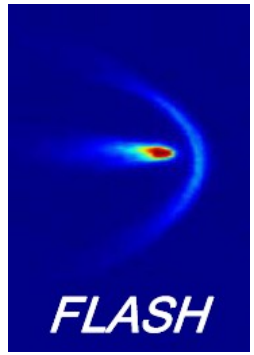

FLASH
Free-Electron Laser
in Hamburg




# Gun Study at FLASH

Jang-Hui Han

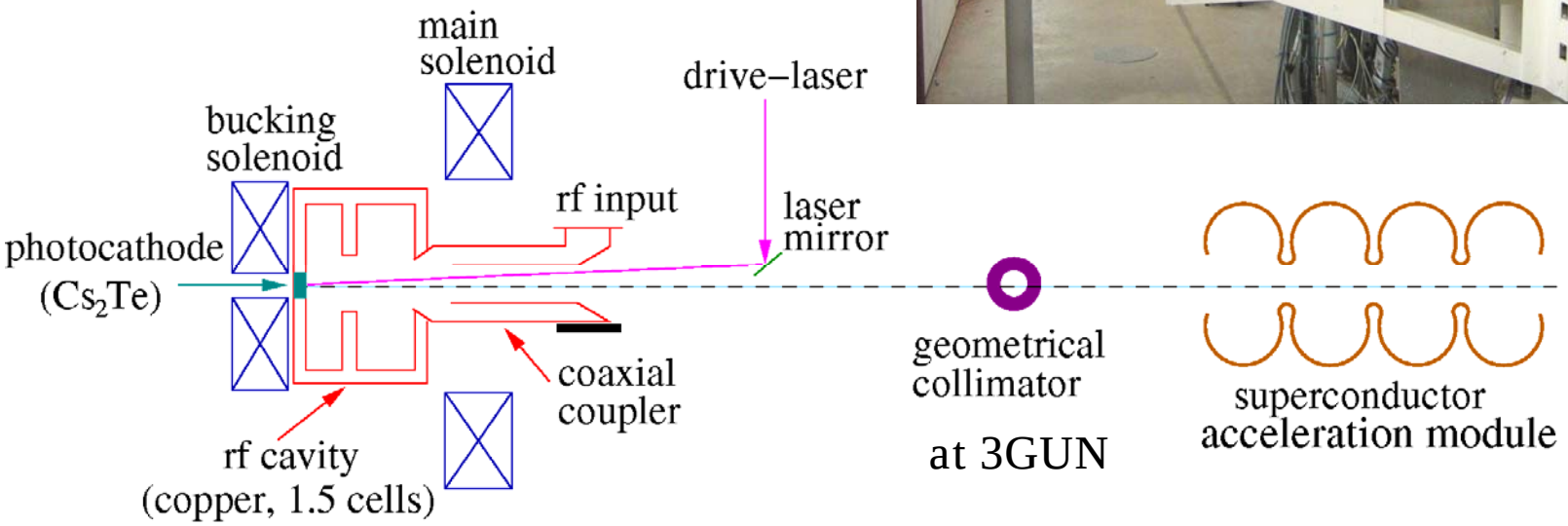
FLASH Seminar, 20 Nov 2007

- FLASH Gun Section
- Cathode Damage
- Dark Current

# FLASH Gun Section

1.3 GHz RF Cu cavity gun
Pulsed, 5 or 10 Hz
RF pulse length up to 900 µs

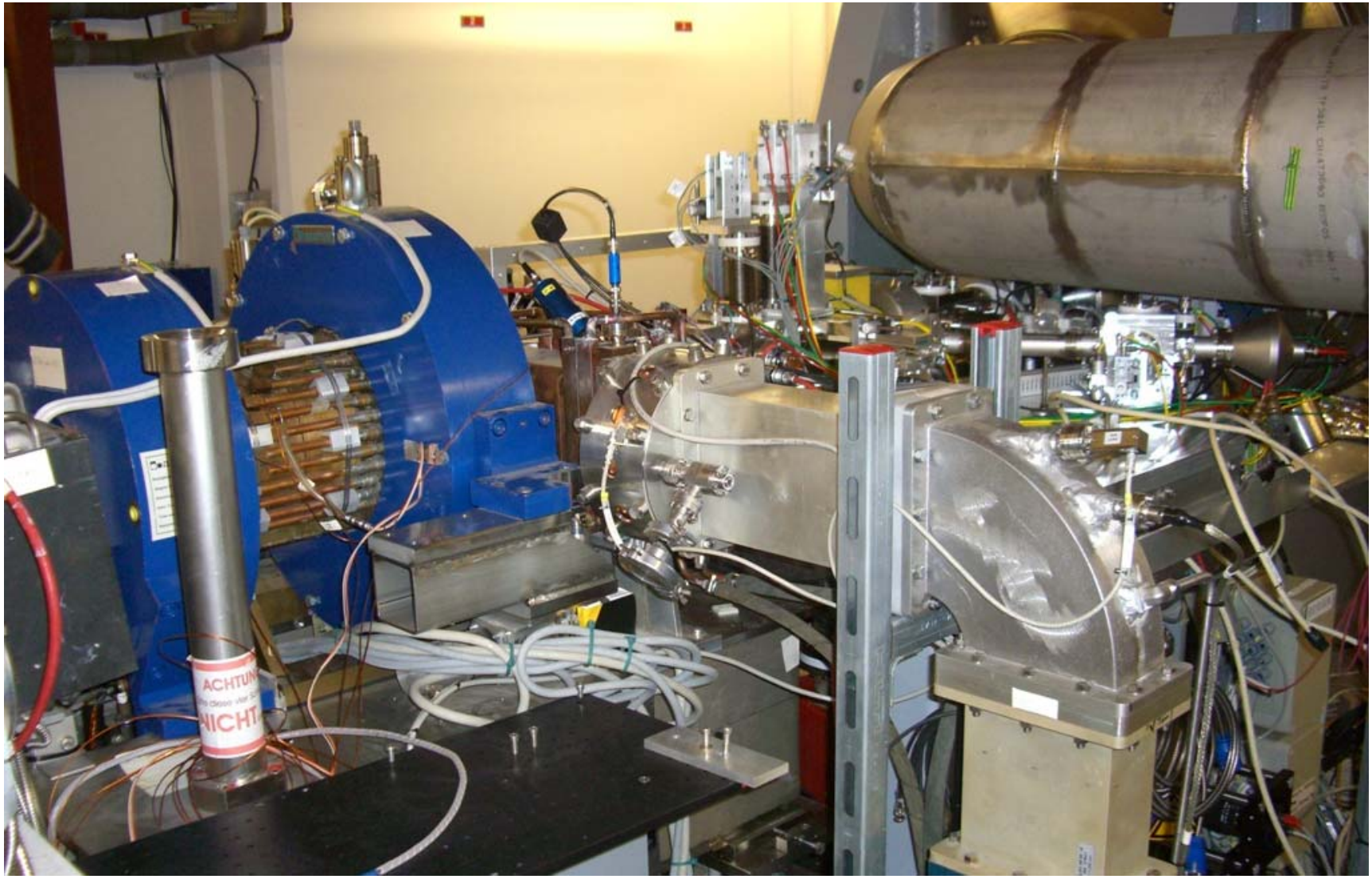
RF power 3.2 MW
(42 MV/m max field at cathode)
**Dark current ~0.1 mA**
**Dark current collimator at 3GUN**



