JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Status of the Endcap Disc DIRC

Michael Düren, 3.12.2015

HIC for FAIR
Helmholtz International Center

DIRC Conference

50 Participants

25 Talks from Experiments and Industry (No theory:-)
+ Panda Cherenkov submeeting

- optics, sensors, readout, system designs

- all world DIRC projects were covered

- PANDA-Barrel, PANDA-Disc, TORCH/LHCB, TOP/BELLE2, EIC, GLUEX, CLAS12, CBM/FAIR,...

- Proceedings soon...


adidas

Technical Report of the Endcap Disc DIRC

- **July 2014: Submission**

Editors:
Michael Düren
Erik Etzelmüller
Klaus Föhl
Avetik Hayrapetyan
Matthias Hoek
Albert Lehmann
Oliver Merle
Julian Rieke

- **Sept. 2014: Referee Report**
  - Nicolas Arnaud *(CNRS/IN2P3, France)*
  - Angelo Rivetti (*INFN Torino, Italy)*
  - Jochen Schwiening (*GSI, Germany)*
  - Jerry Va'vra (*SLAC, USA)*

Internal Report:

The $\overline{\text{P}}$ANDA Endcap Disc DIRC

(AntiProton Annihilations at Darmstadt)

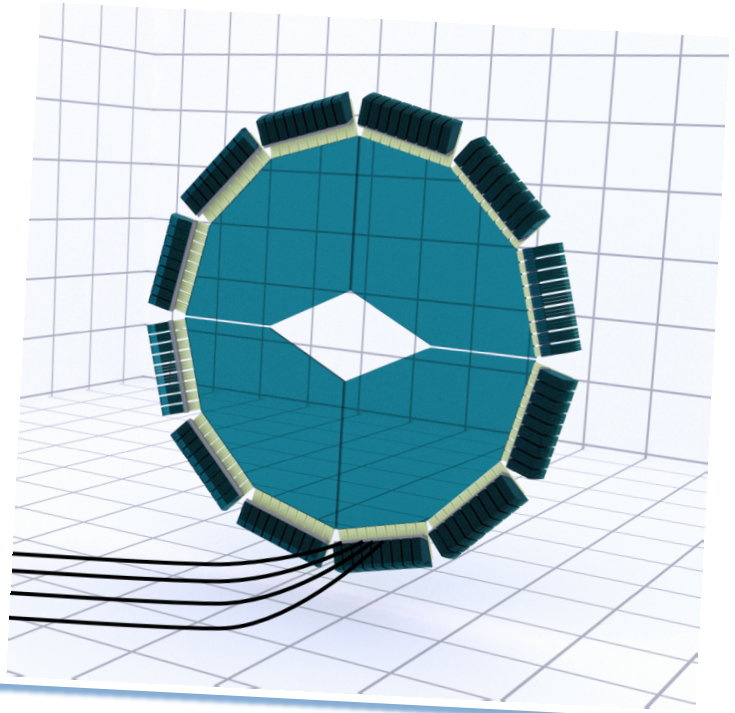
Strong Interaction Studies with Antiprotons

$\overline{\text{P}}$ANDA Collaboration

CONFIDENTIAL

For internal $\overline{\text{P}}$ANDA use only!

July 4, 2014



Referee report from Sept. 2014 and our answers…

- **Designing such a detector is a real challenge given the associated constraints.**
  - We agree … and it is also fun…
- **The EDD design is a promising detector concept that matches these requirements.**
  - …if it would not, PANDA would have to be partially re-designed
- **Some areas need more work and some R&D activities are still ongoing.**
  - …therefore we applied successfully for PANDA R&D money from BMBF.

Preliminary referee report from Sept. 2014 and our answers…

- **The RC recommends that the current developments should be continued with the goal to build a full-scale quadrant pre-production prototype using the final optics and readout electronics and to test it with particle beams.**
  - The BMBF referees objected and are of the opinion that we do not need a full-scale prototype. If PANDA insists on a full-scale prototype, we can re-apply for money from BMBF earliest in 2018.
  - Instead we will build a small size 50x50 cm^2 squared quartz prototype with few readout modules. Final focussing optics, (final) MCP-PMTs, (final) TOFPET readout.
  - We plan to construct the new prototype in 2016 and test it in test beams in fall 2016. Julian and Erik will write their PhD theses on the – hopefully positive – results (i.e. single photon resolution, cross talk, charge sharing, reconstruction and PID, ToFpet,…)

Preliminary referee report from Sept. 2014 and our answers…

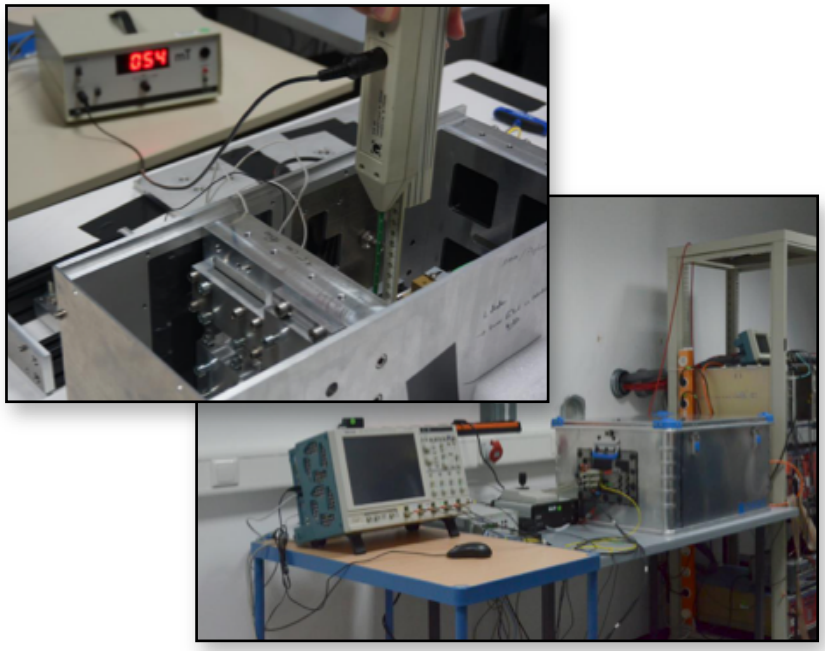
- **Given the manpower and funding situation of the EDD collaboration, the RC recommends that the necessary manpower and financial resources be allocated to these groups in order to allow them to complete this prototype, which is the key milestone ahead for the EDD.**
  - BMBF did not nearly fund the requested manpower. We will continue the R&D with limited manpower.
  - There have to be visible positive developments in FAIR and PANDA funding soon, in order not to loose the young experts in the collaboration, especially in case that the ENDCAP DISC DIRC is not in the first stage of PANDA.

Preliminary referee report (Sept. 4): Points to be carefully studied in future

1. **The photomultiplier (PMT) selection is at a critical stage, with the first R&D prototypes just produced by companies. These prototypes need to be tested in detail to see if they match the EDD requirements. These are a few parameters to stress.**
   a) The most crucial parameter to measure, as the EDD group knows well, is the pixel-to-pixel cross-talk. To be meaningful, this measurement should be done with close-to-final electronics.
   b) Another crucial parameter is the level of charge sharing, which should be measured with the final pixel granularity and in the right magnetic field.
   c) MCP-PMT tubes are fast. One should check their ringing, especially when one such tube is hit by a very large signal coming from a large number of single photons. It is important to use close-to-final electronics for this measurement as well.
   d) One needs to study very carefully a proper matching between the front-end electronics and the MCP-PMTs, in order to achieve the best possible performance.

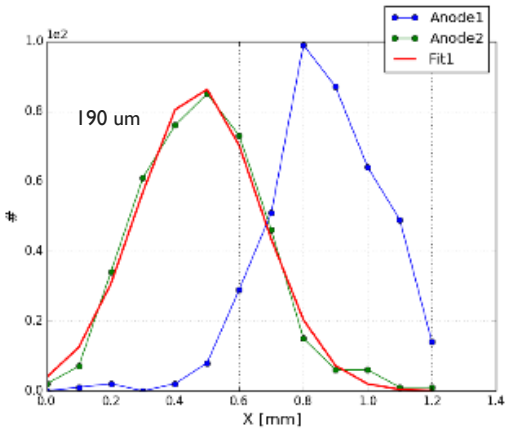
- **First tests positive (spatial resolution, magnetic field effects,…)**

sensors and readout



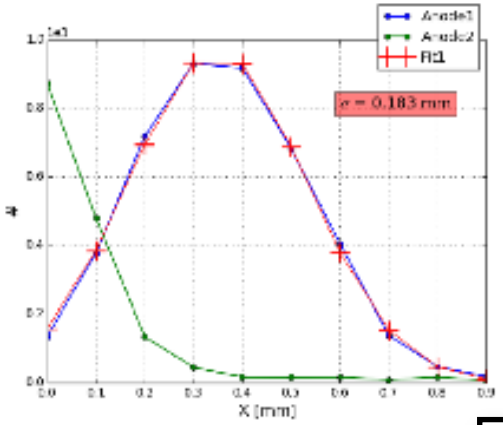
- automated setup for precise MCP-PMT QA measurements and setup with permanent magnets available
- Photonis MCP-PMT without proximity focussing works well in a magnetic field
- Hamamatsu measurements are on the way

