Progress and Update

10/1/2018

Zulkaida Akbar

Outline

- Hardware: Turbomolecular pump (E1039)
- Heat transfer simulation (E1039)
- GlueX experiment (PAC/LOI proposal preparation) (GlueX)
- Machine Learning study: Self organizing map (General Analysis)

Turbomolecular Pump

Turbo Molecular Pump

Pre-condition	Action	Result & Conclusion
Error E006	Set the start-up time	Works
Turbo didn't go to Max speed	Set Venting off	Works, pump attained Max speed
	Set Rotation speed mode ON	
	Set Stand by mode off	
Background He leak = 10^-5	Found leak on the oil place	Background He leak = 10^-8
Final P = 1 x 10^-4	Put Heli coil, order new screw	P going down to min 7 x 10^-5 then
	Put new slot	Going up to Final P = 9x10^-5

History: The turbo delivered to UVA after 15 years sitting in LANL. We sent to company twice to fix some problems before I come.

Turbo Molecular Pump

Pre-condition	Action	Result & Conclusion
Background He leak = 10^-8	Try different vessel & backing pump	Nothing change
P going down to min 7 x 10^-5 then	Call the company	Suggested leak
Going up to Final P = 9x10^-5		
	Find the leak on venting screw, put	Background He leak = 7^-9
	Seal tape	P going down to min 6 x 10^-8 then
		Going up to Final P = 8.2x10^-5
		Oscillatory background leak
		P proportional to background leak
		Leak pop out on small Pressure

Preliminary Conclusion: Either a few more small leak or pump is dirty

Next action: Try the pump for few days

Turbo Molecular Pump: Update

Pre-condition	Action	Result & Conclusion
Background He leak = 10^-8	Running for 3 days	It doesn't work
P going down to min 7 x 10^-5 then		
Going up to Final P = 9x10^-5	Run leak checker for around 1 hours	No Luck. See some big peak but always failed to reproduce. Oscillatory behavior still there. Hypothesis: Since the pressure is low, the helium accumulated first before it "pushed" to detector
	Running the turbo after 1 hours run leak checker	It works successfully. It went to 10^-7 Torr. The background rate start at 10^-7 (higher than usual) and slowly going down

Turbo Molecular Pump

Pre-condition	Action	Result & Conclusion
	Running with mechanic pump. Turn ON the turbo after P = 3X10^-2 using mechanic pump only. Run overnight	It works. The lowest is 2x10^-7 It reach 10^-7 in 15 minutes
	Re do it again to see if it is reproducible	It still works
	Running the turbo simultaneously with the mechanic pump	It works
	Testing for the real Vessel	Still Running

Notes: The manual suggest to turn on the backing pump FIRST before the turbo

Next Plan: Build the remote controller and Lab View (1 week)

Heat Transfer Simulation

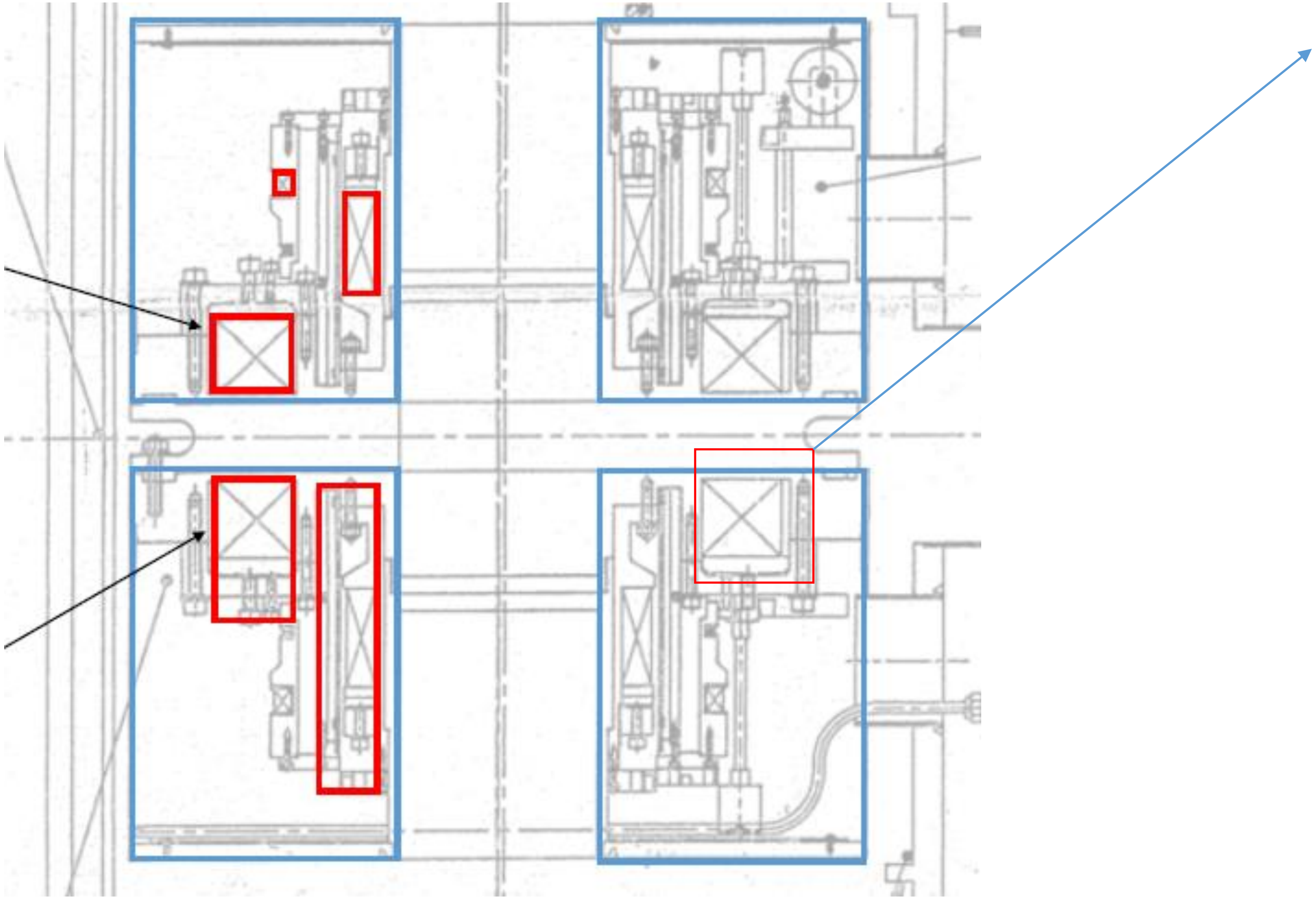
Outline

- Geometry
- Process
- Parameter Input
- Result
- Outlook

Goal: Make sure that the temperature in the coil does not exceed 9 Kelvin (quench)

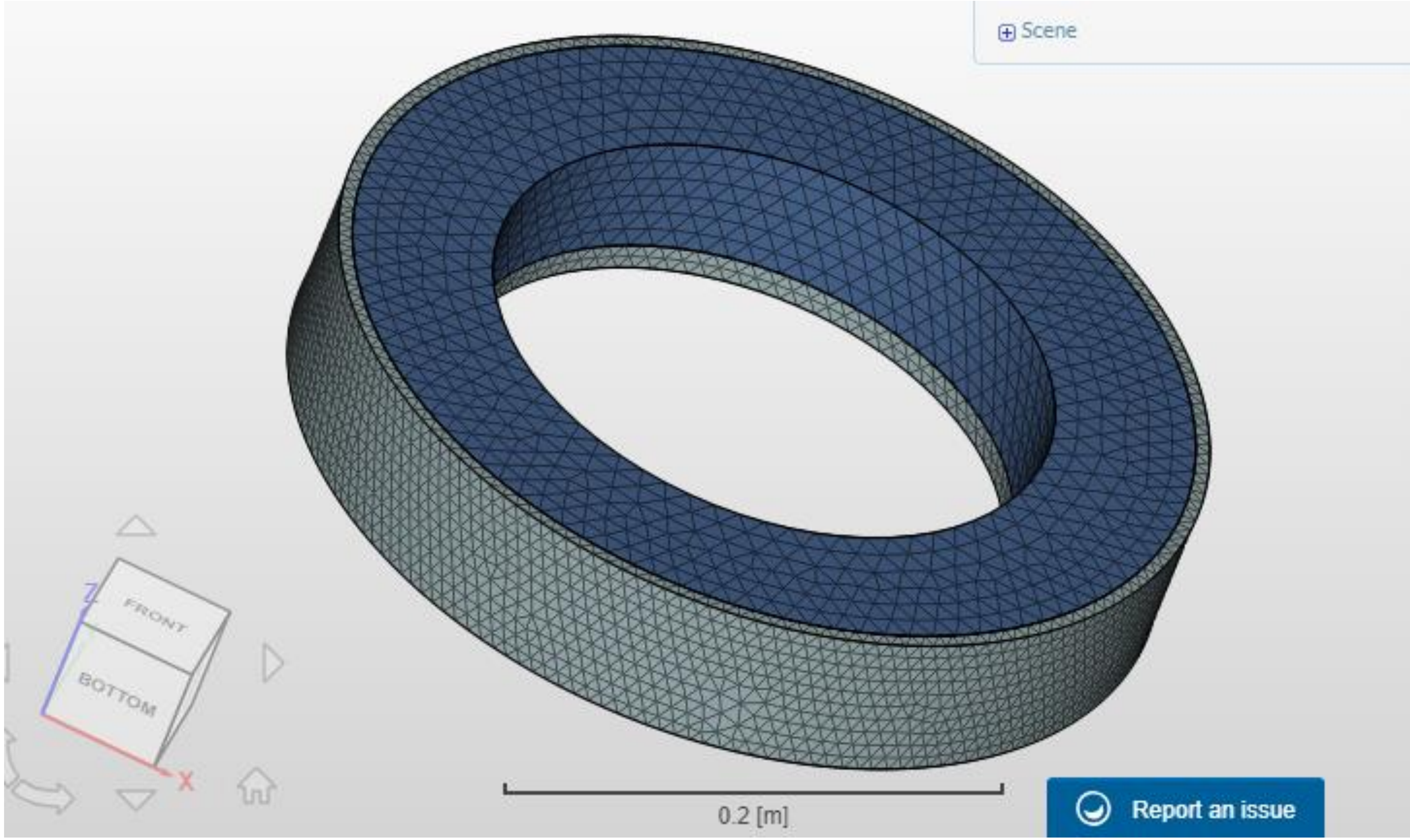
Notes: This first (second) iteration used simplified geometry, process and parameter input. Our target ->
By the end of October make the simulation as realistic as possible

