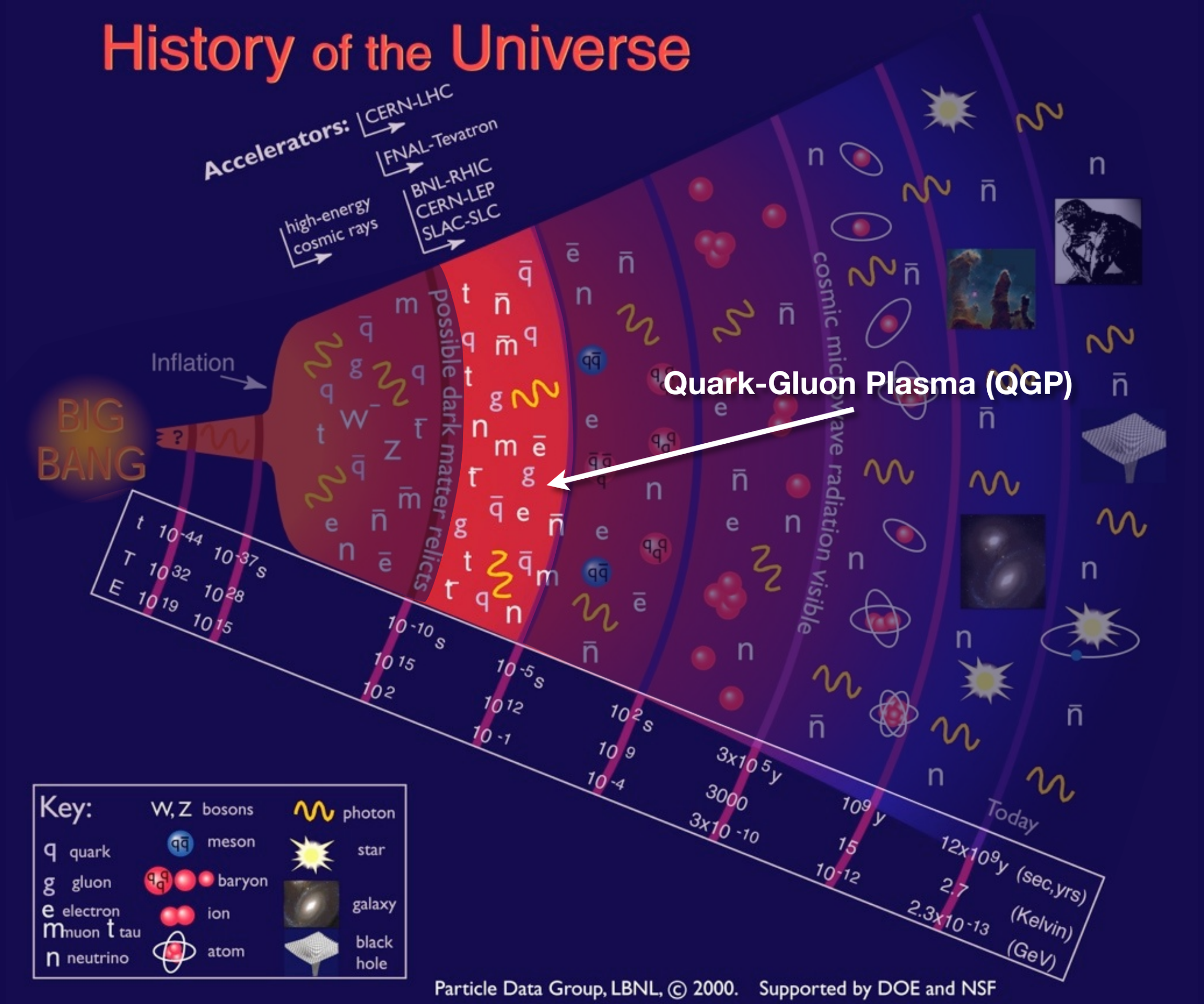
Precision Charged Particle Tracking with PHENIX

Michael P. McCumber
Los Alamos National Laboratory
for the PHENIX Collaboration

APS DNP Meeting 2015
Santa Fe, New Mexico
October 29th 2015


History of the Universe
Accelerators:
CERN-LHC
FNAL-Tevatron
BNL-RHIC
CERN-LEP
SLAC-SLC
high-energy cosmic rays
Inflation
BIG BANG
possible dark matter relicts
cosmic microwave radiation visible
Quark-Gluon Plasma (QGP)
t 10-44 10-37 s
T 1032 1028
E 1019 1015
10-10 s
1015
102
10-5 s
1012
10-1
102 s
109
10-4
3x105 y
3000
3x10-10
109 y
15
10-12
12x109 y (sec,yrs)
2.7 (Kelvin)
2.3x10-13 (GeV)
Today
Key:
q quark
g gluon
e electron
m muon t tau
n neutrino
W, Z bosons
meson
baryon
ion
atom
photon
star
galaxy
black hole
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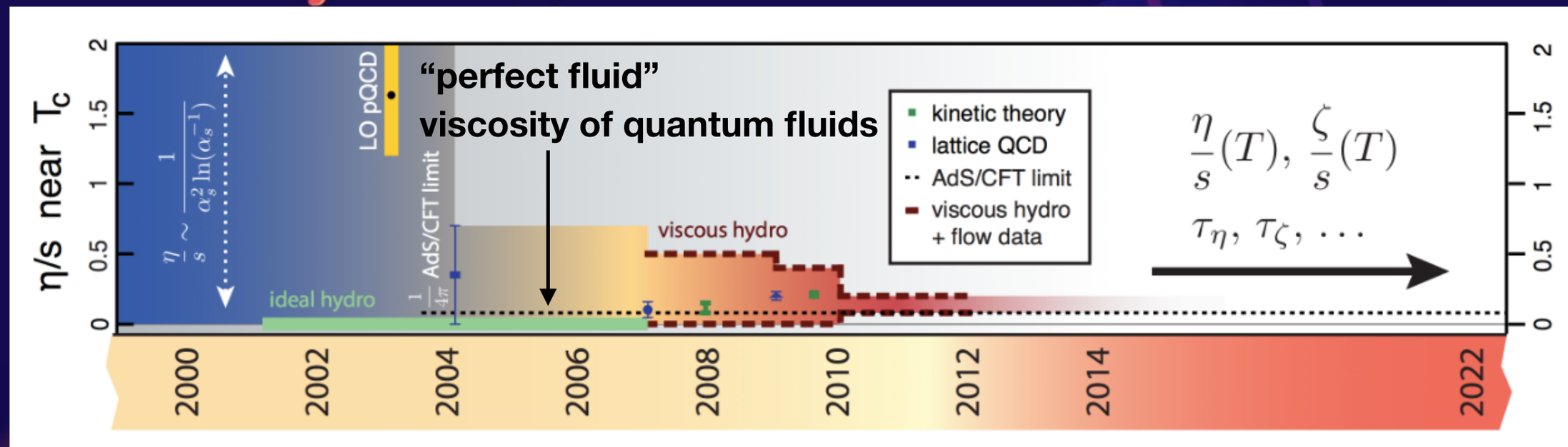
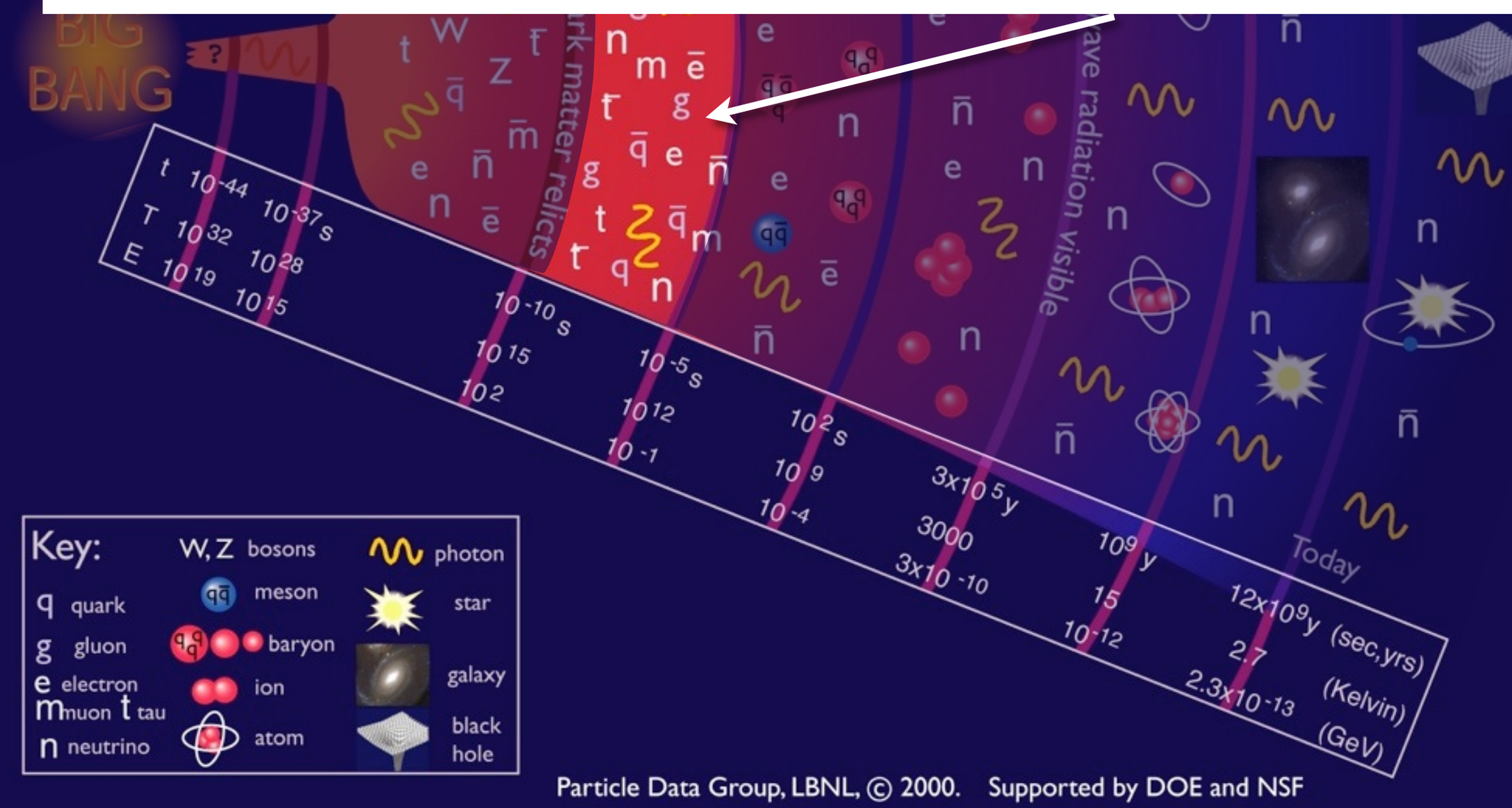
History of the Universe





