Costs for a CW SRF Linac for ADS

Bob Rimmer, JLab

ADS workshop

VTech, 9/28/10

Disclaimer

- All costs are highly dependent on machine design and political climate

- But: two examples may be illustrative
  - Jlab 12 GeV upgrade
  - SNS original production

Note: both these projects had reduced overhead!

(see also Cornell ERL and UK NLS studies)

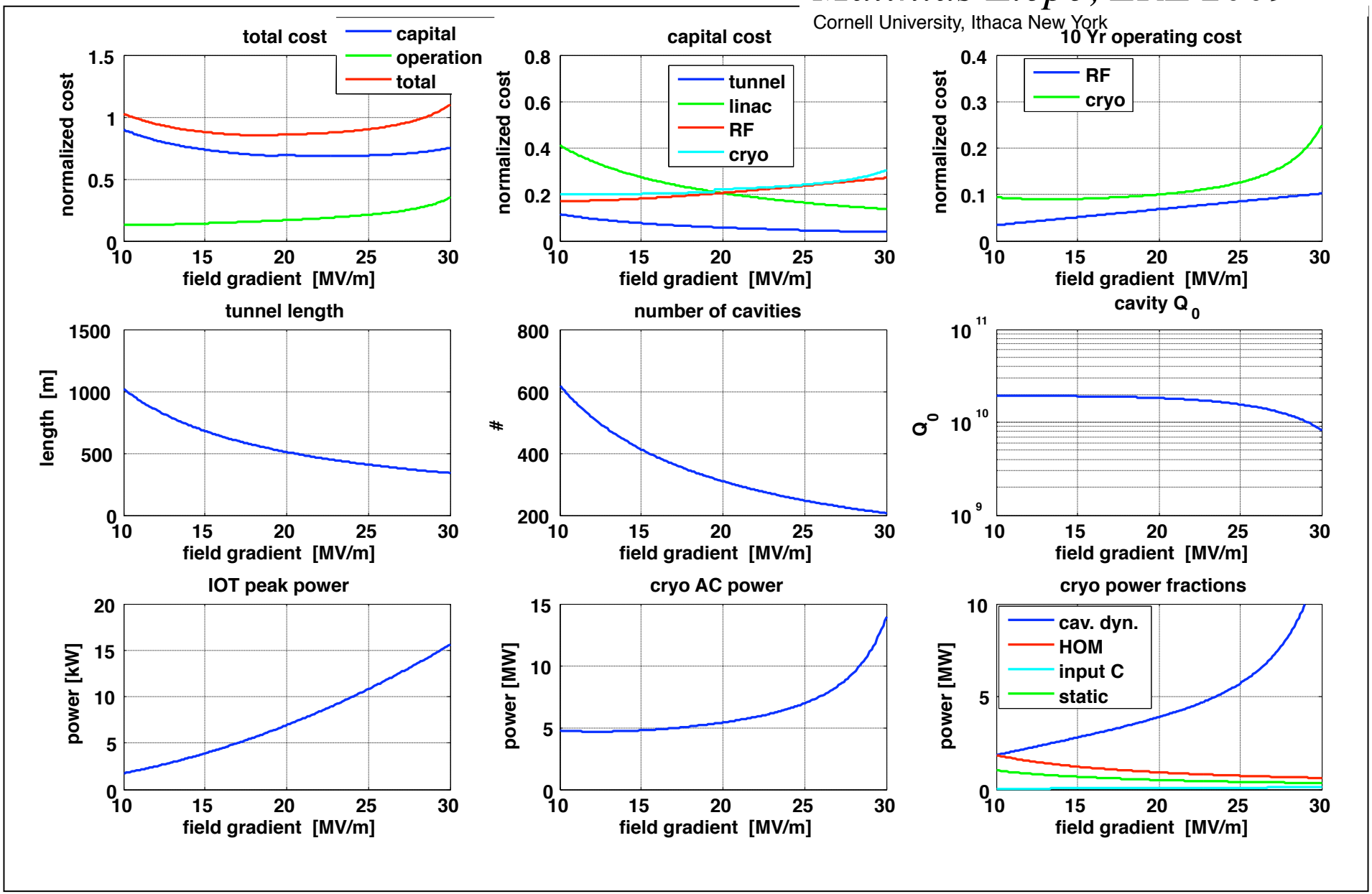
Some typical CW parameters (JLab upgrade)

- Frequency 1.5 GHz (should be lower for ADS)
- 15-20 MV/m CW (~10 MV/m real estate gradient)
- $Q_o \sim 10^{10}$ at 20 MV/m (has been demonstrated)
- CM Cost ~$2.6M*/100 MeV (Jlab upgrade module)
- RF ~$1.7M/cryomodule (8x13kW RF stations) @~1mA
  - At 10 mA (claiming some efficiency) use $10M
- 2K cryogenic plant ~$30M/GeV (4.5 kW CHL2) excl. distribution & cold box . Use $50M for new site?
- ~$176M/GeV (excluding tunnel costs)
- ~$17.6/watt beam power (10ma @ 1GeV =10MW)