Hamamatsu

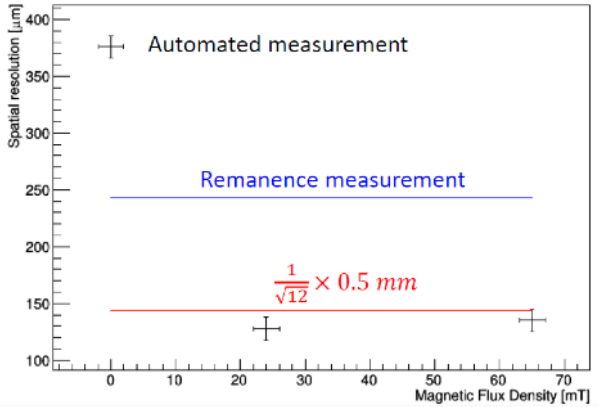


Photonis

prox. focus



no prox. focus



see talk by J.Rieke @ DIRC2015

Preliminary referee report (Sept. 4): Points to be carefully studied in future

2. **The potential pollution of optical surfaces from the front-end electronics during the projected 10 years of PANDA operation is a major concern. This requires:**
   a) to prepare a long-term realistic pollution test to prove that the internal reflection coefficient is not affected by the electronics outgassing, and
   b) a design of suitable restrictions to direct the N2 boil-off gas flow in a correct direction with no stagnating pockets in critical regions.

- **Makes sense only when we have a quartz plate of the final size and with final PCBs**

Preliminary referee report (Sept. 4): Points to be carefully studied in future

3. The RC would also like to see the following data analysis studies done

(a) The available test beam data should be analyzed to determine the single photon Cherenkov angle resolution and photon yield. Both quantities should then be compared to a detailed full Monte-Carlo (MC) simulation. If the MC simulation is too optimistic compared to the reality, we suggest that the EDD group tries to simulate defects, for example for the optical surface quality, and see if these can explain the data. If not, some other variables should be investigated until a proper explanation is found. This may yield a better understanding of the detector.

(b) The RC would like to see a plot showing all wavelength-dependent quantities affecting the detection efficiency. This includes the MCP-PMT quantum efficiency, the bulk transmission, the glue transmission, the choice of the filter response, the internal reflection coefficient for a typical number of bounces, etc.

(c) The RC would like to see the explicit breakdown of the various contributions to the single photon Cherenkov resolution.

(d) The RC would like to see a 2D plot with the Cherenkov angle resolution per photon and per particle and the number of photons as a function of the θ and φ variables (or x & y if more convenient), in order to see if there are areas of worse PID performance in the detector.

(e) The RC would like to see a comparison of the reconstructed single photon Cherenkov resolution obtained either from the analytical method or from the look- up table method.

- **Partial answers are found in PhD thesis of Oliver. Mustafa will continue on these studies in his PhD thesis.**

Preliminary referee report (Sept. 4): Points to be carefully studied in future

4 The RC would like to see more details regarding the data analysis procedure, in particular the use of photon and event timing in the reconstruction

- **Mustafa thesis**

5. The RC would like to see a study of the simulated PID performance as a function of the number of particles hitting a disk quadrant per event. Similarly, the RC would like to see the simulated PID performance as a function of different design parameters, such as MCP-PMT anode pitch or disk thickness.

- **Has been done by Oliver**

6. The RC would like to see a plan for future test beam efforts.

- **The 2015 test beam was successful and is being analysed. Next test beam in fall 2016 at CERN or DESY.**

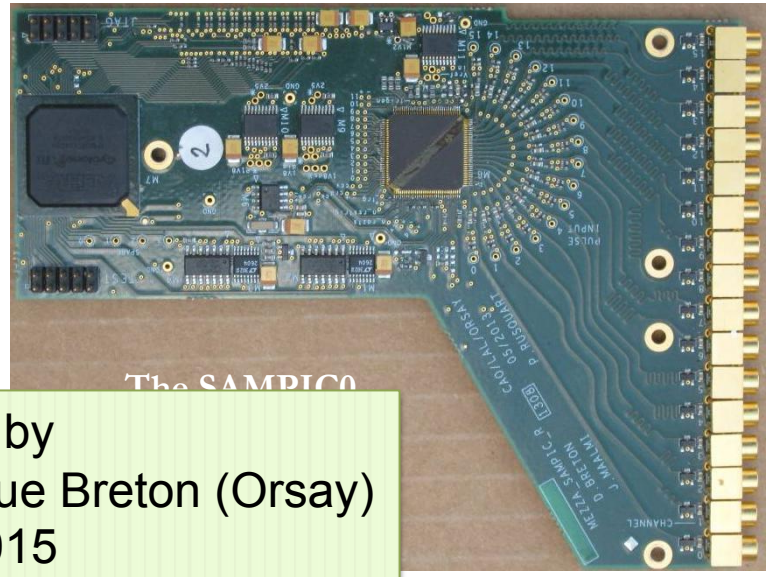
Preliminary referee report (Sept. 4): Points to be carefully studied in future

7. Upgrading the existing **cosmic ray telescope setup in Giessen** to one closer to the SLAC cosmic ray telescope would be a clear plus to test the EDD quadrant prototype. Special attention should be given to the selection of straight tracks through the use of a thick absorber. It is a big effort to set it up initially, but if designed properly, many detectors, including the **PANDA Barrel DIRC and other devices**, could be tested in it. Over a period of 3-4 years it would pay back.

- We have no money for a large scale multi channel cosmics test stand.
- We are working on an upgrade of our 3 plate, 12 PMT cosmic stand with new PMTs and a triggerless fast sampling readout (SAMPIC) to fit pulse shapes.
  (Overkill for cosmics)

PROTOTYPING & ACQUISITION SETUP

- **Chip prototyped in AMS 180nm CMOS (8mm^2)**
- **First version: SAMPIC0. Now using SAMPIC1.**
- **32-channel module integrating 2 mezzanines**
- **1 SAMPIC/mezzanine**
- **USB, Ethernet UDP**

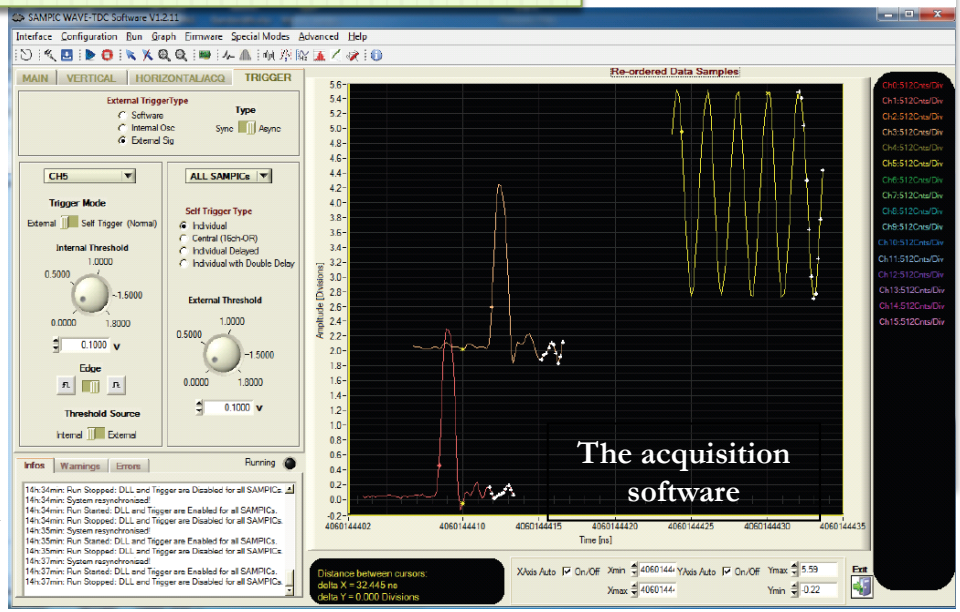


See talk by
Dominique Breton (Orsay)
@Dirc2015

- **Acquisition software** and C libraries

=> full characterization of the chip & module

- Timing extraction (dCFD, interpolation…)
- **Special display** for **WTDC mode**
- Already used for small scale experiments



Next step:

- **“Publish” the technical report as PANDA report in arxiv.org now. Any objections?**

- **Write an EDD TDR end 2016? (Refer to the EDD technical report and the Barrel DIRC TDR)**

Critical Issues:

- **Funding of final EDD**
- **Manpower for future full scale production in case current experts leave**

Scrutinity report:
These statements are not helpful as they may screw up the motivation.

