Preparation for Human Resource Required for the ILC Accelerator Construction

ILC 加速器建設への必要な人材と育成

The Planning Office for the ILC, KEK

KEK ILC推進準備室

To be reported, 2015/01/05

報告の内容
Contents

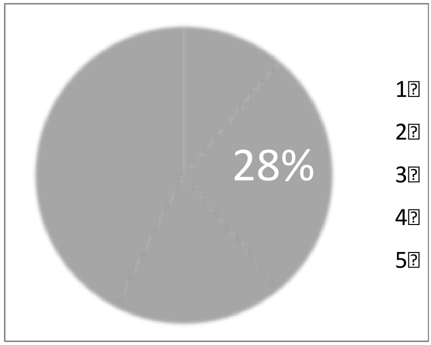
- ILC加速器建設に必要な人材全体像
  - Human resource (HR) required for the ILC accelerator construction

- ILC加速器建設にむけた準備課題・準備期間
    - Issues in the ILC preparation phase
  - 施設建設に必要な人材と人材育成
    - Human resource and preparation required for “CFS”
  - 超伝導加速器技術に必要な人材と人材育成
    - Human resource and preparation required for” SRF acc. technology”
  - ナノビーム技術に必要な人材と人材育成
    - Human resource and preparation required required for “nano-beam”

ILC加速器建設に必要な研究所の人材 (FTE)

HR required for the ILC acc. Construction

		Int. Labor in (Person-hr)	Integ. labor in FTE(p-yr)	平均/年 Av. In yr	規模 Scale
	Acc. Constr（9 yrs）	22,898	13,471		
1	CE and Build. (CFS)	2,546（11%)	1,495	166	
2	Acc. (SRF-ML)	6,380（28%)	3,753	417	1,124
3	Acc.（etc）	4,269（19%)	2,518	280	
4	Aministration	3,998（17%)	2,352	261	
5	Install. (in ~4 yr）	5,700（25%)	3,353	(+838)	
	Opeartion (> ~30 yr）				~ 850



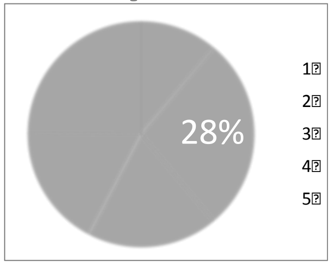
~1,000 staff
To be realized
in ILC

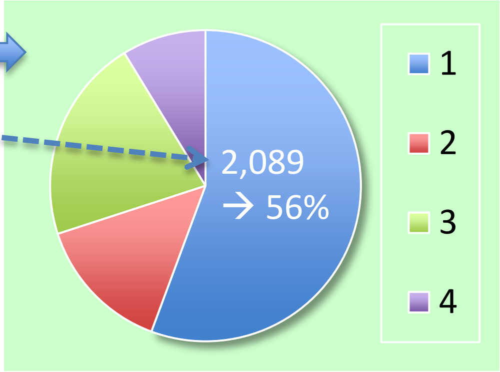
For a reference：
- 各国の研究所：
  - Number of employees/staff of particle and other physics laboratories, related to ILC ：
  - CERN： ~ 2500 , DESY: ~1500, CEA-Saclay: ~2500, CNRS-LAL: ~1,000, etc.、
  - Fermilab: ~1,700, SLAC: ~1,500, BNL: 2,000, JLab : ~1,000, etc.,
  - KEK: ~750, IHEP: ~3,000、PAL: 700, RRCAT: 3,000、etc.,
- これらの研究所（大学）を基盤とした国際協力・連携によりILC の建設・運用が計られる.
  - ILC is anticipated to be realized, based on global cooperation with the above institutions.

A2: ILC加速器建設に必要な研究所人材 (内訳）

HR required for the ILC acc. Construction (breakdown)

Item	Sub-Item	Integr. K P-hr	Integr. P-yr	Average <FTE/yr>	%
1, CFS	Sub-total	2,540	1,495	<166>	11%
	- Civil	1,359	799	~89	
	- Site-specific	1,181	695	~77	
2. Acc-SRF –ML	Sub-total	6,380	3,753	<417>	28%
	(1) Cavity and CM	3,551	2,089	~232	
	(2) HLRF(1.3GHz)	915	538	~60	
	(3) Int-Control-LLRF	1,357	798	~89	
	(4) Cryogenics	557	328	~36	
3. Acc-Others	Sub-total	4,269	2,518	<280>	19%
	- Magnets	387	228	~25	
	- Power Supplies	1,411	830	~92	
	- Vacuum	119	70	~8	
	- Instrumentation	517	304	~34	
	- Dump-Collimator	211	124	~14	
	- Computing infra.	1,392	819	~91	
	- Other-(non-L)-HLRF	68	40	~4	
	- Simulation & op.	175	103	~11	
4. Management	Administration	3,998	2,352	<261>	17%
5. Installation	Installation (4 yrs)	5,700	3,353	<838>	25%
	Total	22,898	13,471	<1,124>, <838>	100%





Cavity-CM の労務が
SRF の56%を占める

Cavity-CM corresponding
To 565 of SRF

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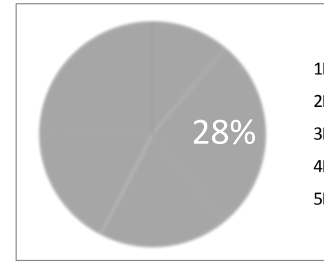
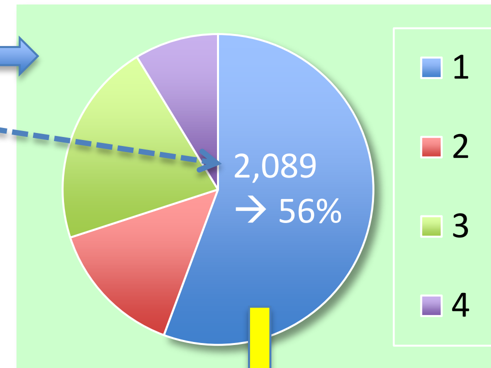
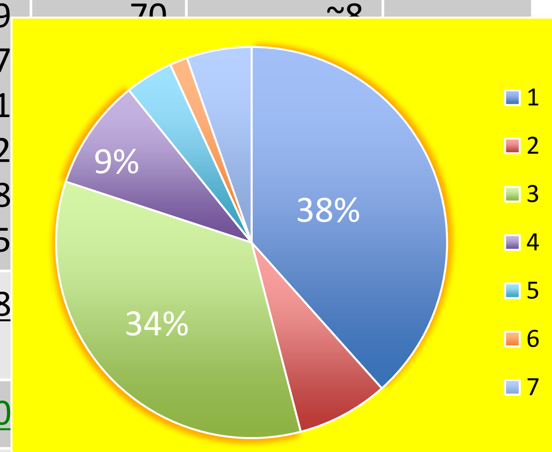




As a representing sample, Cvity-CM labor examined



Coupler processing (38%)

CM EDIA

CM qualification (34%)

Cavity qualification (9%)

Q-Mag qualification

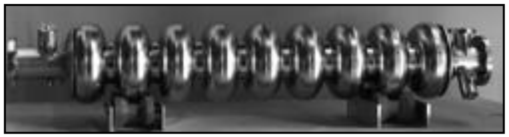
Vacuum EDIA

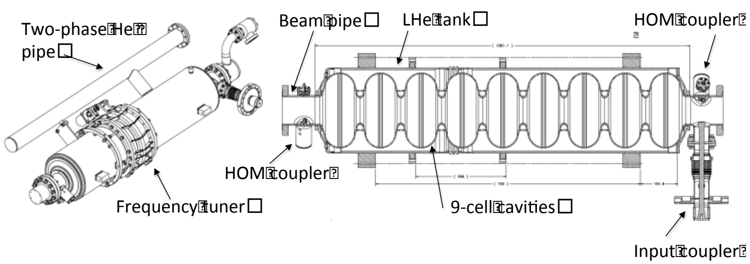
CM tunnel commissioning

> 80%

Cavity-CM qualification

Cavity/Cryomodule Fabrication
空洞･CMの製造





- Purchasing Material/Sub-component
- Manufacturing Cavity：機械加工
- Processing Surface：表面処理
- Assembling LHe-Tank ：組み立て
- Qualifying Cavity, 100 %：性能評価
- Cavity String Assembly：多連空洞組立
- Cryomodule Assembly:: CM 組立
- Qualifying CMs, 33 + 5 %：CM性能評価

Cavity-CM 性能試験に必要な 研究所人材数の検証(EXFELとの比較）

Evaluation of Cavity-CM labor work, in comparison with EXFEL

	EXFL (in progress）	ILC（TDR estimate）	
Cavity – CM性能試験 (Tests)			Consistent with EXFEL, even though further cavity test efficiency required.
Cavity：required（% tested）	800 (x 100%)	16,000 (x 100%)	
CM： required （% tested）	100 (x 100%) = 100	1,850 (x 38%) = 703	
試験従事者数x 年数（FTE integrated)	~50 x 2.5 yr = 125 p-y	2089 p-y x0.43 = 898 p-y	
FTE/CM	**1.25** FTE/CM	1.28 FTE/CM	
Power Input Coupler Process			Auto-test process progressed in EXFEL, and ILC to be redundant
Coupler: required (% proc.)	800 (x 100%)	16,000 (x 100%)	
試験従事者数x 年数（FTE integrated)	~6 x 2.5 yr = 15 p-y	2089 p-y x0.38 = 794 p-y	
FTE/Coupler	**0.019** FTE/Coupler	**0.050** FTE/Coupler	

SRF-ML における主要な人材必要数は、EXFEL の進捗により、妥当性が実証されつつある

ILC (SRF-ML, cavity-CM) labor estimate is being verified with the EXFEL progress/fact.

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ILC 準備期間に於ける主要課題

Main issues in the ILC Preparation Phase

分野 (field)	課題 (Issues/Subjects)	協力体制 (Global Cooperation)
施設設計 CFS	候補地特性を反映した地質環境調査： Site-specific CFS design, env. assess. 基本計画、詳細設計、図面整備 General plan, eng. Design, drawings	JP-CFSがコアとなり国際連携、候補地域との連携 JP-CFS to take a central role in cooperation with global experts and regional experts.
加速器設計 Acc. Design Int.	詳細設計・パラメータ最適化 Engineering design, Parameter optim.	LCC-ILCを中心とした国際連携による検討 LCC-ILC to take a central role with global cooperation
SRF技術 SRF	製造・性能検証技術、 Fabrication and Testing technology 性能の安定化 Stabilization of the performance	Tesla Tech. Collab., as common community - KEK-STF: Hub-Lab function - EXFEL: mass production and testing - LCLS : mass production and testing
ナノビーム技術 Nano-beam	低エミッタンス、極小ビームの安定的実現、運用 Ultra low emittance, nano-beam to be realized and stabilized	ATF Collab. As common community - KEK-ATF to be maximized in use, as a global unique facility for next generation training as well as the advance studies.
研究所運営 Management	新国際研究所の設立準備 Preparation for the int'l ILC laboratory	今後の検討課題 A main Issue for the ILC to be prepared

ILC 加速器建設に必要な人材育成の基本方針

General Guideline for HR preparation for the ILC Construction

施設（土木、建築、設備）: CFS including CE, Building, Utilities：

- 明確は、人材の充当が不可欠 (現状は、国際的にも、数名の貢献のみ）
  - Major HR needed to be boosted. Currently there are only a few person worldwide.
- ホスト国が~ 100 % 責任を担う事を基本モデル. LHC, Tevatron, SLC 等の経験を活かし、反映すべく、人的国際貢献を求める。
  - Host country to take nearly 100% responsibility, although global experts and HR expected, base on LHC and Tevatron experience.
- 研究所には、総合的な設計責任を担うリーダ、各専門分野（土木、建築、設備（電気、機械））の専門家を確保•育成する。
  - Laboratory needs, at least, to have a head and several experts to be responsible for the design,
- 一方、準備期間および建設期に集中する専門的な人材であることを考慮し、できる限りアウトソーシングにより設計検討、図面化、大型入札の準備作業を進める。
  - On the other hand, outsourcing and/or sub-contracting is to be maximized, because of the special and time-limited HR required.
- 建設期には、上記の考え方を踏まえつつ、現地の工区毎に、スタップと業務委託・契約を併用して必要な人材を確保する。
  - In the construction phase, HR required in each sub-construction sited, in combination of the laboratory staff and sub-contractors,

加速器; Accelerator design and technologies：

- 現在、KEK および世界における先端加速器開発に取り組む人材を活用、移行する（50 ~ 60 名）。
  - The staff currently in charge of Adv. Acc. Technology development (50 ~ 60 world wide) to be transferred to the ILC preparation.
  - KEK; Staff 25, sub-contractor 17, University: several, World wide: 5 ~ 20 % of 140 staff worldwide tohave been counted.
- 準備期間には、国際的な枠組みで、人材を段階的に（1.5 ~ 2倍）増強し、建設期にコアとなるリーダ を育成。
  - In preparation phase, the staff number should be double (x 1.5 ~2) increased, and they will be trained for future group leaders.
- 建設期間には、国際協力合意の枠組みに沿った人材貢献をもとめる。
  - In the construction phase, the HR contribution needs to be decided according to the global agreement.
- 日本国内では、加速器本体要素建設に必要な人材のうち、1/3~1/2 の範囲内で、業務委託による人材の補填を想定し、業務委託を含めた人材育成を計る。
  - In Japan, the HR should be boosted by using “sub-contracted persons” (also need to be trained) within fractiona of 1/3 ~ ½.

