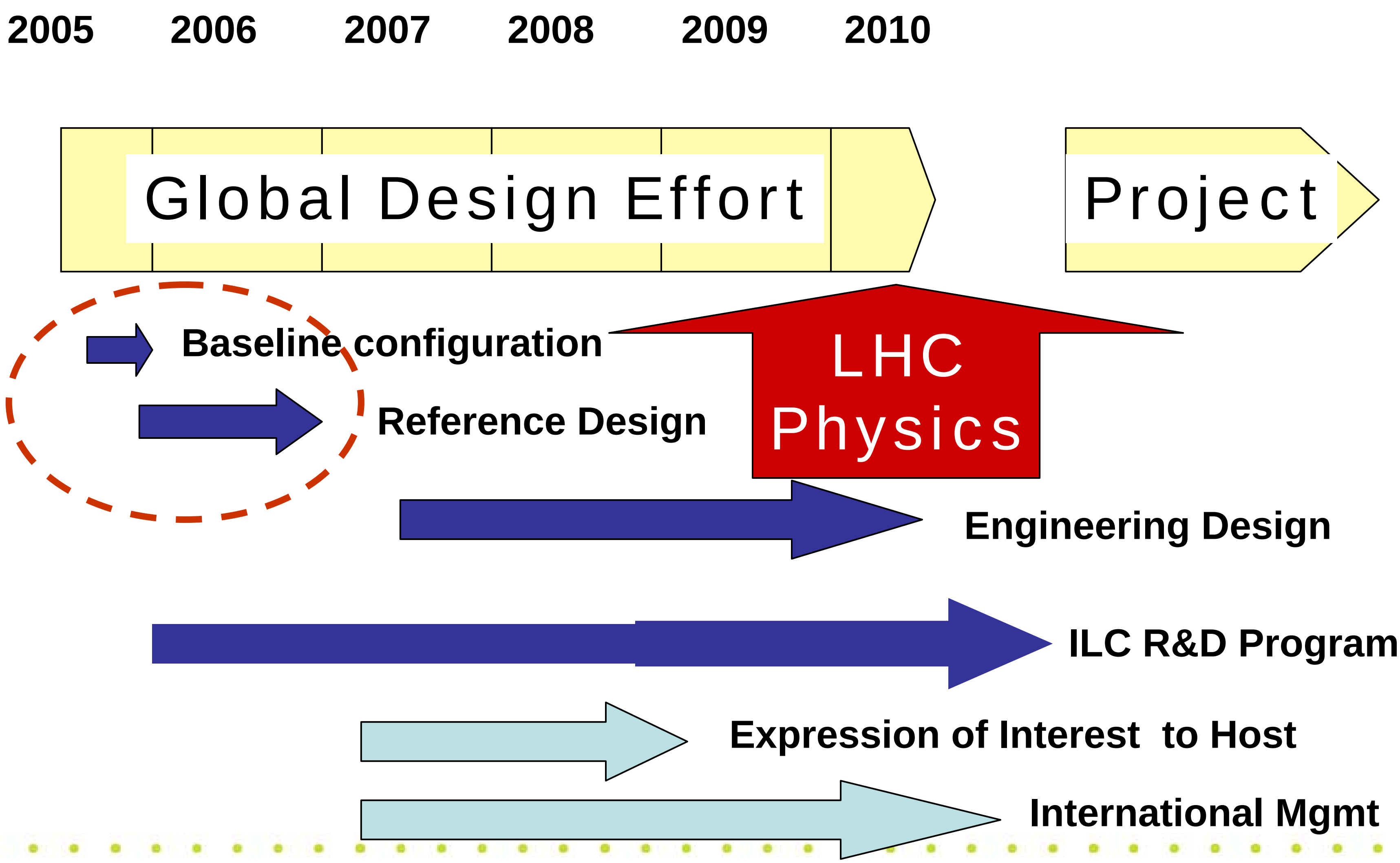
Towards an International Linear Collider

Barry Barish

Caltech / GDE

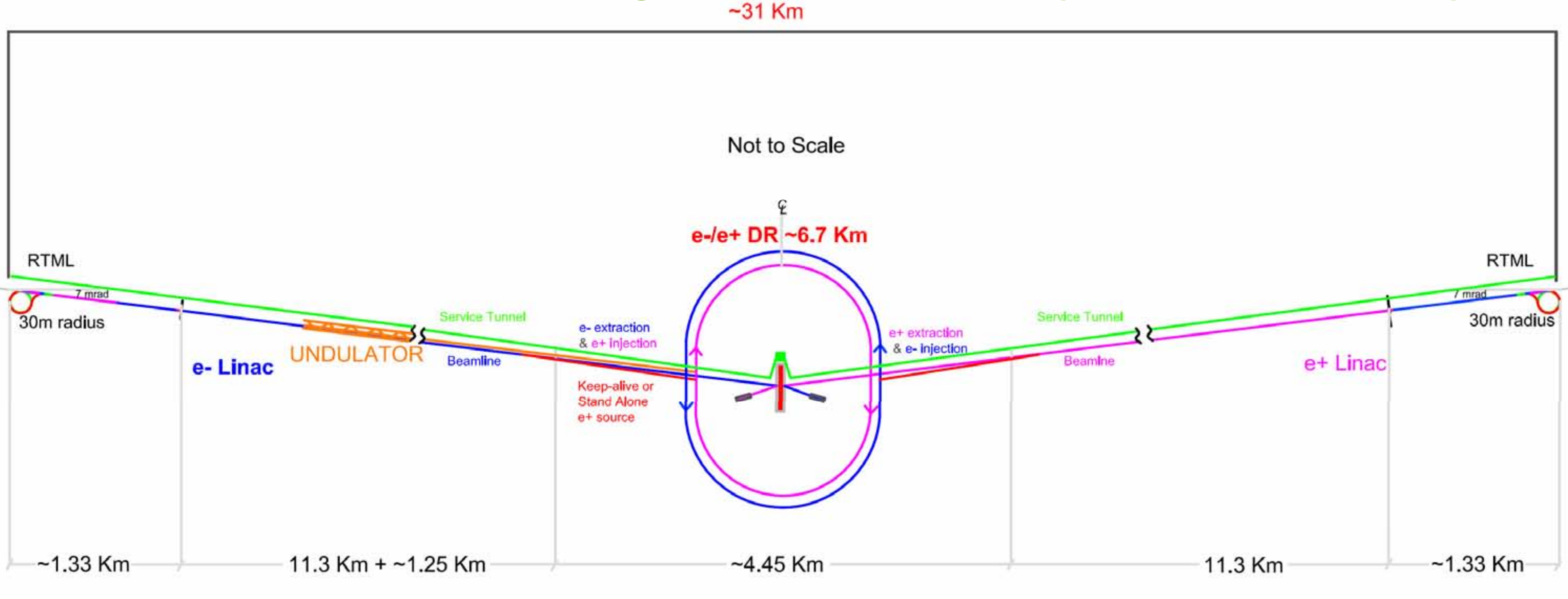
25-June-07

The GDE Plan and Schedule



RDR ILC Schematic

- 11km SC linacs operating at 31.5 MV/m for 500 GeV
- Centralized injector
  - Circular damping rings for electrons and positrons
  - Undulator-based positron source
- Single IR with 14 mrad crossing angle
- Dual tunnel configuration for safety and availability



RDR Design Parameters

Max. Center-of-mass energy	500	GeV
Peak Luminosity	~$2x10^{34}$	$1/cm^2s$
Beam Current	9.0	mA
Repetition rate	5	Hz
Average accelerating gradient	31.5	MV/m
Beam pulse length	0.95	ms
Total Site Length	31	km
Total AC Power Consumption	~230	MW

RDR Design & “Value” Costs

The reference design was “frozen” as of 1-Dec-06 for the purpose of producing the RDR, including costs.

It is important to recognize this is a snapshot and the design will continue to evolve, due to results of the R&D, accelerator studies and value engineering

The value costs have already been reviewed twice

- 3 day “internal review” in Dec
- ILCSC MAC review in Jan

Σ Value = 6.62 B ILC Units

Summary
RDR “Value” Costs

Total Value Cost (FY07)

4.80 B ILC Units Shared

+

1.82 B Units Site Specific

+

14.1 K person-years

(“explicit” labor = 24.0 M person-hrs @ 1,700 hrs/yr)

1 ILC Unit = $ 1 (2007)

Assessing the RDR

- **Reviews (5 major international reviews + regional)**
  - **The Design: “The MAC applauds that considerable evolution of the design was achieved … the performance driven baseline configuration was successfully converted into a cost conscious design.”**
  - **The R&D Plan: “The committee endorses the approach of collecting R&D items as proposed by the collaborators, categorizing them, prioritizing them, and seeking contact with funding agencies to provide guidelines for funding.**
  - **International Cost Review (Orsay): Supported the costing methodology; considered the costing conservative in that they identify opportunities for cost savings; etc.**

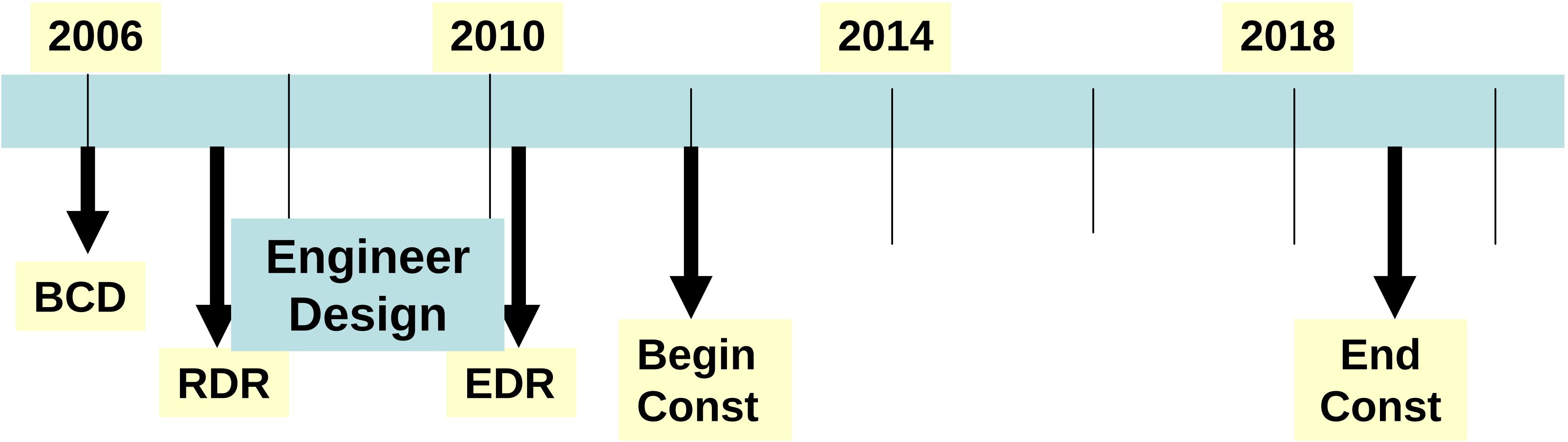
- **Final Steps**
  - **The final versions of Executive Summary, Reference Design Report and Companion Document will be submitted to FALC (July), ILCSC and ICFA (August).**

On track … but what about Orbach?

