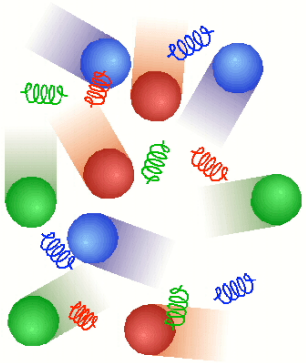
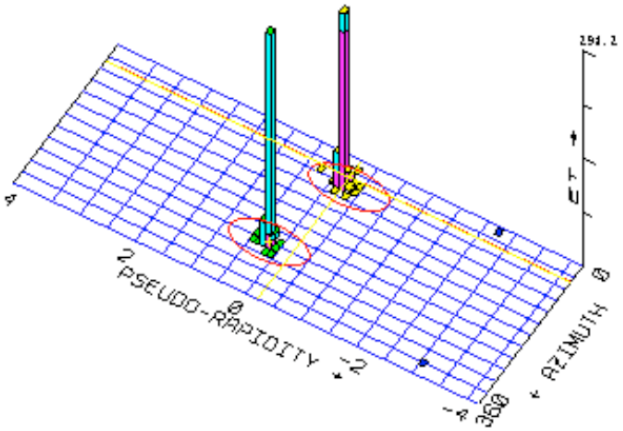
Back-to back jet with parton ID as a probe of QGP



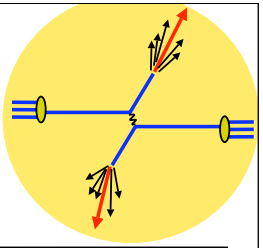
Proposal of small addition to ALICE
in order to enhance physics capability

