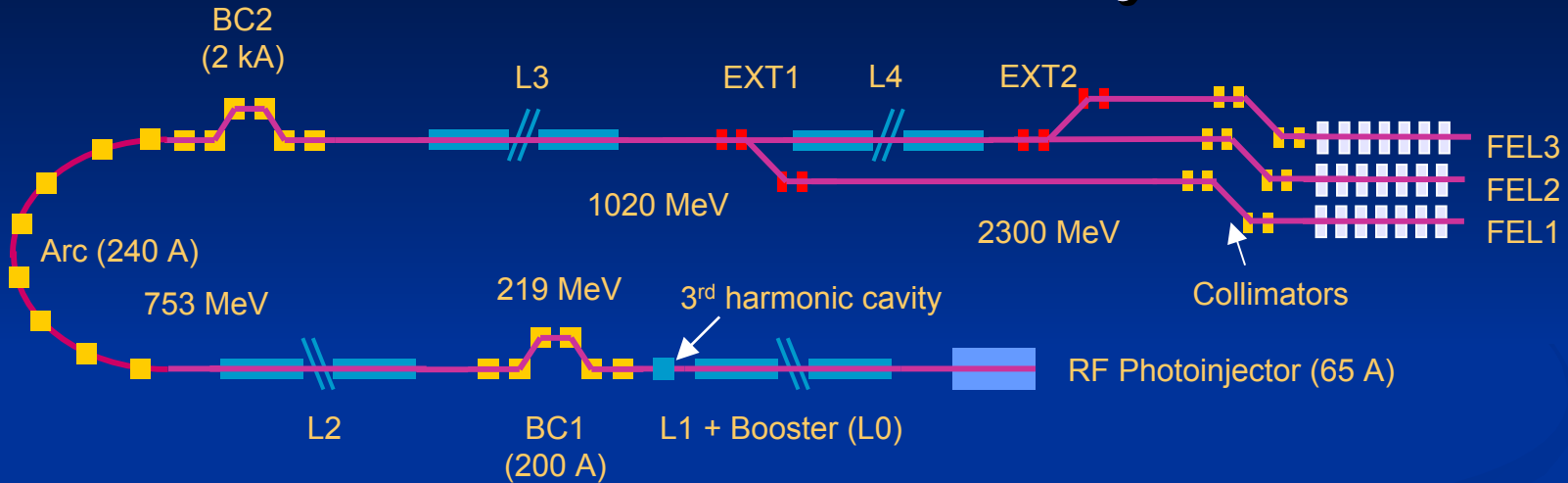


CW Cryogenics

J. Knobloch
BESSY, Berlin

BESSY FEL Layout

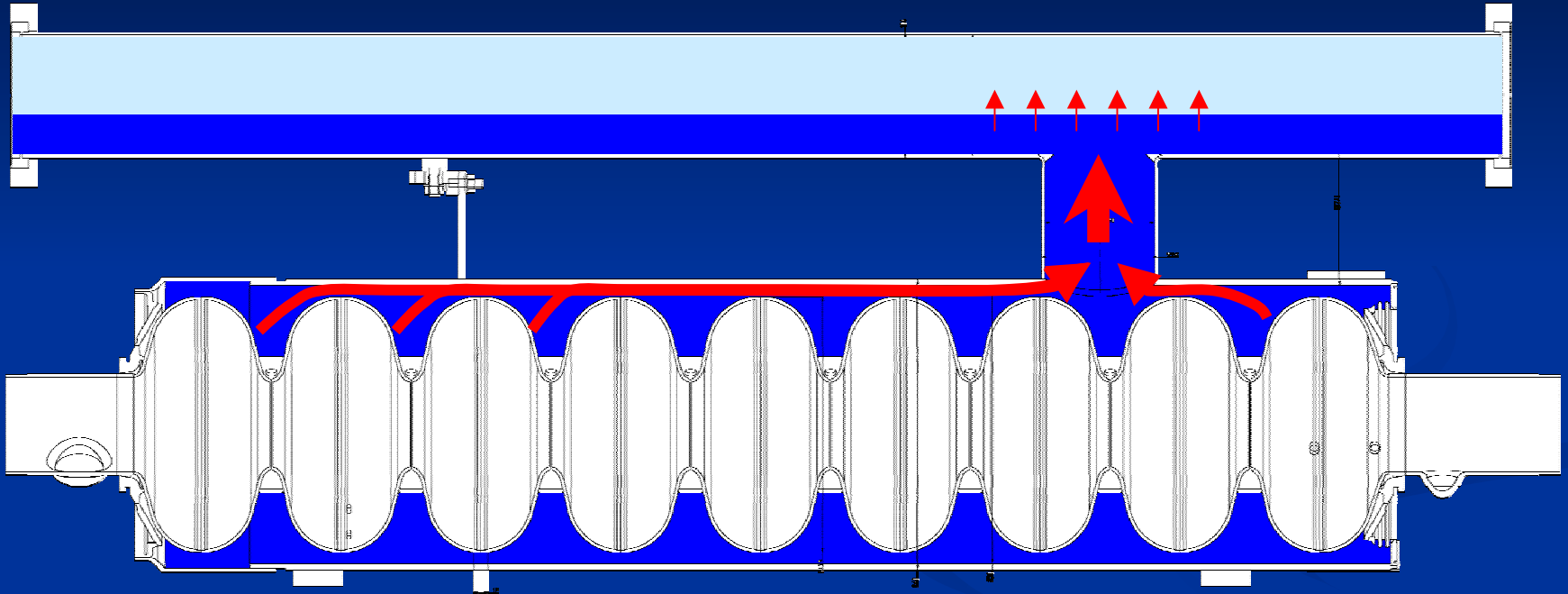


Full Energy	2.3 GeV
Duty Factor	CW
Number of cavities per module	8
Number of modules	18
Accelerating field	16 MV/m (< 20 MV/m)
Operating temperature	1.8 K
Cavity quality (Q_0)	> 1.3×10^{10} or higher
Dynamic losses at 1.8 K per cavity	< 30 W
Dynamic losses at 1.8 K per module	< 151 W
Total dynamic losses at 1.8 K	< 3 kW

