
SiD
Running on the Z R
A long story
In a few slides
11/November/2016
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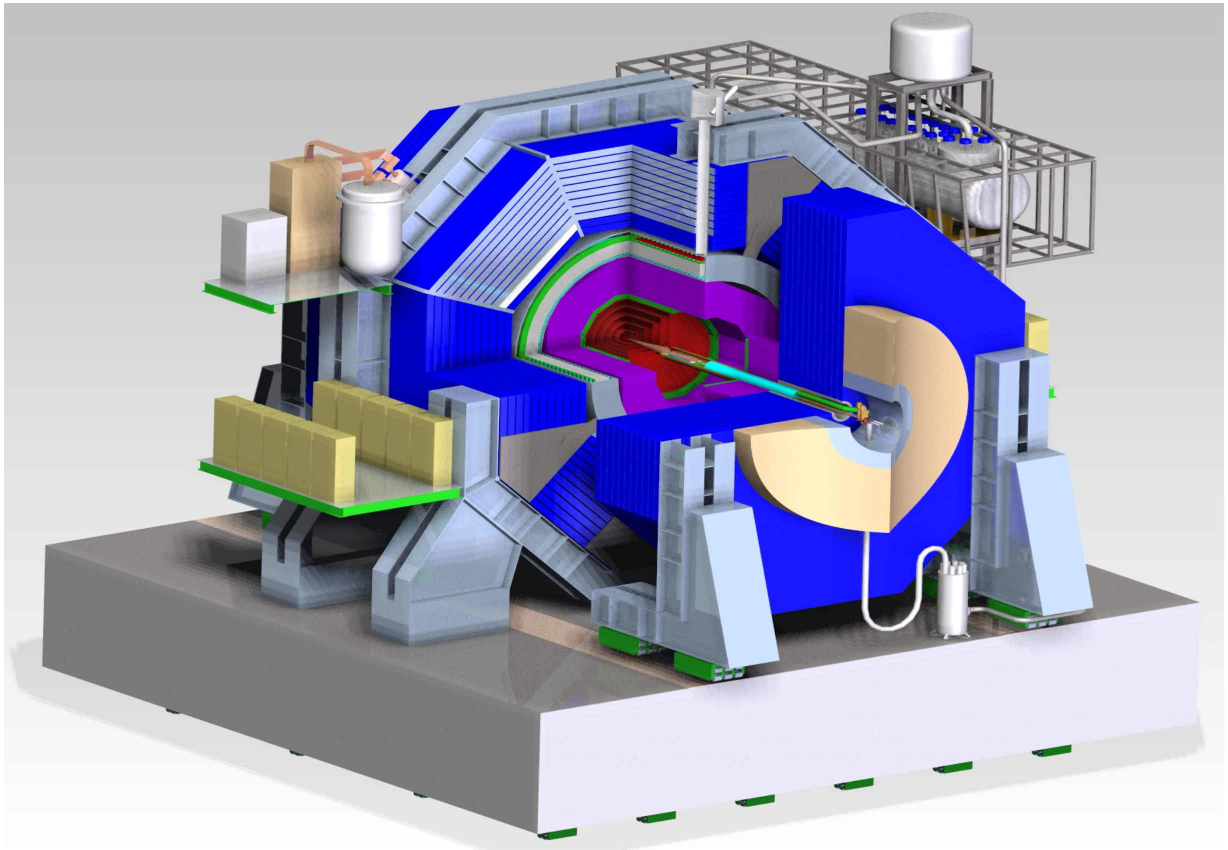
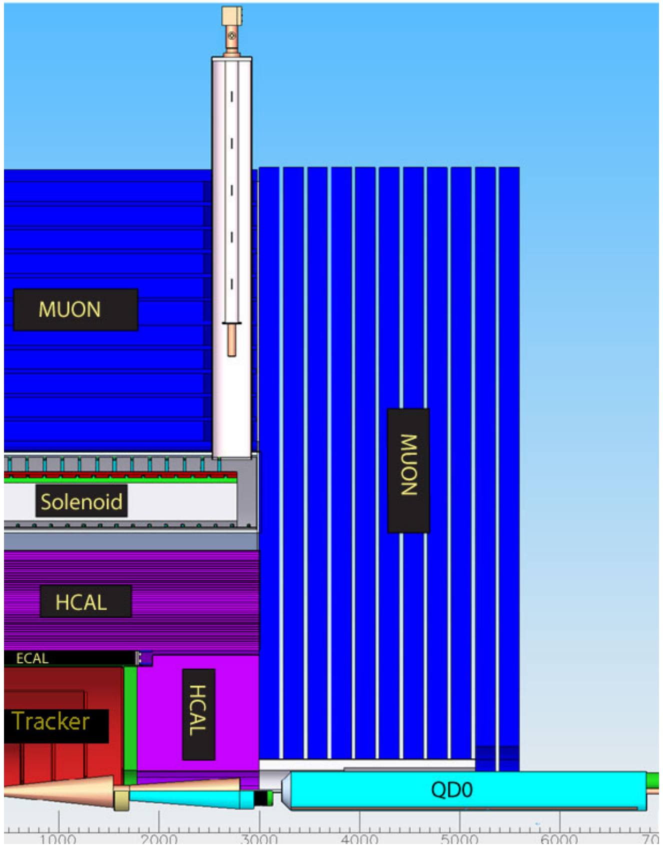
The SiD detector





- SiD is fully designed for push-pull (using a platform)
- Particle flow paradigm has driven design choices

