



Latest news from R³B Phase 0

NUSTAR Annual Meeting

24/02/2021

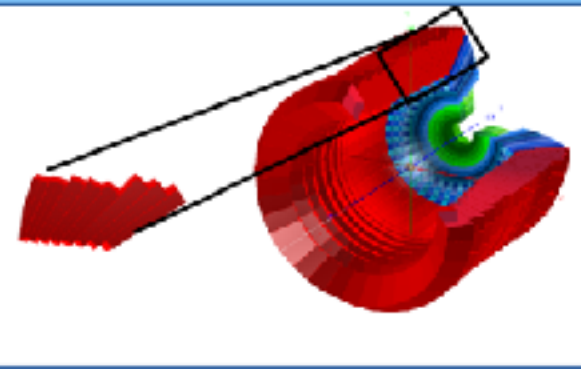
Outline

- **Short overview of R³B essentials**
 - Cave C
 - GLAD
 - NeuLAND
- **Recent developments**
 - Fiber Trackers
 - Improvements of CALIFA
 - Cosmic test of AMS
 - Target area preparations for 2021 campaign
- **Analysis progress of Phase 0 experiments**
- **Summary and outlook**

R³B overview (Phase 0)

- Versatile setup for complete kinematics measurements with RI beams
- Large acceptance, multi-particle detection
- Missing/invariant mass reconstruction

CALIFA



Final Design:

- Barrel (red) - 1952 CsI(Tl) Crystals
- Endcap - 608 Crystals
 - iPhos (blue) - CsI(Tl)
 - CEPA (green) - LaBr₃ & LaCl₃
- 2560 crystals in total

NeuLAND

8/12 (30) double planes + frame
1600/2400 (6000) el. channels & HV

GLAD magnet

Advanced tracking

PSPs, MUSIC, plastic ToF (ΔE , position), fibre trackers (partly in vacuum, with electronics)

Silicon tracker

L3T (DSSSD, delayed) →
AMS up to 8 systems
18 det.ladders (6+12)
Strip pitch 50 μ m
912 ASICS 116736 channels

DAQ & Controls (NUSTAR DAQ / EPICS)
Simulation-Analysis (UCESB/R³BRoot)

Cave C (2021/2020)



Large-acceptance superconducting dipole magnet GLAD

(French-German In-kind, partly EU funded)

Magnet parameters: “Specs” by experimentalists

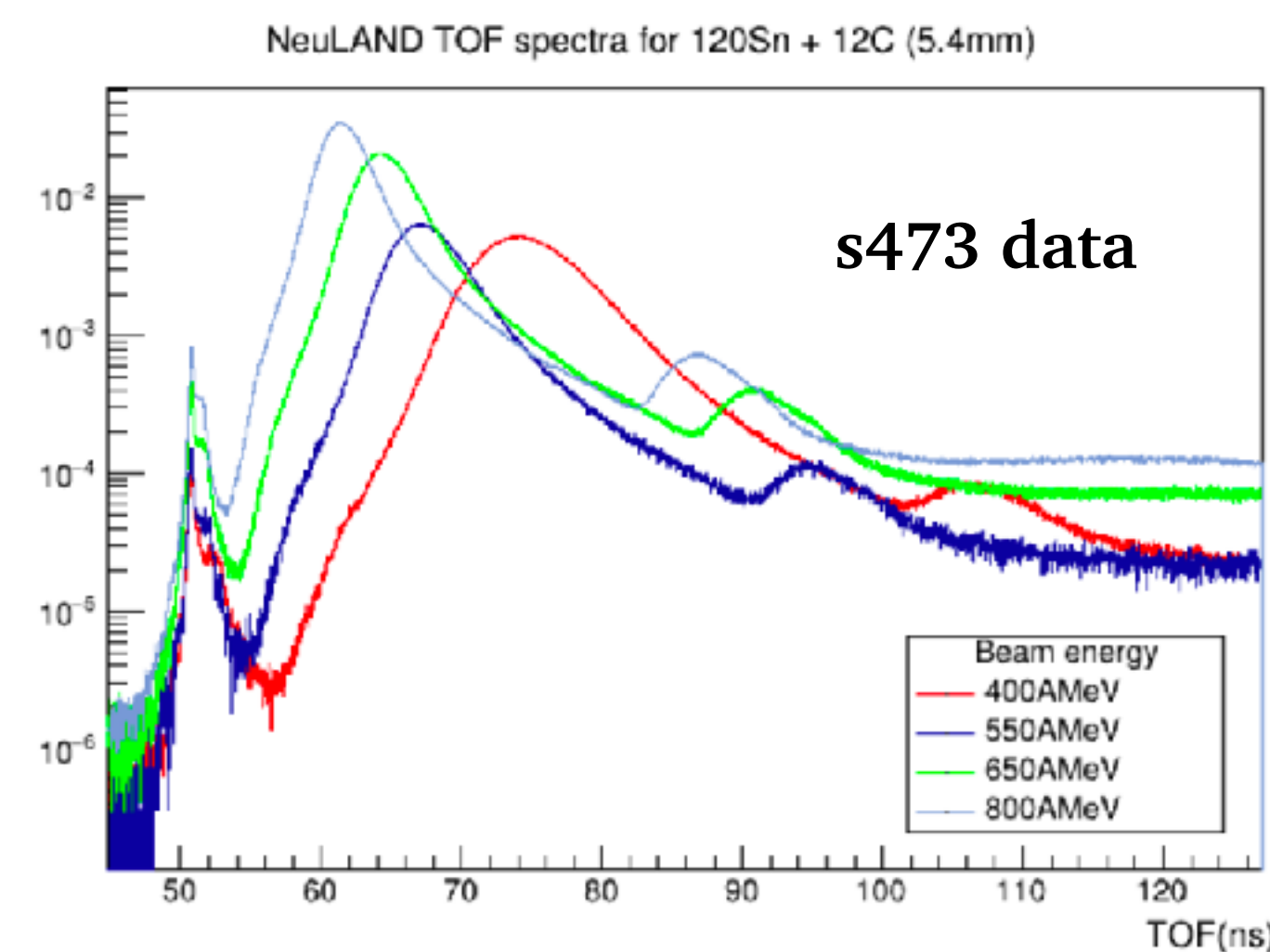
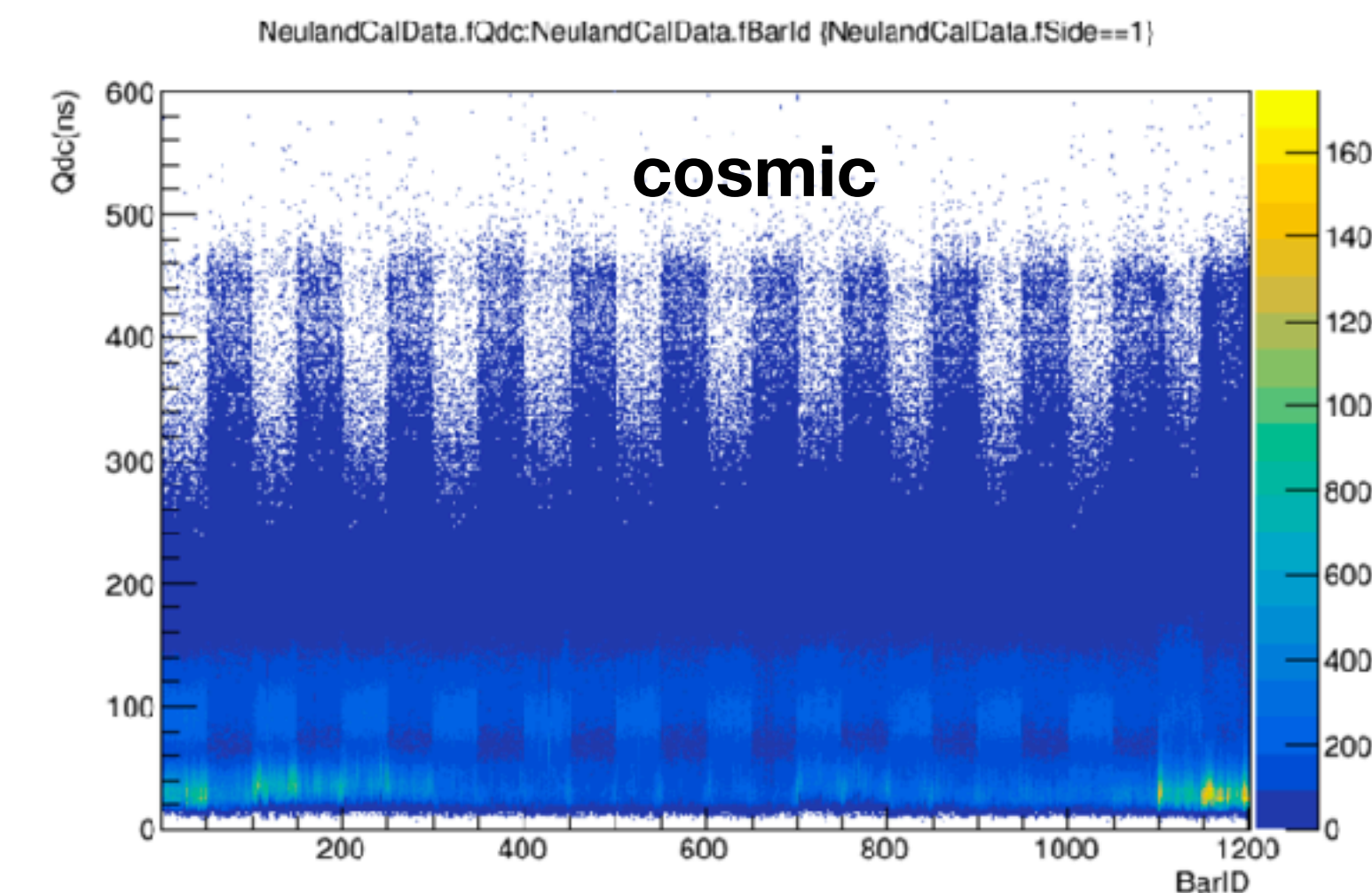
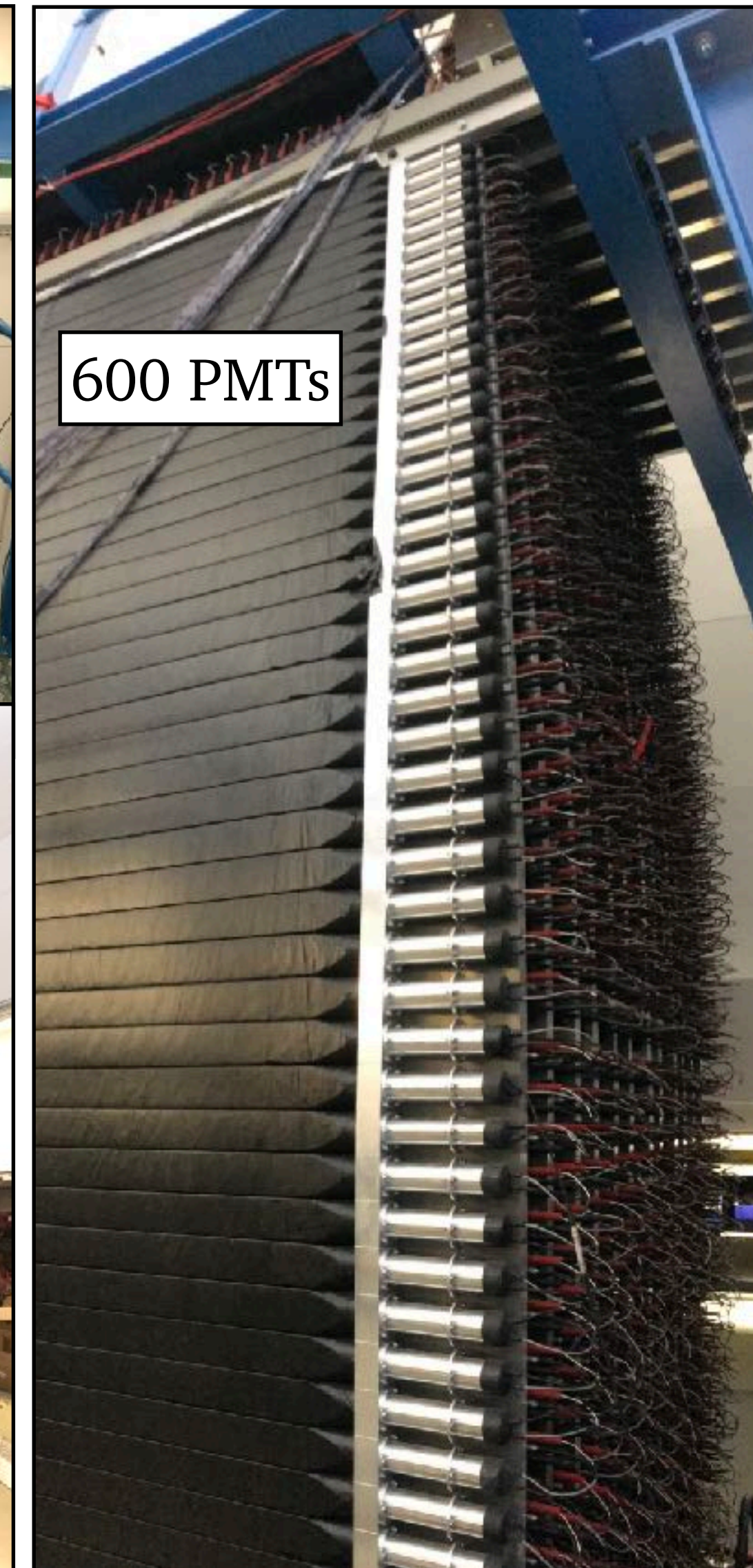
- Large vertical gap ± 80 mrad (vacuum or He)
- High integrated field of 4.8 Tm
 - Operational temperature 4.6 K
 - Max current ~ 3.6 kA
 - Fringe field < 20 mT @ target
- The overall size of the conical cryostat: 3.5m x 3.8m x 7m
- Hardware and operation upgrades (H. Simon): LN₂ pre-cooler, new cool down return line and more..

Magnet is now ready in its final (i.e. original !!!) configuration



NeuLAND with 12 double planes

- 2019/2020 - only 8 double planes
- **1200 bars, 2400 channels** → all channels operational!
 - 3000 bars in the complete configuration (30 DP)
- Gamma peak resolution (sigma) for all bars $\approx$ **140 ps**
- Compact, high-density readout system
 - 12 x (13 FQT-TAMEX + interface cards)
- **~ 20 kHz count max rate**



Courtesy of D. Jelavić Malenica and I. Gasparic

Outline

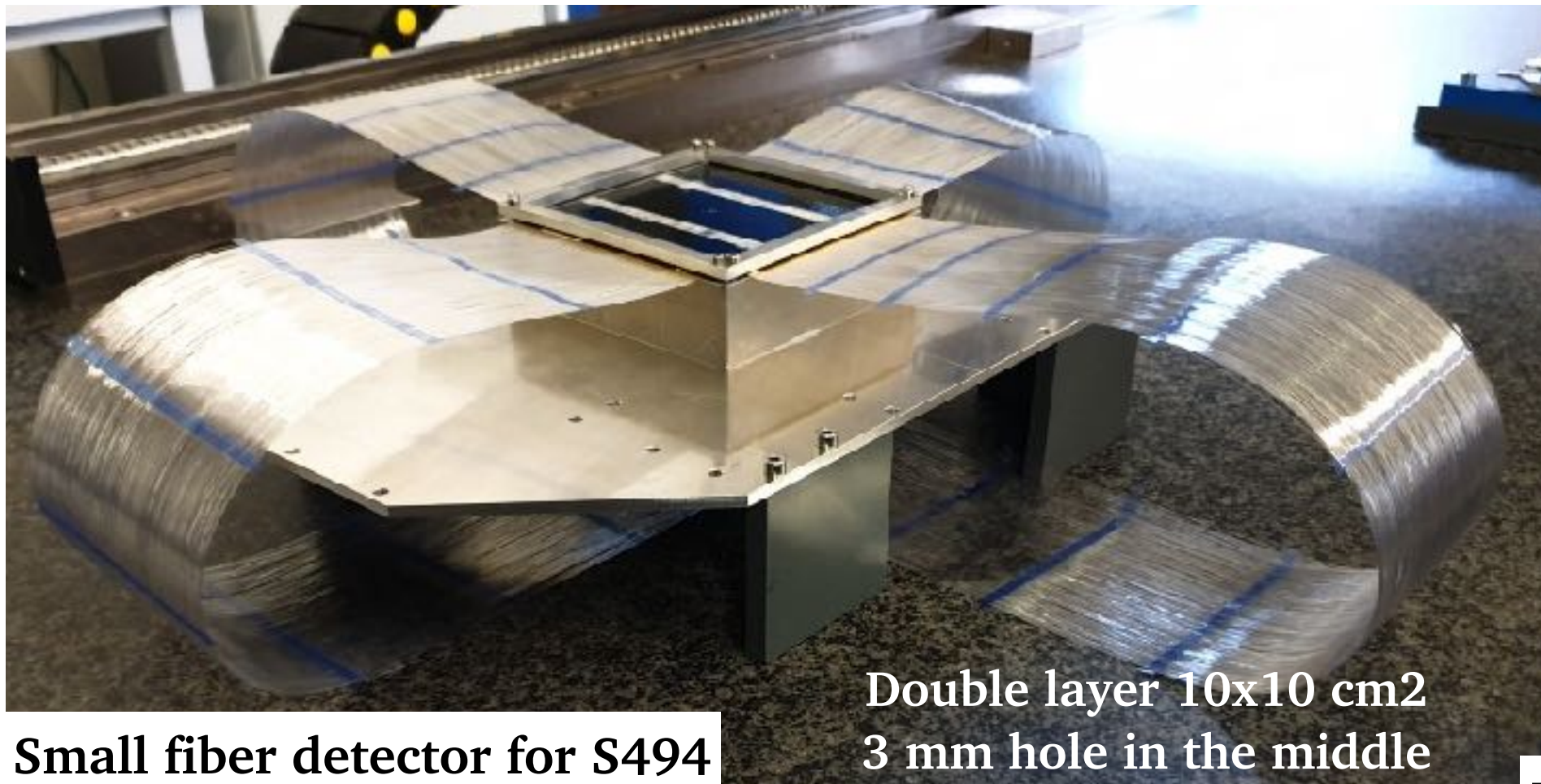
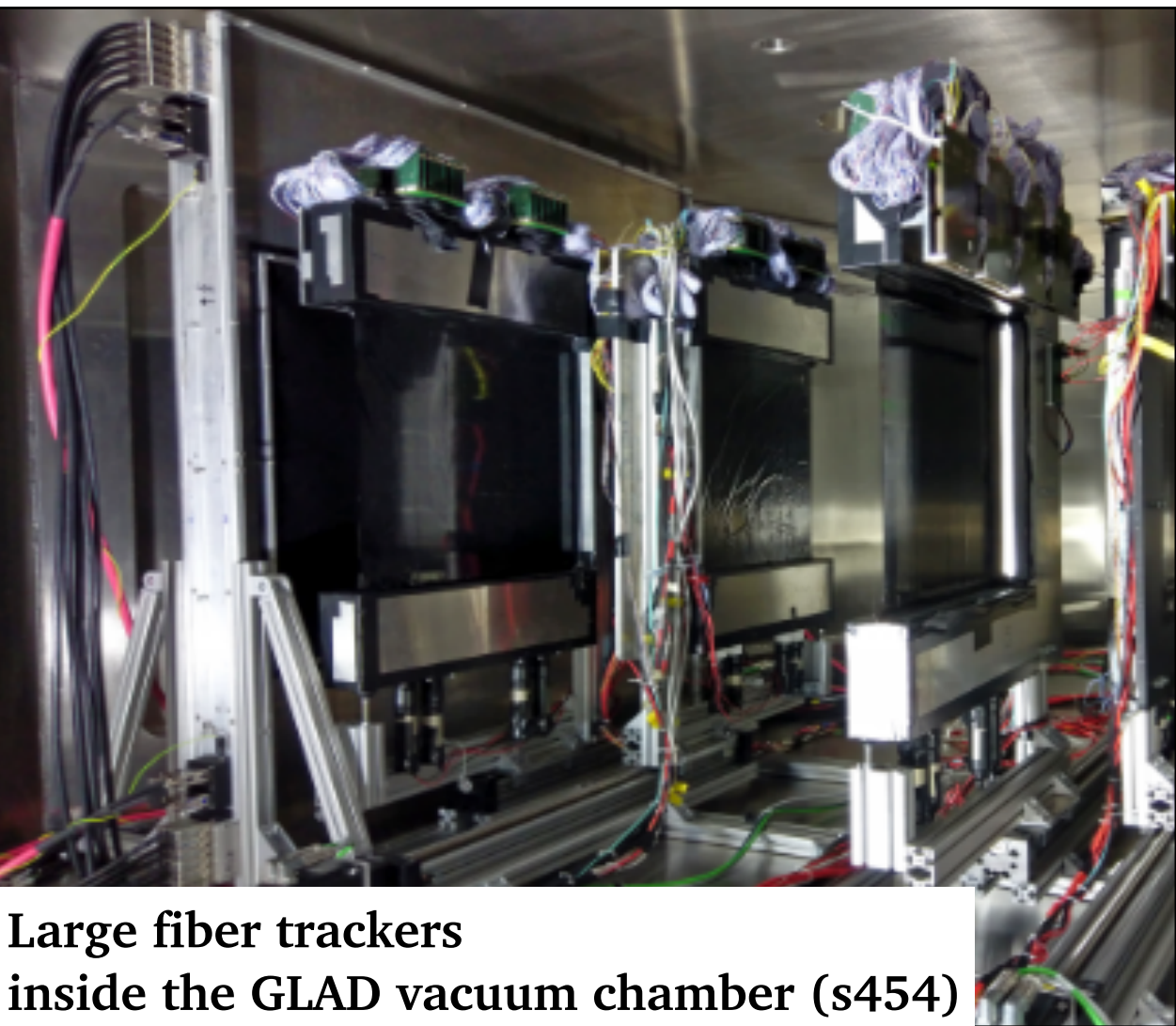
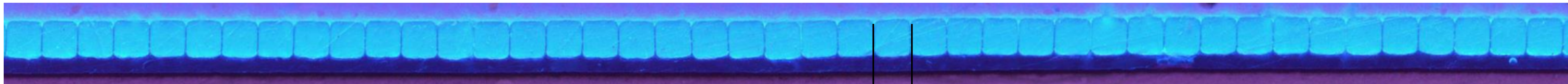
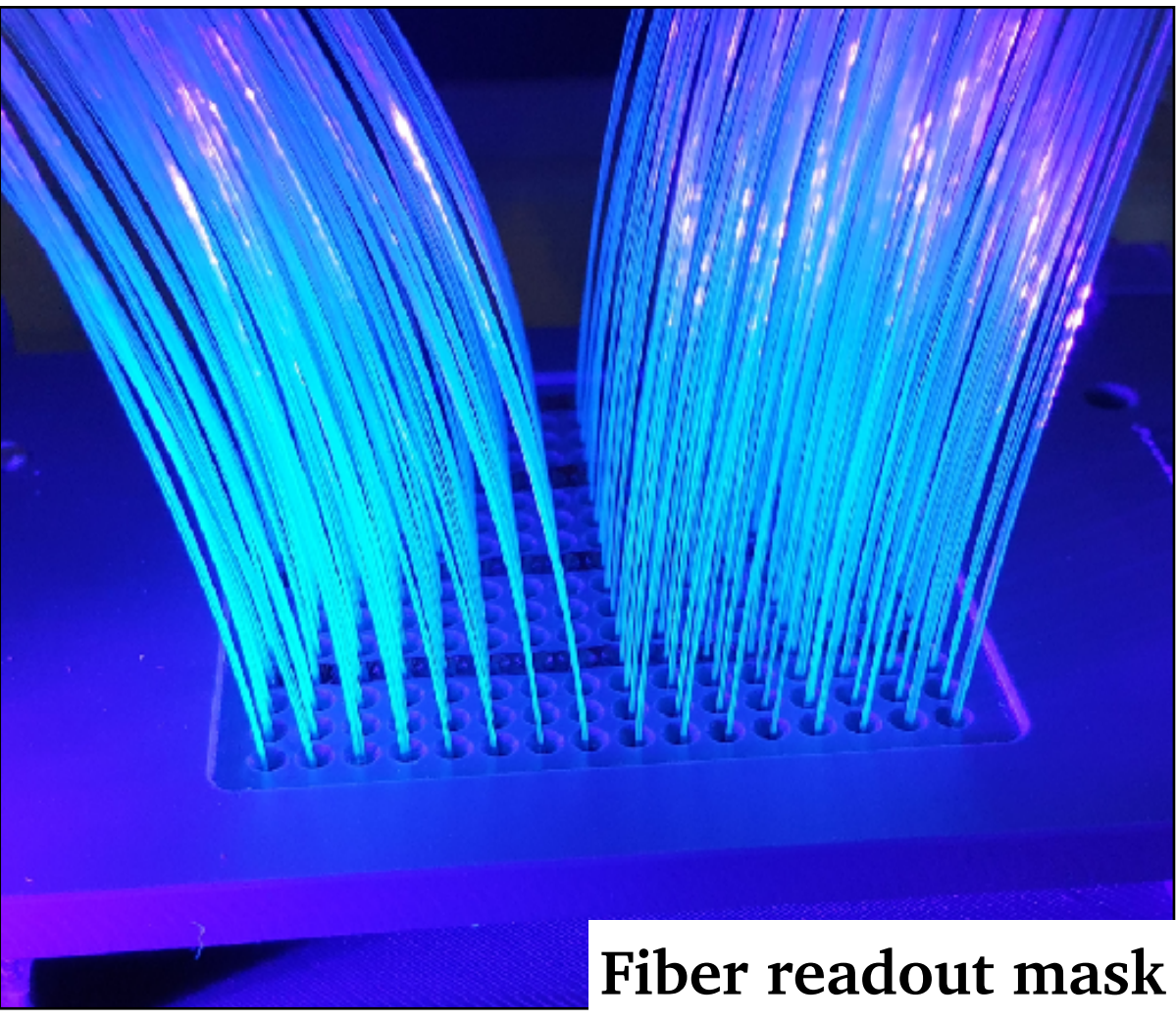
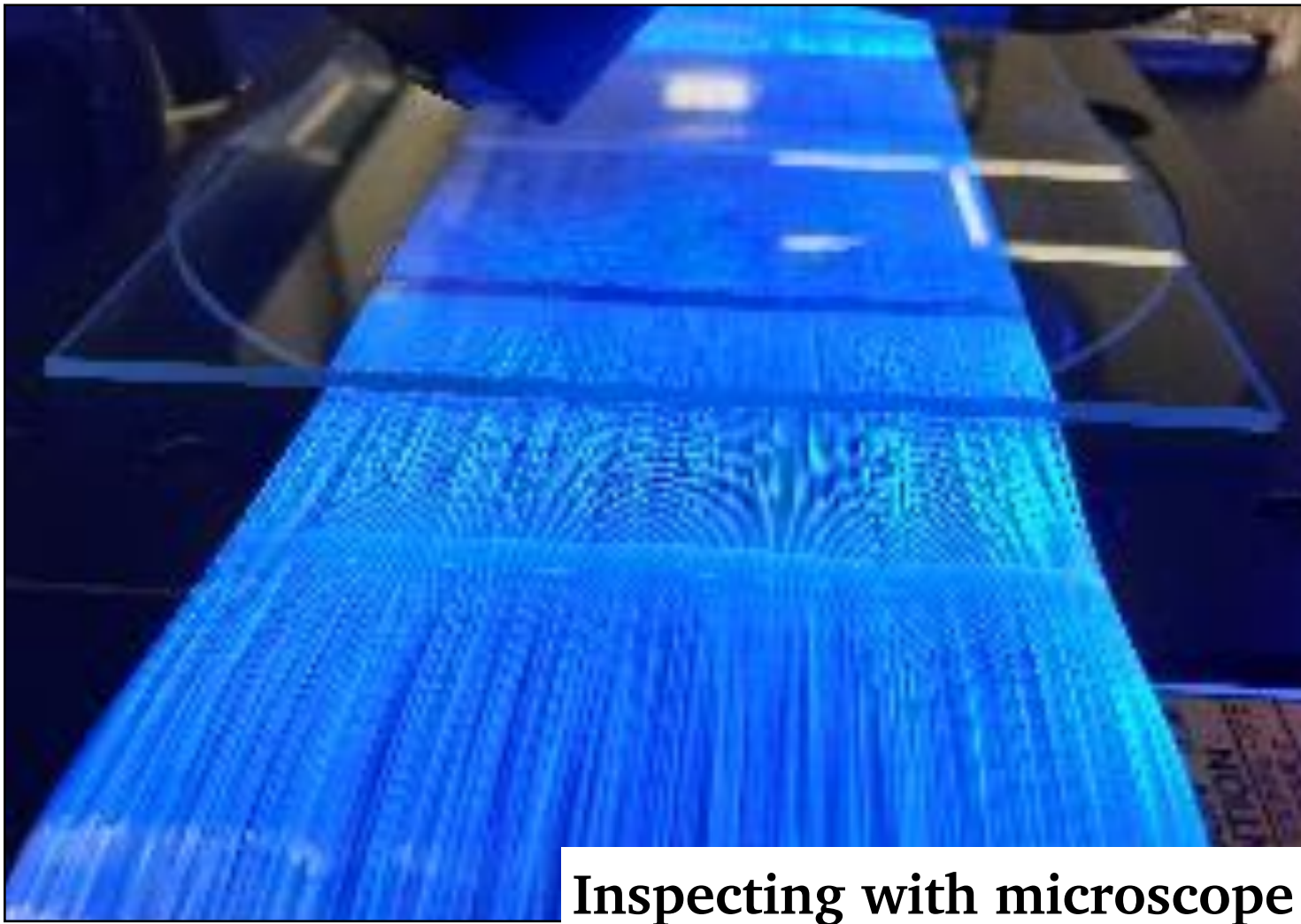
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Scintillating Fiber Tracker