"Completing the R&D and engineering design, negotiating an international structure, selecting a site, obtaining firm financial commitments, and building a machine could take us well into the mid-2020s, if not later,"

- **Our technically driven timeline is**
  - **Construction proposal in 2010**
  - **Construction start in 2012**
  - **Construction complete in 2019**
- **What do we need to do to achieve <u>our</u> timeline?**

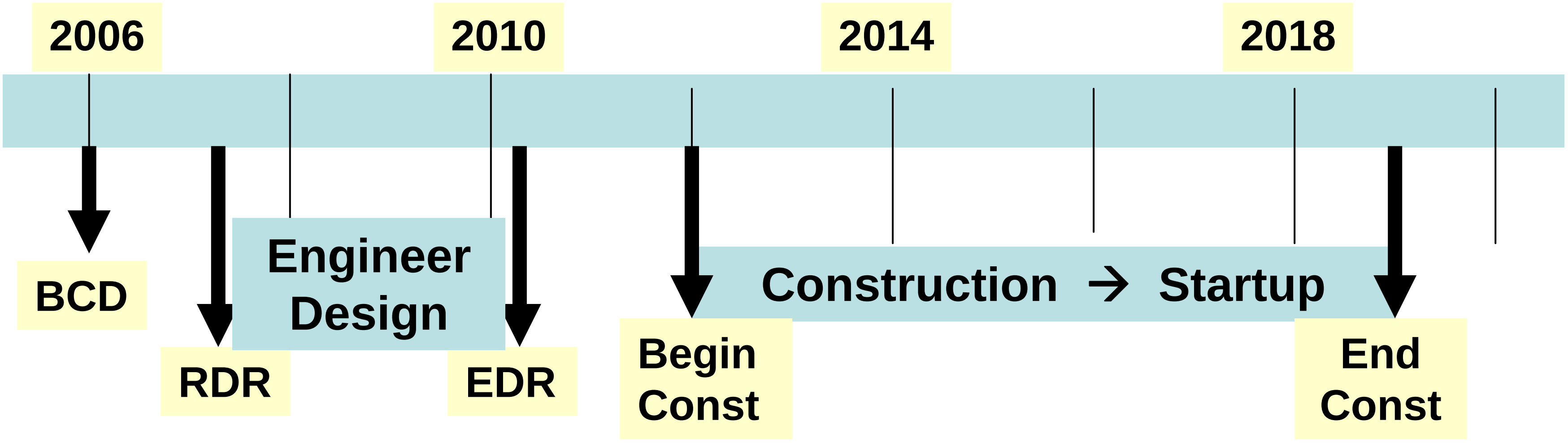
Technically Driven Timeline



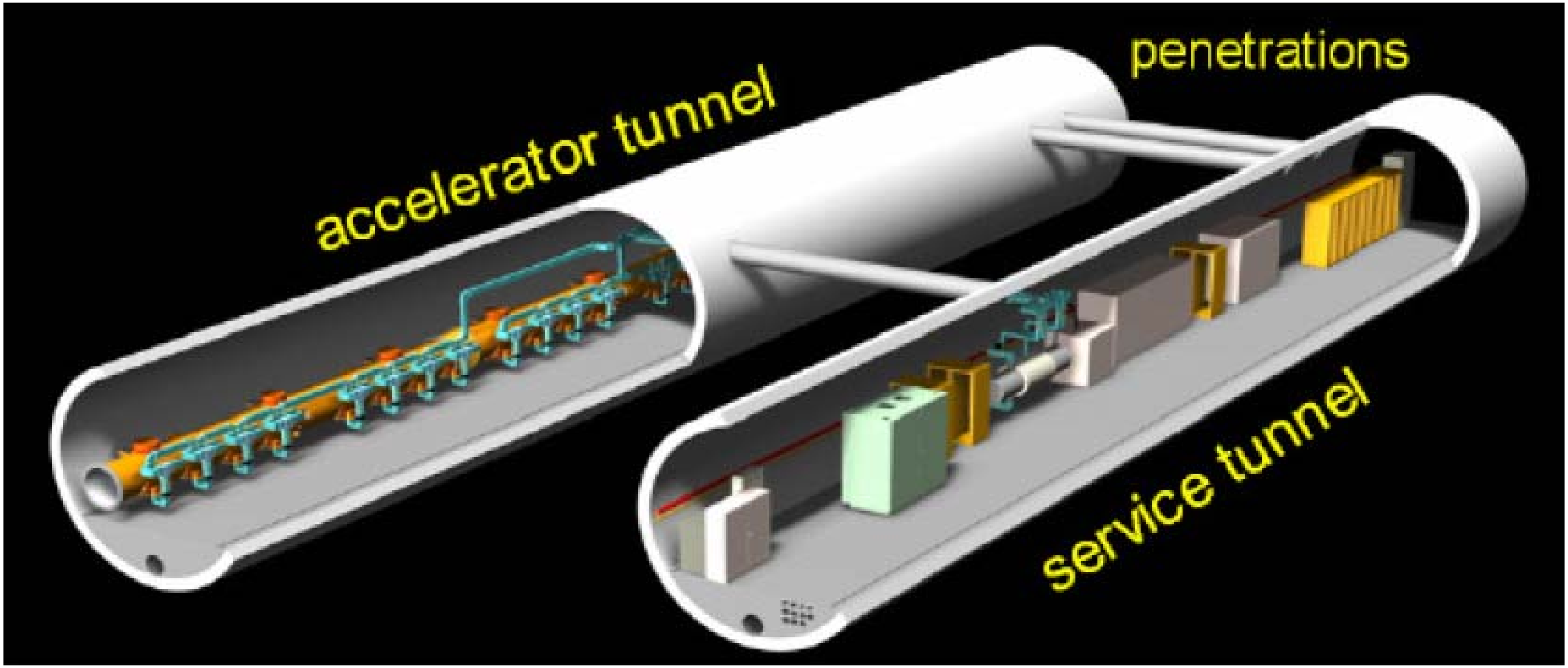
Engineering Design Phase

- **ILC Engineering Design**
  - **We have a solid design concept in the reference design, but it is immature and needs engineering designs, value engineering, supporting R&D and industrialization.**
- **GDE will be reorganized around a Project Management Office to reach this goal**
  - **M. Ross, N. Walker and A Yamamoto – PM "Troika" + high level engineering managers in the project office**
  - **Central management will have authority to set priorities and direct the work**
  - **Resources for the engineering design and associated R&D appears feasible**
  - **Investments toward Industrialization and siting**
  - **Anticipate LHC results by ~2010. We are committed to be ready at that time!**

Technically Driven Timeline



Double Tunnel



- Three RF/cable penetrations every rf unit
- Safety crossovers every 500 m
- 34 kV power distribution

Conventional Facilities

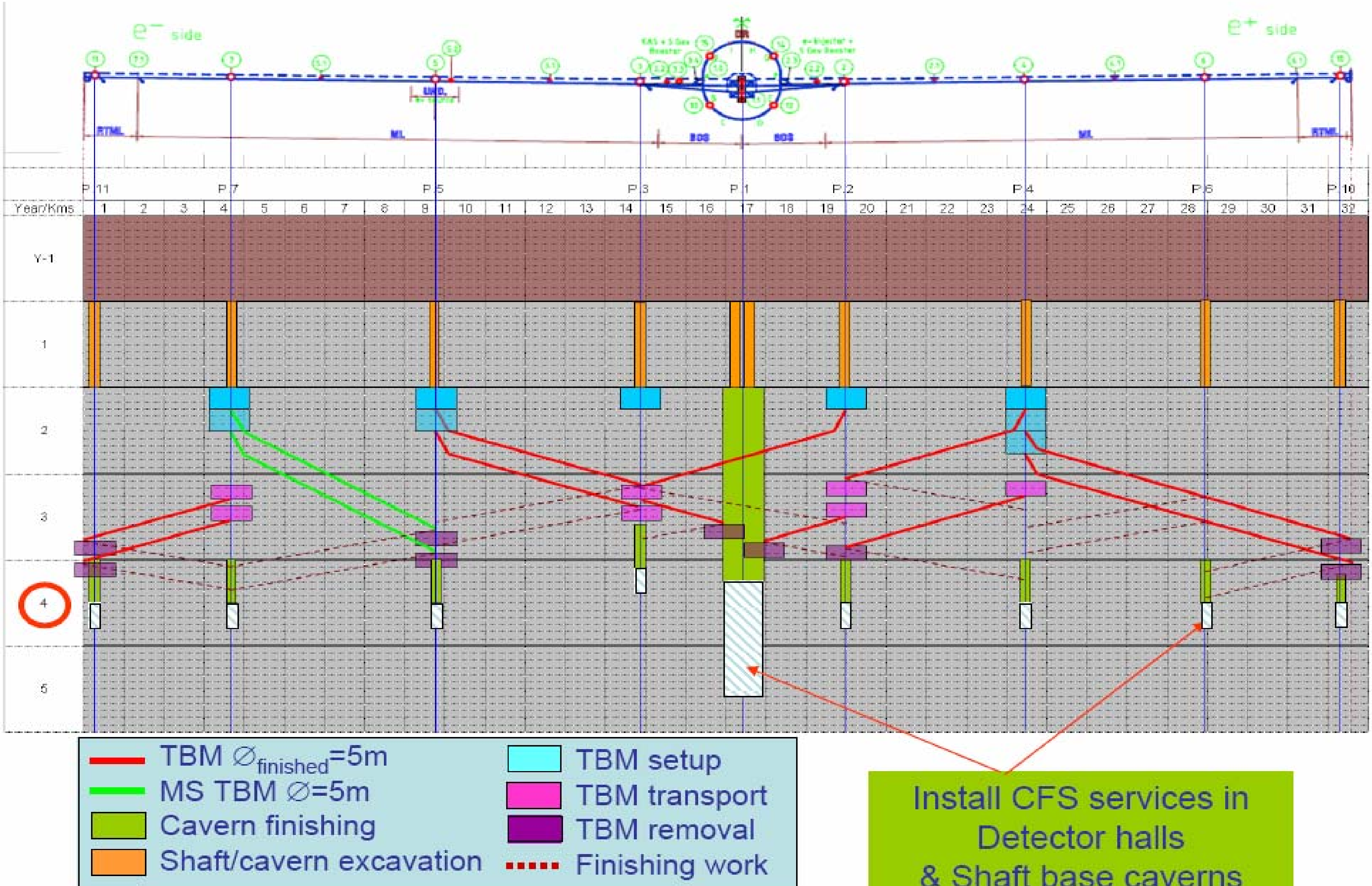
72.5 km tunnels ~ 100-150 meters underground

13 major shafts $\geq$ 9 meter diameter

443 K cu. m. underground excavation: caverns, alcoves, halls

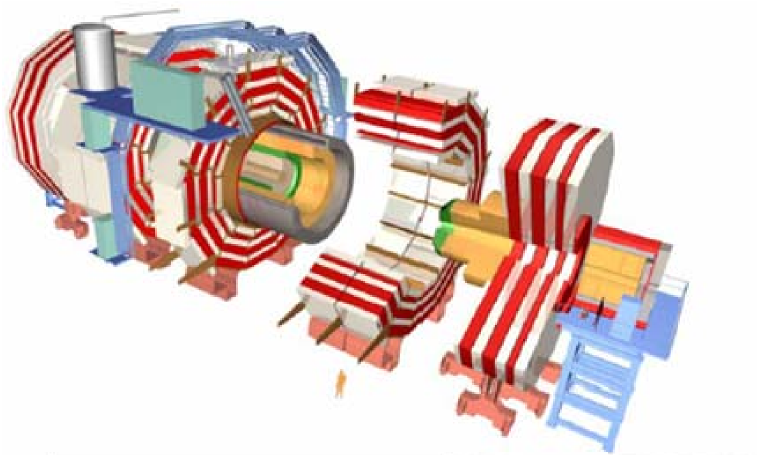
92 surface "buildings", 52.7 K sq. meters = 567 K sq-ft total

