
# ILC Machine Status and Energy Staging Scenarios

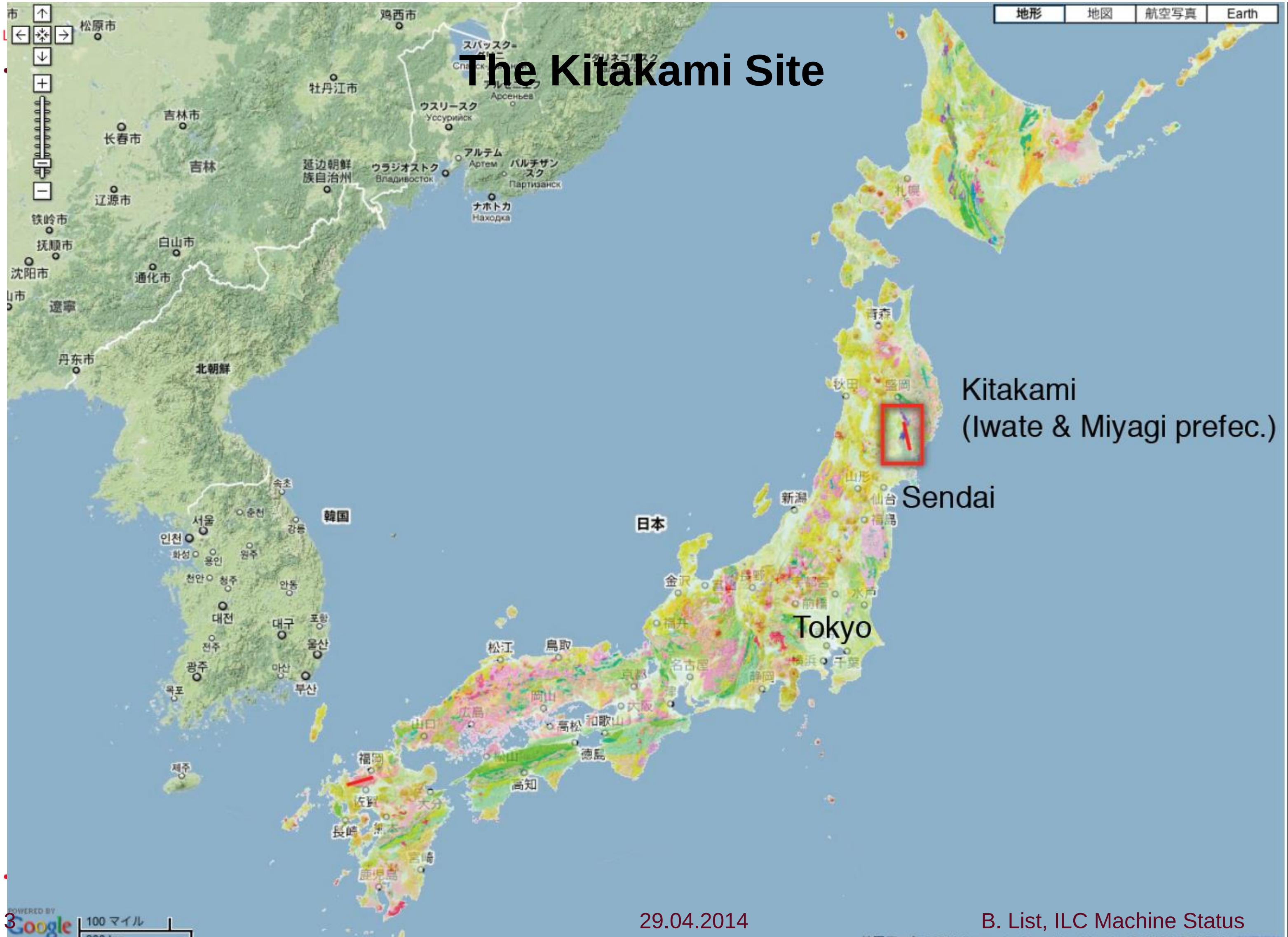
**Helmholtz Alliance Linear Collider Forum**
**Bonn, April 29, 2014**

**Benno List, DESY**

# Outline of for this talk

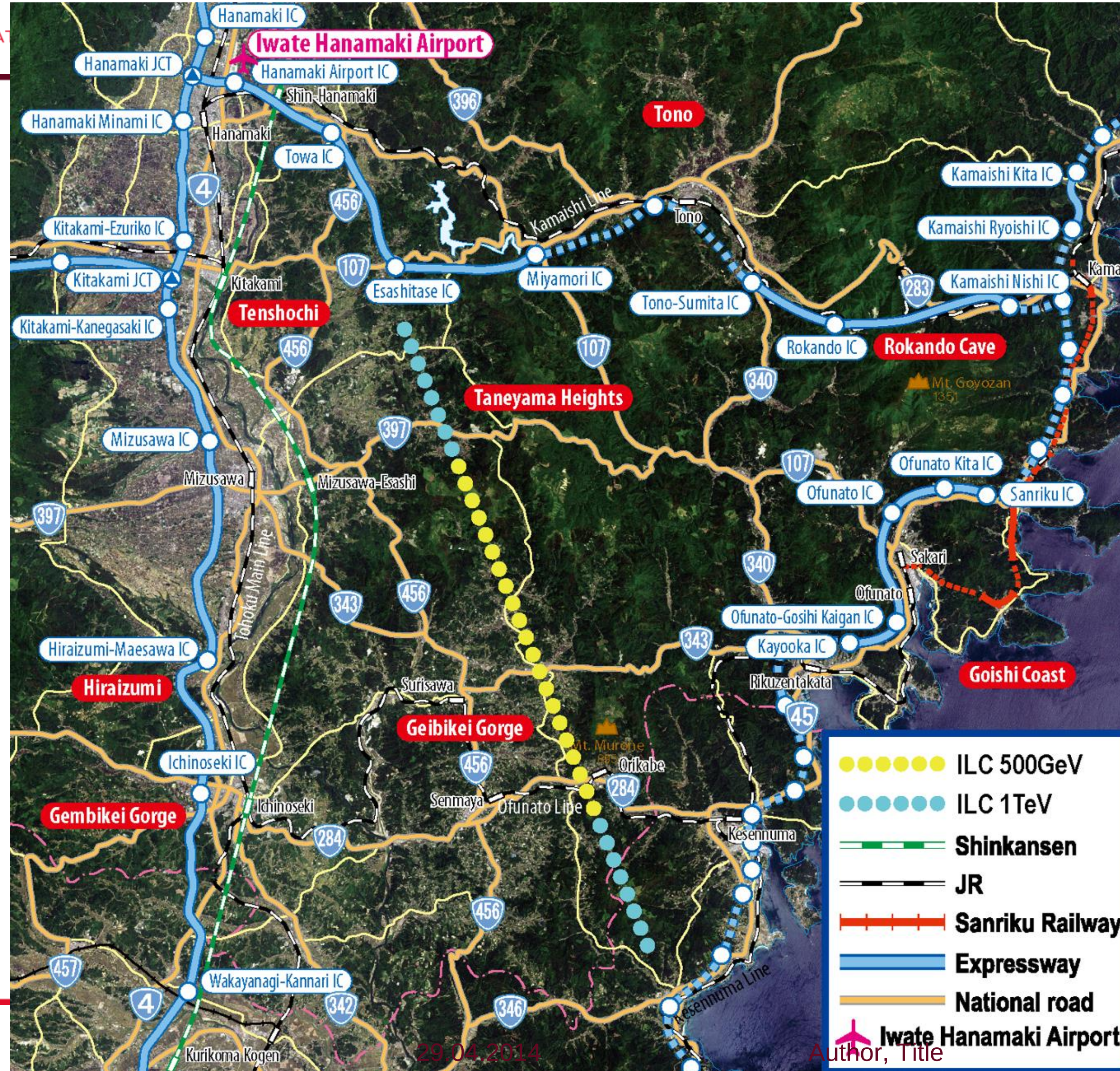
- The proposed site in Kitakami
- Plans for the pre-construction phase, current activities
- Fixing the Interaction Point location:
  horizontal vs. vertical access to experimental hall
- Fixing the length: energy and gradient
- Scenario for a 250GeV first stage
- Outlook

# The Kitakami Site




T. Sanuki

# Kitakami Site

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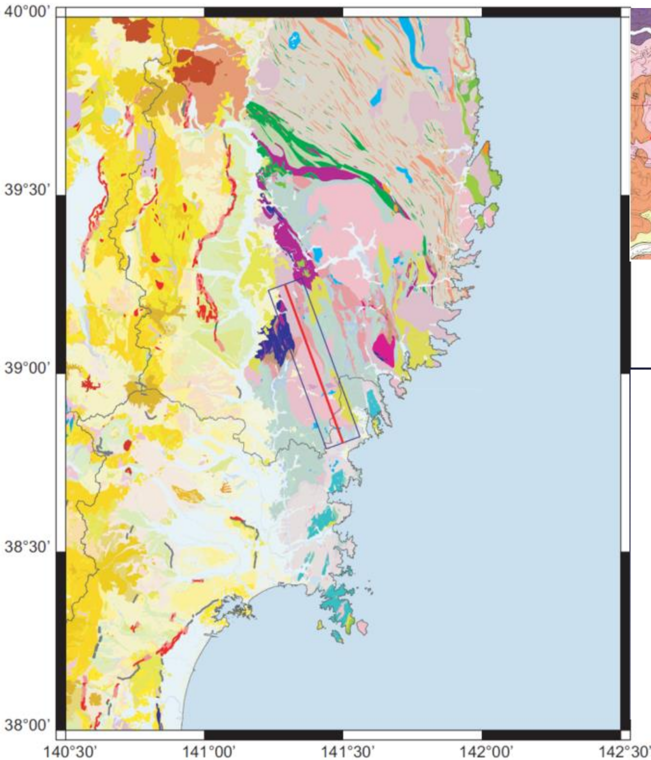
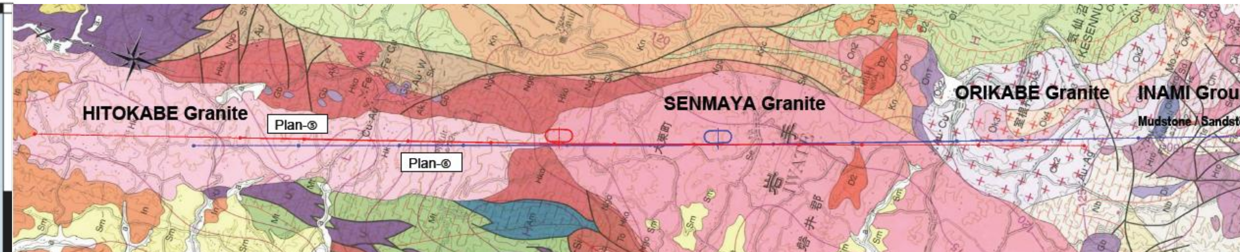
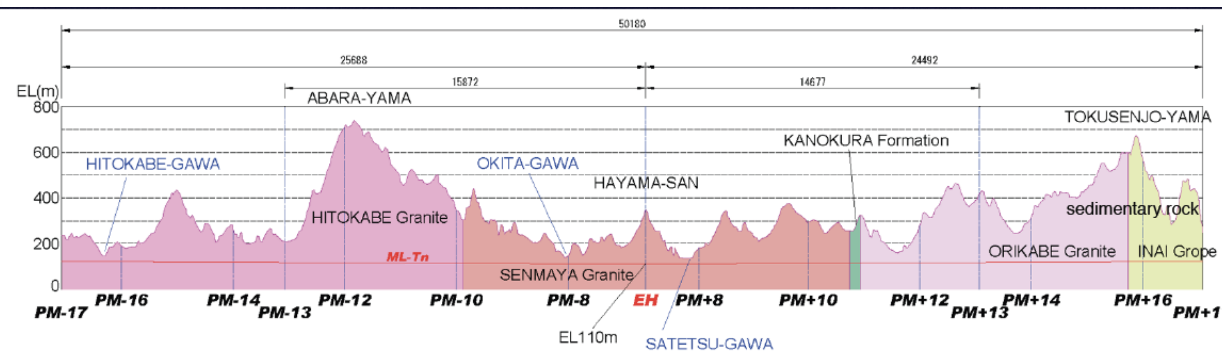
# Geology and Topography