DBD baseline parameters

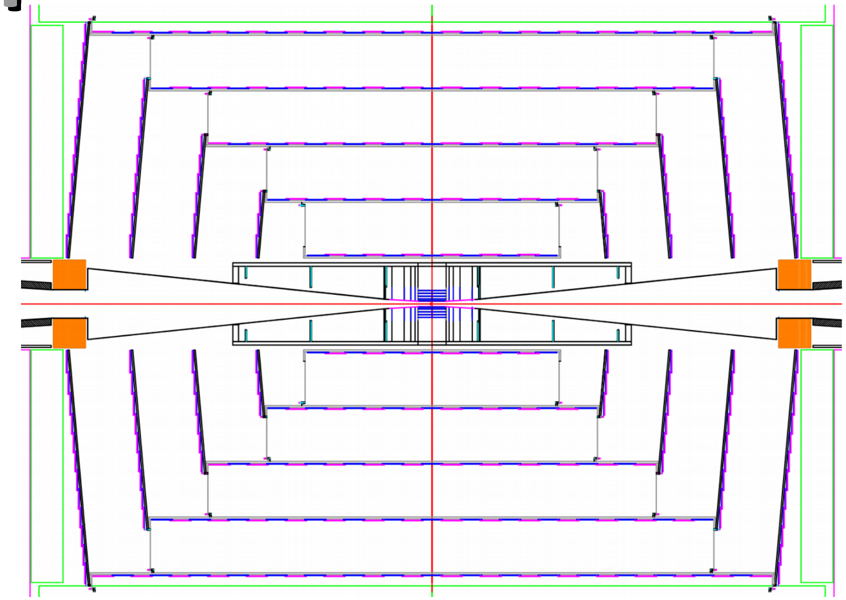
SiD BARREL	Technology	Inner radius	Outer radius	z max
Vertex detector	Silicon pixels	1.4	6.0	± 6.25
Tracker	Silicon strips	21.7	122.1	± 152.2
ECAL	Silicon pixels-W	126.5	140.9	± 176.5
HCAL	~~RPC-steel~~ AHCAL	141.7	249.3	± 301.8
Solenoid	5 Tesla	259.1	339.2	± 298.3
Flux return	Scintillator/steel	340.2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

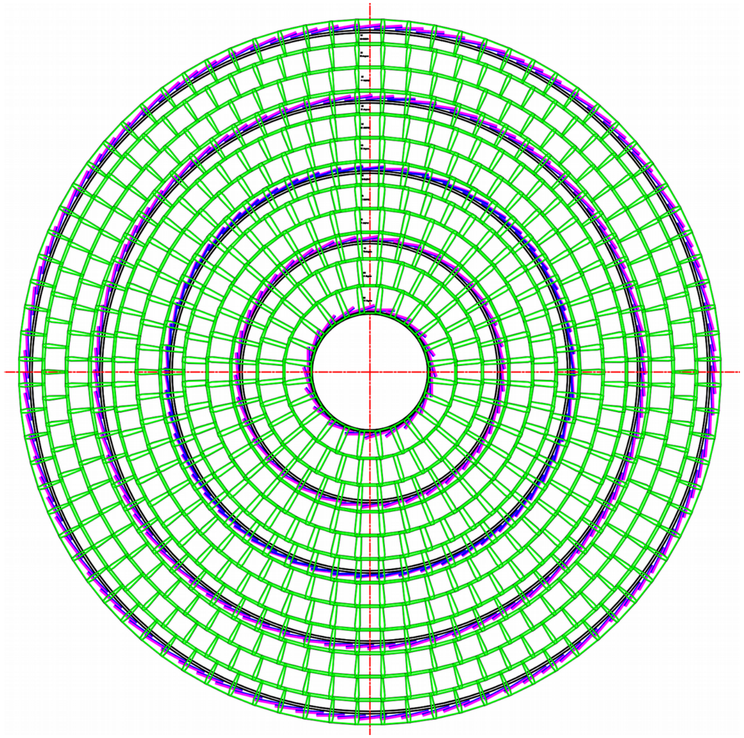
SiD ENDCAP	Technology	Inner z	Outer z	Outer radius
Vertex detector	Silicon pixels	7.3	83.4	16.6
Tracker	Silicon strips	77.0	164.3	125.5
ECAL	Silicon pixel-W	165.7	180.0	125.0
HCAL	~~RPC-steel~~ AHCAL	180.5	302.8	140.2
Flux return	Scintillator/steel	303.3	567.3	604.2
LumiCal	Silicon-W	155.7	170.0	20.0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

Silicon Strip Tracker

- All silicon tracker
  - Using silicon micro-strips
  - Double metal layers
- 5 barrel layers and 4 disks
- Cooling
  - Gas-cooled
- Material budget

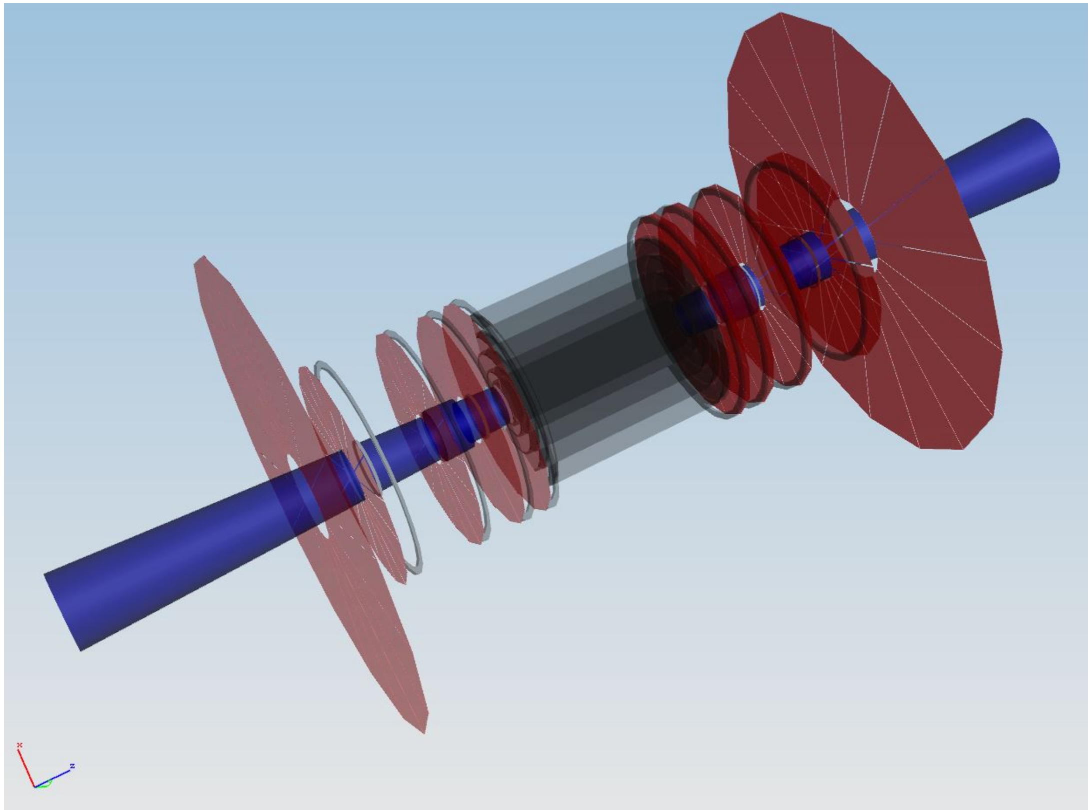
  less than 20 % X_0 in the active area
- Readout using KPiX ASIC
  - Bump-bonded directly to the modules





