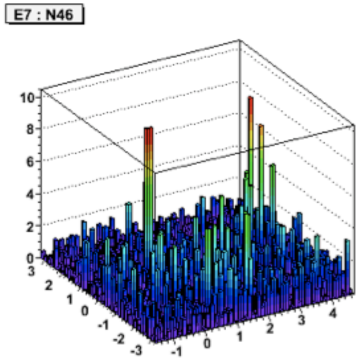
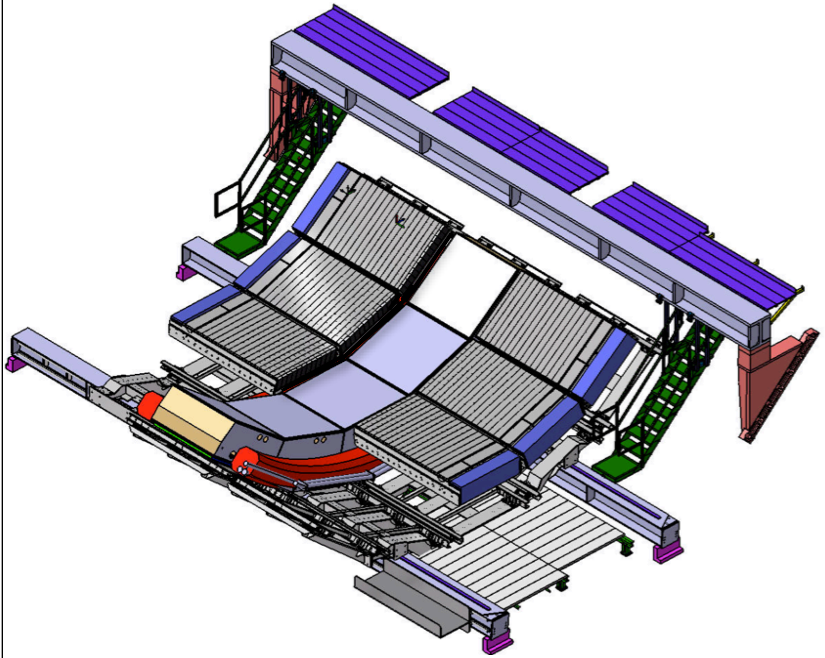
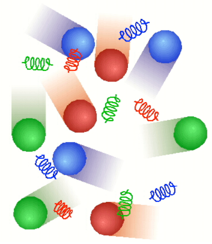
Exploitation of hard EM probes and Jets to study the QGP with LHC-ALICE





Yasuo MIAKE
Univ. of Tsukuba

Outline

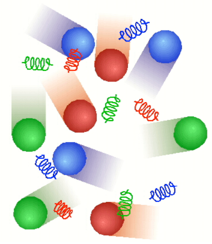


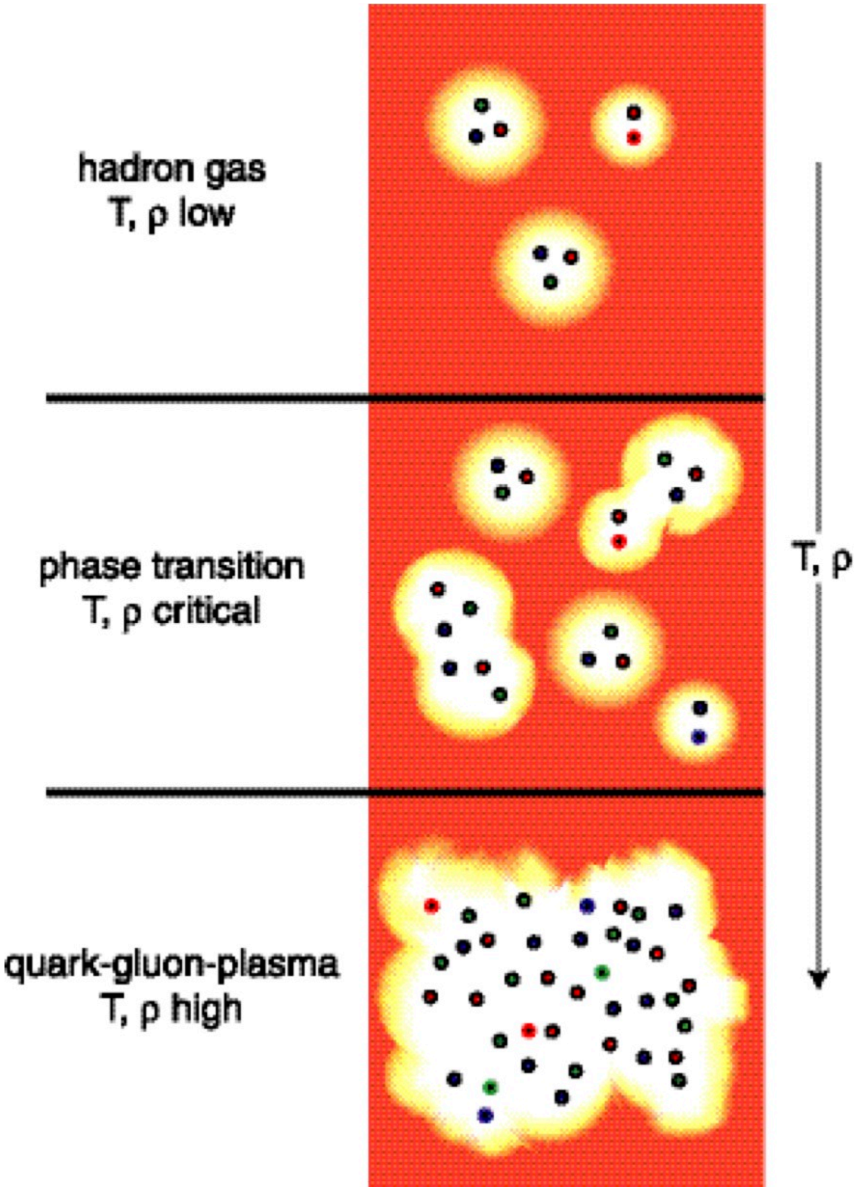
- QGP
  - what we learned at RHIC and homework for LHC
- Jet quench
  - Jets/hard EM
  - property of QGP
- DiJet Calorimeter
  - design, rates, schedule
  - Japan-French collaboration
- Analysis Mechanism
- Summary

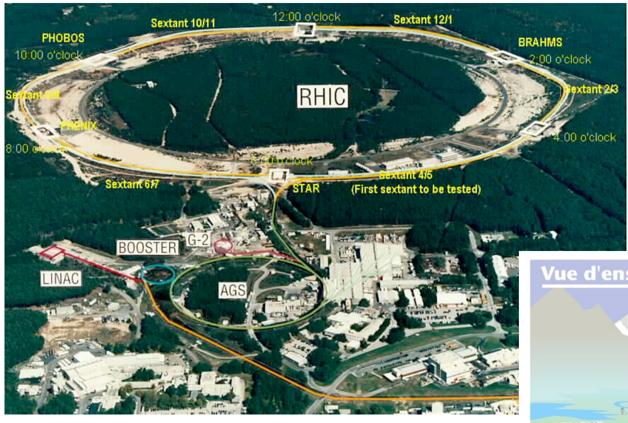
New proposal in FJPPL2010

in this talk, focus on Jet Quench

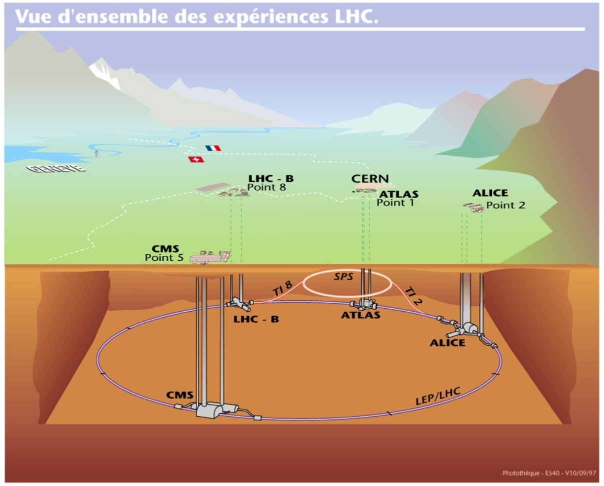
Quark-Gluon Plasma







RHIC(200GeV)
since 2000



LHC(5.6TeV)
soon

- ✓Physics of QCD in extreme T, ρ and small x
- ✓Nucleus-Nucleus collisions

What we learned at RHIC

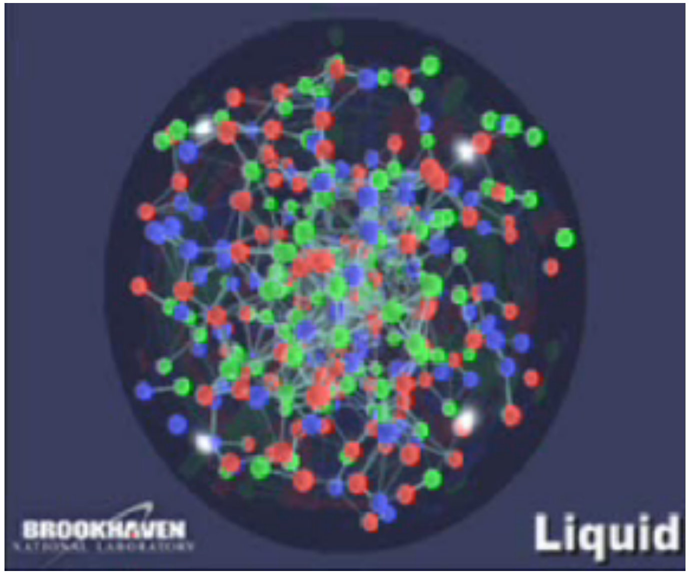
$$\epsilon_{\mathrm{QGP}} \sim 2\ [\mathrm{GeV/fm^3}]$$

$$< n_{q,\bar{q}} > \sim \frac{\epsilon_{\mathrm{QGP}}}{< m_T >} \sim \frac{2\mathrm{GeV}}{0.4\mathrm{GeV}} \sim 5$$

$$\lambda_q = \frac{1}{n\sigma_{qq}}$$

$$\sim \frac{1}{5 \times 0.4} = 0.5\ [\mathrm{fm}]$$

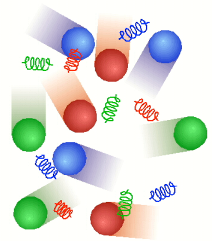
$$\lambda_q \ll R_{\mathrm{system}}$$



- **Strongly interacting QGP**
- **Statistical nature & space/time evolution of collisions well established**
  - ➡**Hadro-chemical equilibrium (T, μ)**
  - ➡**Kinematical equilibrium (T, β)**
  - ➡**Universal pt&azimuthal distributions of quarks (Quark coalescence model)**

Soft physics well understood (I think)

Good textbook on QGP!