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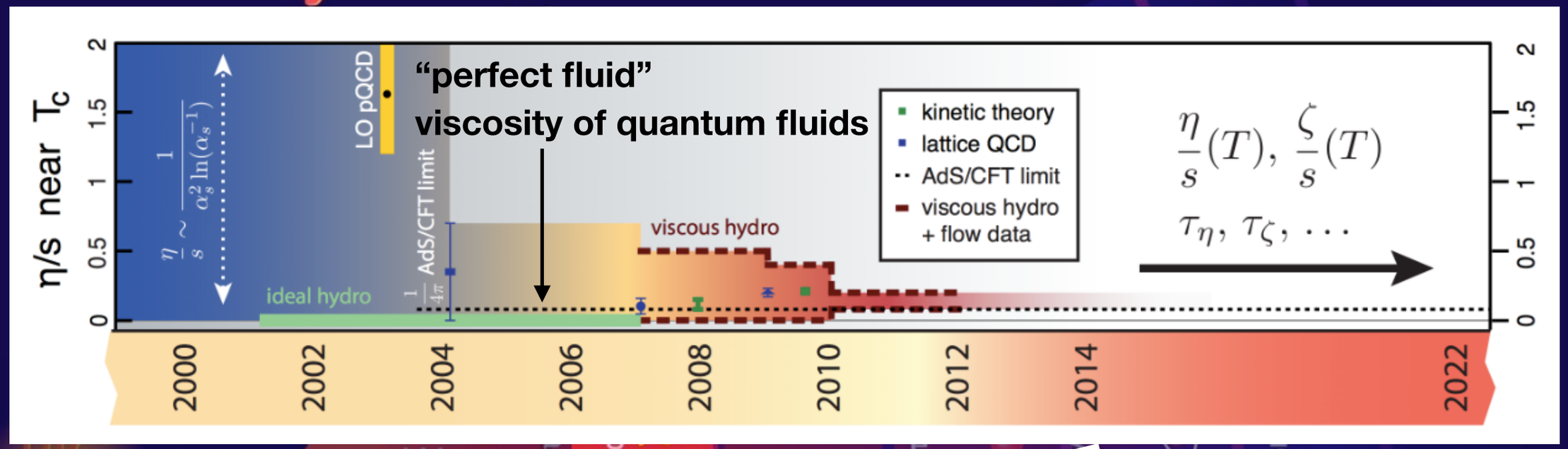

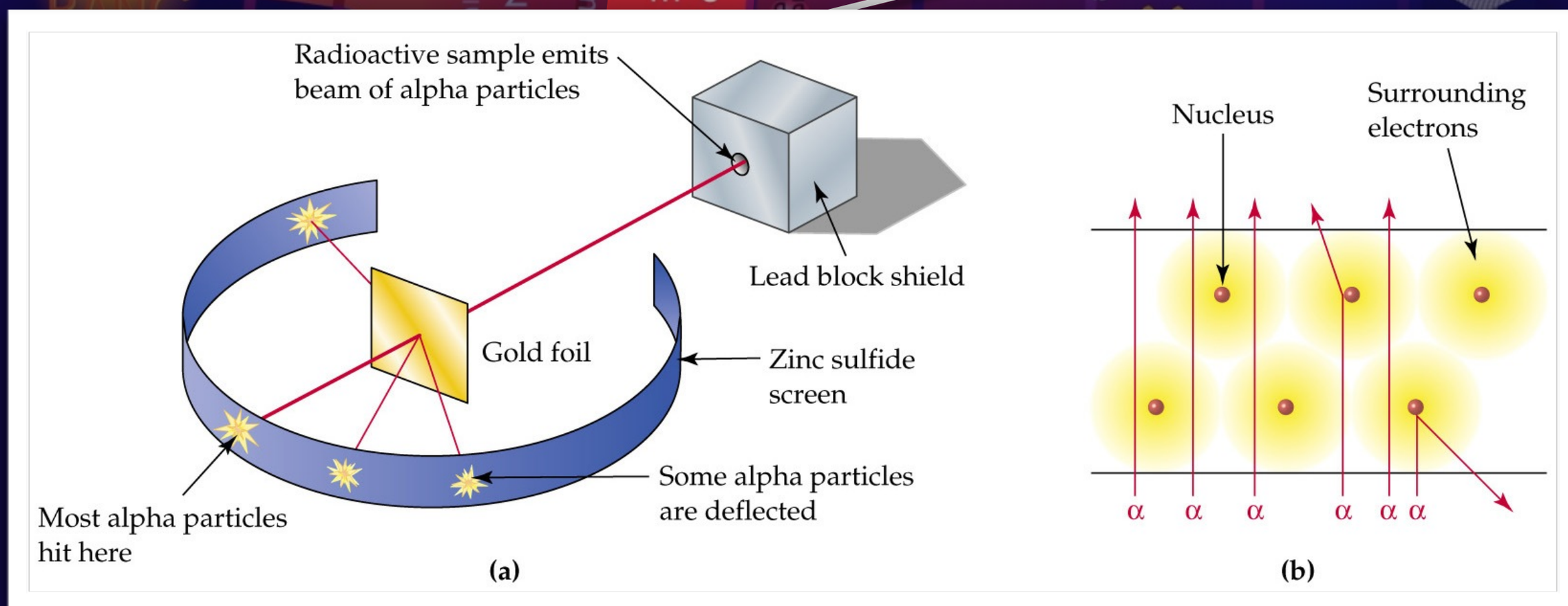

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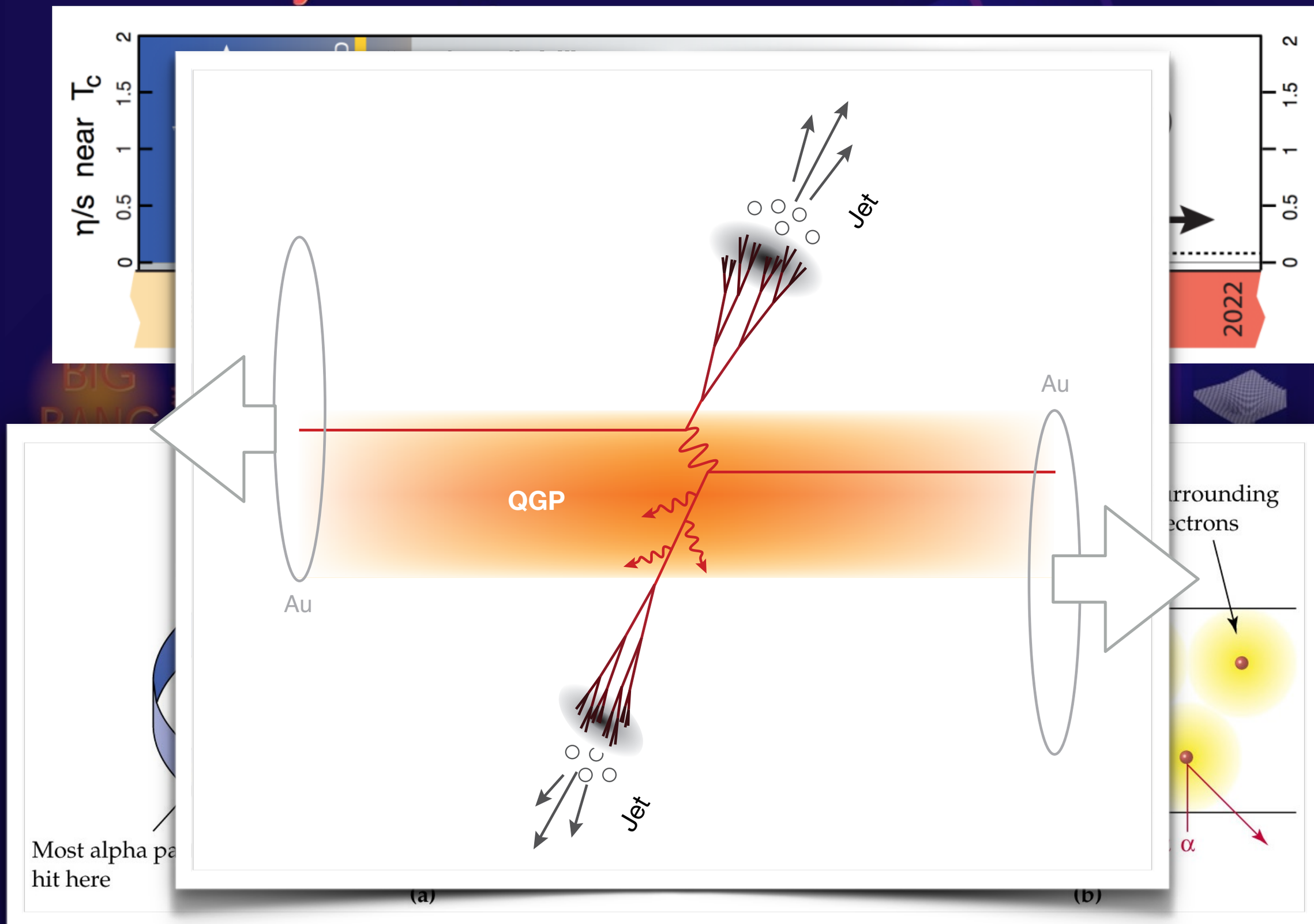
History of the Universe



