Status of Fiber ToF Tracker

UNIVERSITÉ DE GENÈVE

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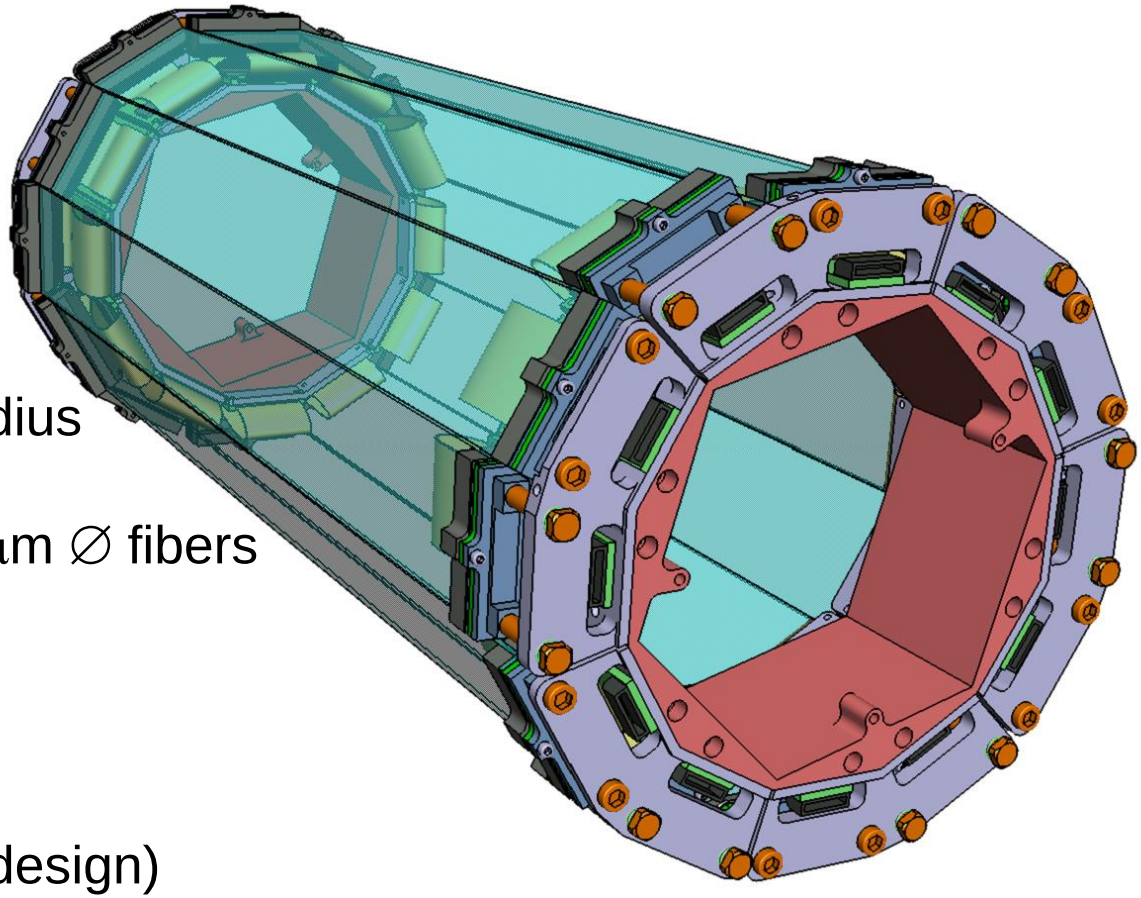
50th BVR Review
28 January '19

Alessandro Bravar
Université de Genève

Quick Reminder



Design Parameters

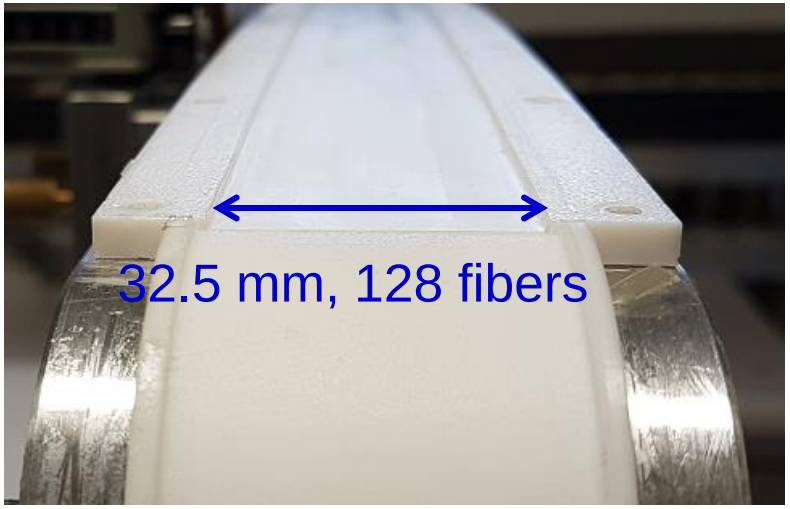
12 SciFi ribbons at ~6 cm radius
- 32.5 mm × 300 mm
- 3 staggered layers of 250 μm ∅ fibers
- SCSF-78MJ
- very thin ~0.2% x_0