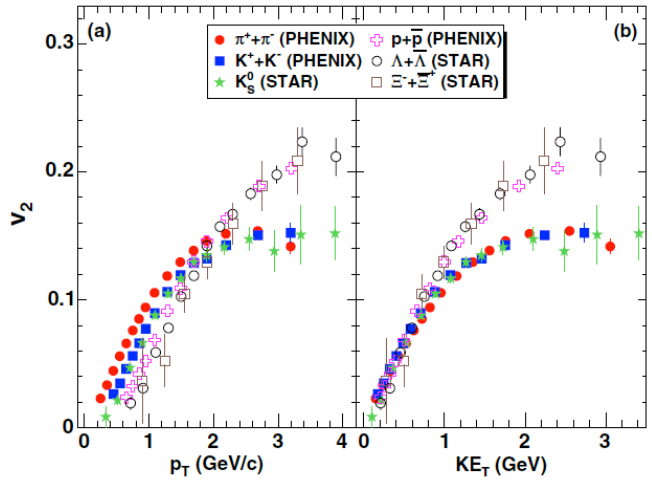


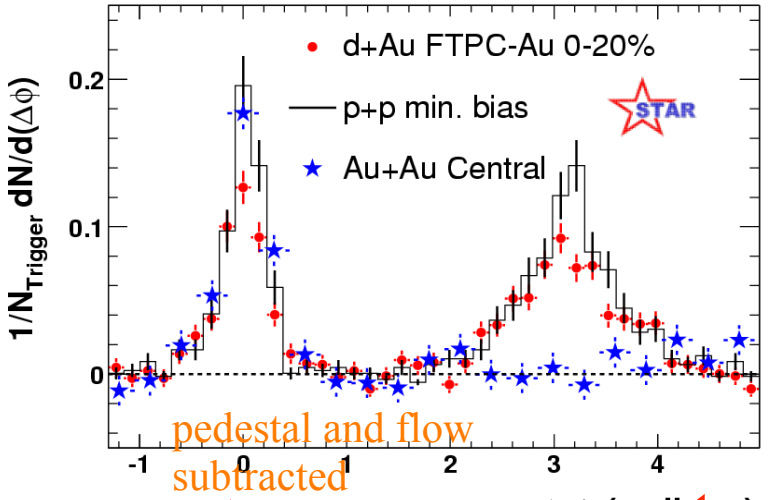
Yasuo MIAKE
Univ. of Tsukuba

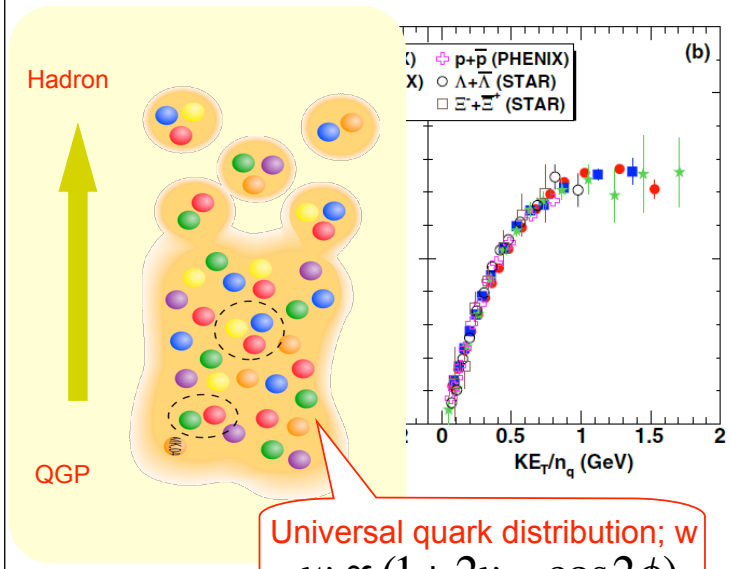
D. Sakata
S. Esumi
H. Yokoyama

Major Two Discoveries on Soft & Hard at RHIC



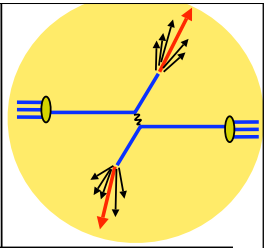




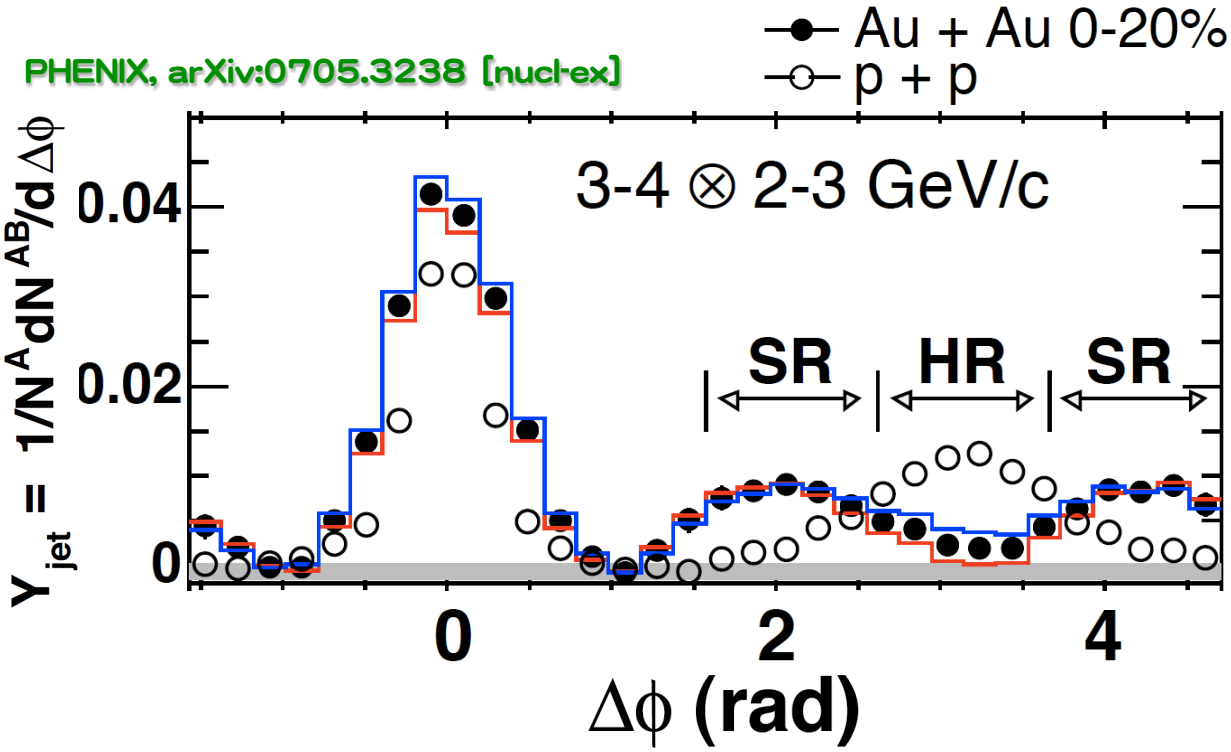


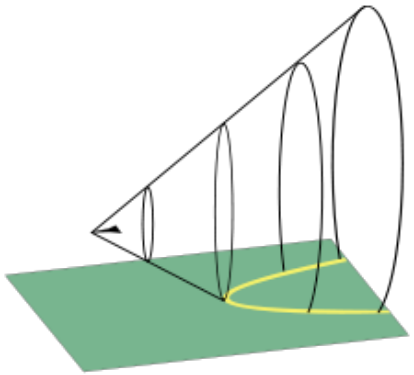
- ✓ **Large elliptic flow**
  - hydro + recombination
- ✓ **Jet quench**

Shoulders at $\Delta\Phi = \pi \pm 1.1$



PHENIX, arXiv:0705.3238 [nucl-ex]



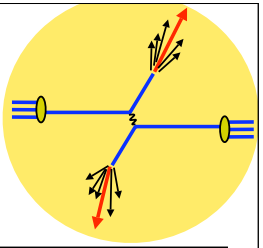


✓Shoulders appear at lower momentum.

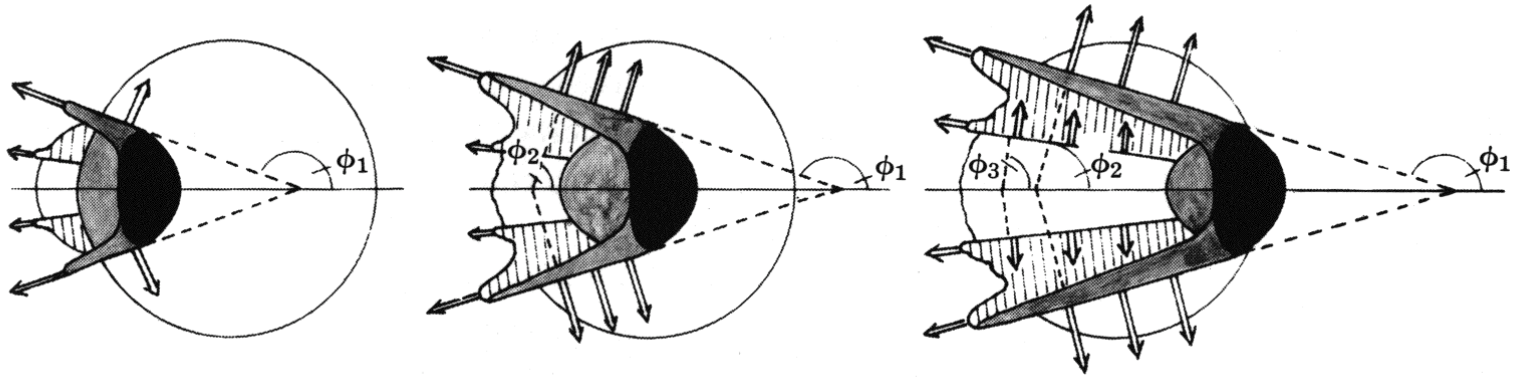
✓Location & <pt> of shoulder seem to be independent of centrality and pt.

➡Shock wave / Mach Cone?

Shock Wave from Bevalac



From slides shown by S. Nagamiya at Tamura Symposium, Nov. 2008



(a) diving stage

(b) penetration stage

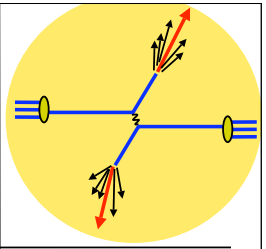
(c) final stage

Figure 4. Schematic figure of the various stages in a central collision between an incident smaller (relativistically contracted) and a heavier target nucleus. The head-front shock is drawn very dark. The Mach-shock wave, which is traveling to the sides, also contains high density but not as high as the projectile head. A minor backward fragment ejection along the Mach-front is also indicated. This is expected especially in the diving stage, where it is easier to eject fast particles along the Mach-shock into free space. A secondary Mach-shock wave of intermediate density is also indicated.

W. Greiner's proposal.

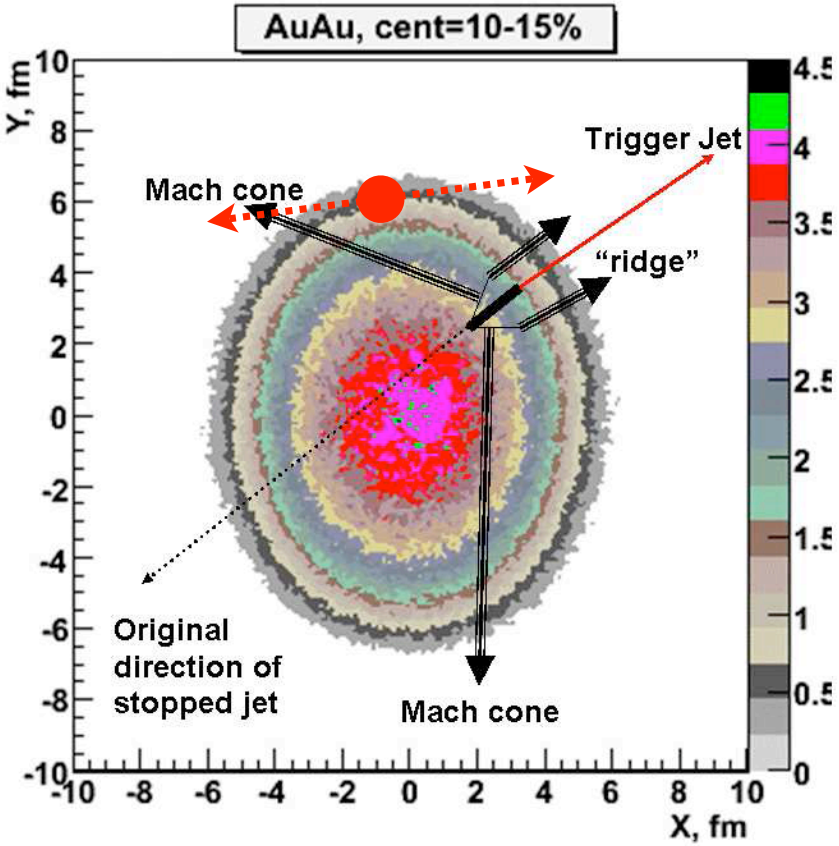
✓I was very excited with this idea, when I was a grad. student.

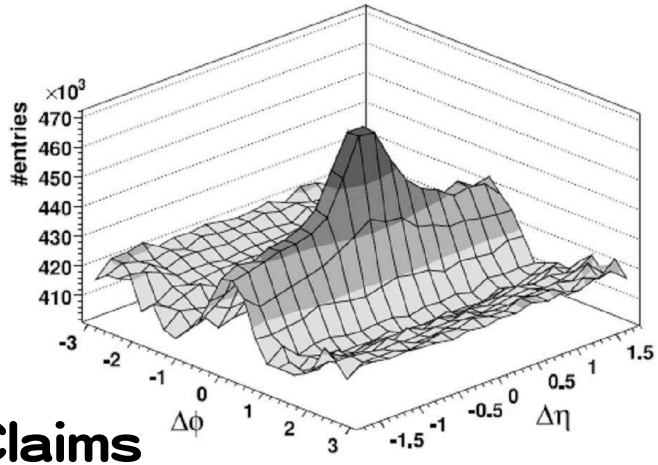
Wish jets to penetrate !



