ePIC SVT WP3 Electrical Interfaces Meeting

October 10, 2024

Multilayered multicomponent FPCs from LTU for ePIC SVT: some features of SpTAB and current status/updates

RPE LTU:
Vyacheslav (Slava) *Borshchov*
Ihor Tymchuk (responsible, speaker)
Maksym Protsenko

viatcheslav.borshchov@cern.ch, ***ihor.tymchuk@cern.ch***

Outline

- Brief updates on LTU's activities for ePIC SVT
- Delivered ePIC SVT L4 FPC: some comments
- Some features of SpTAB:
  - equipment
  - pull-strength measurements
  - SpTAB test elements
  - wedges for SpTAB
  - some features of aligning during SpTABing
- Possible next steps
- Conclusions

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

Brief updates on LTU's activities for ePIC SVT

- ePIC SVT OB:

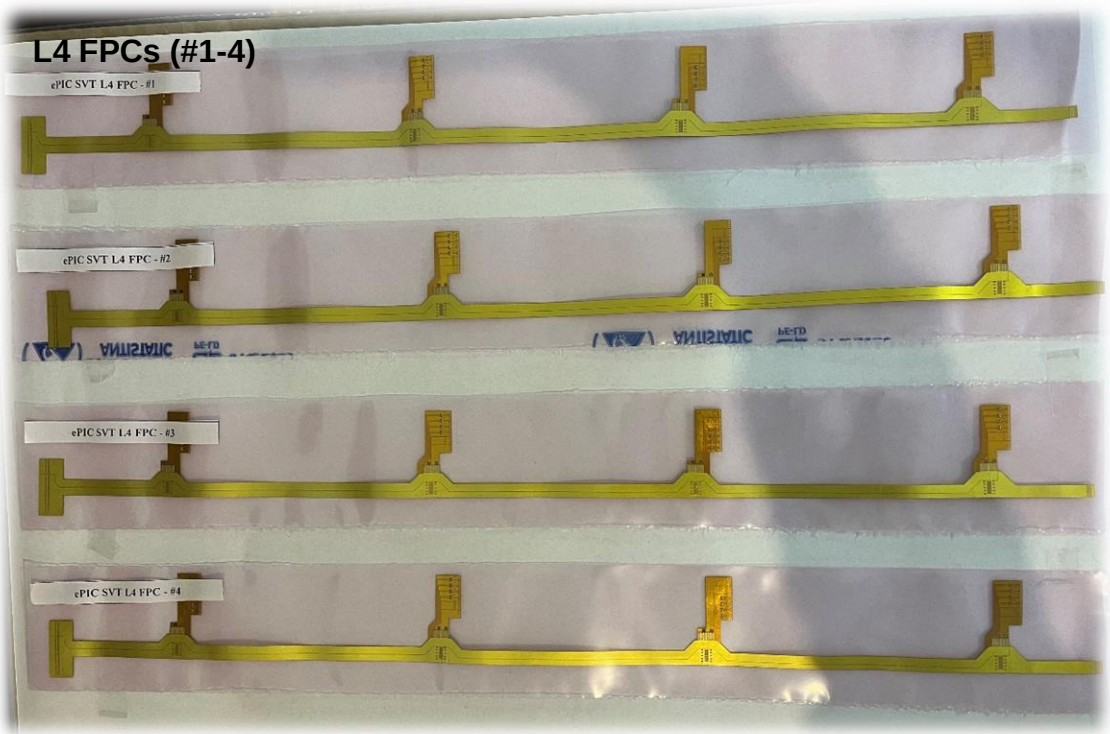
  Prototypes of ePIC SVT L4 FPCs delivered to STFC DL (this week)

- ePIC SVT Disk:

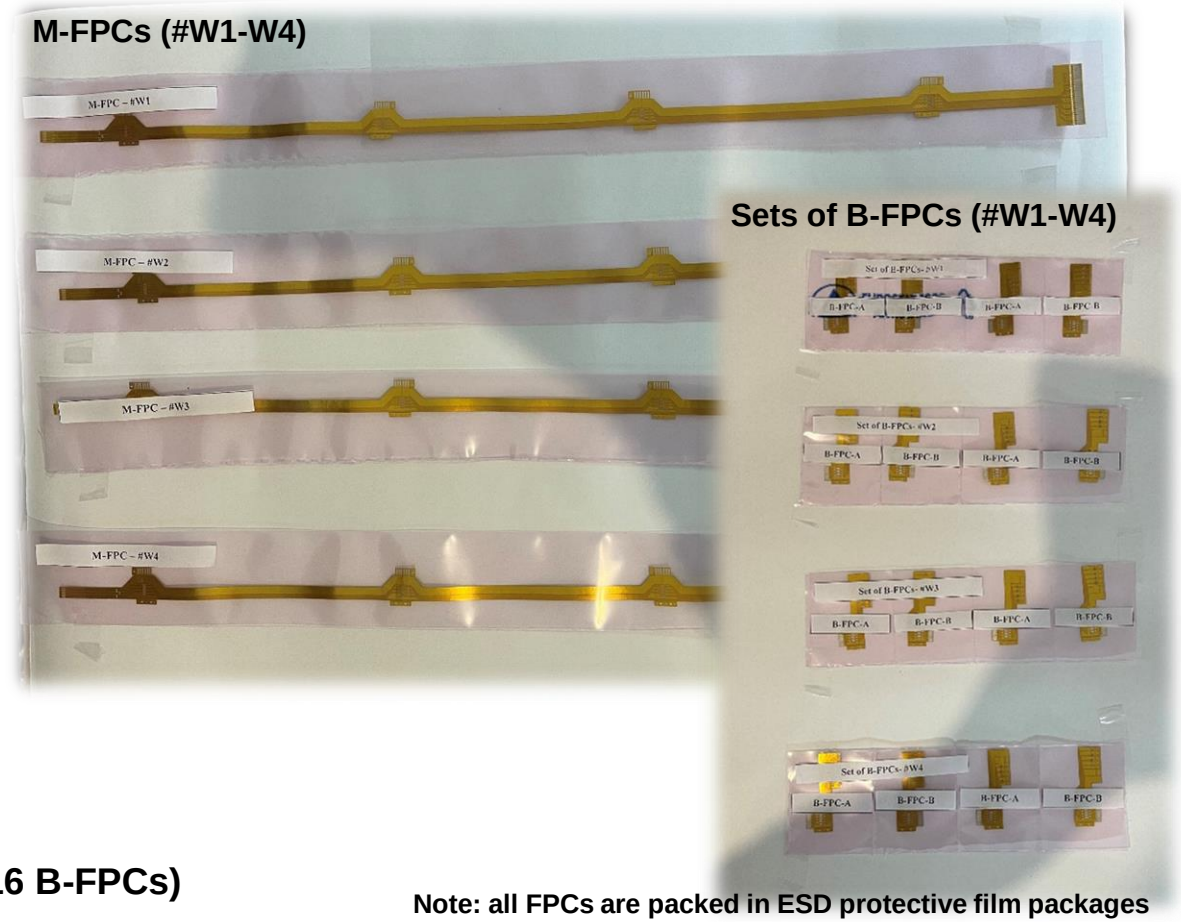
  Preliminary/first dedicated meeting with Zhenyu, Nikki and Zhengwei (held last week)

ePIC SVT L4 FPC prototypes and sets of FPCs shipped to STFC DIL

Assembled multilayered multicomponent ePIC SVT L4 FPC prototypes



Sets FPCs for ePIC SVT L4 FPC prototypes



Delivered FPCs:

- **4 prototypes of assembled ePIC SVT-L4 FPC**
- **4 sets of FPC prototypes for ePIC SVT-L4 FPCs (4 M-FPCs+ 16 B-FPCs)**

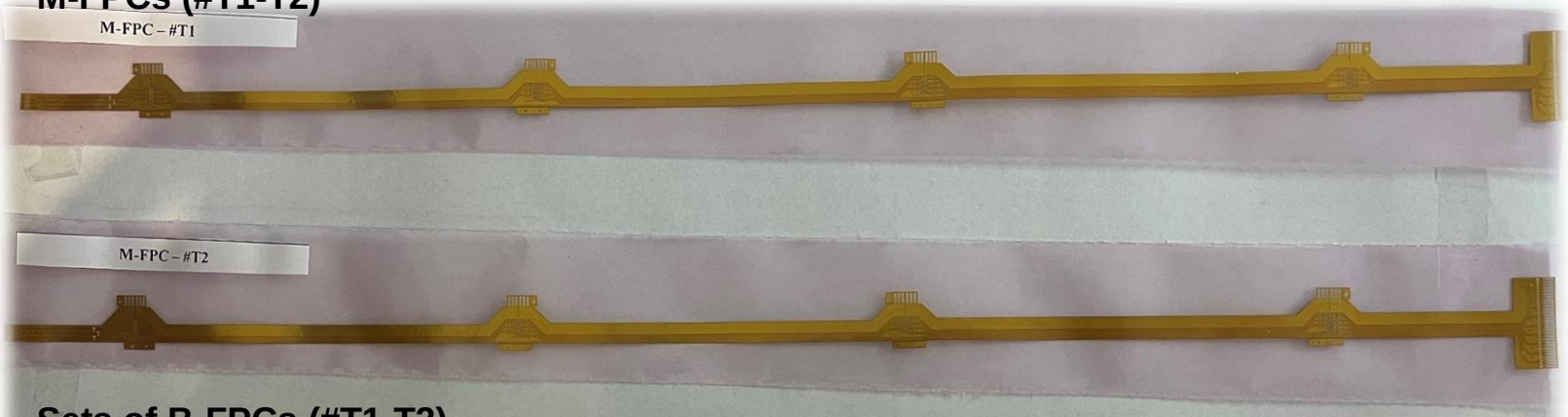
Note: all FPCs are packed in ESD protective film packages

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

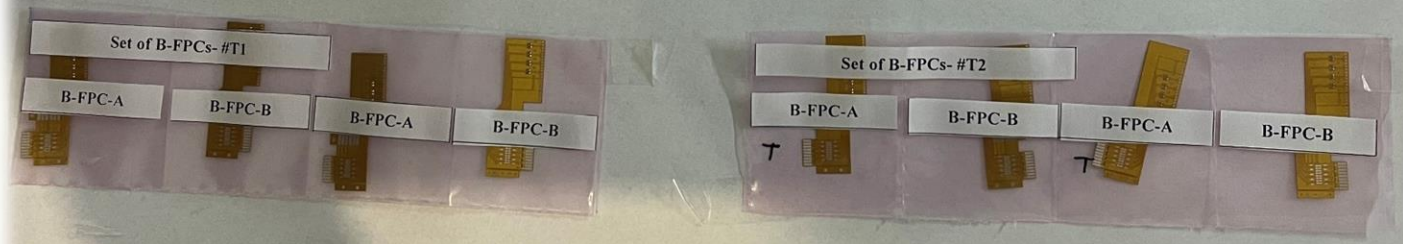
Additional (test) FPCs shipped to STFC DIL

Additional Test FPCs delivered for SpTAB tunning, test procedure/fixture tunning etc.

M-FPCs (#T1-T2)



Sets of B-FPCs (#T1-T2)



SpTAB tests

Additionally delivered:

- ✓ **M-FPC – 2pcs**
- ✓ **B-FPCs – 2 sets (4x2 B-FPCs)**
- ✓ **SpTAB test elements – (~70pcs)**

Important notes:

- ✓ M-FPC – OK (only a bit imperfectness in interlayer aligning presents)
- ✓ B-FPCs – 6 pcs are OK , only 2pcs are NOK (marked by letter T)

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

Equipment/ultrasonic wedge bonders for SpTAB

Ultrasonic Bonders for SpTAB

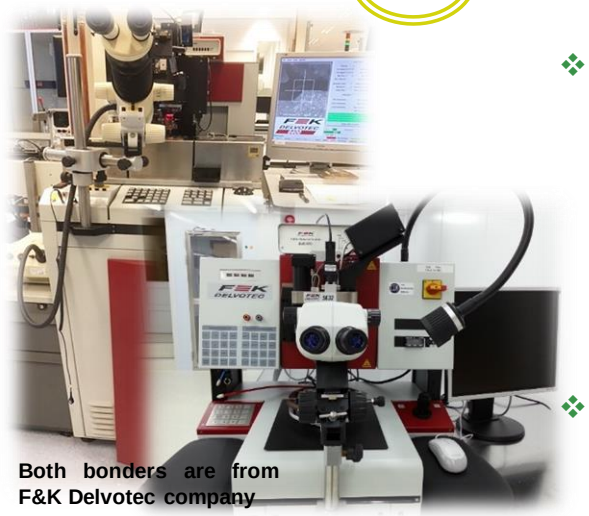
(preferable to have in lab)

- ✓ **Automated wedge bonder**
- ✓ **Semi-automated/manual bonder**

for

- SpTABing FPC to LAS/PCB
- SpTAB joints repairing (if needed)

Note: Automated bonder: it is preferable if bond head is movable in X-Y-Z and rotatable and objects for bonding are fixed (unmoved) – realized e.g. in Delvotec bonders (in some e.g. Kullicke&Soffa and other bonders bond head is realized as only rotatable but objects for bonding are movable in X-Y-Z)



Both bonders are from F&K Delvotec company

Tuning bonders to SpTAB

- **Automated wedge bonder (e.g. Delvotec G4) is not too complicated (if bonder typically is using for wire bonding):**
  - ***Change wedge***
  - ***Software – excluding using second bond (all parameters are 0 or minimal values)***
  - ***Bonder – removing/disconnecting wire clamps on bond head (removing might be needed at production stage, at R&D stage only disconnecting might be sufficient)***
- **Semi-automated/manual wedge bonder is very easy**
  - ***Change wedge***

Tuning automated bonder (Delvotec G4): possible steps and time

1. **Changing wire wedge on SpTAB wedge** – 5-10 min
2. **Loading SpTAB program** – 1-2 min
3. **Aligning SpTAB wedge (Correct Offset mode for Delvotec G4 bonder)** – 15-20 min
4. **Checking/verifying bond parameters (early defined)** – 10-30 min

Labs were SpTAB implemented/using (used in the past)

- ✓ ***GSI /FAIR – CBM-STS & STRASSE***
- ✓ ***Uni Heidelberg – Mu3e***
- ✓ ***Uni Oxford – Mu3e***
- ✓ ***Uni Mainz/Uni Bochum – PANDA***
- ✓ ***Uni Helsinki – ALICE ITS1***
- ✓ ***INFN -Turin – ALICE ITS1***
- ✓ ***…***