Considerations

- Heat conduction in the LHe tank
- Mass flow in the module
- Mass flow in the linac

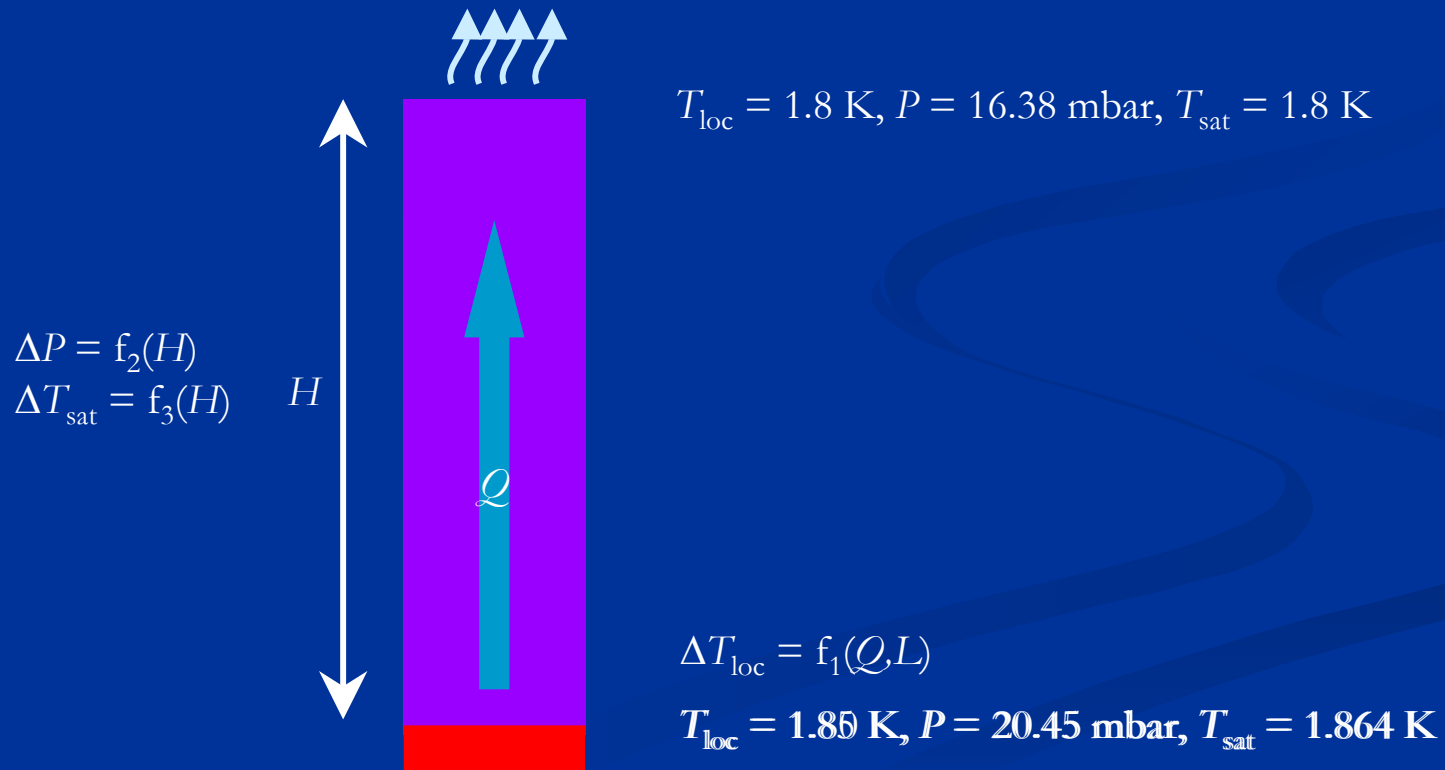
Bottlenecks in the LHe tank

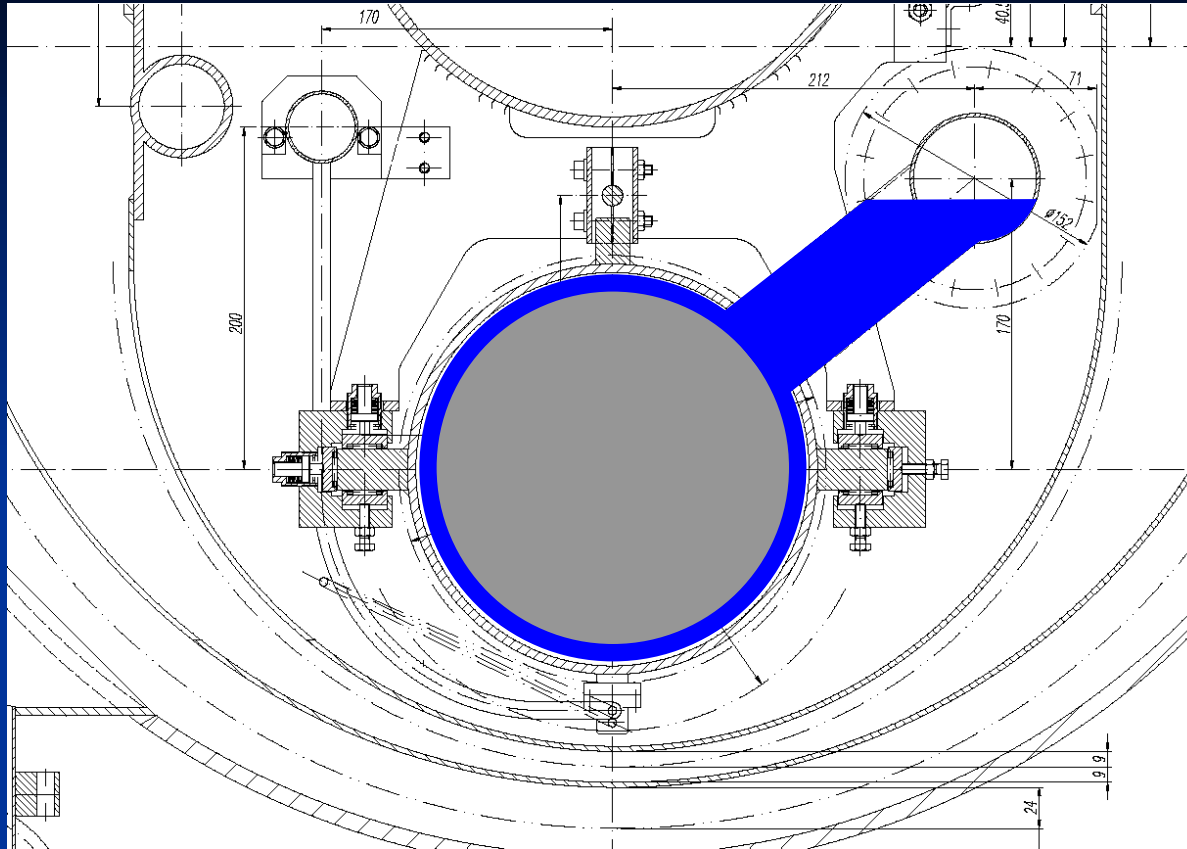


- Want to avoid boiling in He-II, otherwise danger of microphonics

Heat Conducting in He-II

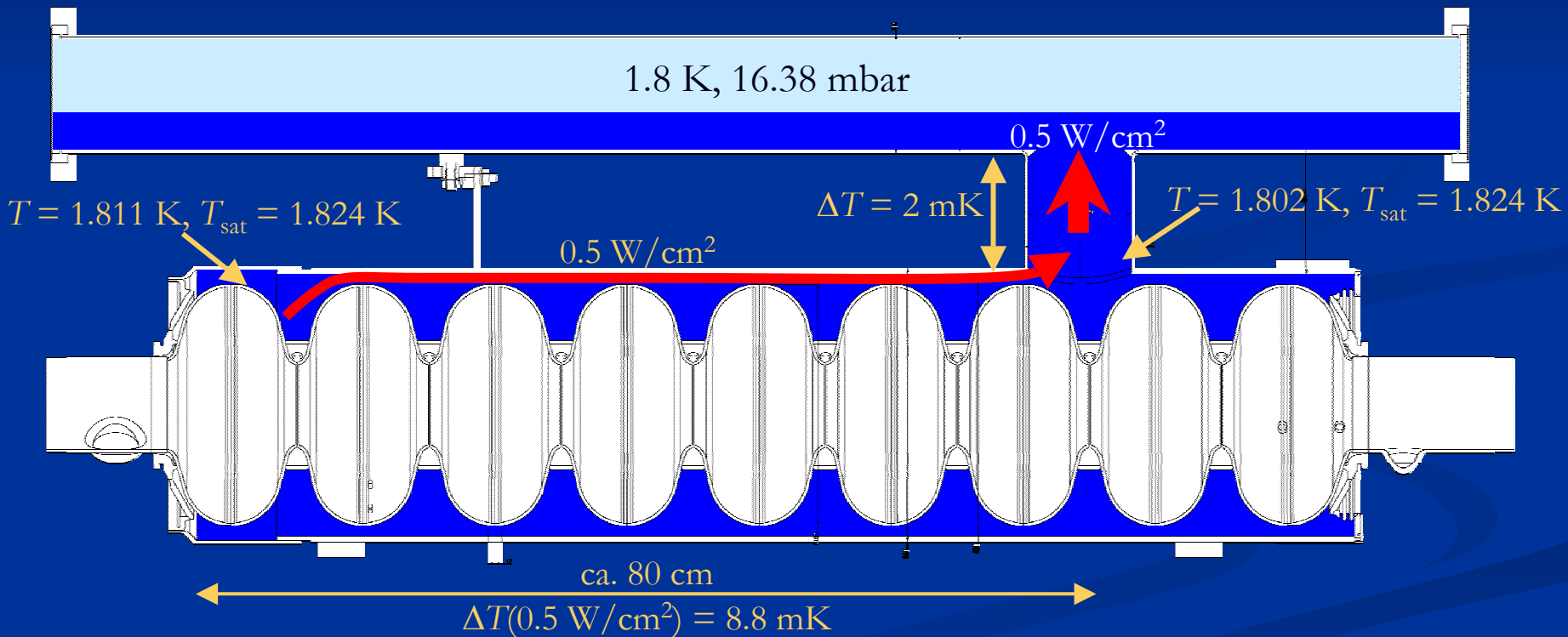
