John Adams Institute for Accelerator Science

Imperial College London

Royal Holloway University of London

UNIVERSITY OF OXFORD

For discussion of Final Focus and IR of plasma-based collider

Andrei Seryi

ANAR workshop

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Assumption: plasma acceleration allows to make very short linacs ☺
But:
"CLIC Final Focus is 3km long" ☹

How to use advantages of plasma acceleration
Why FF of conventional LC is 3km?

How the requirements to detectors (physics reach or precision) need to be modified to take full advantage of the new technology and to devise a compact plasma-based collider?

In the following slides, will make significant simplifications of the issues

Why 3km for CLIC FF?

First of all, 3km is entire BDS (beam delivery), and FF is a short fraction of BDS

BDS includes – beam diagnostics, coupling correction section, betatron collimation, energy collimation, final focus.

In CLIC the longest components of BDS are E-collimation and FF

Let's ignore other systems and consider, very approximately, only the two main:

E-collimation (2.3km)	FF (0.7km)

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Where the requirements for the length are coming from?

They are coming not really from the optics, but really originates from requirements from detectors, e.g. physics reach

CLIC FF length – what defines it?

E-collimation (2.3km)	FF (0.7km)

Collimation system – defined by the requirement from detector to cut all beam tails beyond certain number of sigmas (e.g. 10)

The collimation system is thus ensures that there are no losses closer than few hundred meters from the IP – maintain clean background-free conditions in the detector

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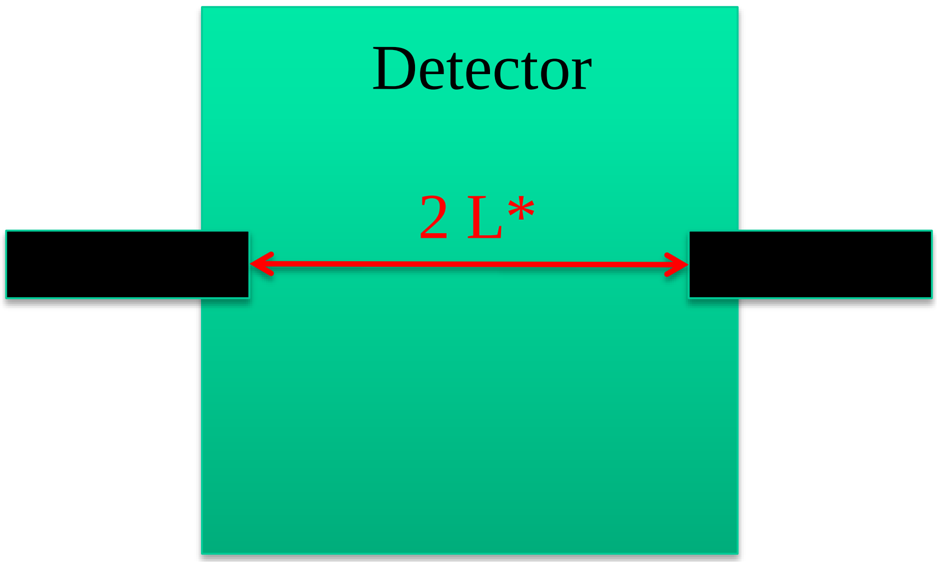
The length of the collimation system, maybe surprisingly, is primarily defined by machine protection system requirements – the collimators should be able to survive a full mis-steered train

(In ILC, where bunch separation is much longer, collimators have to survive just two bunches, as the rest of the train can be diverted)

CLIC FF length – what defines it?

E-collimation (2.3km) | FF (0.7km)

Final focus – defined by 1) the requirement from detector to have the L* longer than certain value, to avoid interference with accelerator; and 2) push for lowest beta* to minimize beam size



