Magnet Stations for LHCb

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Magnet Side Stations - U2PG Workshop, March 31, 2020

The (Dream) Team

Los Alamos NATIONAL LABORATORY EST. 1943

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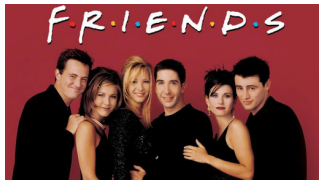
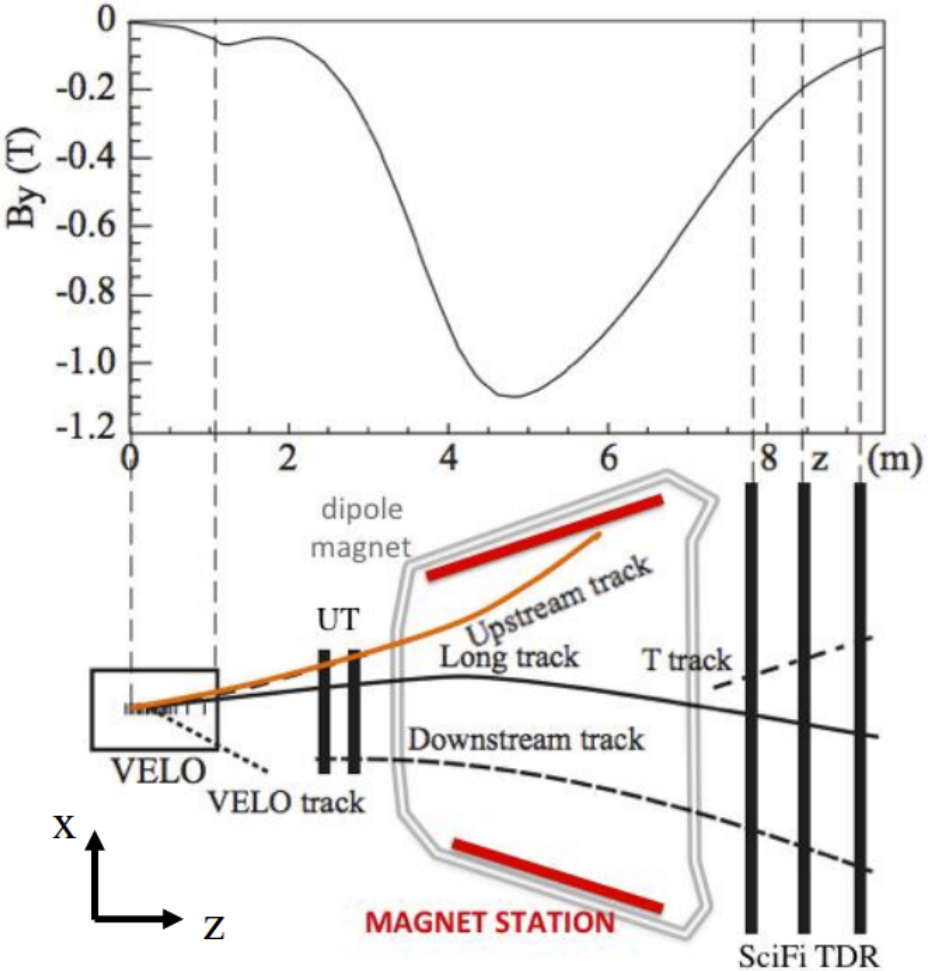
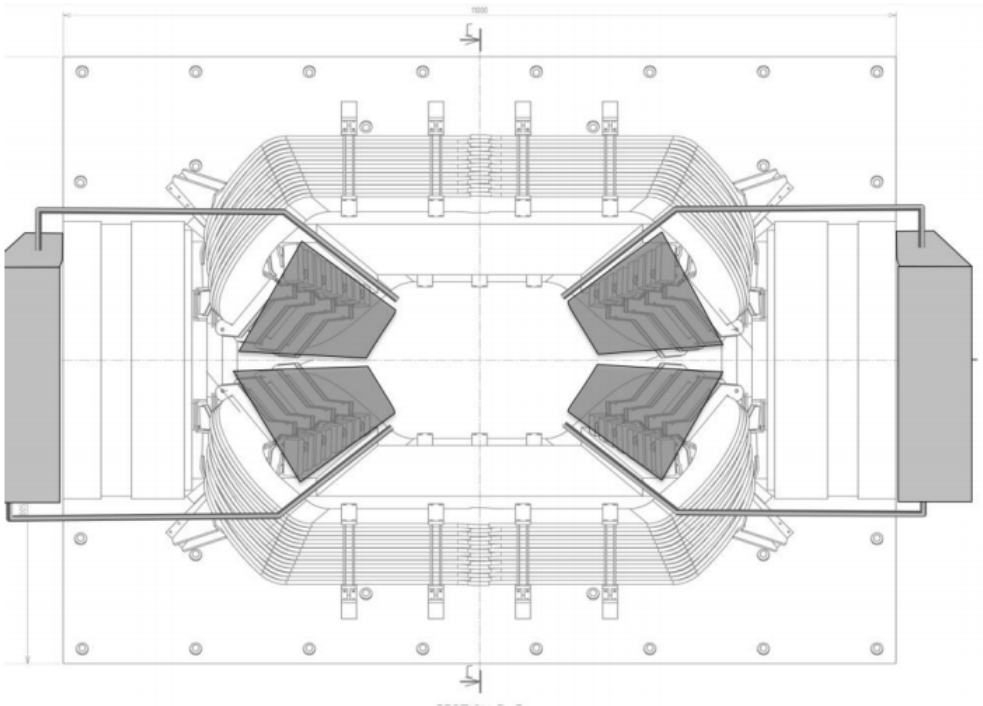


