A New GEM Module for a Large Prototype TPC: Status and Plans

By

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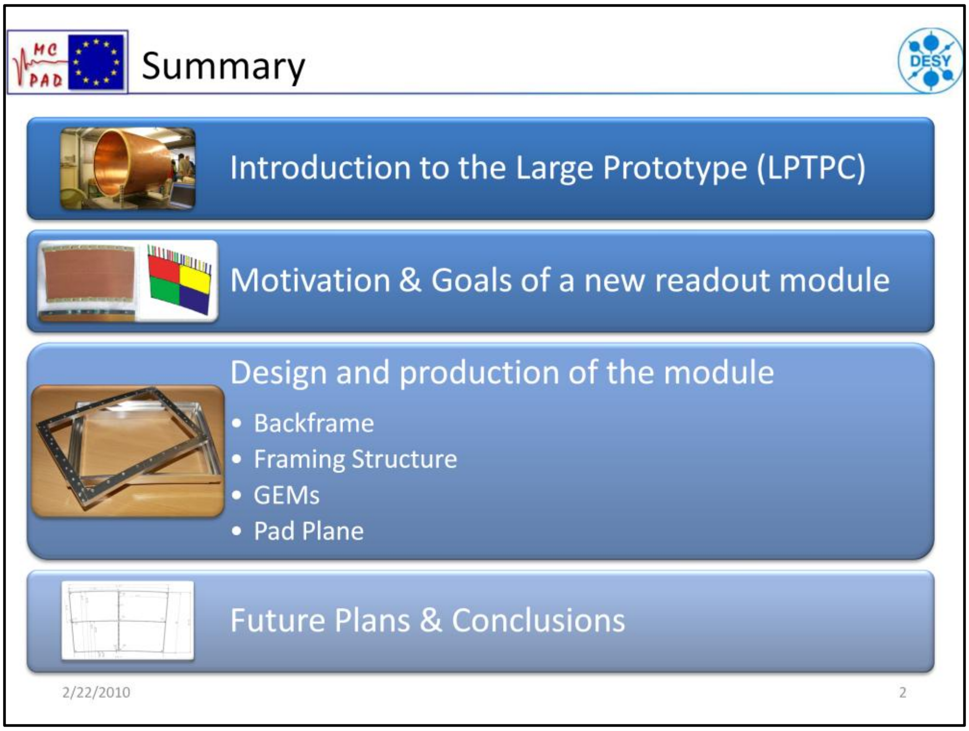
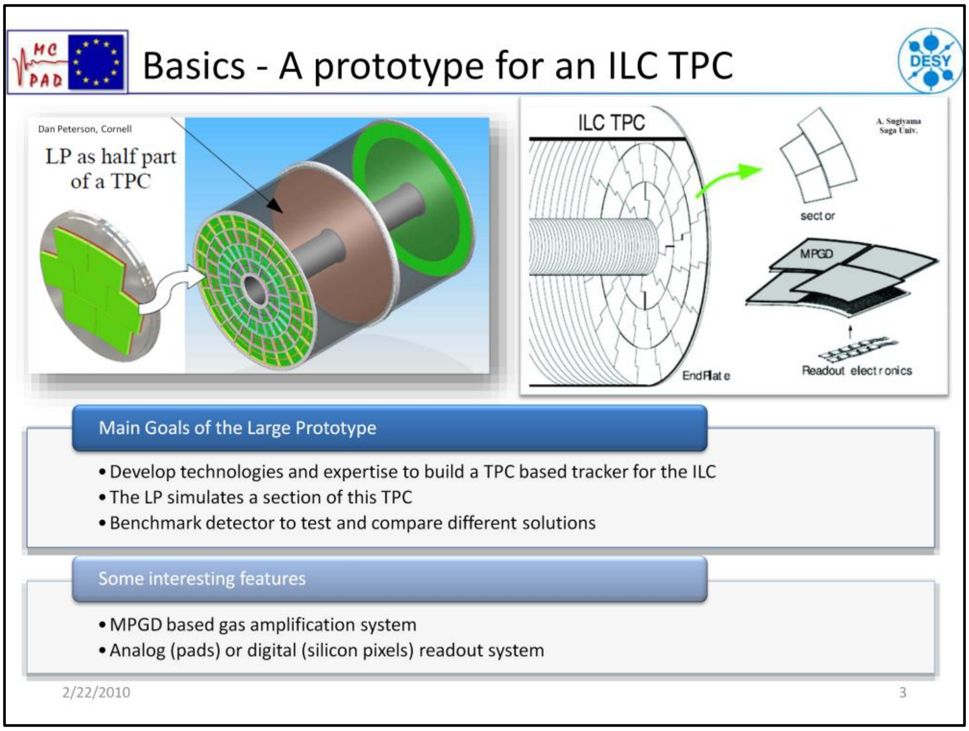
The goal of this talk is to present you with the development of the design of a new GEM readout module for a Large Prototype TPC that is going on at DESY



In this talk I would like to introduce the LPTPC to the one of you that don't know this device yet

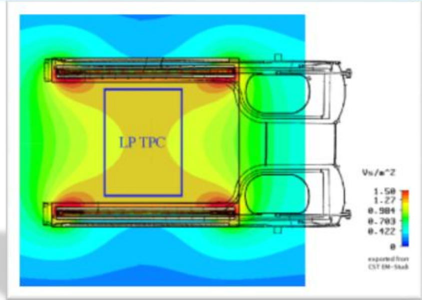
I'll then proceed motivating the need for the development of a new GEM-based readout module for this TPC, following with the description of the design effort and the production plans of this device

