



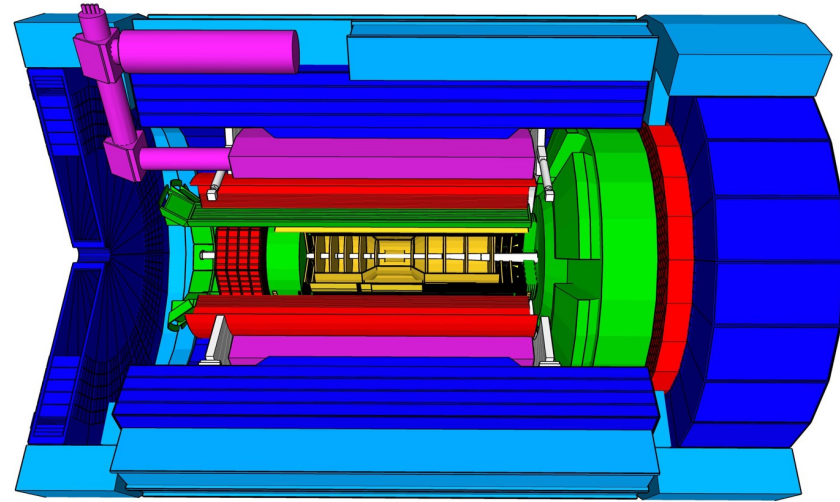
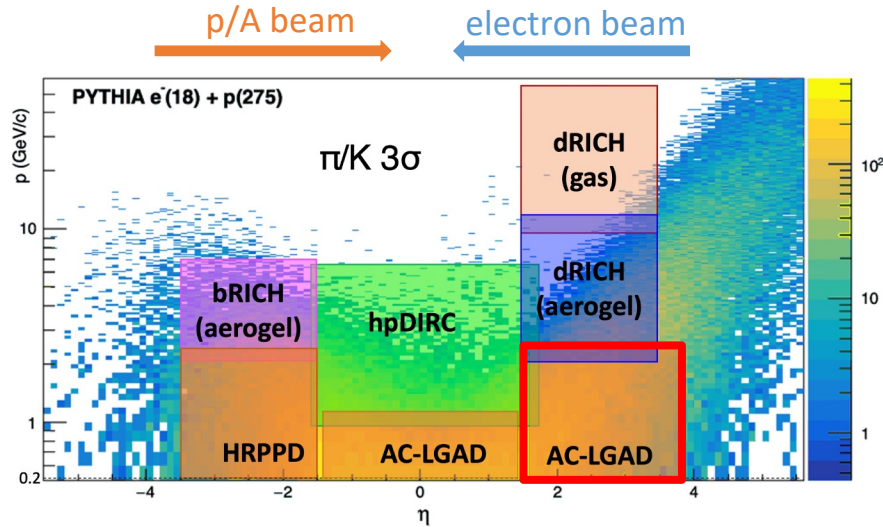
ePIC Forward TOF overview

Wei Li (Rice University)

TOF and AC-LGADs Workfest@ePIC collaboration meeting
July 26, 2024

Electron-Ion Collider

AC-LGADs TOF system for PID



Latest envelope ([link](#))

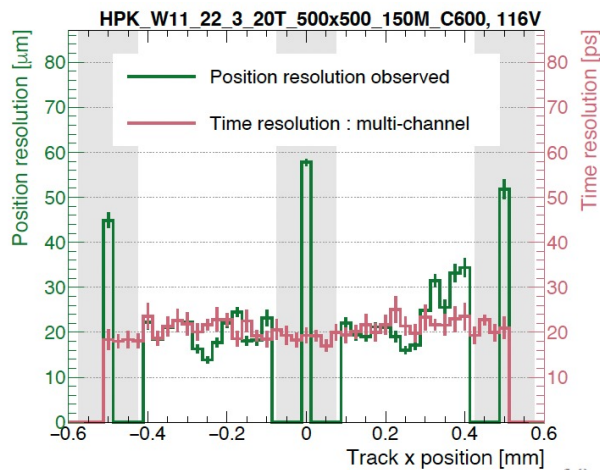
Detector	r (cm)	z (cm)	Momentum range for 3σ π/K separation
Barrel TOF	$62 < r < 69.5$	$-117.5 < z < 171.5$	$0.2 < p_T < \sim 1.2$ GeV
Forward TOF	$10.5 < r < 60$	$185 < z < 193$	$0.2 < p < \sim 2.3$ GeV

