

StepIV Upgrade Physics Performance

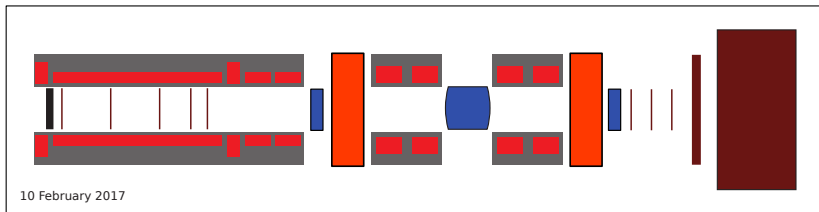
C Hunt

G Barber, A Dobbs, K Long, J Pasternak, C Rogers, M Uchida, et al.

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Introduction



The current baseline design - Not as simple as it first seems!



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2. Downstream Tracker Module
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4. RF Noise Tolerance
5. Downstream Reconstruction Performance



Points of Contention

1. The Downstream Tracker :
 - 3 Stations - Better transmission,
 - 4 Stations - Better noise rejection.
2. The RF Noise : e^- or γ , energies, brightness
3. Reconstruction : KL or not KL?
4. Secondary Absorbers : LiH or Polyethylene
5. Tracker placement : The contracted geometries
6. AFC safety window flanges



The Downstream Tracker Module



The Downstream Tracker

Dimensions and aspect ratio of tracker determines the physical and dynamical acceptances respectively.

3 Stations improves the aspect ratio at the expense of the noise rejection.

A modular design has been produced and has already started construction.

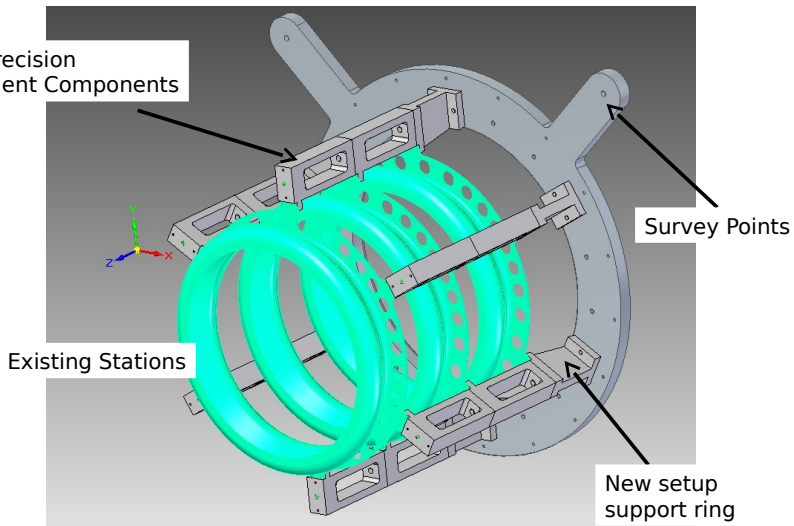


Outline

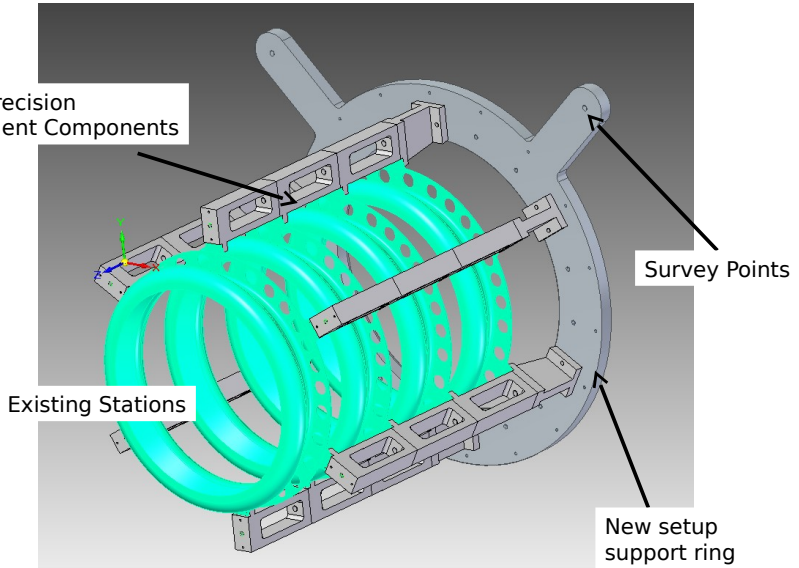
This proposal uses the existing Patch Panel, it is a robust base from which to hang the 3 or 4 stations as it was machined from a solid piece of aluminium. This scheme uses many of the existing parts but will require a set of precision machined components which are being machined by Nikhef.



