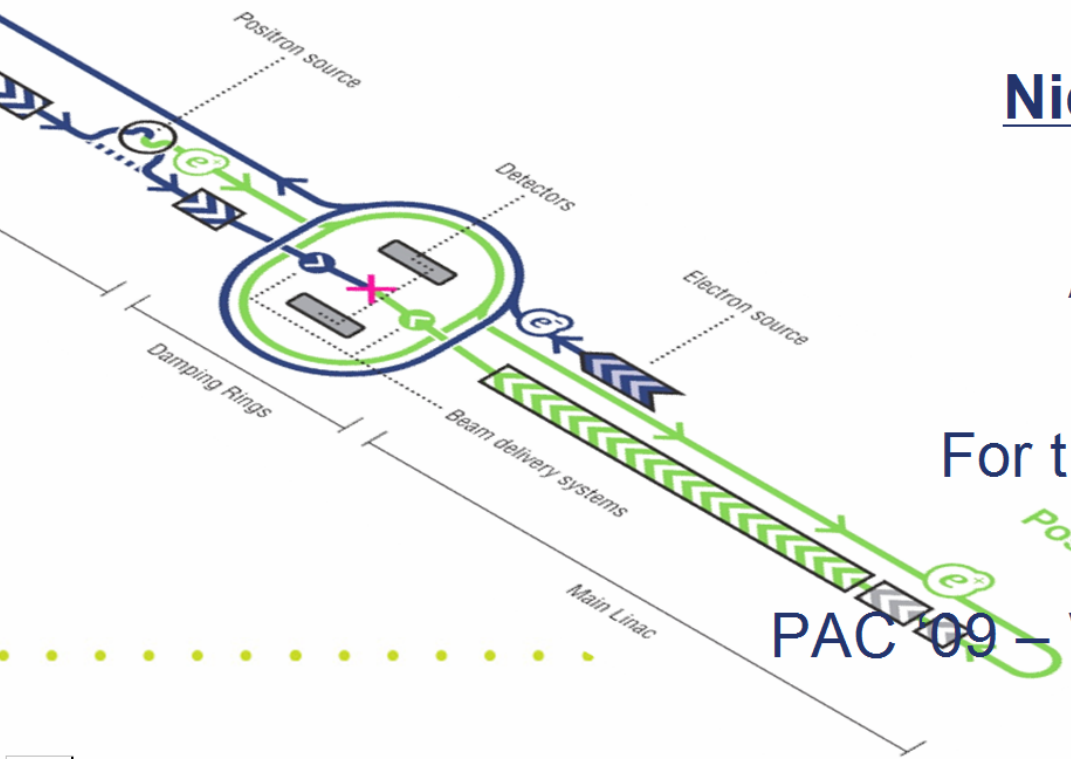
Progress Toward the International Linear Collider



Nicholas Walker (DESY)

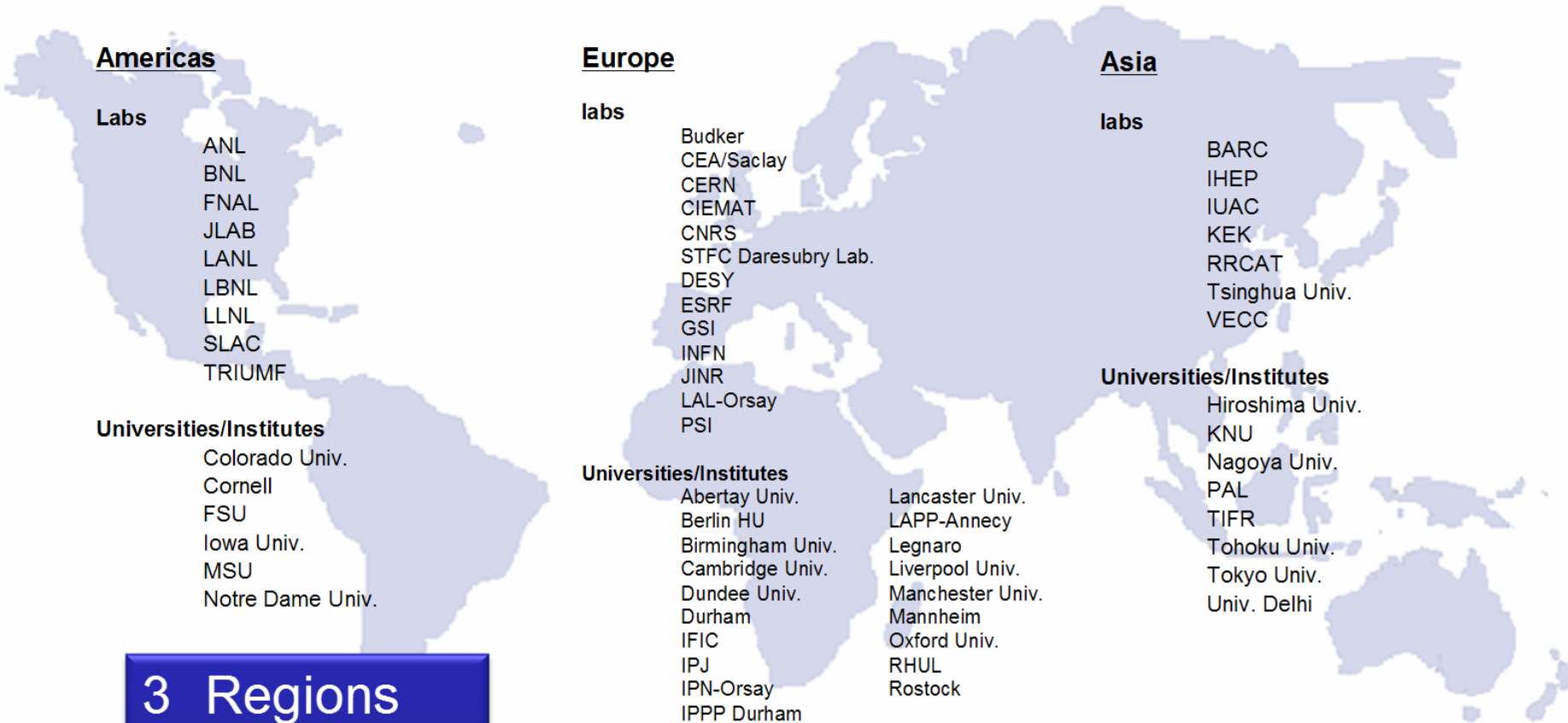
Marc Ross (FNAL)

Akira Yamamoto (KEK)

For the Global Design Effort

PAC '09 – Vancouver – 8.05.2009

The Global Design Effort*



Americas

Labs

ANL
BNL
FNAL
JLAB
LANL
LBNL
LLNL
SLAC
TRIUMF

Universities/Institutes

Colorado Univ.
Cornell
FSU
Iowa Univ.
MSU
Notre Dame Univ.

Europe

labs

Budker
CEA/Saclay
CERN
CIEMAT
CNRS
STFC Daresubry Lab.
DESY
ESRF
GSI
INFN
JINR
LAL-Orsay
PSI

Universities/Institutes

Abertay Univ.
Berlin HU
Birmingham Univ.
Cambridge Univ.
Dundee Univ.
Durham
IFIC
IPJ
IPN-Orsay
IPPP Durham
Krakow
Lancaster Univ.
LAPP-Annecy
Legnaro
Liverpool Univ.
Manchester Univ.
Mannheim
Oxford Univ.
RHUL
Rostock

