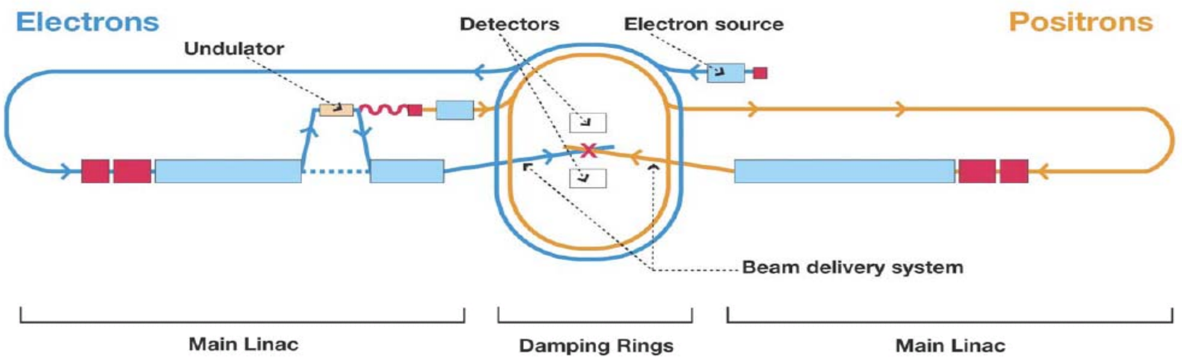
Report from GDE

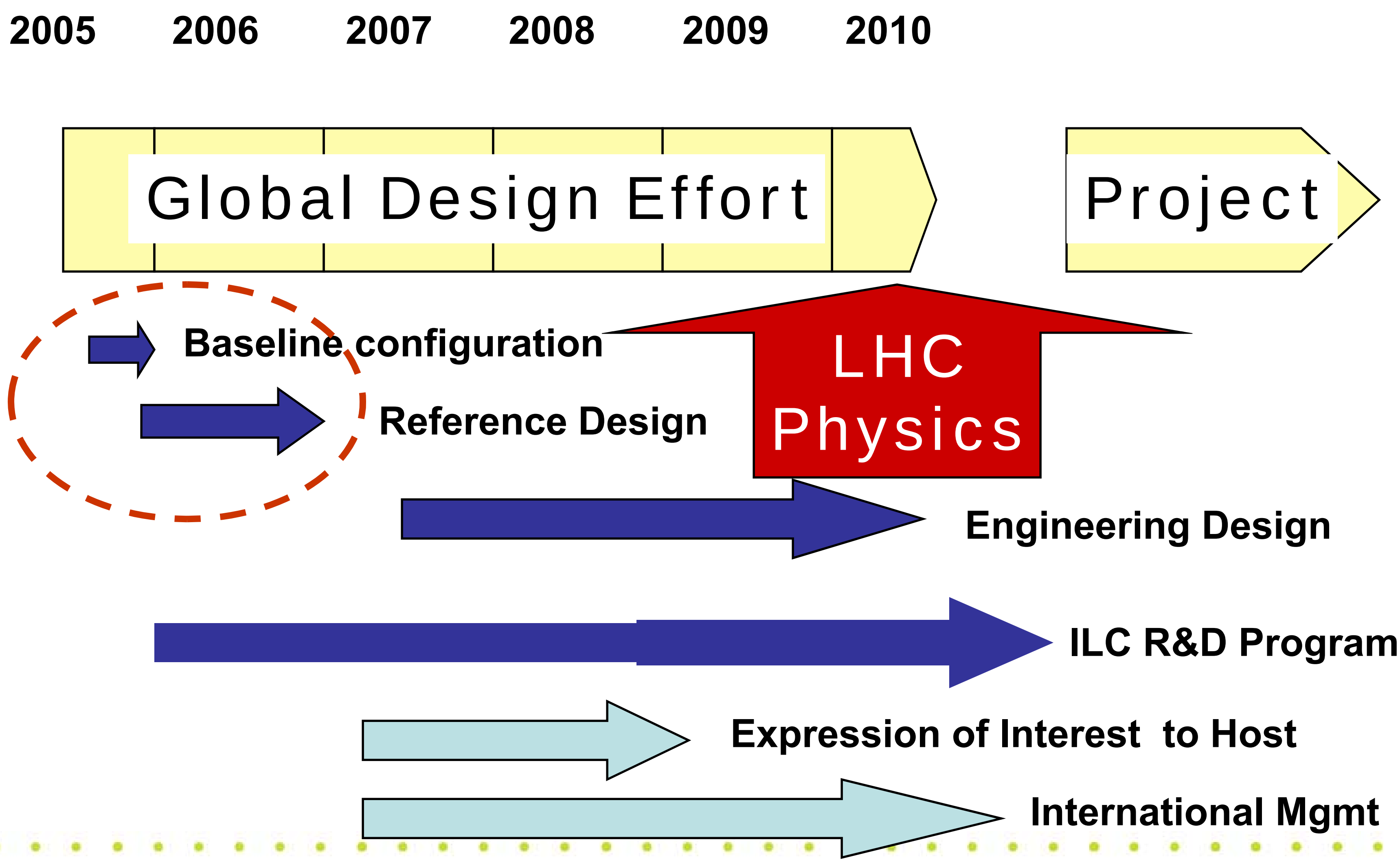


Barry Barish

Caltech / GDE

25-Sept-07

The GDE Plan and Schedule

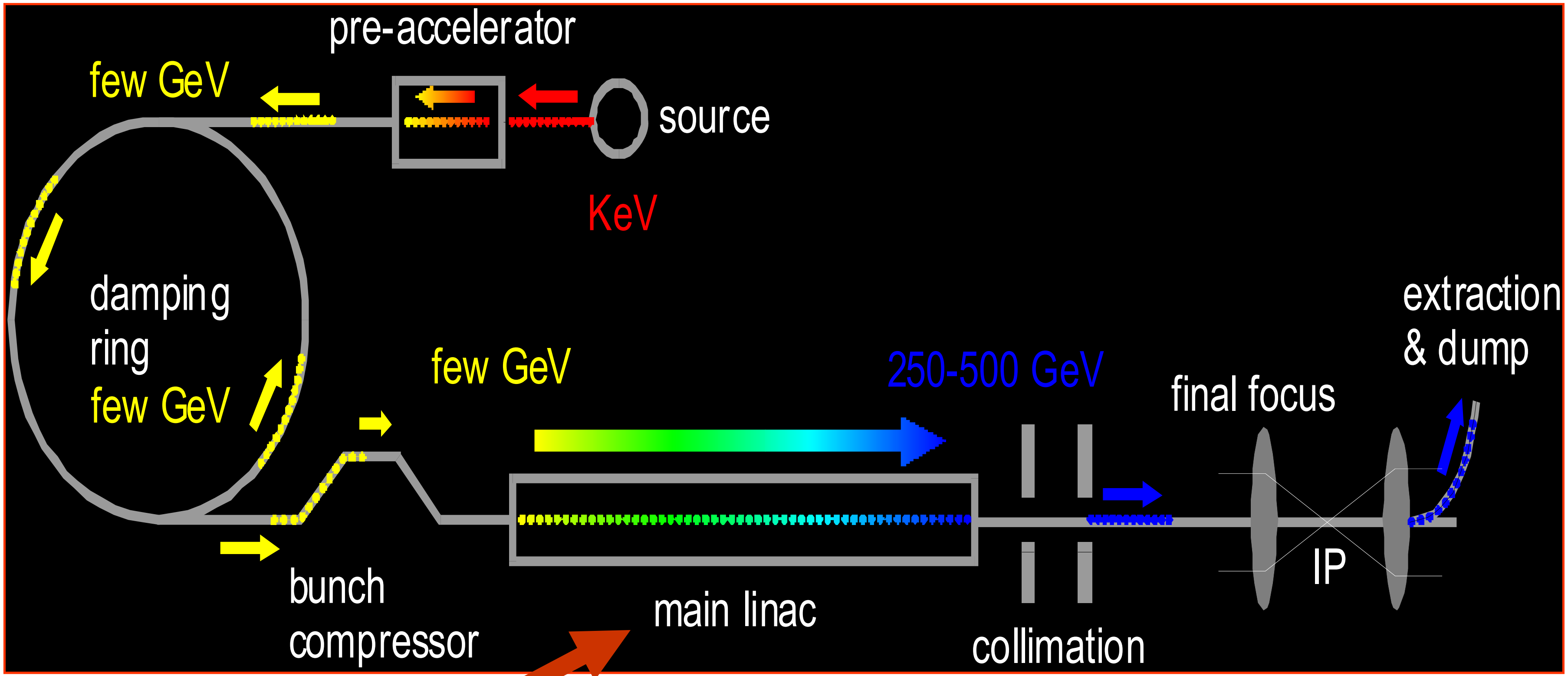


Parameters for the ILC

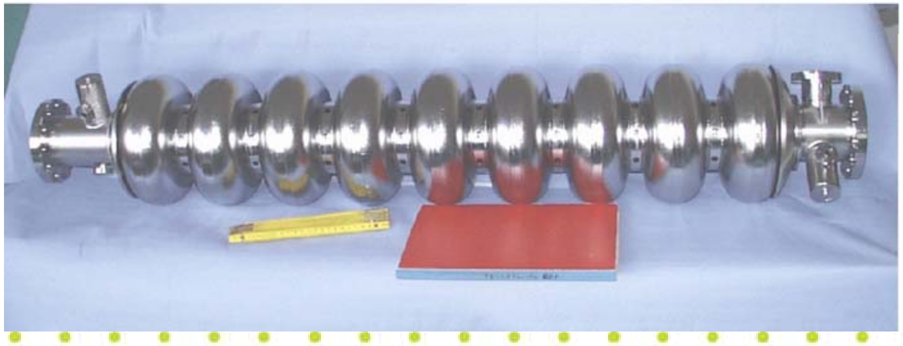
- E_{cm} adjustable from 200 – 500 GeV
- Luminosity → $\int L dt$ = 500 fb^{-1} in 4 years
- Ability to scan between 200 and 500 GeV
- Energy stability and precision below 0.1%
- Electron polarization of at least 80%

- The machine must be upgradeable to 1 TeV

Designing a Linear Collider

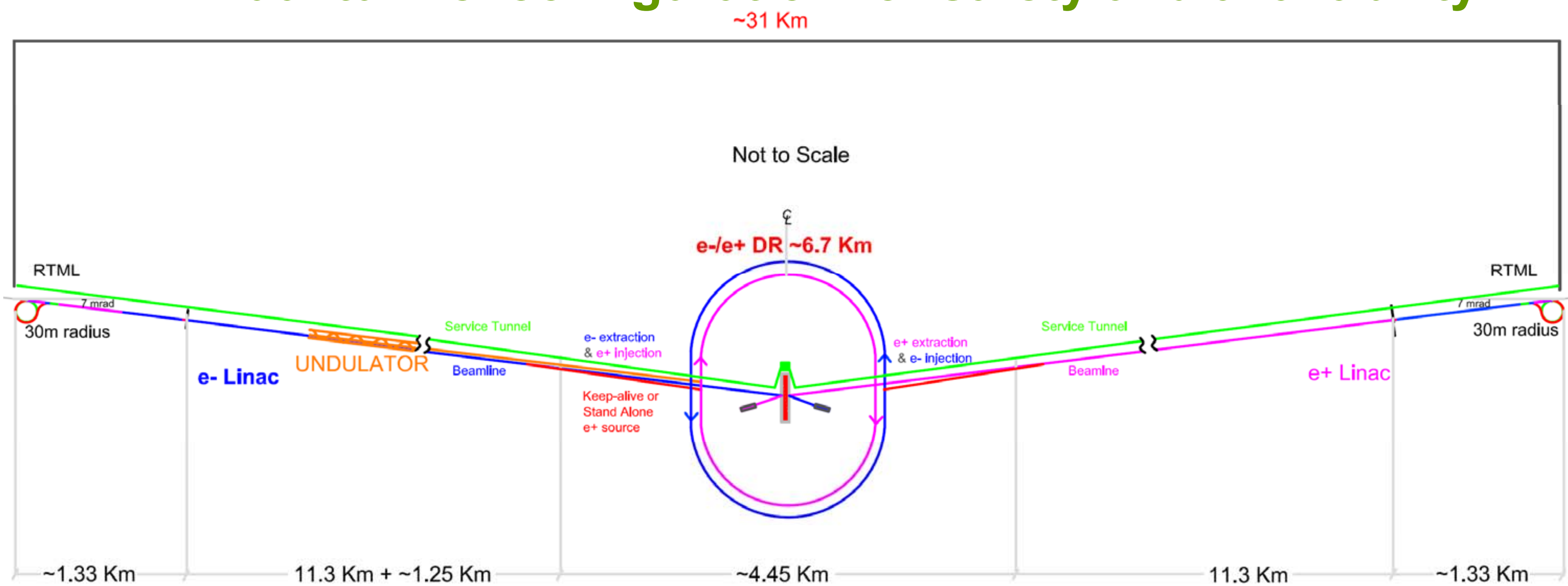


Superconducting RF Main Linac



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)

