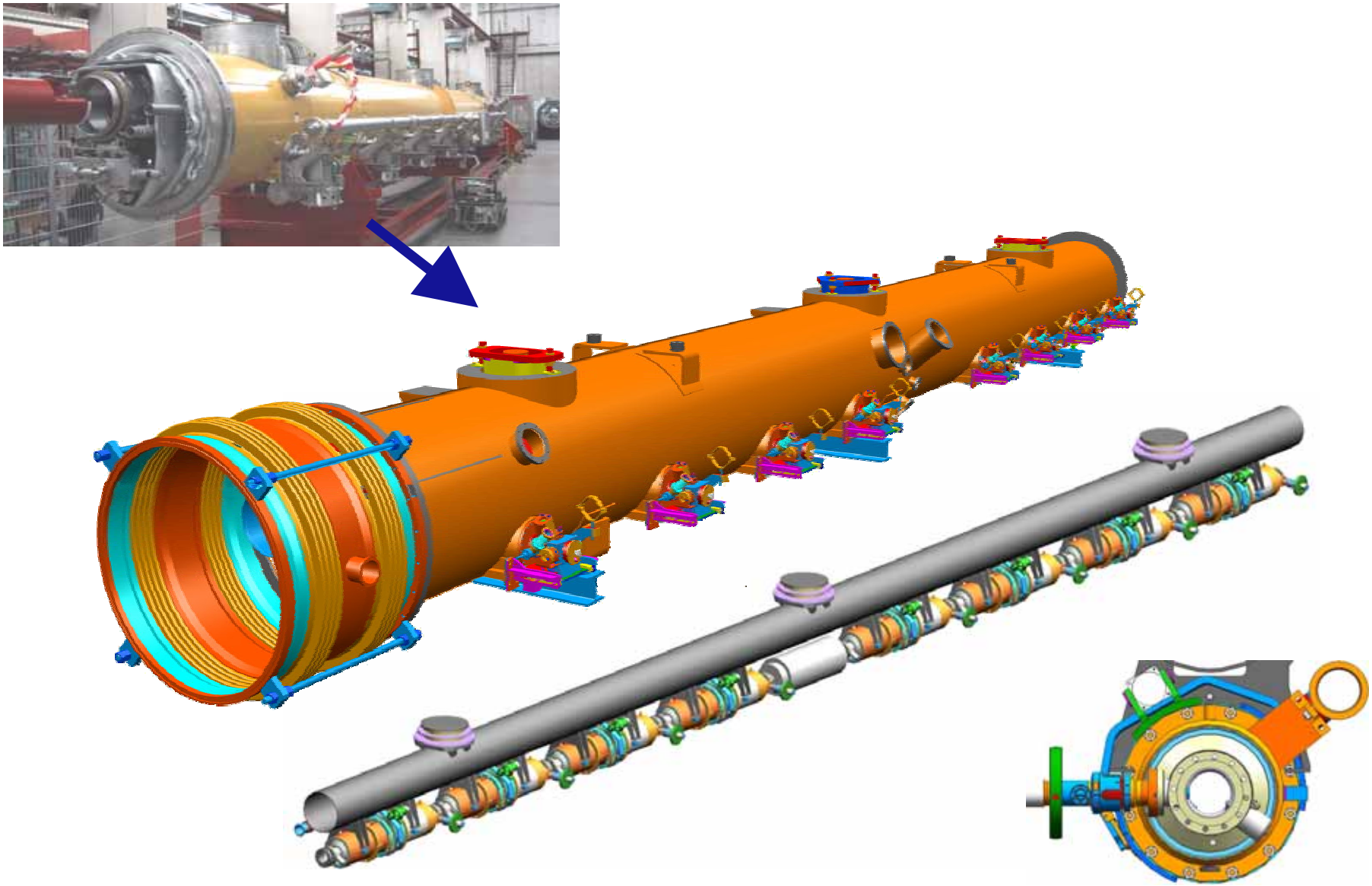
13. ILC Cryomodule

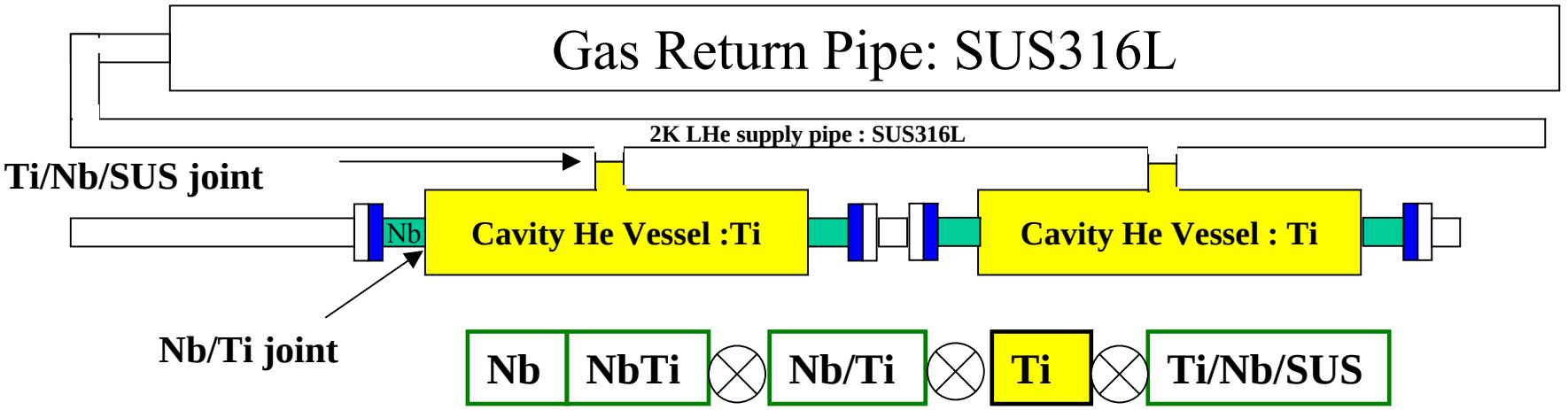


High Pressure Regulation

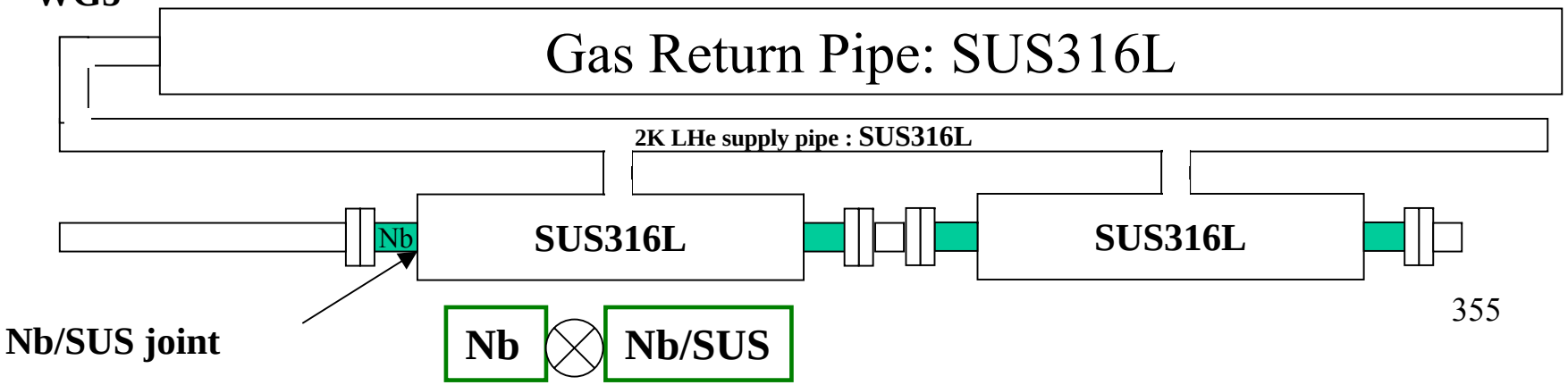
Niobium, Titanium and other different material joints (Nb/Ti, Nb/SUS) are issues of high pressure regulation.

Genially speaking from point of view safety, one should no use none experience material at low temperature for such a huge accelerator like ILC.