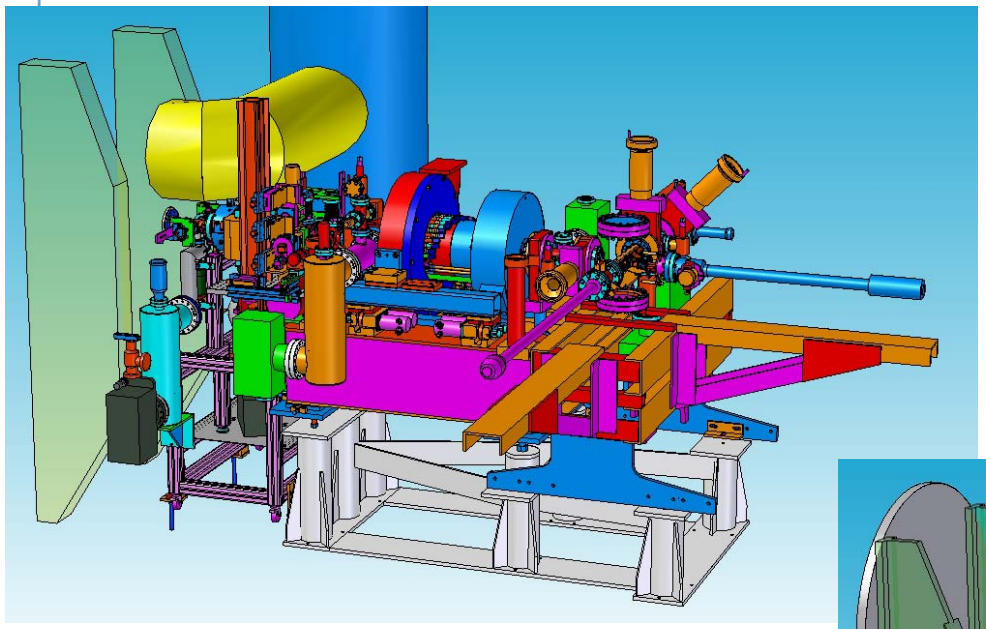
# Gun Section before Maintenance 1

- Difficulty to access to the components
- Narrow vacuum port
- Very short (a few weeks) cathode life time
- Dark current collimator is not effective
- No chance to change the main solenoid current in a wide range due to vacuum problem

