Ian-Woo Kim

CERN Theory Group Retreat 2013

About Myself & My Own Works

My itinerary

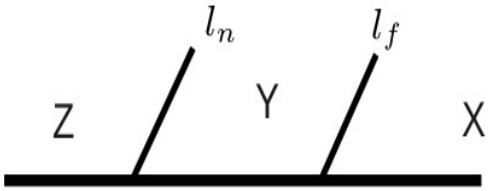
- KAIST → SNU → Wisconsin → Michigan → CERN

My Work Highlights

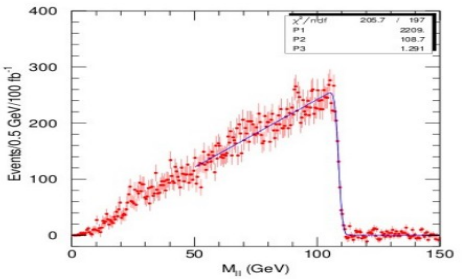
- Gauge Coupling Renorm. in a slice of AdS_5: Orbifold GUT Model Building
- SUSY Breaking: Gauge Messenger Model, Deflected Mirage Mediation
- Principled Kinematic Variable Design:
  - Kinematic Cusps → Algebraic Singularity Method
- Analysis with Exp data: Top A_{FB} Model Survey of Tevatron/LHC, Flavor/Collider Physics of Asymmetric Dark Matter
- Physics Software Development: `HROOT`, `pipeline`, `evchain`

Finding Optimized MET variables

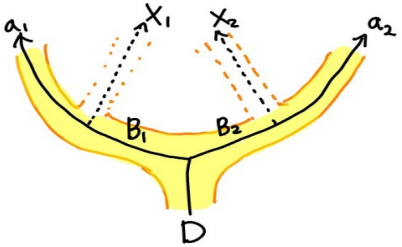
Invariant mass



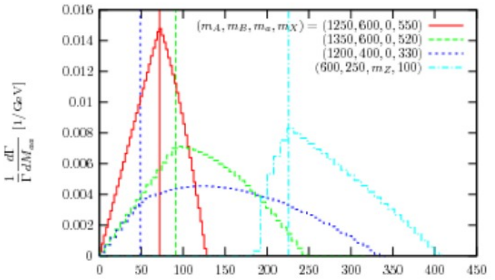
From Bachacou, Hinchliffe, Paige (1999)



Kinematic Cusps

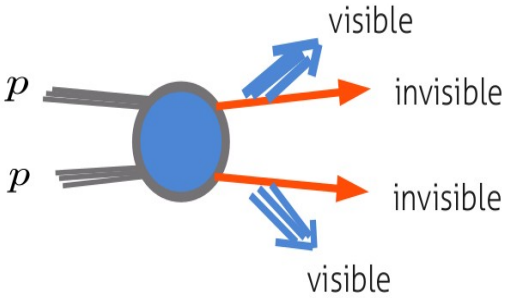


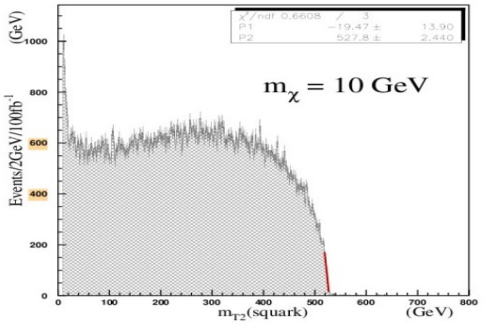
Han, IWK, Song (2009)
Han, IWK, Song (2012)

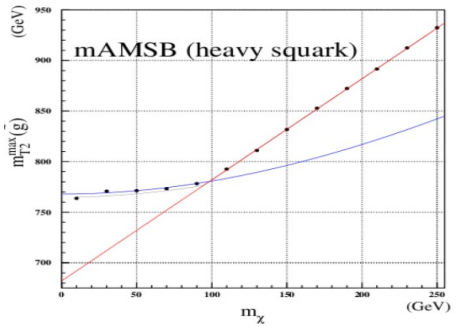


Lester, Summers (1999)