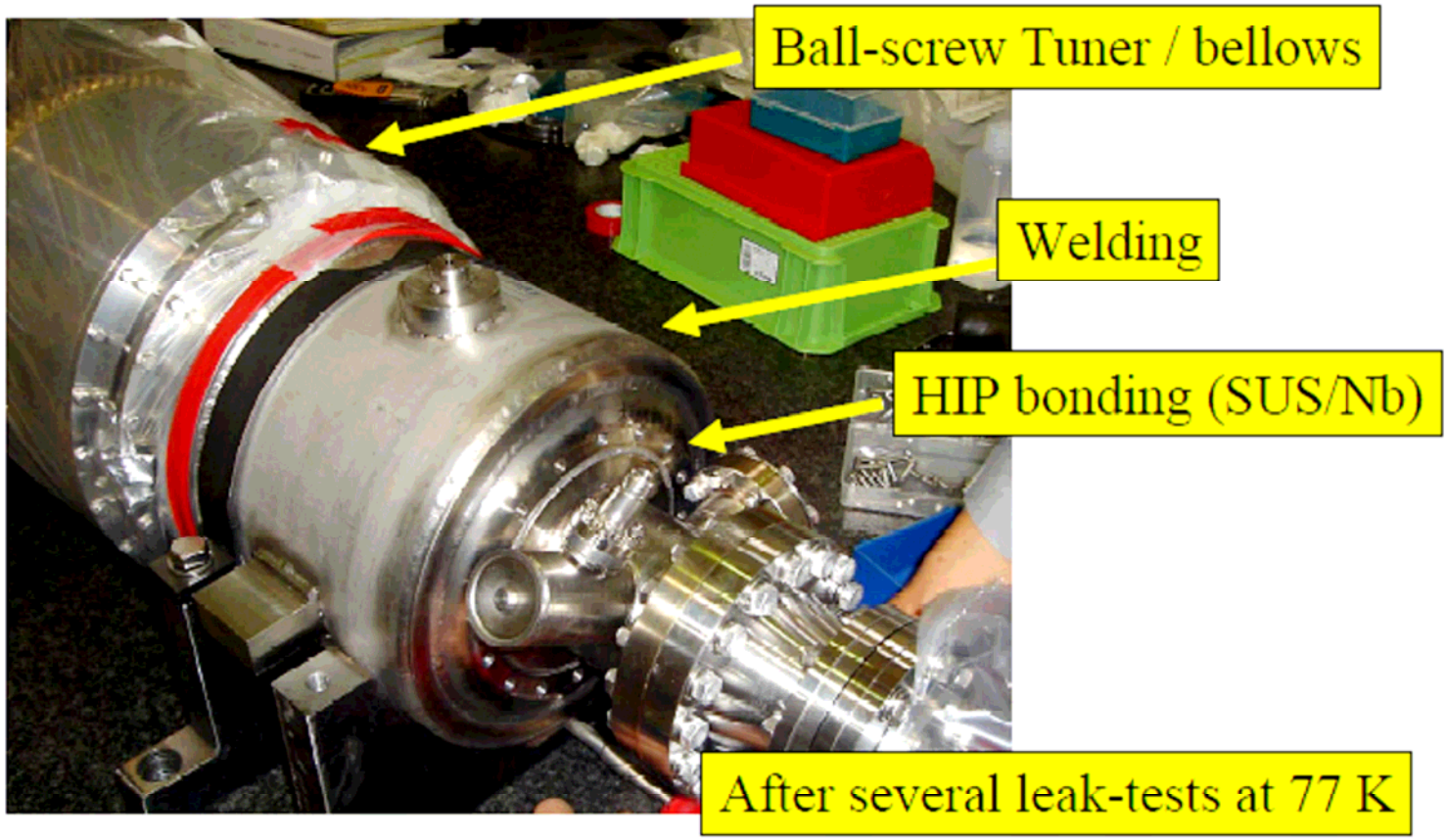
ILC BL/SFT BL



WG5



Leak Tight @ 2K!



High Pressure regulation in Japan: Charpy energy > 27J @ 4.2K
Recent measurement result(Nakaki and Terashima) >33 J

Nb/Cu/SUS316L joint might be no problem.

Characteristics of the Liquid Helium

Very small efficiency !

Generation efficiency of LHe: η_{eff}

$$\eta_{\text{eff}}(\text{T}) = \frac{\text{T}}{300\text{-T}} \cdot \eta_{\text{tech}}, \quad 6.71\text{E-3 @ 2T},$$

$$\eta_{\text{eff}}(2\text{K}) \approx 0.1\% \ @ \ \eta_{\text{tech}} = 0.2,$$

This means that one needs 1kW energy to remove 1 W of the heating.

Very small Latent heat !

	LHe	LN2
Boiling temp.[K]	**4.22**	**77.35**
Density [kg/L]	**0.125**	**0.809**
Latent heat[kJ/L]	**2.55**	**161**
Volume ratio of Gas/Liquid	**769**	**710**

