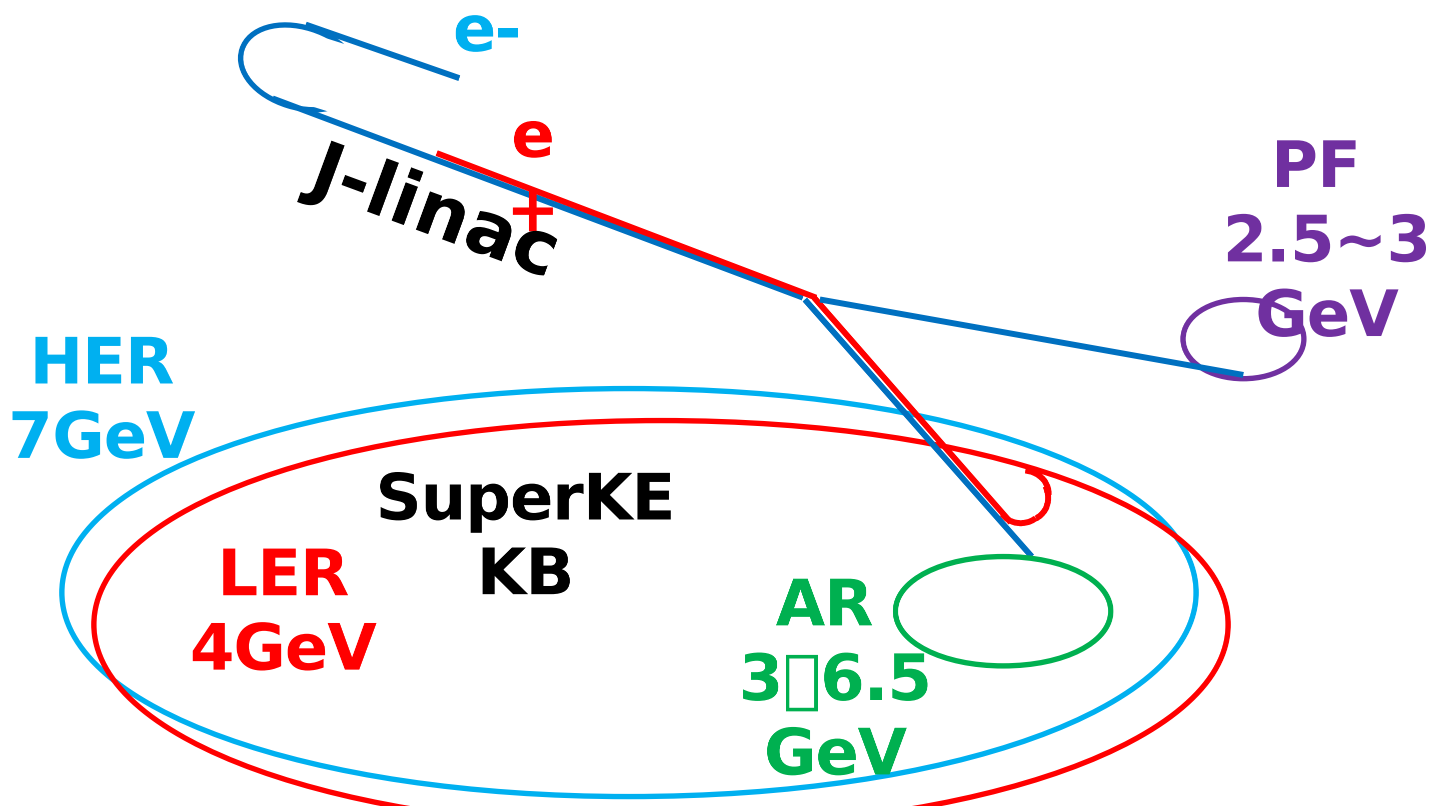
RF Source for Linac (Upgrade for SuperKEKB)

S, Fukuda (KEK)

