May 2019 Accelerator Status

Michael Tiefenback

Hall B Accelerator Physics Liaison

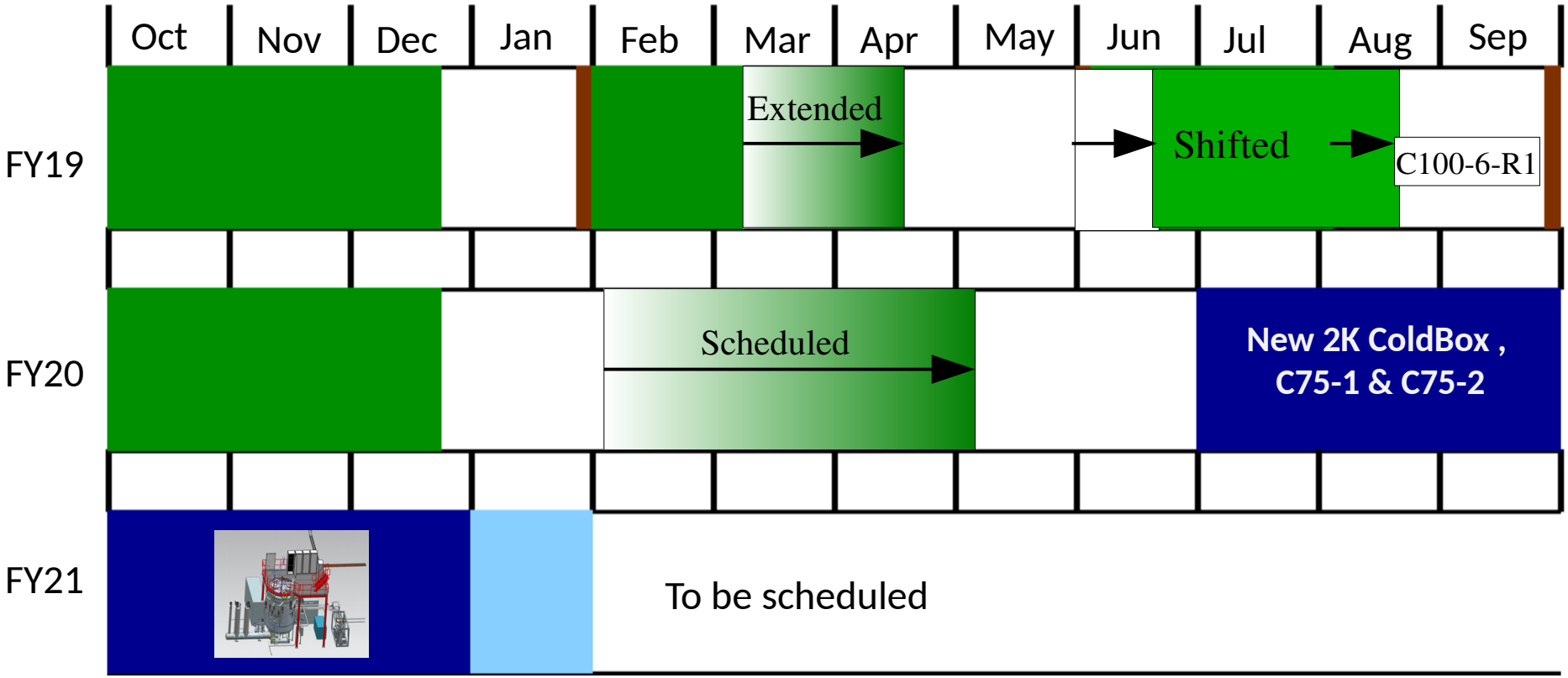
Past, Present, and Yet To Come

(updated from 2019-03-05 CLAS12 status)

The Beat Goes On

- Site Utilities (power, LCW, ...)
- Upcoming expt. schedule (you probably already know)
- Work for others (LCLS II, SBIR, etc)
- Accelerator details (something old, something new, ...)
  - Organizational reminder (Hall liaisons, etc)
  - Magnets
  - Beam performance
  - SRF (gradient and margin, etc)
  - CEBAF Performance Plan
- Summary

Replay: FY19, FY20 & FY21 Plans (Modified 25 Feb 2019)



- FY19/FY20 Schedule adjusted ~~ment under consideration~~ to recover lost weeks from Aug/Sep 2018 startup and improve alignment with C100-6-R1 delivery

Summer 2019: 9 weeks of low linac gradient Physics

- Hall A: E12-11-101
  - 1-pass, 70 microAmpere
  - Parity Violation Asymmetry measurement on a Pb target.
  - Expect significant injector optimization to maintain parity quality beam.
- Hall B: HPS
  - 5-pass beam
- Hall C: Various experiments
  - 3/4/5 pass beam, up to 90 microAmpere
  - High beam current simultaneously with Parity Quality Beam will stress the injector setup and RF due to beam loading.
  - 3 pass changes in the eight days of the run
- No Hall D operations
  - B&C may receive 499 MHz beam on 5-pass if useful.

(A. Freyberger; JLAAC 10/11/18) [no significant changes as of 2019-05-29 – M.Tiefenback]

LCLS II, SBIRs, etc: helpful "residuals"?

- LCLS II production and testing
  - Q measurement approach: LHe mass flow monitoring
  - Improved cryogenic management
- SBIR development (high-power harp)
  - Apply developments to modernize CEBAF harps
- Alternate phosphors and transition radiators
  - Improved diagnostic precision using CEBAF viewers

