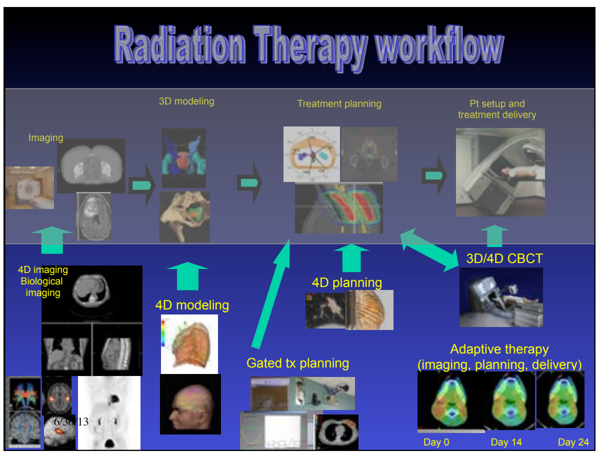
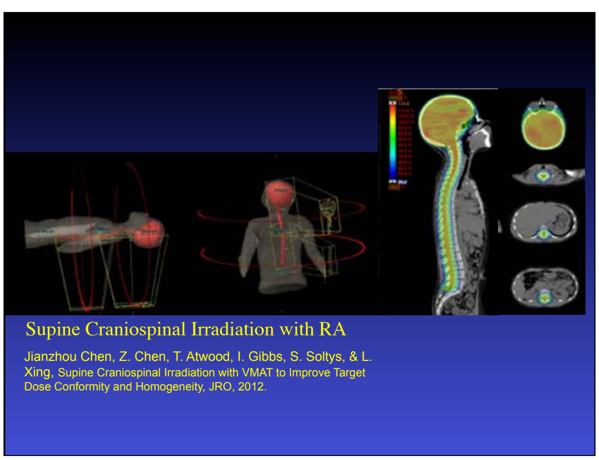
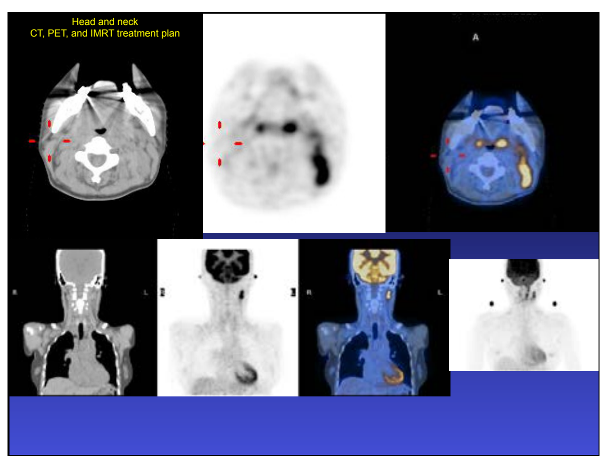
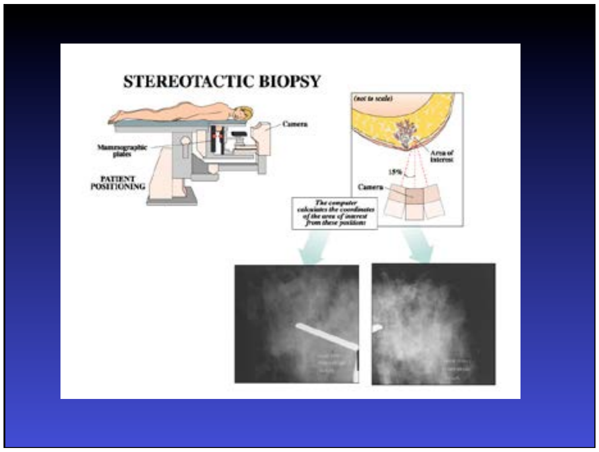
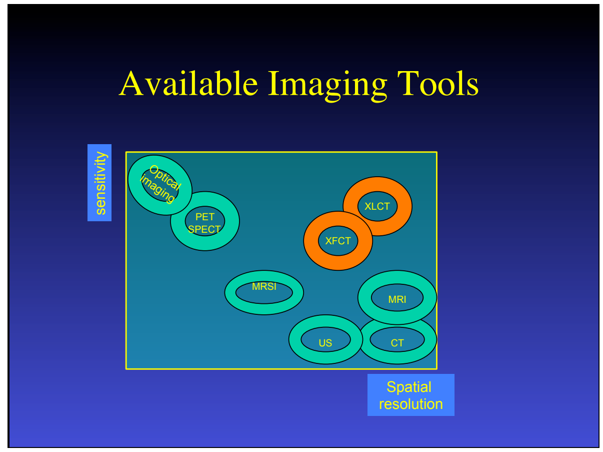