Geometry



- Closest coil to the beam line
- Two surfaces are in contact with the Stainless steel
- Other surfaces of stainless steel are in contact with the liquid-helium bath
- Two surfaces of coil are in contact with the liquid-helium bath

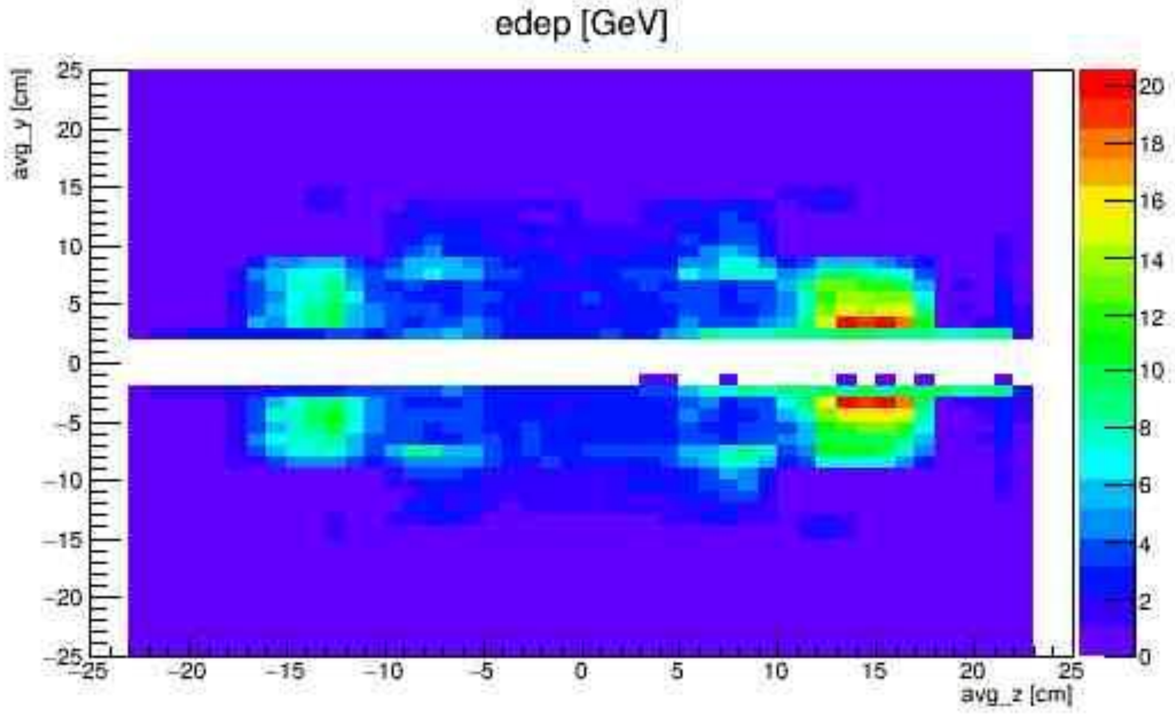
Geometry



The geometry is discretized for the Finite Element Analysis

Process

- Volumetric heat source: Determine from the MC simulation



- Only 25K events -> Scale to 1e12
- Extreme scenario -> maximum heat load (20 GeV)
- Result in 5500 W/m^3 as the heat source on both coil and stainless steel

Process

- Conductive heat transfer inside coil and stainless steel
- Convective heat transfer for the surface that are in contact with the liquid helium bath (Boiling Convection)

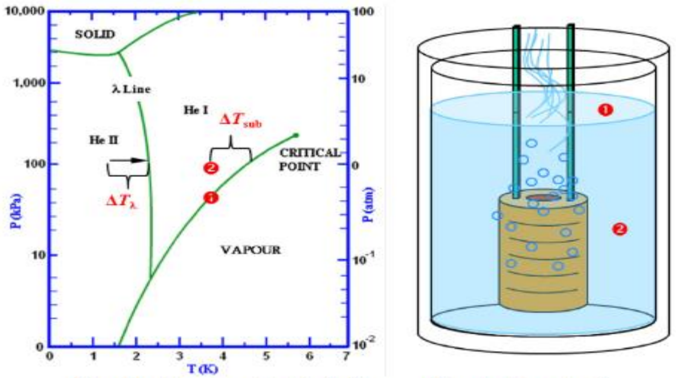


Fig. 19: An example of a helium cooling bath method

- Radiative process is not yet considered
- Kapitza resistance is not yet considered

Parameter Input: specific heat

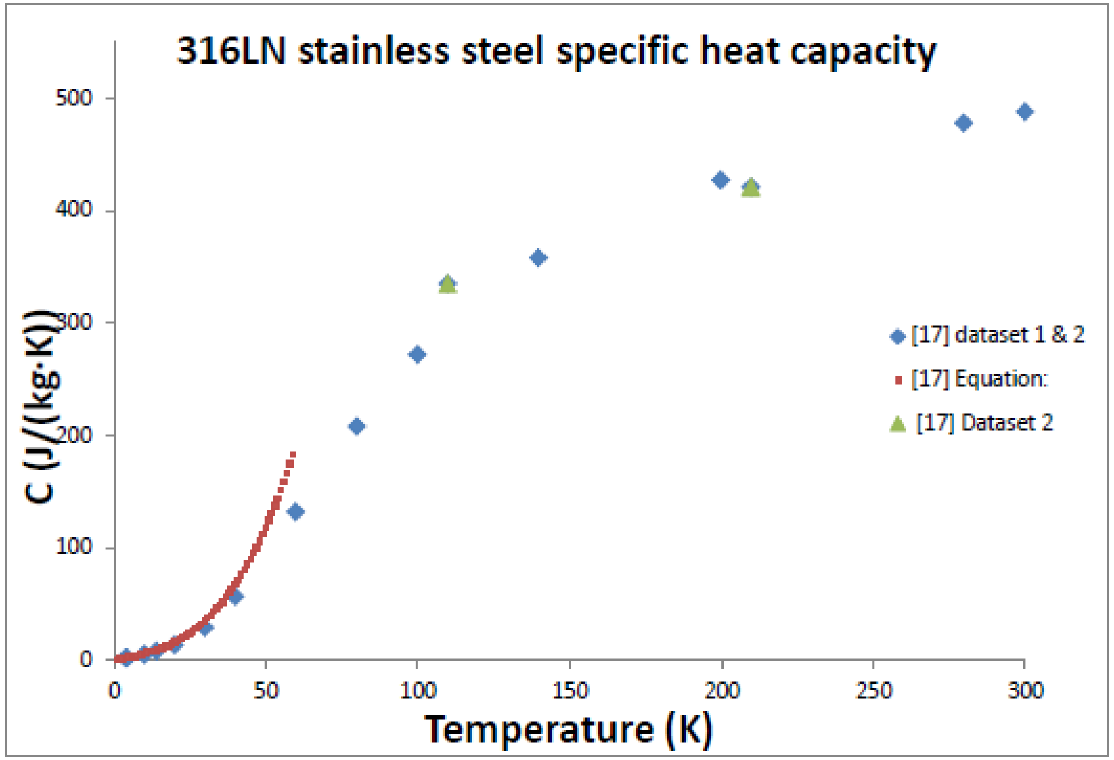
- Specific heat of NbTi superconductor

$C_{SC} = .008767857*T^3 + .014428571*T*B$ (J/(kg*K))

- Specific heat of stainless steel 316 LN

C_p (J/(K*kg))= $.48\,T + 0.00075\,T^3$

- Extreme scenario -> T = 4.2 K



Parameter Input: heat conductivity

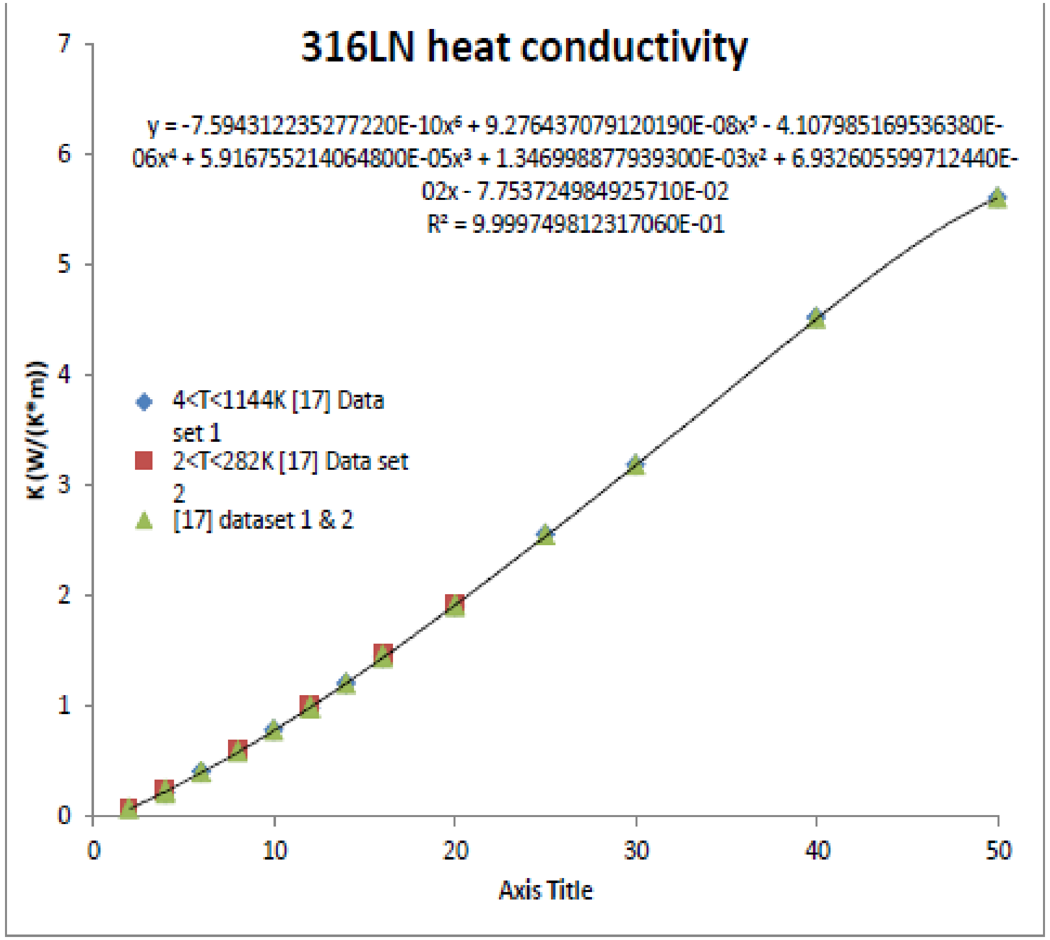
- Heat conductivity of NbTi superconductor

$$k = -0.0008908535069623 60T^3 + 0.01670638630455 3200T^2 - 0.04478987649669 9500T + 0.06810565349137 8900$$

