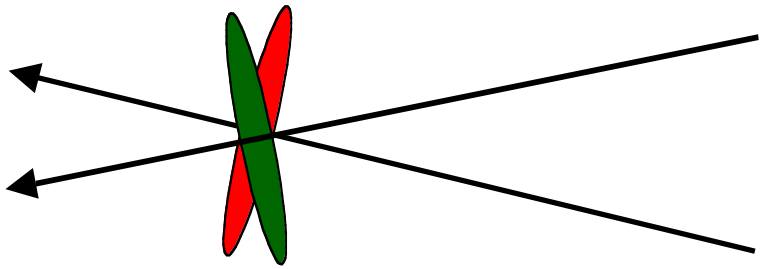
CTR AND CSR INTERFEROMETRY



Uwe Happek

The University of Georgia, Athens

C.L. Bohn, Kim Mai, Long Pham, J. Santucci, Y. Xi

Presented to FNPL Advisory Committee on October 14, 2002

MOTIVATION

Electron Bunch Optimization

FEL, SASE, LC

Coherent Radiation as a diagnostic tool:

Synchrotron: Nakazato 1989

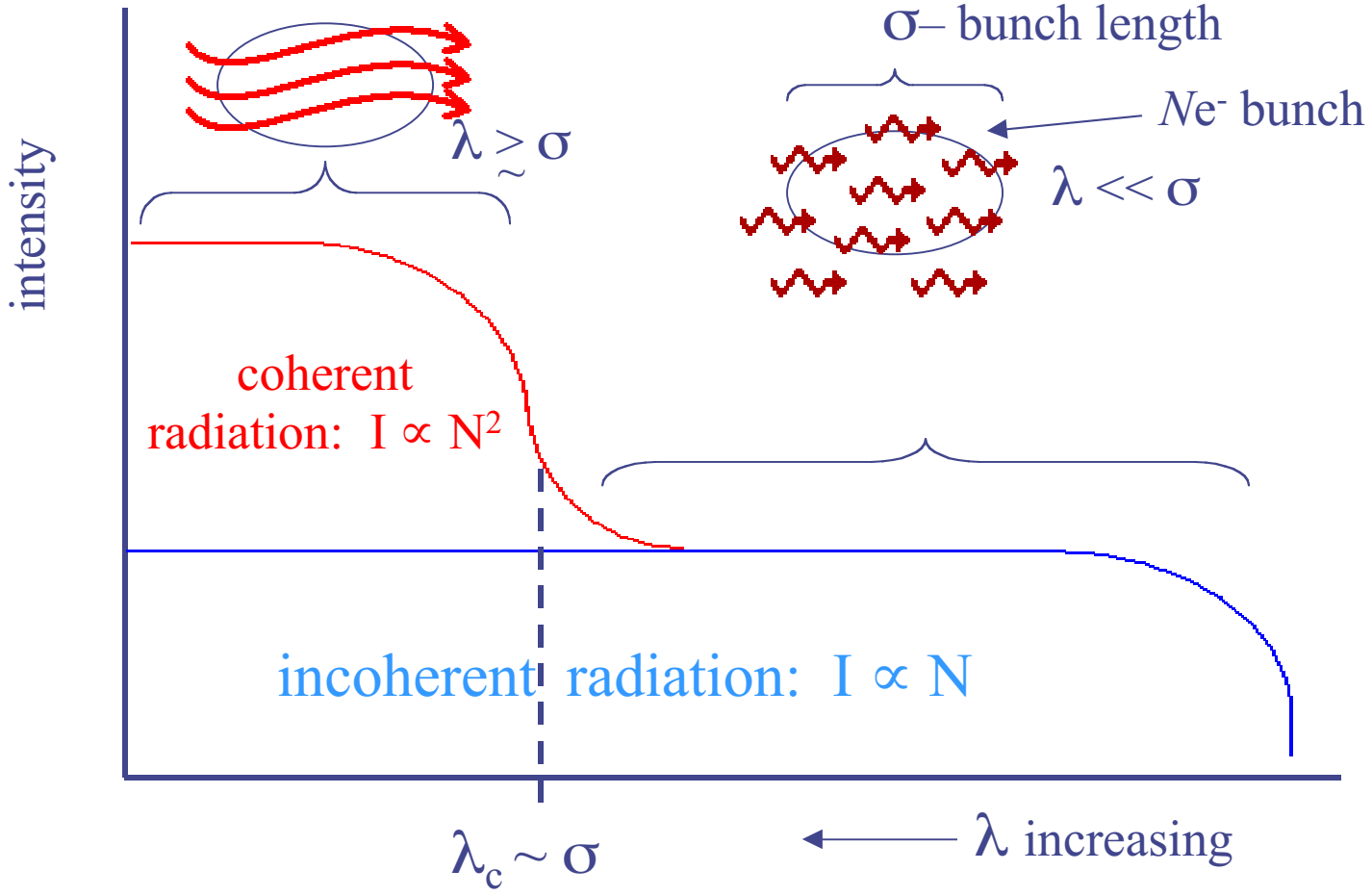
Blum, Happek, Sievers, 1991

Transition: Happek, Blum, Sievers 1991

Cerenkov, Diffraction, Smith Purcell, Undulator

Instruments (U.H.): Cornell (2), Vanderbilt, UCLA, JLAB (2), Argonne(2), Fermi (1-2)

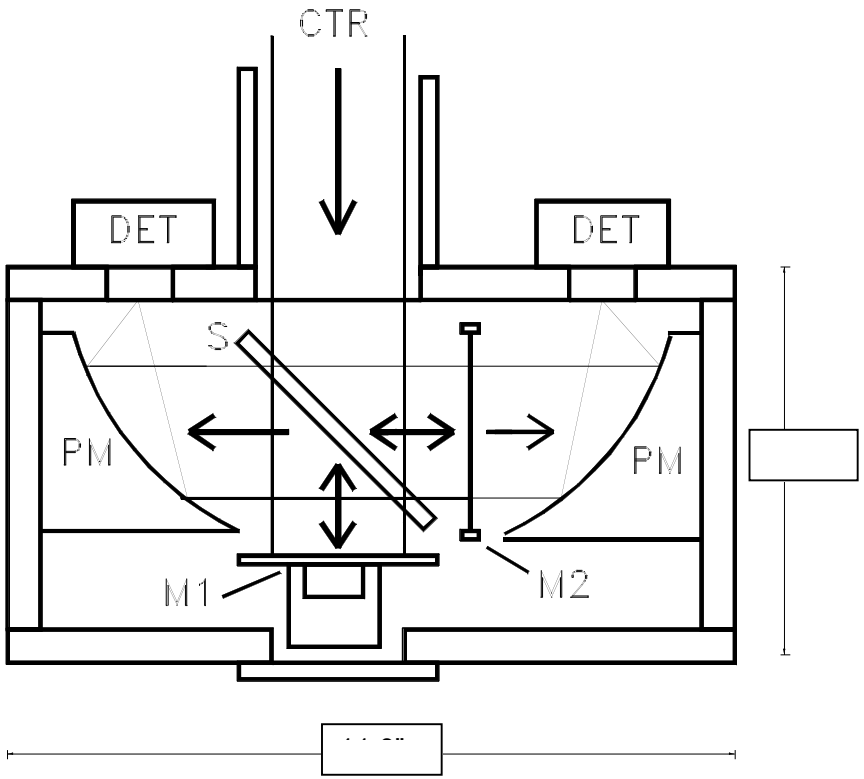
Coherent & Incoherent Transition Radiation Spectra



DREAM DEVICE

SINGLE SHOT	- pulse fluctuations
FAST	- transient phenomena
UHV	- windowless design
20 μm - 10 mm	- dynamic range
COMPACT	- bolt onto beam line
ROBUST	- diagnostic tool
INEXPENSIVE	- sure

WHAT DO WE HAVE (Oct 31)?



Michelson-Type Interferometer

proven design (Argonne) with extended range (20 μm - >5 mm)

Reference Detector

Fermi Interferometer

SINGLE SHOT	- pulse fluctuations
FAST	- transient phenomena
UHV	- windowless design
20 μm - 10 mm	- dynamic range
COMPACT	- bolt onto beam line
ROBUST	- diagnostic tool
INEXPENSIVE	- yes

SINGLE SHOT BUNCHLENGTH MONITOR

Previous attempt:

Nakazato:

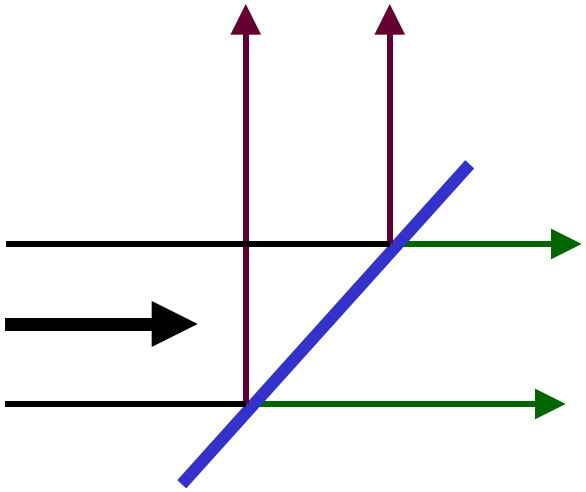
Grating Instrument with multichannel det.

Limited throughput (Slits)

Small dynamic range, factor 2

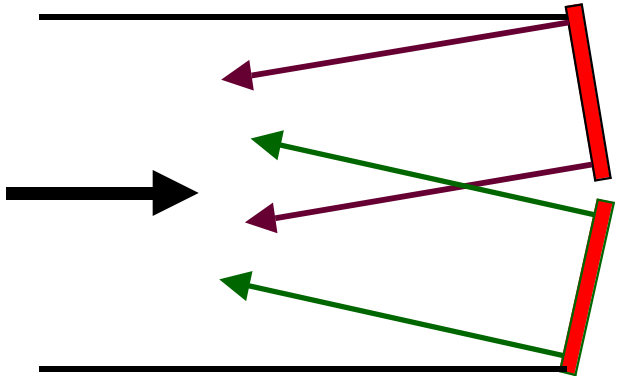
SINGLE SHOT CONCEPT

Michelson Interferometer:
Division of **Amplitude**



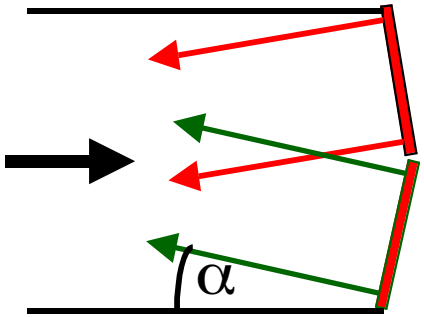
Coherent or Incoherent Source

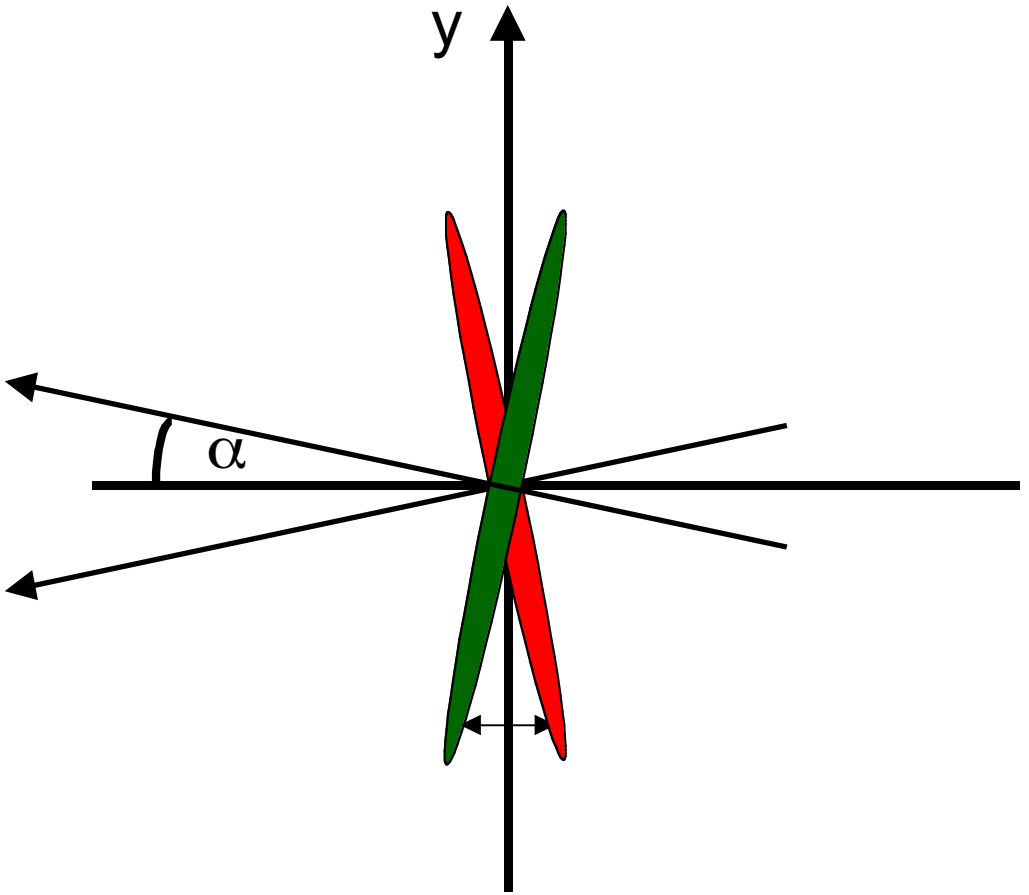
Fresnel Mirror:
Division of **Wavefront**