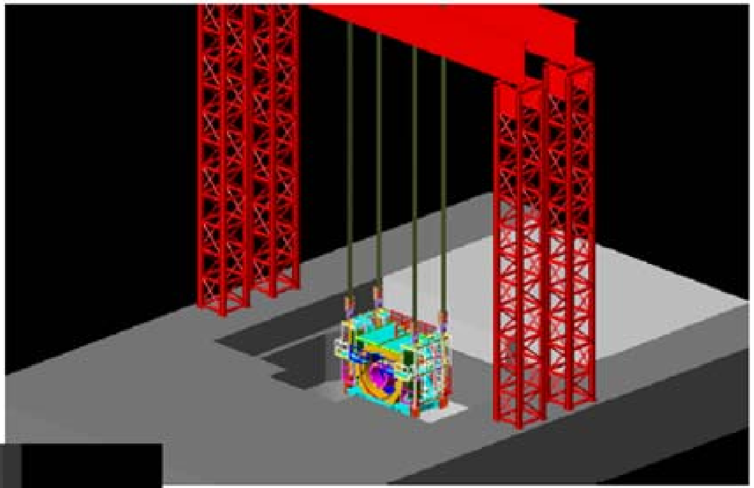
Civil Construction Timeline

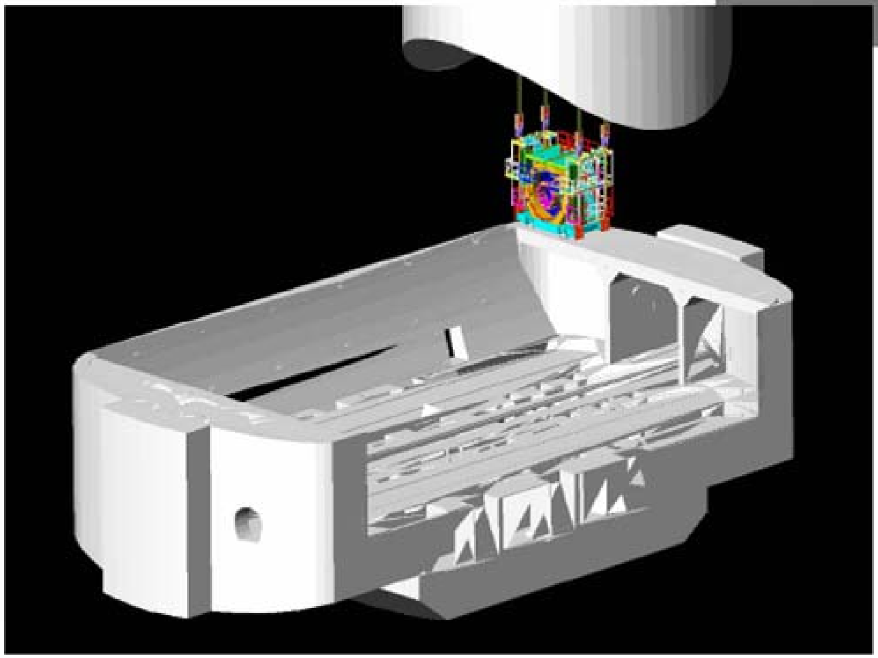


Install CFS services in Detector halls & Shaft base caverns

On-surface Detector Assembly
CMS approach



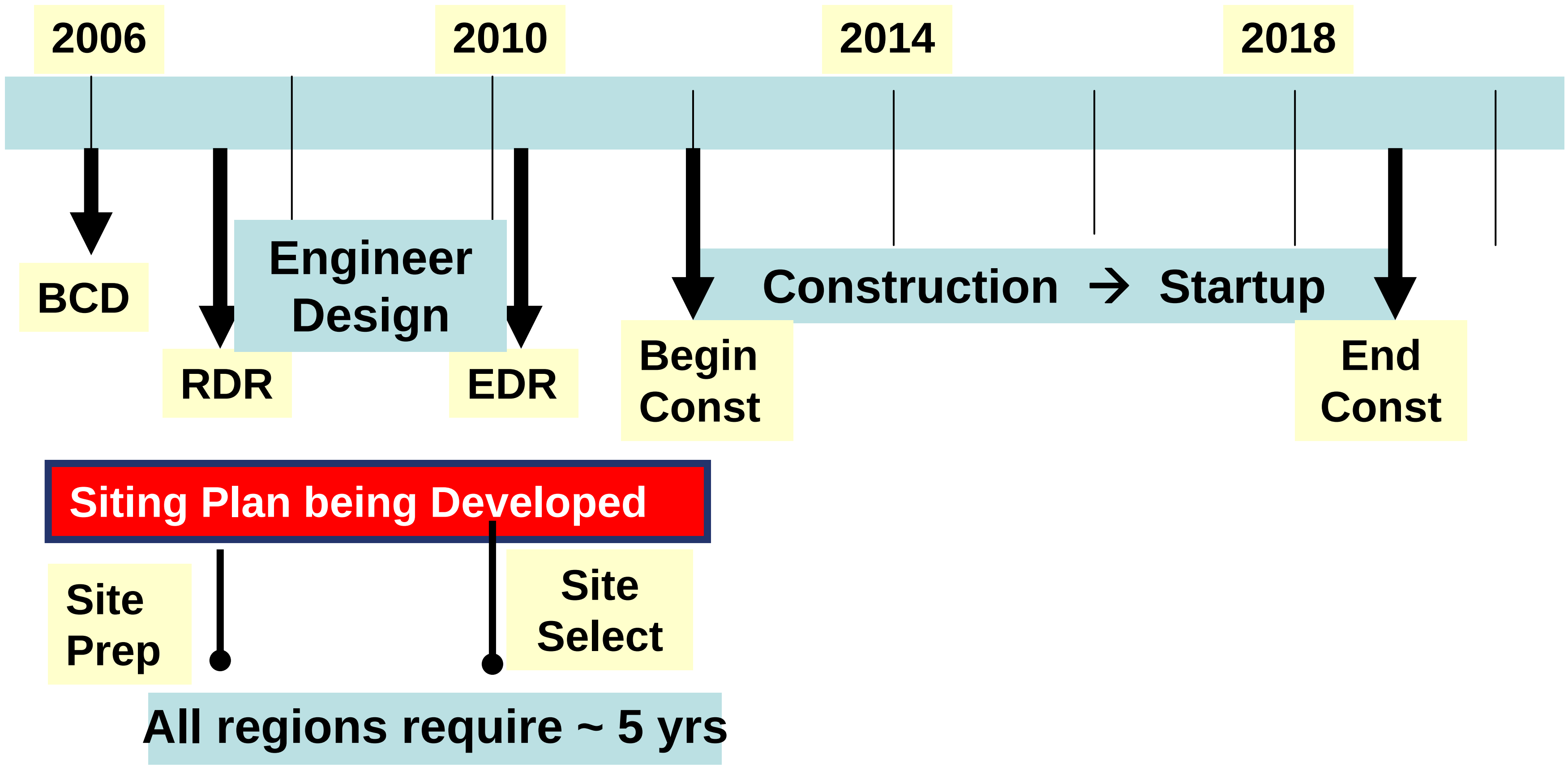




CMS assembly approach:

- **Assembled on the surface in parallel with underground work**
- **Allows pre-commissioning before lowering**
- **Lowering using dedicated heavy lifting equipment**
- **Potential for big time saving**
- **Reduces size of required underground hall**

Technically Driven Timeline

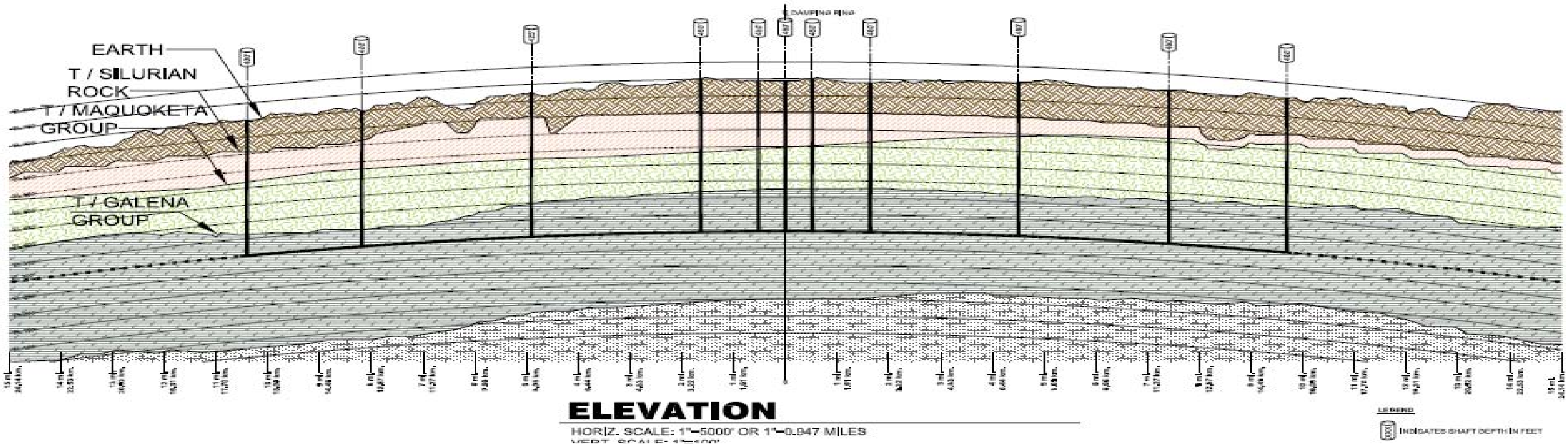


Americas Fermilab Sample Site

Situation : *in solid rock, close to existing institute, close to the city of Chicago and international airport, close to railway and highway networks.*

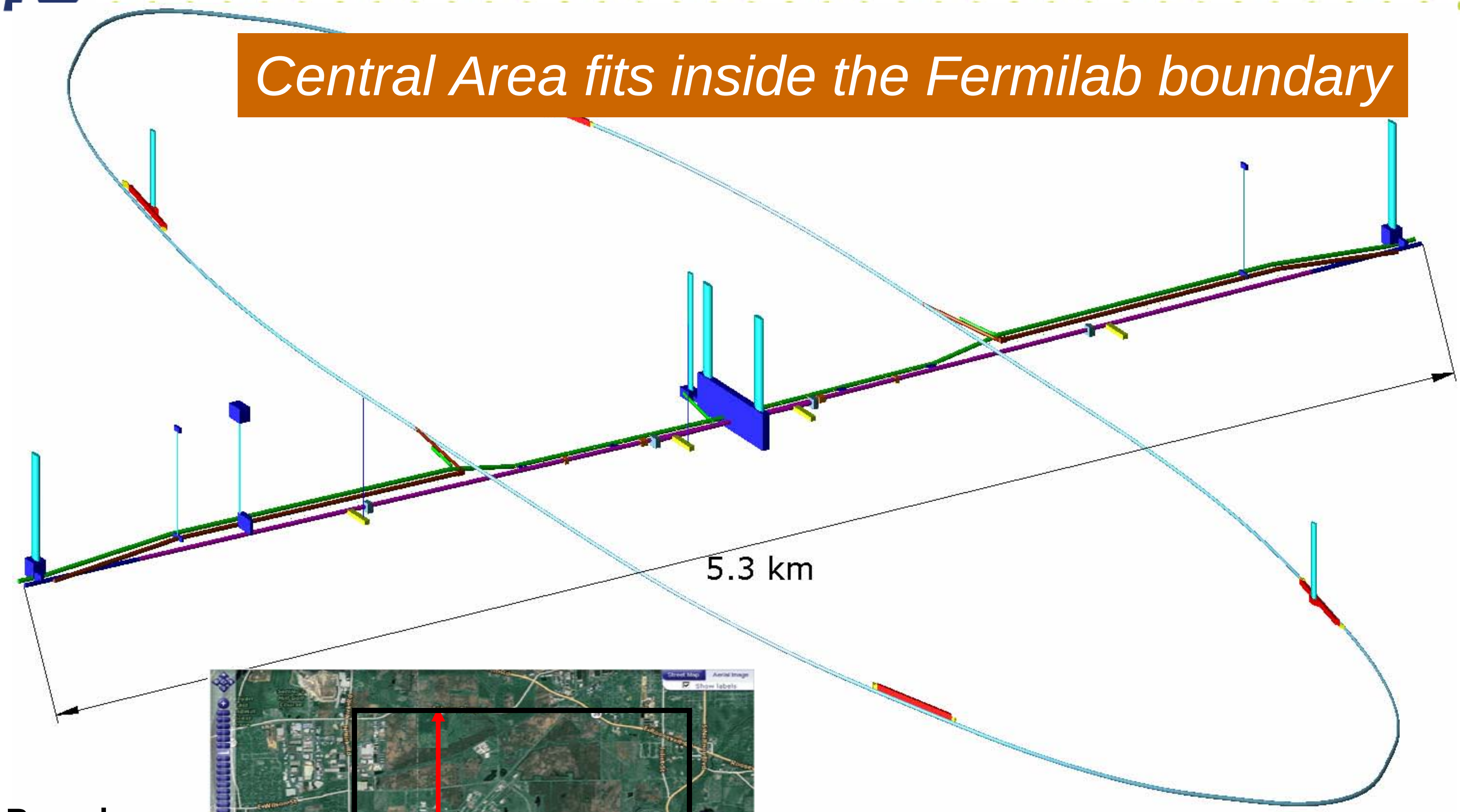
Geology : *Glacially derived deposits overlaying Bedrock. The concerned rock layers are from top to bottom the Silurian dolomite, Maquoketa dolomitic shale, and the Galena-Platteville dolomites.*