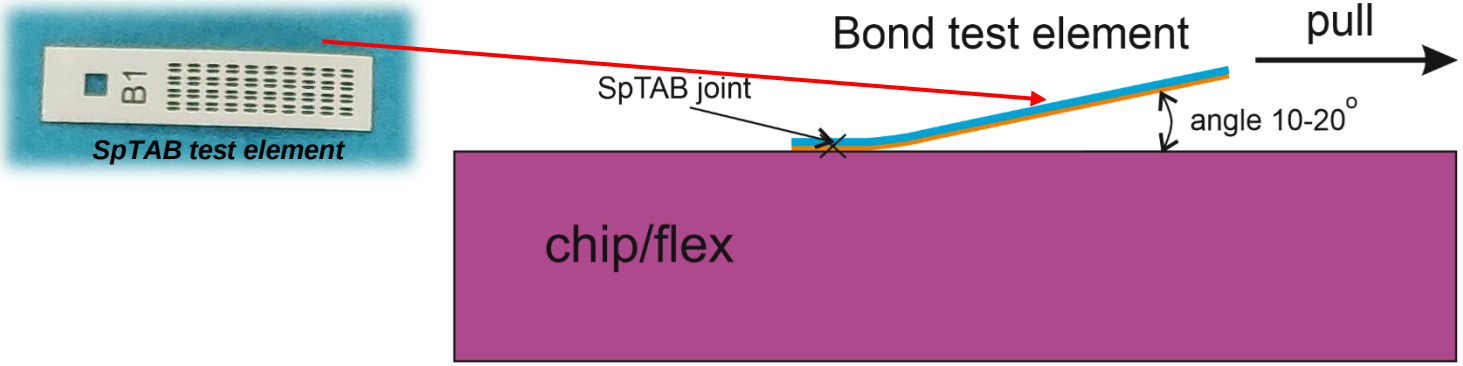
Outcomes:

- **Tuning bonders to SpTAB is not too difficult and combining SpTAB activities with other ,,wire-bond,, activities is possible**
- **Total time for tuning automated bonder (Delvotec G4) from wire bonding to SpTAB - 30-60 min (when process is worked-off)**

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

SpTAB: pull-strength measurements

- Pull-strength for SpTAB joins measuring approach



SpTABed traces

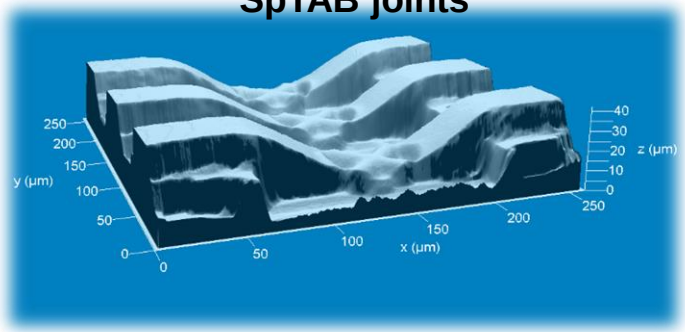
Bond area after pulling test element

SpTAB joints are good quality when small pieces of aluminium are remaining on contact pads after pull tests

- For measuring pull-strength of SpTAB joins can be used:
  - Manual tester (grammometer)
  - Portable tester
  - Industrial wire pull-tester (Delvotec, Bondtec, EMEA etc.)

pull-strength testers

SpTAB joints

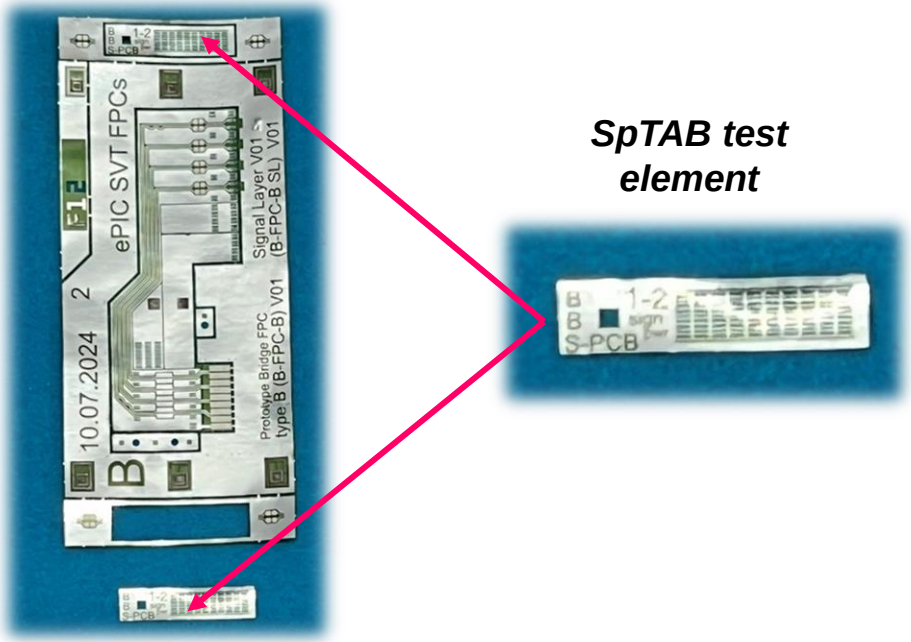


Note: figs are from ALICE ITS1 project (HIP, Helsinki)

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

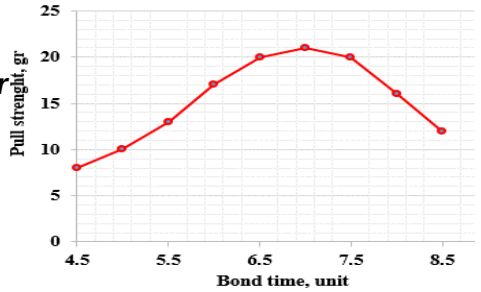
SpTAB test elements for investigating/checking bond parameters

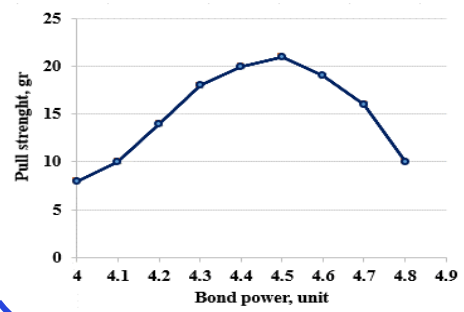
- ***For SpTAB need to be done investigating and verifying bonding parameters***
- ***For this purpose special bond test elements are using*** *(same trace width as in bond area)*
- ***Bond test elements are made of same material as object for bonding*** *(top and bottom layers of multilayered flex)*
- ***Bond parameters need to be investigated/verified for each/different bonder***

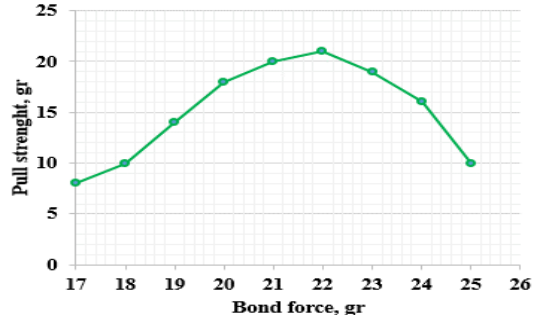


SpTAB test element

Examples of dependencies of pull strength on bonding parameters for SpTAB bonds of FPC (LTU-15-10) + MAPS chip, trace width 120um (for semi- automated bonder UZSM-type)



