Towards a Technical Prototype

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CALICE Technical Board Review
Fermi National Laboratory
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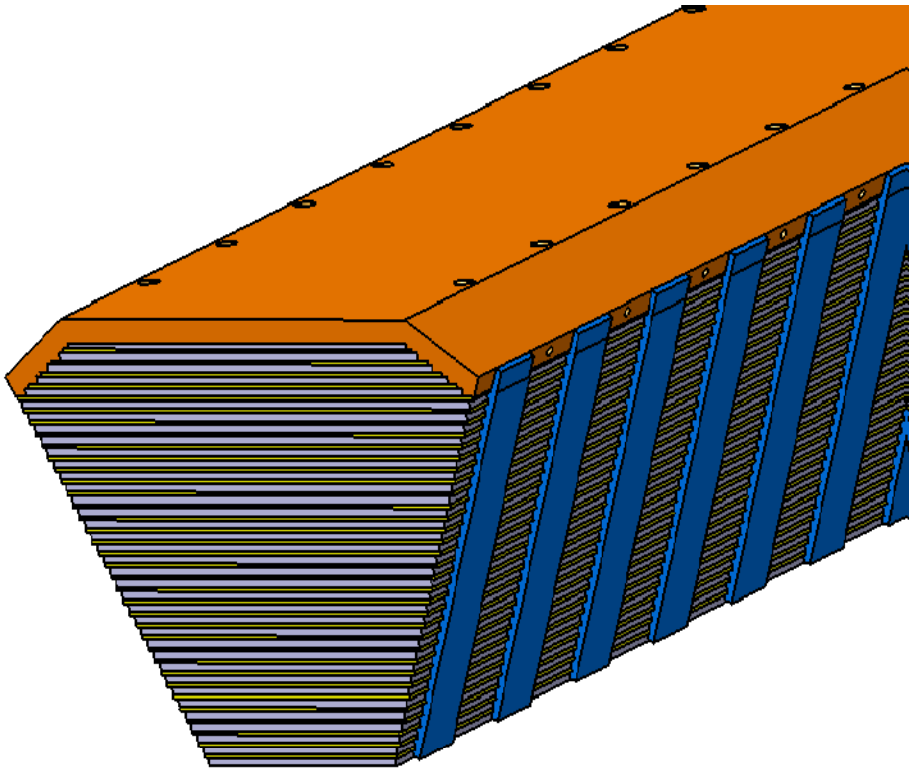
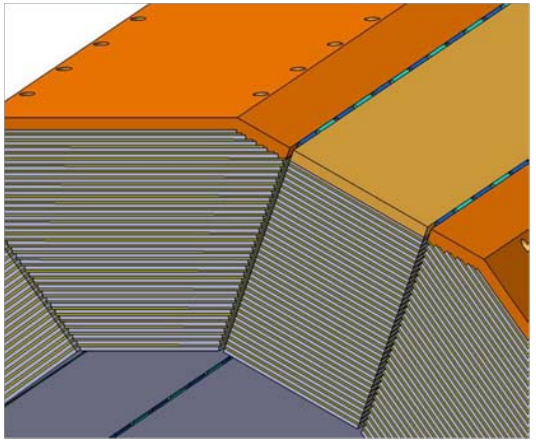
What is a Technical Prototype