M_{T2} and others





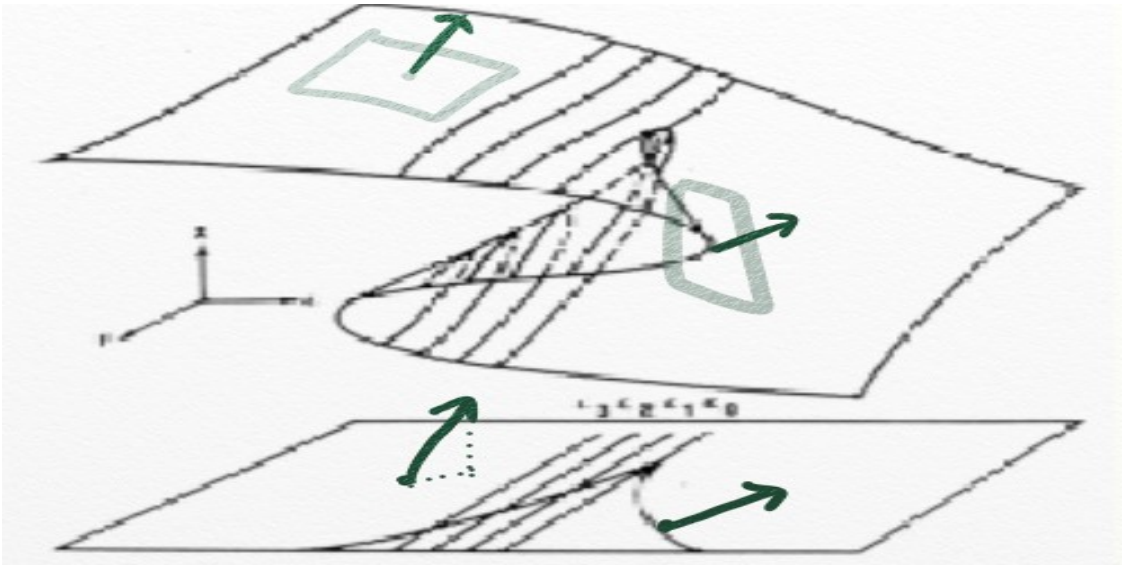


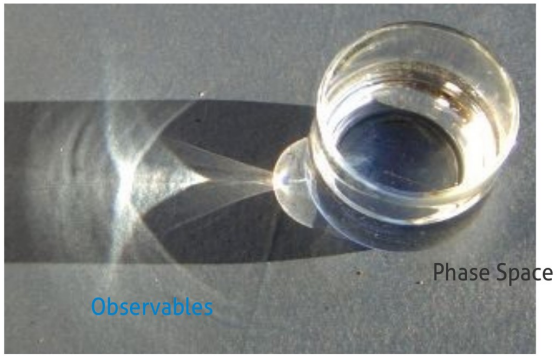
Cho, Choi, Kim, Park (2007)
Barr, Gripaios, Lester (2007)

Finding Optimized MET variables

Algebraic Singularity Method

IWK (2009)





PS is a solution space of algebraic equations

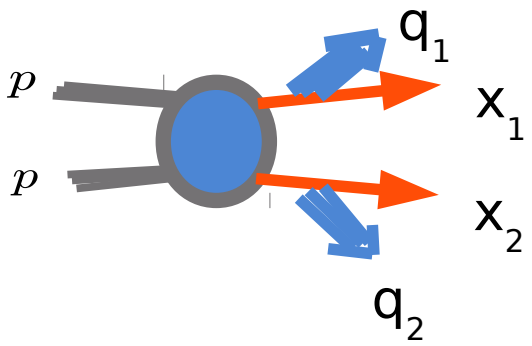
Reduced Rank Condition for Singularity

$$\mathrm{Rank}\left(\frac{\partial g_i}{\partial x_j}\right)_{\mathrm{sing.}} < \mathrm{Rank}\left(\frac{\partial g_i}{\partial x_j}\right)_{\mathrm{reg.}} \longrightarrow \textbf{Singularity Coordinate}$$

