IR Vacuum Systems Update

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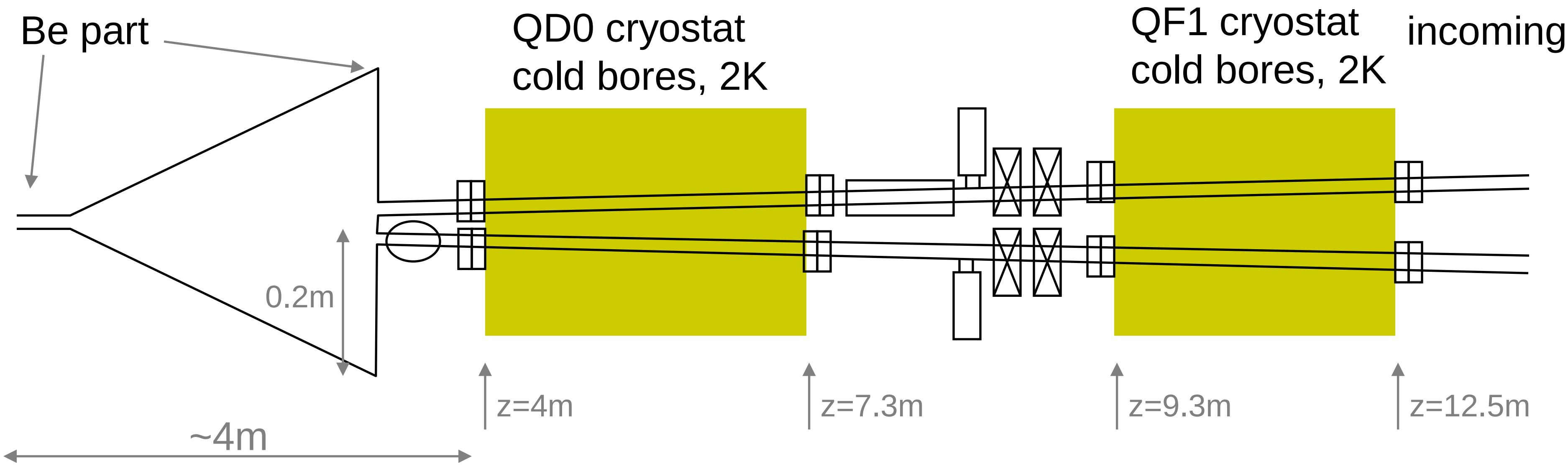
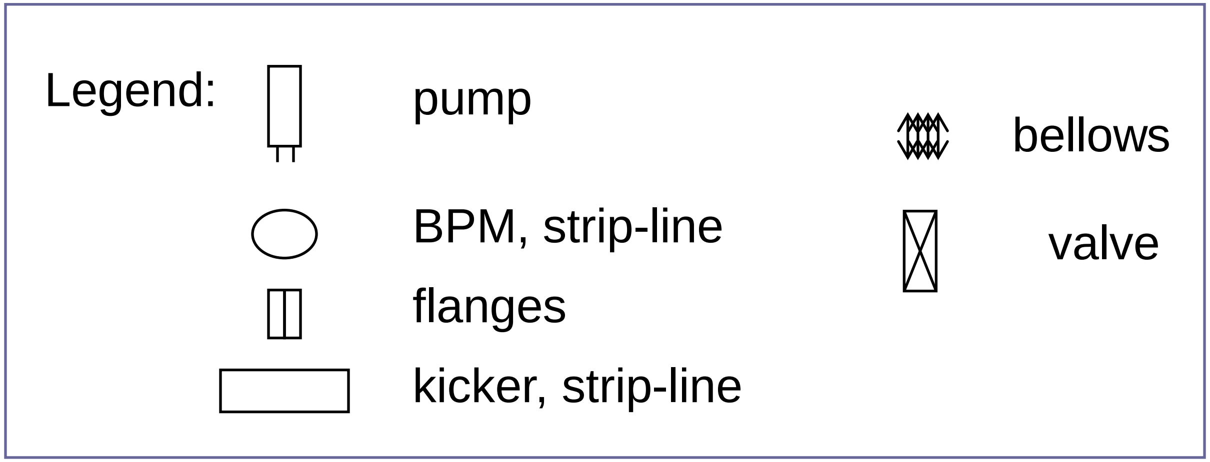
Task

- Possible pumping schemes to provide the required vacuum
  - Required vacuum (Maruyama):
    - 10^{-8} Torr at RT => $3.2 \cdot 10^{14}$ molecules/m^3
- Gas composition
- Ion induced pressure instability