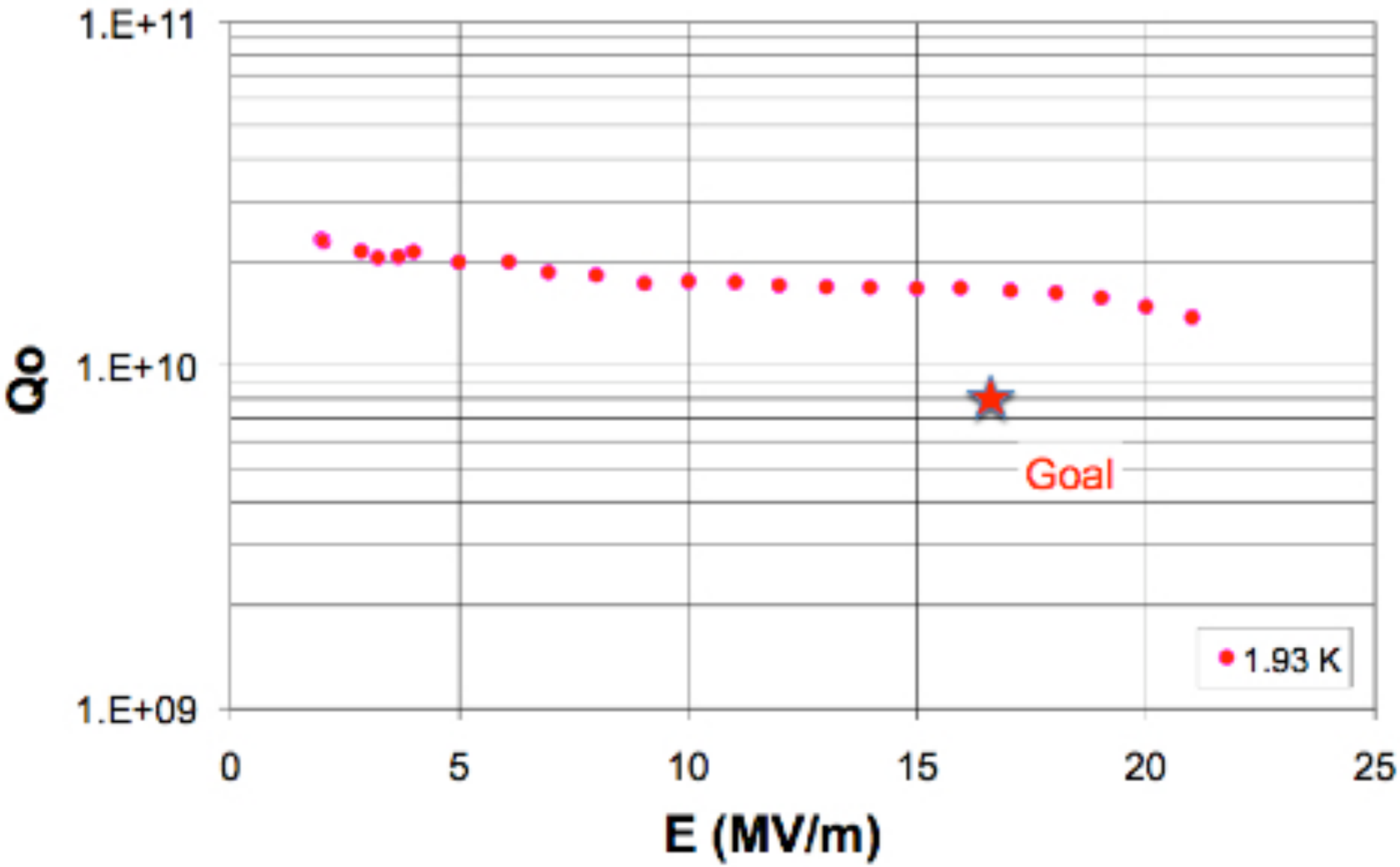
*FY08 loaded dollars, actual 12 GeV project costs will be known soon