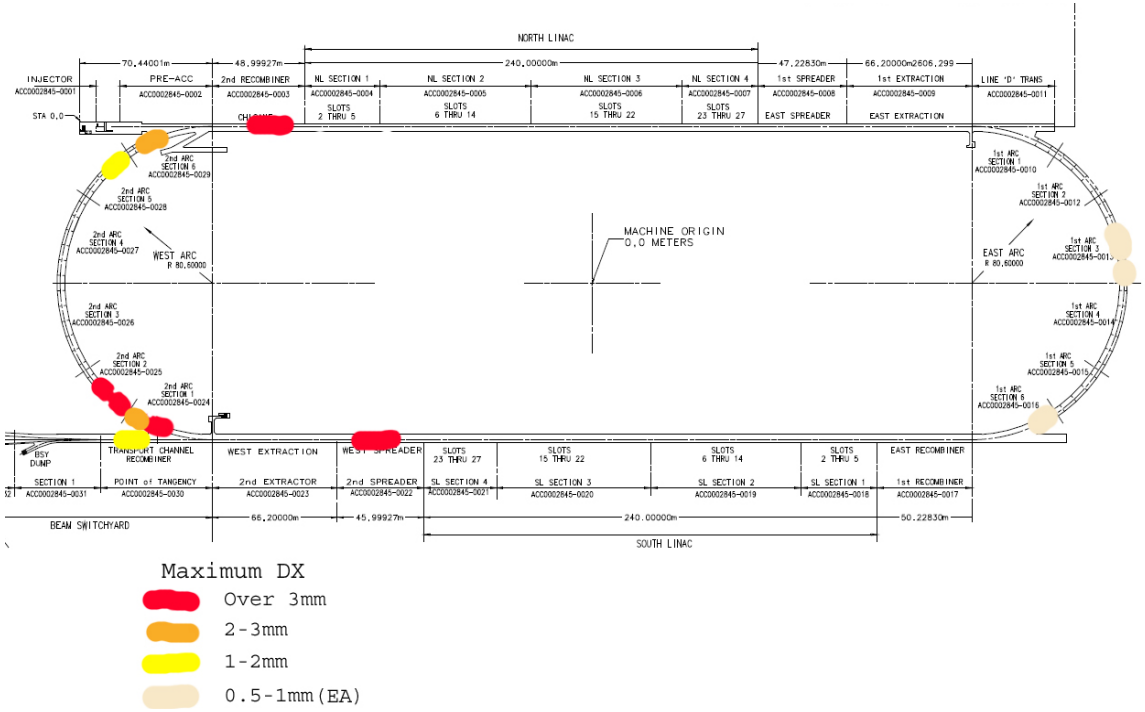
Contacts: In Case You Need Us

Region/System Liaison	Operations	Beam Physics
LERF	Shawn Frierson	Chris Tennant
Injector	Daniel Moser	Alicia Hofler
Hall A	Eric Forman	Yves Roblin
Hall B	Brandi Cade	Michael Tiefenback
Hall C	Lester Richardson	Jay Benesch
Hall D	Michael McCaughan	Todd Satogata

System	Performance Integrator
Gradient	Ken Baggett
Magnets	Michael Tiefenback
High-Power Dumps	Anthony Dipette
Beam Diagnostics	Joe Gubeli

Magnet-specific Bits

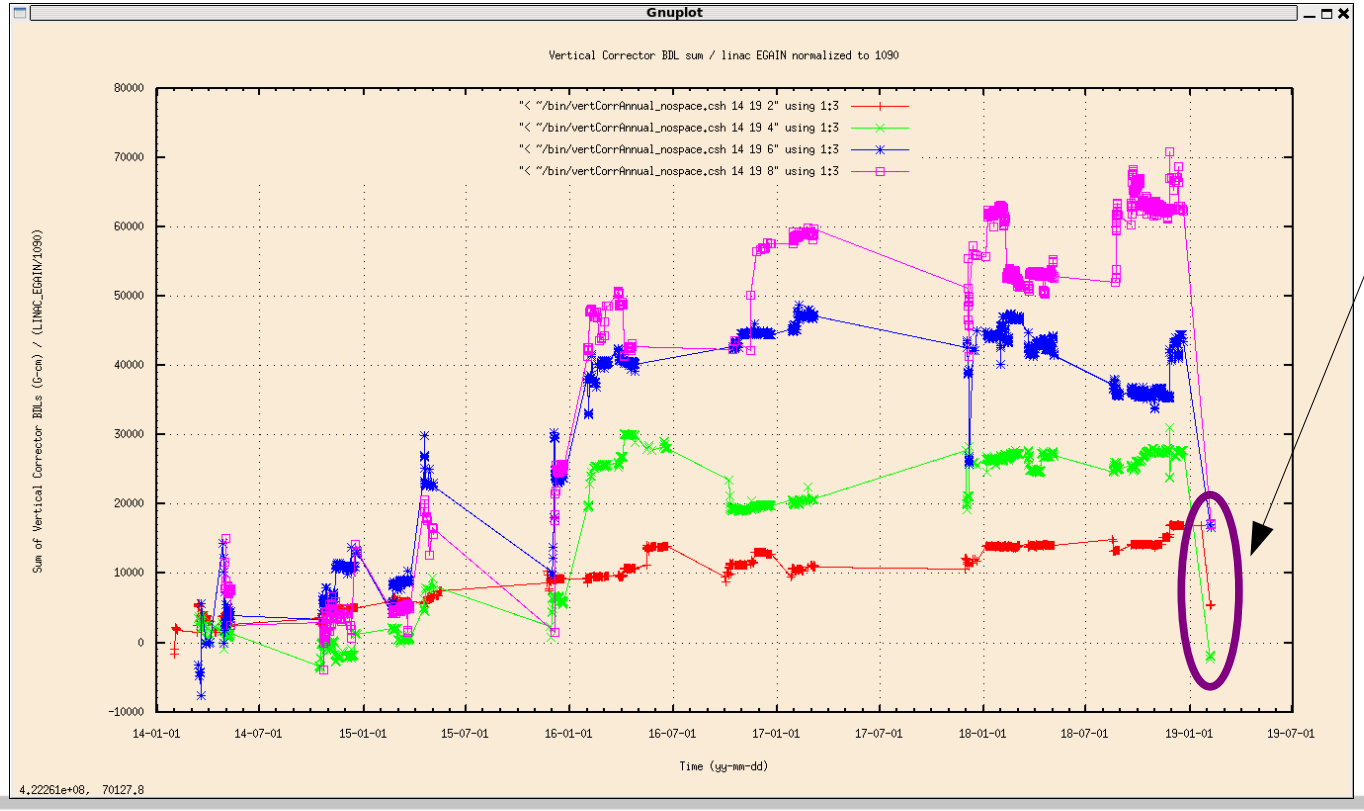
- Misaligned quadrupoles identified in 2R and 6R (2018)
- Discoveries during survey and correction:
  - Dipole stand ceiling mounts found loosened
  - Thermal cycling suspected as cause (open question)



  - Worst offenders (dipoles) corrected short-term
  - Long-term "sticky" corrections being studied
  - Quadrupole supports generally not involved

