

Report on the DUNE ND Workshop at DESY.

DUNE Monthly CM Call

Eldwan Brianne
DESY, 8th November 2019



The DUNE Near detector Workshop.

~2 weeks ago

- Open workshop concentrated on the DUNE ND sub-detectors, particularly MPD, Magnet.
- Various topics covered
 - Physics
 - HPgTPC
 - The MPD magnet system
 - MPD ECal
 - Integration in the ND Hall
 - Software

DUNE Near Detector Workshop

21 - 23 October • DESY Hamburg

<https://indico.fnal.gov/event/21340/>

You are invited to attend this open workshop to learn about opportunities and potential for international participation!

Physics opportunities • High pressure gas TPC • Detector magnets • Calorimetry

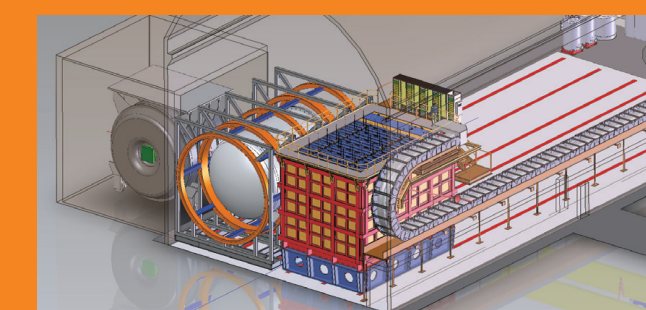
Local Organizers

Eldwan Brianne (DESY)
Matthias Kasemann (DESY)
Lucia Masetti (Mainz)
Krisztian Peters (DESY)
Felix Sefkow (DESY)
Frank Simon (MPP)
Marcel Stanitzki (DESY), Chair
Anita Teufel (DESY)

International Organizers

Alan Bross (FNAL)
Asher Kaboth (Royal Holloway London)
Marco Pallavicini (INFN Genova)
Frank Simon (MPI Munich)
Hiro Tanaka (SLAC)
Alfons Weber (Oxford and UKRI/STFC/PPD)

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The DUNE Near detector Workshop.

Specifics

- Was held for the first time in Germany at DESY
- ~3.5 days of meetings (quite full agenda - 41 talks)
 - Pre-meeting on Sunday and Monday morning
 - Overview of the ND sub-detectors
 - ECAL/HPgTPC
 - Software/Muon system
 - Magnet/Integration
- Participation ~60 people
 - Much more than what was expected!
- Large participation from
 - US, UK, Italy, Germany, France and Switzerland
- Great opportunity for discussions on the potential German contribution to the DUNE ND
- Agenda: <https://indico.fnal.gov/event/21340/other-view?view=standard>



Some highlights.



ECAL Highlights.

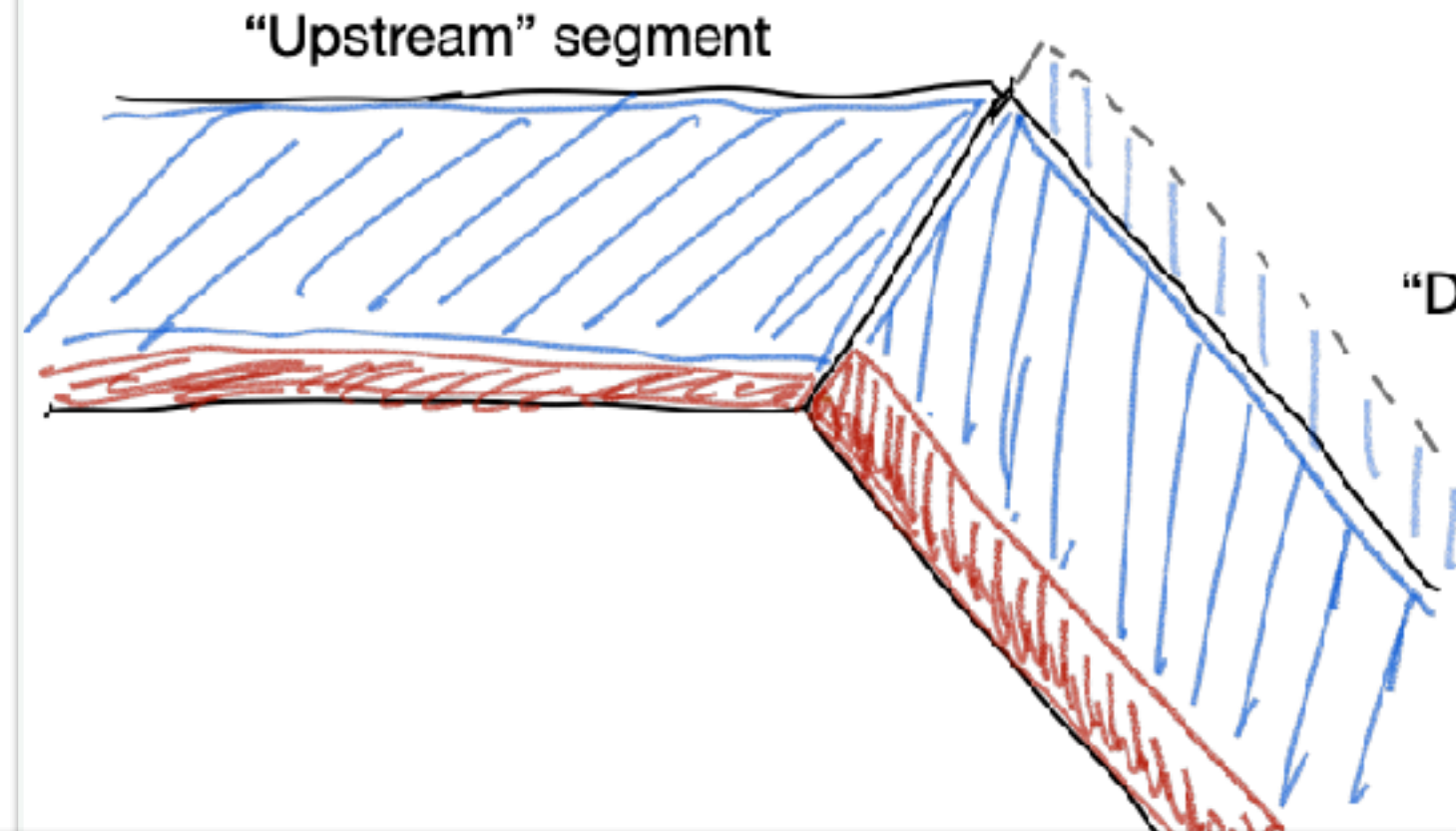
Concept and simulation

- The DUNE ND ECAL Concept is evolving fast to the needs of the ND
- Simulation are ongoing to optimise the detector performance and cost

The Current Detector Model

A starting point - likely not what would get built

Frank Simon (MPP)



- low granularity layers: alternating orthogonal bars
- high granularity layers: tiles

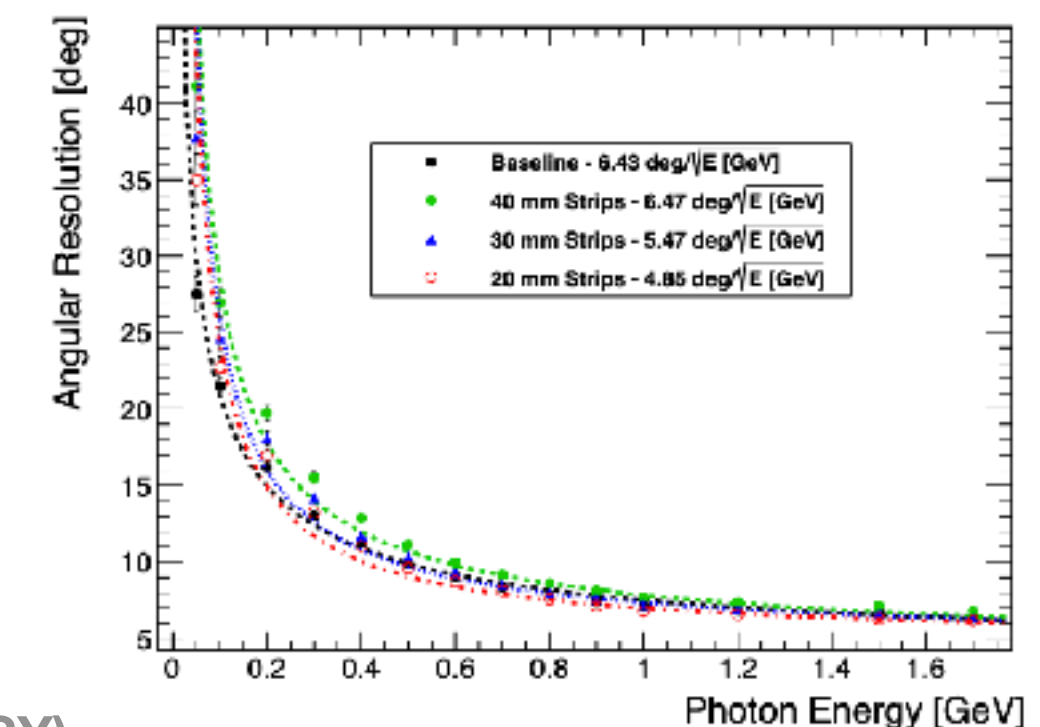
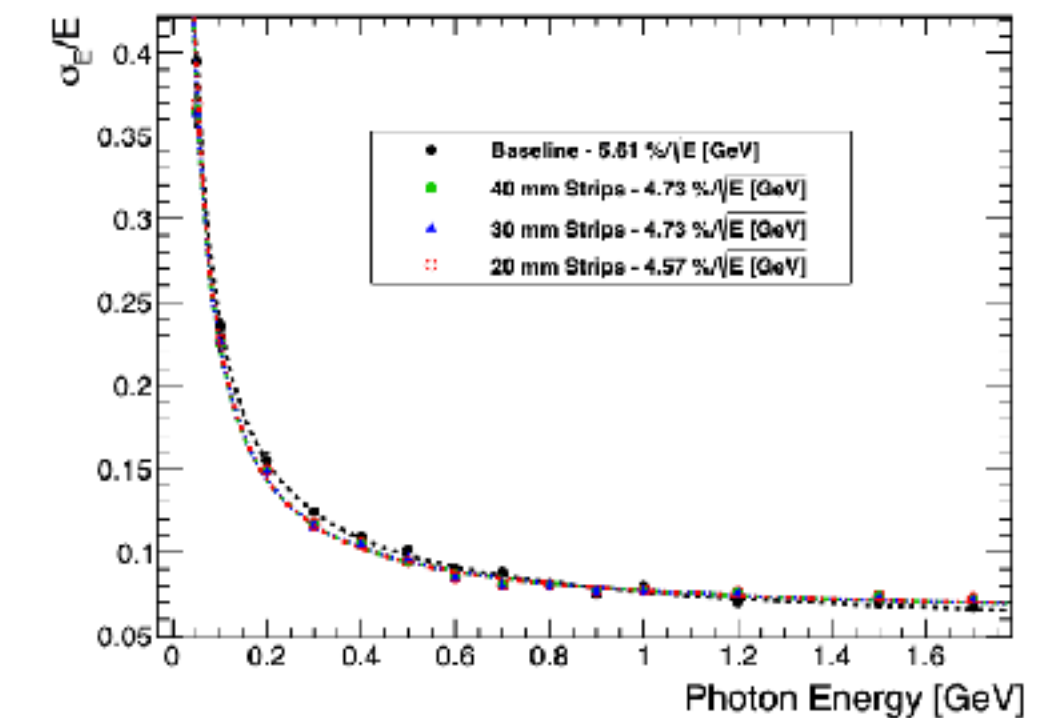
“Downstream” segment