Vertex Detector

- Many potential technology choices
  - No baseline selected yet
  - Technology “not there” yet
- Requirements
  - <3 μm hit resolution
  - Pixel sizes of O(20 μm)
  - ~ 0.1 % X_0 per layer
  - < 130 μW/mm²/20 W total
  - Single bunch timing resolution
- Insertion of Vertex straightforward
  - Allows to make late technology choice



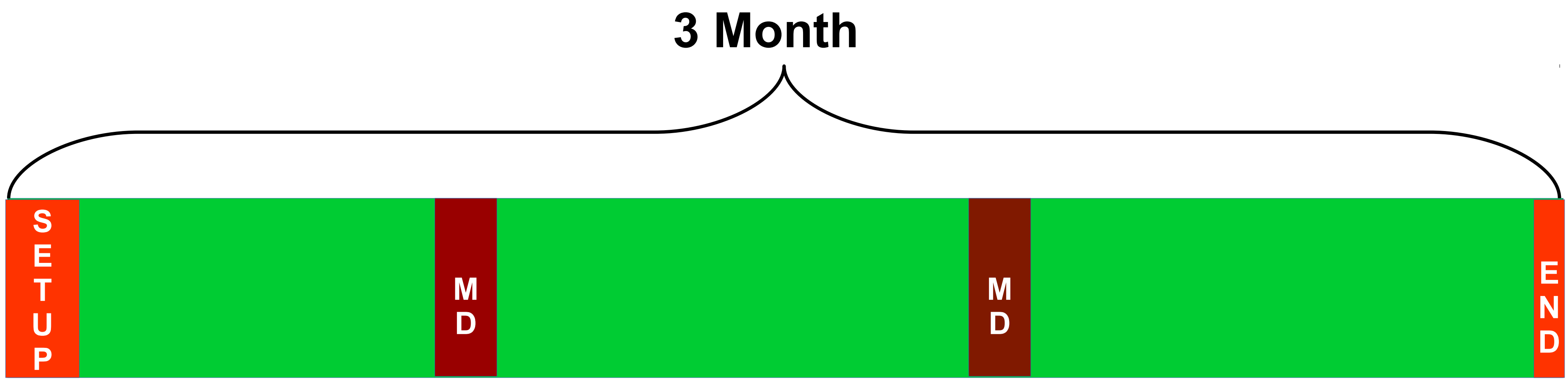
General Assumptions

- We're Talking about a Z calibration run
  - Not about a Giga-Z run at some later point in time
- SiD built around Silicon
  - If you don't bath it in neutrons, very nice and stable …
  - Detector Calibration will be straightforward & stable in time
- Push-Pull every ~ 3 month
  - I don't think, either detector would be happy with a switch once a year

LHC Detectors Strategy & Experience

- pp at 7 TeV
  - 100 m Underground
- Basic ideas
  - Precision Alignment of modules (< 10 micron)
  - FSI System
  - Cosmics
  - Tracks
- Reality
  - 1 year of cosmics
  - Sooo many tracks
- Upgrade
  - Precision alignment strategy for components relaxed