I'll then conclude my talk illustrating some of our future plans



The LPTPC is part of the effort to develop technologies and expertise to build a TPC based tracker for an ILC detector.
The LP simulates a section of this detector to benchmark different solutions (left hand side picture).
For the following of this talk I will only list two of the features that we are interested to test uding this device, namely an MPGD based gas amplification system readout with both analog (Pads + ADC) or digital (silicon pixel) electronics

Basics – Some features of the LPTPC



Field Cage designed and produced by DESY

- 60 cm drift length, 72 cm inner diameter
- Field Quality: $10^{-4} < \Delta E / E < 10^{-3}$
- Operational since the end of 2008
- Designed to fit inside PCMAG

PCMAG

- Superconductive Solenoidal Magnet with standalone Lhe Cooling and low mass coil supplied by KEK.
- 1 Tesla Magnetic Field

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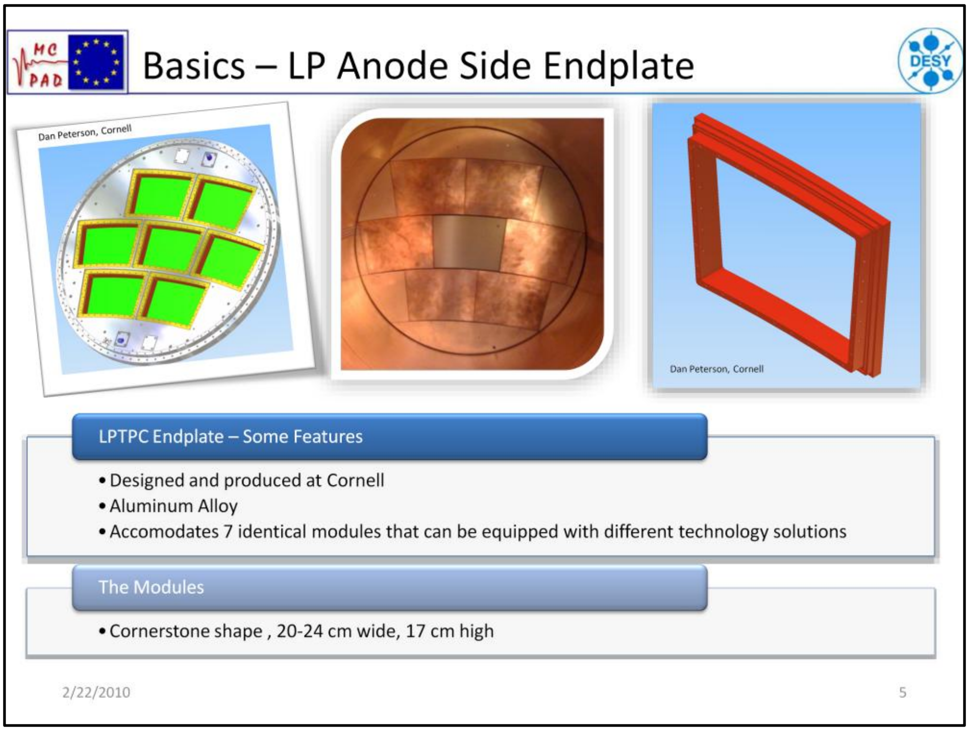
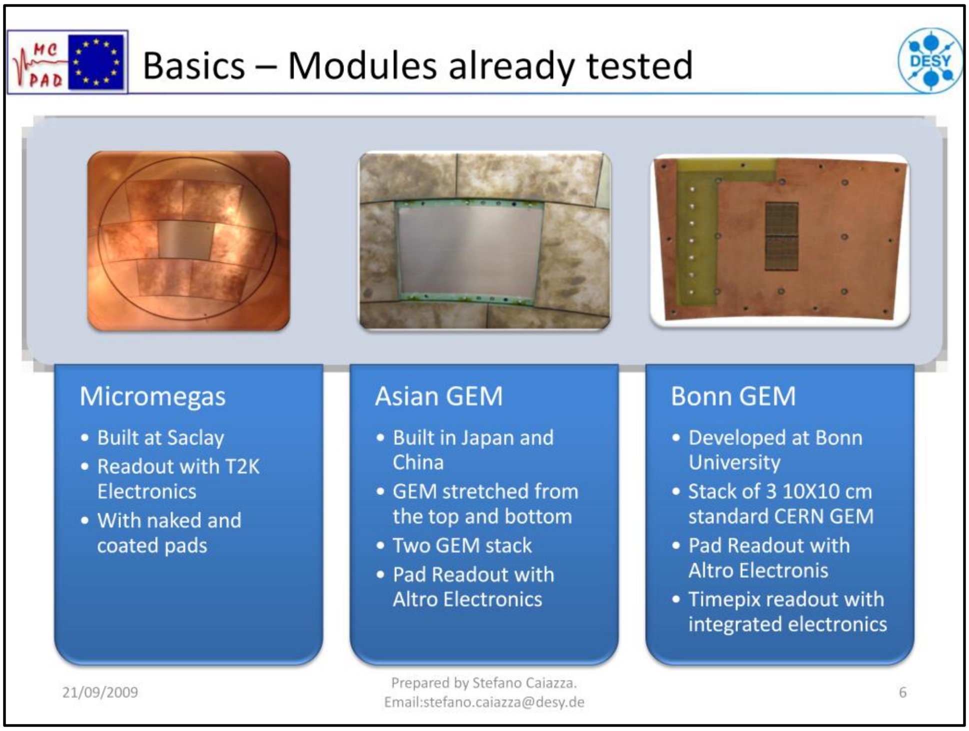
Now I want to present you with some more details of the LPTPC.
The field cage of this detector has been designed and produced by DESY. On the left hand side the picture shows this field cage during the final fase of the production. This field cage has been hosted and operated since the end of 2008 in a Superconductive Magnet called PCMAG, supplied by KEK. The field map inside and around the solenoid is shown on the right hand side