- Downstream layout [3 downstream octagon segments]:
- 60 layers, first 8 high granularity [benefits for energy resolution with 20 additional layers, geometrically possible in detector layout]

Optimisation of the granularity.

Going full strip

- What if we drop the high granular layers?
 - Main cost driver
- Different strip width from 40 mm to 20 mm
- Energy resolution
 - As expected not much change compare to the baseline
- Angular resolution
 - Worse (~10 deg @ 50 MeV to ~few deg at GeVs) for large strip widths
 - Can be “recovered” with smaller strip width (10-20 mm)
 - May be improved with shorter strips
- May be an option, however
 - Timing → Need for fiberless + more transparent scintillator
 - Effect on neutrons?



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ECAL Highlights.

Neutrons!

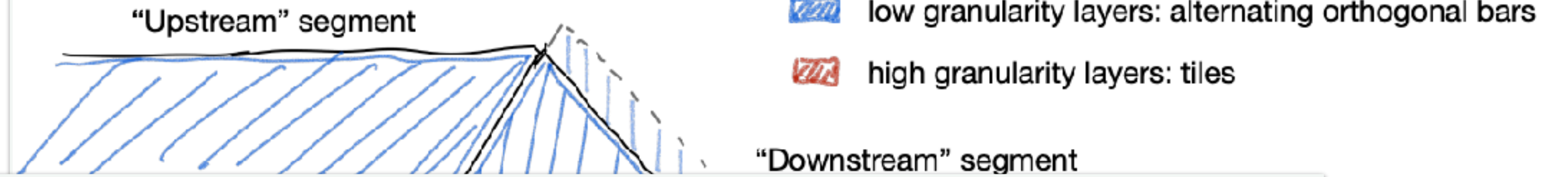
- The DUNE ND ECAL Concept is evolving fast to the needs of the ND
 - Simulation are ongoing to optimise the detector performance and cost
- With the current concept, the ECAL does well at neutron detection and energy reconstruction (optimisation should take it into account)

The Current Detector Model

Frank Simon (MPP)



A starting point - likely not what would get built



Conclusions

Chris Marshall (LBNL)

- Neutron reconstruction from TOF is possible in MPD ECAL, with ~40% efficiency and ~40% (50%) purity in FHC (RHC) mode
- Can further improve purity by looking at forward events only, or looking at leading neutron only, up to ~60-70%
- But energy resolution is poor, and biased toward low neutron KE, primarily due to missing the initial neutron interaction
 - This could be improved by reducing the passive fraction, or by adding a (10s cm) fully-active inner ECAL
- This measurement is interesting and worth pursuing as is – but is it worth re-optimizing the ECAL design to improve it?

stream octagon

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mpp.mpg.de)

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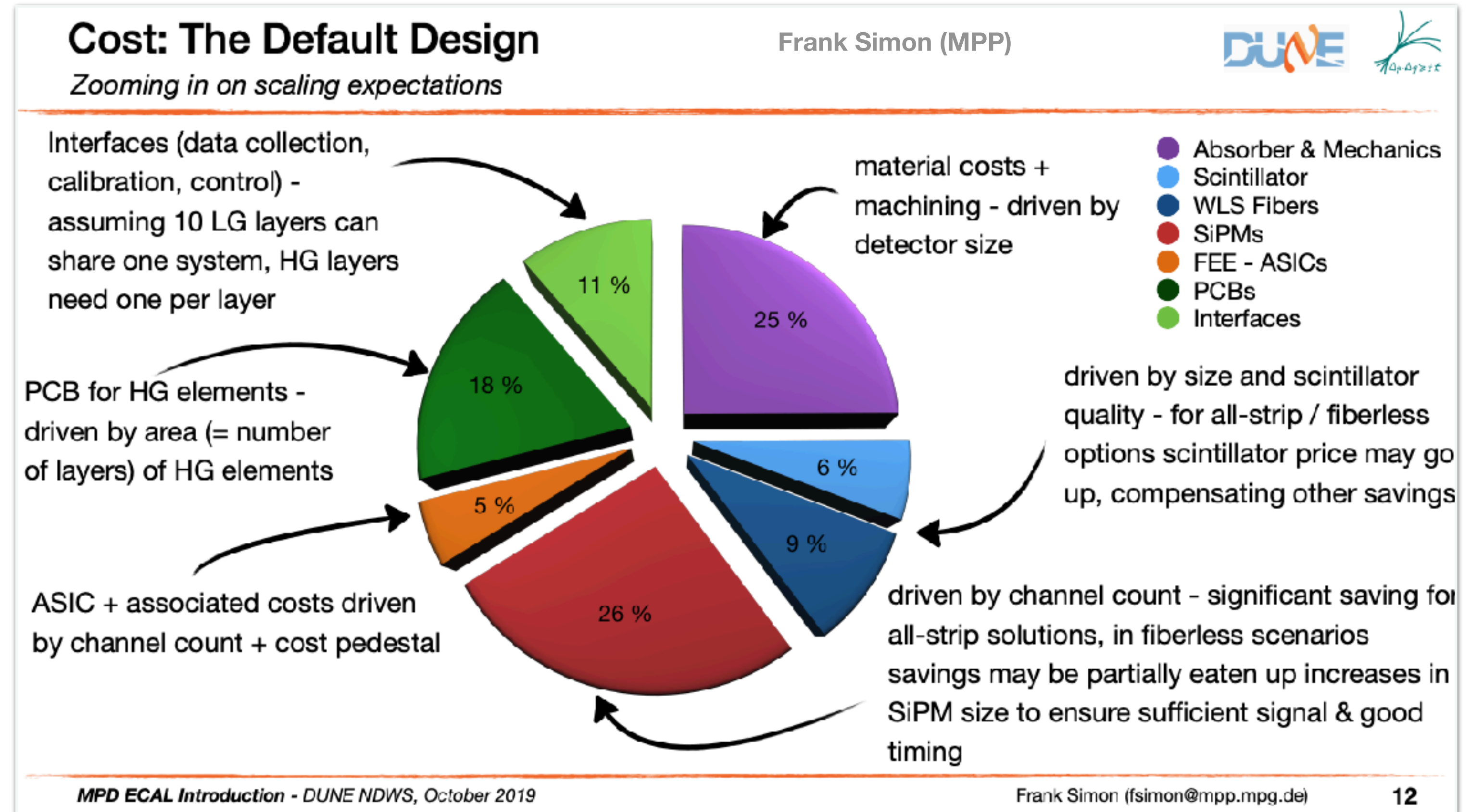
Chris Marshall



ECAL Highlights.

Cost modelling

- The DUNE ND ECAL Concept is evolving fast to the needs of the ND
 - Simulation are ongoing to optimise the detector performance and cost
- With the current concept, the ECAL does well at neutron detection and energy reconstruction (optimisation should take it into account)
- A cost model is well established and understood where the main cost drivers are



ECAL Highlights.

Expertise from Germany

- The DUNE ND ECAL Concept is evolving fast to the needs of the ND
 - Simulation are ongoing to optimise the detector performance and cost
- With the current concept, the ECAL does well at neutron detection and energy reconstruction (optimisation should take it into account)
- A cost model is well established and understood where the main cost drivers are
- Can benefit from the expertise of several German groups
 - DESY (AHCAL/CMS), Mainz (Ship), ASIC design (Heidelberg)

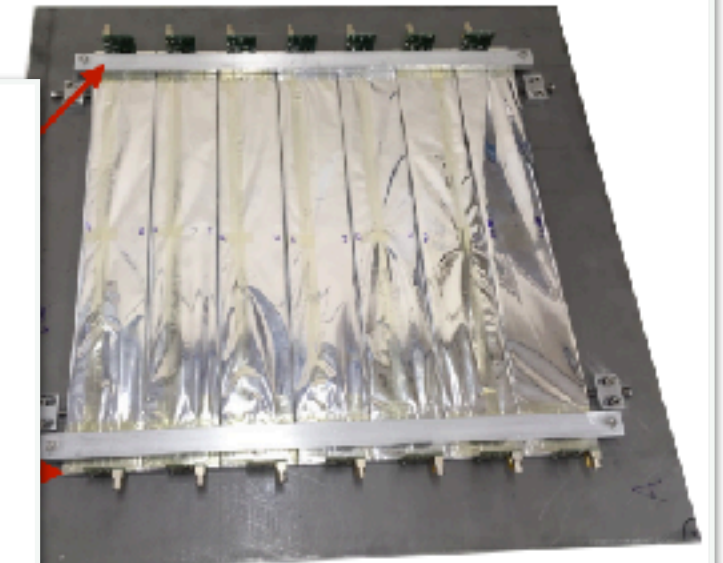
Scintillating Planes

Rainer Wanke (U Mainz)



Each scintillating plane consists of one absorber plate, with 7 scintillating strips mounted.

