Forward Tracker Upgrade

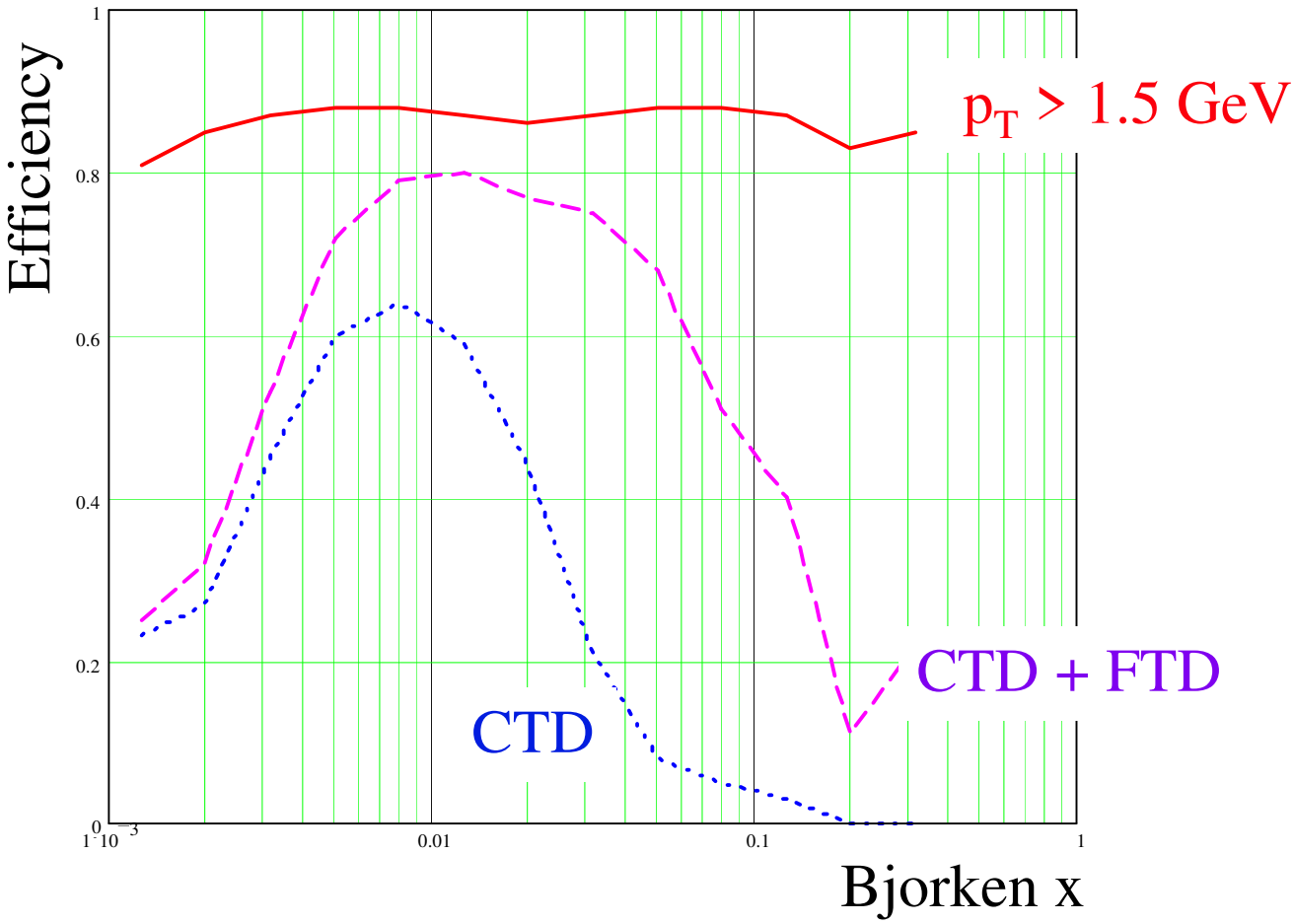
- Why?
  - Physics that needs tracks in the forward direction.
  - Current FT.
  - Track finding in FT.
  - FT performance.
- How?
  - Removal of TR vol.s and MWPCs.
  - Forward scintillator trigger.
  - New planar chambers.
  - Costs.
  - Cutting costs.
- Expected performance.
- When?
- Summary

Physics using Forward Tracks

- High $\mathscr{L}$ HERA extends Q^2 reach.
- New high mass states travel forwards, decay products found mainly in forward direction.
- E.g. for > 200 GeV scalar leptoquark, either electron or quark jet found in FTD 75% or more of time.

