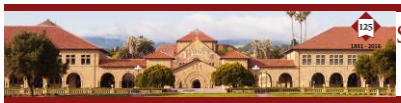

Stanford | Department of Radiation Oncology

SLAC NATIONAL ACCELERATOR LABORATORY

The Promise of FLASH: Clinical translation

Billy W Loo Jr MD PhD
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Department of Radiation Oncology & Stanford Cancer Institute
Stanford University School of Medicine

AAPM 2019 JUL 14–18
61ST ANNUAL MEETING & EXHIBITION | SAN ANTONIO, TX
BUILDING BRIDGES. CULTIVATING SAFETY. GROWING VALUE

@BLoo_LT_SABR
#FLASH_RT #PHASER

PHASER

What are FLASH & PHASER?

FLASH:
Ultra-fast near-instantaneous radiation treatment

PHASER:
Novel technology platform being developed for clinical translation of FLASH RT

Ultra-rapid "FLASH" RT: New biology

Stanford MEDICINE
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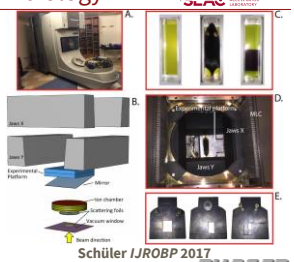
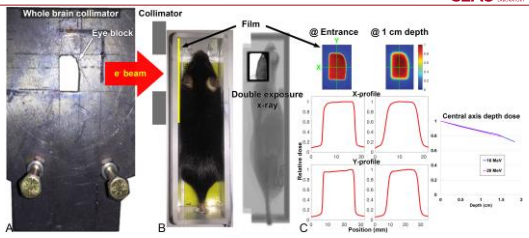
FLASH RT biology experiments at Stanford



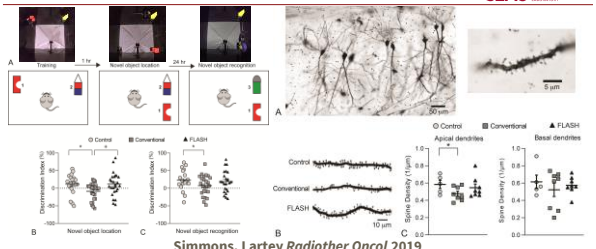
Schüler *IJROBP* 2017

FLASH whole brain irradiation



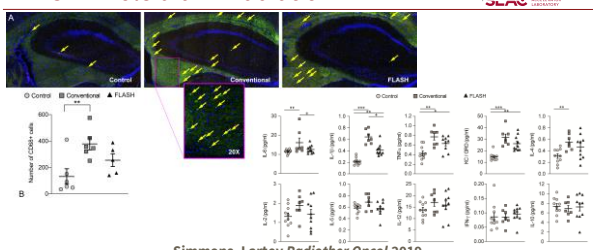
Simmons, Lartey *Radiother Oncol* 2019

FLASH whole brain irradiation



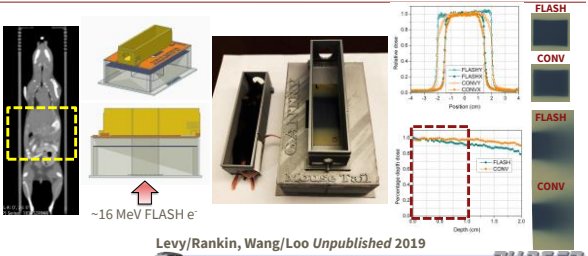
Simmons, Lartey *Radiother Oncol* 2019

FLASH whole brain irradiation



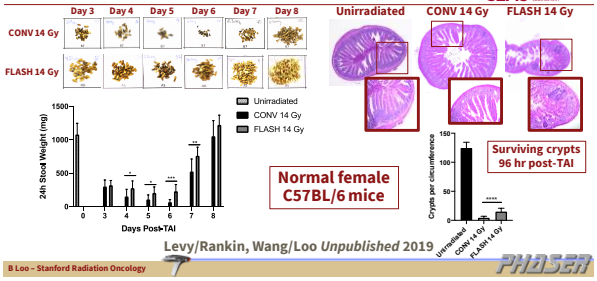
Simmons, Lartey *Radiother Oncol* 2019

FLASH total abdomen irradiation



Levy/Rankin, Wang/Loo *Unpublished* 2019

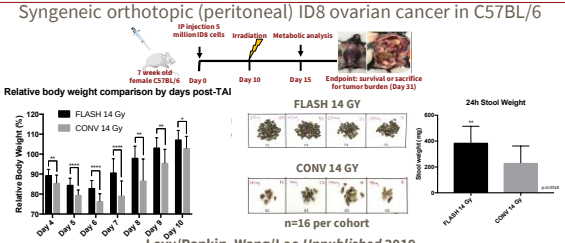
FLASH total abdomen irradiation



Levy/Rankin, Wang/Loo *Unpublished* 2019

FLASH total abdomen irradiation

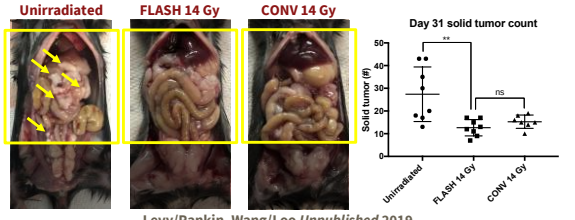
Syngeneic orthotopic (peritoneal) ID8 ovarian cancer in C57BL/6



