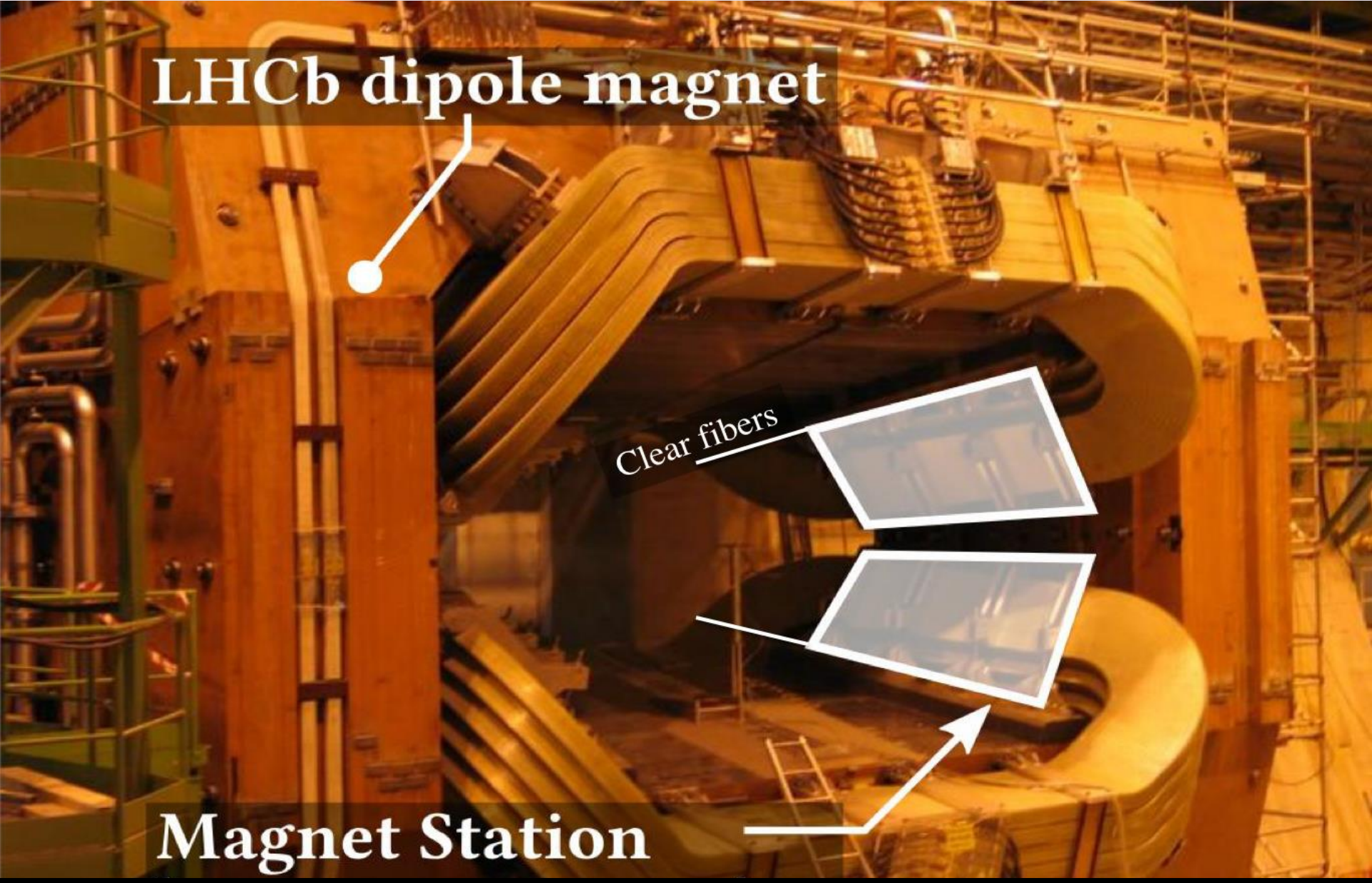
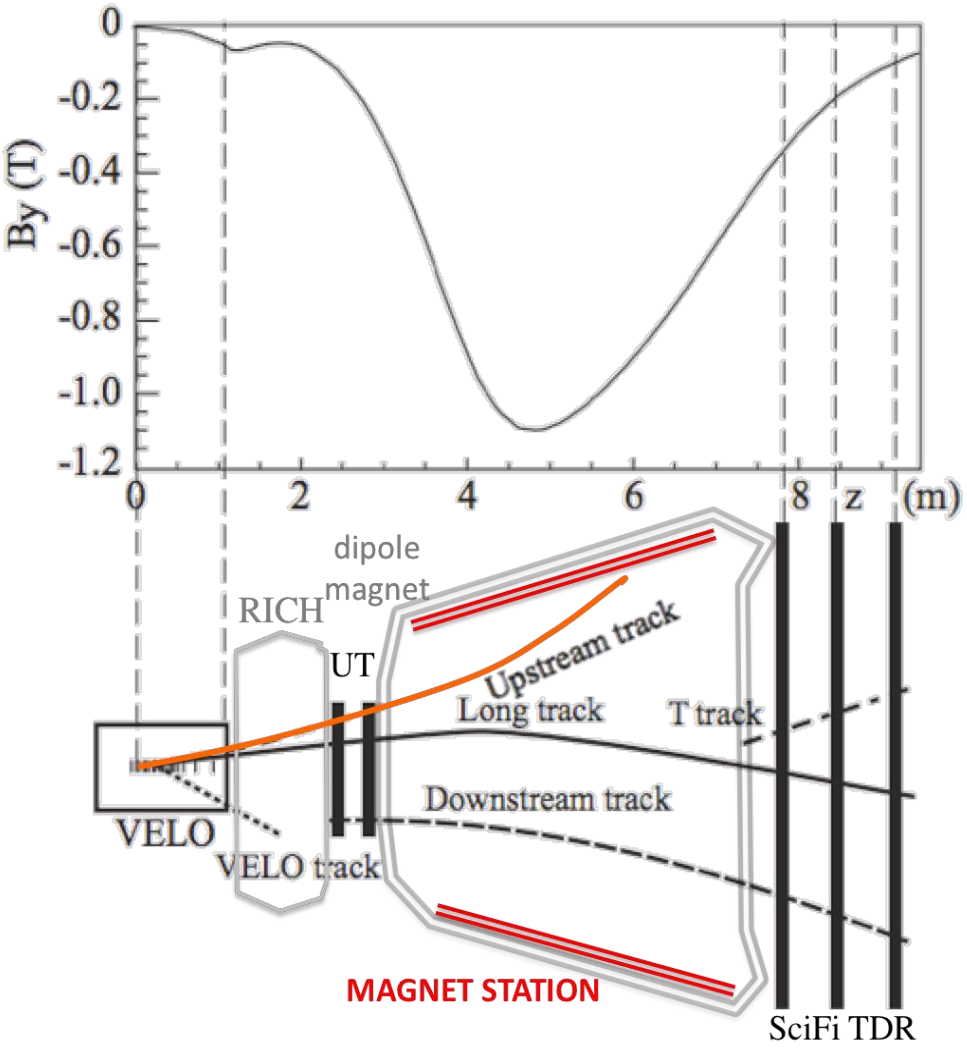