Contents on Linac Upgrade

- Gross scope
  - Required changes
  - General strategy
- High-charge positron source
  - L-band and/or LAS and capture magnetic field
- High-charge low-emittance electron gun
  - Effort to judge best combination of cathode, cavity and laser
- Emittance preservation Yoshida
  - Finding causes for the growth and suppression strategy
- Schedule

Simultaneous injection for 3 rings + AR injection



Parameter changes for Linac Upgrade

	KEKB obtained (e+ / e-)	SuperKEKB required □ (e+ / e-)
Beam energy	**3.5 GeV / 8.0 GeV**	**4.0 GeV / 7.0 GeV**
Bunch charge	e- □ □ e+ / e- 10 □ **1.0 nC / 1.0 nC**	e- □ e+ / e- 10 □ **4.0 nC / 5.0 nC**
Beam emittance (γε) [1σ]	**2100 μm / 300 μm**	**10 μm / 20 μm**

Injector Upgrade strategy

(e-)

- **High charge**
- **Low emittance**

▶ **Photo RF gun**

(e+)

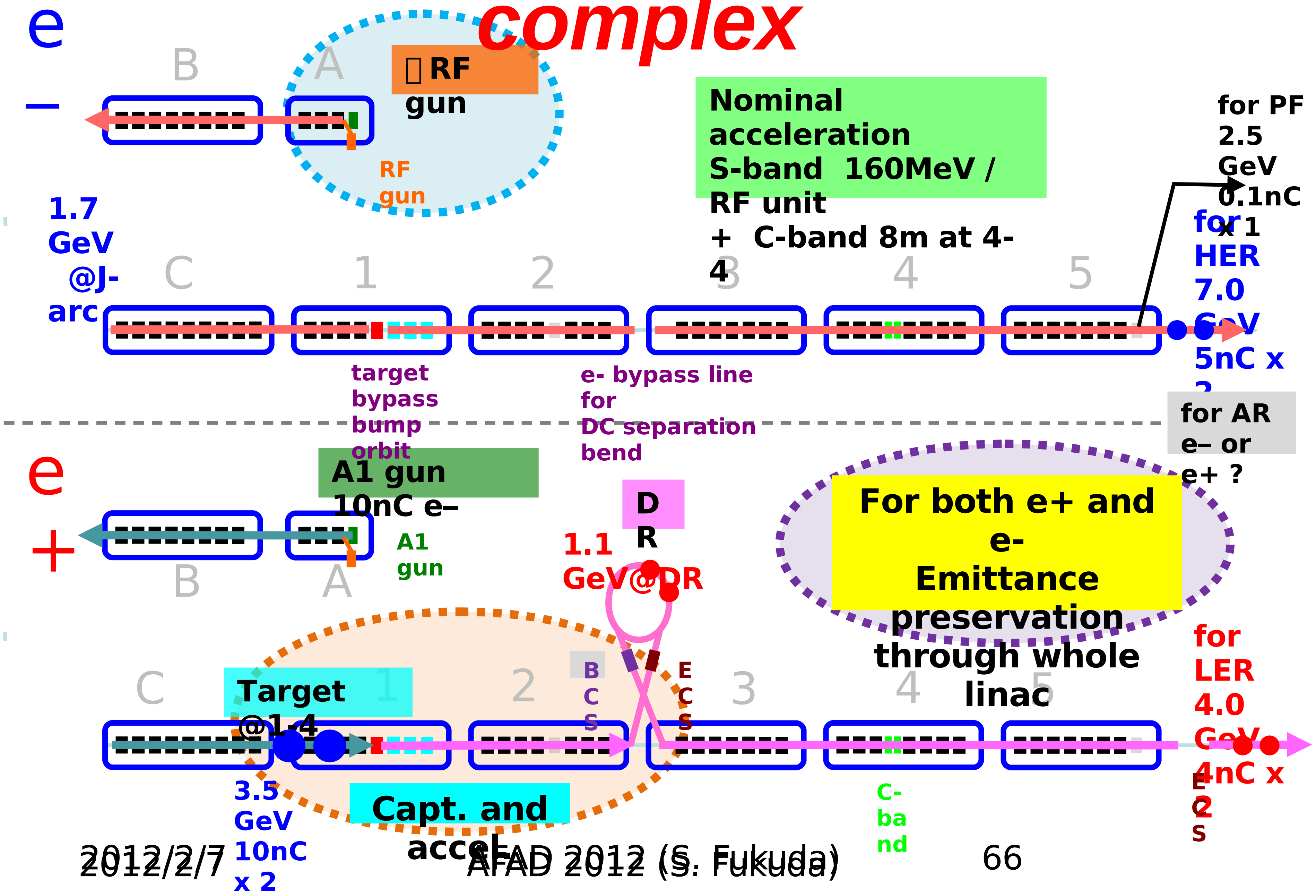
- **High charge** ▶ **AMD + Large aperture acc.**
- **Low emittance** ▶ **DR**