5.12. DISC DIRC

System manager: Michael Düren

The DiscDIRC development is carried by a qualified but too small research group. The status of the DiscDIRC changed fundamentally since the first questionnaire and the Interim Report because it is now back to the R&D phase. Financing of the R&D work is secured for the next three years, and the results from tests at CERN in the first half of 2015 seem to be promising. The amount of invest money that will be available in the next years is far below the money needed for a fully functional DiscDIRC quadrant that could be mounted in the early phase in $\bar{P}$ANDA. The DiscDIRC will be mounted onto the support frame of the EMC Forward Endcap. Cooperation with the EMC group concerning mechanics and cable routing has been started. The simulation and reconstruction code for the DiscDIRC in PandaRoot exists just in a private version, which has to be merged with the main development branch of PandaRoot as soon as possible.

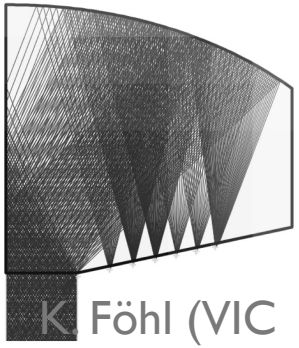
Because the R&D is still on-going and because of the financial and manpower problems, it is unclear when the DiscDIRC may become available.

Summary:

The system is still in the R&D phase. The manpower in the group is too small, and there is no secured financing of the detector. Therefore it remains unclear when the DiscDIRC or minimally one sector of the DiscDIRC may become available.

Compare: It remains unclear when the Panda experiment or minimally one stage of the Panda Experiment may become available.