The anode endplate of the LP has been designe at Cornell by Dan Peterson and features seven holes for seven identical modules that can be equipped with the different technologies solutions to be tested. On the left hand side you can see one of the 3d rendering of this device. In the middel picture, on the other hand, you can see this same device built and installed inside the LP equipped with one Micromegas module.

This talk is focused on the development of a GEM-based readout module to be installed on this endplate. Each of this module is shaped like a corner stone, and can be installed in any position in the endplate. A 3d rendering of this device is shown on the right hand side picture

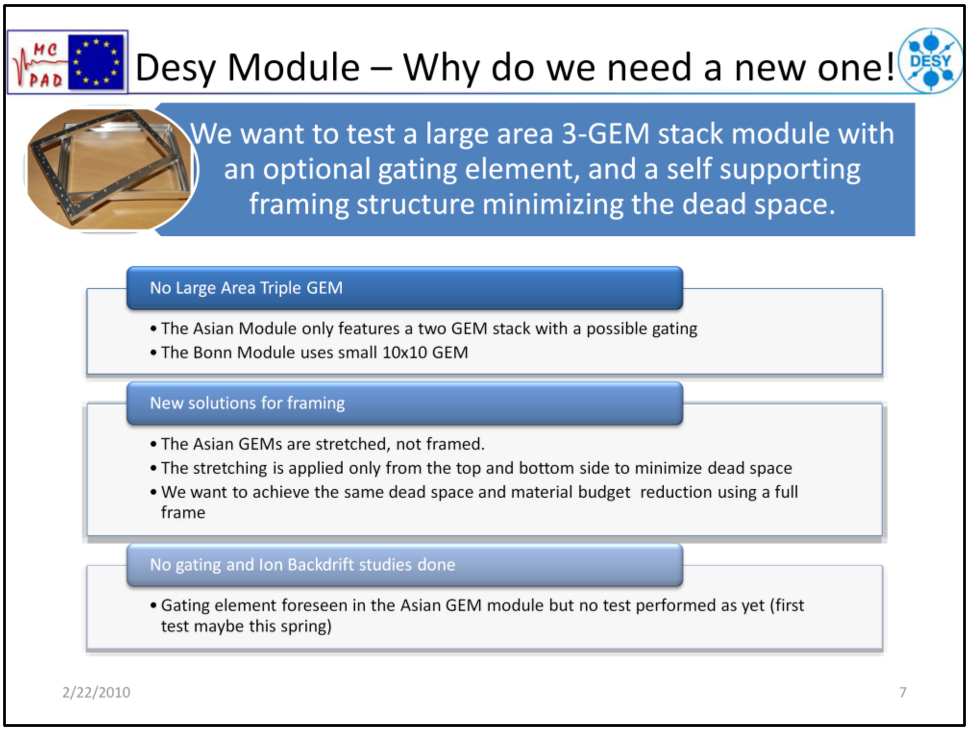


Up to now the LP has been used to test three different kinds of modules, three different technological solutions:

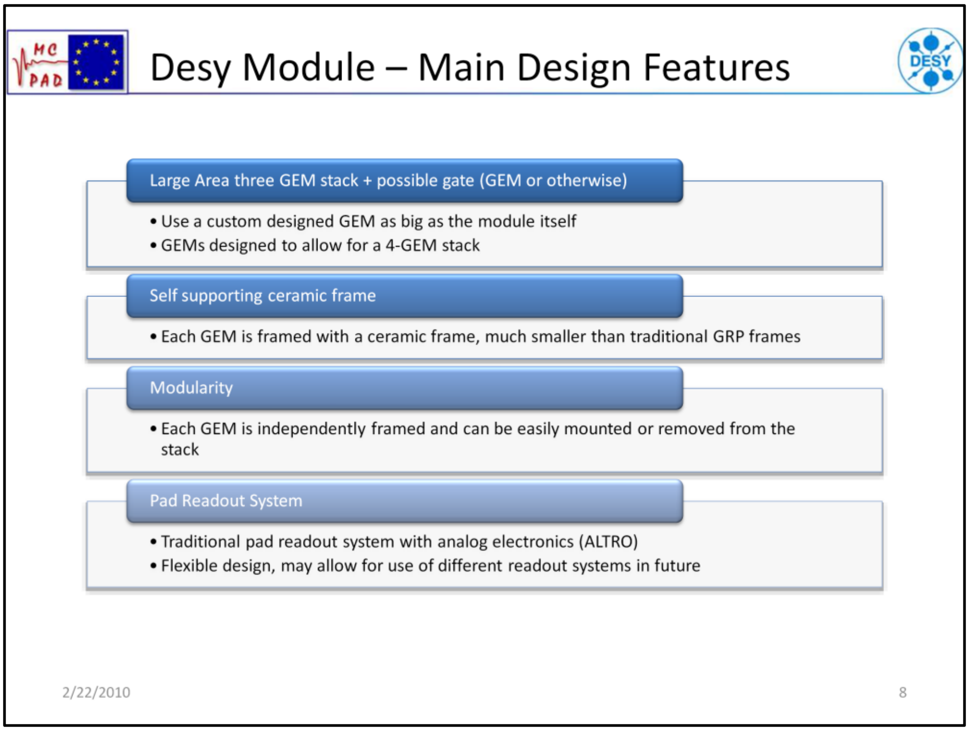
The Micromegas Module built by Paul Colas and his group at Saclay, with both naked and resistive coated pads