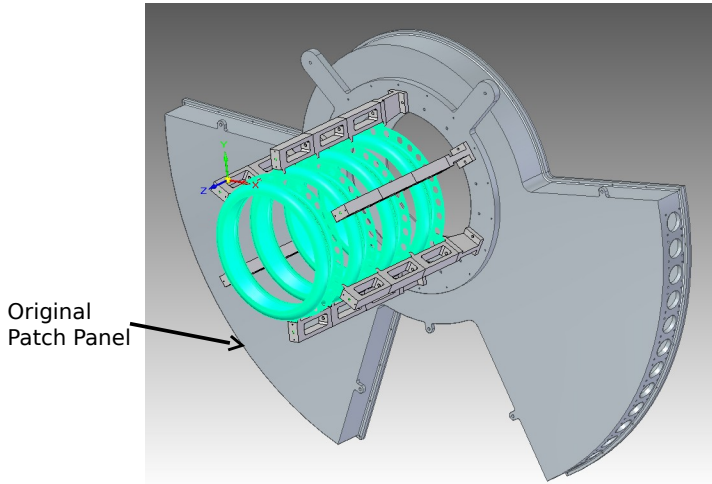
3 Tracker Layout



4 Tracker Layout



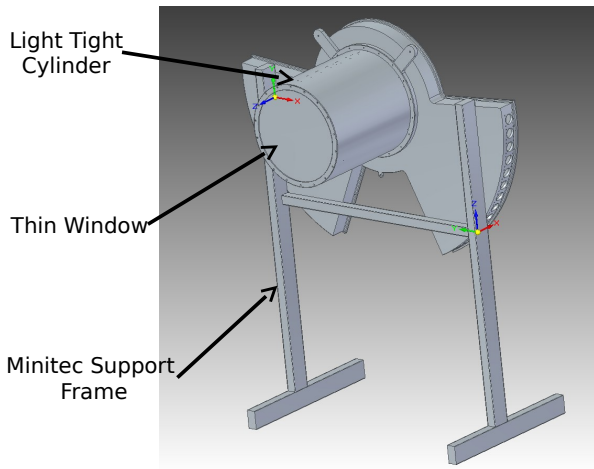
Assembled Tracker Fitted to Original Patch Panel



Original
Patch Panel



Complete (self contained) Tracker with Light Tight Cover and Support Frame Fitted



Things to think about

- As stated the layout uses tried and tested equipment
- There appears to be enough room to bring in the tracker already assembled so no problems of 'blackout'.
- I have used the minimum 130mm pitch for the stations, this is the smallest pitch achievable given the bend radius of the fibres
- The structure incorporates survey points that will have already been measured relative to the tracker plane positions therefore the positions of the 3 or 4 stations are known.
- The low mass exit window in the patch panel cover will probably need to be made larger to give a bigger aperture.

The design work is done and the machining of the precision parts is underway at Nikhef. I believe that more simulation is required to understand the geometry better and this is happening now. If we use 3 stations we only require one cryo-cooler + readout, if we have 4 stations we need two, but will have more built in channel redundancy.....FOOD FOR THOUGHT.



Tracker Position

The position of tracker also affects the transmission: Closer to the beam focus will reduce the scraping effect.

3 current options:

1. Baseline positions
2. Contracted Lattice, 56mm shorter (shown below):
 - Bellows removed between Cavity and AFCD,
 - LiH moved towards cavity, etc.
3. Contracted Lattice-II, $\sim 100\text{mm}$ shorter (not included here):
 - Cavity module may require some additional engineering,
 - Cavity direction needs to be specified,
 - RF couplers would move - Possibly an issue regarding the PRY.