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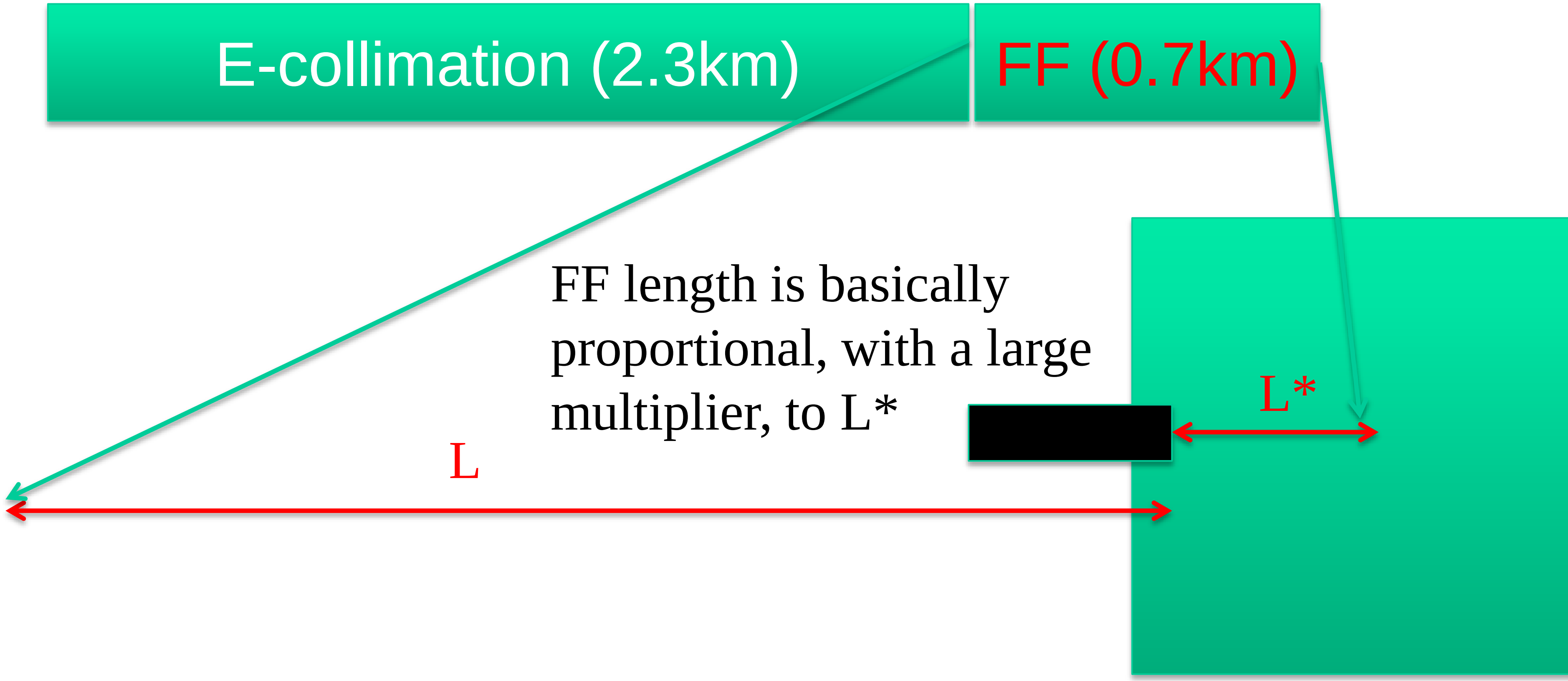


FF length is basically proportional, with a large multiplier, to L*

To derive very rough scaling assume that chromaticity of final lenses (which is L*/beta*) dominates. This gives