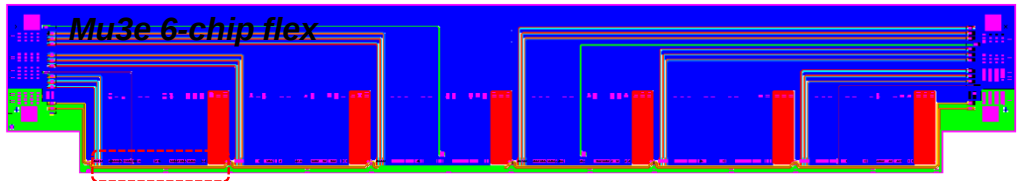




Note:
typically SpTAB test elements are delivering together with FPCs

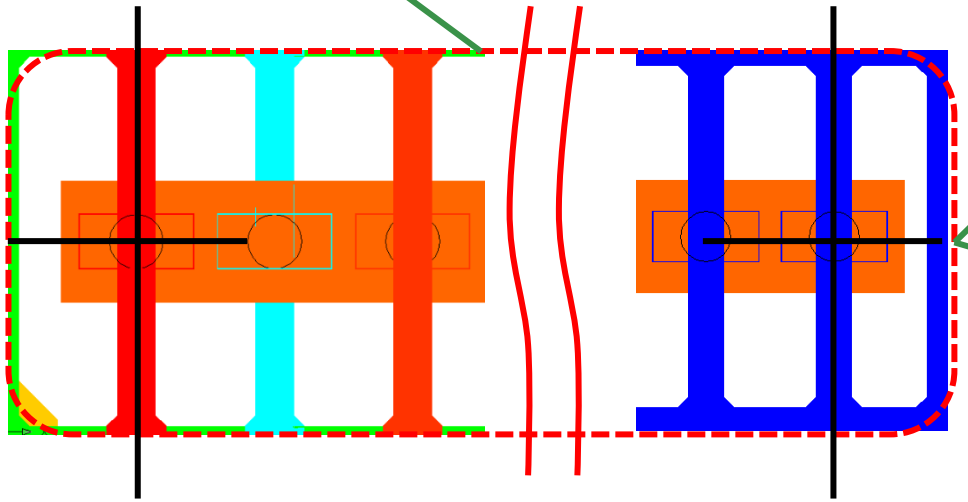
viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

Some features of aligning during SpTABing single layered flexes using automated bonders



Single chip area

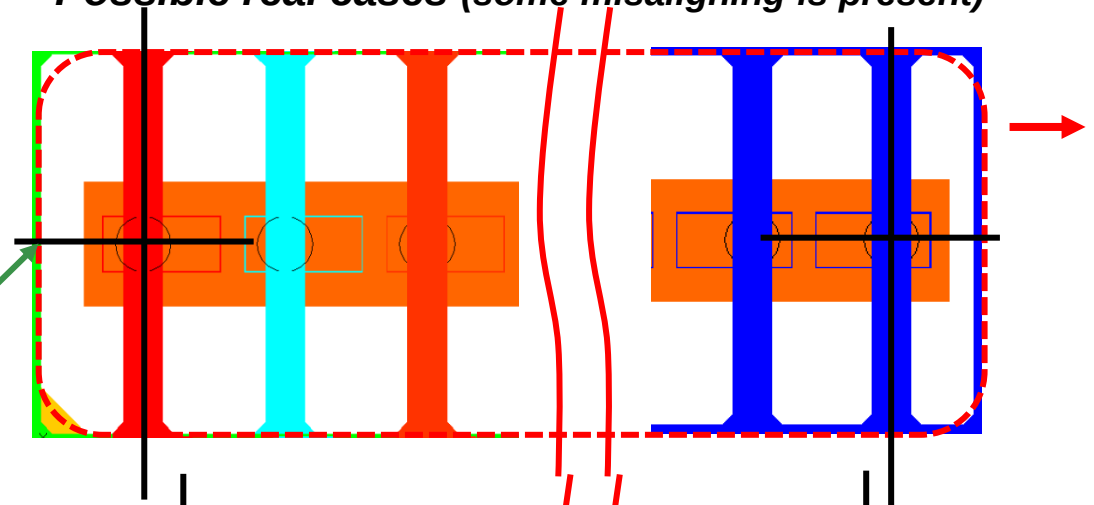
Ideal case
(misaligning is absent)



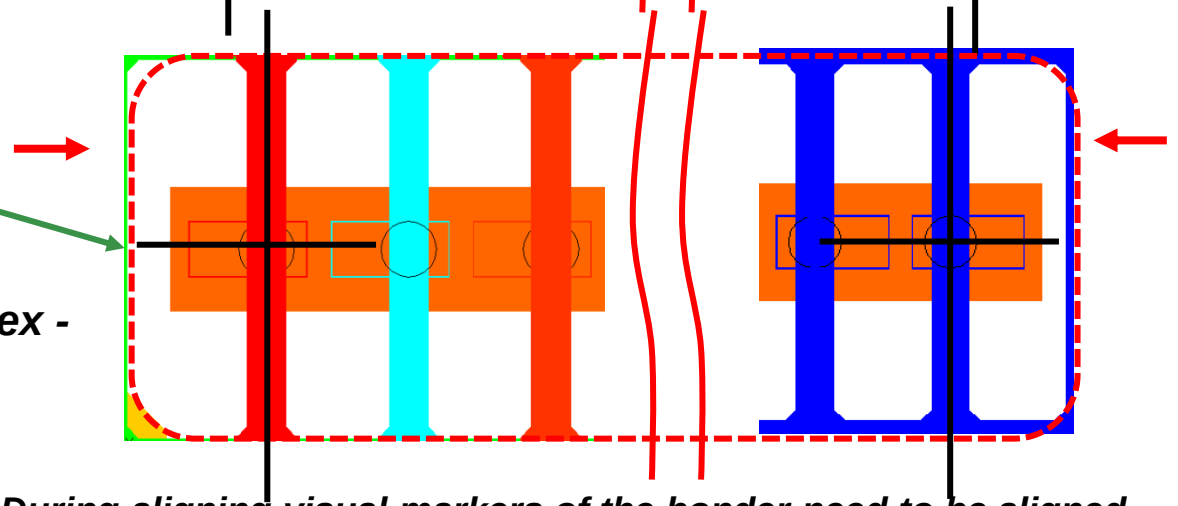
During aligning visual marker of the bonder need to be aligned precisely in the <u>centers of contact pad/trace</u> (centers of traces and contact pads coincide)

Possible real cases (some misaligning is present)