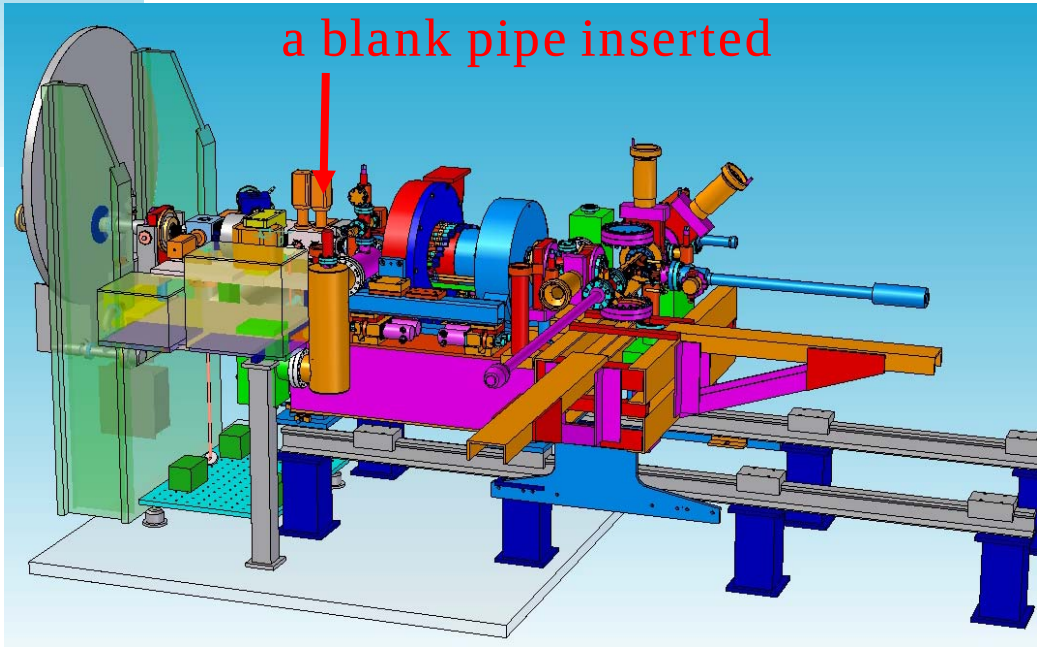
# Gun Section before Maintenance 2



# Gun Section Modification

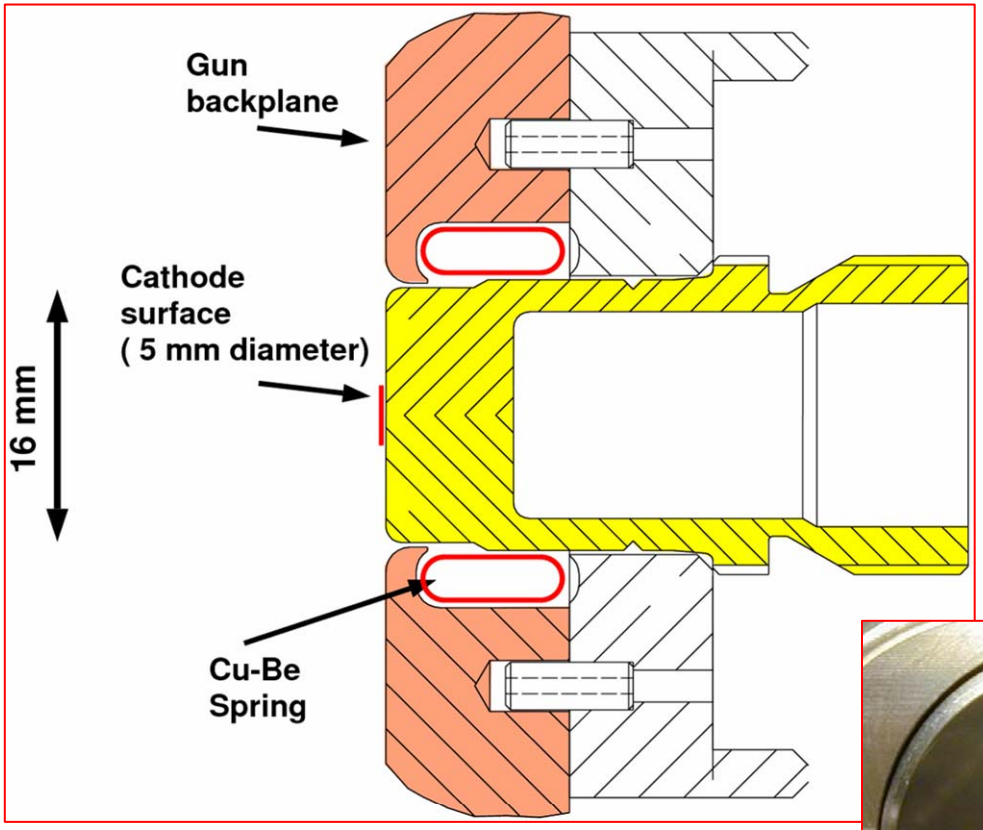


Setup since 2004
- Cathode manipulation system on a rail
- Cathode system, gun cavity, and drift section with diagnostics are supported on different girders.

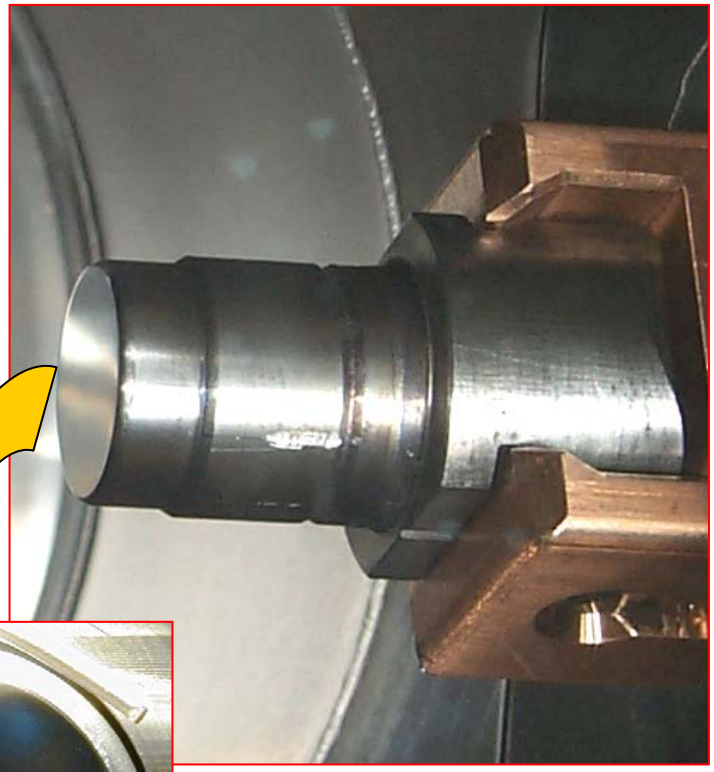


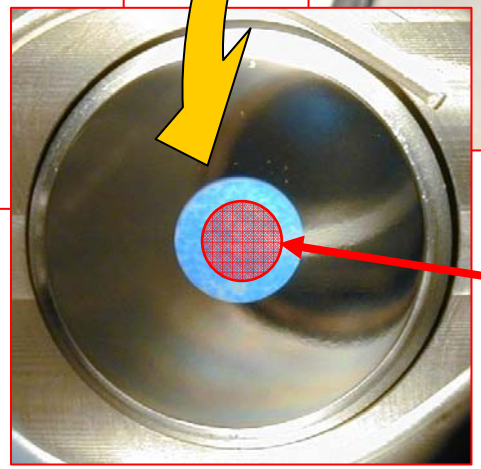

Setup from July 2007
- Cathode system and gun cavity on a common rail
- New diagnostic cross (No Teflon washer, bigger pumping port, ...)
- Drift section with diagnostics now on an optical table

