Highlights and perspectives of future detectors

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The 2020 International Workshop on the High Energy Circular Electron Positron Collider (CEPC)
October 28, 2020

Speakers

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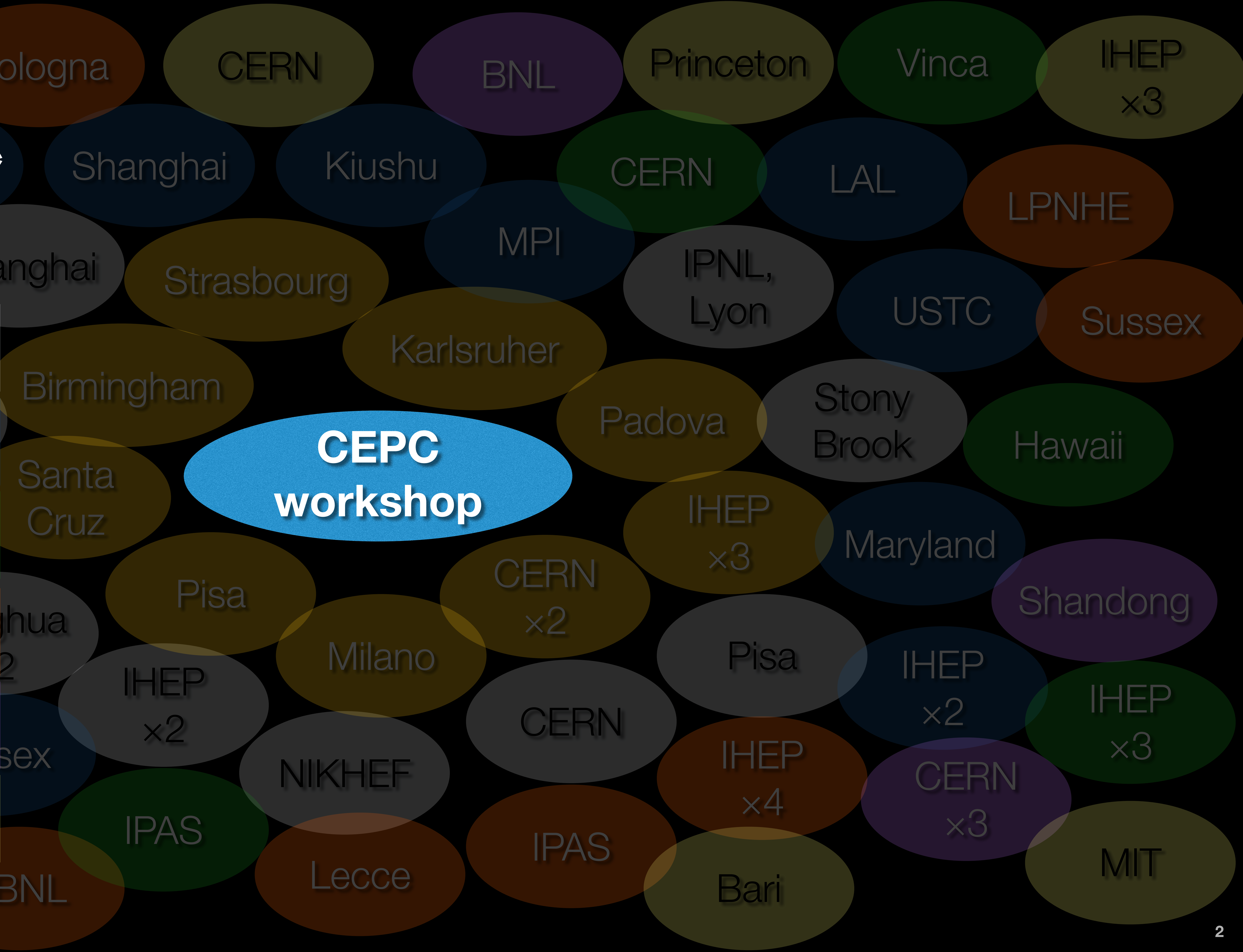

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Collaborations

**** Sessions ****

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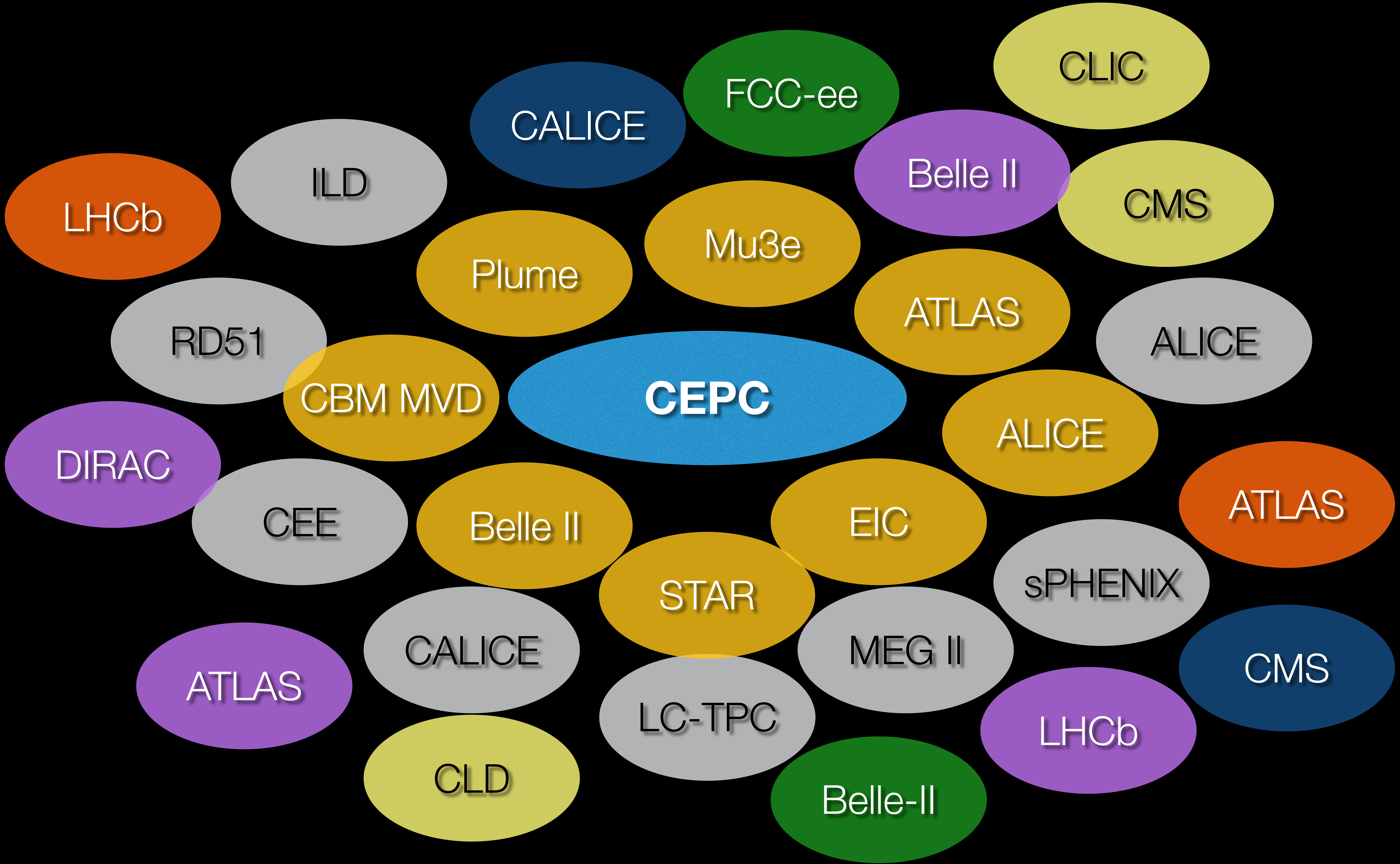
- Performance

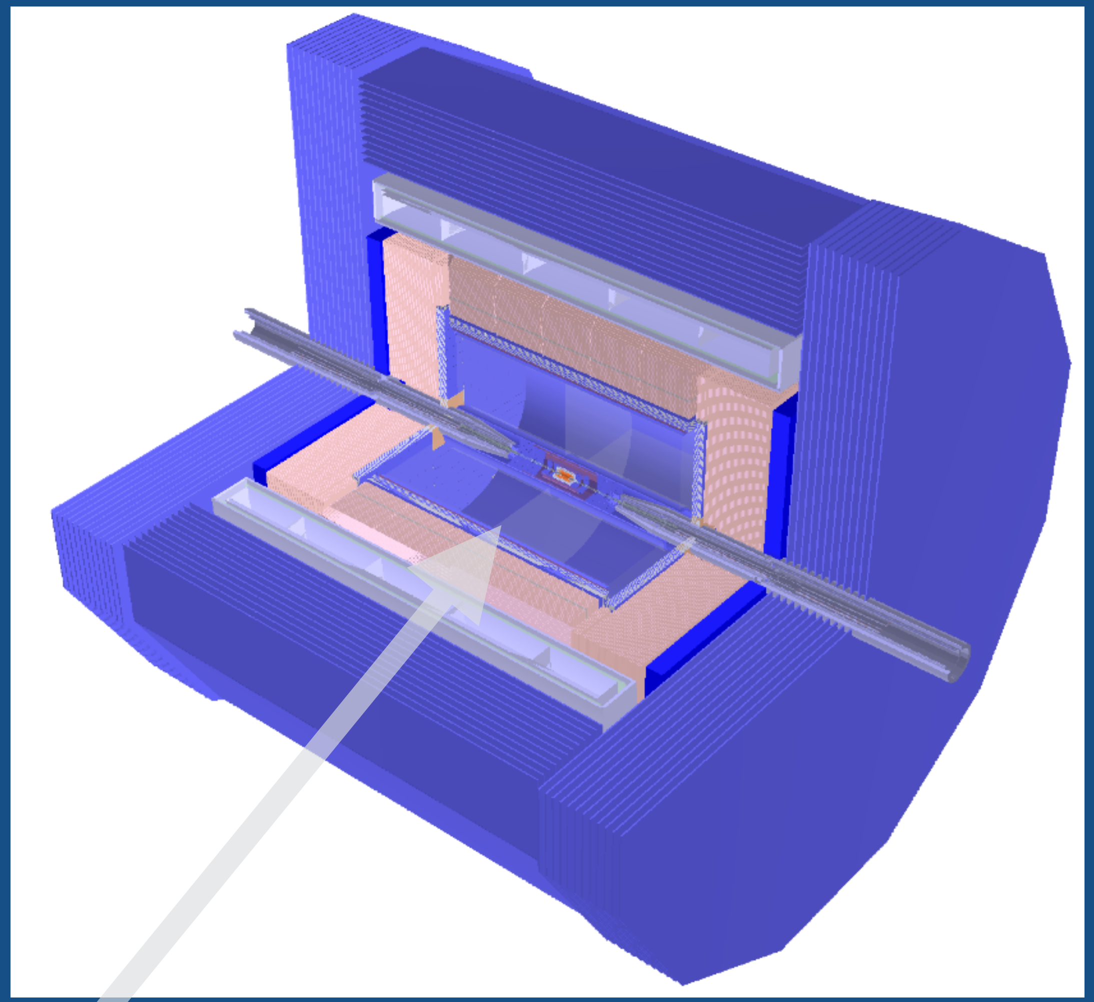


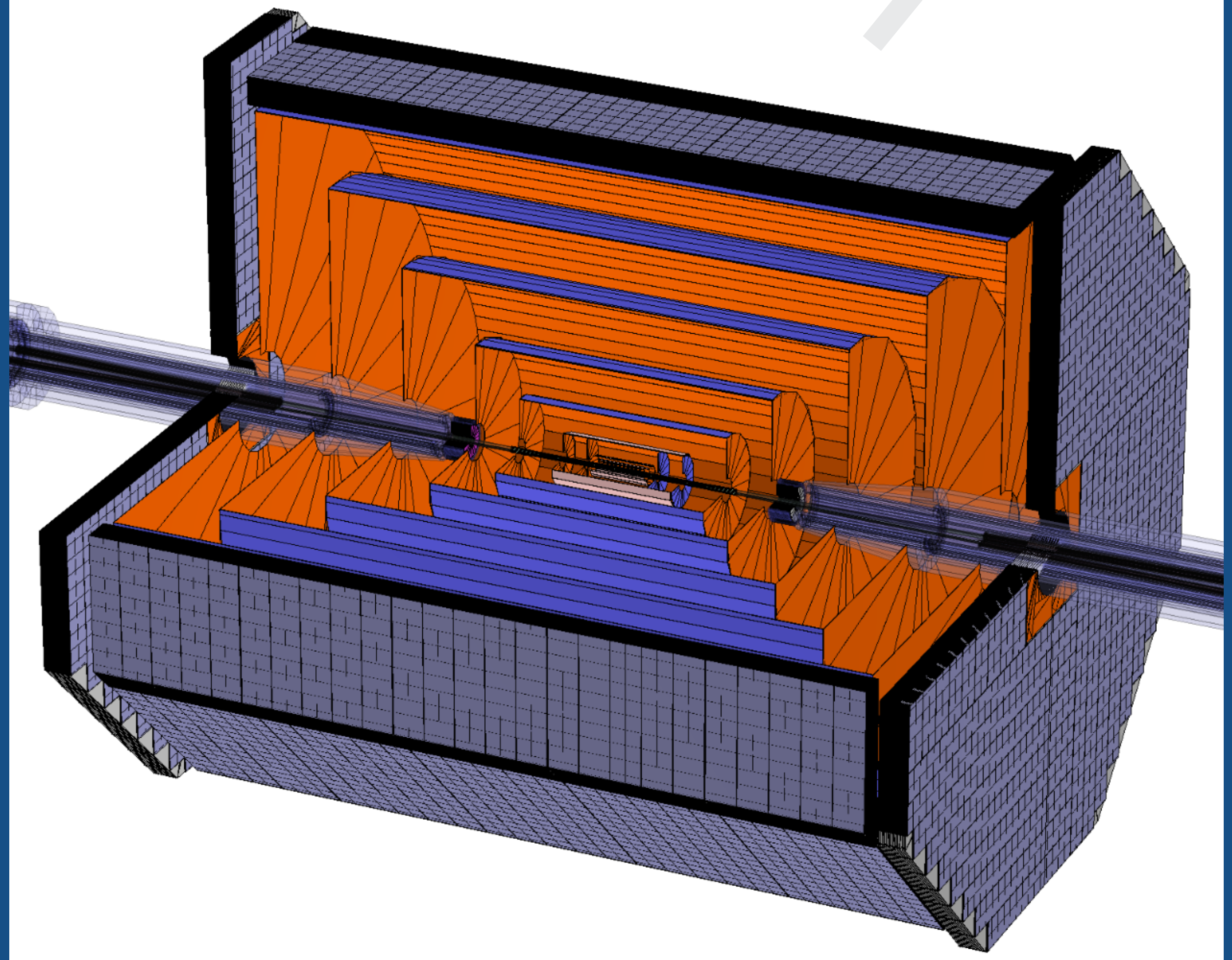
CEPC Detector Concepts studied

2 interaction points

Particle Flow Approach

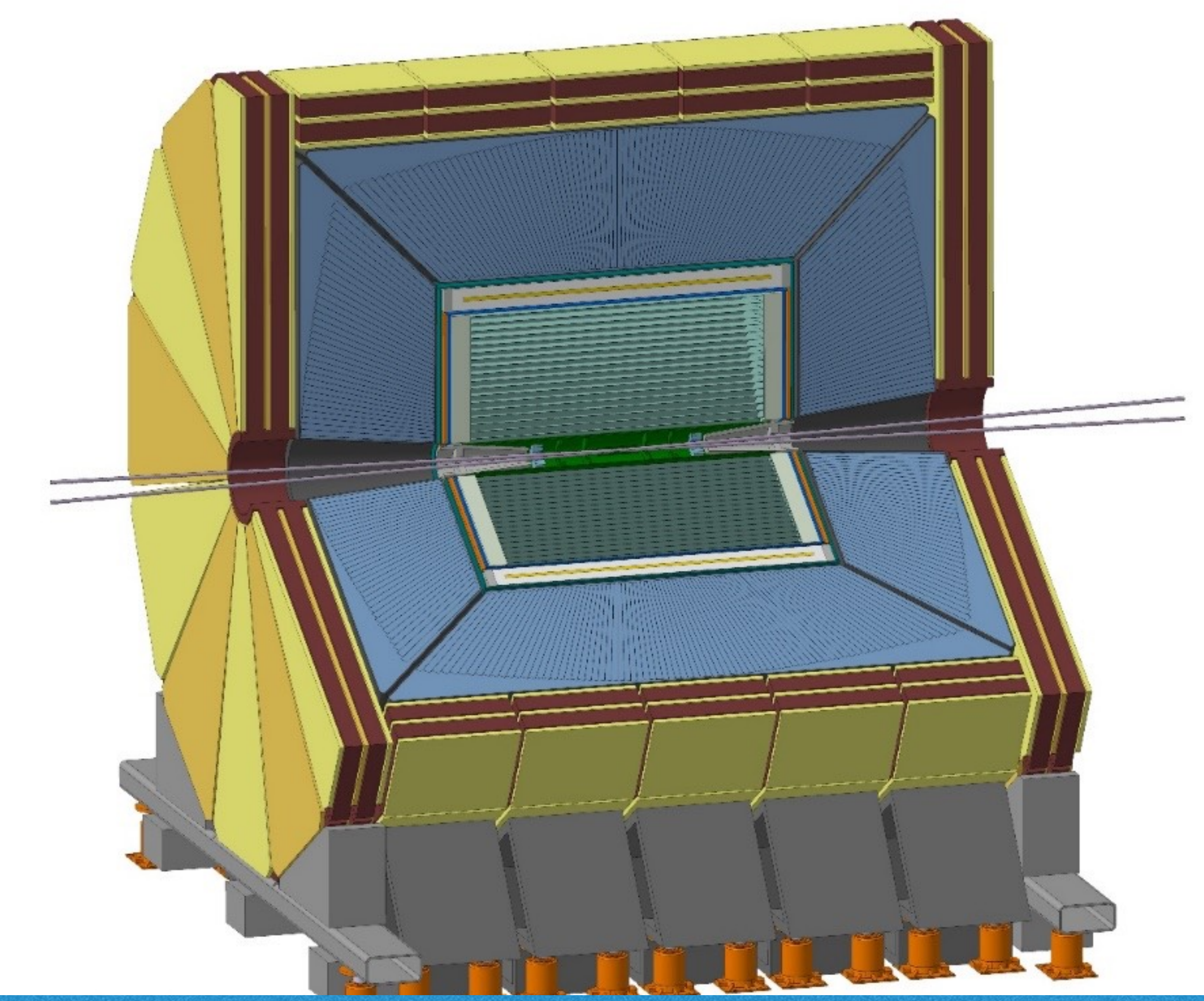
High
magnetic field
concept
(3 Tesla)





Full silicon
tracker
concept

Low
magnetic field
concept
(2 Tesla)



IDEA Concept

also proposed for FCC-ee

Final two detectors WILL be a mix and match of different options

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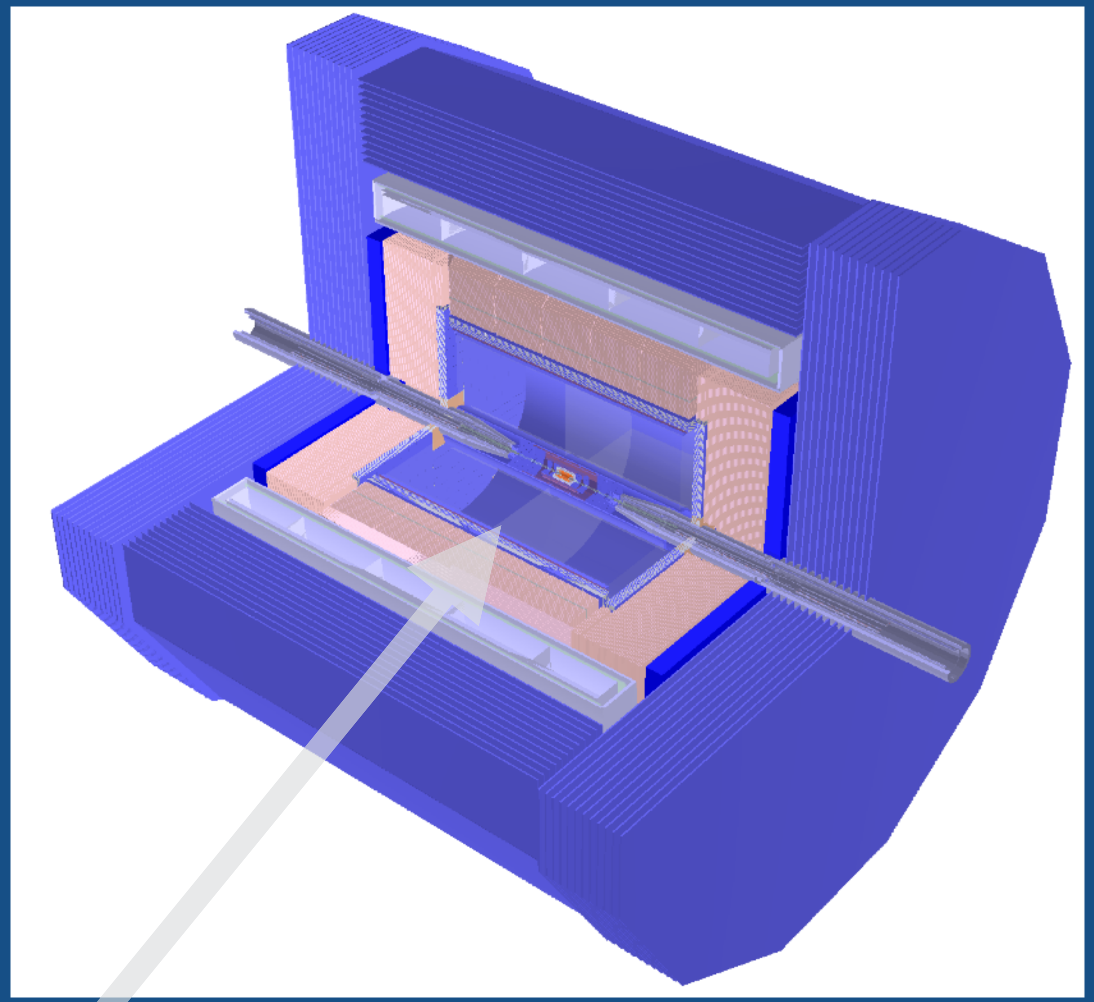

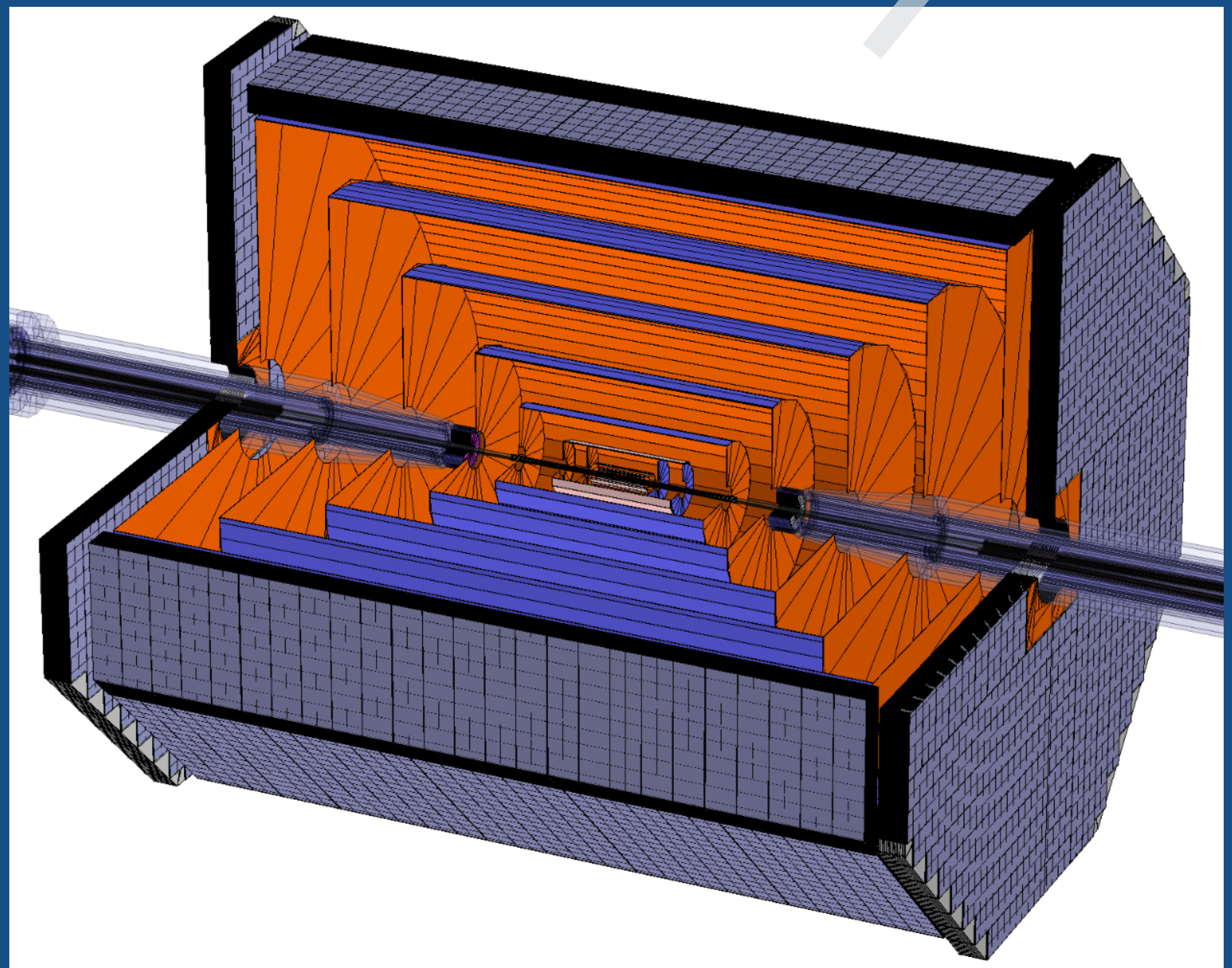

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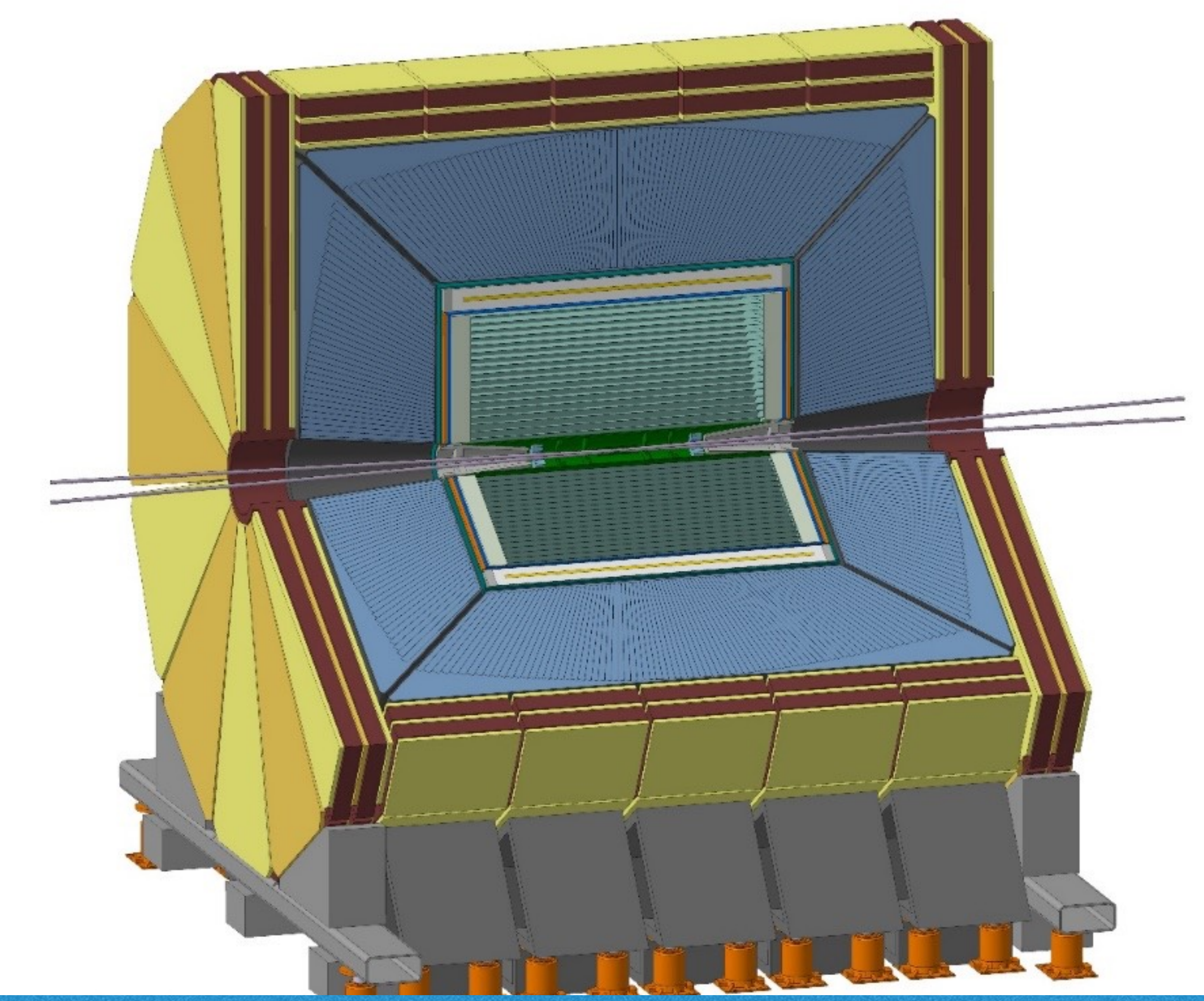

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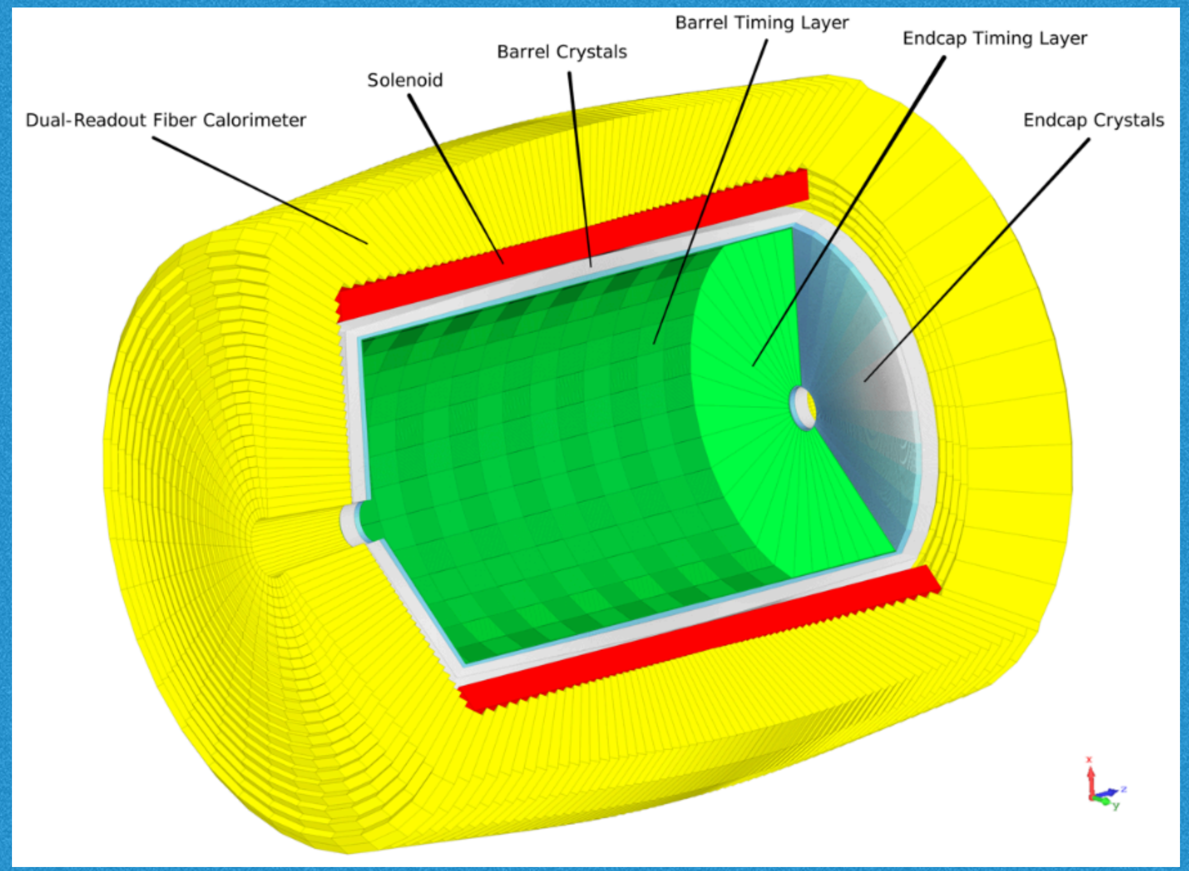


Crystal Calorimeter
based detector
(2-3 Tesla)

News reported at this conference

Final two detectors WILL be a mix and match of different options

CEPC CDR: Particle Flow Conceptual Detector

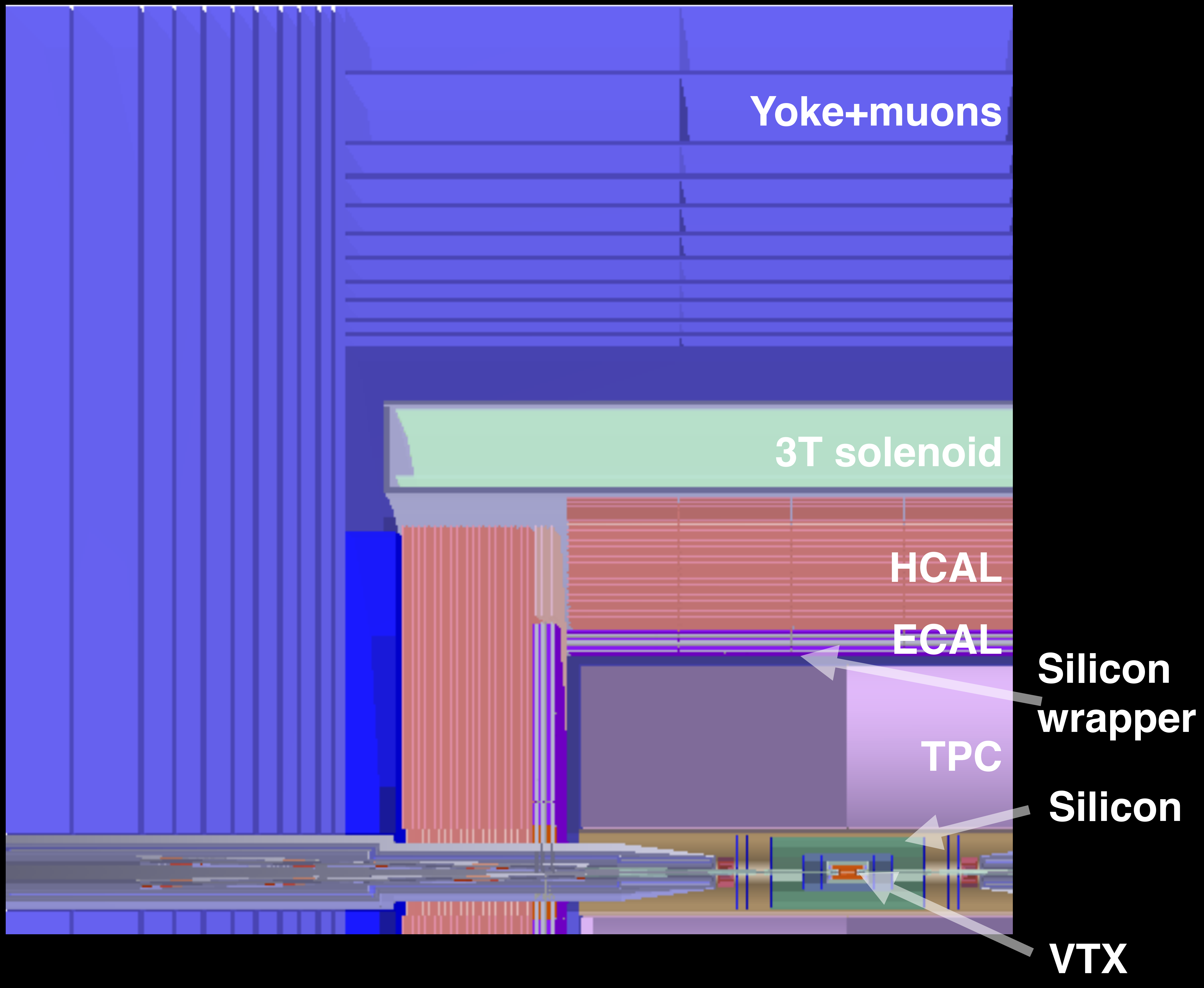
Major concerns being addressed

1. **MDI region highly constrained**
   L* = 2.2 m
   Compensating magnets

2. **Low-material Inner Tracker design**

3. **TPC as tracker in high-luminosity Z-pole scenario**

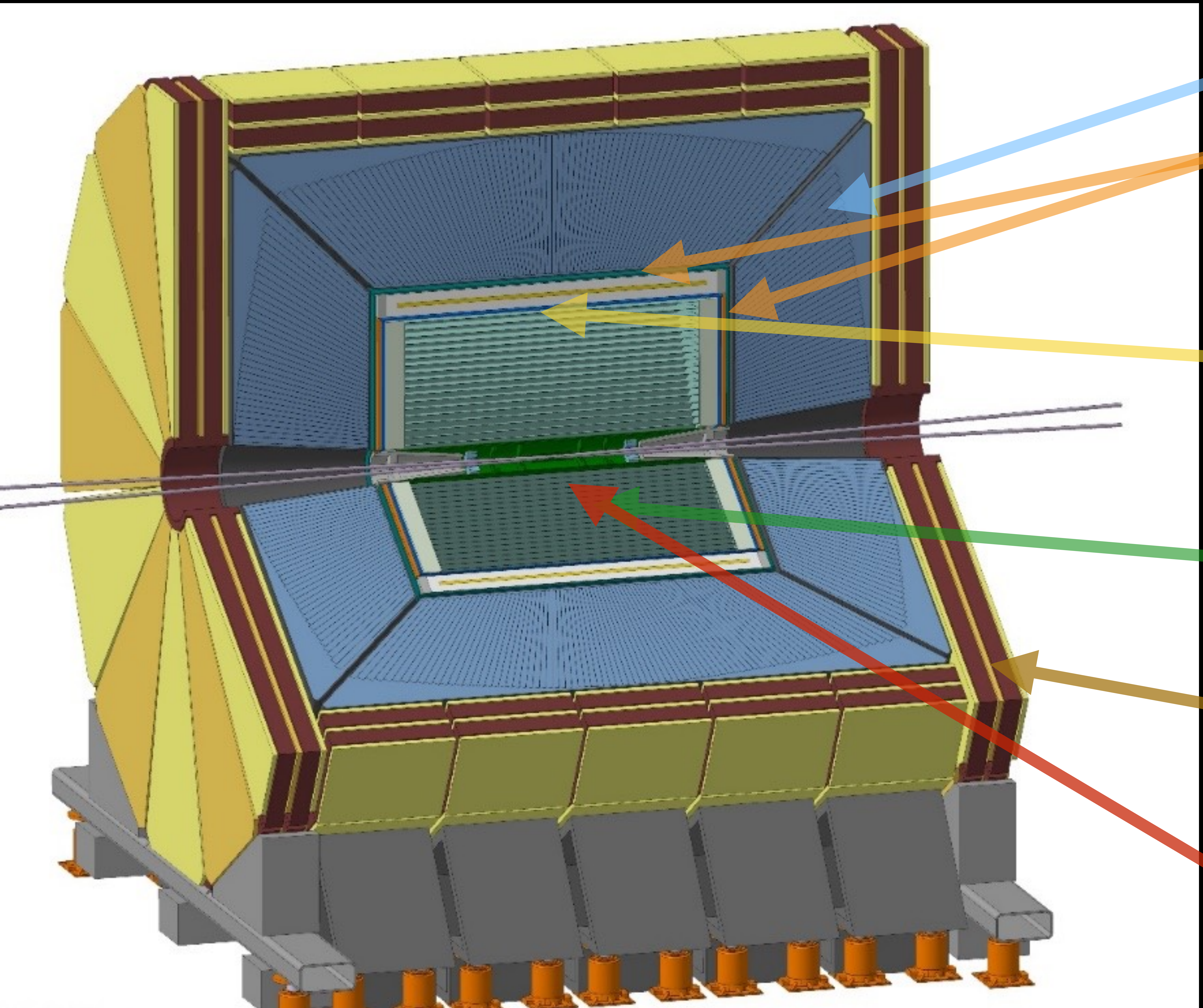
4. **ECAL/HCAL granularity needs**
   Passive versus active cooling
   Electromagnetic resolution



Magnetic Field: 3 Tesla

CEPC CDR: IDEA Conceptual Detector (CEPC + FCC-ee)

Inspired on work for 4th detector concept for ILC



Calorimeter outside the coil

* Dual-readout calorimeter: 2 m/8 λ_{int}
* Preshower: ~1 X_0

Magnet: 2 Tesla, 2.1 m radius

Thin (~ 30 cm), low-mass (~0.8 X_0)

* Drift chamber: 4 m long; Radius ~30-200 cm, ~ 1.6% X_0 , 112 layers
* (yoke) muon chambers

Vertex: Similar to CEPC default

Detector requirements for high-energy e^+e^- colliders

Precision measurements

Require excellent momentum resolution and flavor tagging

Low-mass vertex and tracking detectors, high granularity

Require excellent energy resolution

Employ excellent calorimeters (particle flow, dual readout)

No major concerns about radiation hardness, unless for very forward detectors and inner most layer of vertex detector

Complementary subsystems

Subsystem	Measurement
Vertex detector	vertex position
	impact parameter → helps determine flavor
	track momenta of charged particles
Tracking detector	track momenta of charged particles
ECAL: electromagnetic calorimeter	energy of γ, $e^\pm$ and hadrons
HCAL: hadronic calorimeter	energy of hadrons (including neutrals)
Magnet system	bend charged particles → momentum measurement
Muon system	identify muons
Hermicity	missing energy (e.g. ν)
Luminosity detectors	luminosity

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Precision measurements

Require excellent momentum resolution and flavor tagging

- Low-mass vertex and tracking detectors, high granularity

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No major concerns about radiation hardness,
- unless for very forward detectors and
- inner most layer of vertex detector

Physics process	Measurands	Detector subsystem	Performance requirement
$ZH, Z \to e^+e^-, \mu^+\mu^-$ $H \to \mu^+\mu^-$	$m_H, \sigma(ZH)$ $\mathrm{BR}(H \to \mu^+\mu^-)$	Tracker	$\Delta(1/p_T) =$ $2 \times 10^{-5} \oplus \frac{0.001}{p(\mathrm{GeV}) \sin^{3/2}\theta}$
$H \to b\bar{b}/c\bar{c}/gg$	$\mathrm{BR}(H \to b\bar{b}/c\bar{c}/gg)$	Vertex	$\sigma_{r\phi} =$ $5 \oplus \frac{10}{p(\mathrm{GeV}) \times \sin^{3/2}\theta} (\mu\mathrm{m})$
$H \to q\bar{q}, WW^*, ZZ^*$	$\mathrm{BR}(H \to q\bar{q}, WW^*, ZZ^*)$	ECAL HCAL	$\sigma_E^{\mathrm{jet}}/E =$ $3 \sim 4\%$ at 100 GeV
$H \to \gamma\gamma$	$\mathrm{BR}(H \to \gamma\gamma)$	ECAL	$\Delta E/E =$ $\frac{0.20}{\sqrt{E(\mathrm{GeV})}} \oplus 0.01$

Detector R&D Major R&D Breakdown

17 documents

1. Vertex
   1.1. Pixel Vertex Prototype
   1.2. ARCADIA/LFoundry CMOS
2. Tracker
   2.1. TPC
   2.2. Silicon Tracker
   2.3. Drift Chamber
3. Calorimeter
   3.1.ECAL Calorimeter
      3.1.1. Crystal Calorimeter
      3.1.2. Scintillator-Tungsten
   3.2. HCAL PFA Calorimeter
      3.2.1. DHCAL
      3.2.2. Sci AHCAL
   3.3. DR Calorimeter
4. Muon Detectors
   4.1. Muon Scintillator Detector
   4.2. Muon and pre-shower MuRWell Detectors
5. Solenoid
   5.1. LTS Solenoid
   5.2. HTS Solenoid
6. MDI
   6.1. LumiCal Prototype
   6.2. Mechanics
7. TDAQ
8. Software and Computing

Machine-detector interface (MDI) in CEPC

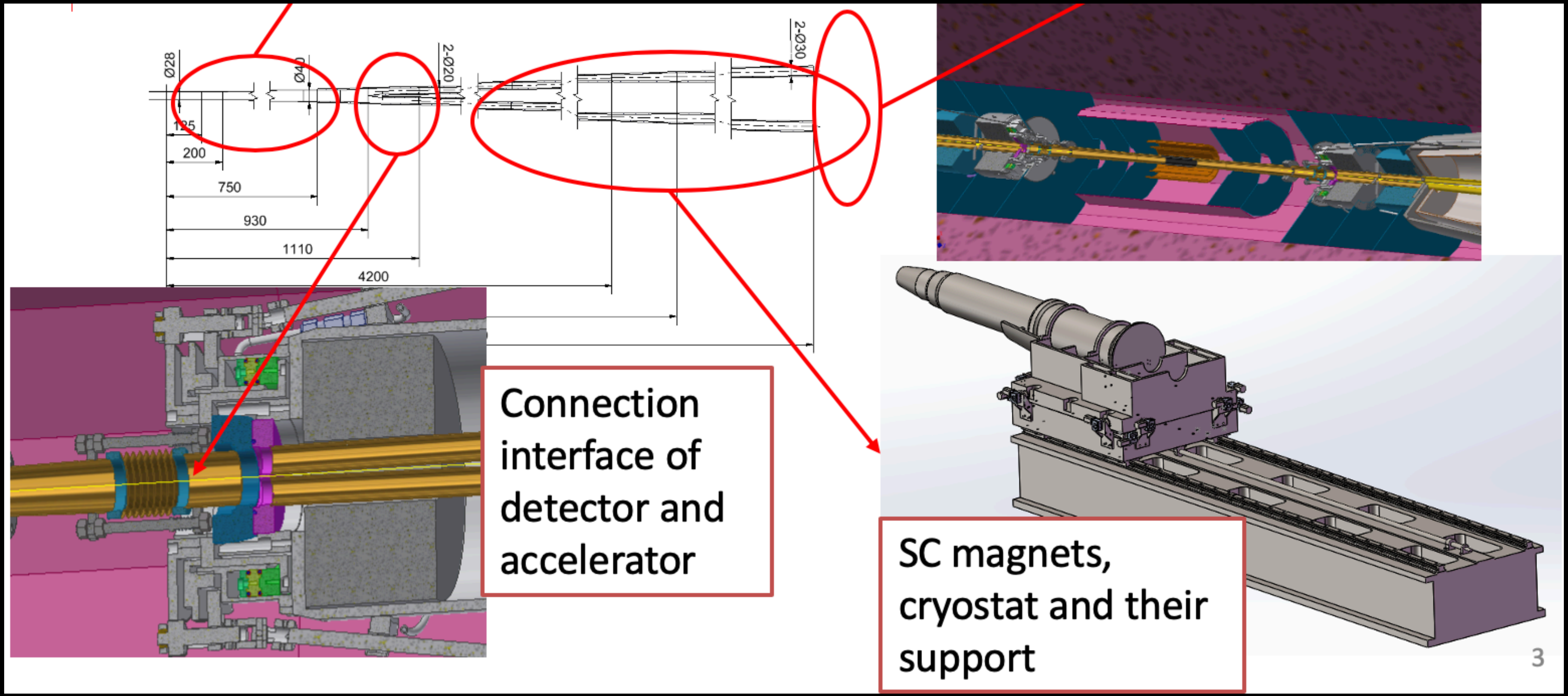
Rates at the inner layer (16 mm):
Hit density: ~3.2 hits/cm²/BX
TID: 2.4 MRad/year
NIEL: 6×10^{12} 1MeV n_{eq}/cm^2
(Safety factors of 10 applied)

Final focusing quadrupoles (QD0) need to be very close to IP

Detector acceptance:
> ± 150 mrad

Solenoid magnetic field limited:
2-3 Tesla

due to beam emittance blow up



Cooling of beampipe needed → increases material budget near the interaction point (IP)

Beampipe design

Ruiqiang Zhang, et al

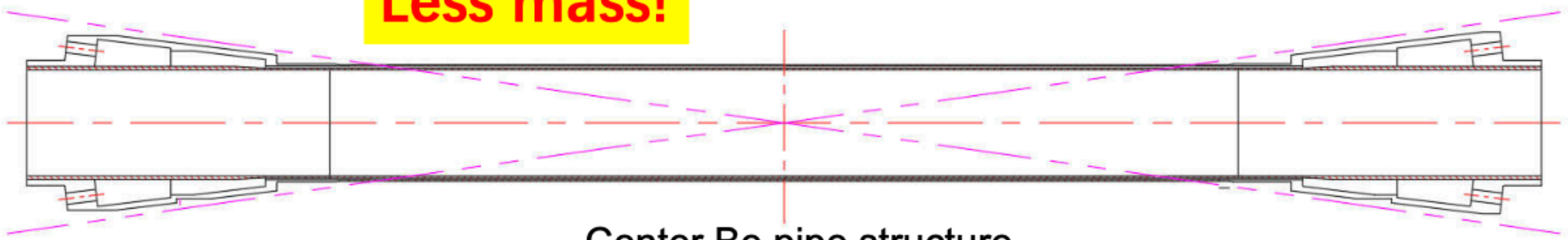
2.1 Be pipe

Based on the current domestic manufacturing capability, it is possible to manufacture the thin-wall beryllium pipe with wall thickness of **0.15mm and inner diameter of 20mm.**

Less mass!