Flex +



Flex -

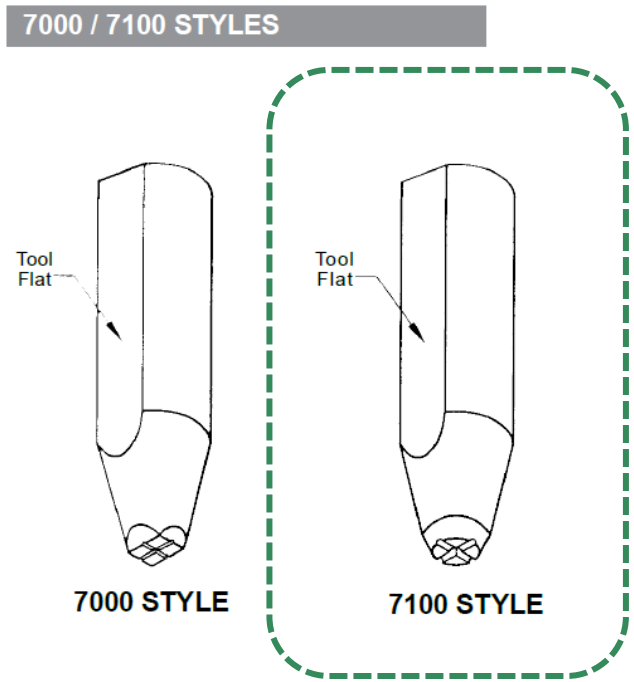


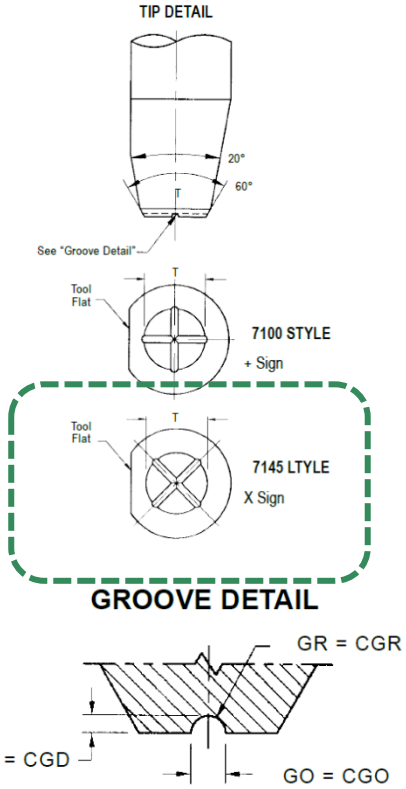
During aligning visual markers of the bonder need to be aligned precisely in the centers <u>of traces</u> (not of the contact pad)

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

Wedges/tools for SpTAB

- For SpTAB preferable to use Double Cross Groove Single-Point TAB Tool
- Different wedges from GaiserTool (Corstek), SPT and some other suppliers were investigated in the past
- 1183 series wedges from GaiserTool (Corstek) were preferable but now Gaiser company isn´t existing anymore
- But SPT company has taken over some of their products





STANDARD DIMENSIONS

7000, 7045 Tool Style			7100, 7145 Tool Style	
W/FL	Foot Wifth W in / *µm* ±.0002/*5*	Foot Length FL in / *µm* ±.0002/*5*	T	Tip Diameter T in / *µm* ±.0002/*5*
4025	.0040 / *102*	.0025 / *64*	0030	.0030 / *76*
4030	.0040 / *102*	.0030 / *76*	0035	.0035 / *89*
4035	.0040 / *102*	.0035 / *89*	0040	.0040 / *102*
4040	.0040/ *102*	.0040/ *102*	0045	.0045 / *114*
5030	.0050 / *125*	.0030 / *76*	0050	.0050 / *125*
5035	.0050 / *125*	.0035 / *89*	0055	.0055 / *140*
5040	.0050 / *125*	.0040 / *102*	0060	.0060 / *152*
5045	.0050 / *125*	.0045 / *114*	0070	.0070 / *178*
5050	.0050 / *125*	.0050 / *125*		
5055	.0050 / *125*	.0055 / *140*		
6045	.0060 / *152*	.0045 / *114*		
6050	.0060 / *152*	.0050 / *125*		

FPC-to-LAS/PCB
(trace width 65-70um)

Information from https://www.smallprecisiontools.com/

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

Possible LTU's next steps

- ePIC SVT L4 FPCs:
  - *Expecting test results from STFC team*
  - *Creating next iteration of the L4 FPCs (end of this year/early next year)- tbd*

- ePIC SVT Disk FPCs:

Continue and development of discussions/cooperation on FPCs with Disk team:

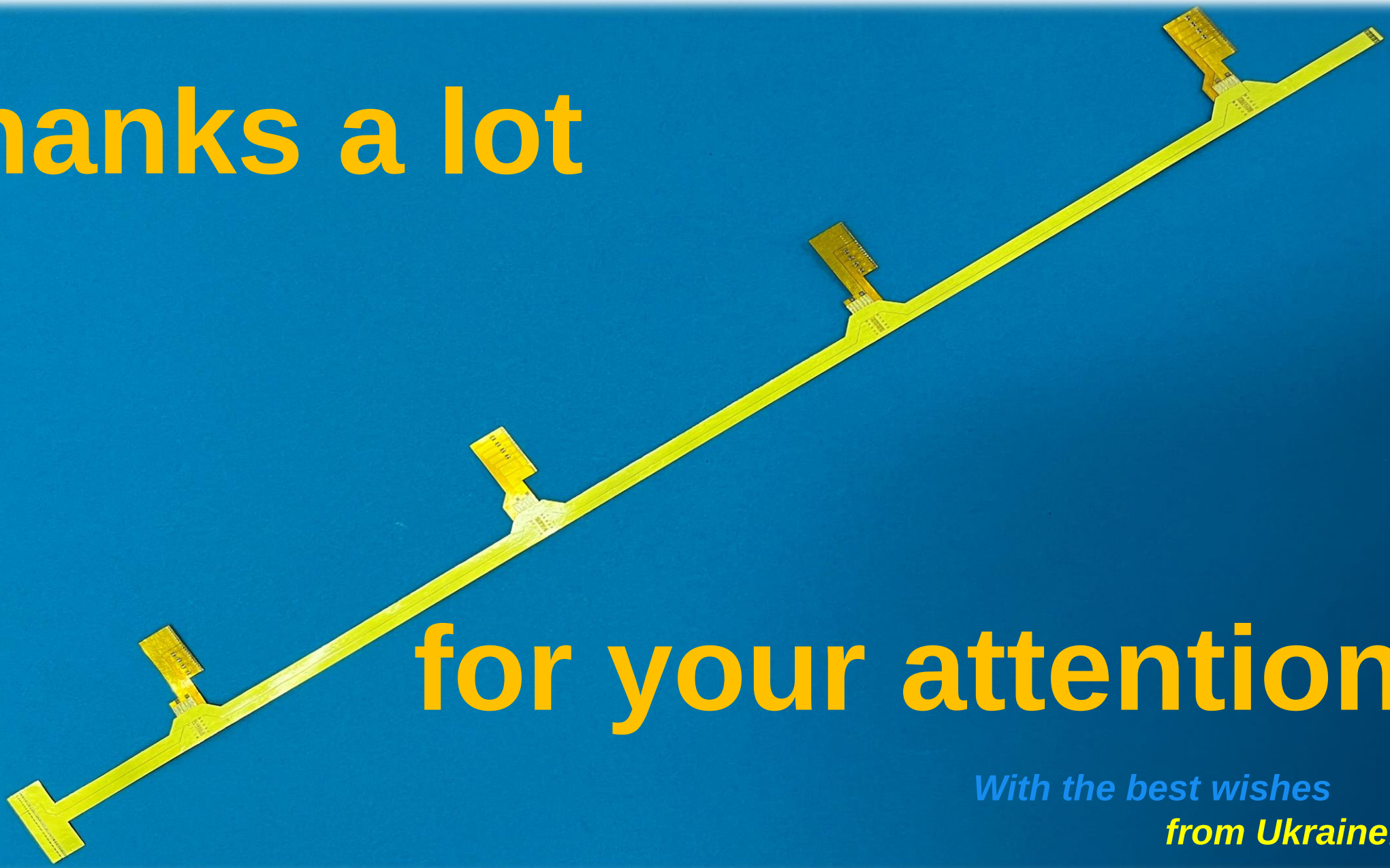
- *Receiving/considering preliminary design/layout of the Disk FPC*
- *Preparing proposal on possible realization of the FPC*
- *Discussing and agreeing approach and preliminary design*
- *Creating technological FPCs*
- *Creating and delivery prototypes of the Disk FPCs*

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

Conclusions

- The first prototypes of ePIC SVT L4 FPCs and sets of FPCs are delivered to STFC-DL
- The first/preliminary meeting with ePIC SVT Disk team dedicated to Disk FPC preliminary discussion held last week
- For SpTABing FPCs standard wedge wire bonders can be used. Tuning bonders to SpTAB is not too difficult and combining SpTAB activities with other ,,wire-bond,, activities seems possible and acceptable
- Possible next steps/activities of LTU for ePIC SVT are defined and proposed

Thanks a lot



for your attention!