4d Tracking at High Rate with High Dynamic Range

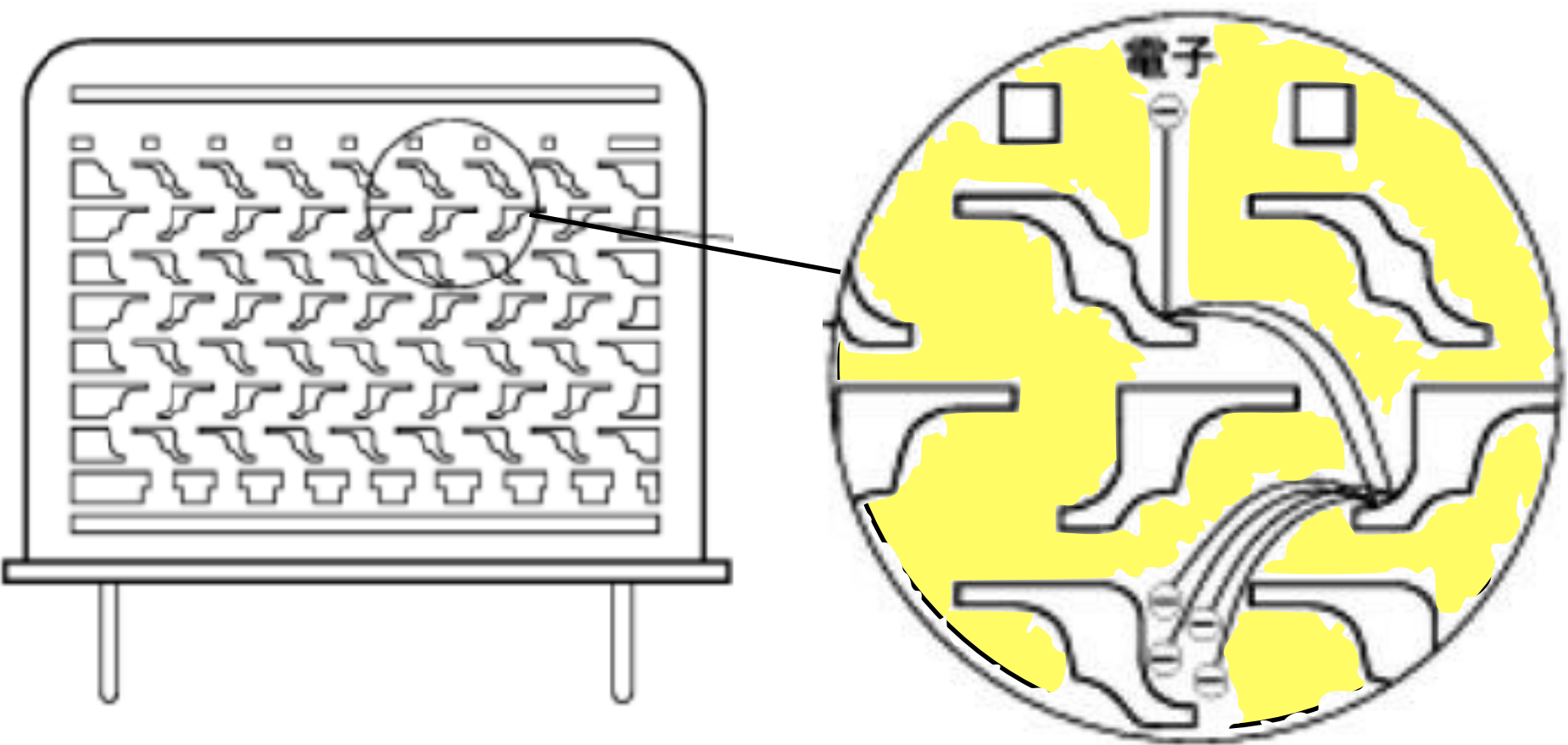
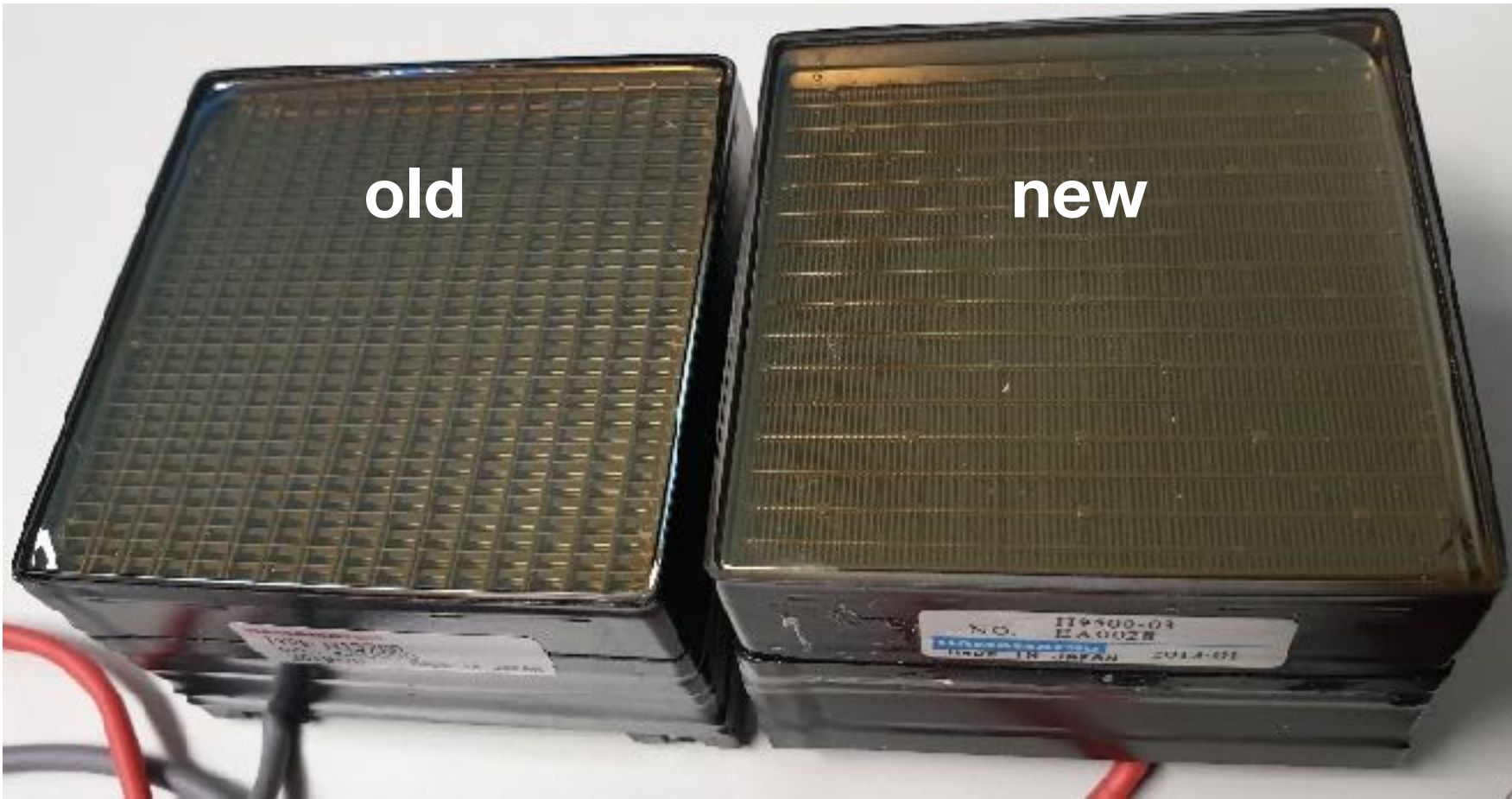
C. Caesar and D. Savran

Infrastructure upgrades



Double layer 10x10 cm²
3 mm hole in the middle

256ch multi-anode PMT assembly

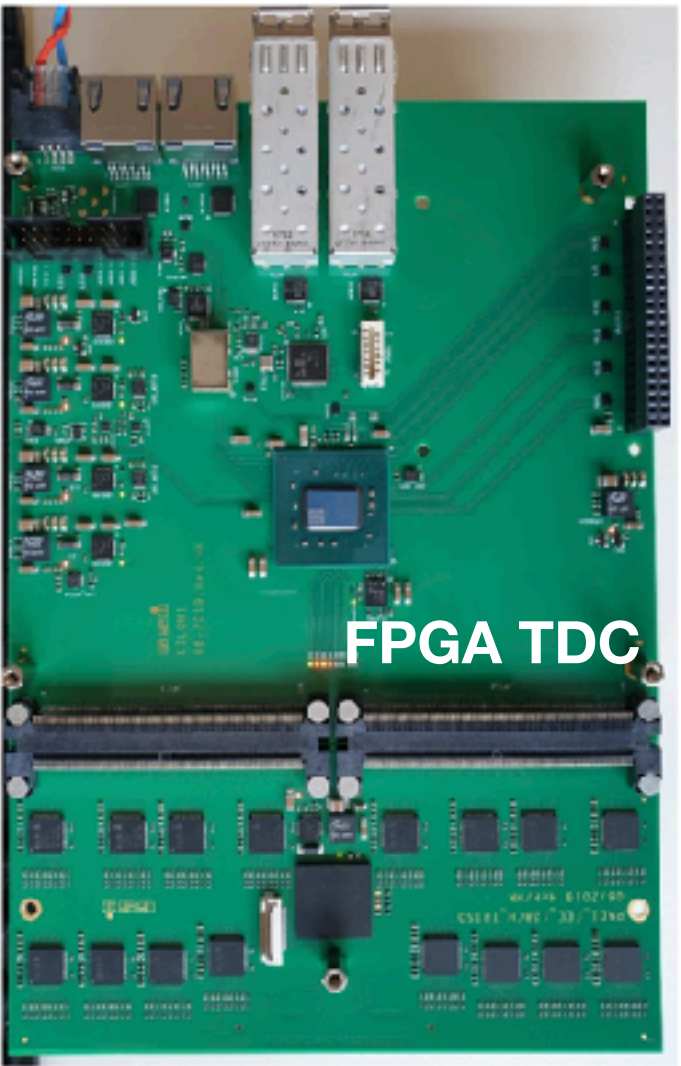
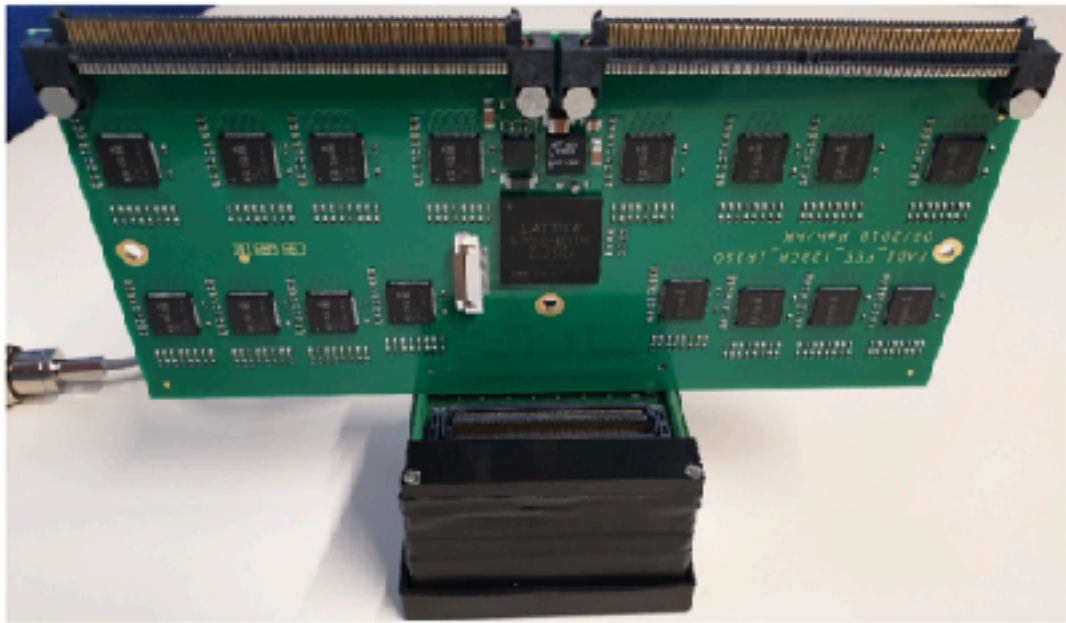
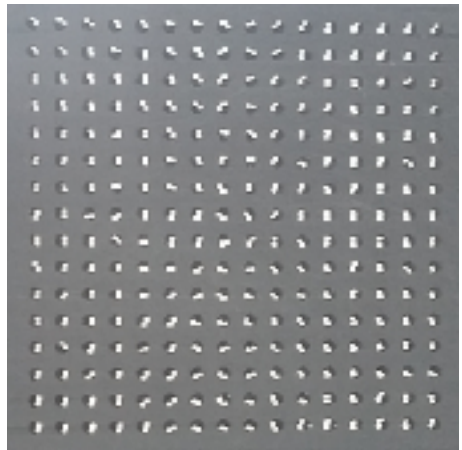
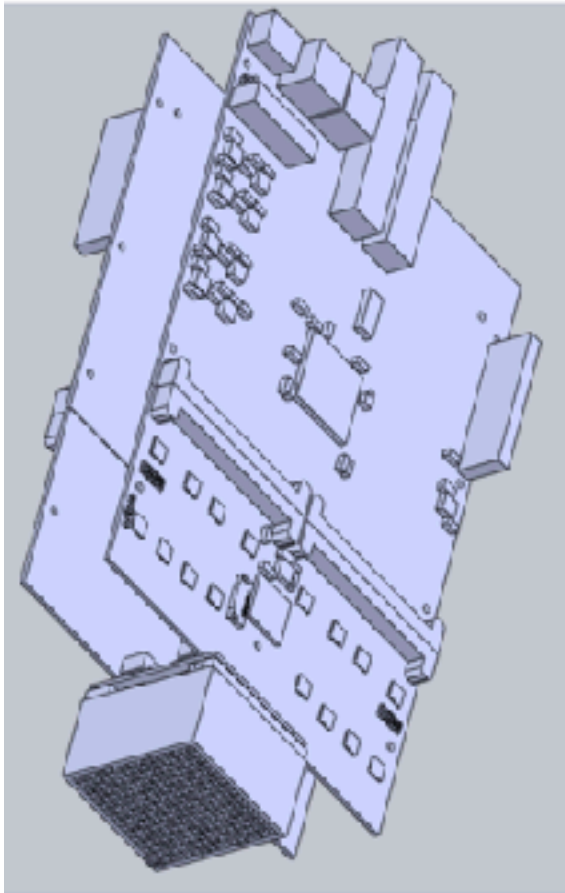


