Baseline Assessment Workshop II Report

Day 3 - Day 4
"Positron Source Location"

include a part of Day2 (a part of Physics)
include Proposal of New Parameter (end of Day4)

17-Feb-2011
ILC-CLIC e+ studies
T. Omori (KEK)

GDE Activities after RDR
Minimum Machine、
Accelerator Design & Integration、
SB2009
Baseline Assessment

Motivation is Cost Reduction
(Containment)

Overview

BAW2 Day 1
Marc Ross さん

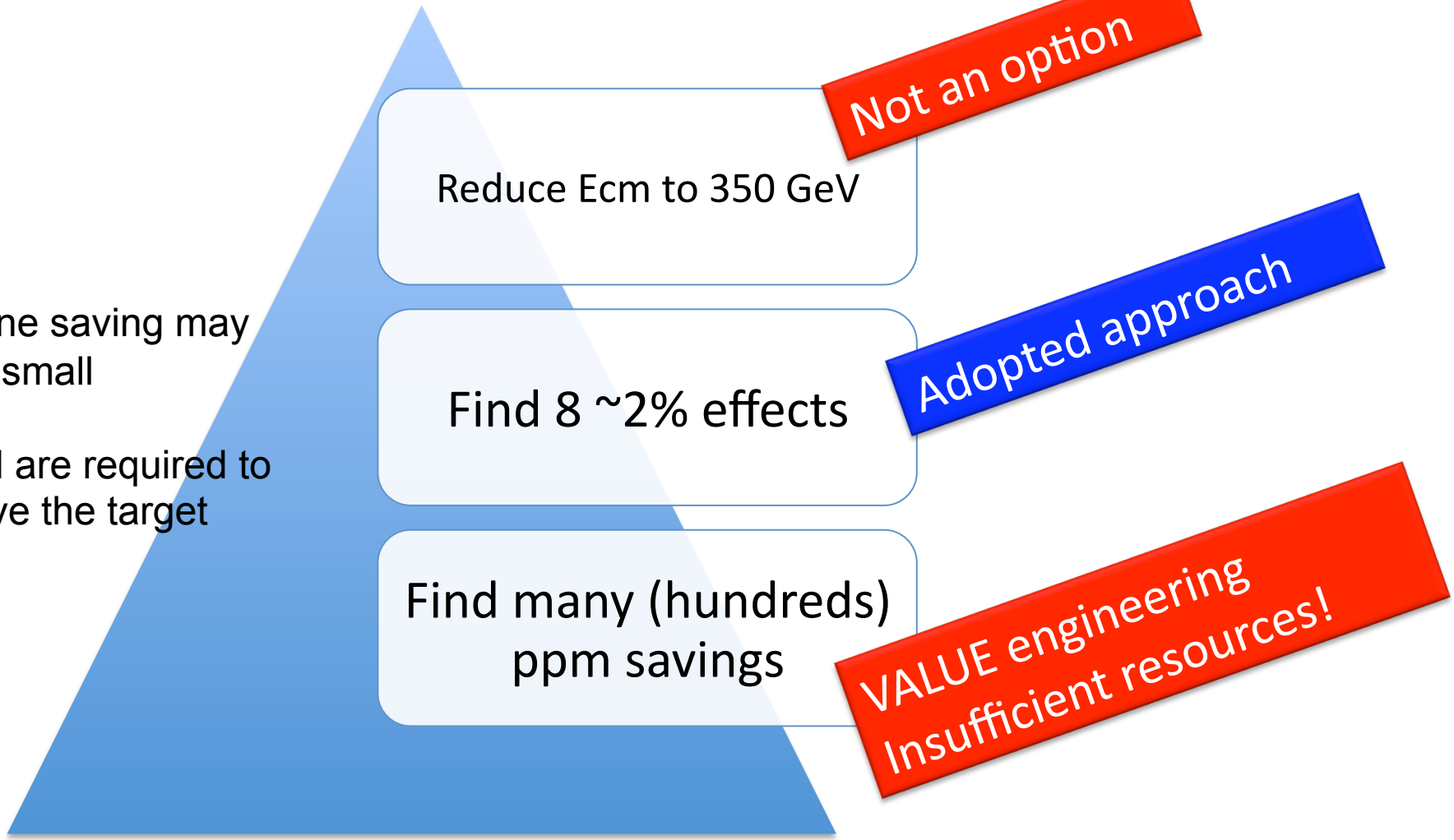
- **Changing the ILC Baseline – TLCC / BAW Process**
- **Background: Motivation for Cost Containment** red line: omori
  - TDR will have updated cost estimates for SRF and CFS

1. **Reduced Beam Parameter Set**
2. **Positron Source Relocation**
   - →(Ewan Paterson, Thursday Jan 20)

- **Summary**

BAW2 Day 2 Nick さん

Approach to finding 15%



Any one saving may seem small

But all are required to achieve the target

BAW2 Program

GDE Baseline Assessment Workshop (BAW-2)

2nd Baseline Assessment Workshop on 'Reduced Beam Parameter set' and 'Positron Source Location'

Dates: January 18-21, 2011 (Tuesday to Friday)
Place: SLAC

Dates:	from 18 January 2011 08:00 to 21 January 2011 18:00
Timezone:	America/Los_Angeles
Location:	*SLAC* Room: ROB (Research Office Building #48)
Additional info:	2nd Baseline Assessment Workshop on 'Reduced Beam Parameter set' and 'Positron Source Location'

Subjects:

1. 'Reduced Beam Parameter set' and
2. 'Positron Source Location'

What is "Positron Source Location" ?
（Positron Source Relocation）

1. Move Undulator location from "middle of e- linac (E=150 GeV)" to "end of e- linac".

Eliminate double tunnel for undulator → Cost down

e+ Source at 250 GeV

Albuquerque (2009 Sep/Oct) GDE Summary

- cost reduction, dogleg instead of chicane; shares emergency extraction (MPS) and emittance diagnostics with BDS, also one less (emergency) dump. Operations impact - MPS

- need to decelerate beam (RDR). Conceptually feasible but not easy with full beam loading. Energy spread and stability of decelerated beam. Beam energy plus klystron forward power (for beam loading compensation) all dumped into RF loads in tunnel. Wasn't studied for RDR.

- Rdr solution requires front end of linac to run flat out at 31.5MV/m no "risk" margin for operations.