Depth of main tunnels : *Average ~ 135 m*

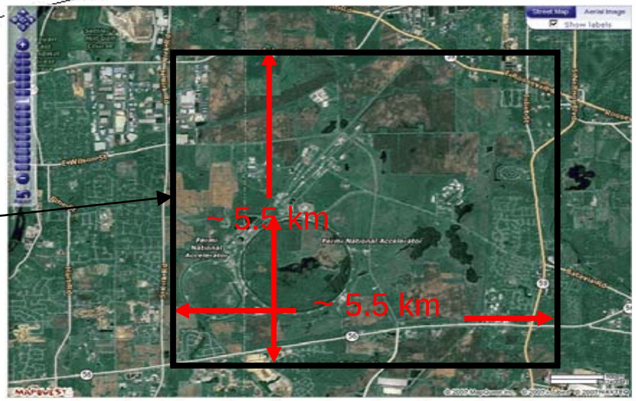


Preconstruction Plan for Fermilab

Central Area fits inside the Fermilab boundary

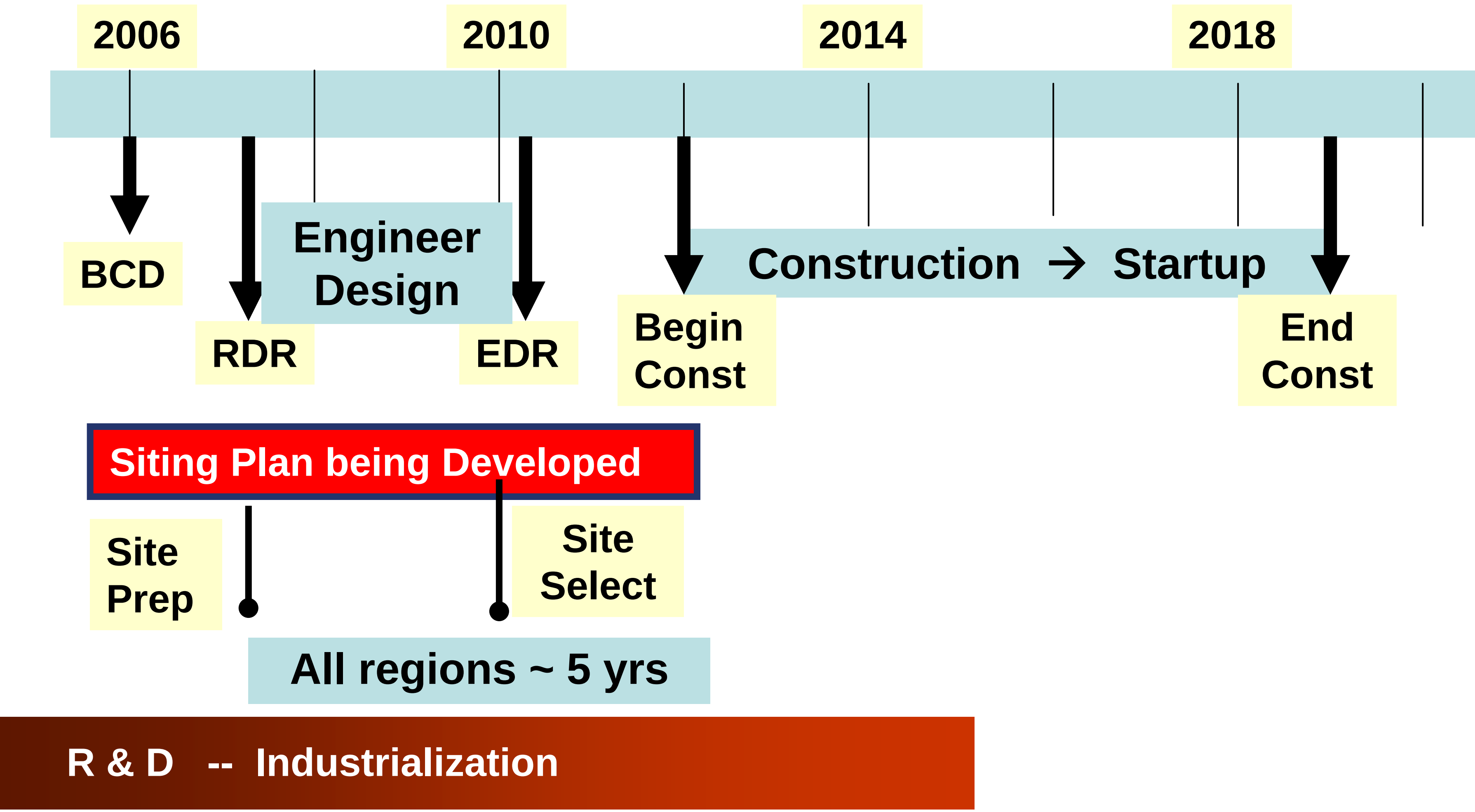


~ Boundary of Fermilab



Site Characterization of the Central Area can be done

Technically Driven Timeline

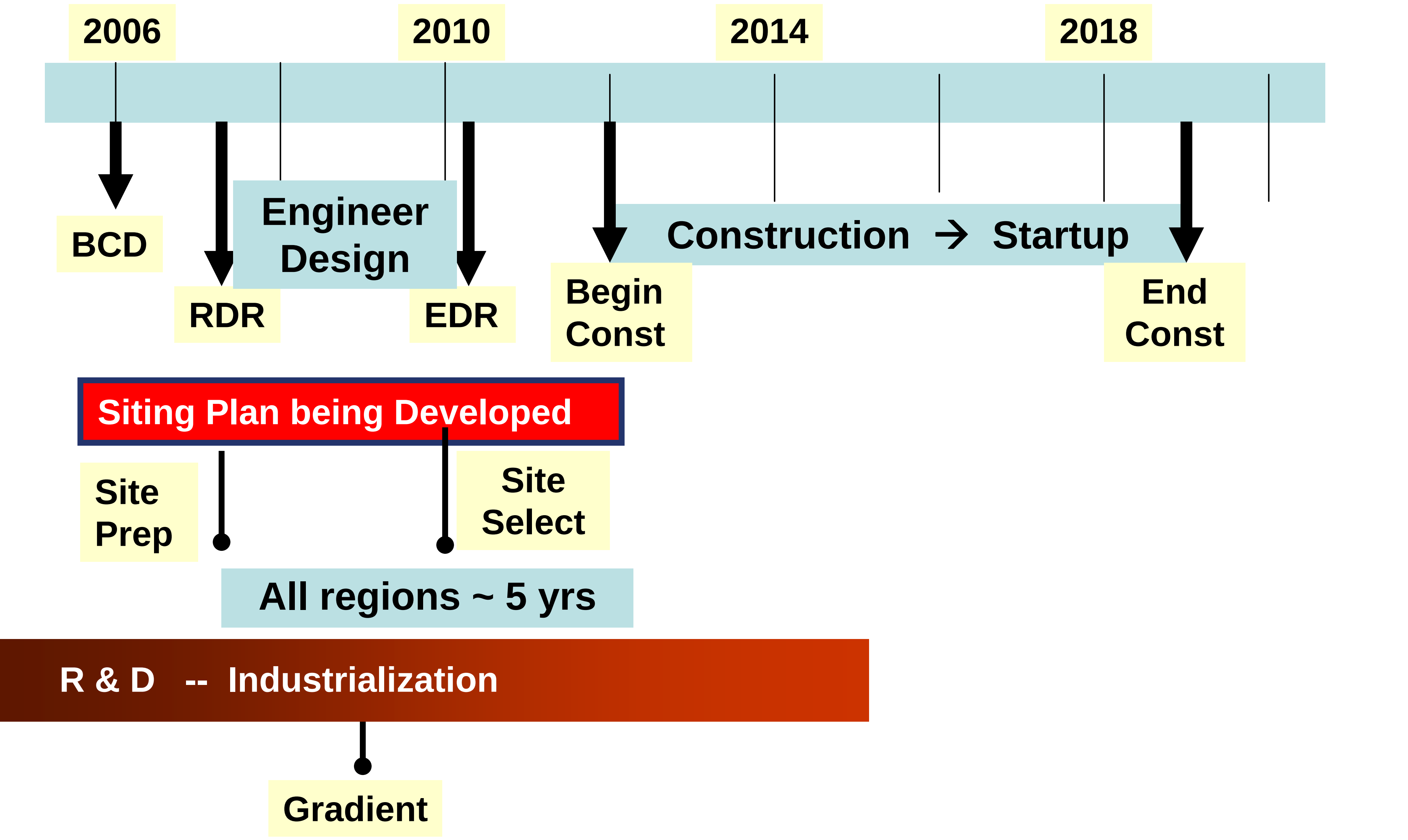


The Task Forces

- **The Task Forces were put together successively over a period of five months:**
  - **S0 / S1-Cavities, Cryomodule**
  - **S2 -Cryomodule String Tests**
  - **S3 -Damping Rings**
  - **S4 -Beam Delivery System**
  - **S5-Positron Source**
  - **S6-Controls, not yet active**
  - **S7-RF**

- **Working in close collaboration with the Engineering and Risk Assessment team.**