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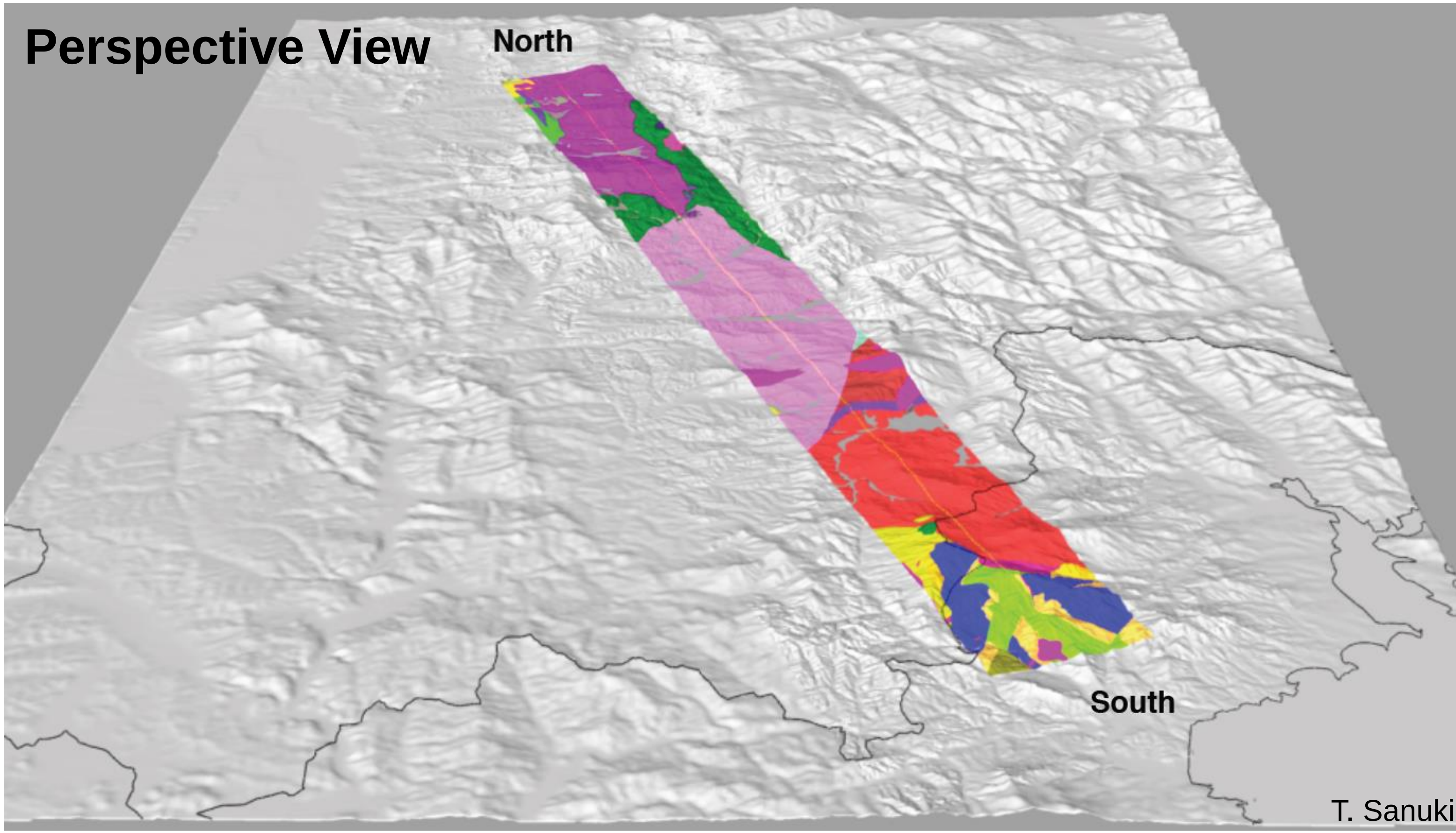
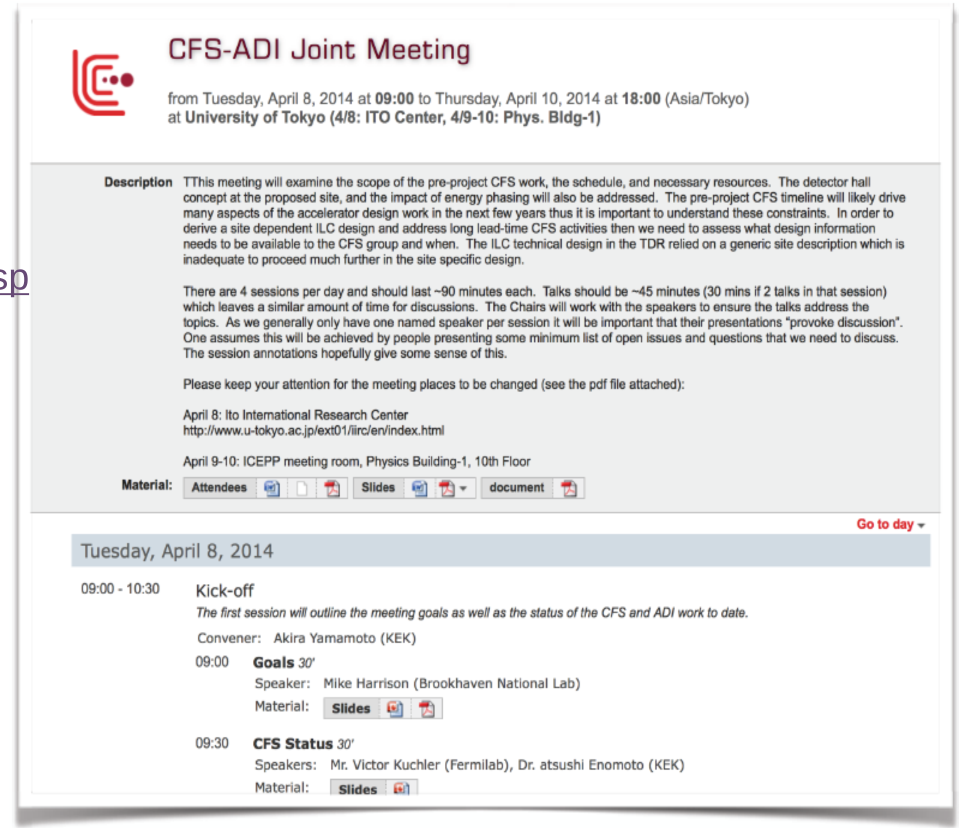

Perspective View
North
South
T. Sanuki

# Candidates for the Interaction Point location

# Current / Recent Activities

- April 8-10: Workshop in Tokyo between CFS (Conventional Facilities & Siting) and ADI (Accelerator Design & Integration) groups
- Agenda: https://agenda.linearcollider.org/conferenceDisplay.py?confId=6342
- Focus: Pre-construction plan for the Kitakami site
- 24 participants, 50/50 international/Japan



CFS-ADI Joint Meeting

from Tuesday, April 8, 2014 at **09:00** to Thursday, April 10, 2014 at **18:00** (Asia/Tokyo)
at **University of Tokyo (4/8: ITO Center, 4/9-10: Phys. Bldg-1)**

**Description** TThis meeting will examine the scope of the pre-project CFS work, the schedule, and necessary resources. The detector hall concept at the proposed site, and the impact of energy phasing will also be addressed. The pre-project CFS timeline will likely drive many aspects of the accelerator design work in the next few years thus it is important to understand these constraints. In order to derive a site dependent ILC design and address long lead-time CFS activities then we need to assess what design information needs to be available to the CFS group and when. The ILC technical design in the TDR relied on a generic site description which is inadequate to proceed much further in the site specific design.

There are 4 sessions per day and should last ~90 minutes each. Talks should be ~45 minutes (30 mins if 2 talks in that session) which leaves a similar amount of time for discussions. The Chairs will work with the speakers to ensure the talks address the topics. As we generally only have one named speaker per session it will be important that their presentations "provoke discussion". One assumes this will be achieved by people presenting some minimum list of open issues and questions that we need to discuss. The session annotations hopefully give some sense of this.

Please keep your attention for the meeting places to be changed (see the pdf file attached):

April 8: Ito International Research Center
http://www.u-tokyo.ac.jp/ext01/iirc/en/index.html

April 9-10: ICEPP meeting room, Physics Building-1, 10th Floor

**Material:** Attendees Slides document

Go to day

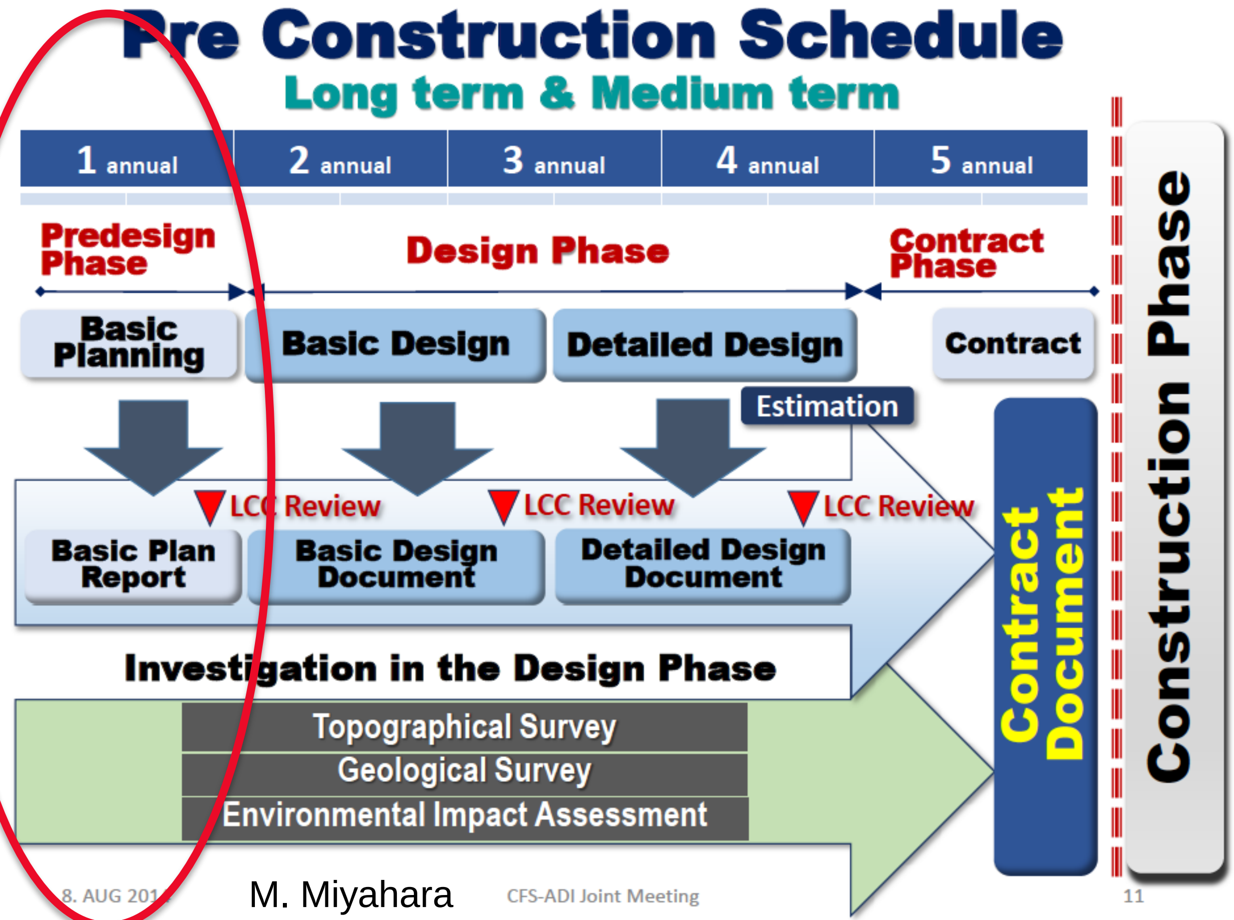
Tuesday, April 8, 2014

09:00 - 10:30 Kick-off
*The first session will outline the meeting goals as well as the status of the CFS and ADI work to date.*
Convener: Akira Yamamoto (KEK)

09:00 **Goals** *30'*
Speaker: Mike Harrison (Brookhaven National Lab)
Material: Slides

09:30 **CFS Status** *30'*
Speakers: Mr. Victor Kuchler (Fermilab), Dr. atsushi Enomoto (KEK)
Material: Slides

We are here, but need more funds in Japan



# Pre Construction Design Work

## Civil Engineering Design

| WORK SCOPE TABLE by every phase | | | |
|---|---|---|---|
| | **Basic Planning** | **Basic Design** | **Detailed Design** |
| **Facility Arrangement** | **R** | **OR** | **NR** |
| | Determination of<br>- IR point, Access system<br>- BL Route & Elevation | Revision of<br>- IR point, Access system<br>- Site & Access portal | - Minor modifications of the basic design |
| **Shape & Dimension** | **R** | **OR** | **NR** |
| | Determination of<br>- Cross Section Shape<br>- Basic Dimension | Revision of<br>- Cross section Shape<br>- Whole Dimension | - Minor modifications of the basic design |
| **Structure & Materials** | **-** | **OR** | [illegible] |
| | | Structural plannir<br>- Load condition,<br>- Seismic Design p | [illegible] |
| **Schedule & Cost** | **R** | **NR** | [illegible] |
| | - Assumption Schedule<br>- Outline Cost Estimation | Trial Estimation<br>- Direct Cost, Unit | [illegible] |

**Legend:** **R**=Required **OR**=Optional Required **NR**=Not Required

8 AUG 2014 CFS-ADI Joint Meeting 5

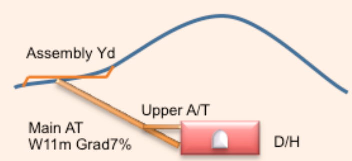
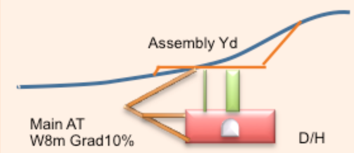
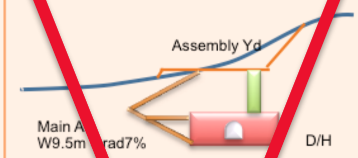
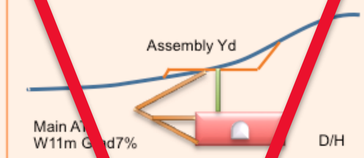
End of 2014:

