

HAD_01:

**Measurements of Jets and
Photons in Heavy Ion Collisions
at the Highest Beam Energy
during the LHC-Run 2 by ALICE**

Tatsuya Chujo (Univ. of Tsukuba)

2016 Joint Workshop of FKPPL and TYL/FJPPL
(Particle Physics Laboratories) @ KIAS

May 18, 2016

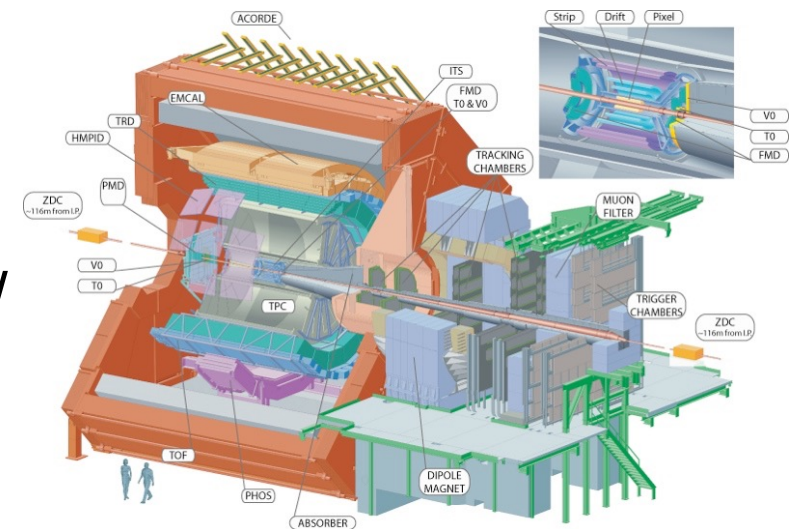
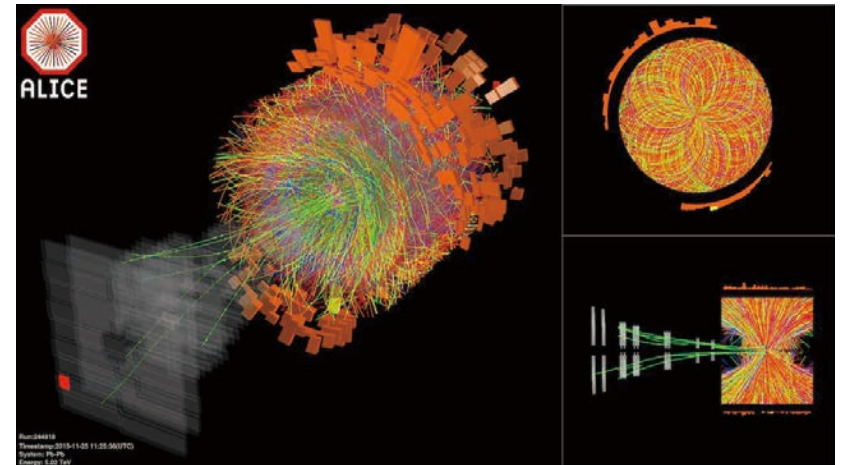
KIAS, Seoul,