Difficulties of manufacturing:

To meets the requirements of length(150mm), strength, stiffness and ultra-high vacuum.



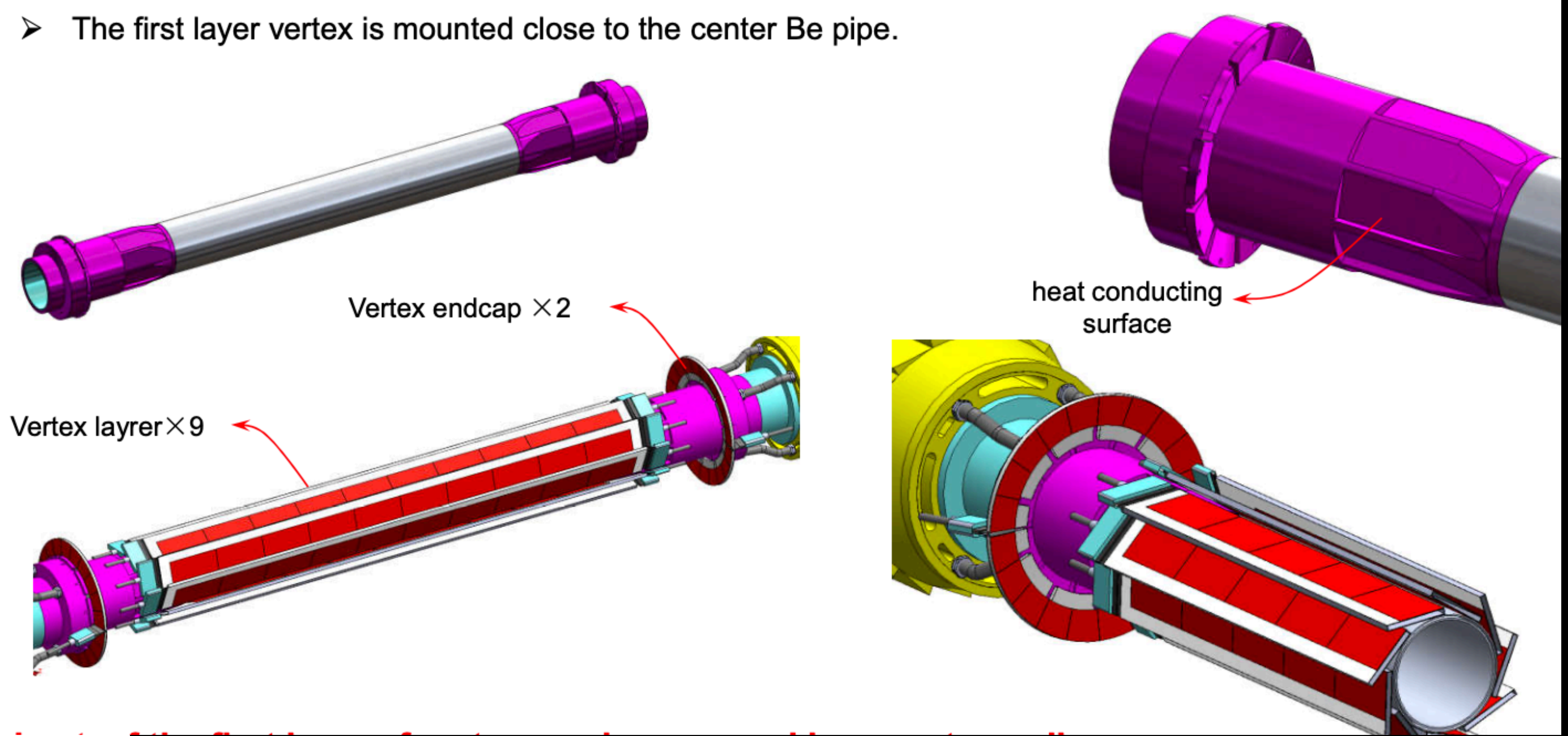
Center Be pipe structure

The critical pressure contrast of Be pipe with different wall thickness

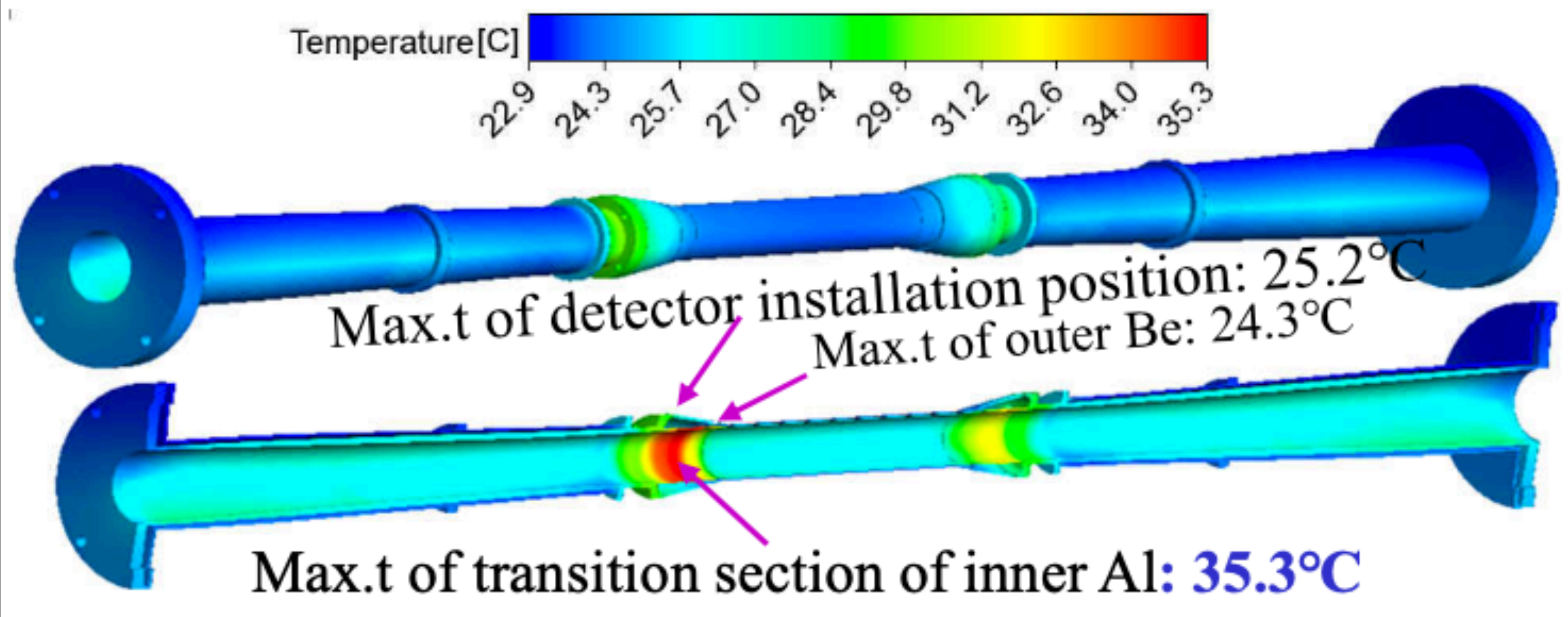
Version	Name	Wall thickness (mm)	Inside radius (mm)	External radius (mm)	Critical pressure (MPa)	Gap(coolant)
Previous design	Inner Be pipe	0.5	14	14.5	3.3053	0.5mm (Between inner and outer Be pipe)
	Outer Be pipe	0.35	15	15.35	0.9388	
New design	Inner Be pipe	0.2	10	10.2	0.5941	
	Outer Be pipe	0.15	10.7	10.85	0.2064	

2.2 Structure for detectors installation and cooling ---Vertex

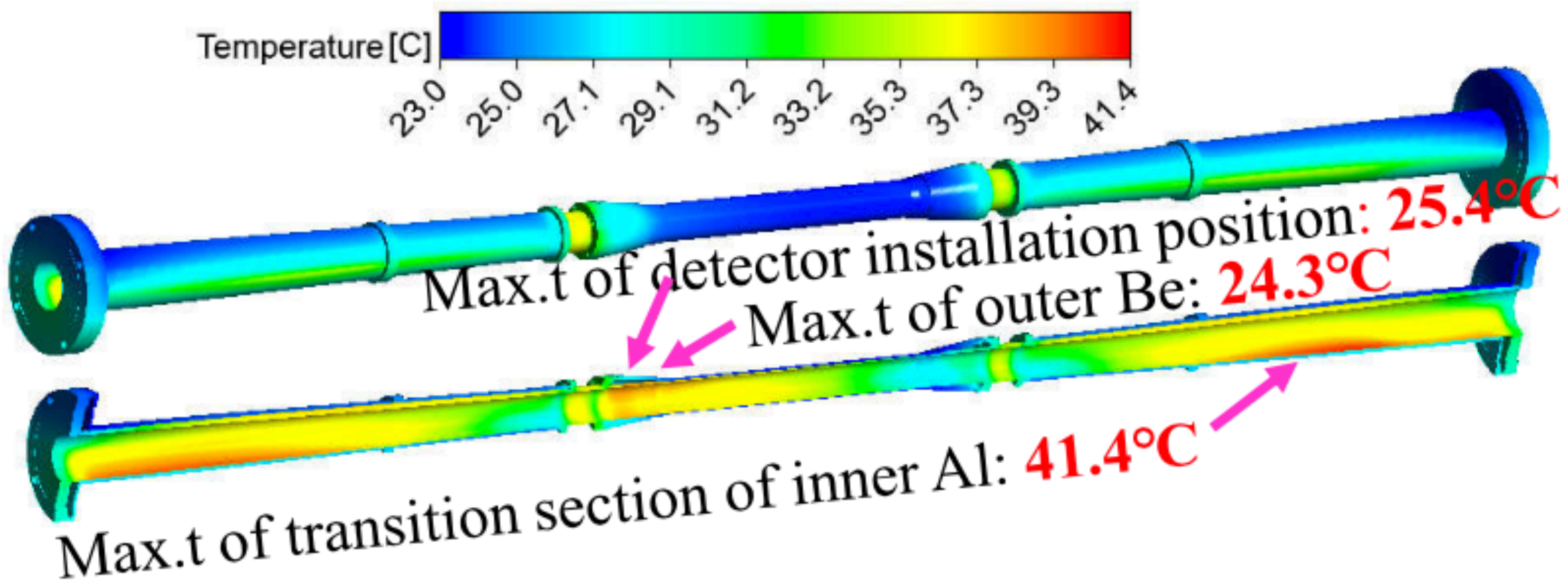
- The first layer vertex is mounted close to the center Be pipe.



Temperature distribution in Z model



Temperature distribution in High Luminosity Z model



MDI Region and Backgrounds from other projects

Marian Lückhof

FCC-ee, MDISim

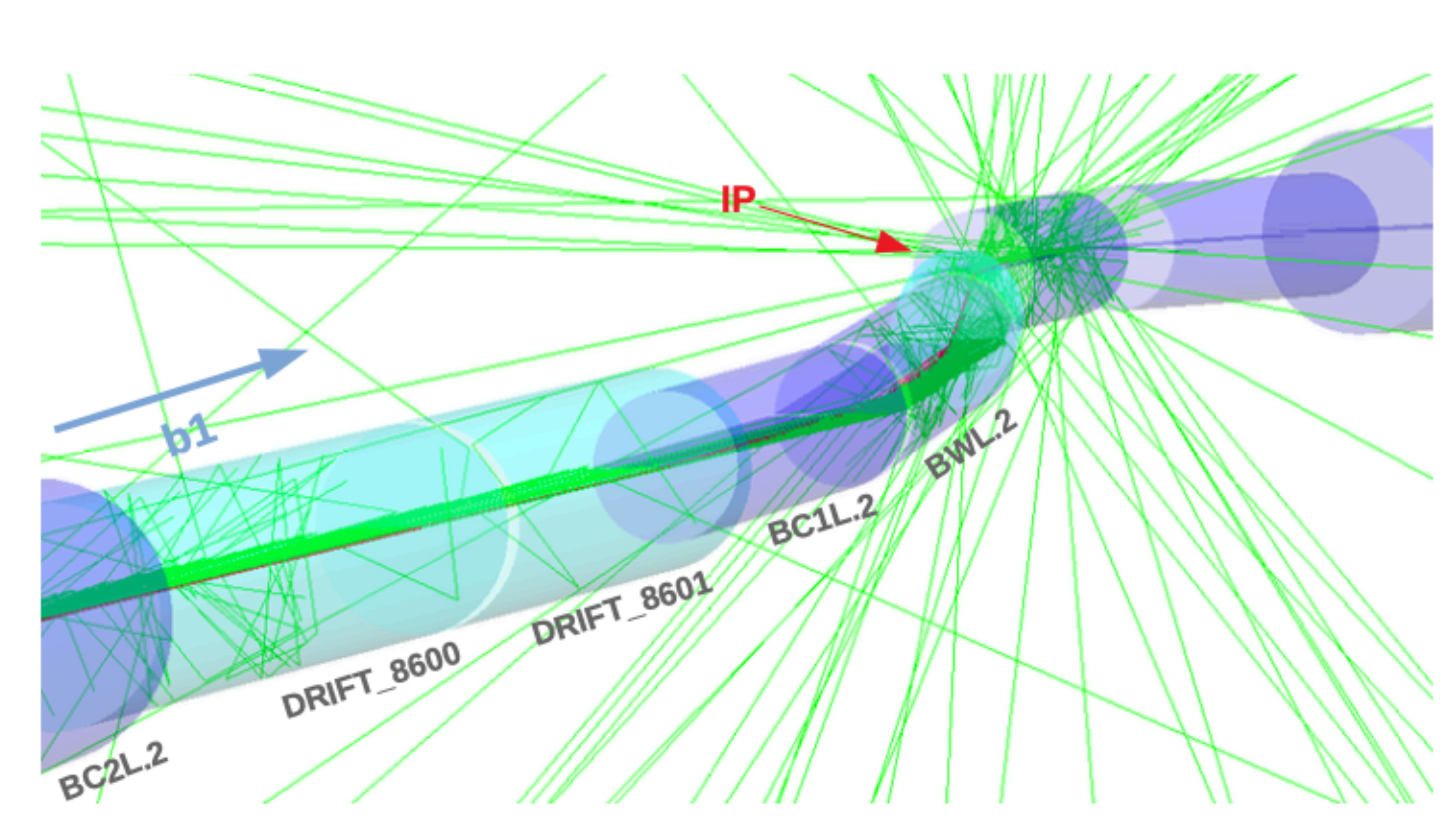
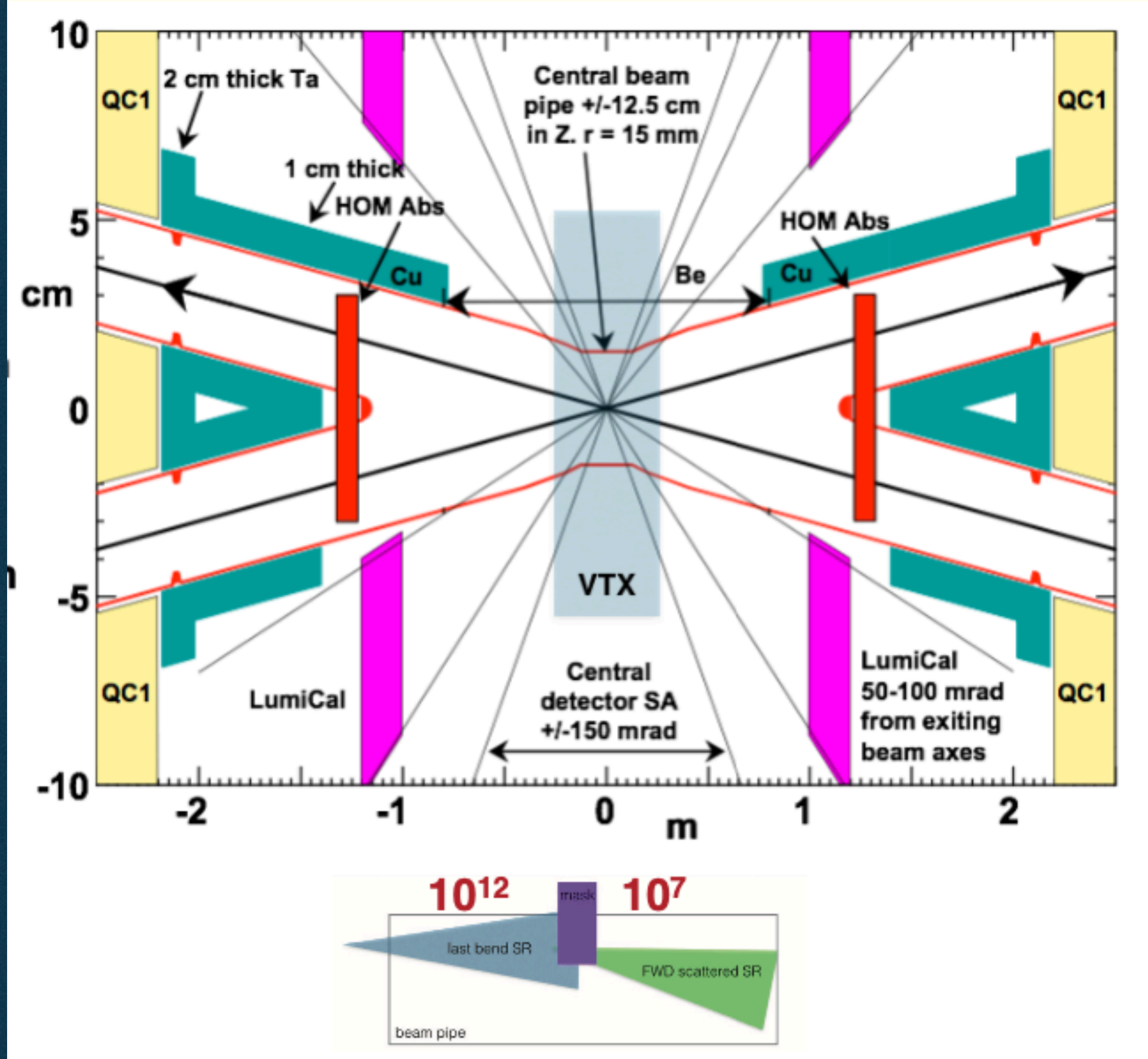


Figure: Same as before but with SR tracks in overlay (Root display).

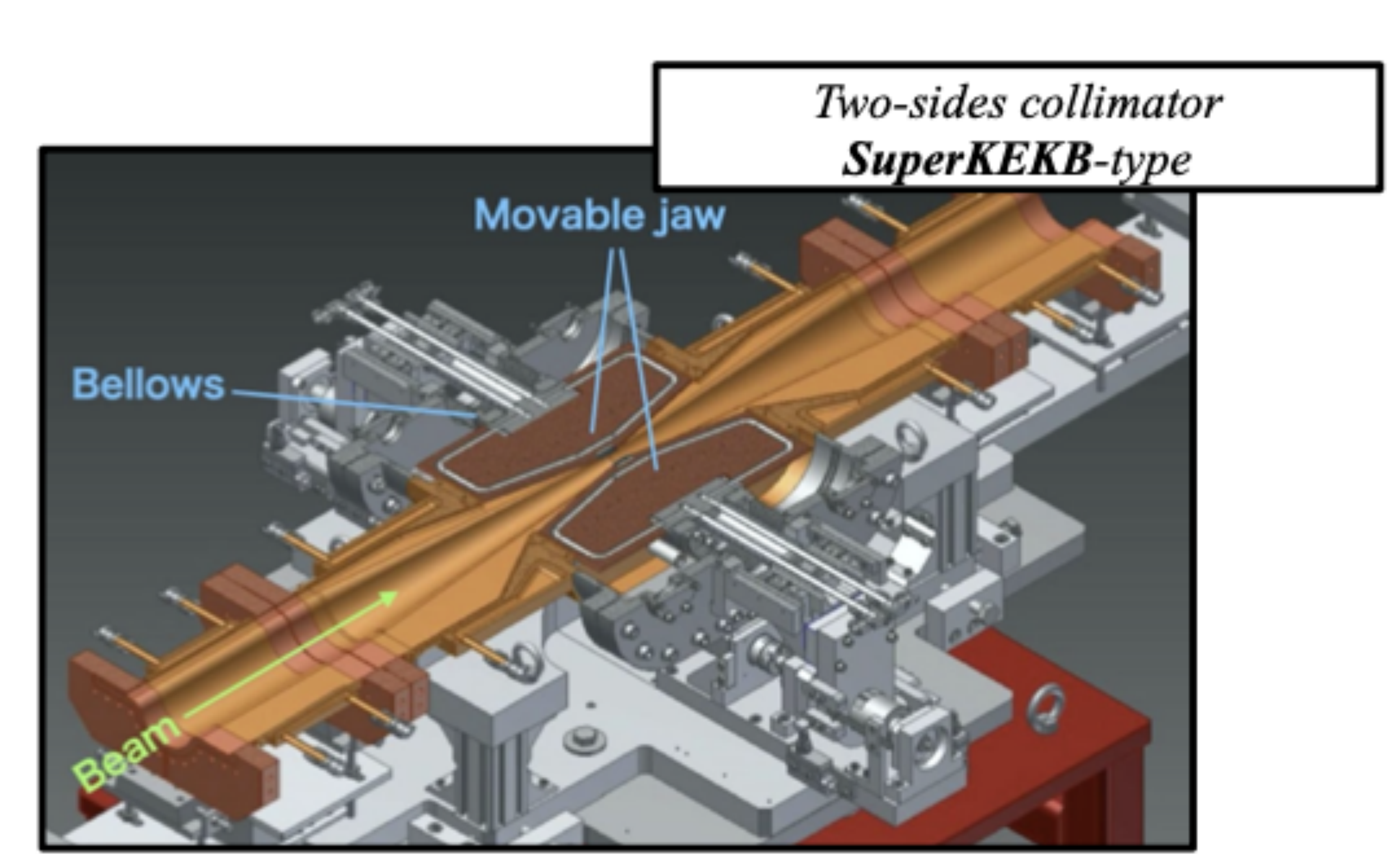
Yorgos Voutsinas

FCC-ee, Backgrounds



Andrii Natochii

Belle II, Background Simulation



Hiroyuki Nakayama

Belle II, Background Measurements

Luminosity world record !

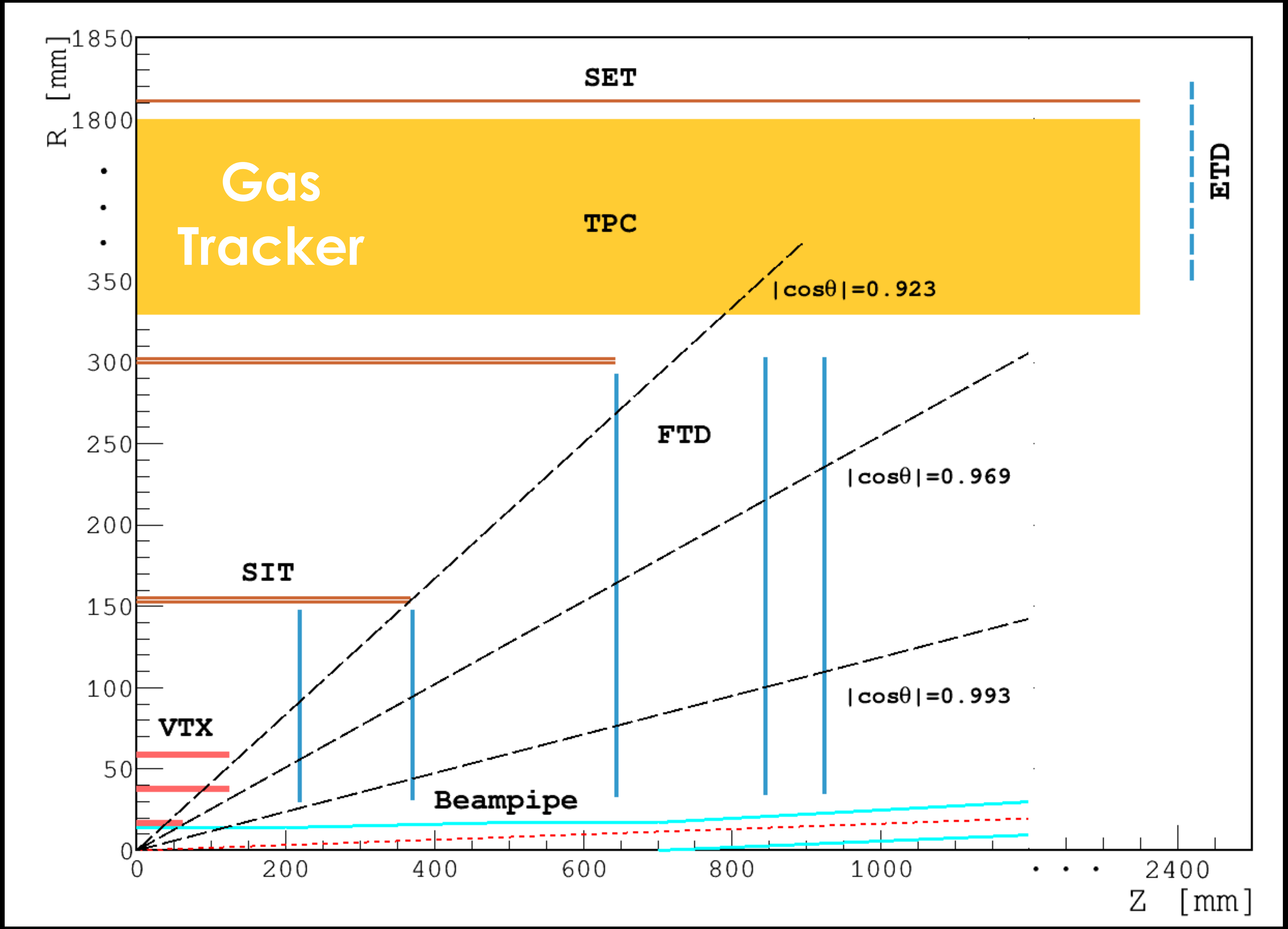
L_{peak}=2.402 x 10^{34}/cm2/s achieved on June 21st

SVD data/MC ratio

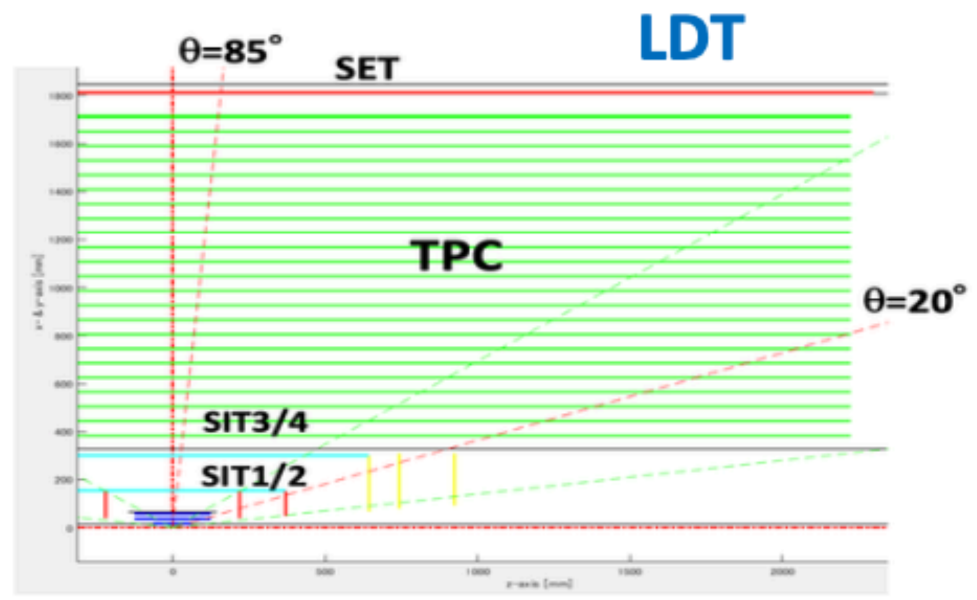
Tanigawa

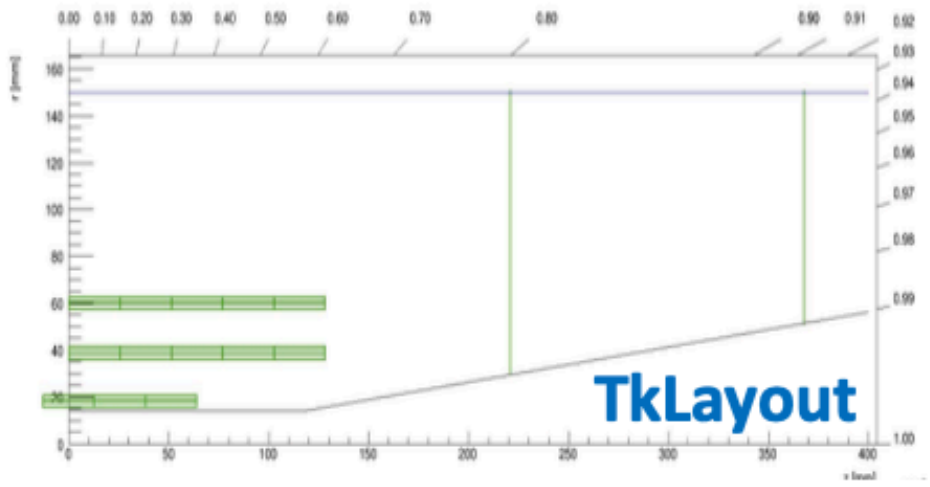
BG sources	Old simulation	New simulation*
HER beam-gas (base)	x11	x3.4
HER beam-gas (dynamic)	x15	x6.3
HER Touschek	x130	x0.24

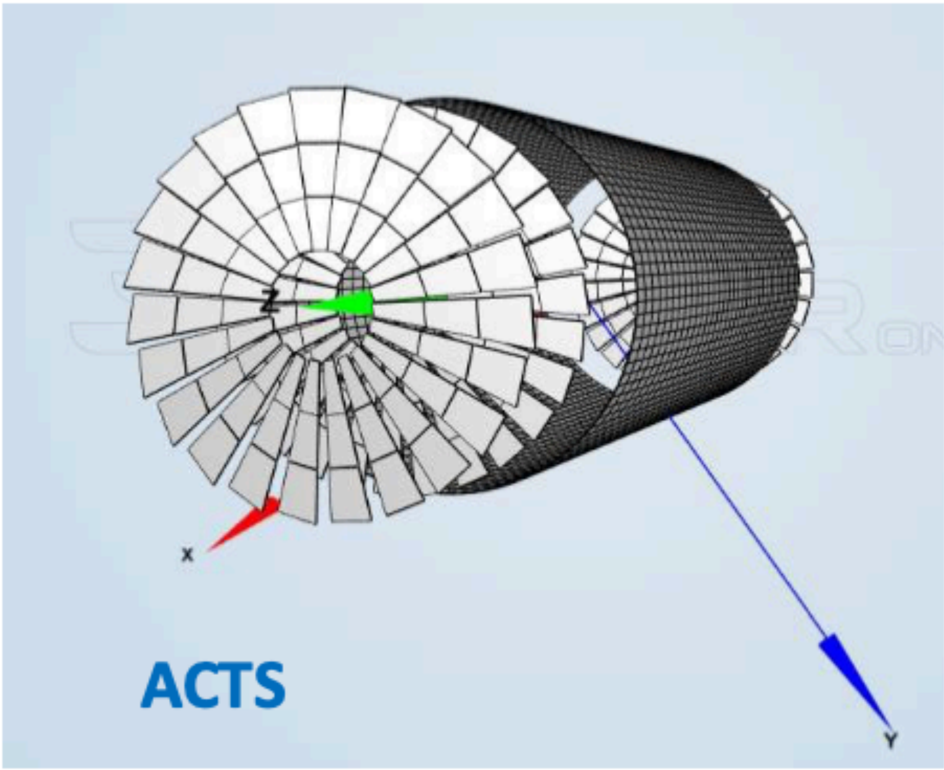
Silicon Tracker design

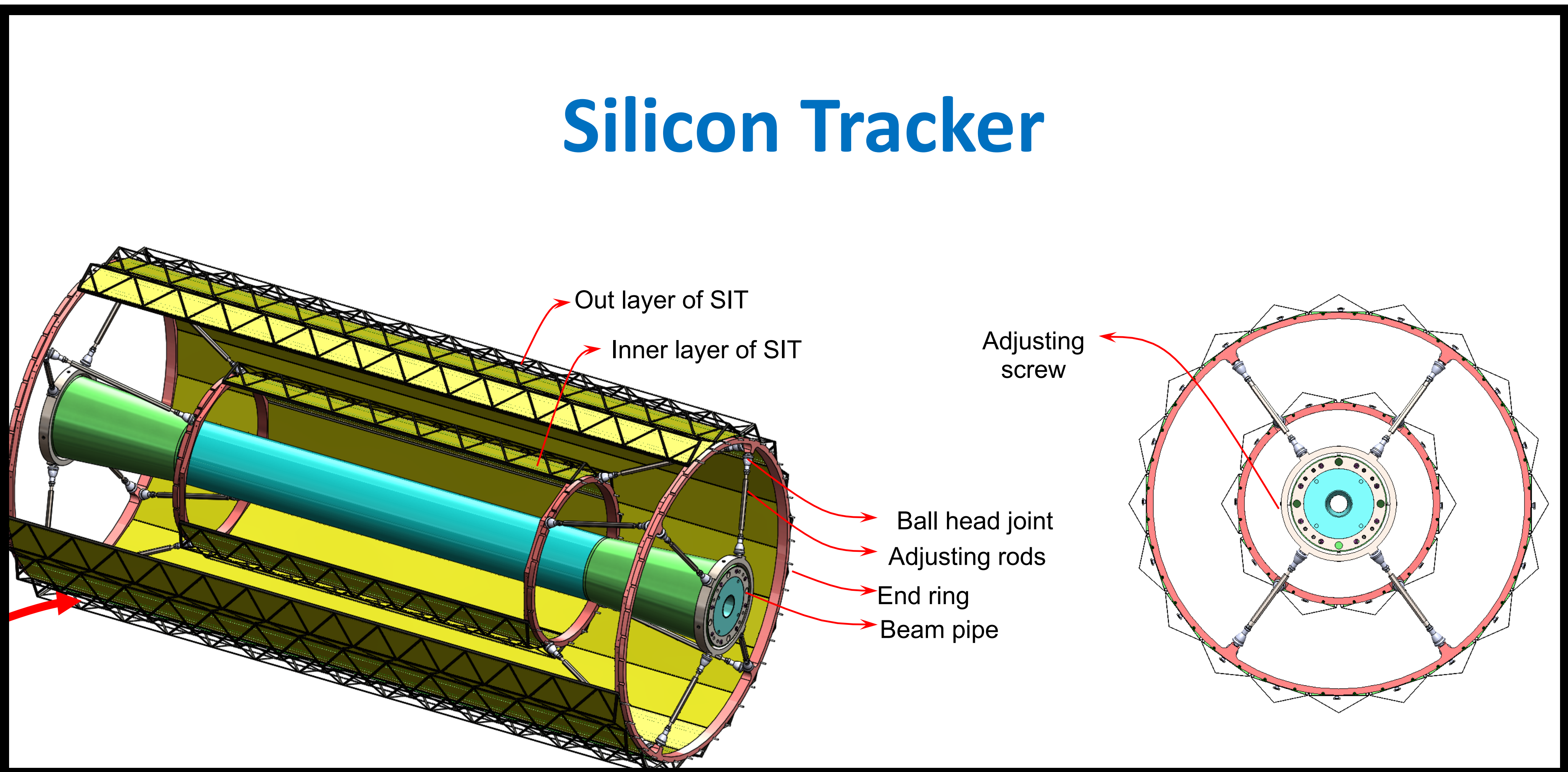


- **LDT** or **TkLayout** to validate basic tracking performance before implementing detailed geometry in **ACTS**









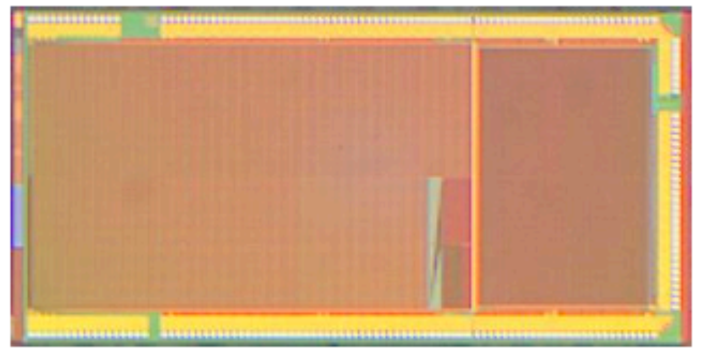
CEPC Sensor Development

Developed CMOS Pixel Sensor prototypes overview

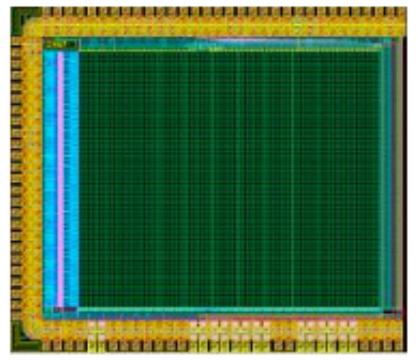
	JadePix1	JadePix2	MIC4	JadePix3
	2015	2017		2019
Architecture	Roll. Shutter + Analog output	Roll. Shutter + In pixel discri.	Data-driven r.o. + In pixel discri.	Roll. shutter + end of col. priority encoder
Pitch (μm²)	33 × 33 /16 × 16	22 × 22	25 × 25	16 × 26 16 × 23.11
Power con. (mW/cm²)	--	--	150	~ 55*
Integration time (μs)*	--	40-50	~3	~100
Prototype size (mm²)	3.9 × 7.9 (36 individual r.o)	3 × 3.3	3.1 × 4.6	10.4 × 6.1
Main goals	Sensor optimization	Small binary pixel	Small pixel + Fast readout+ nearly full functional	Smaller pixel + Low power + fully functional

* Assuming a matrix of 512 ×1024 pixels

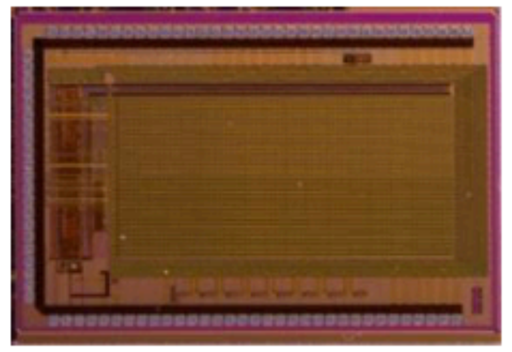
All prototypes in TowerJazz 180 nm process



JadePix1 (IHEP)

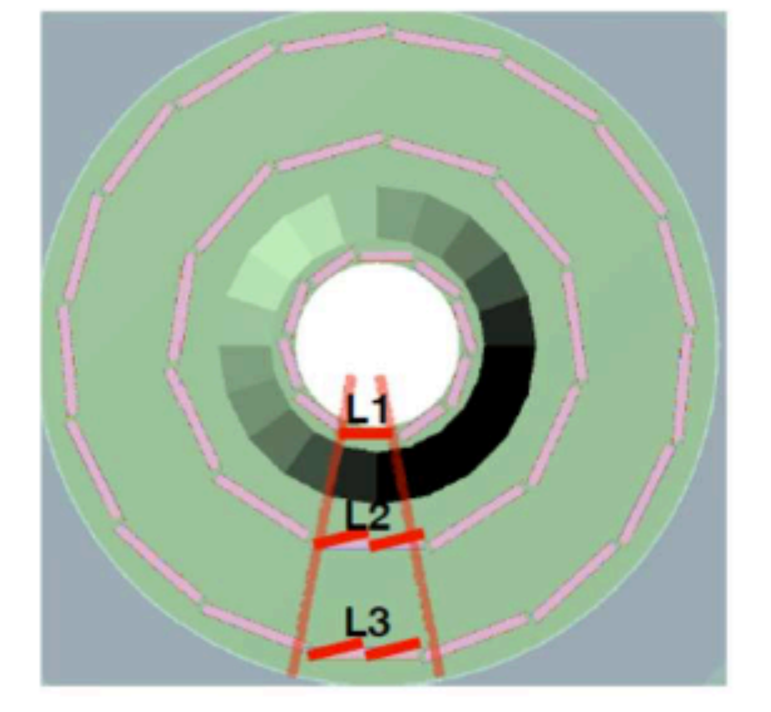


JadePix2 (IHEP)

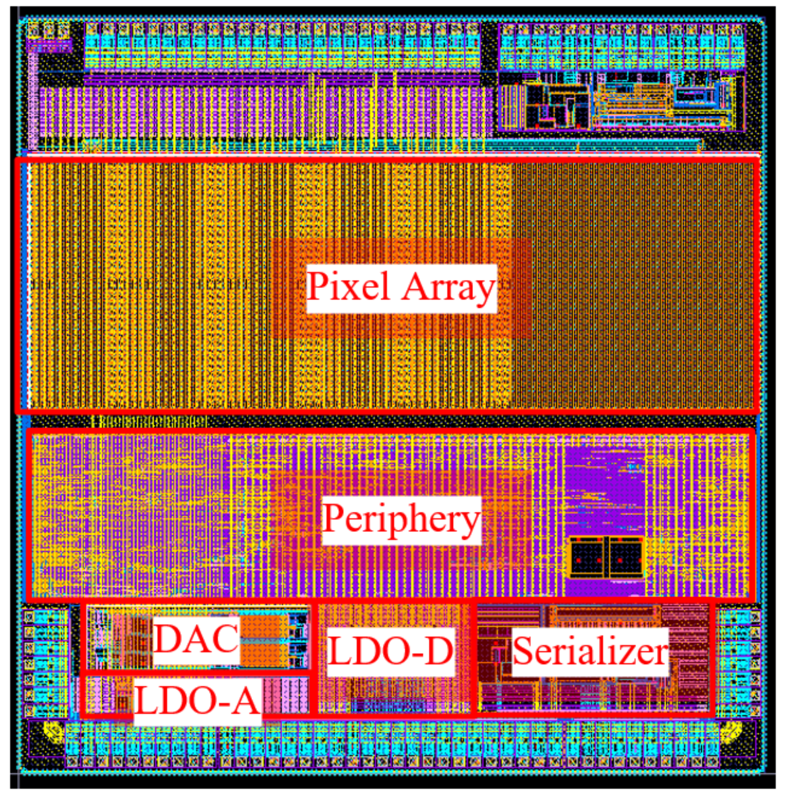


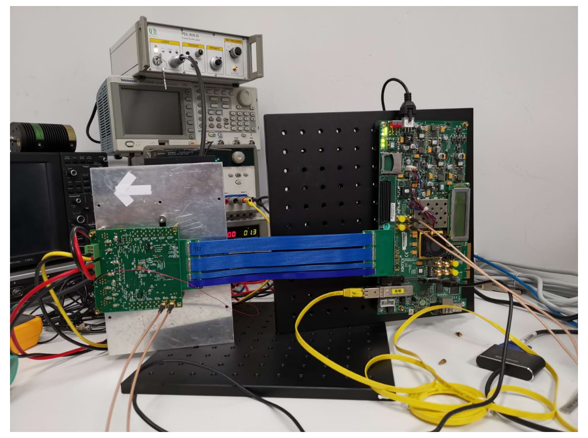
MIC4 (CCNU & IHEP)

JadePix3 (IHEP, CCNU, Dalian Minzu Unv., SDU)



TAICHUPIX-2





- 64×192 pixel array with the same dimension as TaichuPix-1
  - 32 double column modified FE-I3 readout, 32 modified ALPIDE readout
  - 6 variations of pixel analog design, each with 16 columns
- New features added to TaichuPix-2
  - Two LDOs for power supplies
  - 8b10b encoder added for Triggerless output and balanced data stream
  - X-chip buses added for multiple chip interconnections
- Test status: functional verification completed (I/O, bandgap, PPL …), more detailed tests on-going