Example: Dependence on Accelerating Field Gradient

Matthias Liepe, ERL 2009
Cornell University, Ithaca New York

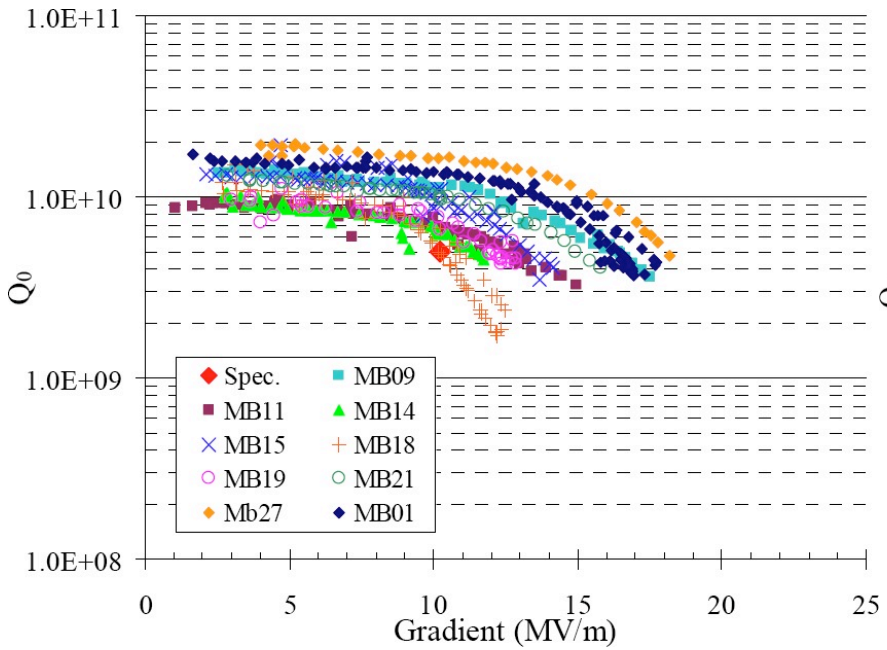


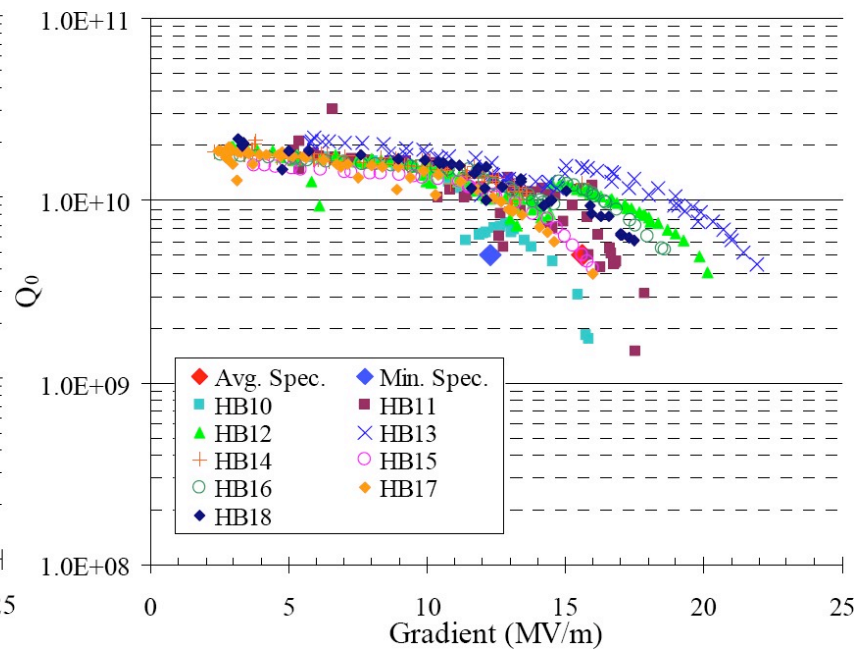
748.5 MHz HC 5-cell first test, BCP only, no outgas



SNS experience

SNS cavity processing data



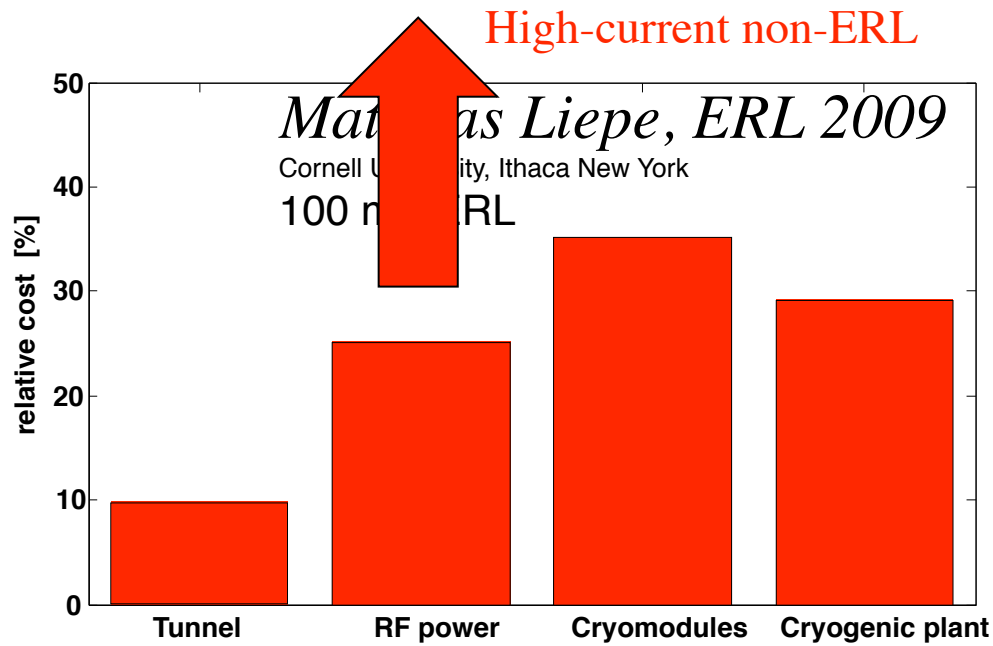


Typical SNS cavity performance in vertical test at JLab

[J. Ozelis. J. Delayen, PAC05]

Cost drivers & technical risk

- Linac cost drivers:
  - Cryomodules
  - RF
  - Cryogenics
  - tunnel
- Technical risks
  - Field emission
  - BBU
  - Beam loss (heating & activation)