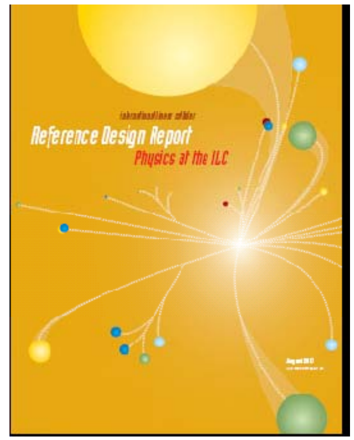
Assessment of the RDR

- **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):** **Supports the costing methodology; considered the costing conservative in that they identify opportunities for cost savings; etc.**

RDR Complete

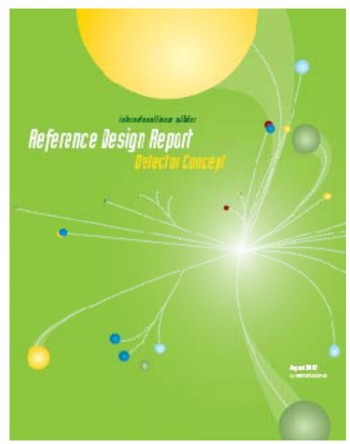
- **Reference Design Report (4 volumes)**

Executive Summary



Physics at the ILC

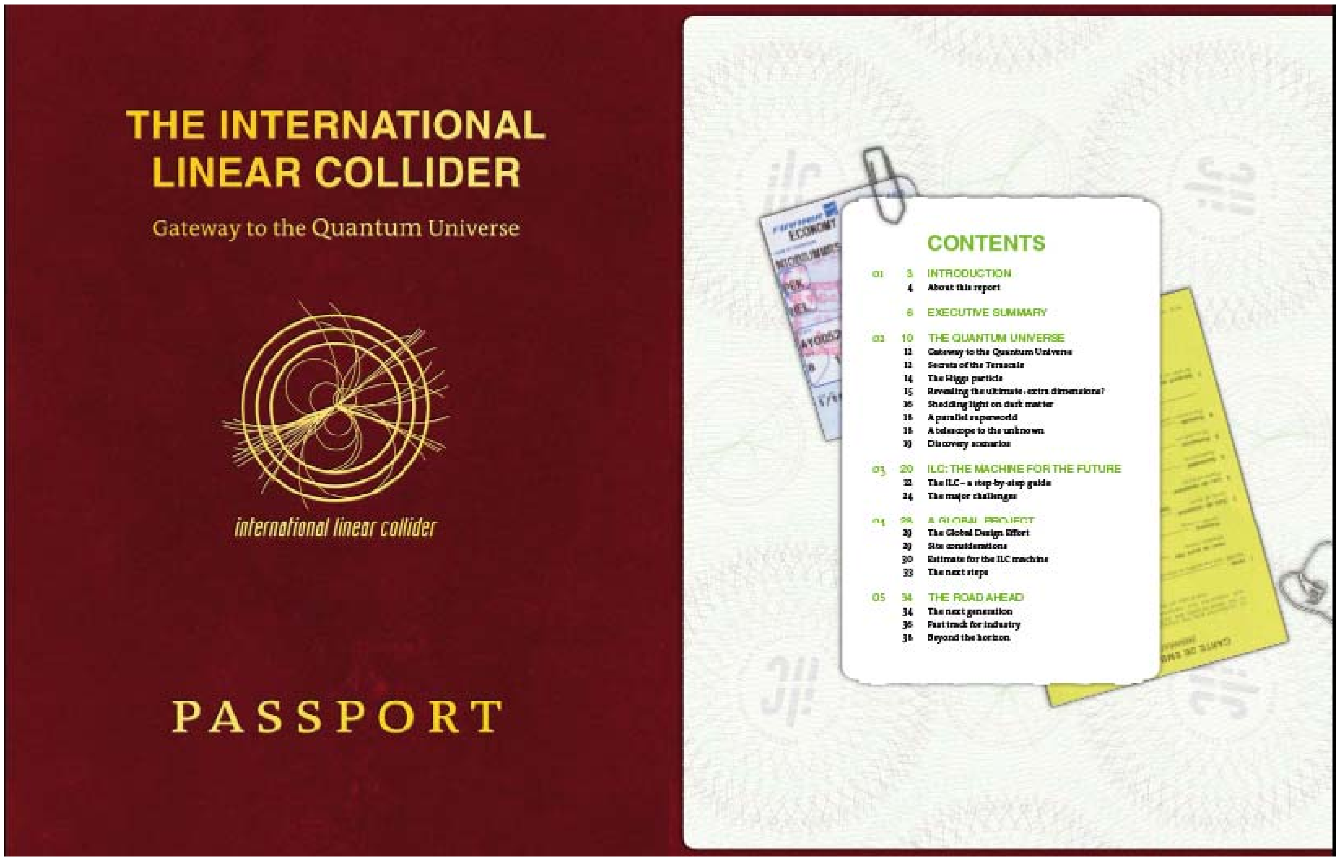
Accelerator



Detectors

RDR Complete

- **Companion Document (printed & website in October)**

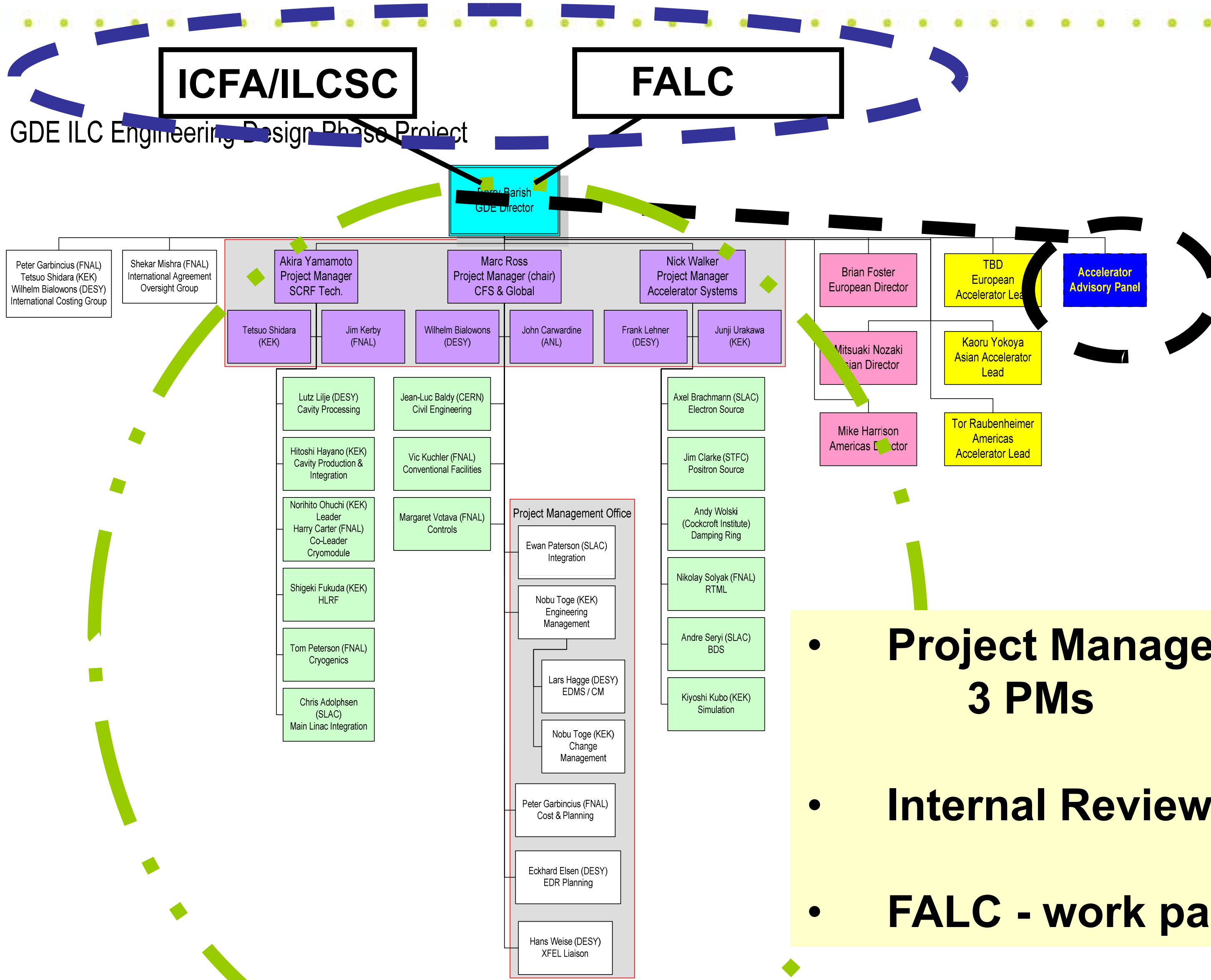


Gateway Document for broad circulation, including translations

Prepare to Propose ILC Construction

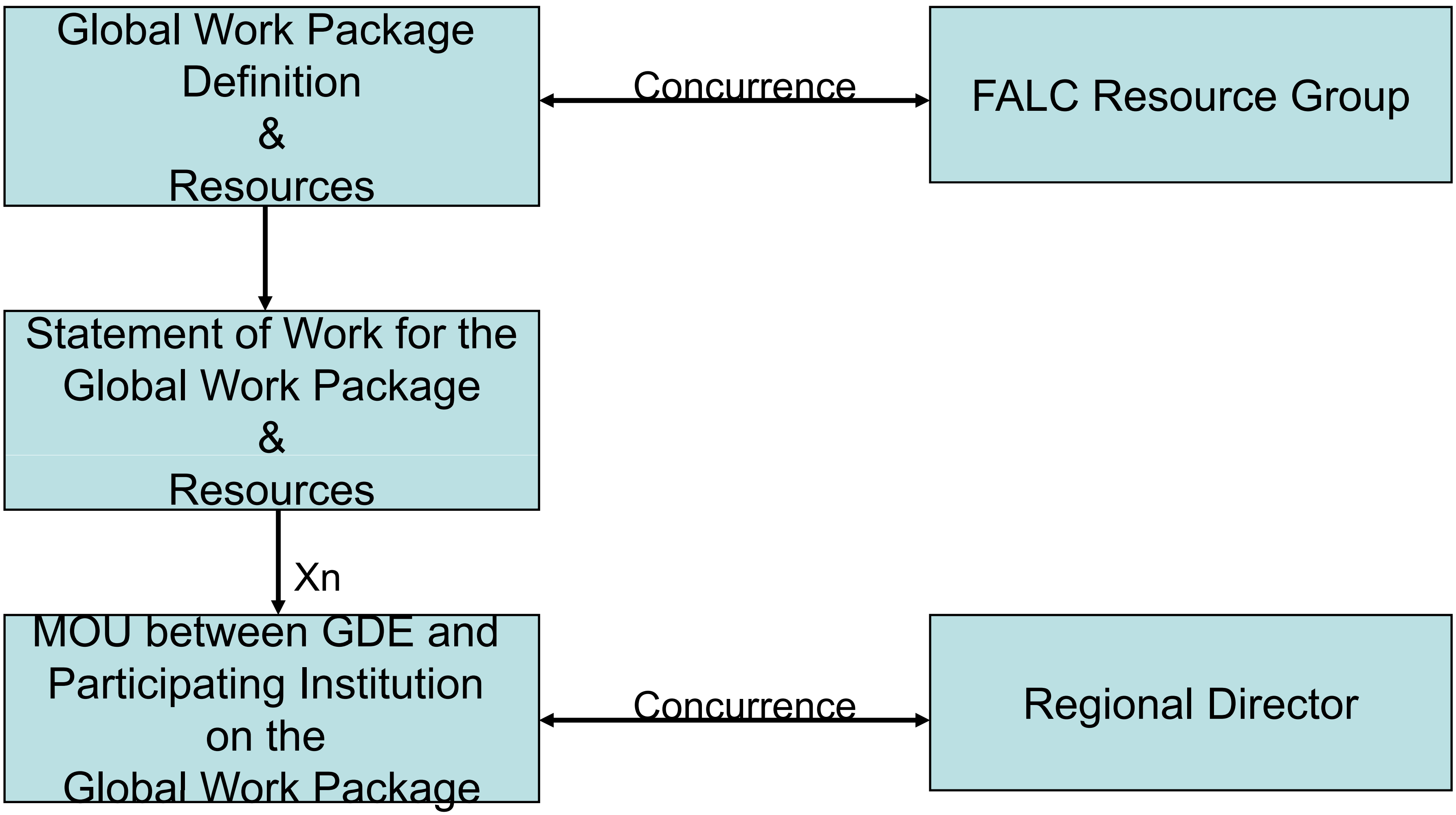
- ILC Engineering Design
  - We have a solid design concept in the reference design, but it is immature and needs engineering designs, value engineering, supporting R&D and industrialization.
- GDE has been reorganized around a GDE Project Management Office to reach this goal
  - Marc Ross, Nick Walker and Akira Yamamoto
  - Central management being given the authority to set priorities and direct the work
  - Resources for the engineering design and associated R&D appears feasible (FALC will concur on work packages)
  - Investments will be made toward Industrialization and siting
  - Anticipate LHC results in about 2010. We plan to be ready whenever the physics motivation is in place!

