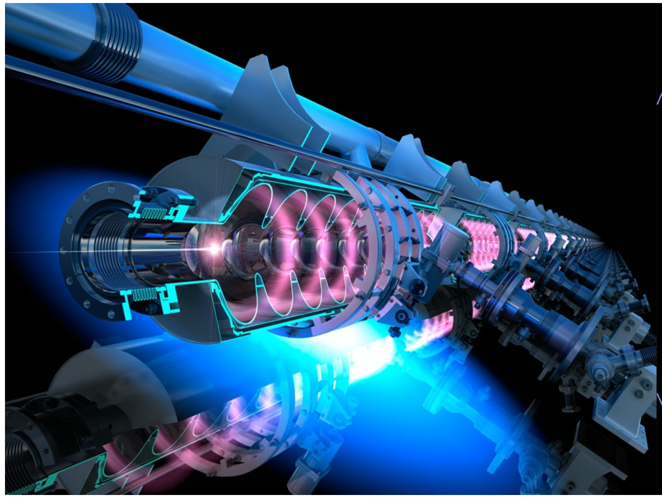
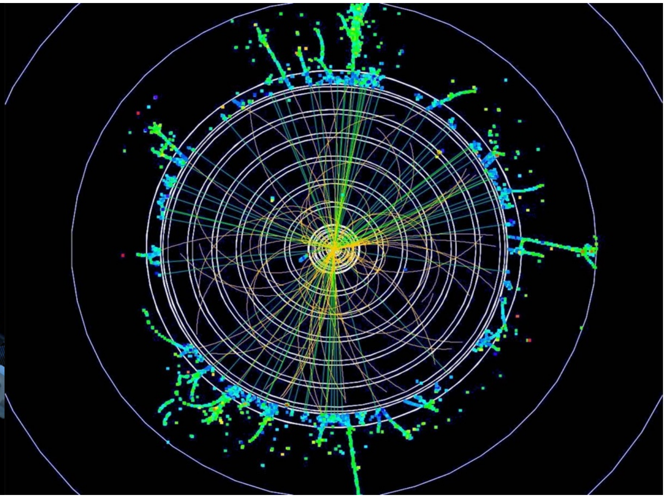
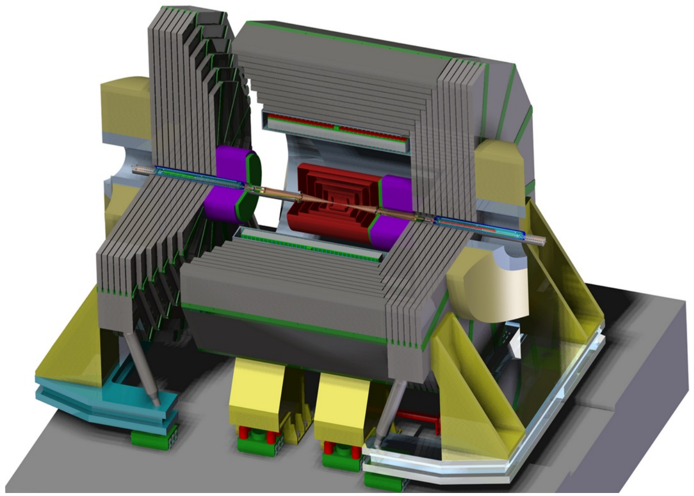
SiD