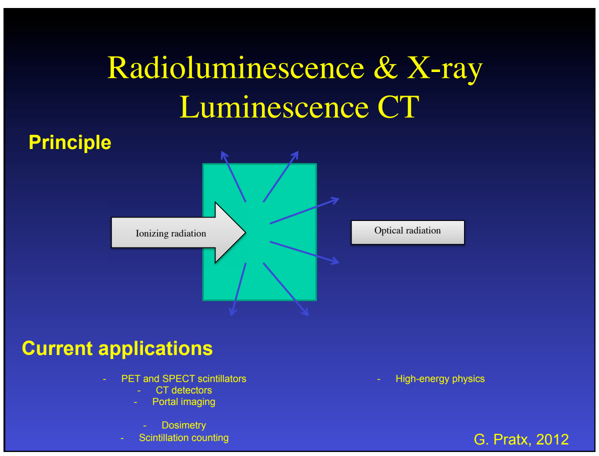


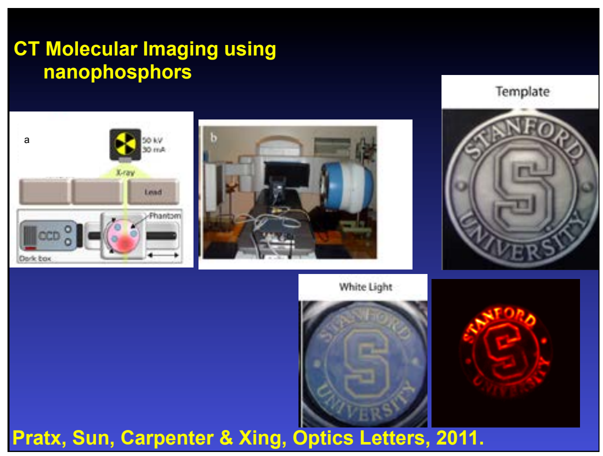


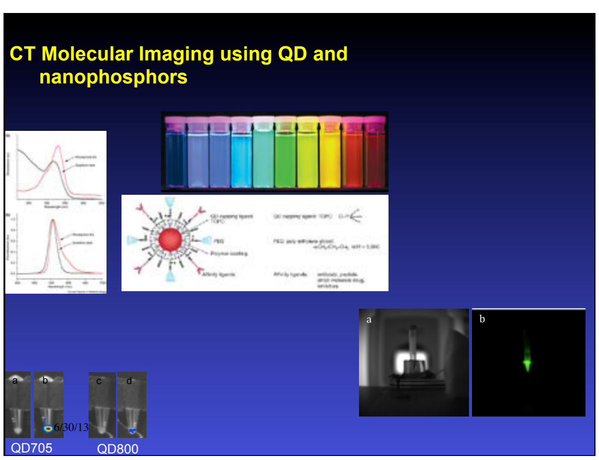
@01-258_via99-011_hepatoma_onscreen

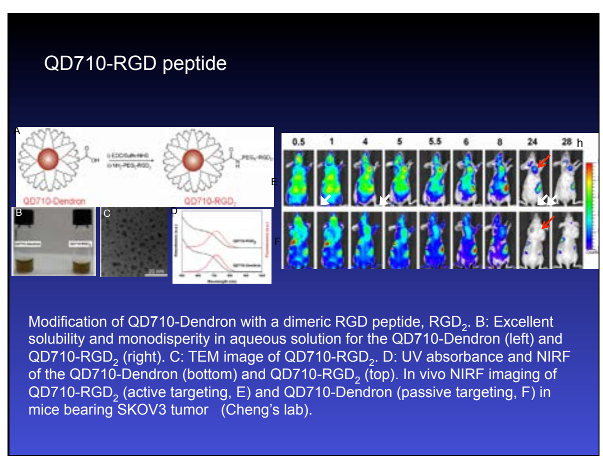




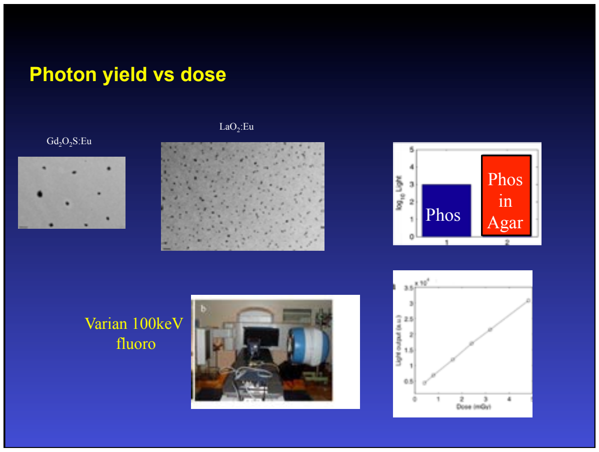


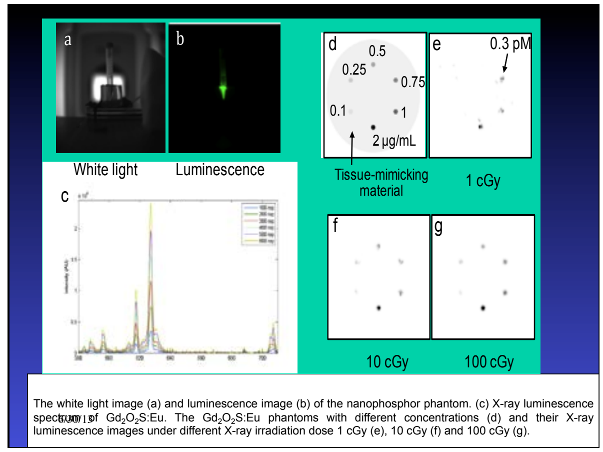


