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ALS-II: Injection + Pulsed magnets

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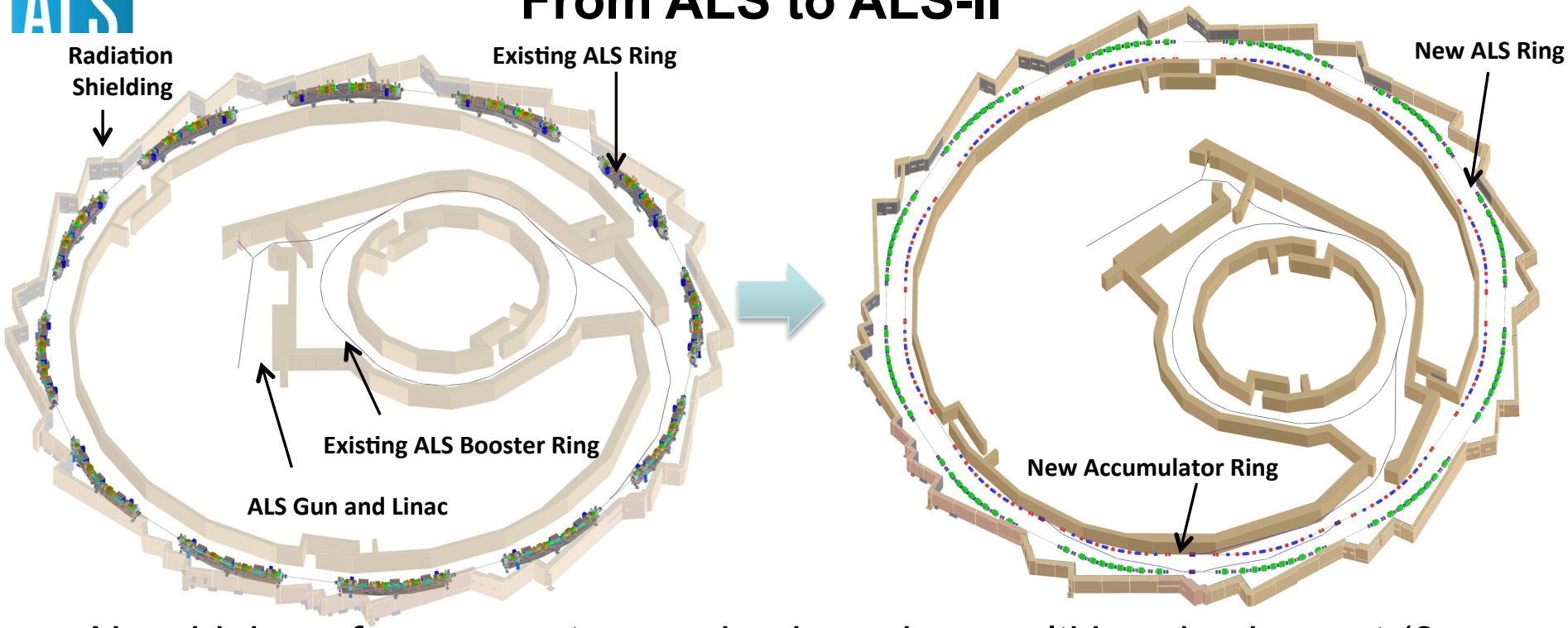
From ALS to ALS-II