(ε) Emittance preservation ▶ **Identify relevant factors**
Alignment, dispersion, wake, CSR

(simultaneous injection)

- **Pulse-to-pulse optics** ▶ **Pulse magnet**

SuperKEKB injector complex



Positron source

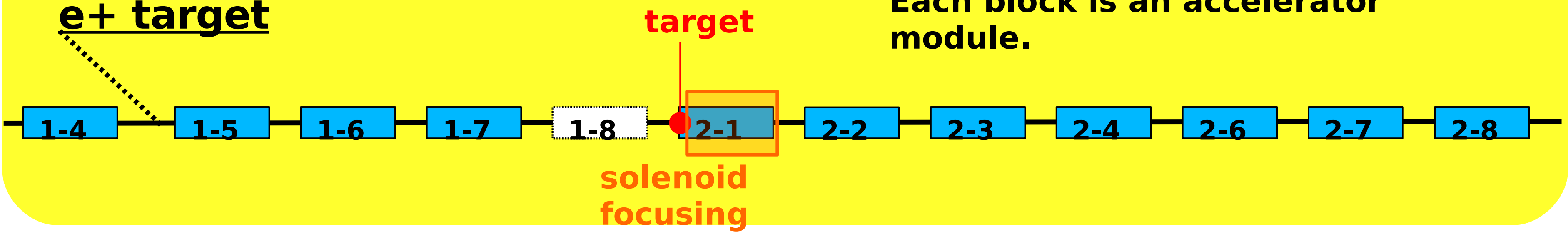
Positron source

- To high charge
  - Higher focus field (**Flux Concentrator**) with AMD (Adiabatic matching device)
  - Large aperture acc & associated focus system
  - Simulation gives 6-7nC with large aperture
- Low emittance
  - DR + emittance preservation
    - 1.1GeV injection energy→target shift to

Configuration change of positron source for introduction of DR

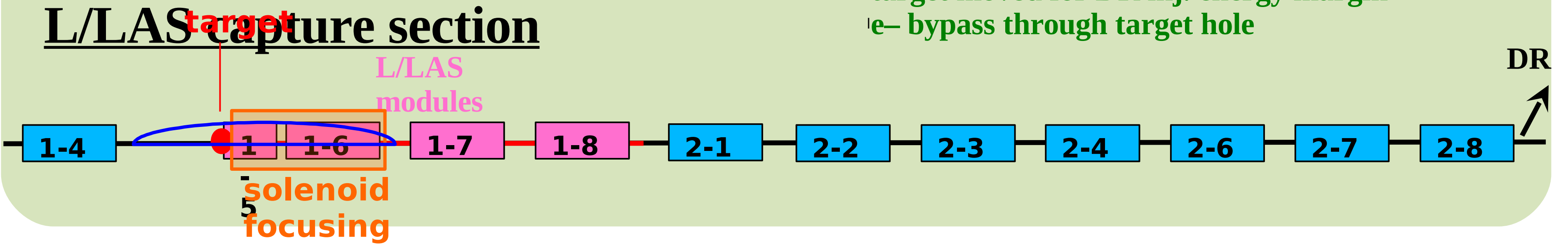
Present layout around e+ target

Each block is an accelerator module.