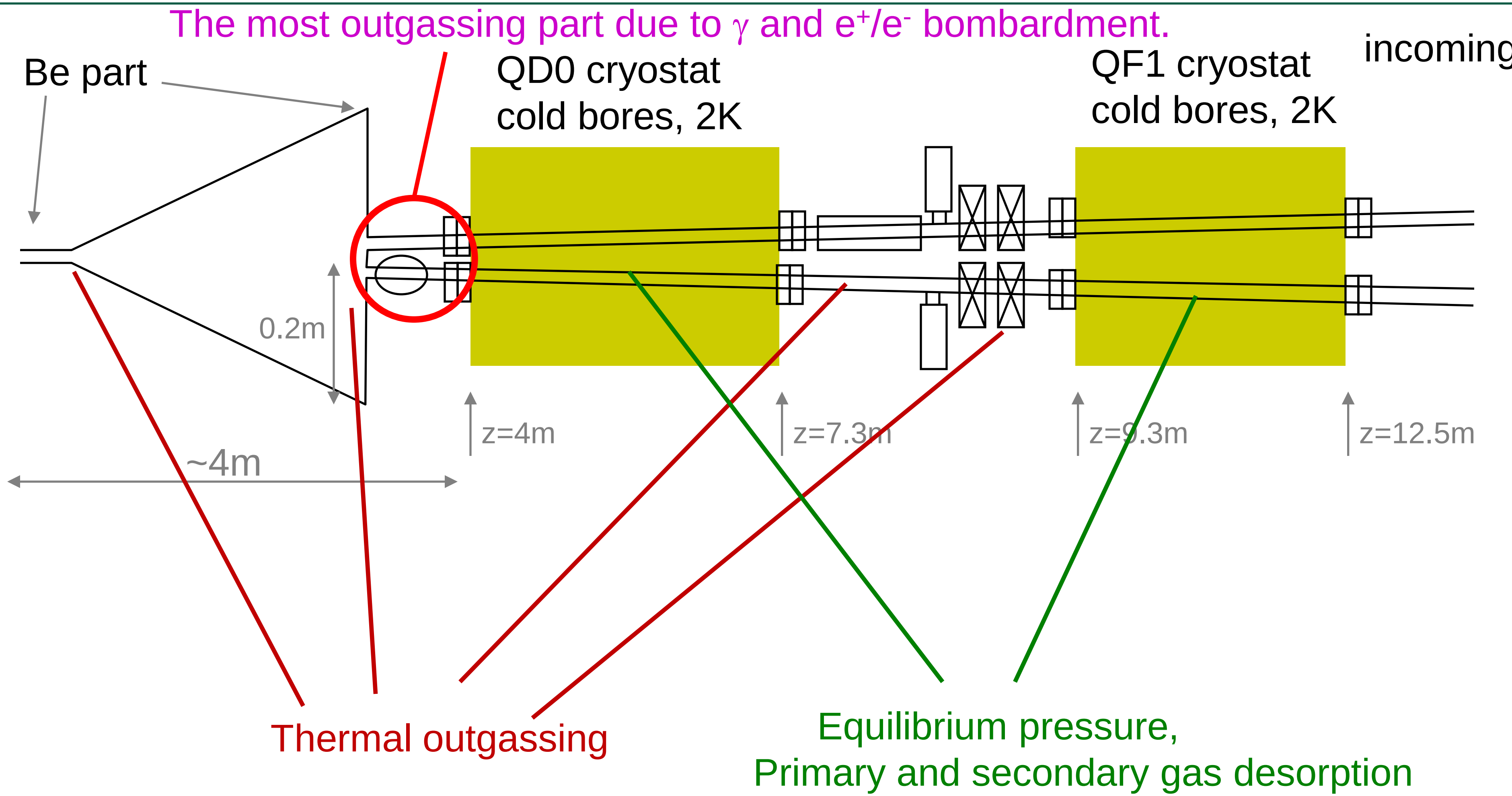
IR layout





Layout sketched by A. Seryi

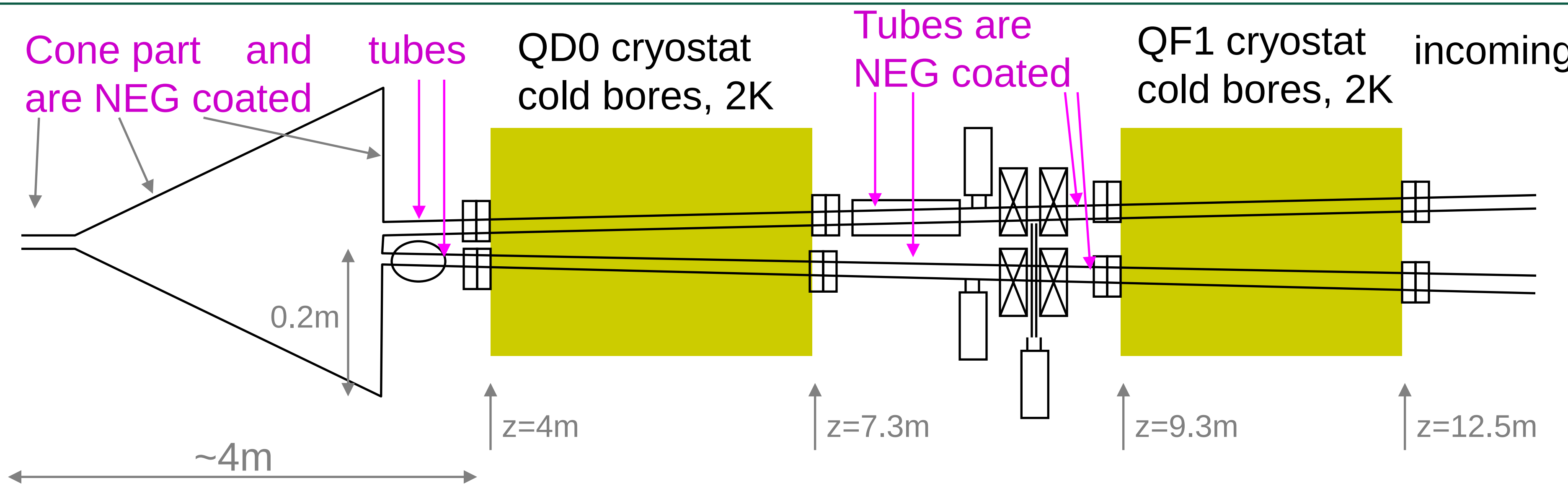
Outgassing

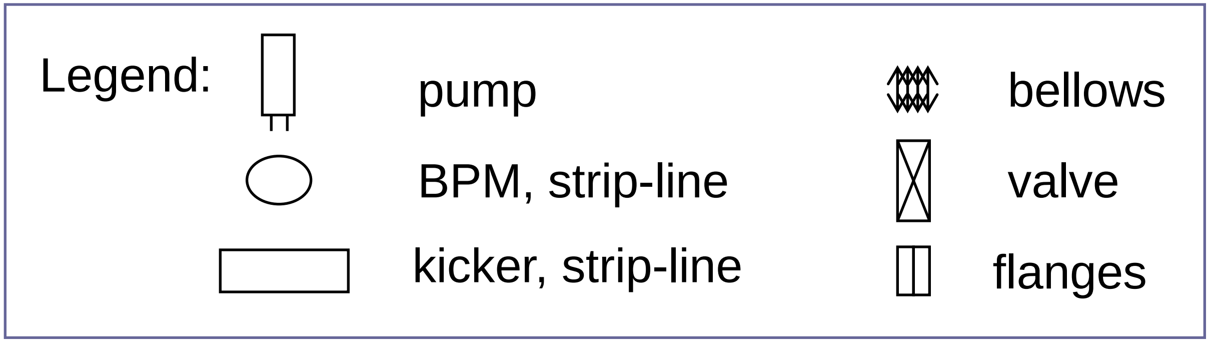

The most outgassing part due to γ and e+/e- bombardment.
Be part
QD0 cryostat
cold bores, 2K
QF1 cryostat
cold bores, 2K
incoming
0.2m
~4m
z=4m
z=7.3m
z=9.3m
z=12.5m
Thermal outgassing
Equilibrium pressure,
Primary and secondary gas desorption

