# TMS Electronics Interfaces

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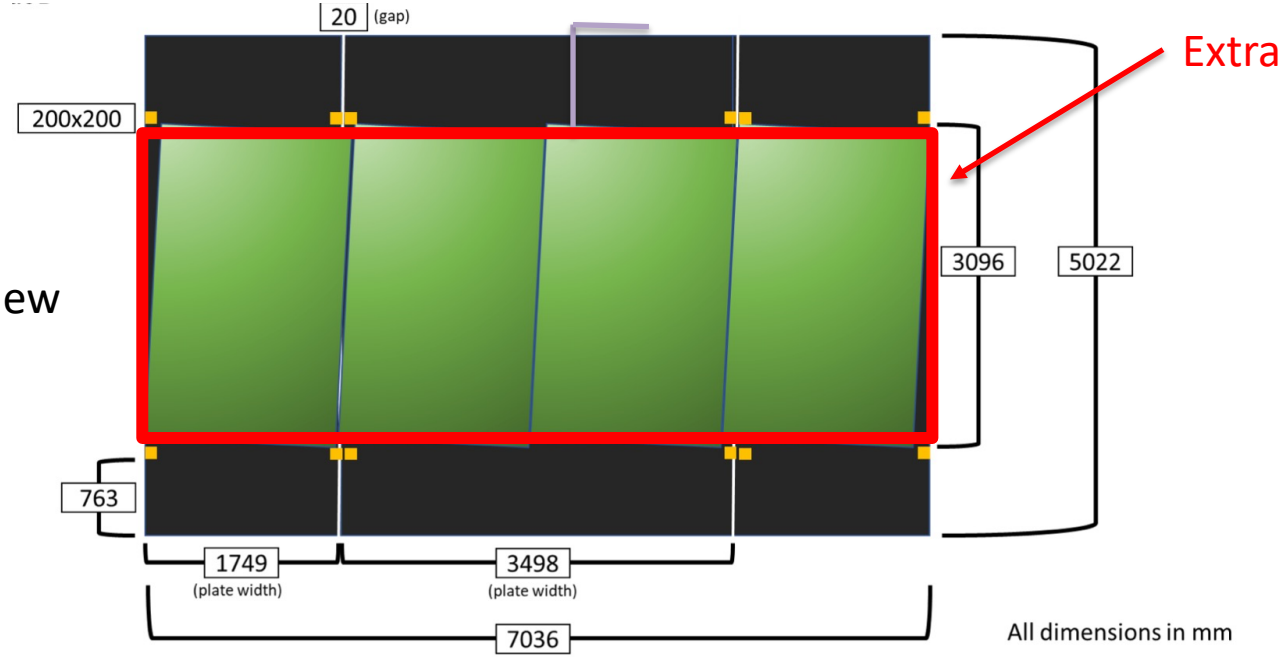
For TMS Engineering Meeting

# Outline

- Conceptual scintillator module/layer assumption
- Interfaces
  1) Electronics hardware location on magnet
  2) SiPM to WLS fiber/scintillator
  3) Cable routing and bundling
- Summary

# TMS Geometry Assumptions

Front view of TMS




**Extractable scintillator cassette (= 1 TMS layer) contains:**

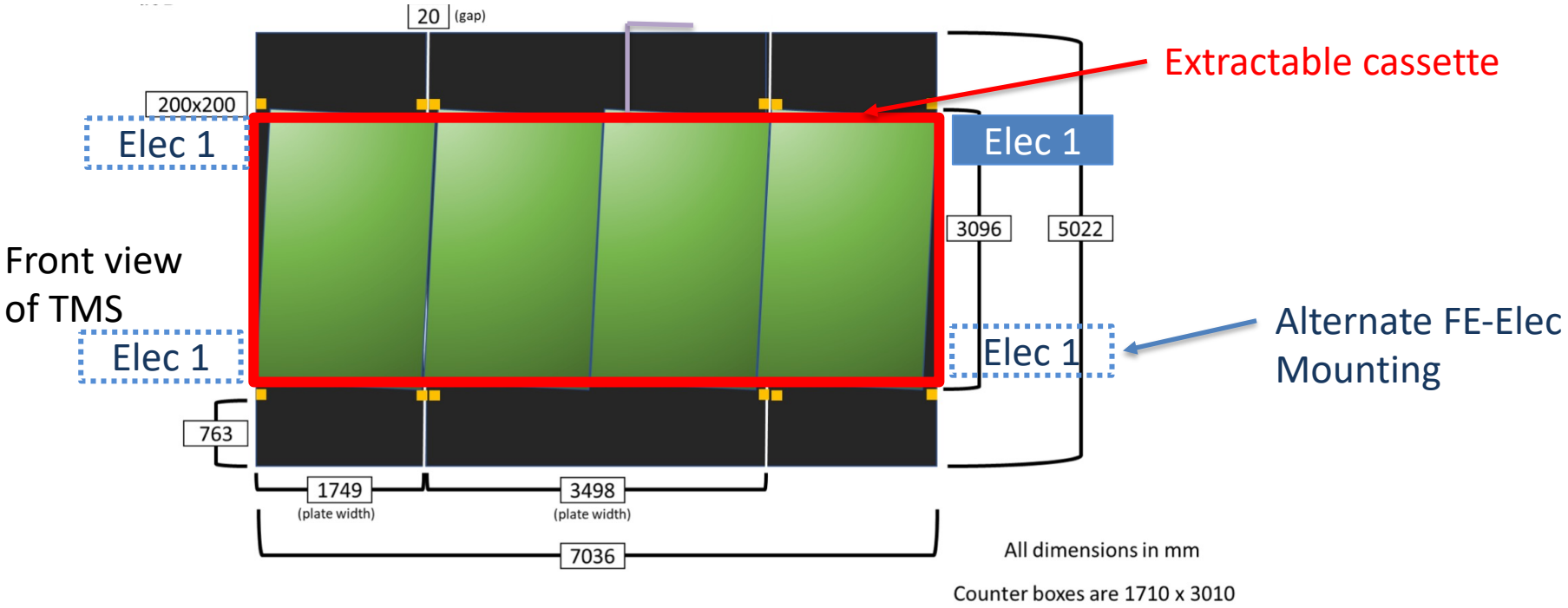
4 modules with 48 scintillator bars each

