# Progress in the Accelerator Design

Operation at Z-pole

Status of Positron Source Development

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# Z-pole Operation of ILC@250

- This report presents study results about the Z-pole ($E_{CM}$ =91.2GeV) operation of ILC@250, assuming the undulator scheme for positron production.
- The possibility of Z-pole operation was first discussed by N. Walker
  - "ILC possibilities at Z and W",
  - http://ilcdoc.linearcollider.org/record/63004?ln=ja
- and by KY at the LCWS2016 at Morioka in Dec.2016 .
  - LCWS2016-ZpoleOperation-Yokoya.pptx in
    https://agenda.linearcollider.org/event/7371/contributions/38173/
- These reports only gave a speculation by a scaling law and some comments on the issues to be studied
- The situation has changed since then
  - ILC energy is now 250GeV rather than 500GeV with shorter linacs
  - The baseline luminosity at 250GeV has been improved from 0.82E34 to 1.35E34 since AWLC at SLAC in Jun.2017, by adopting a reduced (halved) horizontal emittance with a new lattice of the damping ring.

# Issues to Be Considered

- Repetition rate
- Damping Ring
  - Dynamic aperture under increased wiggler strength
- Main Linac
  - Alternating operation 125GeV ←→ 45.6GeV
  - Emittance growth due to the low gradient
- BDS
  - Collimation depth
  - Momentum bandwidth
  - Wakefield
- Beam-Beam
- More technical details for DR, ML and BDS will be presented by K.Kubo and T.Okugi in the Beam Dynamics parallel session (Wednesday 8:30).

# Parameter Set

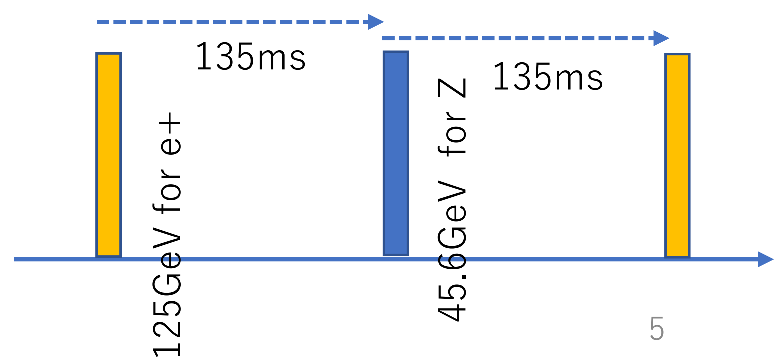
- This is the result of the study by K.Kubo, T.Okugi, and KY
- Uploaded in [http://arxiv.org/abs/1908.08212](http://arxiv.org/abs/1908.08212)
- See parallel sessions for more detail

**Parameters of Operation at Z-pole**

| | | | | |
|---|---|---|---|---|
| Center-of-Mass Energy | $E_{CM}$ | GeV | 91.2 | 250 |
| Beam Energy | $E_{beam}$ | GeV | 45.6 | 125 |
| Bunch collision rate | $f_{col}$ | Hz | 3.7 | 5 |
| Electron linac rep.rate | | Hz | 3.7+3.7 | 5 |
| Pulse interval in electron main linac | | ms | 135 | 200 |
| Electron energy for e+ prod. | | GeV | 125 | 125 |
| Number of bunches | $n_b$ | | 1312 | 1312 |
| Bunch population | N | $10^{10}$ | 2 | 2 |
| Bunch separation | $\Delta t_b$ | ns | 554 | 554 |
| RMS bunch length | $\sigma_z$ | mm | 0.41 | 0.30 |
| Electron RMS Beam energy spread at IP | $\sigma_p/p$ | % | 0.30 | 0.188 |
| Positron RMS Beam energy spread at IP | $\sigma_p/p$ | % | 0.30 | 0.150 |
| Emittance from DR (x) | $\gamma\varepsilon^{DR}_x$ | μm | 4 | 4 |
| Emittance from DR (y) | $\gamma\varepsilon^{DR}_y$ | nm | 20 | 20 |
| Emittance at linac exit | $\gamma\varepsilon^{ML}_x$ | μm | 5 | 5 |
| Emittance at linac exit | $\gamma\varepsilon^{ML}_y$ | nm | 35 | 30 |
| Emittance at IP (x) | $\gamma\varepsilon^*_x$ | μm | 6.2 | 5 |
| Emittance at IP (y) | $\gamma\varepsilon^*_y$ | nm | 48.5 | 35 |
| Electron polarization | $P_-$ | % | 80 | 80 |
| Positron polarization | $P_+$ | % | 30 | 30 |
| Beta_x at IP | $\beta^*_x$ | mm | 18 | 13 |
| Beta_y at IP | $\beta^*_y$ | mm | 0.39 | 0.41 |
| Beam size at IP (x) | $\sigma^*_x$ | μm | 1.12 | 0.515 |
| Beam size at IP (y) | $\sigma^*_y$ | nm | 14.6 | 7.66 |
| Disruption Param (x) | Dx | | 0.41 | 0.52 |
| Disruption Param (y) | Dy | | 31.8 | 35.0 |
| Geometric luminosity | Lgeo | $10^{33}$ | 0.95 | 5.29 |
| Luminosity | L | $10^{33}$ | 2.05 | 13.5 |
| Luminosity at top 1% | | % | 99.0 | 74.0 |
| Luminosity emhancement factor | $H_D$ | | 2.2 | 2.55 |
| Number of beamstrahlung | $n_\gamma$ | | 0.841 | 1.91 |
| Beamstrahlung energy loss | $\delta_{BS}$ | % | 0.157 | 2.62 |

# Repetition Rate

- Obviously, the electron beam with energy E=91.2/2=45.6 GeV is not sufficient to produce the positron beam
- TDR adopted 5+5Hz operation at $E_{CM}$ =250GeV, assuming the power system for 500GeV
  - 5Hz to produce positron, 5Hz for colliding beam
  - Assumed positron production at $E_e$=150GeV
  - No power problem
    - The required power for 150GeV (5Hz) + 45.6GeV (5Hz) is lower than that for 250GeV (5Hz)
- However, the power system of ILC@250 is not sufficient for 5+5Hz operation
- Here, we assume 3.7+3.7 Hz operation is possible
  - This value was estimated by T. Matsumoto
  - Klystron output power can be changed at 5Hz but the loaded Q (5.46x$10^6$) cannot be changed
  - Assume same bunch interval (554ns) for 125 and 45.6GeV
  - Parameters: (obtained by T.Matsumoto, KEK)
    - Gradient 31.5 ←→ 8.76 = 31.5x (45.6-15)/(125-15) MV/m
    - Peak power per cavity 189 ←→ 77.2 kW
    - Klystron peak power 9.82 ←→ 4.15 MW
    - Klystron efficiency 67% ←→ 53%
    - Modulator output 14.66 ←→ 7.83 MW
    - Fill time 0.927 ←→ 0.328 ms
    - Beam pulse length 0.727 ←→ 0.727 ms
    - RF pulse length 1.65 ←→ 1.06 ms
    - Rep rate 3.7 ←→ 3.7 Hz

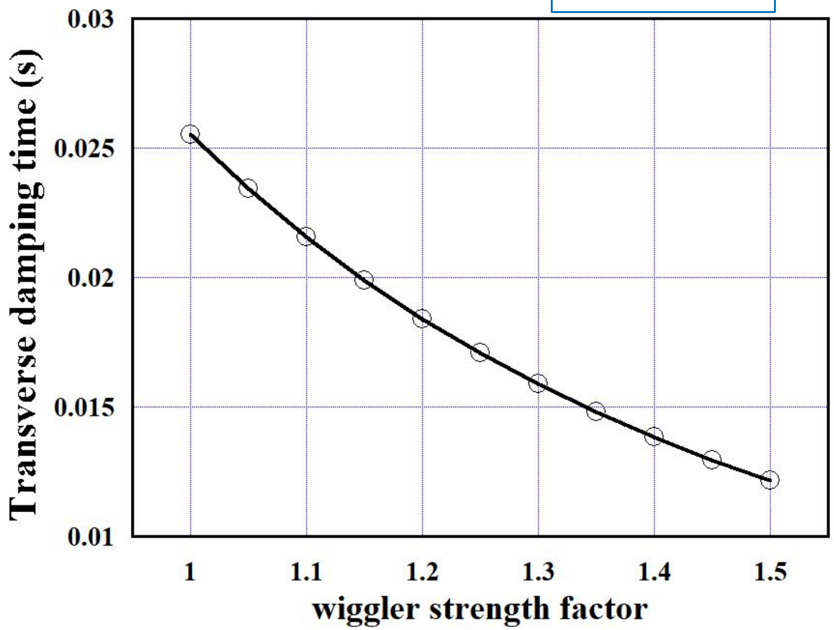


# Damping Ring

- Horizontal emittance improved 6μm → 4μm (AWLC2017@SLAC)
- Reinforce the wigglers for the shorter time for damping
  - 5Hz: 200ms → 3.7+3.7Hz : 270ms/2=135ms
  - Wigglers are ready (TDR)
- Dynamic aperture of the new lattice with stronger wigglers must be confirmed

K. Kubo

Damping time vs. wiggler strength factor →
Factor 1.0 corresponds to 1.29T ($\rho^{-1}$=0.07745$m^{-1}$)