IR location ±100m
Machine end points ±300m

Masanobu Miyahara

# Options studied

Access scheme (horizontal or vertical) determines location

| Baseline | Hybrid-A | Hybrid-B | Hybrid-C |
|---|---|---|---|
|  |  |  |  |
| • 1 HT (11x11m 7%grad)<br>• Detector assembling is inside of DH | • 1 HT (8.0x7.5m 10%gradl)<br>• 2 VS (D18m, D10m)<br>• Detectors assembling is on-ground. | • 1 HT (9.5x9.0m 7%gradl)<br>• 1 VS (D18m)<br>• ILD assembling on-ground<br>• SiD inside D/H | • 1 HT (11x11m 7%grad)<br>• 1 VS (D10m)<br>• Detector assembling is inside of DH |
| • UT lines in DR/AT | • UT lines in UT shaft | • UT lines in Main shaft | • UT lines in UT shaft |
| • DH 175,000m3<br>• L144m H42m W25m | • DH 128,000m3<br>• L108m H42m W25m | • DH 165,000m3<br>• L134m H42m W25m | • DH 175,000m3<br>• L144m H42m W25m |
| • Heavy lowering system non | • Heavy lowering system necessary | • Heavy lowering system necessary | • Heavy lowering system non |
| • Location of DH and assembly yd. can be selected individually. | • Assembly hall is above D/H | • same as on the left | • same as on the left |
| • Human pass way :car<br>• Machine and materials tunnel by vehicles | • Human pass way :elevator<br>• Machine and materials tunnel by vehicles | • Human pass way :elevator<br>• Machine and materials ILD:VS HT , SiD:HT | • Human pass way :elevator<br>• Machine and materials tunnel by vehicles |
| • Environmental impact will be smaller during construction. | • Noise reduction | • same as on the left | • same as on the left |
| • Evacuation ways Main AT and DR HT. | • same as on the left | • same as on the left | same as on the left |

Y. Nisimoto, J-Power

# (My personal) summary of the situation in Japan

- Japan is really serious about the ILC, but nothing is decided yet
- Planning resources very limited till FY 2015 (April 2015)
- Pre-construction phase is 5 years – construction could start 2019/20
- Detailed investigations (geology and environmental impact) have to start as soon as money is available
- This requires decisions on
  - Location of IP / experimental hall
  - Total length of accelerator

  by the end of **this year**

# Staging

**All the world's a stage, and we are merely players in it…**

# A Remark

- A common misconception from the circular collider days:
  Even a little more energy costs a lot of money and watts,
  and reduces performance (lumi, beam lifetime, availability)
- This is not true for a linear collider!
- At a linear collider:
  a little more energy costs a little more money and a little more watts,
  at equal or improved performance (lumi goes up with E_beam)
- For a helical undulator source:
  Around its design threshold energy, higher ("drive" beam) energy drastically improves performance (more production margin)
- This means: The best operating energy for a Linear Higgs Factory is **not necessarily** "as close to threshold as possible", in contrast to a circular machine! -> 270GeV may be easier than 235GeV
- And: a 250GeV machine neither saves a huge fraction of money, nor does it produce a lot of luminosity easily! It is not a "Higgs factory"

# Motivation for a 250GeV 1st Stage

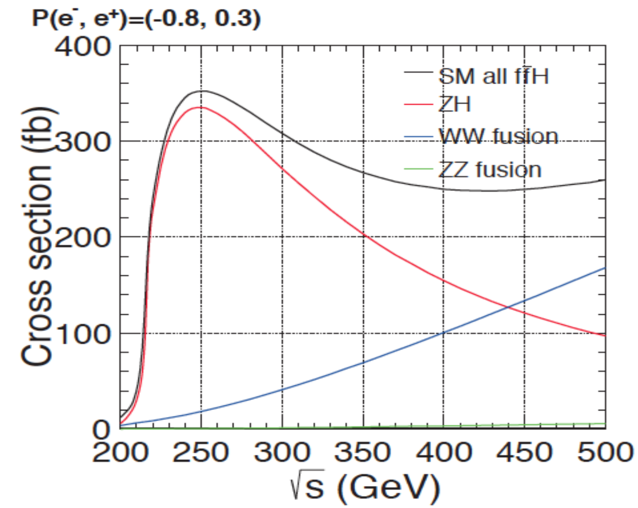
- Higgs discovery triggered interest in ILC as Higgs-Factory
- Higgs Production maximal around 235 GeV
- Save initial cost and time by starting at ~250 GeV
- This was proposed by JAHEP in Oct 2012

Questions:

- What is the expected performance at 250?
- How much money and time can one save?

Needs an Answer to this Question:

- What is the “first stage” exactly?



# Proposal for Phased Execution of the ILC Project

The Japan Association of High Energy Physicists (JAHEP) accepted the recommendations of the Subcommittee on Future Projects of High Energy Physics(1) and adopted them as JAHEP's basic strategy for future projects, in March 2012. Later in July 2012 a new particle consistent with a Higgs Boson was discovered at LHC, while in December 2012 the Technical Design Report of the International Linear Collider (ILC) will be completed by the worldwide collaboration.

On the basis of these developments and following the subcommittee's recommendation on ILC, JAHEP proposes that ILC shall be constructed in Japan as a global project based on agreement and participation by the international community in the following scenario:

(1) Physics studies shall start with precision study of "Higgs Boson" and will evolve into studies on top quark, "dark matter" particles, and Higgs self-couplings, by upgrading the accelerator. A more specific scenario is as follows:

(A) A Higgs factory with a center-of-mass energy of approximately 250 GeV shall be constructed as a first phase.

(B) The machine shall be upgraded in stages up to a center-of-mass energy of ~500 GeV, which is the baseline energy of the overall project.

(C) Technical extendability to a 1 TeV region shall be secured.

**ILC = Global Project**

(2) A guideline for shares of the construction costs is that Japan covers 50% of the expenses (construction) of the overall project of a 500 GeV machine. The actual shares, however, should be left to negotiations among the governments.

(a translation of the official JAHEP statement, Oct 2012)

Slide: Toshi Mori, at LCWS 12, Arlington, TX
JAHEP statements: http://www.jahep.org/office/doc/201202_hecsubc_report.pdf
update: http://www.jahep.org/office/ doc/201210_ILC_staging_e.pdf

# Scope: What is the first stage exactly?

Report has to make some basic assumptions

based on JAHEP Statement:

- Running at 250GeV for Higgs production (“Higgs factory”)
- Machine shall be upgraded to ~500GeV
  -> Build tunnel for full (500GeV) machine right away
- Machine shall be extensible to 1TeV
  -> Keep the full-scale BDS

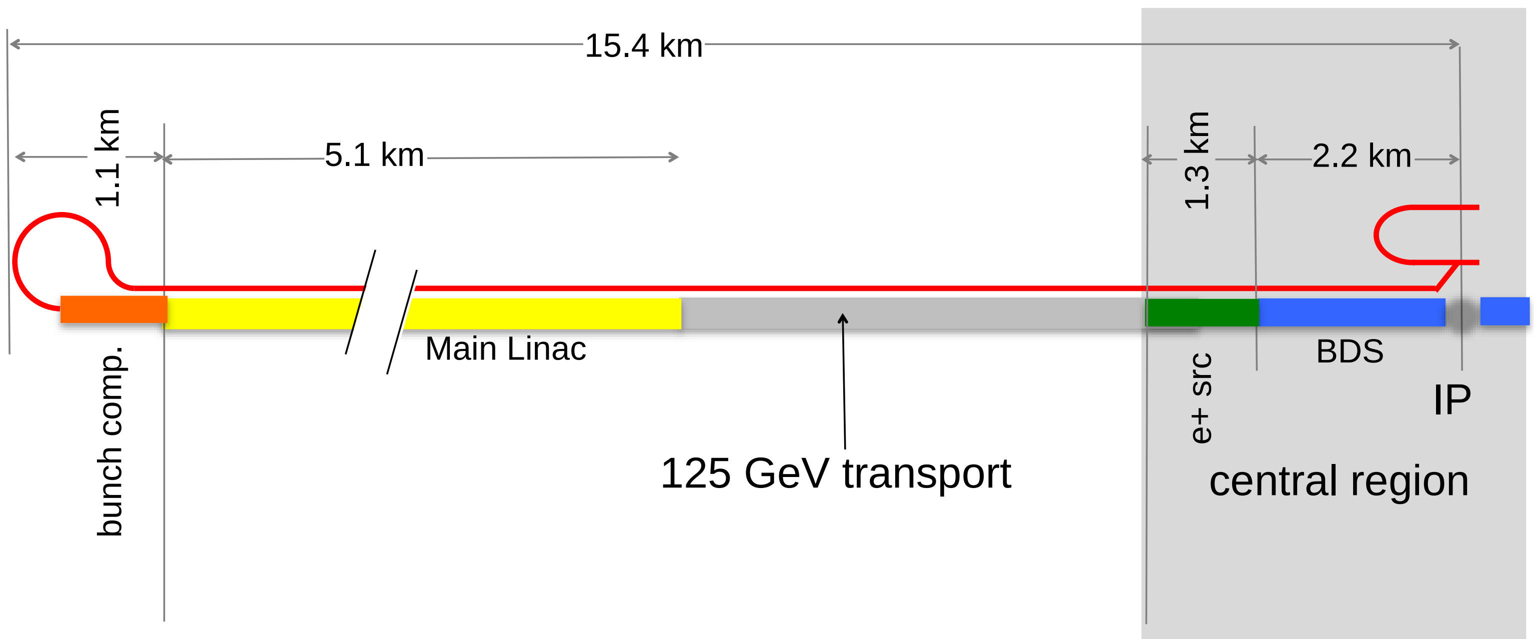
A big cliff avoided!

The report considers a 250GeV first stage of the TDR baseline design for 500GeV, with the footprint of the full 500GeV configuration.

It is assumed that machine runs at ~1+4 years at 250GeV, then is upgraded to 500GeV in a single step, taking ~1 year.

Does this make sense?

# Basic Configuration



# Report to the LCC Directorate

https://ilc-edmsdirect.desy.de/ilc-edmsdirect/file.jsp?edmsid=D00000001046475&fileClass=native

Presented recently to directorate

Discusses technical issues of possible staging scenarios – neither physics not political pros and cons are considered

## Implications of an Energy-Phased approach to the realization of the ILC

Prepared for: LCC Directorate
Prepared by: G. Dugan, M. Harrison, B. List, N. Walker

FINAL VERSION 26.02.2014

### Concept

In the ILC requirements document "Parameters for the Linear Collider[1]", the ILC design as given in the Technical Design Report (TDR), describes a 500 GeV machine with the possibility of extending the energy up to 1 TeV. Following the discovery of the Higgs boson at the LHC, the Japan Association of High Energy Physicists (JAHEP) recommended that the ILC physics studies "shall start with a precision study of the Higgs boson and then evolve into studies of the top quark, dark matter particles, and the Higgs self-couplings, by upgrading the accelerator. A more specific scenario is as follows:

- A Higgs factory with a centre of mass energy of approximately 250 GeV shall be constructed as the first phase.
- The machine shall be upgraded in stages up to a centre of mass energy of ~500 GeV which is the baseline energy of the overall project.
- Technical extendibility to a 1 TeV region shall be preserved."

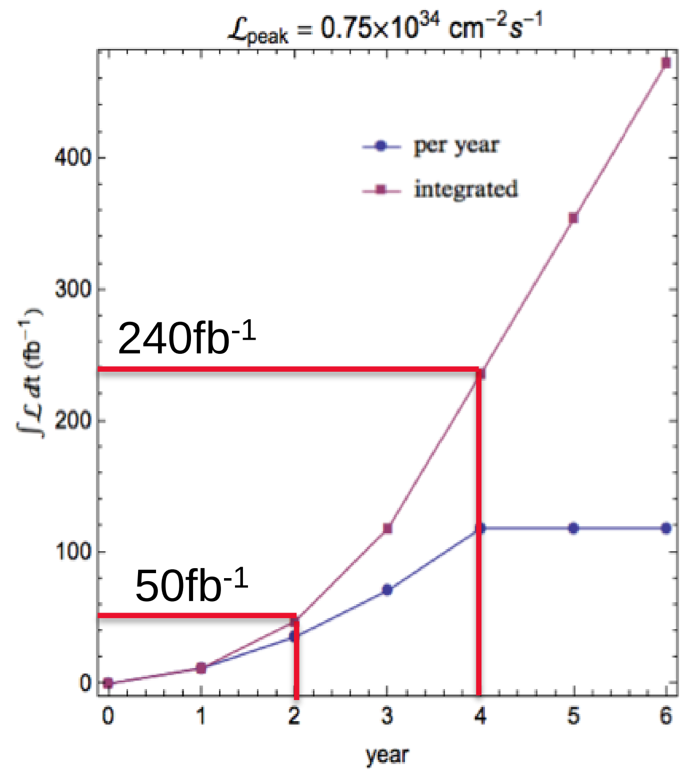
A multiple staged energy implementation, while technically feasible, will require several stop-start cycles with associated complications: thus the LCC Directorate has interpreted the JAHEP statement to mean a project with a first stage of 250 GeV. A pause in installation would then ensue to allow for a period of commissioning (~1 year) and physics operation of approximately 4 years after which time a single shutdown of ~1 year would be used to complete the project to 500 GeV.