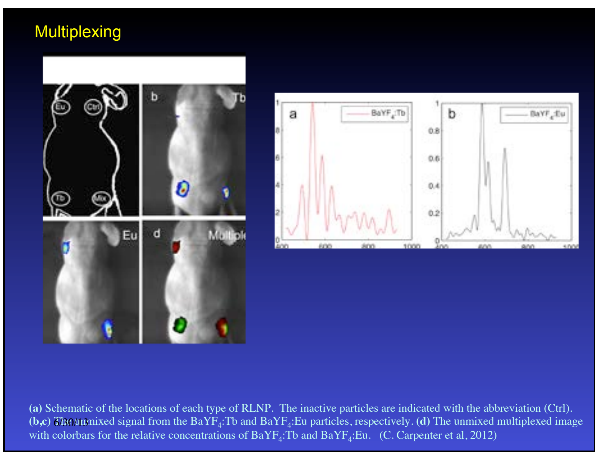


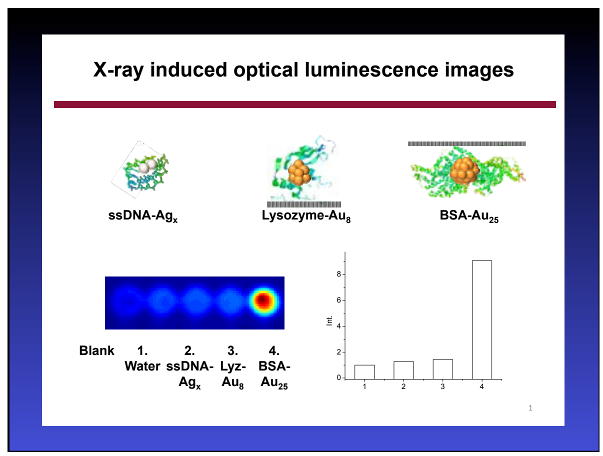


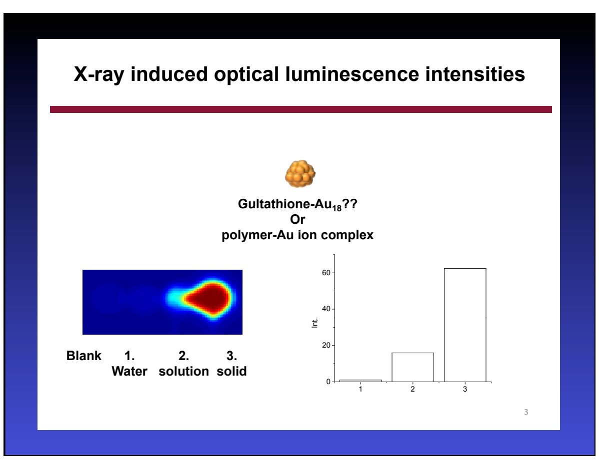
@01-258_via99-011_hepatoma_onscreen

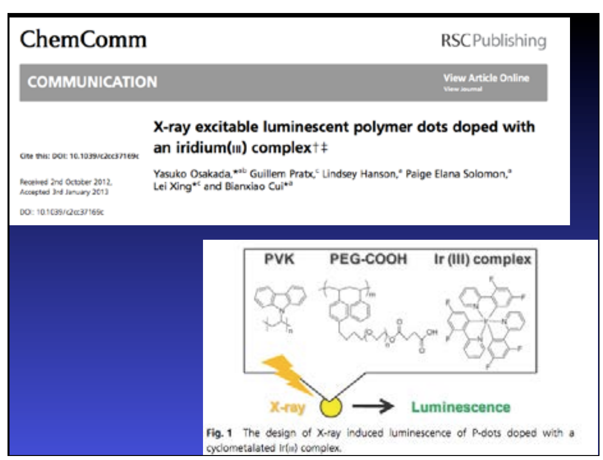

Photon yield vs dose
Gd2O2S:Eu
LaO2:Eu
Phos
Phos in Agar
Varian 100keV fluoro
Dose (mGy)