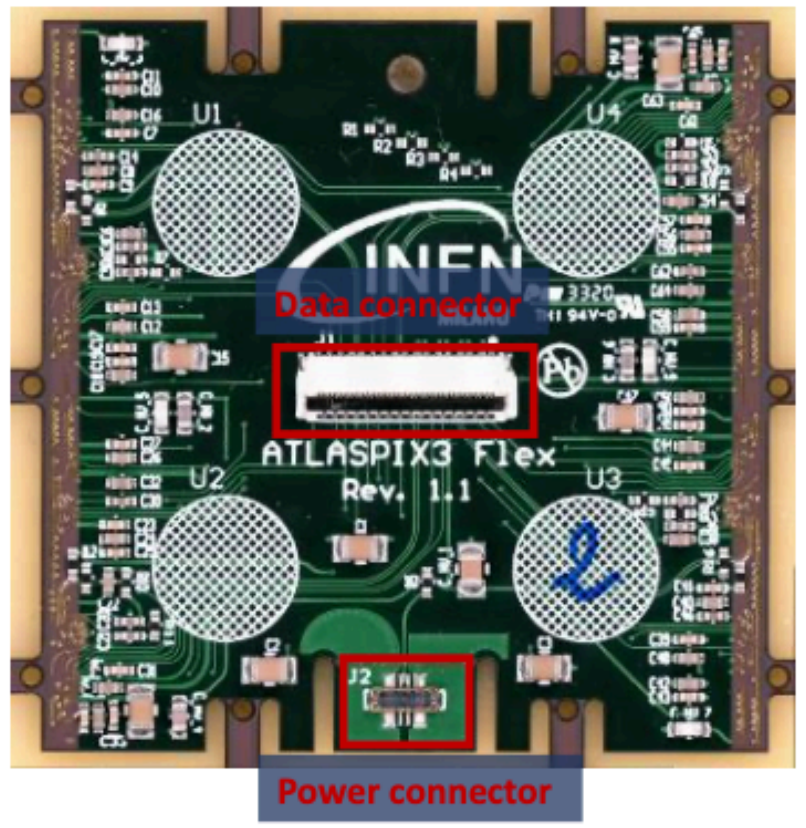
Full size prototype to be built

Silicon tracker demonstrator

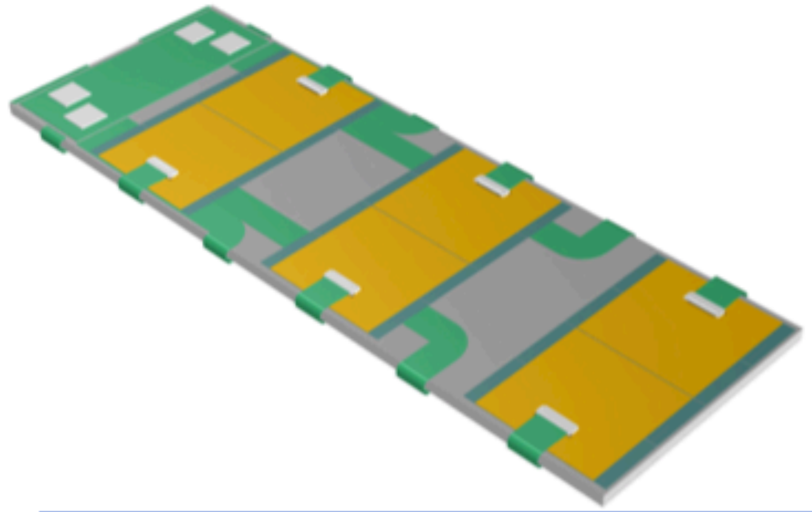
Hui Zhang
Ivan Peric

Demonstrator (Short Stave)

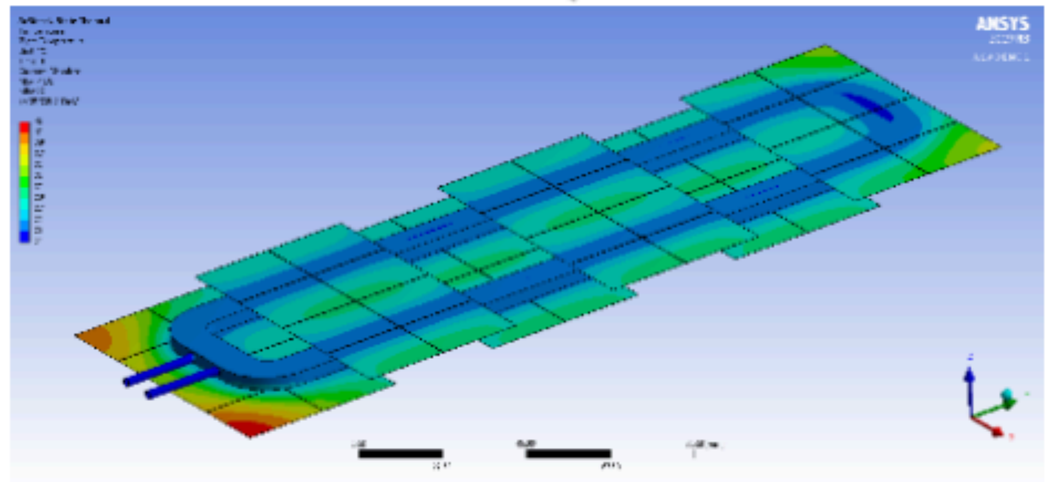
QuadModule Concept

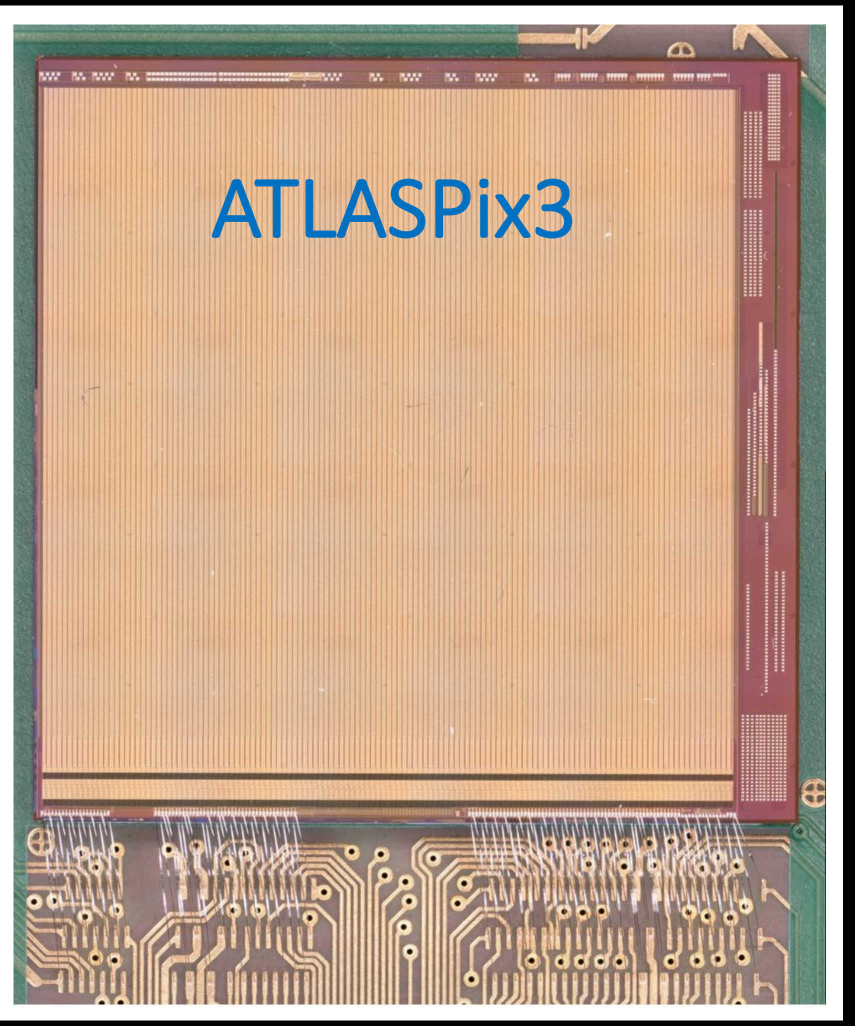


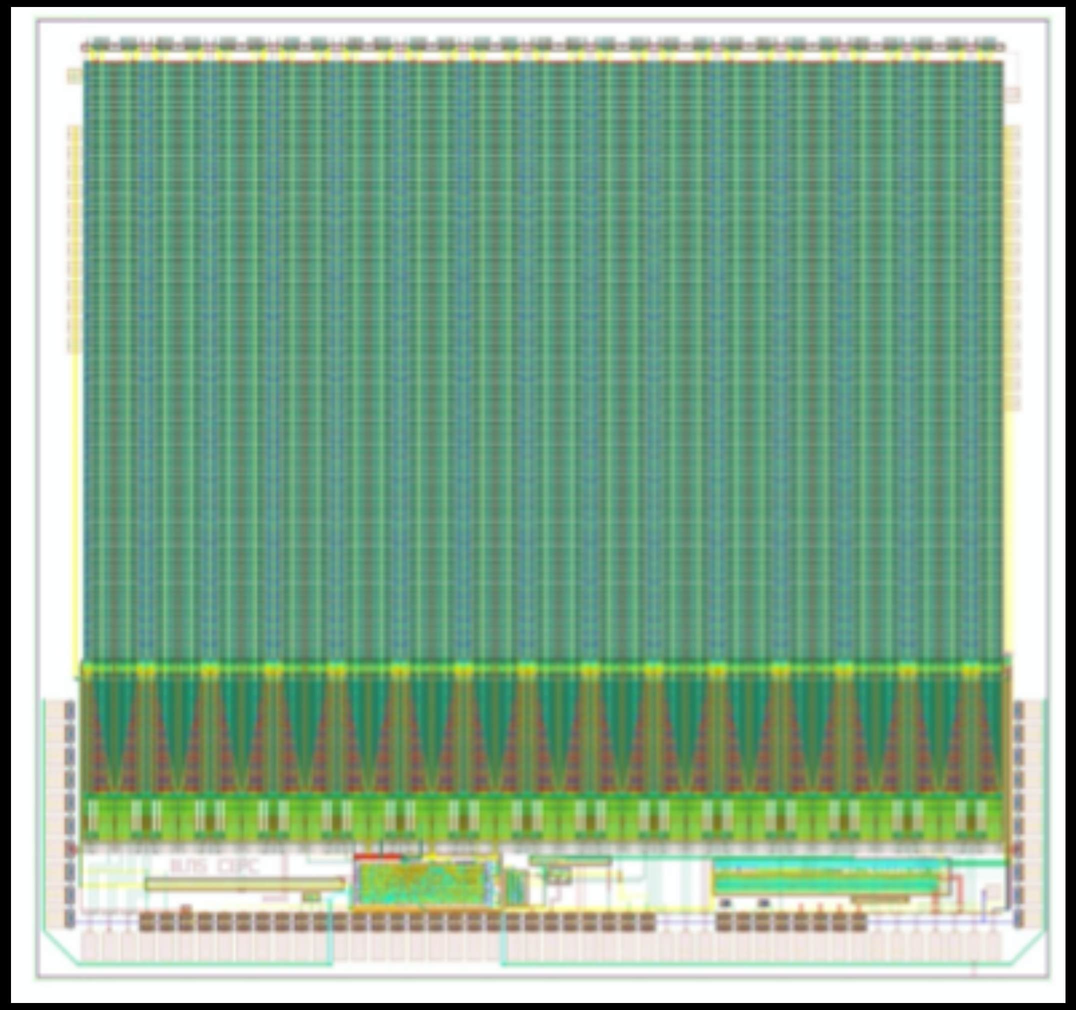
- Multiple modules on light composite support
  - Alternate tile pattern for hermeticity
  - Aggregation of data/optical conversion at the end-of-stave; serial powering



- Readout unit based on 4 chips
  - Shared services among 4 sensors by common power connections and configuration lines
  - Benefits of in-chip regulators to reduce connections







- **China**
  - Institute of High Energy Physics, CAS
  - Shangdong University
  - Tsinghua University
  - University of Science and Technology of China
  - Northwestern Polytechnical University
  - T.D. Lee Institute – Shanghai Jiao Tong University
  - Harbin Institute of Technology
  - University of South China
- **Italy**
  - INFN Sezione di Milano, Università di Milano e Università dell'Insubria
  - INFN Sezione di Pisa e Università di Pisa
  - INFN Sezione di Torino e Università di Torino
- **Germany**
  - Karlsruhe Institute of Technology
- **UK**
  - University of Bristol
  - STFC – Daresbury Laboratory
  - University of Edinburgh
  - Lancaster University
  - University of Liverpool
  - Queen Mary University of London
  - University of Oxford
  - University of Sheffield
  - University of Warwick

Attilio Andreazza
Hongbo Zhu

Sensors with smaller feature size: 65 nm

Motivations for 65 nm in HEP

- State-of-the-art MAPS for HEP use 180 nm CMOS imaging technologies
  - These technologies are now around 20 years old
- Proposed future HEP facilities, planned over the next few decades will need improved performance in terms of granularity, power consumption, rate and radiation hardness → smaller feature size technology needed
- The HEP community is starting exploration of 65 nm technologies
  - Higher logic density (increased performance/area, higher granularity)
  - Lower power
  - Higher speed (logic, data transmission…)
  - Process availability
  - Higher NRE costs and complexity, but lower price per area

ALICE ITS3 Sensor Specifications

Parameter	ALPIDE (existing)	Wafer-scale sensor (this proposal)
Technology node	180 nm	65 nm
Silicon thickness	50 μm	20-40 μm
Pixel size	27 x 29 μm	O(10 x 10 μm)
Chip dimensions	1.5 x 3.0 cm	scalable up to 28 x 10 cm
Front-end pulse duration	~ 5 μs	~ 200 ns
Time resolution	~ 1 μs	< 100 ns (option: <10ns)
Max particle fluence	100 MHz/cm^2	100 MHz/cm^2
Max particle readout rate	10 MHz/cm^2	100 MHz/cm^2
Power Consumption	40 mW/cm^2	< 20 mW/cm^2 (pixel matrix)
Detection efficiency	> 99%	> 99%
Fake hit rate	< 10^{-7} event/pixel	< 10^{-7} event/pixel
NIEL radiation tolerance	~3 x 10^{13} 1 MeV n_{eq}/cm^2	10^{14} 1 MeV n_{eq}/cm^2
TID radiation tolerance	3 MRad	10 MRad

EIC SVT Sensor Specifications

Parameter	EIC Vertex and Tracking MAPS
Technology	65 nm (Backup: 180 nm)
Substrate Resistivity [kohm cm]	1 or higher
Collection Electrode	Small
Detector Capacitance [fF]	<5
Chip size [cm x cm]	Full reticule or stitched
Pixel size [μm x μm]	20 x 20
Integration Time [μs]	2
Timing Resolution [ns]	< 9 (optional)
Particle Rate [kHz/mm^2]	**TBD**
Readout Architecture	Asynchronous
Power [mW/cm^2]	< 20
NIEL [1MeV neq/cm^2]	10^{10}
TID [Mrad]	< 10
Noise [electrons]	< 50
Fake Hit Rate [hits/s]	< 10^{-5}/evt/pix
Interface Requirements	**TBD**

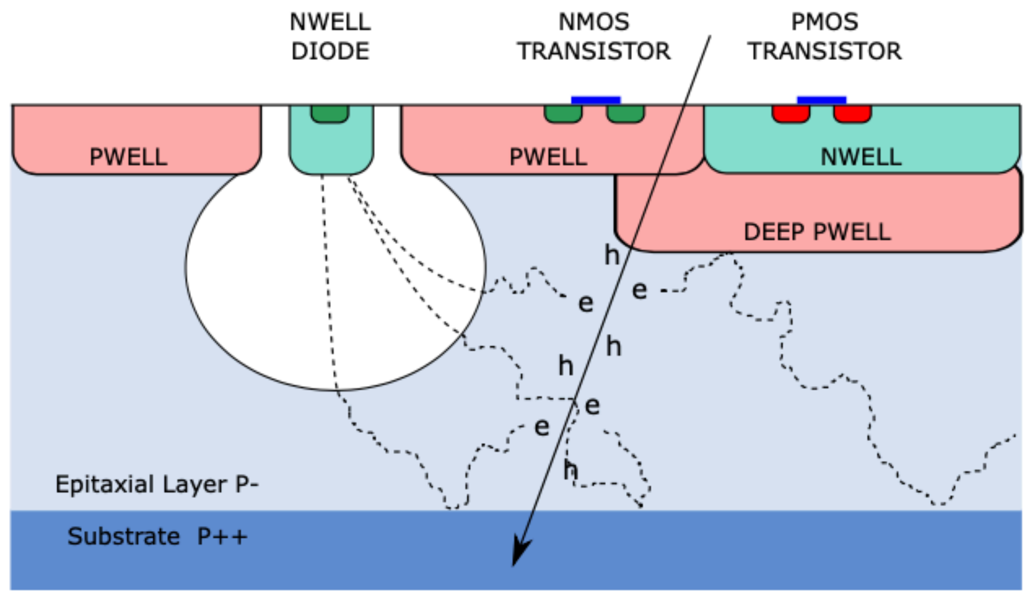
Sensors with smaller feature size: 65 nm

First technology selection

- Several 65 nm flavours: high density logic, RF, and imaging (ISC)
- ISC preferred
  - 2D stitching experience, special sensor features, lower defect densities, at present limited to 5 metal layers but more metals later, no MPWs available
- Modus operandi agreed by foundry in May: start directly in ISC with Multiple Layers per Reticle with standard metal stack
  - Avoid non-representative results (for transistor irradiation measurements)
  - Multiple Layer per Reticle (in between MPW and engineering run)
  - Several starting materials available; the collection electrode is always n-type, the same readout circuit can be used for different starting materials

Starting material: first possibility

- Similar sensor structure possible as in ALPIDE
  - Deep wells available
  - High resistivity p-type epitaxial layer ~ 10 micron thick
  - Depending on pixel size and area taken by readout, sensitive layer not necessarily fully depleted



J. Phys. G: Nucl. Part. Phys. 41 (2014) 087002

See W. Snoeys, https://indico.cern.ch/event/929387/contributions/3907086/attachments/2063152/3585457/WP1-2_24_6_2020_b.pdf

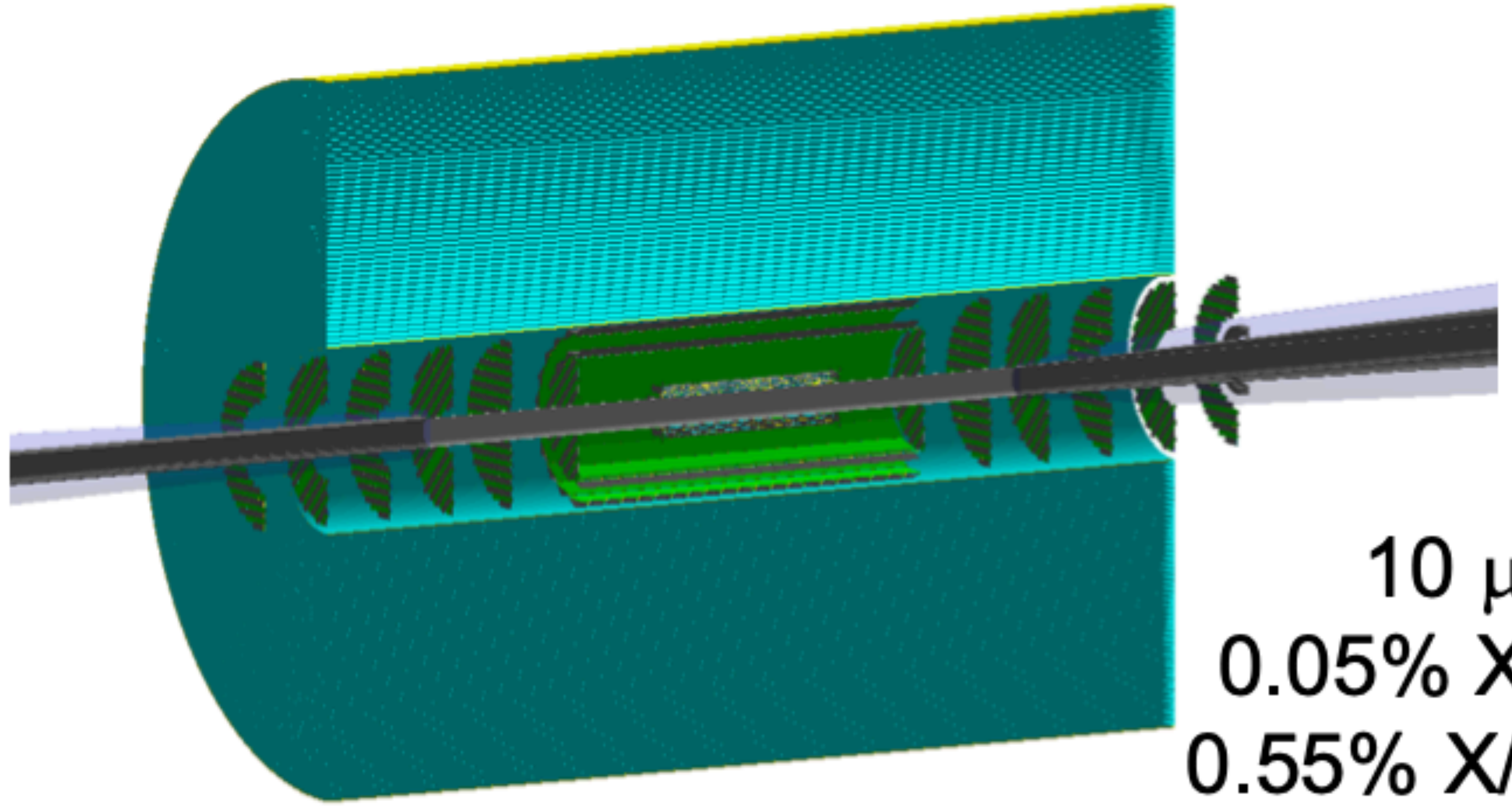
First test structures to be submitted: Nov 15

Participating institutes
CERN, CPPM, DESY, Yonsei University Seoul, IPHC Strasbourg, NIKHEF Amsterdam, RAL/Uni Birmingham/LBNL (EIC institutes)

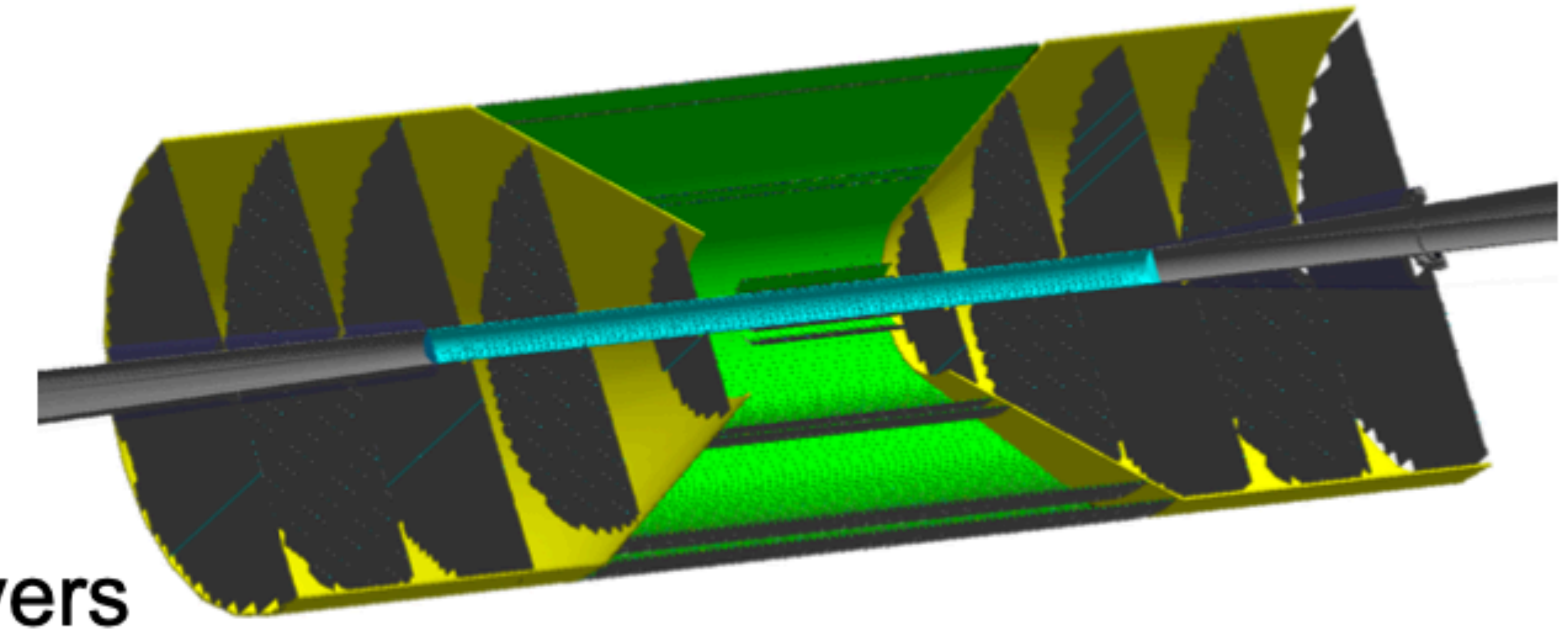
EIC SVT

- A well integrated, large acceptance Silicon Vertex and Tracking (SVT) detector designed with high granularity and low material budget is planned for the Electron-Ion Collider to enable high precision measurements that are key to its science programme
  - Expected start of operation approximately 2030

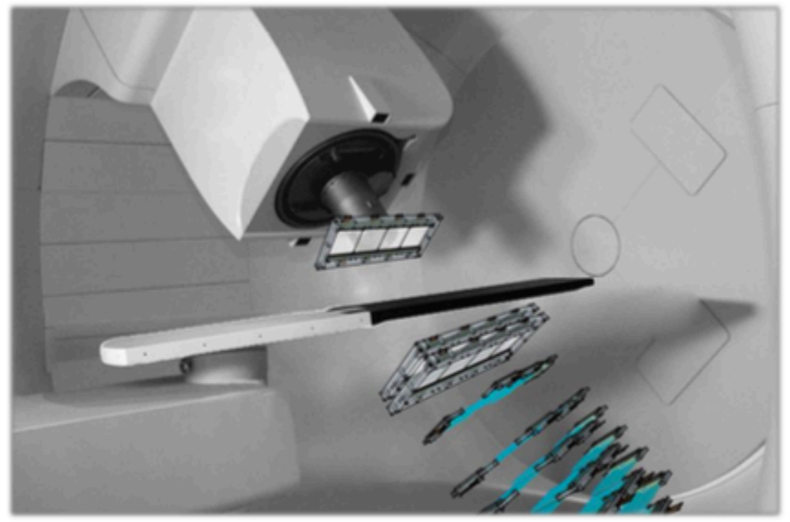
- Two baseline configurations are studied, based on ITS3 sensor technology
  - Hybrid, i.e. silicon SVT complemented by gas outer tracker and end-caps, ~12m^2
  - All-silicon compact design, ~15m^2
  - Vertex and tracking layers in the central region, disks in the forward/backward region

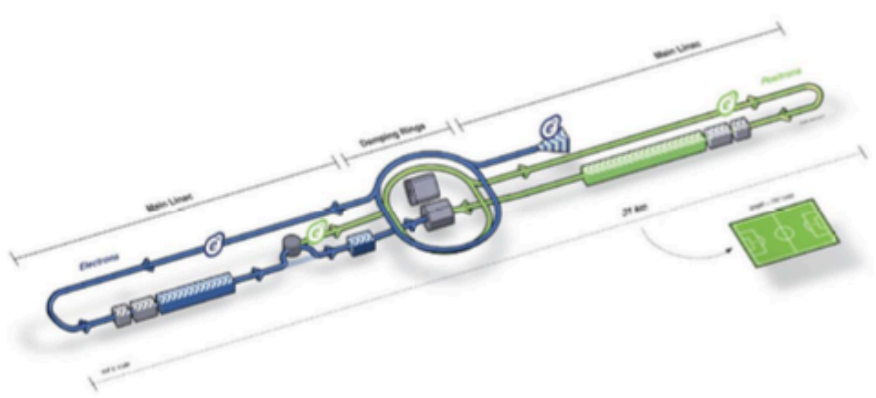


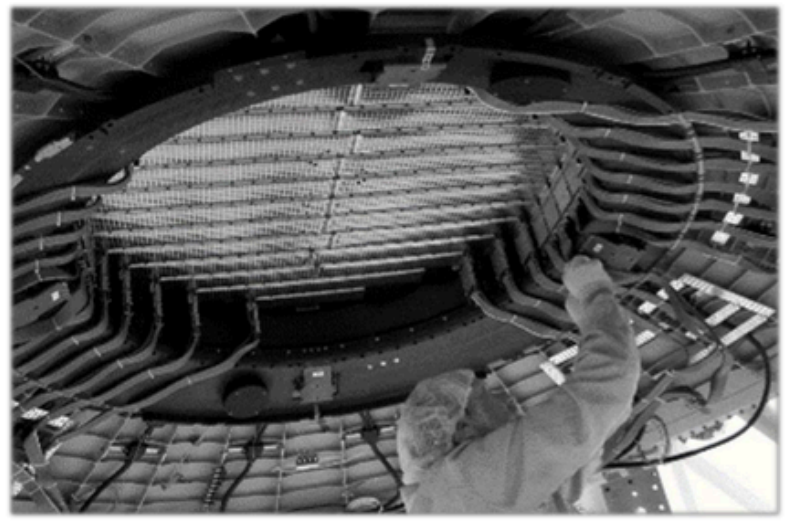
10 μm pixel pitch
0.05% X/X_0 vertex layers
0.55% X/X_0 tracking layers
0.24% X/X_0 disks



ARCADIA - CMOS Sensors







Medical
- Low power (≤ 40 mW/cm²)
- Medium rate ≈ 10 MHz – 100 MHz/cm²
- Ultra low material budget (low energy)
- Very large area (≥ 16 cm²)
- 3-side buttable
- Low to medium rad-tolerance ≈ 10 kGy

Lepton collider
- Low power (≤ 40 mW/cm²)
- Medium rate ≈ 10 MHz – 100 MHz / cm²
- Very low material budget
- Large area (≥ 6 cm²)
- 3-side buttable
- Low to medium rad-tolerance ≈ 10 kGy

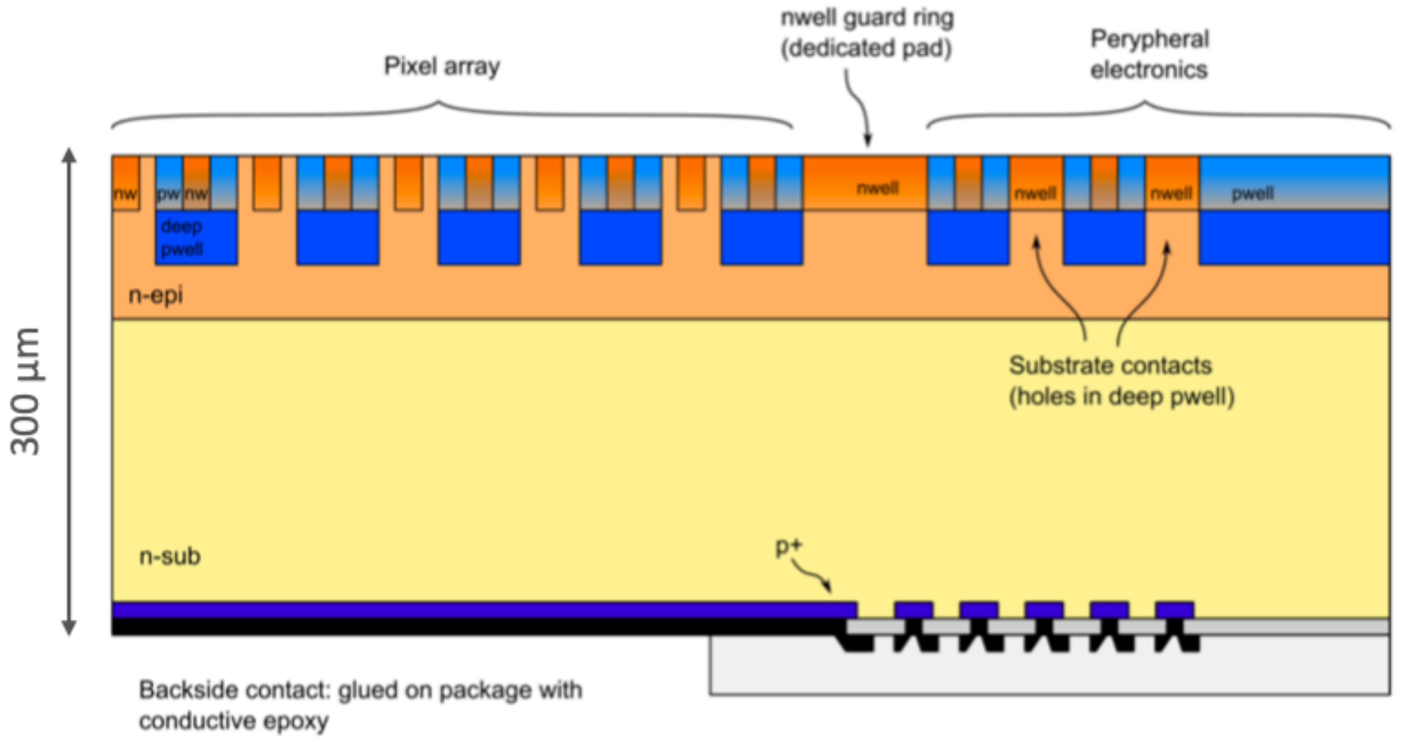
Space
- Ultra low power (≤ 10 mW/cm²)
- Very low rate ≈ kHz/cm²
- Low material budget
- Large area (≥ 6 cm²)
- 3-side buttable
- Low rad-tolerance ≈ 1 kGy

P. Giubilato – CEPC 2020 – Shanghai 2/14

Fully depleted sensor

The ARCADIA design uses a sensor solution (SEED) developed in collaboration with LFoundry to achieve uniform, full depletion over thicknesses of few hundreds microns by virtue of a patterned backside (4 mask process).

- **Technology**: 110 nm CMOS technology, high-resistivity bulk substrate
- **Full depletion** with fast charge collection
- Both NMOS and PMOS transistors, 6 metal layers
- Custom patterned backside (patented) with LFoundry
- 50 µm to 500 µm sensor thickness (more if necessary)

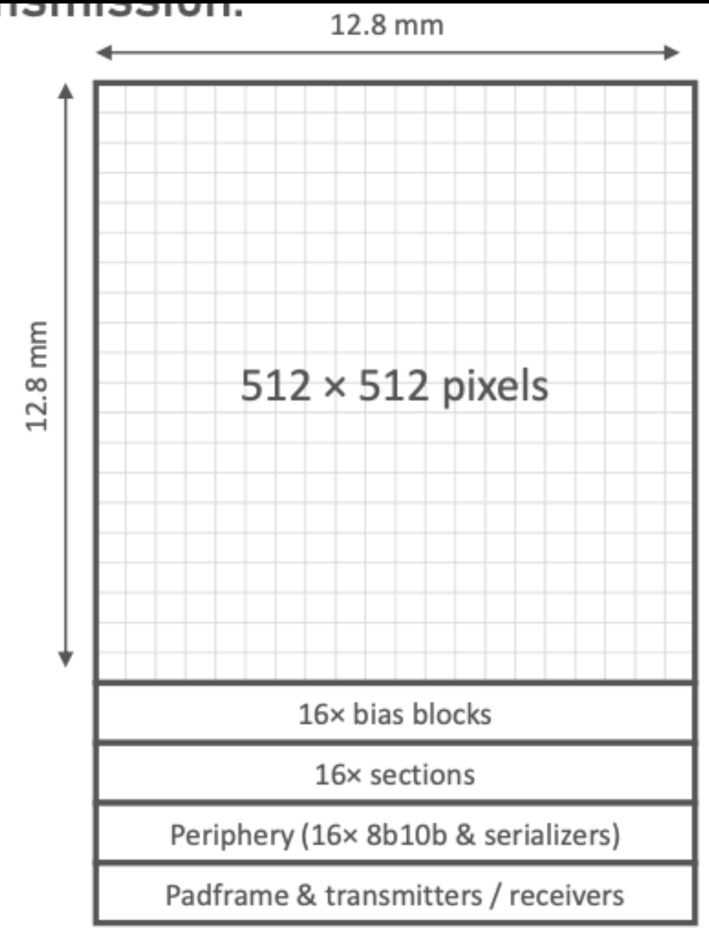


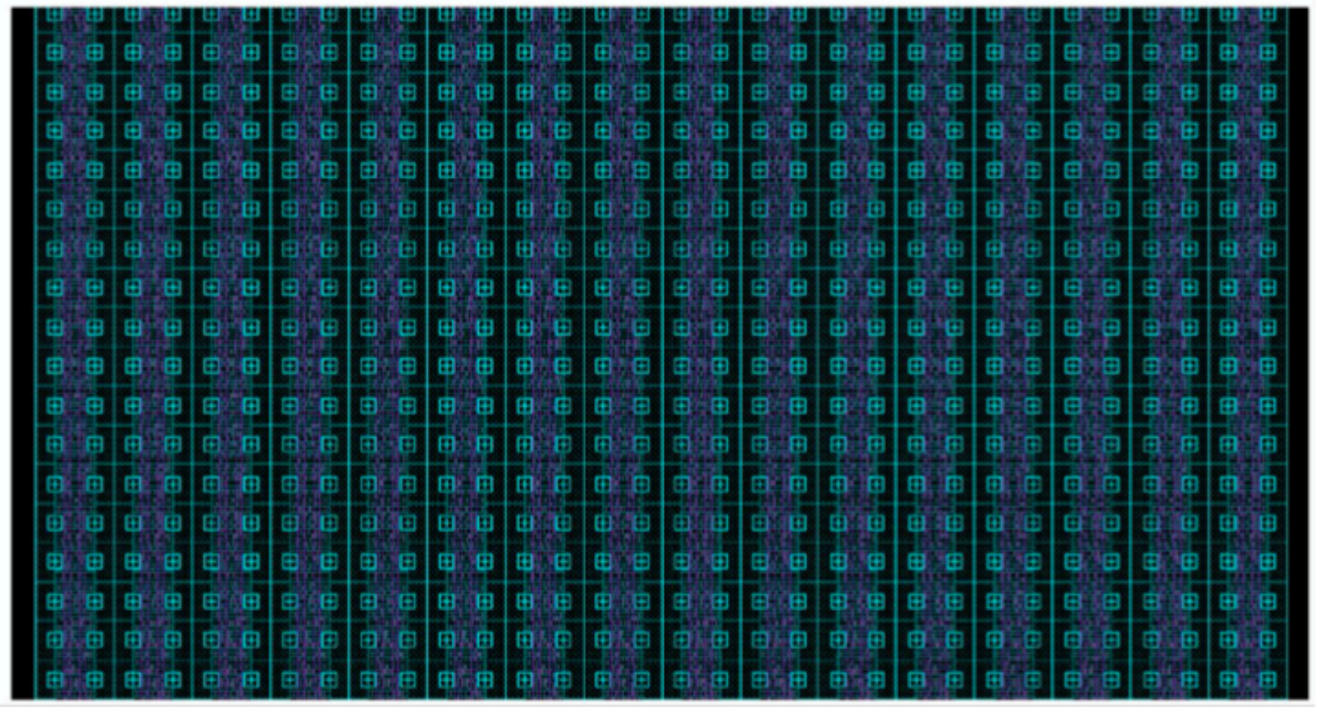
A "thin" 100 µm thickness version has been also successfully produced and tested

P. Giubilato – CEPC 2020 – Shanghai 4/14

	Min	Max	Note
Power consumption	5 mW/cm²	20 mW/cm²	
Pixel pitch	-	25 µm	In demonstrator the largest dictated by CCE
Matrix area	4 cm²	24 cm²	1 cm² in the first demonstrator
Hit Rate	10 MHz/cm²	100 MHz/cm²	Assuming 4 px/hit
Timing resolution	O (1 µs)	O (10 µs)	For first demonstrator
Radiation hardness	-	5 kGy	Clearance required if > 5 kGy (lepton collider)

Main features
- **Clock-less matrix** (to minimize power dissipation)
- **Trigger-less** readout
- **Binary readout** (with pixel masking)
- Easy replicable, identical sections (512 × 32 px each in the demonstrator)
  - Scalable architecture able to cope with 2048 pixel high sections
  - One output link per section (with power-off and bypass for space-mode operations)
- **Ultra low power "space" mode**, using only one high speed output for all the sections.





- Pixel size: 25 µm x 25 µm
- Matrix core 512 x 512, side-buttable.
- Matrix, EoC architecture, data links scalable to 2048 x 2048
- Trigger-less binary data readout, up to 10-100 MHz/cm²

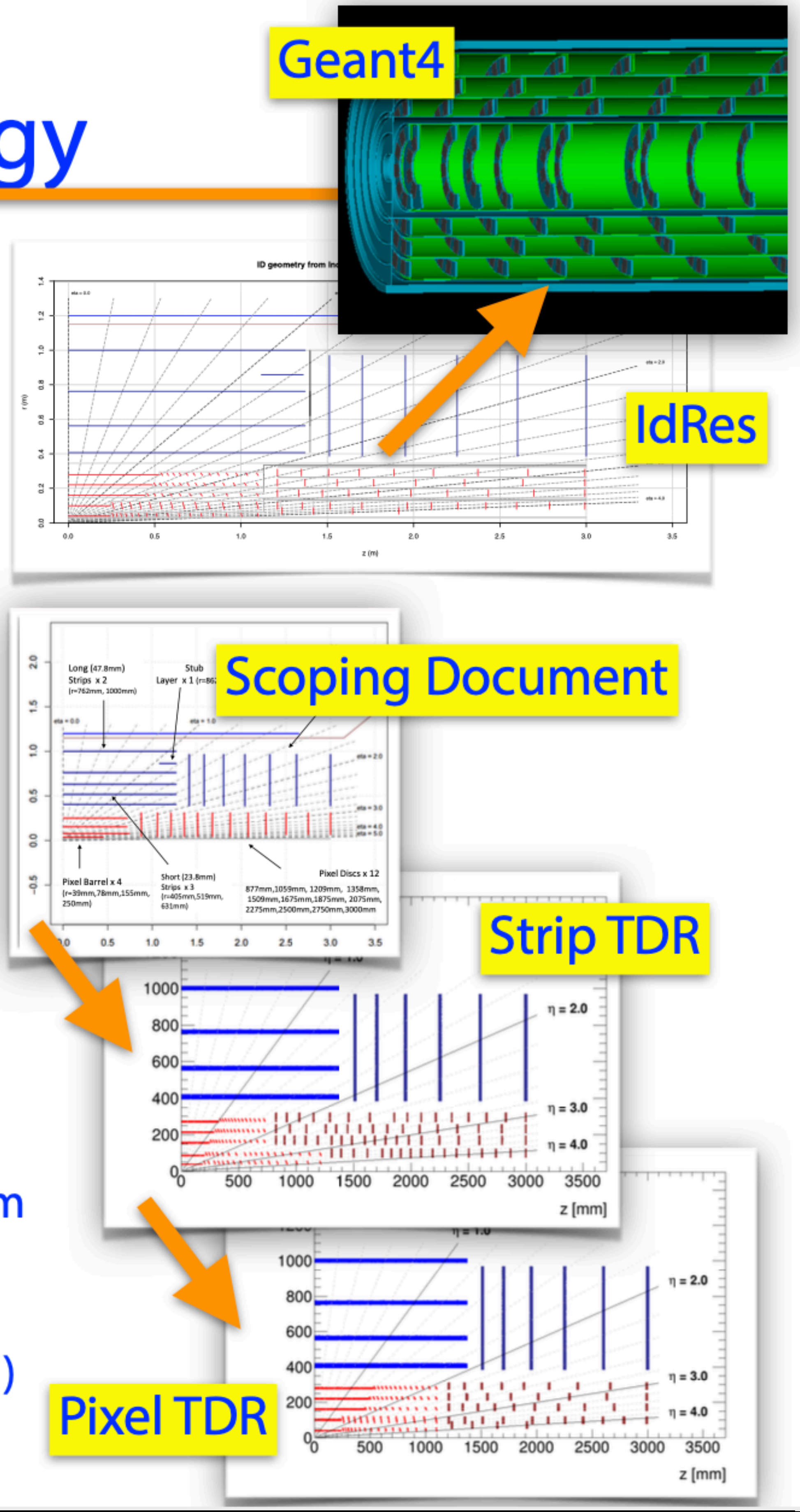
First prototype: November 2020
Second prototype: Spring 2021
Stitching: End of 2021

Lessons learned from the ATLAS upgrade tracker design

4

Layout Optimisation Strategy

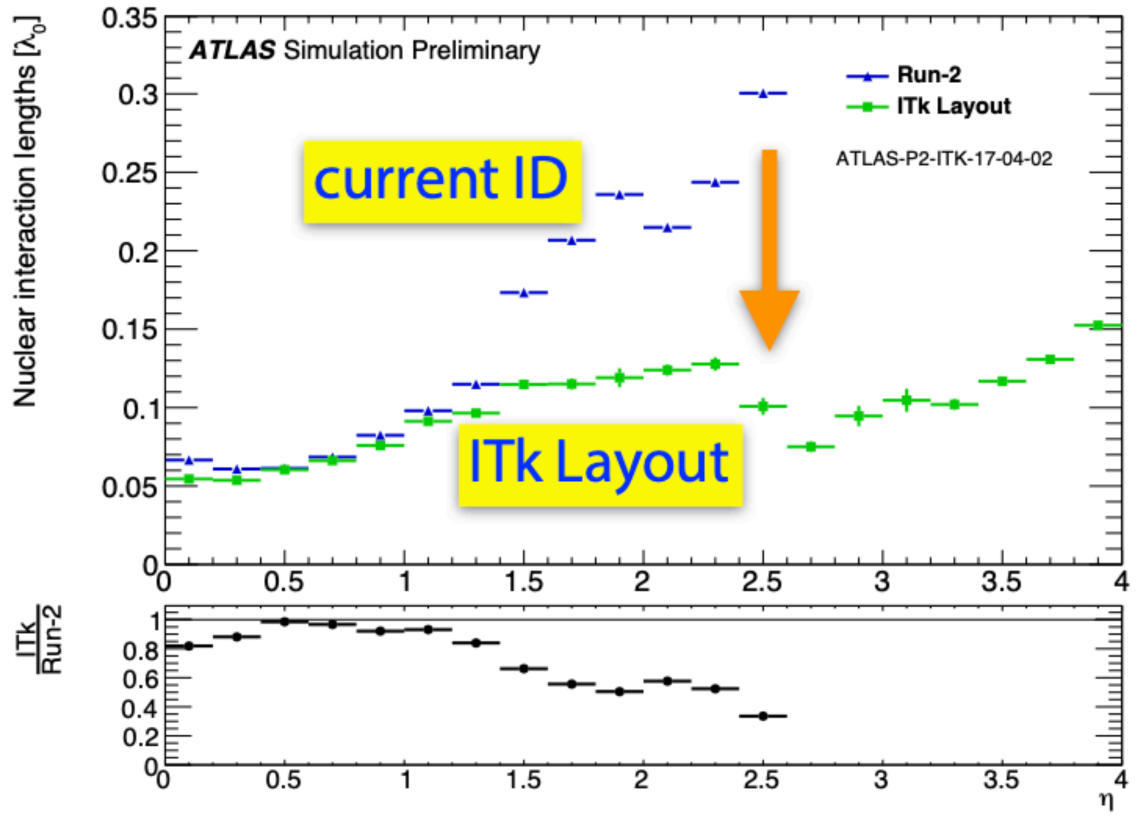
- optimisation is an iterative procedure
  - ➡ design tool **IdRes** allows for fast layout optimisation
    - hit coverage, resolutions, ...
  - ➡ **Geant4** to assess full layout performance
    - 3D hermeticity, tracking, CPU, ...
  - ➡ **simulation** studies support **engineering** work
    - supports, services, materials, clearances, ...
- a whole series of **layout evolutions**
  - ➡ **Strip TDR** layout evolved from **Scoping Document**
  - ➡ **Pixel TDR** layout basis for fully engineered final Pixel design one year later (**final ITk** layout)
- metric used for layout optimisation:
  - balance ambitions with **constructibility**
  - **performance** required for Phase-2 physics program
  - tracking **robustness** against detector failures
  - minimise **cost** (silicon surface, complexity, ...)
  - minimise **CPU** for reconstruction (computing cost)