Asia

labs

BARC
IHEP
IUAC
KEK
RRCAT
Tsinghua Univ.
VECC

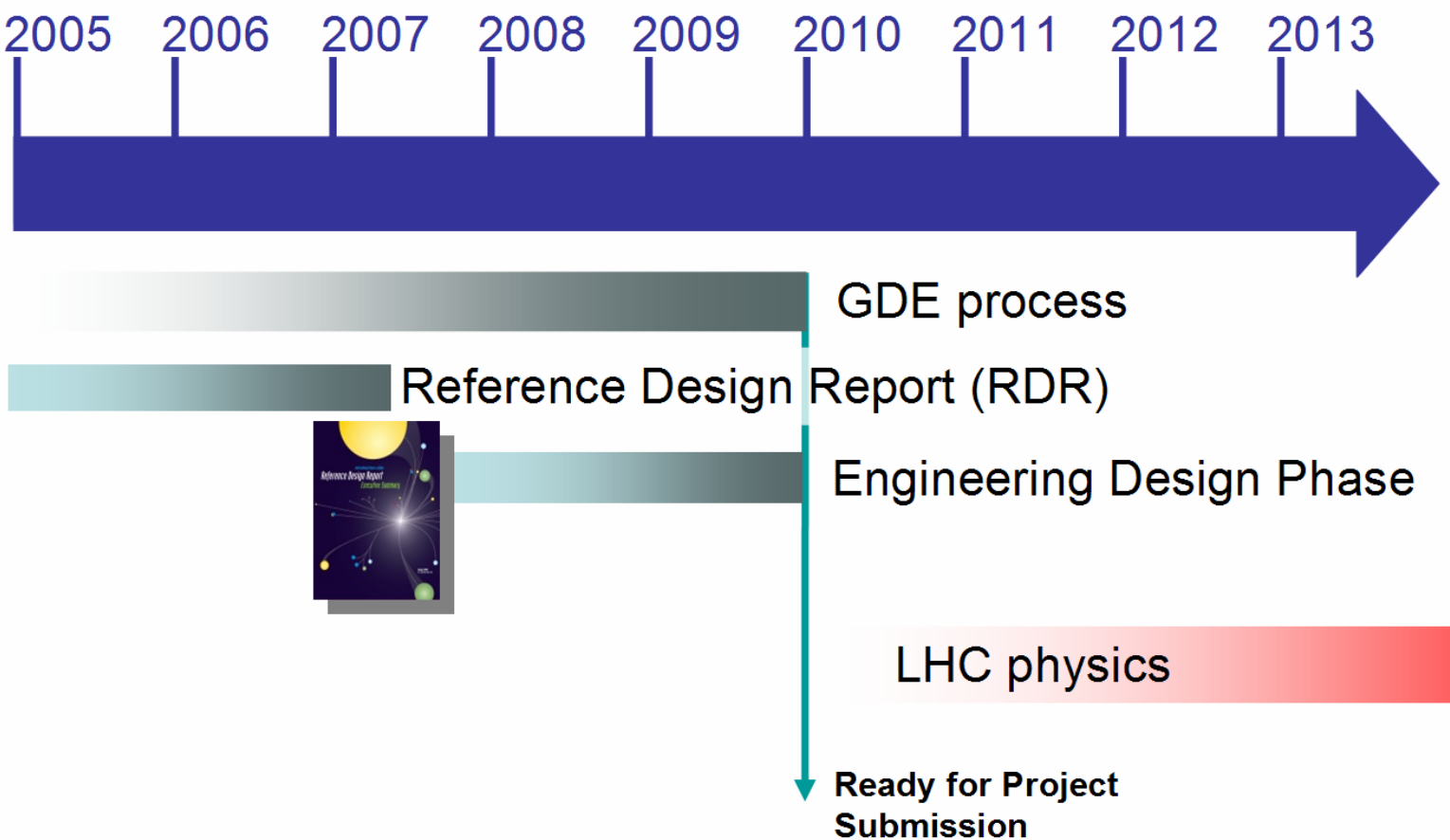
Universities/Institutes

Hiroshima Univ.
KNU
Nagoya Univ.
PAL
TIFR
Tohoku Univ.
Tokyo Univ.
Univ. Delhi

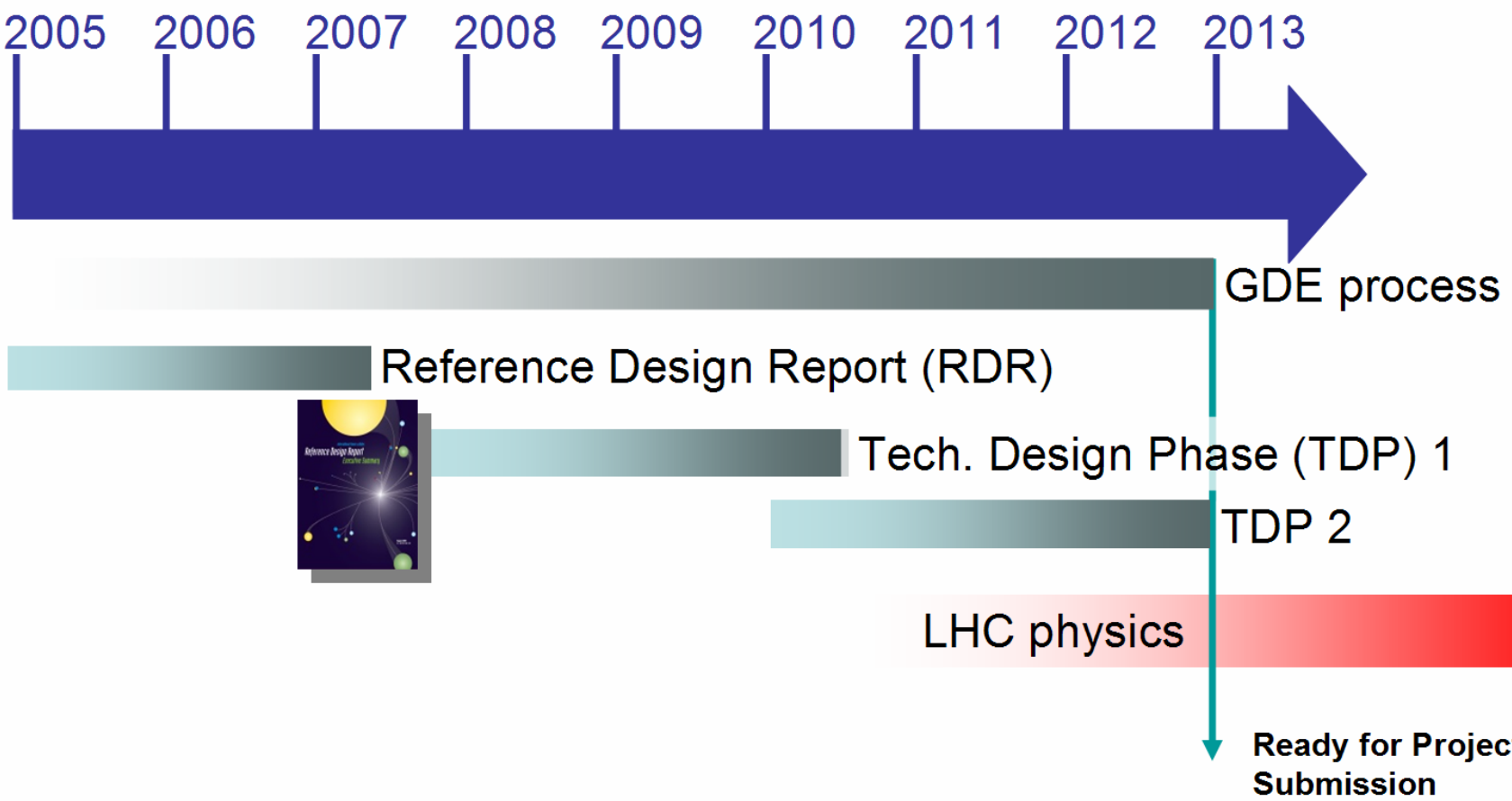
3 Regions
16 Countries
76 Institutes

*Based on known participation and received expressions of interest

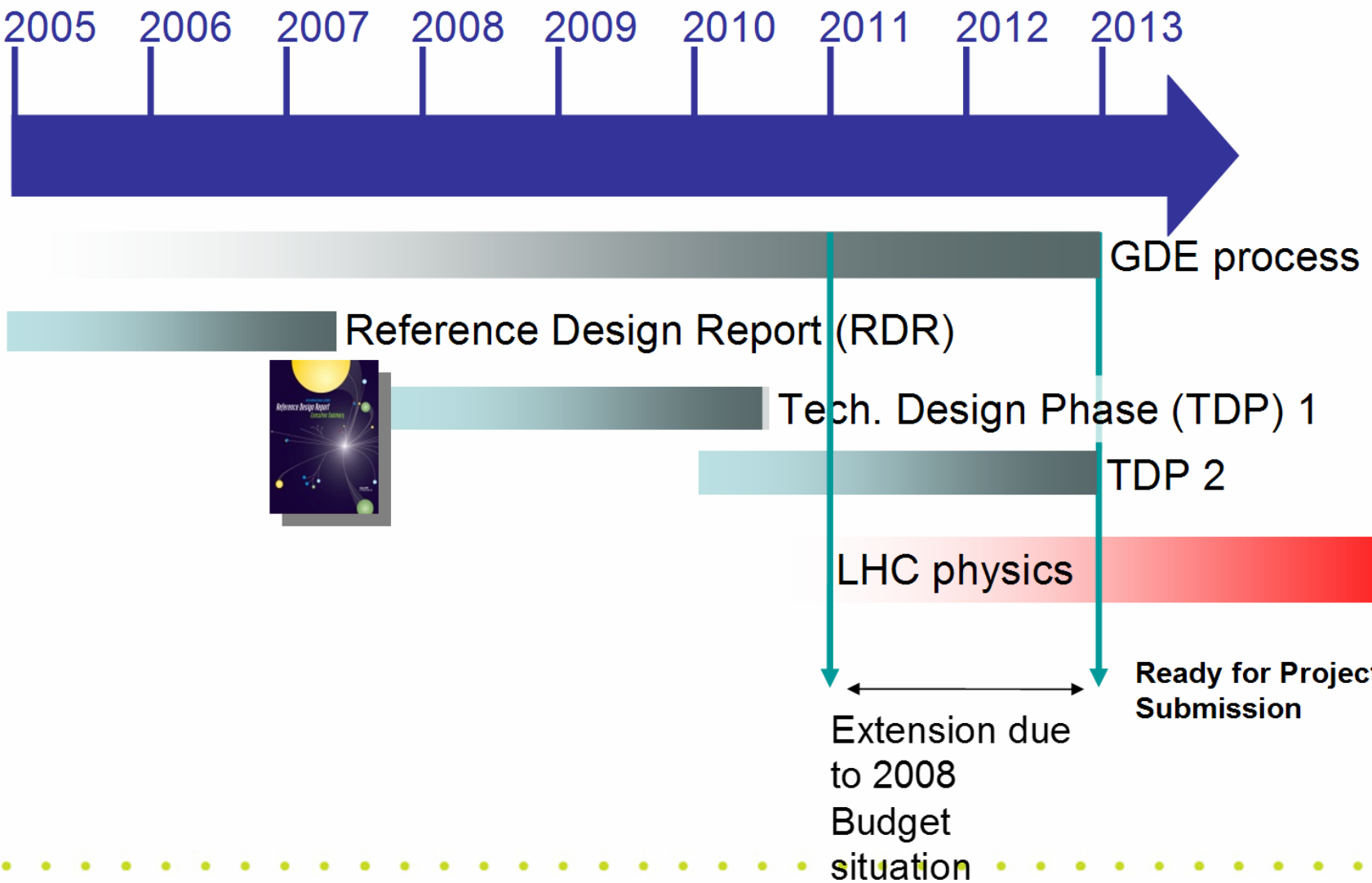
GDE ILC Timeline (2008)



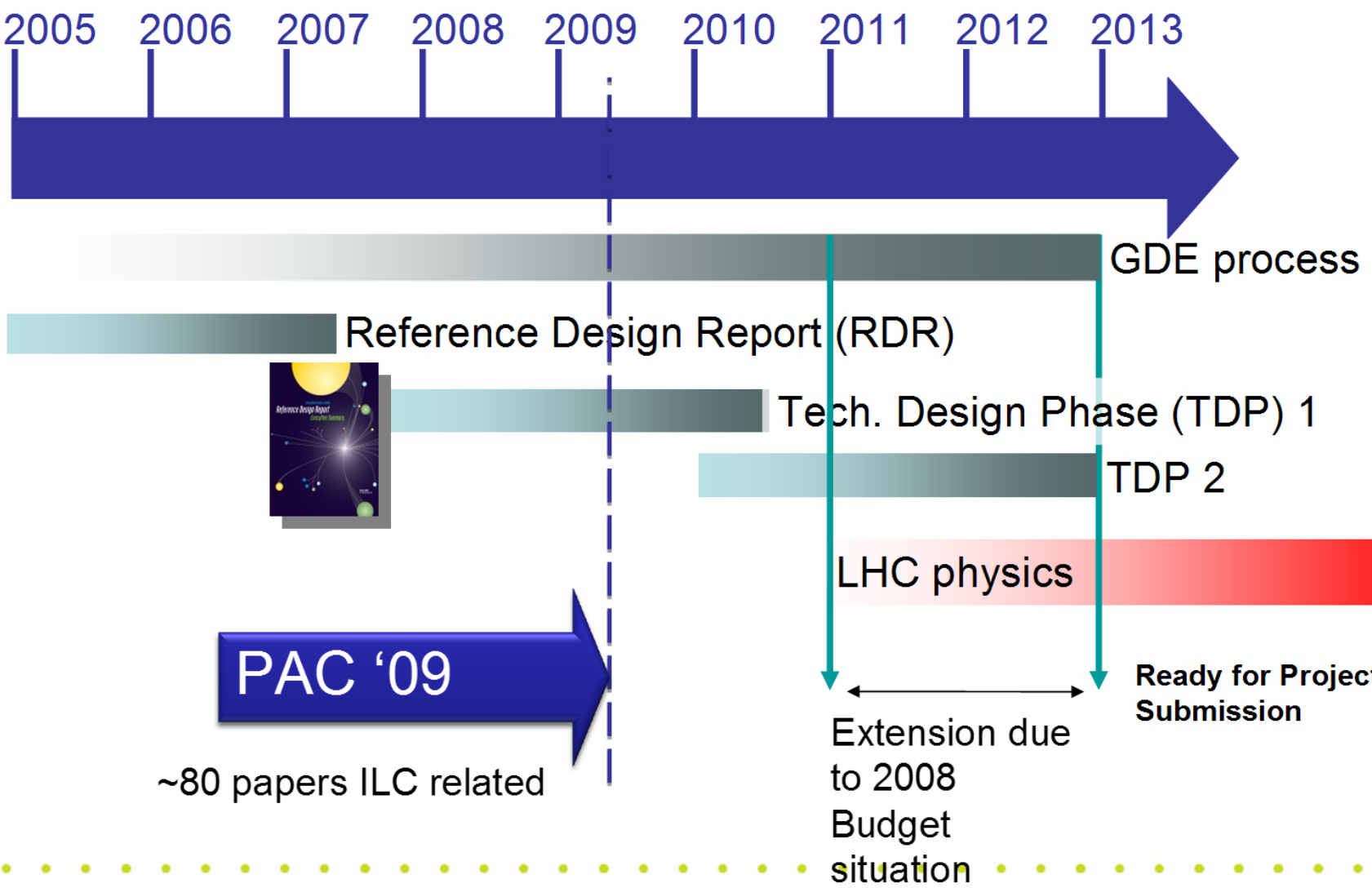
GDE ILC Timeline (current)