Stauts and Planning

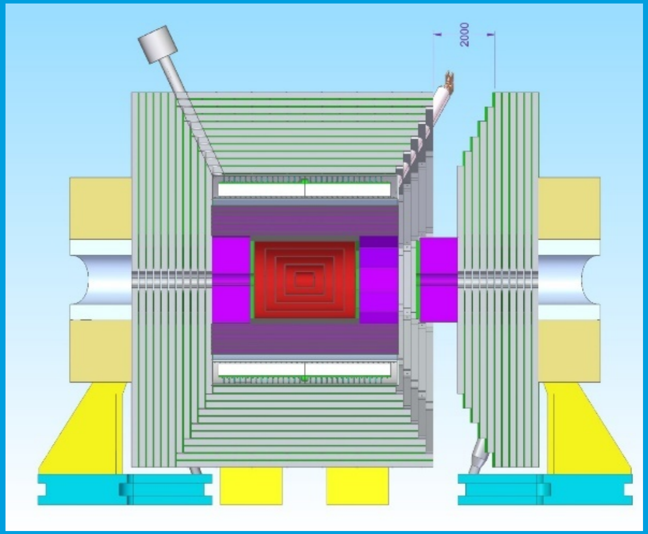




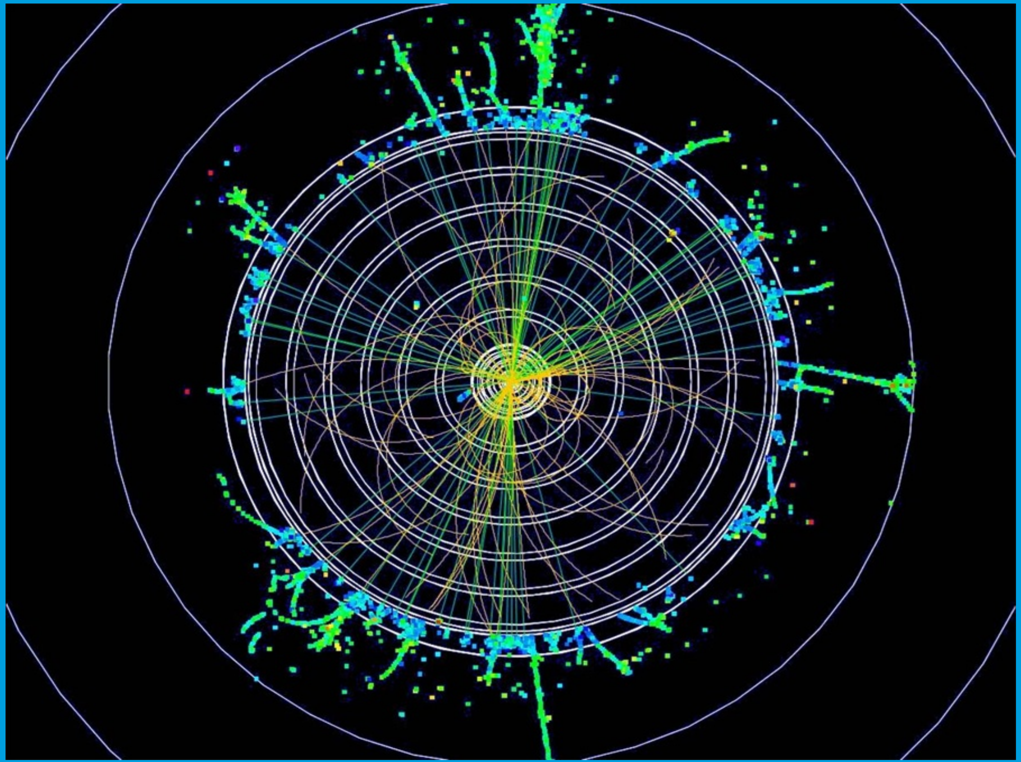
Marcel Stanitzki

Detector Concept Status and Planning Workshop

31/05/2024

SiD
Concept Introduction

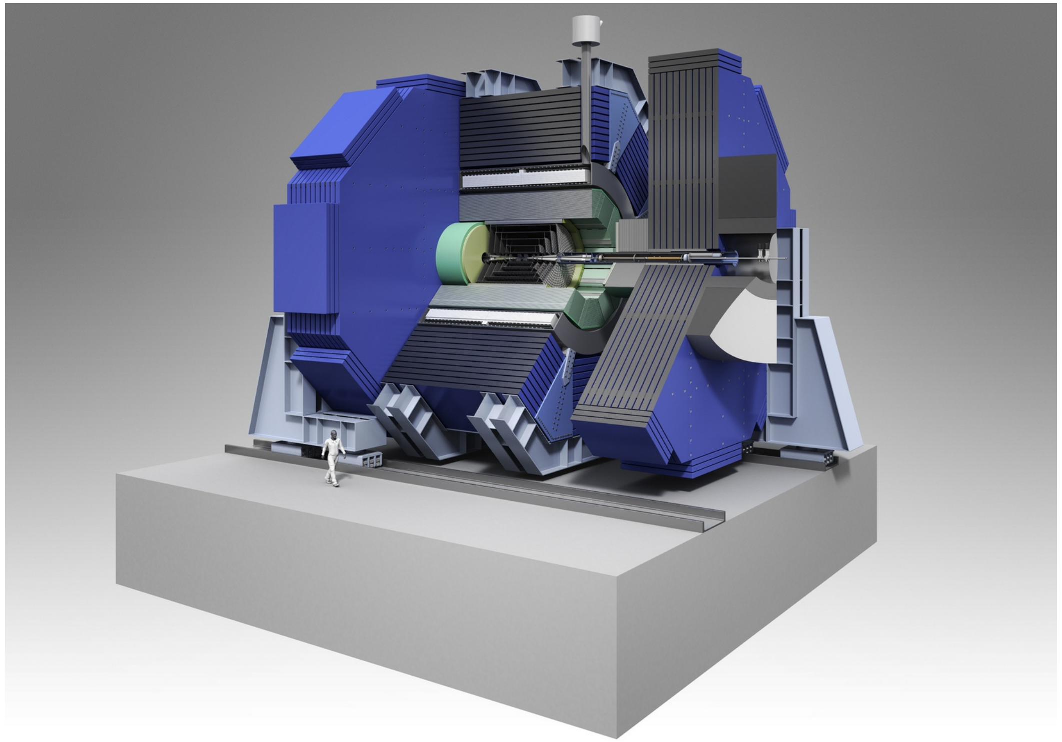




SiD – Rationale

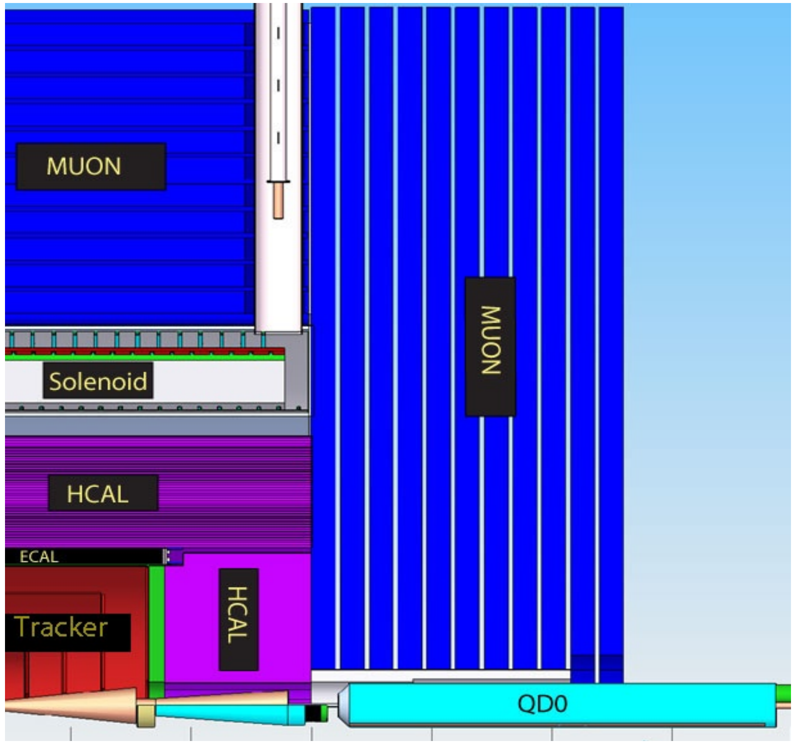
How it all started

- SID Rationale
  - A compact, cost-constrained detector designed to make precision measurements and be sensitive to a wide range of new phenomena
- Design choices
  - Compact design with 5 T field
  - Robust silicon vertexing and tracking system with excellent momentum resolution
  - Highly granular Calorimetry optimized for Particle Flow
  - Time-stamping with single bunch crossing resolution
  - Iron flux return/muon identifier is part of the SiD self-shielding
  - Detector is designed for rapid push-pull operation



SiD – Compact Silicon Detector

The "Post-DBD" Configuration

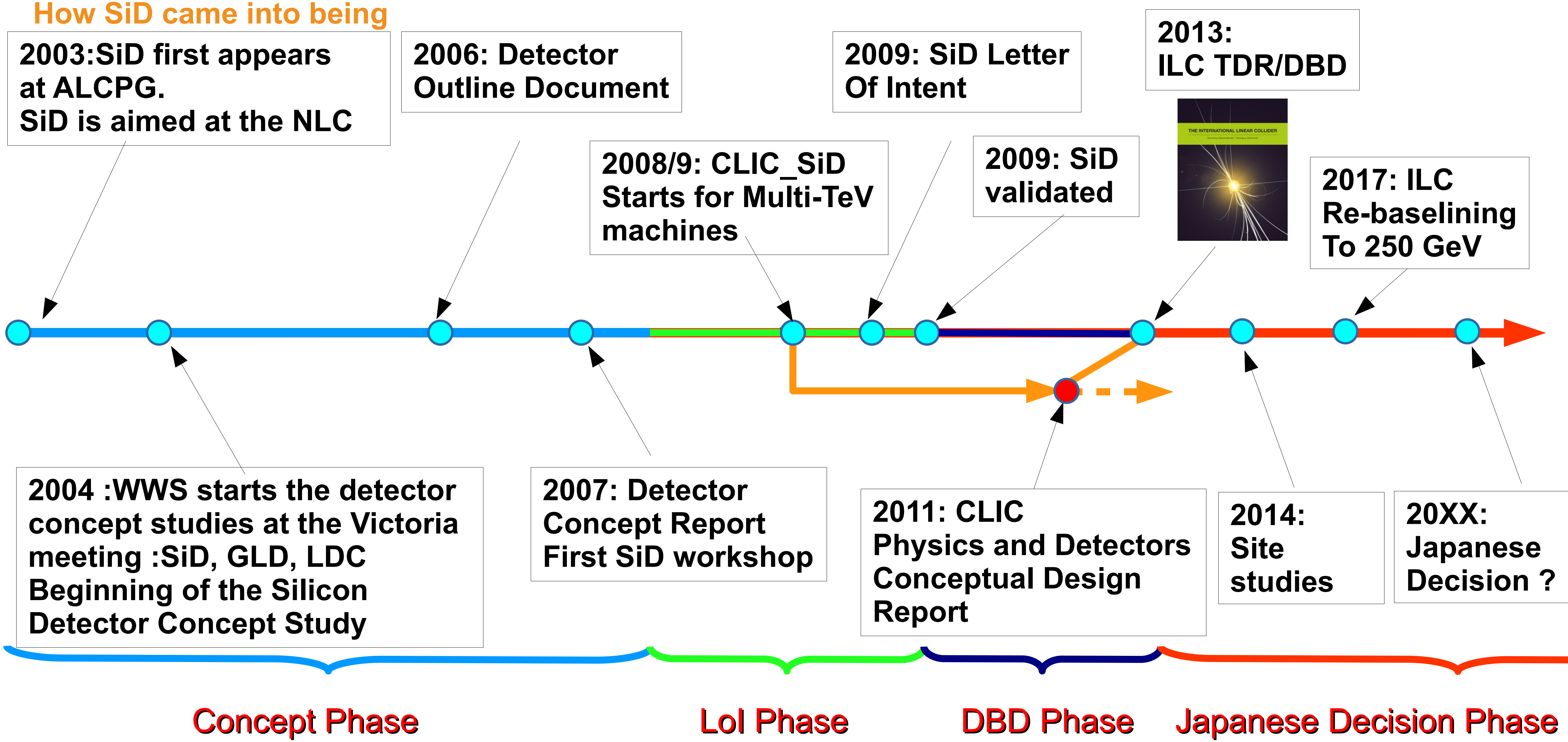


SiD BARREL	Technology	Inner radius	Outer radius	z max
Vertex detector	Silicon pixels	1.4	6.0	± 6.25
Tracker	Silicon strips	21.7	122.1	± 152.2
ECAL	Silicon pixels-W	126.5	140.9	± 176.5
HCAL	Scintillator-Steel	141.7	249.3	± 301.8
Solenoid	5 Tesla	259.1	339.2	± 298.3
Flux return	Scintillator/steel	340.2	604.2	± 303.3

SiD ENDCAP	Technology	Inner z	Outer z	Outer radius
Vertex detector	Silicon pixels	7.3	83.4	16.6
Tracker	Silicon strips	77.0	164.3	125.5
ECAL	Silicon pixel-W	165.7	180.0	125.0
HCAL	Scintillator-Steel	180.5	302.8	140.2
Flux return	Scintillator/steel	303.3	567.3	604.2
LumiCal	Silicon-W	155.7	170.0	20.0
BeamCal	Semiconductor-W	277.5	300.7	13.5

SiD – A bit of history

How SiD came into being

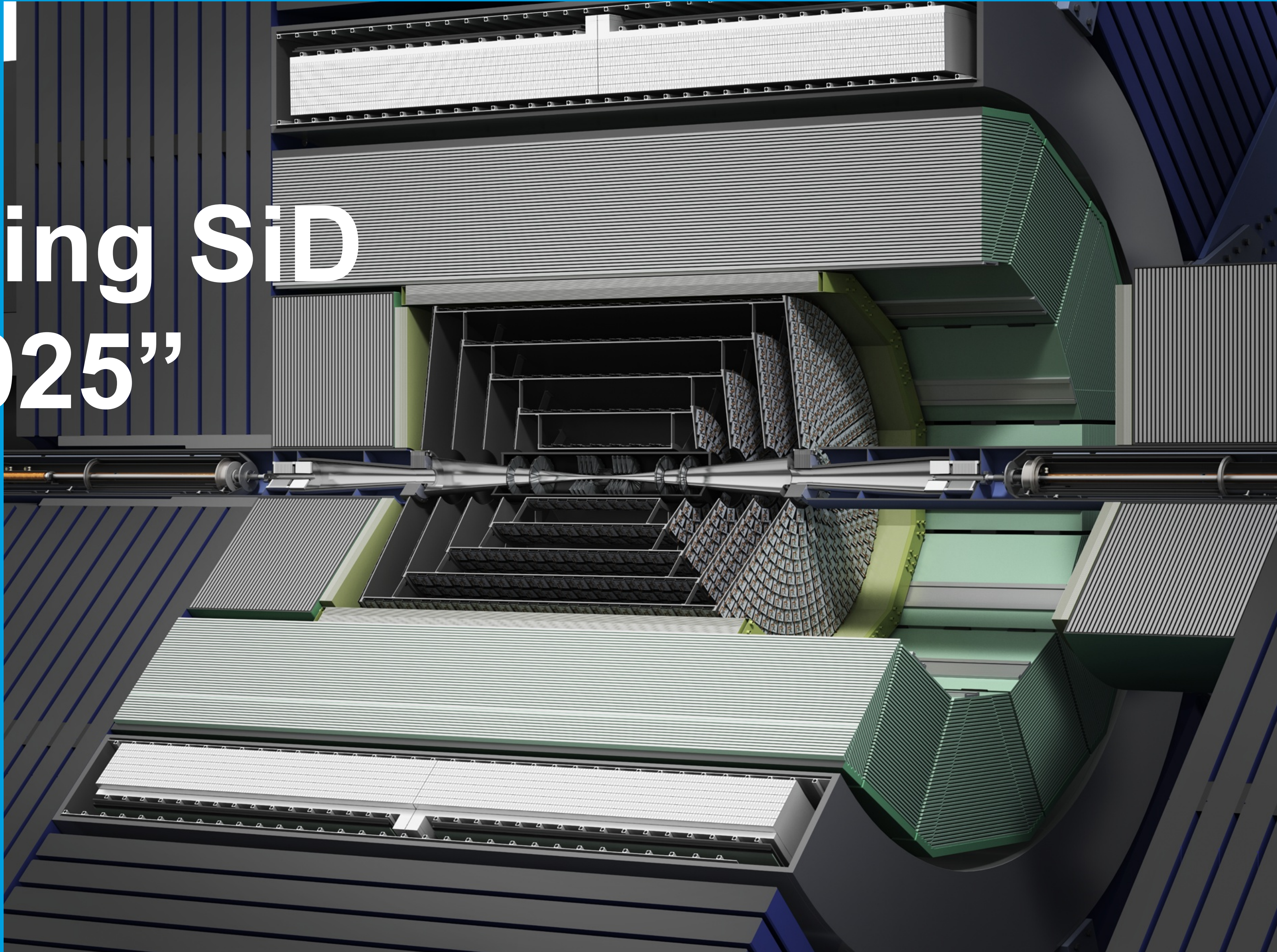


SiD – A Highlight slide

R&D and Analysis

- 1) the concept introduction
- 2) the status including the ongoing activities, and where the major R&D activities are being pursued (ILC-Japan, DRD, RDC, etc)
- 3) what is the plan to “modernize" the concept by utilizing new technologies (timing, MAPS, etc)
- 4) the optimization/upgrade scheme needed for the full energy range of (91 GeV - 1 TeV)
- 5) how to (re)engage the community, particularly the early-career

