SiD
Detailed Baseline Design

Marcel Stanitzki
for the SiD Detector Concept

LCWS 2012 Arlington, TX

SiD Detector overview

- 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 5T field.
  - Robust silicon vertexing and tracking system with excellent momentum resolution
  - Time-stamping for single bunch crossings.
  - Highly granular Calorimetry optimized for Particle Flow
  - Iron flux return/muon identifier is part of the SiD self-shielding
  - Detector is designed for rapid push-pull operation

Moving towards the DBD

2003:SiD first appears at ALCPG.
SiD is aimed at the NLC

2006: Detector Outline Document

2008/9: CLIC_SiD Starts for Multi-TeV machines

2009: SiD Letter Of Intent

2009: SiD validated

2004 :WWS starts the detector concept studies at the Victoria meeting :SiD, GLD, LDC
Beginning of the Silicon Detector Concept Study

2007: Detector Concept Report
First SiD workshop

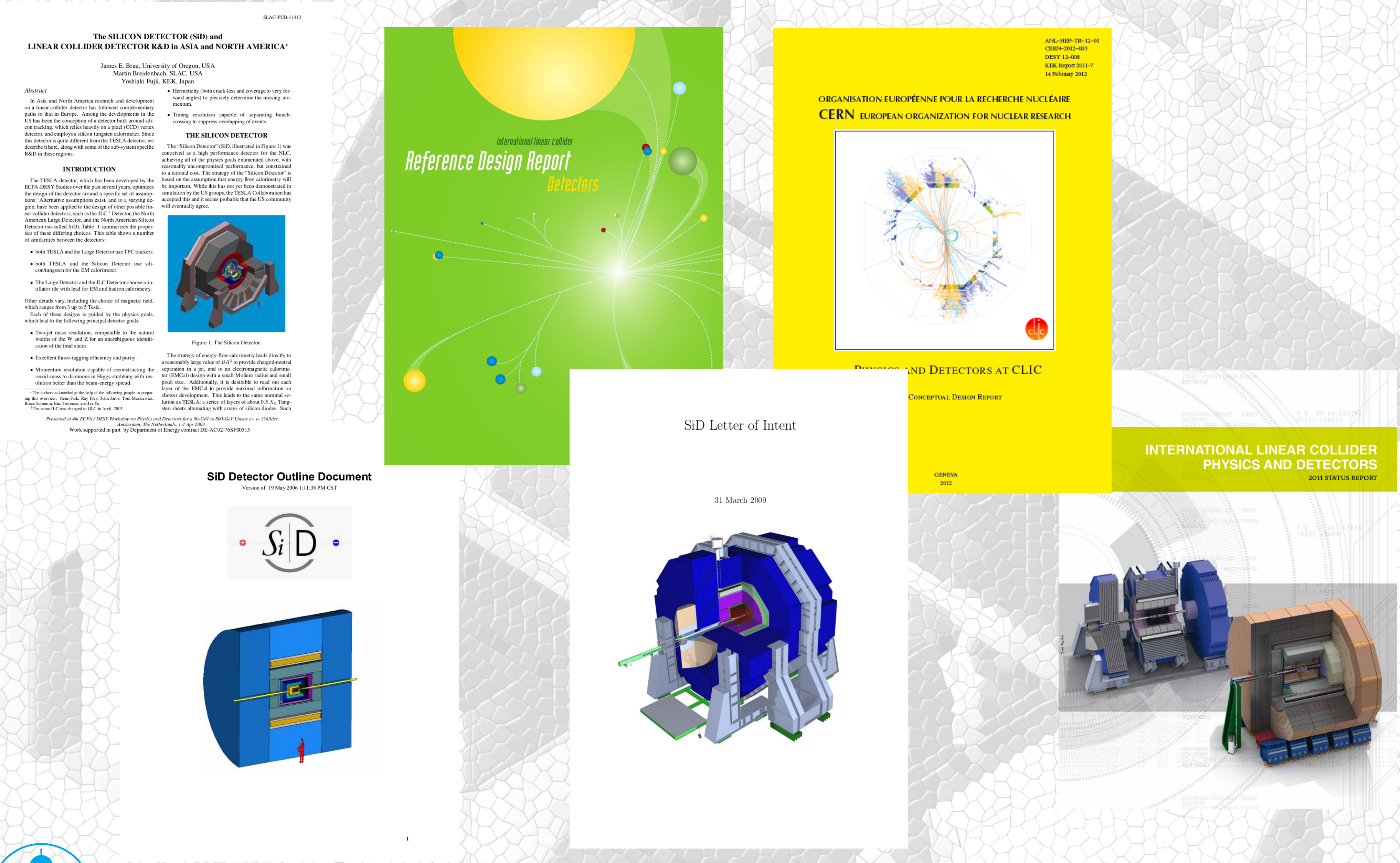
2011: CLIC Physics and Detectors Conceptual Design Report

Concept Phase

LoI Phase

DBD Phase

And many reports...



Marcel Stanitzki

SiD & the DBD

- The DBD describes a baseline of SiD for the ILC
  - Choices have been made for all subsystems besides the Vertex detector, however options have been kept
  - The detector is fully costed
- The DBD is not a TDR (M. Breidenbach)
  - Engineering effort not sufficient
  - Not all R&D has been completed
- In SiD's view the subsystem options offer
  - Improved performance or lower cost
  - Not as mature as the baseline choices yet

Writing the DBD

- Started planning in 2011
- Appointed four main editors
  - P. Burrows (Oxford), L. Linssen (CERN), M. Stanitzki (DESY), A. White (UTA)
- Outline presented at KILC 2012
- SiD Workshop in August 2012 at SLAC
- Draft submitted to the IDAG on 23rd of September

SiD

DETAILED BASELINE DESIGN

DRAFT SUBMITTED TO THE IDAG
24/SEPTEMBER/2012

SiD DBD Current status

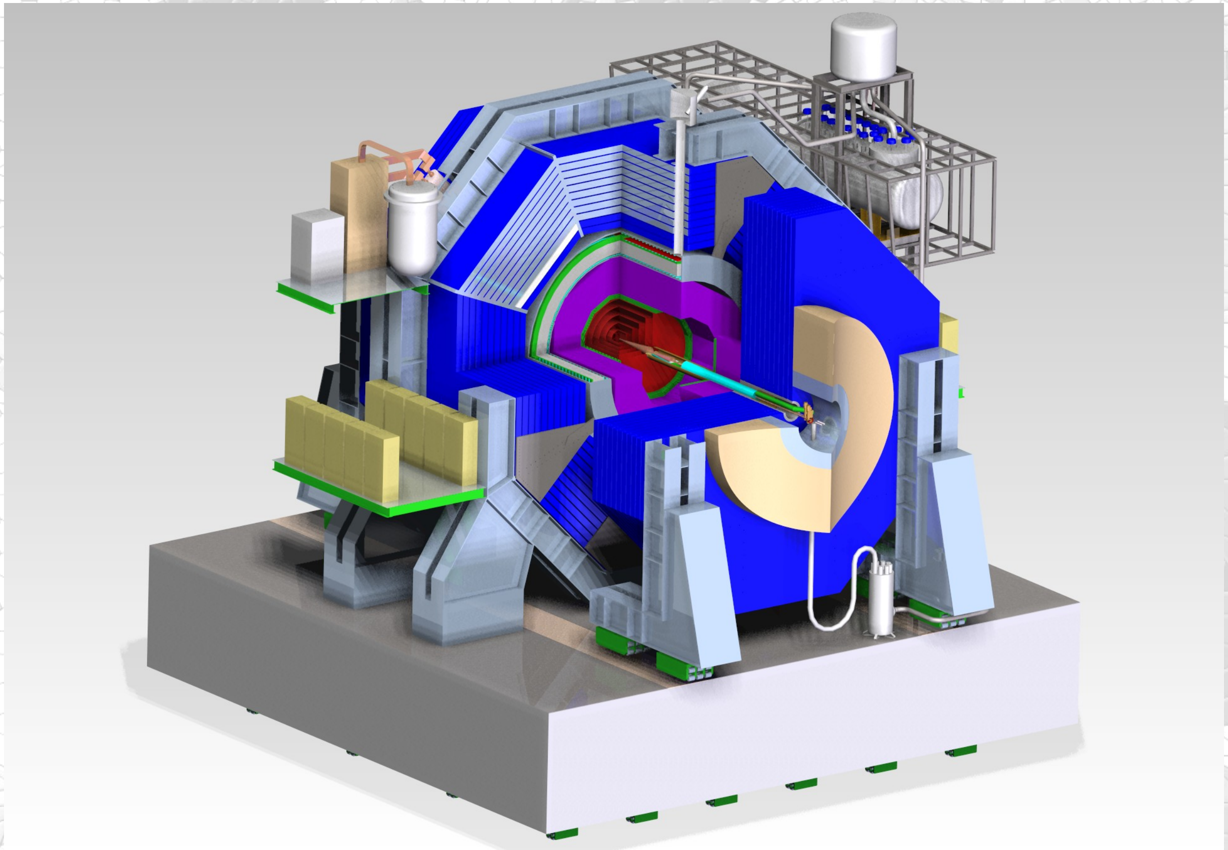
- As promised to the IDAG, we delivered a "rather complete" draft on 23rd of September 2012
- Known "features" at the time of submission
  - Simulation & Reconstruction wasn't completed
  - Performance plots were preliminary
  - No Benchmarking results were available
- Page limits
  - in the right ball park
- Incorporating the common section
  - This came too late for the "IDAG" draft

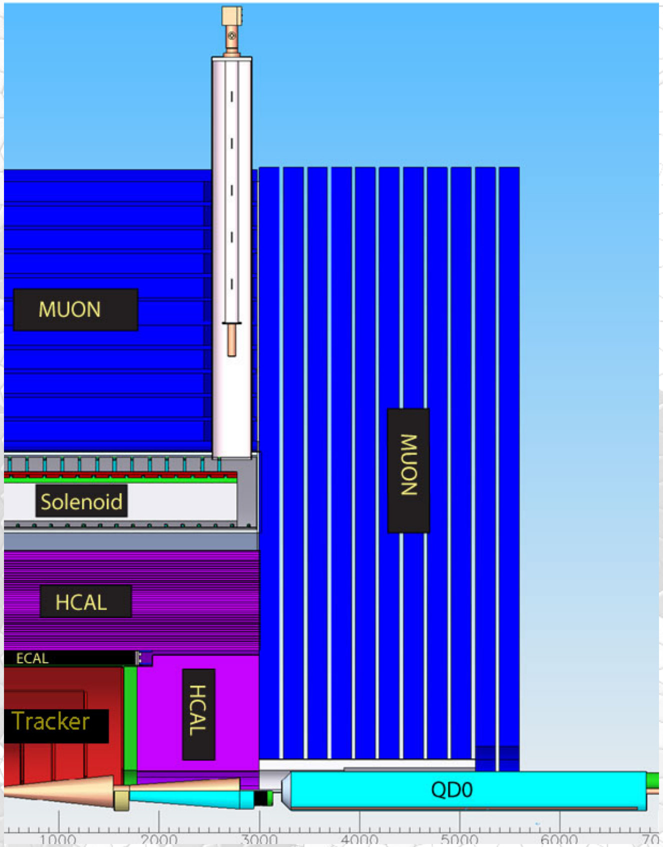
Marcel Stanitzki

Highlights from the DBD

- The DBD is a write-up of three years of activity
  - Lots of things have been achieved
- Will give a few selected highlights
  - Focus on new things since the LoI
  - R&D Highlights from the subsystems
  - Simulation & Reconstruction
  - Engineering
  - Costing
- 25 min is way too short to cover 150+ pages
  - Can't cover it all