A possible Run Plan

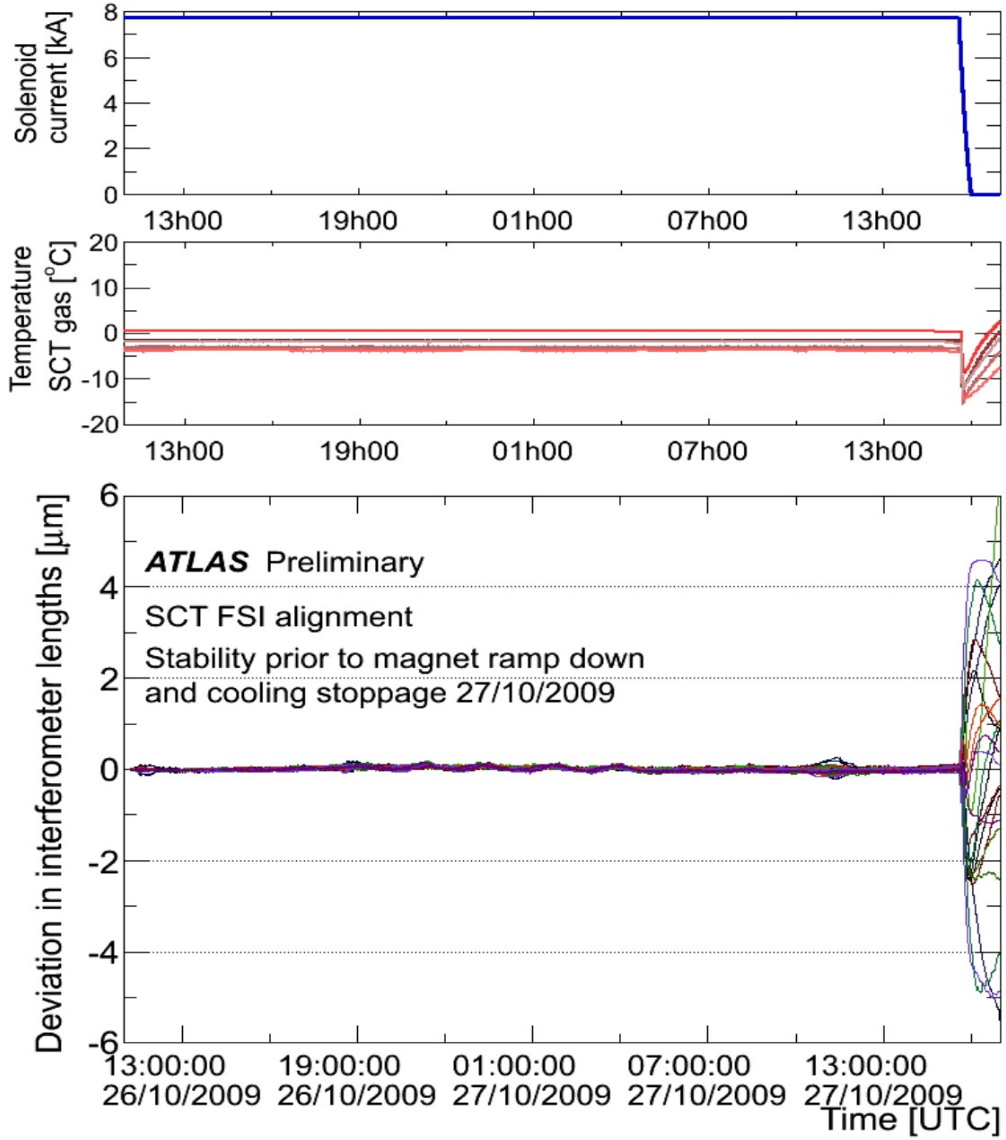


- Running scenario
  - 3 Month Running per Detector
  - 2 MD Weeks
  - Setup, Tunings, End-Of-Run 1-2 Weeks
  - 8 Weeks with ~ 90 % machine availability for physics (That is ambitious)→ 7 weeks of data
- Alignment Periods
  - Initial (In the garage position)
  - Setup (After move into beam position)
  - During MD
  - Gorilla in the room: "Stability between bunches..."

SiD Alignment Strategy

- Multi-pronged approach
  - Rigid Structures, well surveyed
  - FSI
  - IR Laser
  - Cosmics
  - Beam-based (tracks)
- Depend as minimal as possible on machine performance
  - Track record of new colliders… beginning almost always tough
  - Sensible alignment for the early data

FSI



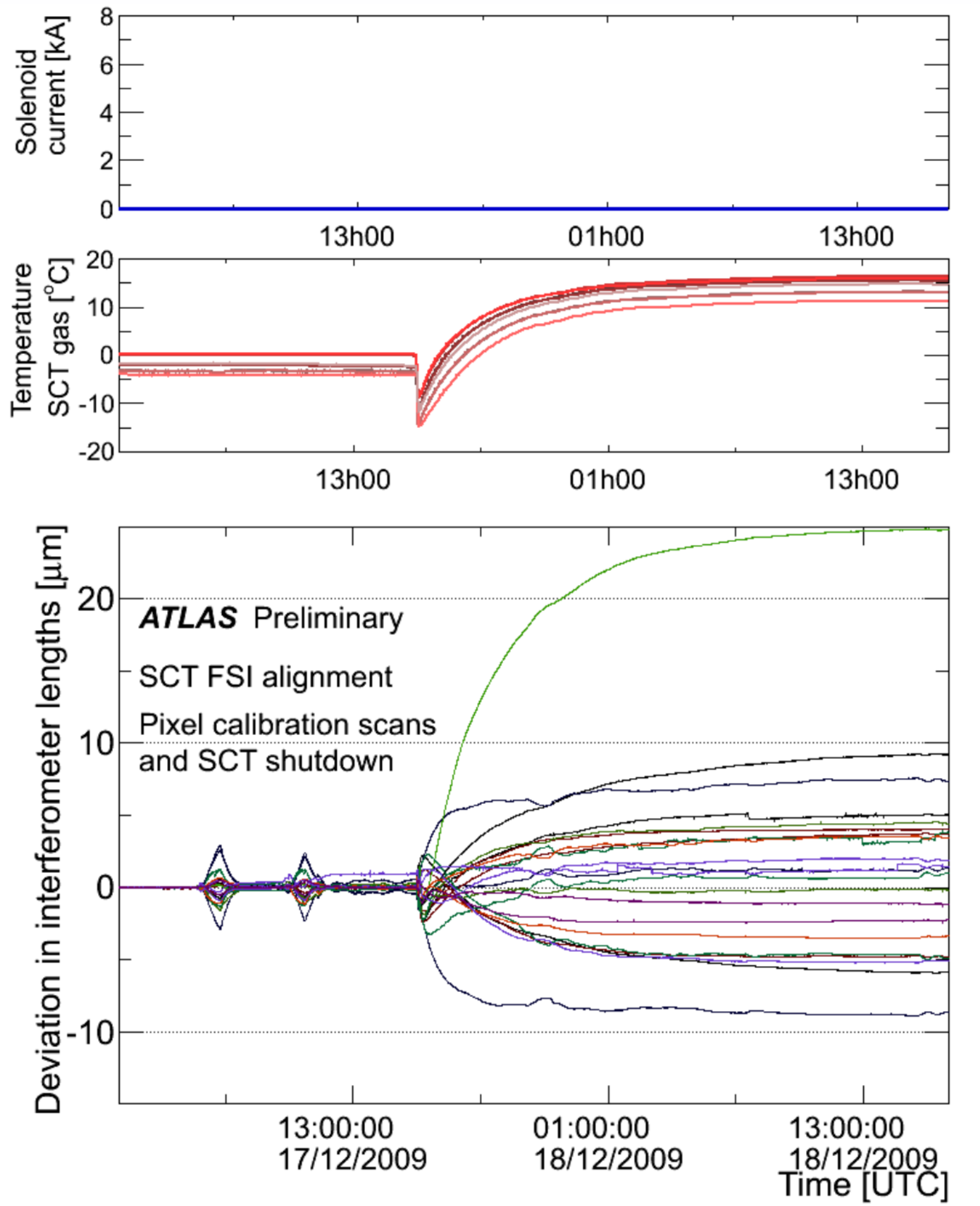
Plot 3: 24hr stability

Event: smooth SCT operation, followed by a fast magnet ramp down, which also triggered a stoppage of the Inner Detector cooling system.

Result 1: The barrel flange interferometers are stable with individual stdev **< 50nm over a 24 hour period**.

Result 2: Correlated movements of up to **+/- 5µm** are seen following the magnet ramp down and cooling stoppage.