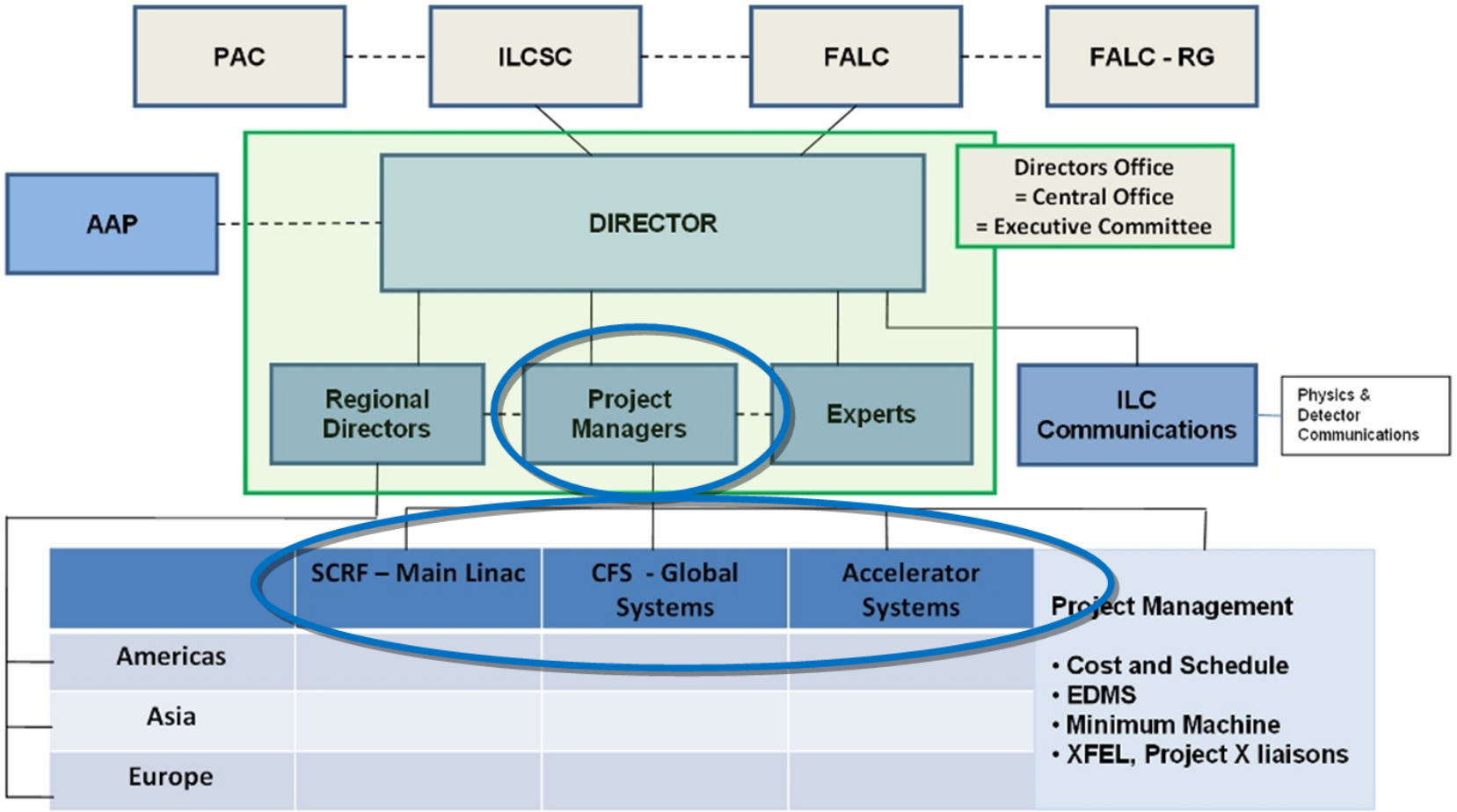
GDE ILC Timeline (current)

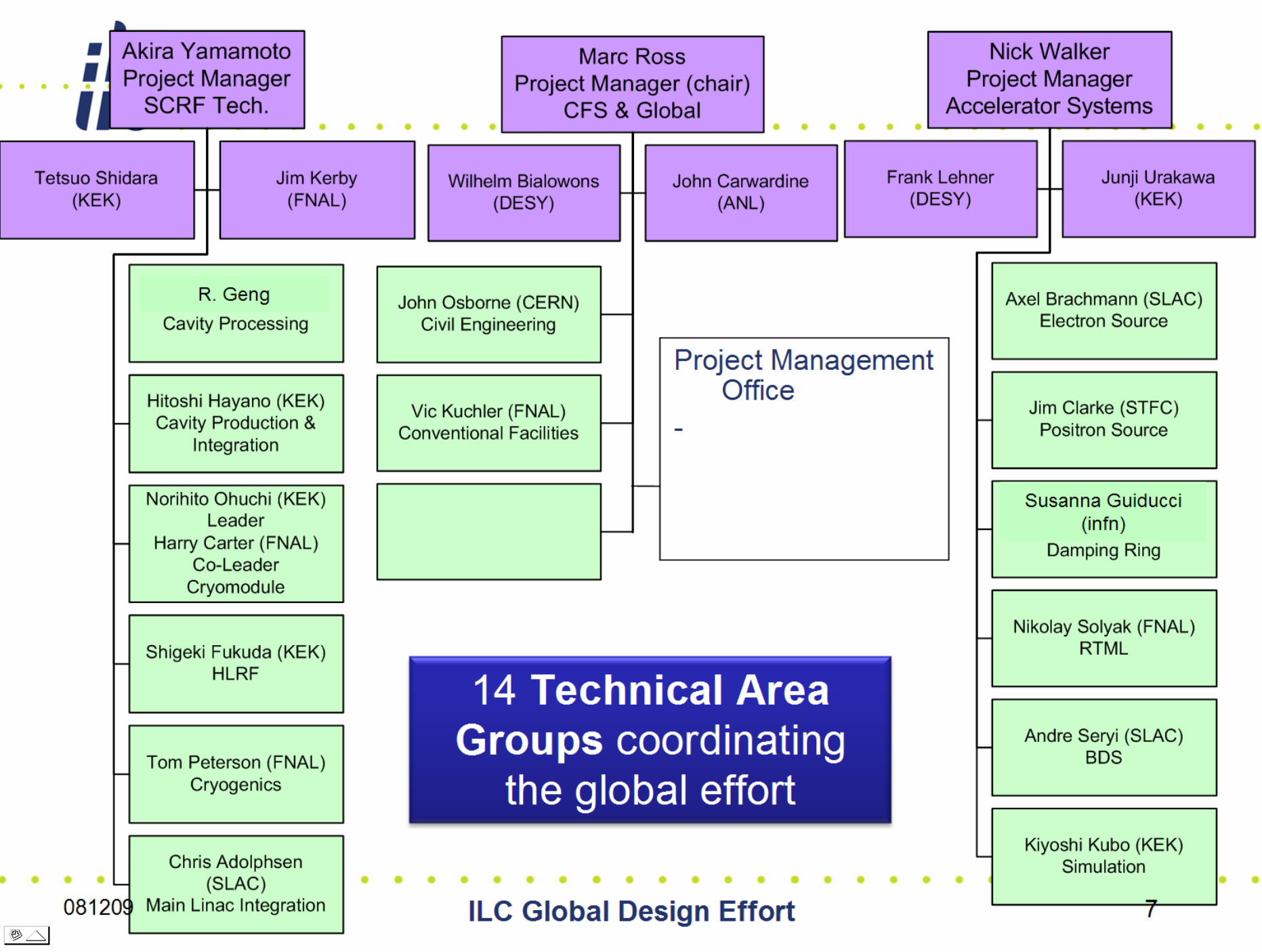


GDE ILC Timeline (current)



GDE Project Structure




Akira Yamamoto
Project Manager
SCRF Tech.
Marc Ross
Project Manager (chair)
CFS & Global
Nick Walker
Project Manager
Accelerator Systems
Tetsuo Shidara (KEK)
Jim Kerby (FNAL)
Wilhelm Bialowons (DESY)
John Carwardine (ANL)
Frank Lehner (DESY)
Junji Urakawa (KEK)
R. Geng
Cavity Processing
Hitoshi Hayano (KEK)
Cavity Production & Integration
Norihito Ohuchi (KEK)
Leader
Harry Carter (FNAL)
Co-Leader
Cryomodule
Shigeki Fukuda (KEK)
HLRF
Tom Peterson (FNAL)
Cryogenics
Chris Adolphsen (SLAC)
Main Linac Integration
John Osborne (CERN)
Civil Engineering
Vic Kuchler (FNAL)
Conventional Facilities
Project Management Office
-
Axel Brachmann (SLAC)
Electron Source
Jim Clarke (STFC)
Positron Source
Susanna Guiducci (infn)
Damping Ring
Nikolay Solyak (FNAL)
RTML
Andre Seryi (SLAC)
BDS
Kiyoshi Kubo (KEK)
Simulation
14 Technical Area Groups coordinating the global effort

TD Phase 1 & 2: The R&D Plan

- Stated TDP Goals:
  - **Updated ILC design**
  - **Results of critical risk-mitigating R&D**
  - **Updated VALUE estimate and schedule**
  - **Project Implementation Plan**

ILC Research and Development Plan for the Technical Design Phase

Release 3

February 2009

ILC Global Design Effort

Director: Barry Barish

Prepared by the Technical Design Phase Project Management

Project Managers: Marc Ross, Nick Walker, Akira Yamamoto

TD Phase Stated Priorities (R&D Plan)

Risk Mitigating R&D	• SCRF Technology (e.g. gradient) • Damping ring electron cloud • …
Beam Test Facilities	• ATF / ATF 2 (KEK) • CesrTA (Cornell) • TTF/FLASH (DESY) • …
Machine Design / Cost	• CFS / Value Engineering • Accelerator Design & Integration

Global SCRF Technology

Implicit but critical GDE goal:

Promote development of 1.3GHz nine-cell expertise & infrastructure in all three regions

