LINEAR COLLIDER COLLABORATION

Designing the world's next great particle accelerator

Report fromAccelerator Sessions

Benno List

ILC@DESY Project Meeting

15.6.2018

DESY.

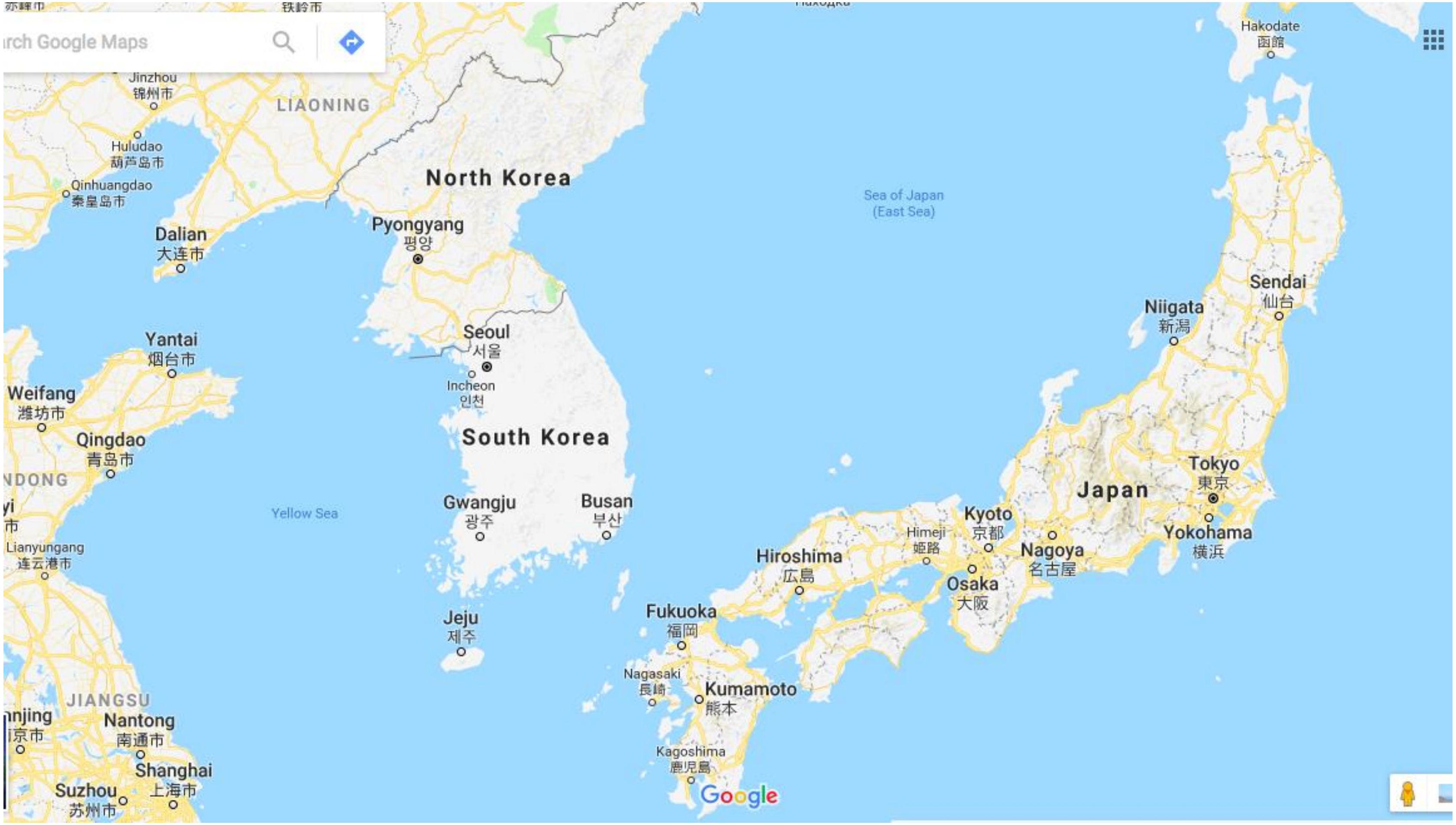
E-JADE

Asian Linear Collider Workshop 2018

May 28 - June 1, 2018 Fukuoka International Congress Center *Fukuoka, JAPAN*

Illustration: Rey.Hori

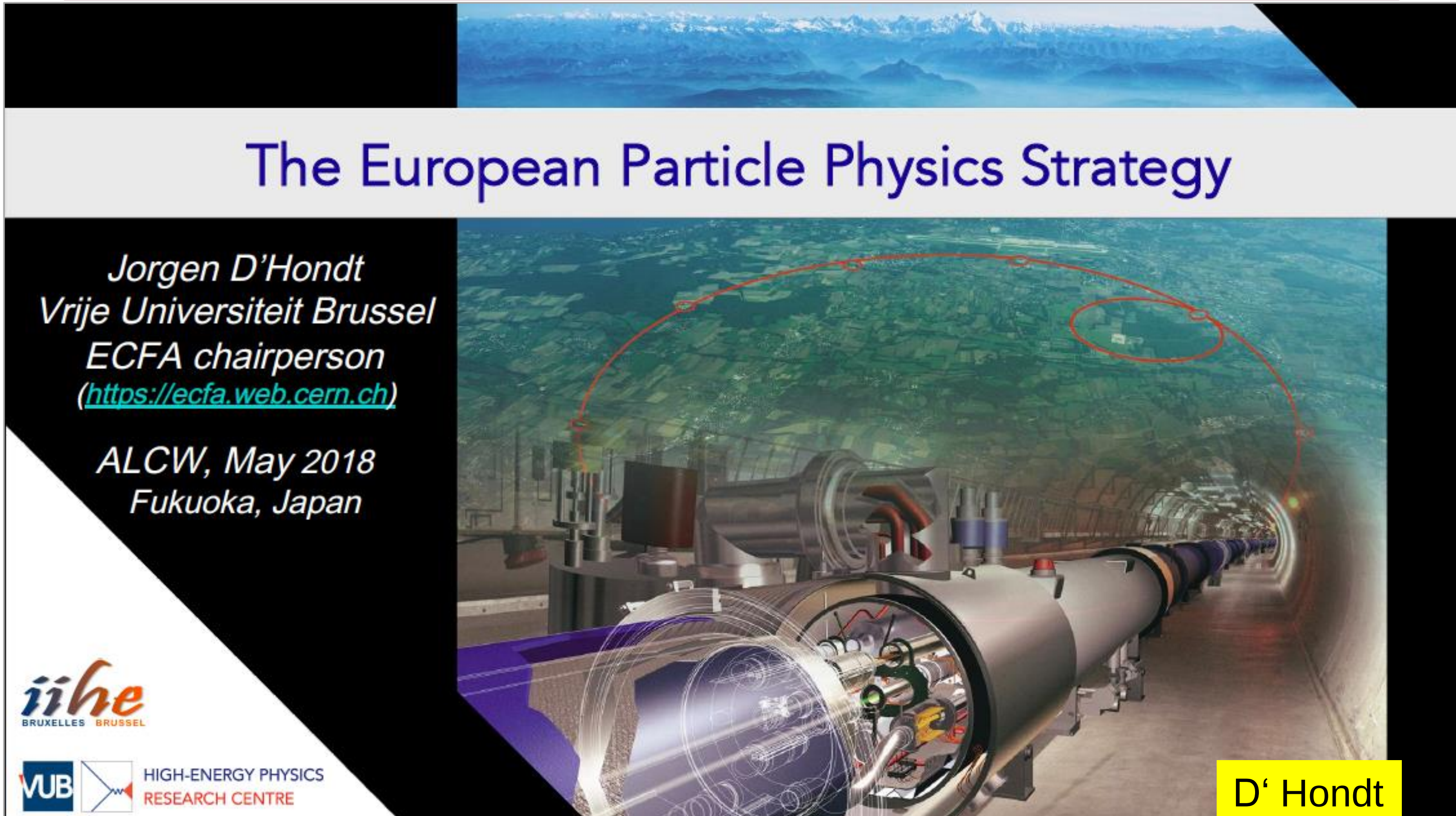
Fukuoka



North Korea
Pyongyang
평양
Seoul
서울
Incheon
인천
South Korea
Gwangju
광주
Busan
부산
Jeju
제주
Sea of Japan
(East Sea)
Yellow Sea
LIAONING
Jinzhou
锦州市
Huludao
葫芦岛市
Qinhuangdao
秦皇岛市
Dalian
大连市
Yantai
烟台市
Weifang
潍坊市
Qingdao
青岛市
Lianyungang
连云港市
JIANGSU
Nantong
南通市
Shanghai
上海市
Suzhou
苏州市
Hakodate
函館
Sendai
仙台
Niigata
新潟
Tokyo
東京
Japan
Yokohama
横浜
Kyoto
京都
Himeji
姫路
Nagoya
名古屋
Osaka
大阪
Hiroshima
広島
Fukuoka
福岡
Nagasaki
長崎
Kumamoto
熊本
Kagoshima
鹿児島
Google