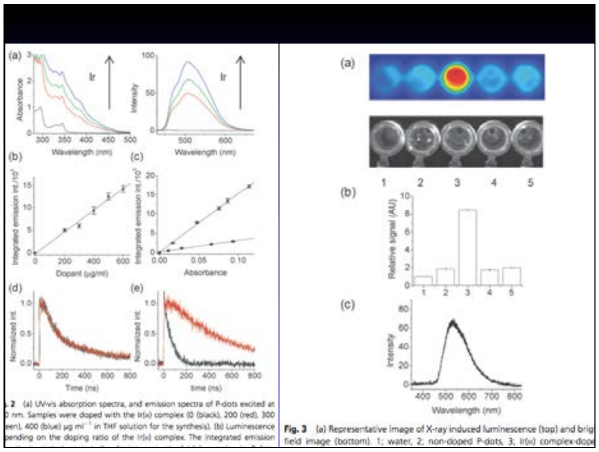

a
b
White light
Luminescence
c
d
0.5
0.25
0.75
0.1
1
2 μg/mL
Tissue-mimicking material
e
0.3 pM
1 cGy
f
g
10 cGy
100 cGy
The white light image (a) and luminescence image (b) of the nanophosphor phantom. (c) X-ray luminescence spectrum of Gd2O2S:Eu. The Gd2O2S:Eu phantoms with different concentrations (d) and their X-ray luminescence images under different X-ray irradiation dose 1 cGy (e), 10 cGy (f) and 100 cGy (g).

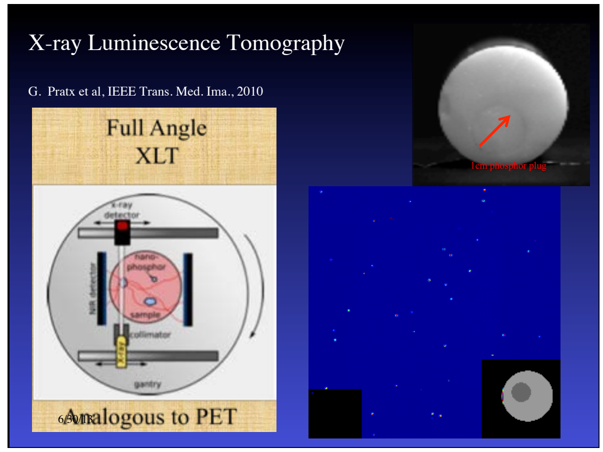

Multiplexing
Eu
Ctrl
Tb
Mix
b
Eu
d
Multiple
a
BaYF4:Tb
b
BaYF4:Eu
(a) Schematic of the locations of each type of RLNP. The inactive particles are indicated with the abbreviation (Ctrl). (b,c) The unmixed signal from the BaYF4:Tb and BaYF4:Eu particles, respectively. (d) The unmixed multiplexed image with colorbars for the relative concentrations of BaYF4:Tb and BaYF4:Eu. (C. Carpenter et al, 2012)


X-ray induced optical luminescence images
ssDNA-Agx
Lysozyme-Au8
BSA-Au25
Blank
1. Water
2. ssDNA-Agx
3. Lyz-Au8
4. BSA-Au25
Int.

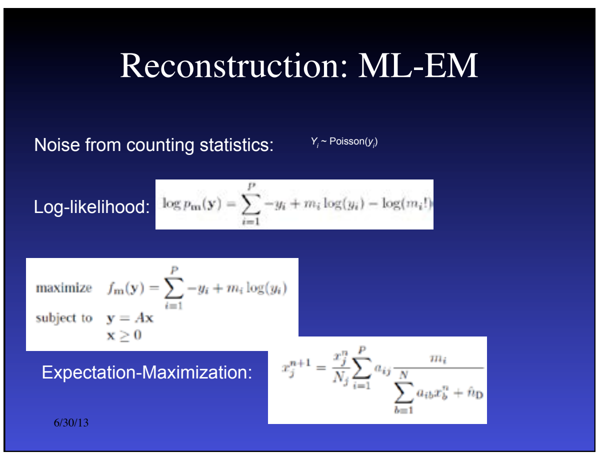

X-ray induced optical luminescence intensities
Gultathione-Au18??
Or
polymer-Au ion complex
Blank
1. Water
2. solution
3. solid
Int.