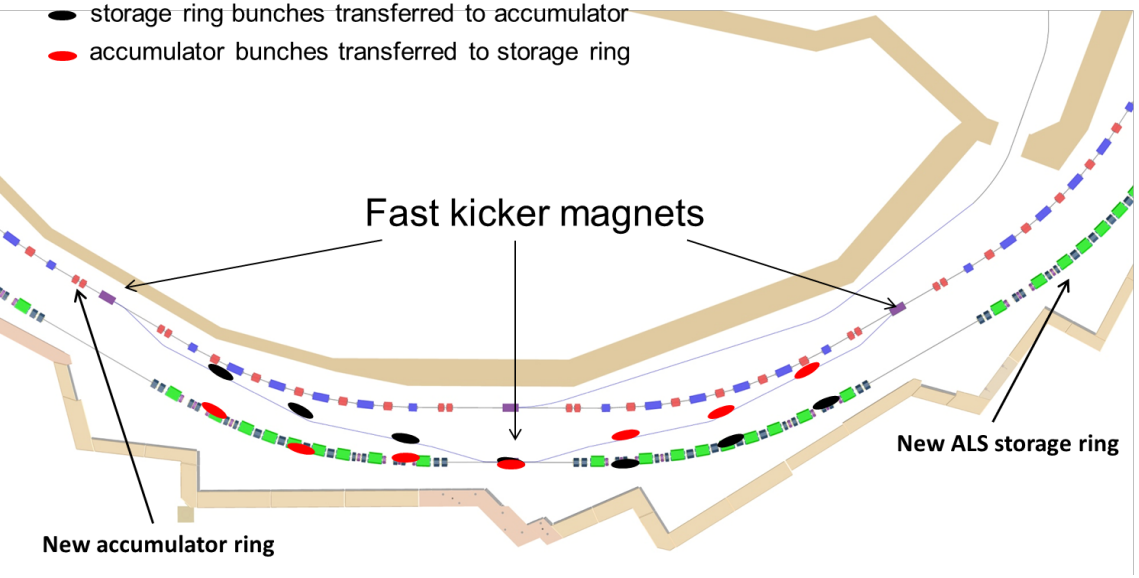
- New high performance storage ring based on multi bend achromat (9 bends per arc) in same building and tunnel
  - Same circumference, straight section length, location and symmetry
- Injector upgrades:
  - Full energy accumulator ring in shared storage ring or booster tunnel
- Optics, Undulator, conventional facilities, detector upgrades, …
  - Scope + timing to be decided

ALS and ALS-2 in numbers

Parameter	Units	Current ALS	ALS-2
Electron Energy	GeV	1.9	1.9-2.2 (2.0 baseline)
Horiz. Emittance	pm rad	2000	~50
Vert. Emittance	pm rad	30	~50
Beamsize @ ID center (σ_x/σ_y)	μm	251 / 9	<15 / <15
Beamsize @ Bend (σ_x/σ_y)	μm	40 / 7	<5 / <7
Energy Spread	$\Delta E/E$	9.7×10^{-4}	$<8.5\times10^{-4}$
Typical Bunch Length (FWHM)	ps	60-70 (harmonic cavity)	150-200 (s/c harmonic cavity)
Circumference	m	196.8	~196.2
Bend Magnet Angle	degree	10	3.33

ALS-II Injection - Accumulator Ring (AC)

- Accumulator Ring for On-axis injection into SR to allow injection into small dynamic aperture
  - Full energy accumulator ring in shared storage ring or booster tunnel.
- Requirements for AC ring:
  - Cost effective, lifetime of ≥ 2 hours and DA of ±10 mm to allow Off-axis injection from ALS booster



Swap-out injection was first proposed by M. Borland for possible APS upgrades.

Parameters of SR-size AC ring	
Energy	2 GeV
Nat. Emittance	500 pm.rad
Circumference	184.8 m
Tunes ν_x/ν_y	28.18 / 8.23
Nat. Chromaticity [x/y]	-58 / -28
$\tau_x/\tau_y/\tau_l$ *[msec]*	7.1/9.9/6.3
Energy Loss	246 KeV
Max Bend Flux	1.164 T
Max. Bend Grad.	-17.2 T/m
Max. Quad. Grad.	56 T/m