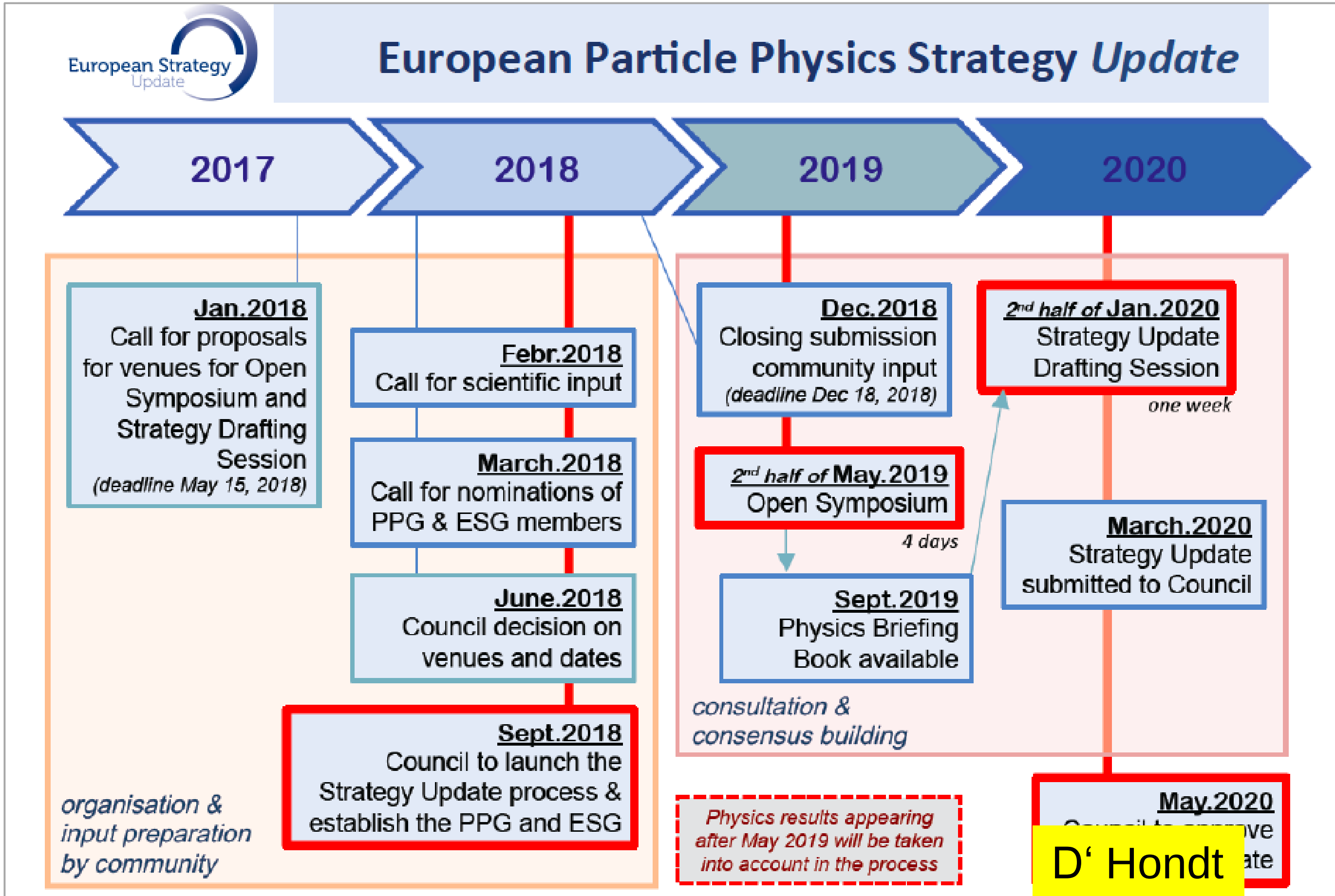
Impressionen

European Strategy Update

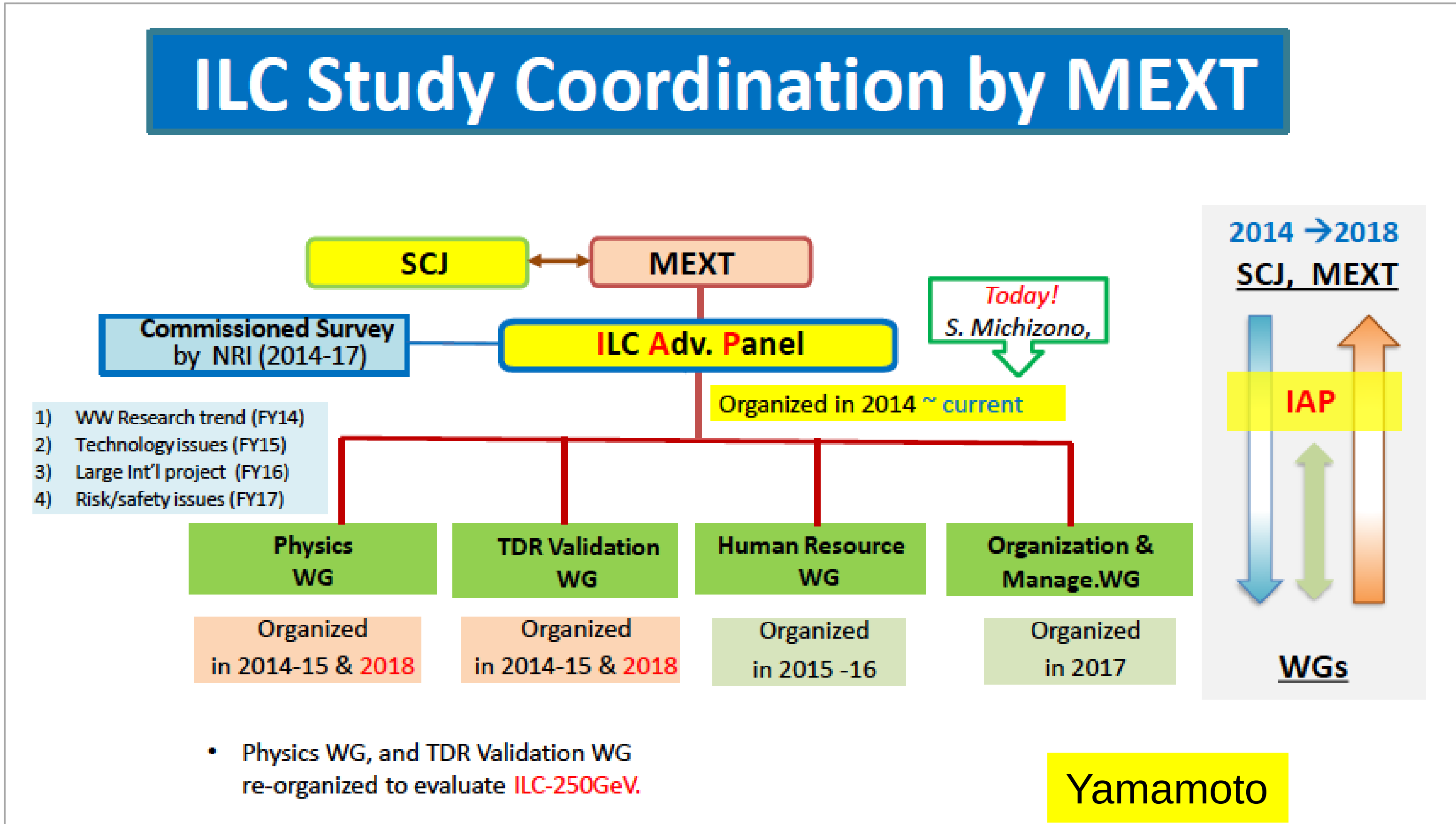


D' Hondt

European Strategy Update



Japan


ILC Study Coordination by MEXT
SCJ
MEXT
Commissioned Survey by NRI (2014-17)
ILC Adv. Panel
Today!
S. Michizono,
Organized in 2014 ~ current
1) WW Research trend (FY14)
2) Technology issues (FY15)
3) Large Int'l project (FY16)
4) Risk/safety issues (FY17)
Physics WG
TDR Validation WG
Human Resource WG
Organization & Manage.WG
Organized in 2014-15 & 2018
Organized in 2014-15 & 2018
Organized in 2015 -16
Organized in 2017
2014 → 2018
SCJ, MEXT
IAP
WGs
Physics WG, and TDR Validation WG re-organized to evaluate ILC-250GeV.
Yamamoto

Opening Plenary

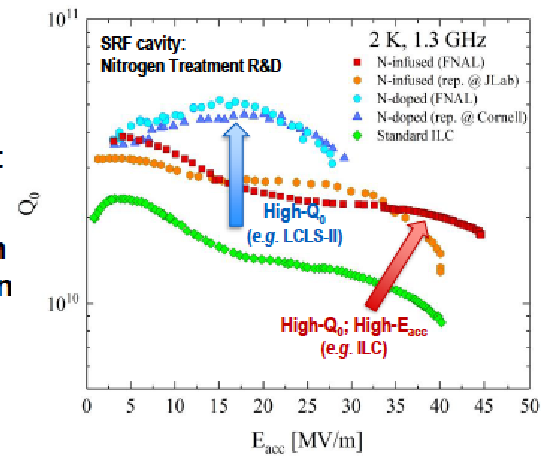
ILC in the US

ILC: Status in the U.S.

While awaiting a decision by the Government of Japan to host the ILC, the U.S. continues R&D efforts, focusing on areas of cost reduction for the accelerator (*e.g.* SRF cavities, gradient, *Q*-factor).

R&D:

- **U.S. has invested heavily in ILC and detector R&D in past years, particularly Superconducting RF.**
- **Present R&D program focuses on cost reduction for SRF** (gradient, Q_0).
- **Builds upon past investment and upon Fermilab & Jefferson Lab experience in providing SRF for the LCLS-II light source at SLAC**
- **Other ILC R&D efforts, *e.g.* positron source, detectors, are very modest in current budget situation.**



See A. Grassellino presentation.

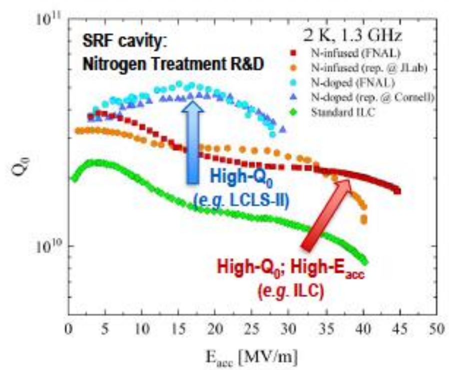
ALCW Fukuoka 2018 Montgomery, Particle Physics Program in North America

Montgomery

Situation in US and Canada

Future Colliders

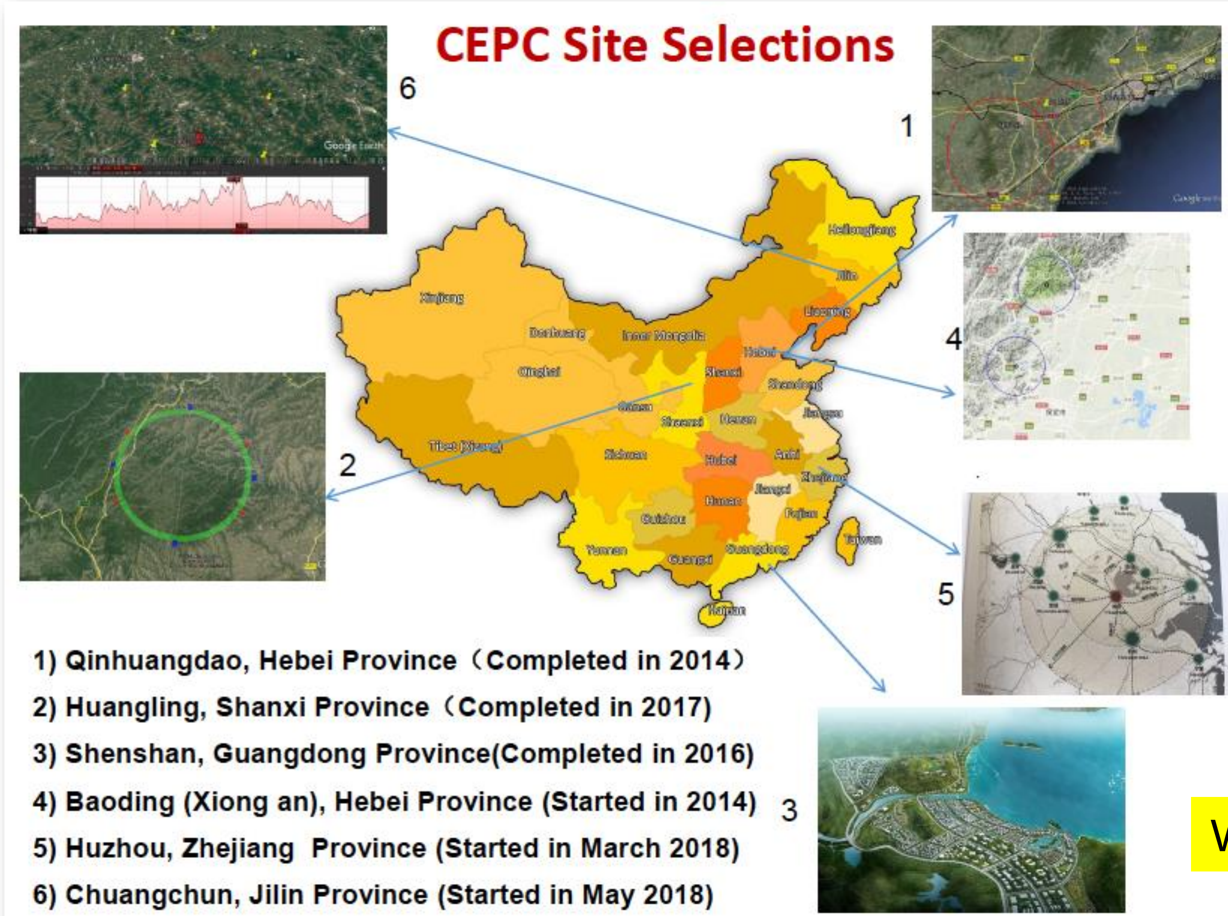
- **DOE has been coordinating with the international community towards the development of the next collider program**
  - The U.S. looks forward to a decision this year by Japan to host the ILC as an international project
  - Global strategy for the next circular collider awaits the 2020 European Strategy Update for Particle Physics
- **Interest from U.S. HEP community to pursue R&D studies for future collider options (*e.g.*, Europe/CERN Future Circular Collider or Japan-proposed ILC)**
  - Current DOE efforts focused on next generation high-field magnet technology to enable higher energy future proton-proton collider
  - For ILC, current DOE efforts focused on cost reduction R&D—for e.g., nitrogen treatment in SRF accelerator cavity technology: potential for up to 10% cost reductions in 3-5 years, up to 15% in 5-10 years
- **Caveat: Under any fiscal budget constraints in the Energy Frontier program, near-term priorities will aim to support the LHC program as well as R&D for the High-Luminosity LHC upgrades**



U.S. DEPARTMENT OF ENERGY | Office of Science

Montgomery

China


CEPC Site Selections
6
1
2
4
5
3
1) Qinhuangdao, Hebei Province（Completed in 2014）
2) Huangling, Shanxi Province（Completed in 2017)
3) Shenshan, Guangdong Province(Completed in 2016)
4) Baoding (Xiong an), Hebei Province (Started in 2014)
5) Huzhou, Zhejiang Province (Started in March 2018)
6) Chuangchun, Jilin Province (Started in May 2018)

Wang

China

Latest Politics

- Science & Technology is strongly supported by this government
➔ also a "requirement" to local governments (difference seen at Beijing & Shanghai since 2016)
- No difficulty to find local support for the site
- State Council announced in March "Implementation method to support China-initiated large international science projects and plans"
  - Matter, Universe, life science, earth, energy, ...
  - Goal:
    - up to 2020, 3-5 preparatory projects; 1-2 construction projects
    - up to 2035, 6-10 preparatory projects; ? construction projects
  - Possible competitors: ~ 50 ideas collected, Fusion reactor, space program, brain program, Investigation of the Qinghai Tibet Plateau, CEPC, ...
- We are working with the MOST to be included in the roadmap planning, project selection, etc.