The Asian GEM module, with a two GEM stack, each of this GEMs stretched only from the upper and lower side, and produced in Japan, readout with naked pads

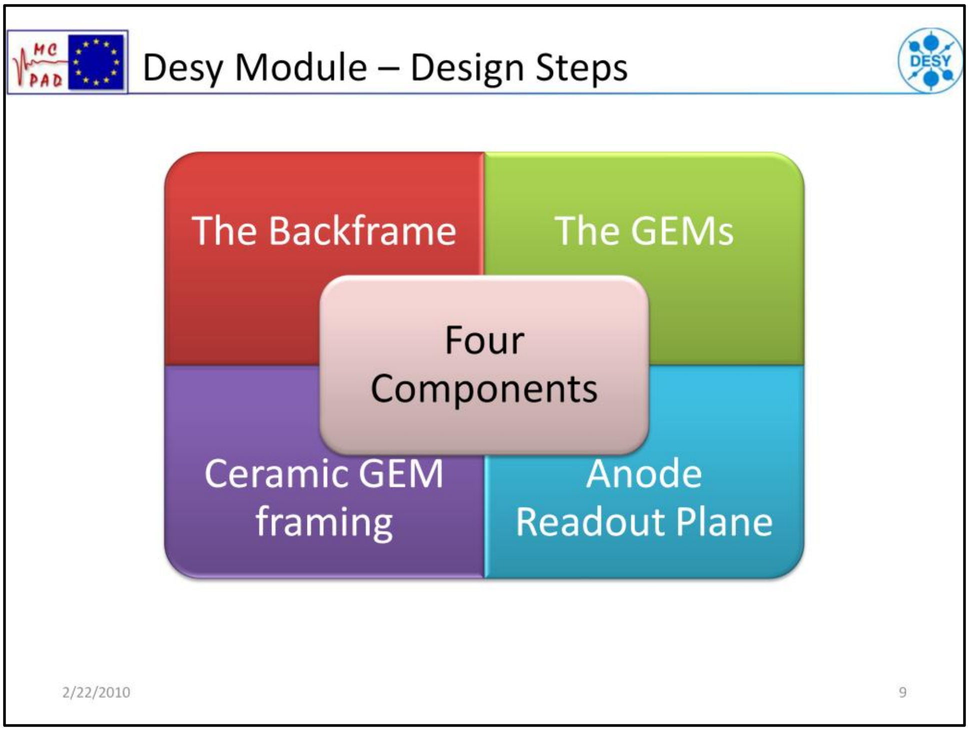
The Bonn Module featuring standard 10X10 Cern GEMs with both a pad readout system with ALTRO electronics or a silicon pixel readout with integrated electronics (the picture refers to the Timepix module yet to be tested on the LPTPC)



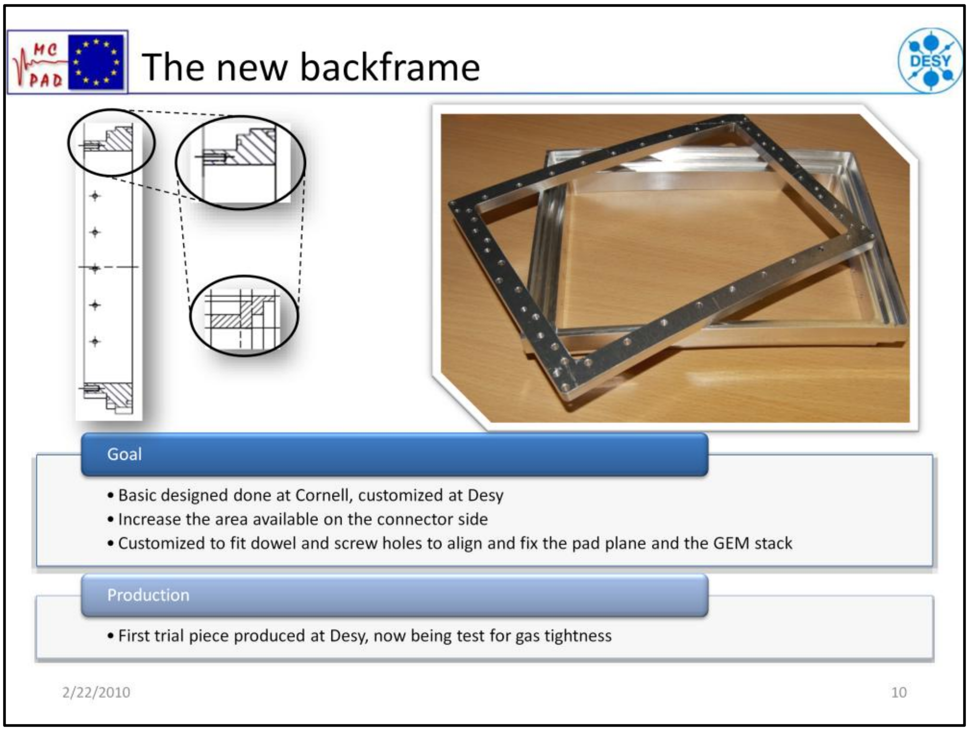
This said, why do we need another module. What do we want to test that cannot be tested with the others?
We want to test a large area, 3 GEM stack module with an optional gating element, and a self supporting framing structure minimizing the dead space.
Why this can't be done with what we already have:
The Asian GEM only features a two GEM stack, while the Bonn module only uses somall GEMs.
Moreover the Asian GEMs use a novel system to build the GEM stack, only stretching those GEMs from the top and bottom side. We want to achieve similar results in terms of dead space and material budget reduction using a full frame
Finally we want to develop and test new gating techniques compatible with the operations of a GEM module and we would like to test and compare the ion backdrift suppression of different technologies.