# Photocathode System



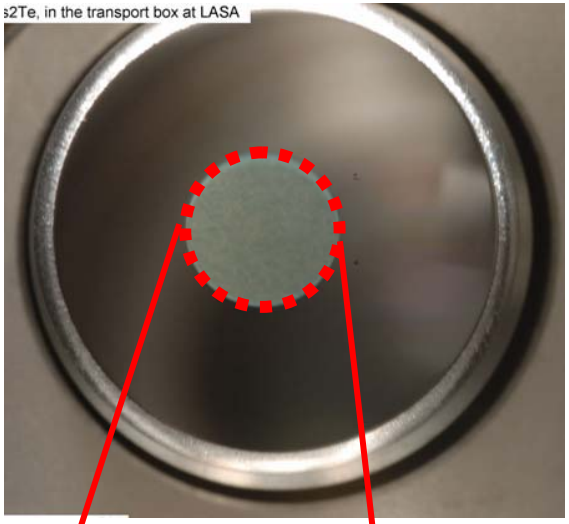

Prepared by INFN - LASA



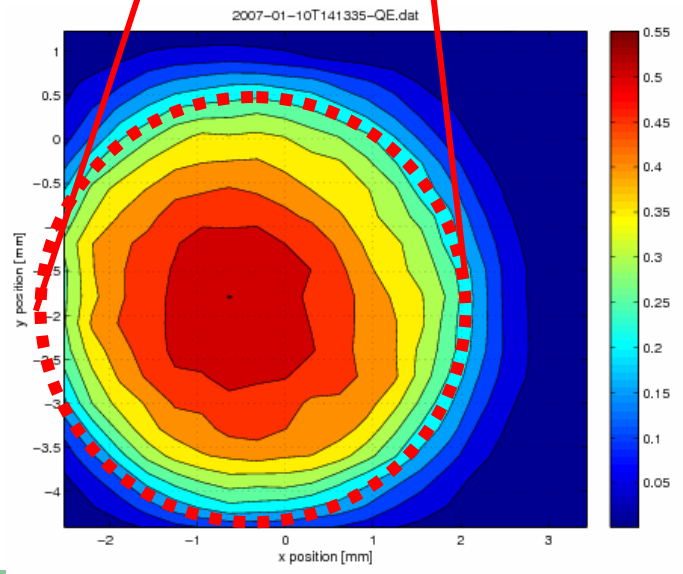


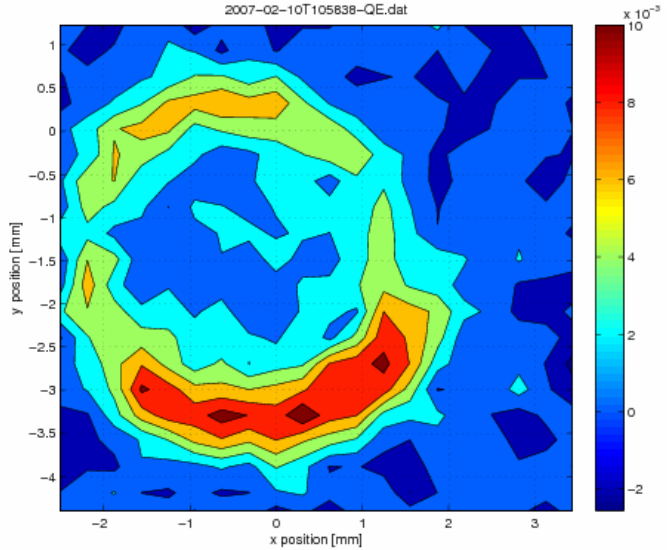
Cathode laser
illuminated
on the cathode