V.S. Pantuev, arXiv:hep-ph/0701.1882v1

STAR, arXiv:nucl-ex/0701074



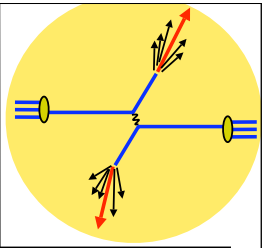


✓Claims

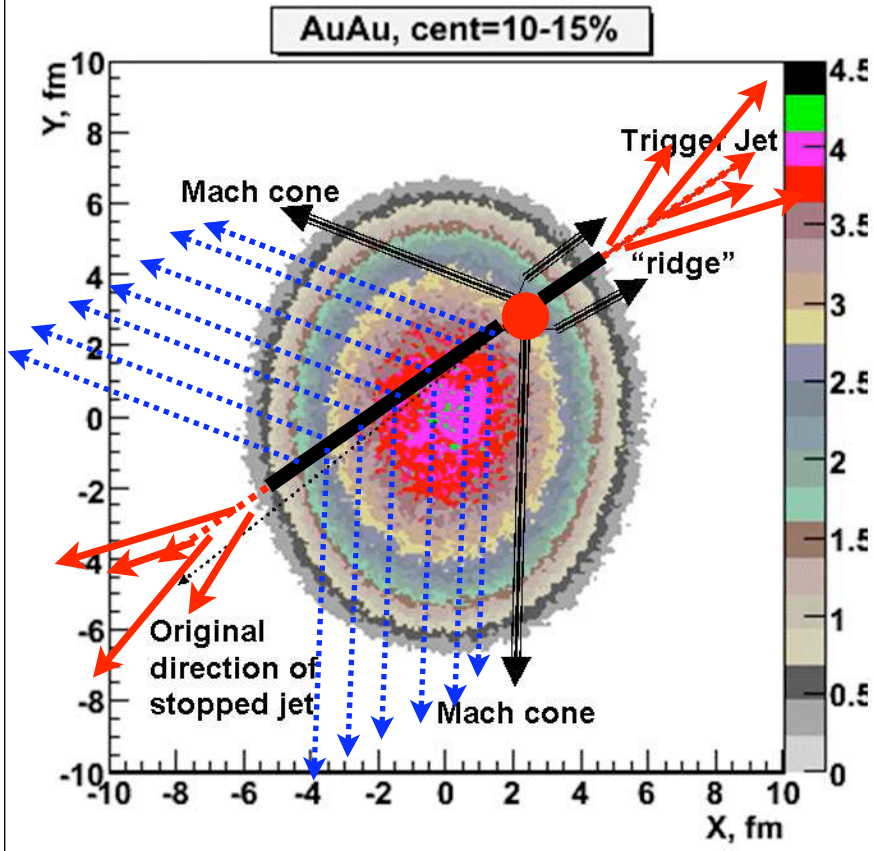
- Stopped parton is the source of ridge as well as Mach cone.
- This happens only at the surface
- There should be velocity boost at the ridge region (pi,K,p)
- v3 components independent of R.P.

I wish to have jets with higher energy!

If we have higher energy jets,

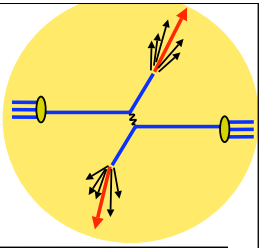


V.S. Pantuev, arXiv:hep-ph/0701.1882v1



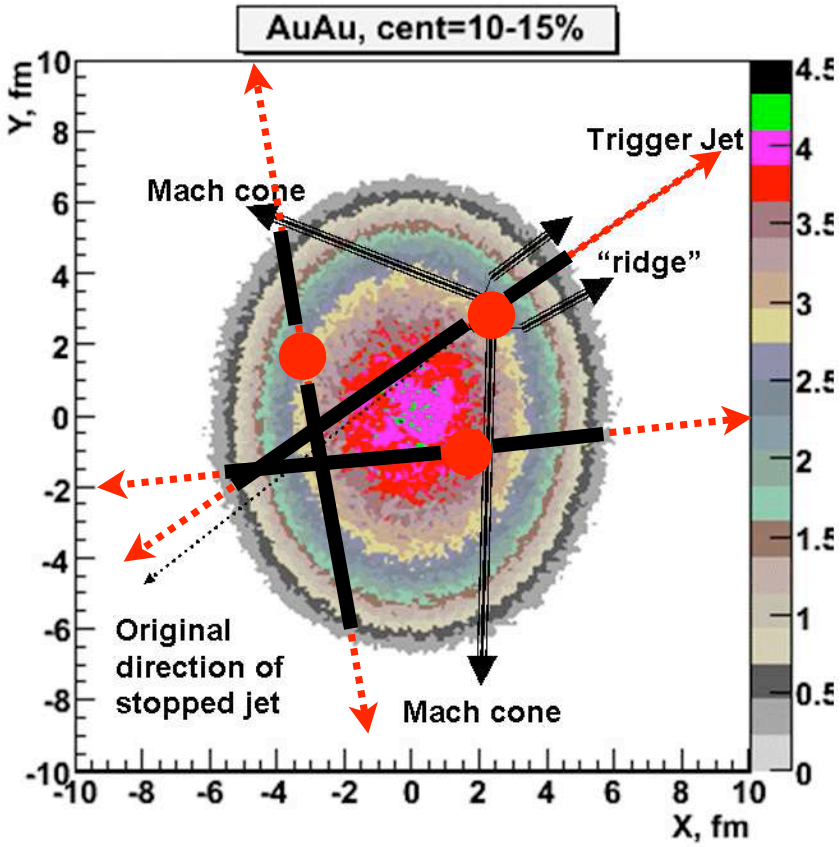
- ✓Mach cone with away side jet.
- ✓Higher, the better;
  - Clear separation in momentum and ϕ

