Development of a Pulse Stacking Cavity at KEK-ATF

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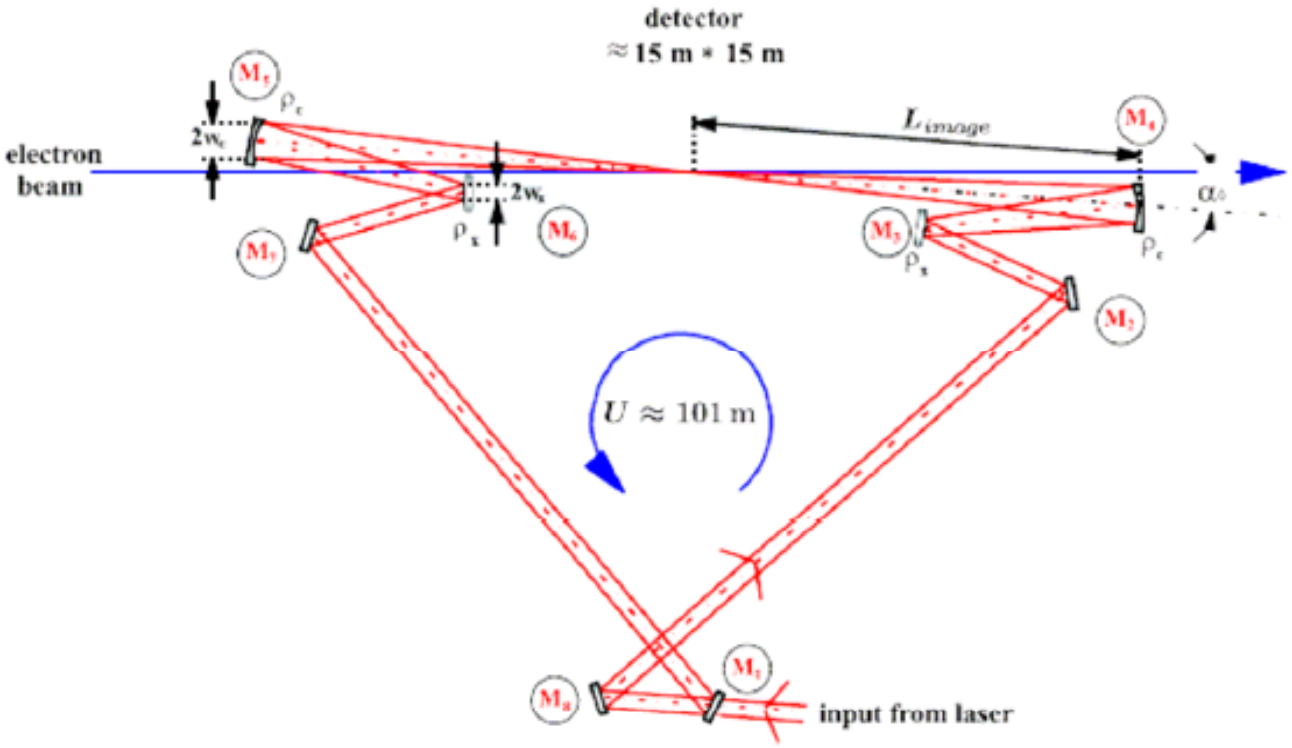
LCW07 DESY

A recirculating cavity can simplify the laser by reducing the required power

Gronberg

Stacking cavity design from MBI / DESY- Zeuthen is designed to reach 9J per bunch



G. Klemz et al.

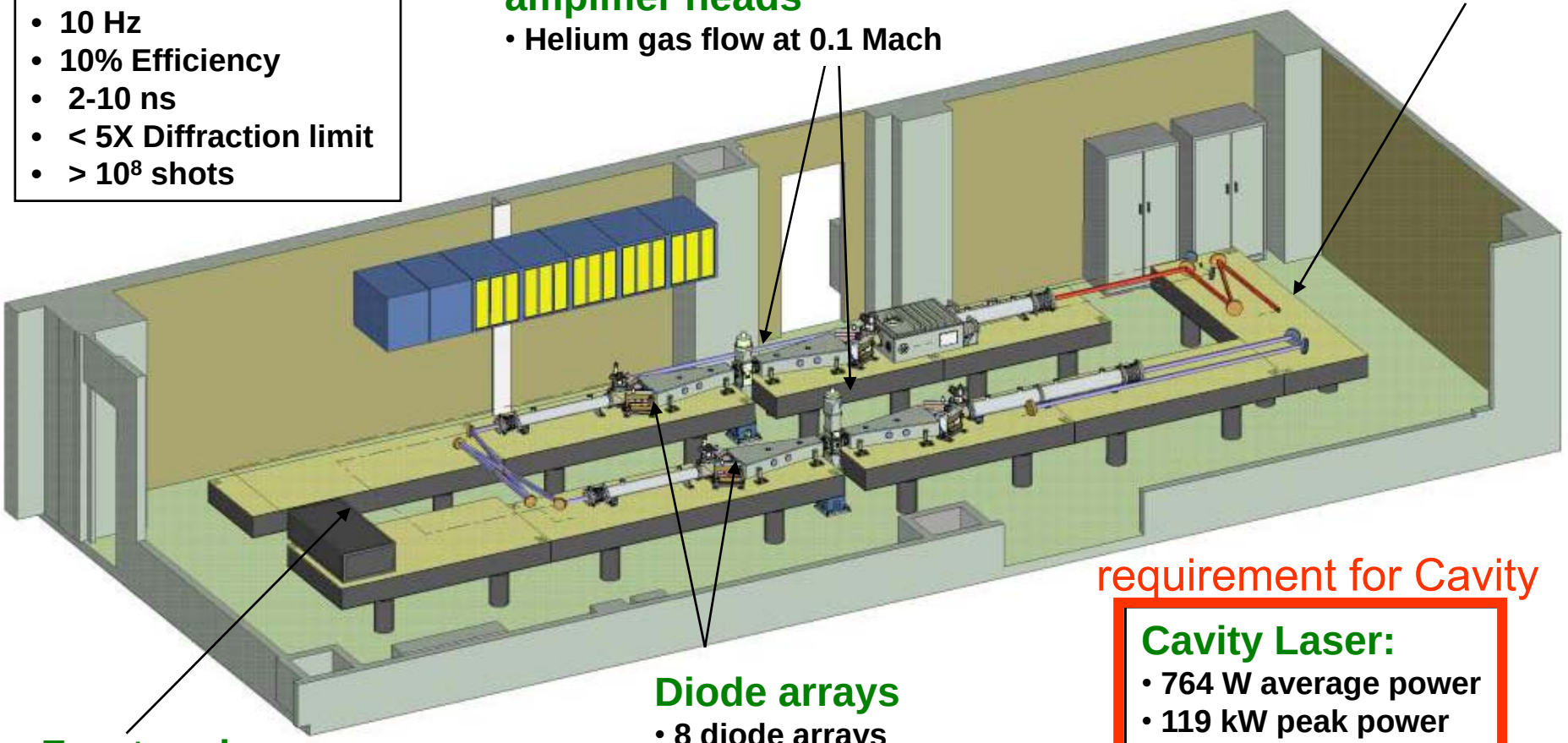
Laser requirements:

- 5 Hz operation
- 1000+2820 bunches / train
- 40mJ / pulse
- 764 W average power
- 119 kW peak diode power

The MERCURY laser already has more average power than we need

Goal:
- **100 J**
- **10 Hz**
- **10% Efficiency**
- **2-10 ns**
- **< 5X Diffraction limit**
- **> 10^8 shots**

