

Future e^+e^- Higgs Factory

Charlie Young

Storage rings

- FCC-ee ([link](#) to CDR)
- CEPC (links to CDR for [accelerator](#) and [detector](#))

Linear colliders

- ILC (link to TDR for [accelerator](#) and [detector](#))
- CLIC ([link](#) to CDR)
- C³ ([link](#) to HEP Retreat 11/12/20)
- Photon collider (future HEP Retreat presentation)

Focus here on first three since the others are higher energy and/or newer technologies needing more development

Facility Proposals

- Many things have changed and will continue to change...
- Technically, FCC-ee and CEPC are looking more and more alike. Remaining differences mostly due to inputs:
 - Synchrotron radiation power budget (30 or 50 MW / beam)
 - Number of bunches at Z-peak, enabled by different RF
- Schedules are fluid and are not technically driven
 - See Andy today about ILC
 - FCC-ee and CEPC in next slides

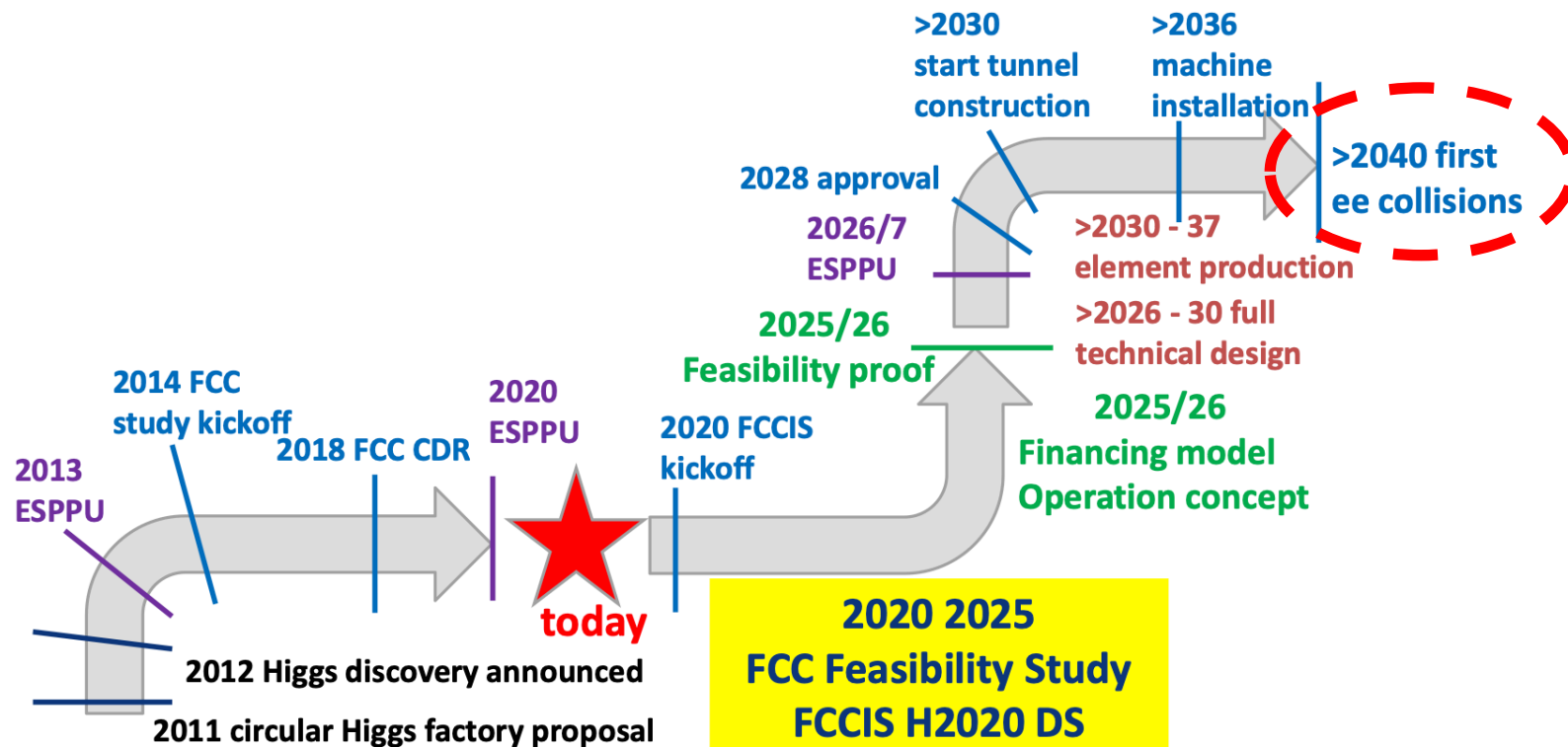
CERN vision and goals from Fabiola's [slides](#) on 2020 Medium Term Plan (2021 – 2025).

