

Jet substructure in a quark gluon plasma

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University

Nikhef



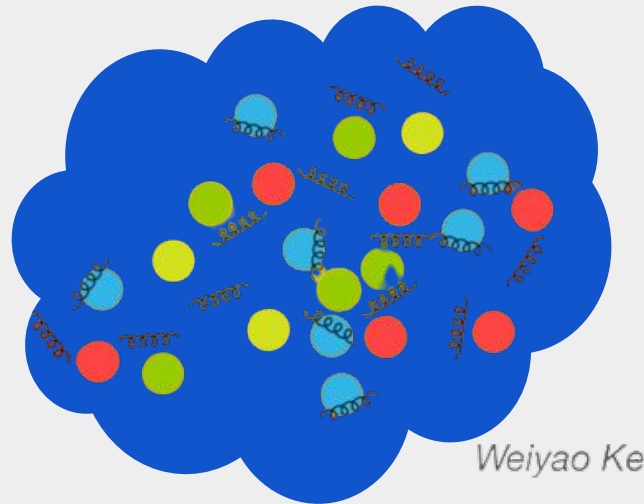
ALICE

Quark gluon plasma

Lifetime $\sim 10 \text{ fm}/c \sim 10^{-24} \text{ s}$
Cannot probe externally

T $> 150 \text{ MeV} \sim 10^{12} \text{ K}$
Hadronic matter unstable

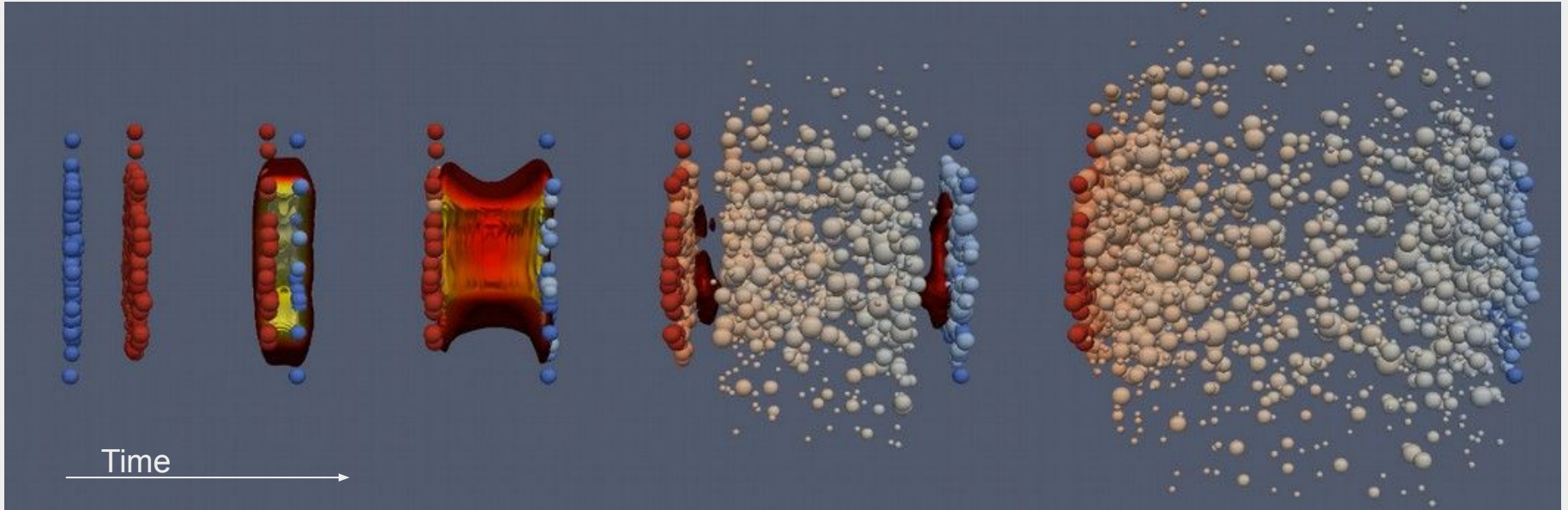
Recreate early universe
before $\sim 10^{-6} \text{ s}$