Gas-cooled amplifier heads
- **Helium gas flow at 0.1 Mach**



Front-end
- **300 mJ**

Diode arrays
- **8 diode arrays**
- **6624 diodes total**
- **730 kW peak power**

requirement for Cavity

Cavity Laser:
- **764 W average power**
- **119 kW peak power**

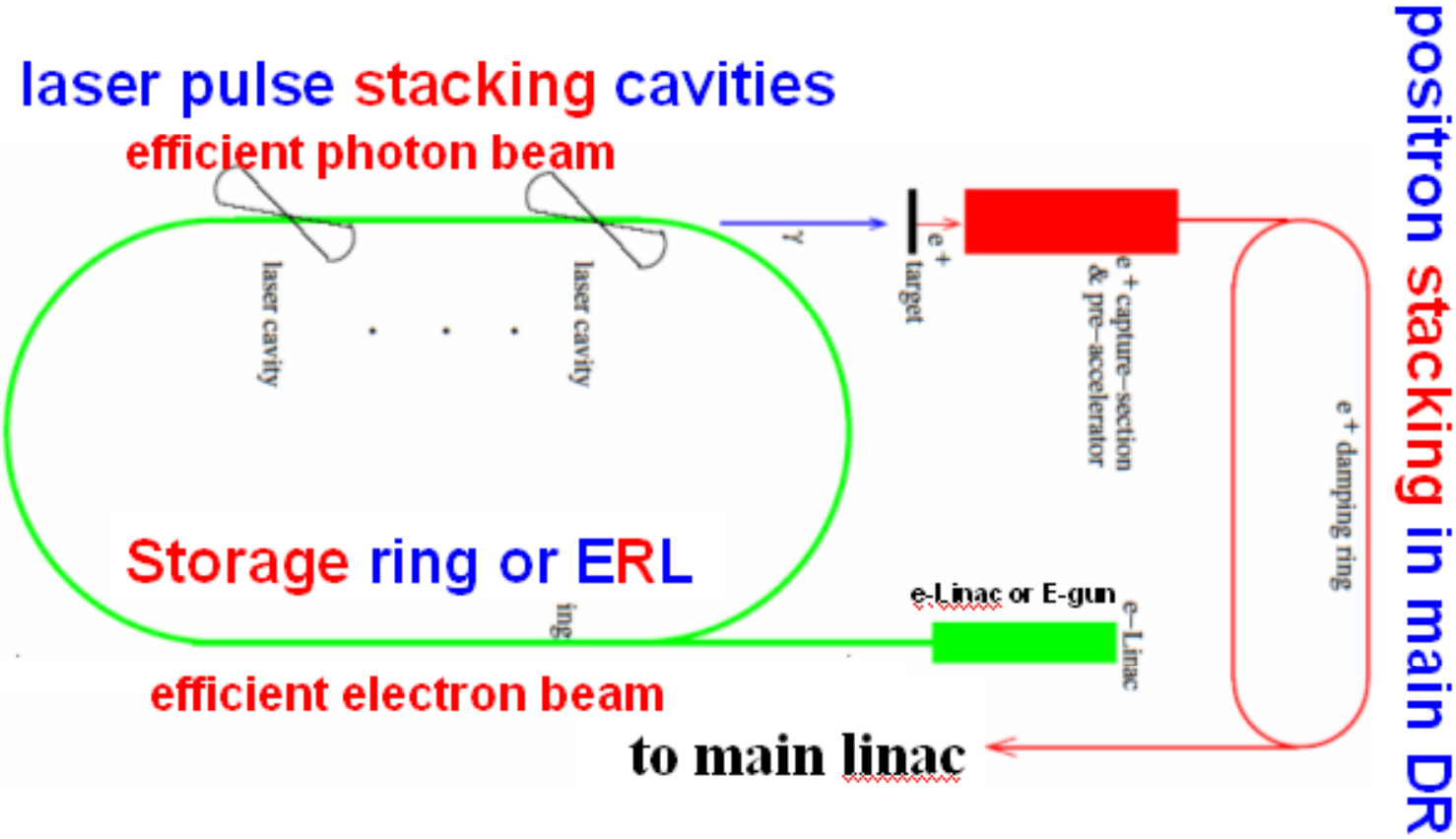
R&D for the Cavity is a Key

- No R&D for Photon Colliders
- Starting with Compton Based PosiPol

Omori
PosiPol2007

Ring/ERL Compton

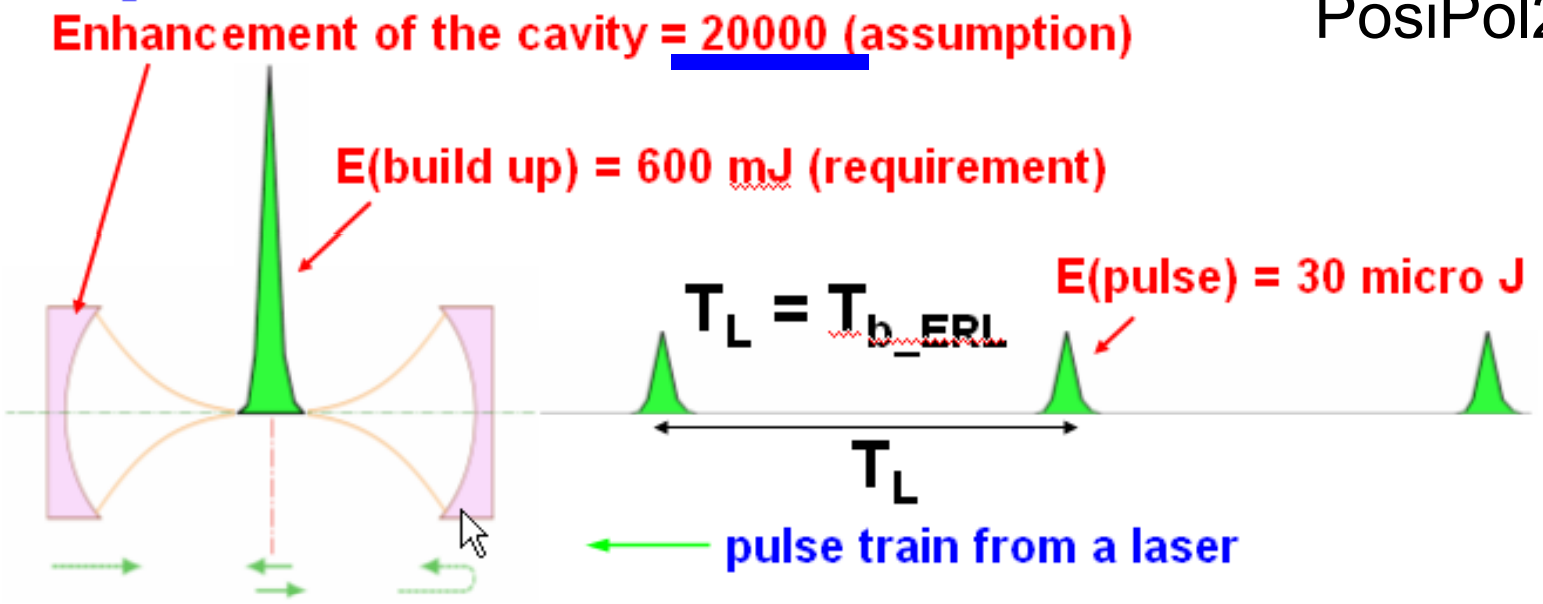
Re-use Concept



Laser and Cavity for PosiPol (some examples)