This is consistent with the TDR physics goal of 250 $fb^{-1}$ of integrated luminosity at 250 GeV using the nominal TDR peak luminosity of $7.5 \times 10^{33}\ cm^{-2}s^{-1}$ and assuming a yearly luminosity progression of 10%, 30%, and 60% of peak as proposed in the requirements document (see Figure 1).

[1] R. D. Heuer *et al.*, "Parameters for the Linear Collider, Update November 20, 2006," http://ilc-edmsdirect.desy.de/ilc-edmsdirect/file.jsp?edmsid=*948205. Prepared by the parameters sub-panel of the International Linear Collider Steering Committee.

# Performance (Luminosity) Estimate

- Peak lumi: $\mathcal{L}$=0.75E34cm$^{-2}$s$^{-1}$
  -> assumed to be the same as for full linac at 250GeV in baseline design
- Assume 4 year ramp-up of luminosity (plus year 0): 10%, 30%, 60%, 100%
  -> Σyears 1-3 = 1 full year
- Assume 8 months running @ 75% availability per year
  -> 1.6E7 seconds per year
- 4 years result in 240fb$^{-1}$
- Consistent with "rule of thump":
  first 4 years give 250fb$^{-1}$ at 250GeV,
  350 at 350, 500 at 500…
- But note: after commissioning, one gets these data sets every **2** years!

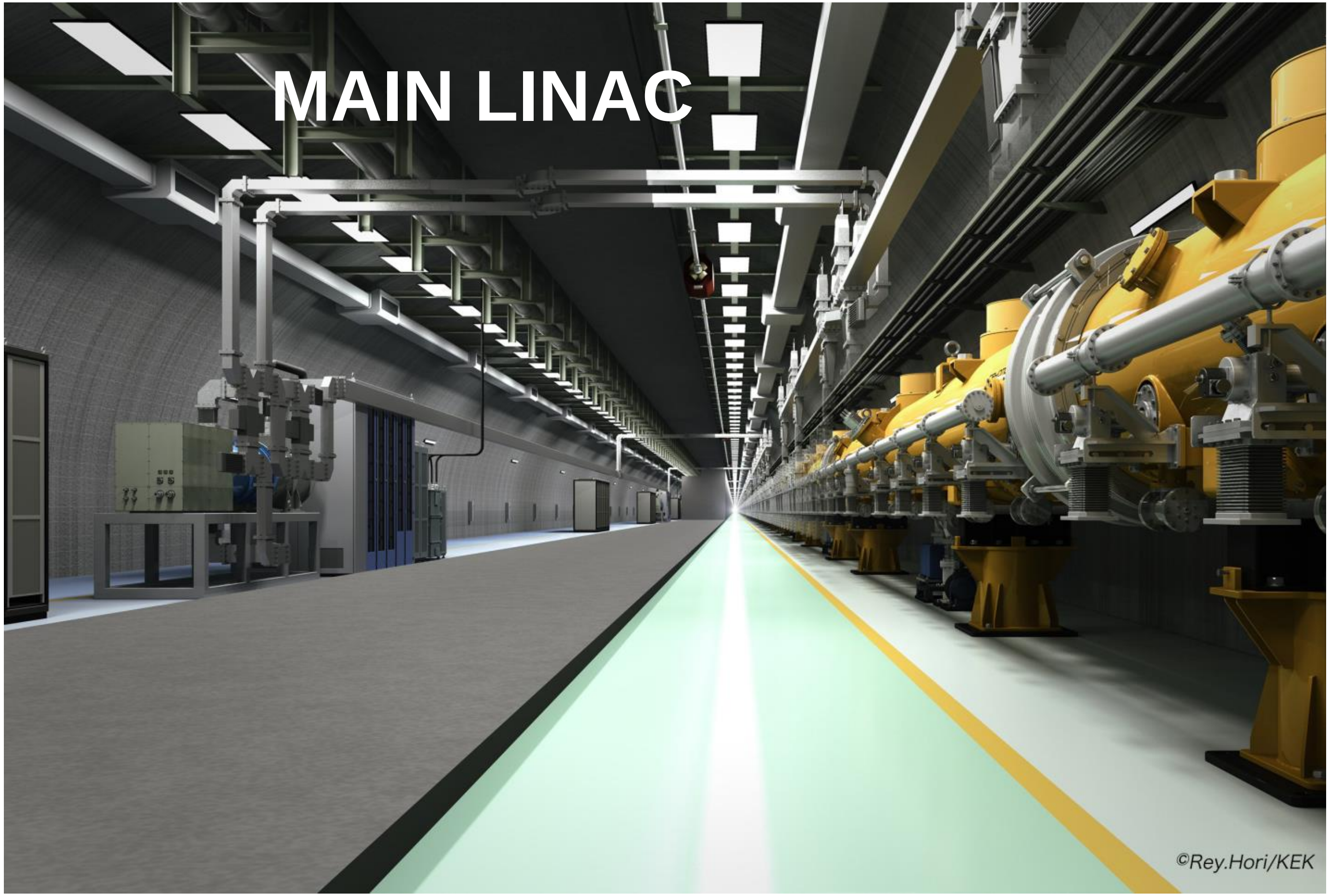


# Scope: Questions to the Parameters Group

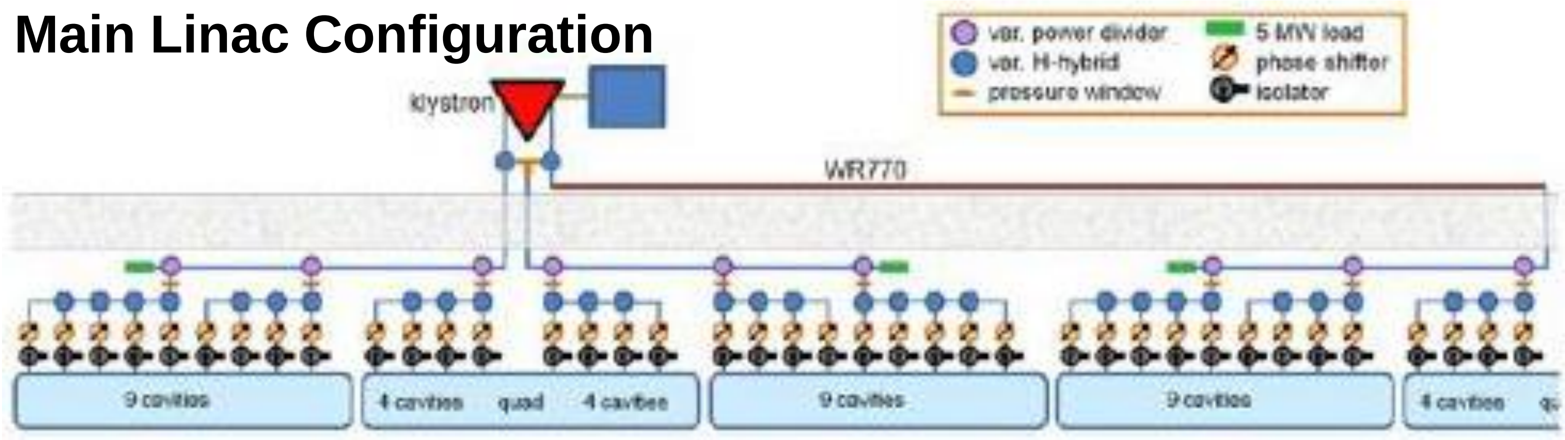
A fuller analysis, and a realistic design, require input from the parameters group.

- What is the real energy for the full machine? 500? 550? 600?
- How much integrated luminosity is needed at 250GeV?
- How fast should one upgrade the energy? 3 years? 4?
- What is the next energy step? 350? 500?
- What is the first upgrade? Energy or luminosity (at 250 GeV)?