M.Bettler[a], P.Billoir[b], M.Chrzaszcz[a], C.da Silva[d], M.Durham[d], R.Greim[g], W.Karpinski[g], T.Kirin[g], M.Martinelli[e], M.M.Pikies[f]
[a]CERN, [b]CNRS, [c]UZH, [d]LANL, [e]EPFL, [f]PAN, [g]Aachen

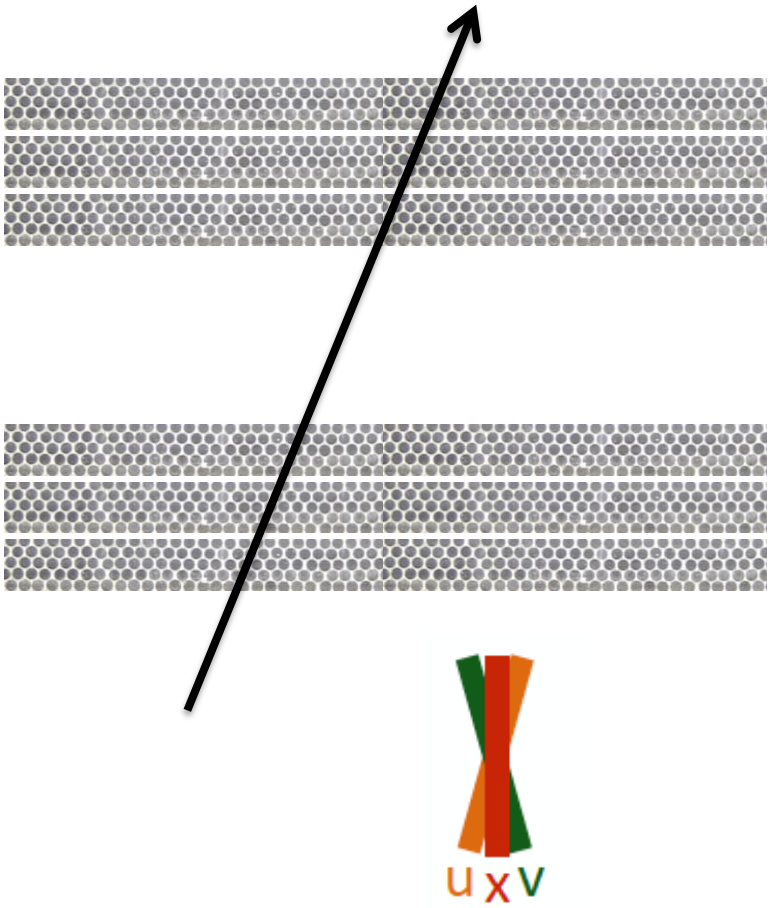
MOTIVATION



- δp/p~15%-20% for upstream tracks
- A 1mm z resolution tracker inside the magnet provides momentum resolution similar to long tracks
- See Marcin's presentation for physics possibilities

Proposed Implementation (1)