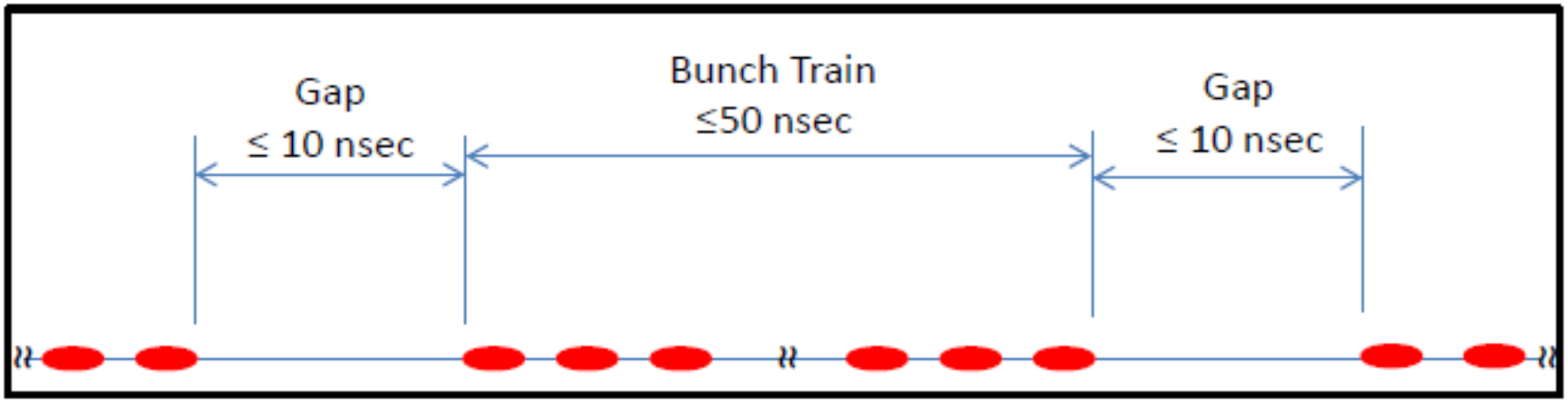
Baseline Concept Considerations

- Bunch train / Fill structure for ALS-2 very critical with respect to achievable bunch lengthening factor
- Harmonic RF – IBS – Instability considerations strongly tied to pulsed magnets
- Lower Lifetime (>= 1 h) and (preferred) 2 ns bunch spacing pushes towards swap-out of multiple bunches with recycling of extracted beam
  - Draft is splitting storage ring beam into 10 trains with about 30 bunches, each. Train spacing <= 10 ns

ALS-II Injection Scheme

- Partial Swap-out is foreseen for ALS-II injection:
  - Relaxed requirements on AC ring (vacuum, RF, instabilities) and pulsed magnets, I≤100 mA.
  - Fill pattern for ALS-II of bunch trains is foreseen, i.e. 10 trains with about 30 bunches and train spacing of ≤ 10ns.
  - Recycling the extracted beam.