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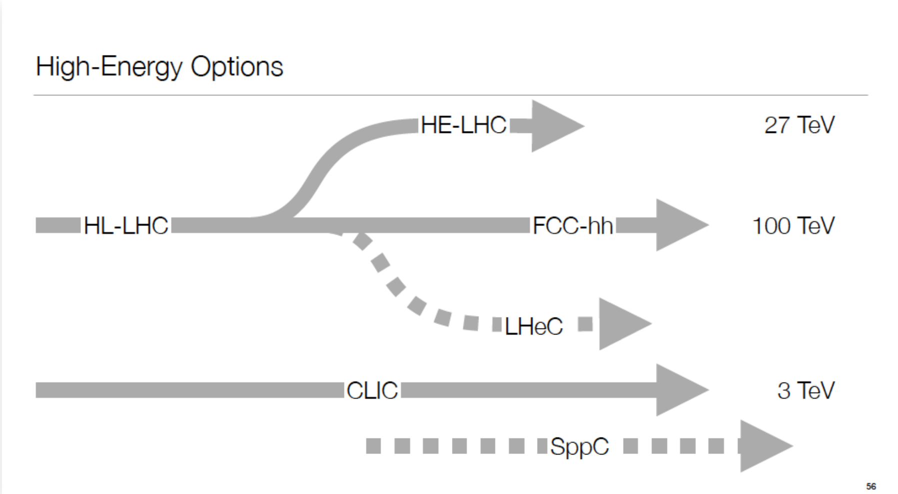
Wang

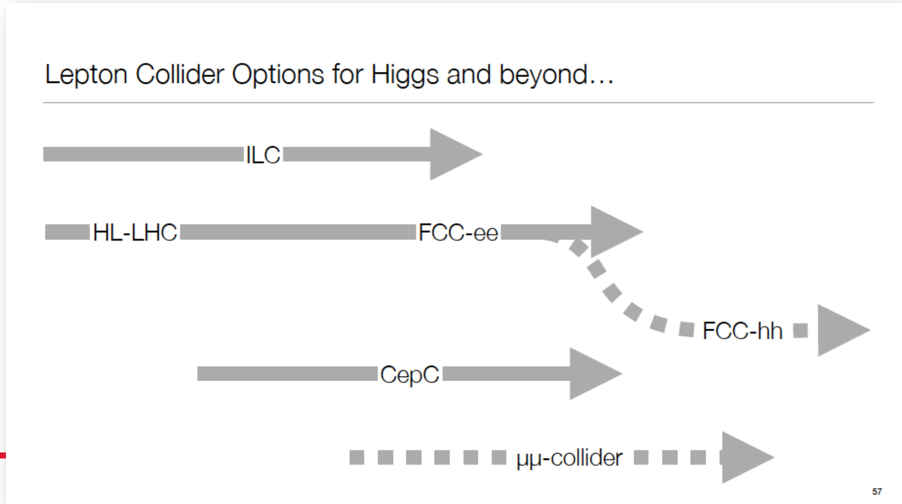
Situation in Europe

There must be more than the Standard Model…

Elsen

The ways ahead





Elsen

Report from LCB

Presentation to the MEXT expert panel

- Presentation at the MEXT expert panel meeting in Tokyo in December 2017:
  - LCB/ICFA statements (LCB Chair)
  - Particle physics programme at CERN (Director of Research and Computing)
  - Some members of the panel were surprised to know that the LCB stated
    - "major contribution" from the host country and
    - "the host country to take initiative" to start discussion with interested countries,

    and asked why the XFEL and FAIR mentioned, rather then the ITER?

- Further explanation to clarify the exact meaning of the LCB position was submitted to the MEXT in May 2019
  - Two relevant points of the FAIR and XFEL for the ILC are
    - the host country is making large contribution
    - the host country declared their wish to host the projects with indicating a level of their contribution and initiated the international negotiation,

  i.e. for the realization of the ILC in the current situation, the host country has to take an initiative to call for an international negotiation and expressing their readiness for a substantial level of contribution as a host country.

Cambridge LCB discussion

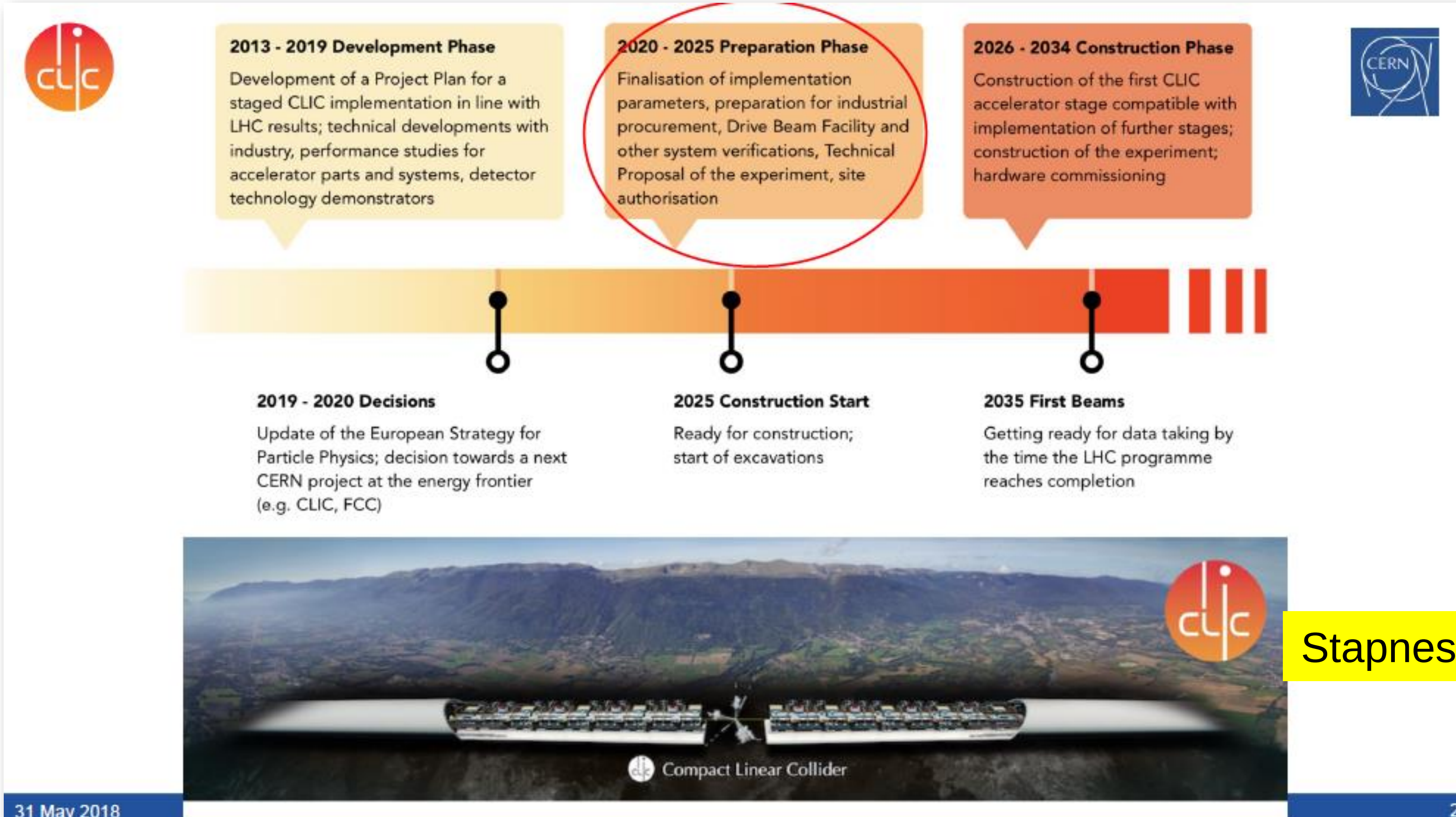
General consensus is that

- without a statement from Japanese government by the end of 2018,
  - the ILC will not likely to be in the 2019 European Strategy update discussion,
  - resources for the ILC R&D in Europe and US would likely diminish and activities could not be maintained,
- and such statement should imply
  - the interest to host the ILC in Japan
  - with an indication for a level of contribution that is substantial
  - readiness to initiate discussion with interested countries.

Nakada

Accelerator Plenary

CLIC



Stapnes

Near Future for CLIC

LINEAR COLLIDER COLLABORATION

While being strategized

Look at common areas in all scenarios – consider key topics or facilities 2019-2023

Cover all existing **existing** agreements with (INFN, UK, Spain, etc) that go into 2020, it also covers CompactLight obligations, ARIES transnational access, LCC

Also consider the key developments needed for eSPS

Wait and see budget 2019-2023
LC design team
Nanobeams and related system tests ATF, DR, etc
CLEAR
High Eff Klystrons/modulator and test-areas, module
Xbox operation and test-structures
Gun and positron studies (AWAKE, CLEAR, Compact Light, eSPS)

Stapnes

31 May 2018 Budget planning 14

CLIC: Preparing for ESU

LINEAR COLLIDER COLLABORATION

European Strategy documents

- **Official short submissions:**
  1) CLIC project (accelerator + detector)
  2) CLIC physics
- **Supporting documents ('yellow reports'):**
  1) CLIC Project implementation Plan 'PiP' (~160pp):
     Accelerator parameters, cost, power, site, staging, construction schedule, summary of main technical issues, preparation phase summary
  2) CLIC preparation-phase (2020-2025) plan (~60pp):
     Critical parameters, status and next steps - what is needed before project construction, strategy, risks + mitigation
  3) Executive summary (~60pp):
     Accelerator, detector, physics
- **Supporting physics papers (H, t, BSM ...), detector R&D reports, technical documentation in EDMS etc.**