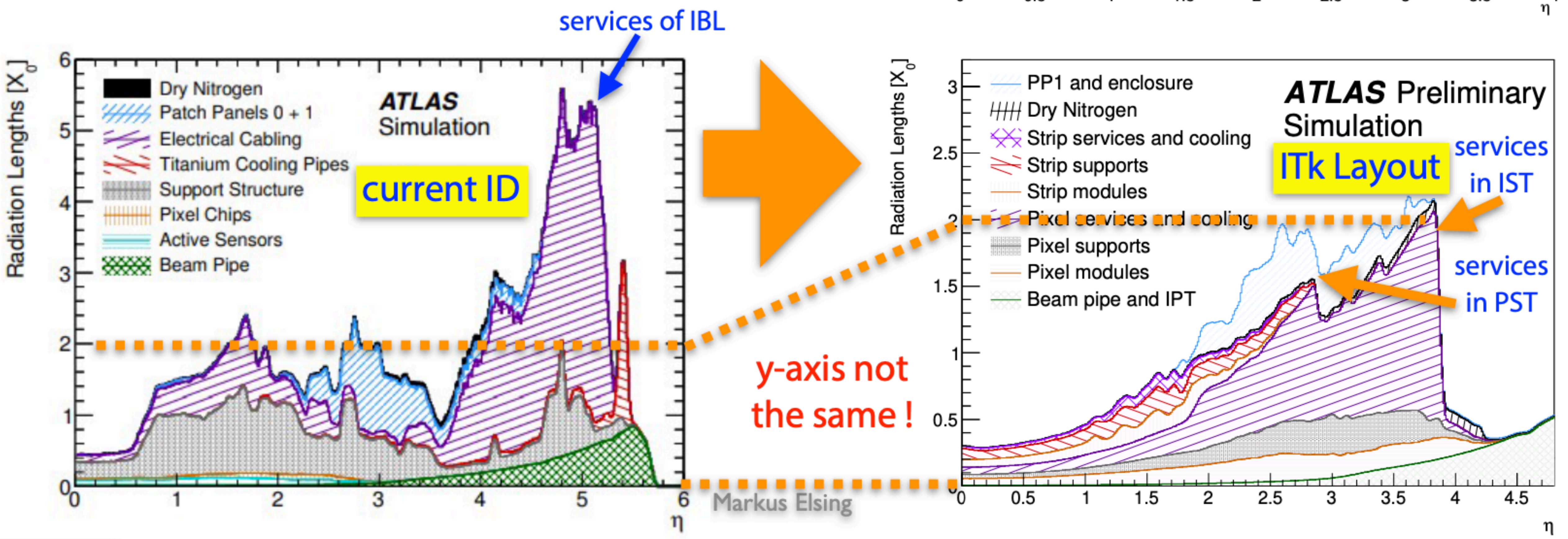


Markus Elsing

Passive Material ITk vs current ID

- ITk has less material that current ID
  - ➡ despite increase in channels, data rates, ...
  - ➡ inner Pixel services in IST dominating (geometry)
- reduction in λ_0 until hit requirement
  - ➡ 7 hit cut for current ID, 9 hit cut for ITk, less in forward region (7-8)
  - ➡ reduced inefficiency due to hadronic interactions





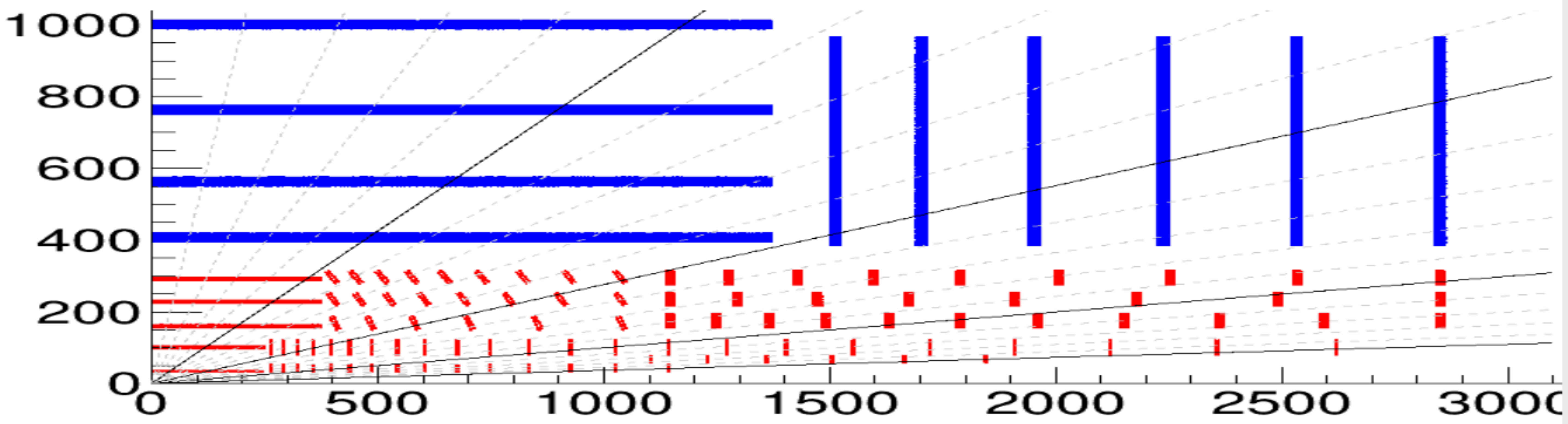
Markus Elsing

Markus Elsing

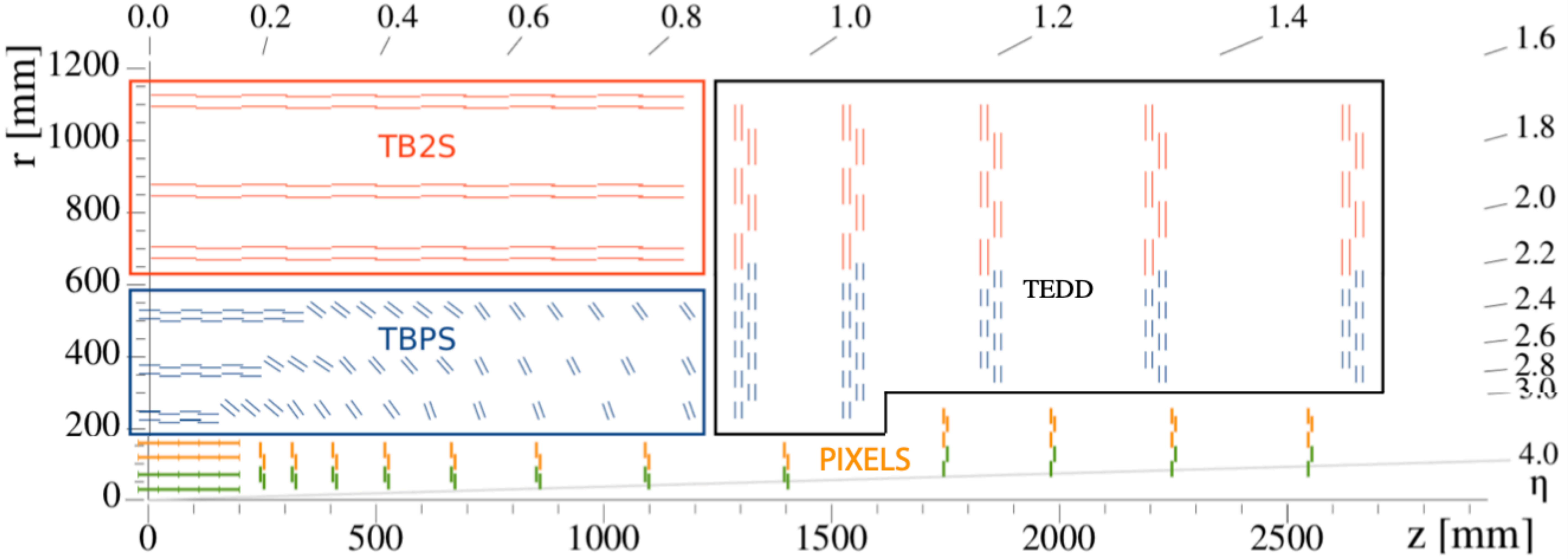
Comparison to CMS Phase-2 Tracker

- tried scaling layout plots to match dimensions...

➡ ATLAS:
- 4 double-strip
- 5 pixel layers
- total **9 layers**
- total **13 hits**



➡ CMS [TDR]:
- 3 double-strip
- 3 strip+pixel (trigger layers)
- 4 pixel layers
- total **10 layers**
- total **16 hits**



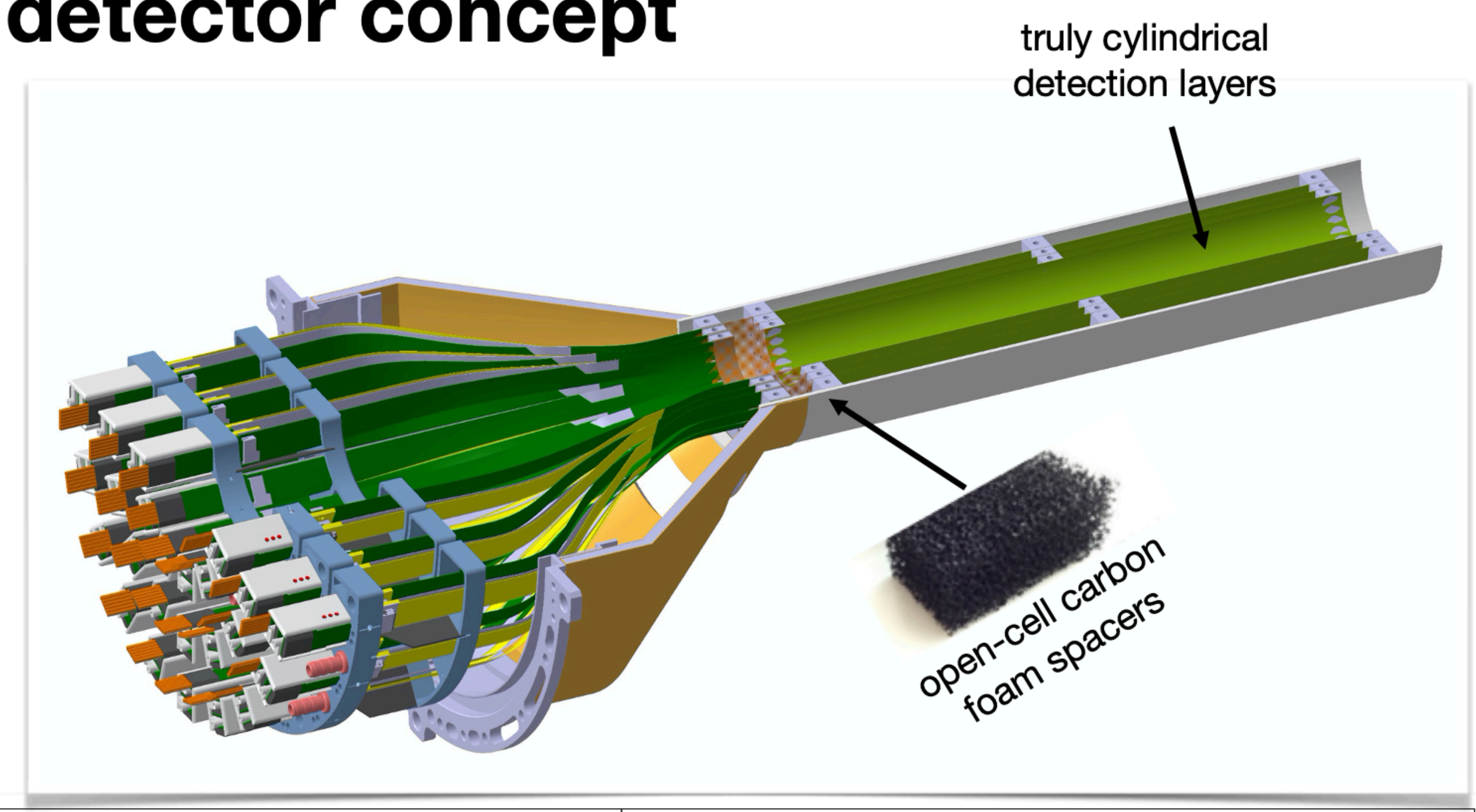
Also, talk by Gabrielle Hugo on the CMS side of things (performance session):
tkLayout: A (tracking) detector design & optimization tool

ALICE ITS3 Vertex Detector

Magnus Mager

ultra-thin, wafer-scale, flexible MAPS for truly-cylindrical, minimum-material-budget layers

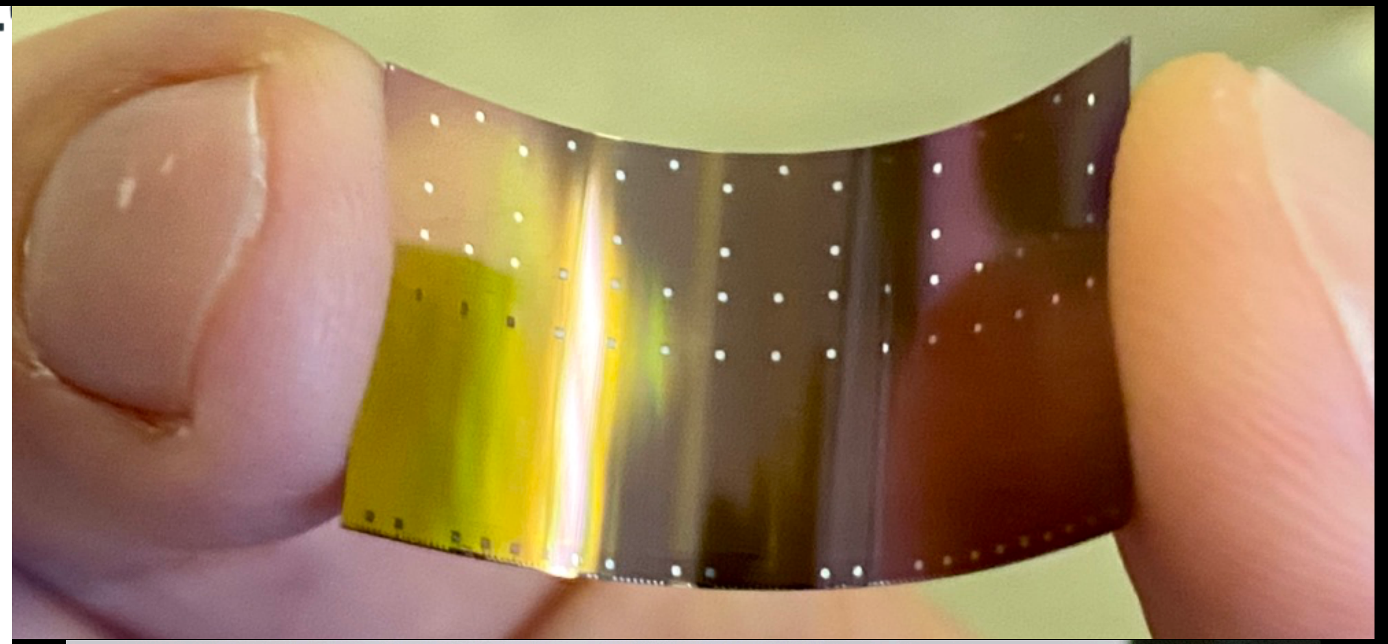
detector concept

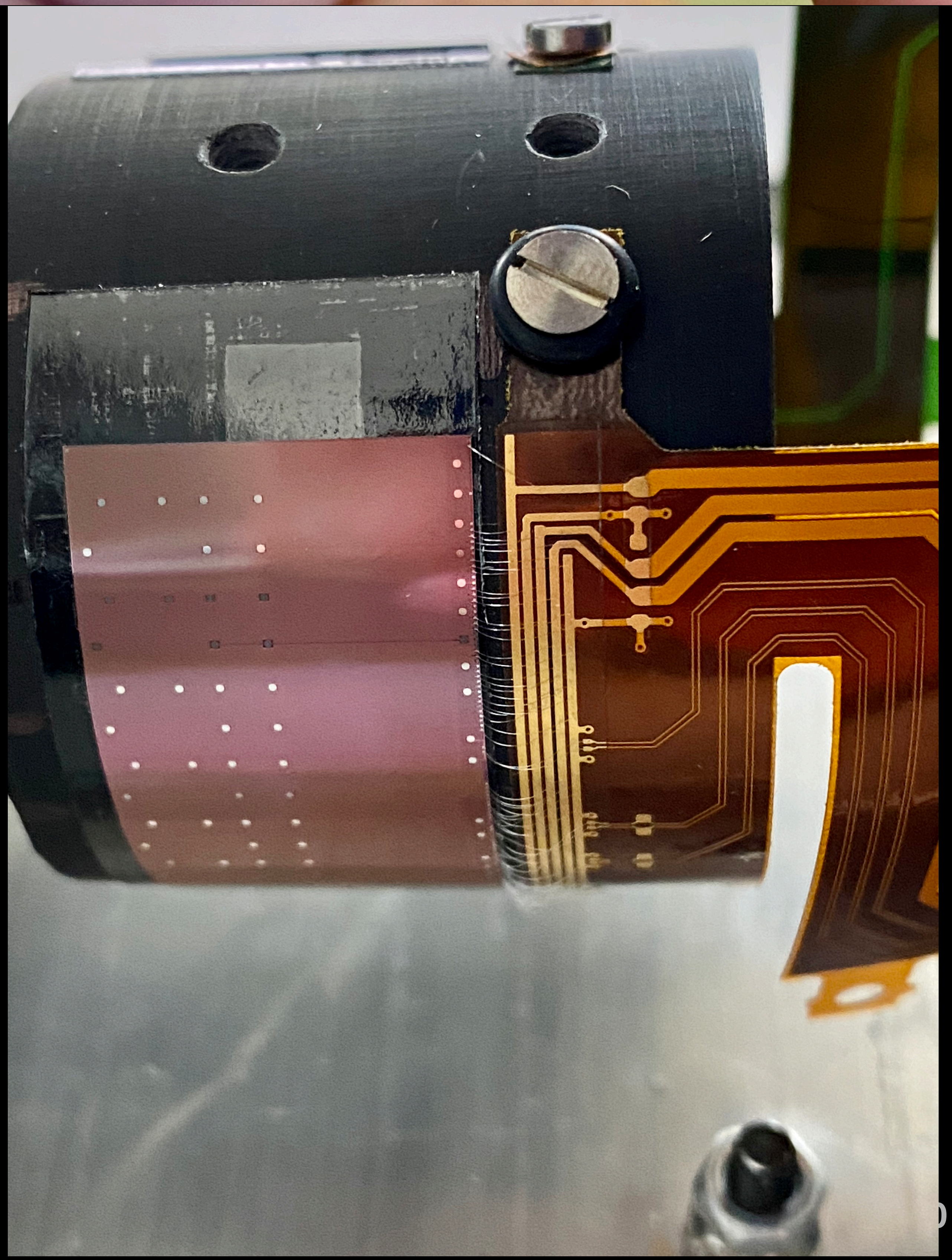


Beam pipe Inner/Outer Radius (mm)	16.0/16.5		
IB Layer Parameters	Layer 0	Layer 1	Layer 2
Radial position (mm)	18.0	24.0	30.0
Length (sensitive area) (mm)	300		
Pseudo-rapidity coverage	±2.5	±2.3	±2.0
Active area (cm^2)	610	816	1016
Pixel sensor dimensions (mm^2)	280 x 56.5	280 x 75.5	280 x 94
Number of sensors per layer	2		
Pixel size (µm^2)	O (10 x 10)		

- Key ingredients:
  - 300 mm wafer-scale chips, fabricated using stitching
  - thinned down to 20-40 µm (0.02-0.04% X0), making them flexible
  - bent to the target radii
  - mechanically hold in place by carbon foam ribs
- Key benefits:
  - extremely low material budget: 0.02-0.04% X0 (beampipe: 500 µm Be: 0.14% X0)
  - homogeneous material distribution: essentially zero systematic error from material distribution

The whole detector will comprise six (!) chips – and barely anything else





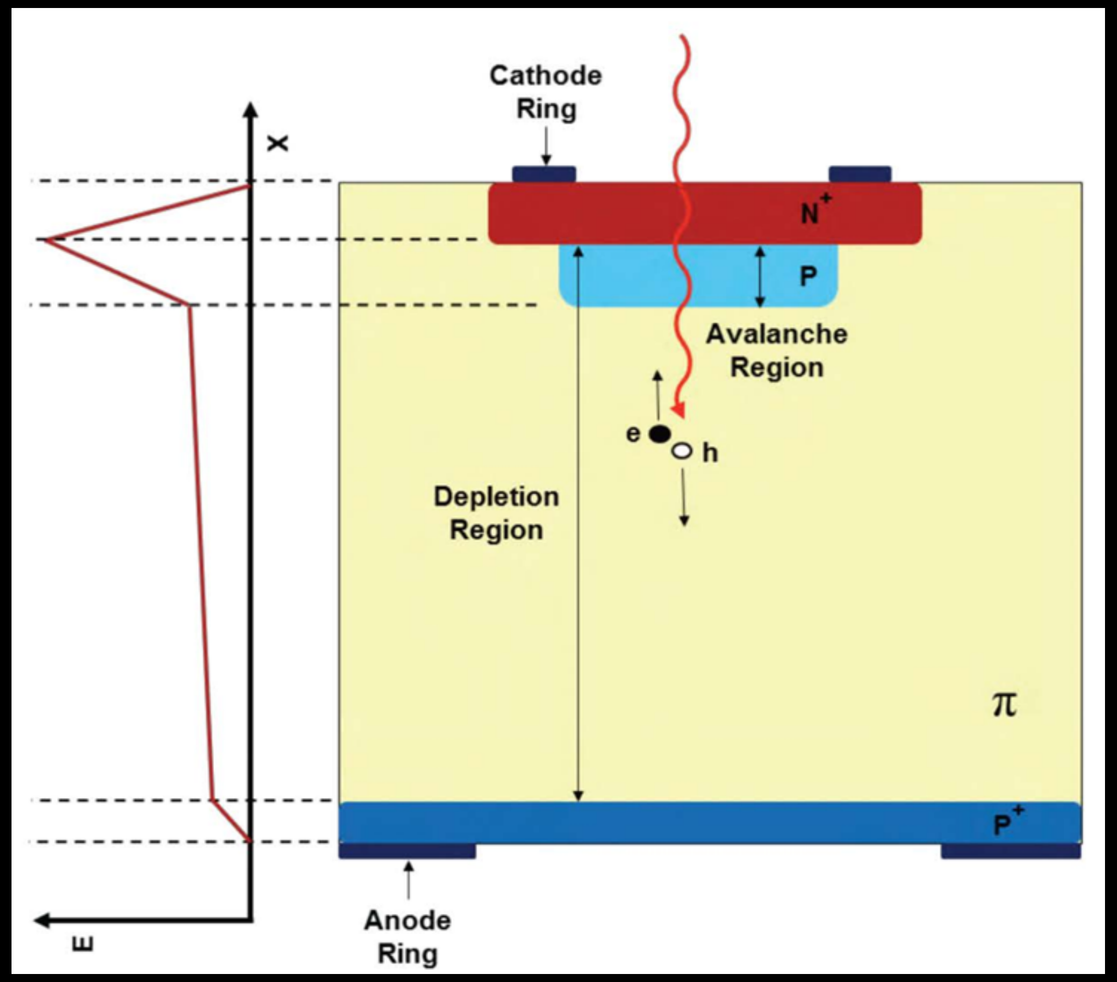
65nm CMOS sensors

Beam test in August 2020

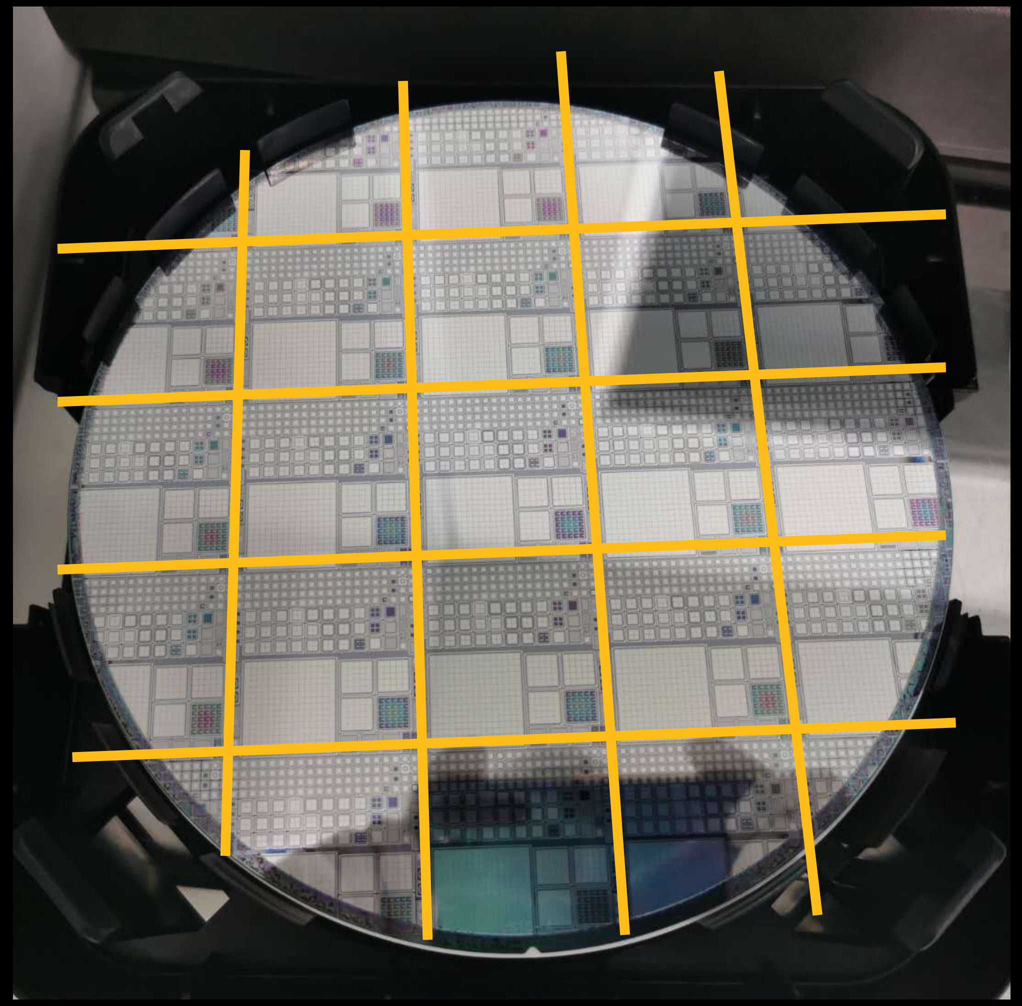
Recent development in LGAD detectors

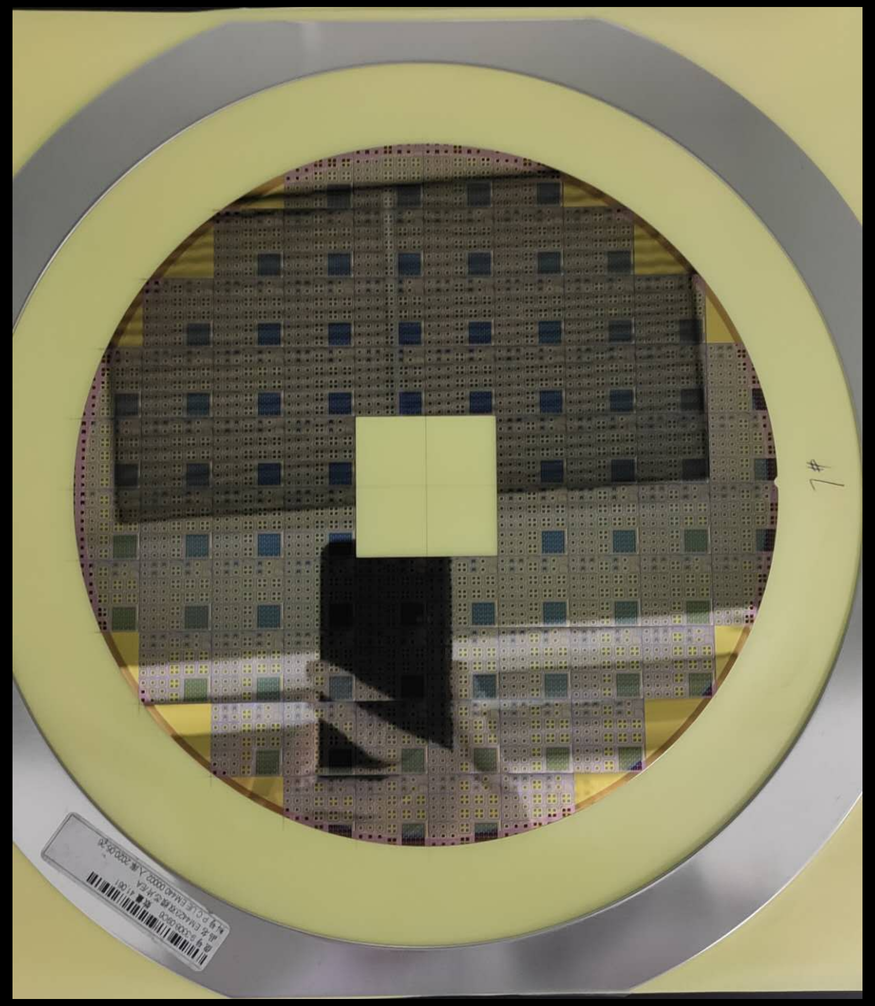
Hartmut Sadrozinski

Silicon-based timing detectors is a new technology
Now being deployed in ATLAS and CMS

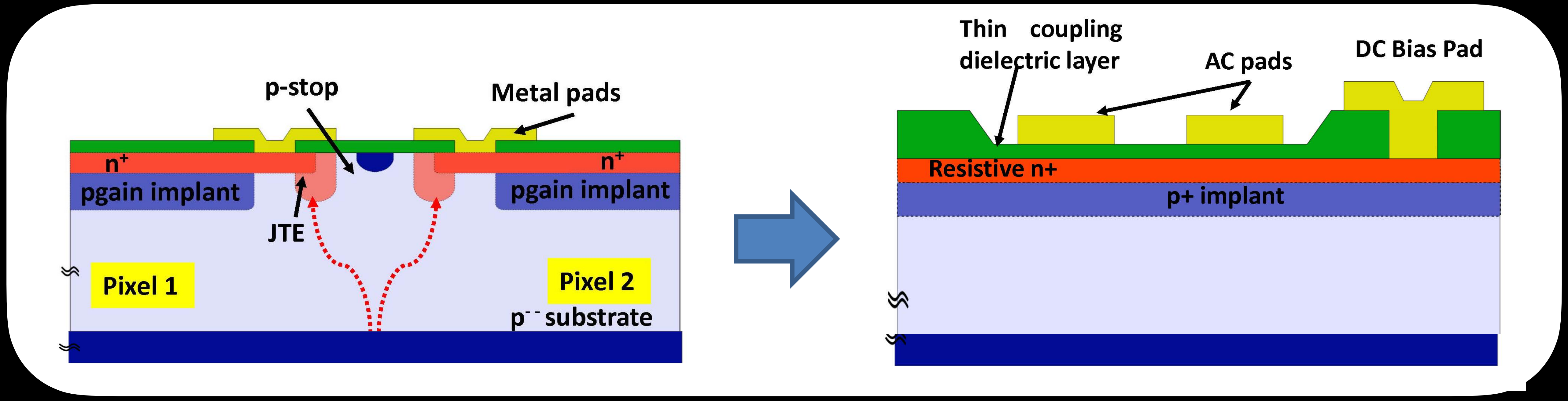


LGAD sensors already being built in China: NDL, IME





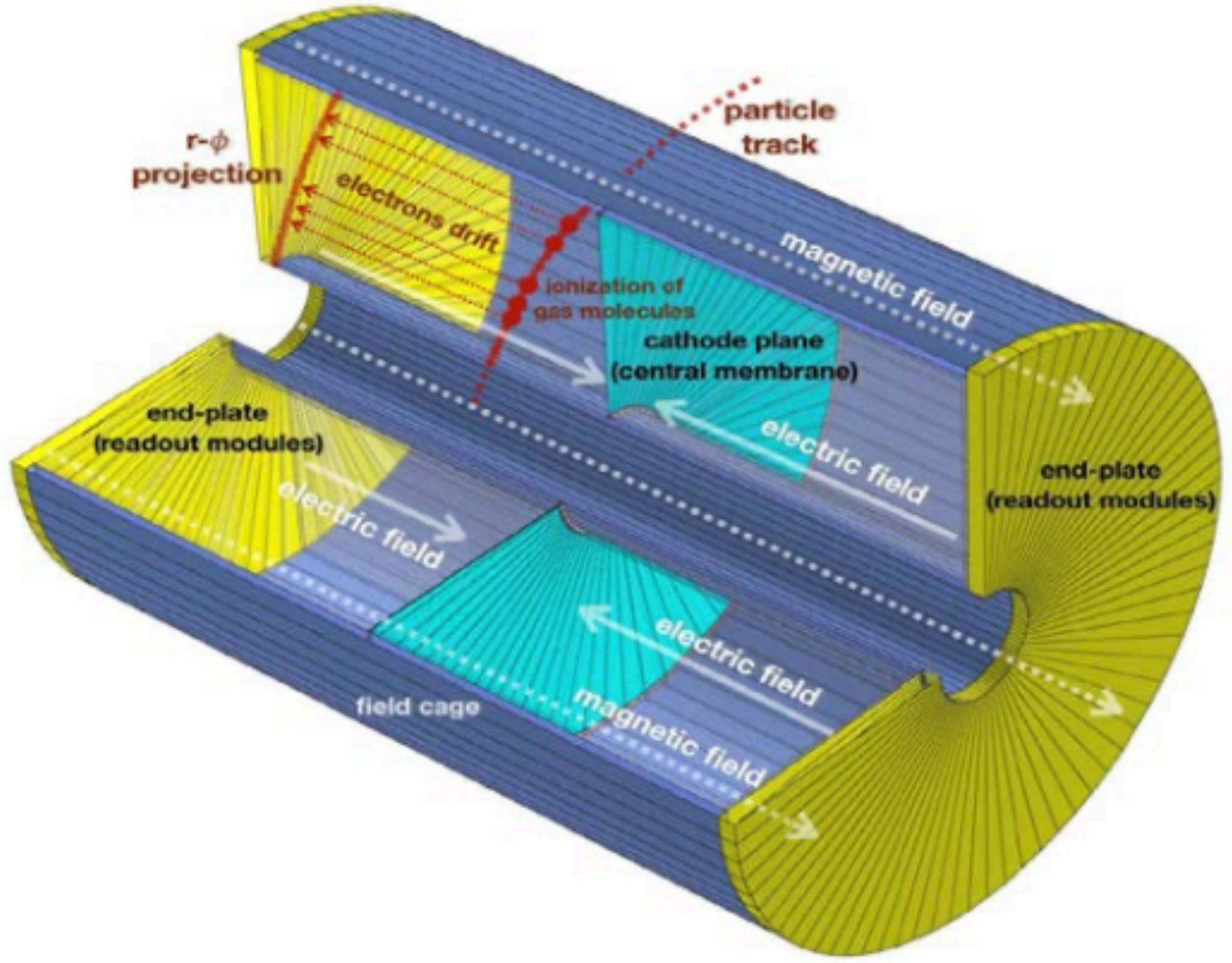
Next step: Combine timing and position resolution in same device → e.g. AC-LGAD

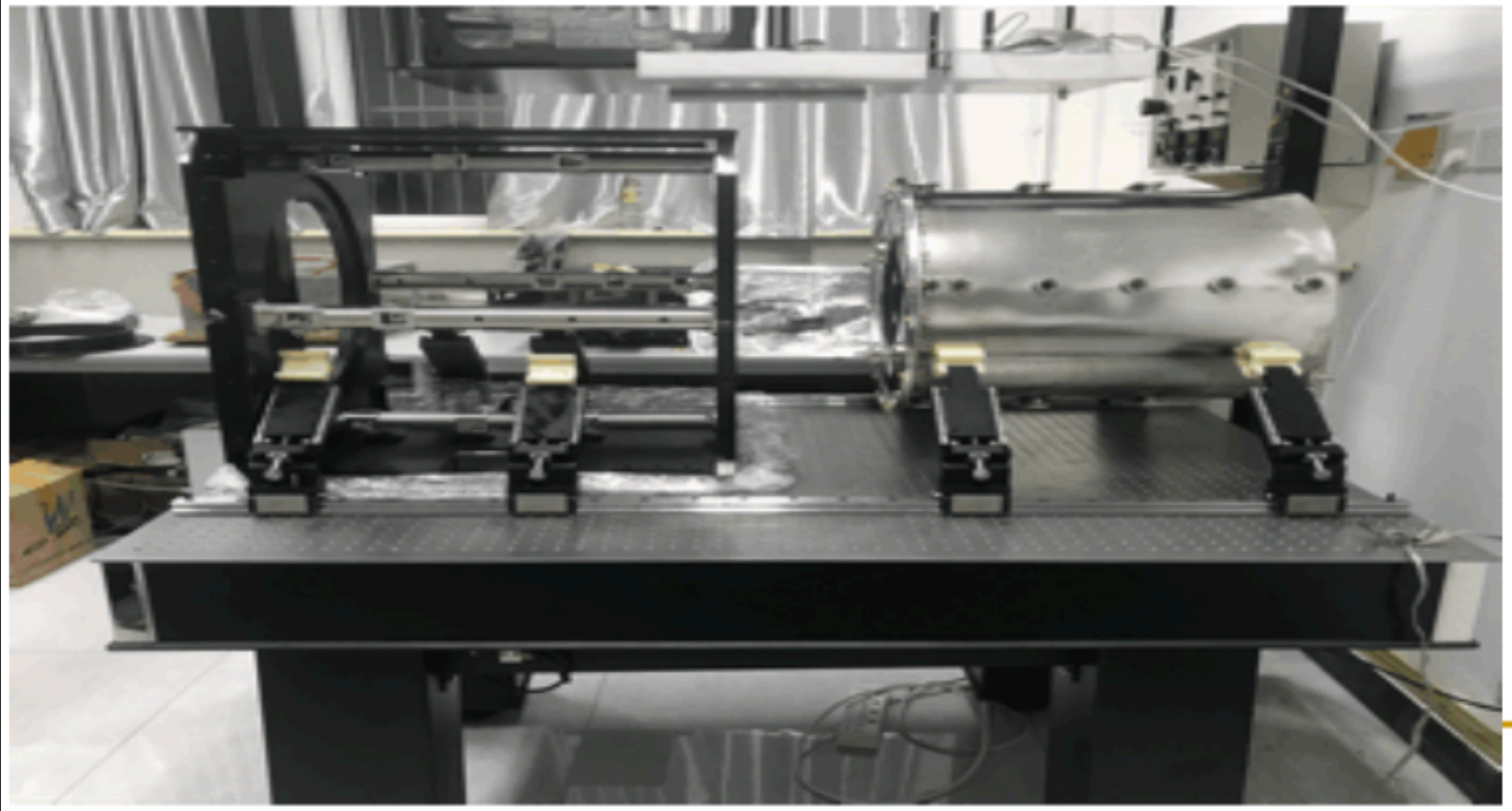


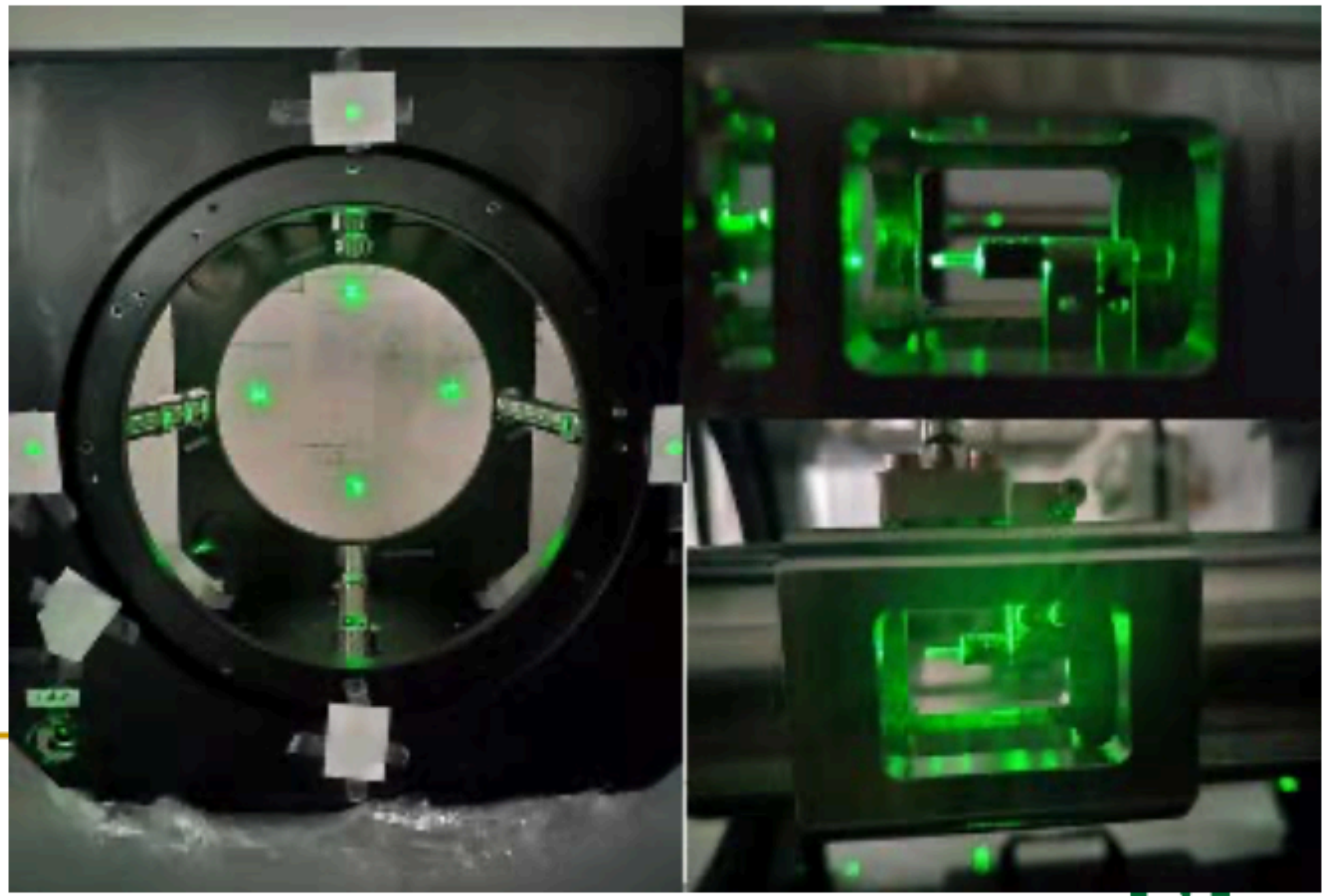
Time Projection Chamber at CEPC

TPC technology R&D

- TPC track technology is as one the baseline options in CEPC CDR
  - TPC limitation items under the high luminosity
  - Ions back flow in chamber (MOST1 funding)
  - Calibration and alignment using UV lasers(NSFC funding)
  - Low power consumption FEE ASIC chip(MOST1)
- Pixel readout R&D as one possible option for circular collider





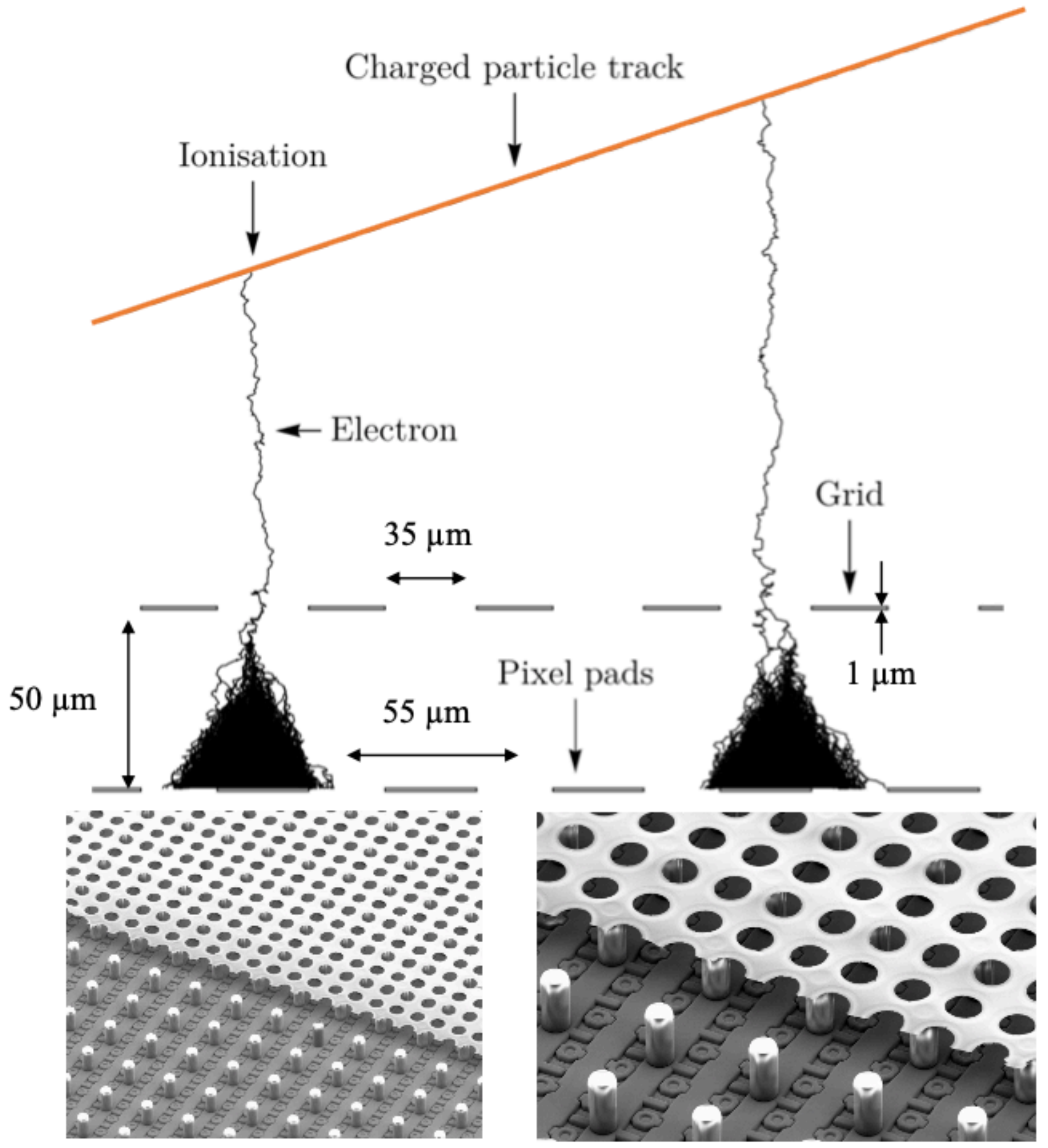


Pixel TPC Technology R&D

Peter Kluit

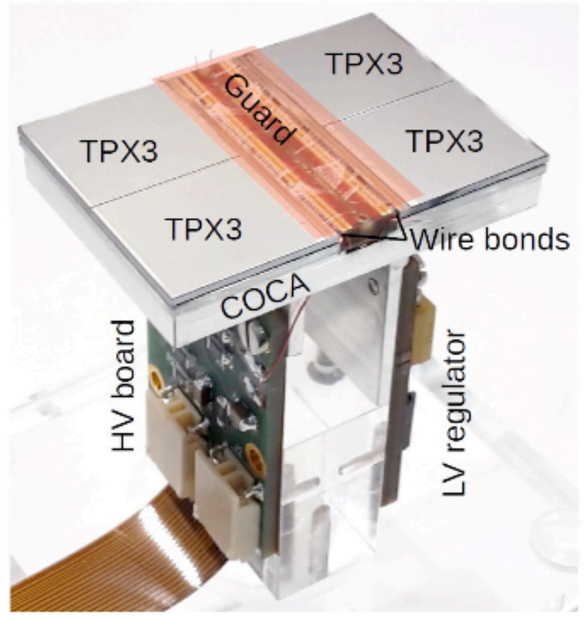
GridPix technology

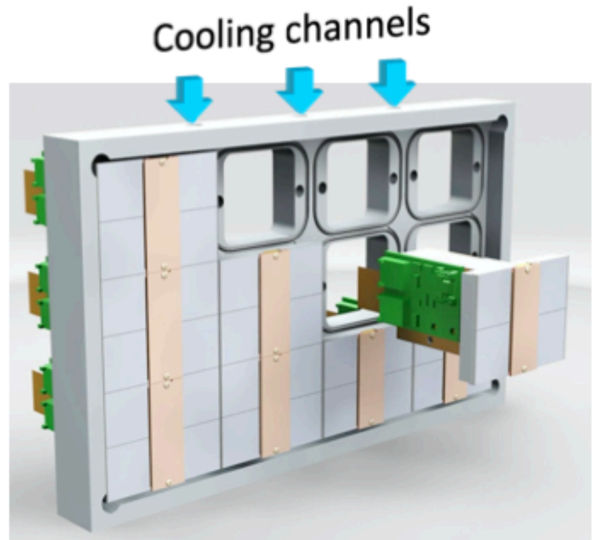
- GridPix is a type of micro-pattern gaseous TPC readout
- The GridPix based on a Timepix3 chip
  - 55 µm × 55 µm pixels
  - Digital simultaneous registration of Time of Arrival (1.56 ns) and Time over Threshold
  - An aligned Aluminium amplification grid is added by photolithographic postprocessing techniques
- Single ionisation electrons are detected with high efficiency
  - The maximum possible information from a track is acquired
  - dE/dx by cluster counting



The quad module

- A four chip module sized 39.6 mm × 28.38 mm
- The quad module has all services under the active area
  - Can be tiled to cover arbitrarily large areas.
- Area for IO connections was minimised
  - Maximises active area (68.9%)
- To maintain a homogenous electric field wire bonds are covered by a central guard
- High precision < 20 µm mounting of the chips and guard to limit E (xB) deformations





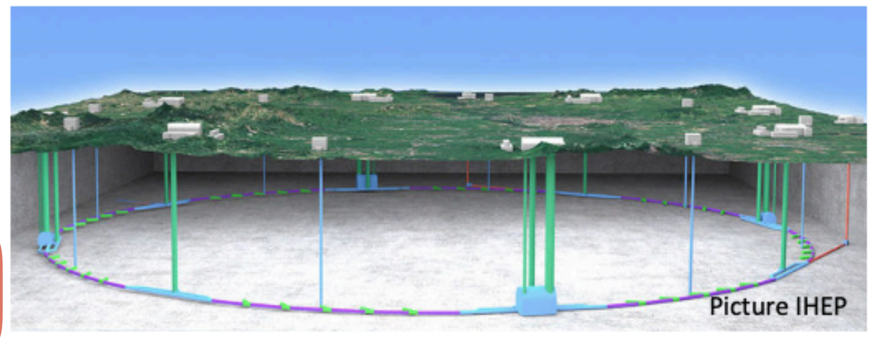
Published paper on quad testbeam: doi:10.1016/j.nima.2019.163331

A Pixel TPC at the CEPC?

