# Some opportunities with SoLID Hall A for GPDs with an upgraded E=22 GeV beam

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“The next generation of 3D imaging”

## Disclosure

This talk is mostly to introduce discussions, as no complete studies have been done yet

# Motivations

- JLab programs with 6 GeV and 12 GeV beams provide first constraints to nucleon GPDs in the valence region

- Mostly DVCS has been measured: still many questions for DVCS, and not all polarization observables measured yet (proposals exist for 12 GeV ( not Hall A)

**How SoLID in Hall A can contribute to this program?**

**What an upgraded beam energy (E=22 GeV) will provide as new insights?**

# Complementarity SoLID vs other setups

**- large acceptance**
**- high intensity**

**=> can do precision measurements in a wide kinematic range**

== complement other Hall A and C experiments, can be a “second” measurement in a wide range after first dedicated measurements with SBS or other

== can reach much higher intensity (in principle) than Hall B and D
Note: about factor of 10 to expect in statistic when balancing intensity vs acceptance vs Hall B

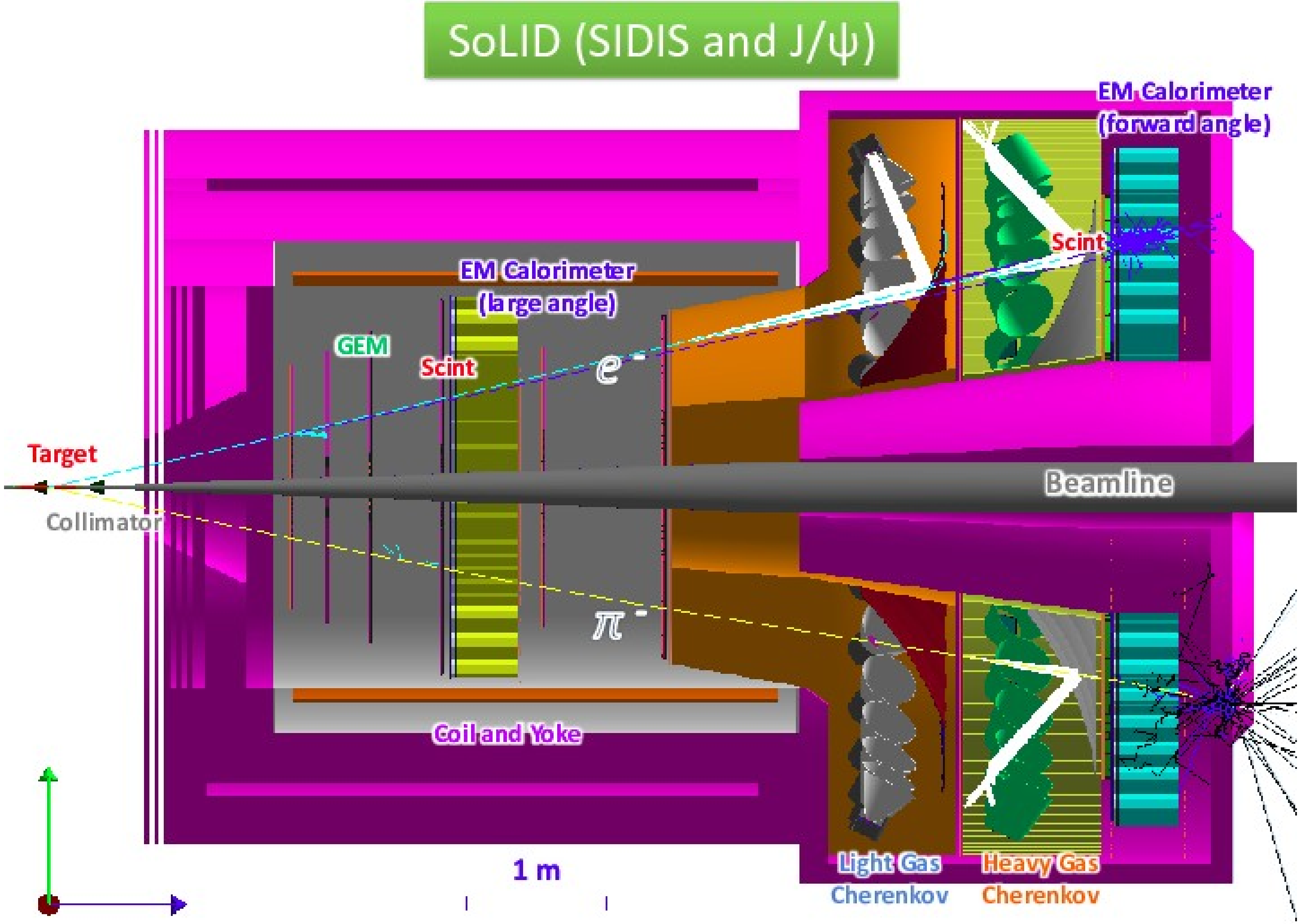
== **evolution in $Q^2$**: need both precision + wide range in $Q^2$. Even better with higher beam E.
For these studies SoLID would be the best place

**=> multiple measurement out of the same set of data**

== enable comparative studies of Hard Exclusive Meson Production, i.e. “**mass evolution”** at fixed kinematics for Vector Mesons, DVCS+DDVCS, final states with more than one meson, …
Range is much broader than other setups, no need of rotating arms (same systematics…) and still high statistic possible compared to other large acceptance setup