z thickness is now 8 cm, instead of 15 cm

FTOF requirements and R&D progress

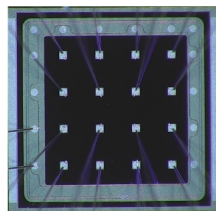
Current requirements (presented at FY23 EIC Project R&D - DAC Meeting)

	Area (m ²)	Channel size (mm ²)	# of Channels	Timing Resolution	Spatial resolution	Material budget
Barrel TOF	10	0.5*10	2.4M	30 → 35 ps	30 μm in $r \cdot \phi$	0.01 X ₀
Forward TOF	1.4	0.5*0.5	5.6M	25 ps	30 μm in x and y	0.08 → 0.025 X ₀
B0 tracker	0.07	0.5*0.5	0.28M	30 ps	20 μm in x and y	0.01 → 0.05 X ₀
RPs/OMD	0.14/0.08	0.5*0.5	0.56M/0.32M	30 ps	140 μm in x and y	no strict req.



Max BV limited at
~11V/micron due to SEB

HPK Pixel Sensor (2x2 mm²)

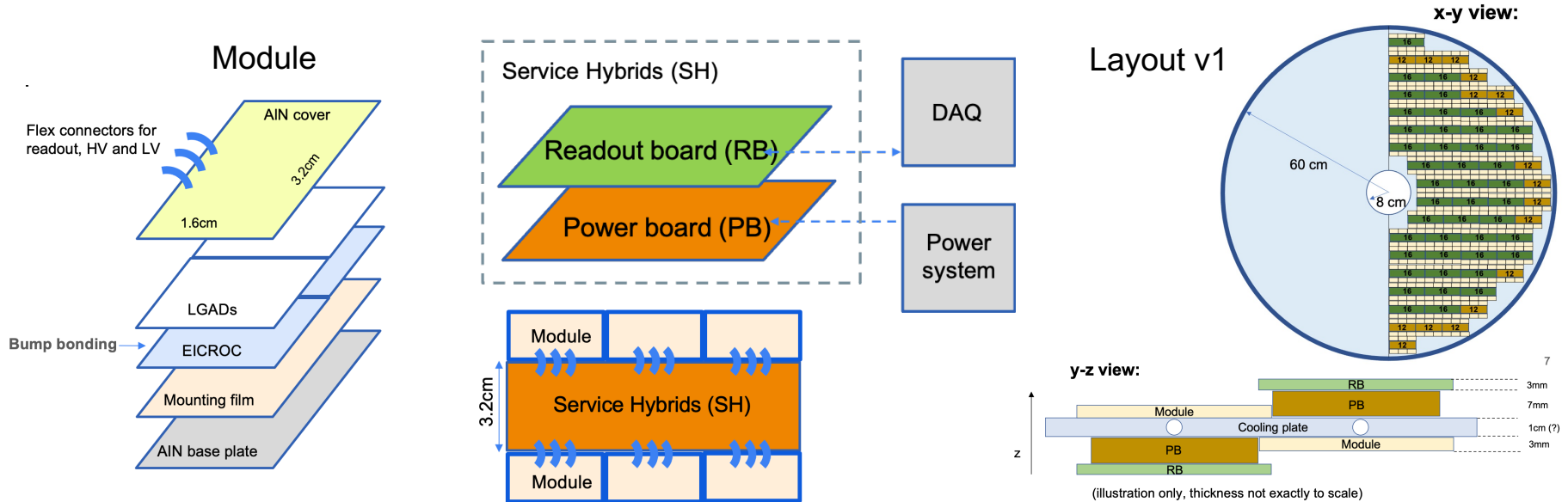


Promising to achieve the requirements with 20-micron thick, 0.5x0.5mm² pixel sensors