Fiber readout version 2021

FANOUT+16 PADI FEEs
(+Cables) + ClockTDC

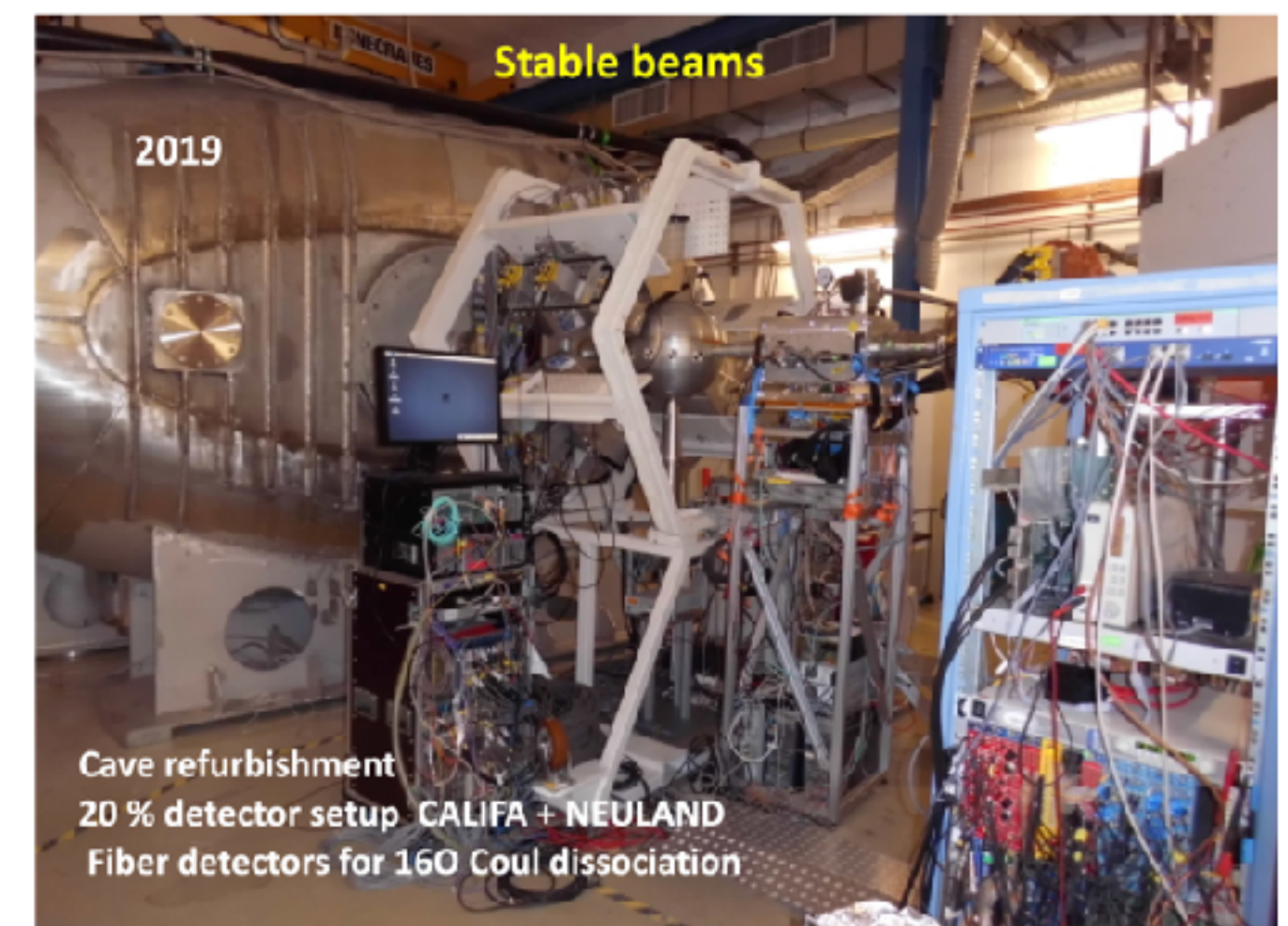
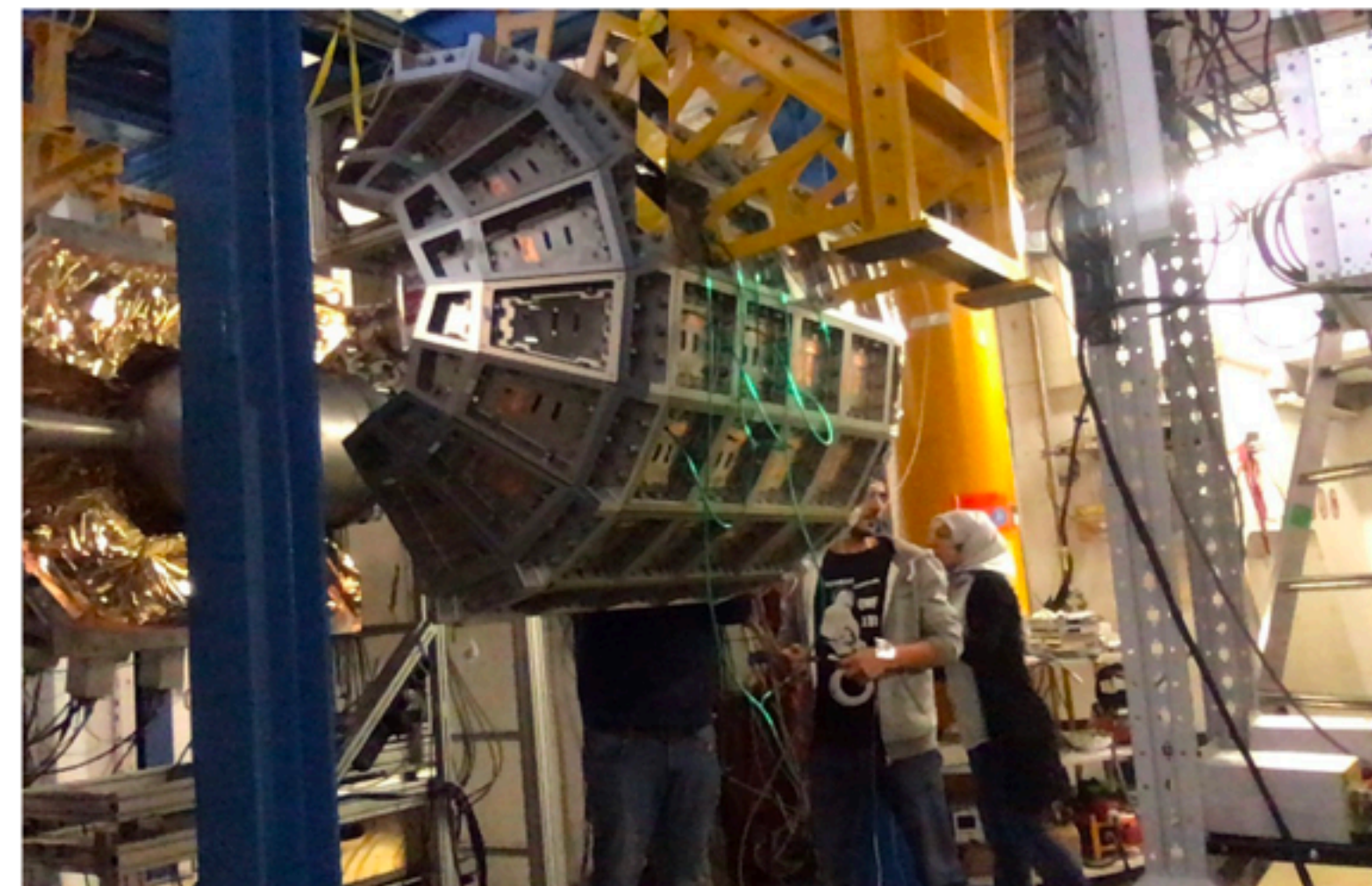
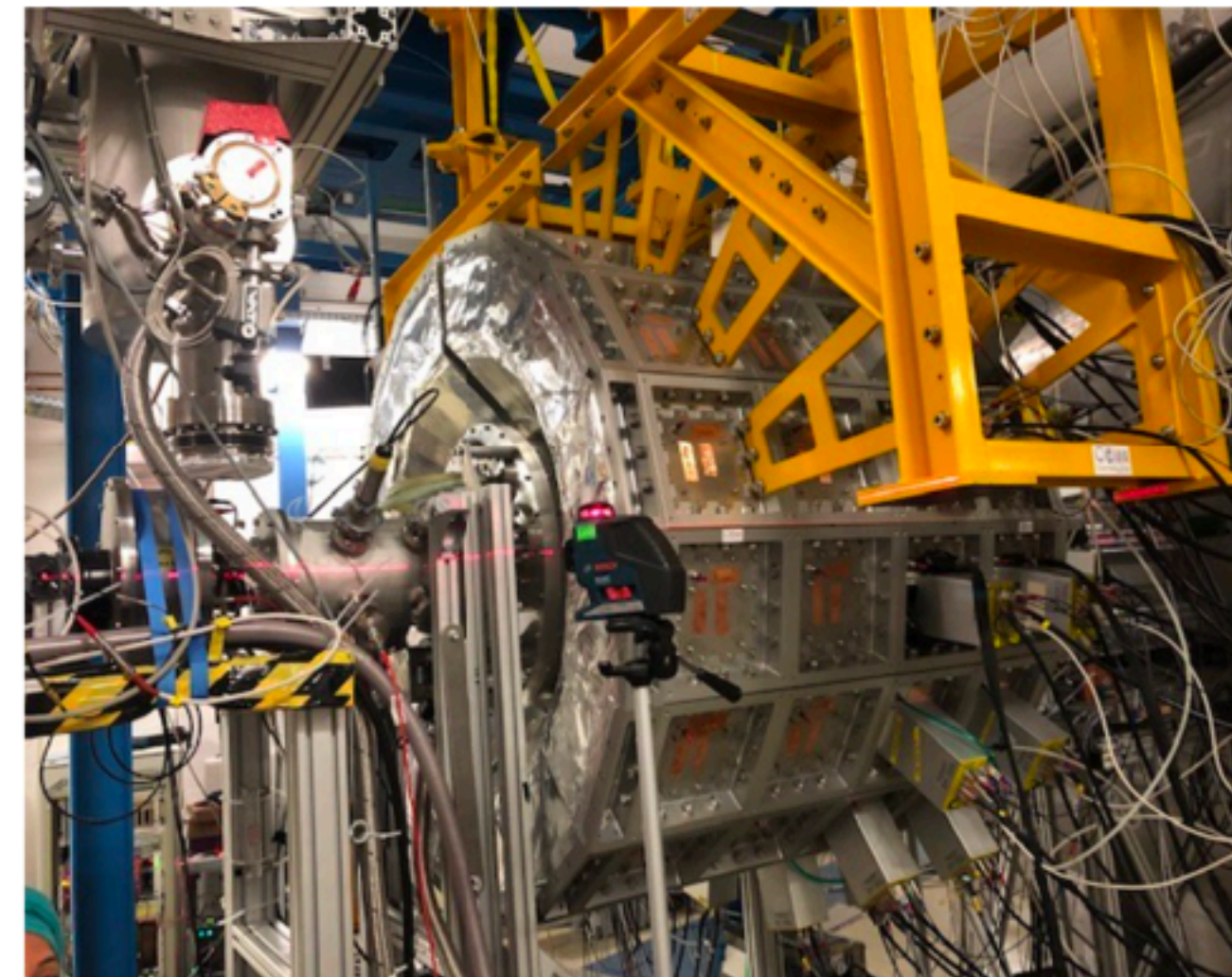
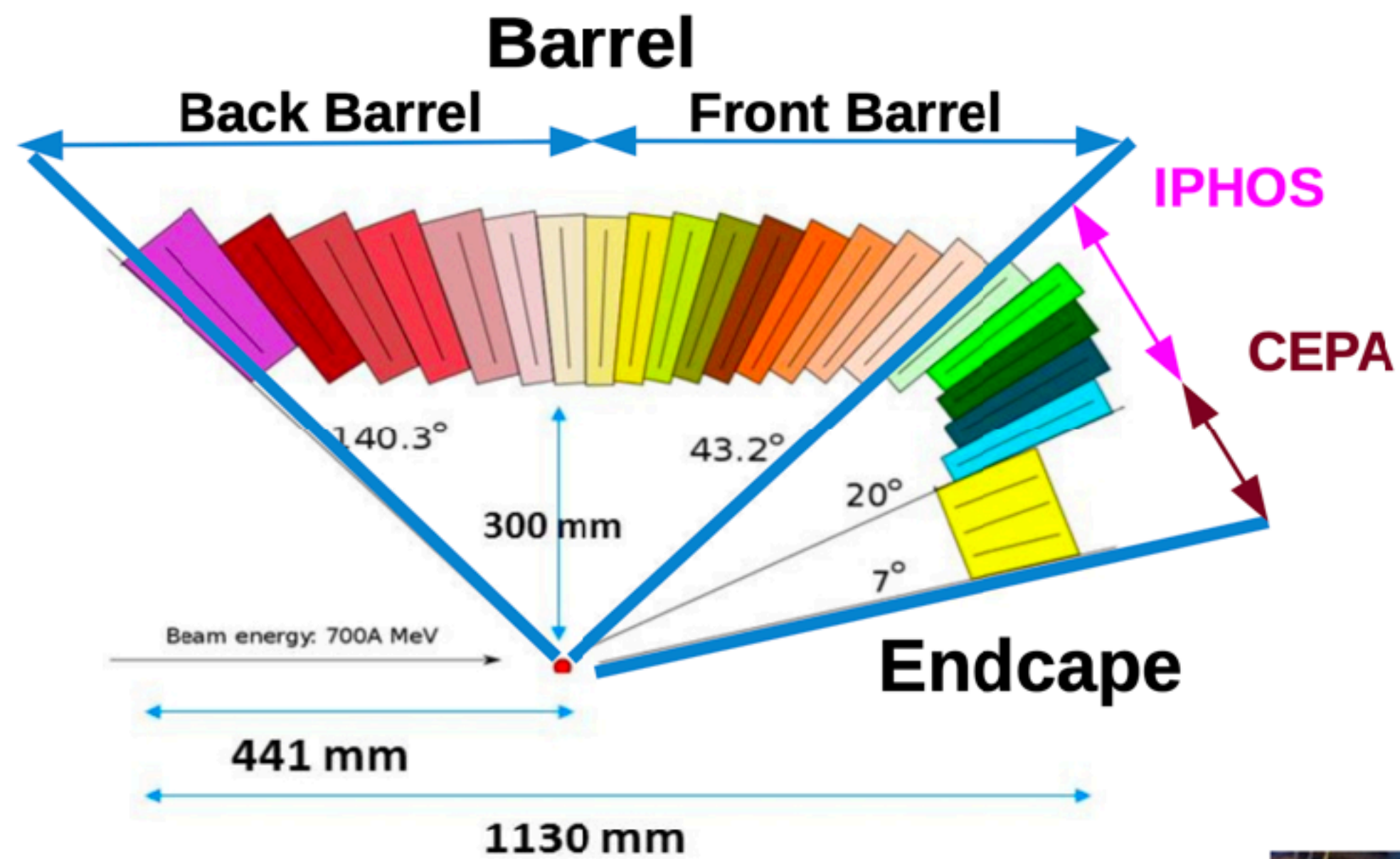


One compact Module
KILOM2



CALIFA barrel and forward endcap

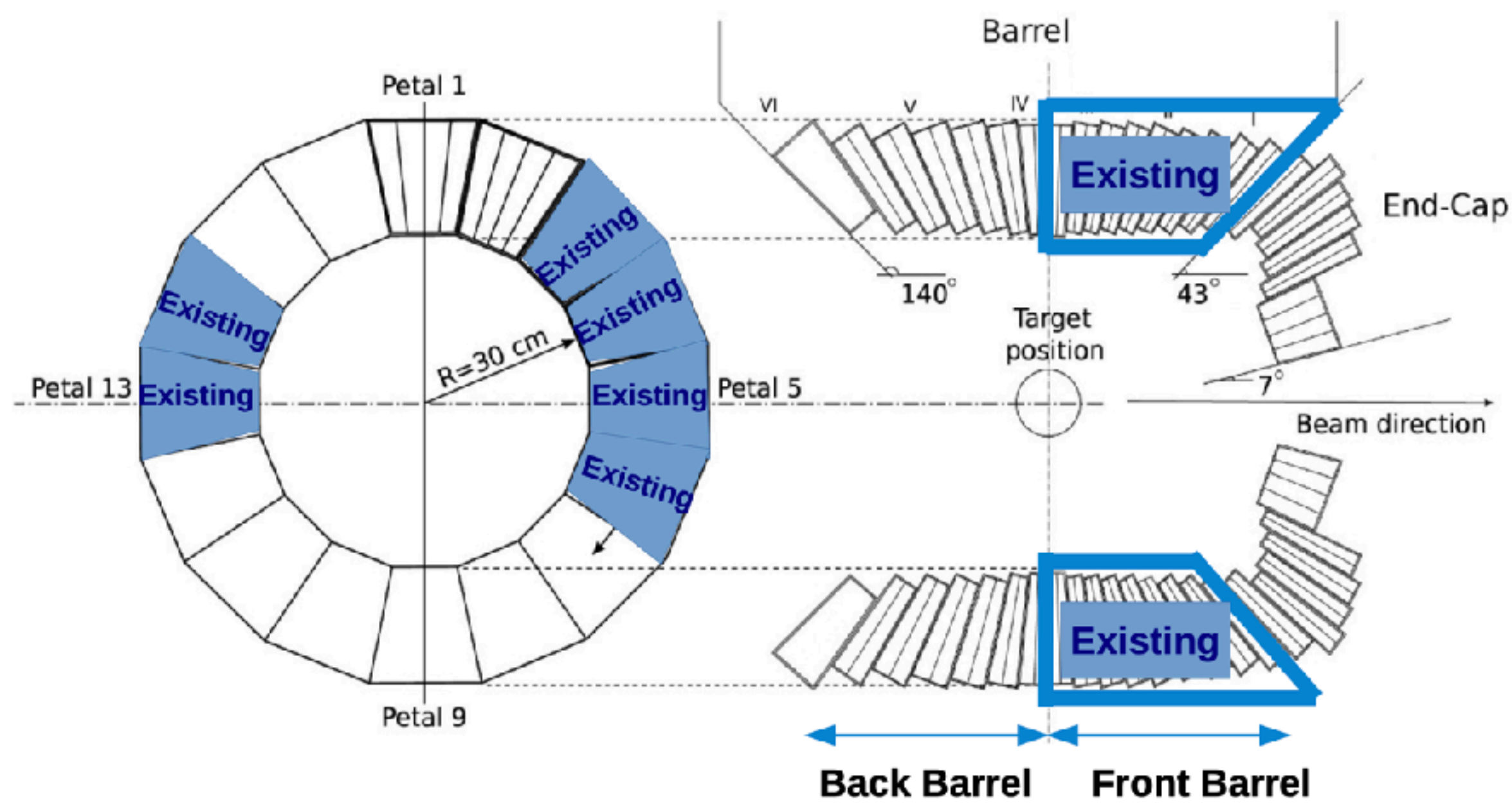
(gamma/particle calorimeter)



Courtesy of L. Atar and CALIFA group

CALIFA status before December 2020

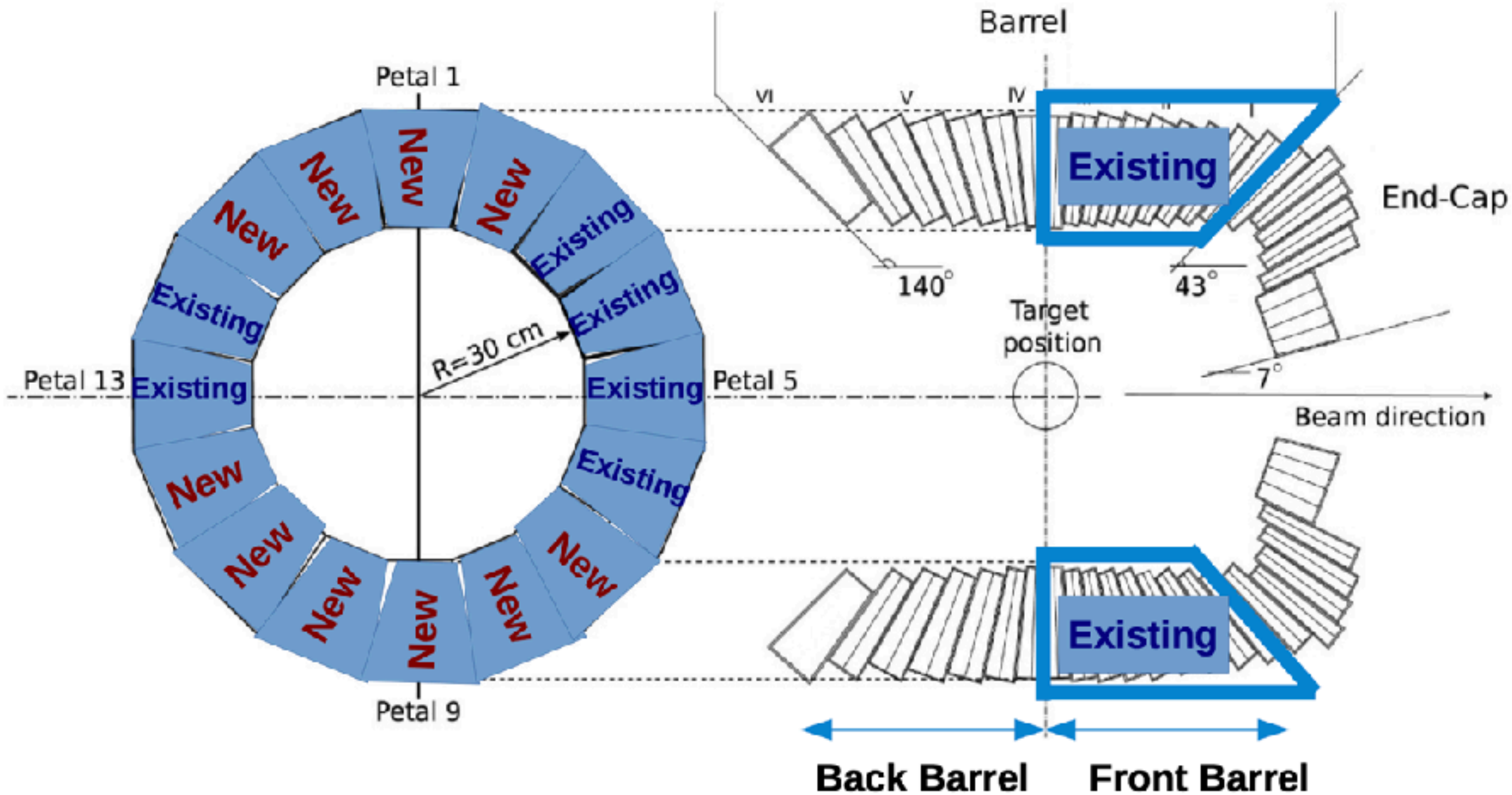
- Forward Barrels are filled with CsI(Tl) crystals
- 37.5% of IPHOS is filled with CsI(Tl) crystals
- 3-4% dead/noisy channels



1204 crystals

CALIFA current status: Full IPHOS

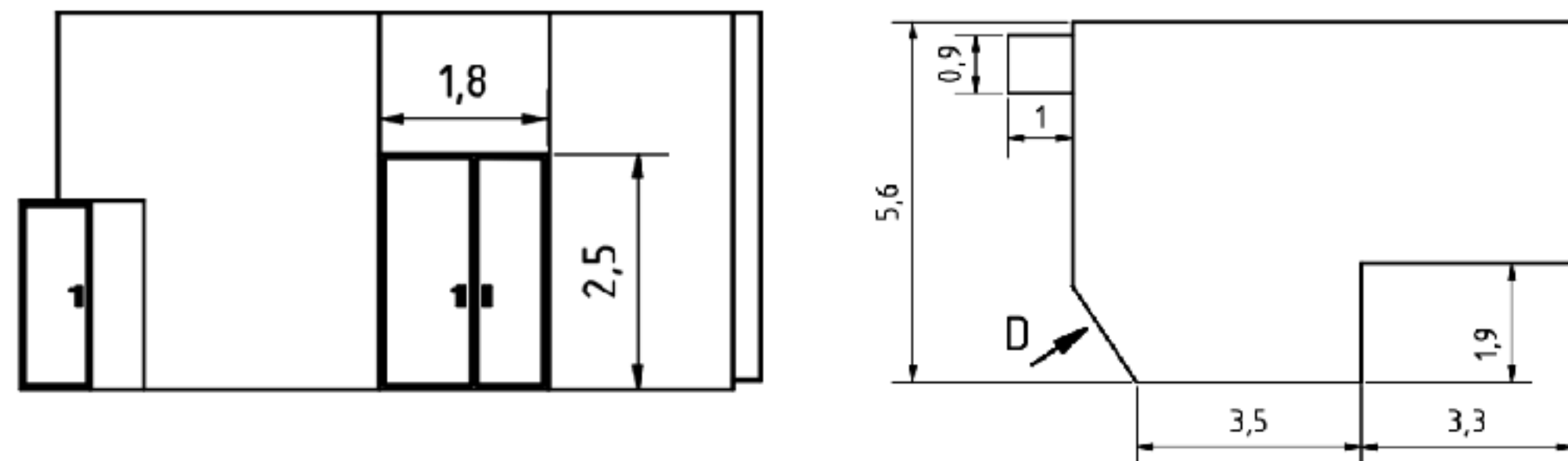
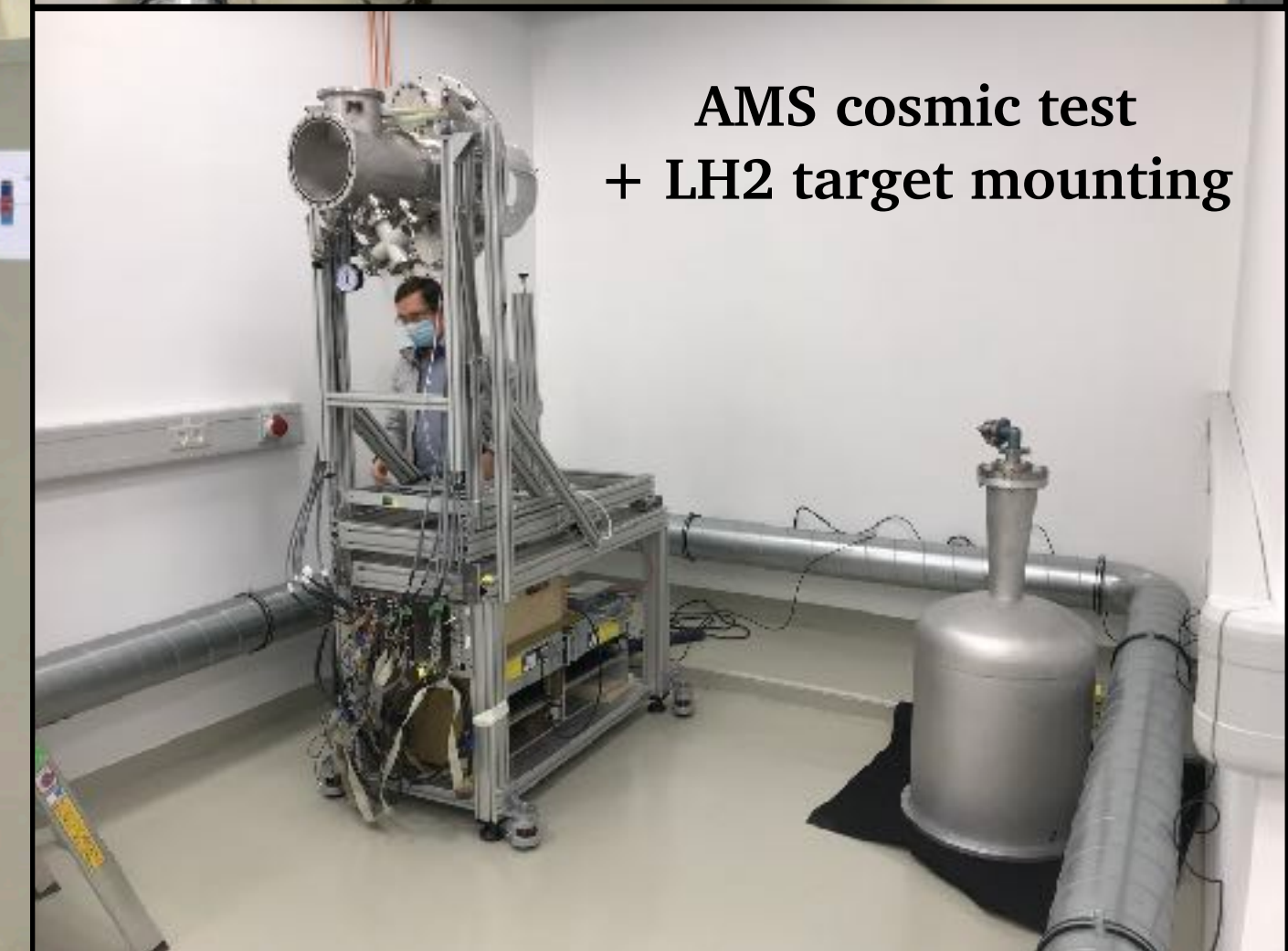
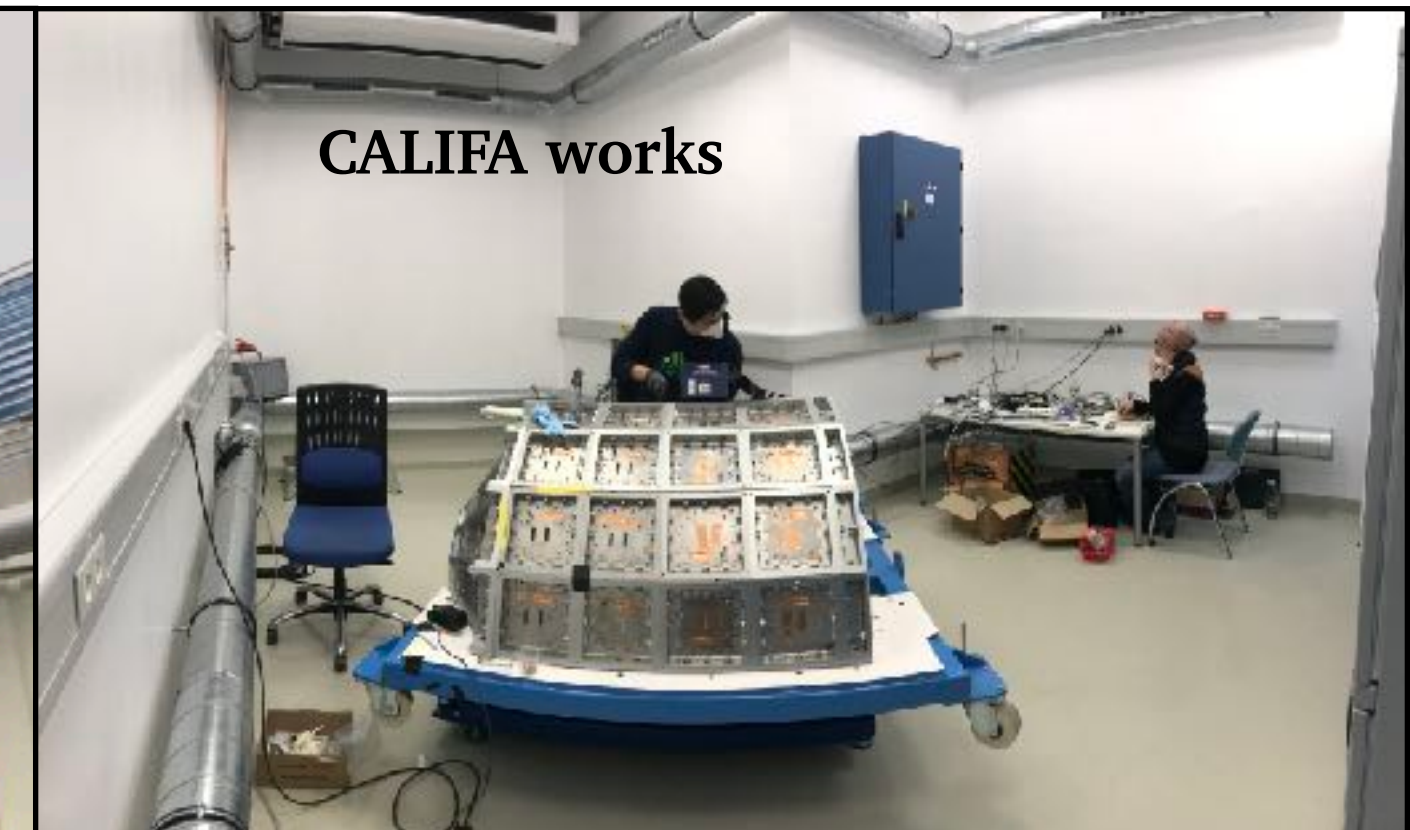
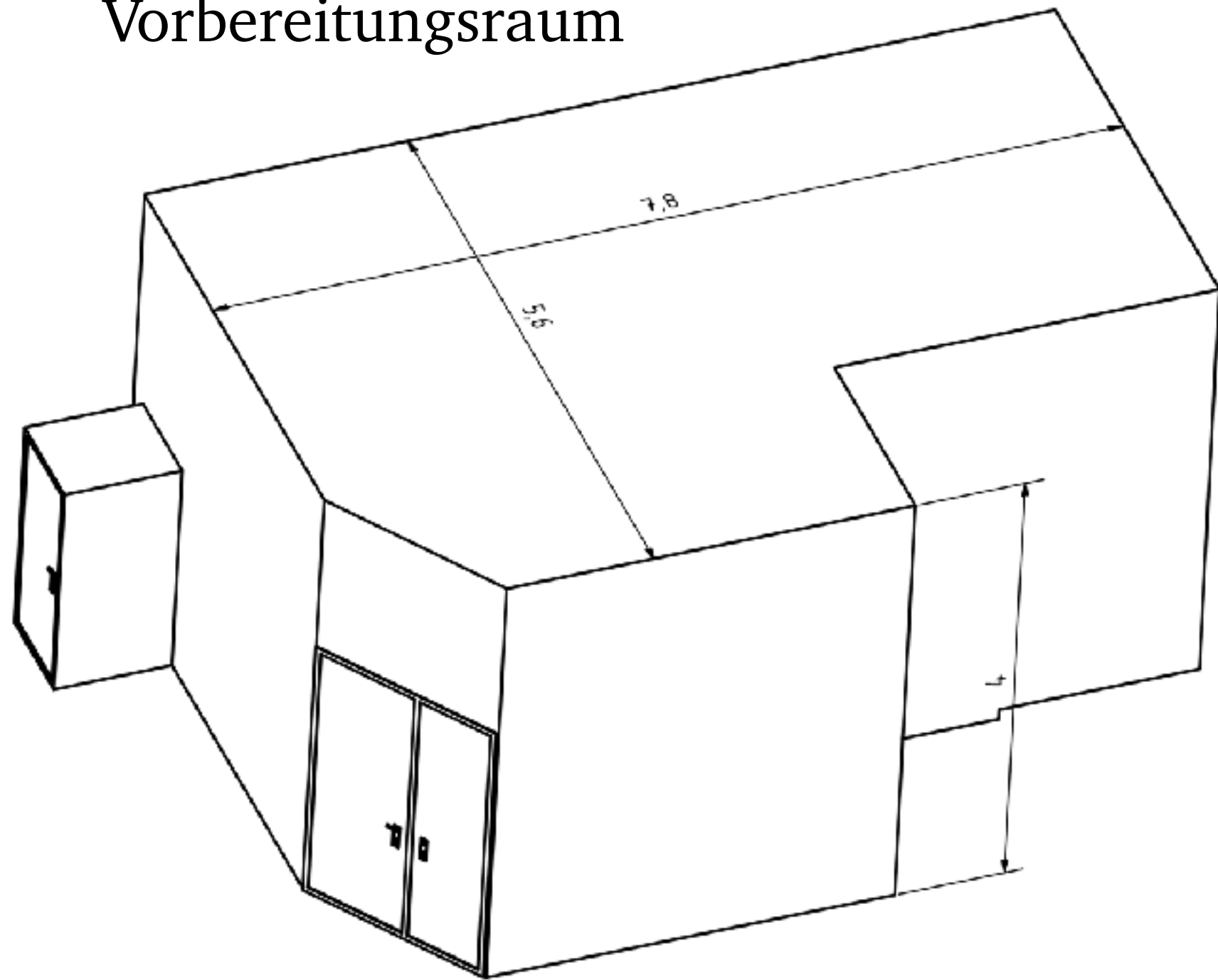
- Forward Barrels are filled with CsI(Tl) crystals
- IPHOS is completed
- Dead/noisy channels are recovered