Major progress in infrastructure development in all three regions

Global SCRF Technology: ASIA

KEK, Japan

Global SCRF Technology: AMERICAS

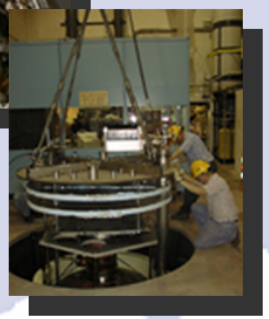
FNAL, ANL

SLAC

Cornell

JLAB

KEK, Japan



Global SCRF Technology: EUROPE

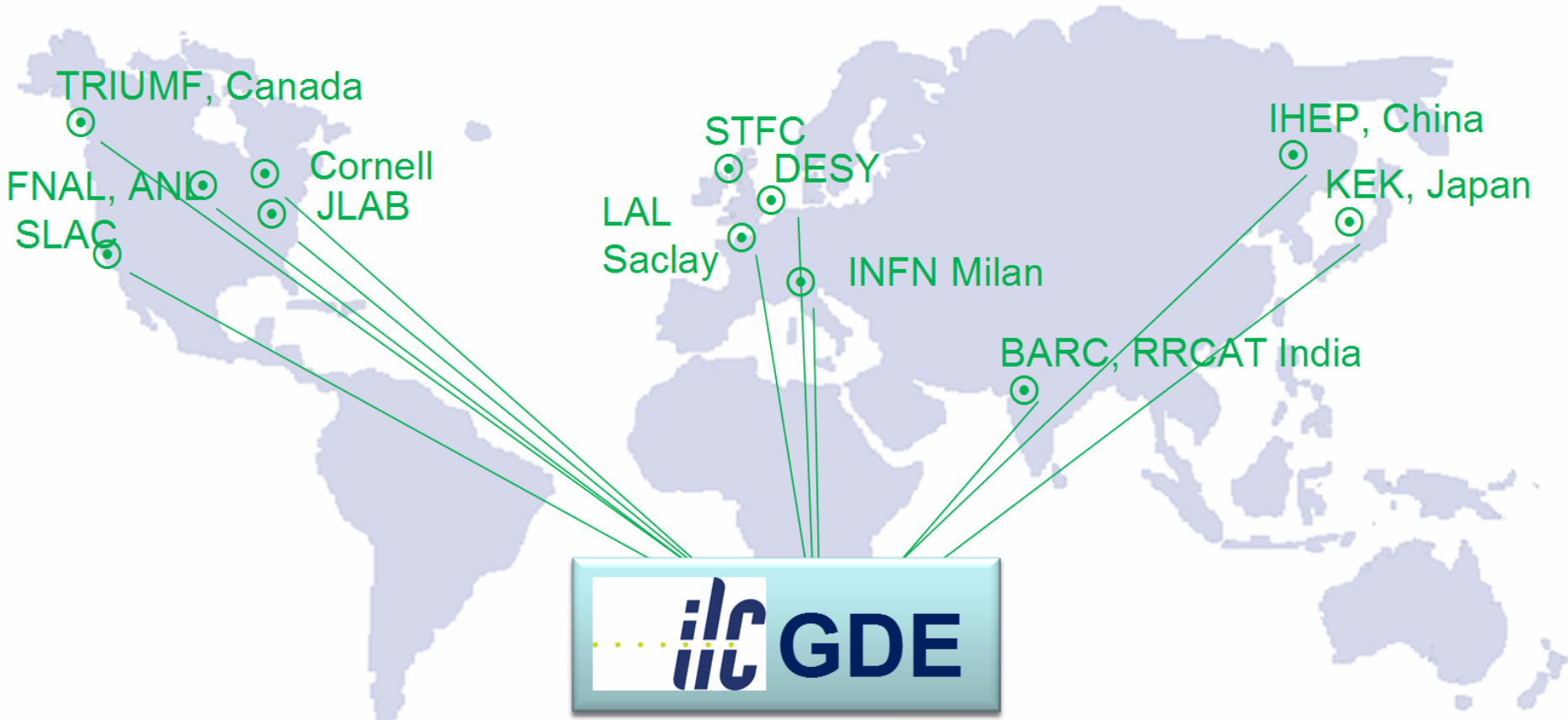
DESY

LAL
Saclay

INFN Milan

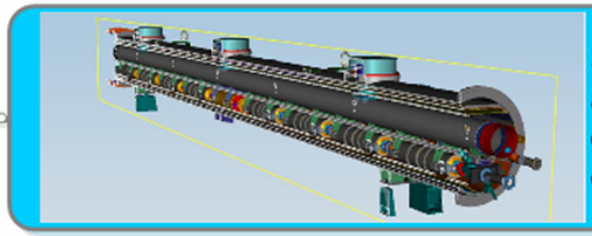
KEK, Japan

Global SCRF Technology



Superconducting RF Technology


35 MV/m
Gradient Yield
in 9-cell cavities

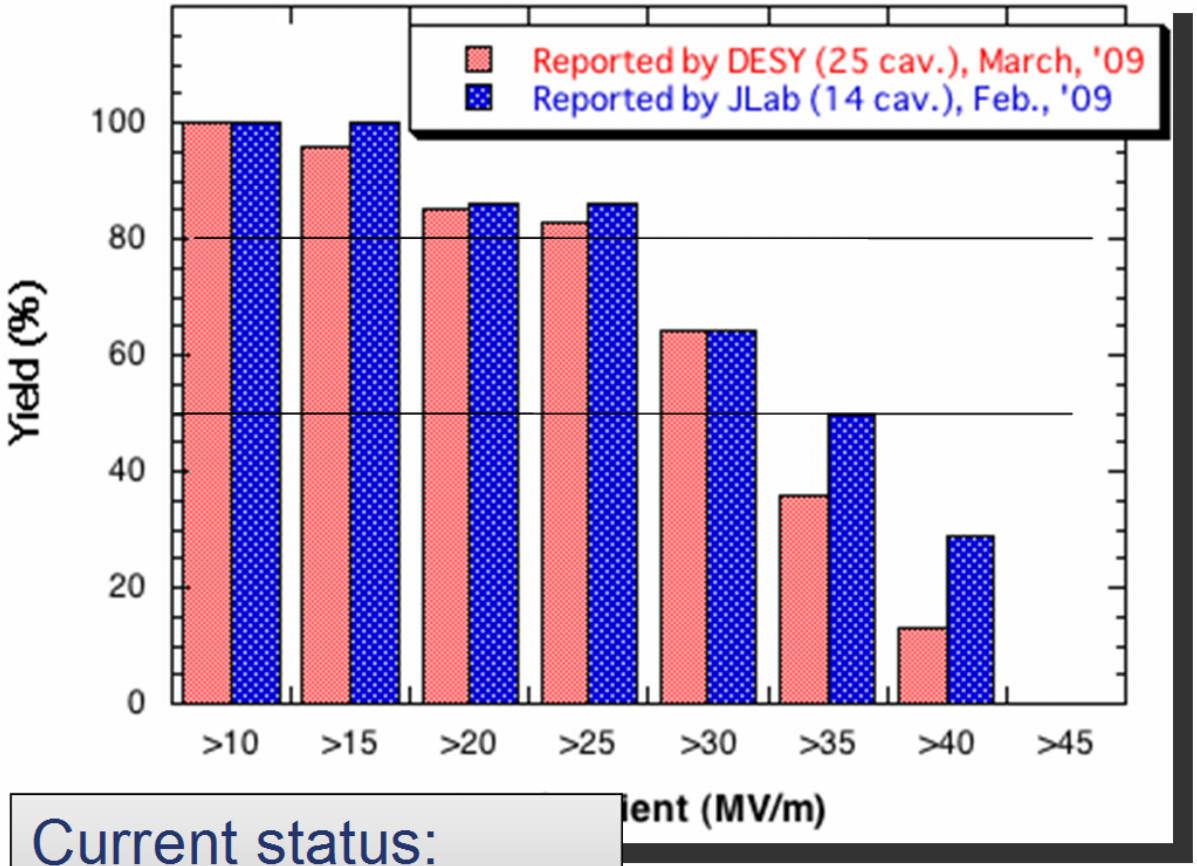

31.5 MV/m
average
gradient in a
cryomodule


Linac
"String Test"

SCRF Priority R&D: Gradient

- Gradient: single biggest cost driver
- RDR baseline:
  - **≥35 MV/m vertical (acceptance) test**
  - **≥31.5 MV/m average operational gradient**
- Proof of principle of gradient achieved
  - **Many single-cells**
  - **Tens of 9-cells**
  - **Operational acceleration demonstrated (TTF/FLASH)**
- GDE Focus on mass-production yield and cost
  - **TDP-1 goal: *process yield* 50%**
  - **TDP-2 goal: *production yield* 90%**

Progress Towards High-Gradient Yield



Current status:
50% yield at ~ 33 MV/m;
(80% >25MV/m)

Recent DESY/JLab "production" series.

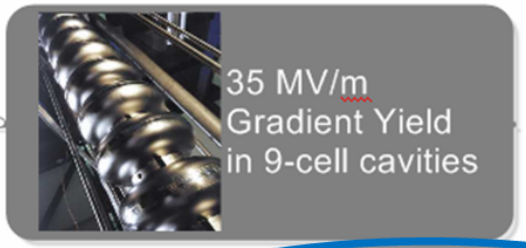
Total 39 cavities (08/09)

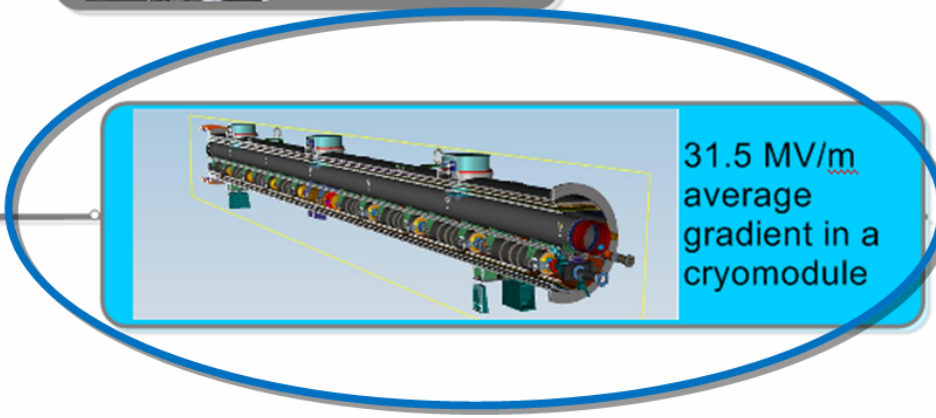
Mostly result of **first cold-test** (few cases second-test)

Field Emission greatly reduced (rinses)
→ identified RDR barrier

Baseline gradient re-evaluation (TDP1) expected to be based on sample of >60 cavities

Superconducting RF Technology

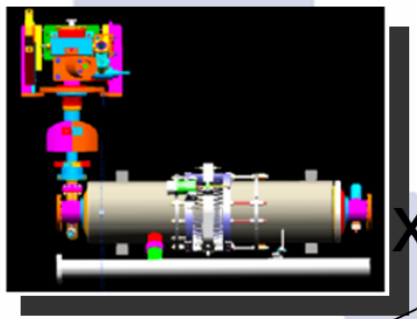




S1-Global Collaboration

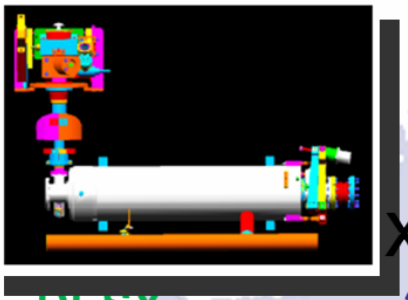
Complementary activity to regional cryomodule development