The DBD detector





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

Marcel Stanitzki

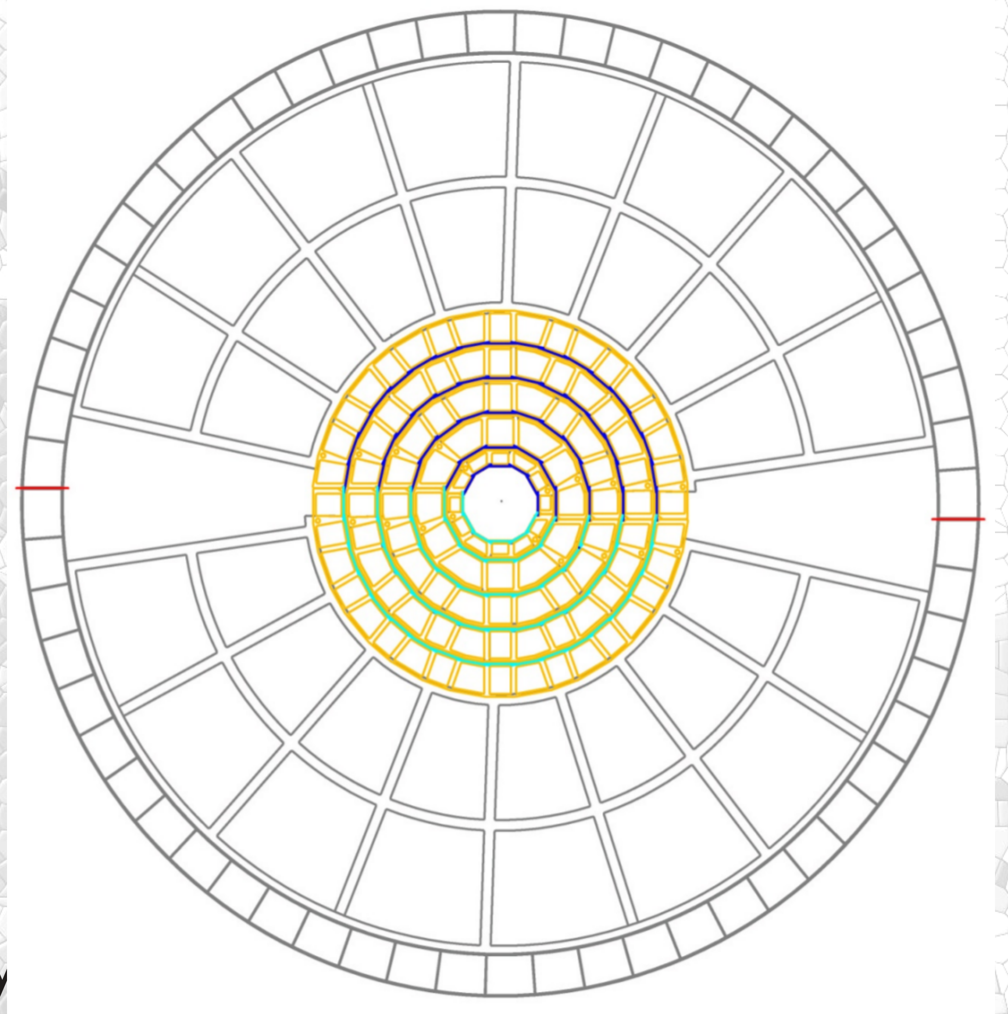
Detector parameters

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

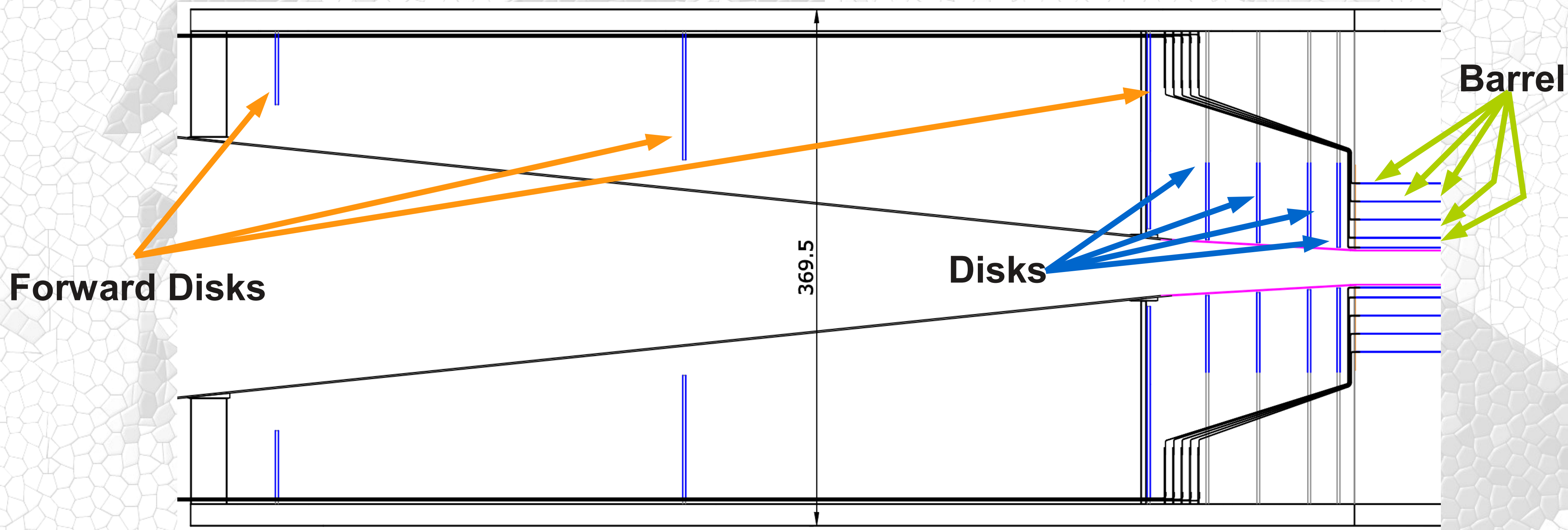
Vertex Detector

- Many potential technology choices
  - No baseline selected yet
- Requirements
  - <5 μm hit resolution
  - ~ 0.1 % X_0 per layer
  - < 130 $\mu W/mm^2$
  - Single bunch timing resolution
- Insertion of Vertex straightforward
  - Allows to make late technology choice



Marcel Stanitzki

Vertex Mechanics

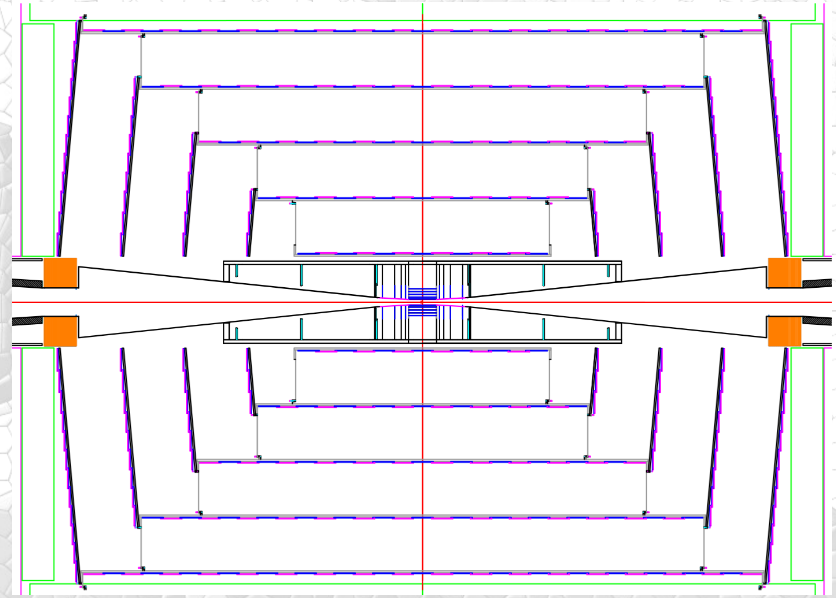


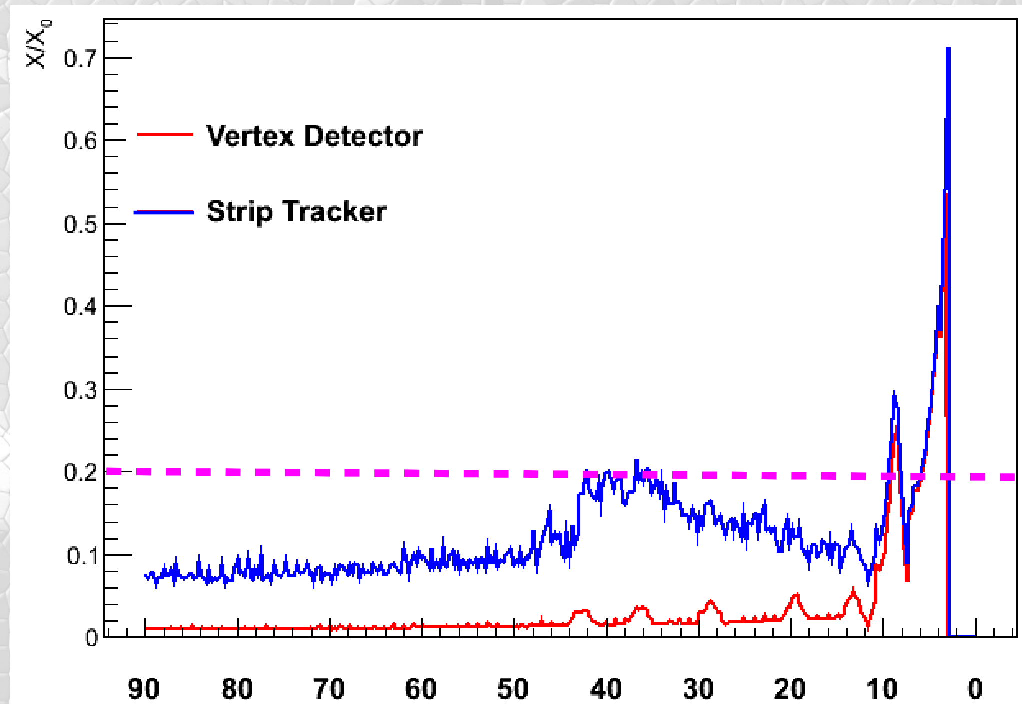
- 5 Barrel Layers, 4 Disks, 3 Forward Disks
- Total power consumption ~ 20 W
- Air-cooled
- Powering using DC-DC or serial powering
  - Learn from LHC upgrade experiences

Marcel Stanitzki

Tracker

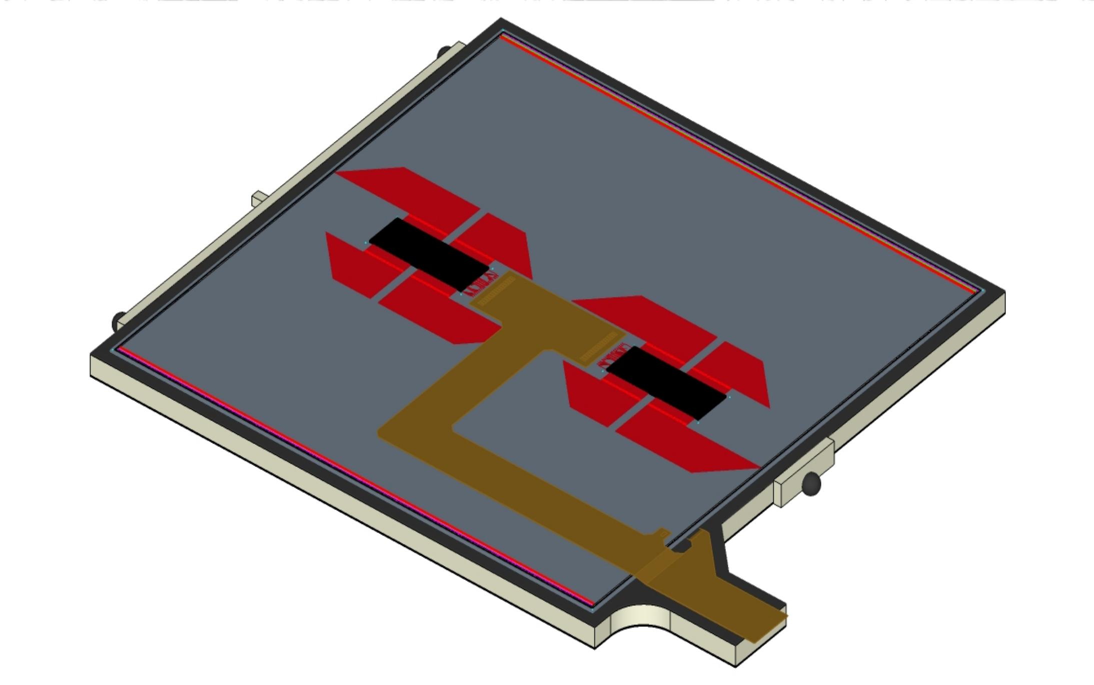
- All silicon tracker
  - Using silicon micro-strips
- 5 barrel layers and 4 disks
- Cooling
  - Gas-cooled
- Material budget
  - less than 20 % X_0 in the active area
- Readout using KPiX
  - Bump-bonded directly to the modules