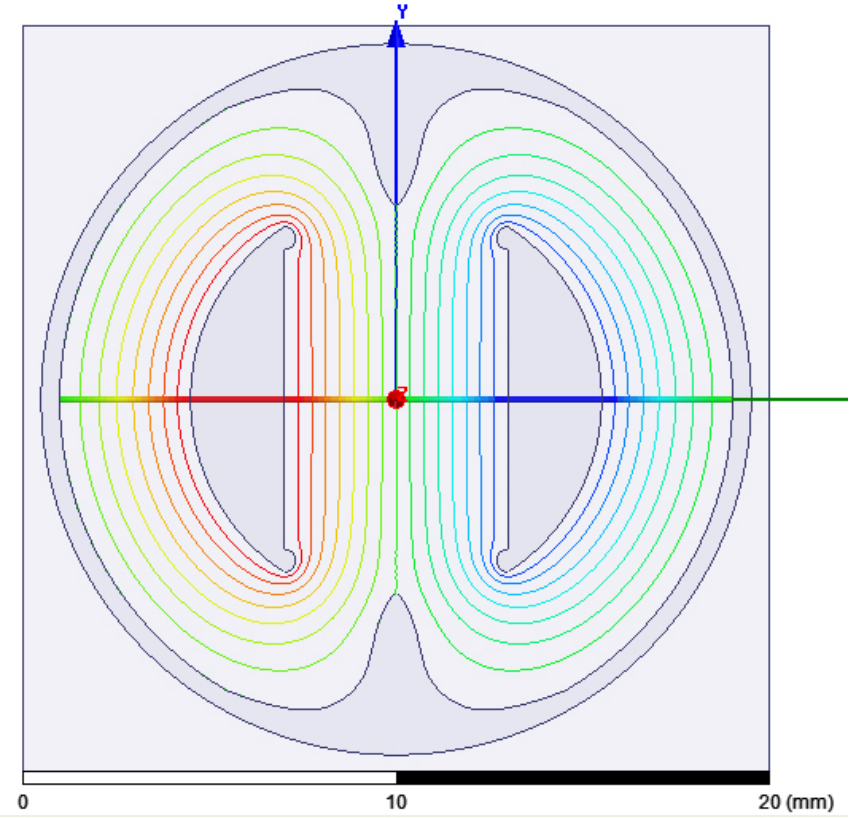
ALS-II Fill Pattern



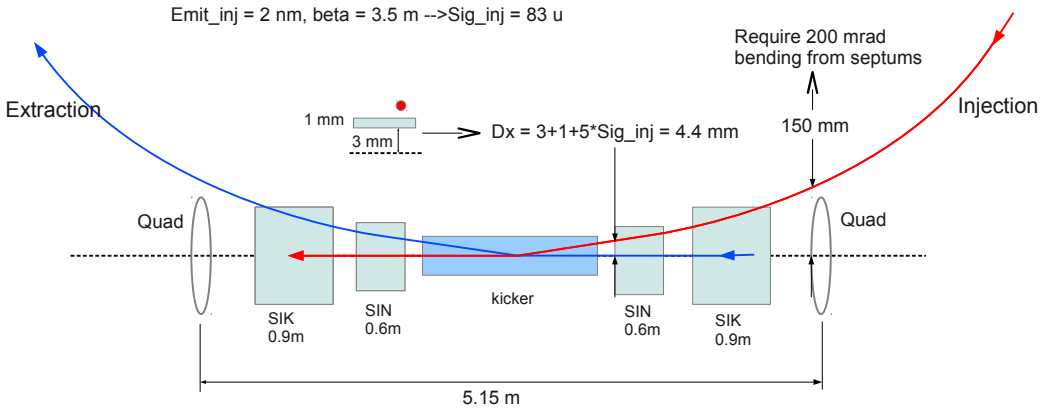
Pulsed Magnets draft concept

- We are very early in the actual technical development (seriously started on work for this applications at beginning of October)
  - Stripline kicker, 2 mrad, +/- 6 kV pulse voltage, 5-10 ns rise+fall time, 50 ns flat top
  - Using 10 mm stripline aperture, total stripline length 2x1 m
- Pulser concept based on inductive adder with off the shelf switching elements
  - Parameters (except for pulse length) very close to ATF demonstrated parameters

Stripline Kicker



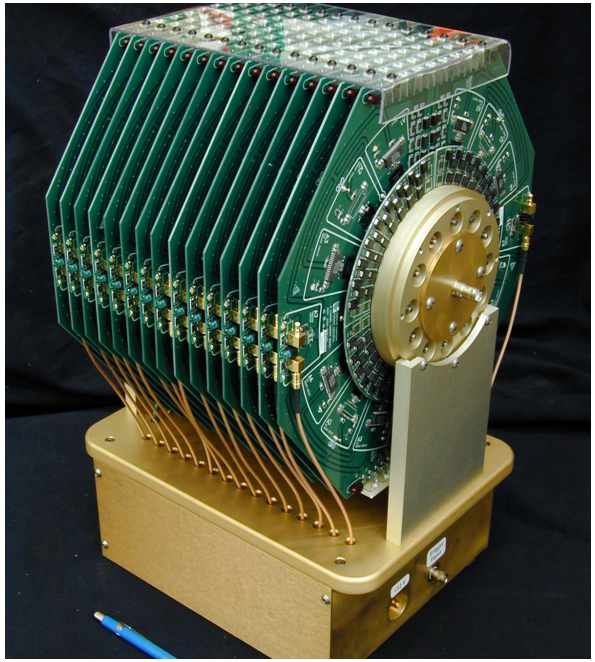
Magnets layout for swap-out injection at straight