FNAL ⊙

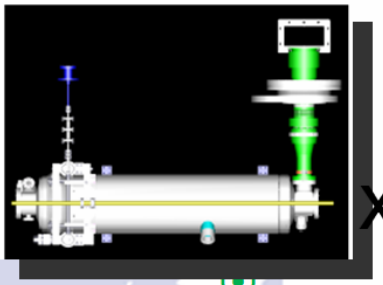


x2

DESY

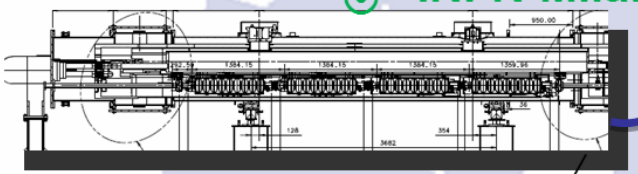


x2

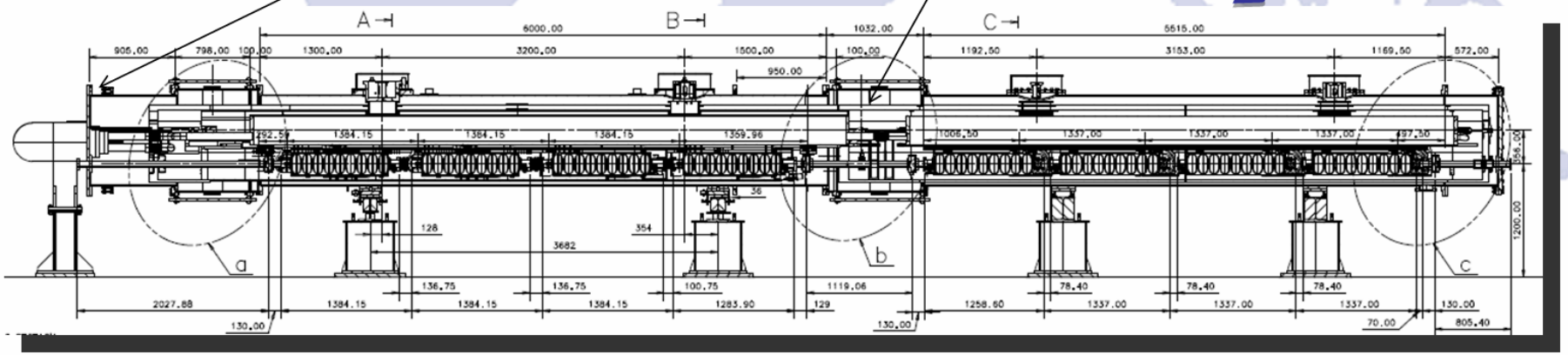


x4

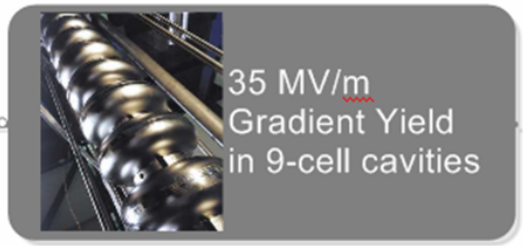
⊙ INFN Milan

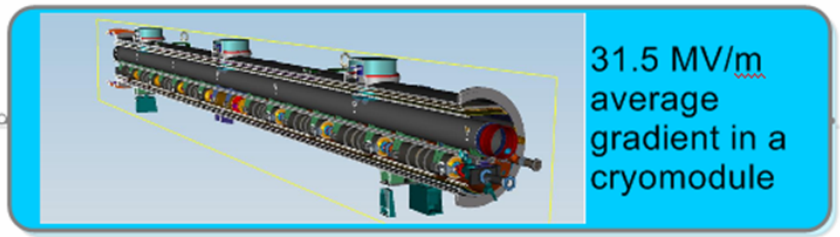


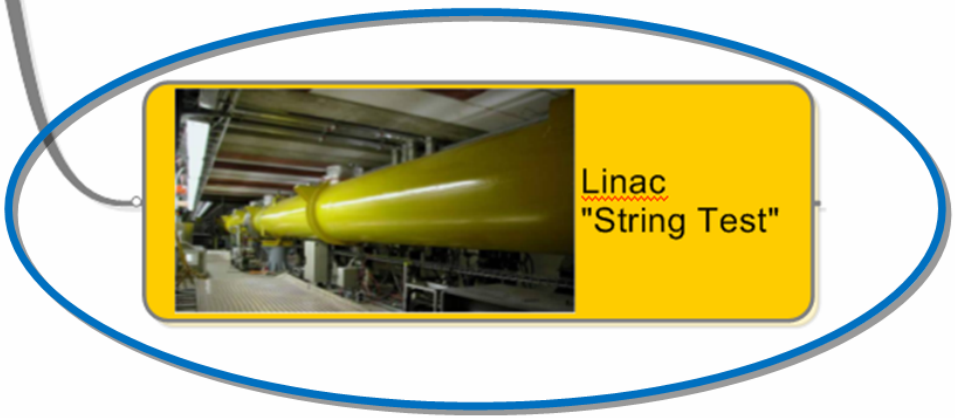
KEK, Japan



Superconducting RF Technology

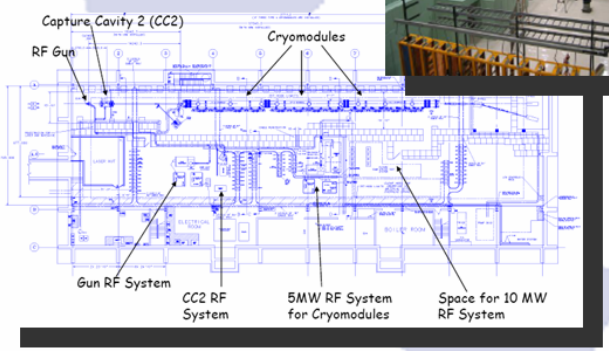






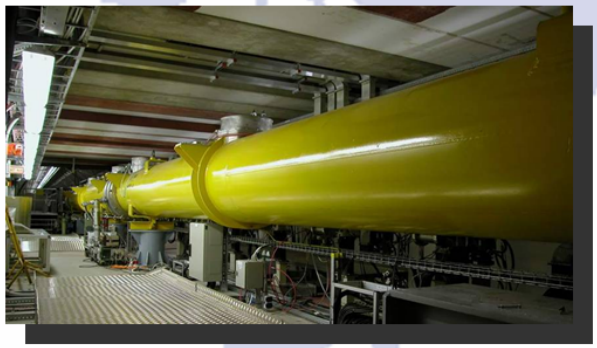
SRF Test Facilities

FNAL



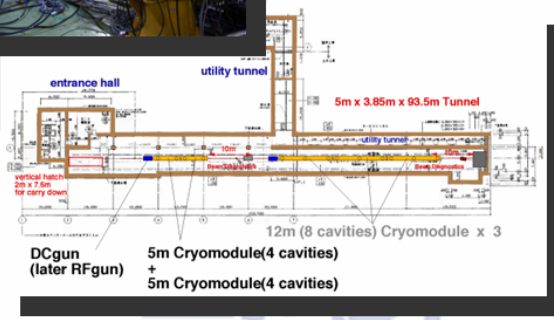
NML facility
Under construction
first beam 2010
ILC RF unit test ~2012

DESY



TTF/FLASH
~1 GeV
ILC-like beam
ILC RF unit
(* lower gradient)

KEK, Japan



STF (phase I & II)
Under construction
first beam 2011
ILC RF unit test by 2013

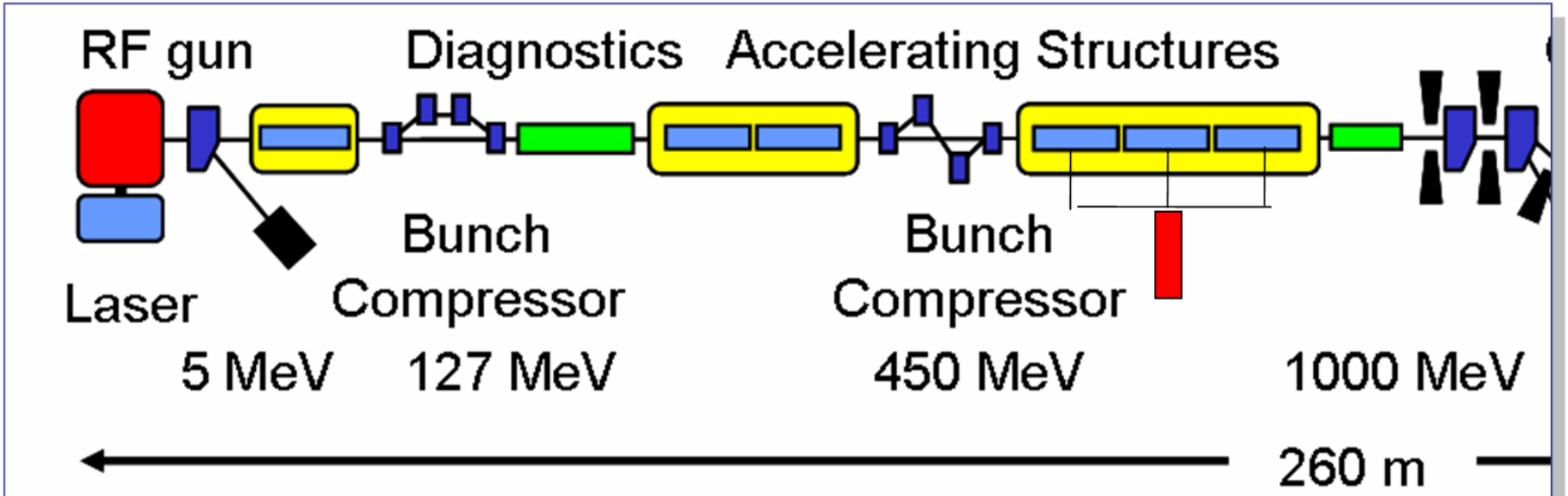
A string test in each region

- **Complementary testing:**
  - Each region must develop industry and must develop 'ownership' of this critical technology

- **No one system will exactly represent the baseline reference design RF unit design (before 2012)**
  - **FNAL**: beam format [under review]
  - **KEK**: number of cryomodules [1 (of 3) by end 2012]
  - **DESY**: gradient [~27MV/m average over 3 cryomodules]

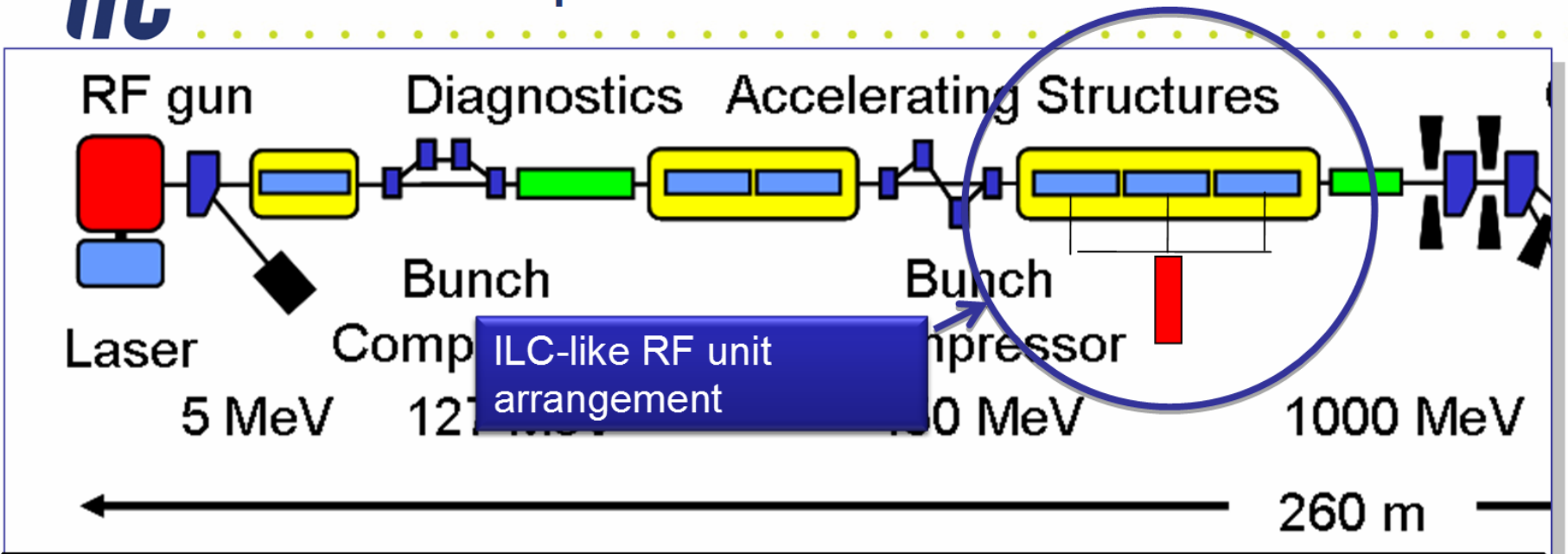
- **Strategy must account for infrastructure limitations and construction schedules at each of the three main linac test facilities under development.**

9mA Experiments in TTF/FLASH



		XFEL X-Ray Free-Electron Laser	ilc	FLASH design	FLASH experiment
Bunch charge	nC	1	3.2	1	3
# bunches		3250*	2625	7200*	2400
Pulse length	μs	650	970	800	800
Current	mA	5	9	9	9

9mA Experiments in TTF/FLASH



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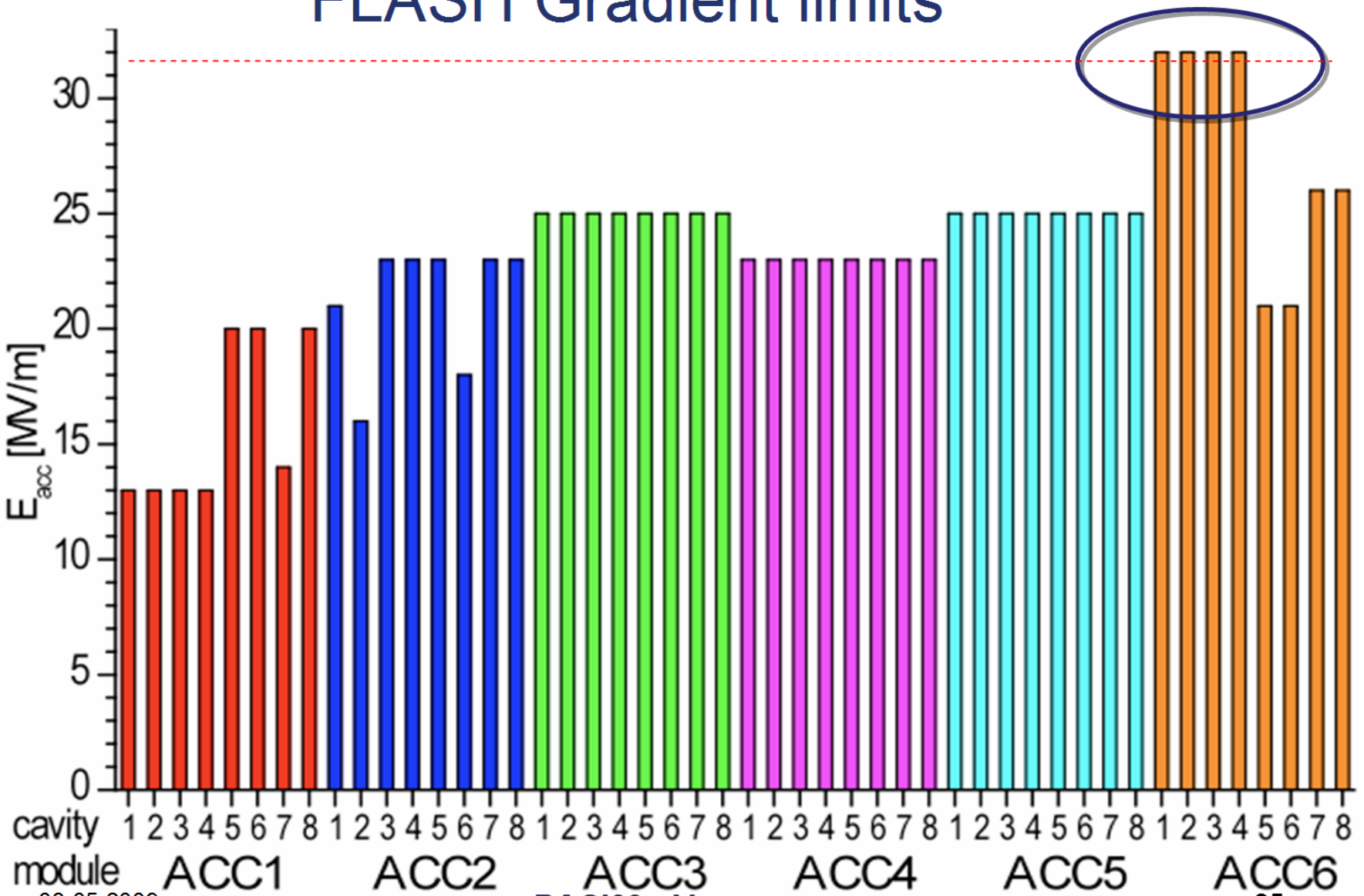
FLASH Gradient limits