FSI (II)



Plot 5: Pixel Scans and SCT shutdown

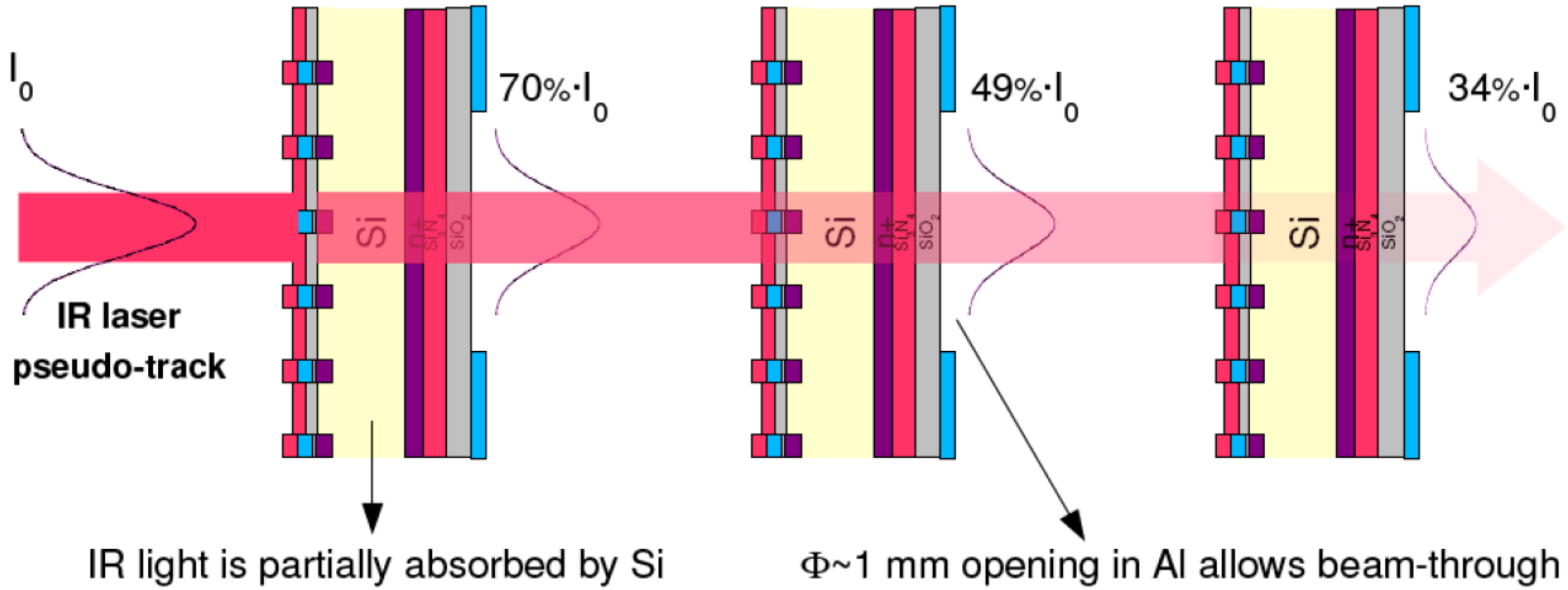
Event: Two calibration scans in the silicon pixel detector (Pixels), followed by the shutdown of the silicon strip detector (SCT).
Up to **+/- 3µm** between the two smallest SCT barrels, closest to the Pixels.
The effect is reduced between the middle and outer pairs of SCT barrels.

Heat dissipated in the Pixels by these scans appear to cause small deformations which propagate via the support structure to the SCT.

With the cooling off, the SCT warms gradually and after 24hrs the temperatures and movements tend to flatten.

The largest movement, of +25µm, may be due to thermal expansion of cooling pipe close to interferometer components.

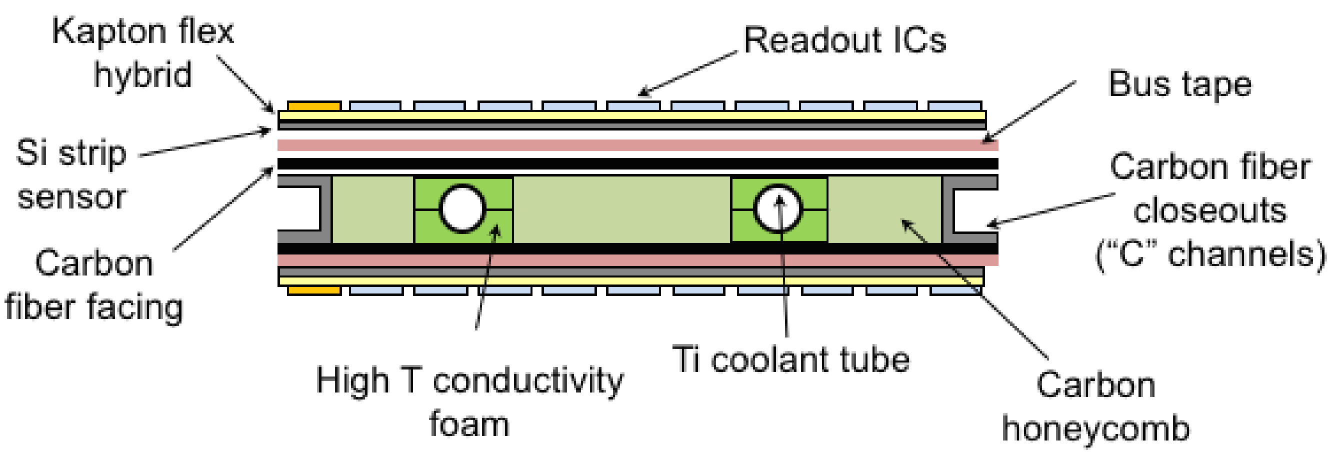
IR Silicon Alignment



- Si is almost transparent to IR light.
- IR beam plays role of straight tracks
- Measure position across several sensors
- Minimum impact on system integration & material budget
- Straightforward DAQ integration

Rigid Structures

- The challenge
  - Rigid
  - Low-mass
- Learning from the LHC Upgrades
  - Amazing, what carbon fiber composites can do for you
- Currently 1.8 % X_0, Actual structure ~ 30 % Silicon Module 60%