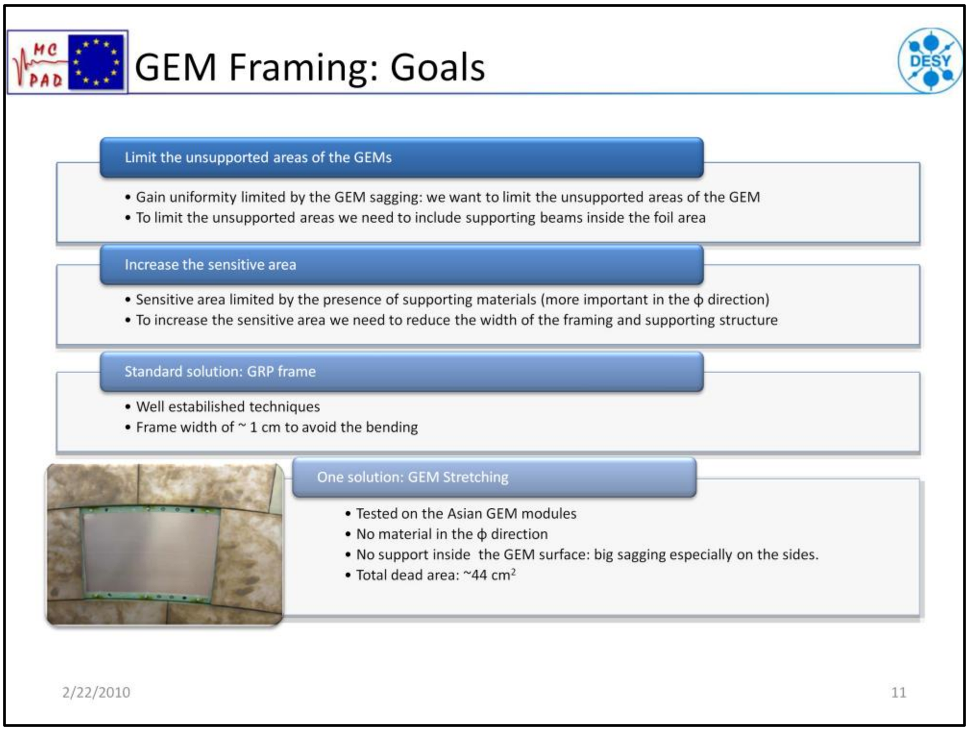
From the goals I just described we got our design features
This module features a large area three GEM stack, with the possibility to add a fourth element, GEM based or otherwise, used as a gating device.
To frame each GEM we used a ceramic framing structure. Each of the GEMs may be framed independently to be exchanged easily if need arises.
Finally we choose a traditional pad readout system for our module, but the design is flexible enough that the same frame and GEM design could be applied later to different readout systems.
We decide



Now I want to get in some more details on the design of this detector.
This detector is composed of four main elements:
The backframe, The GEMs, The Framing structure and the Pad plane