What was done in past

- Number of technical solutions were discussed at IRENG07 on 17th – 19th September 2007.
  - Y. Suetsugu (KEK): A Basic Design of IR Vacuum system
  - O. Malyshev (ASTeC): IR Vacuum Systems (First thoughts)
- WebEx meeting on 2nd October 2009
- The suggested solutions has questions to the detector design people

Possible solutions: solution 1



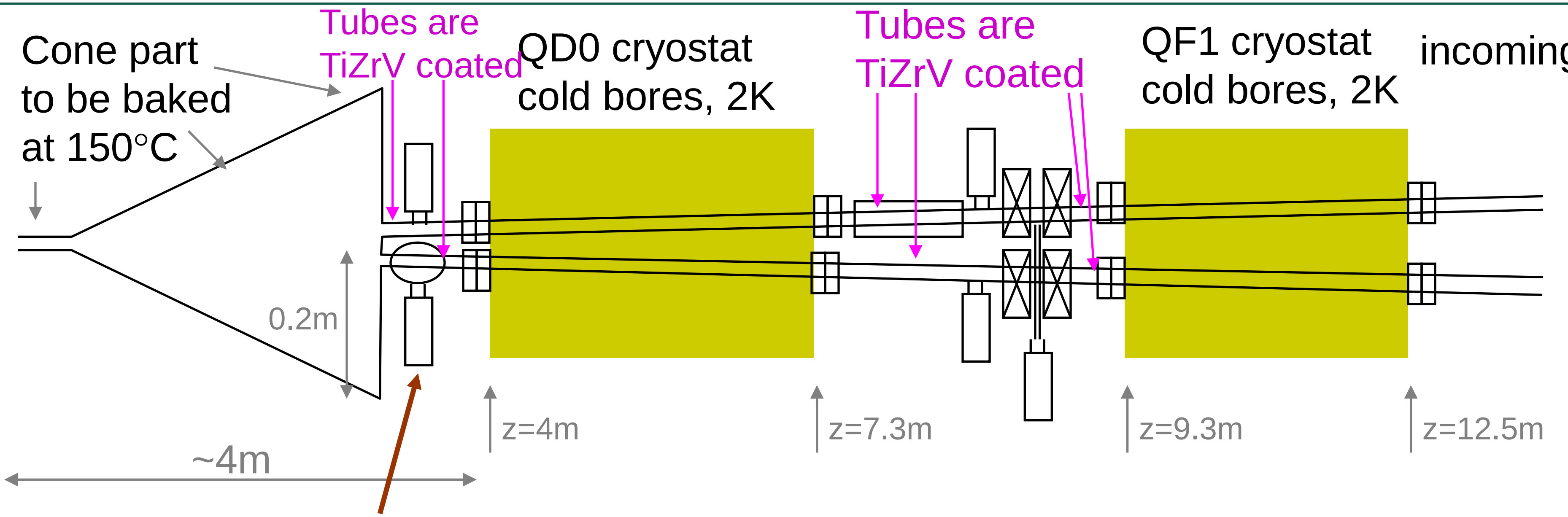


A new 1-μm thick NEG coating developed at ASTeC can be activated at 150°C

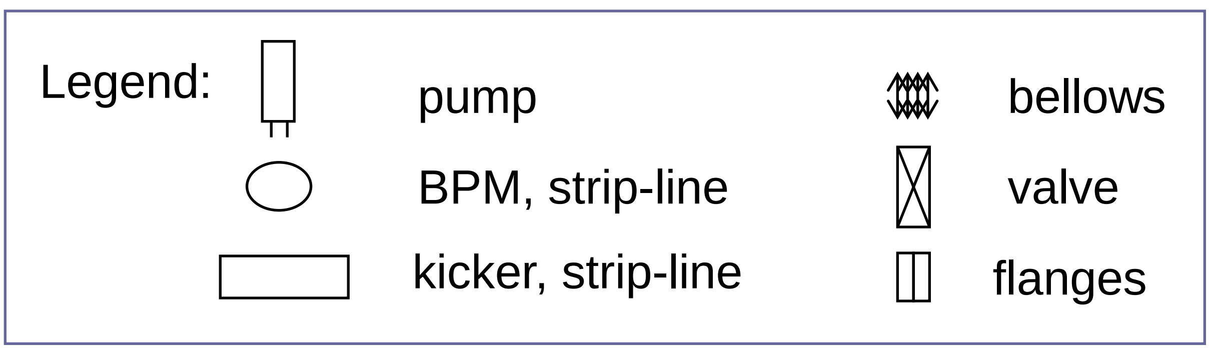
Dominant gases:

H_2 and CH_4

Possible solutions: solution 2



Pumps connected to the tubes close to the cone



Dominant gases: H_2 , CO and CH_4

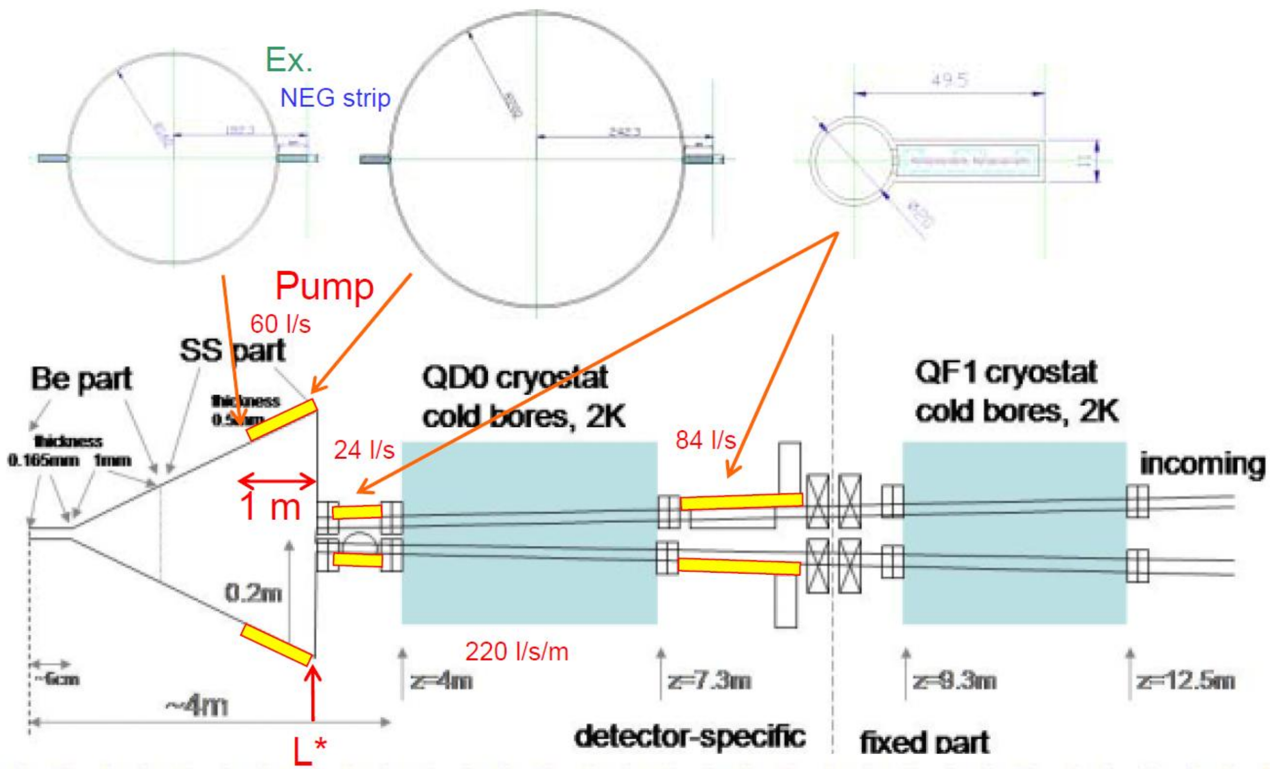
Problems (or questions) for solutions 1 and 2