Si-PM readout at both ends
- 128 ch SiPM array (LHCb design)
- 250 μm pitch

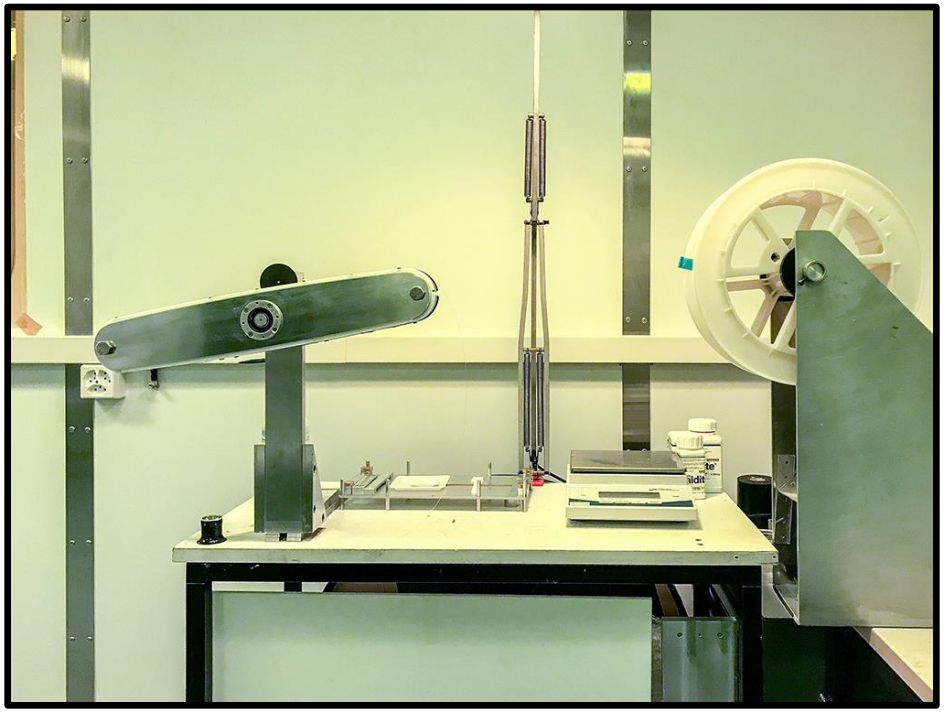
Readout
- MuTRiG ASIC
- 3000 readout channels

SciFi Ribbon Production

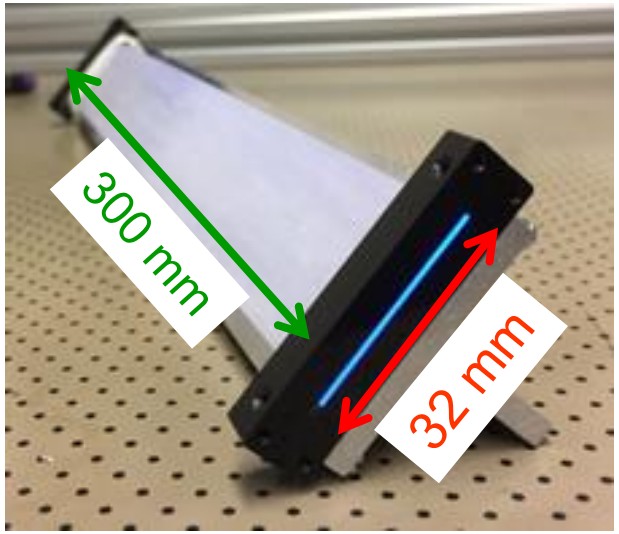
U channel



ribbon winding tool



(full size) ribbon prototype

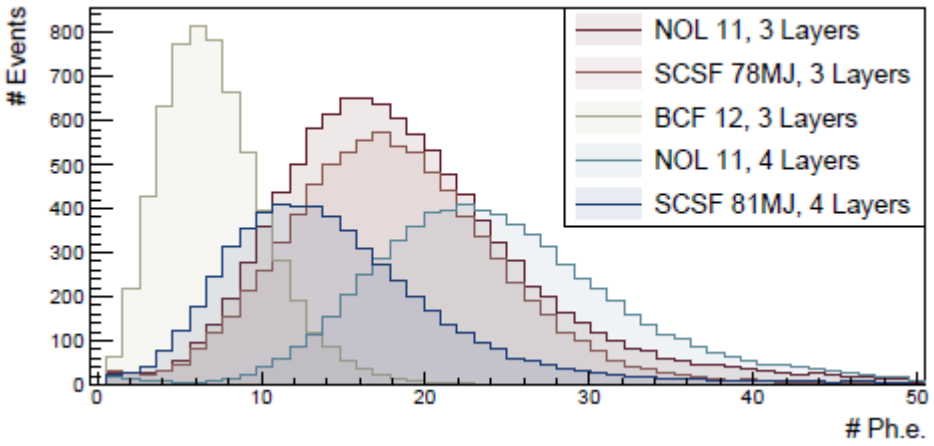


ribbon profile: 3 × ~125 fibers (prototype)