-> Report from Parameter’s Group tomorrow morning by Jenny


MAIN LINAC
©Rey.Hori/KEK

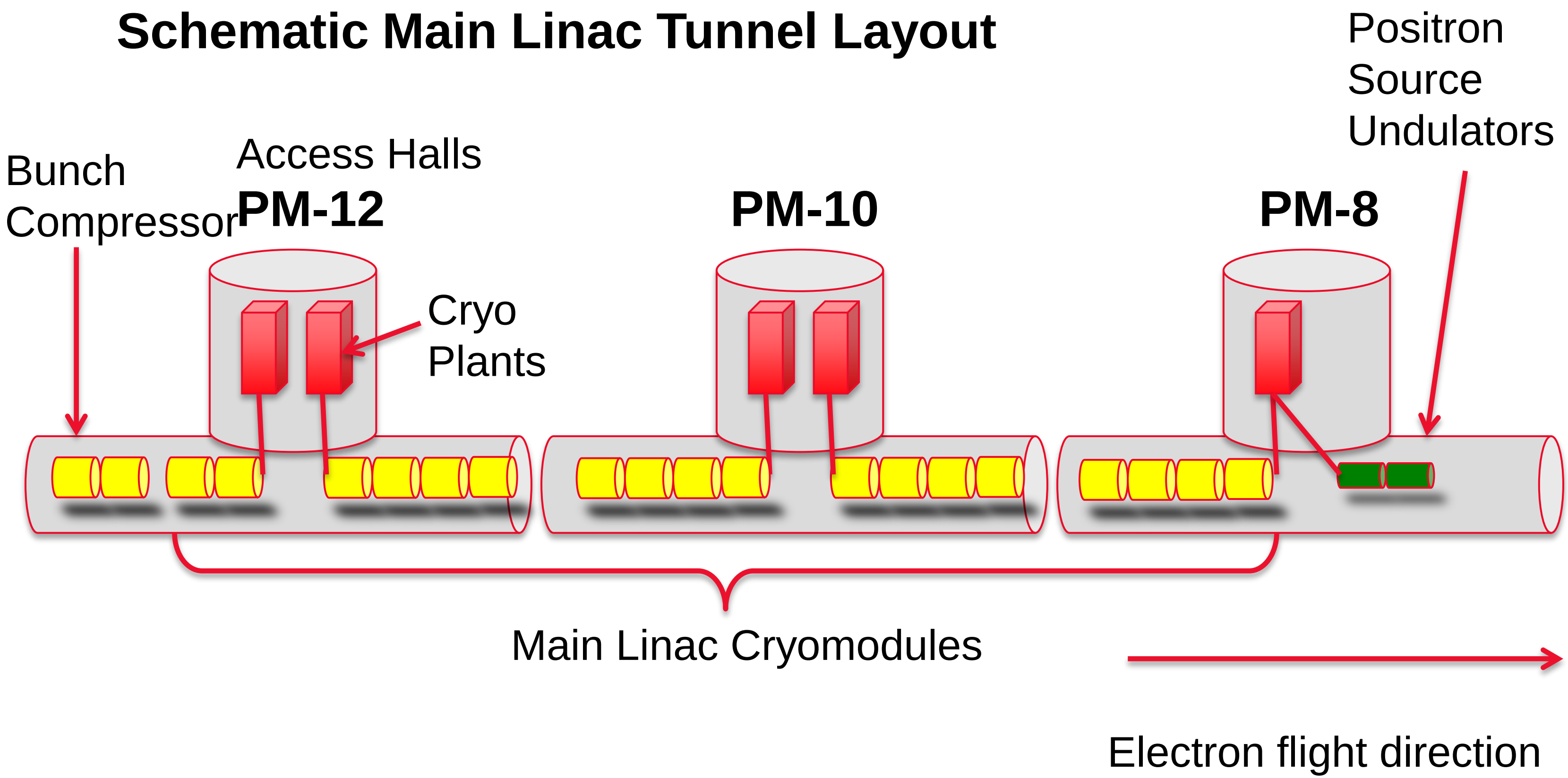
# Main Linac Configuration



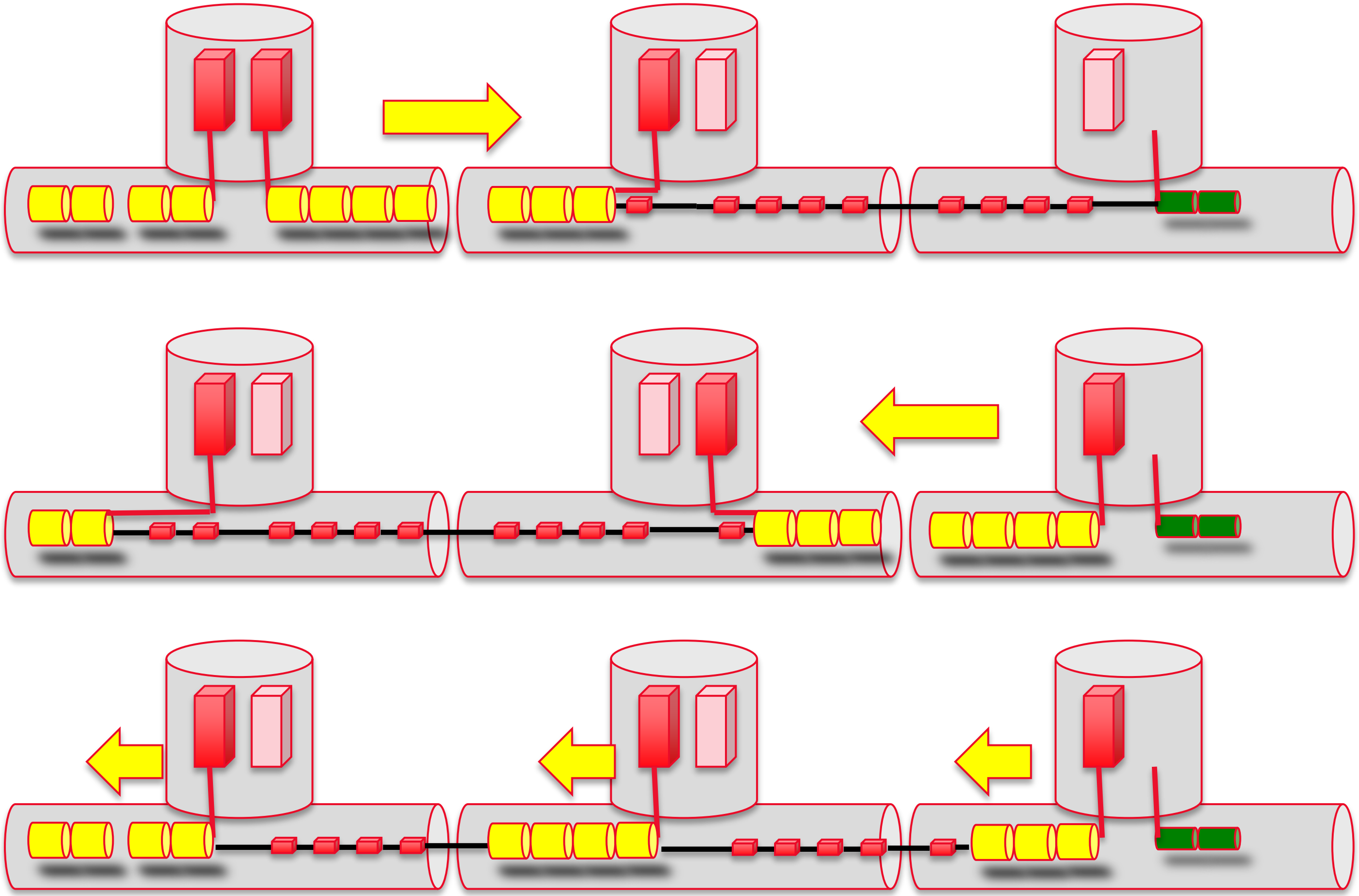

- 3 cryomodules form "1 Main Linac  Unit" (38m long, 26 cavities, 1 quad)
- 2 klystrons power 3 ML units (9 cryomodules)
- 3 ML units supplied by one cold box
  -> 1 "Short Cryo String" (116m, 9cryomodules, 3 quads, 2.54GeV)

- Short cryo strings are basic unit

# Schematic Main Linac Tunnel Layout



# Basic Choices

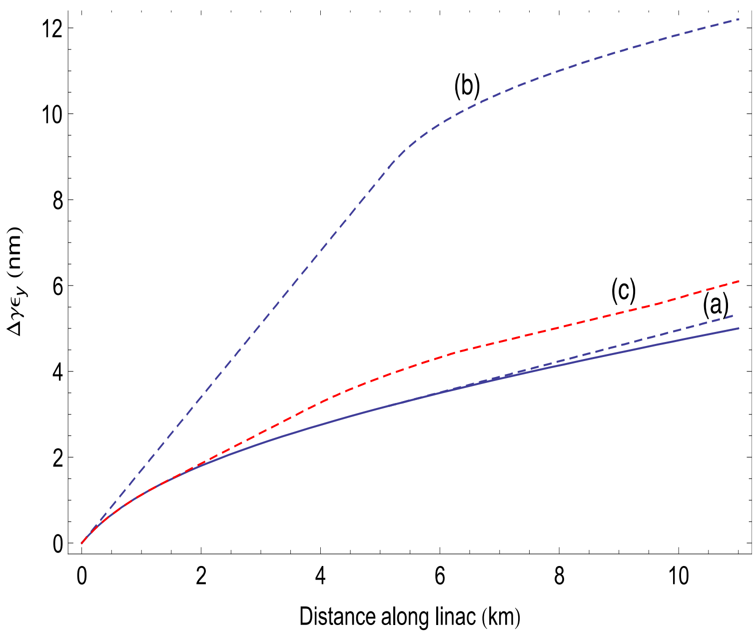


Scenario A:
Fill from upstream

Scenario B:
Fill from downstream

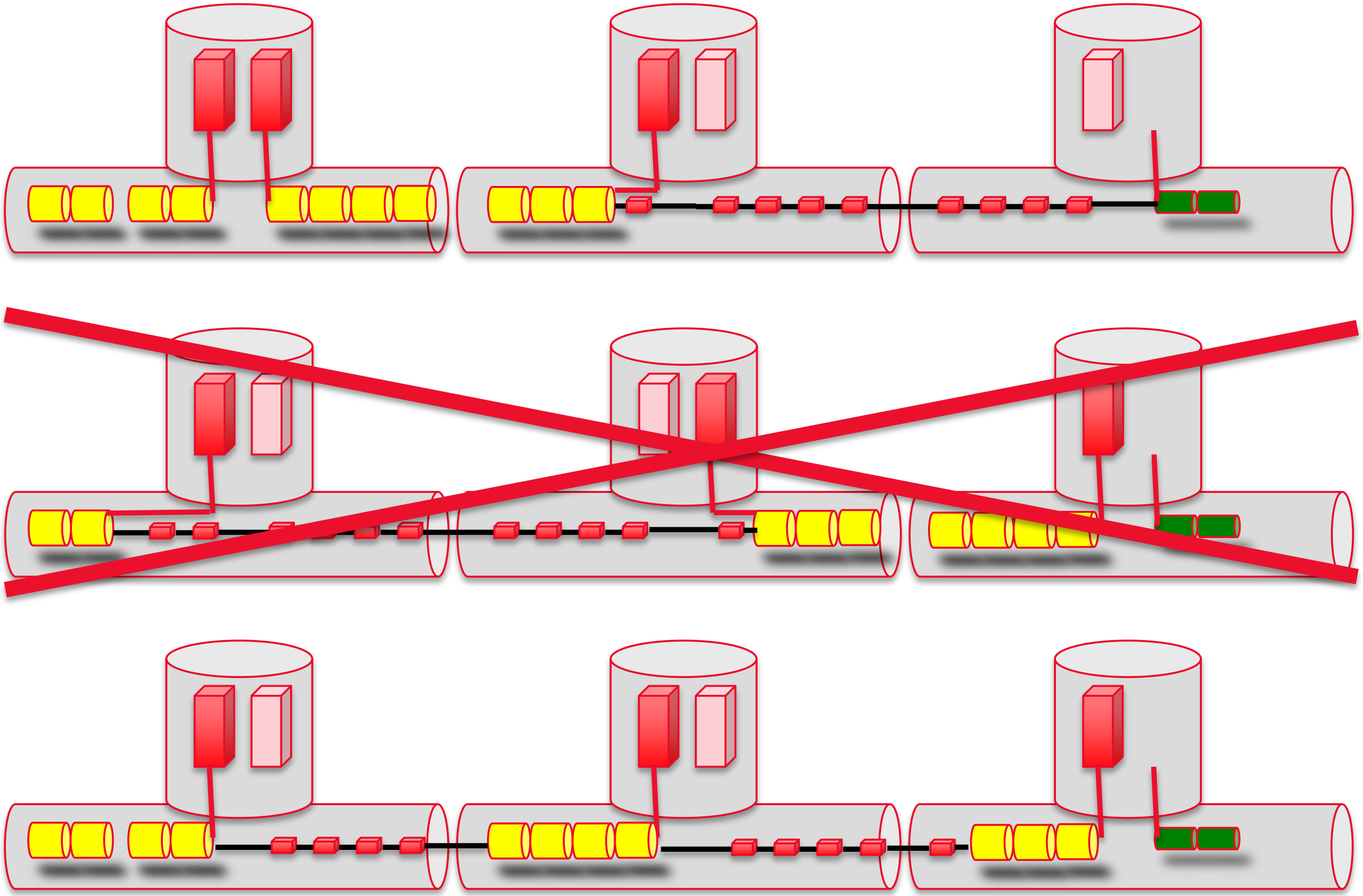
Scenario C:
Fill from Shafts

# Beam Dynamics: Emittance Growth




- Baseline:
  $\gamma\varepsilon_y$ =20nm (DR exit) -> 35nm (IP)
  ML adds 5nm
- Emittance growth scales as 1/γ
- -> accelerate beam asap
- Disfavours scenario B
  (increases emittance by 5nm to 40nm at IP, 6% luminosity reduction)
- Above 40 GeV (2km), growth is moderate
- Scenarios A and C look OK

# Beam Dynamics



Scenario A:
Fill from upstream

- Optimal for beam dynamics

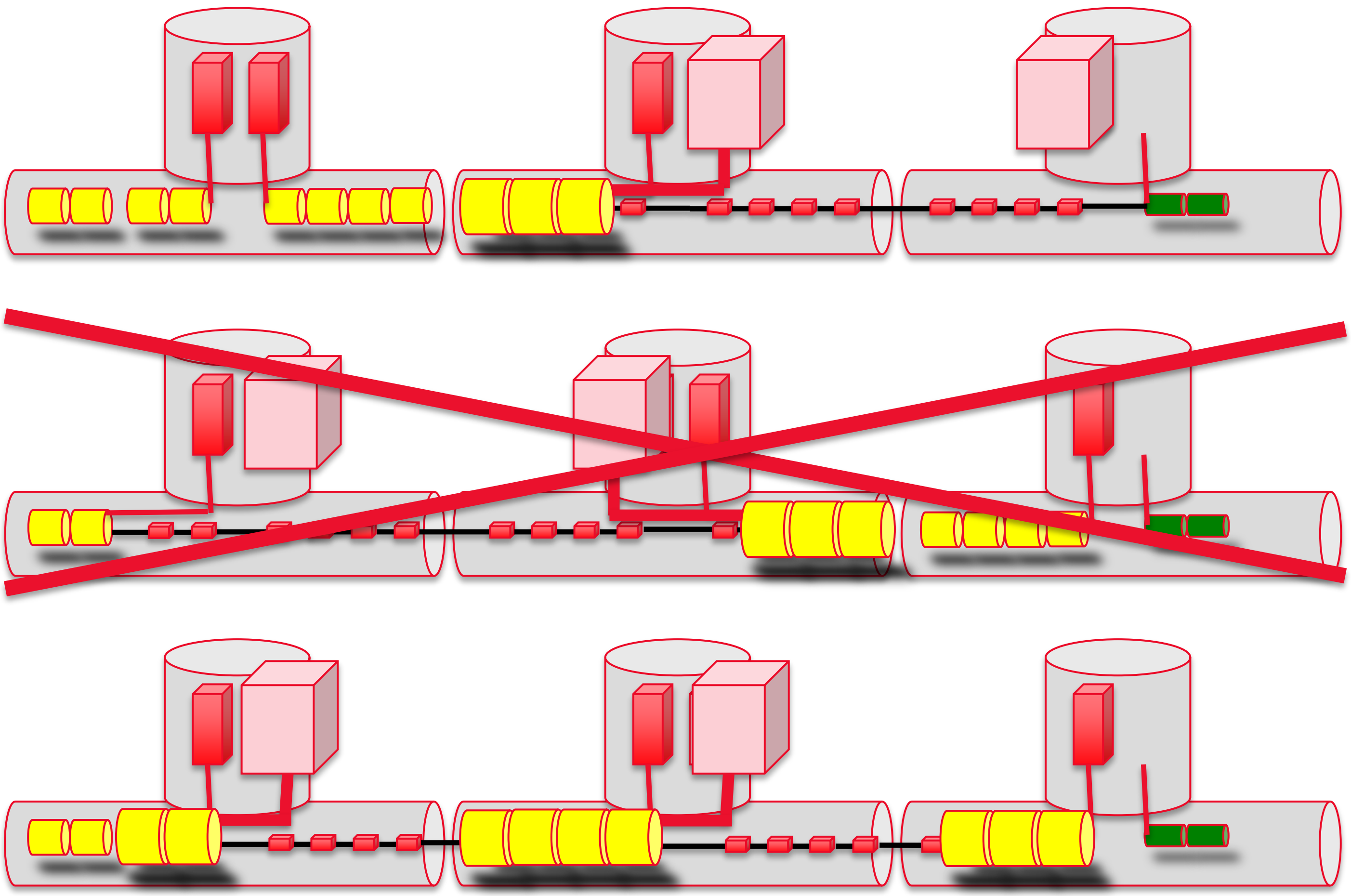
Scenario B:
Fill from downstream

- Worst for beam dynamics

Scenario C:
Fill from Shafts

- OK for beam dynamics

# Cryogenic Spare Capacity



Scenario A:
Fill from upstream

- Optimal for beam dynamics
- Helium transfer line needed
- No spare cryo capacity at PM12