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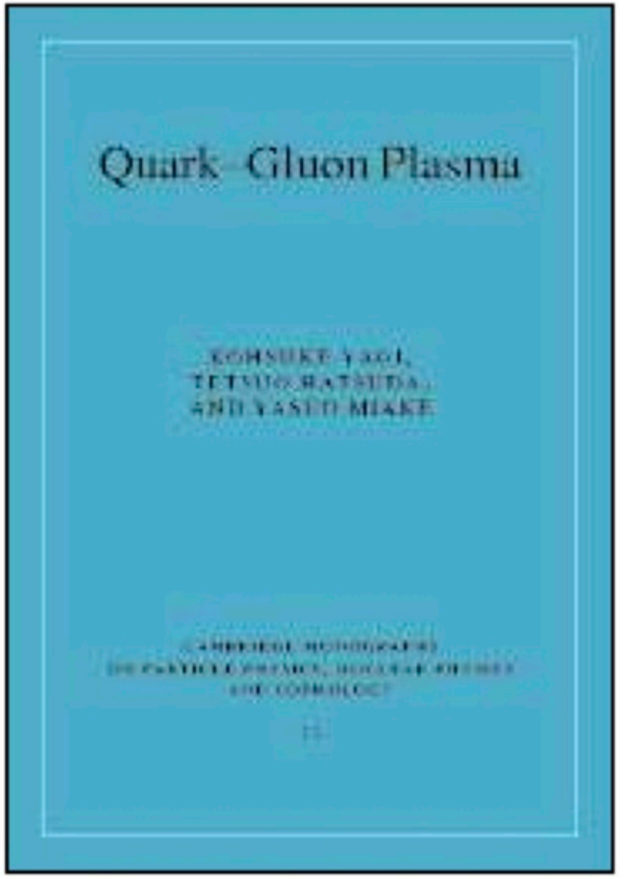

Quark-Gluon Plasma

Series: Cambridge Monographs on Particle Physics, Nucl

Kohsuke Yagi
Urawa University, Japan

Tetsuo Hatsuda
University of Tokyo

Yasuo Miake
University of Tsukuba, Japan

Hardback (ISBN-10: 0521561086 | ISBN-13: 97805215610

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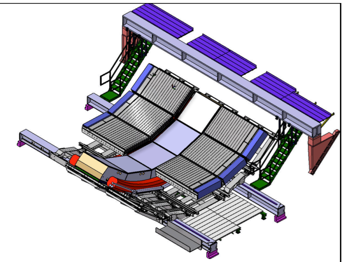
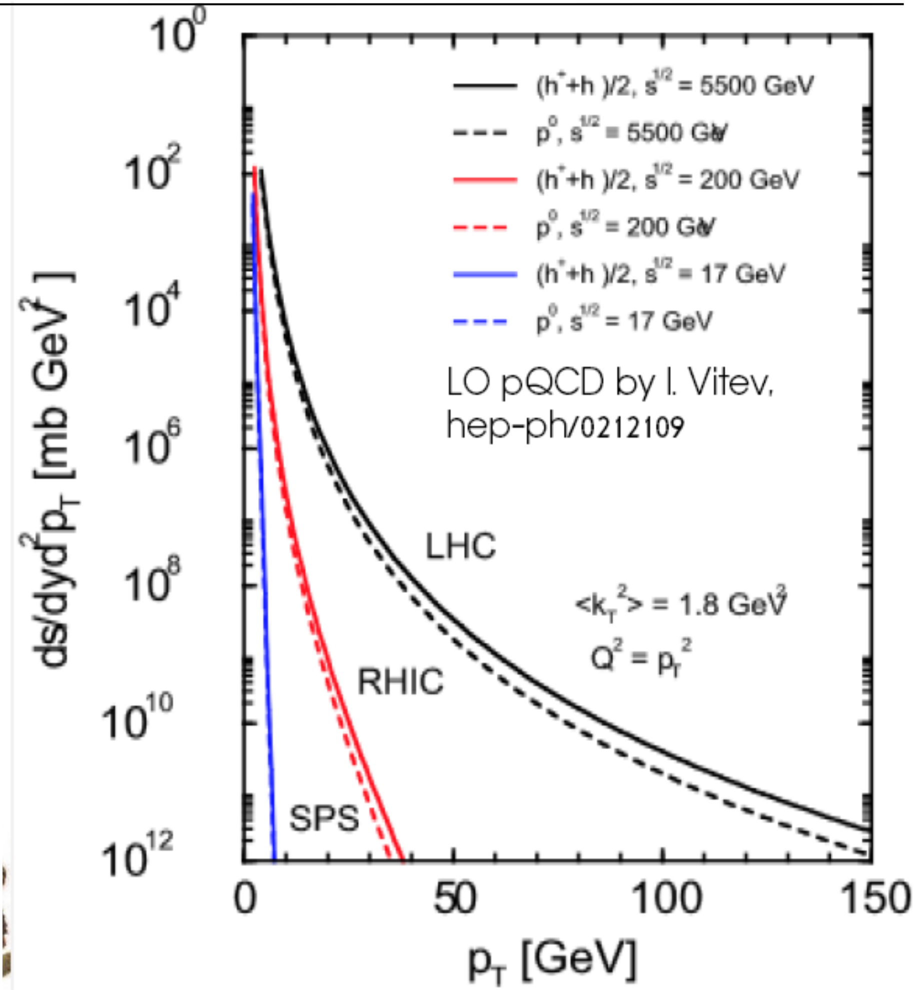
RHIC vs LHC



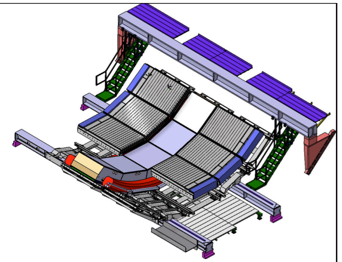
	RHIC	LHC
$\sqrt{s_{NN}}$ (GeV)	200	5500
T/T_c	1.9	3.0-4.2
ε (GeV/fm^3)	5	15-60
τ_{QGP} (fm/c)	2-4	>10

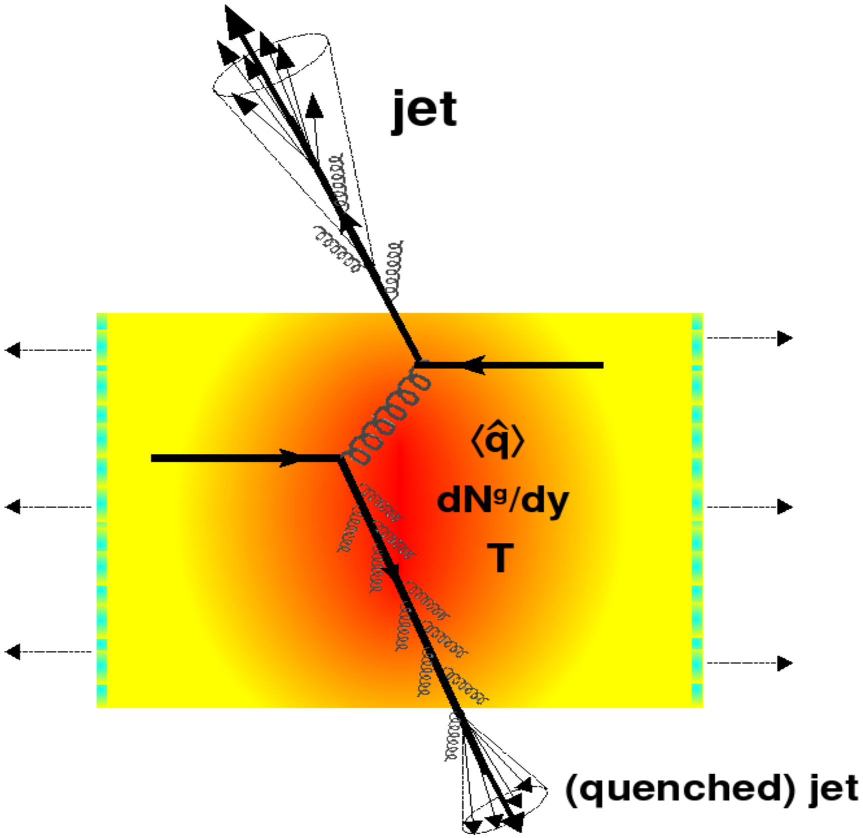


✓ **Home work to the LHC, physics of jet quench**

➡ **LHC has superior advantage in hard probes**

"Jet Quench"





"Jet quenching" in nucleus-nucleus collision.

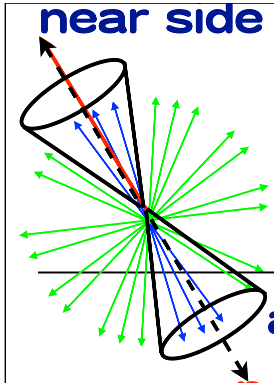
✓Two quarks suffer a hard scattering in AA collision

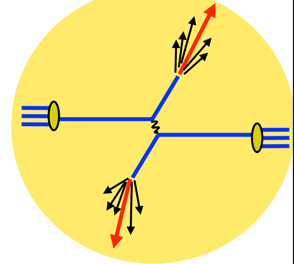
- One goes out to vacuum creating jet,
- but the other goes through the QGP suffering energy loss due to gluon

✓Manifestation:

- attenuation/ disappearance of jet
- suppression of high pt hadrons
- modification of jet frag.

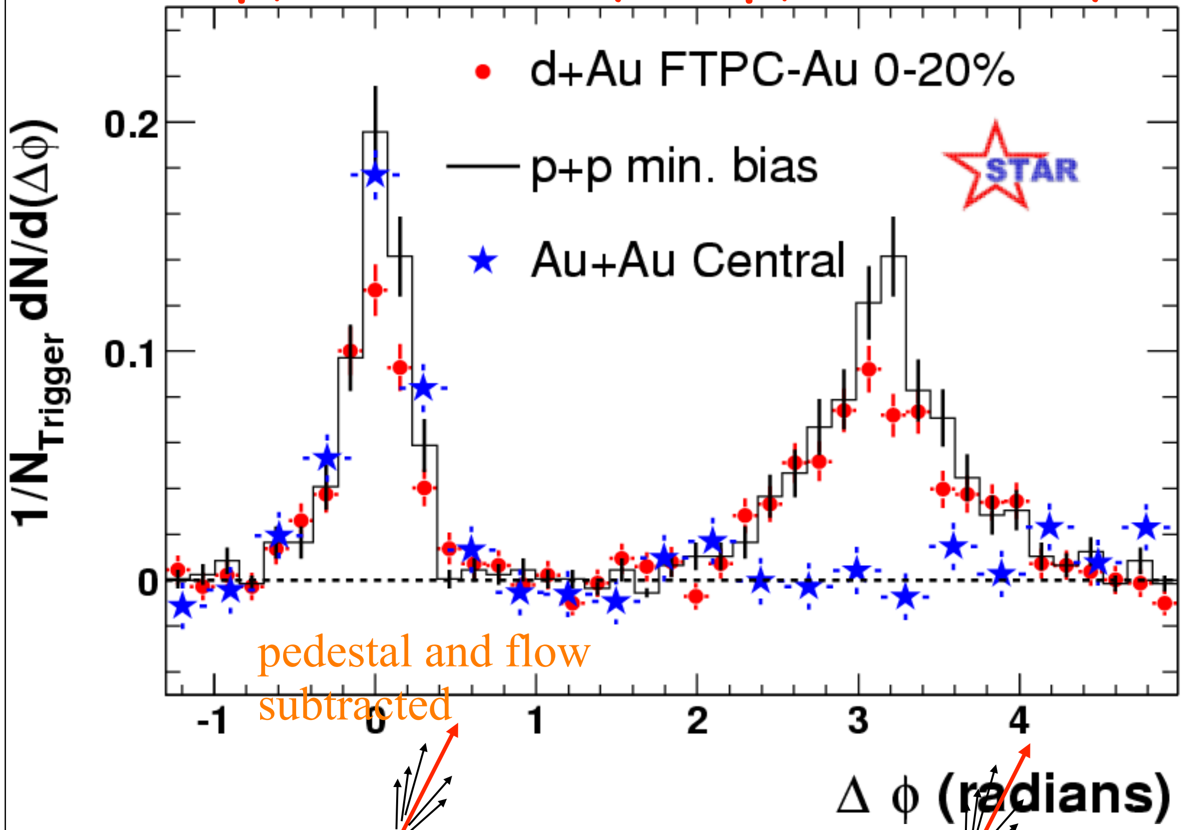
Modification of back-to-back corr.