CEPC running above the Z (WW, Higgs) there are no critical issues

A Pixel TPC can deal with the high beam rates at the CEPC

- At the Z pole the CEPC with L = 34 10^{34} cm^{-2} s^{-1} will produce Z bosons at ~10 kHz
- Link speed of Timepix3 (in Quad) is 80 Mbps: 2.6 MHits/s per 1.41 × 1.41 cm^2
- Excellent time resolution: time stamping of tracks < 1.2 ns
- Power consumption ~2W/chip depends on hit rate
  - No power pulsing possible at the CEPC
  - Good cooling is important



- Ion backflow of the quad is measured to be 1.3% at a gain of ~2000. So IBF*Gain is ~25.

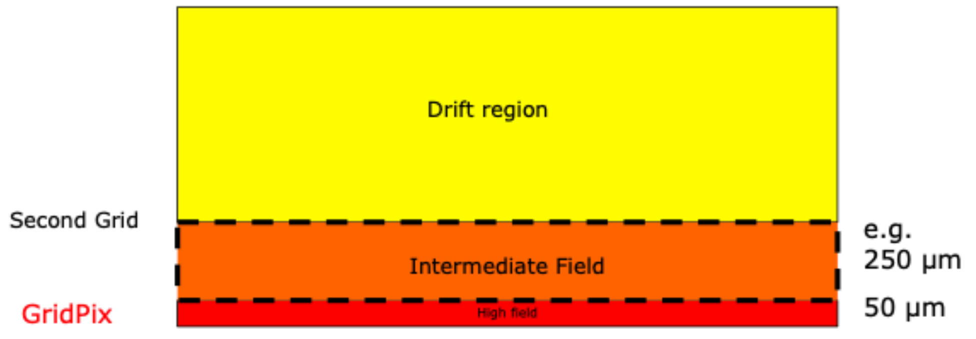
NB: to limit the distortions in de drift volume one needs to achieve < 4 ■ LCWS 2019 Sendai Huirong Qi

Reducing the Ion back flow in a Pixel TPC

The Ion back flow can be reduced by adding a second grid to the device.

It is important that the holes of the grids are aligned. The Ion back flow is a function of the geometry and electric fields. Detailed simulations – validated by data - have been presented in LCTPC WP #326.

With a hole size of 25 µm an IBF of 3 10^{-4} can be achieved and the value for IBF*Gain would be 0.6. Well below the specifications.



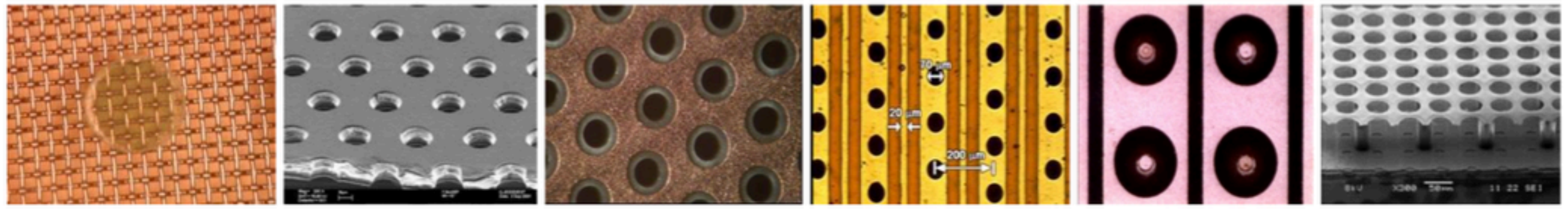
We plan to test this idea at Nikhef

Ion backflow	Hole 30 µm	Hole 25 µm	Hole 20 µm
Top grid	2.2%	1.2%	0.7%
GridPix	5.5%	2.8%	1.7%
Total	12 10^{-4}	3 10^{-4}	1 10^{-4}
transparancy	100%	99.4%	91.7%

Micro pattern gas detectors

Florian Brunbauer

MPGD timeline

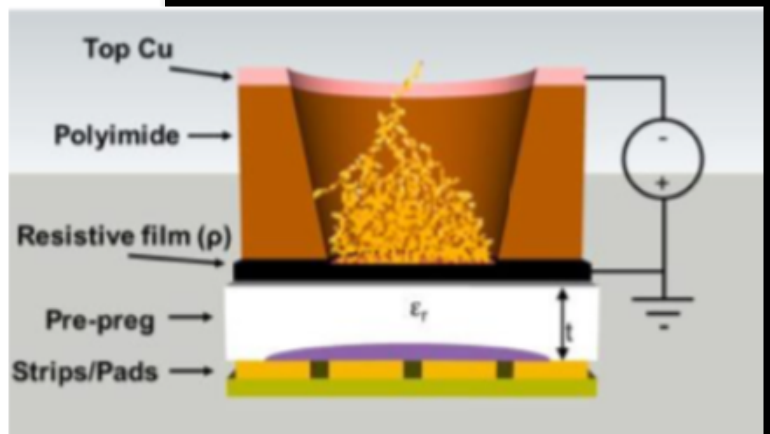

MicroMegas GEM THGEM MHSP microPIC Ingrid

RD51

1988 MSGC
1996 Micromegas
1997 GEM
2000 μPIC
2002 THGEM
2009
2014
2019

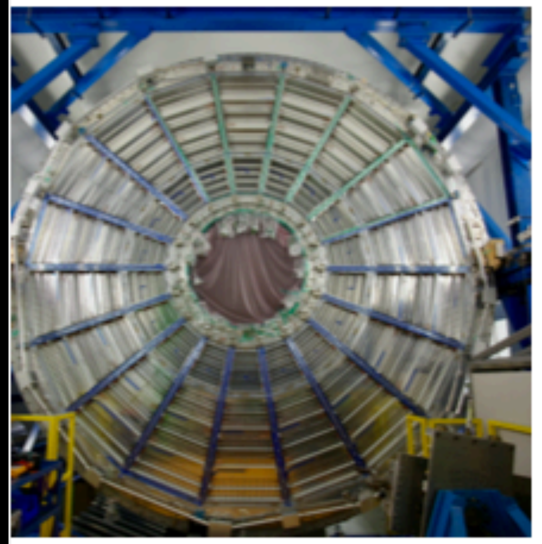
Adoption of MPGD technologies:
ATLAS NSW (Micromegas)
CMS forward tracking update (GEM)
COMPASS RICH upgrade (hybrid MPGD)
ALICE TPC upgrade (GEM)
KLOE2 & BESIII (GEM)
LBNO-DEMO (THGEM)
n-detection at ESS (GEM)
Muon radiography (Micromegas)
…

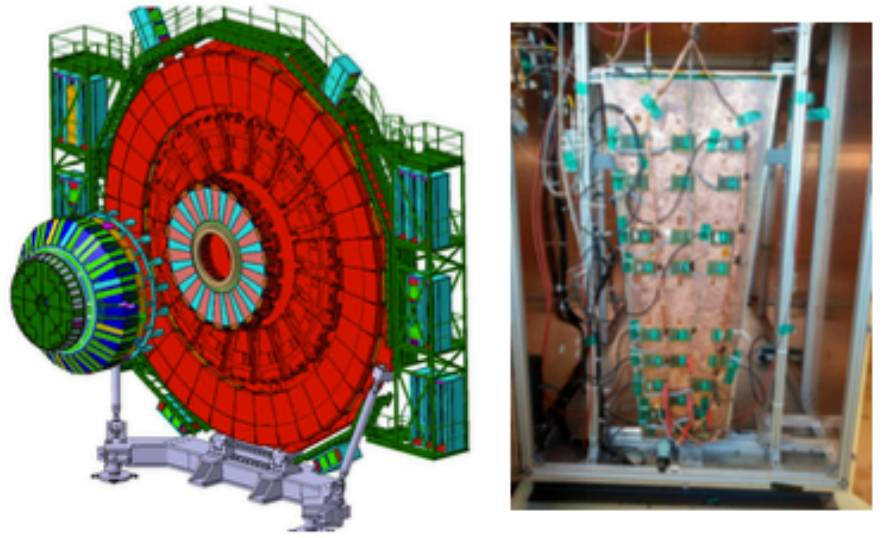
μRWELL

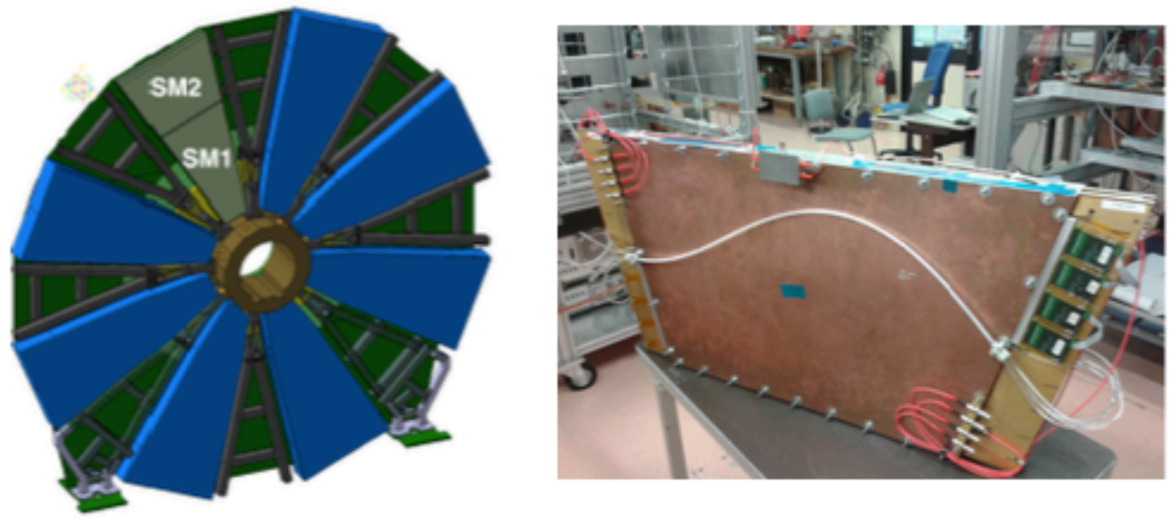


10's MHz readout

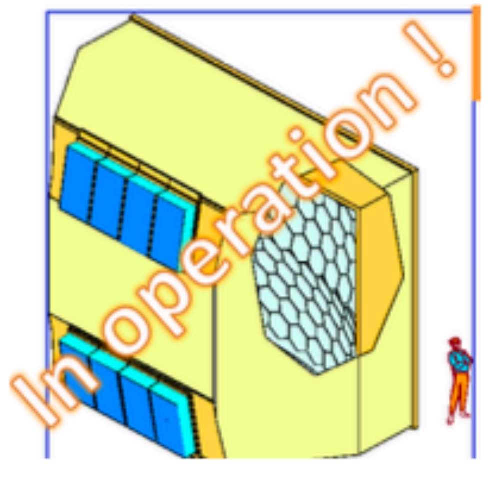
5


Alice GEM TPC

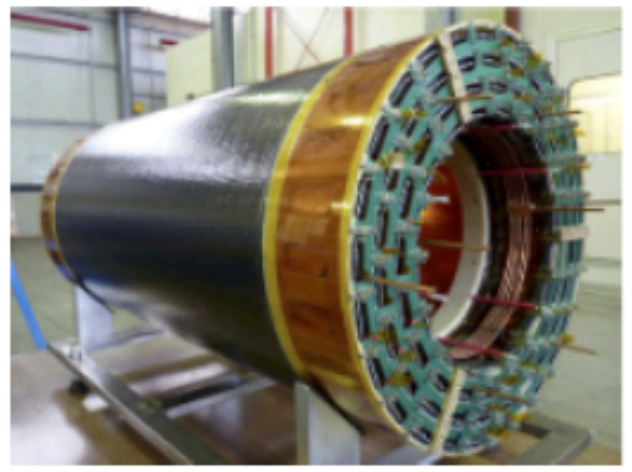

CMS Muon GEM upgrade



ATLAS NSW Micromegas upgrade



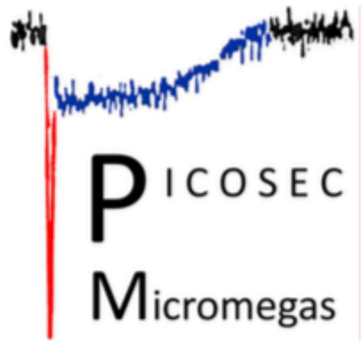
COMPASS RICH

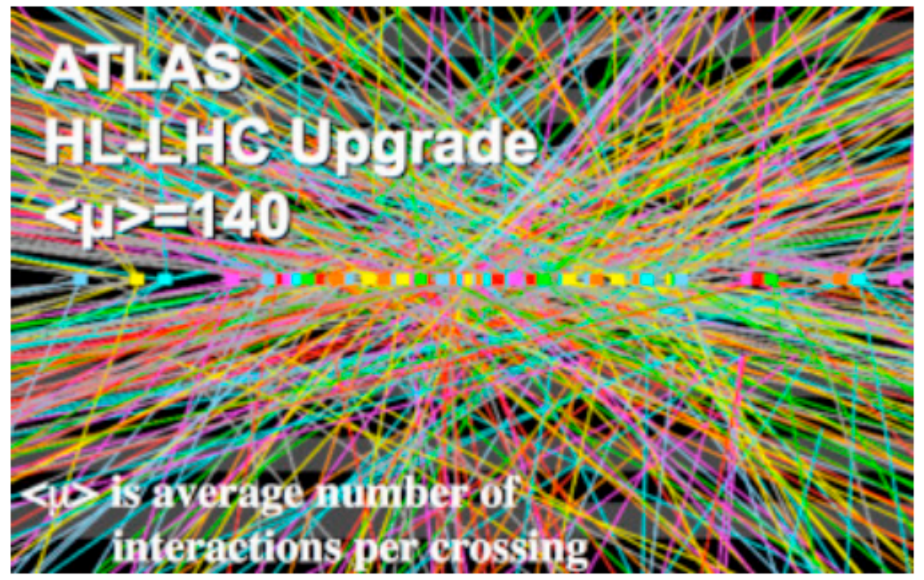

KLOE-2 GEM tracker


Muography with Micromegas

Future perspectives

Precise timing with Micromegas
PICOSEC detection concept





PID techniques: Alternatives to RICH methods, J. Va'vra, NIMA **876** (2017) 185-193, https://dx.doi.org/10.1016/j.nima.2017.02.075

To mitigate pile-up and separate particles coming from different vertices:
- Exploit precise timing to separate tracks

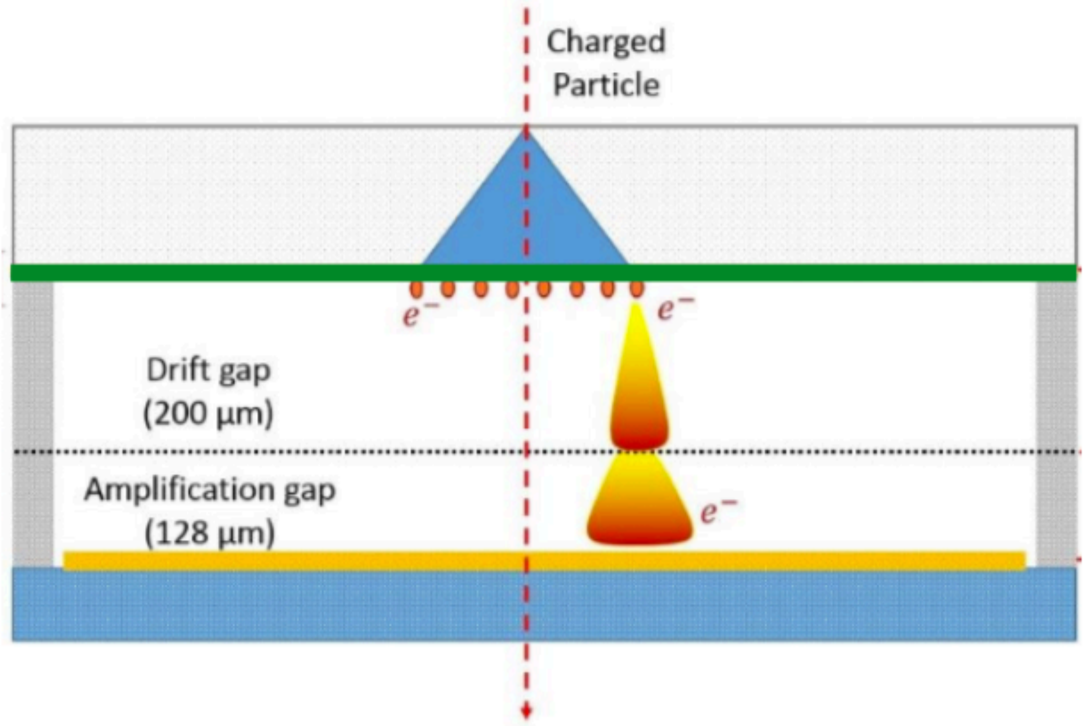
Tens of ps timing + tracking info required

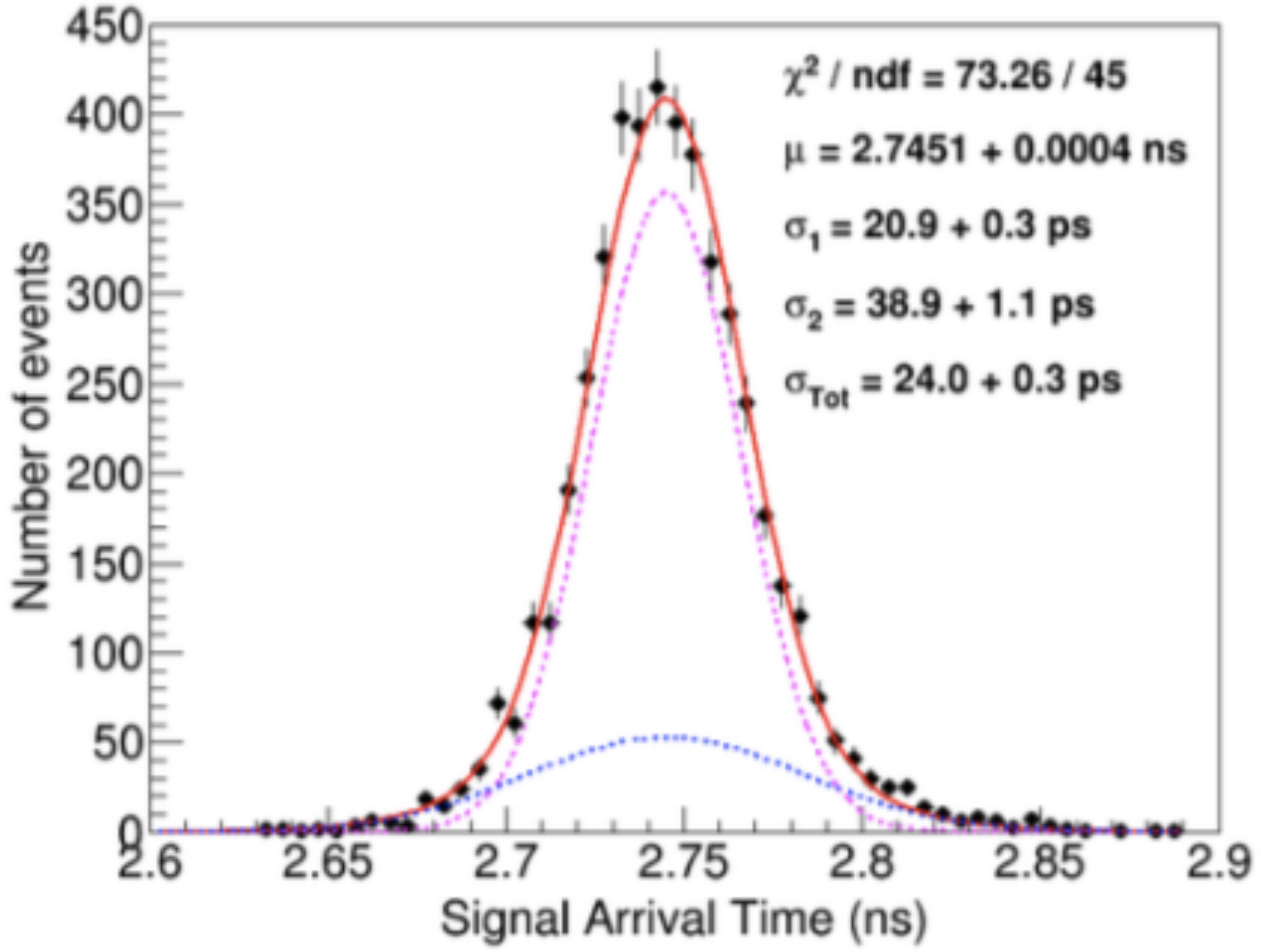
Cherenkov radiator (3 mm MgF_2)

Photocathode (3 nm Cr + 18 nm CsI)

Drift gap (Pre-amplification)

Micromegas (Amplification)





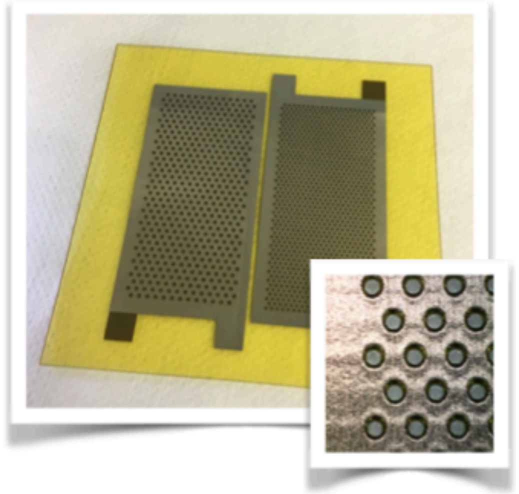
24 ps MIP timing resolution

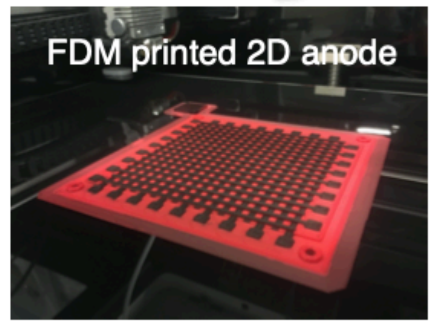
J. Bortfeldt et. al. (RD51-PICOSEC collaboration), Nuclear. Inst. & Methods A 903 (2018) 317-325

Novel manufacturing

3D printing of amplication structures for fast, results-driven prototyping

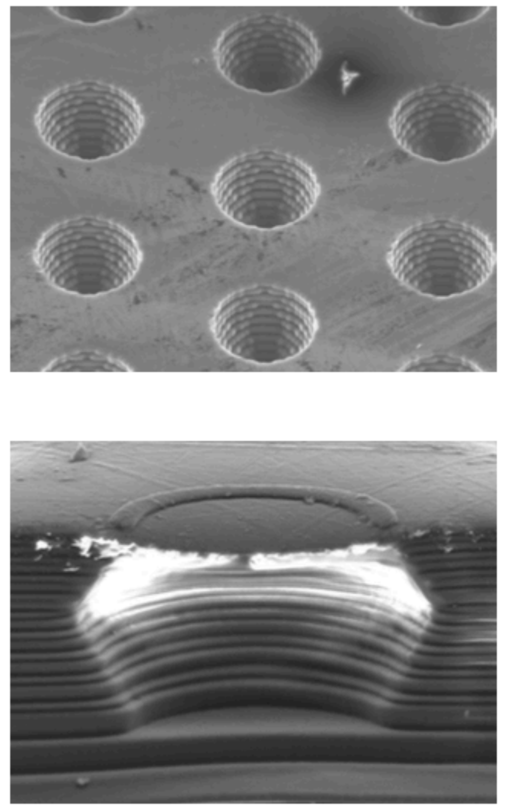
Dual-material inkjet printed THGEM





F.M. Brunbauer et al 2019 JINST 14 P12005

50μm diameter pμSLA printed holes

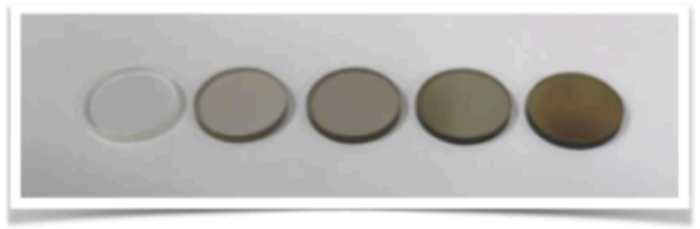


Tiago F. Silva et al., RD51 CM 2020

Novel materials

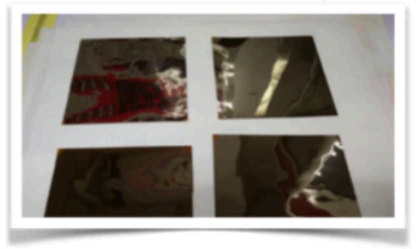
Novel materials as photocathodes, converters or secondary emitters for efficient primary charge production, charge sharing, detector stability, …

DLC photocathode 2.4 p.e. / muon



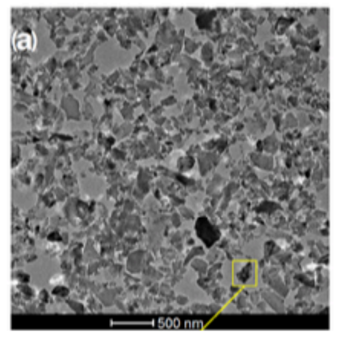
Yi Zhou et al., RD51 collaboration meeting, 2018

DLC + Cu coating



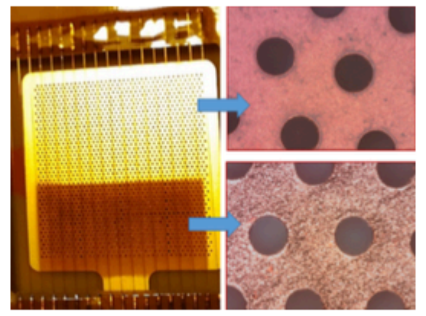
Yi Zhou et al., RD51 collaboration meeting, 2018

Nano diamond powder



L. Velardi, A. Valentini, and G. Cicala, Appl. Phys. Lett.108, 083503 (2016)

ND-coated THGEM



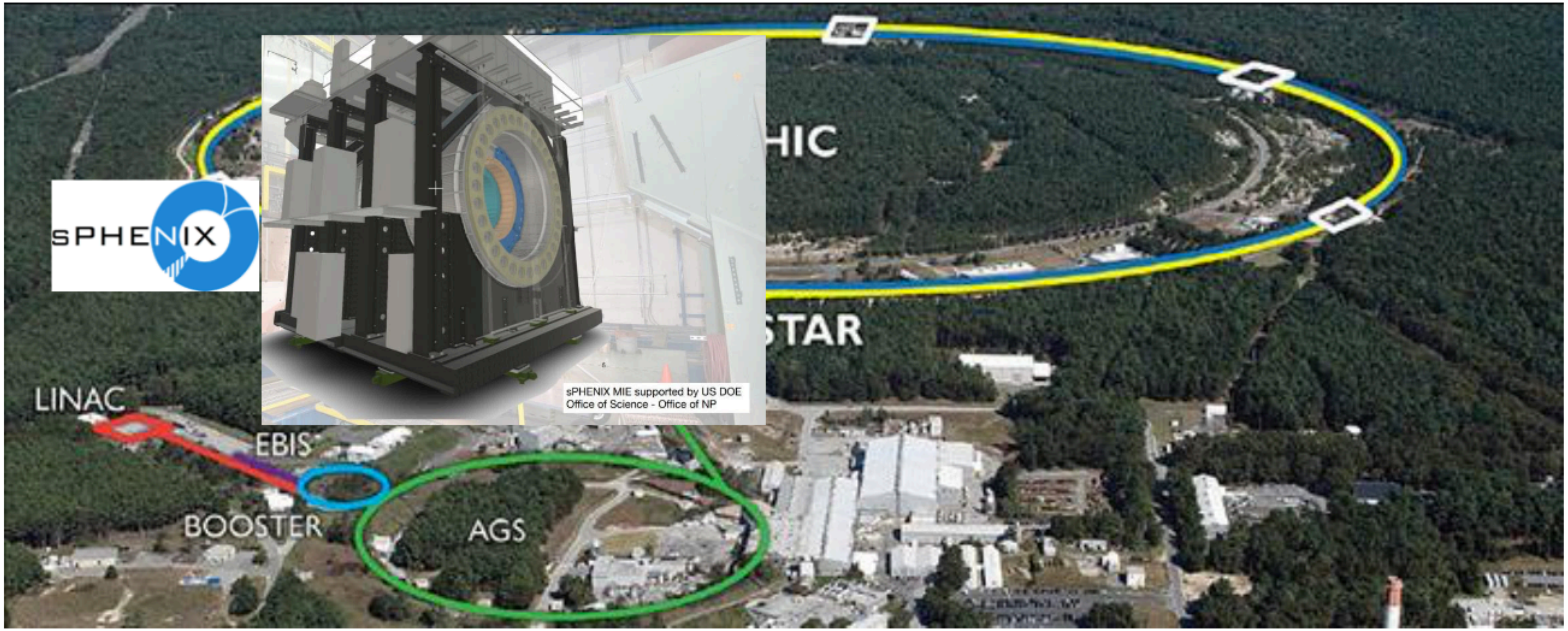
C. Chatterjee et al. arXiv:1908.05058v1 [physics.ins-det] 14 Aug 2019

Klaus Dehmelt

sPHENIX AND THE TIME PROJECTION CHAMBER

2

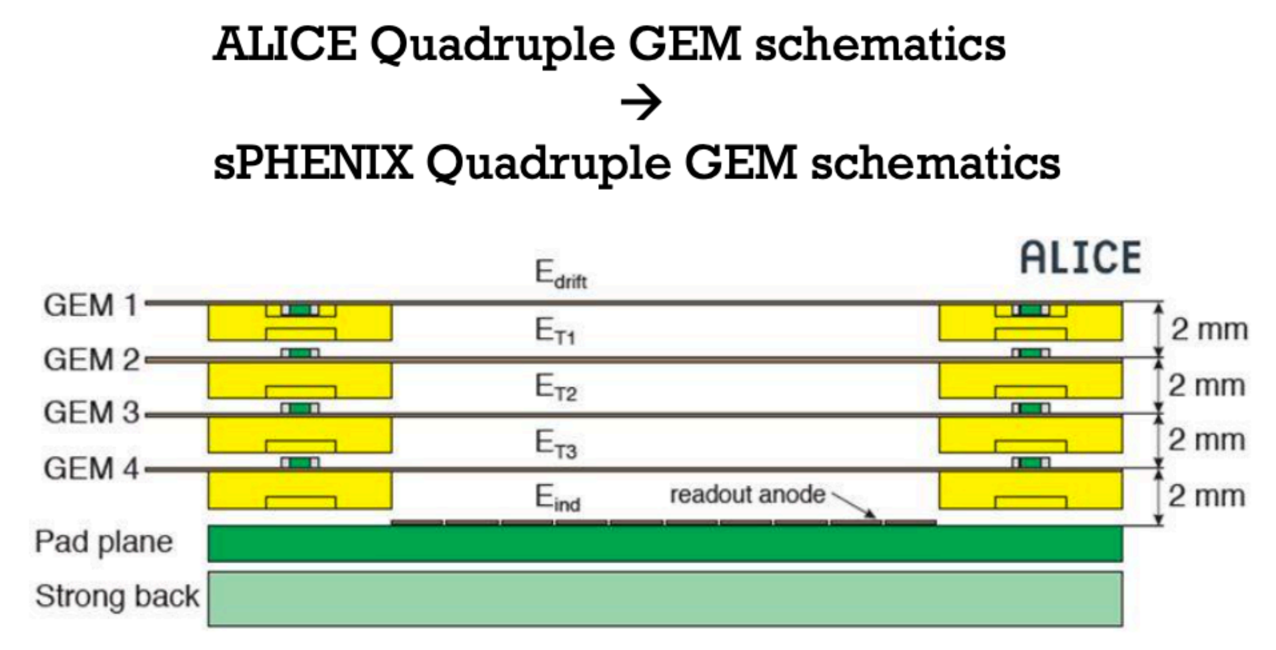
- sPHENIX @ the Relativistic Heavy Ion Collider RHIC in 2023

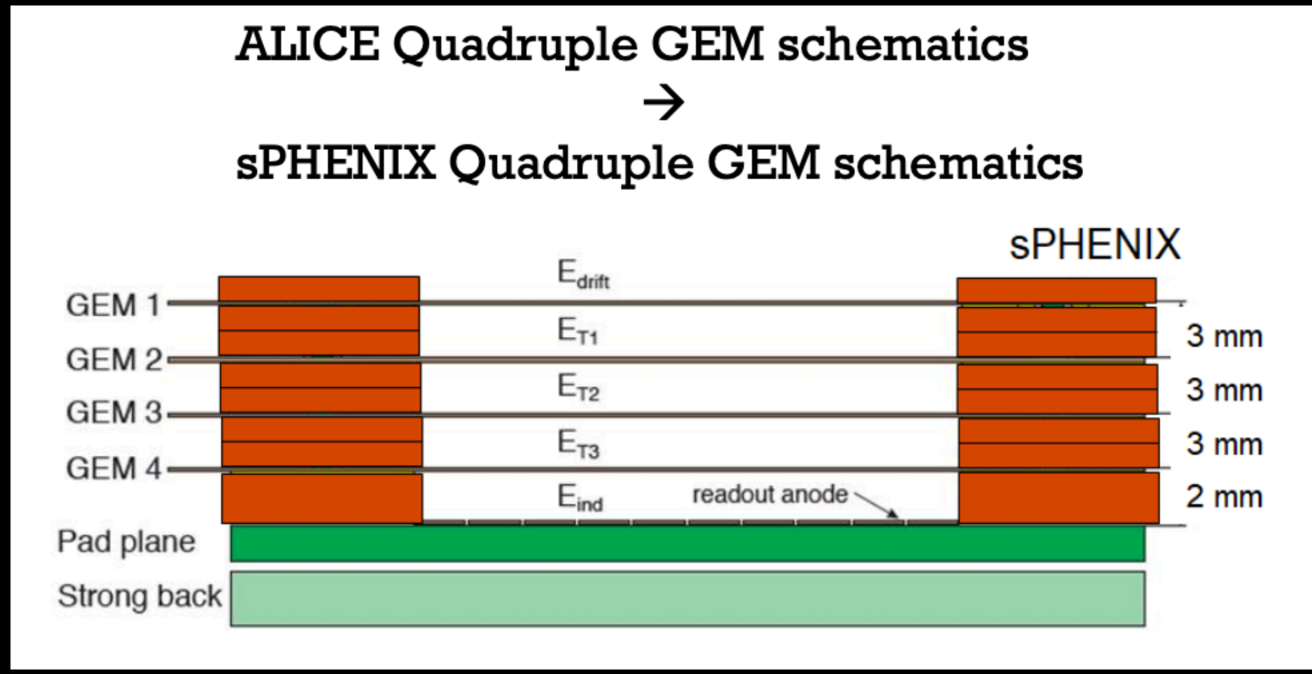


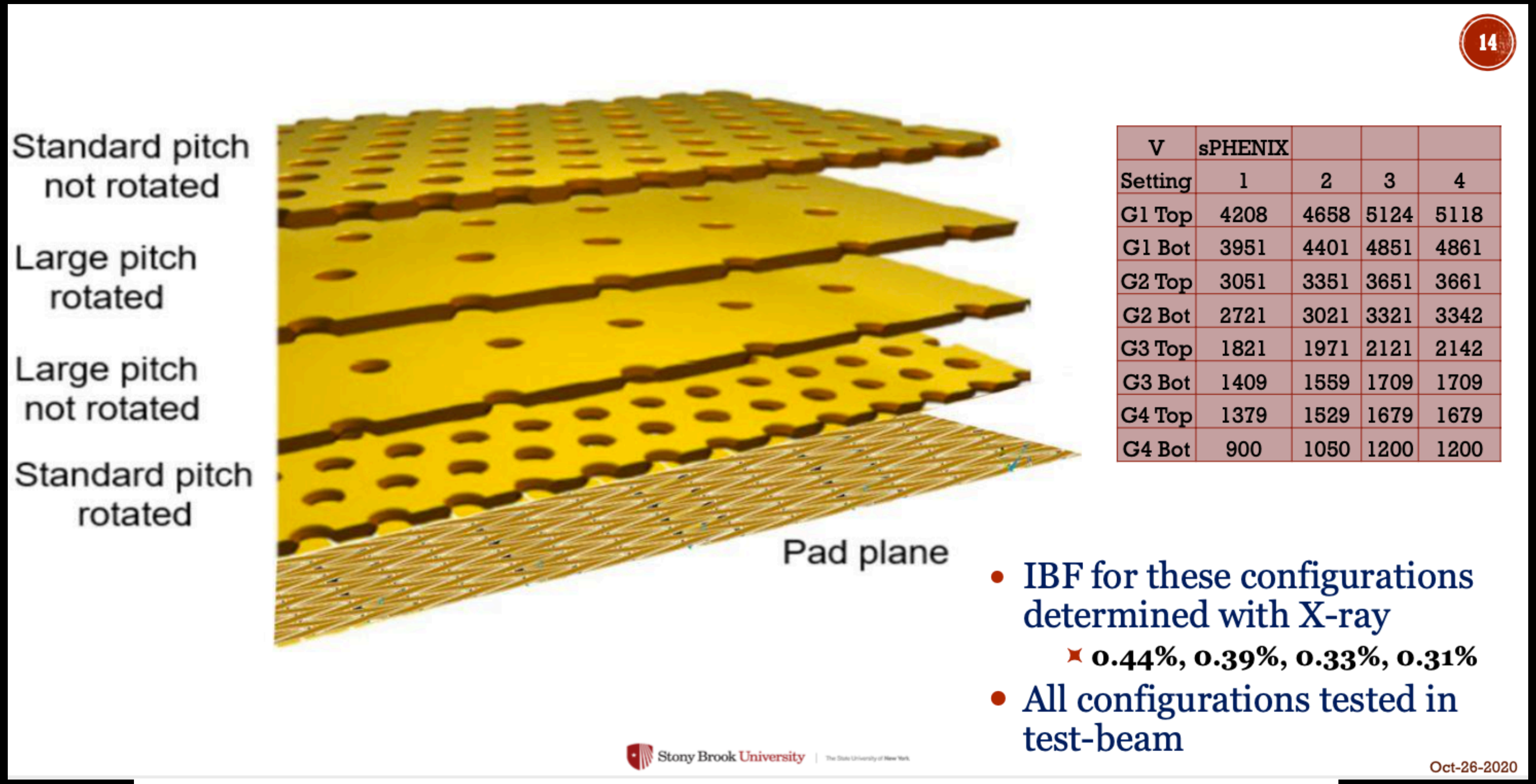
Head-on collisions Au-Au @ 200 GeV/nucleon at RHIC produce thousands of particles
→ Ion Back Flow Problem

The sPHENIX TPC

Optimize amplification device’s operating point: Gain on first GEM determines desired properties→compromise between energy resolution (dE/dX) and IBF



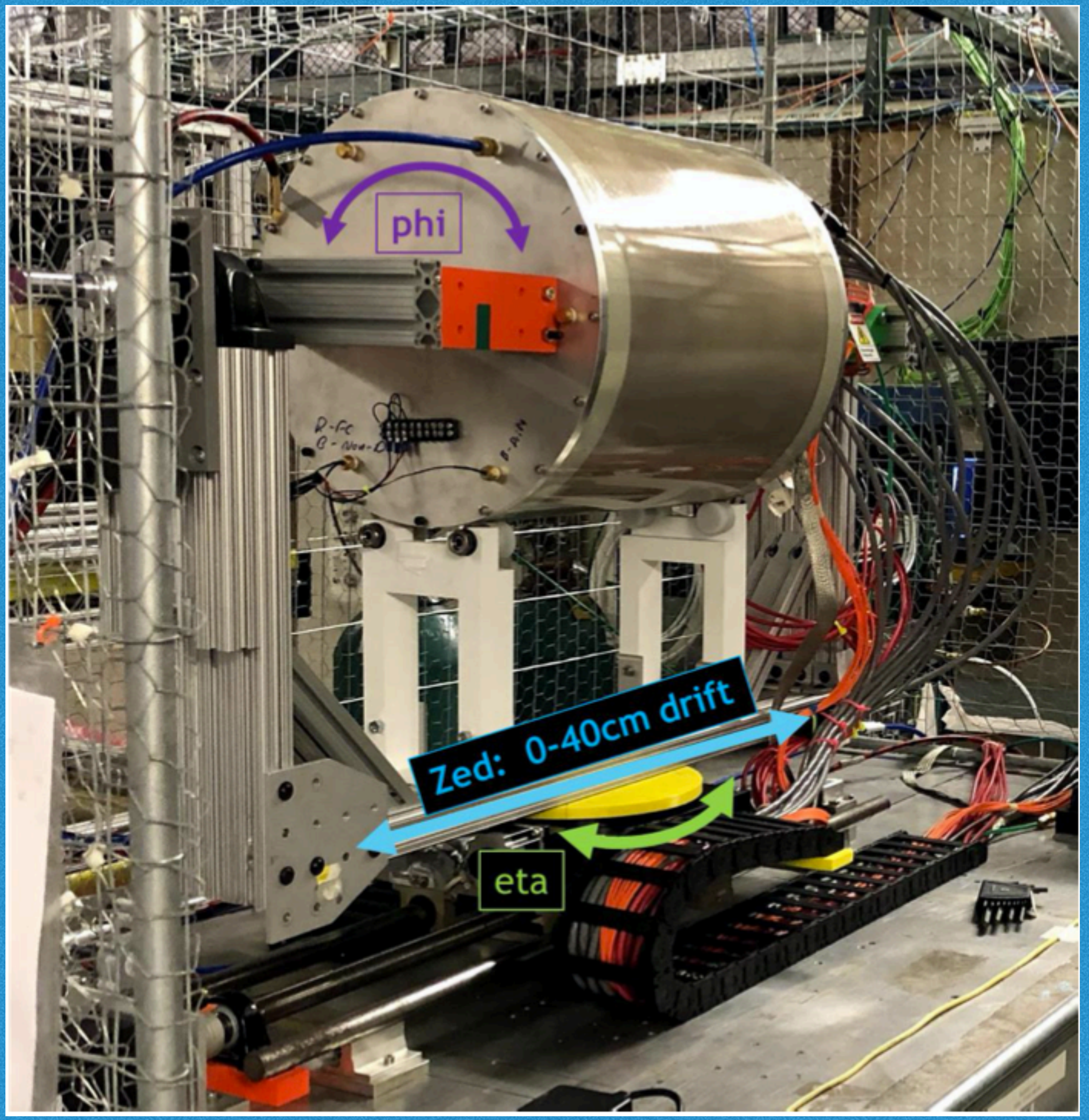




V	sPHENIX			
Setting	1	2	3	4
G1 Top	4208	4658	5124	5118
G1 Bot	3951	4401	4851	4861
G2 Top	3051	3351	3651	3661
G2 Bot	2721	3021	3321	3342
G3 Top	1821	1971	2121	2142
G3 Bot	1409	1559	1709	1709
G4 Top	1379	1529	1679	1679
G4 Bot	900	1050	1200	1200

- IBF for these configurations determined with X-ray
  - 0.44%, 0.39%, 0.33%, 0.31%
- All configurations tested in test-beam

Test beam at Fermilab



Intrinsic resolution 90 μm

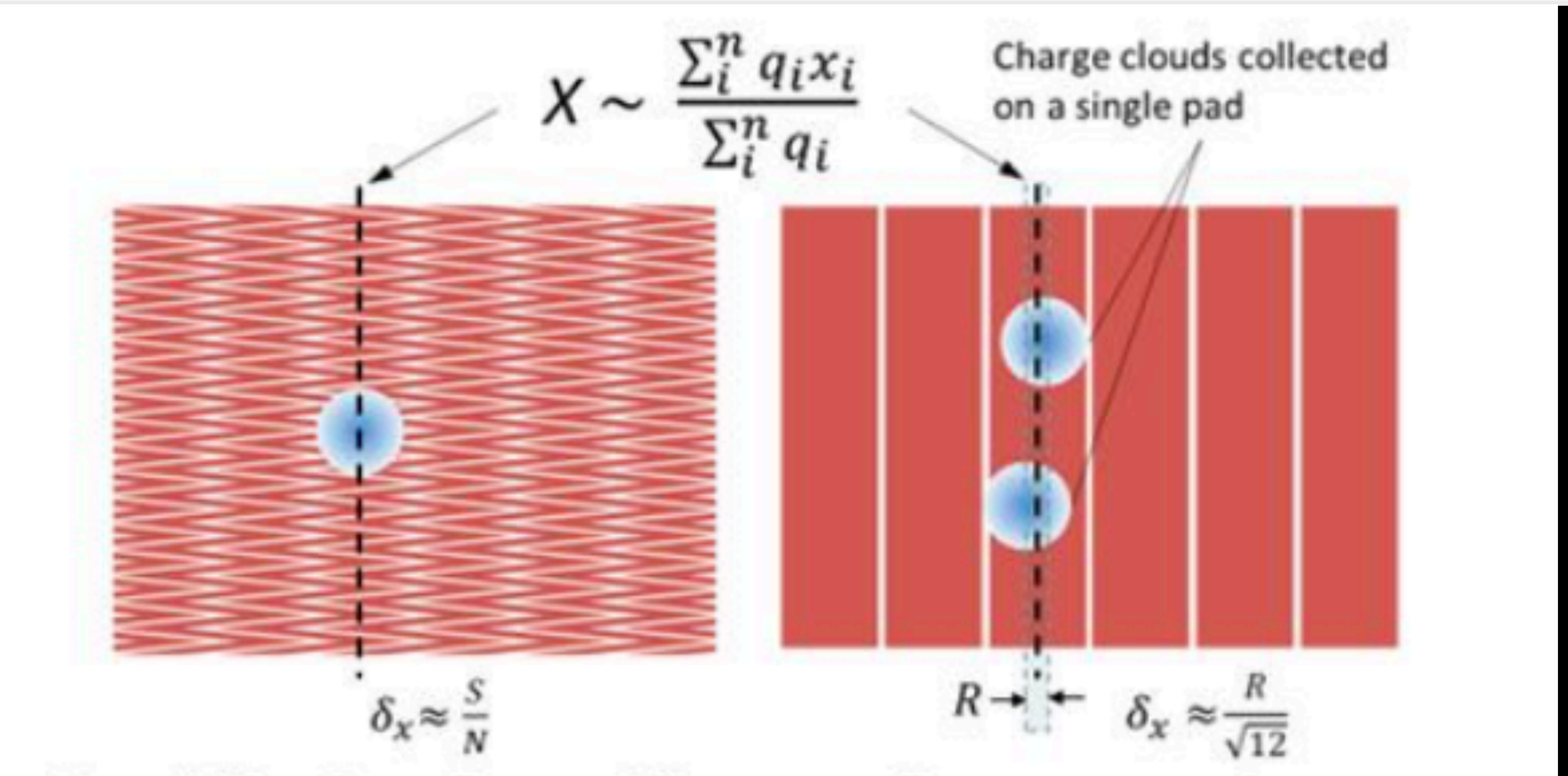
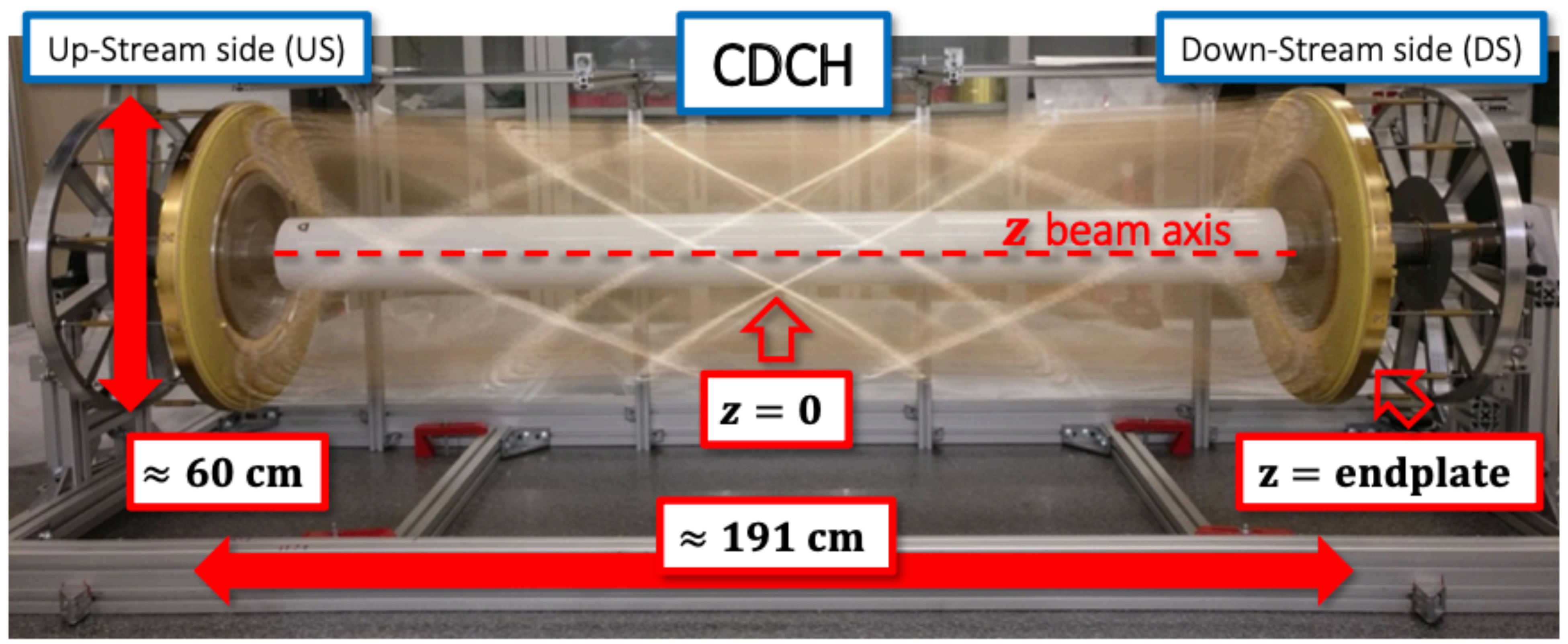


Fig. 1 Sketches of two different readout patterns demonstrate charge sharing and its impact on the centroid calculation and the related position error for a zigzag and rectangular pad geometry. 6 channels are shown for each pattern with the same pitch. (The drawings are to scale.)