- Heat conductivity of stainless steel 316 LN

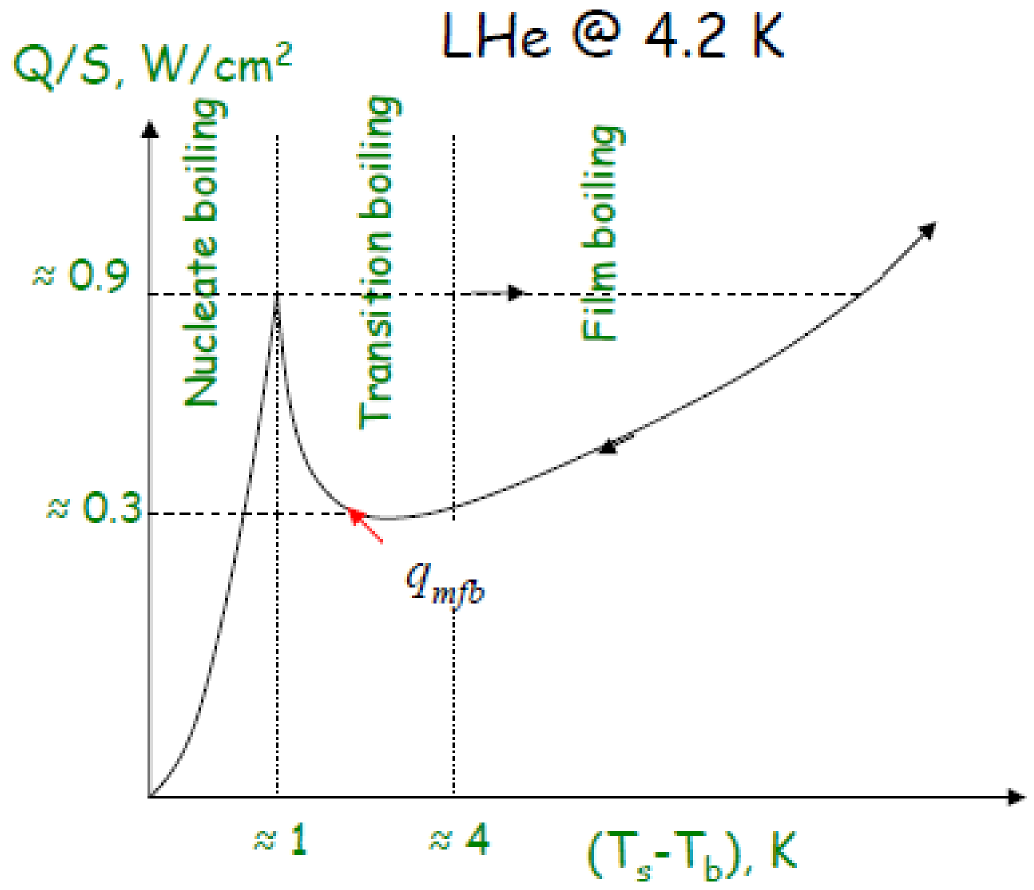
$$k = -7.594312235277220E\text{-}10x^6 + 9.276437079120190E\text{-}08x^5 - 4.107985169536380E\text{-}06x^4 + 5.916755214064800E\text{-}05x^3 + 1.346998877939300E\text{-}03x^2 + 6.932605599712440E\text{-}02x - 7.753724984925710E\text{-}02$$

- Extreme scenario -> T = 4.2 K



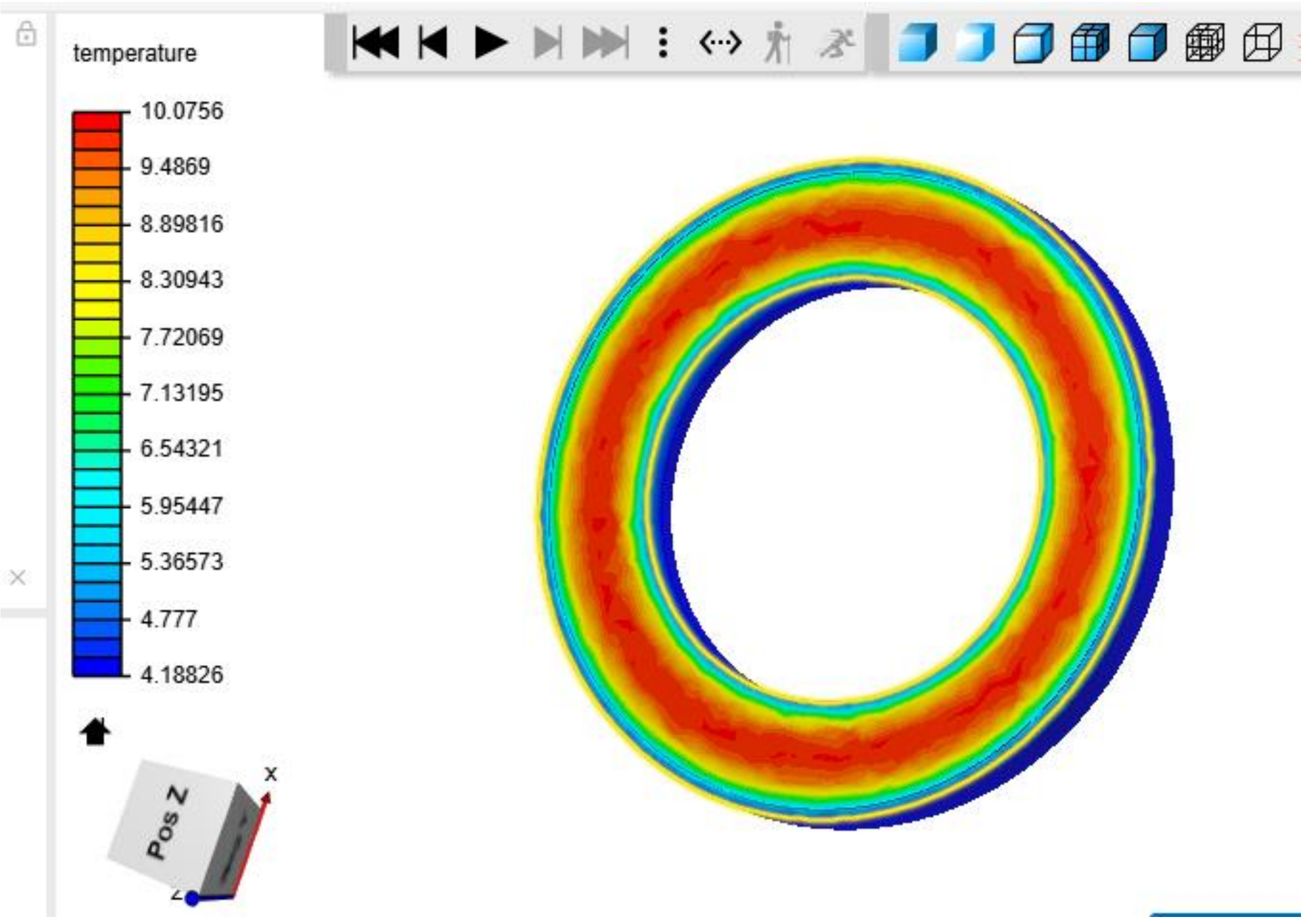
Parameter Input: Convective heat coefficient

- The real calculation is very complex: Need to consider laminar vs turbulent flow, etc.
- Extreme scenario -> minimum point



Result

- Software: Simscale+FreeCad
- The beam is running for 5 second then cooling down for 55 second
- This simulation run for 5 second to see the maximum Temperature
- With this simplified geometry and put the extreme case, the maximum temperature is 10.0756 K
- This means quench !!



Notes: Got a lot of input after I presented this results. The goal -> As realistic as possible simulation by the end of this month.

PAC/LOI preparation for GlueX

Background: UVA sent an LOI to install the polarized target in Hall-D. Get suggestion to wait until we understand the data landscape from GlueX and underlined the specific channel of interest.

Goal: Resend LOI for the next PAC.