→ 192 SiPMs and readout channels per layer

→ Couples to 3 CAEN FE boards (64 channels each) per TMS layer

→ Scintillator bars are (near) vertical with SiPM either at top or bottom

# 1) FE-Electronics Location




**FE-Electronics:**

**1) Side Mounting** (left or right; near top or bottom of cassette, depending whether SiPMs will be mounted on top or bottom of scintillator strips)

→ Mounted on side of magnet near cable channel of cassette

2) **Top Mounting** is in principle viable option (with additional cable routing complications)

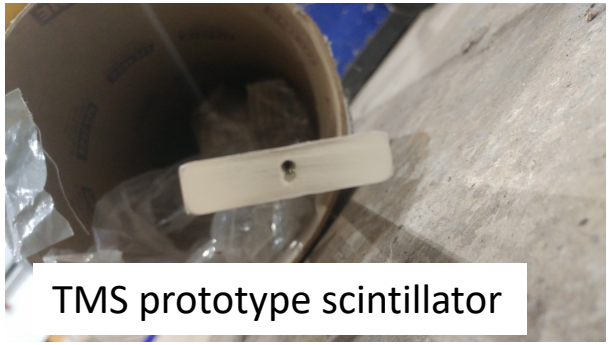
→ Requires interface board between chosen cable/connector type and FE-board interface (conceivable to integrate "correct" connector onto CAEN FE board)

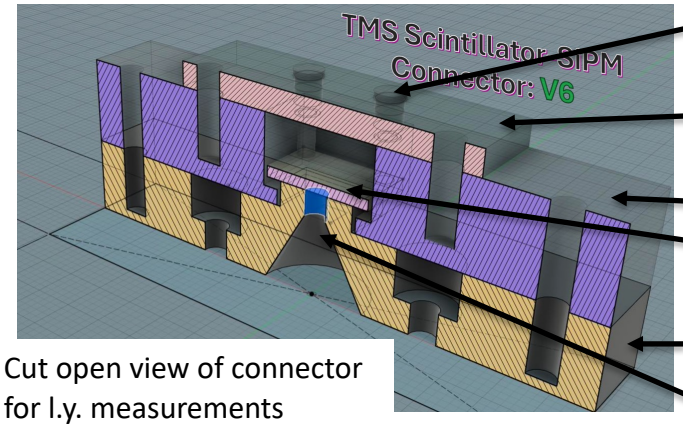
# 1) FE-Electronics Location

**Questions for magnet and facility (and safety) groups:**

- What locations are available for electronics mounting ?
  - Fewer centralized locations ?
  - More widely distributed locations ?
- What will accessibility be ?
- Preferences for type of FE-Electronics Mounting:
  - Crate or boxed stack mounting ?
  - Individually boxed FE card mounting ?

# 2) SiPM to WLS Fiber/Scintillator Interface


TMS prototype scintillator



Cut open view of connector for l.y. measurements

spring loaded pogo pins

miniPCB: connector to cable

Connector top with SiPM and miniPCB

Connector base with WLS fiber ferrule attached to scintillator

**Assumptions:**

- 1 WLS fiber per scintillator bar with nominal diameter of 1.4 mm or smaller
- 1 connector with SiPM and mini-PCB per scintillator
- nominal 2 shielded mini co-ax cables per mini-PCB (one for signal, one for bias voltage) but very likely can reduce to one mini co-ax cable and use AC coupling on FE side

→ R&D task for electronics group: demonstrate single coax cable per channel with AC coupling

**Questions for scintillator group:**

- Does packaging for 48 bars provide light tightness or is other scheme foreseen ?
- What are resulting requirements for connector ?

# 2) SiPM to WLS Fiber/Scintillator Interface

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- What are resulting requirements for connector ?

**Example from T2K SMRD :**

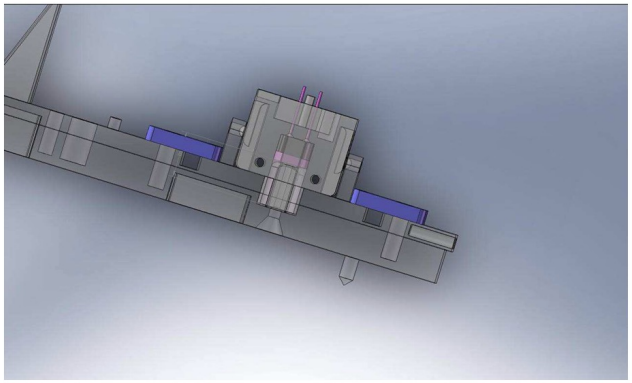


Figure 4: Partial view of a SMRD scintillator counter endcap with the optical connector housing a MPPC and a mini PCB.