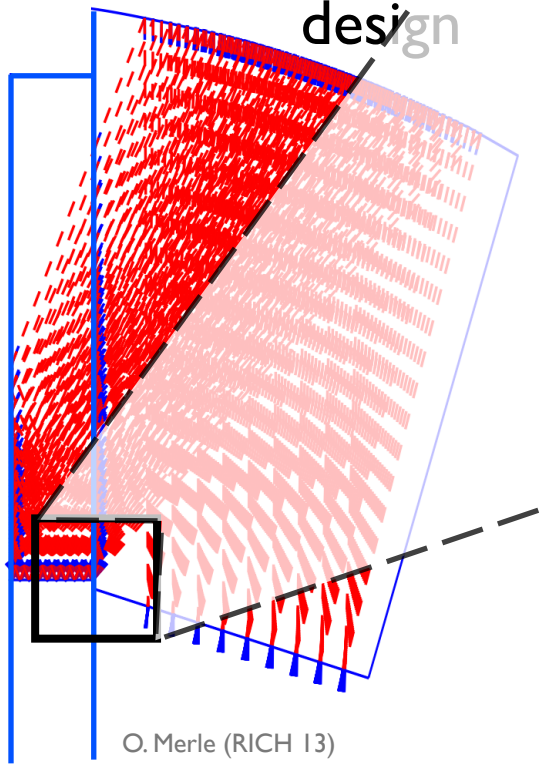
Optical system



K. Föhl (VIC 12)

old dSiPM design

new MCP-PMT design

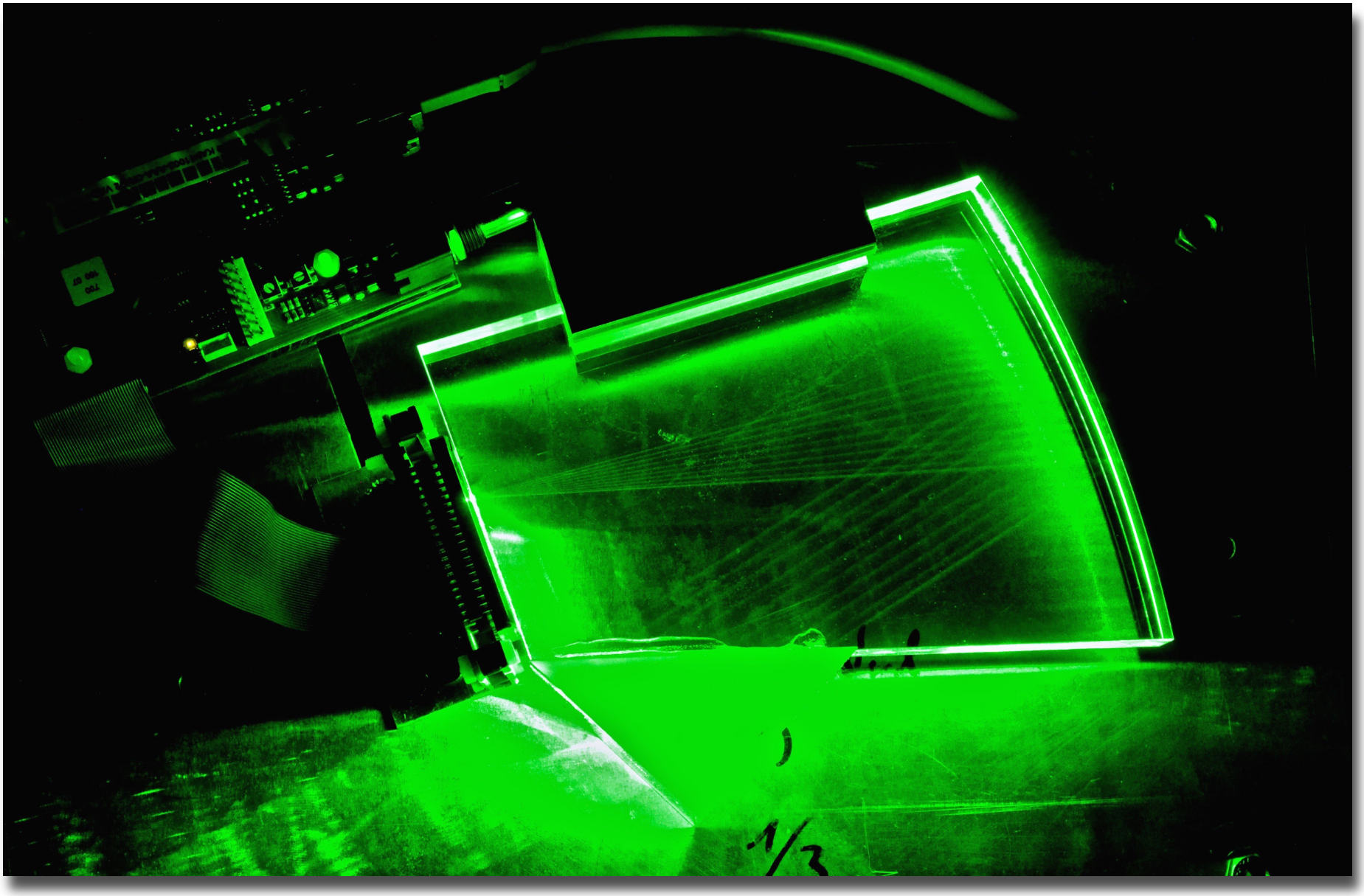


O. Merle (RICH 13)

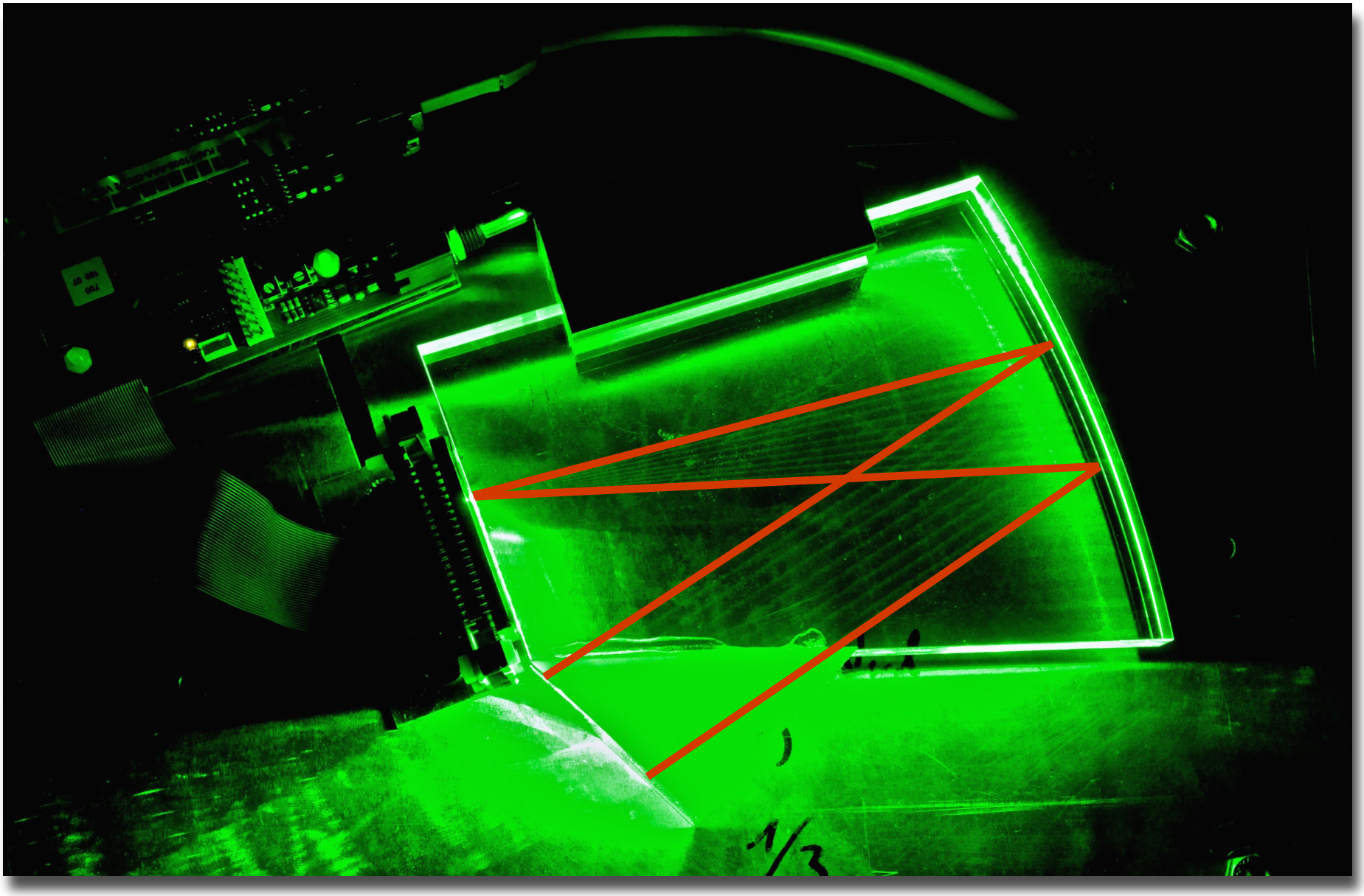
light-guides are to scale

- spot width for focussing matches with the step size of the MCP-PMT anode
- non-adhesive bonding of prism and FLG prevents from losses or defocussing of trespassing photons

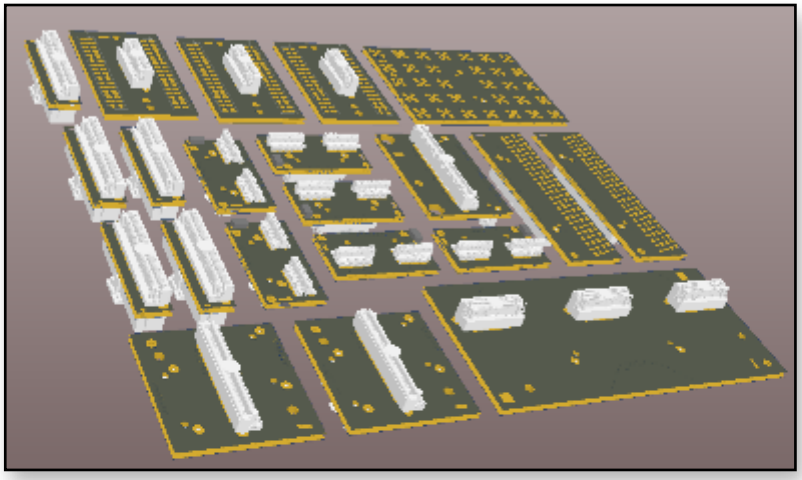
Optical system

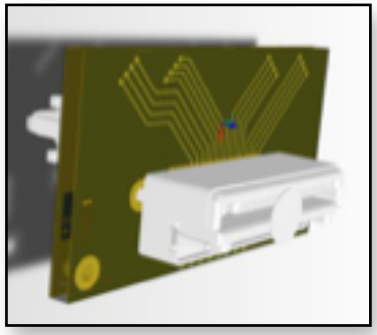


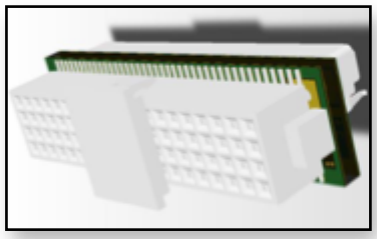
Optical system

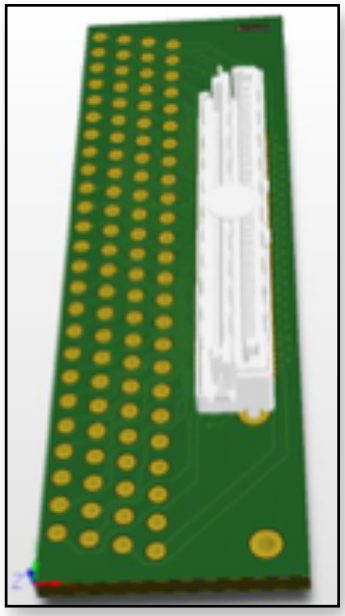


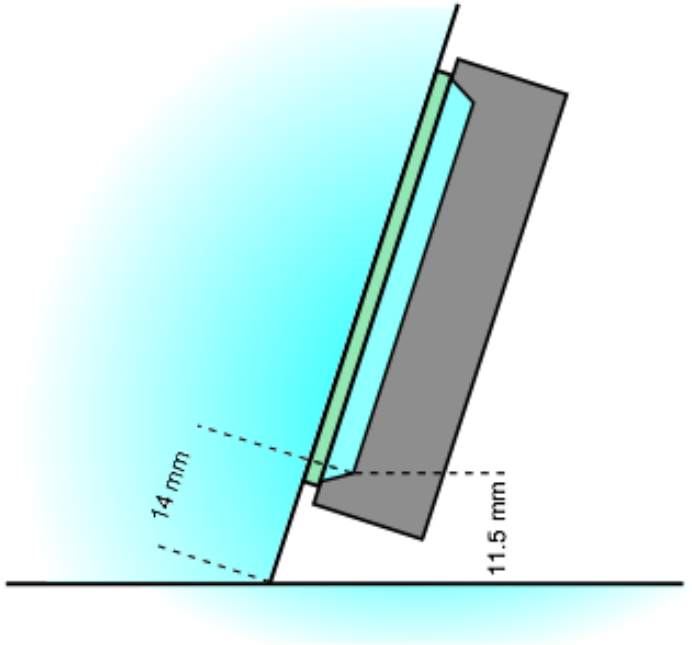
sensors and readout







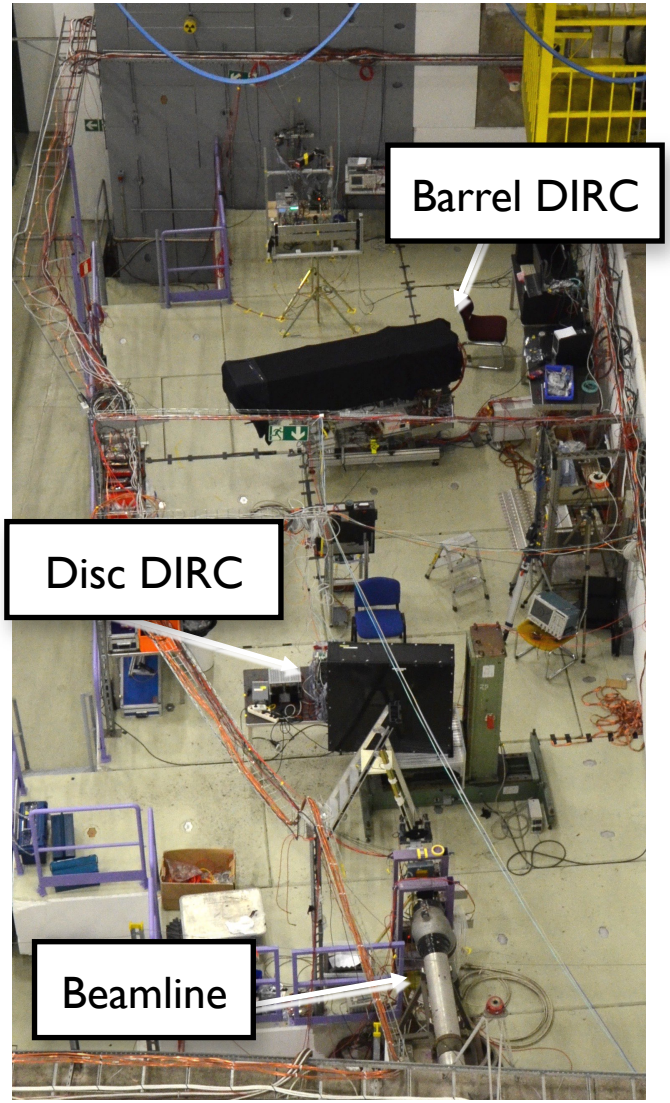




- pointed angle between prism and FLG requires a compact solution
- second iteration of PCBs is being produced in preparation for a TOFPET readout