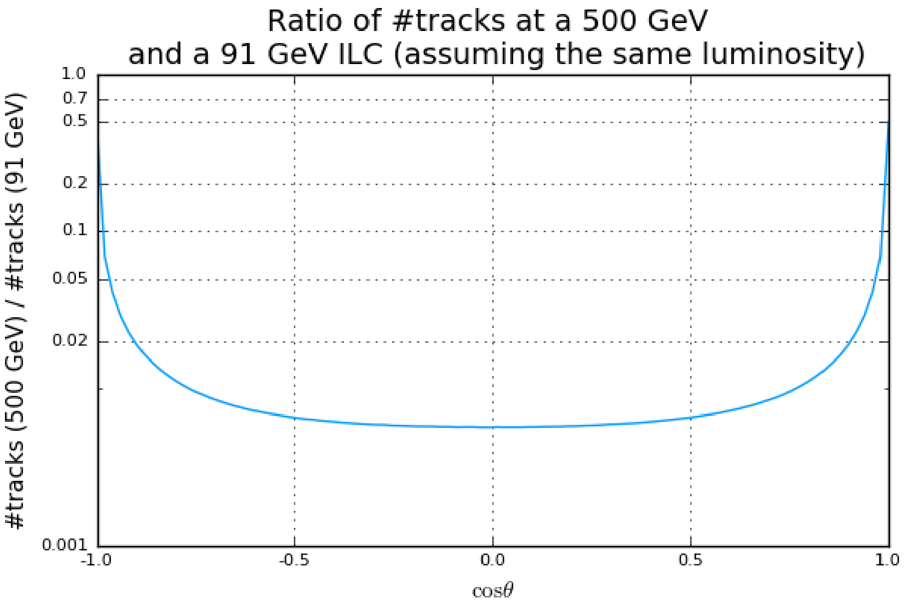


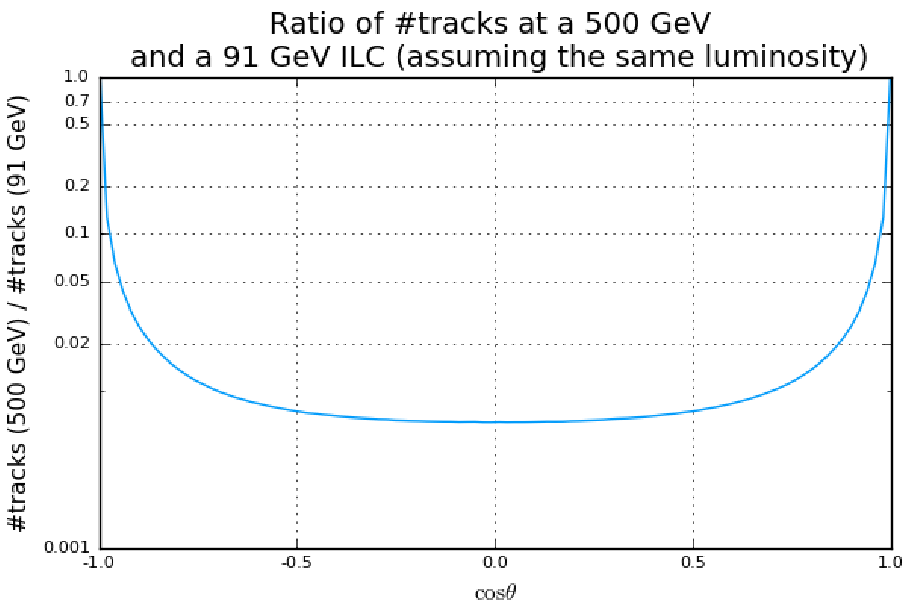
Cosmics

- With a 5 Hz Duty-Cycle, this is certainly not optimal
  - "not designed for cosmics running"
- Rates underground
  - Very difficult to predict (exact overburden unknown)
  - Reference from an ATLAS Measurement on "Triggered" Muons :1.34/m^2/s
- Estimate with 6 Hits in the Tracker Barrel
  - > 50000 muons/month with 1% duty cycle
  - c.f ATLAS 2014 run used 50000 tracks from cosmics for Alignment