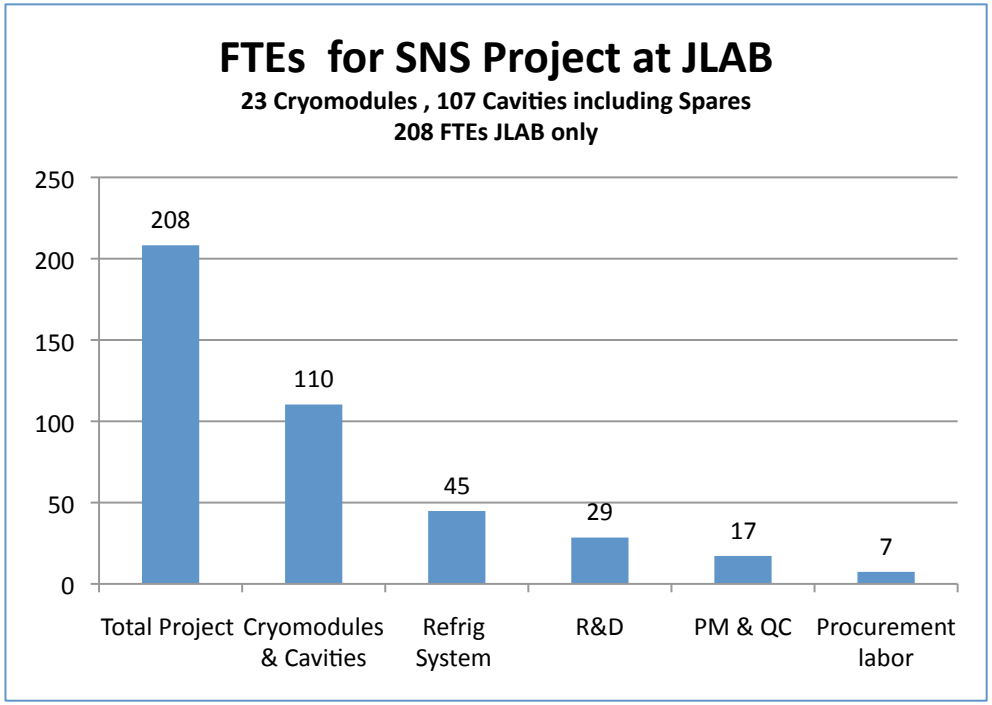
Nb: this study was for an ERL!!!!

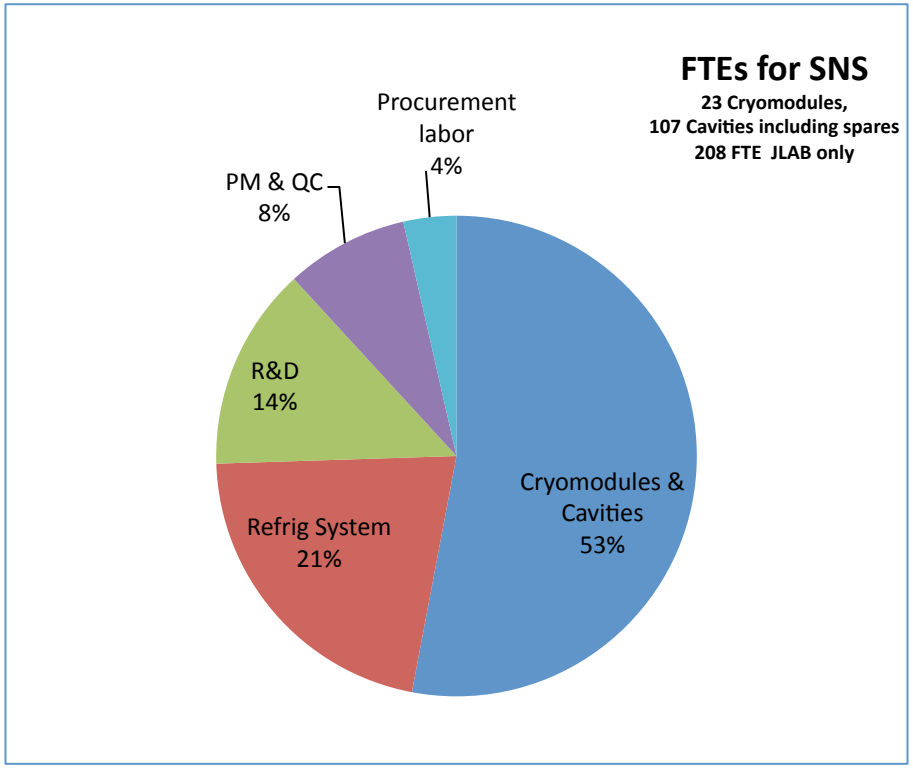
SNS Project
Estimated Costs in 2010 Dollars