E.g. SiD's latest ideas about the HCAL barrel



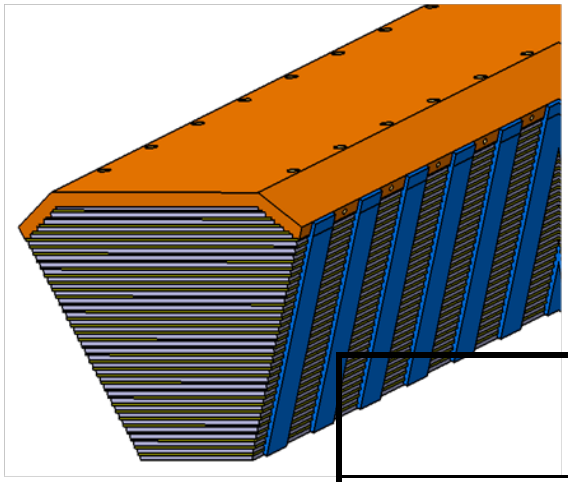
12-sided polygon



Technical prototype module

Wedge-shaped
6 m long
40 active layers
120 m^2 of RPCs

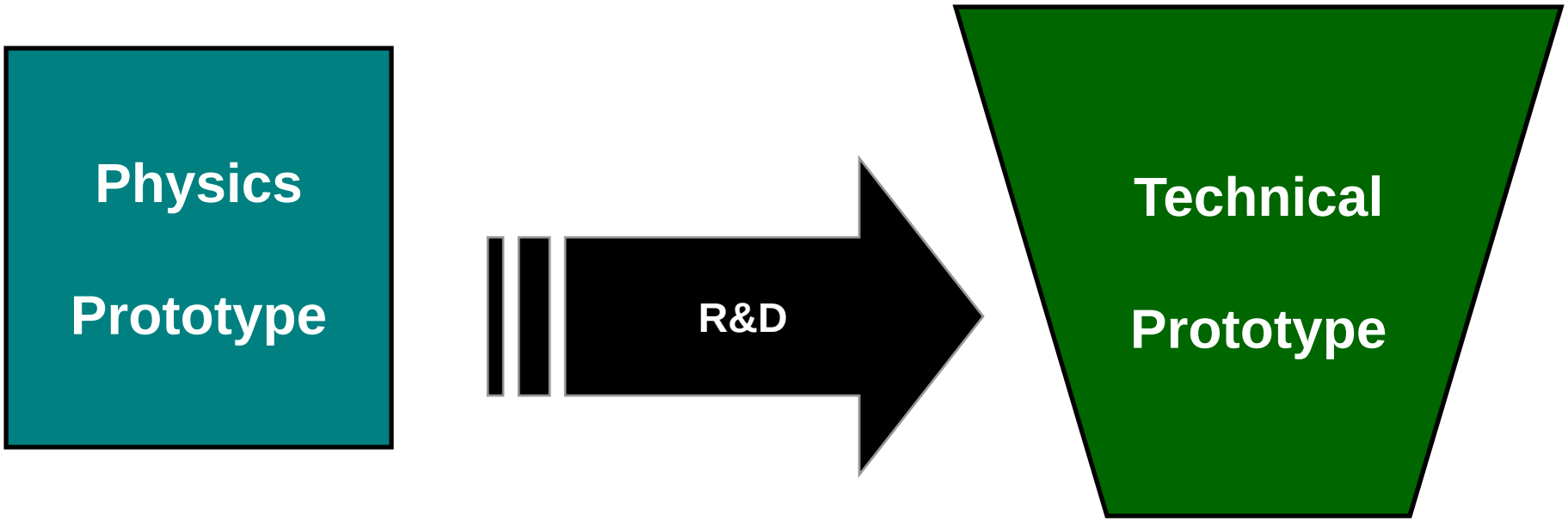
} approximately



Connections to the outside world

	Connection	1 m^3 prototype	Technical prototype
RPC	Gas inlet	40	1
	Gas outlet	40	1
	High-voltage supply	40	1
	High-voltage computer control	-	1
Front-end electronics	Low-voltage	120	1
	Cooling water inlet	40	1
	Cooling water outlet	40	1
	Data cable	240	1

Topic of this Talk



View from the U.S. DHCAL group…

A. Large Area RPCs

Area approximately up to 1 x 6 m^2 in one layer

How to handle 3 - 6 m long glass, is it available?

Typical thickness 0.8 – 1.1 mm

How to distribute high voltage on the surface?

Difference in high voltage leads to different efficiency

How to circulate the gas within a chamber?

Flow needs to be uniform, since gas contamination uniform

How to minimize the dead area?

In 1 m^3 prototype about 3.3% (frame) + 1.4% (fishing lines)

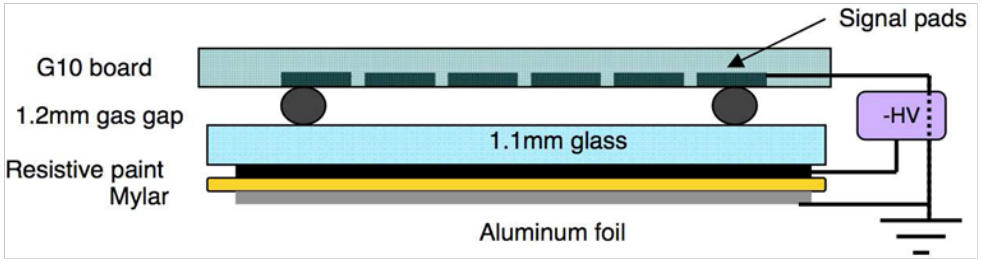
Currently not being investigated

B. Thin RPCs

Marty keeps telling us that every mm costs several M$

One-glass design developed by Argonne

Saves ~ 1mm/layer
Improves rate capability, pad multiplicity
Surface resistivity not critical
No problem with keeping the front-end board flush with the glass



Is it reliable?

