Review of Risks for e+ sources

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Contents

Risk Assessment on e+ source

- Risk control is very important for e+ source of LC.
  - LC is a big system. If there are small, but significant risks on the subsystems, the system availability is close to 0.
  - Positron source of LC is one of the most complicated sub-system among LC sub-systems.
  - The risk is partly assessed, but not fully understood.
  - Nobody knows whether controllable or not.
    - e.g. the cavity gradient is a controllable risk.
- To mitigate or minimize risks on e+ source
  - Find risks.
  - Assess the risks.
  - Control the risks.

Risks on the 3 schemes

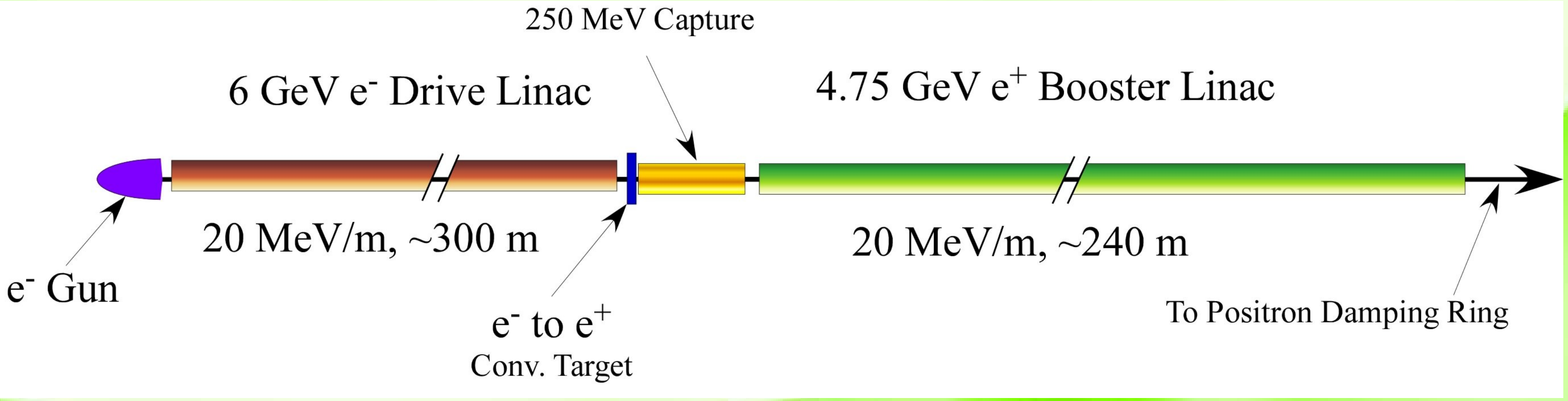
- The three schemes have different nature on risk management.
  - Electron driven
  - Undulator
  - Laser Compton
- Risks should be controlled for each schemes considering the different nature.

Electron driven (Conventional)

- The technology is well established.
- Drive beam, capture optics, e+ booster are conventional, or similar to other LC section.
- Potential damage on the target.
- High radiation.
- The risk can be controlled by,
  - Define the target damage threshold,
  - A new technology (liquid metal, crystalline target),
  - Manipulation on the beam structure (300Hz generation),
  - Remote handling capture system (high radiation area)
- The risk is concentrated on the target.