Levy/Rankin, Wang/Loo *Unpublished* 2019

FLASH total abdomen irradiation

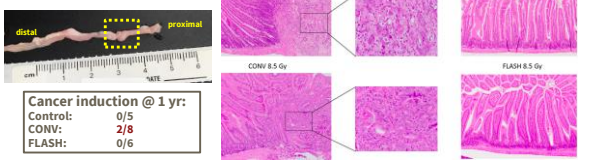
Syngeneic orthotopic (peritoneal) ID8 ovarian cancer in C57BL/6



Levy/Rankin, Wang/Loo *Unpublished* 2019

FLASH total abdomen irradiation

Late cancer induction

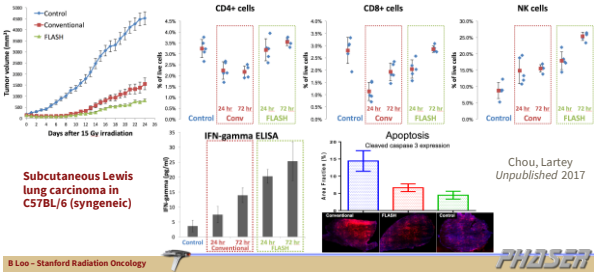


Cancer induction @ 1 yr:

Control:	0/5
CONV:	2/8
FLASH:	0/6

Levy/Rankin *Unpublished* 2018

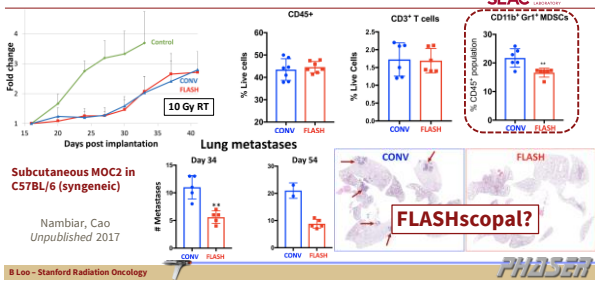
FLASH: Improved tumor control



Subcutaneous Lewis lung carcinoma in C57BL/6 (syngeneic)

Chou, Lartey *Unpublished* 2017

FLASH: Decreased metastasis



Nambiar, Cao *Unpublished* 2017

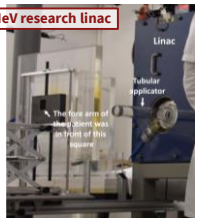
FLASH – Summary of biological findings

Compared to conventional dose rate irradiation, FLASH achieves:

- Reduced normal tissue injury
  - –Multiple organ systems: lung, brain, intestinal tract, skin
  - –Multiple mouse strains, multiple species
- Equal or better tumor killing *in vivo*
  - –Multiple tumor models

Clinical translation of FLASH RT

FLASH – First in human case report



Bourhis *Radiother Oncol* 2019

FLASH – First in human case report

75 yo M with disseminated cutaneous T-cell lymphoma

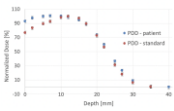
- Progression through multiple systemic regimens over first 10 years
- Treated with 110 courses of localized RT over last 10 years
- 20-21 Gy in 6-10 fractions
- Good local tumor control, severe acute toxicity taking 3-4 mo to heal

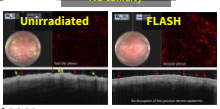
3.5 cm symptomatic ulcerated R forearm lesion selected for treatment on protocol

Bourhis *Radiother Oncol* 2019

FLASH – First in human case report

Day 0 | Day 15 | 5 months





Bourhis *Radiother Oncol* 2019

FLASH – Current technology

It is technically feasible to deliver FLASH to patients using modifications of existing clinical/preclinical systems:

- Electron beams: superficial targets
- Proton pencil beams: small volumes from **single** direction

New technology is needed for FLASH RT to general cancer targets in patients

Precision RT – overcoming a key barrier

Hitting moving targets – current "motion management"

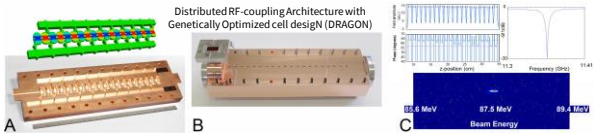
PHASER: Next generation radiation therapy

Current fastest treatment in the world

Pluridirectional High-energy Agile Scanning Electronic Radiotherapy (PHASER)

- ***300X faster:*** Freezes motion, ultimate precision
- FLASH RT: New biological advantages
- Compact & economical: Global access to RT