One prototype has been tested for 18 months
No changes in performance seen
Was opened – deposits around fishing line

Is it practical?

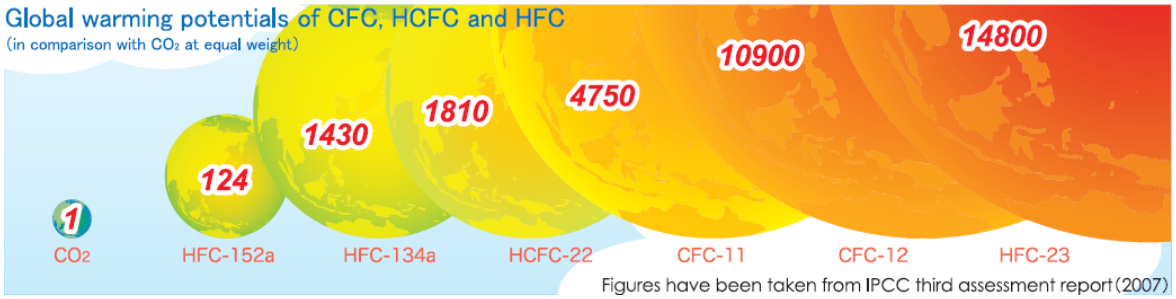
Will be further investigated with the 1 m^3 prototype calorimeter

Once glued on, the front-end board can not be exchanged, without destroying the chamber

C. Gas System

Using Freon HFC-134a

Currently being vented
Will be prohibited in the near future



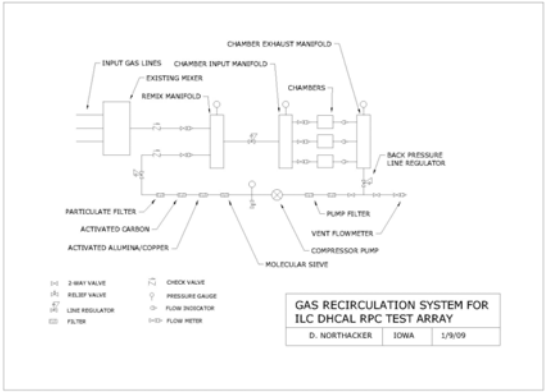
Need to identify an alternative with comparable performance

So far Ar, CO_2 based mixtures do not match HFC-134a
Perhaps HFC-152a will do (just approved as coolant for car A/C systems)

Don't know about recent activities

Need to recirculate the gas

Difficult issue
Not entirely successful at the LHC
We have new ideas…

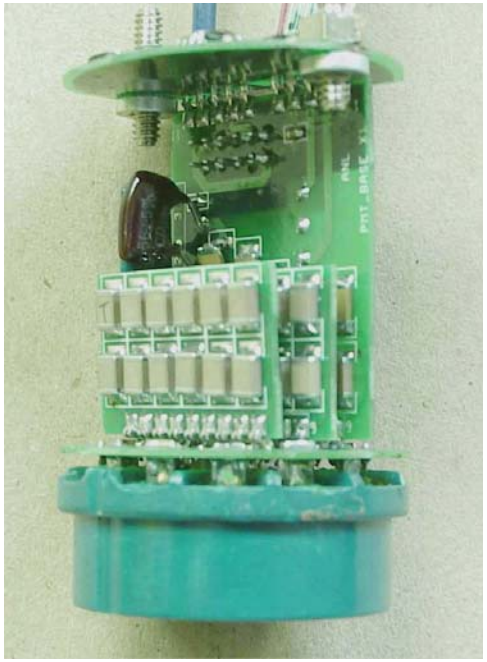


Gas distribution within a module

Major headache
Needs manifolds, implemented in wedge structure
Needs to provide same gas flow to each layer!

Requested funds for Iowa to develop

D. High Voltage Distribution



Currents in RPCs are small (~nA)

Voltages are high (~6.3kV)

Variations between layers due to construction

- Need to set HV in each layer individually
- Need ability to measure current in each layer
- Need ability to switch off sparking layers

Brilliant idea?

- Cockcroft-Walton technology?

Requested funds for Iowa to develop (together with Argonne)

E. Cassette structure

Needed to protect RPCs (glass)
Needed to maintain smallest gap between glass and pad-board

→ Only for 2-glass design ←

Experience with 1 m³ prototype calorimeter will help

Not needed for cooling of Front-end electronics?