ILC 加速器建設･研究所人材構想 (管理事務人材数含む) (2)

[A HR proposal for the ILC preparation, linked to the construction（FTE)]

Stage	Preparation				Construction									Sum
	1	2	3	4	1	2	3	4	5	6	7	8	9	
Prep. CFS Acc Adm	77 9 60 8	96 11 75 10	116 14 90 12	134 16 105 113										423 50 330 43
Const.					410	92 2	1208	1350	1589	1480	1374	1106	679	10,118
Install.							80	80	80	768	1140	683	522	3,353
Sum					410	92	1288	1430	1669	2248	2514	1789	1201	13,471

注）準備
- 準備
- 準備
に対
ため
- 準備
的に
- 準備
託や

Notes: HR required for the ILC preparation (CFS, Acc., and administration):
- HR in the 1st preparation year to be filled from the existing staff in fraction of ~80%),
- HR needs to be gradually increased to reach a factor 1/5 ~ 2, during the prep. phase,
- The guideline is to provide 4~5 % in fraction to the totally required staff in the ILC,
- The global collaborators anticipated from a fraction of 5 % to 20% of existing ones,
- The Japanese HR needs to be boosted/complemented by using “sub-contract,
    - Worldwide fraction in japan,
    - CFS: ~ 90 % , Acc. 60^70%, and (1/3 ~ 1/2 to be subcontracted)

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Acc	60	75	90	105										330
Adm	8	10	12	113										43
Const.					410	92 2	1208	1350	1589	1480	1374	1106	679	10,118
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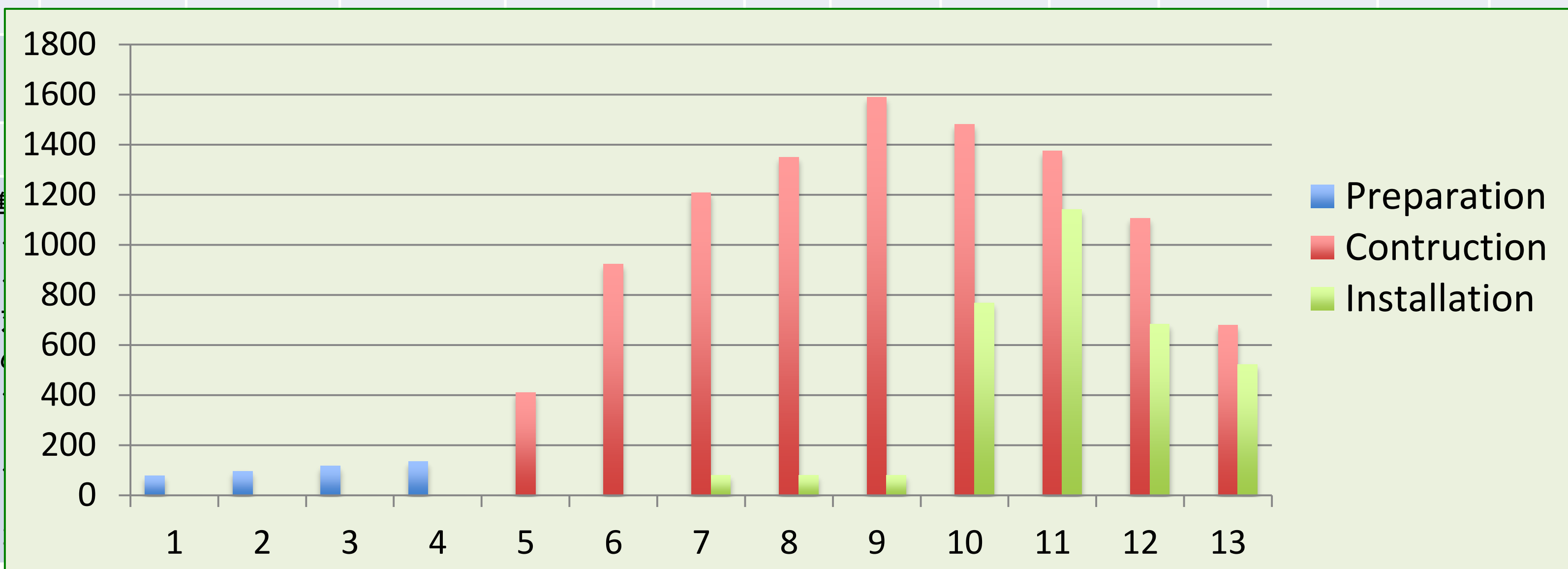
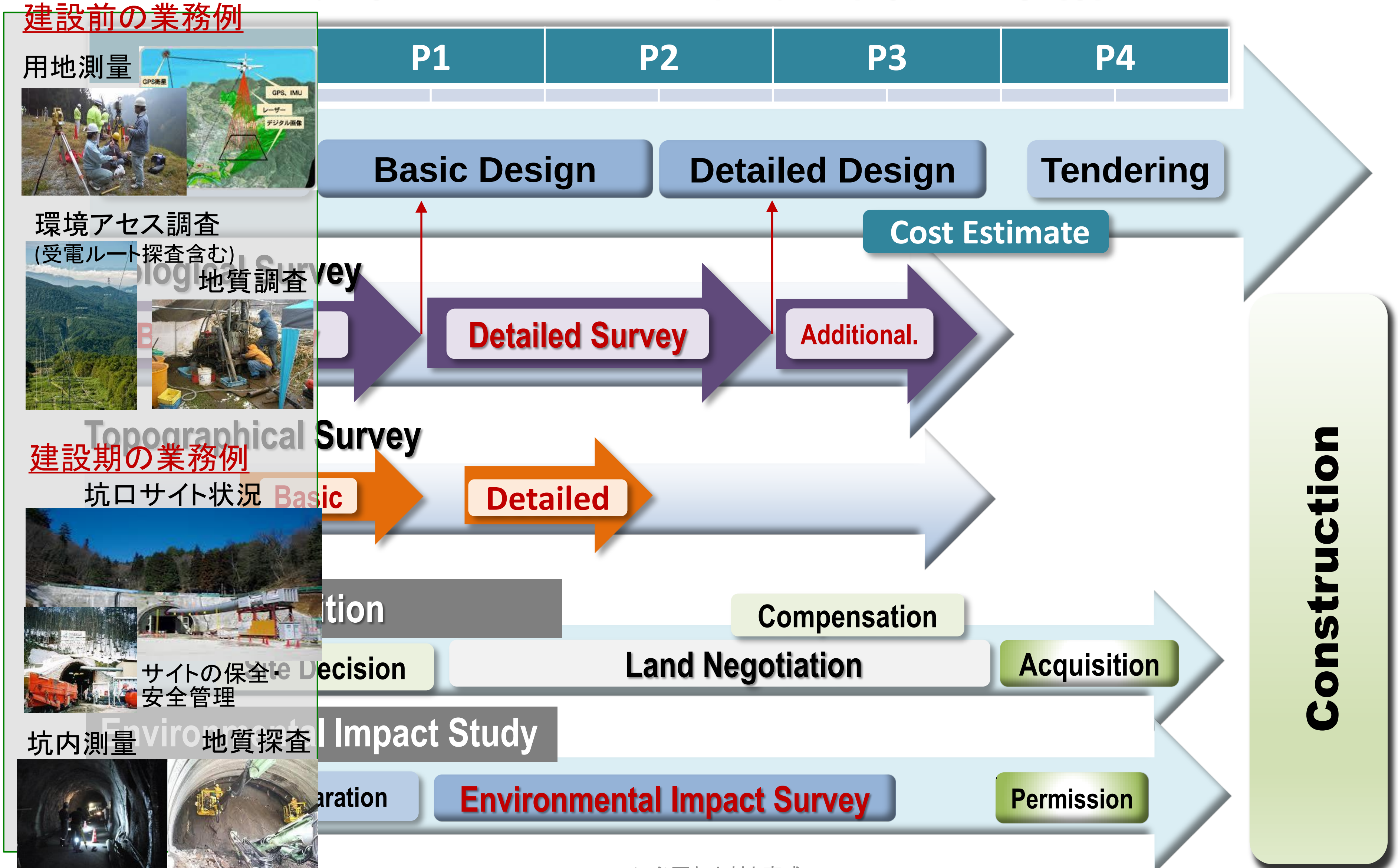


注）準 … り充足。
- 準 …
- 準 … 的な人材
に … 実証する
た …
- 準 … 囲で段階
的 …
- 準 … は業務委
託 …

ILC CFS Plan in Preparation Stage
建設にむけた土木・建築設計準備



ILC加速器・準備活動

ILC Accelerator Preparation Activity Plan

Year		−1	0	1	2	3	4
SRF (STF, COI)	STF Beam Facility	CM1+CM2a		CM2b+CM3a+CM3b		CM4+CM5+CM6	
	SRF Full-CM Test Facility	building construct.	facility construction		facility operation		
nano-beam (ATF)	beam focus study	Nano-beam size target complete			more small beam size		
	beam feedforward/feedback study			nm stability R&D			
source, others (ATF)	source		positron target R&D				
	source backup solution		backup technology R&D				
Euro-XFEL construction	cryomodules (100)	construction/installation					
LCLS-II construction	cryomodules (39)		proto-type cryomodule		construction/installation		

先端加速器技術開発に果たしているKEK-STF, ATF の役割･意義･実績

KEK-STF and ATF Contribution to the Adv. Acc. Technology Development

	STF	ATF
国際連携 Int’l community	Tesla Technology Collab.	ATF Collaboration Unique facility, worldwide
参加国 Participating countries	Germany, Italia, Swiss, France, USA, China, Korea, India, Japan, etc. ..	Swiss, Germany, France, UK, Italia, Spain, Russia, USA, China, India, Korea, Japan, etc.,
国際協力機関数 Numbers of institutions,	~13	~ 25
参加メンバー数 Number of collaborators	~50	55
主な成果 Major progress	S1-Global: Int’l CM test, Quantum beam, In-house Cavity Fabrication New diagnostics	Ultra low emittance beam, Nano-beam test reaching 44 nm.,
博士号取得者数 PhDs awarded	5	52
修士号取得者数 Master deg. Awarded	5	18

Back-up

A2: ILC TDR Cost : Conversion to Japanese Yen using a model

※ Premium (Uncertainty in TDR value/labor estimate, and to be prepared for unknown situation)

不定性として考えるべき範囲：:コスト見積の精度や工事期間の延長・短縮等の事態に伴う予算増減の範囲。

➢ Value Premium ; 26%, Labour Premium; 24%

Value (Jyen) コスト(十億円)　Premium (十億円)　Labor (百万人時)

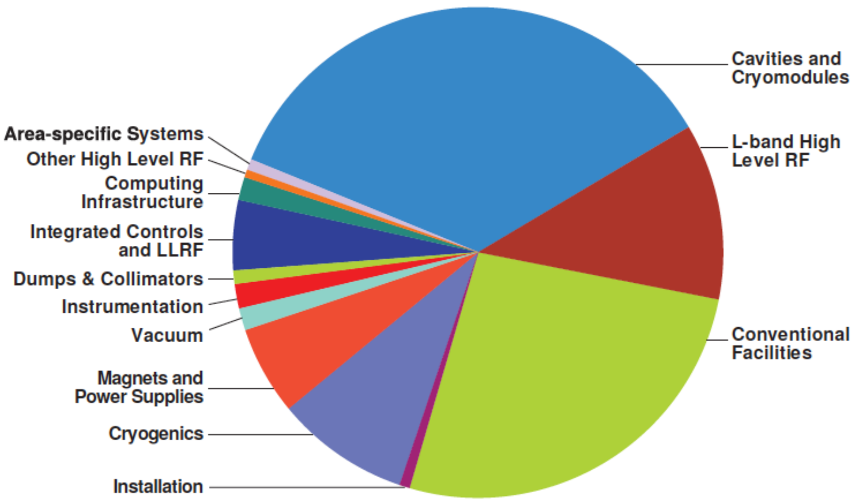
	Value Site specific (BILCU)	Value Shared (BILCU)	Value Total (Ratio)	Value Total (BILCU)	Value Prem.: 26% (BILCU)	Value converted (BJY)	Value Prem.: 26% converted (BJY)	Labor (M p-hr)	Labor Prem.: 24%
RDR-2007 Converted w/ 117 Y/$			(1)	6.31		739		24.4	
RDR-2012 (15% inflation)			(1.15)	7.27		877		24.4	
TDR-Averaged	1.50	6.28	(1.23)	7.78					
TDR-AS (ppp)	1.76 (109/127Y/$)	6.23 (127 Y/$)	(1.26)	7.98	2.04	967*	251	22.9	5.5
R-AS X-a)	1.76 (109/127Y/$)	3.47 (3.47G$) (100Y/$) 2.75 (2.49GEu) (115Y/Eu)	(1.26)	7.98		830 (8,300億円)	216	22.9 (1,598億円)	5.5

Cost based on PPP (full production in Japan)

Cost base on exchange rate Using a model at **1USD=100Yen, 1Euro=115Yen**

Notes; *TDR Cost : PPP indices used for TDR-Value to Convert to JYen (Jan. 2012)
- JY per USD: 127 (non-civil-construction) , 109 (civil-construction)
- JY per EU: 137 (non-civil-construction), 116 (Civil-construction)

ILC Accelerator Cost Fraction



ILC-TDR-V-1

Figure 3.6
Distribution of cost by sub-system.

		Item	Ratio	B.D.	Sum
1	CFS	Civil others	19% 12	1,602 1,000	2,602
2	SRF	Cavity and CM HLRF(1.3GHz) Cryogenics	35% 10 8	2,852 789 675	4,316
3	Others	Install. Equipment Conventional mag Vacuum Instrumentation Dump-Collimator Control-LLRF Computing infra. Non L-band RF Area specific	0,7 5.5 1.4 1.5 0.8 4.3 1.4 0.5 0.6	57 457 113 126 67 357 118 43 53	1,391
		Total		8,309	8,309

ILC Project Overview

Years	TDR baseline Scenario
1 - 2	Pre-preparation for 2yrs (for technical effort continuity) 前段階・先端技術開発の継続（２年）
3 - 6	Preparation (4 yrs) ILC 建設への準備段階（4年）
7 - 15	Construction (9 yrs) 建設（9年）
(12 -)	(start installation) 組み込みの開始
(13 -)	(start preparation for Commissioning and operation (to be studied) 運転経費（加速器要素・試験設備運転等）の段階的立ち上げ (検討要）
16 -	Beam Commissioning start ビームコミッショニングのスタート
17 –	Operation at 250 ~ 500 GeV (550 GeV) 物理実験 @ 250 ~ 500 GeV (550 GeV)
TBD	Toward 500 GeV HL upgrade ルミノシティーアップグレード(500 GeV)
TBD	Toward 1 TeV upgrade エネルギーアップグレード (1 TeV)

