Conceptual ideas on single shot transverse diagnostics for electron bunches at REGAE

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Hamburg University

Scintillating Screen Applications in Beam Diagnostics workshop

GSI,February 2011

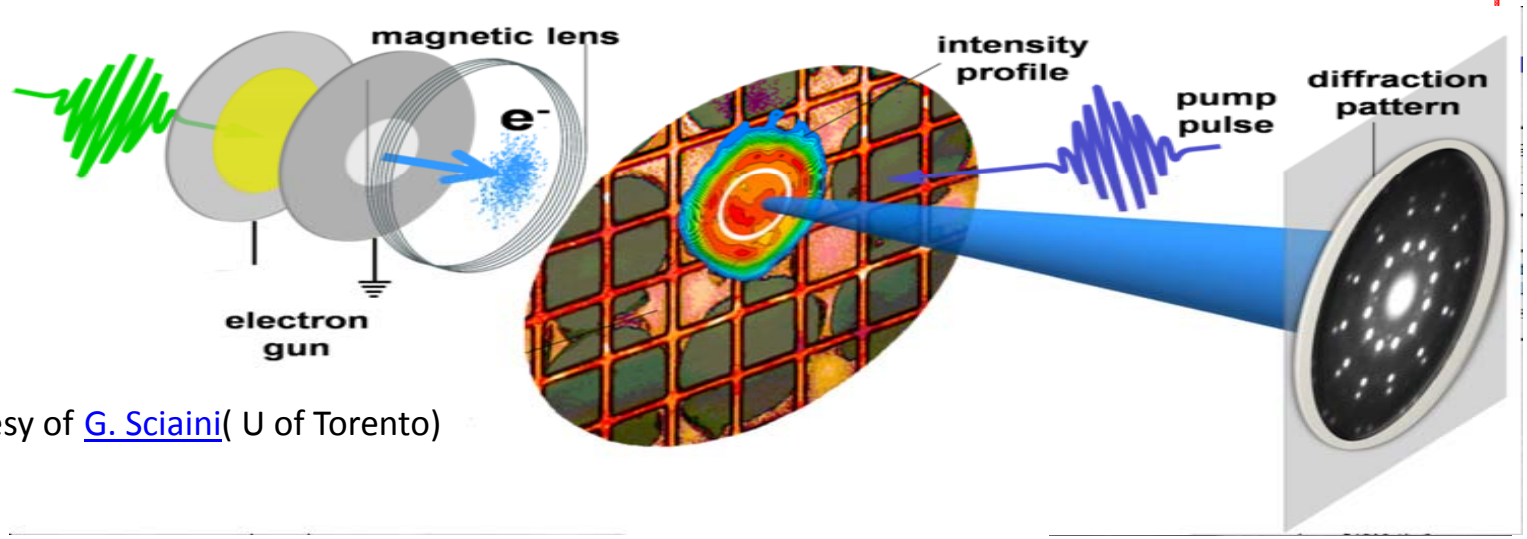
Electron Diffraction Experiment

REGAE (Relativistic Electron Gun for Atomic Exploration)

Femtosecond Electron Diffraction (FED):Fundamental information on ultrafast atomic processes or making a molecular movie,

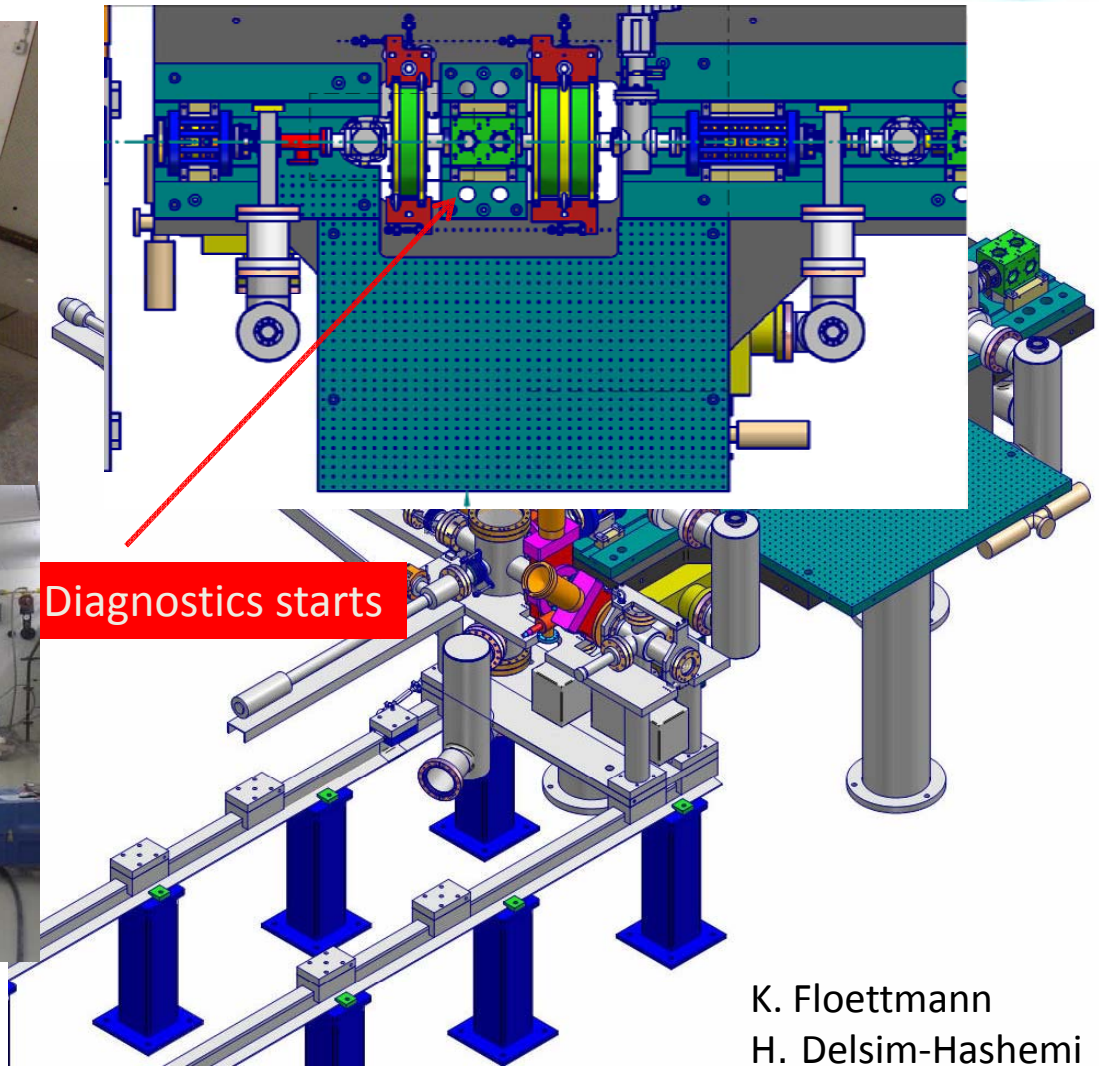
1) Number of electrons per bunch ↓ — reversible process → Time resolution ↑