SCINTILLATING FIBERS



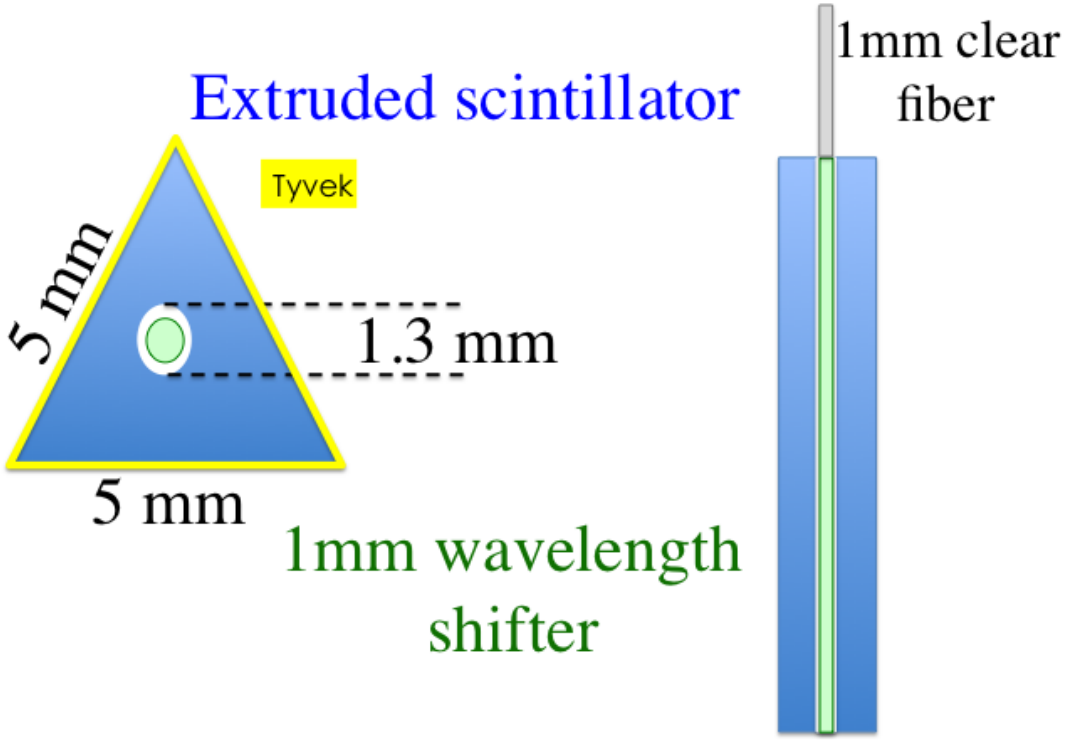
Use SciFi fiber mates (250 μm fibers)

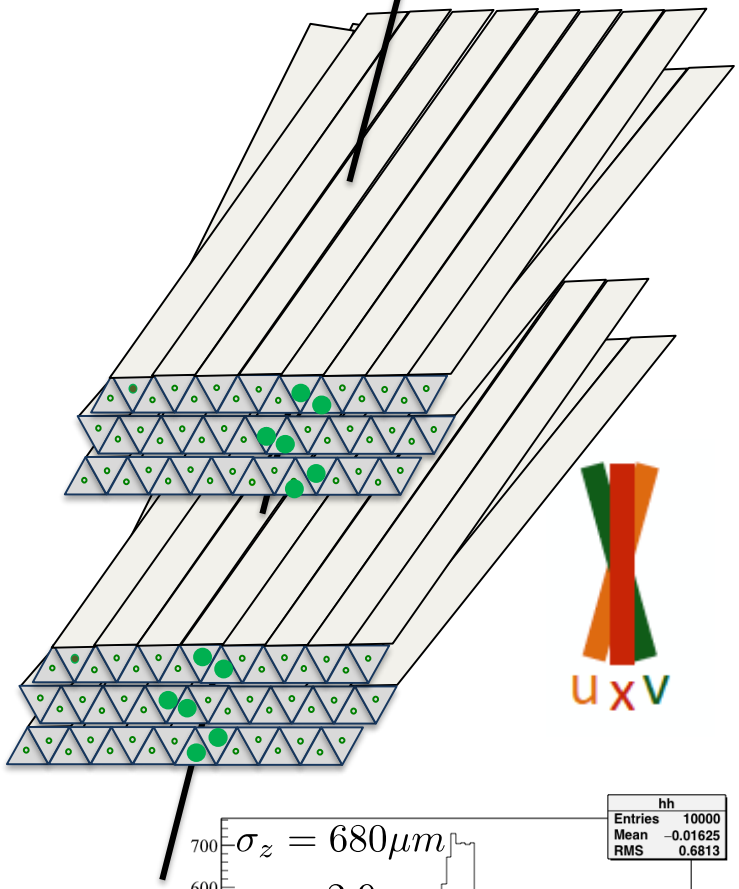
Fiber-light guide coupling options:

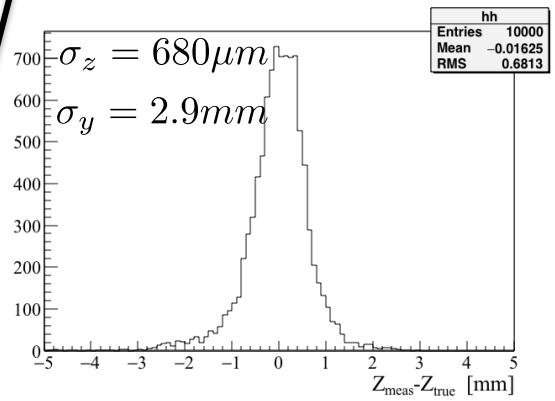
- 250 μm clear fibers
- bundle fibers to 1mm clear fibers

Coupling/bundling under study

Proposed Implementation (2)