Coherent Source Only!

SINGLE SHOT CONCEPT CONT.

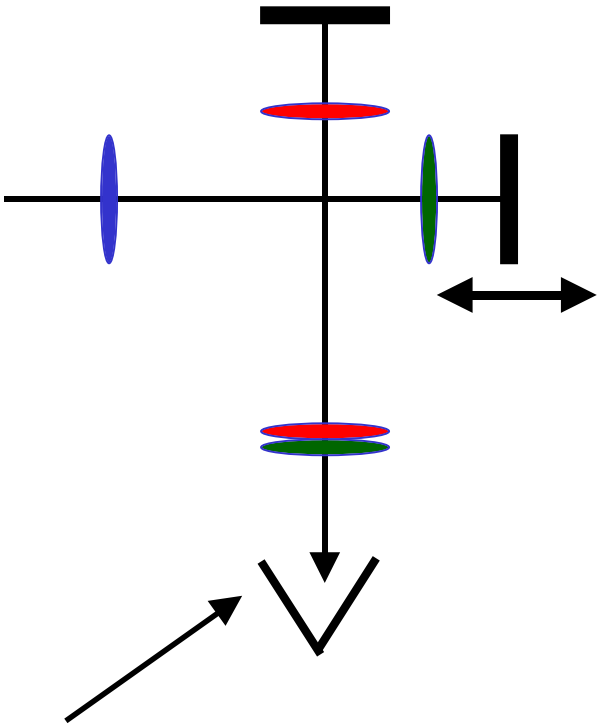




PATH DIFFERENCE: 2y sin α

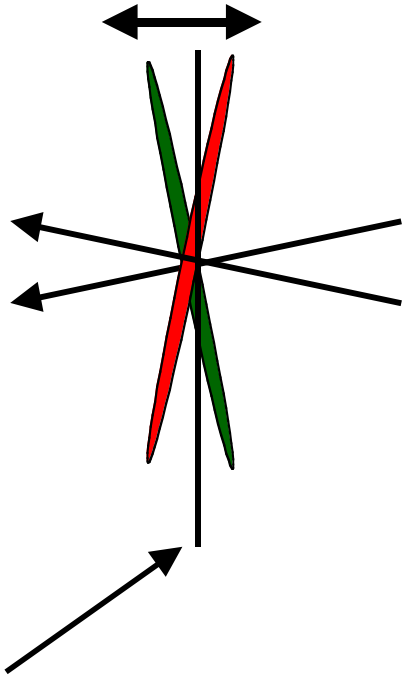
Comparison

Michelson



Single Channel Detector

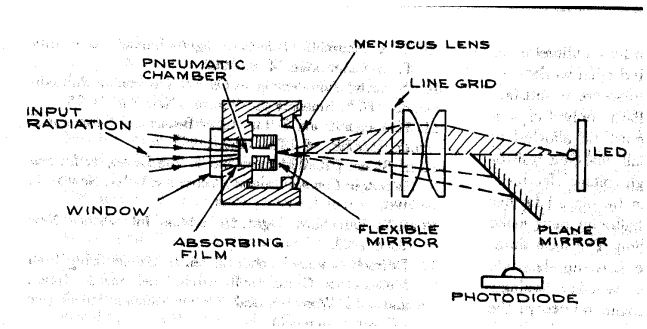
Fresnel Mirror



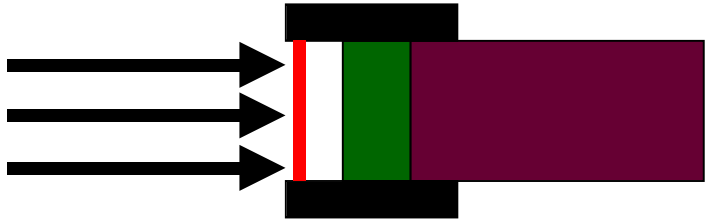