With the best wishes
from Ukraine!

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

Back-up slides

Some features & advantages of „full-aluminium" approach

Features:

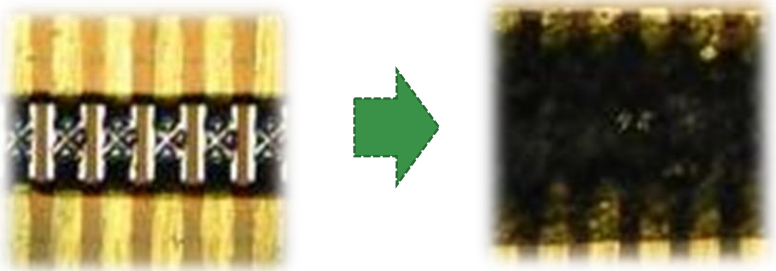
- *Materials for the components:*
  - *conductive layers -* *aluminium-polyimide adhesiveless foiled dielectrics*
  - *dielectric spacer –* *Kapton or polyimide*
- *Layers manufacture techniques:* *photolithography &chemical wet etching*
- *Assembly techniques:* *SpTAB&gluing*

Advantages:

- *conductive layer **is aluminium***
- ***lower material budget** (compared to Cu)*
- ***absence of heavy metals** (Au, Sn) on the flex and on the chip (soldering is not needed)*
- *connection of aluminium leads of the flex to aluminium contact pads of the chip that ensure **high-reliable and mechanically stable connections**;*
- *possibility to realize **3-D (volumetric) design** of the module/component*
- *approach **is verified** in practice in existing ALICE ITS strip and drift detector modules*
- *high-precise and high-throughput standard **automated equipment** can be used for assembly (Delvotec G4, G5 bonders etc.). Tune of the bonder is very simply and can be done in few hours!*

Some features of assembly process

Main process at assembling components of modules is an ultrasonic Single point TAB bonding (SpTAB, manual or automatic) of aluminium traces to aluminium contact pads on chip, sensor or flexible cable with further encapsulating by glue

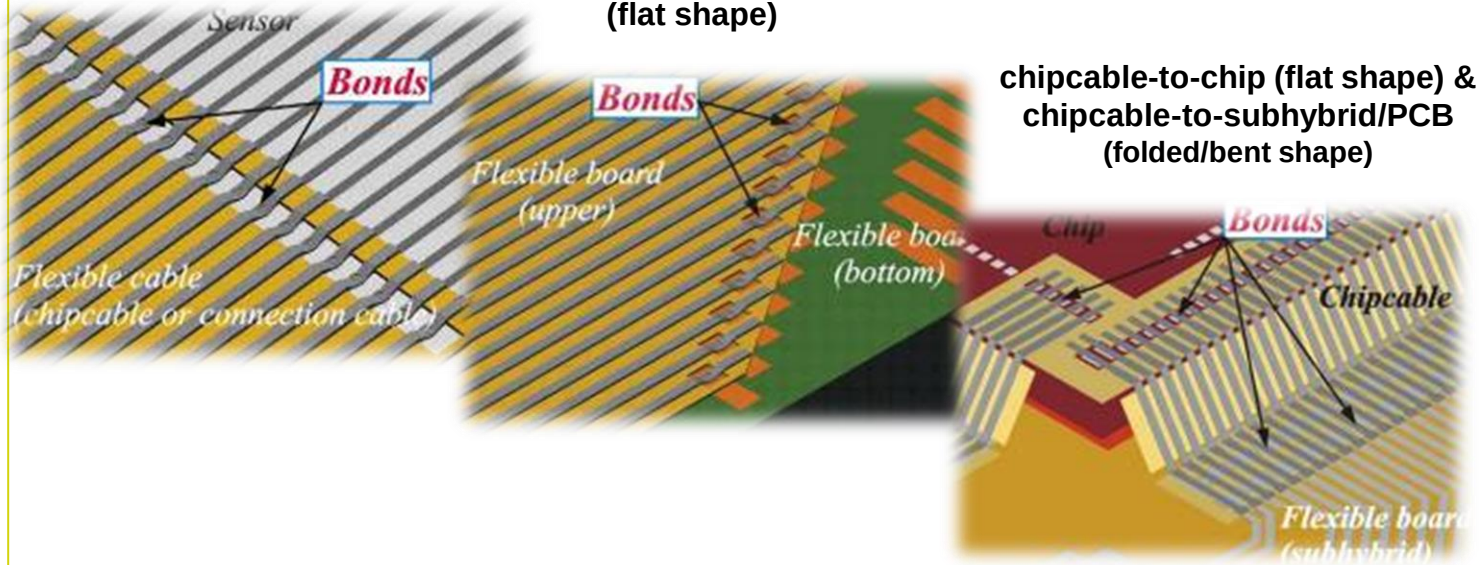


Schematic close-up views of some various SpTAB areas

FPC-to-sensor (flat shape)

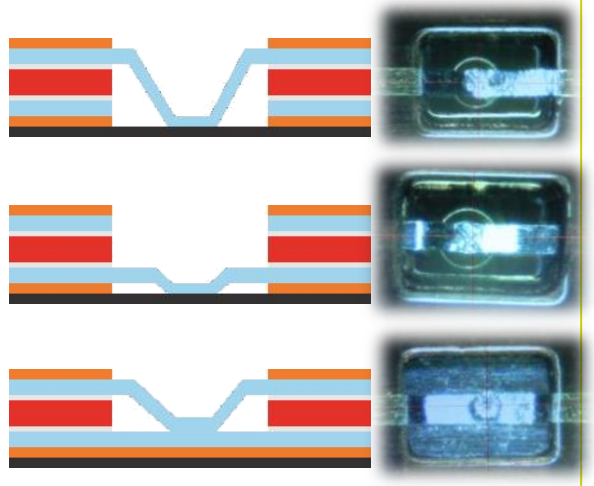
FPC-to-FPC (flat shape)

chipcable-to-chip (flat shape) & chipcable-to-subhybrid/PCB (folded/bent shape)



Typical SpTABed joints

- ***top layer-to-chip***
- ***bottom layer-to-chip***
- ***interlayer connection***



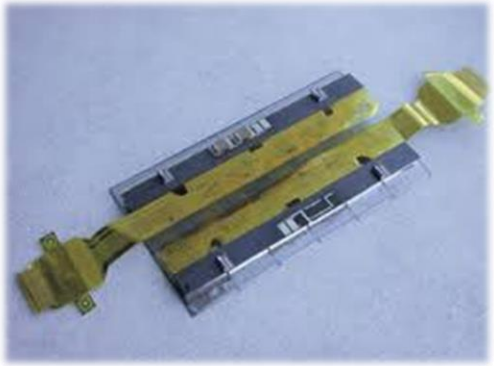
Note: SpTAB technique allows to have two times less bonds (comparing to wire bonding) - higher reliability

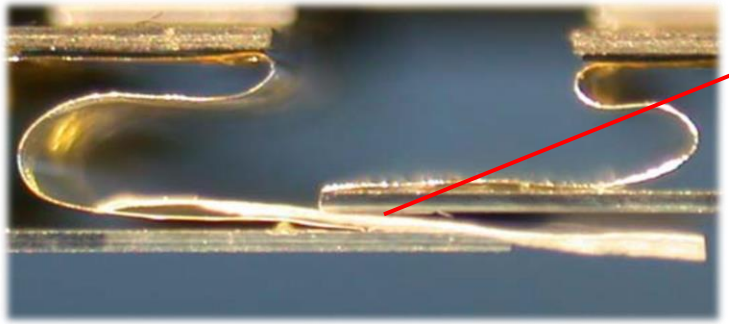
viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