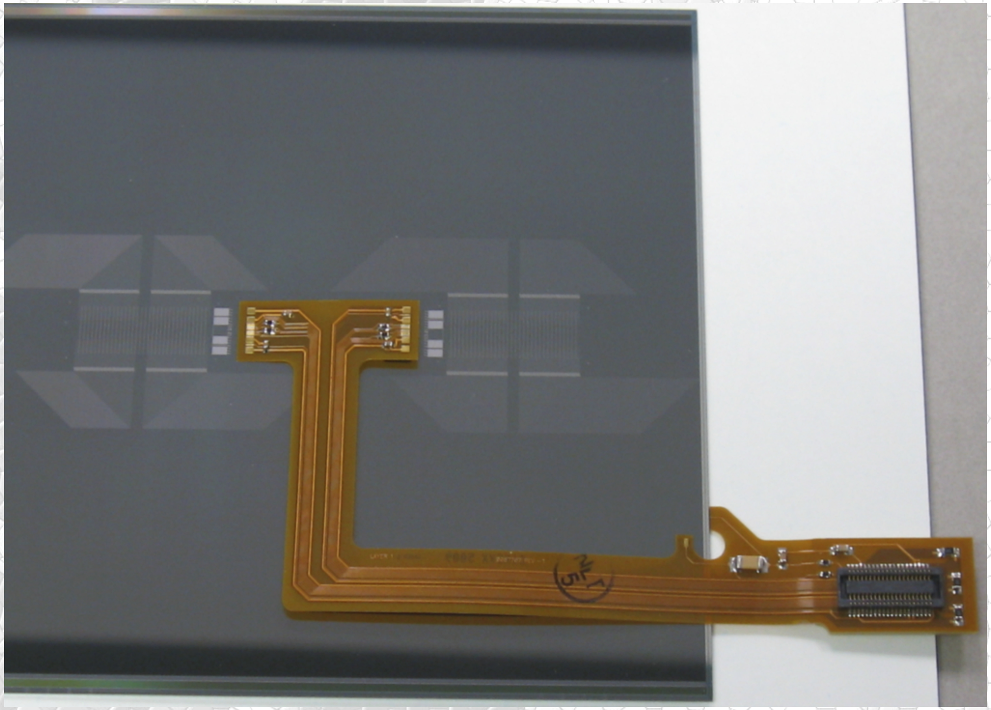




Marcel Stanitzki

Tracker Module

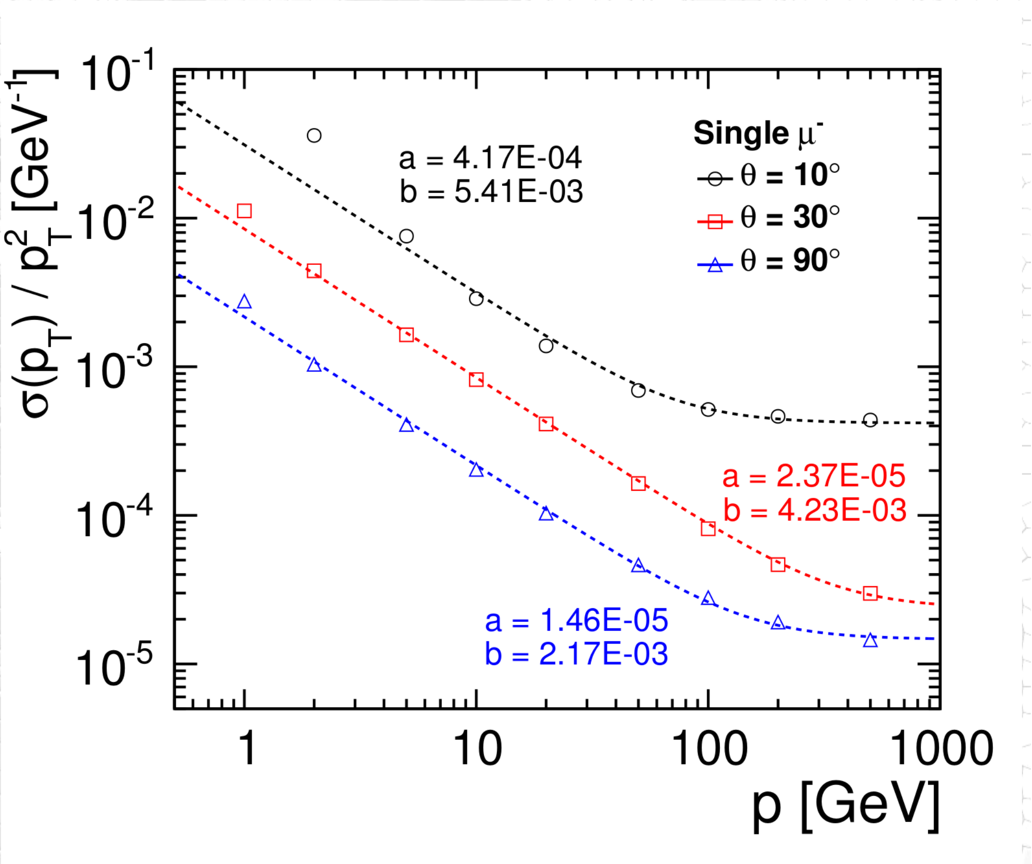




- Tracker modules from drawing to reality …
- Sensors uses double metal layers
- Awaiting KPiX bump-bonding

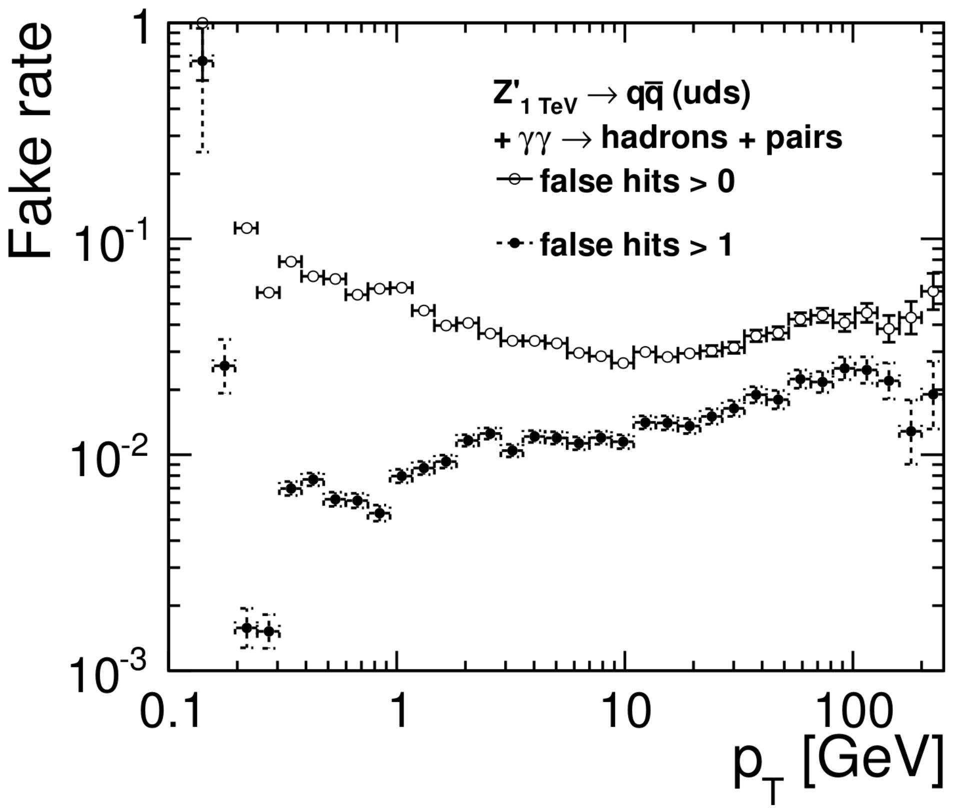
Tracking Performance

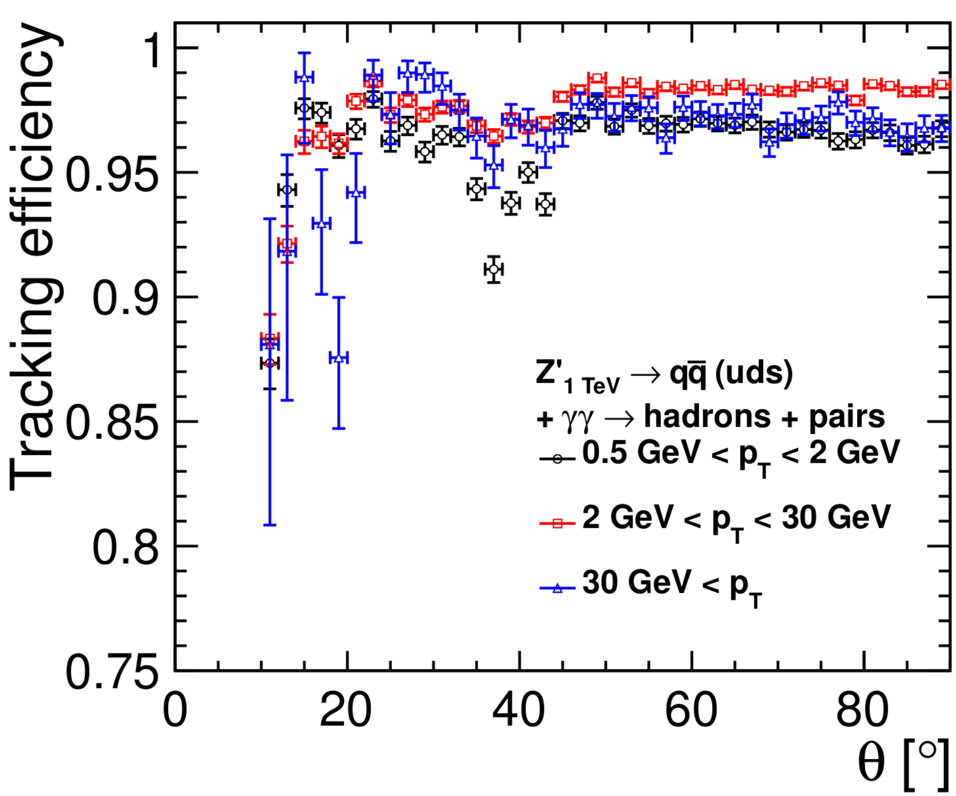
- SiD tracking is integrated
  - Vertex and Tracker
  - 10 Hits/track coverage for almost entire polar angle
- Tracking system
  - Achieves desired $\Delta p_T/p_T$ resolution of $1.46 \cdot 10^{-5}$
  - >99 % efficiency over most of the phase space
  - Impact parameter resolution of ~ 2 μm demonstrated



Marcel Stanitzki

Robustness vs. backgrounds





- Z' → uds at 1 TeV with 1 bunch crossing of background overlaid
- Demonstrates robustness of SiD Tracking