1504 crystals

New preparation room in front of Cave C (in operation since Dec. 2020)

Vorbereitungsraum



Courtesy of D. Körper

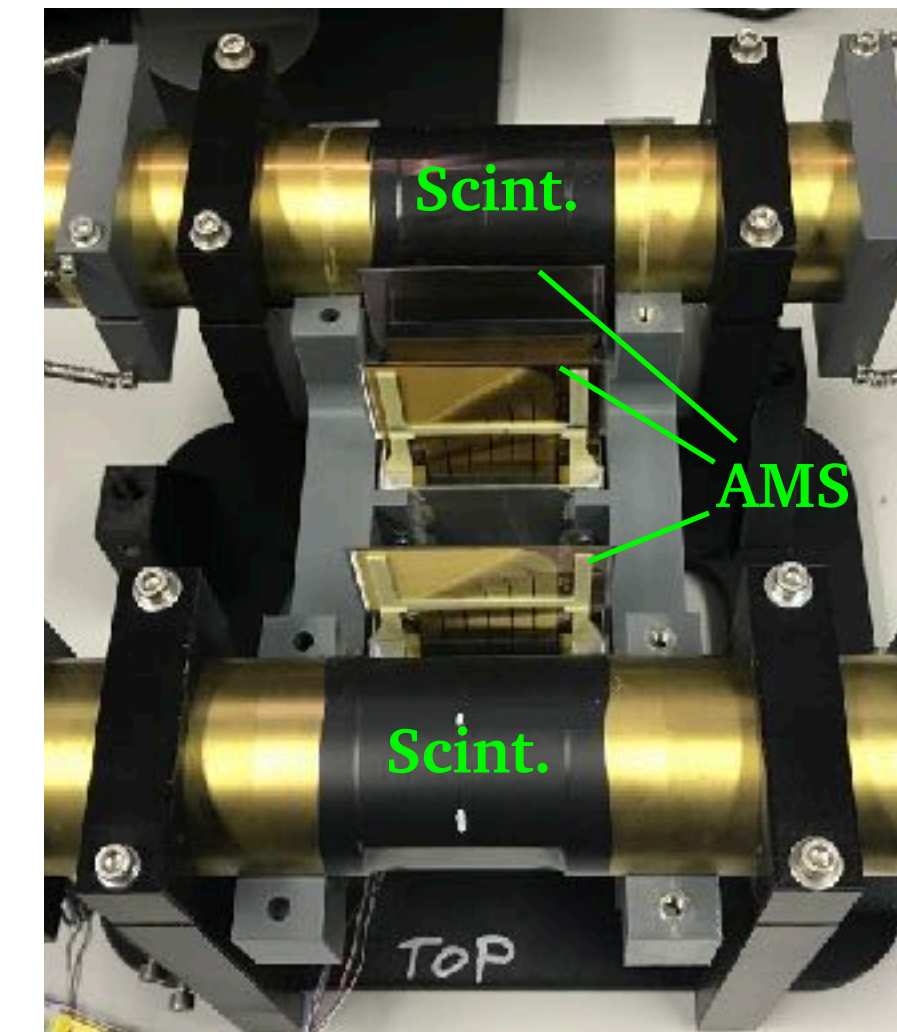
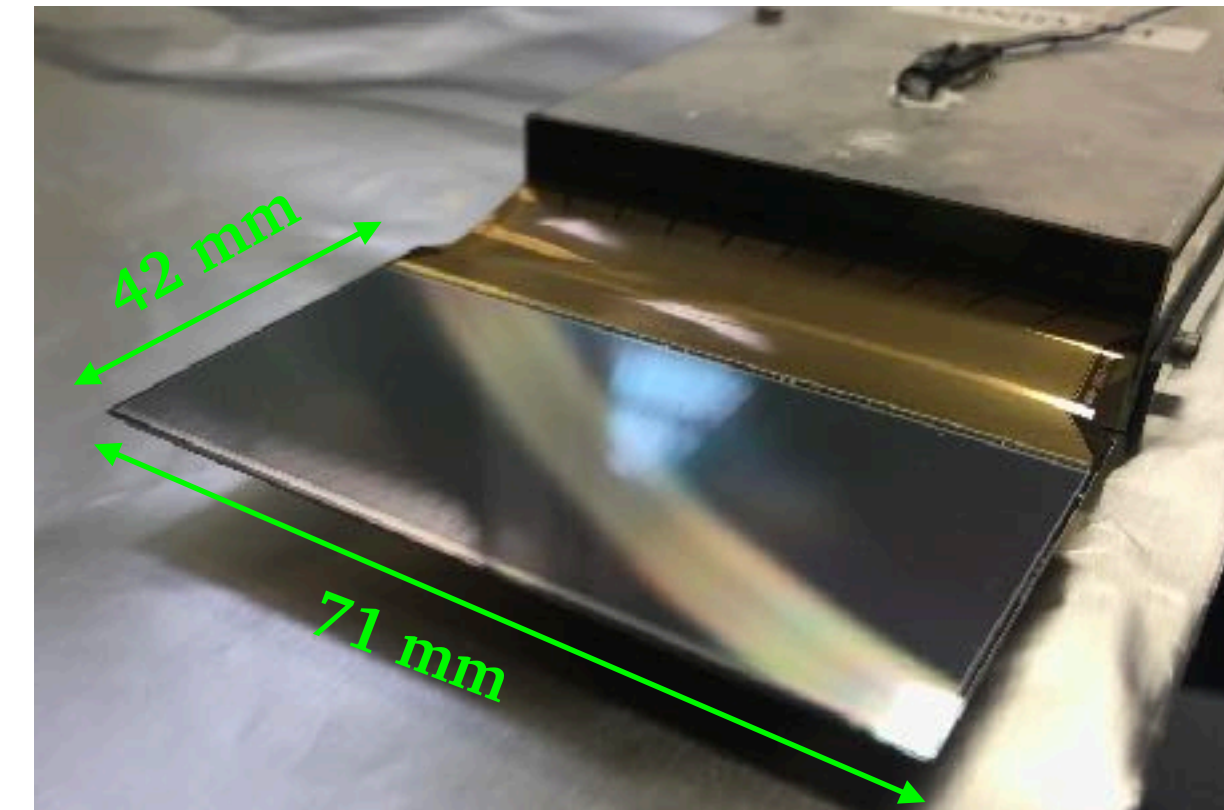
Cosmic test of AMS silicon trackers

(November 2020)

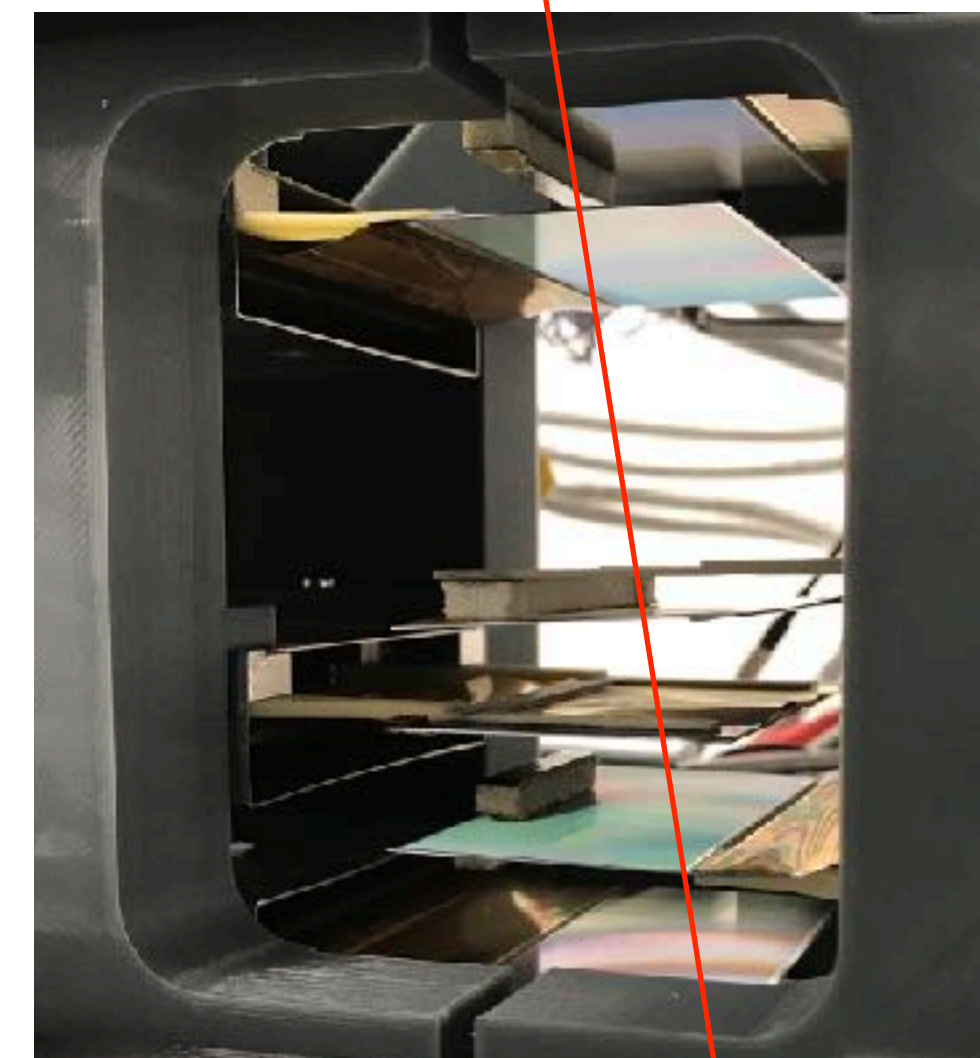
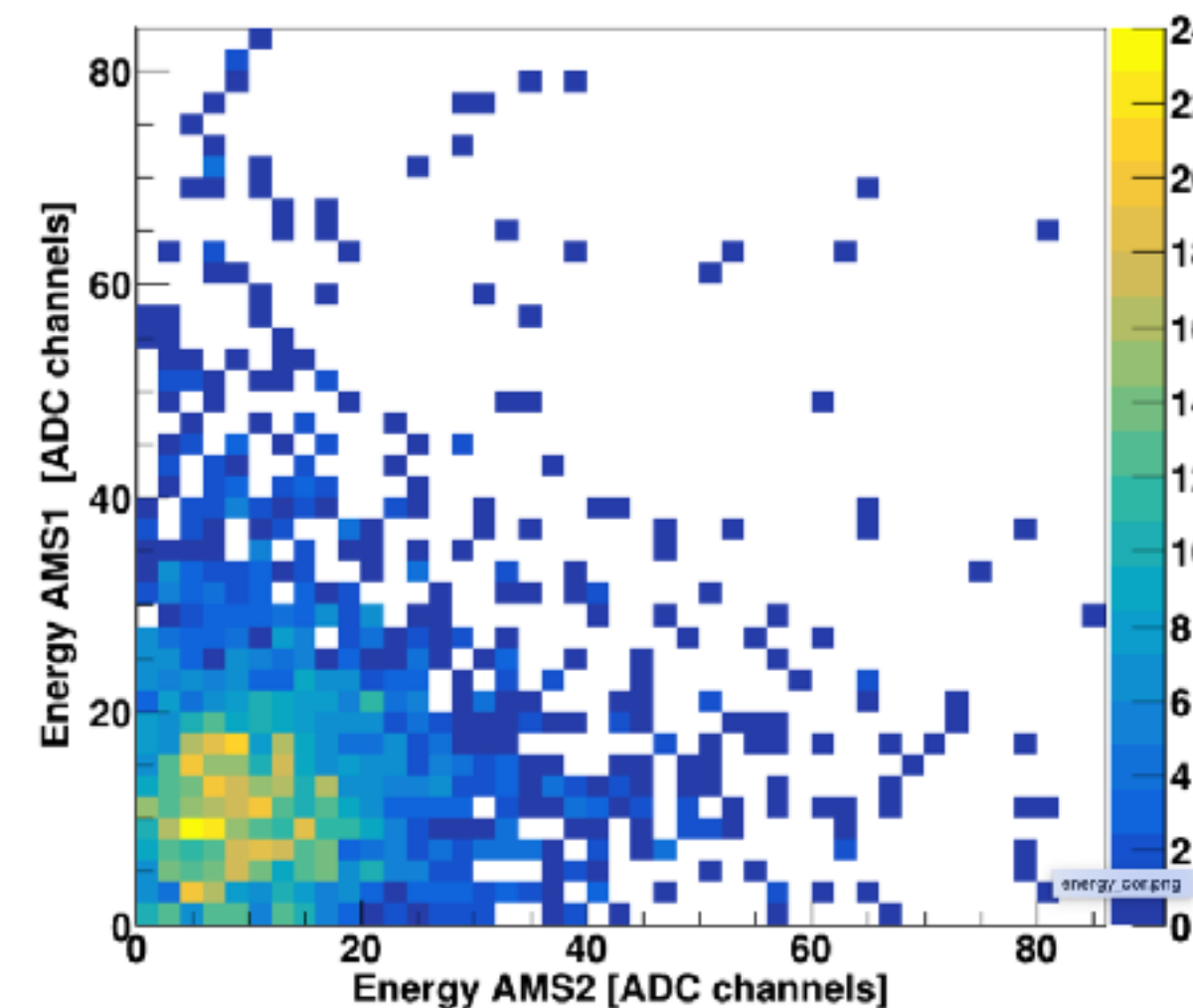
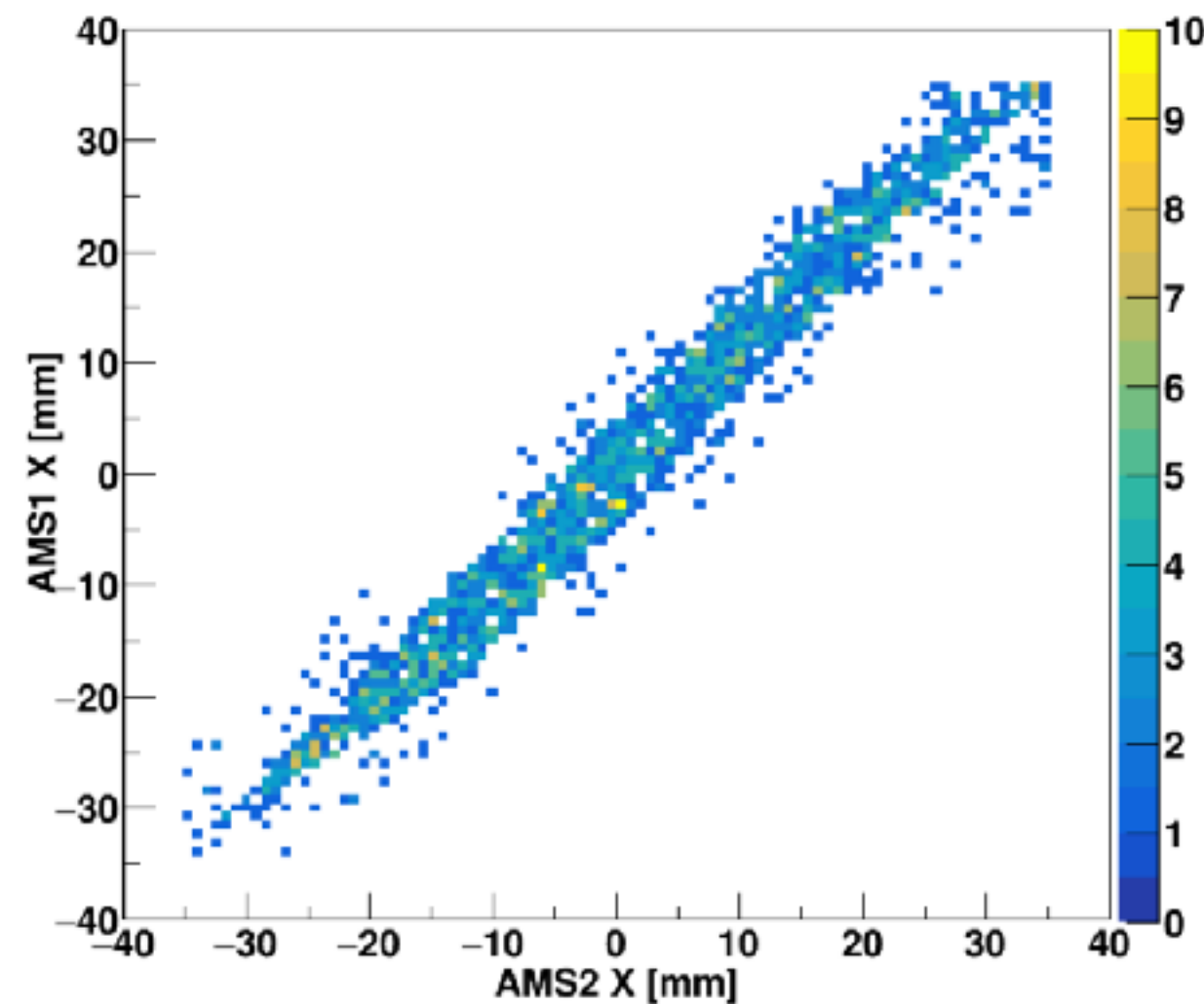
Main goals

- Checking response for MIP particles (protons in the exp)
- Gain-matching strips for MIPs on both sides
- Verifying tracking resolution and efficiency (>90%)
- Choose the best detectors for the upcoming experiments
- Data analysis is in progress

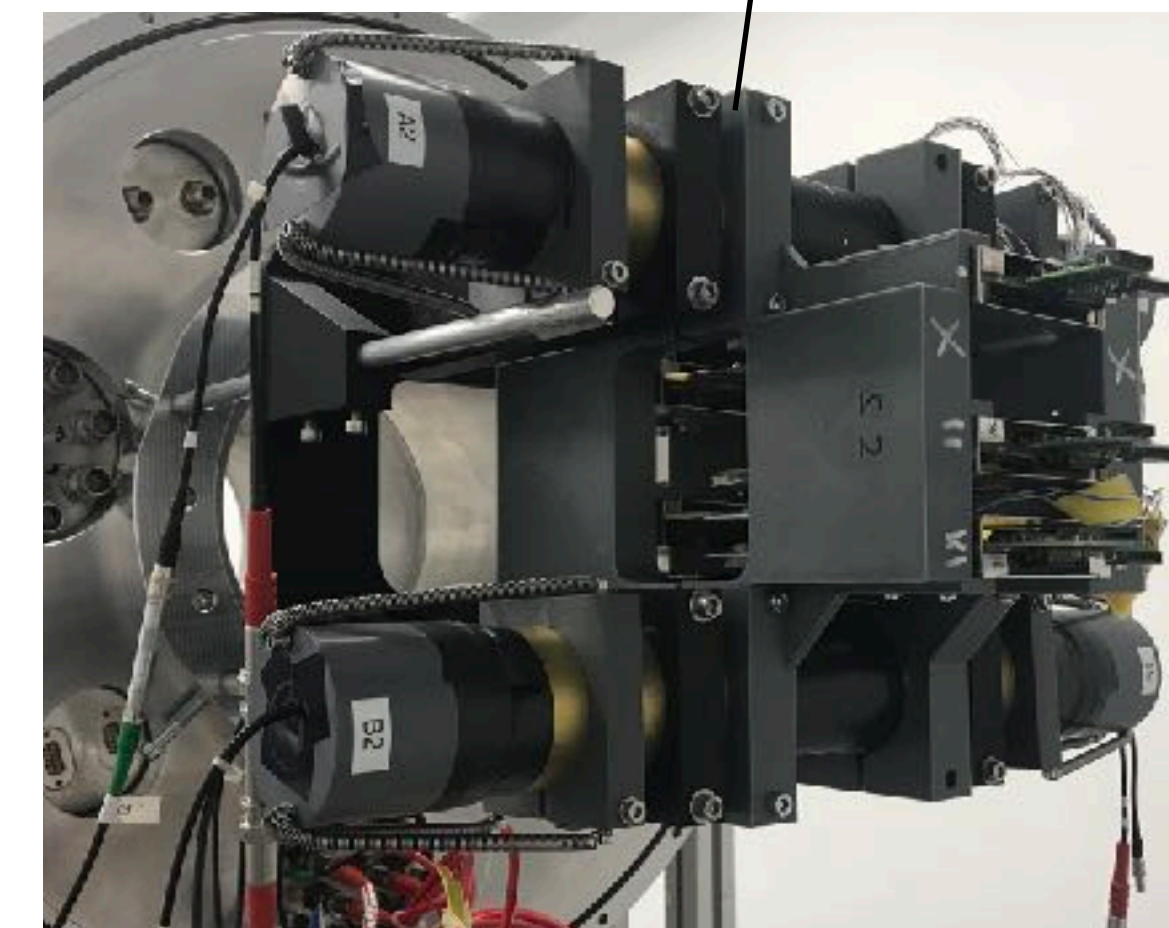
AMS (DSSSD), 1024 strip
300 μm thick, pitch $\sim 100\mu\text{m}$