筑波大学
University of Tsukuba

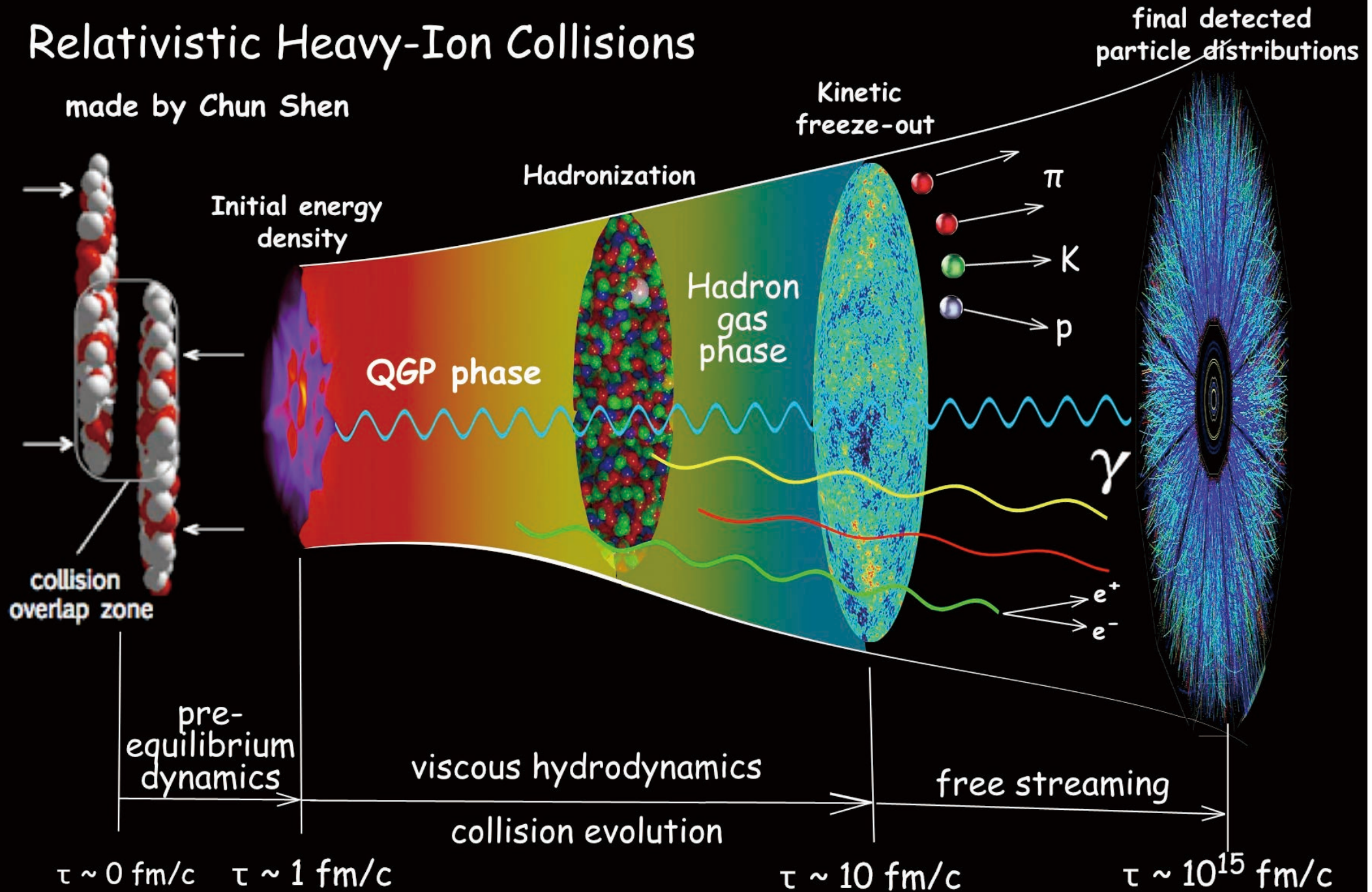
Had_01: project goals

- LHC heavy ion physics at **ALICE experiment**.
- Perform high precision measurements for the quantitative determination of QPG properties at the highest temperature.
- Run-1 (2009-2013) and Run-2 (2015-2018) data.
- **Jets and photons measurements**, Japan and France in ALICE, by EMCal/DCal detectors, which has been built within the framework of France-Japan collaboration.

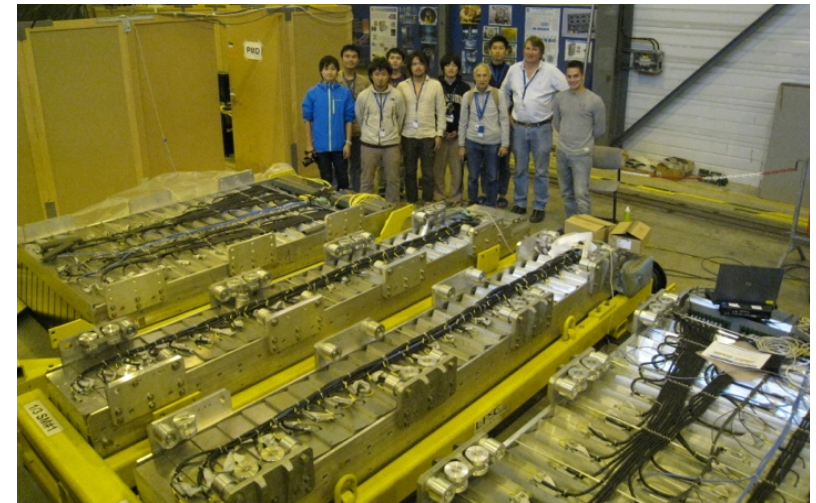
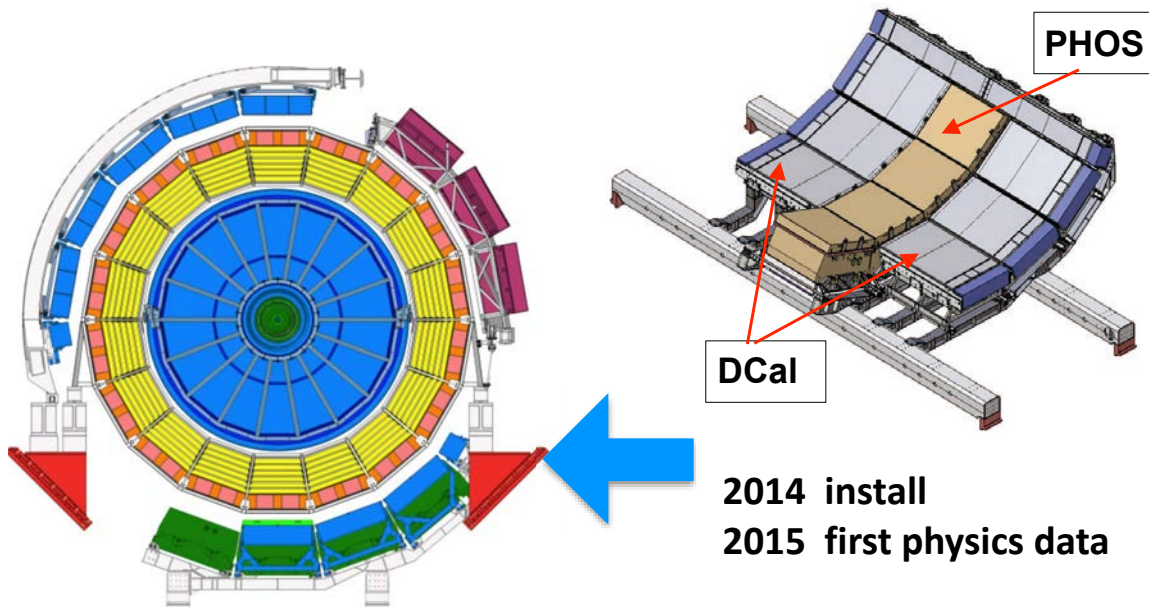