Cylindrical Drift Chamber from MEG II

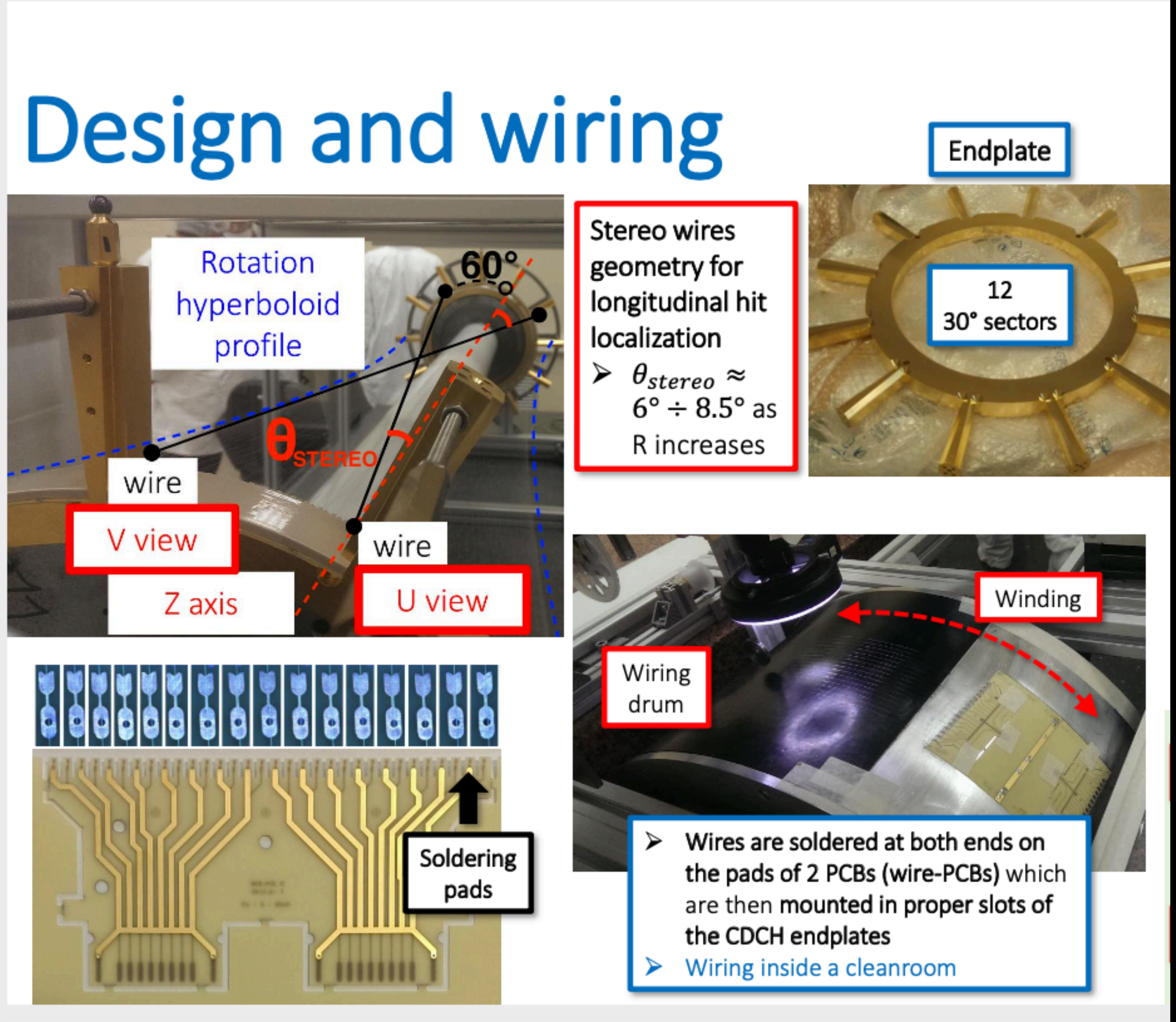
Marco Chiappini



e^+ variable	MEG	MEG II
ΔE_e (keV)	380	90
$\Delta\theta_e$, $\Delta\varphi_e$ (mrad)	9, 9	6, 5.5
Efficiency$_e$ (%)	40	65

- Low-mass unique volume detector with high granularity filled with He:Isobutane 90:10 gas mixture
  - 9 concentric layers of 192 drift cells defined by 11904 wires
  - Small cells few mm wide: occupancy of ≈1.5 MHz/cell at CDCH center near the stopping target
  - High density of sensitive elements: ×4 hits more than MEG drift chamber (DCH)
- Total radiation length $1.5 \times 10^{-3}\ X_0$: less than $1.7 \times 10^{-3}\ X_0$ of MEG DCH
  - MCS minimization and γ background reduction (bremsstrahlung and Annihilation-In-Flight)
- Single-hit resolution (measured on prototypes): $\sigma_{hit} < 120\ \mu m$
- Extremely high wires density (12 wires/cm^2) ➜ the classical technique with wires anchored to endplates with feedthroughs is hard to implement
  - CDCH is the first drift chamber ever designed and built in a modular way
- CDCH design is based on the experience gathered with the KLOE drift chamber (http://www.lnf.infn.it/kloe/index2.html)

3/20



operating voltage: ~1.4 kV

Issues discussed:

- Corrosion and breakage of 70 Al(Ag) field wires in presence of 40-65% humidity level (mostly 40μm)
  - Cured by keeping chamber in dry environment
- Anomalous high currents still under investigation

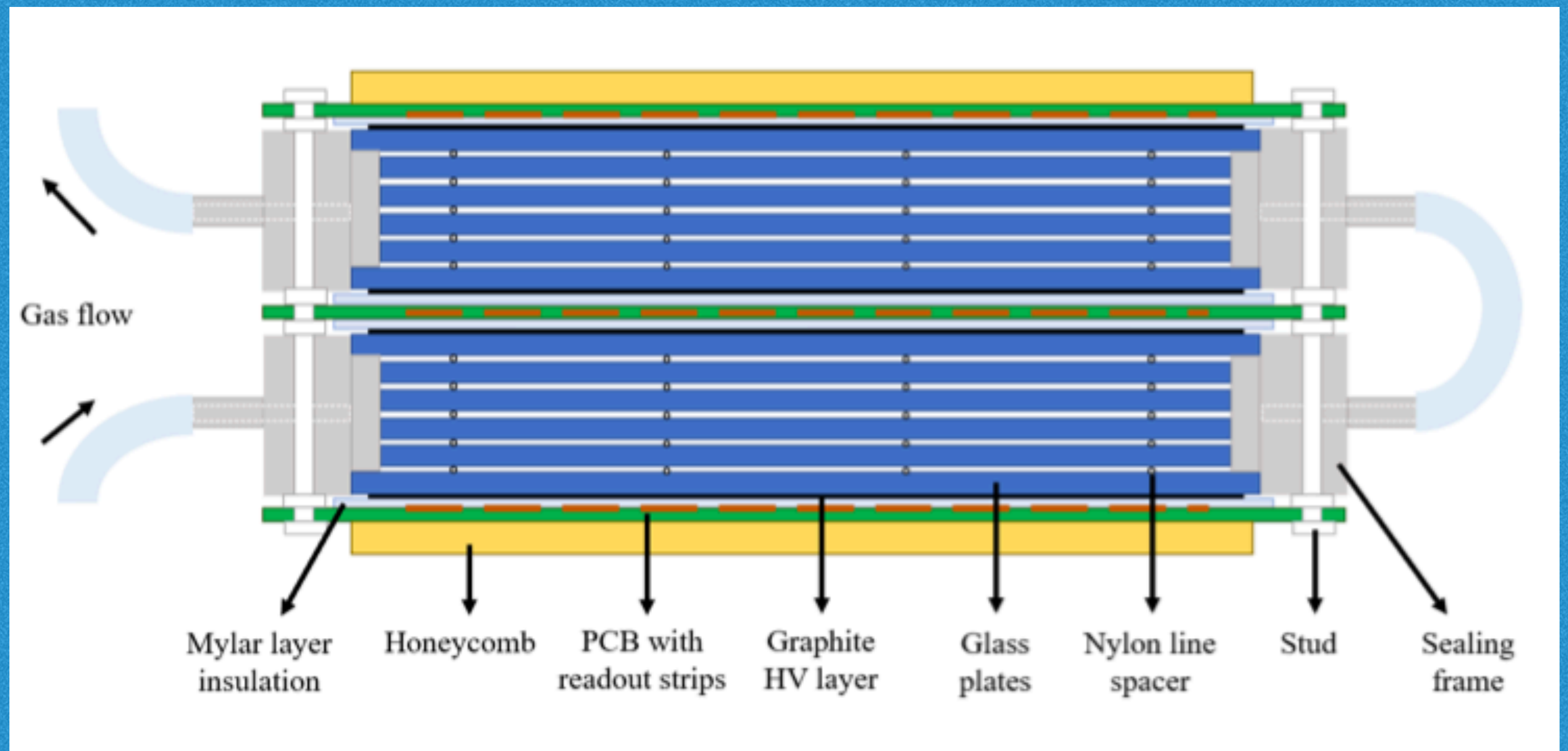
The construction of a new chamber (CDCH2) is under study

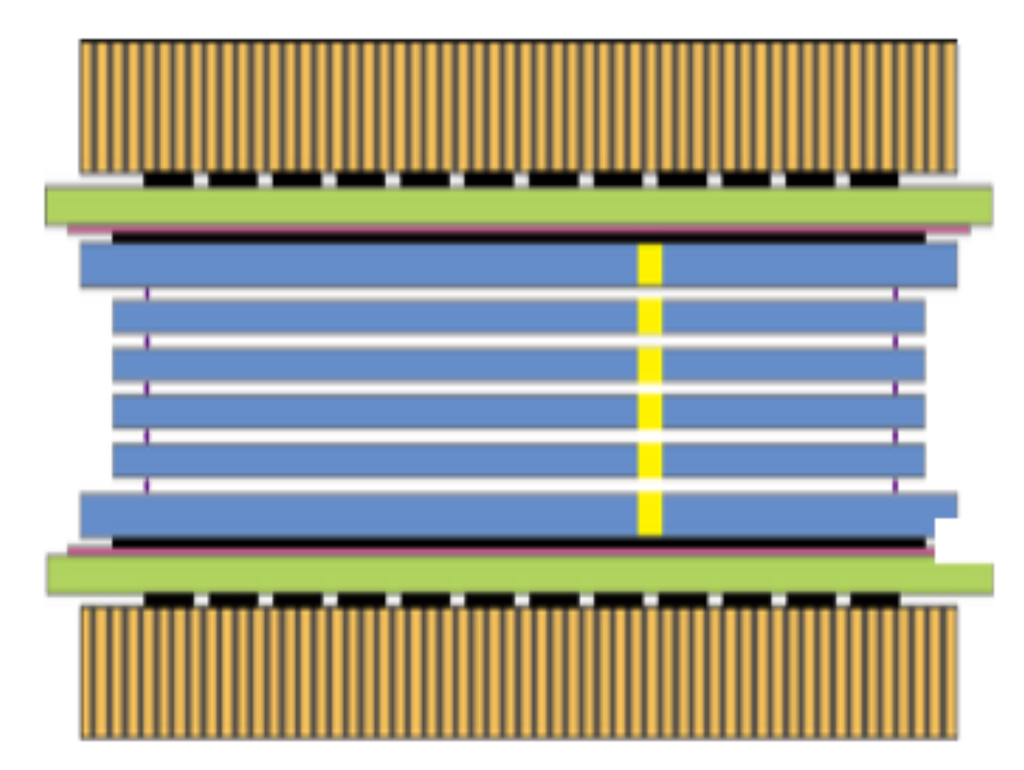
RPC Chambers

Multi-gap RPC are excellent fast timing detectors

The CSR (Cooler Storage Ring) External-target Experiment (CEE)

CEPC





eTOF

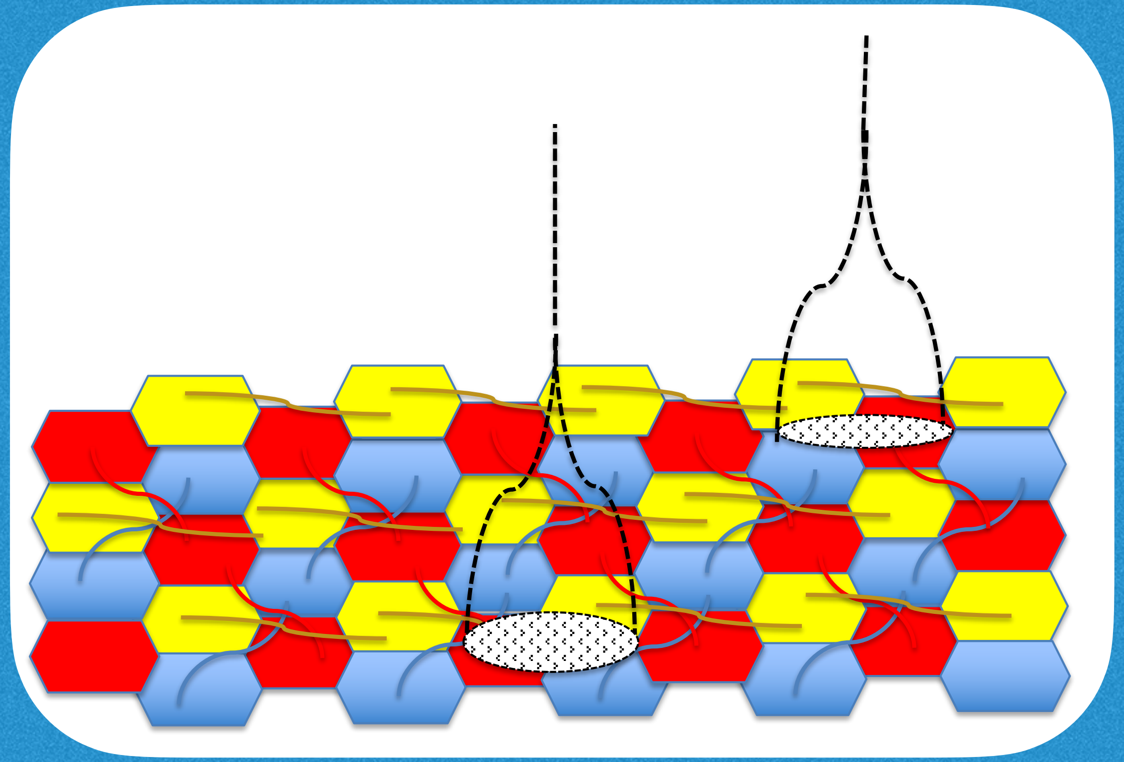
SDHCal

Time resolution: 60-100 ps

Weihao Wu
Botan Wang

New readout scheme

Imad Laktineh

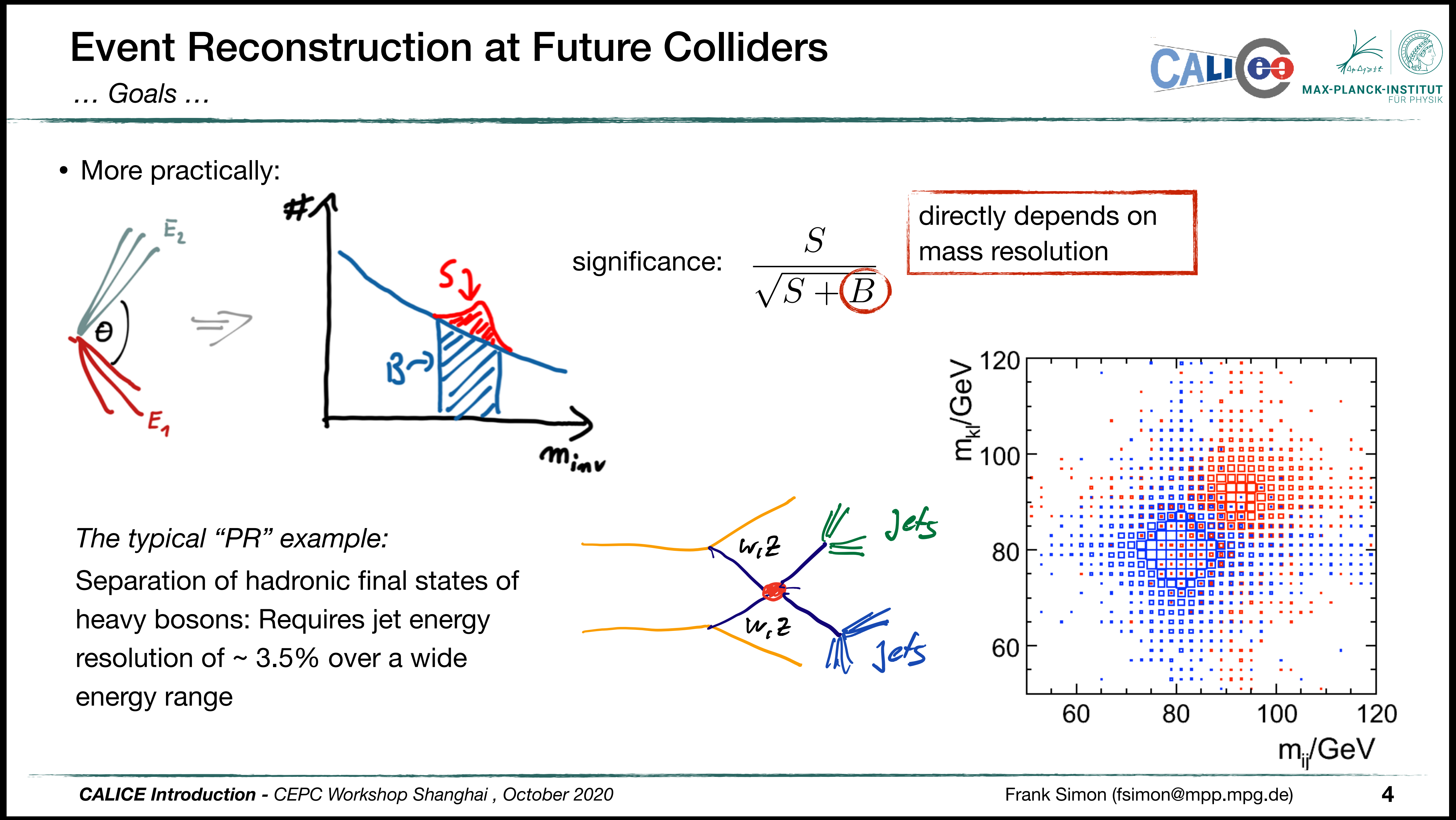


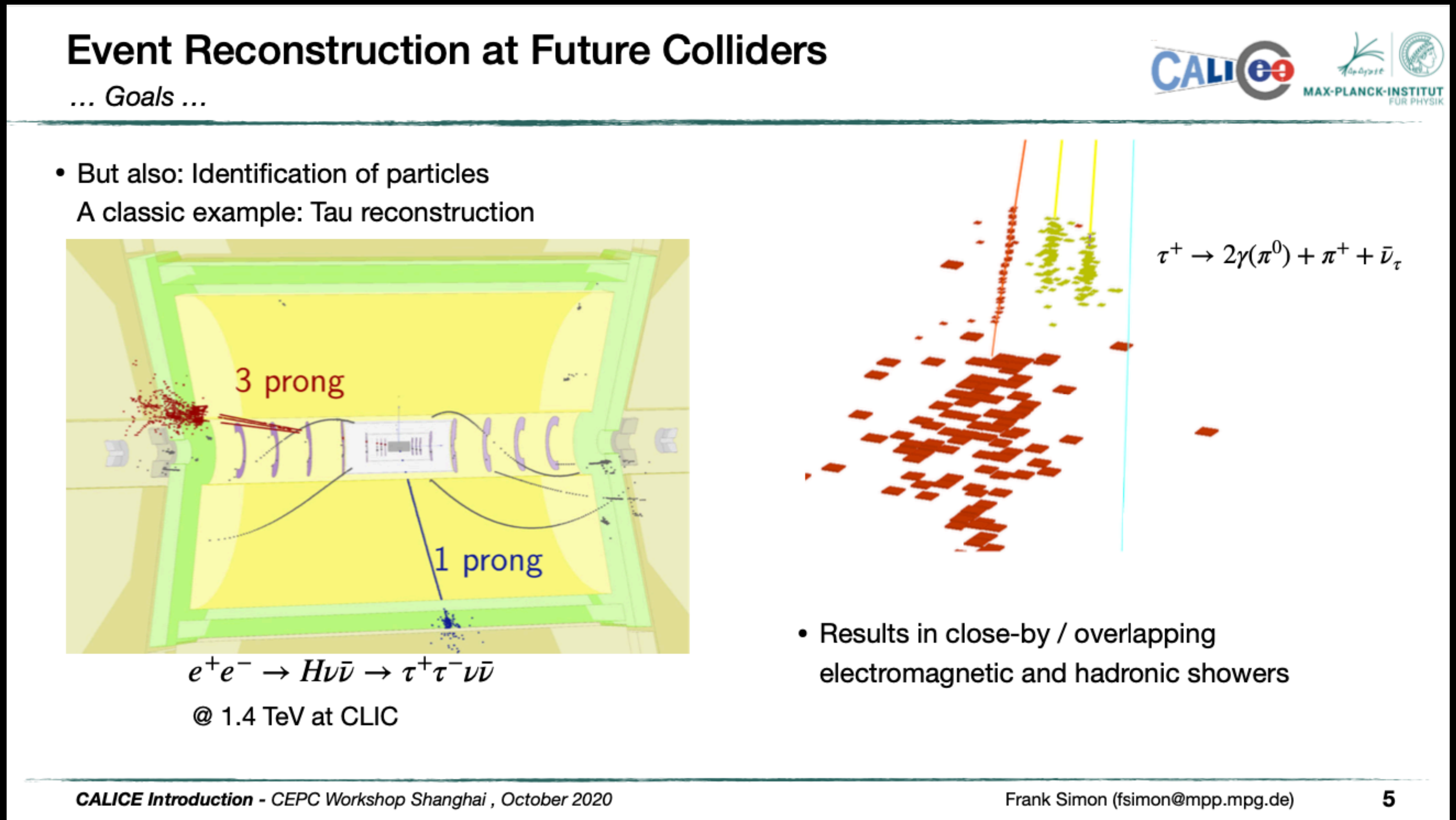
Reduce ghost particles and readout channels

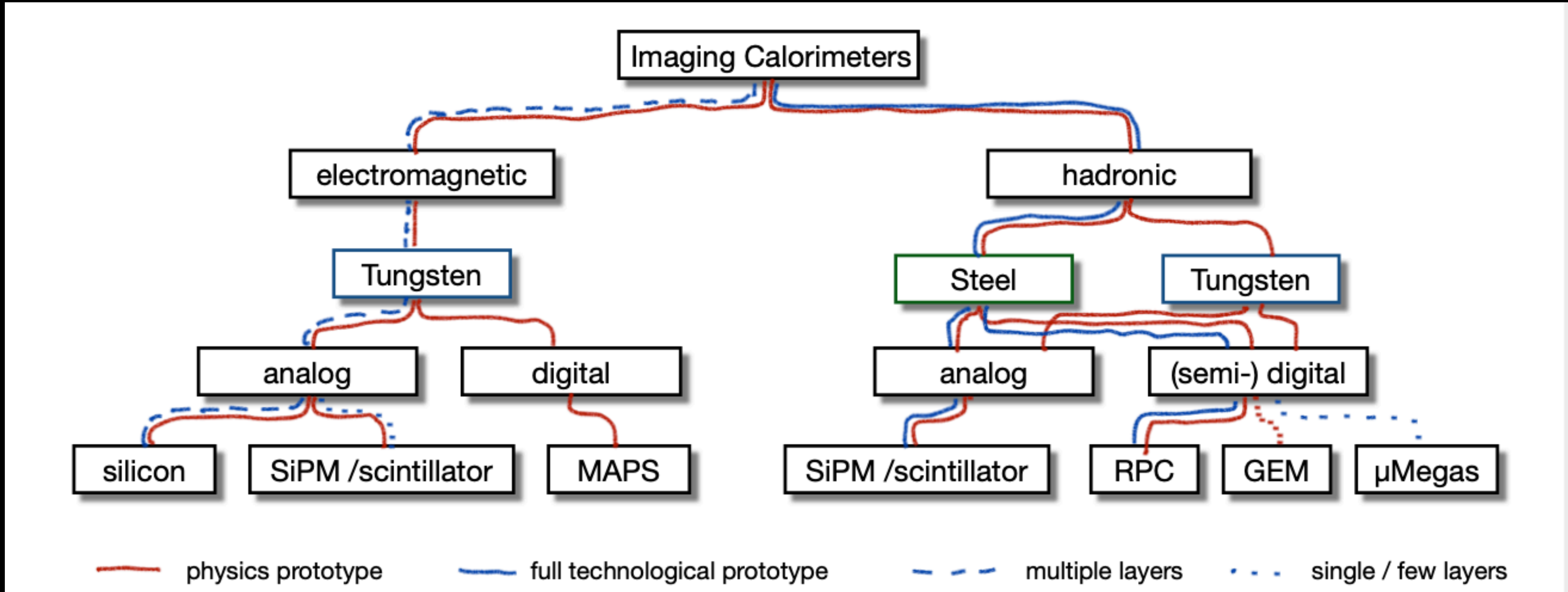
cost and power consumption

Particle Flow Calorimetry (CALICE)

Frank Simon

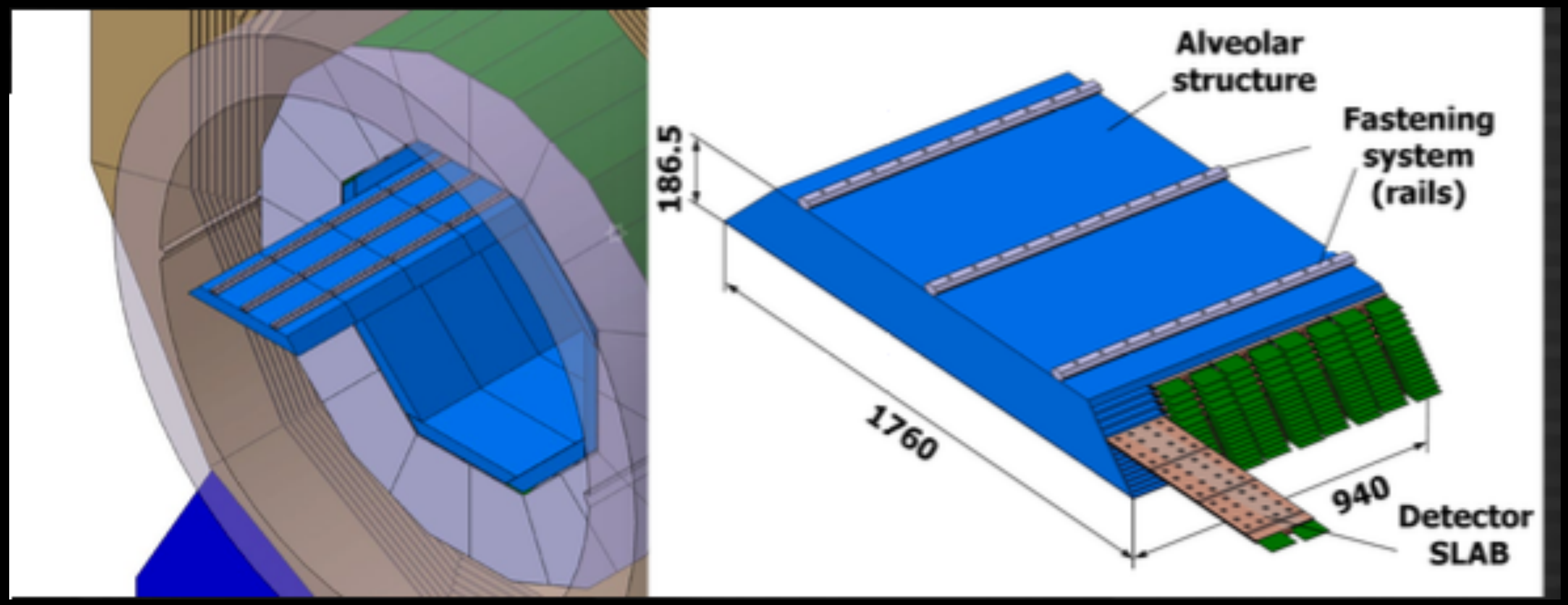


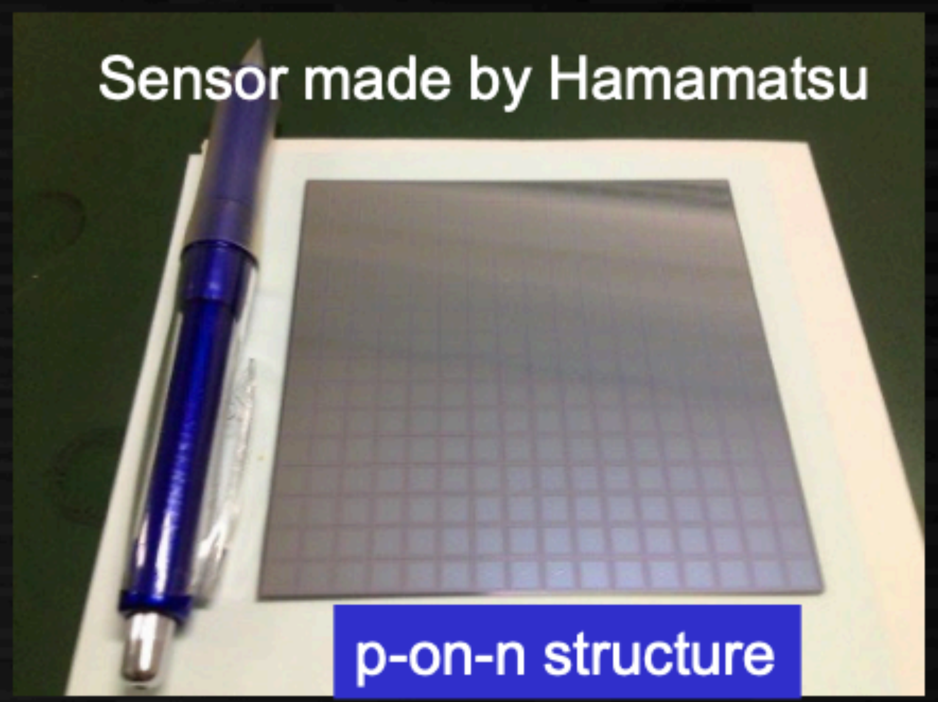




Silicon-Tungsten ECAL (Si-ECAL)

Taikan Suehara

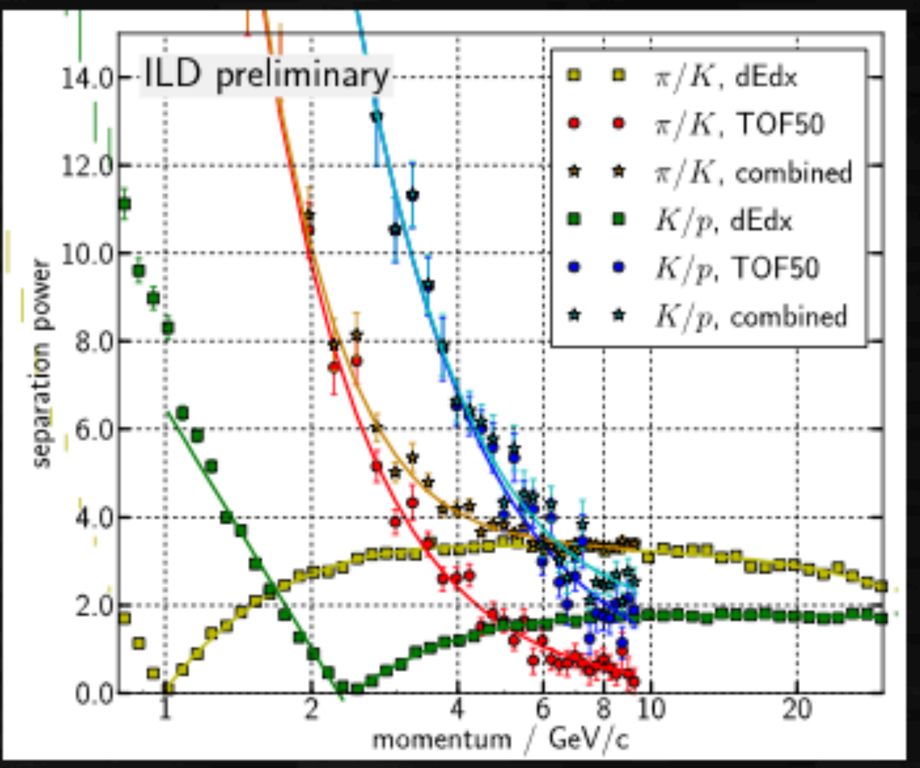


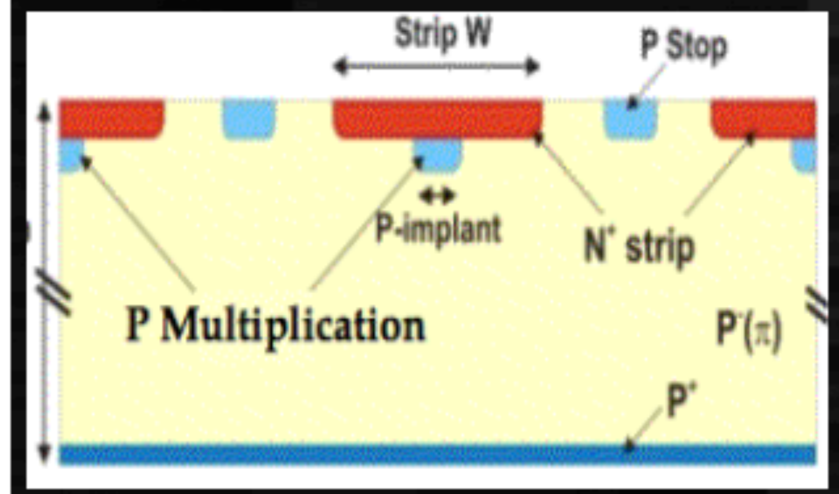


5.5 mm x 256 pixels, 9 x 9 cm / sensor (6 inch)
8 inch sensors: will be tested in 2021-22

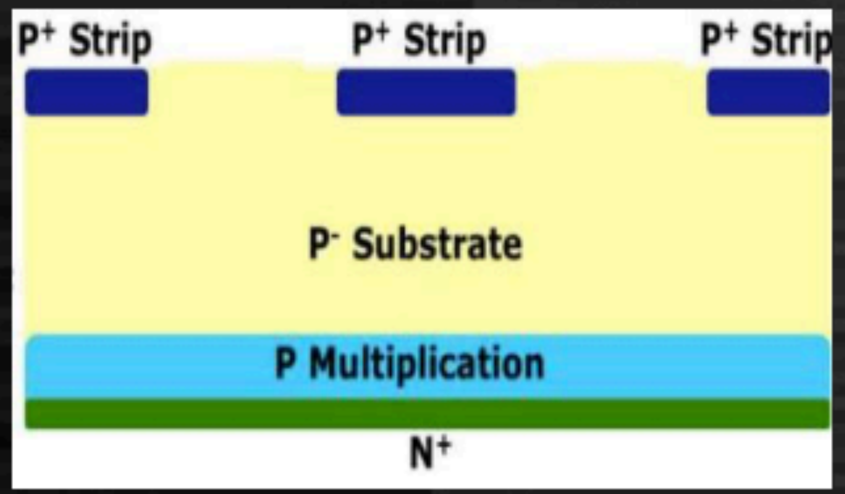
New Silicon Sensor Development

LGAD Silicon + avalanche multiplication (same structure to APD)
< 50 psec timing resolution @ MIP is desired for ToF PID of hadrons



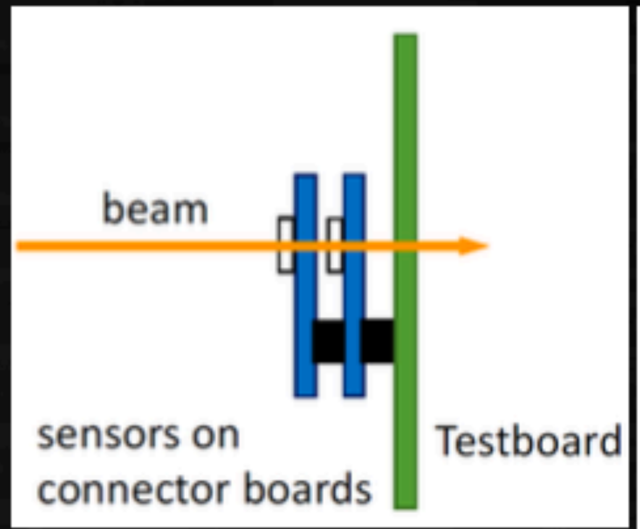


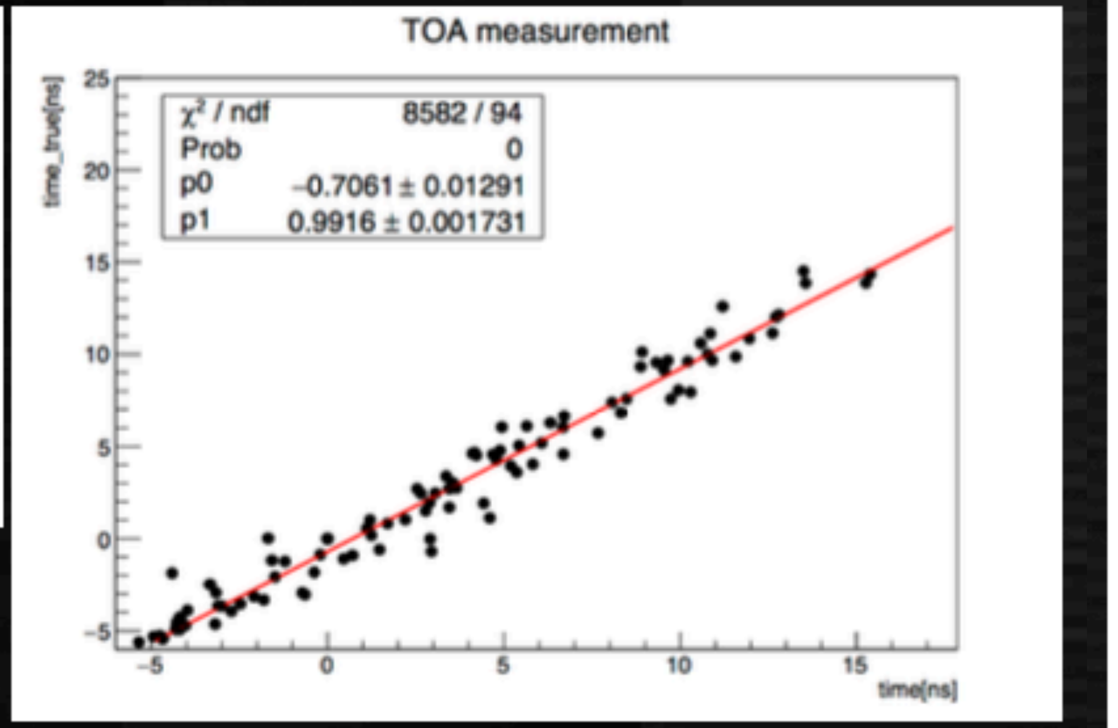
Reach-through LGAD



Inverse LGAD

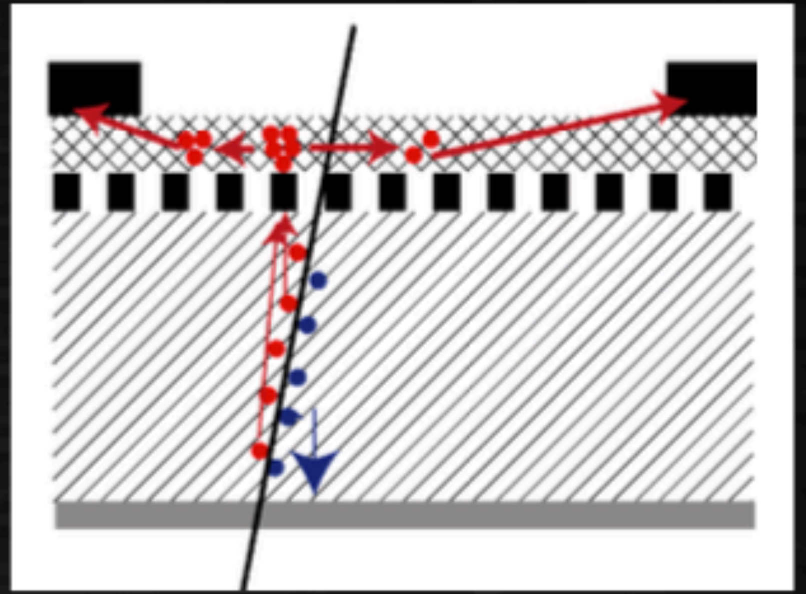
Commercial APD from Hamamatsu



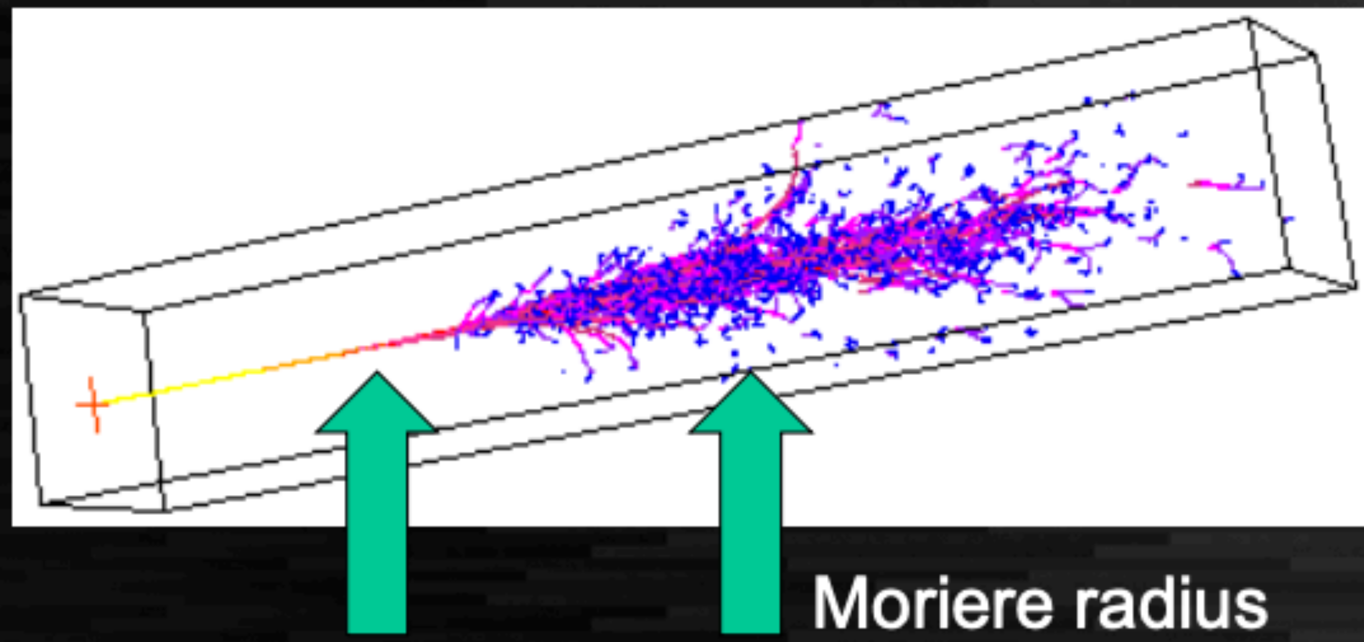


Timing correlation of a few 100 psec seen with test beam: need more study

PSD 4 pads / cell: obtain hit position by charge sharing to identify angle and direction of the particles (photons)