Marc-Oliver Bettler (Cambridge)
Pierre Billor (LPNHE)
Maurizio Martinelli (Milano)

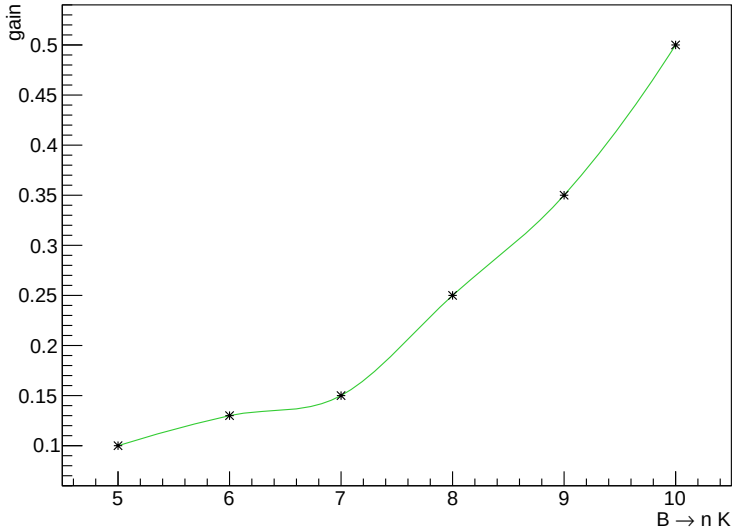
Magnet Tracking Station (MTS)

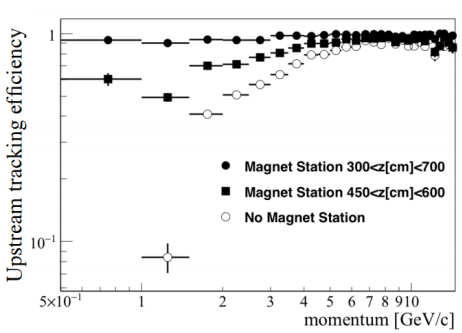


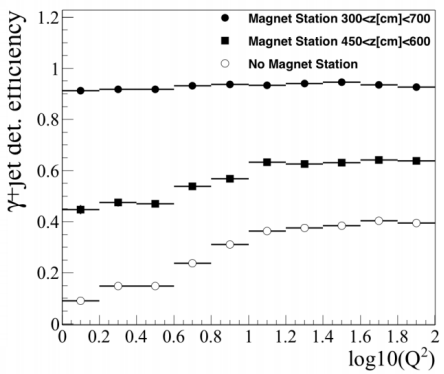


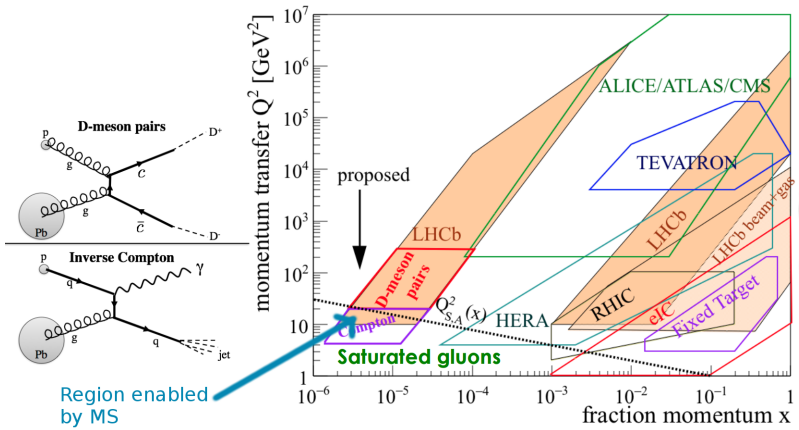
Physics cases

- Gains:
  - $\Rightarrow D^* \to D(\pi K)\pi_{\text{slow}}$: gain 21 %.
  - $\Rightarrow B \to \tau\tau$: gain: 24 %.
  - $\Rightarrow R(\Lambda_c^*) = \frac{\mathcal{B}(\Lambda_b \to \Lambda_c^* \tau\nu)}{\mathcal{B}(\Lambda_b \to \Lambda_c^* \mu\nu)}$,
  $\Lambda_c^* \to p\pi_{\text{slow}}\pi_{\text{slow}}$: gain 60 %.
  - $\Rightarrow R(D^*) = \frac{\mathcal{B}(B \to D^* \tau\nu)}{\mathcal{B}(B \to D^* \tau\nu)}$: gain 26 %.
  - $\Rightarrow B \to nK$: gain $10 - 50$ %.
  - $\Rightarrow \Sigma_b \to \Lambda_b \pi$: gain 29 %.
  - $\Rightarrow$ Gluon PDF: Enabled measurement.