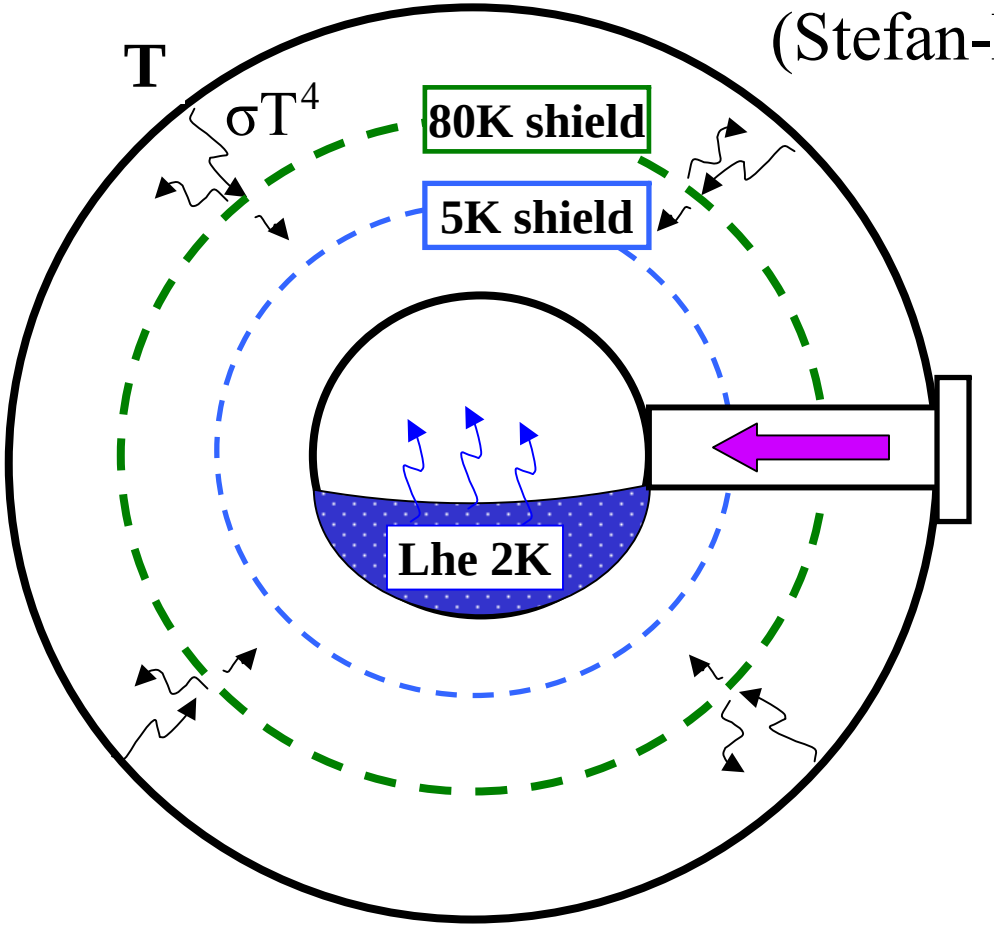
Cryomodule Design
- **Minimize the radiation energy from outside**
- **Reduce heat leak from outside**
- **Use the material with low thermal shrinkage**

Basics for Cryomodule Design

Radiation energy

Radiation Power: $E_r(T)=\sigma T^4$

(Stefan-Boltzmann law)



Stop the direct radiation !
Use the reflection shield!