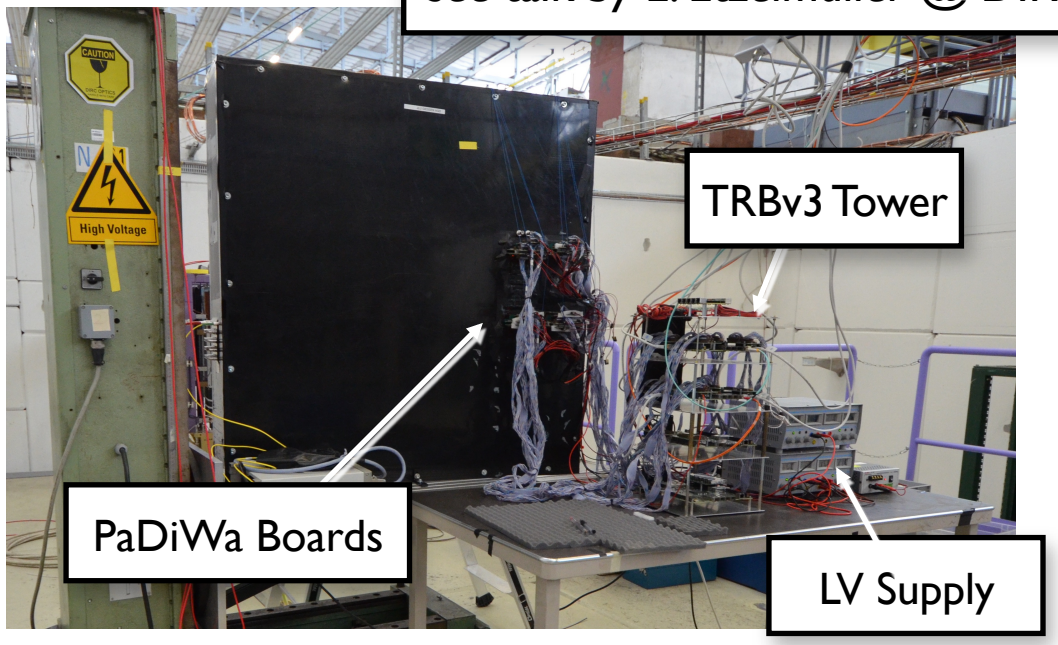
see talk by J.Rieke @ DIRC2015

Testbeam at CERN 2015

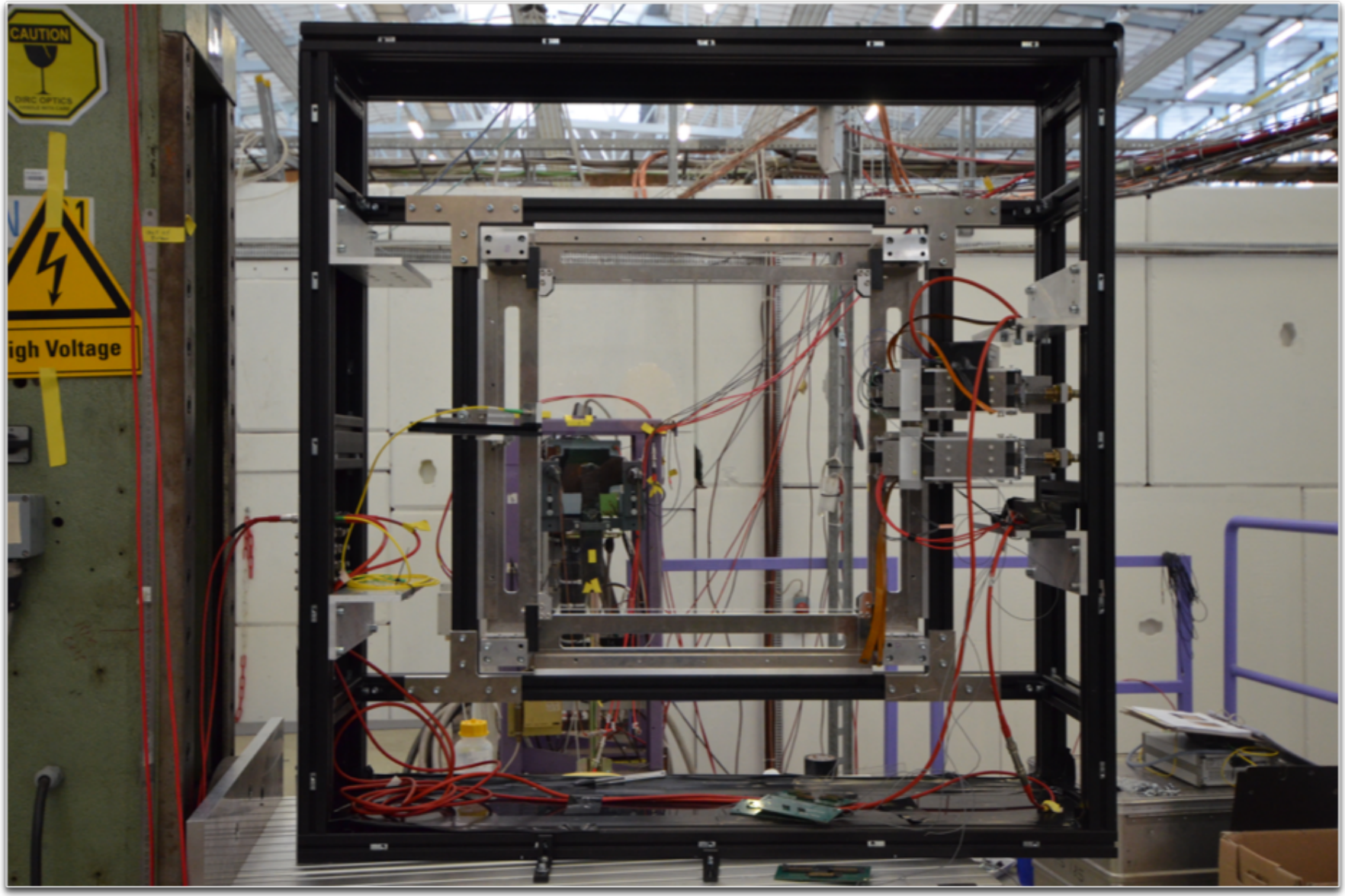


- joint testbeam of the Barrel and Disc DIRC prototypes
- mixed hadron beam up to 10 GeV/c
- common system for data taking (TRBv3)