- Integrated FCC program with *ee* and *hh* colliders
- Costs broken down into three chunks:
 - Tunnel ~ 5.5B
 - FCC-*ee* ~ 5-6B
 - FCC-*hh* ~ 17B
- Impossible to fit into CERN's yearly budget (~1.5B in [2020](#)) + one-off contributions from non-Member States
- New mechanism and funding model required
- Priority is to find ~5B for tunnel outside CERN's budget

FCC-ee Roadmap



FCC roadmap towards stage 1



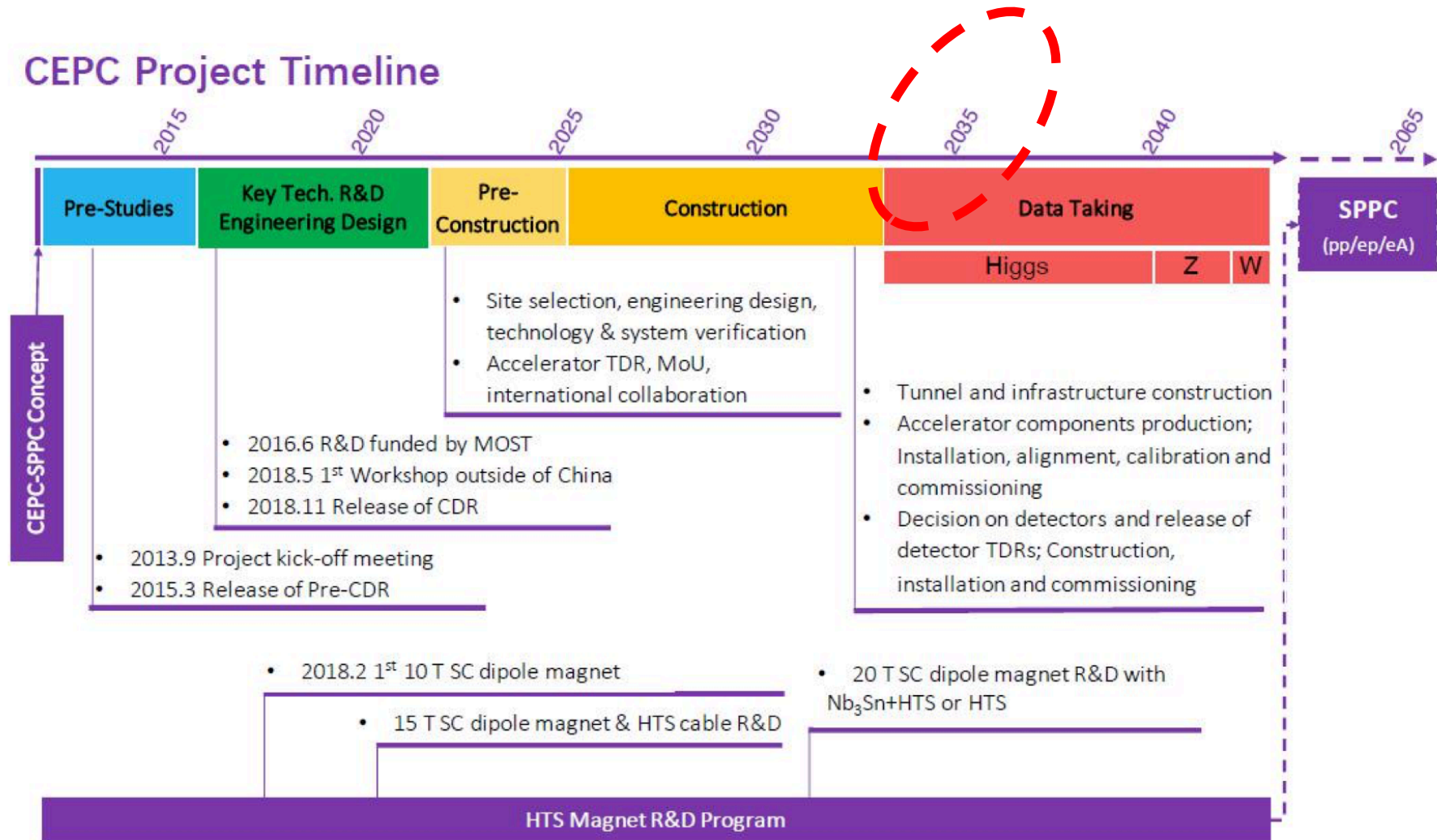
Future Circular Collider Study
Michael Benedikt
ECFA, 19 November 2020