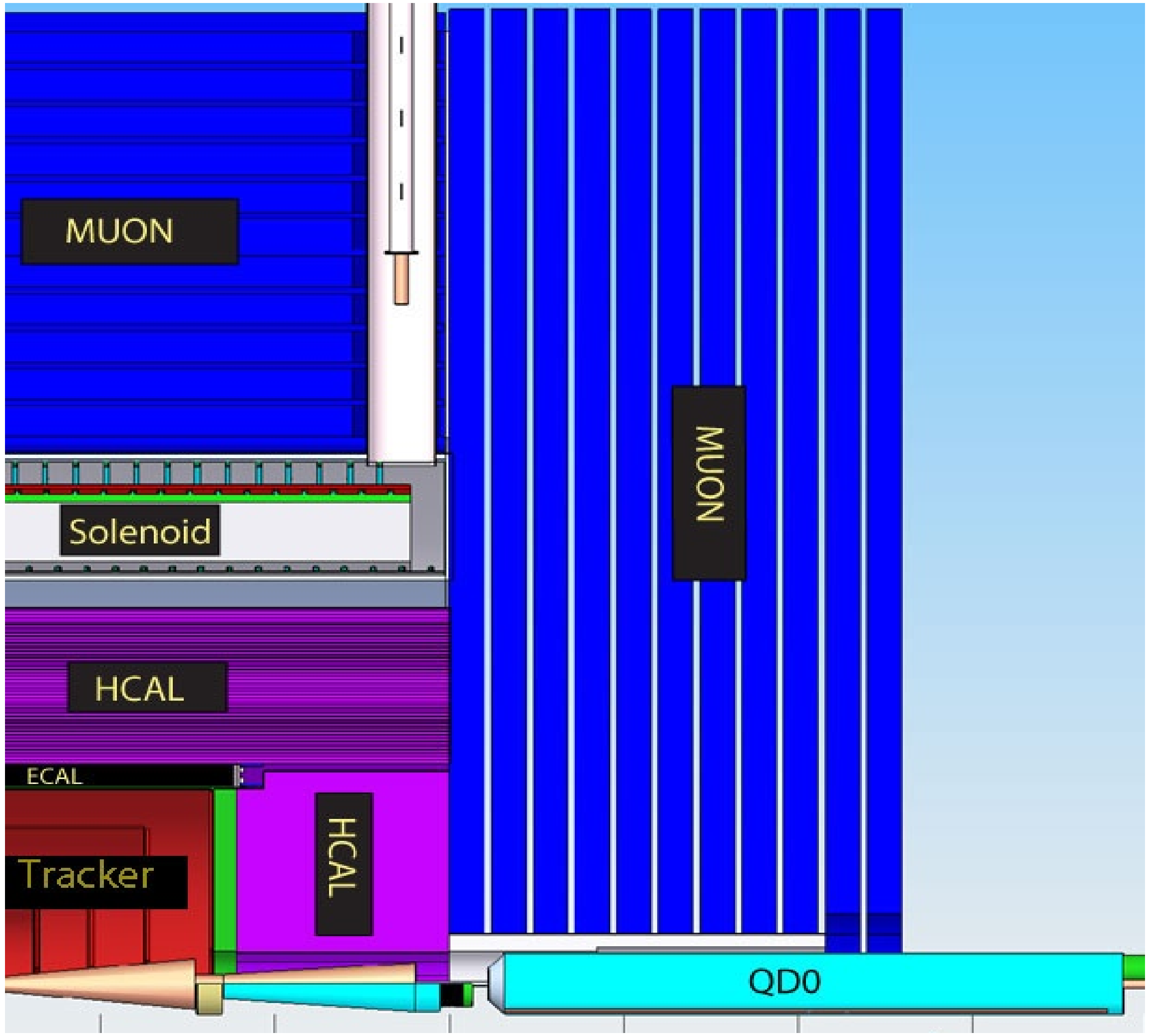
Updateing SiD
"SiD 2025"



SiD – Baseline choices

Baseline Technologies

- The DBD was finalized 2012/13
  - Clearly technology has made huge progress since then
  - HL-LHC as technology driver
- But overall assessment
  - Basic concept of a compact all-silicon detector is sound
- Decisions already taken
  - Move from DHCAL (RPC-based) to SiPM-AHCAL
- A lot of obvious points to take advantage of new technology
- State of conceptual design studies
  - To take it further many studies will now require effort & engineering

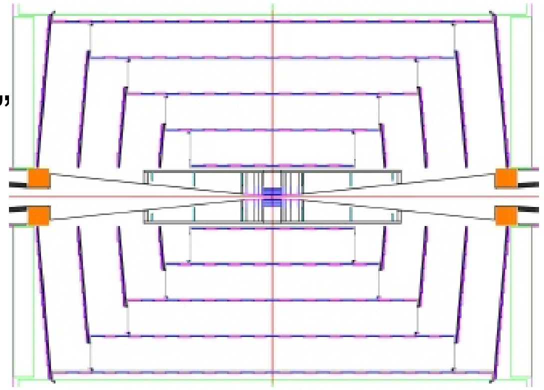


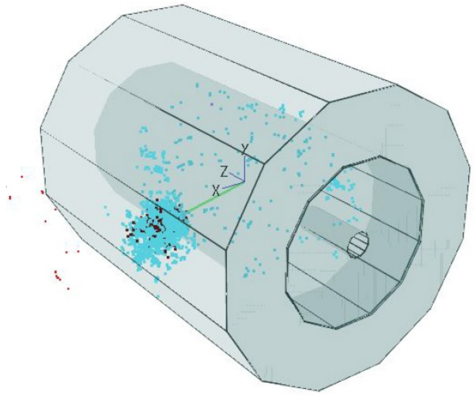
SiD – Overall Detector design choices

Which we should re-visit

Tracker Radius & aspect ratio

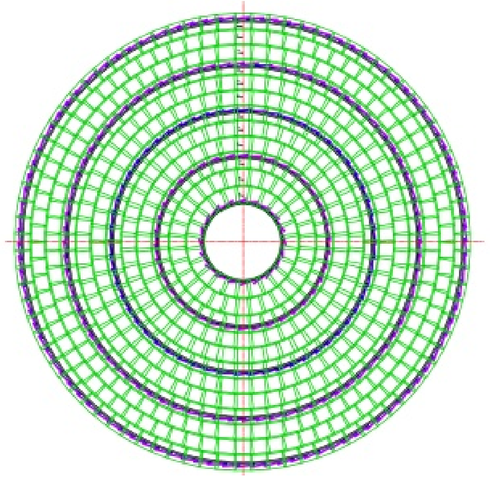
- Extensive work pre-DBD – SiD is in a “sweet valley”
- Idea to make tracker a bit longer, but vetoed by mechanics support team at the time.

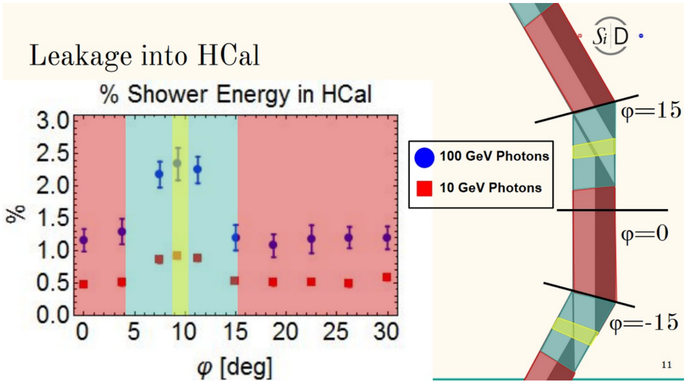




Overall Calorimeter Configuration

- ECAL 20+10 layers
- HCAL 40 layers
- Is this still the optimal configuration?