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Burrows

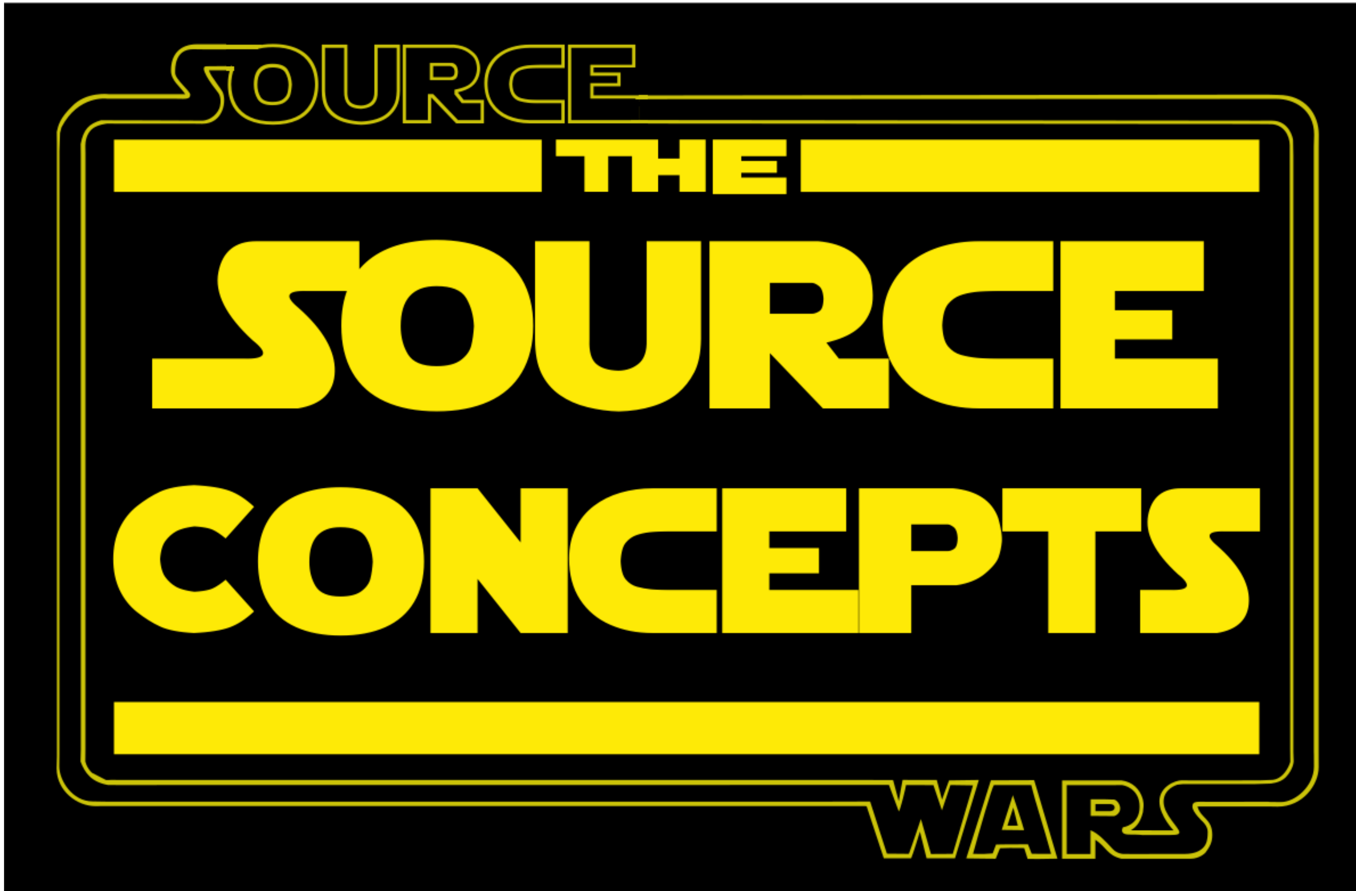
Introduction

- We had a great workshop, at a wonderful venue – thanks to all the organizers!
- A very rich program: 6 tracks with 23 sessions
  - ATF2 and Damping Rings (2 sessions)
  - **Sources (5) + Polarization special session**
  - Green Accelerator (2)
  - **Conventional Facilities & Siting (CFS) (6)**
  - **Superconducting RF (SRF) (4)**
  - RTML and Beam Dynamics (3)
- Sadly missed: ILC Accelerator Design&Integration (ADI), ILC Damping Rings

Apologies to all speakers whose results did not fit into this talk,

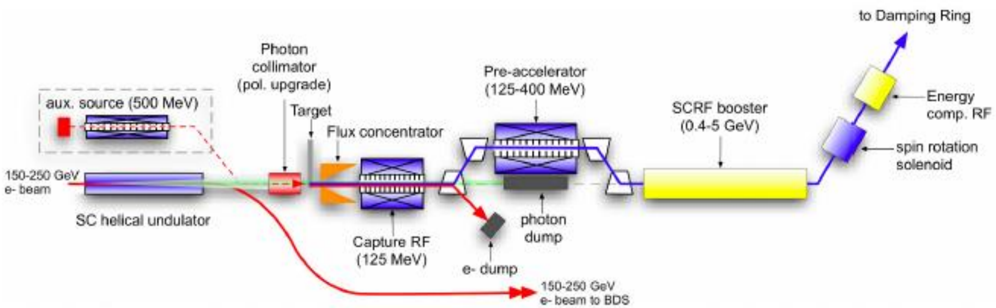
in particular to ATF2 (see K. Kubo's plenary talk), Green Accelerator, RTML&BD, and CLIC in general (but cf. S. Stapnes' and P. Burrowows' plenary talks)!

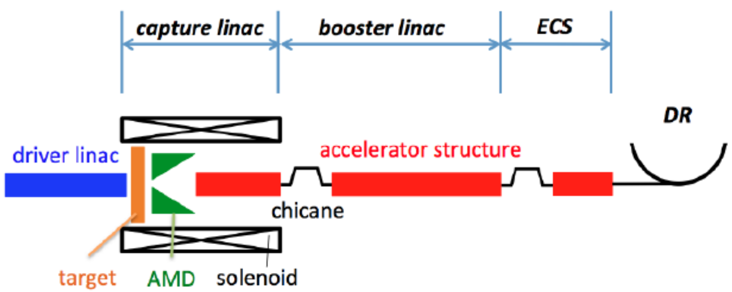
I will show a selection of the many highlights and visions that were presented.


SOURCE
THE
SOURCE
CONCEPTS
WARS

Two Schemes for ILC Positron Source

- Undulator based:
  125GeV electron beam from Main Linac goes through undulator
  -> photons on target produce e+
  - 30% (up to 60%?) positron polarization
  - Requires full energy electron beam
  - Technical issues: target, photon dump
- Electron driven: Dedicated electron accelerator shoots electrons on target
  - No polarization
  - Independent from main electron linac
  - Technical issues: Energy deposition, beam loading





The Report: ~80 Pages

Progress in Positron Source Study

A comprehensive Study Report Published

https://edmsdirect.desy.de/item/D00000001165115

Report on the ILC Positron Source

Positron Working Group

May 23, 2018

Summary

The present report have described the present status and scope of the two schemes of positron production, putting emphasis on the contraversy and/or urgent issues.

The technology status of the undulator and e-driven schemes were summarized in the AWLC2017 at SLAC[63]. It was a result of the discussion within the positron working group. The present status is essentially the same as at AWLC2017. Here, the summary table is reproduced (Table 6.1) with a few updates. (See the reference for the details of the individual components.)

Table 6.1: Summary of the technology status of the two schemes

	Undulator Scheme		e-Driven Scheme	
Target	Further consideration on wheel design, cooling calculation, mechanical performance (magnetic bearing), and Ti-Cu contact needed. Prototype shoud be built.	C	Further test of vacuum seal needed. W-Cu contact must be studied.	B
Matching device	FC has the problems of time-dependent field and PEDD.	D	Improvement from superKEKB and BINP. Design of cooling needed.	B
	QWT: yield marginal. Hardware design still required.	B		
Capture cavity	TDR design almost sufficient	A	Further consideration on thermal deformation and cavity cooling design needed	B
Beam dump	Photon dump still requires detailed design.	C	Beam dump is not an issue but radiation shielding must be studied instead.	B

B Basic partial tests done or known to work. No whole prototype.

C Calculation study only. But no show stopper seen yet.

D Break through needed.

E There is a fatal problem.

A few comments on this table:

- Here, driver beam, booster linac and yield simulation are omitted. These are more or less in the state B or better for both schemes.
- The flux concentrator for the undulator scheme is assigned D. However, as explained in Sec.2.1, the positron yield with QWT is nearly enough, though marginal. Thus, we can eliminate the row for FC of undulator scheme.

Note, however, this table does not mean that every member agrees on the status evaluation of individual items. Some of them suggest to assign severer scores for some items. Re-evaluation of the table is inevitable in the near future by the time to down-select the scheme. But it is more important to make a complete "ToDoList" for each item as stated above.
As shown in the previous section

- The cost of the accelerator components for the two schemes are almost the same.
- The CFS cost of the undulator scheme is higher due to the tunnel longer by ~2 km.
- The power consumption of the e-driven scheme is larger by ~4 MW.

But these are not a decisive factor in the choice.

As the table shows, the technology for neither scheme is ready now. Among the two the e-driven scheme seems to be closer to realization, judging from the present status of prototype development. On the otherhand, the baseline scheme, i.e., the undulator scheme, if feasible, has an advantage of the positron polarization. Therefore, the primary question for the choice of the scheme is

- Is the undulator scheme feasible?
- If so, can the feasibility be firmly verified by the time of design finalization?

We do not know clearly when is the deadline for the decision, but it is not too far, within a couple of years. In this respect of the project schedule we need a guidance from TCMB or LCC.

The working group hope that … ion in the near future.

Yamamoto

2018/5/31 13

Why Write a Positron Source Report?

- „Nomura Report“ about technical feasibility of ILC from 2016
- Report lists several items for both ILC source concepts as critical („**breakthrough needed**“)
- We need to show that we have a (better: 2) working positron source concepts!

Triangle Items

- There is no "cross" item but there are several "triangles"
- Marx modulator
- Undulator source
  - Target (water cooling failed, no prototype for others)
  - Undulator (field accuracy, no beam test)
- e-Driven source
  - No target prototype
  - Detailed design of AMD & booster linac
- Feedback system in Damping Ring (high ADC bit
- Main beam dump (14MW)
  - No prototype
  - Window
  - Safety
  - Possibility of collaboration with CERN being pursue
- Crab cavity
  - No prototype of 9-cell cavity

Yokoya, LCWS2016 Morioka

- The report assigns 4-level ranks for ~30 items of ILC technology
  - ◎ : Double circle: prototype and test done, improvement by small scale R&D
  - ○ : Single circle: prototype and test done, some more R&D needed for mass production
  - △ : Triangle : no prototype, no validation, break through needed
  - × : Cross : basic technology premature

Note: Nomura Report available at (Japanese site!)
http://www.mext.go.jp/b_menu/shingi/chousa/shinkou/038/gaiyou/1374357.htm

„The Table“

- Report contains a table about the „technology status“ – technological maturity
- Was very controvertial within the group!

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Beam dump	Photon dump still requires detailed design.	C	Beam dump is not an issue but radiation shielding must be studied instead.	B

2018/5/29 ALCW2018, Yokoya

8

In this table the status of each component is labeled in five levels:

A Complete model or some prototype exists. Can be finalized if tried.

B Basic partial tests done or known to work. No whole prototype.

C Calculation study only. But no show stopper seen yet.

D Break through needed.

E There is a fatal problem.

„The Table“

- Report contains a table about the „technology status“ – technological maturity
- Was very controvertial within the group!

My personal interpretation:

- Individual grades are controversial, but this is not the point!
- Worst overall grade is „C“:
  „Calculation only. But **no show stopper** seen yet.“
- This is significantly better than Nomura‘s assesment:
  „No prototype. No validation. **Breakthrough needed**.“
- There is no need to reconsider current baseline choice (the undulator source) now or in the immediate future

We are confident that we have two concepts that would work!

A final choice will be made when it is due: not before 2021.

Tabl

Target	Fu de ch be ne bu
Matching device	FC de
	QV wa
Capture cavity	TI
Beam dump	Ph de

2018/5/29 ALCW2018, Yokoya

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led in five levels:

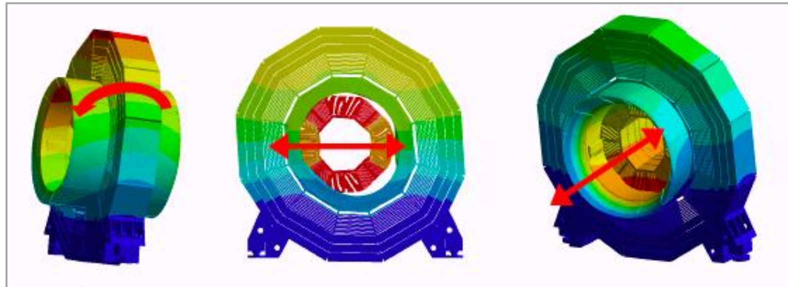
be finalized if tried.

whole prototype.

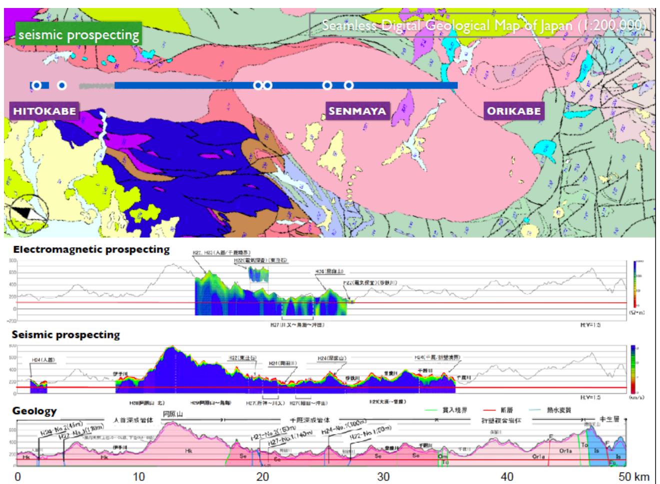
seen yet.