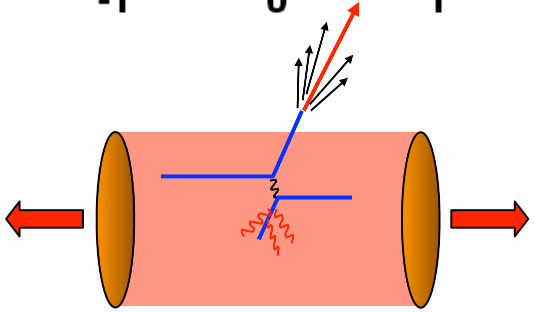


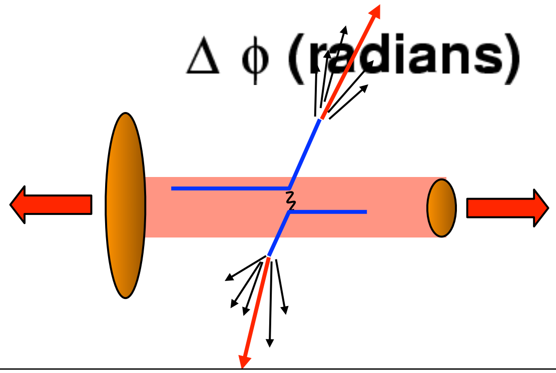


Star; P.R.L. 91, 72304 (2003)

p_T^{trig} = 4~6 GeV/c × p_T^{assoc} > 2 GeV/c

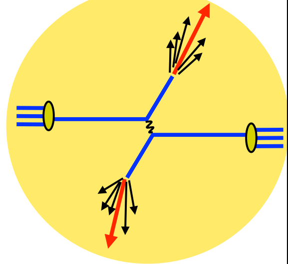






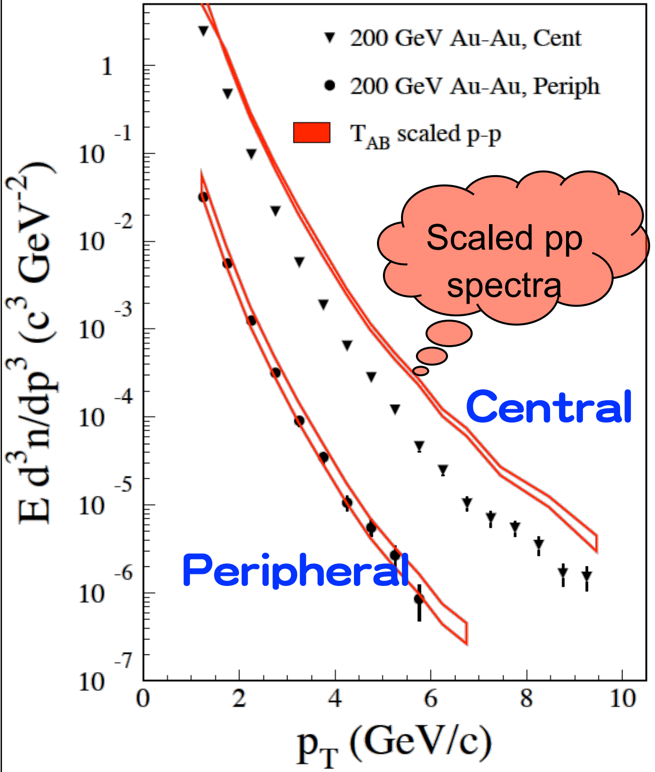
- ✓ Direct evidence of loss of 'jet'
- ✓ Azimuthal correlation w.r.t. high pt leading particle (trigger).
  - pp ; clean di-jet
  - dAu; similar to pp
  - Au+Au; Similar on the same side (suggesting jet-like mechanism), but b-to-b disappeared
    - Effect is not in initial but in final stage
    - Energy loss of partons in dense matter created in Au+Au

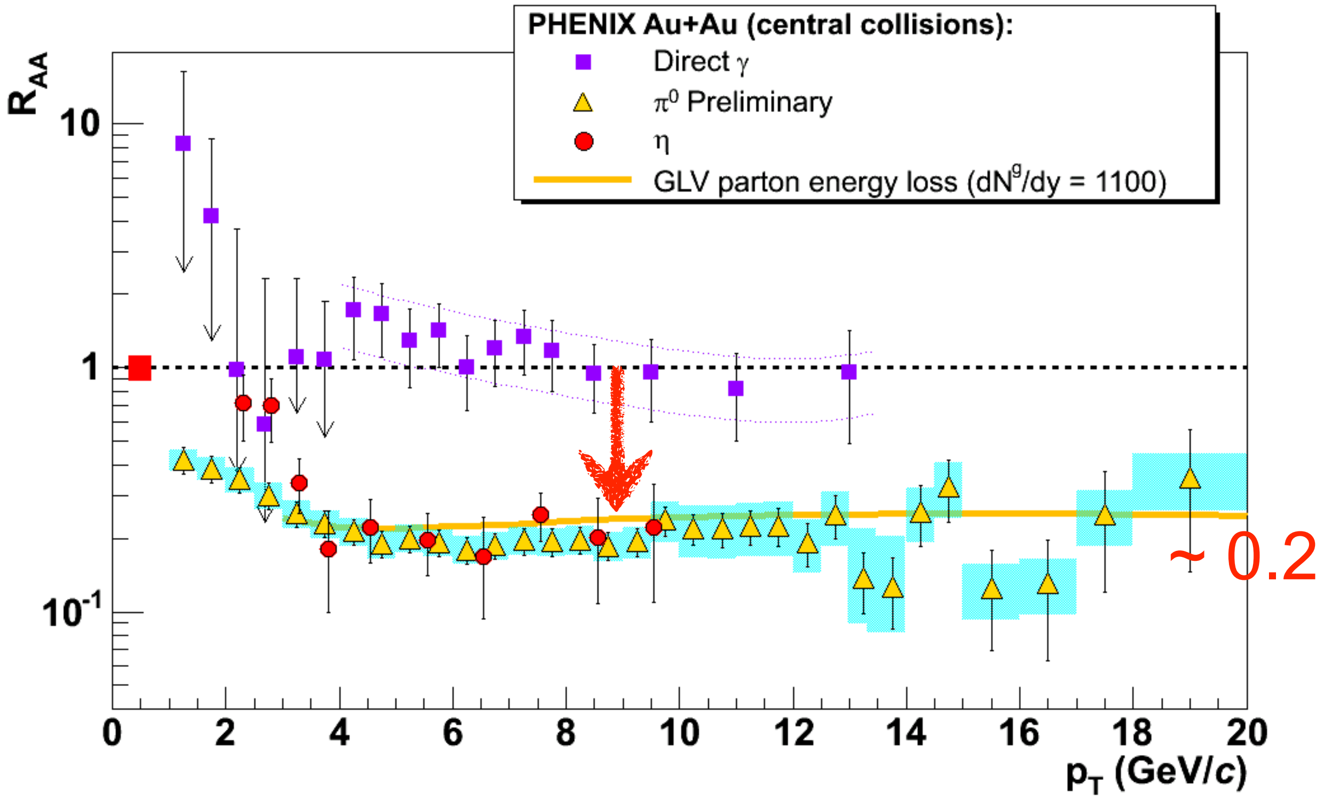
Suppression of high p_t particles



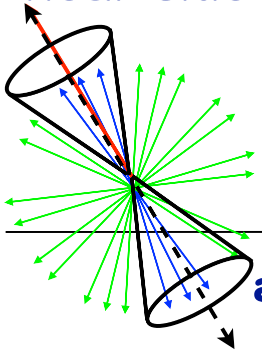
Nuclear Modification Factor

$$R_{AA} = \frac{\text{"hot/dense QCDmedium"}}{\text{"QCD vacuum"}} = \frac{dn_{AA}/dp_T dy}{\langle N_{binary} \rangle \cdot dn_{pp}/dp_T dy}$$