Physics using forward tracks cont.

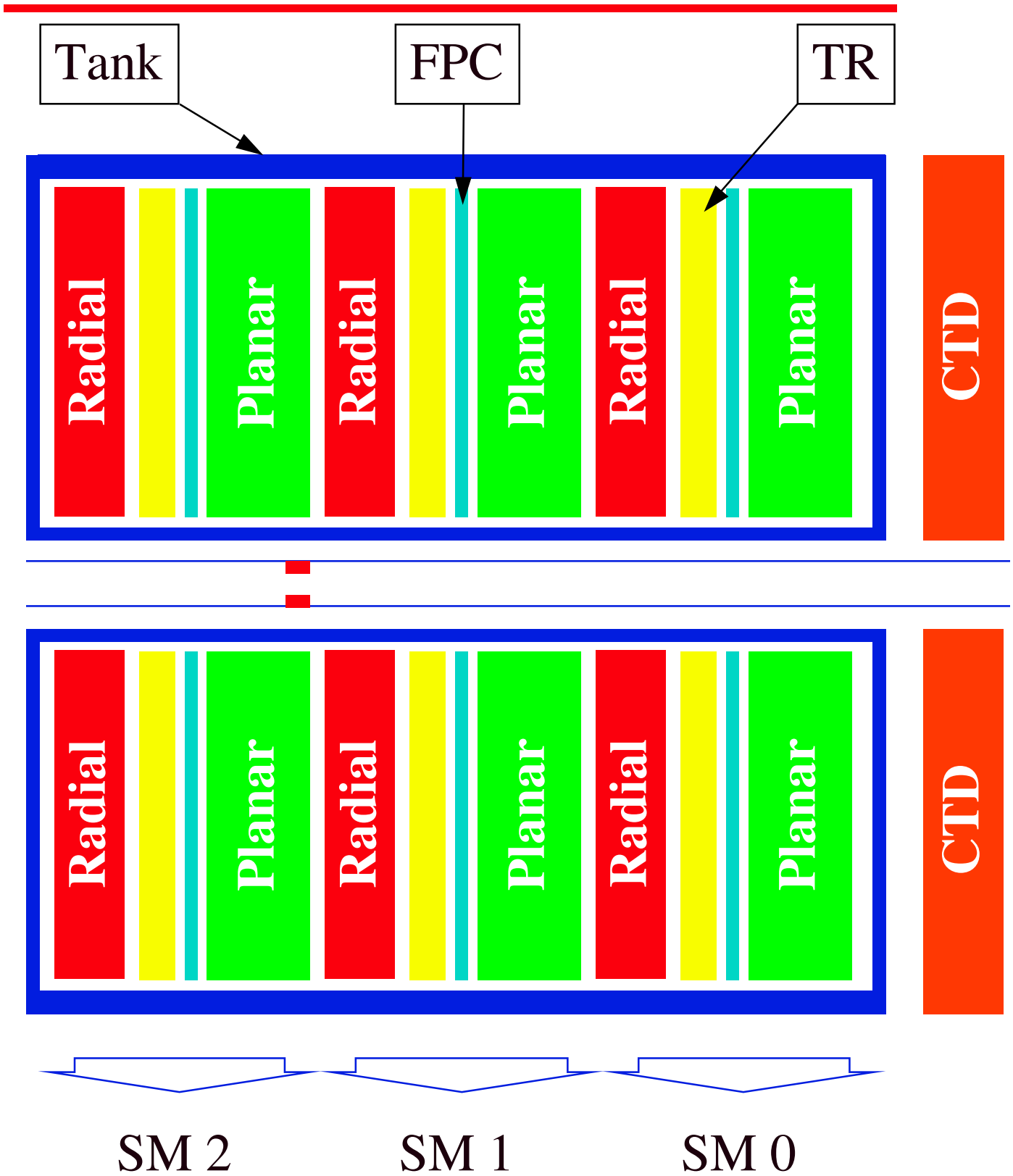
- Charm in forward direction.
  - Detect via $D^* \rightarrow D^0\pi \rightarrow (K\pi)\pi$, efficiency ~ (track efficiency)^3.
  - In DIS FT allows extension of Bjorken-x region covered, e.g. for $Q^2 > 100$ GeV^2:



Physics using forward tracks cont.