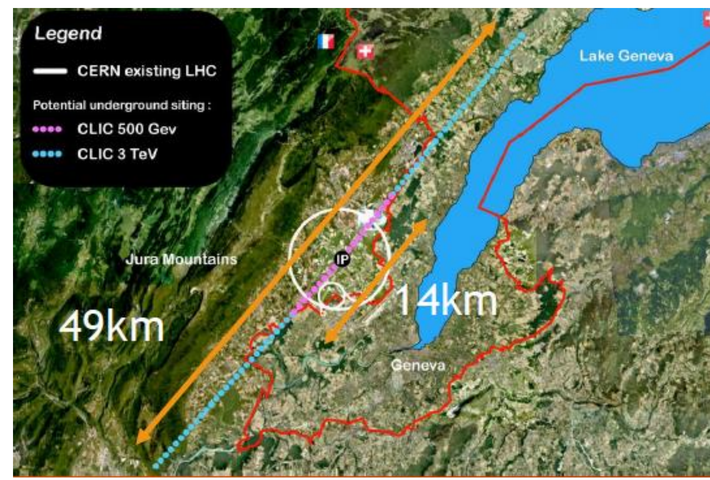
D Break through needed.

E There is a fatal problem.



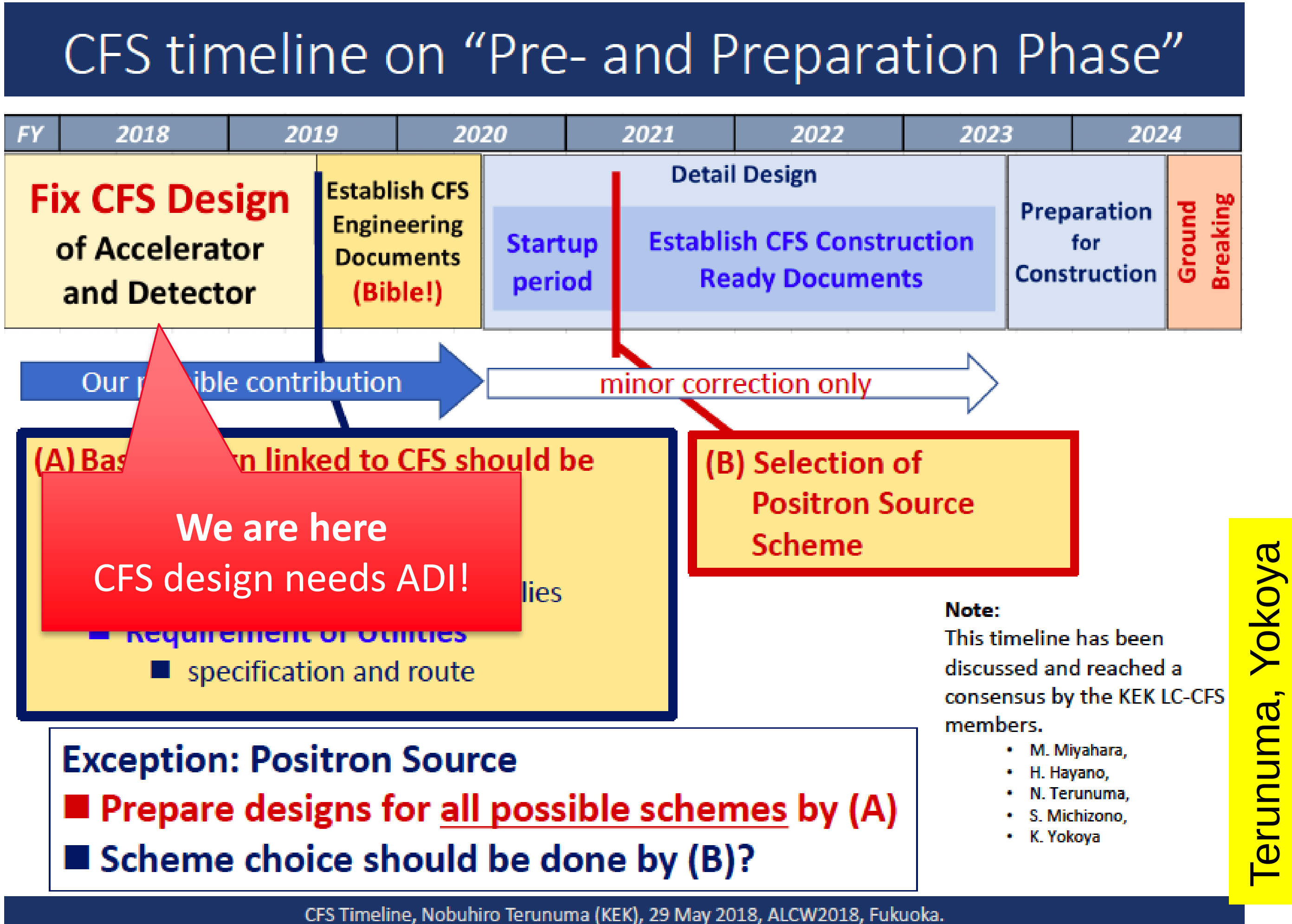
Conventional Facilities and Siting (CFS)