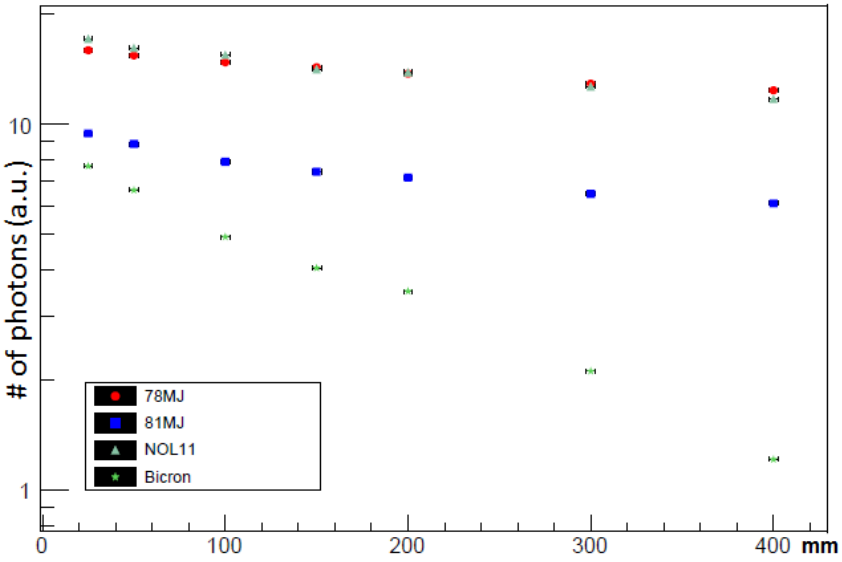
Ready to start production

SciFi Performance 1

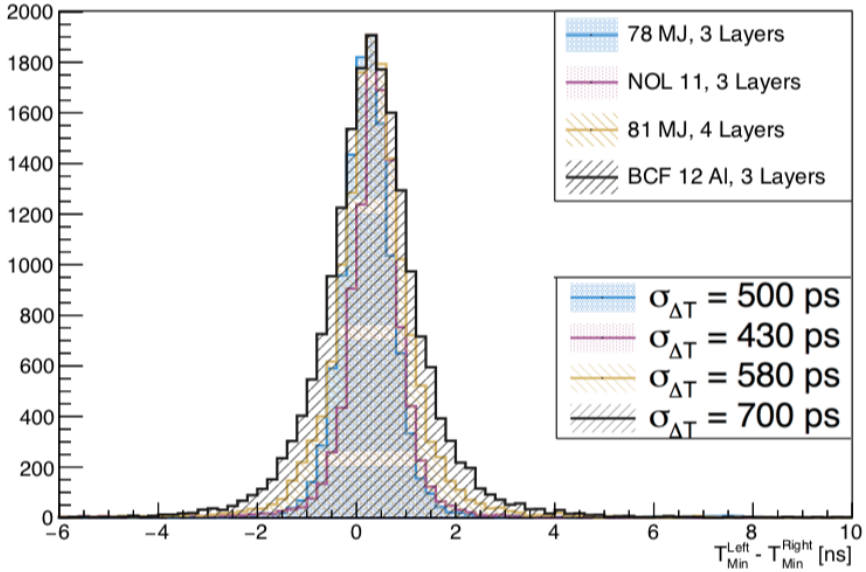
light yield



light attenuation (Sr source)

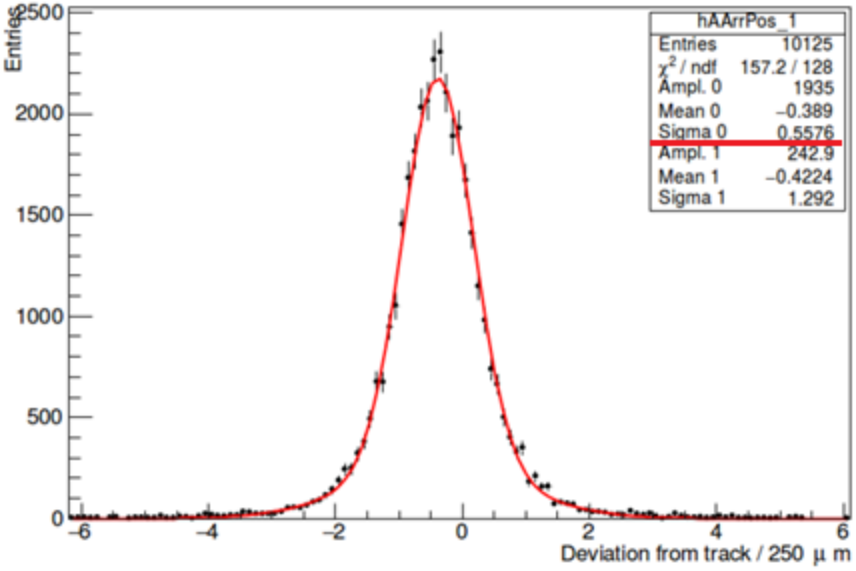


time resolution (ΔT)