Multi Channel Detector

DETECTOR

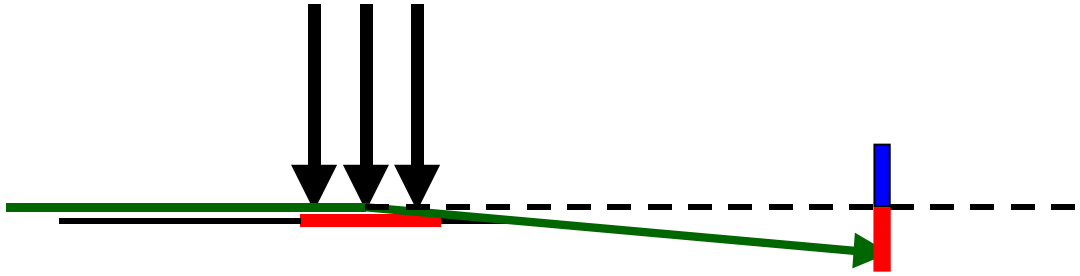
Golay Cell



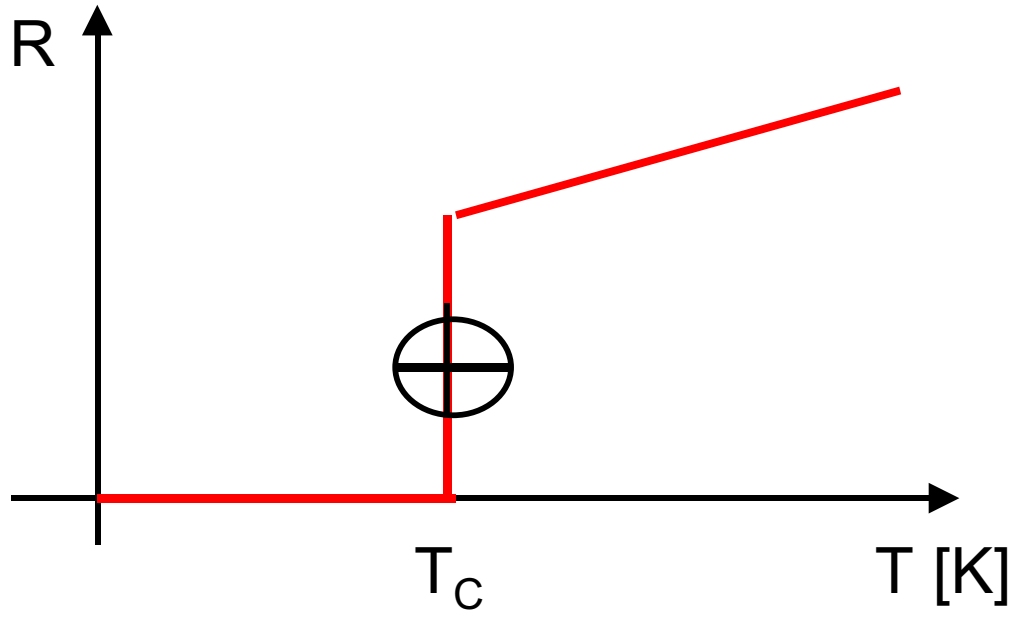
Photoacoustic



Mirage

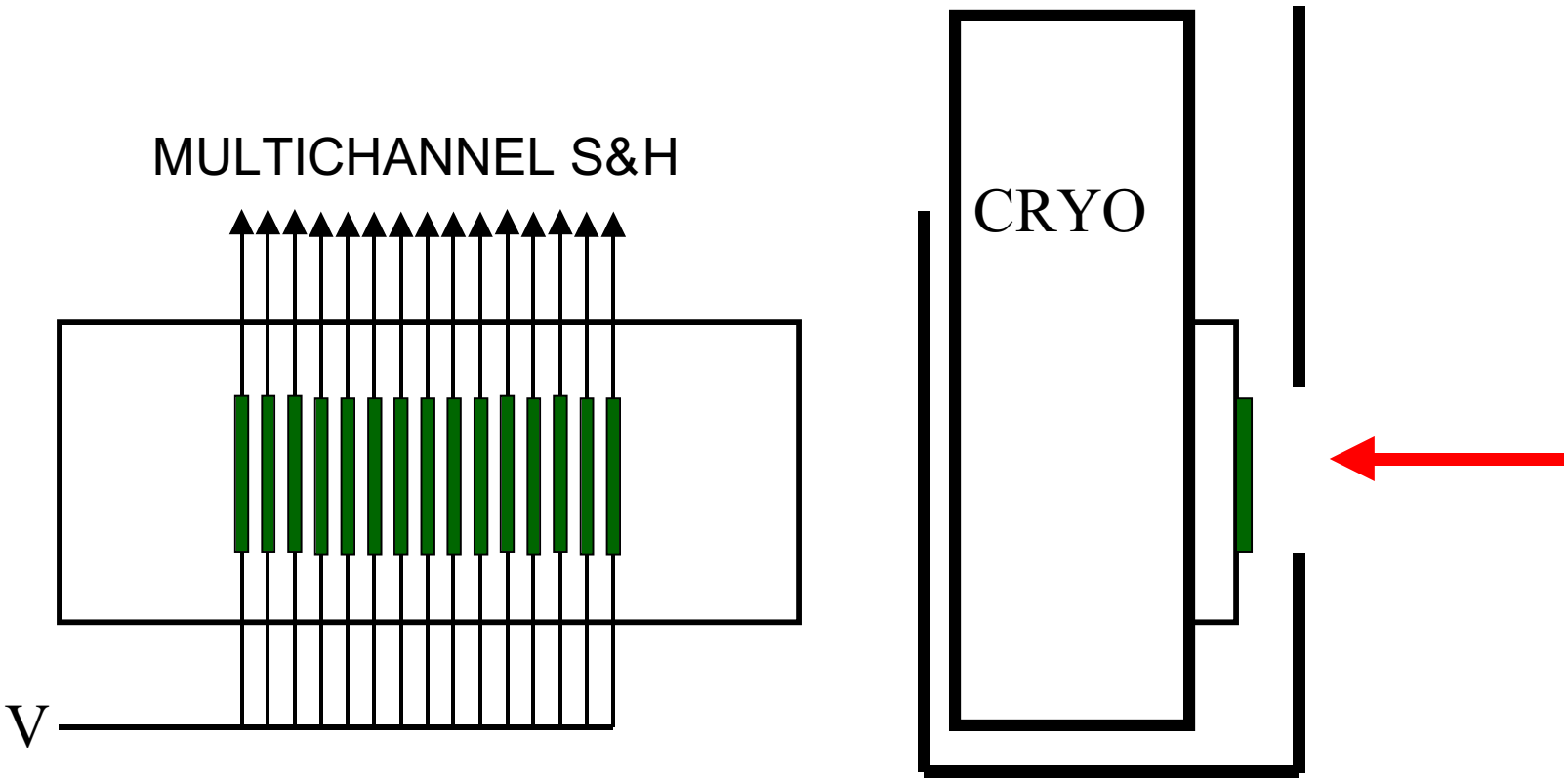


SUPERCONDUCTING TRANSITION EDGE BOLOMETER



SENSITIVE - BROADBAND - FAST