Large sensors (**32x32, 64x32**) being produced by HPK and will be evaluated later this year

Overview

Initial FTOF layout design from the Jan. collaboration meeting



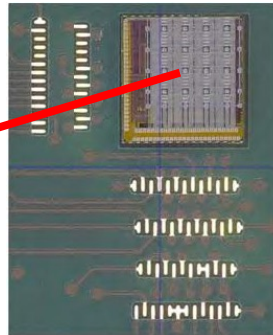
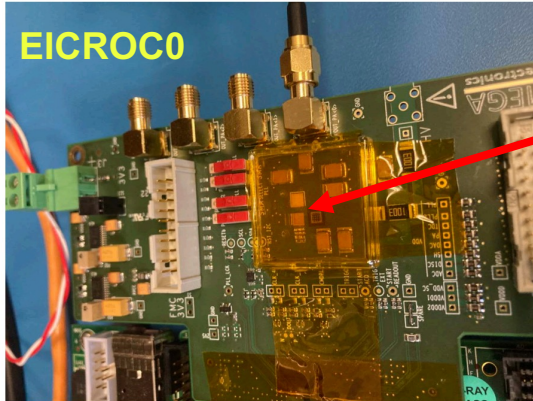
Continue refining the design in light of ongoing SH and module prototyping efforts

- Each SH servicing up to 32 ASICs (previously 16)
- Reduced envelope in z requires us to be more cautious with the layout design

FTOF ASICs - EICROC

ASIC requirements:

- Pixel size: $0.5 \times 0.5 \text{ mm}^2$
- Low jitter: $< 20 \text{ ps}$
- Low power consumption: 1 mV/channel



EICROC0 (4x4): first version



EICROC1 (8x32?): intermediate size



EICROC2 (32x32): full size

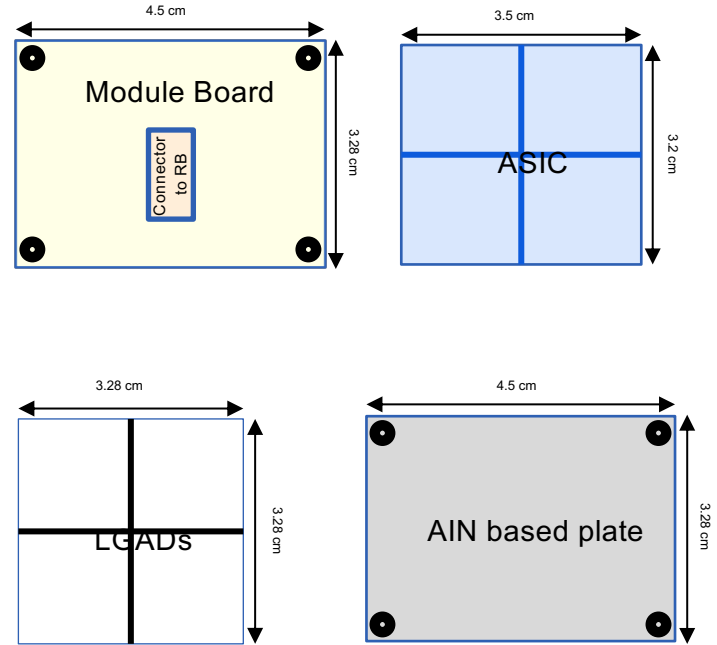
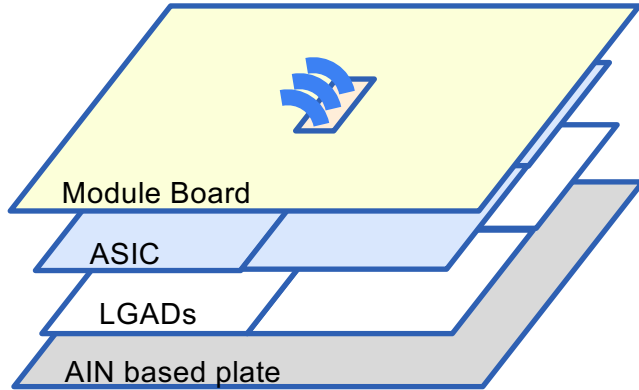