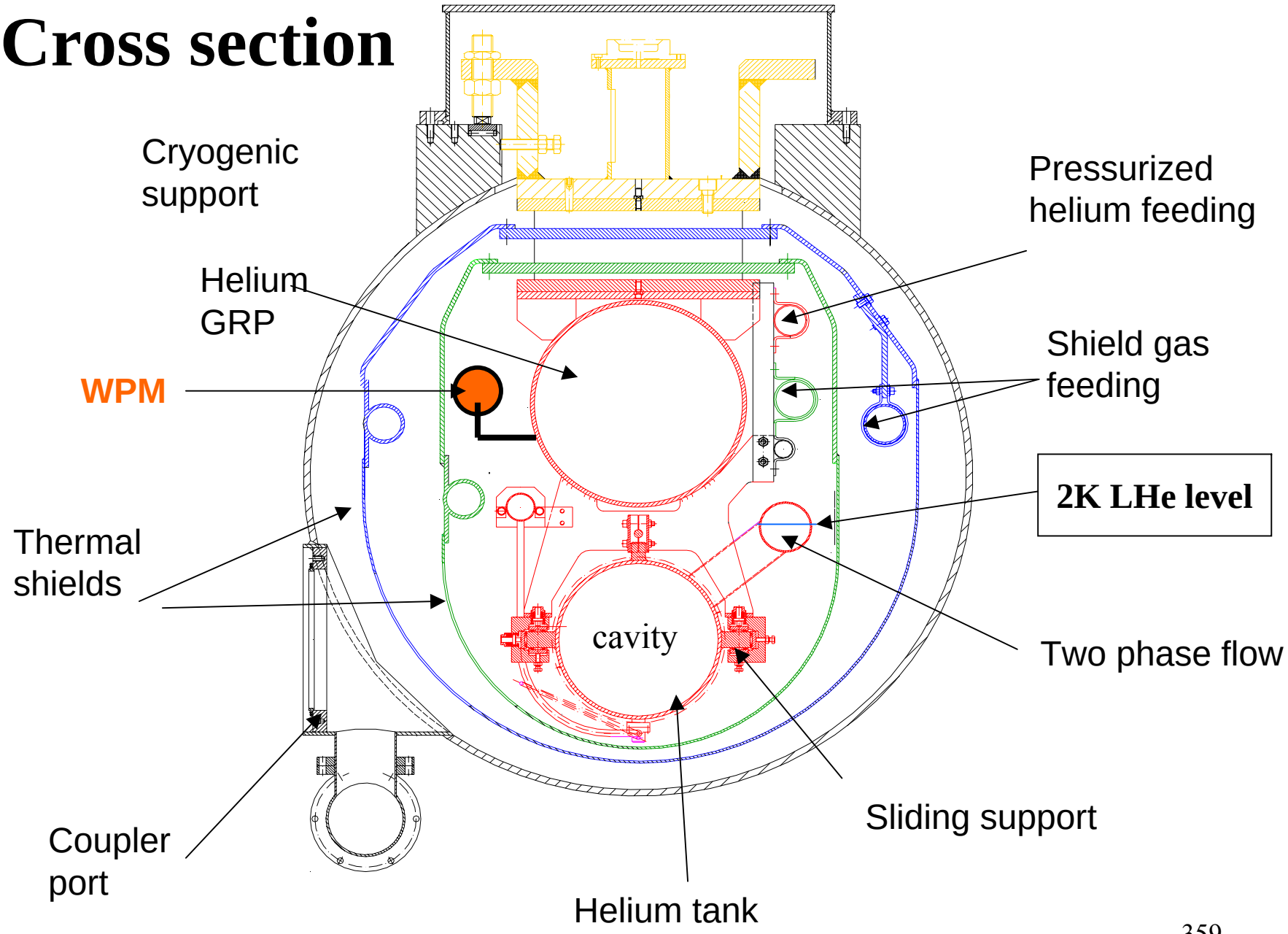
$$\frac{E_r(300K)}{E_r(5K)}=\frac{300^4}{5^4}\approx 13E6$$

$$\frac{E_r(300K)}{E_r(80K)}=\frac{300^4}{80^4}\approx 200$$

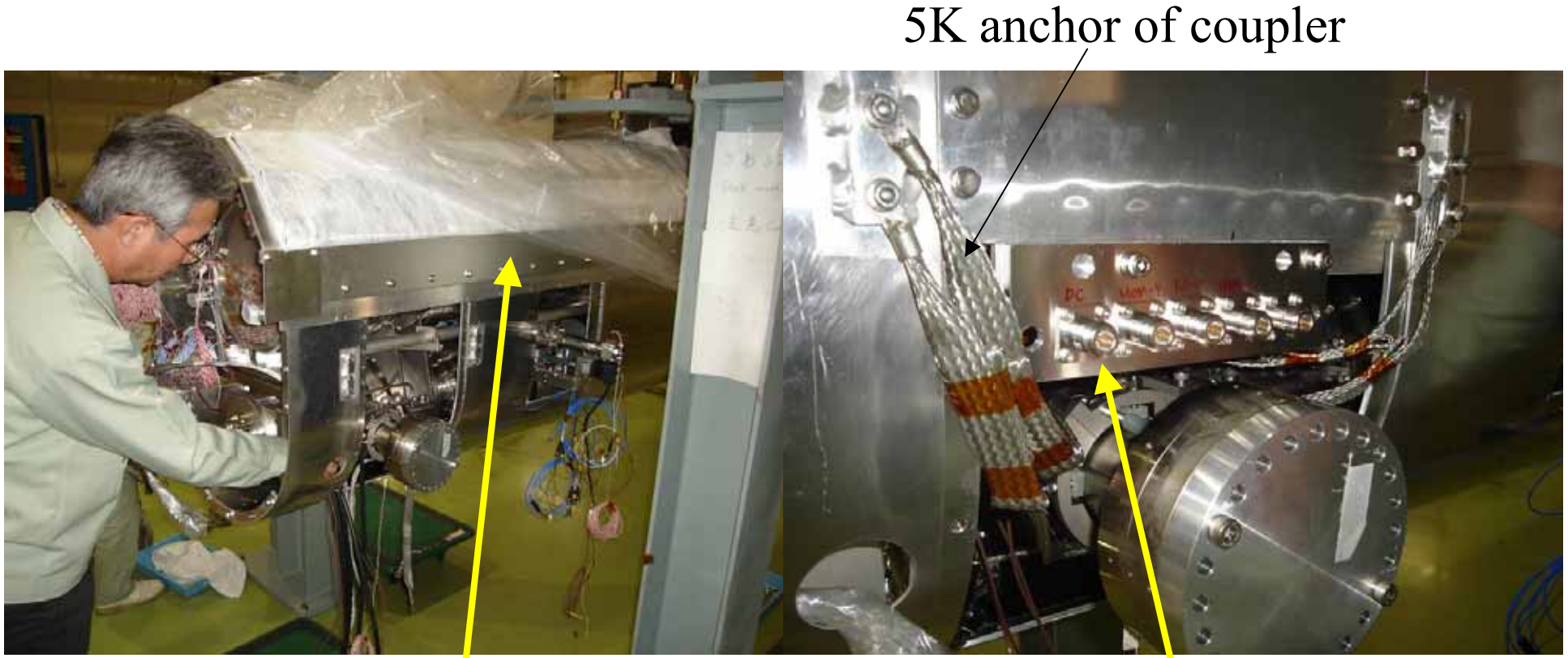
$$\frac{E_r(80K)}{E_r(5K)}=\frac{80^4}{5^4}\approx 65500$$