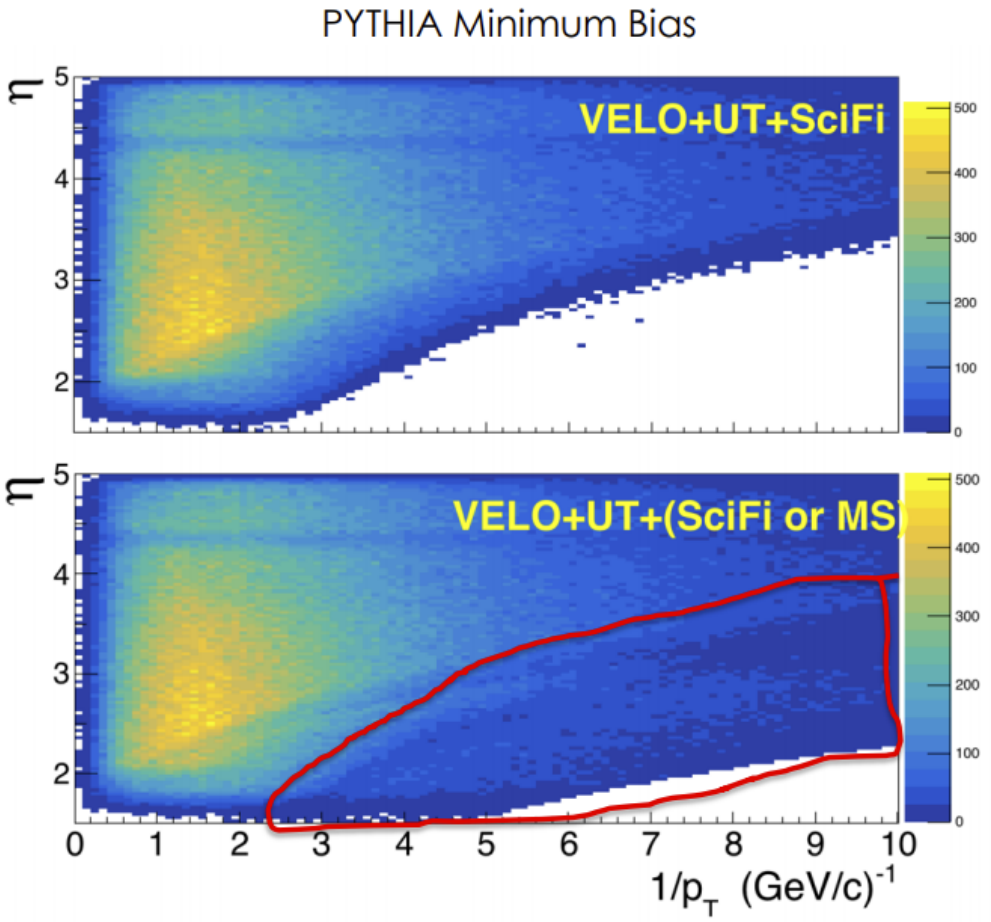








Physics cases

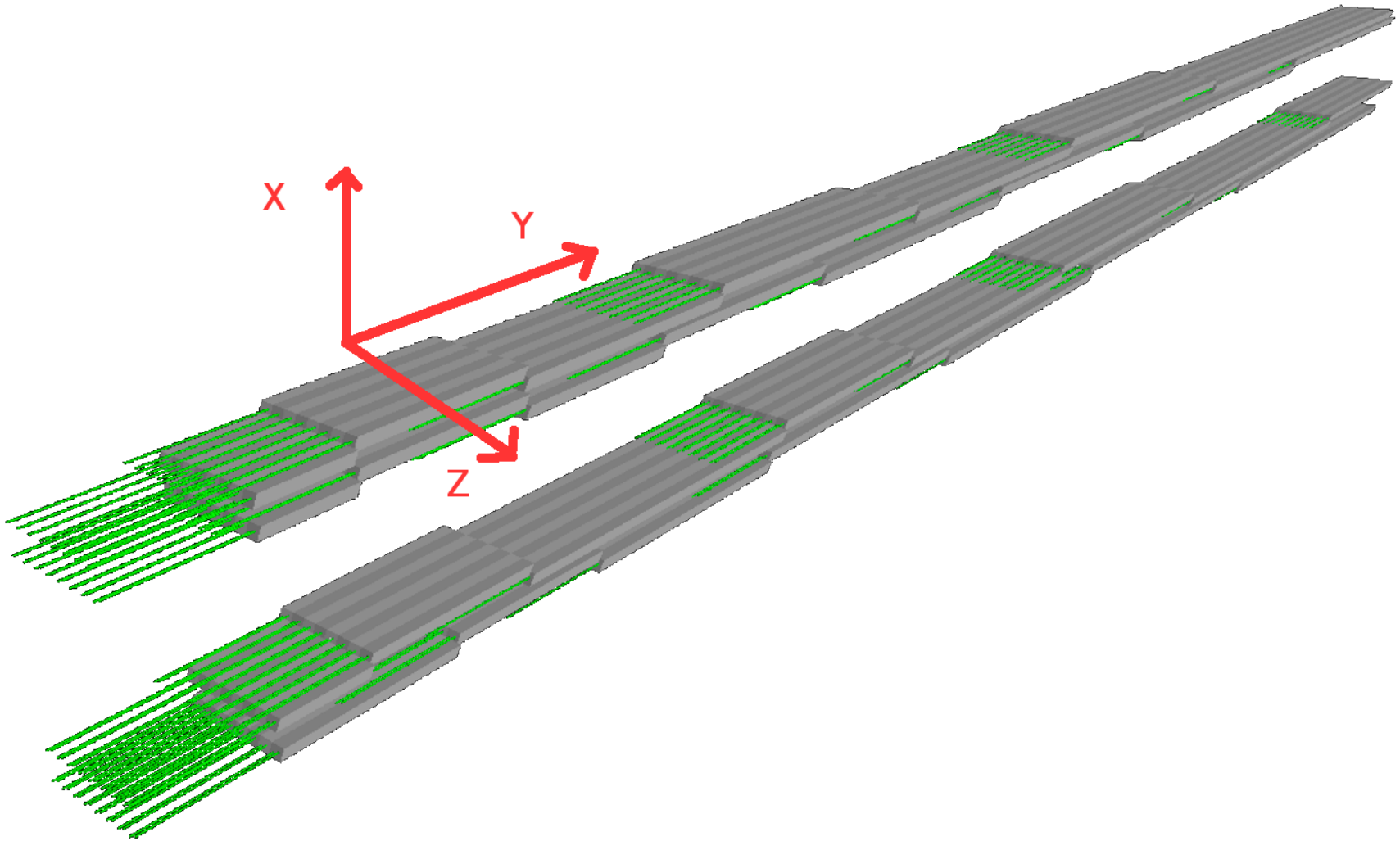


p>500MeV/c

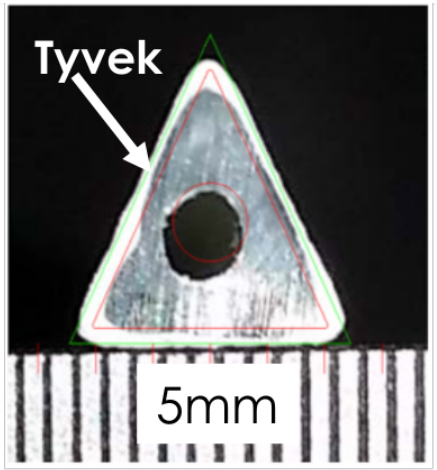
⇒ In terms of global event shape studies we gain access for particles not available as long tracks.

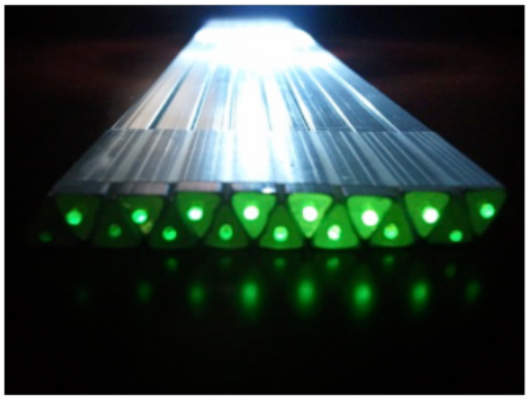
⇒ For more NEW physics case see A. Rybicki slides [LINK].