A2: ILC Acc. Construction Schedule

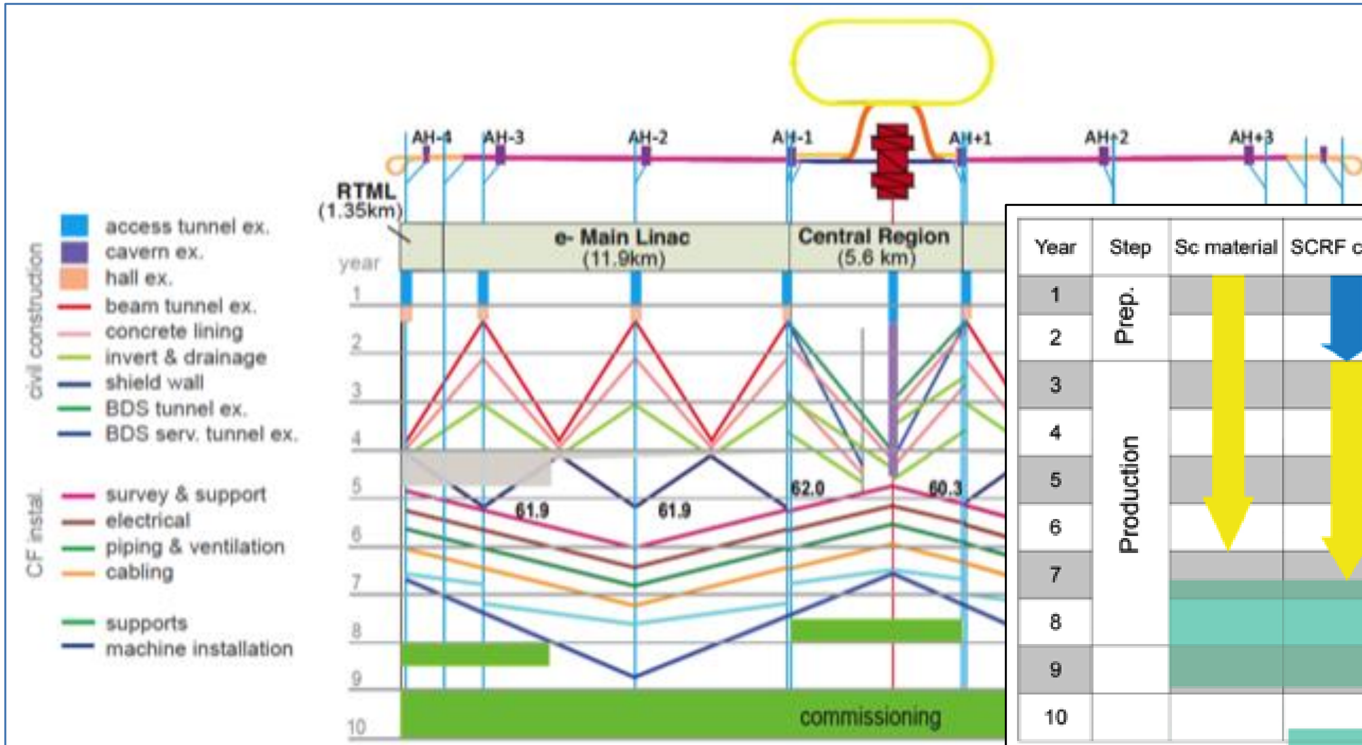
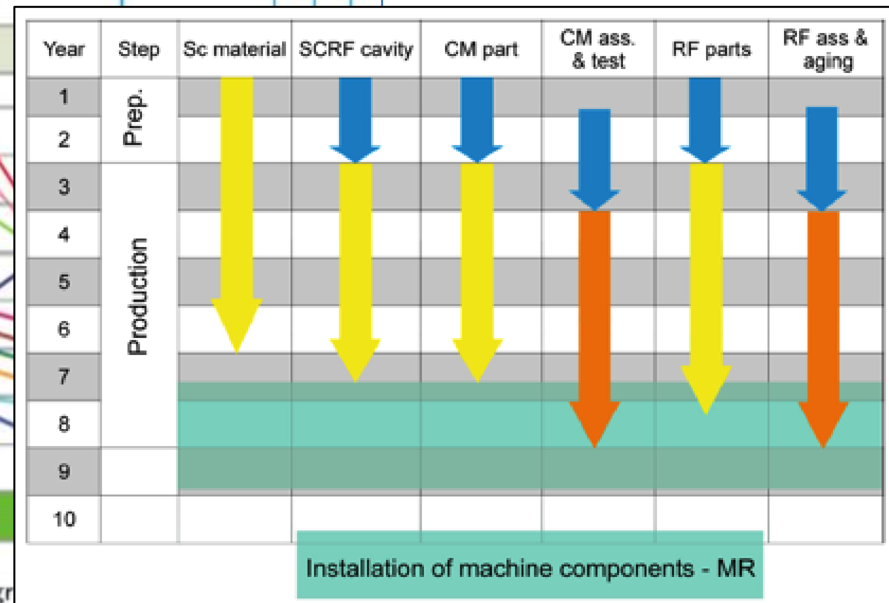


Figure 14.3. The construction and commissioning schedule for the mountain topogr
Fig. 14.2 caption for details.



施設関連建設期間、　SCRF関連建設期間

Consruction：9 years, Commissioning:　1 year　（at 500 GeV）

Revised: 141231

ILC Project-Cost Overview (for 500 GeV)

V- 1410122	Value 物件費 Oku- JY	Uncertainty (-/+) %	Uncertainty (-/+) Oku- JY	Human Resource 労務費 P-hours	Human Resource 労務費 FTE	Human Resource 労務費 Oku-JY	Uncertainty (-/+) %	Uncertainty (-/+) Oku-JY	Value+HR 物件+労務 Oku- JY	Range 範囲 Oku-JY	See note
Formal Preparation (4 years)											
Accelerator + CFS 加速器本体+施設	**214 (123+91)**	---	---	---	**380 (330+50)**	**46 (40+6)**	---	---	**260**	---	A1
Lab. Support. 共通： Land, Load, Lab ...	**66 + TBD**	---	---	TBD	**TBD**	**TBD**	---	---	**66 + TBD**	---	A1
Detectors 測定器	**TBD**			TBD	**TBD**	**TBD**			**TBD**		A1
Construction (9 years)											
Accelerator (Acc. + CFS) (TDR values)	**8,309 (5,709+2602) (7.98 BILC)**	26%	2,160	22.9 M	**13,471**	**1,598**	24%	384	**9,907**	7,363 ~ 12,451	A2
Lab. Support - Safety, Computing, etc	**TBD**			TBD		**TBD**			**TBD**		A2
Det. Constr (for 9 yrs)	**SiD: 315 (315 MILC) ILD: 451 (392 MILC)**	--- ---	+127 (+/-48)	--- ---	**748 1,400**	**89 150**	--- ---	--- ---	**404 601**	404~531 553~649	A2
Full Operation (per year)											
Acc. + CFS Operation	**390 (390 MILC)**	40%	156	---	**850**	**101**	25%	25	**491**	TBD	A3
Lab. Support	**TBD**	---	---	---	**TBD**	**---**	---	---	**TBD**	TBD	A3
Det. Operation	**TBD**			---	**TBD**	**---**			**TBD**		A3

Revised: 141231

ILC Project Human Resource Overview

V- 1410122	Human Resource 労務費 P-hours	FTE	Oku-JY	Uncertainty (-/+) %	Oku-JY	See note
Formal Preparation (4 years)						
Accelerator + CFS 加速器+ 施設	---	**380 (= 330+50)**	**46 (= 40+6)**	---	---	A1
Lab. Support. 共通： Land, Load, Lab ...	TBD	**TBD**	**TBD**	---	---	A1
Detectors 測定器	TBD	**TBD**	**TBD**			A1
Construction (9 years)						
Accelerator (Acc. + CFS) (TDR values)	22.9 M	**13,471**	**1,598**	24%	384	A2
Lab. Support - Safety, Computing, etc	TBD		**TBD**			A2
Det. Constr (for 9 yrs)	--- ---	**748** **1,400**	**89** **150**	--- ---	--- ---	A2
Full Operation (per year)						
Acc. + CFS Operation	---	**850**	**101**	25%	25	A3
Lab. Support	---	**TBD**	**---**	---	---	A3
Det. Operation	---	**TBD**	**---**			A3

A2: ILC加速器建設に必要な研究所の人材(内訳）

Item	Sub-Item	Integrated K P-hr	Integrated Person-yr	Adm. Risk (Head)	Sci/(Senior)	Eng. (Core)	Tech.
CFS (9 yrs)	Sub-total	2,540	1,495	64	211	1,012	206
	- Civil	1,359	799	0	0	799	0
	- Site-specific	1,181	695	64	211	213	206
Acc-SRF (9 yrs)	Sub-total	6,380	3,753	341	156	1,355	1,901
	- Cavity and CM	3,551	2,089	193	114	410	1,372
	- HLRF(1.3GHz)	915	538	79	0	275	184
	- Int-Control-LLRF	1,357	798	48	0	503	247
	- Cryogenics	557	328	21	42	167	98
Acc-Others (9yrs)	Sub-total	4,269	2,518	94	393	672	1358
	- Magnets	387	228	10	0	58	159
	- Power Supplies	1,411	830	0	0	54	776
	- Vacuum	119	70	8	0	20	43
	- Instrumentation	517	304	0	101	101	101
	- Dump-Collimator	211	124	10	0	38	76
	- Computing infra.	1,392	819	61	189	380	189
	- Other-(non-L)-HLRF	68	40	5	0	21	14
	- Simulation & op.	175	103	0	103	0	0
Manage. (9 yrs)	Administration	3,998	2,352	1313	295	248	497
Installation (4 yrs)	Installation	5,700	3,353	168	0	335	2,850
	Total	22,898	13,471	(1,980)	(1055)	(3622)	(6812)

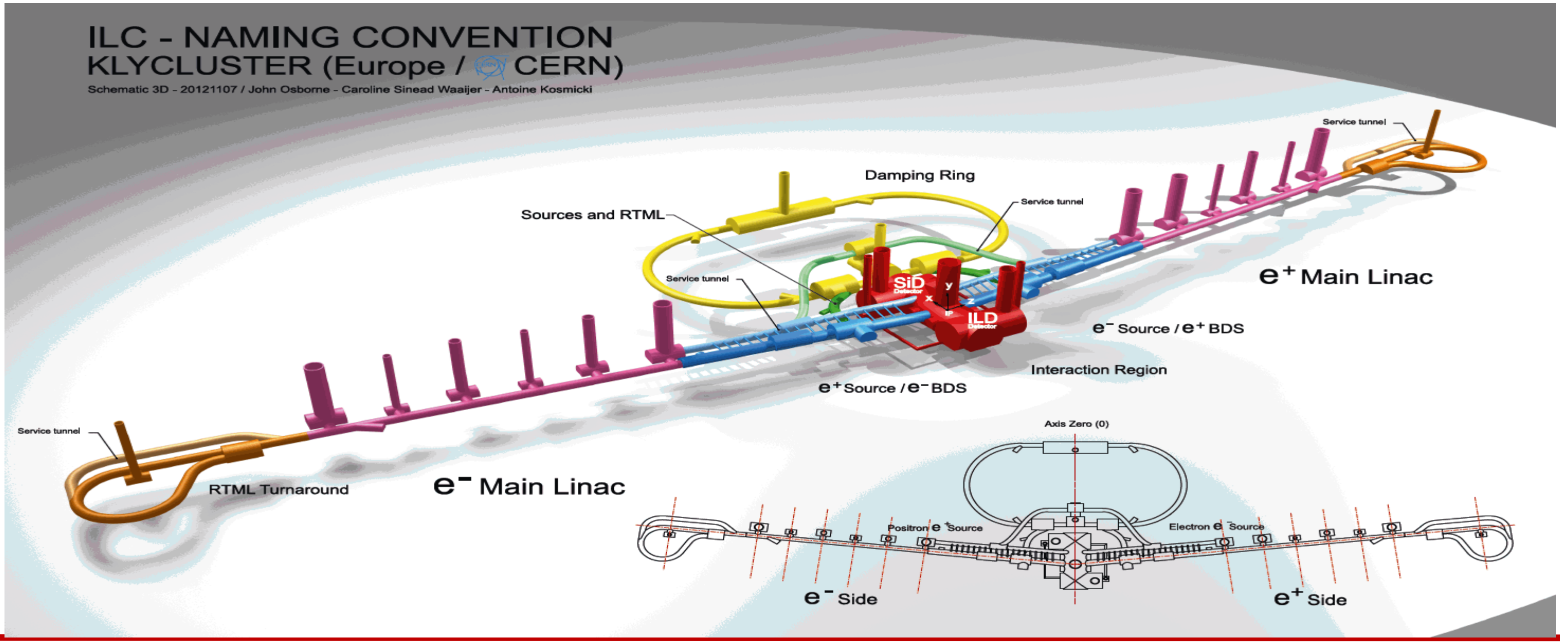
International Linear Collider TDR Cost Review

Installation Overview

Fred Asiri, Keith Kershaw

Introduction - Overview

- ***The TDR installation activities cover a large geographical area.***
  - ***Approximately 31 linear km long which includes a complex network of about 44 km of underground tunnels at the depth of about 100 m and associated surface buildings.***
- ***Requires the installation of***
  - ***About 1,855 cryomodules, over 11,130 magnets, approximately 410 high level RF stations (FR-ML), and associated cryogenic systems, vacuum equipment and their support systems.***



Approach

The RDR Installation Cost Estimate Approach were as follows:

- ***Obtained, compiled, studied and discussed the data for installation cost estimate of other projects (Ref. to back-up for details).***
  - KEKB, PEP II, SLC, Spear, Fermi Main Injection, etc.
  - None offered a one-for-one scalable comparison, but collectively they provided a range, " 2% to 12%", an average of 7% of the total project cost.
- ***Obtained components list from TSG and ASG managers***
- ***Defined scope on site deliverable for each subsystem.***
- ***Defined the subsystem installation requirements.***
- ***Established subsystem interfaces/boundaries.***
- ***Prepared and maintained an up-to-date data base.***
- ***Prepared WBS to level 5***
  - *The back-up work carried out at level 6.*
- ***Visited CERN and DESY***
  - *Discussed and obtained parametric data for LHC installation*
  - *Observed installation of Cryomagnets and assembly of the CMS detector*
  - *Participated in the ILC Main Linac cost model meeting in DESY*

Main Linac installation (RDR)

Benchmarked Cryomodule installation

- ***Assumptions:***
  - *One ML section and associated services tunnel completely ready for joint occupancy*
  - *One large and two small access shafts available during installation*
  - *ML installation period of three years plus 1/2 year ramp up time*
  - *At least one installation zone occupied at a time, more zones as become available*
  - *Installation rate: 3 Cryomodules and associated services per day*
- ***Cost variables:***
  - *Number and size of equipment to be installed.*
  - *Distances to installation location and speed of transportation.*
  - *Number of staff in each team needed per activity/function*
  - *Labor productivity ~ 75 %, 6 Hours of productivity per shift, due to transport distances and difficulty in handling.*
  - *Man-hour estimates based on the knowledge or general experience. E.g. Franz Peters' experience at DESY .*
    - *As well as lessons-learned from LHC Cryomagnet installation*

Main Linac installation (RDR)

Benchmarking - Notes from LHC Cryomagnet installation at CERN (Courtesy of Claude Hauviller):

- *Estimate cost of surface and underground transport and handling:*
  - *Procurement and Maintenance: 26 MCHF*
  - *Operation: 23 MCHF*
  - *Higher cost due to a compressed planning & many intermediate storage zones.*
- *Each Cryomagnet costs about 1,000KCHF*
  - *Due to presence of fragile components, tolerance of the internal parts must maintained with in ±0.1 mm during shipping, handling and installation.*
  - *Most of the Cryomagnets were assembled on site.*
  - *Special customized transport system used because of special care in handling*
  - *In tunnel transport maximum speed, 3Km/h.*
- *It took at least 5 days to complete on site assembly and 5 days for testing prior to installation*
- *Installation team consisted of total 70 people (Eng, Tech, Operator)*
- *Installation rate: initially 10 Cryomagnets per week, peaked up to 30 Cryomagnets, working 24 hours a day , 7 days a week.*

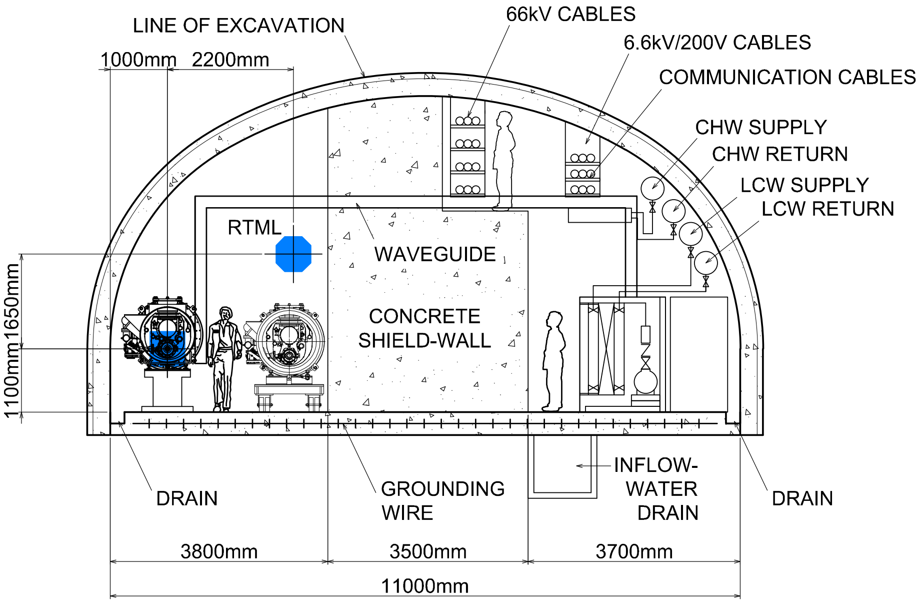
Modifications for TDR

The RDR WBS back-up documents were modified and adjusted to reflect the major changes in the TDR design impacting installation. To achieve this goal, the following steps were taken;