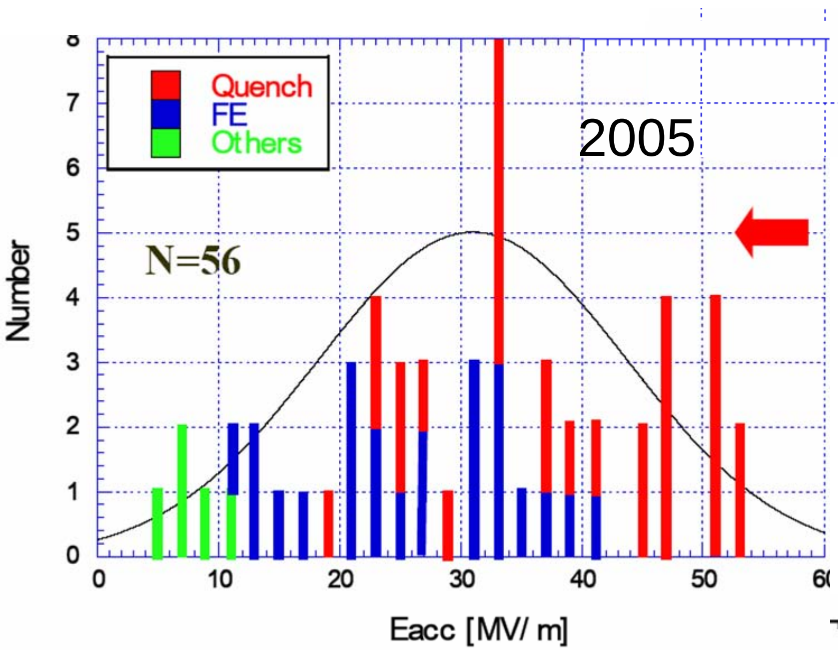
Technically Driven Timeline

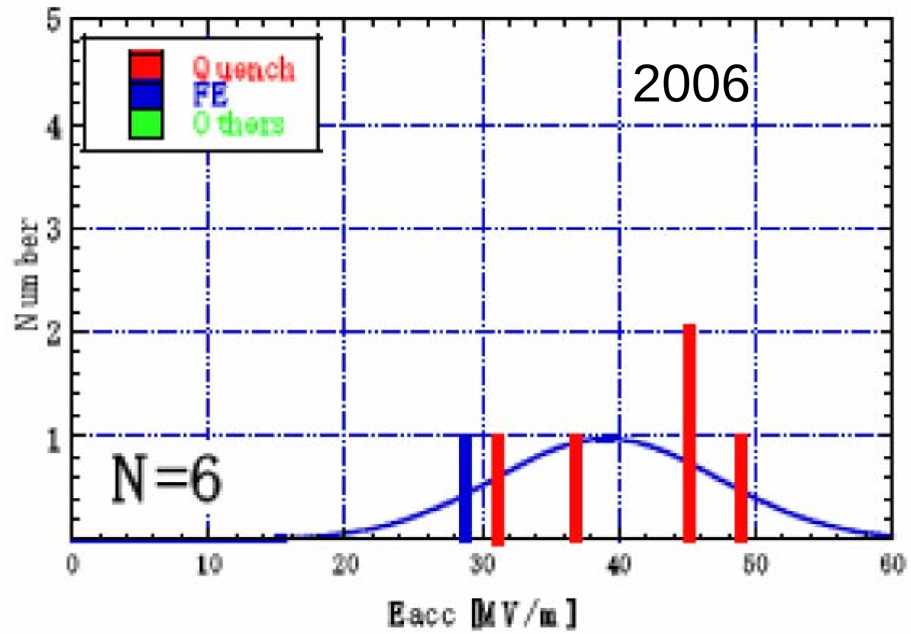


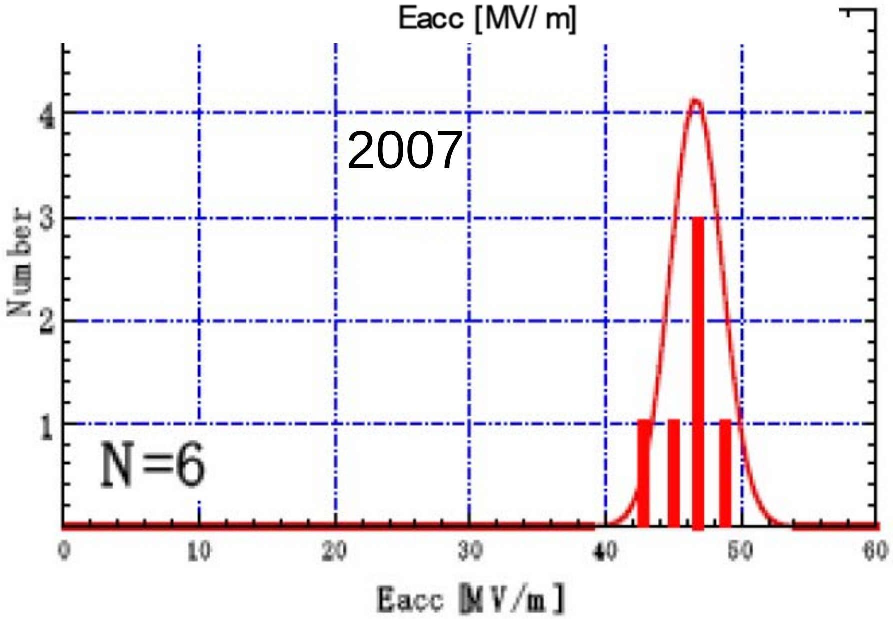
Cavity Gradient – Goal

- Current status: Nine 9 cell cavities have been produced with gradients > 35 MeV/m. Not reproducible and needs several attempts at final processing.
- Goal: After a viable cavity process has been determined through a series of preparations and vertical tests on a significant number of cavities, achieve 35 MV/m at $Q_0 = 10^{10}$ in a sufficiently large final sample (greater than 30) of nine-cell cavities in the low power vertical dewar testing in a production-like operation e.g. all cavities get the same treatment.
  - **The yield for the number of successful cavities of the final production batch should be larger than 80% in the first test. After re-processing the 20 % underperforming cavities the yield should go up to 95%. This is consistent with the assumption in the RDR costing exercise.**

Cavity Gradient – Results







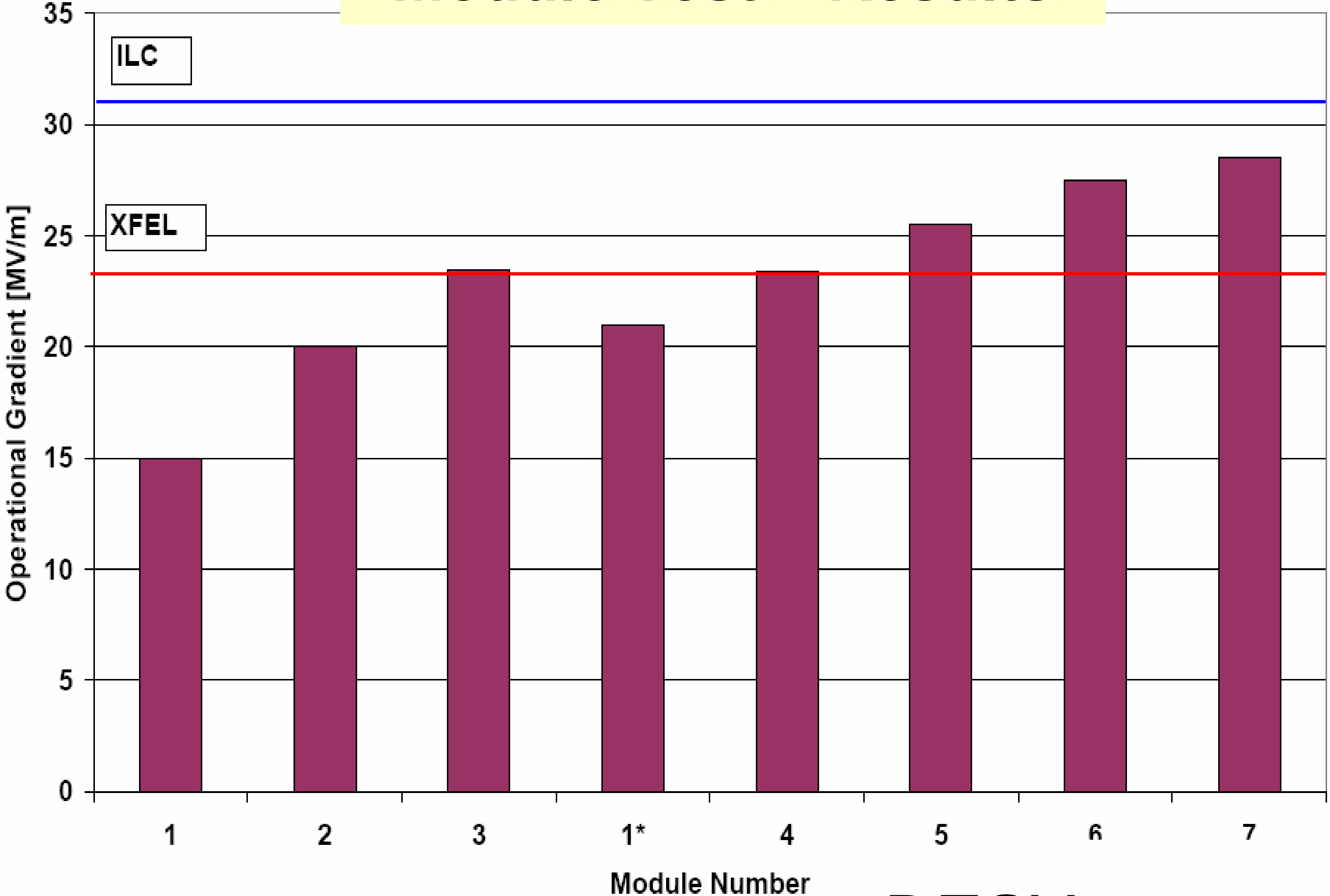
KEK single cell results:
2005 – just learning
2006 – standard recipe
2007 – add final 3 μm fresh acid EP

Note: multi-cells are harder than singles

Module Test – Goal

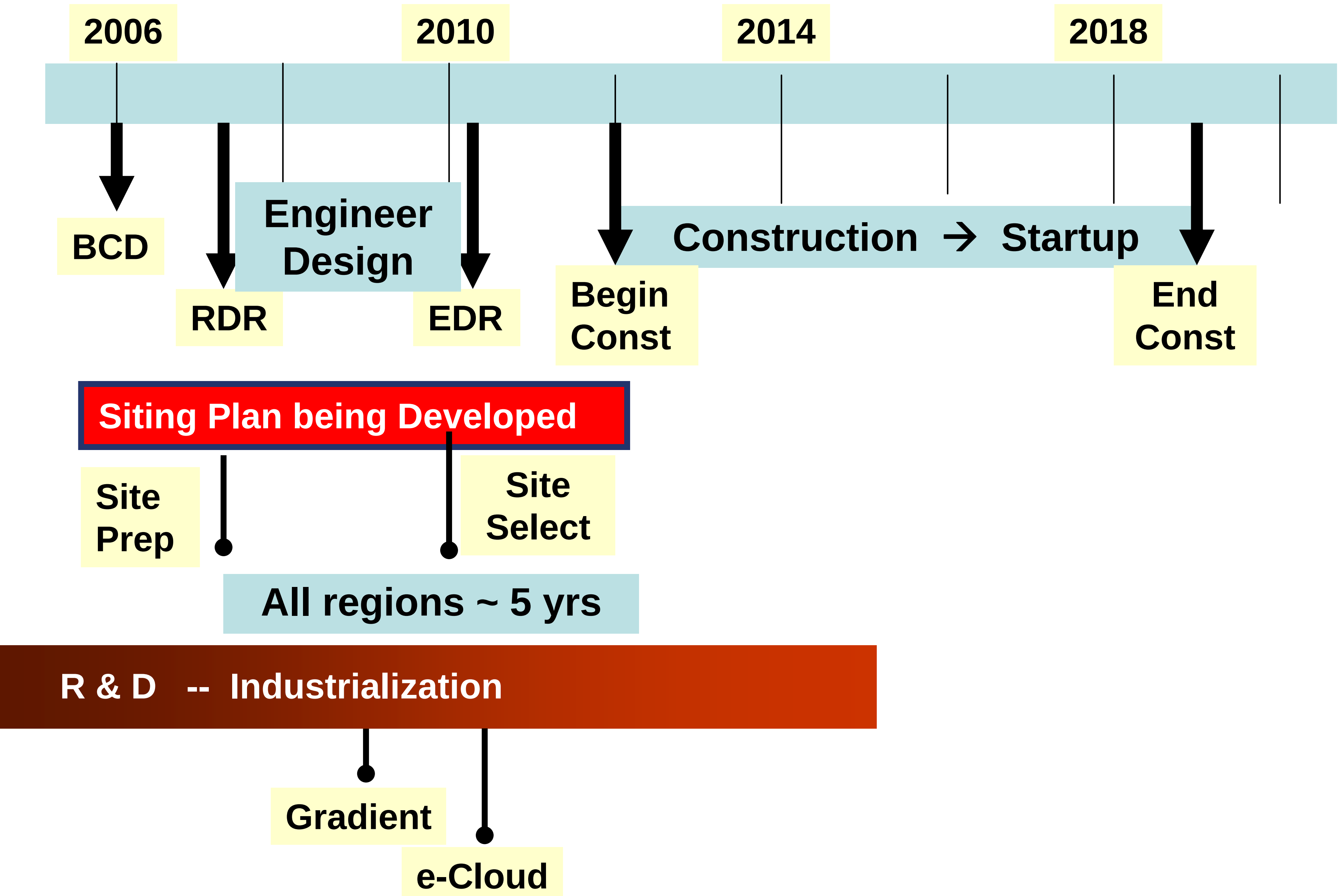
- Intermediate goal
  - **Achieve 31.5 MV/m average operational accelerating gradient in a single cryomodule as a proof-of-principle. In case of cavities performing below the average, this could be achieved by tweaking the RF distribution accordingly.**
  - **Auxiliary systems like fast tuners should all work.**
- Final goal
  - **Achieve > 31.5 MeV/m operational gradient in 3 cryomodules.**
  - **The cavities accepted in the low power test should achieve 35 MV/m at $Q_0 = 10^{10}$ with a yield as described above (80% after first test, 95% after re-preparation).**
  - **It does not need to be the final cryomodule design**