PAC proposal for GlueX

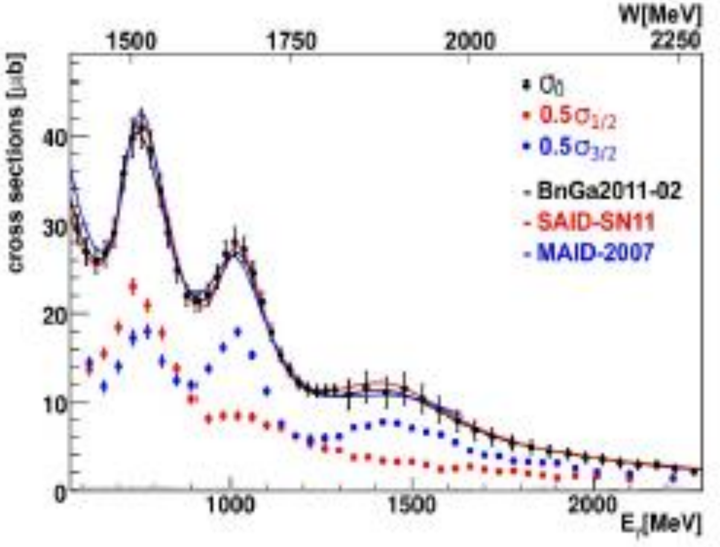
- First Consideration -> Main GlueX proposal: Mapping Hybrid Baryon (Including exotic)
-

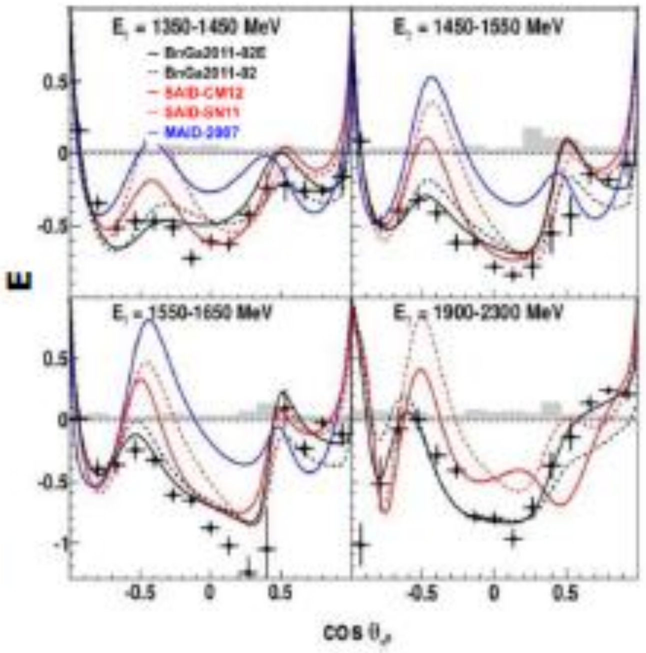
Name	$\mathbf{J^{PC}}$	Total Width (MeV) PSS	IKP	Large Decays
π_1	1^{-+}	$81-168$	117	$b_1\pi$, $\rho\pi$, $f_1\pi$, $a_1\eta$
η_1	1^{-+}	$59-158$	107	$a_1\pi$, $f_1\eta$, $\pi(1300)\pi$
η_1'	1^{-+}	$95-216$	172	$K_1^m K$, $K_1^l K$, $K^* K$
b_0	0^{+-}	$247-429$	665	$\pi(1300)\pi$, $h_1\pi$
h_0	0^{+-}	$59-262$	94	$b_1\pi$, $h_1\eta$, $K(1460)K$
h_0'	0^{+-}	$259-490$	426	$K(1460)K$, $K_1^l K$, $h_1\eta$
b_2	2^{+-}	$5-11$	248	$a_2\pi$, $a_1\pi$, $h_1\pi$
h_2	2^{+-}	$4-12$	166	$b_1\pi$, $\rho\pi$
h_2'	2^{+-}	$5-18$	79	$K_1^m K$, $K_1^l K$, $K_2^* K$

Evidence "claim" but controversial. Evidence based on PWA using cross section data that is model dependent

State	Mass (GeV)	Width (GeV)
$\pi_1(1400)$	1.351 ± 0.03	0.313 ± 0.040
$\pi_1(1600)$	1.662 ± 0.015	0.234 ± 0.050
$\pi_1(2015)$	2.01 ± 0.03	0.28 ± 0.05
State	**Production**	**Decays**
$\pi_1(1400)$	$\pi^- p, \bar{p}n$	$\pi^-\eta^\ddagger, \pi^0\eta^\ddagger$
$\pi_1(1600)$	$\pi^- p, \bar{p}p$	$\eta'\pi, b_1\pi, f_1\pi, \rho\pi^\ddagger$
$\pi_1(2015)$	$\pi^- p$	$b_1\pi, f_1\pi$
State	**Experiments**	
$\pi_1(1400)$	E852, CBAR	
$\pi_1(1600)$	E852, VES, COMPASS, CBAR	
$\pi_1(2015)$	E852	

- Opportunity for the polarization observables
- Polarization observables are more sensitive than cross section





Benchmarking:

★	E-06-013	M. Bellis V. Crede* S. Strauch	 FSU USC	Meaurement of π+π- Photoproduction in Double-Polarization Experiments using CLAS	4.00	A-
★	E-02-112	P. Eugenio F. Klein* L. Todor	FSU CUA CMU	Search for Missing Nucleon Resonances in the Photoproduction of Hyperons Using A Polarized Photon Beam and A Polarized Target	20.00	A-

Second consideration : We need specific channel and specific observables

- First Challenge -> If we shoot for exotic π, CLAS g12 does not show its evidence. It may not produced in photoproduction
- We may shoot for another unobserved exotic

Photoproduction of Hybrid Mesons

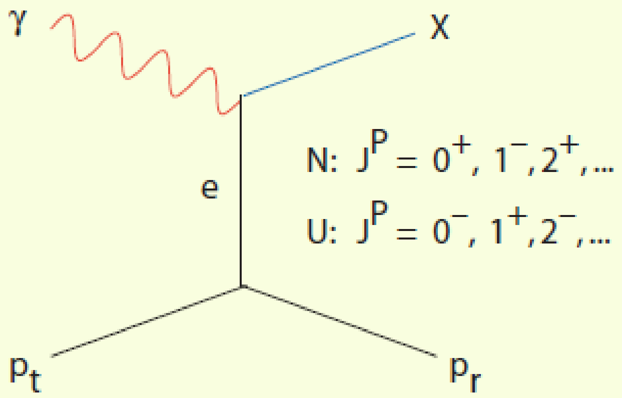
T. Barnes

Physics Division, Oak Ridge National Laboratory
Oak Ridge, TN 37831-6373, and
Department of Physics , University of Tennessee
Knoxville, TN 37996-1501

Abstract. In this contribution I discuss prospects for photoproducing hybrid mesons at CEBAF, based on recent model results and experimental indications of possible hybrids. One excellent opportunity appears to be a search for $I = 1$, $J^{PC} = 2^{+-}$ "b_2^o" hybrids in $(a_2\pi)^o$ through diffractive photoproduction. Other notable possibilities accessible through π^+ or π^o exchange photoproduction are $I = 1$ 1^{-+} "π_1^+" in $f_1\pi^+$, $(b_1\pi)^+$ and $(\rho\pi)^+$; $\pi_J^+(1770)$ in $f_2\pi^+$ and $(b_1\pi)^+$; $\pi^+(1800)$ in $f_0\pi^+$, $f_2\pi^+$, $\rho^+\omega$ and $(\rho\pi)^+$; a_1 in $f_1\pi^+$ and $f_2\pi^+$; and ω in $(\rho\pi)^o$, $\omega\eta$ and K_1K.

- Third consideration: Is searching for Hybrid Meson require polarized target?

Why linear polarization?

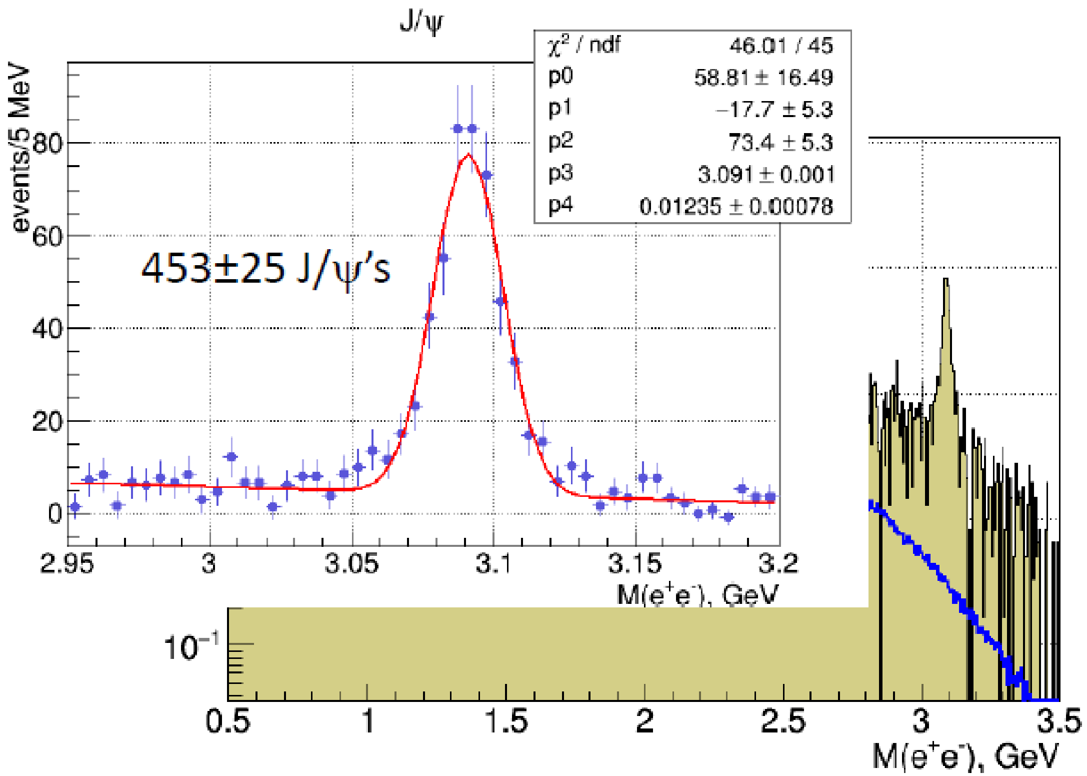


Exotic Production:
Takes place via unnatural (U) parity exchange
Diffractive Production:
Through natural parity (N) exchange

Unpolarized or circular polarized photons cannot distinguish between U and N.