MULTICHANNEL DETECTOR

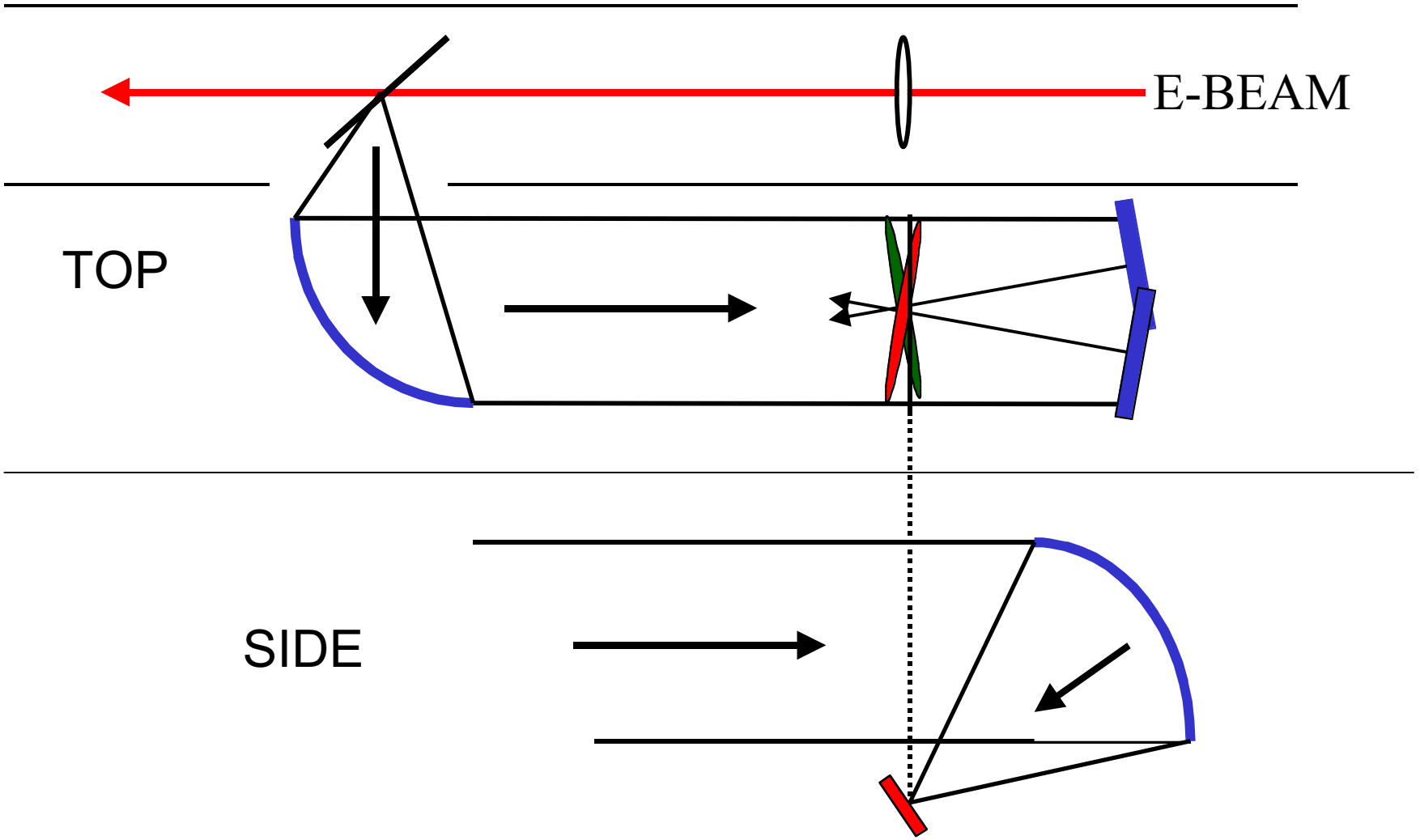


LITHOGRAPHY: element size 0.5mm x 5 mm

Material: Al, Nb, Pb, In

Response: 10 MHz

IMPLEMENTATION



WHAT NEXT, HOW MUCH?

i) Proof of Concept ($ 10k)

ii) UHV Instrument ($ 50k)

mirror	$ 5k	Detector:	$ 15k
electronic (NIM)	$ 5k	Chamber:	$ 15k
S&E	$ 5k	Design	$ 5k

(probably subject to increase)

SUMMARY

SINGLE SHOT DIAGNOSTIC - IT WILL BE DONE

TAKING ADVANTAGE OF COHERENCE

FRESNEL MIRROR DESIGN

NO MOVING PARTS

BEST FOR SYNCHROTRON RADIATION

Single Shot	**Fast**
Robust	**UHV**
10 μm - 10 mm	**Compact**

“Low Cost”