- ***At CERN CFS workshop – March 2012***
  - ***Reviewed scope and content of the RDR Installation***
  - ***Learned about the lessons-learned from LHC installation***
  - ***Identified some of the major changes since RDR***
- ***At KILC12 workshop – April 2012***
  - ***Met with technical system lead persons for the Main linac and damping ring and learned about the major changes impacting the installation work in these areas and collected pertinent information***
- ***Since KILC12 workshop***
  - ***Collected data impacting the changes to the Installation***
  - ***Adjusted the benchmarked cryomodule installation model***
    - Scaled the rest of the Main Linac accordingly
  - ***Other Areas - Incorporated the changes and adjusted the RDR installation labor to reflect the changes***
    - Scaled based on number of magnets
  - ***Prepared cost estimated for special mobile equipment for in tunnel installation***
  - ***Prepared the TDR Installation Estimates with the supporting back-up documents***

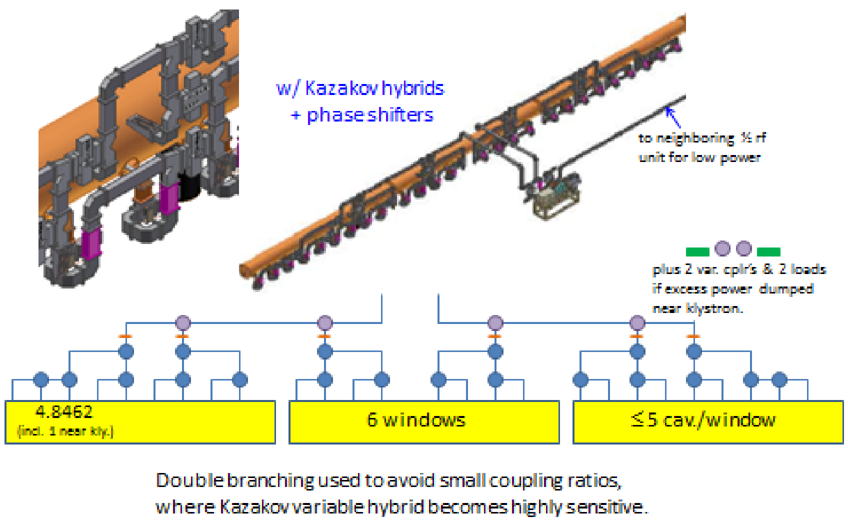
Modifications for TDR – ML mountainous site

- **From installation stand point, the TDR ML tunnel arrangement in the mountainous site is similar to the one in the RDR. One has two separate spaces in one large tunnel and the other has two separate tunnels.**
- **TDR provides for low power installation of HLRF**
  - *One klystron powers 4.5 cryomodules instead of 3 in RDR*
  - *378 Klystron unit total instead of 556 in RDR*
- **Marx modulator used instead of the Bouncer modulator**
  - *Marx modulator does not contain oil and does not require pulse transformer*



TDR Main Linac Cross Section

Shigeki's Tree-Like Layout



Modifications for TDR

Installation at mountainous site for ML Tunnel – Relative Evaluation

	Subsystem installation underground	Location	Units	%	Assumptions
1	Cryomodules	BLS*	1701	25	Optimized for installation
2	RF Power distribution system	BLS	1701	25	One unit per Cryo Module
3	Beam Lines: Magnets, supports, pipes etc.	BLS		10	Optimized for installation
4	Marx Modulator	STS**	378	8	Container versions
5	Electronic racks and local control cable	STS	378	10	Ready to go assembly
6	Klystron include shielding	STS	378	7	Klystron on wheels
7	AC Power station & distribution	STS	378	7	Container version
8	Miscellaneous			8	From different sub systems
	Installation underground			100	

* BLS = Beam Line Section
** STS=Service Tunnel Section

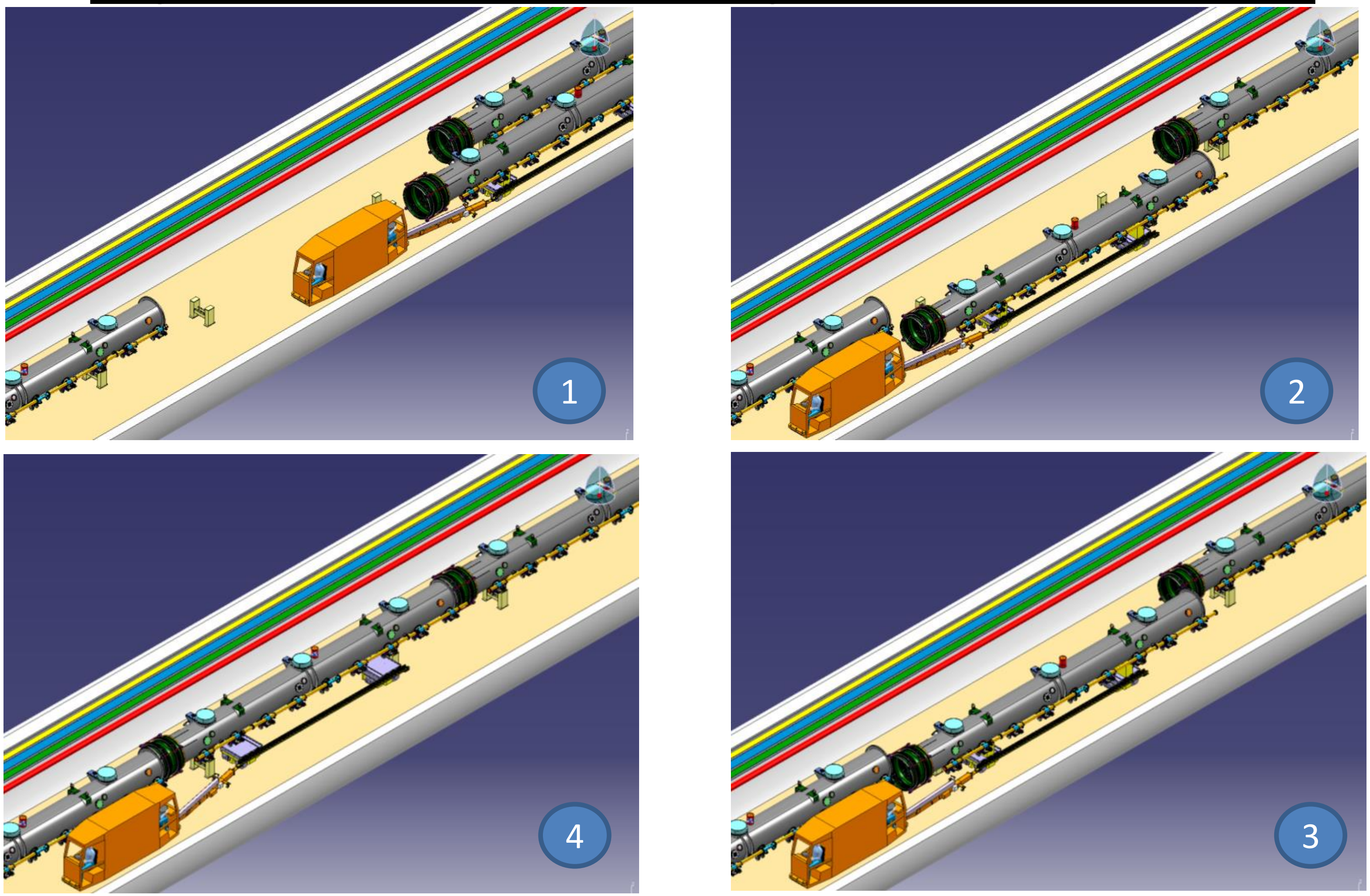
It take staff of (90) (100/25)=360 about three (3) years to install all ILC ML
360x3x2000= 2,160,000 man-hours
Adjustment for Cryomodules from RDR;
(1701/1668)(2160000)= ~2,200,000 Labor-hour

Mobile Equipment for Tunnel Installation

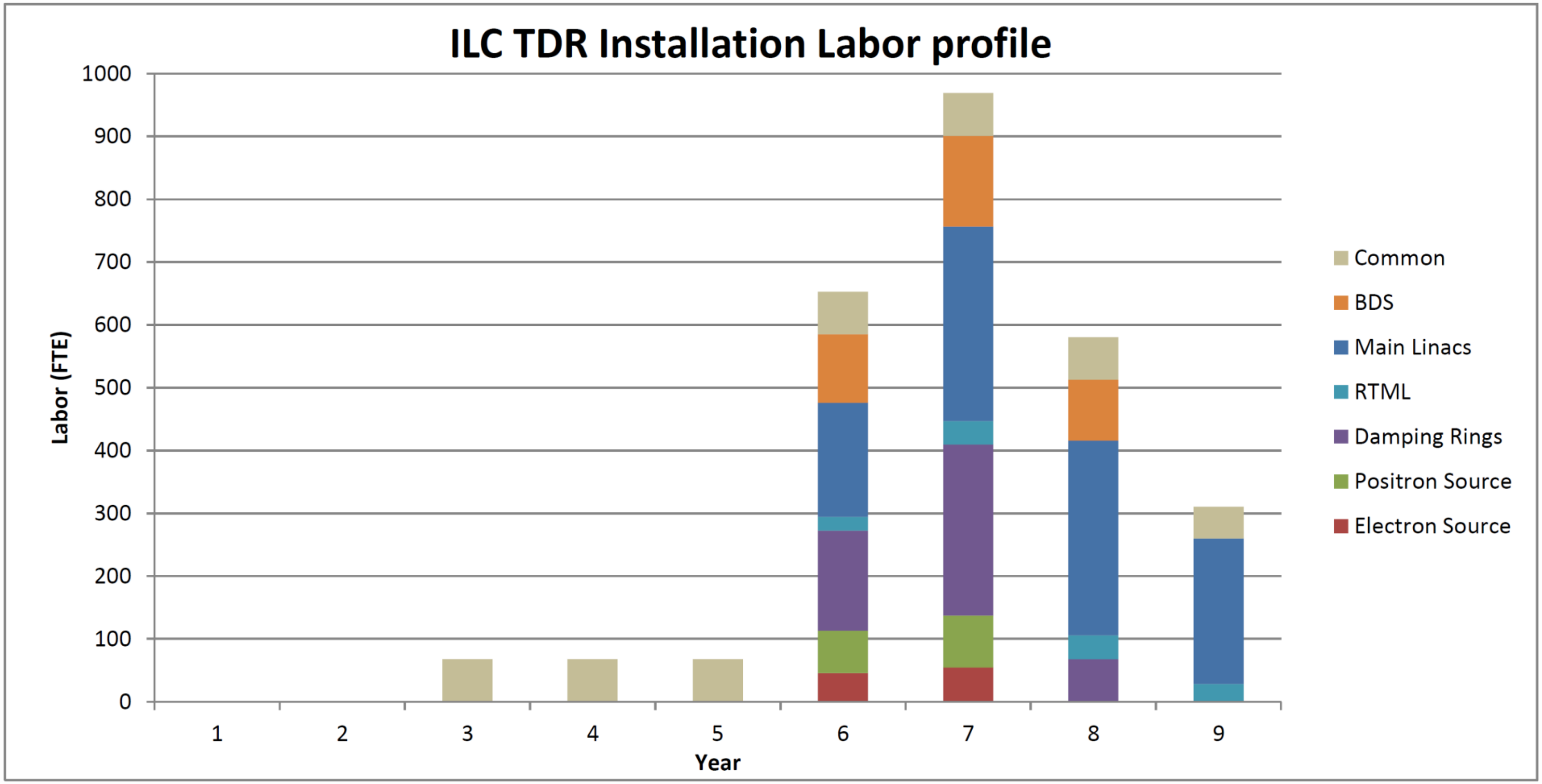
Methodology

- ***Identified suitable technical solutions for cryomodule, RF and magnet installation***
- ***Determined number of convoys based on number of items to install, time available for installation, distances, speeds and estimated times for loading and unloading.***
- ***Included powering and guidance infrastructure.***
- ***Added estimate for ad-hoc solutions to allow installation of other equipment.***
- ***Standard industrial equipment quantities are based on LHC installation experience***
- ***The cost of the equipment is based on European costs for similar equipment purchased by CERN.***
- ***Manpower estimates for mobile equipment engineering activities are included in the "General Installation" estimate.***

Cryomodule tunnel transport and installation

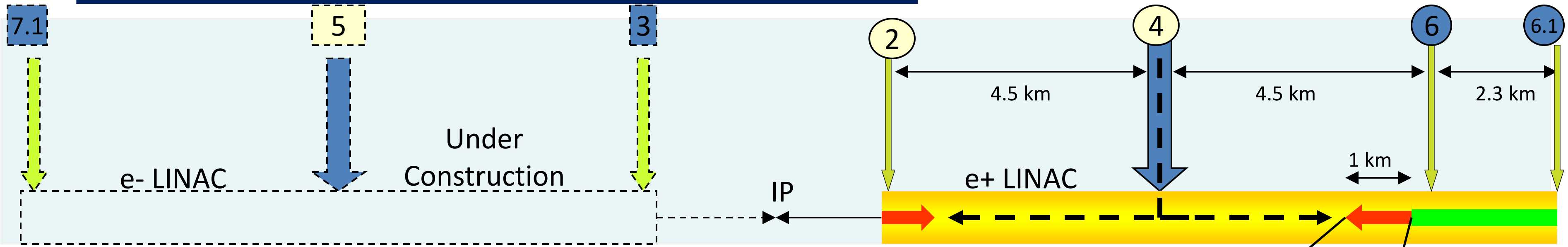


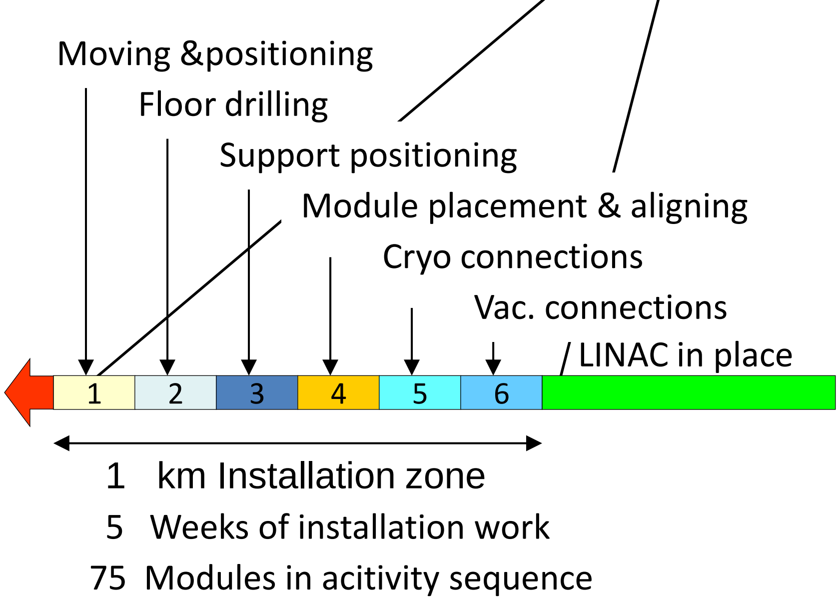
Installation labor profile based on TDR construction schedule



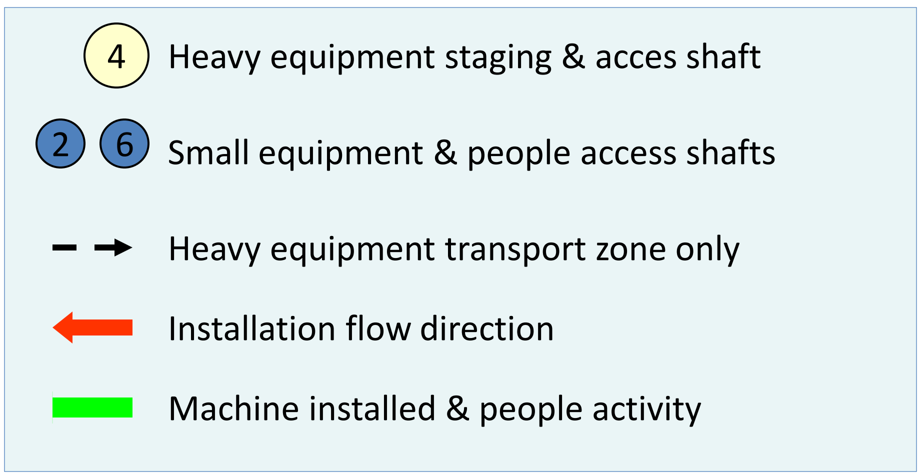
An installation model plan

Cryomodule installation sequence was used as a model for underground installation of all major accelator equipment.





