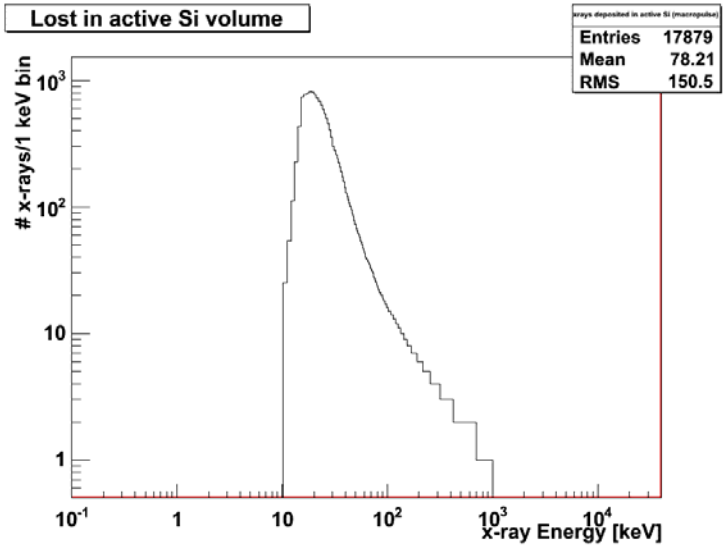
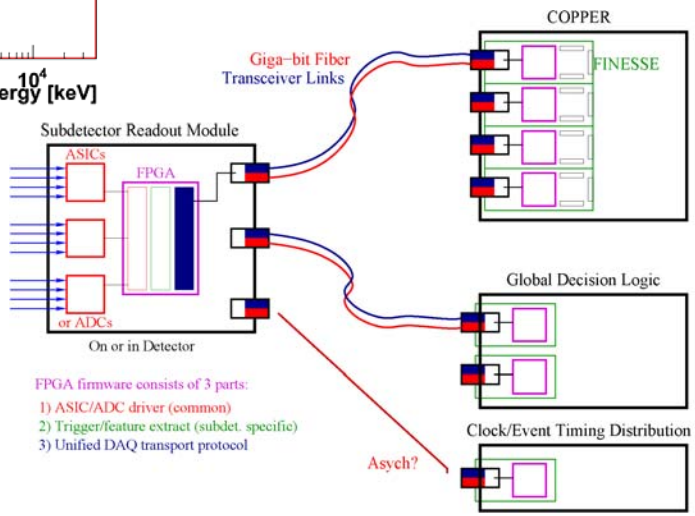
X-ray FEL Detector & DAQ

- Flux update: air case
- Dedicated (single pass) source



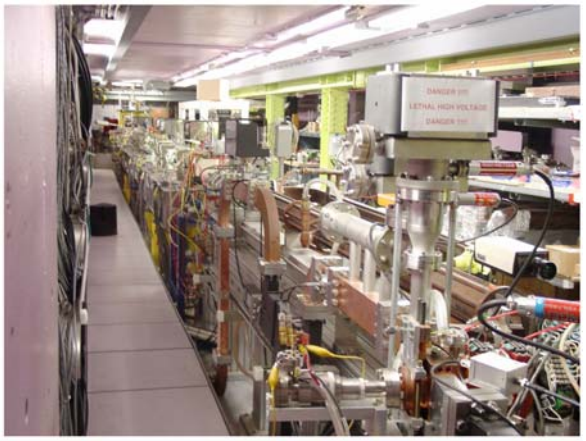


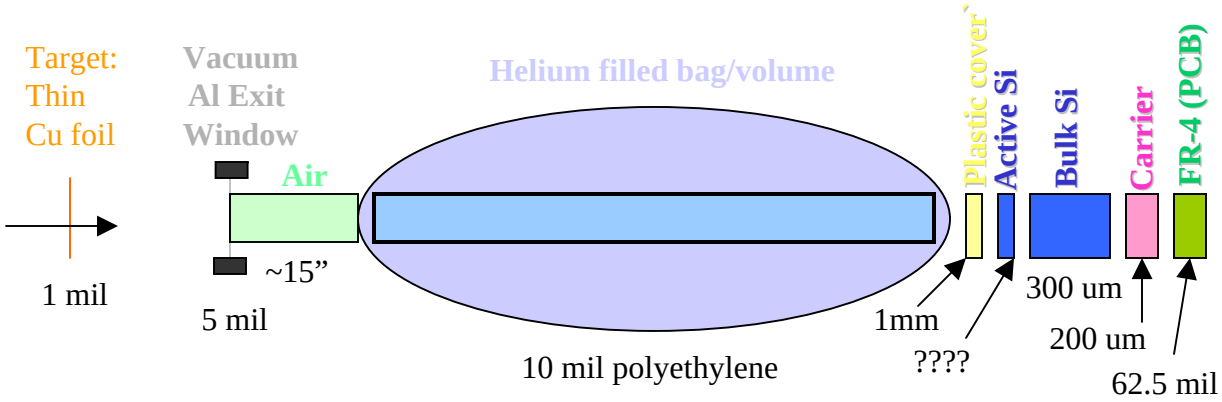
Juaquin Anderson
Matt Andrew
Michael Cooney
Xin Gao
James Kennedy
Luca Macchiarulo
Marc Rosen
Larry Ruckman
Gary Varner

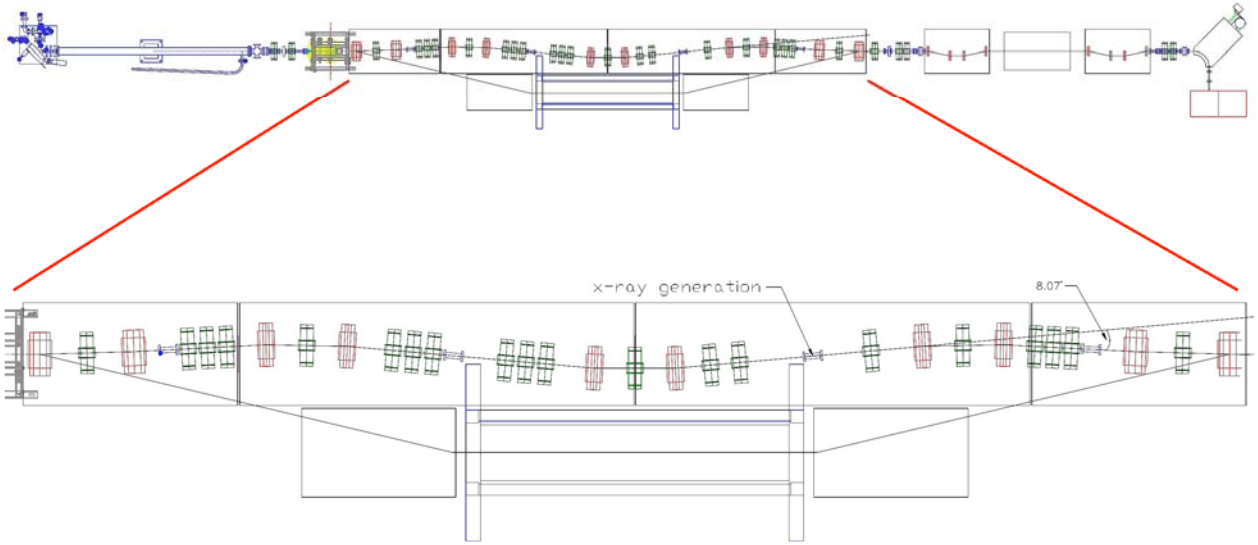
5-FEB-2010

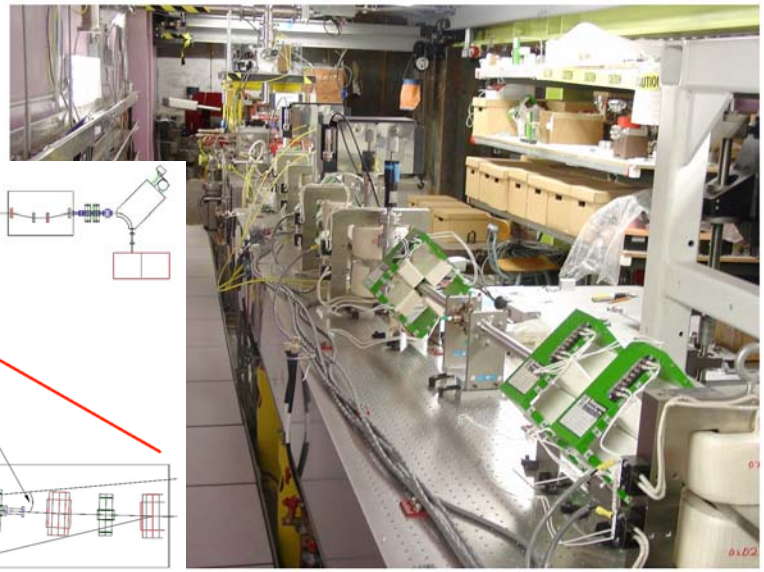
Bremsstrahlung Beamline Estimates

Dec.-2009 model

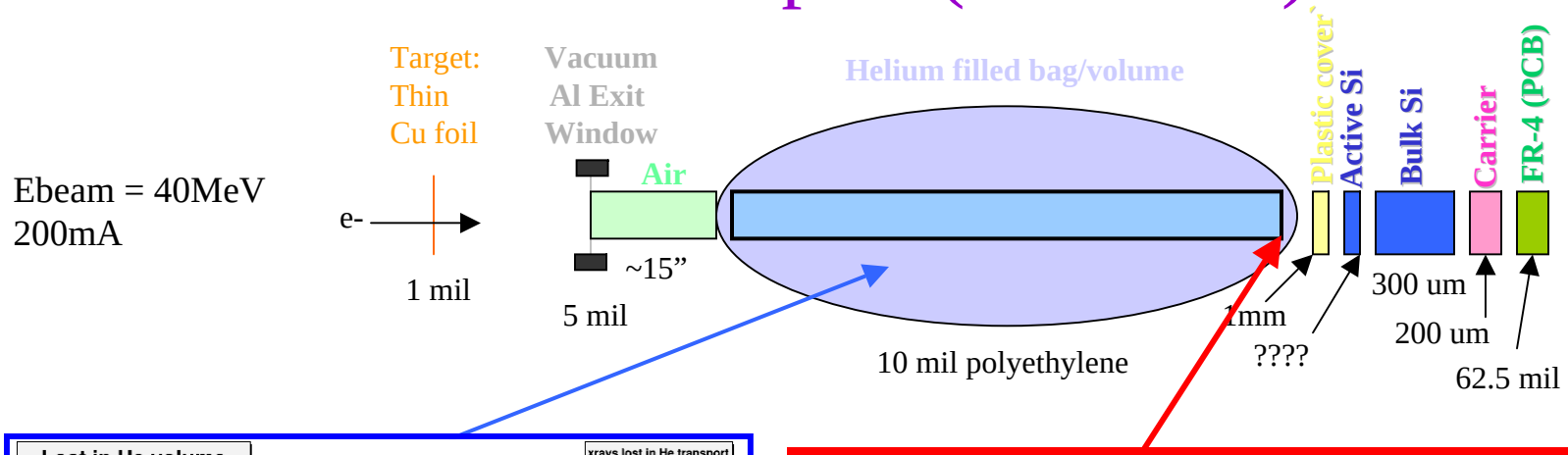


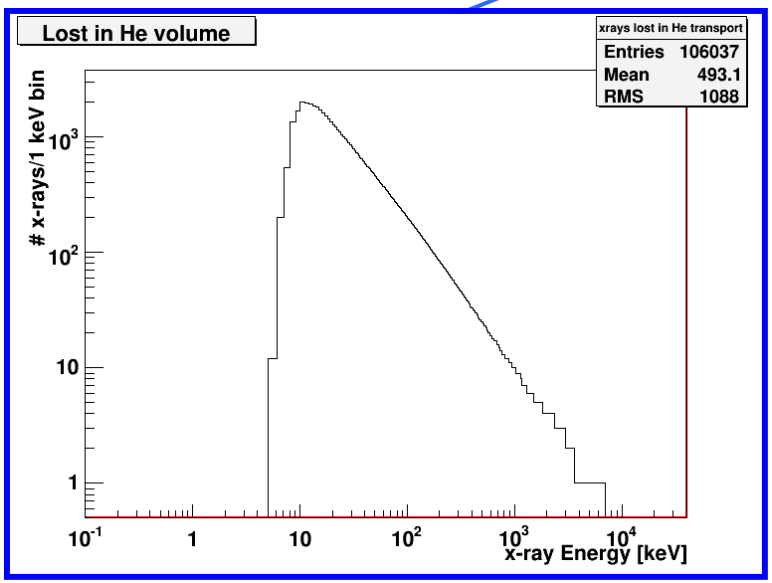


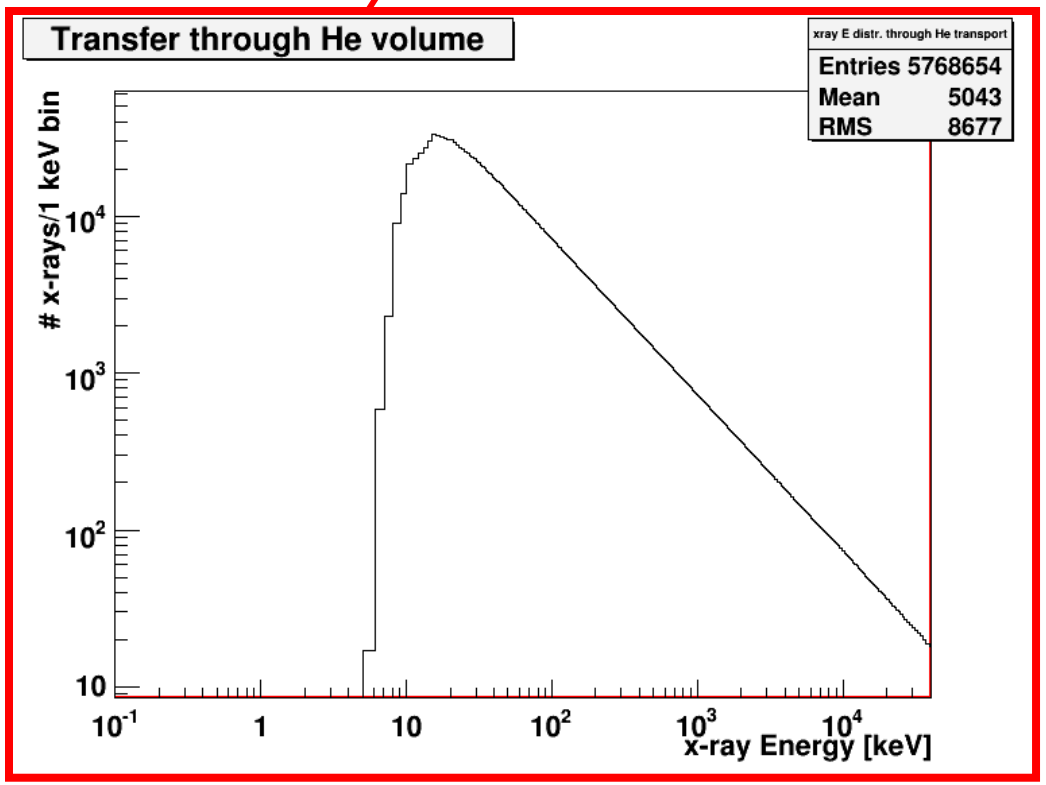




He transport (9.5m line)

