PHYSICS & ASTRONOMY
TEXAS A&M UNIVERSITY

Unpacking IPAC'18

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May 18, 2018

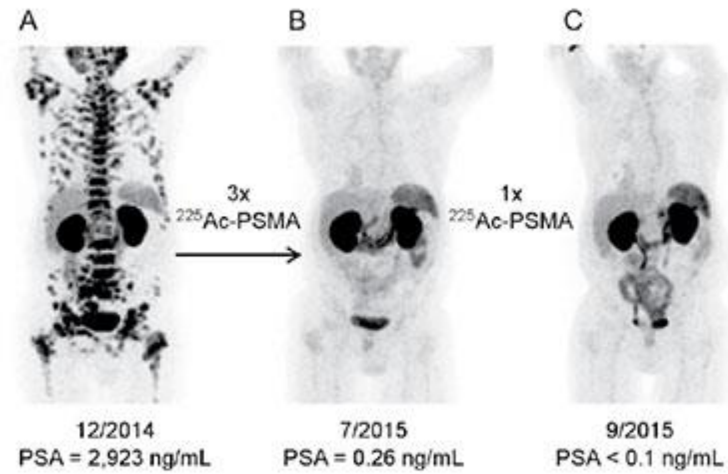
Slides available at http://www.github.com/jgerity/talks

IPAC

- International Particle Accelerator Conference
- Over 1,300 (!) registrants from labs and universities around the world
- Typical paper/poster + contributed talks format
- Pre-press is already online http://ipac2018.vrws.de/

TRIUMF and radioisotopes

- TRIUMF interested in producing radioisotopes for medical imaging and therapy
- Start-up ARTMS recently received \$3M funding



Prostate cancer patient before (left) and after (middle, right) successive treatments with prostate-specific membrane antigen (PSMA) with α-emitting ^{225}Ac attached.

Figure from C. Kratochwil et al., 2016, http://dx.doi.org/10.2967/jnumed.116.178673

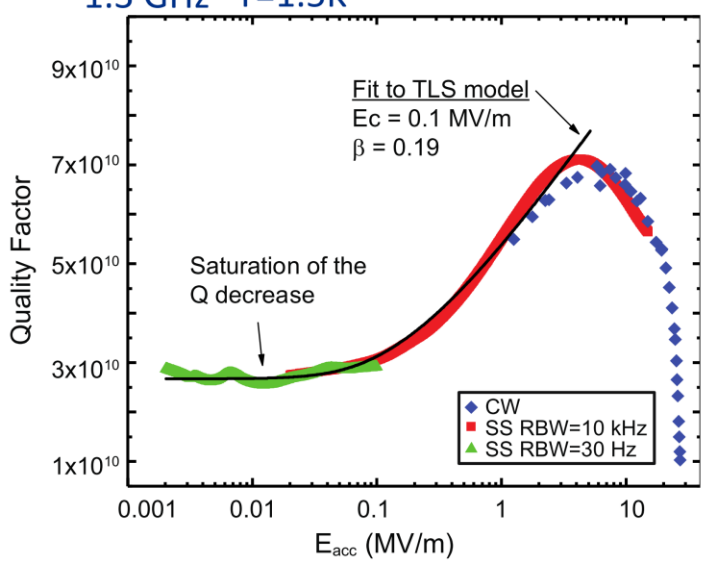
Microphysics of niobium SRF (WEYGBF2)

- Alexander Romanenko's @ FNAL suggests a new "time barrier" to characterize SRF performance
- Big idea: materials with vortex forming/dissipation time $\tau \ll \tau_{rf}$ do not "see" RF in a flux sense → better Q!
  - Some prior art for this, e.g. electron-phonon τ_{e-ph}

- Q at low fields is well-described by a two-level system (TLS) model

Saturation of Q decrease

1.3 GHz T=1.5K



A. Romanenko and D. I. Schuster, Phys . Rev. Lett. **119**, 264801 (2017)

Good news: low field Q saturates at Q>**3 x 10**^{10}

Now measured down to <N> ~ 1000 photons

Slide taken from A. Romanenko's presentation (WEYGBF2) @ IPAC'18

Beam screen R&D for HE-LHC, FCC-hh, etc. (MOZGBE5)

- FCC-hh has synchrotron radiation power of 32 W/m
  - Requires a new design!
- Reflector design has been tested: BESTEX @ KARA

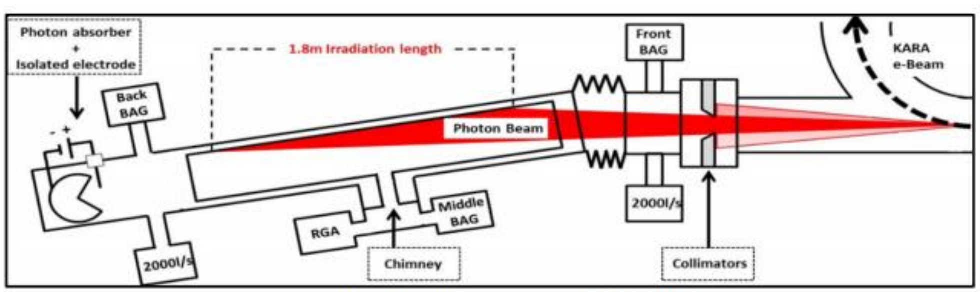
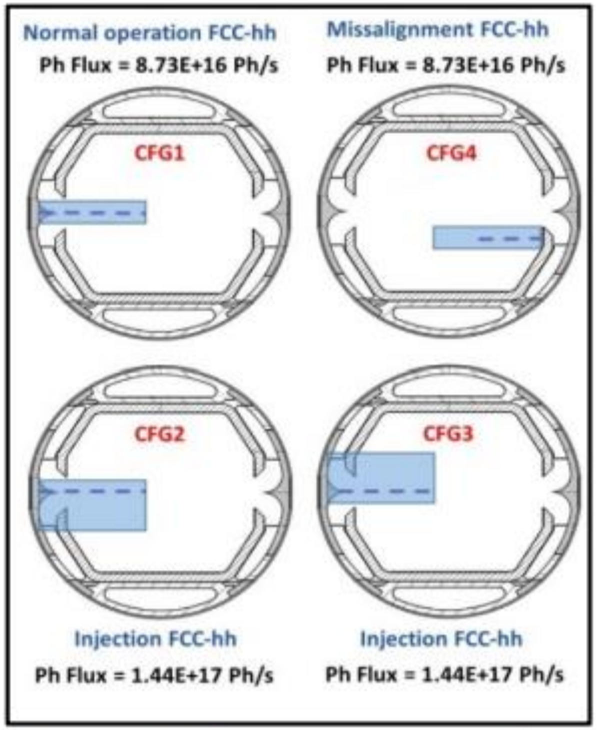


Figure 1: Schematic description of BESTEX.



ure 2: Graphical descriptions of the different metrical configurations in which the samples were diated.