Finding Optimized MET variables

Algebraic Singularity Method

IWK (2009)



$$x_1^2 = m_X^2 \quad x_2^2 = m_X^2$$

$$(x_1 + q_1)^2 = m_Y^2$$

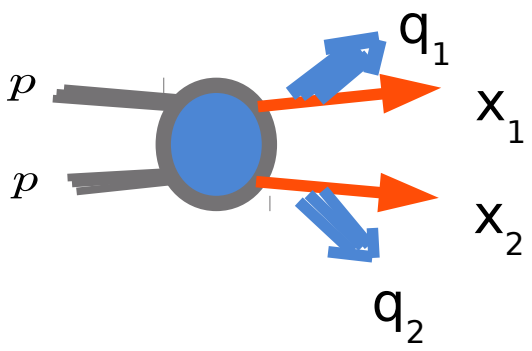
$$(x_2 + q_2)^2 = m_Y^2$$

$$\vec{x}_{1T} + \vec{x}_{2T} = \vec{p}_T$$

Finding Optimized MET variables

Algebraic Singularity Method

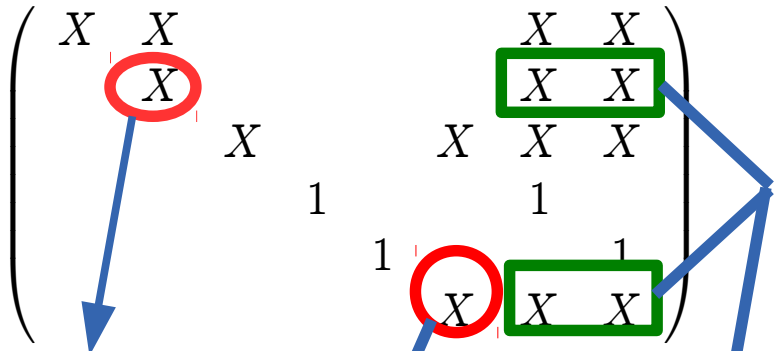
IWK (2009)



$$
\begin{aligned}
g_1 &= q_{10}x_{10} - q_{13}x_{13} - q_{11}x_{11} - q_{12}x_{12} - C_1, \\
g_2 &= \left(q_{10}^2 - q_{13}^2\right) x_{13}^2 - 2q_{11}q_{13}x_{13}x_{11} - 2q_{12}q_{13}x_{13}x_{12} \\
&\quad -2C_1q_{13}x_{13} + \left(q_{10}^2 - q_{11}^2\right) x_{11}^2 - 2q_{11}q_{12}x_{11}x_{12} \\
&\quad + \left(q_{10}^2 - q_{12}^2\right) x_{12}^2 - 2C_1q_{11}x_{11} - 2C_1q_{12}x_{12} \\
&\quad + \left(m_X^2 q_{10}^2 - C_1^2\right), \\
g_3 &= q_{20}x_{20} - q_{23}x_{23} + q_{21}x_{11} + q_{22}x_{12} - C_2, \\
g_4 &= x_{21} + x_{11} - p_{T1}, \\
g_5 &= x_{22} + x_{12} - p_{T2}, \\
g_6 &= \left(q_{20}^2 - q_{23}^2\right) x_{23}^2 + 2q_{21}q_{23}x_{23}x_{11} + 2q_{22}q_{23}x_{23}x_{12} \\
&\quad -2C_2q_{23}x_{23} + \left(q_{20}^2 - q_{21}^2\right) x_{11}^2 - 2q_{21}q_{22}x_{11}x_{12} \\
&\quad + \left(q_{20}^2 - q_{22}^2\right) x_{12}^2 \ + \left(-2p_{T1}q_{20}^2 + 2C_2q_{21}\right) x_{11} \\
&\quad + \left(-2p_{T2}q_{20}^2 + 2C_2q_{22}\right) x_{12} \\
&\quad + \left(\vec{p}_T^{\,2} + m_X^2\right) q_{20}^2 - C_2^2,
\end{aligned}
$$

Grobner basis

Jacobian



$$
\left.
\begin{aligned}
2(q_{10}^2 - q_{13}^2)x_{13} - 2A_1q_{13} = 0 \\
2(q_{20}^2 - q_{23}^2)x_{23} - 2A_2q_{23} = 0
\end{aligned}
\right\}
$$

$$
\det \begin{pmatrix} \partial g_5/\partial x_{11} & \partial g_5/\partial x_{12} \\ \partial g_1/\partial x_{11} & \partial g_1/\partial x_{12} \end{pmatrix} = 0
$$

M_{T2} is derived and can be more optimized.