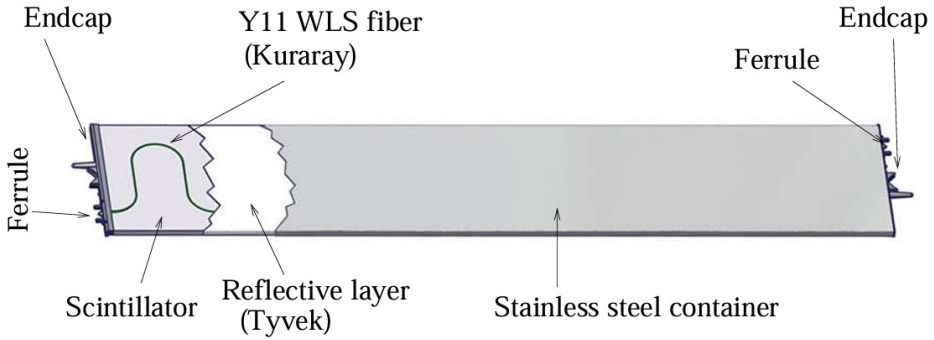



Figure 5: SMRD counter sliced view.

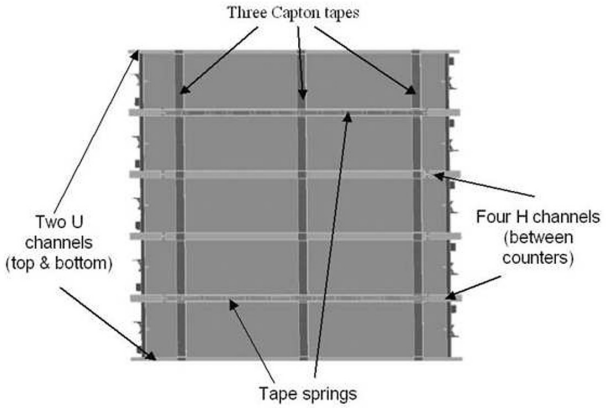



Figure 6: Scheme of the vertical SMRD module.

Reference:
NIM A 698 (2013) p. 135-146
https://arxiv.org/abs/1206.3553

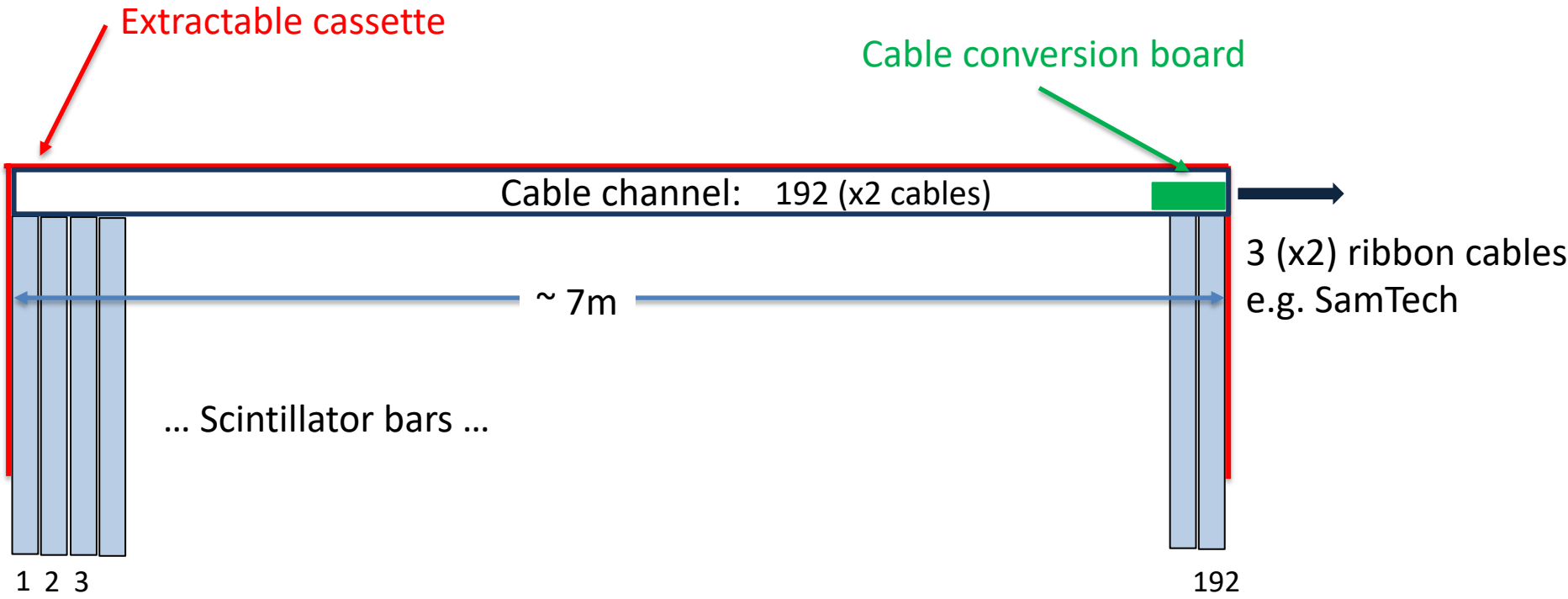
# 3) Cable Connections Approach

**Cabling options summary for all cases:**

1) Establish cable connections and perform tests of many individual cables at factories