Requirement to a laser

Omori
PosiPol2007



(a) f_{rep} = 163 MHz ($T_{b\_ERL} = T_L$ = 6.15 ns) Lcav=0.92m

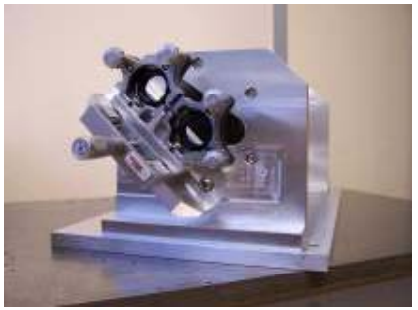
Laser beam power (average) = 4.8 kW

(b) f_{rep} = 40.8 MHz ($T_{b\_ERL} = T_L$ = 24.6 ns) Lcav=3.69m

Laser beam power (average) = 1.2 kW

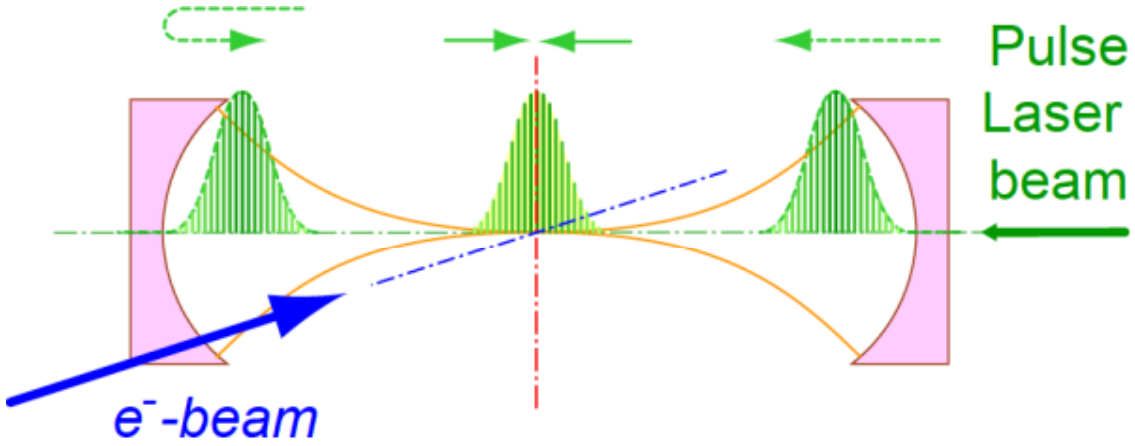
Easier, But, Difference exists only in average power.

Two Major R&D for cavities

	KEK	LAL
		
type	2 mirrors FP	4 mirrors ring
enhancement	1000	10000
Laser spot size	30μm	15μm
Feed back	Analog PID	digital
e-	at ATF, to get experiences with e-beam	stand alone (new w/ e- beam being designed. to be at ATF?)

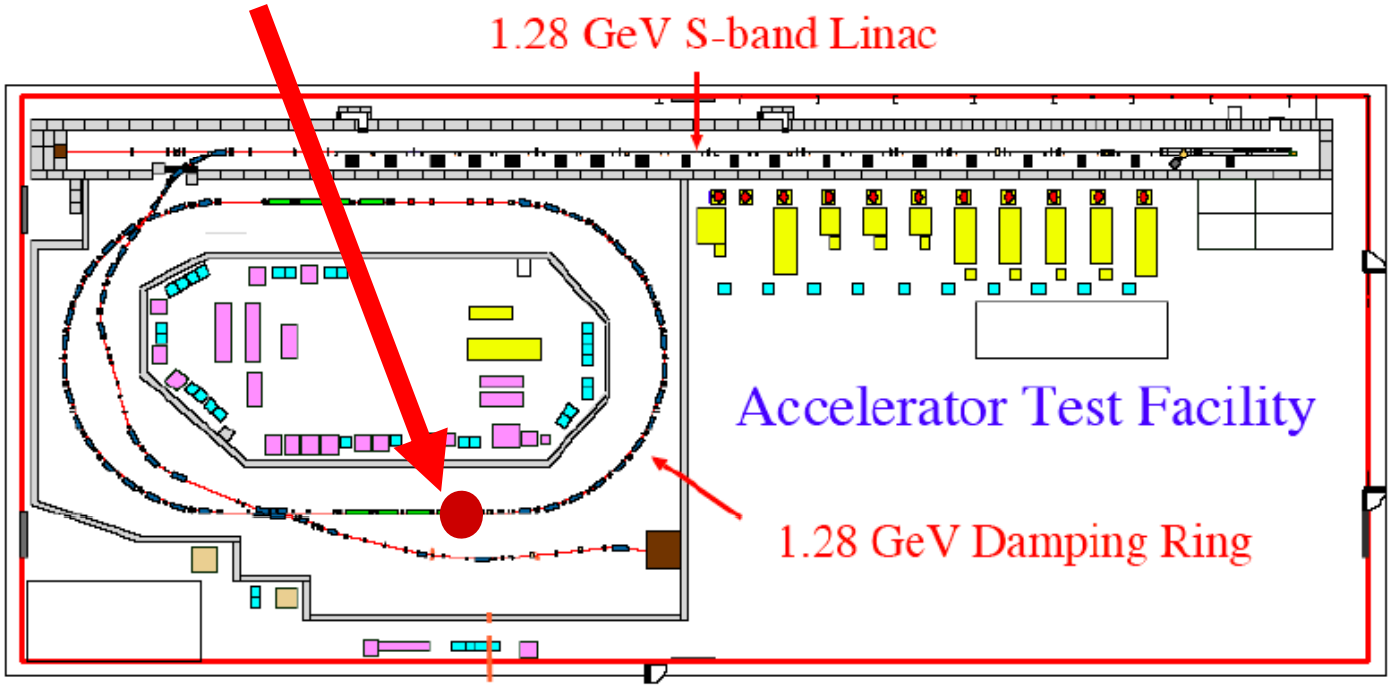
Experimental R/D at ATF

Hiroshima-LAL-IPN-CERN-Kyoto-Waseda-KEK



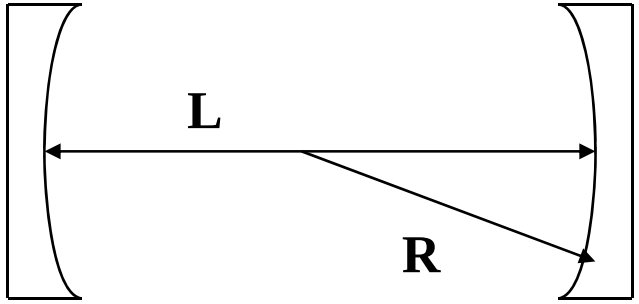
- 2 mirror FP
- L_{cav} = 420 mm for 2.8ns bunch spacing