SuperKEKB □□ Layout with L/LAS capture section

- target moved for DR inj. energy margin
- e– bypass through target hole

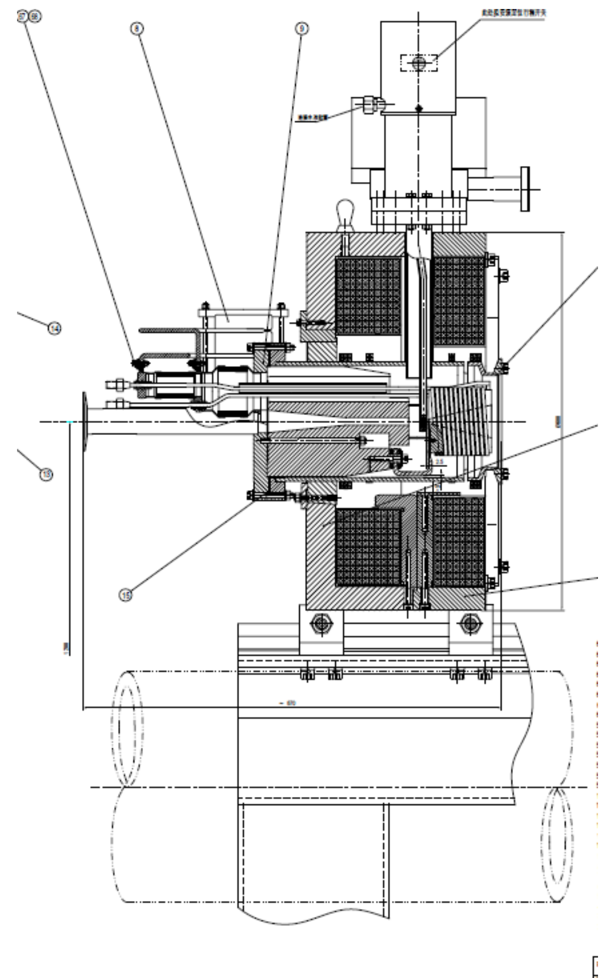


Strategy and R&D's

- Increasing focus magnetic field with AMD
  - FLC（Flux concentrator） under development aiming at 10T
  - Development for stable system in mind
- Satellite in S-band bucket
  - Need to be suppressed because it results in DR injection loss associated with DR radiation problem
  - Inclusion of L-band system is considered to suppress
- Method of electron bypass
  - No independent line because too expensive and less energy gain
  - Emittance growth with offset beam should be suppressed

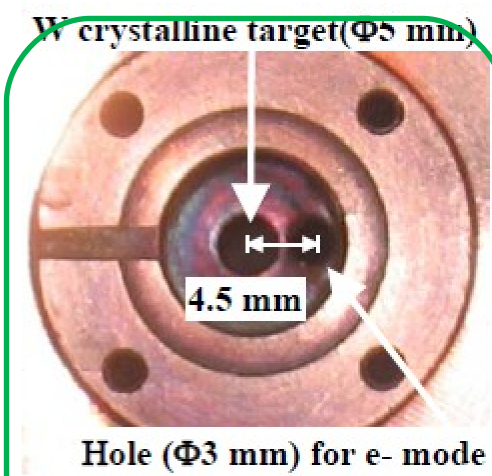
IHEP(SLAC) FC as Basic Line

- ***Structure: right figure***
- ***There are no joint in the water channel in the vacuum vessel***
- ***Structure is simpler than BINP(?)***
- ***There are big solenoid out side the FC and its size is possibly used in KEK's girder system***