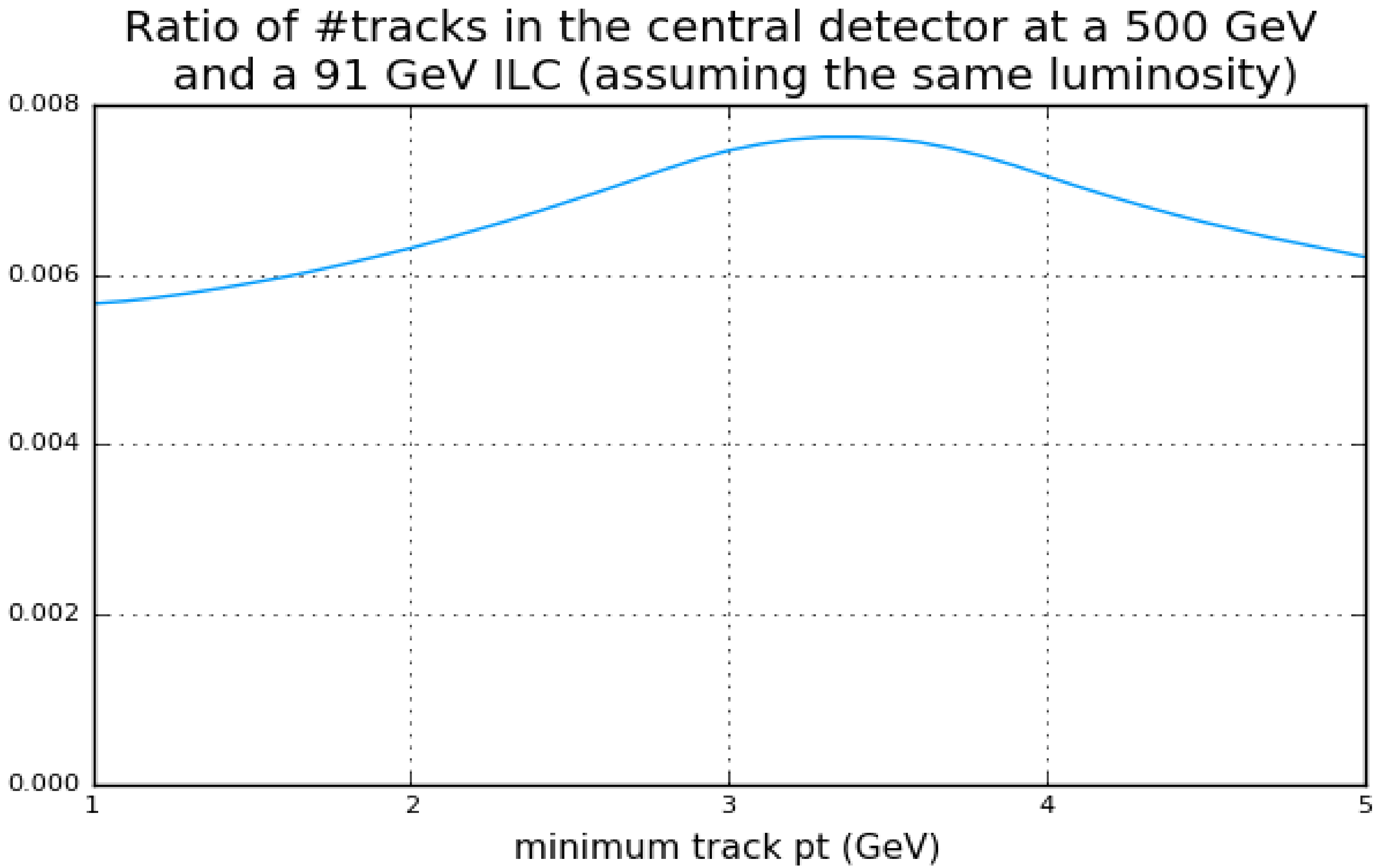
Track-based Alignment

- Scenarios:
  - $Lumi_Z = 0.01\ Lumi_{500\ GeV}$
- Looking at complete MC samples for both 91 GeV and 500 GeV
  - 2 Fermion and 4-Fermion processes
- Looking at all tracks with $P_T > 1\ /2$ GeV
  - Doing well in the end-caps
  - Central Barrel takes a hit