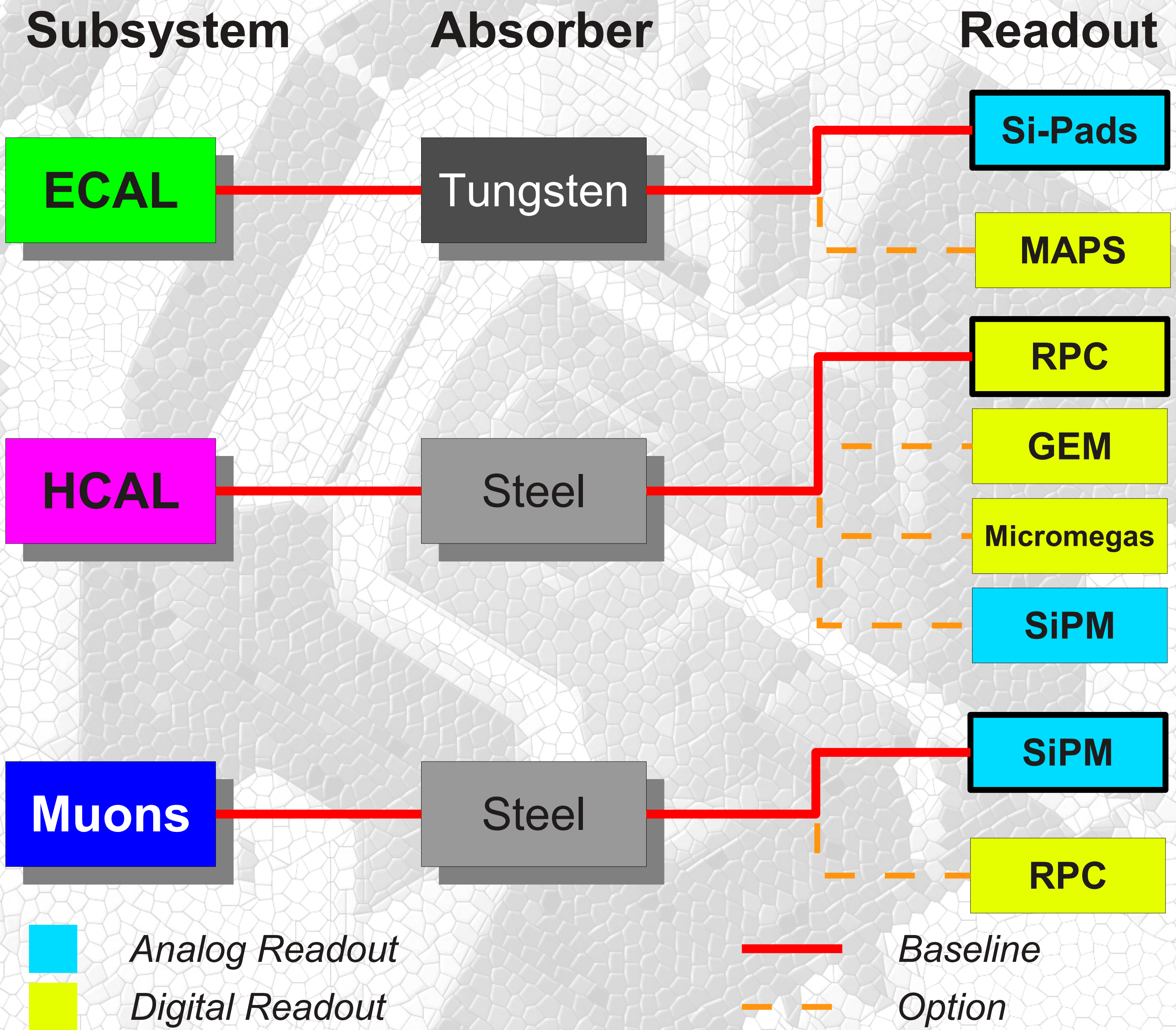
Marcel Stanitzki

Calorimetry

- SiD ECAL
  - Tungsten absorber
  - 20+10 layers
  - $20 \times 0.64 + 10 \times 1.30\ X_0$
- Baseline Readout using
  - 5x5 mm^2 silicon pads
- SiD HCAL
  - Steel Absorber
  - 40 layers
  - $4.5\ \Lambda_i$
- Baseline readout
  - 1x1 cm^2 RPCs
- SiD has selected baseline choices for its Calorimeter
  - Options are being considered
- Lots of test beam activities (past, present and future)
  - Parts of the program done as part of the CALICE effort

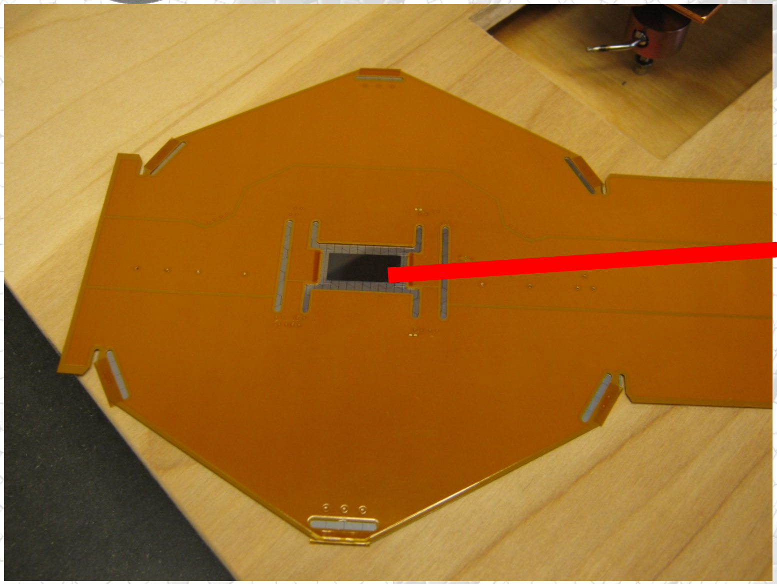
Marcel Stanitzki

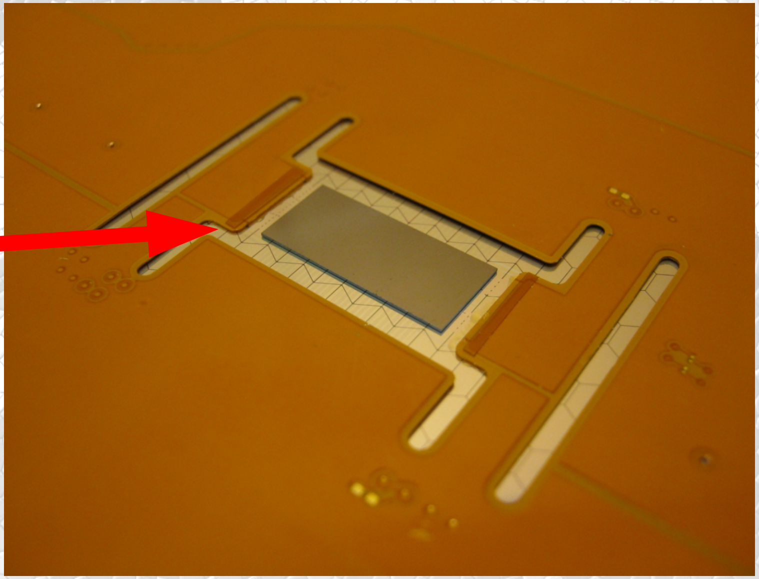
Calorimetry Tree



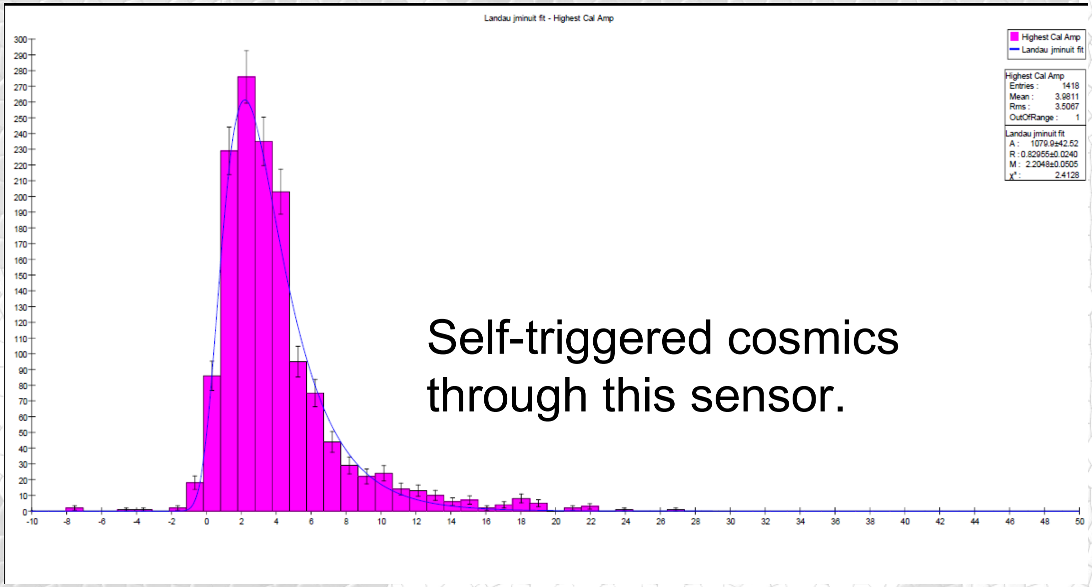
Marcel Stanitzki

Bonded Sensor for the ECAL



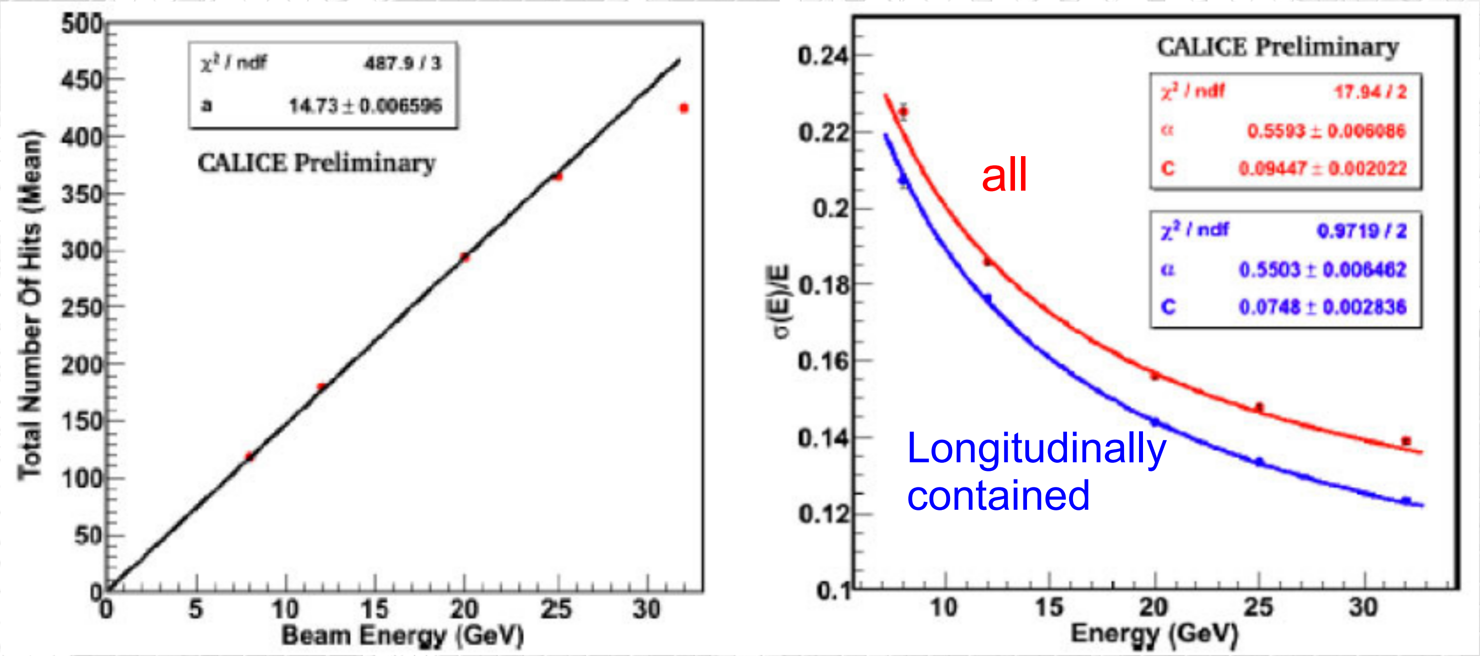


- KPiX bump bonded to 1024 pixel sensor
- Cable bump bonded to sensor
- Assembly is 1 mm high