2) relativistci electron beam — irreversible process →
   - Space-charge ↓
   - Time resolution ↑
   - bunch current ↑



Courtesy of G. Sciaini(U of Torento)

REGAE layout



K. Floettmann
H. Delsim-Hashemi

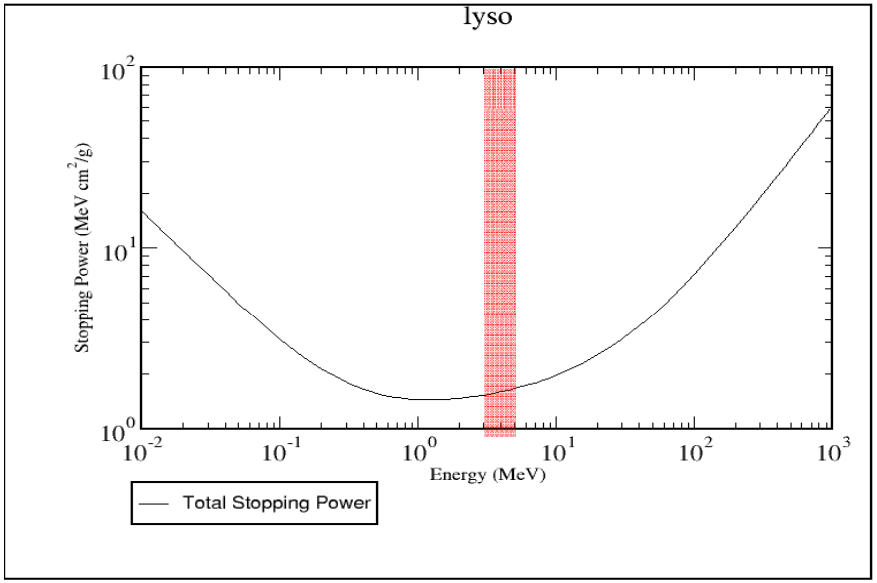
Beam requirements

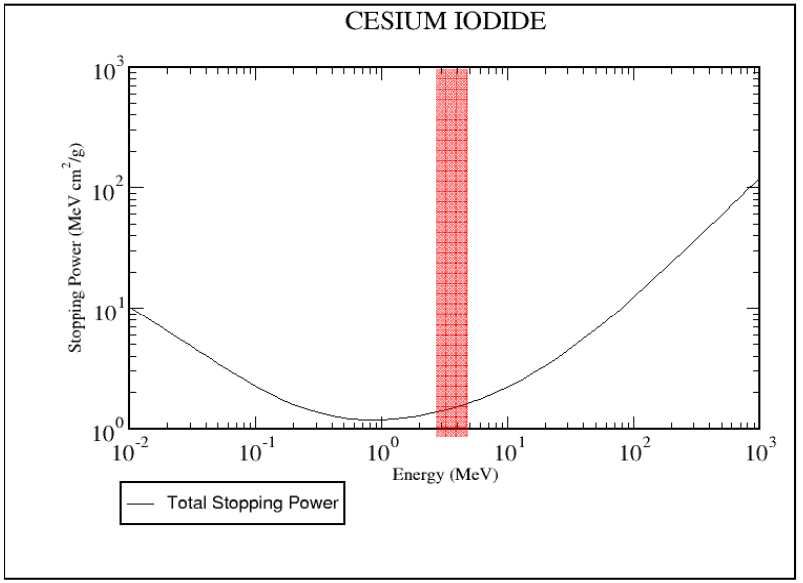
single shot capability

Electron beam energy	2-5 MeV
Beam charge	100fC
Bunch length	30 fs (9 µm)
Coherence length	30nm
Transverse emittance	$6 \cdot 10^{-3}$ mrad mm
rep. rate	single pulses with 10 - 100 Hz

	LYSO	CsI(Tl)
Density (g/cm^3)	7.4	4.51
Effective Atomic Number	66	54
Radiation Length (cm)	1.10	2.43
Decay Constant (ns)	40-44	1000
Peak Emission (nm)	428	560
Light Yield /MeV	27000	51800
Index of Refraction	1.82	1.79