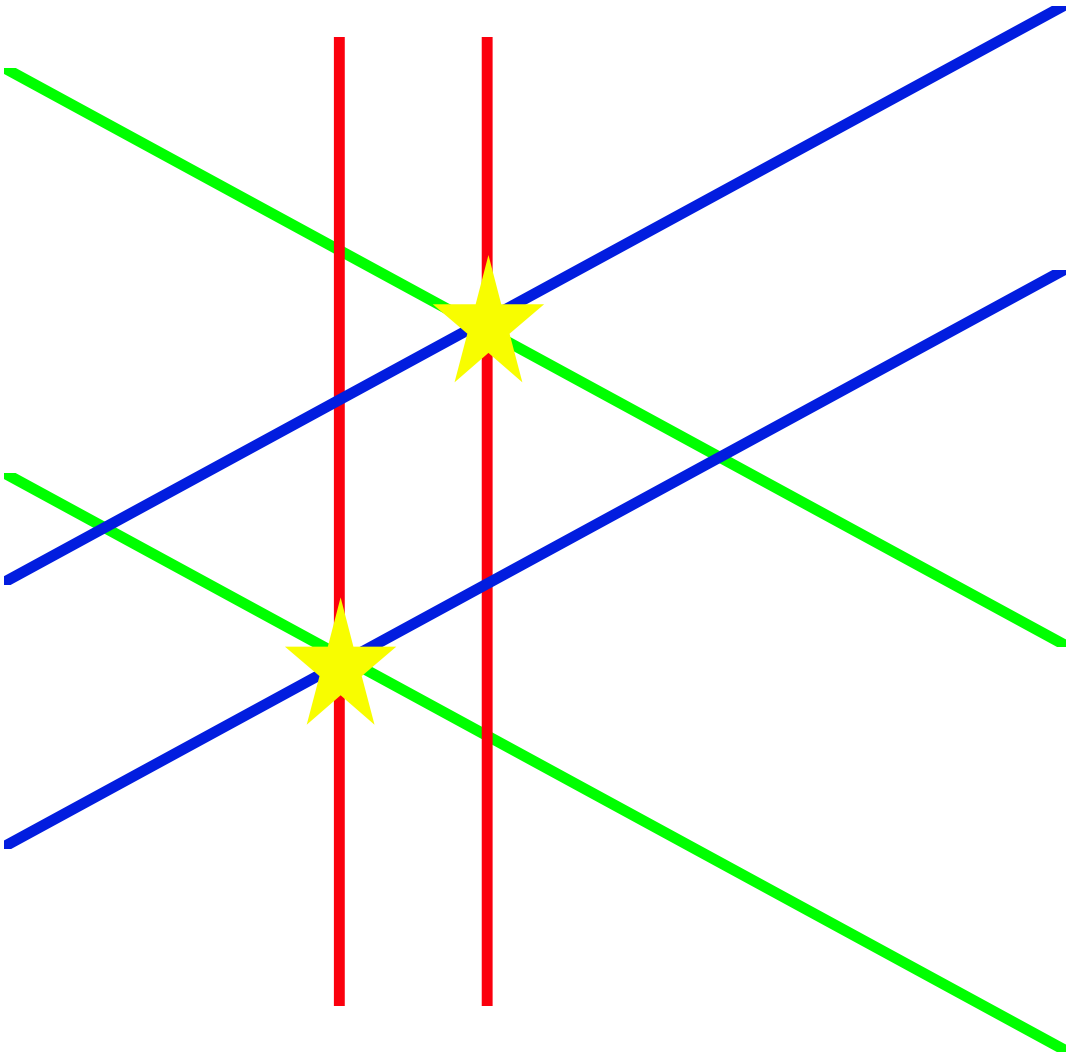
- b events.
  - FT adds between 40% and 65% to di-muon sample.
- Gluon recombination, long range correlations important.

Current FT


Tank
FPC
TR
Radial
Planar
Radial
Planar
Radial
Planar
CTD
Radial
Planar
Radial
Planar
Radial
Planar
CTD
SM 2
SM 1
SM 0

Track Finding in FT

- Find “clusters” in planar chambers.
- Find sets of three clusters in planar module compatible with coming from one track.