StepIV Upgrade Lattice Performance



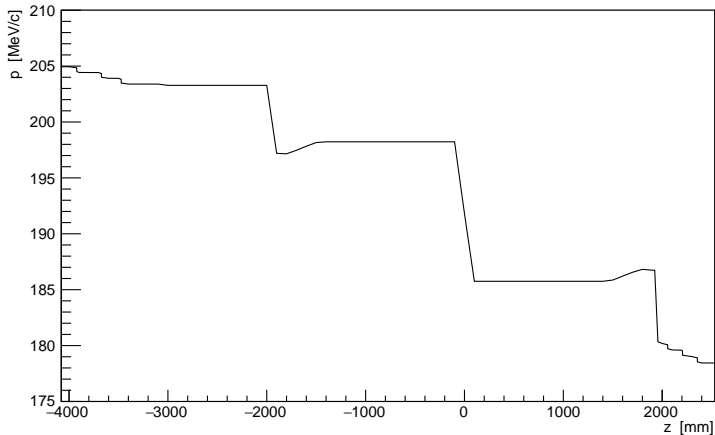
Degrees of Freedom

Degree of Freedom	Amount	Impact
1. Separation of the AFC Modules	Small	Small
2. Tracker Design (Number of Stations)	3 vs 4	Large
3. Tracker Position (WRT to AFCD)	V. Small	Large
4. M1, M2, AFCU, AFCD Currents	Large	Moderate