Stopping power for LYSO and CsI



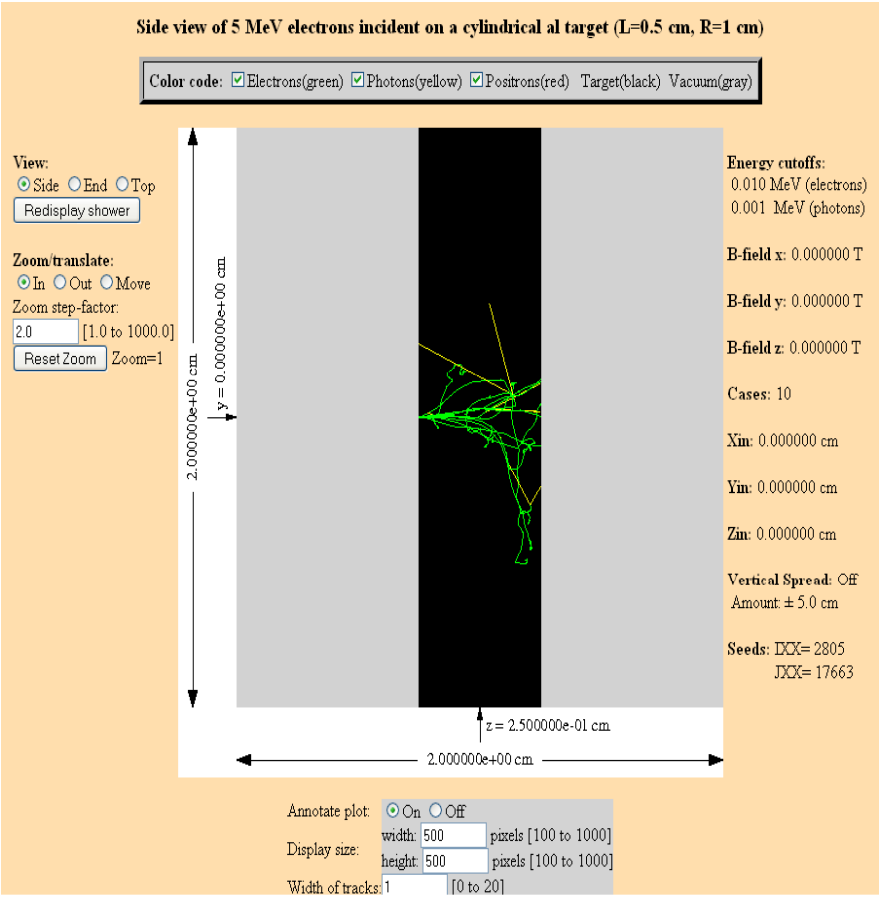


Electron Gamma Shower (EGS)

Type	electron			electron
Incident kinetic energy	5	MeV	.010 to 1000	100
Number of particles in beam	10		1 to 100	10
Incident particle vertical spread	◉ Off ○ Random in Y axis ○ Uniform in Y axis			Off
If on, define y-axis spread ±	5.0	cm	0 to 100	5
Define the Target				
Target medium	aluminum			concrete
Target length	0.5	cm	0 to 100	20
Target radius	1	cm	0 to 100	10
Define the Magnetic Field Strength and Direction(s)				
Horizontal, parallel to the beam	0	Tesla	-10 to 10	0
Horizontal, perpendicular to the beam	0	Tesla	-10 to 10	0
Vertical, perpendicular to the beam	0	Tesla	-10 to 10	0
Define the Image Display Characteristics				
Calculate all electrons and positrons of an energy greater than	0.010	MeV	0.010 to 1000	0.010
Calculate all photons of energy greater than	0.001	MeV	0.001 to 1000	0.001
Display which types of particles?	☑ Electrons (green) ☑ Photons (yellow) ☑ Positrons (red)			Display all
View shower from?	◉ Side ○ End ○ Top			Side view

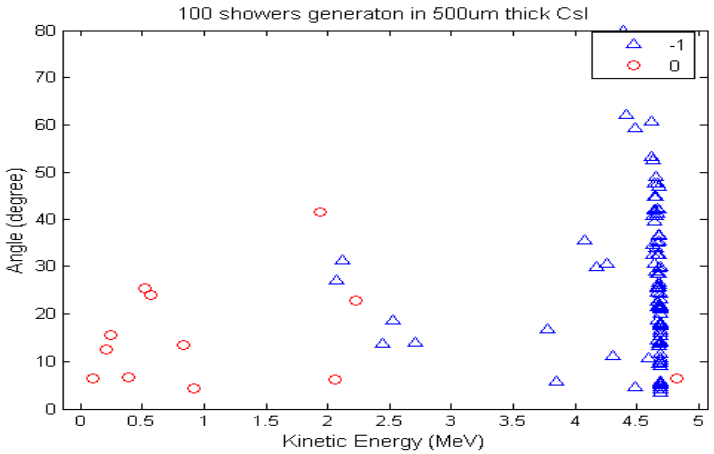
Generate Shower

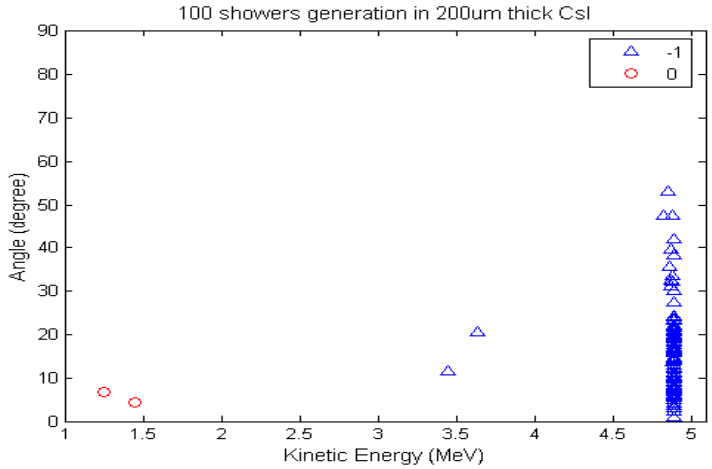
http://www2.slac.stanford.edu/vvc/egs/basicsimtool.html