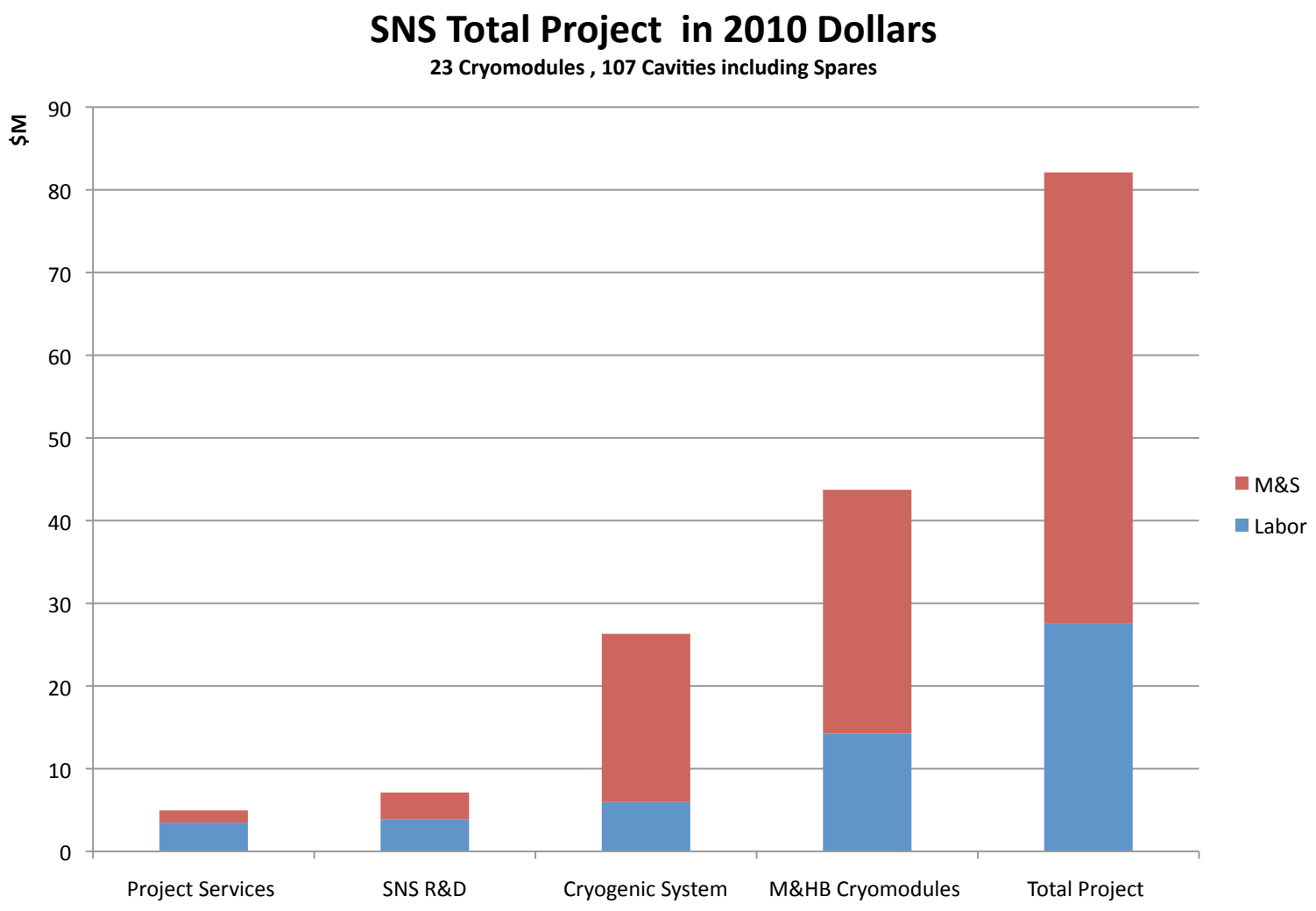
27-Sept-2010

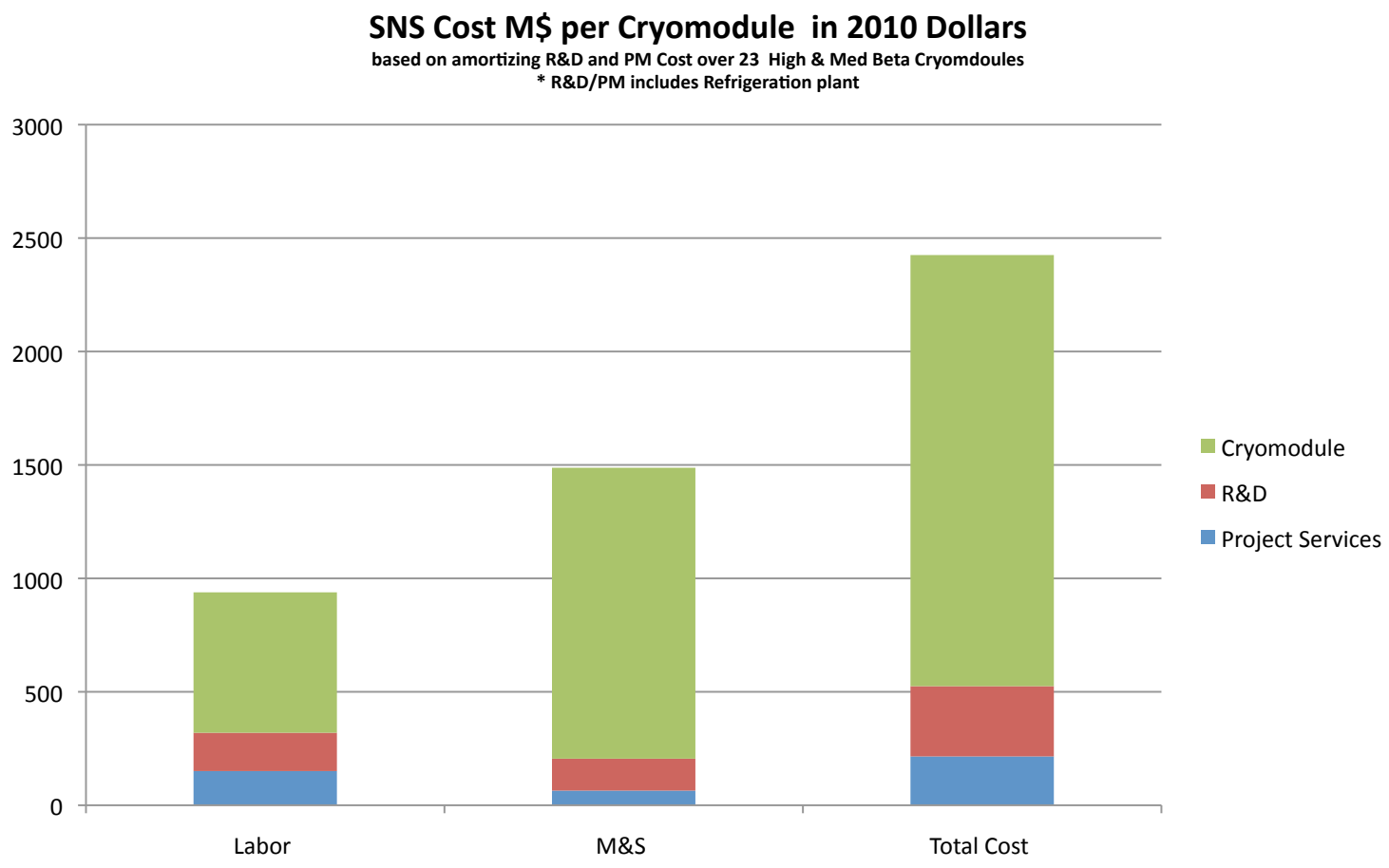
A. McEwan, JLab

SNS FTEs


FTEs for SNS Project at JLAB
23 Cryomodules , 107 Cavities including Spares
208 FTEs JLAB only
250
200
150
100
50
0
208
110
45
29
17
7
Total Project
Cryomodules & Cavities
Refrig System
R&D
PM & QC
Procurement labor