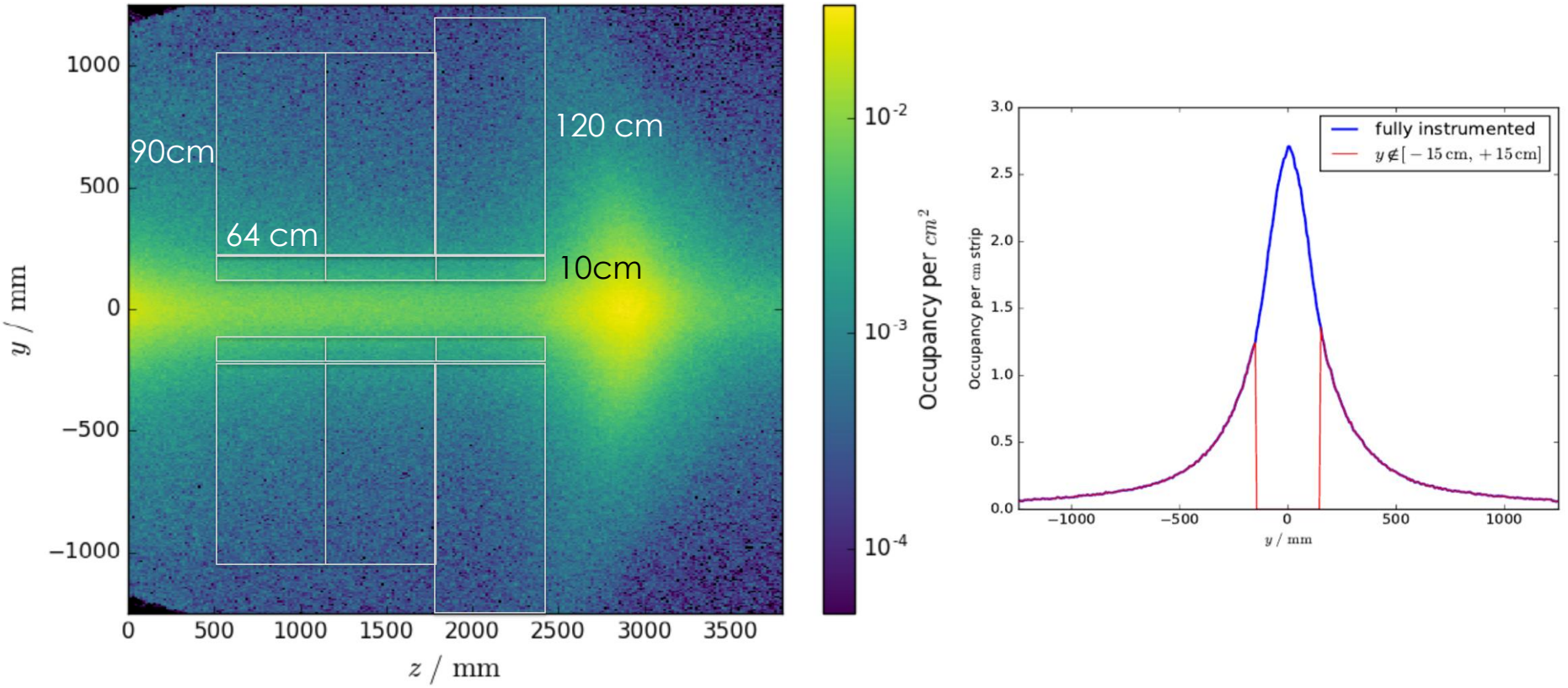






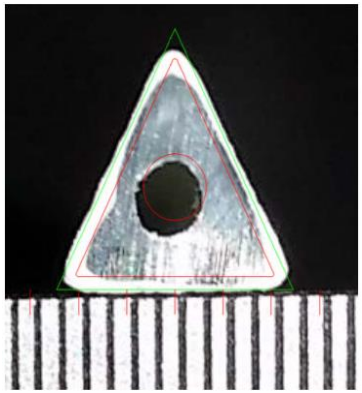
- Leverage R&D from D0 preshower
- Easier WS-clear fiber coupling
- Fewer number of channels

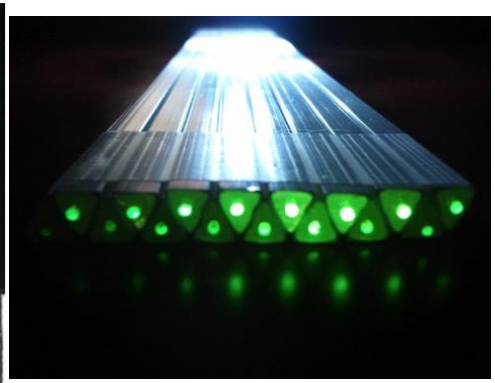
Suggested Segmentation



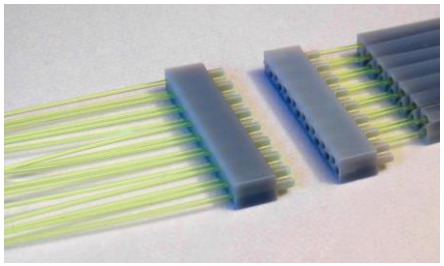
- 24 panels, could be a combination of fiber-based and bars-based panels
- < 5 % occupancy determines the location and horizontal size of the panels
- Run IV occupancies are 10x larger
- Need a simulation to have some idea about occupancies in the fiber and triangular bars
- Each panel: 128 triangular bars x 6 planes = 1536 bars/panel

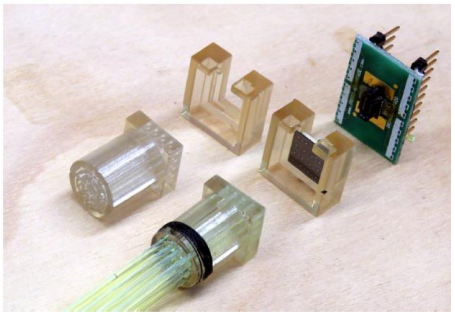
R&D for triangular bars





- 500 m of triangular bars produced by Fermilab extruded scintillator factory
- smallest extruded bar ever produced in that facility, had to develop new tooling for 5mm triangular bars