EICROC3 (32x32): final (if needed)

See talk by Christophe et. al. for latest development

FTOF module (updated)

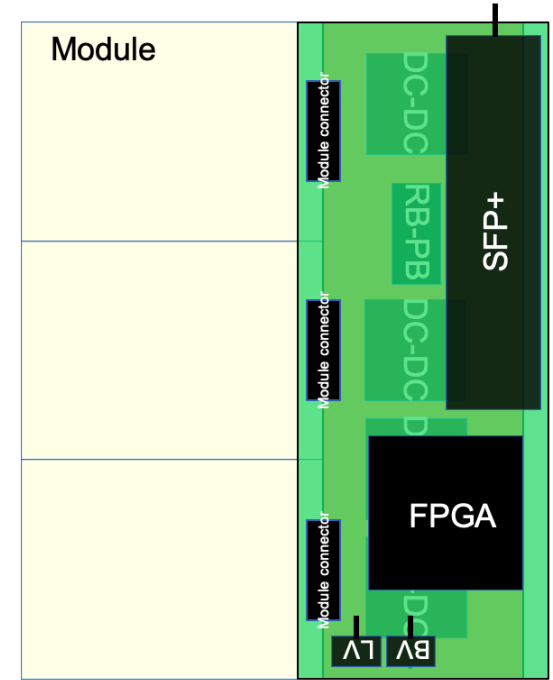
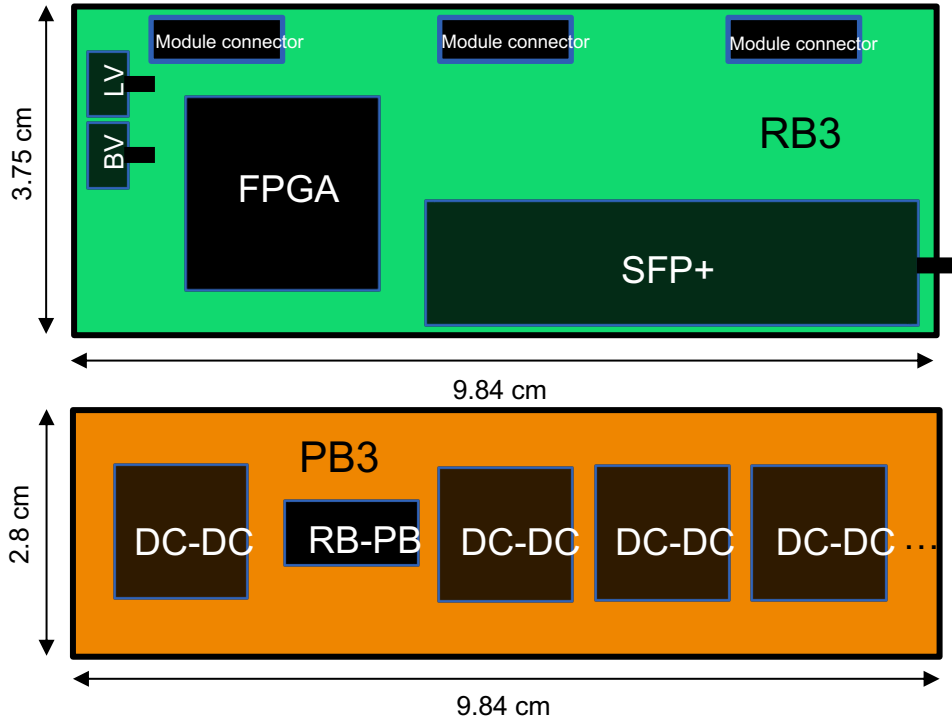
- 4 AC-LGADs sensor per module
- Each sensor: 32x32 pixels and 1.6x1.6 cm²



More realistic dimensions considering guard rings, mounting holes etc.