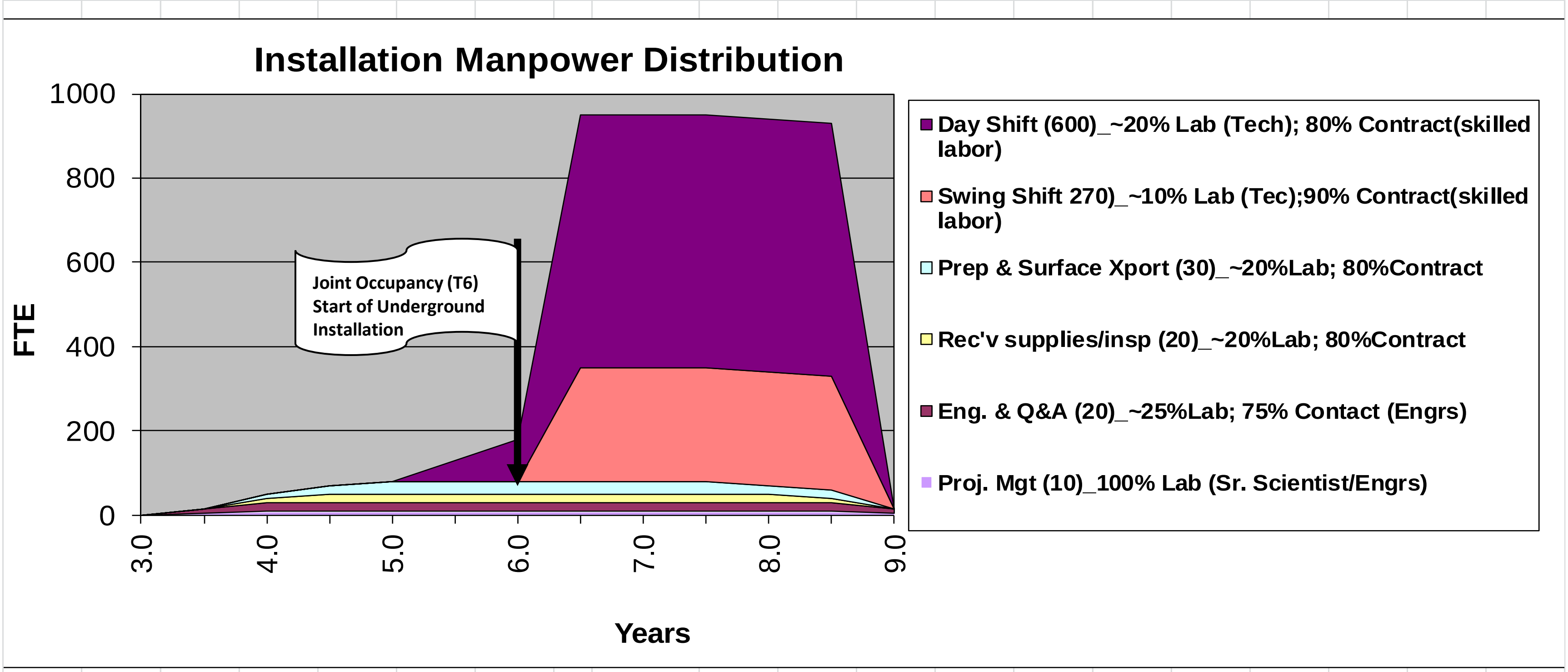
Legend



Installation Rate- 3 Cryomodules per day

An installation model plan

- ***The underground installation activities are divided in two groups.***
  - *Heavy lifting, transport , positioning, affixing, etc. are done in swing shift*
  - *Critical , highly specialized operation , e.g. in ML cryogenic and vacuum joints connection are carried out in day shift*
- ***All activities are planned on the 5 days per week***
  - *The owl and weekend shifts are reserved for contingency*



ILC 加速器建設にむけた研究所人材構想(1)

[人・年（FTE) 国際協力分担の仮定を含む]

Stage	Preparation				Construction									Sum
	1	2	3	4	1	2	3	4	5	6	7	8	9	
Prep. CFS-jp CS-ww Acc -jp Acc-ww Admin.	69+x 4+4 1 30+20 10 x	86+x 5+5 1 35+25 15 x	104+x 6+6 2 40+30 20 x	121+x 7+7 2 45+35 25 x										380+x 22+22 6 150+110 70
Const.					410	922	1208	1350	1589	1480	1374	1106	679	10,118
Install.							80	80	80	768	1140	683	522	3,353
Sum					410	922	1288	1430	1669	2248	2514	1789	1201	13,471

Note:
- Preparation フェーズには、KEK-STF< -ATF 等に於ける在来日
- Preparation: 国内および国外比率を50%-50% となるように増強する。 準備4年目は、国内・国外75 ・75名とする。 国内では、40名のスタッフ、30名の業務委託を想定。

ILC 計画･人材育成への考え方 (1)

- 施設（建築･土木）設計準備
- 限られた期間に特別な技術･技量が求められる。 できる限りアウトソーシングを行う･
- 最低限、職員として以下の人材を必要とする
  - 施設全体監督者
  - 土木技術･設計施工･監督指導
  - 建築技術･設計施工･監督指導
  - 電気設備･設計施工･監督指導
  - 機械（冷却、空調）設備･設計施工･監督指導
  - 契約事務･監督指導、予算執行責任／担当

ILC 計画・人材育成への考え方 (2)

超伝導加速器技術:

- 国際協力によるグローバルな人材育成
  - TTC collaboration (> 150) は、その基盤的な役割を果たしている。
- 各地域に、技術的ハブラボ機能・技術の醸成を計る
  - ヨーロッパ: EXFEL (1/20 スケール）における工業生産化、試験評価のための人材育成
  - アメリカ: LCLS (~1/50 スケール）による工業生産化、試験評価のための人材育成
  - アジア: KEK にハブラボ機能を整備
    - （早野さんからの報告）
    - 若手研究者の研鑽の場となっている。
    - 博士論文などの成果リストを、参考資料とする。

ILC 計画･人材育成への考え方 (3)

ナノビーム加速器技術:

- ATF を核とした、国際協力によるグローバルな人材育成
  - ATF Collaboration は、国際協力の要となっている。
  - 最終収束40 nm → 20 nmまでを目標とした研究開発推進
  - 世界中の加速器研究所から、博士論文をテーマとした、若い研究者の研鑽の場となっている。
    - これまでの研究成果、博士論文リストなどを参考資料に添付する。

Global Cooperation for Test Facilities

国際協力による加速器試験施設

TTF/FLASH (DESY) ~1 GeV
ILC-like beam　ILC RF unit

STF (KEK) operation/construction
ILC-like Cryomodule test：S1-Gloabal
SRF beam acceleration : QB, STF2

CesrTA (Cornell)
electron cloud
low emittance

DESY

INFN Frascati

KEK, Japan

FNAL

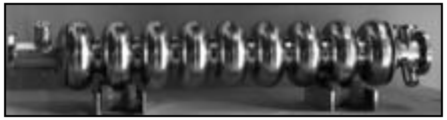
Cornell

DAΦNE (INFN Frascati)
kicker development
electron cloud

ATF & ATF2 (KEK)
ultra-low emittance
Final Focus optics, nano-beam
KEKB electron-cloud

NML/ASTA facility
ILC RF unit test
Full-CM Test,
SRF beam acceleration, soon

SCRF Procurement/Manufacturing Model



ILC Host-Lab

Technical Coordination for Lab-Consortium

World-wide Industry responsible to **'Build-to-Print' manufacturing**

Regional Hub-Lab: A

Regional Hub-Lab: B

Regional Hub-Lab: C: **responsible to Hosting System Test and Gradient Performance**

Regional Hub-Lab: D

Regional Hub-Lab: E, & …

- 市場は世界共通
- 企業は製造責任
- 研究所が性能責任

Regional hub-laboratories responsible to regional procurements to be open for any world-wide industry participation

: Technical coordination link

: Procurement link

A Model for Cavity and CM Production and Qualification Process

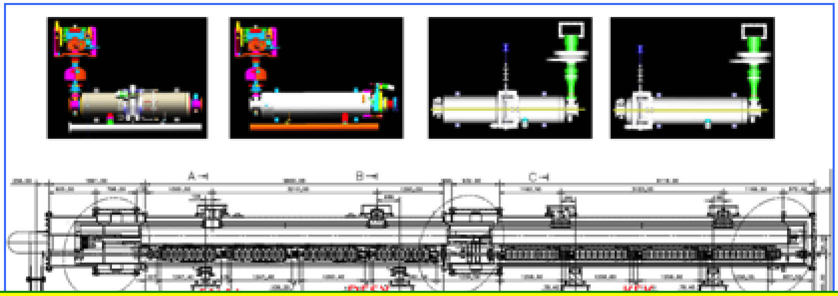
空洞とクライオモジュール製造と性能評価

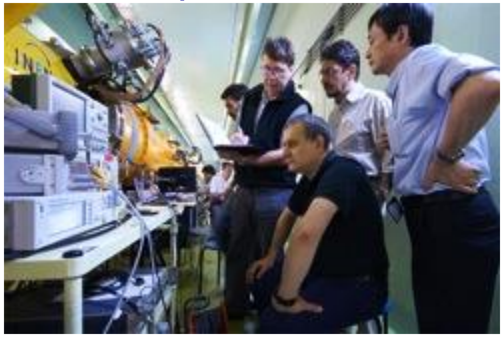
Step hosted	Industry	Industry/Laboratory	Hub-laboratory	ILC Host-laboratory
Regional constraint	no	yes or no	yes	yes
Sub-comp/material - Production/Procurement	Nb, Ti, specific comp. …		Procurement	
9-cell Cavity - Manufacturing	9-cell-cavity, Process, He-Jacketing		Procurement	
9-cell Cavity - Performance Test			Cold, gradient test	
Cryomodule component - Manufacturing	V. vessel, cold-mass ...		Procurement	
Cryomodule/Cavity - Assembly		Cav-string/ CM-assembly		
SCRF Cryomodule - Perofrmance Test			Cold, gradient test	
Accelerator integration, Commissioning				Accelerator sys. Integ.