GDE EDR Organizational Structures



- **Project Management**
  3 PMs
- **Internal Reviews**
- **FALC - work packages**

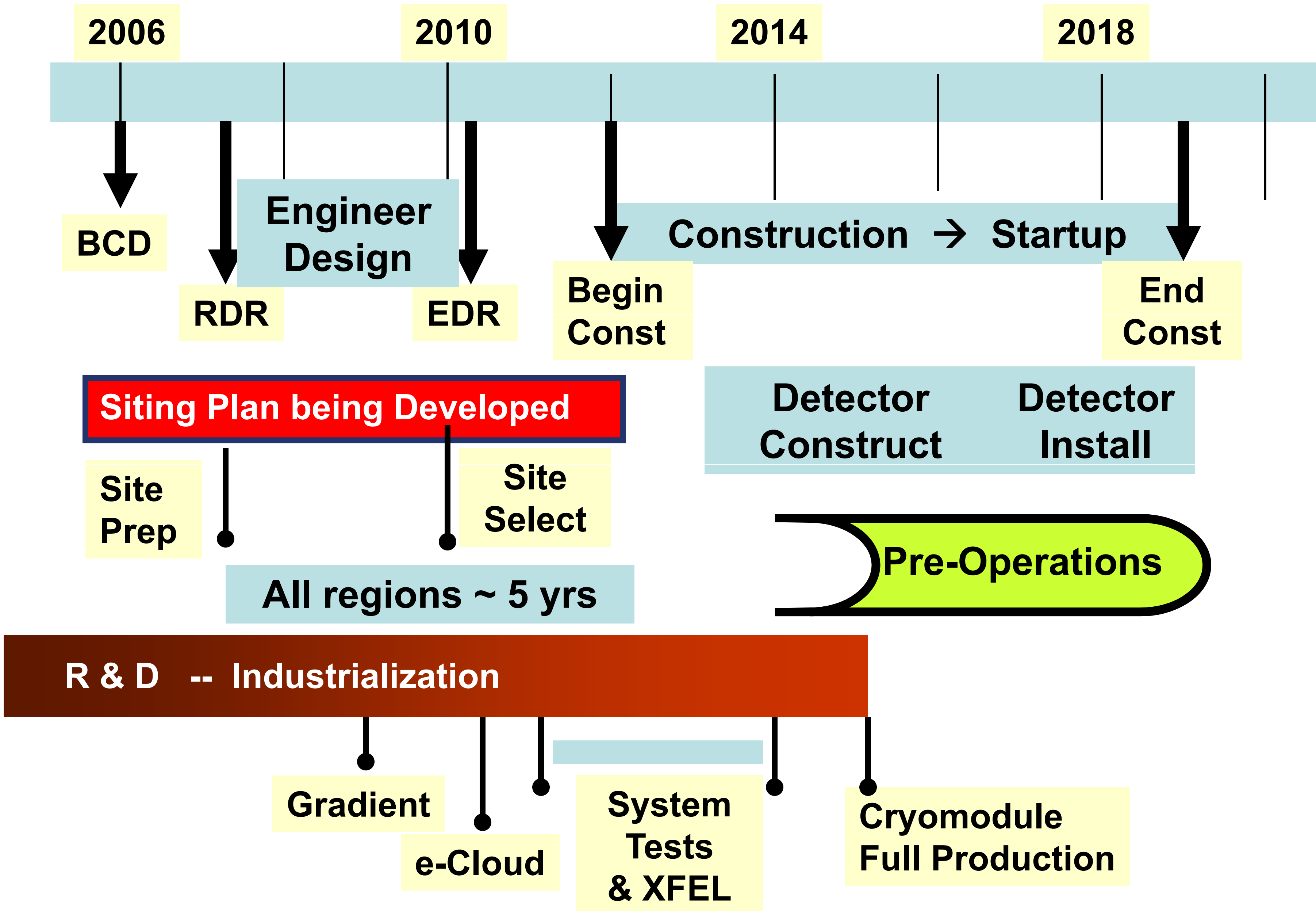
ILC Work Package Agreement



Supporting R&D & Regional Programs

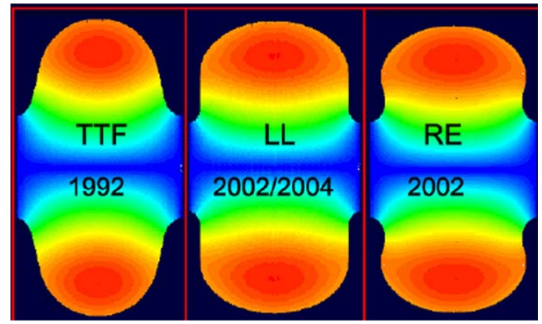
- **Global R&D**
  - Organized around task forces to achieve milestones linked to EDR schedule
  - S0 task force - globally coordinated program to demonstrate gradient for EDR by 2009
  - S2 task force – RF unit test and string tests by construction
  - S3 task force – Electron Cloud tests to establish mitigation and verify one damping ring is sufficient.
- **Regional Preparations**
  - Siting preparations – prepare to bid to host
  - Developing regional expertise on SCRF
  - Regionally based infrastructure and facilities
  - Industrialization

Technically Driven Timeline



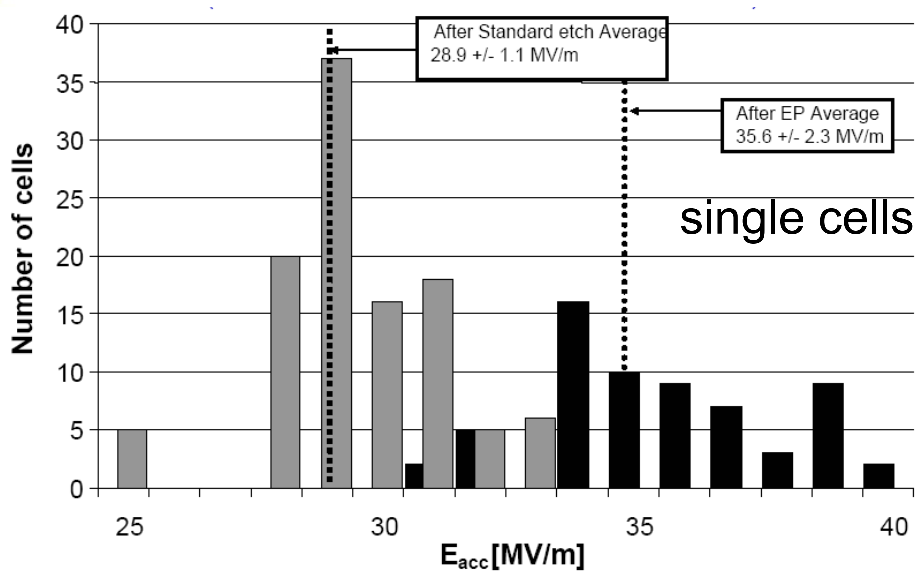
Reference Design and Plan

Producing Cavities

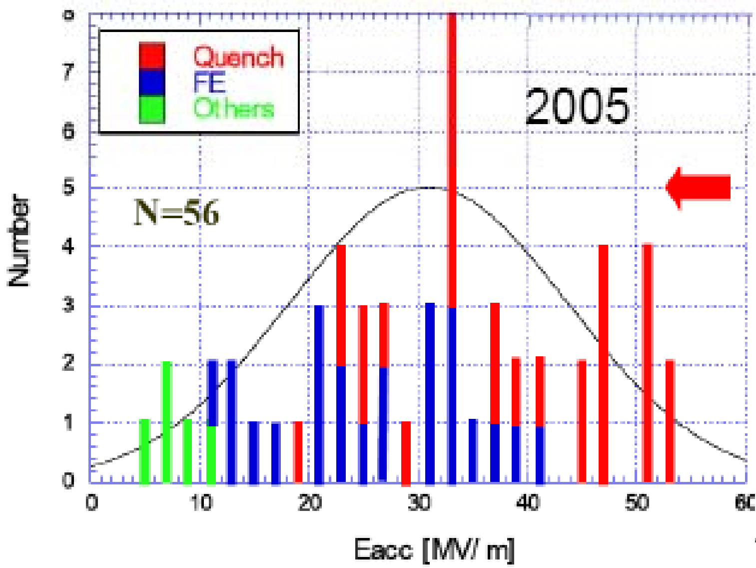


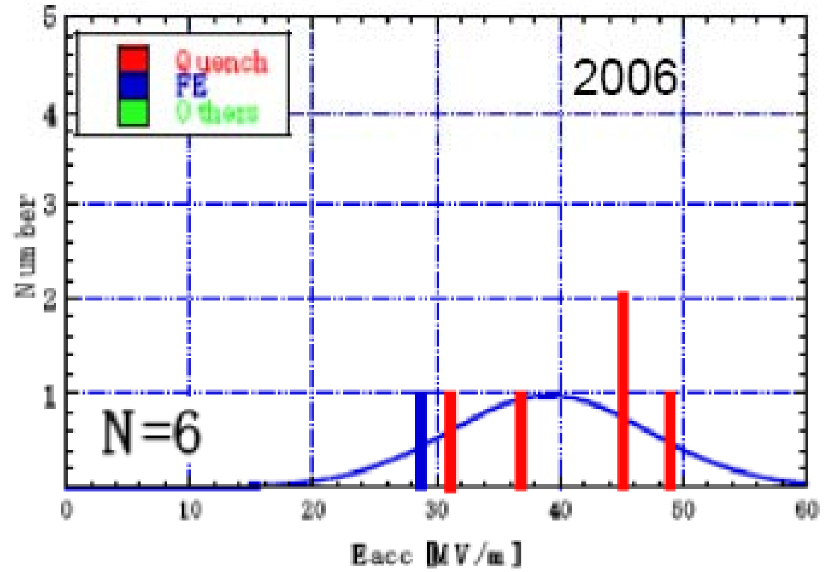
Cavity Shape

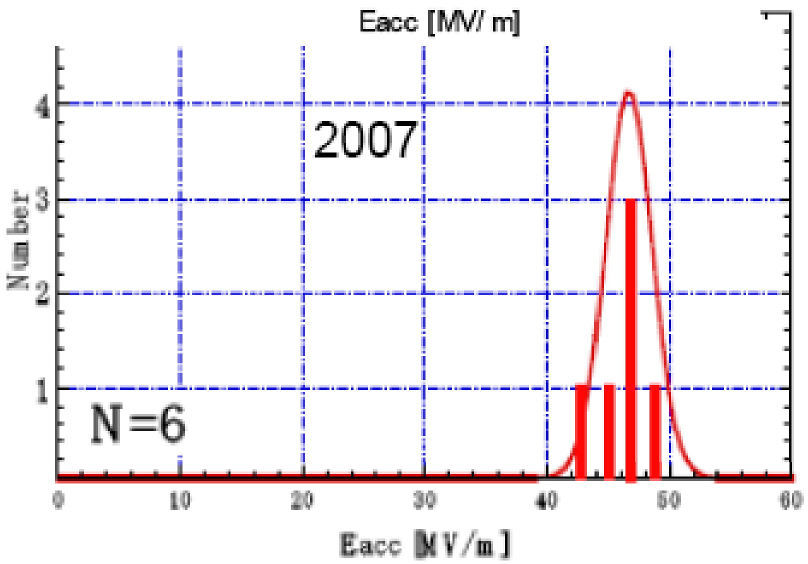
Obtaining Gradient



Cavity Gradient - Results







KEK single cell results:

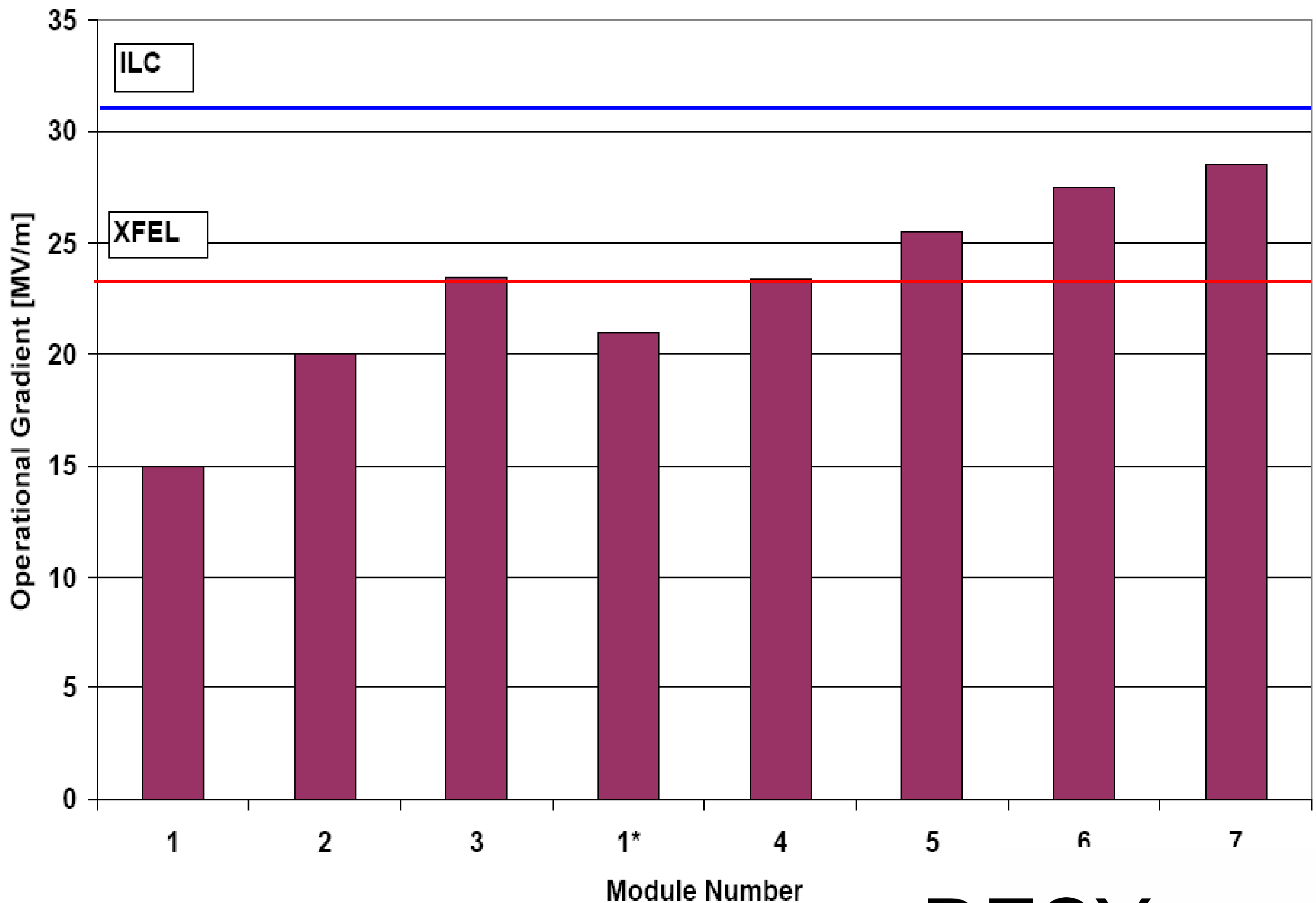
2005 – just learning

2006 – standard recipe

2007 – add final 3 µm fresh acid EP

Note: multi-cells are harder than singles

Module Test – Results

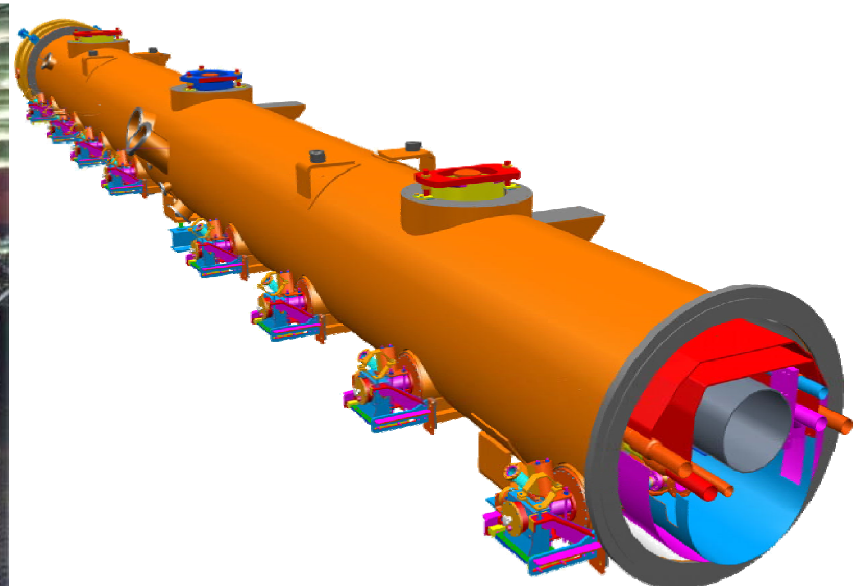


DESY

Cost Benefit: S0 Gradient R&D

- Optimistic scenario with final batch + tightloop
  - Costs 36 MILCU for the R&D
  - Gives highest confidence about the gradient distribution
- This needs to be compared to:
  - A reduction of the average gradient for the ILC from design of 31.5 to 28 MV/m
  - ~ 600 MILCU

Cryomodules



TESLA cryomodule

4th generation prototype ILC cryomodule

S2 String Tests

- Build 1 RF unit (3 cryomodules + 1 Klystron)
  - What gradient spread can be handled by LLRF system?
- Test with and without beam loading.
  - For heating due to high frequency high order modes
  - Amplitude and phase stability.
  - Static and dynamic heat loads.
- Purpose is to test
  - Reliability; Dark current; Degradation or other weaknesses
- Second phase string test needed before construction to verify modules for the ILC.

S2 String Tests

- Risk with no string tests → Build ~1.5 BILCU of cryomodules, then discover a design flaw.
  - Schedule/Cost risk -- fixing them could take years and cost > 20% of the original cost.
  - Categorize as medium risk (25%) → Risk*Cost ~75 MILCU, plus schedule loss (years).
  - Risk would be higher 50-100% if not for the Tesla Test Facility.
- The planned string tests (One RF Unit) ~ $50 MILCU.

The Main Linac

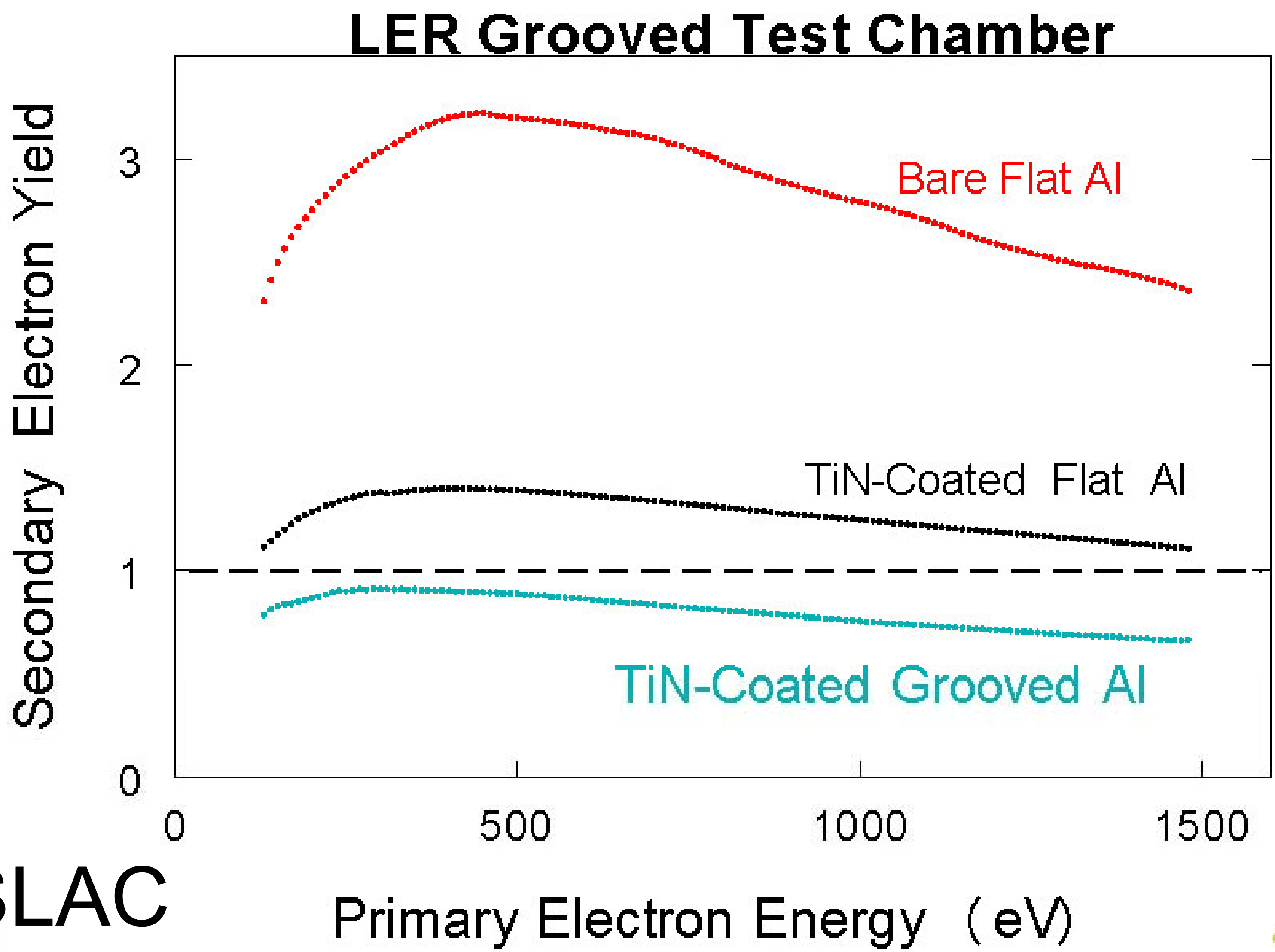
Subdivision	Length (m)	Number
Cavities (9 cells + ends)	1.326	14,560
Cryomodule (9 cavities or 8 cavities + quad)	12.652	1,680
RF unit (3 cryomodules)	37.956	560
Cryo-string of 4 RF units (3 RF units)	154.3 (116.4)	71 (6)
Cryogenic unit with 10 to 16 strings	1,546 to 2,472	10
Electron (positron) linac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

- **Developing capability to construct in all three regions**
  - **Facilities developed regionally**
  - **Industrialization; assembly; testing**

Electron Cloud Mitigation

- Low Emittance Damping Ring
  - Ensure the e- cloud won't blow up the e+ beam emittance.
  - Baseline -- Two positron damping rings – alternate bunches.
  - RDR – Change to one damping ring; move to central injectors; share tunnel
  - Assumed mitigation of electron cloud successful
- R&D Program
  - Simulations (cheap and encouraged making change)
  - Test vacuum pipe coatings, grooved chambers, and clearing electrodes effect on ecloud buildup
  - Do above in ILC style wigglers with low emittance beam to minimize the extrapolation to the ILC.