ATF at KEK



Laser stacking cavity with Two Spherical Mirrors

Choice of R and spot size

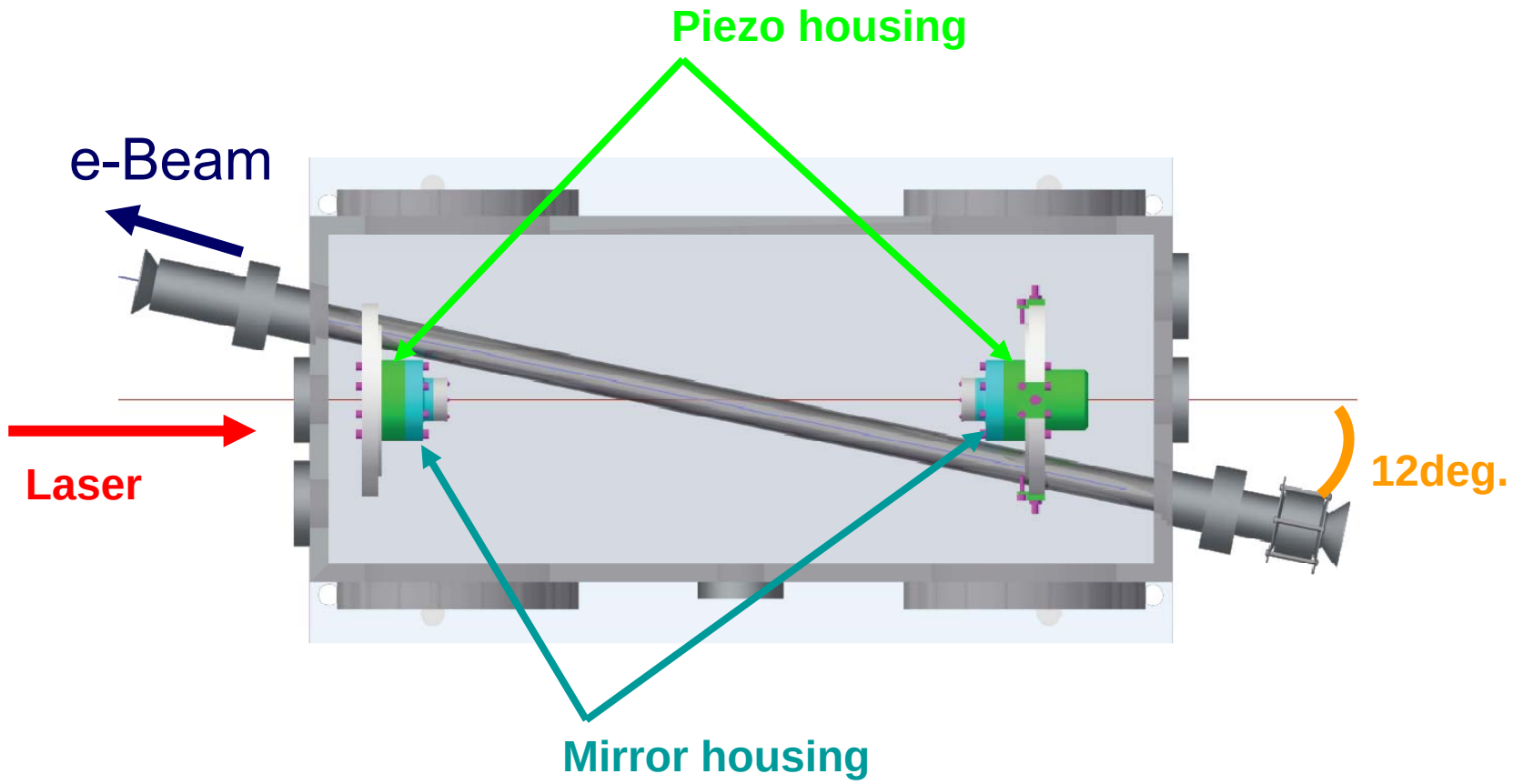


L = 420.00 mm

our choice for
1st prototype

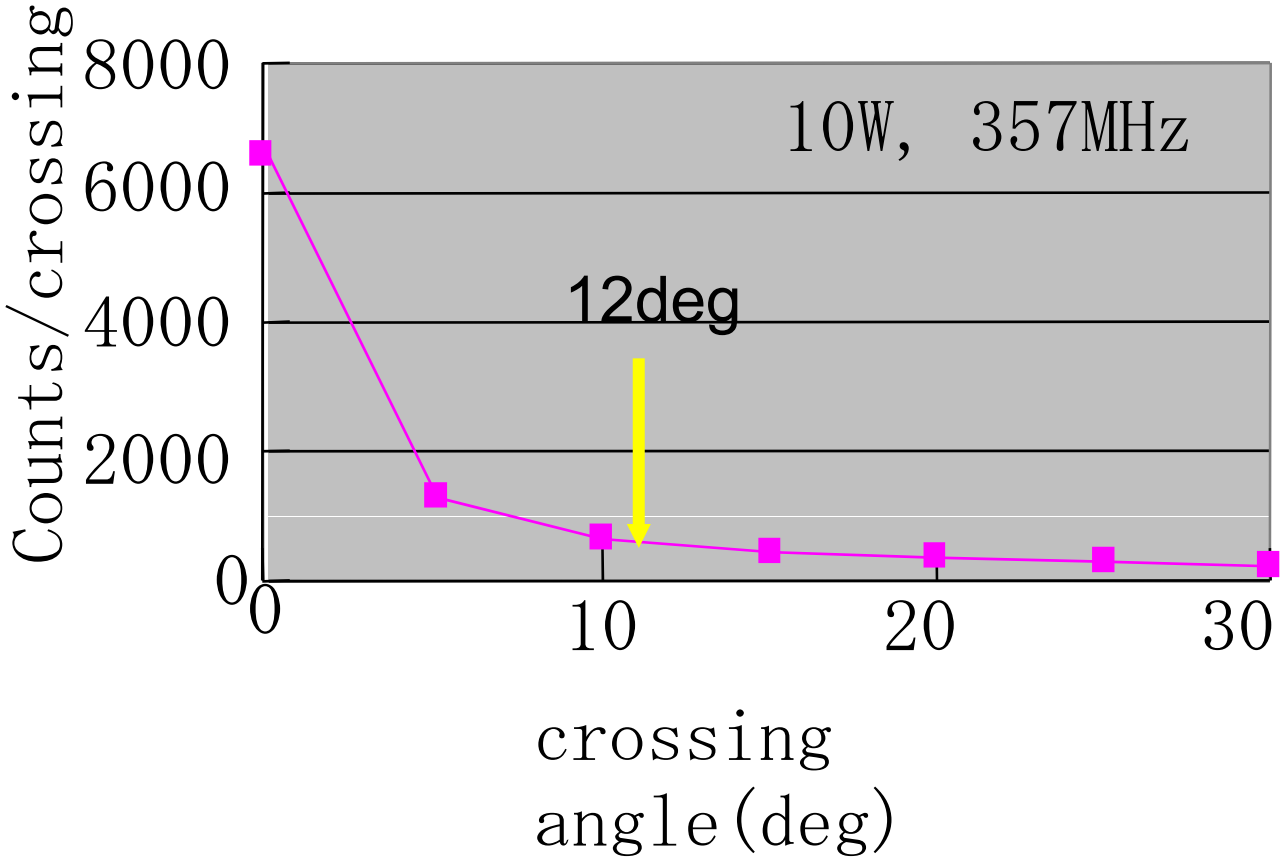
Mirror R (mm)	rms laser spot size (micron)
250	88
211	35
210.5	30
210.1	20
210.01	11
210.001	6

Schematic of the cavity



smaller crossing angle is preferred but is 12 deg
to accommodatemirrors etc.