Finding Optimized MET variables

Algebraic Singularity Method IWK (2009)

Future Directions:

- Develop mathematical techniques/computer tools

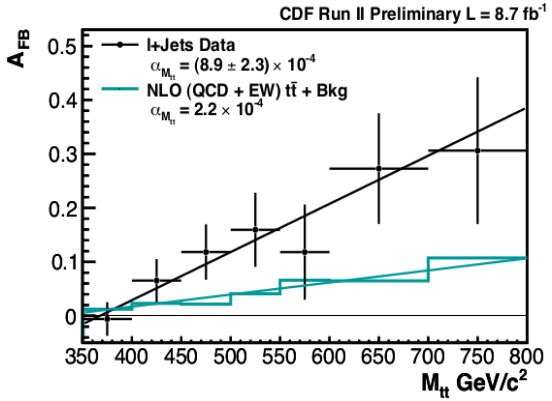
- Apply to other useful topologies and make more use cases:
  - Asymmetric chains
  - Different # of missing particles
  - Subsystems

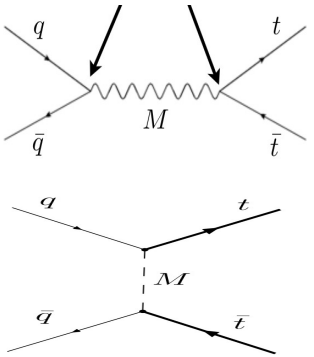
- Extend singularity coordinate:
  - Higher dimensional singularity coordinate
  - Correlations
  - Accommodate Full Amplitude

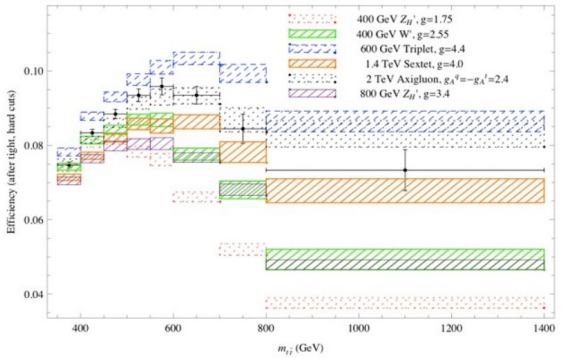
New Physics Model Analysis

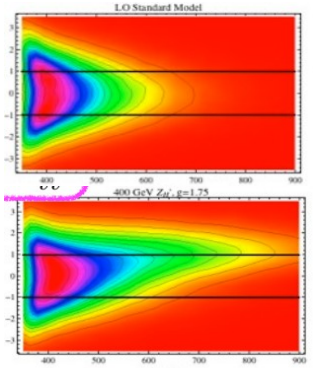
Tevatron Top A_{FB} Anomaly

Gresham, IWK, Zurek (2011)



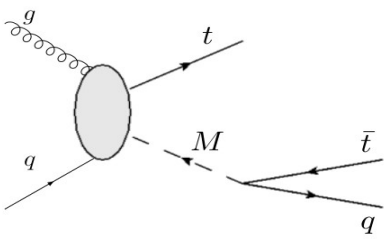


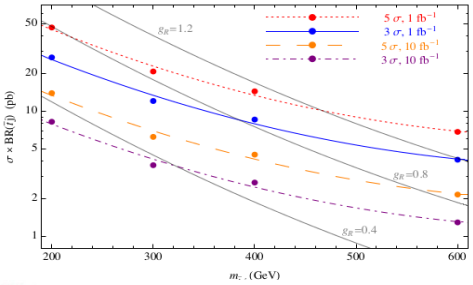


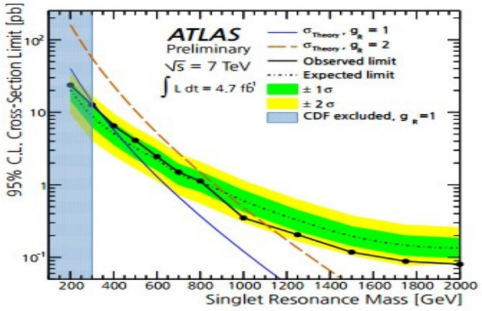


Top-jet Resonance Search Study

Gresham, IWK, Zurek (2011)







Performed in current exp searches

Atomic Parity Violation Constraint

Gresham, IWK, Tulin, Zurek (2012)

