QUARTZTOF

An isochronous & achromatic Cerenkov Counter

Making Cerenkov light parallel → point focusing

Mike Albrow (Fermilab)

New and original design/concept for fast timing Cerenkov counter

Ray-tracing calculations done:
Expect > factor 10 more photoelectrons than either GASTOF or QUARTIC
Photons arrive promptly (< few ps) at MCP-PMT

Full (wavelength dependent) simulations being done.
Needed for [x,y] position dependence over [2mm x 20mm] area.

Two being made for beam tests (July-Aug?).

How many photoelectrons (all prompt)?

$$N_{p.e.} \cong 90.L(cm).\sin^2(\vartheta_c)$$ PDG Rule-of-thumb

$$= 90.L(cm).\left(1-\frac{1}{n^2}\right)$$

$$\left(1-\frac{1}{n^2}\right)(C4F8O-gas,1atm) = 0.0028$$

$$\left(1-\frac{1}{n^2}\right)(QUARTZ) = 0.804, factor \sim 290$$

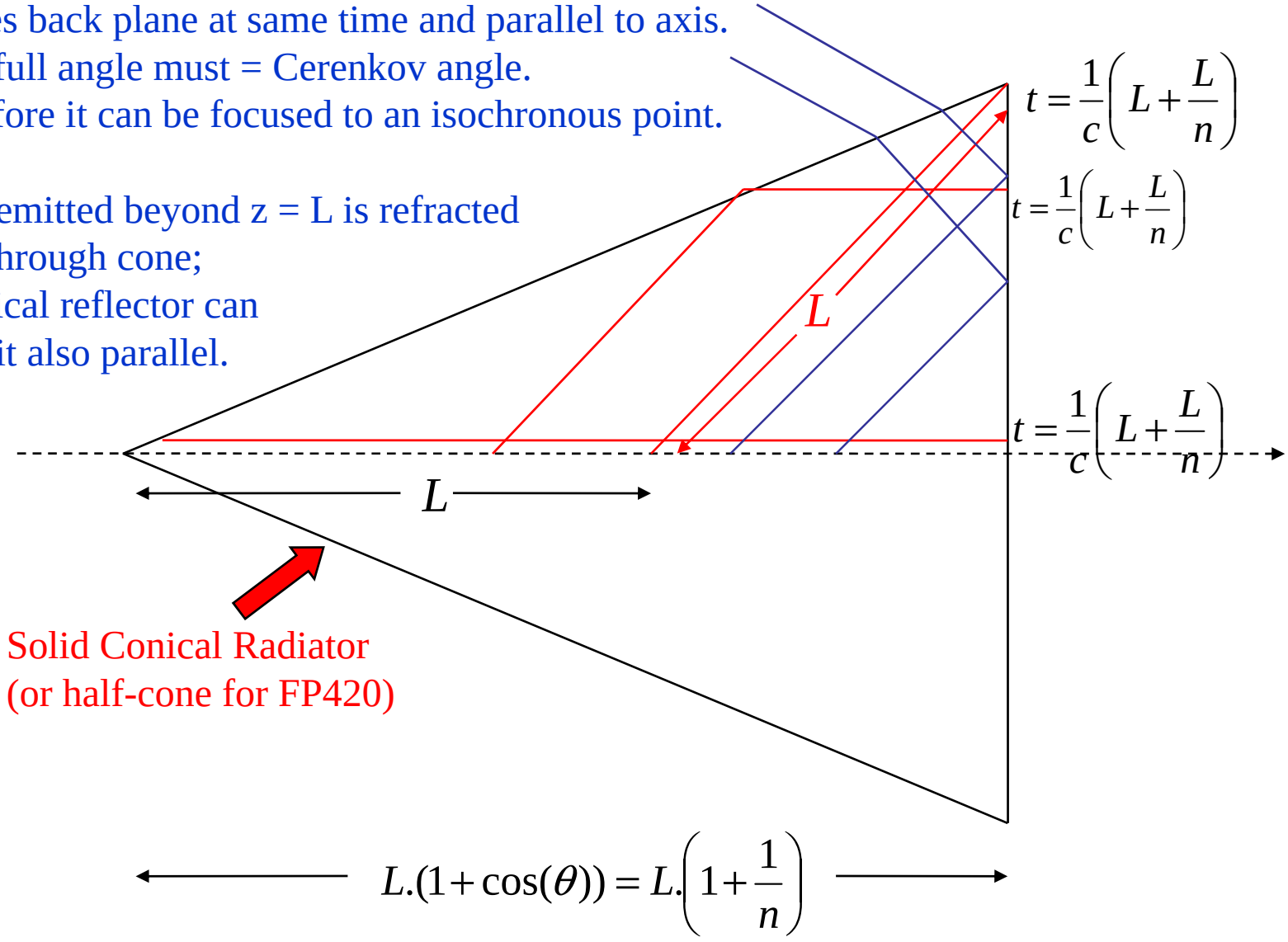
3 cm quartz ~ 29 x 30cm gas (latter ~ 10 pe.)
Difficulty with quartz has been in focusing it.
Can have quartz plate e.g. 2mm thick – 45deg concave mirror (proximity focus) which gets ~ 2 x 30 cm gas and is simpler.