- long e+ low-e transport line not needed in ML tunnel (more power supplies and space needed in single tunnel)

GDE Summary: M. Ross, N, Walker, A. Yamamoto, 2009 Oct., Albuquerque

What is "Positron Source Location" ?
（Positron Source Relocation）

1. Move Undulator location from "middle of e- linac (E=150 GeV)" to "end of e- linac".
   Eliminate double tunnel for undulator --> Cost down

2. In low energy operation (Ecm < 300 GeV), e- beam energy running through undulator is too low.
   ---> too low Luminosity
   Recovery by 10 Hz (5+5 alternative*) operation
   （10 Hz is for only low energy operation --> expect small cost increase）

*）collision@5 Hz
   e- 150 GeV @5Hz + (e- 125 GeV x e+ 125 GeV) @5 Hz
   e- 150 GeV @5Hz + (e- 100 GeV x e+ 100 GeV) @5 Hz

Day 3

Thursday 20 January 2011

09:00 - 18:00 **Positron Source Relocation**

09:00 **Overview and Layout** *45'*
Speaker: Ewan Paterson (SLAC)
Material: Slides

09:45 **Positron system performance** *45'*
Speaker: Wei Gai (ANL)
Material: Slides

10:30 break--> *30'*

11:00 **DRFS operation at lower gradient (10Hz)** *30'*
Speaker: Shigeki Fukuda (KEK)
Material: Slides

11:30 **KCS operation at lower gradient (10Hz)** *30'*
Speakers: Chris Adolphsen (SLAC) , Christopher Nantista (SLAC)
Material: Slides

12:00 **CFS for 10 Hz** *30'*
Speaker: Victor Kuchler (Fermilab)
Material: Slides

12:30 lunch--> *1h30'*

14:00 **DR @ 10 Hz** *30'*
Speakers: Susanna Guiducci (INFN) , Mark Palmer (Cornell University LEPP)
Material: Slides

14:30 **Source @ 10 Hz** *30'*
Speaker: Axel Brachmann (SLAC)
Material: Slides

15:00 **Alternate pulse operation in electron Main Linac** *30'*
Speaker: Kiyoshi Kubo (KEK)

Day 4

Friday 21 January 2011

09:00 - 14:30 **Positron Source Relocation**

09:00 **Undulator R & D** *30'*
Speaker: Jim Clarke (STFC Daresbury Lab)
Material: Slides

09:30 **Cost implications** *1h00'*
Speaker: Peter Garbincius (FNAL)
Material: Slides

10:30 coffee--> *30'*

11:00 **New low charge parameters** *20'*
Speaker: Jie Gao (IHEP)
Material: Slides

11:20 **Summary / discussion** *1h10'*
Speaker: Nicholas Walker (DESY)
Material: Slides

Day 2 afternoon (physics)

Wednesday 19 January 2011

12:30 **lunch**--> *1h30'*

14:00 **Low-mass susy scenario study** *25'*
Speaker: Paul Grannis (Stony Brook University)
Material: **Slides**

14:25 **Higgs cross section and mass measurement** *25'*
Speaker: Hengne Li (LPSC)
Material: **Slides**

14:50 **Higgs branching ratios study** *20'*
Speaker: Hiroaki Ono (Nippon Dental University)
Material: **Slides**

15:10 **Background studies** *20'*
Speaker: Takashi Maruyama (SLAC)
Material: **Slides**

15:30 **break**--> *30'*

16:00 **physics requirements for positron polarization** *25'*
Speaker: Sabine Riemann (DESY)
Material: **Slides**

16:25 **physics studies with polarization** *25'*
Speaker: Mikael Berggren (DESY Hamburg)
Material: **Slides**

Overview
(overview of whole WS)
(Day1)

Marc Ross さん

Workshop Program – *BAW-2*

1. **Reduced Beam Parameter set**
   - *n_b* reduced 2x from 2625 to 1312 ('low beam power')
2. **Positron Source Relocation**
   - Source moved from the 2/3 point to the end of the linac

red box: OMORI

Objectives of the Workshop:

- **Assess technical implication**
- **Including impact across system interfaces**
- **Discuss with community**
- **Prepare recommendations for 'Top-Level' Change Control (TLCC)**

Overview and Layout
(overview ofe+ source relocation)
(Day3)

Ewan Patterson さん

Brief History of Designs and Layouts From RDR on.

- Insert at Mid Linac → Complicates any design changes (gradient or energy upgrade) and operation of the linac.
- Conceptual to Detail design → Has revealed more complexity and longer insert than RDR
- Complex underground layouts → Impact on site and layout. High radiation vaults and shafts. Many different subsystems need RF or Pulsed power. Unsuitable for single tunnel designs Need two tunnel design in mid linac!
- Add machine protection system for undulator → longer insert
- Some concerns about operation that requires front half of linac to run at high gradient all the time then accelerate or decelerate in second half.
- Linac insert becoming less and less attractive !

Brief History of Designs and Layouts Leading up to SB2009

- End of Linac sharing with BDS → Revisit pro's and cons
- Reduces number of components or systems →Cost savings
- Reduced underground volume for all central region but maintain support tunnel shared with BDS → Cost savings
- Remote radioactive handling in central region only → Site simplification and cost savings.
- Variable drive beam energy and vary undulator length→ Conservative above 300 GeV but fails performance goals at 250 and below.
- Start re-considering options!
- With modifications to DR etc, evaluate 5+5 or 10 Hz operation with good yield at all energies. → Cost increase

10 Hz System Operation

- E- Source, DR's and e-Linac operate at 10 Hz
- E- Linac energy alternates between 100 to 125 GeV (for collisions)and ≥ 150 GeV (for E+ production with yield ≥ 1.5) but uses the whole linac length at low gradient.
- DR's Damping time reduced to ½ of RDR value
- E+ DR operates with 50% duty cycle
- Need some additional transport lines to dump the electron beam used for e+ production. Several options need study.

All are technically feasible but (RED) indicates increased cost.

- Many related talks today by Gai, Fukuda, Adolphsen, Kuchler, Guiducci, Brachmann, Kubo, and by Garbincius and Clarke tomorrow morning.