Weiyao Ke

Quark gluon soup

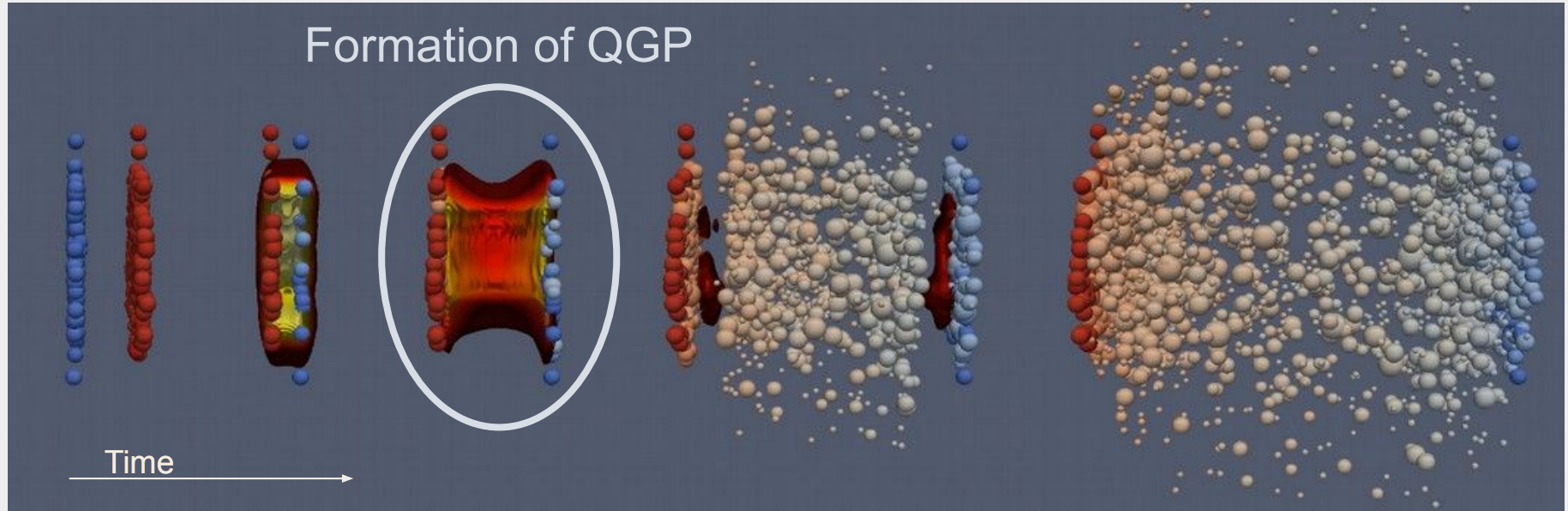
Quark gluon plasma



Evolution of a heavy ion collision

MADAI collaboration, Boris Hippolyte

Quark gluon plasma

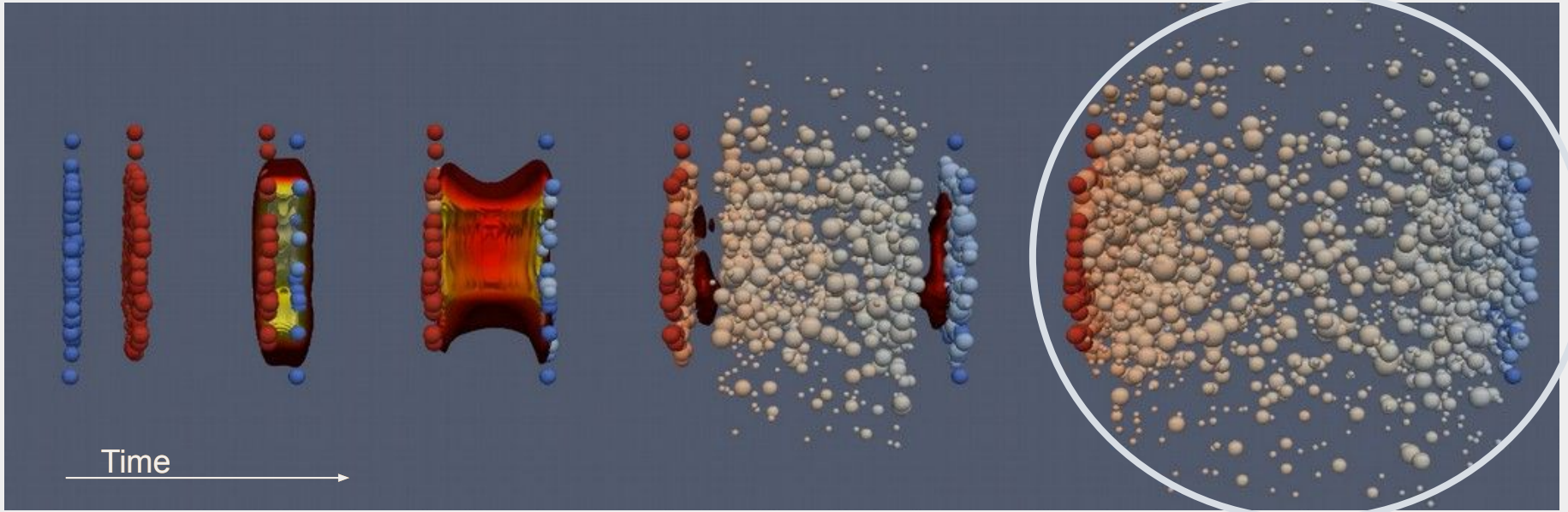


Evolution of a heavy ion collision

MADAI collaboration, Boris Hippolyte

Quark gluon plasma

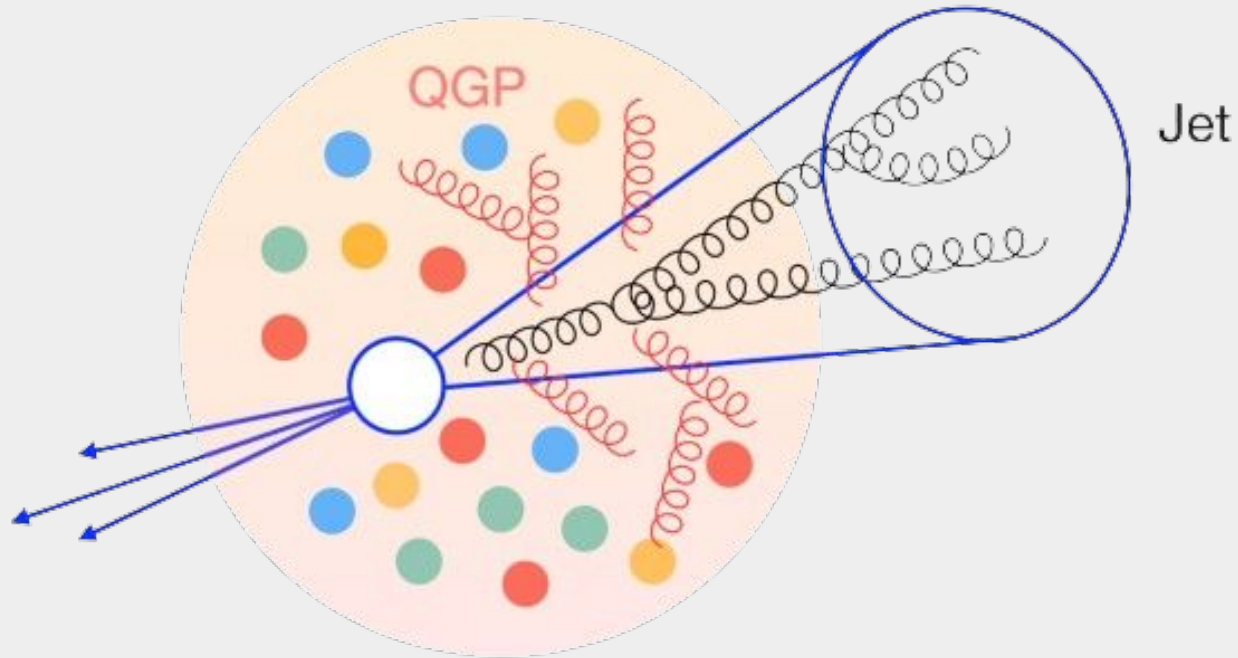
What reaches the detector



Evolution of a heavy ion collision

MADAI collaboration, Boris Hippolyte

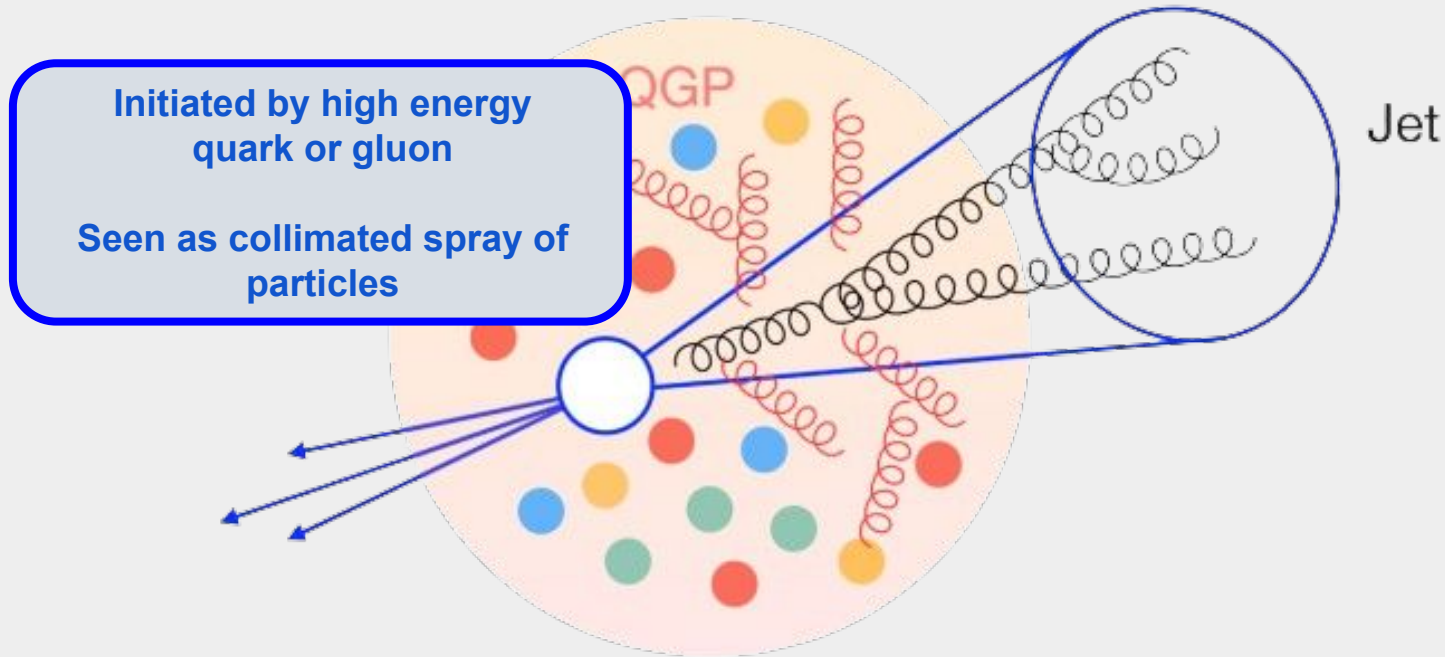
Quark gluon plasma



How can we probe this medium?

Jets

Quark gluon plasma



How can we probe this medium?

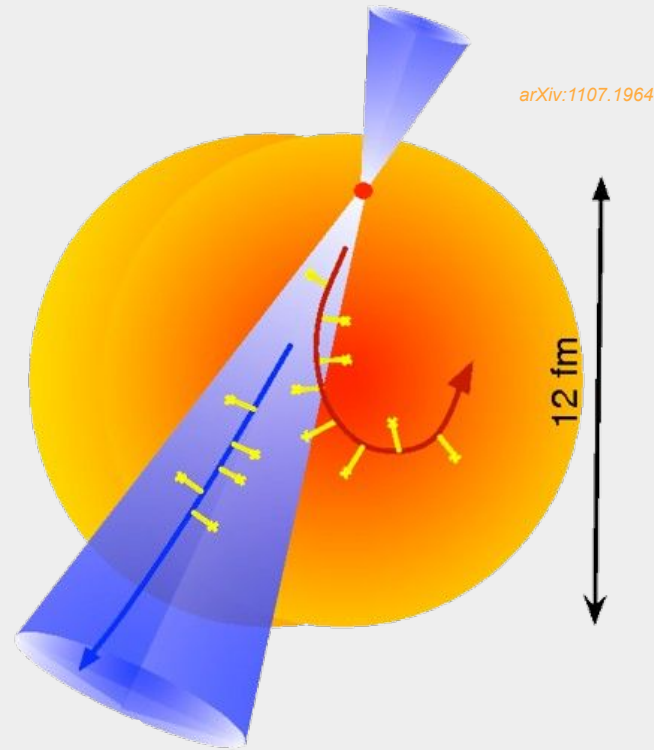
Jets

Jets in heavy ion collisions

Travel in the plasma

Can interact with the plasma

Interactions with the plasma
cause additional gluon radiation

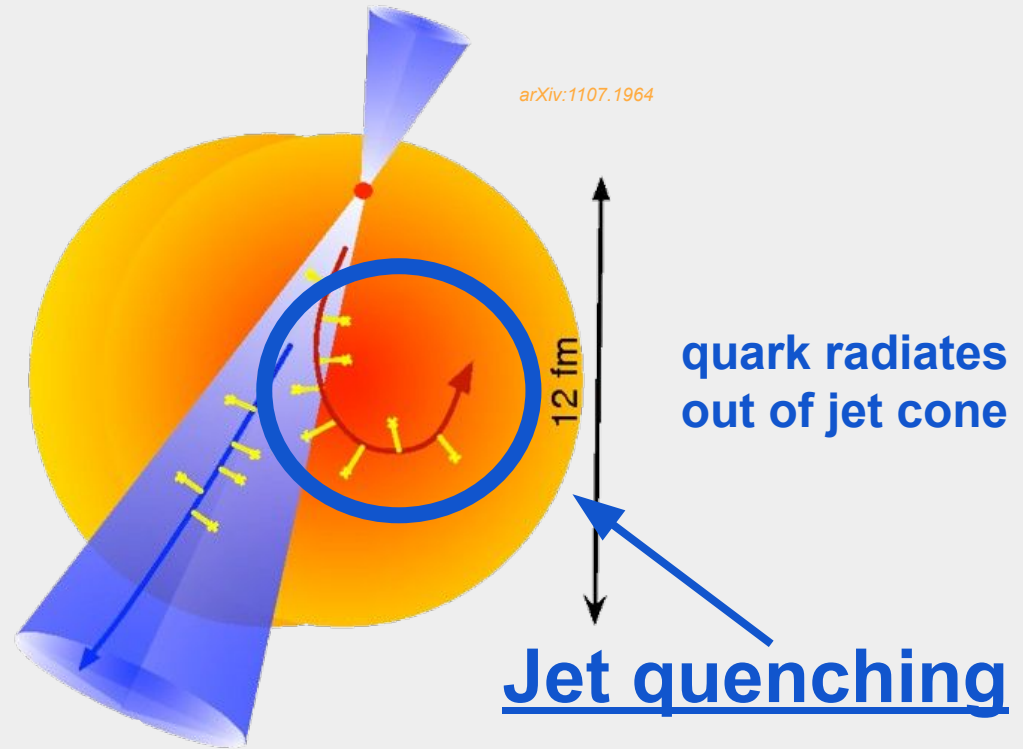


Jets in heavy ion collisions

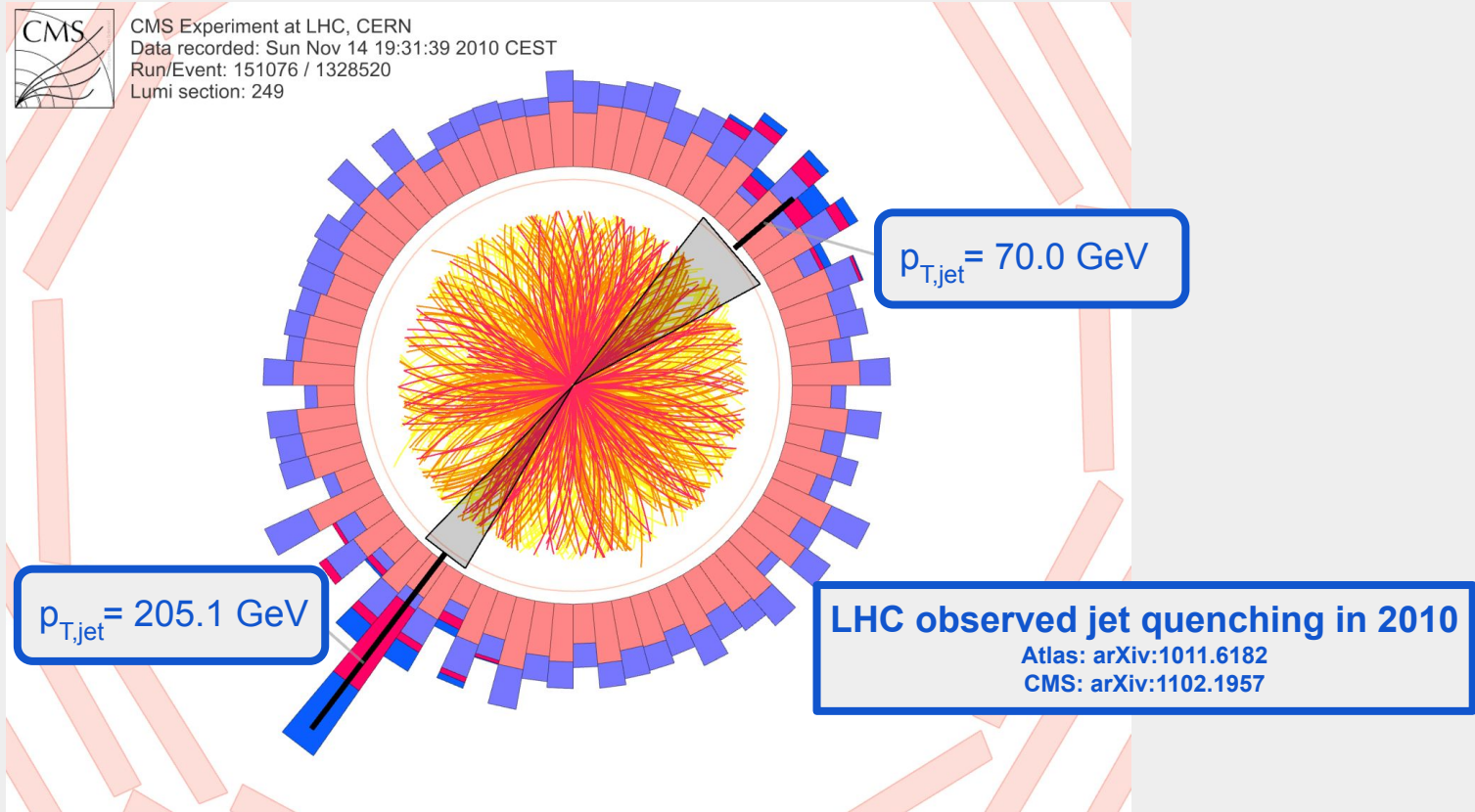
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Jets in heavy ion collisions

