KLF Accelerator Requirements and R&D

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- Hall D GlueX operating parameters
- Updated beam requirements for KLF
- Challenges and R&D
- Summary and open questions

Accelerator Parameters

Electron Beam Parameters

$E_e = 12\ GeV$	$I = 5\ \mu A$
Bunch spacing	$64\ ns$

No major problems.

Doable !

Confirmed by accelerator experts

Slide 29 of Moskov's talk ☺

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12 GeV CEBAF Beam Parameter Tables

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https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-154003/18-022.pdf

Abstract

A team including four APELs (Accelerator Physicist Experimental Liaisons): Y. Roblin (Hall A), M. Tiefenback (Hall B), J. Benesch (Hall C) and T. Satogata (Hall D), has been charged with generating a 12 GeV Beam Parameter Tables document similar to the table describing 6 GeV CEBAF beam properties produced by L. Cardman and J-C. Denard in 2001 (see Appendix A).

This resulting document consists of four tables describing beam parameters, a potential user may expect, for beam delivery to Halls A, B, C and D. The fifth table – Parity Beam Parameters - summarizes standard beam properties for parity violation experiments along with a list of special considerations.

These are typical numbers that are readily achievable at the various halls with standard 12 GeV era setup procedures. Other parameters may be achievable with extra setup time, hardware changes or additions, or both. Experiment planners considering parameters outside of this scope should consult the relevant hall APEL and accelerator experts when writing experimental proposals to assess feasibility of those parameters. Presented tables provide the 'next level' refinement on 'Beam Requirements for Out-Year Operations' (see Appendix B).

This note will hopefully serve as a useful guide to proponents of new experiments at CEBAF.

- Hall D ”design” beam parameters from Parameter Tables Tech Note
- Revisit these after reviewing PAC47 proposal KLF beam parameter requirements

Bunch length o(3 ps)
Can make shorter with larger energy spread

Hall D

Beam Property	Nominal Value/Range	Temporal Stability over 8 hours
Spot size at target♦ (rms) [μm]	Horizontal < 1000 Vertical < 500	Horizontal ~ 100 Vertical ~ 100
Angular divergence at target [μrad]	< 15	< 1
Current [nAmp]	1 - 2000#	10%
Charge per bunch [fCoul]	4×10^{-3} - 8	10%
Bunch repetition rate [MHz]	249.5*	NA
Beam position	± 1 mm	< 40 μm (with 5C11B lock)
Energy spread♠ (rms)	2×10^{-3} - 3×10^{-3}	~ 10% of nominal (linac crested)
Beam direction	± 30 μrad	< 2 μrad (active collimator lock)
Energy range [GeV]	8.8 - 12.1	NA
Energy accuracy♥ (rms)	3×10^{-3}	stable
Background beam halo	< 0.1%	stable
Beam availability (including RF trips)	60%	stable

'<' – 'not to exceed'

♦ Based on emittance measurement at 5C00 logged since late 2015. Straightforward tuning provides geometric emittances of: $\varepsilon_x \sim 7\times10^{-9}$ m-rad, $\varepsilon_y \sim 5\times10^{-9}$ m-rad.

Consistent with 900 kW beam power and limits on Faraday cup and beam stopper.

* Other frequencies, such as 499 MHz are also available.

♠ These are ideal numbers, no RF phase errors, just synchrotron radiation. This assumes phasing software running in background to minimize effects of RF curvature

♥ Set by errors in dipole field measurements only.

KLF Requirements

- Documented in PAC47 proposal, section 6.1.1
- Easy (or easily assumed) parameters:
  - 12 GeV unpolarized electron beam
  - Bunch-coincident timing signal / trigger (resolution o(3ps))
    - Good enough for TOF resolution requirements (section 6.1.4)
- Challenges:
  - Lower bunch rep rate for clean TOF measurements
    - Reduce bunch rep rate by factor 32-64 from nominal 499 MHz
      - Beam delivery at 15.59 MHz (64 ns) or 7.80 MHz (128 ns)
    - Requires laser system modifications
  - Maximize beam current up to CPS dump power limit
    - 30-60 kW dump power at lower rep rate => 2.5-5.0 uA beam
  - High bunch charge operations
    - Helped by ongoing injector upgrade (FY20 summer SAD)

KLF Current and Bunch Charge Options

- Documented in PAC47 proposal, Table 3 (p. 25)

CPS Power (kW)	Current (μA)	Rep Rate (MHz)	Harmonic of 499 MHz	Bunch Charge (pC)	Equivalent 499 MHz Current (μA)
30	2.5	15.59	32nd	0.16	80
	2.5	7.80	64th	0.32	160
60	5.0	15.59	32nd	0.32	160
	5.0	7.80	64th	0.64	320

- Laser modifications required
  - Pulse picking system for subharmonic generation
  - Multiple-stage amplification for high bunch charge
  - Made somewhat easier if bunch charge stability requirements are not stringent
  - Expect few nA of out of time bleedthrough (Joe Grames/Reza Kazimi 5/6/19 email)
  - Modifications are o($100k) (Joe Grames/Matt Poelker 5/9/19 email)