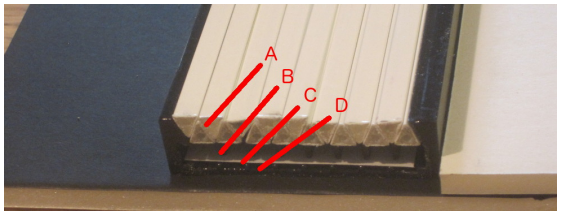
Prototyping

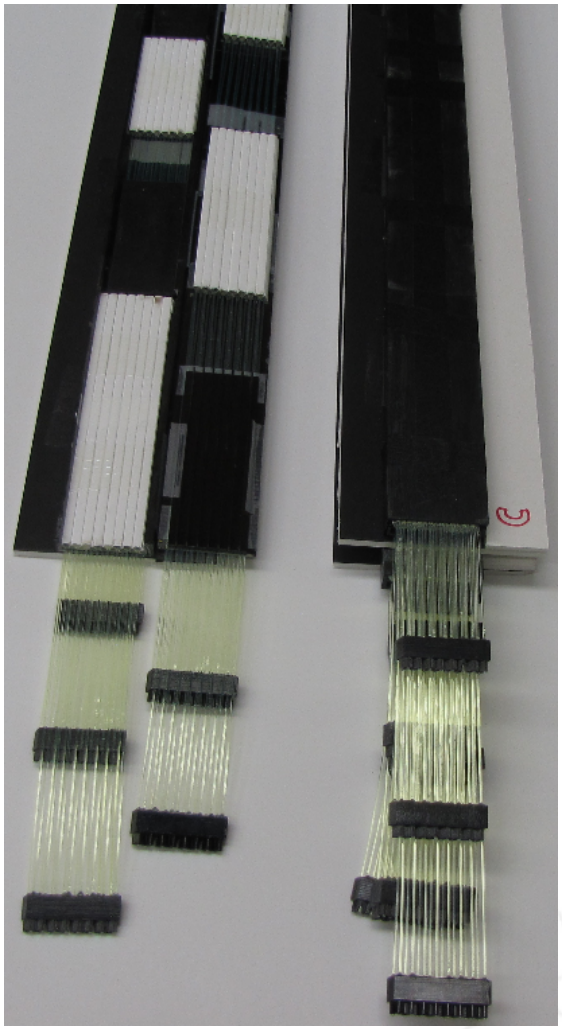


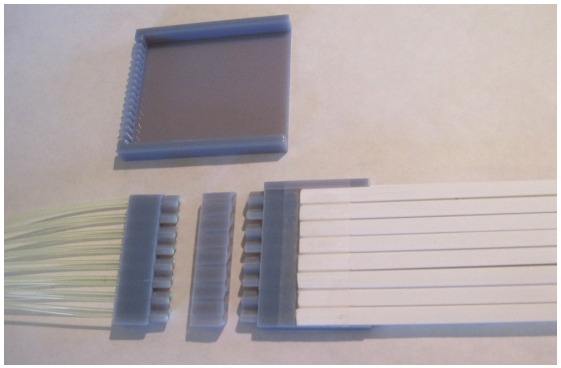
Prototyping

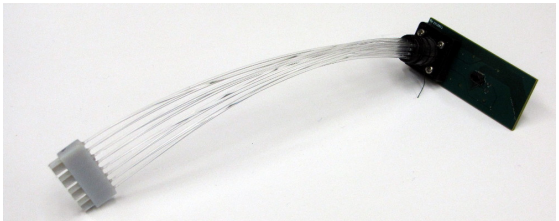








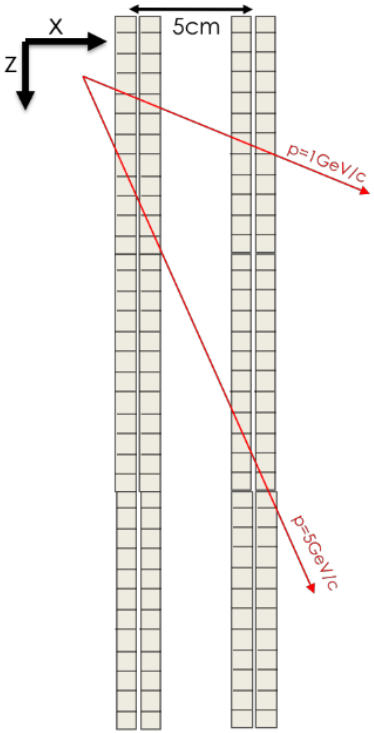


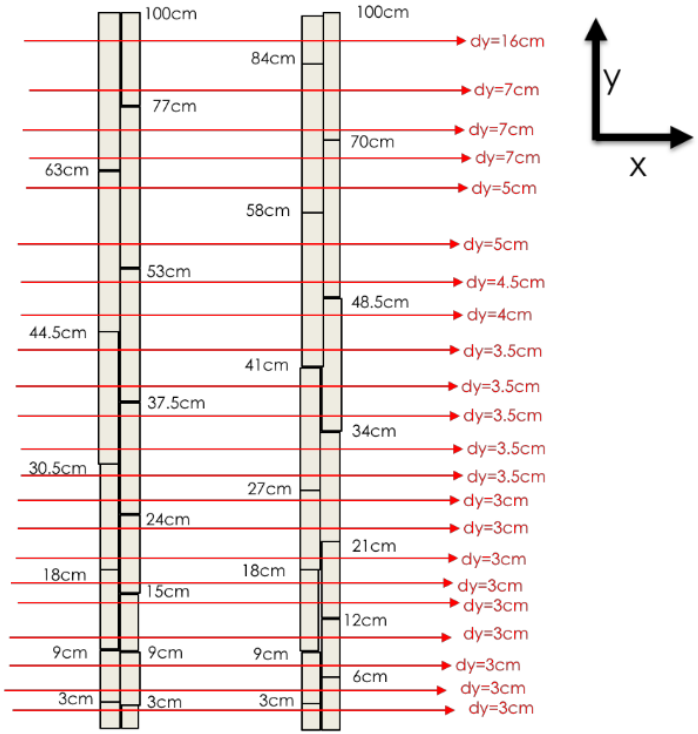


⇒ Attenuation length:

- WS = 3m