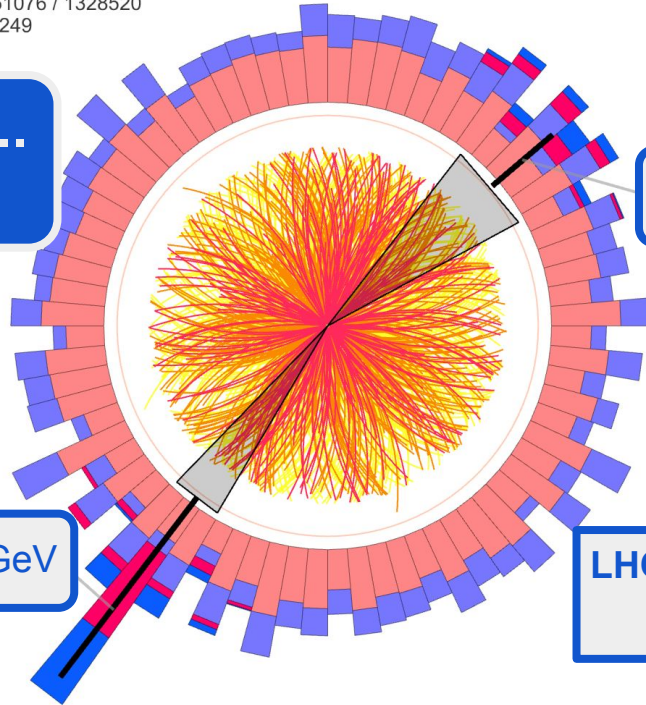


Jets in heavy ion collisions



CMS Experiment at LHC, CERN
Data recorded: Sun Nov 14 19:31:39 2010 GEST
Run/Event: 151076 / 1328520
Lumi section: 249

**Back to back jets..
Not balanced!**



$p_{T,jet} = 70.0 \text{ GeV}$

$p_{T,jet} = 205.1 \text{ GeV}$

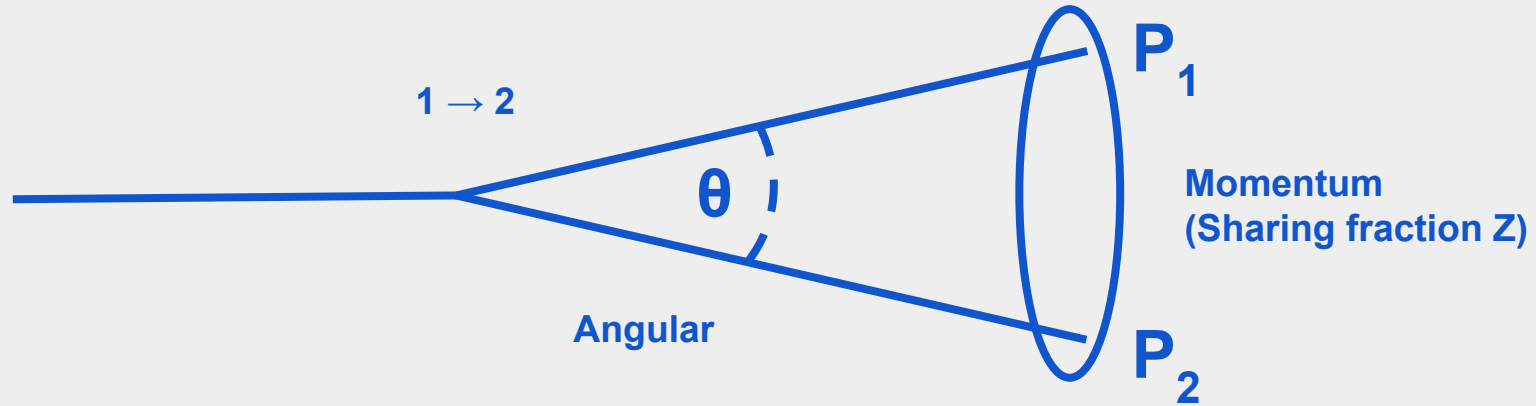
LHC observed jet quenching in 2010

Atlas: [arXiv:1011.6182](https://arxiv.org/abs/1011.6182)
CMS: [arXiv:1102.1957](https://arxiv.org/abs/1102.1957)

Jet substructure

Not only the **energy** of the jet can be modified

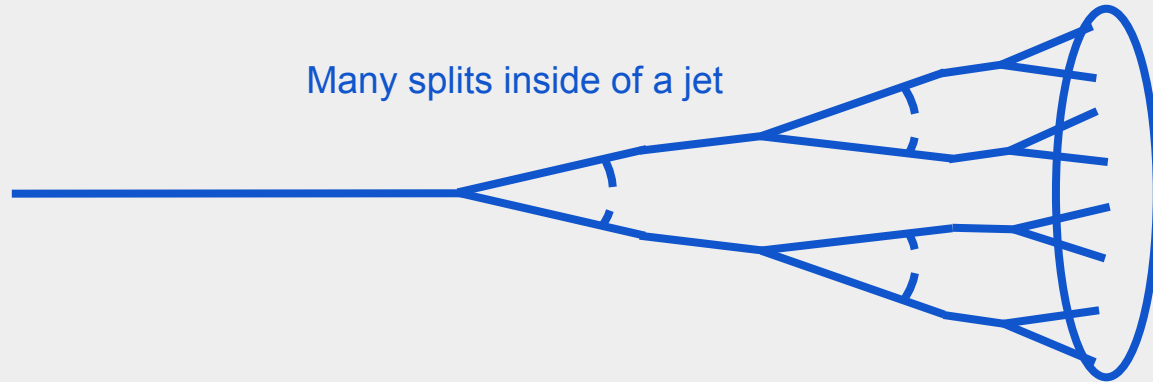
Also the **structure** of the jet might change



Jet substructure

Not only the **energy** of the jet can be modified

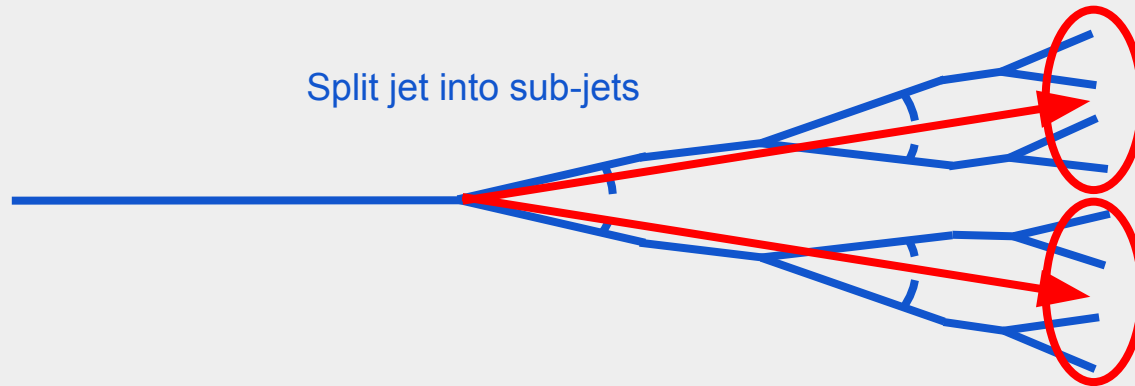
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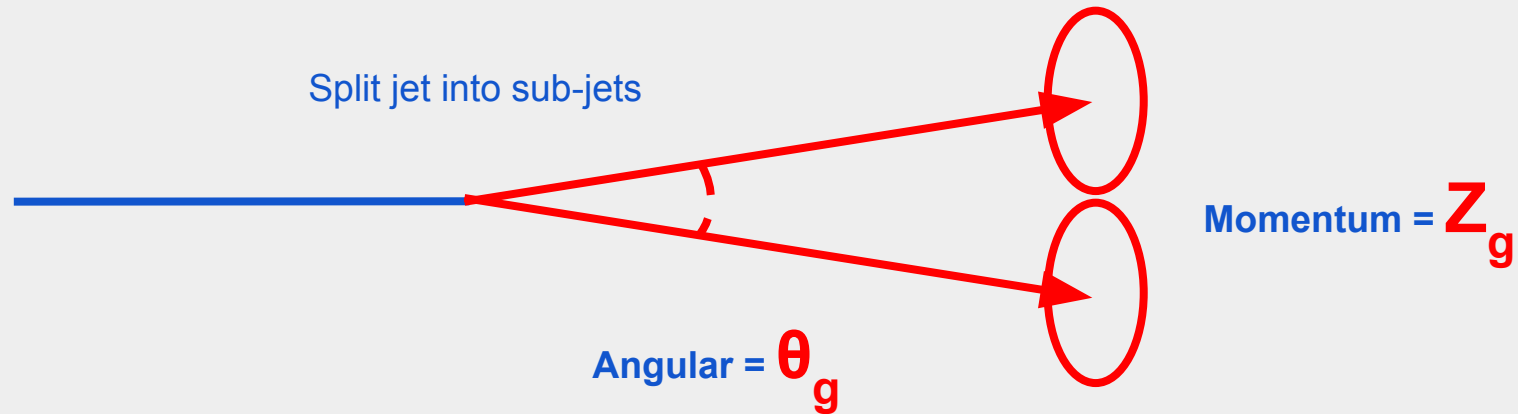
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Jet substructure