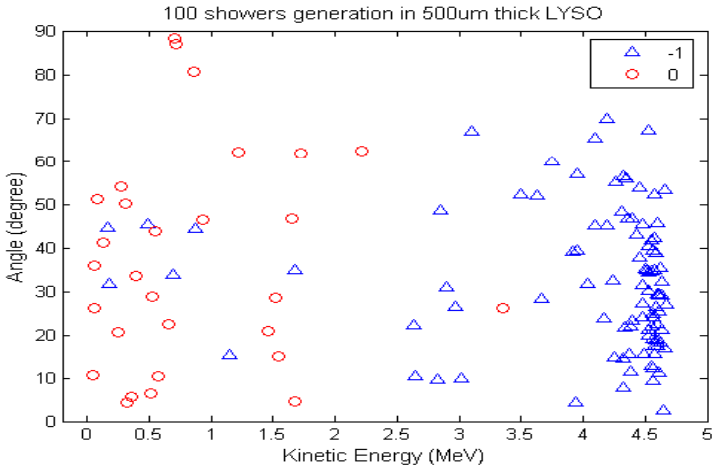


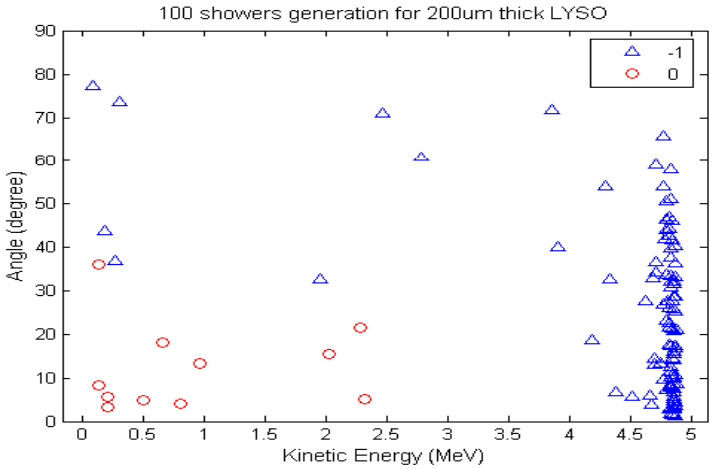
Results of EGS5

➢ With EGS we cannot go to energies lower than 10 KeV and in the following figures we find just energetic electrons and x-rays.