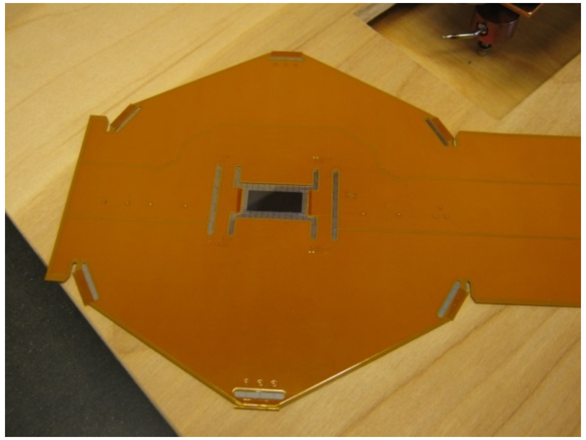


Opportunities for newcomers

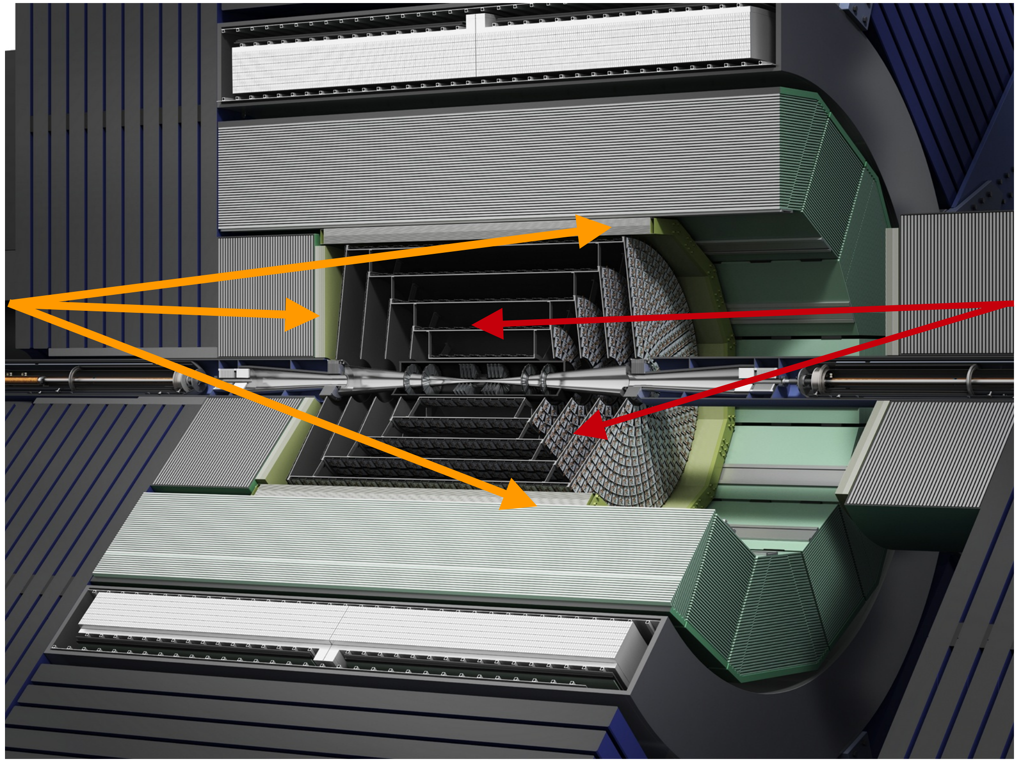
- A lot of important studies that could be done
- Ideal to bring in new ideas

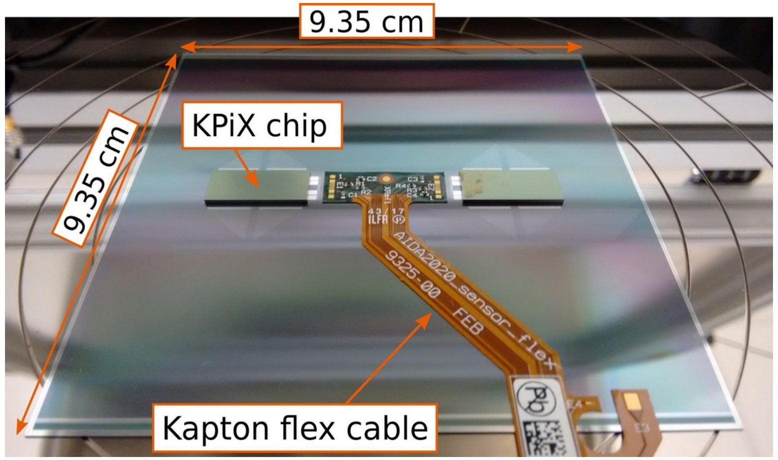
The SiD MAPS program

Using MAPS for Tracker & ECAL



ECAL:
1200 m^2 sensor area





Tracker:
67 m^2 sensor area

The SiD MAPS program

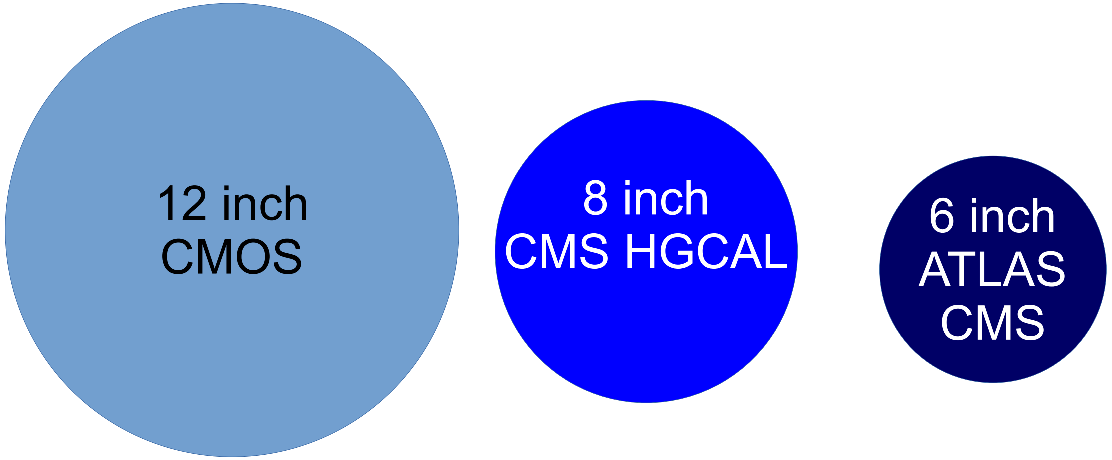
Necessary Studies

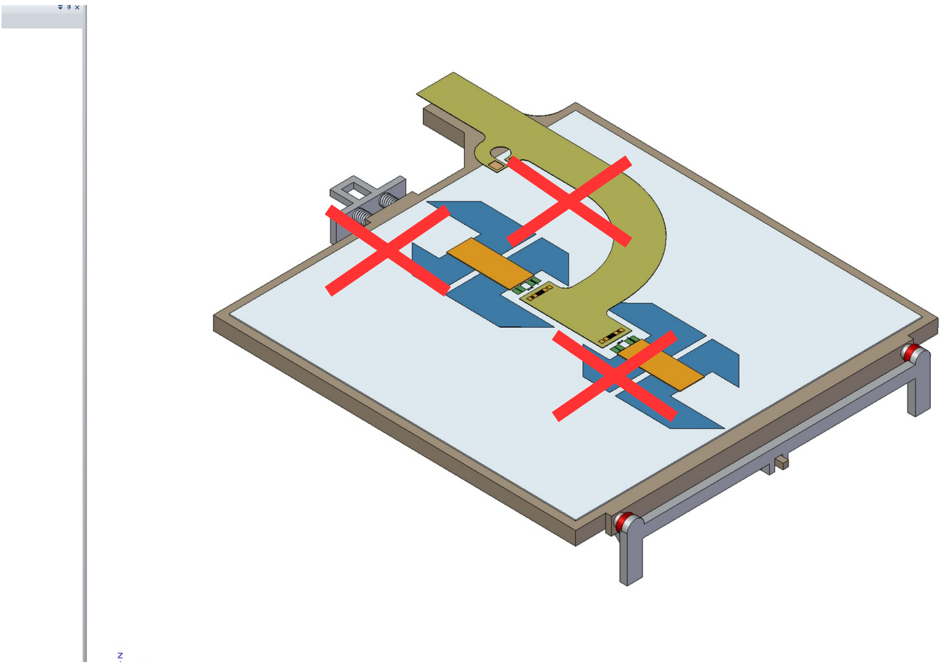
Status

- Currently MAPS is a candidate technology for the Vertex detector – it's the front-runner

The way forward for SiD

- Develop large-scale MAPS for the Tracker and ECAL
- Eliminate bump-bonding and need for readout ASICs
  - Reduces material
  - Simplifies construction
- Reduced cost and increased availability of wafers
  - 6 inch   ~ 40000 wafers /year
  - 12 inch ~ 12 million a year
- Explore new processes now
  - Time scale of HEP project vs. lifetime of CMOS processes





The SiD MAPS program

Ideas, Concepts

R&D Goals

- Follow closely to CERN-lead 65 nm MAPS program
- Start designing prototypes targeted for SiD
- R&D on Stitching is essential → ALICE is spearheading this
- Inform Vertex Detector R&D