Track finding in FT cont.

- Form “planar segments” from optimal groupings of three clusters.
  - Primary segments where all clusters have 3 or 4 hits.
  - Secondary where two 3 or 4 hit clusters combined with 2 hits in third planar chamber.
- Find “radial segment” in radial chambers.
- Link segments to form tracks.

FT Performance

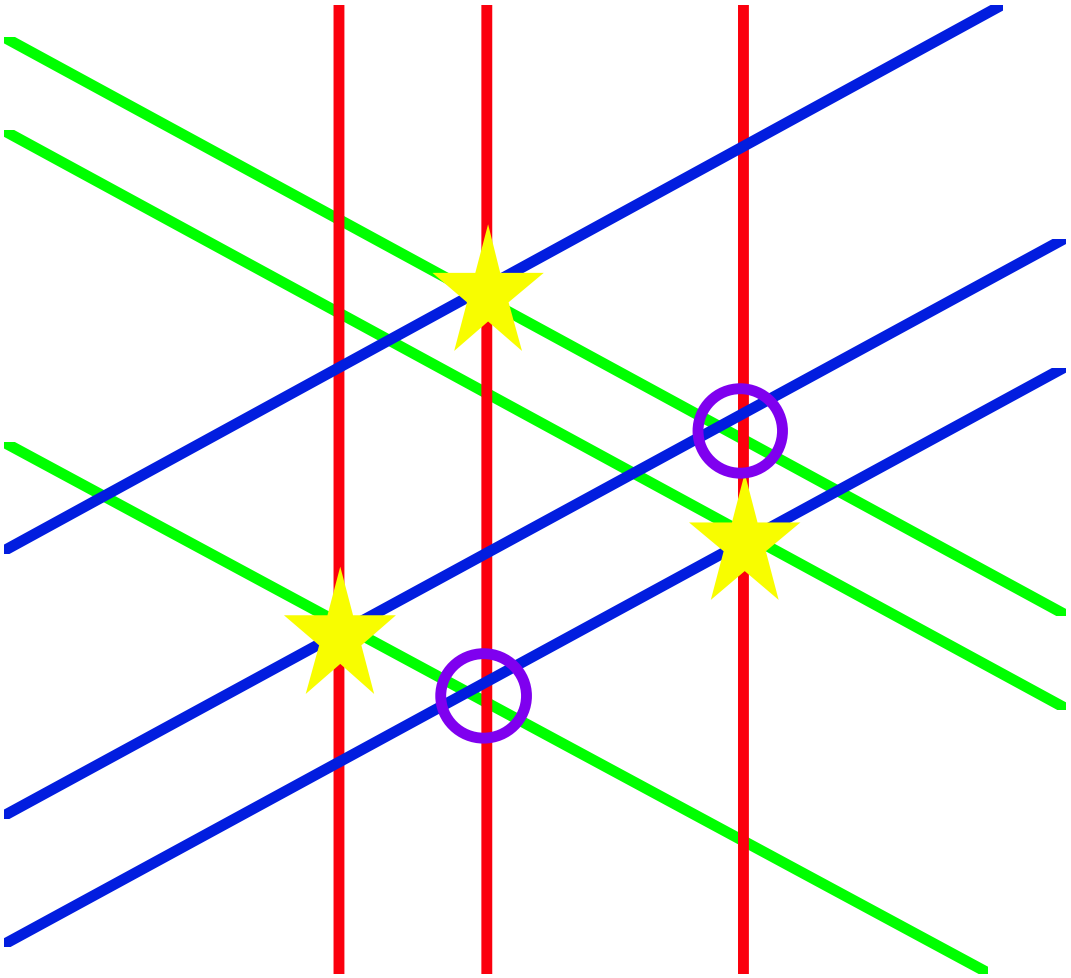
- Wire efficiency, determined in ep data:
  - Planar chambers ~ 98%.
  - Radial chambers ~ 93% (except for two wires nearest TR window).
- Radial segment efficiency,
  - Radial 0 ~ 86%.
  - Radial 1 ~ 86%.
  - Radial 2 ~ 66%.
- Planar cluster efficiency (in central planar module):
  - Cluster efficiency 89% (prob. cluster lost 11% per chamber).
  - Prob. two clusters lost 71%.
  - Prob. three clusters lost 30%.
  - Cluster loss effects “independent”.