Jet Tomography

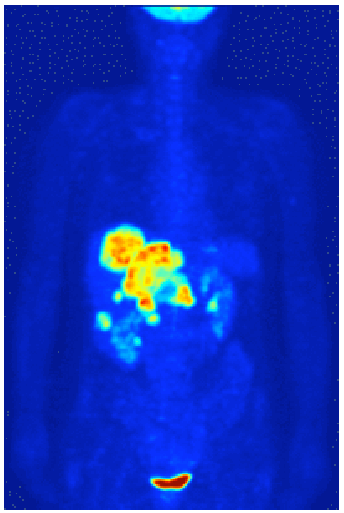


Jet Tomography

M. Gyulassy ?

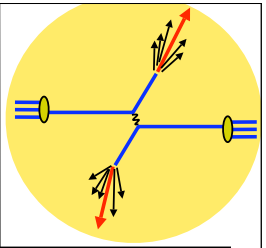


Positron EmissionTomography



✓Final tool to prove structure of the dense matter

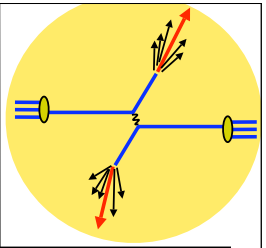
View from RHICians

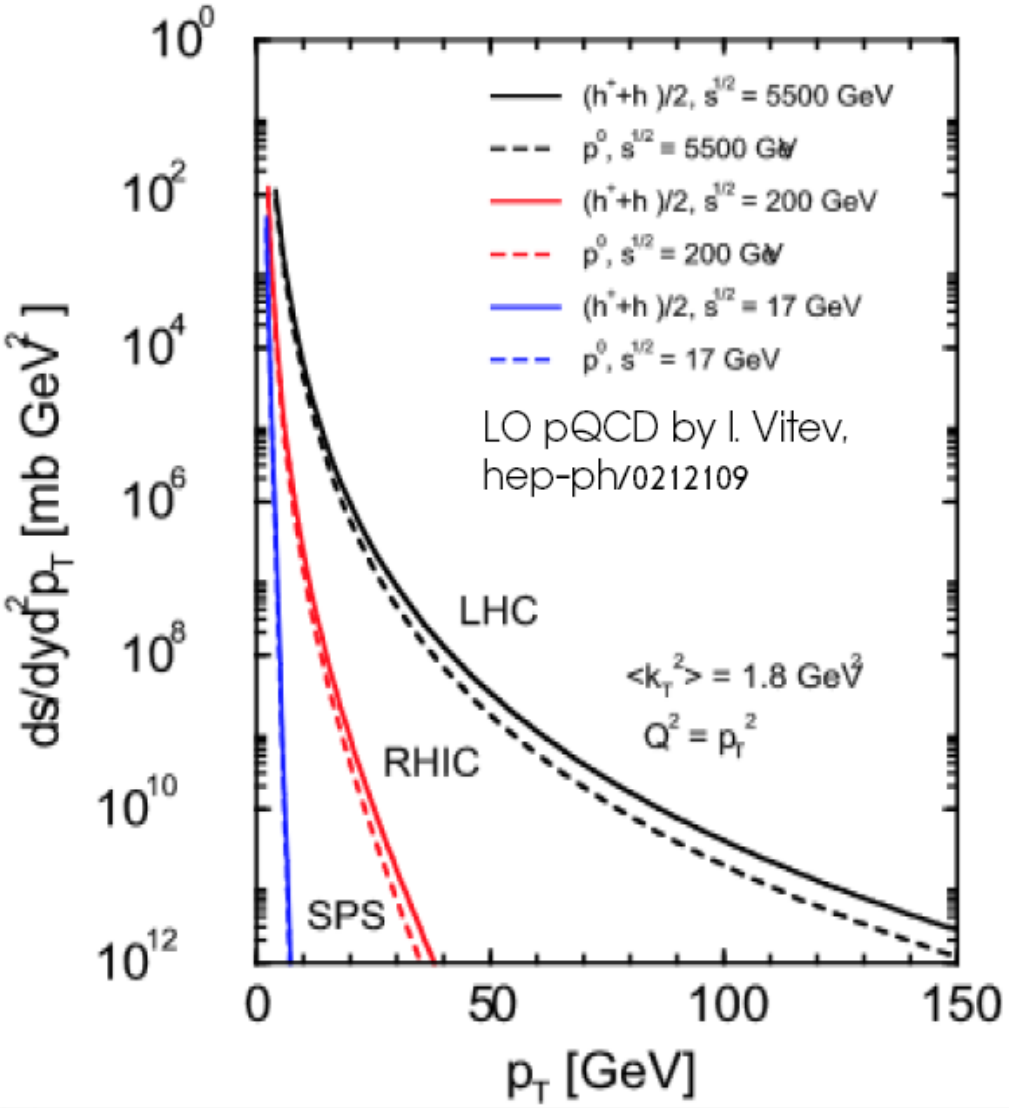


	RHIC	LHC
$\sqrt{s_{NN}}$ (GeV)	200	5500
T/T_c	1.9	3.0-4.2
ε (GeV/fm^3)	5	15-60
τ_{QGP} (fm/c)	2-4	>10

- ✓Nothing much changes from what we see at RHIC.
- ✓Nevertheless,
  - Larger/longer QGP
  - High pt jets become available!

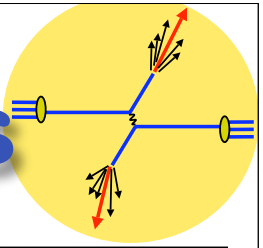
Plenty of high p_t jets

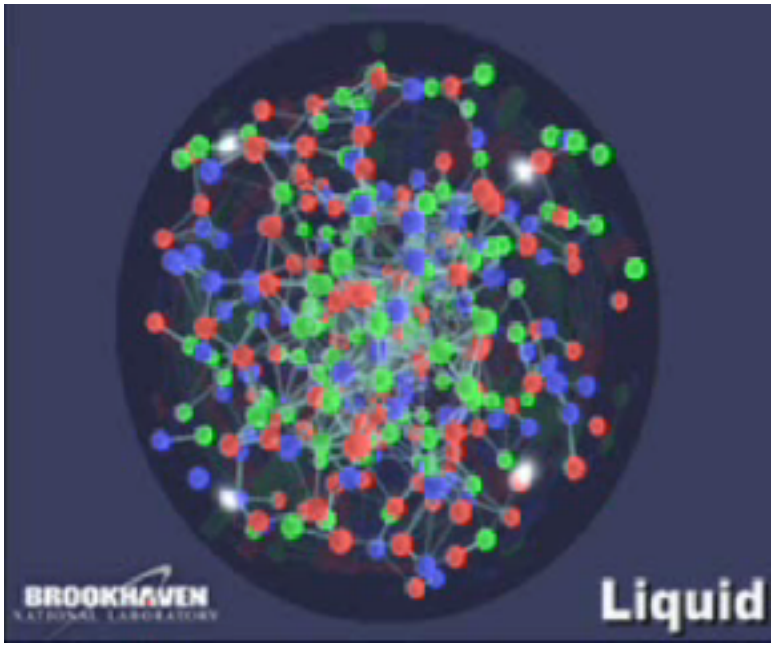




✓**Many orders of magnitude!**

QGP made of soft particles

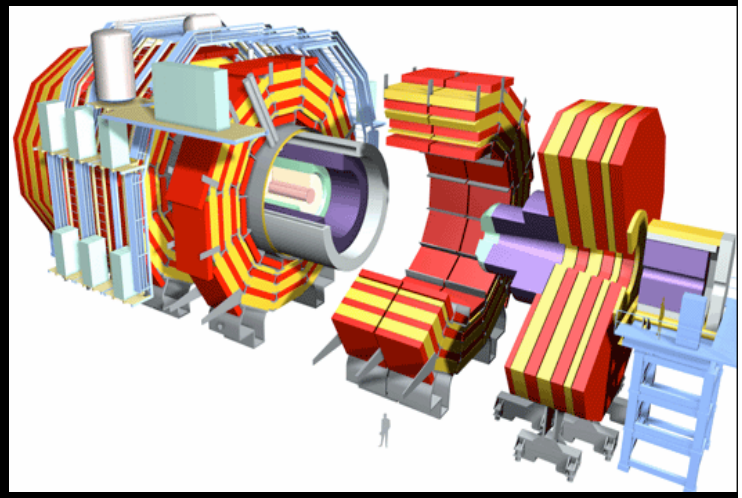




Animation by Jeffery Mitchell (Brookhaven National Laboratory). Simulation by the UrQMD Collaboration

- ✓QGP with T~a few 100 MeV is made of soft particles.
  - Meas. of soft/low pt particles is a must for the property of QGP.
- ✓As a probe of QGP, high p_t parton is important
- ✓In other words, modification of soft particles with high energy jet is what we want to study.