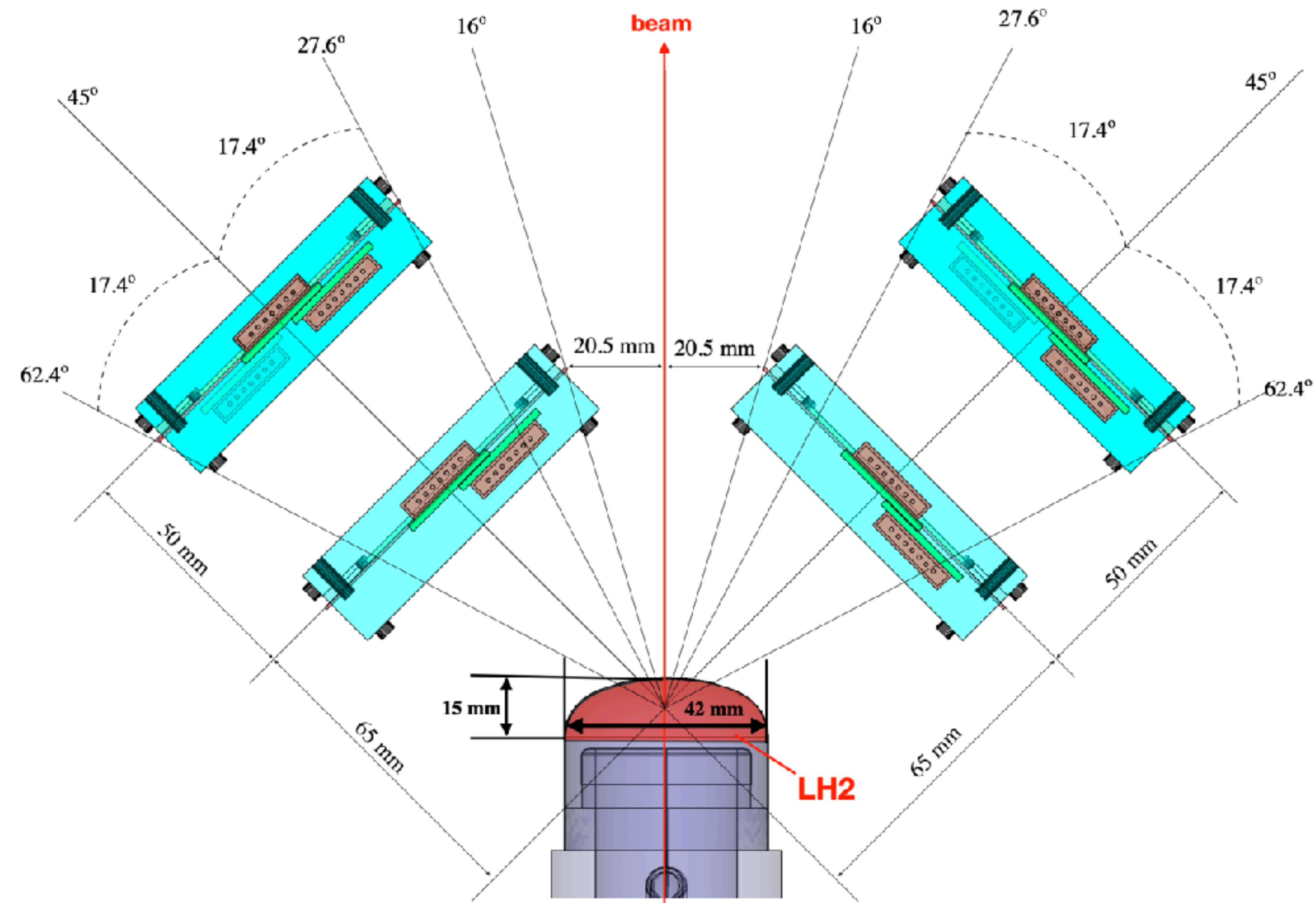
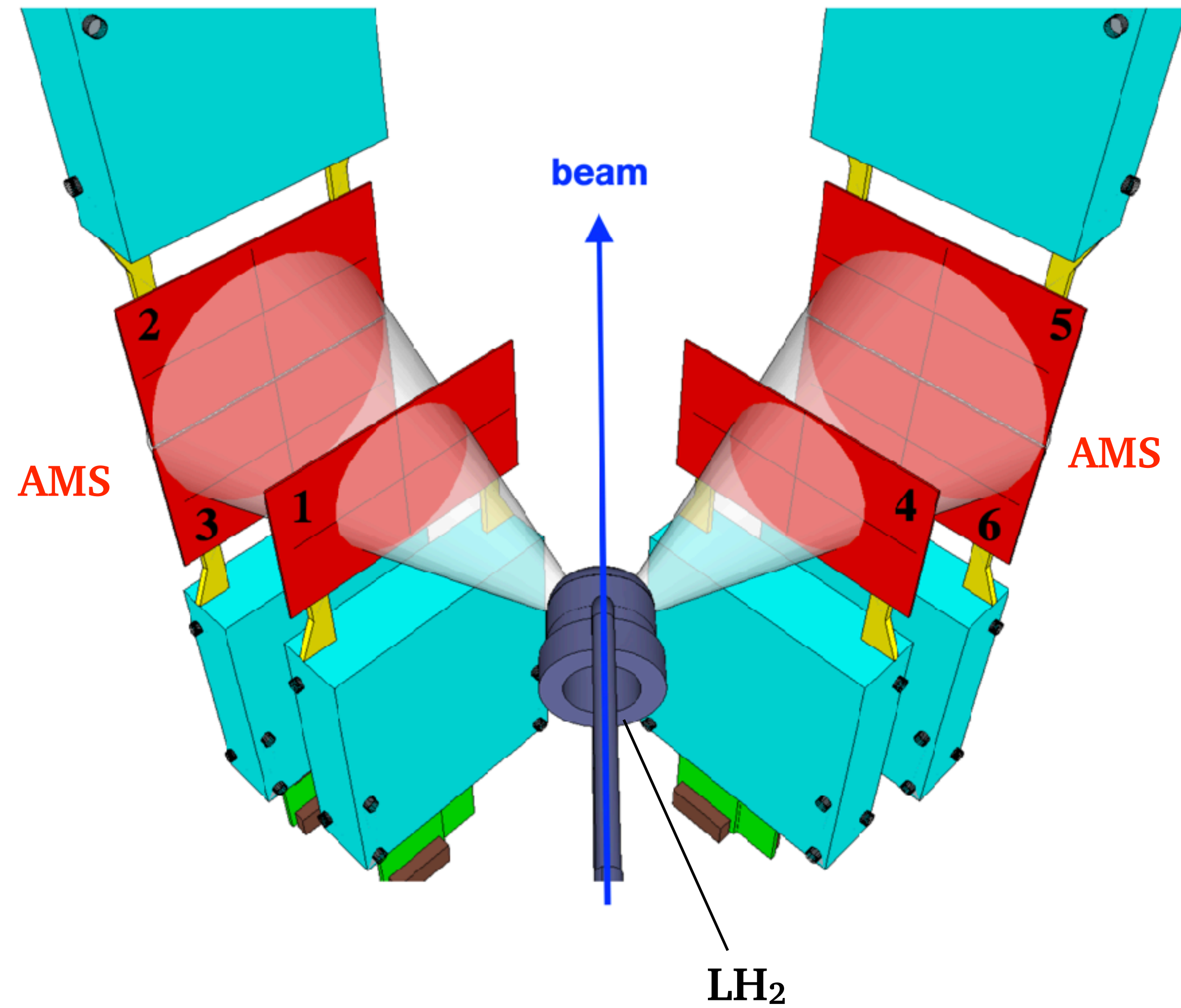
cosmic ($\sim 40\text{k/day/det}$)



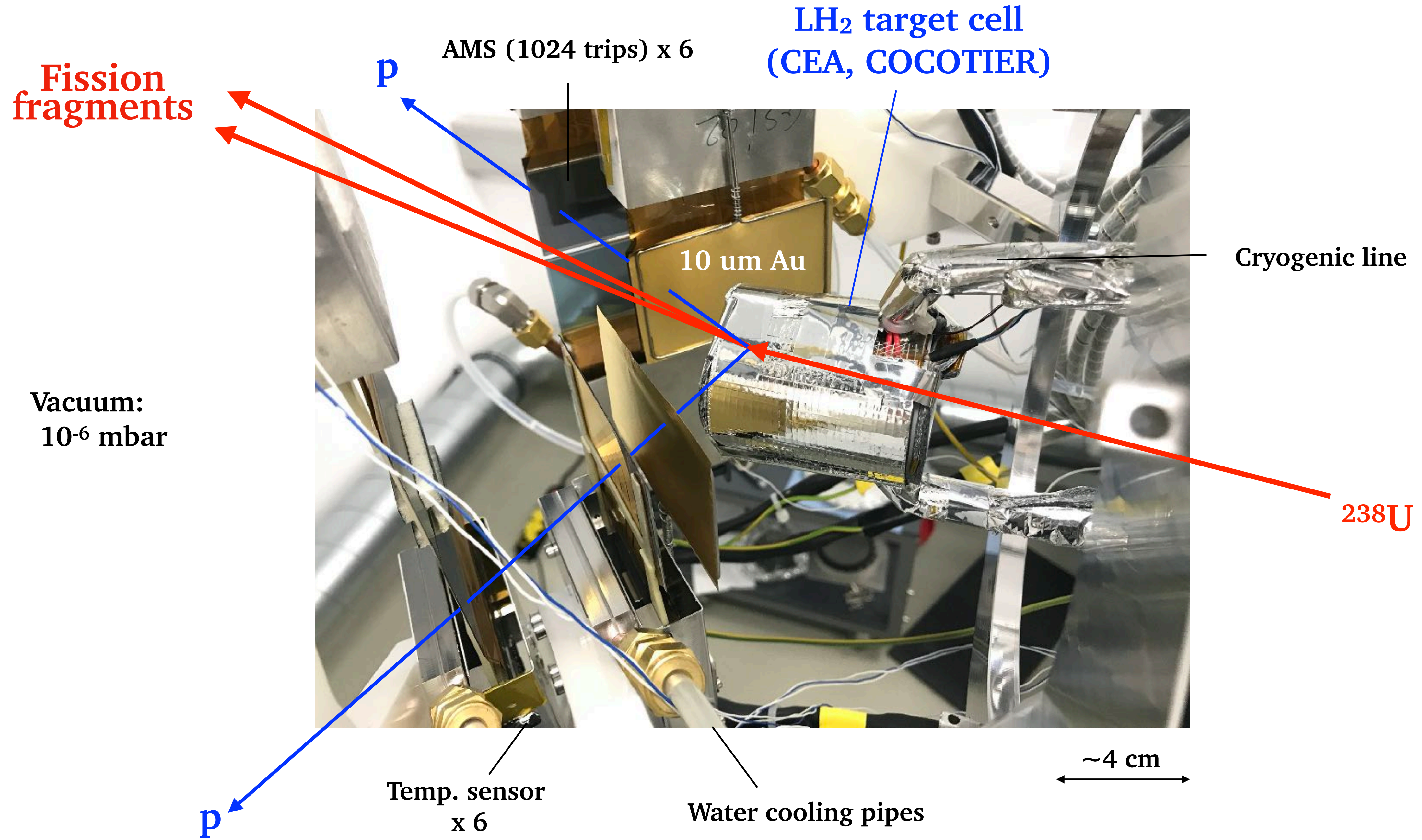
3D printed

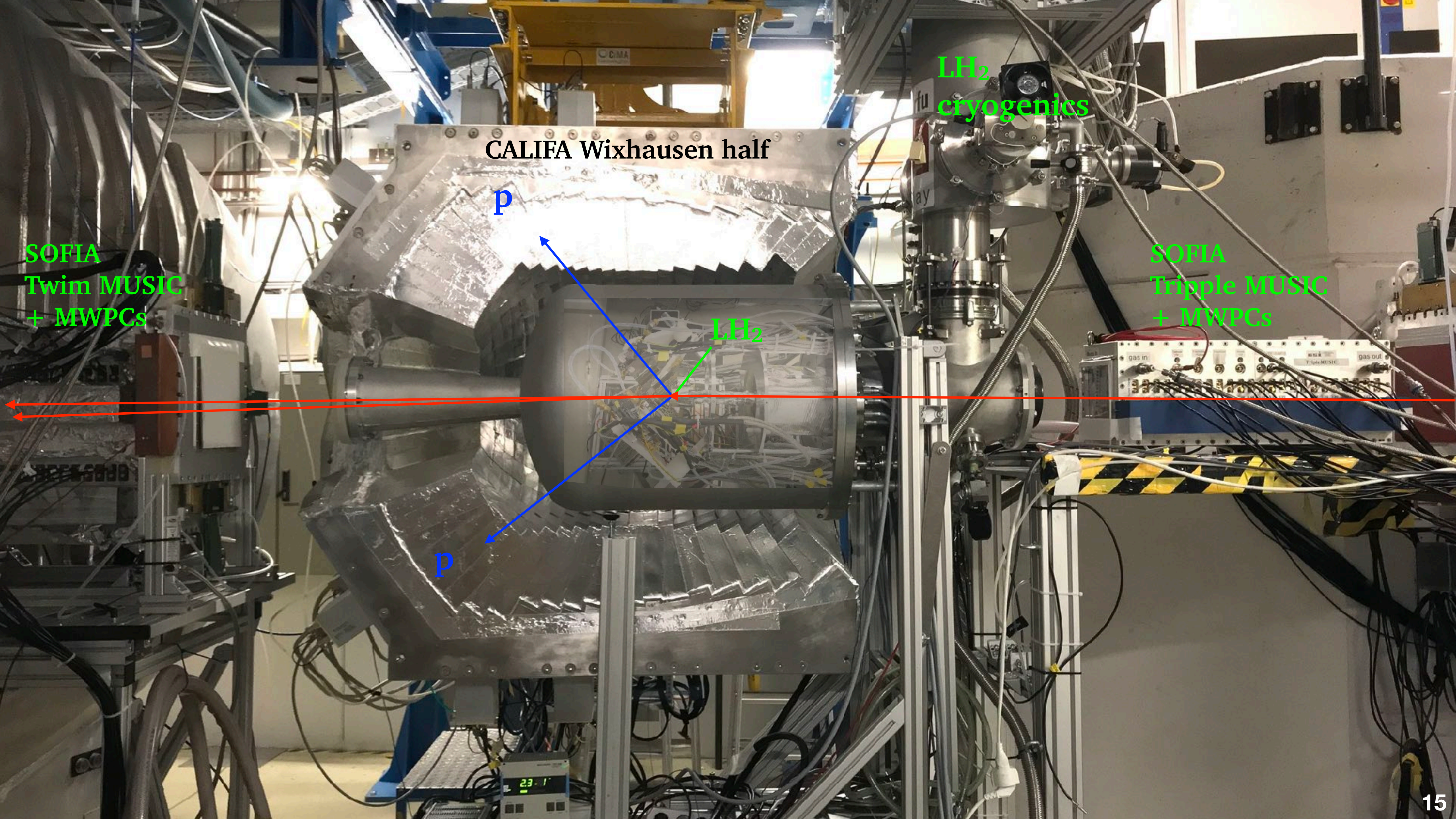


AMS+LH2 configuration for S455 (study of fission barrier via QFS reactions) (March 2021)



AMS+LH2 configuration for S455 (study of fission barrier via QFS reactions) (SOFIA, March 2021)