# Cathode Damage 1




# 92.1
12 Dec 06 –
7 Feb 07

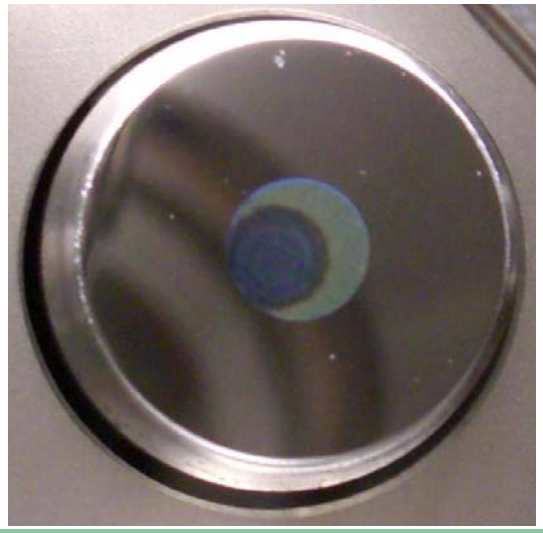


# Cathode Damage 2

# 77.1
11 July –
24 Oct 06

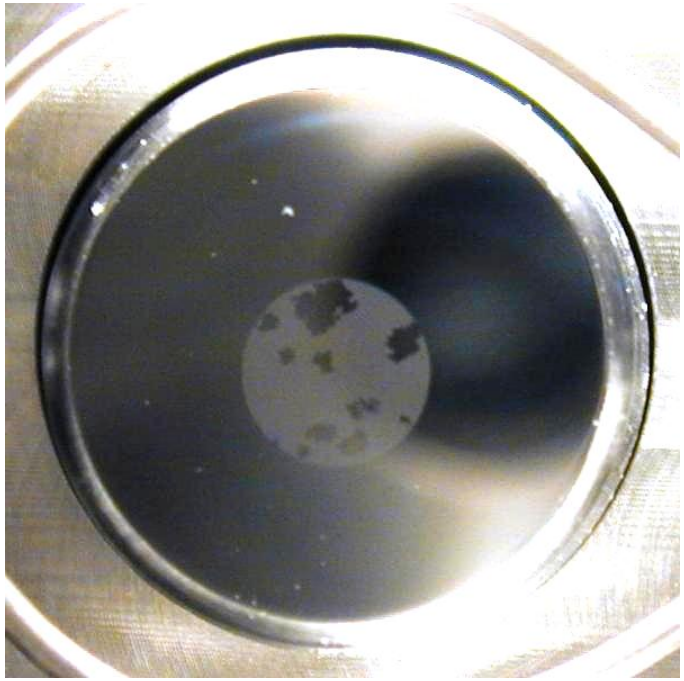
# 13.3
3 Nov –
12 Dec 06



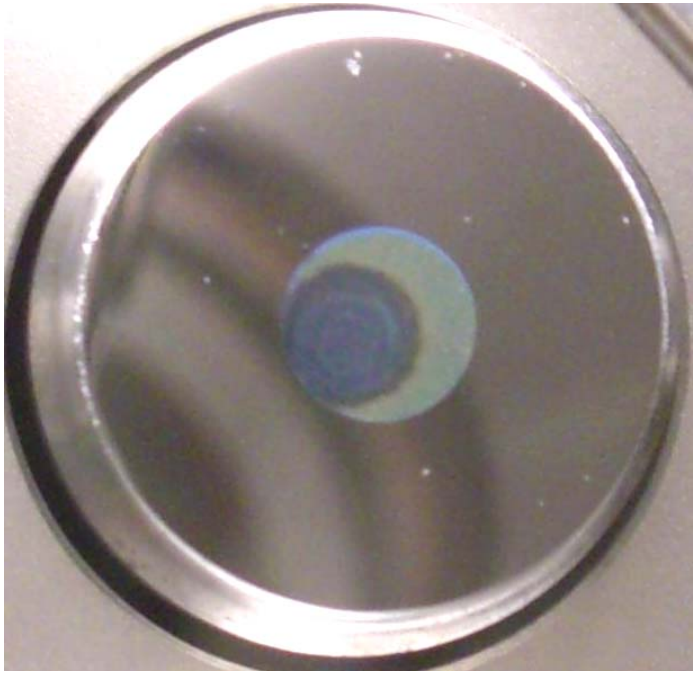
# 94.1
7 Feb –
13 Mar 07

# 95.1
13 Mar –
25 Mar 07

# Cathode Damage 3



Cathode #61.1 after use
(2003 ~ 2004) at PITZ



Cathode #94.1 after use
(Feb ~ Mar 2007) at FLASH

Recently used cathode #108.1 is partly damaged similar as #61.1 and exchanged this morning

# Cathode Damage 4

- Quantum efficiency (QE) starts high ~10 % and drops to ~0.5% during a couple of weeks, change of cathodes routine operation
- XPS at BESSY: traces of F and C found, depleted part: metallic Te

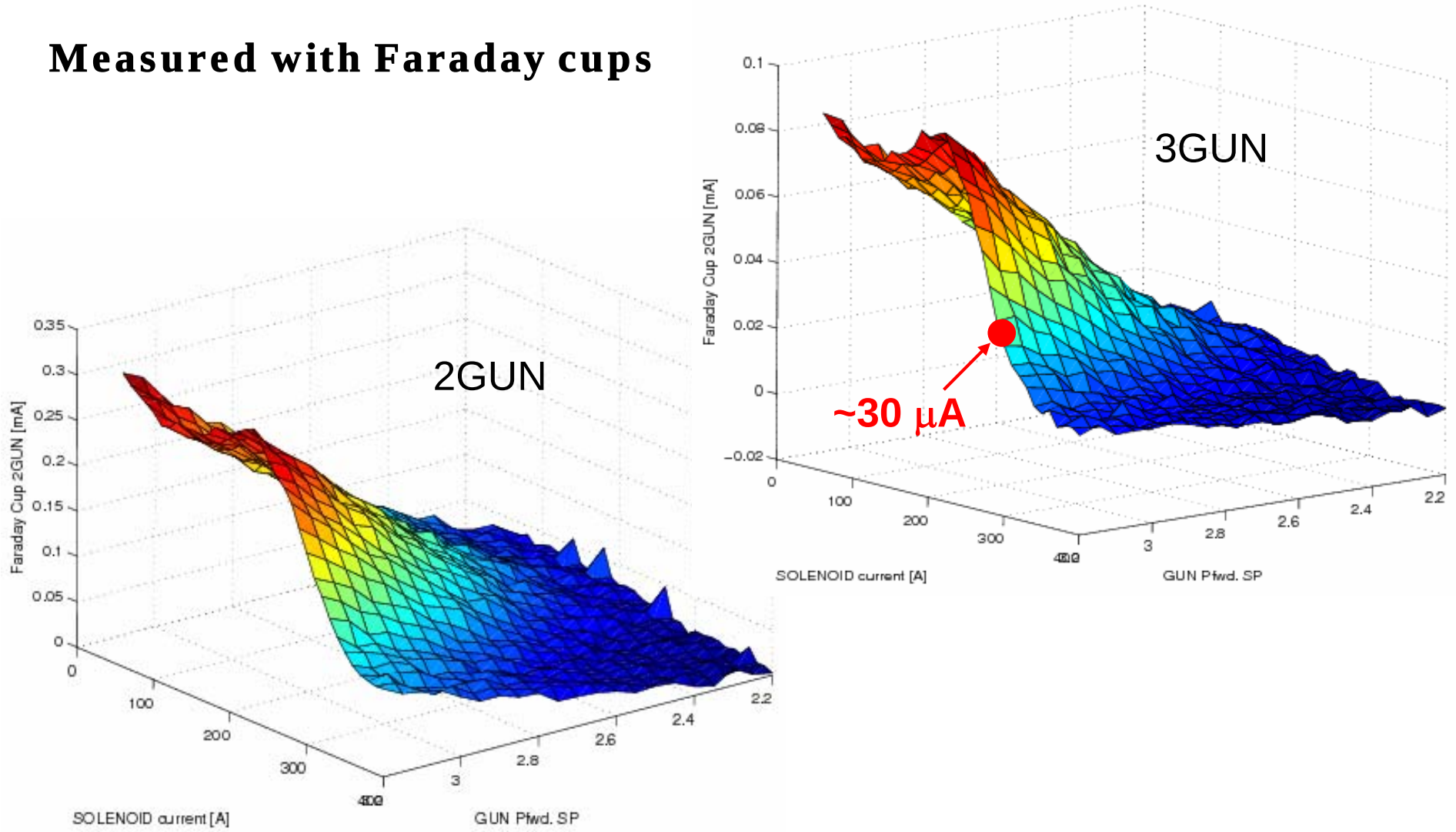
<Present understanding:>

- Cs reacts with F and leaves metallic Te – efficiently with UV laser
- F from Teflon washers in the diagnostic cross
- Washers have been removed
- QE stable since then (usual slow drop in QE)

→ Now, the problem is gone.