ChemComm
RSCPublishing
COMMUNICATION
View Article Online
X-ray excitable luminescent polymer dots doped with an iridium(III) complex†‡
Yasuko Osakada, Guillem Pratx, Lindsey Hanson, Paige Elana Solomon, Lei Xing and Bianxiao Cui
Received 2nd October 2012, Accepted 3rd January 2013
PVK
PEG-COOH
Ir (III) complex
X-ray
Luminescence
Fig. 1 The design of X-ray induced luminescence of P-dots doped with a cyclometalated Ir(III) complex.

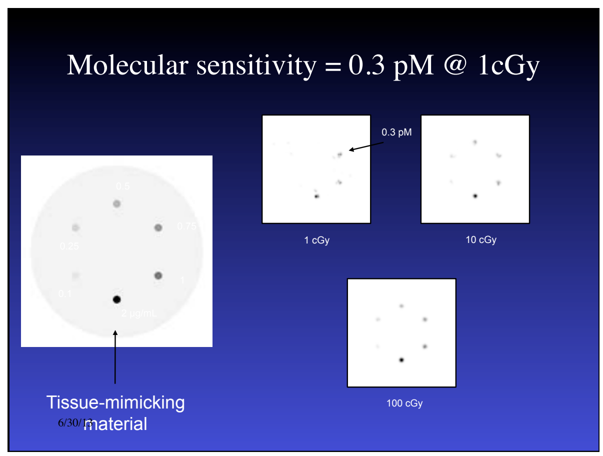




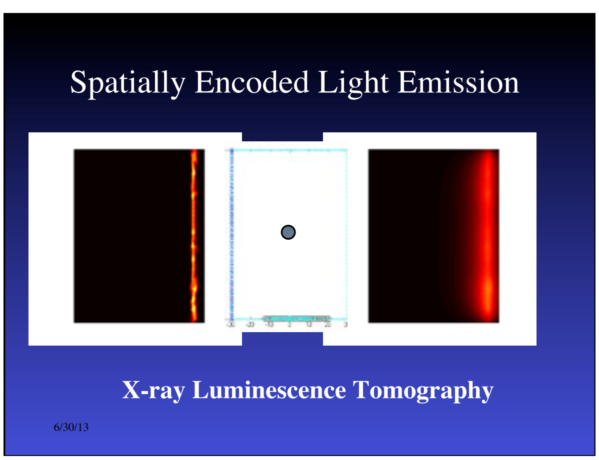
X-ray Luminescence Tomography
G. Pratx et al, IEEE Trans. Med. Ima., 2010
Full Angle
XLT
Analogous to PET



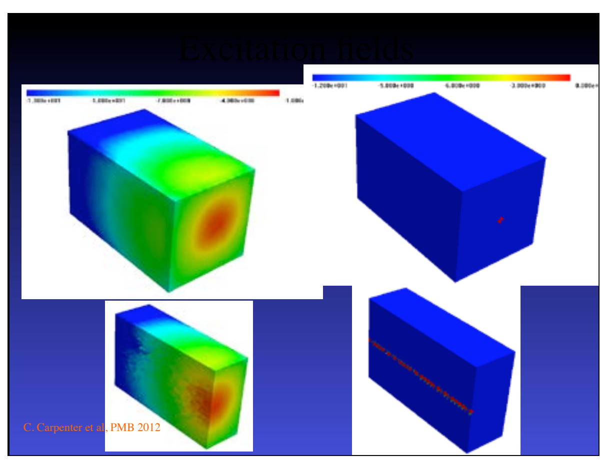
Reconstruction: ML-EM
Noise from counting statistics: $Y_i \sim \text{Poisson}(y_i)$
Log-likelihood: $\log p_m(\mathbf{y}) = \sum_{i=1}^{P} -y_i + m_i \log(y_i) - \log(m_i!)$
maximize $f_m(\mathbf{y}) = \sum_{i=1}^{P} -y_i + m_i \log(y_i)$
subject to $\mathbf{y} = A\mathbf{x}$
$\mathbf{x} \geq 0$
Expectation-Maximization: $x_j^{n+1} = \frac{x_j^n}{N_j} \sum_{i=1}^{P} a_{ij} \frac{m_i}{\sum_{b=1}^{N} a_{ib} x_b^n + \bar{n}_D}$
6/30/13



Molecular sensitivity = 0.3 pM @ 1cGy
0.3 pM
1 cGy
10 cGy
100 cGy
Tissue-mimicking
material

