# BDS Cryogenic System
# RDR Status and EDR Plans

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# Cryogenic devices in BDS

- Tom, I use this slide for comment.
- As last workshop:
  - **there will be a CMS type Solenoid magnet for each detector, 4.5 K cooling**
  - **There will be two detectors, for operation and at garaged position.**
  - **Cooling must be provide to both detectors for DQ0s and Solenoid at the same time in either positions.**
  - **Among the 15 W 2 K heat load for DQ0, only ~ 1 W is for beam heating.**
  - **We don't know the heat load of crab cavity.**
  - **Independent Warmup/Cooldown on some hardware (for example 2 QD0 or cavity, QF1) maybe needed.**
  - **Other than the refrigerator/liquefier (in experimental hall), Compressor etc. will be installed on ground level similar to CMS? This has an impact on cost etc.**

# Cryogenic devices in BDS

- Considering just one of the two sides, neglecting detector cryogenics in this summary
- At 1.8 K
  - **One cryomodule with two 3.9 GHz cavities**
  - **13.4 meters from the IP**
- At 2.0 K (for magnet at 2 K, we need 1.8 K cooling)
  - **Two final focus cryostats with multiple magnets**
  - **Within 12 meters of the IP**
  - **One cryostat travels with the detector, one is fixed**
- At 4.5 K
  - **Need 4.5 K shield for QD0 and QF1**
  - **Tail folding octupoles**
  - **Far from the IP, would require a long cryogenic transfer line**
  - **May be cooled by means of separate cryocoolers**

# Assumptions for heat loads

- The superconducting magnets, especially final focus quads, may absorb some significant beam-induced heating
  - **Two cryostats on each side**
  - **Rather complex cryostats**
    - Multiple magnets
    - Warm-cold transitions
    - Many current leads for independently powered magnets
    - Use of HTS leads may minimize cooling required
- Crab cavity cryostats are relatively small
  - **Heat loads dominated by RF heating**
- No liquid nitrogen in the tunnel
  - **40 K to 80 K helium gas thermal shields and intercepts**

# RDR BDS cryogenic system heat

- A lump-sum heat load estimate for magnets, crab cavities, and distribution losses, which is for each side
  - **2 grams/sec liquefaction**
    - Provides 30 W cooling at 1.8/2.0 K with room-temperature pumps, plus some current lead flow **(baseline heat load is 30 W for DQ0 + QF1 alone)**
  - **200 W at 4.5 K**
    - May be divided as some 2 K and some 4.5 K cooling with each 2 K Watt "costing" as much as 3.5 W at 4.5 K.
  - **1000 W at 40 K to 80 K**
    - Helium gas thermal shield cooling
- Doubling (for two sides) and multiplying by a factor 1.5 for uncertainty and control gives the numbers in the following spreadsheet
  - **This estimate was done nearly a year ago and provided input for the RDR cost estimate for BDS cryogenics**

# RDR BDS cryogenic capacity

May need revise

| Cryo plant description | ILC BDS |
|---|---|
| Plant capacity at each temperature level (after all factors) | (factor 1.5) |
| 40 to 80 K (kW) | 3.00 |
| 5 to 8 K (4.5 K for DR) (kW) | 0.60 |
| 2 K (kW) | 0.00 |
| liquid production (gr/sec) | 6.00 |
| | |
| Plant efficiency at each temperature level | |
| 40 to 80 K (W/W) | 16.00 |
| 5 to 8 K (W/W) | 328.00 |
| 2 K (W/W) | 800.00 |
| liquid production equivalence (4.5 K Watts per gr/sec) | 125.00 |
| | |
| 4.5 K ideal reference power (W/W) | 65.66 |
| 4.5 K reference efficiency (fraction carnot) | 0.30 |
| 4.5 K reference efficiency (W/W) | 218.87 |
| **Equivalent overall 4.5 K capacity (kW)** | **1.868** |
| Wall plug power (MW) | 0.409 |

# Conclusions for RDR

- Very approximate but generously (??) large heat load estimates
  - **Followed by additional factor 1.5**
- No distribution system details nor cryogenic end box details were developed during RDR
- Overall plant size for just the two sides of BDS (not detector) is equivalent to about 2 kW at 4.5 K, not a very large cryogenic plant
  - **For comparison, Fermilab's magnet/SRF test facility cryogenic plant is 1500 W at 4.5 K, about this size**

# Conclusions for EDR

- EDR goal -- a full preliminary system design
  - **Develop features for push-pull**
  - **Make bottom-up heat load and flow rate estimate**
  - **Develop flow schematic with approximate line sizes and instrumentation**
  - **Determine cryostat locations, transfer line lengths**
  - **Work out the tail folding octupole cooling scheme**
  - **Create top level CAD models of cryogenic system components, not detailed drawings**
    - Helps to define space occupied and interfaces
  - **Define relationship with detector cryogenics**
  - **Revise cryoplant size and cost estimate**
- Estimate 0.2 FTE during EDR for above work