Cluster loss due to δ-rays?

- Probability of δ-ray production per hadron per planar chamber ~ 12%.
- Example of GEANT δ-ray, T > 10 keV.

FT performance cont.

- Track multiplicity and planar segments.



- High multiplicity leads to hodoscope ambiguities.
- Resolved using sophisticated algorithm.
- If wrong solution chosen, three true segments lost.

FT performance cont.

- Planar segment finding efficiency dependent on multiplicity.
- Note, for each true primary π^+/π^-:
  - One $\pi^0 \rightarrow \gamma\gamma$.
  - In $0.5X_0$ of CJC end-wall, $\gamma\gamma \rightarrow \gamma e^+e^-$.
  - Add particles from secondary interactions, each primary hadron accompanied by 4 secondaries.
  - Secondaries low momentum, number increases as θ decreases.

FT performance cont.

- Net effect, strong track density dependence of efficiency.
- For low Q^2 DIS:

Track selection	Effic. (%)	FWHM q/p (GeV^{-1})	Prop. well measured (%)
1R or 1P(p or s)	97	0.076	50
1P(p)	77	0.070	66
1P(p) and V	70	0.068	75
1P(p) and V and (1P or 1R)	66	0.063	89
1P(p) and V and F and (1P or1R)	60*	0.057	92

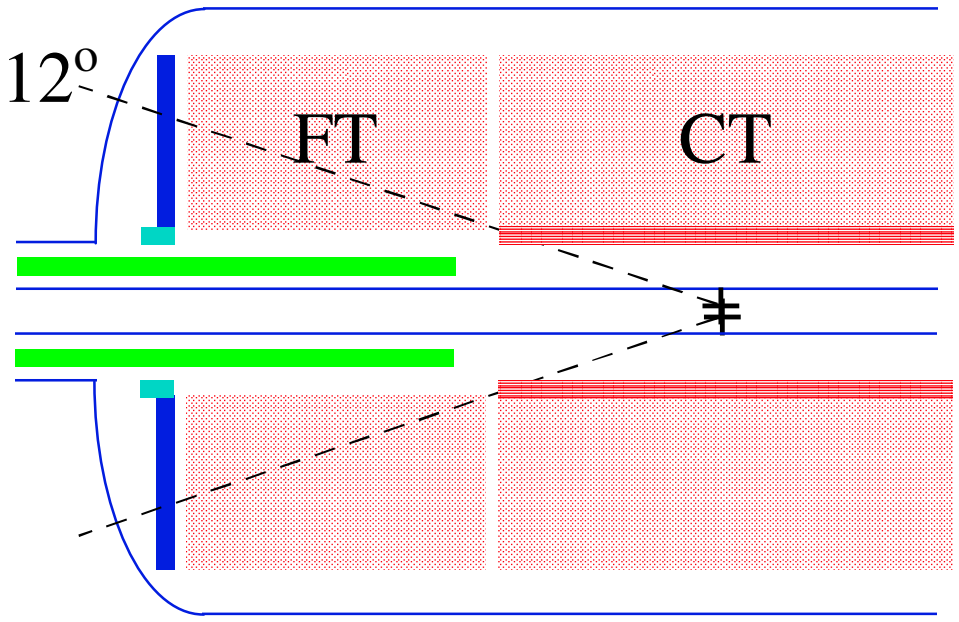
* For high Q^2 events decreases to 42%.

FT Upgrade

- Remove TR volumes.
- Remove MWPCs.
- Add one new planar chamber to each planar module.
- Add scintillator forward trigger.

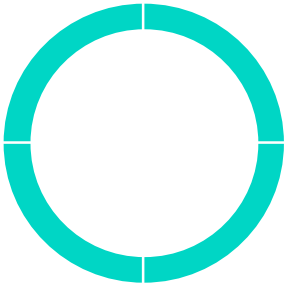
Removal of TR/MWPCs

- TR unusable in electromagnetic shower surrounding high energy electron.
- MWPCs form forward ray and part of z-vertex trigger.
- New CIP takes over z-vertex function.
- Add scintillators to maintain forward ray capability for $\theta < 12^{o}$.

