1. Doc Edgerton inspired us with awe and curiosity with a visualization of a bullet piercing thru an apple using an exposure of only a millionth of a second

3. Now 50 years later, we can go a million times faster, where we can visualize (the world) not a mil, bil but a trillion frames per second

I present you with a new type of photography.. Femto photography

An imaging technique (virtual slow motion) so fast that we can create slow motion videos of light in motion,

And with that we can even create a Camera that can look around corners beyond line of sight,

Or see inside our bodies without x-rays

And really challenge the way we think about a camera

4. If I turn this laser pointer ON and OFF in less than a one trillionth of a second .. i.e. in a few femto-second ..

I will create a burst of photons, less than a millimeter long .. (pulse)

a bullets of LIGHT moving at speed of light .. but nearly a million times faster than an ordinary bullet

5. So how does light in slow motion look like?

What if we send this bullet of light into the bottle ..

Can we see the bullet of photons SHATTER inside this bottle ?

The whole sequence is less than a nanosecond stretched to about 10 seconds i.e. 10 billion times slowed down

And no .. coca cola did not sponsor this research

6. There is a lot going on this movie .. So lets break this down .. Pulse .. Scatters inside the bottle .. Ripples on the table Hits cap .. Pocket of air .... Reflection after several picoseconds ..

In each frame .. Photons are traveling less than a milimeter

If an oridinary bullet travel the same distance at such a slow motion video, do you know how long you will have to sit here to watch the movie? A day, a week .. a whole year .. it will be a very boring movie ..

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What about some still life photography

Light wash over the tomato as if ripples of waves after dropping stone in a pond of water

Btw this is how nature PAINTS a photo in time, one femto-frame at a time .. But our eye can only perceive the integrated composite

But watch the tomato again, it continues to glow after ripple of light washes over it .. why ..

Light is bouncing around inside a ripe tomato before it comes out several femtoseconds later

Imagine if you have this in your phone few years from now. You will be able to go to your supermarket and tell if that fruit is ripe without touching it

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So how did my team build this imaging technique at MIT and Media Lab

painstakingly put together a collection of hardware in unexpected ways .. starting w a so called streak tube, new optical tricks, synchronization and computational technique to weave together video from raw data.

And short exposure remember you really don’t get any light, so at one trillionth of a second ..

so we have to use a stroboscopic sampling method to fire the bullet millions of times and do clever sync and record raw data, and use computational techniques to to weave together femto-video.

So we are not capturing fate of a single photon.

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Superman can fly and heroes can becomes invisible .. But what about a new power for a future super-hero ..

A camera that can look around corners ..

The idea is to bounce light from other surfaces (use echoes of light .. Multiple bounces .. )

We send flash light with our femto-camera to the door, part of it scatters into the room

 A small fraction comes back to the door and even tinier fraction comes back to our femto-camera

By analyzing these multiply bounced photos with trillion frames per second imaging, it turns out we can look around corners beyond the line of sight

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Not just science fiction but we have actually shown this in our lab on a tabletop setup

The femto-camera is on the left and the mannequin is hidden behind the wall .. so how do we do it? Our paper was recently published and highlighted on nature.com and Nature produced this animation

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After taking dozens of such femto-photos and using a mathematical technique ..

Here is our blobby mannequin with full 3D shape recovered

We have a long way to go before we take this out on the road .. but in the future

We can avoid collision with what is around the bend .. can we proclaim that in 20 years there will be no car accidents?

Or look for survivors in hazardous conditions from changes in light reflected from open windows

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And to see deep inside the body with endoscopes that look in narrow channels in lungs

Or colons

Or heart .. offcourse many challenges due to tissue and blood .. but this is call to scientists to solve the next generation of imaging problems with femto-photography

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And just like Doc Edgerton, a scientist himself .. The science turned into art .. Art of ultra-fast photography ..

I realized .. the data we collect is not just for scientific imaging ..

We need a new form of computational photography to visualize this huge amount of data .. using time lapse and color coding .. and now you can see ripples of light but remember the time between each is only trillionth of a second

Like ripples of waves you see after throwing a stone in a pond of water (1 sec -> 300 years)

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But there is also something funny going on here .. the ripple are moving away from the camera towards the cap of the bottle when we know that light should be moving from cap to the camera?

Well Einstein would have loved to see this femto-photo

It turns out that because we are recording nearly at the speed of light, there is reversal in how we observe events in the world. After a correct mathematical space-time warp, we can correct for this time distortion.

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So whether photographing around corners, or create next generation of health diagnostics, novel visualizations

Since our invention .. we have open-sourced all the details and datasets, and we hope the DIY and creative folks will show us that we should stop boasting about the megapixels in our cameras and start focussing on the next dimension in imaging .. and it is about time.