- ▶ Double-sided readout → $2 \times 7 = 14$ chan/plane.
- ▶ 2 horizontal & 2 vertical planes.
- ▶ SiPMs, preamps, and bias voltage mounted



Absorber plate with 7 strips

2nd, 2019 JGU 16

Technologies for Highly Granular Calorimeters

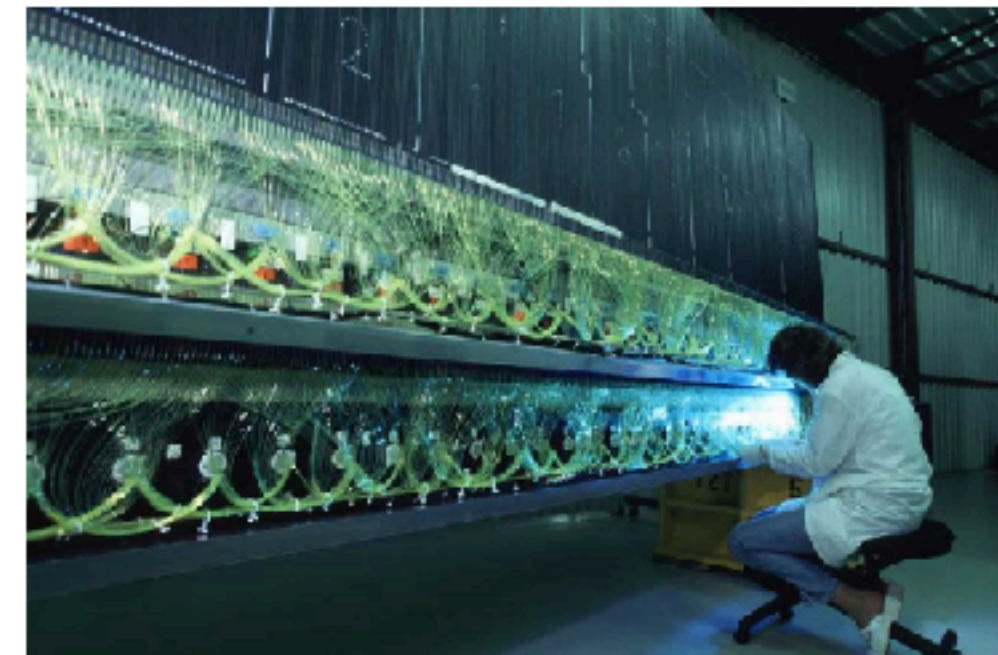
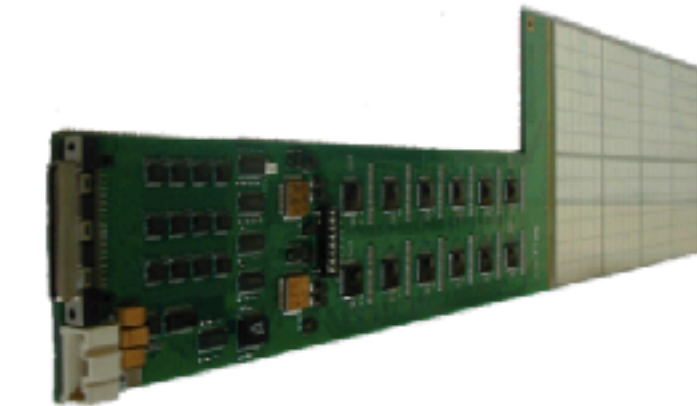
Because we can.

Large area silicon arrays

- silicon calorimetry grows out of the domain of small plug devices

New segmented gas amplification structures (RPC, GEM, μ Ms)

Silicon photomultipliers on scintillator tiles or strips



DESY. CALICE High Granularity SiPM-on-Tile Prototype | Felix Sefkow | May 22,

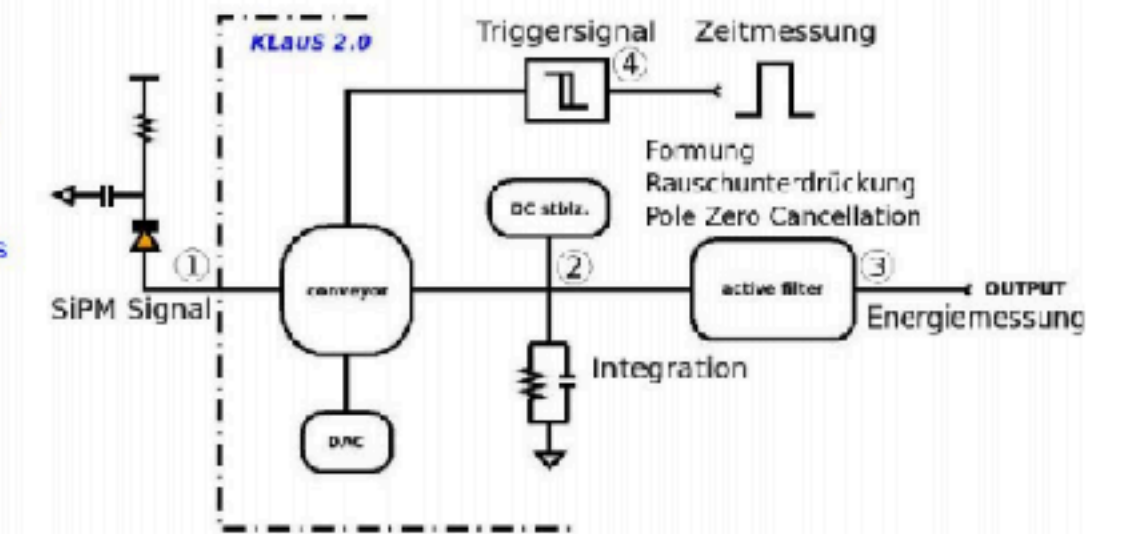
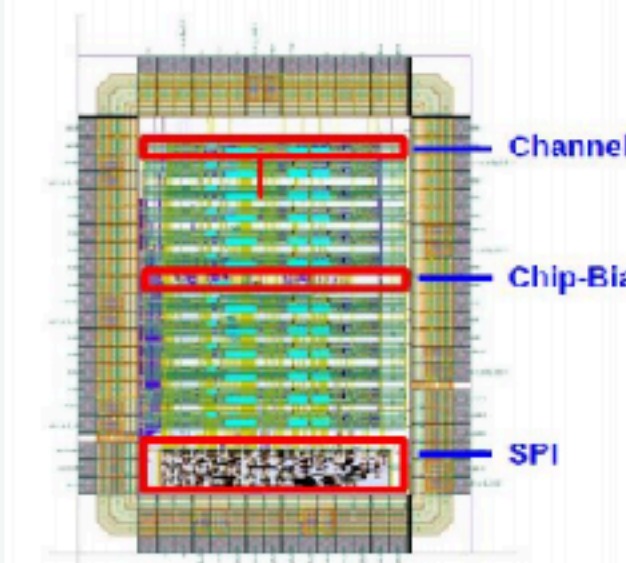
Felix Sefkow (DESY)



3x3cm² tile

KLauS overview

Wei Shen (U Heidelberg)



- 12 Channels
- SiPM bias tuning with a 8bit DAC
- Trigger with low time-jitter

- Analog output for charge measurement
- SPI configuration
- Powergating Capability



TPC Highlights.

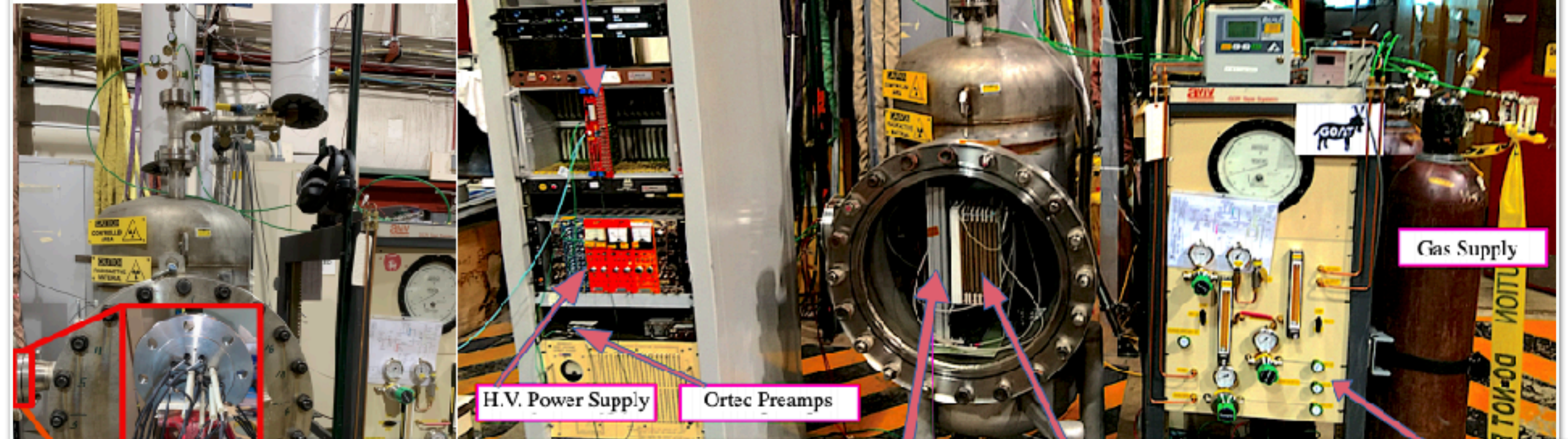
Test stands

- The design of the TPC is going forward
- Testing of ALICE chambers is ongoing at different voltages and pressures at Fermilab and RHUL/ICL
- Great ideas are coming for T0 fluorescence tagging