CMS Heavy Ion Program



Overview:

CMS has a broad heavy ion physics program

- **precision tracking $|\eta| < 2.5$**
- **muon identification $|\eta| < 2.5$**
- **high-res calorimetry $|\eta| < 5$**
- **forward coverage**

CMS expects to excel at

- **photon-tagged jet measurements (FF modifications)**
- **quarkonium measurements**

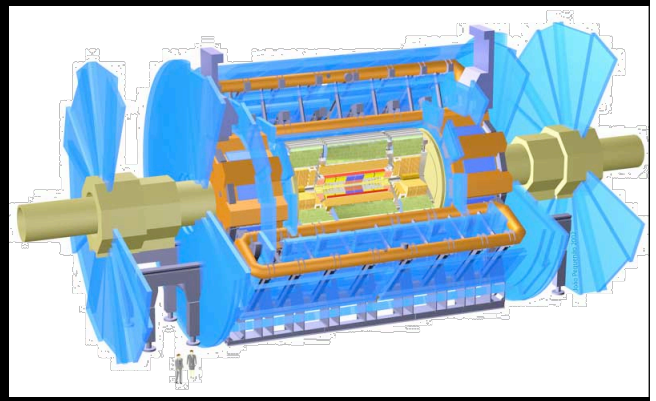
US Members:

University of California at Davis
University of Illinois at Chicago
University of Iowa
University of Kansas
Los Alamos National Laboratory
University of Maryland
MIT
University of Minnesota
Rice University
Vanderbilt University

ATLAS Heavy Ion Program

Overview:

ATLAS has a broad heavy ion physics program
- excels at jet and photon measurements

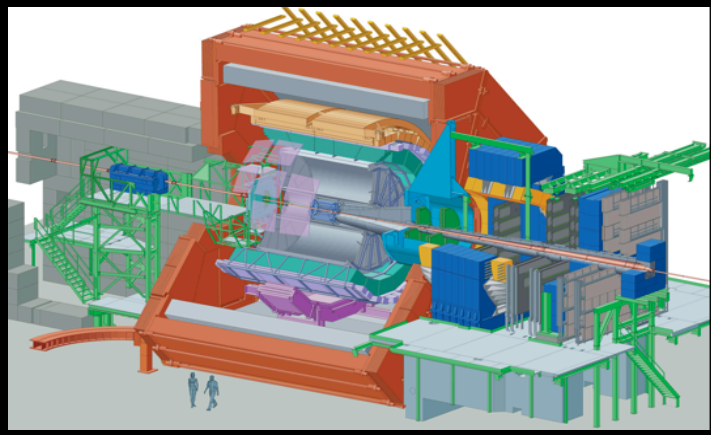


Jets
- reconstruct jets in a large kinematical range
  $E_T > 40$ GeV and $|\eta|<5$
- perform key fragmentation measurements
- jet shape and FF modifications
- multi-jet studies

US Members:
Brookhaven National Lab
Columbia University
Iowa State University
Stony Brook University

Photons
- isolate / measure photons in large range, $E_T > 10$ GeV and $|\eta|<2.5$
- unique calorimeter design allows additional rejection beyond isolation

ALICE – the Heavy Ion Experiment



ALICE is a versatile, heavy ion detector at the LHC

Overview:

Soft Probes – "ala RHIC"

- Expansion dynamics different from RHIC
- Soft physics measurements ala RHIC
  + extended PID
- Day 1 physics +

Hard Probes – Jet Quenching

- Jets, γ , pi-zeros, leading particles to large p_T

Hard Probes – Heavy Quarks

- Displaced vertices ($D^o \rightarrow K^- \pi+$) from TPC/ITS
- Electrons in Transition Radiation Detector (TRD)

Hard Probes – Quarkonia

- J/ψ, Υ, Υ' (excellent), Υ''(2-3 yrs), ψ' ???

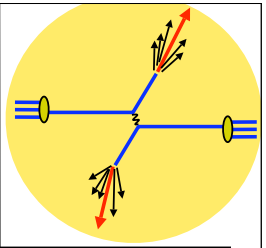
US Members:

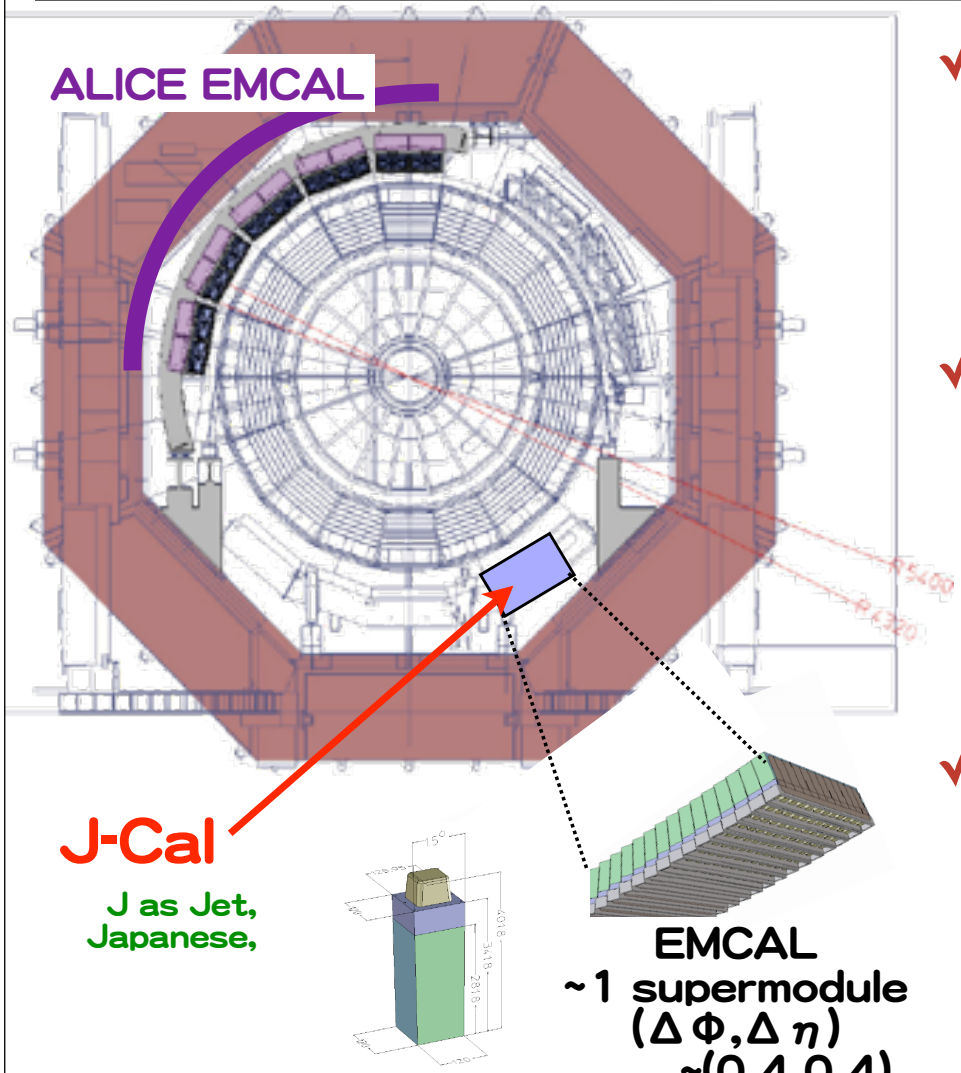
Cal. St. U. – San Luis Obispo
Creighton University
University of Houston
Lawrence Berkeley Nat. Lab
Lawrence Livermore Nat. Lab
Oak Ridge National Lab
Ohio State University
Purdue University
University of Tennessee
Wayne State University
Yale University

Affiliated US Member:

University of Texas – Austin

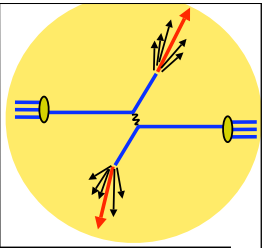
J-Cal (EM)





- ✓ J-Cal (EM) for back-to back jets in ALICE
  - ➡ Define back-to back jets
  - ➡ Trigger back-to back jets
- ✓ Why back-to back jets?
  - Origins clean
  - Kinematically clean
    - ➡ Energy balance
    - ➡ back-to back in phi
- ✓ Physics Goal
  - Modification of soft particles with high E jet
    - ➡ Mach Cone, Ridge, etc
  - Tomography of QGP

Control variables required for Heavy Ion Exp.