Module Test – Results



DESY

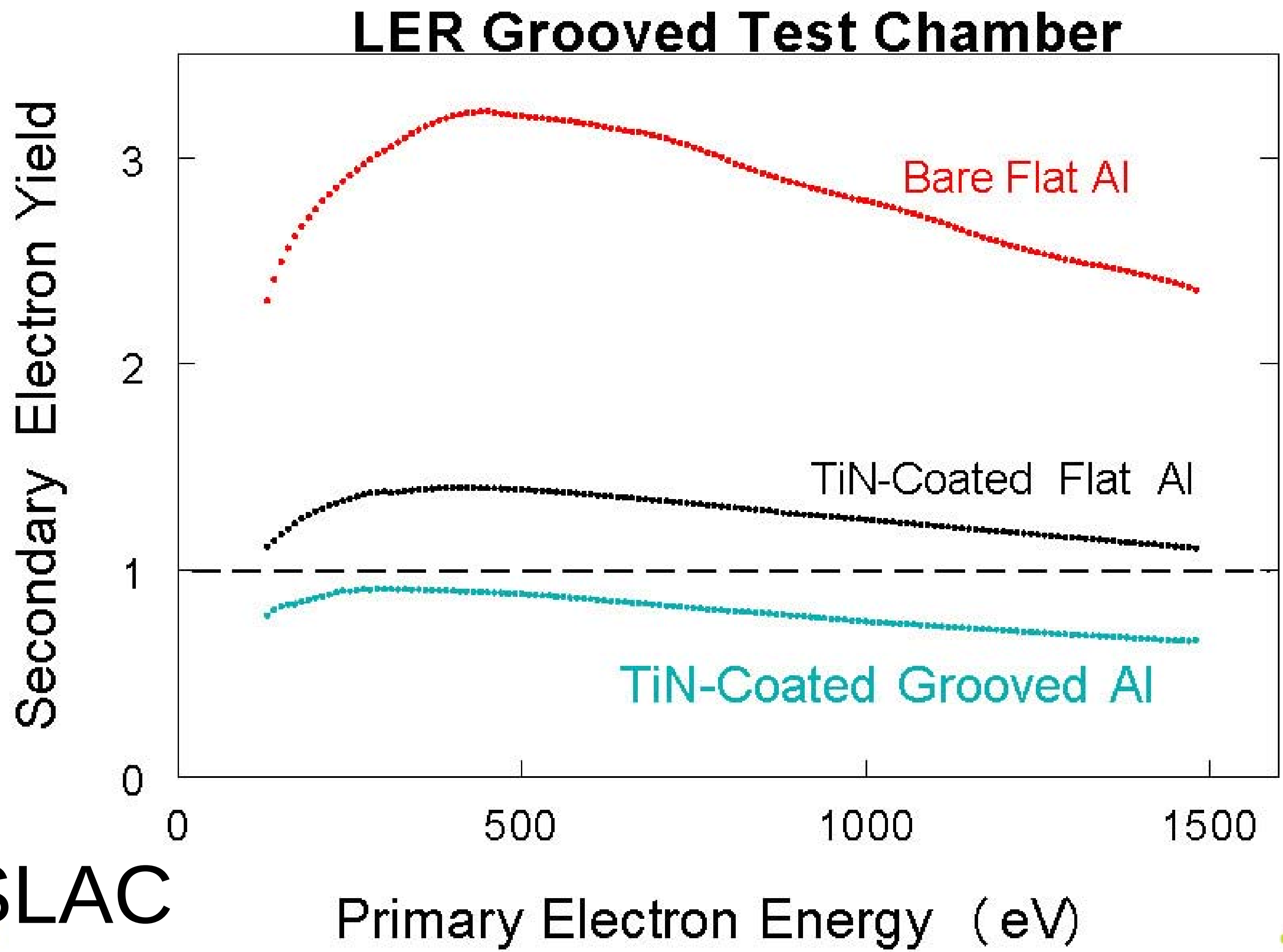
Technically Driven Timeline



E cloud – Goal

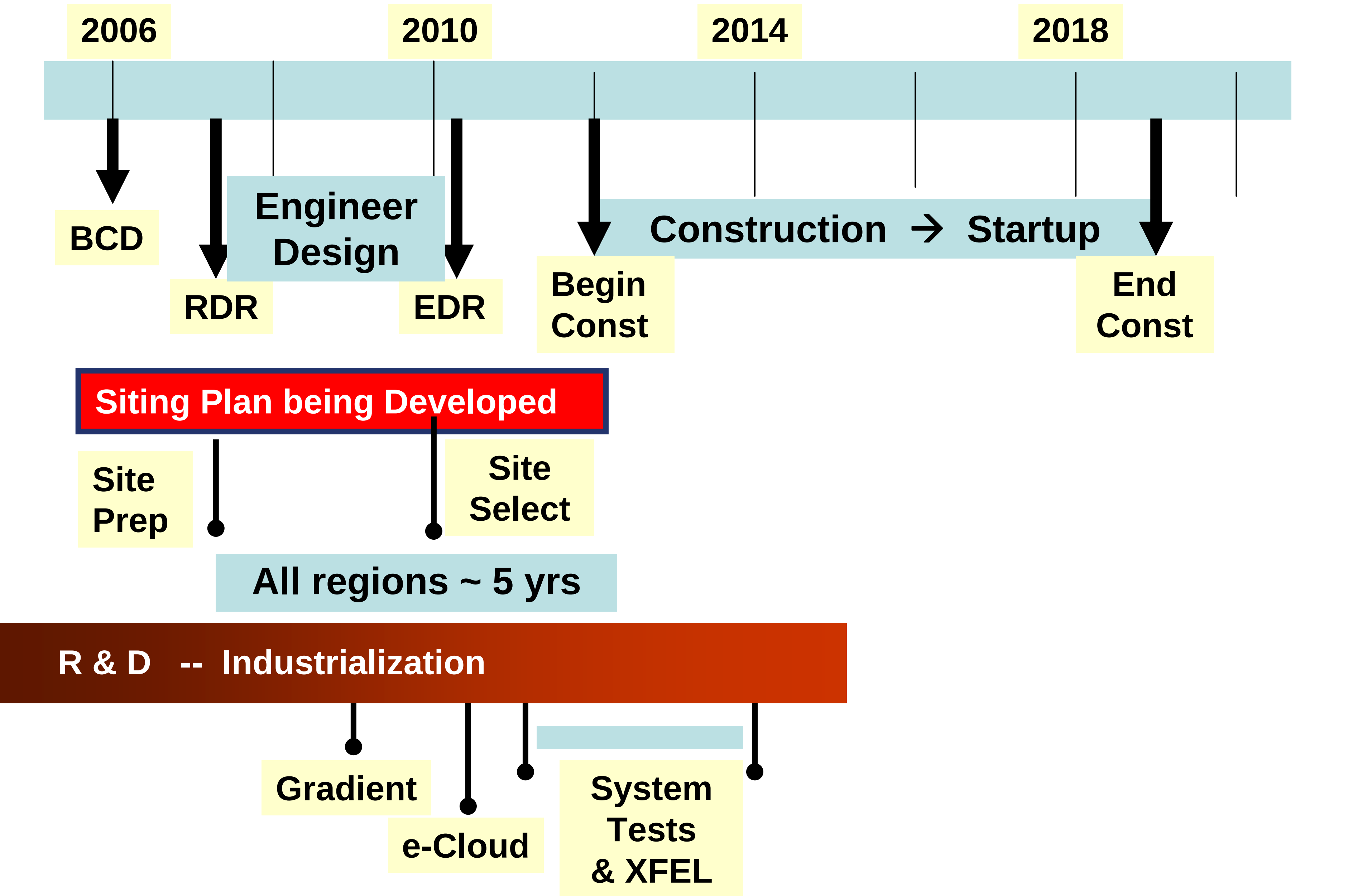
- Ensure the e- cloud won’t blow up the e+ beam emittance.
  - **Do simulations (cheap)**
  - **Test vacuum pipe coatings, grooved chambers, and clearing electrodes effect on e-cloud buildup**
  - **Do above in ILC style wigglers with low emittance beam to minimize the extrapolation to the ILC.**