Marcel Stanitzki

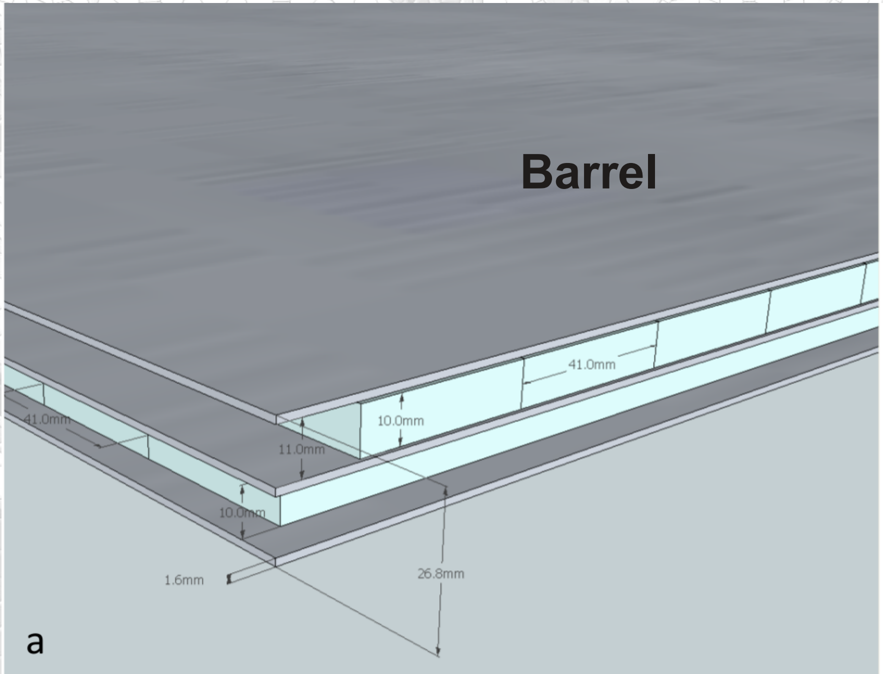
RPC DHCAL

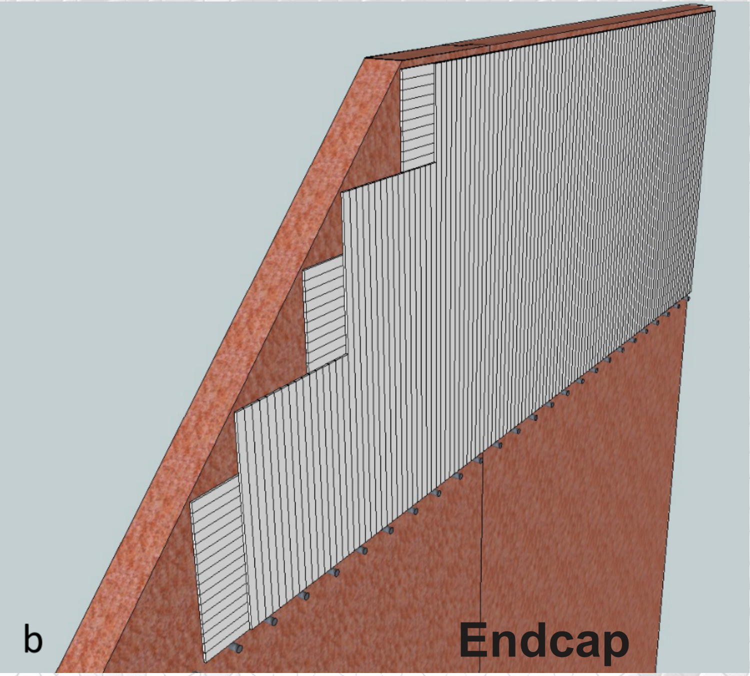


- After an extensive Test beam campaign
  - The RPC technology is a great candidate for the readout of a highly segmented calorimeter.
  - The dark rate in the DHCAL is very low
  - The response is linear up to about 30 GeV/c.

Muons

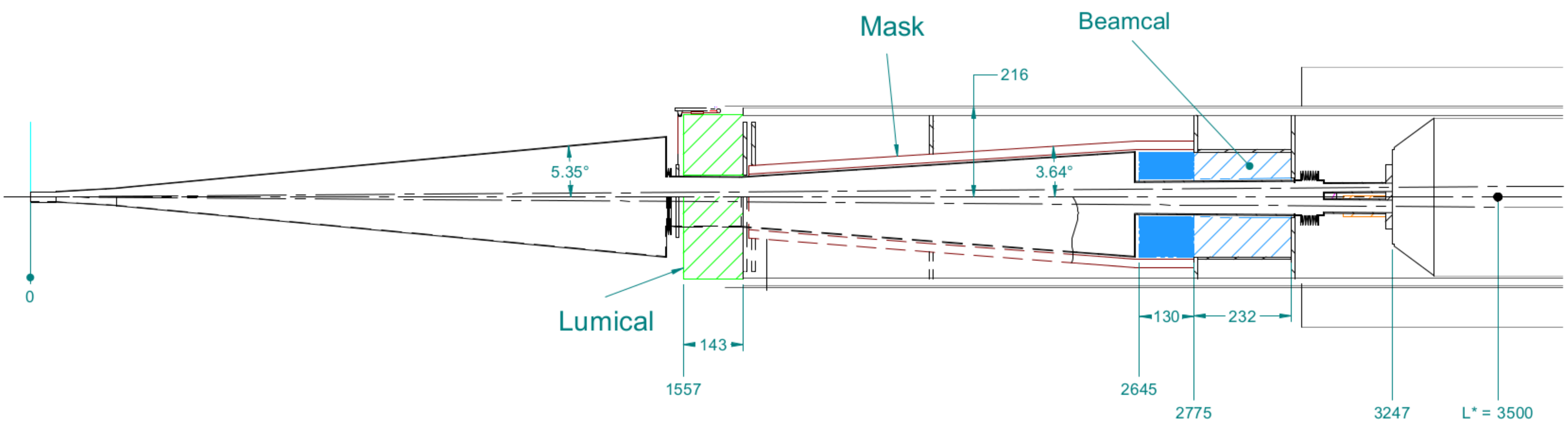
- Major change in baseline option
  - Readout technology
- New baseline option
  - Scintillator bars
  - SiPM readout
  - First engineering desing of the muon layers
- RPC remains an option
  - Still actively being pursued





Marcel Stanitzki

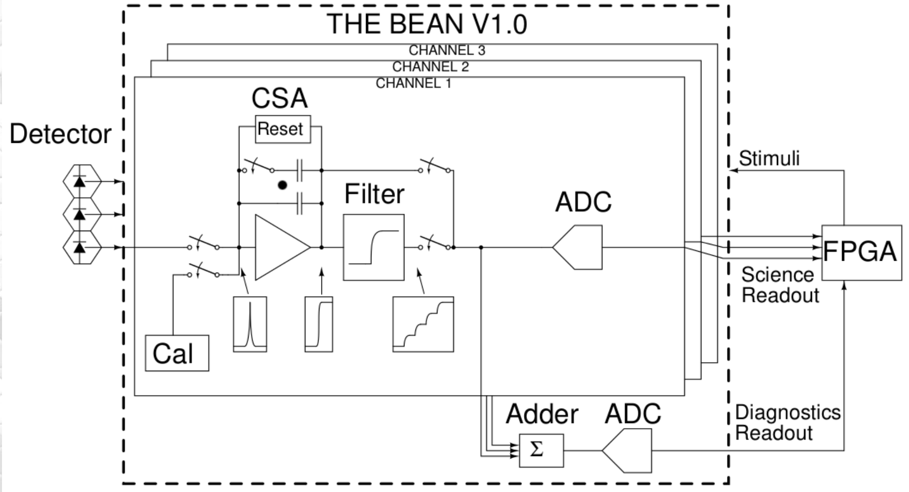
Forward Systems

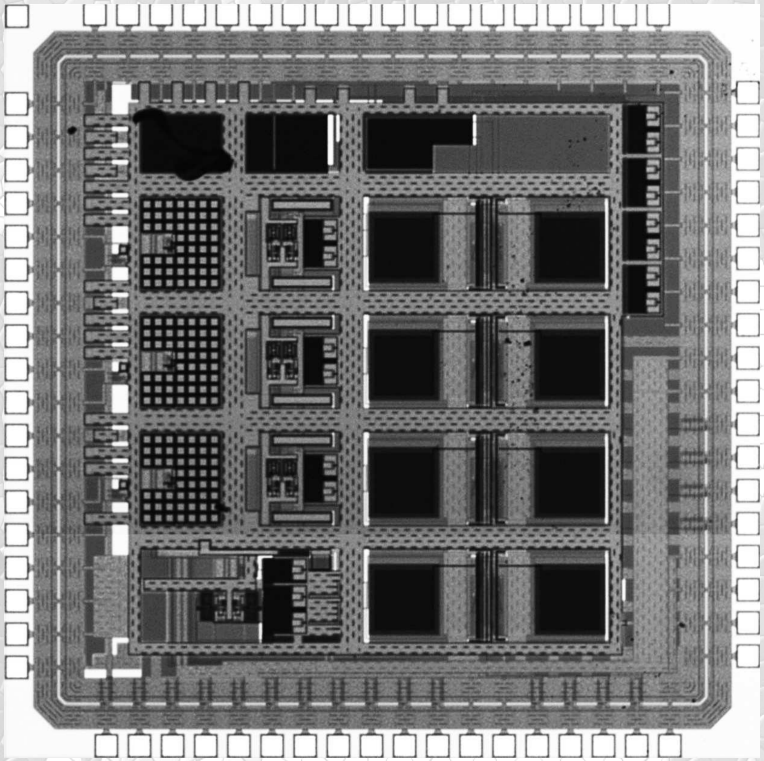


- SiD has two detectors in its forward region
  - LumiCal and BeamCal
  - SiD R&D is part of the worldwide FCAL effort.
  - Close interactions with MDI group
- A dedicated chip for BeamCal (Bean) has been developed

The Bean Chip

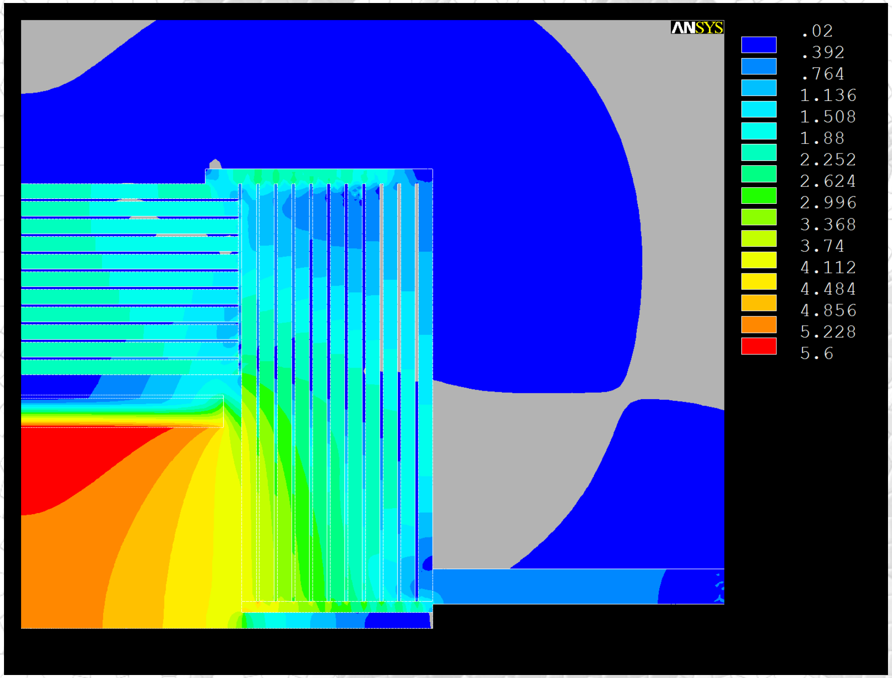
- Bean V1.0
  - Dedicated chip for the high-occupancy environment
- Specs
  - 32 channel
  - 2820 Buffers
  - 10 bit ADC/ channel
  - Fast analog adding
- Successful Test phase just finished