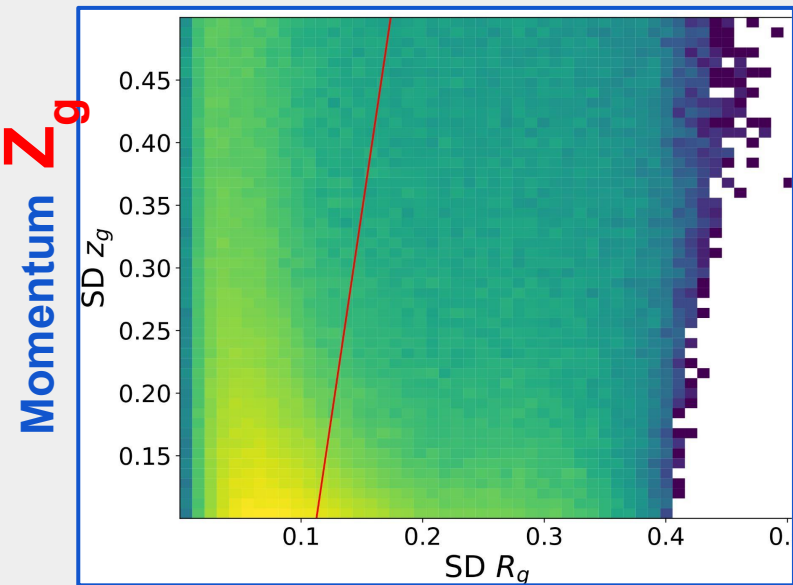
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Jet substructure

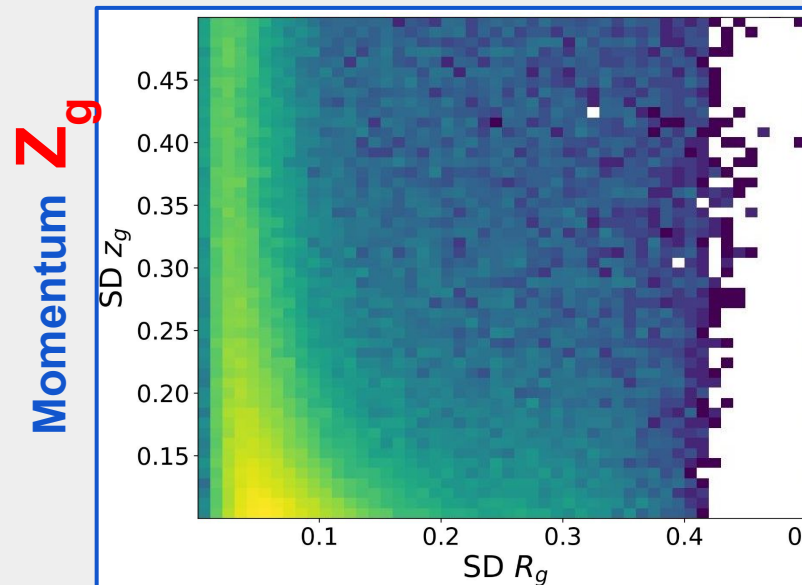
No plasma



Angular θ_g

Jewel monte carlo simulations

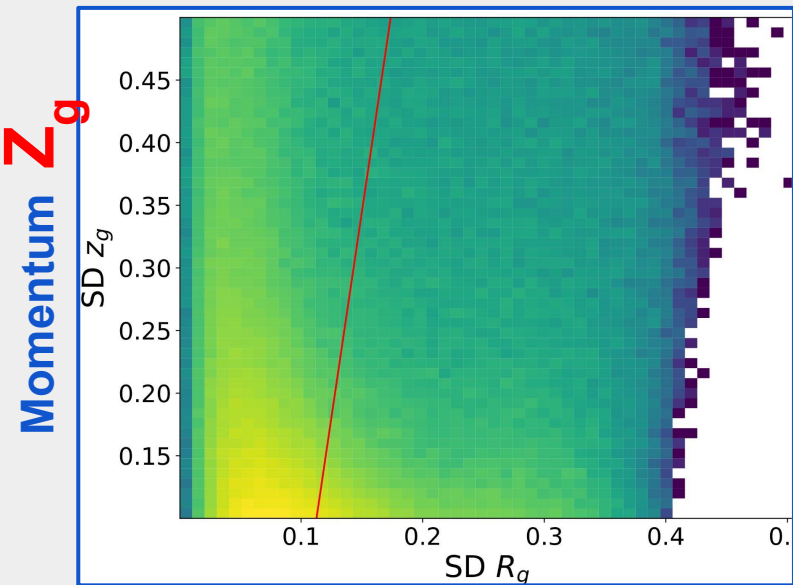
Quark gluon plasma



Angular θ_g

Jet substructure

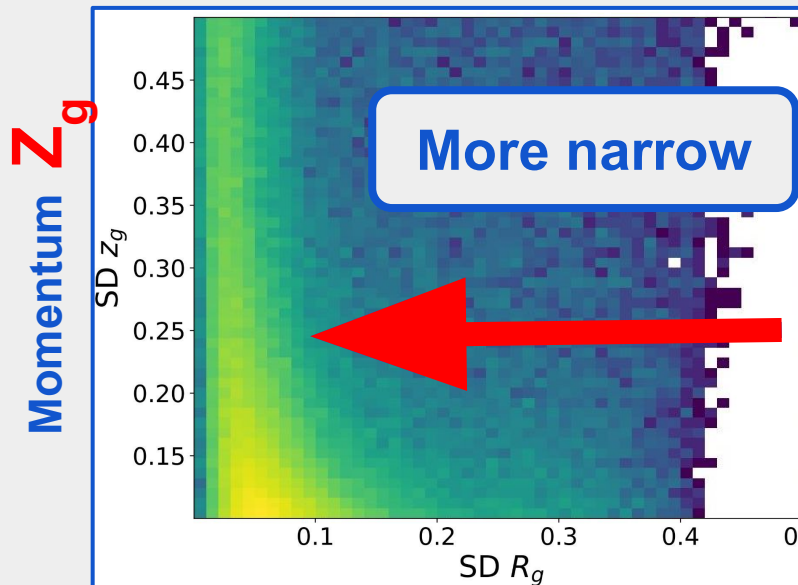
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Angular θ_g

Jewel monte carlo simulations

Quark gluon plasma



Angular θ_g

Jet substructure

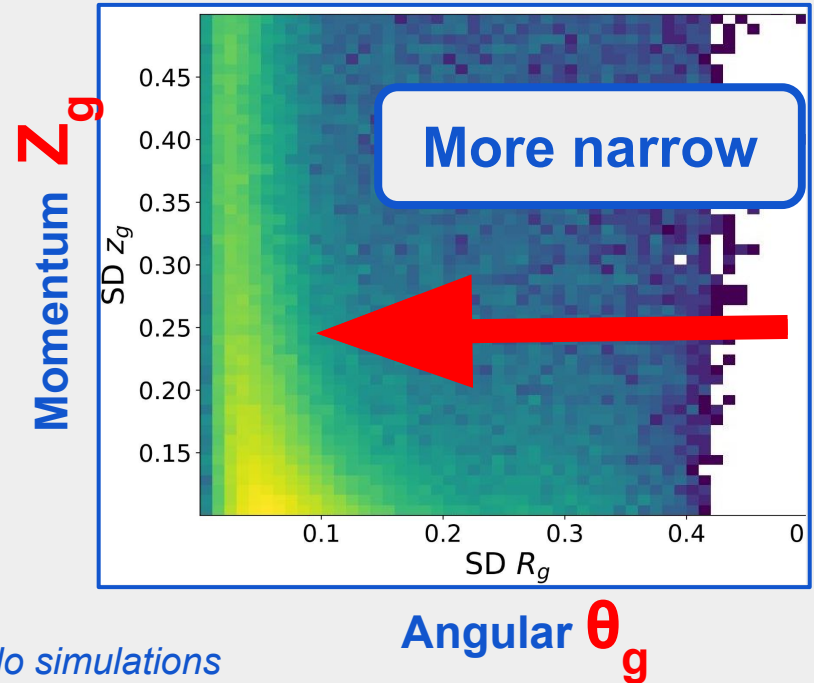
QGP makes jets more narrow?

Comparing jets at same energy...

...But jets also lose energy in QGP

Jewel monte carlo simulations

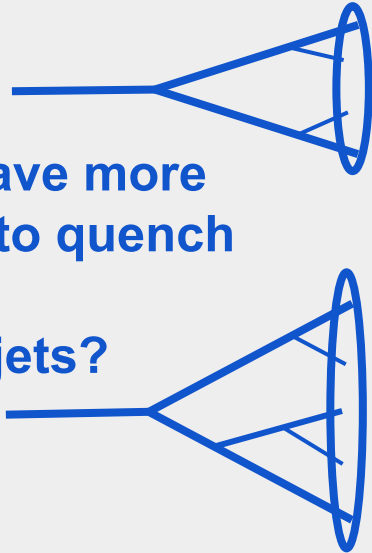
Quark gluon plasma



Jet substructure

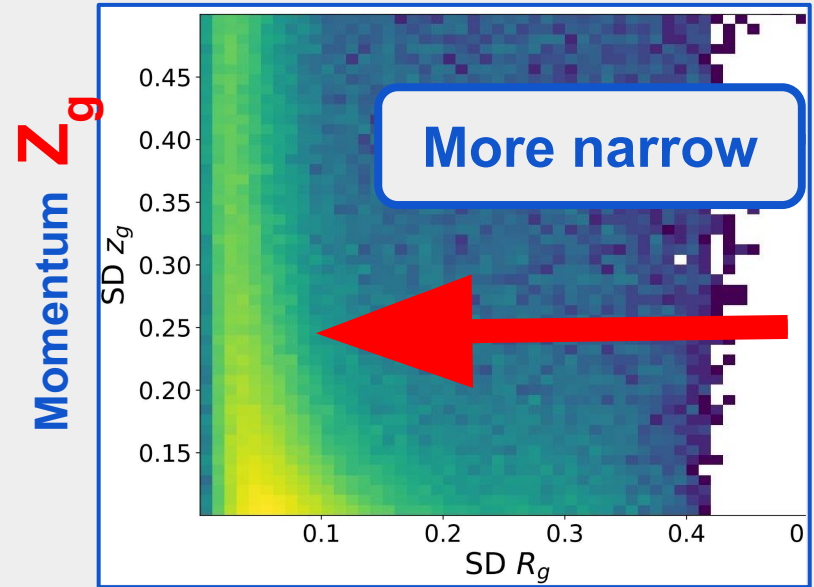
Wider jets have more opportunity to quench

Biasing our jets?