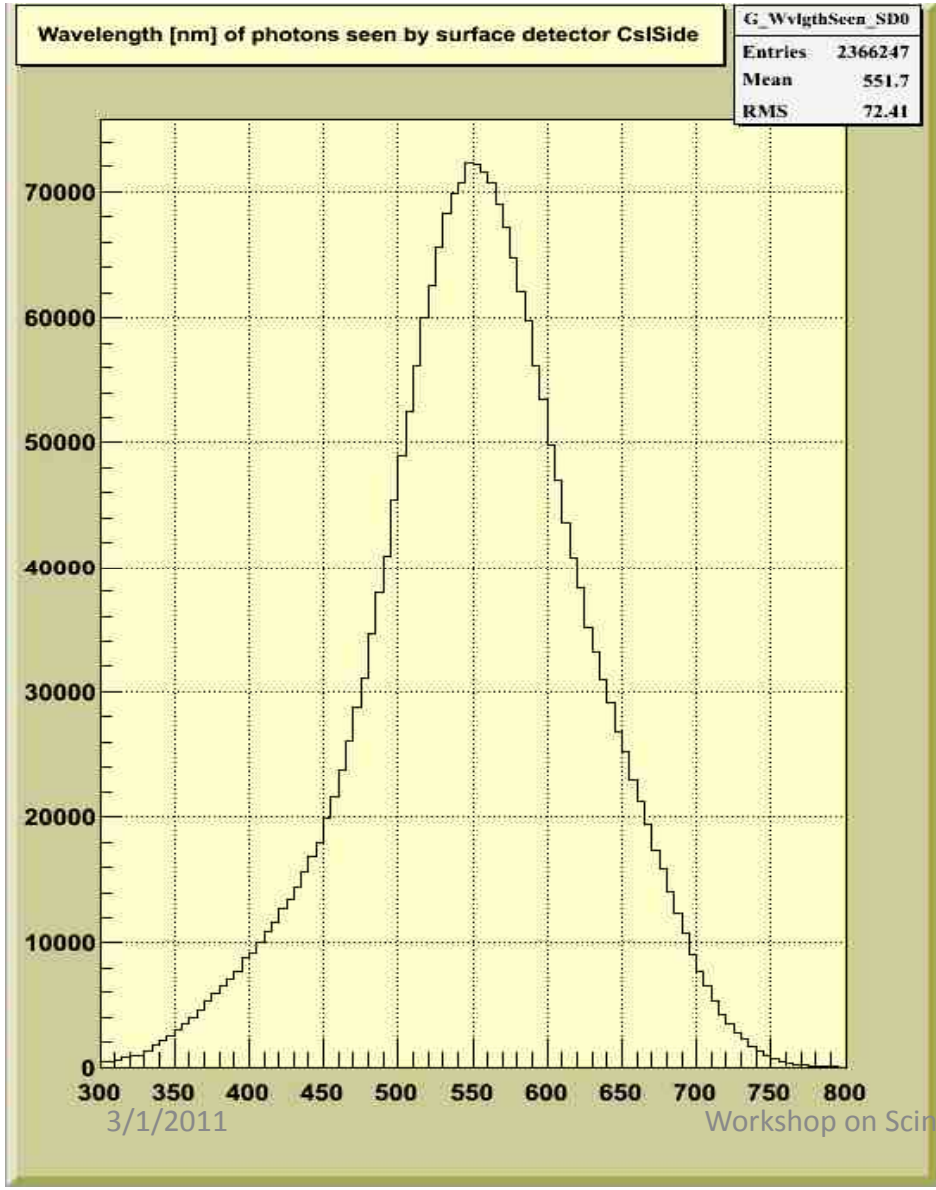


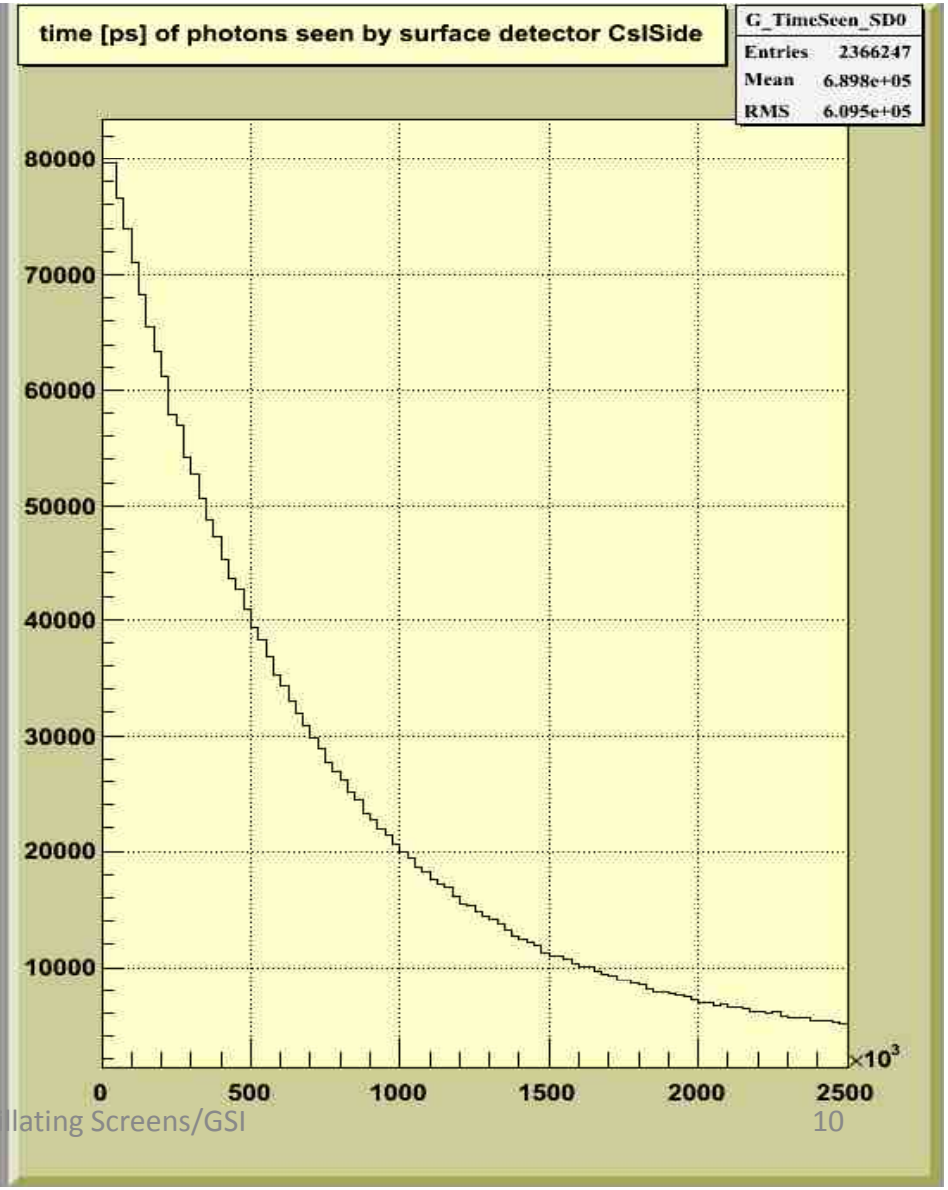


LITRANI
LIght TRansmission in ANIsotropic media

- a general purpose Monte-Carlo program simulating light propagation in isotropic or anisotropic media.
- http://gentitfx.fr/litrani/
- LITRANI is written in C++ and is based on ROOT.
- The program takes into account the variation of the physical parameters as a function of the wavelength.