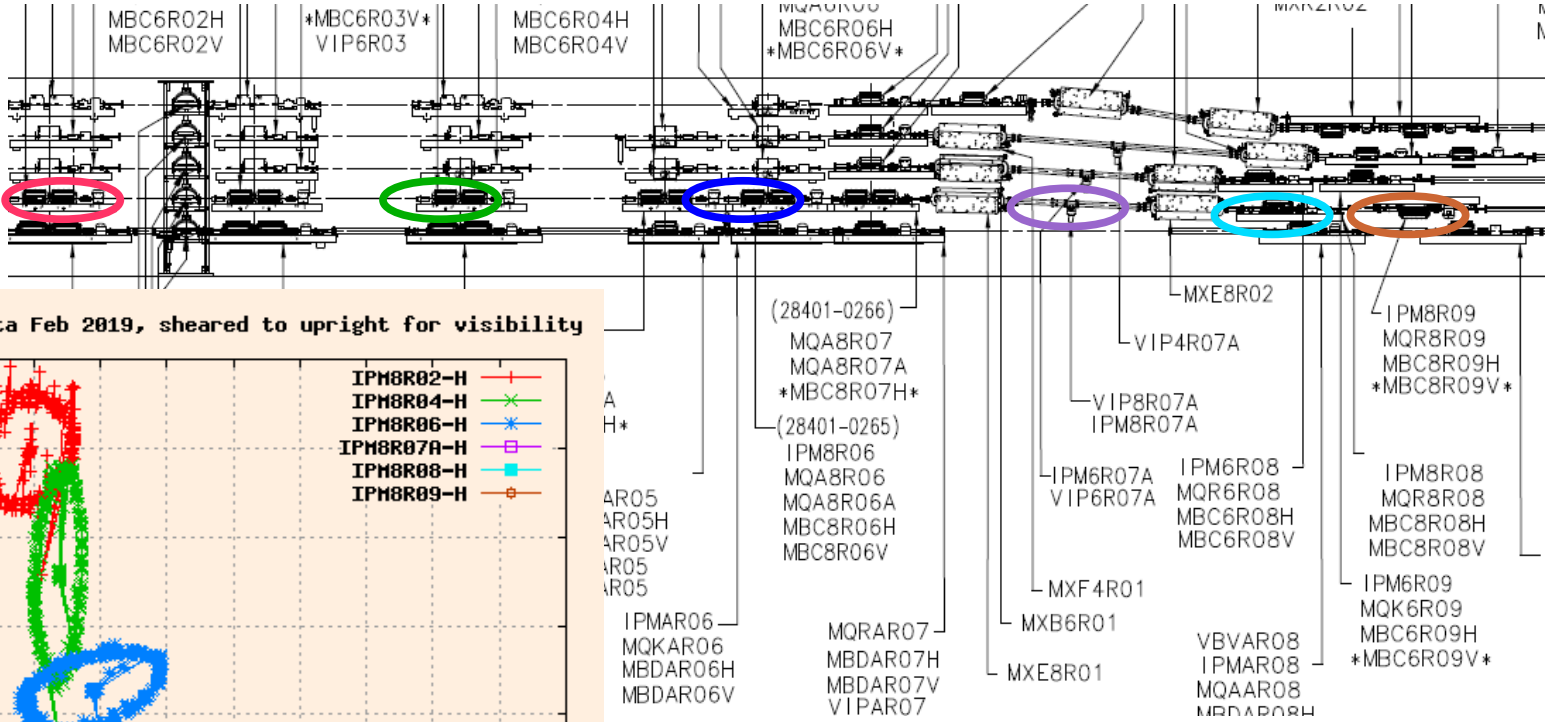
Vertical Corrector Sum: West Arcs

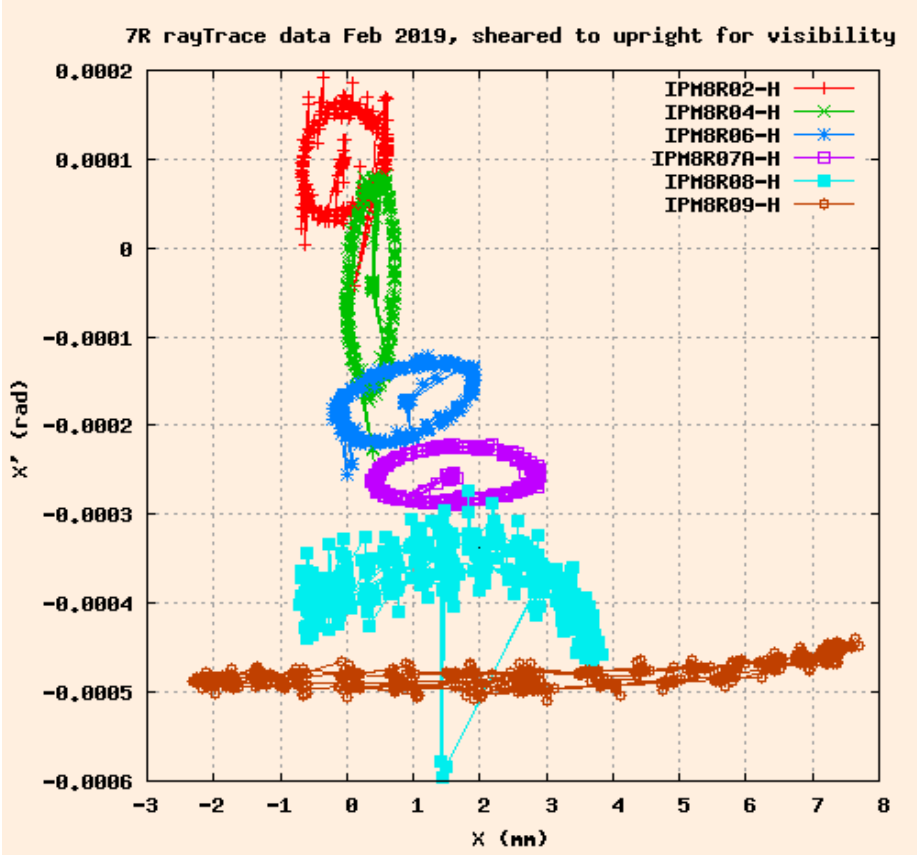
- elog 3648713 showing West Arc corrector sums 2014-2019
- Stand tops tilt inboard (CW); rolled dipoles kick downward
- May be major contributor to recent emittance growth
- After realignment, vertical correctors relax to 2014 strength



Localizing Magnetic Non-linearities?