- Clear Fiber = 10m

Channel Segmentation per Panel

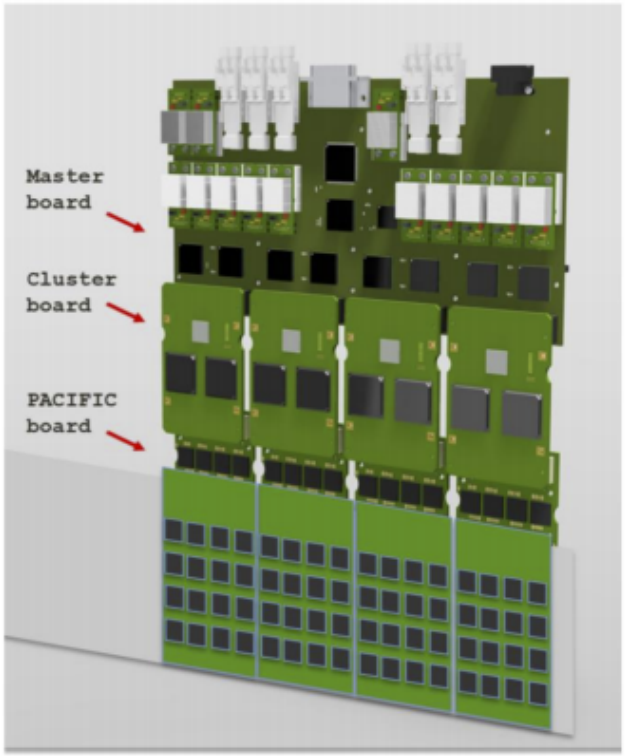


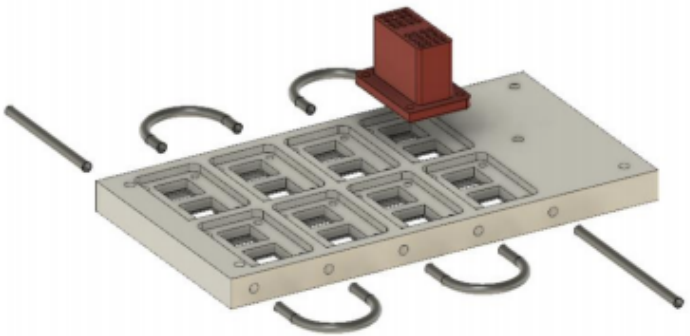


Number of panels	4
Number of planes	2
Y segments	15
Z segments	600
Total number of channels	72000

⇒ Particles do not bend in the y direction, segmentation to reduce the occupancy.