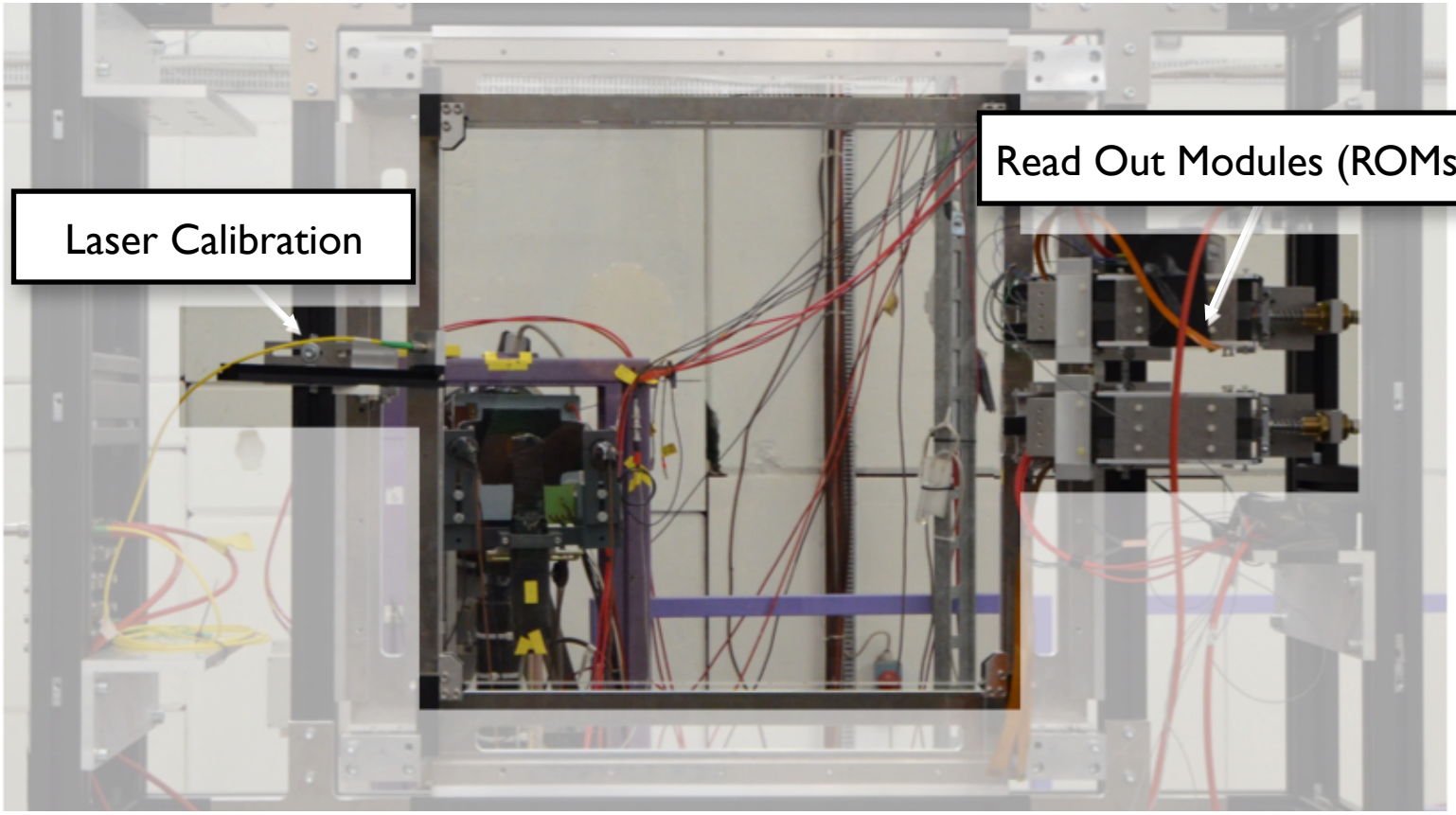
see talk by E. Etzelmüller @ DIRC15



Testbeam at CERN 2015

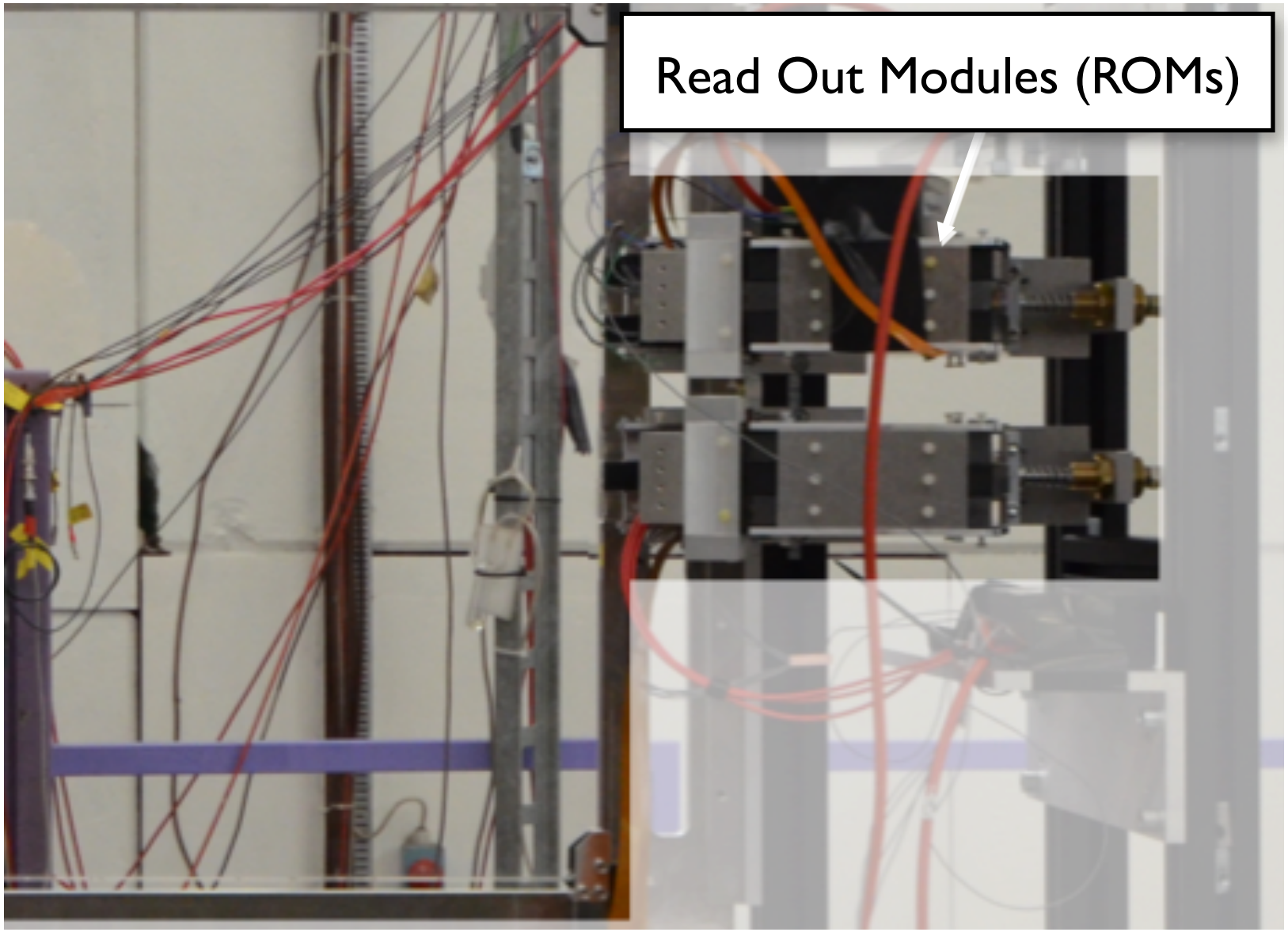


Testbeam at CERN 2015

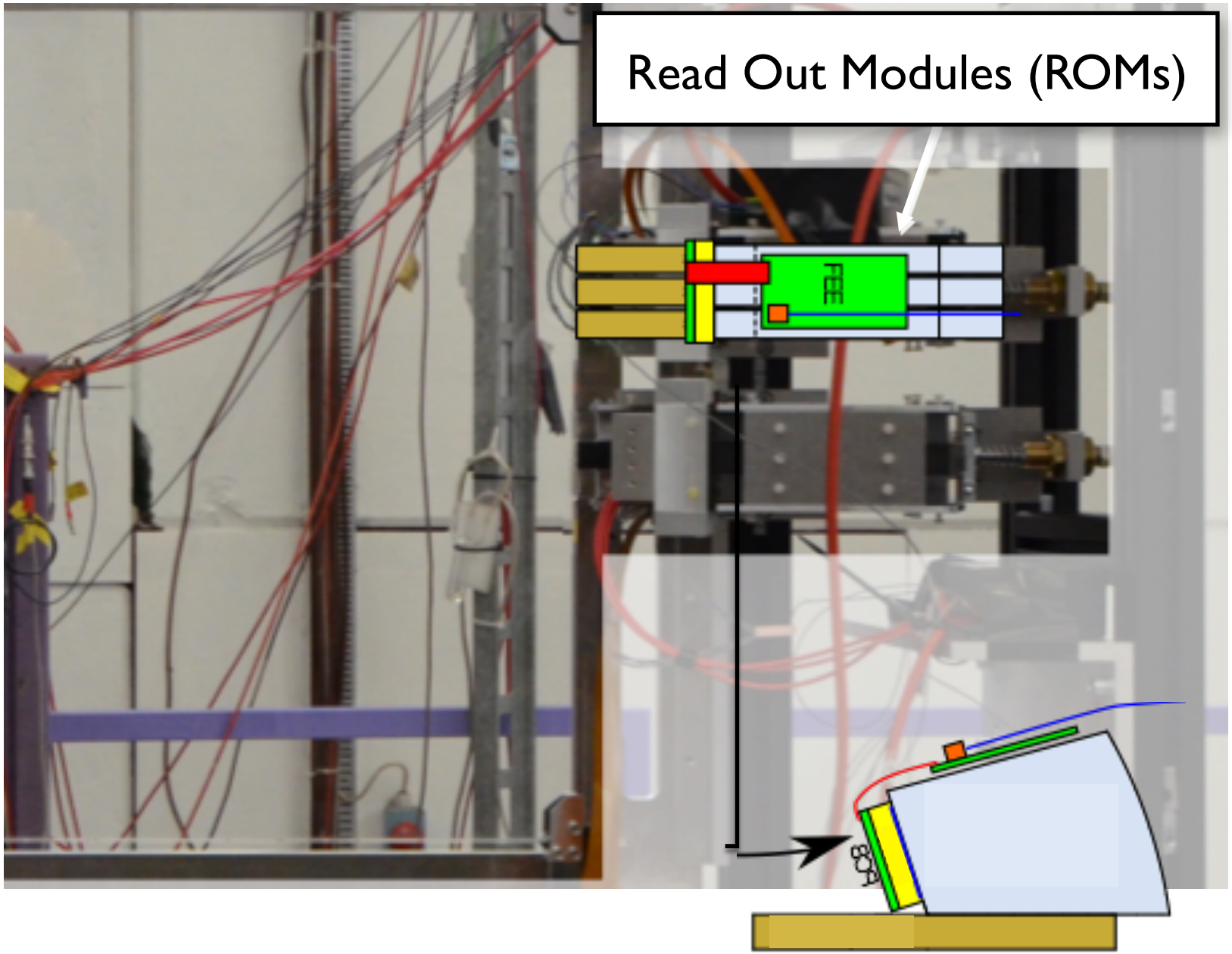


- Minimal setup with laser calibration
- Nevertheless over 300 readout channels
- Fused silica optics