Positron System Performance
Day 3

Wei Gai さん

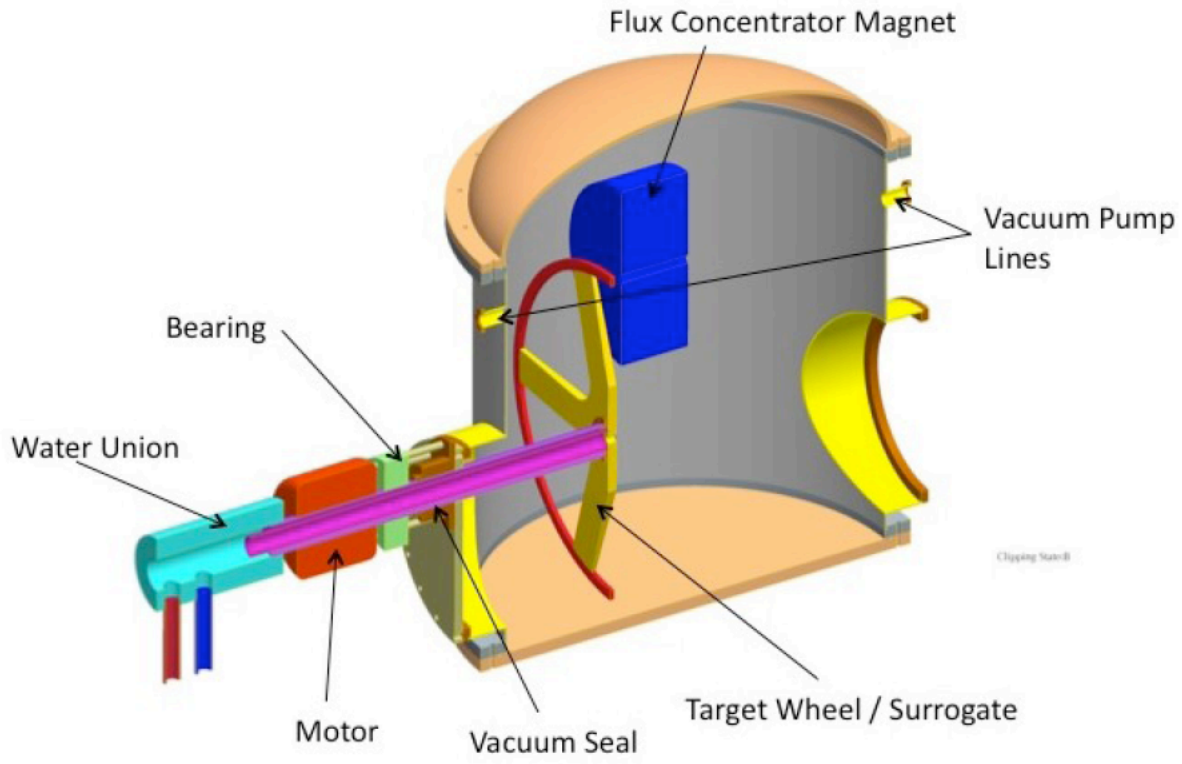
undulator relocation gives big effect to other systems (especially main linac and DR), however it gives only small effect to undulator and e+ generation.

Therefore, here, I (Omori) select topics of hardware R/Ds from Wei's presentation, I skip topics related to relocation.

Target Prototype at LLNL

Prototype II - Rotating vacuum seal test

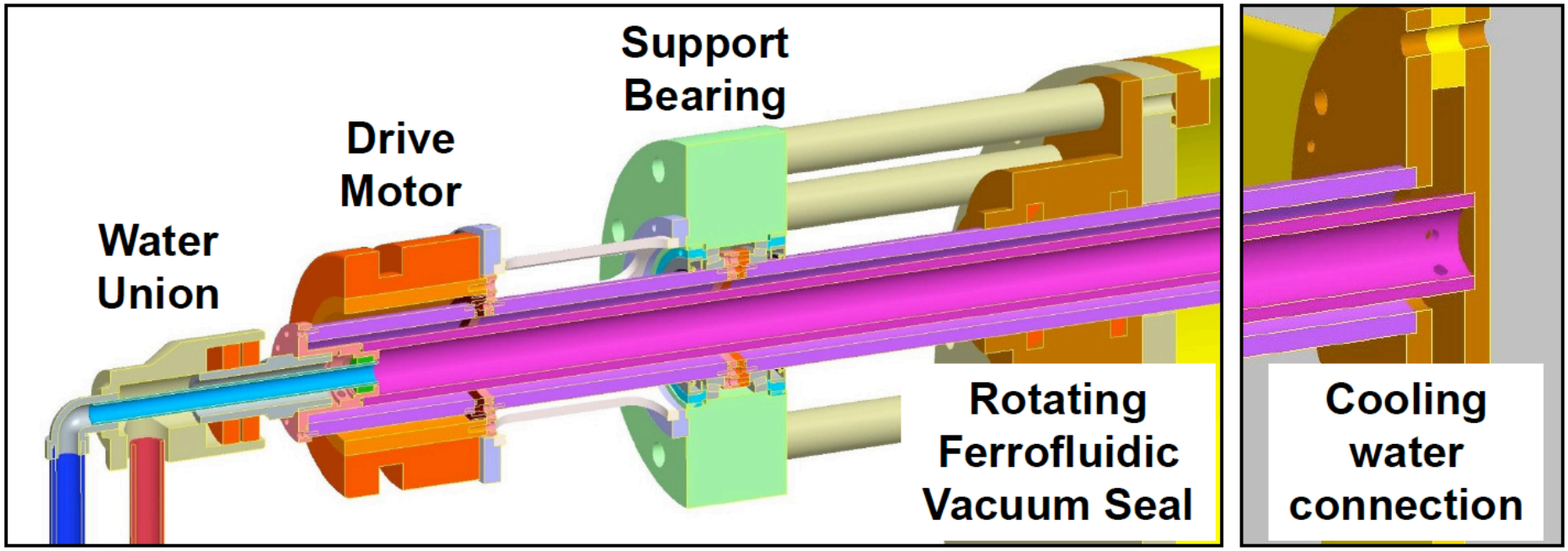
red line: OMORI



- Current design has rotating ferrofluidic vacuum seals
- Cooling water flows along the shaft

- Test leakage of vaccum/fluids from:
  - **Vibration**
  - **Magnetic field effects**

Vacuum seal test



- Altered layout after discussions with Rigaku
- Single-shaft design, larger bore **red line: OMORI**
- Hollow shaft motor Rigaku has used previously
- Water union may not be in this test configuration
  - Daresbury prototype wheel does not have cooling channels
  - Water in shaft only

Vacuum seal test

- Rotordynamics analysis and design for cantilevered layout
  - **Changed layout from Daresbury test**
  - **Requires re-evaluation of vibration modes due to new components and configuration**

赤下線は大森による

- Diagnostics setup (pressure sensors, filter and witness plate chemical analysis, mechanical behavior)