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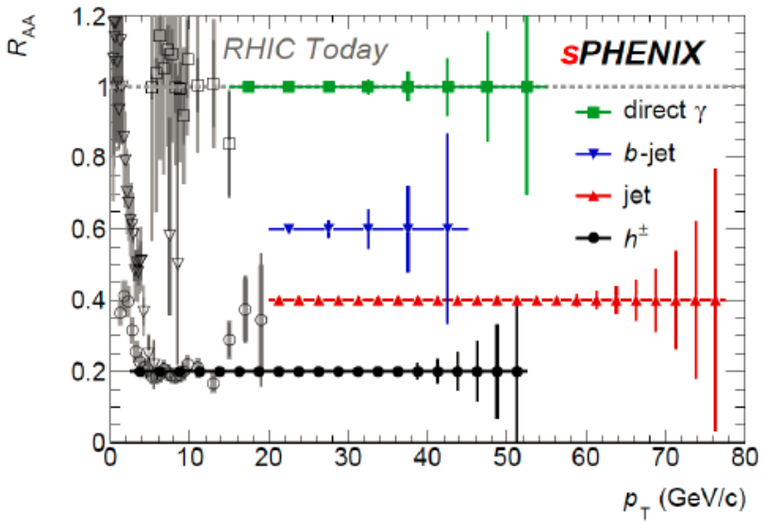
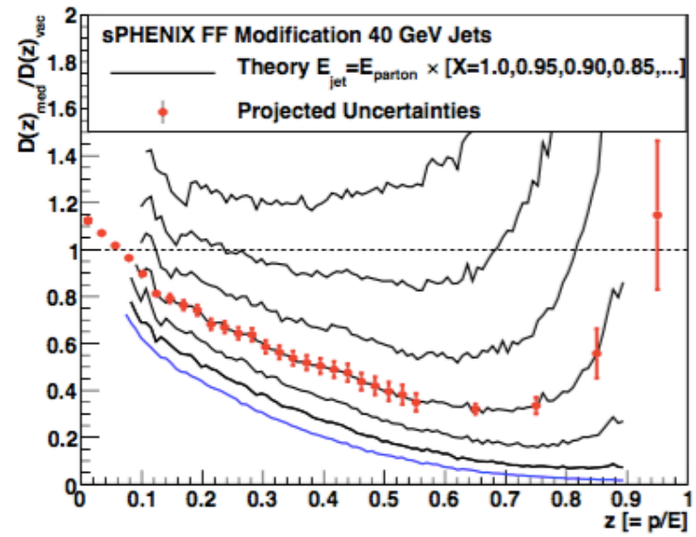
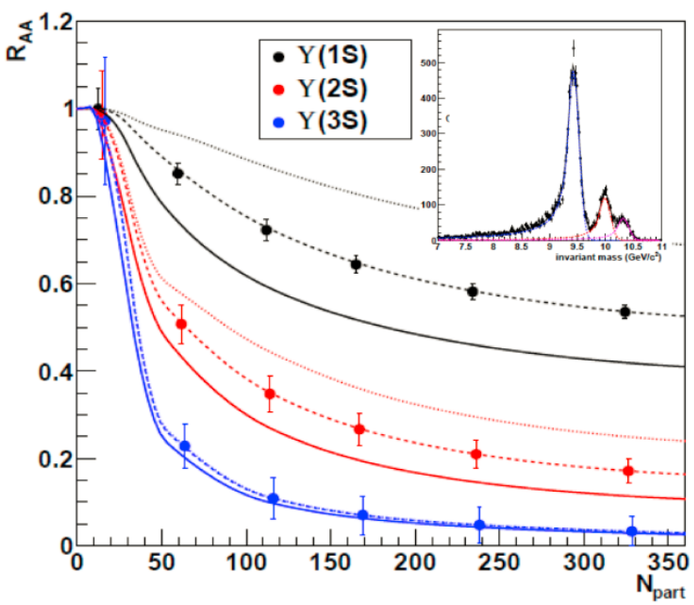
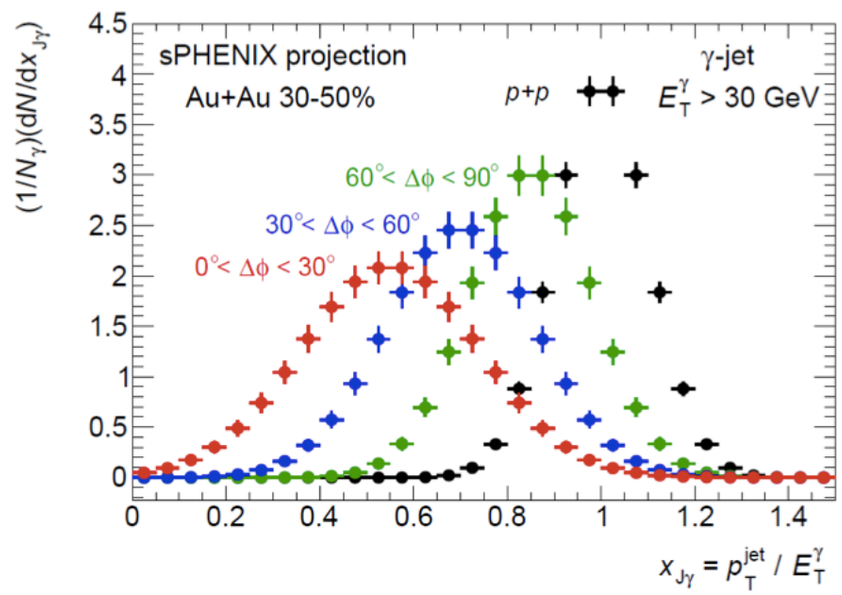
sPHENIX proposal

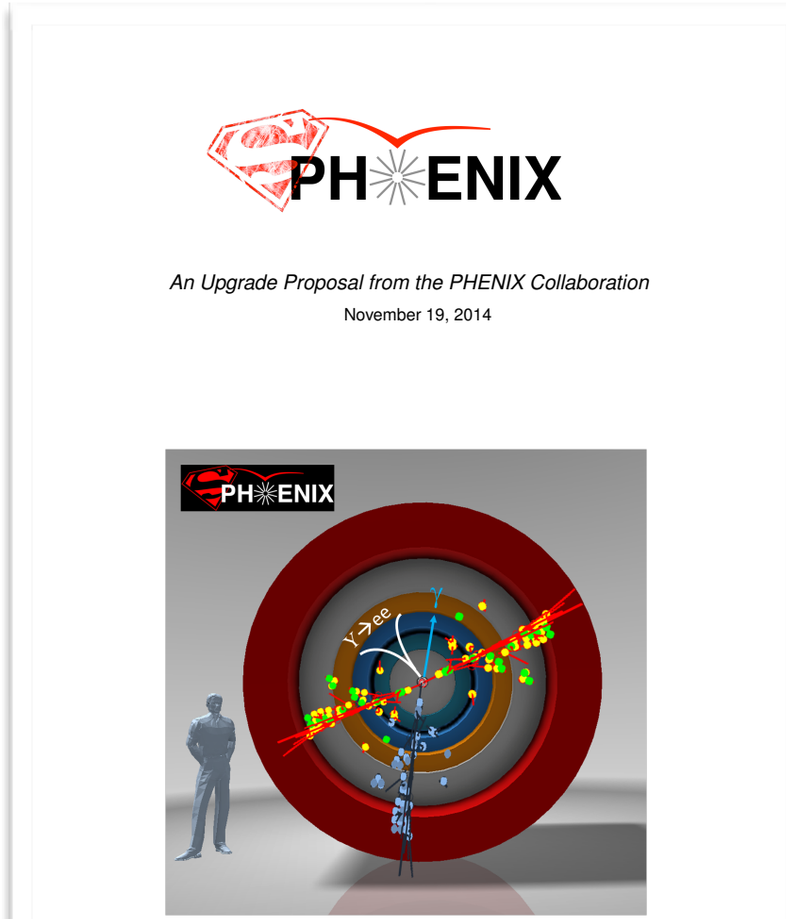
Jets and Upsilons…











nucl-ex/1501.06197

Goal: study of QGP structure over a range of length scales and temperatures with **hard-scattered probes**

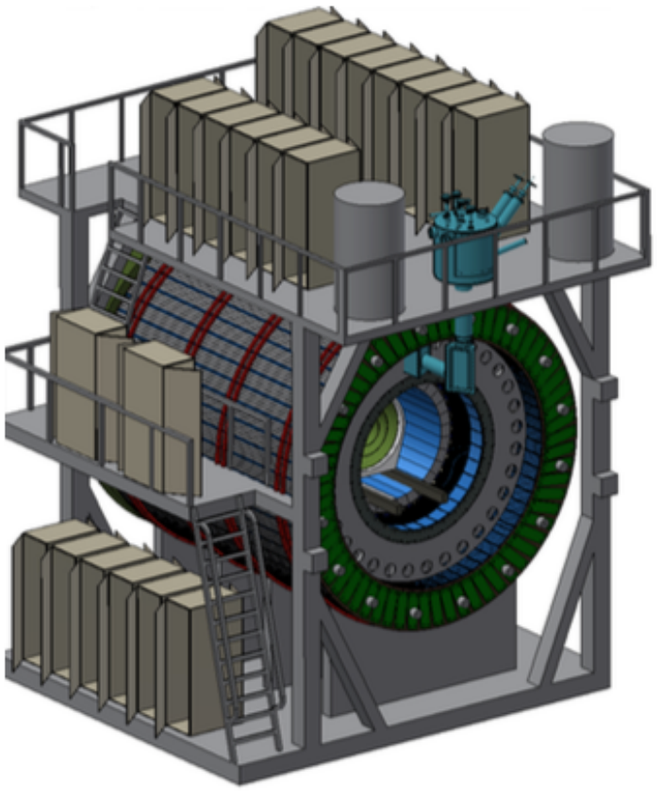
"[sPHENIX] presented a compelling physics program."
~ sPHENIX Science Review Committee

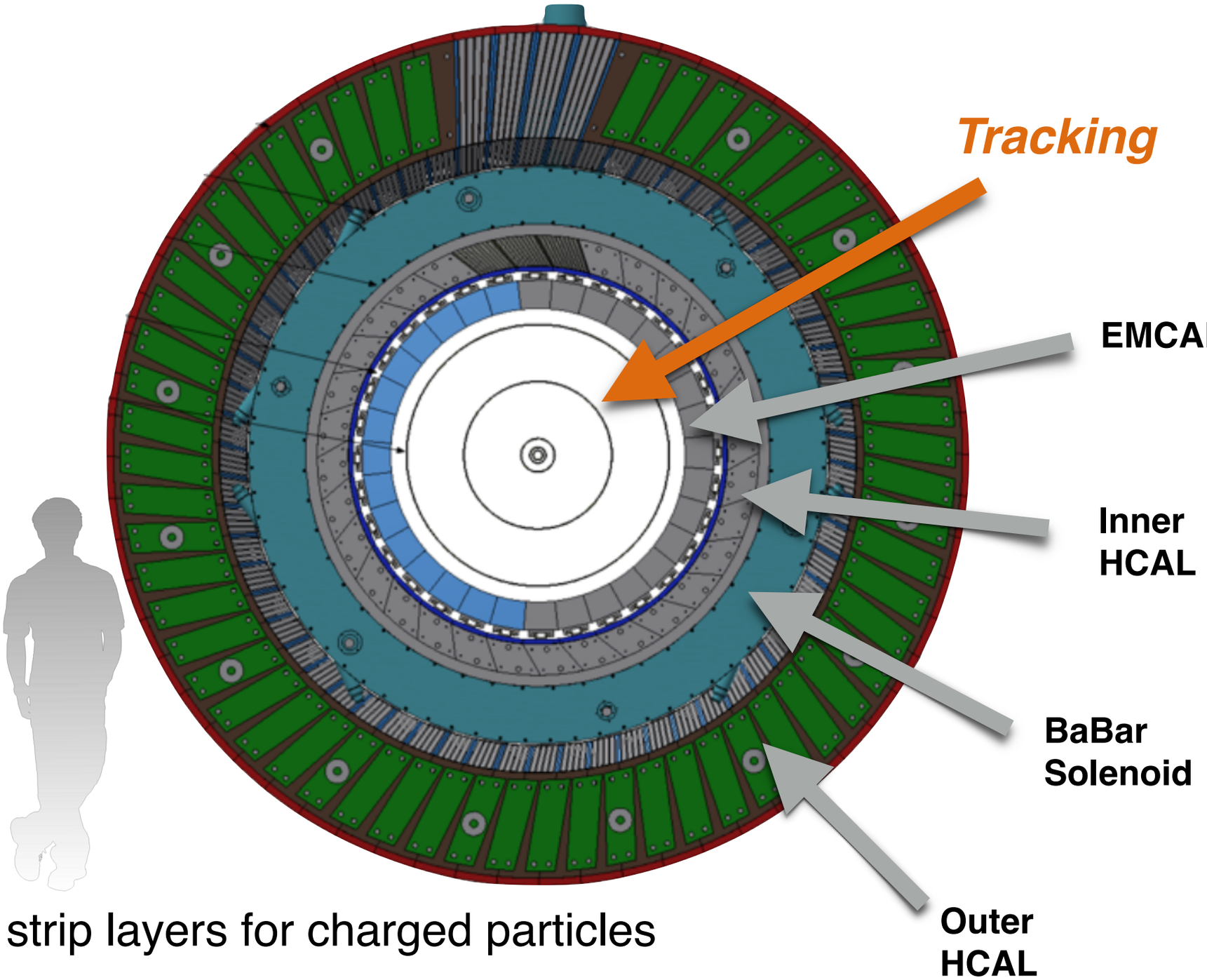
sPHENIX highlighted in Hot QCD Long Range Plan

Updates include:

- jet trigger estimates
- b-tagged jets
- updated luminosity proj.
- jet+X observables
- tracking performance
- etc…

sPHENIX Detector Design

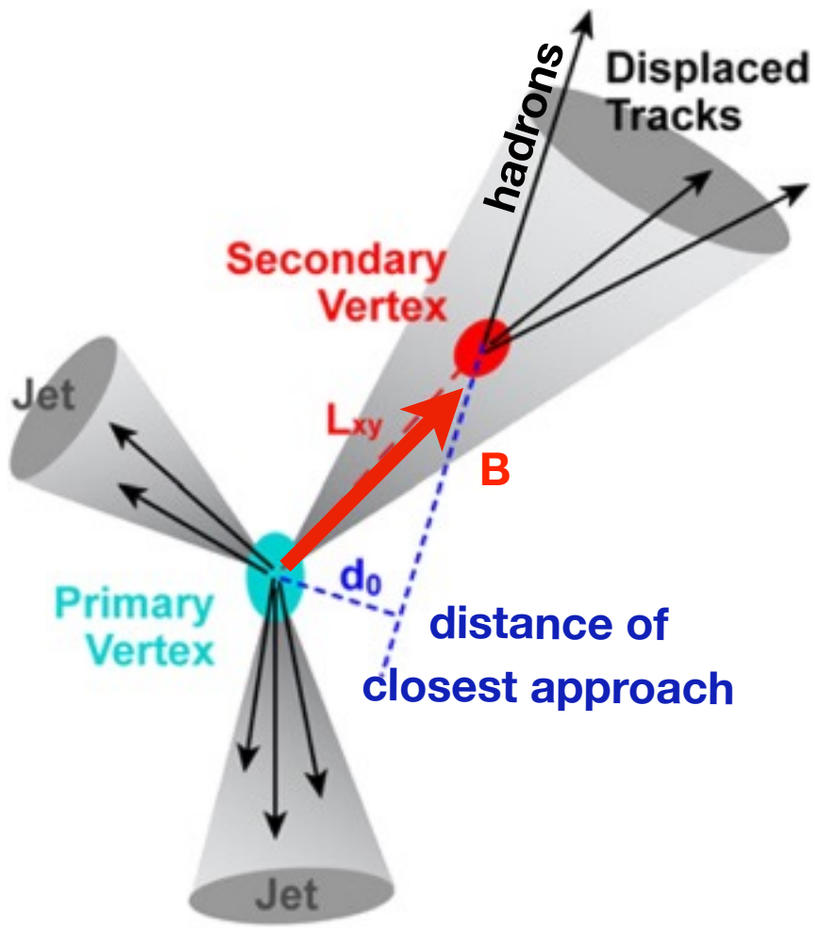




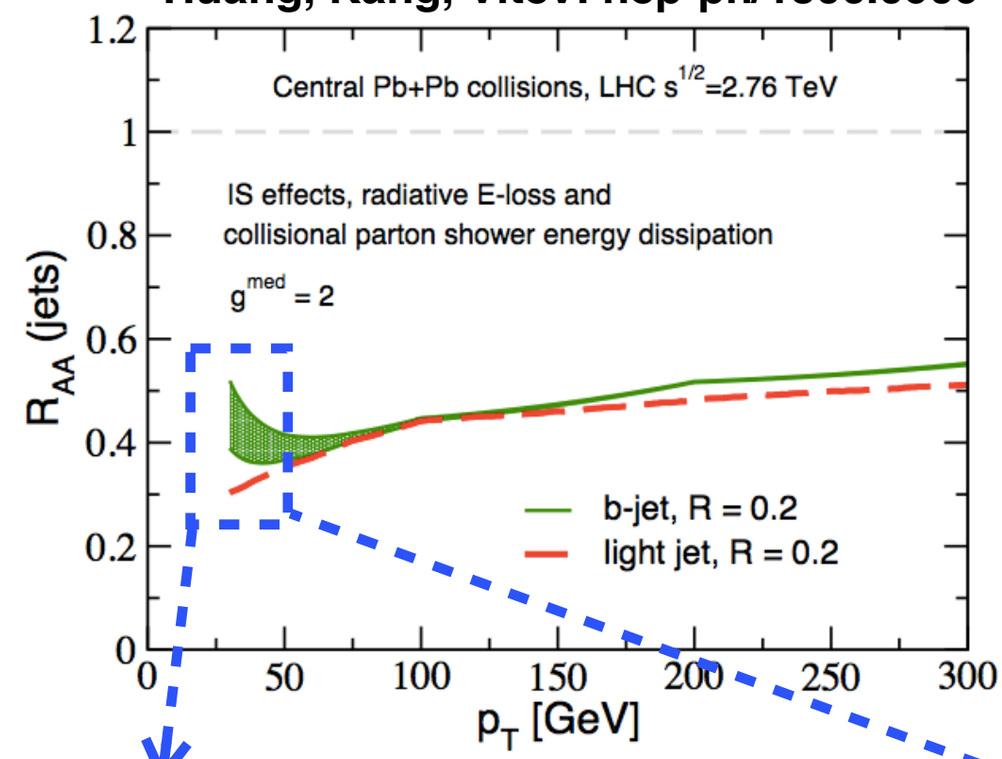
Conceptual Design:

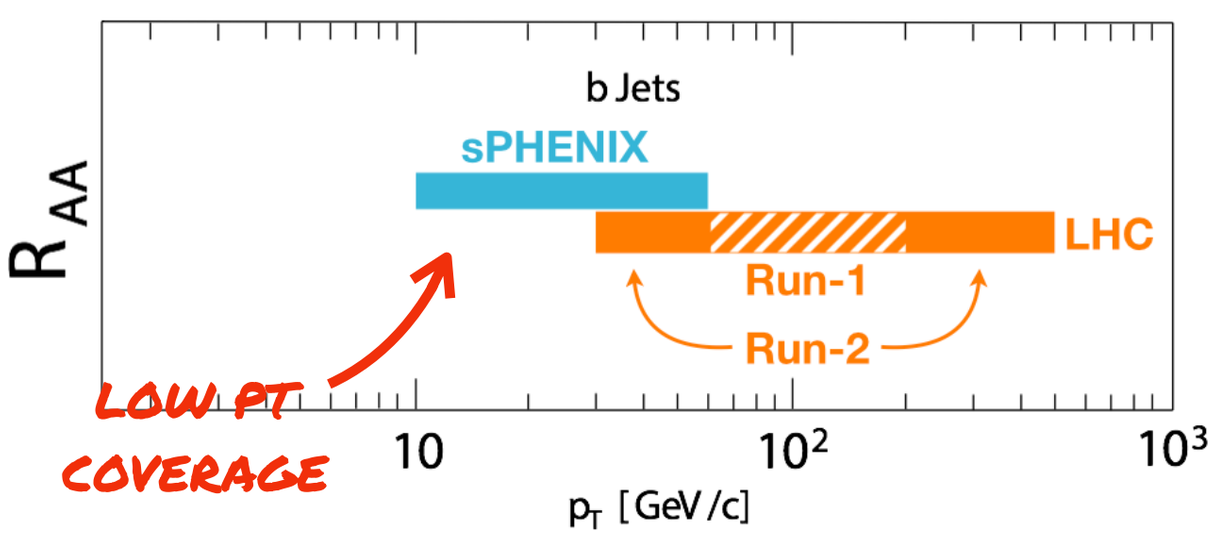
- $-1.1 < \eta < +1.1$, $\Delta\phi = 2\pi$
- BaBar solenoid, 1.5 T
- Reconfigured pixel + new strip layers for charged particles
- EMCal to measure photons & electrons
- Inner+Outer HCAL to complete jet measurement
- High rate DAQ, 15 kHz

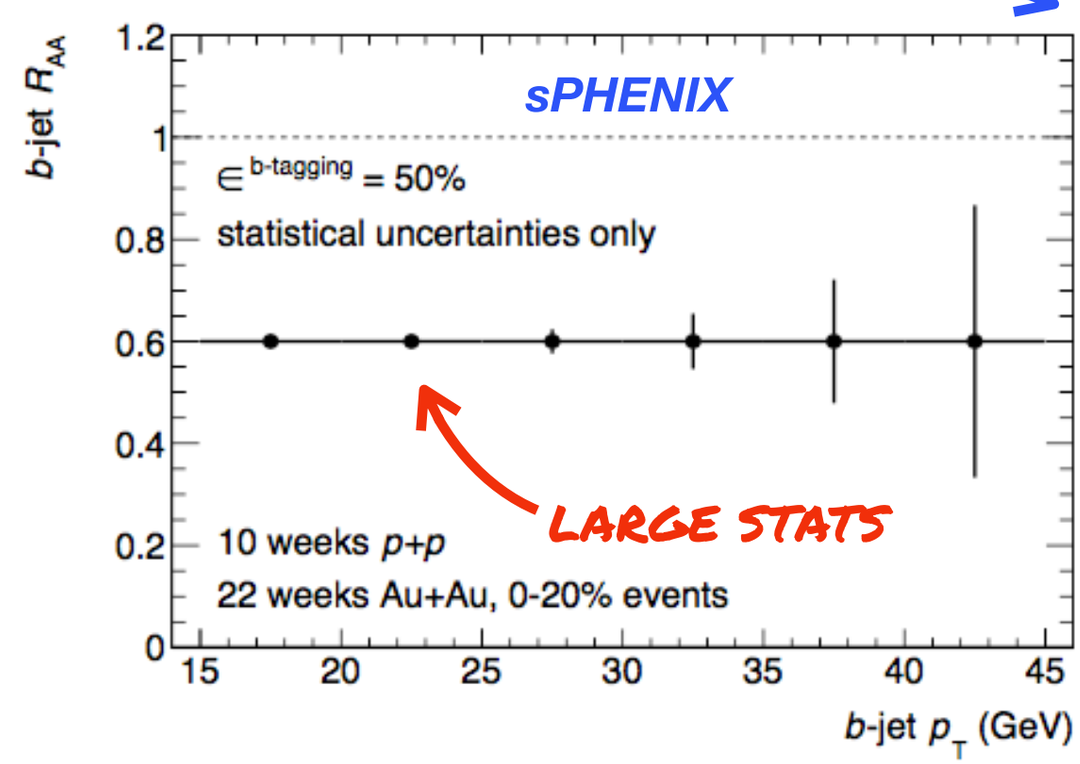
sPHENIX excels: b-jet Channel



Huang, Kang, Vitev: hep-ph/1306.0909







sPHENIX excels: Upsilon Channel

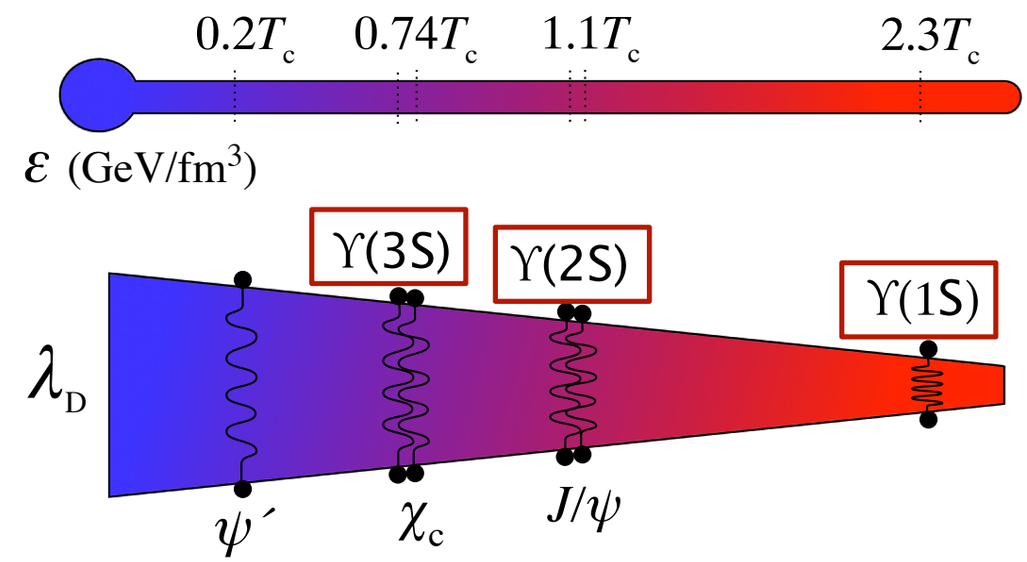
RHIC vs. LHC collision energy:

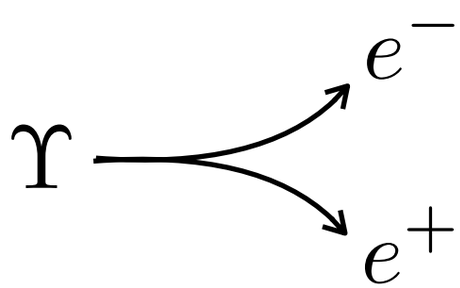
(1)30% temperature reduction

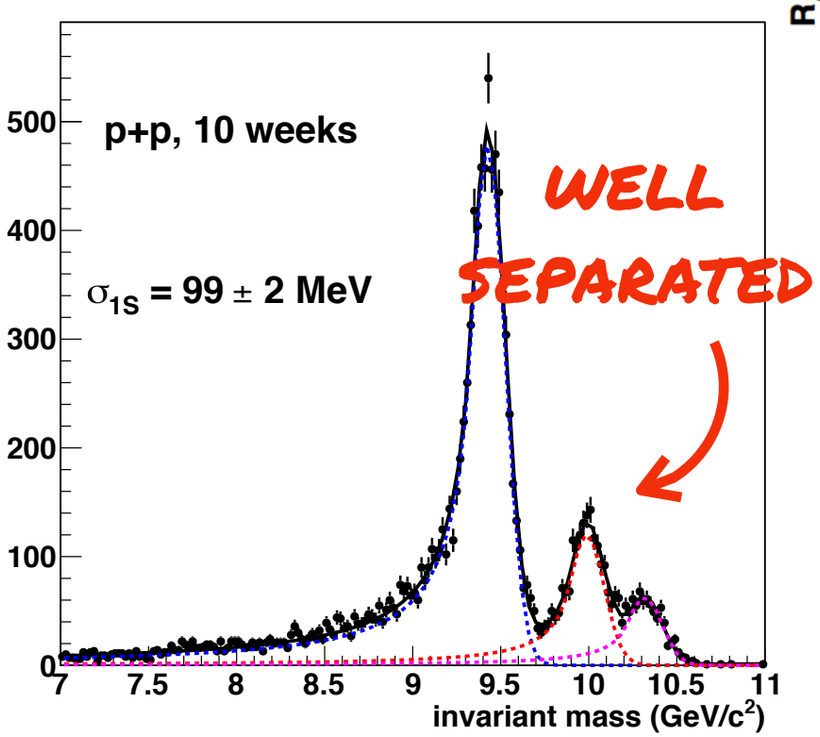
(2)negligible recombination rates

(3)different mixture CNM effects

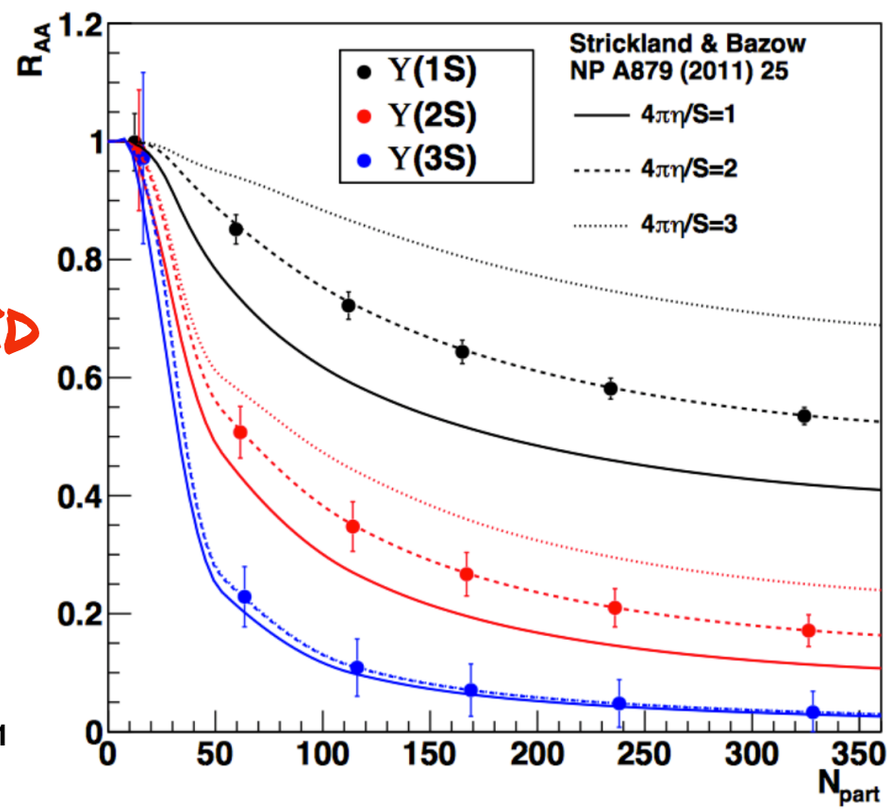
(4)transverse momentum dependent suppression