Testbeam at CERN 2015



Testbeam at CERN 2015



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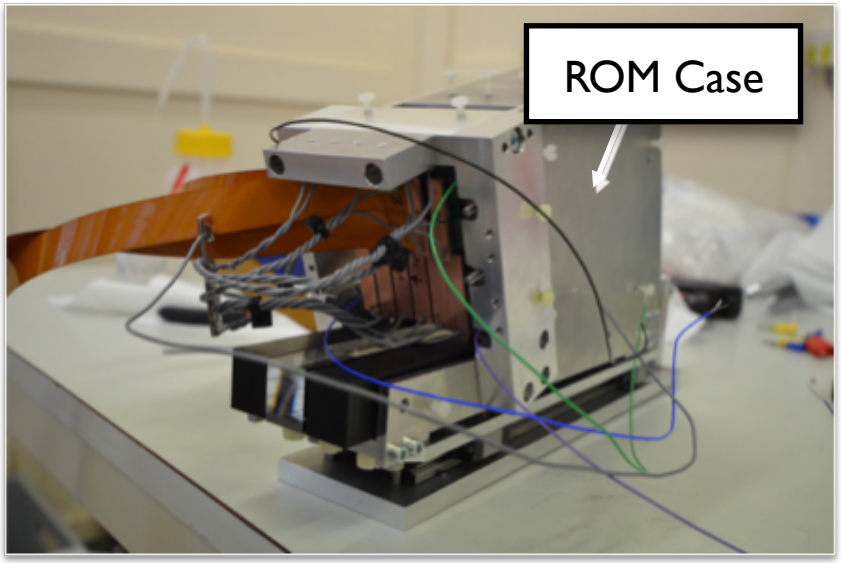
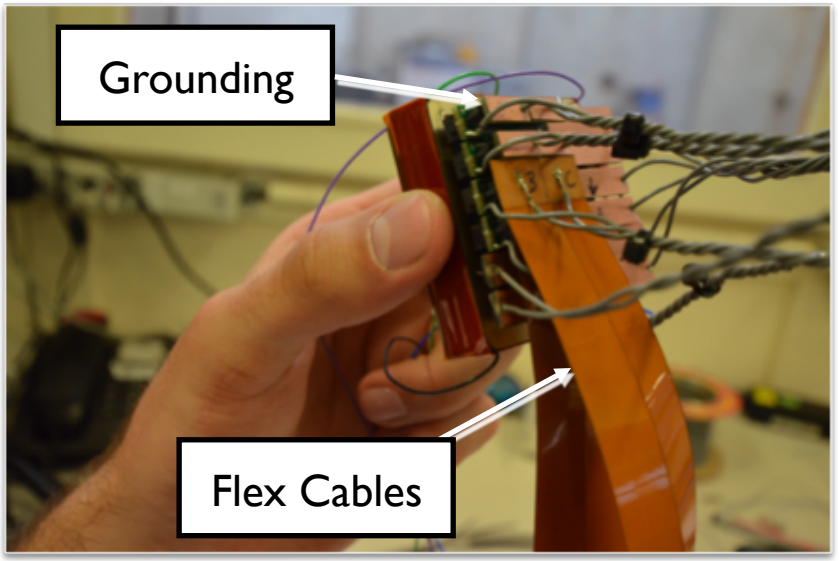
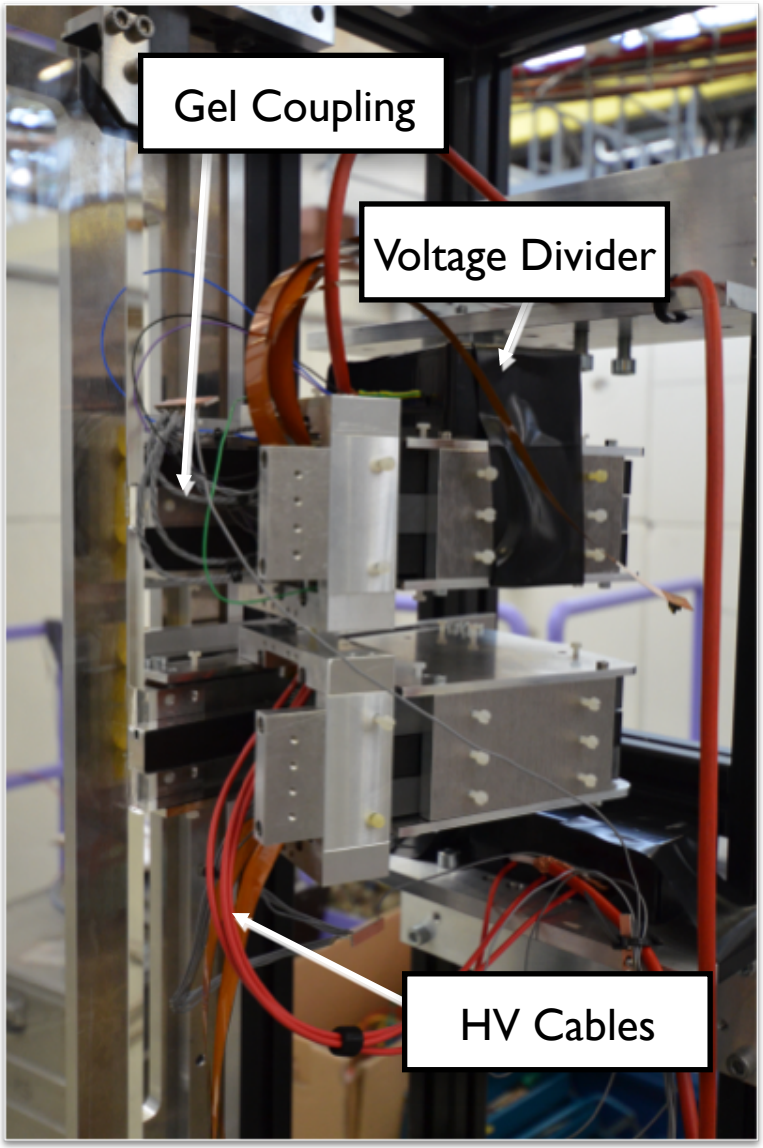
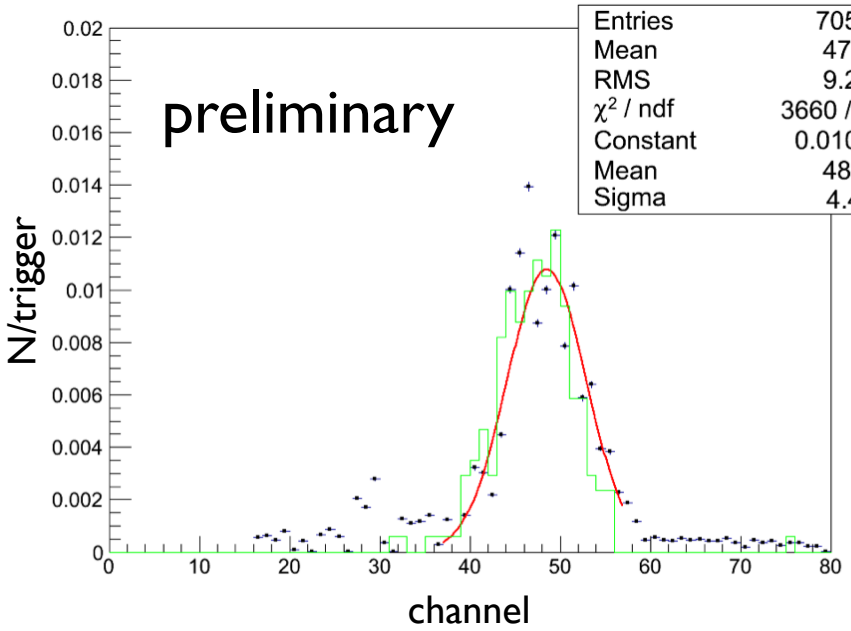
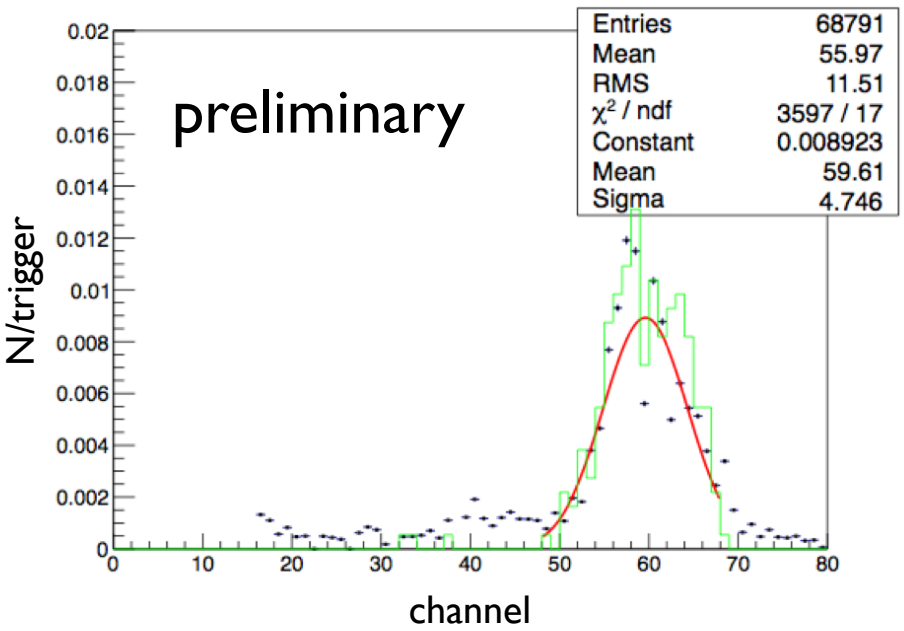