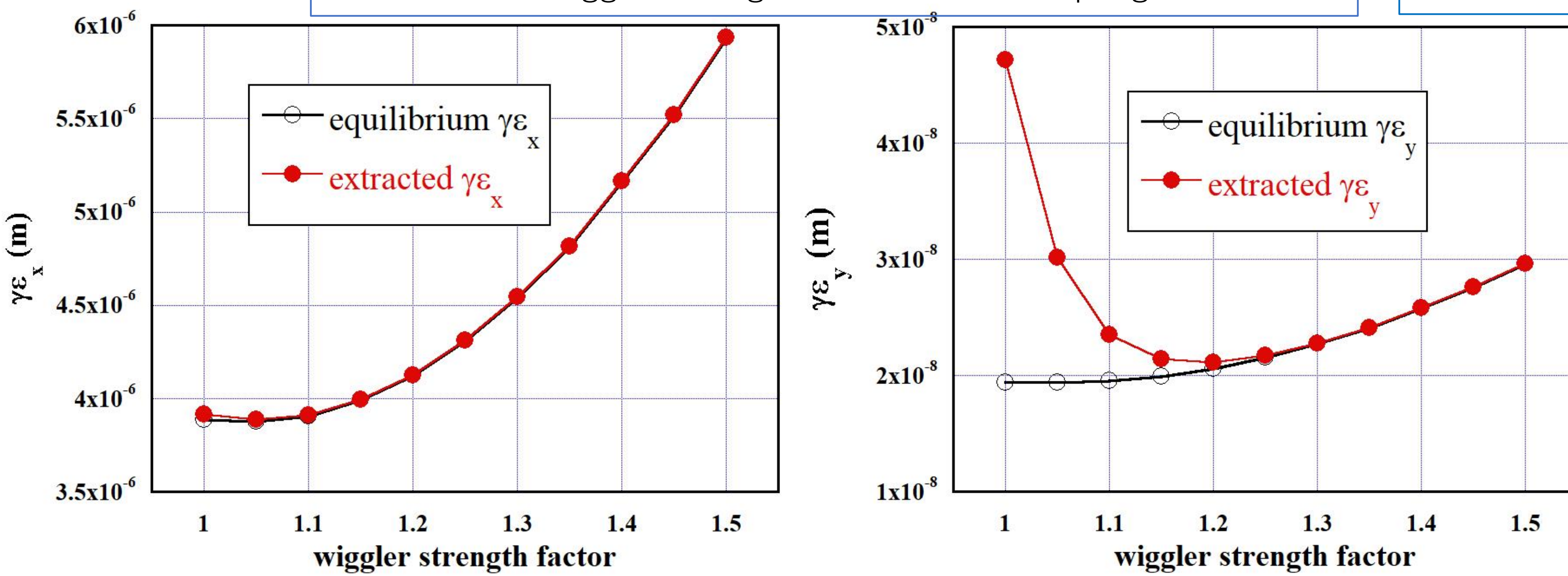


# Extracted Emittance

- The plots below show the equilibrium and extracted emittances as functions of the wiggler strength
- Wiggler strength factor
    - <1.15 gives large vertical exracted-emittance
    - >1.2 gives large horizontal emittance
- Factor ~1.15 (1.48T) gives the extracted emittance $\gamma\varepsilon_x$ ~ 4$\mu$m, $\gamma\varepsilon_y$ ~ 21nm
(extracted at 135ms)

Emittance vs. wiggler strength. Assume V-H coupling 0.005

K.Kubo



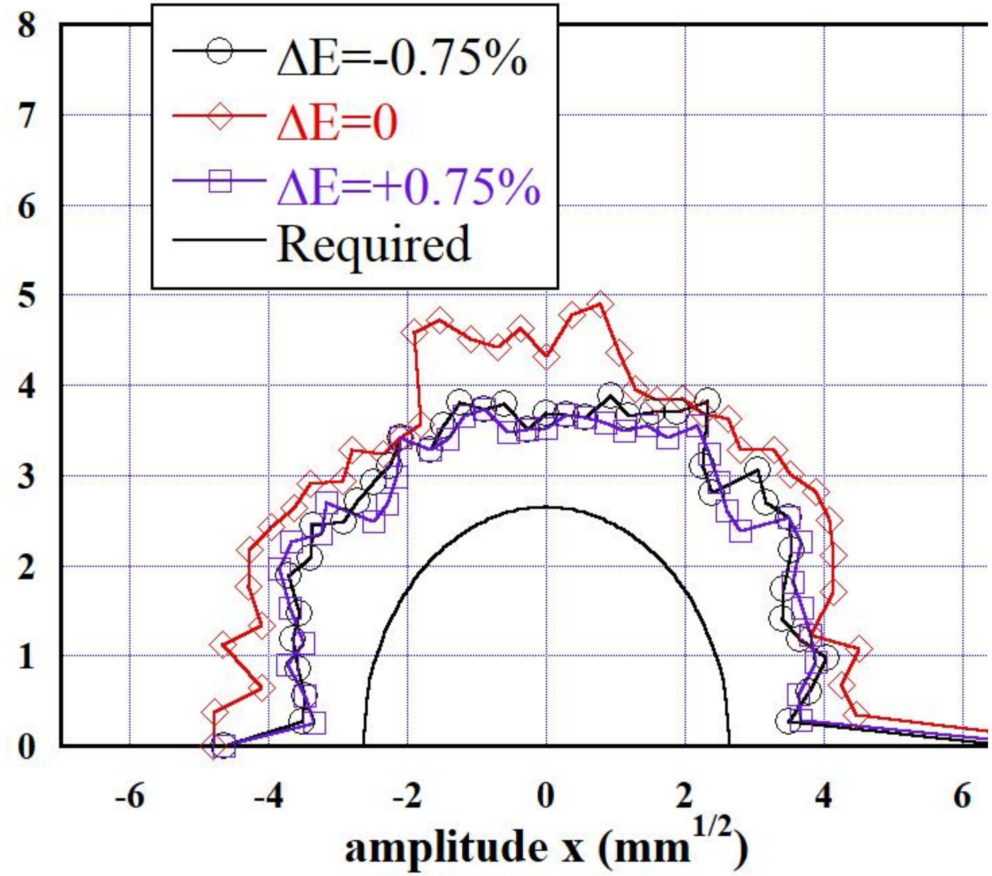
# Dynamic Aperture

- The plot shows the dynamic aperture for the wiggler strength factor 1.15 (The sextupole component of the wiggler field is included)
- The hemi-circle around the origin shows the TDR design value

$$\gamma(A_x + A_y) \leq 0.07\text{m}$$

$$\text{Energy deviation} \leq 0.75\%$$

The dynamic aperture is sufficient




K.Kubo

# Main Linac

- Issues
  - Orbit difference between 125 and 45.6GeV beams (due to the vertical curvature of the earth) must be corrected by pulsed magnets at the end of electron main linac
  - Emittance degradation due to the low gradient for 45.6GeV
  - Emittance degradation of 125GeV beam (Orbit correction to be done only for the colliding beam)
    - From the previous studies we believe this is not serious

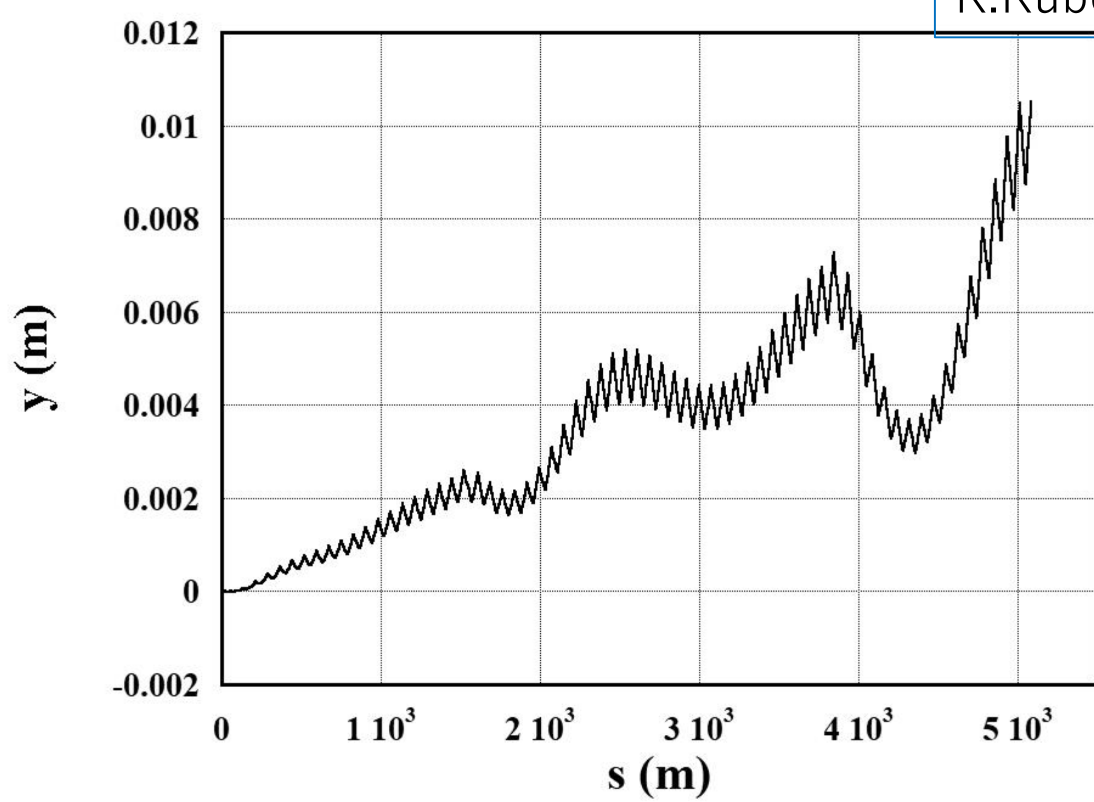
# ML: Beam Dynamics : Positron production beam

- 2 different energy beams in electron main linac
- Orbit is tuned for the colliding beam ($E_{CM}/2$)
- The positron production beam (125GeV) will shift vertically due to earth-following curvature)

250GeV Linac !!

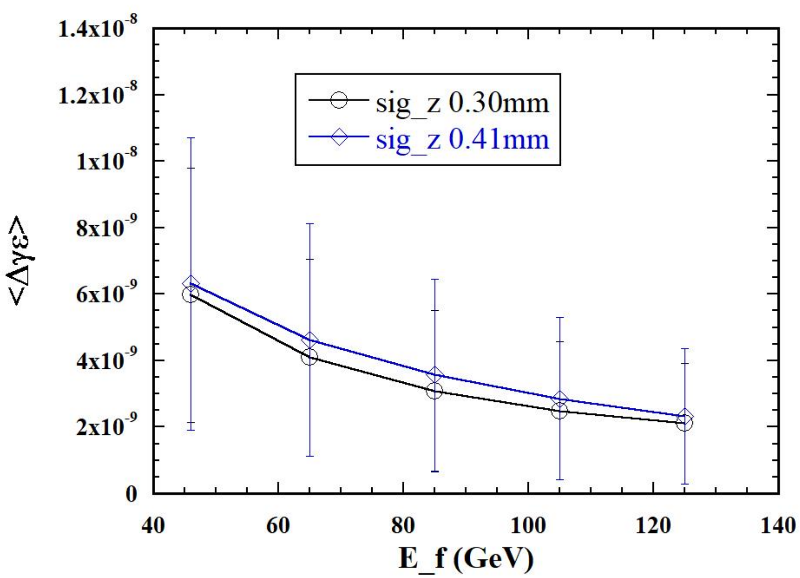
K.Kubo

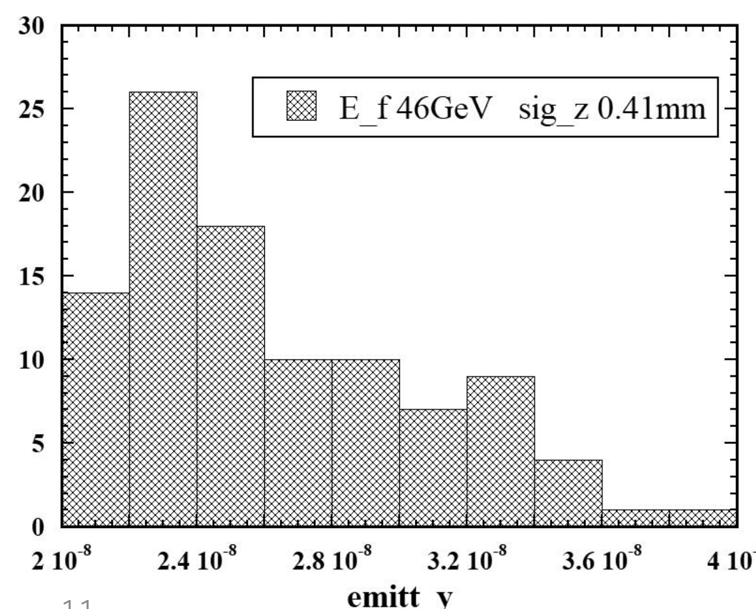
- The orbit difference is ~10mm) for $E_{CM}/2$=45.6 GeV,
- Orbit difference itself can be corrected by pulsed magnets (3.7Hz) at ML exit