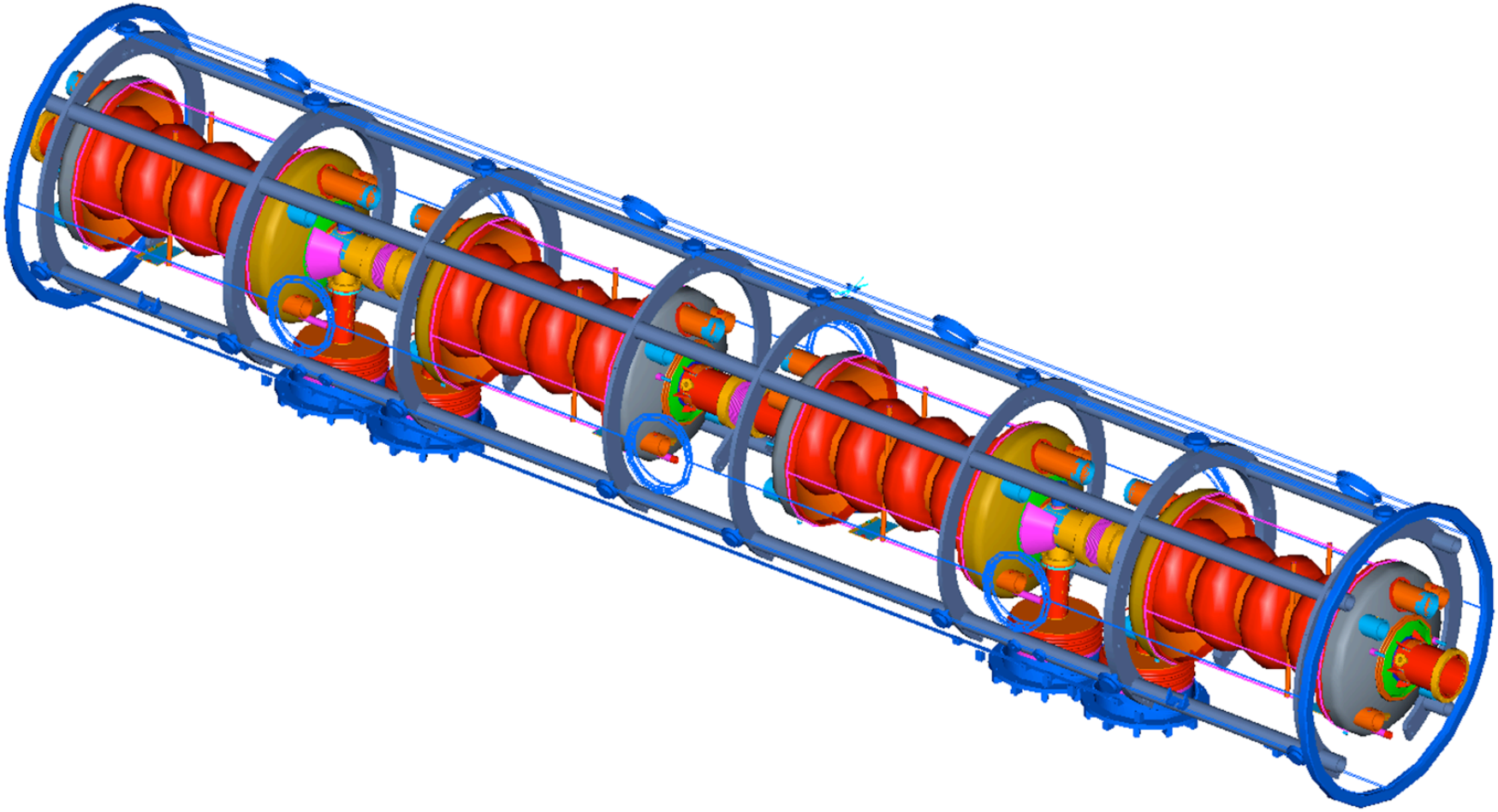

FTEs for SNS
23 Cryomodules,
107 Cavities including spares
208 FTE JLAB only
Procurement labor 4%
PM & QC 8%
R&D 14%
Refrig System 21%
Cryomodules & Cavities 53%


SNS Total Project in 2010 Dollars
23 Cryomodules , 107 Cavities including Spares
$M
90
80
70
60
50
40
30
20
10
0
Project Services
SNS R&D
Cryogenic System
M&HB Cryomodules
Total Project
M&S
Labor