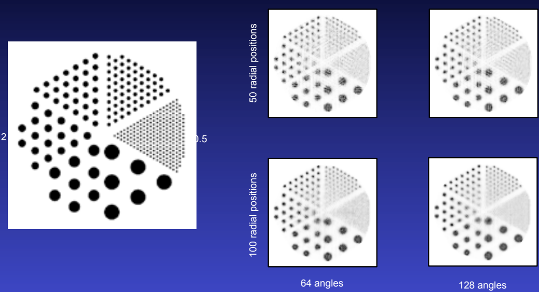


Spatially Encoded Light Emission
X-ray Luminescence Tomography
6/30/13

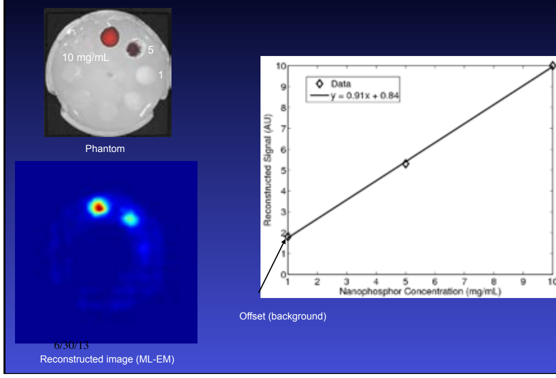


Excitation fields
C. Carpenter et al, PMB 2012

Spatial resolution ~ 1 mm

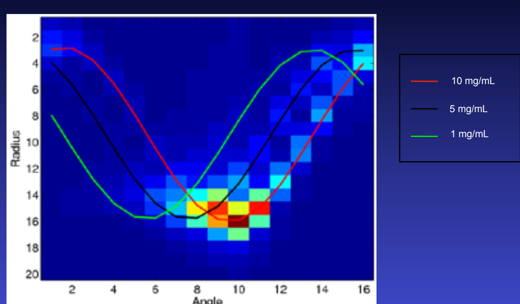


Reconstruction & linearity



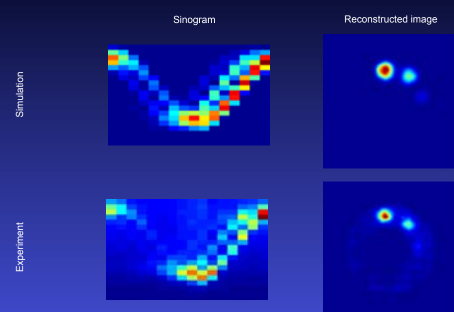
6/30/13

Sinogram



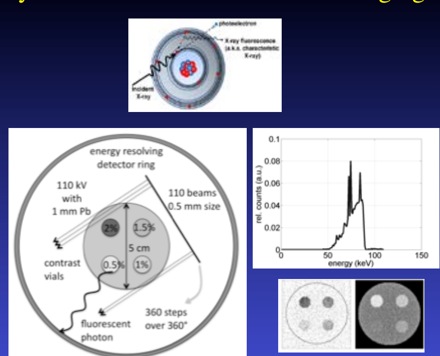
6/30/13

Simulation vs Experiment



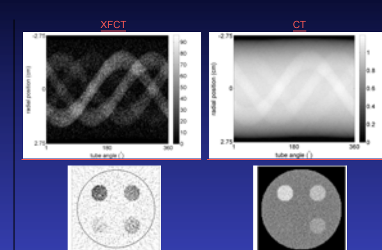
6/30/13

X-ray Fluorescence Molecular CT Imaging