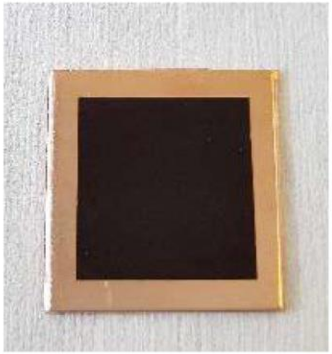
Figures taken from MOZGBE5 @ IPAC'18

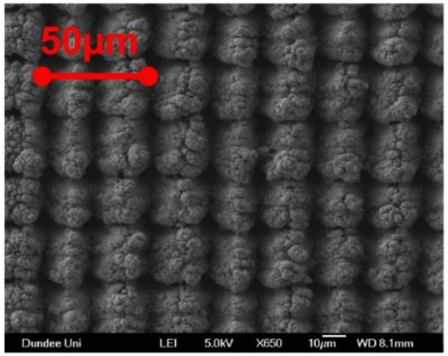
Beam screen R&D for HE-LHC, FCC-hh, etc. (TUZGBE3, WEPMG005)

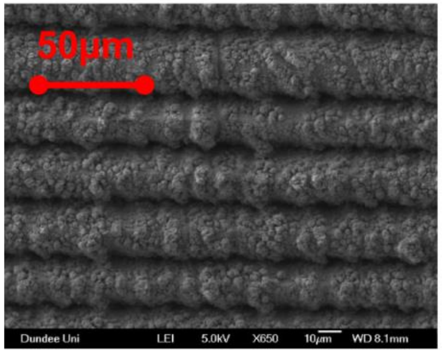
- Problem: reduce surface e$^-$ yield (SEY) to reduce heat load

Laser Engineered Surface Structures (LESS)

Copper surface modified by laser ablation. Surface morphology (➔ **SEY<1.0**) depends on chosen laser parameters.







Slide taken from M. Sitko's presentation (TUZGBE3) @ IPAC'18

Beam screen R&D for HE-LHC, FCC-hh, etc. (TUZGBE3, WEPMG005)

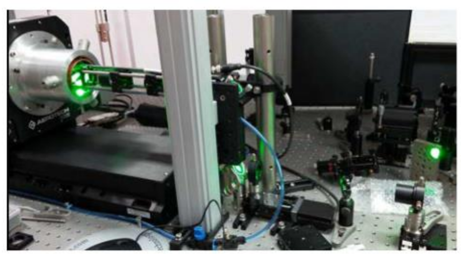
- Treatment tested @ SPS, observed no electron cloud! Still very slow method…

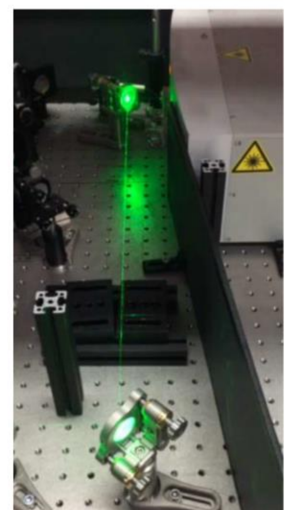
LESS inchworm robot

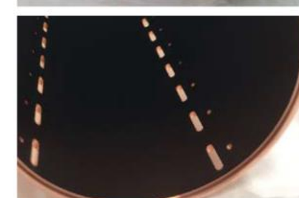
January 2018

LESS treatment of segmented COLDEX beam screen

ıary-February 2017







Slides taken from M. Sitko's presentation (TUZGBE3) @ IPAC'18

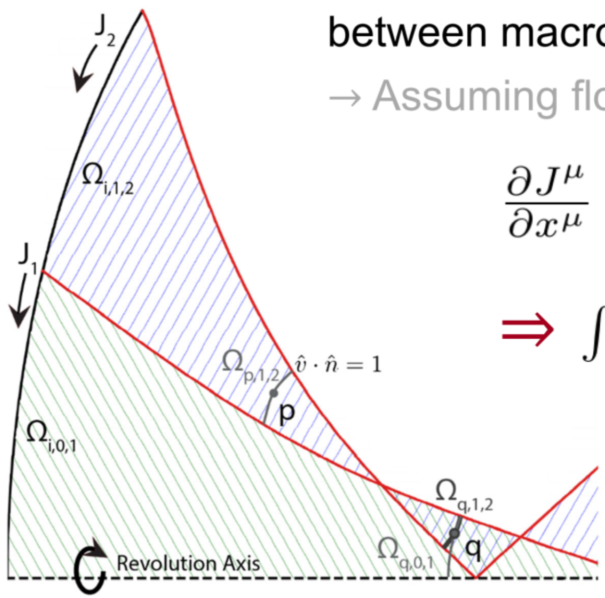
New approach to space-charge simulation (TUYGBD5)

Exploiting Liouville's Theorem

SLAC

Idea: Use charge conservation law to interpolate $\vec{j}$ between macroparticle trajectories

→ Assuming flow between macroparticles laminar



$$\frac{\partial J^\mu}{\partial x^\mu} = \frac{\partial \rho}{\partial t} + \nabla \cdot \vec{j} = 0$$

$$\Rightarrow \int_V \nabla \cdot \vec{j} dx = \int_{\partial V} \vec{j} \cdot \hat{n} \, dS = const = I$$

$$\Rightarrow \vec{j}_q = \frac{I_1}{A_{\Omega_{q,0,1}}} \hat{n}_{q,0,1} + \frac{I_2}{A_{\Omega_{q,1,2}}} \hat{n}_{q,1,2}$$