- Is bakeout to 150°C *in-situ* is possible?
  - ASTeC NEG coating can be activated at 150°C
  - Uncoated parts - to remove water and reduce outgassing
- What is maximum tolerable bakeout temperature?
- What available gap for bakeout tapes.
  - Possible solution is a thin bakeout coating developed at ASTeC on outer part of vacuum vessel.
    - 0.2-mm thick
    - Self regulated power output (‘programmed’ to selected highest temperature)
    - Can be optimised to AC (6-240V) or DC (6-12-24 V) power supply

Possible solutions: solution 3 (no bakeout) – Y. Suetsugu

Pump system_6

- For example, NEG pumps at the last 1 m of cone



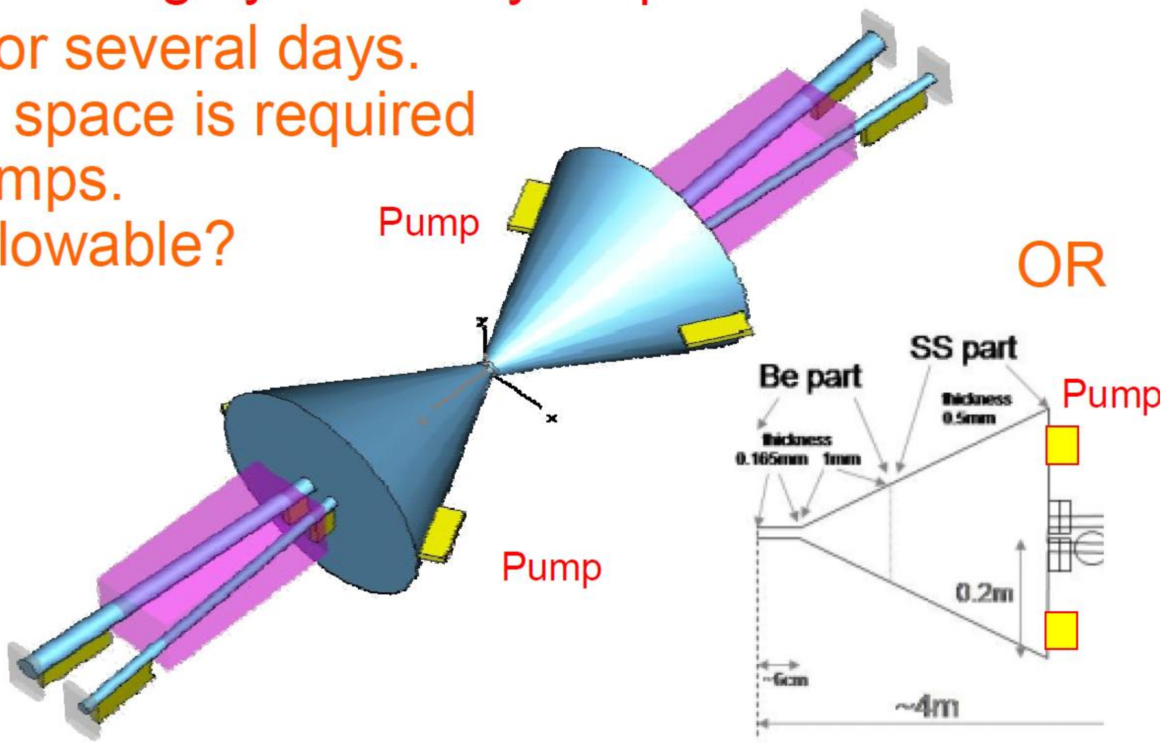
2007/09/17-21 SLAC **IRENG07** 11

Problems (or questions) for solutions 3 – Y. Suetsugu

ilc

Pump system_9

- If some pumps (~120 *l*/s) is prepared at cone, no *in-situ* baking system may be possible.
- Wait for several days.
- Some space is required for pumps.
- Is it allowable?