Jewel monte carlo simulations

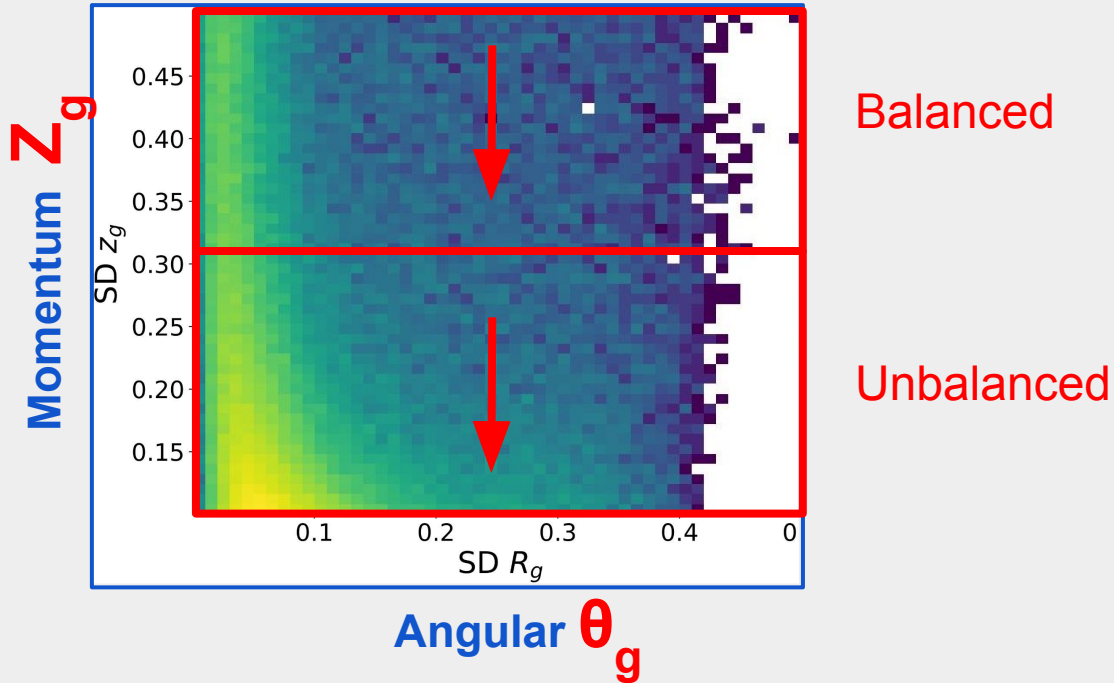
Quark gluon plasma



Angular θ_g

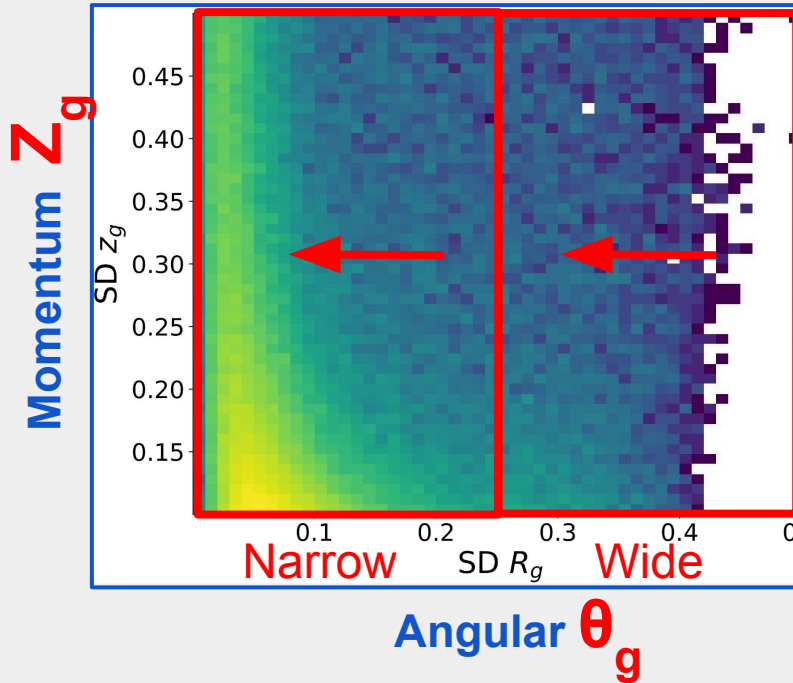
Measuring in heavy ion collisions

Will measure projections:



Measuring in heavy ion collisions

Will measure projections:

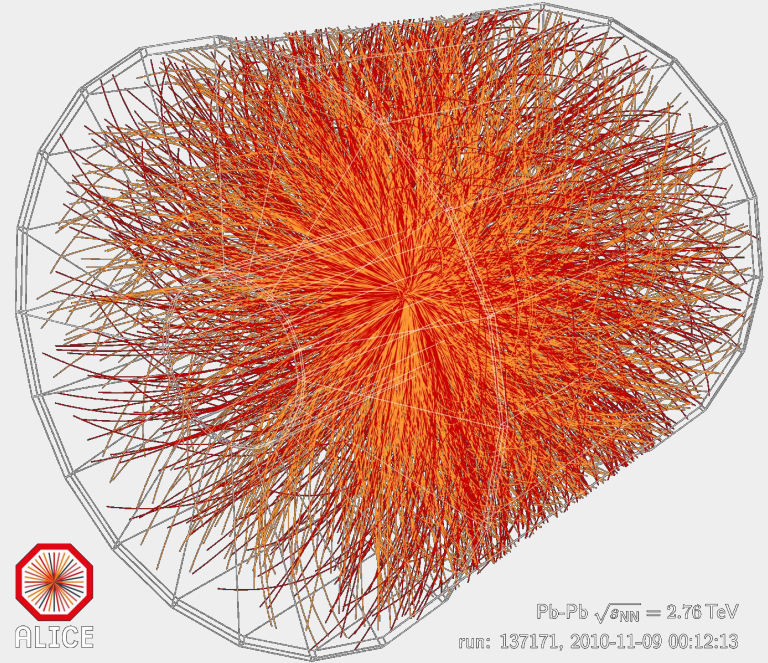


Measuring in heavy ion collisions

Not so easy in practice

Large background in heavy ions

*Need to understand and correct
detector effects*



$$\langle N_{\text{part}} \rangle = \sim \text{thousands}$$

Measuring in heavy ion collisions

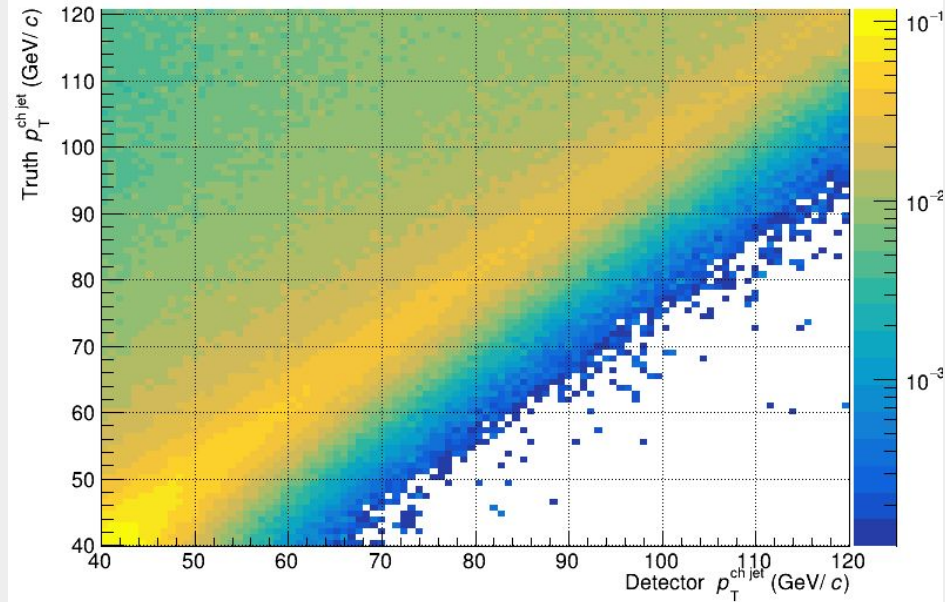
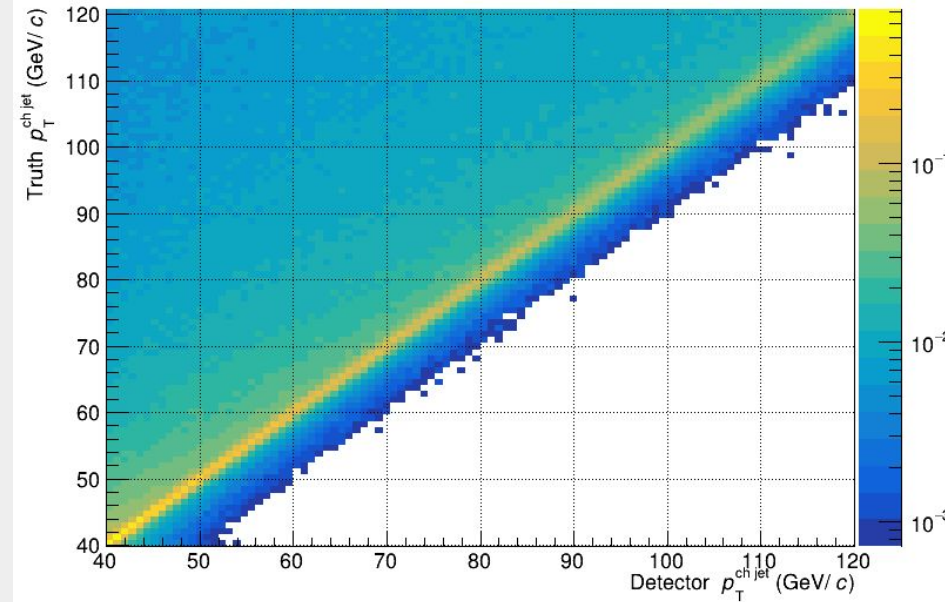
True jet p_T vs. measured jet p_T

pp

PbPb

ALICE MC pp @ 5 TeV, Anti- k_T , $R=0.2$, ch jet, $|\eta_{\text{jet}}| < 0.7$, $40 < p_{T,\text{det}}^{\text{ch jet}} < 120$ GeV/c