Description of the Test Stand

relatively more out-dated picture of GOAT

Tanaz Mohayai (Fermilab)



2019-1

OROC arrival and first steps

Alexander Deisting (RHUL)

- ▶ We received a ALICE TPC test (MWPC) OROC in its original test box.
- ▶ As first step we got tools produced, which allow to access the OROC in the test box.
- ▶ To ensure that the chamber is in theory functional, we did an optical inspection, resistance and capacitance measurements as well as HV tests in air
- ▶ During these tests the OROC was mounted again into the test box, in preparation for tests in gas
- ▶ The test box is equipped with Mylar windows on the cathode side as well as a field cage, allowing for a uniform drift field over 12 cm



(A. Deisting – RHUL)

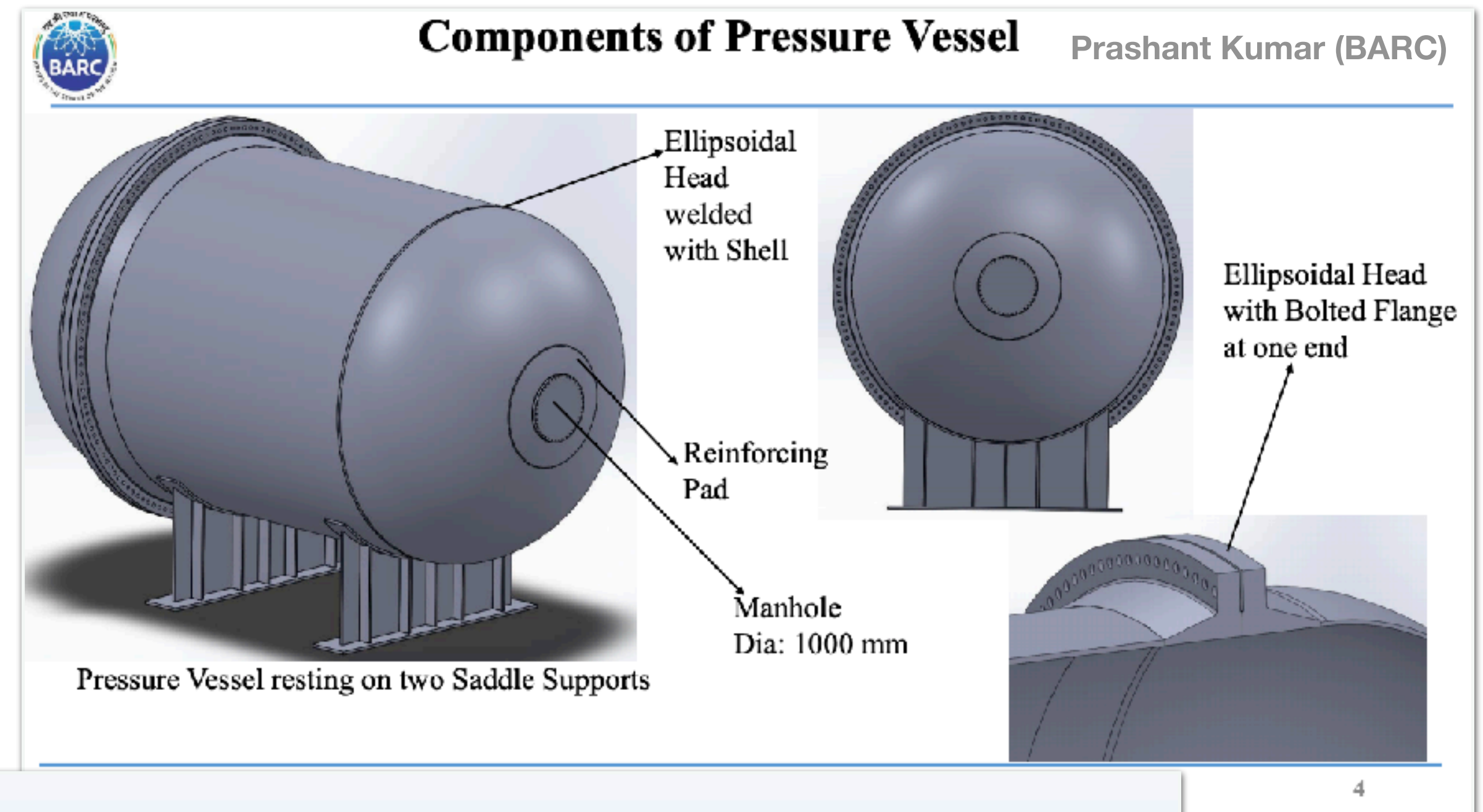
22.10.2019 – DESY ND workshop

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TPC Highlights.

PV and Readout

- The design of the TPC is going forward
- Testing of ALICE chambers is ongoing at different voltages and pressures at Fermilab and RHUL/ICL
- Great ideas are coming for T0 fluorescence tagging
- The design of the pressure vessel is well advanced! Minimum material between TPC and ECAL + would be able to support 300t mass ECAL
- The central region has few preliminary designs \Rightarrow more work is needed in this area
- A conceptual design for the TPC readout is ongoing \Rightarrow occupancy will drive the system requirements



Requirements

Patrick Dunne (ICL)

- Single hit resolution in z direction: aiming for at worst 1cm
- Number of channels: ~700,000 (ALICE ROCs + central region)
- Internal buffering must be sufficient for a trigger decision to be made
 - Exact value for this depends on other aspects of readout system so no hard number
- Dynamic range must be sufficient for signals from both protons and MIPs in 10 bar of Argon
- Heat output into the detector volume should not affect temperature stability of TPC active region

Patrick Dunne

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Imperial College London



Muon System Highlights.

Conceptual design/ideas

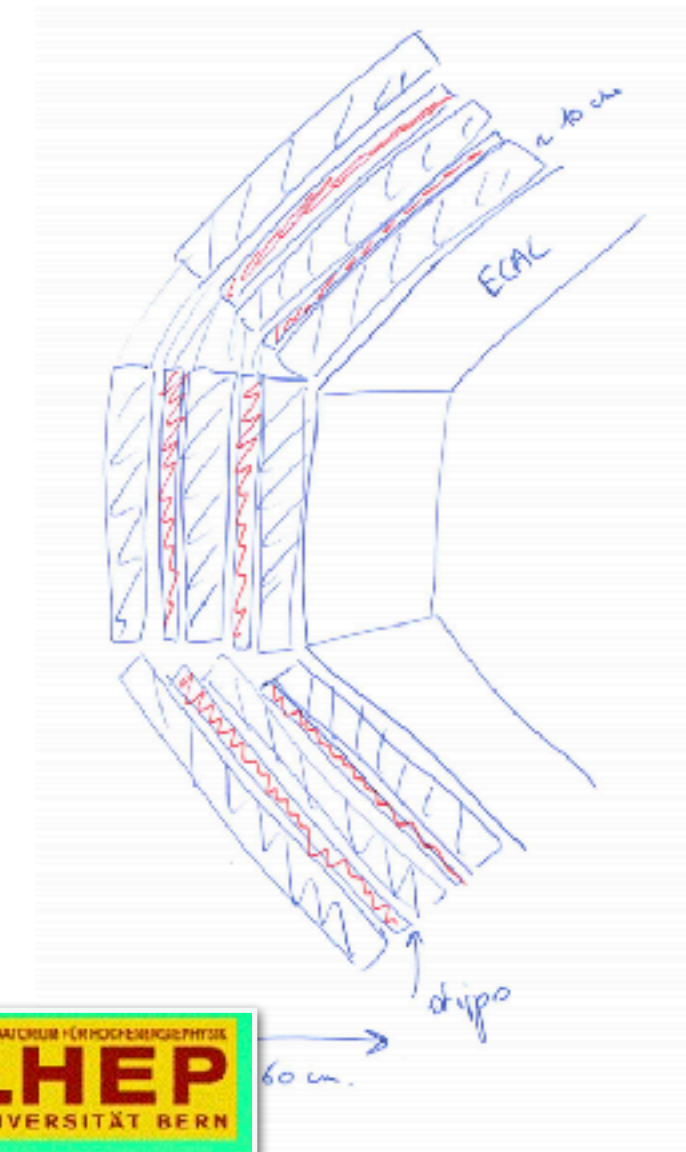
- A muon system is critically needed for the MPD
 - Needs to separate pions/muons (no need to measure the momentum)
- Few thoughts are being put into it
 - Integration after the ECAL between the MPD coils
 - Relatively similar to ECAL design with thick absorbers and strips, could use other technologies
- Design correlated to the magnet design
 - Could be integrated in a Yoke (see later slides)
- Need for simulation studies
 - Acceptance
 - Integration

Design ideas/requirements.