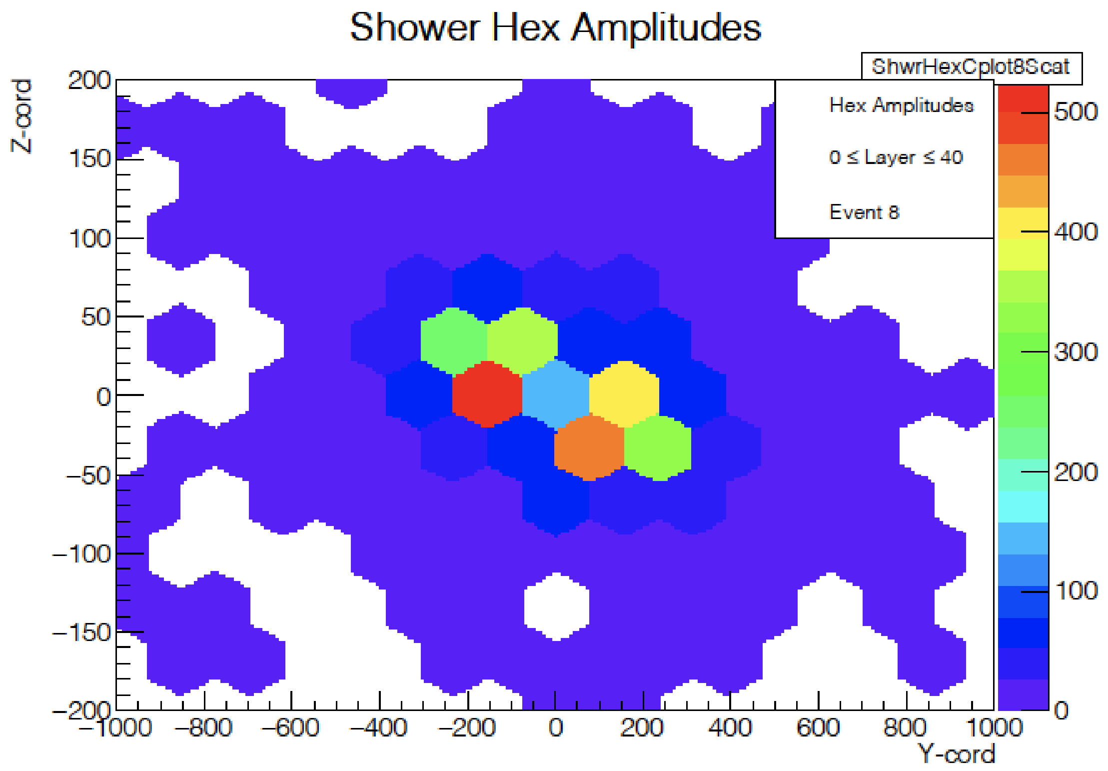
Possible studies

- What is the ideal pixel size for the Tracker/ECAL
  - 25 x 100 μm or 50 x 50 ?
- Pixel readout Analog(ADC) or Digital(binary) ?
  - Revisiting DBD studies for digital ECAL
- Buffer sizes, occupancies → how do they change ?

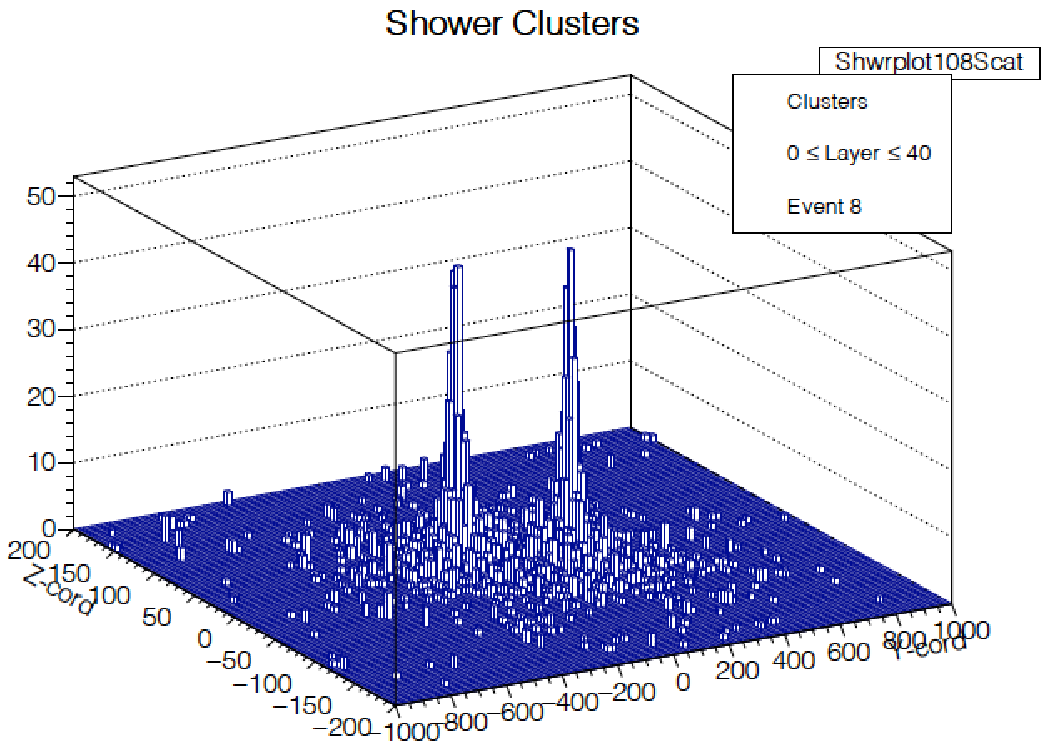
The SiD MAPS A digital ECAL

New studies being performed

40 GeV $\pi^0 \rightarrow \gamma\gamma$



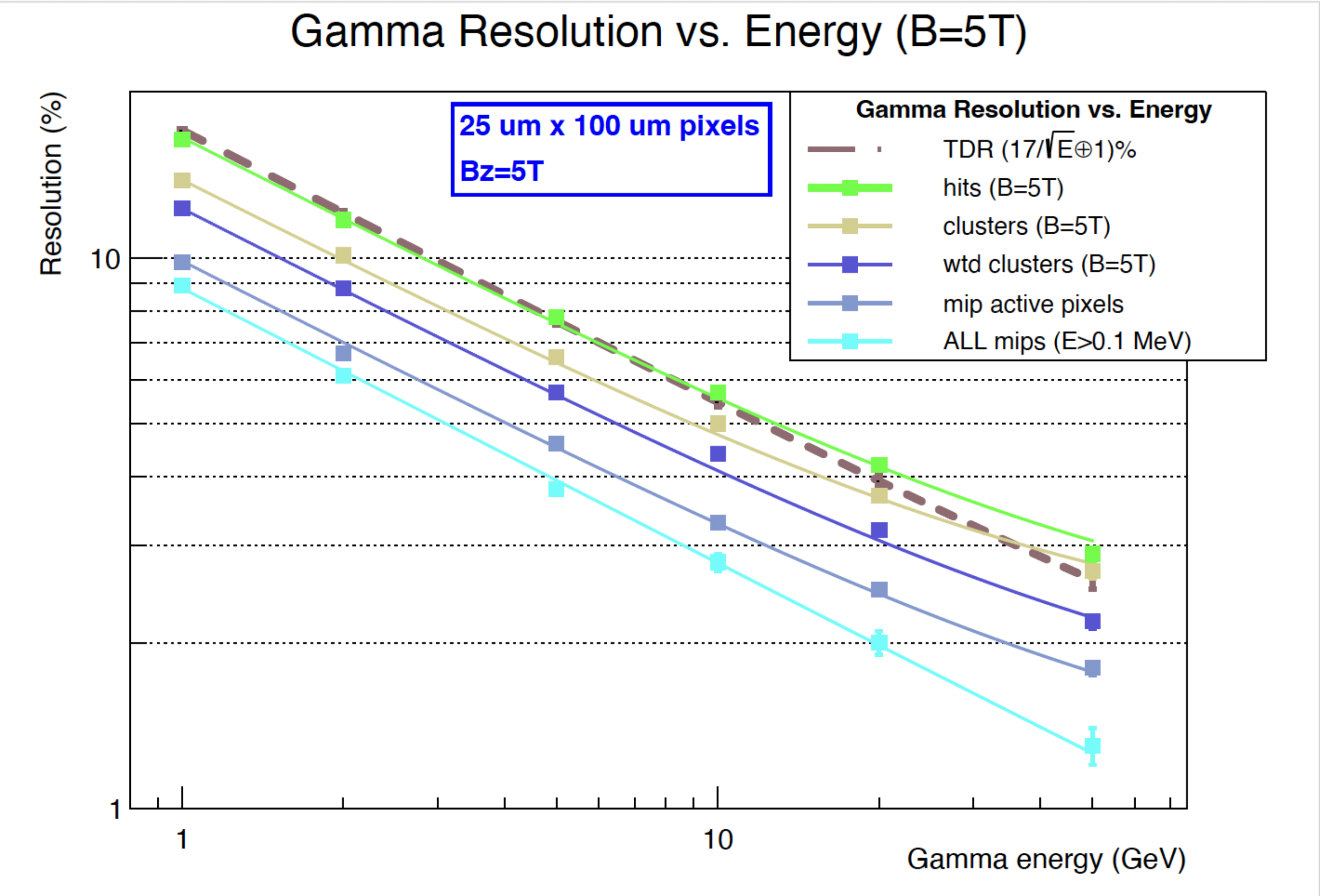
SiD TDR hexagonal sensors
13 mm^2 pixels



New SiD fine pixel sensors
25 µm x 100 µm pixels

The SiD MAPS A digital ECAL

Simulated performance



HCAL & Muons

Studies and Opportunities

The HCAL

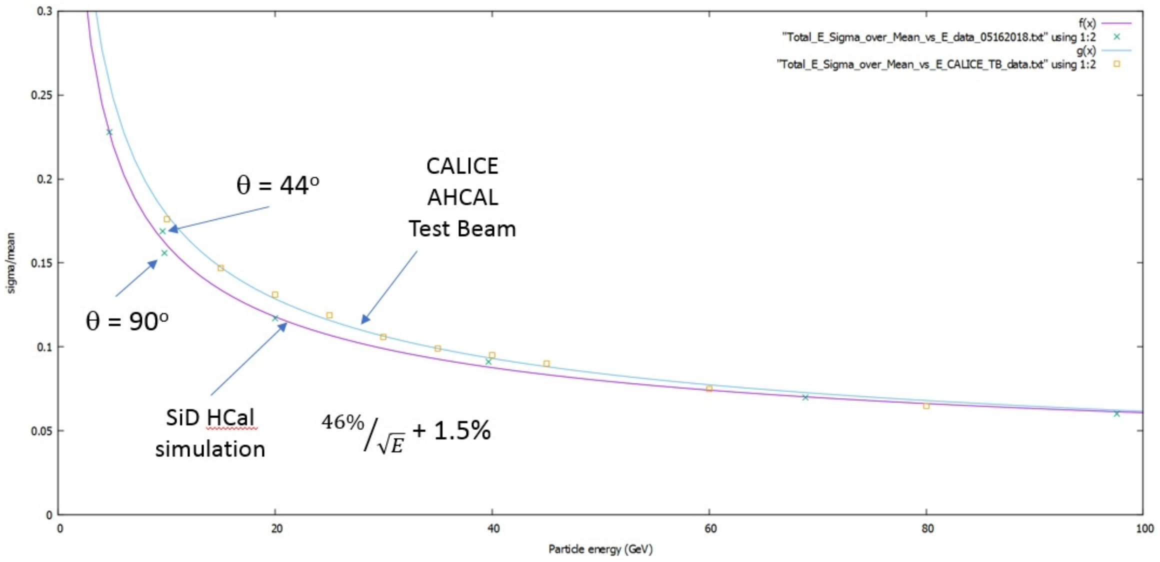
- Baseline is a AHCAL – following the CALICE design

