



Inner Tracker for SCTF: status and perspectives

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The Novosibirsk Super Charm-Tau Factory Detector







CREMLIN PLUS







Number of background tracks in TPC acceptance (R=3 - 20 cm) within 6 µs



4





Plot #12

10

15

28



-15

≥ 25

TPC studies^{max deviations [1m]}

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10	386	657	875	885	878	841	748	675	577	504	519	430	454	Gas	Gas mixture	Ε,	dn _e /dx,	t _{drift} , s	IBF	Max
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	344	622	701	725	713	676	589	502	439	397	360	335	314							mm
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	153	486	560	563	531	485	423	396	320	282	277	238	227	Ar+1	0%CH ₄	125	90	0.14	1%	94
	285	446	480	483	457	420	361	314	264	229	236	192	197							
	259	311	399	392	365	320	294	230	211	178	161	149	147	Ar+1	Ar+10%CH ₄ + 10%CF ₄		90	0.03	1%	5.0
5	201	307	323	320	415	360	214	184	151	139	123	112	105	10%						
	176	251	243	242	217	190	152	167	114	93	86	77	74		500	90 0.03	0.03	2%	15 1	
	116	163	169	155	145	129	100	105	73	62	56	48	47	AI+10%CH ₄ +			370	13.1		
	63	101	102	96	82	74	59	47	39	32	29	27	25	10%	CF4					
	36	41	39	35	32	28	20	18	15	12	1,1	10	9	Ar+1	5%C₄H ₁₀	1000	112	0.02	1%	2.1
		6	1	8	10	0	1	12		14	-	16		18 +40%	6CF4					
		-		_		_		_						Ar+1 +40%	5%C ₄ H ₁₀ %CF ₄	1000	112	0.02	3%	6.2

High-voltage side



Simulation of spatial resolution in TPC





Garfield++

30 cm of drift

Diffusion and spread of avalanches in 4GEM

Gases:

- Ar+10%CH₄ fast drift at the lowest field, 6 cm/μs at 125 V/cm
- Ar+10%CH₄+10%CF₄ the fastest at moderate field 500 V/cm
- Ar+15%iC₄H₁₀+40%CF₄ the best spatial resolution

Optimal pad size is below 1 mm! We must use InGrid or GEMGrid (pixel chip looking in gas volume with amplifying structure on top)



Status of the TPC prototype









The Cylindrical u-RWELL



The two schemes under study are both based on a B2B layout (a double radial TPC – with a central cathode), characterized by low material budget and modular roof-tile shaped active device

micro-TPC readout mode allowing space resolution of O(100 μm) for inclined tracks

(on the radial view)

"2 - B2B small drift gap" cylindrical detector



N.2 small gap B2B C+layers \rightarrow 1.72% X0 2 × 1 cm gas gap/B2B device 4 cm global sampling gas



"1 - B2B large drift gap" cylindrical detector



N.1 large gap B2B C+layers → 0.86% X0
2 × 1 cm gas gap/B2B device
10 cm global sampling gas











To validate the concept we are designing a single-layer small drift-gap (1 cm) C+RWELL prototype



- From standard **micro-RWELL technology on rigid PCB supports** we are • developing a full flexible detector tile
- **Three of such flexible detector tiles** will be **glued** on **composite/foam roof-tiles**, • then mounted on the **anode cylindrical support**
- A full cylindrical-cathode will close (externally) the detector •



Prototype size

- external diameter ≈20cm
- global length ≈ 100cm •
- active length≈ 60cm





Detector Readout - 1D (present)



Roof tile detector prototype (1D – readout)



Tile detector (1-D)

Strips (1-D)

- Number : 256 X
- Pitch : 0,680 mm
- Width : 0,200 mm

Tails

HV side

- n. 2 for signals
- n. 4 for HV

HV sectors : 4

Global size

- Length : 890 mm
- width: 175,8 mm

Active area

- Length : 600 mm
- width : 174,8 mm

DLC area: $620 \times 175,8 \text{ mm}$



1500₁

13 gradi

30 35

 Angolo (gamma)

70 75 80

Z resolution

Detector Readout – 2D (future R&D)





Assuming $\sigma_x / \sigma_{U-V} \sim 100 \,\mu m$ for the single view (X or U/V), the Z-space resolution depends on the stereo angle.

For $\theta \sim 13^\circ$: for XV ($\sigma_7 \sim 600 \,\mu$ m) – while for UV ($\sigma_7 \sim 300 \,\mu$ m)



Cremlin+ \rightarrow the C+RWELL progress (I)



Boards assembly @ LNF

- Signal Interface board, from HIROSE to PANASONIC
- HV board Interface
- HV Filter board
- HV distribution board













Cremlin+ \rightarrow the C+RWELL progress (II)



The design of the prototype has been completely revised and finalized

• Orders of **flex-detector tiles** (CERN − Rui) done → delivery by the end of November

DONE

DONE

DONE

DONE

- Orders of mechanics/tools (anode/cathode, end-caps, plugs, tiles) done → construction in progress (@LOSON):
- anode mould
- cathode mould
- end-caps/plugs in peek →
- tiles (still) under test ightarrow
- HV, signal interface boards ightarrow
- Detector assembly \rightarrow

DONE Nov – Dec 2021















The C+RWELL simulations



- Inserted 2 small gap back-to-back C+RWELL in DD4HEP framework for SCT detector simulation
- Soft pions studies: momentum threshold for hits in C+RWELL

GEANT4

• Detector response parametrization to be refined with data from recent test beam







Conclusions



- The super Charm-tau farm detector will be equipped with an Inner Tracker based on TPC or cylindrical micro-Resistive WELL technology
- The simulations done by the Budker team suggest that the use of Titanium could sensibly reduce the background
- The TCP prototype construction has started and the field cage is ready
- The micro-RWELL technology is another good candidate for the Inner Tracker due to its low $X_{\rm 0}$
- The envelope of the prototype will be ready around the end of November
- Expected progress in detector simulation due to recent experimental data



Task sharing





Geometry – materials updated

2 SETS OF 2 CHAMBERS BACK-TO-BACK



CAD mechanical drawing



Screenshot from GeoDisplay.py CmuRWELL

	#1	cyc. Support Anode	3320	PILCION
CHAMBER 1	#2	Amplif.	103.1	micron
	#3	Anode 2D	106	micron
	#4	Tile Baseline	3175	micron
	11			
	#5	Gas 1 cm	10000	micron
	11			
	#6	Cyl Support + 2 Cathode	3406	micron
	11			
2	#7	Gas 1 cm	10000	micron
HAMBER	11			
	#8	Tile Baseline	3175	micron
	#9	Anode 2D	106	micron
	#10	Amplif.	103.1	micron
U	#11	Cvl. Support Anode	3328	micron

CmuRWELLGeom geo.xml

Sensitive material

Ar - CO2 - CF4 (45% - 15% - 40%)

Passive materials

- copper
- Kapton
- glue
- FR4 → vetronite
- MILLIFOAM
- Diamond Like Carbon
- Pre-preg (106) •
 - \rightarrow 70% glue + 30% fiberglass

GEANT4 MC points registered in each gas gap = 1 cm → 4 cm global sampling gas → readout with µTPC reconstruction

Update

- Inserted FR4 and HONEYCOMB new materials in DetectorDescription/DetBase/xml/Materials/material_mixture.xm
- correct material \leftrightarrow layer description
- MILLIFOAM still missing (need chemical formula), for now 4 replaced with HONEYCOMB