Relativistic Heavy-Ion Collisions

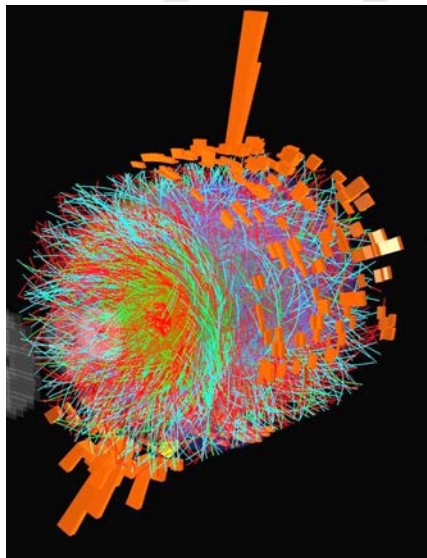
made by Chun Shen



Probing new physics by ALICE-DCal



DCal super modules @ CERN (before installation)

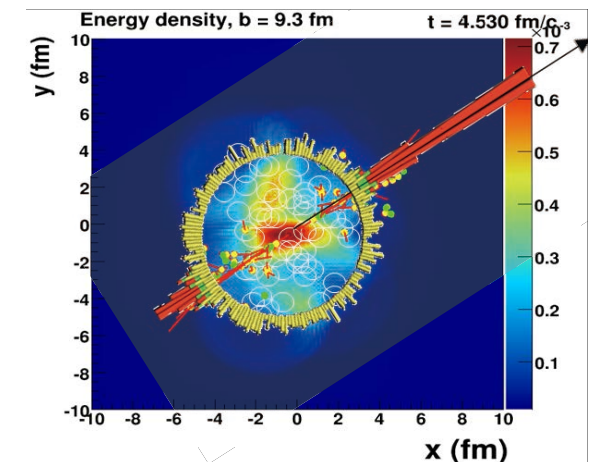


Pb-Pb 5.02 TeV with di-jet candidate (Run-2 data, 2015)

ALICE DCal

New electromagnetic calorimeter for jet and photon physics, by **US, Japan, France, China, Italy**