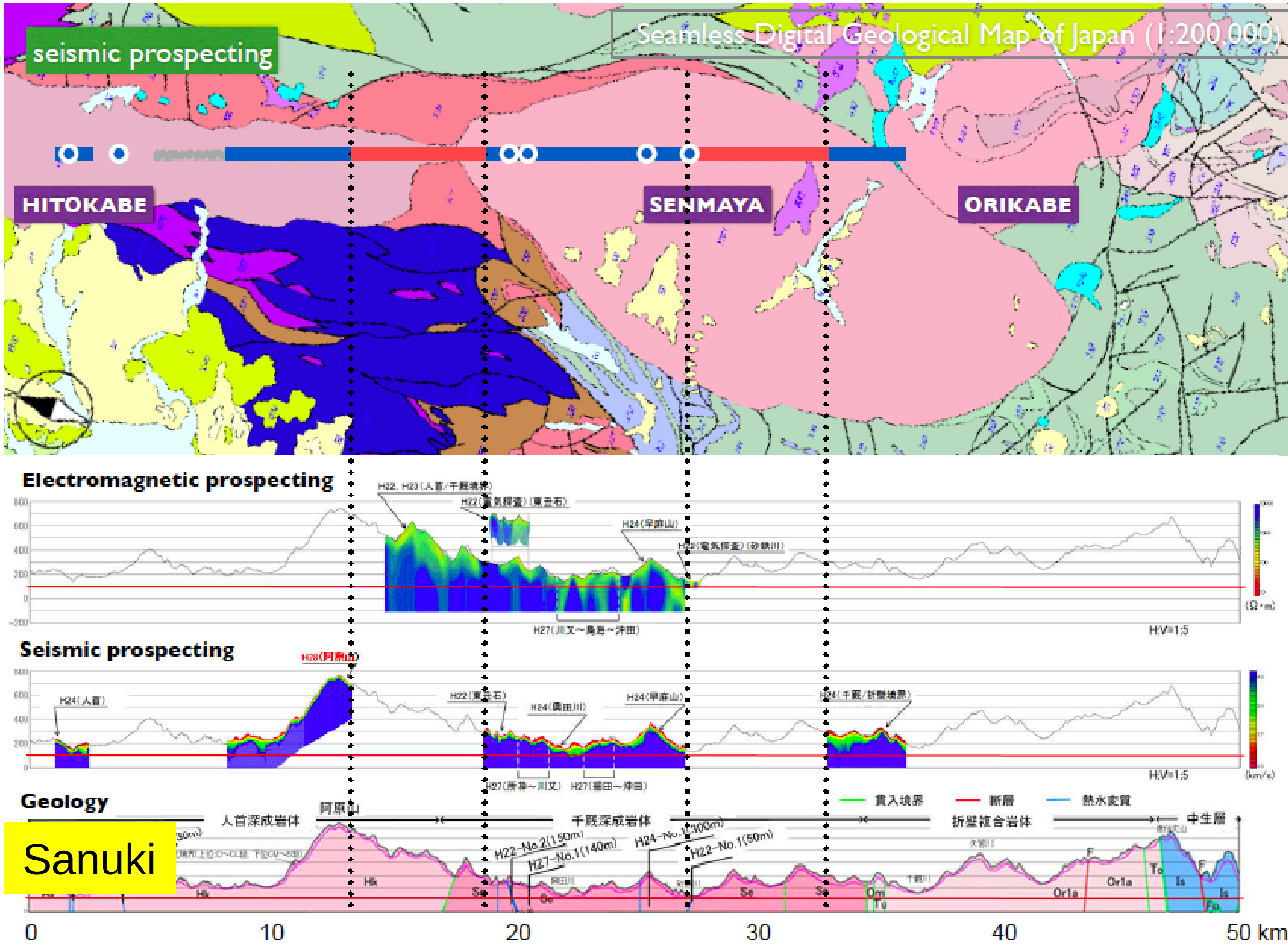


LINEAR COLLIDER COLLABORATION

New CFS Timeline for the ILC

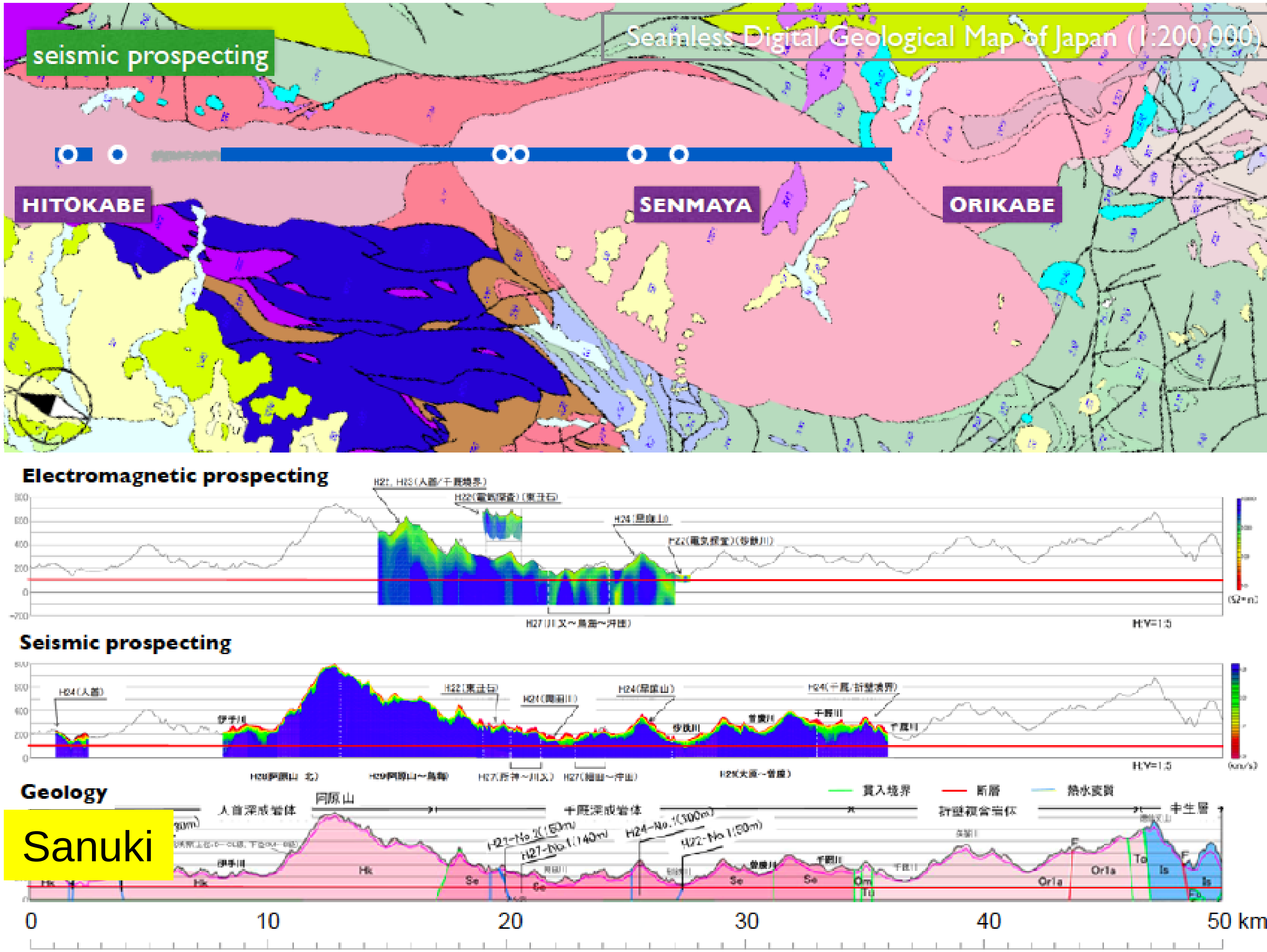


Seismic Survey: Progress in Tohoku



Great progress
In seismic survey
of Kitakami site

Seismic Survey: Progress in Tohoku



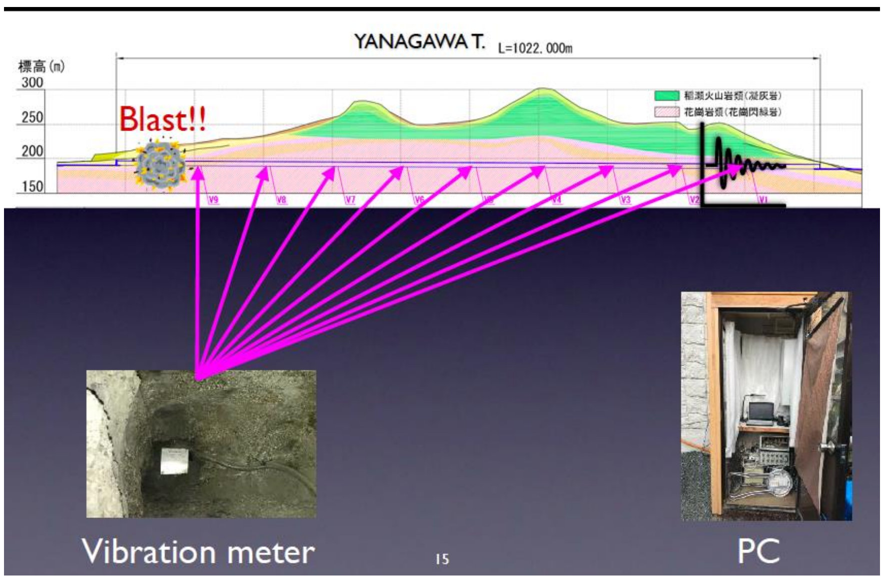
Great progress
In seismic survey
of Kitakami site

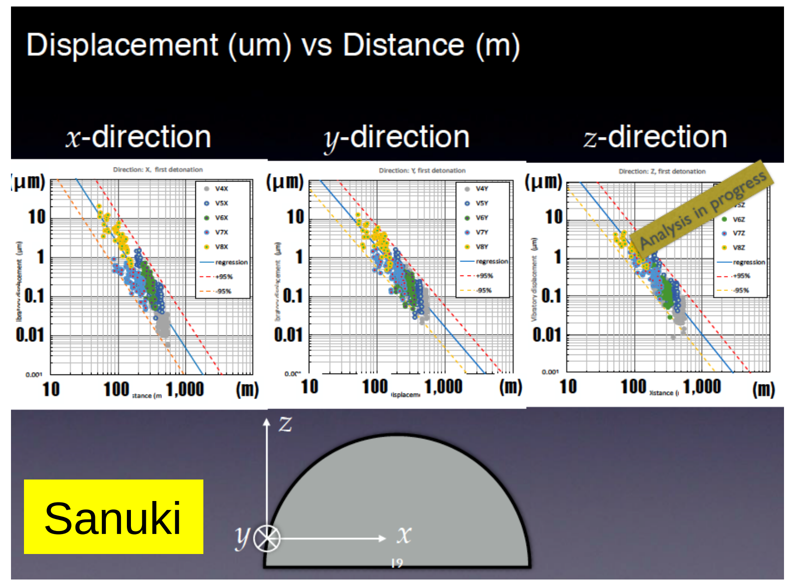
Whole ILC250 site
is now covered

Result is very good

ILC Energy Upgrade: Vibration Issues

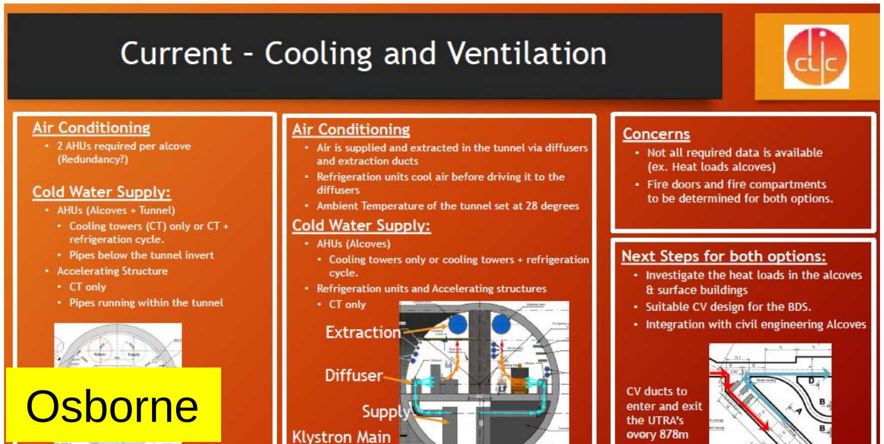
- How much time would an energy upgrade need?
- -> Can the tunnel be extended during operation for an energy upgrade?
- Data taken from road tunnel construction in same geology
- Indicates tunnelling is OK up to ~1000m distrance to operating accelerator
- -> working on energy upgrade is compatible with data taking



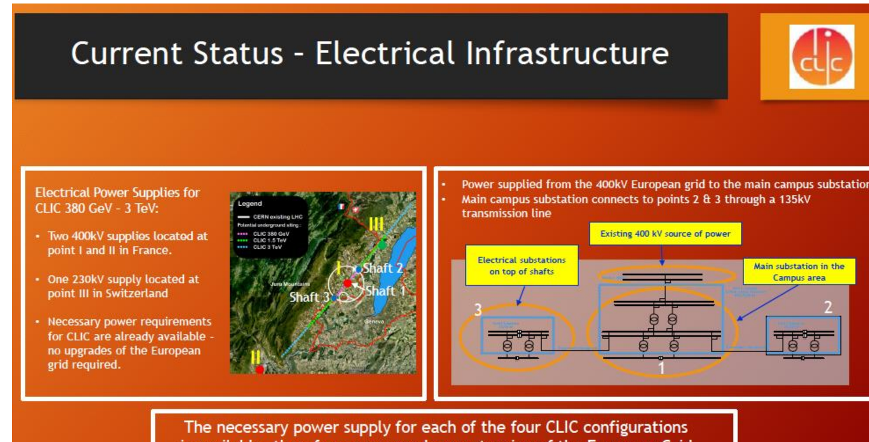


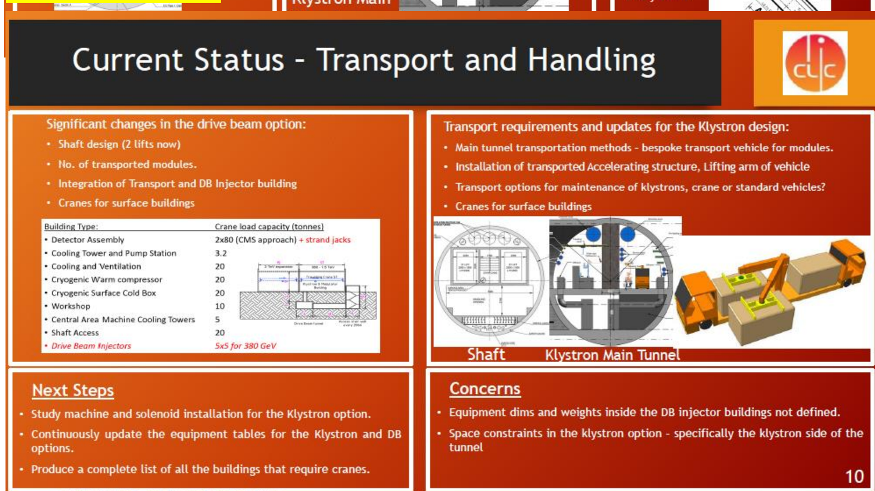
Civil Engineering for CLIC

- Extensive planning for 380GeV CLIC Machine

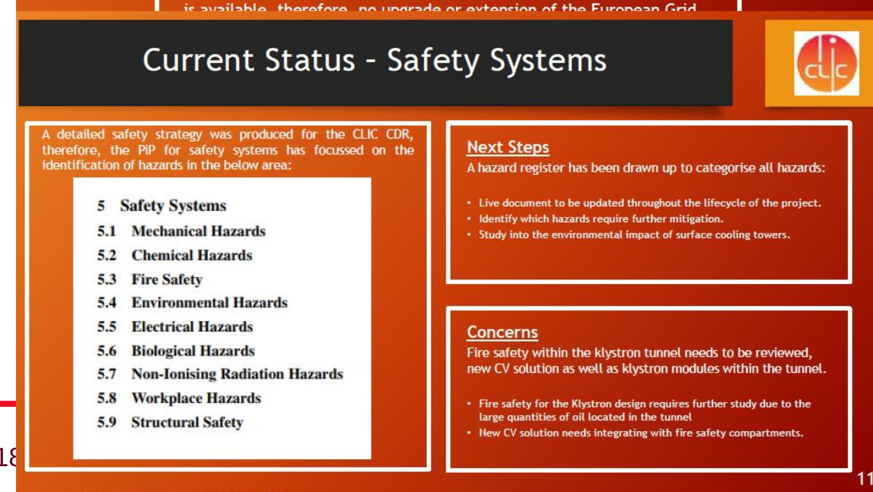


Osborne





/15/2018



Civil Engineering for CLIC

- Extensive planning for 380GeV CLIC Machine
- Resulting in a new cost estimate for the CLIC Project Implementation Plan

Cost Estimate - Civil Engineering

	CDR 500 GeV (CHF)	New 380 GeV Drive Beam (€)	Klystron 380 GeV TBM 10m (€)
Underground Structures	704,673,823*	587,986,135**	884,821,974**
Surface Structures	639,677,291*	218,898,945**	124,898,285566**
Cut & Cover tunnels	Included in "Surface Structures"	131,501,222**	50,834,281**
Site development	88,031,164*	Included in above costs	Included in above costs
Total	1,432,382,278*	938,386,302**	1,060,554,540**
Tunnel Length (km)	14	12	11.6

*Rates for CHF taken from 2010
**Rates for Euros taken from 2016
***This value is for site development



Drive Beam Uncertainties:
1. Shielding wall cost within the Caverns needs to be added to total Cost.
2. CV Ducts could still effect the tunnel cross-section/dia.
3. BDS Cavern and BC2 Caverns need defining.

Klystron Uncertainties:
1. Shielding wall separating the tunnel is based on ILC and could change (currently estimated at 30m Euros).
2. CV Ducts could still effect the tunnel cross-section/dia.
3. An update will be required to include the access points at each UTRC for the services compartment. (could be significant cost increase)
4. More work to be done on the Tunnelling cost for a 10m ID tunnel.