Point out model-dep acceptance due to forward events

Comprehensive Model Comparison w/ Tevatron/LHC data

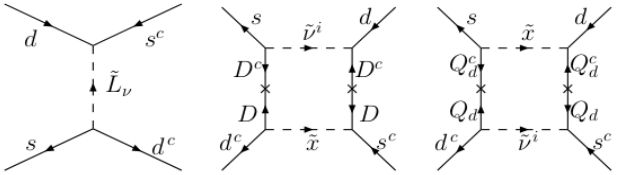
Ian-Woo Kim (CERN)

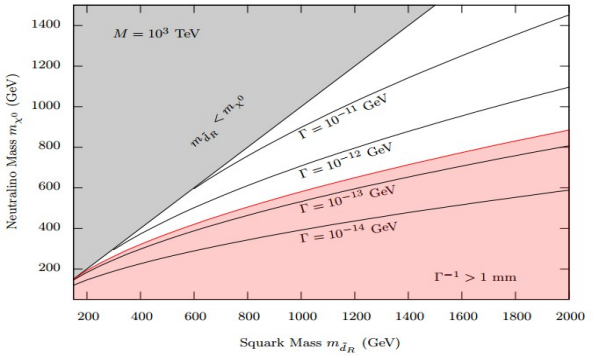
New Physics Model Analysis

Flavor/Collider Physics of ADM

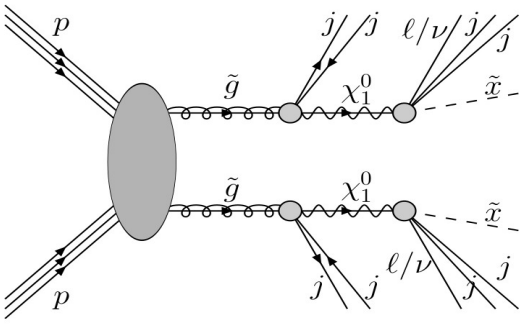
IWK, Zurek (2013)

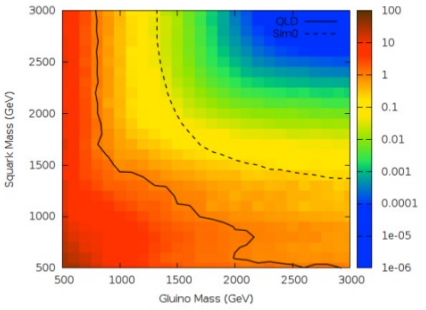
- B-L carrying dark matter particle ↔ associated with Baryogenesis
- Higher Dim. Operator : $W_{\rm ADM} = Xq\ell d^c, Xu^c d^c d^c, X\ell\ell e^c$
- Flavor Constraints: Displaced Vertex