QUARTIC design had 64mm quartz in 8 bars, but only few% of light “prompt”
Got 3-4 p.e. per bar, say ~ 30 per Quartic

36 mm + 15 mm QUARTZTOF → 180 + 75 prompt p.e.

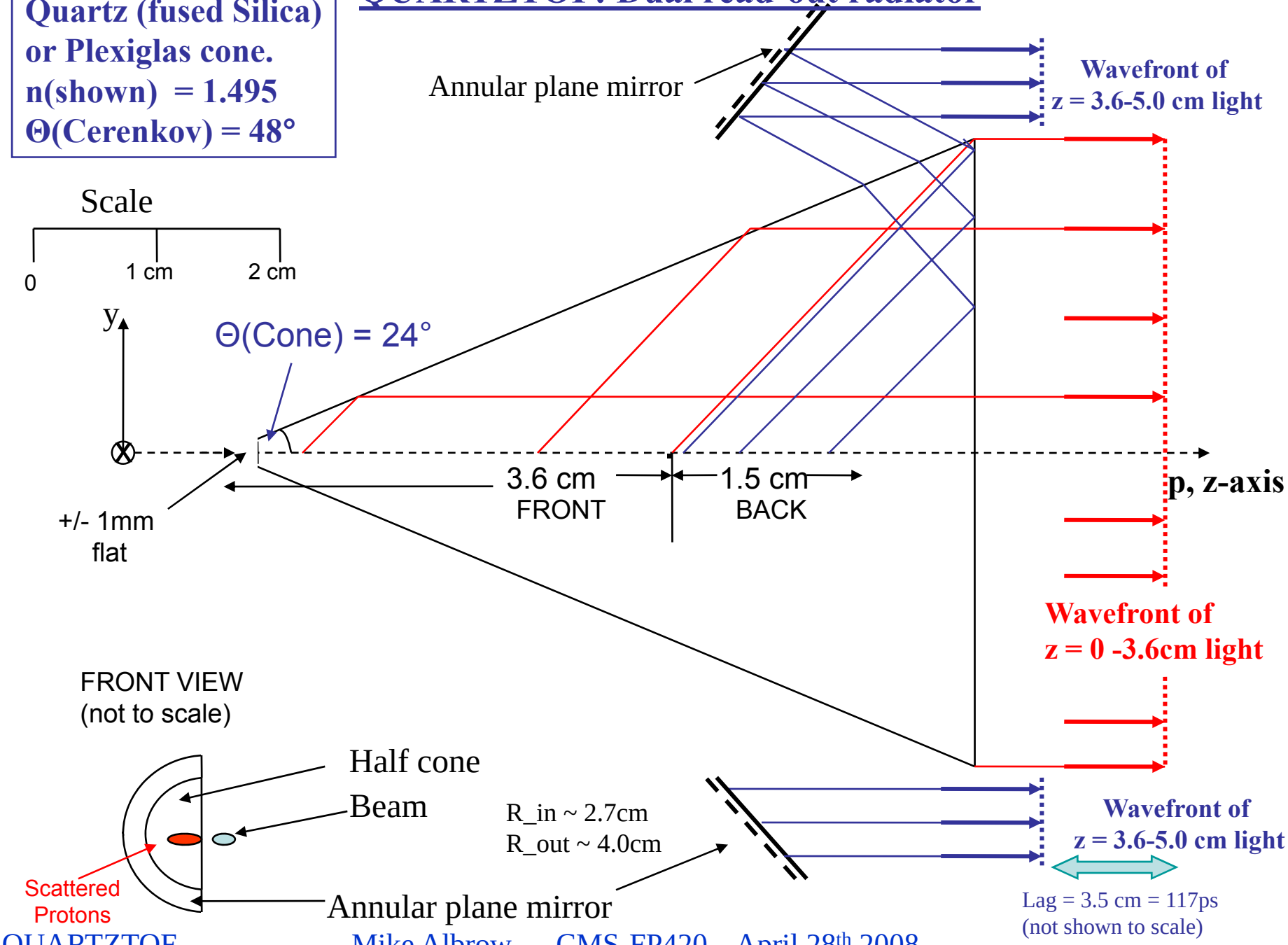
Geometrical optics: All Cerenkov light from z = 0 to z = L
reaches back plane at same time and parallel to axis.
Cone full angle must = Cerenkov angle.
Therefore it can be focused to an isochronous point.

Light emitted beyond z = L is refracted
back through cone;
A conical reflector can
make it also parallel.