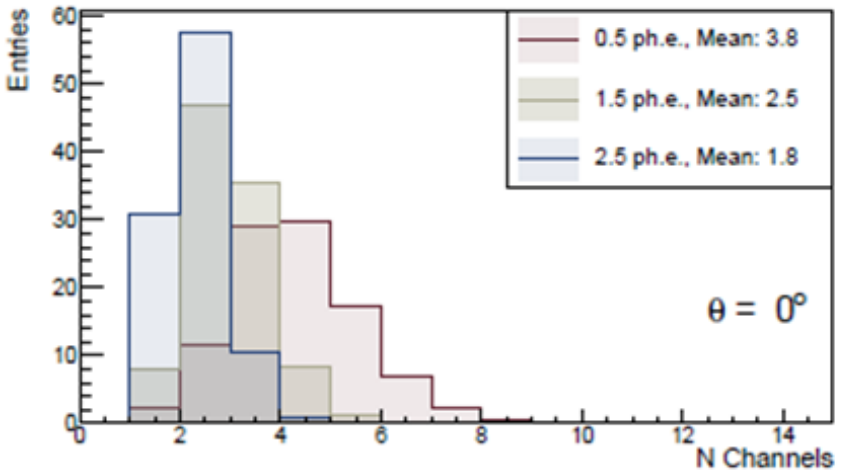
with L.E. algorithm w/interpolation

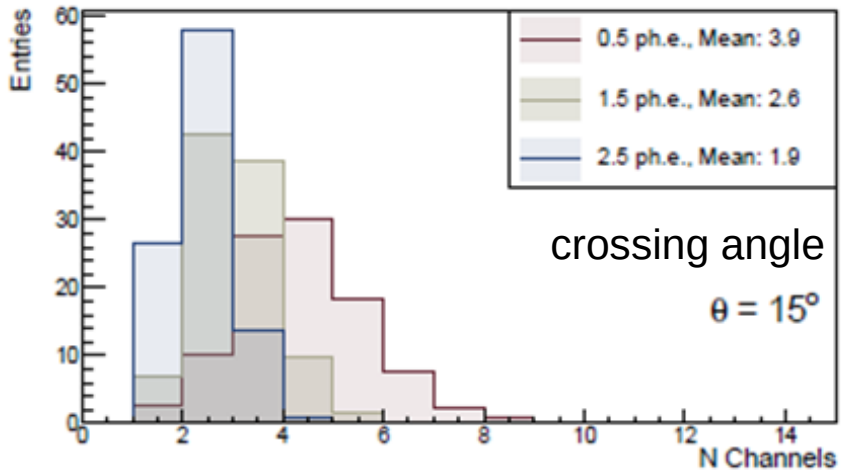
position resolution

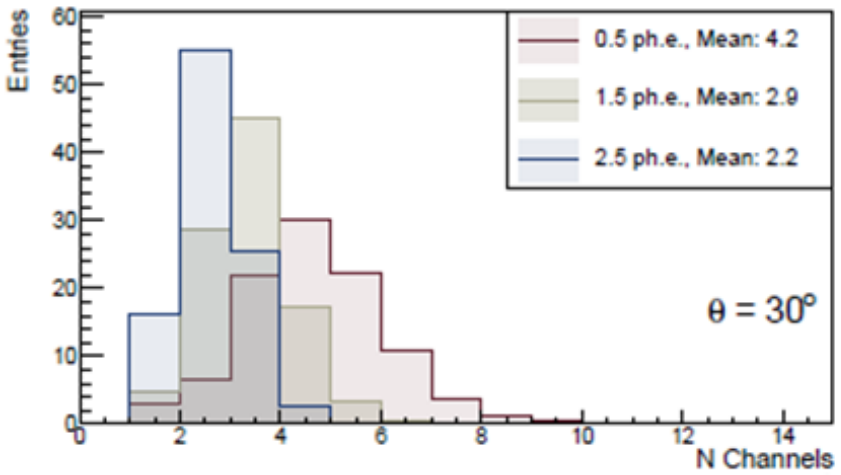


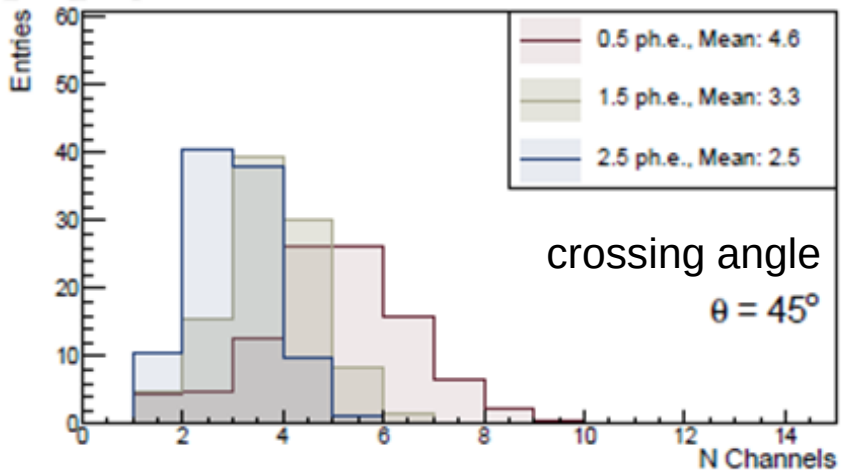
SciFi Performance 2

"cluster size" for different thresholds (SCSF-78MJ fiber, 3 layers)





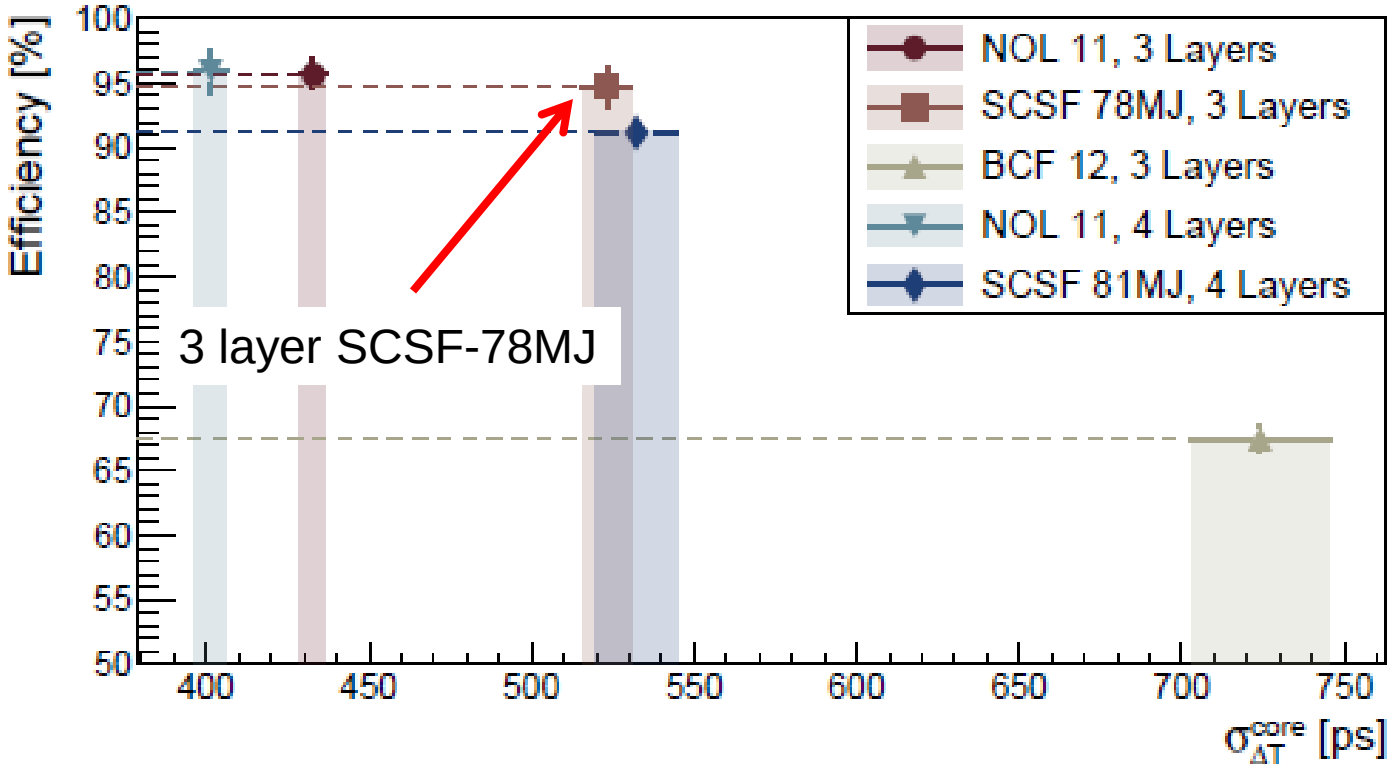




important for reducing the data rate:
lower the threshold, larger the cluster → higher the occupancy and the data rate
(lower the light yield of fibers → smaller the cluster size)