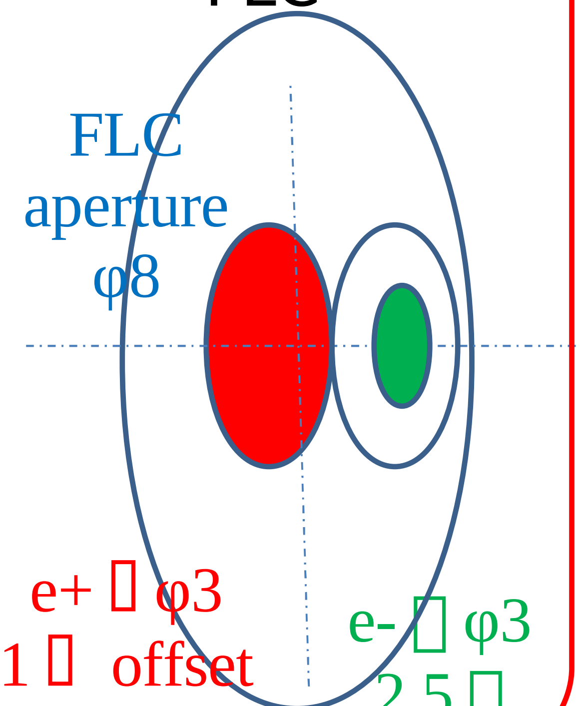
For the magnetic strength of

How to transport electron



Bypass in the present target

Bypass inside FLC

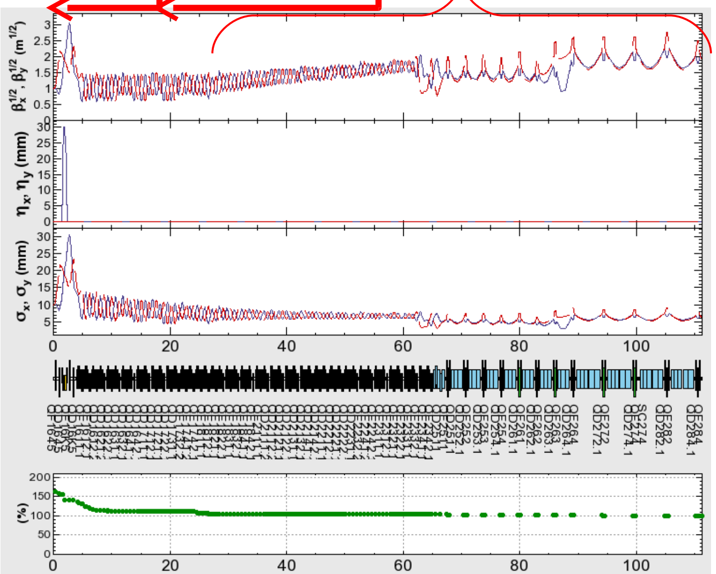


Make electron passage route and suppression of emittance growth

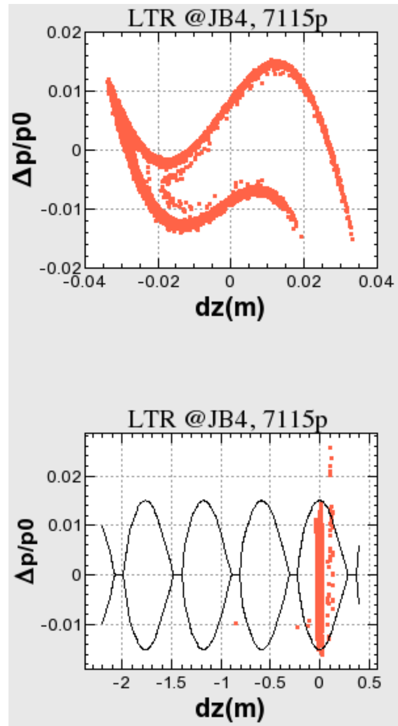
Off-centered positron production point and yield estimation

L-band Structure and Large Aperture S-band

Lx2 +LASx4 +LASx8 +Normal



Optics from target to LTR



DR injection

Summary of yield and loss

Capt 4m	Next 8m	Boost 16m	Charge [nC] @DR	DR loss [%]
L	L	LAS	6.6	0.05
L	LAS	LAS	6.3	0.27
LAS	LAS	LAS	6.3	0.40

6~7 nC is estimated in various configurations with large aperture.

L-band preparation

L-band 1st structure was delivered.