Number of γ expected



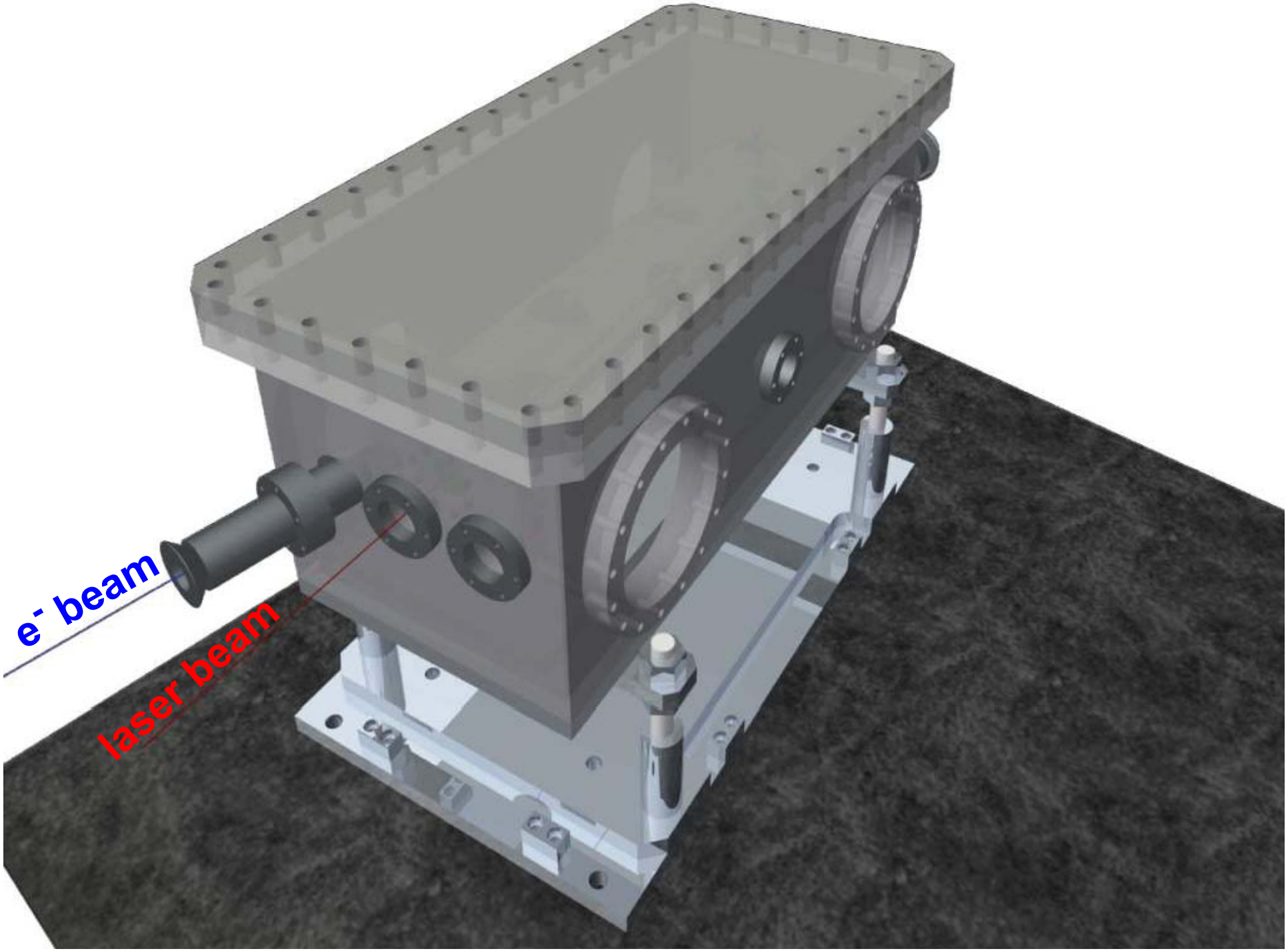
ATF

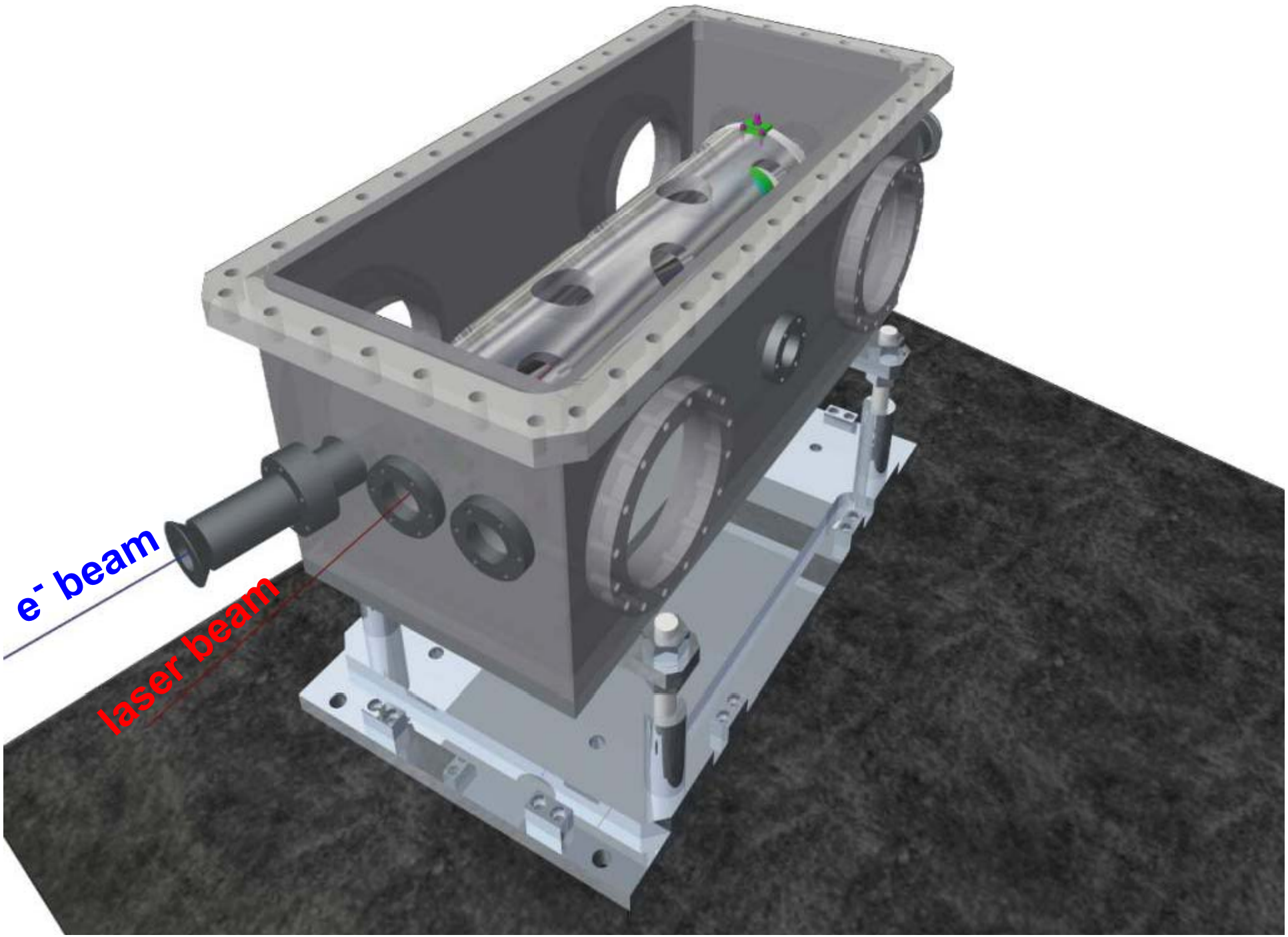
e^- bench length = 9 mm (rms)