SNS Cost M$ per Cryomodule in 2010 Dollars
based on amortizing R&D and PM Cost over 23 High & Med Beta Cryomdoules
* R&D/PM includes Refrigeration plant
3000
2500
2000
1500
1000
500
0
Labor
M&S
Total Cost
Cryomodule
R&D
Project Services

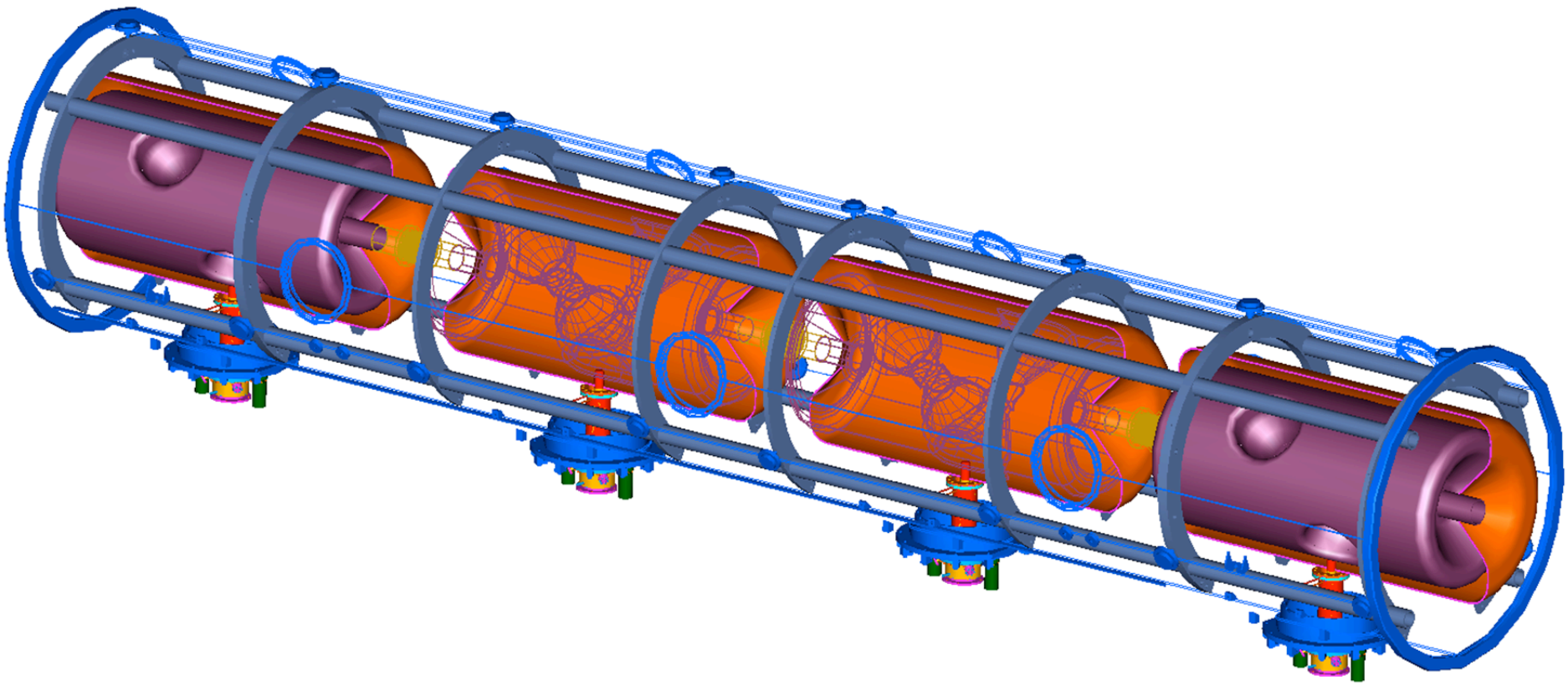
650 MHz elliptical cavities

- Fits in SNS type cryomodule



325 MHz spoke cavities

- Also fit in SNS type CM (two-spoke shown)