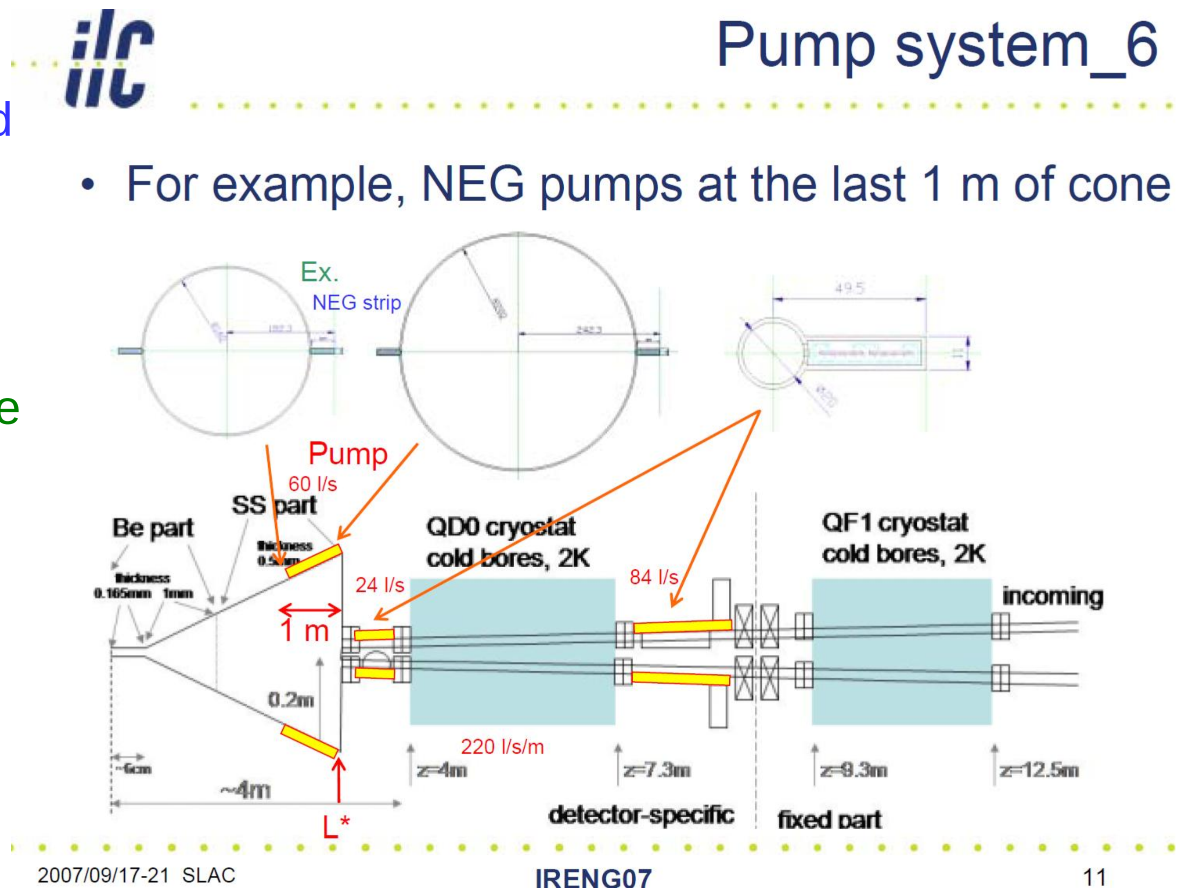


Possible solutions: solution 4 (no bakeout) – CERN

Same as solution 3 but a **sputter ion pump** in the detector solenoid field in stead of NEG strips.

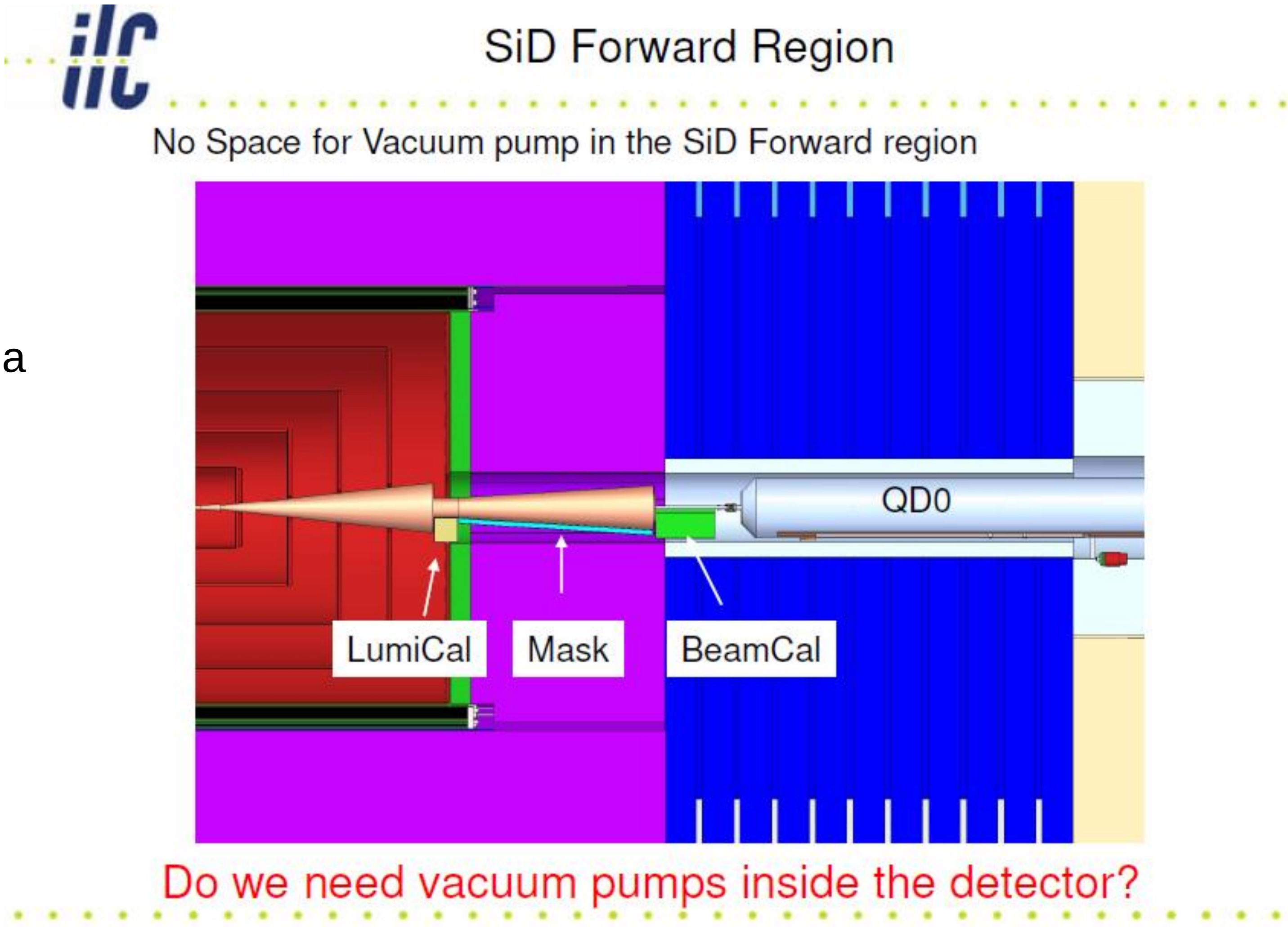
Advantages:
- pumps all gases while NEG does not pump C_xH_y and noble gases

Disadvantage:
- does not work then solenoid is off
- has to be designed



No space for a pump - What about NEG coating?