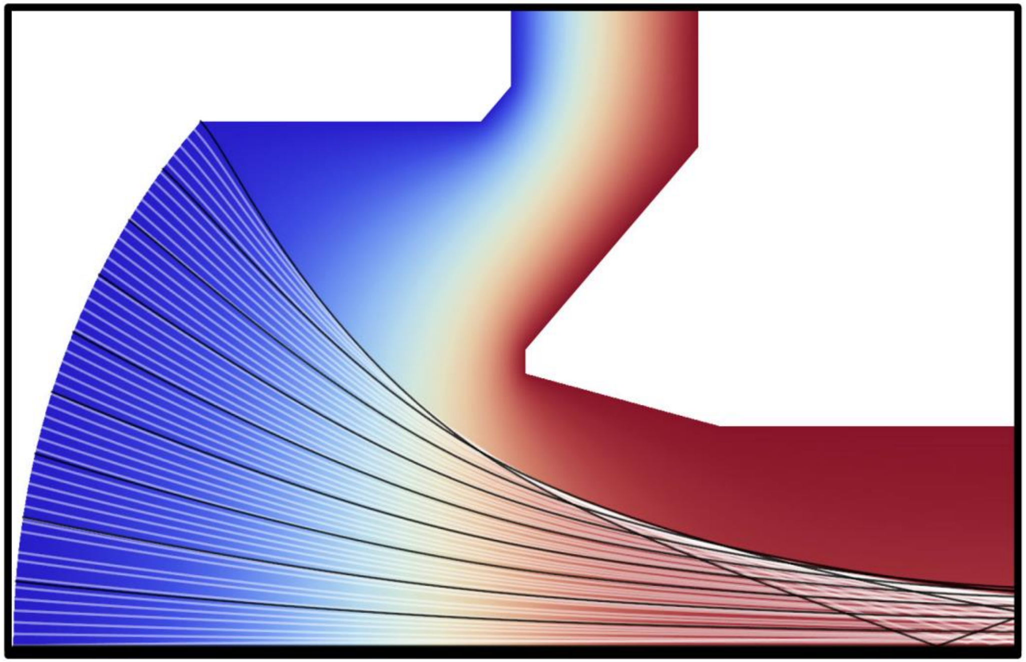
Slide taken from A. Gold's presentation (TUYGBD5) @ IPAC'18

New approach to space-charge simulation (TUYGBD5)

Highly non-laminar flow: 120x faster

SLAC

	COMSOL	HE Method
Number of Mesh Cells	9318	9549
Number of Particles	500	10
Time / Iter. (s)	33.8	0.29



Slide taken from A. Gold's presentation (TUYGBD5) @ IPAC'18

CBETA (TUYGBE2)

- Cornell-BNL ERL Test Accelerator (CBETA) “will be the first ever multi-turn ERL with superconducting RF (SRF) acceleration, and the first ERL based on Fixed Field Alternating Gradient (FFAG) optics”
  – Important implications for JLEIC and eRHIC

CBETA (TUYGBE2)

IN Injector: DC gun, front-end, injector cryomodule, and merger.

LA Linac, containing the MLC.

SX Splitter sections S1, S2, S3, and S4.

FA FFAG arc

TA Transition from arc-to-straight

ZA Straight FFAG section.

ZB Straight FFAG section. This is a mirror of ZA.

FB FFAG straigth-to-arc, arc. This is a mirror of FA.

TB Transition from straight-to-arc

RX Splitter sections R1, R2, R3, R4. This is similar to a mirror of SX sections.

BS Beam stop, including demerging.

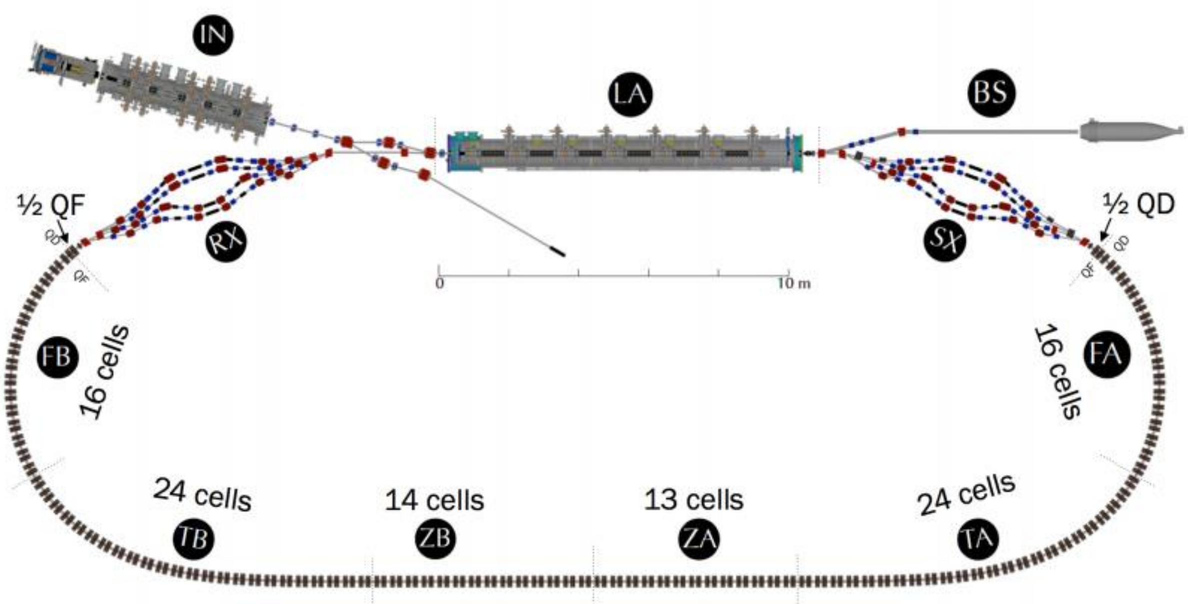
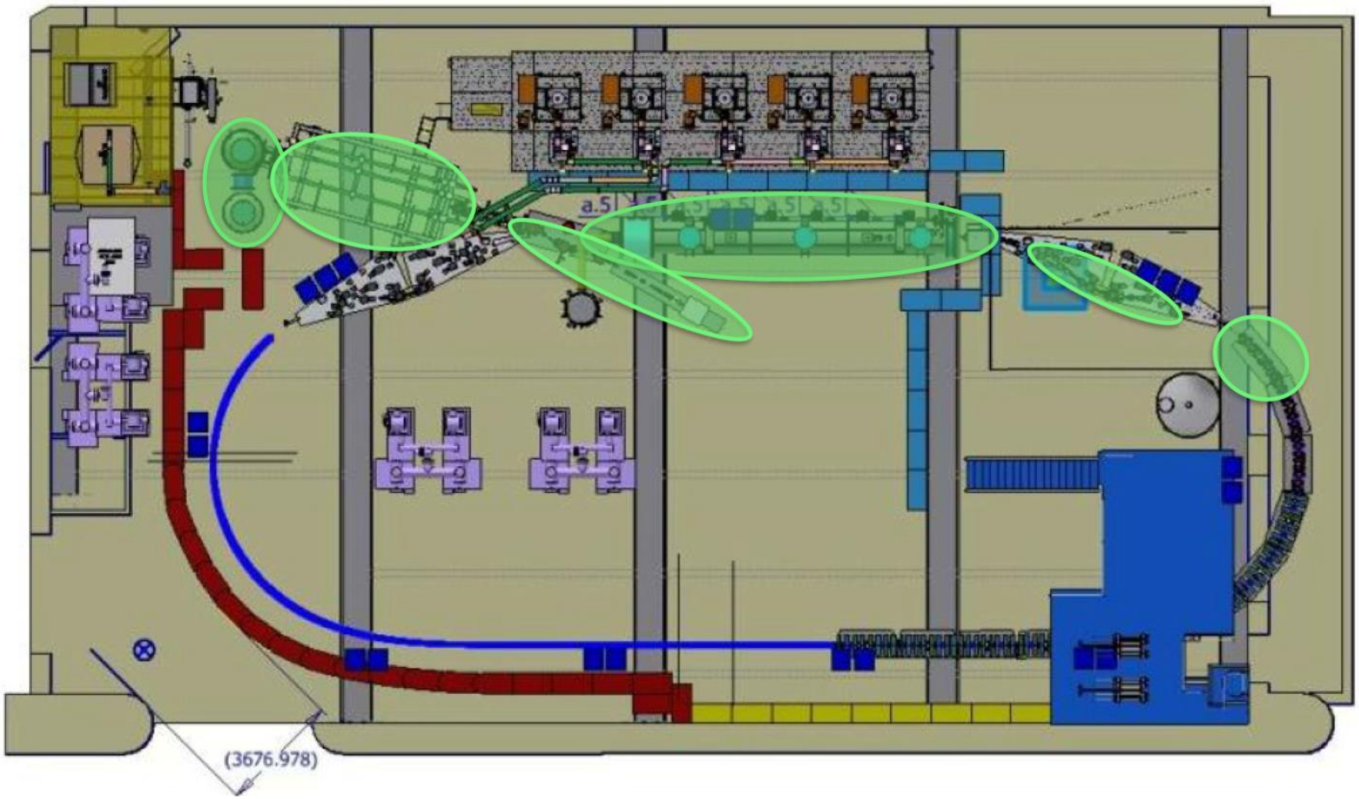