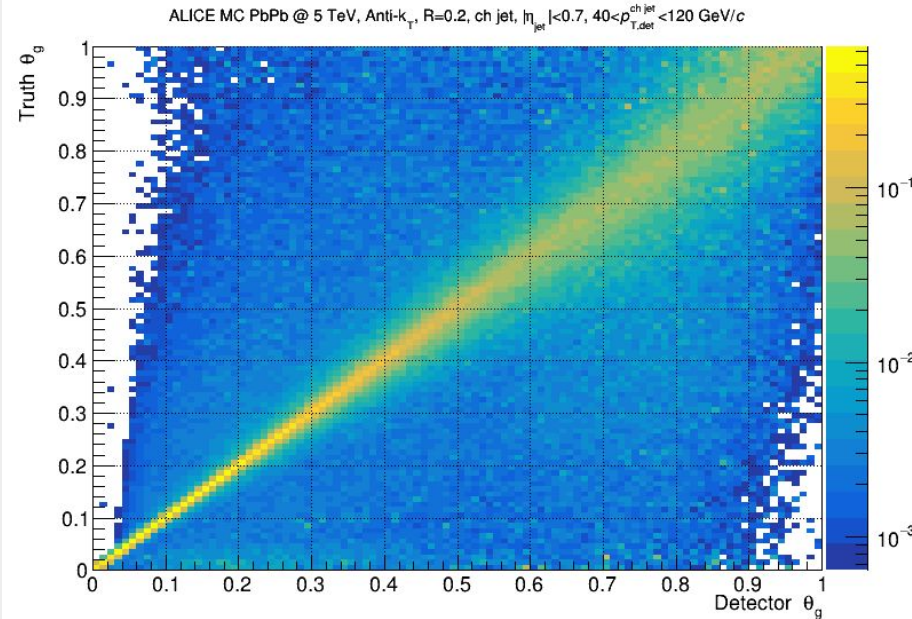
ALICE MC PbPb @ 5 TeV, Anti- k_T , $R=0.2$, ch jet, $|\eta_{\text{jet}}| < 0.7$, $40 < p_{T,\text{det}}^{\text{ch jet}} < 120$ GeV/c



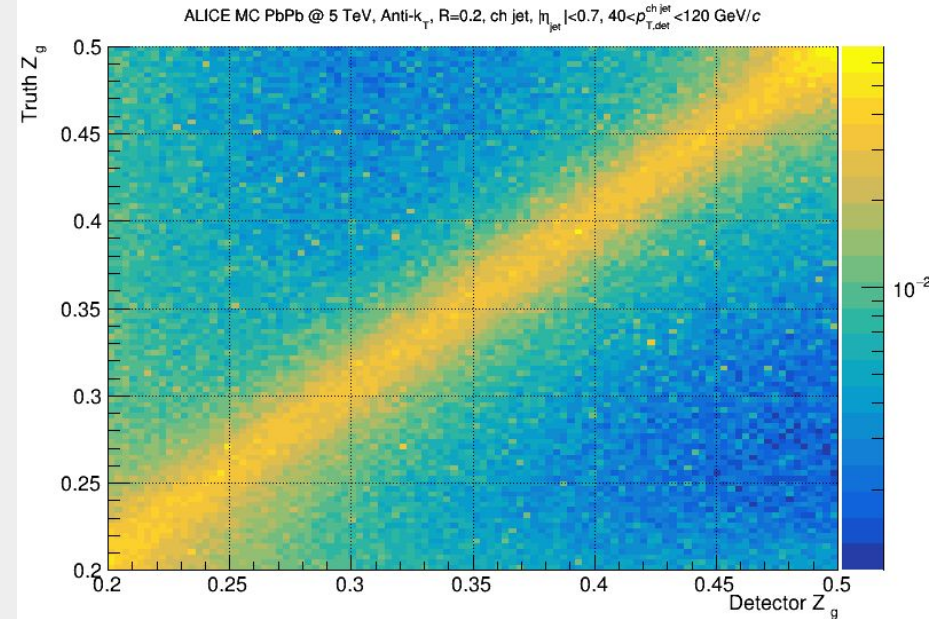
Measuring in heavy ion collisions

Same for other variables
3D problem!

θ_g

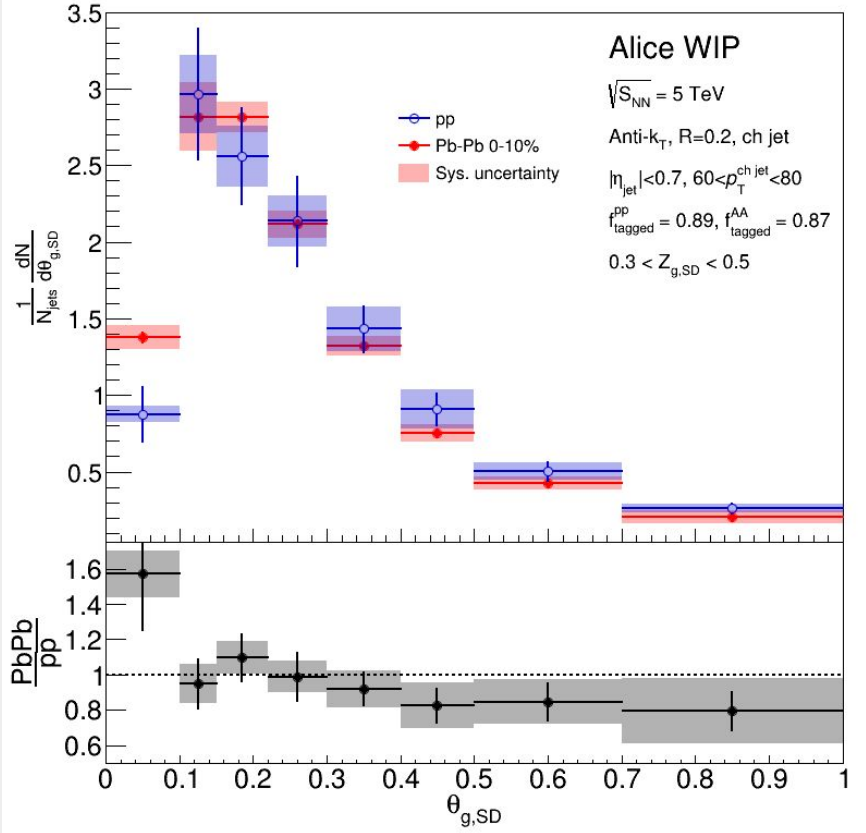
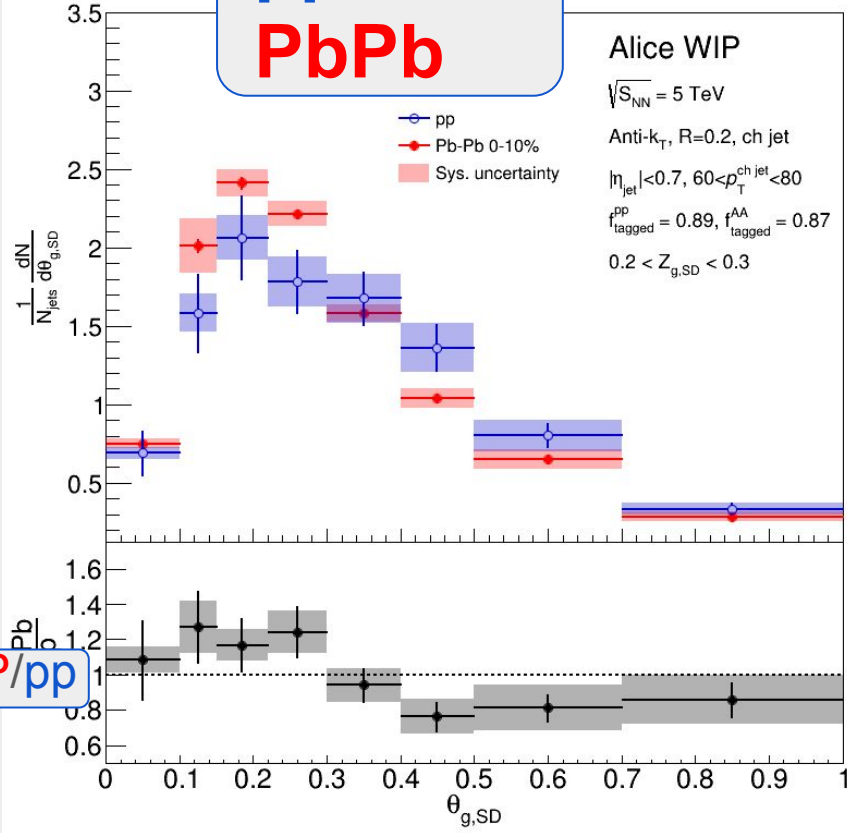


Z_g



Results

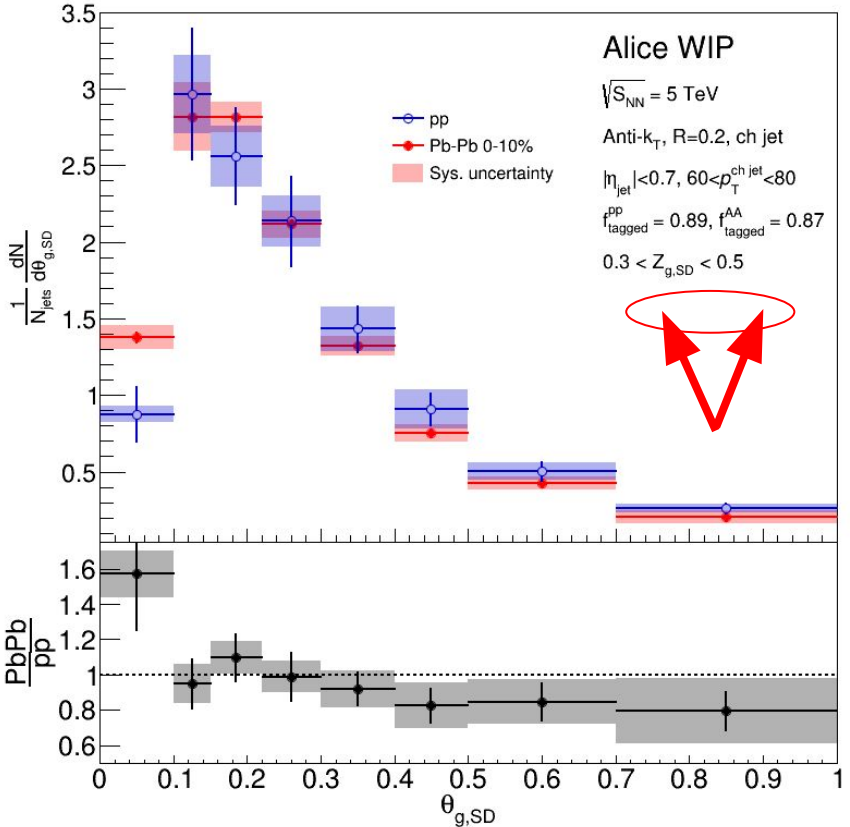
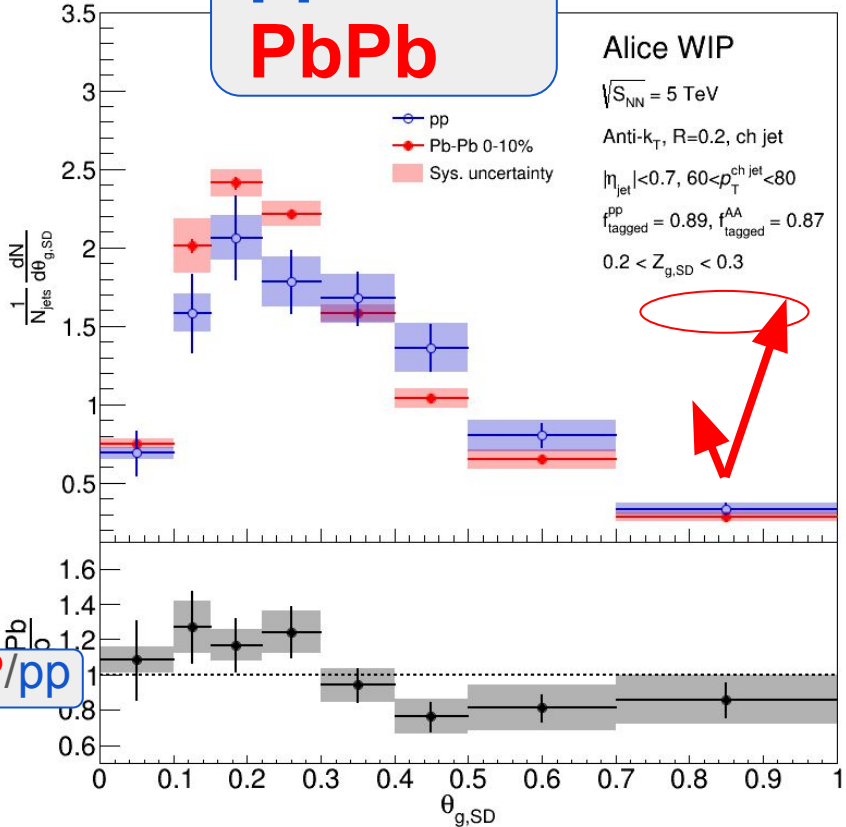
pp
PbPb