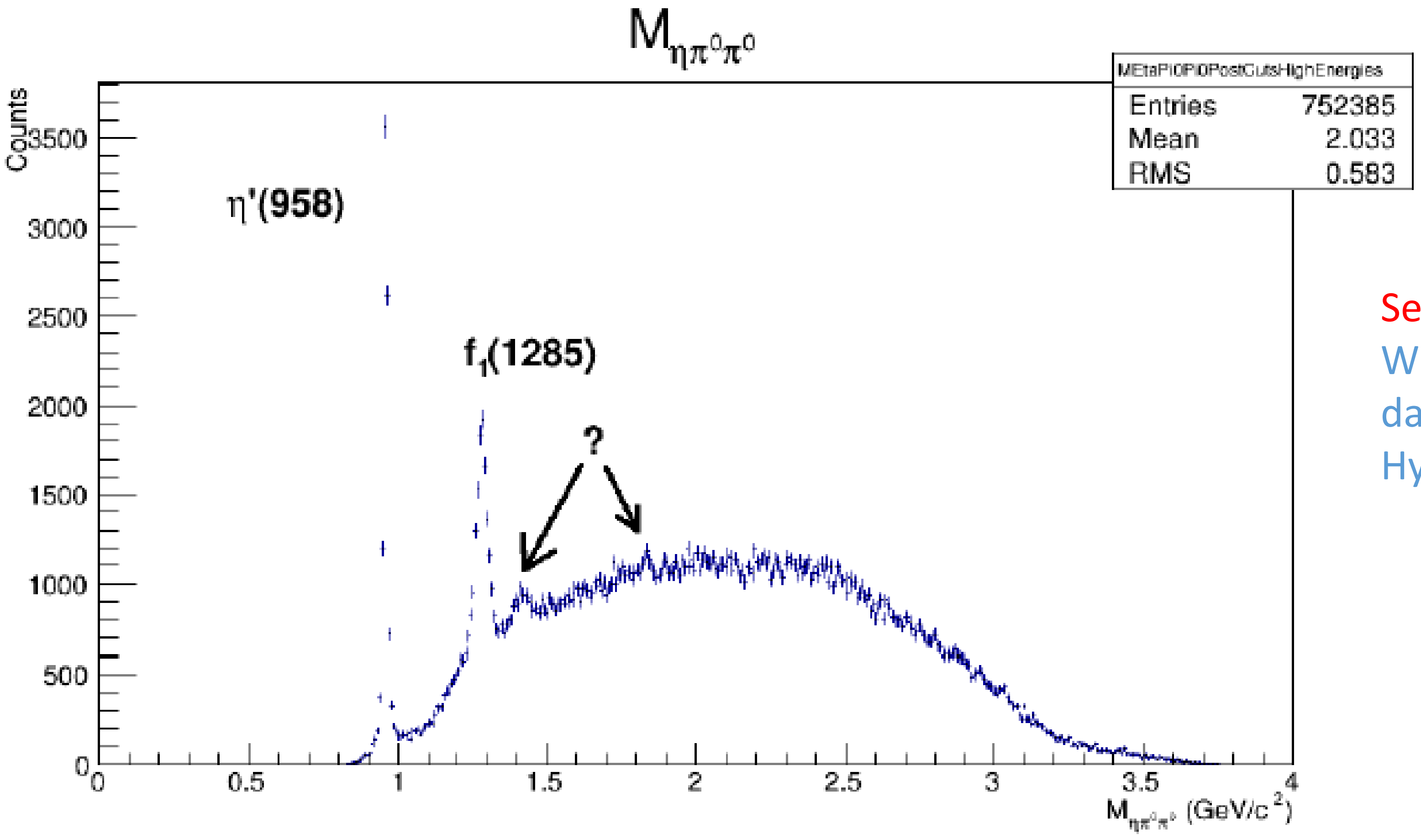
With longitudinal polarization one can distinguish by selection based on the angle the polarization vector makes with the production plane.

Fourth consideration: Statistics is disappointing in GlueX



- Only 453 events J/psi
- Only 1200 Cascades
- Only 50 Exited Cascades

The $\eta\pi^0\pi^0$ mass after the cuts:



Hints of resonances at 1.4 and 1.8 GeV/c^2

Searching for η1

With current statistics from 200 PAC days. It is difficult to sell searching for Hybrid with polarized target

Outlook

- Contact some theorist to get some input
- Goal -> By the end of Oct have one or two specific channel and observables.

SELF ORGANIZING MAP

SOM Is a type of Machine Learning that has a lot of possible application. One of them is to extract small signal from complicated backgrounds

Self organizing map

What we learned so far:

- Running SOM in Amazon (AWS EC2)
- Successfully create clustering for two “distinct” channel with the same final state ($K\Sigma$ and $p\eta$) photoproduction
- When we have “strong” discriminant variable, clear clustering attined even with very few events (hundreds), variables (3) and grid (10 x 10)

Next Challenge:

- Try SOM (supervised) for two channel with “not too strong” discriminant variable

Channel

The signal:

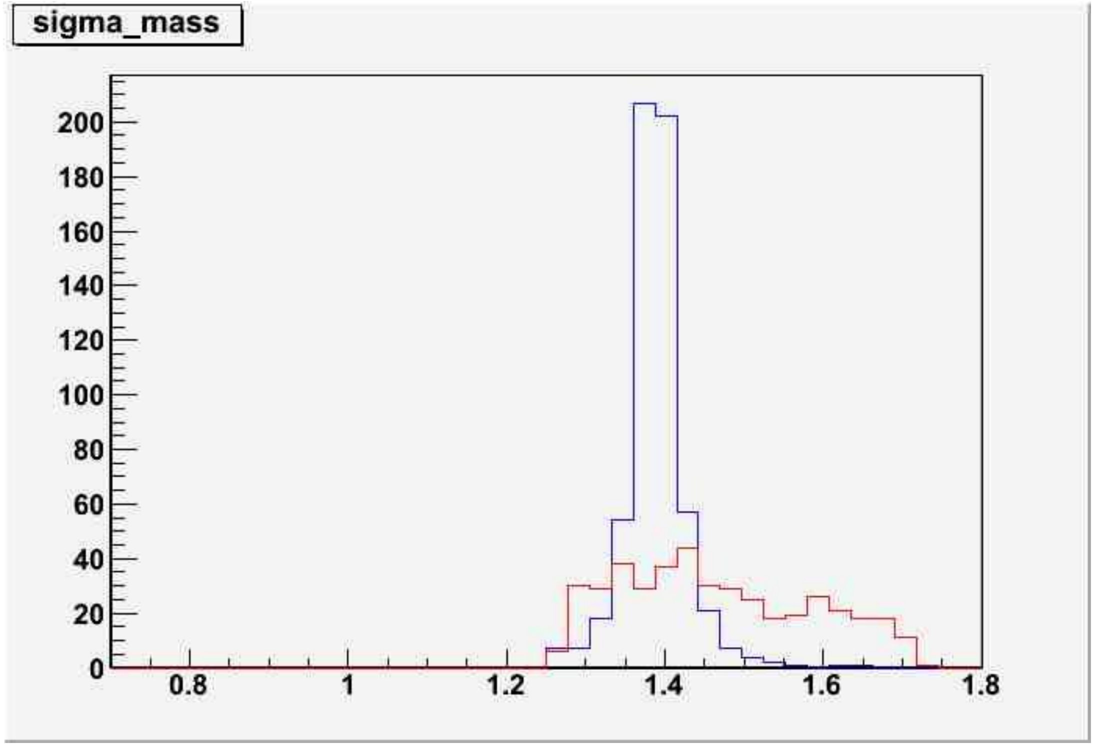
$$\gamma p \longrightarrow K^+\Sigma^{0*}$$
$$\Sigma^{0*} \longrightarrow \Lambda\pi^0$$
$$\pi^0 \longrightarrow \gamma\gamma$$
$$\Lambda \longrightarrow p\pi^-$$

The background:

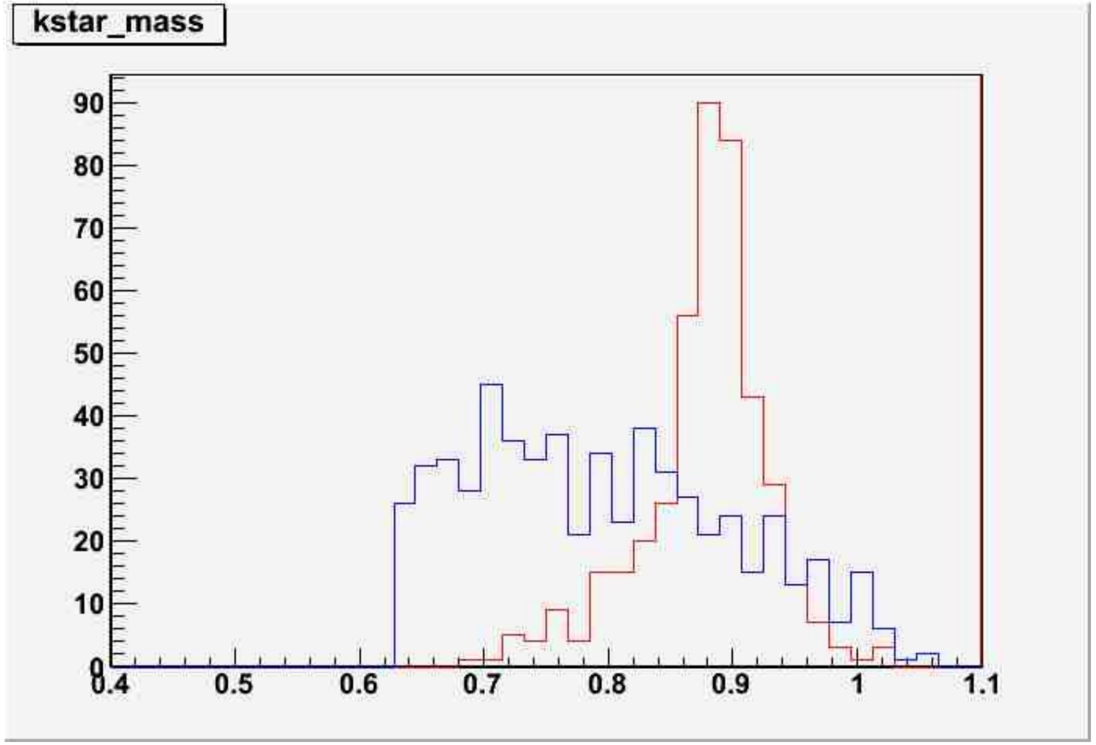
$$\gamma p \longrightarrow K^{+*}\Lambda$$
$$K^{+*} \longrightarrow K^+\pi^0$$
$$\pi^0 \longrightarrow \gamma\gamma$$
$$\Lambda \longrightarrow p\pi^-$$