- Boiling occurs if $T_{\text{loc}} > T_{\text{sat}}(P)$
- Rule of thumb: Heat flux in 1.8 K He-II must be less than 1 W/cm^2 to avoid boiling





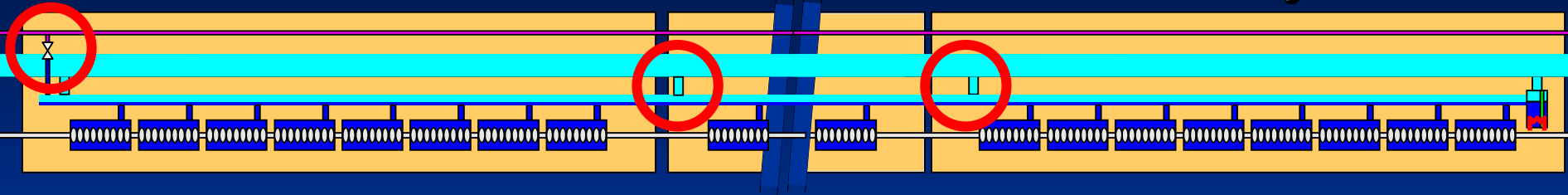
- Area of annulus = $66 \text{ cm}^2 \rightarrow Q < 0.5 \text{ W/cm}^2$
- Area of chimney = $23 \text{ cm}^2 \rightarrow Q > 1 \text{ W/cm}^2$
- Chimney diameter must be increased $\rightarrow 90 \text{ mm}$