E Cloud – Simulation Results

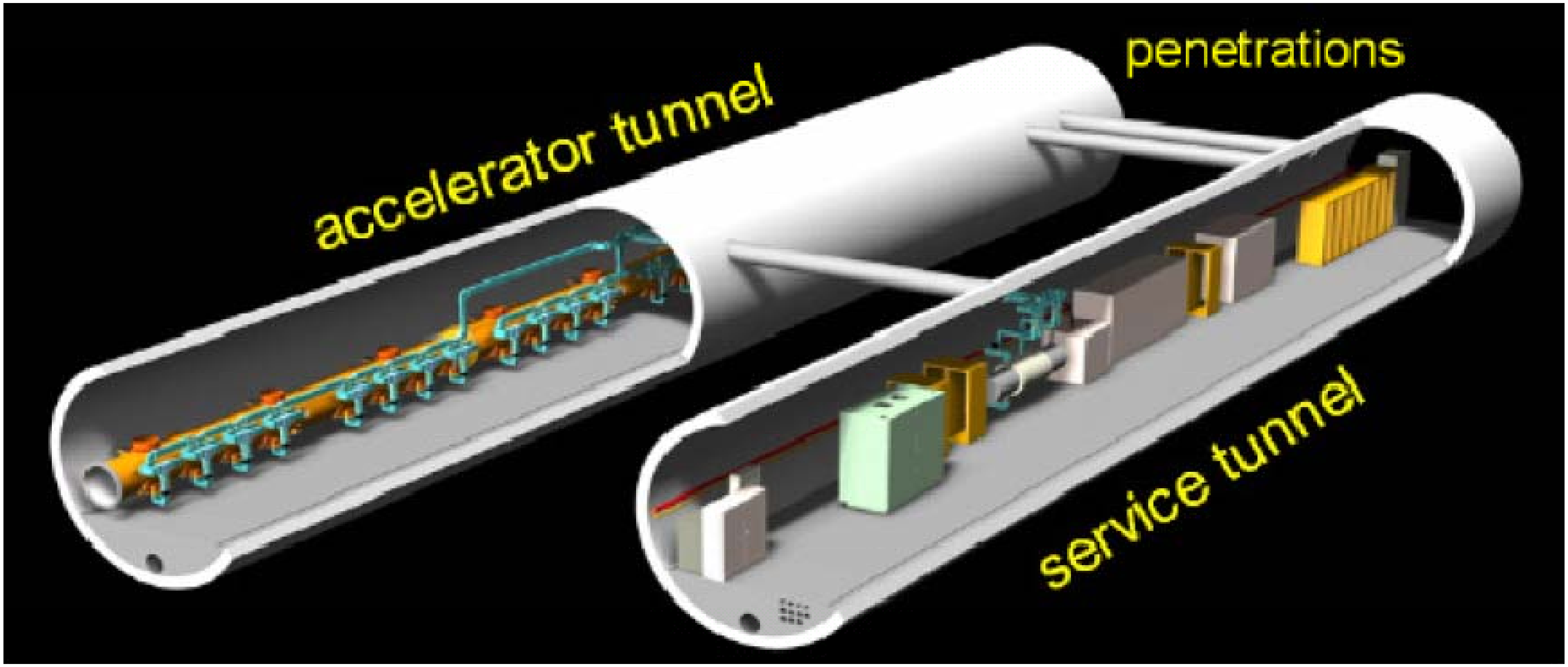


SLAC

Cost Benefit: S3 Electron Cloud R&D

- R&D for Electron Cloud
  - High risk (~50%) that we must build a second e+ damping ring at a cost of 200 MILCU. (Cost risk = 100 MILCU)
  - KEK-B and/or CESR R&D test program will involve dedicated use of the whole ring. The scale of R&D cost ~ 20-30 MILCU.

Main Linac Double Tunnel



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

Conventional Facilities

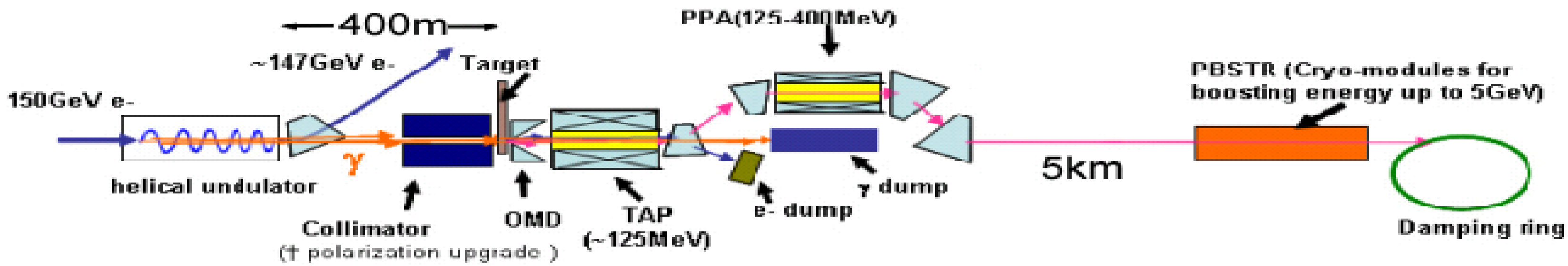
72.5 km tunnels ~ 100-150 meters underground

13 major shafts $\geq$ 9 meter diameter

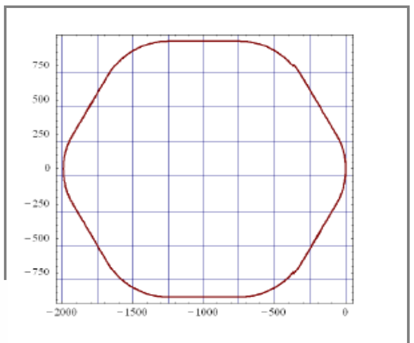
443 K cu. m. underground excavation: caverns, alcoves, halls