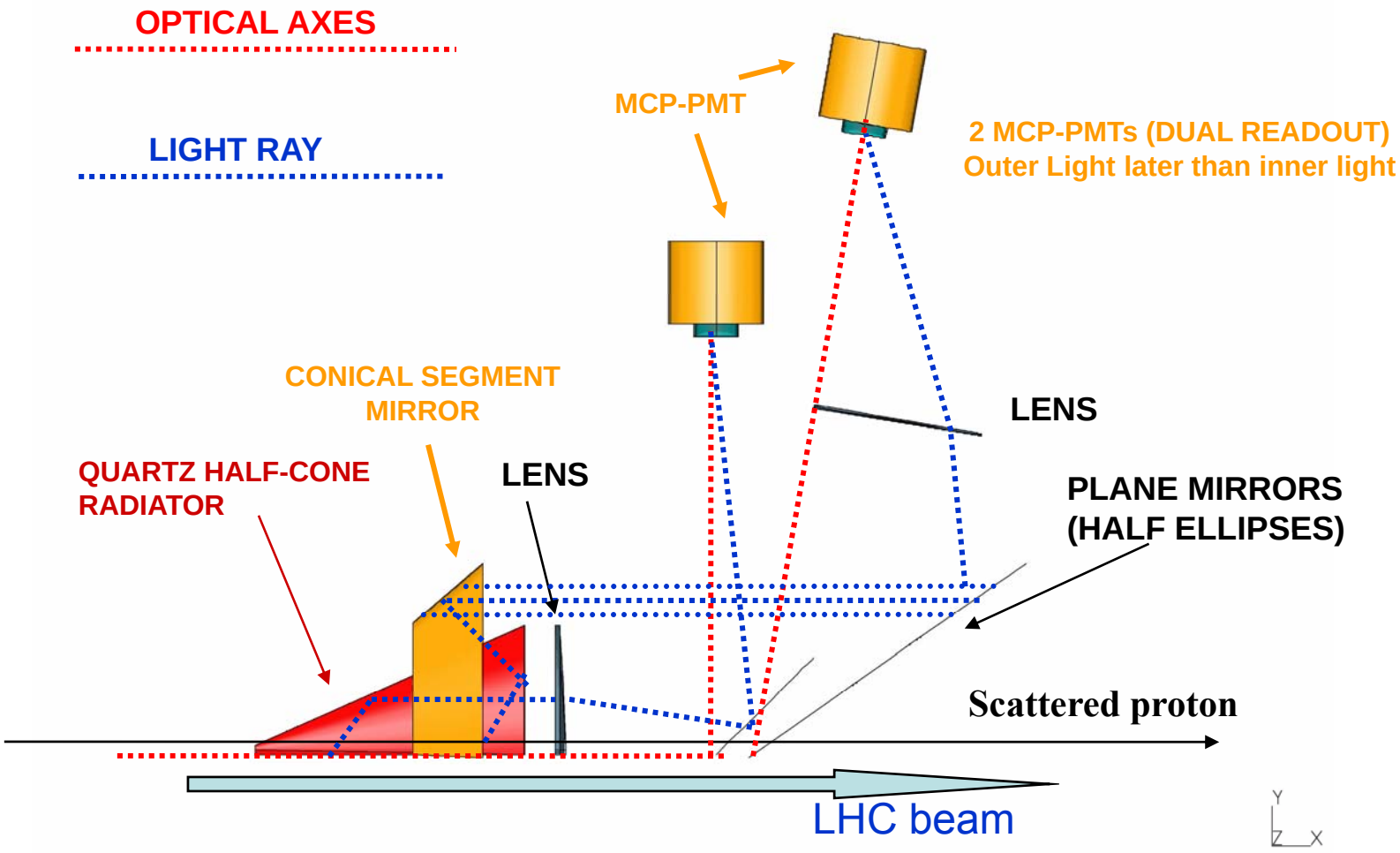
QUARTZTOF: Dual read-out radiator

Quartz (fused Silica) or Plexiglas cone.
n(shown) = 1.495
Θ(Cerenkov) = 48°



Top View: Optics, schematic

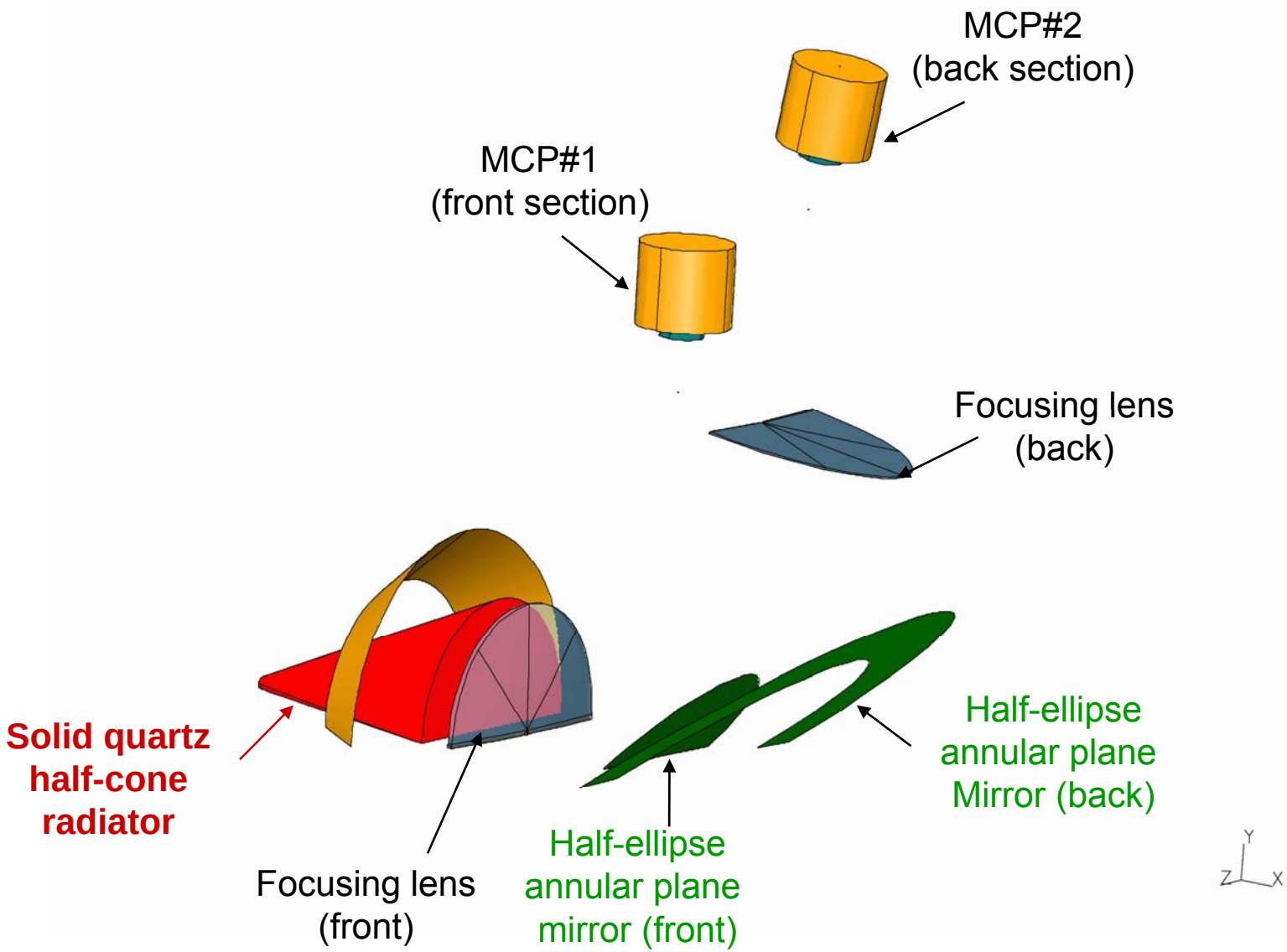
Focusing schematic (variations possible)
Parallel light can be focused to a point!



Note: Reflections shown in horizontal plane, but in LHC will be UP or DOWN or possibly even BOTH

1 dual readout QUARTZTOF (Optical Elements)