Heat Conduction in He-II



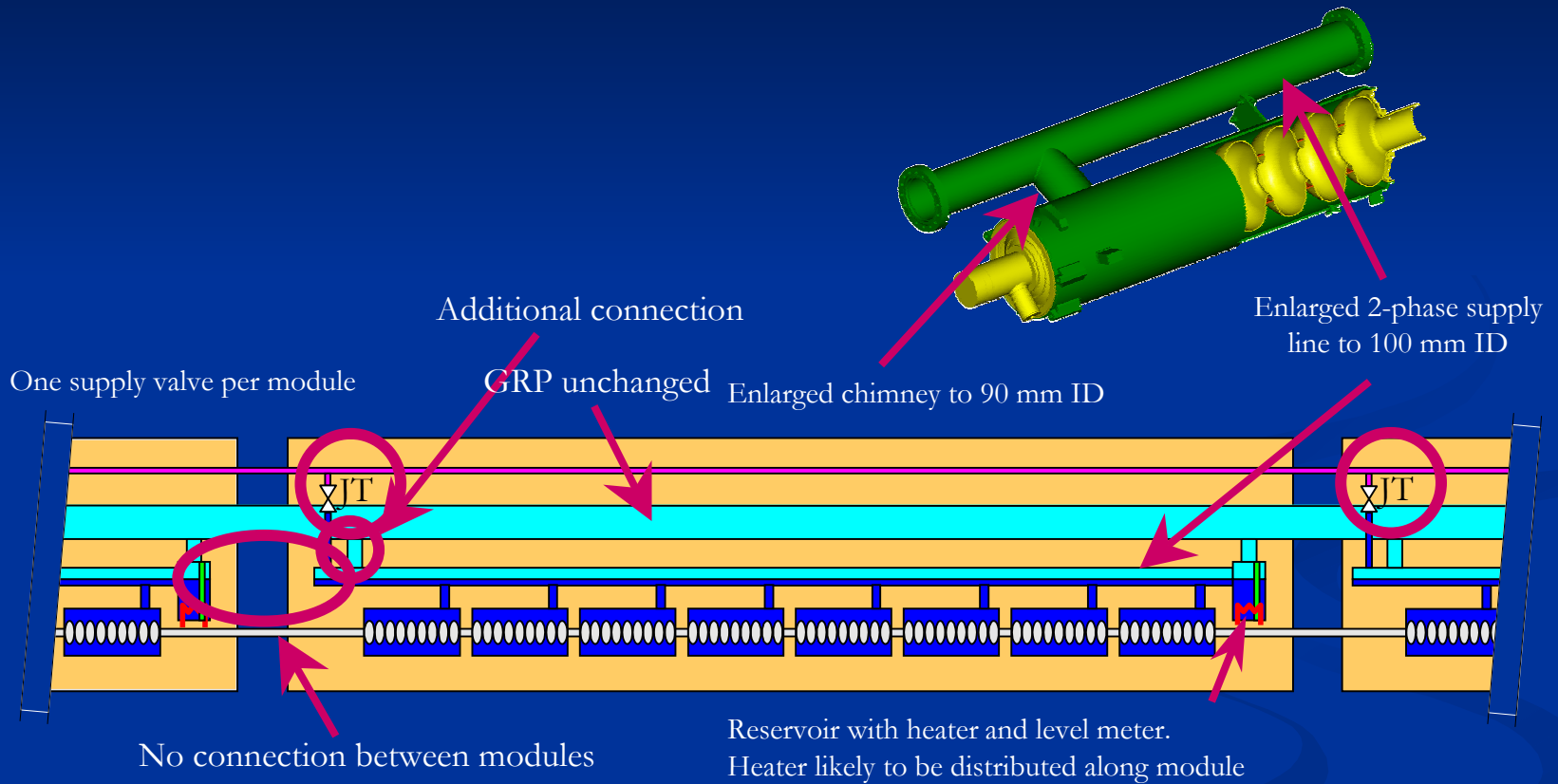
- To be verified experimentally in HoBiCaT

Considerations for Linac Layout



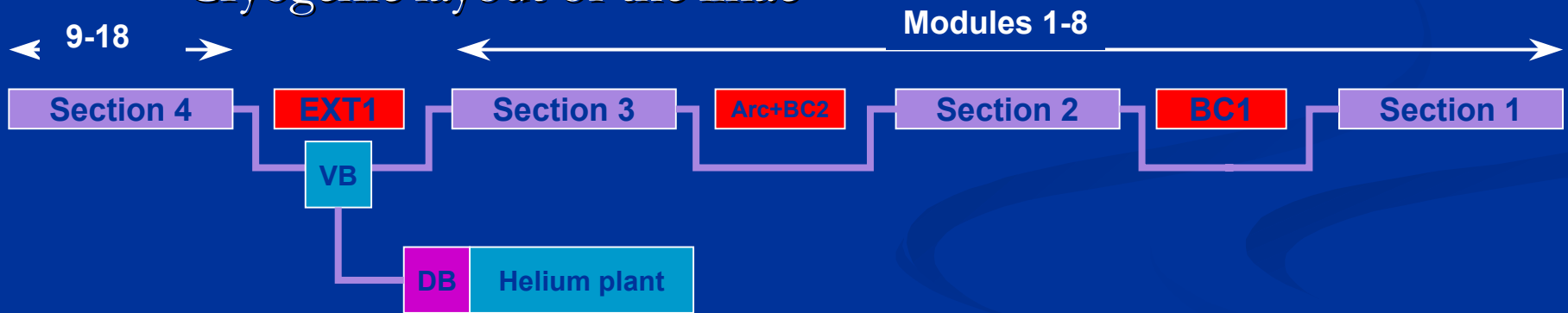
- TESLA: 10 modules (string) form one string
- All supply and return lines span the entire string
- Supply by one JT valve
- Total dissipated power per string = 150 W ~ 1 CW Module
 - Should have one supply per CW module
- TESLA: One conn. between 2-phase line and GRT / module (15 W)
 - Flow in 2-phase line more „relaxed“ than in CW Module
 - 2-phase line should be as big as possible
 - Add connections
- TESLA: GRT handles gas from 16 strings = 2.4 kW
 - Size of GRT should be OK for CW operation