$$L \sim L^* \ (L^* / \beta^*) \ \delta E/E$$

Assume L*=5m, beta*=0.1mm, deltaE/E=0.2% => L~ 500m

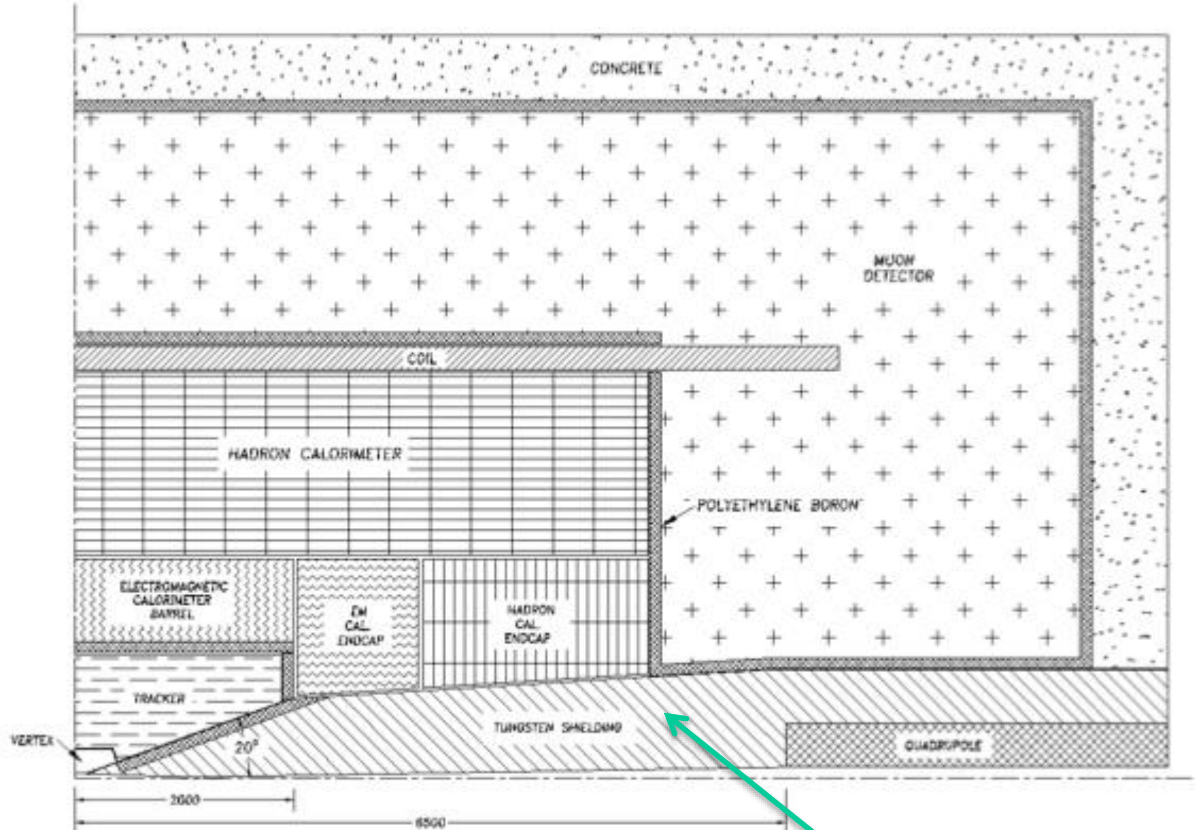
FF and collimations – conclusions for plasma collider:

To take advantage of plasma technology, have to modify detector requirements (and thus work with HEP on a possible detector, background and event reconstructions)

Such a work and detector design modification, due to requirements from the technology, is not unique

Look, for example, how muon collider technology proponents adjusted their detector concept to take into account the fact that muons decay and give background on the detector axis – see next slide

Strawman Detector Concept for a Muon Collider

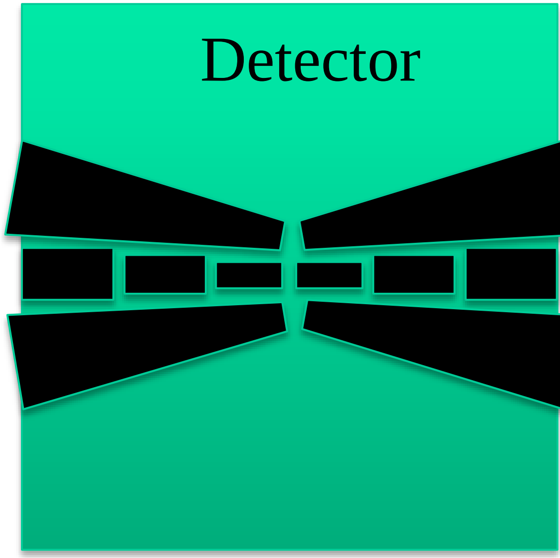


Tungsten shielding cone

A possible FF / IR approach for plasma collider
– for discussion

Radically reduce L* - then the FF is very short and adiabatic focusing with short L* have large energy acceptance
(Maybe use plasma focusing)

May have to have shielded exclusion cone in the detector



Collimation – assume no dedicated stand-alone collimation system to start with
Explore incorporating some collimation in drifts between accelerating stages

Additional slide: Scaling of FF length (very rough!)

Chromaticity:

ChromFD = L*/beta*

ChromFF / ChromFD = L* / L

(FD – final doublet, FF – the entire system excluding FD)

From the above

=> ChromFF = ChromFD L*/ L => ChromFF = (L*)^2 / (L beta*)

To find scaling, require

ChromFF dE/E = 1 (or less than one)

=> L = (L*)^2 / beta* dE/E (or longer than this)