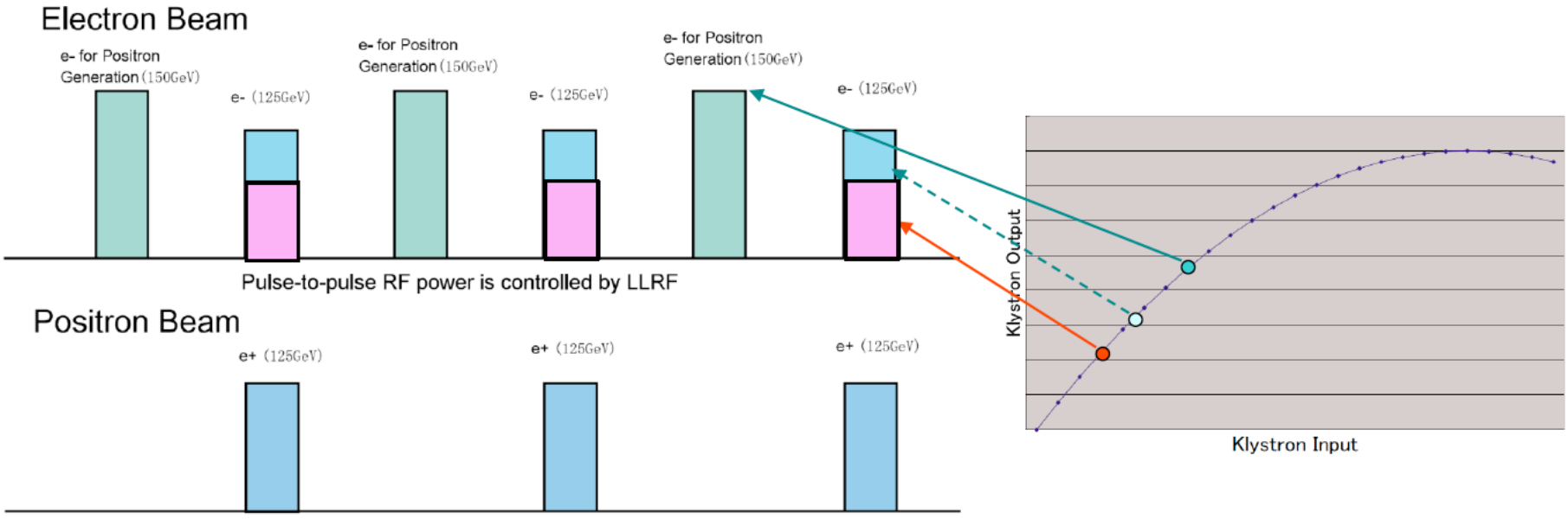
赤下線は大森による

- Developing drawings
- Acquire LLNL ES & H approval for operating plan

DRFS @ lower gradient (=10Hz)
Day 3

Fukuda さん

Pulse Structure (Lower than 250GeV)



Summary

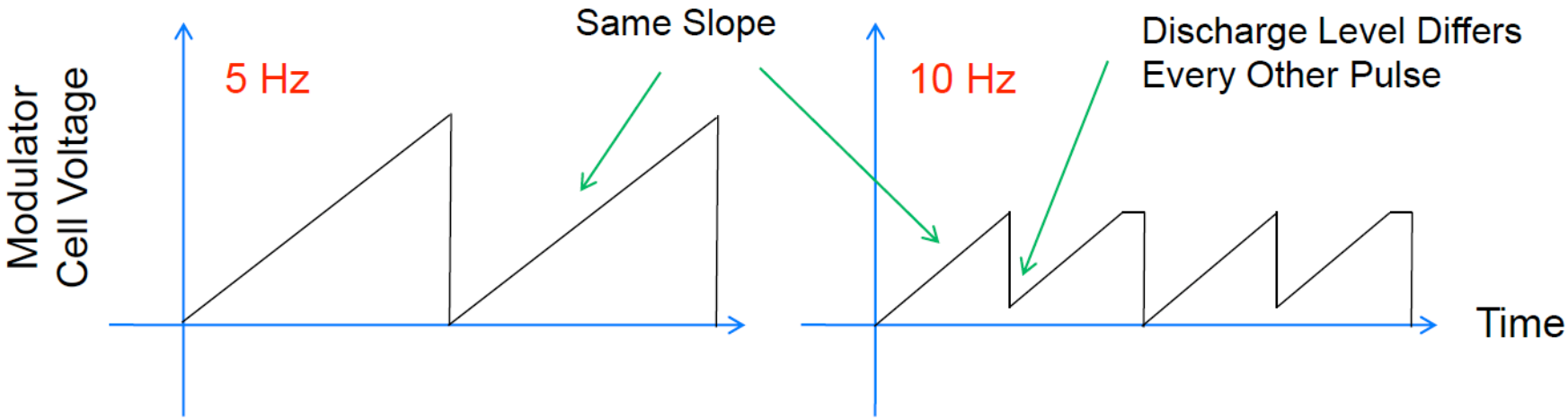
- We presented 2 kinds of scenario in DRFS. Old scenario requires a-week's modification period between the transition of operation.
- In new scheme of low energy 10Hz operation, it is possible to accelerate beams in wide range of energy. There are no period to interrupt the beam schedule comparing with the previous DRFS model.
- In 250 GeV CM energy, maximum rep. rate of 10 Hz is possible without any degradation of the RF efficiency when cavity variation distribution is uniform.
- There is no particular cost up relating with this mode from SB2009 in scenerio-2.
- Heat dissipation in this option is also discussed.

KCS(& RDR TO) @ lower gradient (=10Hz)
Day 3

Chris Adolphsen さん

Assumptions

At lower gradients, reduce modulator voltage and increase pulse rate so nominal average modulator input power not exceeded - thus the charging power supplies would see the same or smaller load (which is roughly constant), and the AC power capacity would not have to be increased.