CALIFA Wixhausen half

p

LH₂

LH₂
cryogenics

SOFIA
Twim MUSIC
+ MWPCs

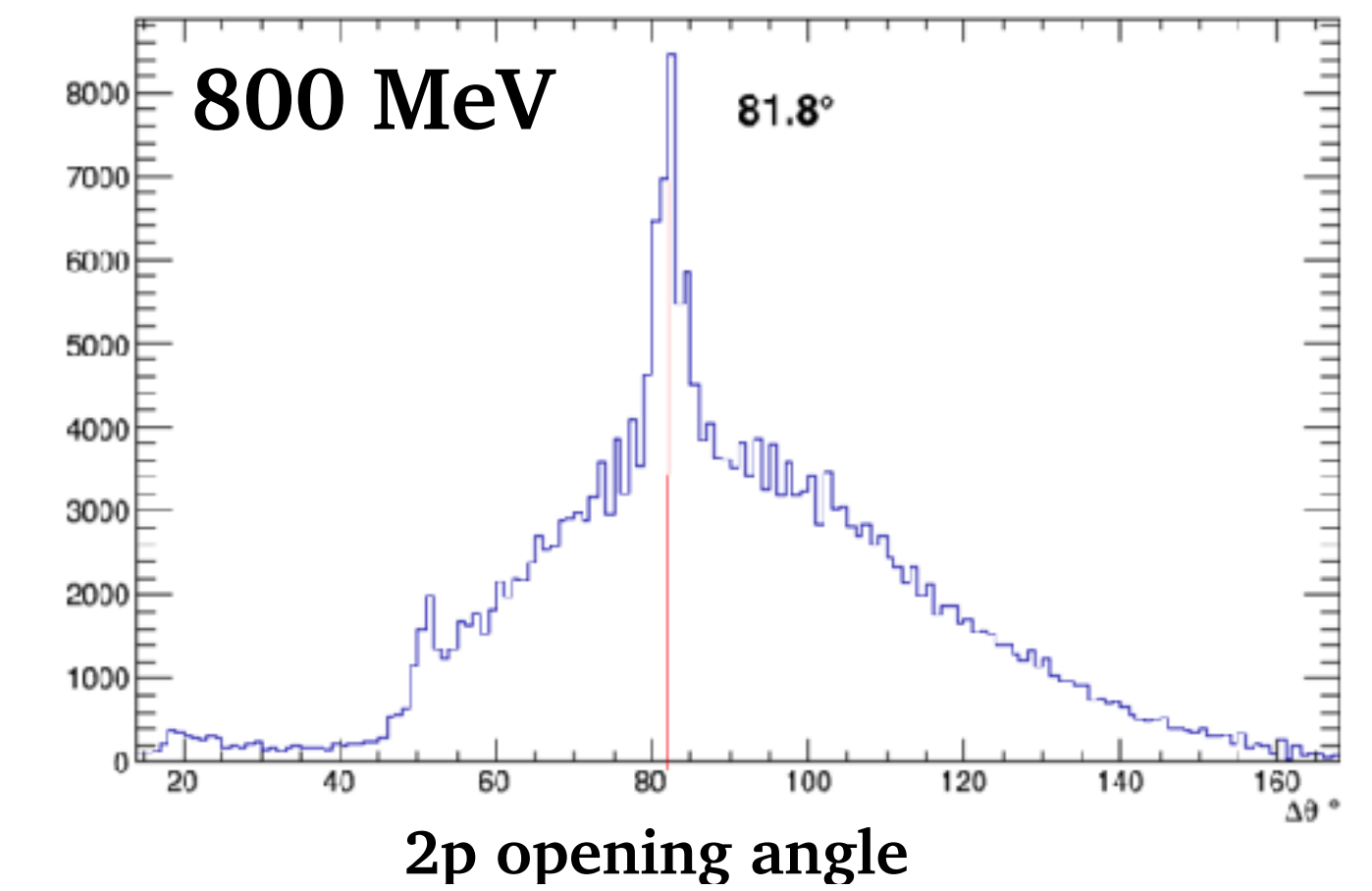
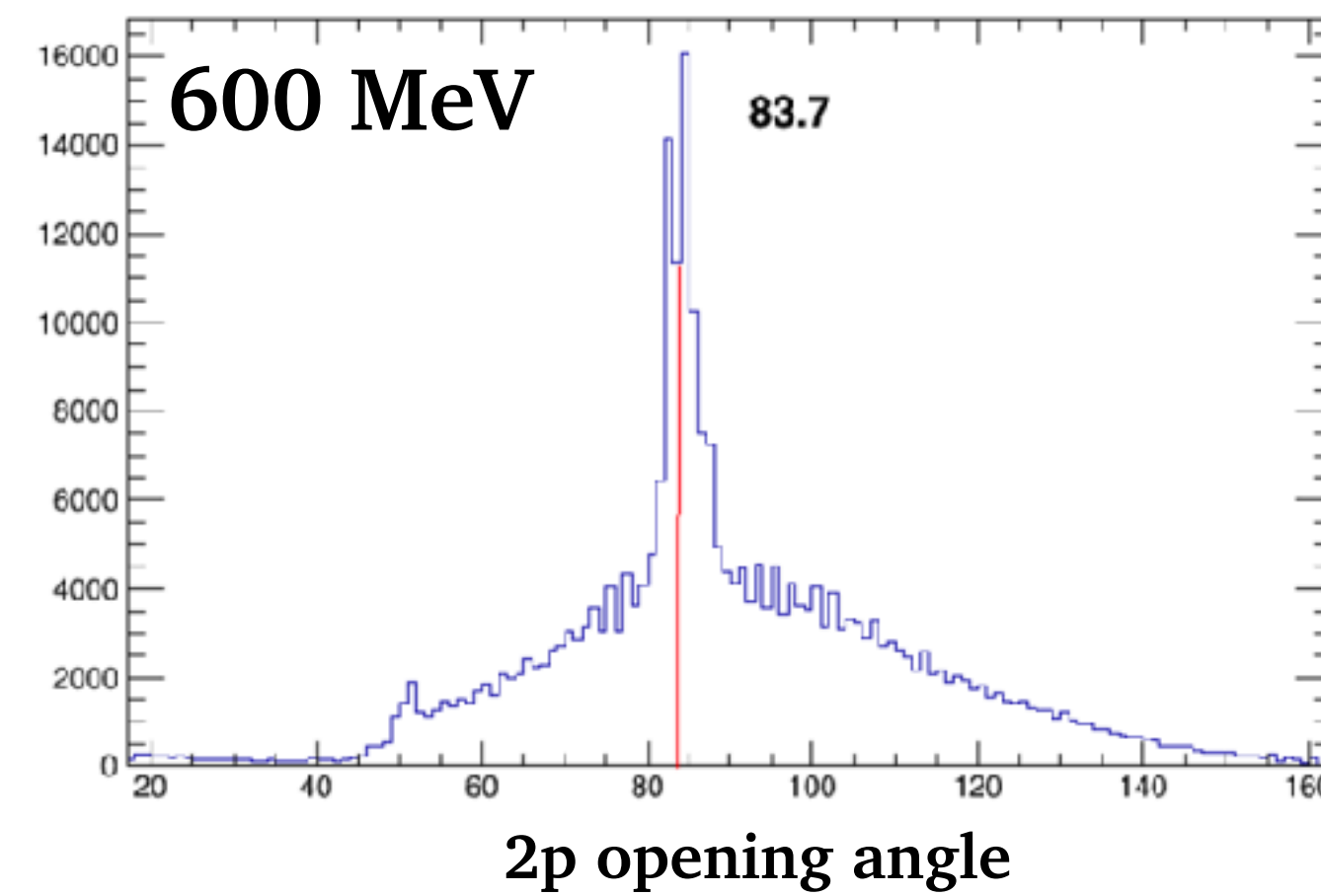
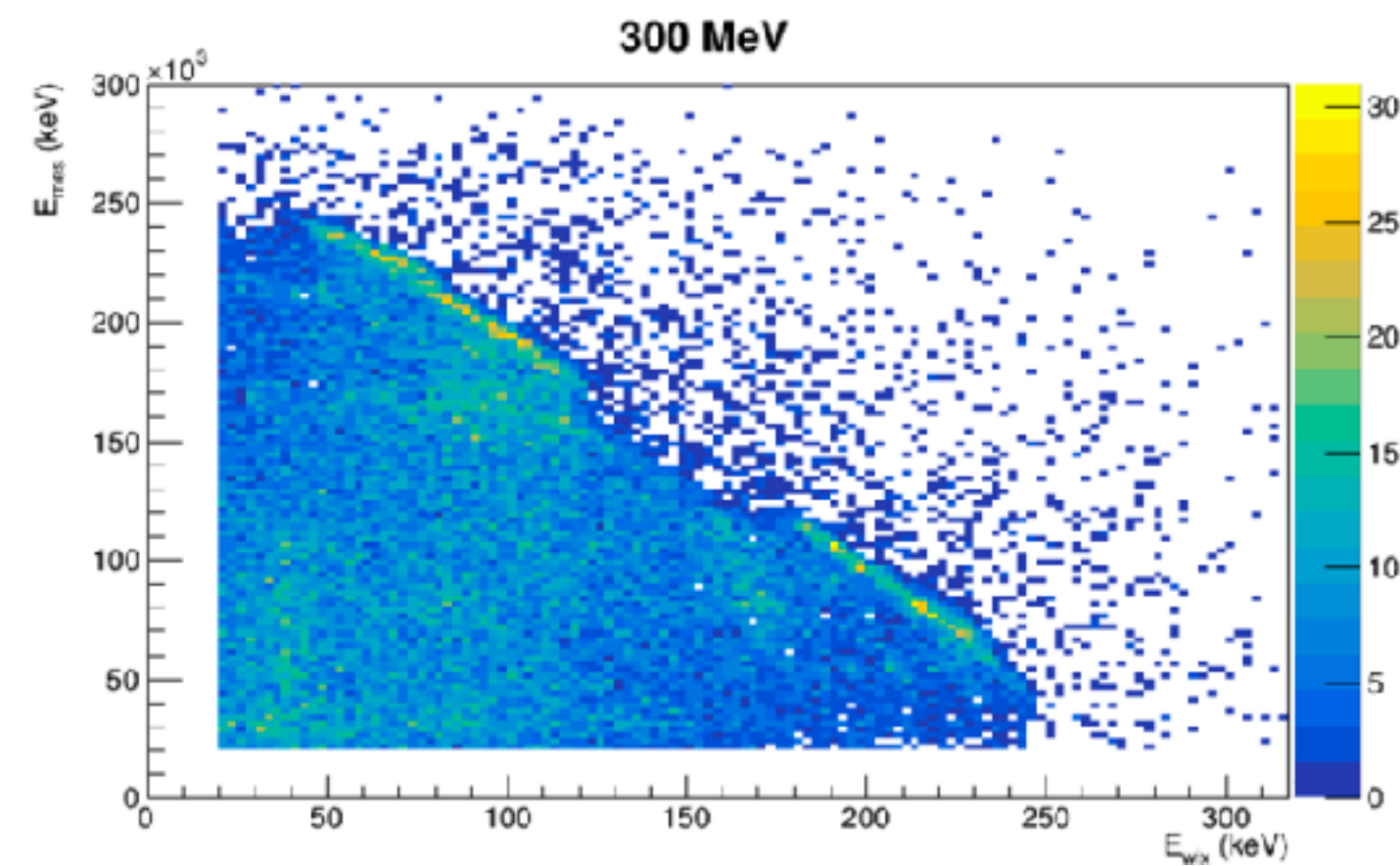
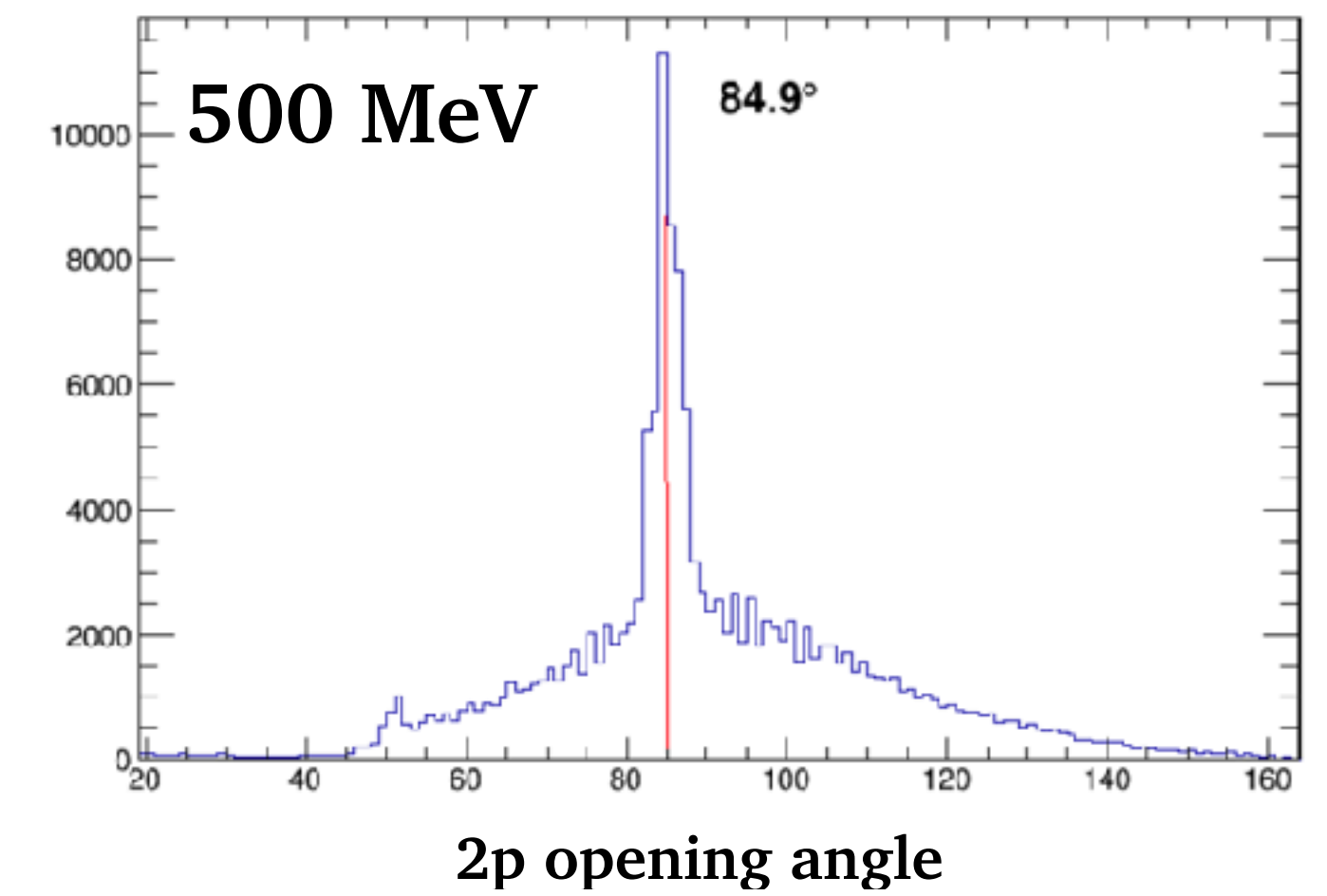
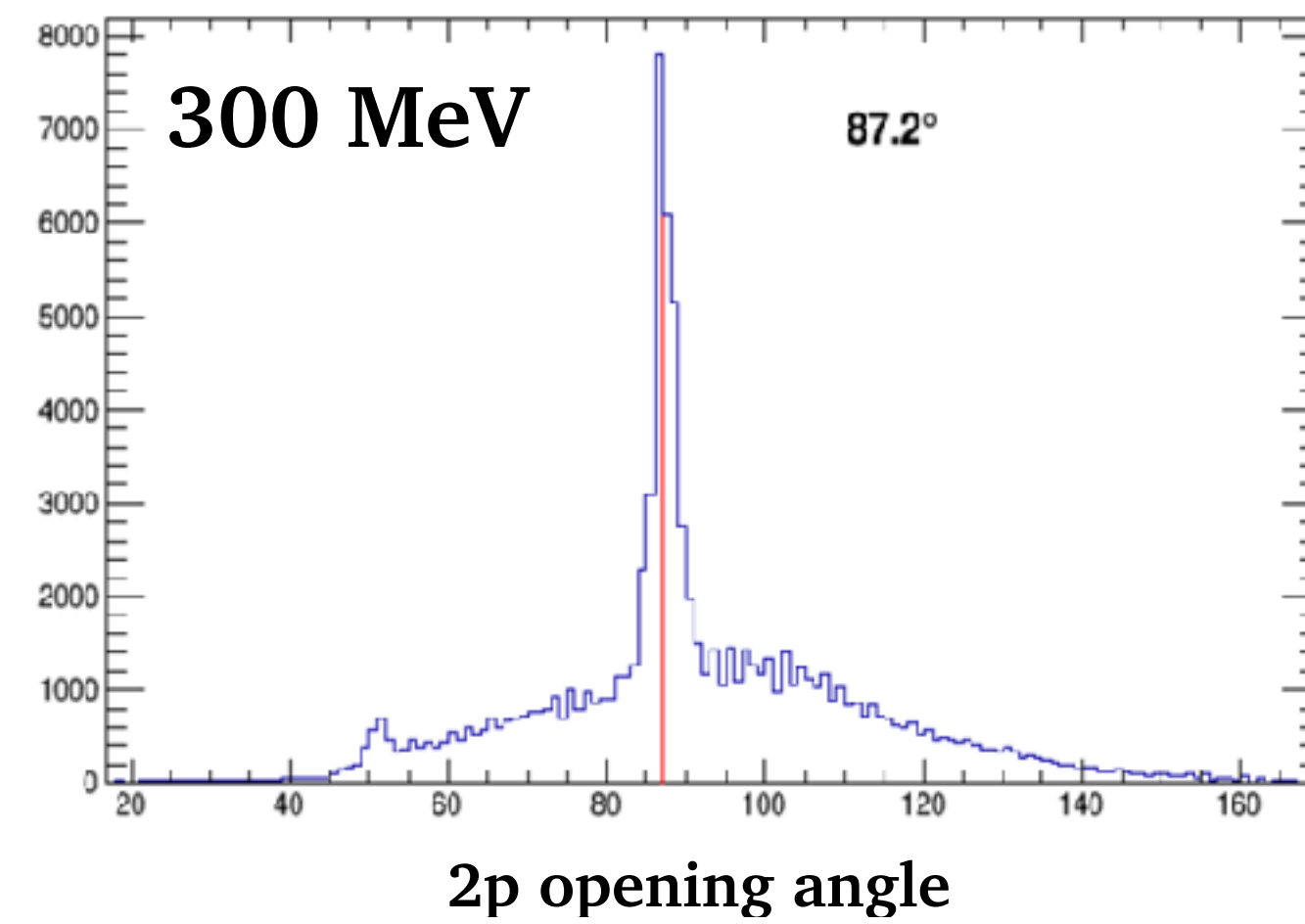
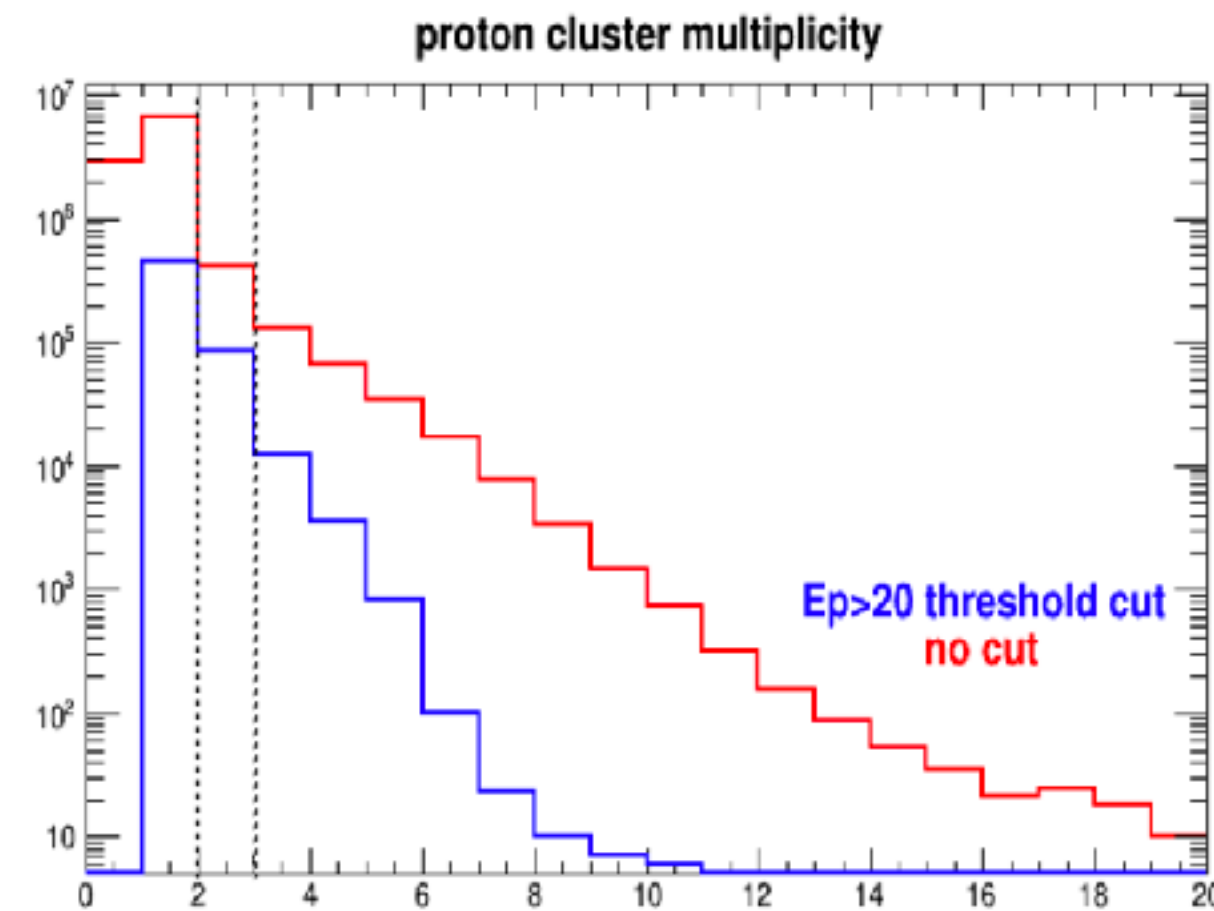
SOFIA
Tripple MUSIC
+ MWPCs

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Preliminary results proton-beam test (proton beam + CH₂ target)

June 2020



Courtesy of L. Atar

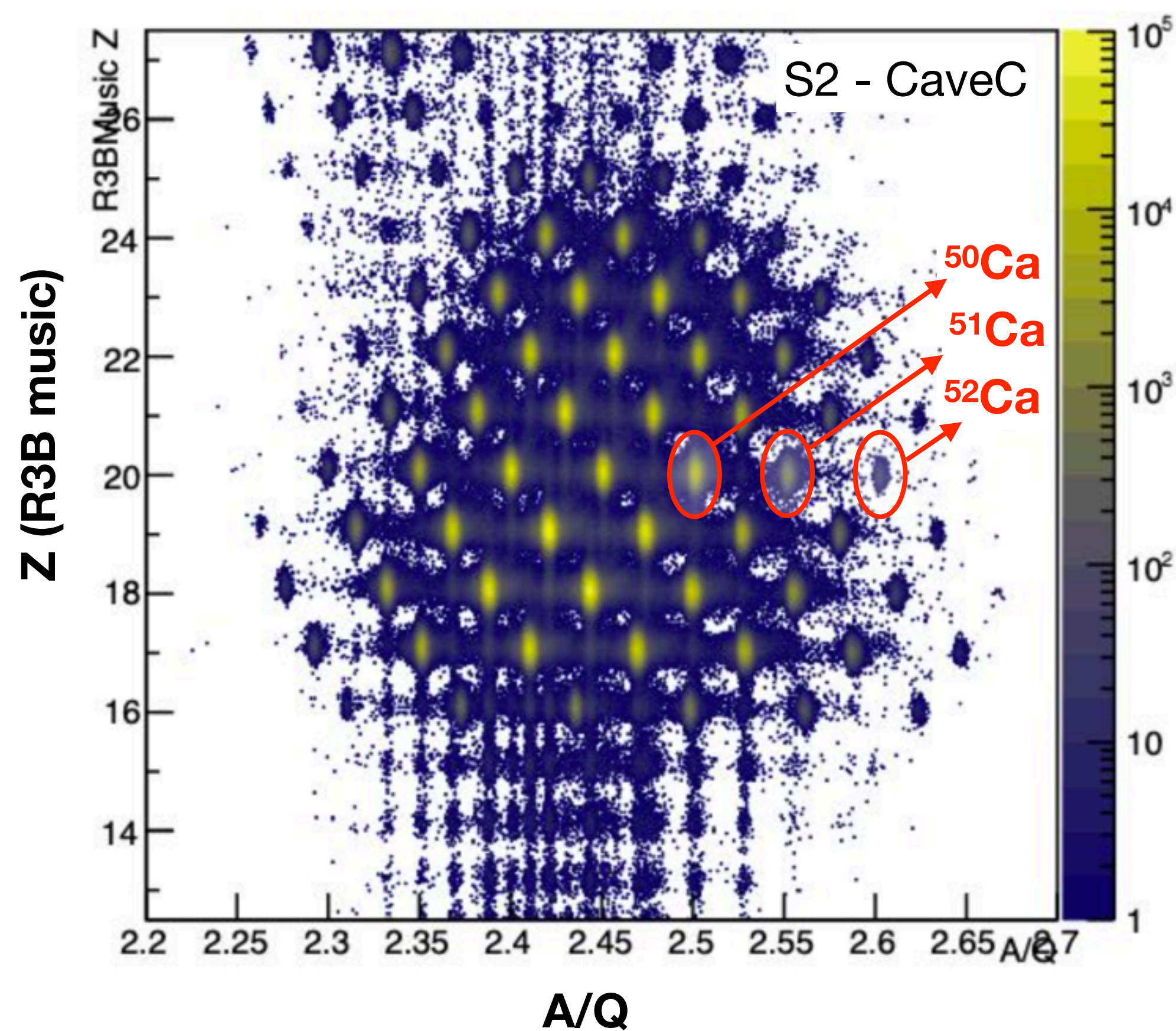
Preliminary results from S467 (proton knockout from Ca isotopes)

February 2020

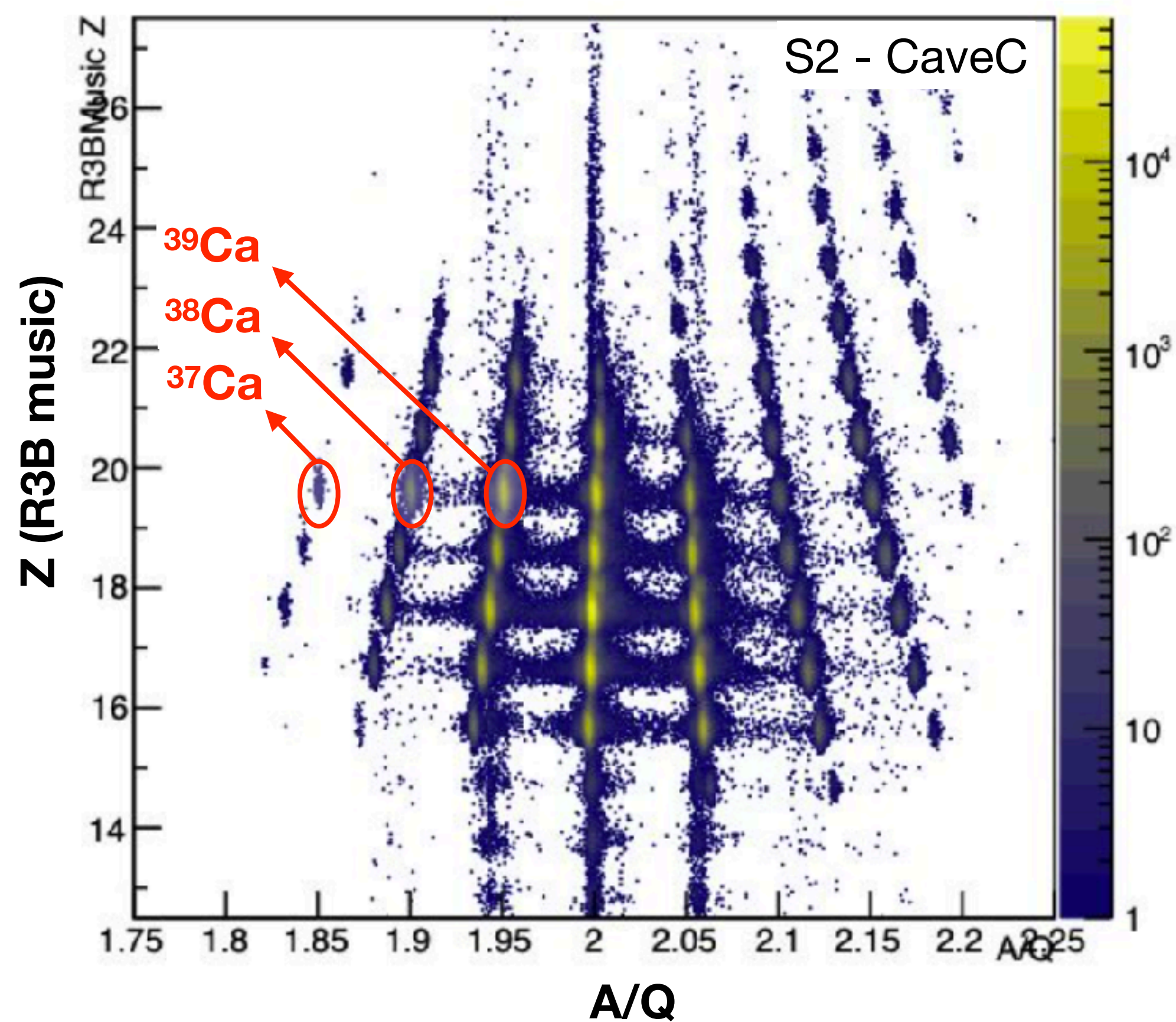
Courtesy of R. Taniuchi

Incoming PID from FRS (from S2 to Cave C)

⁵⁰Ca setting



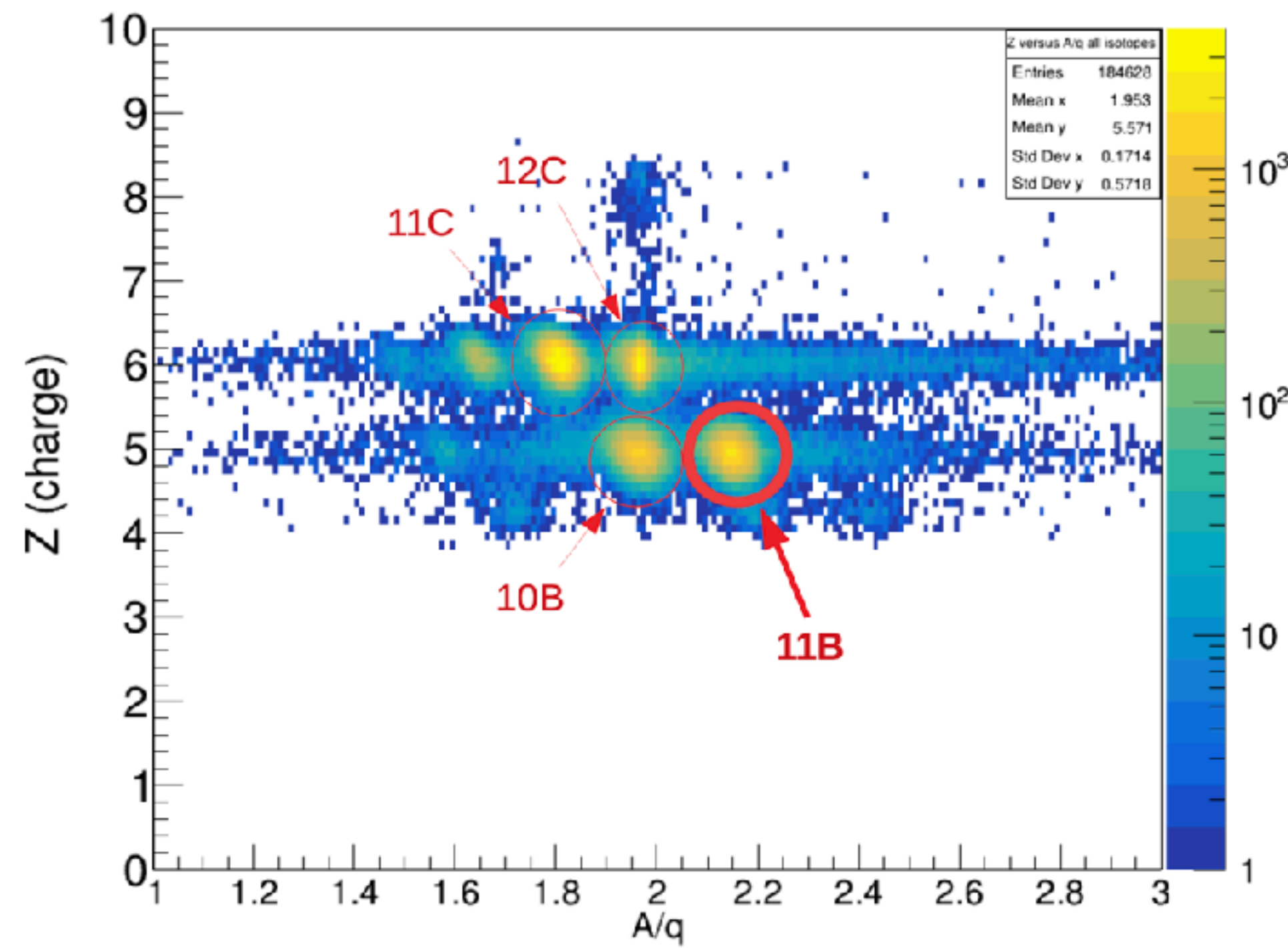
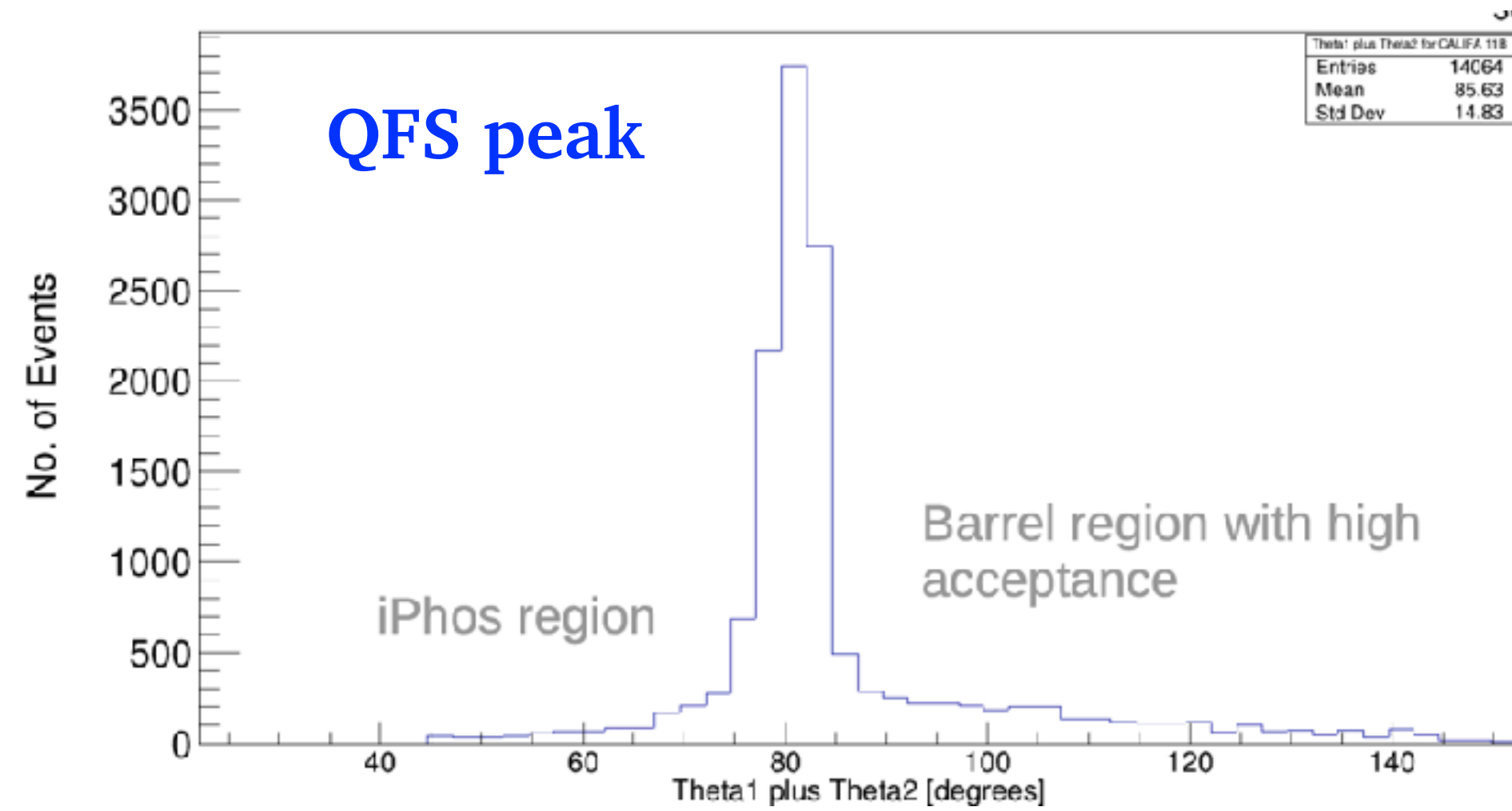
³⁸Ca setting