Simulation results for a crystal of CsITl





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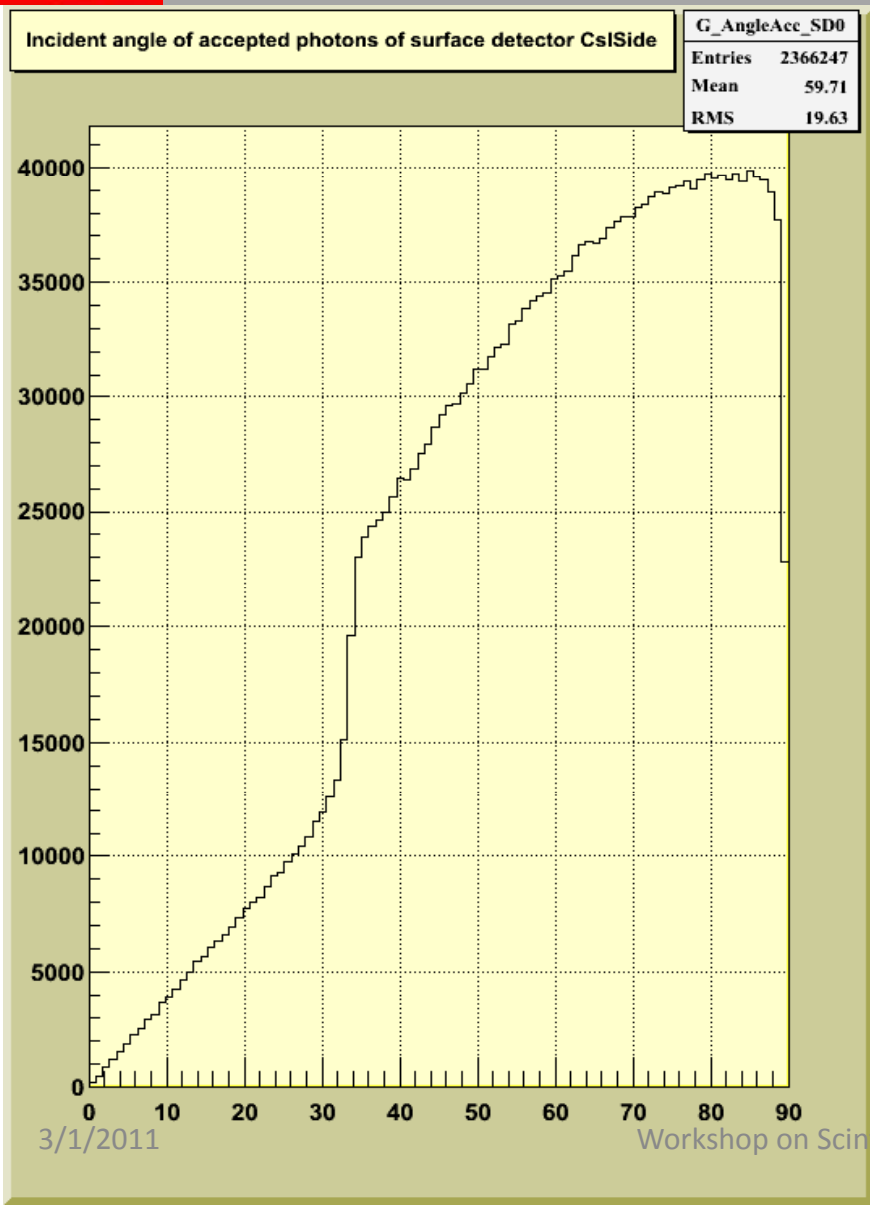
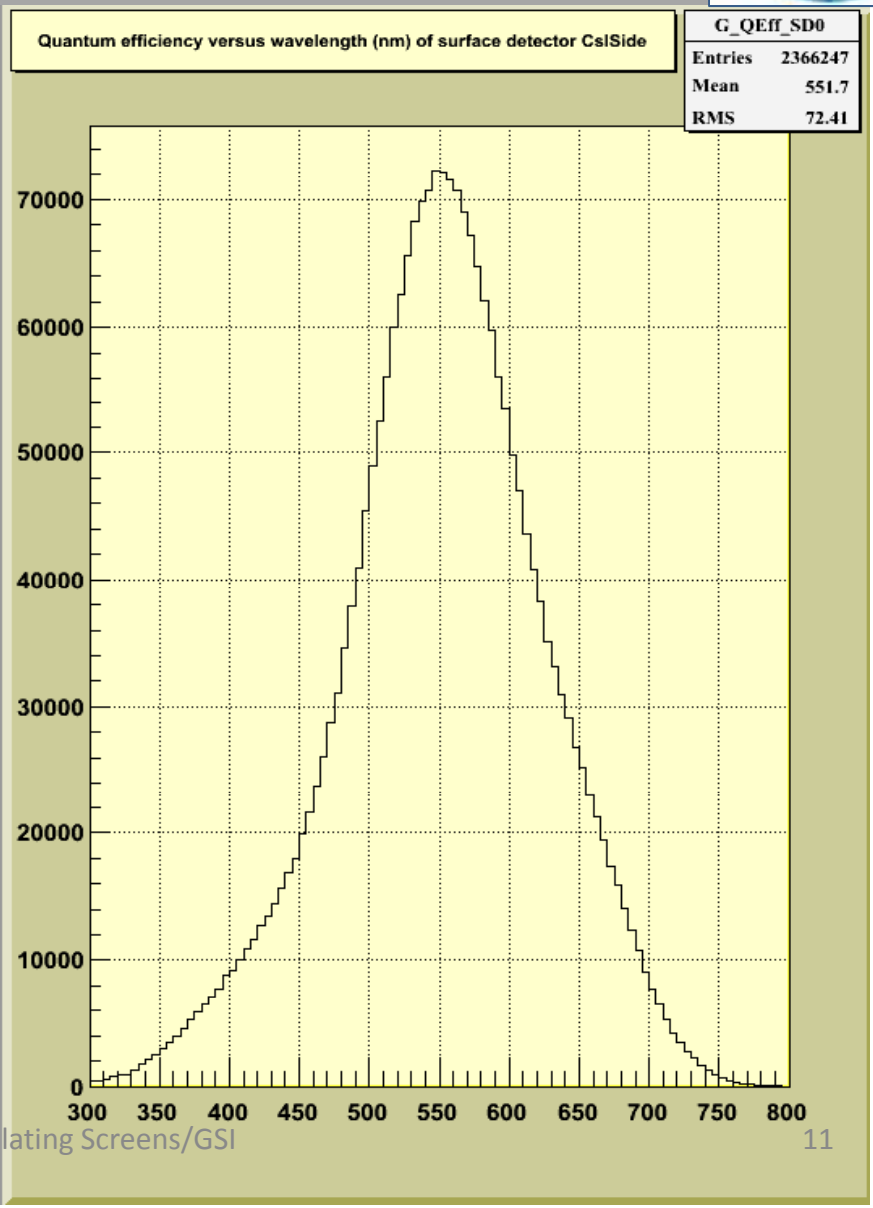
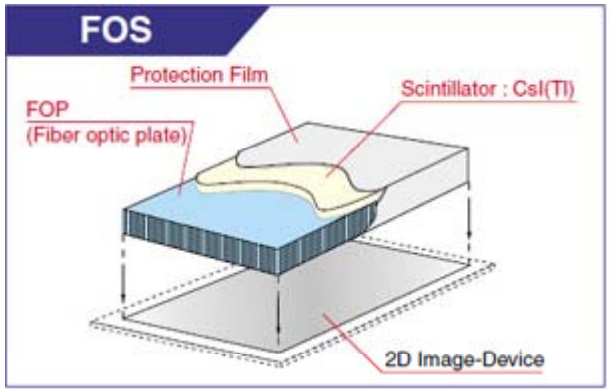