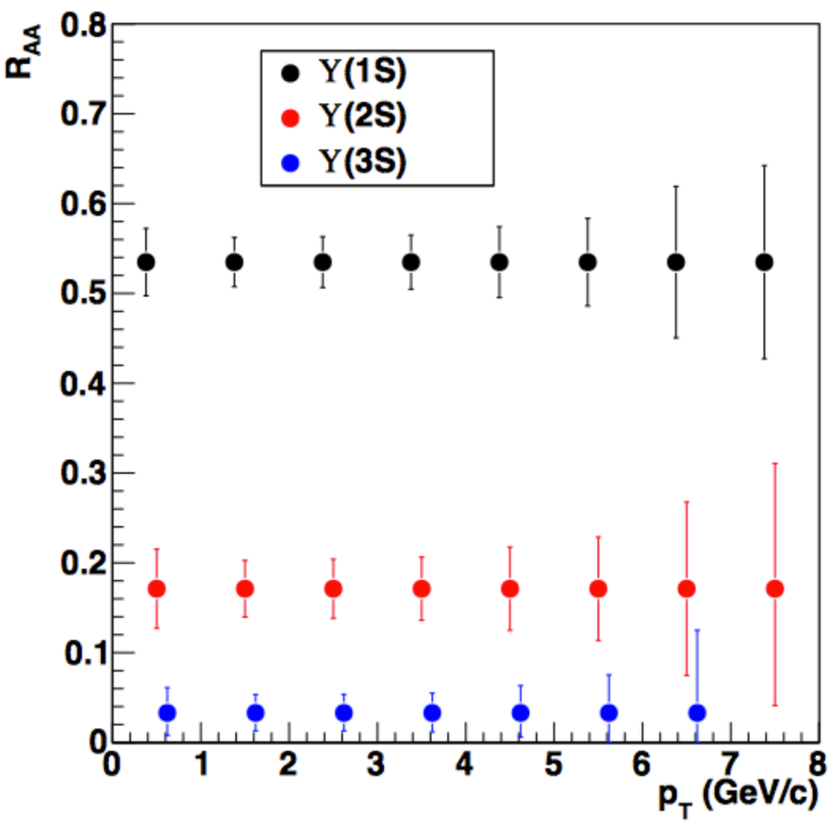




centrality dependence



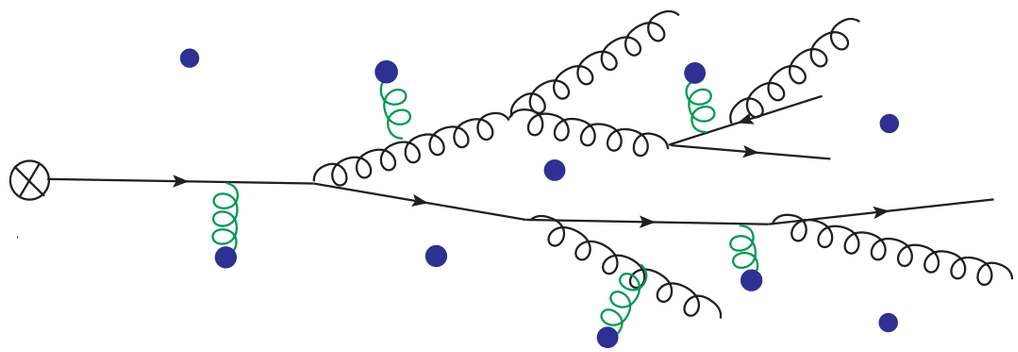
momentum dependence

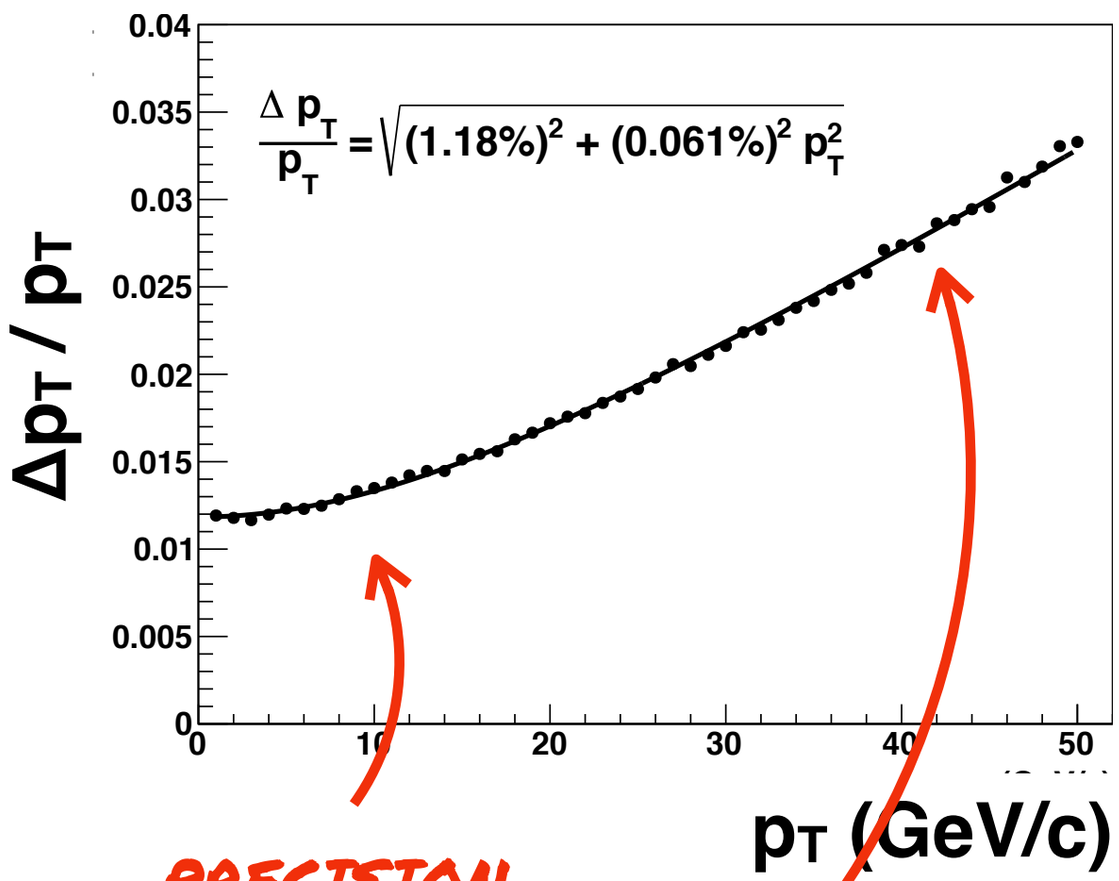


+ comparable CNM measurements in p+A

sPHENIX excels: Jet Fragmentation

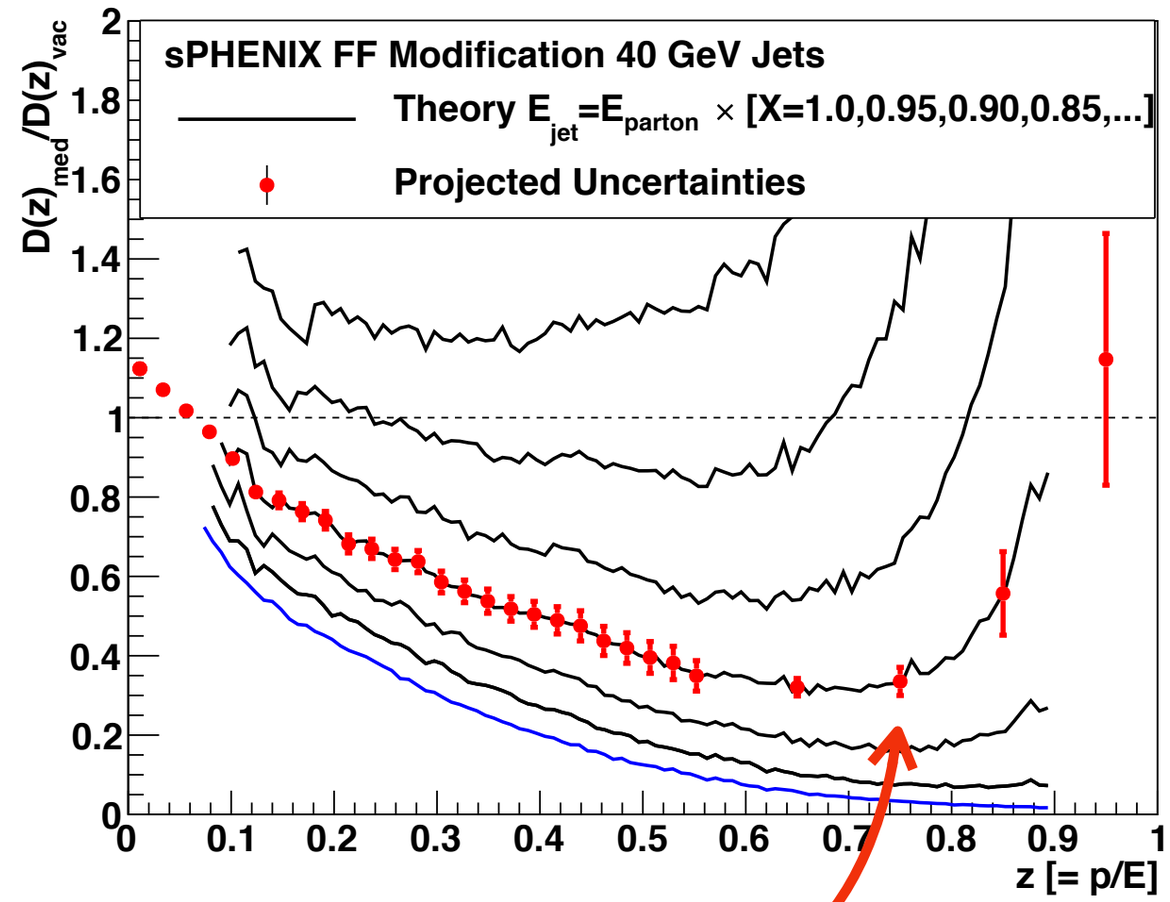
Jet fragmentation substructure at large angles & low momentum





PRECISION FOR UPSILON

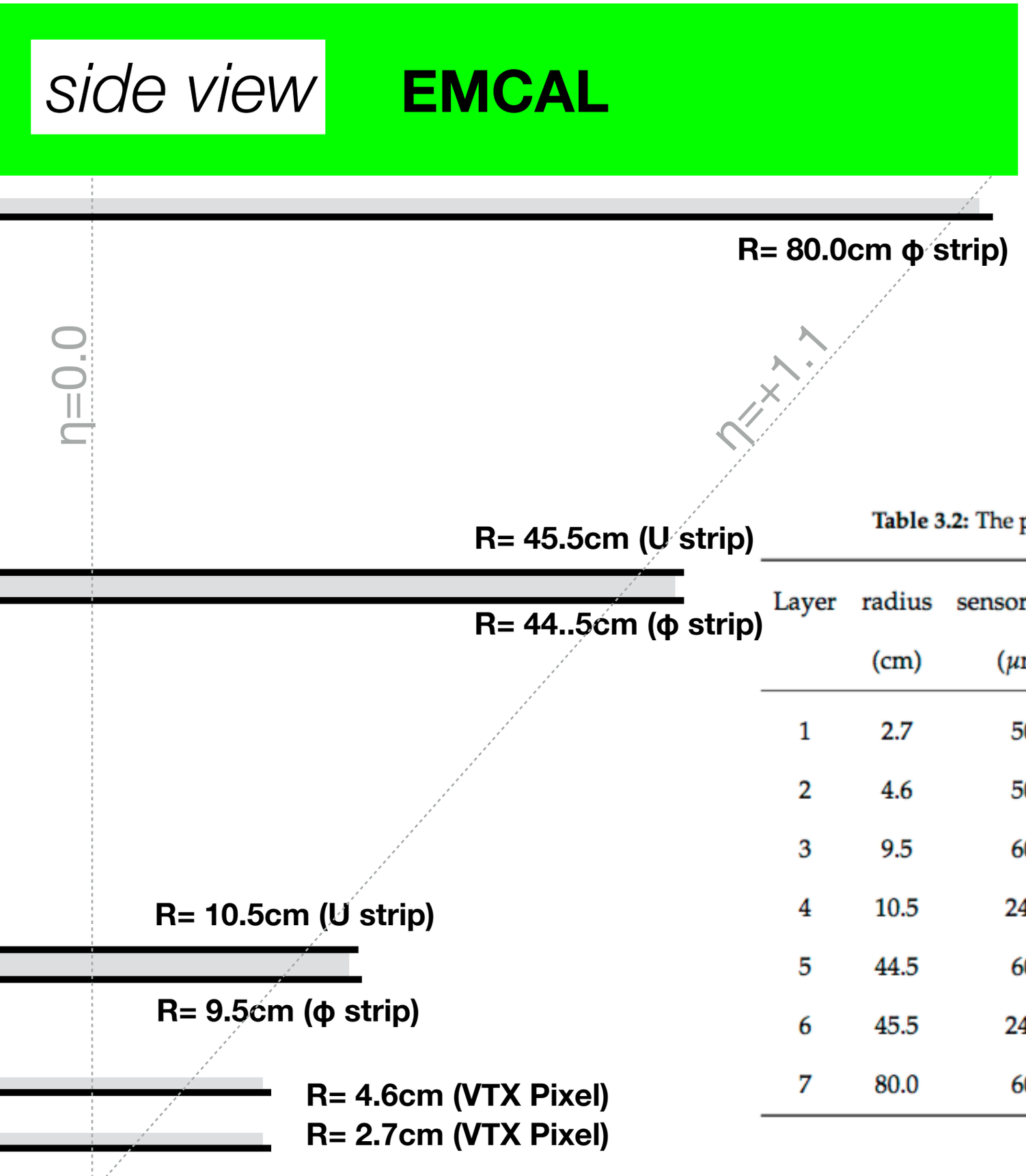
...AND FOR D(Z)



LARGE STATS

Precision measurements of energy loss in and out of jet cone

Hybrid Silicon Tracking Option



sPHENIX conceptual design

Provides 100 MeV/c^2 mass resolution for Upsilon states

Technical design R&D ongoing

Optimizations: smaller mass, smaller area

Table 3.2: The parameters of the reference configuration tracking layers.

Layer	radius (cm)	sensor pitch (μm)	sensor length (mm)	sensor depth (μm)	total thickness % X_0	area m^2
1	2.7	50	0.425	200	1.3	0.034
2	4.6	50	0.425	200	1.3	0.059
3	9.5	60	8	320	1.35	0.152
4	10.5	240	2	320	1.35	0.185
5	44.5	60	8	320	1	3.3
6	45.5	240	2	320	1	3.5
7	80.0	60	8	320	2	10.8