# Dark Current at the Gun

**Measured with Faraday cups**



# How to Reduce Dark Current

- Improved material processing: polishing and cleaning (less field emission from the surface)

  → Fundamental solution, but new field emitters are possibly generated under RF operation

- Selective kick out dark current with a kicker

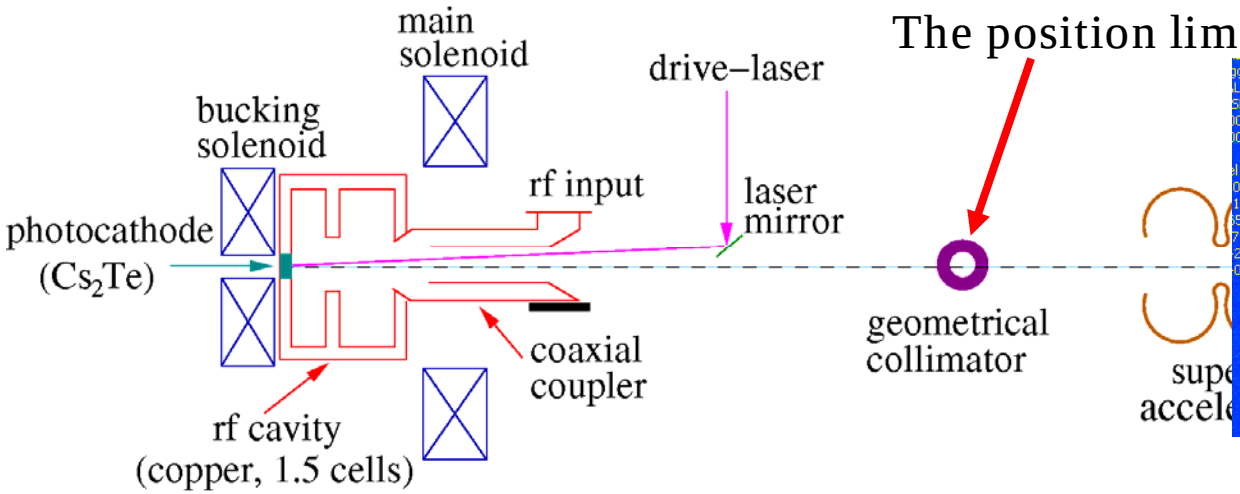
  → Efficiency up to 70%, but active components might be problem

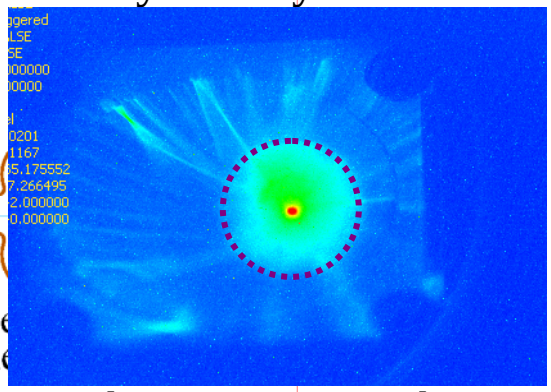
- Cut out with a collimator (geometric and energy collimation)

  → Careful application necessary not to degrade the beam quality

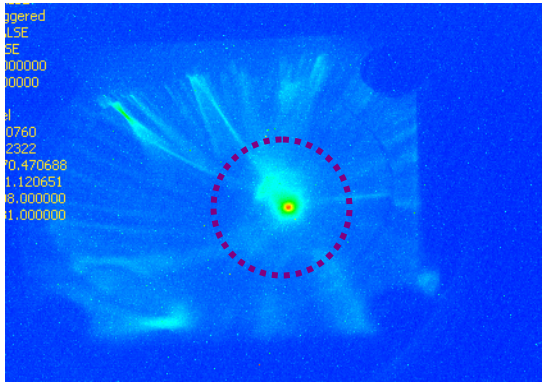
# Dark Current before this Summer

8 mm diameter collimator
1.27 m downstream of the cathode
The position limited by the cryo-module

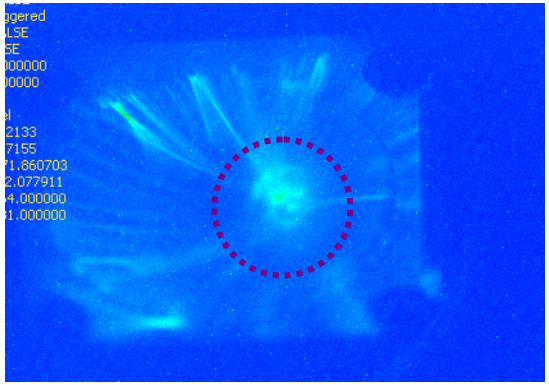


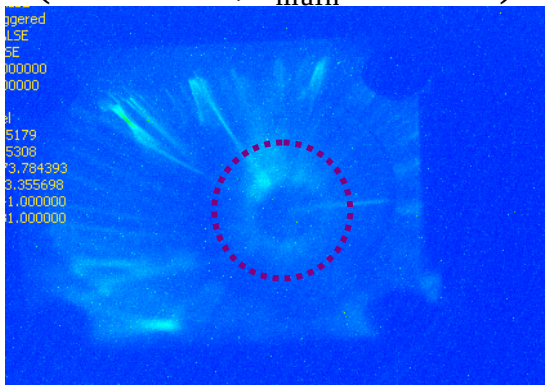
Dark current + 1 nC beam
(44 MV/m, $I_{main}$ = 278 A)