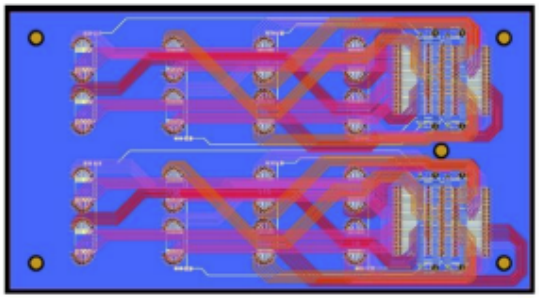
SciFi electronics

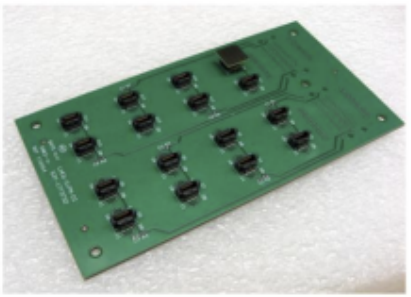


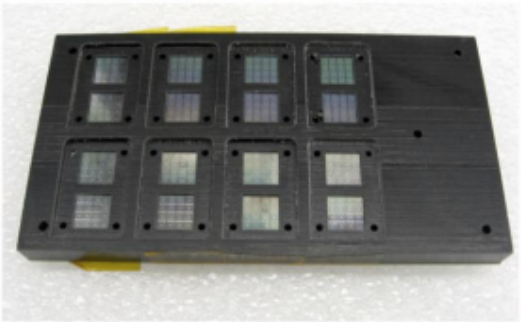


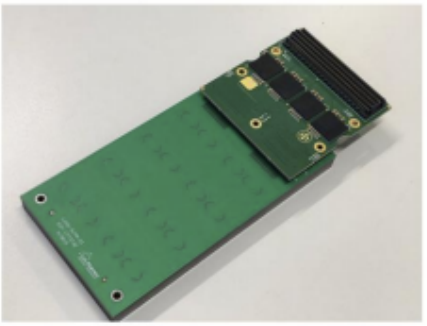
⇛ Adapting 16 SiPM arrays (256 channels) to a SciFi/PACIFIC board.

⇛ Designed cooling concept for SiPMs array board.









Tracking

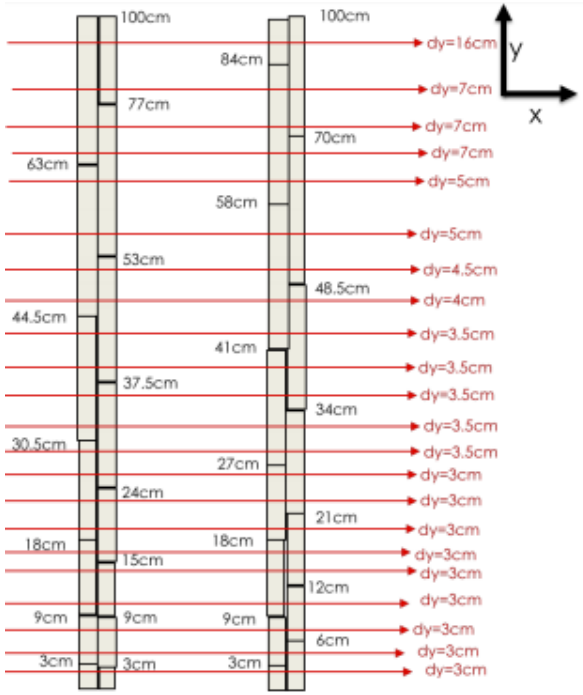
⇛ 22 Y segments per z column (particles from vertex don't bend in y direction)Adapting 16 SiPM arrays (256 channels) to a SciFi/PACIFIC board.

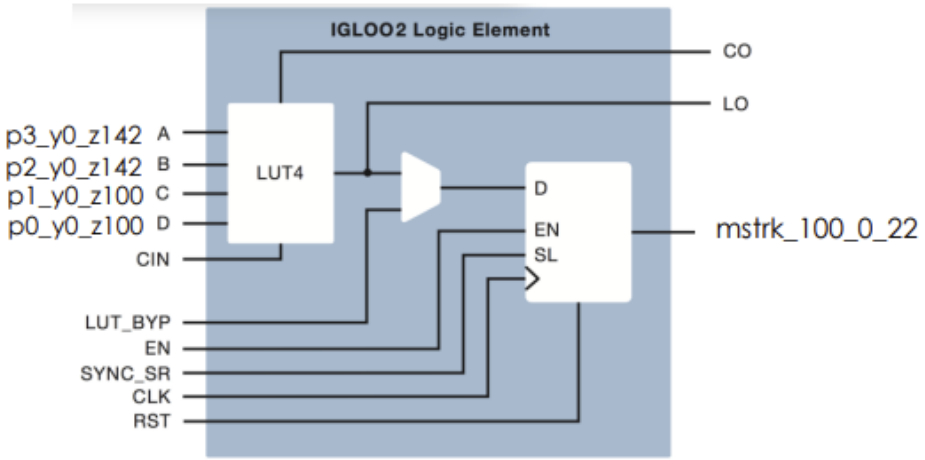
⇛ 40 z0-z1-z2-z3 combinations for 1GeV/c < p < 5 GeV/c