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

Reference Design and Plan

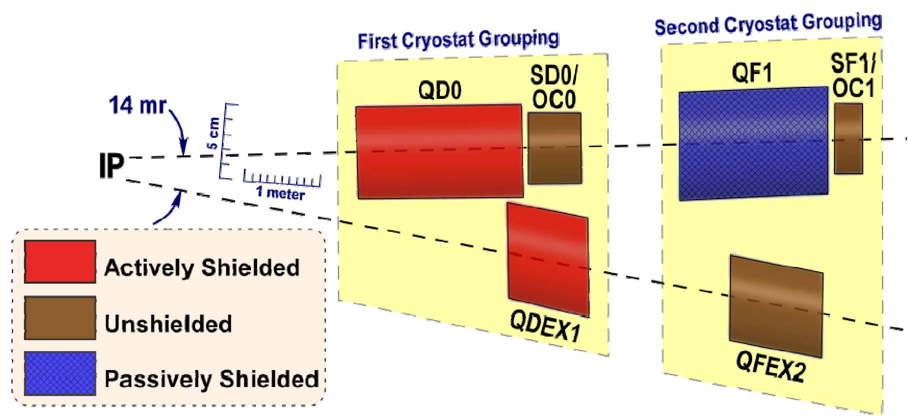


Making Positrons



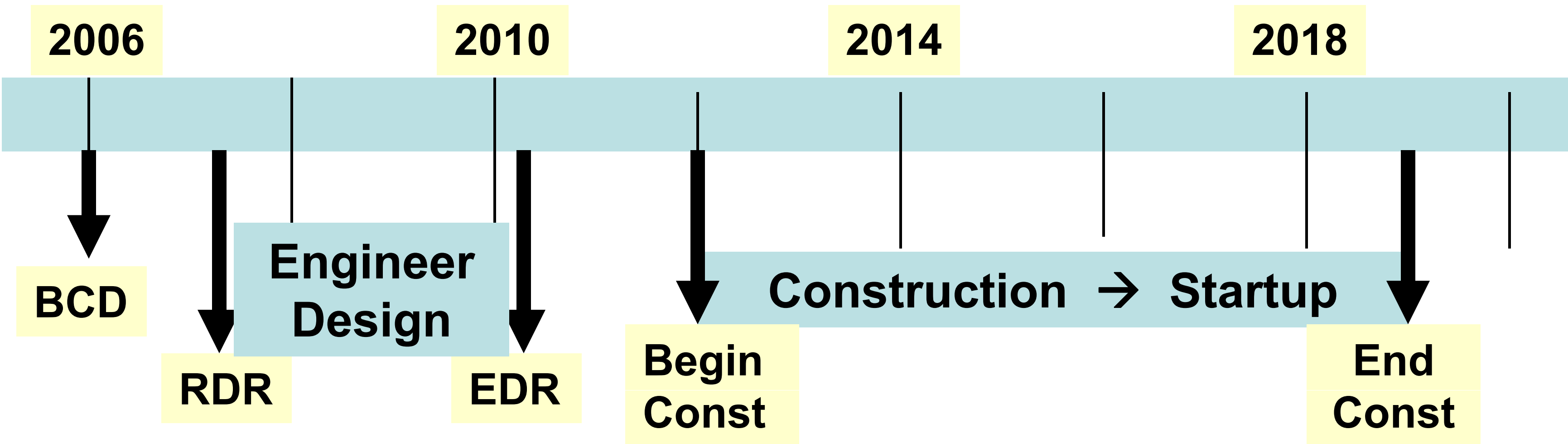
6km
Damping
Ring

10MW
Klystrons

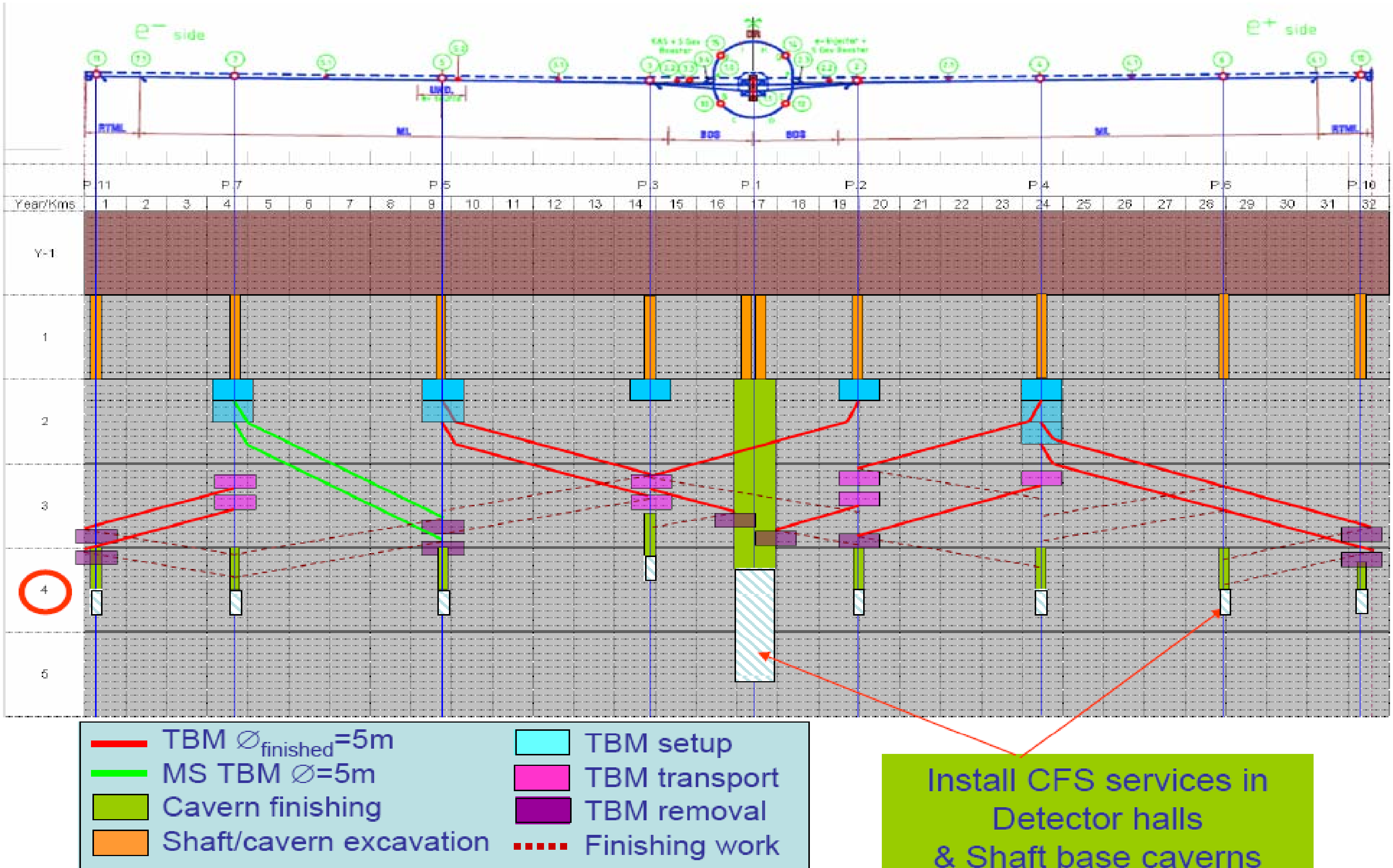


Beam Delivery and Interaction Point

Technically Driven Timeline

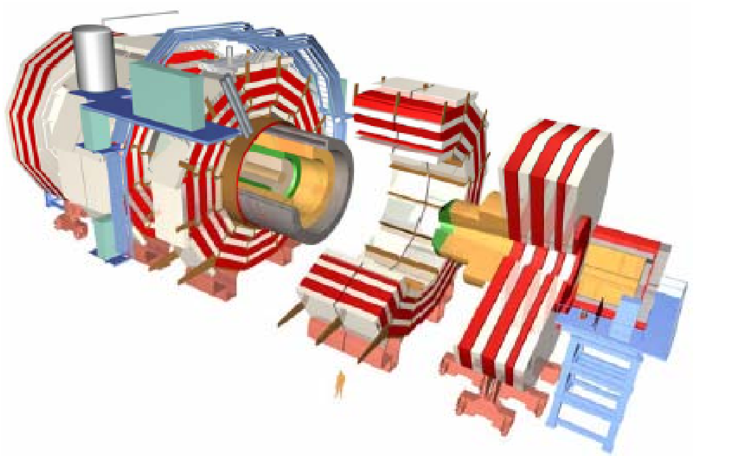


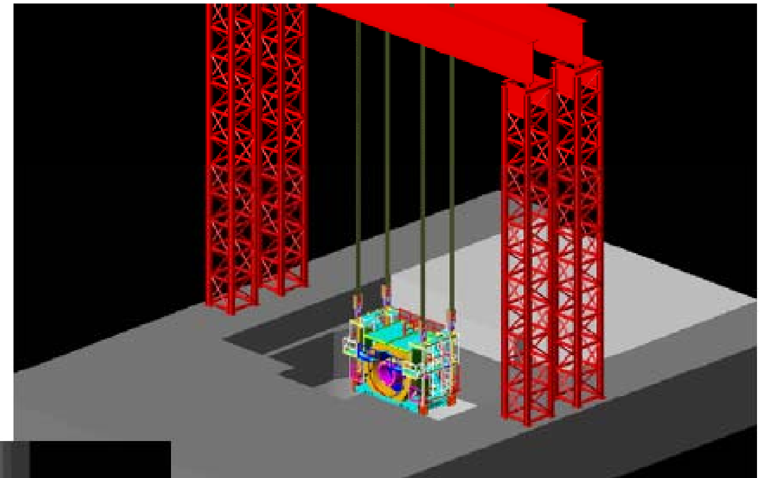
Civil Construction Timeline

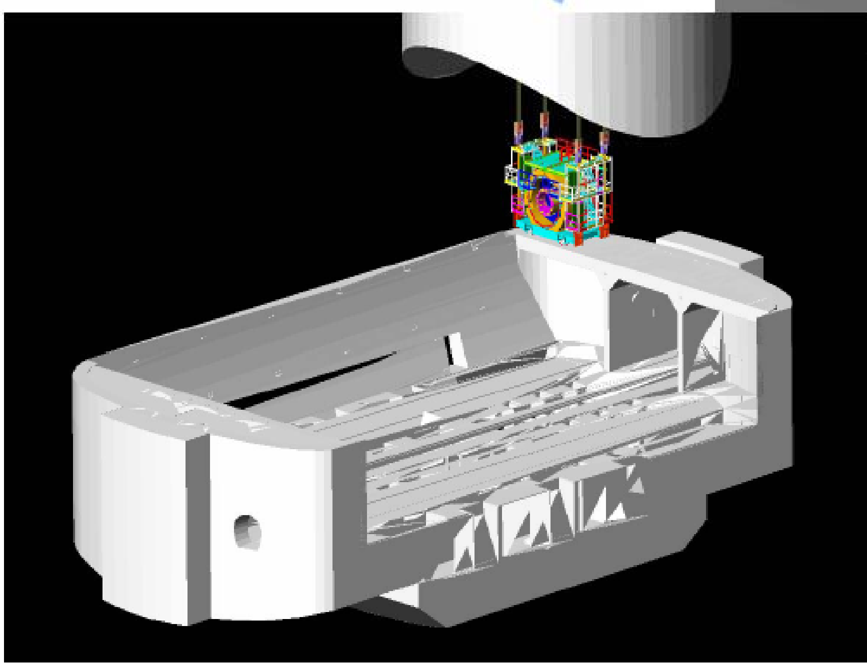


Install CFS services in Detector halls & Shaft base caverns

On-surface Detector Assembly
CMS approach



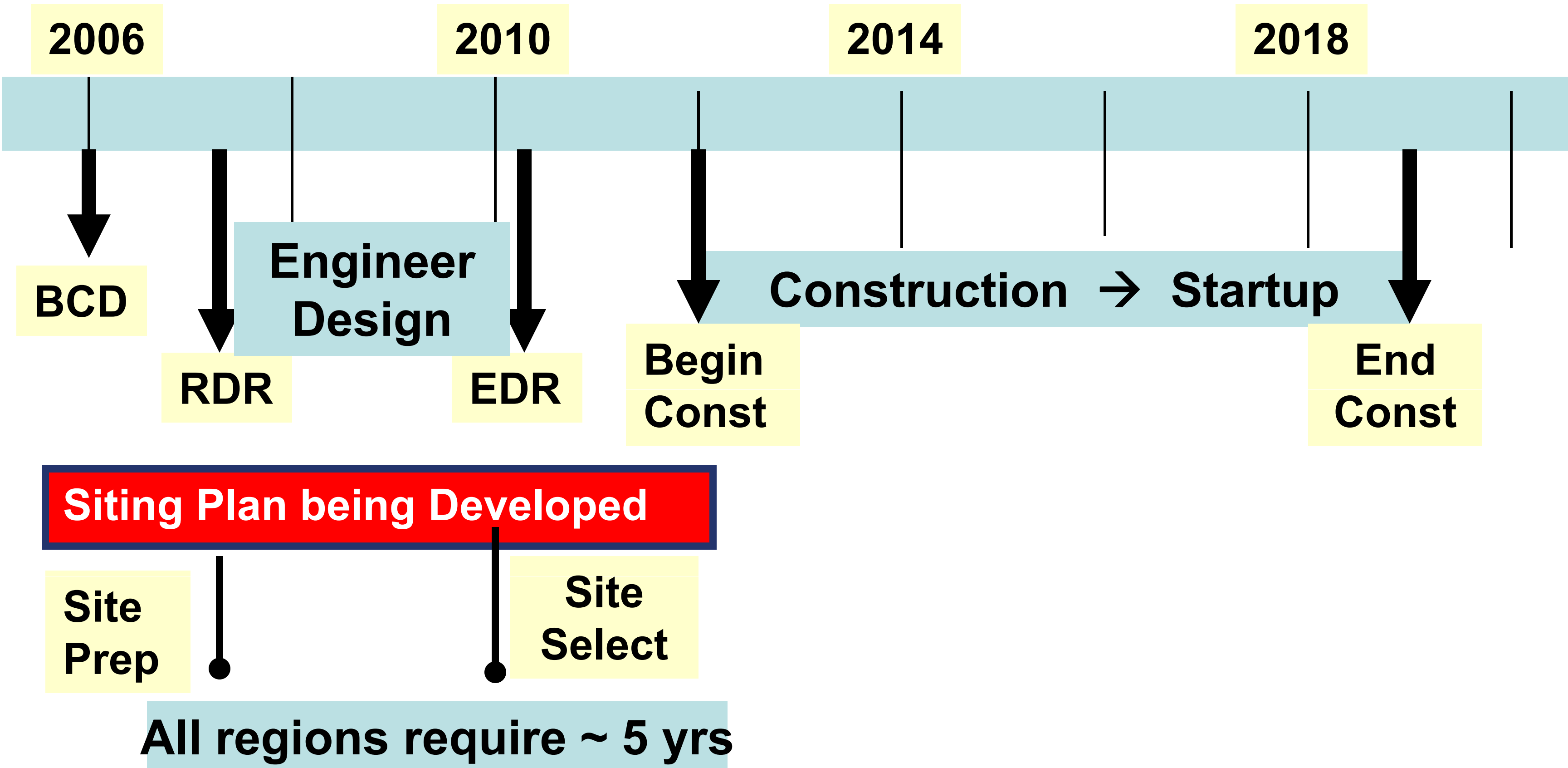




CMS assembly approach:

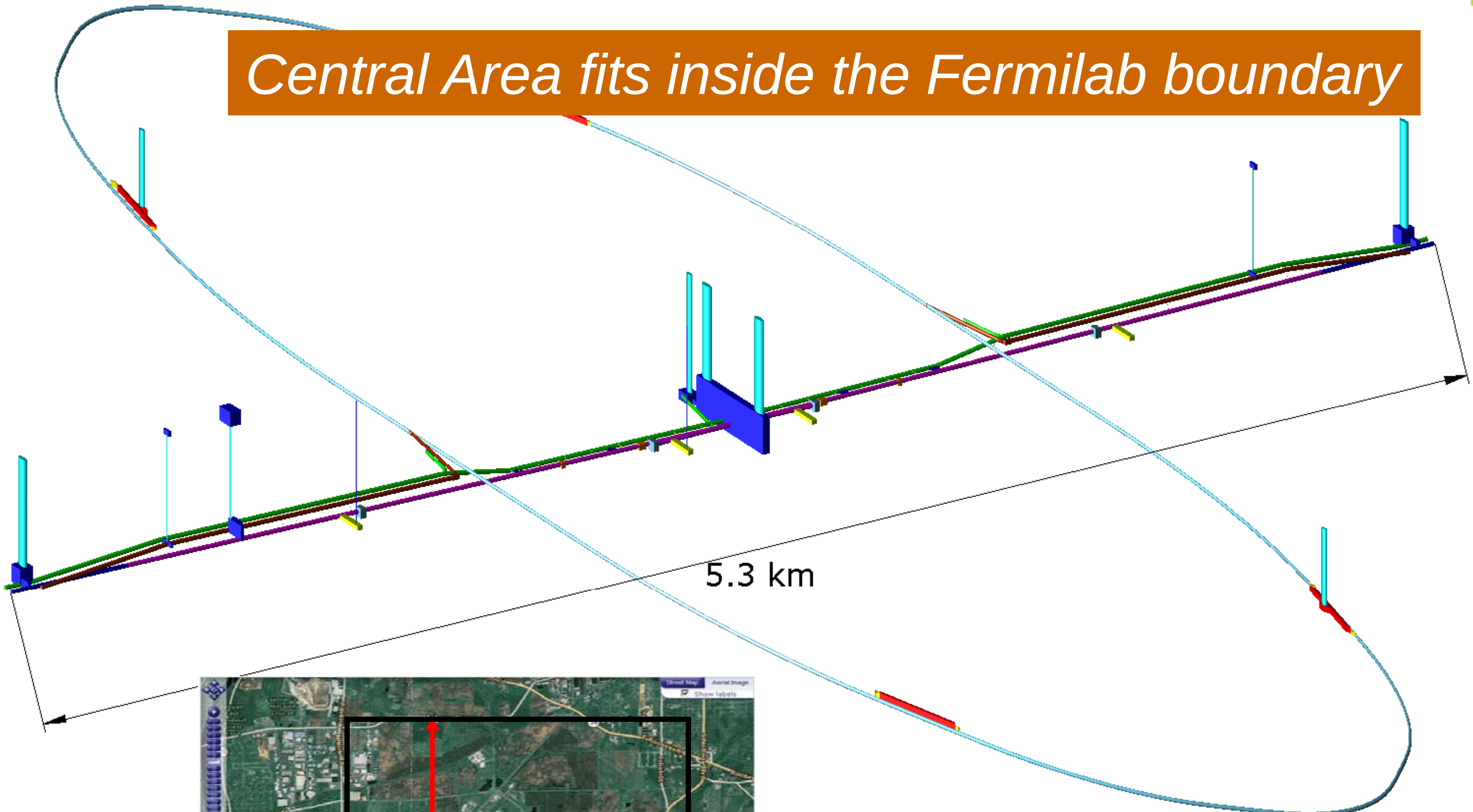
- **Assembled on the surface in parallel with underground work**
- **Allows pre-commissioning before lowering**
- **Lowering using dedicated heavy lifting equipment**
- **Potential for big time saving**
- **Reduces size of required underground hall**