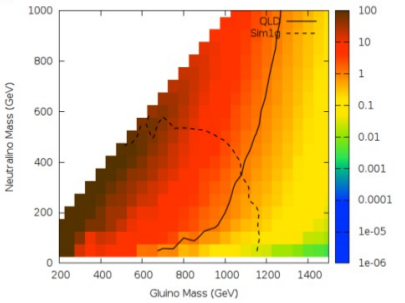


- LHC Constraints





ATLAS SUSY 0lep+2-6j+MET

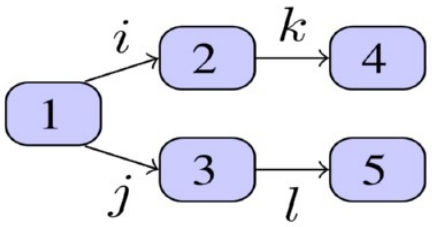


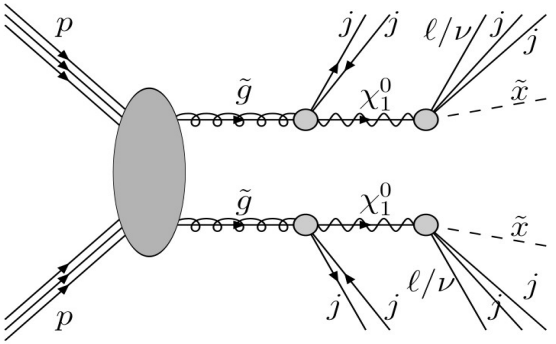
ATLAS SUSY 1-2lep+3-6j+MET

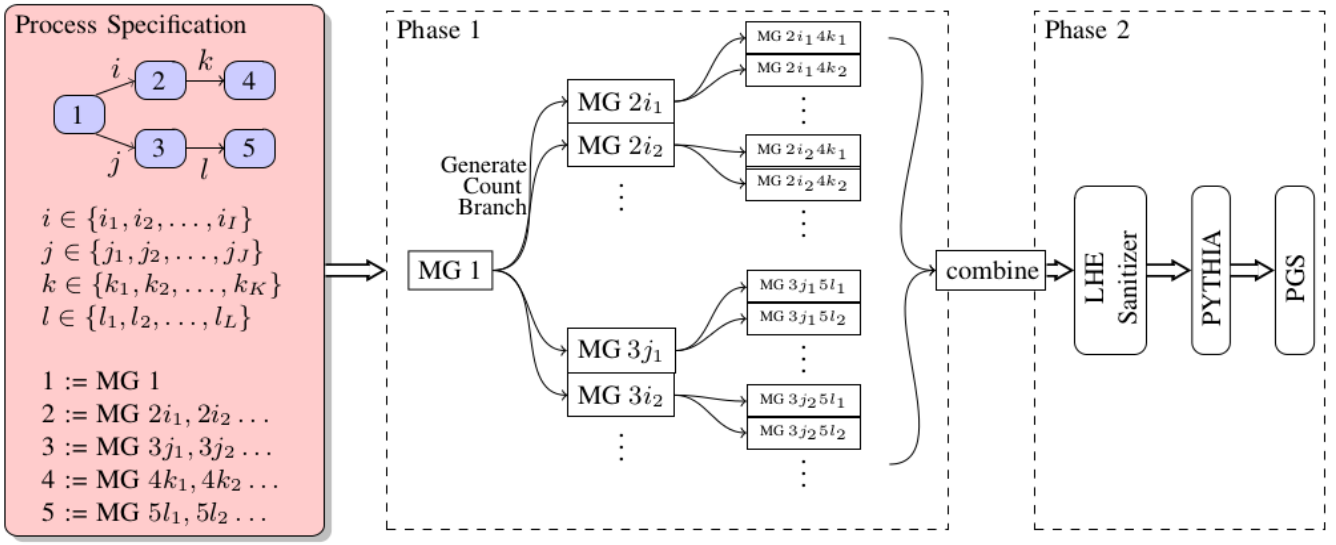
HEP Software Development

- `evchain`: Meta-Event-Generator for Chaining Long Cascade

http://github.com/hep-platform/evchain



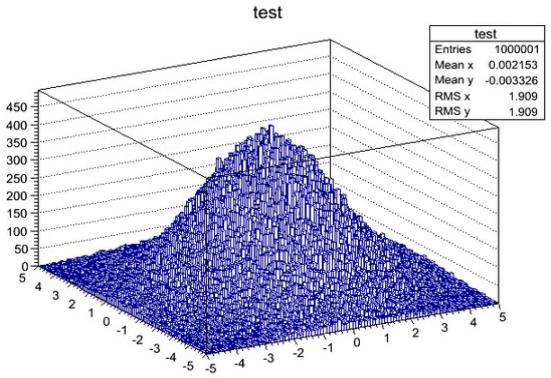




HEP Software Development

- `HROOT` : A Haskell binding to the ROOT analysis tool

http://ianwookim.org/HROOT




```
main :: IO ()
main = do
  tcanvas <- newTCanvas "Test" "Test" 640 480
  h2 <- newTH2F "test" "test" 100 (-5.0) 5.0 100 (-5.0) 5.0

  let dist1 = Normal (0 :: Double) (2 :: Double)
      dist2 = Normal (0 :: Double) (2 :: Double)

  let go n | n < 0 = return ()
           | otherwise = do
               histfill dist1 dist2 h2
               go (n-1)

  go 1000000
  draw h2 "lego"
  saveAs tcanvas "random2d.pdf" ""
  saveAs tcanvas "random2d.jpg" ""


histfill :: Normal Double -> Normal Double-> TH2F ->  IO ()
histfill dist1 dist2 hist = do
  x <- sample dist1
  y <- sample dist2
  fill2 hist x y
  return ()
```

- `pipeline`: HEP EG/Analysis Automation on Cluster

http://github.com/hep-platform/pipeline