ALCW 31/05/2018 – John Osborne & Matthew Stuart

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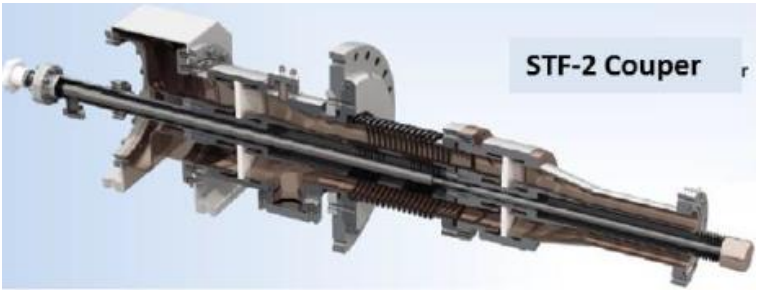
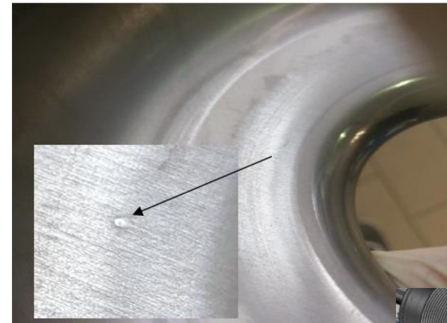
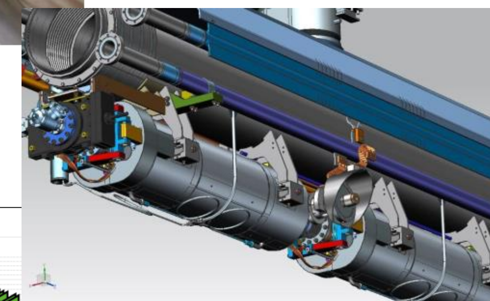
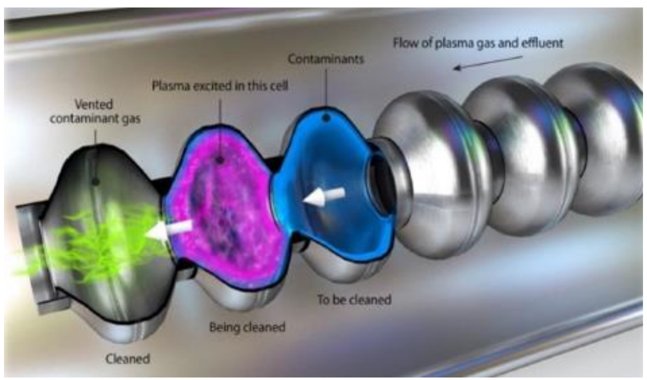
Osborne

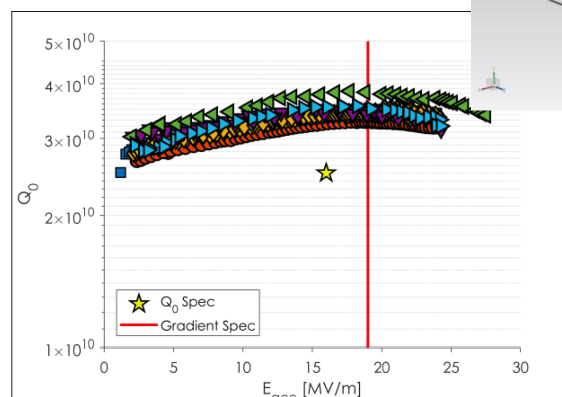




Superconducting RF

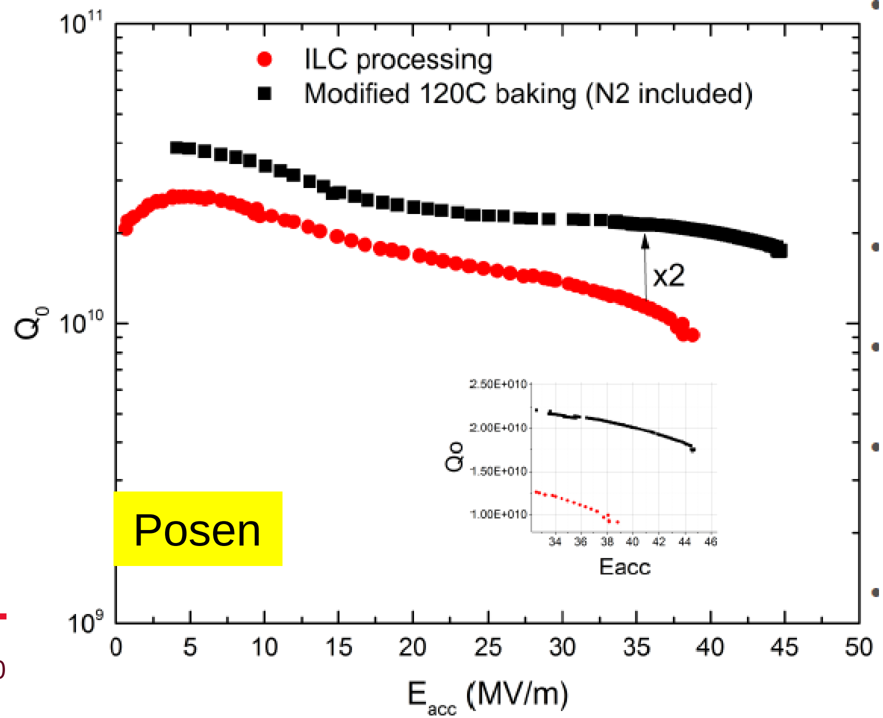






Nitrogen Infusion

- Infusion: Achieve higher gradient, higher Q_0 with „infusion" of Nitrogen in oven (48h at 120C bake), with no electro polishing afterwards.
- Looks like „The holy grail": better and cheaper!
- Pioneered at Fermilab
- Many other labs have tried, with very mixed results so far
  -> Some news at this conference
- The „why" is still under debate,
  -> attacked vigorously

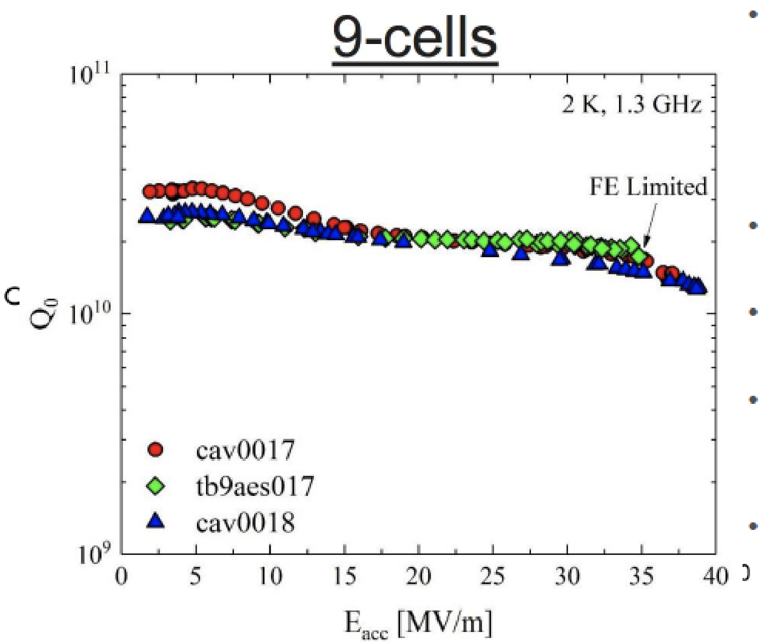


Infusion: News from Fermilab

- Long awaited: 9-cell cavities with infusion -> confirm single cell results!

Cavity performance progress at FNAL: "standard" vs "N infused" cavity surface treatment

A. Grasselino



Increase in Q by > a factor of two
Increase in gradient ~15%

- FNAL recently demonstrated a new treatment, which utilizes "nitrogen infusion", achieving
  45.6 MV/m → 194 mT
  with Q ~ 2×10^{10}
- Systematic effect observed on several single cell cavities
- FNAL has now successfully applied it on three nine cell cavities
- Jlab, KEK have reproduced similar results on single cell cavities with Q >2e10 at 35 MV/m
- R&D work towards:
  - Best recipe for higher Q at high gradient
  - Robustness of process

A Grassellino *et al* 2017 *Supercond. Sci. Technol.* 30 094004

Posen

Fermilab

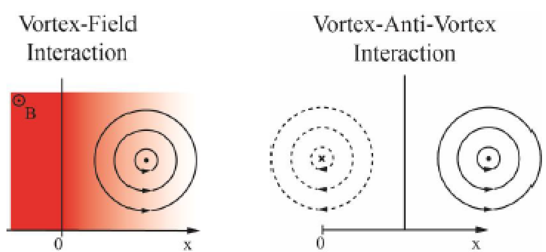
„From Alchemy to Chemistry“

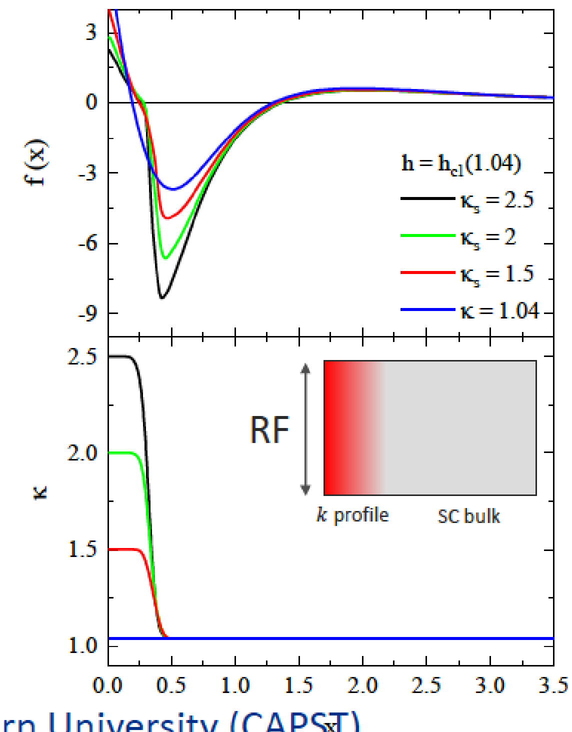
A. Grasselino

Theoretical Understanding -Impurity profile: high gradients

Numerical calculation of Bean-Livingston barrier from GL equations predicts:

- ***High κ layers*** at the surface ***delay vortex penetration***
- Higher force pushing vortices out of the superconductor





M. Checchin, FNAL, Ph.D. Thesis (2016)
T. Kubo, Supercond. Sci. Technol. 30, 023001 (2017)
W. Ngampruetikorn, NU, TTC FNAL (2017) , in submission

Work in partnership with Northwestern University (CAPST)

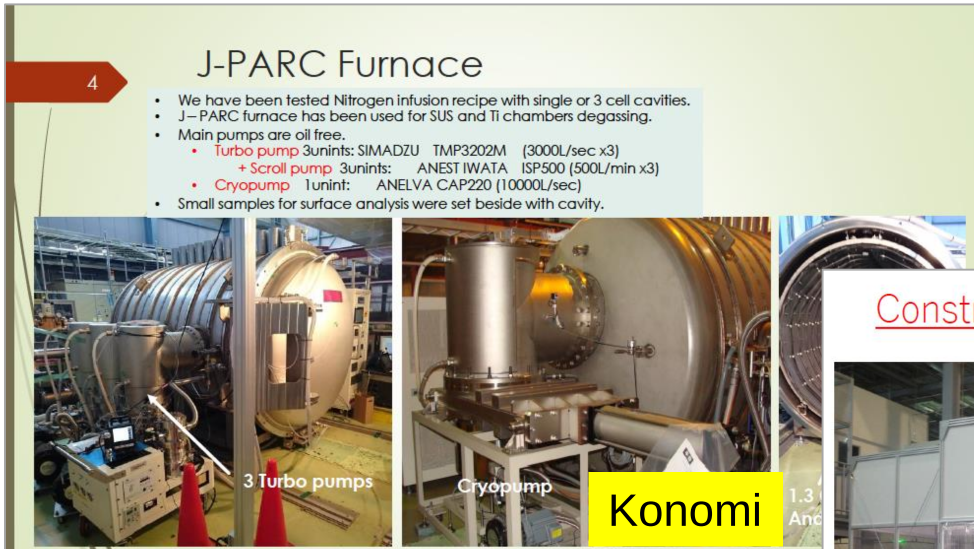
Fermilab

28 Sam Pos Posen 5/31/2018

LINEAR COLLIDER COLLABORATION

Furnace is important...

- Many reports stress importance of very clean furnace
- KEK made experiments with JPARC furnace, now builds ist own



... and lead to success

- KEK reports several successful runs (and several unsuccessful...)