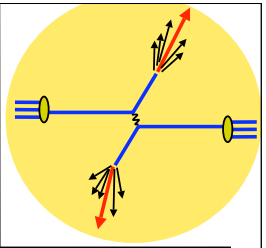


✓Since heavy ion collisions is so complicated, while there is no 'standard model', we need to measure heavy ion collisions w. many control variables.

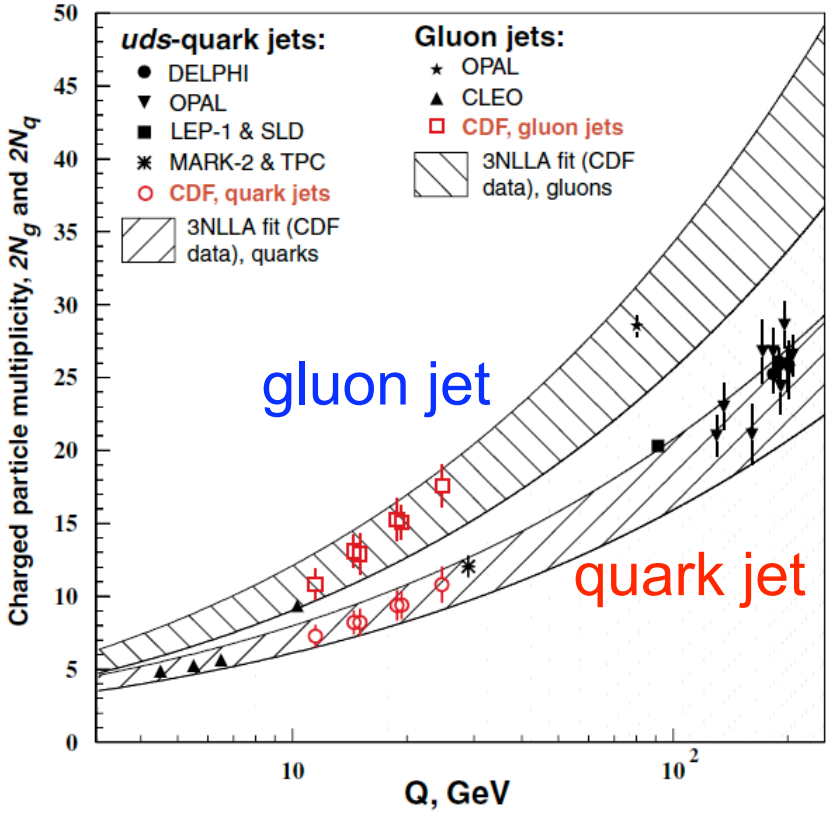
- Centrality / impact parameter of collisions
- Reaction Plane Angle
- Yet, another control variable for the next generation experiments ;

→ Jet Axis

Possibility of Parton ID

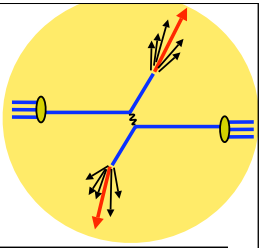


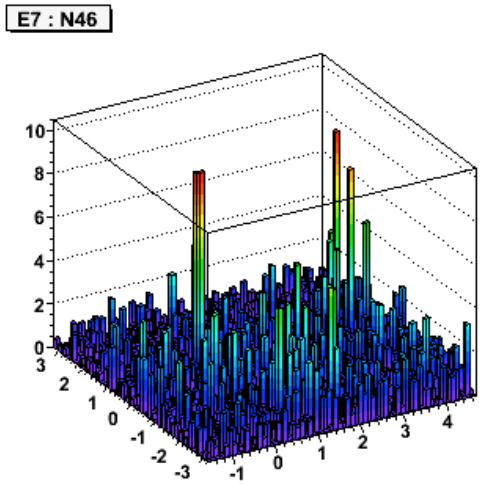
CDF, PRL94(2005)171802

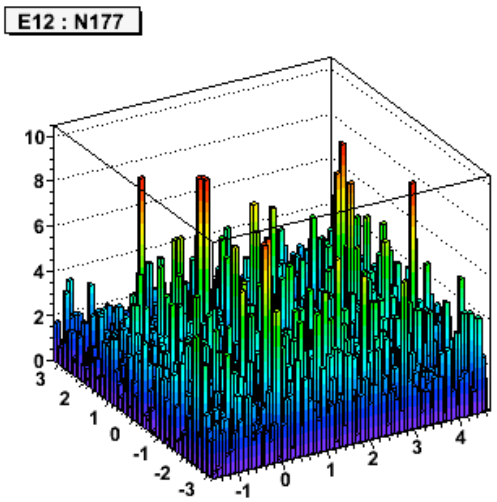


- ✓As a new generation exp., from Particle ID to Parton ID !
  - According to CDF exp., charged/neutral works
- ✓Might be very difficult in heavy ion environment
- ✓Nevertheless, challenge!
- ✓It becomes feasible for higher p_t jet

Technical Challenge





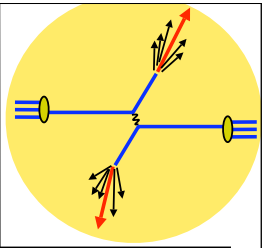


- ✓Backgrounds !
  - A lot of mini-jets may sweep away the jet structure.
- ✓Keys are,
  - higher the jet energy, S/N ratio improves
    - ➡OK as a probe of QGP
  - kinematical cleaness of di-jets structure improves the S/N
  - But, higher the jet energy, the rate drops !
    - ➡Need optimization !

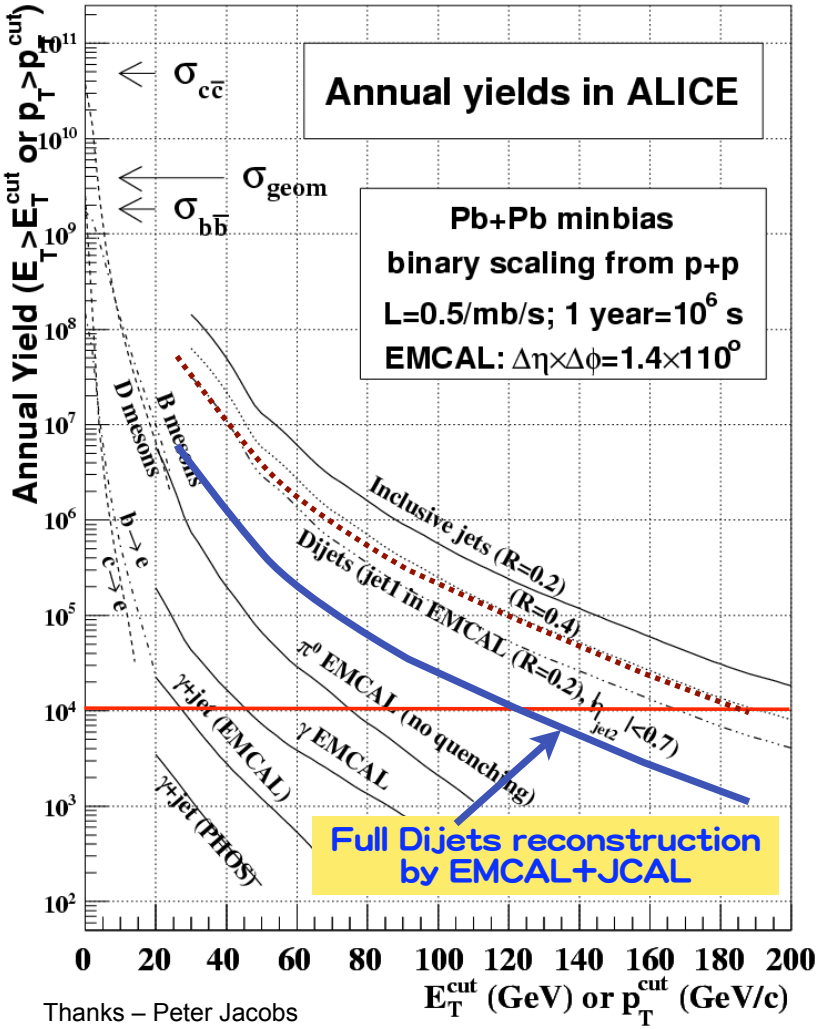
Simulation activities going on

→ Talks by D. Sakata, S. Esumi, H. Yokoyama

Rates and Our Goal



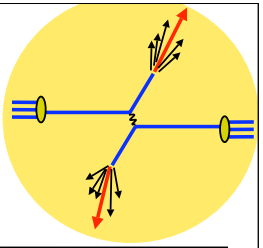
From slides shown by J. Harris at Tamura Symposium, Nov. 2008