Figure taken from CBETA Design Report

CBETA (TUYGBE2)

Installed: DC gun, SRF injector, mirror diagnostics line, ERL cryomodule
1st splitter of 8, 1st Fixed Field Alternating-gradient (FFA) girder of 25.



Slide taken from G. Hoffstaetter's presentation @ IPAC'18

CBETA (TUYGBE2)

Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

12 proof-of-principle magnets (6 QF, 6 BD) have been built as part of CBETA R&D.
Iron wire shimming has been done on 3 QFs and 6 BDs with good results.

Slide taken from G. Hoffstaetter’s presentation @ IPAC’18

eRHIC design status (TUYGBD3)

- Collects lots of parameters that have been slightly hard to come by in a single document
- Pre-CDR expected by end of June
- Strong hadron cooling is active R&D
  - CBETA and coherent cooling proof-of-principle experiment @ RHIC

SIS-18 ORM (WEPAK003)

- SIS-18 at FAIR (GSI) has a complex ramp
  - Smooth transition from doublet to triplet optics
  - Characterization of orbit response matrix (ORM) over this ramp

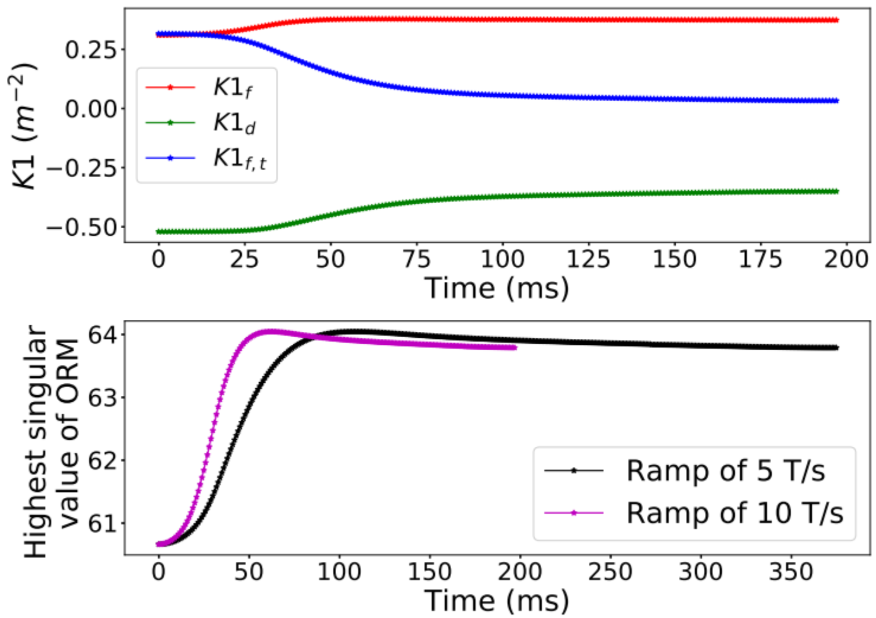


Figure 1: Top: Triplet to doublet quadrupole transition over the ramp. $K1_f$, $K1_d$ and $K1_{f,t}$ are the normalized strengths of the doublet focusing, doublet defocusing and triplet focusing quadrupole families of SIS18, respectively . Bottom: Variation of vertical ORM over ramp.