Dark current
(44 MV/m, $I_{main}$ = 278 A)



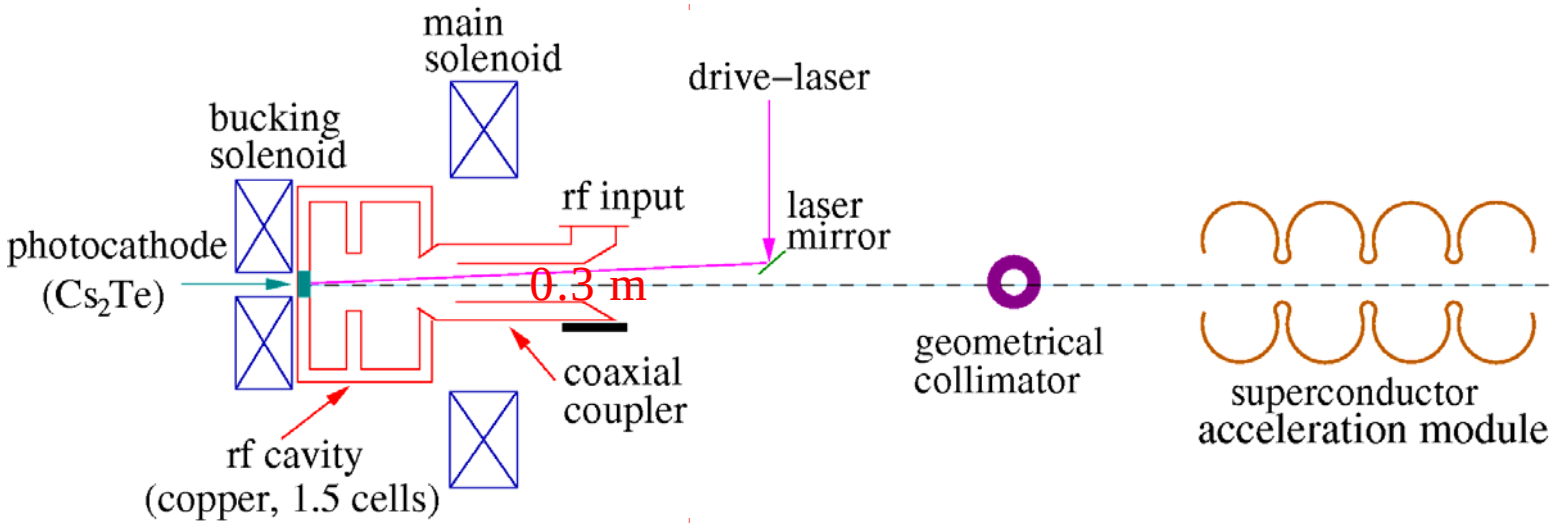
Dark current
(44 MV/m, $I_{main}$ = 283 A)



Dark current
(44 MV/m, $I_{main}$ = 290 A)

# Gun Movement Upstream

0.3 m elongation between the gun and the first module




Distance from the cathode

to the laser mirror 0.66 m → 0.96 m

to the collimator 1.27 m → 1.57 m

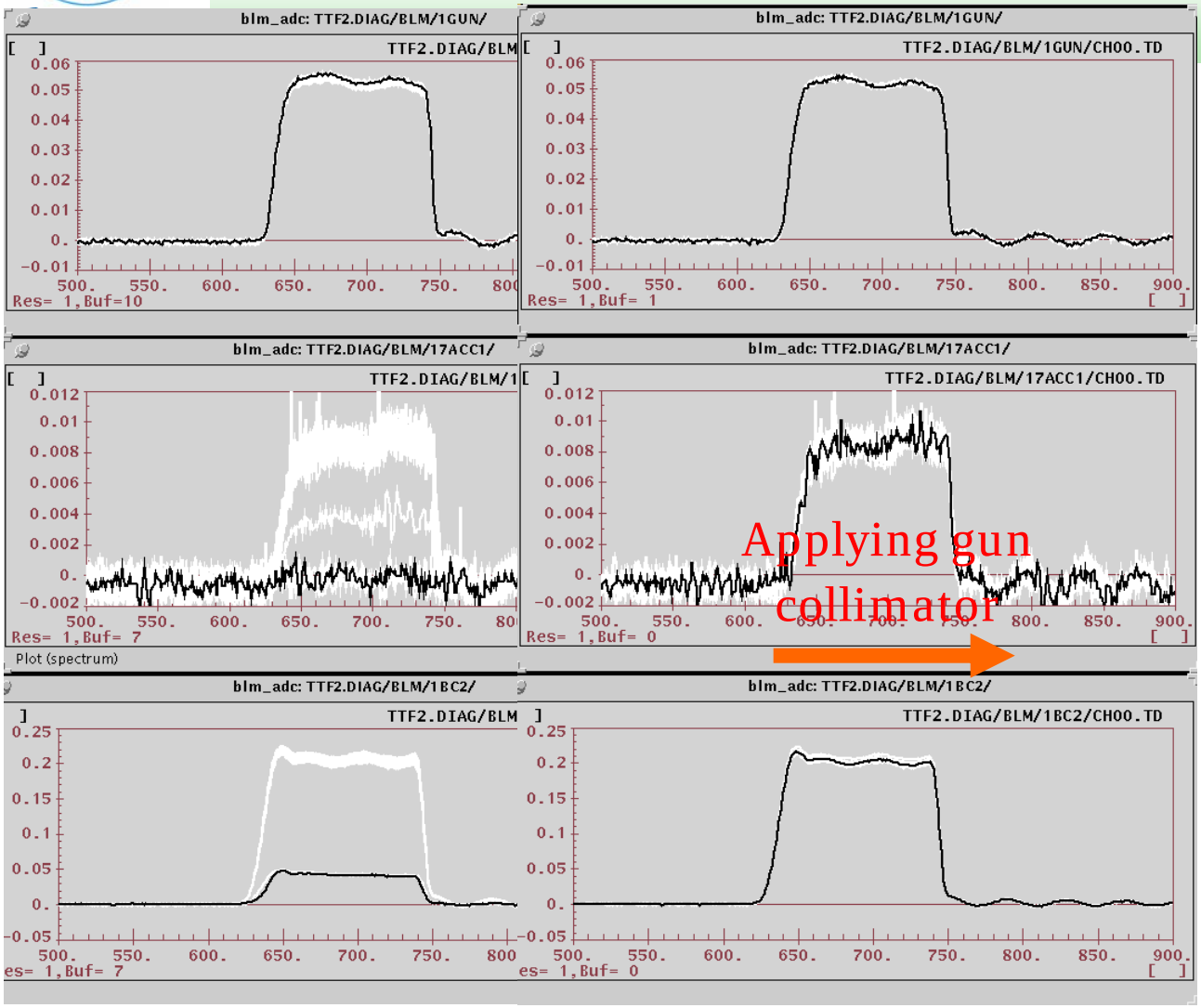
} Smaller beam size at the location → Wakefield effect reduced