Waveguide components are being prepared.

High power test will be early next JFY.

Focus magnets were found very expensive which accept large bore aperture.

- Minimize the large size area.
- Make focus magnets in a cheap manner.

Mitsubishi PV-1040 Klystron for SKEKB Injector

Parameter	PV-1040
Frequency (MHz)	1300
Output Power (MW)	40
Beam Voltage (kV)	295
Beam Current (A)	335
Efficiency (%)	40
Perveance (μP)	2.1

KEKB Klystron and Modulator（S-Band)

Klystron Specifications

Modulator Specifications

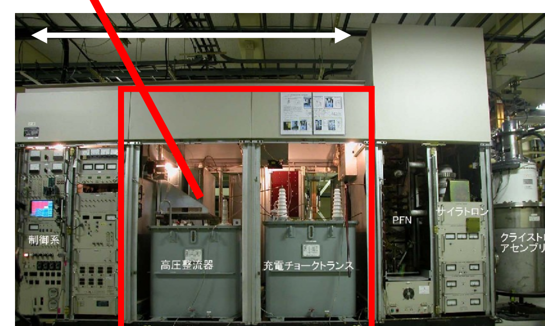
C-band System and Compact Modulator (Charger is replace to Inverter P/S)

· Start the development for C-band scheme of SuperKEKB
· Decrease the modulator size to one-third that of the existing modulator.
·Switching power supply is essential to reduce modulator size.
·Single unit for easy maintainability

Specifications

- **Klystron Output** 50MW (C-band)
- **Klystron Voltage** 350kV
- **Output voltage of Inverter** 50 kV(max.)
- **Output power** 30 kJ/s
- **Voltage regulation** ±0.1%
- **Efficiency** >80%
- **Power factor** >85%
- **Input voltage** 420 V, 3 Phase, 50 Hz, AC
- **Cooling Water** 5 liters/min.
- **Size** 19” rack mount < 530mm(H), 480mm(W), < 700mm(D)
- **Operation** Single and Parallel operation

Compact Modulator



Present modulator

Electron source

Existing RF gun

- Existing RF guns
  - SLAC： Cu cathode life ~1 yr, 0.25～1nC, <1πμm, TiSa 266nm, S-band, 60Hz
  - ATF：CsTe, <5nC, 4πμm（4nC, YAG 266nm, S-band, 1.56Hz
  - DESY : 8nC, 15πμm with L-band
- We need long-term stability
  - Maintenance free > 50Hz * 1yr or easy exchange
  - No established technology exists

R&D items

- Cathode life
  - Material choice
  - Get operation experience and establish long life
- Laser stability
  - No laser specialist, yet to be developed
  - Get operation experience to understand the issues
- Establishment of low emittance
  - Low emittance at high charge should

Studies on cathode, cavity and laser

We start with configurations, blue & green below, though other combinations can actually be applied.

- Cathode
  - Cu → study with 200nm
  - Cs2Te □ 266~205nm
  - LaB6 , Ir5Ce □ Thermal □ 337~266nm
- Cavity
  - 1.6-cell ATF (BNL) type and ½-cell type in high gradient
  - DAW in medium gradient with bunching in cavity
- Laser