Dx = 4.4 mm = Ang * L / 2 ---> Ang = 4.4 mrad, L = 2 m
Ang = 2.2 mrad, L = 4 m
Ang = 5.8 mrad, L = 1.5 m

Inductive Adder

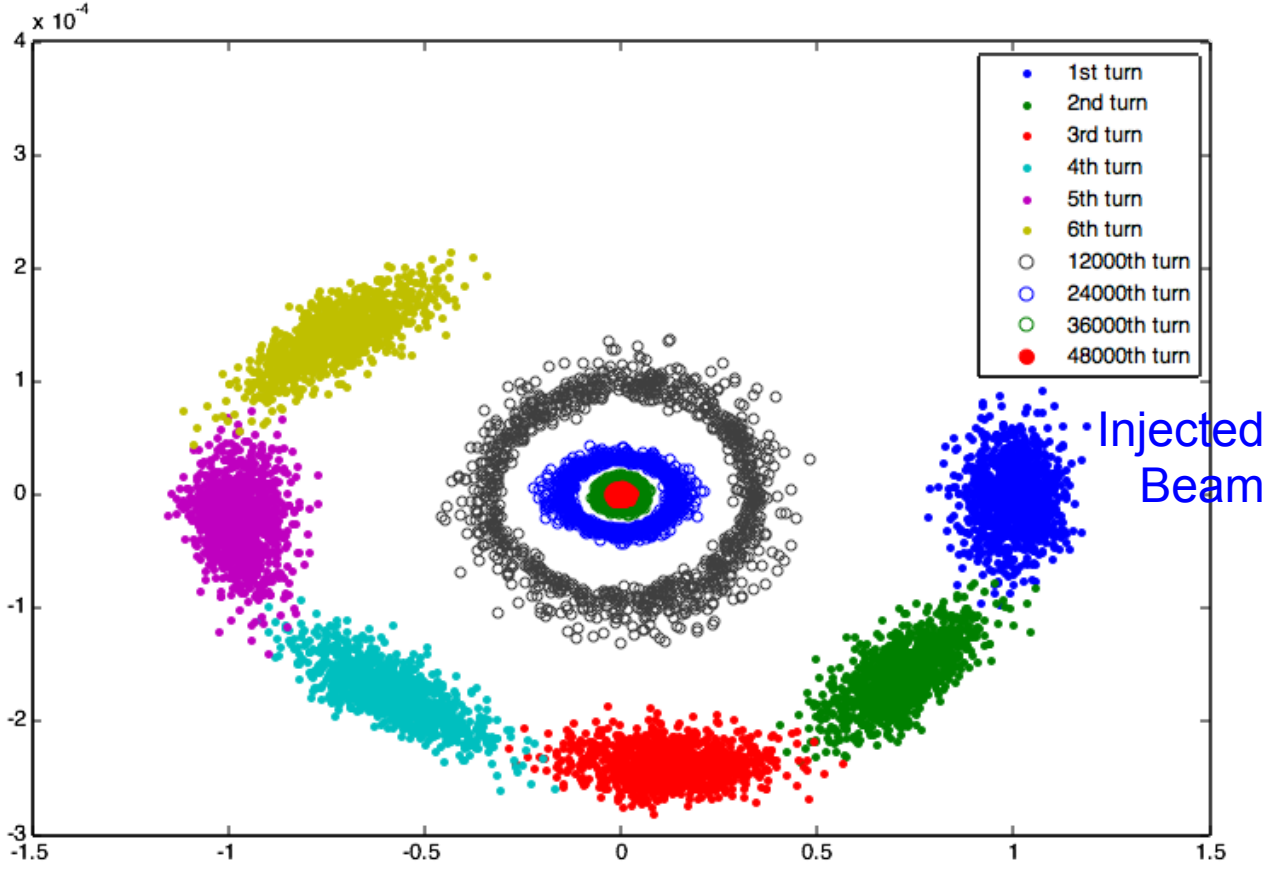
Modulator		
MOSFET Voltage	700	V
MOSFET Current	120	A
# of Cells	9	
# MOSFETs/Cell	6	
Total MOSFETs/Magnet	54	
Core Volt-Seconds	4.20E-05	Vs
Bmax CMD5005	0.32	T
Core Area	1.31E-04	m^2
Core Width/Height	1.15E-02	m