Figure taken from WEKPAK003 @ IPAC'18

Entertainment talk: chief metrologist of CA

- 26th CGPM meets this year! (Nov. 13-16)
- New system predicated on fixing as constants the values of $c, \Delta\nu_{\mathrm{Cs}}, h, e, k, N_A, K_{\mathrm{ed}}$
  - Draft resolution at: https://www.bipm.org/utils/en/pdf/CGPM/Convocation-2018.pdf
- Upshot: some constants (like μ_0!) and old prototype kilogram become measureable

Entertainment talk: chief metrologist of CA

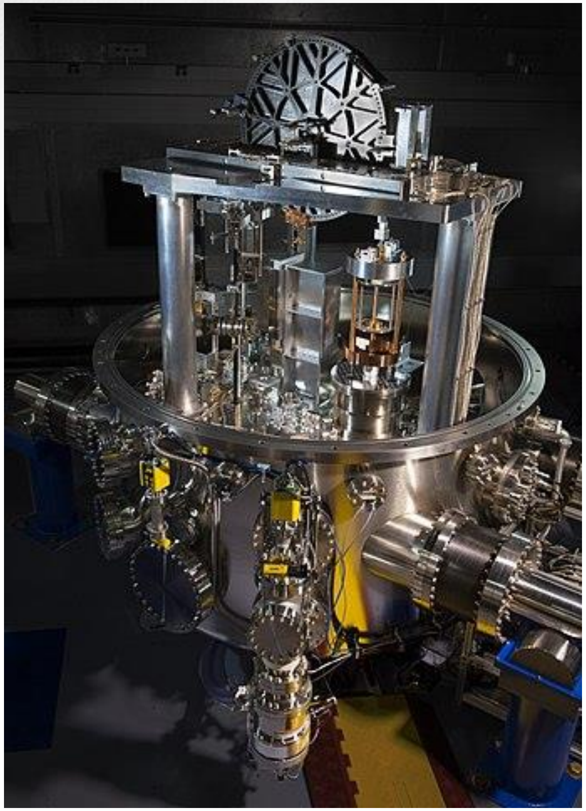


Image by Jennifer Lauren Lee (NIST). Used under Public Domain, retrieved from https://commons.wikimedia.org/w/index.php?curid=62335811

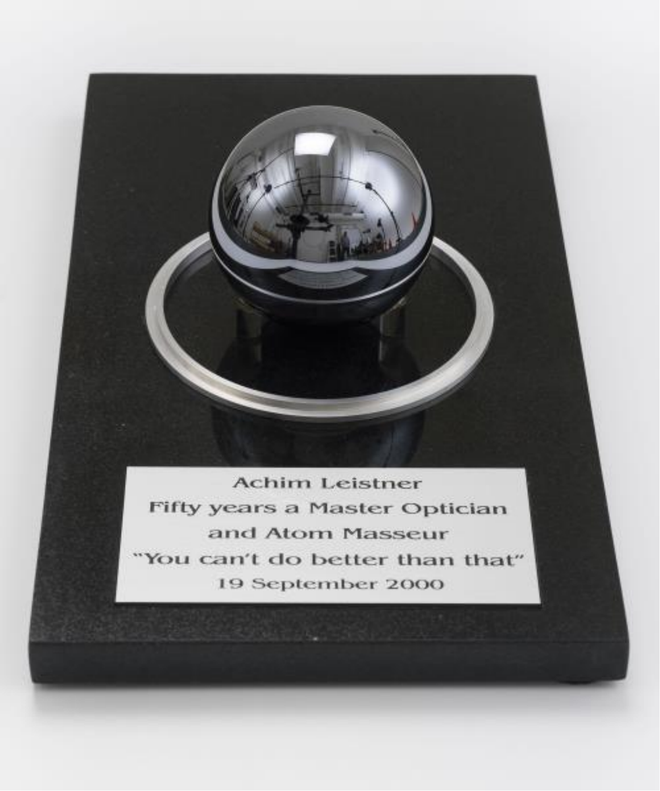


Image courtesy of the Museum of Applied Arts & Sciences, under CC BY-NC-ND 4.0. https://collection.maas.museum/object/539785

UFOs in LHC (THYGBD2)

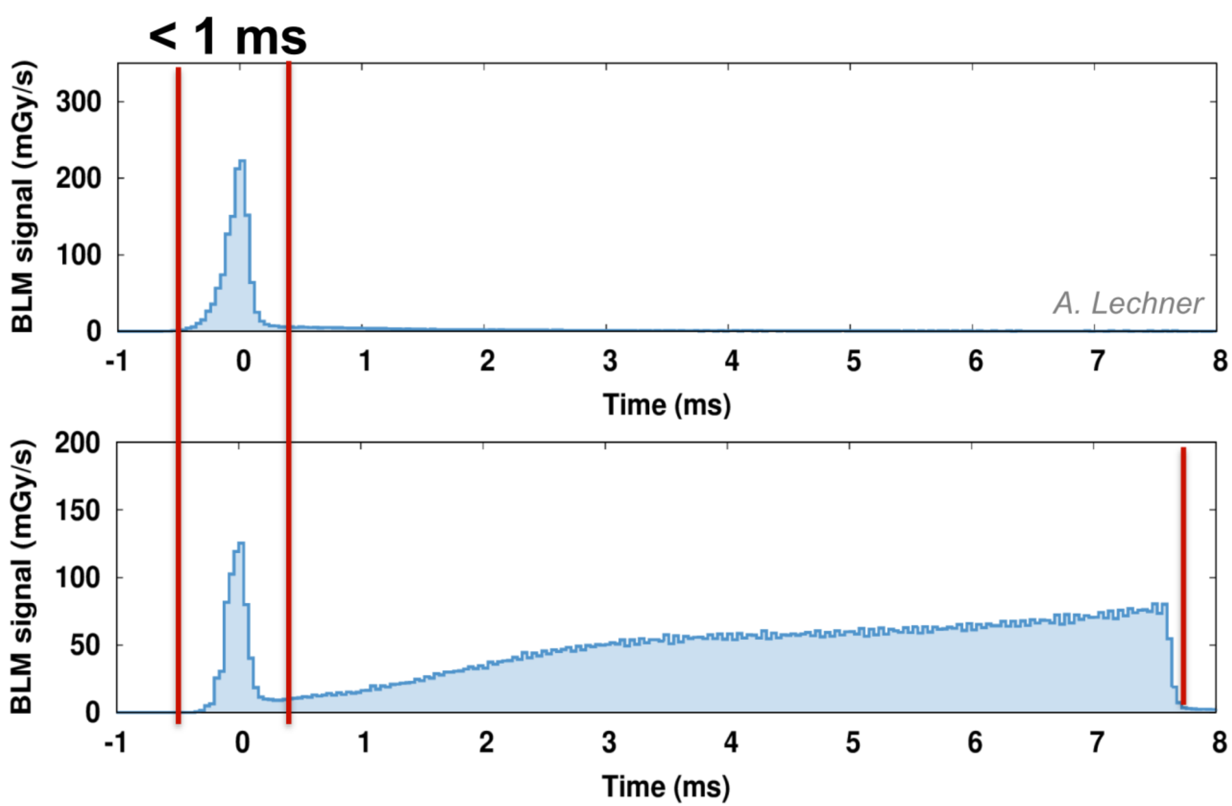
- Type I known for several years
- Type II observed in 2017, fast gas instability after initial peak
  - Specific location at a magnetic interconnect, believed to be vacuum contaminated with air → frozen nitrogen macroparticles on beam screen