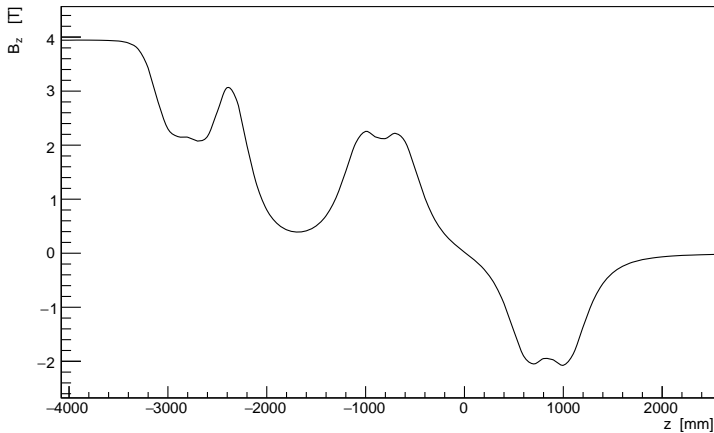
Baseline Design

Momentum Profile



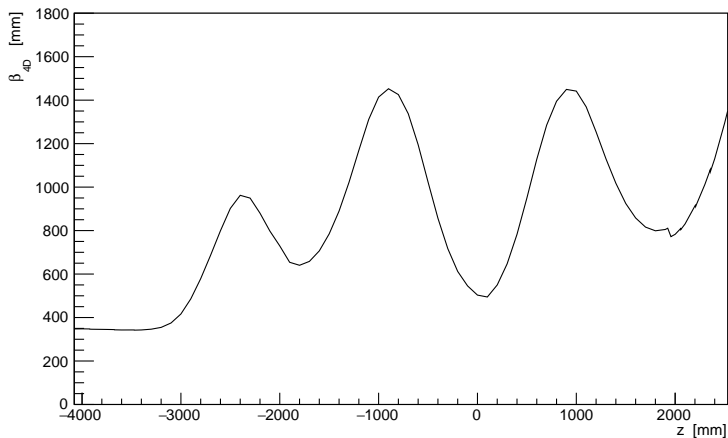
Baseline Design

Magnetic Field



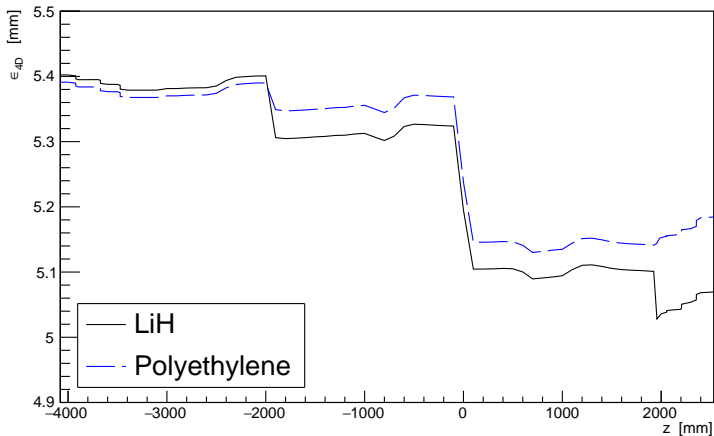
Baseline Design

4D Beta Function

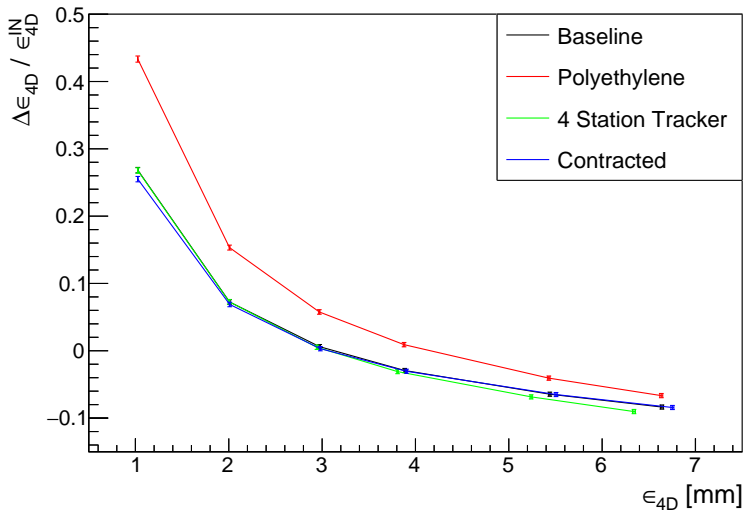


Baseline Design

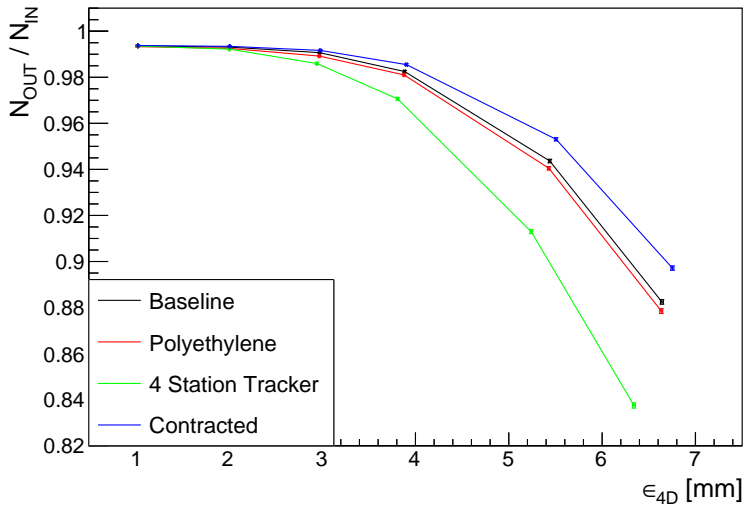
4D Emittance



Emittance Reduction Performance



Emittance Reduction Performance



RF Noise Tolerance



Effects of RF Noise

Ionisation interactions cause damage to the fibres and eventually cause darkening. Sufficient darkening prevents scintillation from being measured.

Melissa has written an excellent note on the sensitivity of the trackers to irradiation. This is currently being circulated and should be uploaded soon.

RF Cavities *can* be excellent sources of high energy electrons and photons.
So we had to be prepared!



Modelling

A Geant4 based model that simulates e^- or γ incident on a standard 5-station tracker was prepared. We can estimate:

- Interaction probability
- Energy deposited
- Stopping power of LiH, Polyethylene and windows
- Rates of degradation of the tracker



Modelling

We have learnt:

- e^- stopped almost entirely by LiH secondary absorbers.
- γ brightness only slightly reduced.
- Need reconstruction to be able to handle additional noise digits

Studies are still ongoing. . .



Modelling

In order to estimate the performance of the reconstruction, a photon only model was designed that estimates the number of photon induced digits are present in each plane of the tracker per event.

It requires a single scaling factor which is the *Effective Cavity Brightness, I* .

I is the total number of interacting photons emitted by the cavity within the tracker readout window.

$I = 100$ corresponds to 30 noise digits per event.