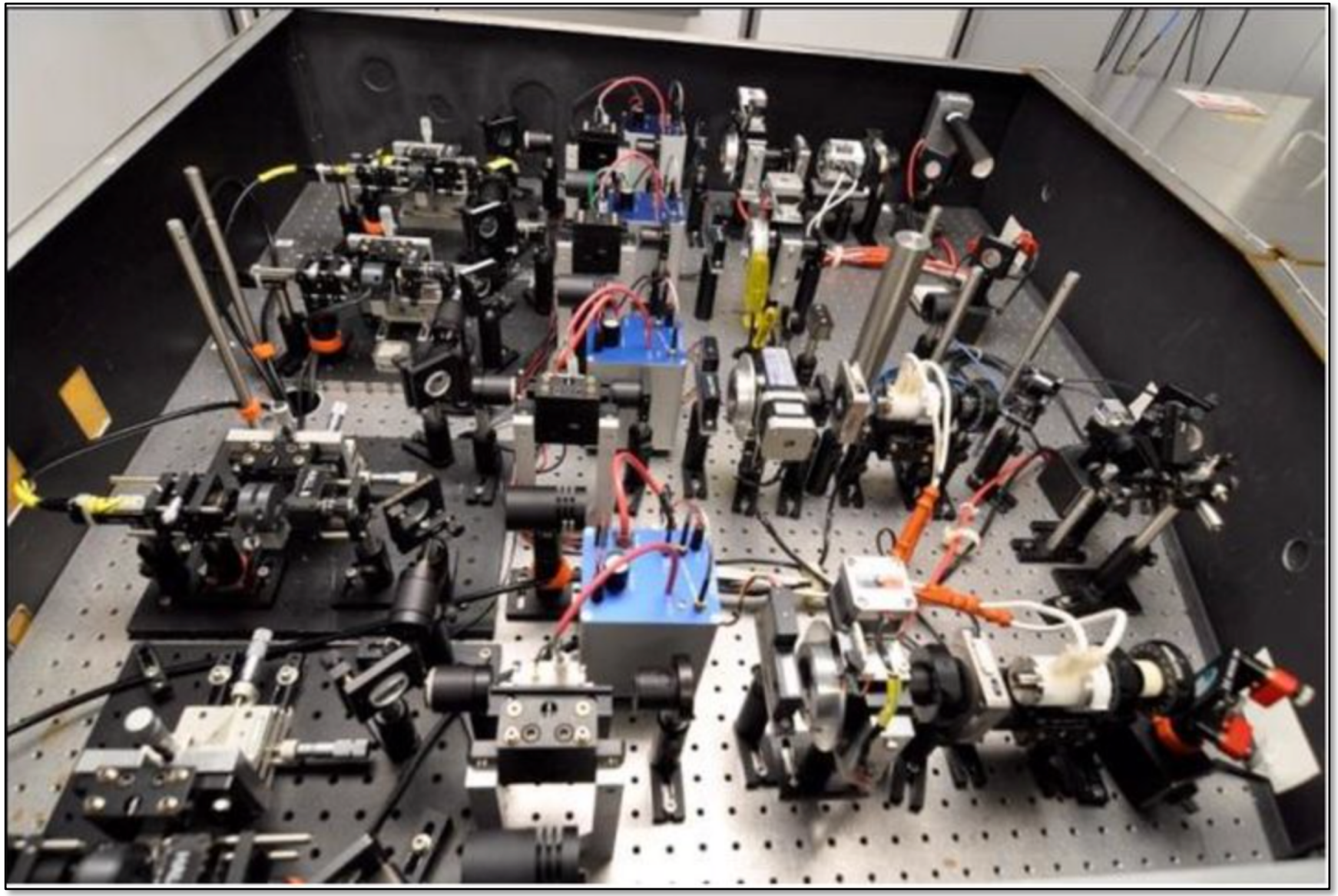
Other Considerations

- Injector upgrade on track
  - 200 kV gun presently being commissioned in CEBAF (e3733126)
  - Complete injector upgrade in summer 2020
  - Will fully support 200 kV gun voltage change (from 130 kV)
  - Will make setup of high bunch charge beam easier
- G0 experiment operations experience is not comparable
  - Different, outdated, very finicky laser system
- JLEIC injector requirements are up to ~30 pC/bunch!
  - May be synergy between KLF and JLEIC requirements