[Link](#) to Michael Benedikt's talk
in Nov/2020 ECFA meeting

- Construction not in the 14th Five-Year Plan (2021 – 2025)
 - Plan drafted in the 5th Plenum of the Chinese Communist Party's 19th Central Committee meeting in 2020. ([Link](#) to full text of communique)
 - See Congressional Research Service [report](#) for its perspective on this Five-Year Plan.
- Current timeline
 - Three years of pre-construction and preparation
 - Construction start in 15th Five-Year Plan (2026 – 2030)
 - Targeting 15% - 30% external contributions
- Near-term activities focused on items that can be synergistic with ILC and/or FCC-ee, e.g.
 - SCRF: ILC and CEPC booster
 - MDI: FCC-ee and CEPC
 - Detector developments

CEPC Timeline

CEPC Project Timeline



Linear Collider vs Storage Ring

	ILC	FCC-ee
Luminosity / IP ($\text{cm}^{-2} \text{s}^{-1}$)		
@ 250 GeV (ZH)	2.7×10^{34}	8.5×10^{34}
@ 90 GeV (Z)	$\sim 0.5 \times 10^{34}$	230×10^{34}
@ 350 GeV (tt)	$\sim 3.2 \times 10^{34}$	1.6×10^{34}
# IP	1	2
Polarization		
Longitudinal	80% (e^-) and 30% (e^+)	No realistic expectation
Transverse	N/A	Possible up to WW for beam energy calibration
Detector solenoid	No significant constraint	Up to ~ 2 Tesla
Bunch structure		
Time between trains	Long: Power cycling	N/A: always-on power
Beam pipe radius (cm)	1.2	1.5



Possible SLAC Contributions

Possible SLAC Contributions to Collider

Thanks to Yunhai Cai, Tor Raubenheimer and Mike Sullivan for discussions!



Mostly relevant to storages rings:

- Injector designs including possibility of PWFA for higher energy injection
- Top-up injection
- Lattice design and beam dynamics such as
 - Spin dynamics – energy calibration in storage ring
 - “Monochromatic” collisions in storage ring
- Diagnostics and control such as recent developments in ML based techniques
- Collimators and kickers
- Machine detector interface: synchrotron radiation, beam gas, shielding design, higher order mode heating

Possible SLAC Contributions to Detectors



Given the uncertain approval prospects for the proposed facilities, suggest these guidelines to select R&D topics:

- Directly relevant to the science output of Higgs Factory
- Not strongly tied to any one facility's parameters
- Recognize the need to adapt / customize when a particular facility is approved to fit its constraints

In other words, focus on “building blocks” for now and move on to “systems” when the situation becomes clearer.