SciFi Performance 3

comparison of different fibers: efficiency vs timing



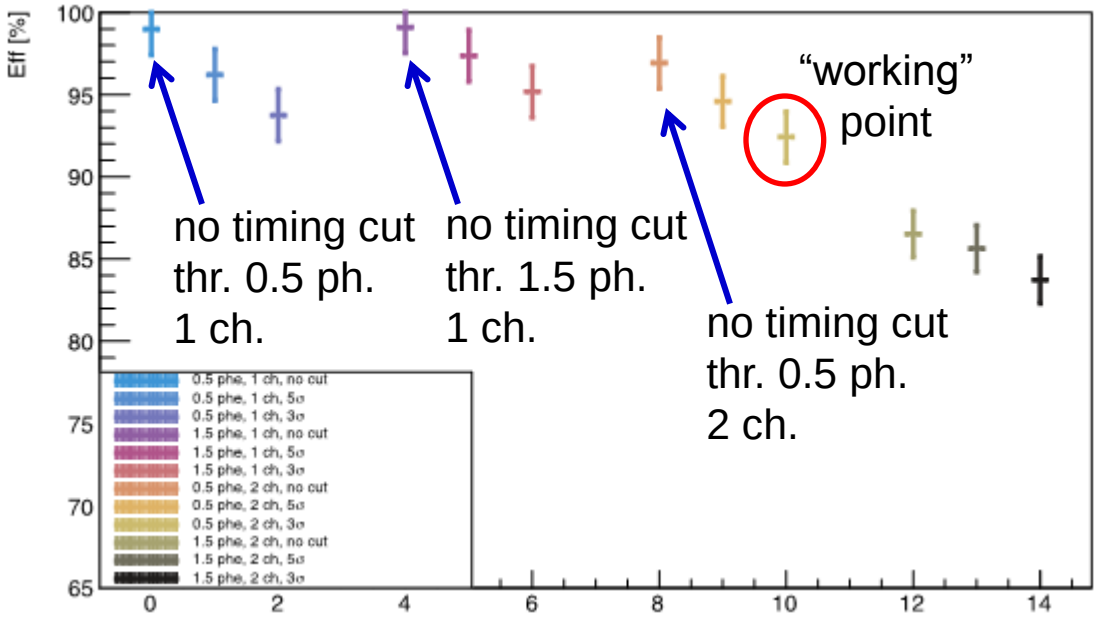
$\sigma_{\Delta T} = \sigma(T_1 - T_2)$; $\sigma_{MT} = ½\ \sigma_{\Delta T}$

we require a cluster on each SciFi ribbon end (coincidence)
cluster: at least two adjacent channels > 0.5 ph. el. threshold
coincidence: $\pm$ 3 σ timing cut
timing with L.E. algorithm w/ interpolation to simulate MuTRiG functioning

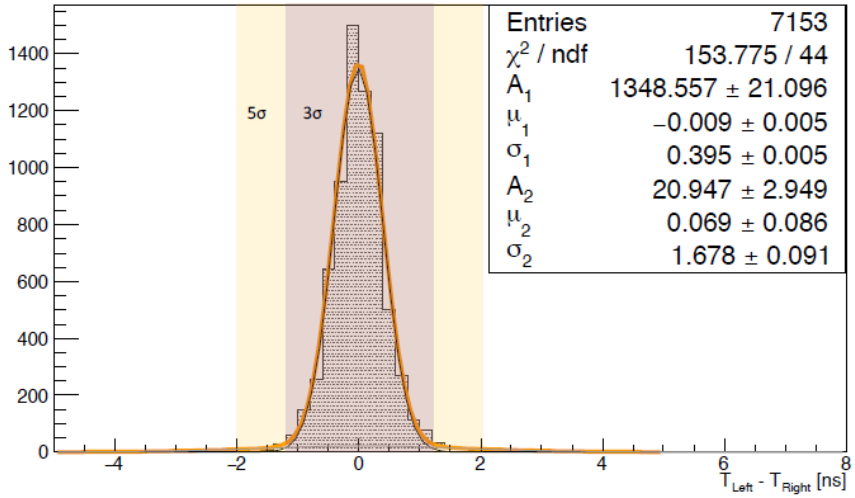
Efficiency (old analysis)

SCSF-78MJ 3 layer ribbon efficiency for different cuts:

1. threshold (0.5, 1.5, or 2.5 ph.)
2. timing cut (no cut, +3σ, or + 5σ
3. cluster size (1 ch. or 2 ch.)



