Operation of Cs-Te photocathode with ATF RF gun

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Energy: 1.28 GeV
Electron bunch:
2x10^{10} e/bunch
1 ~ 20 bunches/train
3 trains/ring
1.56 Hz
\( \varepsilon_{x/y} \sim 1.5\text{nm/4pm} \)

Extraction line
R&Ds with low emittance beam

Damping Ring

1.3 GeV S-band LINAC with \( \Delta f \) ECS for multi-bunch beam

Cs-Te RF gun
**Laser system for ATF RF Gun**

1. **Mode-locked-laser**
   - Nd:YVO$_4$, 1064nm, 357MHz, 410mW(CW)
   - Pulse length: 7.2ps(FWHM)
   - Timing jitter: < 0.5ps(rms)

2. **Pockels cell**
   - Rise&Fall time: < 3nsec

3. **Fast Pockels cell**
   - Rise time: < 1nsec

4. **SHG**
   - CASIX, β-BBO
   - 6×6×6mm

5. **FHG**
   - CASIX, β-BBO
   - 6×6×6mm

Output UV 266 nm
- Pulse length: 12ps(FWHM)
- Power: ~3μJ/bunch (1uJ in 2002)
- 1~20 bunches/pulse

Beam structure at the end of ATF injector
ATF RF Gun

High quality Multi-bunch beam is generated.
1 ~ 20 bunches/pulse, 2.8ns spacing
~ 2 x 10^{10} electrons/bunch
RF Gun for Cs-Te photocathode

Modified BNL type IV: 1.6 cell, 2856 MHz

Cavity was fabricated by KEK with the ultra-fine diamond turning developed for X-band accelerating structure.

CERN-style contactor between the plug and the end plate of cavity
Recent Beam History by Cs-Te RF Gun for ATF operation

ATF Beam Operation History

Beam Intensity ($x10^{10}$e-/pulse)

Year/Month

Multi-bunch Operation

Single bunch operation
Dark Current of ATF RF Gun

Measured in 2002, commissioning of the ATF RF Gun.

Aging means no beam generation (no lasers), it is a RF processing of the RF-Gun cavity.
**Dark Current 2001/2002**

**Old gun**
BNL type-IV, Cu cathode
Tested in 2001
manufactured by Sumitomo Heavy Industry

**New gun**
BNL type IV modified for Cs-Te cathode
Used since 2002
Manufactured by KEK with the ultra-fine diamond turning.
QE in operation

- QE in operation (with a strong surface field ~ 90 MV/m) was evaluated by using the Faraday Cup.

- QE was up to 3 %, although QE in a low field was ~1%. That can be explained as Shottky effect.

- QE was decreased at the end phase, where the transmission from the gun becomes low.
Normalized emittance was measured by Q-scan method at the downstream of the injector, where the beam energy is 80 MeV.

The beam size was measured by W-wire scanner.

The expected beam spot at the cathode is 1.2mm in FWHM.

Figure 4: Beam emittance data are plotted as function of bunch current. The triangle and circle symbol show the single- and multi-bunch data respectively.
Initial QE is sufficiently high ~ 15 %.
It drops quickly when we apply the RF field.
All QE measurements were done by moving the photocathode from the RF gun to the Cs-Te preparation chamber.
Wavelength dependency

- Decrease of QE was measured in all wavelength.
- ATF laser is 266 nm.
- Peak of the QE is shifted to shorter wavelength.
Two months history of the quantum efficiency under the ATF operation

Quantum efficiency is …

- stable about 1%.
- small decrease in the shutdown week? (Cathode was stored in the RF gun. 5x10^-7 Pa)
- recovered after the beam generation?
Quantum efficiency is …

- stable about 1%.
- decreased in the summer shutdown. (Cathode was stored in the RF gun. 5x10^-7 Pa)
- recovered after the beam generation.
Sample Mo#2 2004-Jun15 to 2006Mar25

New Cs-Te formation after surface cleaning

Keep in the formation system
0.7x10^{-7} Pa
4 months

Add Te&Cs to get higher QE for special users
(No surface cleaning)

Keep in the stock area
2x10^{-7} Pa
1 month

Add Cs to get higher QE
(No surface cleaning)

Beam
2 months
+ Keep in RF gun
5x10^{-7} Pa
4 months

RF Gun
Beam
5 months

0.3%
0.6%
Damages?

Just after the Cs-Te formation

After the half-year operation

- We did not see this pattern during the dropping of QE by RF operation.
- Why Q.E. was kept about 1% with this pattern?
- Can we keep a higher Q.E. if we minimize this change?
Summary

• **RF Gun**
  - We have used the RF gun with the Cs-Te photo-cathode about four years for the ATF operation.
  - It can supplies the electron beam about 1~2x10\(^\text{10}\) electrons/bunch and 1~20 bunches/pulse.
  - It works well to supply the electron beam for ATF programs.

• **Cs-Te photocathode**
  - QE just after formation reaches about 16 %.
  - It is decreased with the RF operation.
  - It reaches the stable level about 1%.
Cs-Te RF Guns manufactured by KEK

2002 July  First RF Gun for ATF

2004 June  Second RF Gun for RFGTB/LUCX

2006 Oct  Third RF Gun for Waseda Univ.

End plate of the half cell will be brazed with the full cell.
That is no helicoflex connection. Half cell has four tuning pins. KEK supplies the Cs-Te photocathode.

Other institute are considering to use this RF gun. Kyoto Univ., etc.