• T. Chujo : EMCal • DCal deputy project leader



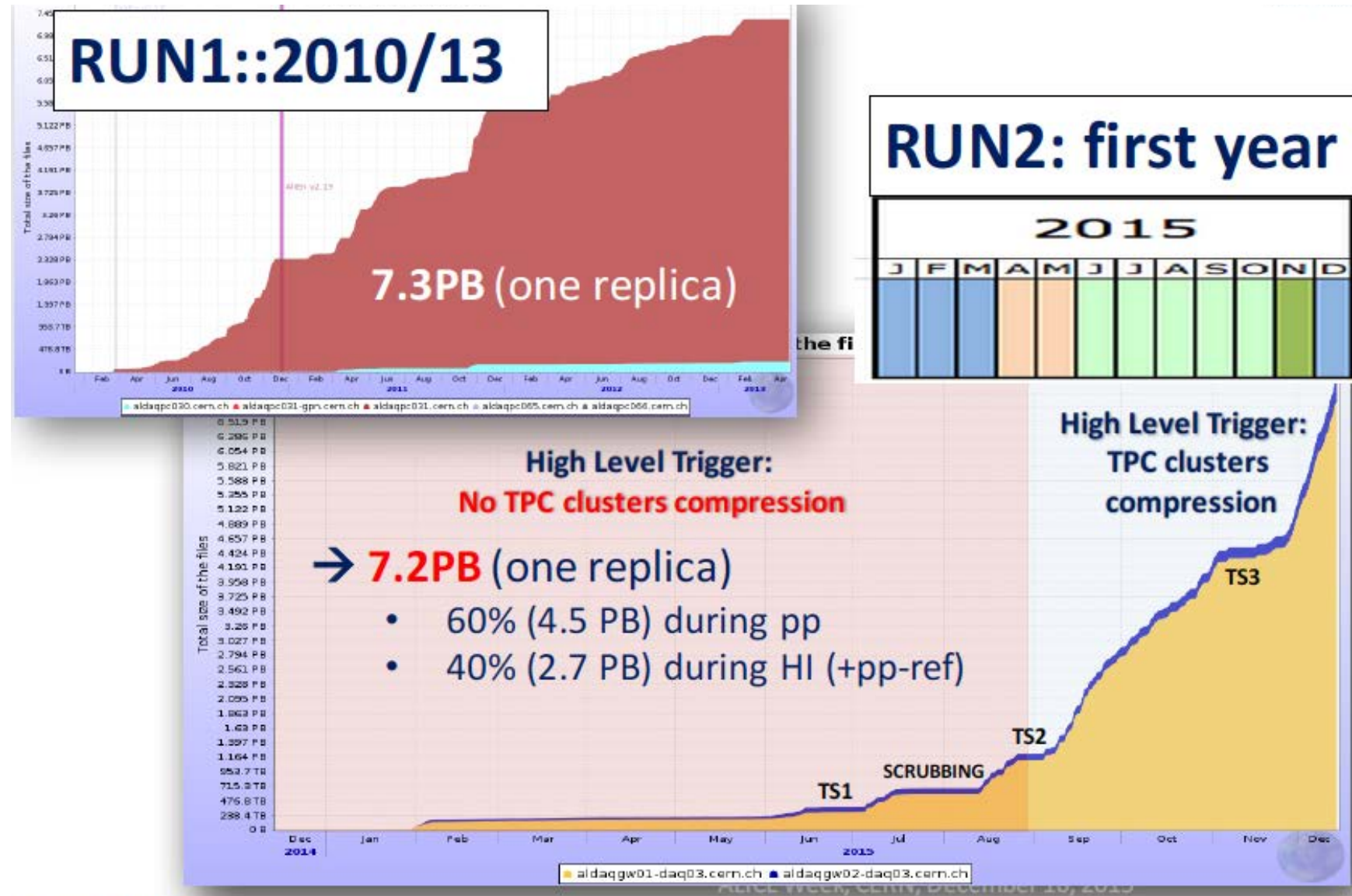
di-jet with mach cone radiation (theory)

**From discovery to determination of properties
Quark Gluon Plasma (QGP) by using jets and photons**



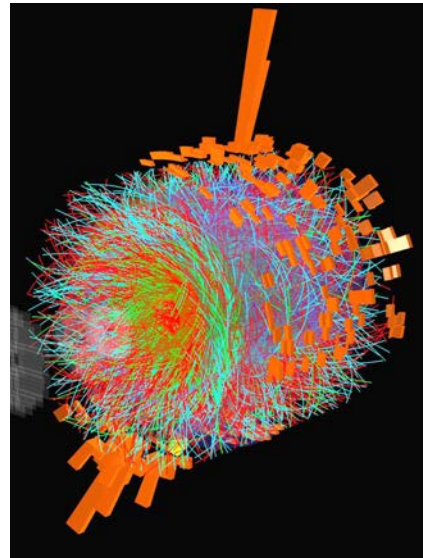
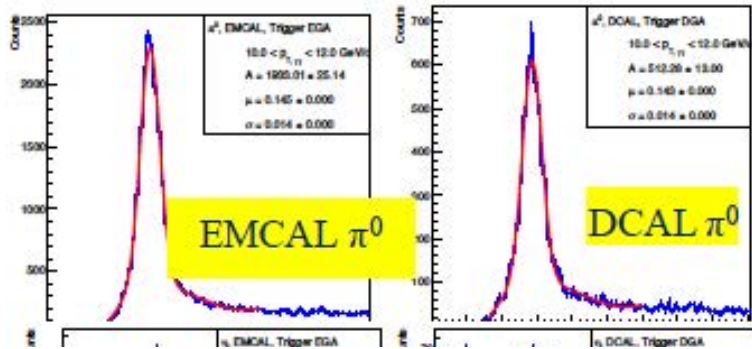
Search for the gluon radiation, Equation of state of QGP

ALICE data taking profile: Run-2 vs. Run-1

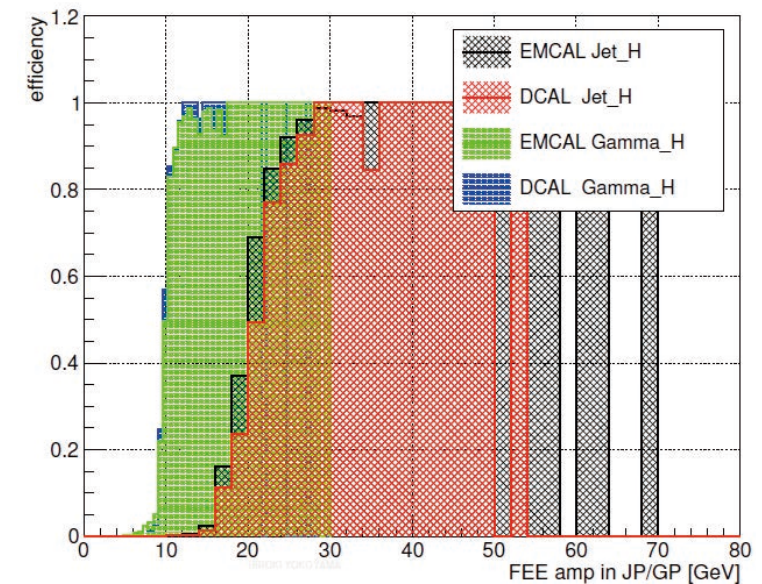


Project report (FY2015)