DCAL power consumption ~ 0.2 Watt/chip
Assuming 120 m² → 1,200,000 channels → 18750 ASICs → 3750 Watt/module
Power pulsing (?) reduces this to 40 Watt/module

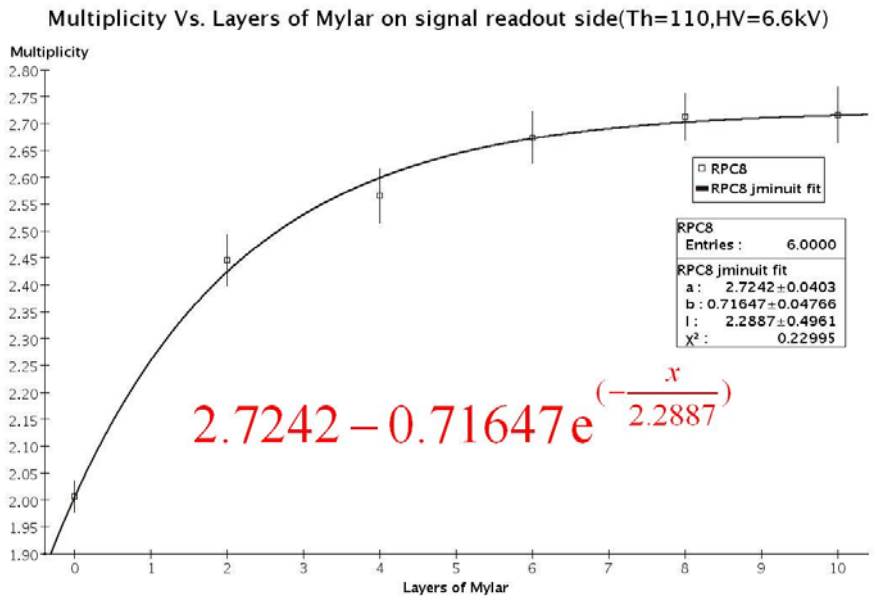
Test beam, Cosmic Rays

Requires triggered readout
Can't apply power pulsing efficientl
Needs cooling…

Additional challenge

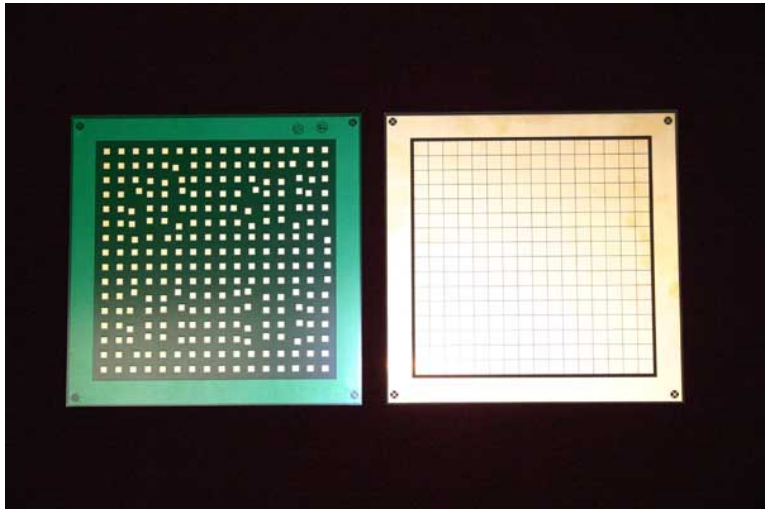
Cassettes needs to be stiff enough not to crash the glass, electronics

→ in any module orientation ←



F. Pad-board

Assuming we keep the 1 x 1 cm^2 segmentation



Current design

Pad-board separate from front-end board
Neither has costly blind or buried vias
Connection to front-end board with conductive glue
Total thickness of pad- + front-end boards ~ 3 mm
Fixed width for 1 x 1 m^2

New design needed

Minimize thickness (but reasonably stiff)
Avoid blind or buried vias
Avoid gluing
Accommodate wedge shape

Currently not yet pursued

Fixed or variable number of pads?
Fixed or variable width of pads?