2) Only make few ribbon cable connections in detector hall during installation

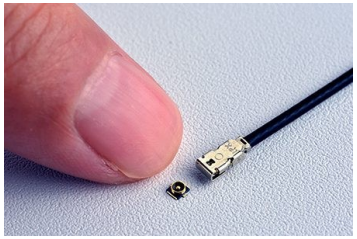
# 3.1) Cable Routing and Bundling




**Cabling option 1a :**

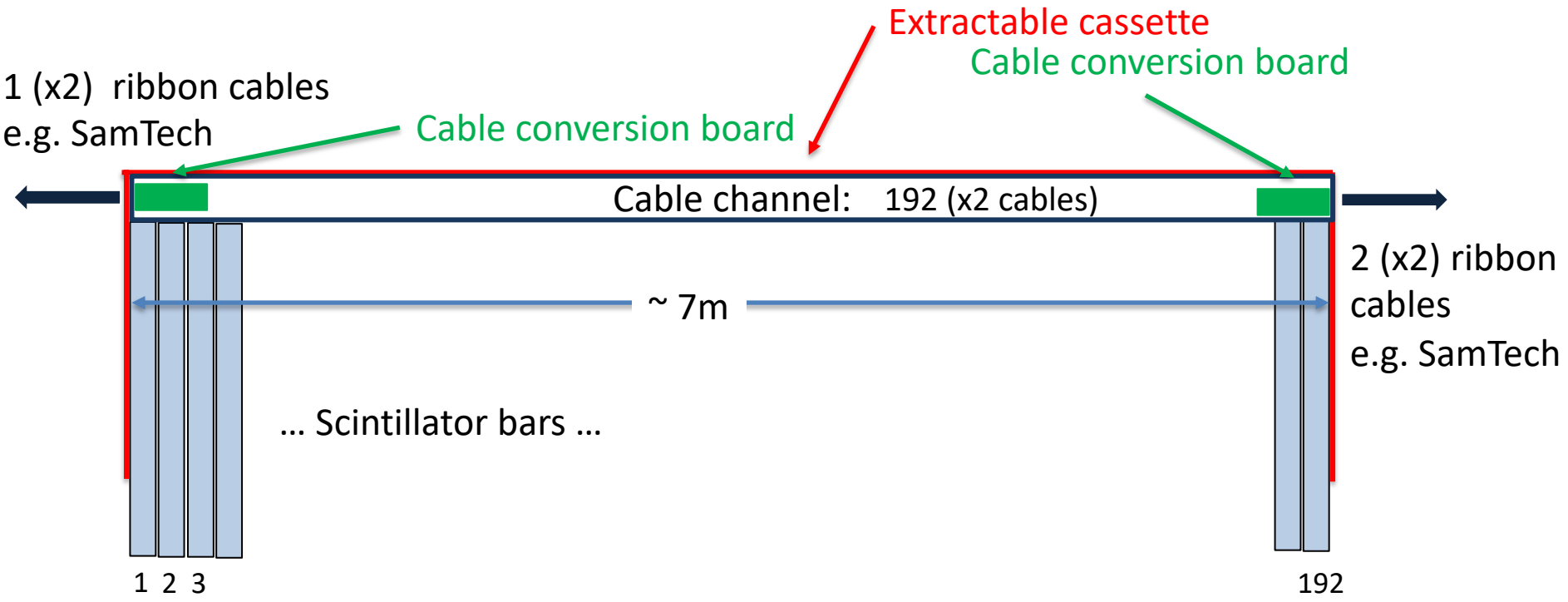
Individual mini-coax cables form each scintillator to conversion board at edge of cassette

e.g. : Hirose mini-coax, typical OD: 1.13 mm, groups of different lengths, cost TBD




Example conversion board

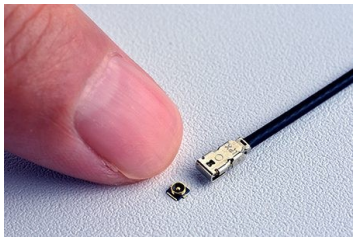
# 3.1) Cable Routing and Bundling




**Cabling option 1b :** **advantage over option 1a: overall shorter cables**

Individual mini-coax cables form each scintillator to conversion board at edge of cassette

e.g. : Hirose mini-coax, typical OD: 1.13 mm, groups of different lengths, cost TBD