First year of DCal, jet/photon L1 trigger

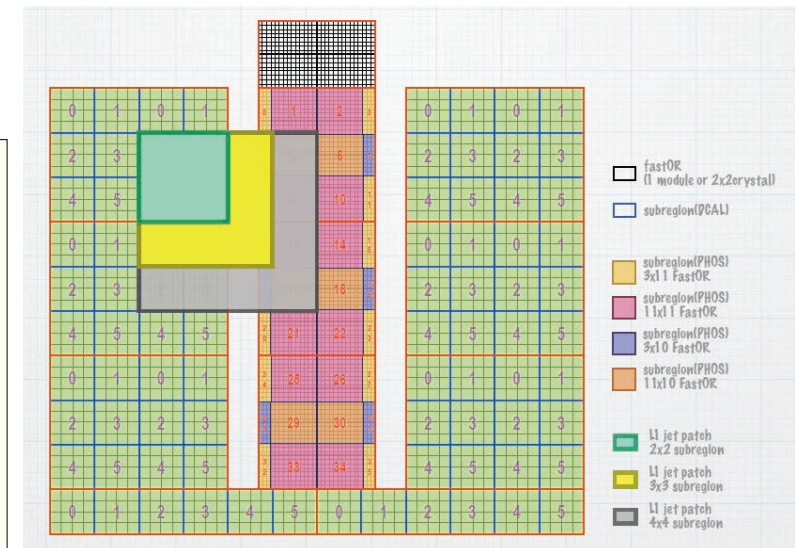


Jet trigger efficiency



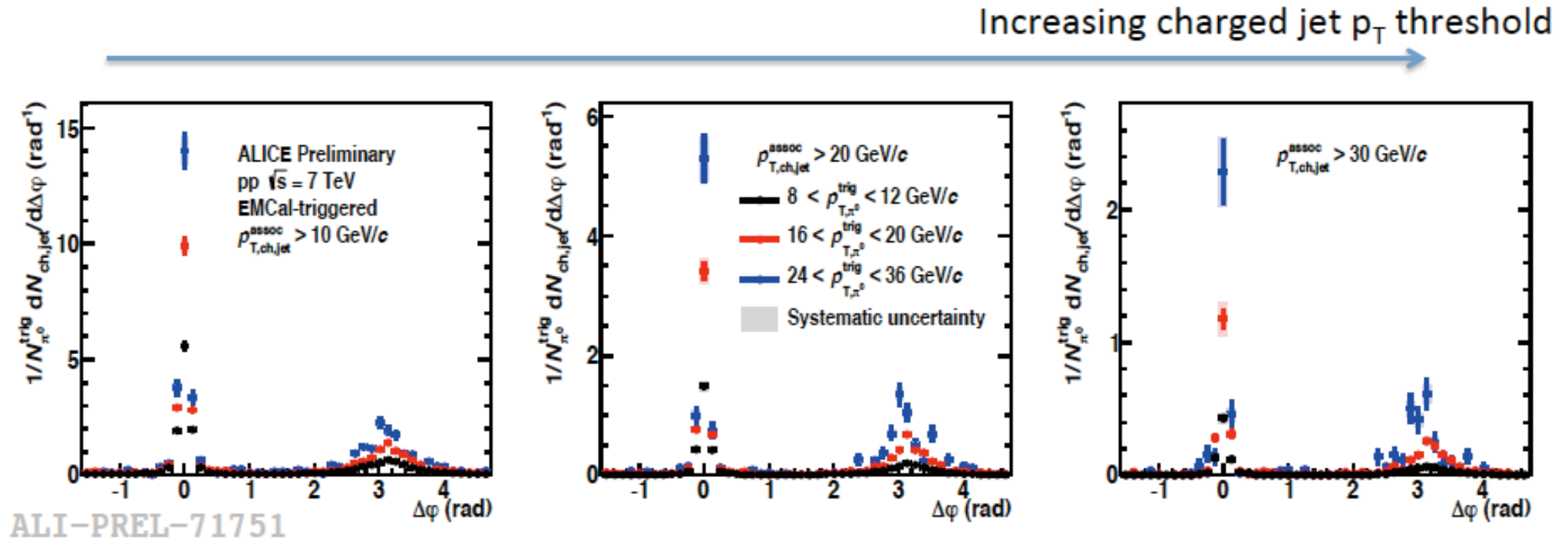
H. Yokoyama, R. Hosokawa, R. Guernane, J. Kral, T. Chujo