UFOs in LHC (THYGBD2)

UFO types

Type 1

Type 2



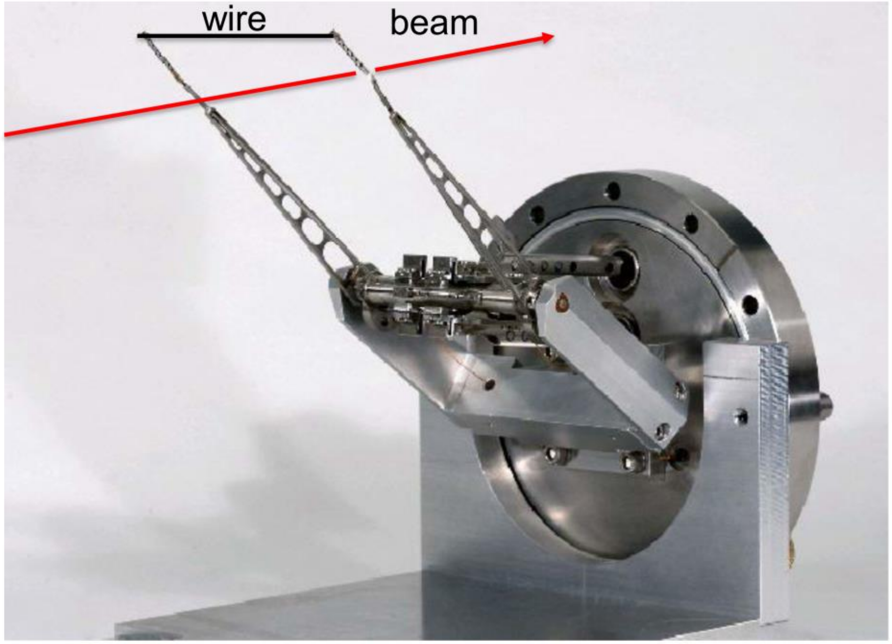
Slide taken from B. Lindstrom’s presentation @ IPAC’18

UFOs in LHC (THYGBD2)

Wire-scanner experiment

Wire-scanner: Thin carbon wire, **~30 µm**, similar dimension to UFO

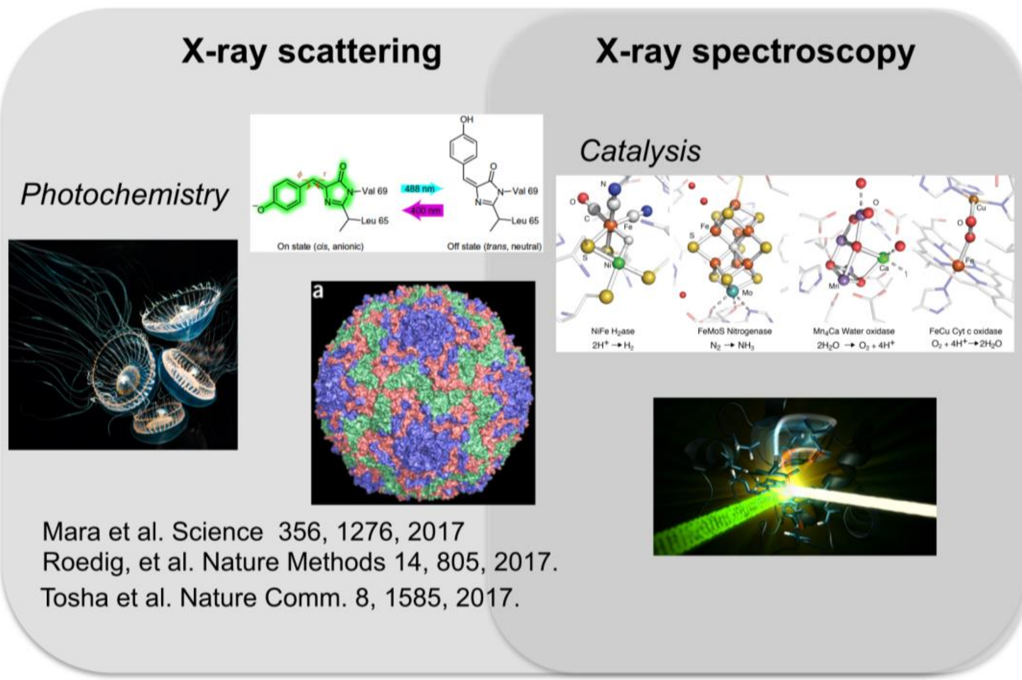
Beam losses detected by fast **diamond beam loss monitor (dBLM)**

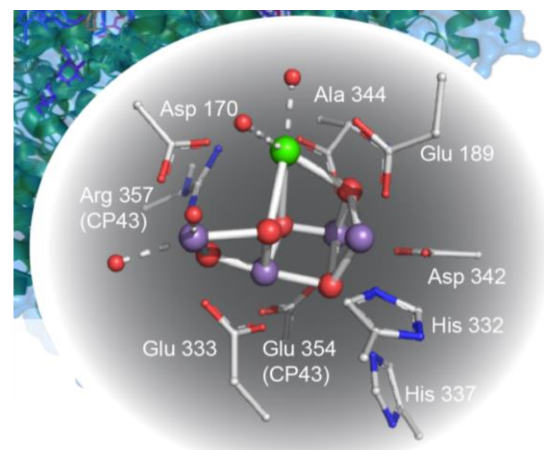


Slide taken from B. Lindstrom's presentation @ IPAC'18

Review of FEL science (FRYGB1)

- *Many* excellent studies done at LCLS and other facilities





Oxygen **E**volving **C**omplex
(Mn_4CaOx cluster)

Umena et al. Nature 473, 55-60, 2011.
Young, I. D. et al. Nature 540, 453-457, 2016.
Suga, M. et al. Nature 543, 131-135, 2017.