8R Layout





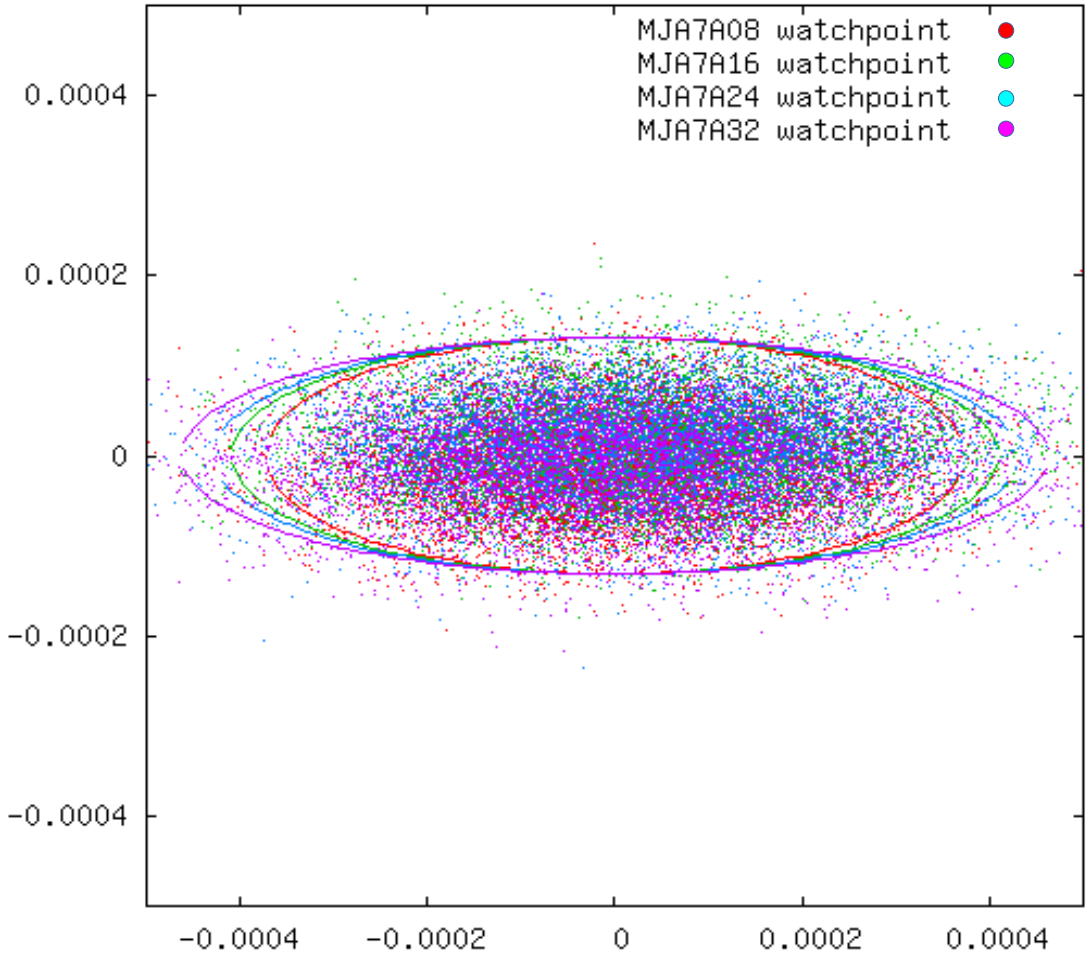
rayTrace data cast suspicion on 8R intermediate step dipoles

Alignment? Other compromises? Investigating...

Diagnostic Updates

- New Synchrotron Light Monitor intalled: 7A08 dipole
  - Chambers for successors in hand
- Alternate viewer material concurrently installed
  - Quantitative comparison of SLM vs. viewer
- SBIR high beam power harp sited in Hall C line
  - Multiple hardware improvements being tested

Computed Profiles: Final Dipoles of 7A SuperPeriods



Location	σ_X (μm)	σ_Y (μm)
MJA7A08	148.	54.
MJA7A16	163.	54.
MJA7A24	170.	54.
MJA7A32	184.	54.

Ellipses in figure are drawn at 2.5 “sigma” to guide the eye

Why SLM-based matching?