G. Front-end ASIC

Memorandum of Agreement between ANL and FNAL concerning the design of ASICs
Plan is to work on DCAL IV
(among other things)

Currently (DCAL III chip)

64 channels/ASIC
No power pulsing
Direct communication with data concentrators
Height ~ 1.4 mm

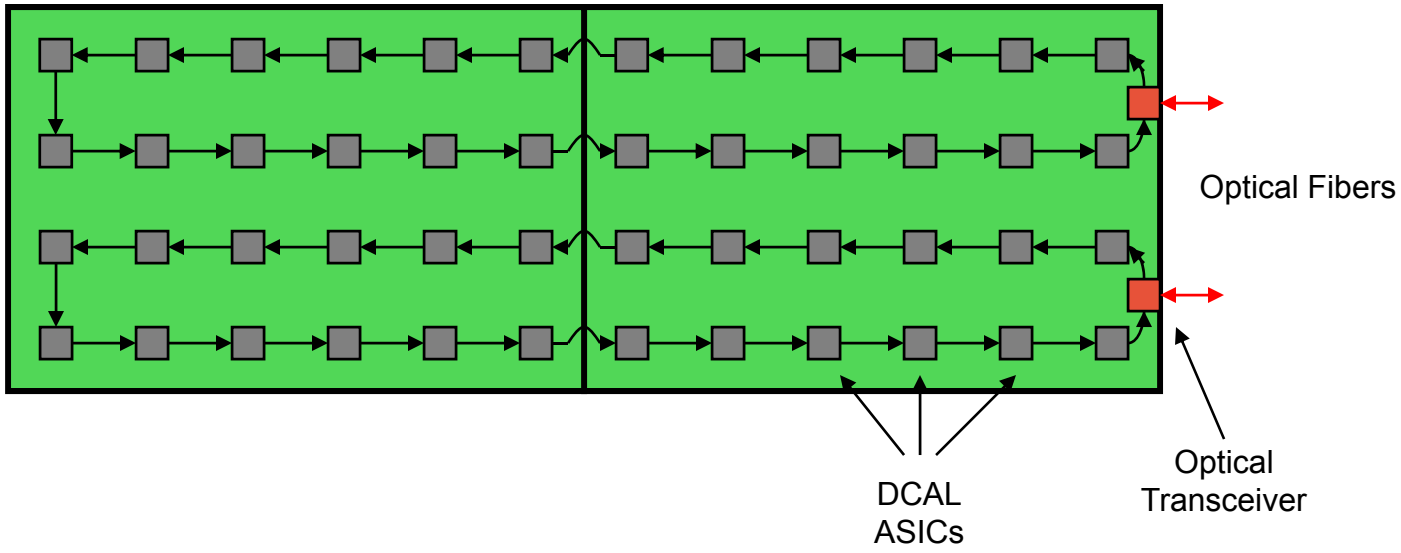
Needed for the technical prototype

Increased number of channels?
Power pulsing
Token ring passing
Minimal thickness (not packaged?)
Keep triggered readout for test beam, cosmic rays
Further improvements to DCAL III

Trivial implementation into chip
Challenge with large pulsing system

→ power supplies
→ em noise

Reliability!



H. Front-end data concentrator

Reliability!

Currently

6 x 4 ASICs per board → 1 data concentrator

Exploit more modern technologies

e.g. Gigabit Transceivers

Serving a whole row of ASICs (up to 50)
Output 1 single optical fiber to be routed to outer edge of module

Currently not yet pursued

I. Low-voltage distribution

Currently

1 cable per front-end board

Need to develop

Distribution system
Ability to turn on/off each layer individually
Ability to measure currents to each layer individually
Ability to handle power pulsing

Currently not yet pursued

J. Back-end readout system

Currently

VME based system located in rack
LVDS communication with data concentrators

Technical prototype needs

System located in back beam area
Optical fiber link with front-end

Currently not pursued (by us)

K. Mechanical Structure

Currently

Being developed by both ILD and SiD

Details of the design

Depend on the outcome of the above mentioned R&D
Significant effort needed to design a viable structure

} **Not yet urgent**

L. Magnetic field

SiD plans on 5 Tesla field
ILD plans on 3.5 Tesla field

RPCs

Ammossov tested RPCs in 4(?) Tesla field and found no effect
Findings need to be confirmed

Electronics

All components need to work in magentic field
Power pulsing the front-end will be particularly challenging

Overview of R&D for Technical Prototype

R&D topic	Being addressed	Planned to be addressed	Plan to be developed
Large area RPCs			x
Thin RPCs	x		
Gas system, distribution		x	x
High Voltage distribution		x	
Cassette structure		x	
Pad board			x
Front-end ASIC		x	
Front-end data concentrator			x
Low Voltage distribution			x
Back-end readout system			x
Mechanical structure	x		

Lots of challenges and work…