timing cut

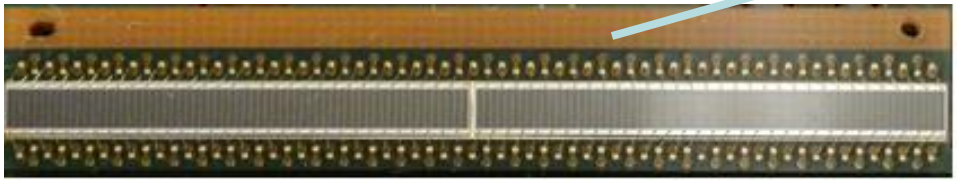


Si-PM Array

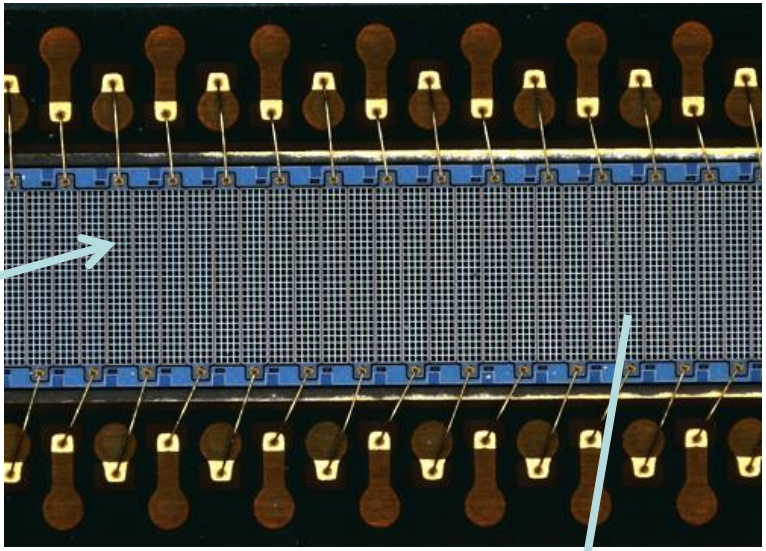
In hand

128 ch SiPM array from Hamamatsu (LHCb type) S13552HRQ

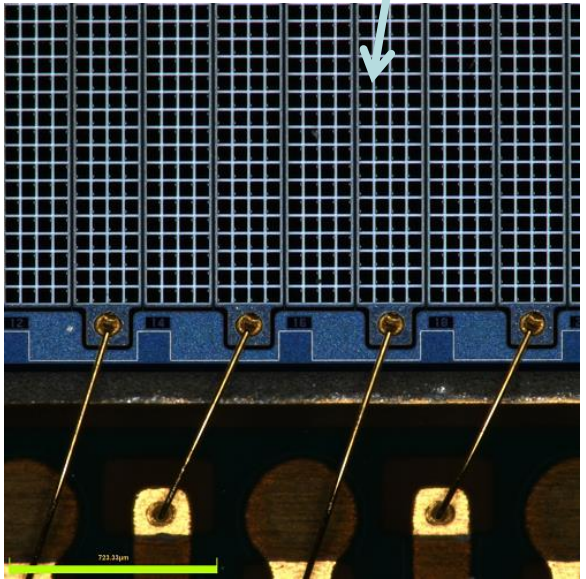
- 250 μm pitch
- pixel size 57.5 μm × 62.5 μm
- 4 × 16 pixels per column
- 230 μm × 1625 μm column area
- V_{break} ~52.5 V (± 0.3 V same array)
- high quenching resistor

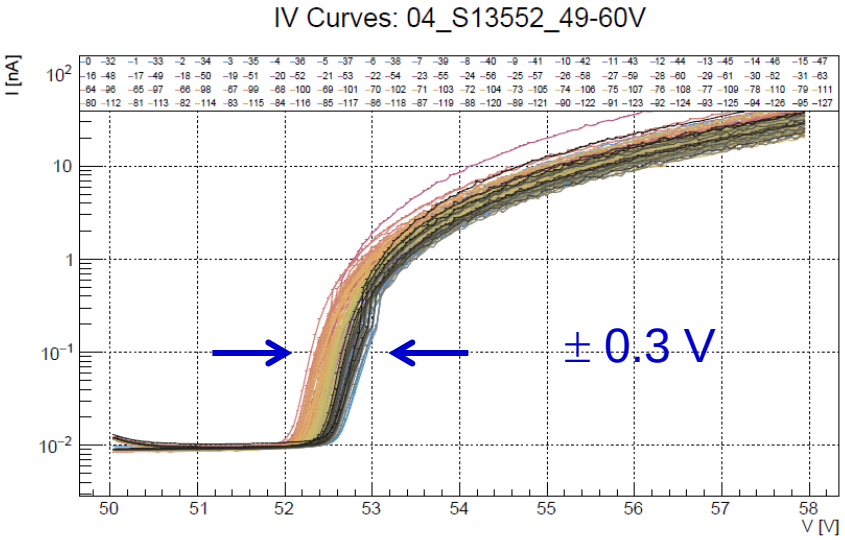


32.5 mm (two 64 ch. dies)

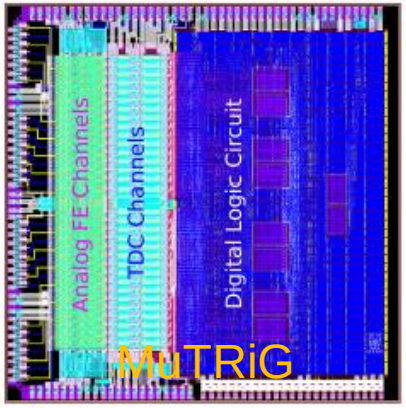


details





Front End Electronics

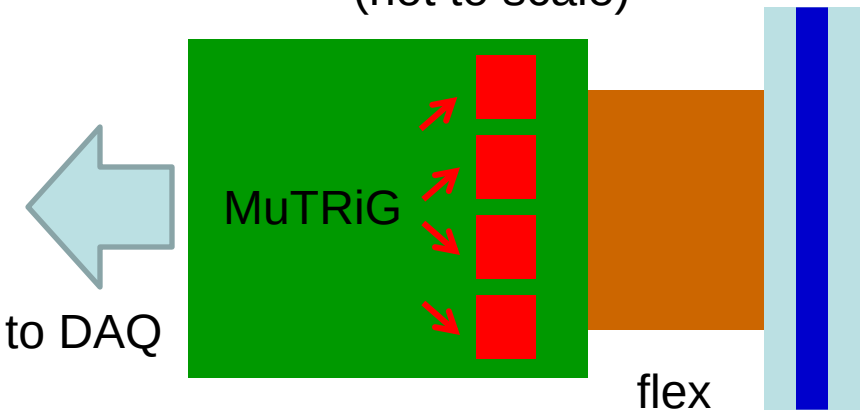


Readout of SiPM arrays using the MuTRiG chip (see Wei's talk)

4 MuTRiG chips are required to read out
one 128 channel SiPM array
1 FE board per Si-PM array (2 × 12 boards)

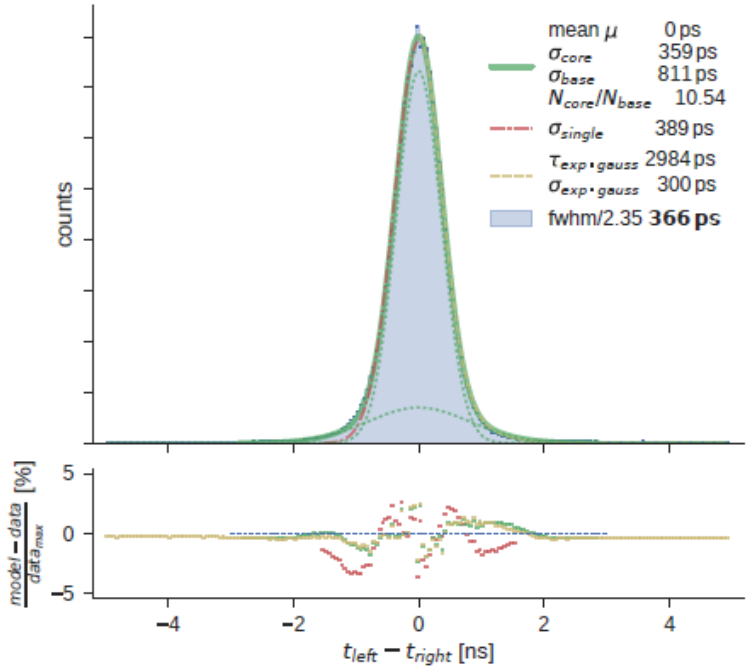
extremely tight space available for the FE chips directly bonded to the FE board

schematic representation of SciFi FE board
(not to scale)



SciFI FE board
~30 mm × ~40 mm

SiPM array



SciFi timing performance w/ MuTRiG
reproduced timing resolution obtained in TB
(4 layer SCSF-78MJ ribbon, 1 ch.)