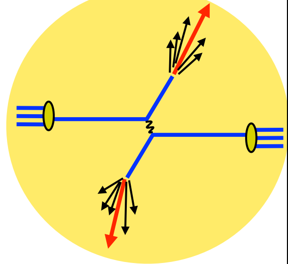




✓ **Pions are suppressed, direct photons are not**

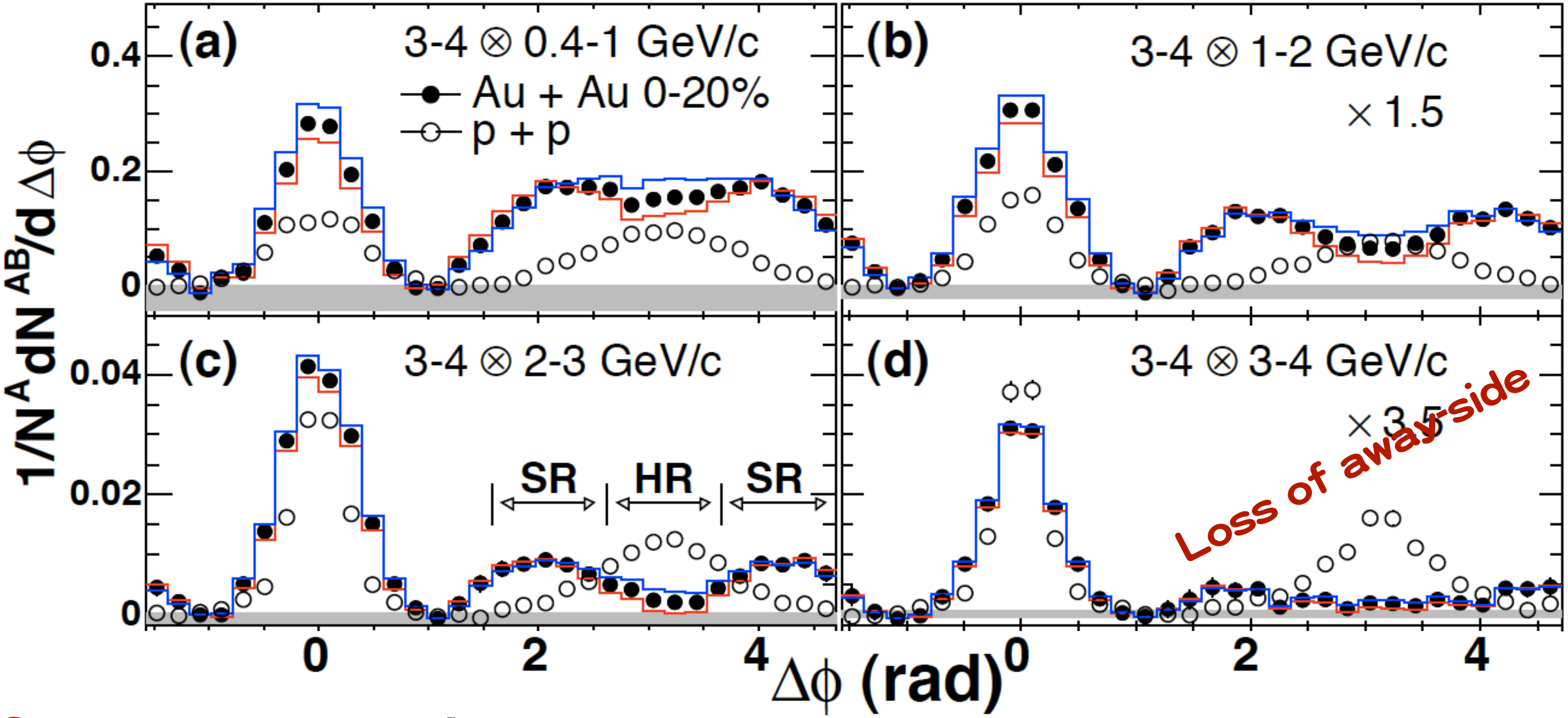


Change of shape in the away-side



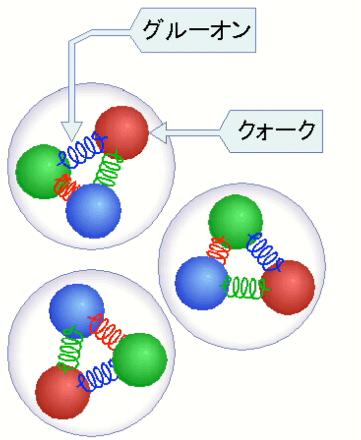
p_T^{trig} = 3~4 GeV/c × p_T^{assoc}

PHENIX, arXiv:0705.3238 [nucl-ex]

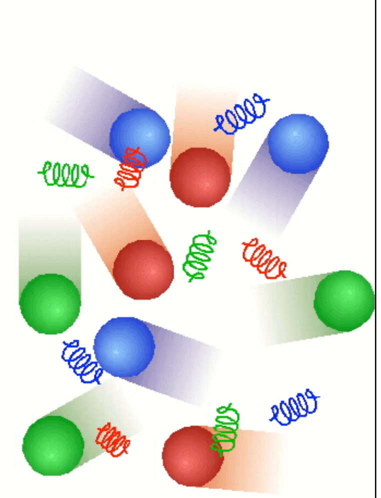


✓From broad/none to distinct two shoulders at $\Delta\Phi = \pi \pm 1$ with decreasing momentum

- Discussed in terms of Mach Cone, Cherenkov Em.



Why the jet quench is important?

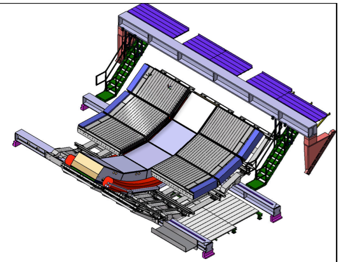


Characteristic Energy Loss in dense matter

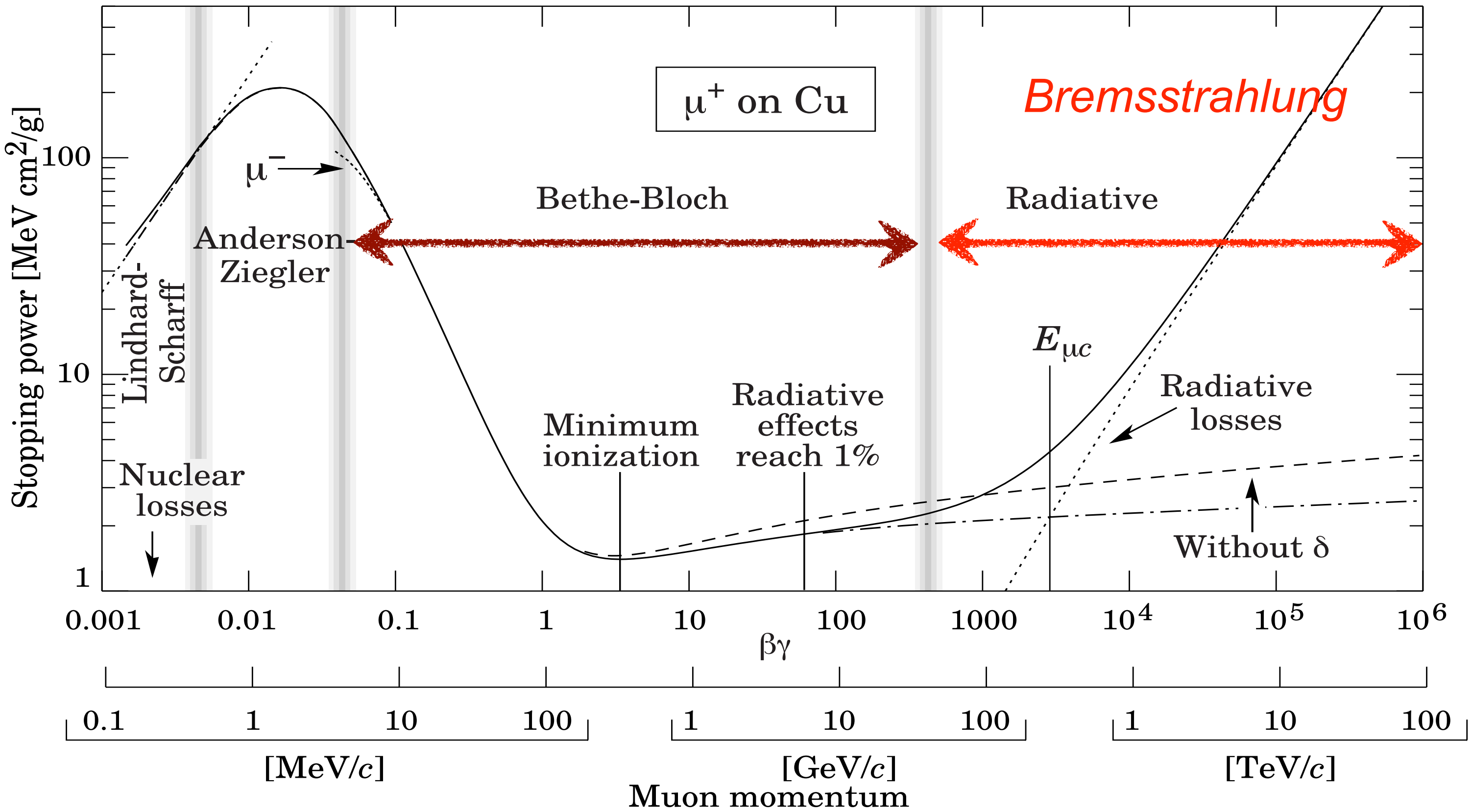
↓

the property of the matter

Energy loss in QED



Energy loss of charged particle in a matter



Collisional

- √Bethe-Bloch

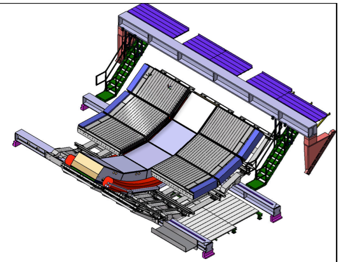
Radiative

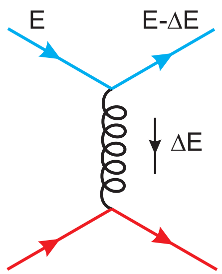
- √Bethe-Heitler (thin; L<<λ)
- √Landau-Pomeranchuk-Migdal (thick; L>>λ)

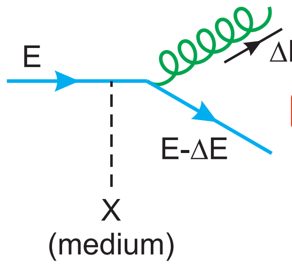
√Measurements of dE/dx gives prop. of matter

- **Energy loss in QED plasma gives T & m_D info.**

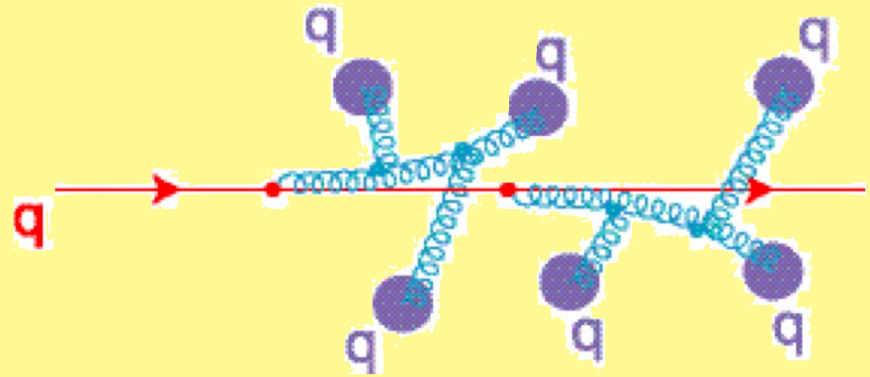
Energy Loss in QCD







✓ **Many theories on**
- **Collisional loss**
- **Radiative loss**
  - ➡ Bethe-Heitler regime
  - ➡ LPM regime
  - ➡ "dead-cone" effect



$$\Delta E \propto \alpha_S C_R \langle \hat{q} \rangle L^2$$

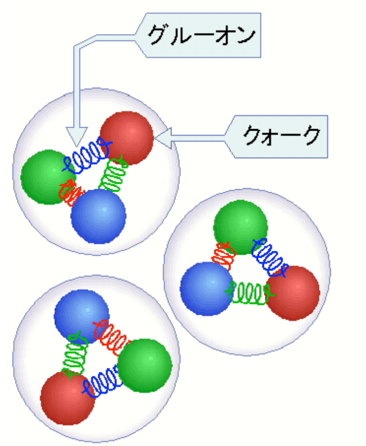
(Executive) Summary

Radiative loss is dominant

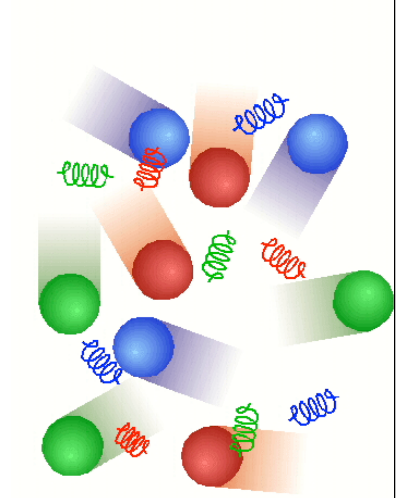
Effects are;

- suppression of high pt hadron
- unbalanced back-to back
- modification of jet fragmentation
  softer, larger multiplicity,
  angular broadening

$$\Delta E_{\mathrm{gluon}} > \Delta E_{\mathrm{quark}} > \Delta E_{\mathrm{charm}} > \Delta E_{\mathrm{bottom}}$$