Simplistic muon tagger

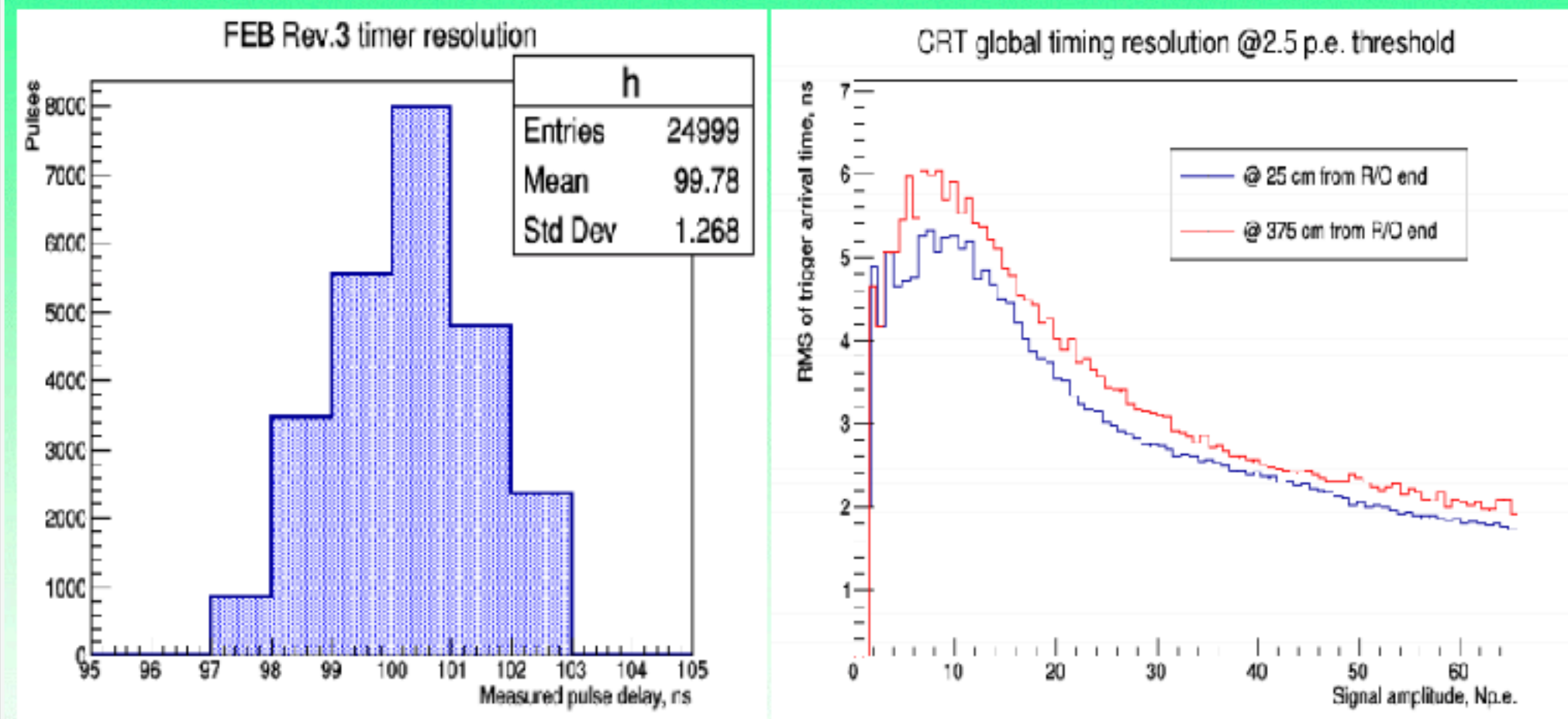
- Simplistic design
 - Large slabs of lead/iron/brass interleaved with scintillator strips
 - Fiber(less)
 - Readout SiPM/PMTs on both sides
- Needs to be ~ 3 lambda thick (98% of pions will interact)
 - $\rightarrow \sim 60$ cm
 - Very limited space after ECAL and between the magnet coils
- Very good MIP efficiency (light collection efficiency, uniformity)
- Timing requirement?
 - \sim ns scale? Bkg reduction?
- Energy loss in iron ~ 11 MeV/cm

Eldwan Brianne (DESY)



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Timing resolution of the 4-m long scintillating bar
Measured with 60-ps 400-nm laser pulse



Event time resolution ranges from 1.7 ns (near end) to 6 ns (far end)


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Igor Kreslo (LHEP)



Software Highlights.

DAQ/Delivery for the CDR

- First discussions on what the ND DAQ should look like
 - Trigger modes, rate, clock precision...
 - Working group is being put in place to provide an initial plan by the January CM
- Software integration group has been working hard to bring the sub-detectors together
 - Full ND suite almost there
- Rock samples have been produced
- Per-detector samples have been produced
- Overlaying in progress
 -  to be used for low-level analysis for the CDR / TDR
- Looking forward
 - Use of different generators, reconstruction framework

Asher Kaboth (RHUL)

Questions

- How unified should the DAQ be?
- What are the triggering modes?
- What are the data rates?
- What is the clock precision needed?
- What technology agreements needed between sub-detectors?
- What existing technology should we use/what new technology needs to be developed?



CDR Request and Status

- Request: Full spill ND Suite simulation through GENIE w/ parameterized performance assessments.
 - ✓ Full hall geometry with upstream rock
 - ✓ Choice of origin
 - ✓ Flux windows for event and rock generation
 - ✓ Gsimple file production
 - ✓ Rock event production
- Detector event production (In Progress)
- Overlaying (In Progress)

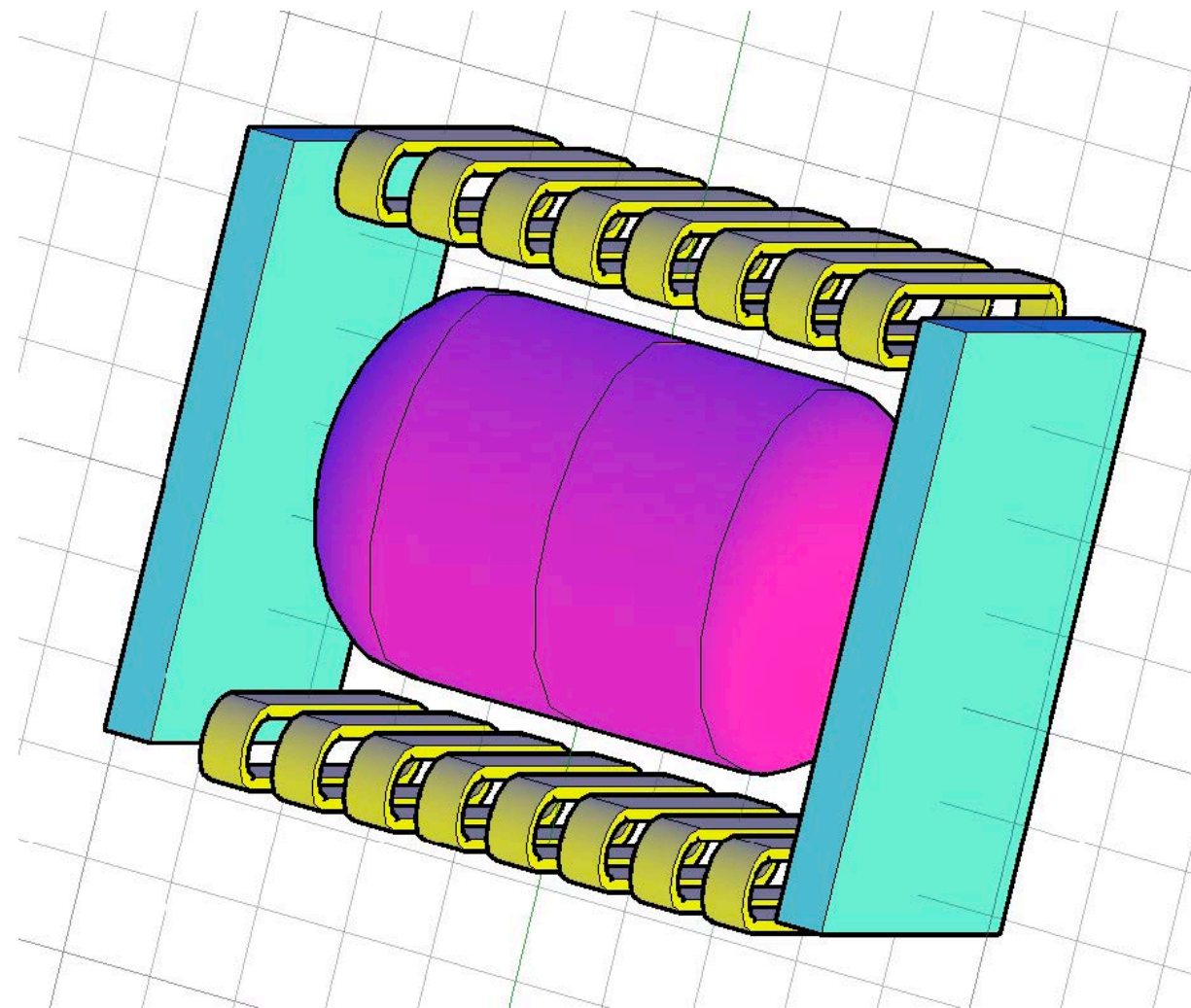
Mathew Muether (WSU)



Magnet Highlights.