# ML : Vertical Emittance Increase

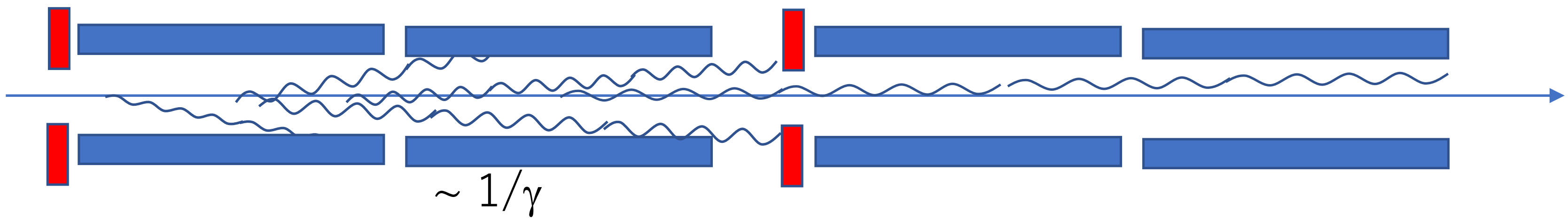
- Simulation of the orbit correction for 45.6GeV beam
  - Q magnet offset 0.36mm, cavity 0.67mm, tilt 0.3mrad, BPM offset 1$\mu$m
  - Vertical only (initial emittance $\gamma\varepsilon_y$ = 20nm)
  - $\Delta$E = 20% for Dispersion Free Steering
- Two cases of the bunch length $\sigma_z$ = 0.3 and 0.41mm (see BDS)
  $\Delta\gamma\varepsilon_y$ slightly large for $\sigma_z$ = 0.41mm
- Final emittance $\gamma\varepsilon_y$ = 33nm : acceptable
  - we adopted 35nm in the parameter table



# Dynamics in the Undulator Section

- In the present design the colliding beam (45.6GeV) also goes through the undulator (active length 231m)
- The resistive wall wake has been studied long ago. Must be revisited for the very low energy electron, but presumably OK.
- Photons opening angle (~$1/\gamma$) is large. Large angle photons are mostly eliminated by the masks, but a significant fraction may hit and heat the undulator
- If these turn out to be serious, we need a beamline to bypass the undulator section (~700m, not expensive at all) and additional pulsed magnets
- We need to study these issues in the future



# Luminosity with a Simple Scaling

$$\mathcal{L} = f_{\text{rep}} \times n_{\text{bunch}} \times \frac{N^2}{4\pi\sigma_x\sigma_y}$$

- Naive scaling: $\sigma_x\sigma_y$ is proportional to sqrt($\varepsilon_x\varepsilon_y$) ~ $1/E_{CM}$ → $L \sim E_{CM}$
- However, the larger beam divergence near IP due to the larger emittance at low energies would cause background.
  - The synchrotron radiation from halo particles from upstream hit the final quadrupole magnets
  - IP beam angle is proportional to $\sqrt{\varepsilon_{x(y)}/\beta_{x(y)}}$
  - These halo particles must be collimated out in the collimator section
  - $E_{\text{beam}}$=125GeV with TDR parameters ($\varepsilon_x=10\mu m/\gamma$, $\varepsilon_y=35nm/\gamma$, $\beta_x*=13mm$, $\beta_y*=0.41mm$) are already at the limit of horizontal collimation depth $\sim 6\sigma_x$ (vertical still has big room: $>40\sigma_y$). (see next page)

# Luminosity with a Simple Scaling (2)

- Now, owing to the new DR design, the horizontal emittance has been improved : $\gamma\varepsilon_x{}^*$=10→5$\mu$m
- Hence, to keep the collimation depth ~6$\sigma_x$, the horizontal beta must be

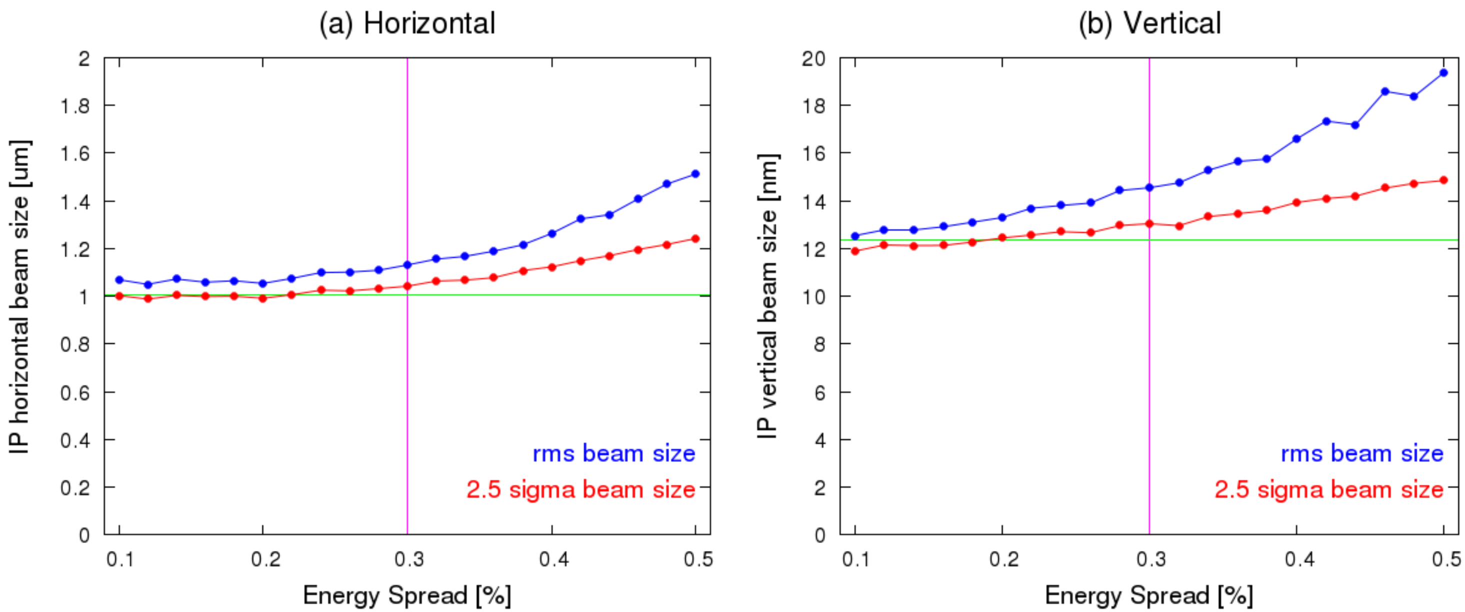
$$\beta_x^* = 13\text{mm} \times (45.6/125)/(5\mu\text{m}/10\mu\text{m}) \approx 18\text{mm}$$

# Issues in the BDS

- Collimation depth
  - Mentioned in the previous page
    Adopt $\beta_y^* = 18$mm
- Momentum band width
- Wakefield effects due to the low energy

# BDS : Momentum Band Width (1)

- Momentum band width in FFS is a bottle neck
  - TDR parameters gives the energy spread $\sigma_E/E=0.41\%$ at 45.6GeV
    (proportional to 1/E, 0.15% for 125GeV)




T.Okugi, No errors included

  - The emittance increase the energy spread $\sigma_E/E=0.41\%$ is too large

# BDS : Momentum Band Width (2)

- The energy spread can be reduced by adopting a longer bunch in the bunch compressor
  - $\sigma_E/E)$ proportional to $1/\sigma_z$
  - Let's adopt
    $(\sigma_z, \sigma_E/E) = (0.3\text{mm}, 0.41\%) \rightarrow (0.41\text{mm}, 0.30\%)$
  - The emittance increase due to the band width is still sizable, but let us be satisfied with this.
  - Side effect: increased transverse wake in the main linac and BDS
    - Main linac: already examined. Accelptable
- It may be possible to adopt new final quads with larger apertures dedicated to Z-pole operation (to relax the collimation depth)
  - Required fields are low for 45.6GeV
  - To be studied next time

# BDS : Tuning Simulation (1)

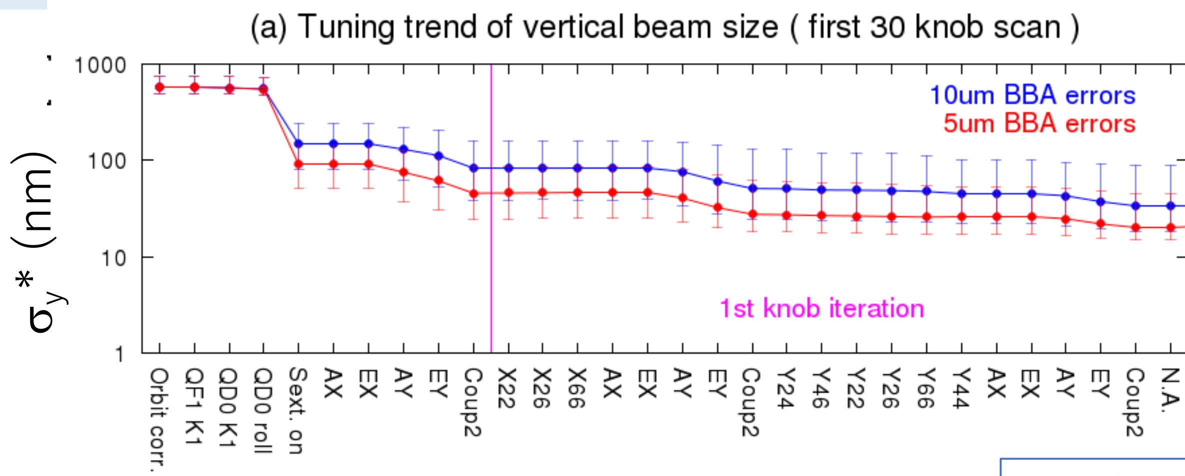
- Tuning simulation done with the error parameters in the table
  - For Q-BPM and sext-BPM alignment, here adopted 5μm, tighter than 10μm in BDS simulations, expecting several year operation experience