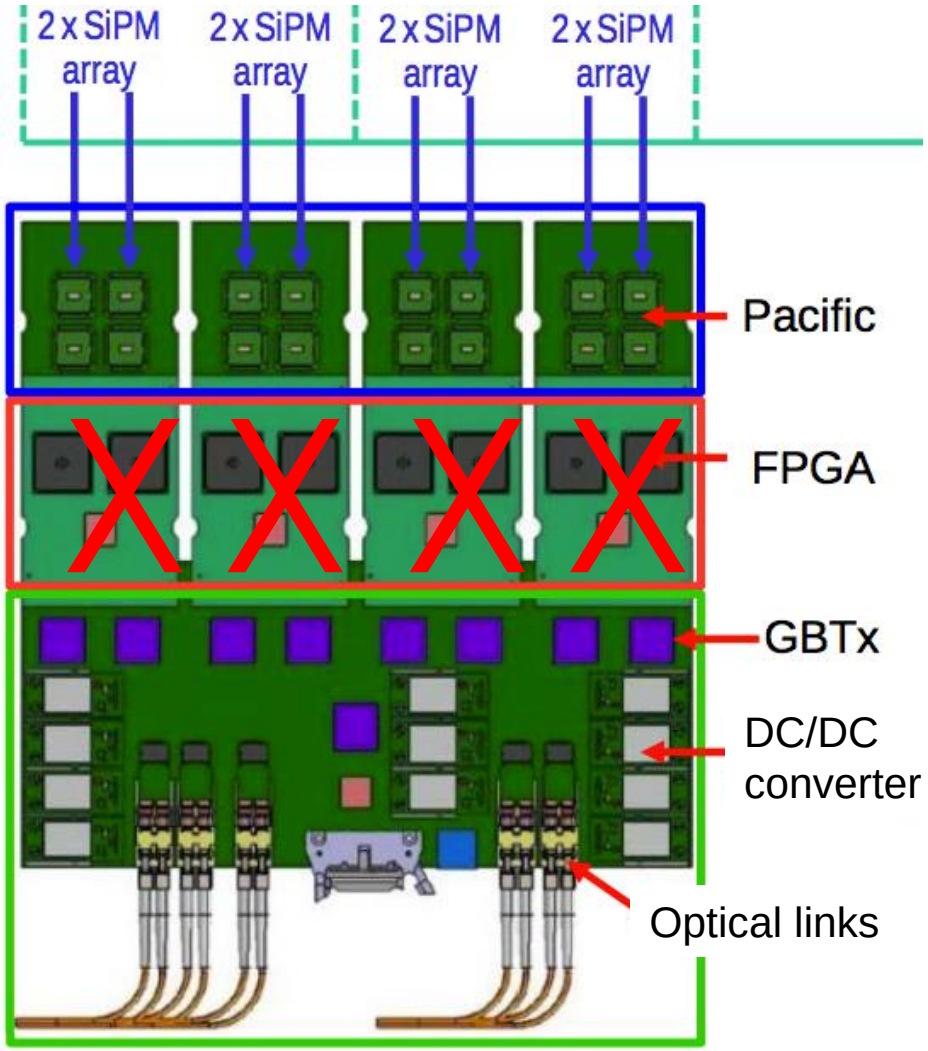




- Wavelength shifter -> clear fiber -> SiPM couplers developed at LANL

- First version of SiPM array board developed at LANL
- Using 2 commercial 4x4 SiPM arrays (2x2 mm^2 each channel, but will change to 1.3x1.3 mm^2)
- Second version with 4 SiPM arrays (64 channels) under development

Adopting SciFi electronics



NO clusterization in the cavern

Online tracking can be done in TELL40

40 MHz x 5% occupancy = 2MHz / channel

1 GBTx per 2 PACIFIC chips

9 bits per signal (ID+2ADC bits)