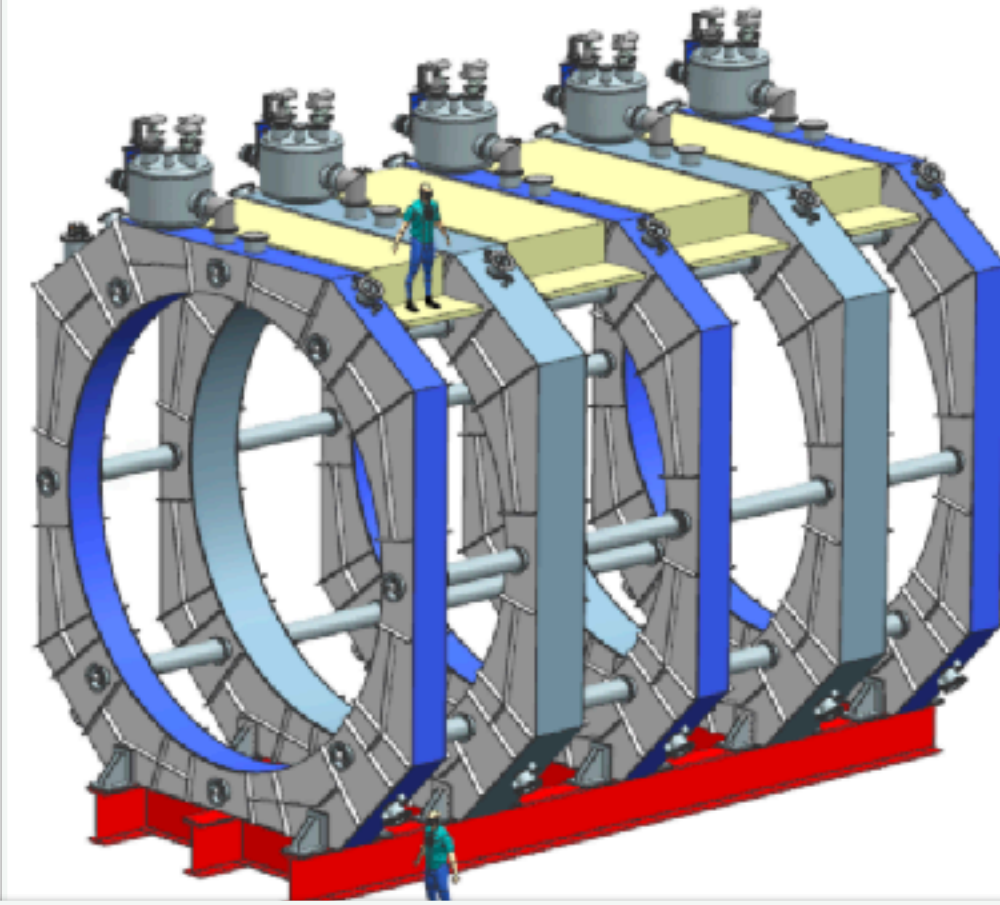
Getting very mature

- A reference design for the MPD magnet is well defined (5 Helmholtz coils)
 - Alternatively, 3 or 2 with PRY coils design are being discussed
- An alternative design appears promising
 - Solenoid with partial return yoke studied in Genoa
- Double dipole concept (with racetrack coils) is dropped



Alan Bross (Fermilab)

MPD Magnet Reference Design: Superconducting 3-coil Helmholtz with 2 superconducting bucking coils

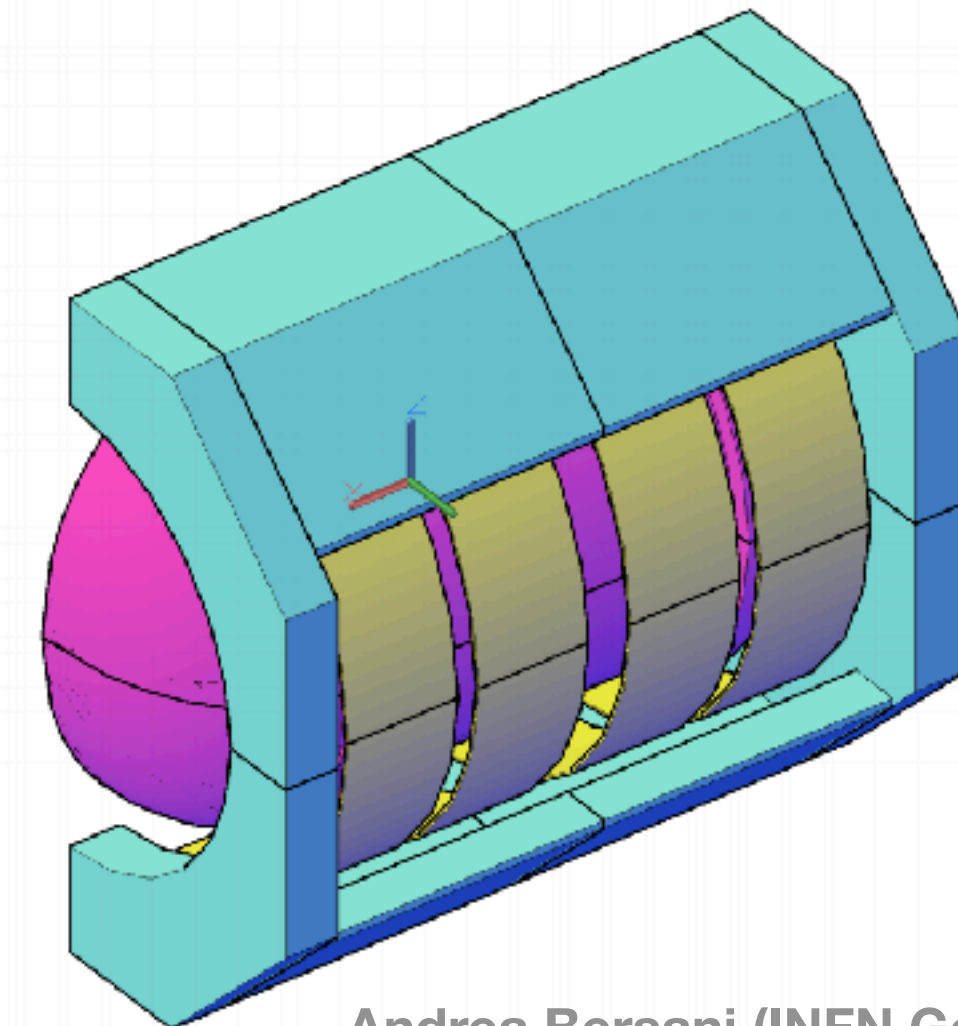


Reference design:

- All cryostats have the same inner radius (3.5m)
 - Permits ECAL to be inside
- Side coils at 2.5 m, shielding coils placed at 5 m from the magnet center in Z.
 - Center and shielding coils are identical.
- Central field = 0.5T
- **Overarching requirements**
 - Large acceptance for particles leaving LAr

Solenoid with Partial Yoke (SPY@DND)

- ↪ Solenoid with a "window" in the yoke
 - ↪ closing the magnetic circuit where iron does not affect particles
- ↪ Good for
 - ↪ reducing stray field
 - ↪ reducing stored energy
 - ↪ having uniform material budget
- ↪ Bad for
 - ↪ heavier
 - ↪ ~ 10cm of aluminium along particles path (outside the calorimeter)