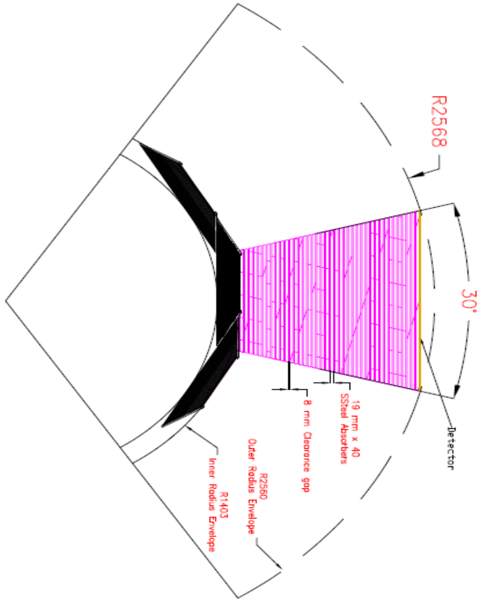
The Muon System

- SiD Baseline – long scintillator strips with WLS fiber and SiPM readout
- Consistent extension of the baseline HCAL scintillator technology
- Need to optimize number of layers, strip dimensions

Possible studies

- HCAL
  - Inclusion of timing layers
  - Revisit impact of projective cracks and barrel-endcap transition
- Muons
  - Need to optimize number of layers, strip dimensions





Timing Detectors

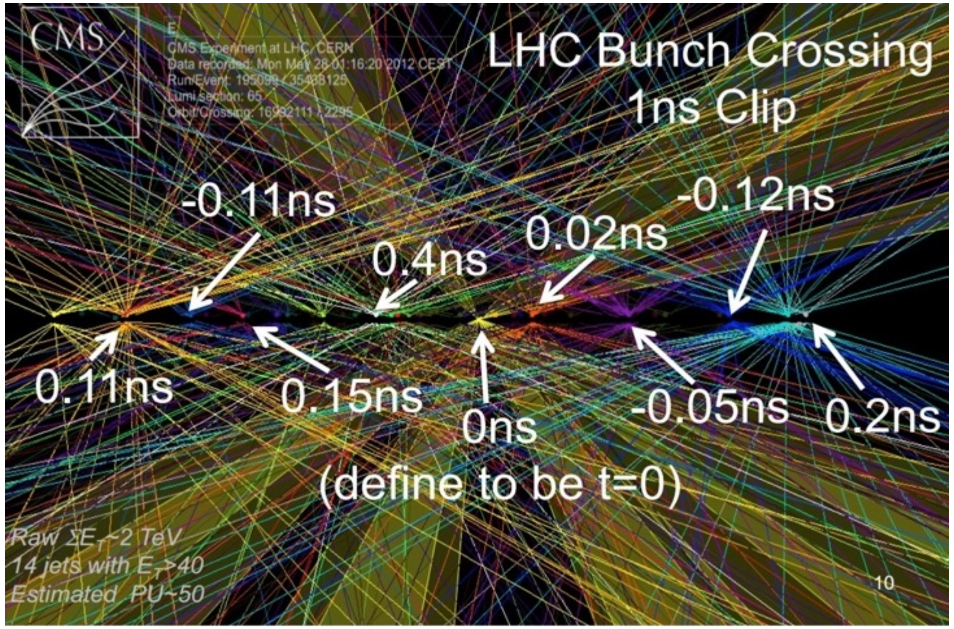
The next “hot thing?

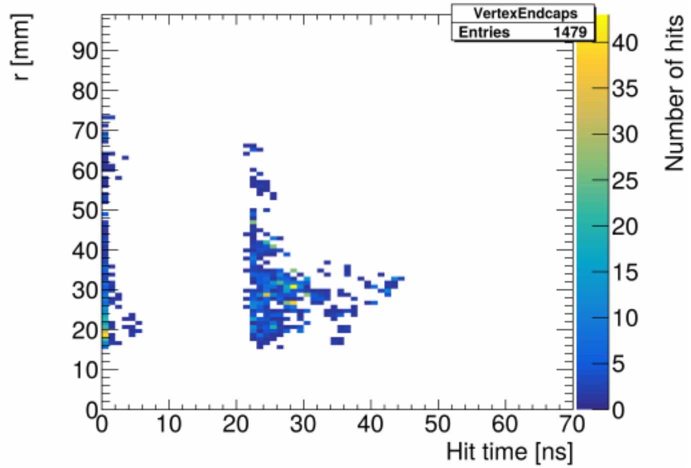
Integrated time-stamping in the trackers

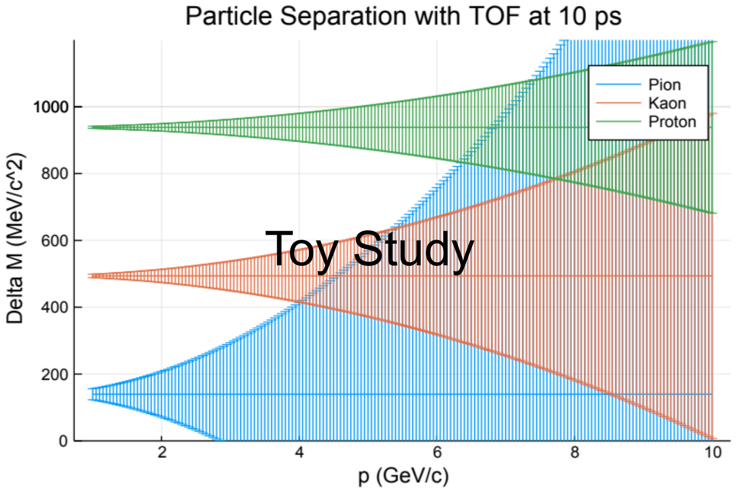
- e.g. Background rejection in the Vertex Detector
- Requires ns-level resolution
- This is doable – already today

Dedicated Timing Layers

- Full 4D Tracking – in the ILC environment
  - Nothing like the LHC
- Time-of-Flight systems for PiD
  - 10 ps resolution as a goal to be competitive
- What kind of physics does this enable?
  - For a detector designed for 250-1000 GeV







Software and computing

Getting ever more relevant

Times have been changing

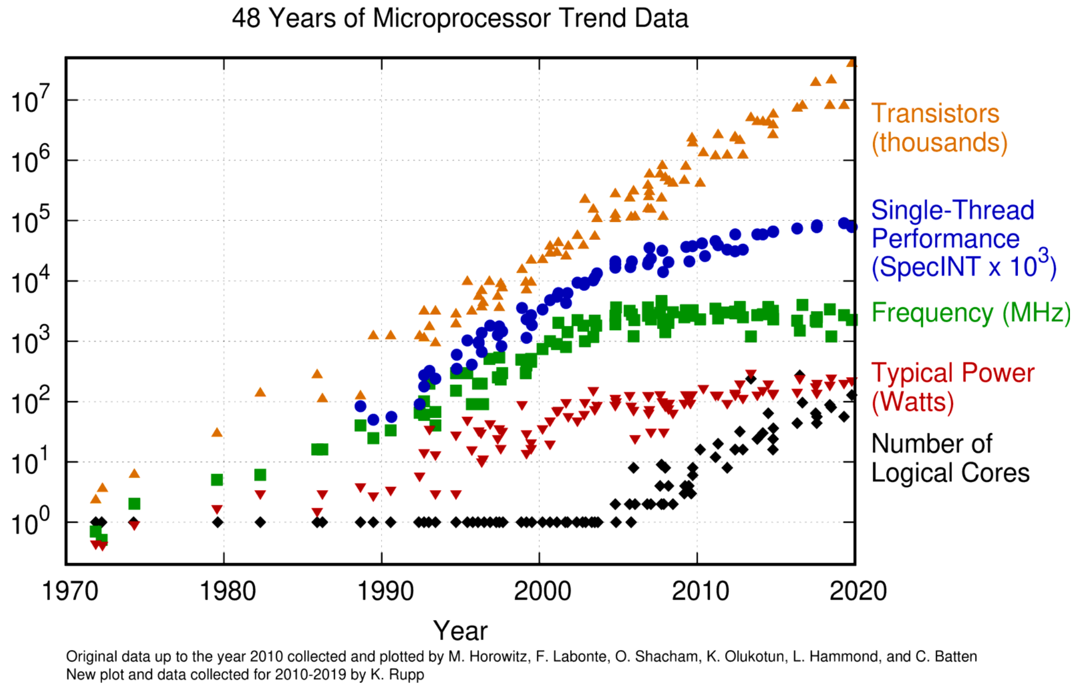
- Single-thread performance is leveling out
- The future is Multi-threaded/Multi-core