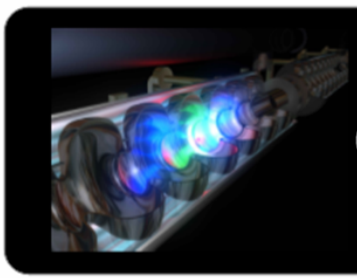


Global Plan for SCRF R&D

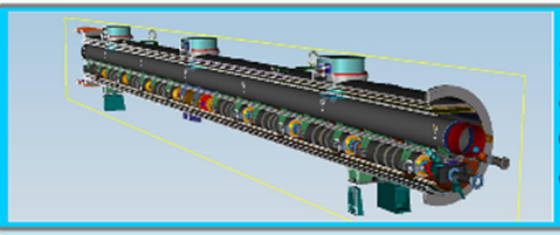
Calendar Year	2007	2008	2009	2010	2011	2012
Technical Design Phase	TDP-1				TDP-2	
Cavity Gradient R&D to reach 35 MV/m		Process Yield > 50%			Production Yield >90%	
Cavity-string test: with 1 cryomodule			Global collab. For <31.5 MV/m>			
System Test with beam 1 RF-unit (3-module)		FLASH (DESY)			STF2 (KEK) NML (FNAL)	

Superconducting RF Technology

35 MV/m
Gradient Yield
in 9-cell cavities



Critical R&D



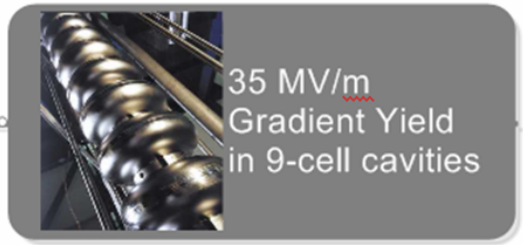
31.5 MV/m
average
gradient in a
cryomodule

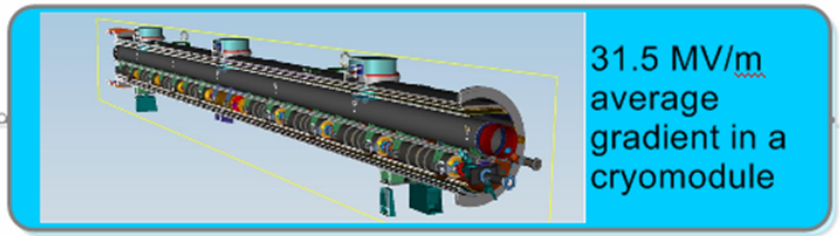
Linac
"String Test"

Engineering
Design
Industrialisation
Mass-Production

cost

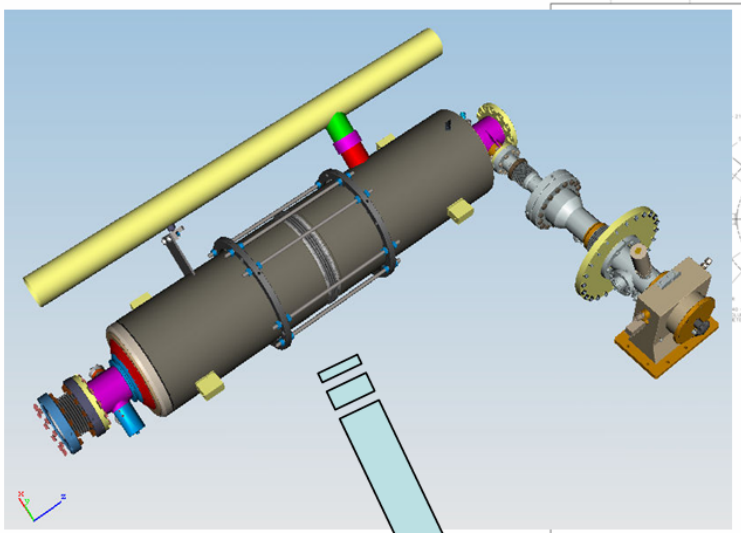
Superconducting RF Technology

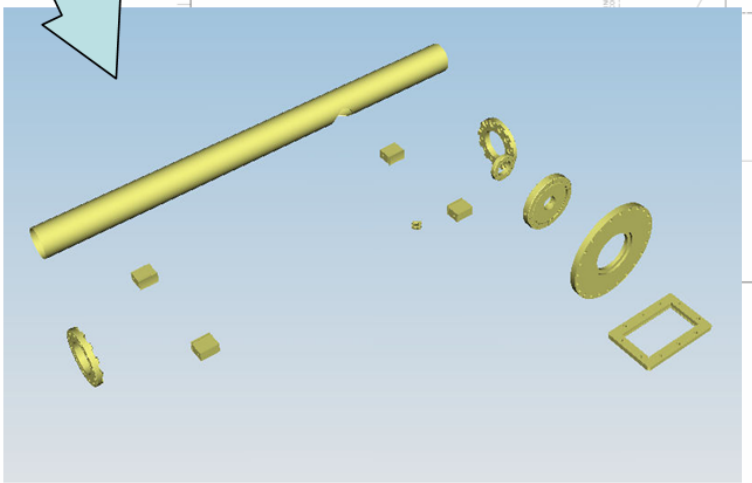




Engineering
Design
Industrialisation
Mass-Production
} cost

Cavity: Plug-compatible Interface





Component interfaces are reduced to the minimum necessary to allow for system assembly

- Allow innovative R&D to continue
  - e.g. novel cavity shapes
- Allow quasi-independent regional development of cost-effective manufacture
- Set boundary conditions and maintain focus

Rapid transition from R&D to construction project

Toward Industrialization

- Global status of Industries
  - **Research Instruments and Zanon in Europe**
  - **AES, Niowave, PAVAC in Americas**
  - **MHI in Asia**

Project Scope			
Euro XFEL	~800	2 years	~1 cavity / day
Project X	~400	3 years	~2 cavities/ week
ILC	~15,500	4 years	~20 cavities / day
(÷ 3 regions			~7 cavities / day)

- Industrial Capacity: status and scope
  - **No company currently has required ILC capacity**
  - **Understand what is needed (and cost) by 2012**

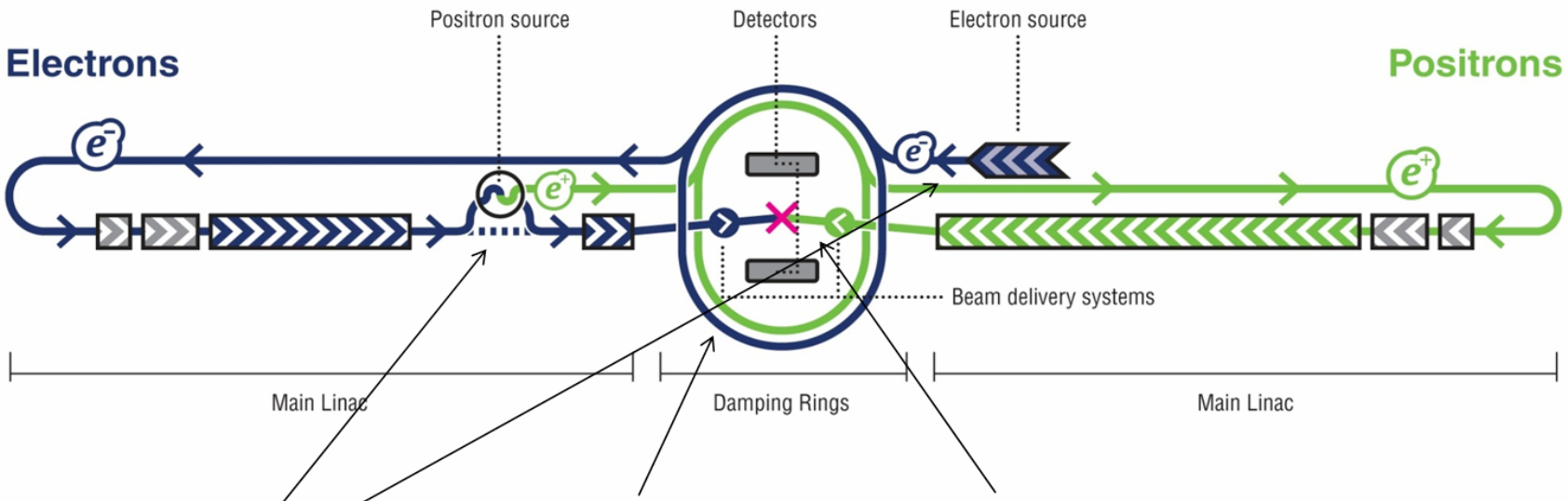
Industrialization and cost reduction

- Re-visit previous effort, and update the cost-estimate for production
  - **Review the RDR cost estimate (based on TESLA)**
  - **Include recent R&D experience (industry/lab)**

- Encourage R&D Facilities for industrialization
  - **Develop cost-effective manufacturing, quality control and cost-reduction in cooperation with industry**

- Reflect the R&D progress for cost-reduction
  - **Baseline ⇒ Forming, EBW, assembly work…**

ILC: more than just SCRF



Sources
-Positron production
-Polarised electrons
-…

Damping Rings
-Electron cloud
-Fast kickers
-Low emittance tuning
-…

Beam Deliver System / MDI
-Optics / demagnification
-FD design
-Stability & feedbacks
-Detector integration
-…