Scenario B:
Fill from downstream

- Worst for beam dynamics
- Helium transfer line needed
- No spare cryo capacity at PM8

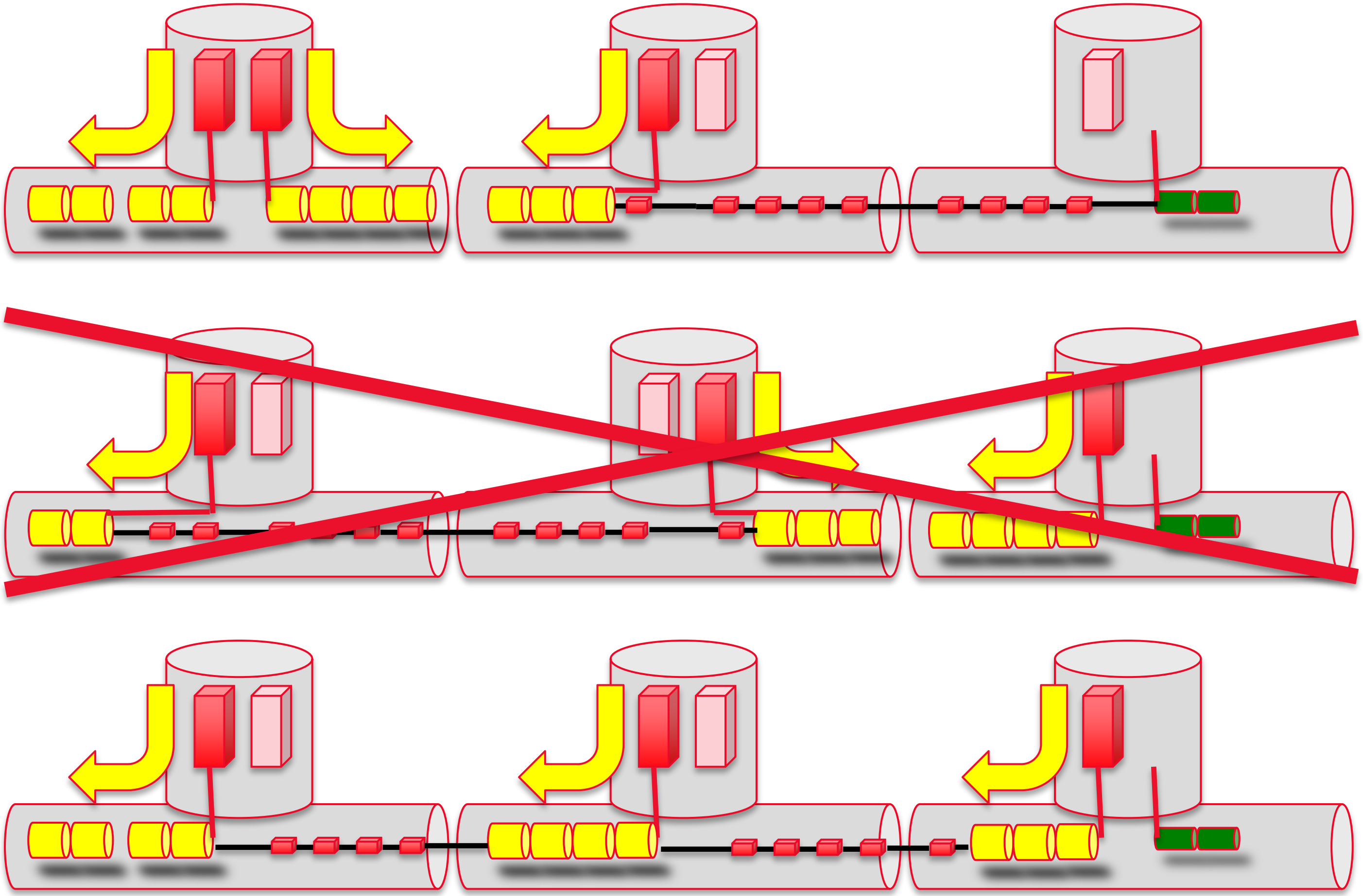
Scenario C:
Fill from Shafts

- OK for beam dynamics
- No helium transfer line
- Spare cryo capacities

# Cryogenic Plants

- Scenarios A and C have each 2x2 cryoplants that are not needed for first stage
- Will installation of these plants be staged?
  - 2 plants per shaft have operational advantages:
    - faster cooldown
    - Redundancy (during maintenance work)
    - -> Risk reduction
  - In scenario C, spare cryo power can be distributed over full Main Linac
    - makes accelerator operation easier (more operational margin)
    - Could be used to increase current / luminosity
    - Is that technically feasible? Cryoplant issues, Cryomodule specifications! **-> needs study**
  - Acquisition of plants at 500GeV upgrade would save some initial cost
  - What would be schedule impact if 2x2 plants are installed during upgrade work in addition to cryomodule installation?

# Initial Installation



Scenario A:
Fill from upstream

- Optimal for beam dynamics
- Helium transfer line needed
- No spare cryo capacity at PM12

Scenario B:
Fill from downstream

- Worst for beam dynamics
- Helium transfer line needed
- No spare cryo capacity at PM8

Scenario C:
Fill from Shafts

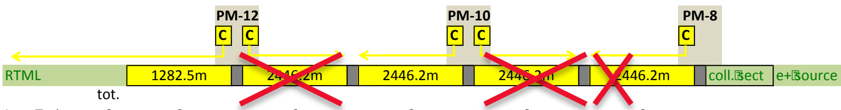
- OK for beam dynamics
- No helium transfer line
- Spare cryo capacities

# Installation

- Installation has not been not thoroughly investigated yet
- Material (cryomodules) has to run through access tunnels
- TDR install rate: 1600 CM / 1 year / 6 access shafts
  - ~ 1 CM / (day*shaft) -> not trivial
- Installation would get easier (or faster) in staged scenario if still 6 shafts are used, but for reduced number of cryomodules
- Same applies to upgrade to 500GeV
- Assumption: Best to install cryomodules such that a free path to access shafts is left (start at center between shafts, work towards shafts)

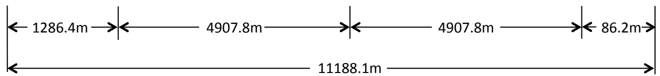
# Baseline Configuration

**Electron Linac**

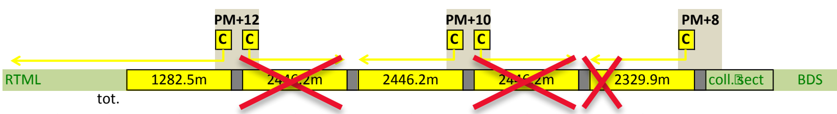



| | tot. | 1282.5m | 2446.2m | 2446.2m | 2446.2m | 2446.2m |
|---|---|---|---|---|---|---|
| Long strings | 0 | 0 | 0 | 0 | 0 | 0 |
| Short strings | 95 | 11 | 21 | 21 | 21 | 21 |
| Cold boxes | 90 | 10 | 20 | 20 | 20 | 20 |
| ML units | 285 | 33 | 63 | 63 | 63 | 63 |
| Cryomodules | 855 | 99 | 189 | 189 | 189 | 189 |
| RF stations | 190 | 22 | 42 | 42 | 42 | 42 |

Beam Energy 15 42.9 96.3 149.7 203.0 256.4 GeV

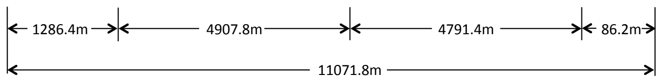



**Positron Linac**

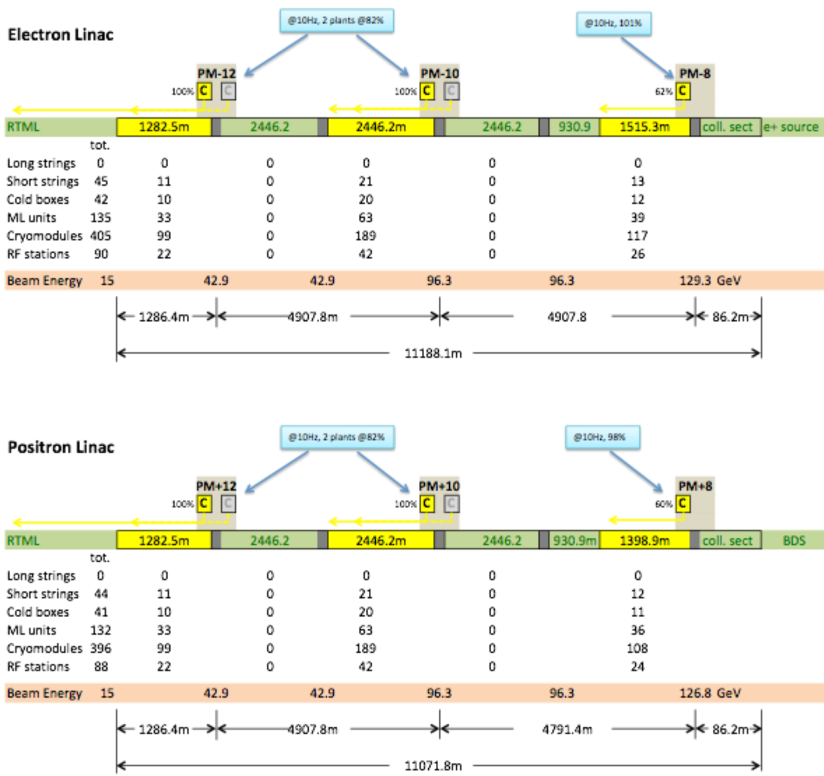



| | tot. | 1282.5m | 2446.2m | 2446.2m | 2446.2m | 2329.9m |
|---|---|---|---|---|---|---|
| Long strings | 0 | 0 | 0 | 0 | 0 | 0 |
| Short strings | 94 | 11 | 21 | 21 | 21 | 20 |
| Cold boxes | 89 | 10 | 20 | 20 | 20 | 19 |
| ML units | 282 | 33 | 63 | 63 | 63 | 60 |
| Cryomodules | 846 | 99 | 189 | 189 | 189 | 180 |
| RF stations | 188 | 22 | 42 | 42 | 42 | 40 |

Beam Energy 15 42.9 96.3 149.7 203.0 253.8 GeV



# Scenario C: Hybrid




Scenario C: Fill from Shafts

PM±12: 1 full cryoplants
PM±10: 1 full cryoplant
PM±8: 1 ML cryoplant at 62/60%

Installation of all cryoplants allows running at 10Hz rep rate

This is the preferred scenario which will be used as basis for future work, in particular lattice design

# Cryomodule Production Schedule / Logistics

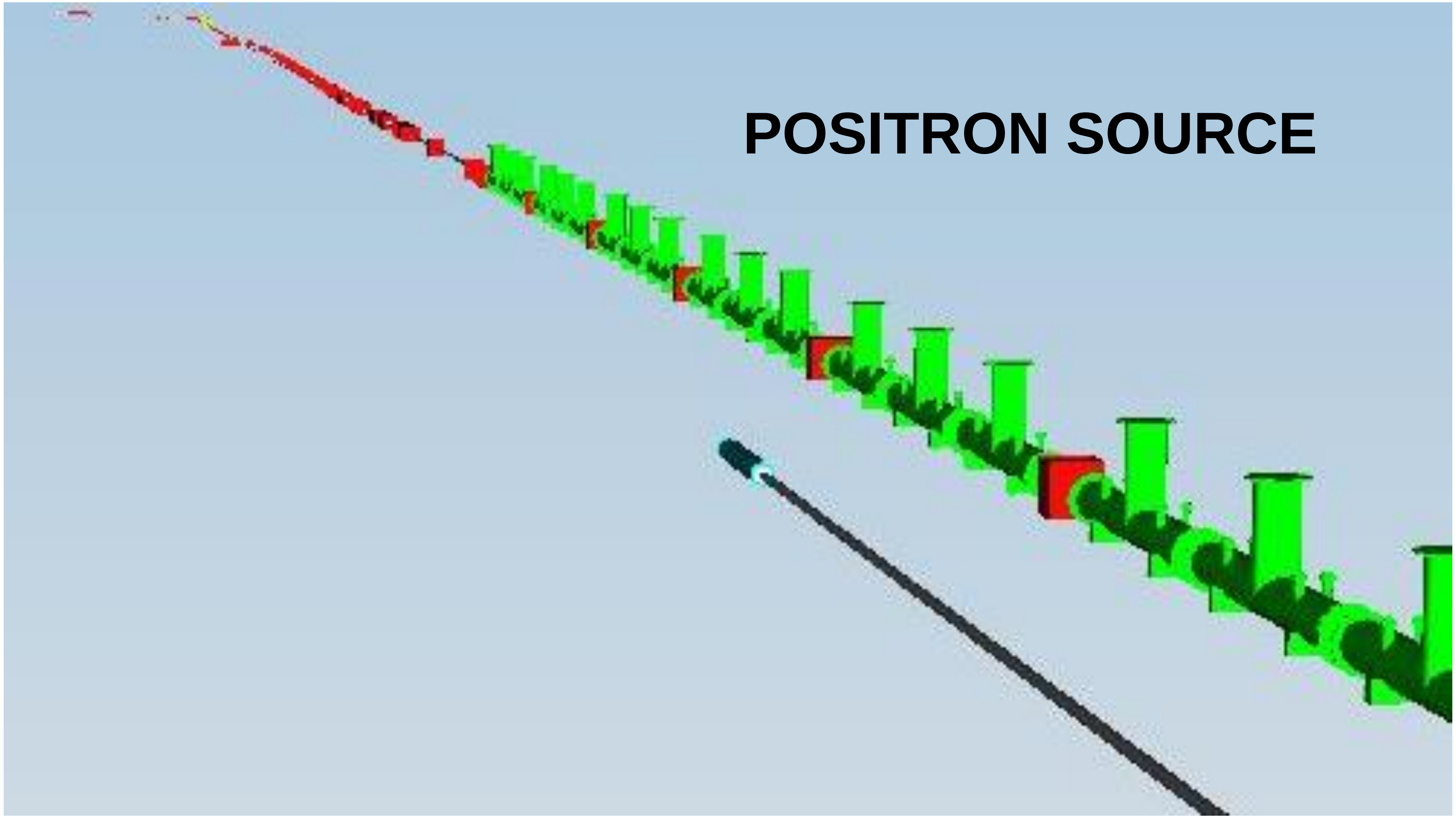
- Energy staging changes schedule:
  Need 877cryomodules for 250 GeV, (500GeV baseline: 1841)
- Production rate: 2/day x 3.5 years -> 1/day x 7 years