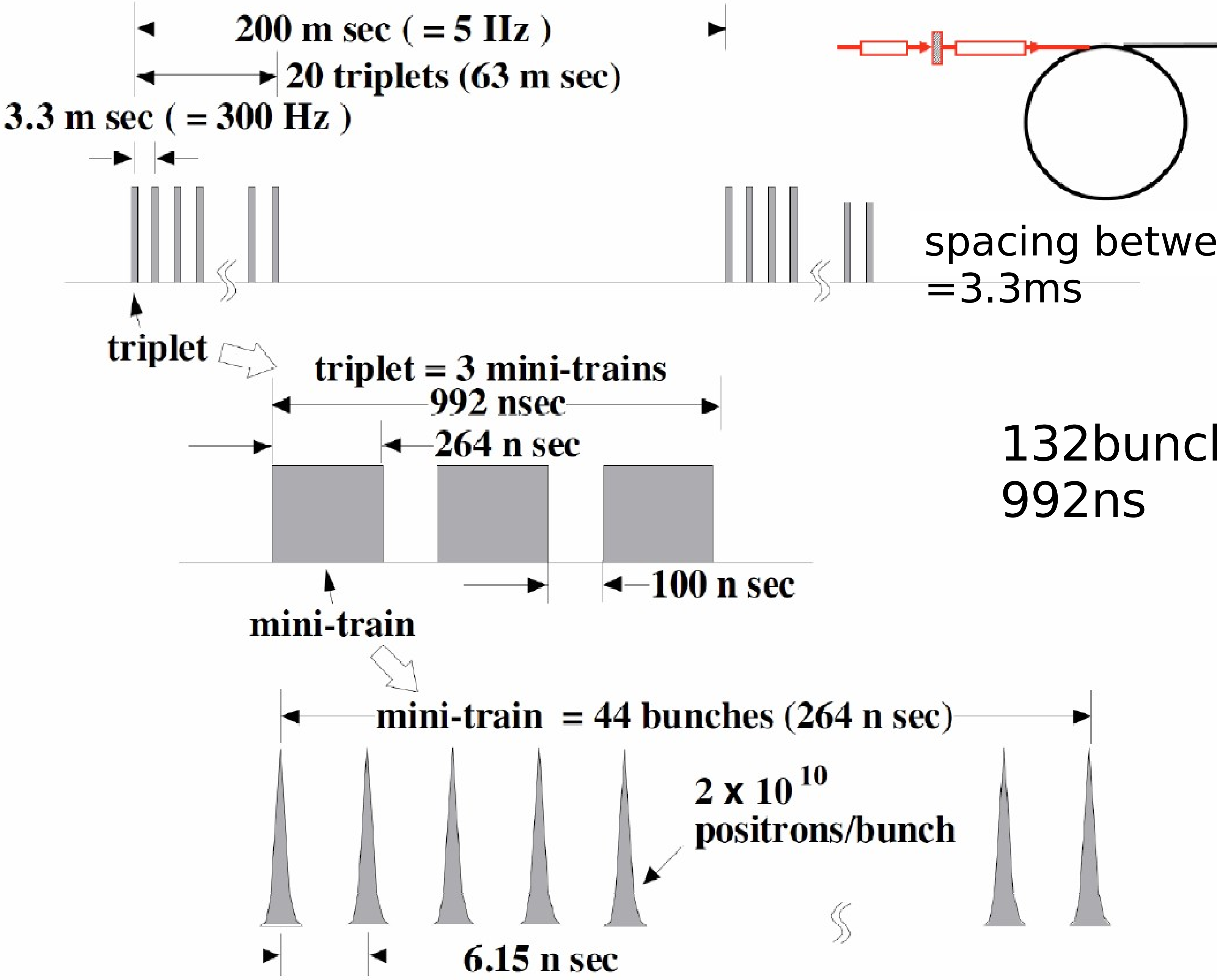
Electron Driven Scheme

- It is desirable to develop the LC positron source based on a well established technology to minimize any risks. Conventional e+ source is the one.
- However, we need a large extrapolation to LC e+ source. Does it really work? Our answer was YES (at least in 2005 Snowmass).
- The conventional scheme driven by 6 GeV electron beam with 4.5 radiation length W-Re target is proposed at Snowmass 05, but it is not approved as baseline.



In the case of 300Hz scheme

T. Omori
T. Takahashi



spacing between triplets =3.3ms

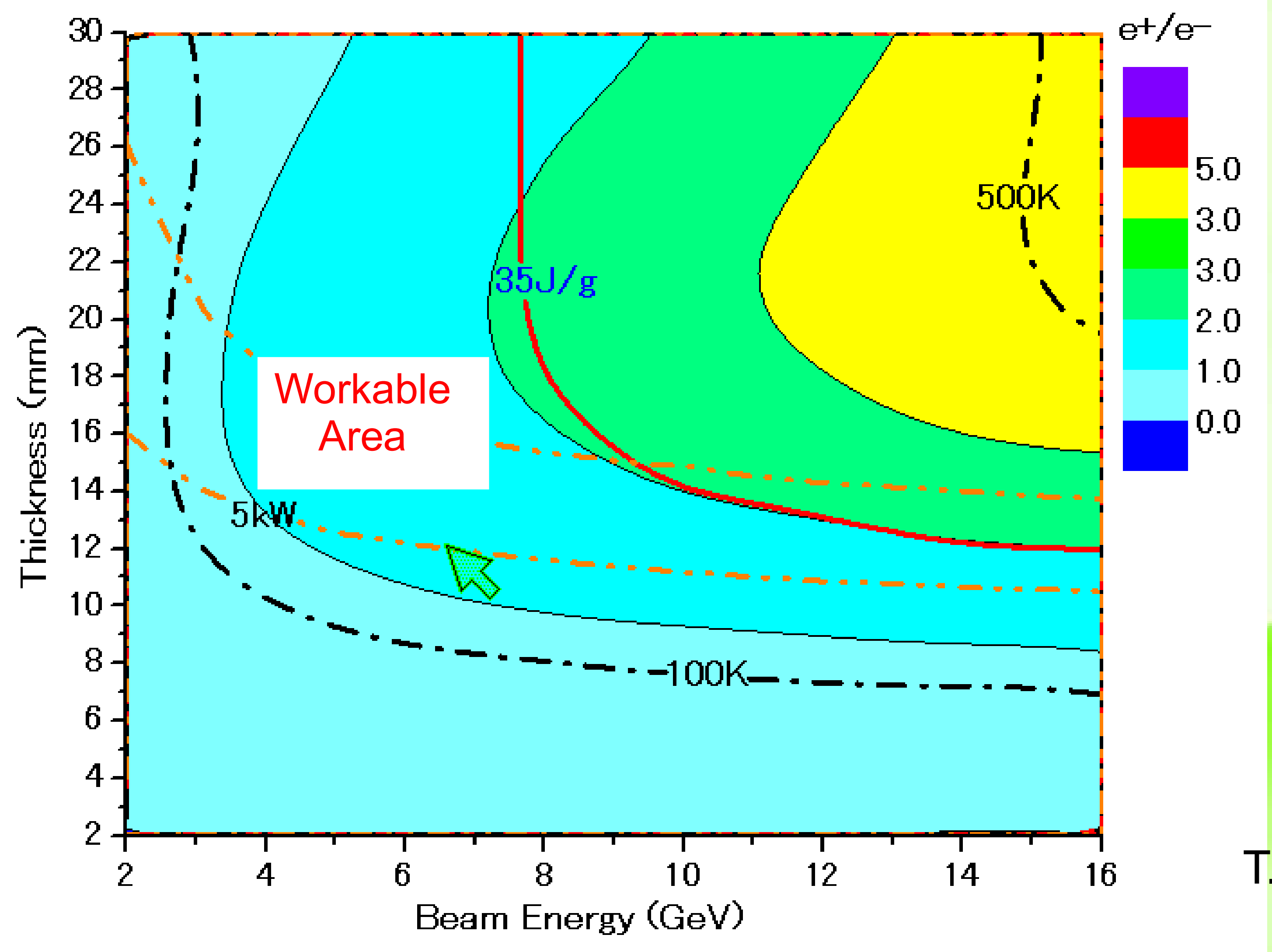
132bunches in 992ns

Parameter Plots for 300 Hz scheme

e- directly on to Tungsten

σ=4.0mm

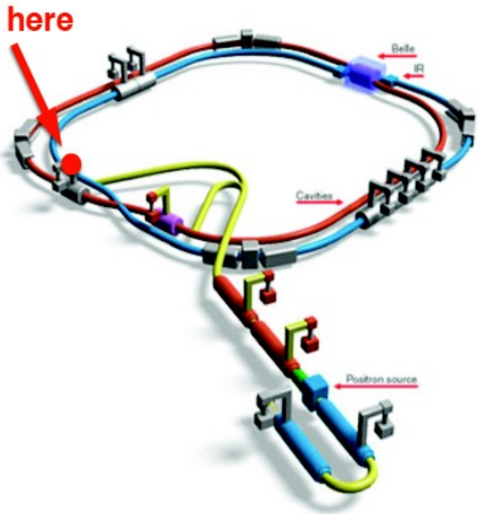
colored band	accepted e+/e-
(red solid line)	PEDD J/g
(dash-dot line)	dT/triplet (132 bunc)
(dash-dot-dot line)	ToTal deposit kW