High-output linear accelerator

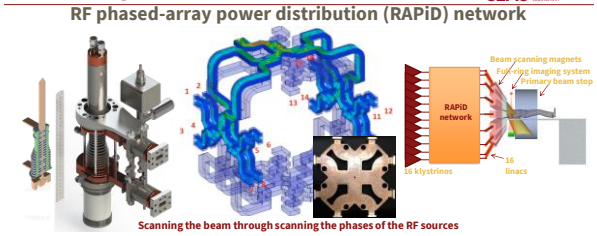


- First new design in 60 years
- ***3X better*** power efficiency
- ***300X more*** beam current
- ***10X lower*** manufacturing cost

Maxim, Tantawi, Loo *Radiother Oncol* 2019

Eliminating slow mechanical motion

RF phased-array power distribution (RAPiD) network



Scanning the beam through scanning the phases of the RF sources

Maxim, Tantawi, Loo *Radiother Oncol* 2019

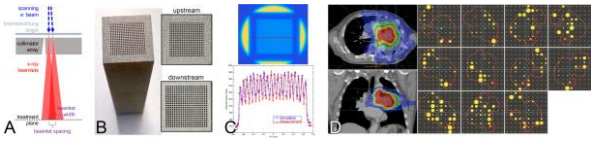
Eliminating slow mechanical motion

Scanning Pencil-beam High-speed Intensity-modulated X-ray source (SPHINX)

Maxim, Tantawi, Loo *Radiother Oncol* 2019

Eliminating slow mechanical motion

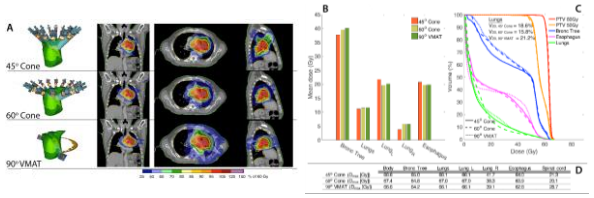
Scanning Pencil-beam High-speed Intensity-modulated X-ray source (SPHINX)



Maxim, Tantawi, Loo *Radiother Oncol* 2019

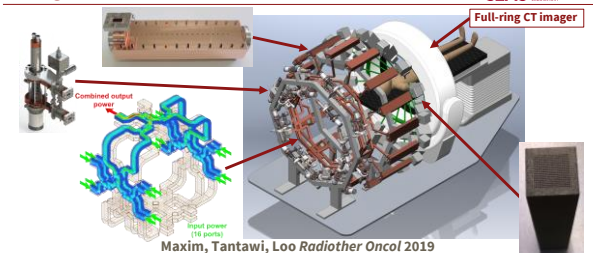
Integrated rapid volumetric imaging

Conical beam geometry – common isocenter between treatment beams and full ring diagnostic-quality CT imager



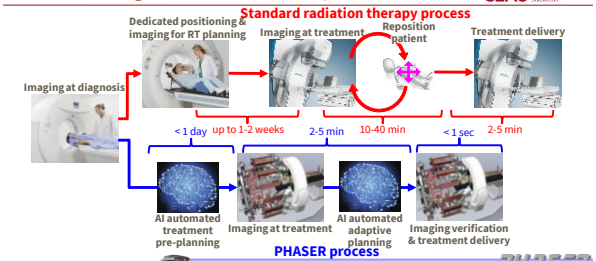
Schüler *Phys Med Biol* 2019

Integrated PHASER system

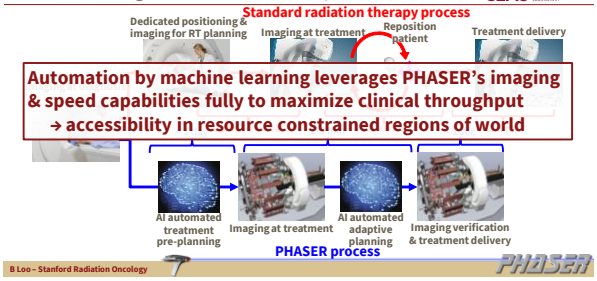


Maxim, Tantawi, Loo *Radiother Oncol* 2019

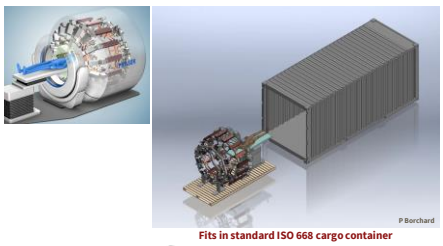
Accelerating clinical efficiency with AI



Accelerating clinical efficiency with AI



Vision: PHASER clinical system



Fits in standard ISO 668 cargo container

Vision: PHASER clinical system

Globally accessible curative cancer care

FAQs

- Don't we risk "missing" the tumor in a FLASH?
  - –No, integrated rapid volumetric image-guidance is key
  - –Rational margin design principles still apply
- Won't ultra-fast delivery be a nightmare for QA?
  - –No, multiple relatively straightforward strategies can be designed up front

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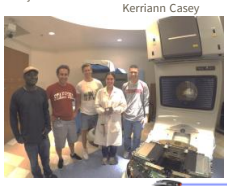
Kerriann Casey



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Pluridirectional High-energy Agile Scanning Electronic Radiotherapy (PHASER)