SOM Setup

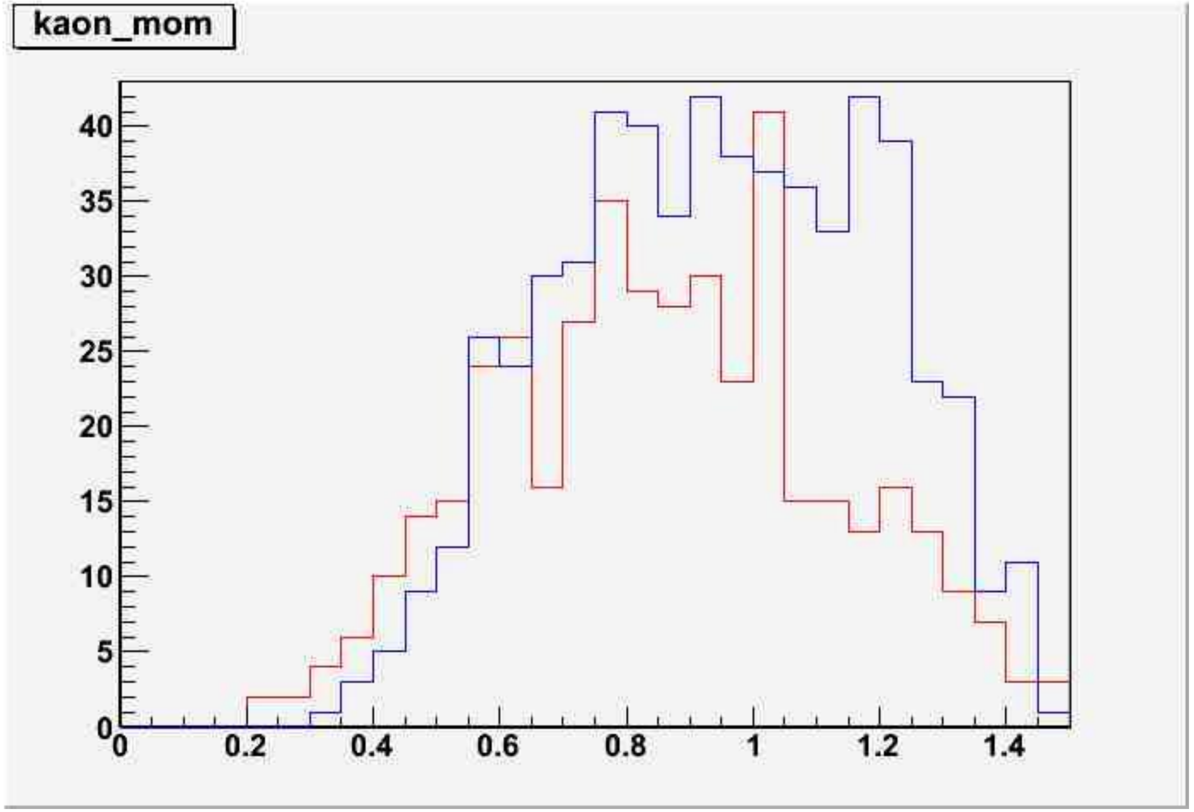
- CLAS-g12 MC generated
- 10x10 and 20x20 grid
- About 1000 events
- 4 variables:
- Invariant mass of proton & pions
- Invariant mass of Kaon & pion
- Kaon momentum
- Kaon angle

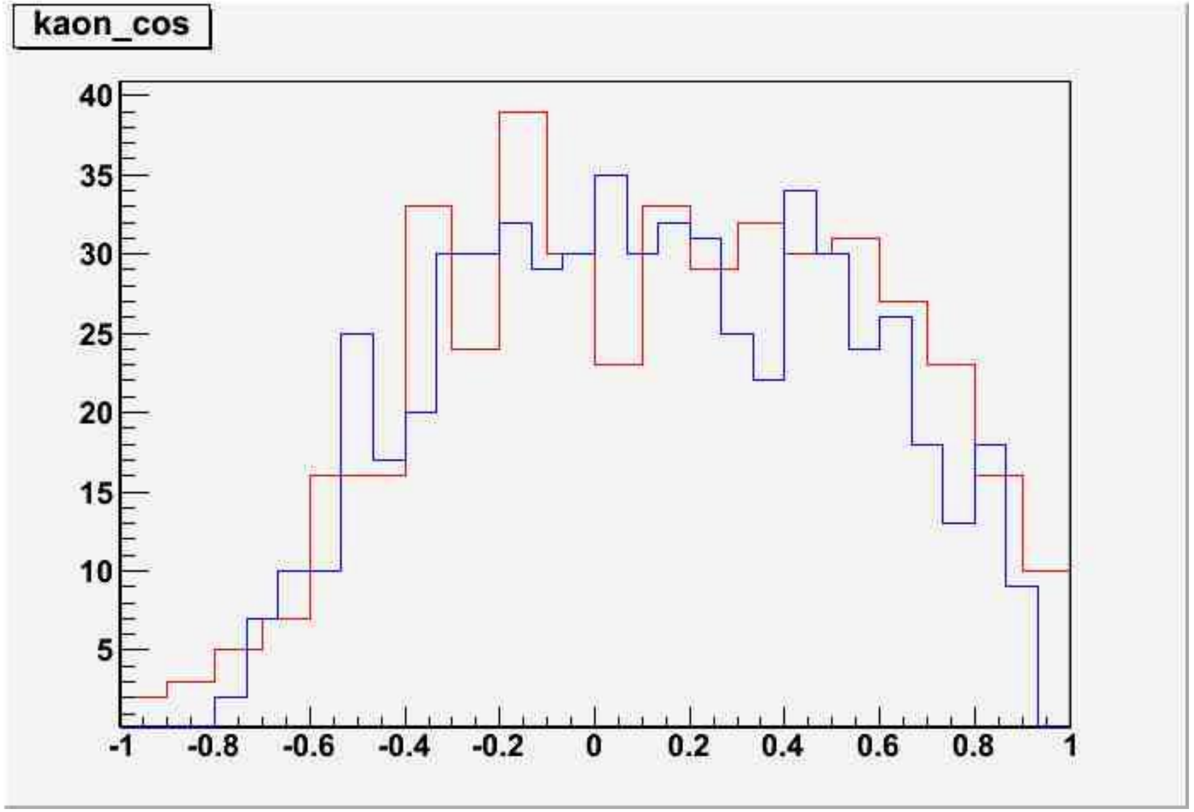


sigma_mass
200
180
160
140
120
100
80
60
40
20
0
0.8
1
1.2
1.4
1.6
1.8



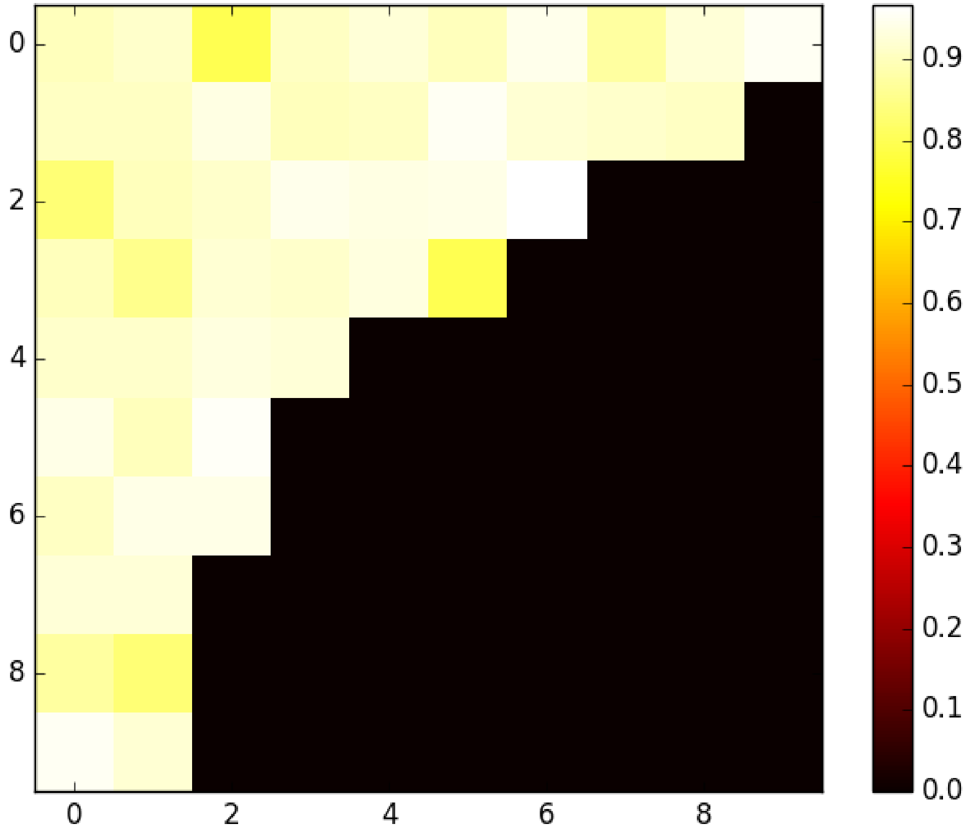
kstar_mass
90
80
70
60
50
40
30
20
10
0
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1