E Cloud – Results



SLAC

Technically Driven Timeline



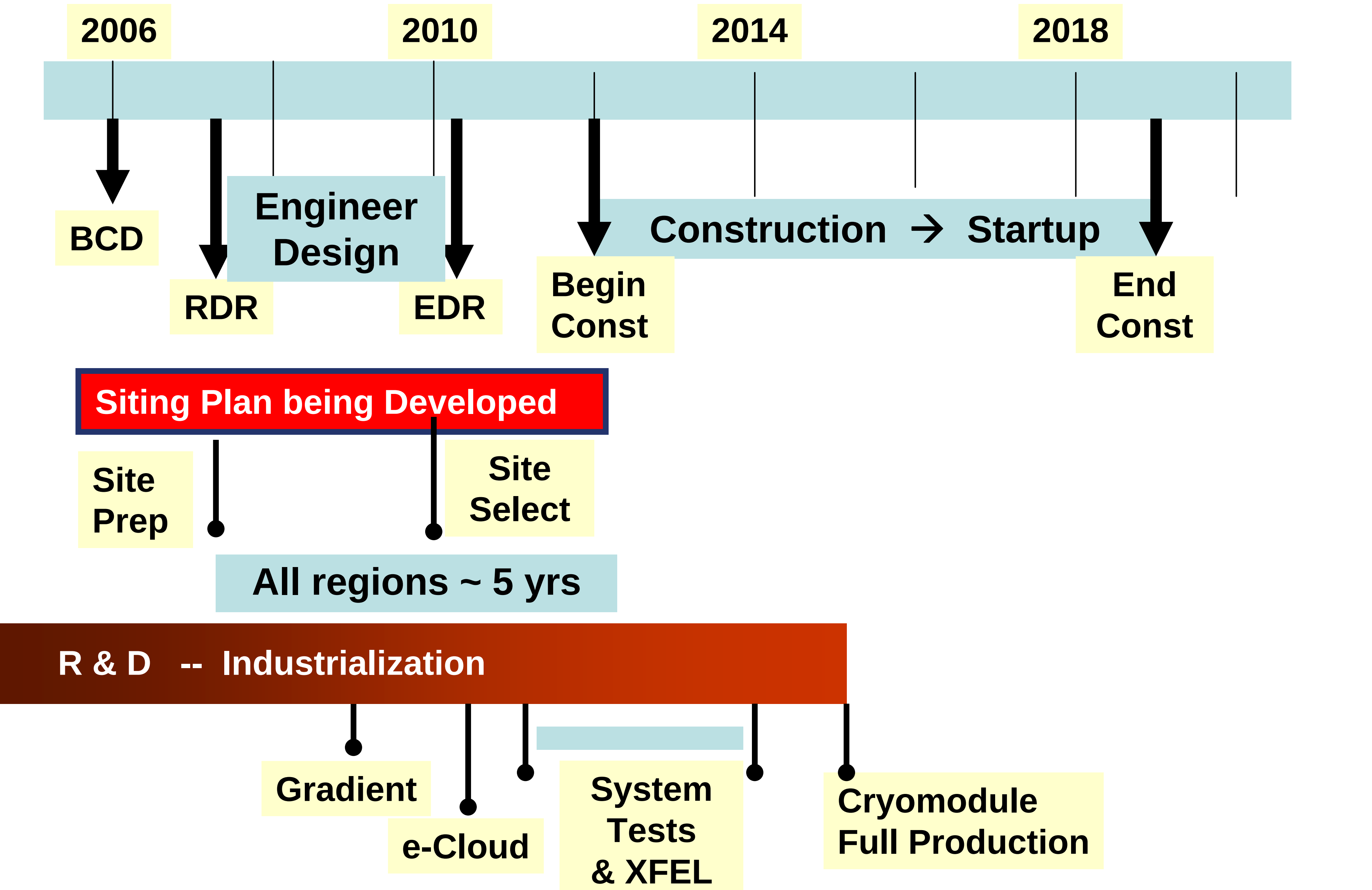
String Test – Goal

- Build 1 RF unit (3 cryomodules + 1 Klystron) to fully check:
  - **What gradient spread can be handled by LLRF system. This test should be done with and without beam loading.**
  - **For heating due to high frequency HOMs.**
  - **Amplitude and phase stability.**
  - **Static and dynamic heat loads.**
- To partially check:
  - **Reliability**
  - **Dark current**
  - **for degradation or other weaknesses**
- The ILC cryomodule is enough different than that of the TTF that a new system test is warranted.

Rough S2 Schedule

Phase	Completion date	Description
0	2005	TTF/FLASH, not final cavity design, type 3 cryomodule, not full gradient, has beam
0.5	2008	Extra tests at TTF/FLASH with same type cryomodules as phase 0
1	2008	1 cryomodule, not final cavity design, type 3 cryomodule (and/or) STF type cryomodule, not full gradient, no beam
1.1	2009	1 RF unit, not all final cavity design, not all type 4 cryomodules, not full gradient, beam not needed for tests, but should be built so it and the LLRF are debugged for the next step
1.2	2010	1 RF unit (replacing cryomodules of phase 1.1), final cavity design, full gradient, type 4 cryomodules, with beam
1.3	2011	1 RF unit (replacing cryomodules of phase 1.1), final cavity design, full gradient, type DFM cryomodules, with beam
1.4	2011	Tunnel mockup above ground. 1 RF unit perhaps built with parts taken from earlier tests. Includes RTML and e+ transport, no beam
2	2013	N RF units at one site (of the final ILC?) as a system test of final designs from multiple manufacturers, no beam
3	2013	XFEL