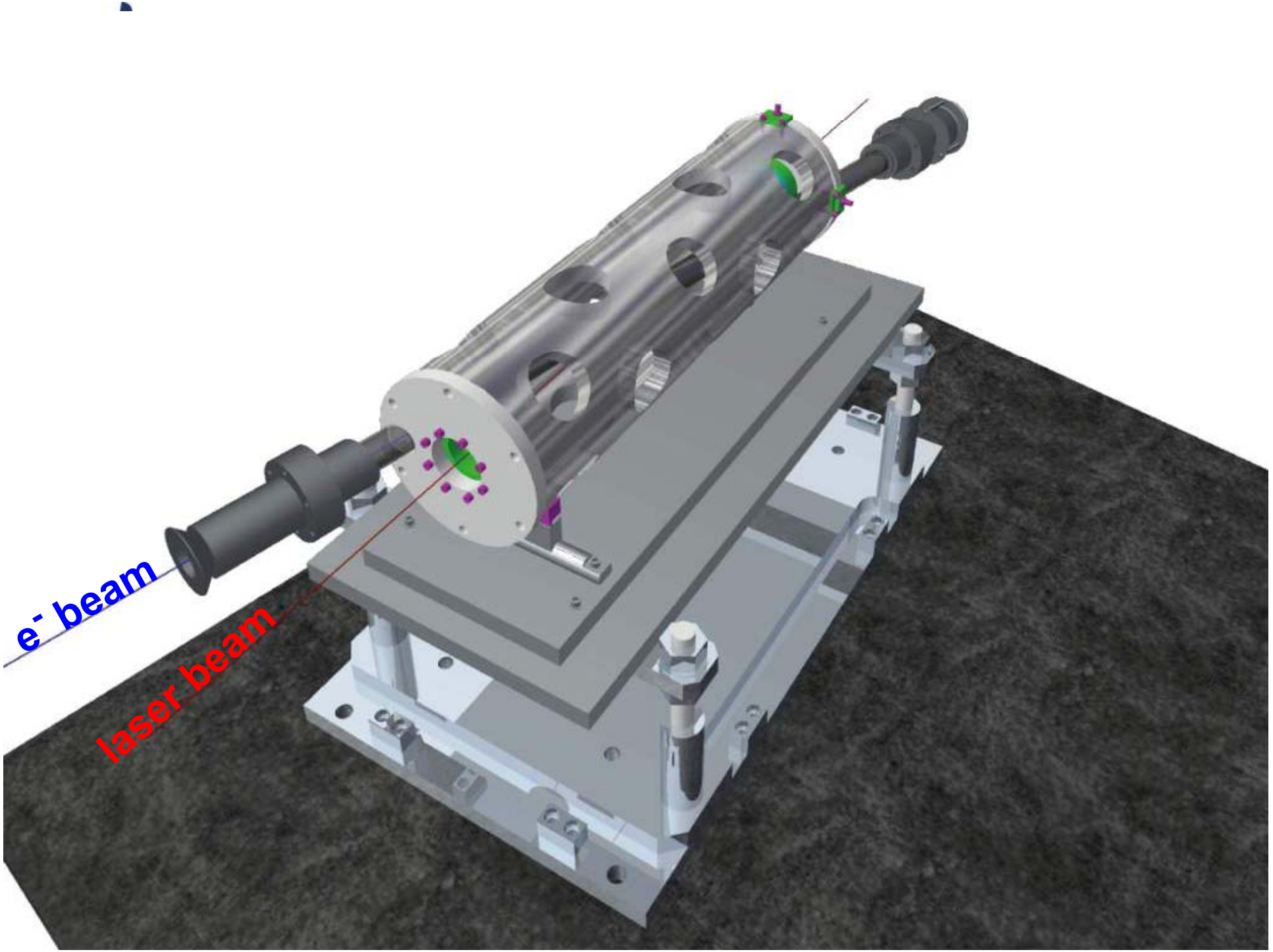
Ne = $2x10^{10}$/bunch

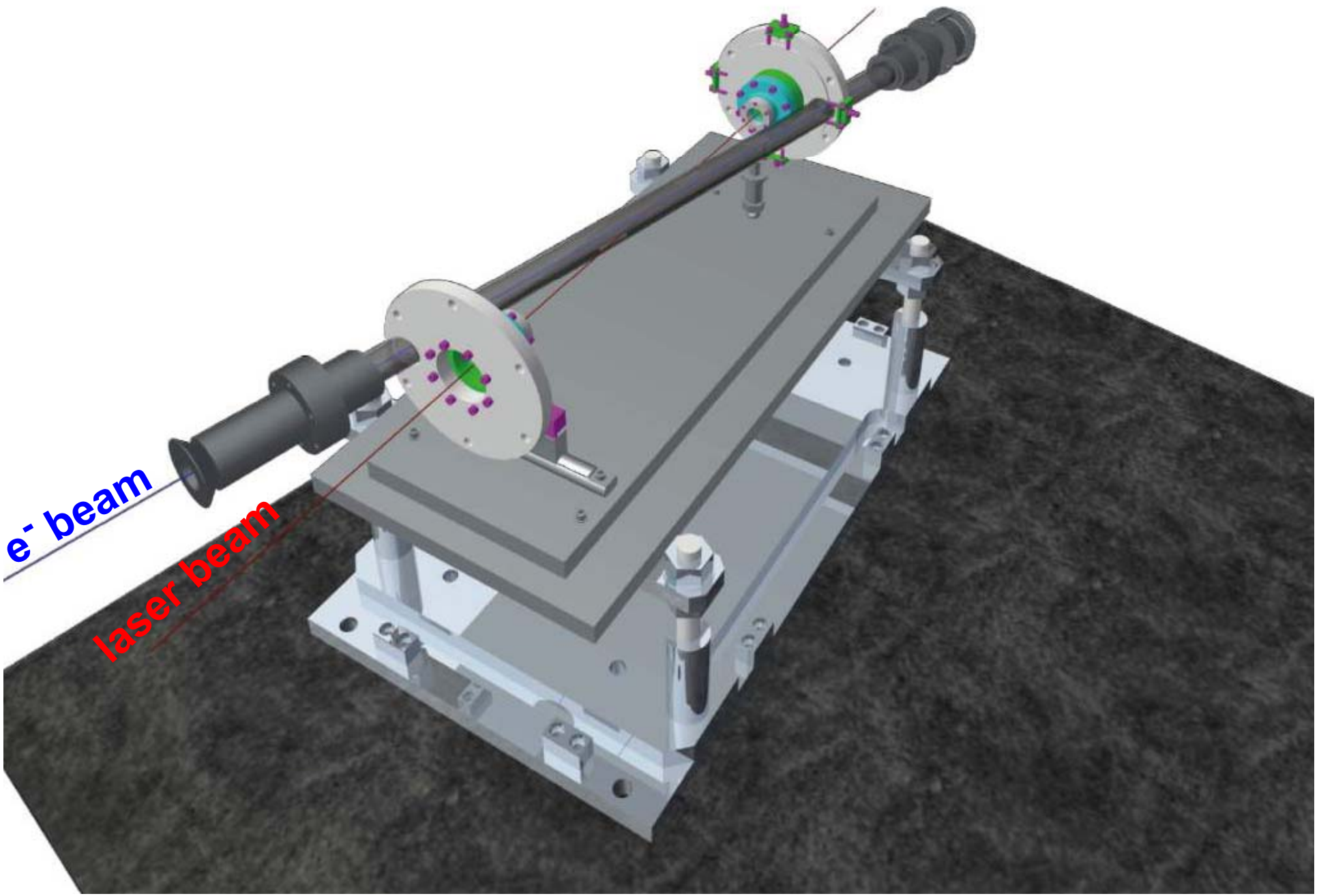
~1000/bunch xing

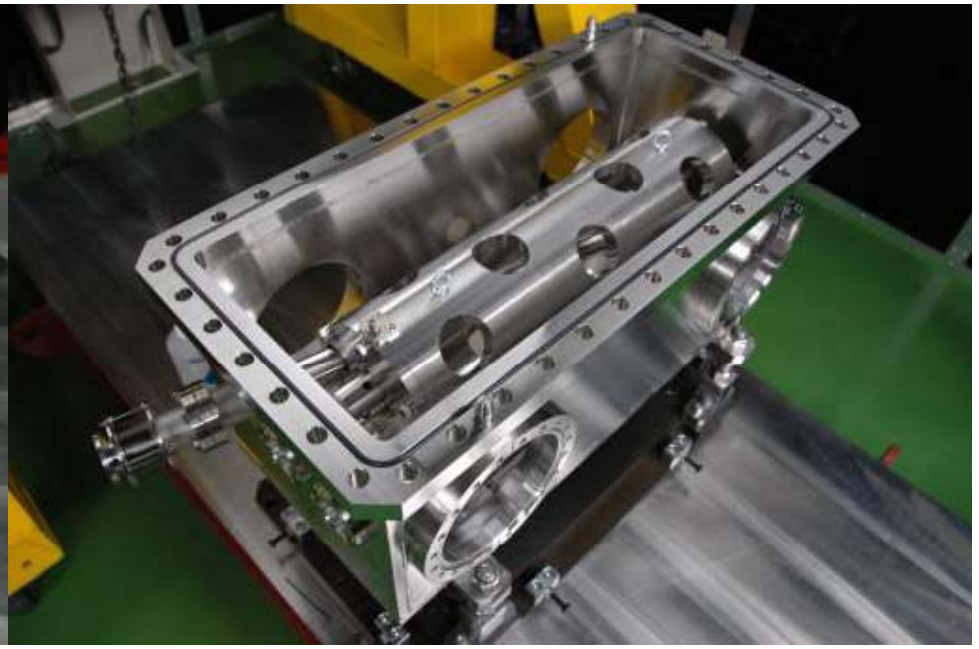
~ $7x10^{10}$/sec for multi-bunch operation (20bunch X 3 /sec