- Cavities & cryomodules account for ~1/3 of the ILC cost
  -> cannot afford to make them more expensive!
- Experience from industry: reducing production quantity by factor 2 increases the price per item by 5-10% (learning curve)!
- Ordering only half of the cavities and cryomodules would increase the overall project cost (for 500GeV) by several % (several 100M$)!
- If cryomodule production is not stopped, cryomodules are available <3.5 years after end of installation ("year 0" + 2.5 years)

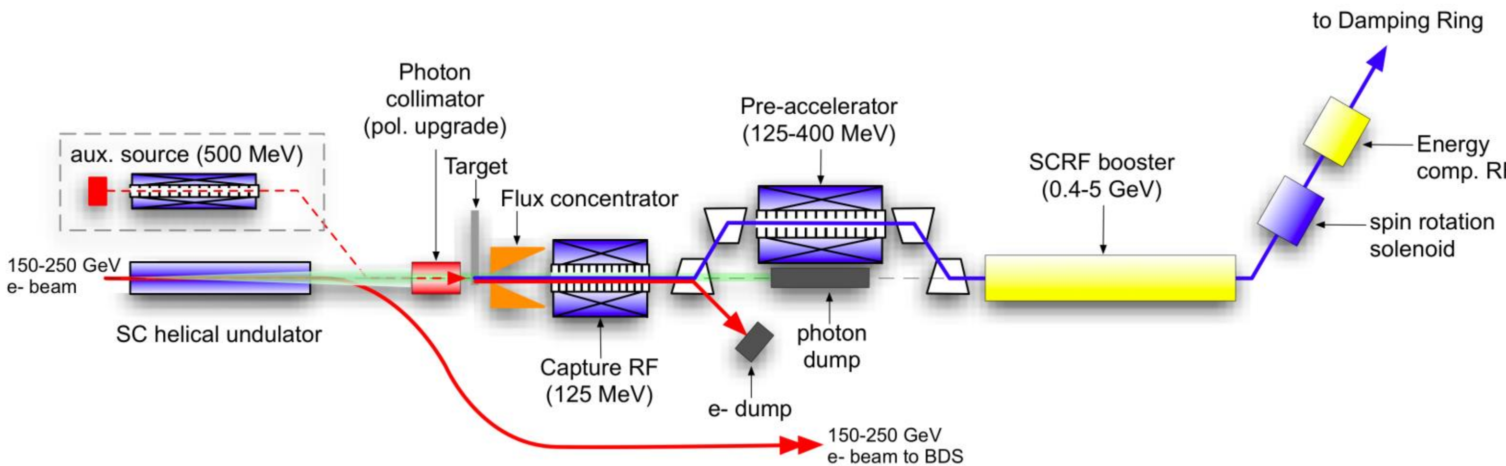
# Energy Overhead and Gradient

- At 31.5MV/m gradient, all cryomodules online:
  e- beam reaches 129.3 GeV, 1% above (125+3.1)GeV needed
  e+ beam reaches 126.8 GeV, 1.5% above 125GeV
- TDR baseline has 1.5% overhead to account for component failures

- 125GeV is close to
  - Physics threshold
  - Operation threshold for positron source
- -> falling 10% below design gradient would have very serious impact
- Define additional safety margin to reduce risk
- Re-evaluate assumed gradient?
  (is final gradient available from year 1 on?)

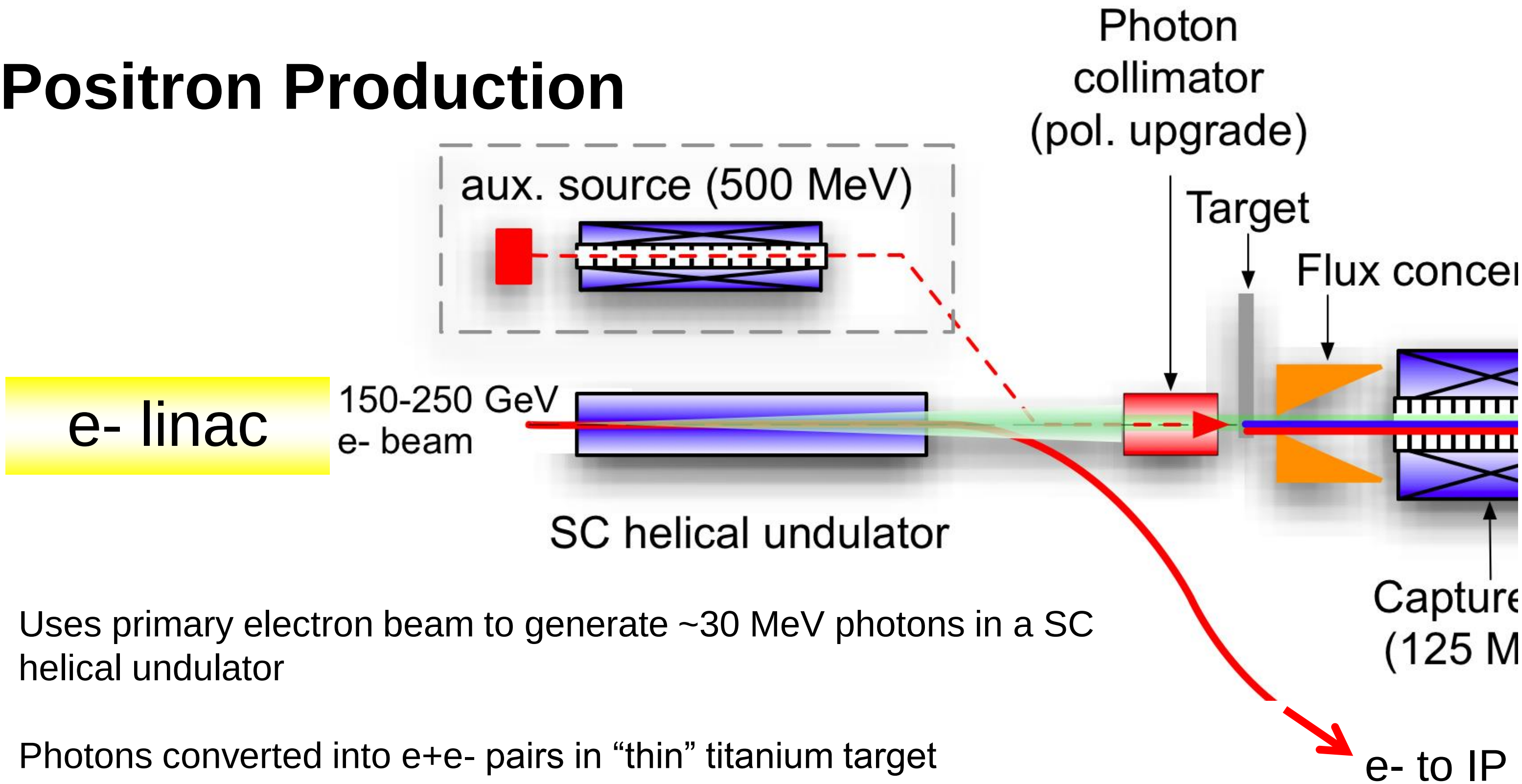

POSITRON SOURCE

# Positron Source Overview




- Positrons are produced from electron beam via helical undulator radiation -> requires minimum electron energy of 150GeV
- Below 150 GeV, operation becomes difficult

# Positron Production




Uses primary electron beam to generate ~30 MeV photons in a SC helical undulator

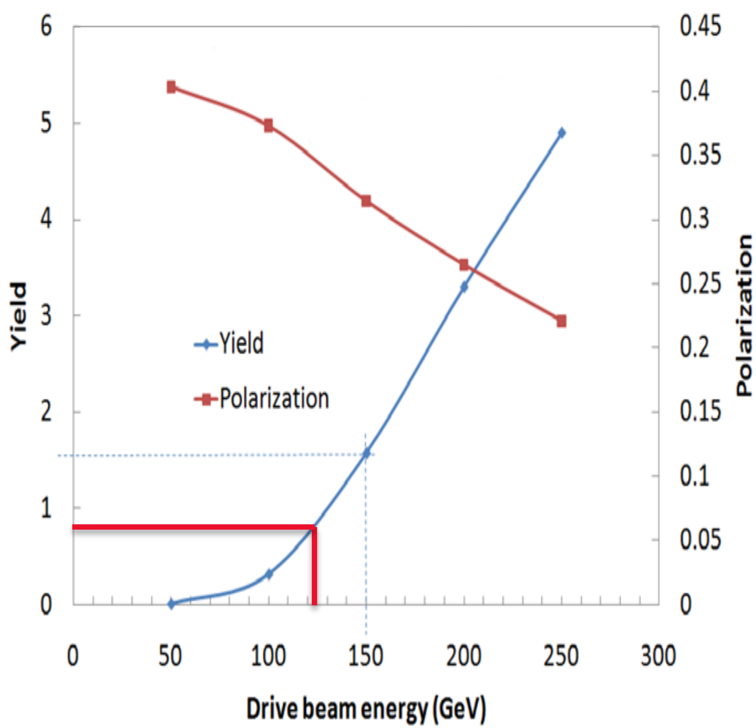
Photons converted into e+e- pairs in “thin” titanium target

Positron production yield dependent on e- beam energy (and therefore $E_{cm}$)

# Positron Source: Operation at low energies

- Baseline Positron Source: Requires 150GeV beam (300GeV CME)
- TDR assumes “10Hz scheme” for CME below 250GeV:
  alternate electron beam for physics (< 125GeV) with 150GeV beam for positron production
- 10Hz scheme uses excess cryo power available when running a 250GeV accelerator at 125/150 GeV (half gradient)
- => 10Hz scheme at a staged machine requires
  - Running electron Main Linac at full gradient at 10Hz
  - -> needs doubling of cryogenic power
  - Needs also 25GeV additional beam energy for e- linac
- Also: 10Hz mode is challenging for machine operation, and requires more power -> not attractive

# Positron Source: Yield




- Required: yield 1.5e+ per 1e-, i.e. 50% operational margin
- Yield drops to ~1 at 125GeV -> could run, but no margin
- TDR baseline: 147m long undulator, 231m available space
- Could install more undulator modules (43->66) in available space
- Would permit operation at 250GeV without need for 10Hz scheme
- Energies below 250GeV still challenging -> is this needed?