**Several advantages make SoLID be a unique, great place for multi-channel GPD measurements**

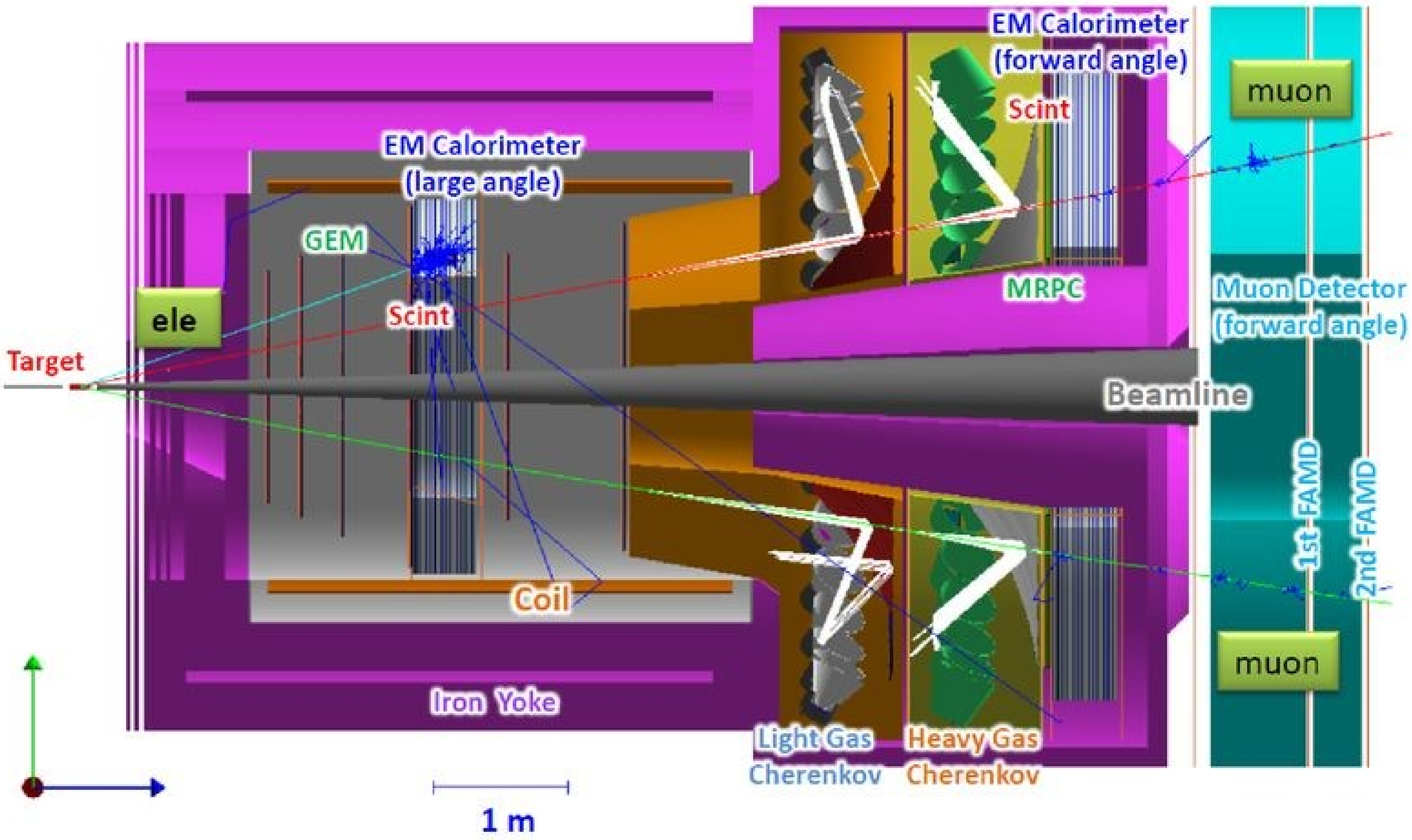
# SoLID configurations considered in this discussion




Considering SIDIS/J/psi setup, with possible added muon detectors, LH2, LD2, He3 targets

# Detector Configuration

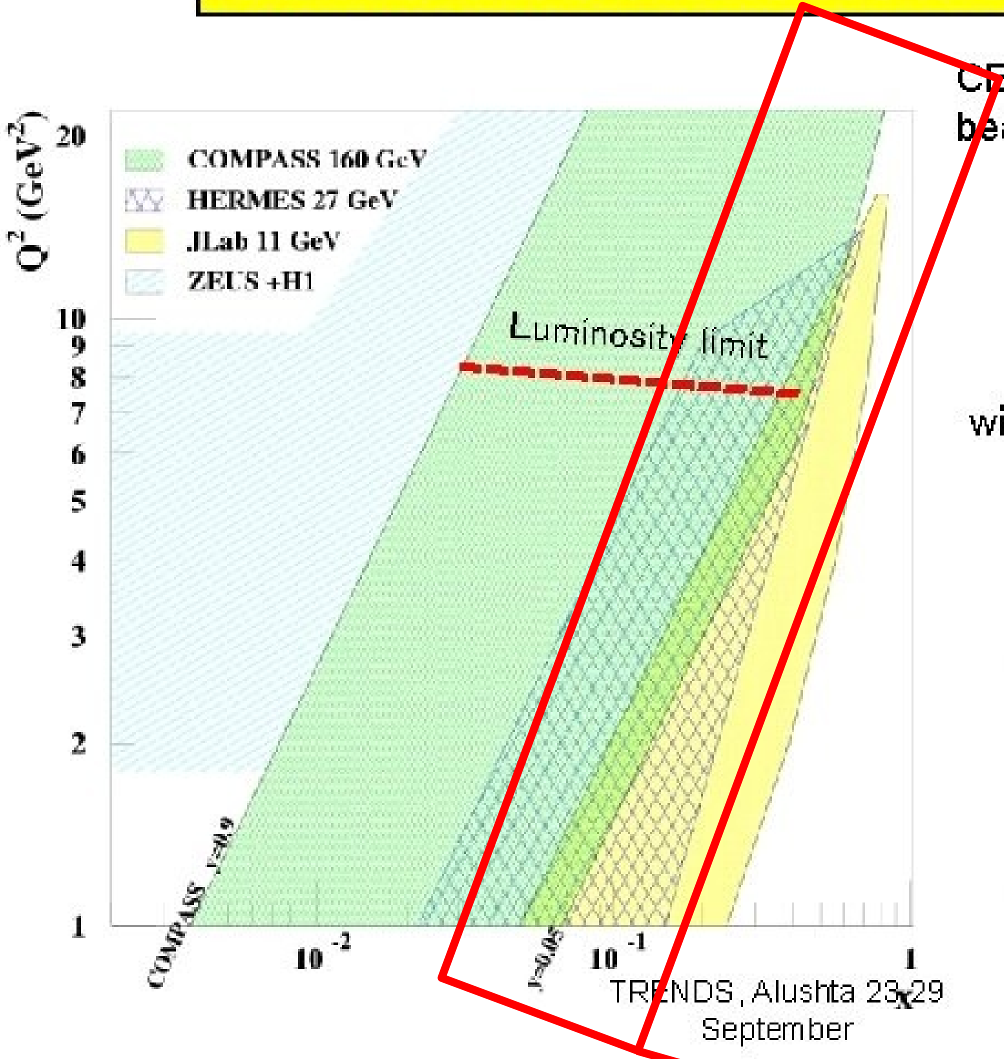
SoLID (DDVCS, JPsi/TCS)