BESSY CW-Module Layout



Cryogenic Analysis

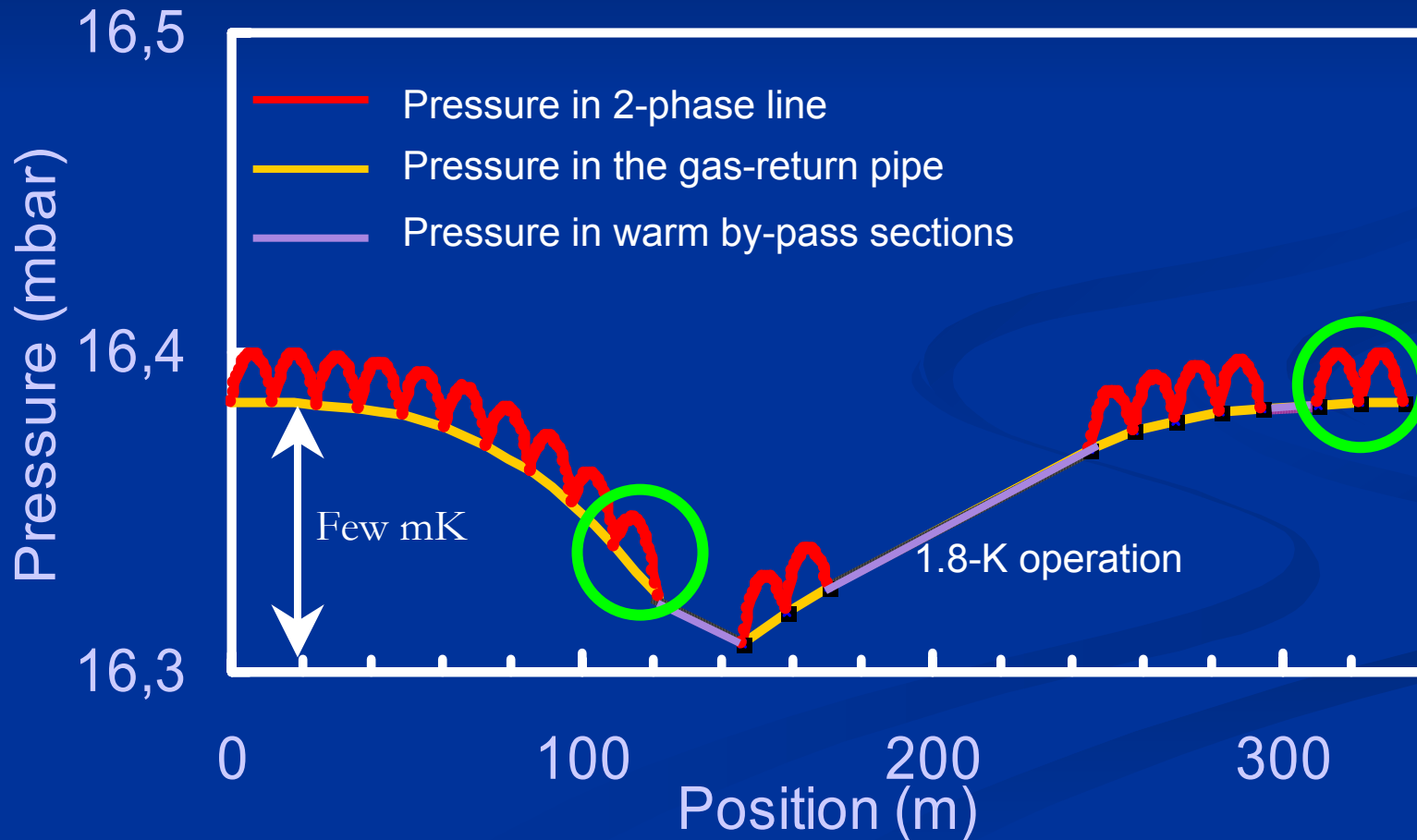
- Wish to analyze behavior of cryogenic distribution → must include:
 - Module layout
 - Cryogenic layout of the linac



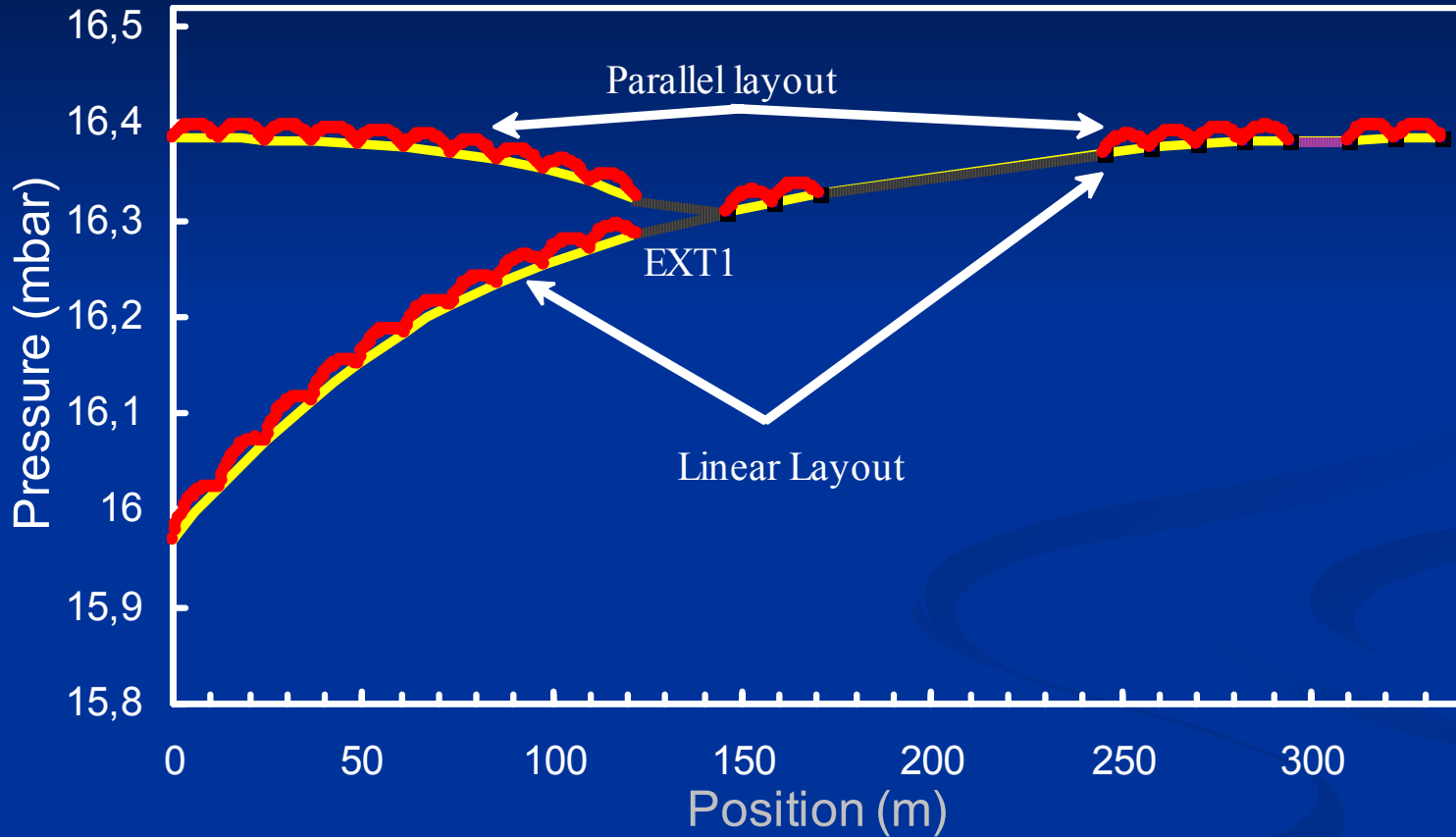
- Analysis must include two-phase flow of He-II in the entire system to:
 - Determine pressure drop along linac
 - Flow characteristics in the two-phase line