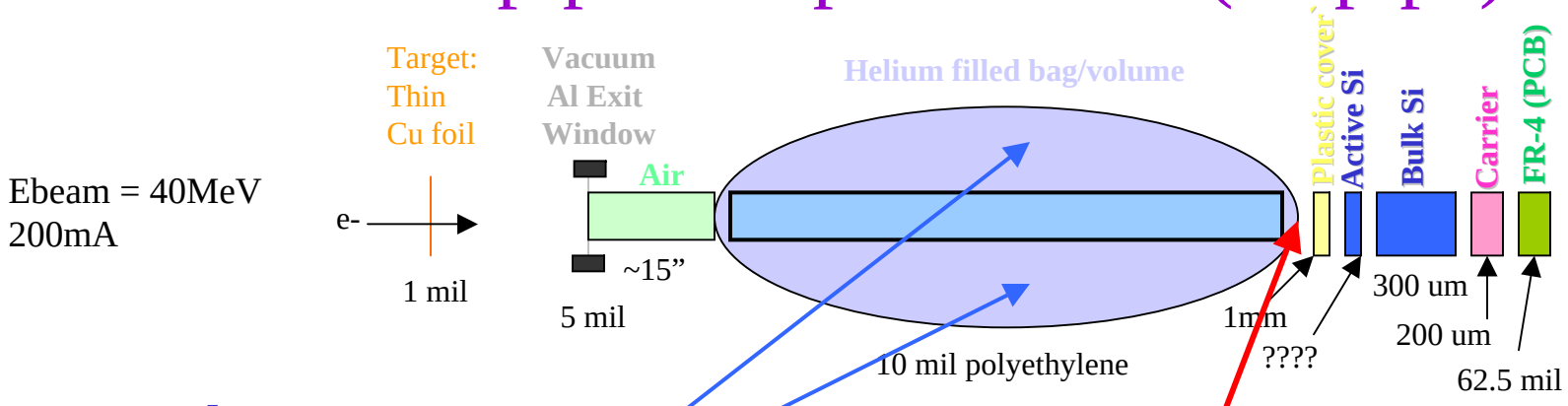




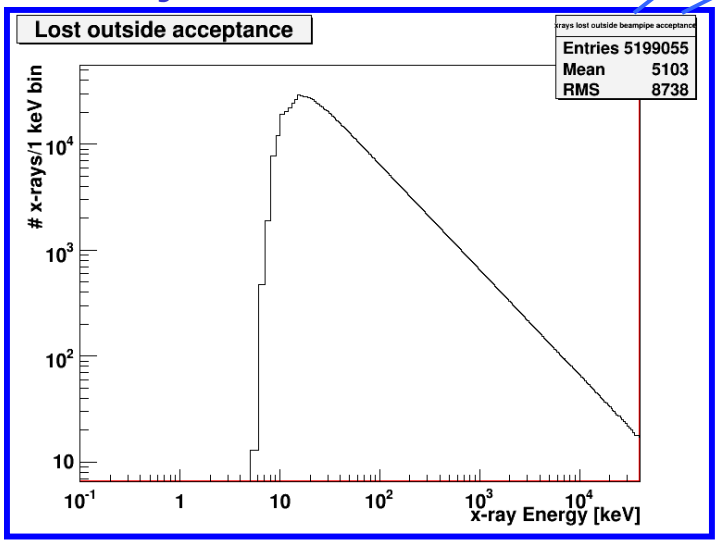


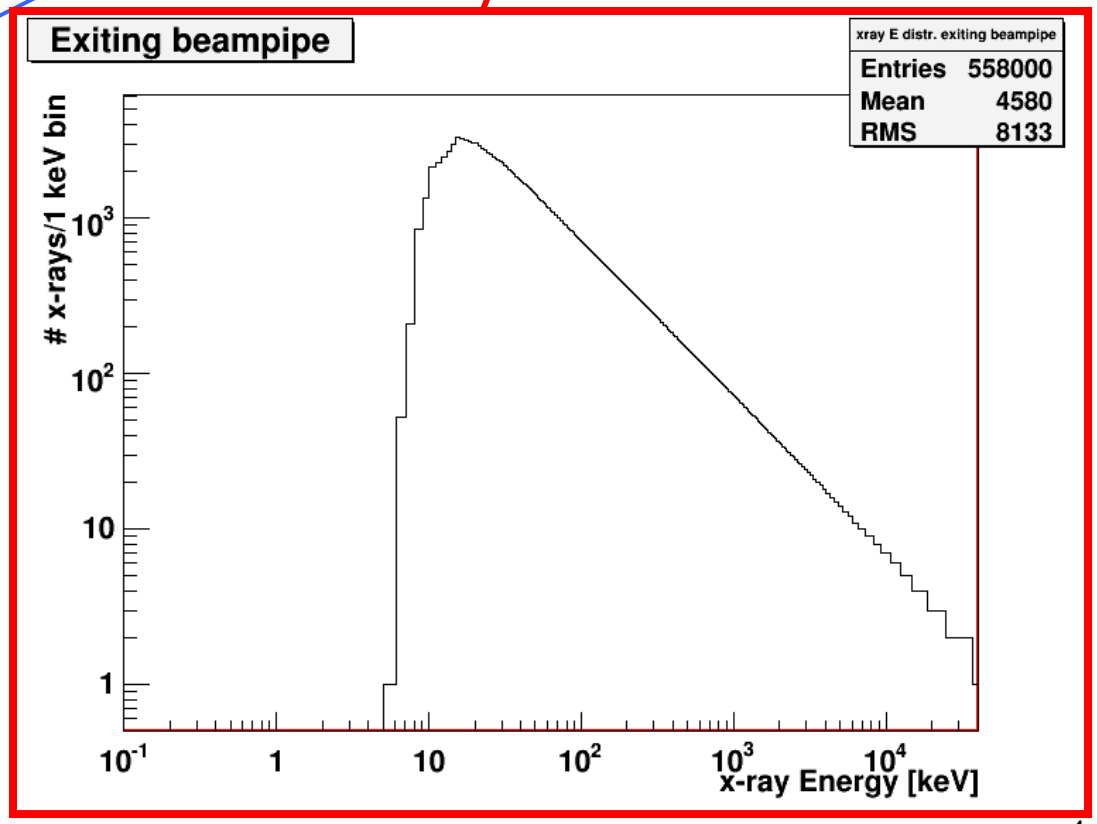
Single bunch

Beampipe acceptance loss (3” pipe)



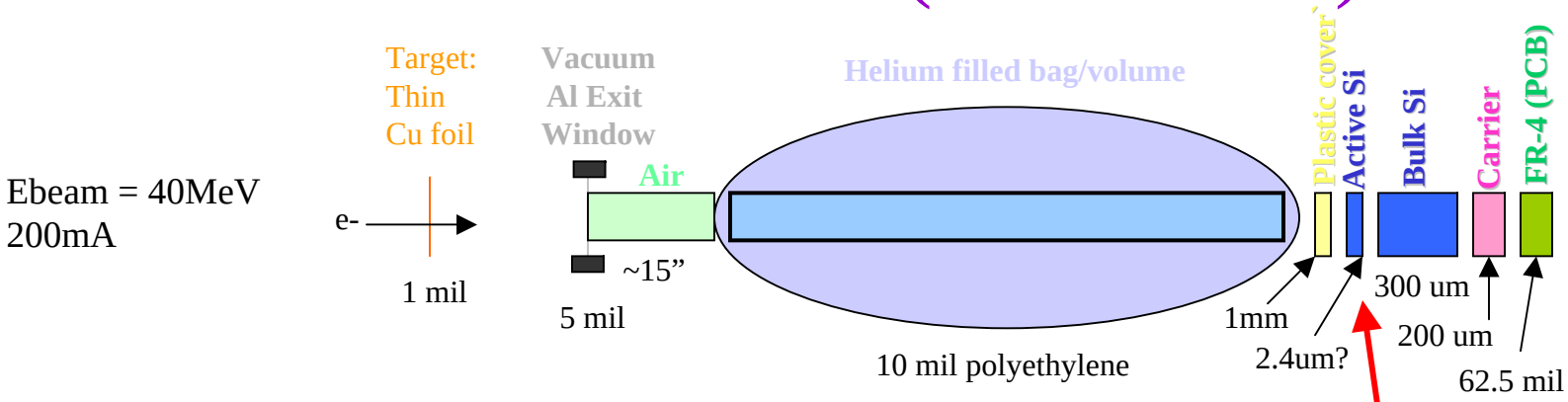
Xrays lost





90% lost:
Shielding?

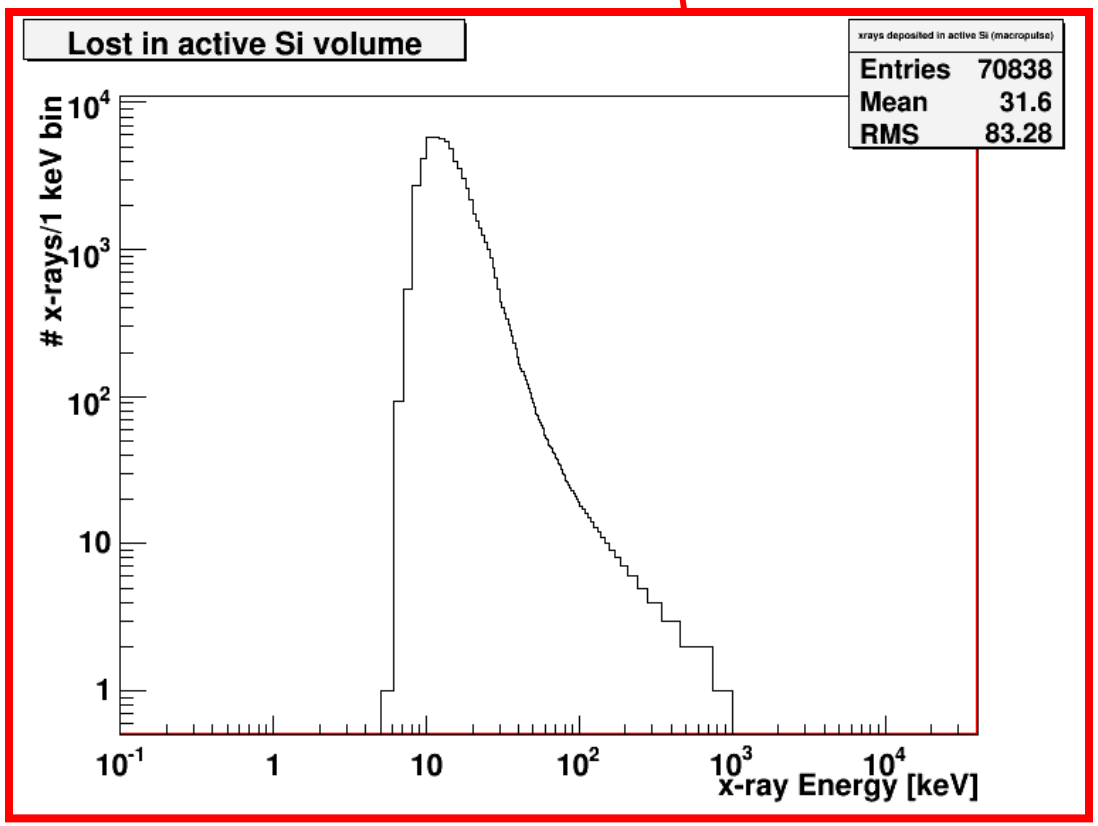
Active Si volume (2.4um thick) loss



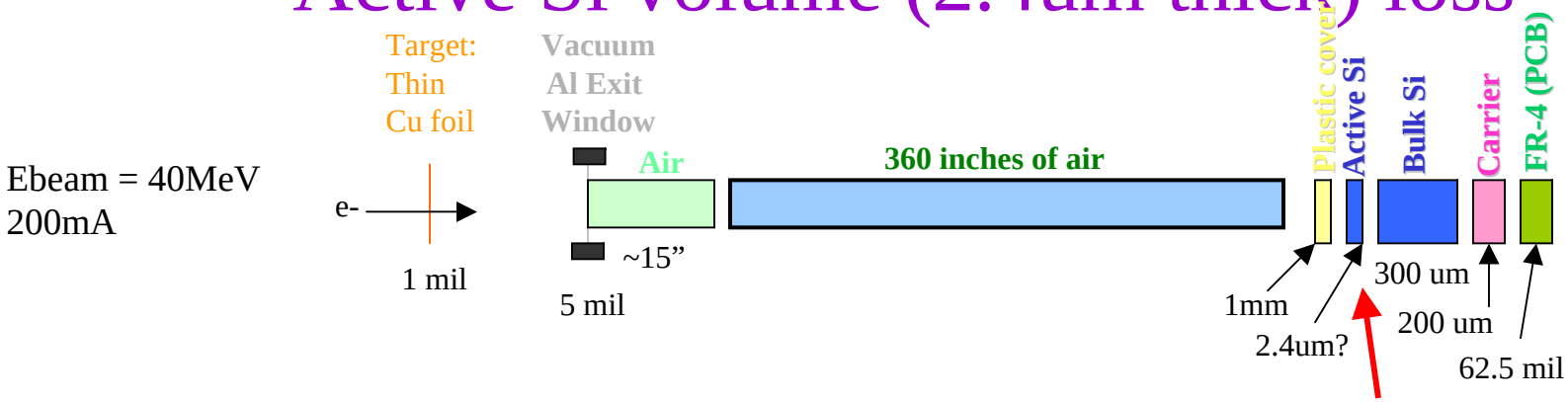
Macropulse (guess based on $3x10^5$V/cm breakdown)