(DDVCS talk from A. Camsonne)

# Kinematic region

Kinematic domain accessible at COMPASS




CERN High energy muon - beam 100 - 190 GeV

μ+ and μ- available

80% Polarisation

with opposite polarization

with a 2.5m long $LH_2$ target

$L = 10^{32}\ cm^{-2}\ s^{-1}$

$Q^2 \rightarrow 8\ GeV^2$

$\rightarrow$ 16 GeV$^2$ if luminosity increased by factor 4

$\sim 10^{-2} < x < \sim 10^{-1}$

$x \rightarrow$ 0.20 with extension of present calorimetry

Will cover the "HERMES" region
With far greater luminosity
== many "statistically" limited measurements
at HERMES/COMPASS would be feasible
== unique access to this region, particularly high
$Q^2$ and small cross sections

(COMPASS slide from O. Kousnetsov)

# What physics?

SoLID advantages
vs others:

Or meson (mass M)

Several in same data
Small cross sections

Or gamma+meson, gamma+gamma,
meson+meson(s)

Large acceptance, can do

Where SoLId is limited vs other
- smaller acceptance than Hall B
- lower resolution/intensity than Hall C

**Opportunity for complementary program for measuring**
**Vector mesons**
**Other mesons (see Garth talk for Hall C)**
**Compton-like**
**Multi-particle exclusive final state**

# $Q^2$ evolution effects / higher twist

$t/Q^2$, $M^2/Q^2 \rightarrow 0$ we are technically far from the limit

Higher twist are not negligible (DVCS, mesons results Hall A)
We are not studying evolution in $Q^2$. Most GPD model also neglect it

Problem: if we only measure DVCS in a limited range or with limited precision, we don't know if models are far off, $Q^2$ effects are important, or higher twist, …

Re(CFF) also poorly parametrized, differences between models

Novel ways:
- TCS vs DVCS
- DDVCS in 2 different regions
- light VM

=> looking for complementary measurements

Wider phase space accessible, more can be achieve, in particular reaching higher $Q'^2$ (or M)

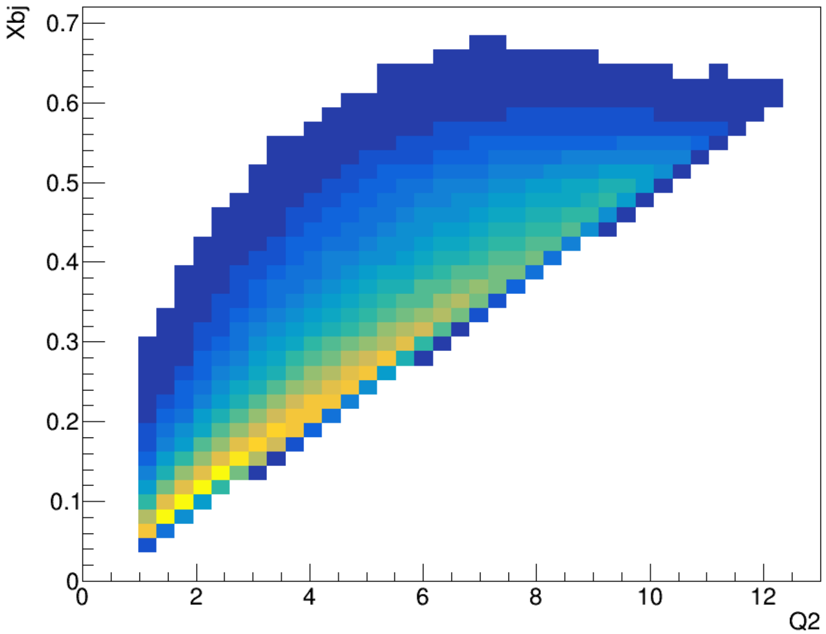
**New with 22 GeV:**
- **extended range to lower xi**
- **can reach higher $Q^2$ provided luminosity**

Finer binning, evolution

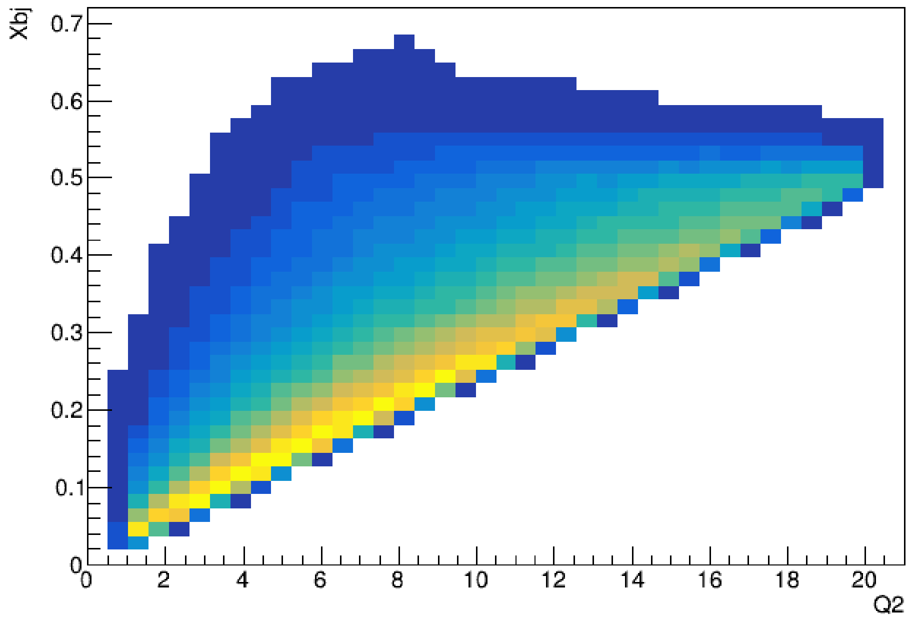
(no cuts)