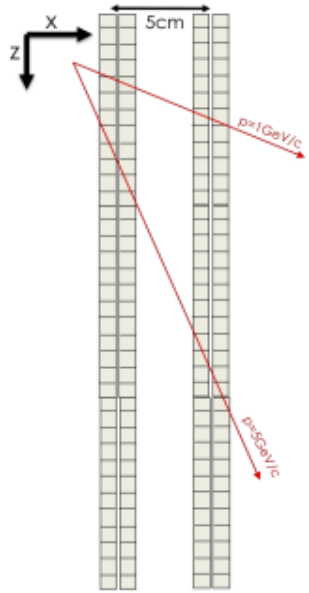
⇛ 600 z columns per panel

⇛ 240k combinations per panel (18 bits ID in the data package)

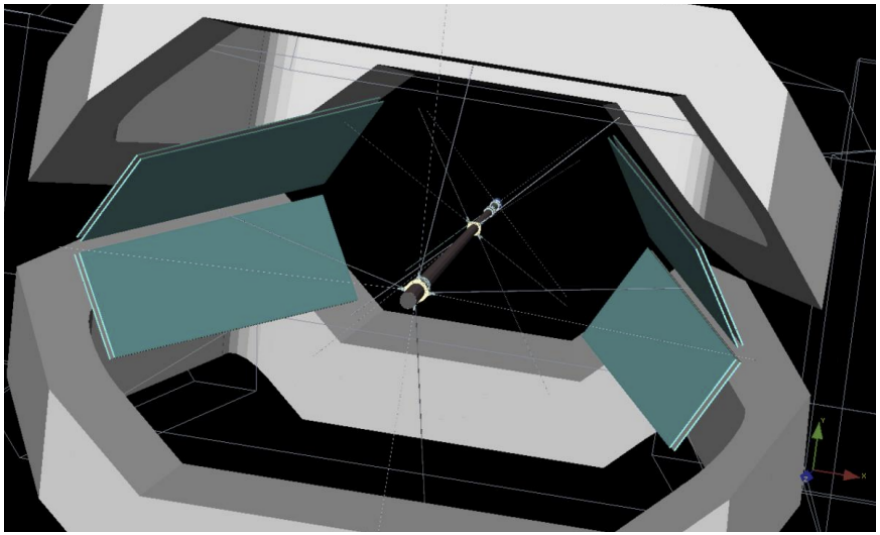
⇛ 2bit ADC information from each of the 4 bars associated to the track for offline ghost track rejection and track clustering







Simulation



⇒ Implemented in Gauss:

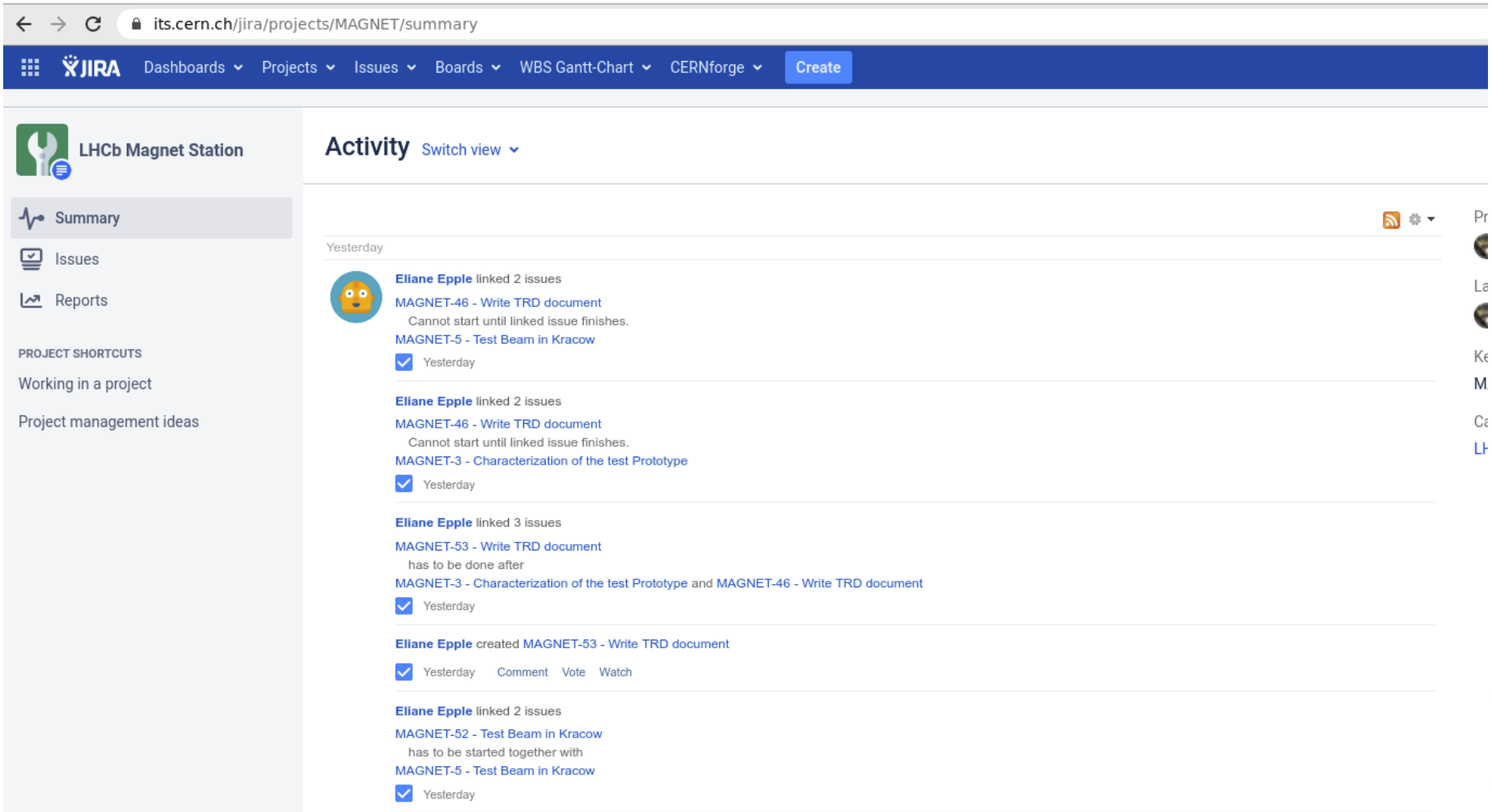
- 4 panels with 2 layers each
- Carbon fiber box
- Tyvek coating
- Scintillator