Pressure Drop

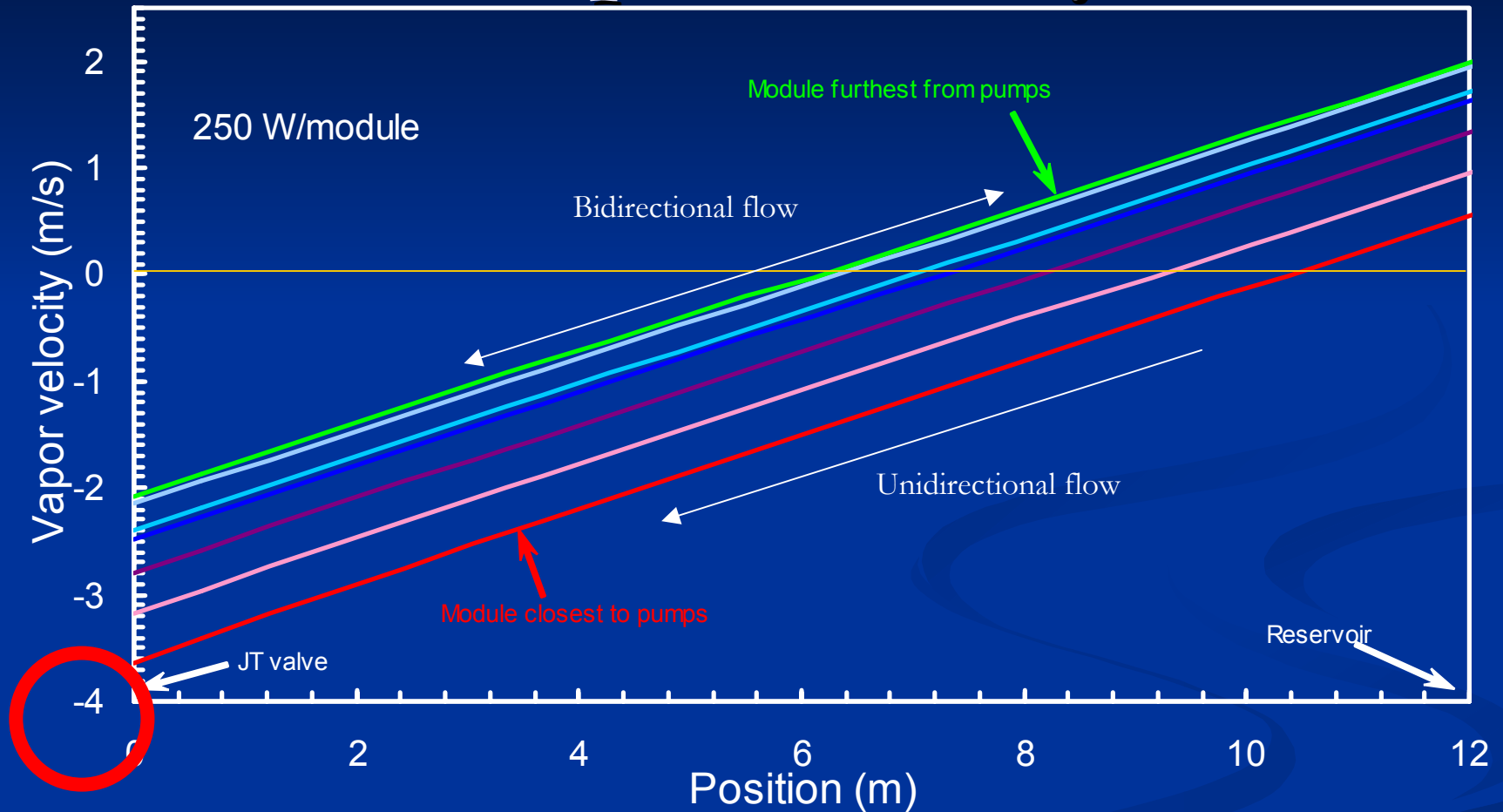
- Analysis for 250 W/module, 4.5 kW/linac
- 1.8-K Operation