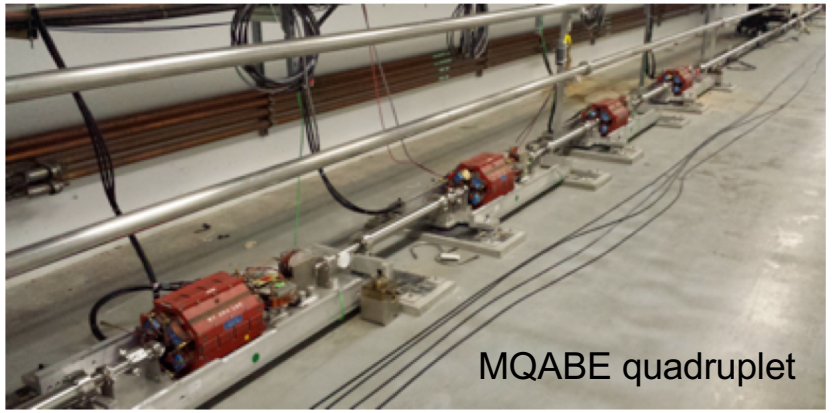
Conclusions

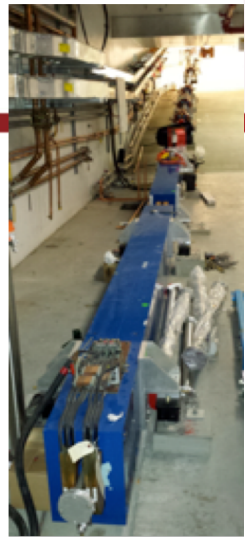
- 12 GeV Hall D beam capabilities are well documented
- KLF beam requirements can be met with investment
  - TOF not limited by bunch-coincident accelerator trigger
  - New laser table pulse picker, amplifier systems needed
    - Down-convert conventional 499 MHz by factor 32-64
    - Provides bunch spacings of 64-128 ns for TOF separation
    - Investment estimate of o($100k) with o(1y) lead time
  - Injector upgrade going well
    - 200 kV gun and injector upgrade support high bunch charges
    - Possible synergy with JLEIC electron bunch requirements
- Open questions
  - Electron beam size, momentum spread requirements?
    - Hall D optics may be further modified as needed
  - Beam spacing extinction requirements?

CEBAF Laser Table

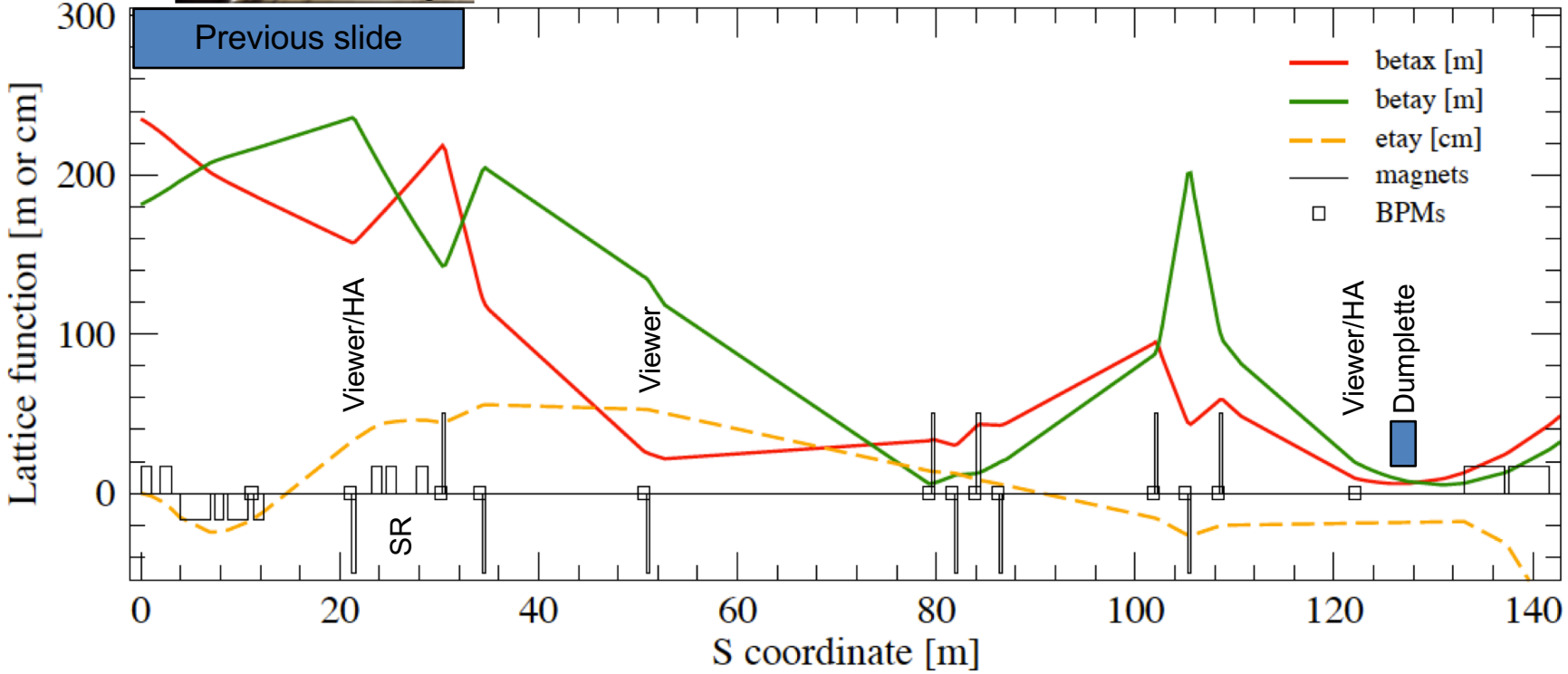


Hall D Transport Line (to insertable dump)





Previous slide



Hall D Transport Line (to tagger dump)