M. Balazova, Y. Kuang, G. Pratx, L. Xing, X-ray Fluorescence Molecular CT Imaging, IEEE Trans Med Ima., 2012

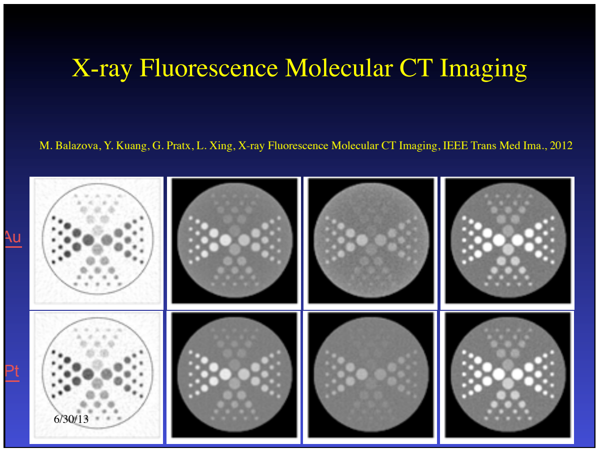
X-ray Fluorescence Molecular CT Imaging

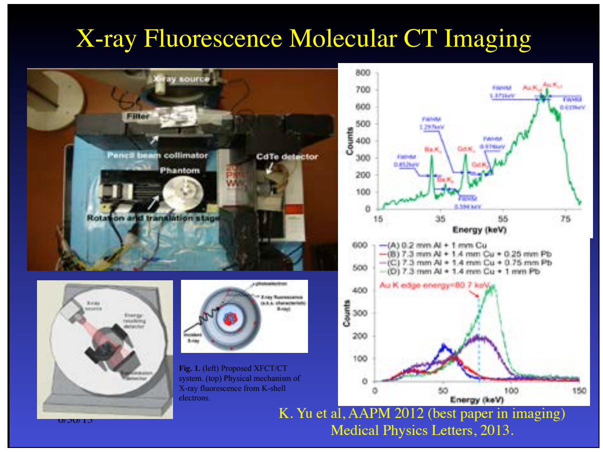


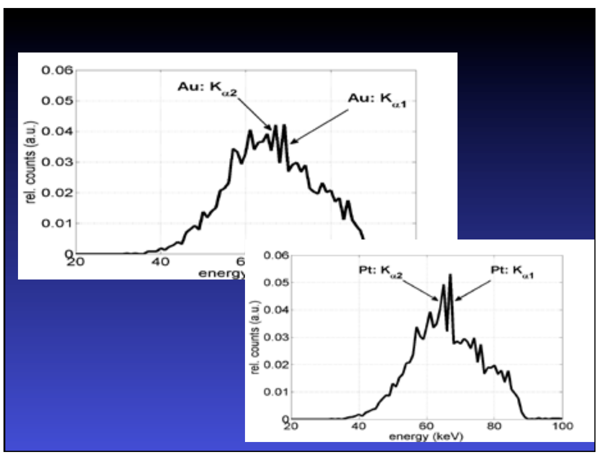
Sinograms (top) and reconstructed CT images (bottom) for XFCT (left) and transmission CT (right) of the low-resolution phantom loaded with gold for a 0.1 mGy imaging dose. (Magda Bozalova et al)

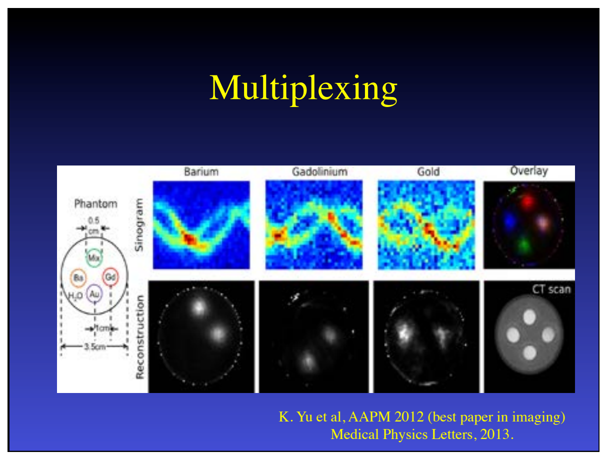
M. Balazova, Y. Kuang, G. Pratx, L. Xing, X-ray Fluorescence Molecular CT Imaging, IEEE Trans Med Ima., 2012