- **DCal and L1 trigger: Operational in 2015, first year of physics data taking.**
- Grenoble LPSC - Tsukuba- Jyvaskyla team for L0/L1 trigger
 - **Tsukuba: EMCal/ DCal /PHOS Level-1 jet & photon trigger, FPGA firmware development.**
- Reasonable turn-on curve on jet trigger.
- Rejection factor 10^4 at 30 GeV jet.
- **Physics data analysis is on-going.**



↑ DCal + PHOS trigger patch (H. Yokoyama)

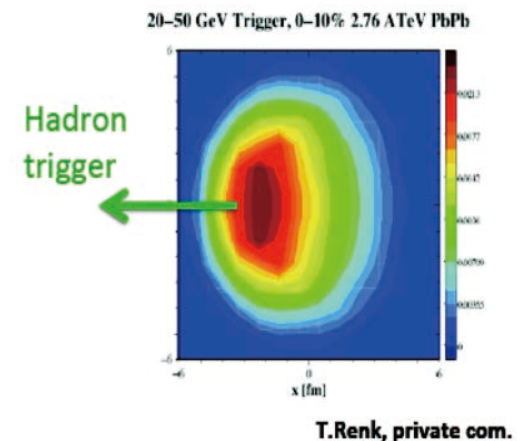
π^0 -jet correlations to determine path length dep. of energy loss



D. Watanabe (PhD)

π^0 -jet correlations in pp and PbPb

- **Daisuke Watanabe (Tsukuba), obtained PhD in 2016, March.**
- Developed by FJPPL, presented at QM2015 (Kobe)
- Study of jet structure by triggering high p_T π^0 hadrons.
- pp 7 TeV finished, and Pb-Pb 2.76 TeV finalizing for the publication.



Dual Degree Program (Ph.D) Grenoble U. - U. of Tsukuba

- Grenoble University (Joseph Fourier) and University of Tsukuba, agreed to start **the joint double degree program (Ph.D) in 2015.**
- Supervised by two institutes (Grenoble and Tsukuba) on same thesis topics.
- Ph.D from both Grenoble and Tsukuba after successful defense.
- URL (in Japanese): <http://www.pas.tsukuba.ac.jp/overview/program/double-degree/>
- **Two students** in this program within the framework of FJPPL:
 - **Hiroki Yokoyama** (U. Tsukuba): started April 2015.
 - “Jet spectra at 5.02 TeV in Pb-Pb (ALICE)”
 - Defence expected Sep. 2017
 - **Ritsuya Hosokawa** (U. Tsukuba): started Sep. 2015.
 - “Full jet pT spectra in 13 TeV p-p” and “jet-hadron correlations in PbPb(future)”


ALICE Calo meeting in Osaka (2015)

- Discussed EMCal/DCal/ PHOS, jet and photon physics, within FJPPL, including Russian collaboration.
- 2.5 days, around 30 participants.
 - <https://indico.cern.ch/event/439906/>



The screenshot shows the Indico event page for the ALICE Calo meeting in Osaka. The header features the ALICE logo and the text "ALICE CALO meeting in Osaka". Below this, the dates "5-7 October 2015" and the location "OSAKA" are displayed. A sidebar on the left contains a navigation menu with links to Overview, Scientific Programme, Timetable, Contribution List, Author List, My Conference, My Contributions, Registration, Participant List, and Videoconference Rooms. The main content area provides details about the meeting, including the date (Oct 5-7, 2015), the venue (Osaka University Nakanoshima center), the address (4-3-53 Nakanoshima Kita-ku Osaka-city Osaka Japan 530-0005), and the agenda (tentative). The agenda lists activities for each day: Oct. 5 (Mon) AM: Registration, PM: PHOS related discussions; Oct. 6 (Tue) AM/PM: Physics by using PHOS/DCal + EMCal; and Oct. 7 (Wed) AM: CALO trigger. A note mentions that presentations by all graduate students participated in this workshop, and to show their current work and plan in 20 min. each.

- Next meeting in Tokyo 2016, May-June.
 - <https://indico.cern.ch/event/506125/>

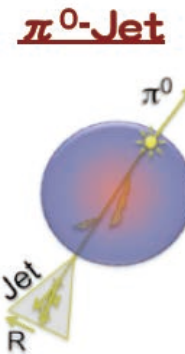
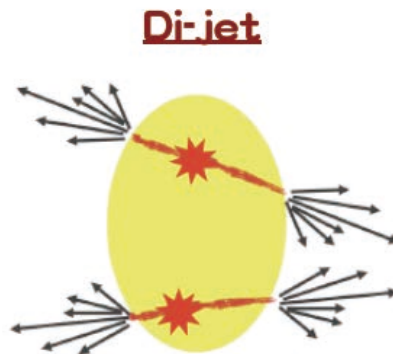
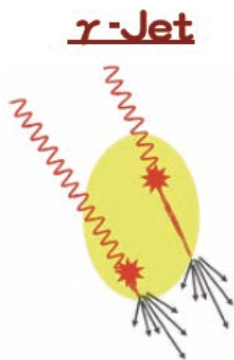