Hybrid Silicon Tracking Option

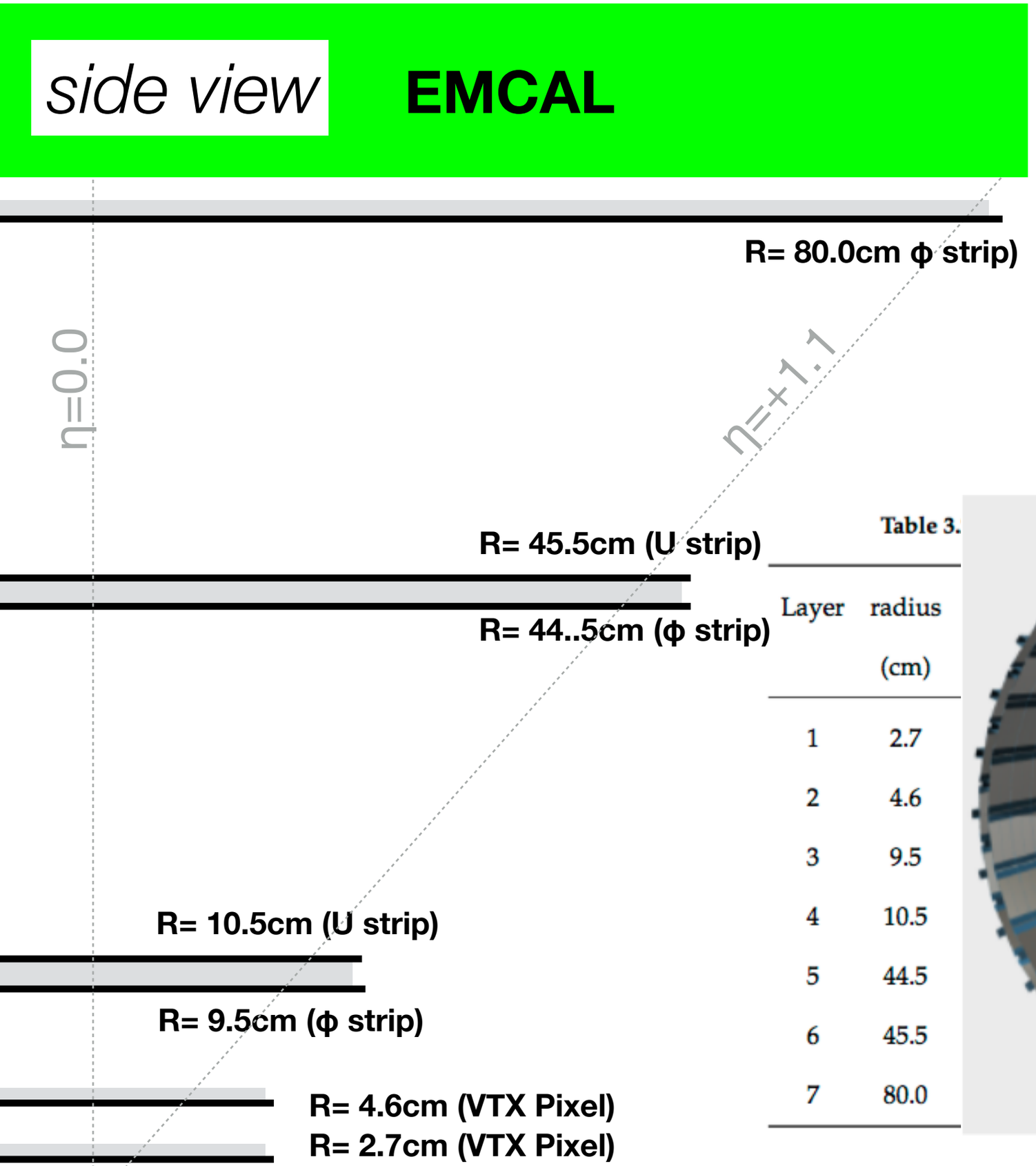


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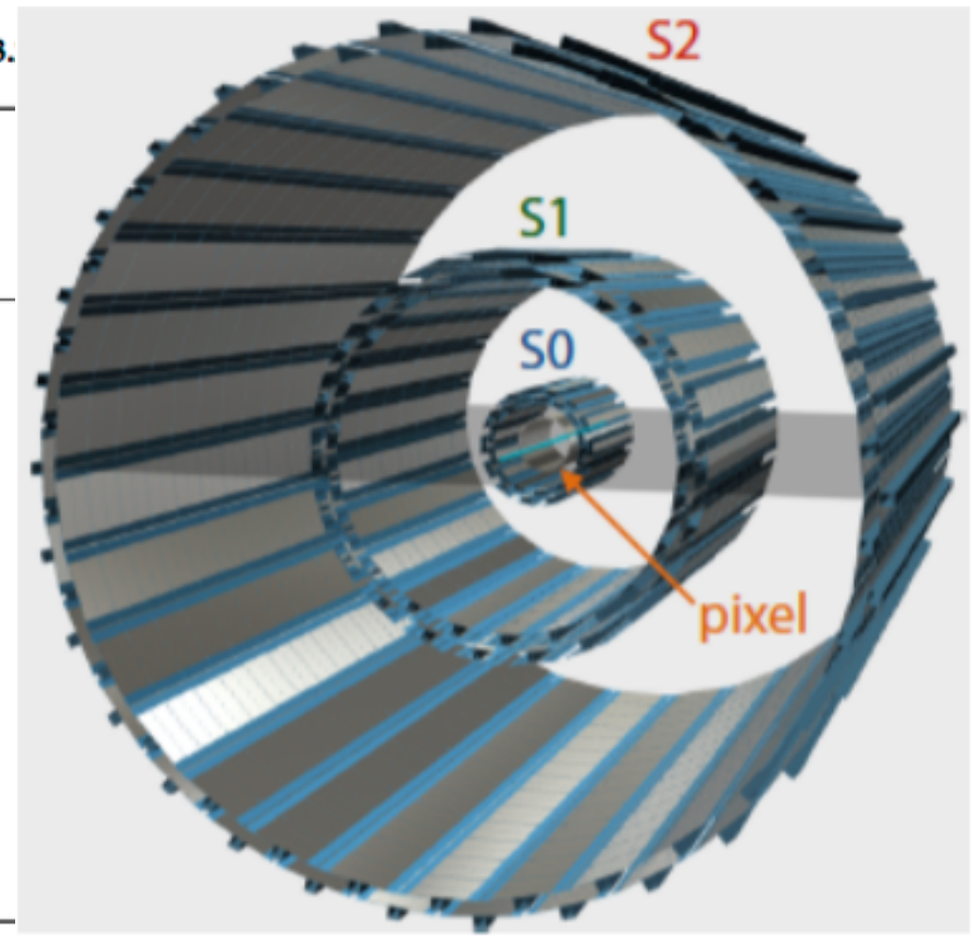
Table 3.

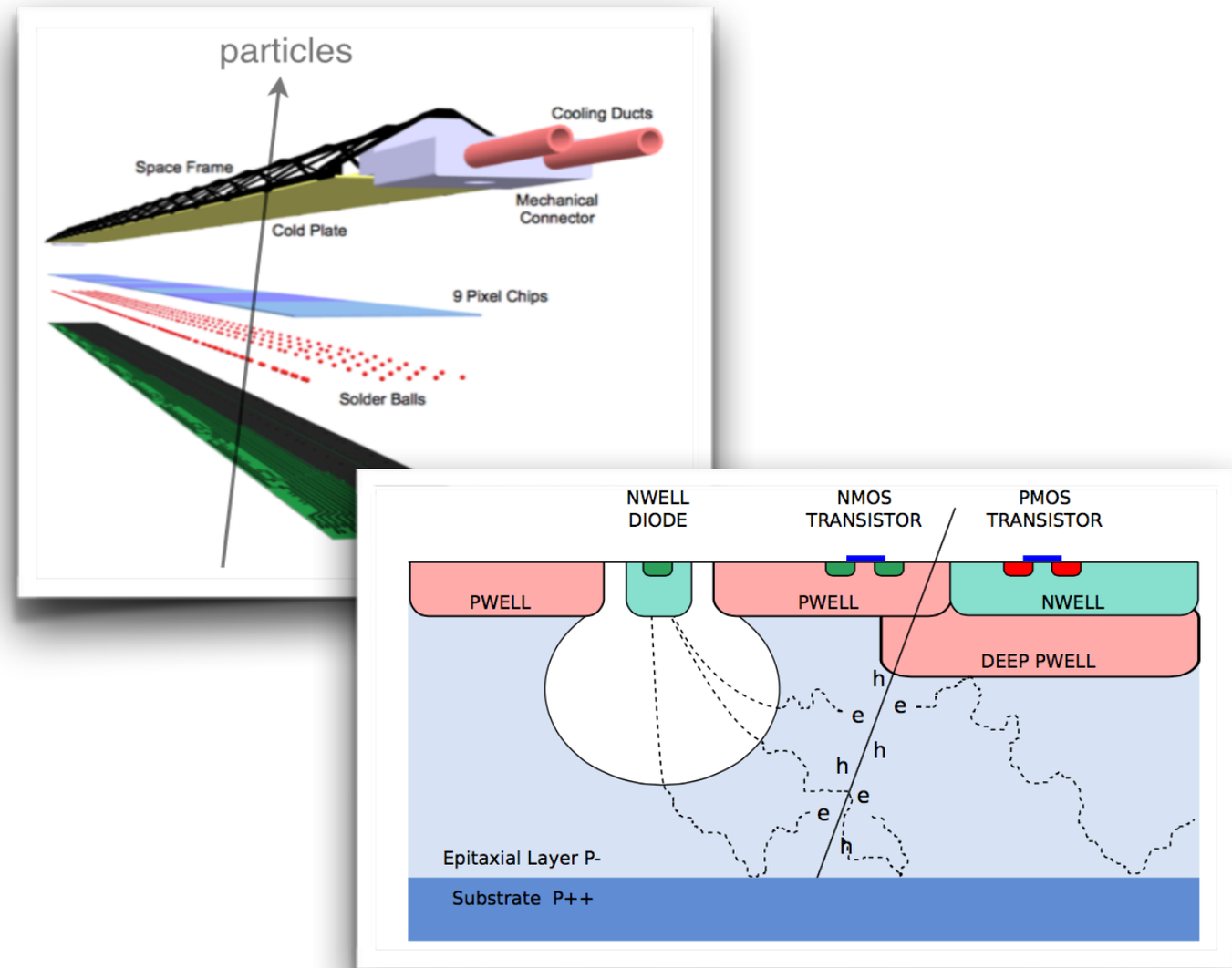
Layer	radius (cm)	area m^2
1	2.7	0.034
2	4.6	0.059
3	9.5	0.152
4	10.5	0.185
5	44.5	3.3
6	45.5	3.5
7	80.0	10.8