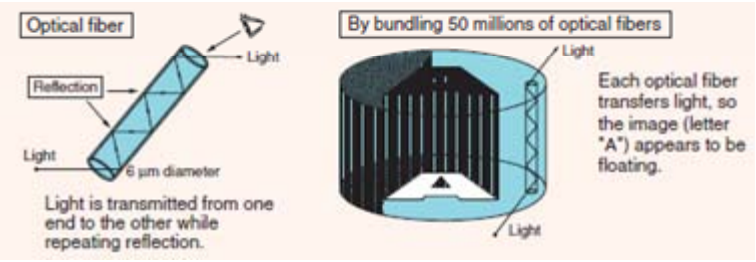
No result for LYSO yet ☹

You have a family of fits giving the distribution for the variating parameter with wavelength. calling any constructor of TSplineFit automatically put the fit into the collection TSplineFit::fgFits.

✓CsITl & Gd_2O_2 S suggested by Hamamatsu

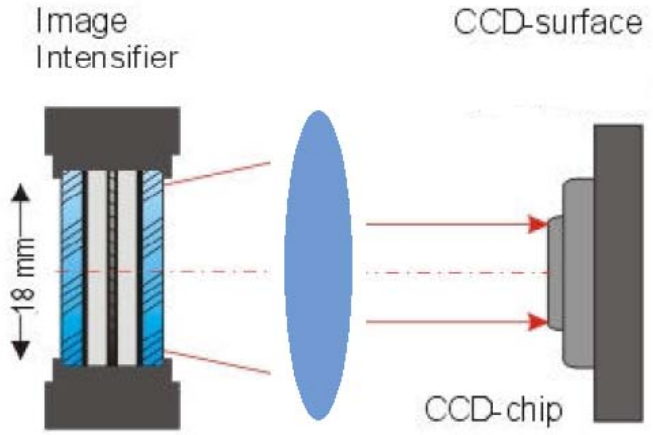


FOP



Detectors

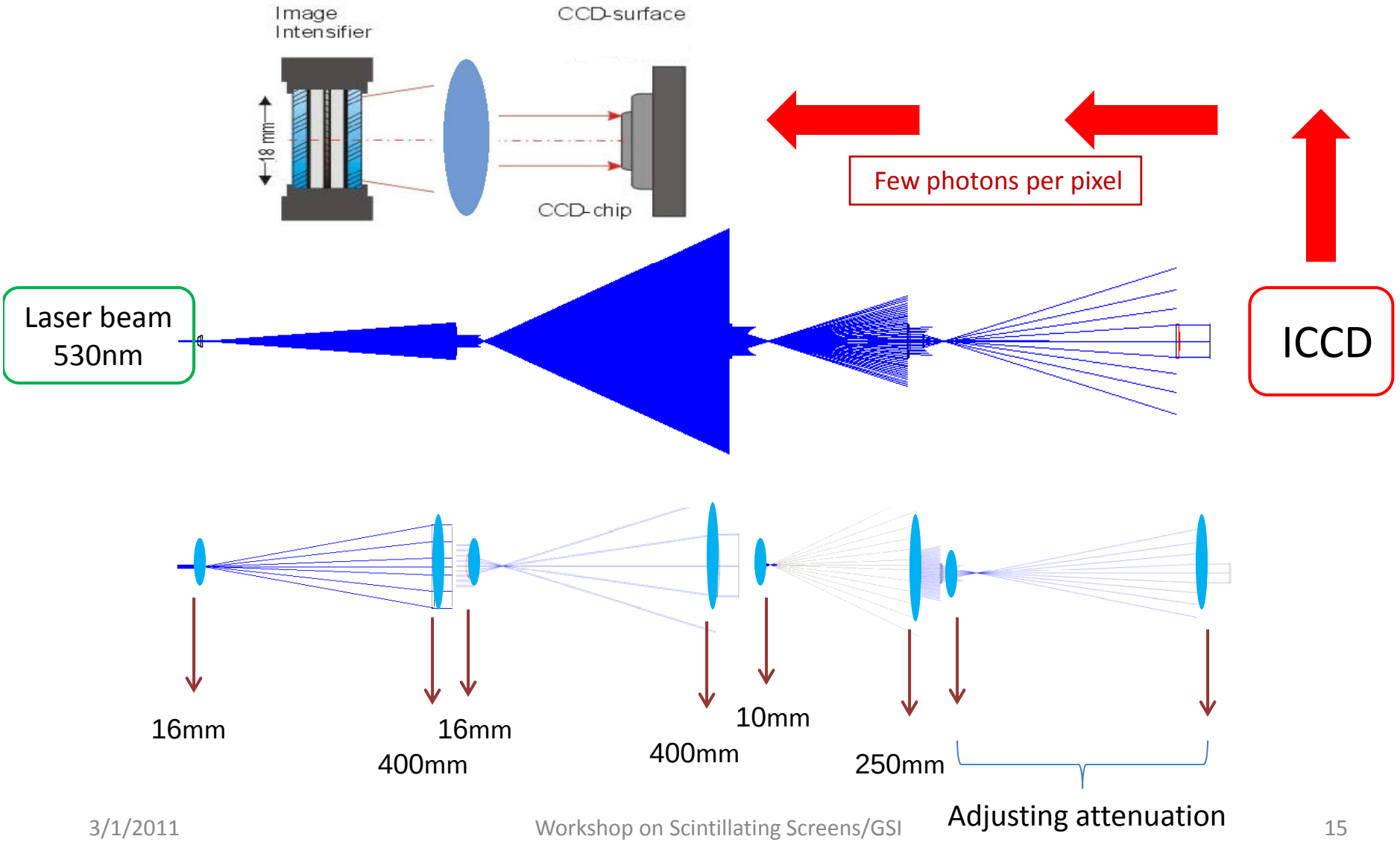
- I+CCD



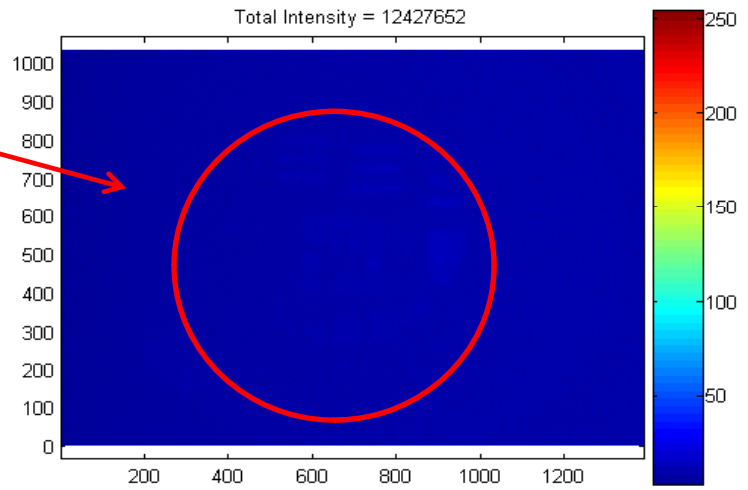
- EMCCD

	ICCD	EMCCD
Gating	100ns	1microsecons
QE	15%	70%
Coupling to CCD	☹	☺