Slides taken from J. Yano's presentation @ IPAC'18

Review of FEL science (FRYGB1)

- J. Yano et al. have developed a very clever droplet-on-tape method for studying the behavior of OEC in Photosystem II
- https://www.youtube.com/watch?v=J7es2VcJD6A

Accelerators as defense (FRYGB2)

- High-altitude nukes → satellite e- damage
  - Starfish Prime (1962) killed Telstar I!
- Defense sector wants a mitigation strategy
  - “shake” the e- out of belt with VLF waves

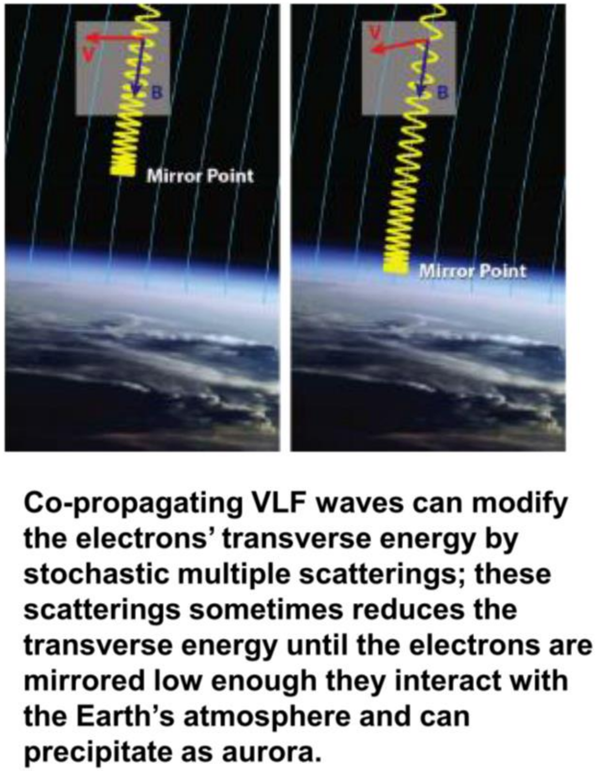
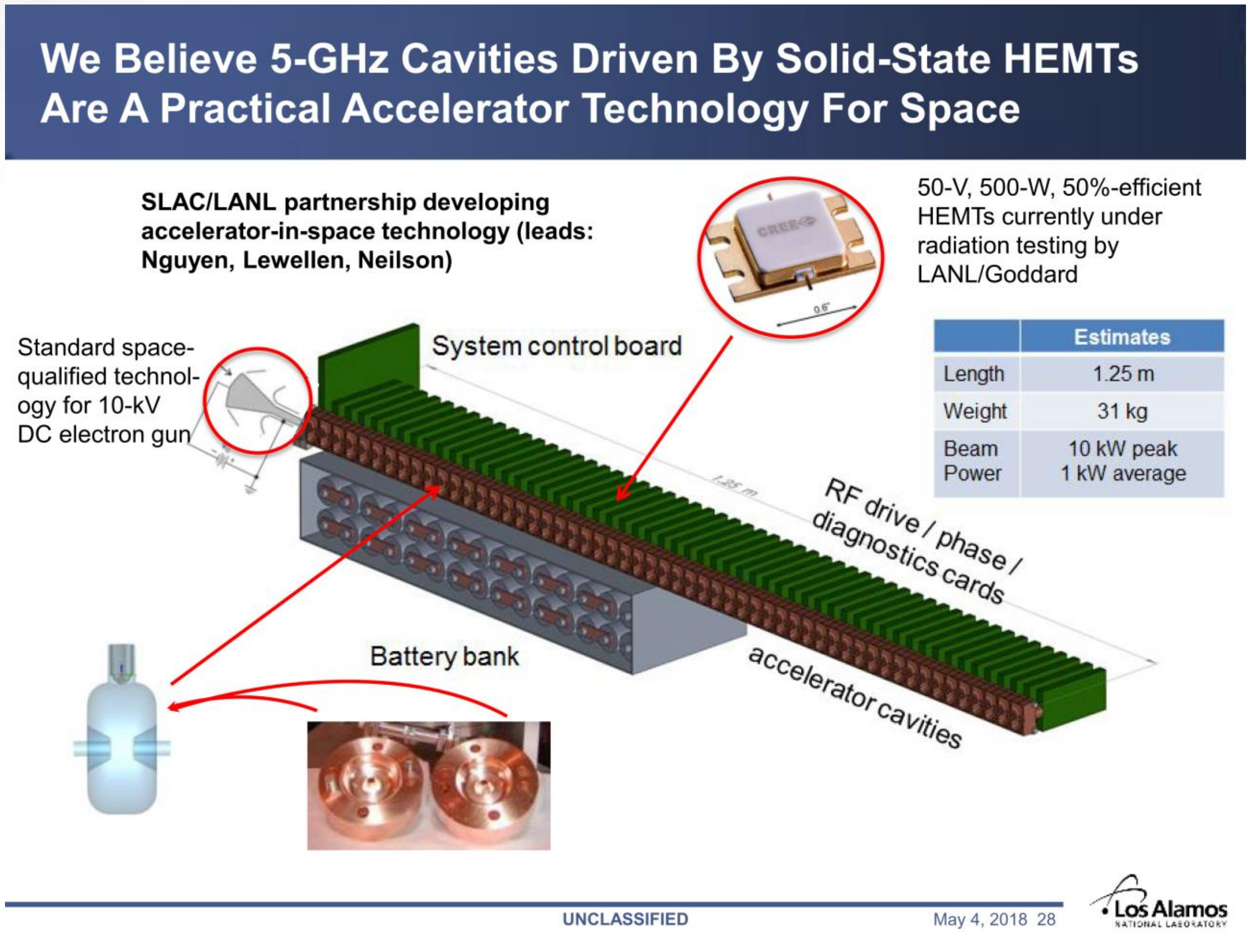


Figure taken from B. Carlsten’s presentation @ IPAC’18

Accelerators as defense (FRYGB2)