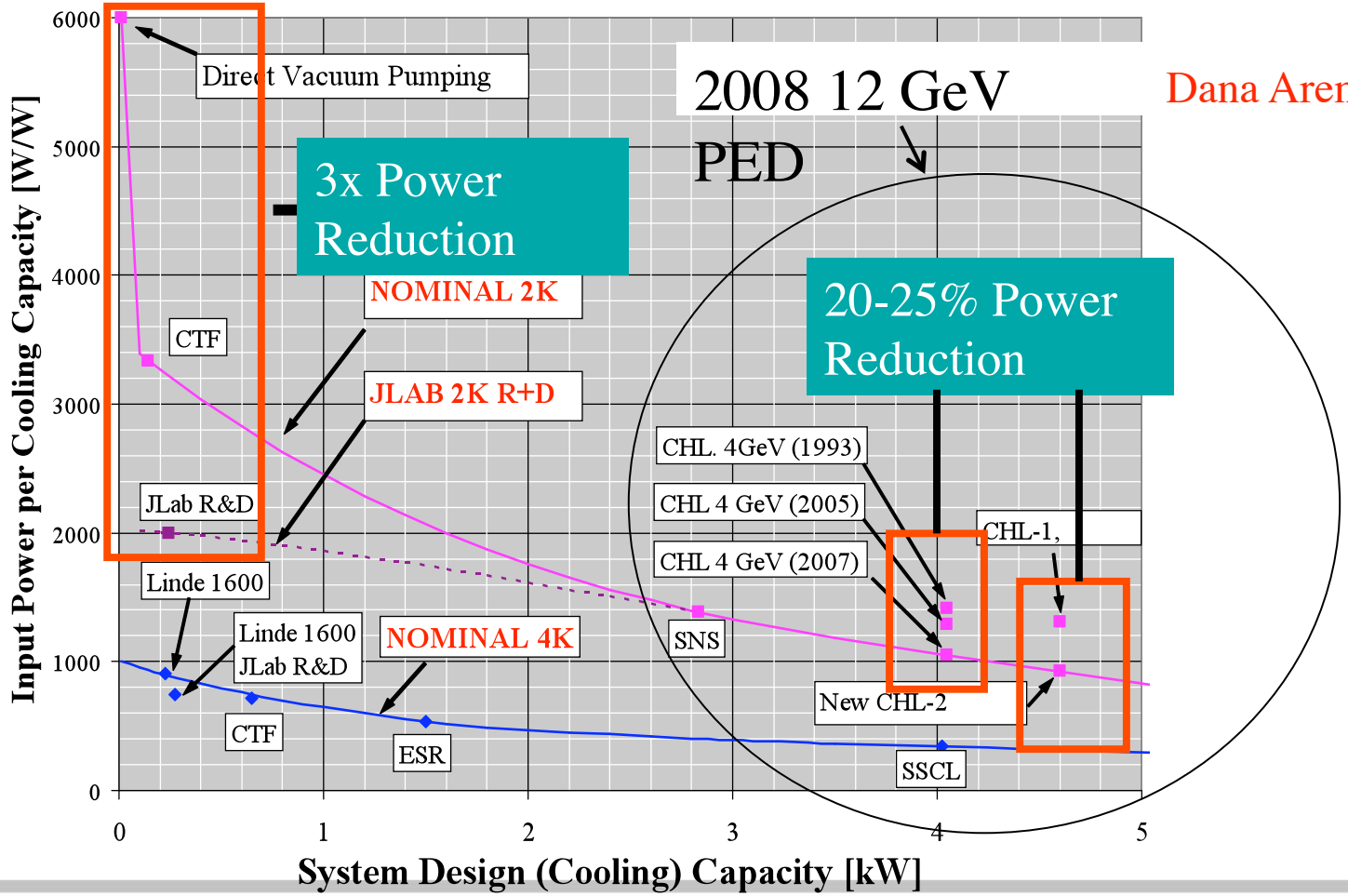
Conclusions

- CW SRF linac is a cost-effective option
- RF power is a significant cost driver
- Cryo capital and operating costs are significant
- Overall efficiency is better at high current
- Cost "optimization" depends strongly on assumptions
- SRF technology is ready for an ADS DEMO machine.
- Order now to beat future price hikes

Back up material

2K and 4K JLab Technology Development Areas

- Large machines are getting more efficient
- Difference between 2K and 4K does not make up for BCS losses



Dana Arenius