~7 x-ray/bunch
(~1 with fill factor)
Mean ~ 30keV

Propose first layer
As bare devices



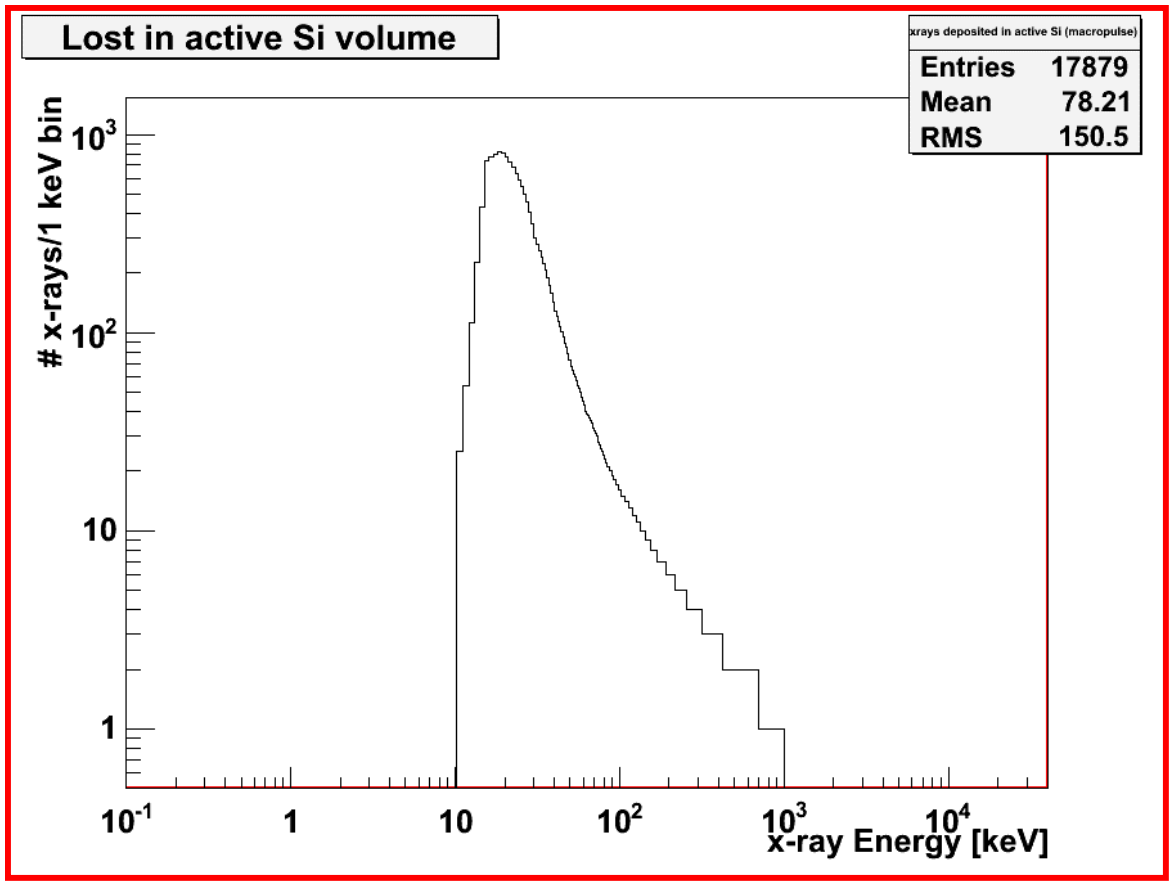
Active Si volume (2.4um thick) loss



About a factor 4 reduction in flux on detector

~1.7 x-ray/bunch
(<<1 with fill factor)
mean @ 78keV

Does have an impact 25%

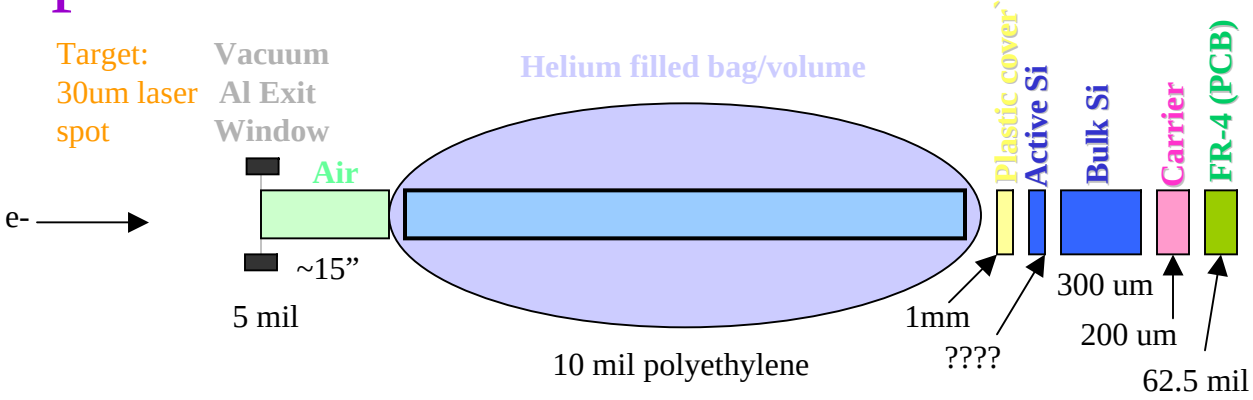


Compton Backscatter Source Production

Ebeam = 40MeV
200mA

(10.4keV)
~1x10^7 γ/macropulse

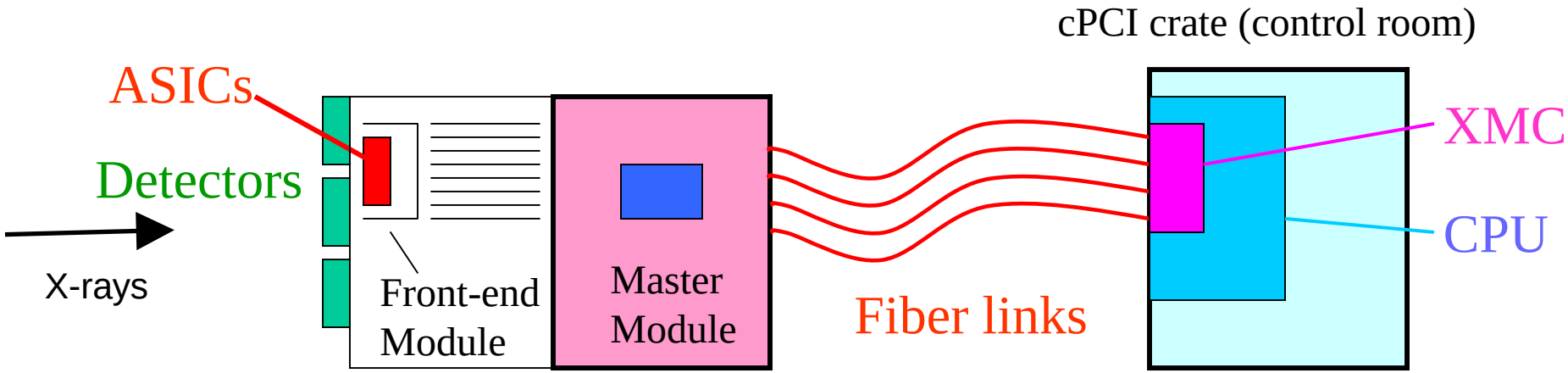
~1054 γ/bunch



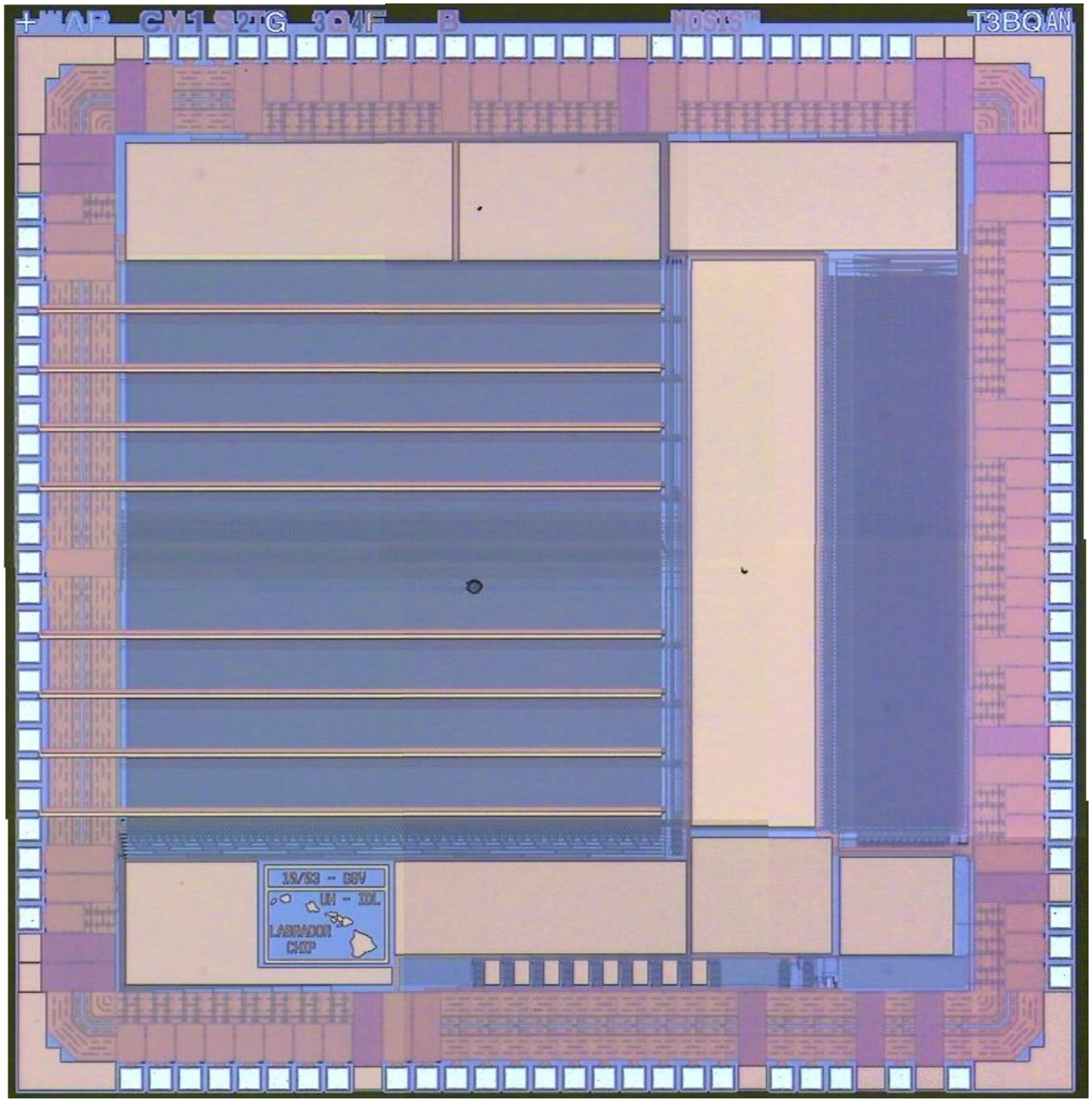
	A	B	C	D
1		x-rays	x-rays	
2	Component	per bunch	per macropulse	Loss
3	Initial production	1054		
4	Pass exit window	429		625
5	Pass air volume	336		93
6	Pass into bag	319		17
7	Pass through He	305		14
8	Exit He bag	298		7
9	Inside 3" beampipe	30		268
10	Detector coverage	0.82	8225	
11	Pass through plastic	0.43	4284	
12	Deposited in Si	0.01	81	
13	BaF2 as first layer	0.73	7267	

FEL x-ray beamline summary

- Bremsstrahlung target
  - Front detector → benefits from He volume
  - Not a huge impact on 2nd plane
- Monochromatic source
  - Must have He volume
  - Acceptance losses high (higher E better)
- Need to pull system together

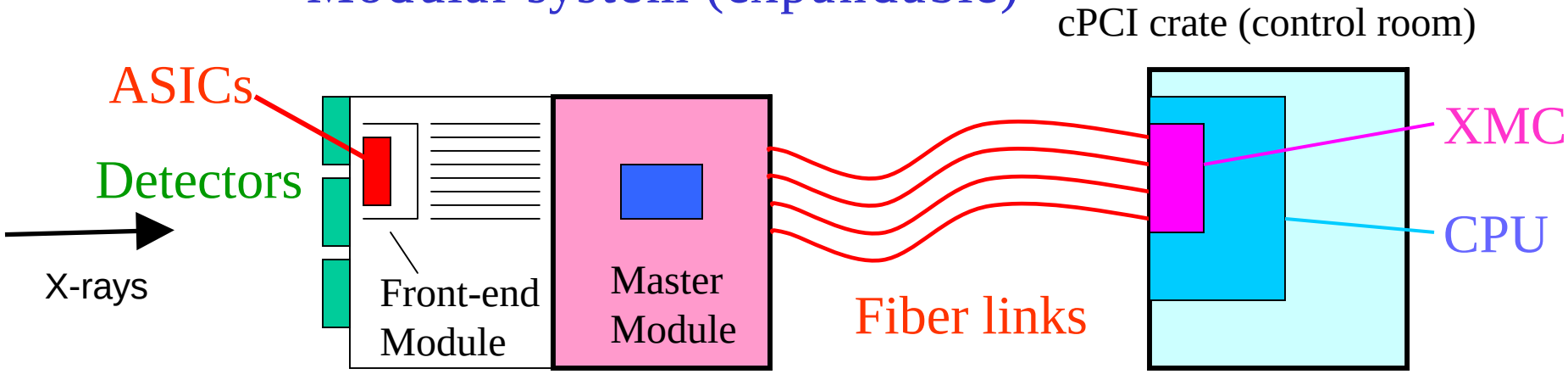


Back-up slides



FEL x-ray beamline instrumentation

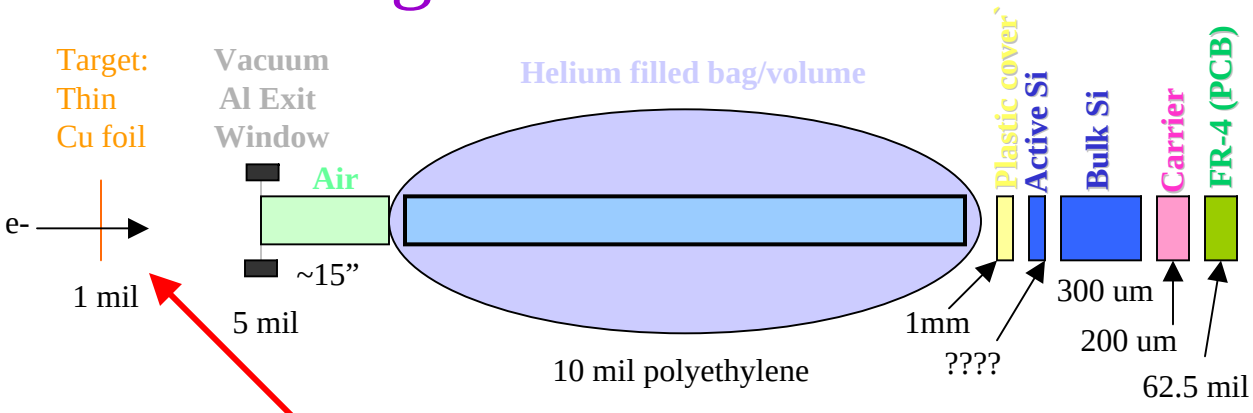
- Sensors (detectors)
  - Base first iteration on commercially avail parts
  - Develop tailored Si sensor devices
- Custom Readout chips
  - Using existing GSa/s transient digitizers initially
  - Develop optimized ASICs for project
- High speed DAQ protocol
  - Leverage concurrent development for Super B-factory, large cosmic stand readout
- Modular system (expandable)