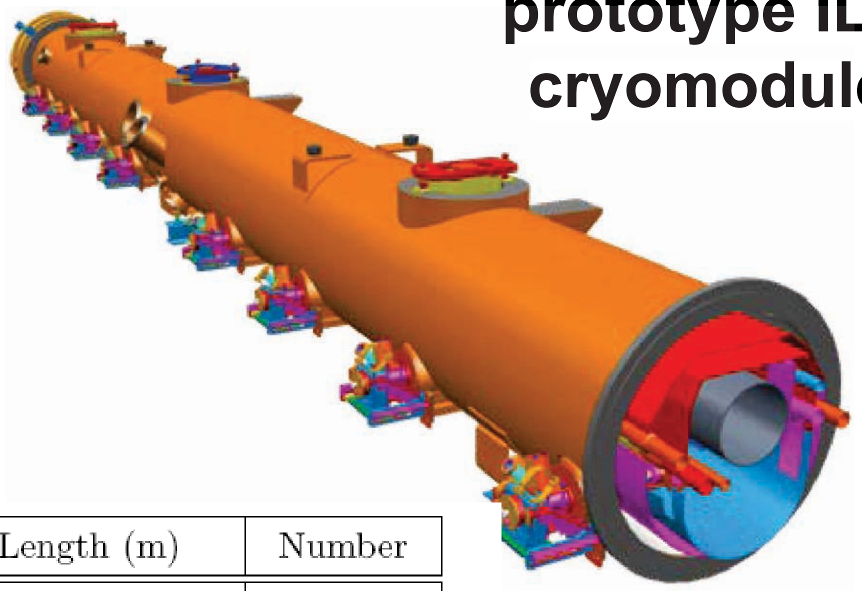
Technically Driven Timeline



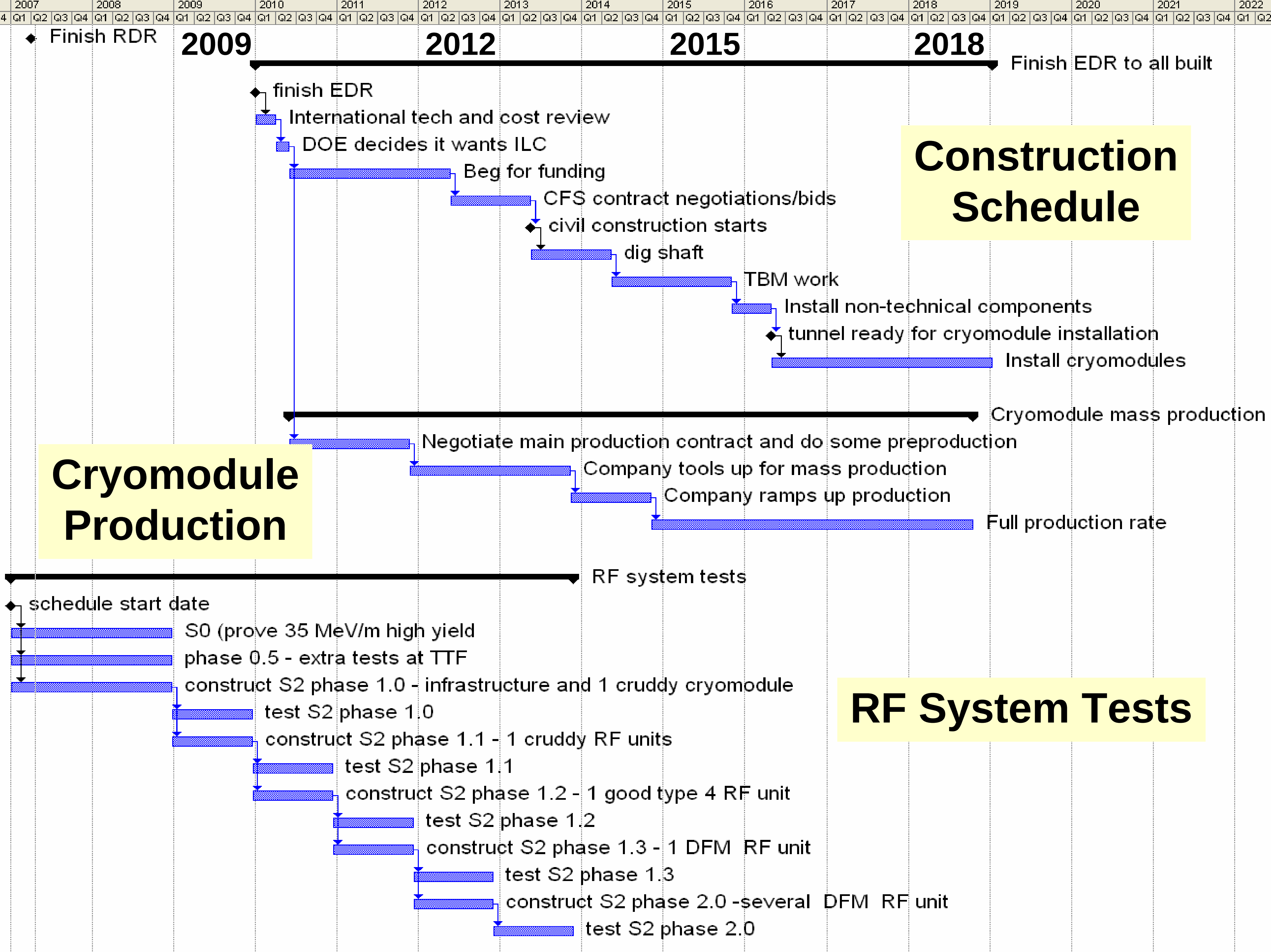
Cavities & Cryomodules

Producing Cavities

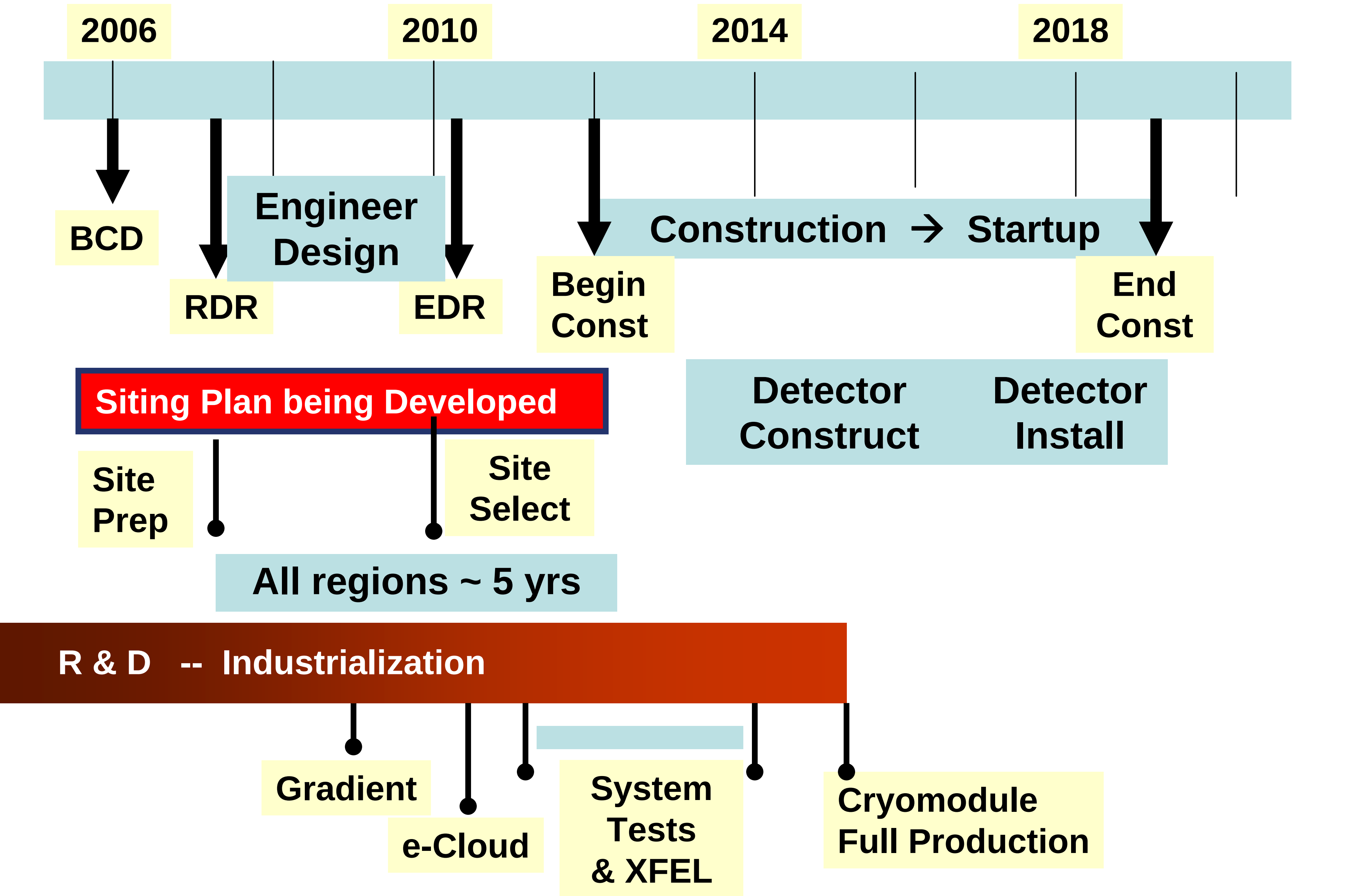
4th generation prototype ILC cryomodule



Subdivision	Length (m)	Number
Cavities (9 cells + ends)	1.326	14,560
Cryomodule (9 cavities or 8 cavities + quad)	12.652	1,680
RF unit (3 cryomodules)	37.956	560
Cryo-string of 4 RF units (3 RF units)	154.3 (116.4)	71 (6)
Cryogenic unit with 10 to 16 strings	1,546 to 2,472	10
Electron (positron) linac	10,917 (10,770)	1 (1)


2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
Q1 Q2 Q3 Q4
Finish RDR
2009
2012
2015
2018
Finish EDR to all built
finish EDR
International tech and cost review
DOE decides it wants ILC
Beg for funding
CFS contract negotiations/bids
civil construction starts
dig shaft
TBM work
Install non-technical components
tunnel ready for cryomodule installation
Install cryomodules
Construction Schedule
Cryomodule mass production
Negotiate main production contract and do some preproduction
Company tools up for mass production
Company ramps up production
Full production rate
Cryomodule Production
RF system tests
schedule start date
S0 (prove 35 MeV/m high yield
phase 0.5 - extra tests at TTF
construct S2 phase 1.0 - infrastructure and 1 cruddy cryomodule
test S2 phase 1.0
construct S2 phase 1.1 - 1 cruddy RF units
test S2 phase 1.1
construct S2 phase 1.2 - 1 good type 4 RF unit
test S2 phase 1.2
construct S2 phase 1.3 - 1 DFM RF unit
test S2 phase 1.3
construct S2 phase 2.0 -several DFM RF unit
test S2 phase 2.0
RF System Tests

Technically Driven Timeline

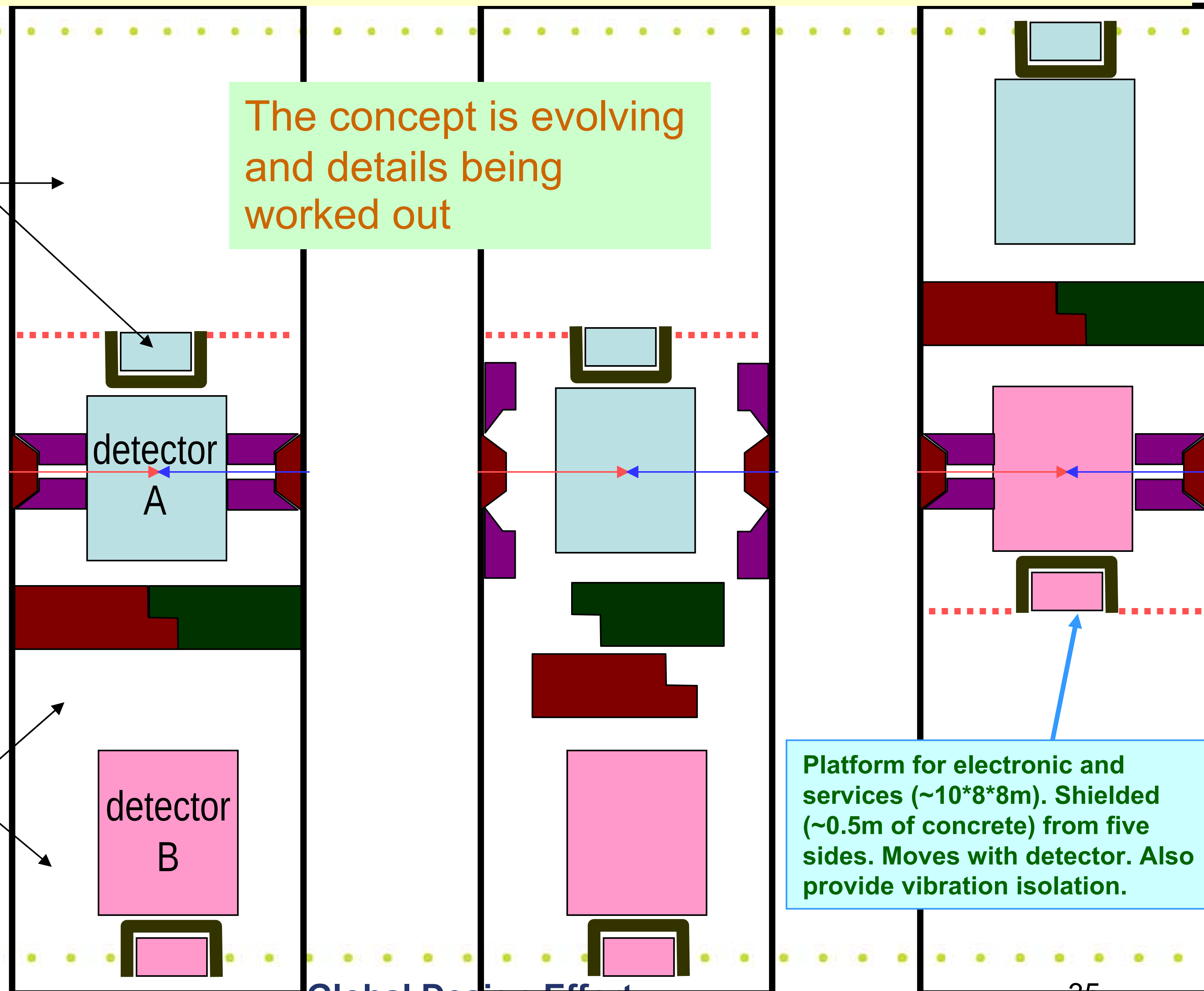


Concept of IR hall with two detectors

may be accessible during run

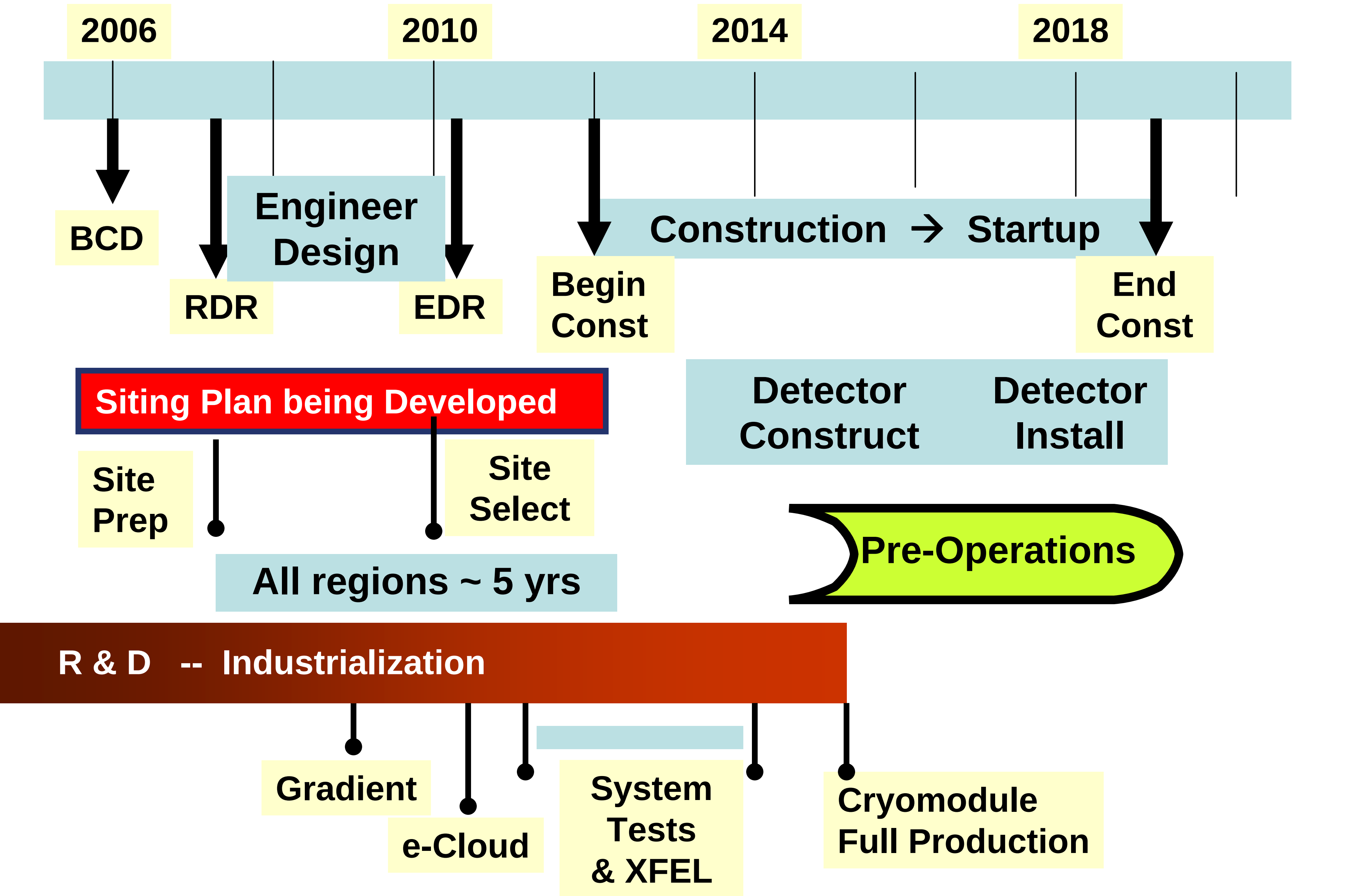
accessible during run

The concept is evolving and details being worked out



Platform for electronic and services (~10*8*8m). Shielded (~0.5m of concrete) from five sides. Moves with detector. Also provide vibration isolation.

Technically Driven Timeline



Achieving our ILC Timeline

"The other issues"

- We need to begin a campaign to prepare the way for submitting a winning proposal in about 2010.
  - Science Motivation is very strong, but we need LHC results for validation (~2010)
  - Must convince broader HEP and science communities on the ILC
  - Must engage the global governments to take ownership and develop international governance
  - Must develop a siting strategy
- The key to maintaining our timeline will be working these issues in parallel with developing an engineering design and completing the R&D