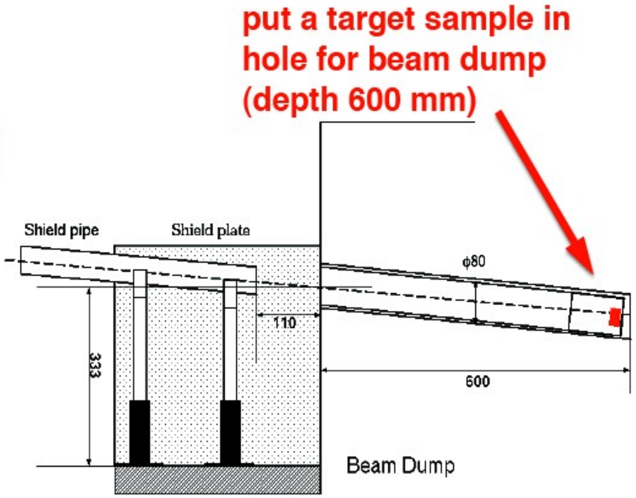


T. Takahashi

Liq. Pb window test

Liq. Pb Window Test at KEB





June/27(Sun)

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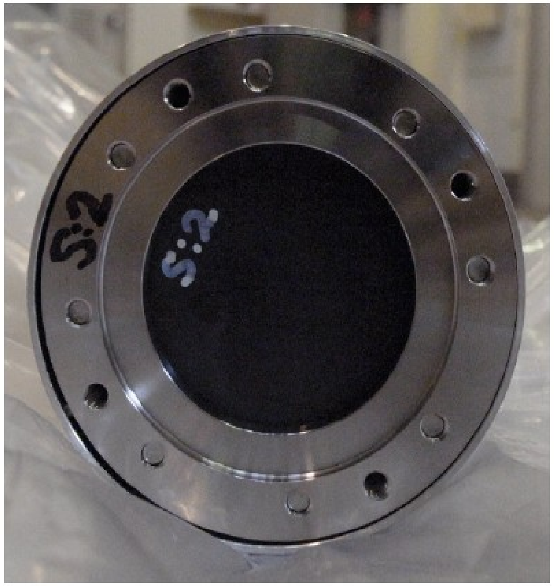


- KEKB-HER: 8GeV, 10nC (Max), 1600 bunches
- The beam is deflected by the abort kicker as sh
  it is dumped.

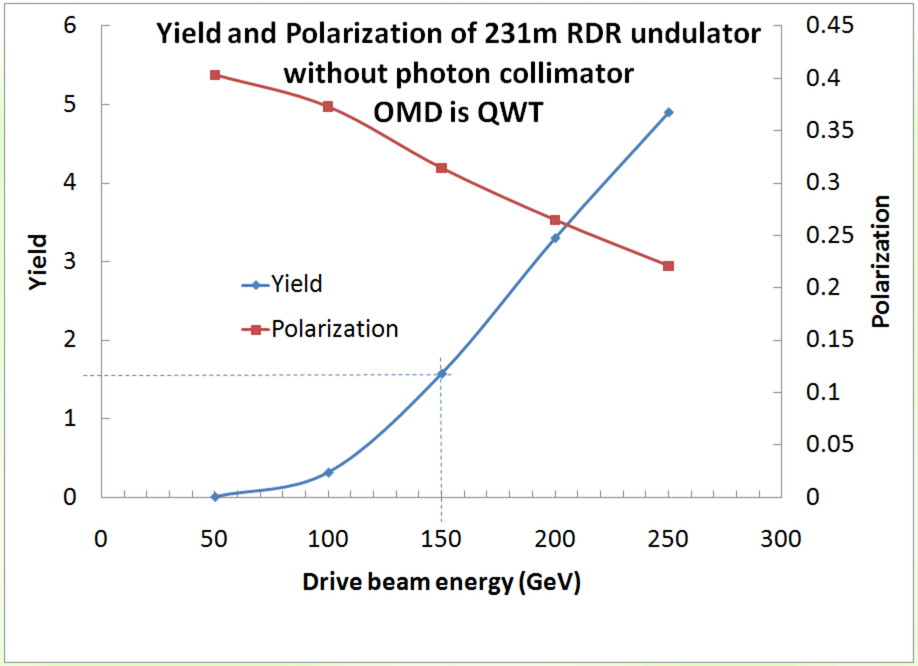
No obvious defect was observed in any sample.