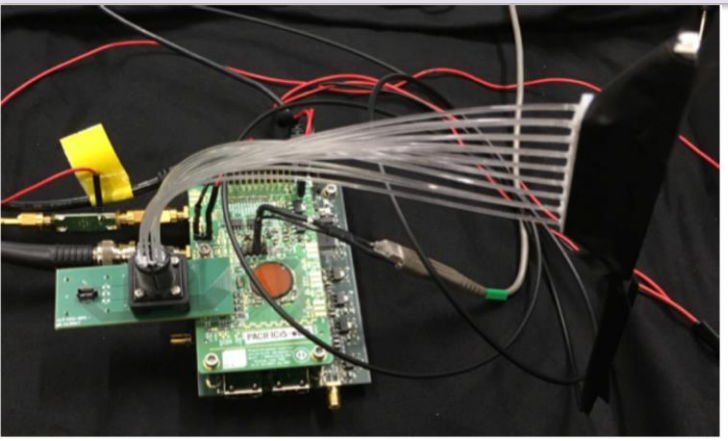
18 Mbits/s/channel

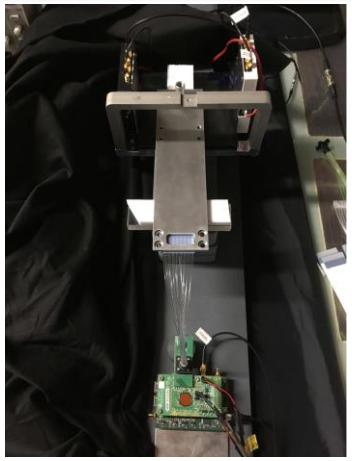
2.3 Gbits/s / GBTx chip

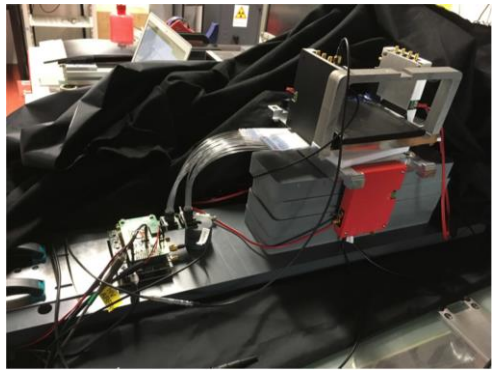
83 Gbytes/s for the entire detector

SiPMs and electronics placed in a rack on the sides of the magnets: 10^{-4} less radiation than in SciFi

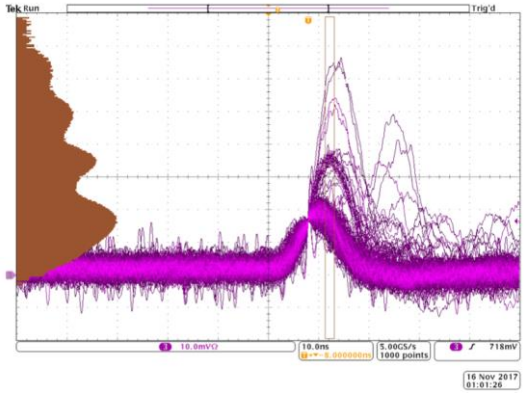
Tests w/ PACIFIC in Heidelberg



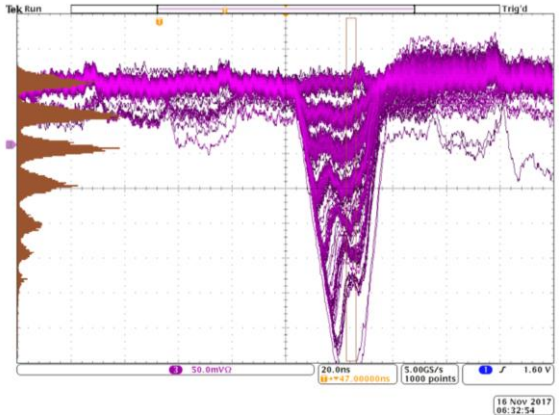




Dark count



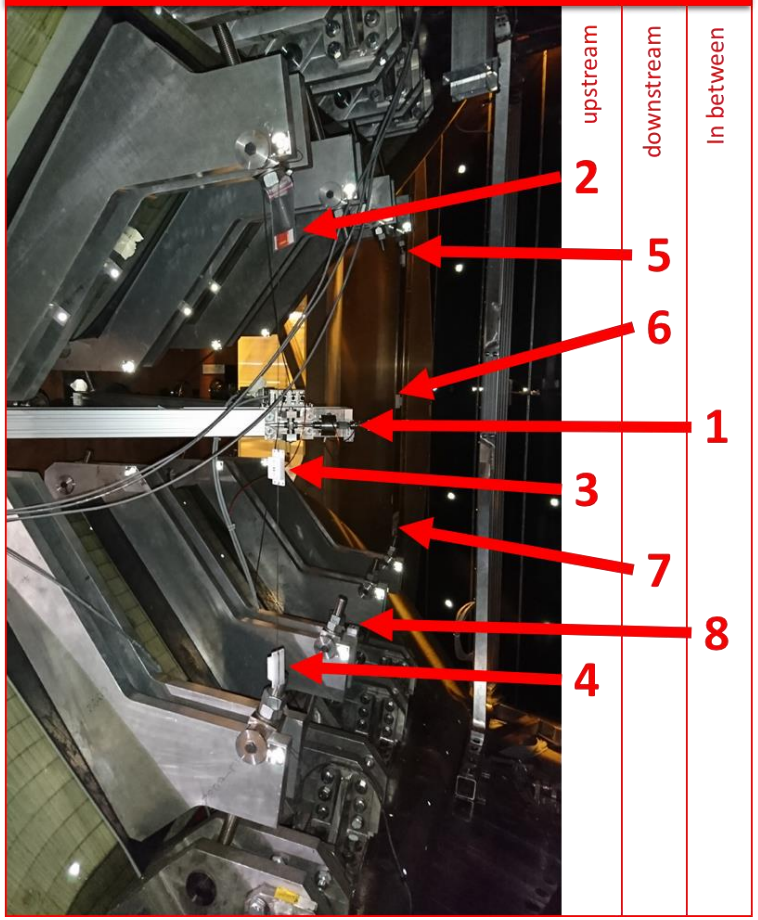
Synchronous light



- All channels worked
- Dark count signal shaping and gain same as SciFi
- Signal from Sr^{90} close to saturation, but using very short clear fibers
- Observed cosmics, but needs a long run and longer bars (in preparation at LANL)

Magnet Dosimetry

Position Labels



Dosimeters read out in TS2 2017 (Sept.)