Pressure Drop

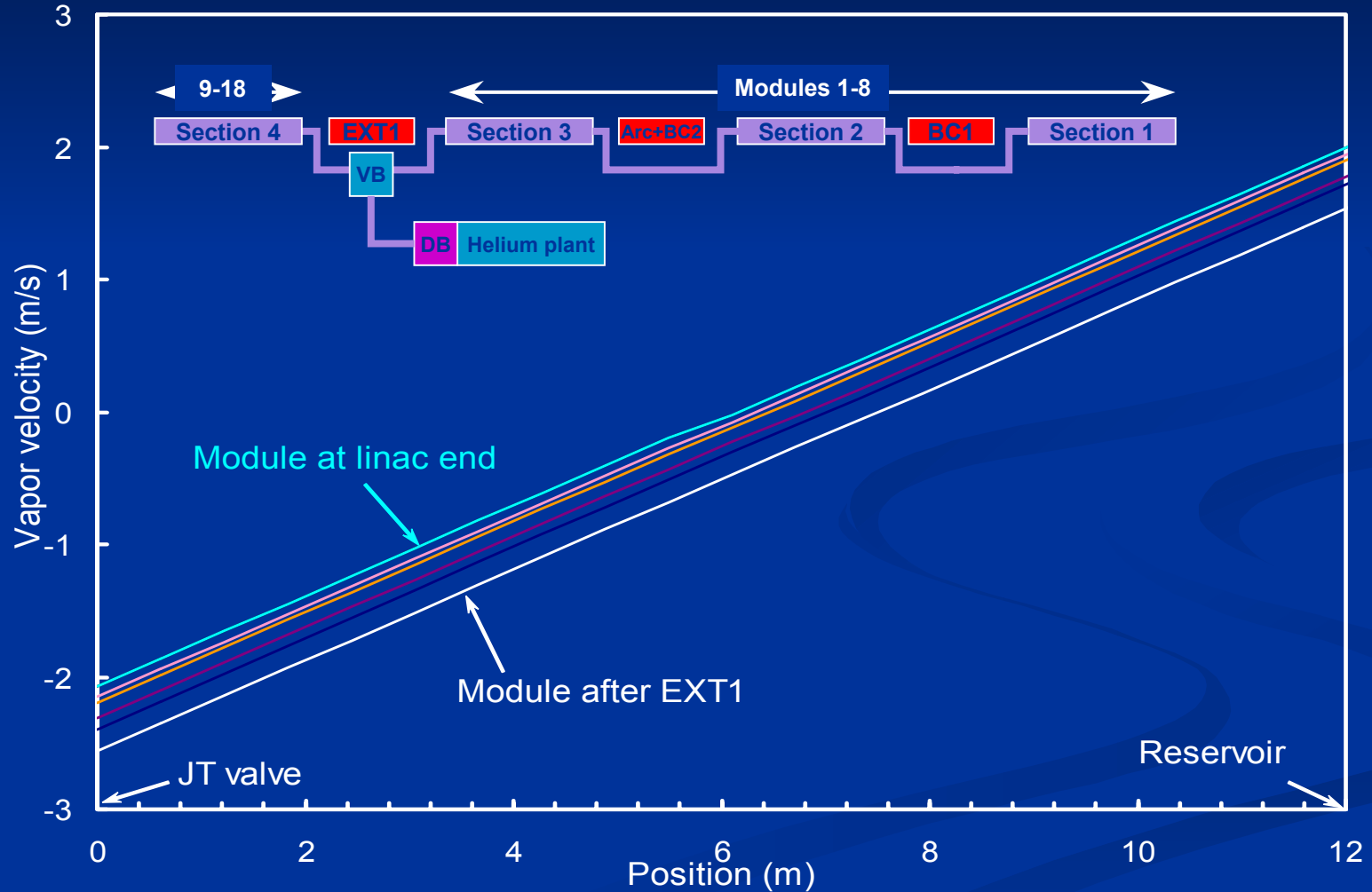


Vapor Velocity

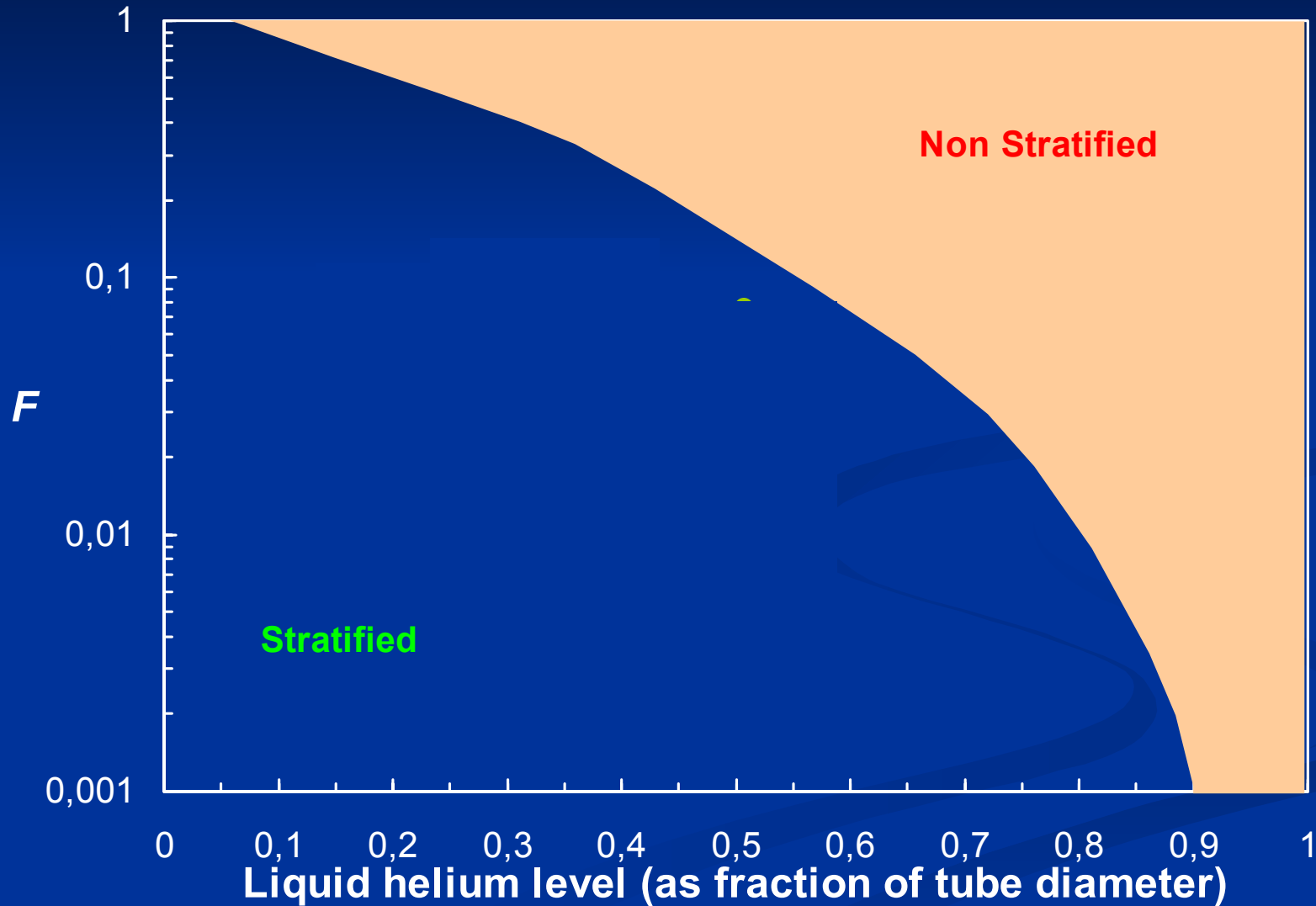


Anything above 4 m/s can lead to non-stratified flow!

Vapor Velocity



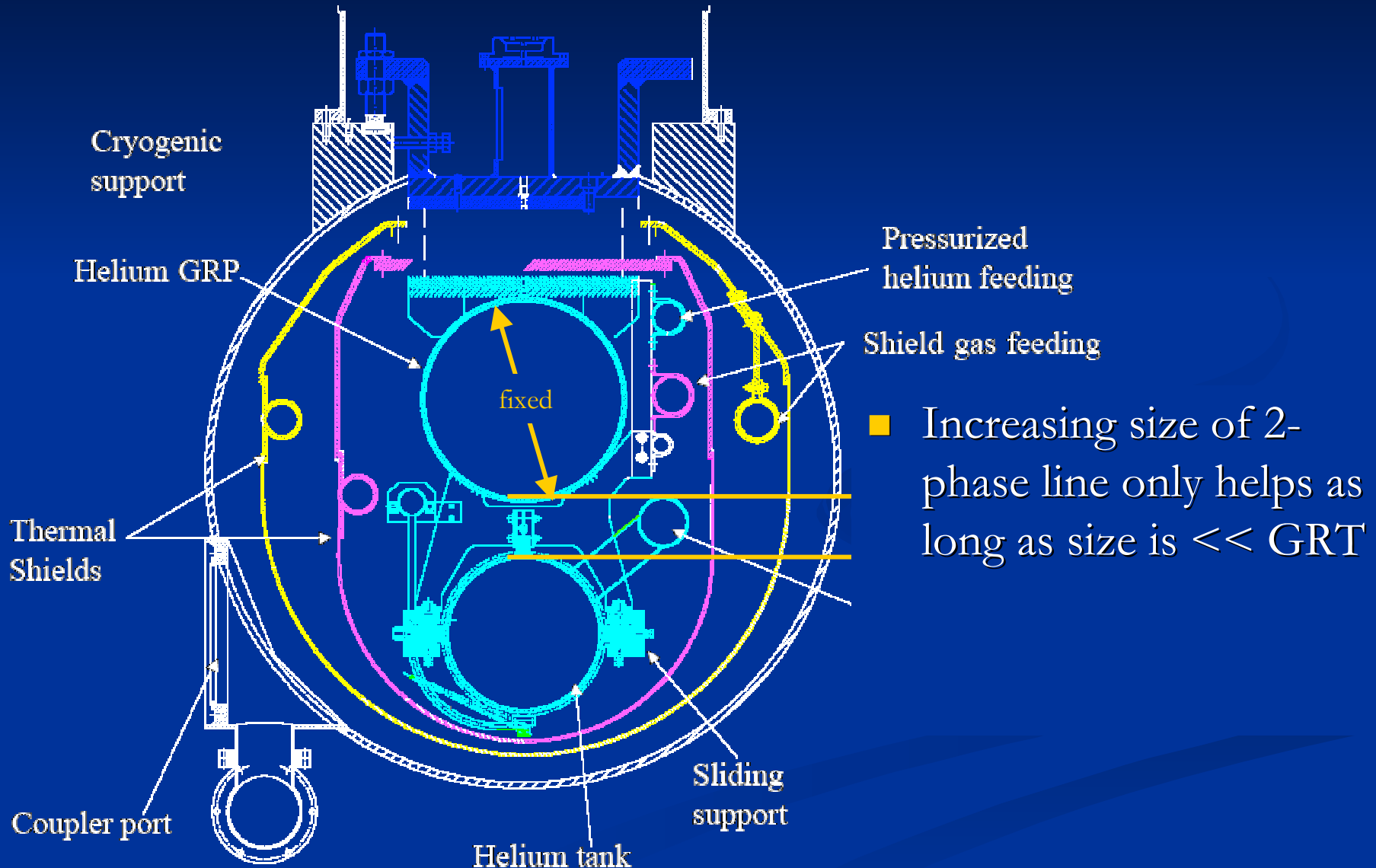
Flow Pattern



Conclusion

- In the LHe tank up to about 60 W/cavity is OK
- 250 W per Module, 31 W/cavity is OK
- 4.5 kW for the entire linac (18 modules) is OK
 - provided the helium is returned from the mid section
- 400 W for a single (underperforming) module OK as well

Maximum Dimensions



- Increasing size of 2-phase line only helps as long as size is \ll GRT