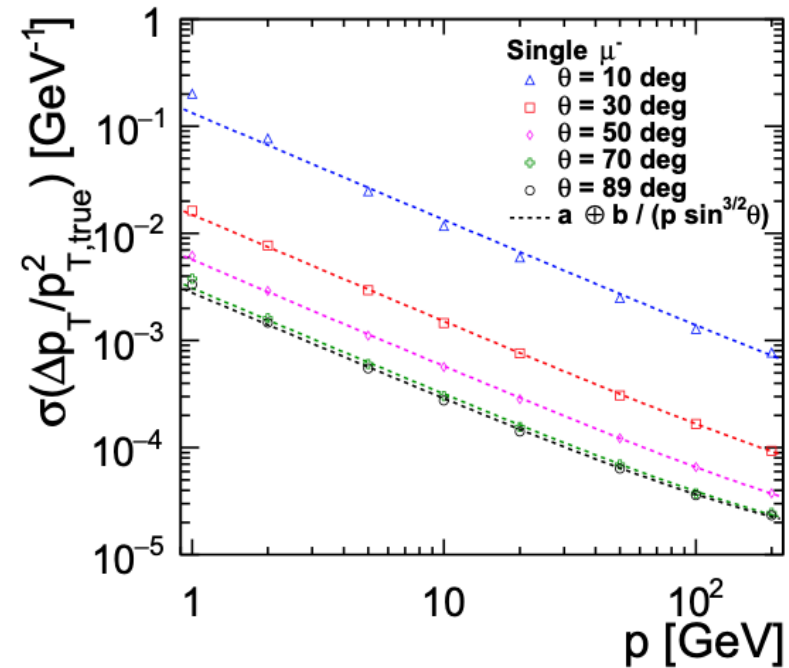
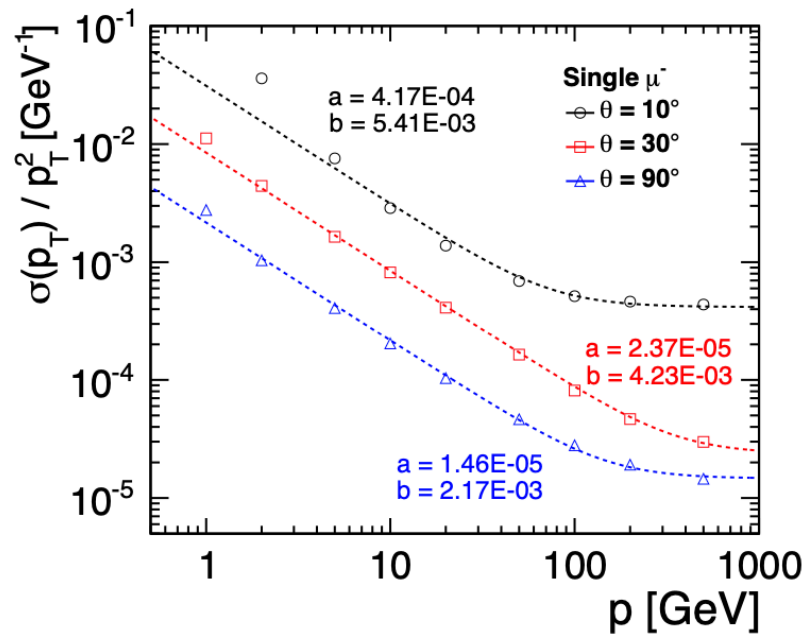