Service hybrids design and prototyping

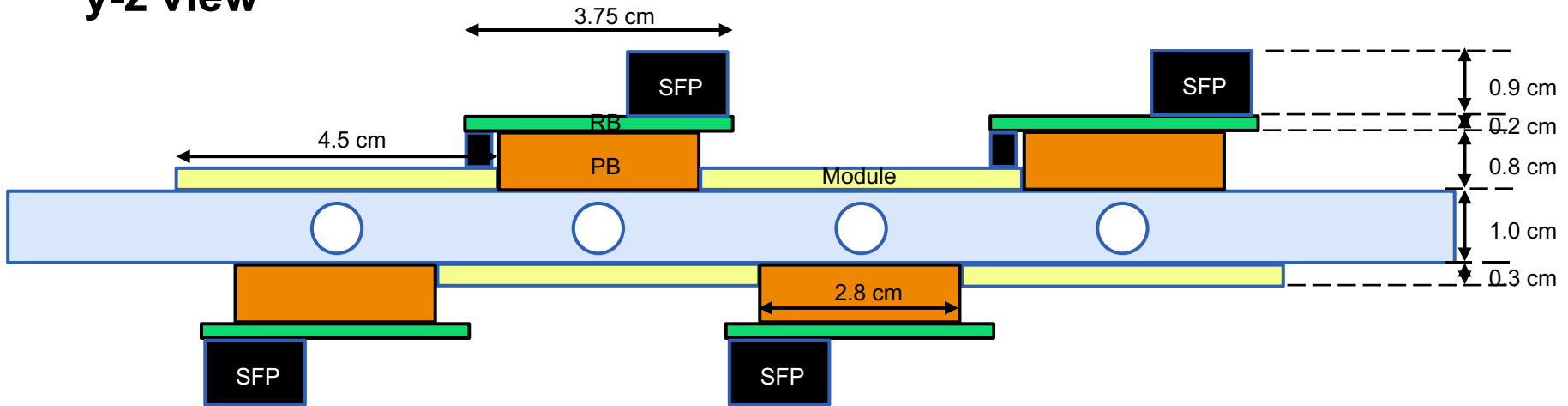
Shortest readout (RB3) and power (PB3) board serving 3 modules or 12 ASICs



Another two longer versions serving 6 and 7 modules, or 24 and 28 ASICs

FTOF detector layout v2

y-z view



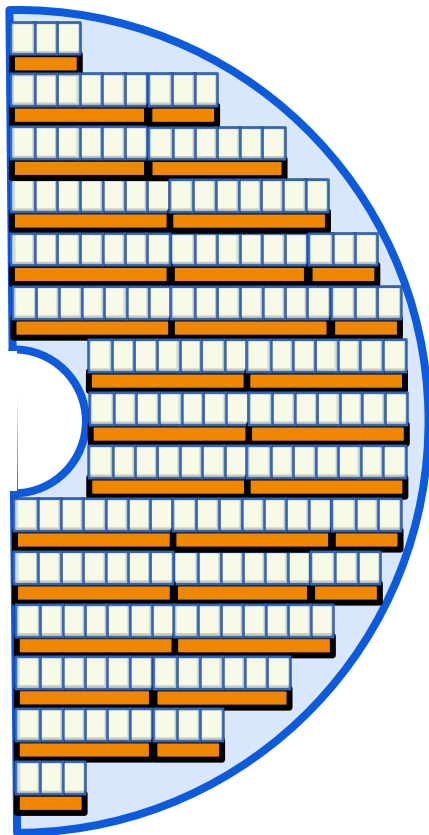
Total thickness is about 5cm, which would fit within 8cm z-envelope

- Thickness of cooling and support structure still uncertain
- Need to take into account routing of cables and fibers as well

FTOF Layout v2 (x-y view)