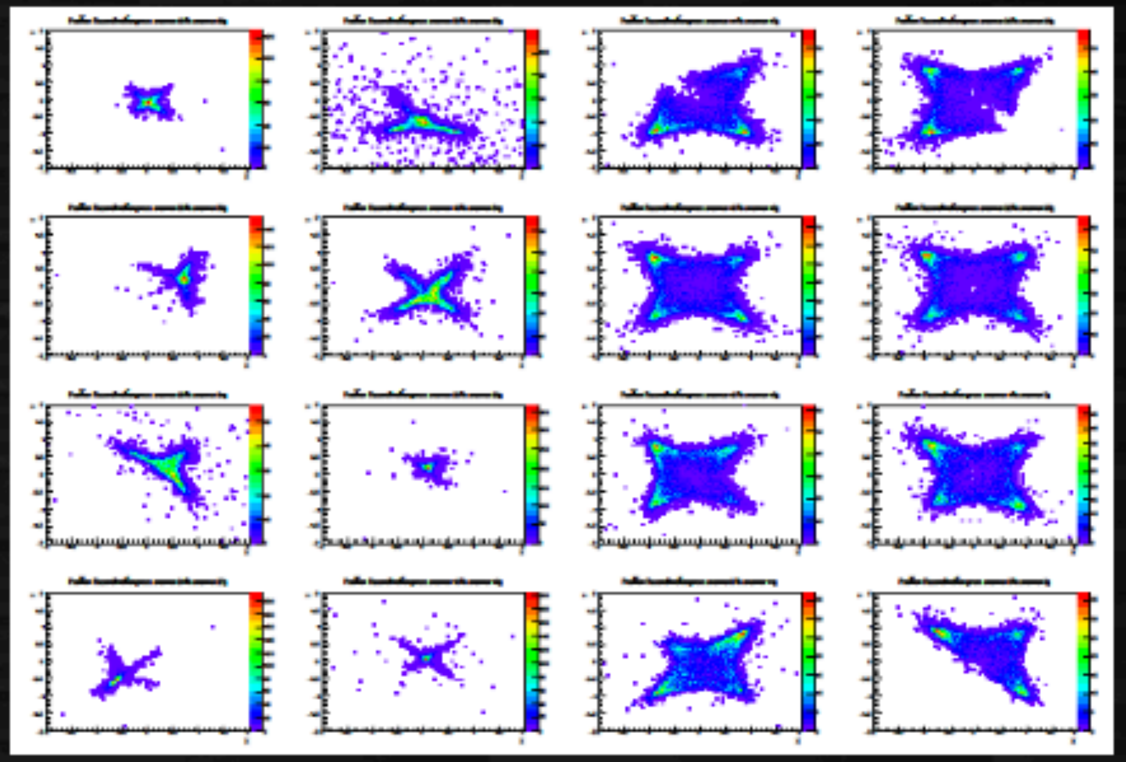


R layer
Dotted P+



Position resolution is important

Moriere radius and number of hits are more important



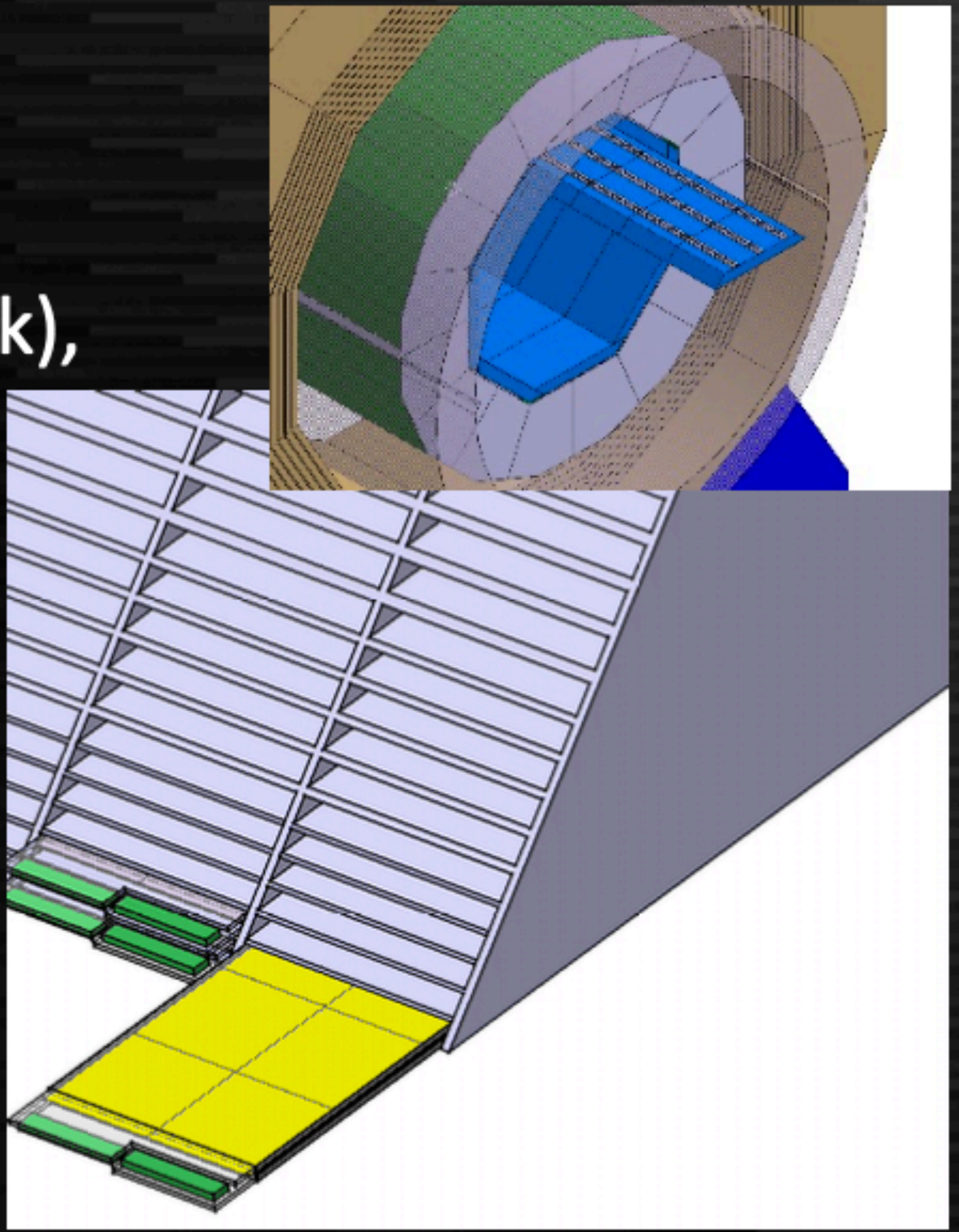
Position reconstruction checked with β source

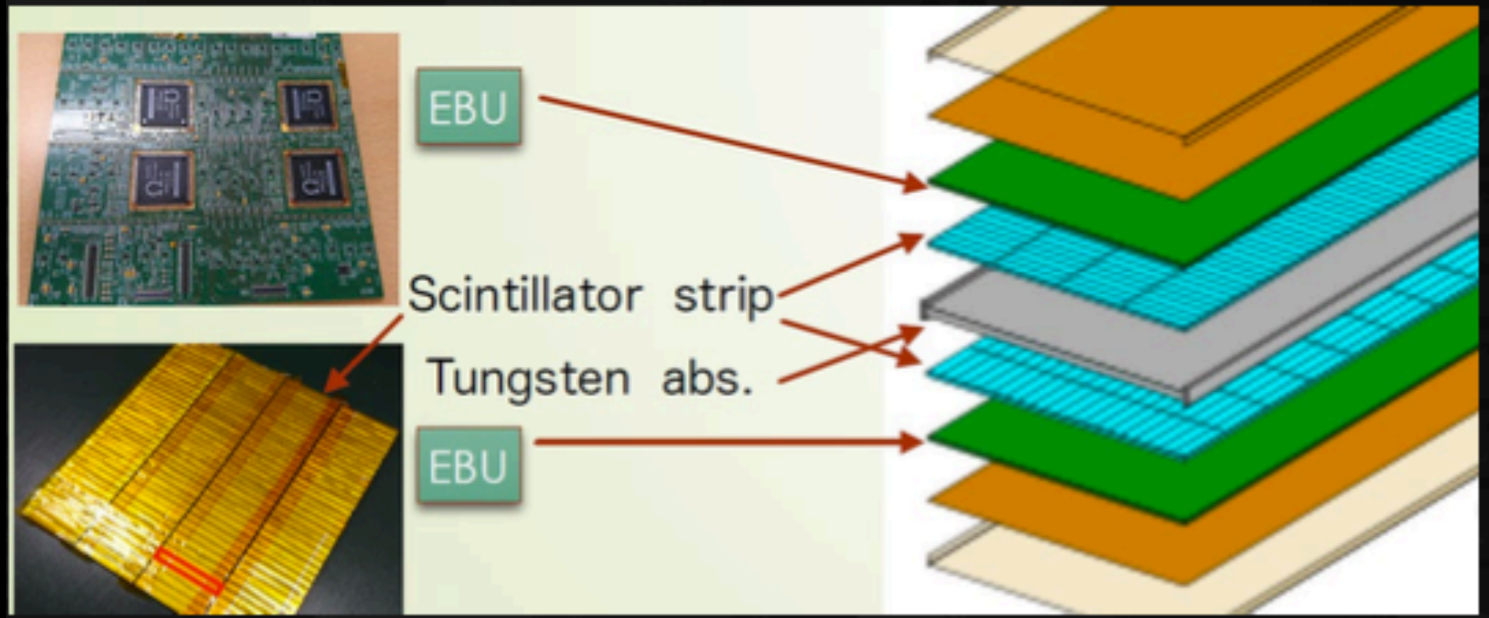
R on right cells are 10x higher

Scintillator ECAL

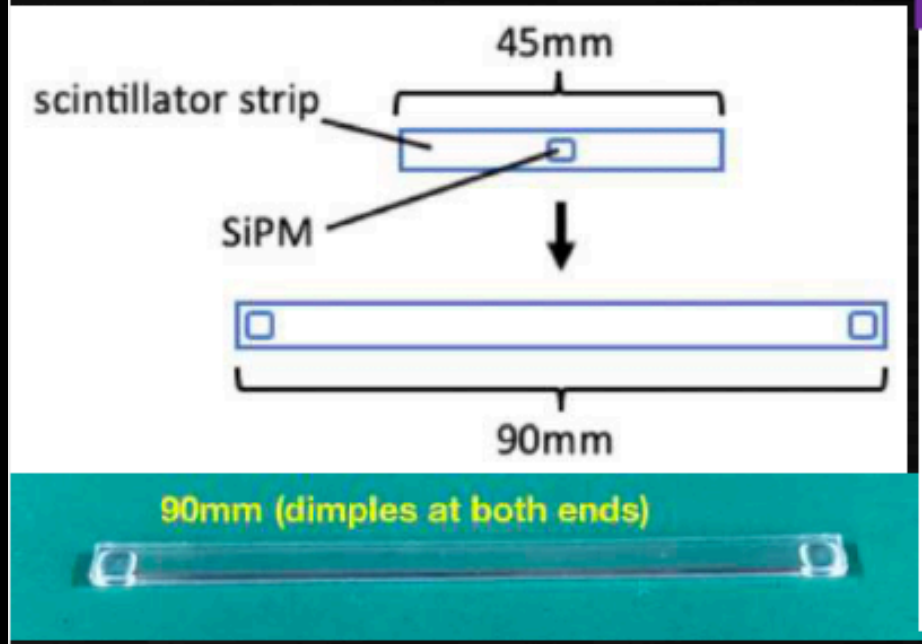
Yazhou Niu
Taikan Suehara

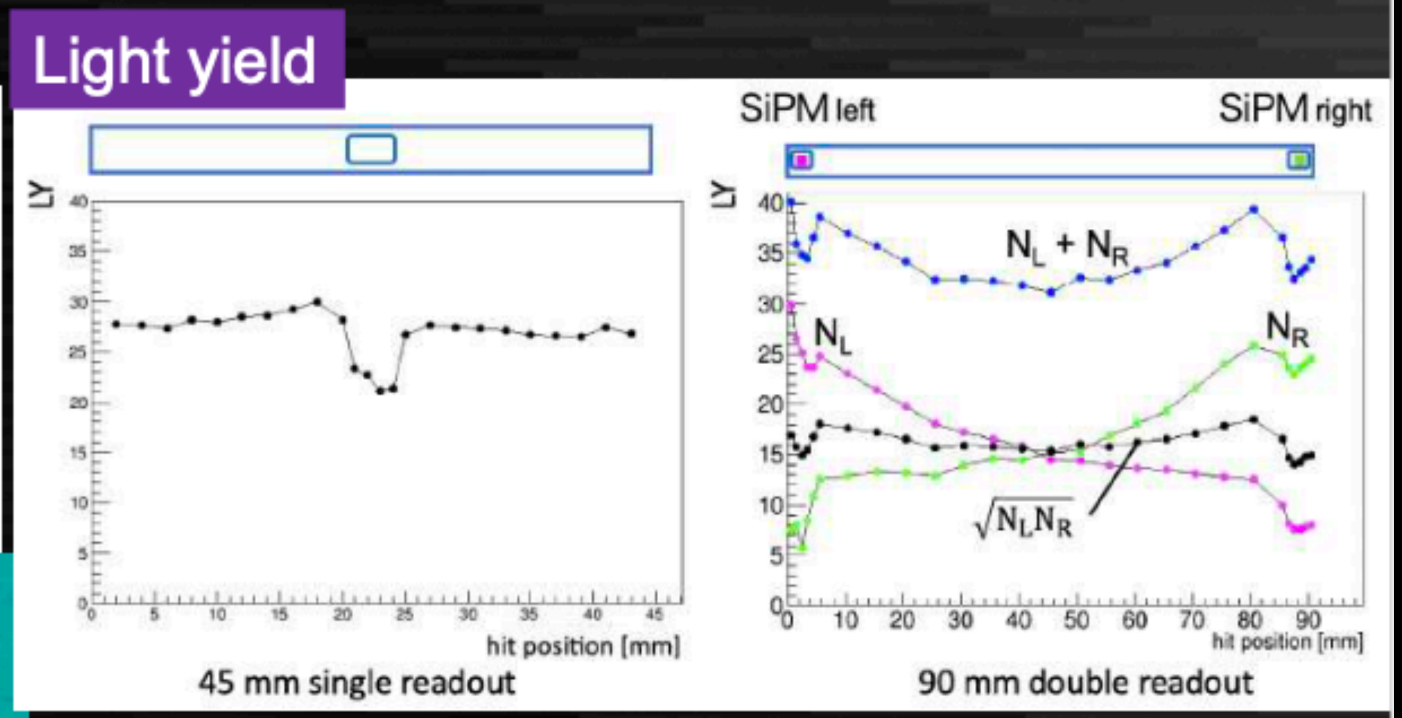
- Long developed in Japan with electronics of DESY
  - China joins for CEPC application
- 5 x 45 mm sci. trips (2 mm thick), 30 layers, ~10^7 cells in total
- EBU (ECAL base unit) with 4 SPIROC (2b)





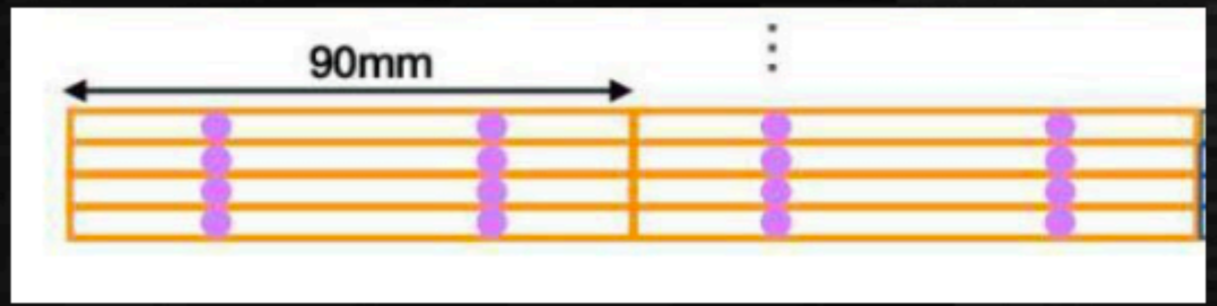
Double-sided readout





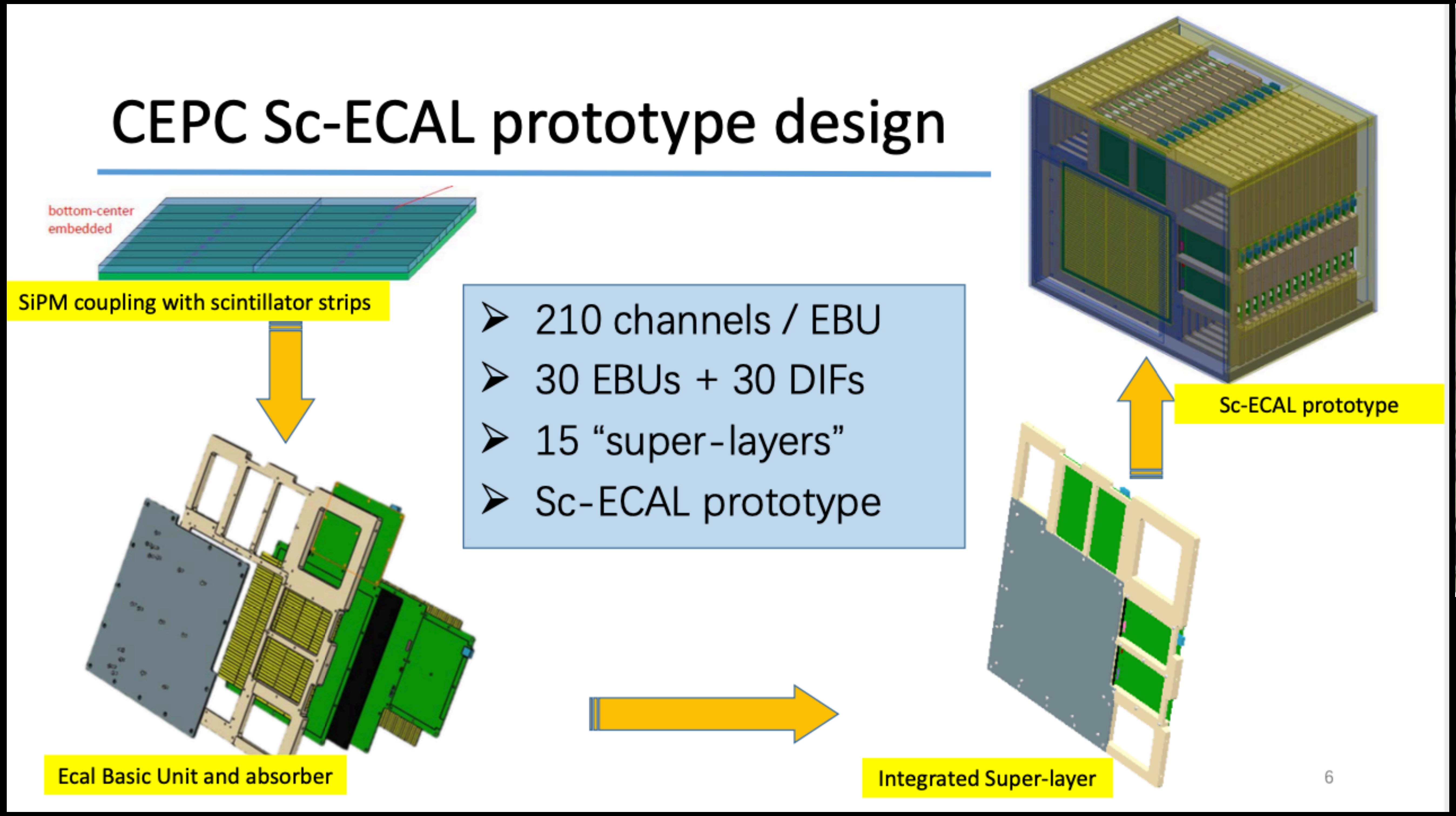
With double-sided readout,
- More light yield by adding outputs of two SiPMs on the side.
- Background suppression by coincidence of the outputs.
- Position ID (s = 22 mm) by fraction of the light yield and timing difference.

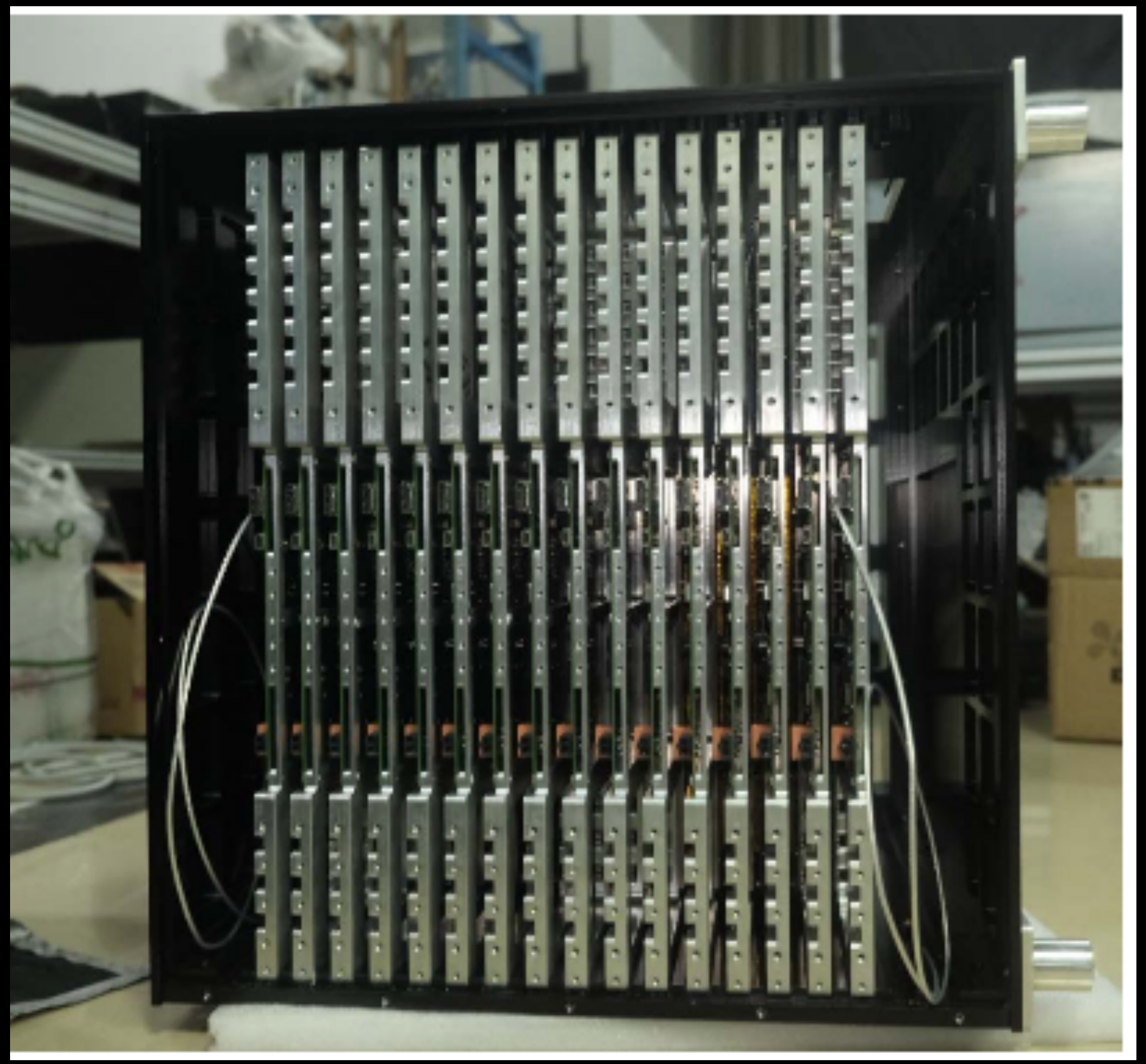
EBU with double-sided strips has been prepared for the coming test beam.



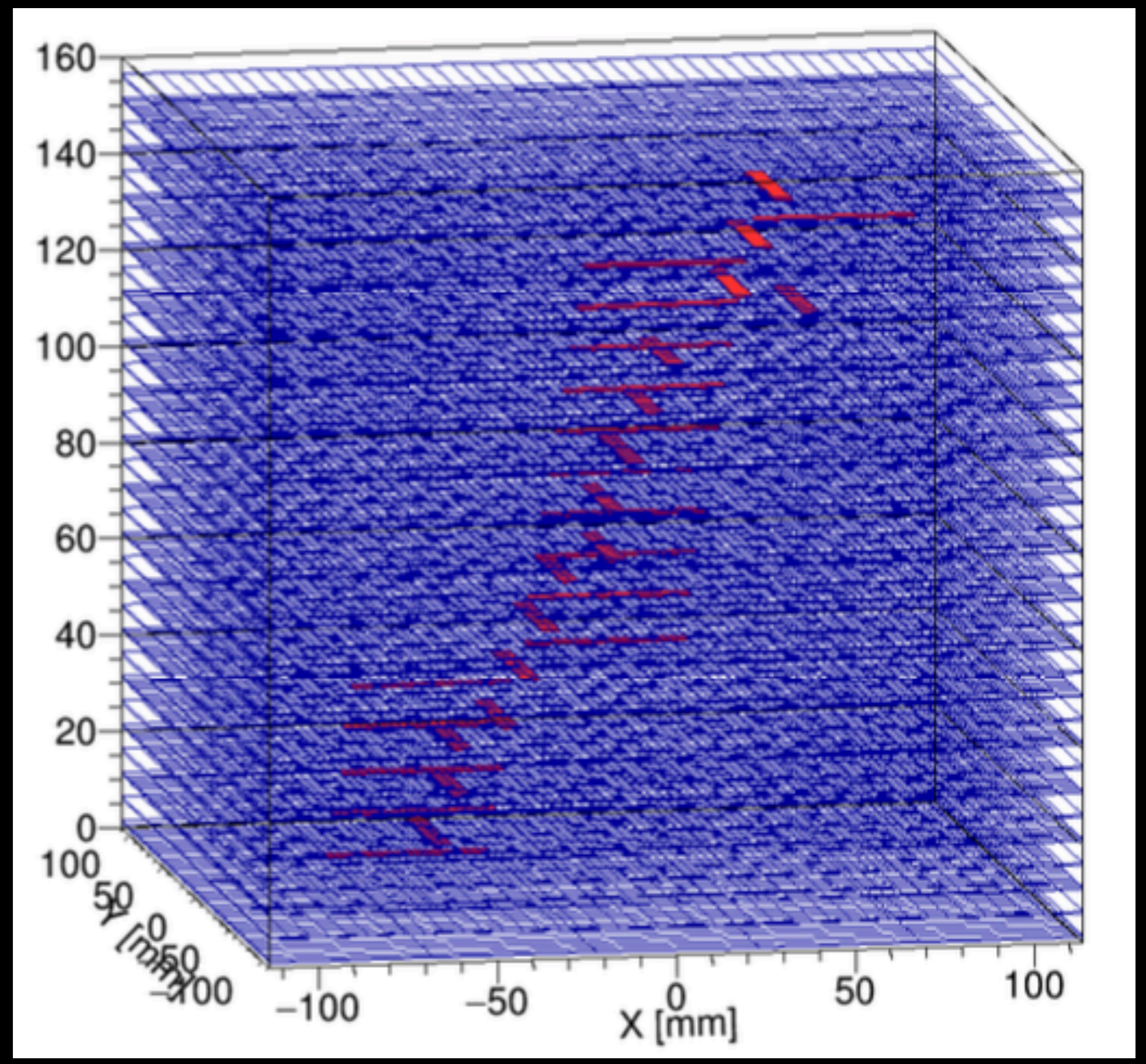
Taikan Suehara, Intl. WS on CEPC at Shanghai, 26 Oct. 2020 page 15

Scintillator ECAL Prototype





Cosmic ray



30 full layers prepared in China-Japan collaboration

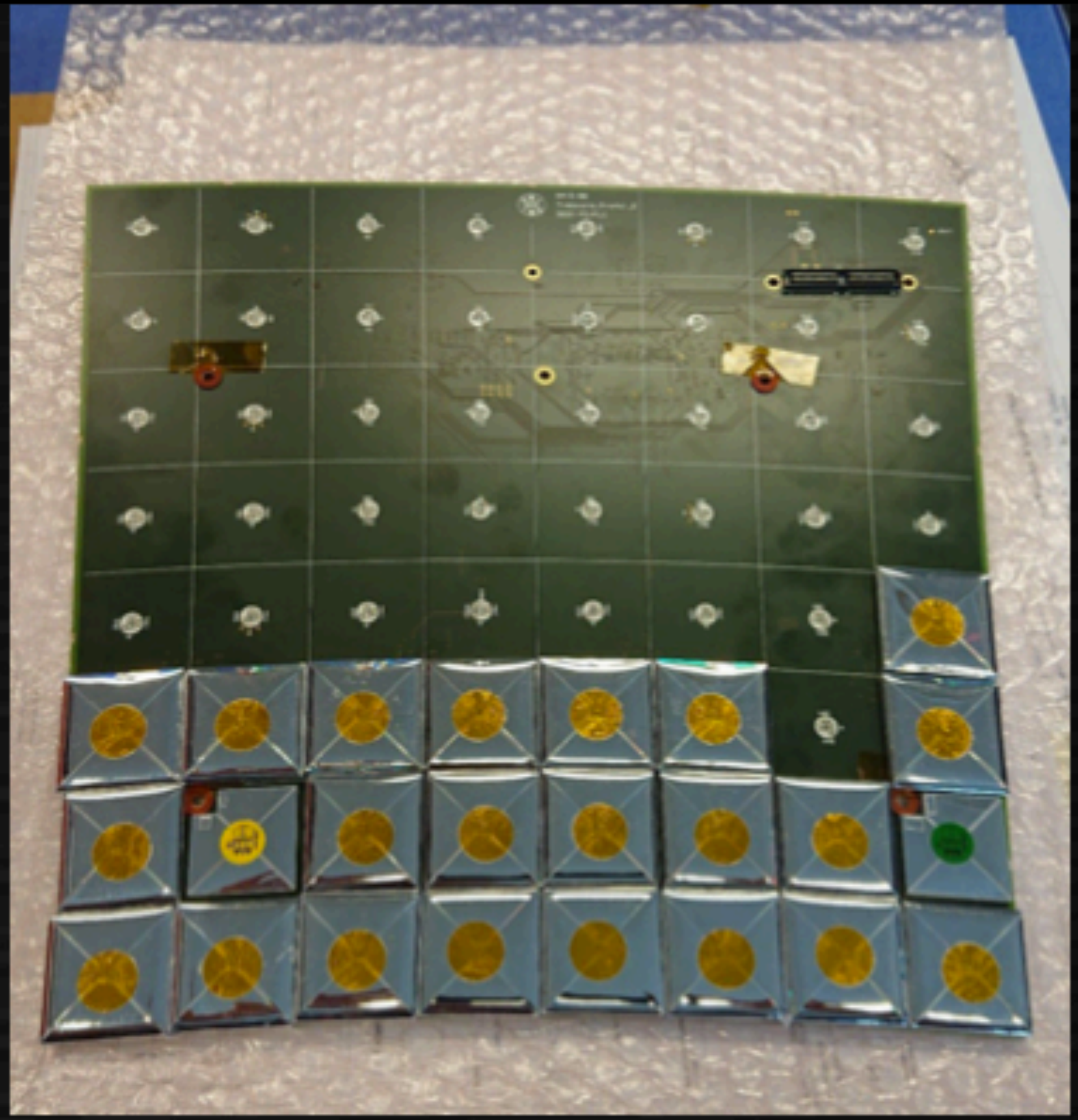
Test beam in China in next two weeks

Test beam planned for February 2021 at DESY

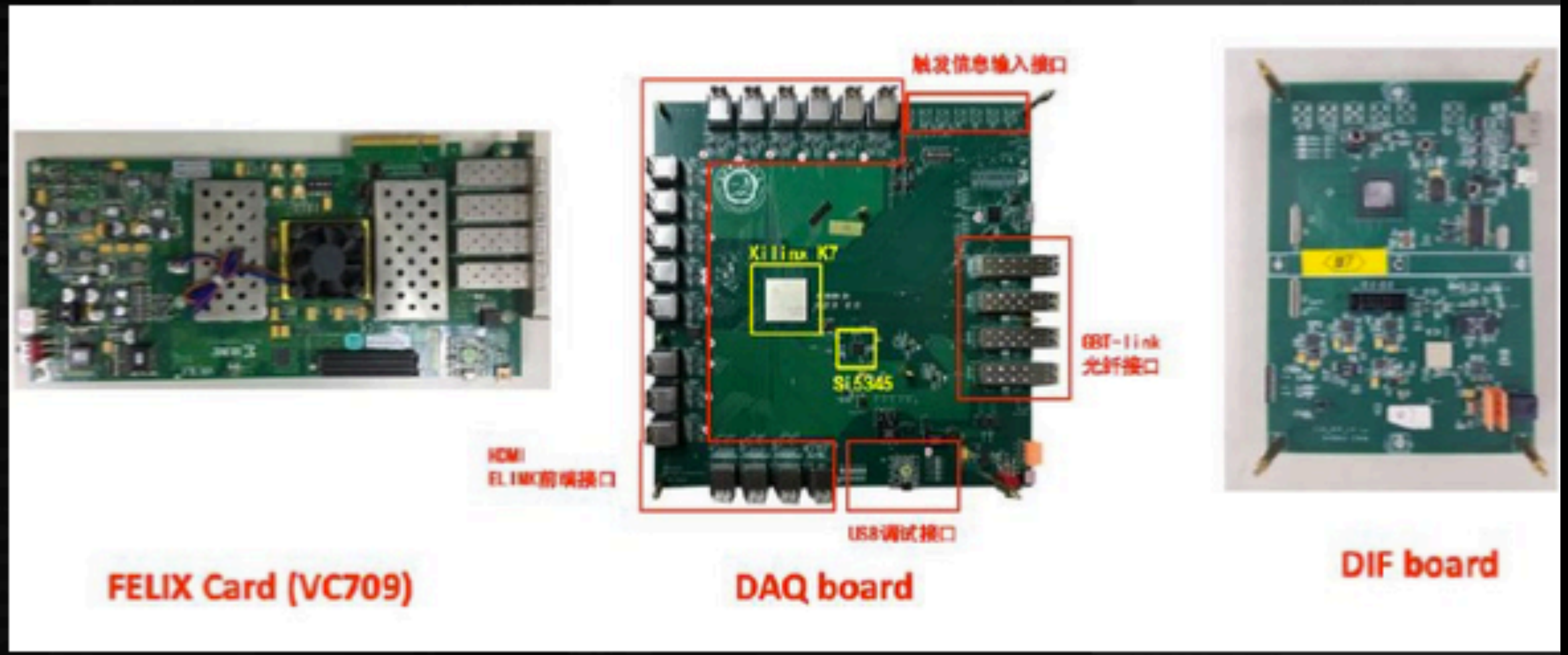
Scintillator HCAL/CMS (HGCAL) - Steel

Jiechen Jiang
Taikan Suehara

Studies of light yield, tile size, uniformity, SiPM



See talk by J. Jiang this morning for details

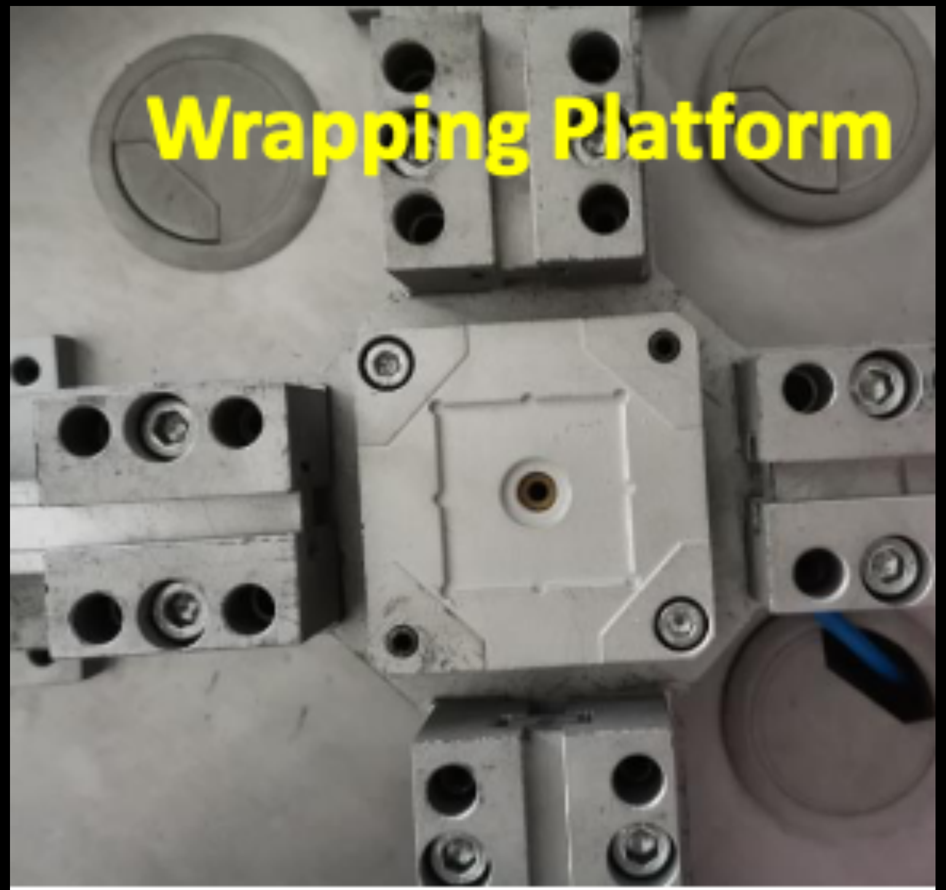


Electronics for CEPC similar to ScECAL being commissioned

- Channels with 2mm² and 4mm² SiPMs
- Trapezoidal tiles
- HGCROC ASIC
- MIP seen at latest TB

Machine-wrapped tiles of 3x3 and 4x4 cm²

Batch assembly and testing



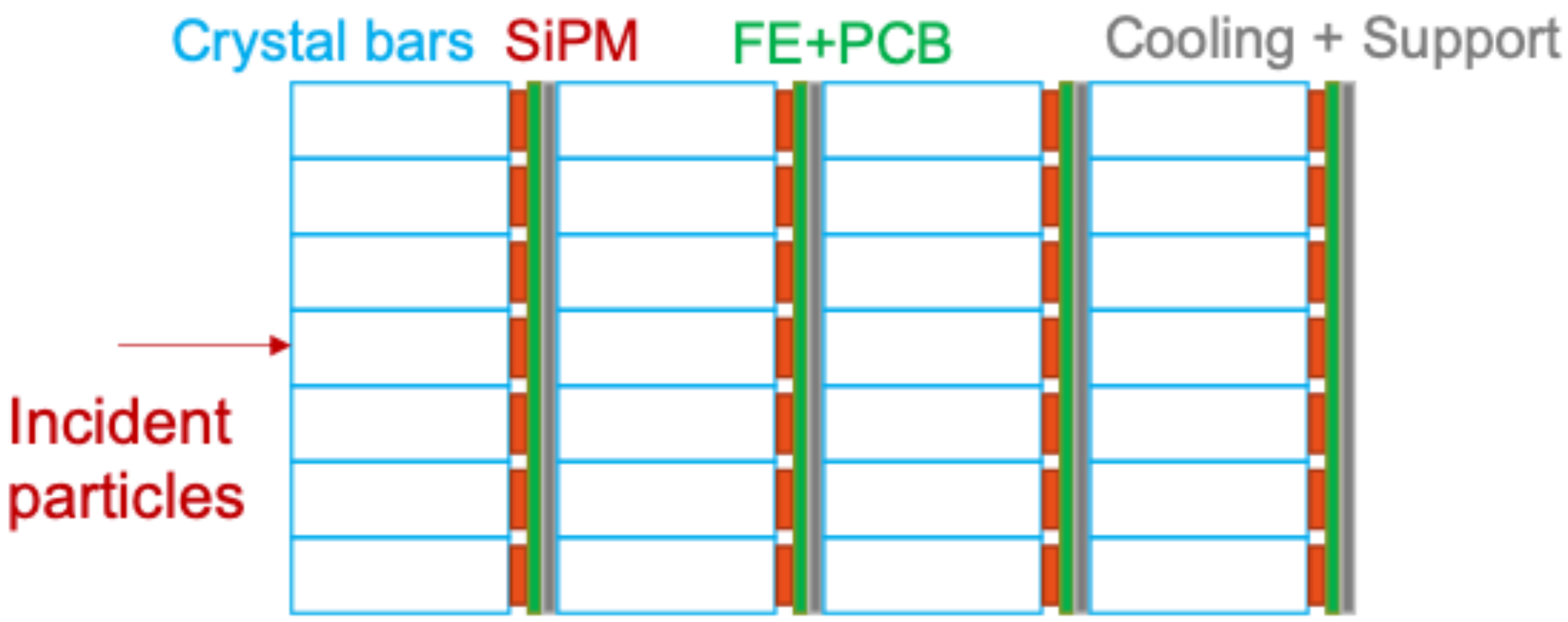
Prototype for CEPC being developed

New Ideas: Crystal Calorimeters

Yong Liu

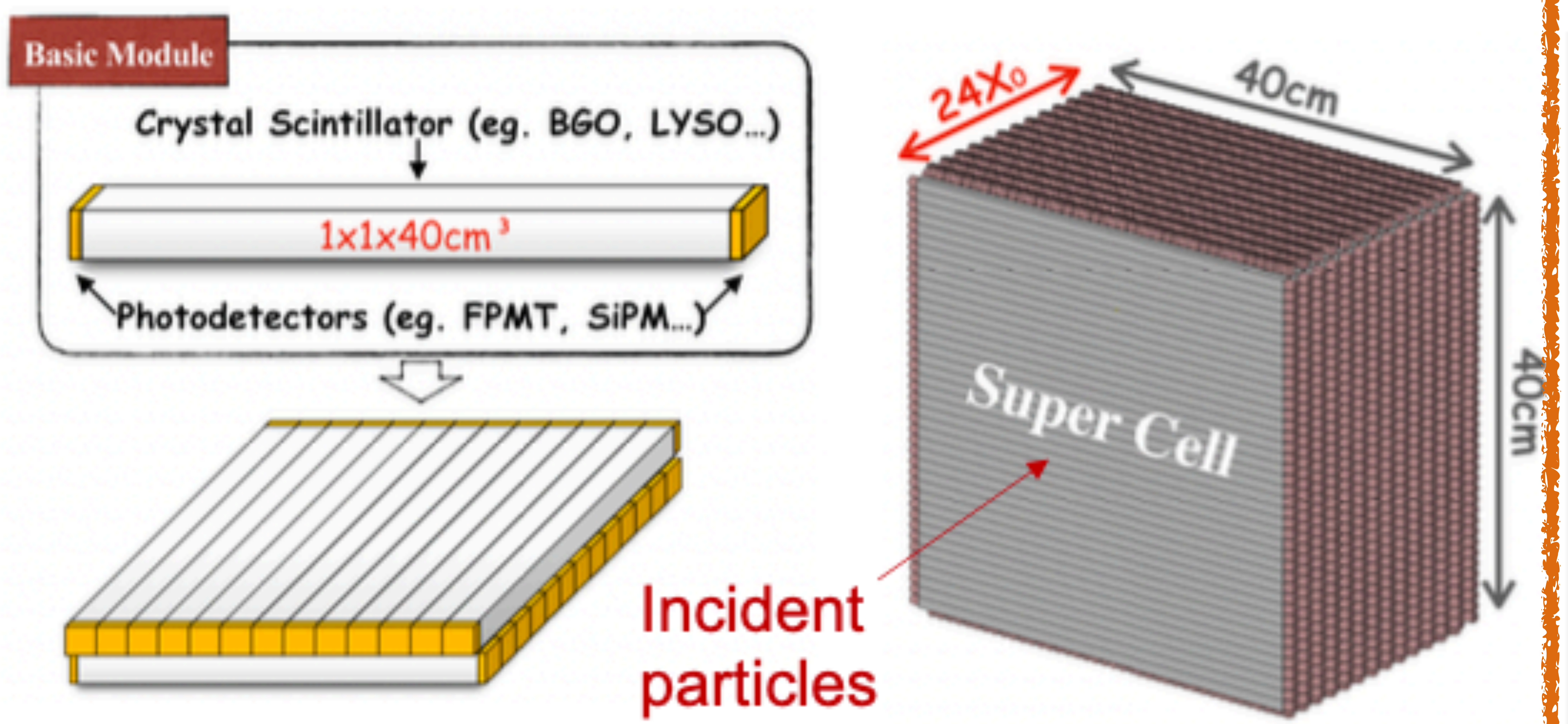
Two new segmented ECAL designs based on crystals