Additional space reserved for a dark current kicker

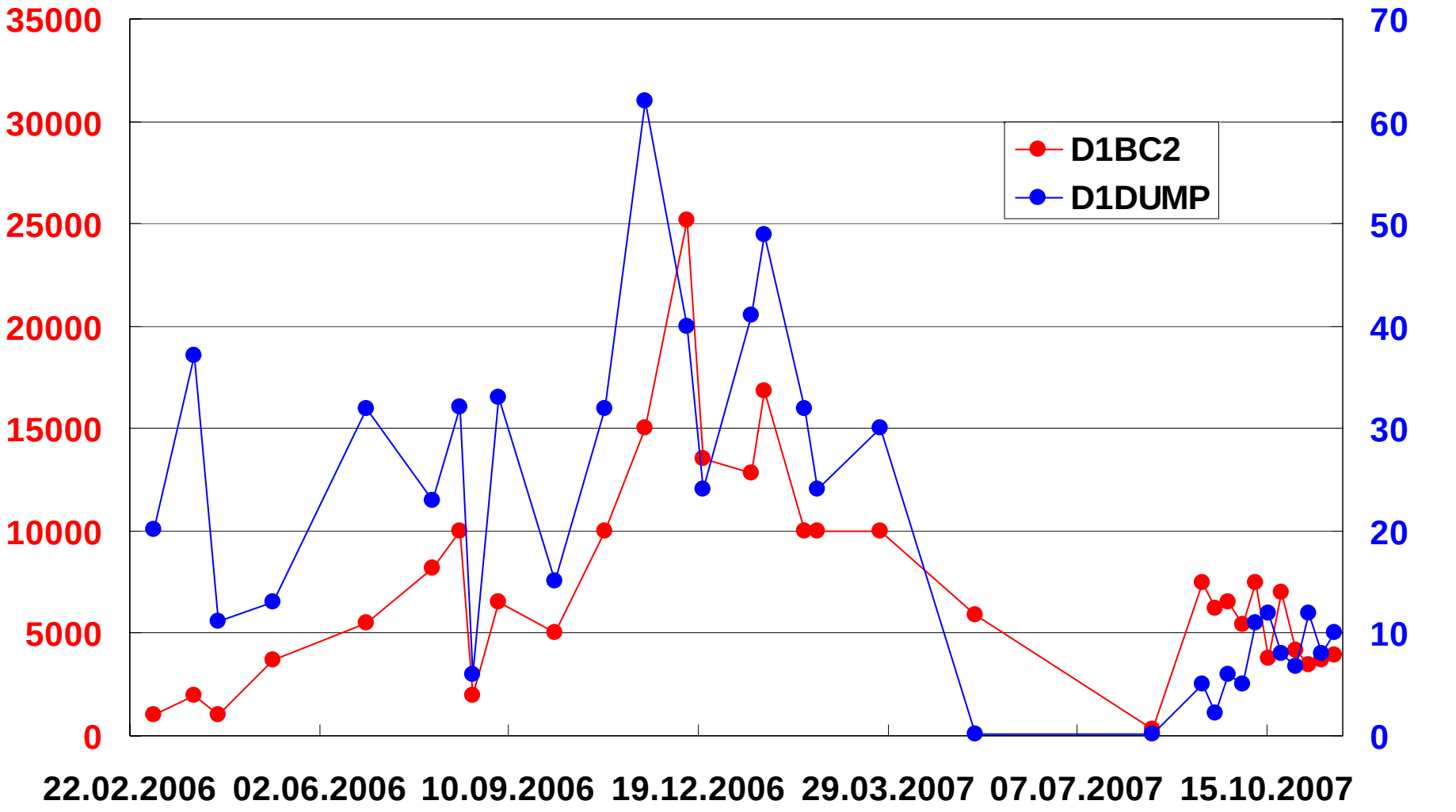
# After the Modification

- Beam transverse emittance improved ~10%
- Dark current collimator in the gun section does not degrade the beam quality
- Without the collimator, dark current reduced by ~50%
- With the collimator, dark current lost at the first bunch compressor reduced by ~80%
- No decrease of the cathode QE > 7%

# Dark Current Loss



# Dose Rate due to Dark Current



# Summary

- Cathode degradation is not so fast as before the maintenance
- The gun collimator reduces the dark current from the gun by 90%.
- The collimator does not reduce the bunch charge (only < 1%) nor degrade the beam transverse emittance remarkably (less than 10%)