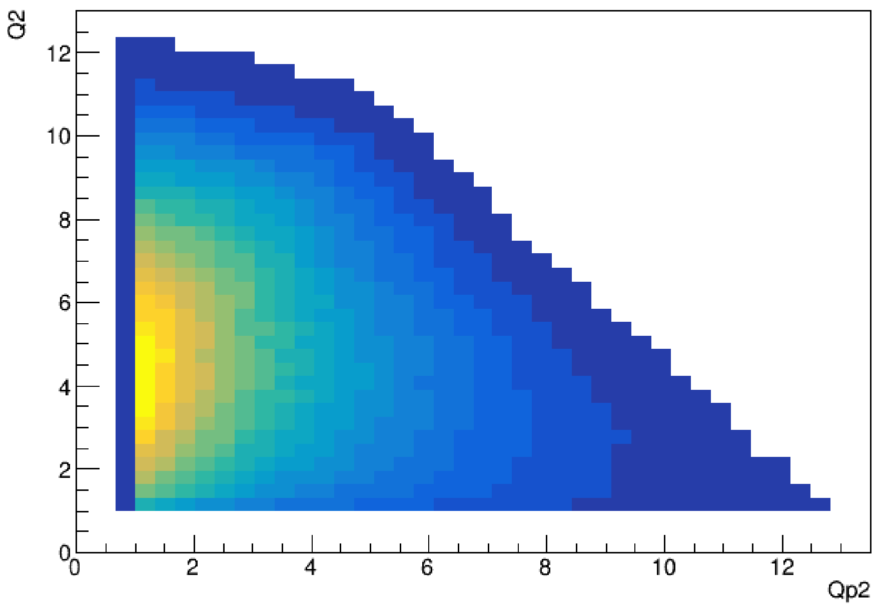
# DDVCS accessible phase space

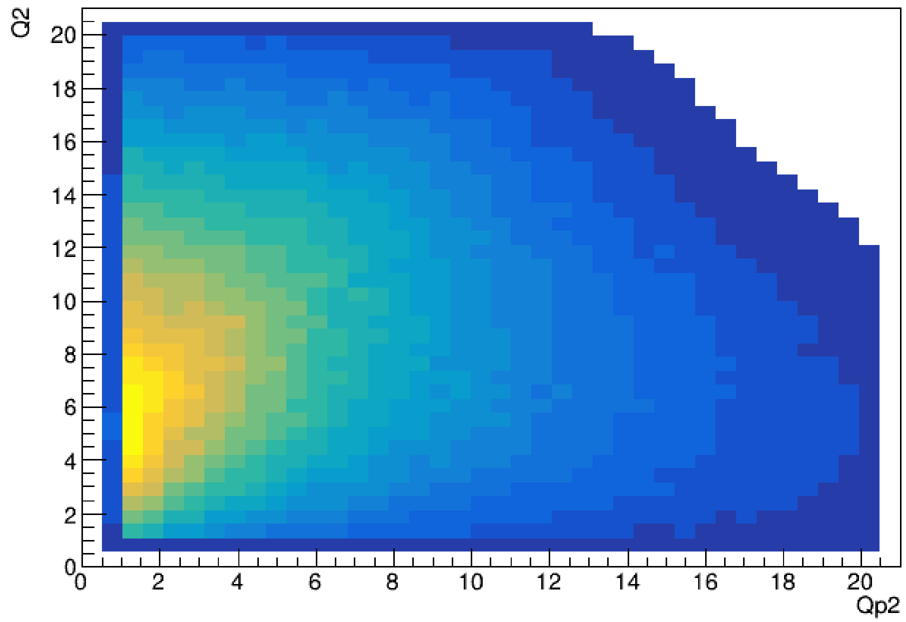
11 GeV




22 GeV



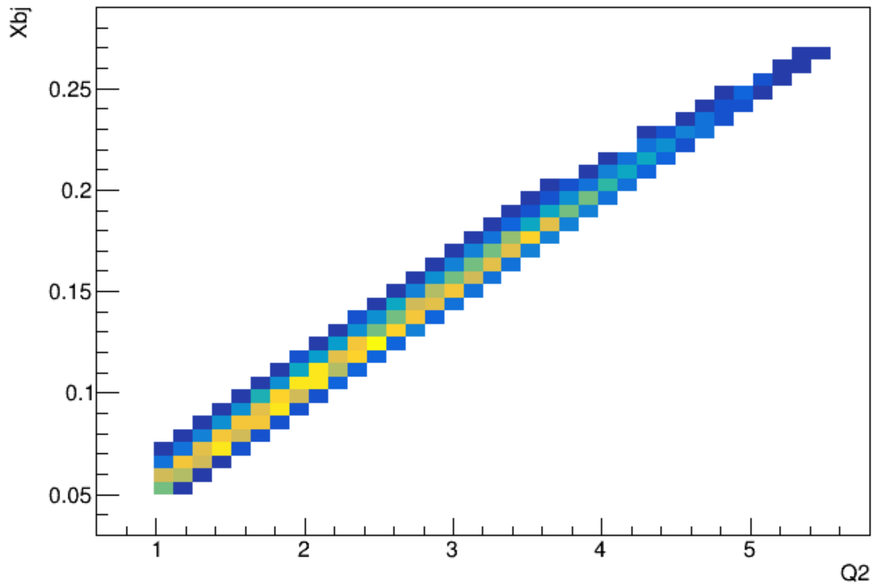
# J/psi accessible phase space

Mass range with 11 GeV: 1 to ~3.4 GeV
=> near threshold J/psi
=> unclear GPD interpretation
- good for studies of J/psi structure and production mechanisms