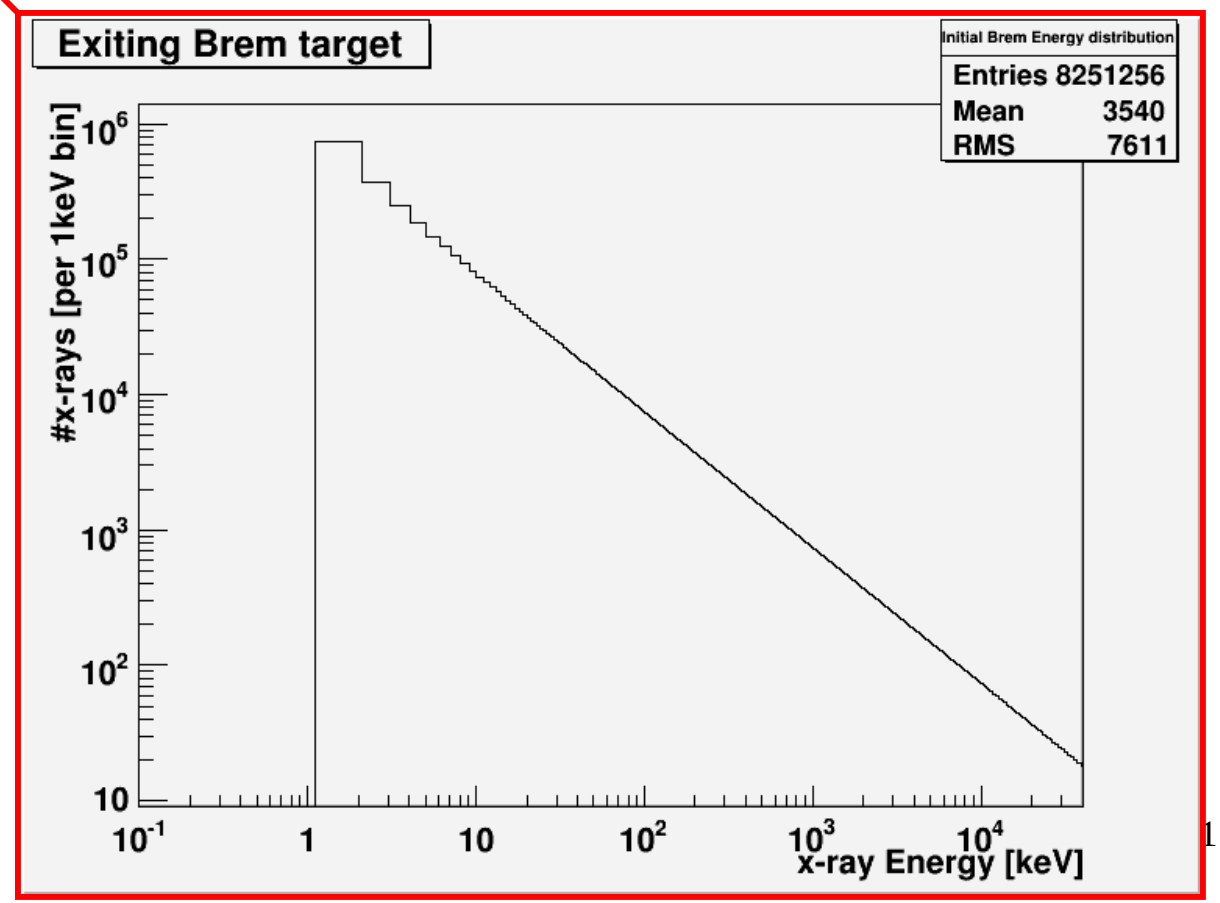
Target Production

Ebeam = 40MeV
200mA

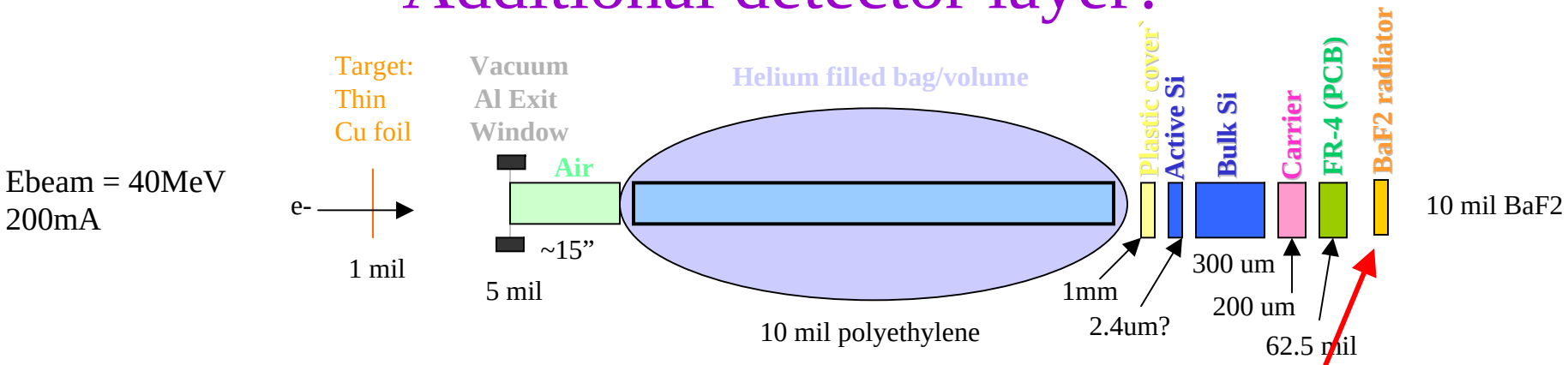
(10-11keV bin)
8.1×10^8 γ/macropulse
~71k γ/bunch

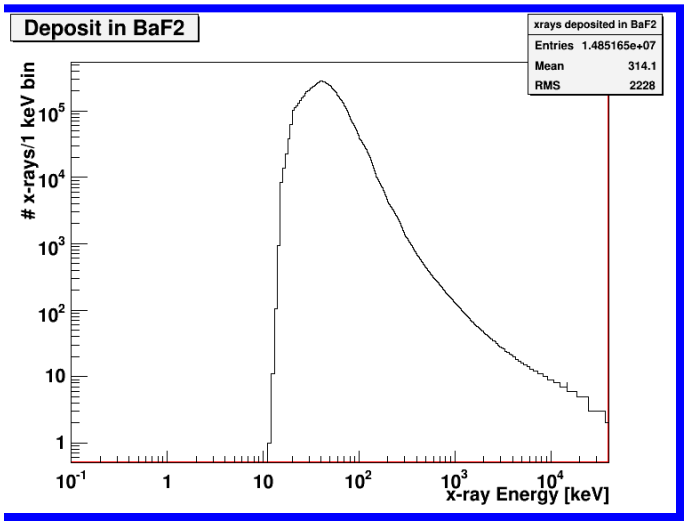


Single bunch

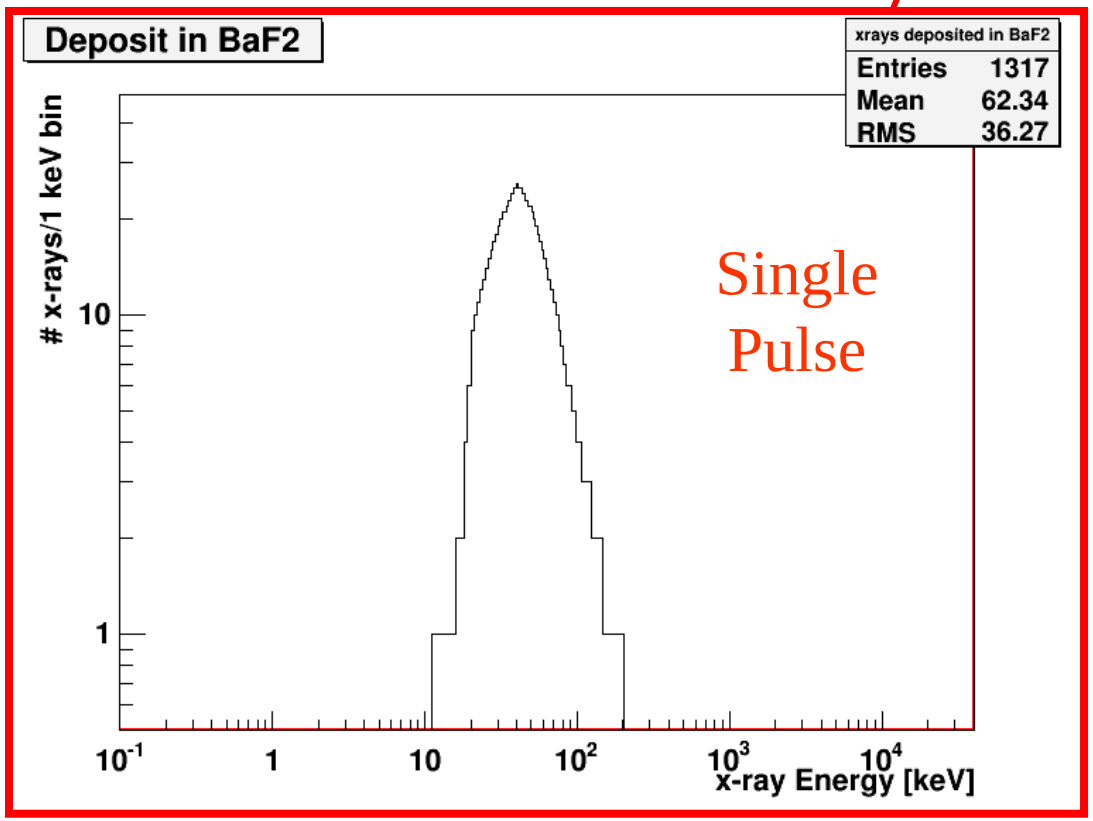


Additional detector layer?





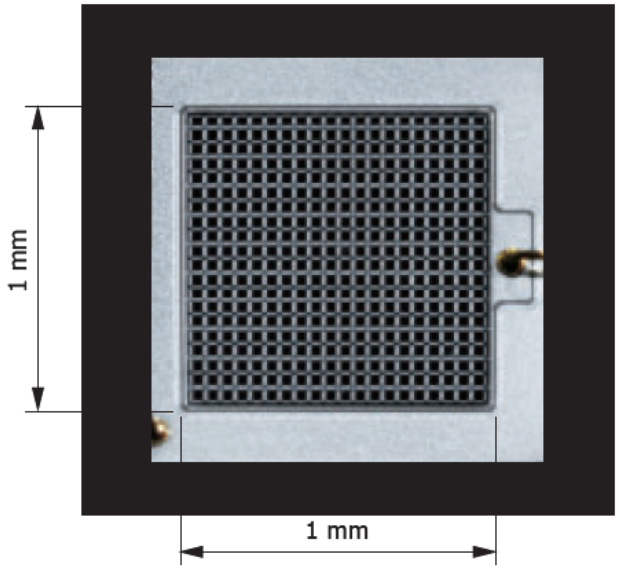
Macropulse



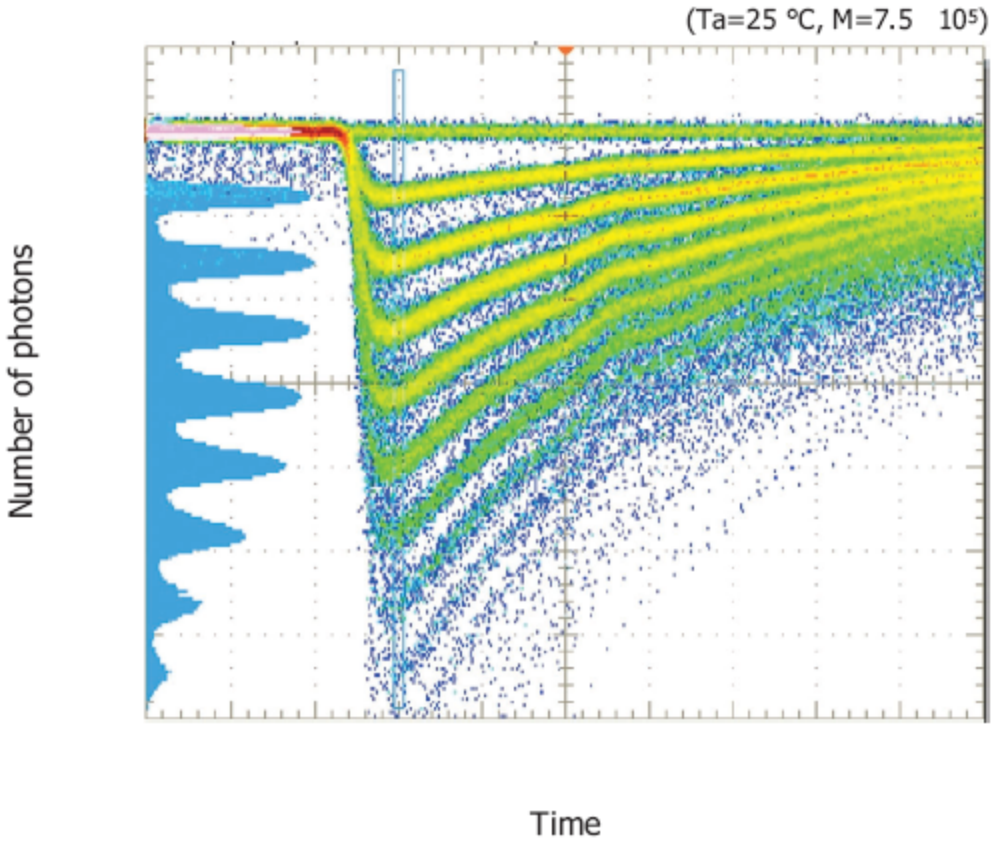
1, 3 mm^2

Hamamatsu MPPC

Macrophotograph of MPPC



Pulse waveform (S10362-11-050U,) when using an amplifier (120 times)