kaon_mom
0
5
10
15
20
25
30
35
40
0
0.2
0.4
0.6
0.8
1
1.2
1.4

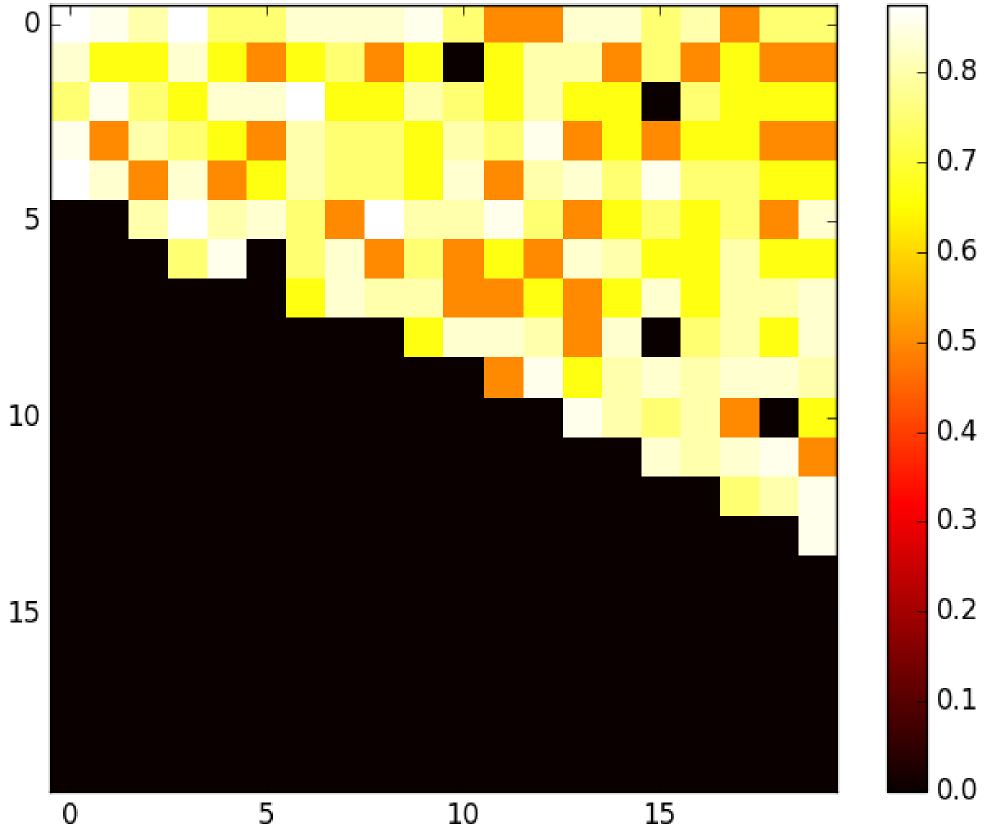

kaon_cos
5
10
15
20
25
30
35
40
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

SOM Results

10 x 10



20 x 20

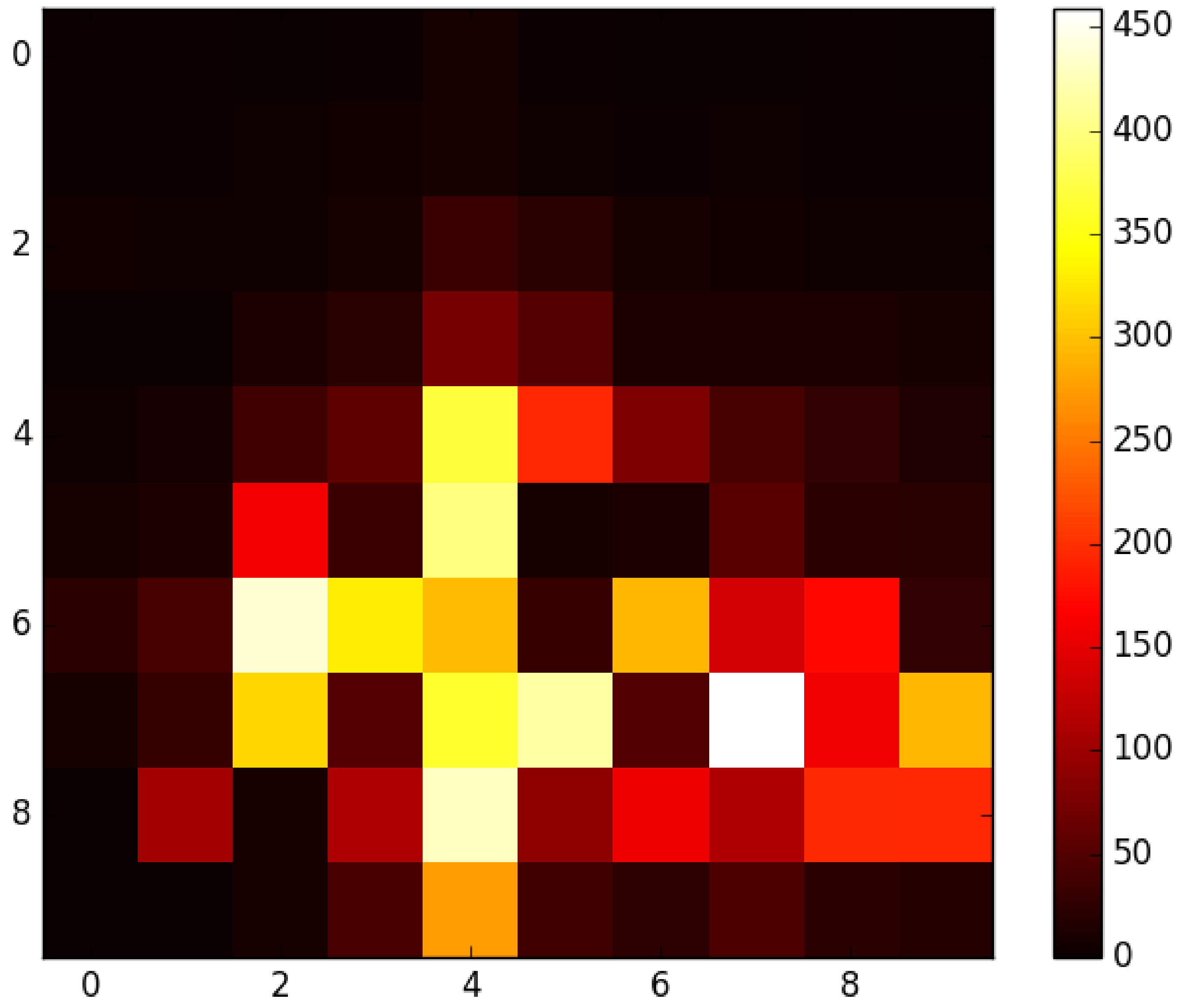


Self organizing map: Update

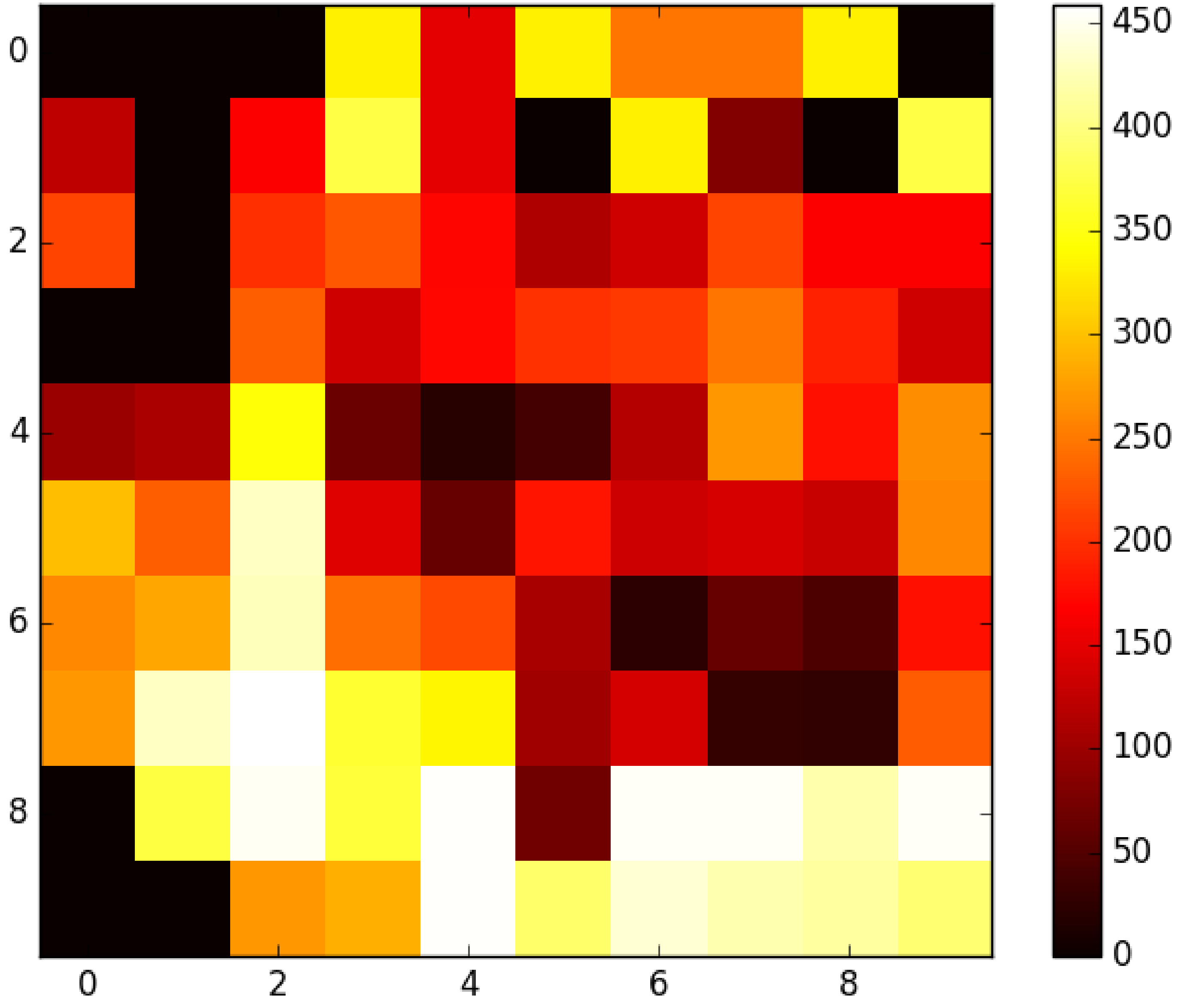
- New Channel: photoproduction of K*Λ with K* decay to Kπ (signal) and Kγ (background)
- 14 Variables, most of the are pull distributions for the MC reactions fitted to missing π and missing γ
- Around 8000 MC events
- 10 x 10 grid

- On the next 4 slides:
- The resulting SOM map
- Signal purity map
- Background purity map
- Efficiency plot