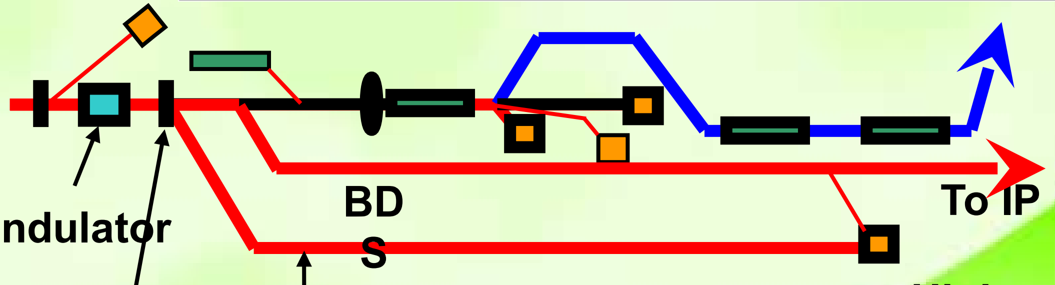
Undulator Scheme

- It is a totally new approach.
- Proof of principle has been demonstrated, but it is difficult to confirm the system reliability prior to the real LC.
- Inter-system dependence; It is not a simple system.
  - Beam structure manipulation is not possible,
  - Possible low availability,
  - Less yield in the low-energy running.
- Drive beam: e- beam for collision
  - It must be ready, but risks on MD, commissioning, less availability.
  - Impact on e- beam.
- Small aperture, SC helical undulator: It is a new device.
  - Technical maturity
  - Alignment
- Heavy load on target.
- AMD: undulator length depends on the capture efficiency.

Operation mode (SB2009)

- Undulator is moved to the end of linac for cost saving.
- E+ yield is dropped at lower energy region.
- It is cured by alternate operation (switched mode)
  - One pulse for e+ generation
  - Another pulse for collision
- Load on target is doubled.
- If LowP option works well, the problem is much relaxed.





Photon Energy Deposition

- Condition
  - 231m long undulator
  - QWT
  - 5Hz @ 150GeV and + 5Hz @ 125GeV
  - 1300 bunches per train (LowP)
  - Both beams go through undulator

J. Clarke, 7th e+ meeting

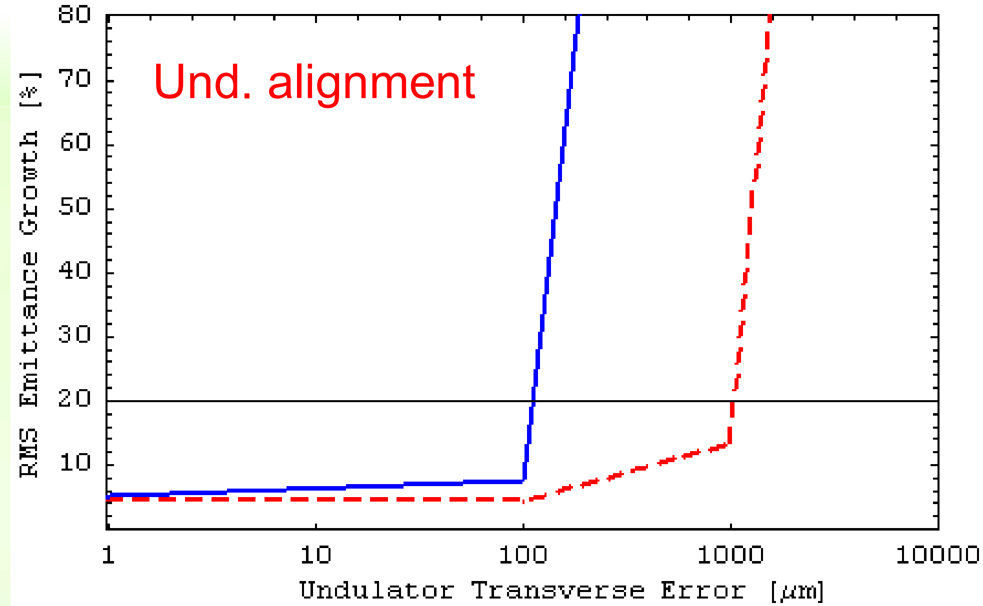
- Photon beam power generated by undulator:
  - 173 kW average photon power (102+71kW)
  - 14kW deposited on target (8+6kW), it is doubled for nominal.
  - It is below RDR assumption, 21kW. Manageable?
  - With 2625 bunches, 28kW is marginal.

Undulator Prototyping

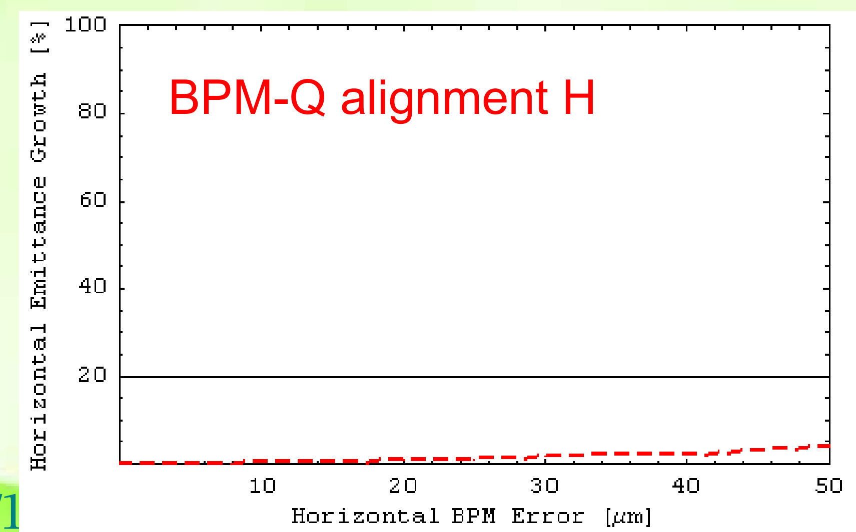
- 4m undulator (re-condensing cryomodule).
- Vertical test was successfully done.
- In horizontal test, thermal penetration (larger heat load) problem. It must be solved to fix the technical design.
- Field quality measurement?
- Alignment?
- The field quality and alignment have impact on
  - Electron beam degradation
  - Positron yield, polarization