- A compact e- accelerator in space could generate needed radiation
- Terrestrial NSF experiment using 1 MeV linac from Lancaster University
  - characterize the fundamental beam physics
- NASA Beam-PIE experiment mentioned
  - 60 keV C-band RF accelerator
  - Cannot find any information about this…

Accelerators as defense (FRYGB2)



	Estimates
Length	1.25 m
Weight	31 kg
Beam Power	10 kW peak 1 kW average

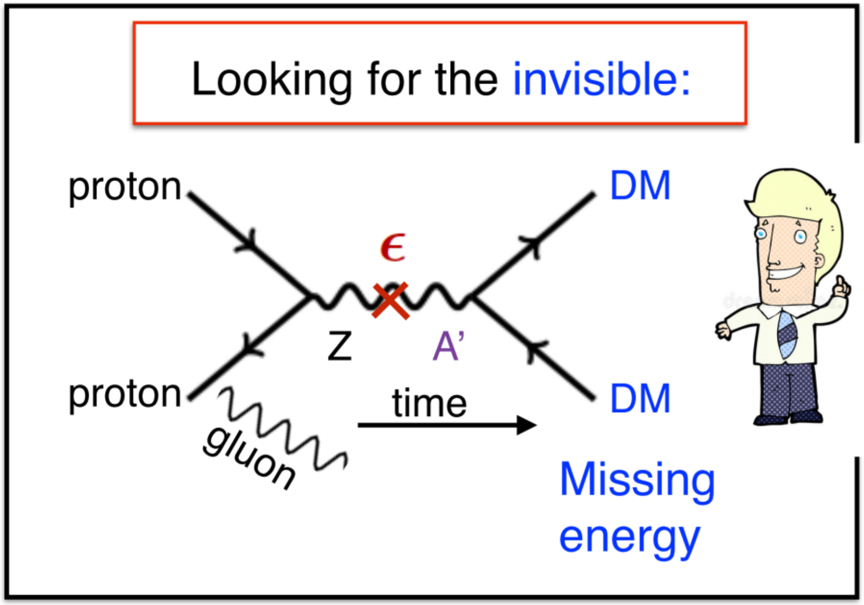
Slide taken from B. Carlsten's presentation @ IPAC'18

Dark sectors (FRYGB3)

- Extremely good review of dark sector possibilities, current exclusion bounds, etc.

$$\epsilon Z^{\mu\nu} A'_{\mu\nu}$$

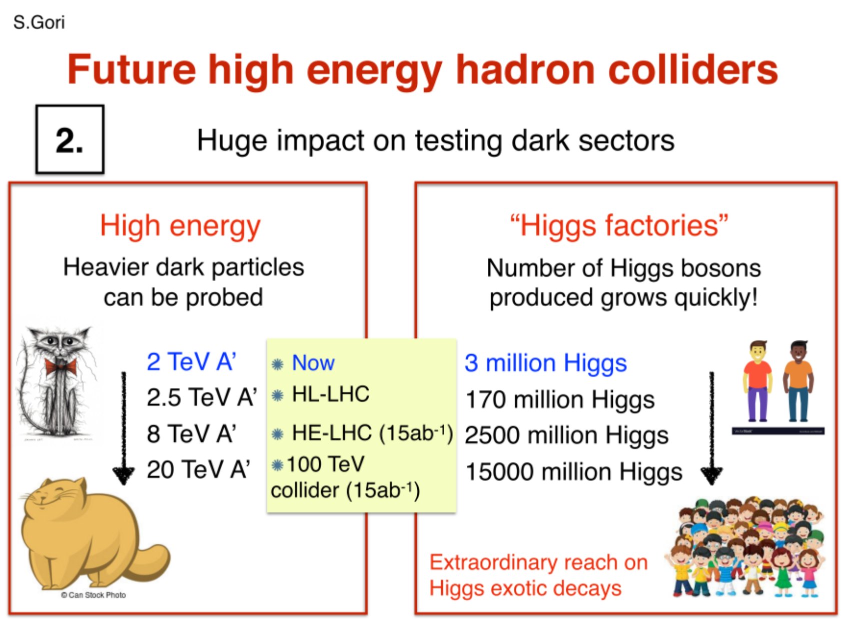
The dark photon, A', will have a small quantum component of the SM Z boson and vice versa



Slide taken from S. Gori's presentation @ IPAC'18

Dark sectors (FRYGB3)

- Can also exploit Higgs's natural interaction with dark matter



Slide taken from S. Gori's presentation @ IPAC'18

Dark sectors (FRYGB3)

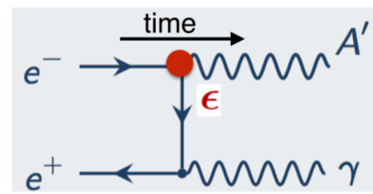
S.Gori

B-factories & $e^+ e^-$ colliders

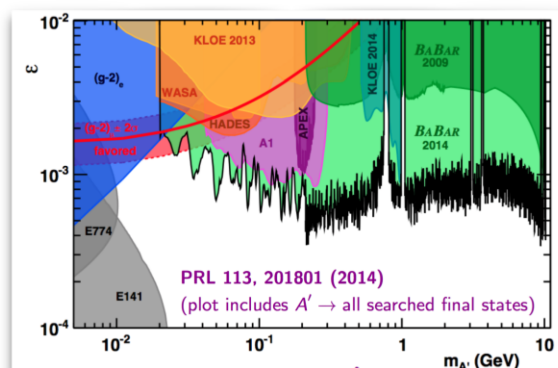
3.

Many (lighter) dark photons are produced at e^+e^- facilities

Advantage: very clean environment



As an example,
Babar has lead a broad program for dark sector searches
(e.g. invisible and visible dark photons, light scalars, axions, …)



$$\epsilon Z^{\mu\nu} A'_{\mu\nu}$$

In the future…

- Belle-II will have a unique opportunity to spearhead a even broader program
- Fantastic opportunities for higher energy e^+e^- colliders (ILC, FCC-ee, CLIC,…) ahead

Slide taken from S. Gori's presentation @ IPAC'18

…and a whole bunch more

- Pre-press is already online! http://ipac2018.vrws.de/


Thank you!

Backup Slides

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TRIUMF Tour

- The TITAN team has a Pikachu figurine that they hide every shift for esprit de corps