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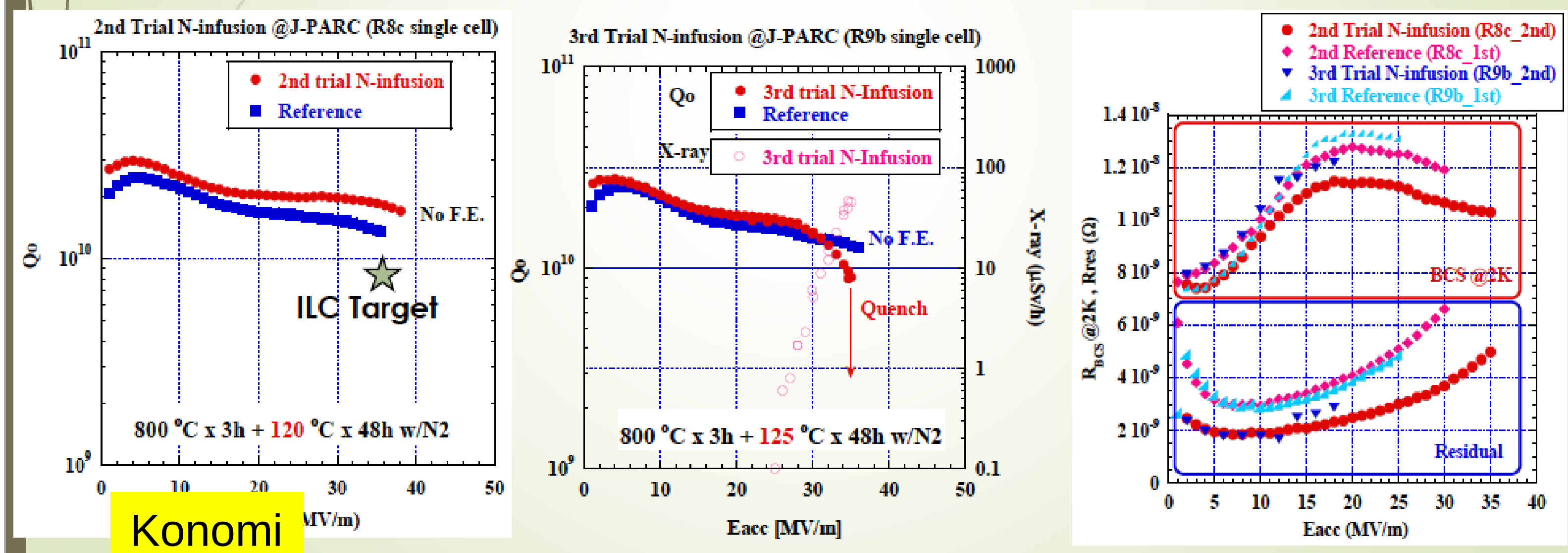
Success of N-infuison

- Both 2nd and 3rd trial N-infusion was succeeded.
- 2nd trial (120 °C N-infusion): Gradient was improved 5% and Q_o was improved 30%.
- 3rd trial (125 °C N-infusion): Unfortunately Q value at high gradient was degrader by field emission.
- Both residual resistance were lowered than reference and BCS resistance of 2nd trial were lower than reference.

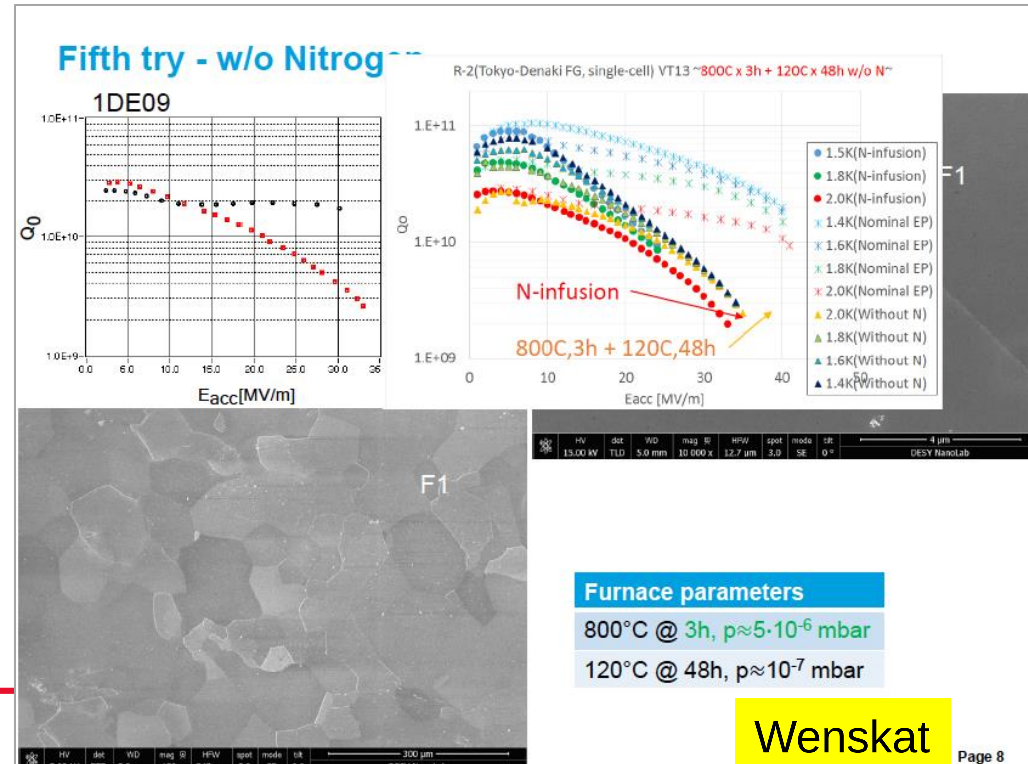


At DESY: Jury is Still Out

- DESY has conducted a number of tests
- So far no success, but:
- Many interesting observations (precipitates, effect (or not?) of nitrogen)
- Works intensively on material samples (are they representative for cavity?)

Series production requires an understanding of which parameters are relevant to control the result.

Clearly we are not there yet.



Series Production of Cavities

- Reports on LCLS-II Cavity Production from SLAC and JLAB
- Diligent QA and detective work are needed
- Problems often have more than one cause!

Residual Resistance After Recipe Change

SLAC

After Increasing Bulk EP and Degas Temperature
R_{res} is consistently ~2 nΩ

Gonella

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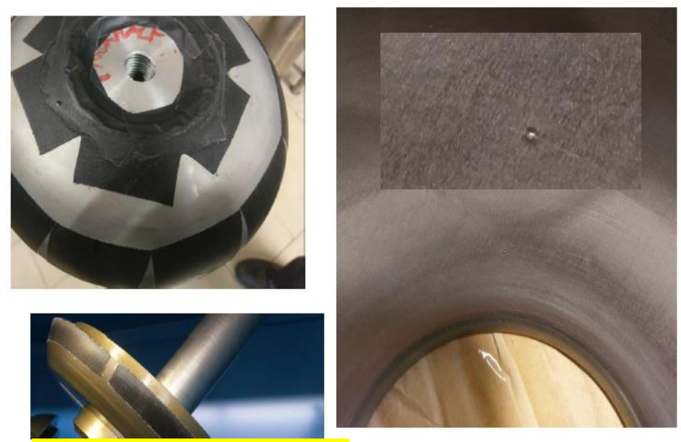
Tape on re-stamping dies found



- Tape was being used on re-stamping and holding facture to reduce the change of scratching.
- Embedded metal flakes found of the edge of the tape, which would inturn press into the inner RF surface
- Embedded material defects found on half-cells at the edge of the tape location.

Palczewski

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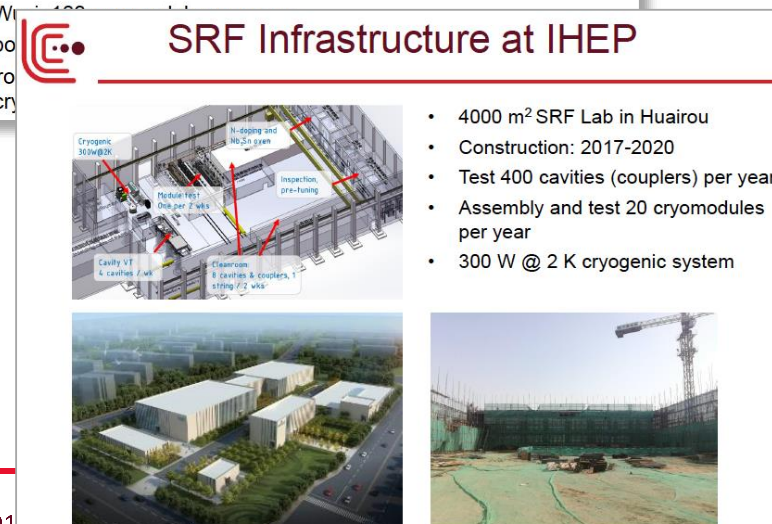
Jefferson Lab

New Customers -> new Vendors

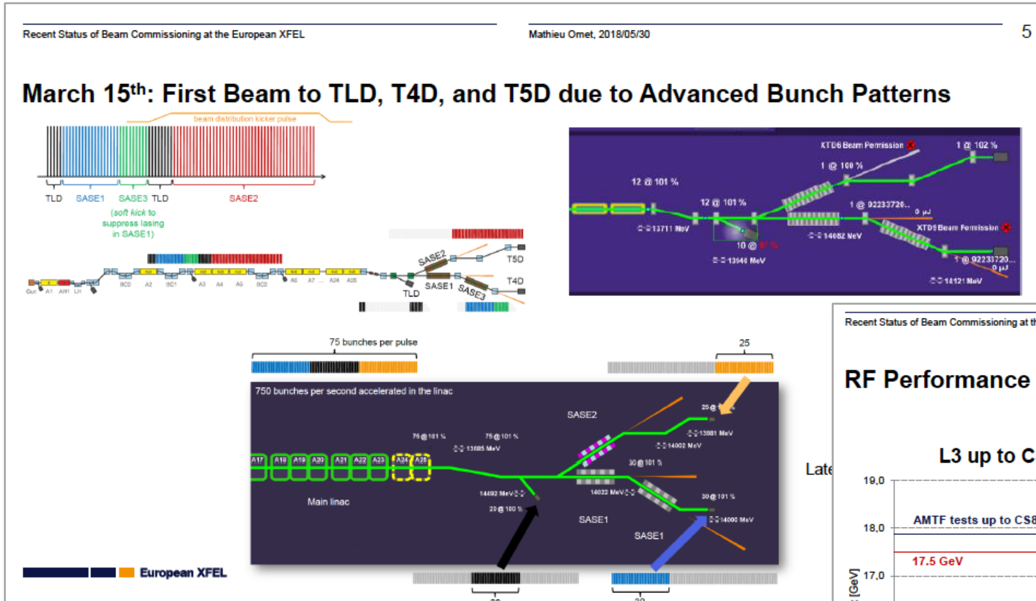
- A new customer: Shanghai Coherent Light Source SCLS will use 600 cavities -> new capabilities in China

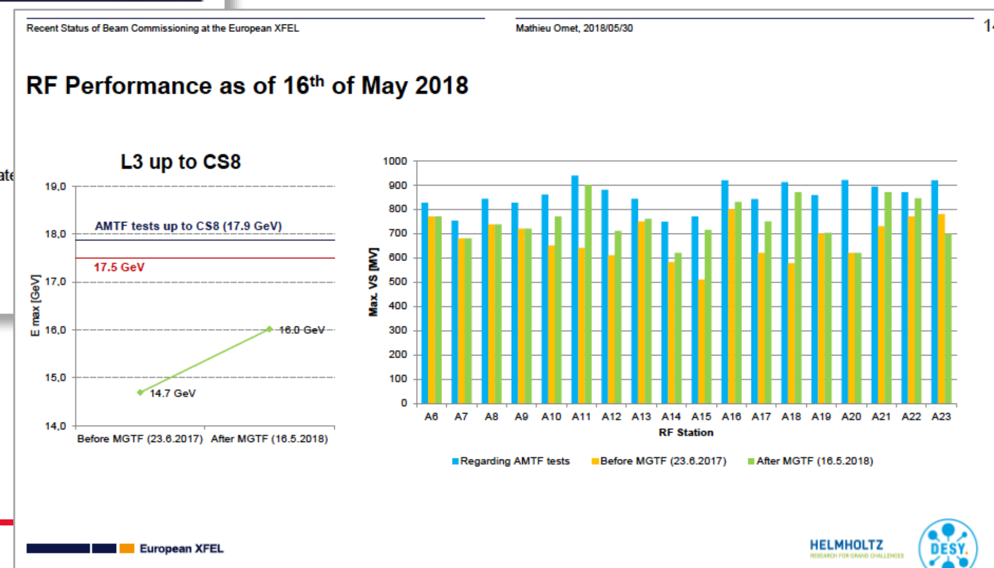


Zhai

XFEL Operation

- Successful turn-on: Europen XFEL in user operation
- Maximum Gradient Task Force set up to push modules to their limit





Omet

Summary

- My personal impression: „Die Ruhe vor dem Sturm.“
- Not much activity in ILC accelerator planning (except positron source!)
- CLIC prepares for European Strategy
- R&D effort in SCRF continues
- All are waiting if Japanese Government finally moves