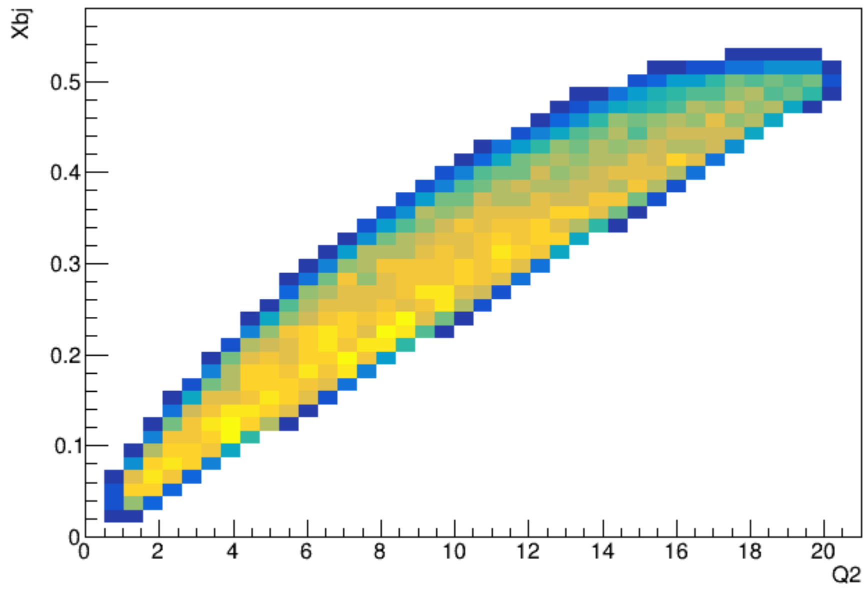
Mass range with 22 GeV: 1 to ~4.5 GeV
=> above threshold (provided luminosity)
=> can interpret into GPDs?
- need theoretical studies at high x (projections for high energy mostly / low x)
- should be feasible, worth to study

(no cuts)

11 GeV




22 GeV



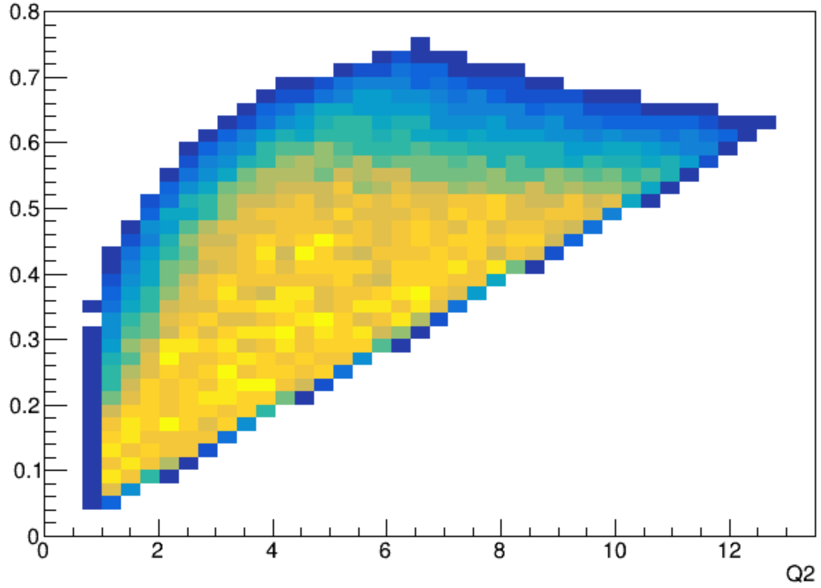
# Other VM HEMP ($Q^2$>1 GeV$^2$)