How we study Jet quench at LHC



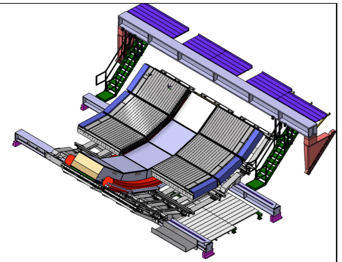
Meas. of high pt suppression/

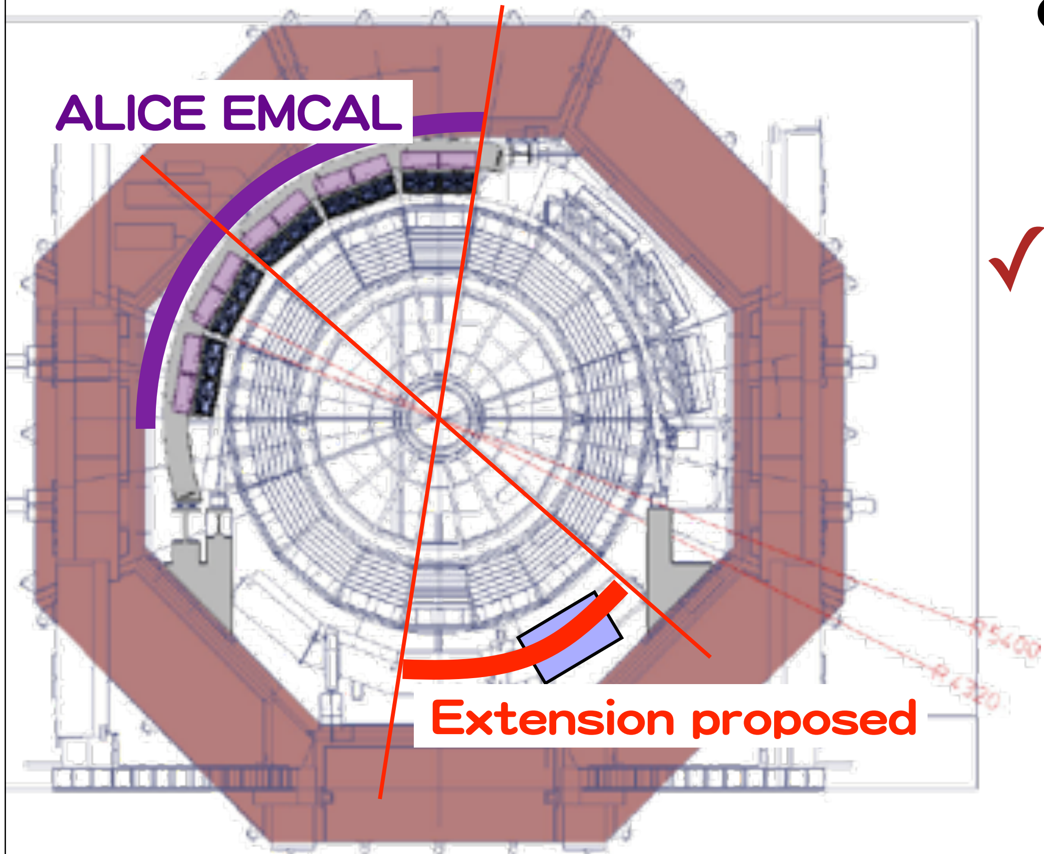
Hadron corr.

↓

Full back-to back jet analysis of higher energy jets

DCal as an extension of EM-Cal

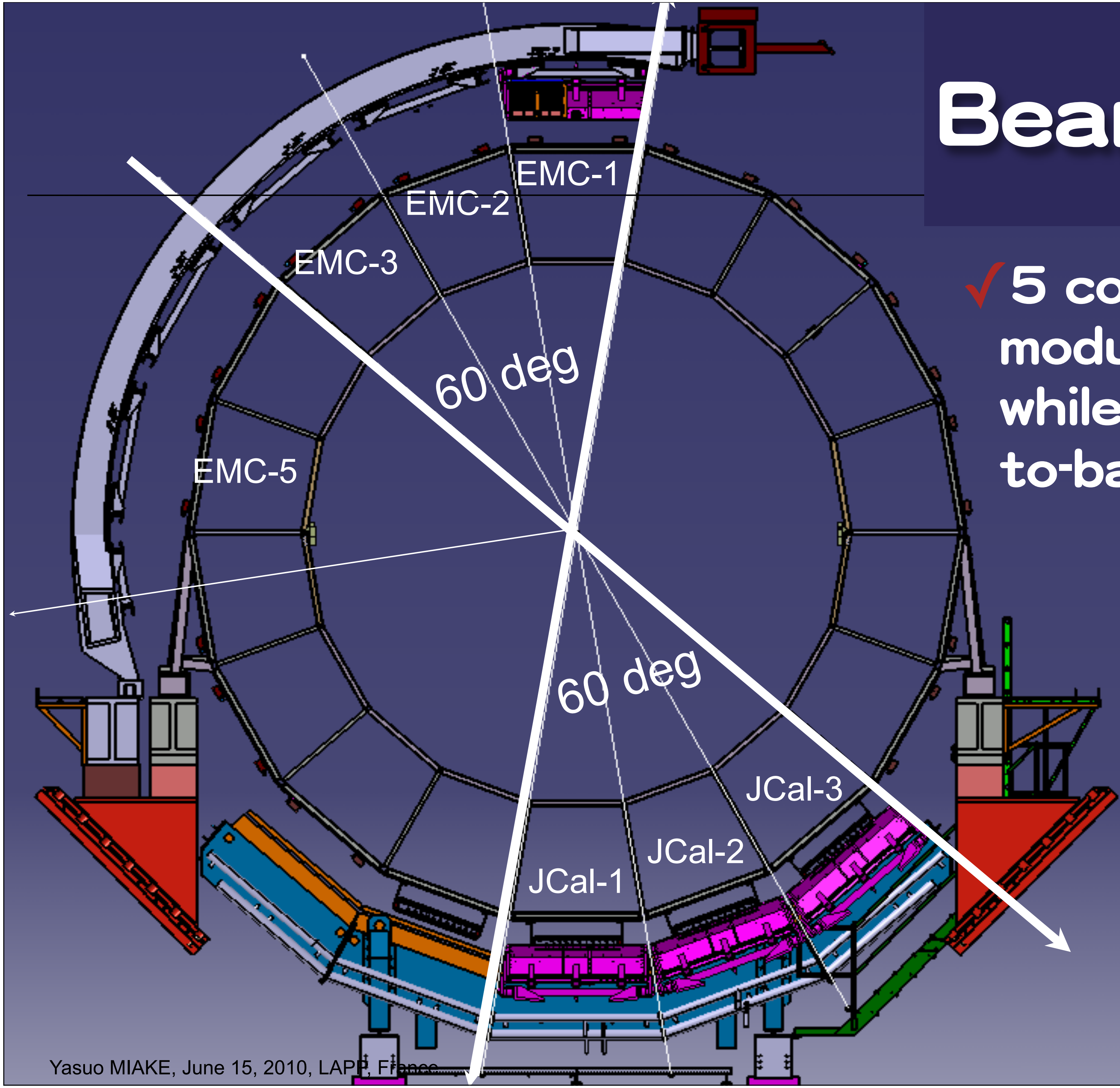




DiJet Calorimeter

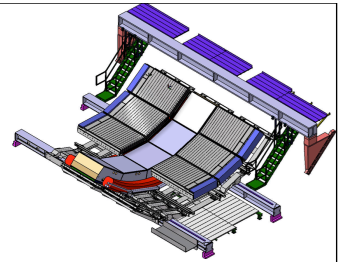
- For better performance of back-to back capability
  - ➡Define back-to back jets
  - ➡Trigger back-to back jets
- Progress
  - Proposed in Feb.,09
  - Discussed w. IN2P3 in May, 09
  - Discussed in March,09
  - Proposal in May, 09
  - Partial approval in July, 09
  - Full approval by ALICE in Oct. 09
- Construction started !

Beam View

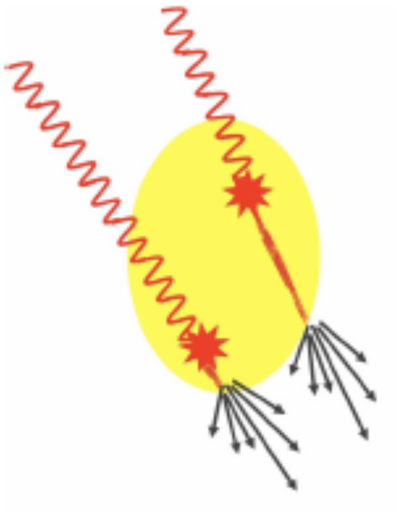


- ✓ 5 contiguous modules possible, while exact back-to-back is 3

Probes for the study

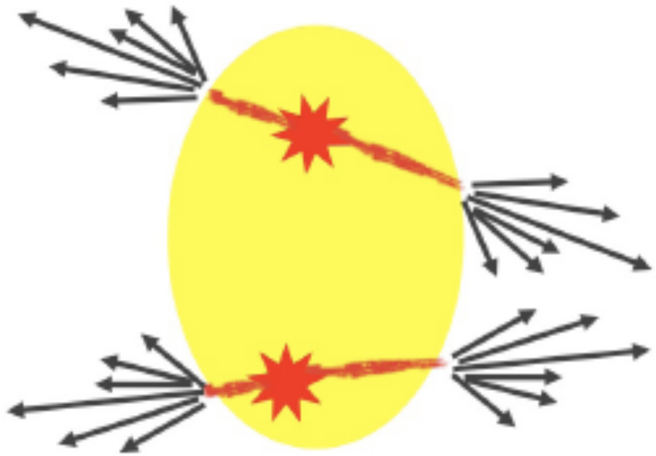


γ-Jet



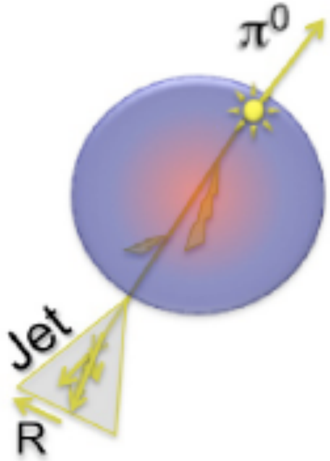
- ✓**Quark Jet**
- ✓Small Xsection
- ✓Experimentally challenging