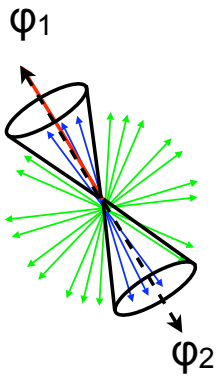


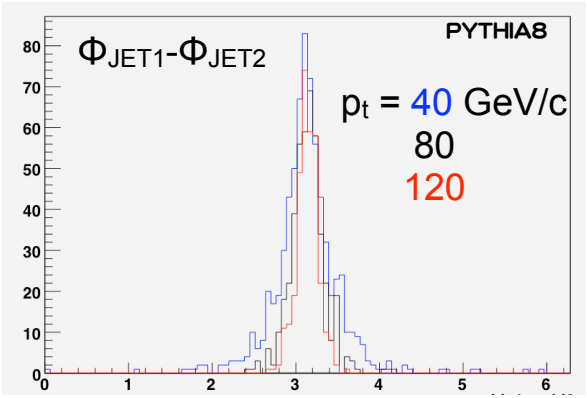
Thanks – Peter Jacobs

- ✓ 1 month running/year
- ✓ 10^4 events/year
- ✓ Using Day-1 ALICE with J-Cal
  - Establish Dijets Axis up to 100~150 GeV

Clean Kinematics



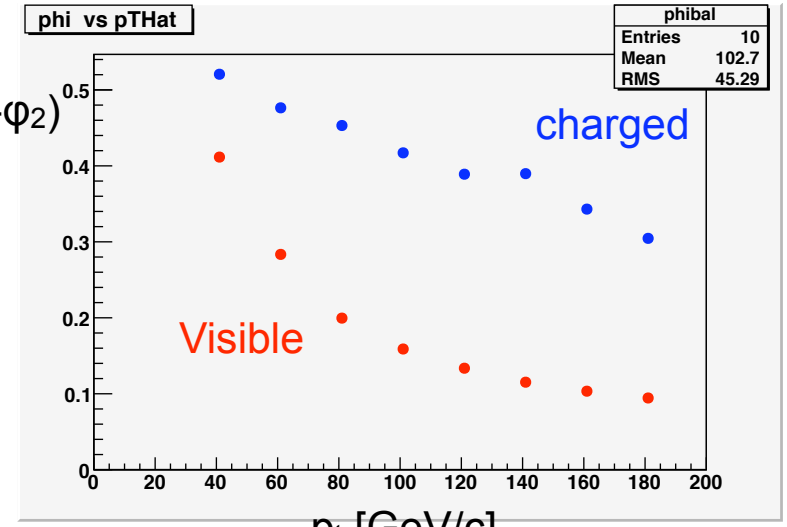




✓We want a clean back-to back jets as a probe.

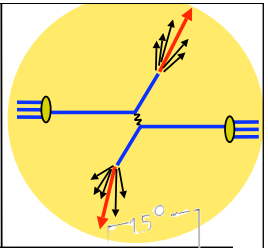
- back-to back in ϕ
  - ➡ ϕ resolution is the key

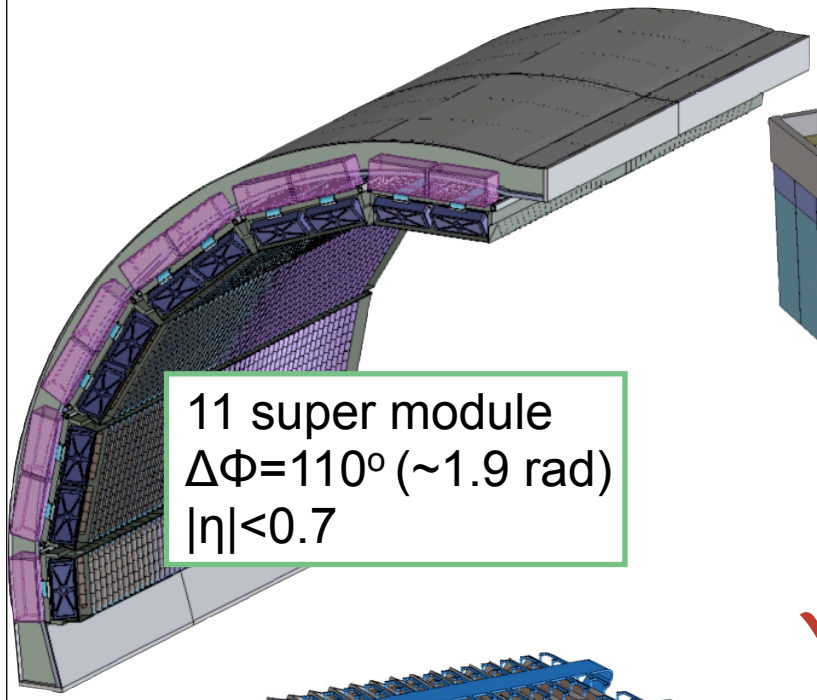
RMS of $(\varphi_1-\varphi_2)$



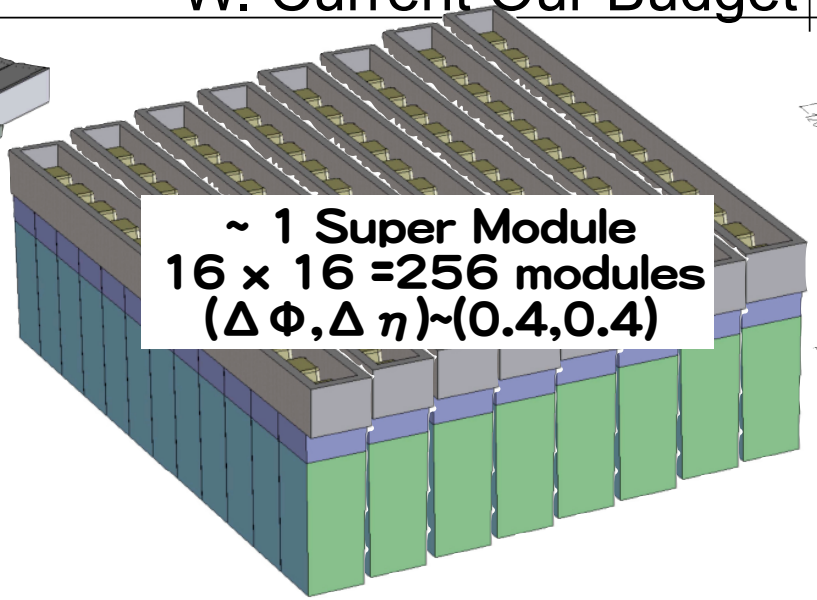
Technical details

W. Current Our Budget

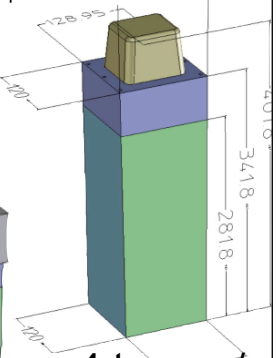




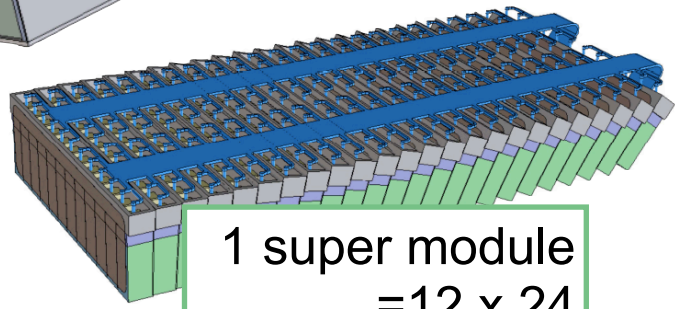
11 super module
ΔΦ=110° (~1.9 rad)
|η|<0.7