  - For wakefield simulation the dislocation of 0.3mm is assumed for the wake sources (~100 BPMs)

| | | | |
|---|---|---|---|
| Bend | rotation | 100 | μrad |
| | field strength | $1\times10^{-4}$ | |
| | alignment to BPM | 100 | μm |
| Quad | alignment (x,y) | 100 | μm |
| | rotation | 100 | μrad |
| | field strength | $1\times10^{-4}$ | |
| | sext. component $B_2/B_1$ at r=1cm | $1\times10^{-4}$ | |
| | alignment to BPM | 5 | μm |
| Sext. | alignment (x,y) | 100 | μm |
| | rotation | 100 | μrad |
| | field strength | $1\times10^{-4}$ | |
| | alignment to BPM | 5 | μm |

# BDS : Tuning Simulation (2)

- Example of tuning simulation process

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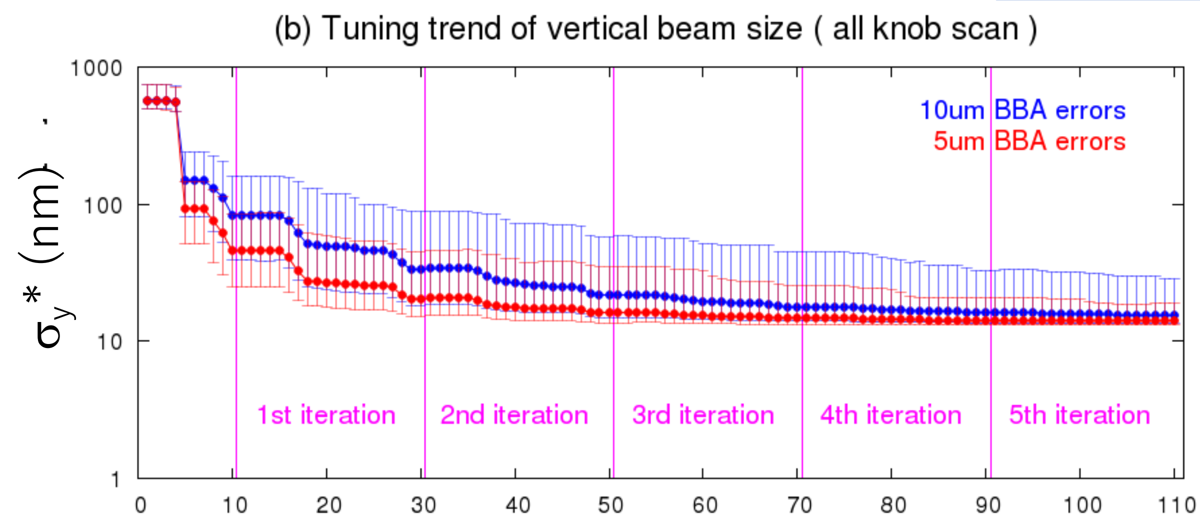


# BDS : Tuning Simulation (3)

Simulation Results

| | $\sigma_x^*$(μm) | $\sigma_y^*$(nm) |
|---|---|---|
| No errors | 1.04 | 12.7 |
| Magnet errors + correction | 1.12 | 14.0 |
| Magnet errors + static wake + correction | | 14.3 |
| Magnet errors + static&dynamic wake + correction | | 14.6 |

T. Okugi

The effective emittance increase as

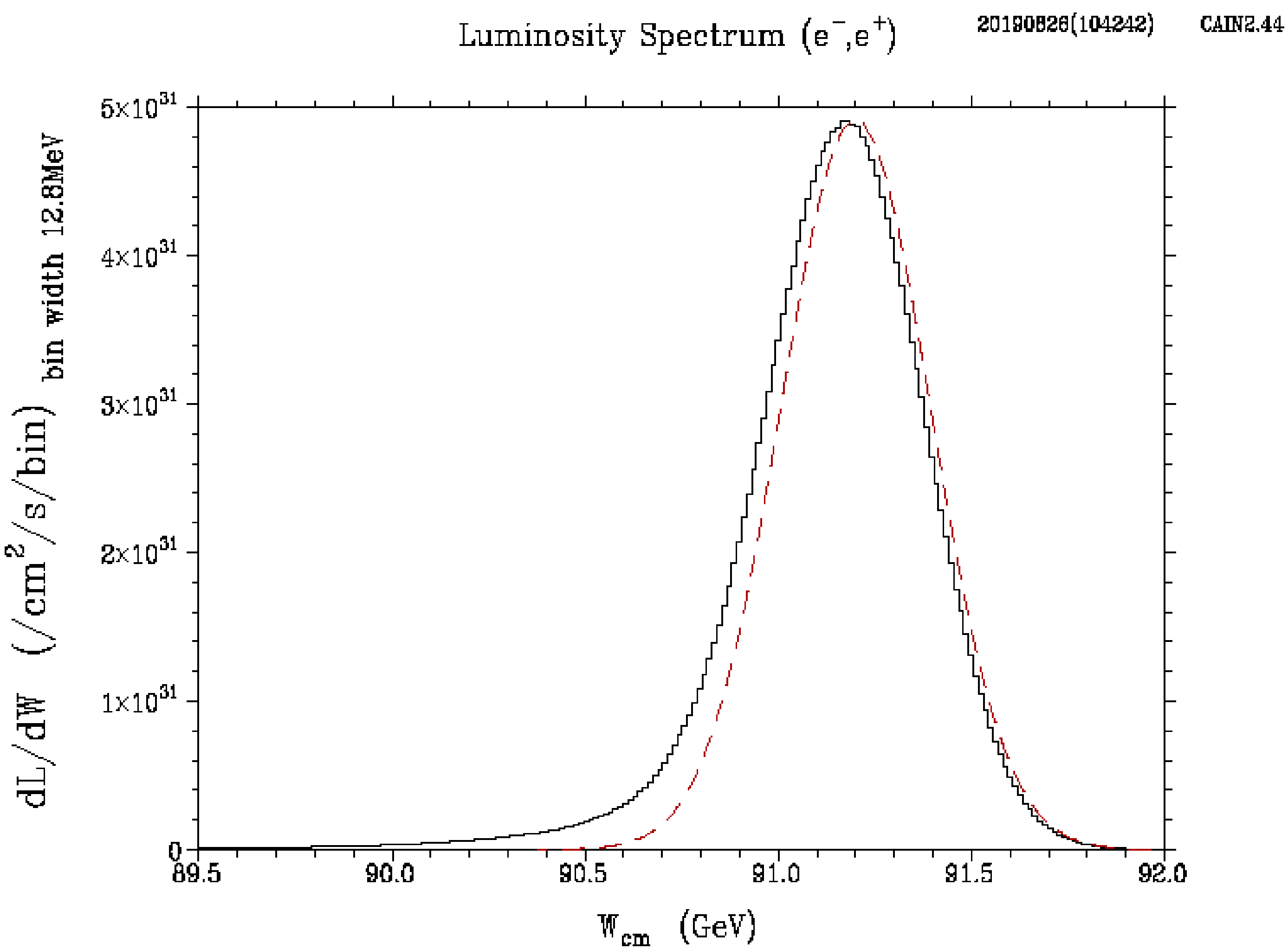
$\gamma\varepsilon_x^* = 5\mu m \rightarrow 6.2\ \mu m$

$\gamma\varepsilon_y^* = 35nm \rightarrow 48.5nm$

These values are used for the beam-beam simulation

# Beam-Beam Interaction

- The effets of beamstrahlung is small
  - L at top 1% is ~99.0%
- The disruption parameter ~32 is not larger than 250GeV value ~35
- So, we did not check the luminosity sensitivity to offset



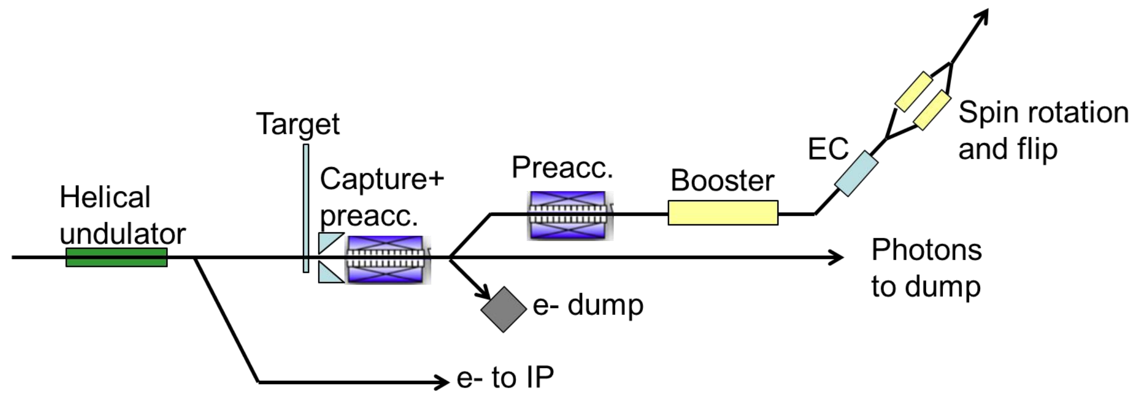
# Z-Pole Summary

- The previous reports (N.Walker, KY at LCWS2016@Morioka) suggested the expectation L=(1-1.5)x$10^{33}$ /cm$^2$/s at Z-pole in 5+5Hz operation of ILC500
- ILC250 (shorter linac) is
  - Worse in total available power → up to 3.7+3.7Hz operation
  - But better in beam dynamics (emittance growth at low gradient)
- The previous luminosity improvement for ILC250 by smaller horizontal emittance (AWLC2017@SLAC) brings about significant effects for Z-pole operation
- Expected luminosity is now L ~ 2.1 x $10^{33}$ /cm$^2$/s
- No particular problem is expected in doubling the luminosity by doubling the number of bunches
- If you want even higher luminosity, the bottle neck is the momentum band width of BDS under the large energy spread of the low energy beam