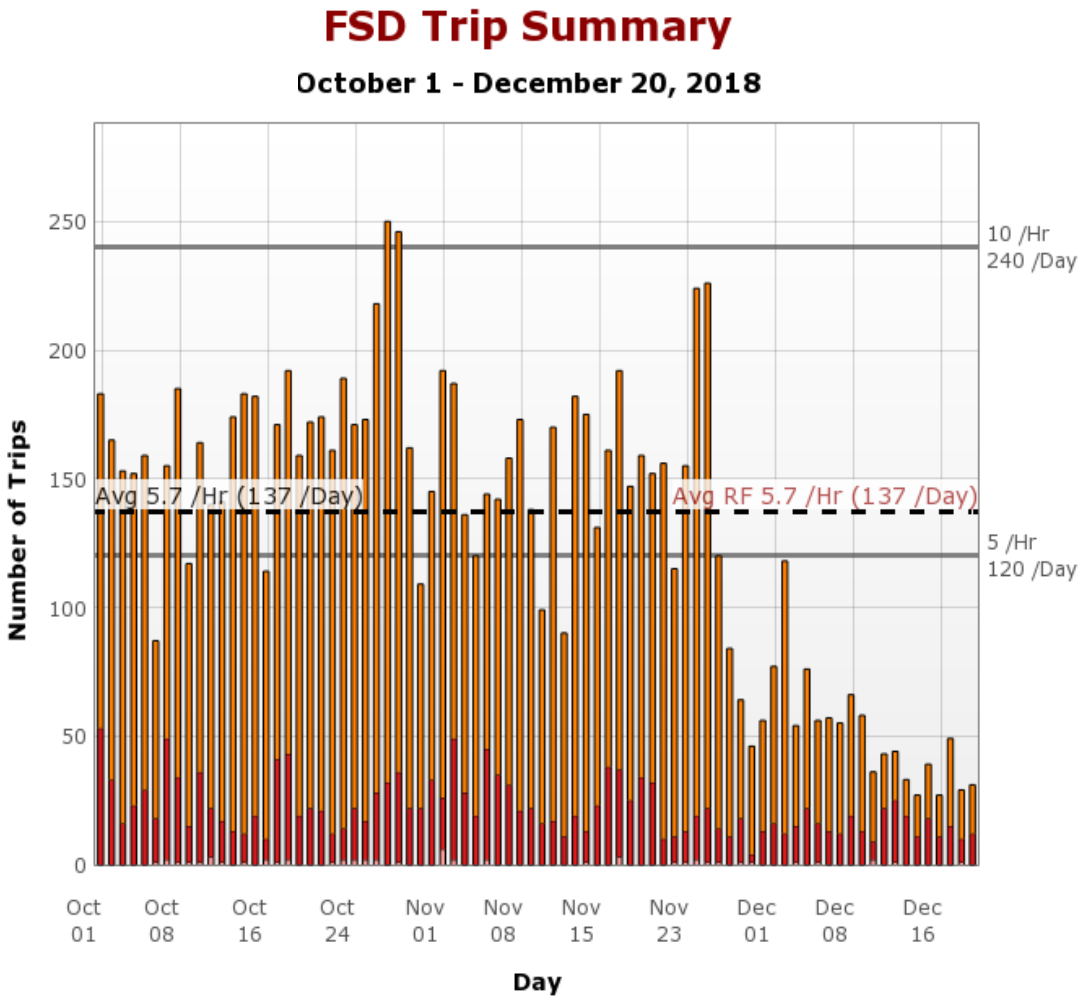
- Existing optical processing demonstrated by B. Freeman in bunch length measurements provides beam size info
- Bench tests of identical hardware prior to installation
  - verifies calibration
  - ensures systematics are truly systematic
- Arc 7A installation is a representative high arc test
  - 70% emittance growth, σ_x ~ 150-200 microns
  - Compare qsUtility solutions and 4-SLM protocol solution
  - Tests procedural convergence and execution time
  - Provides continuous intermediate arc beam profiles
  - Design easily adapted to other arcs if justified by setup efficiency gains
  - Instant comparison of multiple laser-sourced beams

Low Linac Gradient Margin

- Attempts to improve linac gradient margin in 2018:
  - Install "P1" cryomodule (7-cell cavities) in 1L07
  - Exchange warm windows in 1L20 for ceramic
- Each effort resulted in *decreased* margin
- First mitigation: asymmetric linac operation 1040/1060
- Chronic low NL margin results in poor beam reliability
  - Excessive trip rate, especially for NL
- Subsequent linac energies reduced to 1000/1020
  - More favorable reliability, but lower energy
- Help is on the horizon (not yet installed/commissioned)

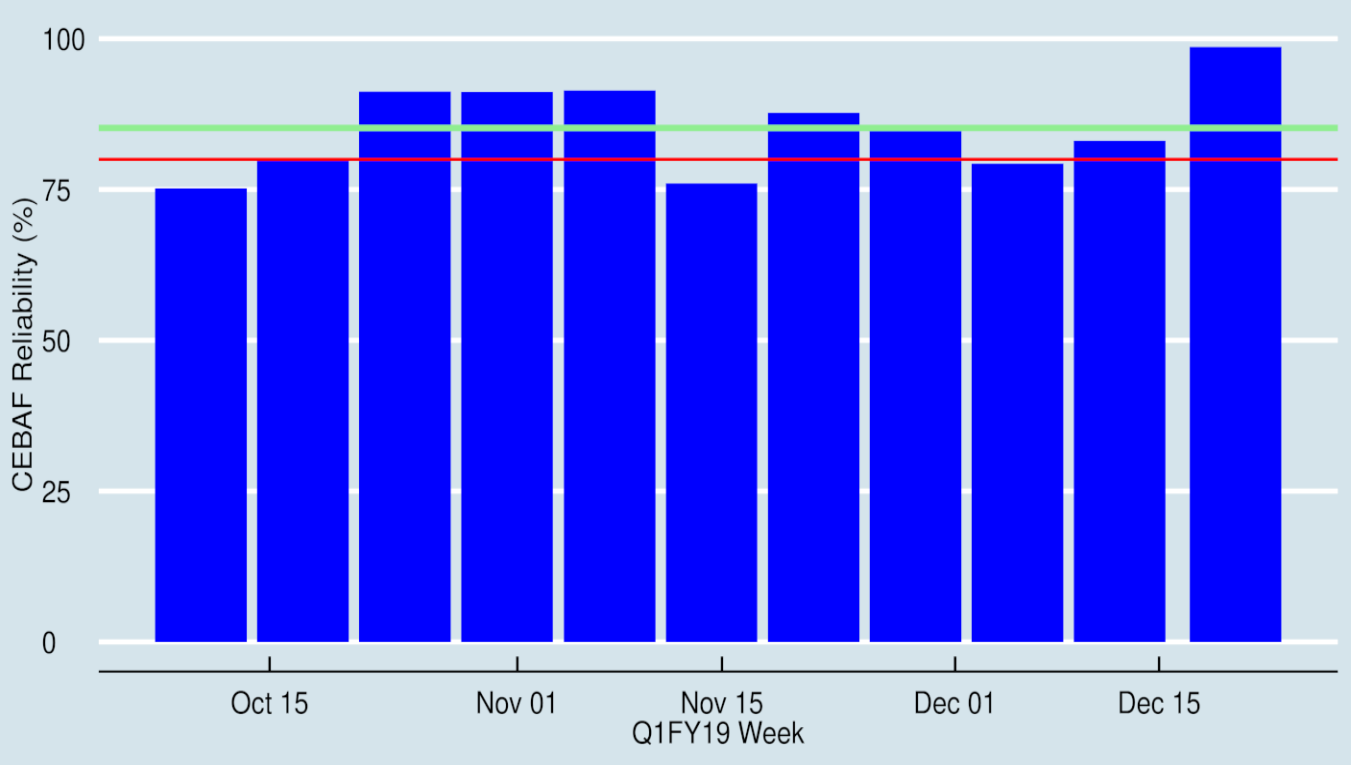
Q1FY19 CEBAF Performance

- Oct/Nov operations at 1050 MeV/linac: trippy but productive
- December ops at 930 and 805 MeV/linac demonstrated benefits of extra headroom
  - Trip rate dropped as expected
  - Able to bypass cavities and even complete cryomodules mostly eliminated RF recovery days