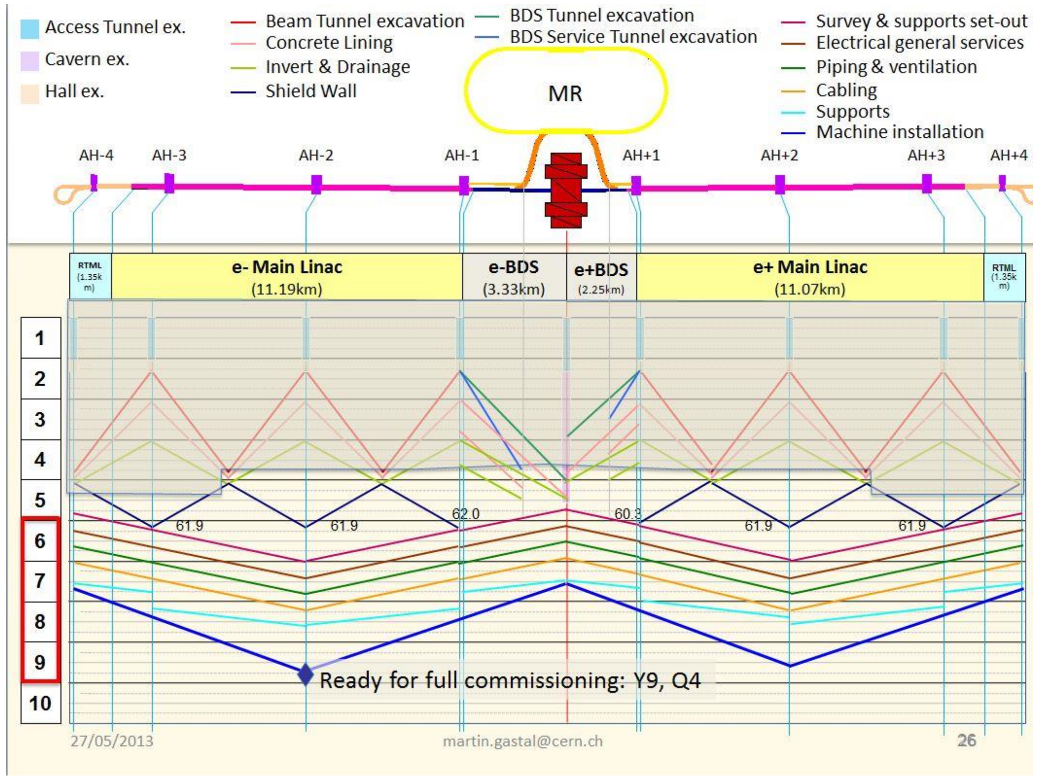
# Positron Source: Summary

- Proposal: Increase undulator length to 231m
- Does not change footprint of machine compared to TDR
- Allows “regular” operation with 125GeV electron beam
- Increases cryo power needed for undulators

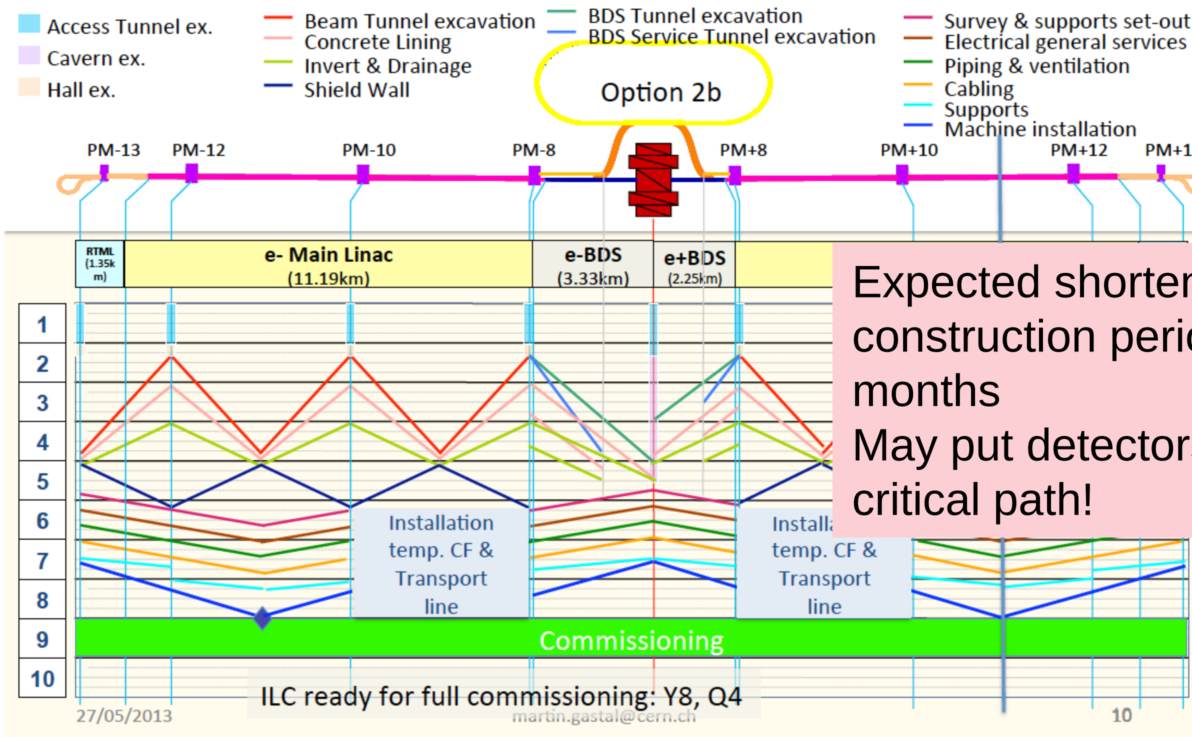
- Operation below 200-250 GeV requires alternating beams for physics and e+ production (“10Hz scheme”), at full ML gradient
- needs doubled cryogenic power in ML,
  or reduced pulse frequency -> reduce luminosity by factor 2

- An additional, electron-driven source would be most valuable in this first stage: risk reduction, easier operation

# Baseline Schedule

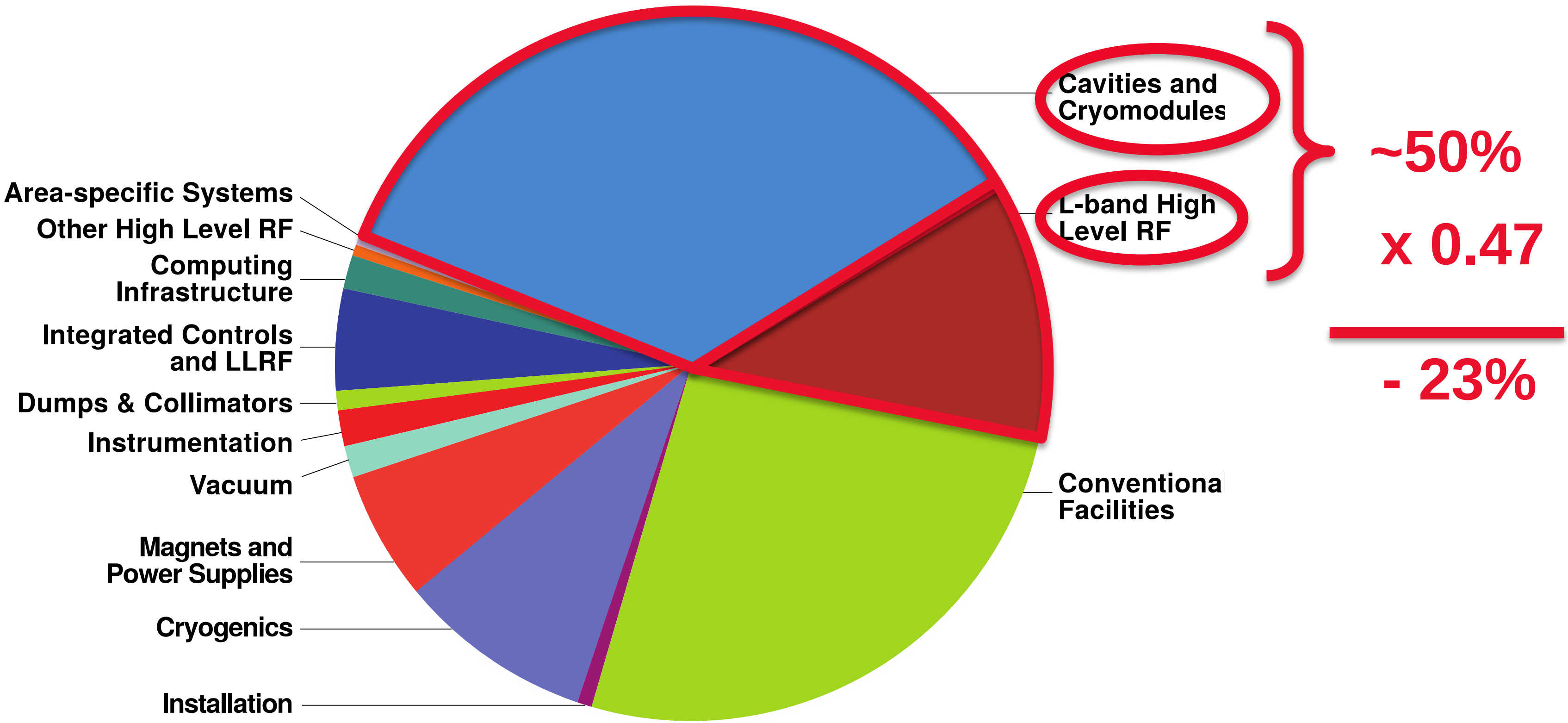


# Study for Staged Schedule (M. Gastaal, CERN)




Expected shortening of construction period: ~9 months
May put detectors on critical path!

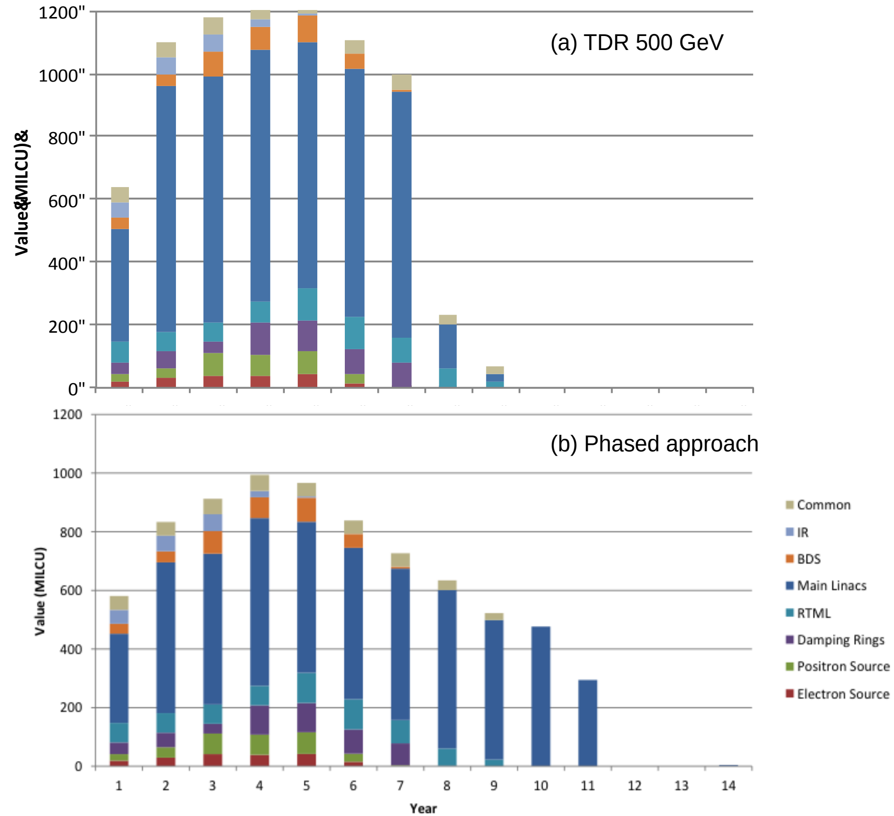
# Major systems costs



# Spending Profile

- Reduce cryomodule and HLRF spending rate
- Extend spending by 4 years
- Peak spending rate drops by 200MILCU/year (16%)

- Increase of overall budget due to transfer line and larger undulator ~1.1%



# Conclusions

- Staging scenario considered:
  - full tunnel for 500GeV machine, full BDS for 1TeV operation
  - 53% cryomodules in ML for 1$^{st}$ stage
  - Extended undulator for positron production at 250GeV
  - Running at 250GeV for ~5 years gives 250fb$^{-1}$,
    but more cryomodules may be ready after 3years, i.e. ~50fb$^{-1}$!
  - Then upgrade in one step to 500GeV, about 1 year shutdown
  - Cryomodule production is never stopped
- Physics requirements (exact energy, integrated luminosity) needed from parameters group
- Design decisions: ML configuration, cryoplant staging?
- Revised / refined production and installation schedule needed for CFS requirements: storage/staging areas, transport capacities
- Cryomodule production plan has large impact

# Staging: My personal summary

- Drive for a initial 250GeV stage is more political than accelerator driven (which makes the 250GeV stage more likely…)
- A 250GeV stage reduces peak funding profile, and reduces necessary cryomodule production capacity: risk reduction
- But it drags out cryomodule production time: companies may go out of business, labs may change priorities -> increased risk
- Stopping cryomodule production after 250GeV will make a 500GeV machine much more expensive, and **less likely**
  (and indicates lack of commitment to go for 500GeV?)
- Continuing cryomodule production means that after ~2 years of data taking ($50fb^{-1}$) an upgrade is possible
- Is a dataset with $50fb^{-1}$ at 250GeV useful?

# Summary

- The most pressing questions for the Japanese site:
  - Where is the IP? Needs decision on access tunnel scheme
  - How long is the accelerator? Needs decision on maximum energy, assumed gradient and overhead
    -> discussion initiated by Physics&Detectors Deputy Director (H. Yamamoto)
    -> Parameter's group
    -> be careful not to look the gift horse into its mouth…
  - Answers needed by end of 2014
    -> ALWC in May at Fermilab
    is time for arguments, ECFA WS in Belgrade might see the result
- Japan needs 5 years pre-construction, plus 10 years construction
  -> have the 5 years already started? Not clear
- A 250GeV first stage is likely, but it is unclear how long it will last

# BACKUP