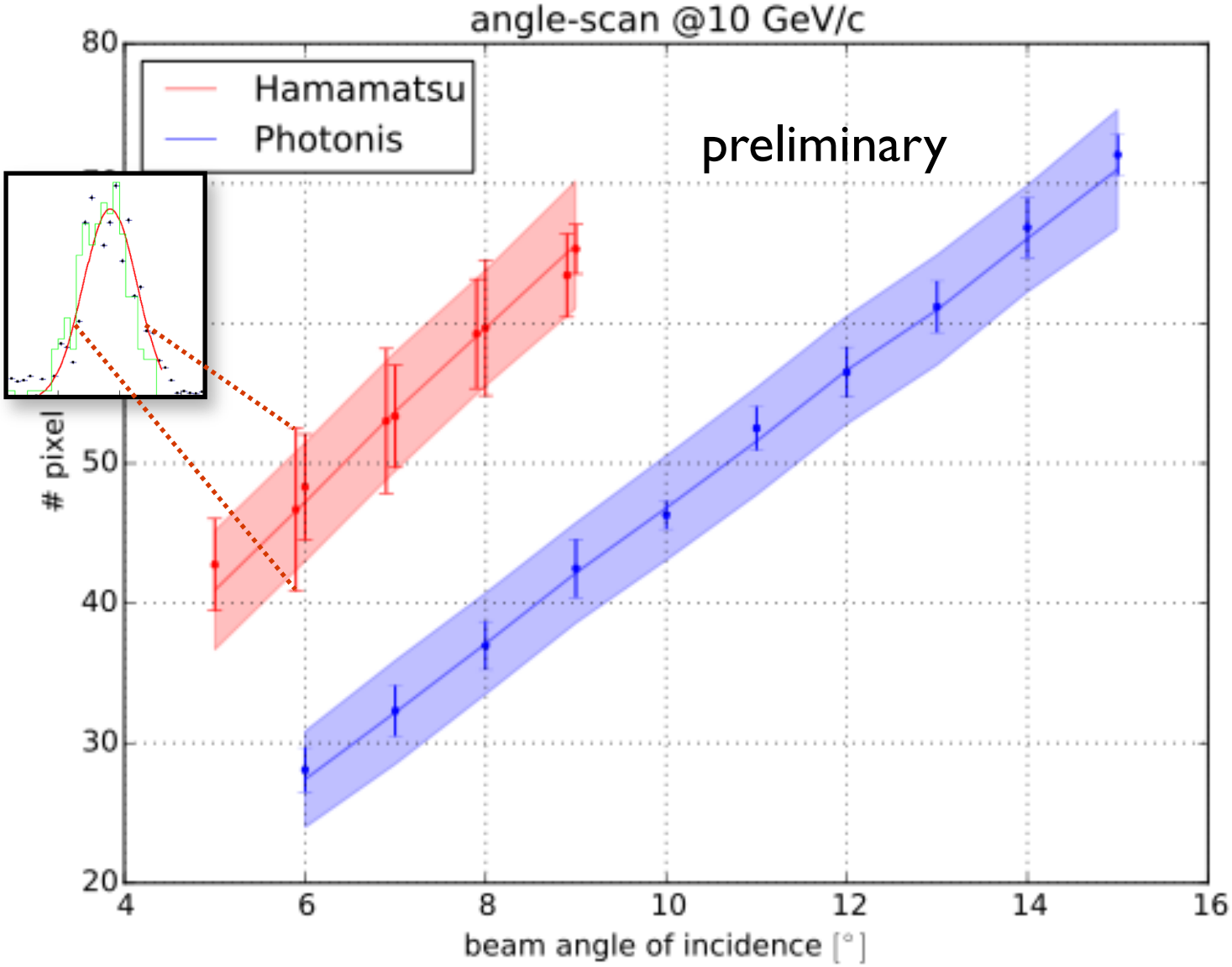
Testbeam at CERN 2015



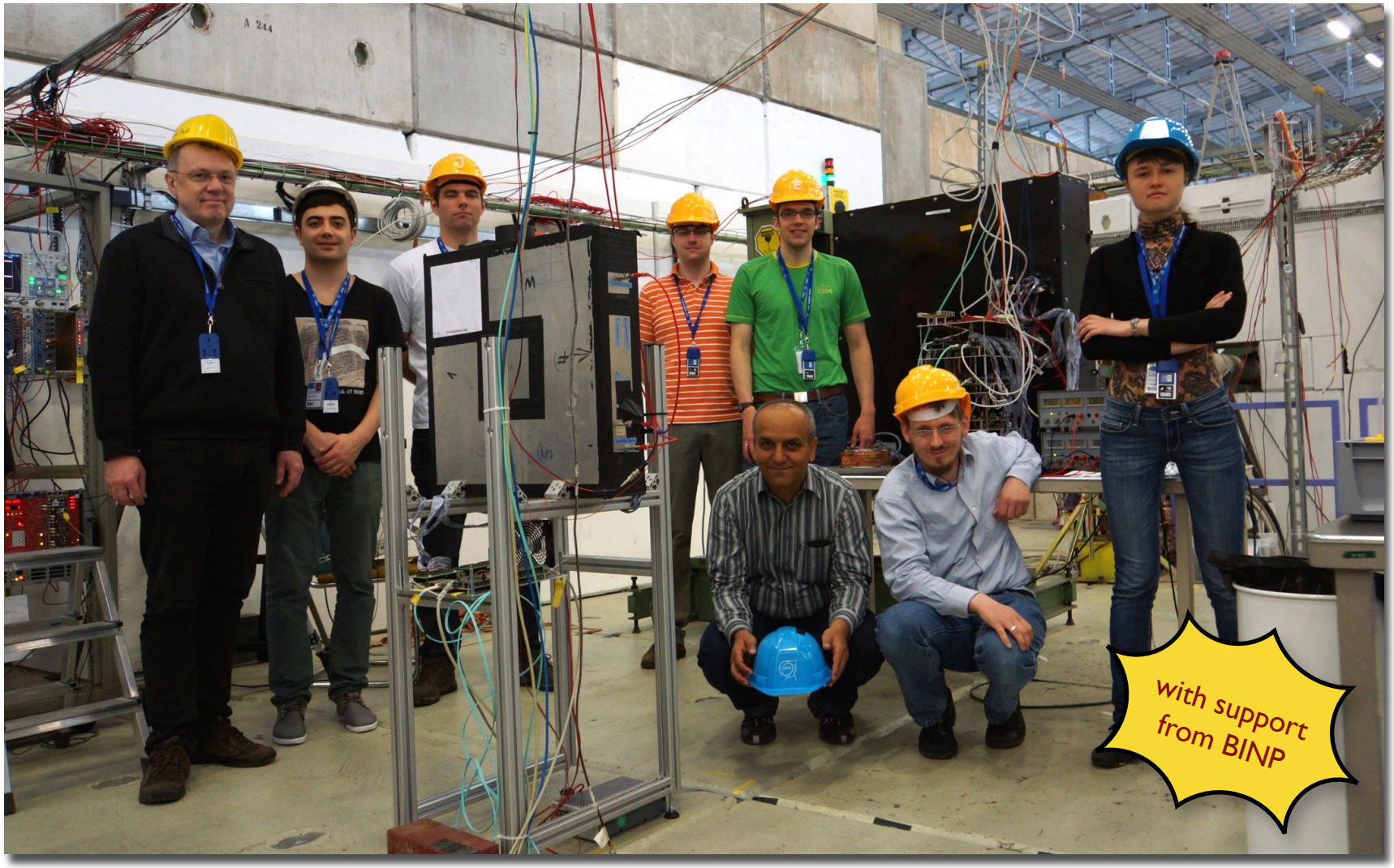


- 10 GeV/c mixed hadron beam
- angles of incidence are 6° (left) and 8° (right)
- Preliminary plots show a good agreement between MC and real data for number of hits vs. channel number

Testbeam at CERN 2015



CERN Testbeam 2015



Thank you for your attention