Price	☺	☹

Experiments on detection efficiency

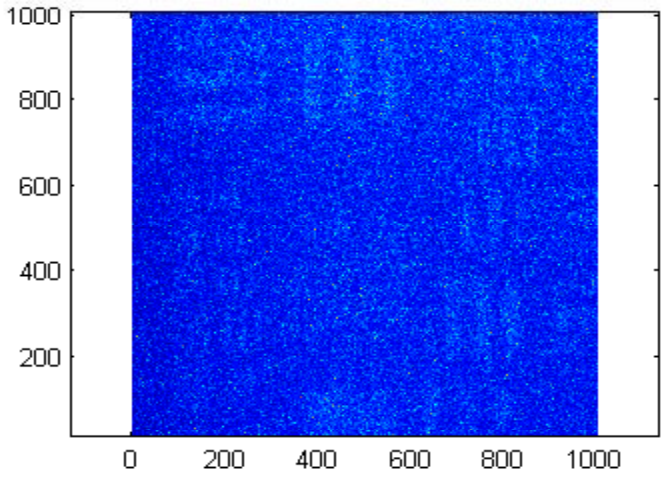


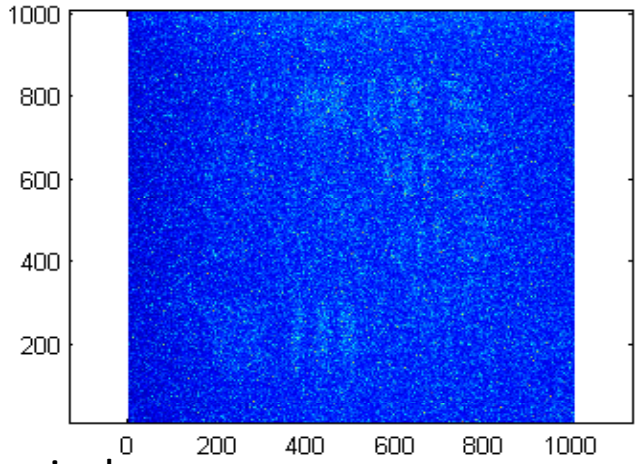
➢ ICCD



Region of interest averaged on 20 shots. (24±2) photons per pixel.

➢ EMCCD





Few photons per pixel

outlook

- Studying and simulating other scintillators specially those can be coupled to FOP by companies.
- Test on new Image Intensifier to consider its efficiency for detection in comparison with EMCCD.
- Installation of a pre-setup for diagnostics.

Thanks for your attention!