Under development

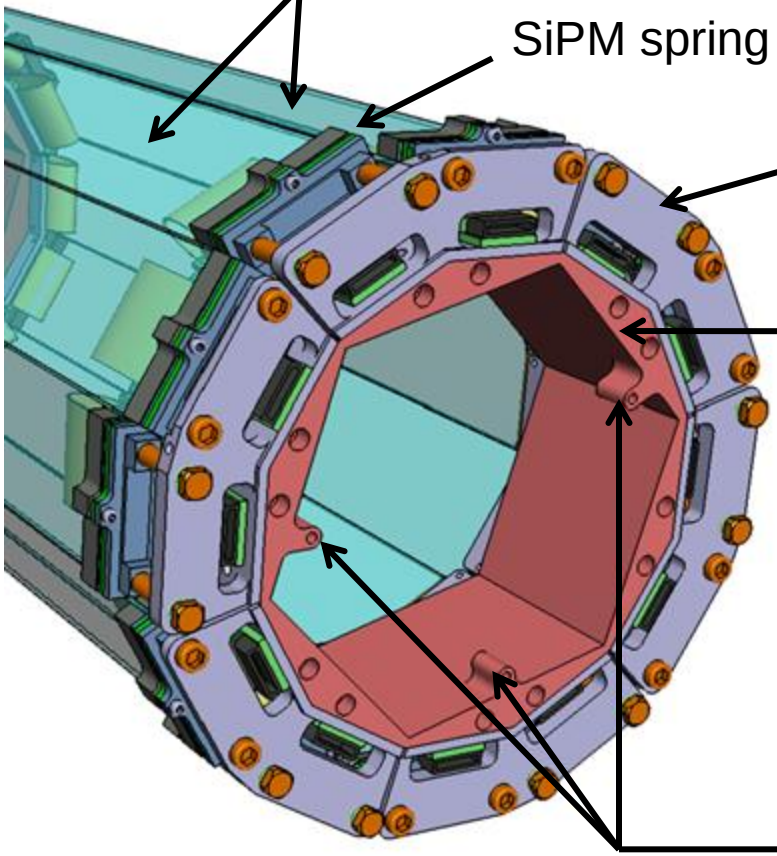
SciFi Mechanics 1

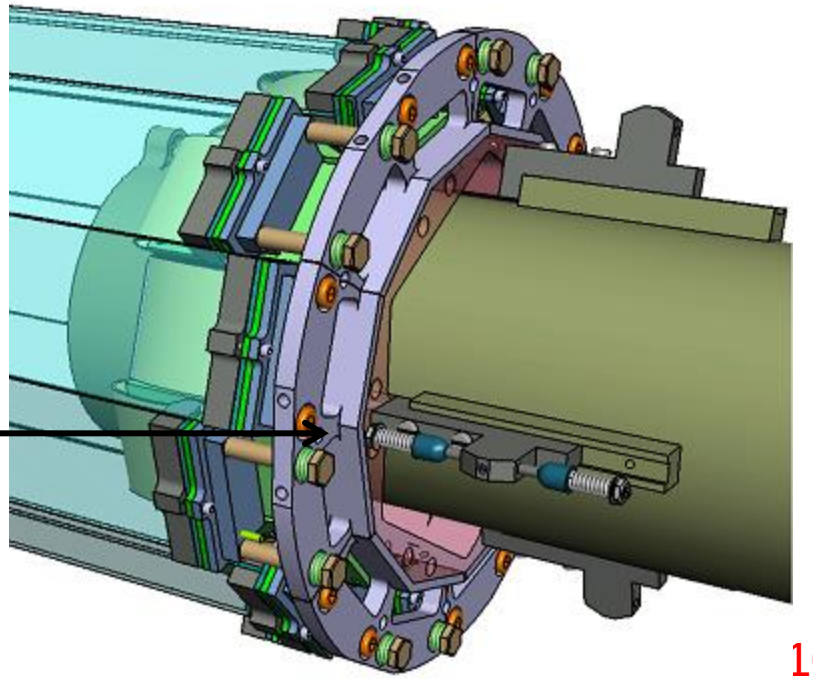
SciFi ribbons
longitudinally staggered to minimize dead space between ribbons

SiPM spring loaded support

SciFi module support structure
(2 ribbons per module)