S1-Global hosted at KEK:
国際協力による共同作業、空洞相互整合性、評価試験

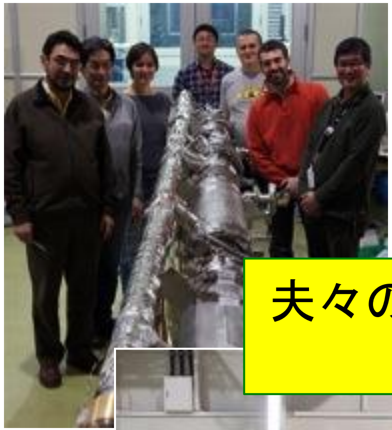
DESY, FNAL, Jan., 2010

DESY, Sept. 2010





FNAL & INFN, July, 2010



INFN and FNAL Feb. 2010

夫々の設計による空洞を持ち寄り、お互いに評価
協調した運転に成功

March, 2010

DESY, May, 2010

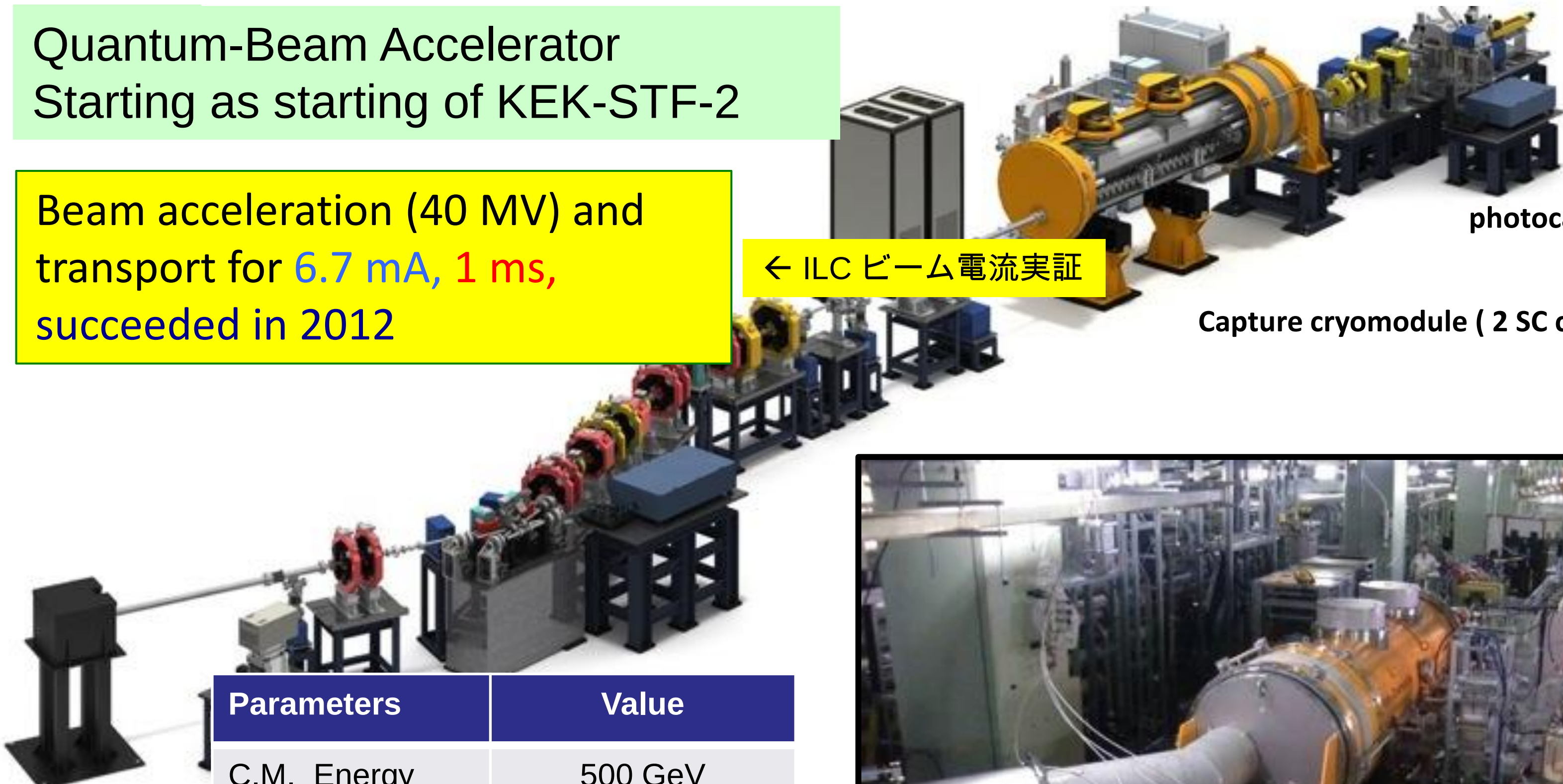
June, 2010 ~

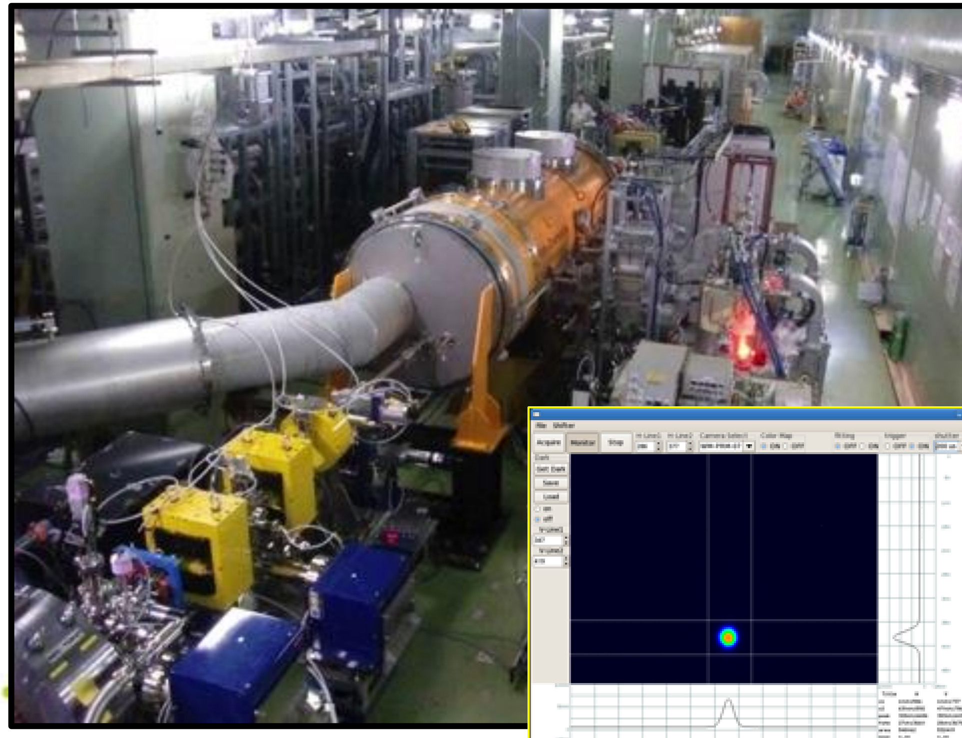
ILC beam Acceleration at KEK STF

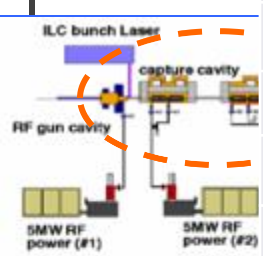
KEK-STF でのビーム加速実証試験

Quantum-Beam Accelerator
Starting as starting of KEK-STF-2

Beam acceleration (40 MV) and transport for 6.7 mA, 1 ms, succeeded in 2012





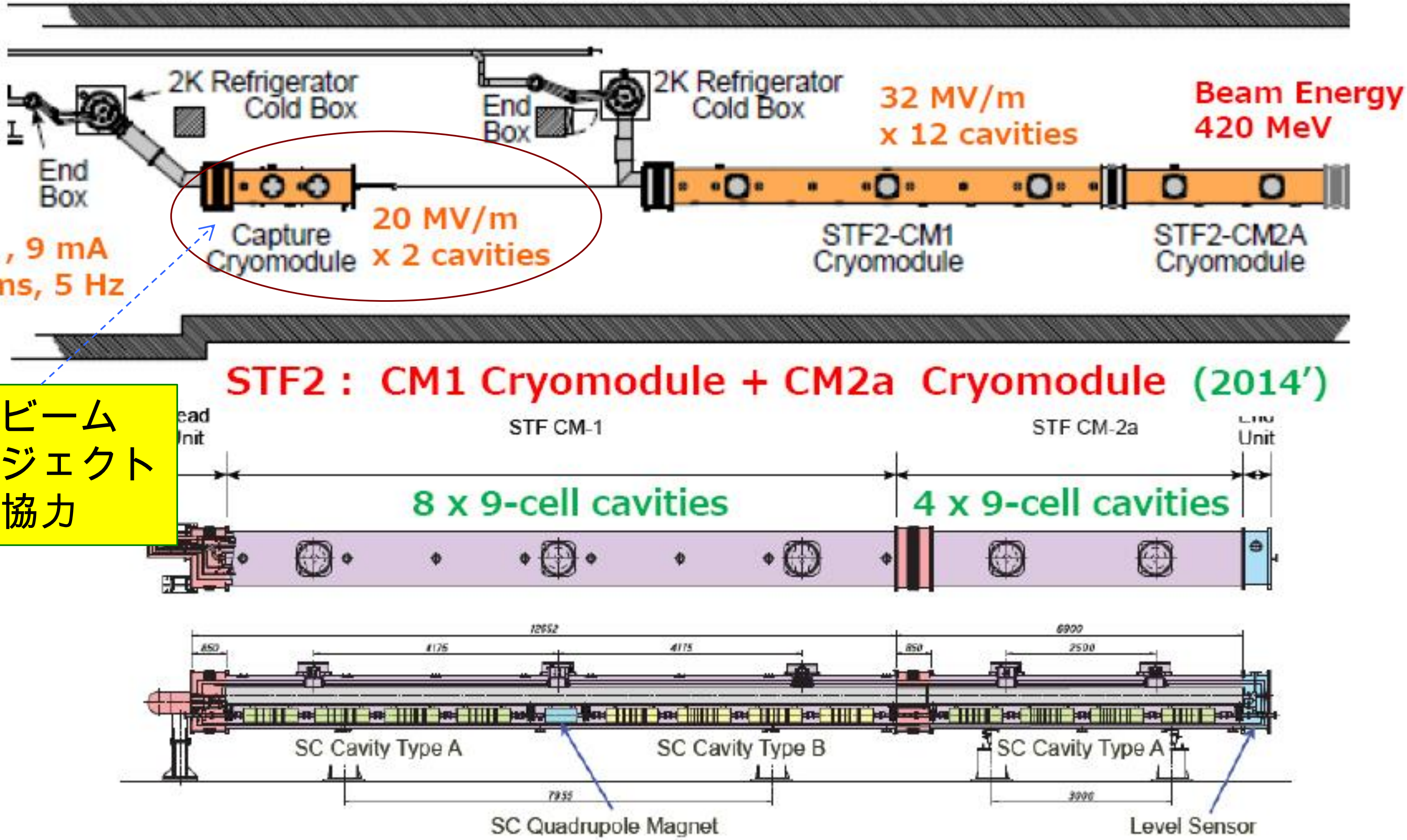


Parameters	Value
C.M. Energy	500 GeV
Peak luminosity	1.8 x10^{34} $cm^{-2}s^{-1}$
Beam Rep. rate	5 Hz
Pulse duration	0.73 ms
Average current	5.8 mA (in pulse)
E gradient in SCRF acc. cavity	31.5 MV/m +/-20% Q_0 = 1E10

E. Kako, Dec. 2013

10 year Evolution of STF at KEK

KEK-STF: 10年をかけた超伝導RF 試験加速器の進展



量子ビーム
プロジェクト
との協力

up to ~ 420MeV

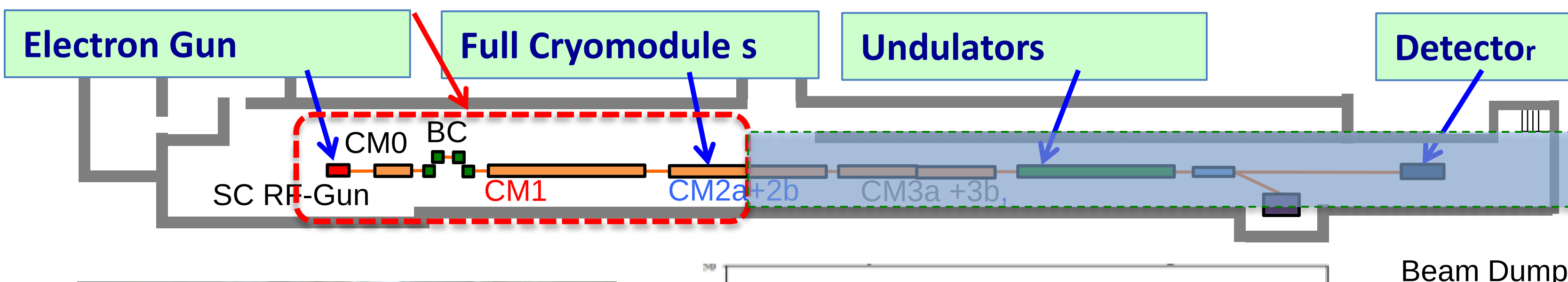
KEK-STF2：超伝導ビーム加速の実証、応用

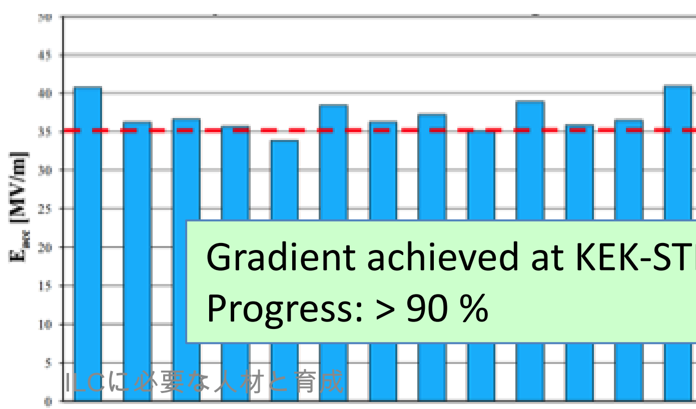
■ Objective

- High Gradient (31.5 MV/m)
  ＝＞Demonstration of full cryomodule
- Pulse and CW operation (for effective R&D
- Better efficiency power sources
- SCRF electron gun
- Training for next generation s

Plan:

- Multiple CM for system study
- In-house Cavity to be installed in cooperation with industry
- Wide range application including Photon Science

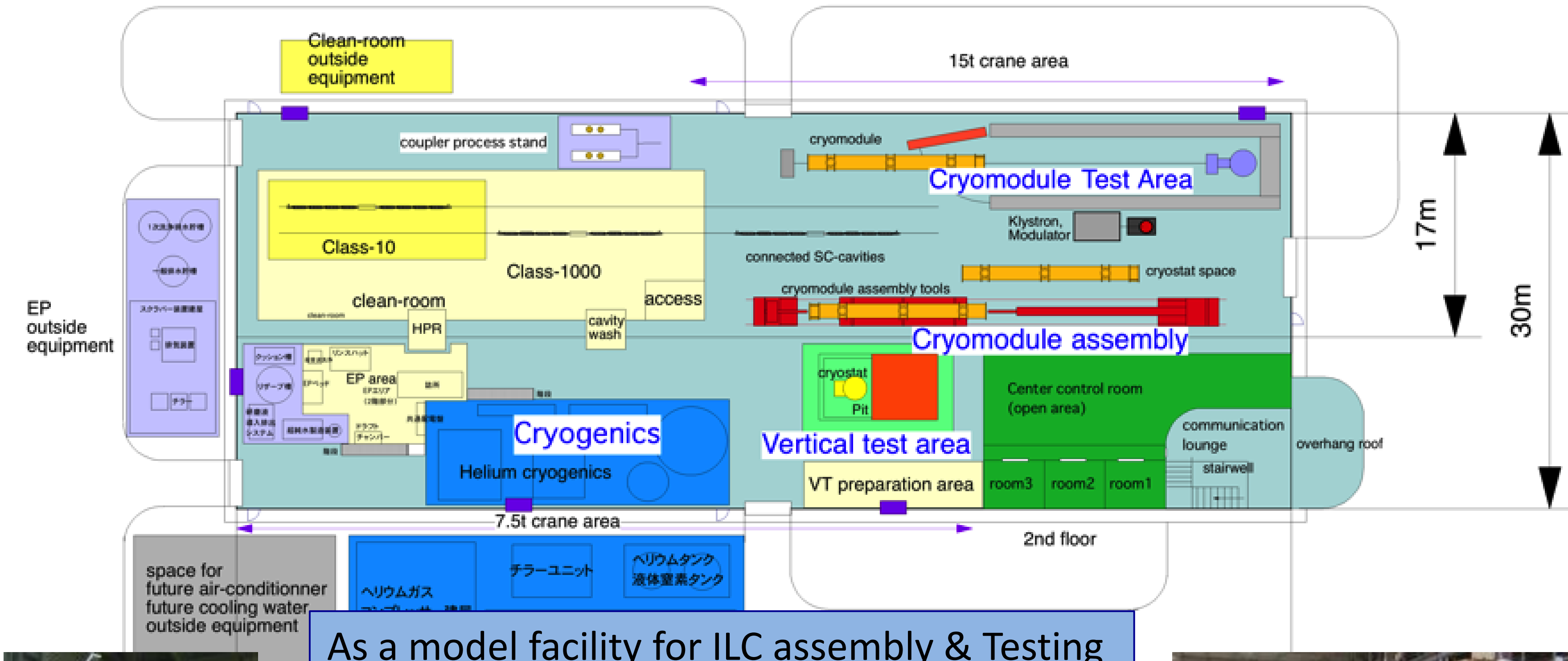




Gradient achieved at KEK-STF: > ~ 35 MV/m
Progress: > 90 %

Pilot Hub-laboratory Plan at STF

Superconducting Accelerator Development Hall (2014)