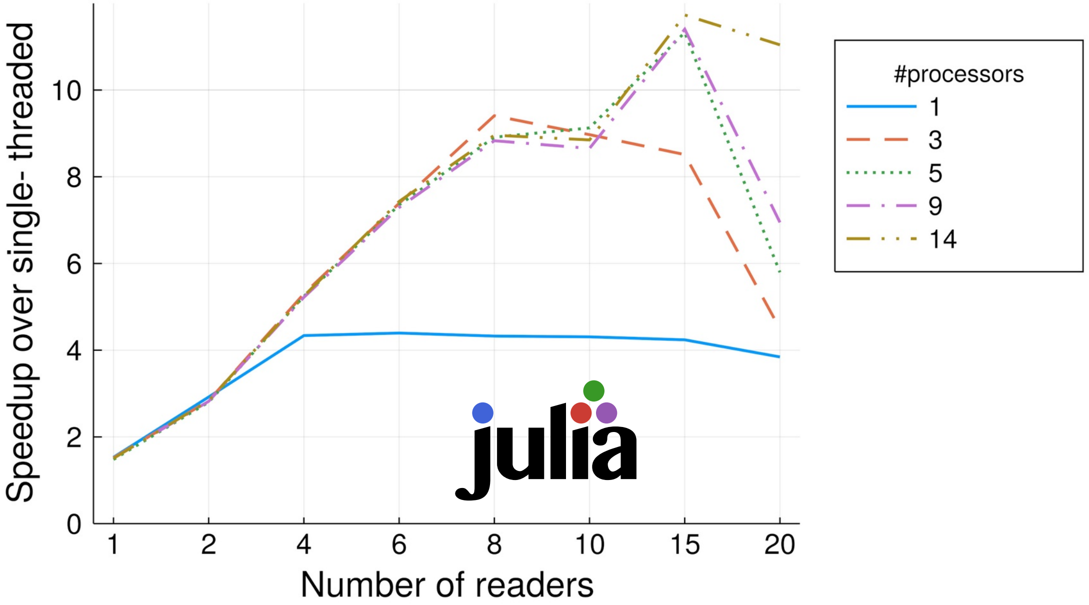
Next-generation Software

- Build on all the good experiences we have with the current software
  - Common EDM, Geometry description
- Will we still be using C++ in 2030 ?
  - Explore other languages like Julia

Attract newcomers

- Exploring Julia and Jupyter notebooks as a way to lower the threshold to contribute





Other items

As we have only 15 minutes

Vertex Detector

- Technologically, it remains the most challenging sub-detector
- The obvious advantage is, it's the last detector going in

DAQ

- With the "MAPSsification" the role of front-ends will change
- ASICS will most likely move to purely digital

Coil

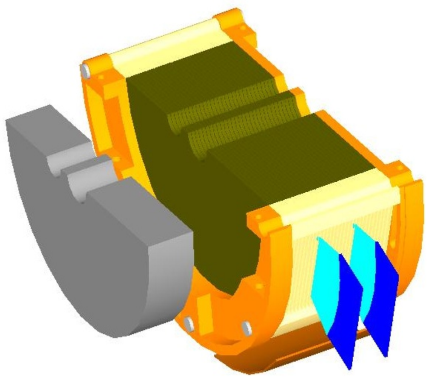
- Looking into alternative conductors like CICC
- Implications for field, Cost … needs to be studied

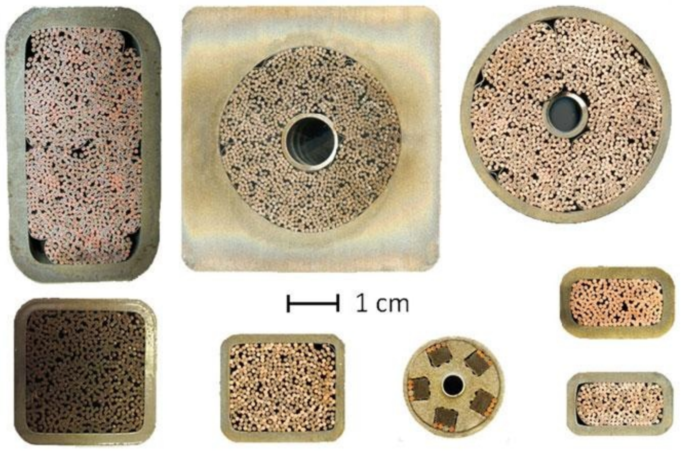
Forward systems

- Lots of opportunities and studies

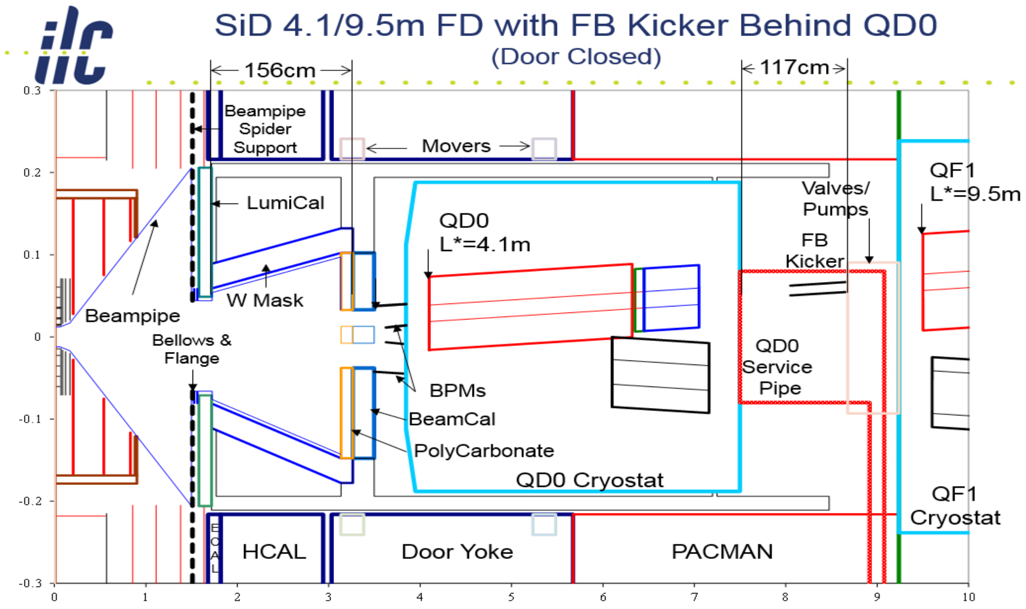
MDI & CFS

- Follow developments in WP2





Cable-in-Conduit Conductors



Push Pull vs. Two Interaction Regions

Reviving an old discussion

The Push-Pull Requirement

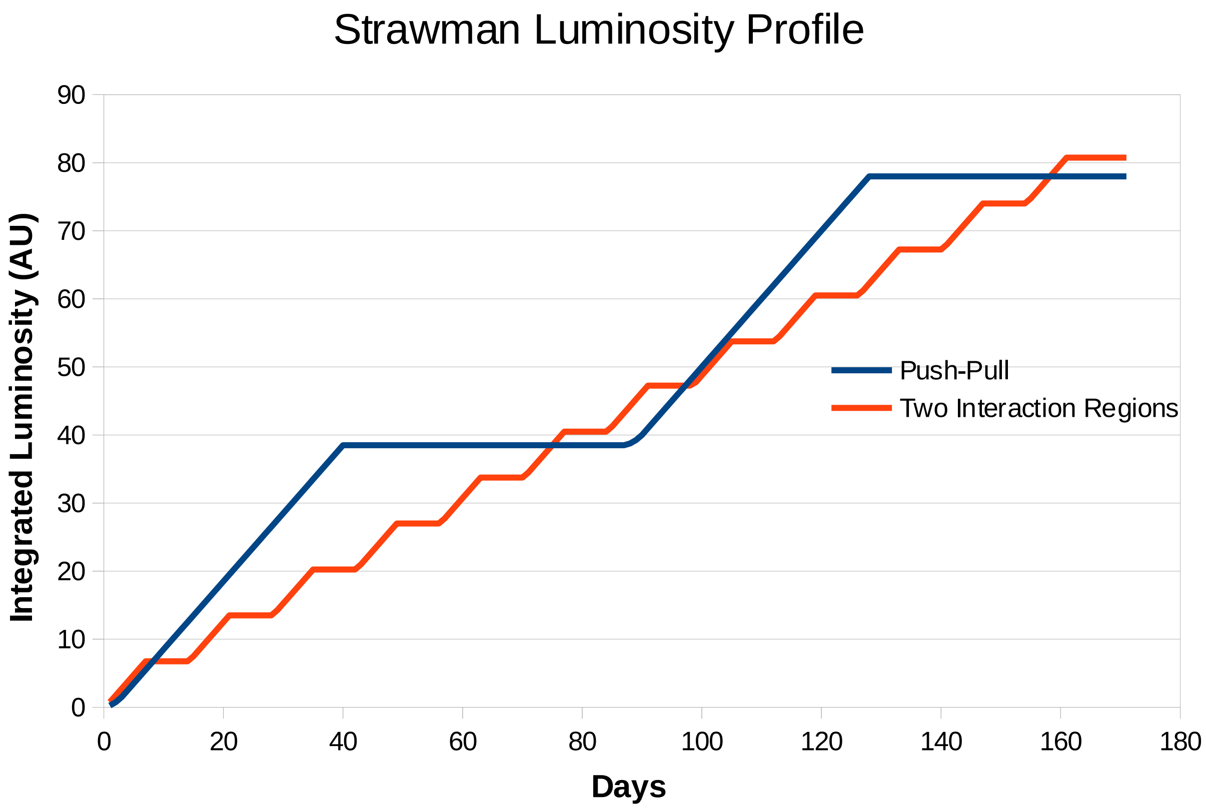
- During RDR (2007) Two Interaction Regions are too expsensive
- Given criticism by our circular colleagues, rethink this ?

Two interaction regions Benefits

- Fixing the L* quarrels
- Simplify detectors – no moving around, no delicate alignment systems
- Less risk and cost saving on detectors (how much?)