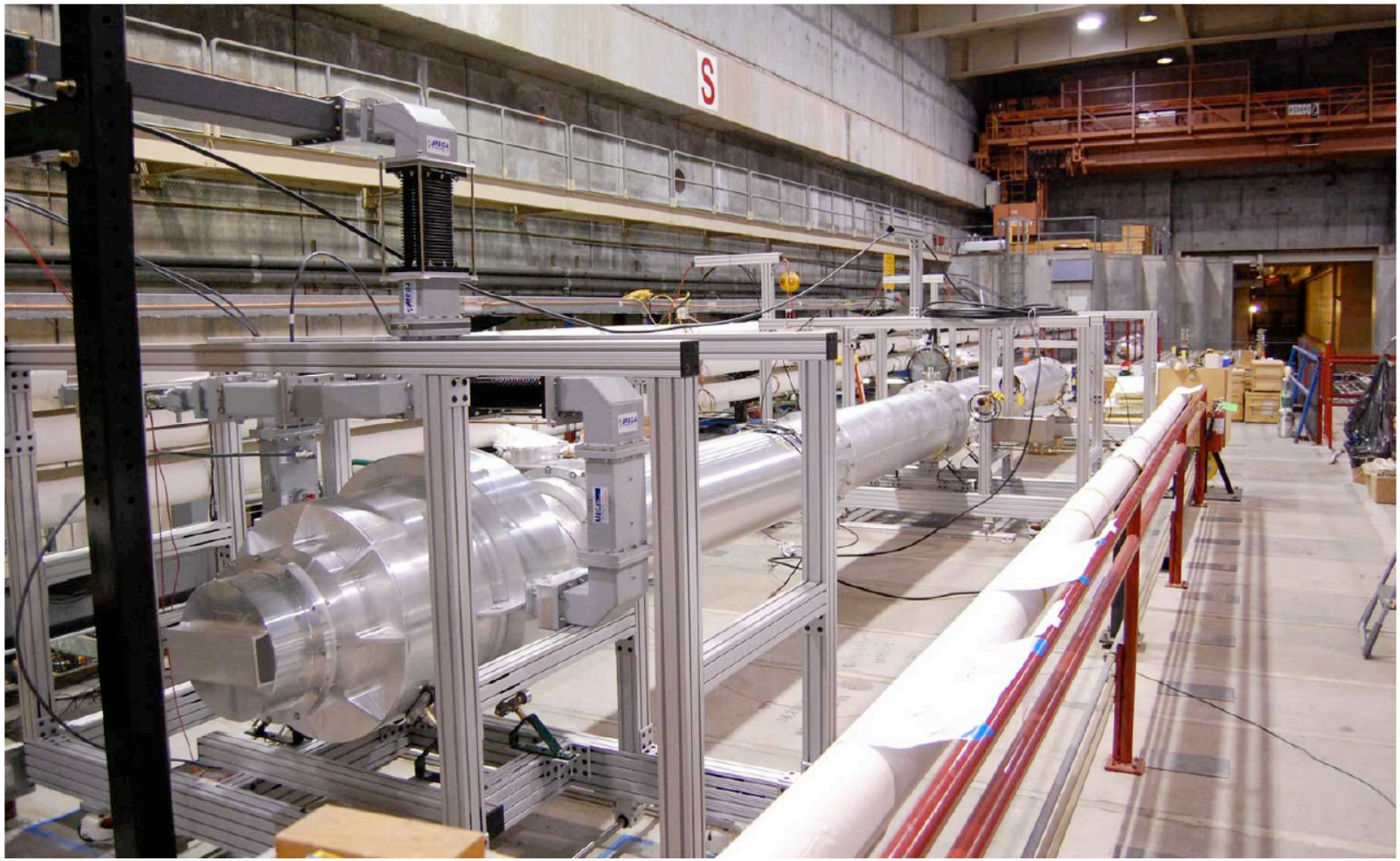
Additional line ripple introduced by alternating discharge levels would need to be reduced in the site electrical distribution system.

Summary

- The half current case clearly exceeds the RDR average modulator input power limit when running at 150 GeV (5 Hz) + 125 GeV (5 Hz), but this added capacity is needed anyway run at 250 GeV (5 Hz) with half current.
- The full current case is marginal at 10 Hz although if can alternate the modulator voltages, only 4% more AC power would be required.
- The half bunches, same rf pulse case for 150 GeV (5 Hz) + 125 GeV (5 Hz) would work and does not require any increased capacity (AC, cooling or cryo)

Klystron Cluster Scheme Tests

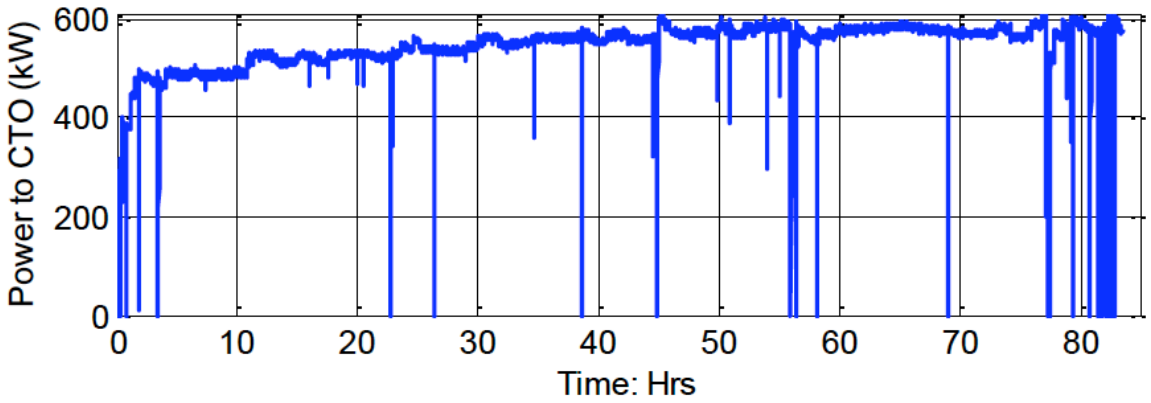
Resonantly power a 0.5 m diameter, pressurized (1 atm N2), 10 m long aluminum pipe to 300 MW TE01 mode field equivalent in 1 ms pulses

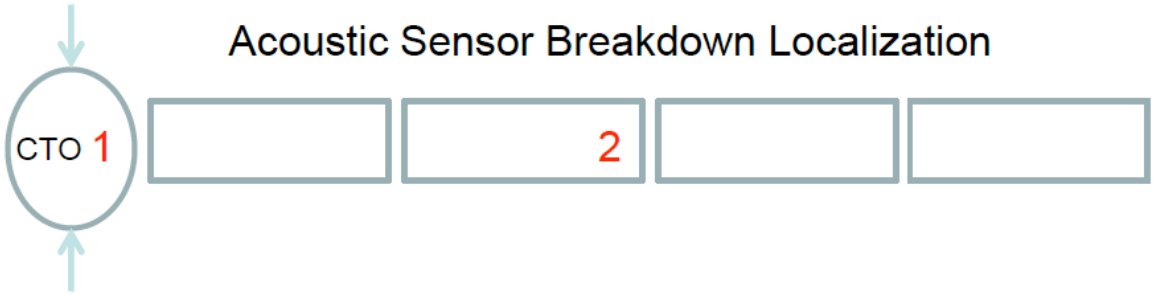


BAW2: C. Adolphsen, 20-Jan-2011, SLAC

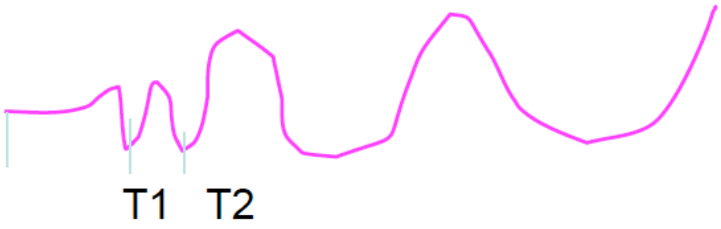
‘Big Pipe’ Operation

550 KW input power yields 300 MW equivalent surface fields in the pipe - see bkd every ~ 15 hours, maybe from CTO or upstream – rate seems very pressure dependent





Time of Position 2 markers (T1,T2) are ~ 1 ms later than those from Position 1, which suggest events are much closer to Position 1 (5 m / 5100 m/s ~ 1 ms)



BAW2: C. Adolphsen, 20-Jan-2011, SLAC

CFS@10Hz
Day 3

Victor さん

Baseline to Relocated Positron Source (10 Hz)

- *Civil Construction*
  - *No Fundamental Change*
- *Process Cooling and HVAC*
  - *Increase in Cooling Towers for Process Water (DR)*
  - *Increase in Cooling Tower Pump and Accessories for Process Water System (DR)*
  - *Increase in Chiller Capacity (DR)*
  - *Increase in LCW System (DR)*
- *Electrical*
  - *Increase in Medium Voltage Substations (DR)*
  - *Increase in Medium Voltage Distribution and Transformers (DR)*

Note: by OMORI

There are only DR marks, no ML marks, why?
We will do "10 Hz alternative operation) at low energy only.
Initial cost CFS (cooling power for example) increase in main linac is very small (150+125+125 < 250+250).