Example conversion board

# 3.1) Cable Routing and Bundling

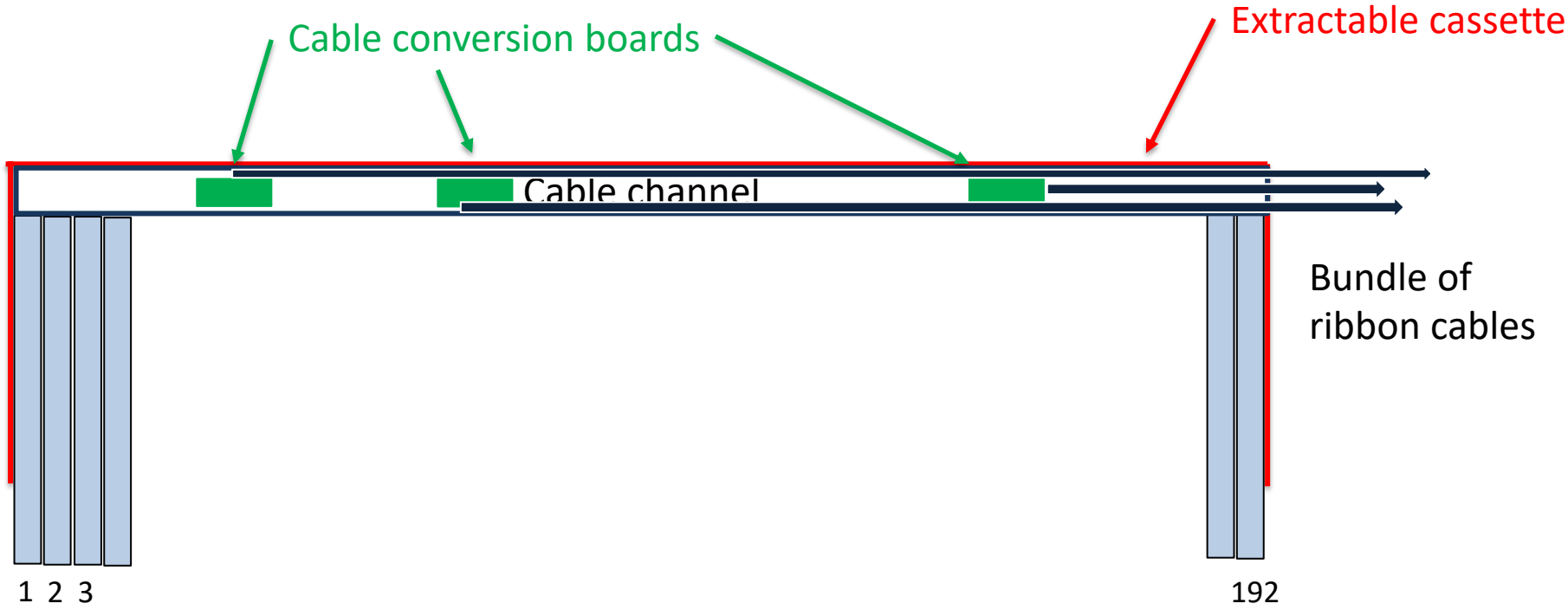
**Cabling option 1:** e.g. : Hirose mini-coax, typical OD: 1.13 mm

## Product Specifications

| | | | |
|---|---|---|---|
| Nominal Impedance | 50 Ω | Operating Temperature | -40 to +105℃ (90% RH Max.) |
| Rated Frequency | 0 to 8GHz | Storage Temperature | -30 to +70℃ (90% RH Max.) |

| Item | Standards | Condition | | |
|---|---|---|---|---|
| Contact Resistance | Center: 20mΩ Max. (50mΩ Max.)<br>External: 10mΩ Max. (20Ω Max.) (U.FL(A)) | Measured at 10 mA Max. | | |
| Insulation Resistance | 500MΩ Min. | Measured at 100V DC | | |
| Withstanding Voltage | No insulation break down | 200V AC for 1 minute | | |
| V.S.W.R.* | Cable Type | 0 to 3GHz | 3GHz to 6GHz | 6GHz or faster |
| | U.FL-LP-040HF φ0.81 | 1.3 Max. | 1.35 Max. | 6 to 8 GHz: 1.4 Max. |
| | U.FL-LP(V)-040HF φ0.81 | 1.3 Max. | 1.3 Max. | 8 to 12 GHz: 1.4 Max. |
| | U.FL-LP-068HF φ1.13 | 1.3 Max. | 1.4 Max. | 6 to 8 GHz: 1.6 Max. |
| | U.FL-LP-066HF φ1.32 | 1.3 Max. | 1.5 Max. | 6 to 8 GHz: 1.7 Max. |
| | U.FL-LP-062HF φ0.95 | 1.3 Max. | 1.3 Max. | 6 to 8 GHz: 1.4 Max. |
| | U.FL-LP-088HF φ1.37 | 1.3 Max. | 1.4 Max. | 6 to 8 GHz: 1.6 Max. |
| | U.FL(A)-LP(P)-068 φ1.13 | 1.3 Max. | 1.4 Max. | 6 to 9GHz : 1.5 Max.<br>9 to 12GHz : 1.6 Max.<br>12 to 15 GHz: 1.7 Max.<br>15 to 18GHz : 2.0 Max. |
| | U.FL(A)-LP(P)-088 φ1.37 | | | |
| Female Contact Retention Force | 0.15N Min. /0.1N Min. (062, U.FL (A)) | Measured with a pin gauge of φ0.475 | | |
| Mating Durability | Contact Resistance : Initial + 5 mΩ | 30 times | | |
| Vibration Resistance | No electrical discontinuity of 1 μs or more<br>No damage, cracks or part dislocation. | Frequency 10 to 100Hz, Half amplitude 1.5mm, Acceleration 59 m/s$^2$<br>for 5 cycles in each of the 3 axes direction. | | |
| Shock Resistance | | Acceleration 735 m/s$^2$, for a duration of 11 ms,<br>sine half-wave waveform, 3 cycles in each of the 6 axes direction. | | |
| Humidity Resistance (Steady State) | Insulation Resistance<br>10M Min. (in a high humidity environment)<br>500M Min. (in a dry environment) | 96 hours at temperature of 40℃ and humidity of 95%. | | |
| Temperature Cycle | No damage, cracks or part dislocation. | Temperature: -40℃→ +5 to +35℃→ +105℃→ +5 to +35℃<br>Time: 30 minutes → within 5 minutes→ 30 minutes → within 5 minutes. 5 cycles | | |

# 3.2) Cable Routing and Bundling




**Cabling options:**

Individual cables to nearby conversion boards then ribbon cable(s) out to edge of cassette and to FE boards, e.g.: short Hirose cables + longer SamTech cables

a) Use 10, 20, 30, 40, 50 coax Samtech cable/connector:
b) Use 80 pin coax Samtech cable/connector → total of 3 (one per FEB)