A slide from
a previous talk
by Dr. Maruyama



Other possibilities

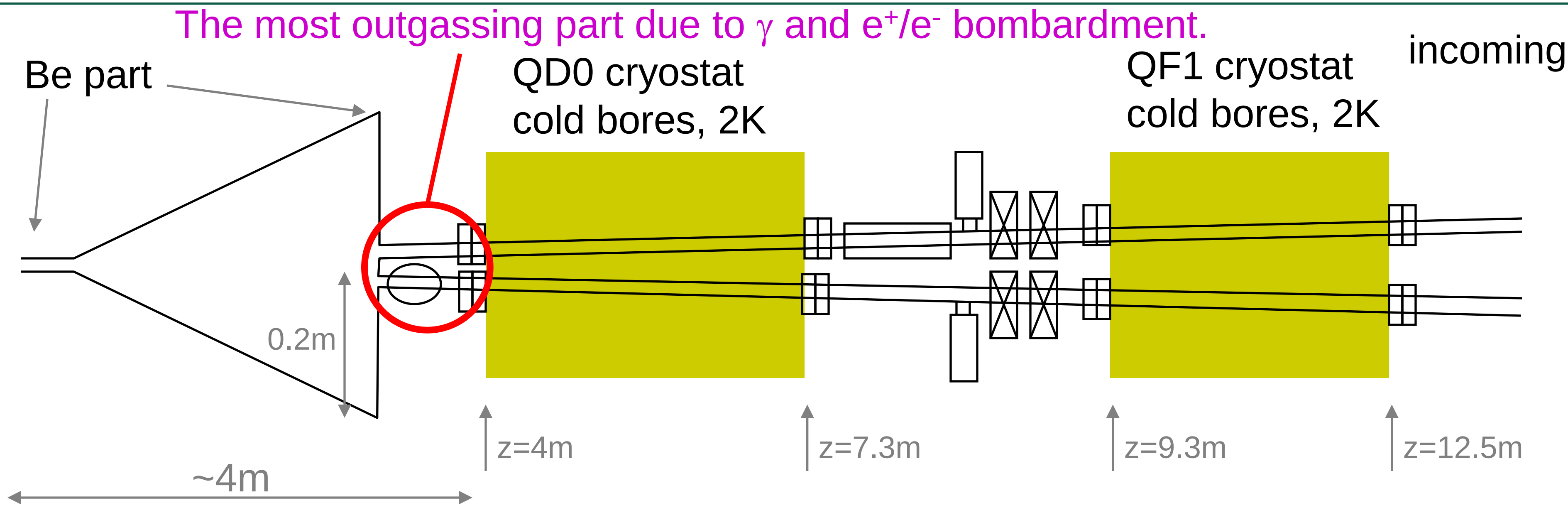
- *Low outgassing coating, ex: Ti, Au, etc.*
    -
- *Ex-situ* bakeout/activation
    - It could be quite efficient when
        - Either no went to air (like at SLS in Switzerland)
        - Or short (5-10 min.) went (filling with dry N_2) quick assembly and pump down (like at DLS in UK)

Assumption for gas density calculation

- Ougassing a week after bakeout **(used for TPMC calculation on the following slide)**:
  - H_2: 10^{-11} mbar·l/(s·cm^2)
  - CO: 10^{-12} mbar·l/(s·cm^2)

- Without bakeout after a week pumping (Suetsugu):
  - H_2: $2\cdot10^{-10}$ mbar·l/(s·cm^2)
  - CO: $2\cdot10^{-11}$ mbar·l/(s·cm^2)

Tube between cone and QD0



Photon and e^+/e^- stimulated desorption:

The 'critical' energy of photon near IR is ε_c ~ 0.5 MeV.

Photon flux Γ=~$7\cdot10^{10}$ γ/(s·m) (calculated by Dr. Takashi Maruyama)

- Estimated pressure raise due to photon stimulated desorption is much larger than thermal:
  - $P(H_2) = 1.5\cdot10^{-8}$ Torr; $P(CO) = 3\cdot10^{-9}$ Torr
- e^+/e^- flux 10 particle/s (per metre or what?)
- e^+/e^- stimulated desorption may lead to an order of magnitude larger pressure raise.

=> these tubes must be also NEG coated and activated

QD0 cold bore

- Gas density with no beam is
  - negligible at T=2 K (except for He)
  - too high at T=4.5 K (equilibrium H_2 pressure for >0.1ML).
- Gas density with a beam increase due do:
  - Photon, electron, ions, lost positron and electron stimulated desorption inside the cold bore.
  - Gas from the IR vacuum vessel and connecting tube!
  - Desorbed gas cryosorbed and accumulated on the cryogenic walls
  - Accumulated molecules will be desorbed by photon, electron, ions, lost positron and electron.
  - **=> Gas density is growing with time**