CAUTION: operation cost increase is not counted!

DR@10Hz
Day 3

Susanna さん

Positron emittance damping

~8 damping times are needed for the vertical emittance

5 Hz $\Rightarrow \tau_{x,y} \leq 26$ ms

10 Hz $\Rightarrow \tau_{x,y} \leq 13$ ms

Electron emittance damping

~5 damping times are needed for the vertical emittance

5 Hz $\Rightarrow \tau_{x,y} \leq 36$ ms

10 Hz $\Rightarrow \tau_{x,y} \leq 18$ ms

RF issues for pulsed beam operation

Alessandro Gallo (INFN-LNF)
Sergey Belomestnykh (BNL)

See also Damping rings RF session at IWLC10, CERN October 2010:

S. Belomestnykh, RF system issues due to pulsed beam in ILC DR, slides

K. Kubo, Transient beam loading correction at ILC DR, slides

Conclusions

- 10 Hz operation of the ILC Damping Ring RF system seems to be feasible.
- Cavity operation at fixed tuning is the most easily implementable configuration. No extra RF power is required for overvoltage factors η lower than 2, while optimal choice of the coupling and tuning parameters allow working up to η = 3 with modest RF power increase.

Common concerns & studies needed:

- RF window/coupler power handling with full reflection
- Feedforward to mitigate transients during beam injection/extraction
- Pulsed operation of the RF system is worth considering as it will save power and reduce thermal load on RF window/coupler. Two options here: (i) pulsed RF and klystron mod anode; (ii) pulsed klystron HV.

Source@10Hz (e- Source)
Day 3

Axel Brachmann さん

e- source change by "5 Hz → 10 Hz" is small. skip it

Alternate Pulse Operation in e- Main Linac Day 3

Kubo さん

Summary + solutions (1)

In Main Linac tuned for low energy beam (100 GeV):

- High energy beam (150 GeV) at linac end will have
  - Vertical orbit Δy~1 mm
  - Vertical emittance $\gamma\varepsilon_y$~1 um (nominal x 50)

    (250 GeV beam will be worse:
    - Vertical orbit Δy~6 mm
    - Vertical emittance $\gamma\varepsilon_y$~4 um (nominal x 200))

No problem in ML.

For down stream:

- Probably x50 emittance is OK.
- But, need orbit correction

  (Pulse by pulse changing magnets.)

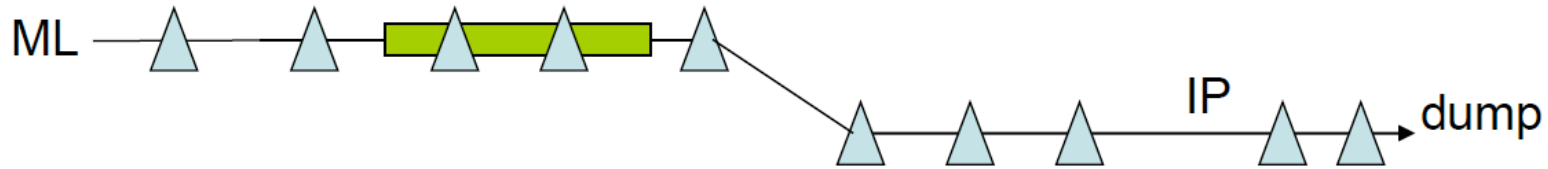
Summary + solutions (2)

- Need orbit corrections for both high and low energy beams → alternately changing magnets
- In undulators
  - Orbit of high energy beam should be good.
  - Emittance of low energy beam should be preserved.
  - Can be satisfied both?
    - If not, low energy beam bypass undulator?

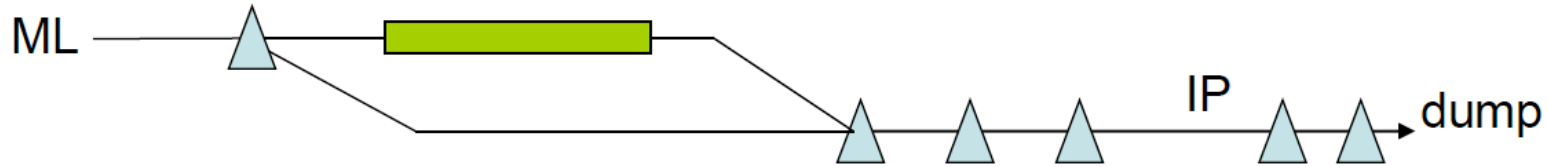
- High energy beam may cause problems around IP?
  - bypass IP (go to e+ dump)?.

Possible Solutions

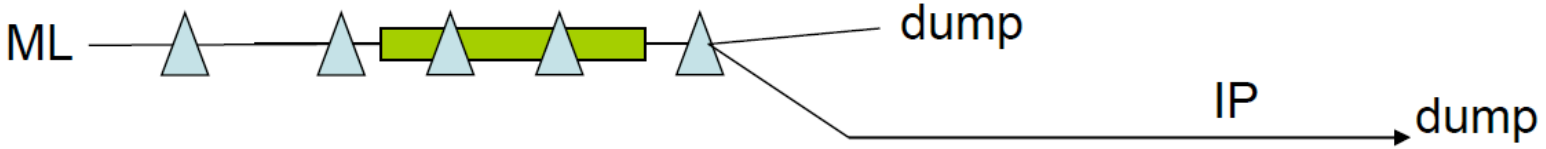
Pulse-by-pulse switching magnets (How Many?). No additional lines