The accumulated dose corresponds to an **integrated luminosity of 0.9512 fb^{-1}**

ID	Label	Alanine Dose [Gy]	Simulation Dose [Gy]	Ratio Sim/Al	x [cm]	y [cm]	z [cm]
16211	1	39	79	2.03	190	-3	525
16212	2	18.4	48	2.61	172	42	458
16213	3	129.1	140	1.08	172	-1	458
16214	4	16.6	47	2.83	172	-42	458
16215	5	8.9	18	2.34	245	67	639
16216	6	167.7	96	0.57	245	-1	639
16217	7	11.1	18	1.62	245	-67	639
16218	8	9	17	1.89	190	-58	525

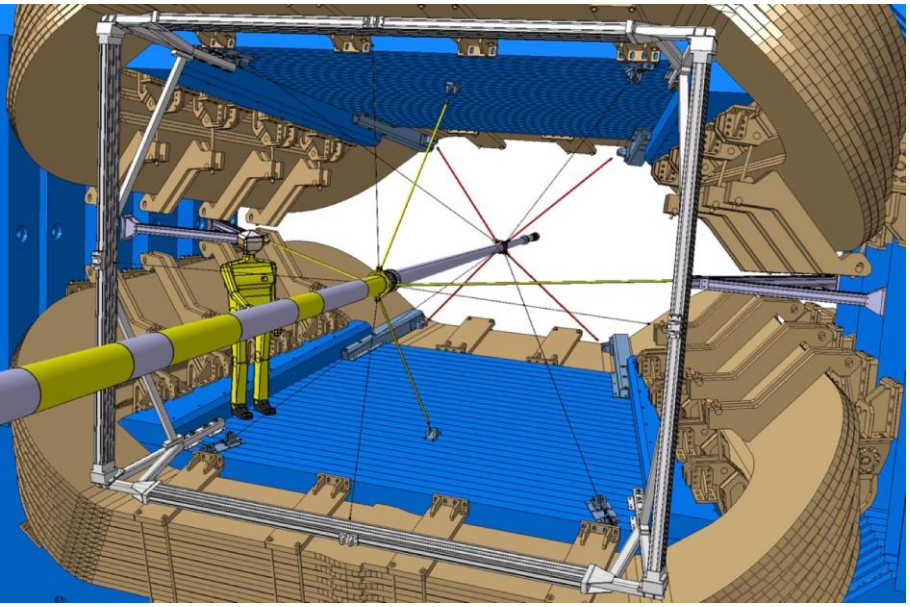
Difference of simulation/measurement within factor of 3 at the evaluated positions

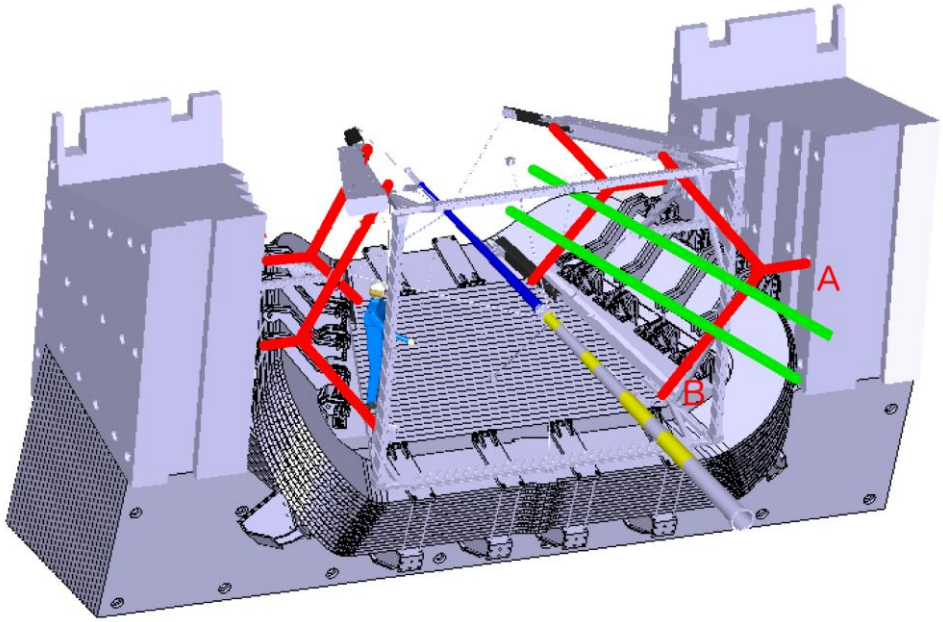
Extrapolation for an **integrated luminosity of 50 fb-1**

ID	Label	0.95 fb^{-1} Dose [Gy]	50 fb^{-1} Dose [Gy]	x [cm]	y [cm]	z [cm]
16211	1	39	2050.042	190	-3	525
16212	2	18.4	967.1993	172	42	458
16213	3	129.1	6786.165	172	-1	458
16214	4	16.6	872.582	172	-42	458
16215	5	8.9	404.7519	245	67	639
16216	6	167.7	8815.181	245	-1	639
16217	7	11.1	583.4735	245	-67	639
16218	8	9	473.0866	190	-58	525

- Extruded scintillators + WS have 5% yield reduction after 10 kGy (gamma)
- clear fibers may run through top and bottom of the magnet, ~ half of radiation from center