John Rauch drawings



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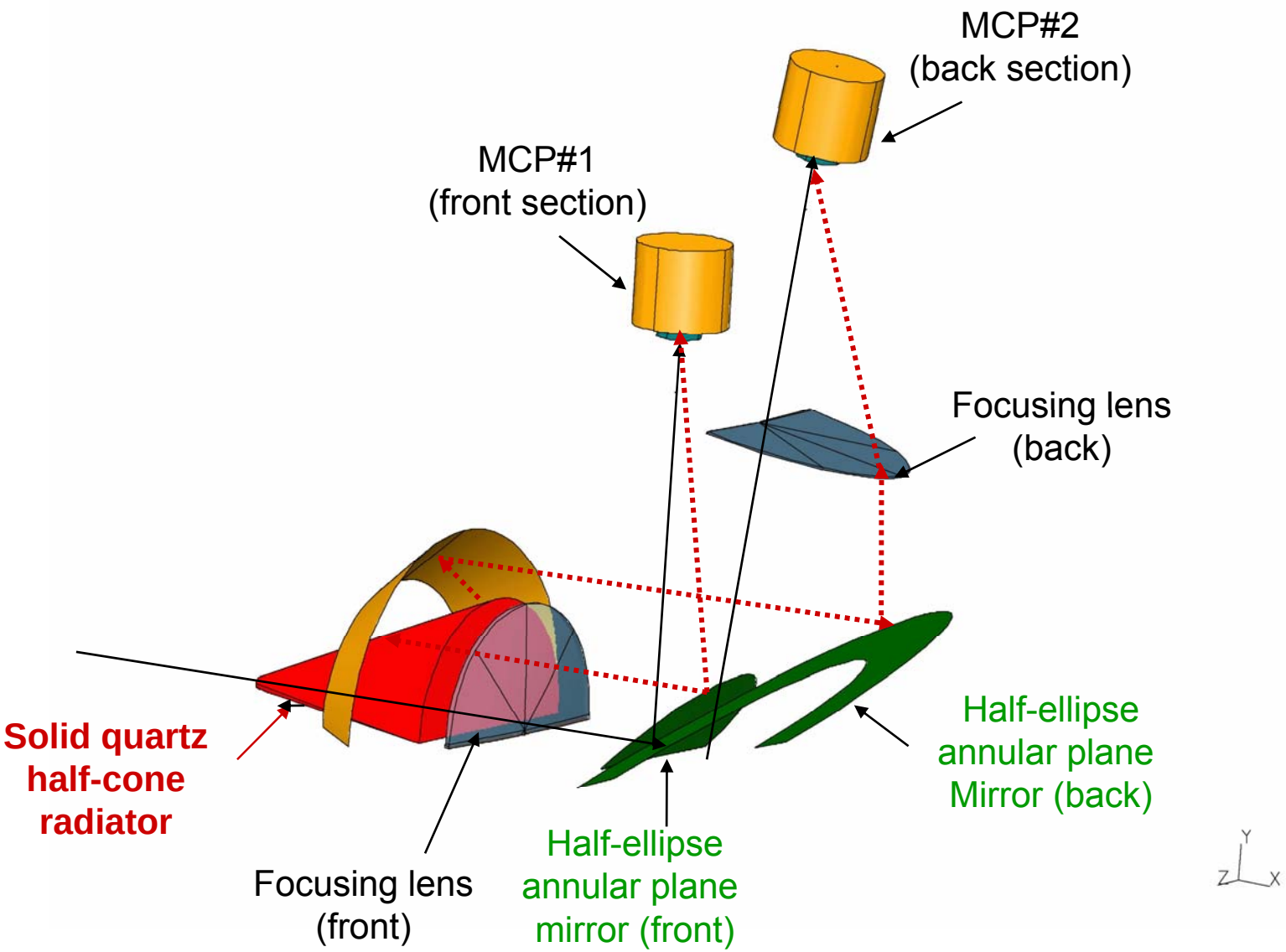
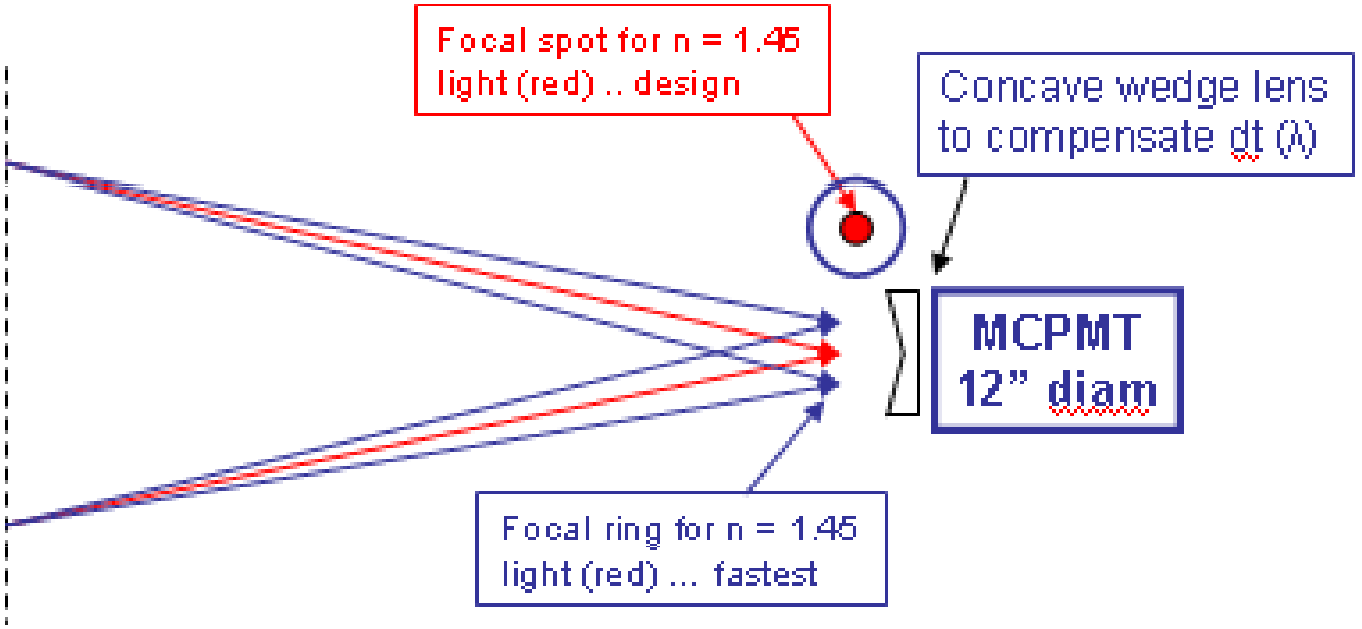