# Positron Status

- Undulator (many slides from Sabine Riemann)
- e-Driven
- Positron Working Group Report written in May last year, available at http://edmsdirect.desy.de/item/D00000001165115
- Since this report there has been no essential progress in the undulator scheme due to lack of resources

# Undulator System




- Superconducting helical undulator
  - passed by e- beam → circularly polarized photon beam for e+ production in thin target
- Target
  - Ti6Al4V target wheel  spinning with 2000rpm in vacuum to distribute heat load
- Positron capture
  - Pulsed flux concentrator offers higher capture efficiency but so far no reliable design
  - Alternative: QWT
- positron beam is polarized

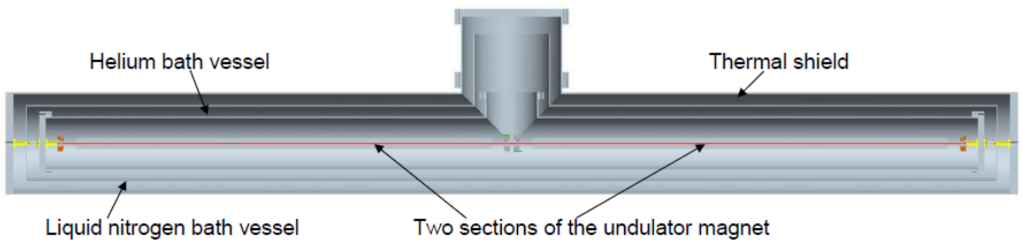
Goal:  positron yield at damping ring  Y = 1.5e+/e-

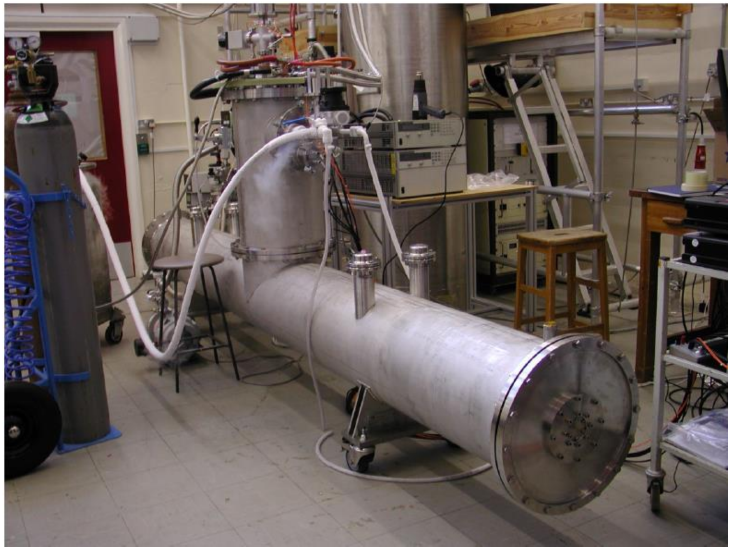
S.Riemann

# Superconducting Helical Undulator

D.Scott et al.,
Phys. Rev. Lett. 107, 174803

- Prototype developed at RAL
  - 2 unduator modules of 1.75m in 4m cryomodule



- Parameters
  - Undulator period, $\lambda_U$ =11.5mm
  - Undulator strength K ≤ 0.92 ($B_{max}$ ≤ 0.86T)
  - Beam aperture (diam.) 5.85mm

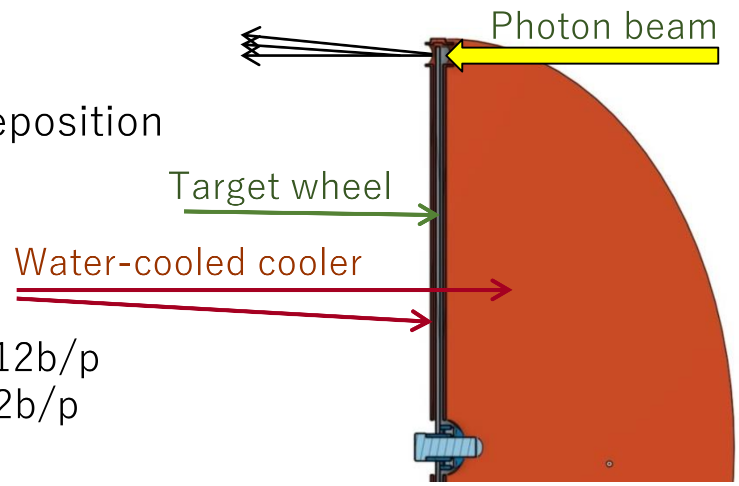
  - Max 231m active undulator length available (132 undulator modules ⇔ 66 cryomodules]
  - Quadrupoles every 3 modules → total length of undulator system is 320m

S.Riemann

# Target for the Undulator-based e+ Source

- Ti alloy wheel, Ø 1m, spinning in vacuum with 2000rpm (100m/s tang speed)
- ILC250, GigaZ: E(e-) = 125GeV
  - Photon energy is O(7.5 MeV);
  - target thickness of 7mm to optimize power deposition yield
- Target cooling
  - $T^4$ radiation from spinning wheel to stationary water cooled cooler
    - Peak temp in wheel ~550˚C for ILC250, 1312b/p
    - Peak temp in wheel ~500˚C for GigaZ, 1312b/p

    for wheel designed as full Ti alloy disk




- Test of target material resistivity against high temperature and cyclic load using an intense pulsed e- beam at the Microtron in Mainz (MAMI)
  - No substantial damage obtained although material was loaded below and above the phase transition limit
- Magnetic bearing for spinning wheel
  - Vacuum-tight, oil free, maintenance free even for very high speed
  - Technology and experience exists (e.g. neutron chopper; companies: Juelich, SKF)

S.Riemann

# Undulator Positron Source Parameters

| | | | | | |
|---|---|---|---|---|---|
| | | ILC250 | | GigaZ | |
| Electron beam energy (undulator entrance) | | 126.5 | | | GeV |
| Active undulator length $L_{und}$ | | 231 | | | m |
| | | with FC | with QWT | | |
| Undulator K | | 0.85 | 0.92 | | |
| Photon energy (1st harmonic) | | 7.7 | 7.2 | | MeV |
| Average photon beam power | | 62.6 | 72.2 | 53.5 | kW |
| Distance target-middle undulator | | 401 | | | m |
| Photon beam spot size on target ($\sigma$) | | 1.2 | 1.45 | | mm |
| Average power deposited in target | 1312 bunches | 1.94 | 2.2 | 1.63 | kW |
| | 2625 bunches | 3.88 | 4.4 | 3.23 | kW |
| Peak energy deposition density in target | 1312 bunches | 61.2 | 59.8 | 59.8 | J/g |
| | 2625 bunches | 92.6 | 90.4 | 90.4 | J/g |
| Positron polarization | | ~30 | | | % |

S.Riemann

# Undulator : Positron yield

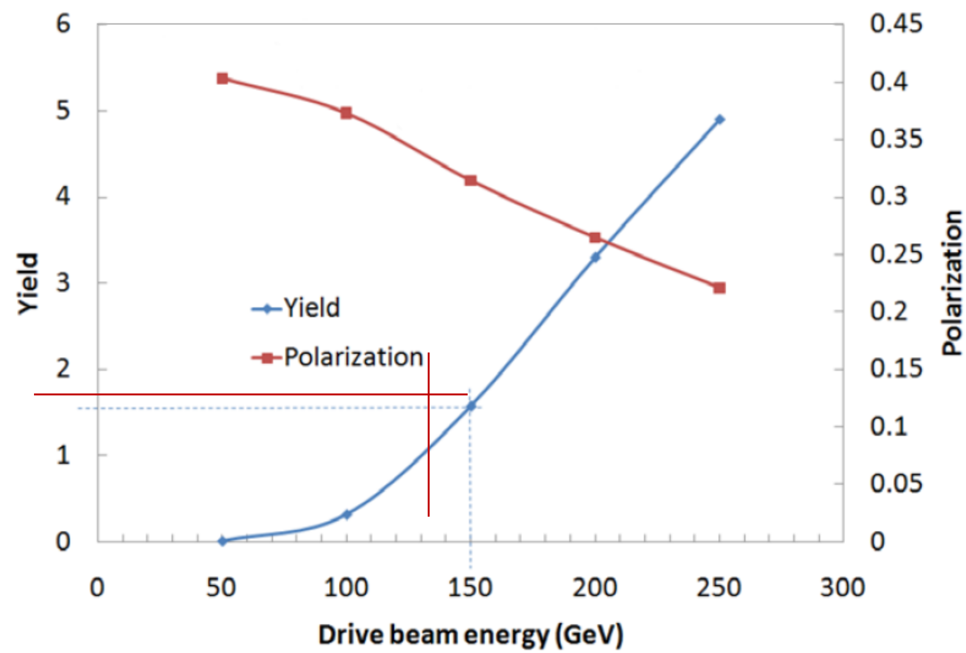
- Electron energy 125GeV (126.5GeV to compensate loss in undulator)
- Photon energy is O(7.5 MeV)

- Expected yield from this figureis ~1e+/e-
  for E(e-) = 125GeV
- The simulation described in the positron WG report gave ~1.3e+/e-
- More recent simulation gives a smaller value

Need to optimize/improve the e+ capture

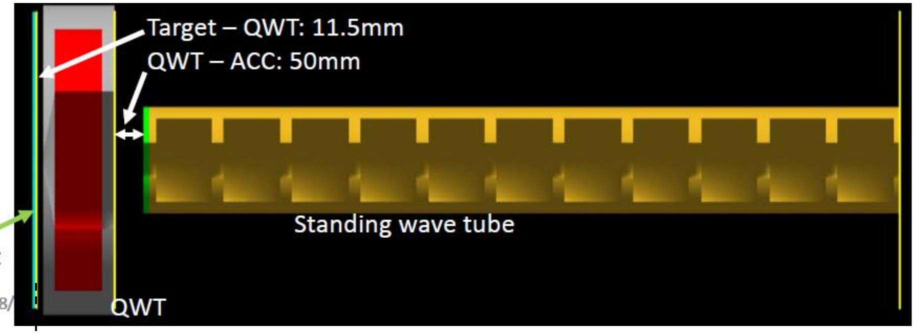
Simulation results of positron source yield and polarization for 231 m RDR undulator with QWT as OMD.