Arne Freyberger

Q1FY19 CEBAF Performance



- First quarter of 12 GeV era with >80% reliability
- 805 MeV/linac in last eight days of run had reliability >98%
  - Necessity of CEBAF energy reach and RF gradient plan

CEBAF Performance Plan

- **Goal**: Operate CEBAF at design energy with adequate margin
  - 1090 MeV/linac with 100 MeV of margin in each linac
  - 100 MeV margin permits entire C100 bypass if necessary
- Emergent problem cavities can be bypassed
  - collect and address during RF recovery days
  - with marginally higher but tolerable trip rates
- **Issues**:
  - "Current" energy reach 1050 MeV/linac vs 1090 MeV/linac design
  - Energy reach degrades at 34-48 MeV/pass/year
    - JLAB-TN-022 and preliminary analysis of 2016-18 operations
- **Strategy: add gradient, slow or stop degredation**
  - CEBAF Performance Plan

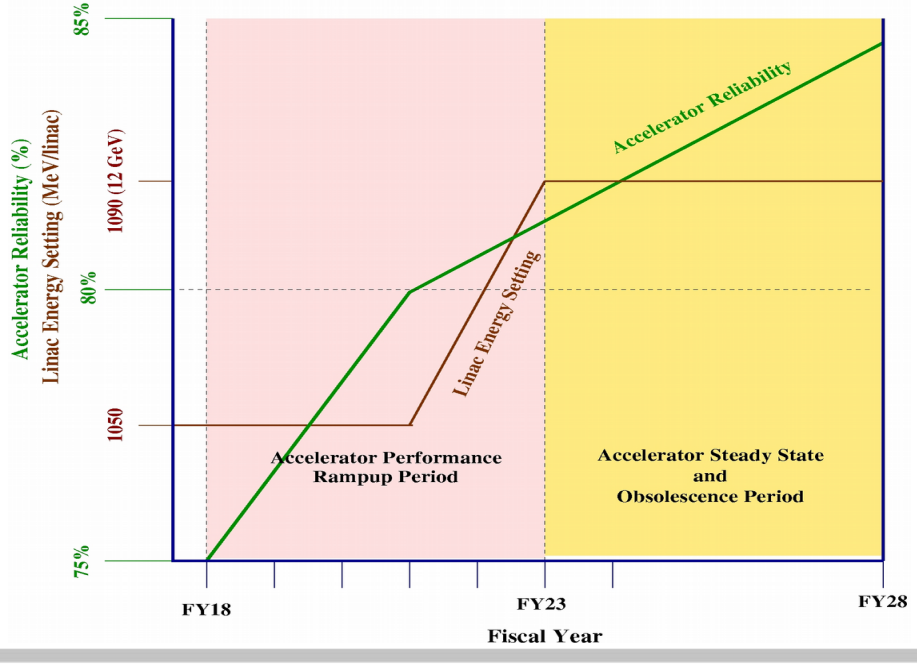
[slide credit: Todd Satogata]

CEBAF Performance Plan

- Long-term strategy
  - Identify and purchase critical spares
  - Replenish consumed spares (e.g. klystrons)
  - Increase energy reach
    - C75: refurbish 8 original C20 modules
    - C100: refurbish modules
    - Particulates: Clean warm girders, upgrade vacuum systems
  - Mitigate obsolescence
- Target: 34 weeks/year ops at >80% reliability

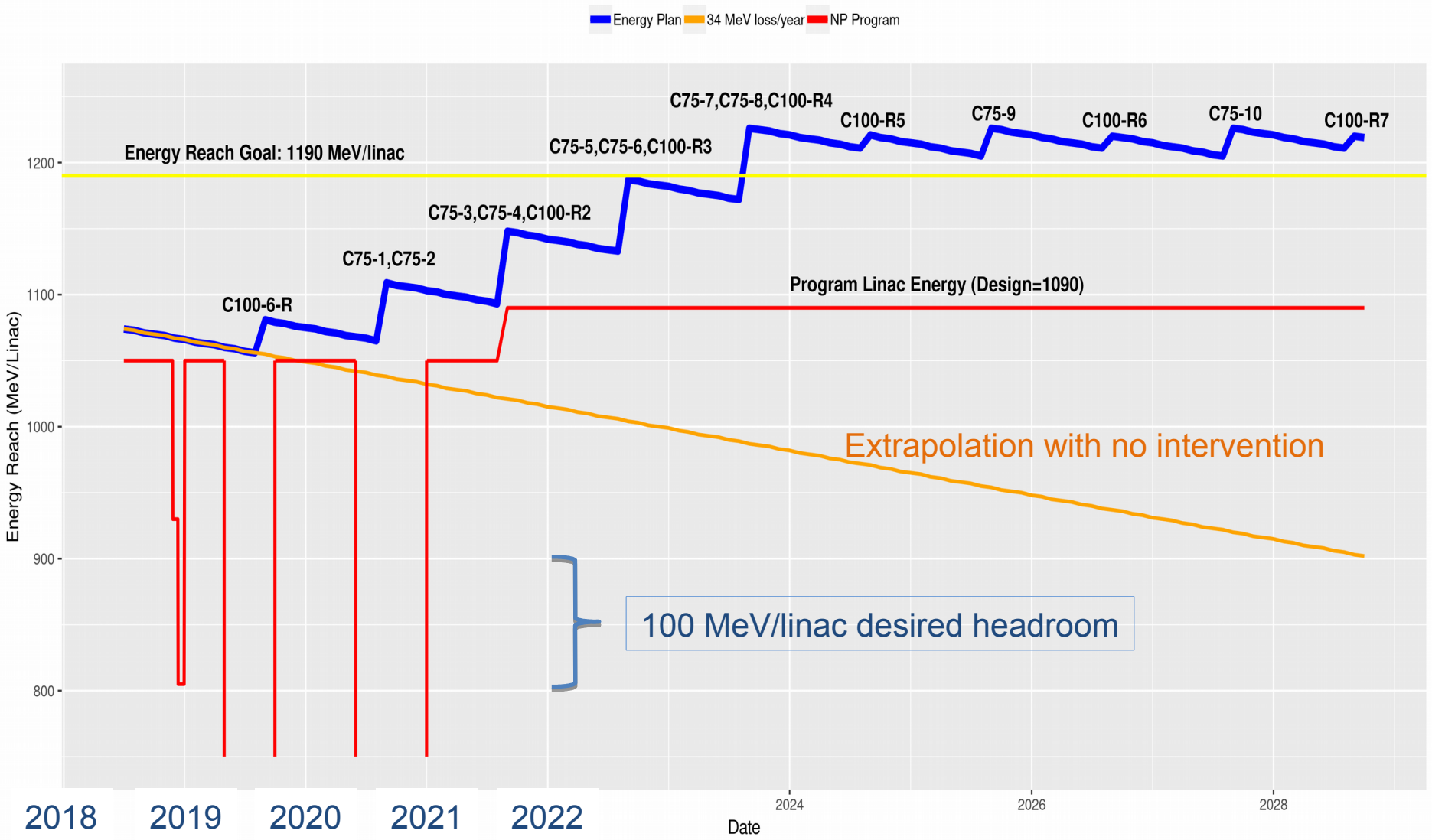
Category	Unit/Metric	Goal
Reliability	%	> 80
Optimal Weeks	weeks-per-year	34
Beam Tuning Hours	h/week	< 8
Peak Hall Multiplicity	Number of halls	4
12 GeV Program Expected Duration	years	20
Linac Design Energy	MeV	1090
Required Linac Energy Margin at start of FY	MeV	> 110
Overall FSD Trip rate	trips/hour	< 15
Overall FSD Trip Downtime	min/hour	< 5
RF Trip rate	trips/hour	< 10
Beam Loss Trip rate	trips/hour	< 5