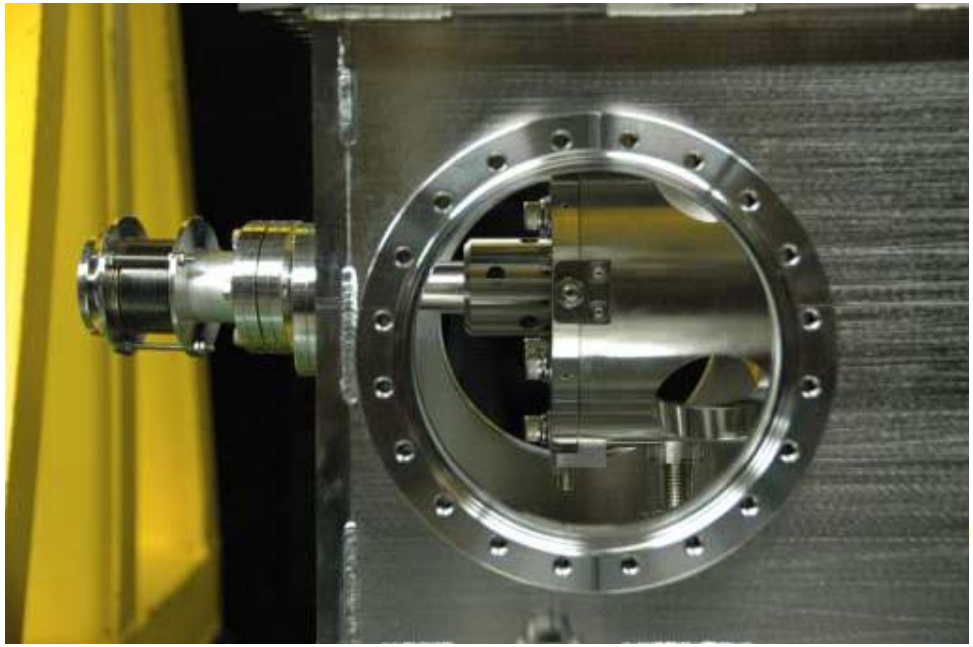

e- beam
laser beam


e- beam
laser beam


e- beam
laser beam

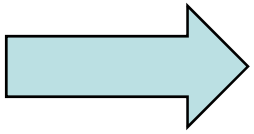

e- beam
laser beam





Stauts

- Components
  - **Cavity, Vacuum Chamber, Laser**



all delivered

  - **being tested at off site**
    - finness of 1000 achieved with CW laser
    - ~200 with pulse laser
    - spot size ~30μm achived
  - **feedback system studied and tested**
- Will be installed in the ATF ring coming summer

Future plan?

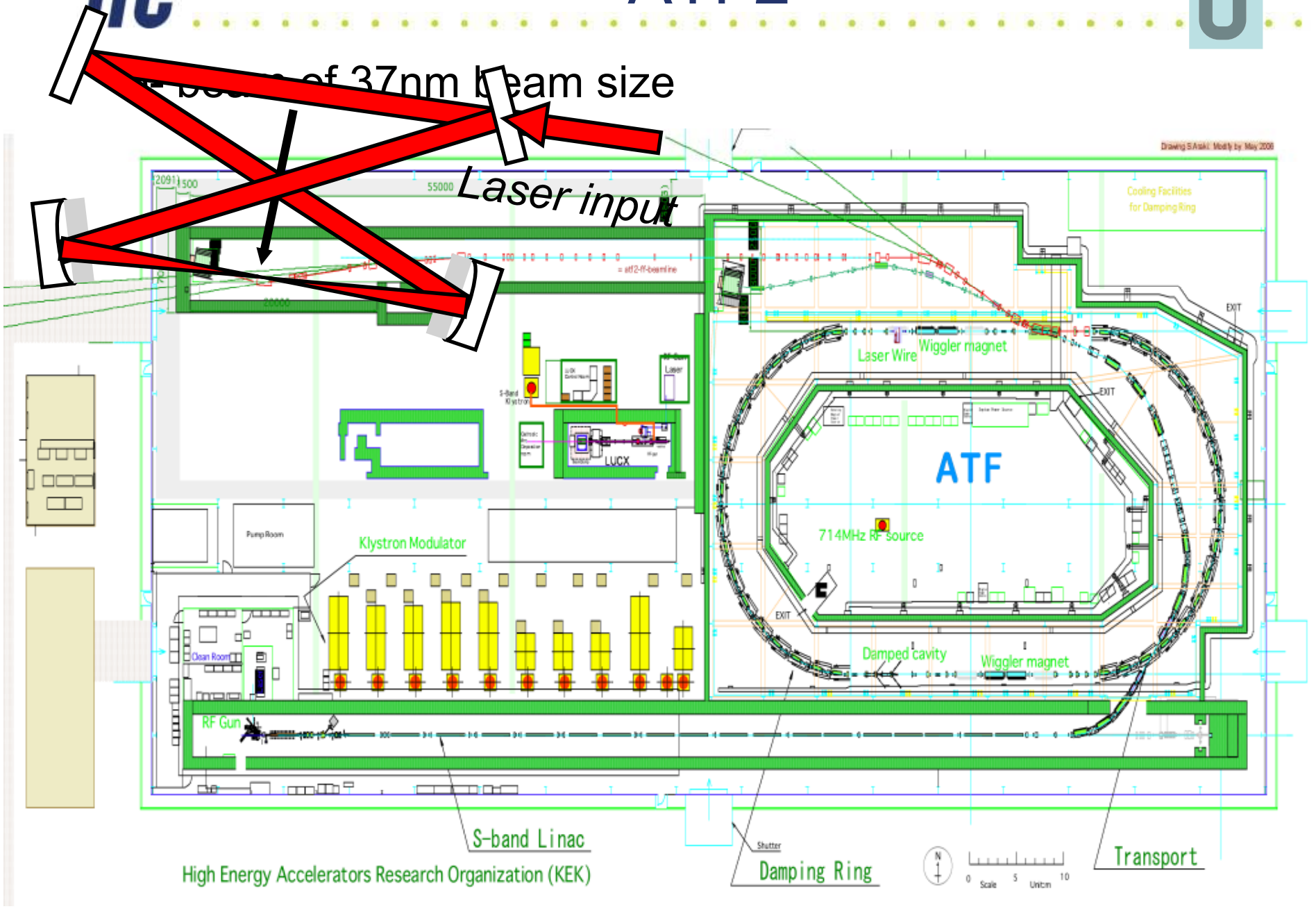
1. Stay with PosiPol R&D,,,,,
   - **4 mirror cavity is planned**
   - **if PosiPol choose 40MHz ring scheme,**
   - **it is(,3.6m ring cavity) a good step toward large cavity**
2. High Power cavity?
   - **PosiPol 600mJ ←→ PLC ~10J**
   - **test at ATF2 beam line2**
3. Large scale prototype?

need dedicated R&D for photon collider

Summary

- Pulse Stacking cavity w/ ATF beam is under way
  - **it is a good chance to accumulate experiences for laser technology**
- more to learn from PosiPol collaboration
- however
  - **need to setup R&D program dedicated to photon colliders**
    - high power
    - larger cavity
    - w/ detector