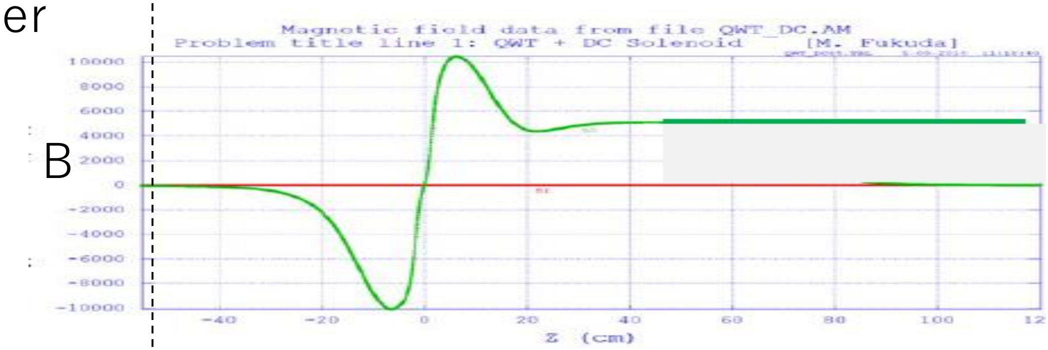
TDR



# QWT

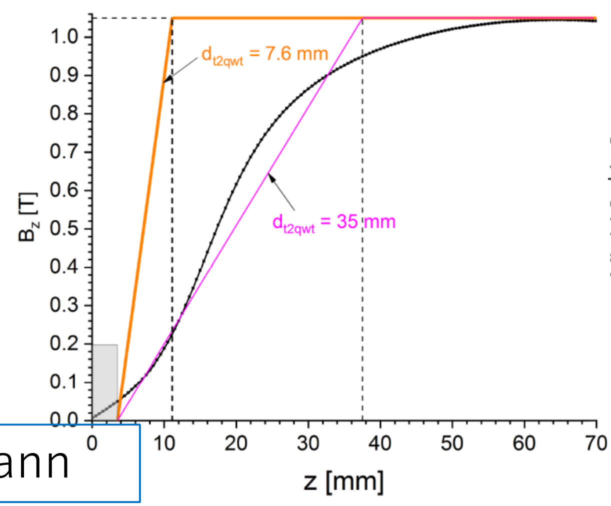
- Flux concentrator (TDR) does not seem feasible due to the long pulse
- To be replaced by QWT (Quarter Wave Transformer)
- M. Fukuda, LCWS18
  - Y < 1e+/e



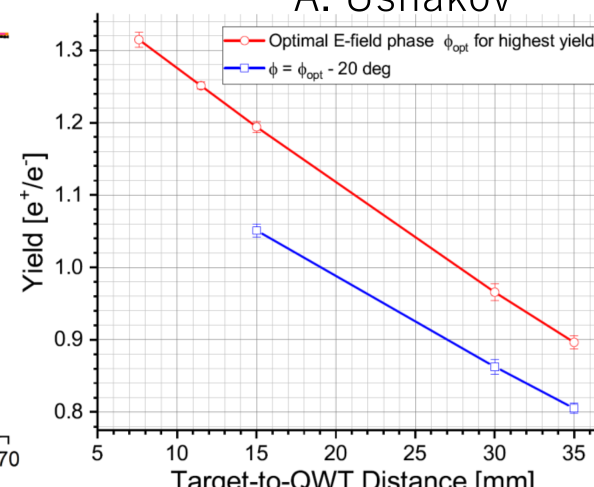

## B field is decisive for positron yield

- Steeper field rise close to target needed for yield > 1e+/e-
- Immersed target could help but eddy current increase heat load for non-pulsed operation
- Optimization is under study



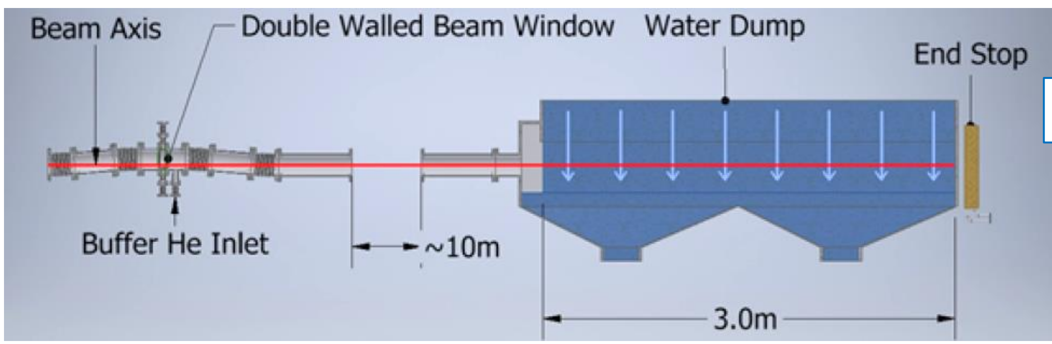

S.Riemann

A. Ushakov



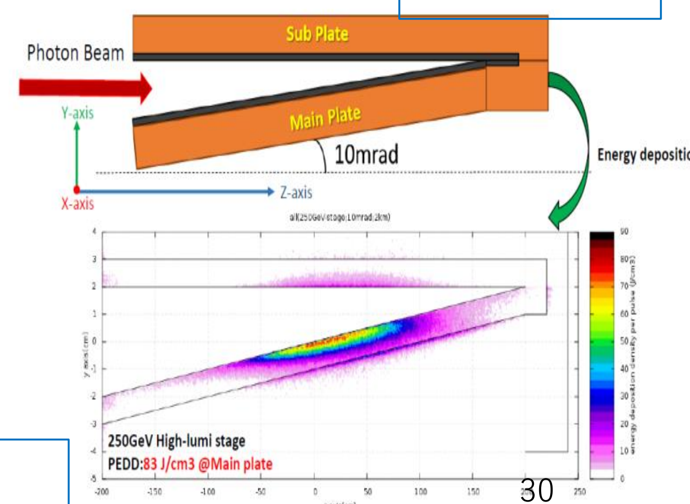
# Undulator : Photon dump

- Narrow 60-120kW photon beam deposits only few percent in target
- Problem: high energy density of photon beam even at distance of O(km) from target
- Options under study
  - Water dump
    - Tumbling Ti window, He cooled → acceptable stress and heat load
    - Free falling water curtain to absorb the photon beam and to scatter particles at safe distance to Ti window




P. Sievers

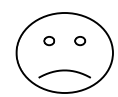
Y. Morikawa




  - graphite dump
    - Shallow angle (~10mrad) to beam
    - No need for exit window
    - But: high peak load and graphite degradation

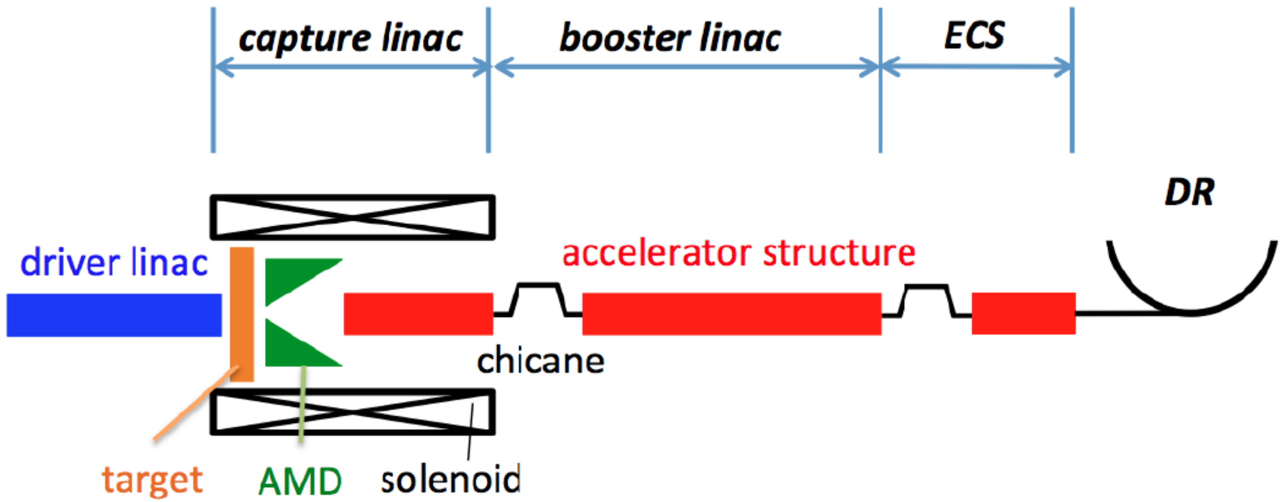
S.Riemann

# Undulator Summary

- No showstopper seen for undulator-based source
- Detailed engineering specifications for target wheel and experimental tests still to be done
  - Test cooling efficiencies by thermal radiation for a target piece
  - Develop full-size mock-up for the target to test the target rotation in vacuum
  - Photon dump design
- resources….(only for information)
  - DESY e+ source group decreased: 
    - Andriy and Felix left, Sabine retired; no successors
    - Khaled (PhD student) studies realistic undulator (see his talk)

S.Riemann

# e-Driven System




- Intensive design/simulation studies on-going
- New powers
  - H. Ego, Y. Enomoto： KEKB linac experts
  - A. Miyamoto ： physics, radiation environment

# e-Driven System Latest Parameters

- Based on a paper being prepared for a journal
- There are various simulation results giving slightly different yields
- The data here is the one being used for a consistent parameter set
- The yield $n(e^+)/n(e^-)$ ~ 1.2-1.3 confirmed
- This defines the required bunch charge in the electron driver, and all the power deposition (next page) in the entire system

| | | | | |
|---|---|---|---|---|
| Electron Driver | | | | |
| | Beam energy | | 3 | GeV |
| | Linac type | | NC S-band TW | |
| | Bunch charge | | 3.7 | nC |
| | Beam power | | 74 | kW |
| | Beam size on the target (rms) | | 2 | mm |
| Target | | | | |
| | Material | | W | |
| | Thickness | | 16 | mm |
| | Diameter | | 0.5 | m |
| | Required rotation speed at the rim | | 5 | m/s |
| Adiabatic Matching Device (Flux Concentrator) | | | | |
| | Peak field (at 5mm from the entrance) | | 5 | T |
| | Distance from the target end to FC entrance | | 1.0 | mm |
| Capture Linac | | | | |
| | Linac type | | NC L-band SW | |
| | Aperture radius | | 30 | mm |
| | Solenoid field | | 0.5 | T |
| | Positron energy at the exit | | 260 | MeV |
| Positron Booster | | | | |
| | Linac type | L-band TW and S-band TW | | |
| | Positron energy at the exit | | 5 | GeV |
| Energy Compressor | | | | |
| | Type | | L-band TW | |
| Positron Yield | | | | |
| | N(e+ captured in damping ring)/N(e- in the driver) | | 1.28 | |