Example of past implementation:
E. Cook, LLNL

Injection tolerances for ALS-II

- Injection from ALS booster-size accumulator ring with ε_x=2 nm.rad, ε_y=20 pm.rad.
- Tracking with beam offset of 1 mm, physical aperture of ±5mm and lattice errors in all BMs & QMs of $\Delta g/g = 1\times10^{-3}$ (normal) and $\Delta g/g = 1\times10^{-4}$ (Skew).
  - 1 mm offset corresponds to easy requirements for injection kicker pulse to pulse reproducibility and pulse flatness of >10%



Summary

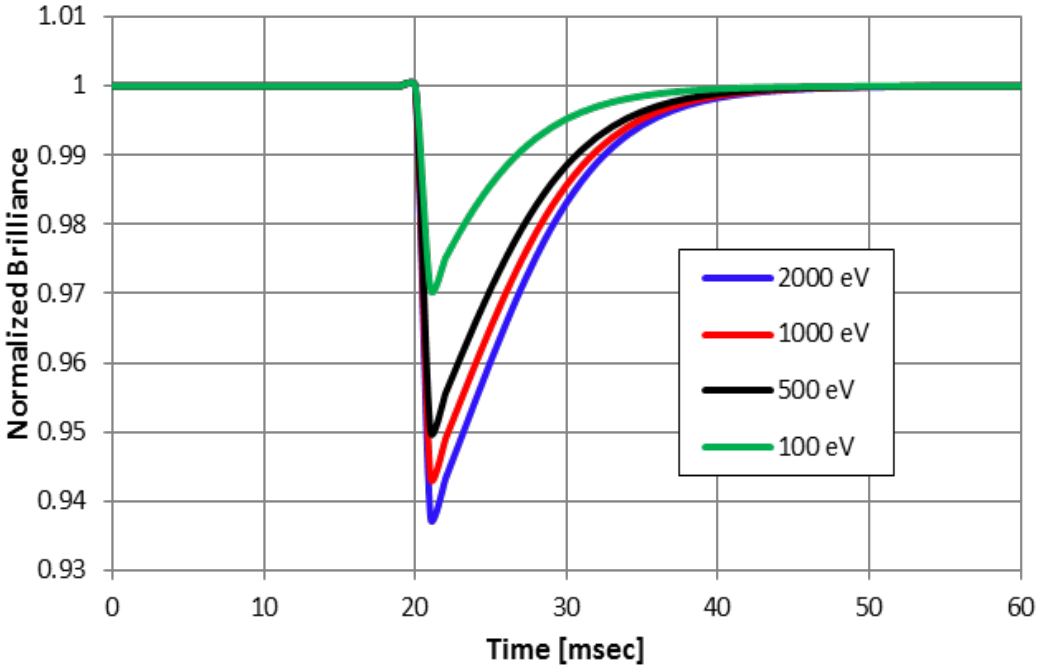
- On-axis, swap-out injection enables ultimate lattice performance
  - Kicker magnets are demanding
  - Transfer efficiency insensitive to (large) kicker errors
- Early in R+D effort
  - Draft design for Pulser and Stripline exists
  - Plan is to build prototype pulser within this fiscal year
  - Parameters appear feasible

Backup Slides

Effect of Swap-out Injection

- Brightness dip due to injection of one bunch train (ε=500 pm.rad) is transparent for most users. Gating will be used for sensitive experiments.

Brightness evolution: inject 0.1*I_{beam}



LBNL Experience

- Stripline kickers for feedback systems (ALS, PEP-2, ...)
- Stripline kicker for ALS pseudo single bunch
- Involvement in stripline kickers for SPS, ATF,…
- Pulsers for ALS pseudo single bunch kicker
- Pre-conceptual design of NGLS spreader (in the earlier pulsed magnet version)
- Many other pulsed power applications (accelerator driven fusion, …)