As a model facility for ILC assembly & Testing
- Clean-room
- He Cryogenics
- EP(vertical-EP)
- Cavity Testing(4-cavities-test)
- Cryomodule Assembly(cantilever)
- Cryomodule Testing


Vertical-EP


Cantilever

IPAC14: Courtesy: H. Weise

An Accelerator Complex for 17.5 GeV

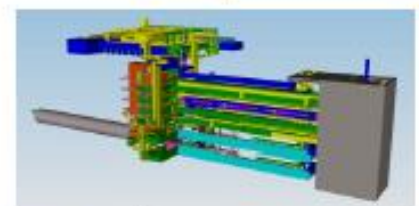
100 accelerator modules

Some specifications

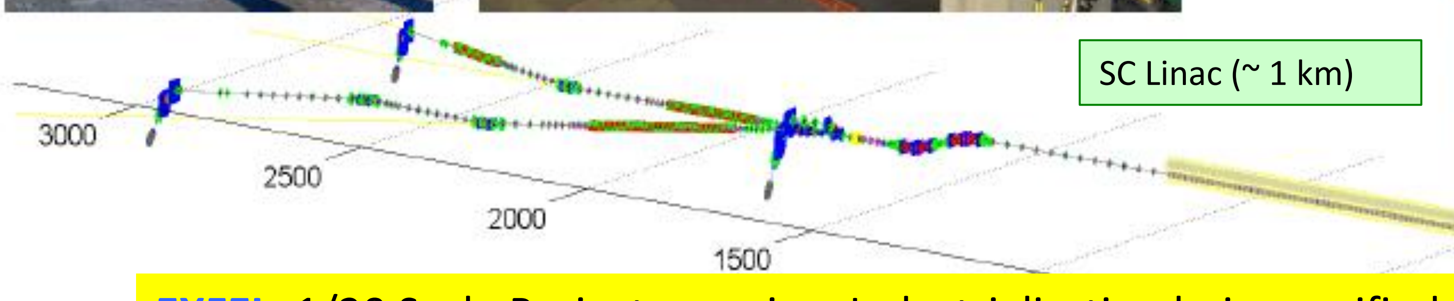
- Photon energy 0.3 - 24 keV
- Pulse duration ~ 10 - 100 fs
- Pulse energy few mJ
- Superconducting linac. 17.5 GeV
- 10 Hz (27 000 b/s)

800 accelerating cavities
1.3 GHz / 23.6 MV/m

25 RF stations
5.2 MW each



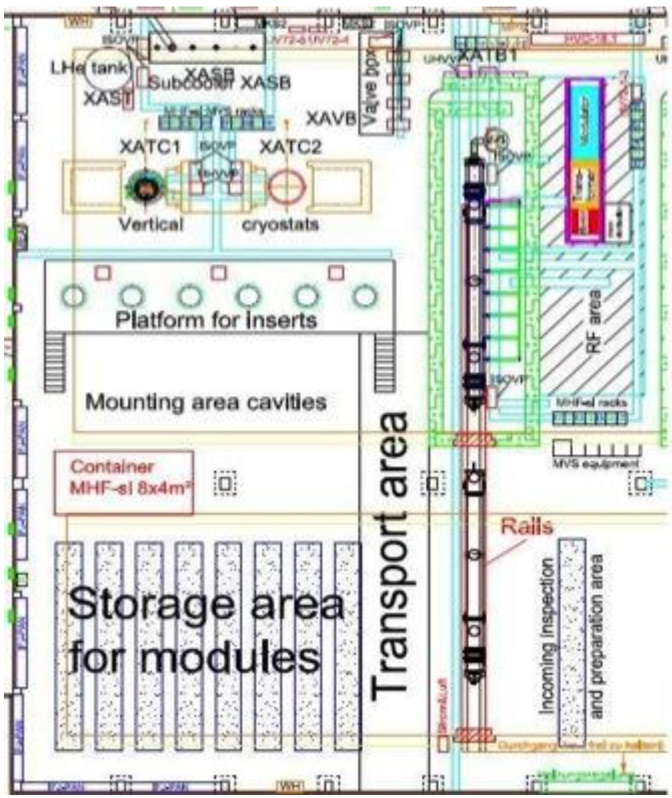
SC Linac (~ 1 km)



EXFEL: 1/20 Scale Project on going, Industrialization being verified !!
EXFEL: 1/20 スケール実計画、進行中→工業化技術を実証中

XFEL: AMTF Hall - XATC

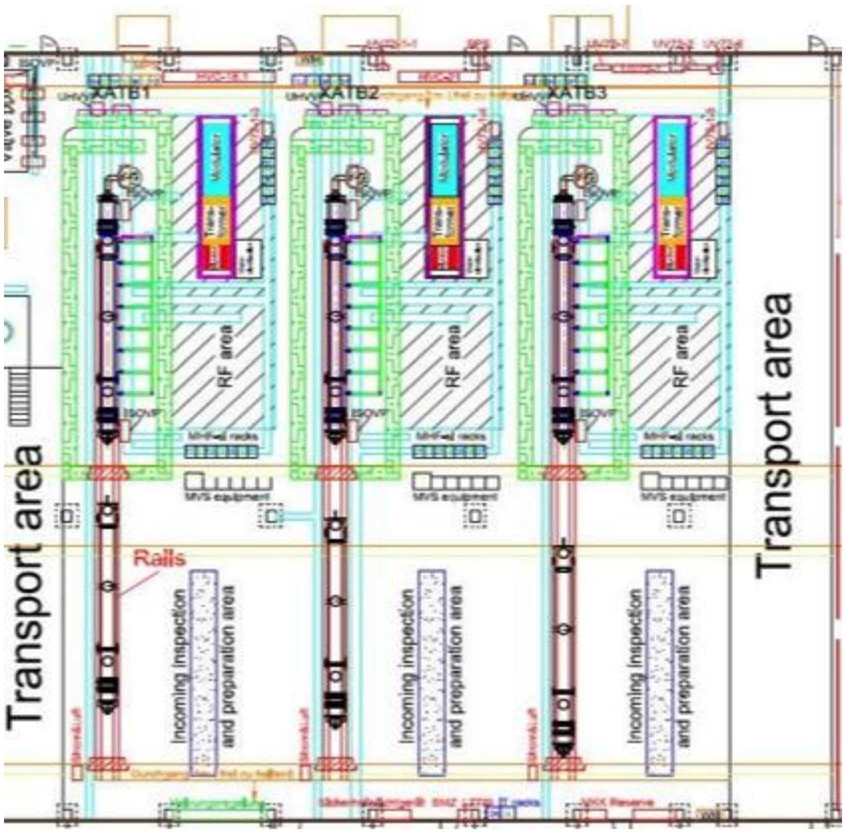
AMTF: 70m x 40m



Cavity Testing

XATC: 20m x 40m

XFEL: AMTF Hall - XATB



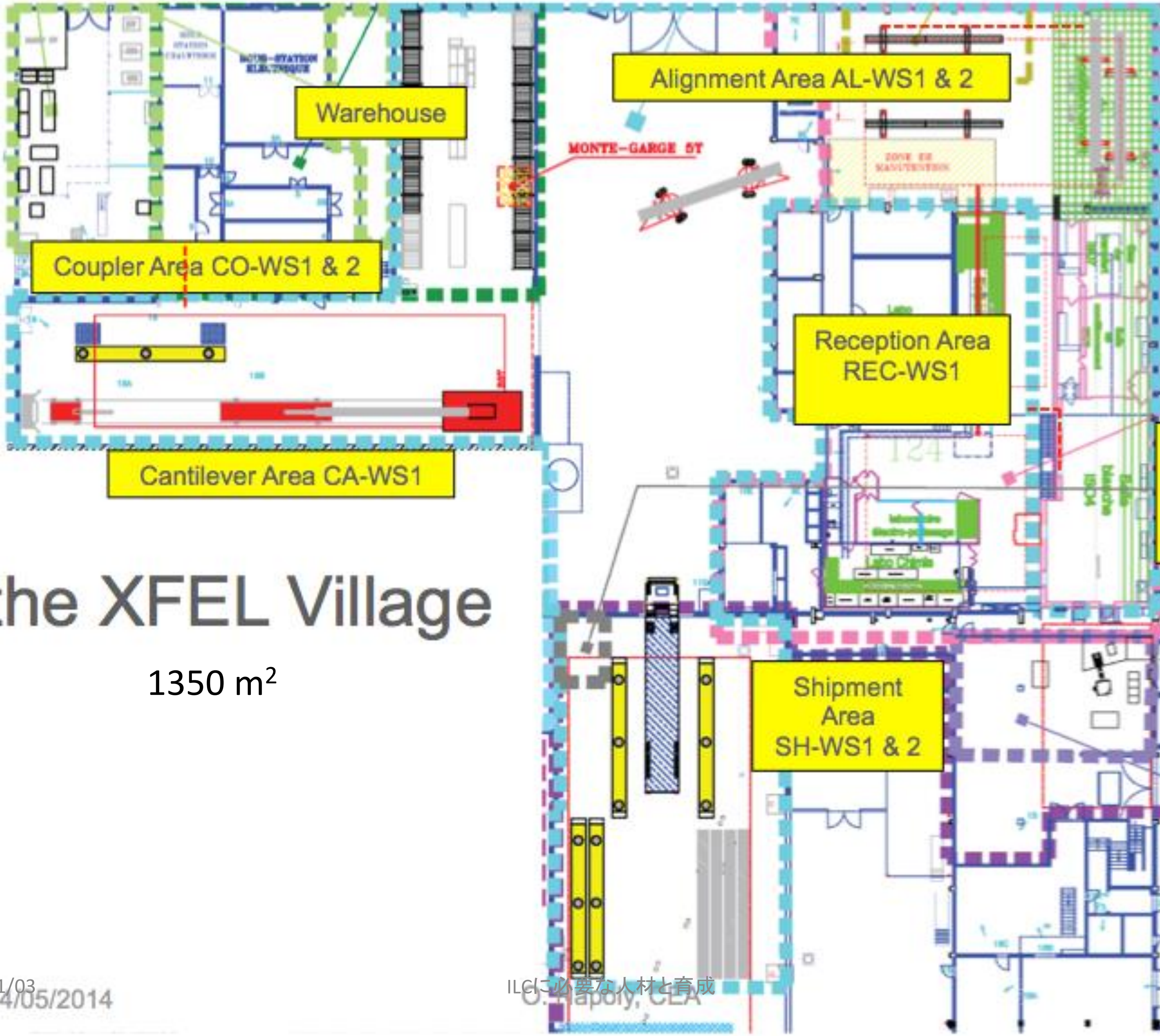
Cryomodule Testing

XATB: 50m x 40m

RF conditioning at LAL:

- 70m² ISO 5 clean room.
- 3 ovens equipped with pumping systems to treat up to 6 coupler pairs at the same time.
- 4 RF test bench allowing the conditioning of 4 coupler pairs simultaneously.

Cryomodule assembly at CEA-Saclay



the XFEL Village

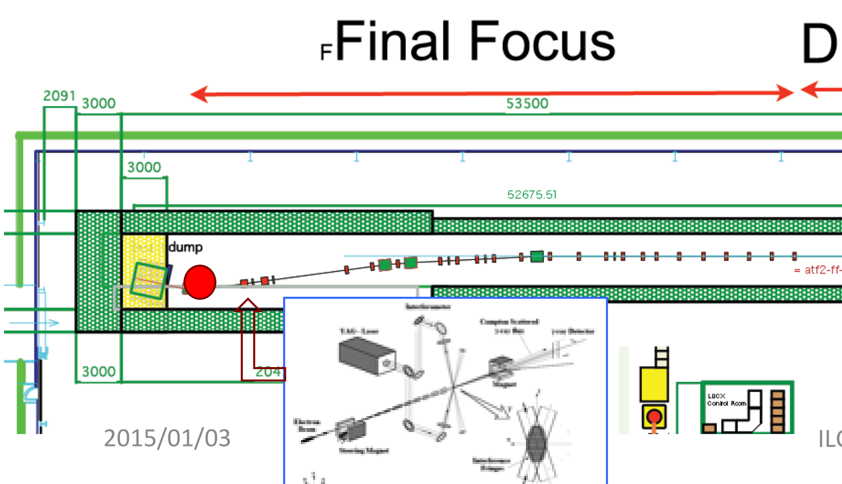
1350 m^2

AWLC'14 , 14/05/2014 O. Napoly, CEA

KEK-ATF2: BDS, FF Test Facility for ILC

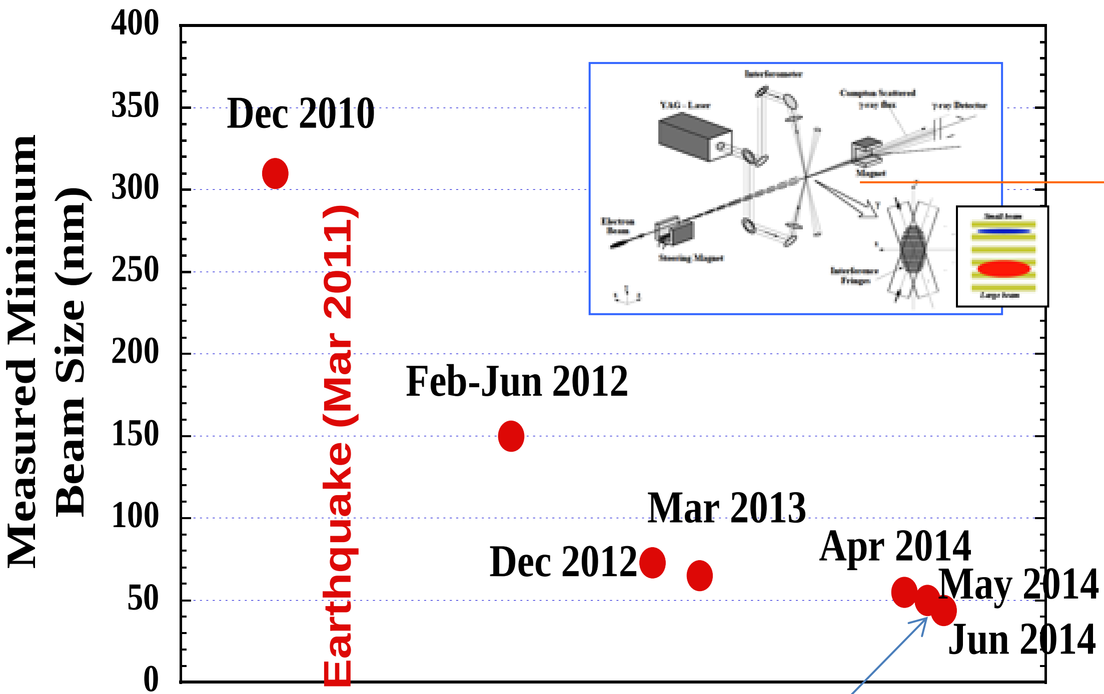
- Modeling of ILC - BDS
  - Same Optics:
  - Int'l Collab.
- ~25 Lab. , > 100 Collaborators