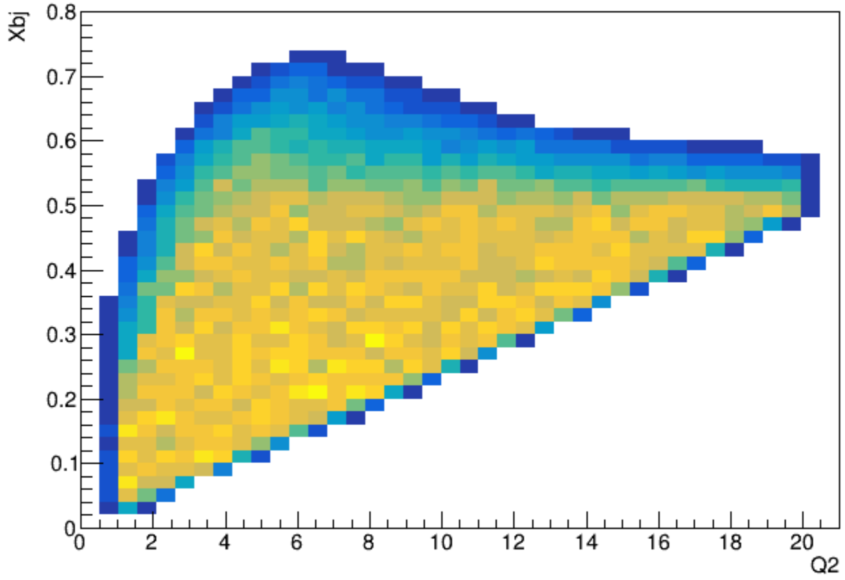
Rho meson

11 GeV

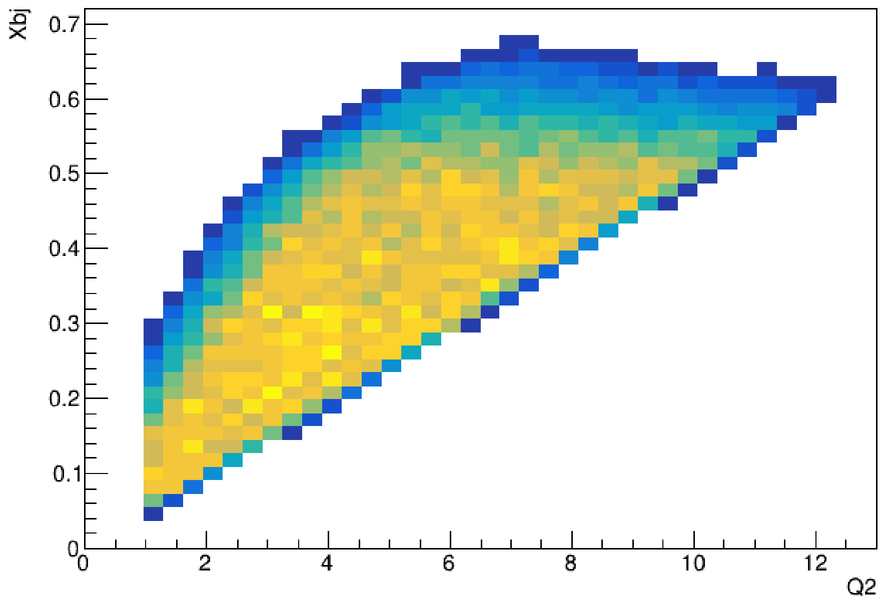
22 GeV

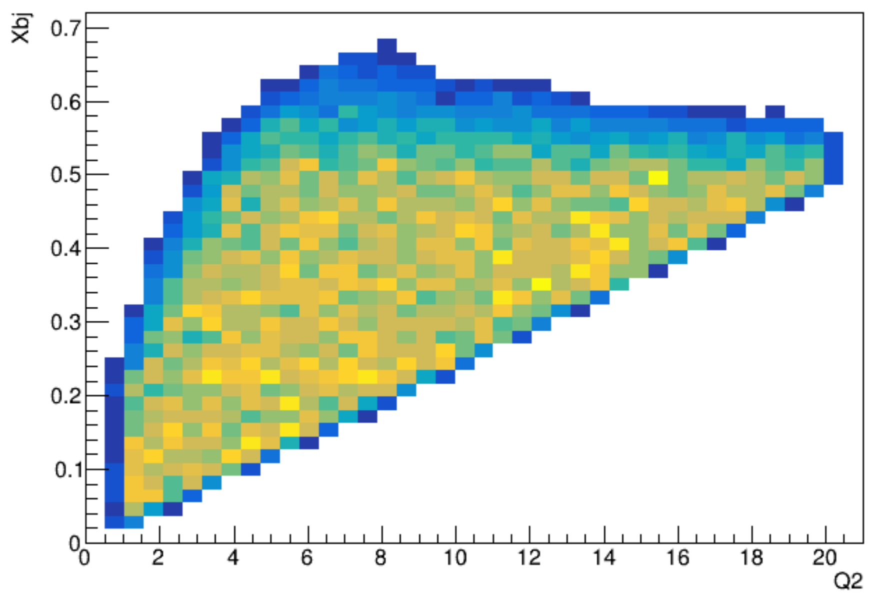
(no cuts)




Phi meson



# Tomography

Tomographic interpretations need extrapolation to xi = 0

Problem: with only DVCS, we constraint “one point” xi = x (“diagonal”)

An approach: “mass evolution”, fix $Q^2$ (or not)

Multiple mesons & DDVCS

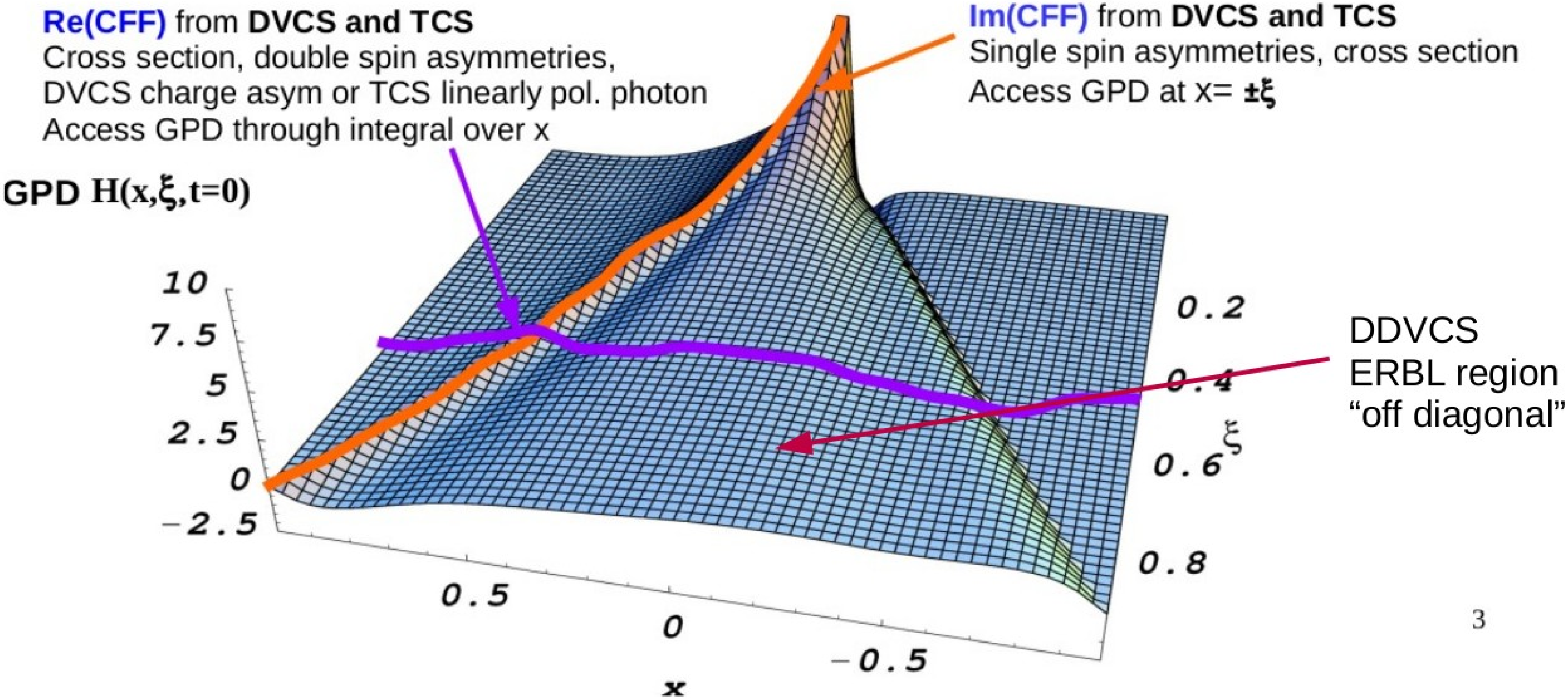
=> let see how doubling the energy enhance our phase space

## DVCS amplitude decomposition into Compton Form Factors (TCS similar):

ξ, t = measurable
x = integrals

$$T^{DVCS} \sim \int_{-1}^{+1} \frac{H(x,\xi,t)}{x \pm \xi + i\varepsilon} dx + \ldots \sim \underbrace{P\int_{-1}^{+1} \frac{H(x,\xi,t)}{x \pm \xi} dx}_{\mathrm{Re}(\mathcal{H})} \underbrace{- i\pi H(\pm\xi,\xi,t) + \ldots}_{\mathrm{Im}(\mathcal{H})}$$