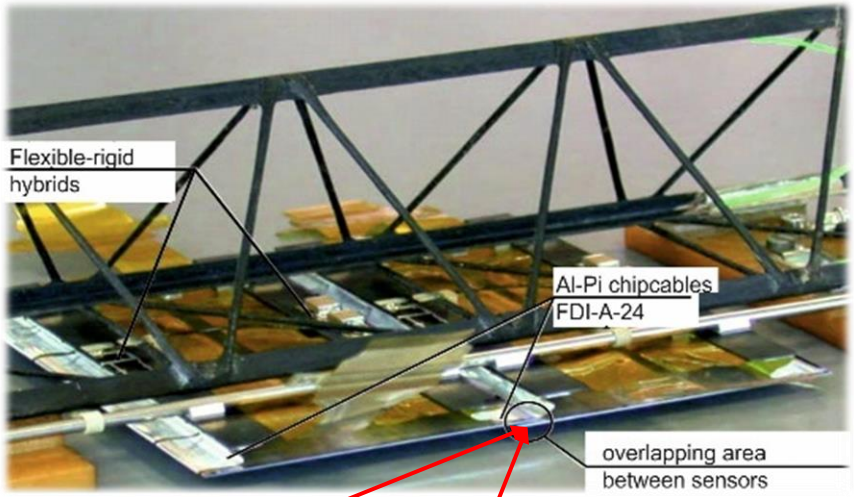
3-D (volumetric) approach realized by LTU's FPCs: ALICE ITS1

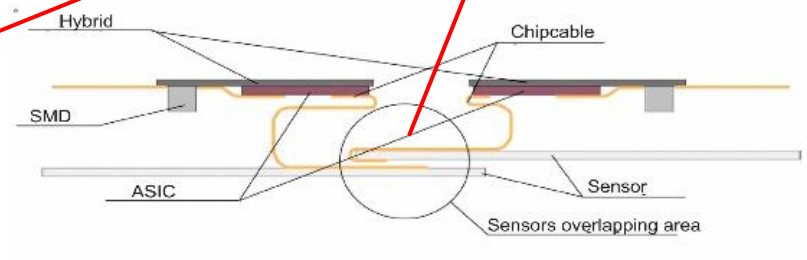
Bent microcables have been used for creating ALICE ITS SSD and SDD modules

ALICE ITS SSD







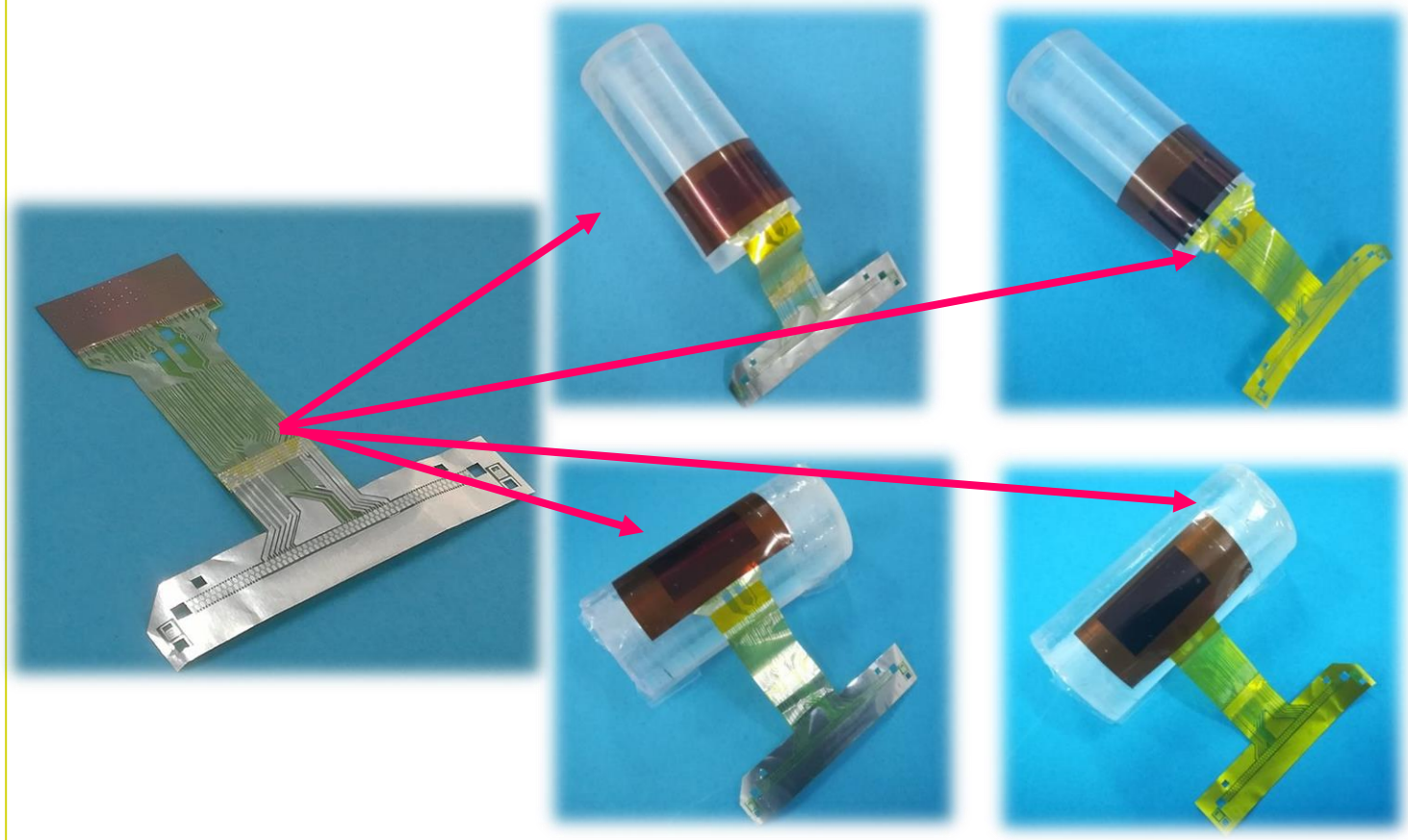


Note: activity performed in close cooperation with CERN, Uni Utrecht/NIKHEF, Uni Helsinki, INFN-Turin