Di-jet



- ✓Mostly **Gluon Jet**
- ✓Larger Xsection
- ✓Interpretation is complicated

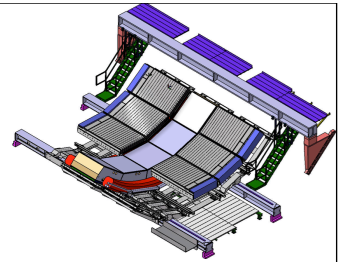
π^0-Jet

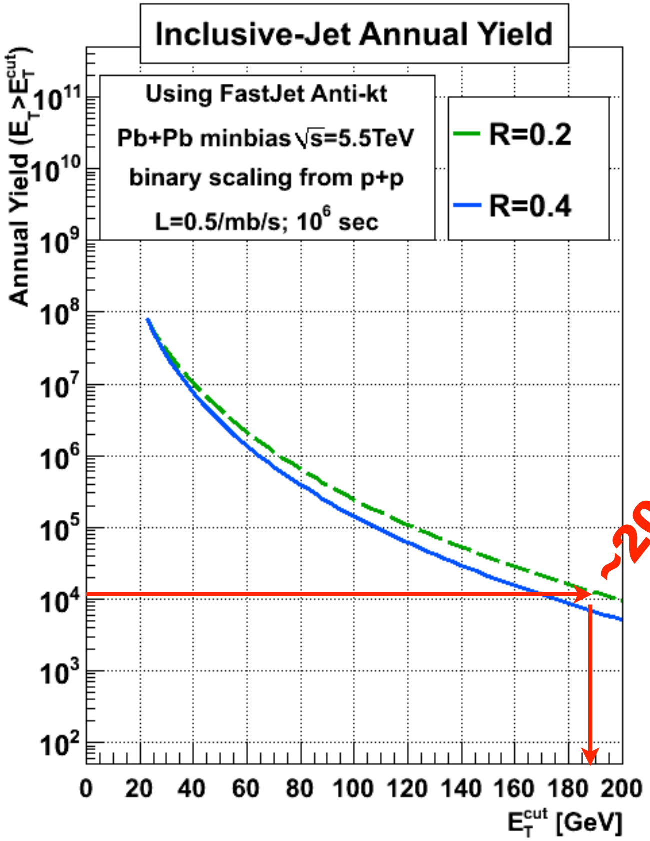


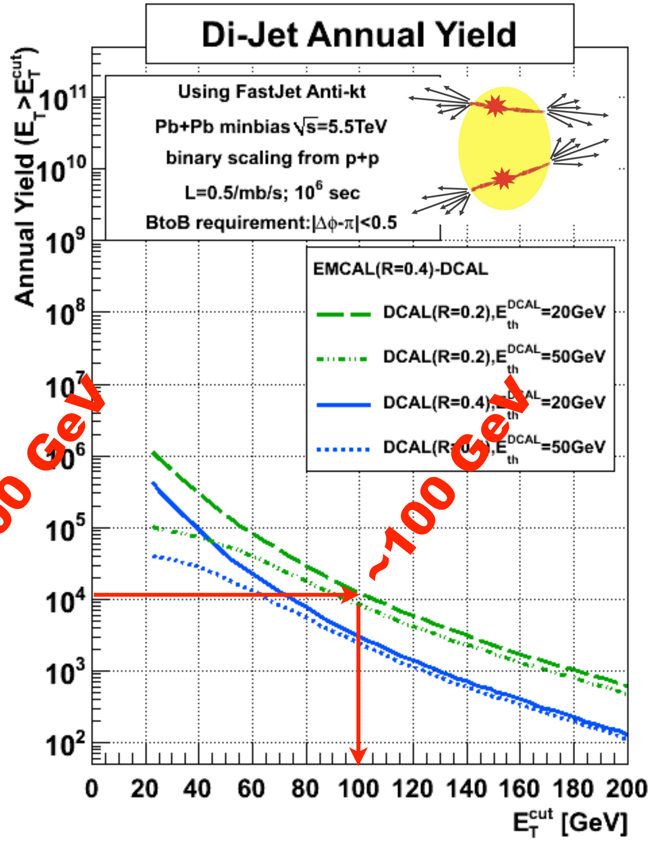
- ✓Clean π^0 trig
- ✓Large Xsection
- ✓Important for DCal

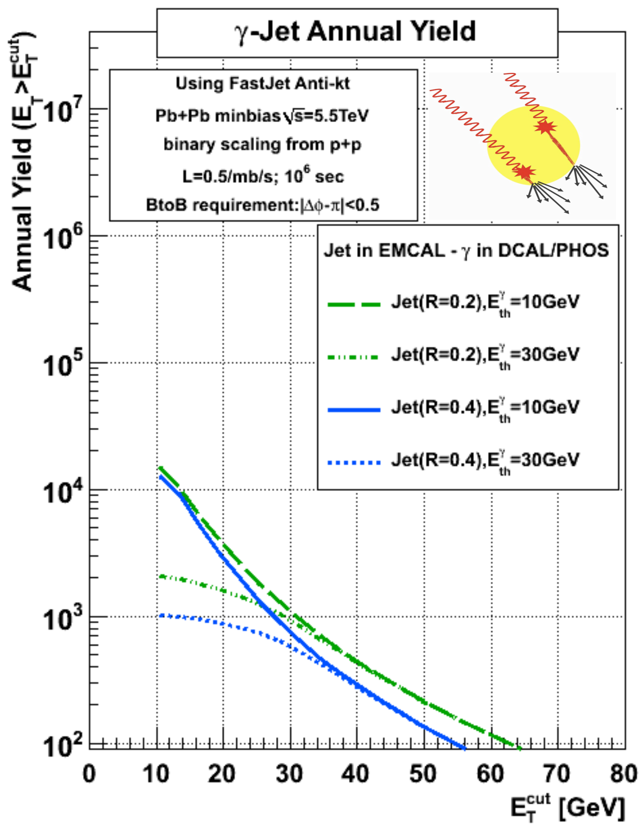
Systematic meas. of these processes for model comparison provides at high precision level.

What we expect; Reach of Jet Energy





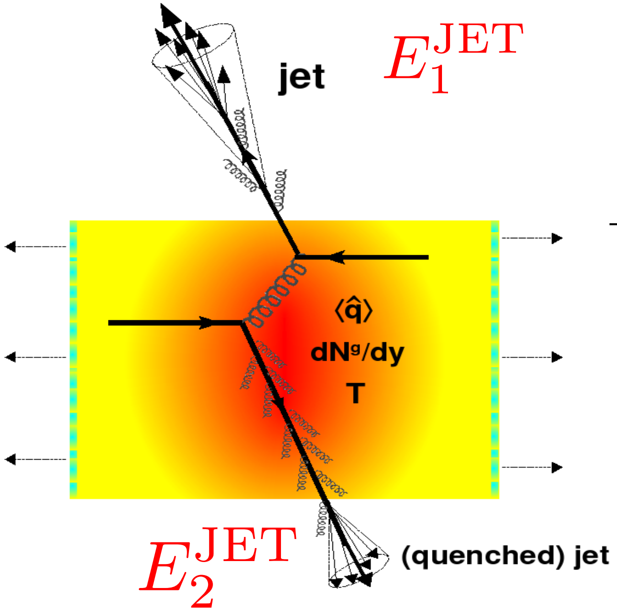


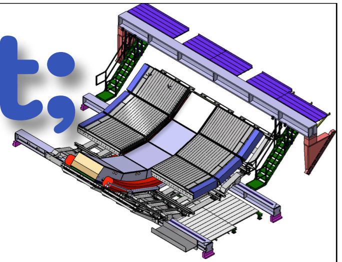


✓ For 10^4 events/year in Pb+Pb@5.5TeV,

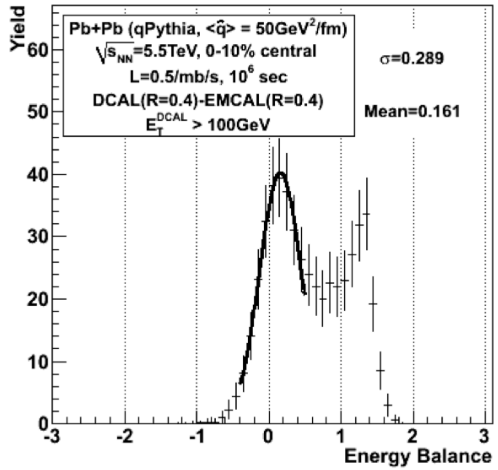
- Inclusive jet up to 200 GeV
- Di-Jet to 100 GeV

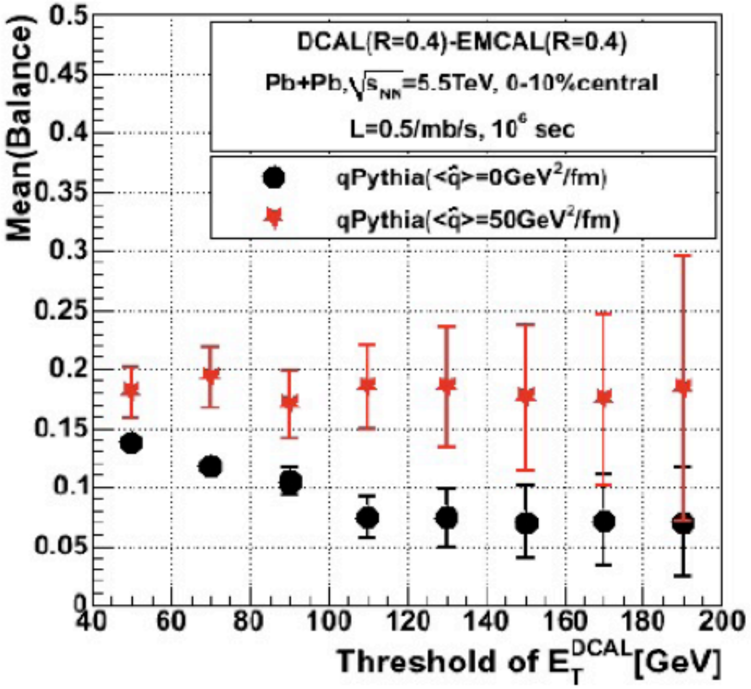
What we expect; sensitivity

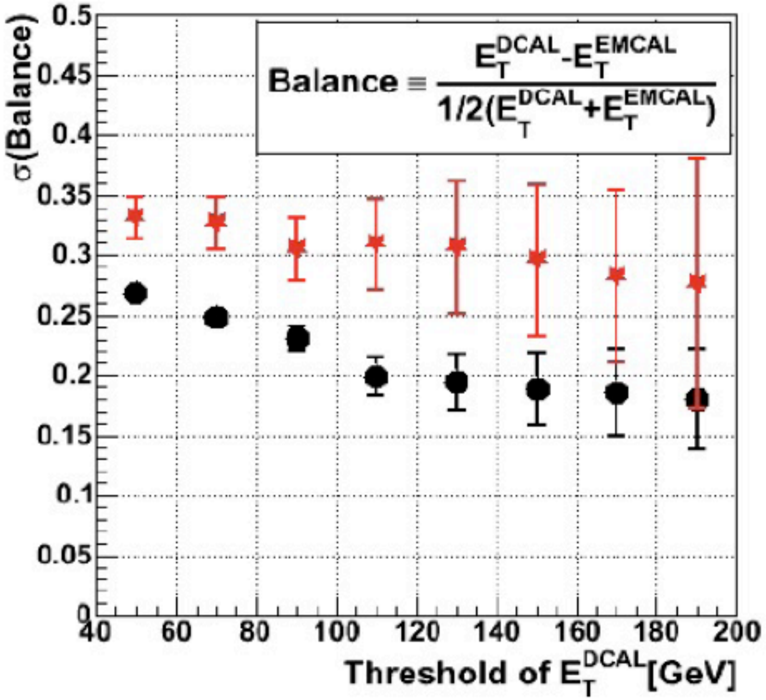




$$\mathrm{Balance} \equiv \frac{E_1^{\mathrm{JET}} - E_2^{\mathrm{JET}}}{1/2(E_1^{\mathrm{JET}} + E_2^{\mathrm{JET}})}$$