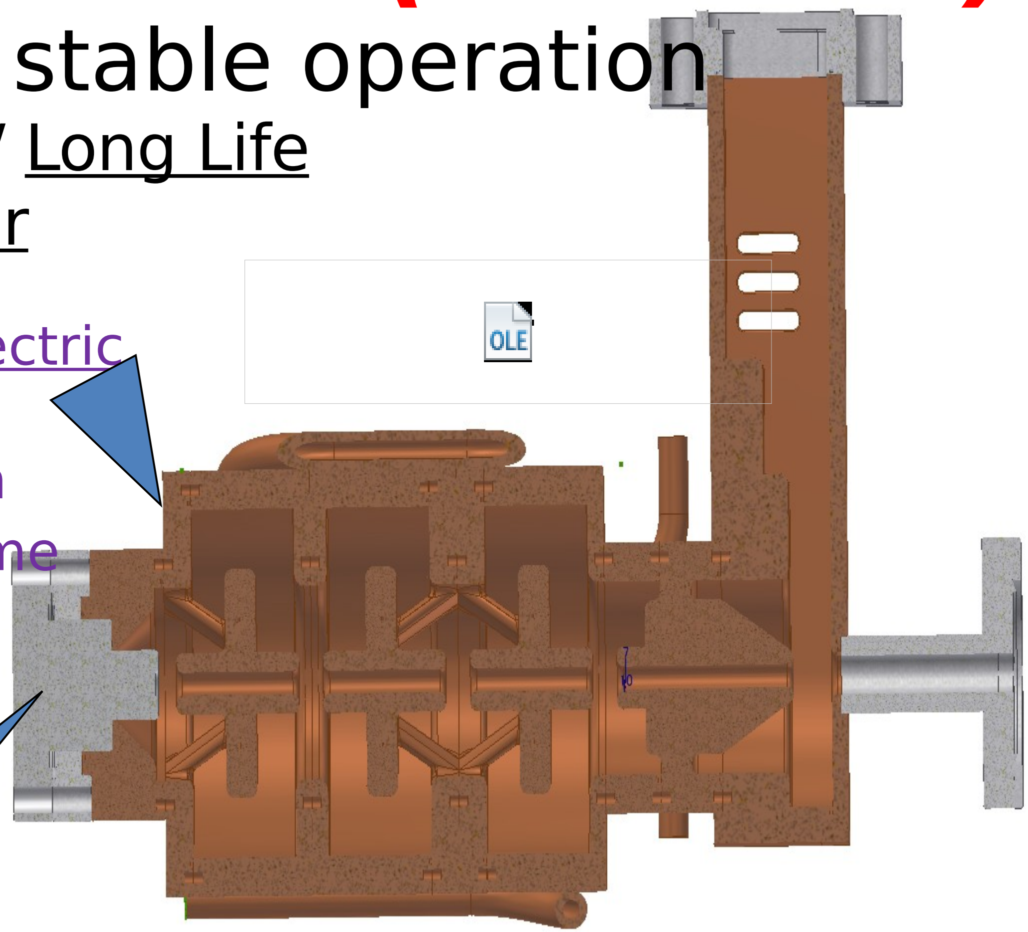
DAW + LaB6 (or Ir5Ce)

- For long-term stable operation

<u>Maintenance Free</u> / <u>Long Life</u> / <u>Purged into air</u>

<u>Cavity : Lower Electric Field</u>

- Stable operation
- Short Ageing Time



This RF-Gun(DAW + LaB6 thermal) was already in operation at Tokyo University of Science since 2008.

<u>Stable cathode : LaB6 or Ir5Ce</u>

- Not active, Solid (not thin film), High Melting Temperature : life time >> Cs2Te
- Work function ϕ =2.8 eV(LaB6), 2.57 eV(Ir5Ce) : laser power << metal

Planning

- Test with installing one system into A1
  - System with DAW+ LaB6 by YVO4 laser
  - Installation at A1 from April 2011
    - Low-emittance beam for emittance growth study
    - Evaluation of RF gun property and potential
- Efforts to study feasibility of key components
  - TiSa 4th 200nm, 100μJ
  - High gradient RF gun (Half-cell or 1.6-cell)

Emittance preservation

Refer to the following talk by Yoshida

Source of growth and strategy

- Possible sources
  - Dispersion
  - RF kick mostly from cavity
  - Wake field
  - CSR □ J-ARC
- Strategy
  - Improve alignment
  - Measurement of slice emittance and compensation

Emittance strategy and R&D's

- Improve alignment where possible
  - Conventional method is applied □ < 1mm
- Growth source should be identified
  - Measurement of emittance
    - Add more measurement points
    - Measurement of slice emittance
- Suppression and/or correction
  - Dispersion correction
  - Wake field suppression and compensation with offset injection
  - Proceed BBA with better BPM resolution

Thanks for Listening