Downstream Reconstruction Performance



Ideal Reconstruction

1. Produce tracks in all detectors

DONE

2. Use field and material stepping algorithms to match tracks between EMR, TOF2 and Tracker

DONE

3. Use global track fitting to optimize the track description at the reference plane of the tracker

TBC



Current Reconstruction

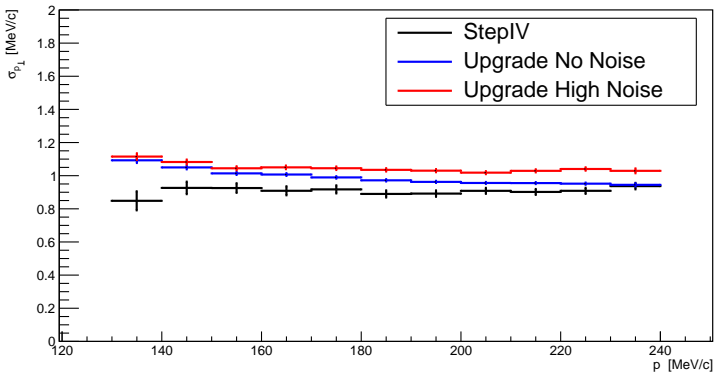
1. Ignore the TOFs,
2. Require precisely 1 track in EMR and 1 track in the Downstream Tracker,
3. Propagate the EMR track through to the reference plane of the downstream Tracker,
4. Use the propagated EMR momentum to scale the p_x , p_y and p_z components.

No special steps were taken to reduce the effect of the RF noise.



Momentum Resolution

Transverse Momentum Resolution

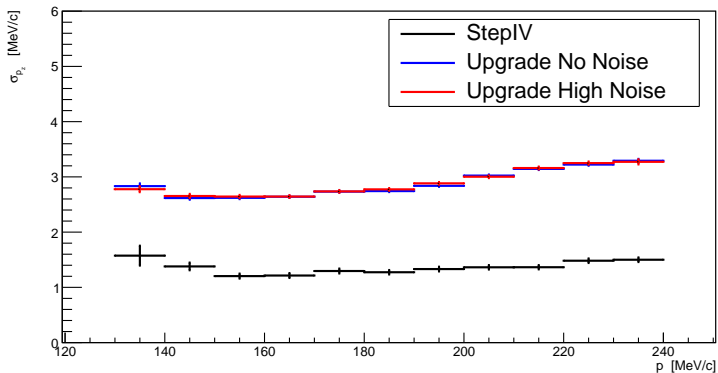


Approx 5% max impurity.



Momentum Resolution

Longitudinal Momentum Resolution



Approx 5% max impurity.



Track Finding Efficiency and Purity

Currently at a *very* early stage of analysis!

- Events with multiple tracks are ignored
- Stock Pattern Recognition was used
We should require 4 spacepoints in the 4-station tracker!
- There is a distinct combinatorial effect in the number of impurities
- Intelligent track selection/global track matching is not implemented
- Statistical discriminators not included



Track Finding Purity

Noise	3 Stations		4 Stations	
	Impurity [%]	N	Impurity [%]	N
0	0.15	65041	0.18	67826
10	0.15	63694	0.17	67726
40	0.16	60154	0.19	67314
70	0.18	56560	0.19	66702
100	0.16	53413	0.19	66094
130	0.18	50739	0.26	64617
160	0.23	47068	0.36	63145
190	0.27	44545	0.50	61104
220	0.37	41645	0.56	59052
250	0.55	39617	0.90	54031



Conclusions



Where are we now?

1. 3 Station Downstream Tracker is preferred.
2. RF noise model exists with estimates of efficiency, purity and resolution.
3. Studying reconstruction performance so No KL.
Space has been left in the geometry for it to be easily inserted for PID studies.
4. LiH is preferred but expensive. . .
5. Tracker Placement Baseline is decided, but the Contracted Lattice is preferred.



Conclusions

- We must be careful to ensure the transmission is sufficient as to not bias the emittance measurement.
- Scrapping can be clearly seen in the phase space distributions (not shown). KDE or amplitude change measurements will prove necessary to ensure any selection bias is accounted for.
- To optimize the performance we are making life increasingly difficult for the engineers and technical designers. (Sorry!)
- Someone needs take a grinder to the AFC. Still need to follow that up.



Conclusions

- A genuinely emittance reduction of 6.4% at 94% transmission is predicted with minimal systematic biases.
- The baseline design, without any additional hardware difficulties can be used to make the measurement. Albeit not an optimal measurement.
- The new downstream tracker module has actually begun construction and is perfect for the job.
- Optimizations to the magnetic settings are still possible and ongoing. Expect improved transmission.
- Can still investigate He-Window mounted upstream secondary absorber.



Conclusions

Thats all folks!

Requests, comments or questions?