cooling ring
supports the SciFi modules

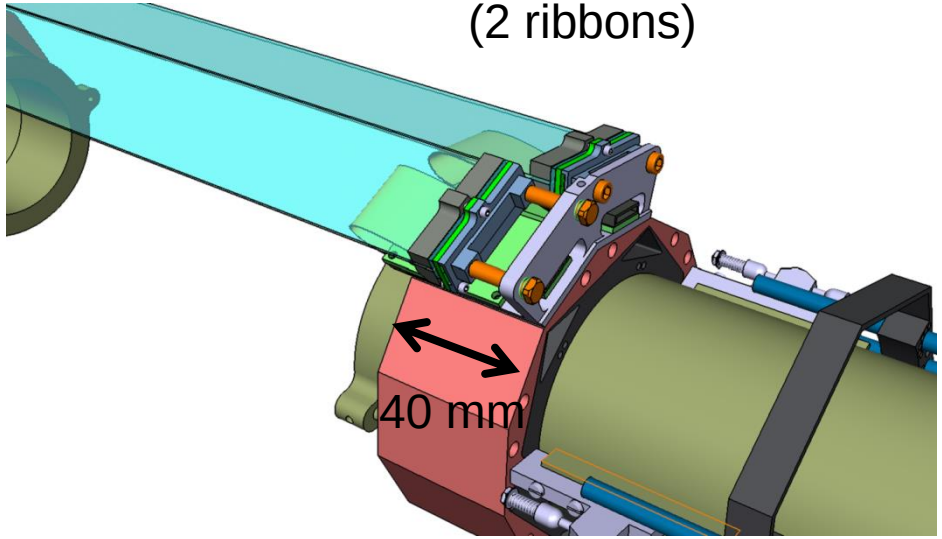




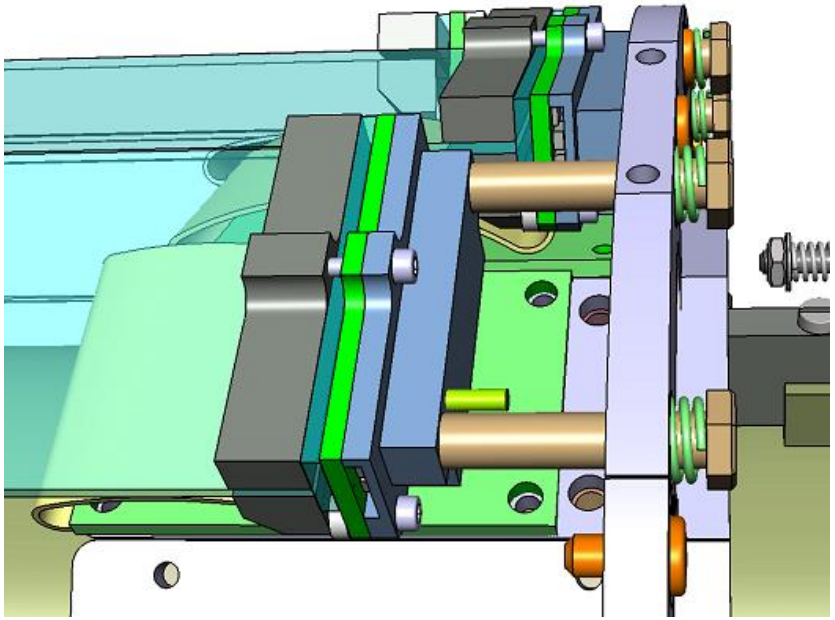
fixations to beam pipe

SciFi Mechanics 2

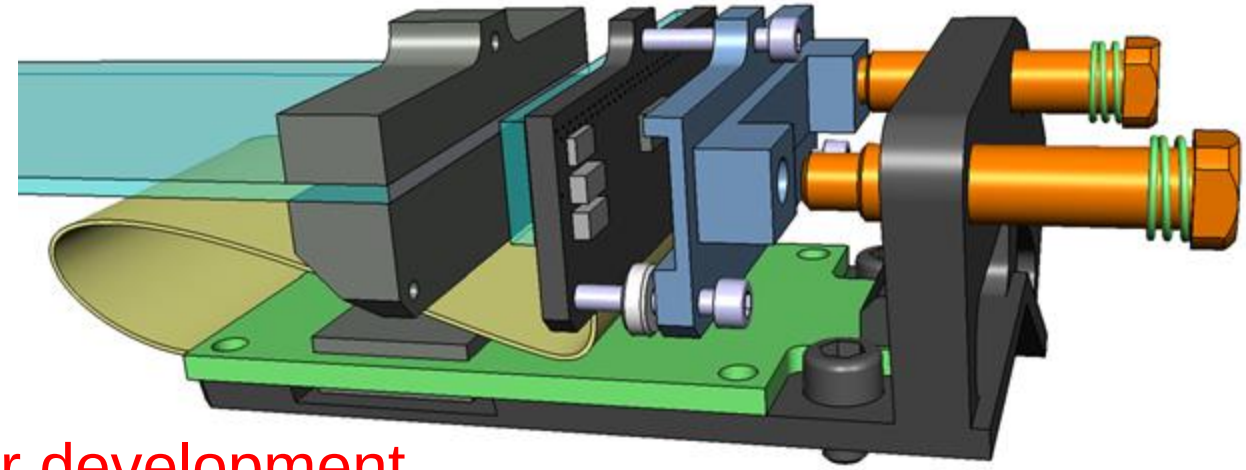
one SciFi module
(2 ribbons)



top view



"expanded" view of SciFI – SiPM coupling + spring loaded SiPM support



Under development

QA

SciFi ribbons

visual inspection of ribbons and of fiber polishing
mechanical measurements of ribbons
validation of each SciFi ribbon with beam or β source

SiPM arrays

I-V curves for each channel (+ DCR)
visual inspection for surface defects

Front-End

validation of the SiPM – FE chain with e.g. a laser (excite the SiPM)

Ongoing Work

Finalize the mechanical design / integration

- very tight space constraints
- connection to the Mu3e cooling system
- cooling of SiPM arrays
- thermal model
- “cabling”

Fully develop the SciFi Front End electronics

- extremely tight space constraints
- 4 MuTRiG chips per board
- develop FE board in steps
  1. SciFi protoboard w/ 4 MuTRiG v1 chips almost ready
     validate SiPM array readout and DAQ integration
  2. SciFi protoboard w/ 4 MuTRiG v2 chips once MuTRiG v2 is available
  3. final design

Radiation hardness

- SiPM arrays (studies ongoing, almost completed)
- Scintillating fibers
- MuTRiG

Outlook

Milestone	BVR48	BVR49	BVR50
Fiber selection	Q2/17	✓	
SiPM array selection	Q2/17	✓	
SiPM radiation hardness studies	Q4/17	Q2/18	Q2/19
Production and Q&A SciFi ribbons	Q3/17	Q3/18	✓
MuTRiG readout demonstrator (SciFi protoboard w/ 4 MuTRiG's v1)	Q3/17	Q3/18	Q2/19
Mechanical design (incl. integration)			Q2/19
Front End integration (DAQ)			Q2/19
Final SciFi Front End (MuTRiG v2)			Q4/19
Alignment and calibration scheme	Q3/17	Q3/18	Q3/19
Use demonstrator in V-slice tests		Q1/19	Q2/19
Full prototype (integration ready)	Q1/18	Q2/19	Q2/19
Full detector		Q4/19	Q4/19

The Team

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engineers