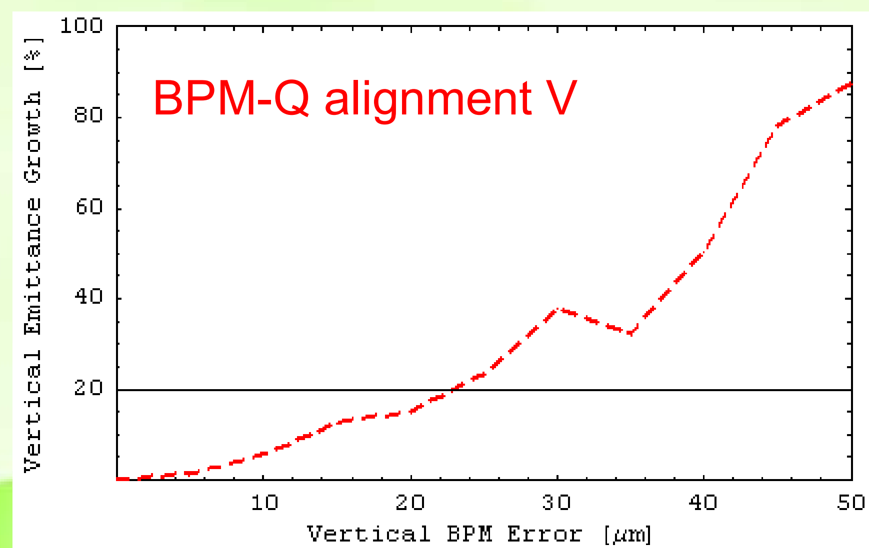
Electron beam degradation

- The tolerance on the vertical and horizontal alignment of the undulator ~100microns for 6eV kicks.
- The tolerance on the Quad-BPM alignment ~20µm.



D.Scott, ILC e+ meeting



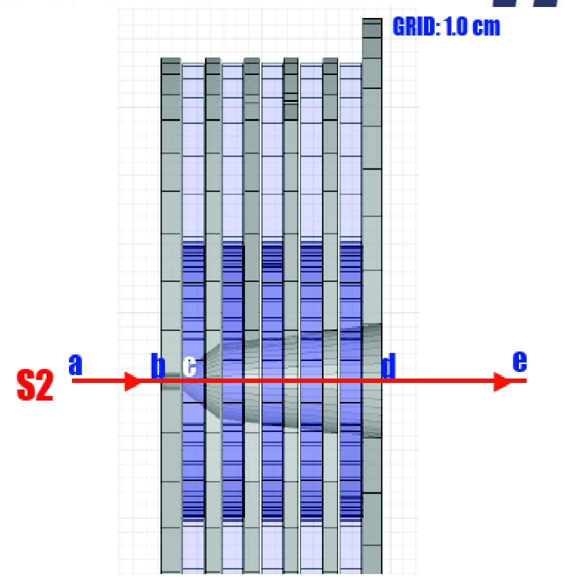


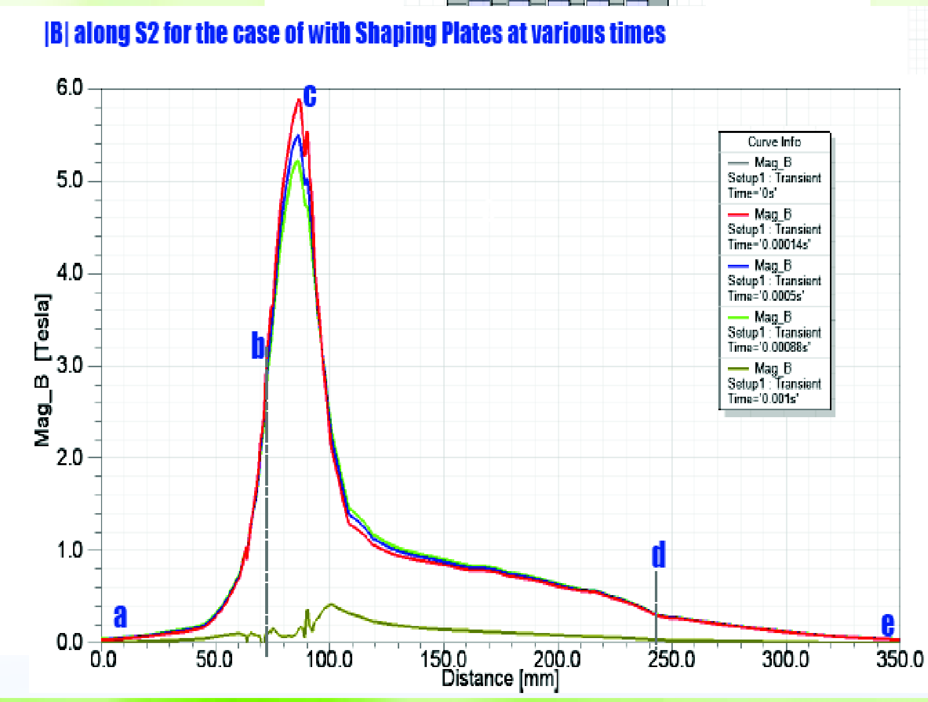
Alignment of Undulator Section

- Undulator alignment tolerance is 100μm.
- Beam should be aligned within 20μm to quad center.
- For a good collimation of photon beam, the beam trajectory should be aligned within ~4μrad(2mm spot 500m drift).
- These numbers have to be satisfied simultaneously.
- How much is the alignment error in cryostat?
- Do we have alignment scenario for the undulator section?

Flux Concentrator

- It is a key device; High capture efficiency makes
  - Less undulator length,
  - Less heat load on target
- FC R&D is also very important mitigating the risk.
- LLNL : engineering design study.
- Experimental test is planed.
- The current design assume QWT, which has lower capture efficiency. It is desirable to be replaced with FC/AMD .