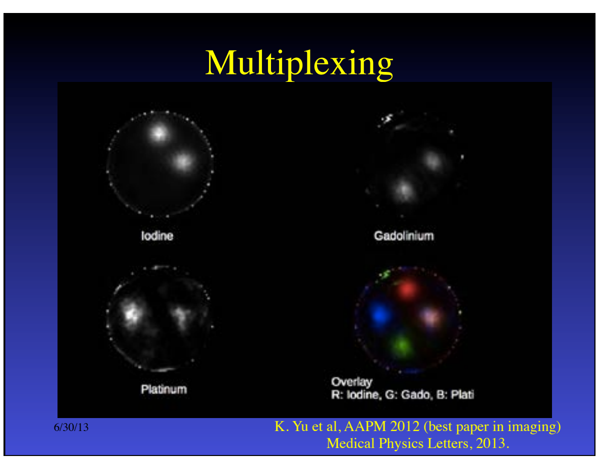
@01-258_via99-011_hepatoma_onscreen

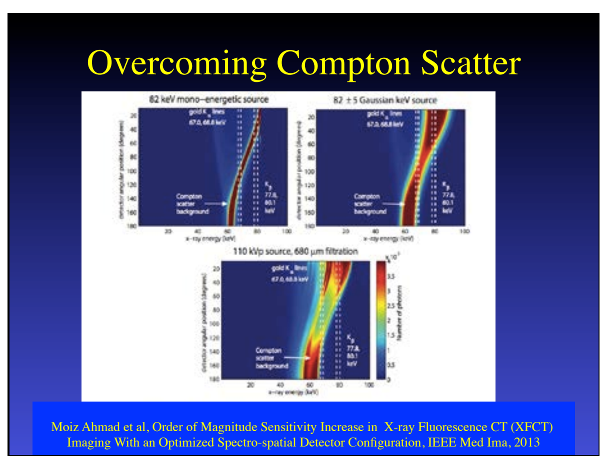












@01-258_via99-011_hepatoma_onscreen

Going Beyond K-Schell Imaging

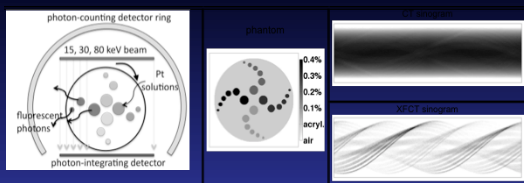


Figure 1: Monte Carlo imulation geometry of XFCT and CT imaging using 1st generation CT scanning (left). Monoenergetic pencil beams with 15, 30, and 80 keV were simulated using 55 dwell positions across the extent of the phantom and rotated by 360 in 1 steps. The 2-cm diameter phantom (middle) contained 0.6 to 2.2 mm diameter vials with 0.1 to 0.4% solutions of Cisplatin. Transmission CT (top right) and XFCT (bottom right) sinograms of the phantom were generated. CT and XFCT images were then reconstructed with three different reconstruction techniques.

Magda Bazalova, to be published, 2013

High-sensitivity x-ray fluorescence CT imaging of Cisplatin with L-shell x-rays

Magda Bazalova et al, to be published

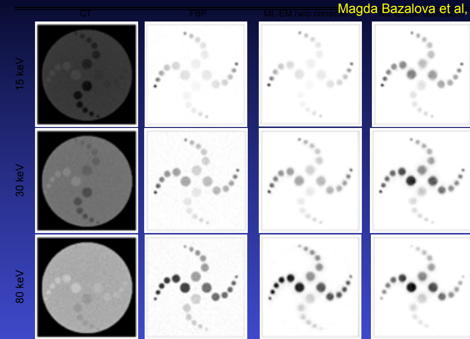


Figure 2: CT images (first column, W/L = 800/0) and XFCT images reconstructed with filtered back-projection (FBP, second column) and maximum likelihood expectation maximization (ML-EM, 20

High-sensitivity x-ray fluorescence CT imaging of Cisplatin with L-shell x-rays

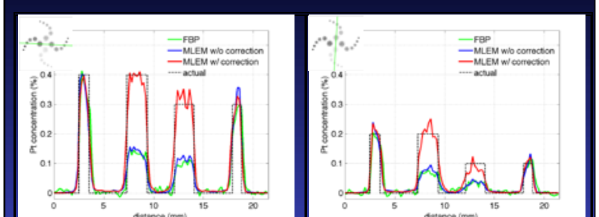
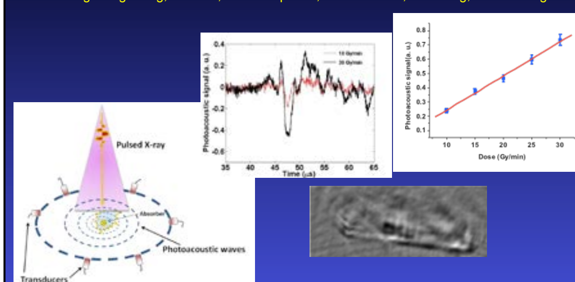


Figure 5: Profiles along a horizontal (left) and vertical (right) line across the phantom for the 15 keV images reconstructed with FBP (green), ML-EM without (blue) and with (red) attenuation correction.The actual profile is marked by the black dashed line. The accuracy of concentration reconstruction is significantly increased when attenuation correction is applied.

X-ray acoustic tomography (XACT) with pulsed X-ray beam from a medical linear accelerator

Liangzhong Xiang, Bin Han, Colin Carpenter, Guillem Pratx, Yu Kuang, and Lei Xing



30 picoseconds per pulse

Xiang L et al, Medical Physics Letters, 2013

Summary

- Interaction of X-ay with endogenous or exogenous media provides the basis for X-ray molecular imaging.
- Highly sensitive and specific X-ray molecular imaging is possible.
- XFCT, XLCT and XACT are a few examples of X-ray molecular/physiological imaging that are being developed at Stanford.

@01-258_via99-011_hepatoma_onscreen