PbP/pp

Results

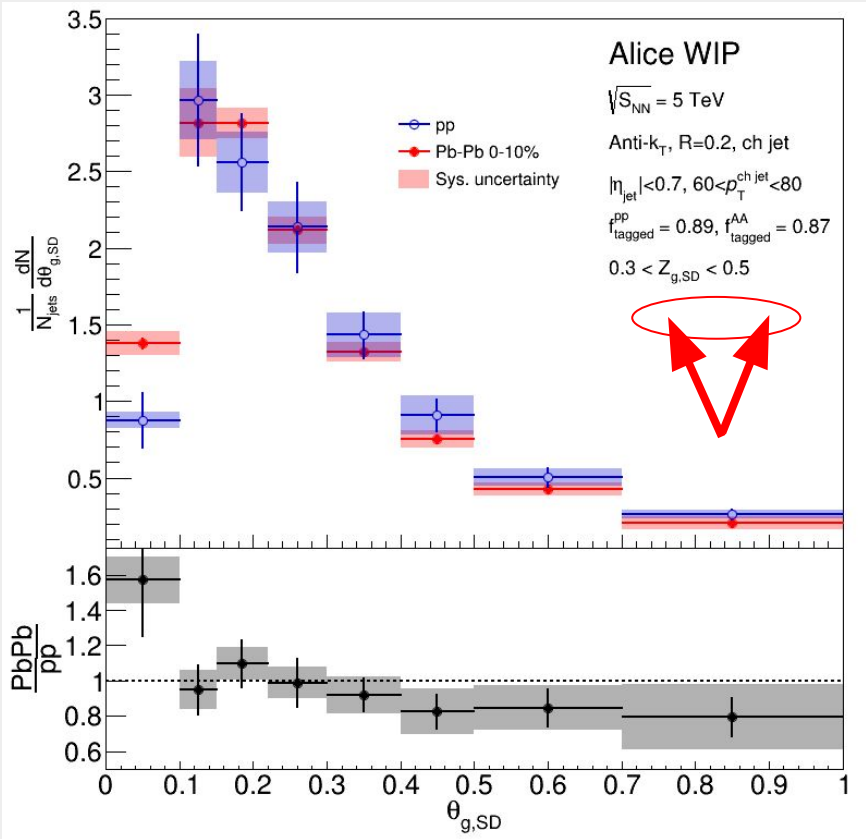
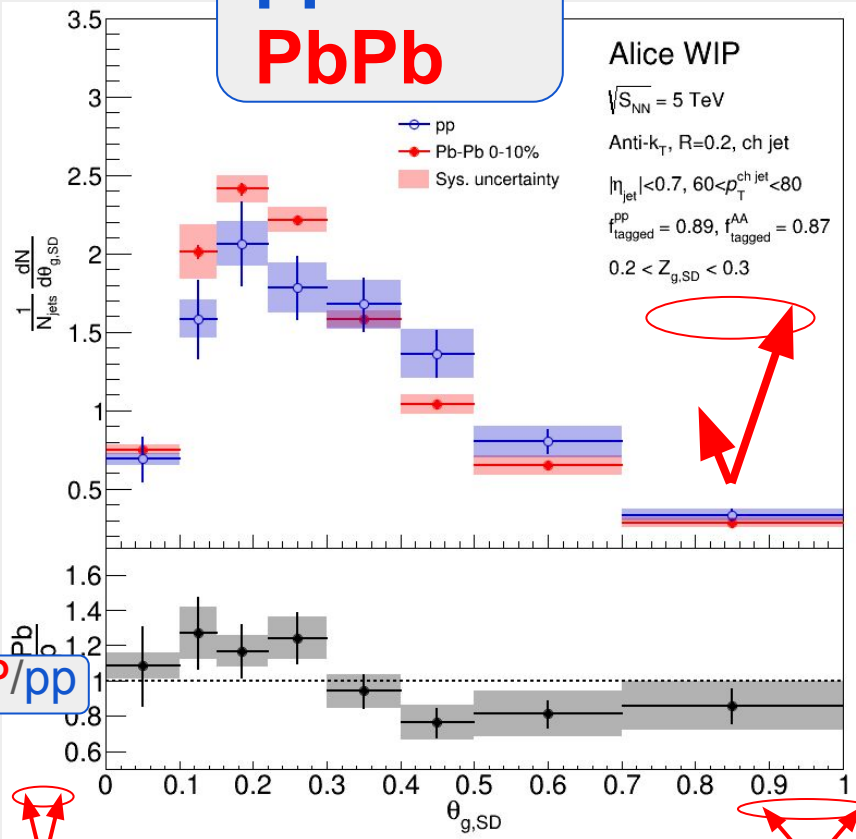
pp
PbPb



PbPb/pp

Results

pp
PbPb

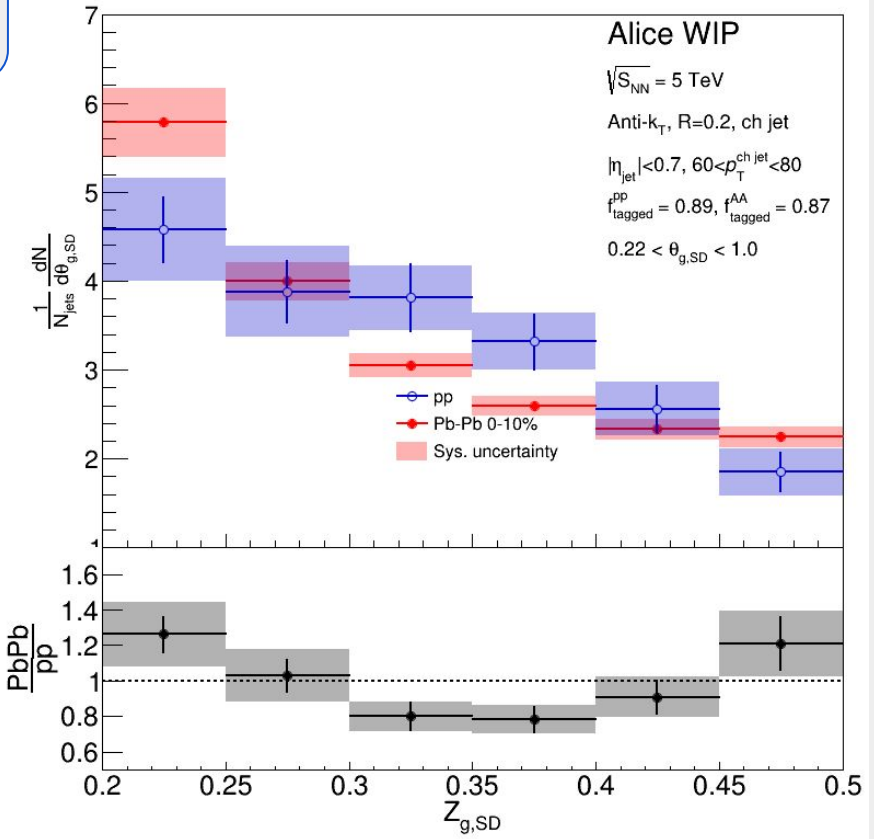
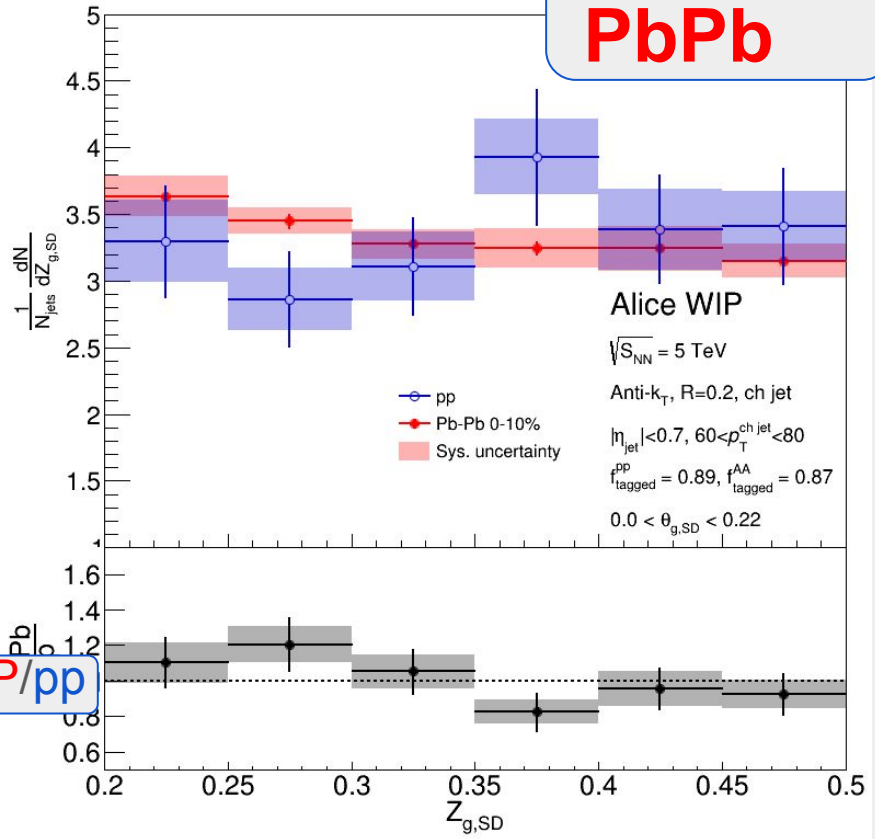