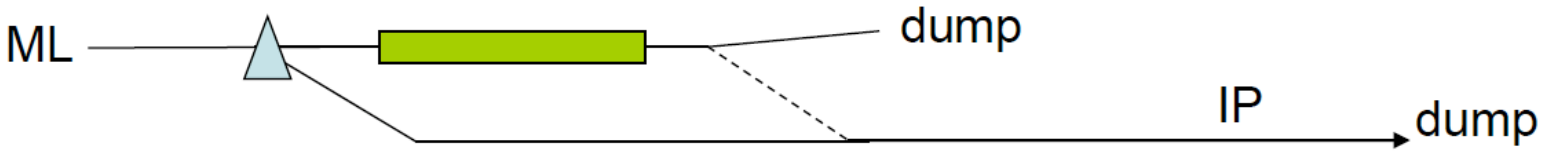
Bypass undulator



Dump High E beam



Both



BAW2: K. Kubo, 20-Jan-2011, SLAC

Undulator R/D
Day 4

Jim Clarke さん

Undulator Cryomodule

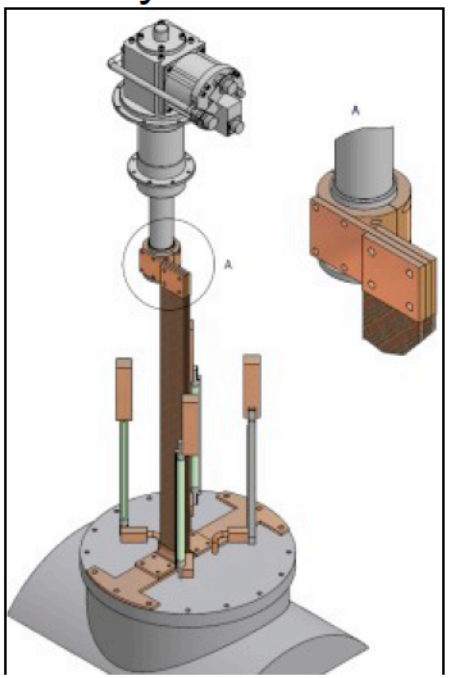
July 2010 – Top plate cooled by cryocooler

It was seen that it did not take much heat input to change temperature of top plate and HTS/LTS join.

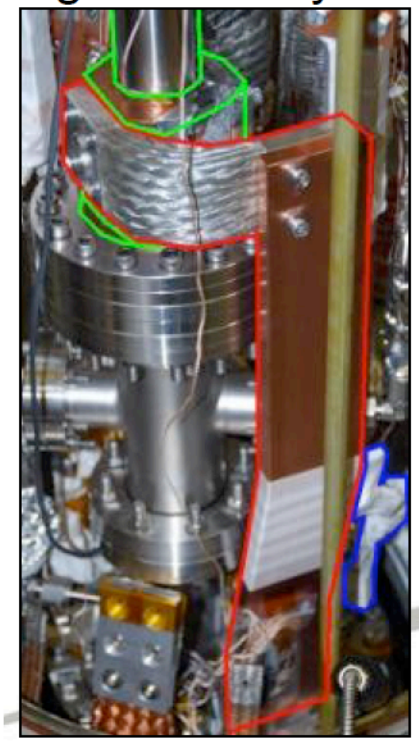
good news!: horizontal test successful

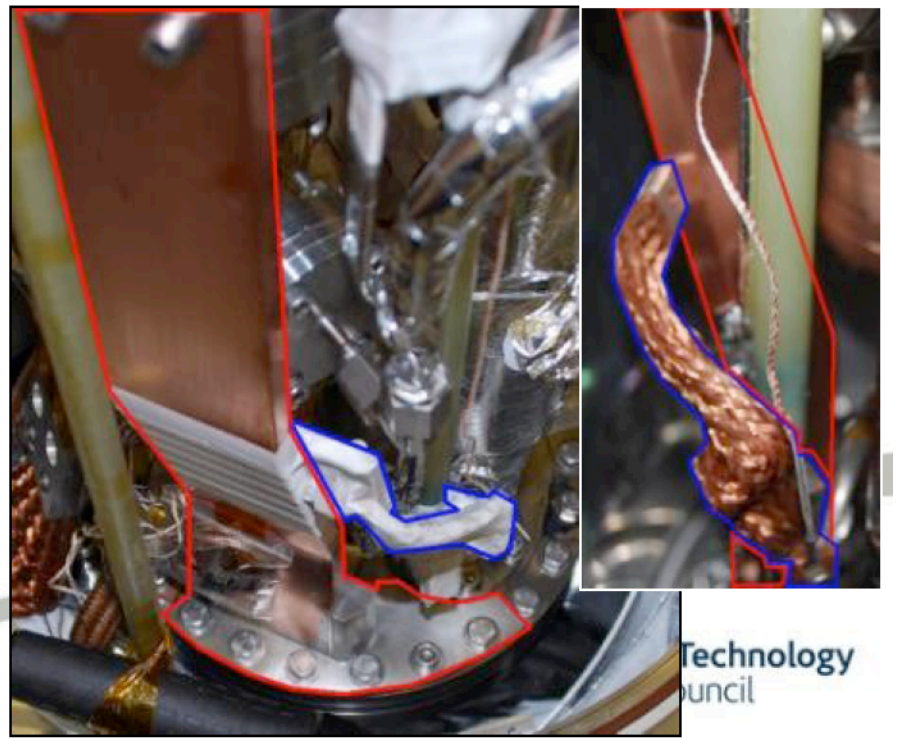
red letter: by Omori

Large copper bars have been inserted to cool top plate and HTS/LTS join directly from the 2nd stage of the cryocooler.



Owen Taylor, STFC





Technology
uncil

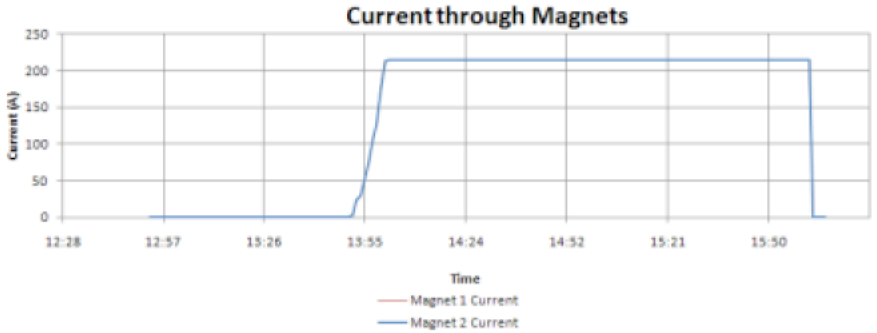
BAW2: J. Clarke, 21-Jan-2011, SLAC

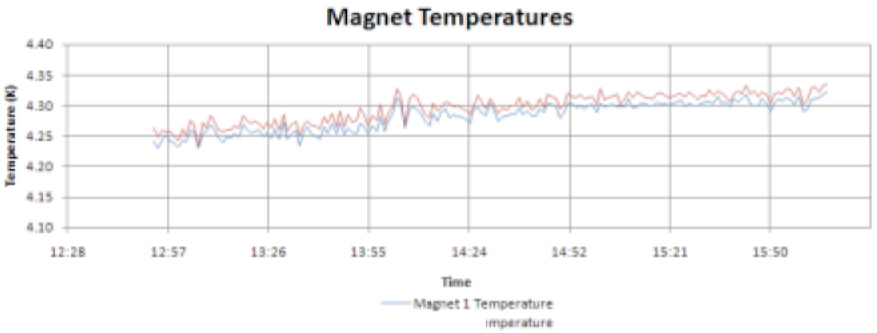
Undulator Cryomodule

- Both undulators now powered individually and together at 215 A (0.86T) – stable operation (during 2 hour test)
- Both also powered at 252A for > 1hour but then lead quenched above top plate
  - Not enough margin on top plate temperature at high current?
  - No magnet quenches so far