Technically Driven Timeline

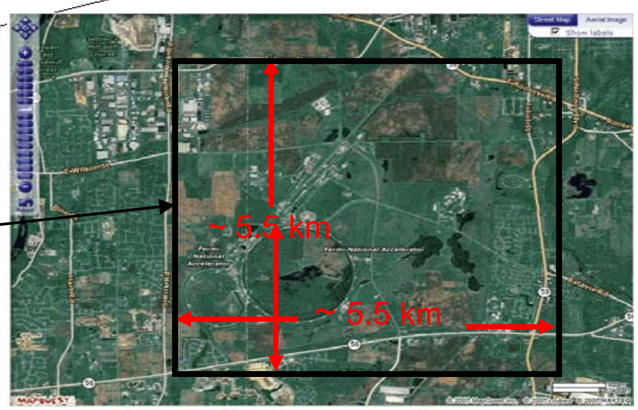


Preconstruction Plan: Fermilab

Central Area fits inside the Fermilab boundary

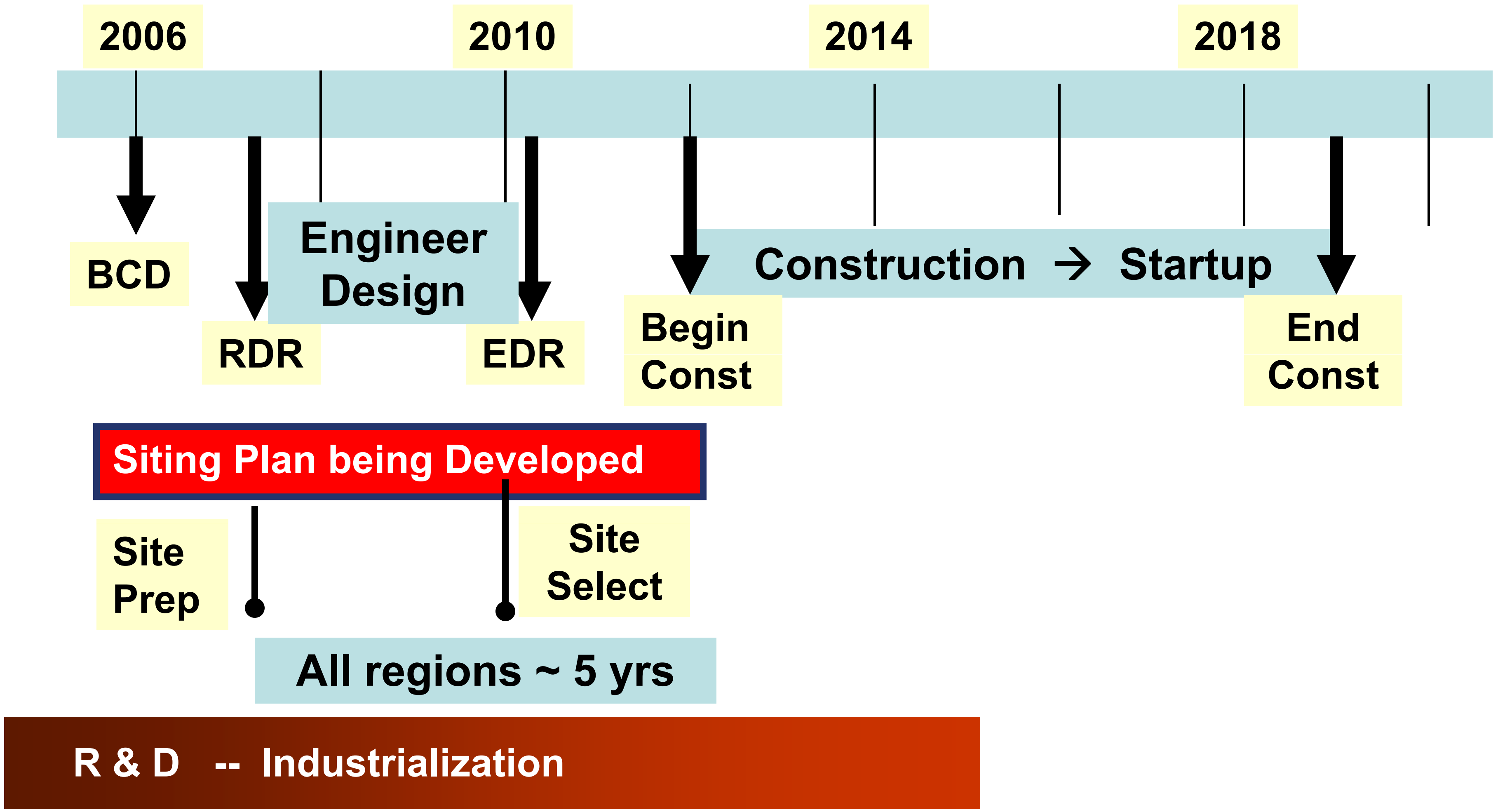


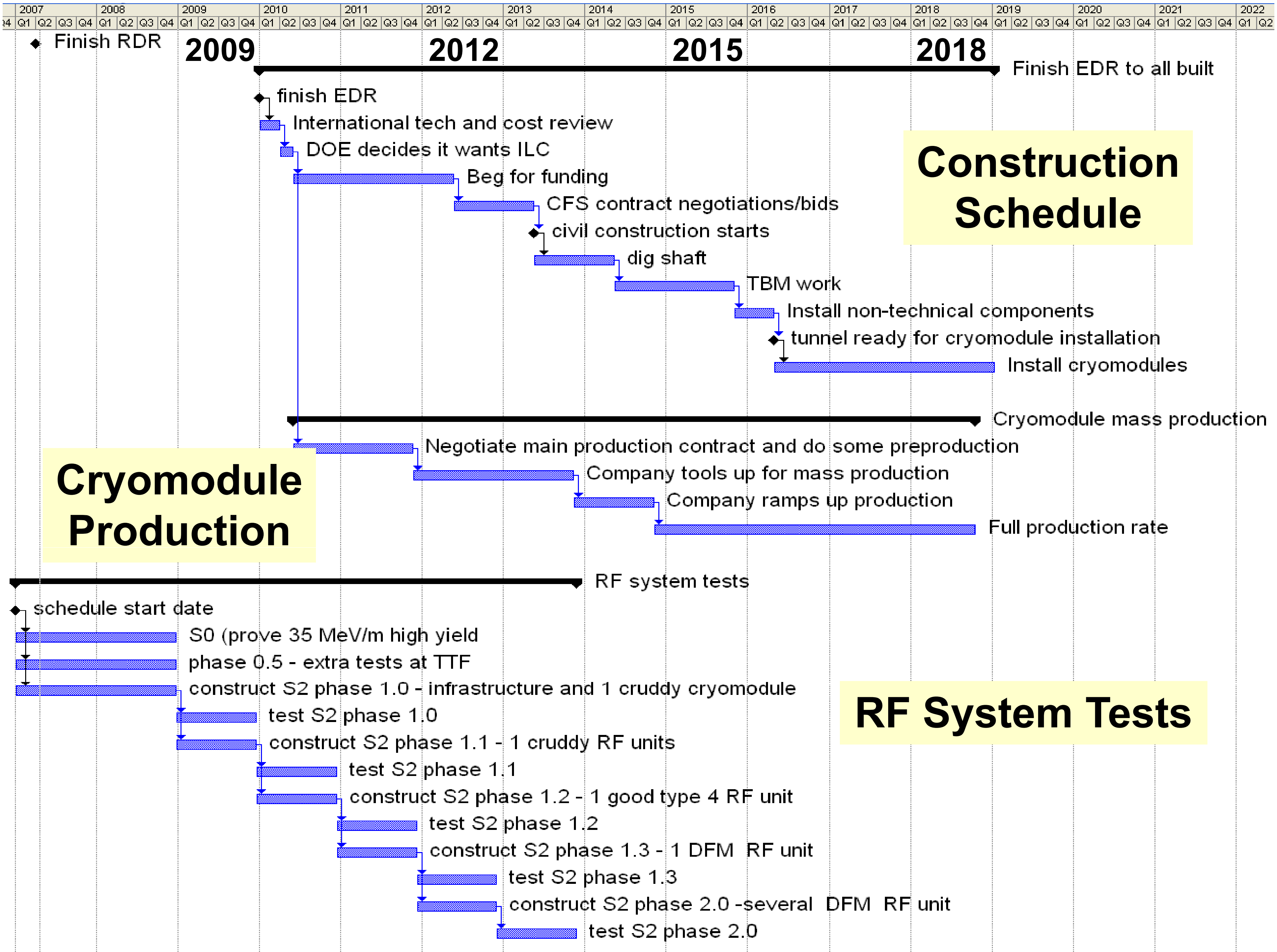
~ Boundary of Fermilab



Site Characterization of the Central Area can be done

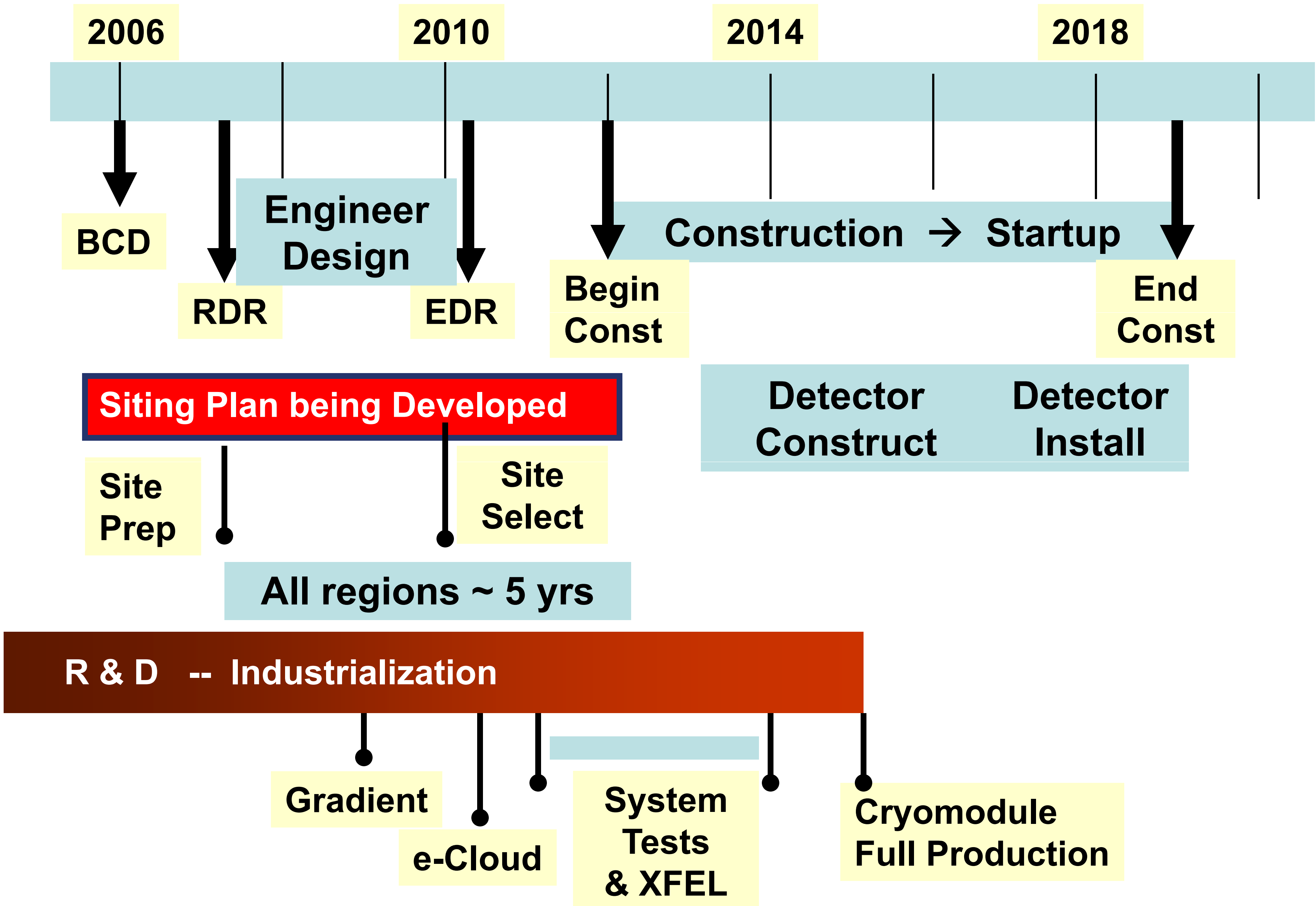
Technically Driven Timeline



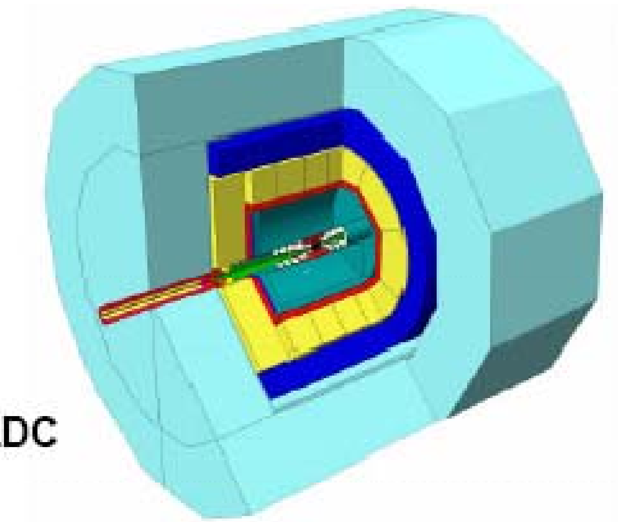


2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Q1 Q2 Q3 Q4
Finish RDR
2009
2012
2015
2018
Finish EDR to all built
finish EDR
International tech and cost review
DOE decides it wants ILC
Beg for funding
CFS contract negotiations/bids
civil construction starts
dig shaft
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