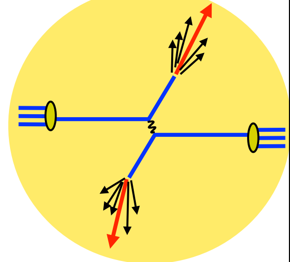


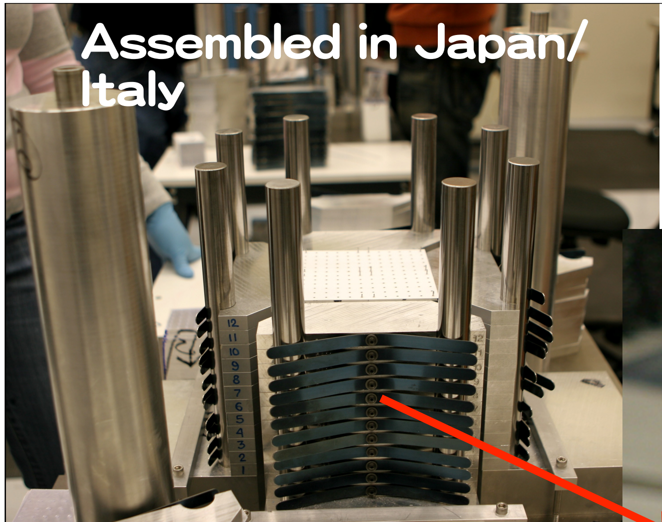


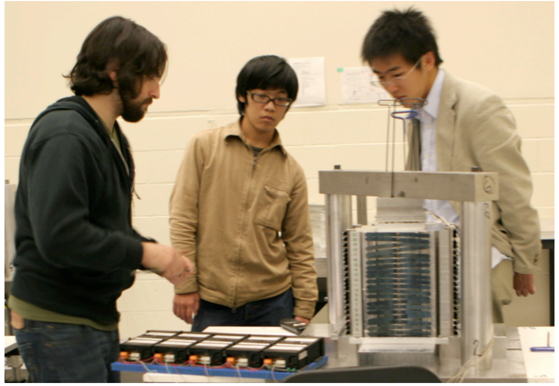


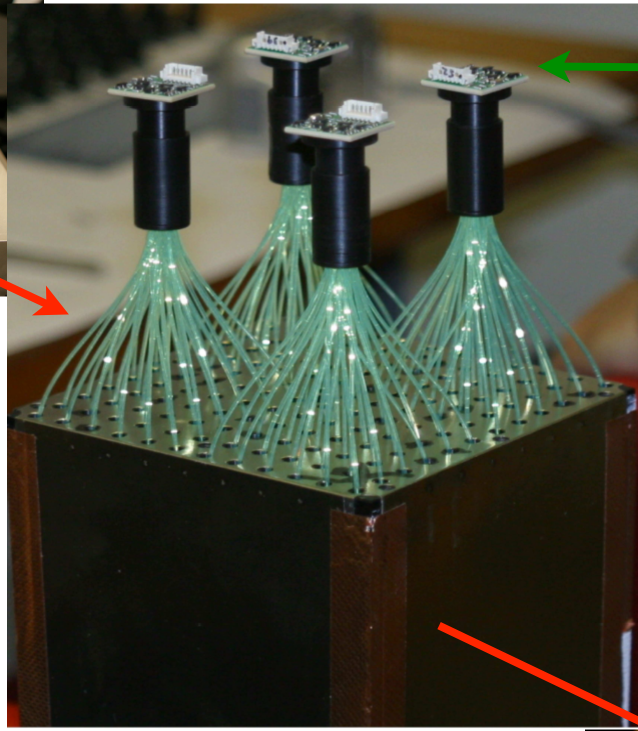
✓ Sensitivity in data of 1 year

DCal assembly



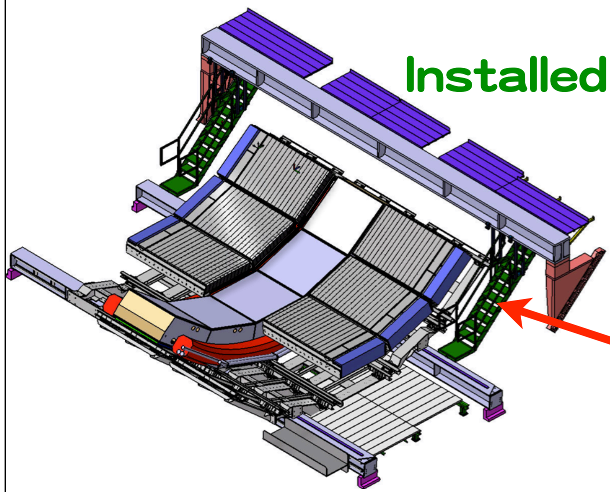




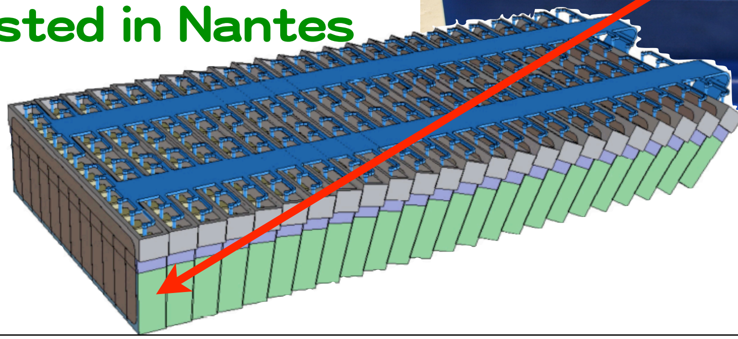


APD tested in Italy

Installed at CERN



Tested in Nantes



France-Japan collaboration for ALICE-DCal

Institute & People

LPSC Grenoble
- Christophe Furget
- Jean-François Muraz

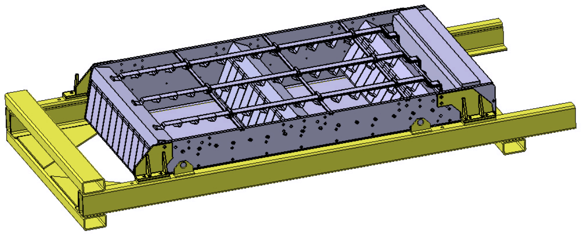
Subatech Nantes
- Manoel Dialinas

IPHC Strasbourg
- Christelle Roy

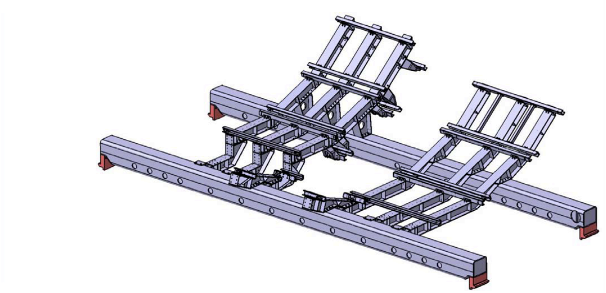
Contributions to DCal

LPCS Grenoble:
-DCal module straps
-DCal supper module (SM) cables
-DCal platform, shipping boxes
-DCal SM assembly

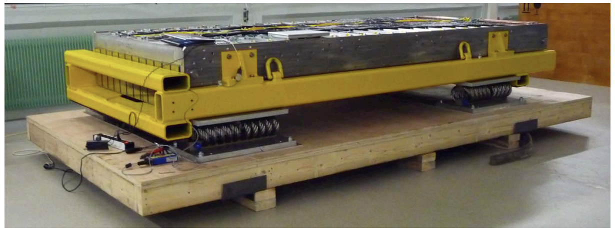
Subatech Nantes:
•DCal SM installation tool, support structure, integration
•DCal strip module production, DCal strong back



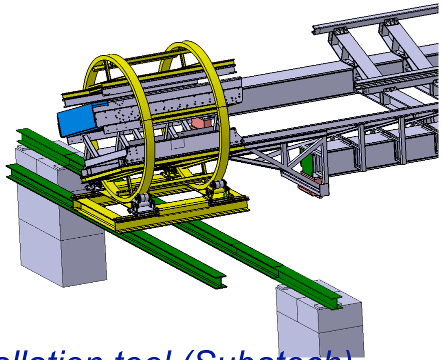
DCal SM platform (LPSC)



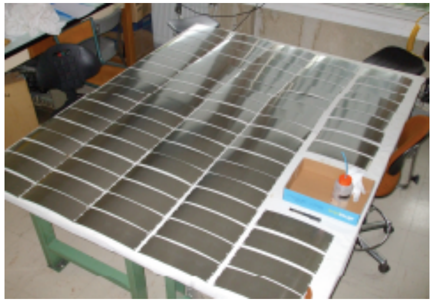
DCal support structure (Subatech)



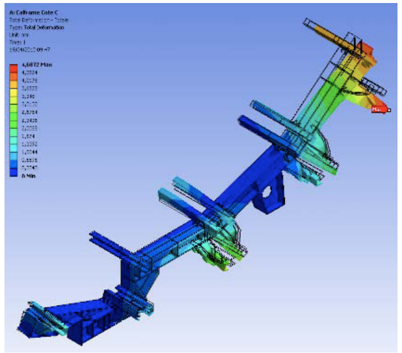
DCal SM shipping crate (LPSC)



DCal installation tool (Subatech)



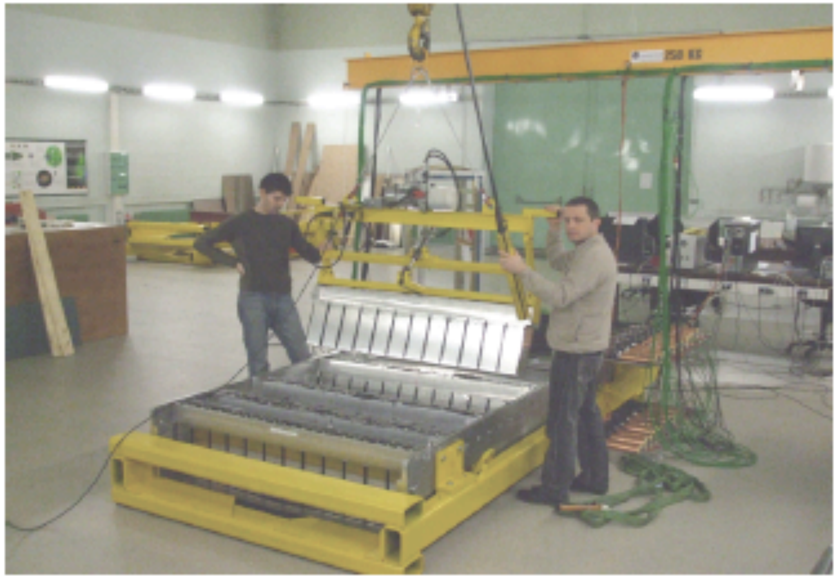
DCal straps (LPSC)



DCal weight cal. (Subatech)


LPSC Grenoble (July, 2009)
Christophe Furget
Jean-François Muraz
MATTER
MATIÈRE
FRAGILE