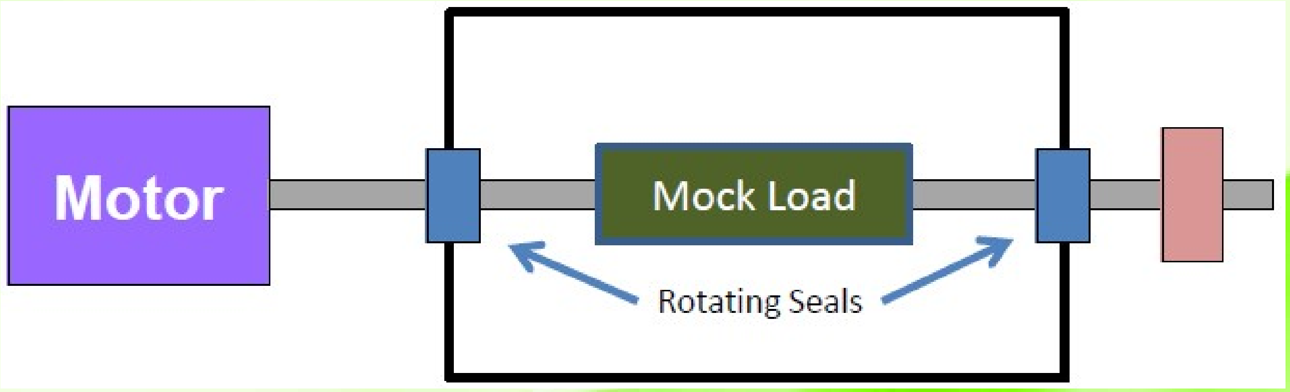




T. Pigott,
7th Positron source meeting

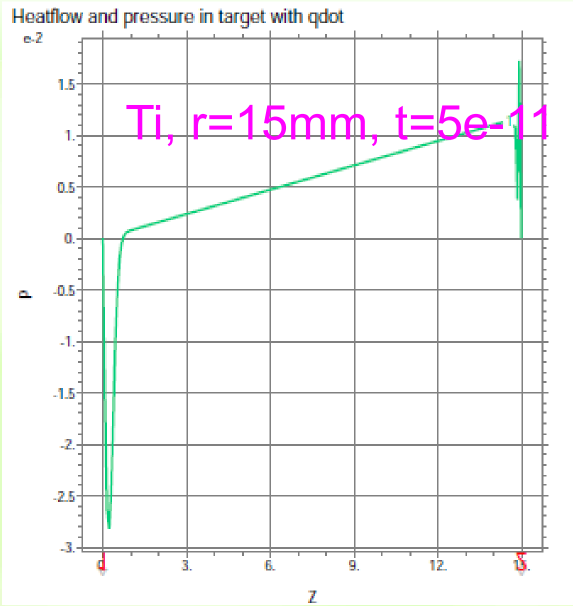
Vacuum Seal

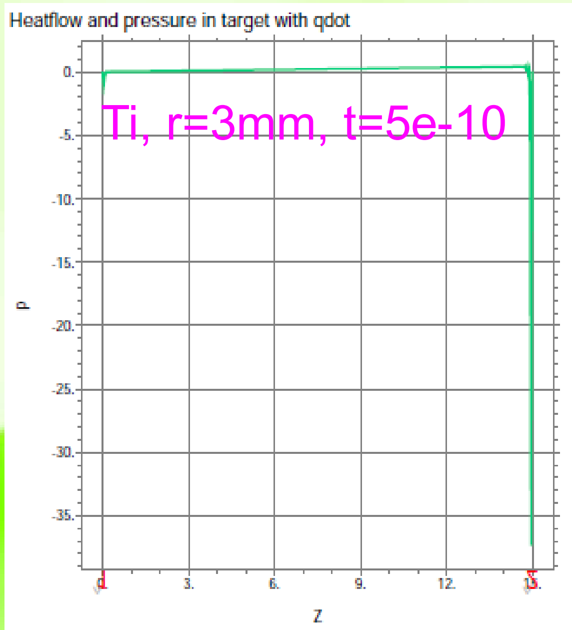
- The fast rotating target is placed in ultra high vacuum.
- Rotation rod should be properly sealed to keep a good vacuum for target & capture section.
- Ferro-fluid seal is a candidate.
  - Design study.
  - Experiment:What is the criteria?
  - The test experiment will be carried out at LLNL with a dummy target. Is it enough?



Thermal Shock wave

- The effect could be serious for electron driven and undulator (eventually for laser Compton).
- Two studies: LLNL and Cornel.
- FlexPDE (Hydrodynamical model)
  - O(10-100) MPa with r=3mm beam size.
  - The effect is less for r=15mm(RDR).
  - Tensile strength Ti = 965 Mpa
- Is Ti target safe with RDR parameters?
- Do we need an experimental evidence? Is experiment with KEKB beam useful?