"Lucky Light" (chosen by cone angle) focused to central point.
Choose **RED** or **UV**. All other wavelengths → rings, earlier or later.
Earlier light retarded with quartz wedge lens (2mm / 10ps) → achromatic

Focusing and wavelength compensation (schematic)



Focusing element
E.g. 45° concave mirror
or achromatic lens

(here shown normal for simplicity)

Designed to point-focus reddest light;
all bluer light in halo, R(λ) can be retarded
With lens on MCPMT

With focused light can use the best single channel MCP-PMTs Hamamatsu or Photek.

HAMAMATSU MICROCHANNEL PLATE-PHOTOMULTIPLIER TUBE
R3809U-61/-63/-64

Compact High Sensitivity MCP-PMT Series
Featuring with Fast Time Response

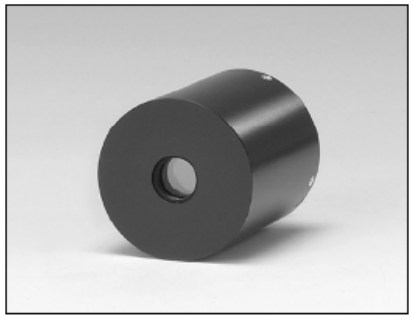
TTS (single p.e.) < ~ 30ps
100 prompt p.e. < ~ 3ps

FEATURES

- High Sensitivity
  QE: 12 % (-61), 36 % (-63), 40 % (-64)
- High Speed
  Rise Time: 200 ps (-61), 180 ps (-63/-64)
  IRF® (Instrument Response Function): 150 ps at FWHM: (-61)
  60 ps at FWHM: (-63/-64)
- Compact Profile
  Effective Photocathode: 10 mm diameter
  (Overall length: 70.2 mm, Outer diameter: 45.0 mm)

APPLICATIONS

- Molecular Science
  Analysis of Molecular Structure
- Medical Science



Photek Microchannel Plate PMT

	PMT210	PMT212
Anode Size	10 mm	12 mm
Electron Gain	10^6	10^6
Peak/Valley	2:1	1.5:1
Dynamic Range cps	40,000	40,000
Pulse Rise Time	100 ps	100 ps
Pulse FWHM	170 ps	170 ps
Transit Time Jitter	30 ps	30 ps
MCP Pore Size	5/6	5/6

Plans:

Discuss with collaborators.

Full simulation especially for {x,y} performance variations, with wavelength dependence of Cerenkov emission, light transmission, reflections and QE (MCP-PMT).

Make two units, with >= 2 MCP-PMTs (single channel) together with state-of-art commercial electronics.

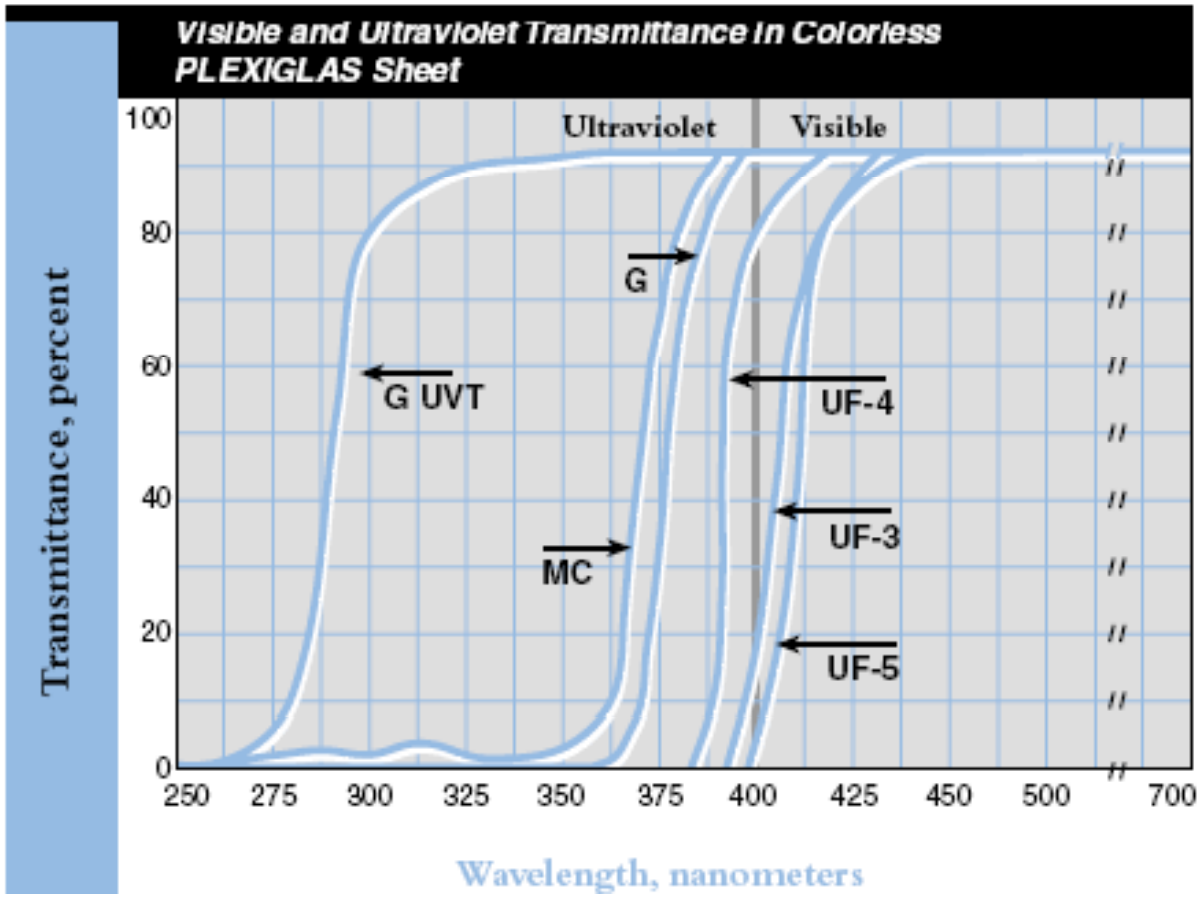
Beam tests at Fermilab June (?) – Aug.