## Probing GPD x vs ξ dependence with experimental observables:



# Access non-diagonal part with DDVCS

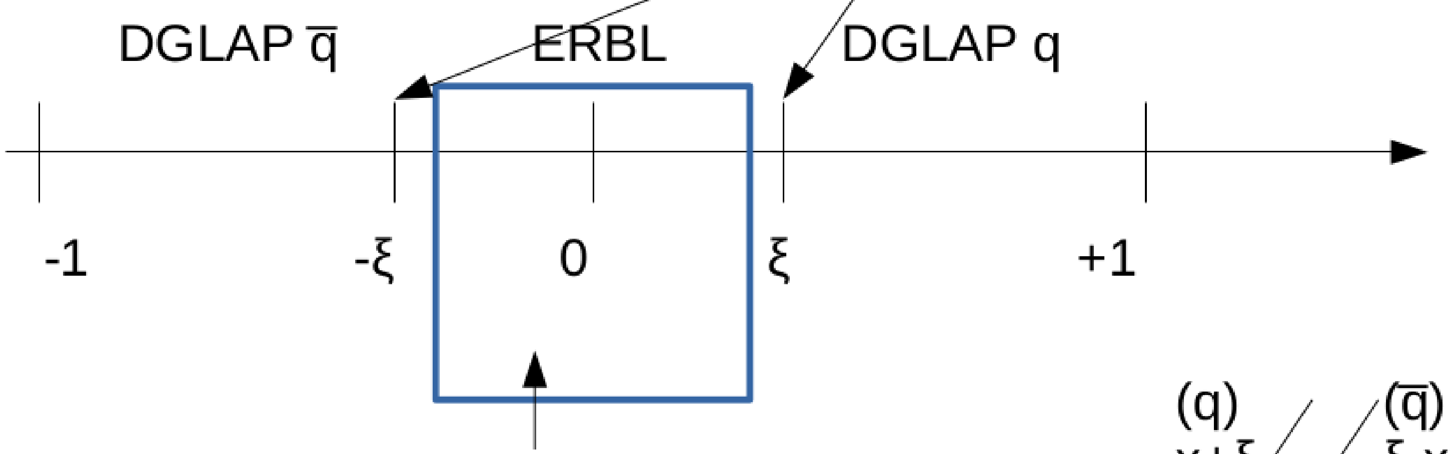
DVCS and TCS get GPDs at the limit between DGLAP and ERBL regions
ERBL region need constraints: DDVCS better than mesons

$\xi>|\xi'|$: ERBL region; $\xi<|\xi'|$  DGLAP region

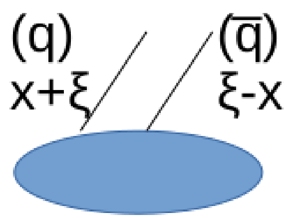
Quark propagator normalized to $\xi$ at asymtotic limit: $(1-Q'^2/Q^2) / (1+ Q'^2/Q^2)$
→ up to $t/Q^2$ factor, we play with respective value of $Q^2$ and $Q'^2$ to go "out of diagonal" for GPD
→ neglecting t, we are restricted to $\xi>|\xi'|$