The screenshot shows the Indico event page for the ALICE Calo Meeting in Tokyo 2016. The header features the ALICE logo and the text "ALICE Calo Meeting in Tokyo 2016". Below this, the dates "from 30 May 2016 to 1 June 2016" and the location "Tokyo" are displayed. A sidebar on the left contains a navigation menu with links to Overview, Scientific Programme, Timetable, My Conference, Registration, and Participant List. The main content area provides details about the meeting, including the start and end times (Starts 30 May 2016 08:00, Ends 1 Jun 2016 18:00), the location (Tokyo, 3-3-6 Shibaura Minato-ku Tokyo 108-0023 Japan), and the contact information (Toru Sugitate, Tatsuya Chujo). A note mentions that there are no materials yet.

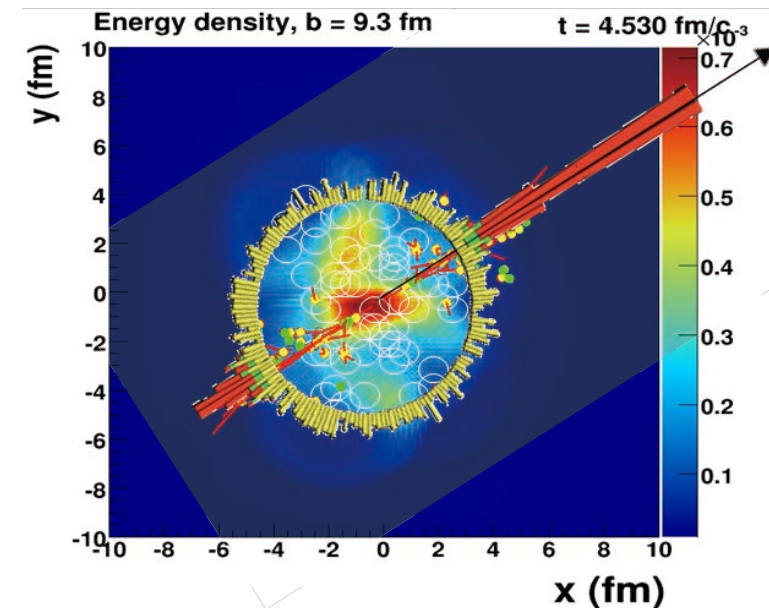
Project proposal (FY2016)

Keys to understand dE/dx in QCD plasma

1. Control path length (parton scattering point)
2. Energy calibration (e.g. γ -jet)
3. Detection of medium response by jet (parton) propagation



- Within the framework of FJPPL and FCPPL, we developed the new analysis team in ALICE, called **AAF (ALICE Asian France) collaboration**.
- First results on jet at “Hard Probe 2016 (Wuhan)”, and continue for the future jet/ photon analysis.



QGP fluid + jet model

Y. Tachibana, T. Hirano
(QM2015)

1. Mach cone as a hydrodynamic response

- Fluidity of the bulk medium
- Properties of QGP e.g. sound velocity, viscosity, stopping power, etc.

2. Bulk dynamics of the QGP in jet events in HIC

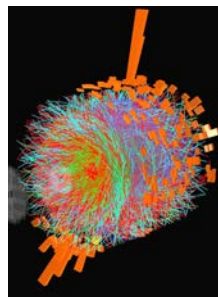
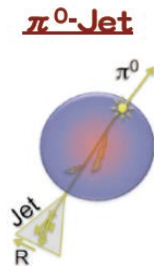
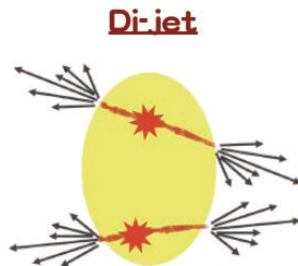
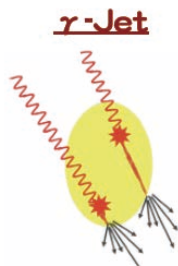
- Hydrodynamic response to jets in the expanding QGP
- Consequent spectra of particles from the bulk medium