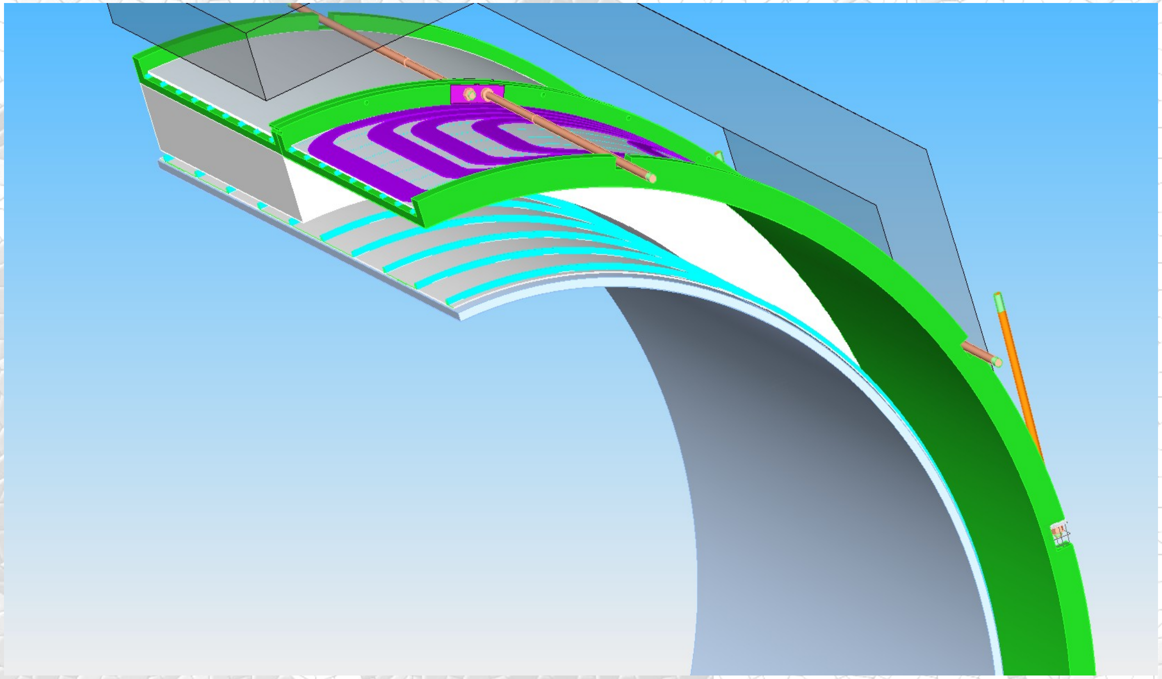




Marcel Stanitzki

Magnet

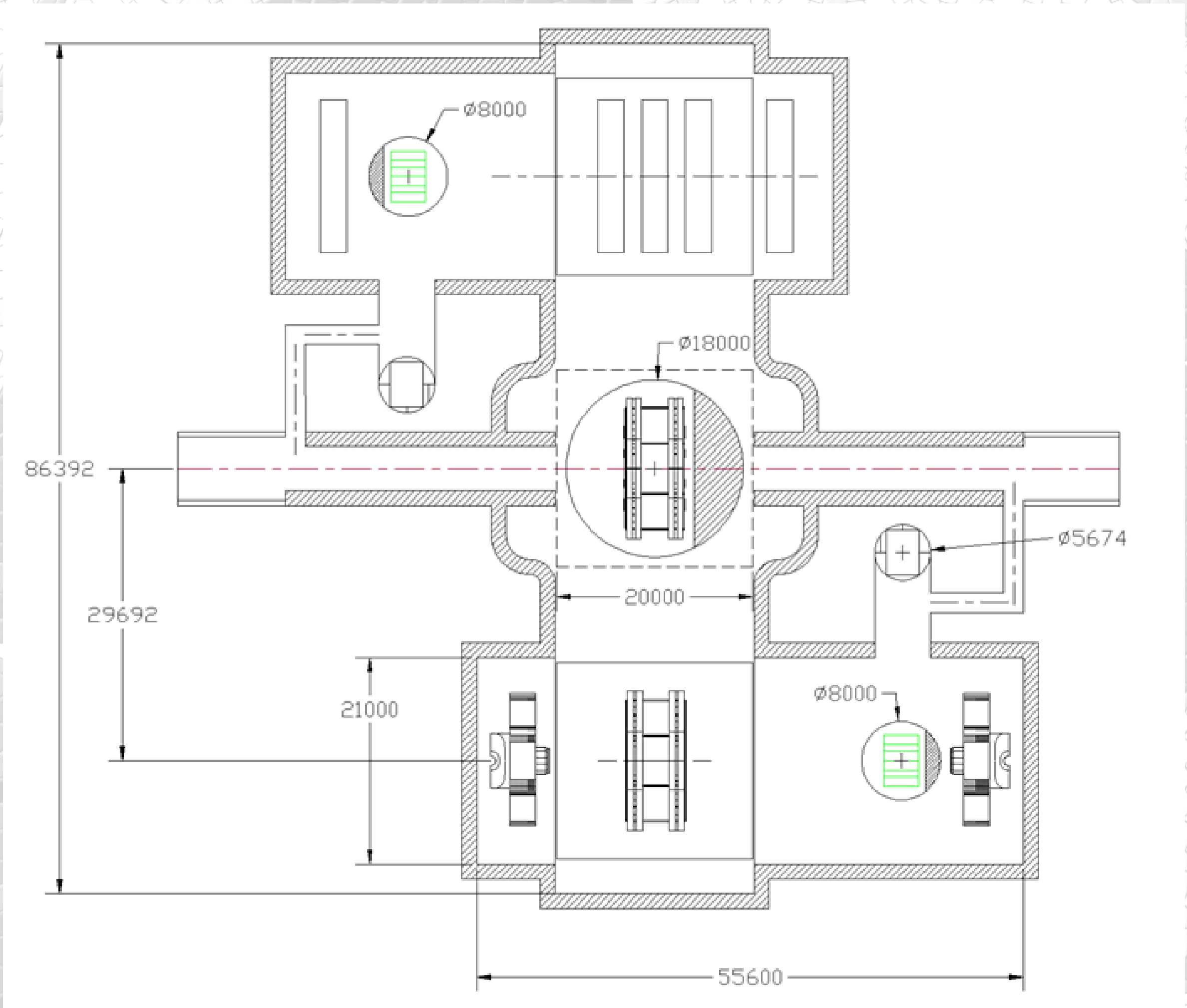




- The 5 T coil builds on the CMS experience
  - Especially on the CMS Conductor
- Engineering challenges are well understood
  - Advances in computing ease the design
- Summary: Feasibility of SiD design demonstrated

Marcel Stanitzki

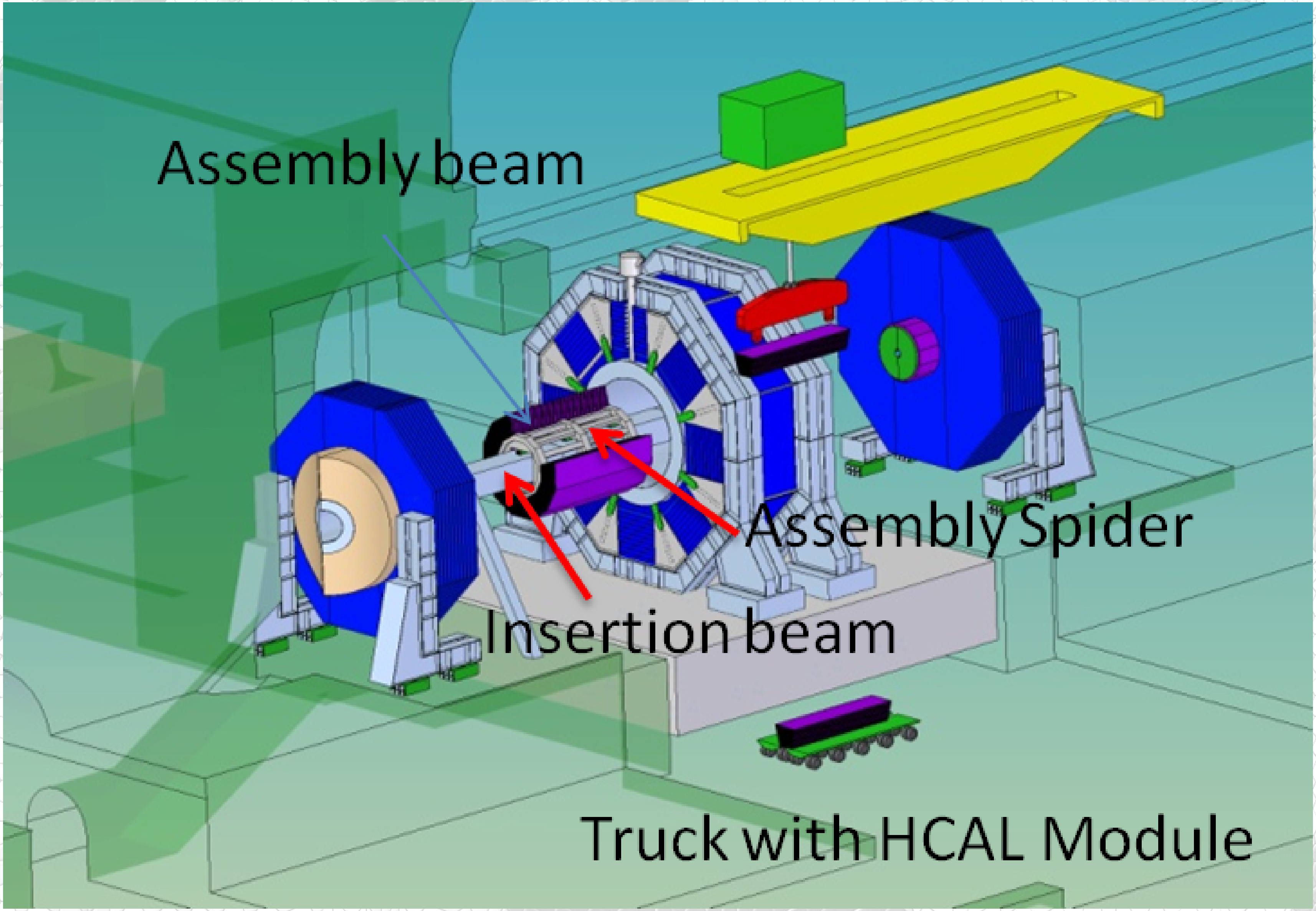
Push-Pull Concept



- Push-Pull using concrete platform
- SiD is optimistic to do Push-pull in a few days
  - Minimum estimate is 32 hours