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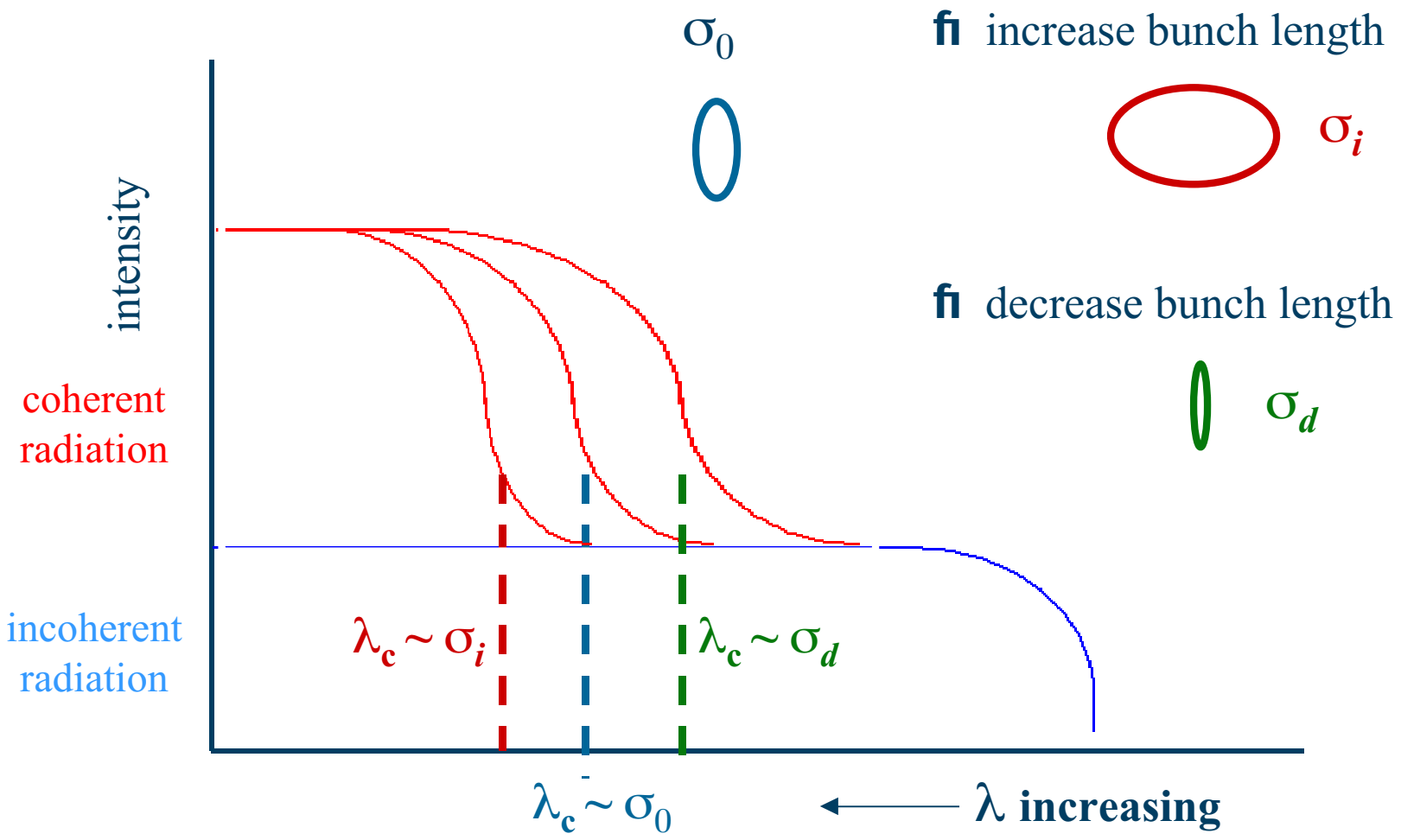
Coherent Radiation



BACKGROUND

$$I_{tot}(\lambda) = I_1(\lambda)\,[N + N(N-1)f(\lambda)]$$

$$= I_{inc}(\lambda)\,[1 + (N-1)f(\lambda)],\ \text{where:}$$

$I_1(\lambda)$	≡	radiation intensity of one electron at λ
N	≡	number of electrons in bunch
$I_{inc}(\lambda)$	≡	intensity of incoherent radiation
$f(\lambda)$	≡	form factor

$$f(\lambda) = \left| \int dz\, e^{2\pi i z/\lambda}\, S(\boldsymbol{r}) \right|^2$$

where $S(\boldsymbol{r})$ is charge distribution & z is dir'n of propagation