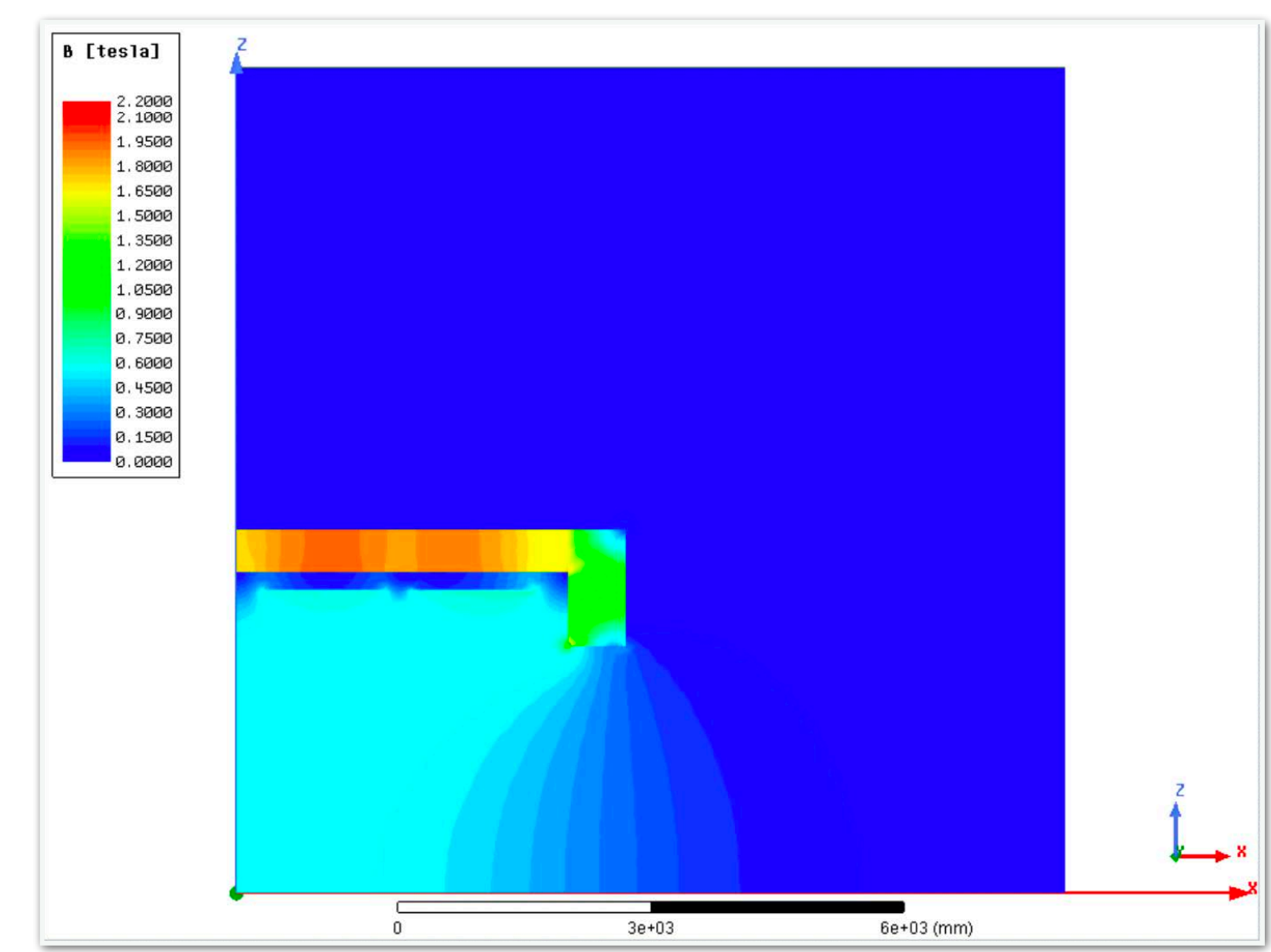
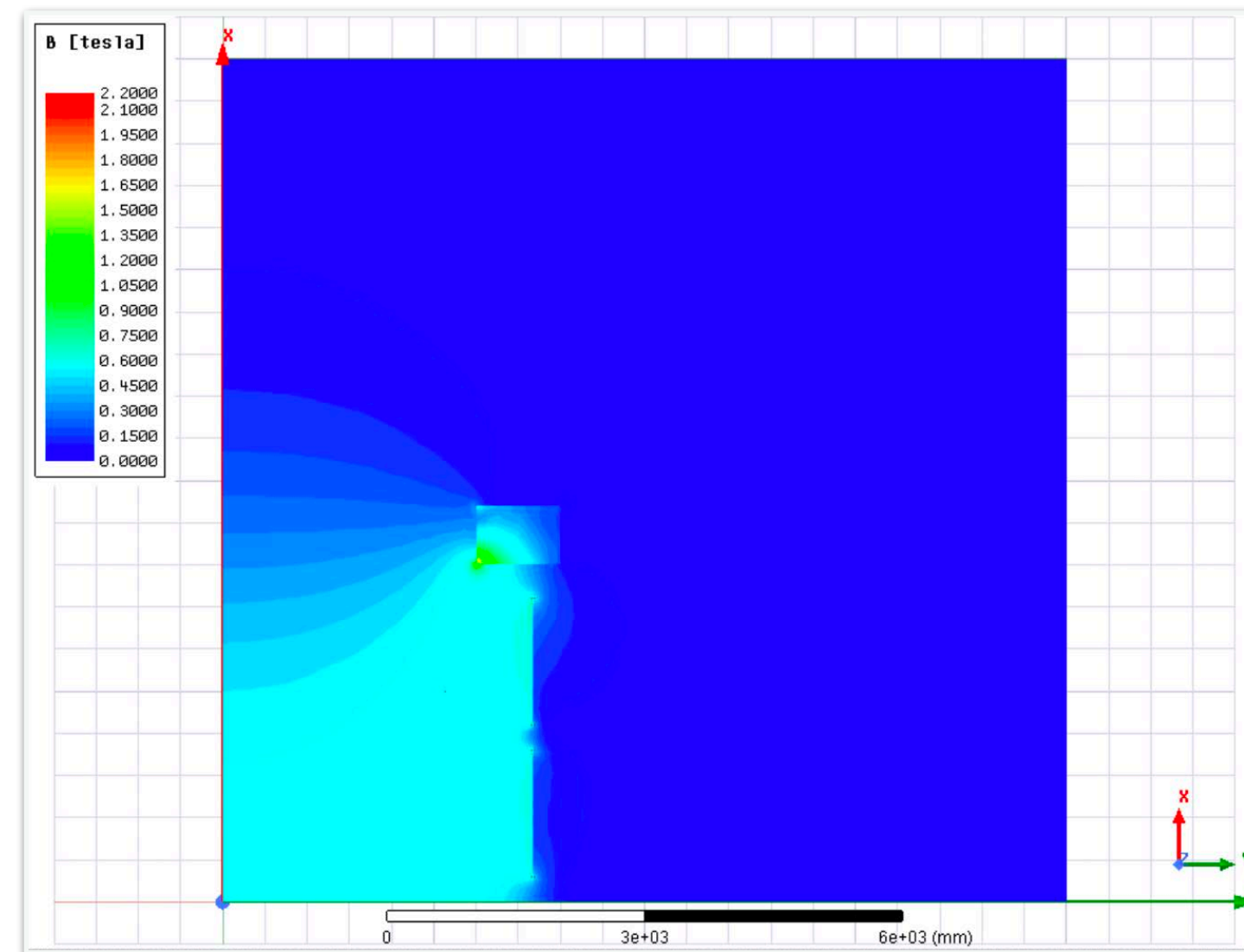
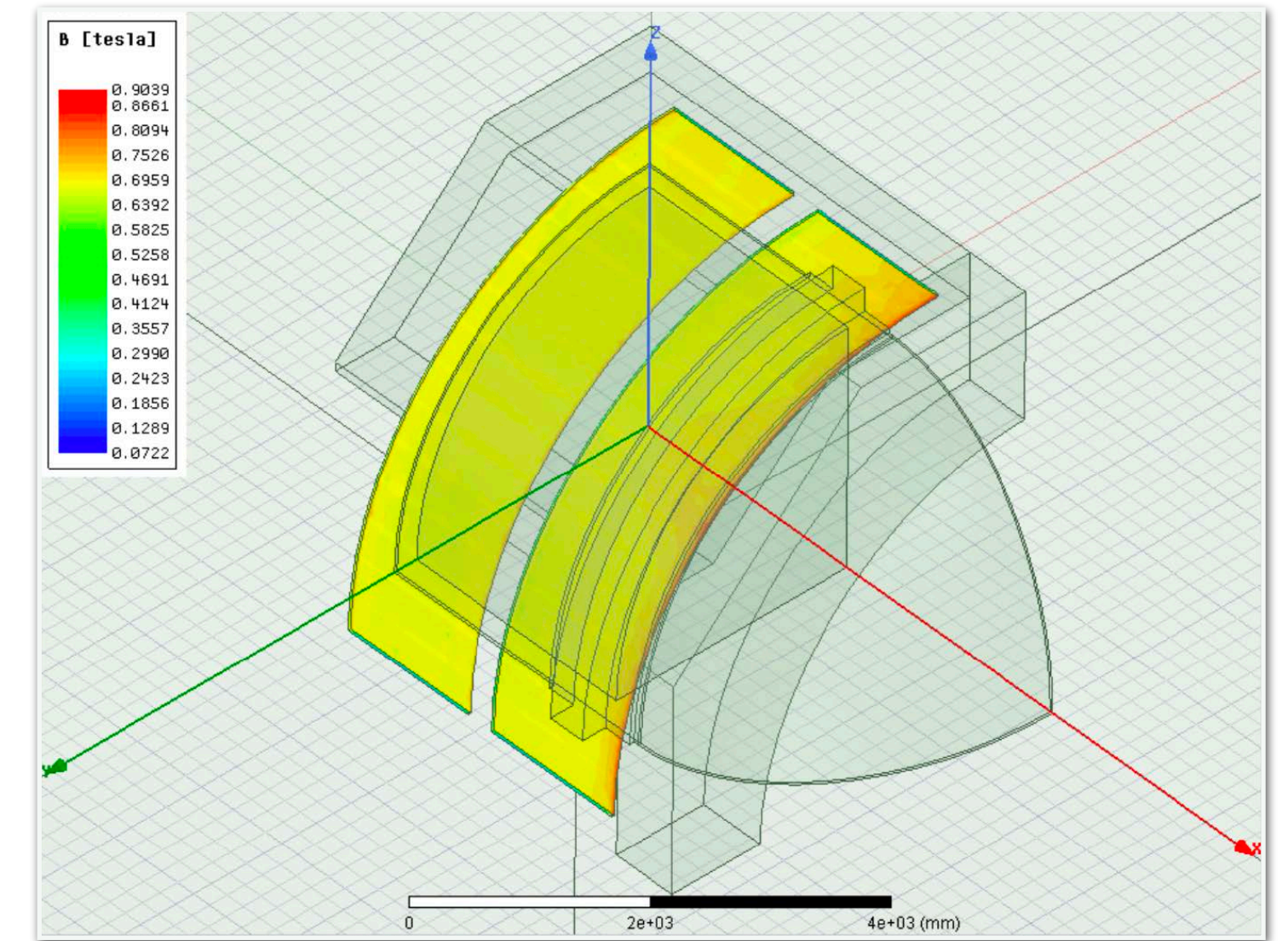
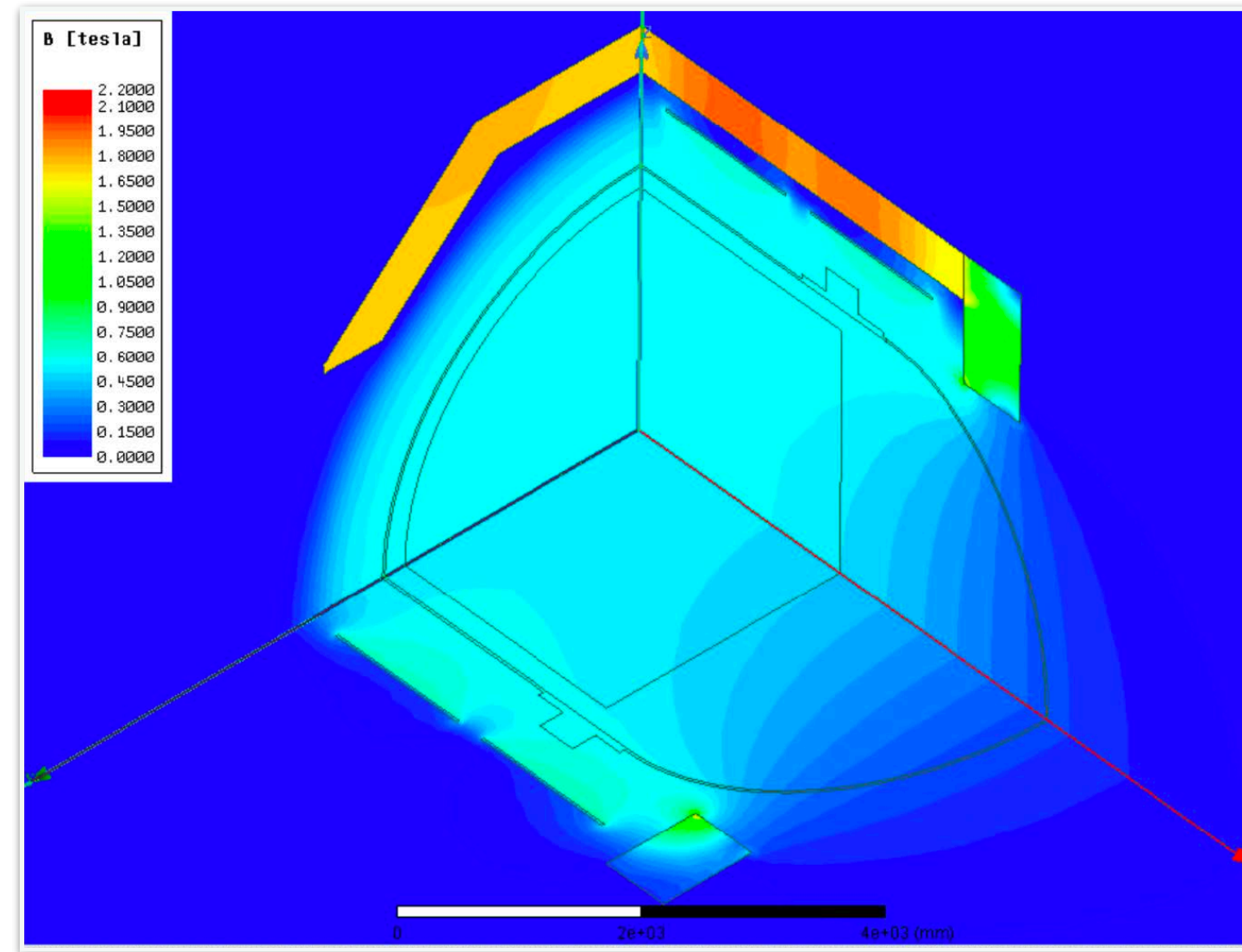
Andrea Bersani (INFN Genoa)

Magnet Highlights.