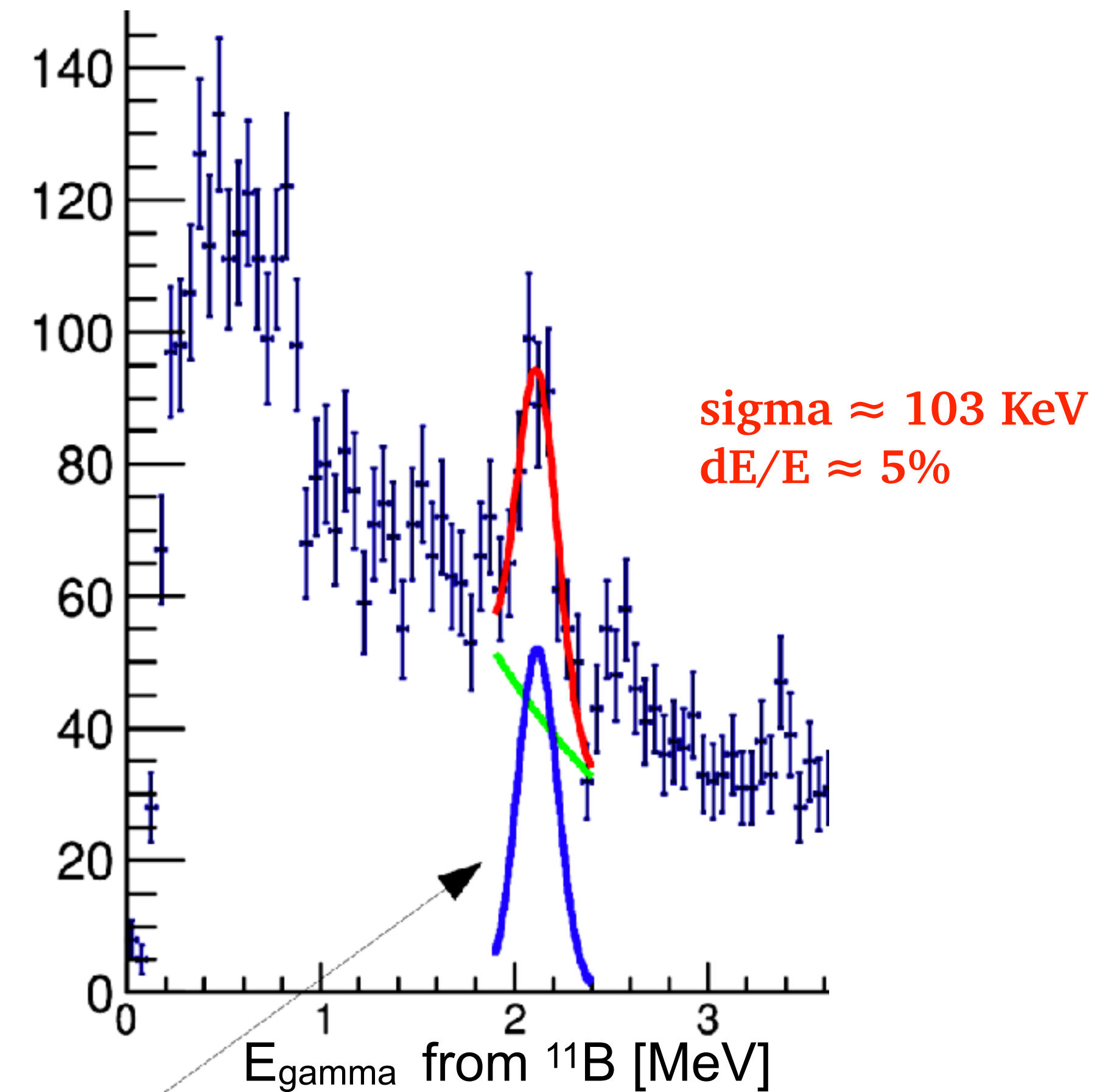
Preliminary results from S455 (^{12}C beam + CH_2 target)

February 2020

Courtesy of T. Jenegger



$^{12}\text{C}(\text{p},2\text{p})^{11}\text{B}$ @ 400 MeV/u
Doppler corrected gamma-spectrum

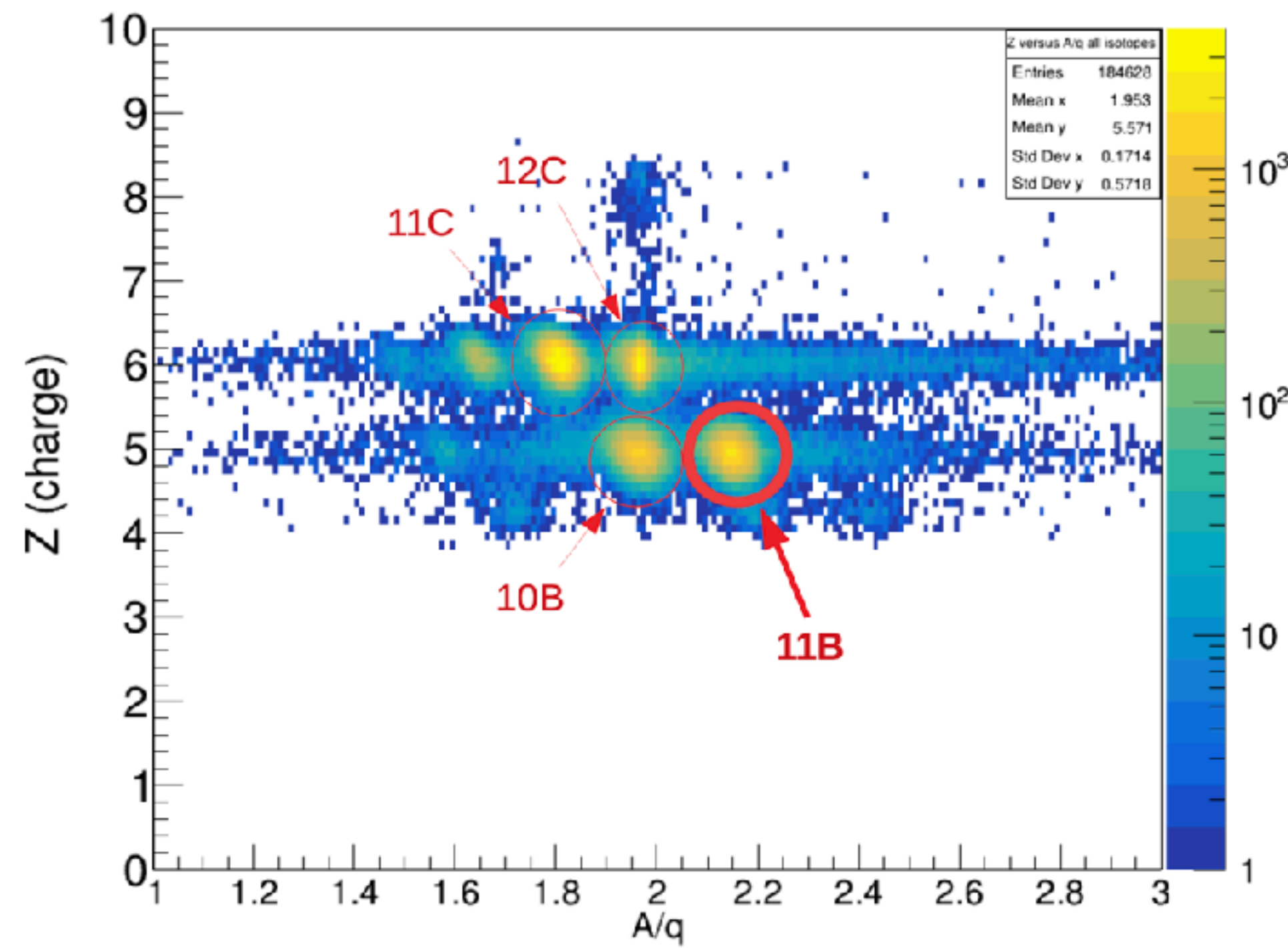
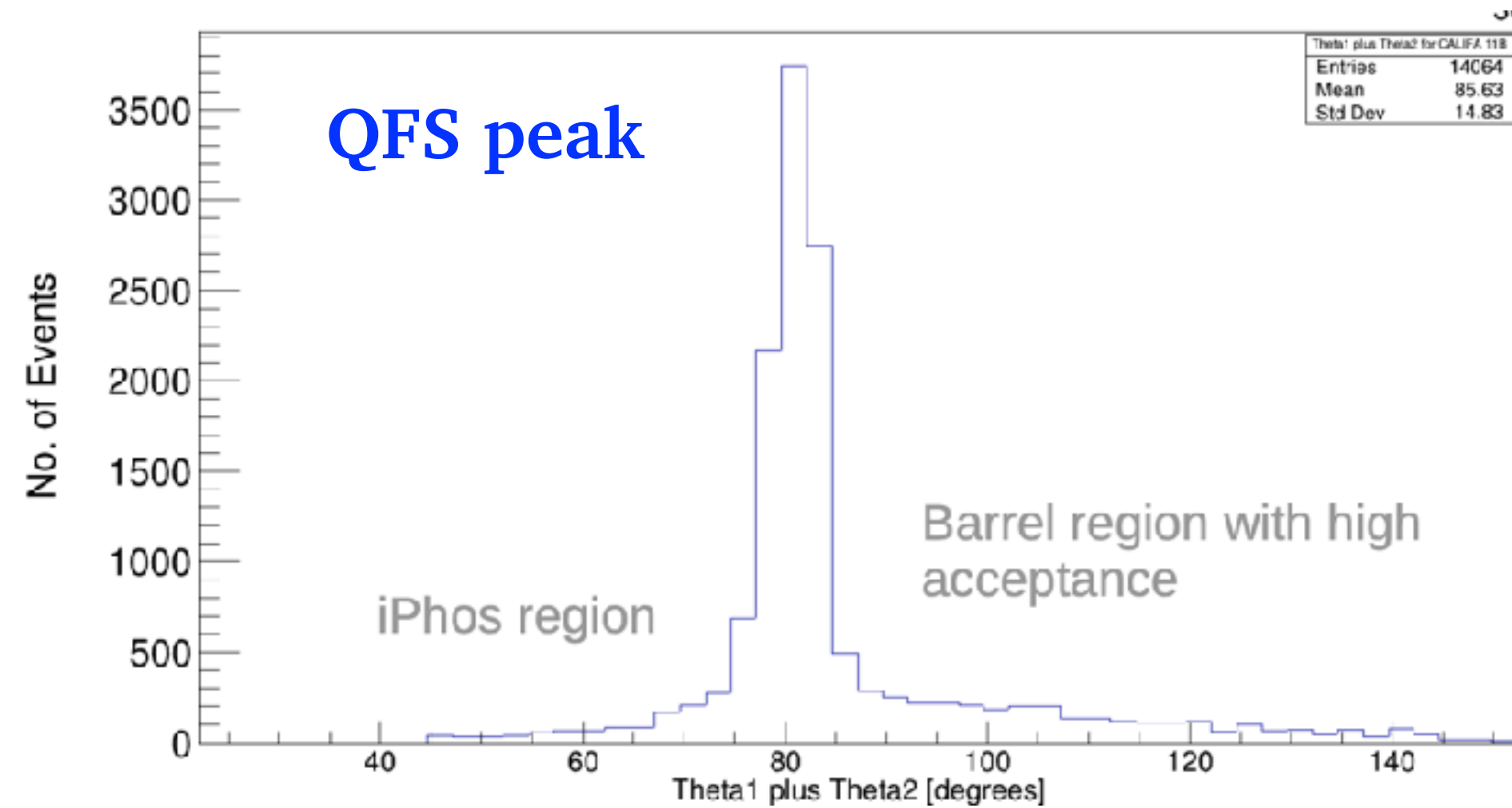