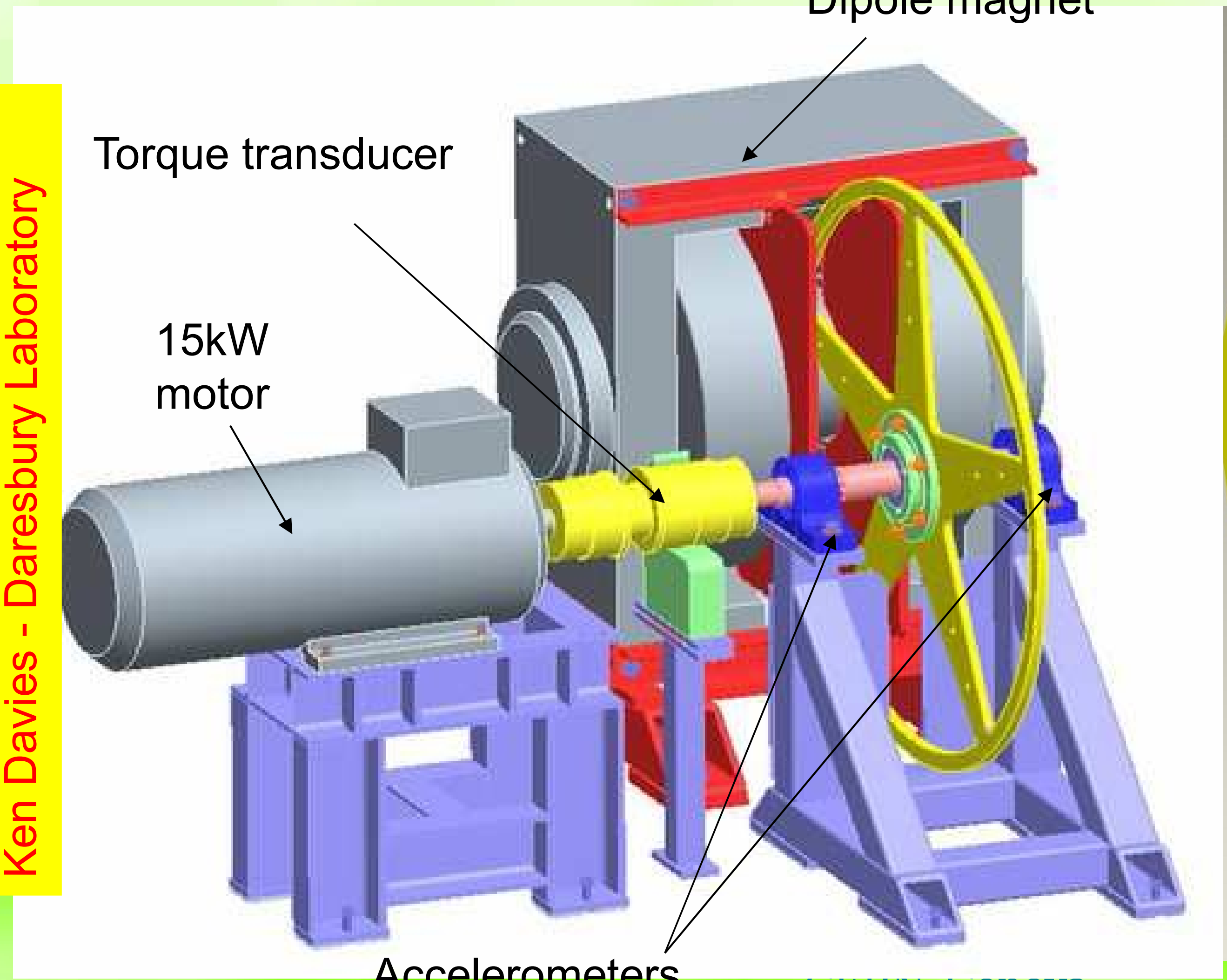


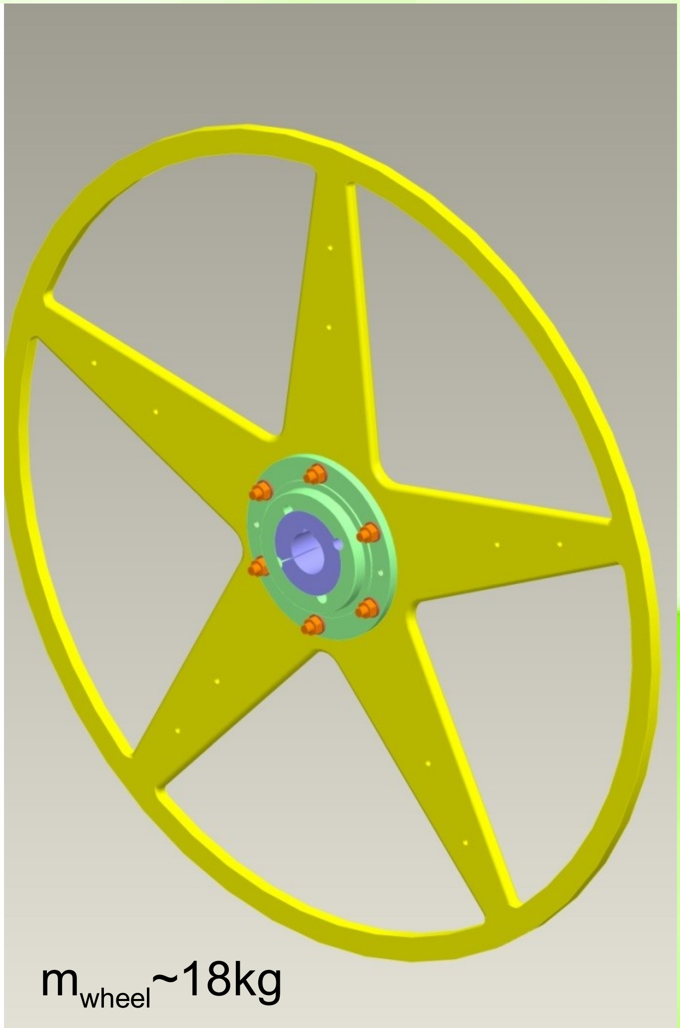
S. Hesselbach, 7th Positron meeting

Target Prototype Design

Prototype I - eddy current and mechanical stability

I. Bailey

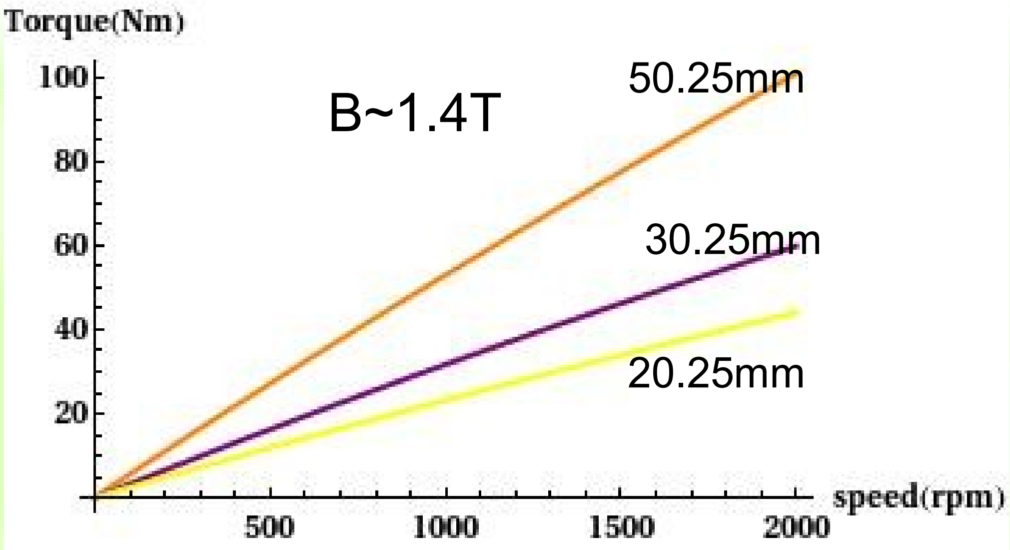


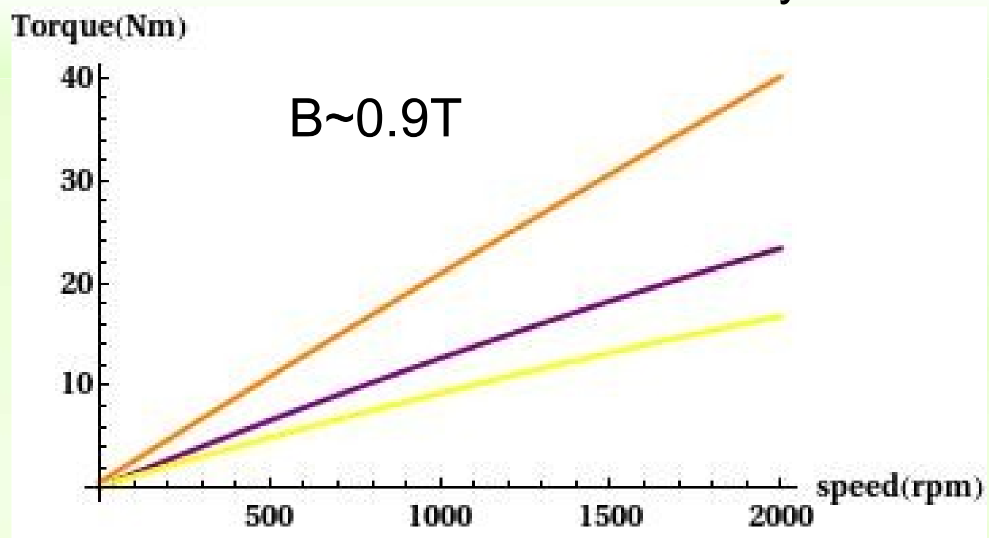


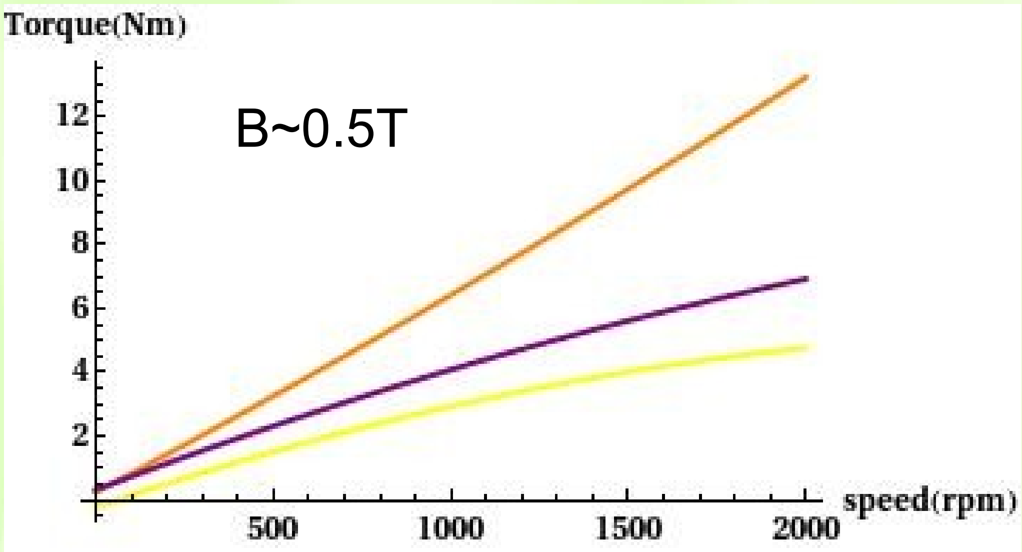
Ken Davies - Daresbury Laboratory

Effect of B Field on Average Torque

I. Bailey







- The plots show a quadratic fit to the measured torques (≤ 1500rpm) where the effects due to bearing friction have been removed.
- The colours represent different immersion depths of the wheel in the field.

1.0T immersion operation looks feasible.

Laser Compton

- It is a totally new approach.
- Proof of principle has been demonstrated.
- We need to understand the risks on the critical items,
  - High power laser: High power Mode-lock laser + PC-PM-LMA Fibre amplifier.
  - High finesse optical cavity: 4 mirror 3D small waist configuration + fine feedback control.
  - Beam dynamics: Stable acceleration or circulation in Linac, storage ring, and ERL.
  - DR stacking : Less loss is better, but what is enough level?
- It is a important step to confirm an enough yield of positron/gamma experimentally.
- Can we answer all questions after all?

What will be remain?

- If R&D for critical devices were finished and an enough positron (or gamma) yield was experimentally confirmed, some ambiguities are still remained on
  - DR stacking.
  - Beam dynamics in electron driver.
- These risks can be controlled if a wide range of parameter manipulation is possible.
- Because the scheme is independent system, the manipulation is possible, when operational margins are reserved for
  - Bunch intensity
  - Laser power
  - ...

Summary

- Risks on positron source for LC is considered and partly reviewed.
- R&D for critical devices are important for all schemes.
- Conventional: Risk is concentrated on target. It is controllable.
- Undulator: Risk control by parameter manipulation is very limited. The risk should be well understood.
- Laser Compoton: When the enough yield is demonstrated , the risk can be controlled by parameter manipulation.