Use the material with small thermal conductivity
Example: SUS, G10….

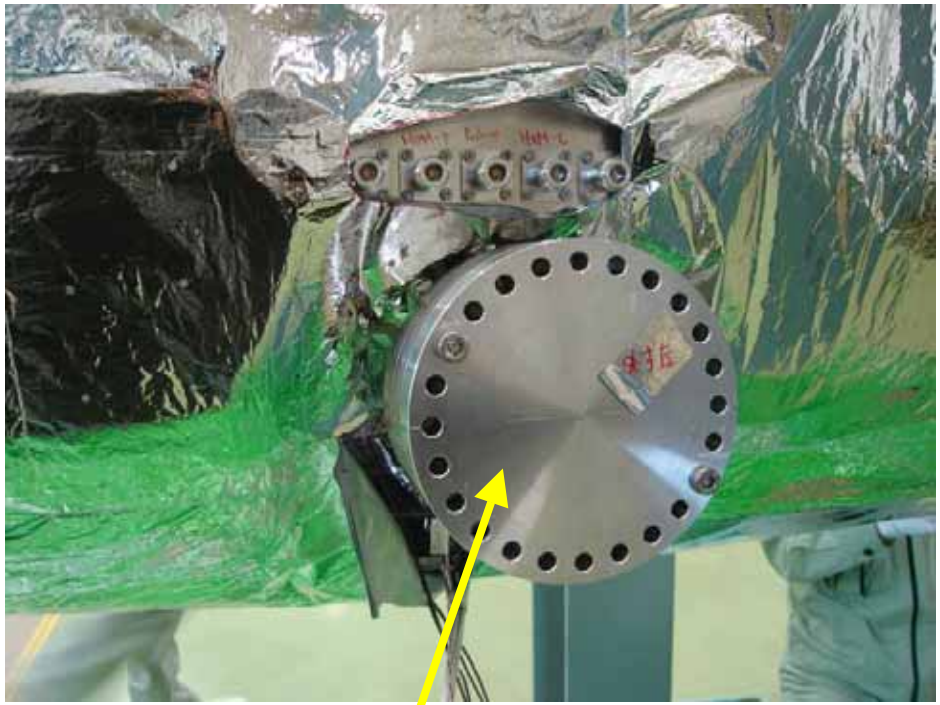
Cross section



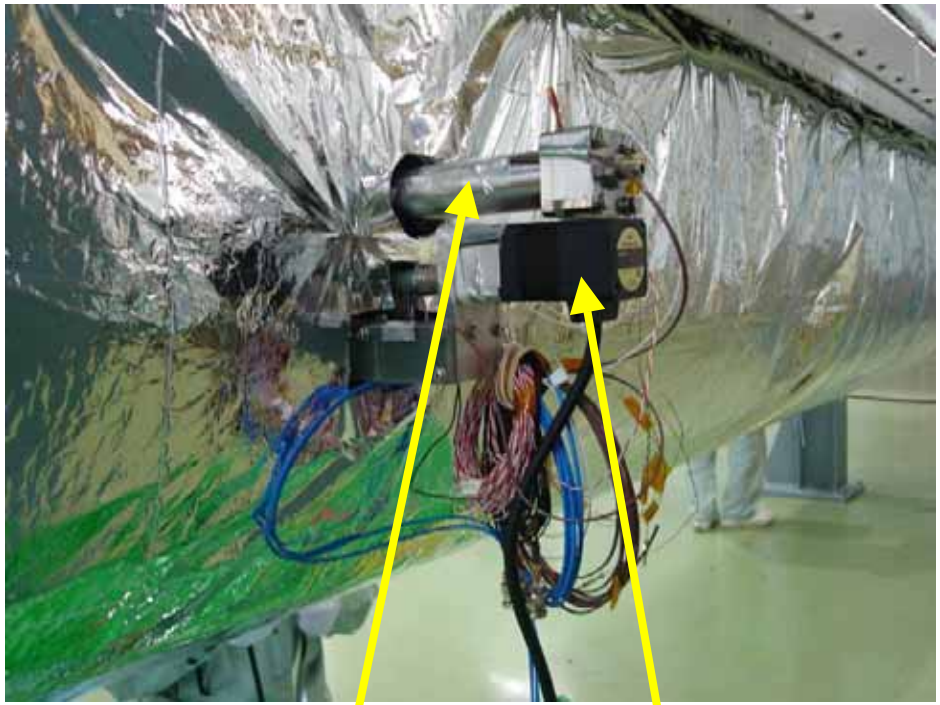
5K Shielding @ KEK



Coupler and Tuner in the cryomodule @ KEK



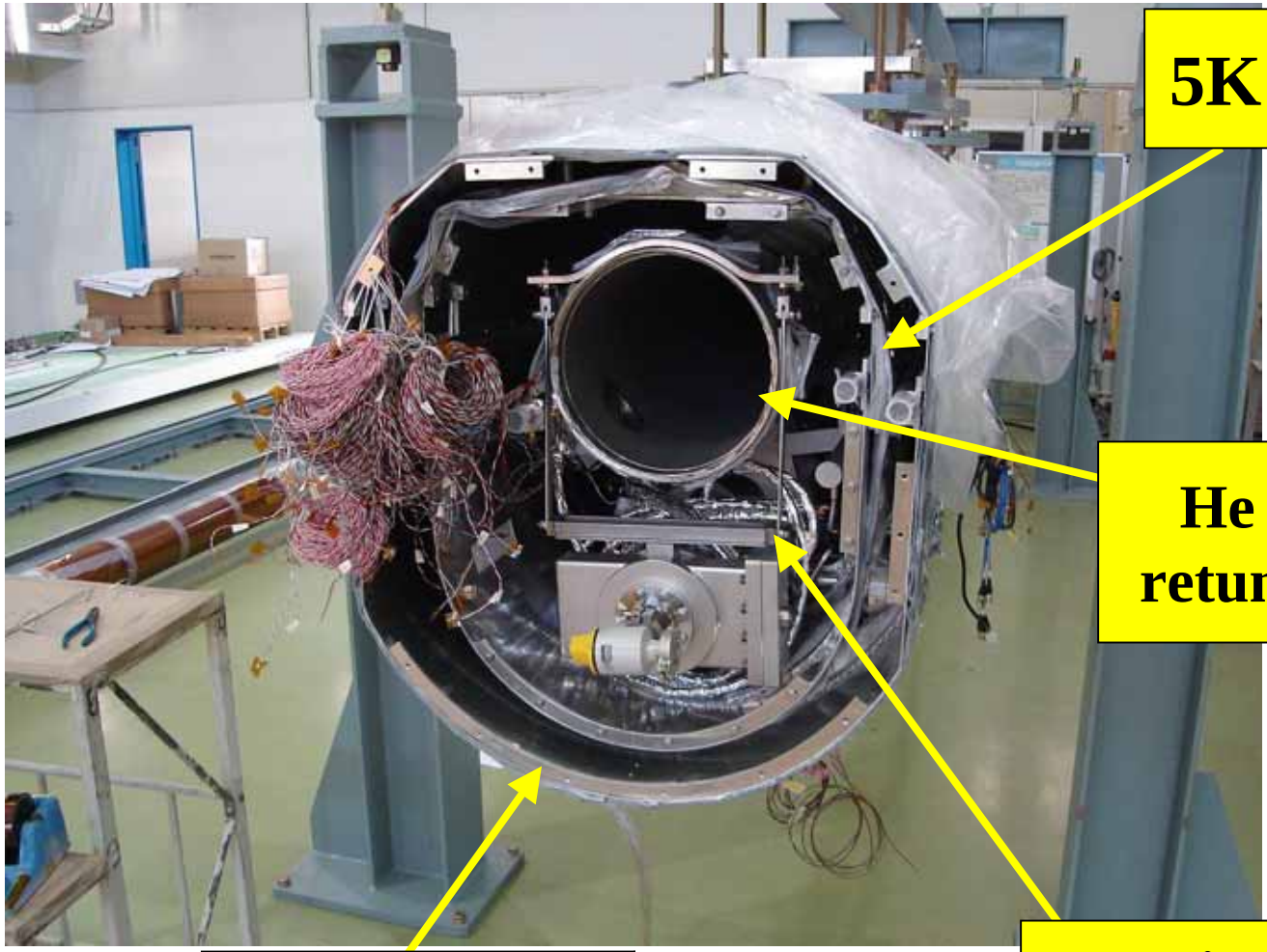
Cold window cover