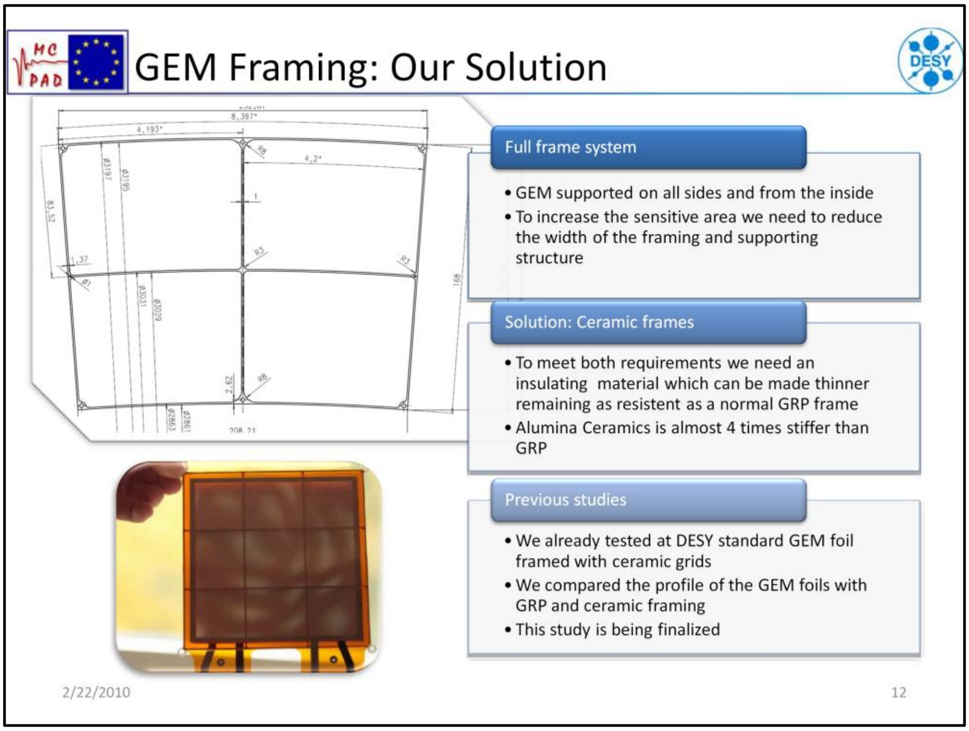
The backframe of the LP modules was designed at Cornell with the Endplate that hosts them. We customized this design to increase the available area on the connector side, as you can see from the left hand side picture where I have emphasized the major changes we made to the original designed. Moreover we added screw and dowel holes to fix and align all the element of the module, backframe, pad plane and framed GEMs



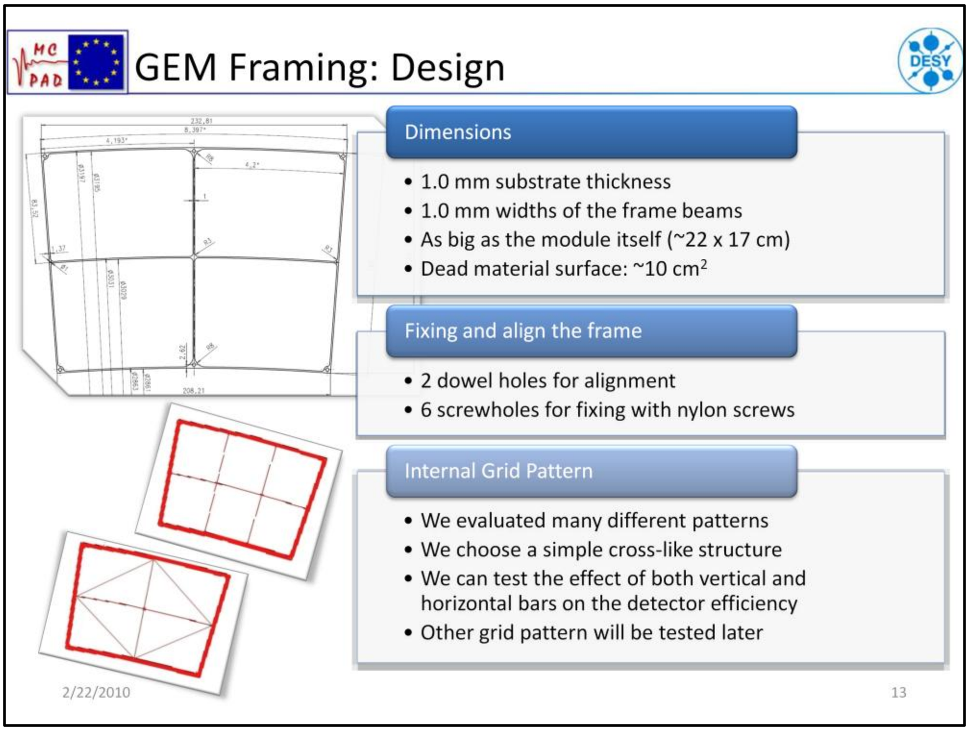
One of the most important features of our design is the GEM framing structure. Our goal in the development of this element of our project was to create a structure which can support and frame the GEM, increasing the sensitive area, reducing the dead space and the amount of material used and supporting as much of the GEM area as possible, keeping that flat and stable

The standard solution for this kind of frames is a wide fiberglass frame outside the GEM area with thin spacers in the middle of the GEM area (see COMPASS experiment)