I believe < 5ps timing is possible if electronics up to it (25ns)

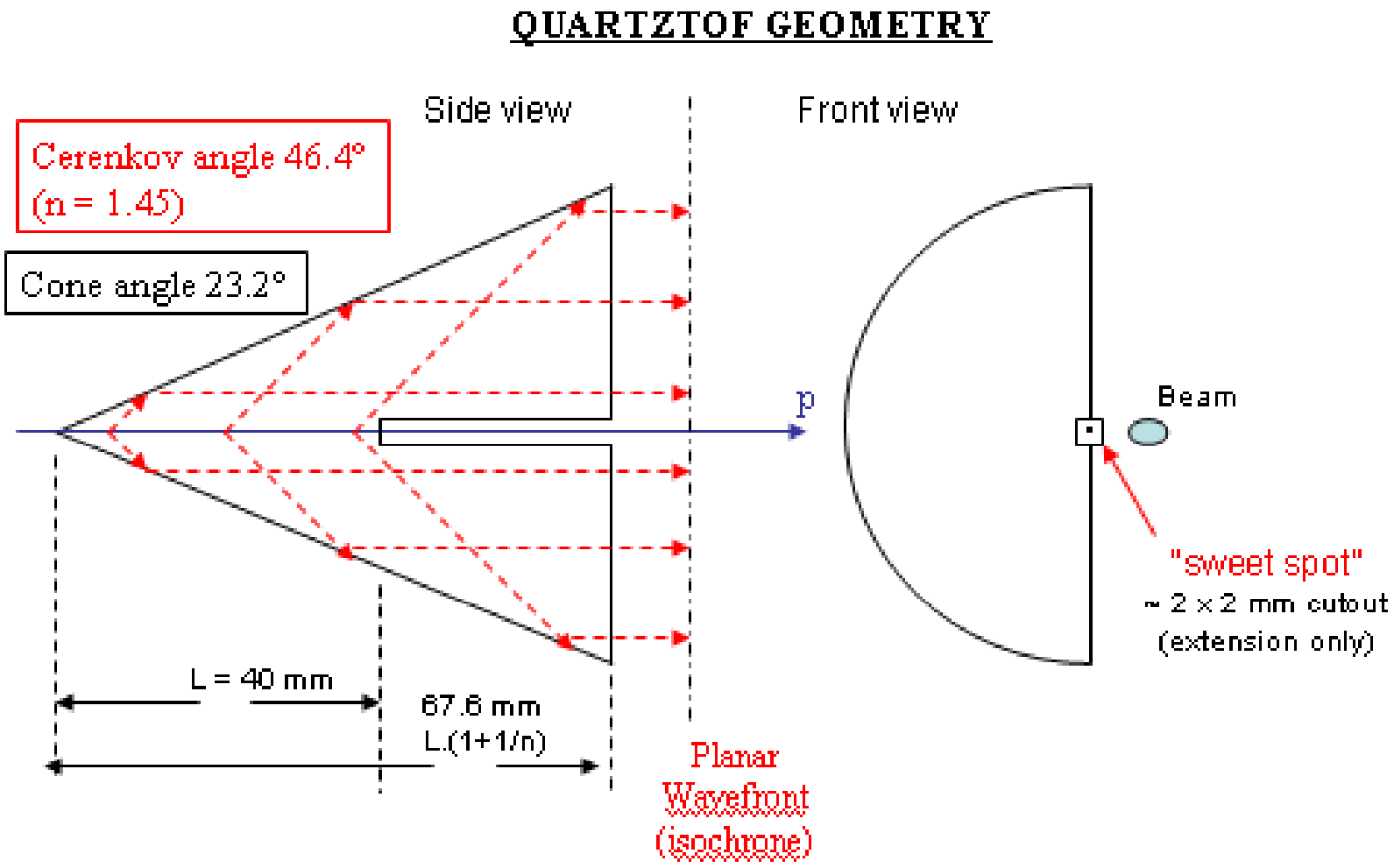
Additional Slides

Will make prototypes in UVT Plexiglas (cheap and easy to machine at FNAL).
Similar optical properties. LHC version probably fused silica (Rad Hard)

Altuglas International