~ 1 Super Module
16 x 16 =256 modules
(Δ Φ, Δ η)~(0.4,0.4)



4 towers/
module



1 super module
=12 x 24
=288 modules

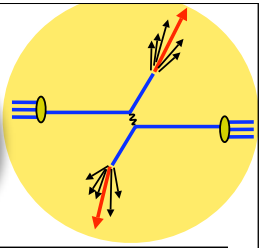
✓We like to increase #of mod. by sacrificing read outs

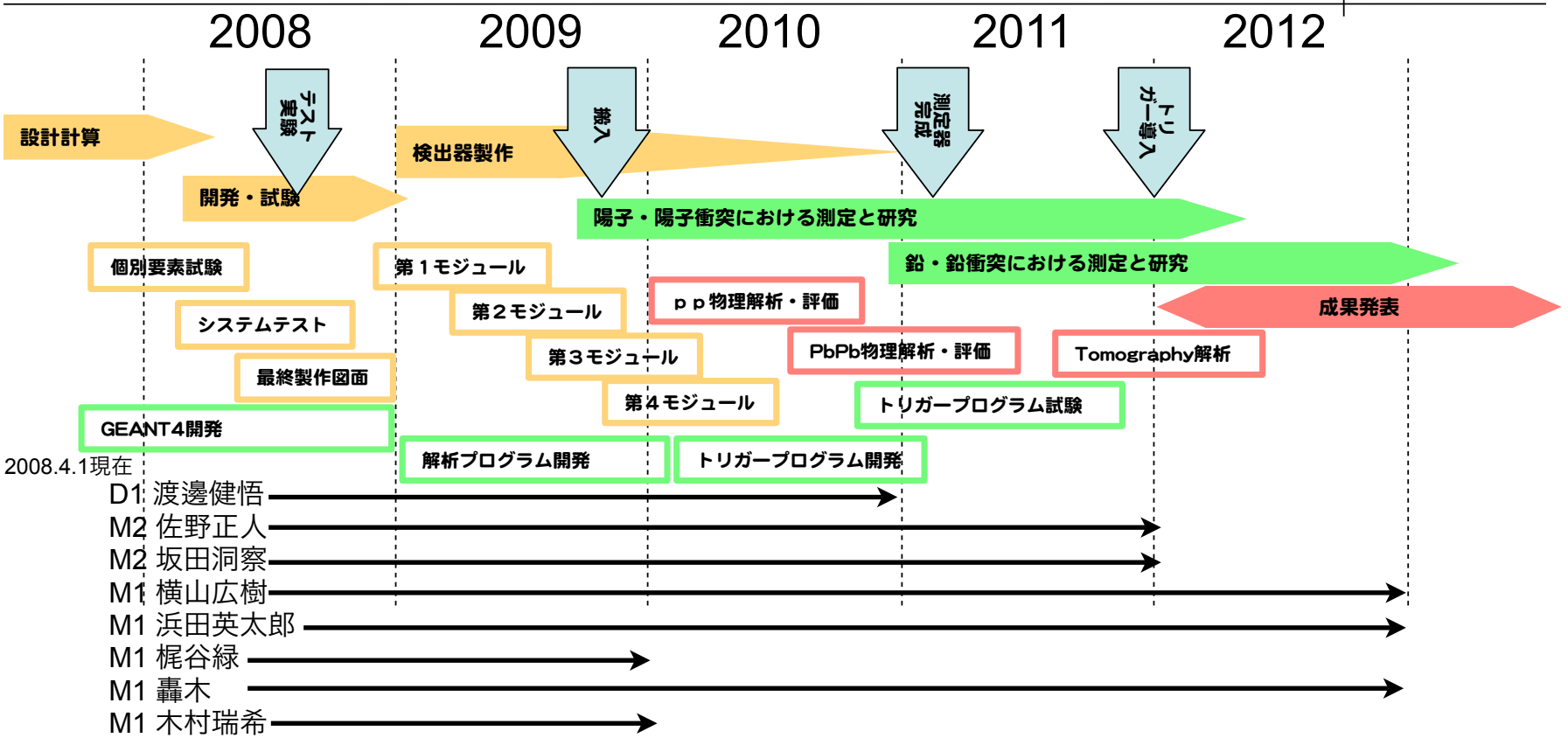
➡for larger yields and for jet broadening

✓Why not with PHOS?

➡Too narrow in phi for jet finding

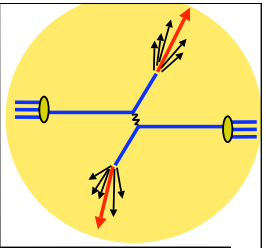
Budget (Grant in Aid,JSPS)





- ✓ Total of ≲1 M$ in 5 yrs
- ✓ T. Chujo, Y. Sekine, R.Takeuchi visits Wayne State next week.
- ✓ We are looking for a Post Doc for J-Cal.

Summary



- ✓ J-Cal (EM) for back-to back jets in ALICE
  - ➡ Define back-to back jets
  - ➡ Trigger back-to back jets
  - ➡ Yet, another control variable ; jet axis
- ✓ Physics Goal
  - Modification of soft particles with high E jet
    - ➡ Mach Cone, Ridge, etc
  - Tomography of QGP
- ✓ Need your support/help !!!
  - Rate is important → More money, more coverage!
  - We have just started !
  - We are looking for a PostDoc

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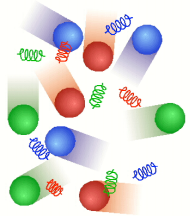

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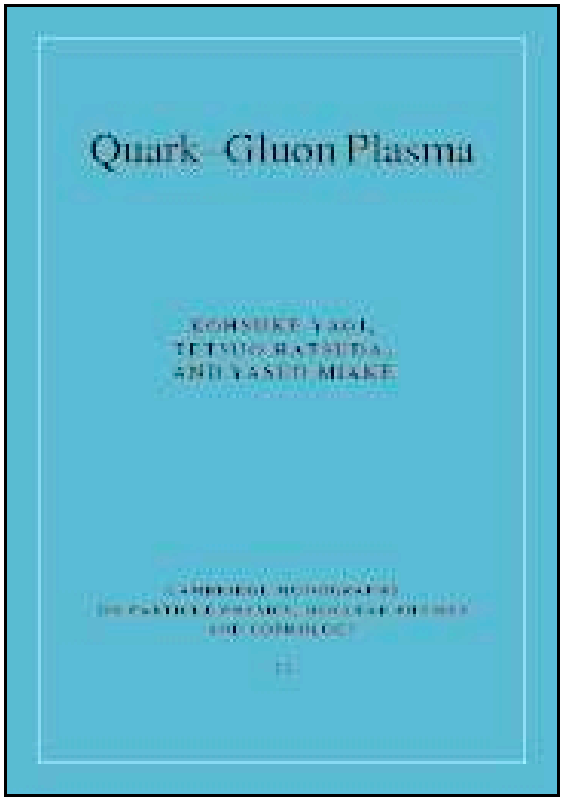

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