Table 1: The CEBAF Performance Goals for the 12 GeV CEBAF era.

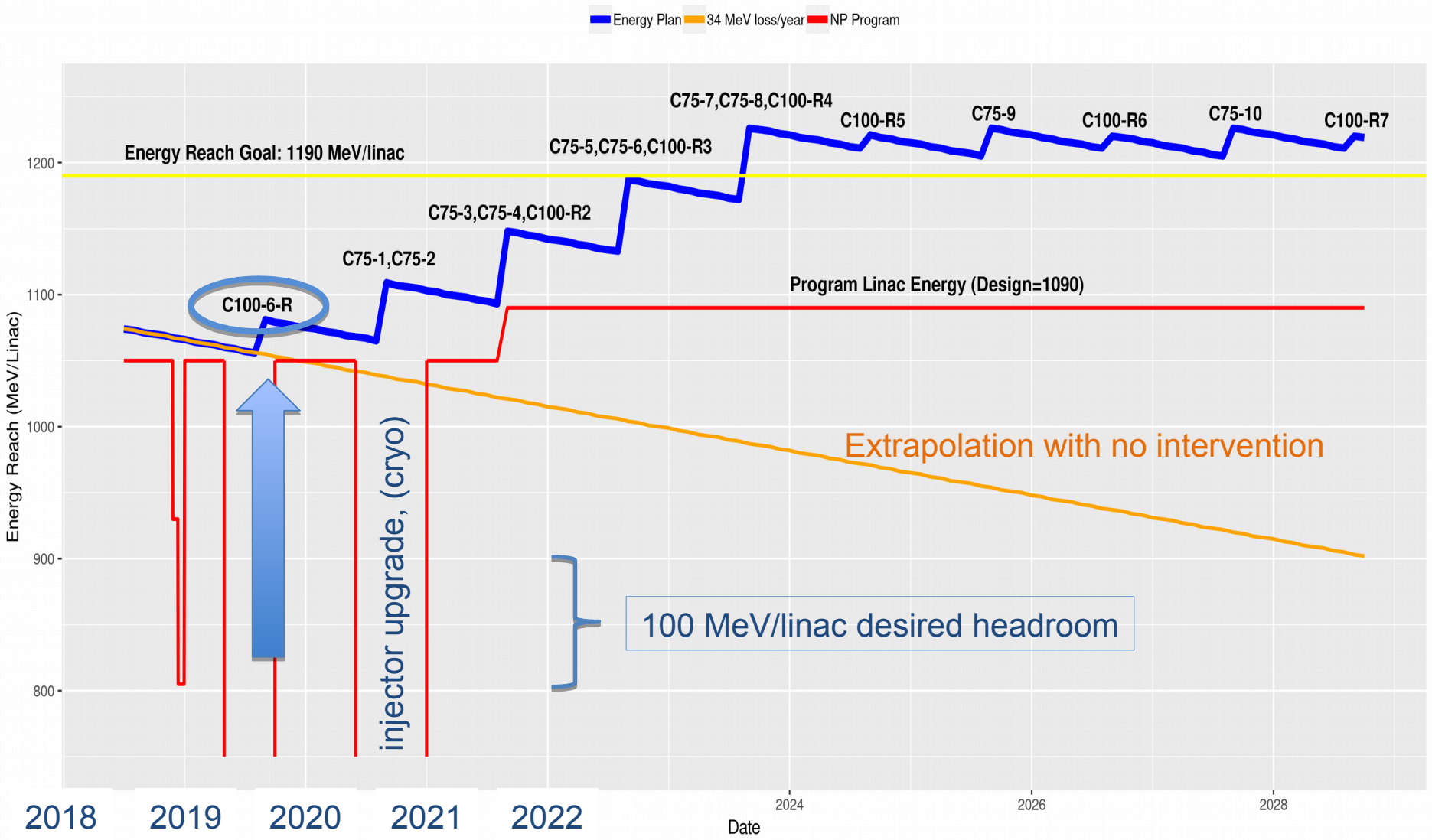


Arne Freyberger/Randy Michaud

Energy Reach Chart



Energy Reach Chart



C100-06R Refurbishment Status

C100-06R Status

- The cryomodule was removed from the linac as part of the 2018 summer down and set aside to “cool down”
- Disassembly of the cryomodule completed Nov 2018
  - No signs of radiation damage in components from field emission
- Cavities reprocessed and tested Dec 2018-Feb 2019
  - Field emission free cavities beyond the operational limit after ultra pure high pressure rinsing!
- Cavities met all operational and assembly requirements

C100-06R Plans

- Assembling cavity string in February 2019
- Complete cryomodule assembly by end of July 2019
- Complete cryomodule acceptance test by Labor Day
- **Install and commission in September 2019**