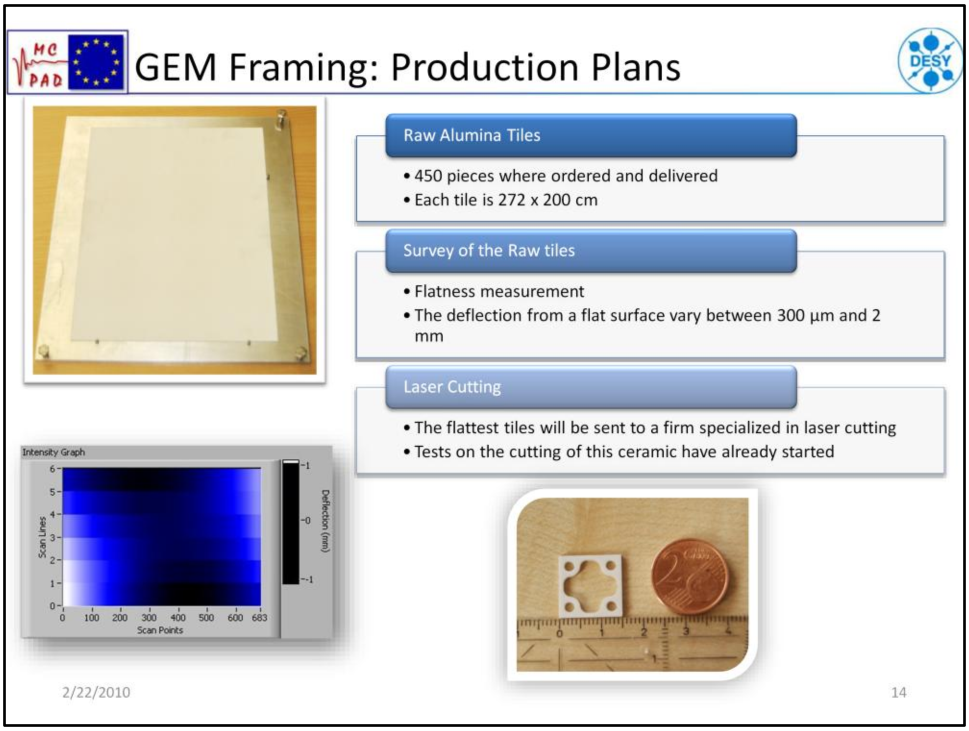
Another solution has been devised by the Asian GEM group I mentioned earlier and it consists in stretching the GEM on the top and bottom sides only leaving everything else unsupported



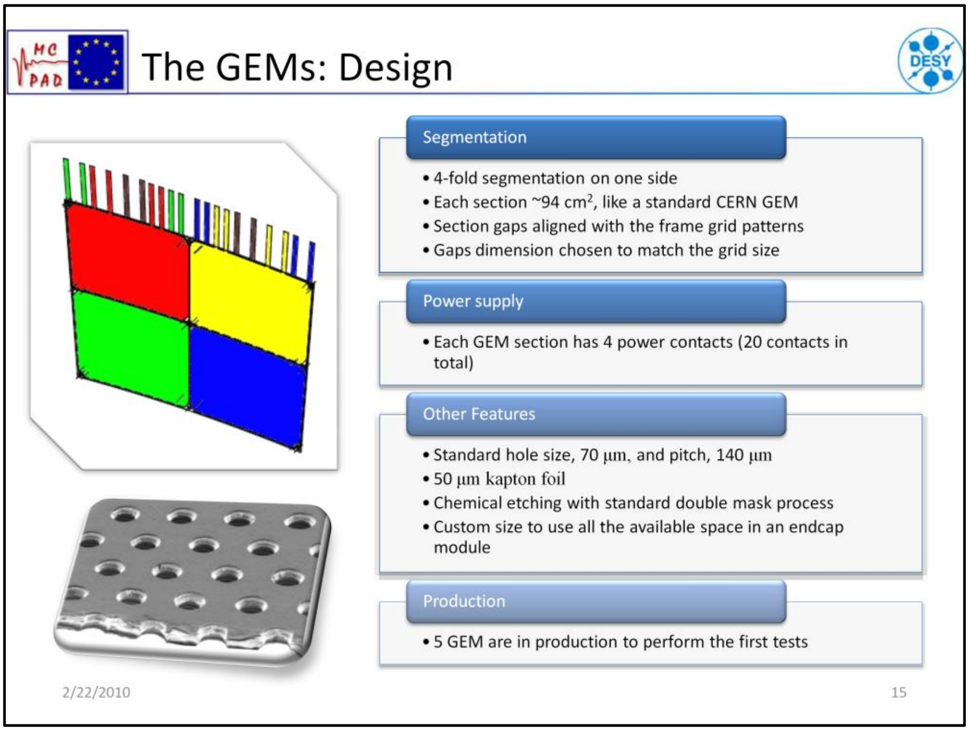
Our solution is an evolution of the fiberglass framing. Our supporting structure frames the module on the outside but also features spacer-like structures on the inside. To reduce the width of the framing structure we decided to use a material stronger then fiberglass, thus we choose ceramics. The Alumina Ceramics we choose is 4 times stiffer than the GRP which allows for a consisten reduction on the amount of material necessary to support the GEM. This solution has already been tested on standard 10X10 GEM and proved successful, now we are trying to use the data we acquired to develop a bigger frame for the LP module