Cold bore – behaviour under SR

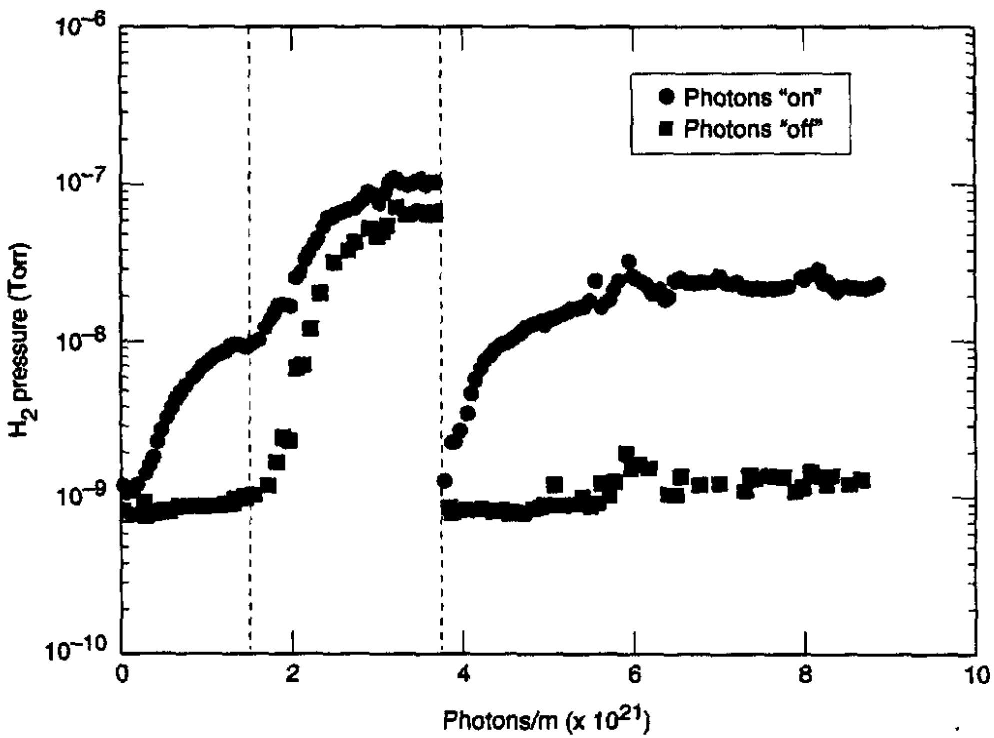


FIG. 1. Room-temperature RGA H_2 pressure measured at the center of the 4.2-K beam tube vs integrated photon flux with photons on and photons off. The raw pressure difference "on" minus "off" has been normalized to 1×10^{16} photons/m/s. The vertical dashed lines correspond to features discussed in the text.

- Experiment was performed with photons with ε_c = 300 eV
- Initial gas density will be quite good
- But after some dose there will be a **pressure bump** in a cryogenic vacuum chamber irradiated with photons and electrons

Investigation of synchrotron radiation-induced photodesorption in cryosorbing quasiclosed geometry

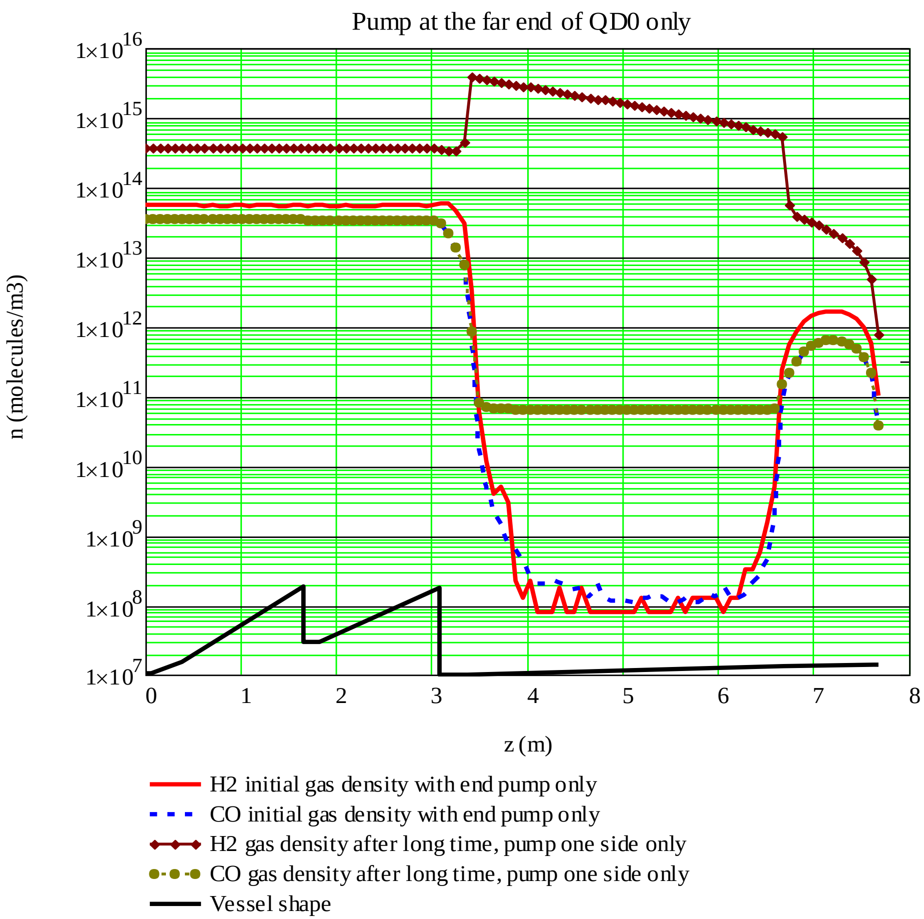
V. V. Anashin, O. B. Malyshev, and V. N. Osipov
Budker Institute of Nuclear Physics, Novosibirsk, Russia

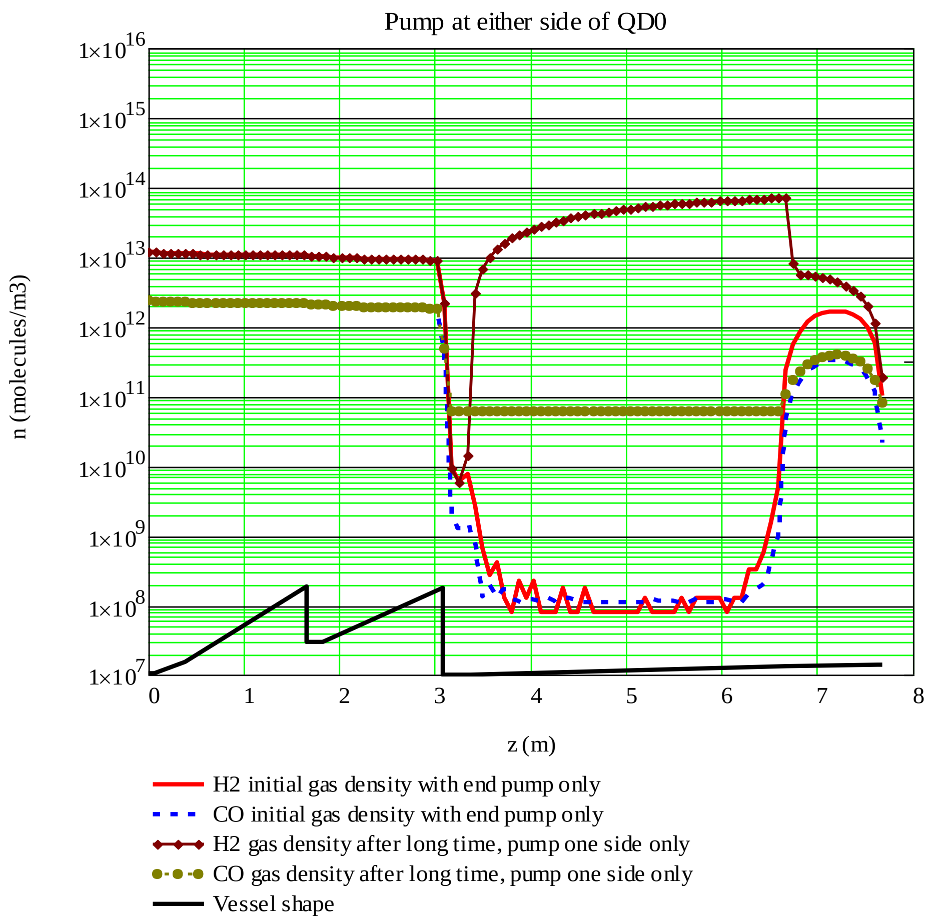
I. L. Maslennikov and W. C. Turner
Superconducting Super Collider Laboratory, Dallas, Texas 75237