# e-Driven : Heat and Power Parameters

| | | | |
|---|---|---|---|
| Electron Driver | | | |
| | Beam power of electron | 74 | kW |
| Target | | | |
| | Average energy deposit on the target by the beam | 18.8 | kW |
| | PEDD in the target | 33.6 | J/g |
| Flux Concentrator | | | |
| | Average energy deposit on the FC by the beam | 6.4 | kW |
| | PEDD on FC | 9 | J/g |
| | Average energy deposit in the absorber afer FC | 10.3 | kW |
| Capture cavity (L-band standing wave) | | | |
| | Average energy deposit in the capture cavities | 39.9 | kW |
| | Maximum energy deposit in a cavity cell | 2.0 | kW |

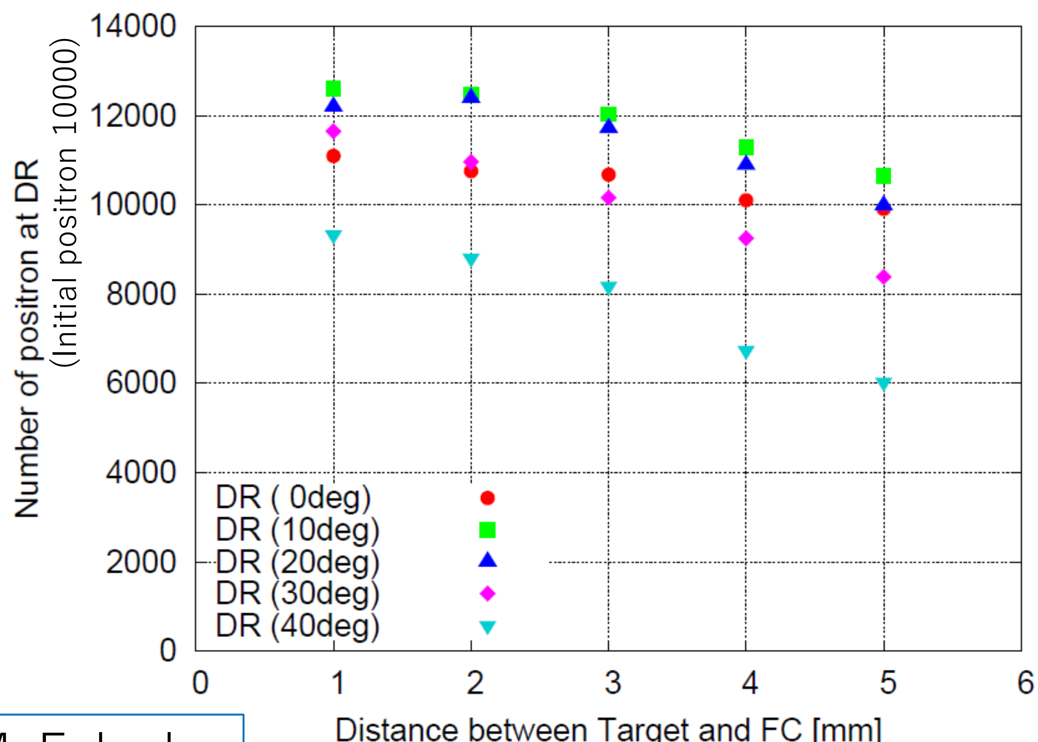
# e-Driven : Yield Simulation

- Simulation works by Nagoshi (Hiroshima) was succeeded by Fukuda (KEK)
- Detailed consistency checks done
  - In good agreement between Nagoshi and Fukuda to a few percent level
- Added more reality and details
  - Solenoid field : divided into pieces, interval, gap,
  - FC field calculated by Pavel
  - Target-FC distance
  - QWT field (undulator)
  - Tracking by SAD to DR
  - Chicane after capture section (not finalized yet)
  - ECS chicane parameters
  - Booster acceleration gradient
  - …………
- Cannot go into detail → Fukuda's talks in the positron session on Thursday

# An example: Target-FC Distance

- Yield increases 1.06→1.26 (15%) as 5mm → 1mm
- No essential difference between 1mm and 2mm
- But there is a significant difference in the eddy current heating due to the rapid (10's of $\mu$s) change of the field of FC

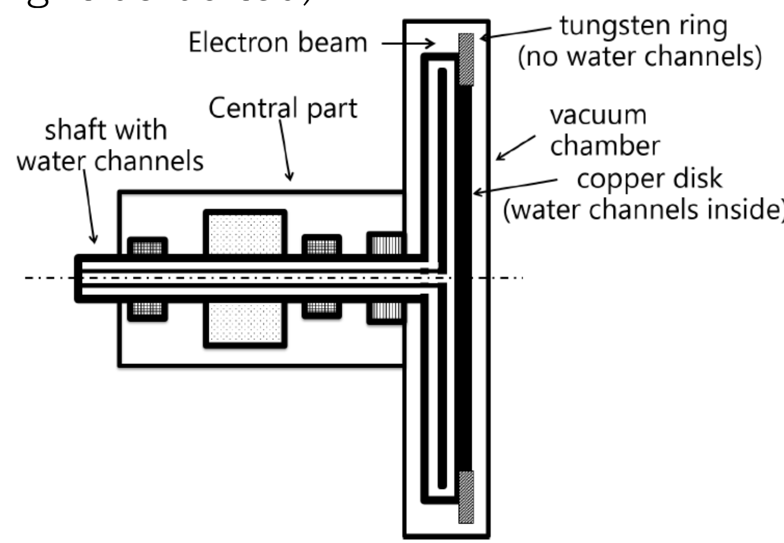
| D(mm) | yield |
|---|---|
| 1 | 1.26 |
| 2 | 1.25 |
| 3 | 1.20 |
| 4 | 1.13 |
| 5 | 1.06 |




M. Fukuda

# e-Driven : Target

- Design
  - Tungsten 16mm thick, diameter 50cm, rotating at 5m/s (225 rpm)
  - Copper disk brazed to tungsten (or might be bolted)
  - Water-cooled
  - Vacuum seal by ferro-fluid
- R&D
  - Heat & stress simulation
  - Prototype fabricated
  - Vacuum test with ferro-fluid seal and rotation (but no load)
  - Irradiation (Co60) test of ferro-fluid at QST Takasaki
  - These have been reported in previous LC workshops already
- 2019
  - Irradiation test continued
  - Analysis of gas generated at the irradiation to study the surface physics (Feb.2019)
  - Need a test against neutron irradiation




- Design of the next prototype being discussed
  - Should the ferro-fluid seal be replaceable?
  - I do not know the final conclusion
  - Listen to the talk by Omori in the positron session

# Capture Cavities

- L-band Standing Wave same as in TDR (undulator scheme) has been used in the simulation works
  - Designed and studied at SLAC for the undulator system

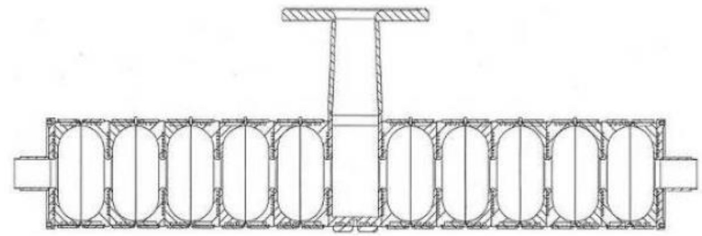
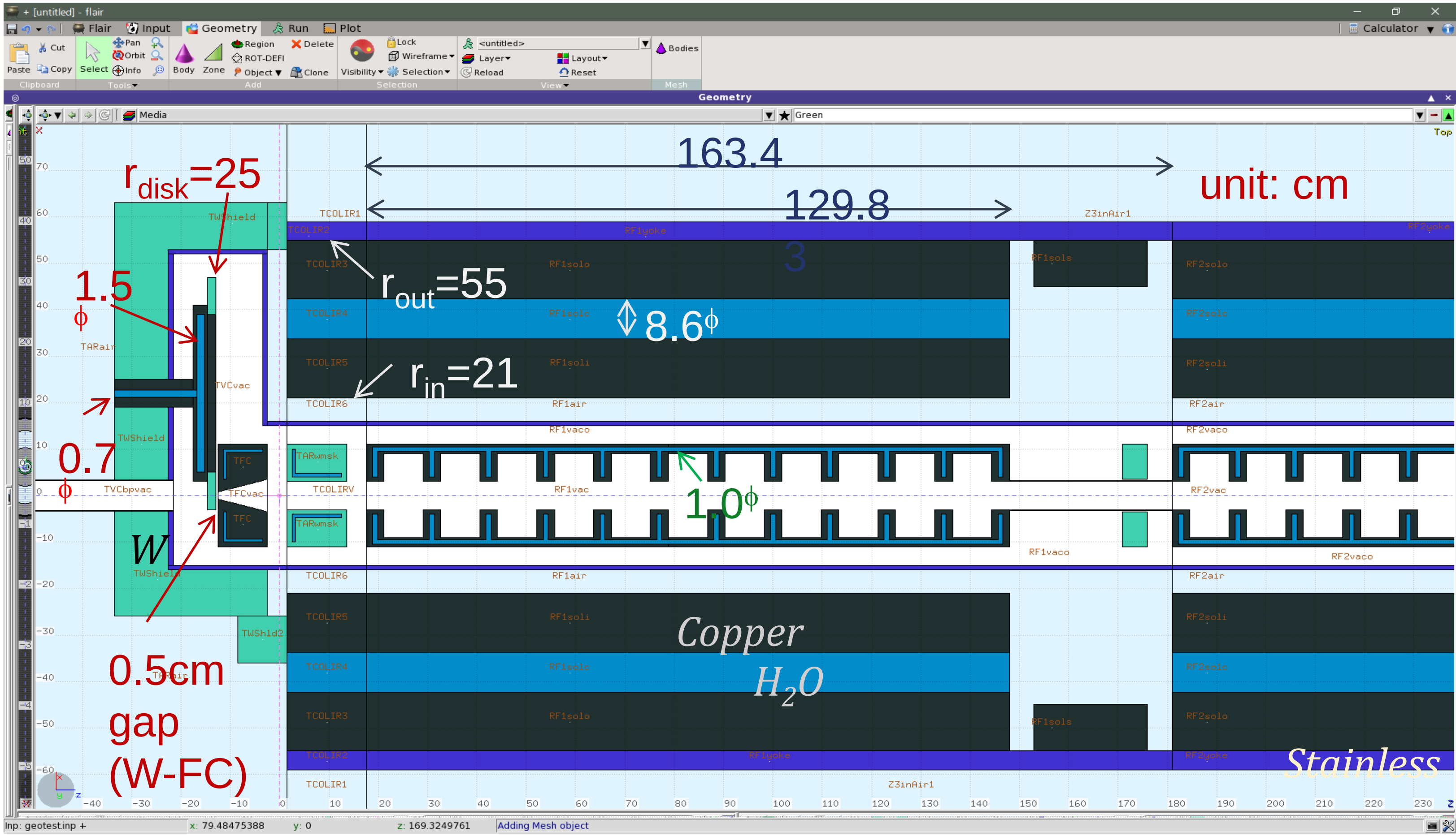


Figure3: 11–cell SW structure.