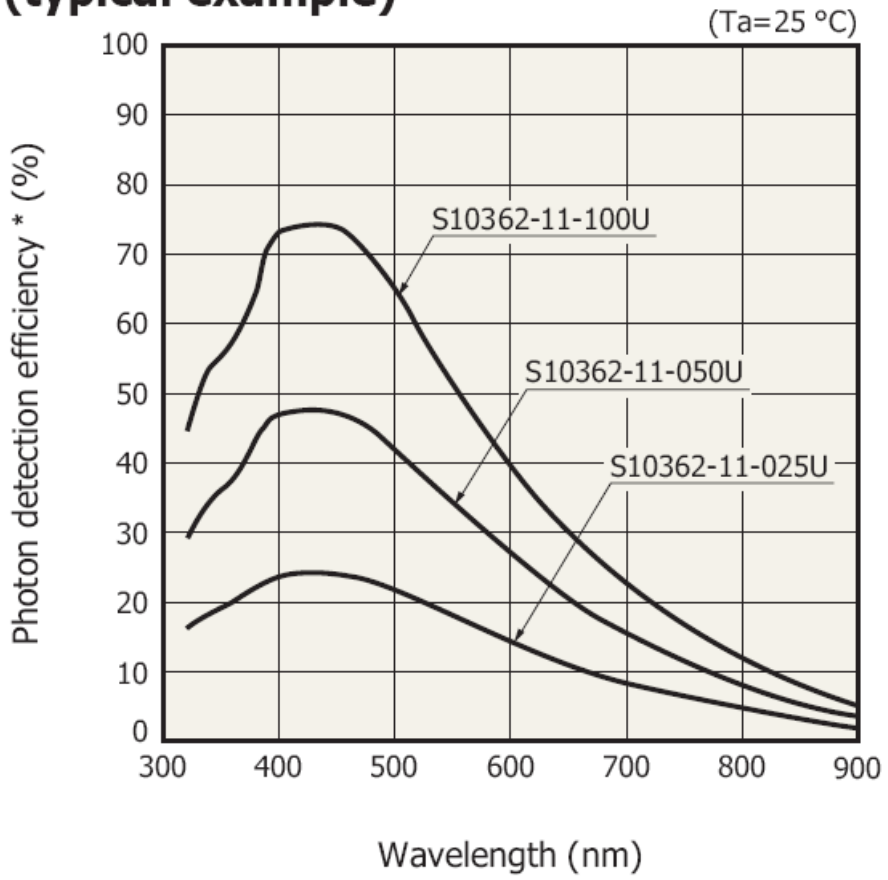


25, 50, 100μm
Pixel sizes avail.

1, 3 mm^2

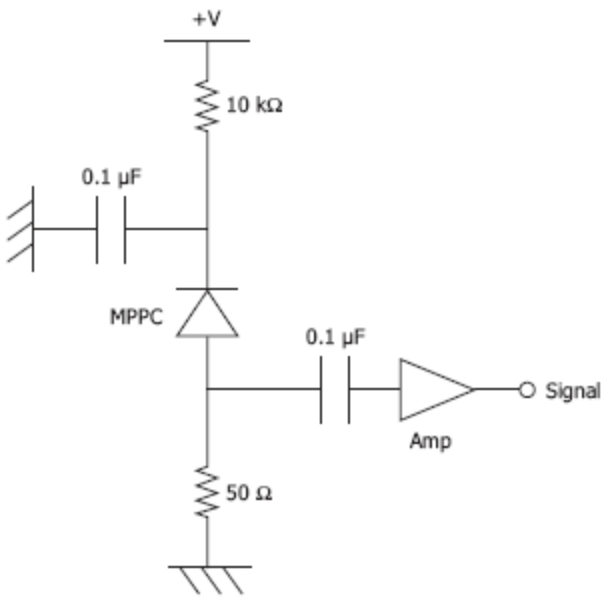
Hamamatsu MPPC

Photon detection efficiecy (PDE) vs. wavelength (typical example)

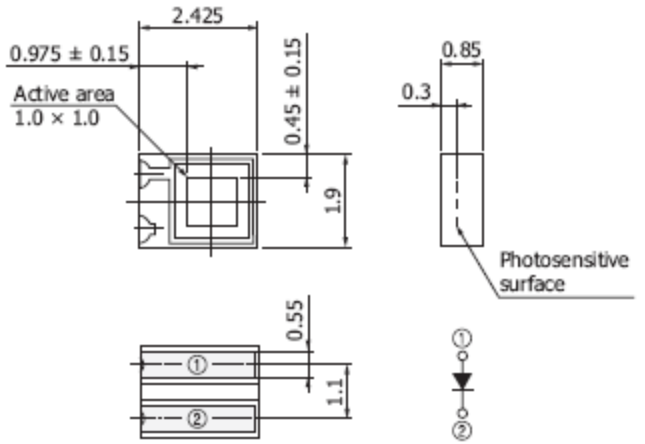


* Photon detection efficiency includes effects of crosstalk and afterpulses.

Connection example



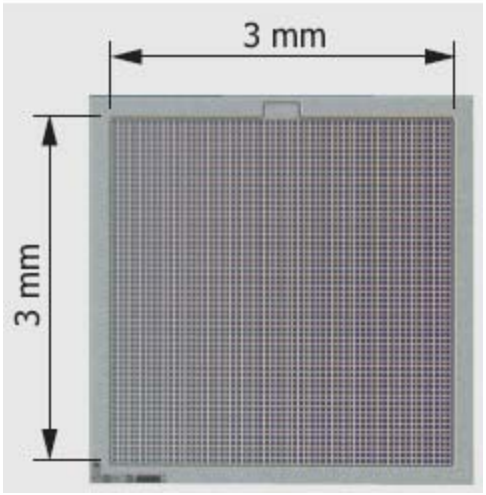
S10362-11-025P/-050P/-100P

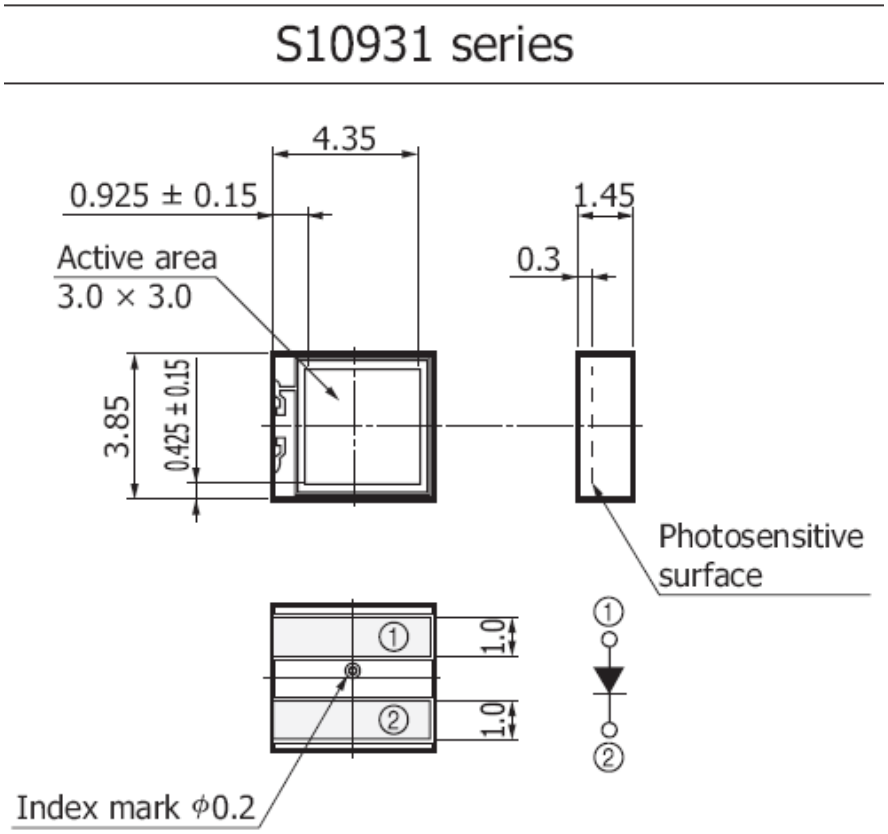


Ordered 10x 1, 3 mm^2

3 mm^2 Hamamatsu MPPC coverage

14,400 pixels for the 25μm pixel case





Better fill-factor for tiling → ~53% active

G = 2.7×10^5

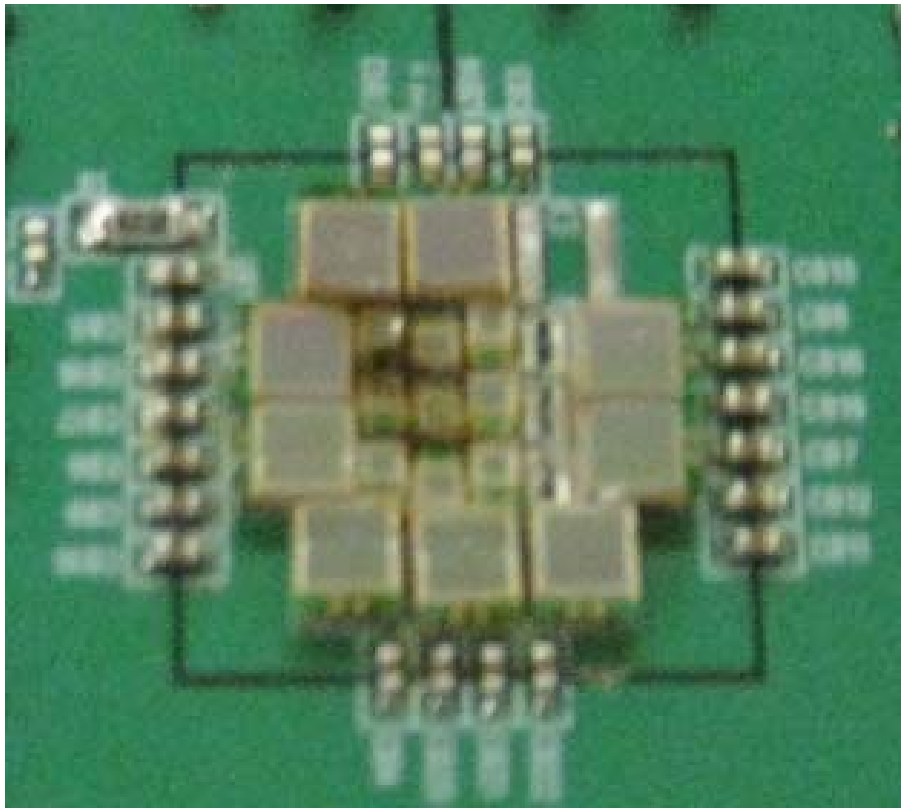
TTS ~ 250ps RMS (single p.e.)

First COTS detector array

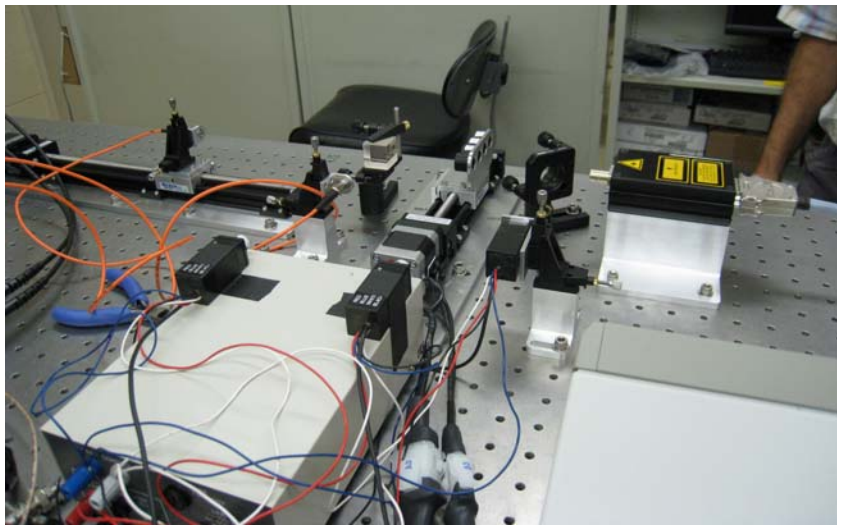
Specifications

- Outer ring 3x3mm active
- Inner 3x3 array of 1 mm-sq active MPPC
- "Geiger-mode" Avalanche Photo-diodes with ~10^6 gain
- Instrument with available electronics prototypes