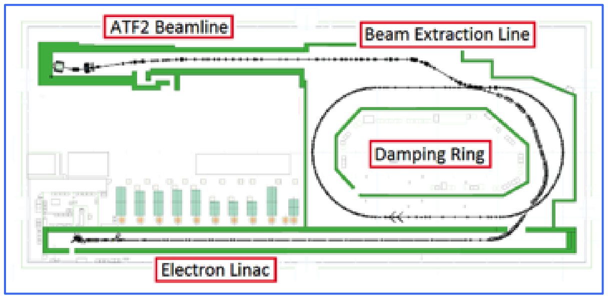
- Goal:
  FF Beam Size: 37 nm
  - (corresponding to 5.9 nm at ILC

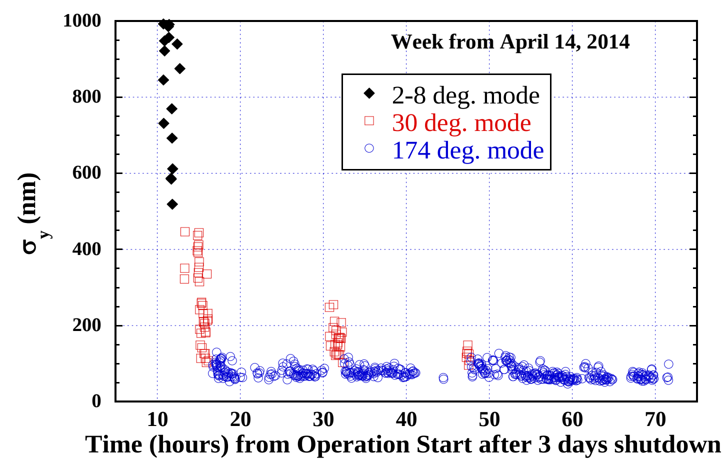


Parameter	ILC	ATF2
Beam Energy [GeV]	250	1.3
Energy Spread (e^+/e^-) [%]	0.07/0.12	0.06~0.08
Final quad – IP distance (L^*) (SiD/ILD detector) [m]	3.5/4.5	1.0
Vertical beta function at IP (β^*_y) [mm]	0.48	0.1
Vertical emittance [pm]	0.07	12
Vertical beam size at IP (s^*_y) [nm]	5.9	37
L^*/β^*_y (~natural vertical chromaticity, SiD/ILD detector)	7300/9400	10000

Progress in Beam Size at ATF2







Beam Size 44 nm observed,
(Goal : **37** nm
corresponding to **6** nm at ILC)

ATFに参加している代表的研究機関
- ATF International Collaboration -

欧州原子核研究機構(CERN)

ドイツ(Germany)
- **電子シンクロトロン研究所(DESY)**

フランス(France)
- **IN2P3; LAL, LAPP, LLR**

イギリス(UK)
- **オクスフォード大学(Univ. of Oxford)**
- **ロイヤルホロウェイ・ロンドン大学**
  (Royal Holloway Univ. of London)
- **STFC, Daresbury**
- **Univ. of Manchester**
- **Univ. of Liverpool**
- **Univ. College London**

イタリア(Italy)
- **INFN, Frascati**

スペイン(Spain)
- **IFIC-CSIC/UV**

ロシア(Russia)
- **トムスクエ科大学(Tomsk Polytechnic Univ.)**

アメリカ(USA)
- **SLAC国立加速器研究所**
- ローレンス・バークレー国立研究所**(LBNL)**
- フェルミ国立加速器研究所**(FNAL)**
- ローレンス・リバモア国立研究所**(LLNL)**
- ブルックヘブン国立研究所**(BNL)**
- **コーネル大学(Cornell Univ.)**
- **ノートルダム大学(Notre Dome Univ.)**

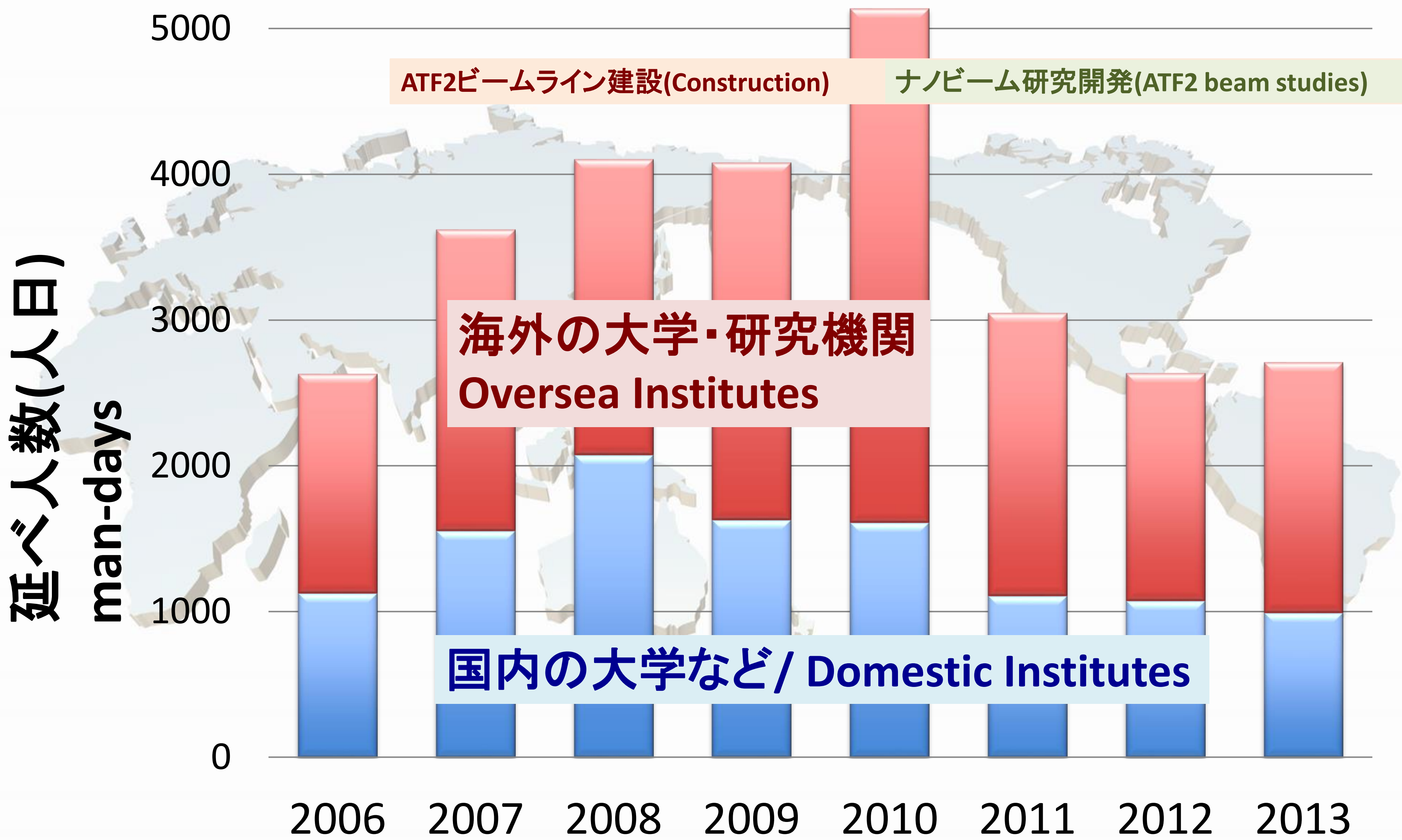
日本(Japan)
- **高エネルギー加速器研究機構(KEK)**
- **東北大学 (Tohoku Univ.)**
- **東京大学 (Univ. of Tokyo)**
- **早稲田大学(Waseda Univ.)**
- **名古屋大学(Nagoya Univ.)**
- **京都大学 (Kyoto Univ.)**
- **広島大学 (Hiroshima Univ.)**

中国(China)
- **中国科学院高能物理研究所(IHEP)**

韓国(Korea)
- **ポハン加速器研究所(PAL)**
- **キョンプク大学(KNU)**

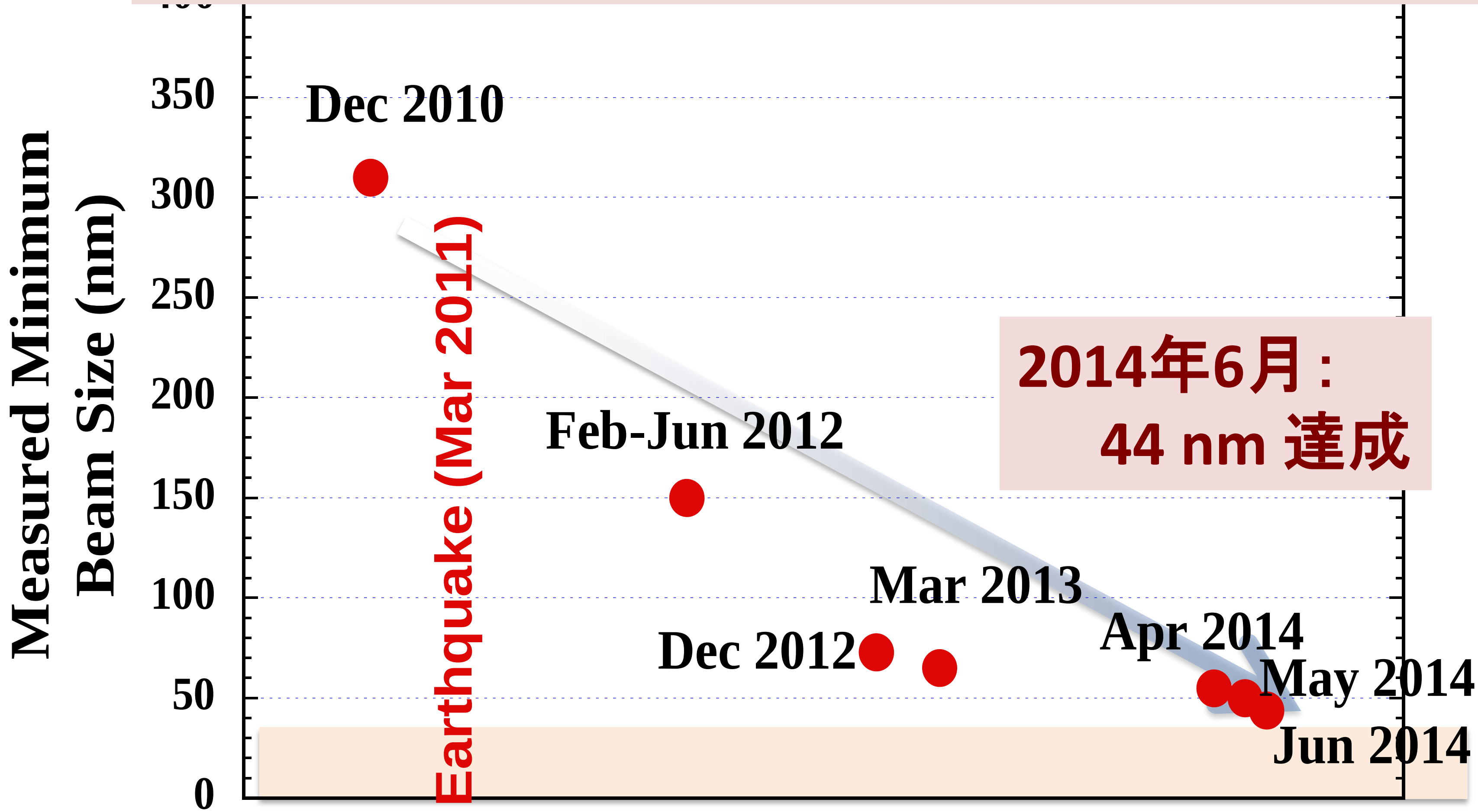
インド(India)
- **Raja Ramanna Centre for Advanced Technology**

ATFでの研究開発に参加した共同研究者数(訪問者)
Collaborators visiting ATF



ナノビームの実現 / Small beam achieved at ATF2

極小ビーム開発(最終収束システムの技術検証)
目標: 垂直方向37 nm （ILCでの6nmに相当）



List of ATF relate PhDs (1)

Institute	Counry	Name	Institute
2014	Sokendai	Japan	Arpit Rawankar
2014	Oxford university	UK	Michael Davis
2013	University of Tokyo	Japan	Masahiro Oroku
2013	Hiroshima University	Japan	Tomoya Akagi
2013	ICIF, Valencia university	Spain	Javier Alabau-Gonzalvo
2013	Royal Holloway, University of London	UK	Nirav Joshi
2013	Oxford university	UK	Douglas Bett
2012	LAL	France	Francoisn Labaye
2012	CERN	Spain	Eduardo Marin Lacoma
2012	Kyungpook National University	Korea	Youngim Kim
2011	The University of Manchester	UK	Anthony Scarfe
2011	Oxford University	UK	Laurence Nevay
2011	Hiroshima University	Japan	Shuhei Miyoshi
2011	IHEP	China	Dou Wang
2011	Oxford university	UK	Ben Constance
2011	Oxford university	UK	Robert Apsimon
2010	IHEP	China	Sha Bai
2010	Oxford university	UK	Christina Swinson
2010	Soken-dai	Japan	Abhay Deshpande
2010	UNIVERSITAT DE VALÈNCIA	Spain	María del Carmen Alabau Pons
2010	Université Paris-Sud 11	France	Yves Renier
2009	Royal Holloway, University of London	UK	Lawrence Deacon

List of ATF relate PhDs (2)

Institute	Counry	Name	Institute
2008	Oxford university	UK	Christine Clarke
2007	Soken-dai	Japan	Takashi Naito
2007			Sean Walston
2007	Soken-dai	Russia	Alexander Aryshev
2007	Université de Savoie	France	Benoit Bolson
2007	University of Tokyo	Japan	Fumito Sakamoto
2007	University of Tokyo	Japan	Taikan Suehara
2007	名古屋大学	日本	山本尚人
2006	Queen Mary University of London	UK	Stephen Molloy
2006	Soken-dai	Japan	Koichiro Hirano
2006	Soken-dai	Japan	Yoshio Yamazaki
2004	Waseda University	Japan	Kuroda Ryunosuke
2004	Kyoto University	Japan	Yosuke Honda
2004	Tokyo Metropolitan University	Japan	Masafumi Fukuda
2004	Tokyo Metropolitan University	Russia	Pavel Karataev
2003	Tokyo Metropolitan University	Japan	Toshiya Muto
2002	Tokyo University of Science	Japan	Takayuki Imai
2002	Tokyo Metropolitan University	Japan	Izumi Sakai
2001	Kyoto University	Japan	Hiroshi Sakai
2001	Tokyo Metropolitan University	Japan	Katsuhiro Dobashi
1999	Soken-dai	Japan	Shigeru Kashiwagi
1999	Tokyo Metropolitan University	Japan	Toshiyuki Okugi

List of ATF relate PhDs (3)

Year	Institute	Counry	Name
1996	Nagoya University	Japan	Masafumi Tawada
1994	Soken-dai	Japan	Atsushi Miura
1994	Soken-dai	Japan	Masashi Yamamoto
1994	Tohoku University	Japan	Tsutomu Taniuchi
1993	Soken-dai	Japan	Kenji Itoga
1992	Nagoya University	Japan	Hideki Aoyagi
1992	Soken-dai	Japan	Hiroshi Akiyama
1990	University of Tsukuba	Japan	Yoshikazu Yamaoka