QUARTZTOF: 1st simple concept
Front section read-out



Focusing schematic (variations possible)
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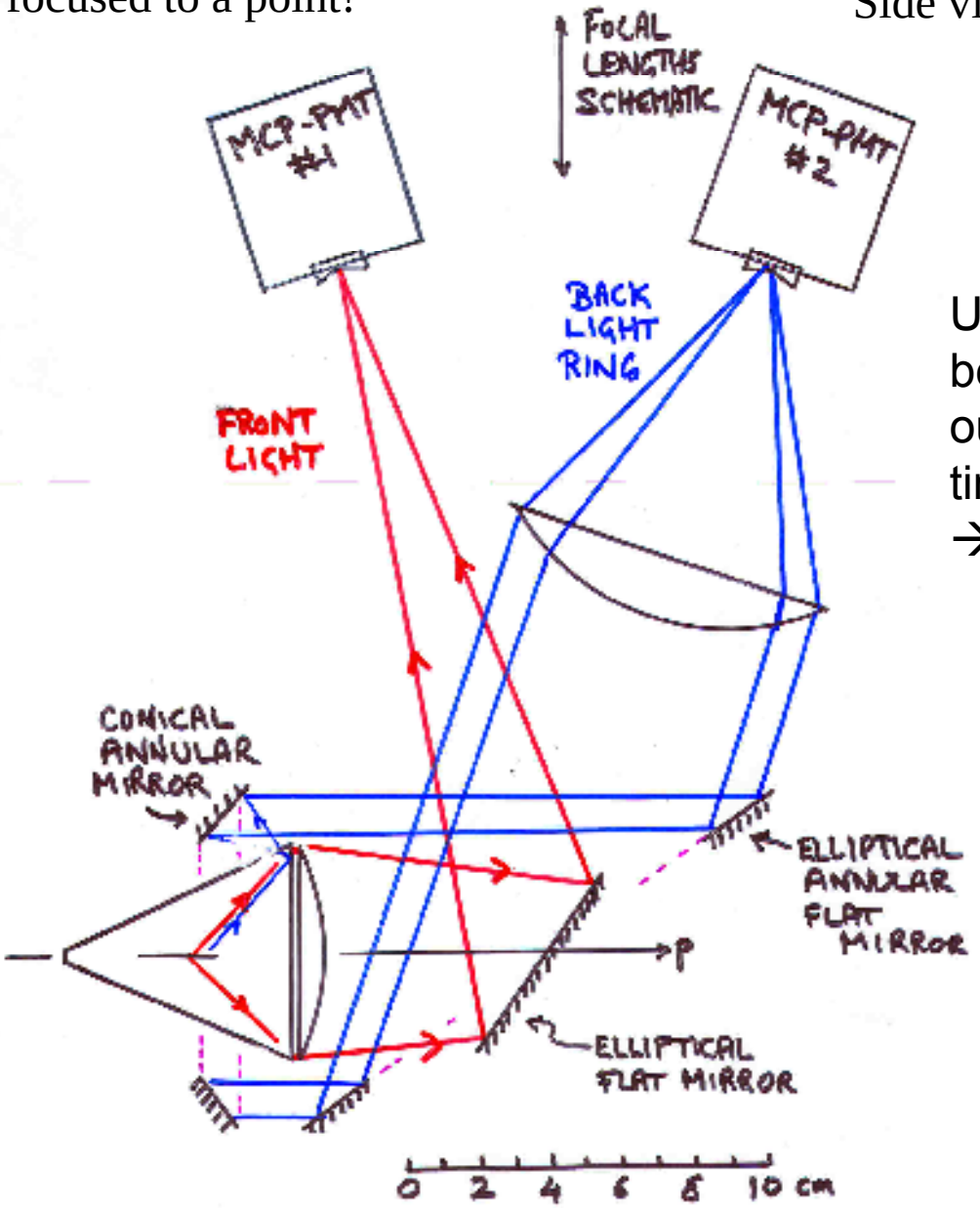
QUARTZTOF

Side view: PMTs UP or DOWN



Use 2 MCP-PMTs because inner & outer light at different times.
→ Dual Read-Out