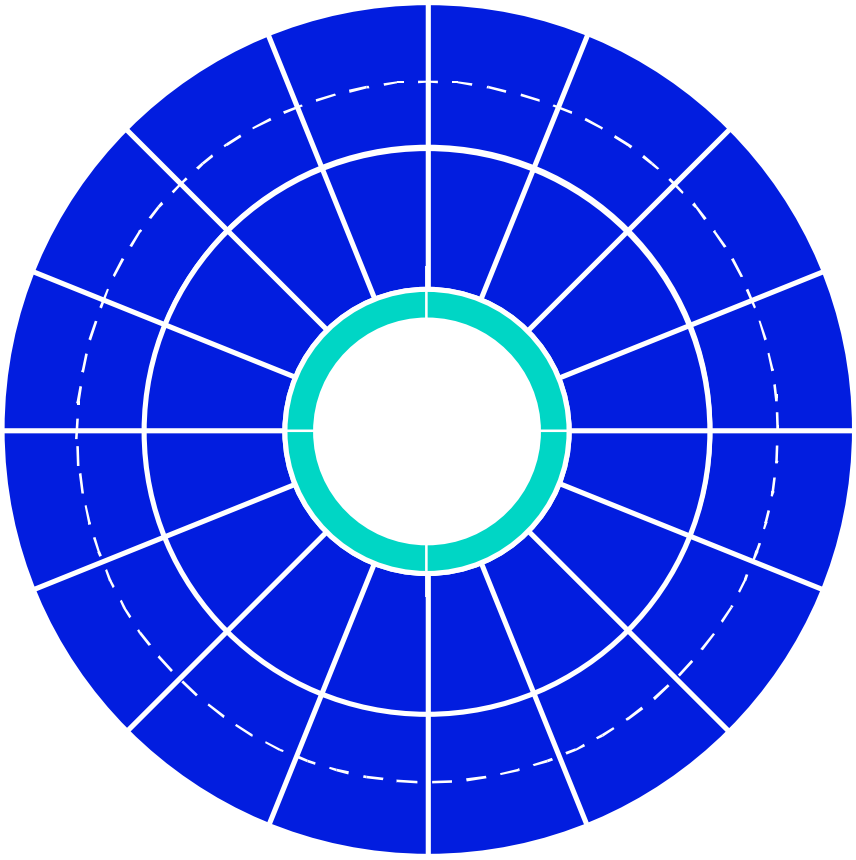


Forward Scintillator Trigger

- Fast scintillator for proton satellite measurement (sub-nanosec timing)



- Scintillator to form forward rays, matched to LAr big towers



Forward scintillator cont.

- Fast scintillator readout using PMs (SpaCal type).
- Forward ray readout using vacuum phototriodes plus amplifier (as for CMS).
- Need 40 channels, available using old ToF system.
- No local coincidences formed, OK only if background in forward region tolerable.
- Manfred Fleischer studying this area in 1998 using part of old ToF system.

New Planar Chambers

- Give redundancy in planar segment finding.
  - Reduce problems due to cluster loss.
  - Reduce effect of hodoscope ambiguities.
- Extra wires to aid resolution of left/right ambiguity.
- Re-orient old planars and add new planar so module now has chambers at $\phi = +60^{o}, -60^{o}, 90^{o}$ and 0^{o}.

Radial TR Window

- Two wires closest to TR window suffer from reduced gain/efficiency due to charge accumulating on window.
- Replace window with G10/copper electrodes.

Cutting Costs

- FADCs may become available following CT upgrade, then £ 194 580 wasted.
- Can take FADCs from 4 radial chamber wires closest to TR window (frees 36 FADCs).

Expected Performance

- Planar segment finding efficiency 70% $\rightarrow$ 94%.
- 63% of tracks cause signal in all four planars, for which hodoscope ambiguities negligible.
- Remove four cluster segments, performance as current FT for low multiplicity.

Track selection	Effic. (%)	FWHM q/p (GeV^{-1})	Prop. well measured (%)
1P(p) and V and F and (1P or1R)	60	0.057	92
As above new FTD	>90	0.050	97

Summary

- Main problems affecting efficiency of FT understood.
- Solution available without compromising H1 performance.
- Costs: £ 260 000 (DM 780 000).
- Manpower: 6.25 man-years of technical effort.
- Proposed to approach UK funding agency for support on 23rd March.
- We request H1's support!