Beam Test Facilities

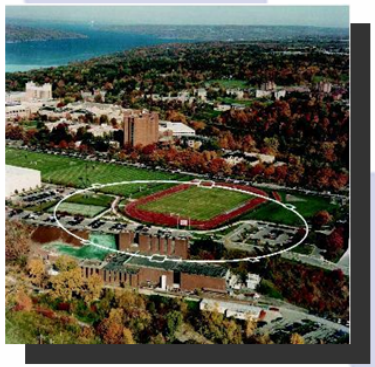
(Non-SRF) Beam Test Facilities

ATF & ATF2 (KEK)
ultra-low emittance
Final Focus optics

Cornell

KEK, Japan

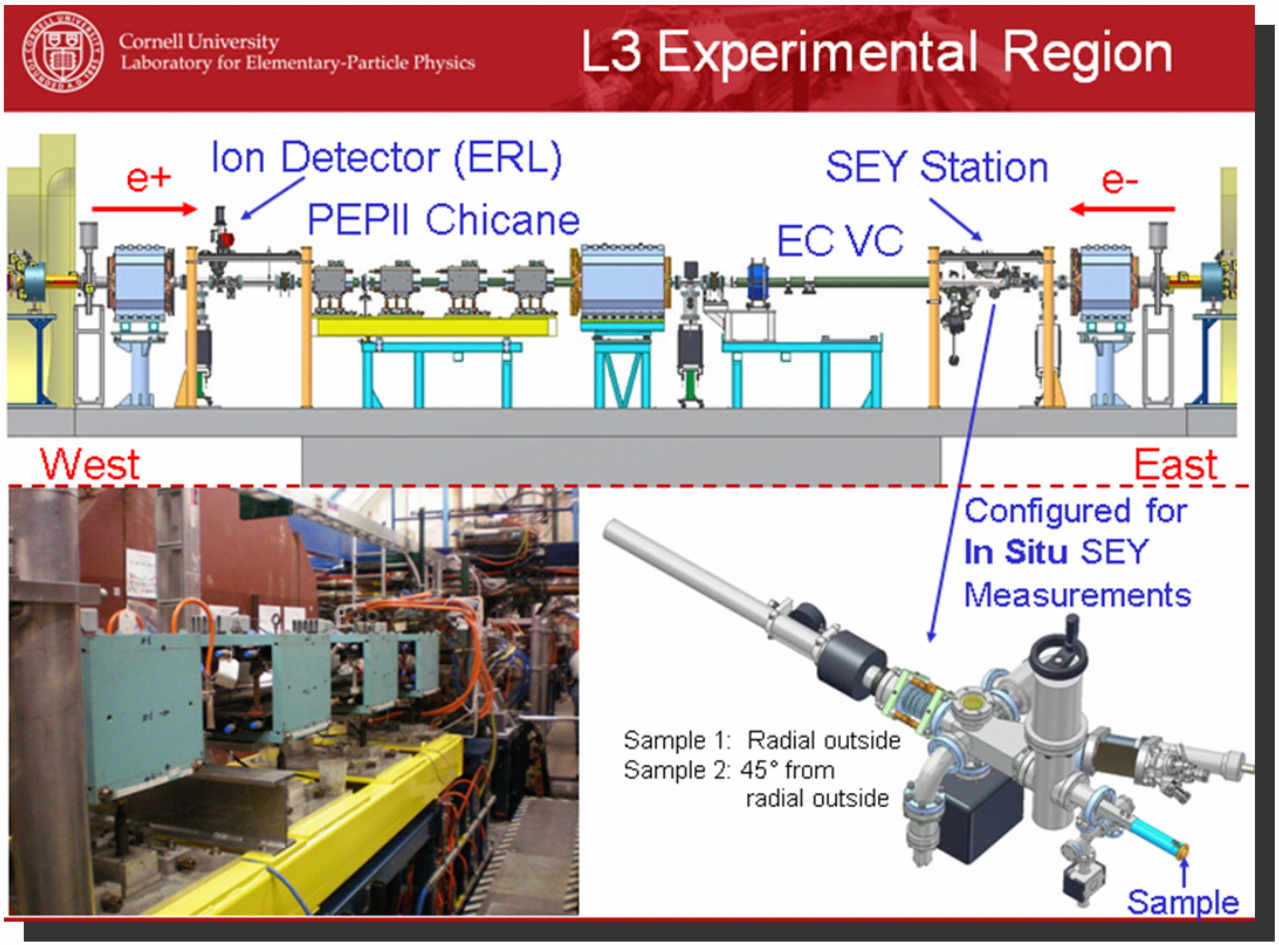
INFN Frascati



CesrTA (Cornell)
electron cloud
low emittance

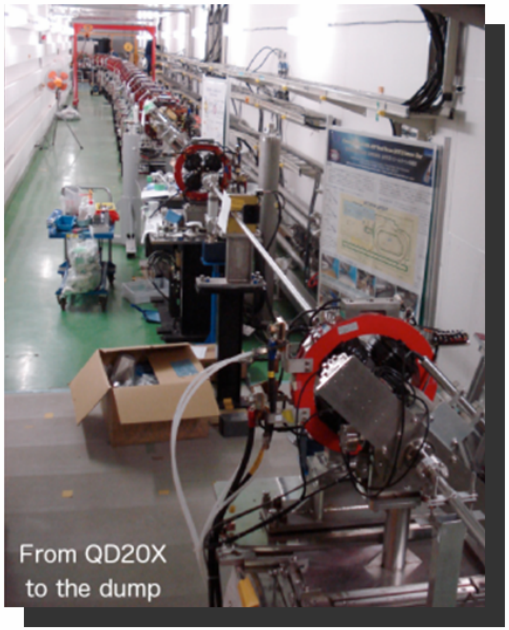
DAΦNE (INFN Frascati)
kicker development
electron cloud

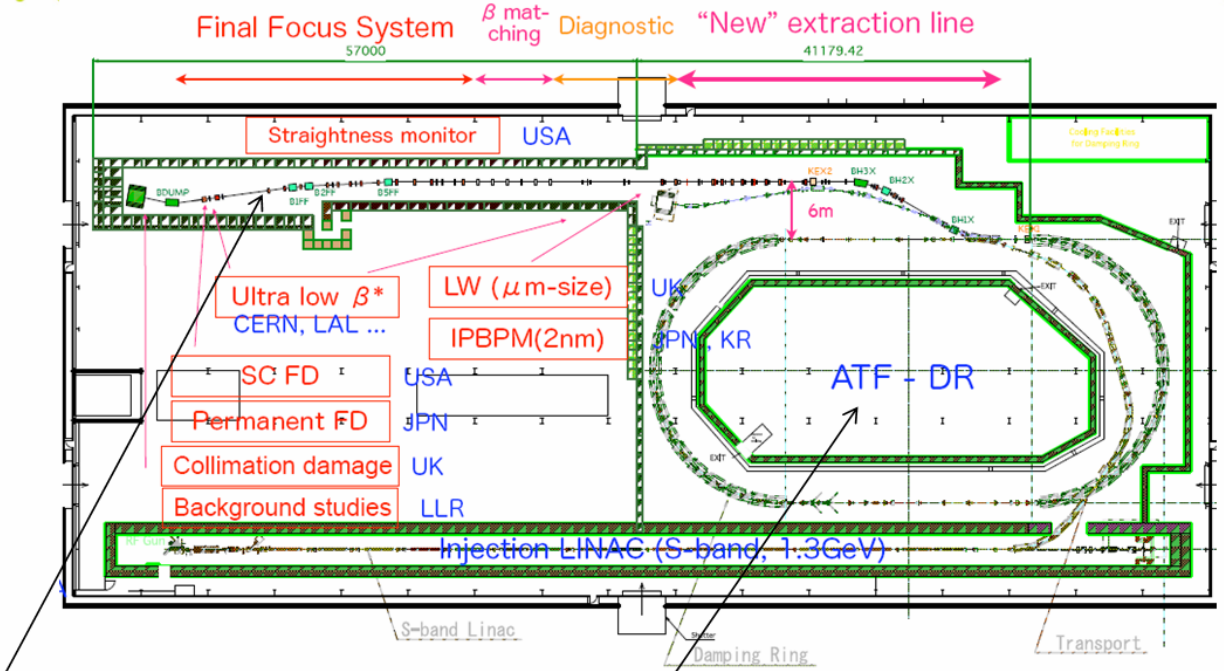
Example: e-cloud & CesrTA (Cornell)



- e-cloud: high-priority risk mitigating R&D
- Cornell SLAC KEK INFN…
- CesrTA: dedicated test facility to
  - **Test e-cloud suppression techniques**
  - **Benchmark and develop theoretical understanding (codes)**
  - **Develop low-emittance tuning techniques**

Example: ATF & ATF2 (KEK)





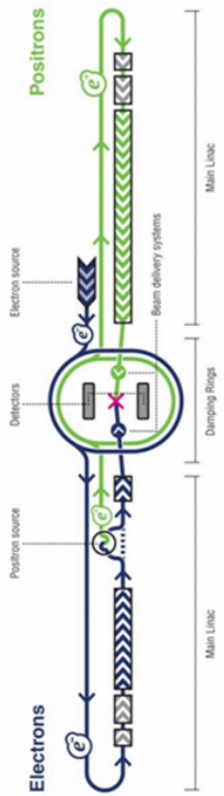
ATF2 (Final Focus)

- Demonstration of demagnification / compact optics
- Vibration stabilisation
- Instrumentation

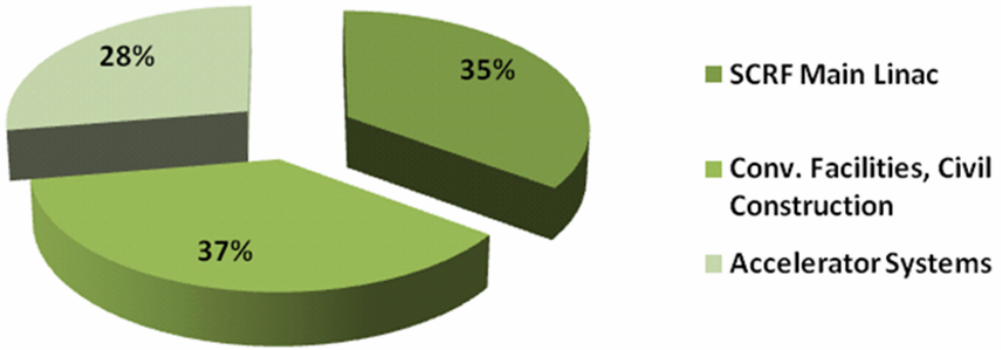
ATF (Damping Ring)

- Demonstration of ultra-low emittance (2pm) and its stability
- Fast kicker (beam) tests

Cost (VALUE) Estimate



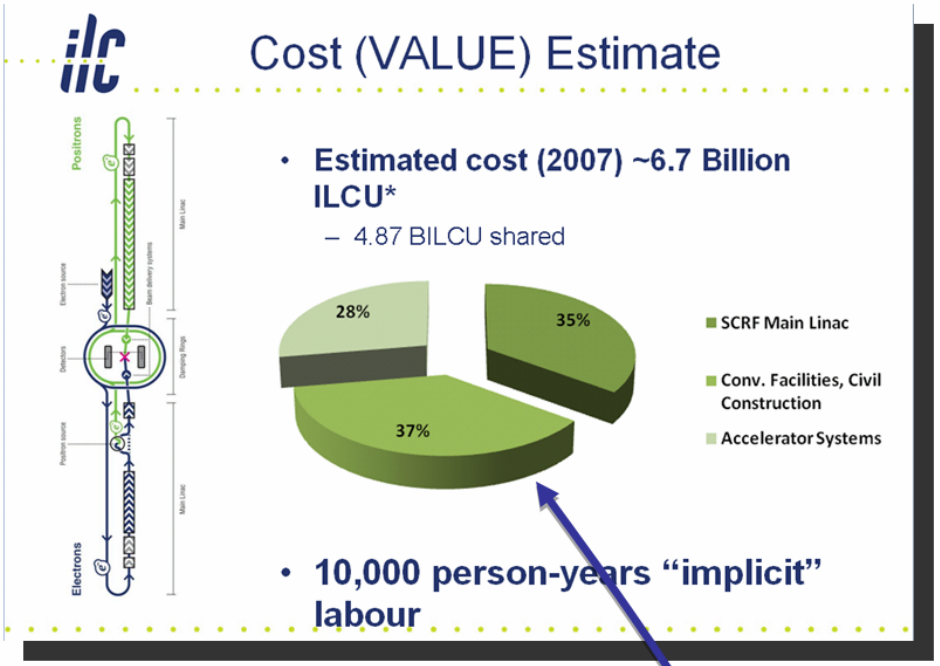
- **Estimated cost (2007) ~6.7 Billion ILCU***
  - 4.87 BILCU shared



- **10,000 person-years "implicit" labour**

Integration & Design Activities

- Primary TD Phase Deliverable:
  - **Updated design**
  - **Updated VALUE estimate**
- RDR sound base-line
  - **Mature, *but***
  - **Conservative**
- Use 'additional' time to look at options
  - **Cost not performance driven**
  - **CFS cost-driver ⇒ reduce underground volume**



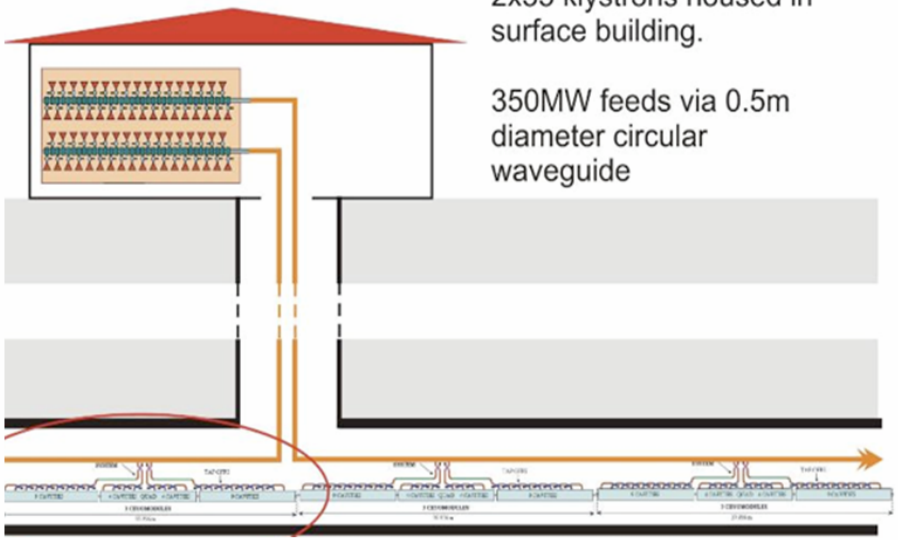
Cost-Driver Design Studies

- Single Tunnel Configuration(s)
- Reduced Beam Power
  - **less RF,**
  - **smaller DR**
- Central Injector Housing Integration
  - **Sources sharing tunnel with BDS**
- CFS: Value Engineering