# 3.2) Cable Routing and Bundling

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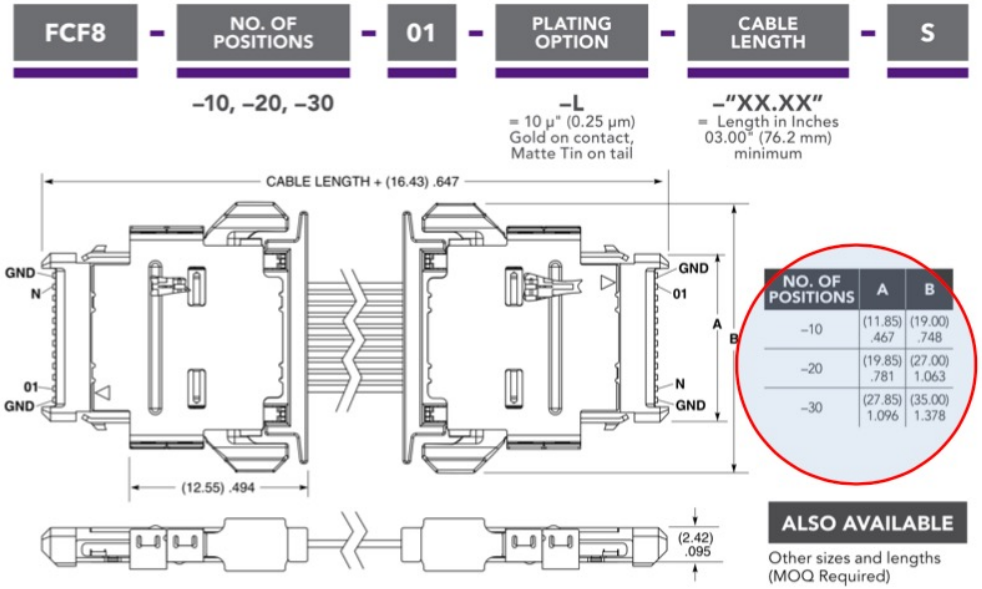
Individual cables to nearby conversion boards then ribbon cable(s) out to edge of cassette and to FE boards, e.g.: short Hirose cables + longer SamTech cables



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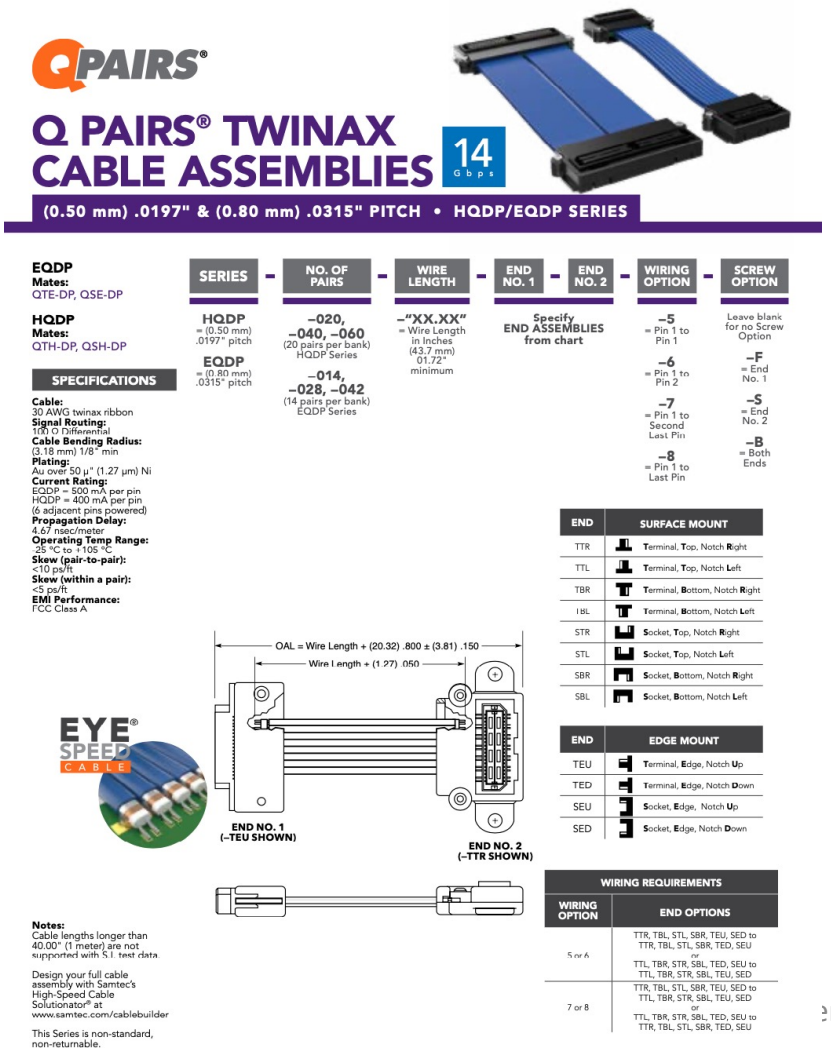


QPAIRS®

**Q PAIRS® TWINAX CABLE ASSEMBLIES** 14 Gbps

**(0.50 mm) .0197" & (0.80 mm) .0315" PITCH • HQDP/EQDP SERIES**

**EQDP**
**Mates:**
QTE-DP, QSE-DP

**HQDP**
**Mates:**
QTH-DP, QSH-DP

| SERIES | NO. OF PAIRS | WIRE LENGTH | END NO. 1 | END NO. 2 | WIRING OPTION | SCREW OPTION |
|---|---|---|---|---|---|---|
| HQDP = (0.50 mm) .0197" pitch<br>EQDP = (0.80 mm) .0315" pitch | –020, –040, –060 (20 pairs per bank) HQDP Series<br>–014, –028, –042 (14 pairs per bank) EQDP Series | –"XX.XX" = Wire Length in Inches (43.7 mm) 01.72" minimum | Specify END ASSEMBLIES from chart | | –5 = Pin 1 to Pin 1<br>–6 = Pin 1 to Pin 2<br>–7 = Pin 1 to Second Last Pin<br>–8 = Pin 1 to Last Pin | Leave blank for no Screw Option<br>–F = End No. 1<br>–S = End No. 2<br>–B = Both Ends |