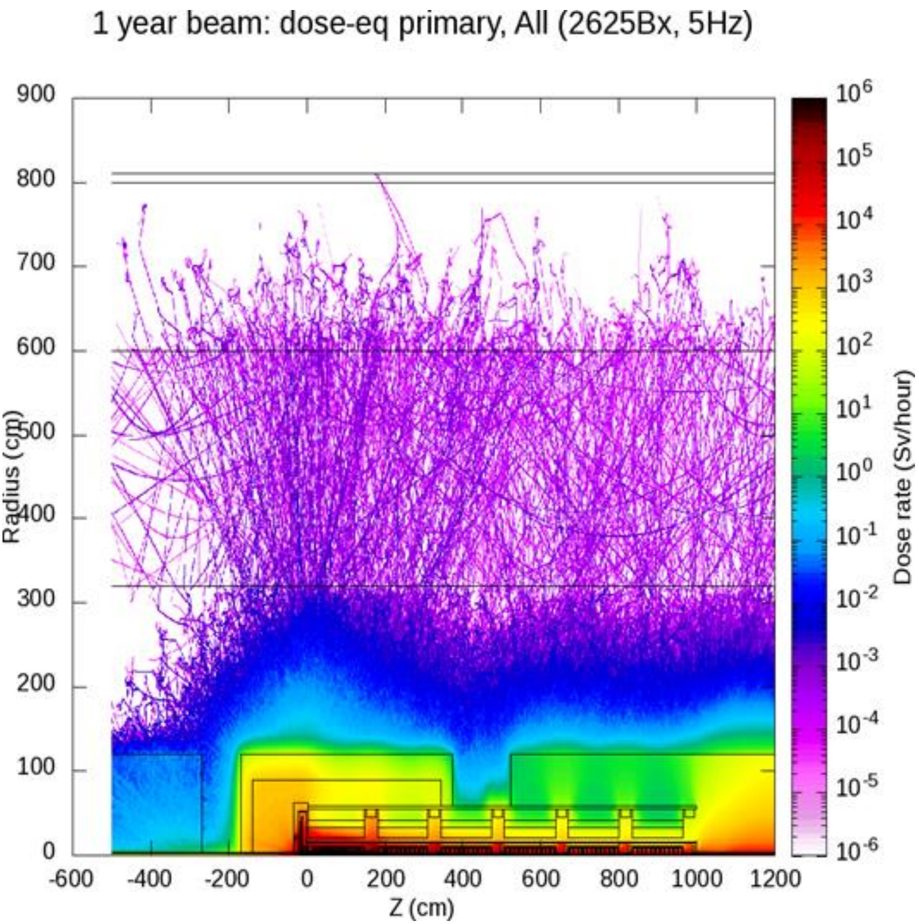
- But, for e-driven system, several problems associated with the standing wave nature(zero group velocity) pointed out
  - Multiple cell, high $\beta$,
  - High beam-loading for e-driven
    - Up to 0.5-1A (~6mA in undulator scheme)
- New design being considered including APS (Alternating Periodic Structure) but it will take time

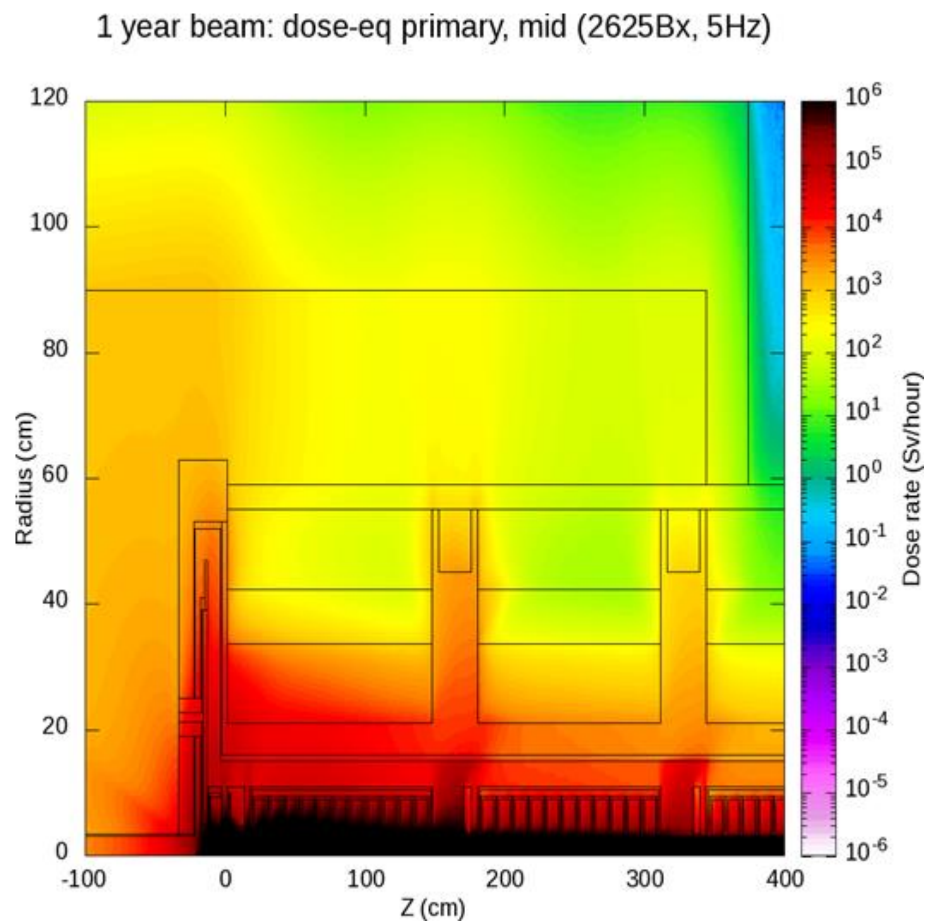
# Radiation Environment (1)

- Target/capture region
- Accurate modeling



Primary dose
(not depend on run year)



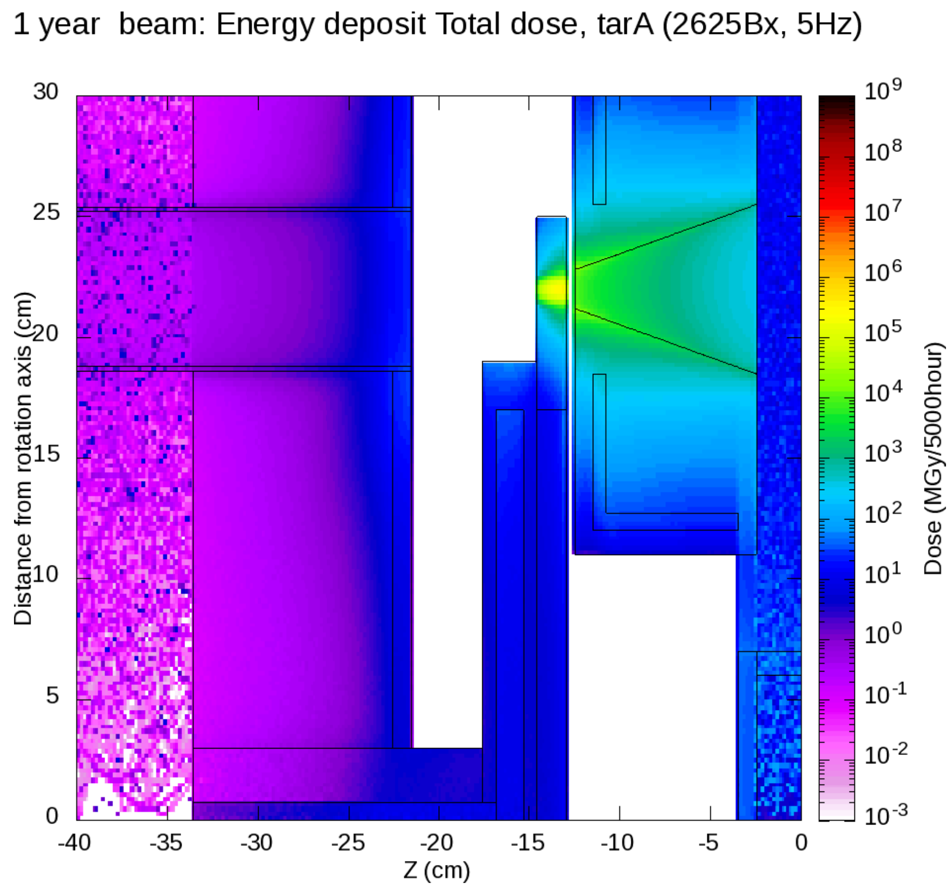




A. Miyamoto

Giving the basic data in designing the shield sytem around the target

# Radiation Environment (2)

- Detailed simulation of the Radiation near the rotating target
- Radiation on the ferro-fluid seal
  - Check neutron flux




Miyamoto

- 10MGy/year
- Need more shield for < 1MGy/year

# Radiation Enviroment (3)

- All along the beamline from the chicane to DR
- Turned out the loss at ECS very large (comparable to the target)

| Section | Beam loss [kW] | Ave. Energy [MeV] | Num. of e+ |
|---|---|---|---|
| Chicane | 0.92 | 187 | 1553 |
| 4Q1L | 3.74 | 299 | 3944 |
| 4Q2L | 1.37 | 556 | 779 |
| 4Q4L | 1.27 | 1555 | 257 |
| 4Q4S | 5.62 | 2741 | 647 |
| ECS | 21.72 | 4700 | 1459 |

Fukuda

# Remaining Issues of e-Driven System

- Target
  - Prototype test for more realistic model
  - Endurance against neutron
- Flux concentrator
  - Cooling
- Capture cavity (standing wave)
  - New design (multiple cell, high $\beta$)
  - Transient beam loading
  - Cooling system
- Beamline
  - Chicane (after capture)
- Replacement system of target-capture area
- Radiation shield
  - Target-capture region
  - Entire beamline
- Layout
  - Possible transition from e-driven to undulator

# Positron Summary

- Intense studies of e-driven scheme on-going
  - Overall design
  - Yield calculation
  - Target
  - Radiation calculation for the design of the shielding of the entire positron system
- Still more detail necessary for the above topics, plus
  - Shield and tunnel design
  - Capture cavity design and loading calculations
  - Target exchange system
  - Entire layout
- Need resources for the undulator scheme