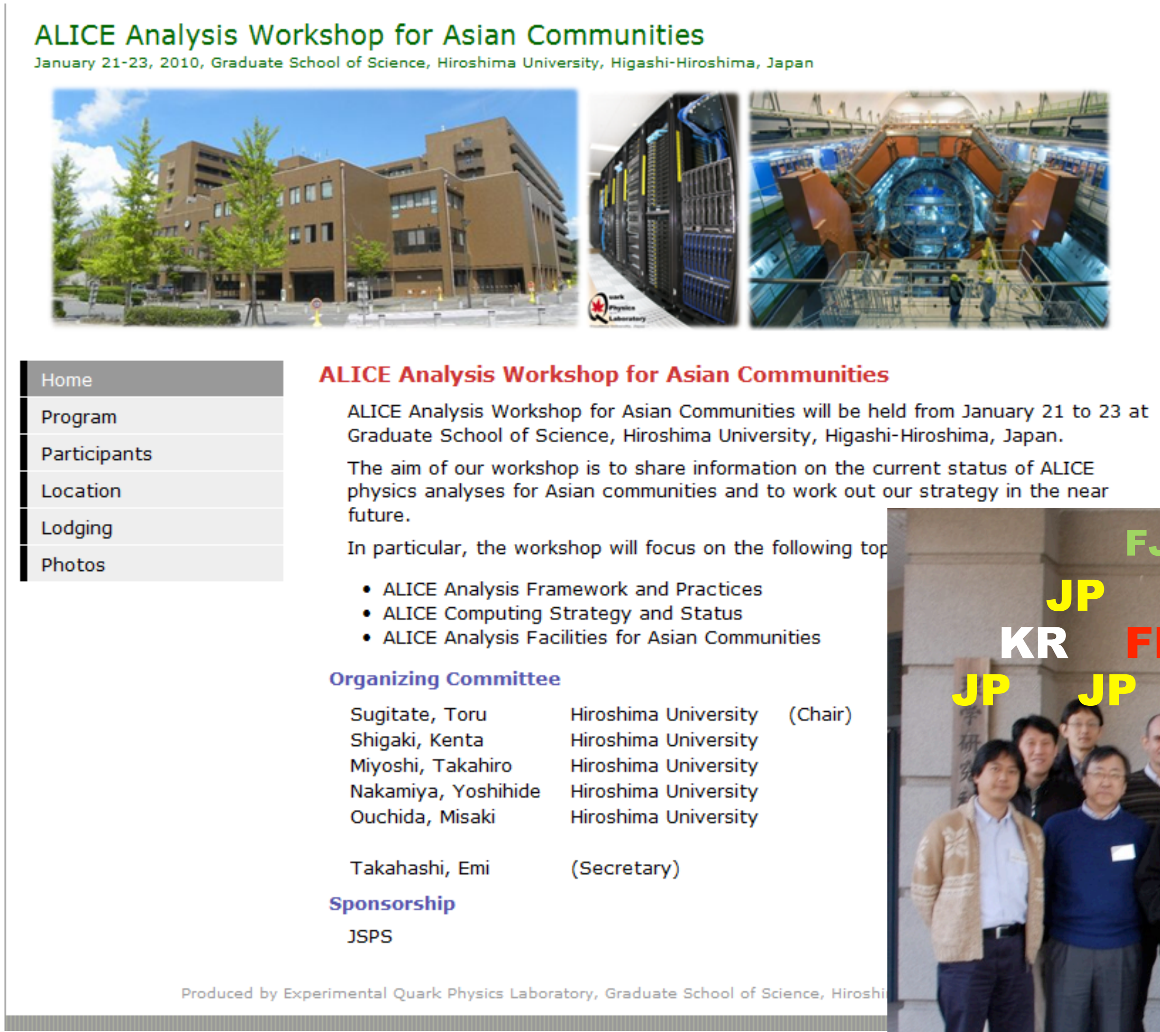
Assembly, cabling, calibration, storage and shipping of all DCal SModules.



Responsibilities

Group	Group Leader	Proposed Responsibilities
USA	T.J. Symons, LBNL	3 super modules Detector design Overall project management Project technical coordination DCal LED system
Japan	Y. Miake, Tsukuba	1.5 super module
France	C. Roy, IPHC Strasbourg	0.5 super modules Support structure design, fabrication Oversight and payment of up to 2/3 the cost Installation tooling design Installation oversight Jet trigger Design, hardware and integration SM integration and cosmic calibration
China	D. Zhou	1 super module
Italy	N. Bianchi	Module assembly Fiber production facilities

Japanese Analysis Facility discussed with French experts within Asian communities at Hiroshima in Jan. 2010


ALICE Analysis Workshop for Asian Communities
January 21-23, 2010, Graduate School of Science, Hiroshima University, Higashi-Hiroshima, Japan

- Home
- Program
- Participants
- Location
- Lodging
- Photos

ALICE Analysis Workshop for Asian Communities

ALICE Analysis Workshop for Asian Communities will be held from January 21 to 23 at Graduate School of Science, Hiroshima University, Higashi-Hiroshima, Japan.

The aim of our workshop is to share information on the current status of ALICE physics analyses for Asian communities and to work out our strategy in the near future.

In particular, the workshop will focus on the following top

- ALICE Analysis Framework and Practices
- ALICE Computing Strategy and Status
- ALICE Analysis Facilities for Asian Communities

Organizing Committee

Sugitate, Toru	Hiroshima University	(Chair)
Shigaki, Kenta	Hiroshima University	
Miyoshi, Takahiro	Hiroshima University	
Nakamiya, Yoshihide	Hiroshima University	
Ouchida, Misaki	Hiroshima University	
Takahashi, Emi	(Secretary)	

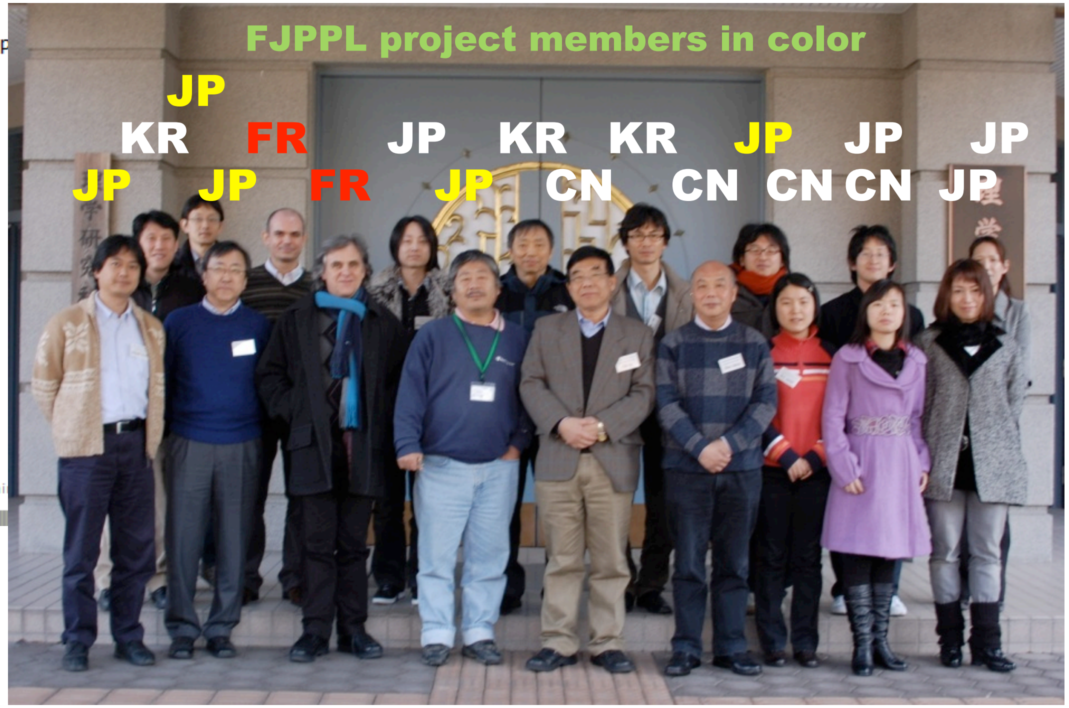
Sponsorship

JSPS

Produced by Experimental Quark Physics Laboratory, Graduate School of Science, Hiroshi

Remarks from the workshop;

- ◆ Active discussion started.
- ◆ FJPPL project members involved.
- ◆ Successful PROOF demo. carried out.
- ◆ Asian communities quite interested in.
- ◆ Task-force group formed.
- ◆ All activities are in scope of this project.



ALICE Tier-2 at Hiroshima

- The ALICE WLCG site "JP-HIROSHIMA-WLCG" with EGEE/gLite3.2 on SLC5;
- A full WLCG service up and running;
  VOBOX , LCG-CE, CREAM-CE, BDII, WMS/LB, XROOTD-SE, APEL, UI, etc..
- CPU and storage resources;
  752 Xeon-cores and 276 TB disk servers
  Currently ~2/3 of resources in local use
- Network B/W: MPLS 1Gbps to KEK on SINET3
- ALICE associated Tier-1 in CCIN2P3/Lyon
  37/50Mbps to CCIN2P3/Subatech
- Responsible by Prof. T. Sugitate/Deputy Leader

◆ Some more resources at Tsukuba and Tokyo.

Summary of Japanese Analysis Facility

- Infrastructure (CPU, storage, network) exists in Asian institutes, e.g., at Hiroshima and KISTI
- Software framework exists or under development in French institutes
- Closer collaboration between France/Japan turns out to
  - challenge fast data analyses and strengthen Asian communities
  - establish and spread new technologies, e.g., PROOF on GRID
  - innovate a global computing model at large distances
- Primary people involved and request
  - France: YS/SUBATECH, RV/CCIN2P3, ??
  - Japan: TS/Hiroshima, HH/Tokyo, ??/Tsukuba

Our requirements

EXPLOITATION OF HARD EM PROBES AND JETS TO STUDY THE QGP WITH LHC-ALICE

French Group			Japanese Group		
Name	Title	Affiliation	Name	Title	Affiliation
Leader: Yves Schutz	DR1	SUBATECH	Leader: Yasuo Miake	Prof.	Univ. of Tsukuba
Deputy leader Chistelle Roy	CR1	IPHC	ShinIchi Esumi	Prof.	Univ. of Tsukuba
Christophe Furget	Pr	LPSC	Tatsuya Chujo	Dr.	Univ. of Tsukuba
Renaud Vernet	Dr	CCIN2P3	Takuma Horaguchi	Dr.	Univ. of Tsukuba
Manoel Dialinas	IR1	SUBATECH	Deputy leader: Toru Sugitate	Prof.	Hiroshima University
Magali Estienne	CR1	SUBATECH	Kenta Shigaki	Prof.	Hiroshima University
Gustavo Conesa	Dr	LPSC	Hisayuki Torii	Dr.	Hiroshima University
Rachid Guernane	CR1	LPSC	Hideki Hamagaki	Prof.	Univ. of Tokyo
Julien Faivre	MC	LPSC	Takuma Gunji	Dr.	Univ. of Tokyo
Marco Bregant	Dr	SUBATECH			

Description				
Visit to Japan	€/unit	Nb of units	Total (€)	Requested to: [1]
Travels	150/day	20 days	3000	IN2P3
	1000	4 travels	4000	IN2P3
Total			7000	
Funding from Japan				
Description	**k¥/Unit**	**Nb of units**	**Total (k¥)**	**Requested to**
Travel	150	10	1500	KEK
Visit to France	20/day	150	3000	KEK
Travel + per diem	300	10	3000	KEK
			7500	
Total				

✓French ; 10 people asking 7000€ for travel

✓Japanese; 9 people asking 7500k¥ for support

Summary

✓New application to FJPPL

✓Asking support for DCal/EMCal projects,

- which has emerge as rapid growing prjects at ALICE
- Tighten Japan-France-USA-Italy-China collaboration
- Daily collaboration between Japan-France

➡Two students/PD will stay Nates, Grenoble,,,