**SPECIFICATIONS**

**Cable:**
30 AWG twinax ribbon
**Signal Routing:**
100 Ω Differential
**Cable Bending Radius:**
(3.18 mm) 1/8" min
**Plating:**
Au over 50 µ" (1.27 µm) Ni
**Current Rating:**
EQDP = 500 mA per pin
HQDP = 400 mA per pin
(6 adjacent pins powered)
**Propagation Delay:**
4.67 nsec/meter
**Operating Temp Range:**
-25 °C to +105 °C
**Skew (pair-to-pair):**
<10 ps/ft
**Skew (within a pair):**
<5 ps/ft
**EMI Performance:**
FCC Class A

| END | SURFACE MOUNT |
|---|---|
| TTR | Terminal, Top, Notch Right |
| TTL | Terminal, Top, Notch Left |
| TBR | Terminal, Bottom, Notch Right |
| TBL | Terminal, Bottom, Notch Left |
| STR | Socket, Top, Notch Right |
| STL | Socket, Top, Notch Left |
| SBR | Socket, Bottom, Notch Right |
| SBL | Socket, Bottom, Notch Left |

| END | EDGE MOUNT |
|---|---|
| TEU | Terminal, Edge, Notch Up |
| TED | Terminal, Edge, Notch Down |
| SEU | Socket, Edge, Notch Up |
| SED | Socket, Edge, Notch Down |

OAL = Wire Length + (20.32) .800 ± (3.81) .150

Wire Length + (1.27) .050

END NO. 1 (–TEU SHOWN)

END NO. 2 (–TTR SHOWN)

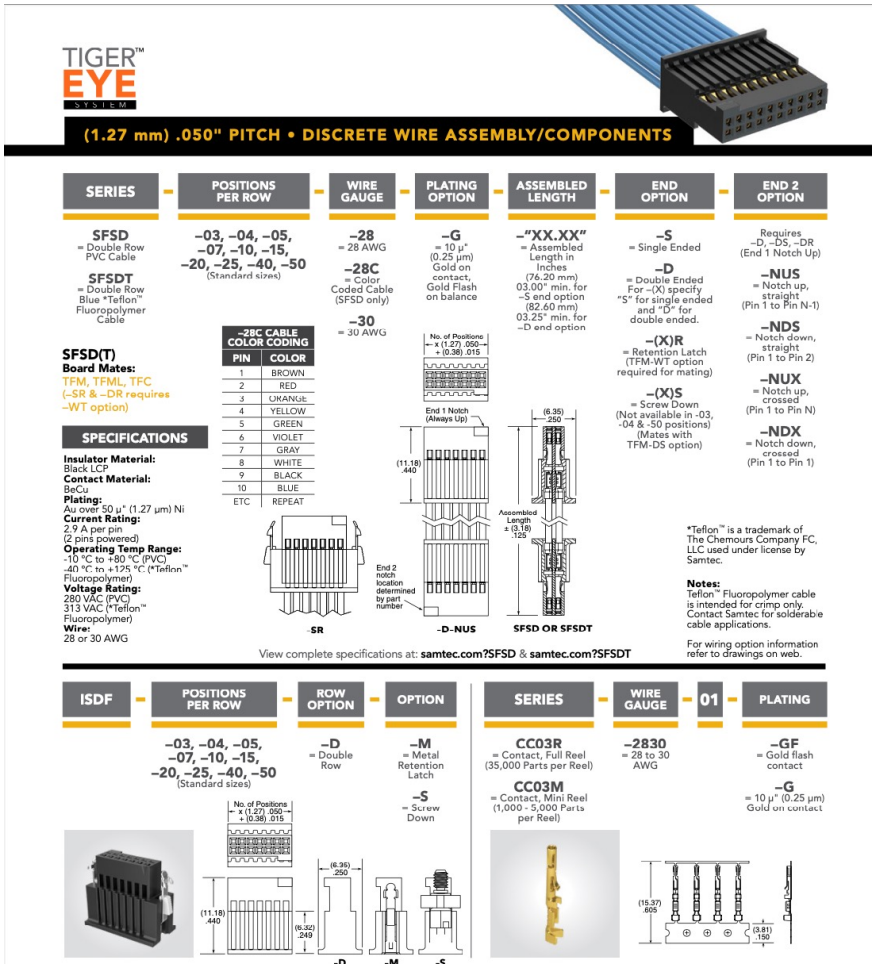
| WIRING REQUIREMENTS | |
|---|---|
| WIRING OPTION | END OPTIONS |
| 5 or 6 | TTR, TBL, STL, SBR, TEU, SED to TTR, TBL, STL, SBR, TED, SEU or TTL, TBR, STR, SBL, TED, SEU to TTL, TBR, STR, SBL, TEU, SED |
| 7 or 8 | TTR, TBL, STL, SBR, TEU, SED to TTL, TBR, STR, SBL, TEU, SED or TTL, TBR, STR, SBL, TED, SEU to TTR, TBL, STL, SBR, TED, SEU |

EYE® SPEED CABLE

**Notes:**
Cable lengths longer than 40.00" (1 meter) are not supported with S.I. test data.

Design your full cable assembly with Samtec's High-Speed Cable Solutionator® at www.samtec.com/cablebuilder

This Series is non-standard, non-returnable.