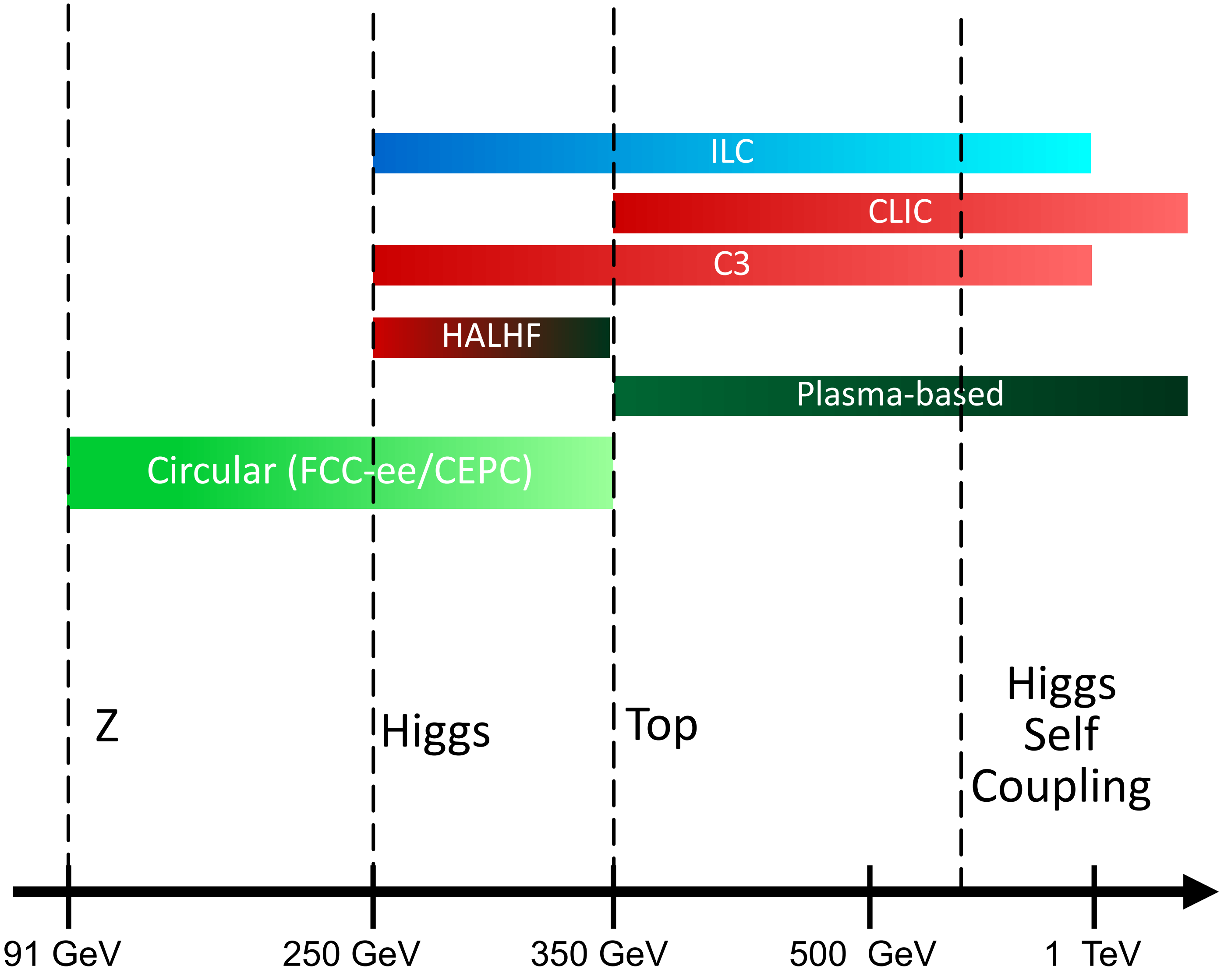
Whats the impact on integrated luminosity?

- Straw-man study
  - Push-Pull 40 days running 3 days break of switch-over
  - Two interaction regions, 7 days running, 7days off
- Some gains, but not a game changer



Optimizing for different Energy ranges

The Return to the Z?



Optimizing for different Energy ranges

From Z to Multi-TeV

Baseline

- SiD designed and optimized for an energy range from 250 GeV to 1 TeV
- Doesn’t mean it can’t work at the Z ...

From Z to Top only

- Lower solenoid B field and reduce calorimeter depth

Going beyond 1 TeV

- Make calorimeter deeper – as much as the coil permits

Remarks

- Mostly affected are the calorimeter depth and the solenoid strength
- These are “fixed” once SiD is completed
- Upgrading/optimizing especially the vertex detector is always possible

Optimizing for a Z run -What about PiD

“MultiGiga-Z” style

Baseline design

- With some adaption to the B field and the tracking, we’re convinced, SiD will perform well on the Z

What about the flavor programme ?

- What is there actually left to do after LHCb and Belle II ?
- How many Z’s would you need to become competitive ?

PiD discussions at last LCWS

- If you really need PiD, a ToF system will not be sufficient, PiD needed up to ~ 40 GeV
- It’s either a RICH or don’t do it
- This will affect physics performance in many other channels, sign is clear magnitude is not ...

Worth doing for

- For $A_{LR,} s\bar{s}$
- For $H \rightarrow s\bar{s}$
- ???

No clear case for dedicated PiD system in SiD

Safety and Sustainability

Old and new perspectives

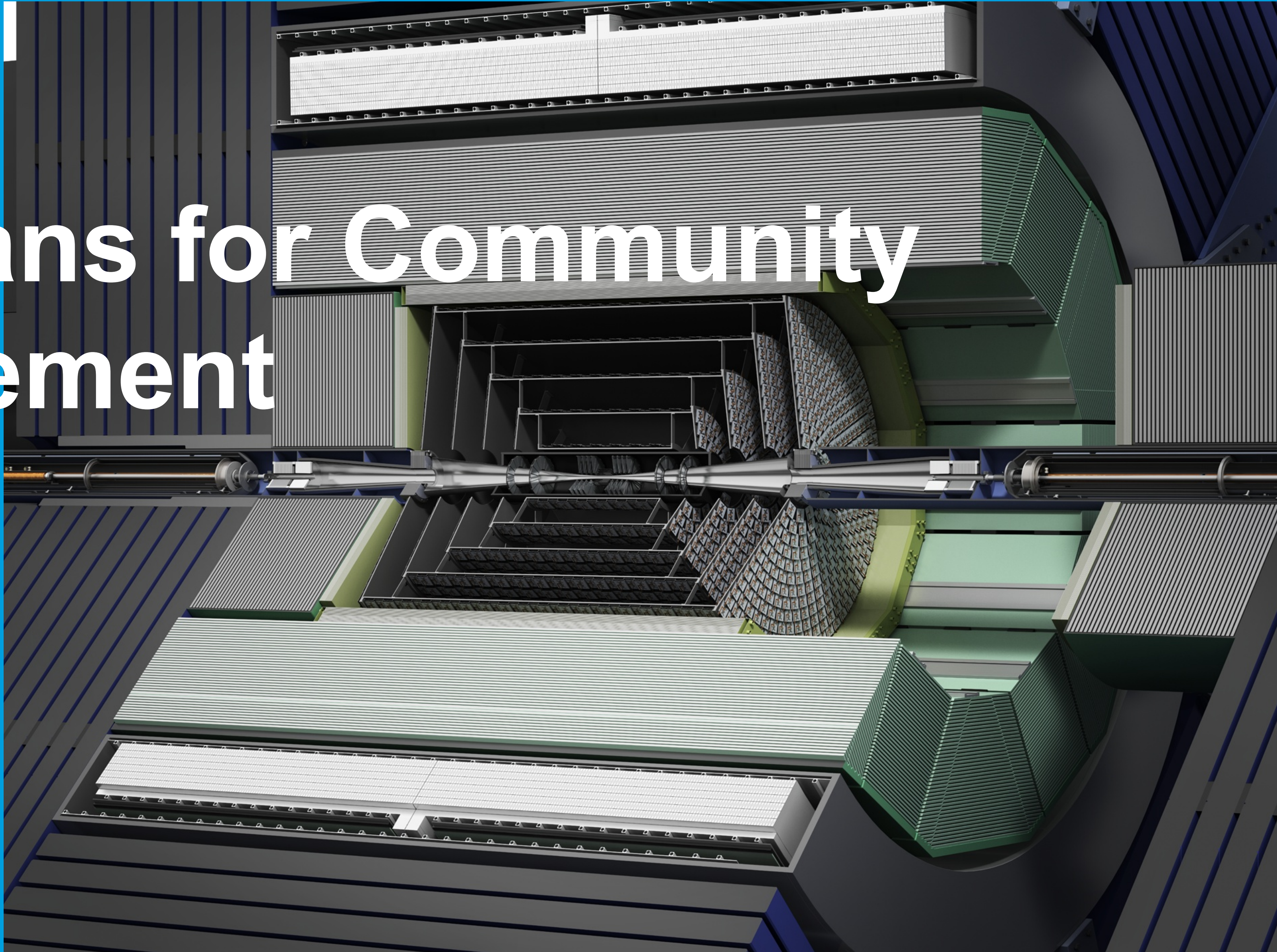
Detector Safety

- The move to scintillator +SiPM in HCAL and Muons comes with several safety benefits
- No HV throughout the detector
- No dedicated gas system required – eliminates a lot of services

Sustainability

- The elimination of the RPC technology also means → only Gas used by SiD is N_2
- No potent greenhouse gases like SF_6
- Still loads of steel, tungsten and silicon ….

The Plans for Community Engagement



Engaging the community

Some clear words are in order

ILC detector R&D Status

- SiD and ILD and also CLIC have been very successful to pick all the low-hanging fruits
- We know, what we want to build and have clear ideas how to do it
- There are always a few things to do, but they'll not decisive …

ILC – A phase change is required

- To do the next steps, detailed technical work is necessary
- Requires engineering, submissions, larger prototypes → needs sizable and sustainable funding
- Most people don't like to design systems, only to put them on the shelf for much later

Attracting people

- A project on the real axis and funding will also attract people
- For young (non-tenured) people, working on the ILC must be possible without risking their careers

Summary

SID Status

SiD remains an excellent detector design for linear collider physics

SiD update options

- Summarized in the SiD 2025 document
- https://arxiv.org/abs/2110.09965

Optimizing for different energy ranges

- Can be done – general parameters known

Next steps and engaging young people

- The ILC needs a phase-change towards the real axis
- Funding will enable ramping up targeted R&D again
- Job perspectives: for young non-tenured people working on ILC, this must not be a career dead end

Thank you

Overview of the collider options