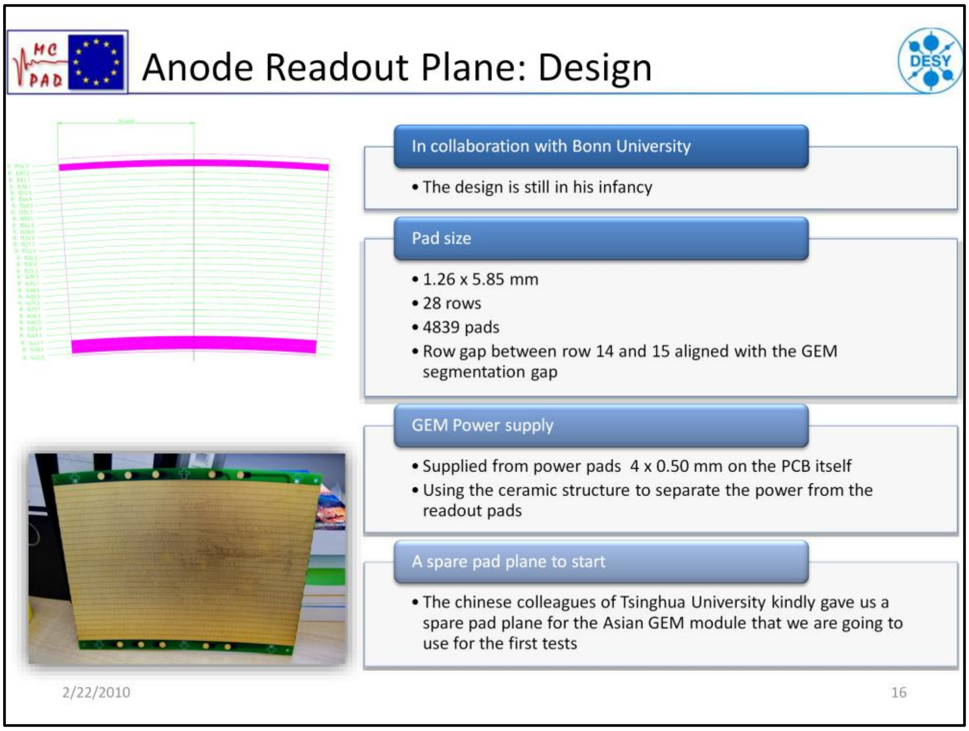
The frame we are designing is as big as the module itself, with a substrate thickness of 1 mm and the frame beams, both the horizontal and vertical ones 1 mm wide
To align and fix the structure to the module we included 2 dowel holes and 6 screwholes where we are going to fit nylon screws. With this system we will avoid glueing the pieces which is of great importance in the test phase where you would like to exchange parts or replace pieces which are damaged during operations
At this moment we are focussing on a simple grid like pattern where we can test the effect of both the horizontal and vertical beams



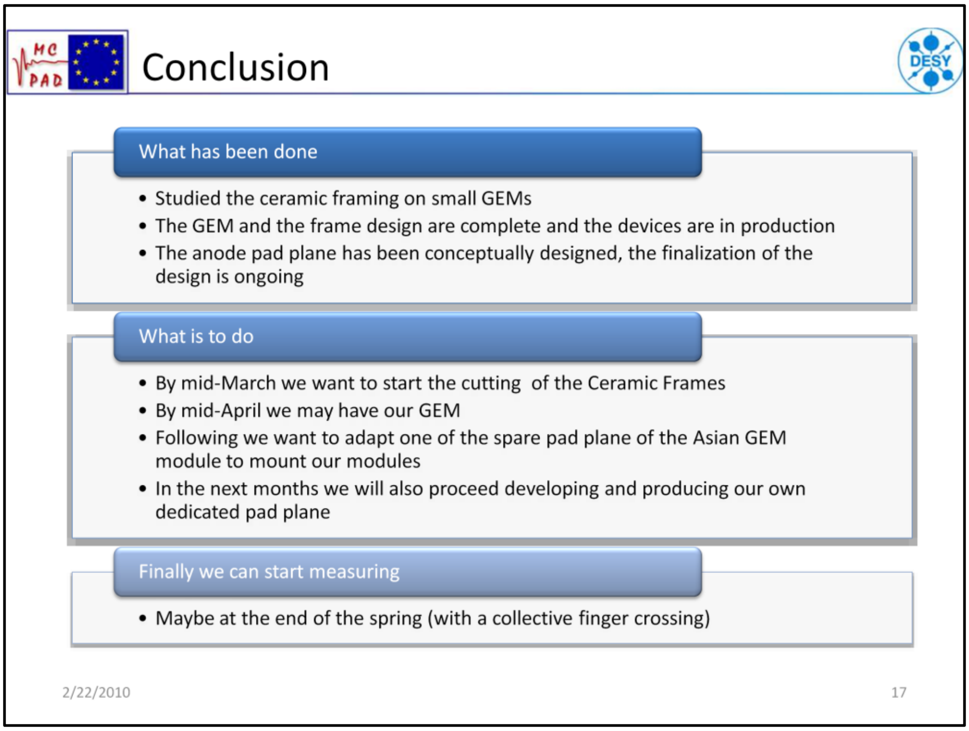
To produce these frames we bought 450 raw tiles and, after a survey of the flatness we are going to laser cut them into the due shape



The next step in the development of this module is the production of the GEM foil. This GEM foil has been customly designe, with 4 copper segment on one side to reduce the sparking risk and section gaps with the same shape of the ceramic frame to glue them together out of the sensitive area. Because we need to power up each of the GEM section from the pad plane side we need a total of 5 electrical contacts per GEM. But because we are going to stack 4 GEM over one another and we would like to use a single layout to build all the GEM we need a total of 20 contacts for each of the GEMs. Finally we want to save as much space as possible on the module sides so we could only place the electrical contacts on the upper and lower side. Of these we could only choose one, otherwise the contacts on two adjacent modules, which are only 1 mm apart, could touch each other or generate sparks. We choose the upper side because is the longer one.
At the moment we ordered 5 GEMs for production



Finally we got to the Pad plane design.
This design is still in his infancy and it's done in collaboration with Bonn University.
The pad plane features almost 5000 channel, each connected to a pad 1.26 X 5.85 mm. We decided to create a small gap between row 14 and 15 aligned with the GEM segmentation gap.
To start our measurment in the meantime our collegues of Tsinghua university have kindly given us one of their spare modules to mount our equipment



To conclude this presentation I want to summarize what have been done, and what is yet to do