TIGER™ EYE SYSTEM

**(1.27 mm) .050" PITCH • DISCRETE WIRE ASSEMBLY/COMPONENTS**

| SERIES | POSITIONS PER ROW | WIRE GAUGE | PLATING OPTION | ASSEMBLED LENGTH | END OPTION | END 2 OPTION |
|---|---|---|---|---|---|---|
| SFSD = Double Row PVC Cable<br>SFSDT = Double Row Blue *Teflon™ Fluoropolymer Cable | –03, –04, –05, –07, –10, –15, –20, –25, –40, –50 (Standard sizes) | –28 = 28 AWG<br>–28C = Color Coded Cable (SFSD only)<br>–30 = 30 AWG | –G = 10 µ" (0.25 µm) Gold on contact, Gold Flash on balance | –"XX.XX" = Assembled Length in Inches (76.20 mm) 03.00" min. for –S end option (82.60 mm) 03.25" min. for –D end option | –S = Single Ended<br>–D = Double Ended For –(X) specify "S" for single ended and "D" for double ended.<br>–(X)R = Retention Latch (TFM-WT option required for mating)<br>–(X)S = Screw Down (Not available in -03, -04 & -50 positions) (Mates with TFM-DS option) | Requires –D, –DS, –DR (End 1 Notch Up)<br>–NUS = Notch up, straight (Pin 1 to Pin N-1)<br>–NDS = Notch down, straight (Pin 1 to Pin 2)<br>–NUX = Notch up, crossed (Pin 1 to Pin N)<br>–NDX = Notch down, crossed (Pin 1 to Pin 1) |

**SFSD(T)**
**Board Mates:**
TFM, TFML, TFC (–SR & –DR requires –WT option)

| –28C CABLE COLOR CODING | |
|---|---|
| PIN | COLOR |
| 1 | BROWN |
| 2 | RED |
| 3 | ORANGE |
| 4 | YELLOW |
| 5 | GREEN |
| 6 | VIOLET |
| 7 | GRAY |
| 8 | WHITE |
| 9 | BLACK |
| 10 | BLUE |
| ETC | REPEAT |

**SPECIFICATIONS**

**Insulator Material:**
Black LCP
**Contact Material:**
BeCu
**Plating:**
Au over 50 µ" (1.27 µm) Ni
**Current Rating:**
2.9 A per pin
(2 pins powered)
**Operating Temp Range:**
-10 °C to +80 °C (PVC)
-40 °C to +125 °C (*Teflon™ Fluoropolymer)
**Voltage Rating:**
280 VAC (PVC)
313 VAC (*Teflon™ Fluoropolymer)
**Wire:**
28 or 30 AWG

No. of Positions x (1.27) .050 + (0.38) .015

End 1 Notch (Always Up)

(11.18) .440

End 2 notch location determined by part number

(6.35) .250

Assembled Length ± (3.18) .125

–SR

–D-NUS

SFSD OR SFSDT

*Teflon™ is a trademark of The Chemours Company FC, LLC used under license by Samtec.

**Notes:**
Teflon™ Fluoropolymer cable is intended for crimp only. Contact Samtec for solderable cable applications.

For wiring option information refer to drawings on web.

View complete specifications at: **samtec.com?SFSD** & **samtec.com?SFSDT**

| ISDF | POSITIONS PER ROW | ROW OPTION | OPTION | SERIES | WIRE GAUGE | 01 | PLATING |
|---|---|---|---|---|---|---|---|
| | –03, –04, –05, –07, –10, –15, –20, –25, –40, –50 (Standard sizes) | –D = Double Row | –M = Metal Retention Latch<br>–S = Screw Down | CC03R = Contact, Full Reel (35,000 Parts per Reel)<br>CC03M = Contact, Mini Reel (1,000 - 5,000 Parts per Reel) | –2830 = 28 to 30 AWG | | –GF = Gold flash contact<br>–G = 10 µ" (0.25 µm) Gold on contact |

No. of Positions x (1.27) .050 + (0.38) .015

(11.18) .440

(6.35) .250

(6.32) .249

(15.37) .605

(3.81) .150

# 3.2) Cable Routing and Bundling

**Cabling options:**

Individual cables to nearby conversion boards then ribbon cable(s) out to edge of cassette and to FE boards, e.g.: short Hirose cables + longer ribbon cables

Other potential vendors:



# Preliminary task list for Electronics Group

- Select suitable SiPM
- Design SiPM board (connector interface)
- demonstrate single coax cable per channel with AC coupling
- Identify cable options and perform tests (routing interface)
- LED light injection (connector interface)
- Identify FE electronics housing/crates (magnet interface)
- Check CAEN electronics features
  - SiPM spectra in timing mode,
  - trigger rates and deadtime
  - Trigger configurations
  - Integration of LED pulsing
  - …

# Summary/Outlook

- Many questions and unspecified parameters exist
- Used conceptual approach to readout 19,200 TMS WLS fibers/scintillators to start discussion of layout and interfaces

- Interfaces and preliminary list of options
  - Options for FE-electronics locations → need input
  - SiPM to scintillator → need input
  - Cable routing and types in TMS module cassette → only brought forward some ideas to solicit feedback and narrow options before being able to identify candidate cables

- Meant as start of discussion and to collect external constraints