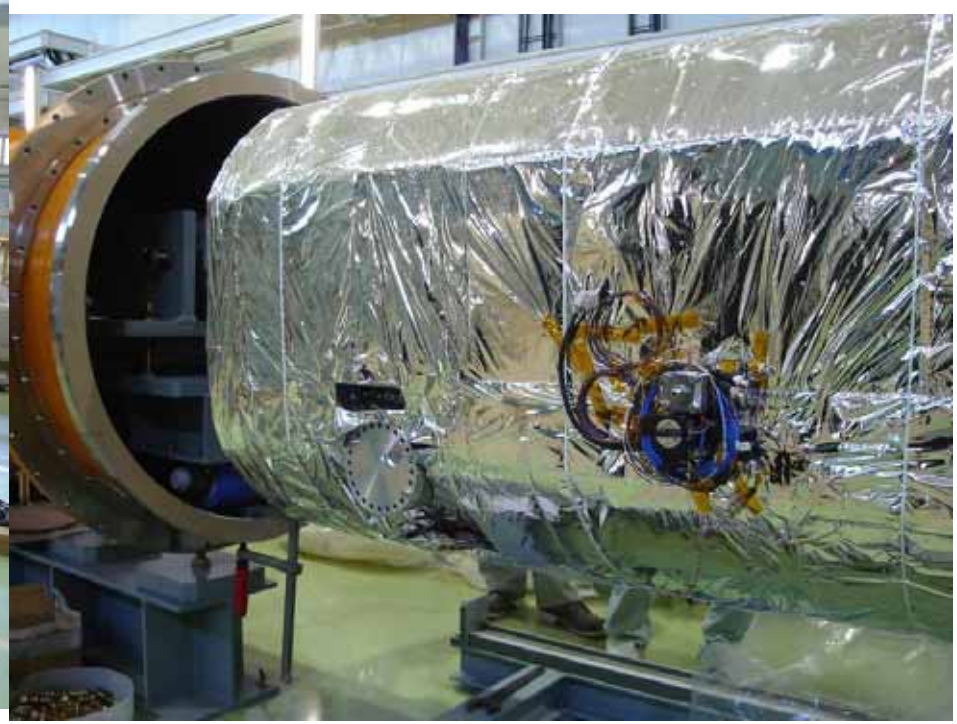
Piezo Tuner

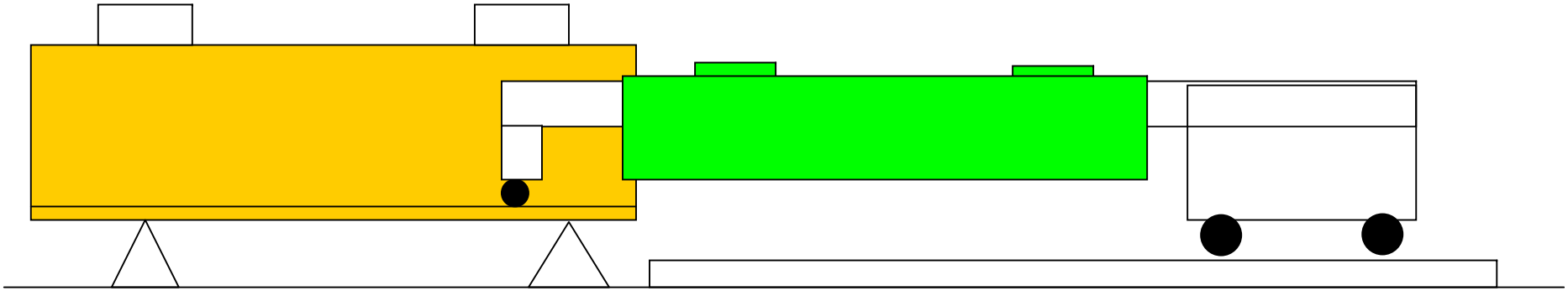
Motor

80K Shielding



Installation into vacuum vessel





Move into the tunnel

Cryomodule in the STF Tunnel

For ILC Cryomodule Design

Minor changes to address major concerns.

- Magnet alignment and vibration issues.
- Cryomodule with and without magnet package
  - Define BPM, Steering, and Quad parameters
  - Possible option for separate magnet cryo vessel
- Reduced cavity length (which tuner design?)
- Reduced cavity spacing (new interconnect)
- Need for functional Fast-Tuner