Marcel Stanitzki

SiD Assembly

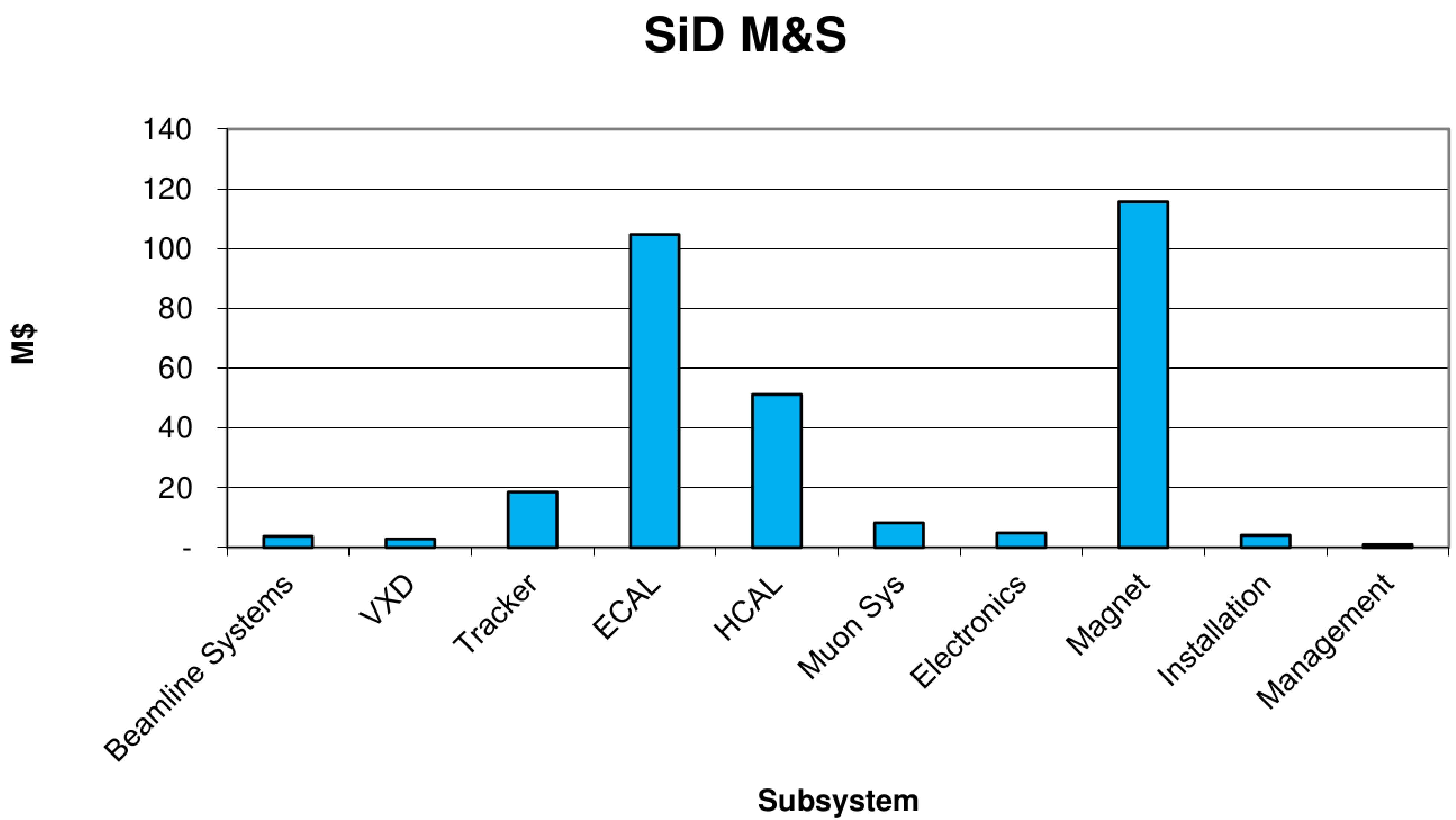


Marcel Stanitzki

SiD Costing

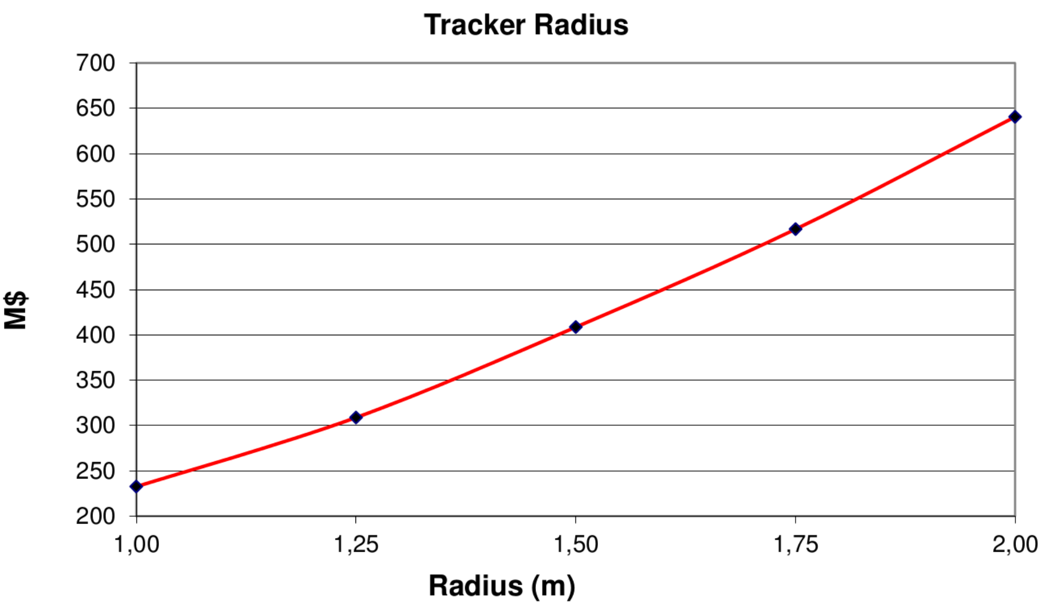
- SiD is using the agreed-upon unit costs
  - As agreed by SiD,ILD and CLIC
- Assuming “almost everything beyond the platform” is machine cost
- Costs in 2008 US-S
  - M&S : 315 M$
  - Contingency: 127 M$
  - Effort: 748 MY
- Cost Sensitivity analysis (double unit costs)
  - Silicon sensors and magnet have largest impact
  - 26 and 14 % cost increase respectively
  -

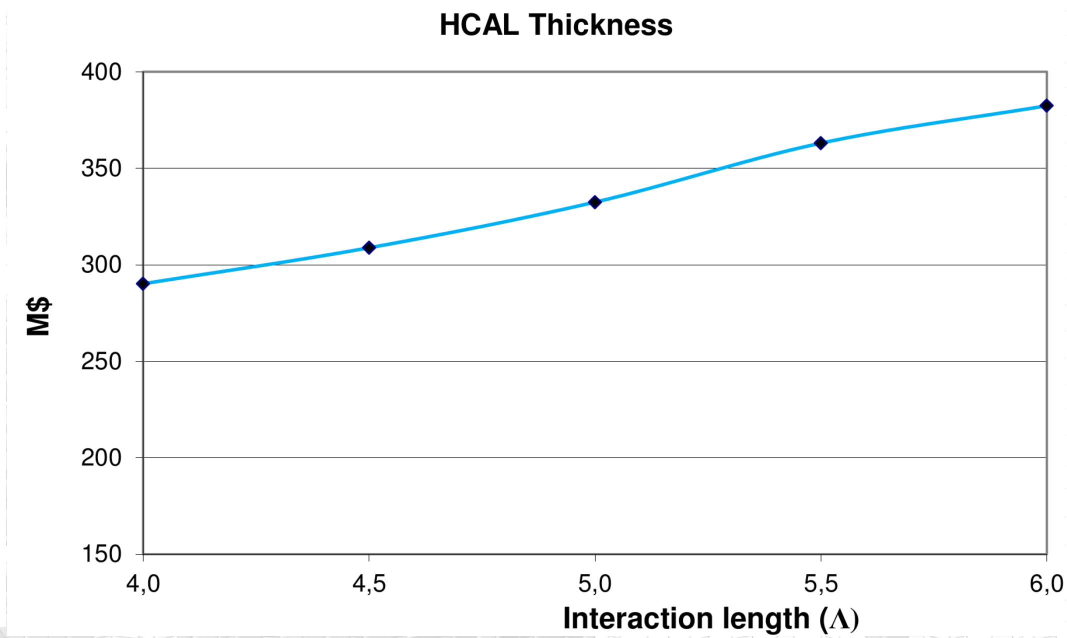
Costing M&S



Marcel Stanitzki

Cost Dependence



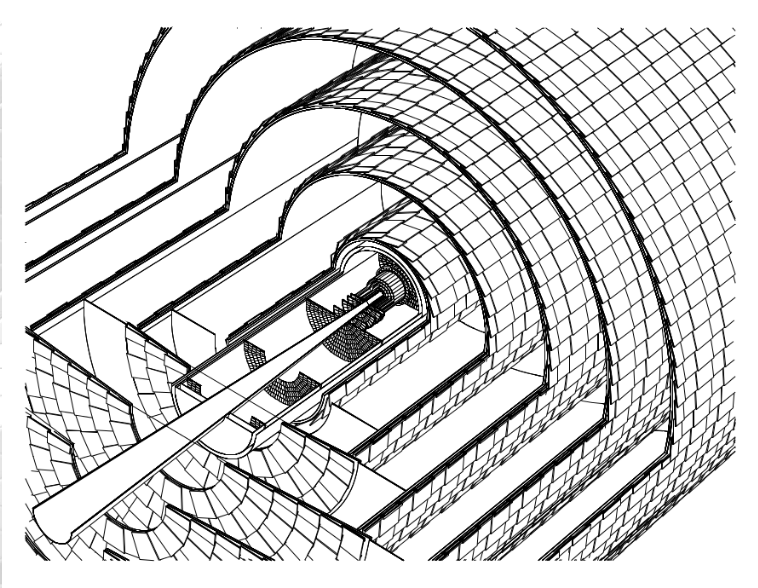


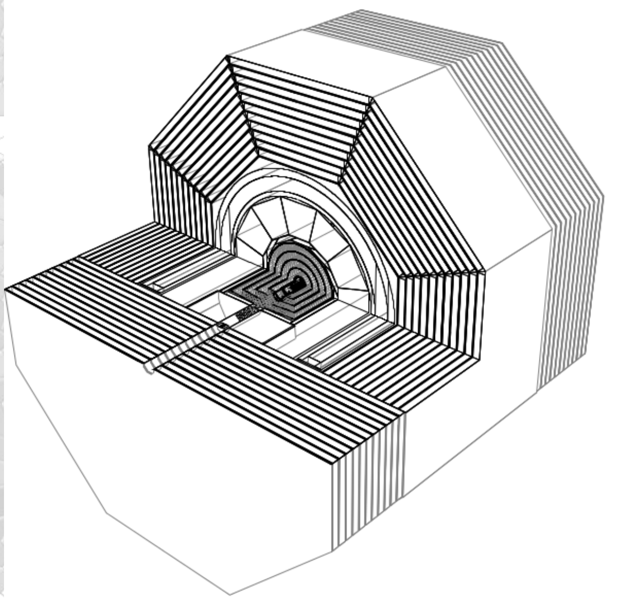
- Parametric Detector costing model allows study of main parameter dependencies
- Shown is Base M&S cost
  - Labor and Contingency excluded

Marcel Stanitzki

Simulation & Reconstruction

- Many updates since LoI
- Simulation
  - Tracker modules and calorimeter segments now simulated
  - Background Overlay
- Reconstruction
  - Improved Tracking
  - Usage of SLICPandora
  - Reconstruction with full backgrounds
- Successfully tested during the CLIC-CDR.