Hydrodynamic equations with source terms

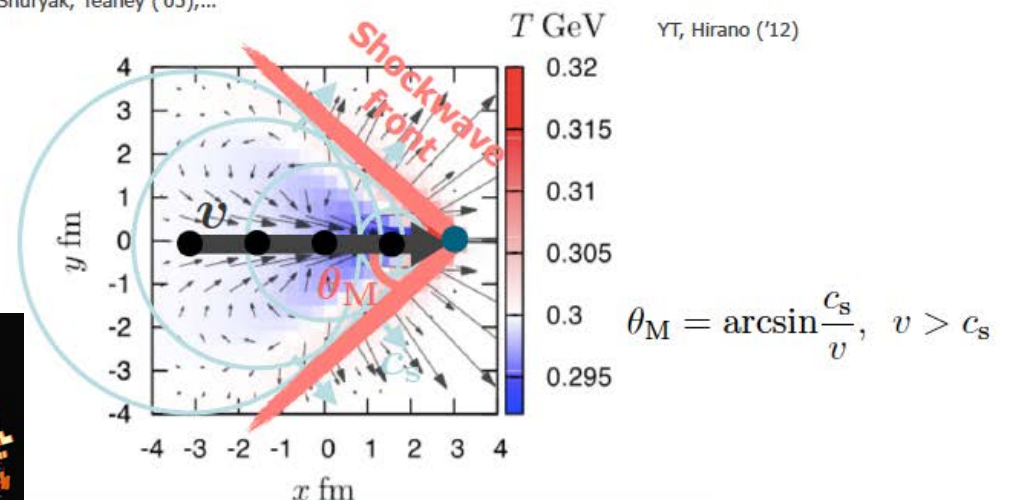
$$\partial_\mu T^{\mu\nu} = J^\nu$$

Energy-momentum tensor
of the QGP fluid

Energy and momentum
deposited from the jets



Stoecker ('05), Casalderrey-Solana,
Shuryak, Teaney ('05),...



HAD_01: Project Members

FJPPL (TYL) application 2016-2017

Fiscal year April 1st 2016 – March 31st 2017

Please replace the red examples by the appropriate data in black

| ID ¹ :HAD_01 | Title: Measurements of Jets and Photons in Heavy Ion Collisions at the Highest Beam Energy during the LHC-Run 2 by ALICE | | | | | |
|-------------------------|--|-------|----------------------------|------------------------------|-------|---------------------------|
| Leader Members | French Group | | | Japanese Group | | |
| | Name | Title | Lab./Organis. ² | Name | Title | Lab/Organis. ³ |
| | <u>Leader:</u> Yves Schutz | DR1 | IPHC | <u>Leader:</u> Tatsuya Chujo | Dr | U. Tsukuba |
| | <u>Deputy leader:</u> Christophe Furget | Pr | LPSC | Yasuo Miake | Pr | U. Tsukuba |
| | Gustavo Conesa Balbastre | CR2 | LPSC | ShinIchi Esumi | Dr | U. Tsukuba |
| | Renaud Vernet | IR | CCIN2P3 | Oliver Busch | Dr | U. Tsukuba |
| | Alexander Shabetai | CR1 | SUBATECH | Toru Sugitate | Pr | U. Hiroshima |
| | Marie Germain | CR1 | SUBATECH | Kenta Shigaki | Pr | U. Hiroshima |
| | Rachid Guernane | CR1 | LPSC | Hideki Hamagaki | Pr | U. Tokyo |
| | Julien Faivre | MC | LPSC | Taku Gunji | Dr | U. Tokyo |
| | Gines Martinez | DR2 | SUBATECH | Yosuke Watanabe | Dr | U. Tokyo |
| | | | | Motoi Inaba | Pr | U. Tsukuba Tech. |
| | | | | Ken Oyama | Pr | NiAS |
| | | | | | | |

HAD_01: Funding request (2015-2016)

| France | | | | |
|-------------------------------|---------|---------------------------|------------|-----------------------------|
| Funding Request from France | | | | |
| Description | €/unit | Nb of units | Total (€) | Requested to ⁴ : |
| Visit to Japan (Travels) | 1200 | 4 travels | 4800 | |
| Stay in Japan (local expense) | 90/day | 40 days | 3600 | |
| Stay in France | 90/day | 20 days | 1800 | |
| Total | | | 10200 | |
| Japan | | | | |
| Funding Request from KEK | | | | |
| Description | k¥/Unit | Nb of units | Total (k¥) | Requested to: |
| Travels (students) | 150 | 4 travels (Round trip) | 600 | KEK |
| Stay in France (students) | 10/day | 60 days | 600 | KEK |
| Total | | | 1,200 | |

* Requested same amount as last year for the travel support in France and Japan, most for the students and young researchers.

Summary

✓ 2015:

- Successful first ALICE DCal data taking with L1, developed by FJPPL
- Started double degree PhD program between Grenoble - Tsukuba, two students enrolled.
- Presented jet results (Run-1) developed by FJPPL at QM2015
- Held “ALICE Calo meeting in Osaka (2015)” within FJPPL
- New “AAF analysis team” formed by FJPPL, FCPPL, work on Run-2 data.
- D. Watanabe obtained Ph.D (2016, March, Tsukuba U.)
- Two master students in Tsukuba have been supported by “TYL-FJPPL Student or Early Stage Researcher Secondment”). **Thank you!**

✓ 2016:

- Continue 2015 activities:
 - **Data analysis (Run-2 jet and photon results) → physics outputs & publications (by FJPPL, AAF)**
 - Double degree program, EMCal/DCal and L1 trigger

Thank you for the continuous and strong support by TYL/FJPPL !