good news!: horizontal test successful

red letter: by Omori





Steve Carr, STFC

BAW2: J. Clarke, 21-Jan-2011, SLAC

Cost Implication
(related to undulator relocation)
Day 4

Peter Garbincius さん

cost impacts of moving of e+ source

Cost Differentials for Centralized e+ Source - M ILCUs	Savings	Additions	Notes:
one set of MPS sacrifical collimators, abort, & dump	???		never estimated for RDR
301 m tunnel (for above)	3.0		
301 m tunnel widening (for above)	4.7		
4 m dia rad material handling shaft & grouting	9.5		
Radioactive Materials Handling & Storage Bldg	3.1		
KAS e+ target station & acceleration to 400 MeV	28.2		- see next page for details
electrical power	???	???	not considered yet by CFS
thermal cooling	???	???	not considered yet by CFS
spent 150 GeV e- from undulator => dump 1,166 m dogleg, min FODO, min instrumentation, rastering?		???	also need 100 msec beam switches
LET bypass around undulator for beam to I.P. (620 m)		???	- do we need/want this?
total change (= savings minus additions) - M ILCU	48.5	???	M ILCU

150 + 125x125 Centralized e+ Source

+ 37 M ILCU (more)

- 48 M ± ???

tab: needs

Summary - 11 ± ?? M ILCU

BAW2: P. Garbincius, 21-Jan-2011, SLAC

Summary
(related to undulator relocation)
Day 4

Nick Walker さん

Cost Impact

- Approx. Cost of 10Hz Alt. +0.6 %
- Approx. Cost of moving source -0.6 %
- Net cost ±0.0%

red box: by Omori

- Primary motivation for this proposal is not cost.

- Note high-field short-period undulator would be more cost effective

Cost Impact

- Approx. Cost of 10Hz Alt. +0.6 %
- Approx. Cost of moving source -0.6 %
- Net cost ±0.0%

red box: by Omori

- Primary motivation for this proposal is not cost.

??? red letter & red box: by Omori

- Note high-field short-period undulator would be more cost effective

Physics Requirement for Positron Polarization Day 2

Sabine Reimann さん

There were 6 physics talks in Day 2.
I introduce only one which is related to e+ source.

Positron polarisation is upgrade option, not baseline

Sabine-san submitted a question. **red letter: by Omori**

Is P(e+) indispensable for a future linear collider?

- **new physics signals are expected at the LHC; they can be interpreted and fixed with substantially higher precision if positron polarization is available**

  → distinction of new physics models

What are the physics requirements to have positron polarisation?

- **Overview of physics goals: see Moortgat-Pick et al., Phys.Rept. 460(2008)131**

BAW2: S. Riemann, 19-Jan-2011, SLAC

Summary and outlook

Sabine-san didn't conclude that pol e+ was indispensable. **red letter: by Omori**

- Positron polarization
  - **Increases significantly the physics goal**
  - **will be available from the beginning with helical undulator as baseline design**
  - **Undulator at end of ML ⇔ some measures needed to take full advantage of e+ polarization**

- Under work:
  - **scenarios with polarization and consequences for physics precision**
  - **spin tracking from start to end for updated design**
  - **Depolarization effects at IP**
  - **Demonstrate target (and photon collimator) reliability**

Many thanks to the polarization group at DESY and Uni Hamburg, in particular Andriy Ushakov, Gudi Moortgat-Pick, Andreas Schälicke for contributions and discussions!

BAW2: S. Riemann, 19-Jan-2011, SLAC

New Low Charge Parameter
Day 4

Jie Gao さん

This proposal is NOT related to "undulator relocation".

New low charge parameters for ILC

D. Wang (IHEP), J. Gao (IHEP)
K. Kubo (KEK)

ILC BAW2, SLAC, January 21, 2011

- Main changes in the new low charge parameters
  - bunch charge: 2e10→1e10
  - bunch number: 1320 →2625
  - bunch length: 300 um →166 um

Risk of SB2009

- Beam beam effects are very strong.

  -Dy=38.4, collision stability may become a problem

  -$n\gamma$=1.74, Nhadron=3.6, the noise background level in the detector will be high

  -δ_B=5.6%, the uncertainty of physics experiments is large

  -the large disruption angle (0.48 mrad) will interfere with the detection of small-angle events

- It will be difficult to reduce the bunch length further (under 300 um) with the one-stage bunch compressor. The flexibility of the whole machine is limited a lot.

point: double bunch-compressor

red letter: by Omori

Note by OMORI:

Gao-san only mentioned about reduction of machine background as a positive effect to physics studies.

However, there is another good effect to physics studies. It is increase of "Peak 1 % Luminosity" (60% → 75%). It makes smaller physics background.

Philosophy behind the new parameter list proposal

- To have better IP physics qualities
- Try to make all subsystem technically ready at the same time when the ILC is projected
- Keep the ability to transfer technical difficulty from one subsystem to another without compromising IP physics qualities

Considerations for the new parameters

- Reducing the bunch charge by a half will mitigate the difficulties for source further. (porlarized positron production may still have problem??)
- Emittance preservation in RTML and ML will be easier with the low charge parameters.
- The bunch number per train can be increased twice assuming the same 3.2 km DR.
- Try to decrease the beam beam effects in SB2009
- the two-stage bunch compressor will be needed to get 160 um bunch length. (also more flexibility)
- Keep low beam power and low AC power in SB2009

Summary

Summary

1. Cost decrease of "undulator relocation" and cost increase of "10 Hz" cancels each other. There is NO net cost reduction.

2. Nevertheless PMs proposed undulator relocation. I think that they thought followings were good reasons;
   * large energy overhead to drive the source
   * all high radiation sources now contained in ‘central region’ campus area, , , ,

3. Proposal of New Parameters by Gao-san was interesting.