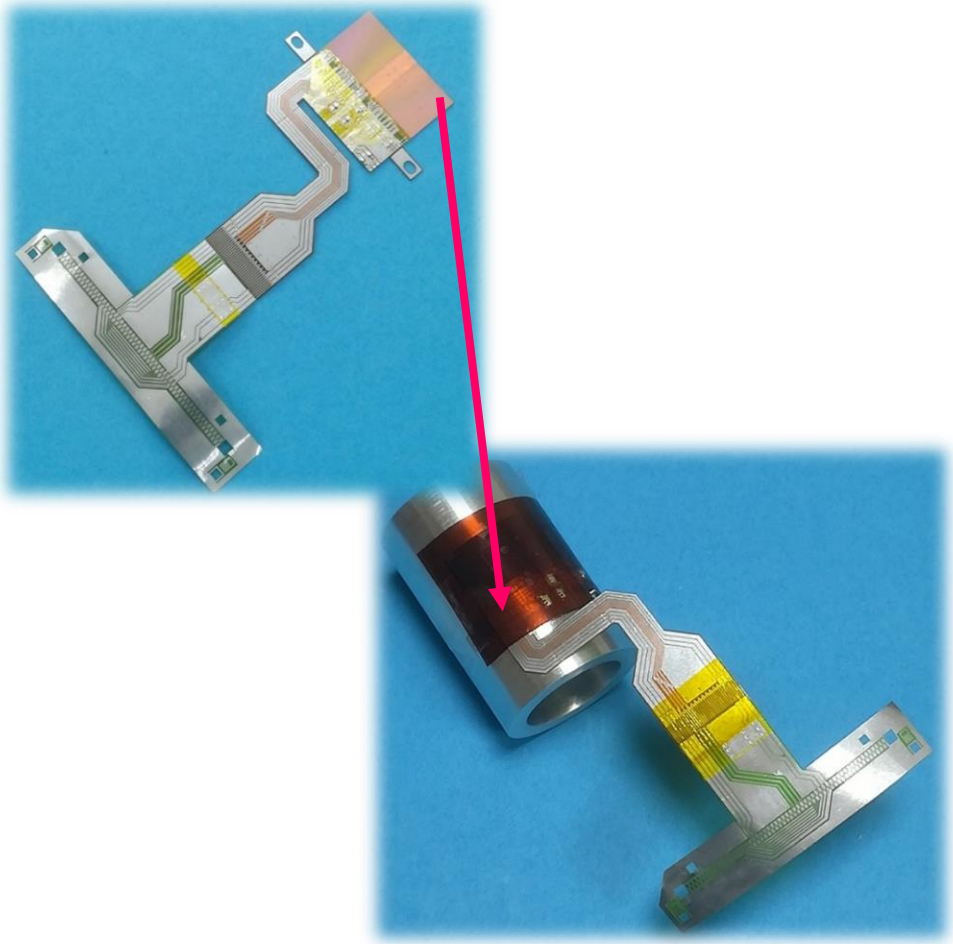
viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

3-D (volumetric) approach realized by LTU's FPCs: ALICE ITS3 prototypes

SpTAB chipcable assembly with ALPIDE chip



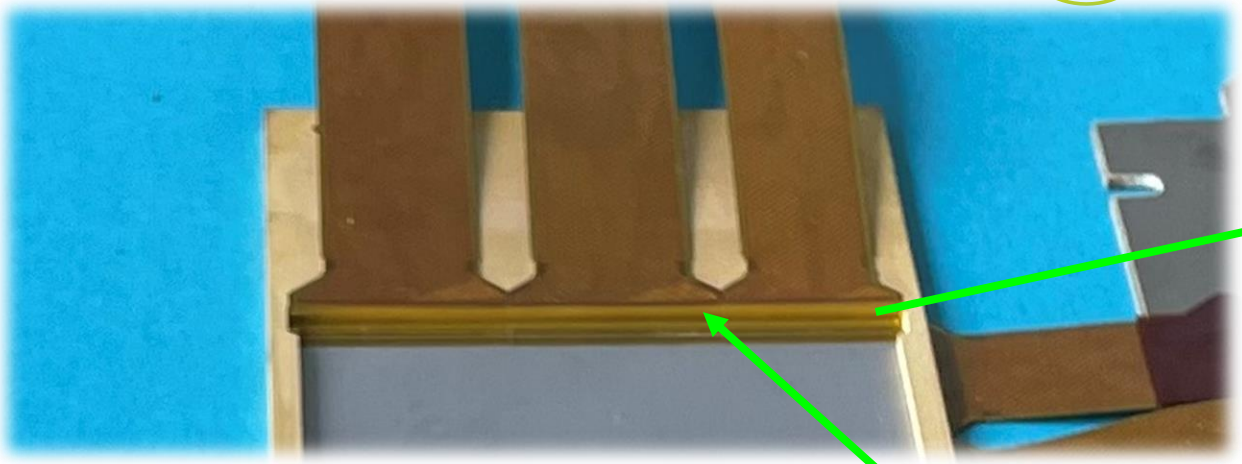
SpTAB single-ALPIDE prototype



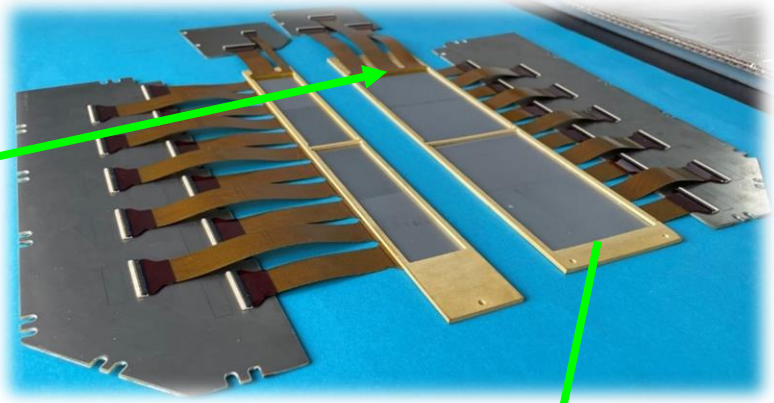
Note: activity performed in close cooperation with CERN, Uni Bergen, Uni Utrecht/NIKHEF

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch

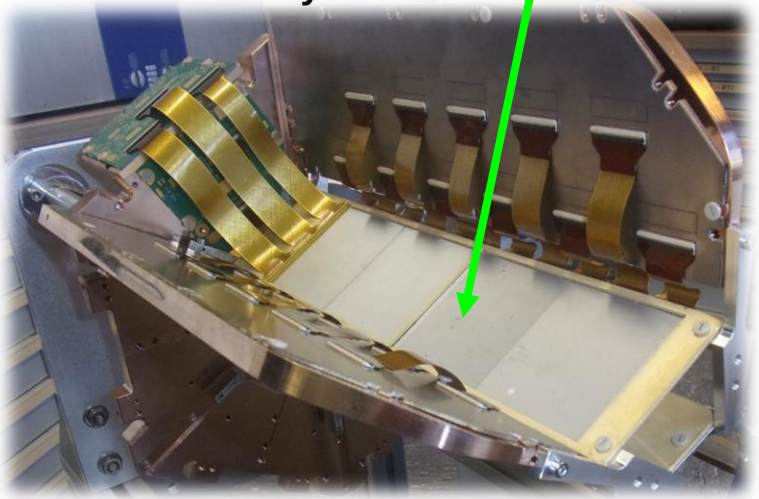
3-D (volumetric) approach realized by LTU's FPCs: STRASSE

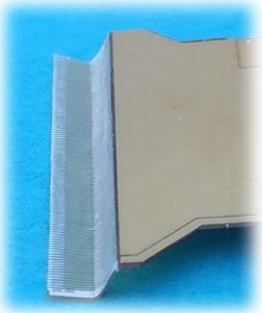


Flat (unfolded) dummy modules

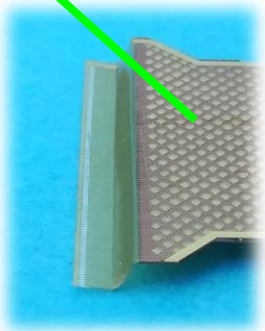


Part of STRASSE detector with folded dummy modules





Folded/bent FPC/microcable



Note: activity performed in close cooperation with Tech Uni Darmstadt, GSI, LPC CEAN

viatcheslav.borshchov@cern.ch, ihor.tymchuk@cern.ch