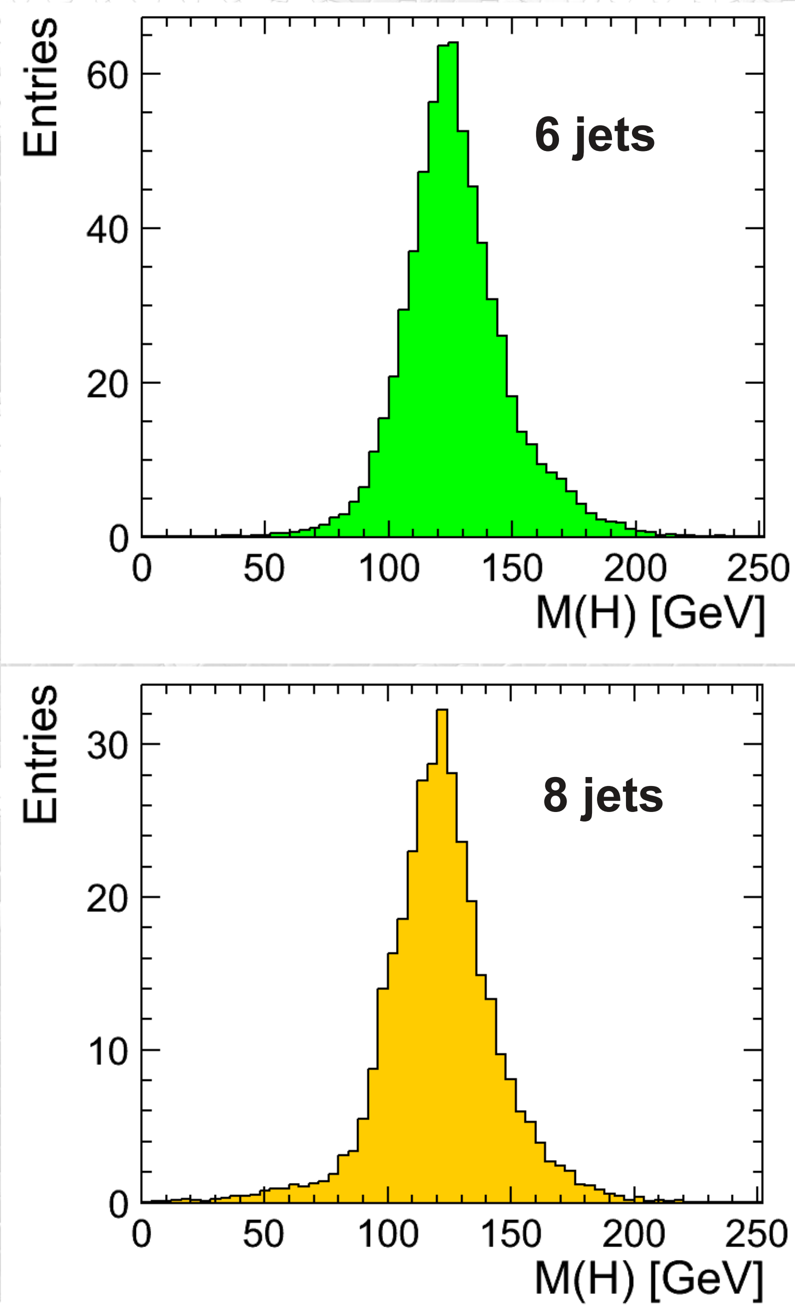
Marcel Stanitzki

Updates since submission

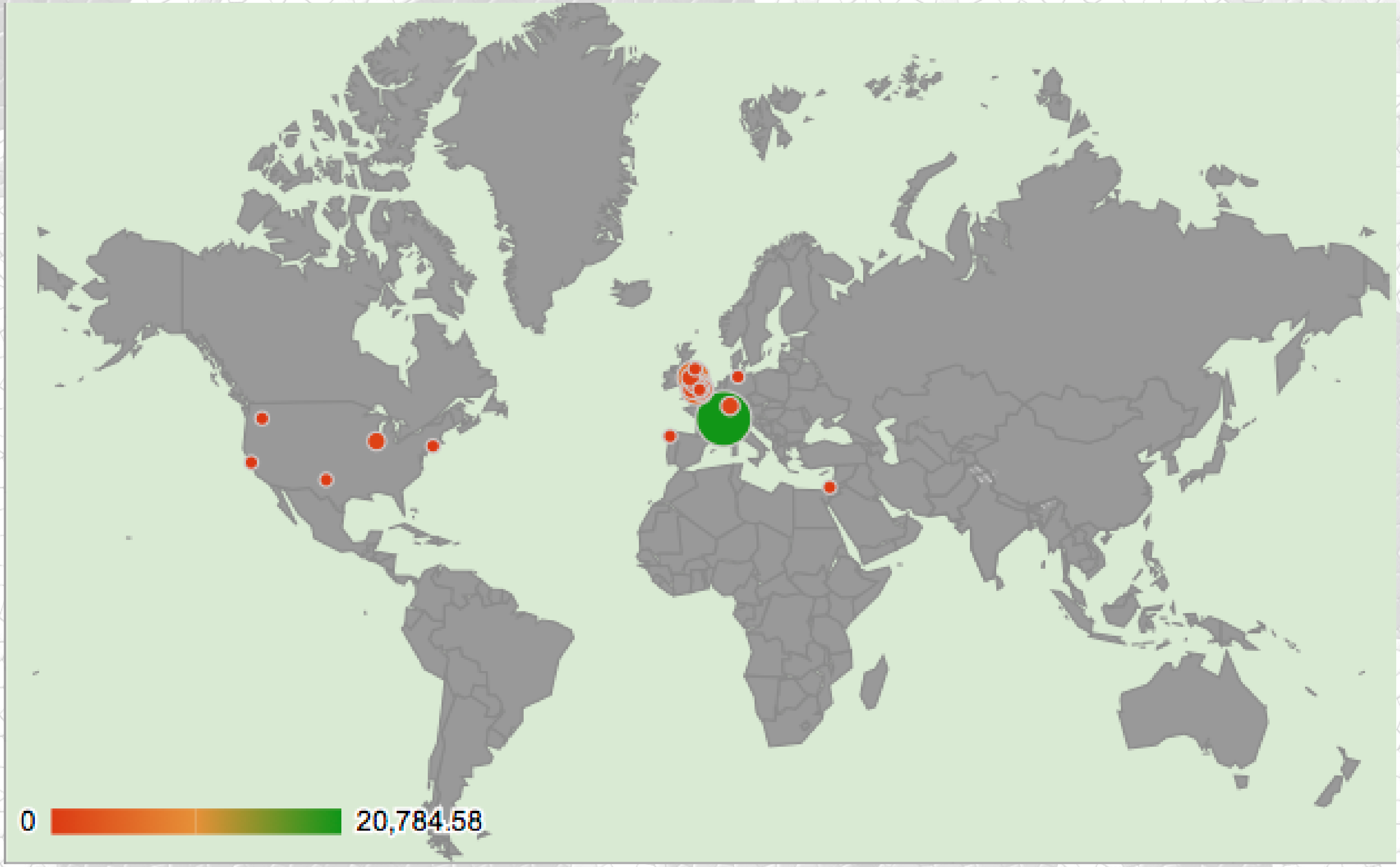
- SiD MC event sample corresponds roughly to 2000 fb^{-1} at E_{cm}=1TeV and 250 fb^{-1} at E_{cm}=500 GeV.
- Background from incoherent e^+e^- pairs and $\gamma\gamma \rightarrow$hadrons are included.
- 66,421,842 events in 60 categories have been simulated and reconstructed; currently in the middle of 2nd iteration of reconstruction following identification of some bugs
- Benchmark analysis tools - flavor tagging, handling of background from incoherent e^+e^- pairs and $\gamma\gamma \rightarrow$hadrons, etc.– have been developed and tested.
- Individual benchmark analyses are at various levels of completion

ttH Status

- Studying ttH at 1 TeV
  - 6 jet and 8 jet final states
  - Full reconstruction
- The physics events were overlaid with beam-related backgrounds corresponding to 1 BX:
  - incoherent pairs (450.000 particles)
  - 4.1 γγ → hadrons interactions
- χ^2 for jet pairing

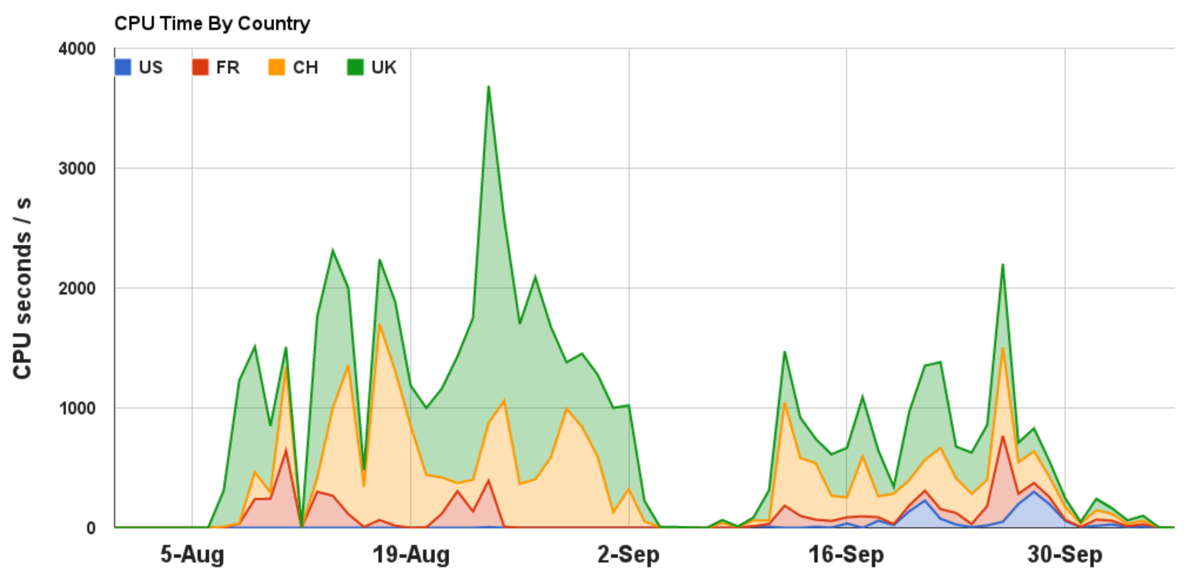


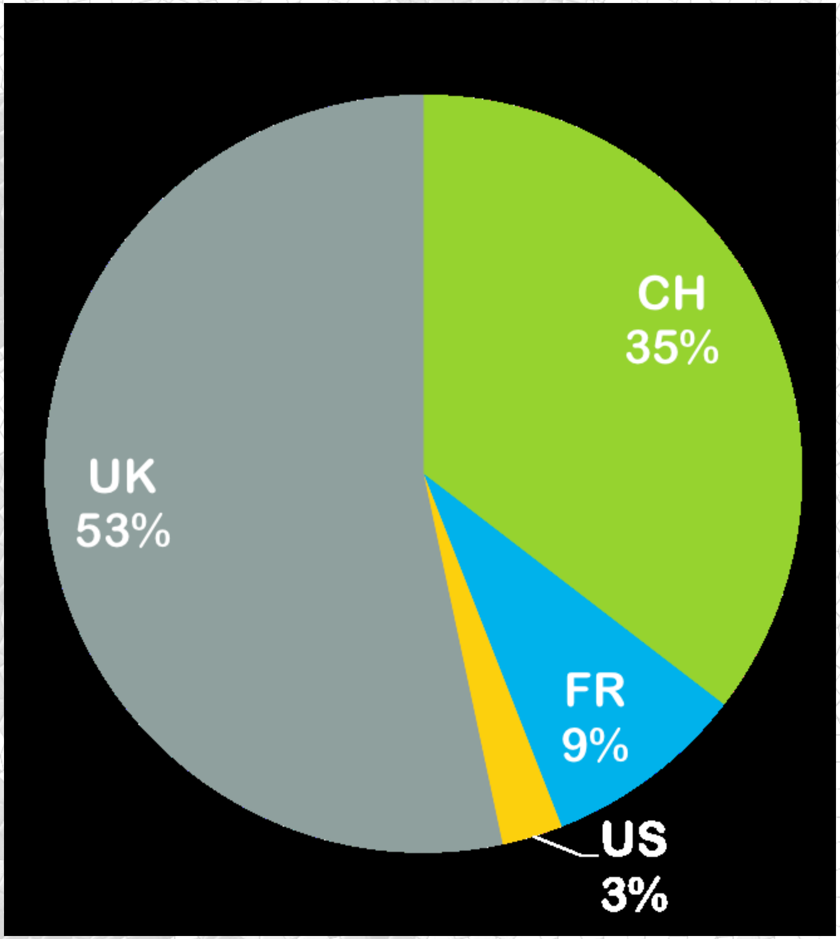
Production update



- Production is an worldwide effort
  - Success at the side, merging the two ILC VOs
- Using ILCDIRAC, already used for the CLIC CDR
  - Well tested system

CPU time per Country





Total Storage: 127 TB in 2,681,083 Files

More details in Jan Strube's Talk

SiD-related Talks at LCWS

- Tuesday 10/23
  - 0900 MDI Update from SiD Marco Oriunno
  - 1118 slic and lcsim Jeremy McCormick
  - 1136 ALCPG software: status and future plans Norman Graf
  - 1212 SiD DBD production (DIRAC) Jan Strube
  - 1400 First results from Tungsten-DHCAL tests Jose Repond
  - 1420 Micromegas/SDHCAL Andy White (for the LAPP group)
- Wednesday 10/24
  - 0940 Measurement of the top Yukawa coupling at sqrt(s) = 1 TeV using the SiD Detector Philipp Roloff
  - 1100 GEM/DHCAL status Seongtae Park

Cont'd

- Wednesday 10/24
  - 1440 SiD silicon-tungsten ECal and KPiX efforts Marty Breidenbach
  - 1500 DECAL using MAPS technology Tony Price
- Thursday 10/25
  - 0930 Current progress on SiD muon detection Gene Fisk
  - 1100 Combined detector performance in the SiD DBD Jan Strube
  - 1120 Occupancies from beam-related backgrounds in SiD at ILC and CLIC Christian Grefe
  - 1600 SiD DBD Tracking Performance Christian Grefe

Summary

- SiD DBD gives a detailed description of the current status
  - Just an overview given
- Significant progress since the LoI
  - Despite difficult funding climate
- Production is well under way
  - Updates are keep coming in
- SiD looks forward to the discussion with IDAG
- SiD is ready for the next phase

Marcel Stanitzki