Design 1



- Longitudinal segmentation
- Fine transverse segmentation
  - 1×1cm or 2×2cm cells
- Single-ended readout with SiPM
- Potentials with PFA

Design 2



- Long bars: 1×40cm, double-sided readout
  - Super cell: 40×40cm cube
- Crossed arrangement in adjacent layers
- Significant reduction of #channels
- Timing at two sides: positioning along bar

Crystals: LYSO:Ce, PbWO, BGO? **SiPM: HPK, NLD?**

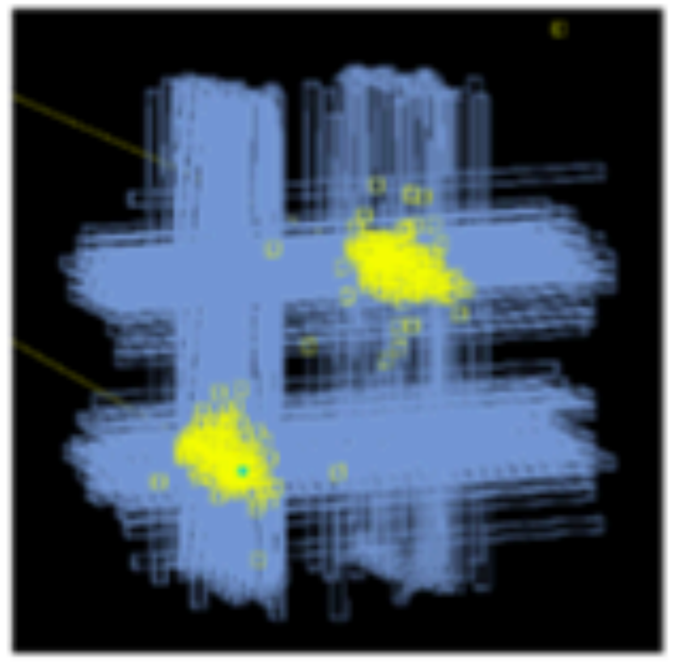
Being incorporated into CEPC Software

Cost is an issue

cReconstruction with 2 incident particles

Yuexin Wang (IHEP)

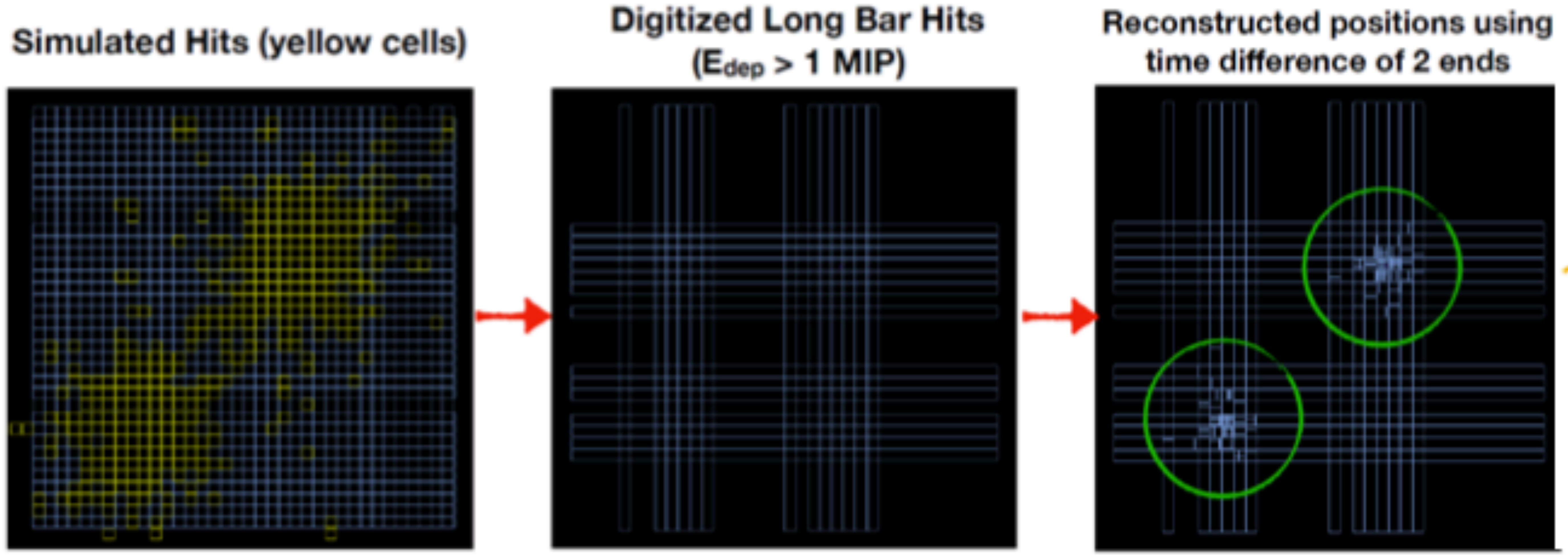
Patterns in event display: 2 photons



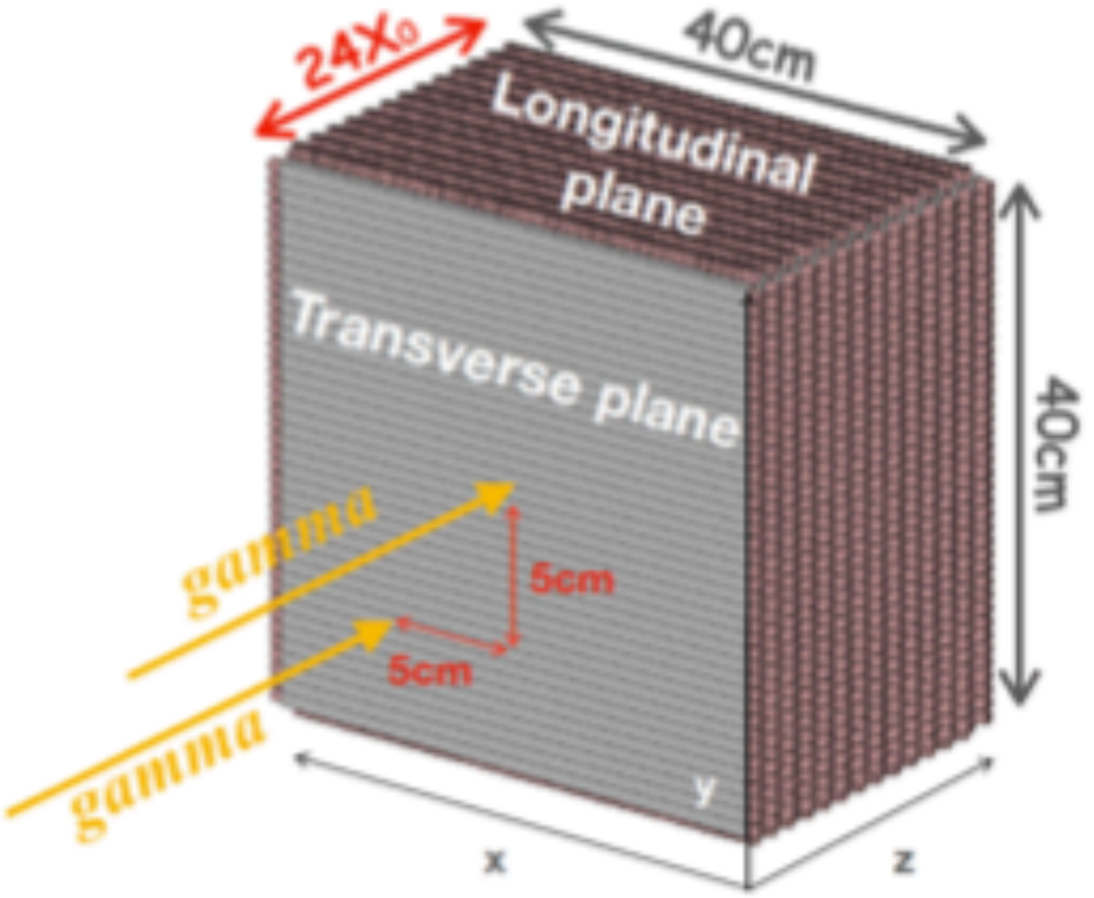
2 parallel 5GeV γ

distance ~20cm along the diagonal

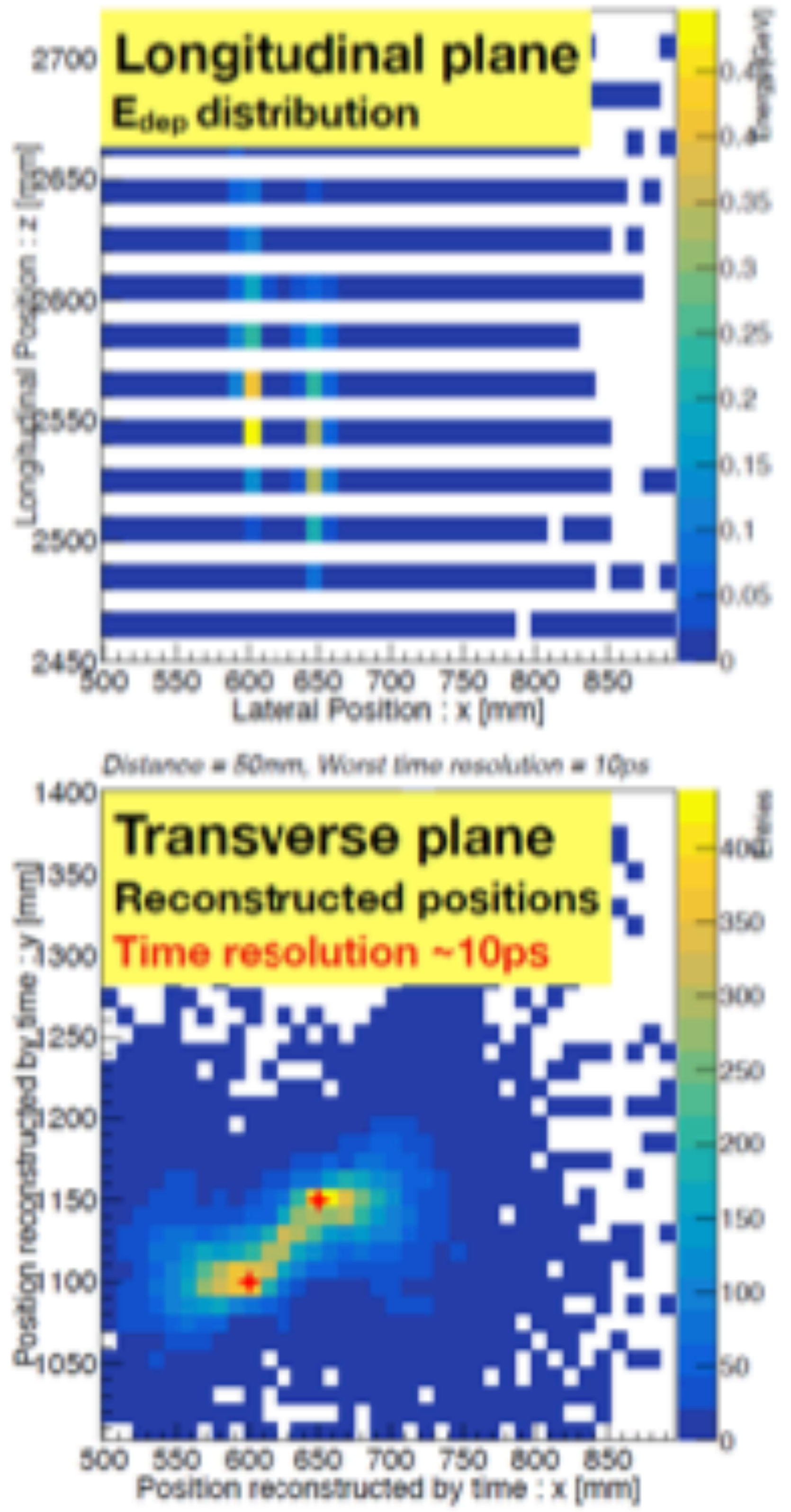
→ can be separated.



Shower profiles: 2 photons



5cm ~ $2R_M$ for BGO (R_M=2.26cm)



Dual Readout Calorimeters

Iacopo Vivarelli
Sarah Eno

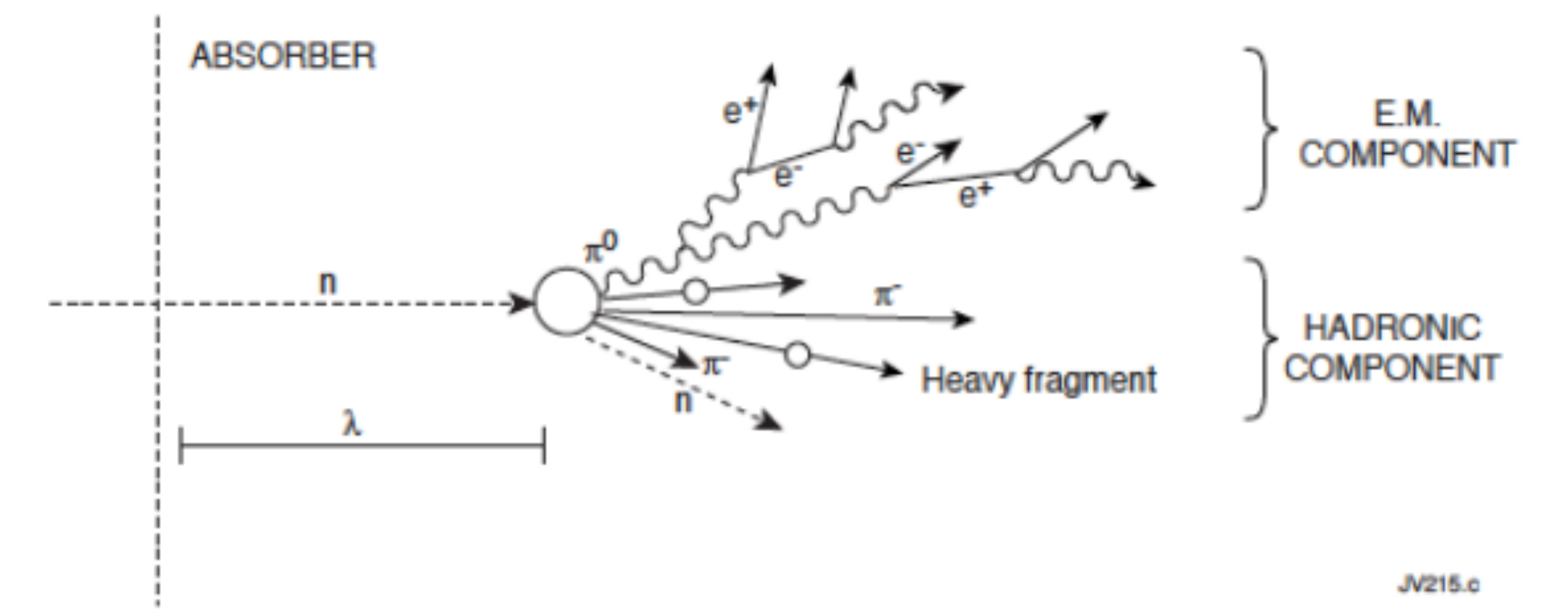
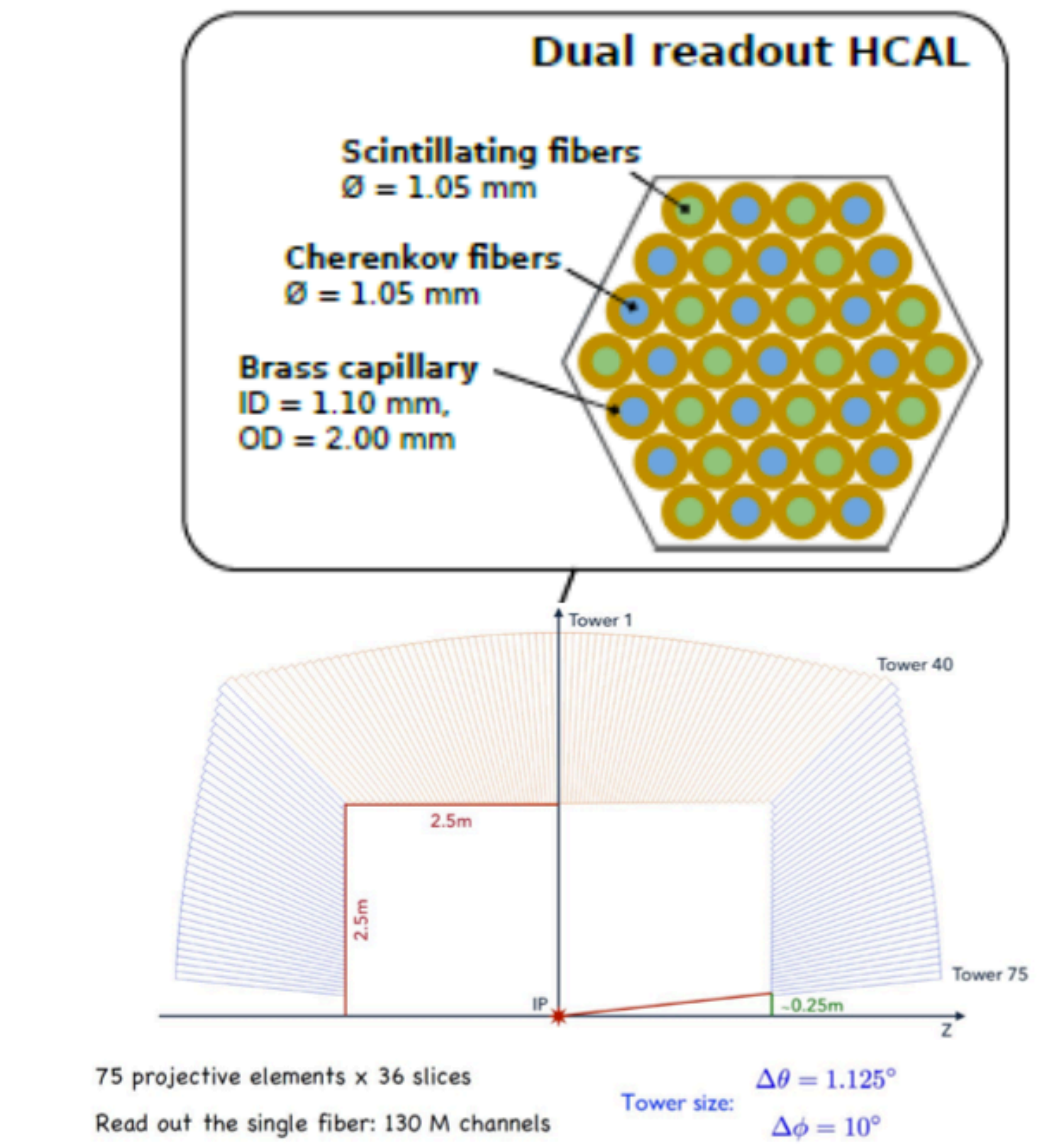


Fig. 9: Schematic of development of hadronic showers.

DREAM
RD52
IDEA



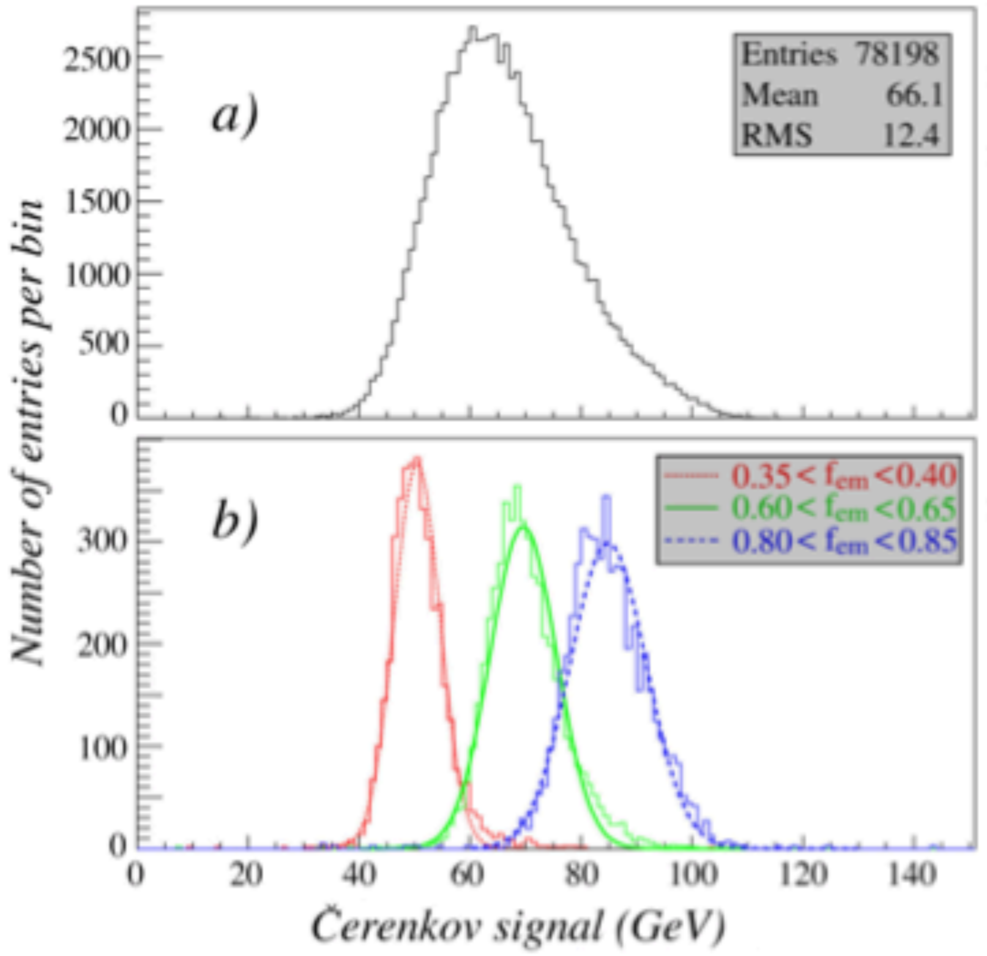
The dual-readout principle in a nutshell

- Sampling the **hadronic shower** with two readouts of **different e/h factor** allows to correct event by event for non-compensation.
- Cherenkov (C) channel mostly sensitive to the em shower component, Scintillation (S) sensitive to all.

$$\begin{cases} E_S = E\left(f_{em} + \left(\frac{h}{e}\right)_S (1-f_{em})\right) \\ E_C = E\left(f_{em} + \left(\frac{h}{e}\right)_C (1-f_{em})\right) \end{cases}$$

Two equations in two unkowns (f_{em} and E)

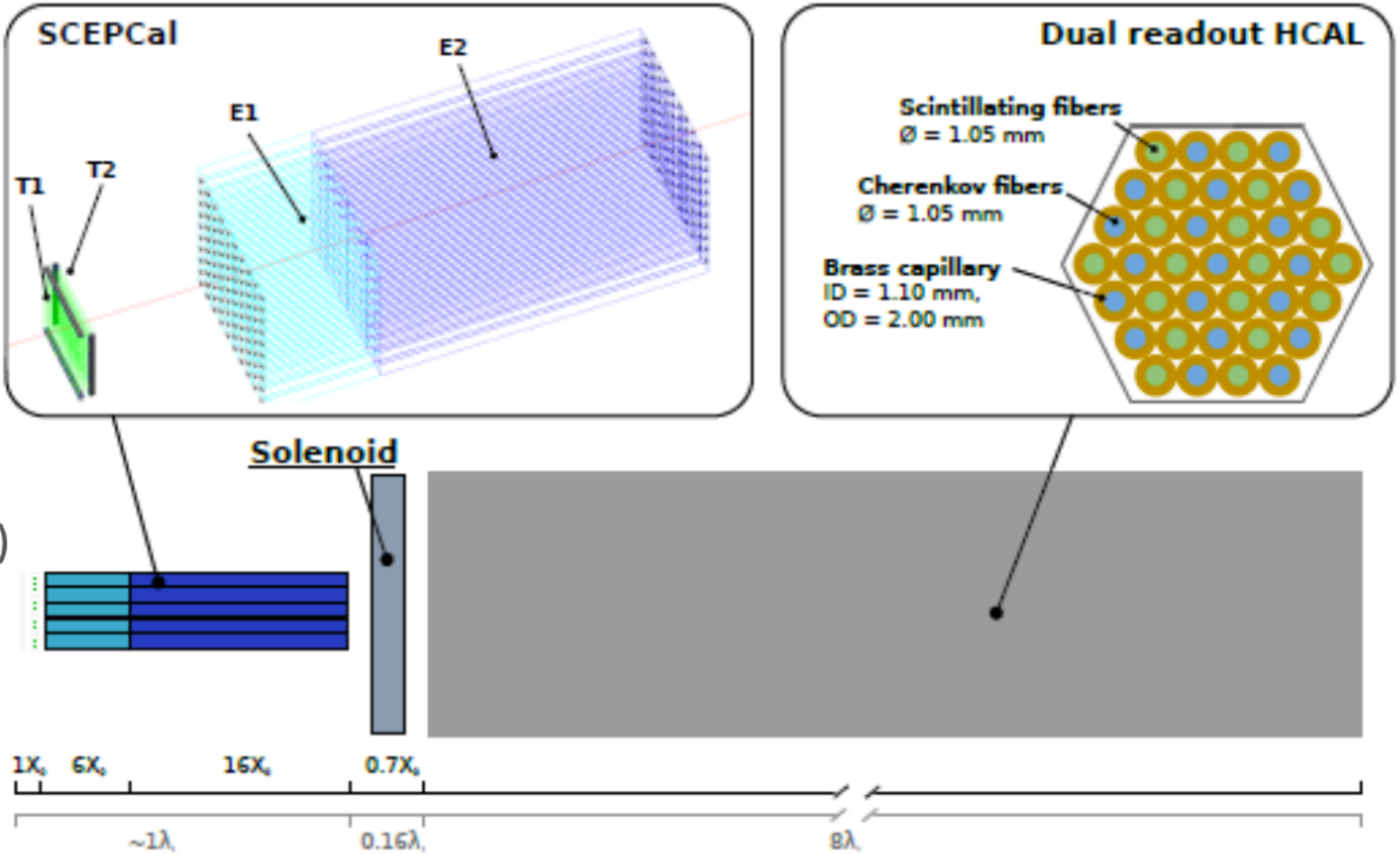
$$E = \frac{(E_S - \chi E_C)}{1-\chi} \qquad \chi = \frac{1-\left(\frac{h}{e}\right)_S}{1-\left(\frac{h}{e}\right)_C}$$



Dual Readout Crystal Calorimeter

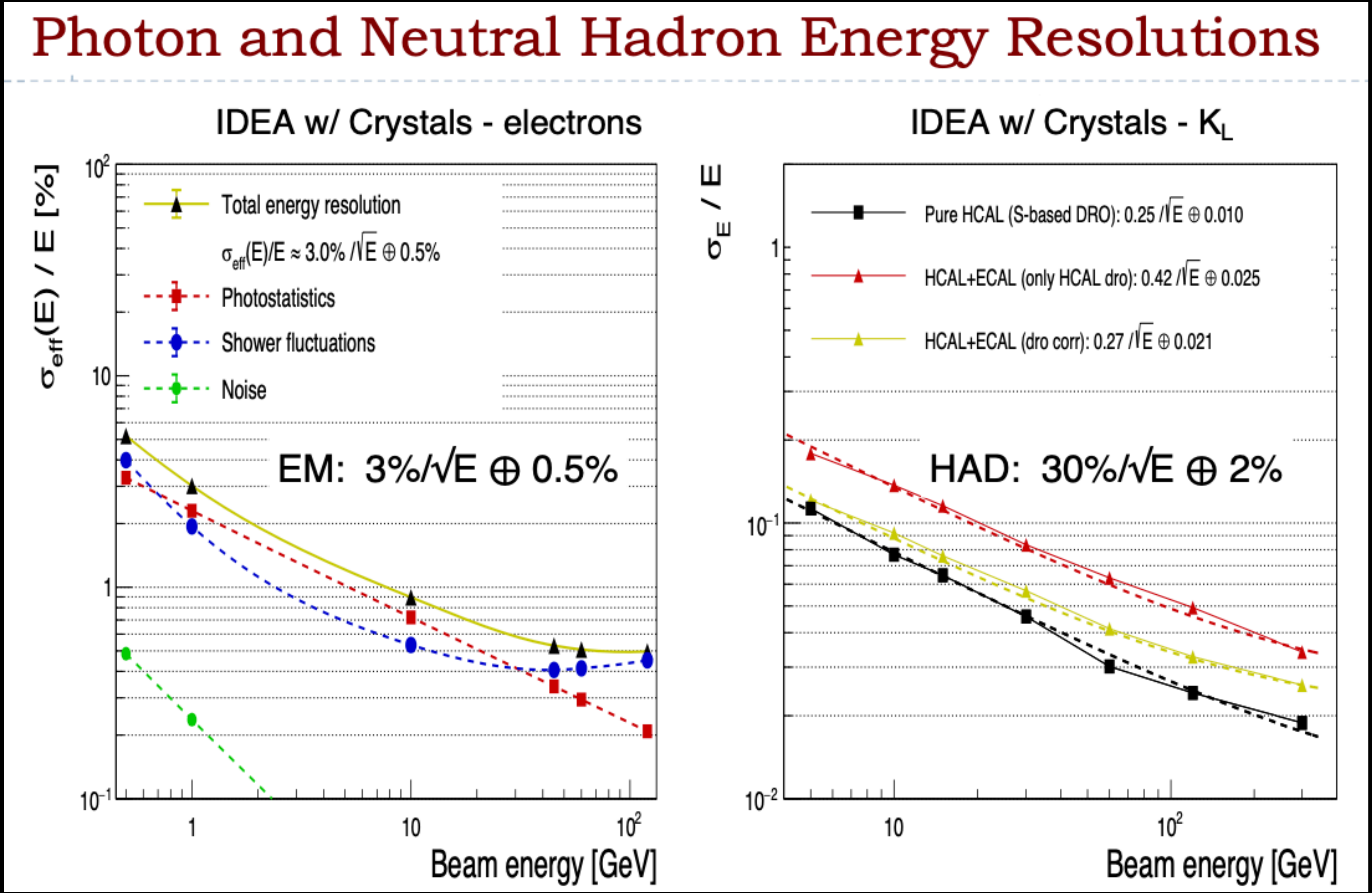
Drawing from the pioneering work of RD52, but upgrading for new developments in inexpensive, high-QE, tailored-wavelength sipmms See: https://arxiv.org/abs/2008.00338 Also see Snowmass LOI: SNOWMASS21-IF6-008.pdf

- **Timing layer** $\sigma_t \sim 20$ ps
  - LYSO:Ce crystals ($\sim 1X_0$)
  - 3x3x54 mm^3 active cell
  - 3x3 mm^2 SiPMs (15-20 um)
- **ECAL layer** $\sigma_E/E \sim 3\%/\sqrt{E}$
  - PbWO crystals
  - Front segment ($\sim 6X_0$,$\sim 0.2\lambda$,~50 mm)
  - Rear segment ($\sim 16X_0$,$\sim 0.7\ \lambda$,~140 mm)
  - 10x10 mm^2 crystal
  - 5x5 mm^2 SiPMs (10-15 um)
  - 3 SiPMs (one on entrance, two on exit)
- Thin solenoid between ECAL and HCAL
- IDEA HCAL



CMS ECAL crystals are 22x22x230 mm

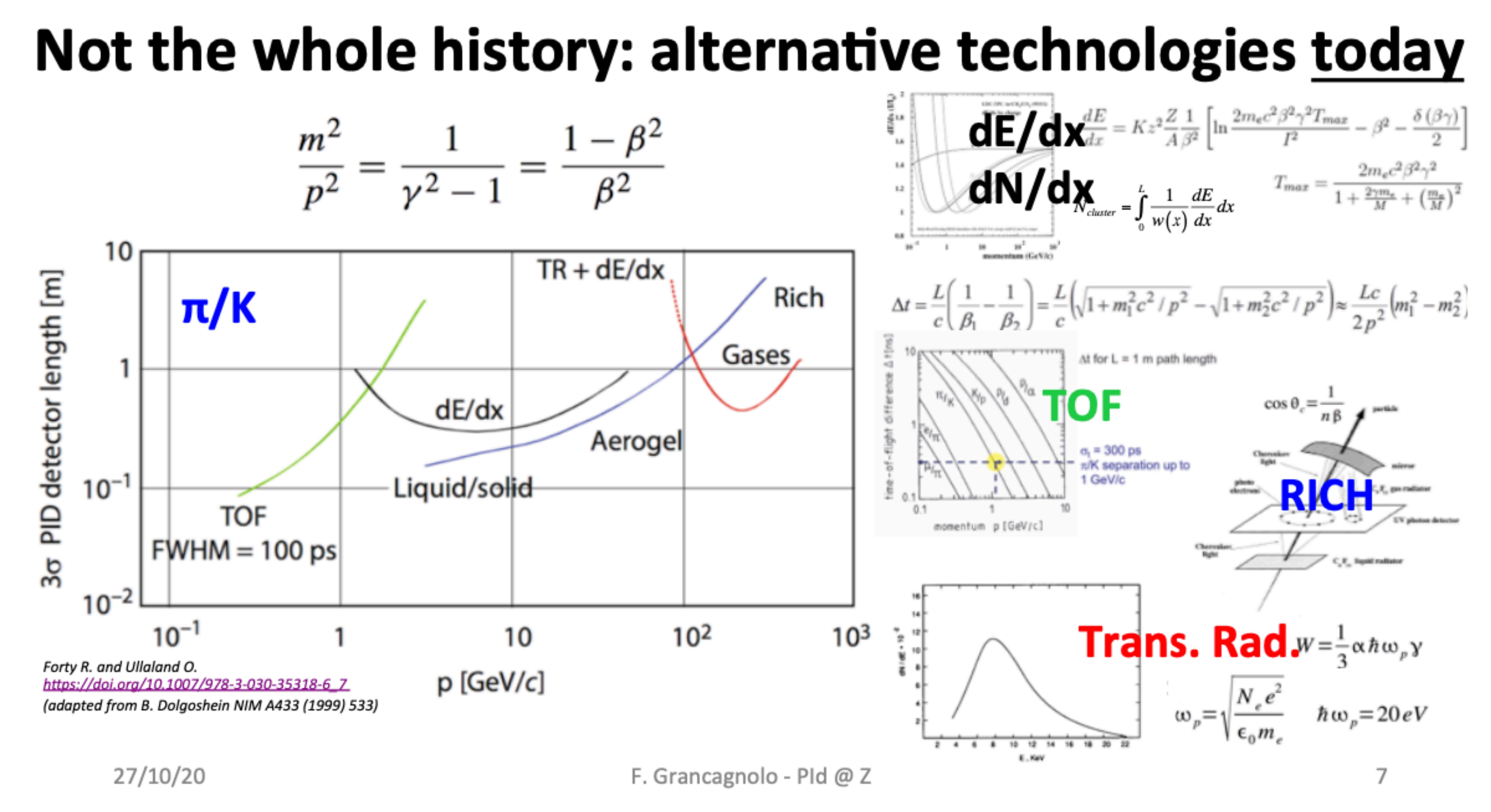
Dual Readout Crystal Calorimeter



Particle Identification at a Z factory

Franco Grancagnolo

Performance session: Nice overview on particle identification techniques



Final remarks

CEPC CDR: http://cepc.ihep.ac.cn/

73 detector-related talks in the parallel sessions

51 talks "supposedly" covered here

Apologies to everyone that was left out and/or not properly referenced

CEPC detector concepts are evolving and adapting

R&D of key detector technologies continues and are being prototyped

final detectors are to be defined by International Collaborations and they are likely to incorporate a mixture of the technologies discussed here

CEPC aims to be an International Global project

At least one future high-energy e^+e^- collider should be built

Continued world-wide collaboration effort is crucial to realize such project

Silicon Detectors — Monday, 8:30 am and 14:00

- Overview of CEPC silicon detector — Hongbo
- CMOS pixel sensors with high resolution and lower power for CEPC (MOST1)
- TaichuPix for CEPC (MOST2) — Weiwei (IHEP)
- TowerJazz 65 nm — Laura Gonella (Birmingham)
- ARCADIA — Piero Giubilato (Padova)

Silicon Detector

Conveners: Sasha Rozanov (CERN), Prof. Meng Wang (Shandong University), Massimo Caccia (I), Harald Fox (Lancaster University)

Location: Grand Ballroom A (Online Meeting Room: https://weidijia.zoom.com.cn/j/69823682265)

08:30 **Overview of CEPC silicon detectors** *20'*
Speaker: Dr. Hongbo ZHU (IHEP)
Material: Slides

08:50 **Development of CMOS pixel sensors with high resolution and low power for the CEPC vertex detector (MOST1)** *15'*
Speaker: Ms. ying zhang (IHEP)
Material: Slides

09:05 **Status of the TaichuPix chip for the high-rate CEPC Vertex Detector (MOST2)** *15'*
Speaker: Mr. Wei WEI (IHEP)
Material: Slides

09:20 **TowerJazz 65nm process for a high resolution pixel detector** *20'*
Speaker: Laura GONELLA (University of Birmingham)
Material: Slides

09:40 **ARCADIA (Advanced Readout CMOS Architectures with Depleted Integrated sensor Arrays)** *20'*
Speaker: Piero Giubilato (University & INFN in Padova (ITALY))

Silicon Detector

Conveners: Sasha Rozanov (CERN), Prof. Meng Wang (Shandong University), Massimo Caccia (I), Harald Fox (Lancaster University)

Location: Grand Ballroom A (Online Meeting Room: https://weidijia.zoom.com.cn/j/69823682265)

14:00 **Current and future development on CMOS pixel sensors** *20'*
Speakers: Dr. Christine Hu-Guo (IPHC-IN2P3/CNRS, UDS), Prof. Jerome Baudot (IPHC-CNRS)

14:20 **From ATLASPix3 to CEPCPix1** *20'*
Speakers: Hui ZHANG (Karlsruhe Institute of Technology), Ivan Peric (K)
Material: Slides

14:40 **status on the silicon tracker demonstrator** *10'*
Speaker: Prof. Attilio Andreazza (Università degli Studi di Milano and INFN)
Material: Slides

14:50 **R&D on low mass mechanics and highly integrated cooling for future inner tracking devices** *15'*
Speaker: Filippo Bosi (INFN)
Material: Slides

15:05 **Recent development in LGAD detectors** *20'*
Speaker: Hartmut Sadrozinski (University of California Santa Cruz)
Material: Slides

15:25 **Lessons learned from the ATLAS upgrade tracker design** *20'*
Speaker: Markus Elsing (CERN)
Material: Slides

15:45 **ALICE ITS3: ultra-thin, wafer-scale, flexible MAPS for truly-cylindrical, minimum-material-budget inner tracking layers** *15'*
Speaker: Magnus Mager (CERN)
Material: Slides

Gaseous Detectors

- Time Projection Chamber
- Drift Chamber
- Micro Pattern Gas Detectors (MPGC)
- RPC

Gaseous Detector

Conveners: Silvia Dalla Torre (CERN), Mr. Imad LAKTINEH (IPNL), Dr. Huirong Qi (Institute of High Energy Physics, CAS), Hongyu ZHANG (EPC, IHEP, CAS, China)

Location: Grand Ballroom A (Online Meeting Room: https://weidijia.zoom.com.cn/j/68389800454)

10:30 **Status and progress of CEPC TPC R&D** *18'*
Speaker: Dr. Huirong Qi (Institute of High Energy Physics, CAS)

10:48 **65nm ASIC FEE for TPC** *18'*
Speakers: 伟 刘 (清华大学), Dr. 智 邓 (清华大学)

11:06 **Development of the uRWELL detector for large area application** *18'*
Speaker: Dr. You Lv (USTC, CAS)
Material: Slides

11:24 **High time presion MRPC for CEE** *18'*
Speaker: Dr. Botan Wang (Tsinghua University)
Material: Slides

11:42 **RPC FEE** *18'*
Speaker: Weihao Wu (Shanghai Jiao Tong University)
Material: Slides

Gaseous Detector

Conveners: Silvia Dalla Torre (CERN), Mr. Imad LAKTINEH (IPNL), Dr. Huirong Qi (Institute of High Energy Physics, CAS)

Location: Grand Ballroom A (Online Meeting Room: https://weidijia.zoom.com.cn/j/68389800454)

16:30 **Pixel TPC Technology R&D** *20'*
Speaker: Peter Kluit (NIKEHF)
Material: Slides

16:50 **MPGD technology** *20'*
Speaker: Florian Brunbauer (C)

17:10 **Drift chamber** *20'*
Speaker: Marco Chiappini (INFN-Pisa)
Material: Slides

17:30 **sPHENIX TPC** *20'*
Speaker: Dr. Klaus Dehmelt (Stony Brook U.)
Material: Slides

17:50 **RPC new readout** *20'*
Speaker: Prof. imad laktineh (IPNL)
Material: Slides

18:10 **Status of the gaseous detector on jet studies with PID** *15'*
Speaker: Dr. Zhiyang Yuan (IHEP)
Material: Slides

Calorimeters

- Crystal calorimeters
  - High granularity crystal calorimeter
  - Crystal and dual readout
- “Traditional” high-granularity calorimeters (CALICE)
- Dual Readout calorimeters

Calorimetry

Conveners: Dr. Yong Liu (Institute of High Energy Physics), Chris Tully (Princeton University), Mr. Roman Pöschl (Laboratoire de l'accélérateur Linéaire), Prof. Sehwook Lee (Kyungpook National University)

Location: Grand Ballroom A (Online Meeting Room:https://weidijia.zoom.com.cn/j/65202545571)

08:30 **Studies on the High-Granularity Crystal ECAL** *25'*
Speaker: Dr. Yong Liu (IHEP)
Material: Slides

08:55 **Studies on combined calorimeters with crystals and dual-readout** *25'*
Speaker: Sarah Eno (University of Maryland)
Material: Slides

09:20 **Development of the CEPC Scintillator-Tungsten ECAL prototype** *20'*
Speaker: Yazhou Niu (USTC)
Material: Slides

09:40 **Development of the CEPC Scintillator-Steel HCAL prototype** *20'*
Speaker: Jiechen Jiang (IHEP)
Material: Slides

Calorimetry

Conveners: Dr. Yong Liu (Institute of High Energy Physics), Chris Tully (Princeton University), Mr. Roman Pöschl (Laboratoire de l'accélérateur Linéaire), Prof. Sehwook Lee (Kyungpook National University)

Location: Grand Ballroom A (Online Meeting Room:https://weidijia.zoom.com.cn/j/65202545571)

14:00 **Introduction: high-granularity calorimeters** *10'*
Speakers: Mr. Roman Pöschl (Laboratoire de l'accélérateur Linéaire), Dr. Frank Simon (Max-Planck-Institute for Physics)
Material: Slides

14:10 **News on technological developments within CALICE** *25'*
Speaker: Taikan Suehara (Kyushu University)

14:35 **Results of CALICE prototypes** *25'*
Speaker: Bing Liu (SJTU/IPNL)

15:00 **Simulation and machine learning for the Dual-Readout Calorimeter** *20'*
Speaker: YunJae Lee (U)

15:20 **Status and plans for Dual-Readout Calorimetry R&D** *25'*
Speaker: Romualdo Santoro (Insubria University and INFN - MI)

15:45 **Performance and analysis results of Dual-Readout simulated data** *15'*
Speaker: Iacopo Vivarelli (U. Sussex)
Material: Slides

Performance

- CEPC detectors performance
- CLIC and FCCee detector performance
- Particle identification

Performance

Conveners: Petra Merkel (FNAL), Franco Bedeschi (INFN-Pisa), Jianming Qian (University of Michigan), Mr. Manqi Ruan (IHEP)

Location: Grand Ballroom A (Online Meeting Room: https://weidijia.zoom.com.cn/j/69005336090)

10:30 **Physics Requirement of the CEPC detector** *30'*
Speaker: Mr. Manqi Ruan (IHEP)
Material: Slides

11:00 **Physics Performance of the CEPC CDR baseline detector** *30'*
Speaker: Dr. Dan Yu (IHEP)
Material: Slides

11:30 **Physics Performance of the New Concept with Crystal ECAL and Dual Readout HCAL** *30'*
Speaker: Chris Tully (Princeton University)
Material: Slides

Performance

Conveners: Petra Merkel (FNAL), Franco Bedeschi (INFN-Pisa), Jianming Qian (University of Michigan), Mr. Manqi Ruan (IHEP)

Location: Grand Ballroom A (Online Meeting Room: https://weidijia.zoom.com.cn/j/69005336090)

16:30 **Performance study of the IDEA detector** *24'*
Speaker: Nicola De Filippis (Politecnico and INFN Bari)
Material: Slides

16:55 **Performance of the CLIC detector and the CLD detector of FCC-ee for high-energy running** *20'*
Speaker: Philipp Roloff (CERN)

17:15 **Performance Study of the New Concept with Bar Crystal ECAL** *24'*
Speaker: Prof. Yong Liu (IHEP)

17:40 **Particle identification at the Z factory** *20'*
Speaker: Prof. Franco Grancagonolo (INFN)

18:00 **(Tracking) Detector design & optimization software : tkLayout tool** *20'*
Speaker: Gabrielle HUGO (M)

MDI, Magnet and Integration

- Background estimations from CEPC, FCC-ee and Belle II
- MDI region design
- Luminosity measurement

MDI, Magnet and Integration

Conveners: Dr. Manuela Boscolo (INFN), Dr. Sha BAI (IHEP), Suen Hou (IPAS), Hiroyuki Nakayama (KEK)

Location: Grand Ballroom B (Online Meeting Room:https://zoom.com.cn/j/96000048278 Password:123456)

16:30 **FCC-ee MDI layout & SR masks in the FCC-ee MDI area** *30'*
Speaker: Marian Luckhof (Hamburg University)

17:00 **FCCee Interaction Region Backgrounds** *30'*
Speaker: Georgios Voutsinas (C)
Material: Slides

17:30 **Belle II beam background simulation** *20'*
Speaker: Andrii Natochii (University of Hawaii)
Material: Slides

17:50 **Beam background in CEPC MDI** *20'*
Speaker: Haoyu SHI (IHEP)
Material: Slides

18:10 **Impact of electromagnetic deflection of initial state in luminosity measurement at the CEPC Z pole** *20'*
Speakers: Prof. Ivanka Bozovic (Vinca Institute of Nuclear Sciences), Ivan Smiljanić, Goran Kacarevic
Material: Slides

MDI, Magnet and Integration

Conveners: Dr. Manuela Boscolo (INFN), Dr. Sha BAI (IHEP), Suen Hou (IPAS), Hiroyuki Nakayama (KEK)

Location: Grand Ballroom B (Online Meeting Room: https://weidijia.zoom.com.cn/j/64951721990)

10:30 **Latest beam background measurements at Belle II and future prospects** *30'*
Speaker: Hiroyuki Nakayama (KEK)
Material: Slides

11:00 **Superconducting magnets design in CEPC IR** *20'*
Speaker: Yingshun Zhu (IHEP)

11:20 **Progress of Beampipe mechanical design** *20'*
Speaker: Ruiqiang ZHANG/Quan JI (IHEP)

11:40 **The geometry and acceptance for CEPC LumiCalA** *20'*
Speaker: Suen Hou (IPAS)
Material: Slides

Extra Slides