2917 J. Vac. Sci. Technol. A 12(5), Sep/Oct 1994

Gas density inside SiD and near IR without NEG coating

Required vacuum: 10^{-8} Torr at RT => $3.2\cdot10^{14}$ molecules/m^3





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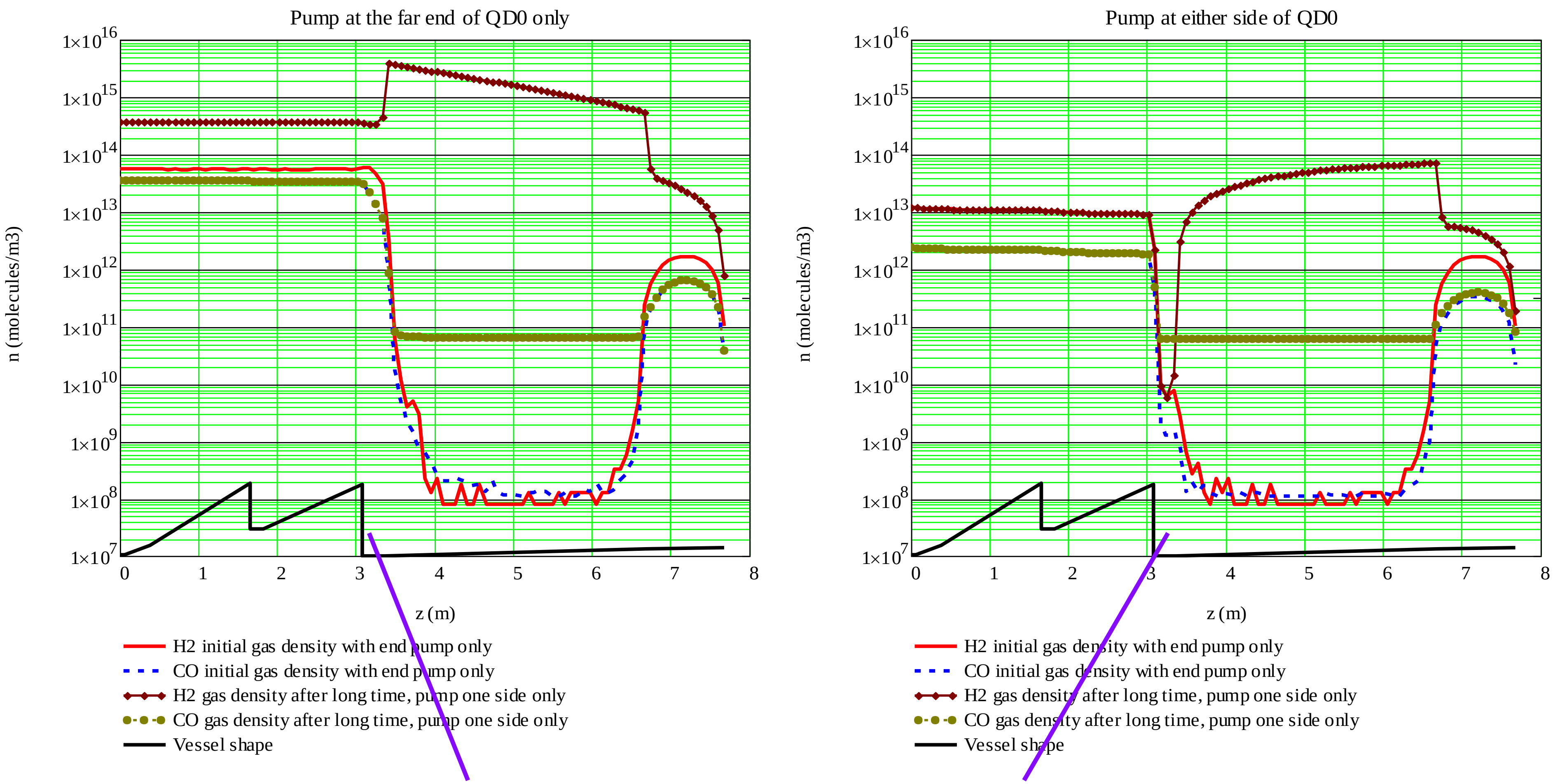

e$^+$/e$^-$ stimulated desorption is not included as some clarification is required

General questions (listed by Y. Suetsugu plus mine)

- The is a few possible solutions for IR vacuum system
- To choose one need to consider that the pumping system design depends on:
  - How long we can wait after installation and after air vent until the pressure decreases to the allowable level.
    - Days or weeks?
    - Strategy of push-pull
  - Whether or how often we have to exposure the IR beam pipe to air
    - NEG coating lifetime is about 60 vents
  - Warming up and cooling down scenario for QD0
- We need a typical operation pattern.

General questions

- Required pressure
  - Gas spectrum depends on technical solution, temperature, location, etc.
  - Ideally required vacuum should be given in gas density for a particular gas. For example:
    - $3.2 \cdot 10^{13}$ H_2/m^3 (hydrogen equivalent)
    - For other gases we can use the ratio of cross sections:
      - For the LHC design we used an *effective* H_2 equivalent gas density given by:

$$n_{eff} = n(H_2) + 5.4\,n(CH_4) + 7.8\,n(CO) + 12.2\,n(CO_2)$$

      - Are these coefficient correct for the ILC?