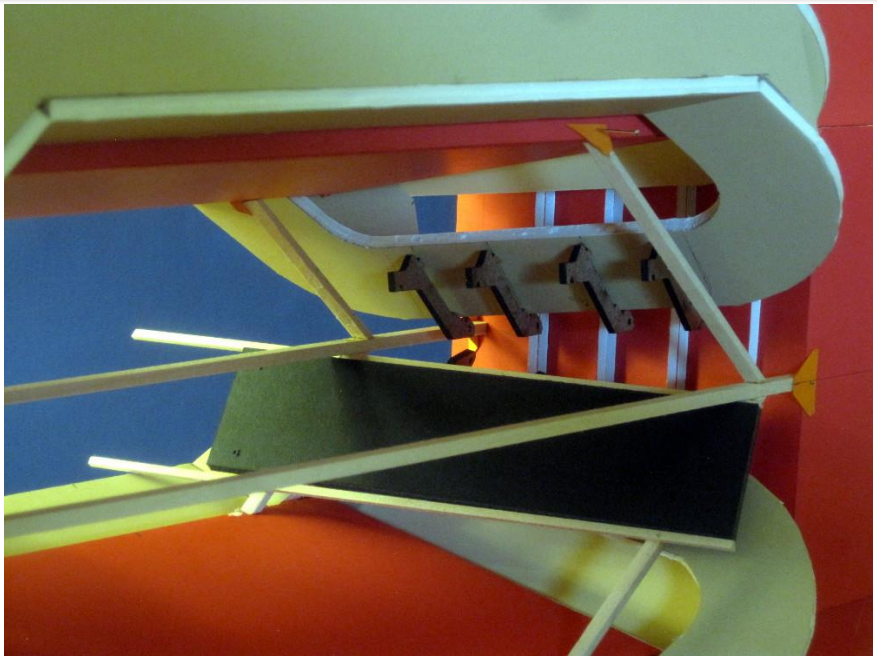
Mechanical Structure

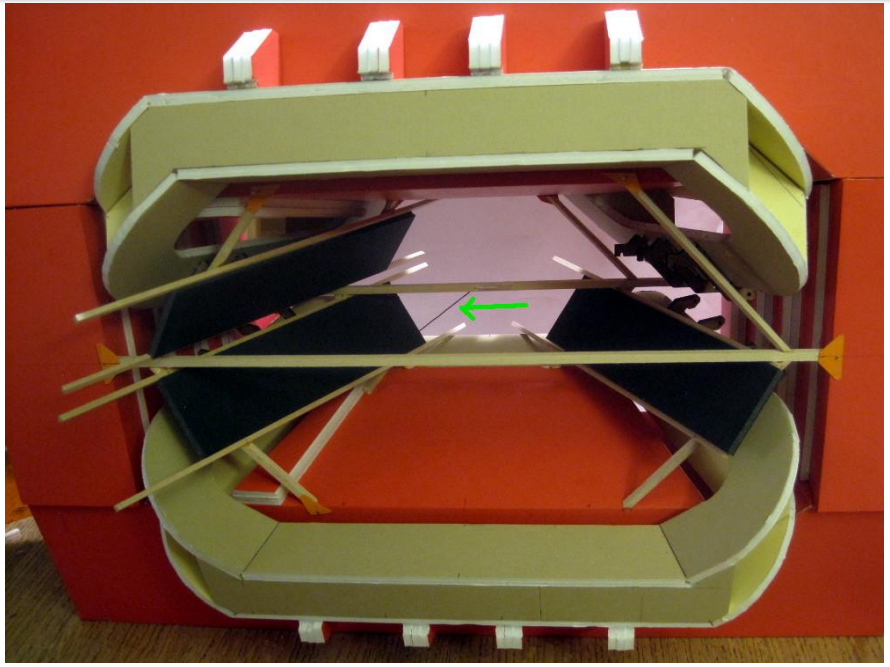




- Planning for installation of rails during LS II, when beam pipe and spiderweb will not be present
- Discussion with LHCb and LANL engineering teams for implementation using LANL manpower under LHCb engineering team supervision
- Still depends on approval
  - Approval of funding from DOE/US
  - LHCb upgrade team official approval of safety, design, technical details, schedule
- **Must have minimal interference with schedule LSII activities**

Installation





- Installation planning using a realistic 1:21 replica of the magnet in card board (vertical bars are only for the model)
- panels installed on rails, rails can fold during installation
- So far just just one conflict: one cable from spiderweb (green arrow on right)
- Connectors may allow ~1mm freedom for magnet moves when changing polarities

COST for bars

Mechanical Structure: rails and support	~50 KCHF
Fibers / bars+WS	~120 KCHF
Clear fibers	~180 KCHF
SiPM	~300 KCHF
Electronics(PACIFIC, GBTx, TELL40, etc…) 10CHF/channel	~400 KCHF
Infrastructure, cooling	200 KCHF
TOTAL	**~ 1.3 MCHF**

SCHEDULE and Effort

- LANL is submitting a proposal to DOE in two weeks
  - Magnet Station R&D
  - Mechanical structure installation during LSII
  - 2/24 panels and corresponding electronics installed in 2022

- Mechanical structure and two panels will allow
  - Background studies
  - Occupancies
  - Aging
  - Tracking
  - Perhaps, first physics results

- Design open for new ideas, as long it fits the rails 😀

BACKUP SLIDES

Table 1: Specifications for the Magnet Station.

N bars per panel	128 × 2 triangle orientations × 6 planes = 1536
position resolution	σ_z=0.68 mm, σ_y=2.9 mm
<light yield arriving the readout>	9-11 photoelectrons
N panels	(6 short+6 long)×2 magnet sides = 24
clear fiber length	<5 m> × 36.9 k channels = 185 km
N PACIFIC readout chips	576
data streaming	2 MHz × 9 bits × 36.9 K channels = 83 Gbytes/s
N GBTx	288
power consumption	0.6 W × 576 chips + 1.5 W× 288 GBTx chips ~ 780 W

May need ~300 optical fibers for data transmission