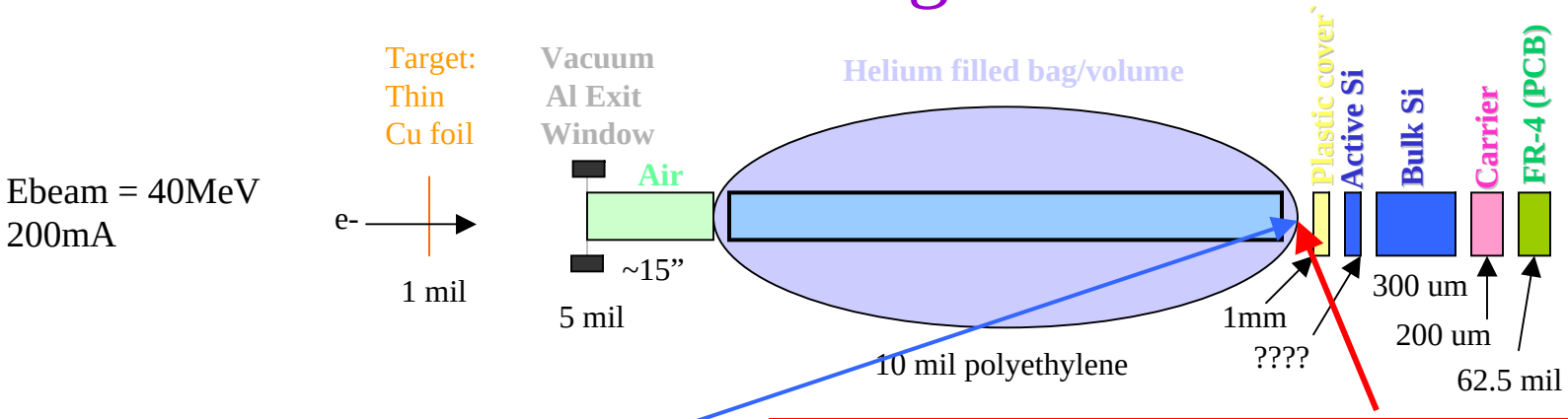
Proto Array Layout

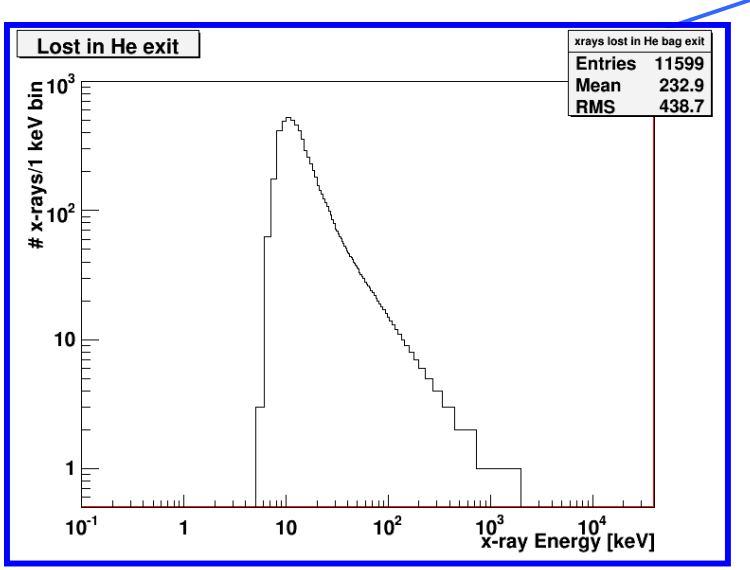


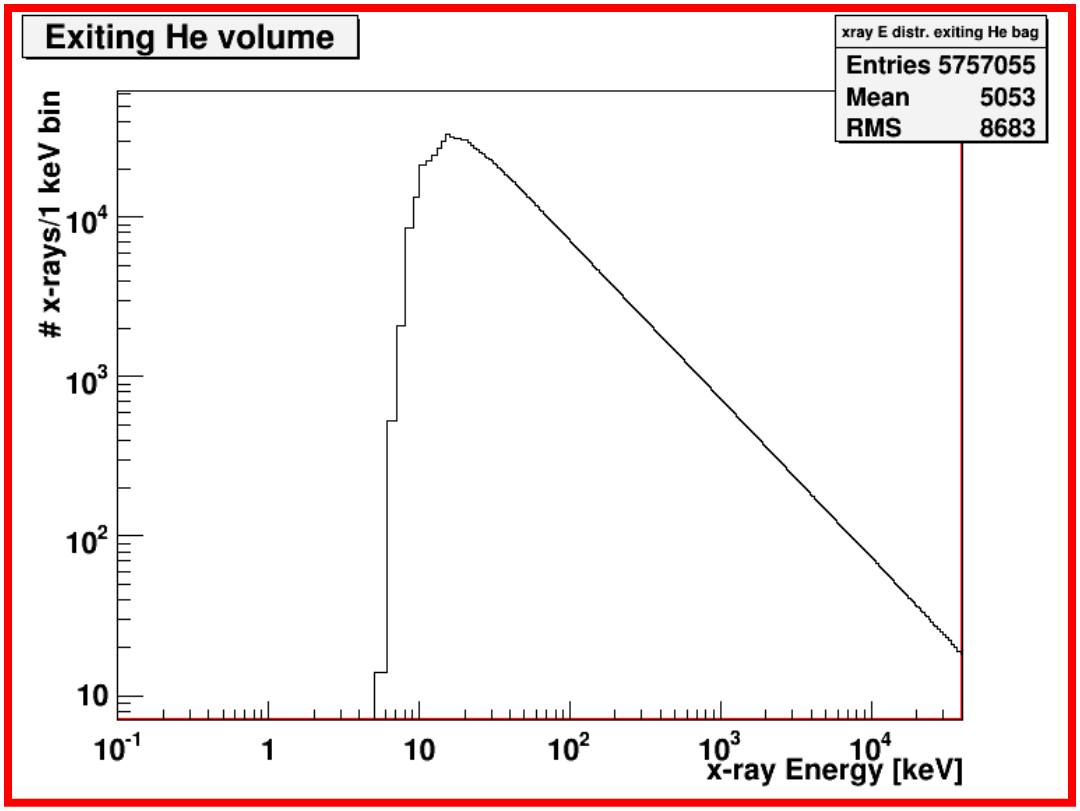
Simulated Bremsstrahlung Flux



He bag exit

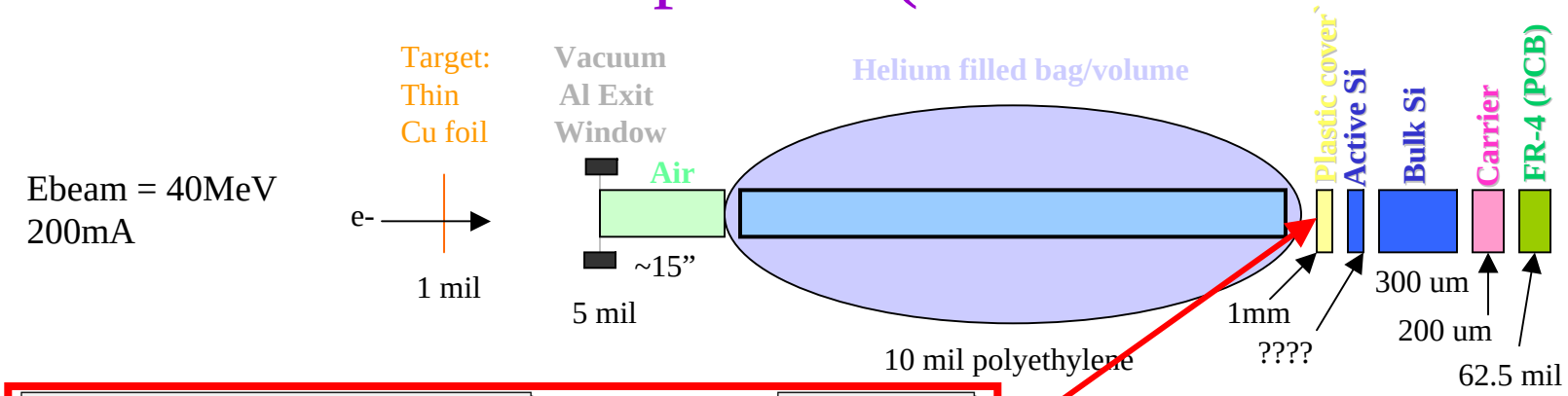




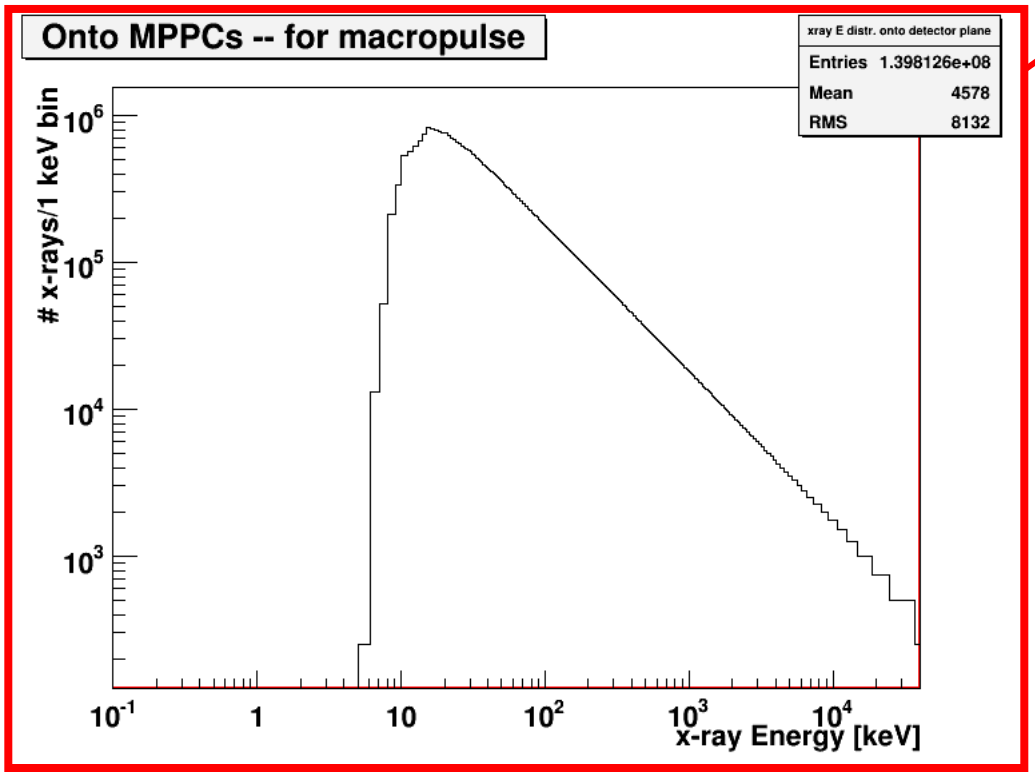


Single bunch

Detector acceptance (1cm^2 instrumented)

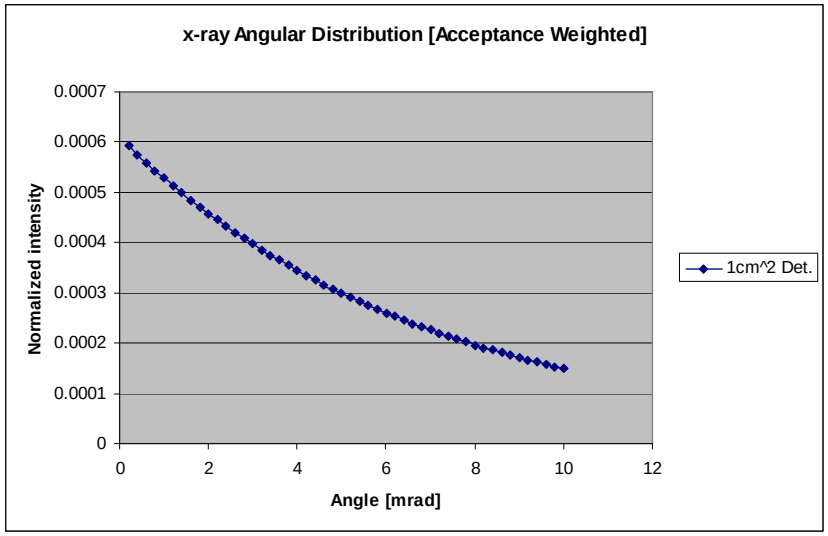


Ebeam = 40MeV
200mA



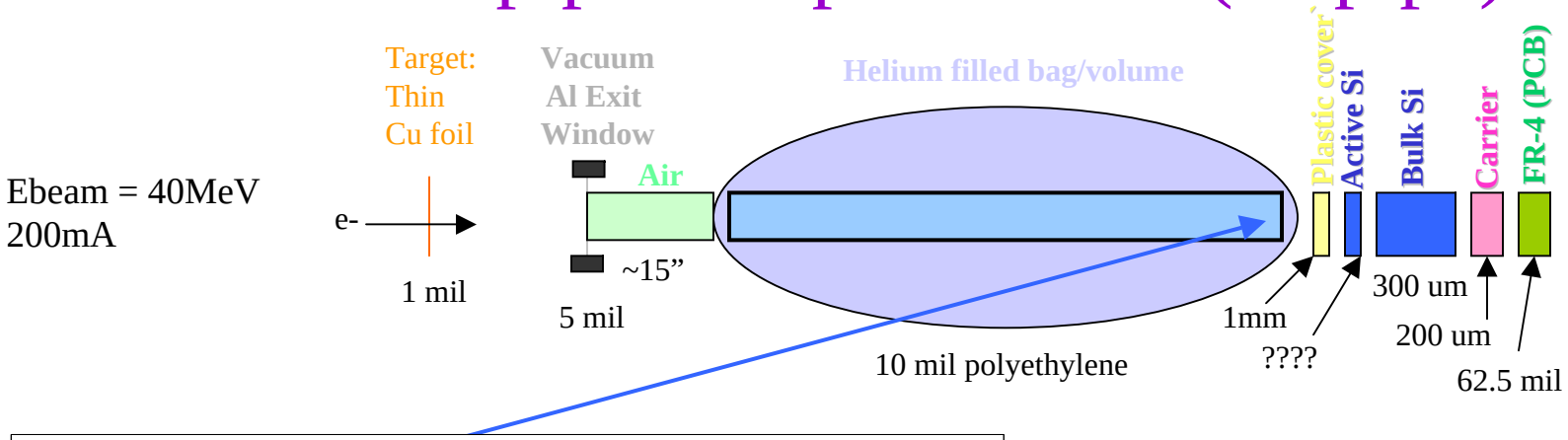
Assume uniform (can put in offset later)
Adet = ~ 2.2% coverage