⇒ All available beam pipe support implemented.

Removed cuts inside Gauss:

```
TrCutsRunAction("TrCuts").KillLoops = False
TrCutsRunAction("TrCuts").MuonTrCut = 10.0;
TrCutsRunAction("TrCuts").pKpiCut = 0.1;
TrCutsRunAction("TrCuts").NeutrinoTrCut = 0.0;
TrCutsRunAction("TrCuts").NeutronTrCut = 0.0;
TrCutsRunAction("TrCuts").GammaTrCut = 0.03;
TrCutsRunAction("TrCuts").ElectronTrCut = 0.03;
TrCutsRunAction("TrCuts").OtherTrCut = 0.0;
TrCutsRunAction("TrCuts").OutputLevel = 2
```

JIRA


its.cern.ch/jira/projects/MAGNET/summary
JIRA
Dashboards
Projects
Issues
Boards
WBS Gantt-Chart
CERNforge
Create
LHCb Magnet Station
Summary
Issues
Reports
PROJECT SHORTCUTS
Working in a project
Project management ideas
Activity
Switch view
Yesterday
Eliane Epple linked 2 issues
MAGNET-46 - Write TRD document
Cannot start until linked issue finishes.
MAGNET-5 - Test Beam in Kracow
Yesterday
Eliane Epple linked 2 issues
MAGNET-46 - Write TRD document
Cannot start until linked issue finishes.
MAGNET-3 - Characterization of the test Prototype
Yesterday
Eliane Epple linked 3 issues
MAGNET-53 - Write TRD document
has to be done after
MAGNET-3 - Characterization of the test Prototype and MAGNET-46 - Write TRD document
Yesterday
Eliane Epple created MAGNET-53 - Write TRD document
Yesterday Comment Vote Watch
Eliane Epple linked 2 issues
MAGNET-52 - Test Beam in Kracow
has to be started together with
MAGNET-5 - Test Beam in Kracow
Yesterday

Current work-flow and opportunities

- bar, fiber, connectors characterization : LANL/PAN
- SiPMs : LANL/PAN + others?
- readout electronics: PACIFIC board
- FPGA online tracking : others ?
- Cooling : others ?
- Assembly and Installation: IFJ/LANL

$\Rightarrow$ There is still room for your group!

Plans for this year

- Study several Physics channels which can benefit from Magnet Station, including interaction with theorists. Publish a dedicated paper.
- Tracking reconstruction software
- Instrument a 4-layers prototype for signal, noise and tracking studies
- Test beams at Krakow and LANL
- Assembly a prototype with LED pulser in each bar controlled by an event generator for stress tests of the readout electronics
- Start develop the FPGA code for online tracking

$\Rightarrow$ Funding for prototyping is secured both from LANL and Krakow.
$\Rightarrow$ Applying for additional funding.

Cost estimate

	Manufactory	Model	Quantity	Price / Unity (US$)	Total Cost (US$)	Contingency	Comment
SiPM array	Hamamatsu	S13615-1050N-04	4500	96.75	435,375	5%	Based on a 130 units quota
Extruded scintillating bar	Fermilab	PAN, 1%PPO, 0.03% POPOP	9600	20	192,000	40%	Extrapolation from 200m quota
0.5mm WS fiber	Saint-Gobain	BCF92 SC, 0.50 DIA, R/C	72000	1.97	141,840	10%	1m per channel, 2ns decay WS
0.5mm clear fiber	Kuraray	Clear (PSM)	360000	0.47	169,200	50%	average 5m long fiber per channel, based on 1mm quota
WS-clear fiber connector	Plastic manufactory		4500	2	9,000	10%	Based on 3D printed parts at LANL
Clear fiber SiPM connector	Plastic manufactory		4500	2	9,000	10%	Based on 3D printed parts at LANL
Readout electronics	SciFi based	SciFi based	72000	5	360,000	50%	Estimation based on TDR and availability of PACIFIC chips
Mechanical Structure					200,000	50%	
TOTAL Material					**1,516,415**	**1,995,568**	

Outlook

⇛ Magnet Tracking Stations are alive and well.
⇛ The R&D work is progressing very well.
⇛ Simulation is more and more detailed.
⇛ Physic use-cases are being extended.
⇛ The founding is secured for R&D and additional funding requests is being prepared.
⇛ More and more people joining.

Backup