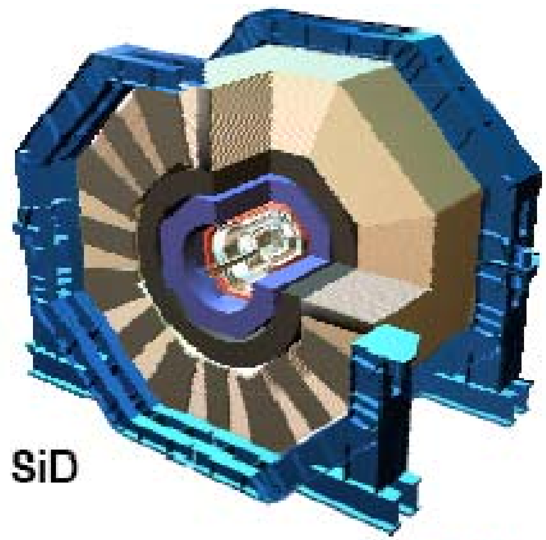
Technically Driven Timeline



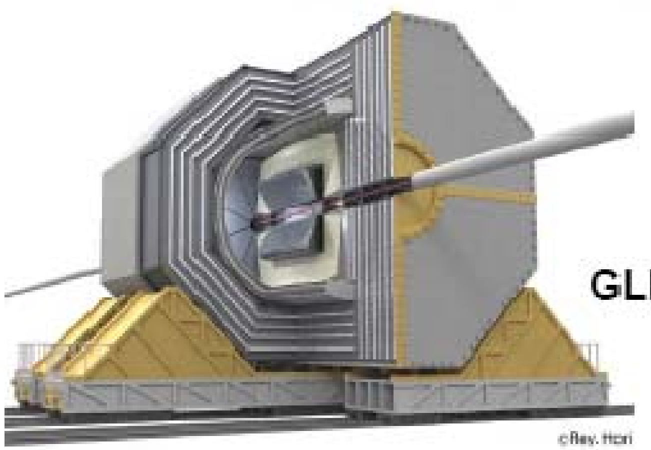
Detector Concepts



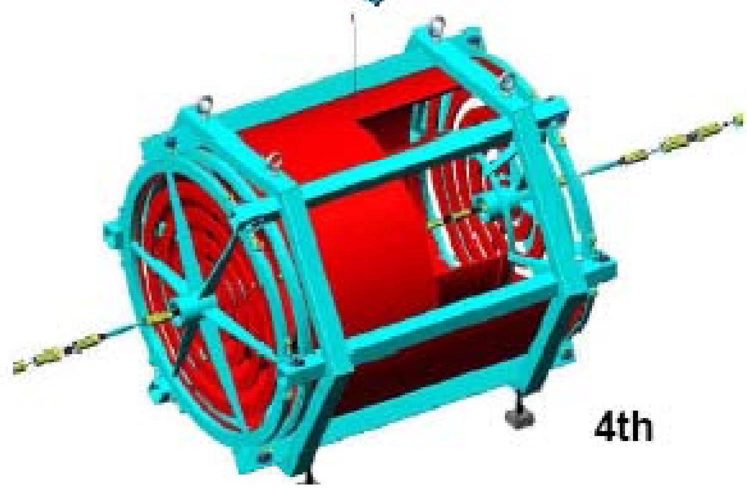
LDC



SiD



GLD



4th

Detector Performance Goals

- **ILC detector performance requirements and comparison to the LHC detectors:**
  - Inner vertex layer ~ 3-6 times closer to IP
  - Vertex pixel size ~ 30 times smaller
  - Vertex detector layer ~ 30 times thinner

  Impact param resolution $\Delta d = 5\ [\mu m] \oplus 10\ [\mu m] / (p[GeV] \sin^{3/2}\theta)$

  - Material in the tracker ~ 30 times less
  - Track momentum resolution ~ 10 times better

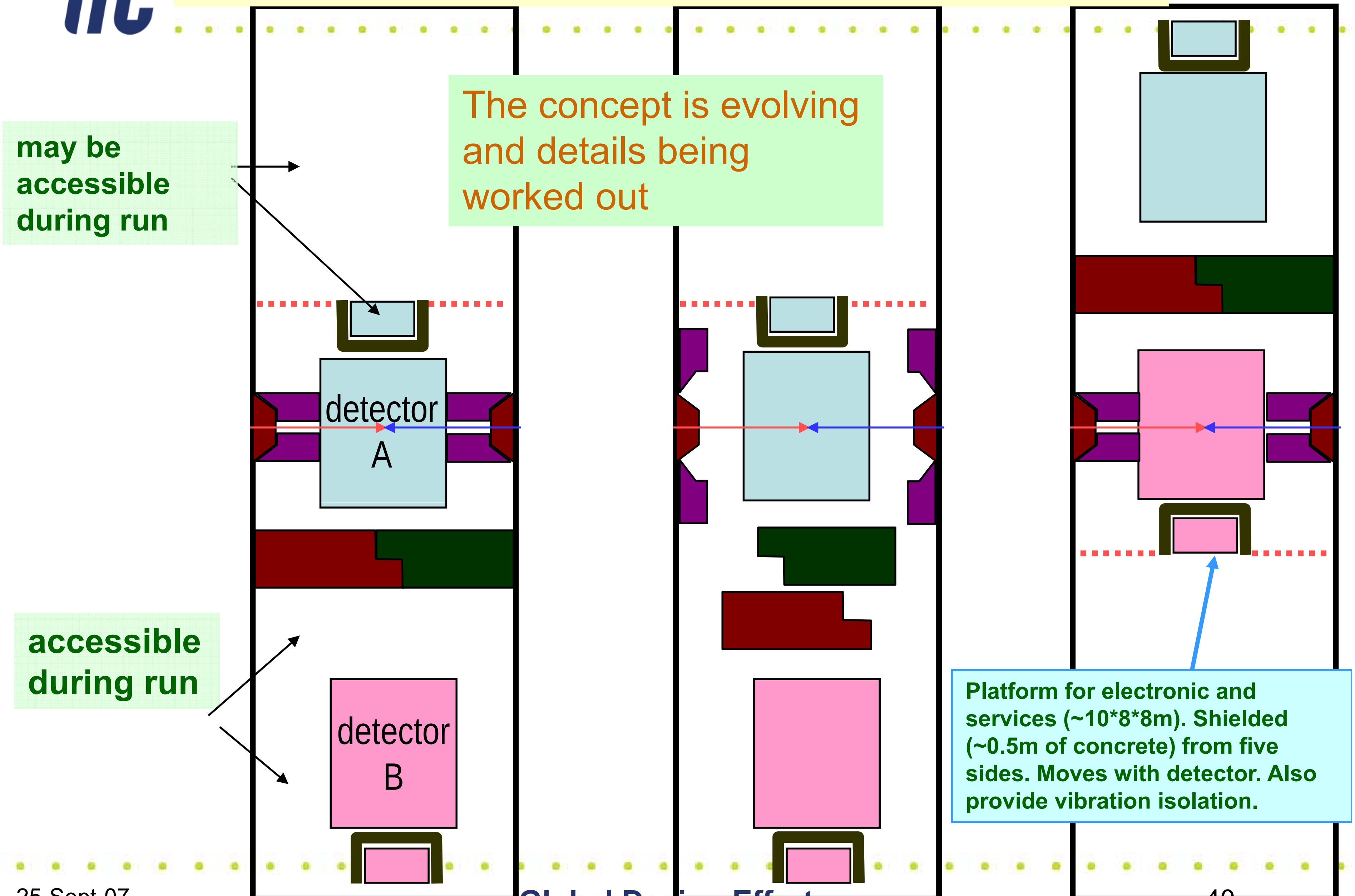
  Momentum resolution $\Delta p / p^2 = 5 \times 10^{-5}\ [GeV^{-1}]$ central region
  $\Delta p / p^2 = 3 \times 10^{-5}\ [GeV^{-1}]$ forward region

  - Granularity of EM calorimeter ~ 200 times better

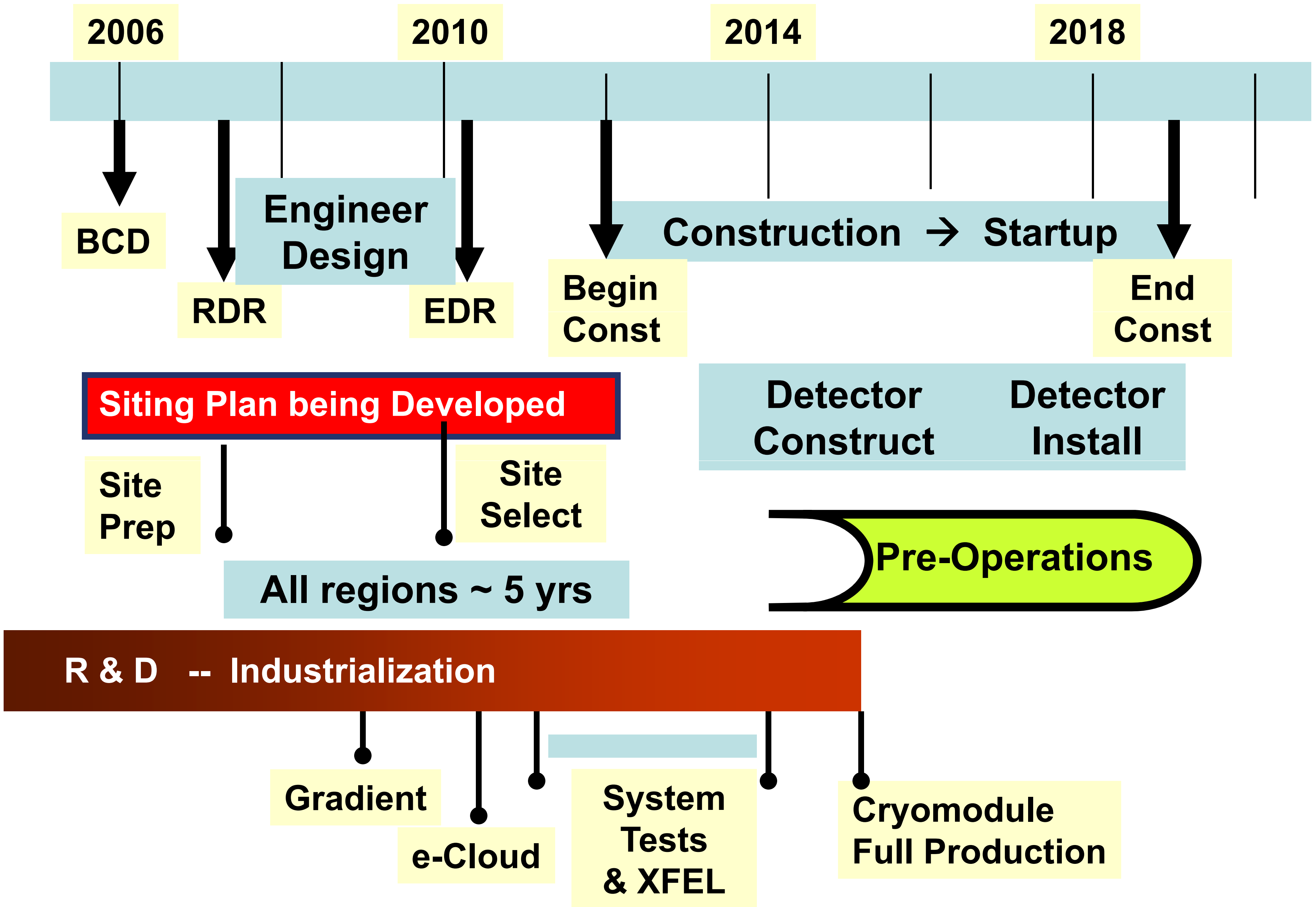
  Jet energy resolution $\Delta E_{jet} / E_{jet} = 0.3 / \sqrt{E_{jet}}$

  Forward Hermeticity down to θ = 5-10 [mrad]

Concept: one IR - two detectors



Technically Driven Timeline



Conclusions

- **The ILC design is proceeding toward an engineering design (EDR) in 2010.**
  - **Be ready to propose construction when LHC results justify!**
- **R&D program is being globally coordinated to determine gradient, electron cloud, industrialization, mass production.**
  - **Overall priorities are being set for risk reduction**
  - **There are regional programs to develop SCRF expertise and prepare to bid to host**
- **Detector R&D/design also very important to be able to fully exploit the ILC (e.g. spatial & energy resolution)**
  - **Appointment of Research Director - S Yamada for better coordination, better regional balance**
  - **LOIs in one year**