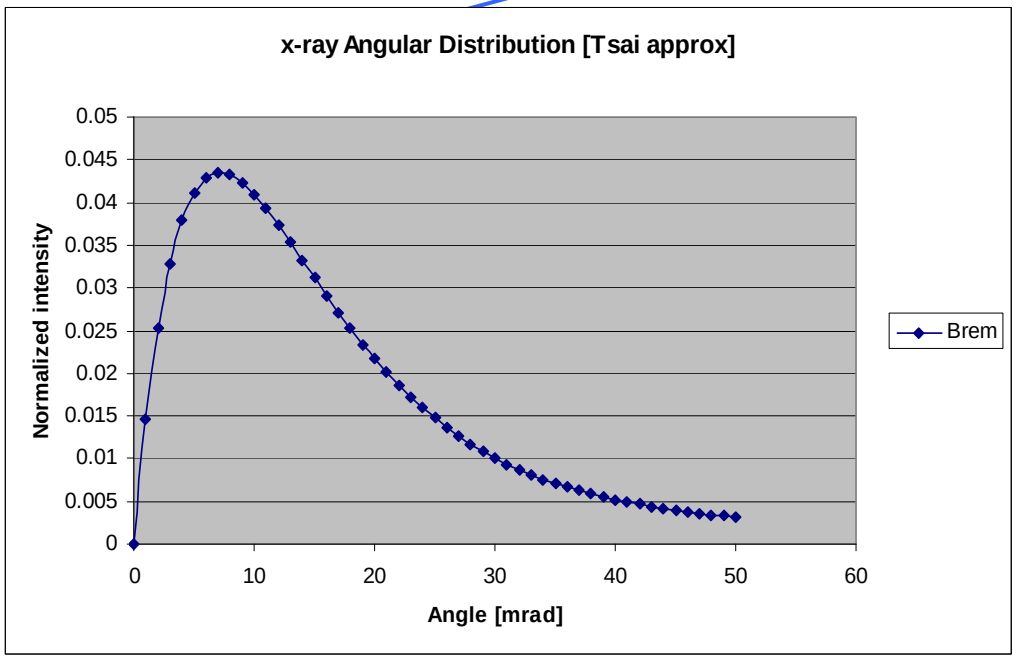
2×10^{-4} per $1mm^2$ detector



Per train (macropulse) flux estimate

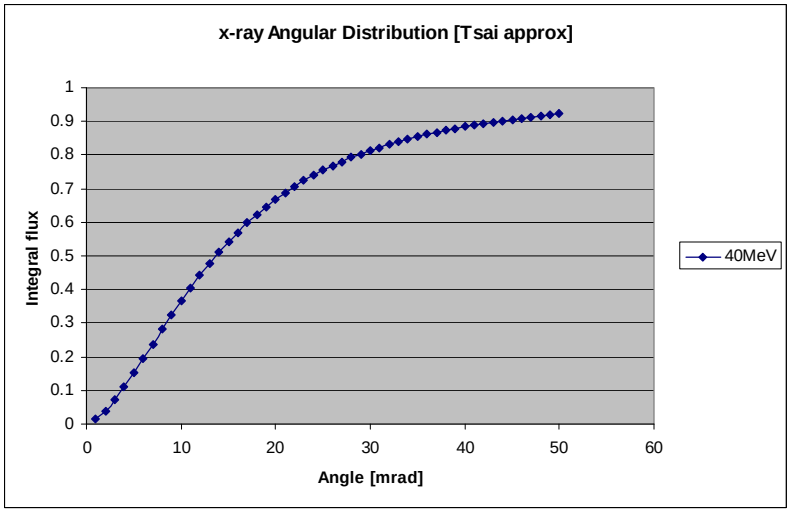
Beampipe acceptance loss (3” pipe)





Assume centered (can put in offset later)
3.81cm rad @ 10m ~ 3.8mrad

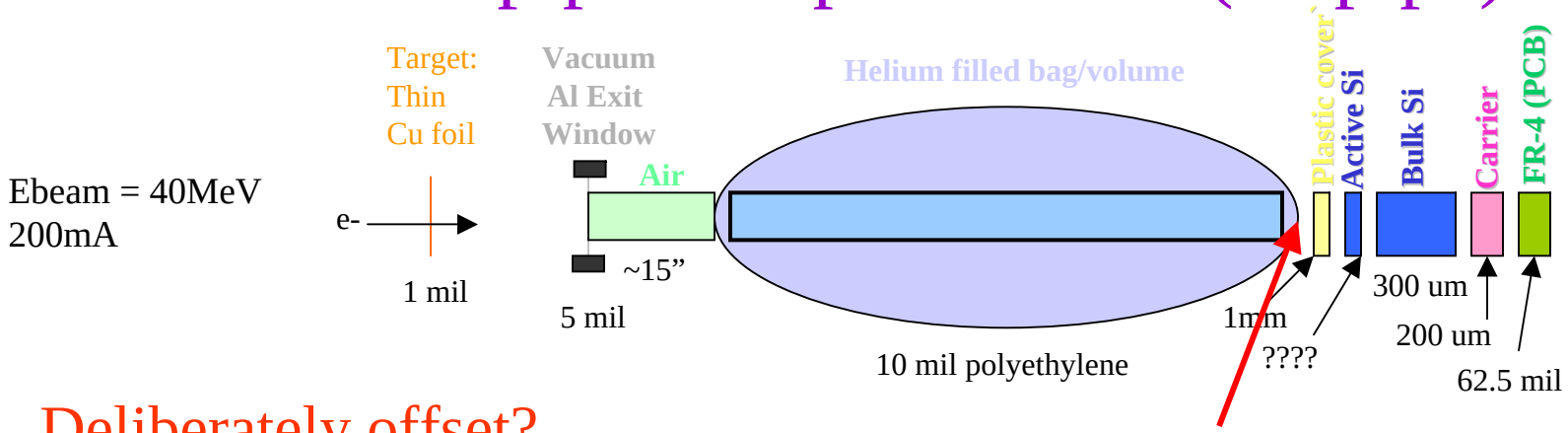
~10% (90% scrape/collimate)



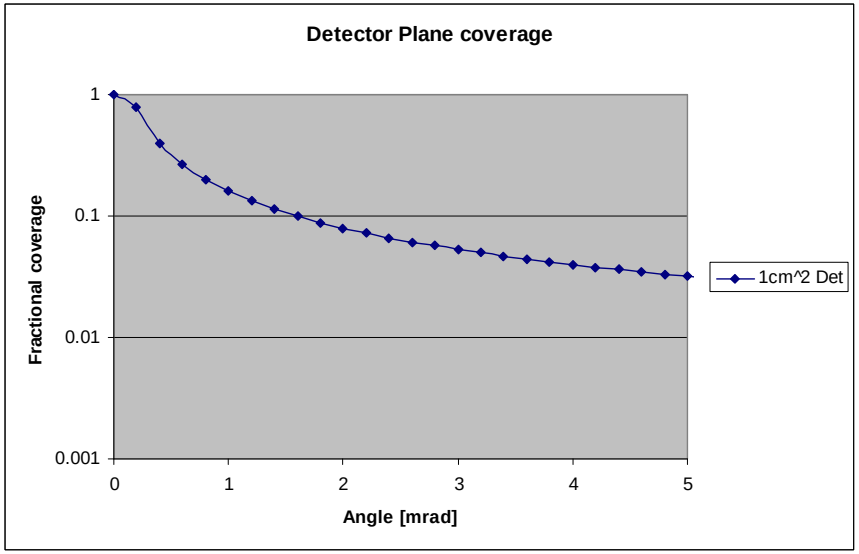
Tsai approximation:
Basically a double exponential

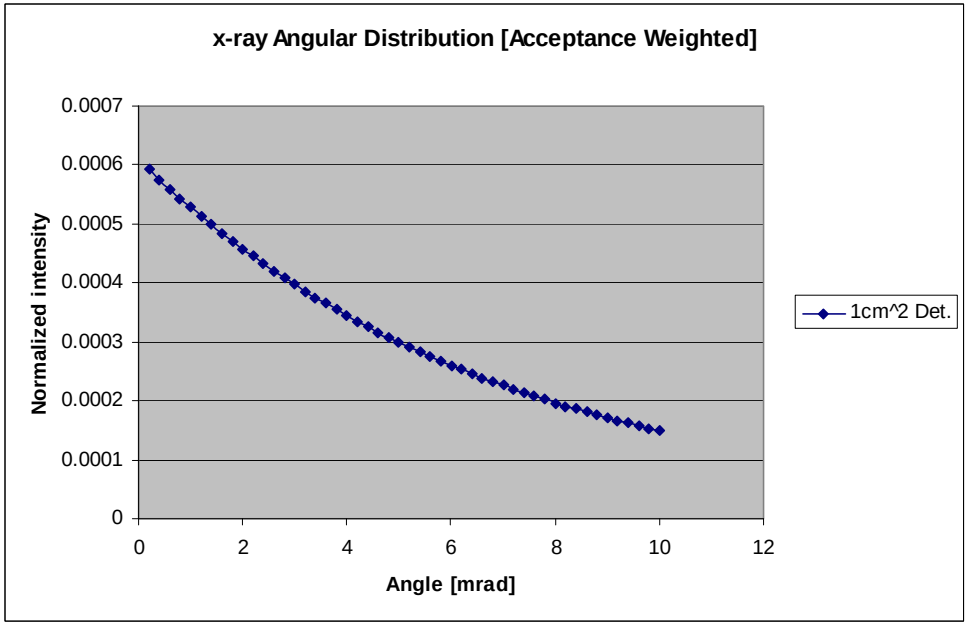
12.5mrad is 50% point

Beampipe acceptance loss (3” pipe)

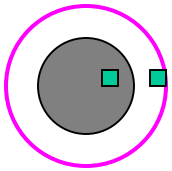


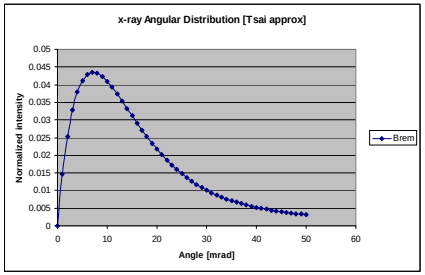
Deliberately offset?