A Specific Proposal

Track Momentum Resolution

SiD

CLD

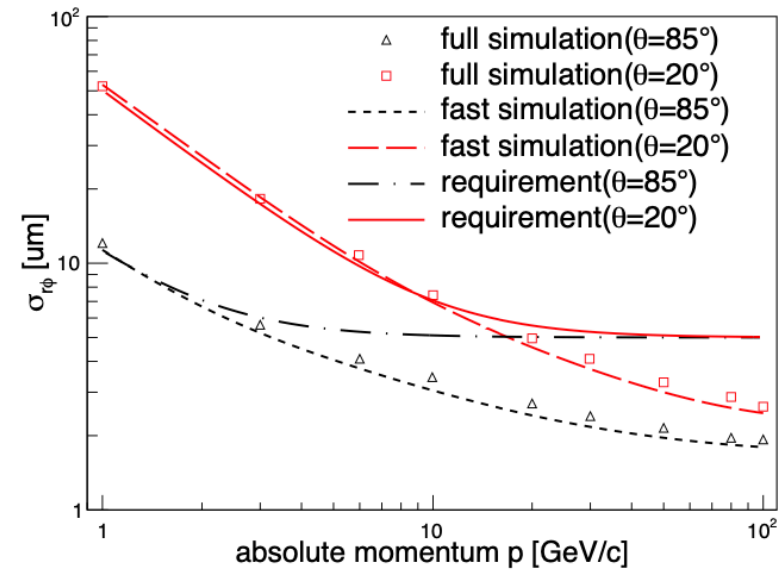
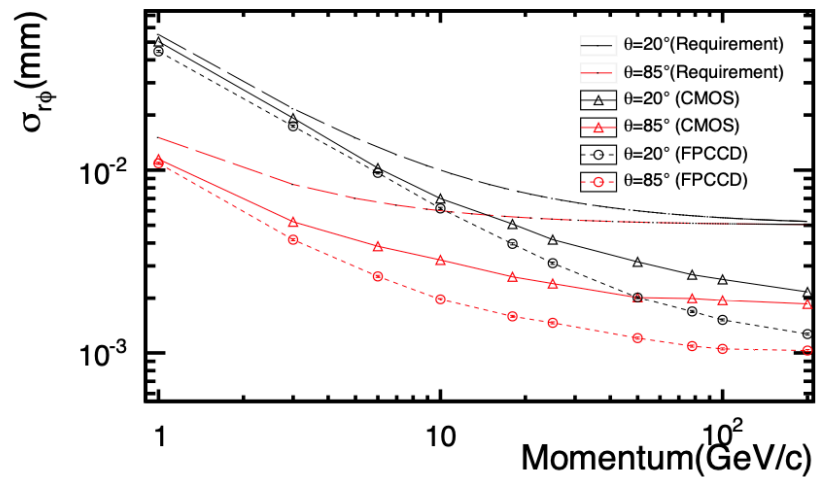


Limited by multiple scattering

Impact Parameter Resolution

ILD

CEPC



Limited by multiple scattering

[Link](#) to Expression of Interest

Expression of Interest for an ALICE ITS Upgrade in LS3

ALICE Collaboration, CERN, Geneva, Switzerland

Abstract

Recent innovations in the field of silicon imaging technology for consumer applications open extraordinary opportunities for new detector concepts, and hence offer strongly improved physics scope. This document presents a proposal for the construction of a novel vertex detector consisting of curved wafer-scale ultra-thin silicon sensors arranged in perfectly cylindrical layers, featuring an unprecedented low material budget of 0.05 % X_0 per layer, with the innermost layer positioned at only 18 mm radial distance from the interaction point. This new vertex detector is planned to be installed during the LHC LS3 to replace the innermost three layers of the ALICE Inner Tracking System. It will provide a large reduction of the material budget in the region close to the interaction point and a large improvement of the tracking precision and efficiency at low transverse momentum. The combination of these two improvements will lead to a significant advancement in the measurement of low momentum charmed hadrons and low-mass dielectrons in heavy-ion collisions at the LHC, which are among the main objectives of the ALICE physics programme in the next decade.