M. Diehl's representations:

limit between the 2 regions:
Im(CFFs) from DVCS and TCS



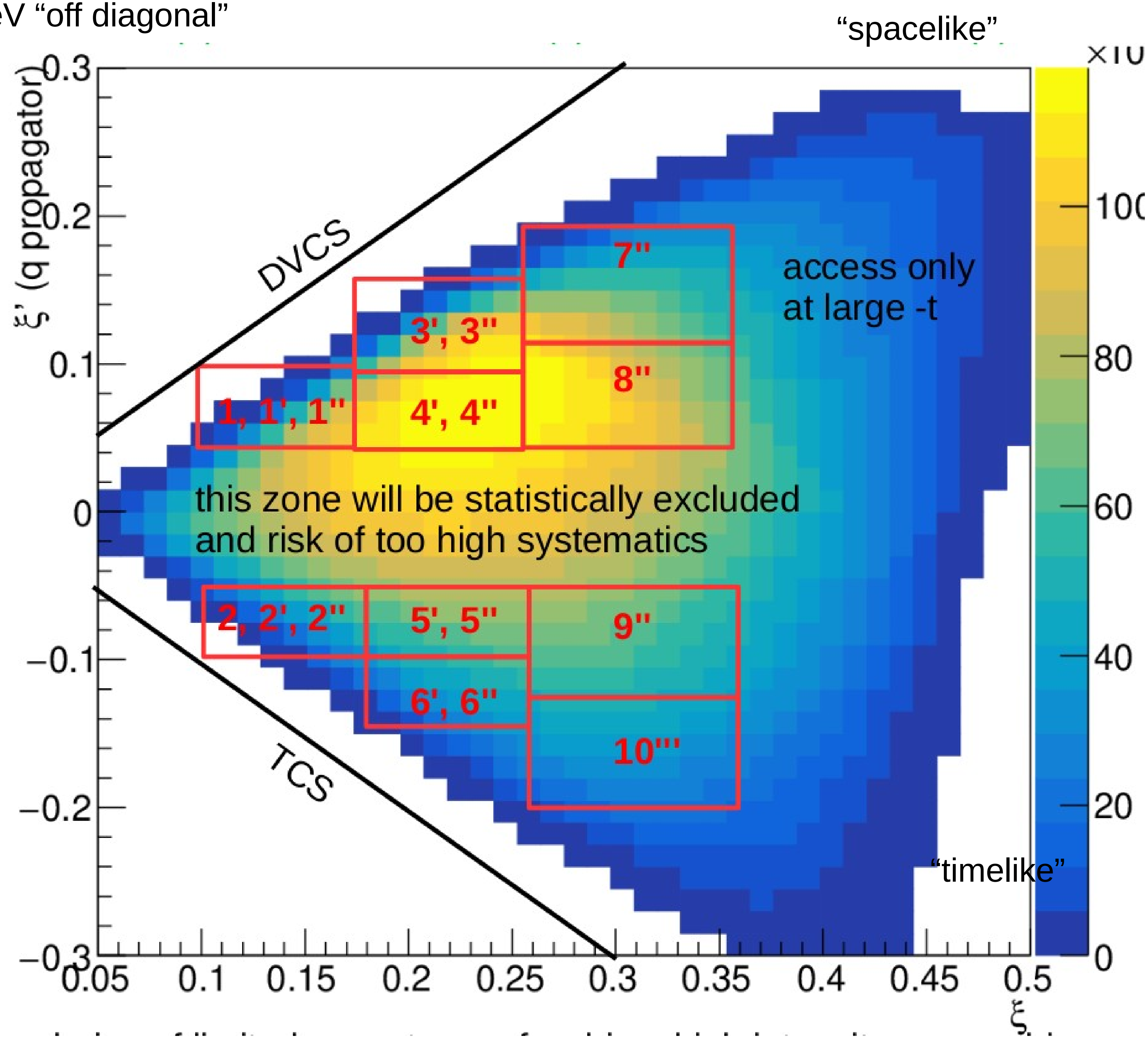

accessible with DDVCS



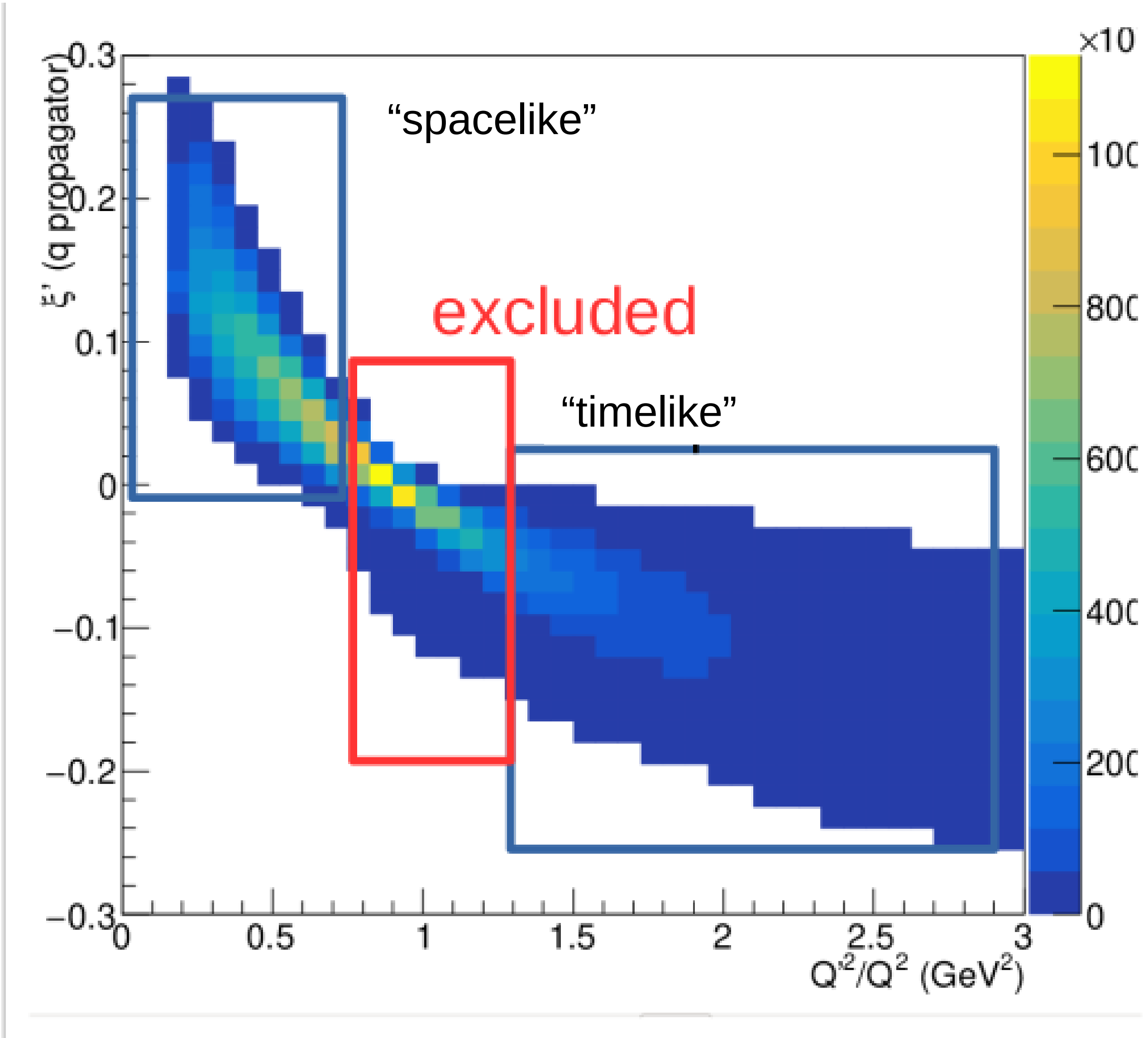

partonic interpretation from M. Diehl in ERBL region

need to map this region for GPD models and extrapolations needed
for tomographic interpretations at $\xi=0$; GPD extrapolated from $\xi\to0$

11 GeV “off diagonal”



11 GeV “off diagonal”




Wider range and possibility to have “meson points” with higher energy

Still limited: no intensity assumption here. Taking same as for 12 GeV program

For 11 GeV:

- TCS is difficult
- DDVCS is very difficult
- 2 photons, non-vector parity might be statisticaly limited (dropping cross section)

For 22 GeV:

Need to do calculations of cross sections and luminosity estimate

Advantage 22 GeV

- $Q^2$ evolution
- higher twist / real part of CFF / wider xi range
- HEMP program possible for VM

# Why a GPD program with SoLID at 22 GeV?

- enhanced phase space DVCS, TCS, DDVCS for Compton-like studies

- enable comparative HEMP Vector Meson program (“mass evolution”)

- HEMP+DDVCS => tomographic interpretations

- TCS+DVCS, DDVCS => GPD universality

- quite large acceptance, high intensity: competitive and complementary with other setup/ Halls