First state ($1/2^-$) in ^{11}B

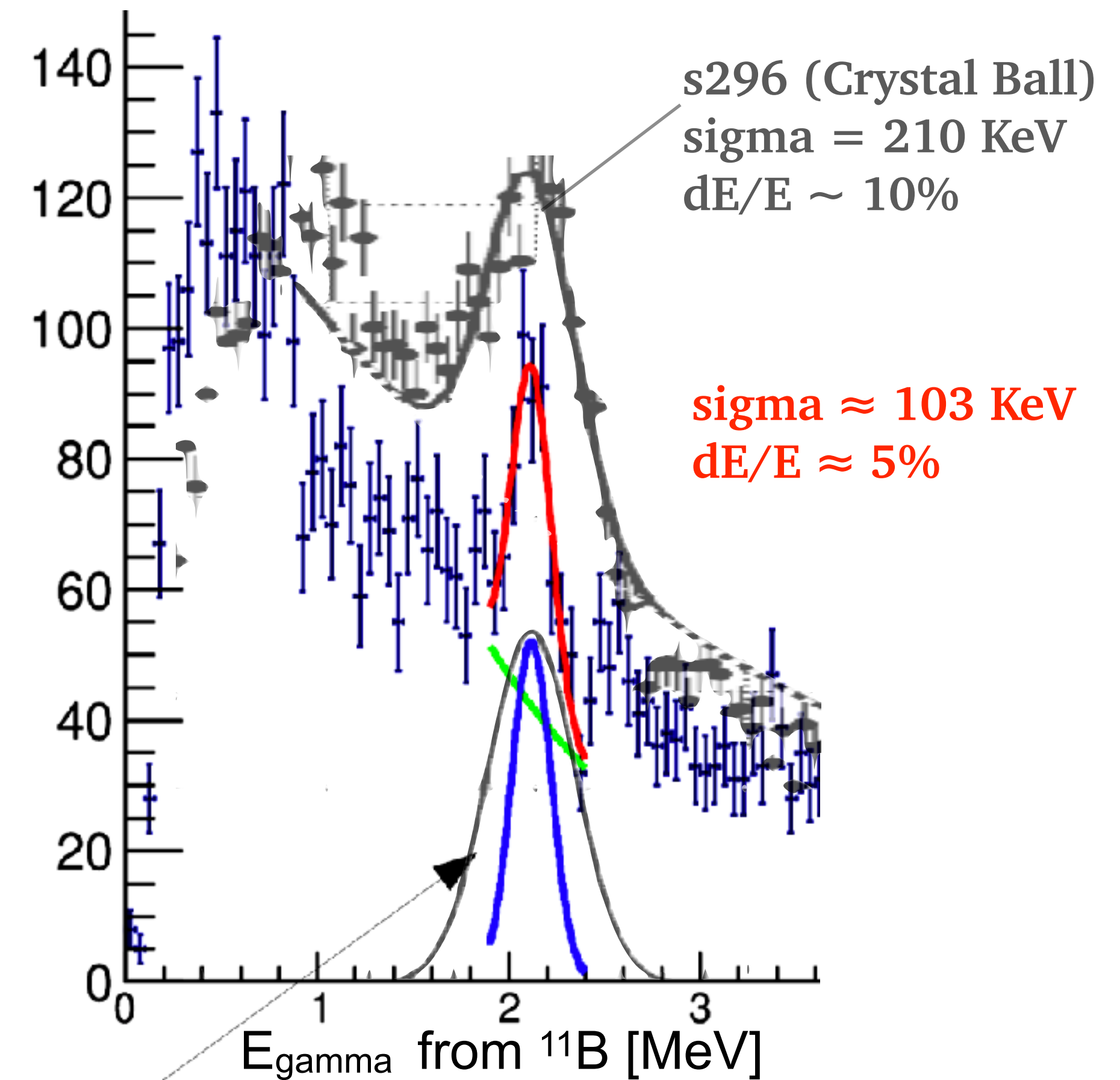
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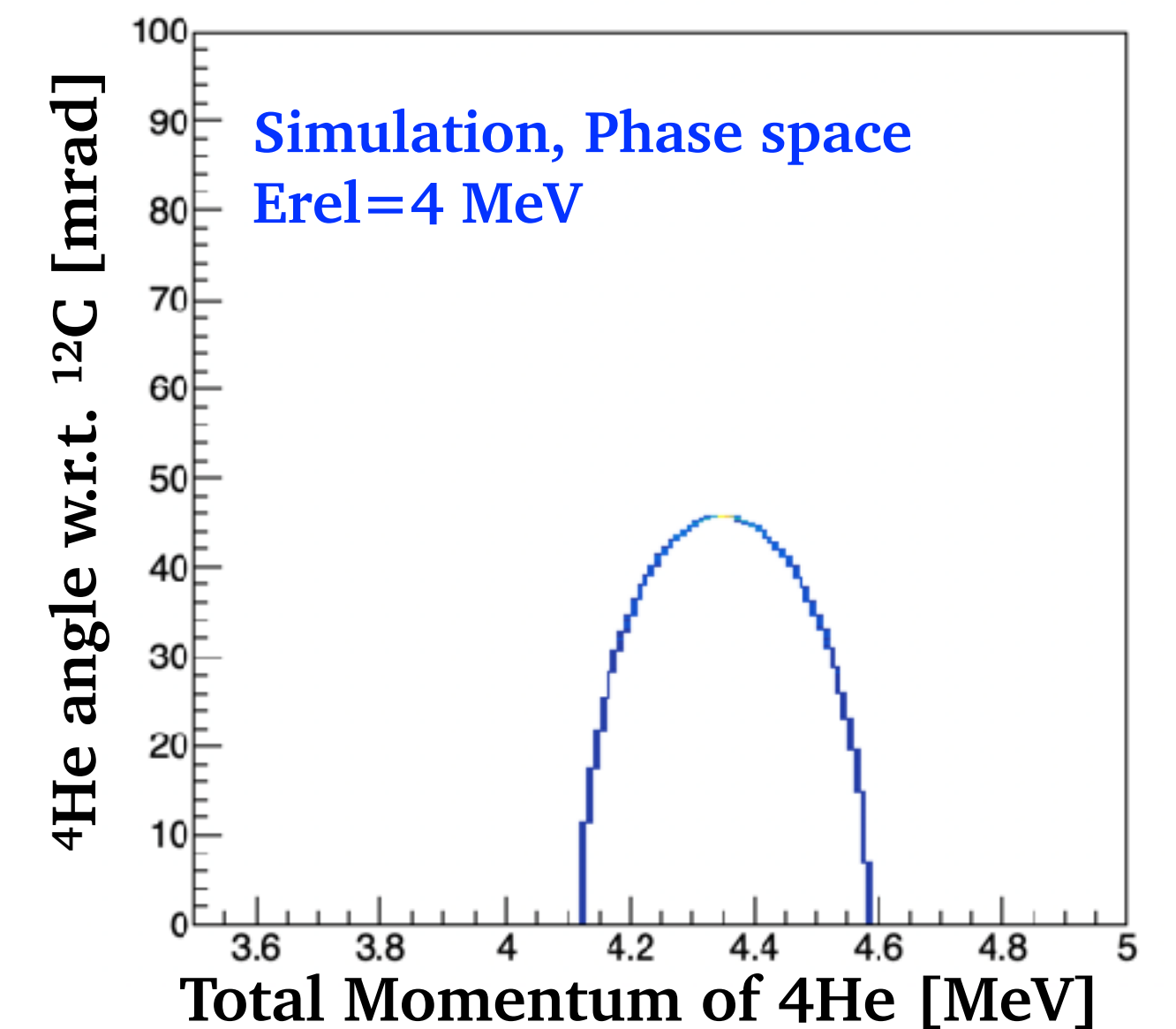
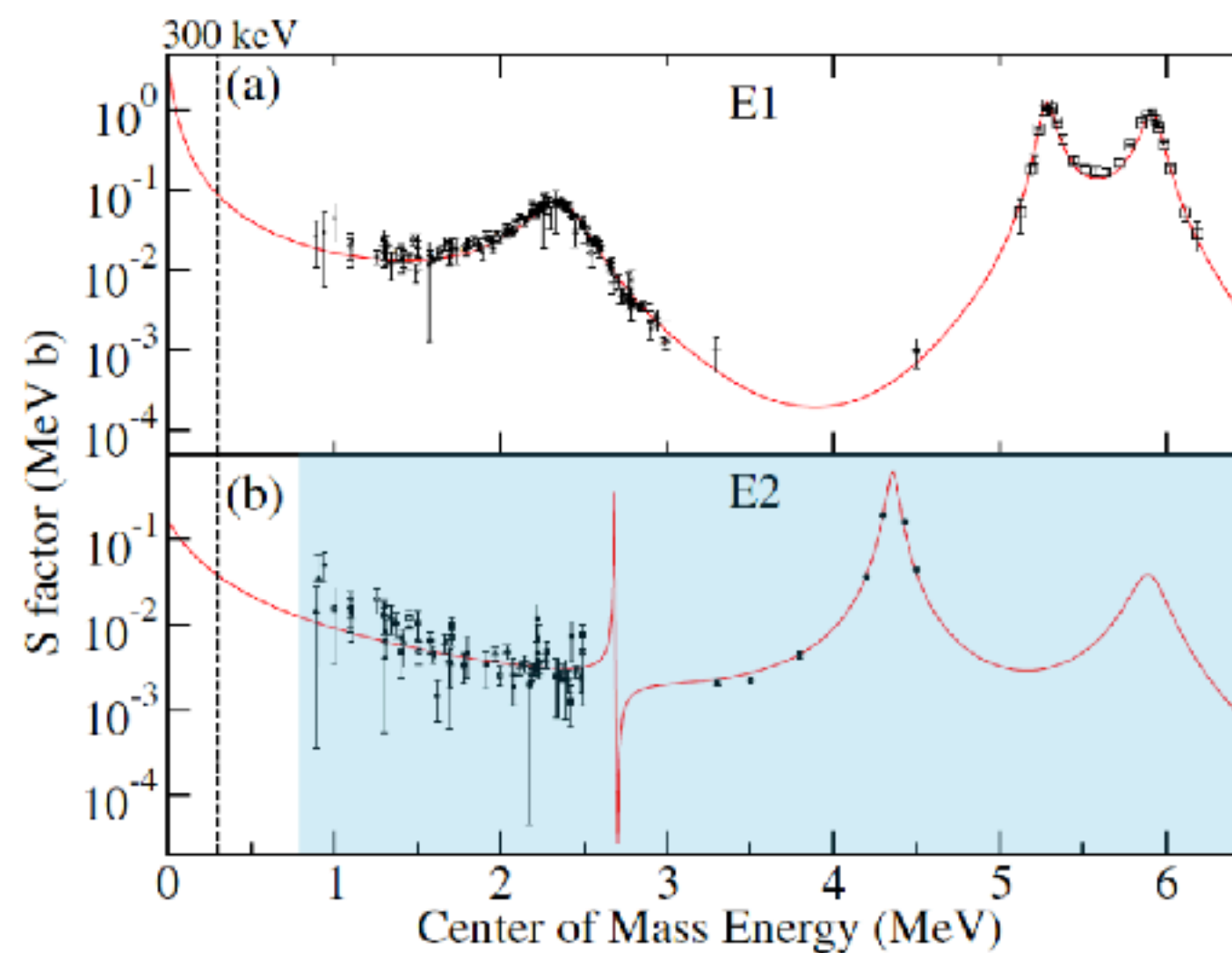
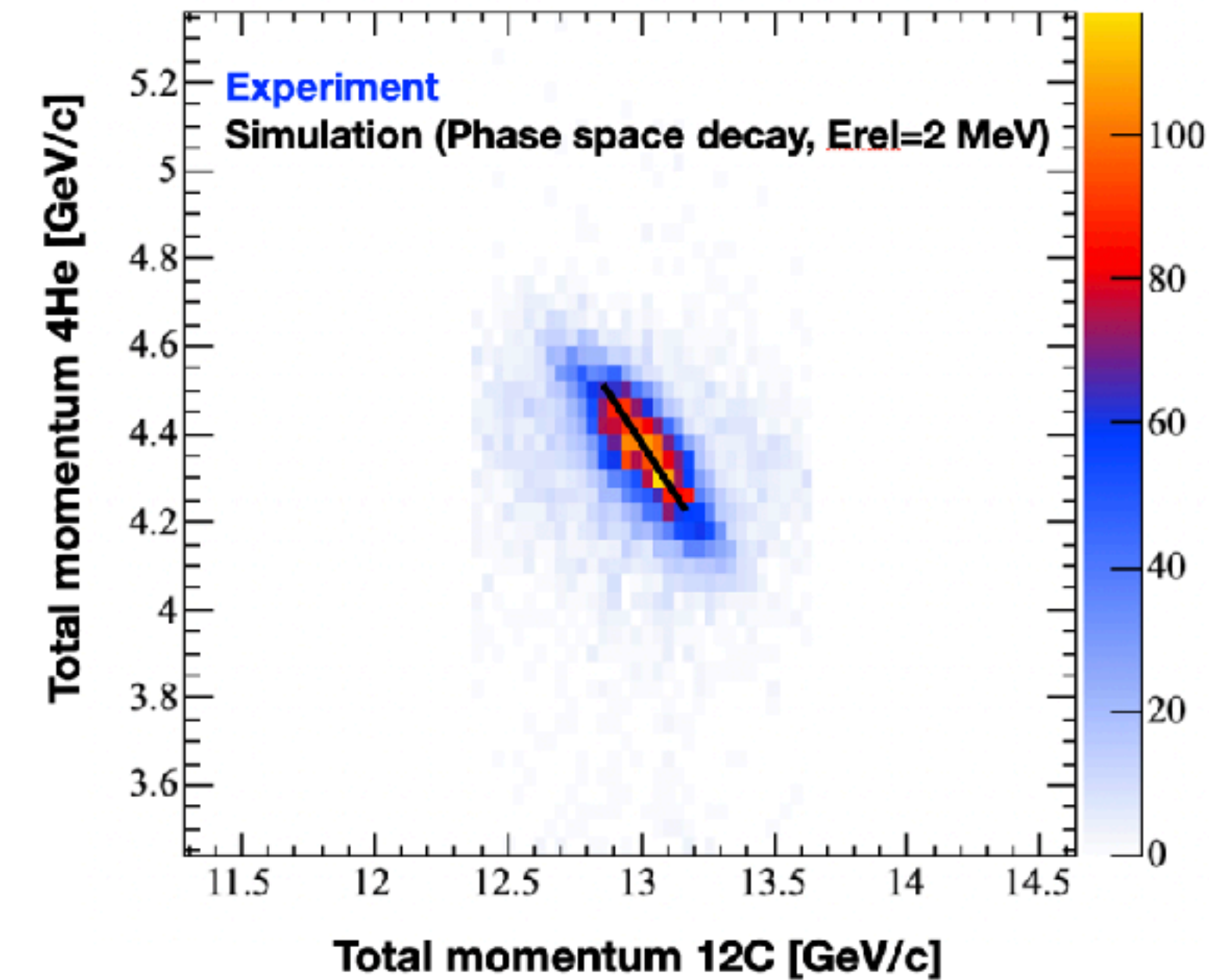
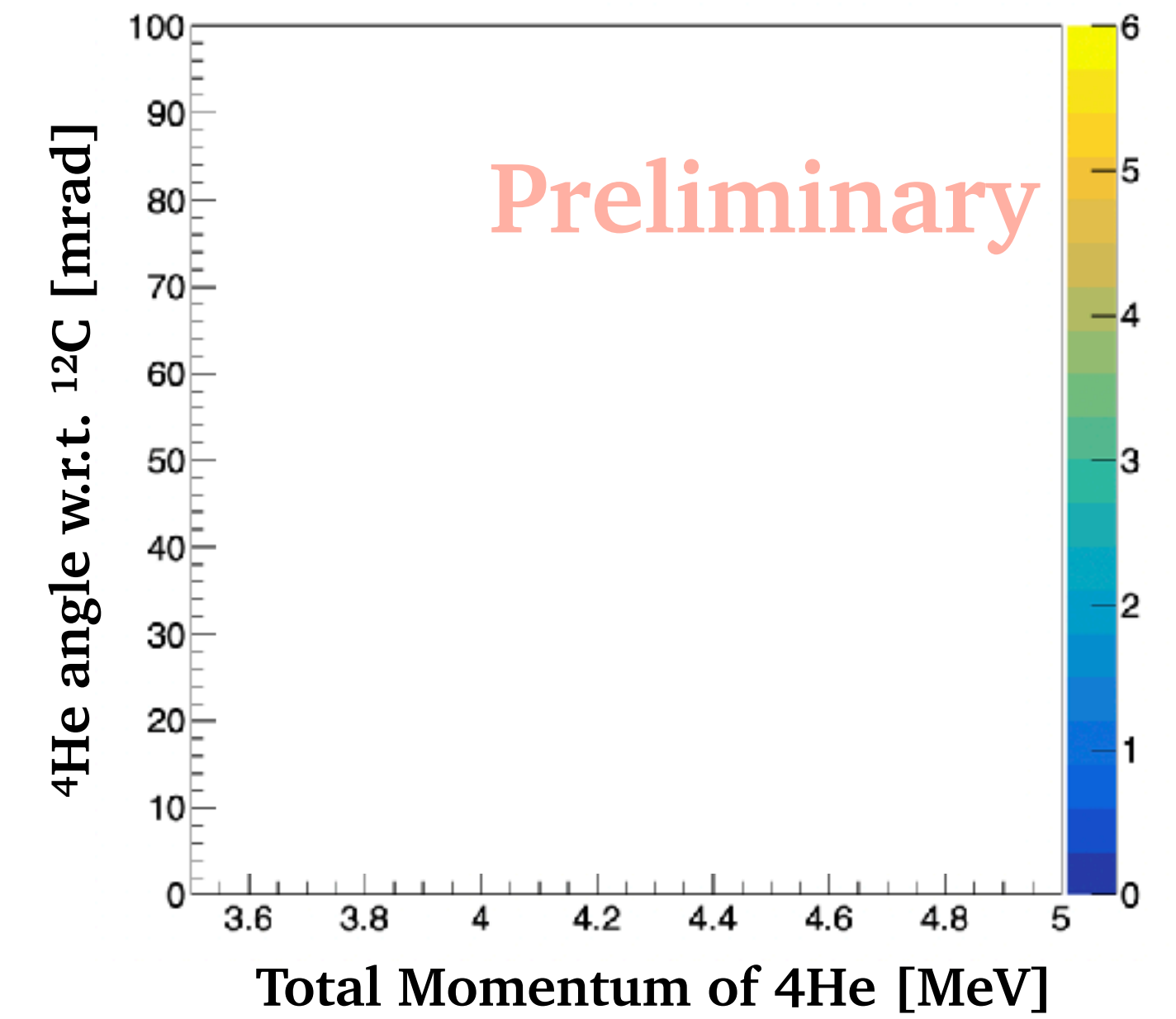
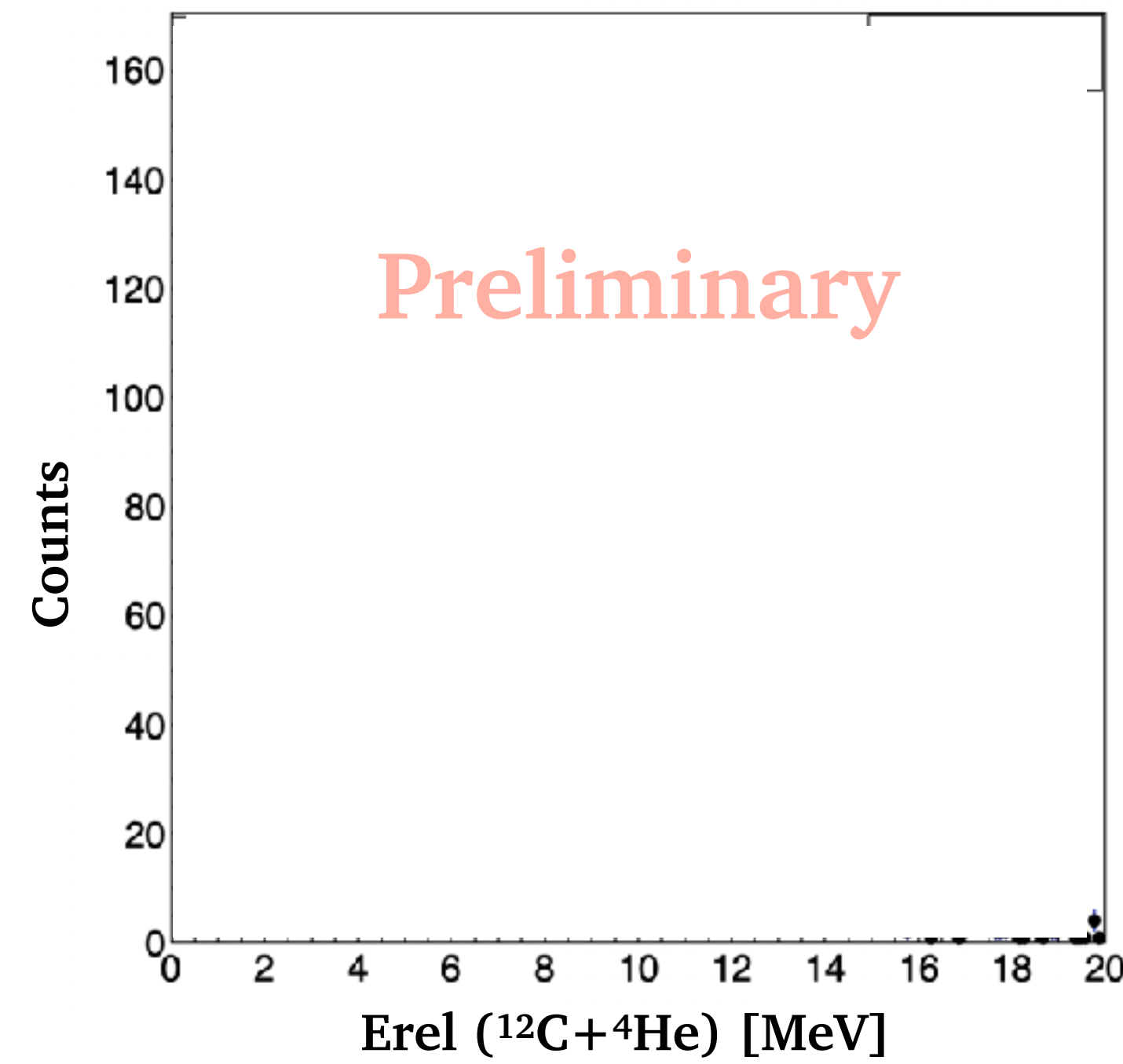
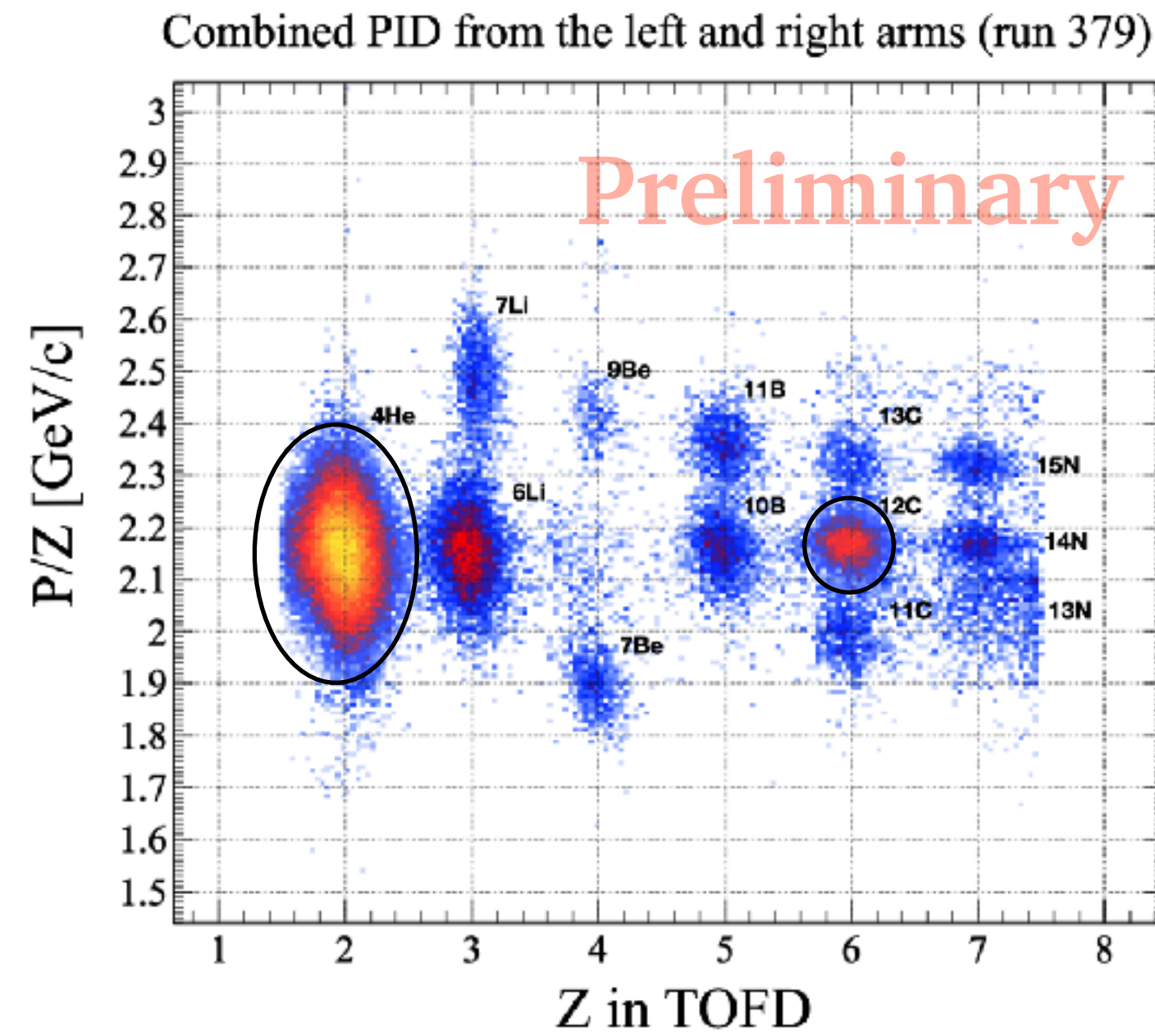


$^{12}\text{C}(p,2p)^{11}\text{B}$ @ 400 MeV/u
Doppler corrected gamma-spectrum



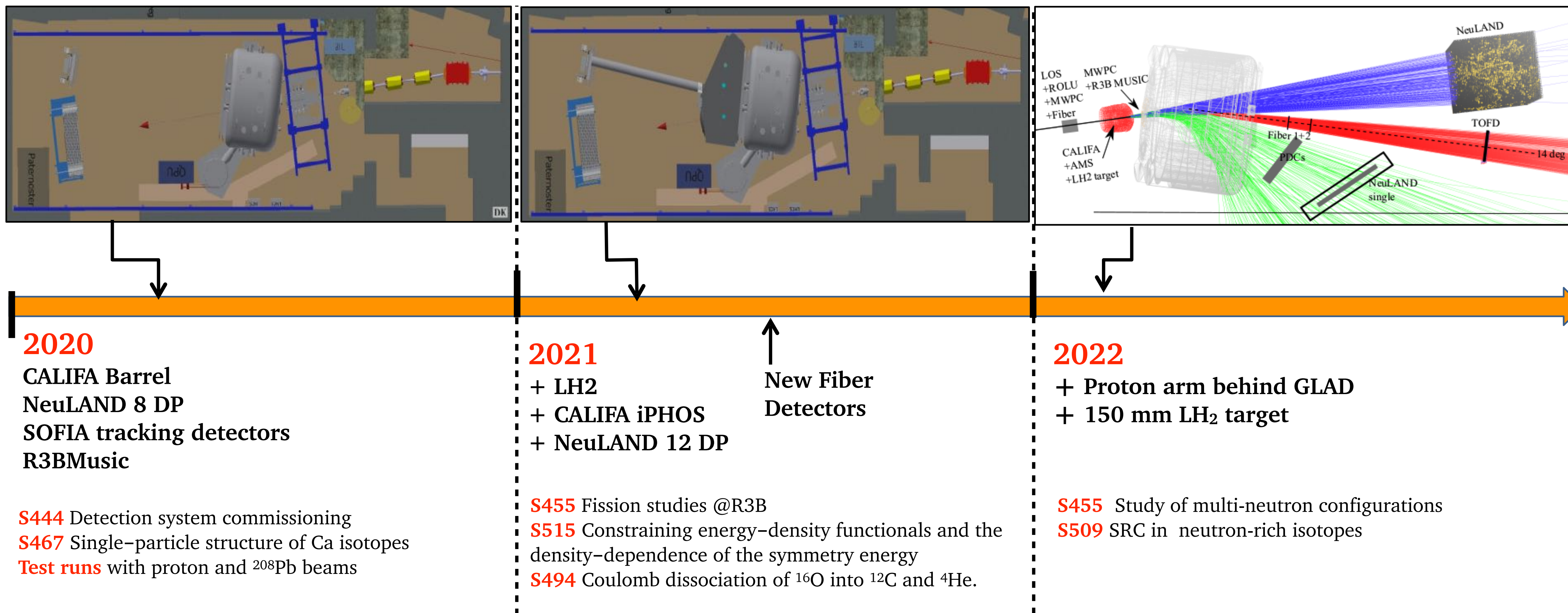
First state ($1/2^-$) in ^{11}B

Fragment tracking in S454 (2019, M. Heil et al.): Coulomb dissociation $^{16}\text{O} \rightarrow ^{12}\text{C} + ^4\text{He}$ @ 500 MeV/u



Summary and outlook

- Readiness for 2021 beam campaign
- Ongoing developments for the future experiments



R3B collaboration

Aksouh, Farouk; Al-Khalili, Jim; Algora, Alejandro; Alkhasov, Georgij; Altstadt, Sebastian; Alvarez, Hector; Atar, Leyla; Audouin, Laurent; Aumann, Thomas; Pellereau, Eric; Martin, Julie-Fiona; Gorbinet, Thomas; Seddon, Dave; Kogimtzis, Mos; Avdeichikov, Vladimir; Barton, Charles; Bayram, Murat; Belier, Gilbert; Bemmerer, Daniel; Michael Bendel; Benlliure, Jose; Bertulani, Carlos; Bhattacharya, Sudeb; Bhattacharya, Chandana; Le Bleis, Tudi; Boilley, David; Boretzky, Konstanze; Borge, Maria Jose; Botvina, Alexander; Boudard, Alain; Boutoux, Guillaume; Boehmer, Michael; Caesar, Christoph; Calvino, Francisco; Casarejos, Enrique; Catford, Wilton; Cederkall, Joakim; Cederwall, Bo; Chapman, Robert; Alexandre Charpy; Chartier, Marielle; Chatillon, Audrey; Chen, Ruofu; Christophe, Mayri; Chulkov, Leonid; Coleman-Smith, Patrick; Cortina, Dolores; Crespo, Raquel; Csatlos, Margit; Cullen, David; Czech, Bronislaw; Danilin, Boris; Davinson, Tom; Paloma Diaz; Dillmann, Iris; Fernandez Dominguez, Beatriz; Ducret, Jean-Eric; Duran, Ignacio; Egelhof, Peter; Elekes, Zoltan; Emling, Hans; Enders, Joachim; Eremin, Vladimir; Ershov, Sergey N.; Ershova, Olga; Eronen, Simo; Estrade, Alfredo; Faestermann, Thomas; Fedorov, Dmitri; Feldmeier, Hans; Le Fevre, Arnaud; Fomichev, Andrey; Forssen, Christian; Freeman, Sean; Freer, Martin; Friese, Juergen; Fynbo, Hans; Gacsi, Zoltan; Garrido, Eduardo; Gasparic, Igor; Gastineau, Bernard; Geissel, Hans; Gelletly, William; Genolini, B.; Gerl, Juergen; Gernhaeuser, Roman; Golovkov, Mikhail; Golubev, Pavel; Grant, Alan; Grigorenko, Leonid; Grosse, Eckart; Gulyas, Janos; Goebel, Kathrin; Gorska, Magdalena; Haas, Oliver Sebastian; Haiduc, Maria; Hasegan, Dumitru; Heftrich, Tanja; Heil, Michael; Heine, Marcel; Heinz, Andreas; Ana Henriques; Hoffmann, Jan; Holl, Matthias; Hunyadi, Matyas; Ignatov, Alexander; Ignatyuk, Anatoly V.; Ilie, Cherciu Madalin; Isaak, Johann; Isaksson, Lennart; Jakobsson, Bo; Jensen, Aksel; Johansen, Jacob; Johansson, Hakan; Johnson, Ron; Jonson, Bjoern; Junghans, Arnd; Jurado, Beatriz; Jaehrling, Simon; Kailas, S.; Kalantar, Nasser; Kalliopuska, Juha; Kanungo, Rituparna; Kelic-Heil, Aleksandra; Kezzar, Khalid; Khanzadeev, Alexei; Kissel, Robert; Kisselev, Oleg; Klimkiewicz, Adam; Kmiecik, Maria; Koerper, Daniel; Kojouharov, Ivan; Korshennikov, Alexei; Korten, Wolfram; Krasznahorkay, Attila; Kratz, Jens Volker; Kresan, Dima; Anatoli Krivchitch; Kroell, Thorsten; Krupko, Sergey; Kruecken, Reiner; Kulesa, Reinhard; Kurz, Nikolaus; Kuzmin, Eugenii; Labiche, Marc; Langanke, Karl-Heinz; Langer, Christoph; Lapoux, Valerie; Larsson, Kristian; Laurent, Benoit; Lazarus, Ian; Le, Xuan Chung; Leifels, Yvonne; Lemmon, Roy; Lenske, Horst; Lepine-Szily, Alinka; Leray, Sylvie; Letts, Simon; Li, Songlin; Liang, Xiaoying; Lindberg, Simon; Lindsay, Scott; Litvinov, Yuri; Lukasik, Jerzy; Loeher, Bastian; Mahata, Kripamay; Maj, Adam; Marganec, Justyna; Meister, Mikael; Mittag, Wolfgang; Movsesyan, Alina; Mutterer, Manfred; Muentz, Christian; Nacher, Enrique; Najafi, Ali; Nakamura, Takashi; Neff, Thomas; Nilsson, Thomas; Nociforo, Chiara; Nolan, Paul; Nolen, Jerry; Nyman, Goran; Obertelli, Alexandre; Obradors, Diego; Ogloblin, Aleksey; Oi, Makito; Palit, Rudrajyoti; Panin, Valerii; Paradela, Carlos; Paschalis, Stefanos; Pawlowski, Piotr; Petri, Marina; Pietralla, Norbert; Pietras, Ben; Pietri, Stephane; Plag, Ralf; Podolyak, Zsolt; Pollacco, Emanuel; Potlog, Mihai; Datta Pramanik, Ushasi; Prasad, Rajeshwari; Fraile Prieto, Luis Mario; Pucknell, Vic; Galaviz -Redondo, Daniel; Regan, Patrick; Reifarth, Rene; Reinhardt, Tobias; Reiter, Peter; Rejmund, Fanny; Ricciardi, Maria Valentina; Richter, Achim; Rigollet, Catherine; Riisager, Karsten; Rodin, Alexander; Rossi, Dominic; Roussel-Chomaz, Patricia; Gonzalez Rozas, Yago; Rubio, Berta; Roeder, Marko; Saito, Takehiko; Salsac, Marie-Delphine; Rodriguez Sanchez, Jose Luis; Santosh, Chakraborty; Savajols, Herve; Savran, Deniz; Scheit, Heiko; Schindler, Fabia; Schmidt, Karl-Heinz; Schmitt, Christelle; Schnorrenberger, Linda; Schrieder, Gerhard; Schrock, Philipp; Sharma, Manoj Kumar; Sherrill, Bradley; Shrivastava, Aradhana; Shulgina, Natalia; Sidorchuk, Sergey; Silva, Joel; Simenel, Cedric; Simon, Haik; Simpson, John; Singh, Pushpendra Pal; Sonnabend, Kerstin; Spohr, Klaus; Stanoiu, Mihai; Stevenson, Paul; Strachan, Jon; Streicher, Brano; Stroth, Joachim; Syndikus, Ina; Suemmerer, Klaus; Taieb, Julien; Tain, Jose L.; Tanihata, Isao; Tashenov, Stanislav; Tassan-Got, Laurent; Tengblad, Olof; Teubig, Pamela; Thies, Ronja; Togano, Yasuhiro; Tostevin, Jeffrey A.; Trautmann, Wolfgang; Tuboltsev, Yuri; Turrion, Manuela; Typel, Stefan; Udias-Moinelo, Jose; Vaagen, Jan; Velho, Paulo; Verbitskaya, Elena; Veselsky, Martin; Wagner, Andreas; Walus, Wladyslaw; Wamers, Felix; Weick, Helmut; Wimmer, Christine; Winfield, John; Winkler, Martin; Woods, Phil; Xu, Hushan; Yakorev, Dmitry; Zegers, Remco; Zhang, Yu-Hu; Zhukov, Mikhail; Zieblinski, Mirosław; Zilges, Andreas; Tobias Jenegger