ALICE ITS3

- Cylindrical layer for mechanical strength
- Low mass 0.05% X_0 ($\approx 50 \mu m$ silicon) per layer
- Low power consumption for air cooling
- ALPIDE sensor verified for radiation up to
 - $10^{13} n_{eq}/cm^2$ (NIEL)
 - 1 kGy (TID)

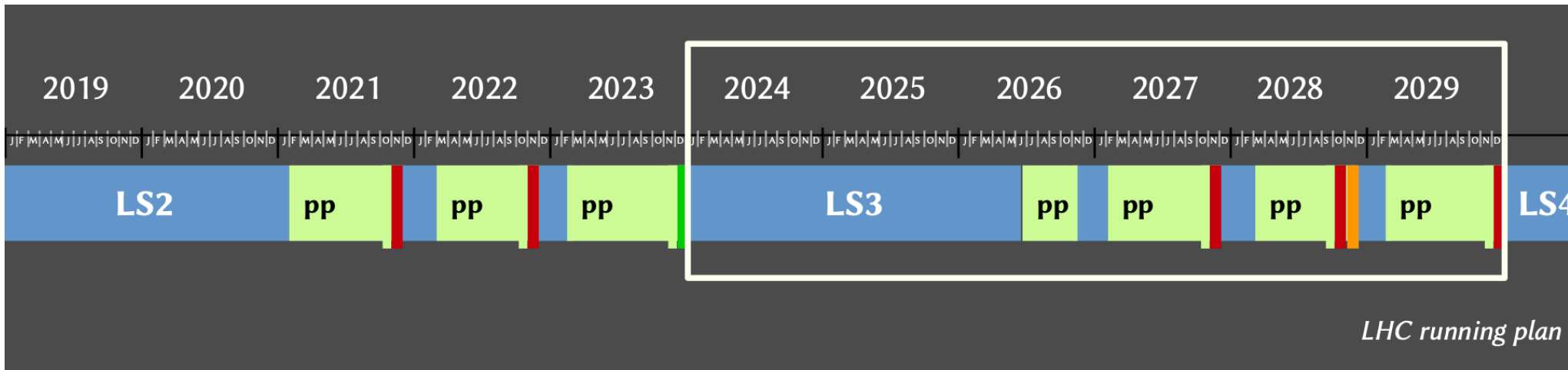


	ITS1 (SPD = 2 inner)	ITS2 (3 inner)	ITS3 (3 inner)
Beam pipe inner radius/thickness	3.0 cm/0.09 cm	1.82/0.08 cm	1.6/0.05 cm
First-layer radius	3.9 cm	2.3 cm	1.8 cm
X/X° per layer	1.1 %	0.35 %	0.05%
$ \eta $ coverage	> 1.4	> 2.0	> 2.0
Number of Sensors per layer	80+160	108+144+180	2 to 4
Technology	Hybrid pixels	CMOS	CMOS
Trigger ?	yes	no	Not foreseen
Pixel size $r\phi \times z$	$\approx 50 \times 425 \mu m^2$	$\approx 30 \times 30 \mu m^2$	$\approx 10 \times 10 \mu m^2$
Intrinsic resolution $r\phi / z$	12 μm / 100 μm	5 μm / 5 μm	3 μm / 3 μm
Readout frequency Pb-Pb	< 3 MHz > 300 ns (SPD)	< 50-100 kHz > 20-10 μs	$\approx \leq 200$ kHz $\approx \geq 5 \mu s$
Power dissipation in the pixel matrix	$\approx 550-736$ mW/cm ² i.e. liquid cooled	~ 40 mW/cm ² , i.e. liquid cooled	~ 7 mW/cm ² , i.e. air flow

A. Maire at [GDR QCD 2019](#)

ALICE ITS3 Schedule and Planning

Installation planned for LHC Long Shutdown 3 (dates shown here will be updated post pandemic)



Focused R&D effort to achieve this

Non-ALICE collaborators not precluded from joining the ITS3 development effort.

Should we start such a conversation with ALICE?