Outer radius:
60 cm

Inner radius:
10.5 cm



Row	modules	RB3	RB6	RB7	All RBs
1	3	1	0	0	1
2	9	1	1	0	2
3	12	0	2	0	2
4	14	0	0	2	2
5	16	1	1	1	3
6	17	1	0	2	3
7	14	0	0	2	2
8	14	0	0	2	2
9	14	0	0	2	2
10	17	1	0	2	3
11	16	1	1	1	3
12	14	0	0	2	2
13	12	0	2	0	2
14	9	1	1	0	2
15	3	1	0	0	1
<i>Sum</i>	184	8	8	16	32

Total number of modules: $184 \times 4 = 736$

Total number of service hybrids: $32 \times 4 = 128$

Channel counts and power budget

	Counts
Modules	736
Sensors/ASICs	2944
Data fiber pairs	128
LV cable pairs	128
HV cable pairs	128

	Power
Sensors	0.3kW
EICROC	2.9kW
DC-DC	2kW
FPGAs	0.5kW
Total	5.7kW

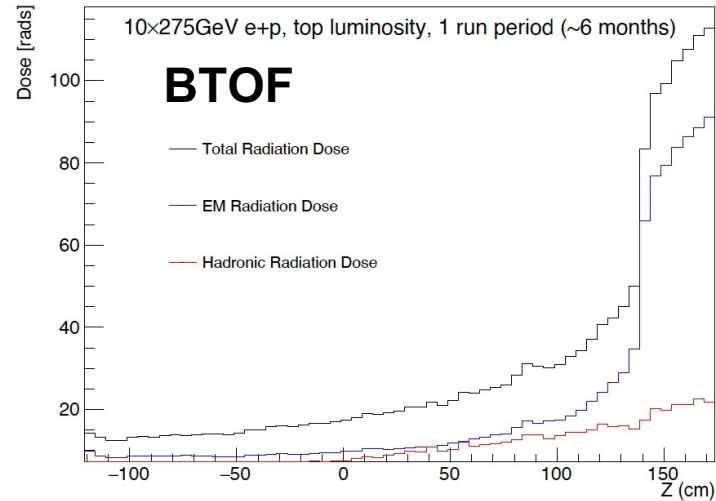
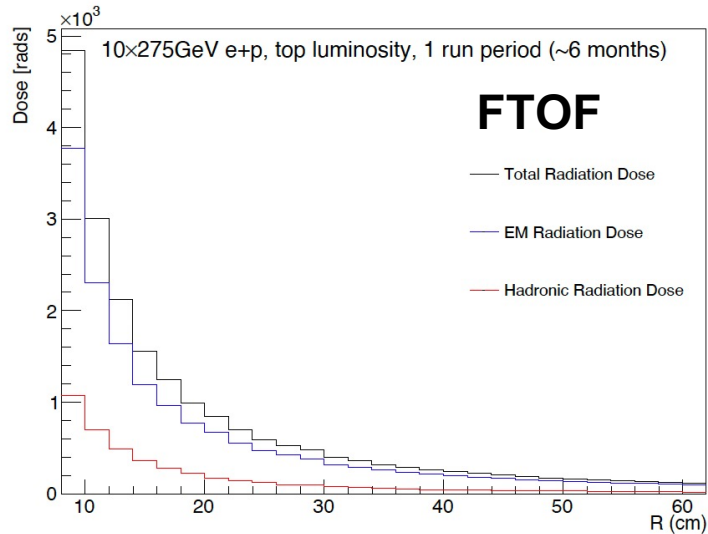
Assuming a single value of HV for each SH

Channels and power budget reduced from v1 by ~30% mainly because of the reduced envelope and # of SHs

FTOF radiation dose

Signal+beam gas (updated)

Xiao Huang



Assuming 10 years of operation and a safety factor of 2, the most inner part of FTOF expects ~ **100 kRad**

Summary

FTOF has been making steady progress toward the final design

- Pixel AC-LGADs sensors of 20 microns in thickness meets the FTOF requirements. Next step is to scale up to large sensors to evaluate their performance and yields.
- EICROC1 design is in progress.
- Service hybrids design and prototyping are progressing very well (see details later in the frontend electronics talk).
- Refined layout design v2

Still lots of work and challenges ahead. We highly welcome more institutes/colleagues to join the efforts and take leading roles!

Backups