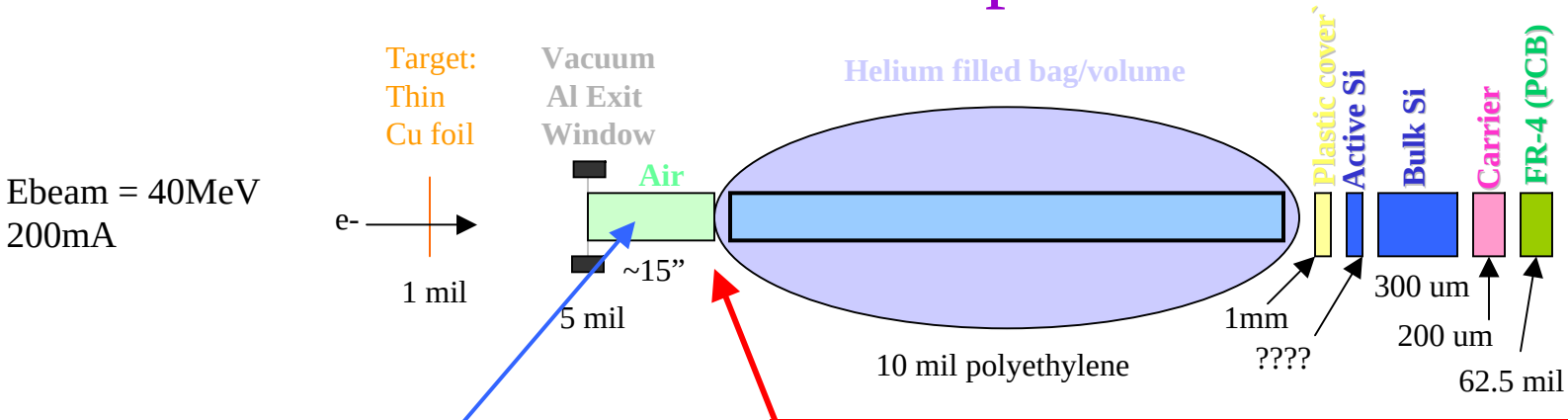
1cm^2

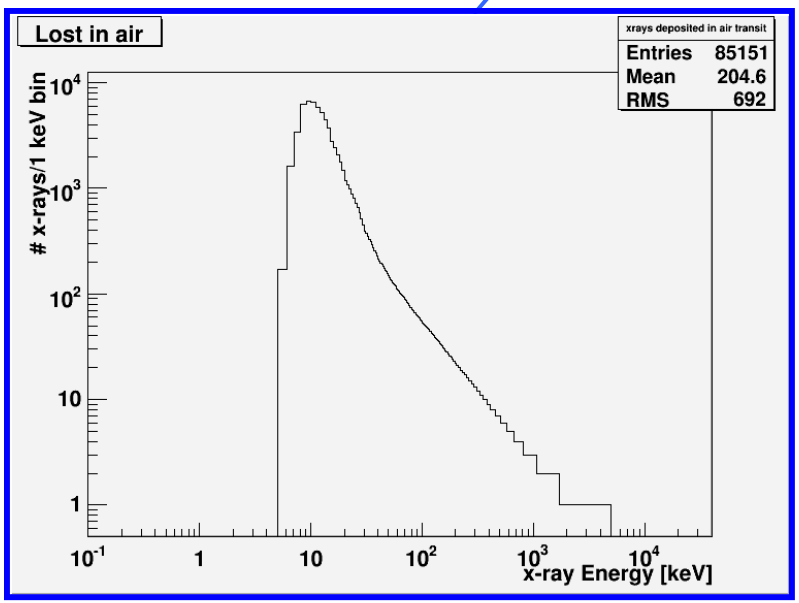


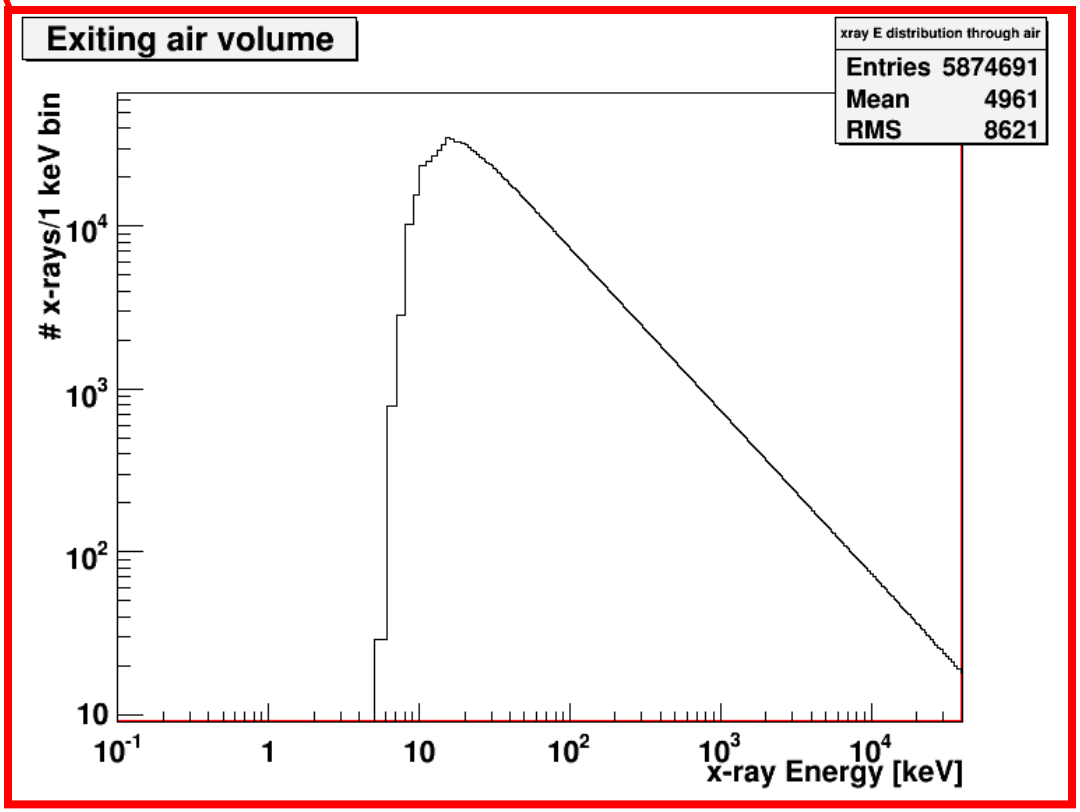


- Not very sensitive to alignment
- Better on axis

Air transport

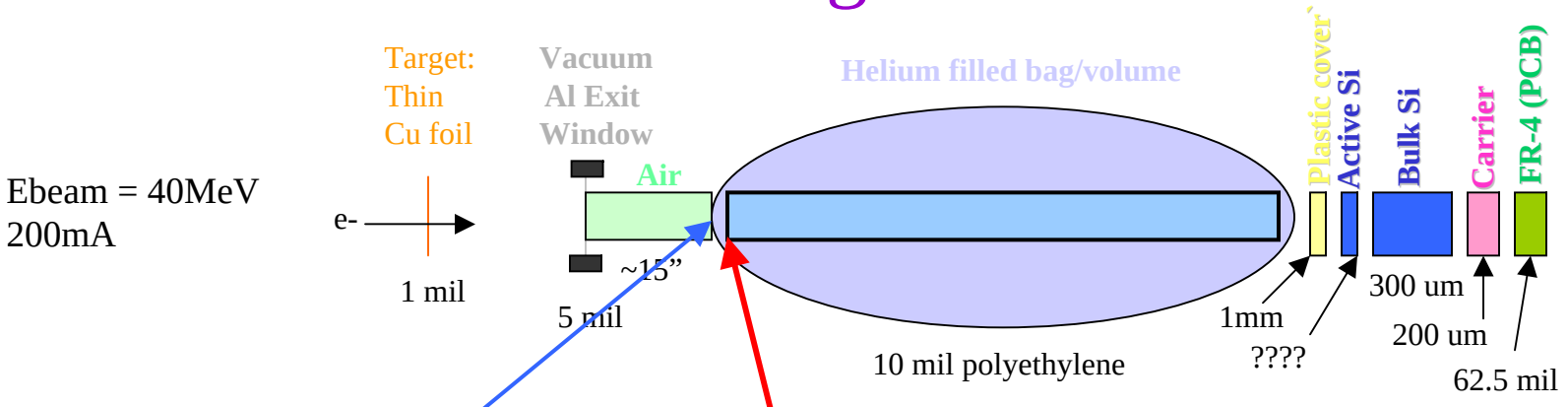


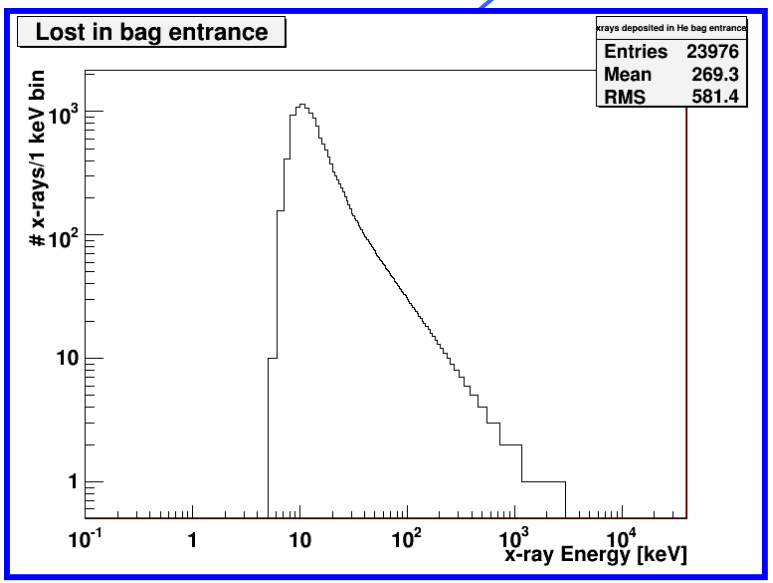


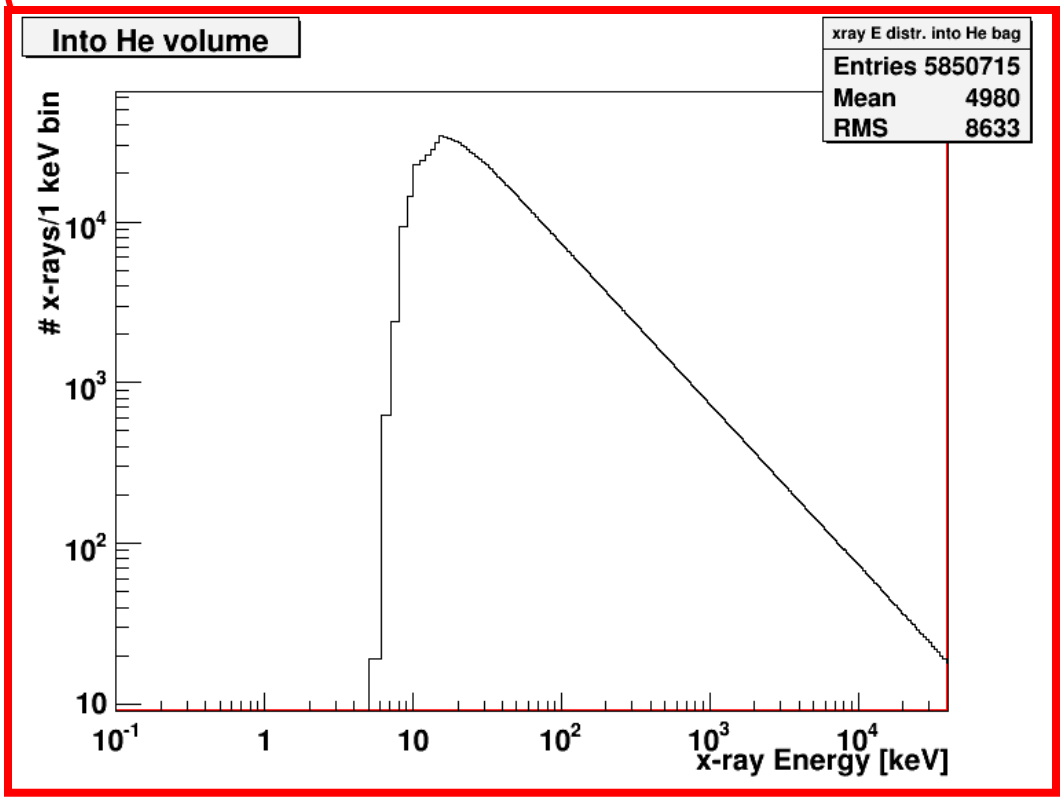


Single bunch

He bag entrance



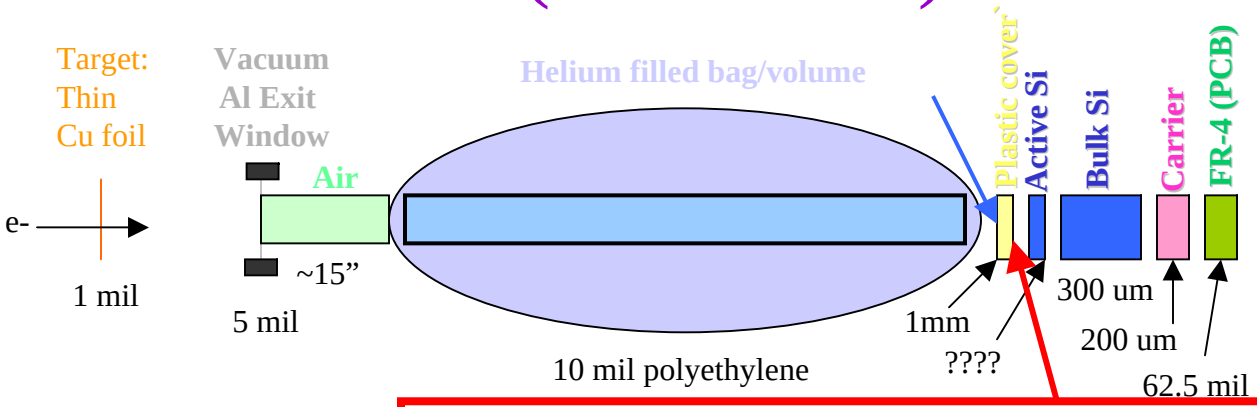


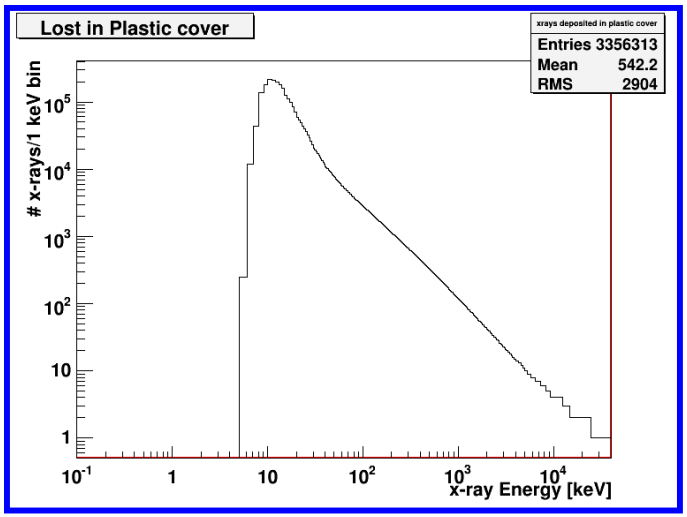


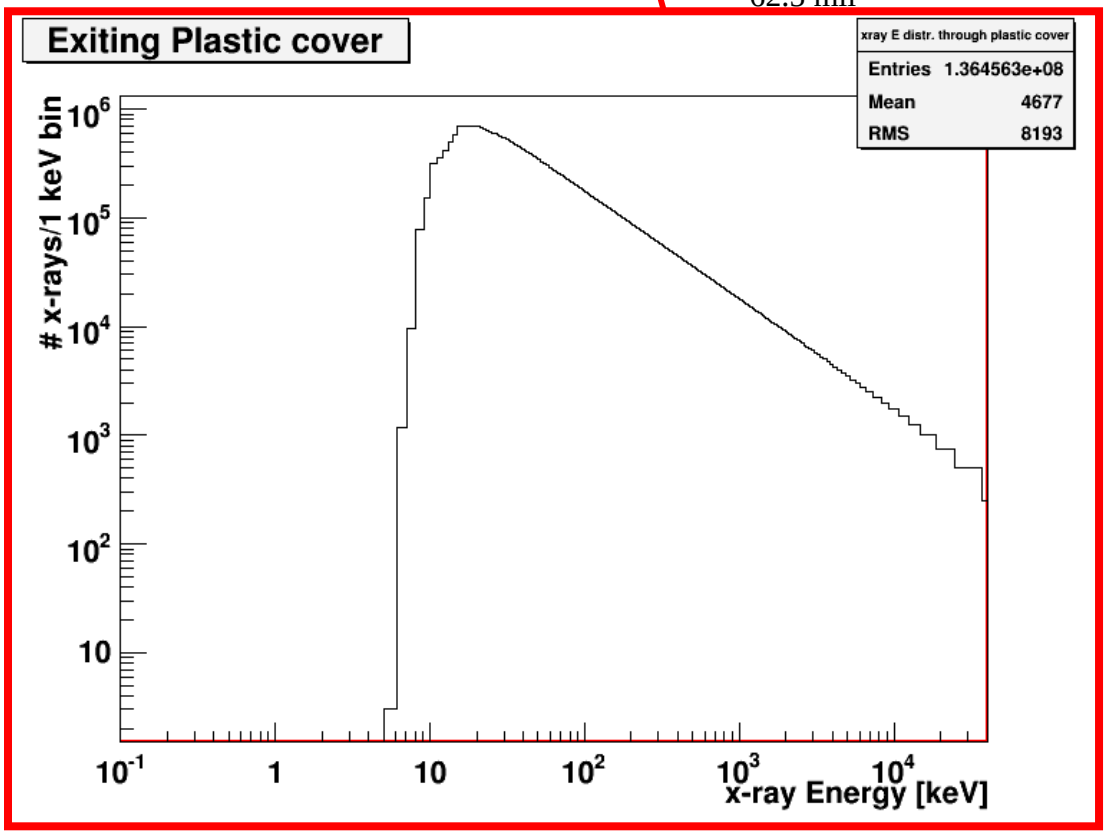
Single bunch

Plastic cover (1mm thick) loss

Ebeam = 40MeV
200mA







Macropulse