PbP/pp



Results

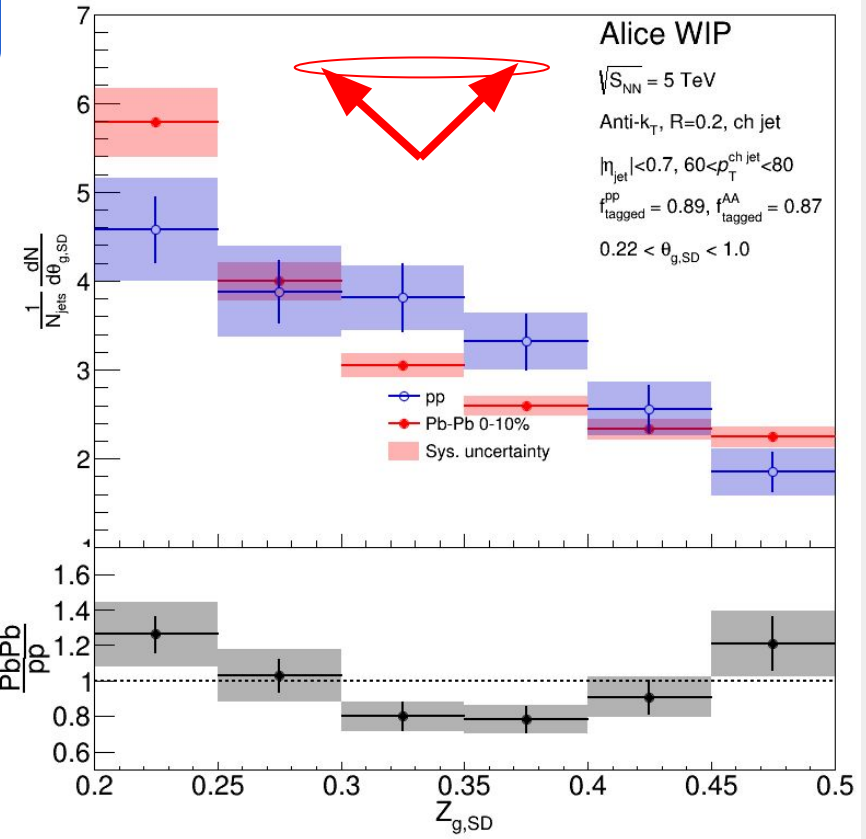
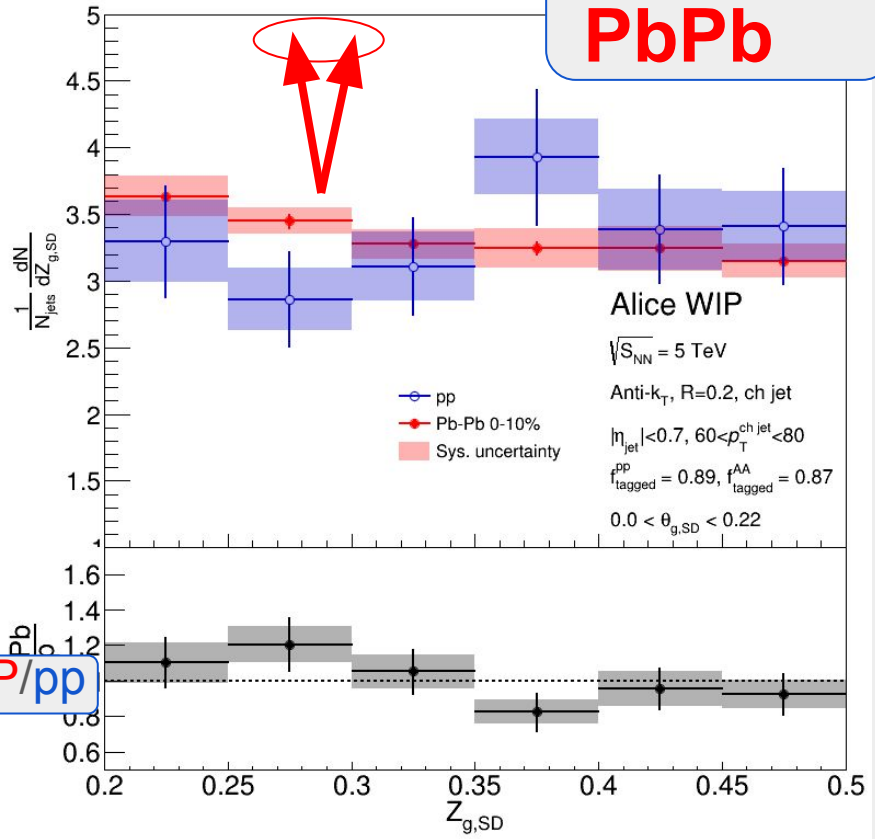
pp
PbPb



PbPb/pp

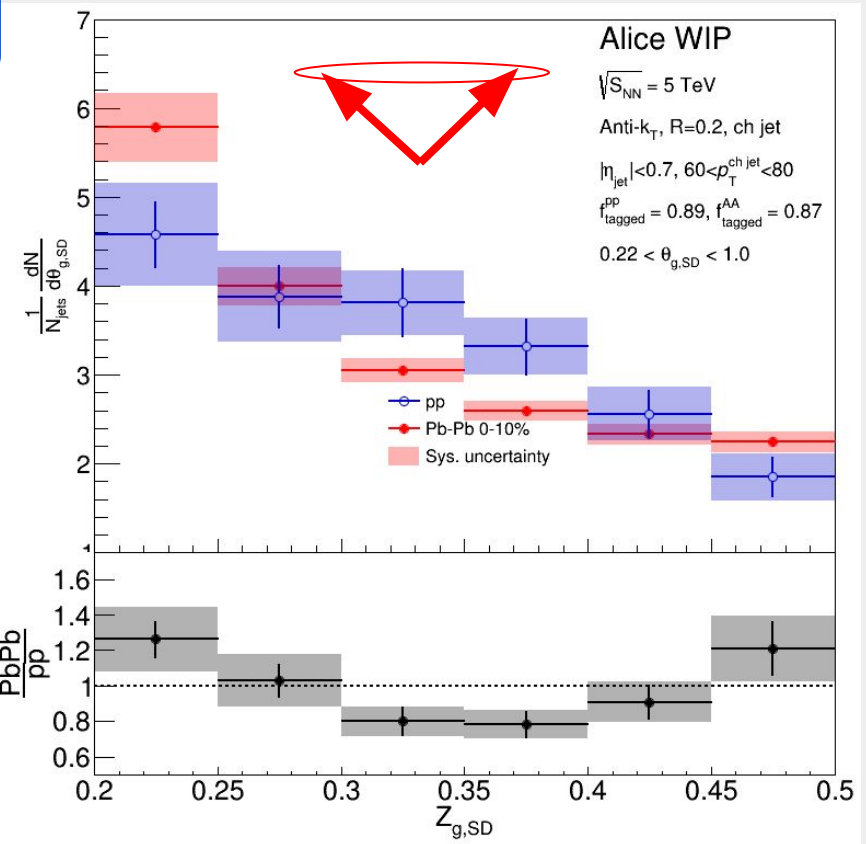
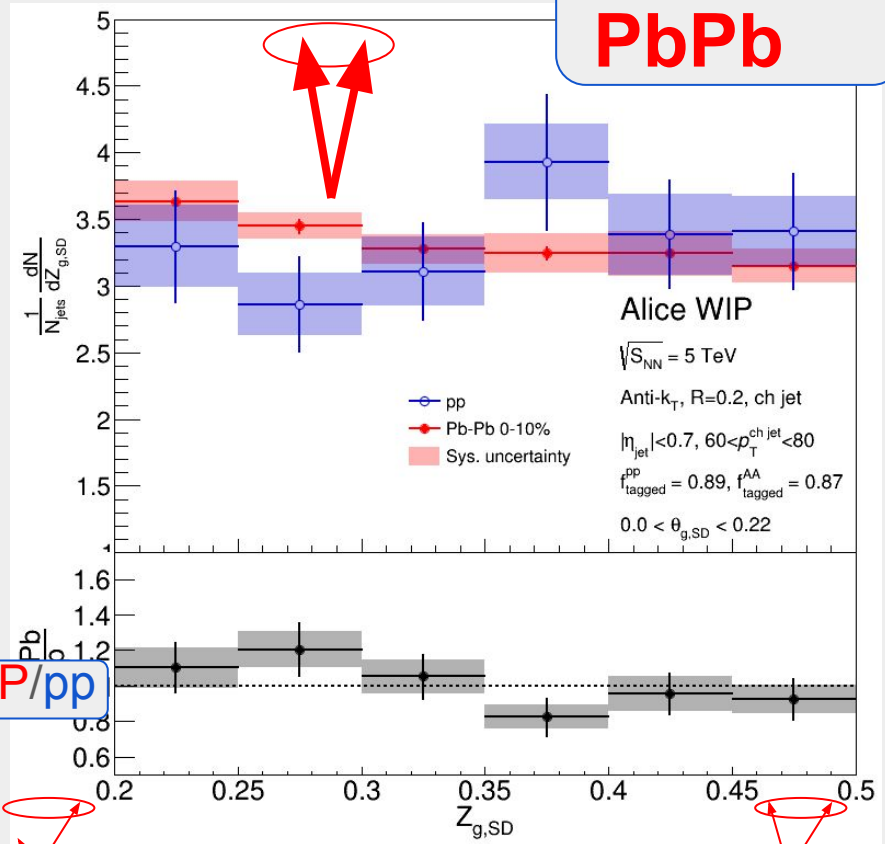
Results

pp
PbPb



Results

pp
PbPb



**Quark gluon plasma + jets
created in heavy ion collisions**

Jets can lose energy in plasma

Also structure might change

Study correlations to find out how

Conclusion

We can see modification of jet
in angular (θ_g) and momentum (Z_g) components

Need to study with Monte Carlo models
to understand physics

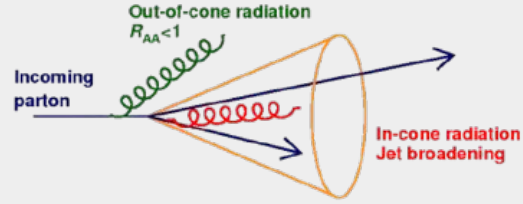
Plan to present on conference in September!

Thanks!

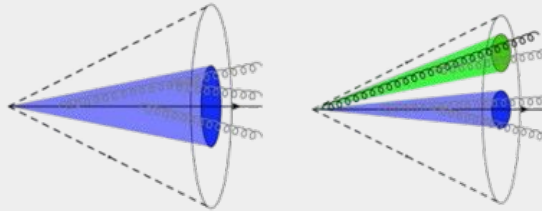
Back up

Medium interactions

Glueon radiation



Color coherence



Medium response