Tony Reilly

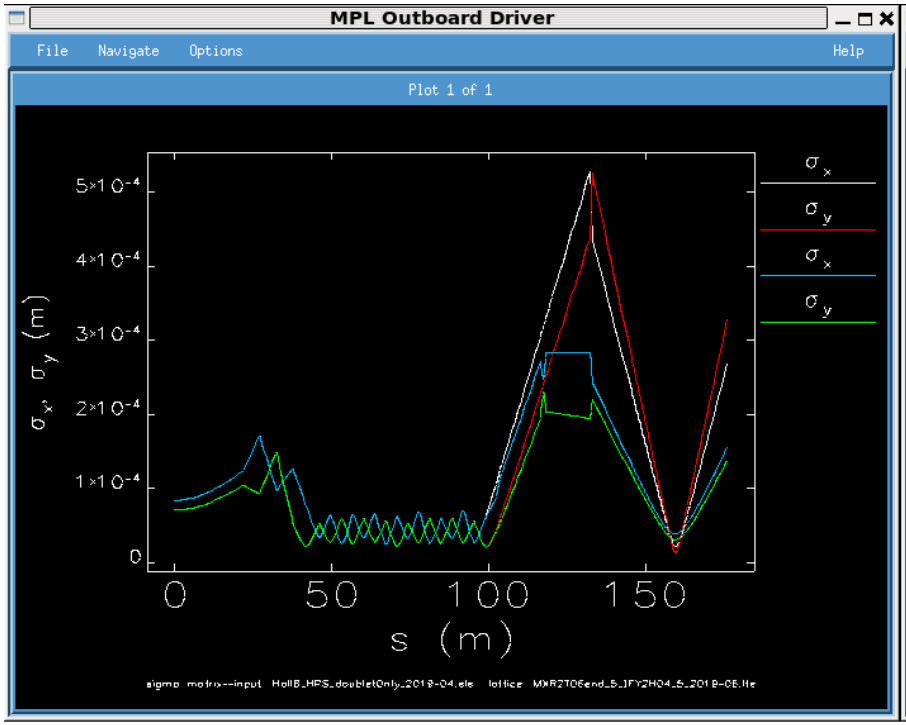
C100-06R VTA Summary – Final

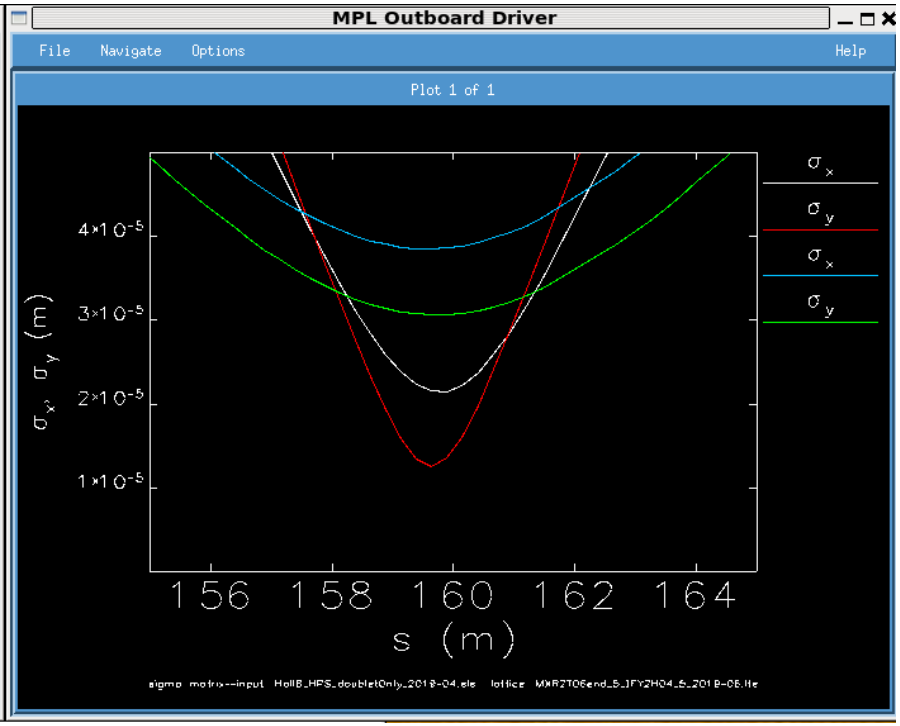
Cavity Number	2011 Q0@20 MV/m	2011 Field Emission Onset (MV/m)	2019 Q0@20 MV/m	2019 Field Emission Onset (MV/m)	Comment
27	Not tested	Not tested	1.00E+10	NA	Pass, FE free Admin limited at 24
39	8.00E+09	15.6	1.00E+10	NA	Pass, FE Free
51	6.60E+09	11	1.00E+10	21	Pass FE onset at 21 MV/m
53	1.26E+10	13.5	1.00E+10	NA	Pass, FE Free
56	1.28E+10	25	1.00E+10	NA	Pass, FE Free
43	8.00E+09	13	1.30E+10	21.5	Pass, FE onset at 21.5 MV/m
47	6.70E+09	12	1.00E+10	NA	Pass, FE Free Admin limted at 24 MV/m
55	7.34E+09	15.5	1.10E+10	NA	Pass, FE Free Admin limited at 24 MV/m

HPS Beam Expectations

- Allow beam expansion downstream from 2C20
- Peak beam size near 2H00/2H00A
- Strong doublet focusing onto target region
- Beam size for HPS:
  - confidently under 50 microns
  - possibly as small as 20 microns
- Beam size limited by
  - metrology
  - drift of incoming beam parameters (waist location)
  - as-found halo (to be determined)
- Weak skew coupling at Lambertson magnet

Optics Options for HPS





- Model beam emittances forecast from recent 5 GeV beam properties
- Tight focus on target increases sensitivity of focus to incoming beam
- 2H02 harp proximity to target facilitates precise beam size measurement
- Halo uncertain at such small beam size; little relevant practical experience

Summary

- Recent operation highlights need for gradient margin
- CEBAF Performance Plan execution is ongoing
- On-site upgrades and maintenance are ongoing
- Contamination control is essential with SRF
  - In-situ recovery may be possible without full overhaul
- We'll do our best to satisfy experimental requirements
- Small beam size expected on HPS target