Additional Tracking Options

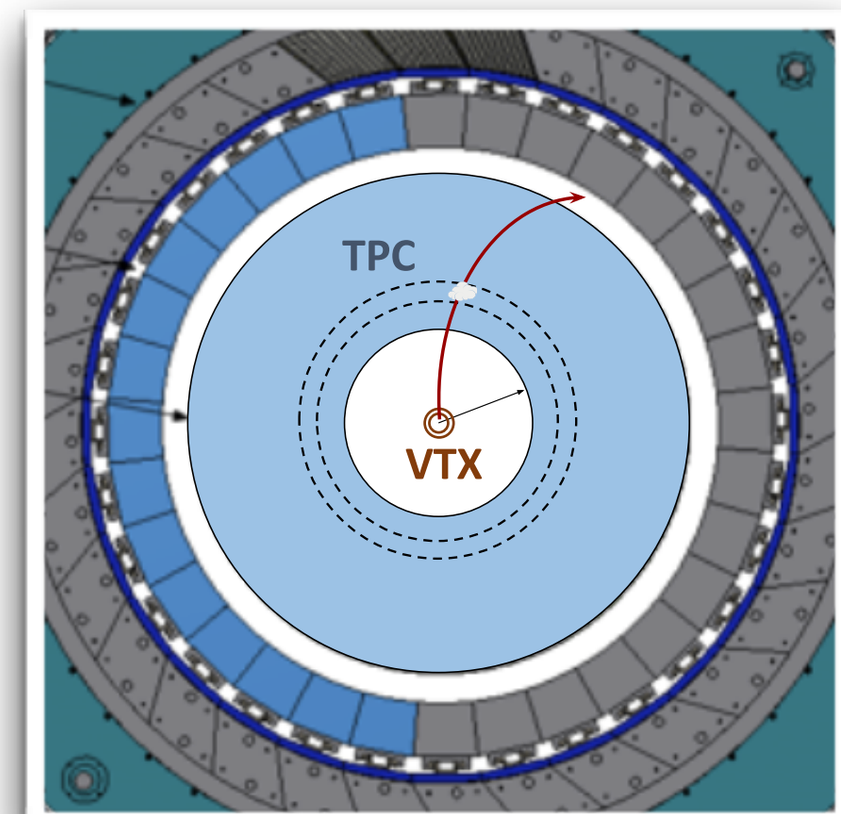
alternative: New Inner Pixels

ALICE-based sensor technology



alternative: Outer TPC

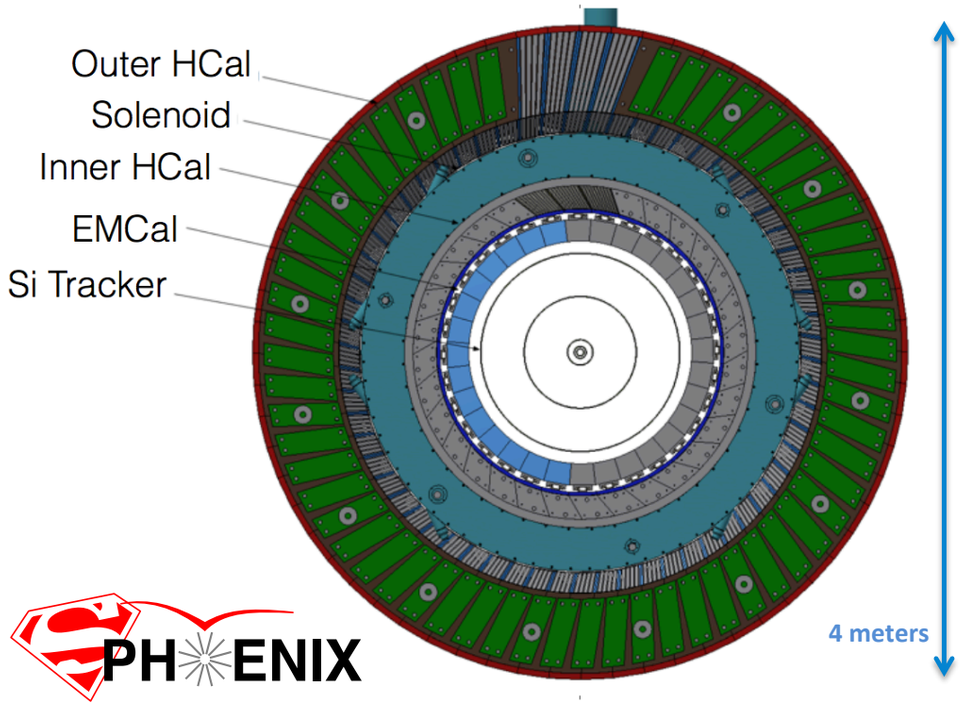
Electron-Ion Collider based technology



These options are currently under study for technical design down-select

Bright Future at the PHENIX Hall

Coming in 2021…



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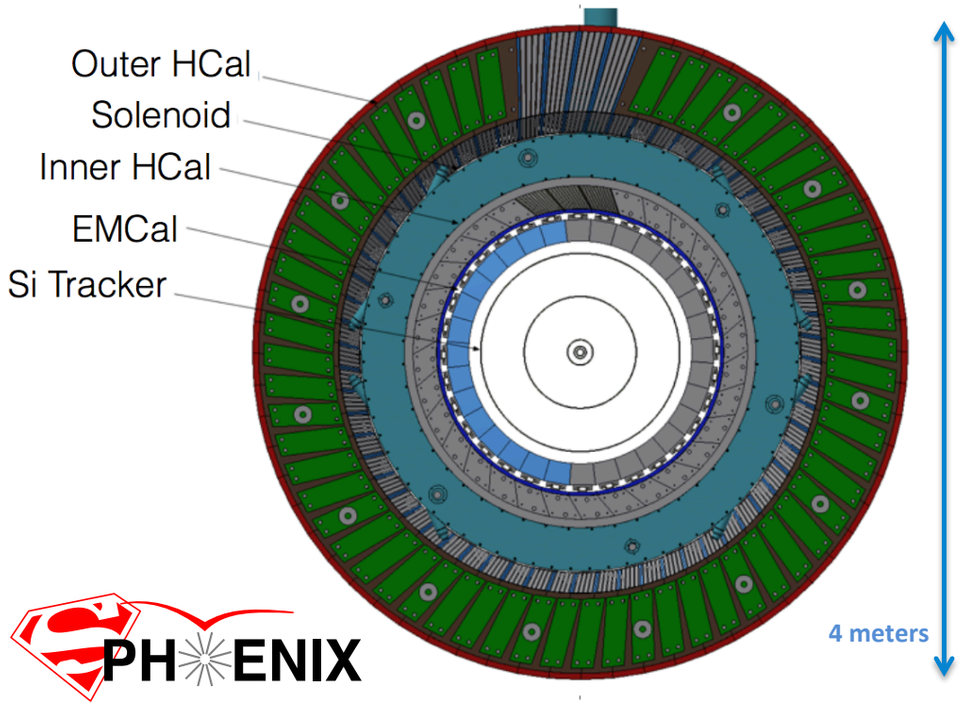
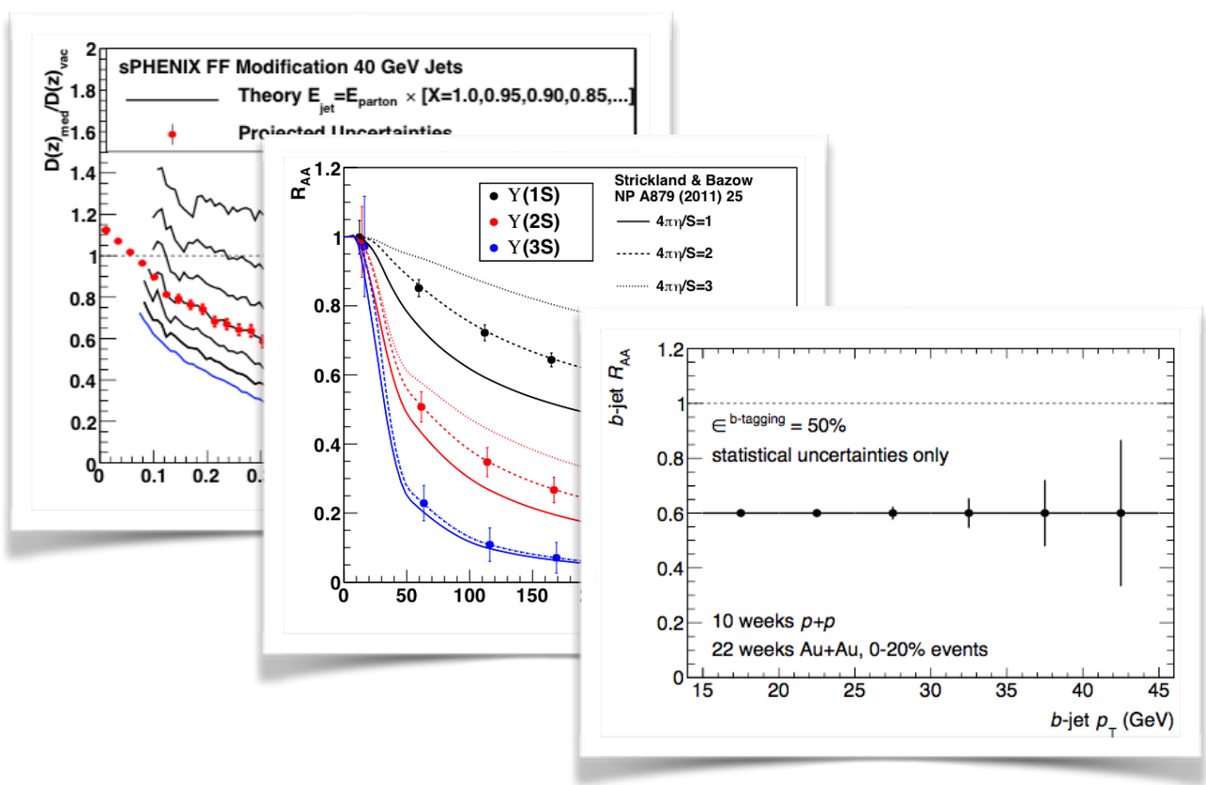
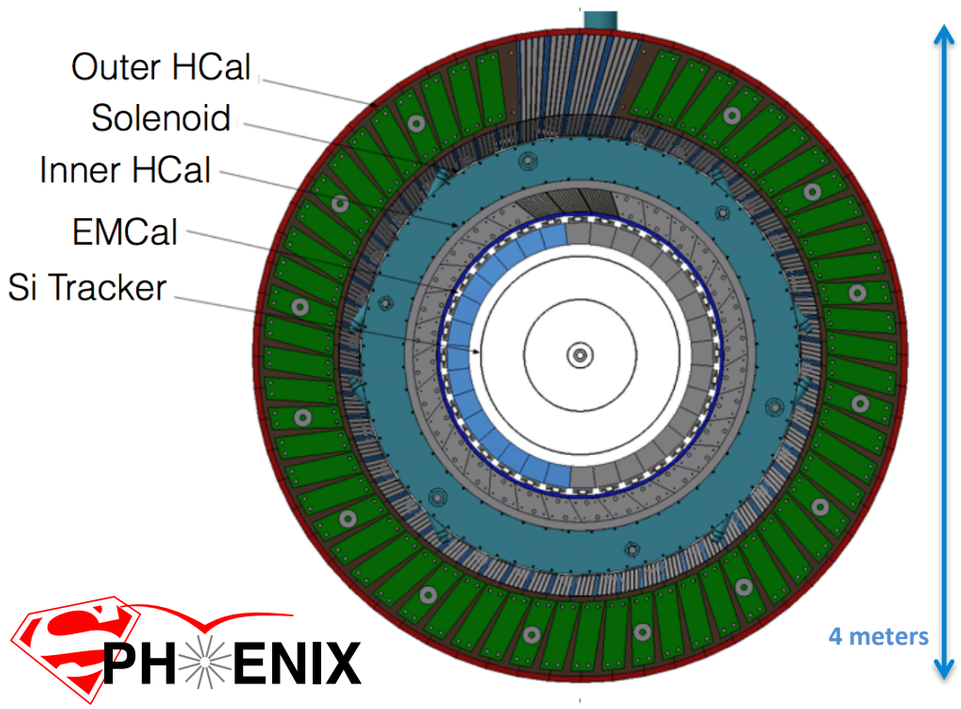
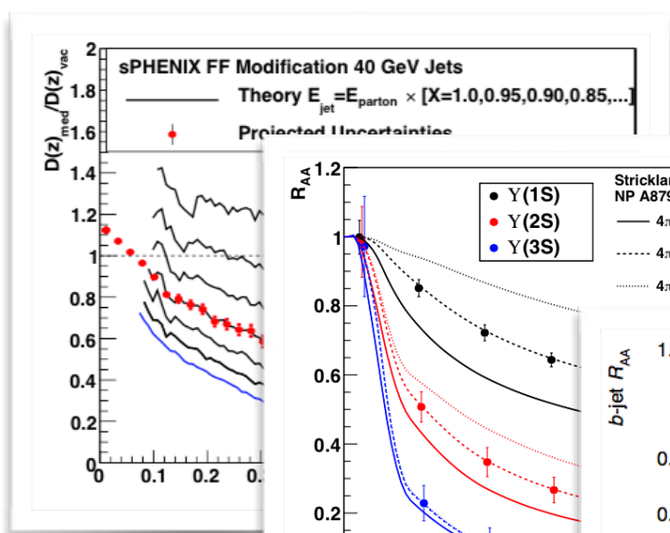
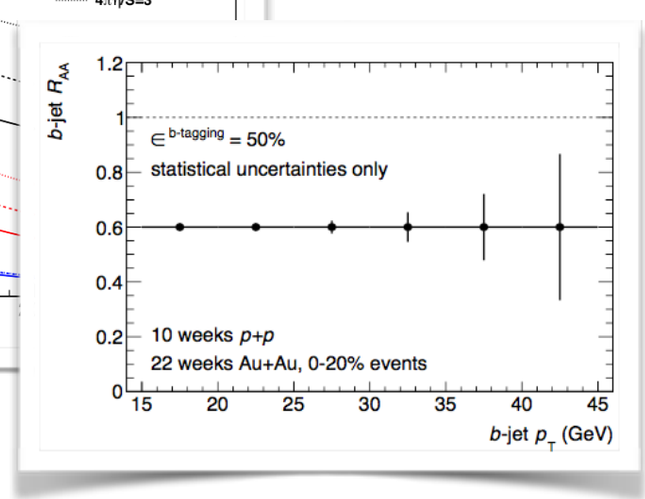




Bright Future at the PHENIX Hall

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