ATF2

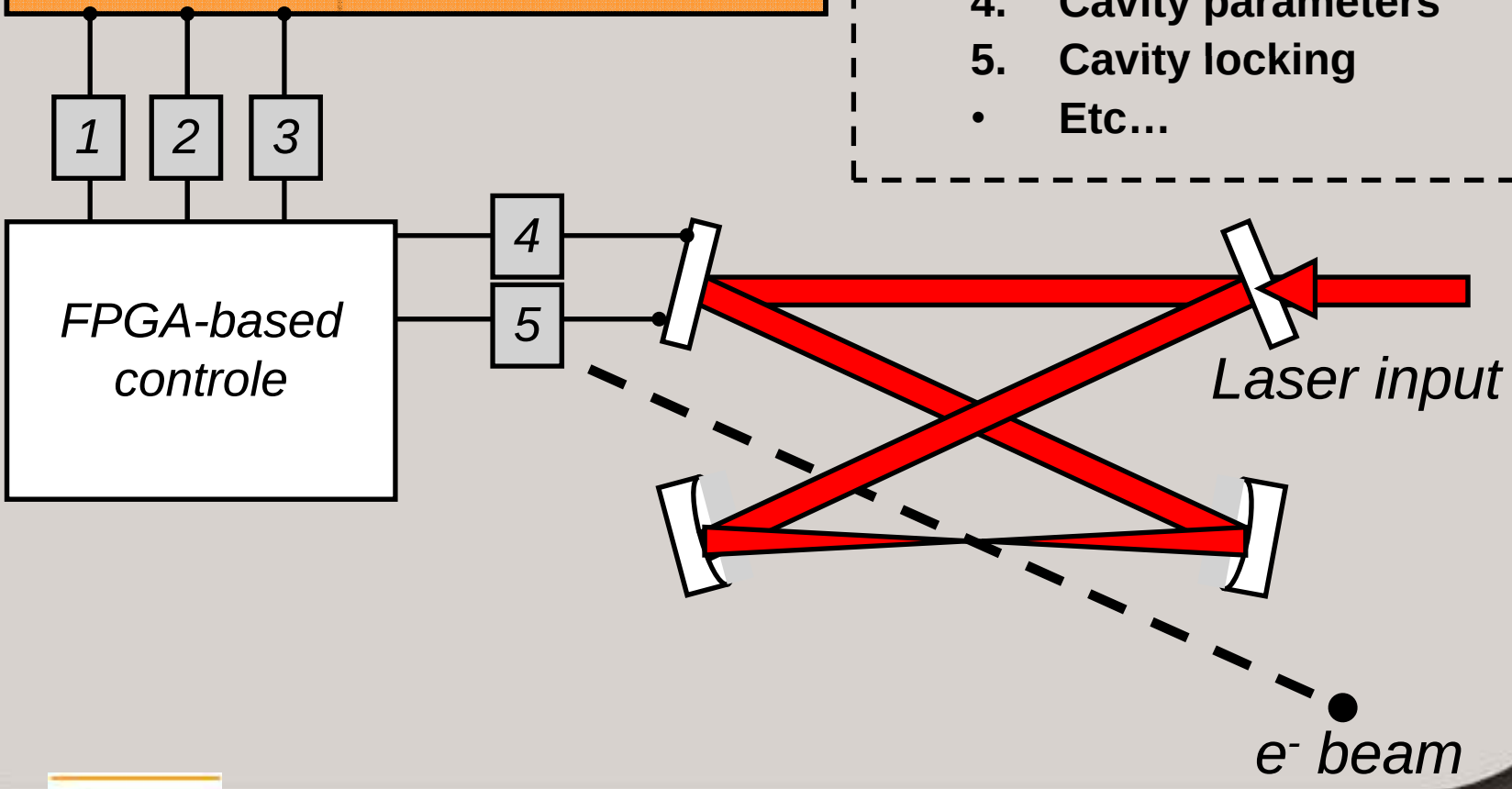

of 37nm beam size
Laser input
Cooling Facilities for Damping Ring
Laser Wire
Wiggler magnet
EXIT
ATF
714MHz RF source
Damped cavity
Wiggler magnet
Klystron Modulator
Pump Room
Clean Room
RF Gun
LUCX
S-band Linac
High Energy Accelerators Research Organization (KEK)
Shutter
Damping Ring
Transport

ANR LAL / Amplitude Systemes

Zaouter
PosiPOL2007

Laser system designed by Amplitude Systemes

- **FPGA control**
  1. **Laser intensity**
  2. **Laser frequency**
  3. **Laser phase**
  4. **Cavity parameters**
  5. **Cavity locking**
  - **Etc…**



Conclusion

- **Presented the best performances to date**
  - High power fibre-CPA
  - High energy fibre-CPA
- **Design of the project submitted to ANR**
  - Very high power 1-ps amplifier with a synchro-locked laser seed
  - Non-planar FP-cavity
  - FPGA global control of the experiment
- **Installation at KEK / ATF**
  - Production of polarized positrons

R&D Report in ATF

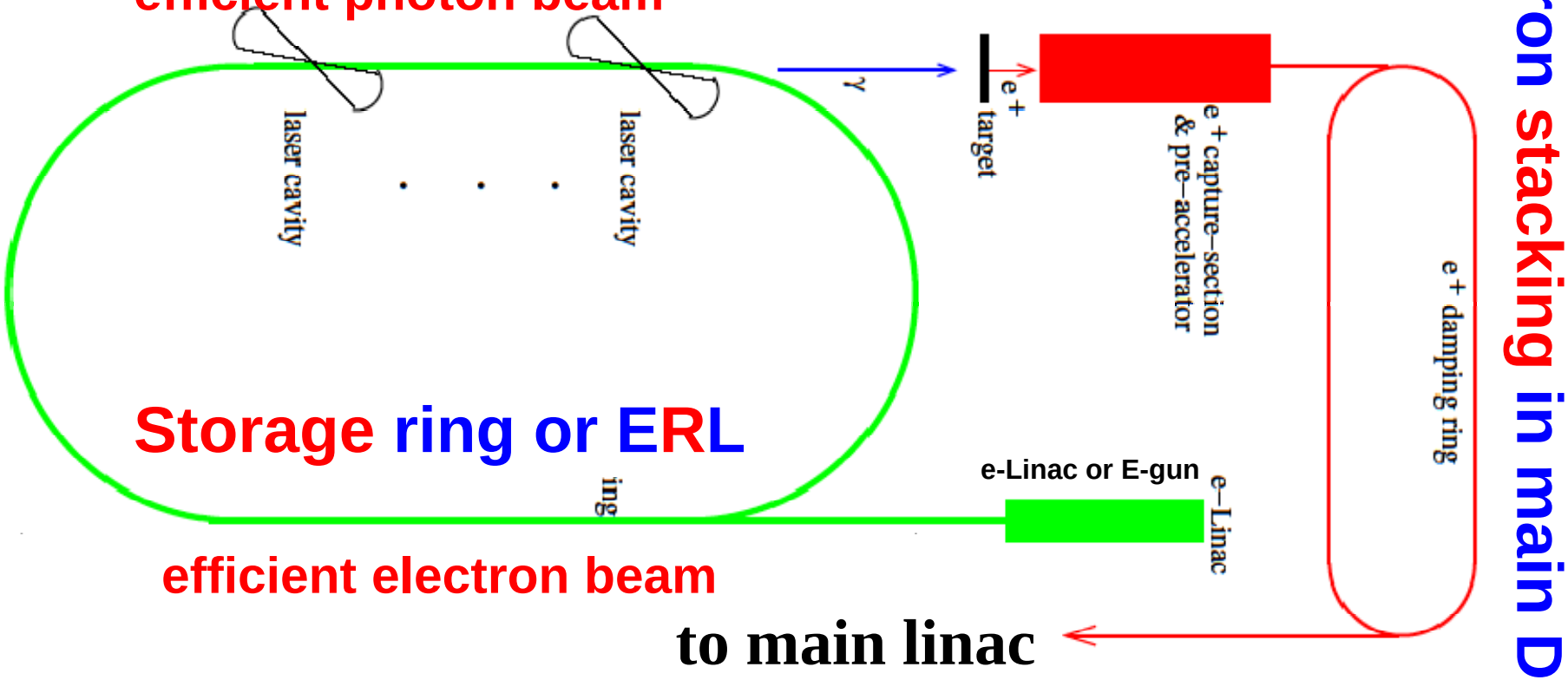
Laser Section	
Type	YAG-VAN (1064nm)
Power	10 W
Frequency	357 MHz
Pulse Width	10 ps
Cavity Section	
Length	420 mm
Mirror Reflection Rate	99.7 %
Beam Waist	30 μm (in σ)
Crossing Angle	12 degree

Ring/ERL Compton

Re-use Concept

laser pulse stacking cavities

efficient photon beam



efficient electron beam

to main linac

positron stacking in main DR