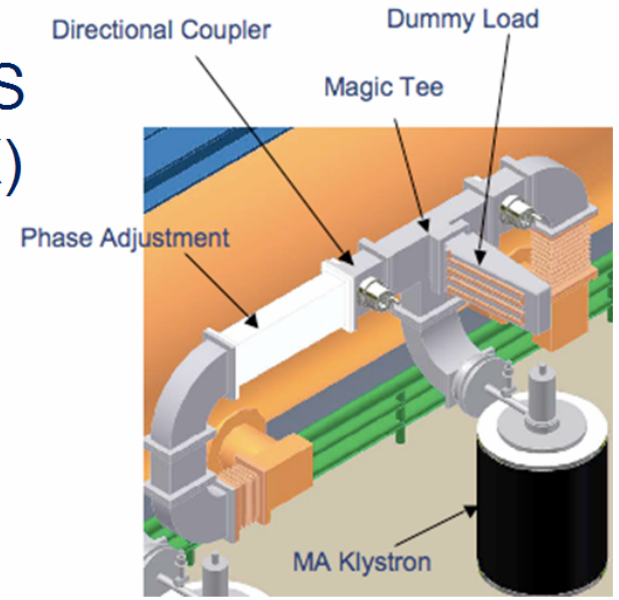
Power In
Power Out
Underground Volume

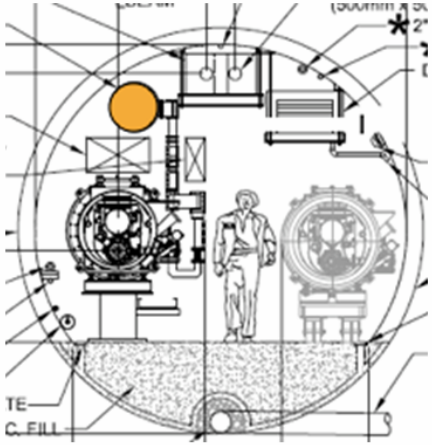
10-15% TPC

Novel RF Distribution Concepts

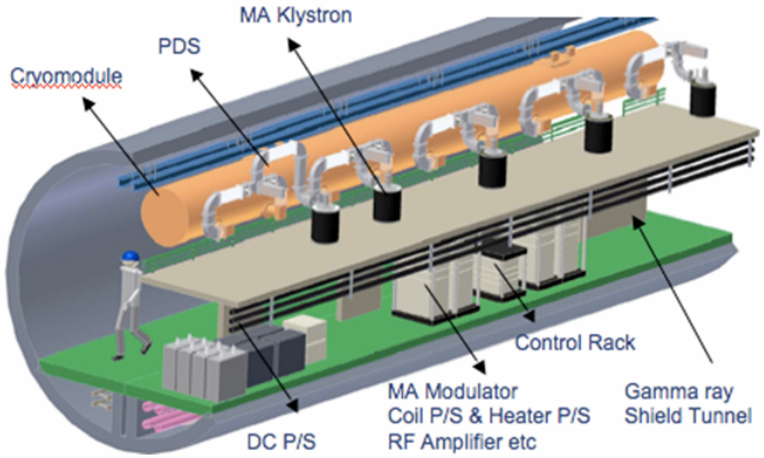


DRFS (KEK)



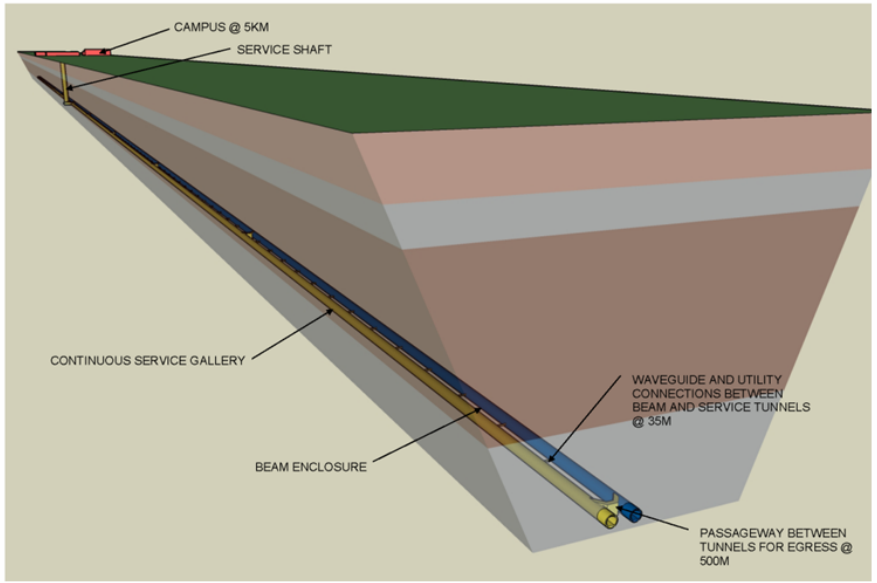


Klystron Cluster (SLAC)

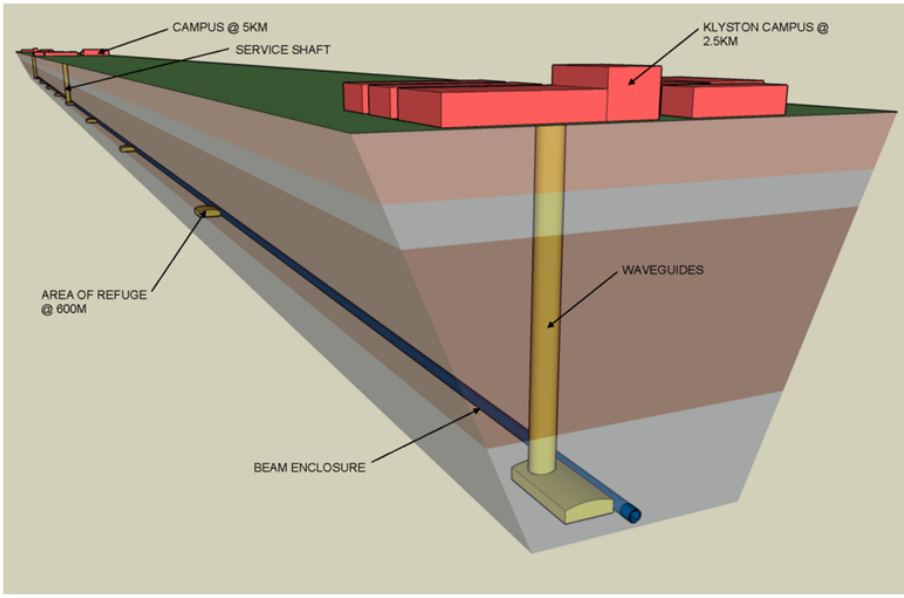


Single Tunnel Solutions

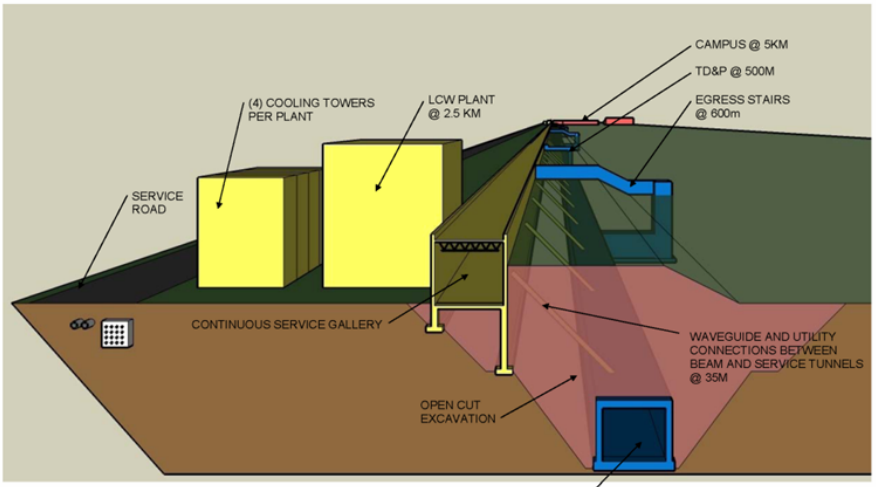
TWIN DEEP TUNNELS; VERTICAL ACCESS



SINGLE DEEP TUNNEL; VERTICAL ACCESS

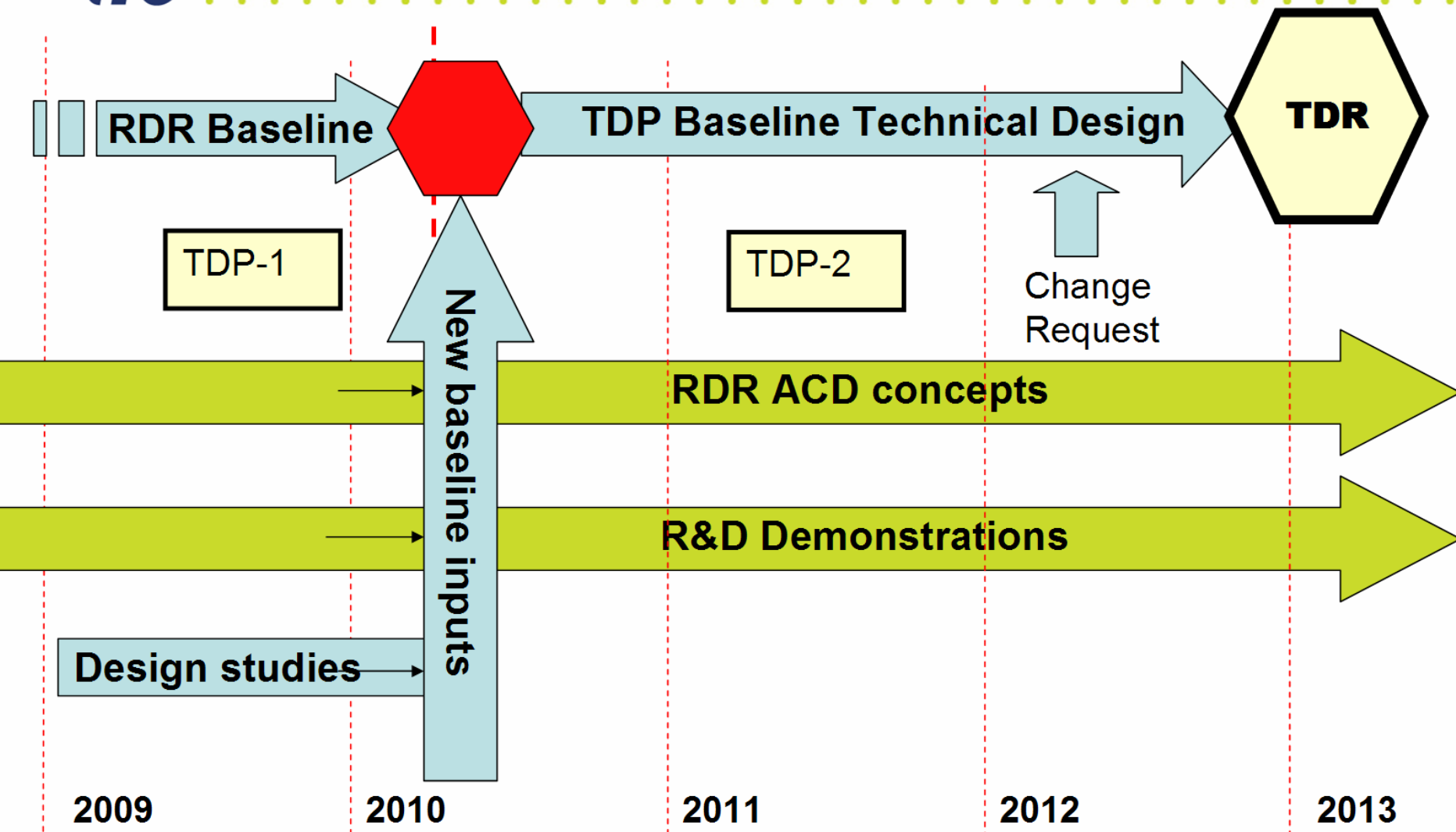


ENCLOSURE IN OPEN CUT EXCAVATION; CONTINUOUS SERVICE



Linac Tunnel configurations – 3 of 7 under study

Technical Design Phase and Beyond



Summary 1/2

- Plans for extended Technical Design Phase now established
- Significant progress on all identified priority R&D
  - **Despite 2008 funding crises**
- Primary focus maintained on SCRF
  - **Cost driver**
  - **Development in all three regions**
  - **On-track**
    - Significant progress on gradient yield
    - S1-global programme: high-gradient CM and plug compatibility demonstration
    - No full “ILC-spec” string test within TDR time-scale

Summary 2/2

- Major Beam Test Facility addressing (non-SCRF) risk mitigating R&D
  - **CesrTA – e-cloud**
  - **ATF2 BDS/MDI issues**
  - **…**

- Design and integration activities (including CFS) focusing on updating baseline for TD Phase 2
  - **Site variants being studied**

We intend to be ready for LHC results in 2012

Thank you for your attention