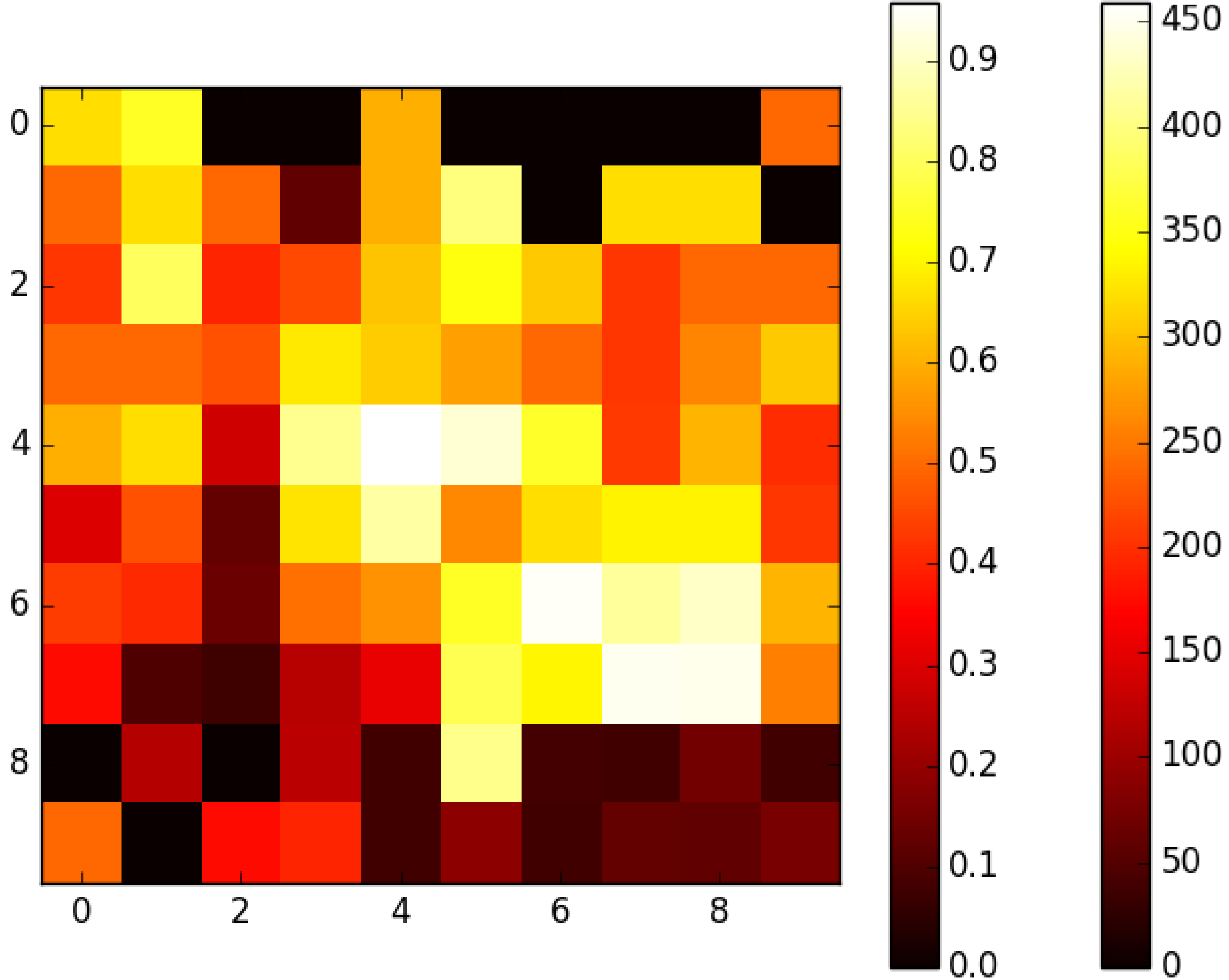
SOM Map



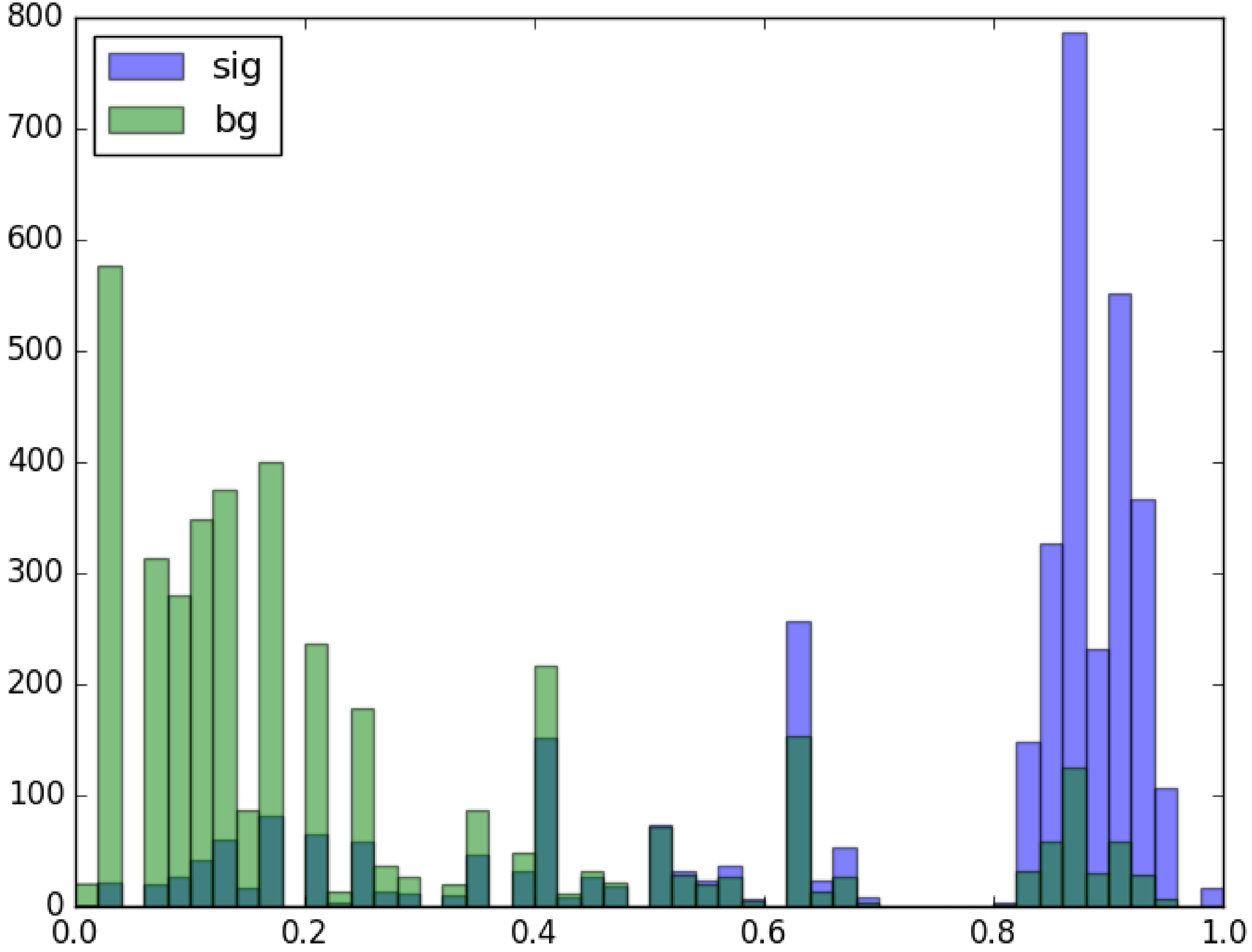
Signal Purity



Background purity

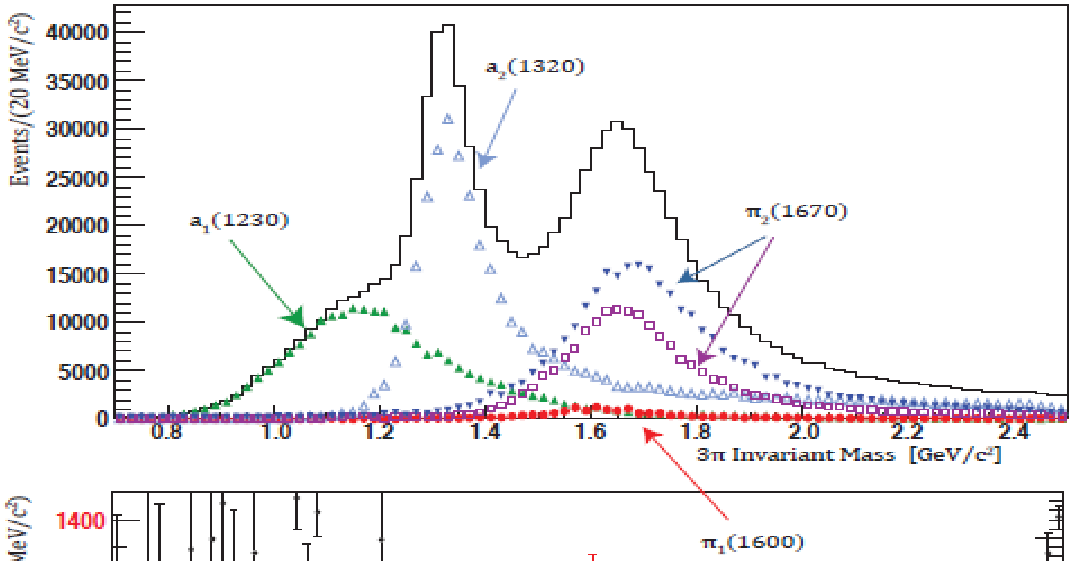


Efficiency Plot



Self Organizing Map: Conclusion & Outlook

- It looks promising
- Keep channel exploring and playing



- Start look into the physics application -> focus on GPD and TMD

More and more interest in particle community

Machine Learning in High Energy Physics Community White Paper

July 10, 2018

Abstract: Machine learning is an important applied research area in particle physics, beginning with applications to high-level physics analysis in the 1990s and 2000s, followed by an explosion of applications in particle and event identification and reconstruction in the 2010s. In this document we discuss promising future research and development areas in machine learning in particle physics with a roadmap for their implementation, software and hardware resource requirements, collaborative initiatives with the data science community, academia and industry, and training the particle physics community in data science. The main objective of the document is to connect and motivate these areas of research and development with the physics drivers of the High-Luminosity Large Hadron Collider and future neutrino experiments and identify the resource needs for their implementation. Additionally we identify areas where collaboration with external communities will be of great benefit.

THANK YOU