Getting very mature

- Need to define clear criterium to judge the designs against
 - Impact of field non-uniformity
 - Material distribution/mass
 - Stored energy/stray field
 - cost
- Moving forward
 - Need detailed PRY design
 - Support structure
 - Moving platform
 - Services
 - Try to also utilise the same PRY design for the SPY and 2 coils option

SPY design: preliminary studies (yoke field, coil field, stray field...)



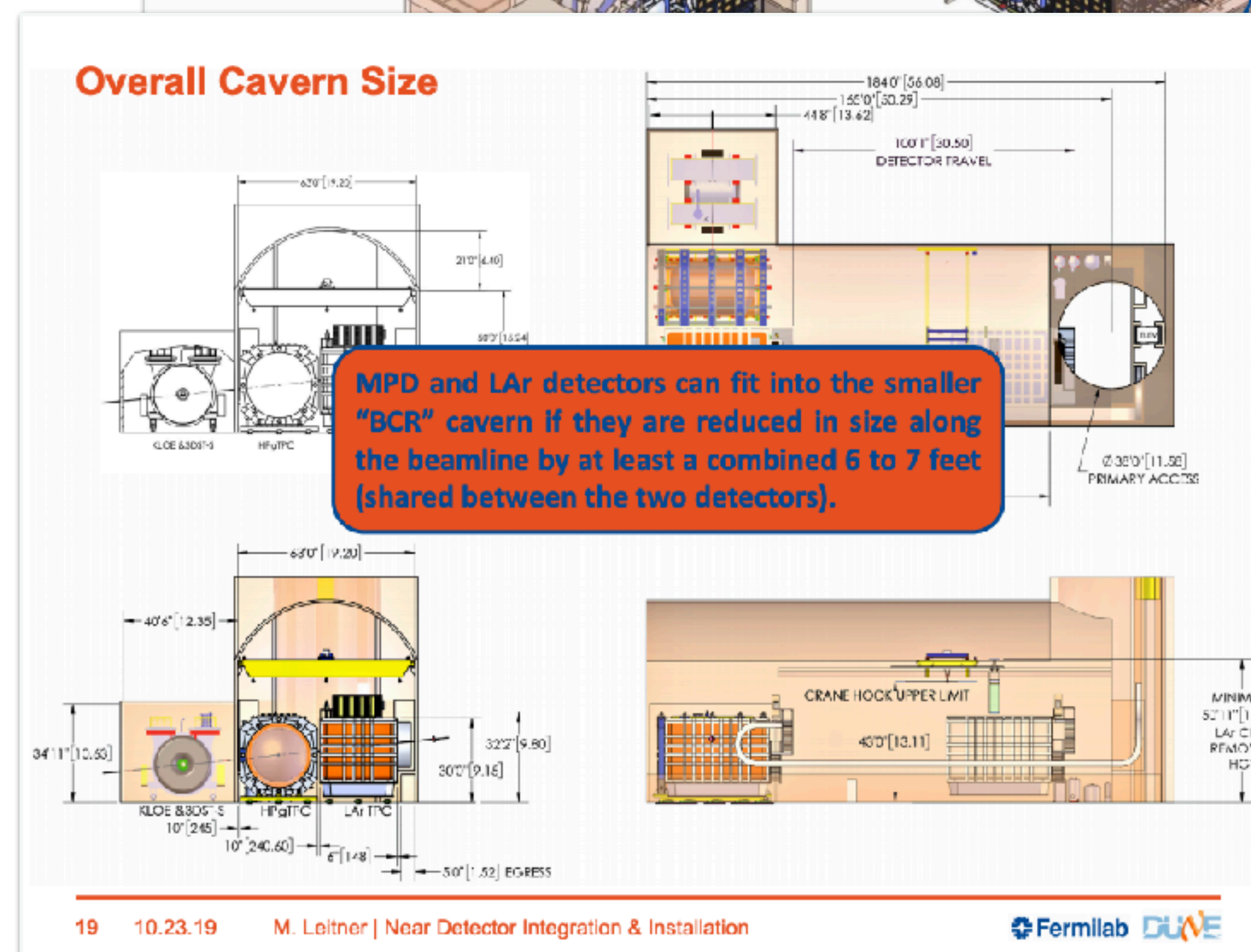
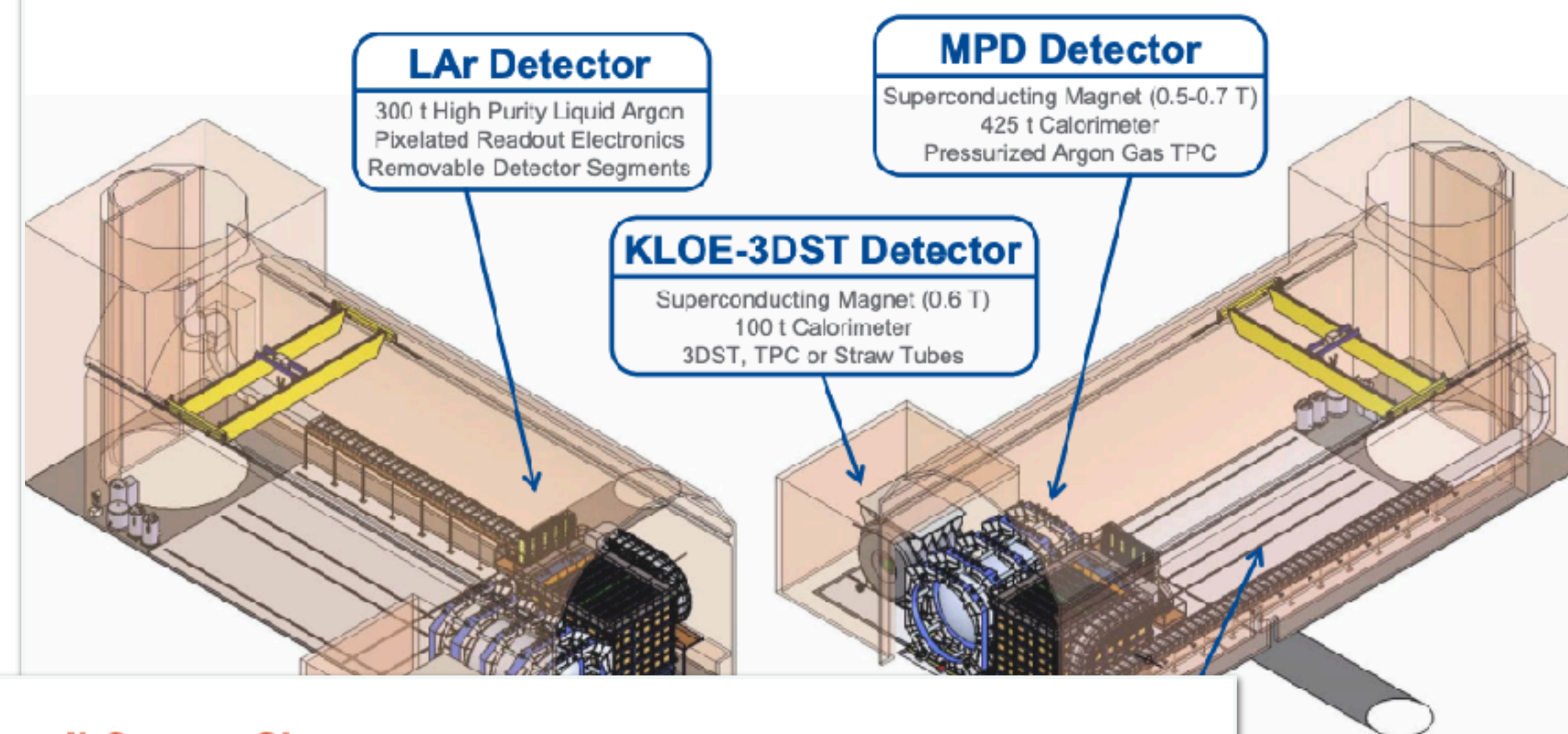
ND Complex Highlights.

Hall size and integration

- The size of the detector hall drives the size of the ND sub-detectors
- Fully integrated design of all ND sub-detectors into the hall
- Load requirements
 - Defined by the heaviest piece: ~50t (KLOE Magnet)
- Overall cavern size
 - 63' in width, 50' in height and 184' in length
- Rock quality not optimal at the site... impact on the structural design of the cavern
 - need effort to reduce cavern height/width
 - MPD + LAr ideally should be reduced in size along the beam by around 6/7' (shared between)
 - Need to evaluate the impact on the physics, MPD design, LAr design, cost... within months

Matthaeus Leitner
(LBNL)

DUNE Near Detector (ND) Scope And Reference Design



Fermilab DUNE

Fermilab DUNE



Conclusions.

A wonderful workshop

- The DUNE ND concept has significantly matured in all areas in the last few months
- A lot of interesting talks and following discussions!
- We need to keep the steam going for the following months (CDR) / year (TDR)
- Overall, very successful workshop!



Backup Slides.