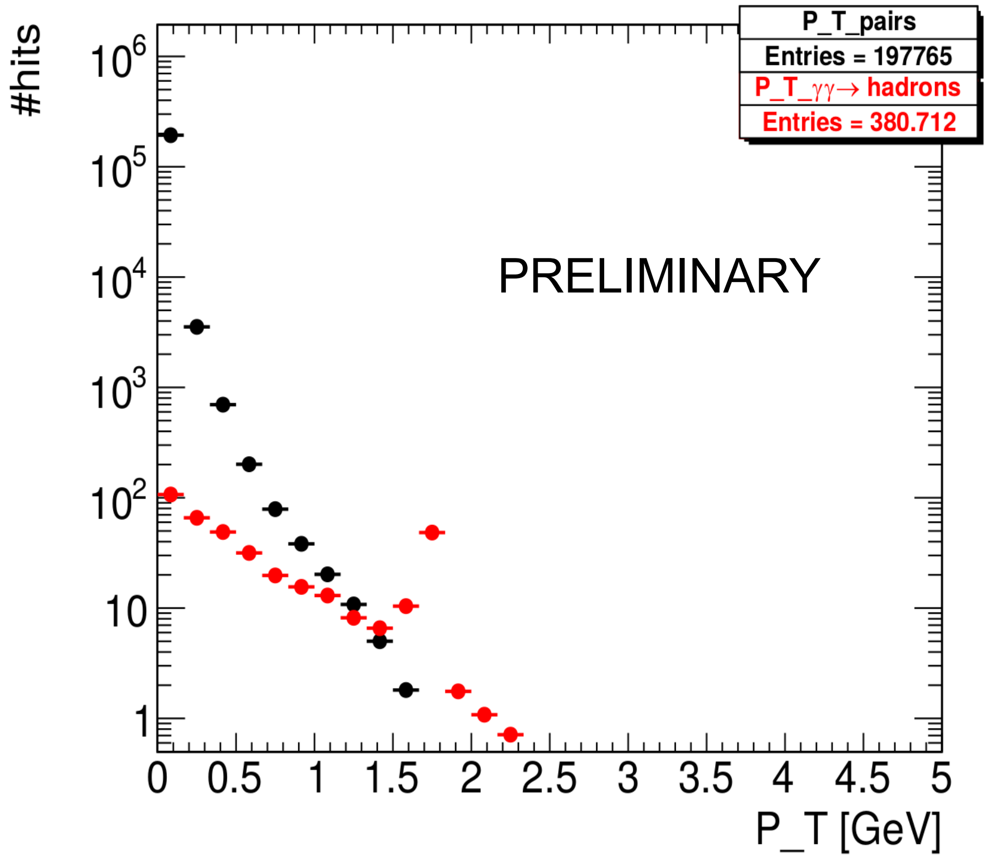


The Central Barrel Plot

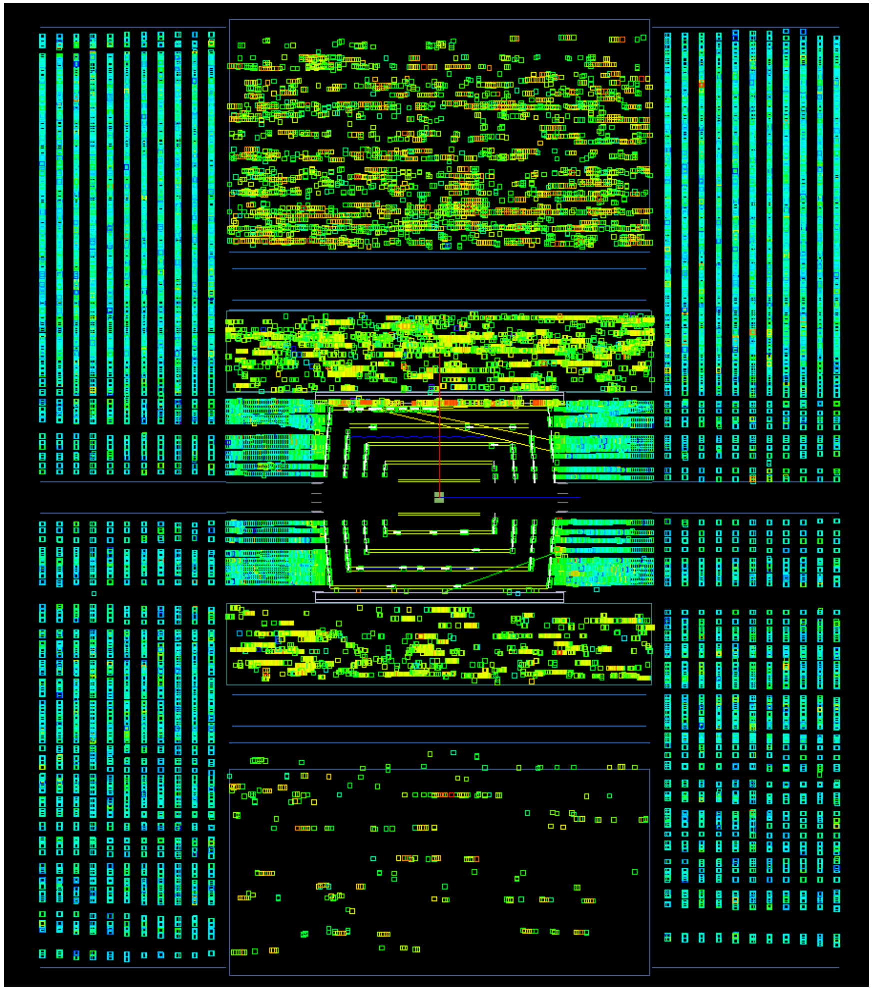
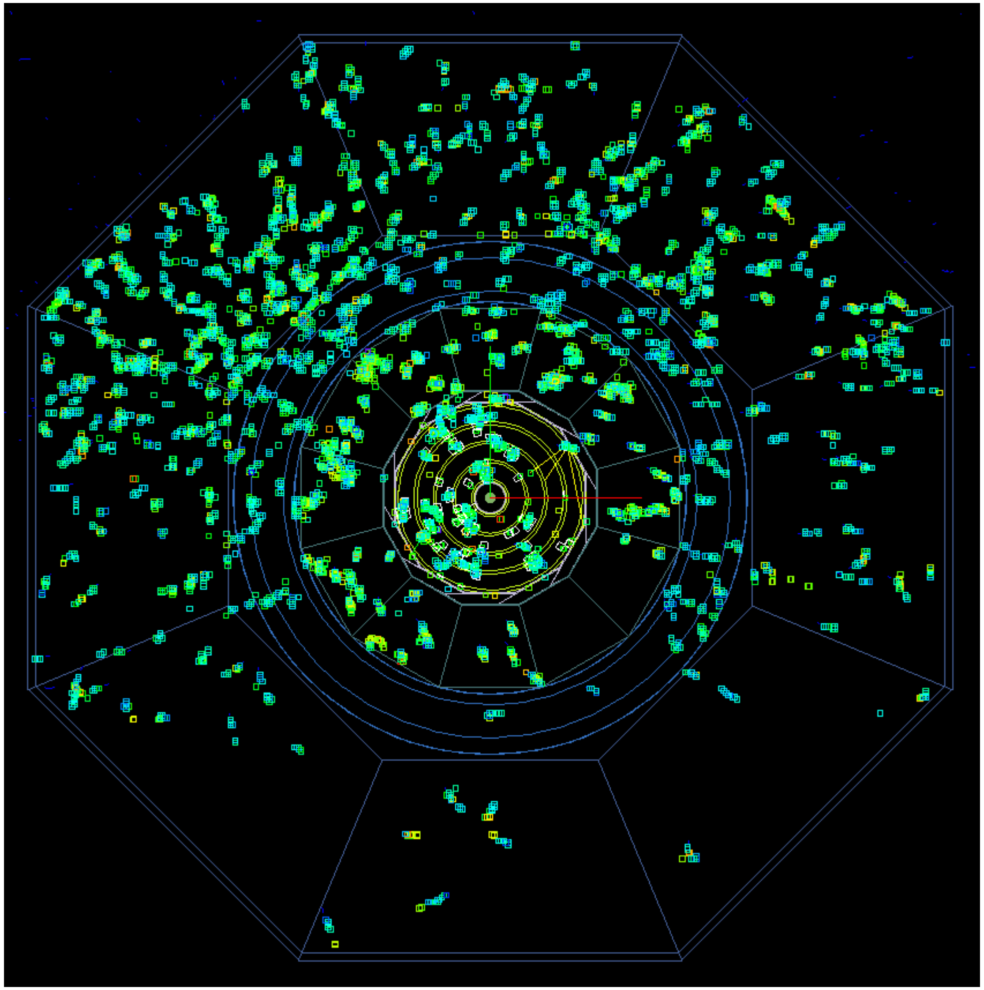


Other track sources ?

- Using beam back grounds ?
  - Pairs
  - γγ→ hadrons
- Some Numbers
  - A few per crossing with P_T> 2 GeV
  - It helps ….
- Muon Halo
  - Lovely 150 GeV + muons
  - Ideal for End-Cap Alignment
  - Precise numbers being simulated



Why Time-Stamping is good for you

Background Hits from upstream muons generated in the Final Focus over the entire bunch train

Why no Z run

- With $Lumi_Z = 0.01\ Lumi_{500\ GeV}$
  - Just not competitive
- If there is more Luminosity ?
  - Interesting only in theory...
  - A Z run after every push-pull ?
  - After every MD?
- Moving the machine from 500 GeV to 91 GeV and back
  - Non trivial (several Days/few weeks)
  - In a 3 month running scenario (7 weeks of data taking) losing another significant fraction of high energy running

Requirements for the Ultimate Alignment

- Integrated Approach to Alignment
  - Not an after-thought
  - Don’t rely on tracks
- Plan for FSI & Lasers
  - From the beginning
  - Fully integrate this into the alignment
- Cosmic Mode
  - Design “Cosmic Mode” for the ASICS
- Operations : KISS (Keep it stable, stupid)

Conclusions

- Our current Conclusions
  - As stated in the draft to the Parameters WG

This is a preliminary study, and a definitive answer will require more understanding of the alignment and calibration algorithms. However, unless the Z-pole luminosity is considerably greater than the expected 1% of that at 500 GeV, our conclusion is that Z-pole running will have a negative impact on the ILC physics programme. The SiD consortium therefore requests running only at high energy.

  - Running on the Z with luminosity is a significant investment
  - Detector needs to be aligned without relying on tracks exclusively
- Plans
  - Continue studying these issues